Final Activity Report for APN 2001-12

Project leader: Ding Yihui

22 February, 2002

Final Activity Report

I. Project title: APN 2001-12

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III. Summary of entire project

The project was supported by APN with 45000USD. Participants from the following countries were funded: China (including HongKong and Macao), Japan, Australia, Korea, Philippines, Indonesia, Vietnam, Malaysia, and U.S.A. Computer charges for prediction of 2001/2002 El Nino event with performing 6 models were funded by NCC/CMA (about RMB: 120000). The major objectives and contents of the project APN 2001-12 during 2001 include collection of data and information; improving the network and issuing new products; continuing to enhance research work, increase the amount of papers, and put related research papers on the web; and improving El Nino/La Nina prediction system. Through one year's efforts, these goals have been successfully achieved. A workshop was successfully held in Macau, China on Feb 5-7 2002.

IV. Introduction/Background

Numerous investigators have shown that ENSO cycles (consisting of El Nino and La Nina phases) have significant relations with and impacts on climate, environment, and socio-economic aspects in the Asian and western Pacific countries and regions. For instance, recent statistics have shown that due to the effect of 1997/1998 El Nino event, global and regional climate changed abnormally, and large-scale severe natural disasters caused 4,829,884 persons to be homeless and direct economic losses up to US$33.9 billions. On the other hand, the sea surface temperature anomaly (SSTA) in the western Pacific Ocean also may exert a teleconnection effect on the weather and climate in East Asia through PJ (Pacific–Japan) pattern or Walker circulation. Therefore, it is very necessary to improve our understanding and knowledge in these fields and very essential to enhance the monitoring and prediction of ENSO events and SSTA on the warm pool over the western Pacific Ocean at the seasonal and interannual time scales with necessary related information, products and data sets distributed to APN countries/regions via an Internet network, thus leading to improvement of seasonal and interannual prediction of monsoon activity and significant climate events in this region.

V. Scientific significance

It is well known that there are close relationships between ENSO phenomenon and anomalous climate through which socio-economic impacts in the tropical and other climatic zones have been produced. Numerous investigators have shown that ENSO cycles (consisting of El Nino and La Nina phases) have significant relations with and impacts on climate, environment, and socio-economic aspects in the Asian and western Pacific countries and regions, such as Indonesia, Philippines, Malaysia, Vietnam, Thailand, Australia, Japan, Korea and China. It may cause droughts, floods, cold injuries, heat waves, landfall of typhoons as well as forest fires in the Asian and Pacific region, thus bringing about huge socio-economic losses and deterioration of environment to these regions. For instance, recent statistics have shown that due to the effect of 1997/1998 El Nino event, global and regional climate changed abnormally, and large-scale severe natural disasters caused 4,829,884 persons to be homeless and direct economic losses up to US$33.9 billions. It has been found that there are some definite correlative relationships between the onset, maturity and decay of ENSO, and the intensity of winter and summer monsoon over Asia. On the other hand, the sea surface temperature anomaly (SSTA) in the western Pacific Ocean may exert a teleconnection effect on the weather and climate in East Asia through PJ (Pacific–Japan) pattern or Walker circulation. The thermal regime of the warm pool and the convection activity in the region around Philippines play important roles in affecting the seasonal and interannual variability of the East Asian summer monsoon. Therefore, from the unique regional view-point, it is an urgent task to set up a network system for monitoring and predicting sea temperature of the warm pool in the western Pacific Ocean and its relationship to the summer monsoon activity. It is very necessary to improve our understanding and knowledge in these fields and very essential to enhance the monitoring and prediction of ENSO events and SSTA on the warm pool over the western Pacific Ocean at the seasonal and interannual time scales with necessary related information, products and data sets distributed to APN countries/regions via an Internet network, thus leading to improvement of seasonal and interannual prediction of monsoon activity and significant climate events in this region.

Scientifically, a unique feature is that this network is designed for APN countries/regions, with a special emphasis placed on oceanic and meteorological conditions over Warm Pool and the South China Sea, the impact of ENSO events and SSTA of Warm Pool on the weather and climate of APN countries (including tropical cyclones and monsoon) which has been often neglected in previous studies. The highlights of this network is to pay more attention to combined effects of ENSO events and Warm Pool on Southeast Asia and East Asia, via the so-called PJ pattern teleconnection or EAP teleconnection. This is a marked difference from the focuses placed by COLA, CPC, and IRI that in most of cases stress ENSO events and their impact on North and South America.

For the recent years, NOAA of US, JMA of Japan, BOM of Australia and NCC of China have made considerable progresses in the monitoring and prediction of ENSO events. They have issued the operational oceanic and atmospheric products over the tropical Pacific Ocean and carried out the monthly, seasonal, inter-annual prediction of SSTA by using both statistical methods and dynamical models in each month respectively. These products are reasonably good and are very useful guidances for other countries. But, most of their monitoring and prediction have been concentrated on the equatorial central and eastern Pacific Ocean. They have paid less attention to the monitoring and prediction of the western Pacific warm pool as well as the monitoring of the effects resulting from warm pool SSTA and ENSO. In 1999, under the assistance and support of APN, China, Japan, Korea, Philippines, Thailand, Malaysia, Vietnam, Indonesia, and Australia jointly proposed and undertook the APN cooperation and research project " Monitoring and prediction of ENSO event and SSTA over the warm pool in the western Pacific Ocean" (1999-2000), which aims to preliminarily set up the internet system for monitoring and predicting ENSO and warm pool SSTA. Since the participating institutions are all of APN countries /regions, affected greatly by monsoon, they are of great concern for ENSO events and the warm pool and their impact on the East Asian monsoon. This is the central issue of our project. Therefore, we have already had a consensus of the project goal, objectives, respective contributions and distributed network. A close regional cooperative relationship has been established and worked jointly very well.

The present project is a continuation and improvement of the project stated above. In the present project, the participating countries/regions (China, Japan, Korea, Philippines, Thailand, Malaysia, Vietnam, Indonesia, and Australia) mainly cooperate in six aspects: collection of data and information, undertaking scientific research work, assessing effect of ENSO/warm pool on weather and climate, improving monitoring system, improving El Nino/La Nina prediction system, setting up the network and issuing products, and holding an international workshop. Among them, CNCC is responsible for integrating data and information provided by various participating countries, improving monitoring system, improving El Nino/La Nina prediction system, setting up the network and issuing products. First, information has been furnished to participating countries and then APN countries. In addition, our project was responsible for organizing an international workshop on monitoring and seasonal to interannual prediction of ENSO event and the warm pool and their impact on the East Asian monsoon in Macau on Feb 5-7 2002. Scientists in APN regions and ENSO experts outside APN regions (in total about 40 people) were invited to attend the workshop. Undertaking scientific research work and assessing effect of ENSO/warm pool on weather and climate were completed by participating countries of this project. Each participating countries will also organize their national related activities. Then, via Internet, FAX, telephone as well as international workshop, they exchange and share achievements. Meanwhile, CNCC put these achievements on to our APN project network for more extensive use in APN region whenever necessary. For a long time period, National Climate Center of China has been keeping the good collaborative relation with many scientists and agencies of USA, Japan, Korea, India and other countries around the Pacific, who have been engaging in studying ENSO and the warm pool. There have been commonly concerned issues of climate and environment among them. All of these have laid a sound foundation for application, cooperation and successive implementation of this project.

VI. Detailed information of activities conducted

1. Maintaining and updating the network and issuing new products, improving the content of the network with the prediction of ENSO, enhancing the research and prediction outputs of the Warm Pool, adding the information of winter monsoon and expanding the data and information contributed by each participating country of this APN project. Highlights of improvement of this network have been made in the following aspects: (1) adding more information of historical background, (2) inclusion of more contributions from participating countries, (3) adding new information and data sets accessible to users in APN countries, and (4) establishing a full and updated network, with internal memory capacity of our workstation expanding, thus providing a more complete set of monitoring information data sets and prediction products as well as graphic outputs. The design of the main web-page of the network with a newer layout and the clearer catalogue and more easily accessible mode has been technically improved, so that the information can be picked up effectively by users. The related countries and experts that participate in this project through E-mail have further updated and supplemented information and data, promoted the time efficiency in updating the web, and validated contact and accessible method.

2. El Nino/La Nina prediction systems (including dynamical models and statistical methods) have been improved to raise the capability of prediction and simulation. At present, 6 dynamical models and 4 statistical models are used to perform ENSO prediction in NCC of China, 2 dynamical models are used in Australian Bureau of Meteorology, 1 dynamical model is used in JMA, and 1 model with dynamical ocean and statistical atmosphere is used in KMA. The Predictions of the tropical Pacific Ocean SSTA during 2001-2002 has been made by the scientists of China, Japan, Korea, Australia, etc, and issued on the APN network. (See Fig.1-4).

NCC/CMA T63 AOGCM

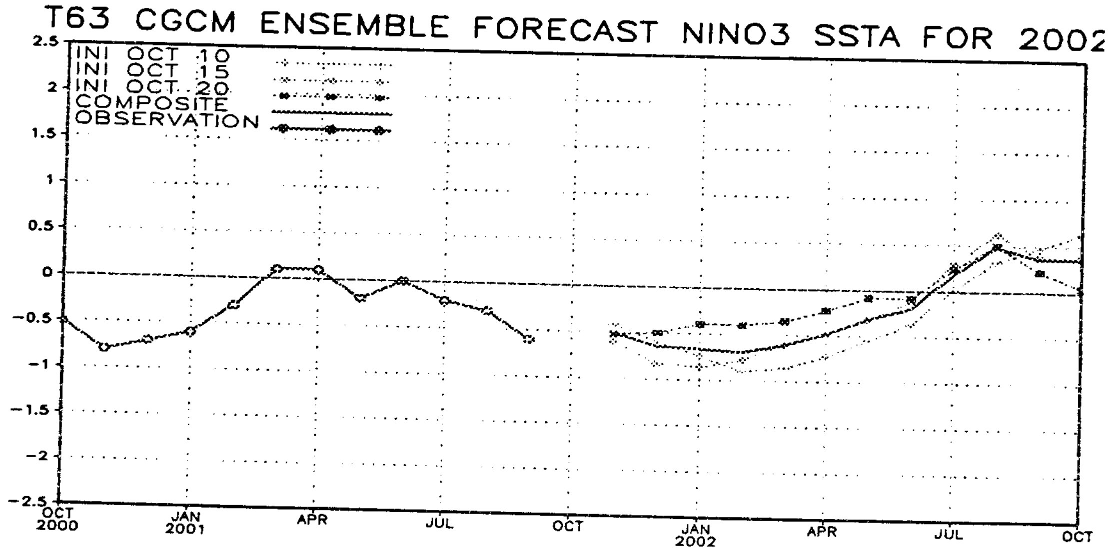


Fig.1

Outlook Of The SST Deviation For Region B (Niño.3) By The El Niño Forecast Model With MOS. (JMA)

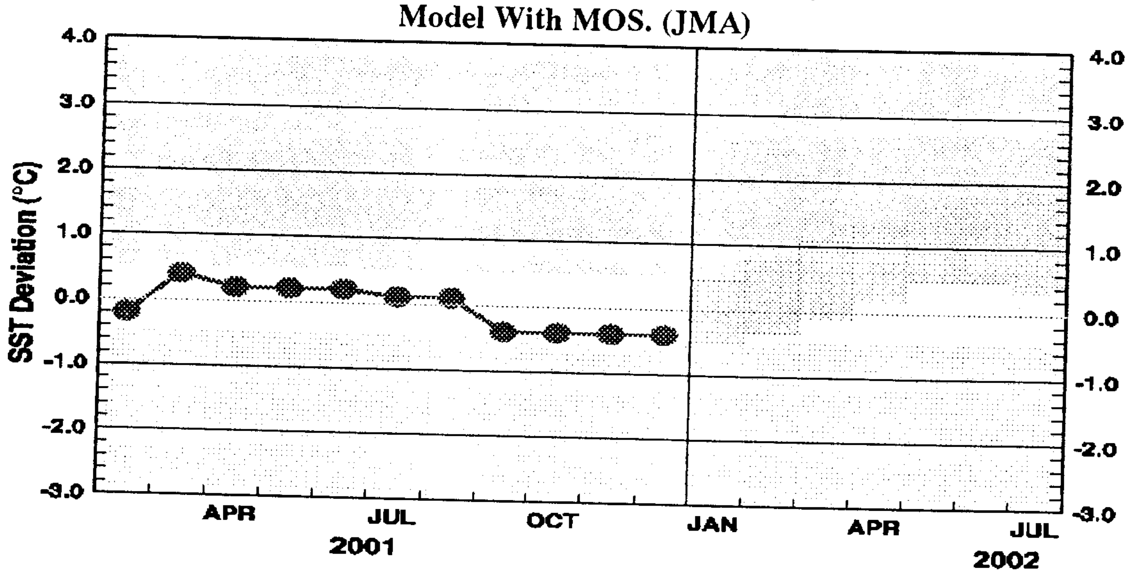
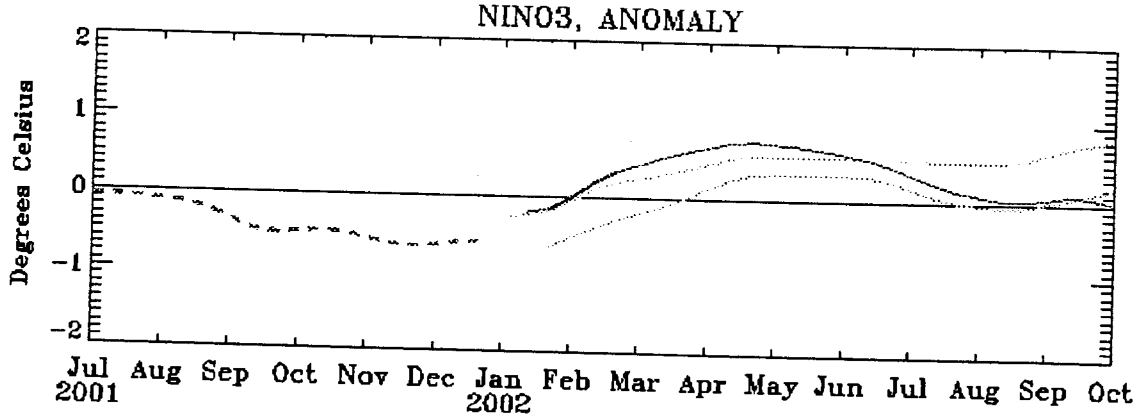


Fig.2

Experimental Predictions Using a Global Coupled Ocean-Atmosphere Model (AUS)

NINO3, ANOMALY



NINO4, ANOMALY

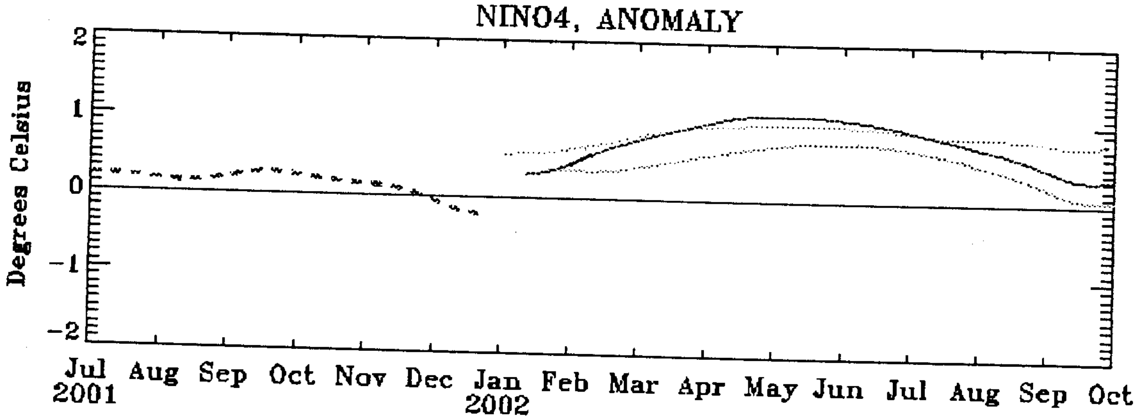


Fig.3

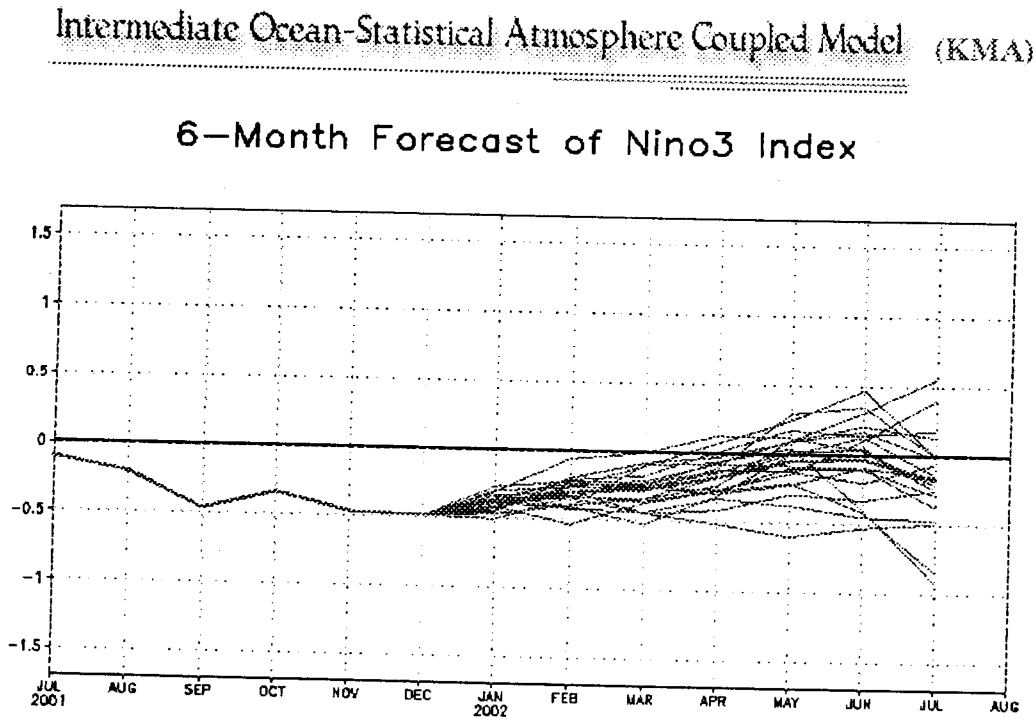


Fig.4

3. Continuing to enhance research work, increase the amount of papers, and put related research papers on the web (about 80 papers). Through those studies, the useful relationships between ENSO and SSTA of Warm Pool, and anomalous weather–climate condition in Southern Asia and East Asia have been established and in turn will be used in operational seasonal and interannual prediction, especially for extreme events such as typhoons, monsoon and droughts/floods.

4.An international workshop on monitoring and prediction of ENSO event and the sea temperature structure of warm pool in the Western Pacific was held in Macao on 5-7 February 2002. Its detailed information and summary is referenced to as items XI and XII.

VII. Outcomes/Products

1. Enlarging the collection of data and information relative to ENSO and the warm pool, such as TOGA—TAO and SCSMEX—A, B, C buoy data, oceanic data of the warm pool and the South China Sea, the oceanic observations of Japan along 137°E, and satellite data such as OLR and TBB, etc. The data sets needed for the project were provided by participating countries.

2. Improving the network and issuing new products. A network and its web-page (http://www.ncc.gov.cn) of the APN project (#99012 and #2000-12) have been fully set up, with their catalogues and information residing on a workstation. China National Climate Center (CNCC) is responsible for maintenance and improvement of

this network in the Internet, and collection and updating of the necessary information.
3. A booklet of this APN Project describing this network has been published.

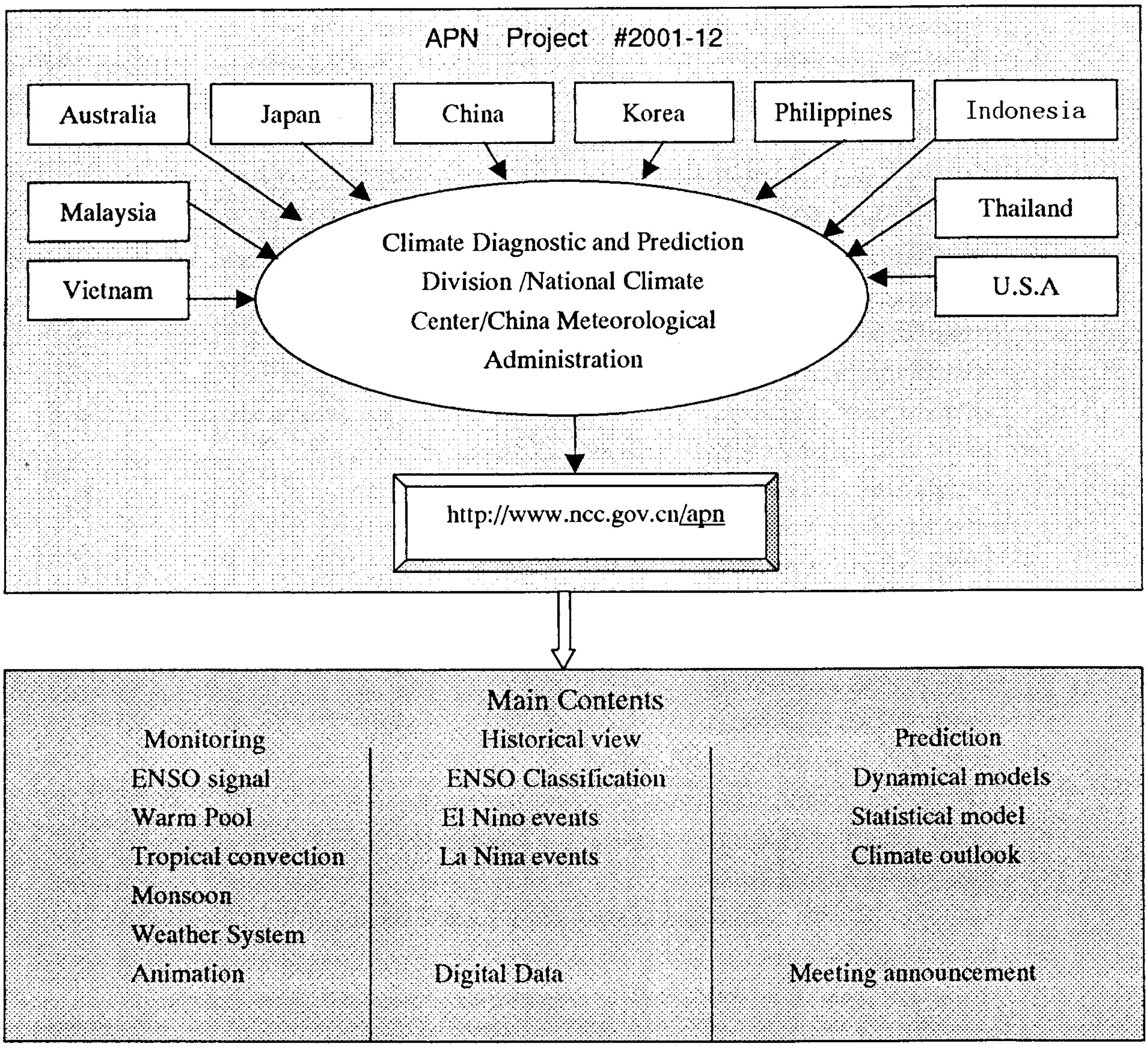
4. The proceedings for the international workshop on monitoring and prediction of ENSO event and the sea temperature structure of the warm pool in the West Pacific which was held in Macau on 5-7 February 2002 were published and issued. They include the agenda (workshop title, date and venue), participant list (contact details of each participant, such as organization, address, phone#,fax#, and email address), and abstract of each presentation in the workshop in the meeting.

VIII. Future directions/follow-up work

The names and affiliation institutions (telephone numbers, fax number and email addresses, etc.) and the major research areas and achievements of the scientists participating in this project will be put on the web-page of this APN project. This will be convenient for keeping contact and exchanging each other. The network system set up by this project will continuously be maintained and updated monthly by NCC of CMA in 2002. In September 2002, a new proposal will be submitted to APN. It is hoped that we can continue to obtain the financial support of APN in 2003. By then, the contents of this network will be expanded, especially, the focuses will be shifted to the impacts of El Nino and Warm Pool on the extreme weather and climate events in the key vulnerable regions.

IX. Project website details

A network and its web-page (http://www.ncc.gov.cn) of the APN project (#99012, #2000-12 and #2001-12) have been set up, with their catalogues and information residing on a workstation. National Climate Center (NCC), China Meteorological Administration is responsible for maintenance and improvement of this network in the Internet, and collection and updating of the necessary information. Other participating countries/regions furnish information and data sets.



Monitoring

ENSO SIGNAL

TIME SERIES OF SSTA INDEX IN NINO 3 + SOI + COI (PRC)

SSTA INDICES IN DIFFERENT NINO REGIONS (PRC)

TIME SERIES OF ENSO INDICES FOR NINO.3, SEA LEVEL, SOI, HIGH CLOUD AMOUNT AND ZONAL WIND (JP)

SOUTHERN OSCILLATION INDEX (AUS)

MONTHLY TROPICAL OCEAN SSTA DISTRIBUTION (PRC, JP, AUS)

TROPICAL SSTA CROSS SECTION (PRC, JP)

MONTHLY MEAN SLP AND SLPA DISTRIBUTION (PRC, JP, AUS)

EVOLUTION OF TROPICAL ZONAL WIND ANOMALIES IN LOWER TROPOSPHERE (PRC)

WARM POOL

MONTHLY MEAN TROPICAL SST DISTRIBUTION VS CLIMATOLOGY (PRC)

STANDARDIZED SSTA DISTRIBUTION (PRC)

W. PACIFIC WARM POOL AREA AND INTENSITY INDICES AND POSITION (PRC)

INDIAN OCEAN WARM POOL AREA AND INTENSITY INDICES AND POSITION (PRC)

DEPTH-LONGITUDE CROSS SECTIONS OF TEMPERATURE AND ANOMALIES ALONG THE EQUATORIAL PACIFIC (JP)

TIME-LONGITUDE CROSS SECTIONS OF OCEAN HEAT CONTENT AND ANOMALIES ALONG THE EQUATOR, 6N AND 6S IN THE PACIFIC (JP)

TIME-LONGITUDE CROSS SECTIONS OF DEPTH OF 20C ISOTHERM AND ANOMALIES IN THE EQUATORIAL PACIFIC (JP)

TIME-DEPTH CROSS SECTIONS OF EQUATORIAL SUBSURFACE TEMPERATURE FOR 160E, 140W AND 110W (JP)

SELECTED REGIONAL SST INDICES IN THE WARM POOL AREA (MALAYSIA)

TROPICAL CONVECTION

MONTHLY MEAN OUTGOING LONG WAVE RADIATION (JP)

MONTHLY MEAN HIGH CLOUD AMOUNT (JP)

MONTHLY MEAN VELOCITY POTENTIAL AND DIVERGENT WIND AT 850 AND 200 HPA (PRC)

MONTHLY MEAN VELOCITY POTENTIAL AT 850 AND 200 HPA (JP)

MONSOON *(A supporting project- SCSMEX)*

MONSOON ONSET (MALAYSIA, AUS, PRC , INDONESIA)

SOUTH CHINA SEA SUMMER MONSOON (PRC)

850HPA AND 200HPA MONTHLY MEAN WIND AND ANOMALY (PRC)

850HPA PENTAD MEAN WIND (PRC)

200HPA PENTAD MEAN WIND(PRC)

PENTAD OLR AND OLRA(PRC)

850HPA AND 200HPA MONTHLY MEAN WINDS (AUS)

200HPA MONTHLY MEAN HEIGHT AND WIND AND ANOMALY(JP)

850HPA MONTHLY MEAN HEIGHT AND WIND AND ANOMALY(JP)

UNIFIED MONSOON INDEX (HK)

RAINFALLS (AUS, PRC , VIETNAM, PHILIPPINES, MALAYSIA, INDONESIA)

WEATHER SYSTEMS

WALKER CIRCULATION CHARACTERIZED BY 850 AND 200HPA ZONAL WIND ANOMALIES (PRC)

NW PACIFIC SUBTROPICAL HIGH CHARACTERIZED BY 500 HPA HEIGHT (PRC)

MONTHLY MEAN VELOCITY POTENTIAL AND DIVERGENT WIND AT 850 AND 200 HPA (PRC)

TIBETAN HIGH REFLECTED BY 100 HPA HEIGHT (PRC)

TRACKS, SUMMERY AND NUMBER OF TROPICAL CYCLONES (JP)

TYPHOONS (AUS PHILIPPINES, VIETNAM, INDONISIA)

SST ANIMATION (PRC)

STARTING FROM 2000 ONWARD (PRC)

Historical View

ENSO CLASSIFICATION

EL NINO EVENTS

LA NINA EVENTS

Predictions & Outlook

DYNAMICAL MODELS

BMRC ENSO MODEL (AUS)

JMA EL NINO PREDICTION MODEL (JP)

KMA EL NINO MODEL (KOREA)

NCCo,NCCn,NCC/STI,NCC/NIM,CANS/NJU MODEL (PRC)

NCC/STI MODEL (PRC)

STATISTICAL MODELS

Singular Spectral Analysis (PRC)

Canonical Correlation Analysis (PRC)

Analogue Prediction (PRC)

Optimum Filter Assembly (PRC)

ensemble of multi-statistical model forecast (PRC)

CLIMATE OUTLOOK

PHILIPPINES

AUSTRALIA

MALAYSIA

KOREA

TYPHOON OUTLOOK

Total number of NW Pacific typhoon (HK)

Total number of typhoons in Philippine Area of Responsibility (Philippines)

Total number of NW Pacific typhoon (PRC)

Digital Data

JAPAN: SST data; Nino 3 SST index

CHINA: General atmosphere circulation index (diagnose@rays.cma.gov.cn);

Pre-summer rainfall and assimilated atmospheric data (jsxue@grmc.gov.cn)

Philippines: Mean sea level pressure, temperatures, rainfalls and tropical cyclones (natcruz@philonline.com.ph)

Australia: Long-term SOI and SLP of Darwin and Tahiti; SST (p.bate@bom.gov.au)

Malaysia: Rainfalls

Vietnam: Rainfalls,tropical cyclone, disasters caused by ENSO Events (nkhieu@imh.ac.vn)

Indonesia: Rainfalls; data of 11 stations (tien@bppt.go.id)

Meeting Announcement

X. CDs

A Compact Disc (CD) for the network is now available. One copy of the CD is included in this package of the APN Final Activity Report. Another copy was given to Dr. Martin Rice in Macau.

XI. The international workshop on monitoring and prediction of ENSO event and the sea temperature structure of the warm pool in the West Pacific was held in Macau on 5-7 February 2002. The agenda (including workshop title, date and venue), and participant list (comprising contact details of each participant, such as organization, address, phone#,fax#, and email address) are listed as followings.

Agenda	
Workshop on the Network System for Monitoring and Predicting of ENSO Event and Sea Temperature Structure of the Warm Pool in the Western Pacific Ocean **5~7 February, 2002, Macao China**	
Monday, 4 February, 2002	
21:45-22:15	Meeting for Scientific and Organization Committee
Tuesday, 5 February, 2002	
9:30~9:50	Workshop Registration outside the Lotus Room **(5/F of WTC)**
OPENING SESSION Chair: Hao I Pan	
10:00	Opening Address **Mr. Soi Kun Fong**, Director, Macao Meteorological and Geophysical Bureau **Prof. Ding Yihui**, Leader of APN project 2001-12 **Mr. Martin Rice**, Programme manager , APN **Dr. Kazuo Kurihara**, Japan Meteorological Agency **Mr. Yunjie Zheng**, Deputy director general, Department of International cooperation China Meteorological Administration **Mr. Ao Man Long**, Secretary for Transport and Public Works, Macao Special Administrative Region
10:35~10:50	**Official Photograph Session**
10:50-11:10	**To UNESCO**
SESSION 1 Introduction and review for APN project **Chair: Soi Kun Fong**	
11:10	**Martin Rice**, Introduction to the Asia Pacific Network for Global Change Research
11:35	**Ding Yihui**, Activity report for 1999-2001
SESSION 2 Monitoring and prediction of EL Nino events and sea temperature structure of the Warm Pool **Chair: Akimasa Sumi**	
12:00	**Kazuo Kurihara**, The current system for monitoring and prediction of EL Nino in JMA and impact of salinity data assimilation in the equatorial western Pacific
12:20	**Lunch (At hotel, 4/F, Ballroom)**
14:00	**Jong-Seong Kug**, A study of ENSO predictability in KMA/SNU model: Impact of FSU and NCEP wind stress data in the initialization
14:20	**Johnny C. L. Chan**, Determining factors for the reversal or renewal of La Nina Events
14:40	**Zhao Zongci**, Evaluation of multi seasonal predictions of SSTA over the tropical Pacific Ocean and summer rainfall in East Asia in 2001 by the climate models
15:00	**Scott Power**, Climate monitoring and prediction in Australia: Services, Research and Applications
15:20	**Tea break**
15:40	**Aida M Jose**, Updates on monitoring the sea surface temperature anomaly in the warm pool area and climate variability in the Philippines for 2001
16:00	**Hiroki Kondo**, Modeling initiative towards dynamical prediction of SST and its effect on seasonal forecasting
16:20	**Jai-Ho Oh**, A coupled atmosphere-streamflow simulation during the 1998 precipitation event at the Pyungchang river basin
16:40	**Xue Jishan**, A new analysis system for satellite data and its application to South China Sea and warm pool
17:00	**Wang Dongxiao**, Preliminary results of model Inter-comparison in the South China Sea.
17:20	**Yuqing Wang**, Simulation of the 1998 severe precipitation event in China with the regional climate model developed at the International Pacific Research Center
17:40	**Li Qingquan**, Predictability of precipitation and temperature over China
18:00	**Tim Li**, ENSO simulation in a coupled GCM

19:30~21:30	**Welcome reception at Macao WTC (5/F, Lotus Room)**
Wednesday, 6 February, 2002	
SESSION 3 Impacts of EL Ninõ events on the monsoon, tropical cyclones and drought/floods in Southeast Asia and East Asia. **Chair: Johnny C. L. Chan**	
9:00	**C-P Chang,** Interactions of Maritime Continent winter monsoon, ENSO and Indian Ocean
9:20	**Huang Ronghui**, Impact of ENSO cycles on the summer climate anomalies in East Asia and the outlook of the SST anomalies in the tropical Pacific in 2002
9:40	**Zhai Panmao**, Report of the second joint meeting on seasonal prediction of East Asian winter monsoon
10:00	**Bin Wang,** How strong ENSO events affect tropical storm activity over the western north Pacific
10:20	**Fong Soi Kun**, The EL Nino and the La Nina events and influence to climate anomalies of the South China Sea and the Southern China
10:40	**Tea break**
11:00	**Sun Zhaobo**, The inter-decadal variations of summer precipitation over North China and its relation with Asian monsoon and ENSO Cycle
11:20	**Shi Xueli**, Modification of the National Climate Center Regional Climate Model for studying the seasonal variations of climate over South China
11:40	**Zhang Zuqiang**, Response of equatorial Pacific to wind stress anomalies in the inter-annual tropical air-sea interaction
12:00	**Wang Shourong**, Studies on regional water cycle and hydrologic modeling in North China in context of climate change
12:20	**Akimasa Sumi,** On the simulation of "super cluster" by using a non-hydrostatic model
12:40	**Lunch (At hotel, 4/F, Ballroom)**
14:00	**Chao Qingchen,** The influence of western tropical Pacific on the development of ENSO event as well as El Nino /La Nina cycle
14:20	**Ooi See Hai**, 1997~2000 ENSO impacts on weather in Malaysia
14:40	**Leung Yin Kong**, Effect of ENSO on number of tropical cyclones affecting Hong Kong
15:00	**Wu Shangsen,** Impact of ENSO event on the anomalies of South China Sea summer monsoon and climate in Guangdong province
15:20	**Tea break**
15:40	**He Jinhai**, Regional difference of temporal-spatial characteristics of air-sea interactions in tropical oceans
16:00	**Lian Yi,** A preliminary study on the relationship among East Asia summer monsoon, El Nino and cold summer in Songliao plain, China
16:20	Tian Slibimawati,(TBD)
SESSION 4 Demonstration of the updated network of the monitoring and prediction of El Ninõ event and warm pool developed jointly by this project **Chair: Bin Wang**	
16:40	**Li Wei,** An introduction to the APN web-page on ENSO and warm pool
17:00	**Zhai Panmao, Zhang Jin and Li Wei,** Demonstration of the updated network of project APN 2001-12Demonstration of the updated network of project APN 2001-12
17:30 **SESSION 5 Discussion of a summary of 3-year APN project and the possibility of continuous implementation of this APN Network** **Chair: Ding Yihui**	
19:30-21:00, **Dinner reception (At hotel, 1/F. Emperor Court)**	

Thursday, 7 February, 2002
Visiting Macau Meteorological and Geophysical Bureau

List of participants

Workshop on the Network System for Monitoring and Predicting ENSO Event and Sea Temperature Structure of the Warm Pool in the Western Pacific Ocean 5-7 February, 2002, Macao China

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XII. Workshop/conference report

1. General description about the workshop

An international workshop on monitoring and prediction of ENSO event and the sea temperature structure of the warm pool in the West Pacific was held in Macau on 5-7 February 2002 (Summary Meeting). The goals of the workshop were: (1) to exchange research results and update the achievements and network on monitoring and prediction of ENSO and sea temperature structure over warm pool, and their impact on East-Asian monsoon, tropical cyclones and extreme events;(2) to demonstrate the updated system developed jointly for this project. About 40 people including experts from 7 APN countries (such as Japan, Australia, China, Korea, Malaysia, Philippines), and US Navy postgraduate school and IPRC, were invited to attend the workshop. They have been directly involved in our project with their contributions in the aspects of research and development of the network.

The workshop is broken out into comprised five sessions. Session I is the introduction and review for the APN project. In this session, Mr. Martin Rice, APN programme Manager, introduced the Asia Pacific Network for Global Change Research. Prof. Ding Yihui, the leader of APN project 2001-12 presented the project activity report for 1999-2001. Session 2 is the monitoring and predicting of El Nino events and sea temperature structure of the Warm Pool. In this session, the scientists from Japan, Korea, China, Australia, Philippines, Malaysia, U.S.A., etc. introduced their current systems for monitoring and prediction of the ENSO, the sea temperature in the Warm pool area and climate variability as well as the improvements, updates and applications of the systems, respectively. Session 3 is the impacts of El Nino events on the monsoon, tropical cyclones and drought/floods in Southeast Asia and East Asia. For example, the scientists from USA introduced the interactions of maritime continent winter monsoon, ENSO and Indian Ocean as well as how strong ENSO events affect tropical storm activity over the western North Pacific. The scientist from Malaysia introduced 1997-2000 ENSO impacts on weather in Malaysia. The relationship among East Asia summer monsoon, El Nino and cold summer in Songliao Plain, China has been studied by Chinese scientists. In session 4, two Chinese scientists from National Climate Center of China Meteorological Administration introduced the APN web-page on ENSO and Warm Pool and demonstrate the updated network for the monitoring and prediction of El Nino event and warm pool developed jointly by the APN project 2001-12. In the last session, session 5, a summary of 3-year APN project and the possibility of continuous implementation of this APN Network in the future were discussed.

The experts participating in this workshop highly spoke of successes and values of the APN project, its network system, the related research achievements, and workshop organized by it. Macau local Newspapers reported the workshop (Fig.5-6). It is hoped that the network can be maintained continuously, its contents can be increasingly complemented and expanded, and its effect can be expanded. For example, when the focus is put on the natural disaster (such as the impacts of ENSO and Warm Pool on monsoon and tropical cyclone), concurrently, it still needs paying attention to the influences on the soci-economics, extreme events, as well as the suggestions for policymakers. When the focuses of monitoring, prediction and research are put in the Asian and Pacific area (including tropical Pacific Ocean and Warm Pool), at the same time, the monitoring and study on the influences of the mid-latitude Pacific and the oceans and continents in southern hemisphere can be enhanced. For instance, it can be considered to include monitoring the variations of snow cover, vegetation, and soil moisture and studying their influences. Our research work should be mainly concentrated on developing prediction technique and increasing prediction skill. Moreover, we need promoting propaganda to make more people know about our project, our work and the network. According to the participants' suggestions, the names and affiliation institutions (telephone numbers, fax number and email addresses, etc.) and the major research areas and achievements of the scientists participating in this project will be put on the web-page of this APN project. This will be convenient for keeping contact and exchanging each other. Finally, it is approved by all participants through discussion that the network system set up by this project will continuously be maintained and updated monthly by NCC of CMA in 2002. In September 2002, a new proposal will be submitted to APN. It is hoped that we continue to obtain the financial support of APN in 2003.


亞太區四十多專家學者參與

監測氣象網絡研討會昨開幕

Fig.5


厄爾尼諾與拉尼娜

Fig.6

The workshop lasted for three days. In the first two days, the main activities were opening ceremony in WTC and the scientific reports of participants from different countries, scientific exchanges, and demonstration of the project network system UNESCO in Macao. In the third day of the meeting, participants visited Macau

Meteorological and Geophysical Bureau. Participants discussed and exchanged with the staff of Macau Meteorological and Geophysical Bureau, visited their offices, outdoor observation filed and inner receiving equipments of observation data. Also, the weather monitoring and prediction system (such as typhoon) was introduced to the participants by the leaders of Macau Meteorological and Geophysical Bureau.

2. Highlights of scientific achievements presented at the workshop

The recent research progress was reported and some key problems were discussed fully about the monitoring of tropical sea temperature structure and its impacts on the climate change in East and South-east Asia as well as the prediction of ENSO with coupled models and statistical methods.

A. Monitoring and prediction

In the workshop, each participating country demonstrated their own homepage related with the monitoring and prediction of SSTA in Warm Pool area. JMA is has been operating an Ocean Data Assimilation Sysytem (ODAS) and an El Nino prediction model (a coupled ocean-atmosphere model). Assimilated 5-day mean subsurface temperatures are used to monitor El Nino and La Nina. The coupled model is used to predicted El Nino and La Nina. TAO buoys west of 156°E have been replaced by TRITON buoys. As they are located in the tropical western Pacific, the observations of the TRITON buoys are valuable for monitoring the warm pool. A new version of ODAS is under development for the assimilation of salinity data from the TRITON buoys, which is expected to increase the accuracy of El Nino predictions. The experiments indicated that the prediction from TSAS (data assimilation with both temperature and salinity observations) initial conditions results in better skills than ones from TAS (data assimilation with temperature observations only) initials. An El Nino prediction system has been developed in KMA, which has an intermediated ocean and statistical atmosphere. The model system was tested to have a predictability skill up to 2 years and was used to predict ENSO during 2001-2002. Five simplified ocean-atmosphere coupled models and one global coupled ocean-atmosphere general circulation model have been developed, improved, and applied to predict the tropical pacific SSTA in the National Climate Center of China Meteorological Center. The predictions of those models that the tropical Pacific SSTs were slightly lower than normal during 2001 is consistent with observations. Recently, a new ENSO forecast system based on a new CGCM has been developed in Bureau of Meteorology in Australia, which is now used to perform experimental prediction and will become operational during 2002. Also, the tropical cyclone summary from Darwin Tropical Diagnostic Statement is already provided routinely to NCC of CMA for the APN web site. The predictions for the tropical Pacific SSTA during 2002 by KMA, JAM, CMA, BOM of AUS are shown in Figures 1-4.

B. Scientific research

The interactions of maritime continent winter monsoon, ENSO and Indian Ocean winds were studied. It found that the maritime continent rainfall often exhibits an inverse relationship with eastern equatorial Pacific SST, such that rainfall deficits are associated with warm (El Nino) events and vice versa. The correlation is highest during northern fall and remains significant during northern winter, which is the wettest season in the annual cycle. However, this negative winter monsoon-ENSO relationship changes over the western part of the maritime continent near Malay Peninsula and Sumatra. From 1950 to mid-1970s, the winter monsoon rainfall in this region shows a slight positive correction with eastern equatorial Pacific SST, while after mid-1970s the correlation is near zero. It is shown that the existence of this low correction region is a result of the varying interactions between the winter monsoon, ENSO and Indian Ocean winds.

Analyses of 35-year (1965-1999) tropical storm activity over the western North Pacific (WNP) leads to a number of new findings on the year-to-year variation of tropical storm activity. (1) The relationship between the WNP TS activity and ENSO strongly depends on the intensity of ENSO episodes. Strong El Nino or La Nina events (NINO3.4 SST anomaly exceeds one standard deviation) have significant impacts, but the moderate warm (cold) events do not show definite significant impacts. (2) In contrast to the common practice in long-term typhoon prediction (forecast of the total number of TC formation in the entire WNP domain), it is confirmed that the total number of TS formation in the entire WNP does not show significant ENSO influence (22.7 for strong warm and 20.2 for strong cold years). However, two sub-regions are identified, where largest variability occurs in close association with strong ENSO events: the SE (5-17°N, 140-180°E) and NW (17-30°N, 120-140°E) quadrants. During the peak season, for instance, the linear correlation coefficient between NINO3.4 SSTA and the number of TS formation in the SE quadrant reaches 0.82, and that in the NW quadrant is –0.61. (3) During strong El Nino (La Nina) years, the TS formation in the SE and NW quadrant exhibits a dipole anomaly pattern with enhanced (suppressed) formation in the SE (NW) quadrant, In addition, about 75% of the TS formed north of 17°N during the cold years, while 74% formed south of the 17°N during the warm years. (4) It is found that mean TS life span is about 7(4) days and the mean total number of TS occurrence is 159(84) days in strong warm (cold) years. (5) It is shown that the TS tracks differ substantially between the strong warm and cold years. The maximum differential frequency of occurrence is used to infer the difference in their prevailing tracks. During El Nino fall, the number of TSs that formed south of 15°N and recurved northward across 35°N is 2.5 times that during cold years. This fact implies that the meridional exchange of heat and energy is greatly enhanced during the strong El Nino years. This is a critical process by which El Nino conveys its impacts to high latitudes and enhances interaction between the tropics and extratropics in the East Asia-WNP.

The relationships among East Asia summer monsoon in 1951-1995, El Nino in 1909-1999 and temperature from May to Sept. in Songliao Plain, China are analyzed. The result is that the relation between SSTA in the same year of El Nino event and May-Sept. mean temperature of Changchun is of clear periodical and inter-decadescale variations, *i.e.* a clear negative correlation during cold episode, but a clear positive correlation during warm episode. In the 1950s-1970s, East Asia summer monsoon was weak, El Nino temperature increase started in the first half a year, the low temperature or cold injury would take place in Changchun summer. During 1980-1995 when East Asia summer monsoon was strong, even El Nino temperature increase started in the first half a year and the Changchun's summer temperature was high in the same year, and slight low in the next year, but there was no cold injury.

The date and intensity of the South China Sea summer monsoon onset in the current and following year of 14 incidents of El Nino over the past 50 years were statistically studied. The results show that the onset date is positively correlated with SSTA in the eastern equatorial Pacific with the correlation coefficient passing the 0.01 significance test for January-May. Specifically, when the SST in the region is positively anomalous (with the appearance of the El Nino event), the monsoon has a late onset; the intensity index is significantly in negative correction with the SSTA there when the SST is high, the monsoon is weak.

The composite method and spectral method are used to discuss the characteristics of monthly temperature in the southern part of China in 15 El Nino years and 15 anti-El Nino years over the period 1911-1986. It is found that temperature is mainly low in the winter, spring and early raining season of the current years of El Nino, but mainly high for the subsequent years, The relationship is generally the opposite in anti-El Nino years. When air temperature is cold in winter and spring in southern China, i.e. cold air mass is vigorous and advances to low latitudes in winter and spring in East Asia, it is possible for the El Nino to take place. A strong and stable El Nino event in turn result in warm temperature in the winter and spring of the subsquent years in southern China.

The relationship between El Nino and La Nina events and climatic anomalies of the South China Sea and the Southern China are also analyzed. The study results presented the typical occurrence and development of both events, and found that the SSTA variation between the equatorial eastern Pacific Ocean and the South China sea is well correlated. During the El Nino (La Nina) event, when the SST anomaly of the equatorial eastern Pacific Ocean gets higher (lower), the SST anomaly of the South China Sea gets higher (lower) as well. During the El Nino events, the subtropical high of the northwestern Pacific is stronger together with the southwesterly winds anomaly observed in the low level. Therefore, more precipitation occurs over the Southern China. During the La Nina events, the subtropical high of the northwestern Pacific is weaker together with the northeasterly winds anomaly observed in the low level. Therefore, less precipitation occurs over the Southern China.

Based on the temporal variation of sea surface temperature anomaly (SSTA) in the Nino3 domain in boreal spring and summer, each decaying La Nina event can be classified into either a reversal (i.e. switching to an El Nino event) or a renewal (i.e. SSTA becoming increasingly negative again) case. Composites of the SSTA for these two types of events during 1958-2000 show that, irrespective of the condition in spring and summer, the enhancement of negative SSTA of the renewal events is primarily confined to the equatorial eastern Pacific Ocean, On the other hand, a remarkable increase of SSTA for the reversal events is found to extend to the far winds were studied. It found that the maritime continent rainfall often exhibits an inverse relationship with eastern equatorial Pacific SST, such that rainfall deficits are associated with warm (El Nino) events and vice versa. The correlation is highest during northern fall and remains significant during northern winter, which is the wettest season in the annual cycle. However, this negative winter monsoon-ENSO relationship changes over the western part of the maritime continent near Malay Peninsula and Sumatra. From 1950 to mid-1970s, the winter monsoon rainfall in this region shows a slight positive correction with eastern equatorial Pacific SST, while after mid-1970s the correlation is near zero. It is shown that the existence of this low correction region is a result of the varying interactions between the winter monsoon, ENSO and Indian Ocean winds.

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Based on the temporal variation of sea surface temperature anomaly (SSTA) in the Nino3 domain in boreal spring and summer, each decaying La Nina event can be classified into either a reversal (i.e. switching to an El Nino event) or a renewal (i.e. SSTA becoming increasingly negative again) case. Composites of the SSTA for these two types of events during 1958-2000 show that, irrespective of the condition in spring and summer, the enhancement of negative SSTA of the renewal events is primarily confined to the equatorial eastern Pacific Ocean, On the other hand, a remarkable increase of SSTA for the reversal events is found to extend to the far central Pacific and even to the west of dateline, The distinctive distributions of zonal wind anomalies are responsible for the difference of SSTA during the decaying phase of the La Nina, For the renewal cases, weak westerly wind anomalies are confined to the east of 140W along the equator, which favor the depression of Ekman pumping of subsurface cold water, despite the presence of strong easterilies to its west, In contrast, notable westerly wind anomalies prevail throughout the equatorial Pacific for the reversal cases, giving rise to the flattening of the thermocline. In addition, the atmospheric circulation in the mid-latitudes of the Pacific Ocean in both hemispheres are nearly opposite in these two types, which implies quite different mechanisms of air-sea interaction.

ENSO event has a large impact on climate anomalies in many regions of the world. Generally, severe floods often occur in the eastern coast and severe droughts appear in the western coast of the tropical Pacific during the occurrence of ENSO event. However, it has different impact on the summer climate anomalies in the East Asia in different stage of ENSO event.

In order to explain the impact of ENSO cycles on the summer climate anoamies in East Asia, first, the correlation between the SSTs in NINO3 in summers and those in last autumns during 1951-1996 has been studied. The result shows that native correlations are located in North China, the Yellow River valley and the area to the south of the Yangtze River, and positive correlations appear in the Huaihe River vally. This means that during the summer with the developing stage of ENSO event, the summer monsoon rainfall may be below-normal in North China, the Yellow River valley and to the south of the Yangtze River, but it may be above-normal in the Huaihe River valley and the lower reach of the Yangtze River. On the contrary, during the summer with the decaying stage of ENSO event, the summer monsoon rainfall may be above normal to the south of the Yangtze River, especially in Dongting Lake abd Boyang Lake valleys, and severe flood may occur in these regions. But the summer monsoon rainfall may be below-normal in the Huaihe River Valley in this case.

The composite distributions of the monsoon rainfall anomaly percentage in China for the summers with the developing of ENSO events occurring in the period of 1951-1999 show that positive rainfall anomalies are located in the Huaihe River valley, and negative rainfall anomalies are located in the Yellow River valley, and negative rainfall anomalies are located in Yellow River valley, North China and to the south of the Yangtze River. This explains that during the summer with the developing stage of ENSO event, hot and drought may occur in North China, but flood may be caused in the Huaihe River valley. However, during the decaying stage of ENSO events, severe flood may occur to the south of the Yangtze River, especially in the Dongting Lake and the Boyang Lake valleys, but drought may be caused in the Huaihe River valley. During the 20th century, the particularly serious flood disasters in the Yangtze River valley of China occurred in the summers of 1954,1998,and 1931, respectively. These summers were in the decaying phase of ENSO event or the developing phase of La Nina event.

XIII. Science-Policy linage

Most of the participants of this project are the directors, heads or chiefs of meteorological, hydrological or some other related agencies which are directly or indirectly in charge of providing necessary information for the governments of their countries to make contingent preparedness measures. The provided information can assist in policymaker to take necessary action for prevention from potential disasters.

PROCEEDINGS

Workshop on the Network System for Monitoring and Predicting ENSO Event and Sea Temperature Structure of the Warm Pool in the Western Pacific Ocean

5~7 February, 2002, Macao, China

APN 2001-12 Project

Acknowledgements

We would like to express our gratitude to Asia Pacific Network for Global Change Research (APN) Secretariat for providing financial support and Macao Meteorological and Geophysical Bureau's excellent work for organizing the workshop on the Network System for Monitoring and Predicting ENSO Event and Sea Temperature Structure of the Warm Pool in the Western Pacific Ocean

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SESSION 1

Introduction and review for APN project

Introduction to the Asia Pacific Network for Global Change Research (APN)

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The Asia-Pacific Network for Global Change Research (APN) is an inter-governmental organisation whose mission is to foster global environmental change research in the Asia-Pacific region, increase developing country participation in that research, and strengthen interactions between the science community and policy makers.

The APN believes that international cooperation among governments and scientists will help increase the understanding of the complex mechanisms and impacts of global environmental change on ecosystems and human society in the Asia-Pacific region. This is necessary to identify and address the problems that may arise from that change.

By assembling researchers and policy makers from different countries in the region to work together, the APN seeks to address those issues that are relevant throughout Asia and the Pacific.

The APN believes that working in partnership with other organisations involved in global change research is essential to maximise the resources available and to deliver the best possible results. In particular the APN cooperates closely with START (the System for Analysis Research & Training in Global Change), the International Geosphere Biosphere Programme (IGBP), the International Human Dimensions Programme (IHDP) and the World Climate Research Programme (WCRP).

Activity Report For 1999-2001

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Project Title:

The network system for monitoring and predicting ENSO event and sea temperature structure of the Warm Pool in the western Pacific Ocean

Project Leader:

Prof. Ding Yihui

Contributors:

China, Japan, Australia, Korea, USA, Philippines, Indonesia, Malaysia, VietNam, and Hong Kong

Supported By:

APN project 99012, project 2000-12 and project 2001-12.

Background

It is well known that there are close relationships between ENSO phenomenon and anomalous climate through which socio-economic impacts in the tropical and other climatic zones have been produced. Numerous investigators have shown that ENSO cycles (consisting of El Nino and La Nina phases) have significant relations with and impacts on climate, environment, and socio-economic aspects in the Asian and western Pacific countries and regions, such as Indonesia, Philippines, Malaysia, Vietnam, Thailand, Australia, Japan, Korea and China. It may cause droughts, floods, cold injuries, heat waves, landfall of typhoons as well as forest fires in the Asian and Pacific region, thus bringing about huge socio-economic losses and deterioration of environment to these regions. For instance, recent statistics data have shown that due to the effect of 1997/1998 El Nino event, global and regional climate changed abnormally, and large-scale severe natural disasters caused 4,829,884 persons to be homeless and direct economic losses up to US$33.9 billions. It has been found that there are some definite correlative relationships between the onset, maturity and decay of ENSO, and the intensity of winter and summer monsoon over Asia. On the other hand, the sea surface temperature anomaly (SSTA) in the western Pacific Ocean may exert a teleconnection effect on the weather and climate in East Asia through PJ (Pacific–Japan) pattern or Walker circulation. The thermal regime of the warm pool and the convection activity in the region around Philippines play important roles in affecting the seasonal and interannual variability of the East Asian summer monsoon. Therefore, from the unique regional view-point, it is an urgent task to set up a network system for monitoring and predicting sea temperature of the warm pool in the western Pacific Ocean and its relationship to the summer monsoon activity. It is very necessary to improve our understanding and knowledge in monitoring and prediction information of ENSO events and the warm pool for APN countries, which is especially useful for developing countries in APN region to timely receive the information and warning for their preparedness of potential disasters. Up to now, the web-page has been visited for about 6000 times. This project has contributed much to CLIVAR of WCRP, in particular for ENSO prediction (interannual time scale prediction in CLIVAR).

Moreover, we have made a significant progress in scientific researches. Trough the studies on ENSO, warm pool, monsoon, typhoon, and their impacts on the soci-economic aspects and environments of APN regions/countries, a lot of new scientific findings have been obtained. The enhanced research work has increased the amount of papers and related research papers have been put on the web. For example, the scientists of the NCC of China have studied the meteorological and oceanographical conditions over Warm Pool and the South China Sea and the effect of ENSO events and SSTA over Warm Pool on onset of summer monsoon and activity of tropical cyclones. The useful relationships between ENSO and SSTA of Warm Pool, and anomalous weather–climate condition in Southern Asia and East Asia have been established and used in operational seasonal and interannual prediction, especially for extreme events such as monsoon anomalous variability and droughts/floods.

In addition, several international workshops have been organized or are being organized by our project. On 16-17 September 1999, the project successfully held an inception meeting in Beijing. On February 27-29, 2000, the international workshop on ENSO and SSTA over the warm pool was held successfully in Shanghai, China. On September 27-28,2000, an interim examination meeting for the APN Project 2000-12 (the network system for monitoring and predicting ENSO event and sea temperature structure of the warm pool in the western Pacific Ocean) was held in Beijing. An international workshop on monitoring and seasonal to interannual prediction of ENSO event and the warm pool and their impact on the East Asian monsoon is prepared to be held in Macau in 5-7 February 2002.

The activity report for 2001

The major objectives and contents of the project APN 2001-12 during 2001 include collection of data and information, improving the network and issuing new products, continuing to enhance research work, increase the amount of papers, and put related research papers on the web, improving El Nino/La Nina prediction system. Through one year's efforts, these goals have been successfully achieved.

1. Enlarging the collection of data and information relative to ENSO and the warm pool, such as TOGA—TAO and SCSMEX—A, B, C buoy data, oceanic data of the warm pool and the South China Sea, the oceanic observations of Japan along 137°E, and satellite data such as OLR and TBB, etc. The data sets needed for the project were provided by participating countries.

2. Improving the network and issuing new products. A network and its web-page (http://www.ncc.gov.cn) of the APN project (#99012 and #2000-12) have been basically set up, with their catalogues and information residing on a workstation. China National Climate Center (CNCC) is responsible for maintenance and improvement of this network in the Internet, and collection and

updating of the necessary information. Other participating countries/regions have furnished and is going to furnish information and data sets. In addiction, CNCC has issued El Nino/La Nina monitoring bulletins on irregular basis, which is now distributed in China. Improvement of this network have been made in the following aspects: (1) adding more information of historical background, (2) inclusion of more contributions from participating countries (3) adding new information and data sets accessible to users in APN countries, (4) establishing a full and updated network, with internal memory capacity of our workstation expanding, thus providing a more complete set of monitoring information data sets and prediction products as well as graphic outputs. Improve the design of the main web-page of the network with a newer layout and the clearer catalogue and more easily accessible mode, so that the information can be picked up effectively by users. The related countries and experts that participate in this project through E-mail to further update and supplement information and data, promote the time efficiency in updating the web, and validate contact and accessible method.

3.Continuing to enhance research work, increase the amount of papers, and put related research papers on the web. Improve the content of the network with the prediction of ENSO, enhancing the research and prediction outputs of the Warm Pool, adding the information of winter monsoon and expanding the data and information contributed by each participating country of this APN project. The research focuses have been placed on: (1) meteorological and ocean-graphical conditions over Warm Pool and the South China Sea; (2) effect of ENSO events and SSTA over Warm Pool on onset of summer monsoon and activity of tropical cyclones; and (3) assessment of impacts of droughts/floods, monsoon, and tropical cyclones in Southeast and East Asia under conditions of ENSO event and anomalous SST of Warm Pool. Through those studies, the useful relationships between ENSO and SSTA of Warm Pool, and anomalous weather–climate condition in Southern Asia and East Asia will be established and in turn will be used in operational seasonal and interannual prediction, especially for extreme events such as typhoons, monsoon and droughts/floods.

4. El Nino/La Nina prediction systems have been improved to raise the capability of prediction and simulation. The predictions of the tropical Pacific Ocean SSTA during 2001-2002 has been made and issued on the APN network.

5. A booklet of this APN Project has been published.

6. An international workshop on monitoring and seasonal to interannual prediction of ENSO event and the warm pool and their impact on the East Asian monsoon is prepared to be held in Macau in early 5-7 February 2002 (Summary Meeting). About 40 people including experts from 8 APN countries and US Navy postgraduate school and IPRC, will be invited to attend the workshop. They have been directly involved in our project with their contributions in the aspects of research and development of the network. The goals of the workshop are: (1) to exchange research results and update the achievements and network on monitoring and prediction of ENSO and sea temperature structure over warm pool, and their impact on East-Asian monsoon, tropical cyclones and extreme events;(2) to

these fields and very essential to enhance the monitoring and prediction of ENSO events and SSTA on the warm pool over the western Pacific Ocean at the seasonal and interannual time scales with necessary related information, products and data sets distributed to APN countries/regions via an Internet network, thus leading to improvement of seasonal and interannual prediction of monsoon activity and significant climate events in this region.

Summary report for the past three years' work

The APN has funded the project "Monitoring and prediction of ENSO event and SSTA over the warm pool in the western Pacific Ocean" (APN#99012) for 1999/2000. A renewal proposal "The network system for monitoring and predicting ENSO event and sea temperature structure of the warm pool in the western Pacific Ocean" for the next two years (2000-2001) was put forward in 1999, and was approved in March 2000. These projects are referenced as APN 2000-12 and 2001-12.

The major objectives of project APN99012 are: 1) monitoring and predicting ENSO event and SSTA over the warm pool in the western Pacific Ocean, 2) setting up the monitoring Internet system of ENSO event and warm pool in the APN region, 3) releasing SSTA predictions to the APN region, 4) organizing International Workshop in the APN region.

The major objectives of project APN2000-12 are: 1) Collection of data and information relative to ENSO and the warm pool, 2) Setting up and improving the network and issuing products, 3) Scientific research work, 4) Improving El Nino/La Nina prediction system.

The major objectives of project APN2001-12 are : 1) To monitor and predict the ENSO event and the sea temperature structure over warm pool; 2) to assess impact on monsoon activity, tropical cyclone (T.C.) and extreme events; 3) to implement network of above information.

Through three year's efforts, all the original purposes and contents outlined in proposals of the APN projects have been achieved. A network and its web-page (http://www.ncc.gov.cn) of the APN projects (#99012, #2000-12 and #2001-12) have been successively set up, with their catalogues and information residing on a workstation. National Climate Center (NCC), China Meteorological Administration is responsible for maintenance and improvement of this network in the Internet, and collection necessary information, updating the network on the monthly basis. Other participating countries/regions furnish information and data sets. In the network, a special emphasis is placed on oceanic and meteorological conditions over Warm Pool and the South China Sea, the impact of ENSO events and SSTA of Warm Pool on the weather and climate of APN countries (including tropical cyclones and monsoon), which has been often neglected in previous studies. Besides, the contents in the aspects of monitoring, historical perspectives, predictions and outlook of tropical SSTA and El Nino/La Nina events as well as the released digital data related with the system, some other data and information associated with ENSO and the Warm Pool, such as TOGA—TAO and SCSMEX—A, B, C buoy data, oceanic data of the warm pool and the South China Sea, the oceanic observations of Japan along 137°E, and satellite data such as OLR and TBB, have been widely collected and most of them have been put on to the network.. This is a distributed network for climate monitoring and prediction contributed by APN countries established successfully in the APN region for the first time. The network system in friendly manner provide useful interface and information to meteorologists, publics, and policymakers and greatly build up APN capability to disseminate and exchange demonstrate the updated system of the monitoring and prediction of ENSO and the warm pool developed jointly for this project; (3) adding new information, including information of effect of Warm Pool on the weather and climate over Southeast Asia and East Asia, activities of East Asian monsoon and its interaction with Warm Pool, and soci-economic impacts of ENSO events and Warm Pool; (4) improving and updating the existing network, with new inputs from each contributing countries/regions, in particular new accessible data sets and predictive outputs; (5) the Macau workshop will be possibly the summary meeting for our 3-year project. We will discuss how to continuously maintain this APN network.

SESSION 2

Monitoring and prediction of EL Nino events and sea temperature structure of the Warm Pool

The Current System for Monitoring and Prediction of El Niño in JMA and Impact of Salinity data Assimilation in the Equatorial Western Pacific on El Niño Prediction

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1. Introduction

ENSO is one of the most distinct phenomena which can affect world climate. The Japanese climate is also connected closely with ENSO. JMA monitors and predicts El Niño and La Niña to support seasonal forecasting for Japan area. In order to carry out these tasks, JMA is operating an Ocean Data Assimilation System (ODAS) (Kimoto et al., 1997) and an El Niño prediction model (a coupled ocean-atmosphere model). First, the current system for monitoring and prediction of El Niño in JMA is introduced.

During the past few years, TAO buoys west of 156° E have been replaced by TRITON buoys which are deployed by JAMSTEC (Japan Marine Science and Technology Center). It is noteworthy that the TRITON buoys are equipped with sensors to measure salinity at several depths. As they are located in the western tropical Pacific, their observations are valuable for monitoring the warm pool. With the salinity observations, it is also expected that the accuracy of El Niño prediction is increased. To understand the importance of the salinity observations by the TRITON buoys, impact of the salinity data assimilation on El Niño prediction was investigated (Ishii et al., 2001). As an example of efforts to develop a new system for El Niño monitoring and prediction, some results of this investigation are given here.

2. The current system for monitoring and prediction of El Niño in JMA

JMA has been operating the ODAS and the El Niño prediction model since 1995 and 1998, respectively. The outline of the system is described as follows.

The ODAS consists of a subsurface analysis scheme and a global ocean general circulation model (OGCM). The upper ocean temperatures are analyzed every 5 days based on ship-based and buoy-based ocean observation data. A two dimensional optimal interpolation scheme is used for the analysis. The analyzed temperatures are assimilated into the OGCM with a nudging technique. During the time integration for data assimilation, surface wind stress, which is calculated from output of the JMA atmospheric data assimilation system, is used as a driving force of the OGCM. The sea surface temperatures (SSTs) of ODAS are nudged to SST analysis data which are obtained from SST objective analysis produced independently of the ODAS. The OGCM of the ODAS has the basic horizontal resolution of 2.0° latitude and 2.5° longitude. Near the equator, the meridional grid spacing is reduced to a minimum, 0.5° . The OGCM has 20 levels in the vertical, and most of them are placed in the upper 500 meters in order to resolve surface mixed layer and thermocline properly. Assimilated 5-day mean subsurface temperatures are used to monitor El Niño and La Niña. They are also used to calculate other quantities as ocean heat content and depth of the 20℃ isotherm. They are useful to see eastward propagation of warm water which may cause the generation of an El Niño event.

The El Niño prediction model is named "Kookai" which means sky and sea in Japanese. The model consists of an atmospheric general circulation model (AGCM) and an ocean model which is identical to that of the ODAS. The AGCM is a lower resolution version of the previous JMA global atmospheric model for operational numerical weather prediction. Its horizontal resolution is T42, and it has 21 levels in the vertical. The ODAS and the JMA operational atmospheric data assimilation system provide the El Niño prediction model with initial conditions. In the coupled model, heat and momentum fluxes computed by the AGCM are given to the OGCM once a day, while the OGCM provides the AGCM with predicted sea surface temperatures. Flux correction is applied to both the heat and momentum fluxes in order to suppress climate drift. The "Kookai" is integrated 15 months ahead from the initial date.

3. Impact of assimilation of TRITON salinity data

Salinity observations are helpful to monitor not only variation of the warm water pool itself, but also water exchange between the ocean and the atmosphere. Though salinity data are not used in the present ODAS, a new version is under development for the assimilation of salinity data. The new system deploys a three-dimensional variational scheme, and an incremental analysis update scheme (Bloom et al., 1996) to fit oceanic observations to the ocean-model dynamics.

Two experiments of data assimilation were made to investigate impact of inclusion of salinity observations to the data assimilation (Ishii et al., 2001). One is data assimilation with both temperature and salinity observations (TSAS) and the other is assimilation with only temperature data (TAS). Salinity is relaxed to the climatology in TAS. A good corresponce is found between TSAS-produced salinity and observations by a TRITON buoy at (156° E, 2°

S); root-mean-square differences (RSMDs) are 0.24PSU at surface, 0.15PSU at 65m and 0.13PSU at 125m.

Maps for diagnosed barrier layer thickness from the model output (Fig.1) show that the interannual variations are much more distinct in TSAS than those in TAS, especially in the warm pool region of the western equatorial Pacific. According to Ando and McPhaden (1997), areas of large barrier layer thickness migrate eastward along the equator corresponding to El Niños.

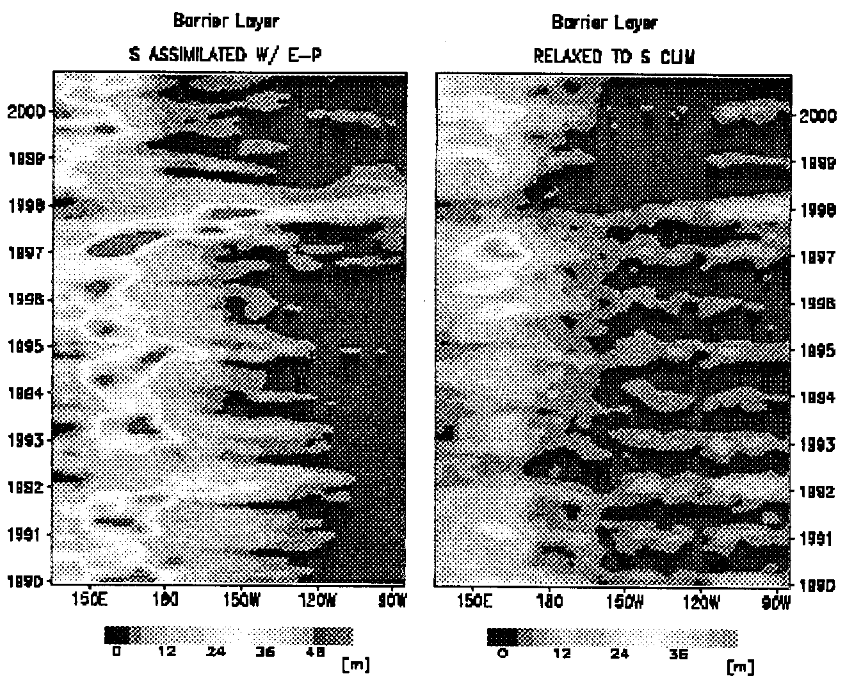

Fig.1 Time-longitude cross sections of barrier layer thickness along the equator (5° S-5° N) Left: the salinity data are assimilated. Right: model salinity is relaxed to climatology. (Ishii et al., 2001)

Two series of one-year El Niño predictions were carried out using oceanic initial conditions produced by TSAS and TAS. The coupled model was started from initial dates selected every 30-day for the period of 1986-2000. Predicted results for 134 cases were obtained so far. Prediction skill for the SST of Niño.3.4 region (5° S-5° N, 170° W-120° W) was evaluated with correlation coefficients and root mean square errors (RMSEs). The predictions from TSAS initial conditions results in better skills than ones from TAS initials. The skill difference becomes large after the lead time of 6 months. This improvement results not only from the salinity data assimilation, but also from differences in treatment of model salinity and fresh water fluxes between TSAS and TAS. More investigations are necessary in terms of the quantitative estimates of the improvements of the skills in TSAS.

4. Future view

The ODAS and the El Niño prediction model will be upgraded in order to increase accuracy of prediction in the near future. Regarding the ODAS, a three dimensional variational scheme is to be introduced and salinity observations is to be assimilated as being introduced above. JMA is also developing a system to assimilate TOPEX/POSEIDON altimeter data. The AGCM of the El Niño prediction model will be replaced by a low resolution version of the latest JMA operational model. JMA also has a plan to increase the resolutions of the ODAS and the prediction model in 2003.

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A Study of ENSO predictability in KMA/SNU Model;

Impact of FSU and NCEP wind stress data in the initialization

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Coupled ocean-atmosphere models have been developed during the last decade and a half for predicting El Nino/Southern Oscillation (ENSO). Among them, intermediate coupled models such as the Lamont model (Zebiak and Cane, 1987) has been widely used in prediction and predictability studies (Goswami and Shukla, 1991; Cane, 1991; Chen et al., 1995, 1998, 1999; Kang and Kug 2000). These intermediate models have a prediction skill not lower than that of the coupled GCMs, which contain complicated physical processes (Barnett et al. 1994). The prediction skill of the Lamont model has been improved by a modification of initialization scheme with nudged wind stress (Chen et al. 1995) and more recently by assimilating sea level data (Chen et al. 1998. These studies indicate that the predictability of the coupled model depends on the initialization method of ocean model.

Many El Nino prediction models have used the Florida State University (FSU) wind stress for initialization. But, Chen et al. (1999)

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showed that the FSU wind stress has a spatial pattern somewhat different from that of the NASA scatterometer (NSCAT) winds. They further showed that the prediction of 1997/98 El Nino with the Lamont model is much improved by replacing the FSU wind stress by that from the NSCAT winds in the initialization. The improvement was mostly attributed to a better-resolved wind field in the southeast tropical Pacific. However, because of a short record of the NSCAT data, their study was limited to a case study and could not evaluate overall forecast skill during a longer period. On the other hand, the NCEP/NCAR reanalysis data provides a longer historical record, although it is not the same as the observation but a model based assimilation data. Because of the assimilation, however, the NCEP surface winds are more physically consistent with the observed SST forcing than the FSU wind stress is. Therefore, it is worthwhile to examine the predictability skill of El Nino using the wind stress based on the NCEP data and to compare the skill to that of the FSU wind stress.

The El Nino prediction system used in the present study is based on the intermediate ocean and statistical atmosphere model developed by Kang and Kug (2000). The present ocean model is modified version of the Lamont Model (Zebiak and Cane, 1987). The primary changes are the subsurface temperature parameterization and basic state. The parameterization of subsurface temperature is replaced by a statistical relationship constructed based on the SVD singular vectors of the 20°C isotherm depth and the water temperature at 45m depth from the NCEP ocean assimilation data. The basic state of the ocean model is modified by the recent climatology for the 20 years of 1979-1998. The statistical atmosphere model is based on a singular value decomposition (SVD) of wind stress and SST. The wind stress used for the initialization of the ocean model is made by combining the observed wind stress and the wind stress derived from the observed SST anomalies. Details of the prediction system, has a predictability skill up to 2 years, can be referred from Kang and Kug (2000).

In this work, we calculate the wind stress using the NCEP reanalysis data, compare it with the FSU wind stress, and examine the predictability skill of a ENSO prediction system using each wind stress data. A historical monthly wind stress data is produced based on the 925 hPa daily winds of the NCEP/NCAR reanalysis data and it is used for the initialization of an intermediate El Nino prediction system of Kang and Kug [2000] with a hope to improve the prediction skill of the system. The NCEP zonal wind stress data is certainly different from the FSU wind stress, particularly the center of the anomalies in the equatorial Pacific. The center of FSU wind stress anomalies locates in the central Pacific near the date line, on the other hand, the NCEP counter part appears in the eastern Pacific near 150°W. The spatial pattern of the NCEP wind stress appears to be more similar to that of the NASA scatterometer data during the onset period of 1997/98 El Nino than that of the FSU wind stress does. The prediction experiments indicate that the prediction skill of the tropical Pacific SST with the NCEP wind stress data is better than that of FSU wind stress for the period of 1980-1999. In particular, the prediction skill of the system with the NCEP wind stress is considerably improved for the recent years of 1992-1999. Also shown is that the prediction with the NCEP wind stress with a lead time of 12 month is clearly better than that of the FSU wind stress, particularly in the central and eastern tropical Pacific.

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Determining Factors for the Reversal or Renewal of La Niña Events

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ABSTRACT

Based on the temporal variation of sea surface temperature anomaly (SSTA) in the Nino 3 domain in boreal spring and summer, each decaying La Niña event can be classified into either a reversal (i.e. switching to an El Niño event) or a renewal (i.e. SSTA becoming increasingly negative again) case. Composites of the SSTA for these two types of events during 1958-2000 show that, irrespective of the condition in spring and summer, the enhancement of negative SSTA of the renewal events is primarily confined to the equatorial eastern Pacific Ocean. On the other hand, a remarkable increase of SSTA for the reversal events is found to extend to the far central Pacific and even to the west of dateline. The distinctive distributions of zonal wind anomalies are responsible for the difference of SSTA during the decaying phase of the La Niña. For the renewal cases, weak westerly wind anomalies are confined to the east of 140W along the equator, which favor the depression of Ekman pumping of subsurface cold water, despite the presence of strong easterlies to its west. In contrast, notable westerly wind anomalies prevail throughout the equatorial Pacific for the reversal cases, giving rise to the flattening of the thermocline. In addition, the atmospheric circulation in the mid-latitudes of the Pacific Ocean in both hemispheres are nearly opposite in these two types, which implies quite different mechanisms of air-sea interaction. Some possible mechanisms related to the different evolutions of the atmospheric circulation are also proposed.

Evaluations of multi-seasonal predictions of SSTA over the tropical Pacific Ocean and summer rainfall in East Asia in 2001by the climate models

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Abstract

Multi-seasonal predictions have been conducted by several climate models of National Climate Center which are the AGCM95, AOGCM95, RegCM95, IPOGCM95, A-IPOGCM95, OSU/NCC and SAOMS95. All of those models predicted the summer precipitation over East Asia or/and the annual SSTA over the tropical Pacific Ocean in the Modeling Prediction Workshop, March 2001 in China. Several climate models of other Institutes such as IAP and CAMS/ZS also jointed this Workshop.

The characteristics of climate models that did the annual predictions of SSTA over the tropical Pacific Ocean in 2001 have been shown in Table 1. Table 2 shows the characteristics of climate models that did the multi-seasonal predictions of summer rainfall over East Asia in 2001.

Table 1 Characteristics of climate models which did annual predictions of SSTA over the tropical Pacific Ocean

Authors	Models' name	AGCM	OGCM	ensembles
Li &Zhao (2001)	SAOMS95	simplified dynamic model		6 * 5
Song (2001)	AOGCM95	L16,T63	L30, T63	3
Zhao (2001)	IPOGCM95	statistic atmosphere	L30 1X1	3
Zhou et al. (2001)	IAP APOGCM	L2, 4X5	P: L14,1X2	3

Table 2 Characteristics of climate models that did multi-seasonal prediction of summer rainfall in East Asia

Authors	Models' name	AGCM	OGCM	ensembles
Gao (2001)	AGCM95	L16,T63	no	6
Lin et al. (2001)	IAP APOGCM	L2, 4X5	P: L14, 4X5	28
Shi & Liu (2001)	RegCM95	L16, 60km	no	1
Song (2001)	AOGCM95	L16,T63	L30,T63	3
Xu et al. (2001)	OSU/NCC	L2, 4X5	60m	6
Zhao (2001)	A-IPOGCM95	L16,T63	L30, 1X2	3
Zheng & Song (2001)	CCM3/RegCM2	L9, R15	L15, 160km	1

The evaluations of models' predictions for the recent years have been detected in this research. It is indicated that the climate models have a certain capability to predict the multi-seasonal SSTA and the summer precipitation in East Asia.

The most models predicted the new El Nino event might not occur before the summer of 2001. Summer precipitation over East and North China in 2001 as predicted by the most models might appear the dry situation. The models also predicted the rainfall in Korean Peninsula and Japan.

The evaluations of the annual prediction for the SSTA in 2001 indicated that the composition of nine models predicted the time evolution of NINO3 index in 2001 well (see Fig.1). To compare with the observation of summer rainfall in East Asia, the most models predicted the trends of summer monsoon rainfall were well (see Fig.2).

Acknowledgements

Several scientists (Zheng Qinlin, Song Qingli, Lin Zhaohui, Zhou Guangqing, Zhao Qigeng, Song Yongjia, Gao Bo, Xu Li, Shi Xueli and Liu Yiming) contributed their predictions to the 2001 Workshop. The observed NINO3 index were from NCEP, APN projects and the observed summer rainfall over China were from Prediction Division of NCC.

Fig.1 The annual predictions of the NINO3 index by the IAP-APOGCM, SAOMS95, AOGCM95 and IPOGCM95 models in 2001, the thick red curve indicated the observation.

Fig.2 The multi-seasonal predictions of the summer rainfall over East Asia by the IAP-APOGCM, AOGCM95, AGCM95, OSU/NCC and CAMS/ZS, the observed summer rainfall over China indicated in the right-bottom side.

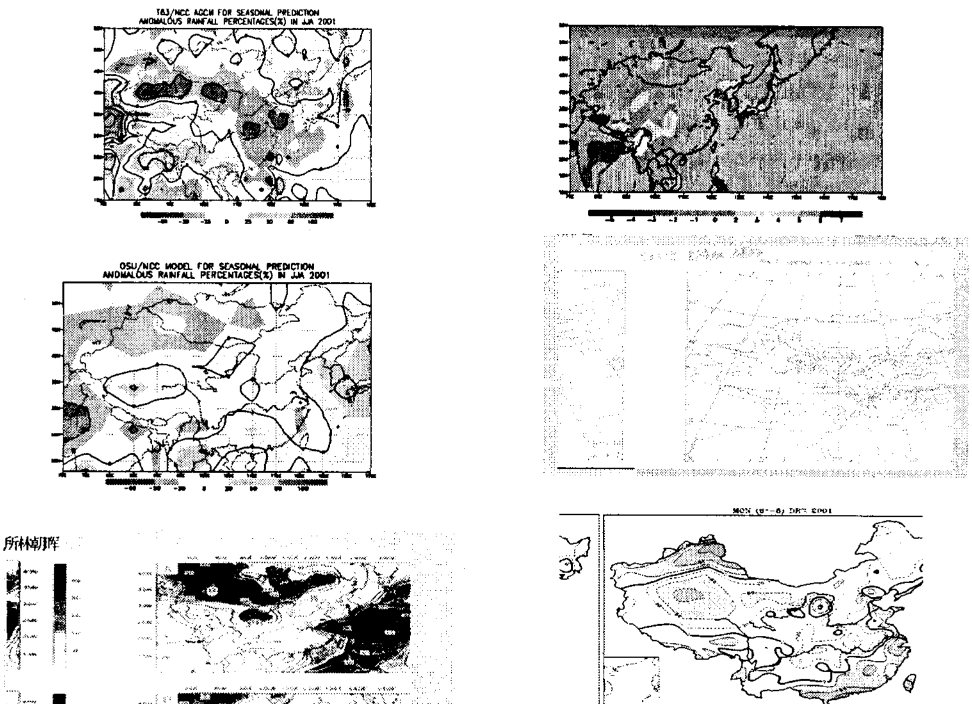

Fig.2

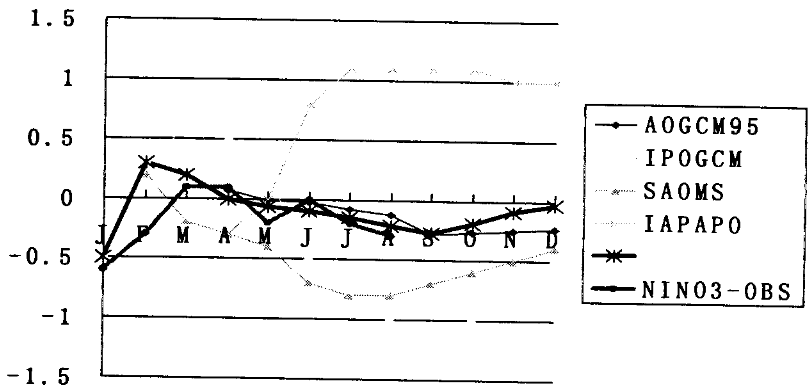
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Fig.1

Asian-Pacific Network, Workshop on the Network System for Monitoring and Predicting ENSO Events and Sea Temperature Structure of the Warm Pool in Pacific Ocean will be held on 5-7 February 2002, Macau, China

Climate Monitoring and Prediction in Australia: Services, Research and Applications

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1. Introduction

The purpose of this report is to provide information (e.g. web-links) on climate monitoring and prediction services in Australia. An overview of research aimed at improving and expanding these services and at encouraging the prudent application of the services available (e.g. in agricultural and environmental management) is also provided.

2. Services

A large fraction of the products the Bureau of Meteorology provides can now be accessed via the web. Please refer to http://www.bom.gov.au/climate

This web-site provides access to a vast amount of information on the status of the current season and the past, as well as predictions for the coming season and beyond

Some of the quantities monitored routinely include rainfall over Australia for previous periods, the SOI, and SSTs (based on the work of Smith 1995). Hundreds of thousands of maps are produced routinely and automatically each year and these are accessed by an increasing number of people via the web. Summary information is also provided by the new "El Niño Wrap-Up" web-page, and the Weekly Tropical Climate Note (http://www.bom.gov.au/climate/tropnote/tropnote.shtml).

A wide range of prediction information is also provided. This includes a Seasonal Climate Outlooks across Australia for the coming three months for rainfall and temperature, 9nine- month outlooks for NINO3 taken from a range of models from around the world (please see, http://www.bom.gov.au/climate/ahead/ENSO-summary.shtml) tropical cyclone outlooks for northern Australia, and a large amount of educational material for farmers, school children and others.

Some of the prediction information is also disseminated via the mass media through radio, newspapers (national, state and rural). The outlooks, together with estimates of their reliability, are useful to a wide-range of users, including farmers, water managers, banking groups, and scientists and many others connected with the rural sector.

The three-3 month outlooks are based on the statistical relationships between rainfall and patterns of sea surface temperature (SST) anomalies in the region (Drosdowsky and Chambers 1998). A similar scheme has also been developed for Australian temperature forecasts has also been developed (Jones 1998). Both schemes use the lagged relationship between sea-surface temperature (SST) and Australian rainfall to provide estimates of the probability of total rainfall (for example) in the following season being above the median, (for example). The scheme uses large-scale Indian Ocean and Pacific Ocean sea surface temperature (SST) patterns as predictors.

Over the longer term we also provide forecasts of NINO3 out to nine months using an intermediate coupled model (Kleeman 1993). The Bureau is also moving towards producing forecasts based on coupled general circulation models (CGCMs) Power et al. 1998; Wang et al. 2001). Recent work has been conducted on building a new forecast system based on a new CGCM is being developed (Wang et al. 2002; Alves et al. 2001) and this is expected to become operational during 2002.

The Bureau also issues two climate monitoring publications in hard copy format each month. These are Climate Monitoring Bulletin Southern Hemisphere (National Climate Centre, Melbourne) and Darwin Tropical Diagnostic Statement (Darwin RSMC). The tropical cyclone summary from DTDS is already provided routinely to NCC of CMA for the APN web site.

Additional prediction services are provided by the Queensland Centre for Climate Applications, and this includes including global forecasts based on a statistical forecast scheme using the SOI. This and other forecasts can be accessed via http://www.bom.gov.au/silo/products/SClimate_OtherPrediction.html, and by clicking on "Future Rainfall Probability Maps - Long Paddock".

3. Improving Climate Prediction Services

The Bureau of Meteorology also has a cost-recovery web-site called "SILO", that provides access to meteorological services (from weather to climate) from a location perspective (for specific locations?)?). Market research tells us that many people here in Australia do not make the distinctions we (scientists) make between weather and climate and also that information for particular locations is of most interest. The SILO web-site (a cost-recovery registered user service) addresses this by providing a clickable map which then provides access to a large number of web-based products produced relevant to that location, ranging from radar images through to seasonal climate outlooks from a variety of sources (http://www.bom.gov.au/silo/SILO2).

The Bureau has also hosted a number of events to get a better understanding of what users think of the climate prediction services we provide and to gather ideas for future services. This included attendance at agricultural field days, hosting climate outlook fora with a small group of key users for in-depth discussion, and a conference called Cli-Manage2000 (Power et al. 2001), which was attended by approximately 120 people from Australia and New Zealand from a range of industries. A report on Cli-Manage2000 is available (Order forms available from http://www.bom.gov.au/climate/ - click on "Cli-Manage 2000))".

4. Research

4.1 Model Development & Initialization

Work in BMRC (Bureau of Meteorology Research Centre) is being conducted on improving the initialization of the coupled system by assimilating subsurface ocean temperature data taking geostrophy into account. Preliminary tests show that this assists in increasing the energy of Kelvin Waves excited by westerly wind bursts, and reduces the excitation of spurious gravity waves. In the tests conducted so far, the method improves the current structure in the west Pacific but makes the temperature structure in the east worse. Nevertheless the method shows great promise and tests are continuing.

A new CGCM has been developed in conjunction with CSIRO Marine Research and this will become operational during 2002. Contacts: Oscar Alves and Guomin Wang, BMRC. Please see http://www.bom.gov.au/bmrc/ocean/staff/fzt/CM/page1.html

CSIRO (Atmospheric Research) has developed a CGCM forecasting system, http://www.dar.csiro.au/res/cm/coca.htm, and have benchmarked it against other prediction systems including CLIPER. Contacts: Ian Smith and Steve Wilson, CSIRO (Atmospheric Research).

4.2 Verification

There has been a great deal of work done on the verification of climate predictions in Australia. For example, the Australian Bureau of Meteorology will act as a lead centre for the WMO/CBS experimental exchange of "Long-range forecast" verification information. The standardized verification makes use of the scores derived from contingency tables (e.g. relative operating characteristics) and RMS skill scores. Participants will verify their own forecasts, make the information available at a local web-site and the address provided by the lead centre. Verification software will be provided by the Canadian Meteorological Center but accessible from the Bureau, as will access to verification data sets.

Variables verified at the Bureau thus far include seasonal values of rainfall, surface air temperature and NINO, for leads of 0-9 months. The full set of variables and regions covered by the original document produced by the Expert Team on the Experimental Exchange of Long- Range Forecast Verification Information (please see http://www.wmo.ch/web/www/DPS/SVS-for-LRF.html) is extremely large. Subsequent informal agreement by the Expert Team members has restricted verification to terciles of rainfall, surface air temperature, NINO3 and 4 and the SOI. This provides a useful starting point. The focus of this project is on ensuring that outlooks made available to the public are verified using standardized methods and that the verification information is also made available. Participation is currently limited to Expert Team members but it is anticipated to expand during the next year or two. There are a number of possible improvements that could be made to the system, though some exchange will proceed under the current arrangements, leaving further improvements to the future. A significant achievement for the future will be to facilitate the verification of all forecast systems made available using sound methods (e.g. on independent data for statistical prediction schemes) and to make this information available to potential users in a user-friendly format. The portal site is expected to be available in early 2002. Contacts: Scott Power, Terry Hart, Andrew Watkins

The Bureau of Meteorology has also been developing ways in which to convey verification information in an easily understood fashion as part of a separate project. Please see http://www.bom.gov.au/silo/products/verif. Click on "submit" and then click on somewhere on the resulting map (of per cent "consistent") to get (cross-validated) a history of hindcasts and corresponding observations for that particular location. We have also produced maps over Australia from a variety of different forecast systems - the BMRC and CSIRO CGCMS, the CMC AGCM, and statistical schemes from the Bureau and the Queensland Department of Primary Industries. Click "research" rather than "operational". The issue of statistical significance and multiplicity is addressed using Monte Carlo methods. This project was funded by the Climate Variability in Agriculture Program (CVAP). Contacts: Andrew Watkins, Scott Power, Bureau of Meteorology

The Bureau has also agreed to help coordinate (with B. Kirtman, COLA and S. Zebiak, IRI) a WGSIP verification project for GCM-based seasonal predictions. Further details for prospective participants will be made available over the coming months. Contact: Scott Power

4.3 Downscaling

BMRC has developed a statistical downscaling analogue technique which uses daily synoptic structures and simple pattern recognition to determine daily analogues which are used to provide seasonal forecasts of station rainfall and temperature. The method is being evaluated using forecasts from a number of different CGCMs. A simpler "statistical bridging" method based on dynamical predictions of tropical Pacific Ocean SST and historical observations is also under investigation. Contacts: Bertrand Timbal and Scott Power

4.4 Modelling studies

The Regional Model Intercomparison Project (RMIP), is an intercomparison of regional models over a large Asian domain (about 50E-150E and 5N-60N), run for an 18-month period (March 1997 to August 1998) at a resolution of about 60 km. Eleven models have run the simulations with lateral boundary forcing supplied by NCEP reanalyses. John McGregor and Jack Katzfey (CSIRO Atmospheric Research) have submitted 2 runs, one for DARLAM and one for the CSIRO conformal-cubic (C-C) model (using a stretched global grid). RMIP is an APN project. Results are being analysed by Congbin Fu's group at IAP in Beijing. An interesting result is that most, but not all, models have a tendency to shift the East Asia monsoonal rainfall too far northwards.

Stuart Godfrey, Rui-Jin Hu and Andreas Schiller (CSIRO Marine Research) are exploring the dynamics and thermodynamics of the Indian Ocean in their global MOM model, to better understand what sets long-term mean surface heat fluxes and SST variations within it. They find that mixing within the Somali Current, down to depths of 1000m or so, sets the depth and temperature distribution of the entire Indian Ocean north of the Indonesian Through-flow at 7°S. This in turn sets the depth distribution of the zonal Indonesian Through-flow jet via geostrophy, which then supplies the western boundary current feeding the Somali Current. Hence mixing events in the Somali Current determine the long-term mean heat transport and surface heat flux into the northern Indian Ocean, rather than the other way round. This may have implications for the design of an ocean monitoring system for climate, in the Indian Ocean.

Coupled model of Indian-Pacific Ocean. Jaci Brown and Stuart Godfrey (CSIRO Marine Research) are working on extending the Kleeman intermediate coupled model of the Pacific Ocean to include the Indian Ocean.

4.5 Diagnostic & predictability studies

Observations from the twentieth century suggested that the IPO (Interdecadal Pacific Oscillation) may play a role in modulating both the vigour of ENSO variability and the teleconnections ENSO has with Australia (Power et al. 1999). This is being tested using perturbation experiments in the BMRC CGCM. The control integration, like the observations, exhibits large fluctuations in ENSO variability and in the association between ENSO and Australia on interdecadal time-scales. However, preliminary analysis of the experiments suggests that the modulation in the model is an unpredictable process. Contact: Scott Power

BMRC is studying the coherence and predictability of seasonal rainfall in the maritime continent. Seasonal variations appear to be predictable during the dry season in this region, but not generally during the wet season (eg, "Spatial coherence and predictability of Indonesian wet season rainfall", Haylock and McBride, J. Climate, in press). Further evidence of this seasonal/spatial variation in predictability emerged at the Third Workshop on Regional Climate Prediction and Applications – Tropical Pacific Islands and Rim (University of Oklahoma, April-June 2001). Contact: John McBride, BMRC.

BMRC continues investigations of the possible effects of Indian Ocean sea surface temperatures on the climate of Australia and the surrounding region. This work indicates that an Indian Ocean Dipole, independent of the El Niño - Southern Oscillation, is rare. Most "dipole-like" behaviour of the Indian Ocean appears to be a response to the El Niño - Southern Oscillation. A paper discussing some of this work was presented at the AMS Annual Meeting in January, and an article has been submitted to published in CLIVAR-Exchanges. Contact: Neville Nicholls, BMRC.

Analysis and Interpretation of ocean thermal structure. Susan Wijffels and Gary Meyers (CSIRO Marine Research) are documenting variability of mass, temperature and salinity transport of Indonesian Through-flow (ITF) and its relationship to winds over the Pacific and Indian Oceans. A key result is that heave of the thermocline along the northern side of ITF (i.e. Indonesian coast) affects SST by upwelling, and this is driven by winds over the Indian Ocean. Ming Feng, Susan Wijffels and Gary Meyers are analysing the large scale propagating features seen in altimeter and XBT data. Tara Ansell (a PhD student at Melbourne University) is using XBT data and ocean-model results to identify the mechanisms that cause SST variability in the eastern and western Indian Ocean.

An additional study was conducted using multiple integrations of the BMRC AGCM to examine the impact that soil moisture has on seasonal predictability. We found that the lagged association in the model between ENSO and climate variability in Australia was fundamentally effected by soil moisture variability (Timbal et al. 2001).

4.6 Applications and Impacts

A new book entitled "Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems. The Australian Experience" (G.L. Hammer, N. Nicholls, C. Mitchell, Eds.), has been published by Kluwer Academic Publishers, and provides a summary of research activities in Australia aimed at improving the benefits of applying climate predictions. More recent applications being investigated by the Queensland Centre for Climate Applications not described in the book are occurring across a number of agricultural industries. For example, an in-depth study is being conducted in conjunction with the sugar industry to determine where in during the production/supply/marketing chain seasonal climate forecasting can be used to benefit decision-making. Contact: Roger Stone, QCCA.

Several international collaborative projects focussed on the application of seasonal climate predictions for agriculture, health, and environmental management, have commenced. Some of the agricultural projects (eg., in Pakistan, India) are organised through the START CLIMAG program. Contact: Holger Meinke, Department of Primary Industry, Queensland.

The effects of the El Niño - Southern Oscillation on marine animals (dugongs) and birds are being studied, Contact: Neville Nicholls, BMRC.

A pilot project titled "Capturing the Benefits of Seasonal Forecasts in agricultural management" has been carried out under the Australian Centre for International Agricultural Research. This 3-year program involved field sites in Matopos Zimbabwe (grazing management), Tamil Nadu India (farm decision making), and Mataram Indonesia (Water and Crop management). The lead scientists in Australia are drawn from the Queensland Department of Primary Industries, the Queensland Department of Natural Resources and the Bureau of Meteorology Research Centre Contact J. McBride, BMRC.

A proposal called *Res Agricola* (Latin for "Farmers' business") has been developed by QDPI, the IRI and others which follows on from the successful OGP South Asia project aimed at using seasonal forecasts to assist agricultural decision-making from farm to policy level. Contact: Holger Meinke, QDPI

A multi-disciplinary project called "*Oceans to Farms*" is a study of the way seasonal climate forecasts can best be used to manage farming and farm-related industries. A lagged statistical relationship is established between ocean surface temperatures and variables such as plant growth and rainfall. The forecast system is tailored for specific regions, industries and decision points in the farming cycle. Different management strategies are tested using 100 years of historical data. A key result is that it is often better to predict plant growth rather than rainfall. Another key result is that skill at predicting rainfall or growth is only one factor in farm management decision-making; the same forecast can end up with very different usefulness in different contexts. The economic and conservation value of this forecast system has been studied in most detail for the northern Queensland extensive grazing industry. This experiment indicates that production increases of 16% are possible at the same time as a 12% reduction in soil loss, given appropriate management strategies based on the forecast.

These benefits exceed those obtained using a forecast based on the Southern Oscillation Index (SOI). Somewhat surprisingly, the ocean-based forecasts also perform slightly better than a perfect knowledge of seasonal rainfall totals. This is because rainfall distribution is important, and predicting an index of plant growth takes this into account. Contact: Peter McIntosh, CSIRO Marine Research.

4.7 Intraseasonal variability

BMRC is enhancing its empirical studies of intraseasonal oscillations, with the aim of attempting to predict these, especially with statistical methods. The approach is to use real-time filtering of OLR data to monitor and predict the convective variations of the Madden-Julian oscillation and various convectively coupled equatorial waves, based on the "climatological" spectral peaks of a long record of satellite-observed data. More information is available at
http://www.bom.gov.au/bmrc/clfor/cfstaff/matw/maproom/maproom.html

Andreas Schiller and Stuart Godfrey (CSIRO Marine Research) have explored intraseasonal SST variability in their ocean GCM. Good simulations are achieved, in which surface heat flux variations are found (as in simpler models) to be the dominant term. However, entrainment through the mixed layer base contributes locally; barrier-layer formation occurs before onset of strong winds; and different processes control intraseasonal dynamics in different events.

Relation of Indian Ocean Variability to Australian Winter Rain. Tara Ansell and Stuart Godfrey (CSIRO Marine Research) have examined moisture flux towards Australia and rainfall onto Australia during intraseasonal oscillation events, using a composite provided by Peter Webster. Five to ten days after a maximum of rainfall over the equatorial Bay of Bengal, a “northwest cloudband” develops with strong moisture fluxes from south of Sumatra extending over Australia; strong rain develops, as a composite average. There is a statistically significant relationship (with a correlation coefficient 0.61) between the number of ISOs each northern summer, and the Indian Ocean Dipole Index (IODI). There are about four Northwest Cloud Bands each winter that are not associated with an ISO event for every one that is; but the unrelated ISOs bring less rain to Australia. Composites of the cloud bands that are not related to ISO events are also associated with strong patterns over the equatorial Indian Ocean six days earlier, but the associated wind patterns are qualitatively different from ISOs.

4.8 Sustained observations

The Darwin Climate Monitoring and Research Station (DCMRS), a cooperative network run by the BMRC and the Northern Territory Regional Office of the Bureau of Meteorology, provides a basis for research activities in a tropical monsoon environment, including support for TRMM and the Atmospheric Radiation Measurement (ARM) program of the US Dept of Energy. The DCMRS undertakes climatological observations and research relevant to the systematic measurement of tropical rainfall, cloud properties and their impact on radiation in the monsoon environment. Emphasis is on providing ground truth data for TRMM and ARM, and process studies including special observing projects on the four-dimensional structure, dynamics and microphysical properties of tropical convection and associated radiation. Contact: Tom Keenan, BMRC.

Indian Ocean Sustained Observations - XBT Network. The lines IX1, 12, 22, 29 and PX2 (Banda Sea) were started in 1983-1986. The lines are now operational (i.e. long-term maintenance assured in an appropriation budget) under direction of the Joint Australian (CMR/BMRC) Facility for Ocean Observing Systems (JAFOOS). JAFOOS also operates the WOCE Upper Ocean Thermal Data Assembly Centre, where all Indian Ocean XBT data are assembled annually and given scientific quality control following published standards and procedures. The assembled data sets are available now for 1990-97. JAFOOS and International Pacific Research Centre (IPRC) are jointly proposing to use the WOCE procedure to QC all T(Z) data in the Indian Ocean for the 20^{th} century. The panel is requested to consider and endorse the idea in principle, pending review of the final draft of the proposal. Contact: Gary Meyers, CSIRO Marine Research.

Argo network. Australia has initiated an Argo float network to collect temperature and salinity profiles to a depth of 2000m. Initially 10 floats were placed in the eastern Indian Ocean between NW Australia and Indonesia. Resources are available to maintain and extend the array southward to the SW corner of Australia and about 1000 km offshore. Contact: Neville Smith, BMRC.

5. Summary

A summary of web-links to existing climate monitoring and prediction services in Australia and recent advances in those services have been provided. A brief overview of some of the research being conducted in Australia to advance climate monitoring, climate prediction, and on applying climate forecast information to help make better decisions was also presented.

Acknowledgments

We wish to thank the many people around Australia who contributed to this paper.

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Updates on Monitoring the Sea Surface Temperature Anomaly in the Warm Pool Area and Climate Variability in the Philippines for 2001

By: Aida M. Jose

Abstract

During the Shanghai workshop held last February of 2000, the Philippine participant presented some information derived from the Preliminary Studies on Monitoring Sea Surface Temperature Anomalies over the Central and Western Equatorial Pacific and Predicting Potential Effects on the Philippine Climate Variability. In this coming Macau workshop updates will be presented on the results of the preliminary studies using the recent 2001 observation as related to the overall objectives of the workshop which include discussion on the impacts of El Niño/La Niña events on the monsoon, tropical cyclones and drought/floods in Southeast Asia and East Asia. In particular the presentation will be based mainly, as a starting point, on the updated correlation of the SSTAs in Niño 3.4 region with sea level pressure anomalies (1951-2000). This will in turn demonstrate the sequential effects on tropical cyclone activity in the Western Equatorial Pacific particularly in the Philippine vicinity. It may be recalled that previous studies indicated that more than 50% of the annual rainfall in the Philippines is attributed to the occurrences of tropical cyclones. The inverse relationship of tropical cyclone activity in the vicinity with the SSTAs in the 3.4 Niño region and the consequent rainfall conditions in the Philippines is exhibited. The peak response of sea level pressure, tropical cyclone activity and rainfall in the Philippines to the SSTAs in the warm pool area has been demonstrated using the monthly sea level pressure anomaly correlation with SSTAs occurs during the winter monsoon months (October to March of the following year). This information confirms the previous studies conducted on Impacts of El Niño/La Niña on Philippine Climate.

General climatic conditions expected in the Philippines during cold and near neutral sea surface temperature condition which prevailed in the warm pool area last year 2001 have been observed. The climatic parameters

examined included quarterly sea level pressure anomaly, tropical cyclone occurrences and rainfall distribution including onset of the summer monsoon rainfall in the Philippines.

The apparent strong signals of the SSTAs exhibited on the local climatic conditions in the Philippines particularly during the winter monsoon months together with the scientific advances in the predictability of the air sea interaction in the warm pool area provides an opportunity for applications of such information for assessing potential socio-economic impacts of extreme climatic events associated with ENSO events.

Modelling initiative towards dynamical prediction of SST and its effect on seasonal forecasting

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1 Introduction

The remarkable development of numerical weather prediction (NWP) models for short-range and medium-range forecasting has been followed by modelling initiatives for general circulation in the atmosphere and a little later by those in the ocean. By coupling these initiatives, climate models have recently been developed by various research institutes for studies of climate variability and predictability, as promoted under the WCRP/CLIVAR.

For seasonal-to-interannual (SI) forecasting, new trends are now emerging from empirical and/or statistical ways to dynamical ones by applying climate models. However, the skill of dynamical ways is not yet necessarily certain with various difficult problems to be resolved.

Better prediction of the sea surface temperature with its adequate effect on the atmosphere is one of the main problems to be addressed in climate modelling besides improvement of such physical processes as cumulus convection, land surface processes, etc. Recent and ongoing modelling activities at the MRI/JMA focusing on the effect of the sea surface temperature (SST), especially at the El Nino events, intending to contribute to operational SI forecasting are discussed. Also several case studies on the impact of the SST on various meteorological fields are also presented.

2. From empirical and statistical to dynamical way for SI forecasting

The predictability of the atmosphere by a dynamical prediction model as an initial value problem has been so far estimated up to 1～2 weeks at most. The dynamical prediction beyond such medium range needs different approaches other than ordinary NWP methodologies. The JMA has already launched operational dynamical prediction for one-month forecasting by an ensemble method applied to existing NWP model with slightly different initial fields. We have also commenced operational dynamical prediction of ENSO events by a specifically developed atmosphere-ocean coupled model with finer resolution near the equator.

As for the operational SI forecasting other than that of ENSO events, we are still relying only on empirical and statistical method. In order to newly develop an dynamical prediction model for the SI forecasting, we need to overcome several essential barriers.

3. Dynamical prediction of SST

One of our research initiative is the generalization of the ENSO prediction modelling focussed mainly on tropical region to the SST prediction modelling in all regions, because that is indispensable to extend dynamical prediction to SI forecasting, considering substantial effect of SST on the atmospheric processes and eventually on SI time-scale variability. Unless we have sufficiently accurate prediction of the change of SST, the atmospheric model has great difficulty to predict the substantial long-range response of the atmosphere to that change.

We are now on the way under the following strategic steps, firstly to study the impact of SST to the atmosphere and secondly to predict SST in an integrated full climate model.

3-1 Short-term strategy

So far we have made simulation experiments of the atmospheric model with prescribed SST as the lower boundary condition over the ocean regions. These experiments have been conducted by the ensemble prediction with several different initial conditions. Results of these experiments made for a number of cases over many years from some selected initial seasonal time are presented.

We have been moving to the next step of studying the effect of the SST predicted by a rather simplified mixed-layer ocean model on the atmosphere in such an atmosphere-mixed-layer ocean coupled model.

3-2 Long-term strategy

We are planning for the future to predict the SST in an integrated atmosphere-ocean full coupled model where we need to improve other physical processes as well, including cumulus convection and land surface physical processes . We have to generalize the ENSO model to an model applicable to all regions. The coupling would be made without any artificial flux corrections which are in most existing climate models still necessary in a long-range time integration to avoid unnatural SST change called as climate drift.

4. Implications of SST prediction

The better dynamical prediction of SST would mean the following implications:

- Better prediction of ENSO events with accompanying atmospheric and oceanic changes including various teleconnections
- Prediction of SST in the Indian Ocean and the Atlantic with accompanying meteorological fields
- Prediction of SST in the middle and high latitude related to air-sea interactions including air mass transformation in winter
- Prediction of the variation of decadal oscillations

Analyzing these implications would lead to mechanism studies on the monsoons, tropical cyclones, various extreme meteorological events under the effect of SST.

5. SI climate variability and predictability

For better SI prediction modelling and more effective utilization of dynamical forecasting products , we need to study variability and predictability as a theoretical basis. Particularly, a research initiative has been ongoing on the predictability study in order to assess our experiment products properly. Some case studies are presented.

A Coupled Atmosphere-Streamflow Simulation during the 1998 Precipitation Event at the Pyungchang River Basin

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1. Introduction

A coupled atmosphere-streamflow modeling system, in which surface hydrology models are coupled to a limited-area atmospheric model (Leavesley et al. 1992; Kim and Miller 1996; Yu et al. 1999; Pereira Fo et al. 1999; Benoit et al. 2000), have become an important tool for predicting precipitation and streamflow (Kim and Miller 1996; Miller and Kim 1996; Kim et al. 2000), and for assessing impacts of climate variations on regional hydrologic cycle and water resources (Leavesley et al. 1992; Kim et al. 1998a; Kim 2001). In this approach, a limited area model is employed to obtain basin-scale atmospheric forcing from coarse resolution large-scale data, and the basin-scale forcing data drives surface hydrology models calibrated for the river basin. The earlier studies above have shown that a coupled atmosphere-streamflow modeling system is capable of capturing short- and long-term quantitative precipitation and streamflow that are important for flood forecasting and water resources management.

We examine a coupled atmosphere-streamflow model for simulating hydrometeorological events in the Pyungchang River basin in South Korea, one of the UNESCO's IHP basins, to better understand short-term responses of streamflow to rainfall and how it impacts floods. This work is a step toward improving hydrometeorolgical forecasts and climate impact assessment using a coupled modeling system. Among the important concerns in coupled atmosphere-streamflow predictions is the accuracy of the atmospheric and hydrologic models in simulating atmospheric forcing and streamflows for selected basins. We examine the effects of domain size and spatial resolution of the atmospheric model on simulating local precipitation and other atmospheric forcing in this study. A streamflow model, semi-distributed TOPMODEL, is calibrated for the Pyungchang River basin to generate hourly streamflow using the basin-scale forcing generated from the atmospheric model.

2. Pyungchang River IHP site and Model Description

The Pyungchang River basin, one of the IHP

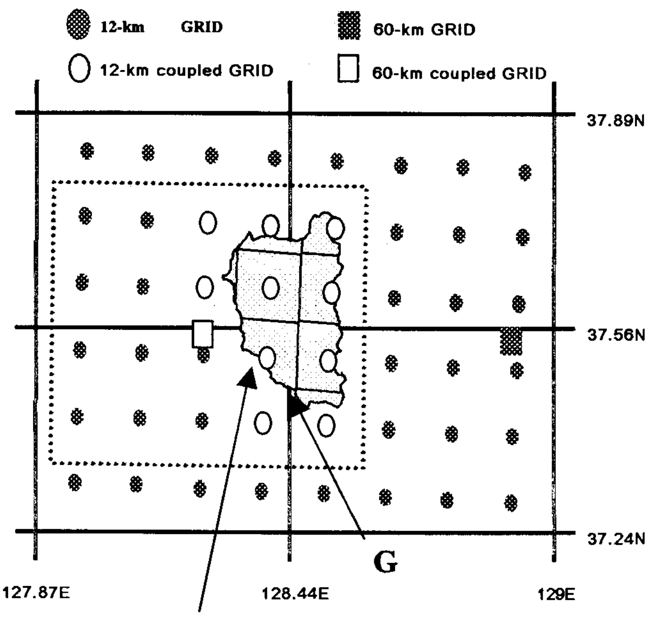

Fig. 1. The Pyungchang study basin coupled with the METRI-meso grid-points. The circles and squares are the 60-km and 12-km METRI-meso grid-points respectively, and the hollows denotes the coupled METRI-meso grid-points with TOPMODEL. The inner-zone area of dotted rectangular frame denotes the area represented by a 60-km METRI-meso grid-point, and the areas bounded by the net within the basin and the basin boundary denote the area-weighted domains of the 12-km grid-points.

(UNESCO's International Hydrological Program; http://www.unesco.org/water/ihp) intensive study sites, is a tributary of the Han river, and is located between 128E, 37N and 129E, 38N with a drainage area of 528 km^2. The locations of the rain and stream gauges in Pyungchang basin are presented in Fig. 1. The Pyungchang IHP site contains 11 raingauge stations and 6 streamflow gauge stations operated by the Korea Ministry of Construction and Transportation (KMOCT). The Pyungchang basin is characterized with a mountainous terrain covered with mixed coniferous and deciduous forests. Terrain elevation of the basin ranges from 252 *m* to 1552 *m* above the sea level. We focus on streamflow at the gage *G*

(Fig. 1). For brevity, the sub-basins that are headwaters of the stream gauge *G* are referred as the Pyungchang study basin (PSB) hereafter.

The METRI-meso is based on the interactively-coupled Mesoscale Atmospheric Simulation (MAS) model (Kim and Soong 1996; Soong and Kim, 1996) and the Soil-Plant-Snow (SPS) model (Mahrt and Pan 1984; Pan and Mahrt 1987; Kim and Ek 1995). This coupled model has been successfully used for NWP and climate simulations over the western U.S. and East Asia (Kim and Soong, 1996; Soong and Kim 1996; Kim and Miller, 1996; Miller and Kim 1996; Kim 1997, 2000; Kim et al. 1998a,b, 2000; Miller et al. 1999). The METRI-meso utilizes large-scale data from analyses and/or global model simulations, as well as local observations, to derive the initial and lateral boundary conditions. Outputs from the METRI-meso drive one-way nested hydrologic models (e.g., Sacramento model, TOPMODEL, PRMS, VIC). In this configuration, hydrologic models do not feedback to the METRI-meso. Detailed formulations of the METRI-meso, for the MAS and SPS, are presented in Soong and Kim (1996) and Kim and Ek (1995), and will not be repeated here.

TOPMODEL (Beven and Kirkby 1979) may be viewed as a system of vertical reservoirs (interception zone storage, unsaturated infiltration zone storage, and saturated zone storage) formulated by using Darcy's Law and water mass continuity. Soil moisture accounting and lateral transport in TOPMODEL are based on two assumptions: (1) the saturated zone dynamics are approximated by successive steady state representations and (2) the hydraulic gradient of the saturated zone is parallel to the surface topography. An important feature of TOPMODEL is the semi-distributed parameterizations and similarity in topographic control of surface and subsurface flows that help to reduce the number of model parameters required for calibration, while maintaining physical representations of the dynamics.

The distribution of the topographic index, λ, is one of the mechanisms for the surface following lateral subsurface transport assumption. Stream channel flow is defined as the sum of surface flow (Q_s) and subsurface base flow (Q_b), where surface flow consists of two terms, direct overland and saturated overland flow associated with water table reaching the surface. Base flow is defined here as the subsurface flow that is laterally transported downslope toward the stream channel. Under the assumption that TOPMODEL sequentially fills the saturated zone storage and then the infiltration zone storage, a local storage deficit or effective depth to the water table is determined. Once the local storage deficit reaches zero, there is local saturation and overland flow. Antecedent conditions and surface permeability also determine the rate of infiltration and flow.

The coupled atmosphere-streamflow model used in this study has been applied for two domains: a large domain covering East Asia at a 60 x 60 km^2 horizontal resolution, and a small domain that covers Korean Peninsula at a 12 x 12 km^2 resolution (Fig. 2). For coupling of the METRI-meso and TOPMODEL, precipitation and evapotranspiration computed by the METRI-meso are used to generate domain-averaged forcing to drive the TOPMODEL. The large-scale domain is used to capture evolution of synoptic scale systems and the small domain is employed to capture the details of local terrain.

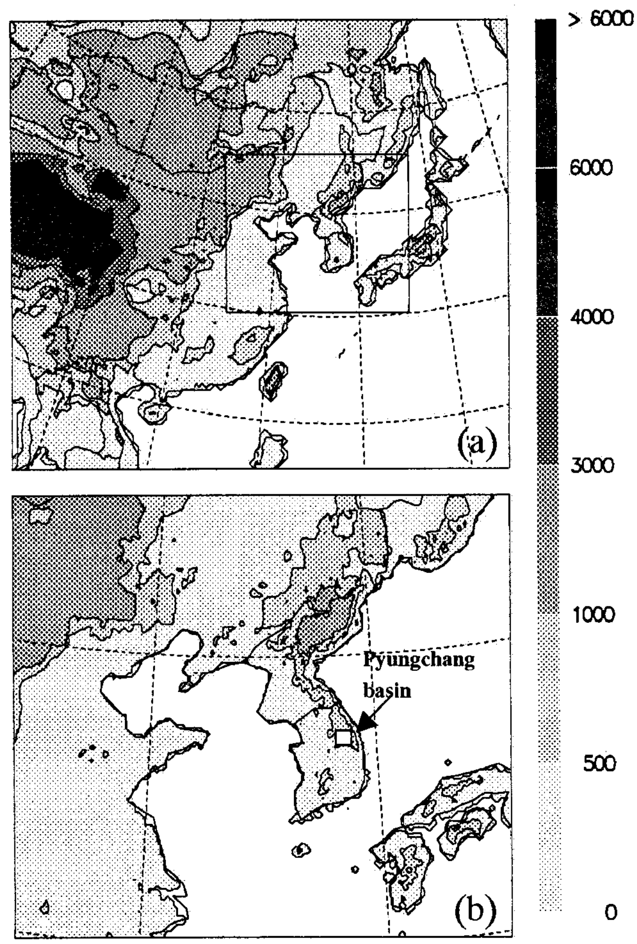

Fig. 2. The East Asian and Korean Peninsular topography used in the coupled precipitation-streamflow simulation and the location of the IHP Pyungchang basin. The upper (a) is the East Asian METRI-meso domain with the 60 km x 60 km horizontal resolution, and the lower (b) is the Korean Peninsular domain with the 12 km x 12 km resolution. The inner solid box in (a) denotes the domain of (b) and contours (meters) represent the mesoscale topography.

Simulated atmosphere variables are mapped onto the Phyungchang IHP basin using an area-weighted averaging scheme (Kim et al. 2000) to obtain spatially uniform inputs for TOPMODEL. Figure 1 shows the 60-km and 12-km METRI-meso grid-points used for the coupling with TOPMODEL in Pyungchang basin.

continues for 72 hours by prescribing the lateral boundary forcing at 6-hour intervals. The initial

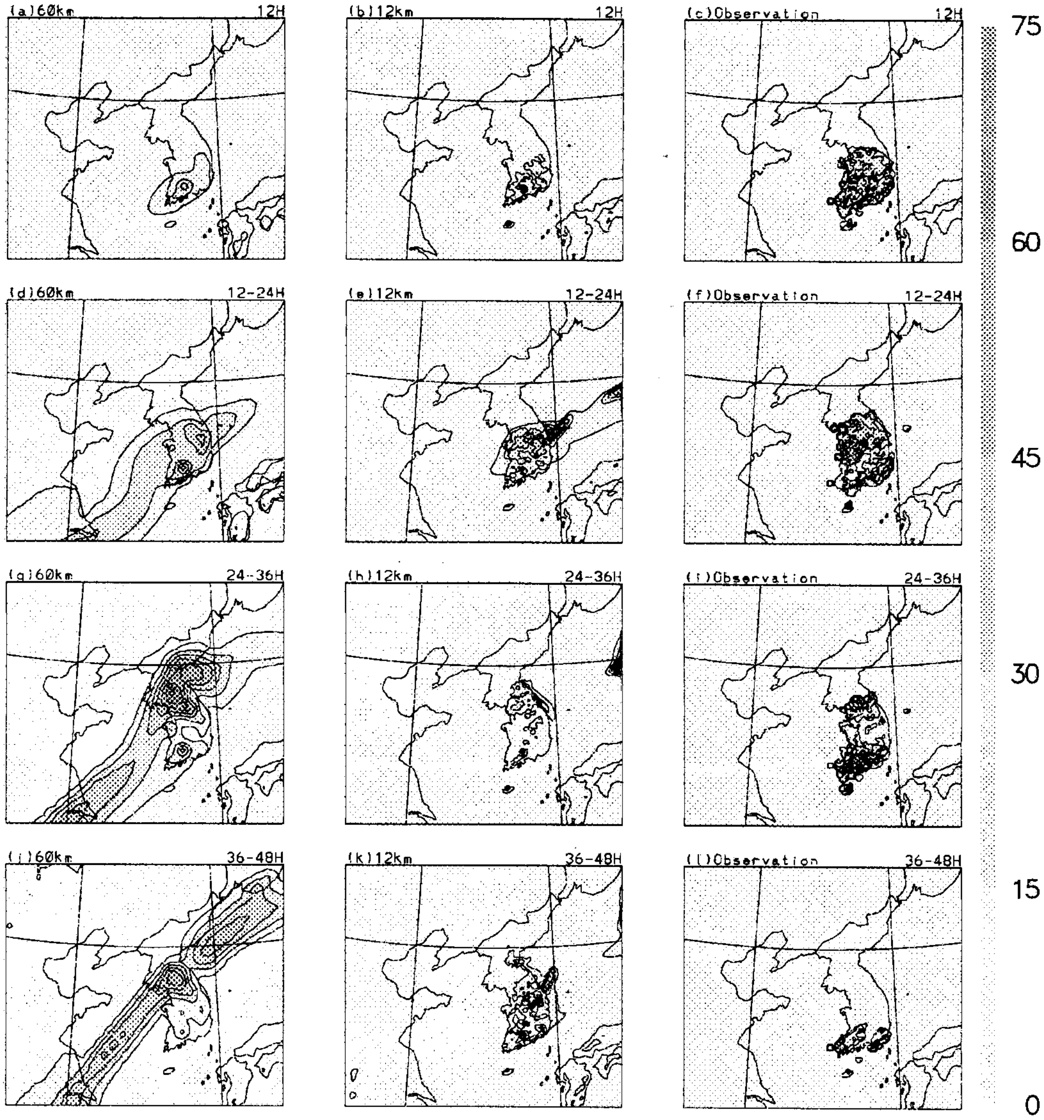

Fig. 3. A comparison of the 12-h accumulated precipitation (*mm*) of the 60-km and 12-km METRI-meso simulations with the observation (391 rain gages in South Korea) after 12 UTC 24 in June 1998.

3. Coupled atmosphere-streamflow simulation

A set of 72-hour predictions have been generated over both domains over the period of 00 UTC 24 June to 12 UTC 4 July in 1998. In this period, each atmospheric and streamflow forecast is initialized using the GDAPS/KMA analysis (Global Data Assimilation and Prediction System analysis from the Korean Meteorological Administration), hereafter Analysis, and the value of observed streamflow, respectively. Each forecast starts at 12-hour intervals (16 simulations for each domain), and and boundary conditions for both domains are obtained by interpolating the Analysis and SST (Reynolds and Smith, 1994). Analyses of the predicted precipitation and streamflow focus on the first 48-hr periods, as the forecast skill deteriorates rapidly after 48 hours in some cases (Figs. 4 and 5).

The preliminary simulation was made for the period of 12 UTC 24 to 12 UTC 27 June 1998 for both domains. Figure 3 shows that reasonable agreements between the observations (391 rain gages in South Korea) and forecasts during the first 48 hours are obtained for both domains. Locations of rain band are well shown in both domains, but large-scale rainfall patterns such as the monsoon rain band over the Korean Peninsula are better simulated in the larger domain runs, and fine-scale patterns such as the orographic precipitation are better represented in the smaller domain runs. During the first 12 hours, the locations of the simulated rainband in the larger (Fig. 3a) and smaller (Fig. 3b) domains compare well with the observation (Fig. 3c). The simulated rainfall intensity, however, is weaker than observations in both domains. During 12 – 24 H (Fig. 3d-f), both the location and magnitude of the observed rainfall are well simulated in both domains. Compared to the results from the smaller domain run, the larger domain run underestimates rainfall, as the effects of local terrain is not well represented with the 60km resolution. During 24 – 36 H (Fig. 3g–i), two rain bands over South Korea are well captured for both domains. During 36 – 48 H (Fig. 3j–l), the smaller domain run over-predicts rainfall in the central South Korea, but captures the rain band located in the southern end of the Korean Peninsula. The preliminary simulations indicate that the METRI-meso

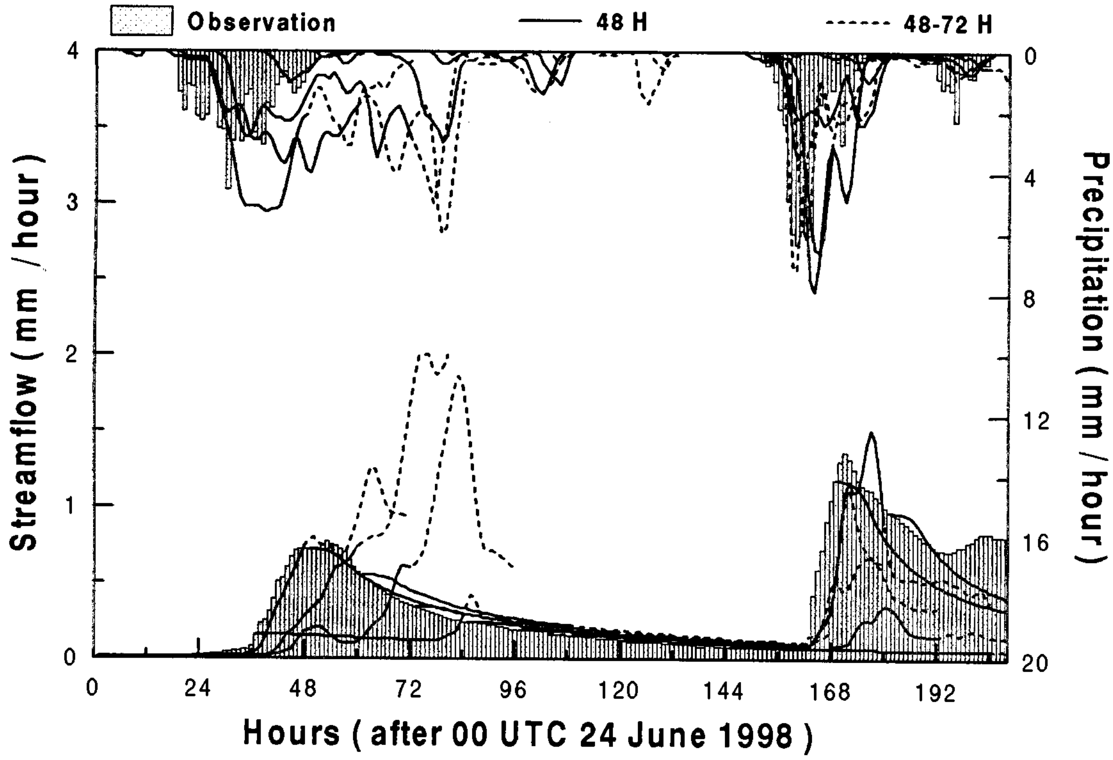

Fig. 4. Comparison of the 1-hr accumulated precipitation and streamflow of the 60-km simulation with the observation for the Pyungchang study basin after 00 UTC 24 June. The bars are the observed rainfall and streamflow. The solid and dashed lines are the simulation results during the first 48 hours and 48 – 72 hours, respectively.

model can simulate the position and magnitude of rainbands with reasonable accuracy for the first 48 hours.

Time series of the simulated and observed rainfall and streamflow at the PSB are shown in Figs. 4 (larger domain) and 5 (smaller domain). The simulated precipitation and streamflow trends are well captured for both domains, but the smaller domain generates somewhat better results than the larger domain, especially during the first 48 hours. During the first 48-hr periods, one of the smaller domain simulations over-predicts rainfall and streamflow than the larger domain runs (A of Fig. 5), but most of them give better prediction (See 60 – 168 hours). Since each streamflow forecast, initialized with the observed streamflow, varies steadily with time from the initial value, agreements between the simulated and observed streamflow are higher in the first about 12 hours.

4.Conclusions and Discussions

A coupled atmosphere-streamflow modeling system was used to simulate the 72-hour rainfall forecasts of quantitative precipitation and streamflow over the IHP basin with useful skill,

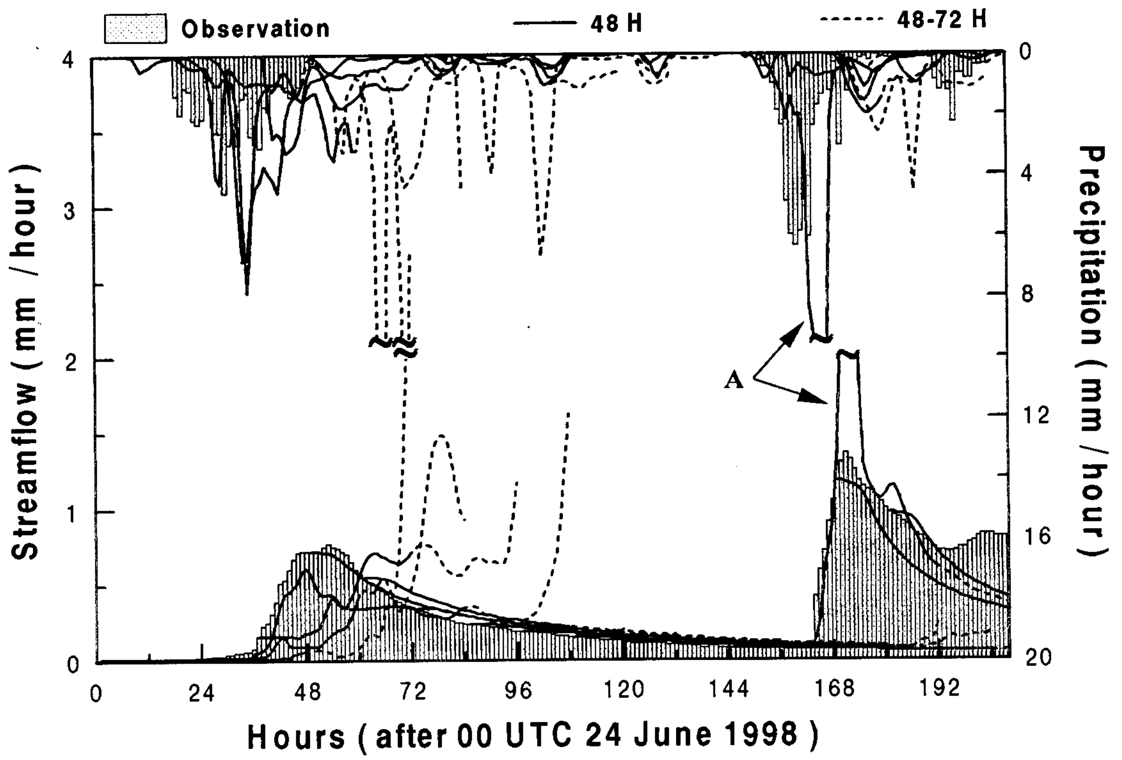

Fig. 5. Same as Fig. 4 except for the 12-km simulated results.

and streamflow at the Pyungchang IHP basin. To examine the effects of domain size and resolution of the atmospheric model, experiments were performed for two domains, a larger domain covering East Asia at a 60 km resolution, and a smaller domain covering the Korean peninsula at a 12 km resolution. A hydrologic model, semi-distributed TOPMODEL, was calibrated for the Pyungchang IHP basin using the observed rainfall and streamflow, and the optimized TOPMODEL parameters yield good agreements with observed streamflow during the verification periods.

It is shown that the overall trends of rainfall are similar in both domains but the synoptic-scale and local rainfall are better captured in larger and smaller domain, respectively. The good efficiency of TOPMODEL calibration for PSB and the streamflow initialization with observation have given the good agreement between the simulated and observed streamflow for both domains especially during the first about 12 hours, which indicates the importance of knowing the initial streamflow as well as the streamflow model calibration for planning the precaution of a flash flood.

It is shown that both the 60- and 12-km coupled atmosphere-streamflow modeling system can produce synoptic- and basin-scale respectively. This is an important first step toward the short-term precipitation and streamflow prediction for this region. Other regions and basins can be added as hydrologic models are calibrated for additional basins. Based on this study, a real-time coupled atmosphere-streamflow forecast system using both 60- and 12-km resolutions is being operated for 72-hour weather/quantitative precipitation/streamflow forecasts over the Pyunagchang and Soyang River basins to help the forecasters of KMA and MOCT (http://72hforecast.metri.re.kr).

The over- and under-prediction of precipitation may be due in uncertainties of the Analysis, SST, the spin-up problem, or the mesoscale convection scheme. The Analysis or SST may not be accurate in due to a lack of observations, especially for the west and east sea of Korean Peninsula, as well as possible assimilation errors. The METRI-meso spin-up time (we estimate it as about 12 (12 km) and 24 (60 km) hours, which will be shown in the next studies.) could shorten by reducing the model integration time, but it makes the model running time increased. Simulating convection in numerical models is also difficult and an important ongoing research issue. Further investigation or improvement of the Analysis, SST, spin-up problem, and model physics will be performed in the next studies.

Acknowledgement: We thank the Numerical Weather Prediction Division / Korean Meteorological Administration for the offer of the GDAPS analysis and the Korea Ministry of Construction and Transportation for providing the hourly data of the Pyungchang study basin. This research was performed for the Natural Hazards Prevention Research Project, one of the Critical Technology-21 Programs, funded by the Korea Ministry of Science and Technology of Korea.

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Preliminary Results of Model Intercomparison in the South China Sea

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Abstract: Four different types of numerical ocean circulation models are used in the circulation study for the South China Sea (SCS). Based on different finite difference representation of the vertical coordinate systems, four models are POM, MICOM, TOM and GFDL Model and each of them adopts sigma coordinate, isopycnal coordinate, depth coordinate and depth coordinate respectively. The model oceans have the same topography, grid resolution, initial conditions and surface boundary conditions. The maximum ocean depth is 1000m. The grid resolution is $0.5^{\circ}\times 0.5^{\circ}$. The initial conditions come from Levitus' climatological temperature and salinity data in January. The surface boundary conditions come from COADS climatological wind stress, surface temperature and salinity. Heat flux and flesh water flux data relax to the surface temperature and salinity. The lateral boundaries take closed boundary conditions temporarily. This paper intercompares circulation pattern, sea surface height, and seasonal cycle of the mixed layer thickness, barotropic stream function and sectional transport, arming to study the simulated capability of different ocean circulation models in the process of the upper ocean circulation establishment. Based the analysis of the intercomparison, this paper also discusses the uncertainty of different ocean circulation models. The analysis of results as follows: The basin scale circulation of the upper ocean is similar. In winter, a strong cyclonic gyre occupies the whole SCS. In summer, a strong anti-cyclonic gyre occupies the southern SCS and a weak cyclonic gyre occupies the northern SCS. The thickness of the mixed layer show unimodal feature in the northern SCS and show bimodal feature in the southern SCS. The sea surface height (SSH) of four modal results shows a good resemblance. The sea surface height anomaly (SSHA) of the northern SCS has an eastward propagating feature as TOPEX observed. Stream functions reflect that the circulation of the upper ocean is mainly forced by inputting of wind stress vorticity under closed boundary conditions. The transport of the different sections coordinate with generation, development and disappearance of the gyres. Other than the difference in the west boundary current, continental shelf current, et al., four models show a lot of common point in basin scale circulation simulation.

Simulation of the 1998 Severe Precipitation Event in China with the Regional Climate Model Developed at the International Pacific Research Center

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During the monsoon/Meiyu season in 1998, the Yangtze-Huai River Valley experienced the second worst recorded severe flooding event since 1954 (Ding and Liu 2000). The year 1998 corresponded to the post phase of the strongest 97/98 El Ni□o event in the past 50 years, indicating a delayed response of anomalous rainfall over the East Asia to the previous El Ni□o forcing. It is our purpose in this study to evaluate the capability of the regional climate model (RegCM) newly developed at the International Pacific Research Center (IPRC) in simulating this extreme event associated with the effect of El Ni□o.

The IPRC regional climate model (IPRC_RegCM) was developed for Asian-Australian monsoon studies. The model uses hydrostatic, primitive equations. The model physics include an E-ε turbulence closure scheme for vertical mixing, a modified Monin-Obukhov scheme for the surface flux calculations, an explicit treatment of mixed-ice phase cloud microphysics for grid scale moist processes, a mass flux scheme for cumulus convective parameterization, and the frictionally-induced dissipative heating (Wang, 1999, 2001a,b; Wang and Wang, 2001). It also incorporates an advanced radiation scheme (Edward and Slingo, 1996), and an advanced land surface model (BATS; Dickinson et al., 1993) together with high-resolution vegetation and soil classification data to better simulate the land surface processes. The NCEP/NCAR re-analysis data provided both initial and lateral boundary conditions. Reynolds weekly SST data were used as the lower boundary condition over the ocean. The soil moisture fields were initialized such that the initial soil moisture depends on the vegetation and soil type defined for each grid cell. The model domain covered East-Asian summer monsoon region: 10°N-40° N and 100°E-135° E with a resolution of 0.25° in both latitude and longitude directions. The model integration was performed over a period between April 28 and August 31. The results were then compared with both the driving fields and the station data available in the domain. Rainfall data from stations were distributed to the model grid cells using a bicubic interpolation technique with positive-definite constraint, and only land points were used in the verification.

Statistics similar to those used by Wang et al. (1999) and Giorgi et al. (1993) were utilized to assess the different aspects of the model performance. These were calculated for a region that covers Yangtze-Huai River Basin and South China (23°N-34°N, 105°E-122°E) for four months (May–August). In general, the IPRC_RegCM model captures main features of the East-Asian summer monsoon reasonably well. Table 1 gives the spatial correlation (SC) coefficients, root mean square errors (RMSE) and biases in sea level pressure, air temperature and water vapor mixing ratio at the lowest model layer between the model estimates and NCEP-NCAR reanalysis data that are interpolated onto the model's grid points. Biases for temperature and water vapor mixing ratio were calculated for all sigma levels, and they were found to be between –0.5 and 0.5 °C and between –0.5 and 0.5 g/kg, respectively.

Table 1 Spatial Correlation coefficients (SC), Root Mean Square Errors (RMSE) and Biases (BIAS) of Sea Level Pressures (SLP), temperature and water vapor mixing ratio (at the lowest model layer) between model outputs and NCEP-NCAR reanalysis data.

Month	SLP (mb)			Temperature (°C)			Mixing Ratio (g/kg)		
	SC	RMSE	BIAS	SC	RMSE	BIAS	SC	RMSE	BIAS
May	0.80	0.95	0.76	0.93	1.29	0.28	0.93	1.46	-0.09
June	0.91	1.16	1.28	0.92	1.22	0.32	0.87	1.80	-0.16
July	0.94	1.32	1.95	0.90	1.40	0.31	0.70	2.57	-0.32
August	0.79	1.52	2.28	0.87	1.54	0.33	0.75	2.70	-0.32

Figure 1 shows the observed and modeled daily precipitation and their spatial standard deviations for the area defined above. The model reproduces realistic trends and fluctuations of precipitation over the region. Spatial variability of estimated and observed rainfall is in fairly good agreement as well. Note that the precipitation was underestimated between Julian days 200-220. Table 2 summarizes monthly statistics related to precipitation. The correlation coefficients of the spatial pattern for precipitation indicate good skill in all months except July.

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Figure 1 Observed and estimated daily precipitation and its spatial standard deviation over the defined region.

Table 2 Monthly mean statistics of observed and simulated precipitation (mm day^{-1}) over the region.

Month	Observed	Estimated	Spatial	Temporal	Bias (mm)

	Mean (mm)	Mean (mm)	Correlation	Correlation	
May	5.74	7.78	0.49	0.92	2.34
June	9.45	8.90	0.67	0.69	-0.33
July	6.70	5.64	0.05	0.67	-1.07
Aug.	5.04	4.00	0.51	0.56	-1.17

Figure 2 shows the diurnal cycles of energy balance components with respect to the months (upper panel) and observed and estimated daily minimum and maximum temperatures (lower panel) over the region considered in this study. The net shortwave radiation at the surface shows a steady increase over the four months. It seems that the excess energy is mostly partitioned into sensible heat flux while latent heat flux remains fairly constant. The estimated minimum and maximum temperatures are in good agreement with the observations, however, a small but persistent cold bias in the daily minimum temperature is evident during the last two months of simulation. The surface processes do not indicate a clear reason for this bias, and we are currently looking into this problem through sensitivity experiments.

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Figure 2 Diurnal cycles of energy balance components with respect to months and observed and estimated daily minimum and maximum temperatures

This study has showed that the IPRC_RegCM is able to capture the unique features of Meiyu fronts, the associated rainfall events, and the land-surface processes and thus can be used to study the regional climate over the East Asia.

Acknowledgments: We would like to thank Dr. Zhian Sun in helping implement the radiation package into our regional climate model. This study has been supported in part by NOAA/PACS program, ONR grant, and in part by the Frontier Research System for Global Change through the International Pacific Research Center (IPRC) in the School of Ocean and Earth Science and Technology (SOEST) at the University of Hawaii.

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Predictability of Precipitation and Temperature over China with An AOGCM

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ABSTRACT

China is a country with high frequency of occurrence of rainstorm in summertime. Occasionally, rainstorm cause flood disaster in China each year. For instance, in the summer of 1998, it occurred sever flood disaster in the Yangtze and Huaihe River Basin, and in the summer of 1999, the middle and low reach area of Yangtze River suffered from the unusually severe flood disaster again, which caused huge losses in national economics. China is situated in the East Asian Monsoon area. It has complex terrain conditions. The variation of weather and climate are influenced by a lot of factors, which make the weather and climate over China difficult to be predicted.

In order to improve the understanding and prediction of the activity of monsoon and rainfall over China with climate model, a global coupled atmosphere-ocean general circulation model (AOGCM), which has relatively higher resolution and completer physical process and is suitable to do seasonal prediction for China, has been developed in National Climate Center of China Meteorological Administration by cooperating with Chinese Academy of Sciences, Peking University, and some other units under the support of National Key Project (1996-2000). The T63 AOGCM is composed of a global atmospheric circulation model (T63L16) and a global oceanic circulation model (T63L30), which are coupled through daily flux anomaly (DFA) scheme.

The T63L16 AGCM is developed on the basis of the dynamical framework of medium-range numerical weather prediction model (version T63) of National Meteorological Center of China Meteorological Administration. The original version of this model was derived from the 1988 version ECMWF T63 model. The model has triangle truncation in the horizontal direction with 63 waves (approximately 1.875X1.875). There are 16 levels in vertical direction. P—σ hybrid coordinate (η coordinate) is used. The dynamic scheme and physical process of the original medium-range operational model have been improved. The improvements in the dynamical framework mainly are the introduction of reference atmosphere and the adoption of static deduction method to reduce modeling truncation errors and improve calculation accuracy of horizontal pressure gradient force near cliffy topography; the employment of semi-Lagrangian method to calculate the horizontal and vertical transport of moisture so as to eliminate the occurrence of negative moisture and pseudo precipitation; the improved conservation of mass during the long-term integration. Besides, the model physical parameterizations have been modified. For instance, the Gregory mass flux scheme was

incorporated to replace the original Kuo convection scheme; the Morcrett radiation scheme was introduced into the new AGCM model; the gravitational wave drag scheme under the unstable atmospheric condition in boundary layer scheme was improved; the one and a half closure scheme of boundary layer turbulent diffusion and boundary layer free convection scheme was adopted in the aspect of boundary layer transport of modeling moisture. Therefore, the new AGCM, comprising topography, radiation, large-scale precipitation, cumulus convection, evaporation, concrete, etc. physical processes, is capable of describing the variations of global atmospheric motions.

The T63L30 OGCM is developed on the basis of the IAP/CAS OGCM that has 20 levels in vertical direction and 4x5 horizontal resolution. The major improvements of the new OGCM include: 1) the increases of the vertical and horizontal resolutions, which are 30 levels and 1.875X1.875 (approximately T63L30); 2) the incorporation of Gent-McWilliams parameterization scheme of isopycnal surface mixture; 3) the adoption of Pakanowski-Philander scheme of vertical mixture of ocean upper layer to reduce the horizontal viscosity; 4) the consideration of penetration of short-wave radiation into oceanic sub-surface layer.

The T63 AOGCM was used to perform the mutil-seasonal predictions of precipitation and temperature over China in 1991-2000. The predictions were compared with observations. The preliminary results indicate the model has a certain capability in doing seasonal prediction. In this presentation, firstly, the models and the initial data will be introduced briefly. Then, the predictions for the spring and summer of 1991-2000 will be examined and the verification results will be shown.

Key words: AOGCM, multi-seasonal prediction, verification

ENSO Simulation in a Coupled GCM

Prof. Tim Li, University of Hawaii.

Abstract:

A coupled atmosphere-ocean model was developed at the International Pacific Research Center, University of Hawaii. The atmospheric component is the Max-Planck Institute ECHAM model and the oceanic component is the Geophysical Fluid Dynamics Laboratory MOM model. The atmospheric and oceanic models are fully coupled without any flux correction. A long-term simulation illustrates the model's capability in simulating ENSO-like phenomenon in the tropical Pacific. For example, the amplitude and structure of the model warm and cold episodes resemble well the observed, and the matural phase of the El Nino/La Nina appears in northern winter. The power-spectrum analysis of time series of the Nino 3 SST anomaly shows that the model is able to capture both quasi-biennial and lower-frequency peaks, which was often missed by many coupled GCMs.

Role of Indian Ocean warming in the development of philippine Sea anticyclone during ENSO

Fei –Fei Jin and Masahiro Watannbe

The anomalous low-level anticyclone near Philippines and suppressed convection over western Pacific associated with the mature warm phase of El Nino-Oscillation (ENSO) have been suggested as an important element in the interaction between ENSO and the East Asian monsoon. We examined the causes of these anomalies in the circulation and convection using a newly developed linear baroclinic model that includes an interactive moist processes of the cumulus convection and surface heat fluxes. A conventional version of the linear model forced by prescribed heating indicates that the diabatic cooling due to suppressed convection over the maritime continent generates the Philippine Sea anticyclone . From a series of the moist linear model experiments, we found that modest warming of the Indian Ocean, in addition to the warming in the central-eastern Pacific and weak cooling in the western Pacific ,is significant to suppress the convection over maritime continent. Observed data also show a coincidence of development between the Philippine Sea anticyclone, Indian warming, and the ascending motion over the Indian Ocean, supporting the model results.

The above results indicate that the atmosphere-ocean system in the Indian Ocean may be one of important factors to improve predictability of the East Asian climate during ENSO.

A Diagnostic Study of 1998/2000 Cold Episode

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1. Diagnosis on ENSO Process

(1) Features of ocean temperatures in the tropical Pacific

(a) Sea Surface Temperatures (SSTs)

1998/2000 cold episode occurred after the end of the strongest warm episode during 20 century. In late May 1998, the central equatorial Pacific suddenly turned from anomalous warm condition into cold. From then on, the cold water expanded and strengthened. The cold episode formed in Oct. 1998 and reached the first peak during Dec. 1998-Feb. 1999 with the SSTA indices of Nino 3 and Nino 4 being -1.0, -1.5 respectively. The SSTA maintained weak cold episode feature during spring and summer 1999. The cold episode reached its second peak in early 2000 with the SSTA indices of Nino 3 and Nino 4 dropping to -1.5, -1.4 respectively.

Compared with the other 11 cold events since 1950, the accumulated SSTA during the cold episode is much lower than that of 1954/1956 episode, but equivalent to 1970/1971, 1974/76 and 1988/1989 strong cold episodes. The duration of this cold episode is relatively long.

(b) Subsurface Temperatures

September 1997, western equatorial Pacific formed strong negative anomalies in the sub-layer. In June 1998, the colder than normal center reached eastern coast and the negative center value was lower than -8℃ in the vicinity of date line. The subsurface east to 105° W was still controlled by warm water and the eastward propagation of cold water was depressed. Colder than normal water initiated in the central Pacific and a cold episode was onset from the central Pacific.

(2) Features of the Tropical Atmosphere

(a) Sea Level Pressure (SLP) and Southern Oscillation (SOI)

From March 1998, SLP in the equatorial western Pacific suddenly dropped, but in the central and eastern Pacific it was higher than normal. The trade wind was than enhanced. SOI increased from -3.5 in March to 0.1 in May. In January 1999 it reached peak value to 2.0. During May to September, SOI remained near normal conditions. Rising from November, SOI reached the second peak in February 2000 but returned normal in May 2000.

(b) Winds

From April 1998, obvious easterly anomalies maintained over the equatorial Pacific between 130° E to 150° W at 850hPa. Weak easterly anomalies were found in the eastern Pacific from 1999. At 200 hPa, westerly anomalies were in the eastern equatorial Pacific east to 130° E. An anticyclonic anomaly Pattern was found in the wind vector anomaly field in the lower troposphere while a cyclonic anomaly Pattern was in the upper troposphere over the Pacific.

From late spring to early autumn 1999, as the northward shift of the trade winds, the zonal wind anomalies were weakened over the equatorial Pacific correspondingly.

(c) Convective Activity

During the cold episode, enhanced convective activity was over Indonesia with OLR anomalies lower than -30Wm^{2}. Depressed convective activity was found over the region east of 140° E, in the region around 150°E~150° W, OLR anomalies were higher than 30Wm^{2}.

The anomalous features of SOI, COI, OLR and winds all indicated that Walker circulation was obviously enhanced during the cold episode.

2. Major Features

(1) This cold episode is a typical onset in the central Pacific. In June 1998, abnormal negative SSTAs were found in the equatorial Pacific at 165~110° W. A narrow strong negative SST anomaly band with the center value lower than 3℃ inserted along the equator in the abnormal positive anomaly region, thus separated the warm water. This feature is very similar to the cold process post 1982/1983 strong warm ENSO event. The SSTA distributions of 1983~1984 and 1998~2000 are different from those of the others. The colder than normal water mainly maintained in the central Pacific and in the eastern Pacific it was very week. Warm water persistently appeared at the two sides of the cold water alone the equator.

(2) During the onset of warm episode, the thermocline gradually adjusted, which resulted in enhanced negative anomalies in the western equatorial Pacific and the gradually eastward shift of the cold water. In the figures of monthly subsurface temperatures showed that the negative temperatures in both Sept. 1983 and Sept. 1998 were all very strong but cold water in 1998 developed much quicker which is favorable for the onset of cold episode.

(3) The features of atmosphere and ocean in 1998 matched well, which provided a favorable condition of rapid onset and maintaining of the cold episode. The easterly anomalies appeared 1-2 months before the negative SST anomalies and the eastward extension of easterly anomalies and SSTA are consistent. This seems very important for triggering the cold episode.

(4) The suddenly warm up in the equatorial eastern Pacific characterized the end of this cold episode, while SSTA in the central Pacific changed slowly. The atmosphere conditions include winds and connectivity lagged the sudden change of SSTA in the equatorial eastern Pacific.

SESSION 3

Impacts of EL Ninõ events on the monsoon, tropical cyclones and drought/floods in Southeast Asia and East Asia.

Interactions of Maritime Continent Winter Monsoon, ENSO and Indian Ocean Winds

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The maritime continent rainfall often exhibits an inverse relationship with eastern equatorial Pacific SST, such that rainfall deficits are associated with warm (El Nino) events and vice versa. The correlation is highest during northern fall and remains significant during northern winter, which is the wettest season in the annual cycle. However, this negative winter monsoon – ENSO relationship changes over the western part of the maritime continent near Malay Peninsula and Sumatra. From 1950 to mid-1970s the winter monsoon rainfall in this region shows a slight positive correlation with eastern equatorial Pacific SST, while after mid-1970s the correlation is near zero. It is shown that the existence of this low correlation region is a result of the varying interactions between the winter monsoon, ENSO and Indian Ocean winds.

Impact of ENSO Cycles on the Summer Climate Anomalies in East Asia and the Outlook of the SST Anomalies in the Tropical Pacific in 2002

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1. Introduction

ENSO event can be considered as the most important phenomenon in the tropical air-sea interaction, especially in the equatorial Pacific. When an ENSO event occurs in the equatorial Pacific, severe climate anomalies will be caused in many regions of the world (see Namias, 1978; Horel and Wallace, 1981; Rasmusson and Carpenter, 1982; Rasmusson and Wallace, 1983). Similarly, ENSO event also has a large impact on climate anomalies in East Asia (See Wang, 1986; Fu and Ye, 1987). In respect of the impact of ENSO event on the summer climate anomalies in China, Huang and Wu's (1989) investigation showed that the influence of ENSO events on the summer climate anomalies in China depends on different stage of ENSO cycle.

During 1997-1998, the strongest ENSO event occurred in the equatorial central and eastern Pacific, and it brought serious climate anomalies in many regions of the world. Particularly, the severe drought and hot summer appearred in North China and the northern part of the Korean Peninsula in the summer of 1997. And in the summer of 1998, the severe floods occurred in the Yangtze River valley and Northeast China, and heavy rainfalls also occurred in South Korea and Japan. These disasters brought huge economic losses in these countries. Thus, in this paper, the NCEP data of the sea temperature in the surface and the sub-layer of the tropical Pacific, the NCEP/NCAR reanalysis data and the daily precipitation data in China for 49 summers from 1951 to 1999 are used to analyze the impact of ENSO cycles on the summer climate anomalies in East Asia, especially the impact of the 1997/98 ENSO event on the summer climate anomalies in China.

2. Influence of ENSO Cycles on the Summer Climate Anomalies in East Asia

As described in the introduction, ENSO event has a large impact on climate anomalies in many regions of the world. Generally, severe floods often occur in the eastern coast and severe droughts appear in the western coast of the tropical Pacific during the occurrence of ENSO event. However, it has different impact on the summer climate anomalies in East Asia in different stage of ENSO event.

In order to explain the impact of ENSO cycles on the summer climate anomalies in East Asia, first, the correlation between the summer (June-August) rainfall anomalies in China and the differences between the SSTs in NINO.3 in summers and those in last autumns during 1951-1996. The result shows that negative correlations are located in North China, the Yellow River valley and the area to the south of the Yangtze River, and positive correlations appear in the Huaihe River valley. This means that during the summer with the developing stage of ENSO event, the summer monsoon rainfall may be below normal in North China, the Yellow River valley and to the south of the Yangtze River, but it may be above normal in the Huaihe River valley and the lower reach of the Yangtze River. On the contrary, during the summer with the decaying stage of ENSO event, the summer monsoon rainfall may be above normal to the south of the Yangtze River, especially in the Dongting Lake and Boyang Lake valleys, and severe flood may occur in these regions. But the summer monsoon rainfall may be below normal in the Huaihe River Valley in this case.

Figures 1(a) and 1(b) are the composite distributions of the monsoon rainfall anomaly percentage in China for the summers with the developing and decaying of ENSO events, occurred in the period of 1951-1999, respectively. It shows in Fig. 1(a) that positive rainfall anomalies are in the Huaihe River valley, and negative rainfall anomalies are located in the Yellow River valley, North China and to the south of the Yangtze River. This explain that during the summer with the developing stage of ENSO event, hot and drought may occur in North China, but flood may be caused in the Huaihe River valley. However, during the summer with the decaying stage of ENSO event, the composite distribution of summer rainfall anomalies shown in Fig.1(b) is opposite to that shown in Fig.1(a). This shows that during the decaying stage of ENSO event, severe flood may occur to the south of the Yangtze River, especially in the Dongting Lake and the Boyang Lake valleys, but drought may be caused in the Huaihe River valley. During the 20th century, the particularly serious flood disasters in the Yangtze River valley of China occurred in the summers of 1954, 1998 and 1931, respectively. These summers were in the decaying phase of ENSO event or the developing phase of La Nina event.

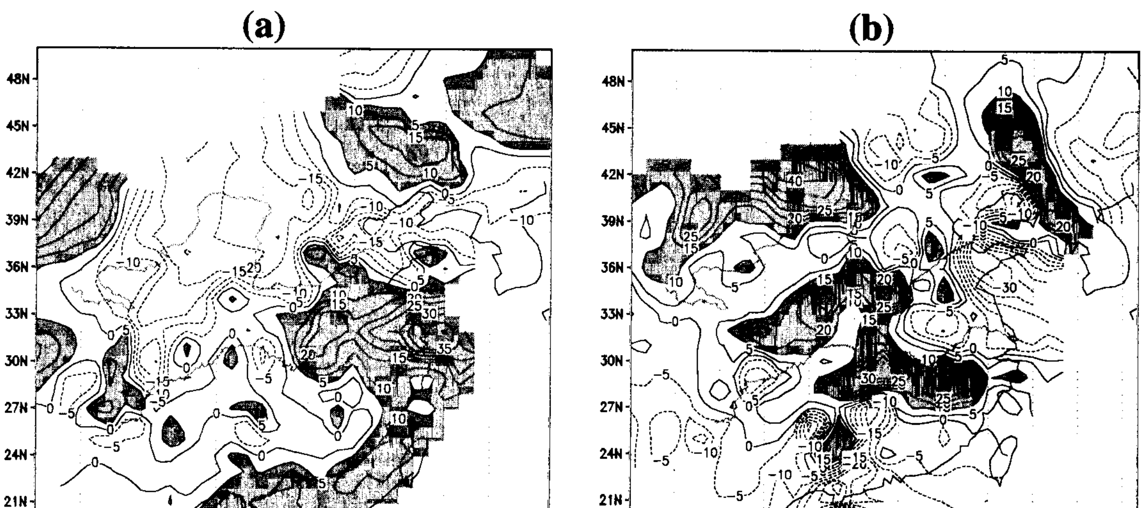


Figure 1. Composite distributions of the summer monsoon rainfall anomaly percentage in China for the summers with the developing (a) and decaying (b) stages of ENSO event. The shaded areas in figure indicate the rainfall anomaly percentage over 10% above normal.

3. Influence of the 1997/98 ENSO Event on Summer Climate Anomalies in China

As the above-mentioned impact of ENSO events on the summer climate anomalies in East Asia, the 1997/98 ENSO event had a large influence on the summer climate anomalies in China. Since this ENSO event was the strongest in the 20th century and it had the characteristics of rapid onset and rapid decay, it had serious impact on the summer climate anomalies in China. Figure 2(a) is the distribution of rainfall anomaly percentage in China in the summer (June-August) of 1997. From Fig.2(a), it can be seen that in North China, the summer rainfall anomalies were about 50% below normal and severe drought occurred there. Moreover, positive surface temperature anomalies with a maximum center of about 2.0℃ continuously appeared in North China and the southern part of Northeast China in July-August (Figure is omitted). Therefore, influenced by the ENSO event, the severe drought and hot summer were cuased in North China in 1997. This is in agreement with the composite distribution of rainfall anomalies shown in Fig.1(a) for the summers in the developing stage of ENSO events, but the rainfall anomalies were weaker than the composite anomalies in the Huaihe River valley.

(a) (b)

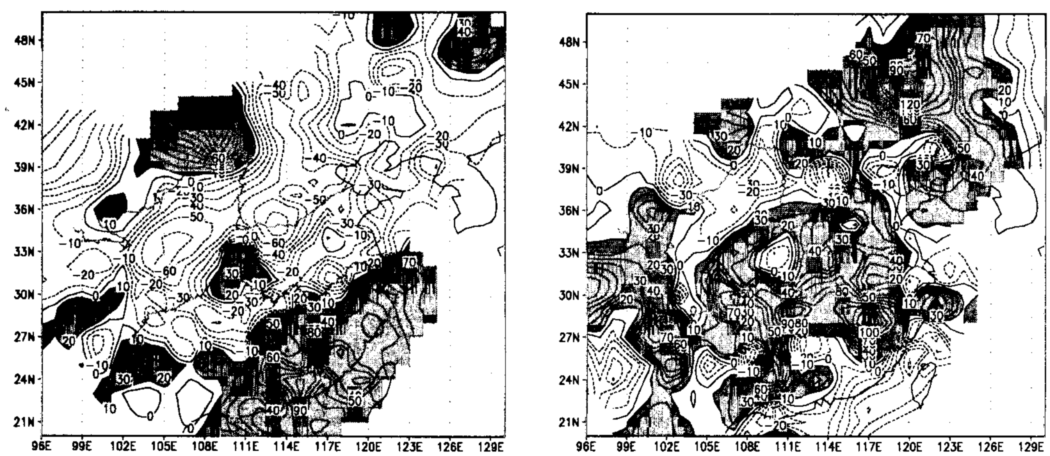


Figure 2. Distributions of the summer (June-August) rainfall anomaly percentage in 1997(a) and 1998(b) in China. The shaded areas in figure indicate the rainfall anomaly percentage over 10% above normal.

However, because the ENSO event was in rapid decay from the spring of 1998, the SST anomalies in the equatorial central Pacific became into below normal from June, 1998. Influenced by the decay of this ENSO event, as shown in Fig.2(b), the rainfall anomalies were 100% and more above normal in the Yangtze River valley, especially in the Dongting Lake and Boyang Lake valleys and in Northeast China in the summer of 1998. This caused the particularly severe flood occurred in the Yangtze River valley and Northeast China. Besides, heavy rainfalls frequently appeared in South Korea and Japan.

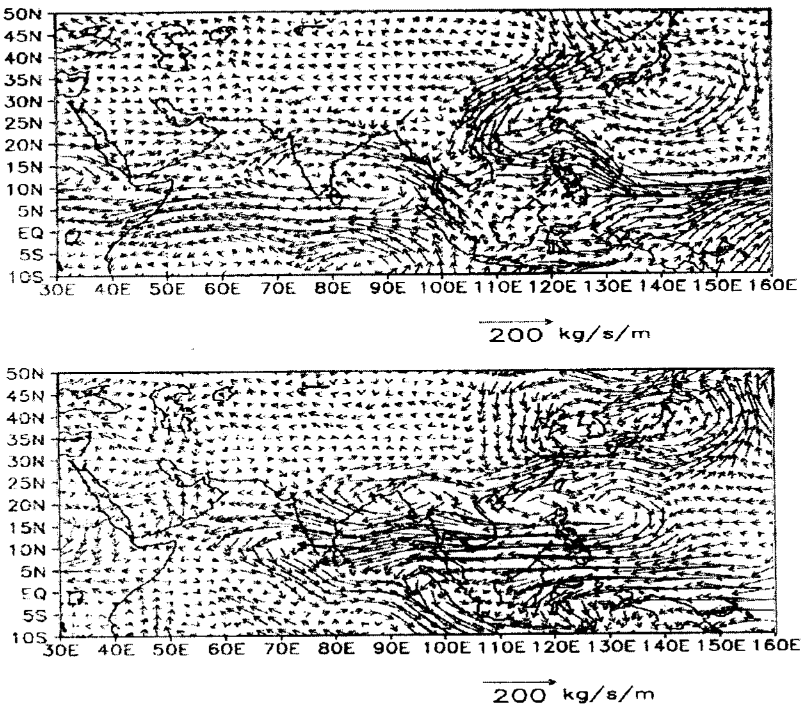
From the above-mentioned facts, it may be concluded that the 1997/98 ENSO event had the serious influence on the summer climate anomalies in East Asia, especially in China.

4. Influence of the 1997/98 ENSO Event on the Water Vapor Transport in East Asia

The Asian summer monsoon can transport a large amount of water vapour from the tropical western Pacific, the South China Sea and the Bay of Bangal into East Asia. However, the interannual variations of the anomaly water vapour transports by the Asian summer monsoon flow are closely associated with the thermal state of the equatorial Pacific (see Huang et al, 1998). The impact of ENSO event on the summer rainfall in East Asia may be through the water vapor transports.

The anomaly distributions of water vapor transports in the summers of 1997 and 1998 calculated by using the NCEP/NCAR reanalysis data are pictured in Figs.3(a) and Fig.3(b) respectively. As shown in Fig.3(a), in the summer of 1997, there were the anticyclonic anomaly distribution of water vapor transports over the region from South China, the

Indo-China Peninsula to the tropical western Pacific, and the cyclonic anomaly distribution appeared over the region from the Huaihe River valley, North China to the Northern part of Japan. This explained that influenced by the ENSO event, the water vapor transports by the summer monsoon flow were weak in North China and the northwest part of the Korean Peninsula. Thus, the summer monsoon rainfalls were weak in North China and the northern part of the Korean Peninsula, and the severe drought and hot summer appeared in North China and North Korea.



(a) in the summer of 1997

(b) in the summer of 1998

Figure 3. The anomaly distributions of water vapor transport flux vectors in the summers of 1997(a) and 1998(b).

Because the ENSO event occurred in May, 1997 was in rapid decay from May, 1998, and the ST in the sub-layer of the equatorial Pacific became into below normal, the convective activities were below normal around the Philippines, and the western Pacific subtropical high shifted southward. Therefore, there were the anticyclonic anomaly distribution of water vapor transports over the region from the South China Sea to the tropical western Pacific and the cyclonic anomaly distribution in Northeast China and Japan, as shown in Fig.3(b). This showed that the strong water vapor transports by the Asian summer monsoon from the Bay of Bangal, the South China and the tropical western Pacific converge in the Yangtze River valley, South Korea and Japan, especially in the Dongting Lake and Boyang Lake valleys. Thus, heavy rainfalls were frequently caused there, and the particularly severe flood occurred in the Yangtze River valley.

5. The Outlook of the Occurrence of Next ENSO Event in the Equatorial Pacific

(1). Evolution of the SST and the sub-surface ST in the equatorial Pacific during 1997/2001

The strongest ENSO event in the 20th century burst out in the equatorial Pacific in May, 1997 and reached to its mature phase in October, 1997. However, from the winter of 1997, the stronger easterly anomalies appeared near the sea surface of the West Pacific Warm

Pool, and then, these wind anomalies propagated eastward from the Warm Pool. Due to the effect of the easterly anomalies, the ENSO event decayed rapidly, and the SST anomalies in the equatorial central and eastern Pacific became into below normal from June, 1998, and then, the *La Niña* event burst out in the equatorial central and eastern Pacific. This *La Niña* event was maintained up to the winter of 2000. Moreover, the SST in the equatorial central and eastern Pacific slowly increased from the spring of 2001, and then the *La Niña* event decayed. Recently, the SST in NINO3 still oscillate near the normal. This may be due to the easterly anomalies were dominant and the westerly anomalies were weak over the tropical western Pacific and the equatorial central Pacific.

The evolution of the *La Niña* event can be also seen obviously from the sea temperature (ST) in the sub-layer of the equatorial Pacific. Because the strong easterly appeared near the sea surface of the equatorial western Pacific and propagated eastward from the winter of 1997. Under the effect of the easterly anomalies, the cold sea water quickly propagated eastward from the West Pacific Warm Pool to the equatorial central and then to the eastern Pacific. Up to July, 1998, the ST anomalies became negative in the sub-layer of all the equatorial Pacific. Thus, this ENSO event was in rapid decay. Moreover, these negative ST anomalies were continuously intensified in the sub-layer of the equatorial central and eastern Pacific. This caused the *La Niña* event occurred in the autumn of 1998.

However, due to the westward-propagation of the warm Rossby waves excited by the unstable air-sea interaction in the equatorial central Pacific (see Huang et al.1998; Zhang and Huang, 1998), the ST in the sub-layer of the tropical western Pacific became into above normal from below normal from the winter of 1998. Moreover, these positive subsurface ST anomalies were intensified in the tropical western Pacific and slowly propagated eastward up to the winter of 2000. This may be due to the easterly anomalies prevailed over the tropical western Pacific and the equatorial central Pacific, which could not cause the eastward-propagating warm Kelvin wave. As a consequence, the warm sea water could not quickly propagated eastward. Moreover, from the spring to summer of 2001, although the positive ST in the sub-layer of the tropical western Pacific slowly propagated eastward from the tropical western Pacific to the equatorial eastern Pacific near 120^0W, since there were no strong westerly anomalies over the equatorial western and central Pacific, the warm sea water could not continue to propagate eastward. This caused the ST has a decaying trend in the sub-layer of the equatorial central Pacific.

(2). The Outlook of the occurrence of next ENSO event in the equatorial Pacific

The above-mentioned observational fact of the SST anomalies in the equatorial Pacific shows that the SST anomaly in NINO.3 has became little positive from the spring of 2001 to the summer of 2001 and its variation is an oscillation near the normal recently. However, there still exist the strong easterly anomalies over the equatorial Pacific, therefore, it is possible that the positive SST anomalies cannot be quickly developed in the equatorial central and eastern Pacific. This may explain that a new *El Niño* event cannot quickly occur in the equatorial central and eastern Pacific before the summer of 2002.

It can be obviously seen from the evolution of ST in the sub-layer of the equatorial Pacific from the spring of 2001 to the summer of 2001 that the warm sea water slowly propagated eastward from the equatorial central Pacific to 120°W. However, since the weaker westerly anomalies still stay over the area to the west of the tropical western Pacific and the easterly anomalies prevail over the equatorial central and eastern Pacific, this can cause the decay of the eastward-propagating warm sea water. Thus, it may be estimated from the evolutive process of the ST anomalies in the sub-layer of the equatorial Pacific that the warm sea water will stay in the equatorial western and central Pacific and cannot quickly propagate eastward to the equatorial eastern Pacific. Therefore, it appears to be impossible that a new *El Niño* event occur in the equatorial Pacific before the summer of 2002.

Moreover, the IAP-TPCGCM is used to make the extra-seasonal prediction experiment of the SST anomalies in the tropical Pacific from the September, 2001. It is predicted that the SST anomalies in NINO.3 will become positive in September , 2001, and this positive SST in the equatorial central and eastern Pacific will develop from the spring of 2002 and a weaker *El Niño* event may burst out in the summer of 2002. However, the occurrence date of next *El Niño* event predicted with the numerical model appears to be too early, because the occurrence of next *El Niño* event in the summer of 2002 appears to be impossible from the evolution of the subsurface temperature in the equatorial Pacific.

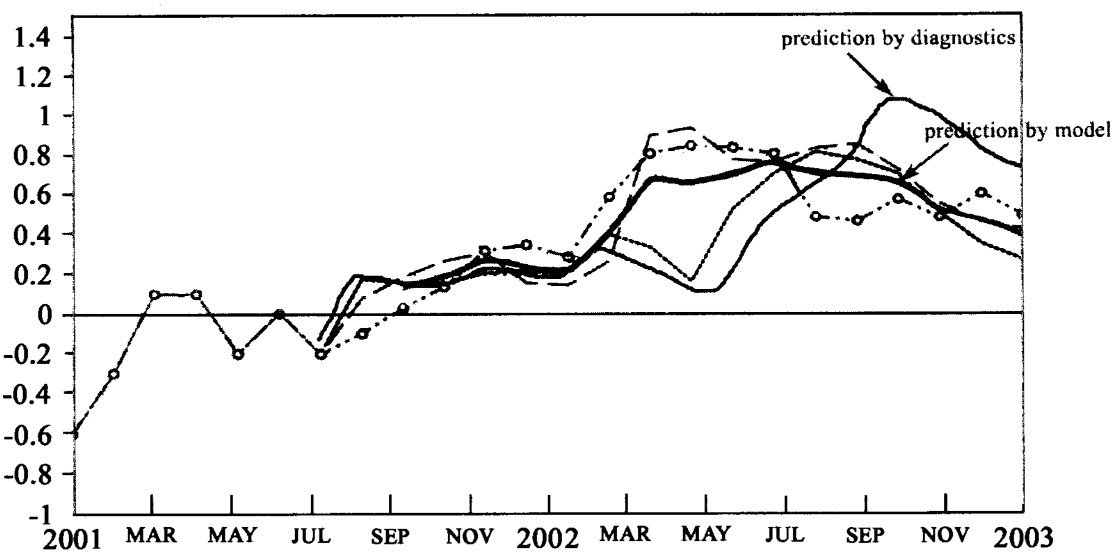


Figure 4. Evolution of the SST anomaly in NINO.3 predicted by using the IAP-TPCGCM and the statistical method, respectively.

6. Conclusions

In this paper, the observed data are used to analyze the impact of ENSO events on the summer climate anomalies in East Asia, especially in the summers of 1997 and 1998. The results show that ENSO event has a significant impact on the summer climate anomalies in East Asia, especially in the Yangtze River valley. However, the impact on the summer monsoon rainfall is different in the different stage of ENSO cycle. In the developing stage of ENSO event, hot and drought may be caused in North China, and summer rainfall may be above normal in the Huaihe River Valley. On the contrary, in the decaying stage of ENSO event, severe flood may be caused in the Yangtze River valley, especially in the Dongting Lake and the Boyang Lake valleys, as in the summer of 1998. In this case, summer rainfall may be below normal in the Huaihe River valley.

Moreover, the extra-seasonal outlook of the SST anomalies in the equatorial Pacific is made by using the statistical method and the IAP-TPCGCM, respectively. The result shows: although it is possible that the positive SST anomalies in the equatorial Pacific may be intensified from the spring of 2002, the occurrence possibility of a new *El Niño* event is not large before the summer of 2002. This may is due to the weak westerly anomalies still stay over the west of the tropical western Pacific and cannot quickly propagate eastward to the equatorial central and eastern Pacific.

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Report of the Second Joint Meeting on Seasonal Prediction of East Asian Winter Monsoon

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Hosted by China Meteorological Administration, the second Joint Meeting on Seasonal Winter Prediction of East Asian Monsoon was held in Harbin, China during 21-23 November 2001. Seven Korean participants, one Japanese participant and seventeen Chinese participants attended the meeting and total fifteen papers were presented. Among them, three papers were on reviews of the recent climate features (Lee, Zou) and review of the predictions for summer 2001 over China (Ai) and Korea, one paper about the winter climate condition in North China (Zhang and Xie), three papers on the recent large-scale features and ENSO outlook (Hong, Zhai, Mao), four papers on interannaul and interdecadal temperature and precipitation variability, impacts of high latitude and East Asian winter monsoon (Qian, Xu, Wu, Lu), and five papers on seasonal and interannual predictions over East Asia area using dynamical and statistical methods (Kim, Watanabe, Li, Sun and Wang). Various dynamical, statistical and analytical prediction techniques were used for 10 days forecast, seasonal and interannual predictions for ENSO, tropical cyclone, temperature, and precipitation, et al. Many factors affected on the East Asian winter monsoon such as SST, the Siberia high and the Aleutian low as well as the teleconnection patterns were discussed.

On ENSO prediction, ***JMA (Japan Meteorological Agency)*** predicted Neutral condition in the eastern tropical Pacific in the coming months. No El Nino or La Nina event will appear in the coming winter. ***KMA (Korea Meteorological Administration)*** predicted weakening cold phase and slightly cold than normal condition will be in the eastern equatorial Pacific. ***CMA (China Meteorological Administration)*** predicted the coming winter will be a transitional period from the cold phase to the warm phase. Warm episode is not likely to occur in 2001. In Spring 2002, SSTs in the eastern tropical Pacific will further increase and possibly form a warm ENSO event. The final prediction from this meeting is that slightly below normal SSTs in the equatorial Pacific will become gradually weakened but no major development of cold or warm event is expected in the coming winter (2001/2002).

On East Asia winter temperature prediction, JMA predicted that it is the most probable that a warm winter may be prevailing in Japan except its northern part. KMA predicted that slightly warmer than normal in southern China and Japan, while near normal in Korea and northern China. Possible frequent cold spells in northern China in January. Based on diagnostic analysis and statistical methods, CMA predicted that in much of Northeast China, eastern Southwest China, and the western Tibetan Plateau are expected colder than normal, while the rest part of China is expected to be warmer than normal. However, the NCC dynamical model predicted that the temperature would be lower than normal in northern China, Korea and Japan. IAP/CAS predicted temperatures would be slightly warmer than normal in East Asia. Peking University predicted that colder than normal conditions will be in northern NE China and northern North China and eastern China. Final Prediction of the meeting: colder than normal conditions are expected in parts of

Southwest China, warmer than normal in East China and Western Japan and the Nansei Islands. Near or warmer than normal conditions are expected in Northwest China, North China and Eastern Japan, and near normal in much of Northeast China, Korea and Northern Japan. However, frequent cold spells are anticipated in late winter, particularly in northern East Asia.
On Precipitation, |based on global spectral model predication, *KMA* predicted that there will be no dry condition anticipated except for northern China, but severe winter weather is likely in late winter. CMA predicted that drier than normal conditions in large part of China, and near or above than normal in some part of China. More than normal in south China and the south part of the Mid-lower Reaches of the Yangtze River, and less than normal in rest part of China. Dry conditions will be in northern China in the 2001/2002 winter and 2002 spring. The Final Prediction from the meeting: overall, precipitation is possible near normal in most parts of China, Korea and Japan, while above normal precipitation is possible in some parts of China including Northern Xinjiang, northern part of North China, the Upper Reach of the Yellow River and part of Southwest China. Less than normal precipitation is expected in some parts of North China and South China and the winter dry conditions may extend to early spring.

This meeting also identified some interesting topics such as the causes of the spring droughts in East Asia, factors impacting on the East Asian Winter Monsoon, winter monsoon prediction techniques, and predictability of the East Asian Winter Monsoon, et al for science community for further study.

The meeting proposed that next meeting to be held in Hangzhou, China in May 2002 on East Asian Summer Monsoon prediction. Also, the meeting suggested JMA to consider organizing a joint meeting in 2002, or later.

How Strong ENSO Events Affect Tropical Storm Activity over the Western North Pacific

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1. Introduction

A rich background of literature can be found in the past 20 years on the ENSO influence on tropical cyclone formation over the western North Pacific (WNP), a vast region spanning from 120°E to the dateline and from the equator to 30°N. Although there is a general consensus that El Nino affects the location of the tropical storm (TS) formation in the WNP, the results are described in a qualitative way and somewhat controversial due to the differences in analysis procedures, datasets, and definitions of El Nino events used by different authors (Atkinson 1977, Chan 1985, Dong 1988, Wu and Lau 1992, Lander 1993, Chen et al. 1998). This calls for a revisit of this issue using the longest possible available dataset. In the previous studies, attention was primarily paid to the TS formation. Changes in the TS tracks, TS life spans, and the frequency of TS occurrence between the El Nino and La Nina years have rarely been documented. In this study, we aim at a methodical exploration and quantification of all afore-mentioned aspects of the variability of TS activity.

A number of mechanisms have been proposed to explain how ENSO impacts TS formation over the WNP, including those through changing a) the vertical shear (Gray 1984), b) the WNP SST (Li 1988), c) the Walker circulation (Chan 1985, Wu and Lau 1992), and d) the WNP monsoon trough (Lander 1994, Chen et al. 1998). Since the TS-ENSO relationship varies with season, the mechanisms operating during the peak season (July-September) and early season (April-June) of the El Nino (La Nina) years could be different from that found in the late season. Further explanation of ENSO effects on WNP TS activity should particularly focus on how ENSO affects (1) the peak season and (2) the early season TS activity.

Data used in this study include the best-track data of tropical cyclones (position and intensity) for the period 1965-1999 obtained from the homepage of the Joint Typhoon Warning Center, the SST anomalies in the different NINO regions extracted from the homepage of the Climate Prediction Center/NCEP, and winds and vertical velocity fields from the NCEP/NCAR reanalyses (Kalnay et al. 1996).

2. Major Results

Analyses of 35-year (1965-1999) tropical storm (TS) activity over the western North Pacific (WNP) leads to a number of new findings on the year-to-year variation of tropical storm activity.

a. Impacts of strong versus moderate El Ninos: The relationship between the WNP TS activity and ENSO strongly depends on the intensity of ENSO episodes. Strong El Nino or La Nina events (NINO3.4 SST anomaly exceeds one standard deviation) have significant impacts, but the moderate warm (cold) events do not show definite significant impacts. Without distinguishing the impacts between moderate and strong events, one would overestimate the effects of moderate events and underestimates the impacts of the strong events. For this reason, we quantify only the impacts of the strong El Nino and La Nina.

b. Number of TS formation: In contrast to the common practice in long-term typhoon prediction (forecast of the total number of TC formation in the entire WNP domain), we confirmed that the total number of TS formation in the entire WNP does not show significant ENSO influence (22.7 for strong warm and 20.2 for strong cold years). However, we identify two sub-regions where largest variability occurs in close association with strong ENSO events: the SE (5-17°N, 140-180°E) and NW (17-30°N, 120-140°E) quadrants. During the peak season, for instance, the linear correlation coefficient between NINO3.4 SSTA and the number of TS formation in the SE quadrant reaches 0.82, and that in the NW quadrant is -0.61. Our results suggest that one should not forecast the total number of TS formation in the entire WNP domain, rather, should predict those in the SE and NW quadrants.

c. **Locations of TS formation:** During strong El Nino (La Nina) years, the TS formation in the SE and NW quadrant exhibits a dipole anomaly pattern with enhanced (suppressed) formation in the SE (NW) quadrant. Fig. 1 shows that *in the SE quadrant, the 5 warmest years have 31 TS formations while the 6 coldest years have only 2.* In the NW quadrant, the situation reverses with 28 TS forming during the cold years while only 7 during warm years. In addition, about 75% of the TS formed north of 17°N during the cold years, while 74% formed south of the 17°N during the warm years. *The seasonal mean latitude of TS formation during the peak season is highly correlated with NINO3.4 SST anomaly (correlation coefficient r=-0.80).* The mean longitude of TS formation during the late season is also significantly correlated with the SSTA in NINO3.4 regions (r=0.68). Consistent with the dipole pattern, the July-September *mean location* of TS formation is 6° latitude lower, while that in October-December is 18° longitude eastward during strong El Nino compared with strong La Nina.

d. Mean life span and frequency of TS occurrence: We found that the mean TS *life span* is about 7 (4) days and the mean *total number of TS occurrence* is 159 (84) days in strong warm (cold) years. This conclusion allows us to estimate the total days (or frequency) of occurrence of TSs over the entire WNP domain.

e. The tracks: We also showed that the TS tracks differ substantially between the strong warm and cold years (Fig. 2). The maximum differential frequency of occurrence is used to infer the difference in their prevailing tracks. During El Nino fall, the number of TSs that formed south of 15°N and recurved northward across 35°N is 2.5 times that during cold years. This fact implies that the *meridional exchange of heat and energy is greatly enhanced during the strong El Nino years.* This is a critical process by which El Nino conveys its impacts to high latitudes and enhances interaction between the tropics and extratropics in the East Asia-WNP.

3. Physical Interpretation

Our explanation focused on two issues that were hardly ever discussed in the literature.

The first issue is concerned with the cause of SE-NW dipole pattern in the peak season TS formation. We propose that the low-level shear vorticity associated with equatorial westerlies is a fundamental cause for the enhanced generation in the SE quadrant, while the upper-level divergence induced by the deepening of East Asian trough and strengthening of the WNP subtropical high suppresses TS generation over the NW quadrant of the WNP. This assertion is supported by evidence shown in Fig. 3.

We argue that during the warm years, the equatorial central and eastern Pacific warming increases equatorial convective heating near the dateline and pronounced equatorial westerly anomalies in the western Pacific. Large meridional shears associated with the equatorial westerly anomalies increase low-level vorticity in the SE quadrant. Since the boundary layer Ekman convergence is proportional to the 850-hPa relative vorticity, the background vertical motion is well correlated with the 850 hPa vorticity (r= -0.80) (Fig. 3a). The increase of the background low-level vorticity would help spin-up tropical depressions by increasing moisture convergence and by entraining potential vorticity into TCs. As a result, the SE quadrant is favorable for TC intensification. *The high correlation coefficient (r=0.72 for 1965-1999) between the background 850 hPa vorticity and the frequency of TS formation in the SE quadrant (Fig. 3a) supports this argument.*

The El Nino induced central Pacific heating also generates a pair of huge anomalous anticyclones in the upper-level that resides on each side of the equator due to equatorial wave adjustment in the tropical atmosphere. Over East Asia, the upper-level troughs in the 500hPa and 200hPa are deeper than normal during El Nino fall. The deepening appears to result from land surface cooling during the El Nino summer over northeast Asia. Thus, the anomalous northwesterlies behind the East Asian trough and the anomalous southeasterlies wind on the southeast side of the subtropical anticyclone generate strong upper-level convergence in the NW quadrant. This El Nino-induced upper-level convergence is a major driving force for the observed descending motion, which suppresses tropical cyclone intensification in the NW quadrant. *The 200hPa divergence appears to be a reasonable indicator for the number of TS formations in the peak season (r=0.61) (Fig. 3b).* The deepening of the East Asian trough in the mid-troposphere also provides a favorable anomalous steering flow for the TS recurvature around 135E.

The second issue concerns the cause of the variability of the January-July TS formation. It is found that the early season TS activity is suppressed after the El Nino developing year. This delayed El Nino impacts to early season TS activity is due to the persistence of the Philippine Sea anticyclone. Wang et al. (2000) pointed out that the Philippine Sea anomalous anticyclone is set up during the fall of El Nino developing year but maintained through the subsequent spring and summer *by the local positive feedback between the Philippine Sea anticyclonic anomaly and the mixed layer ocean thermodynamics.* Thus, during the spring and summer after the peak warming, the anomalous Philippine Sea anticyclone provides large-scale subsidence. The 500-hPa vertical velocity anomalies over the Philippine Sea (10-20N, 130-150E) averaged for the period from January to July is indeed highly correlated with the NINO3.4 SST anomaly in the previous October-December (correlation coefficient –0.82 for 35 years). Therefore, the TS formation in the same period must be suppressed due to the large-scale background subsidence.

4. Discussion

Because the peak warm and cold phases tend to occur toward the end of the calendar year, during the year in which an El Nino or La Nina develops, the NINO 3.4 SSTA in the peak and late TS season can be predicted by simple linear extrapolation using preceding winter and spring SSTA. This forms a physical basis for seasonal prediction of WNP TS activity one or two seasons in advance. After the mature phase of El Nino (La Nina), the Philippine Sea is dominated by anticyclonic (cyclonic) circulation anomalies, thus the TS activity is suppressed (enhanced). This makes it possible to forecast the early-season TS activity using the NINO 3.4 SSTA in the preceding late-fall.

In the present study, we used TS formation to measure the TC intensification from tropical depression to tropical storm, because the number of typhoon formation is significantly less, while the determination of the tropical depression formation is less accurate due to the limitations of observations. However, we expect that physical processes that govern the TS formation should be applicable to interpretation of the variability in typhoon or tropical depression formation. But additional analyses are needed to verify this assertion. We are looking for the common features in the ENSO-TS relationship in the WNP. Decadal trends or variations in TS formation are not a primary concern. Since the strong El Nino years (65, 72, 82, 87, 92, and 97) and La Nina years (70, 73, 75, 88, 98, 99) occur both before and after 1979, our analysis would not be significantly affected by decadal trend. However, the decadal changes in TS activity over the WNP deserve further investigation.

Acknowledgements: This study is supported by the Marine Meteorology Program of the Office of Naval Research. Much of the work of BW was accomplished during his visit to City University of Hong Kong, which was supported by the Research Enhancement Scheme and Grant 7010010, both of the City University of Hong Kong.

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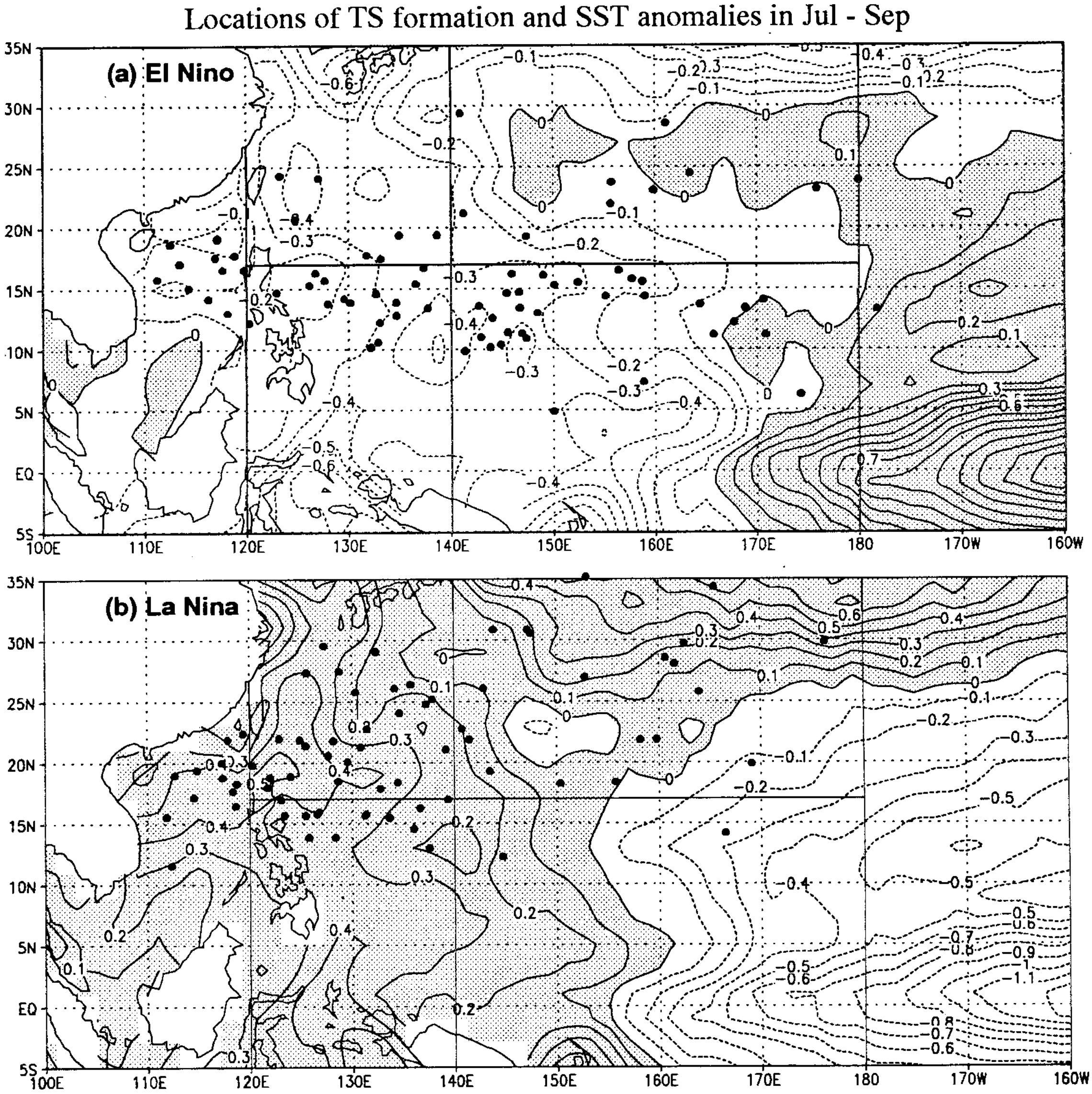

Fig. 1 Locations of initial tropical storm formation and SST anomalies (contours with units of °C) in peak season (July-September) during (a) the six strongest El Nino years (65, 72, 82, 87, 91, 97) and (b) the six strongest La Nina years (70,73,75,88,98,99). The straight solid lines indicate boundaries of sub-regions of the western North Pacific.

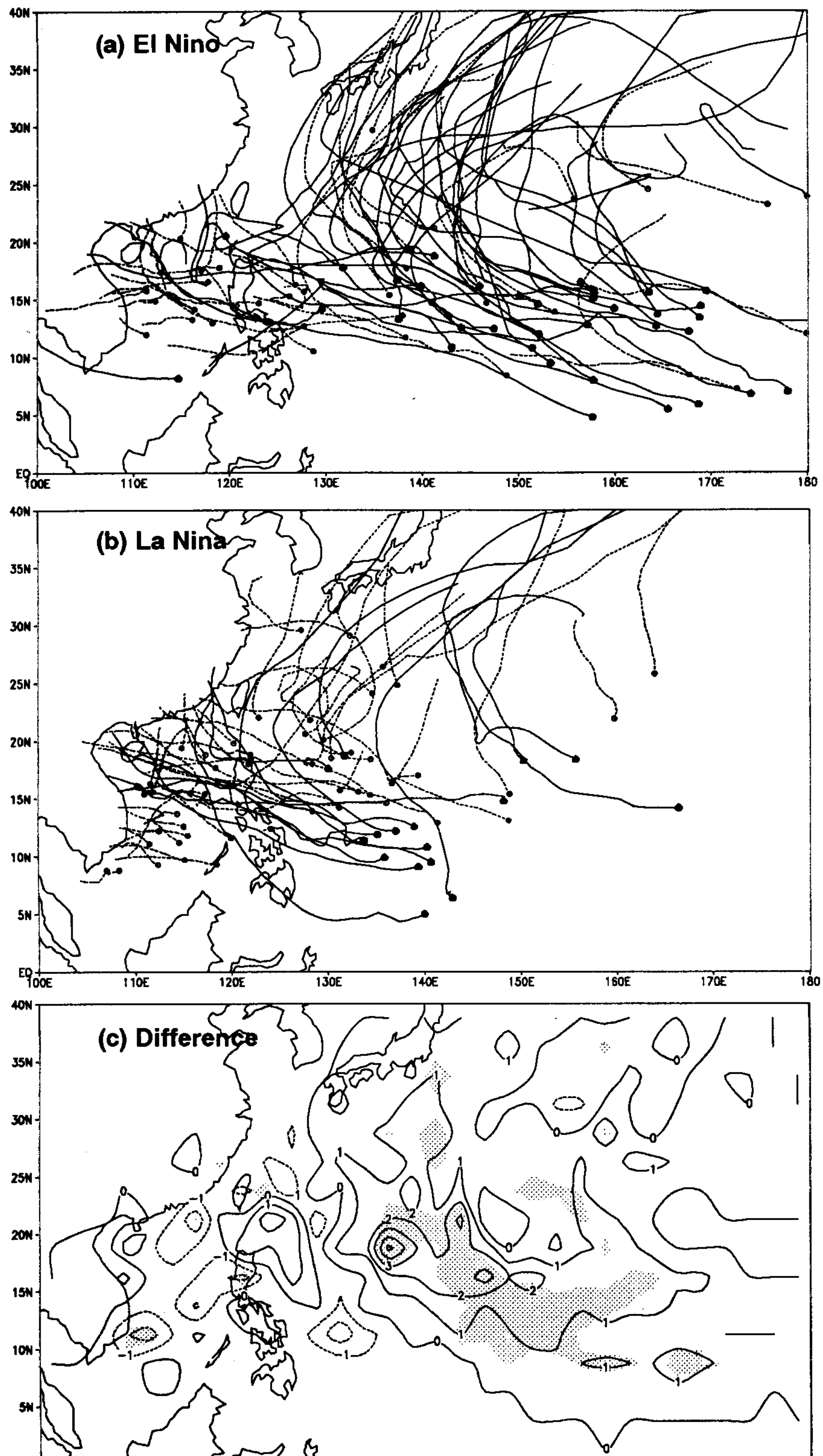

Fig. 2 (a) Sept-November TS tracks during the six strongest warm years. (b) The same as in (a) but for six strongest cold years, (c) The difference in the total number of TS occurrence between (a) and (b).

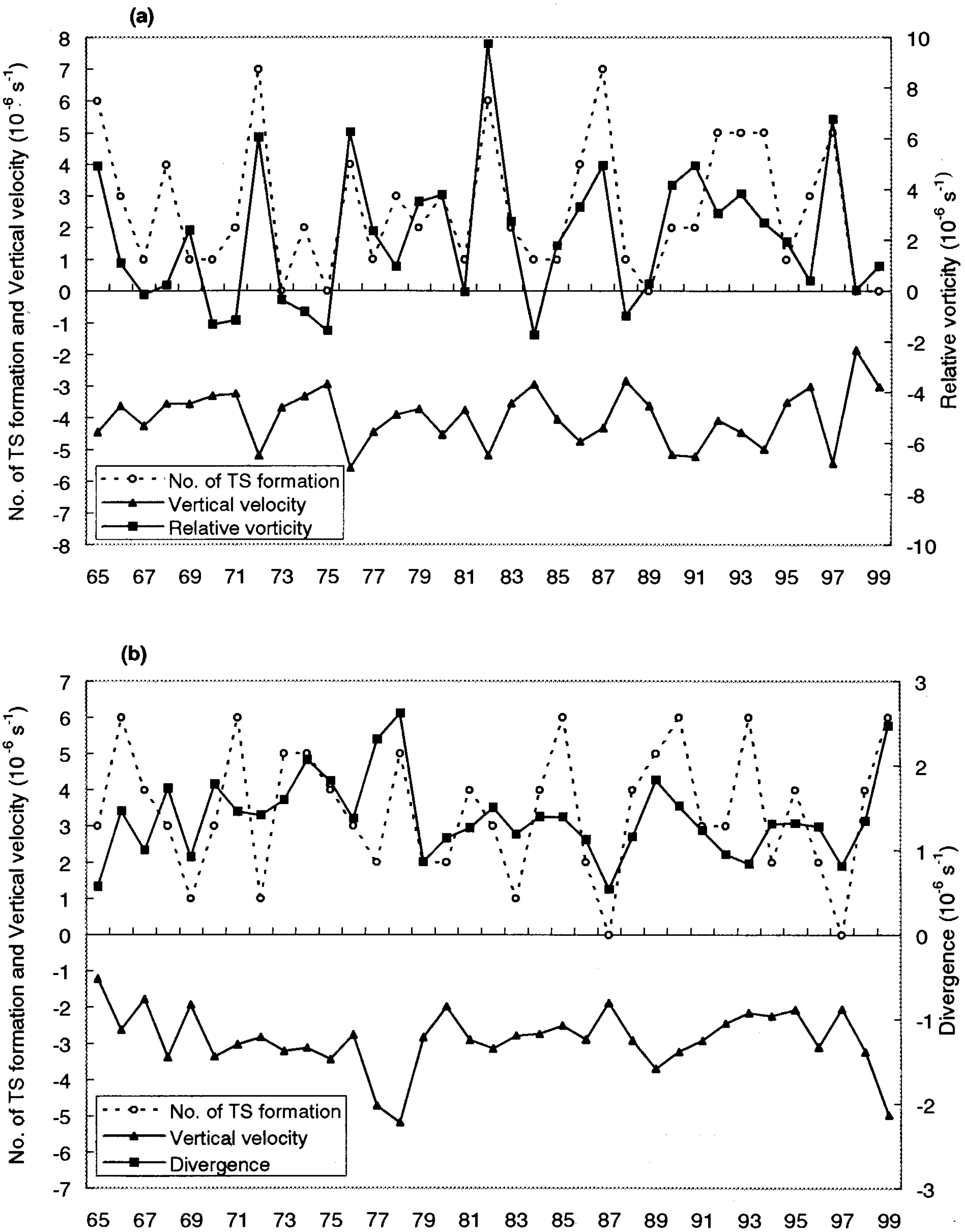

Fig. 3 (a) Jul-Sept mean 850 hPa relative vorticity, 500 hPa vertical p-velocity, and total number TS formation in the southeast quadrant of the WNP (140-180E, 5-17N). (b) Jul-Sept mean 200 hPa divergence, 500 hPa vertical p-velocity, and number TS formation in the northwest quadrant WNP (17-30N, 120-140E).

The Ei Nino and the La Nina Events, and influence to climatic anomalies of the South China Sea and the Southern China

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Abstract

By using reanalysis data (1961-1998) of the National Climate and Environmental Prediction Center (NCEP) of the occurrence and development of the El-Nino and the La Nina events studies in this. The relationship between both events and climatic anomalies of the South China Sea and the Southern China are also analyzed.
The study results presented the typical occurrence and development of both events, and found that the SST (Sea Surface Temperature) anomaly variation between the equatorial eastern Pacific Ocean and the South China Sea is well correlated. During the El Nino (La Nina) event, when the SST anomaly of the equatorial eastern Pacific Ocean gets higher (lower), the SST anomaly of the South China Sea gets higher(lower) as well. This causes further analysis between the two events and the climate anomalies of the South China Sea and the Southern China. Analyzed results show that during the El Nino events, the subtropical high of the western north Pacific is stronger together with the southwesterly winds anomaly appears in the low level. Therefore, more precipitation occurs over the Southern China. During the La Nina events, the subtropical high of the western north Pacific is weaker together with the northeasterly winds anomaly appears in the low level. Therefore, less precipitation occurs over the Southern China.

Key Words: El Nino, La Nina, South China Sea, Southern China, Climate anomalies

The Inter-decadal Variations of Summer Precipitations over North China and its relation with Asia Monsoon and ENSO Cycle

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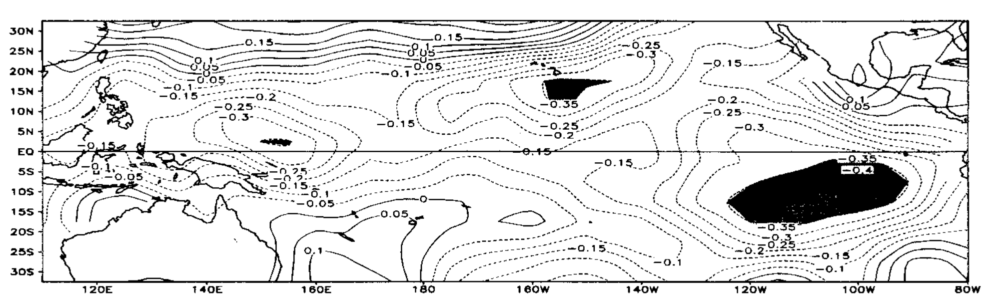
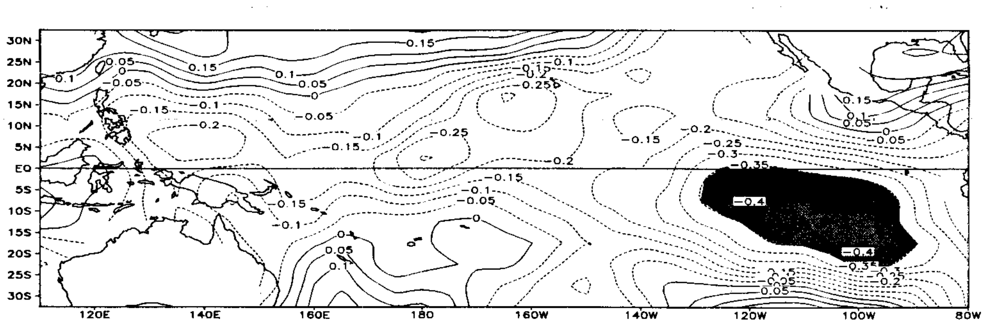
The inter-decadal variations of summer (June-August) precipitations over North China are analyzed by using the observed data from 1900 to 1999. The analyzed results show that the features of inter-decadal variations of summer rainfall in North China are significant. There are two less rainfall periods, from 1900 to end of 1940s and from end of 1970s to nowadays. The period from 1948 to end of 1970s is relatively plentiful rainfall.

The features of inter-decadal variations of summer precipitations in North China are consistent with east Asia summer monsoon variability. The east-Asia summer monsoons are stronger (weak), the precipitations in North China are richer (less).

The summer precipitations in North China are significantly related to ENSO cycles. The correlation coefficients between the summer precipitation and SSTA over tropical Pacific are shown in Fig.1. The statistical significant areas are located in El Nino domain.



a



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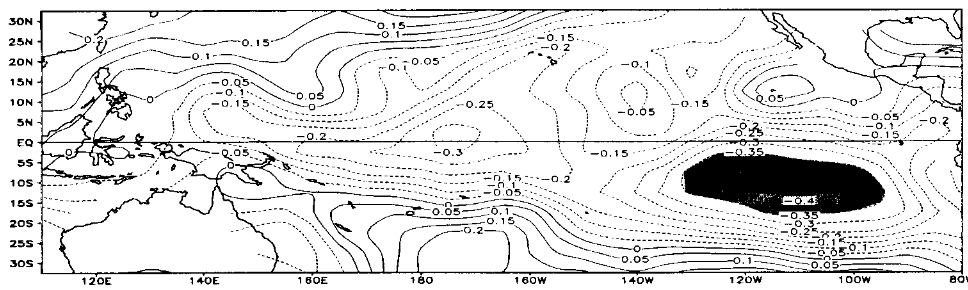
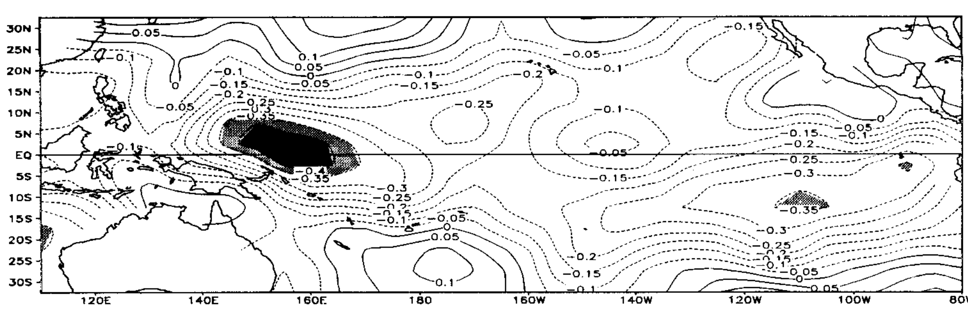


c



d

Fig.1. The correlation coefficients between the summer precipitations in North China and SSTA in different seasons over tropical Pacific. The shadow areas are statistical significant at 99% level.
a. with former Winter, b. with former Spring,
c. simultaneously Summer, d. with later Autumn

The summer precipitations in North China are also related to the summer general circulation systems. When there are negative (positive) anomalies over Asia, the summer precipitations in North China are richer (less). The subtropical High in west Pacific plays important role in the summer precipitation over North China. The High locate in North from 1950s to 1970s, the summer precipitations are richer, in South from 1980s to 1990s, the precipitation are less.

Modification of the National Climate Center Regional Climate Model for Studying the Seasonal Variations of Climate over South China

Shi Xueli (National Climate Center, Beijing)
Chan Johnny C.L. (City University of Hongkong, HK)

Abstract

In order to improve the efficiency and widen the application of the National Climate Center regional climate model (NCC/RegCM), the model is converted from the serial version to the parallel version, and the running environment changed from workstation to PC clusters. In addition, the model is modified to include part of the Southern Hemisphere to study the seasonal variations of the climate over South China. In this talk, some preliminary results will be presented on some comparisons between results from different versions of the model for the South China area.

Based on the second generation regional climate model of NCAR (RegCM2), the NCC/RegCM has been developed by modifying and adding some physical parameterization schemes (including the planetary boundary layer process, cumulus convective and radiation, and so on). It has been used in simulating the abnormal climate events in different regions of China (such as the Yangtze River Valley, the Huai He River Valley). Results have shown that the NCC/RegCM can successfully reproduce most of the abnormal summer precipitation events. The current study represents an extension of these studies for the south China area. Results show that the predictions are in general satisfactory and will be presented at the conference.

Response of Equatorial Pacific to Wind Stress Anomalies

in the Interannual Tropical Air-sea Interaction

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Abstract

The propagation of interannual subsurface Sea Temperature Anomalies (STA) in equatorial and off-equatorial Pacific are disclosed by means of Multiple Singular Spectrum Analysis, and then more study are focused on the possible mechanism responsible for the movement of subsurface STA. It is evident clearly that the interannual STA travels round and round in the low latitude of Northern Pacific basin in a anti-clockwise way, with the reverse anomalies crossing the pacific along equator and 10°N respectively. The subsurface ocean current anomalies driven by the zonal divergent / convergent wind stress anomalies along the equator are in favor of the enhanced / depressed upwelling of sea water in the subsurface layer of equatorial Pacific. Consequently, the sea temperature will rise or decrease, particularly remarkable around the climatological depth of thermocline. Accompanying with the eastward movement of zonal divergent / convergent of surface wind stress anomalies along equator, the dynamic and thermal response of subsurface ocean are observed from western to eastern Pacific, accomplishing the phase transition of ENSO.

Studies on Regional Water Cycle and Hydrologic Modeling in North China

Shourong Wang (NCC*, China) Ronghui Huang (IAP**, China) Yihui Ding (NCC, China)
L. R. Leung, M. S. Wigmosta and L. W. Vail
(PNNL***, USA)
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Abstract

Due to natural variability and anthropogenic affections, climate in North China has been obviously changing for last 50 years. The mean annual temperature of the 1990's is 1.2℃ higher than that of the 1950's, while precipitation decreases 40 mm in the same period. Climate change has significant impacts on water cycle and water resources in that region. Precipitation reduction attributes mainly to the diminishing input water vapor over this region. It is reported that natural runoff in Hai and Luan river basins has rapidly decreased with a rate of 23 percent/10 years for last 40 years. Unbalanced water resources has become the critical factor restricting social and economic development in North China.

In order to assess the impacts of climate change on water resources in North China, a distributed hydrology model DHSVM is developed to nest with regional climate models, and the Luan River and Sanggan River basins are chosen for both atmospheric and hydrologic modeling and analyzing. The watershed model, DHSVM, provides an integrated representation of watershed process at the topographic scale described by digital elevation model (DEM) data. It includes a two-layer canopy model for evapotranspiration, an energy-balance model for snow accumulation and melt, a two-layer rooting zone model, and a saturated subsurface flow model. To apply DHSVM in China for the first time, some improvements, such as change of hydrology model structure, renovation of evapotranspiration model, development of new hydrology, vegetation and soil parameterization schemes, and the connection of DHSVM with regional climate models (PNNL RCM and NCAR RegCM2), have been implemented.

First, DHSVM is driven by observed datasets. The modeling efficiency values for Luan River and Sanggan River basins are 0.90 and 0.82, respectively. Then, DHSVM is nested with PNNL RCM and the modeling efficiency values of Luan River Basin and Sanggan River Basin in 1996 and 1997 are 0.62 and 0.69, respectively. And then, DHSVM is nested with NCAR RegCM2. According to the simulated results, under double CO2 scenarios, temperature in the two river basins will rise about 2.8℃ and mean annual runoff values of Luan and Sanggan river basins will be 74mm and 71mm, respectively, which are approximately a quarter of mean annual runoff value (284mm) of whole China. The simulated results indicate the worm and dry trend will continue for the two river basins under double CO_2 scenarios.

On the simulation of "Super Cluster" by using a non-hydrostatic model

Akimasa Sumi (CCSR,Univ. of Tokyo)

The behavior of a super cluster in the tropical western Pacific region has strong relationship with an evolution of ENSO ebent. Its dynamics has been intensively investigated by using a hydostatic model, but its results are strongly dependent on the parametarization scheme of convection. Then, the dynamics of the super cluster has been investigated by using a non-hydrostatic mode.

First, the super cluster was simulated on the "Aqua-planet" by using T106 AGCM. Then, the non-hydrostativ model was started by using this simulated field. We used a RAMS as a tropical model. Due to the limitation of computing power,we have to use a 50 km grid distance. Boundaries are 40N and 40S and T106 simulated values are used to be boundary values.

In a few days, there are good similarity between T106 simulation and RAMS results. However,it is found that it is very difficult to suppress convection in front of the super cluster. Details will be presented in the conference.

The Influence of Western Tropical Pacific on the Development of ENSO Event as well as El Nino/La Nina Cycle

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National Meteorological Center, Beijing, PRC
Chao Jiping
National Marine Environment Forecast Center, Beijing, PRC
Yuan Shaoyu
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Abstract:

Analysis on the data of 46 years' sea temperature anomaly in western tropical Pacific subsurface layer from 1955 to 2000 shows that 11 El Nino events took place during this period. The initial sea temperature positive anomaly of these events except 1994 event were originally at the depth of about 120 meters in "warm pool" subsurface. With the increasing intensity to some certain degree and after the appearance of abnormal continuous west wind anomaly on western tropical Pacific, the warm sea temperature anomaly spreads eastwards to sea surface along thermocline and reaches Nino 3 or 1, 2 area of the equatorial eastern Pacific sea surface after about one year or so, which is considered to be El Nino event (see Figure 1). The analysis on the data of 40 years' wind field further indicates that, before the burst of west wind anomaly on western tropical Pacific, the anomaly west wind has already existed for about 2 years on equatorial eastern Indian Ocean (southwest monsoon), which spreads eastwards rapidly and becomes anomaly west wind on western tropical Pacific or genuine strong west wind which is one of the essential conditions for the occurrence of El Nino. All the El Nino events within these 40 years shared this process without any exception (see figure 2). The same method can be applied to the analysis of La Nina events within these 46 years. The cold sea temperature anomaly first occurs in the subsurface layer of "warm pool" and spreads eastwards to the surface along thermocline. Before the east wind blows on western tropical Pacific, the continuous east wind has already existed on Indian Ocean.

Based on the above result, we put forward an idea that the following issue needs further study: why the initial sea temperature anomaly of all El Nino/La Nina events originate in subsurface of warm pool and what the physical process and conditions are. So, we analyzed the development of sea temperature anomaly along the thermoclinic curved surface between 1994 and 1998, and found that the positive sea temperature anomaly originated from the depth of 120 meters in "warm pool" subsurface of 1997/1998 El Nino event came from the largest positive sea temperature signal stayed at Nino 3 area of 1994/1995 El Nino event. When the positive anomaly spreads

eastwards from "warm pool", in the meanwhile, a largest negative sea temperature anomaly appears at Nino 3 area and spreads westward. After the analyses of 8 El Nino events and 7 La Nina events since 1970, we found that all positive and negative anomaly spread as a circle to the north of the equator. But the positive and negative anomaly was at different latitude and spread along the opposite direction, which caused the El Nino/La Nina events alternately. The cycle period is usually about 3 to 4 years.

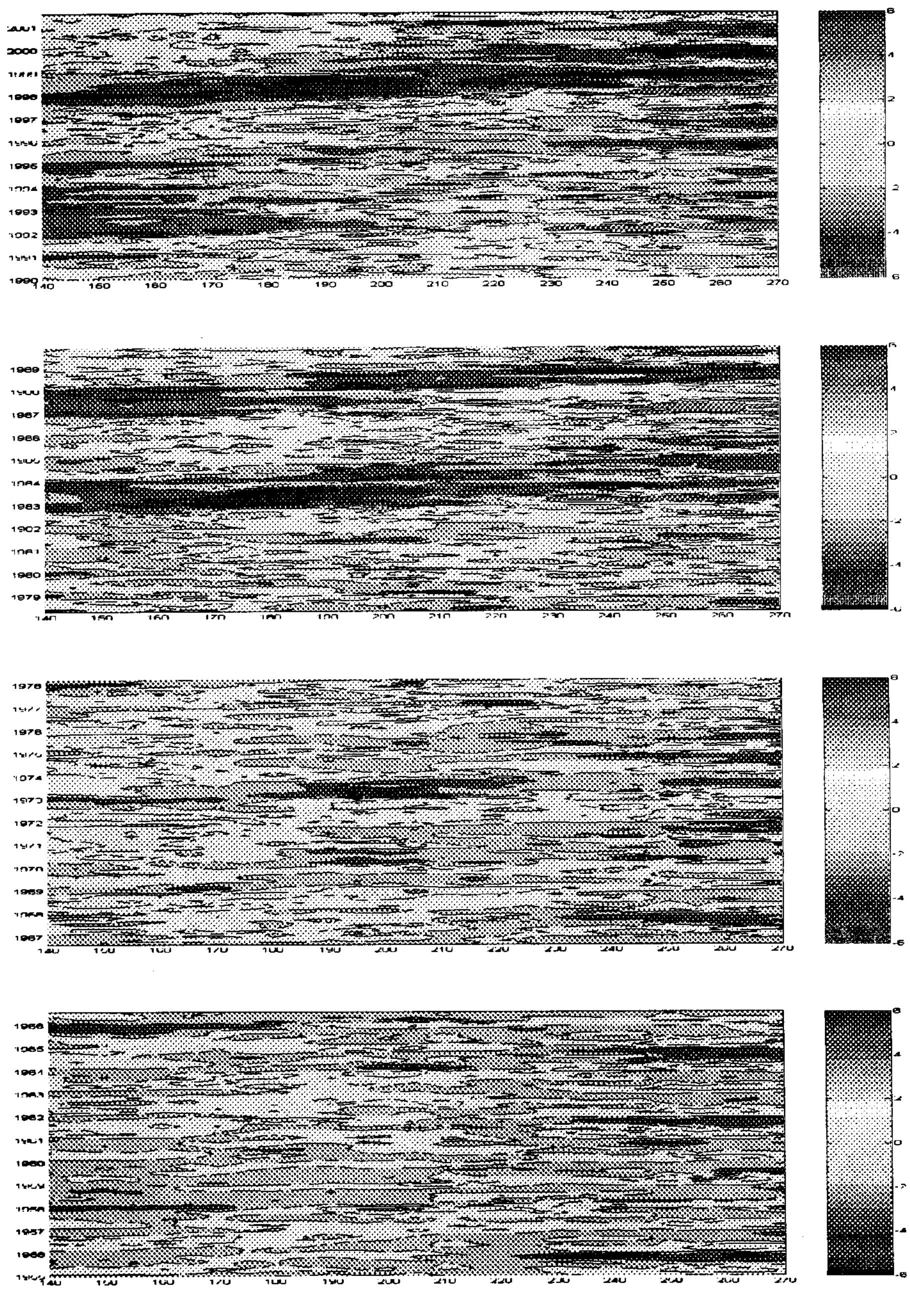

Figure 1 The development of sea temperature anomaly along equator between 1955 and 2000.

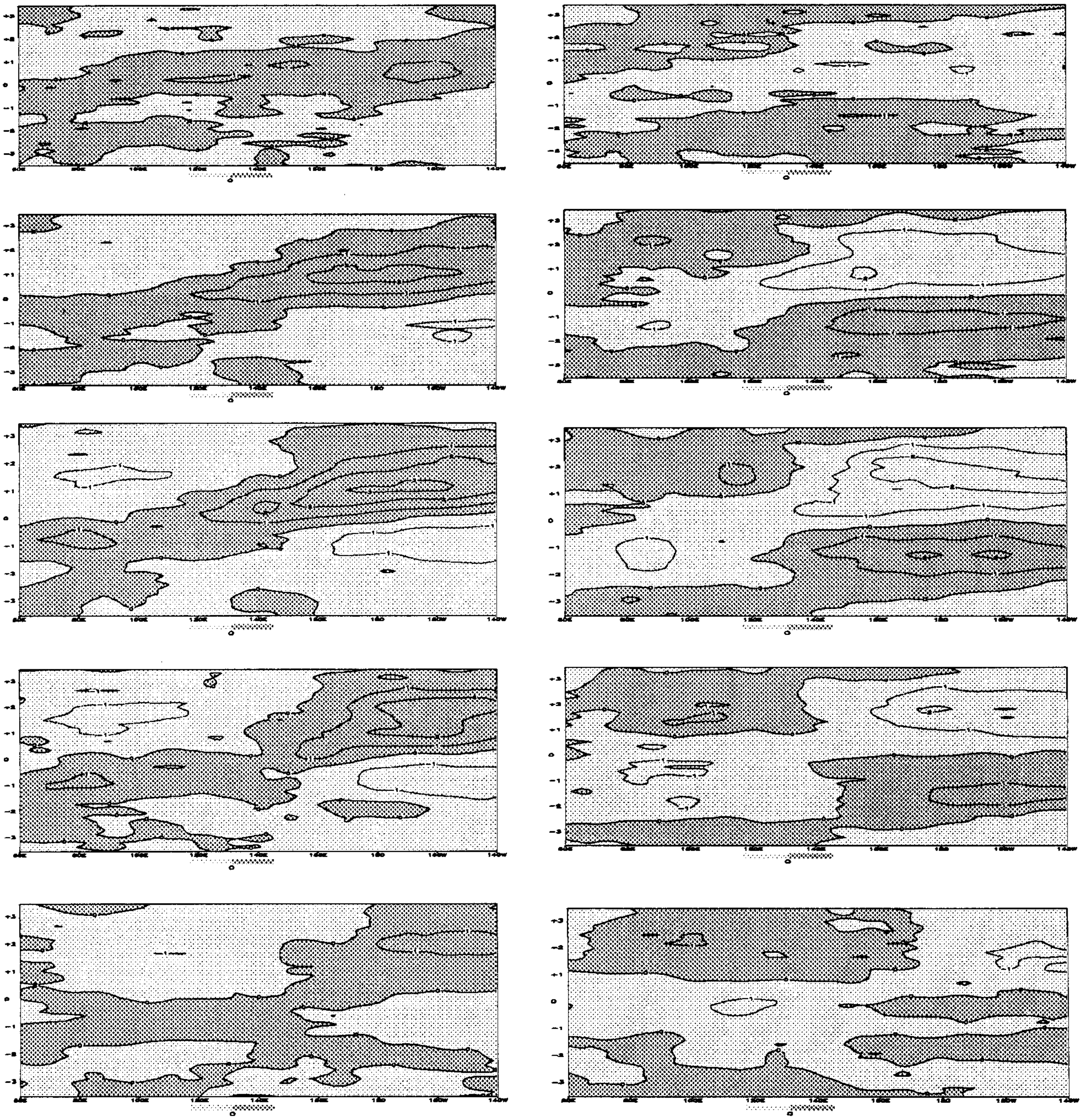

Figure 2 The wind field combining ones of 11 El Nino events (left) and 10 La Nina events (right)
a: along 10N, b: along 5N, c: along equator, d: along 5S, e: along 10S

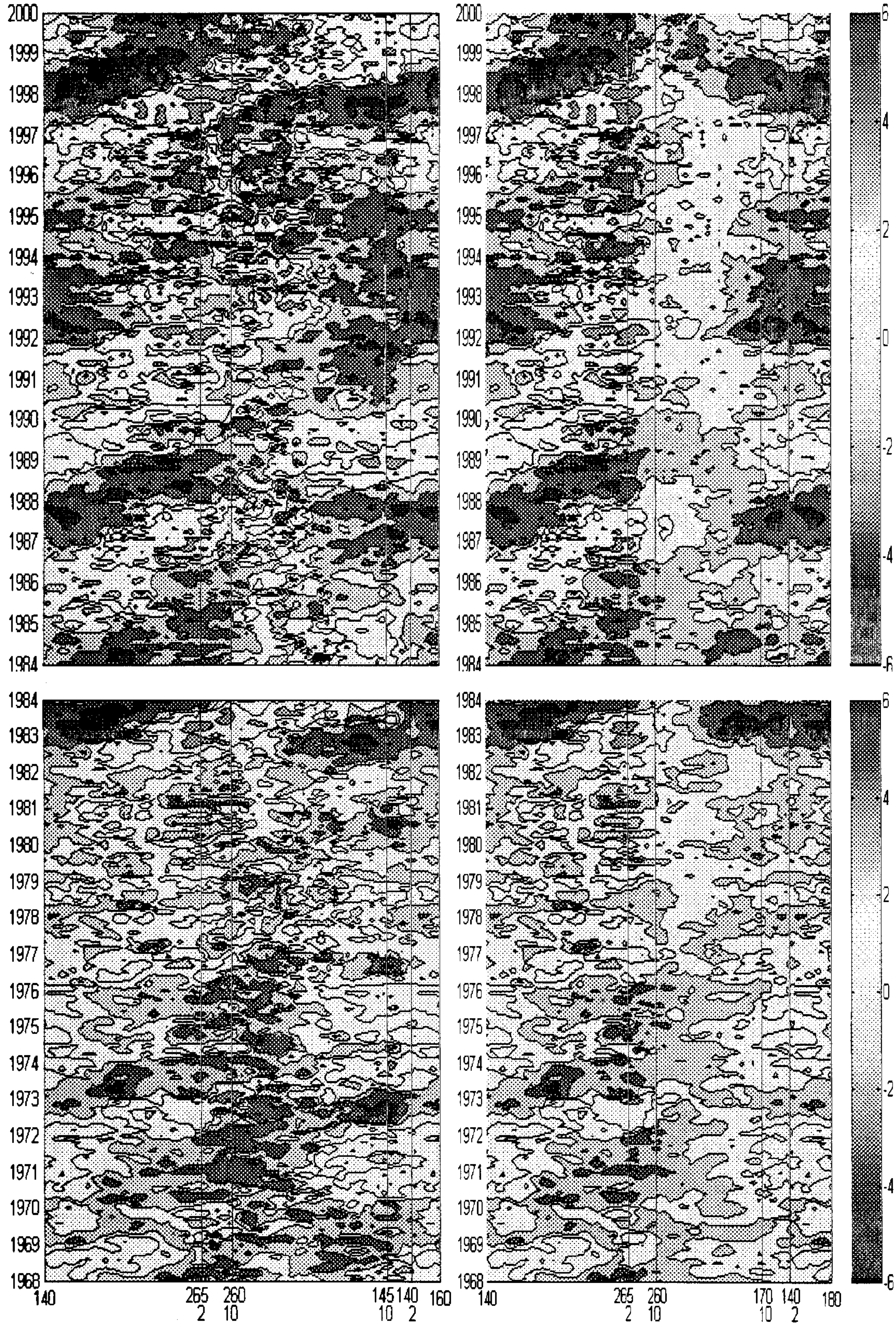

Figure 3 The chart of El Nino/La Nina development between 1968-2000

1997-2000 ENSO IMPACTS ON WEATHER IN MALAYSIA

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The Asian monsoons dictate the seasonal rhythm in Malaysia. The northeast monsoon (mid-November to February) is the major rainy season in the country while the southwest monsoon (mid-May to September) is comparatively much drier throughout the country except for Sabah in East Malaysia. During the two intermonsoon periods (March to early May and October to early November), light and variable winds give rise to frequent afternoon thunderstorms, particularly in the west coast states of Peninsular Malaysia. The seasonal distribution of the rainfall, especially in East Malaysia, is noted to be significantly modulated by the ENSO phenomenon due to its close proximity to the major centres in this sea-level pressure seasaw. This study elucidates the various distinct low-level wind flow patterns and anomalies as well as the associated moisture convergence/divergence that led to significant impacts on the weather in Malaysia during the 1997-2000 ENSO events.

Since 1980, there are more occurrences of ENSO events with varying strength and impacts in spatial as well as temporal extents, inclusive those of the 1982/83 and 1997/98 strong events. It is therefore logical to have recourse to this base period for better insight. In addition, discussion is centered during the full scale southwest monsoon in June-July-August and the early northeast monsoon in November-December.

1.0 850 hPa mean u-component winds along 5^0 N

Figure 1 which shows the variations of mean u-component winds at 850 hPa along 5^0 N between longitudes 70^0 E and 170^0 E was prepared to demonstrate the lower branch of the Walker circulation in response to ENSO.

In the presence of El Nino episodes (1982, 1986, 1990-1994, 1997) and during June-July-August (Figure 1, top), westerly wind flow from the equatorial Indian Ocean extends into the western Pacific, corresponding to the weakening of the Walker circulation. It reaches as far eastwards as to the dateline when the events are particularly strong in 1982 and 1997. In normal and La Nina years (1988, 1998-2000), the easterly trade winds of the Walker circulation strengthen westwards with its upward acending branch close to 120 ~130^0 E especially in 1988 and 1998.

During November-December, the upward branch of the local Hadley circulation is centered close to the equatorial maritime continent (100 ~110^0 E). The interaction between this and the Walker circulation gives rise to rather complex circulation patterns due to modulation by the differing strength of the ENSO forcing. Nevertheless, during the strong El Nino episodes (Figure 1, bottom), easterlies prevail throughout from the dateline to the Indian Ocean while westerlies are detected in the western Pacific during weak or extended El Nino periods. The typical Walker circulation pattern is only noticeable in the western Pacific during La Nina years.

2.0 Onsets of the southwest and northeast monsoons

The delayed and early onsets of the monsoons may be related to its fluctuating strength. In Malaysia, zonal wind at 850 hPa is the sole criterion used as the southwest monsoon is relatively dry while the two intermonsoons and the early northeast monsoon are comparatively wet. The mean onset dates of the southwest and northeast mnsoons are 18

May and 12 November respectively. During the 1997 El Nino, the southwest monsoon set in on 16 May. It is interesting to note that the monsoon set in on 23 May in the 1st year of the extended La Nina period (1998-2000) but was much earlier subsequently, i.e between 1 and 5 May. On approaching the northeast monsoon, the onset was also delayed till 3 December in the 1st year of the extended La Nina and was earlier, i.e. between 4 ~ 12 November during El Nino and the rest of the extended La Nina.

3.0 Moisture convergence/divergence

During the 1997 El Nino and in the months of June-July-August, 850 hPa moisture divergence prevailed in Indonesia, accounting for its drought situation. On entering November-December, moisture convergence centered close to the east coast of Peninsular Malaysia while East Malaysia and most parts of Indonesia remained to be dry.

With the onset of La Nina in 1998, northern Sumatra and eastern Java was dry but the rest of the areas including Malaysia during the southwest monsoon was wet. During the early northeast monsoon , Peninsular Malaysia, East Malaysia, Kalimantan, southern Sumatra and Java were noted to be wet. In the subsequent extended La Nina period, the strength of moisture convergence/divergence was comparatively weaker. Northern Sumatra continued to be dry during the 1999 southwest monsoon. Divergence was only noted in Sarawak during the 1999 northeast monsoon but was widened to extend from northern Peninsular Malaysia to Sarawak during the early northeast monsoon in 2000.

4.0 850 hPa wind anomalies and rainfall anomalies

In the presence of 1997 El Nino, light southeasterly wind anomalies originating from Australia prevailed in Malaysia during the southwest monsoon. At that time, drought occurred in Sumatra and Kalimantan, leading to widescale forest fire. Light southeasterly wind anomalies had in fact advected smoke haze towards Malaysia and other neighbouring countries, reducing the amount of incoming solar radiation reaching the ground. Through feedback mechanism, convective cloud development was suppressed, thereby reducing rainfall as shown in Figure 2. On entering the early part of the northeast monsoon, light easterly wind anomalies caused deficient rainfall in East Malaysia while the converging light southeasterly wind anomalies accounted for the wetter weather particularly in the east coast states of Peninsular Malaysia.

With the demise of 1997 El Nino and the emergence of 1998 La Nina, light northeasterly wind anomalies from the western Pacific penetrated into Malaysia towards the Indian Ocean during the southwest monsoon, leading to enhanced rainfall, particularly over Sarawak and west coast of Peninsular Malaysia. Subsequently in this extended La Nina period, light westerly and northwesterly wind anomalies prevailed during both the southwest and early northeast monsoons with comparatively less enhanced rainfall, especially in East Malaysia.

Summary

Large and significant fluctuations in seasonal rainfall anomalies particularly during the southwest and northeast monsoons can be linked principally to the influence of ENSO. Since 1980, each ENSO event with its unique strength had varying impacts in terms of altered rainfall patterns in spatial and temporal extents but they had some common features of response. The strong 1997 El Nino depicted the weakening of the Walker circulation while the moderate 1998 La Nina heralded its return to its typical state. The resulting low level wind anomalies and associated moisture convergence/divergence indicate that its impact is significant during the southwest monsoon for Peninsular Malaysia and during both monsoons for East Malaysia.

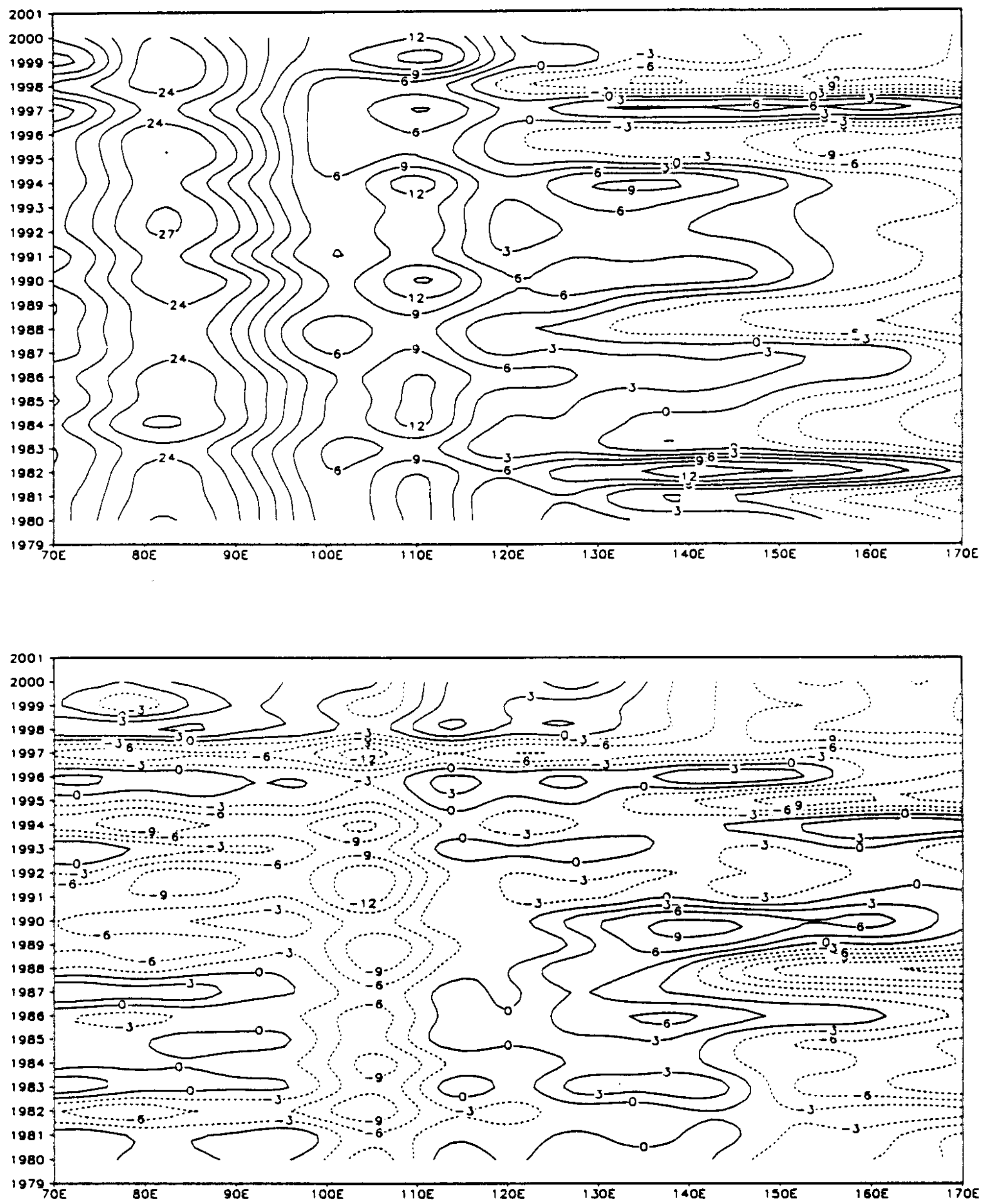

Figure 1: 850 hPa mean u-component winds (kts) along 5^0 N for June-July-August (top) and November-December (bottom). Contour intervals are 3 kts.

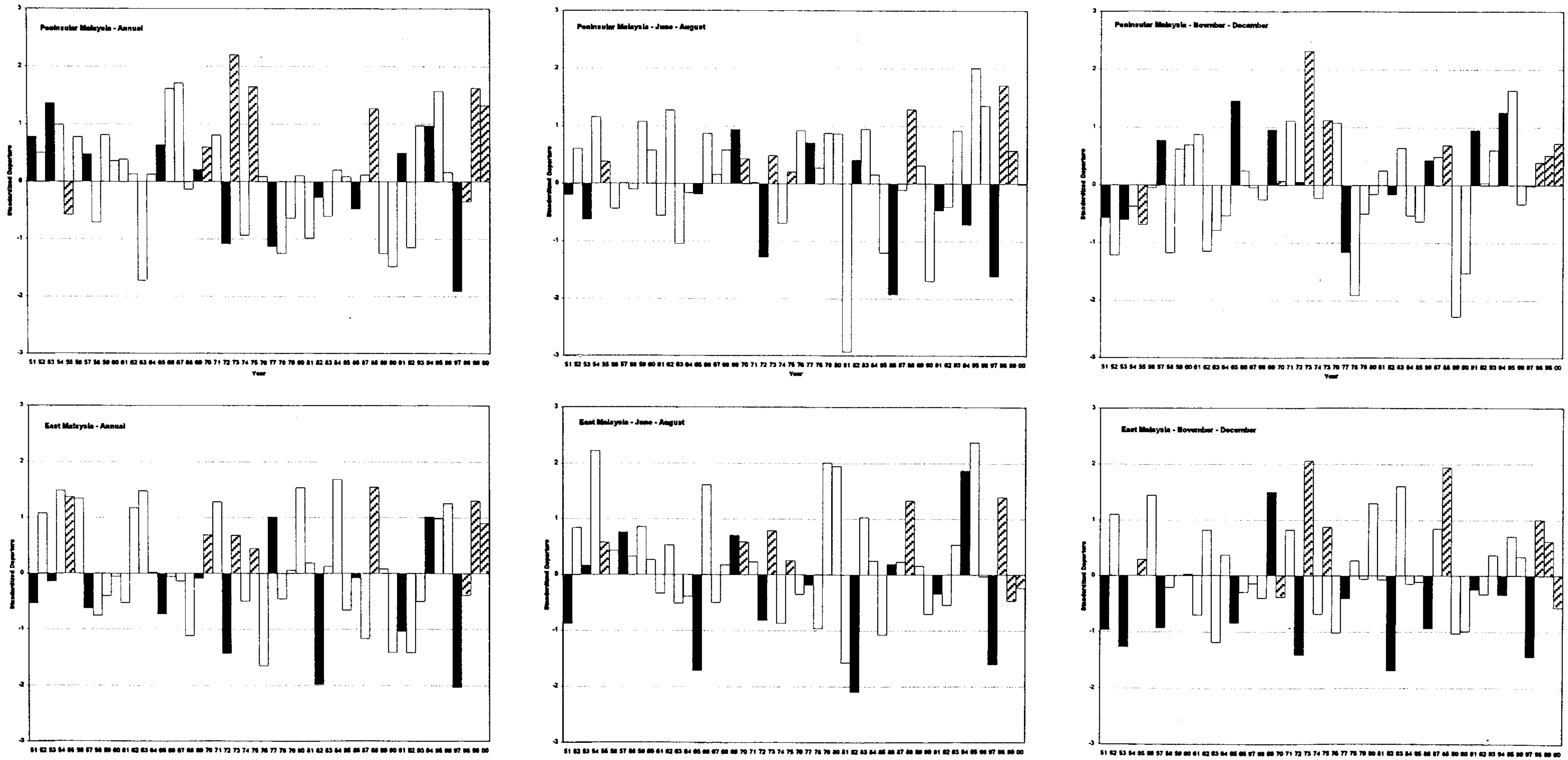

Figure 2: Annual and Seasonal Rainfall Index for Peninsular and East Malaysia

(Note: Standardized Departure = (Actual - Mean (1961-1990))/Standard Deviation (1961-1990)

Stations used: Peninsular Malaysia - Alor Setar, Bayan Lepas, Ipoh, Subang, Malacca, Kota Bharu, Kuala Terengganu, Kuantan & Mersing.

East Malaysia: - Kuching, Bintulu, Miri, Kota Kinabalu, Sandakan & Tawau.

Remarks: Black indicates El Nino Year while shaded represents La Nina Year.

Extended Abstract

Effect of ENSO on Number of Tropical Cyclones Affecting Hong Kong

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A number of studies has shown that over the western North Pacific, the interannual variation in tropical cyclone (TC) activity is related to the El Nino-Southern Oscillation (ENSO) phenomenon (e.g. Chan 1985; Lander 1994). This study investigates if and how this variability influences the number of TCs affecting Hong Kong.

The association is examined by correlating the annual number of TCs affecting Hong Kong (N) with the Sea Surface Temperature Anomalies (SSTAs) in the equatorial Eastern Pacific where ENSO events develop. Forty years of data (1961-2000) are used. TC data are obtained from the Hong Kong Observatory (HKO) and SSTAs from the United States National Center of Environmental Protection (NCEP). A description of NCEP data can be found in Kalnay (1996).

For El Nino or warm ENSO events, the average value of N is 5.1. For La Nina or cold ENSO events, the average value of N is 7.8. They are respectively lower or higher than that of the 40-yr normal of 6.4. Annual variations of N can range from 2 to 11 with the least (most) number 2 (11) attained in El Nino (La Nina) years respectively.

In this study, it is found that N is well correlated with the SSTAs in the equatorial Central and Eastern Pacific (Figure 1). The correlation coefficients between N and mean SSTA for each of the Nino regions shown in Figure 2 are given in Table 1. The values are all negative and statistically significant at 0.05 level. The negative correlation indicates that for an El Nino (La Nina) event, N is generally lower (higher) than that of normal years as the sea surface temperature in the equatorial Central and Eastern Pacific is higher (lower) than normal. This result corroborates those of the study by Liu (2000) for TCs making landfall in Guangdong.

A shift of the TC genesis locations and the anomalous steering flows during El Nino or La Nina events are two factors accounting for variations of N. A plot of the mean TC genesis location (Figure 3) shows that in general the

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genesis positions are shifted to the east in El Nino years as compared to La Nina years. The shift in the mean TC genesis location to the east can be viewed as a result of the longitudinal variation of the monsoon trough (Chen et al. 1998) during El Nino years. When TCs form further east, they are more likely to interact with mid-latitude systems and recurve to the north before entering the South China Sea (SCS) to affect the south China coast and Hong Kong. Vice-versa, when TCs form further to the west in La Nina conditions, chances of their entering the SCS to affect Hong Kong are relatively higher.

Composite maps in Figure 4 show the marked contrast in the mid-tropospheric wind anomalous patterns near the SCS between El Nino and La Nina years. This contrast is more distinct in the fall (September to November) than in summer (June to August). In the fall, anomalous anticyclonic (cyclonic) and cyclonic (anticyclonic) circulation patterns develop in the SCS and Eastern China respectively for El Nino (La Nina) events. These result in an opposite steering flow in the areas around the Luzon Strait and the northern part of SCS for the two events. The anomalous mid-tropospheric circulation pattern for El Nino (La Nina) years reduces (enhances) the steering of TCs towards the region near Hong Kong and thus lower (higher) the number of TCs affecting Hong Kong.

To conclude, the number of TCs affecting Hong Kong is well correlated with the sea surface temperature anomaly in the Nino 3 or Nino 3.4 regions. The change in the mean TC genesis locations and the steering flow patterns resulting from the onset of ENSO events are two main factors accounting for the variation of the number of TCs.

Reference

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Table 1. Correlation coefficients between the annual number of tropical cyclones affecting Hong Kong and the averaged annual sea surface temperature anomaly in various Nino regions.

	Nino 1+2	**Nino 3**	**Nino 3.4**	**Nino 4**
Correlation coefficient	-0.39	-0.47	-0.47	-0.43

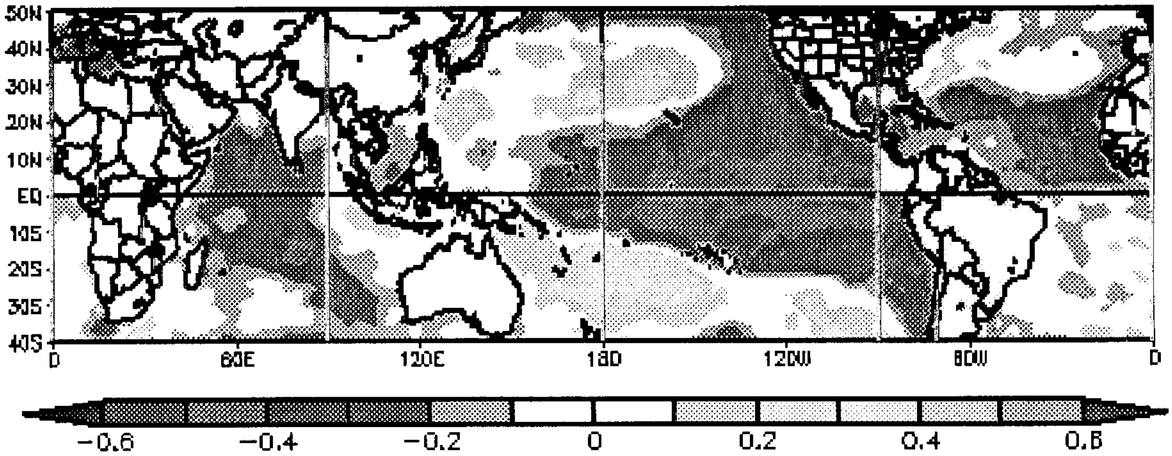

Figure 1. Correlation between the annual number of tropical cyclones affecting Hong Kong and the averaged annual sea surface temperature anomaly in various ocean basins. (Data period: 1961-2000, the colour scale represents values of correlation coefficients. Image is provided by the NOAA-CIRES Climate Diagnostic Center, Boulder Colorado from the web site at http://www.cdc.noaa.gov/.)

Figure 2. Location map of Nino 1+2, Nino 3, Nino 3.4 and Nino 4.

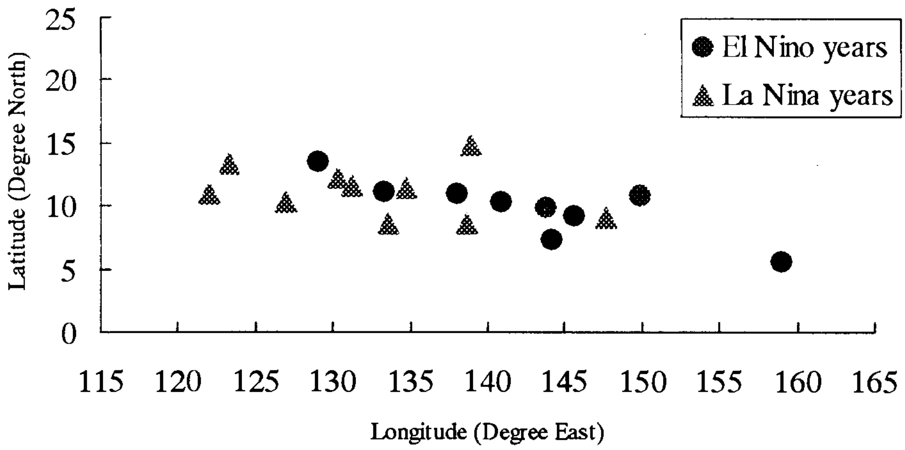

Figure 3. Mean TC genesis location map for El Nino and La Nina years

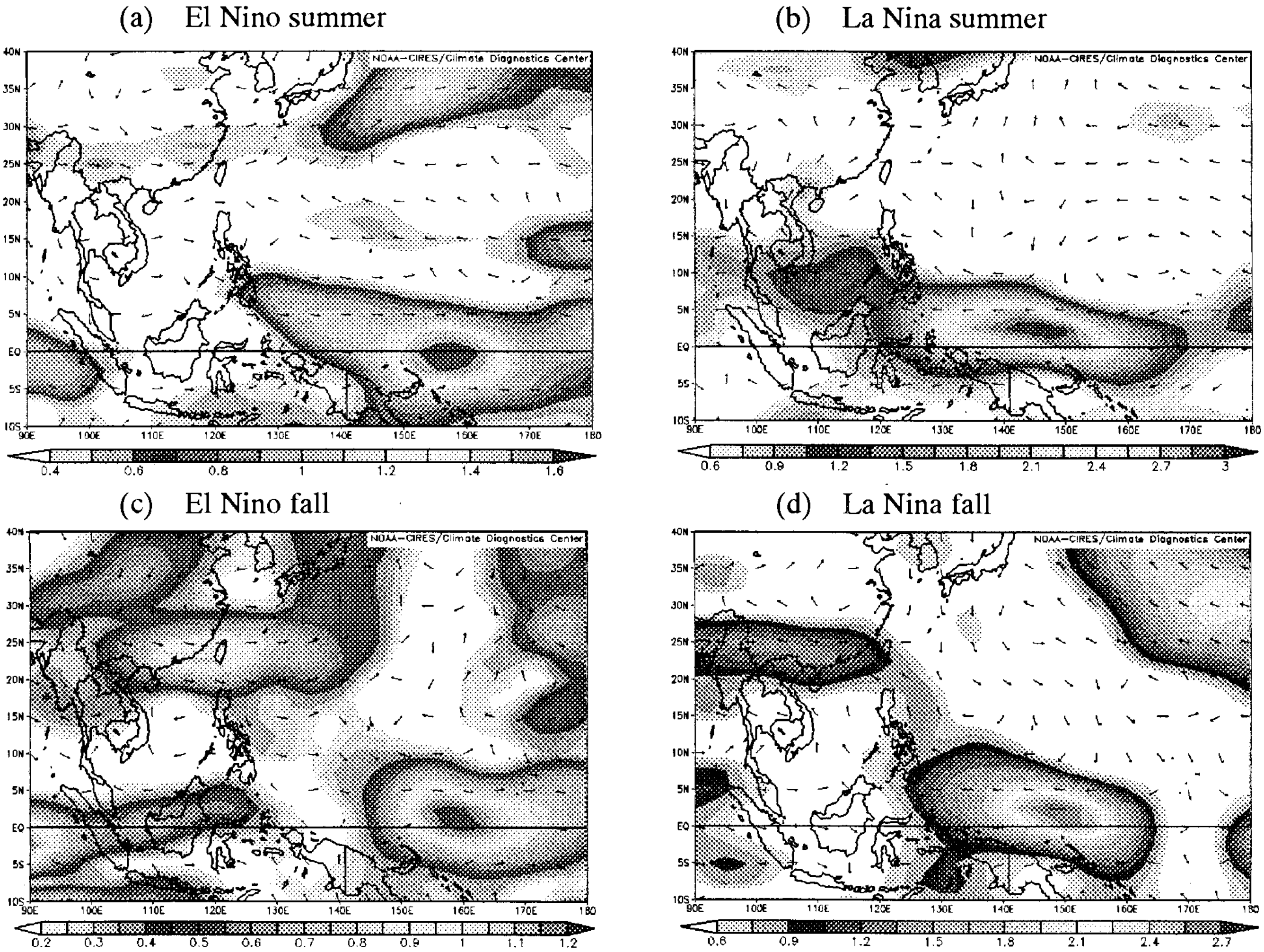

Figure 4. 500 hPa vector wind anomaly composite maps in summer for (a) El Nino years (b) La Nina years and in fall for (c) El Nino years (d) La Nina years. (The arrow indicates the direction of wind anomaly and the colour scale represents the magnitude of wind anomaly in m/s. Image is provided by NOAA-CIRES

Climate Diagnostic Center, Boulder Colorado from the web site at http://www.cdc.noaa.gov/.)

Impacts of ENSO event on the anomalies of South China Sea summer monsoon and climate in Guangdong province

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(1. Guangzhou Institute of Tropical and Oceanic Meteorology, Guangzhou 510080; 2. Guangzhou Central Observatory, Guangzhou 510080)

The ENSO event is the strongest signal with which air-sea interactions cause the anomalies of weather and climate. Being the strongest in the 20^{th} century, the El Nino phenomenon that occurred in 1997 ~ 1998 justifies the argument due to its serious influence on global climate.

With relevant data over the past 50 years or so, the current work studies the effect of ENSO on the date and intensity of onset of summer monsoon in the South China Sea, raining period in Guangdong, frequency of typhoon, date of first and last tropical cyclone in the year and variation of temperature.

1 Impacts on the anomalies of South China Sea summer monsoon

Using the indexes for onset date (I_D) and intensity (I_D) as defined and calculated by the authors and taking reference to relevant documentation, we have made a statistical study of the date and intensity of South China Sea summer monsoon onset in the current and following year of 14 incidents of El Nino over the past 50 years. The results show that for the current year of El Nino, the monsoon is mainly late (6/14) and normal (5/14) but scarcely early (3/14) concerning the onset date; it is mainly normal (7/14) and weak (4/14) but scarcely strong (3/14) concerning the intensity; for the following year of El Nino, the monsoon is dominantly normal (9/14) in terms of onset date and chiefly weak (11/14) in terms of intensity.

As shown in a correlation analysis, the onset date is positively correlated with SSTA in the eastern equatorial Pacific with the correlation coefficient passing the 0.01 significance test for January ~ May. Specifically, when the SST in the region is positively anomalous (with the appearance of the El Nino event), the monsoon has a late onset; the intensity index is significantly in negative correlation with the SSTA there — when the SST is high, the monsoon is weak.

2 Relationship between El Nino event and precipitation in Guangdong

As shown in the statistic study, precipitation is mostly normal or more than average in the raining season (April ~ September) in the Guangdong province in the current year of El Nino event, accounting for 6/14 respectively, while the years with precipitation less than average take up only 2/14. The trend is also evident in the early raining season (April ~ June) when normal and more-than-average rainfall occur at rates of 8/14 and 4/14 respectively and less-than-average rainfall take up only 2/14. Over the late raining season (July ~ September), however, precipitation is either normal (11/14) or more than average (3/14) without any case of less-than-average rainfall. It shows that precipitation is mainly in the normal range. In the year following the El Nino event, precipitation is mainly normal (8/14) with the same probability for rates more or less than average (3/14 in both), in the raining season.

There are two types of El Nino event by the date of onset, which have different effects on precipitation in the raining seasons of the current and subsequent years. The types are statistically studied. It is found that for the type of El Nino starting in spring, precipitation is chiefly normal or more than average over the early and late raining seasons in the current year; for the type starting in summer and autumn, precipitation is less regular than the spring type in the current year but is normal in the subsequent year without much difference in probability between dry and wet years.

3 Linkage between El Nino event and tropical cyclones making landfall in Guangdong

It is well known that the El Nino event is a strong signal indicating the activity of tropical cyclones. Variations in the equatorial eastern Pacific Ocean affects the intensity and location of the subtropical high so as to influence the activity of tropical cyclones in the west Pacific. A statistic study is conducted here of the El Nino event and tropical cyclones making landfall in Guangdong between 1951 and 1997. The results are presented below:

(1) The 3 years with more tropical cyclones (1952, 1974, and 1980) are non-El Nino years.

(2) Among the years with fewer tropical cyclones (1969, 1977, 1987, 1997), 1969, 1987 and 1997 are El Nino years.

(3) In the El Nino years, tropical cyclones making landfall in Guangdong are 0.5 less than historical mean.

(4) For the El Nino years, there can be more landfalls of tropical cyclones, such as 1953, 1958, 1965, 1983 and 1993.

It is obvious that more thorough and detailed study must be done before we can use as reference in routine forecast the relationship between the El Nino event and tropical cyclones making landfall in the Guangdong province.

(5) For the El Nino years, the first tropical cyclones making landfall in Guangdong appear on a late date by a probability of 62.5% and a normal/late date by 87.5% while they appear on a normal/early date in anti-El Nino years by a rate of 12/14. It is seen that the ENSO event is well related with the date on which the first tropical cyclones make landfall in Guangdong.

(6) For the anti-El Nino years, the last tropical cyclones making landfall in Guangdong appear on a late date by 11/12. There is no obvious association with the El Nino event and the last tropical cyclones making landfall in Guangdong.

4 Relationship between ENSO and air temperature in southern China

The composite method and spectral method are used to discuss the characteristics of monthly temperature in the southern part of China in 15 El Nino years and 15 anti-El Nino years over the period 1911 ~ 1986. We have discovered that:

(1) Temperature is mainly low in the winter, spring and early raining season of the current years of El Nino but mainly high for the subsequent years. The relationship is generally the opposite in anti-El Nino years.

(2) The ENSO event varies at a period of 3 ~ 5 years.

(3) There are significant values of coherent spectrum for the monthly mean temperature in Guangzhou and ENSO in the 2-to-3 year period, suggesting close relation between them. The variation of temperature in Guangzhou has a lead by about 5 months against ENSO.

It is therefore our argument that when air temperature is cold in winter and spring in southern China, i.e. cold air mass is vigorous and advances to low latitudes in winter and spring in East Asia, it is possible for the El Nino to take place; a strong and stable El Nino event in turn results in warm temperature in the winter and spring of the subsequent years in southern China.

Regional differences of temporal-spatial characteristics of air-sea interactions in tropical oceans

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I INTRODUCTION

Analysis about the relationship between tropical air-sea interaction and the short-range climate anomaly of China has tended to emphasize impacts of ENSO(Fu 1987; He 1996) since the 1980s. Yeh et al. (1991) gave some examples about possible effects of ENSO on the climate anomaly of China, which are mainly as follows: 1) chilling damage often takes place in the ENSO warm event(viz. El Nino) outbreak years;2)Mei Yu is less in middle and lower reaches of Yangze River in the El Nino outbreak years, and more in the following years;3)the western Pacific subtropical high is weaker and lies to east of normal position in the ENSO warm event outbreak years, and v.v.;4)typhoon frequency in the western Pacific shows an apparently negative correlation with equatorial eastern Pacific SST, namely, typhoon happens less in El Nino event periods.

Since the 1990s,observational studies have been able to identify ENSO event accurately in time. It is found that the relations between ENSO and summer climate anomalies of China are more complicated than those discovered. For instance, during the recent decades or so, especially since the 1990s, El Nino events appear frequently, whereas, chilling damage in North East China is seldom seen; 1991 and 1997 are surely ENSO event outbreak years, but the west Pacific subtropical high is stronger and lies to west of normal position, with heavy floods in Jianghuai valley. It has been found that anomalous summer high temperature took place in North East China in 1982; and there was only a phenomenally connection between the intensity and position of western Pacific subtropical high and the equatorial eastern Pacific SST, and the SST there had no direct and physical contributions to the western Pacific subtropical high.

Wang et al. (1999) analyzed the variation of SSTA in three tropical oceans since the beginning of 1950s and pointed out that although ENSO and interdecadal scale SST warming are both significant signals, whereas regional differences exist between them. In the tropical western Pacific ENSO isn't the sole strong signal, indicating that the SSTA of this area is of district particularity. Wang et al.(1991) and Wang et al.(1996) suggested that ENSO has weaker effect on the interannual variation of circulation in this area , which is different from the tropical central-eastern Pacific and Indian ocean.

In this paper, regional diversities of temporal and spatial structure of tropical air-sea interaction are emphatically examined in the context of SVD method.

II SVD METHOD AND THE DISTRICTING SCHEME OF TROPICAL OCEAN

1. SVD Method

*This work was jointly supported by National Natural Science Foundation of China(No.49975025) and <<National Key Programme for Developing Basic Science>> G1998040900 Part I.

The SVD method for vector fields given by Wang et al.(1997) is used in this paper. In the light of Wang et al.(1997), the main derived quantities of SVD are 1) singular values λ_h, h=1-H, which is usually transformed into the fitting ratio of square of modulus of correlation matrix of $\boldsymbol{F}$ and $\boldsymbol{G}$(referred to as modulus square fit ratio briefly) ρ_h, h=1-H, arranged in descendant order; 2) singular vectors $\boldsymbol{X}_h$ (in scalar form corresponding to *SSTA*) and $\boldsymbol{Y}_h$ (in vector form corresponding to V_{1000}), jointly describing the spatial distribution of the hth pair of singular vectors; 3) time coefficients ${}_h\boldsymbol{T}_f$ and ${}_h\boldsymbol{T}_g$, h=1-H of $\boldsymbol{X}_h$ and $\boldsymbol{Y}_h$, showing the temporal evolution of the weight of $\boldsymbol{X}_h$ and $\boldsymbol{Y}_h$ in constituting *SSTA* and V_{1000} respectively; 4) ${}_h\rho_f$ and ${}_h\rho_g$ denote the variance contribution of left and right singular vectors to *SSTA* and V_{1000} fields time series respectively; 5)the correlation coefficient r_h of the hth pair of singular vectors.

2. Scheme of Area Division

From the purpose of investigating regional difference, major parts of the tropical oceans from 32.5° S~32.5° N is divided into five equal-area regions(identified in table 1). In which, n is the grid number of defined *SSTA* and V_{1000} data in each region, and m is the length of time series(Units: months).

Table 1 Sea areas of tropical ocean and parameters for *SSTA* and V_{1000} data

Region	Csc.	Φ	λ	N	m
Tropical western Pacifc	WP	32. 5° S~32. 5° N	120° E~170° E	138	454
Tropical central Pacific	MP	32. 5° S~32. 5° N	175° E~135° W	154	454
Tropical eastern Pacific	EP	32. 5° S~32. 5° N	130° W~80° W	146	454
Tropical Atlantic ocean	AO	32. 5° S~32. 5° N	50° W~0°	132	454
Tropical Indian ocean	IO	32. 5° S~32. 5° N	50° E~100° E	130	454

For five regions, SVD of vector field(Wang et al. 1997) is performed in the context of normalized *SSTA* (noted as $\boldsymbol{F}_{m\times n}$) and V_{1000} (noted as $\boldsymbol{G}_{m\times n}$) fields time series. Monte Carlo test method is used to estimate objectively statistical significance of SVD results.

3. Monte Carlo Method of SVD Mode Significance Test

Whether SVD results are of statistical meaning or not is determined by significance test. Shen and Lua(1995), Jwasaka and Wallace(1995) put forward two ways checking the significance of SVD results with the aid of Monte Carlo techniques . We apply Monte Carlo method to the significance test of SVD results of five sea areas listed in table 1, ρ_h is chose as a tested object, and the concrete steps are as follows:

(1) $\boldsymbol{F}$ is real data, namely, real *SSTA* data; $\boldsymbol{G}$ is V_{1000} formed by the program

producing (0, 1)normal distribution stochastic numbers.

(2) Produce 1000 pairs of $F_{m\times n}$ and $G_{m\times n}$ and perform 1000 times SVD for each sea area, recording ${}_l\rho_h$, h=1~4, l=1~1000, where, l is natural number of random samples. ${}_l\rho_h$ is the fitting ratio of the hth mode of the lth random experiment SVD to the modulus square of correlation matrix.

(3) ${}_l\rho_h$, l=1~1000, are arranged in descendant order, taking ${}_l\rho_h$, l =2, 11, 51, as the critical values of ${}_l\rho_h$ at the confidence level α =0.001, 0.01, 0.05 for each sea area respectively (n and $SSTA$ are different) (listed in table 2).

Table 2 Critical values $\rho_{h\alpha}$ for the five sea areas in table 1

α	h	WP	MP	EP	AO	IO
	1	0.164	0.212	0.227	0.230	0.228
	2	0.134	0.141	0.142	0.146	0.143
0.001	3	0.107	0.111	0.103	0.102	0.106
	4	0.086	0.098	0.077	0.079	0.077
	1	0.158	0.202	0.212	0.213	0.219
	2	0.029	0.133	0.132	0.135	0.136
0.01	3	0.102	0.106	0.094	0.096	0.097
	4	0.082	0.089	0.071	0.074	0.072
	1	0.149	0.191	0.204	0.200	0.206
	2	0.122	0.126	0.124	0.126	0.026
0.05	3	0.097	0.101	0.090	0.091	0.092
	4	0.079	0.085	0.068	0.069	0.069

III SIGNIFICANCE TEST AND PARAMETERS ANALYSIS OF SVD FOR FIVE TROPICAL OCEAN REGIONS

Table 3 shows ρ_h, h=1~5 and their confidence α for the five tropical ocean areas. Among which, only the ρ_h of the first pair of singular vectors pass the test for the tropical central-eastern Pacific, two for the tropical western Pacific and Indian ocean and four for the tropical Atlantic. We also can see from table 3 that ρ_h at the boundary of significant and nonsignificant modes for each tropical ocean region are apparently different, therefore the area division is reasonable. In addition, from the relative values of ρ_1 and ρ_2, ρ_1/ρ_2 reaches 6.4 and 9.1 respectively for the tropical eastern and central Pacific, 4.3 and 3.3 for the tropical Indian and Atlantic oceans respectively and 1.9 for the tropical western Pacific. Thereby we can believe that there is only a kind of real important process in the climate atmosphere-ocean interaction for the tropical central-eastern Pacific, which is the ENSO cycle pointed out later; thus the air-sea interaction in this area is referred to as the monistic type. There are two important processes for the tropical western Pacific and Indian ocean; hence the air-sea interaction are more complicated than that of eastern-central Pacific on the whole, so it is reffered to as dualistic type; especially for the tropical western Pacific, ρ_1 is close to ρ_2, the interaction is the most typical dualistic type, while the tropical Indian ocean is not so typical than the former because of larger ρ_1/ρ_2. Compared with the above two ocean regions, more singular vectors pass the confidence test in the tropical Atlantic, but the confidence of most of them are lower in such a way that it can be considered as the results of the joint interaction of many relative weaker factors, therefore named as the pluralistic type.

Table 3 $\rho_h(\alpha)$ of SVD analysis for the five tropical sea areas

h	WP	MP	EP	AO	IO
1	0.429(0.001)	0.750 (0.001)	0.659 (0.001)	0.460 (0.001)	0.553 (0.001)
2	0.228 (0.001)	0.082	0.109	0.141 (0.05)	0.128 (0.05)
3	0.085	0.040	0.055	0.123 (0.05)	0.090
4	0.059	0.032	0.033	0.117 (0.05)	0.054
5	0.036	0.021	0.023	0.037	0.039

IV CONCLUSION

The major conclusions of this paper are as follows:

1) statistical analysis show that apparent regional differences exist in the interannual scale air-sea interaction for the tropical oceans, with the tropical central-east Pacific belonging to the monistic type, the tropical western Pacific and Indian ocean to the dualistic type and the tropical Atlantic to the puralistic type;

2)the climatological analysis of the ocean and atmosphere suggests that the ENSO cycle is the sole important process for monistic type area, important but not the sole process for dualistic type areas and no longer important process for pluralistic type area. What mechanisms on earth lead to regional difference of air-sea interaction deserves to be further concerned .

ACKNOWLEDGEMENTS

The authors are much grateful to Dr X.L.Wang and Mr.Y.J.Zhu for providing the NCEP/NCAR data.

A Preliminary Study on the Relationships among East Asia Summer Monsoon, El Nino and Cold Summer in Songliao Plain, China

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1. Introduction

Songliao Plain(42° N-46° N) is a famous corn production area in the world. Located in the East Asia continental temperature monsoon climate region, its crop yield is very sensitive to climate variations, especially to the low temperature during the growing period (May-Sept.). From the end of 1970s to 1980s, Chinese scientists have studied the cold summer disasters in the Northeast China and Songliao Plain. They found that cold summer disasters in the Northeast China occurred in groups and quasi-periodically, usually occurred when global mean temperature is relatively low, and there was a close relationships between the El Nino year and periodical cold summer disasters of Northeast[(1),(2),(3)]. The reference 4 indicated that Jilin province was in a cold period during the 1950s-1970s. From the 1980s, it entered into a relatively warmer period. The summer precipitation and temperature in Songliao Plain are greatly influenced by East Asia summer subtropical monsoon. So we choose the 336K isotherm on the 850 hPa pentad mean map as the index of the northern boundary of East Asia summer subtropical monsoon. If the 336K isotherm reaches more northward over 40° N and persists longer time, the summer in Songliao Plain will have more rainfall and a warmer temperature. Otherwise the summer will have less rainfall and a relatively cold temperature. On this basis, we further analyze the relationships among the East Asia summer monsoon index, El Nino and May-Sept. mean temperature of a typical station Changchun in Songliao Plain, and discover some new related facts[(5)]. Some intraseasonal oscillation features in some typical El Nino years has been analyzed by using of OLR pentad mean data, some mechanism on East Asia summer and winter monsoon and El Nino effect on temperature of crop growing period in Songliao Plain, and some forecasting signals are extracted.

2.Relationship between El Nino and summer temperature in Songliao Plain

Table 1 Relationship between SSTA in the same year of El Nino events and Changchun's May-Sept. mean temperature anomaly

time		Changchun's Temperature Anomaly		Changchun Temperature Anomaly in El Nino year	
		positive (years)	negative (years)	positive (years)	negative (years)
1909—1920	cold period	4	8	1	3
1921—1951	warn period	20	11	6	0
1952—1981	cold period	12	18	1	6
1982—1999	warn period	14	4	5	1

Changchun's May-Sept. mean temperature since 1909 is of a 60-yr extra-long variation period (referred to reference 6). In Table 1, it is clearly indicated that the relationship between SSTA (Nino C region) in the same year of El Nino events and Changchun's May-Sept. mean temperature is of clear stage and a quasi-30-yr (inter-decadescale) variation, *i.e.* correlation coefficient between El Nino and cold summer at the same year is 9/11(0.82) during cold phases, 1909-1920 and 1952-1981, of negative correlation, but 11/12(0.92), clear positive correlation during warm phases 1921-1951 and 1982-1999.

Fig.1a is a time sequences of C region SSTA and Changchun's monthly-mean temperature anomaly in 1976. The SSTA increased to positive clearly in May, but temperature anomaly continued to January 1977 in negative region except for May-Sept. 1976. This figure is a typical map of long-term negative correlation between El Nino and summer temperature in Songliao Plain during cold period.

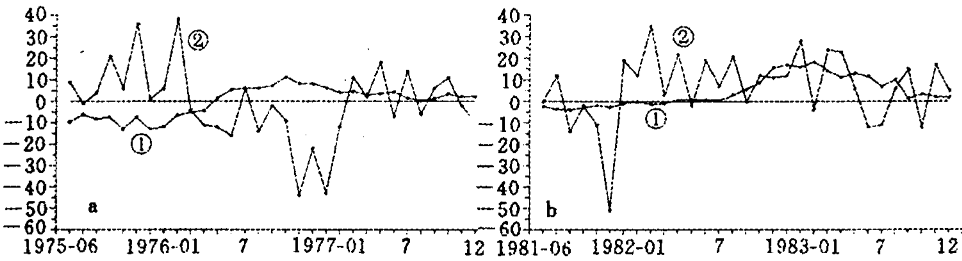

Fig 1 Sea temperature in C region and Changchun's monthly mean temperature anomaly
(①: Sea temperature anomaly;②: Changchun's monthly mean temperature anomaly.
a: 1975-1977; b: 1981-1983; unit: 0.1° C)

Fig. 1b is a time sequence of El Nino SSTA and Changchun's monthly-mean temperature anomaly in 1982-1983. The SSTA increased over 0.5° C in Sept. 1982, and over 1° C in Sept.-Nov. 1982. Changchun's summer temperature is higher in 1982, the same year of the El Nino event, and in 1983 except for lower in June-July 1983. This figure is a typical map of positive correlation between El Nino and summer temperature in Songliao Plain during warm period.

Compared Changchun's May-Sept. monthly-mean temperature anomaly with .C region (0-10° S, 180-90° W) SSTA $\geq$0.5° C in El Nino year from 1950, we find that Songliao Plain was in a low temperature period in the 1950s-1970s, and 7 El Nino events took place. At first; the time of temperature increase was early. Six times started on June or before of the occurred year, averagely on March except for 1963 on July. Most of increasing temperature were gradually change. Changchun's May-Sept. monthly mean temperature anomaly in 1953-1954, 1957, 1965-1966, 1969, 1972 and 1976 were negative as cold summer disasters in this seven El Nino events except for 1963. Table 2, which indicates El Nino and East Asia summer monsoon effect on Songliao Plain temperature during crop's growing period, is the relationships among El Nino, East Asia monsoon and Changchun's mean temperature anomaly during crop's growing period (May-Sept.) in 1951-1996. The probability of negative temperature anomaly in Songliao Plain is 86% at the same year of El Nino events.

Table 2 Relationship among El Nino, East Asia summer monsoon index and Changchun's summer temperature

year		Sea temperature feature		Changchun's May-Sept. Mean Temperature		East Asia summer monsoon index
		Beginning month of temperature increase	Temperature increasing pattern	Temperature anomaly	Negative anomaly months	
1953	El Nino	1	slow	-0.47	4	0.97
1954				-0.97	4	1.04
1957	El Nino	4	slow	-1.2	4	0.98
1963	El Nino	7	slow	+0.8	2	1.26
1965	El Nino	5	slow	-0.2	3	1.66
1966				-0.2	3	1.05
1969	El Nino	2	slow	-1.2	5	0.96
1971				-0.67	5	0.89
1972	El Nino	6	quick	-1.07	4	0.96
1976	El Nino	6	slow	-0.77	4	0.57
1982	El Nino	9	quick	+0.93	0	0.97
1983				+0.13	2	1.27
1986	El Nino	10	quick	-0.27	3	0.85
1987				-0.27	4	1.00
1991	El Nino	5	quick	+0.33	2	1.02
1992				-0.47	4	0.89
1993	El Nino	4	slow	+0.13	3	0.87

1994	El Nino	5	slow	+1.16	0	1.10
1995				-0.27	3	1.12
1996				+0.43	2	

Compared with the 1950s-1970s, El Nino event's characters have clear difference since the 1980s, *i.e.* the time of reaching the temperature increase standard is late. The two El Nino events in 1982-1983 and 1985-1986 started at Sept., and temperature increased quickly---temperature increased more than 1° C during 3 consecutive months when reaching El Nino standard.

The Equatorial Pacific Ocean took place long-term El Nino events in the 1990s, El Nino period is clear difference to that of the 1950s-1970s and 1980s. In Table 2, the beginning time of El Nino temperature increase in the 1970s is at June or before, similar to the 1950s-1970s. The relationship between summer temperature in Songliao Plain and El Nino is of general although El Nino period is so particular. Summer temperature anomaly in 1991, 1993, 1994, the beginning year of El Nino, is high, the relationship is positive. In the next year, temperature is slight low (the absolute value of negative anomaly <0.5° C) such as in 1992 and 1995, but not sever cold summer disasters (the absolute value of negative anomaly ≥0.7° C) compared with the 1950s-1970s.

3 Discussion and Conclusion

(1)The relation between SSTA in the same year of El Nino events and May-Sept. mean temperature of Changchun is of clear periodical and inter-decadescale variations, *i.e.* a clear negative correlation during cold episode, but a clear positive correlation during warm episode. In the 1950s-1970s, East Asia summer monsoon was weak, El Nino temperature increase started slowly in the first half a year, the low temperature or cold injury in Changchun summer would take place, and there was a close relation between strong or weak index of East Asia summer monsoon and warmer temperature in typical El Nino year or colder temperature in typical non-El Nino year. The East Asia summer monsoon index was weak in the early 1950s, the late 1960s and the 1970s. So, we think that a reasonable explanation for cold summer occurred in groups and a negative correlation between temperature anomaly in crop growing period in Songliao Plain and El Nino sea temperature anomaly in the 1950s-1970s is joint effect of El Nino and East Asia summer monsoon.

(2)Since the 1980s, the relation between El Nino and temperature in the same year of crop growing period in Soliao Plain is a positive or weak negative correlation, not a negative correlation in the 1950s-1970s. In the 1990s, El Nino events occurred in consecutive years, and Changchun temperature in crop growing period is high in the same year of El Nino events and slightly low but not a cold disasters in the next year although El Nino temperature increase started in the first half a year. In 1980-1995, East Asia summer monsoon entered a relative strong period. This is an advantage condition for summer temperature in Songliao Plain to enter a relative warm period.

(3)By using of analysis of cross-section of OLR interseasonal oscillation along latitude and longitude in 1976, 1982, 1986 and 1994 El Nino year, some important mechanism that Changchun summer temperature was colder in the 1950s-1970s El Nino years and slightly high or higher in the 1980s are indicated further, *i.e.* the difference of time-space distribution of OLR interseasonal oscillation is very clear. OLR interseasonal oscillation clearly indicated how El Nino relates to 30-60d oscillation in tropical atmosphere, East Asia summer and winter monsoon, especially summer southwest subtropical monsoon at 30°N:

① When the OLR negative central location of oscillation in equatorial mid-west Pacific is to the west (130-150°E) and to the north at 20°N along 120°E in May, this situation is advantageous for negative value convective active zone to progress northward; while in the 1st dekad of June, there is a negative value intersecting center of interseasonal oscillation in 30°N, 110-130°E, the "source region" of OLR interseasonal oscillation is along 120°E, 30°N, and progress towards mid-high latitude to 50°N in many times. All those are the main features of OLR interseasonal oscillation when summer temperature is to high in El Nino years since the 1980s. Conversely, the OLR negative central location of oscillation in equatorial mid-west Pacific is to the east and to the south at 10°N along 120°E in 1976, a typical El Nino year in the 1950s-1970s; in the 1st dekad of June, there is a channel of interseasonal oscillation in 30°N, 110-130°E, the "sink region" is along 120°E, 30°N, the same as in 1986. A reasonable explanation for above difference features is: EL Nino difference developments cause it, such as the beginning increase temperature at equatorial east-Pacific in 1976 and aroused OLR interseasonal oscillation to the east, but the beginning increase temperature at equatorial mid-Pacific in 1994, 1982, 1986, more east in 1986 than in 1982 and 1994, maybe relate to a weak warm center of sea temperature increase; on the other side, it is related to East Asia winter and summer monsoon, especially to subtropical southwest monsoon activity at 30°N, such as a typical strong summer monsoon year in 1994 and a typical weak summer monsoon year in 1976.

②It is usually that Changchun summer temperature in the same year of El Nino was low in the 1950s-1970s when winter monsoon was active in the last year such as in 1976. While in the 1980s, winter warming was clear[4] and winter monsoon entered into a weak period. But OLR interseasonal oscillation positive belt along 120E in the slight low temperature 1986 progressed 3 times from 50°N to 20-30°N during Oct. 1985-March 1986, and one times to 40°N in the higher temperature 1994.

③ The differences of OLR monthly mean in 1994 and 1976 further indicates some important differences of OLR in El Nino year in two different periods. Some researches show that when ITCZ is weak to east in El Nino periods, it causes Northwest Pacific Subtropical High to the east and a negative anomaly of 500hPa to persist in summer in Northeast China[11] such a tele-connection of summer low-temperature in 1976, but ITCZ in 1994 was to the north(a negative belt in Fig 5a), Subtropical High to the north too in August(a broad positive belt in 20-40N in Fig 5b), big negative belts from southeast and southwest intersect at 20°N, 120°E, all those indicate that southeast and southwest monsoon in summer in 1994 is more active than in 1976.

(4)According to above diagnose analysis, it seems that some singles can be extracted to predict May-Sept. mean temperature in Songliao Plain.

①In the 1990s, when El Nino occurs, we can predict that temperature in this region in the same year is positive anomaly. For example, El Nino occurred in May 1997, we predicted that May-Sept. temperature was normal or slight high in the 2^{nd}-dekad of June. There was a high-temperature great area in the North and Northeast China from the 2^{nd}-dekad of June to the 2^{nd}-dekad of July.

②Some features, such as distribution of longitude-time and latitude sections of OLR interseasonal oscillation in May, progressing times of OLR positive value zones in the last winter from high to middle latitude and reaching latitude, advancing and retreating of θ_{se} 336K on the mean panted map of 850hPa, can be regarded as reference indexes to predict summer temperature.

(5)All those features, such as the north-side location of θ_{se} on the mean panted map of 850hPa, which represents activity of synoptic scale East Asia summer subtropical monsoon, and OLR "source" or "sink" distribution along equator, 30°N, 110-130°E and 130°E-180E, show that those ocean-atmosphere and circulation system, El Nino East Asia monsoon and tropical atmospheric low-frequency oscillation, effect on summer temperature in Songliao Plain.

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A Numerical Analysis of Effects of El Nino Event on Summer Temperature in Northeast China

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Based on the diagnostic analysis, simulation experiments have been carried out by using LASG 9-level coupled atmospheric-land model to investigate the response of summer temperature in Northeast China to different sea surface temperature anomalies in Nino 3 region. Summer temperature from June to August in 1983 was also simulated with observed sea surface temperature and sea ice data. The diagnostic analysis of observations showed that the significant correlation between summer temperature and sea surface temperature in North Pacific was found mainly in west wind drift belt and equatorial Central and East Pacific. Most cold summer occurred during El Nino events. According to the result of numerical simulation, 500hPa height anomaly could sustain "two-trough-and-one-ridge" circulation pattern when equatorial East Pacific is abnormally warming, which is favorable to southward inversion of cold air from mid- and high latitudes and causes lower summer temperature. It is proved that El Nino event is an important factor that causes cold summer in Northeast China. The simulation of summer climate in 1983 with observed sea surface temperature showed that modeled 500hPa height anomaly and summer temperature anomaly were similar to observations, which illustrated that El Nino event is not the only factor that affects summer temperature in Northeast China. Other important factors should include sea surface temperature anomalies in other oceans, ice and snow, and solar activities.

Session4

Demonstration of the updated network of the monitoring and prediction of El Ninõ event and warm pool developed jointly by APN project

An introduction to the APN web-page on ENSO and warm pool

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(National Climate Center, Beijing 100081, China)

Abstract

The APN network on ENSO and warm pool(website:\www.ncc.cma.gov.cn\apn) basically meets with the requirements for the information and data for ENSO and Warm Pool in the western Pacific. Up to now, the web-page has been modified three times, the contents have been updated with a special emphasis on oceanic and atmosphere conditions in Warm Pool and the South China Sea, the impact of ENSO events and SSTA of Warm Pool on the weather and climate of the western Pacific (including tropical cyclones and monsoon).This website has been visited for more than 5900 times. Besides the existing contents concluding monitoring, historical perspectives, predictions and outlook of tropical SSTA and El Nino/La Nina events ,and the released digital data, some other data and information associated with ENSO and the Warm Pool, such as oceanic data of the warm pool and the South China Sea, satellite data such as OLR and TBB, have been put on to the network. Also some recent research results are reflected in the web-page.

Therefore, a new network has been designed, set up ,and it is updated each month.

Agenda	
Workshop on the Network System for Monitoring and Predicting of ENSO Event and Sea Temperature Structure of the Warm Pool in the Western Pacific Ocean **5~7 February, 2002, Macao China**	
Monday, 4 February, 2002	
21:45-22:15	Meeting for Scientific and Organization Committee
Tuesday, 5 February, 2002	
9:30~9:50	Workshop Registration outside the Lotus Room **(5/F of WTC)**
OPENING SESSION Chair: Hao I Pan	
10:00	Opening Address **Mr. Soi Kun Fong**, Director, Macao Meteorological and Geophysical Bureau **Prof. Ding Yihui**, Leader of APN project 2001-12 **Mr. Martin Rice**, Programme manager , APN **Dr. Kazuo Kurihara**, Japan Meteorological Agency **Mr. Yunjie Zheng**, Deputy director general. Department of International cooperation China Meteorological Administration **Mr. Ao Man Long,** Secretary for Transport and Public Works, Macao Special Administrative Region
10:35~10:50	**Official Photograph Session**
10:50-11:10	**To UNESCO**
SESSION 1 Introduction and review for APN project **Chair: Soi Kun Fong**	
11:10	**Martin Rice**, Introduction to the Asia Pacific Network for Global Change Research
11:35	**Ding Yihui**, Activity report for 1999-2001
SESSION 2 Monitoring and prediction of EL Nino events and sea temperature structure of the Warm Pool **Chair: Akimasa Sumi**	
12:00	**Kazuo Kurihara**, The current system for monitoring and prediction of EL Nino in JMA and impact of salinity data assimilation in the equatorial western Pacific
12:20	**Lunch (At hotel, 4/F, Ballroom)**
14:00	**Jong-Seong Kug**, A study of ENSO predictability in KMA/SNU model: Impact of FSU and NCEP wind stress data in the initialization
14:20	**Johnny C. L. Chan**, Determining factors for the reversal or renewal of La Nina Events
14:40	**Zhao Zongci**, Evaluation of multi seasonal predictions of SSTA over the tropical Pacific Ocean and summer rainfall in East Asia in 2001 by the climate models
15:00	**Scott Power**, Climate monitoring and prediction in Australia: Services, Research and Applications
15:20	**Tea break**
15:40	**Aida M Jose**, Updates on monitoring the sea surface temperature anomaly in the warm pool area and climate variability in the Philippines for 2001
16:00	**Hiroki Kondo**, Modeling initiative towards dynamical prediction of SST and its effect on seasonal forecasting
16:20	**Jai-Ho Oh**, A coupled atmosphere-streamflow simulation during the 1998 precipitation event at the Pyungchang river basin
16:40	**Xue Jishan**, A new analysis system for satellite data and its application to South China Sea and warm pool
17:00	**Wang Dongxiao**, Preliminary results of model Inter-comparison in the South China Sea.
17:20	**Yuqing Wang,** Simulation of the 1998 severe precipitation event in China with the regional climate model developed at the International Pacific Research Center
17:40	**Li Qingquan,** Predictability of precipitation and temperature over China
18:00	**Tim Li**, ENSO simulation in a coupled GCM
19:30~21:30	**Welcome reception at Macao WTC (5/F, Lotus Room)**

Wednesday, 6 February, 2002	
SESSION 3 Impacts of EL Ninõ events on the monsoon, tropical cyclones and drought/floods in Southeast Asia and East Asia. **Chair: Johnny C. L. Chan**	
9:00	**C-P Chang,** Interactions of Maritime Continent winter monsoon, ENSO and Indian Ocean
9:20	**Huang Ronghui**, Impact of ENSO cycles on the summer climate anomalies in East Asia and the outlook of the SST anomalies in the tropical Pacific in 2002
9:40	**Zhai Panmao**, Report of the second joint meeting on seasonal prediction of East Asian winter monsoon
10:00	**Bin Wang,** How strong ENSO events affect tropical storm activity over the western north Pacific
10:20	**Fong Soi Kun**, The EL Nino and the La Nina events and influence to climate anomalies of the South China Sea and the Southern China
10:40	**Tea break**
11:00	**Sun Zhaobo**, The inter-decadal variations of summer precipitation over North China and its relation with Asian monsoon and ENSO Cycle
11:20	**Shi Xueli**, Modification of the National Climate Center Regional Climate Model for studying the seasonal variations of climate over South China
11:40	**Zhang Zuqiang**, Response of equatorial Pacific to wind stress anomalies in the inter-annual tropical air-sea interaction
12:00	**Wang Shourong,** Studies on regional water cycle and hydrologic modeling in North China in context of climate change
12:20	**Akimasa Sumi,** On the simulation of "super cluster" by using a non-hydrostatic model
12:40	**Lunch (At hotel, 4/F, Ballroom)**
14:00	**Chao Qingchen,** The influence of western tropical Pacific on the development of ENSO event as well as El Nino /La Nina cycle
14:20	**Ooi See Hai**, 1997~2000 ENSO impacts on weather in Malaysia
14:40	**Leung Yin Kong**, Effect of ENSO on number of tropical cyclones affecting Hong Kong
15:00	**Wu Shangsen,** Impact of ENSO event on the anomalies of South China Sea summer monsoon and climate in Guangdong province
15:20	**Tea break**
15:40	**He Jinhai**, Regional difference of temporal-spatial characteristics of air-sea interactions in tropical oceans
16:00	**Lian Yi**, A preliminary study on the relationship among East Asia summer monsoon, El Nino and cold summer in Songliao plain, China
16:20	Tian Slibimawati.(TBD)
SESSION 4 Demonstration of the updated network of the monitoring and prediction of El Ninõ event and warm pool developed jointly by this project **Chair: Bin Wang**	
16:40	**Li Wei,** An introduction to the APN web-page on ENSO and warm pool
17:00	**Zhai Panmao, Zhang Jin and Li Wei,** Demonstration of the updated network of project APN 2001-12Demonstration of the updated network of project APN 2001-12
17:30 **SESSION 5 Discussion of a summary of 3-year APN project and the possibility of continuous implementation of this APN Network** **Chair: Ding Yihui**	
19:30-21:00, **Dinner reception (At hotel, 1/F. Emperor Court)**	
Thursday, 7 February, 2002 **Study tour (Macao one day Tour)**	

List of participants

Workshop on the Network System for Monitoring and Predicting ENSO Event and Sea Temperature Structure of the Warm Pool in the Western Pacific Ocean

5-7 February, 2002, Macao China

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APN

Asia-Pacific Network for Global Change Research

www.ncc.gov.cn

ENSO和西太平洋暖池监测和预测网络

THE NETWORK SYSTEM FOR MONITORING AND PREDICTING ENSO EVENT AND SEA TEMPERATURE STRUCTURE OF THE WARM POOL IN THE WESTERN PACIFIC OCEAN

ENSO和西太平洋暖池
监测和预测网络

THE NETWORK SYSTEM FOR MONITORING AND PREDICTING ENSO EVENT AND SEA TEMPERATURE STRUCTURE OF THE WARM POOL IN THE WESTERN PACIFIC OCEAN

引 言

INTRODUCTION

在中国气象局国家气候中心的积极努力下，在APN和该项目其它参加国的支持下，一个监测和预测ENSO和热带太平洋暖池的网络(http://www.ncc.gov.cn)首次成功地在APN地区被建立起来。该网络的内容每月更新一次，基本上满足了APN国家和地区对ENSO和暖池信息与资料的需求。迄今为止，该网页已经被访问6000多人次。此外，该网络还包含了对热带太平洋的海表面温度异常和厄尔尼诺/拉尼娜事件的监测、历史回顾、预测和展望方面的内容以及发布与该系统有关的数据资料、与ENSO和暖池有关的其它资料和信息，如TOGA-TAO 和SCSMEX-A，B，C 浮标资料，暖池和中国南海的海洋资料，日本沿137° E的海洋观测资料，OLR和TBB等卫星资料被广泛收集、大部分放在网上。因此，设计和建立了相关的网路，其重点是暖池和中国南海的海洋和气象条件、ENSO事件和暖池 SSTA 对 APN 国家的天气和气候的影响（包括热带气旋和季风），这在以前的研究中经常注意不够。该网络系统将友好地为气象学家、公众、决策者提供有用的界面和信息，并大大地加强APN在APN国家和地区发布和交换ENSO事件和暖池监测和预测信息的能力。它对于APN地区的发展中国家尤为重要，可以及时收到预防可能灾害的信息和警报。

Under the great efforts of National Climate Center of China (CNCC) and with the supports of APN and other participating countries of this project, a network for monitoring and predicting ENSO and Warm Pool over the tropical Pacific Ocean has been set up rapidly (http://www.ncc.gov.cn), with its contents being updated every month. It basically meets with the requirements for the information and data of ENSO and Warm Pool in the APN countries and regions. Up to now, the web-page has been visited for

PROJECT LEADER: Prof. Ding Yihui

项目负责人：丁一汇教授

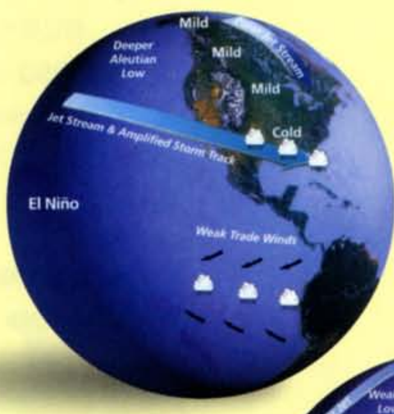
CONTRIBUTORS: China, Japan, Australia, Korea, USA, Philippines, Indonesia, Malaysia, VietNam, and Hong Kong

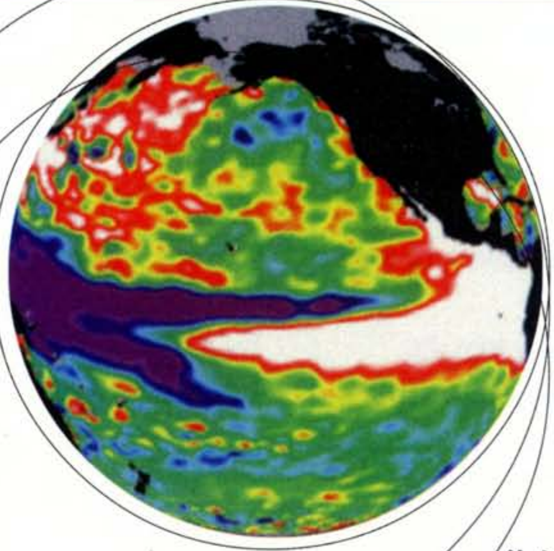
SUPPORTED BY: (1) APN project 99012, project 2000-12 and project 2001-12.
(2) China's National Key Project under the sub-projects: 96-908-04-02 and 96-908-02-05.

about 6000 times. Besides, the contents in the aspects of monitoring, historical perspectives, predictions and outlook of tropical SSTA and El Nino/La Nina events as well as the released digital data related with the system, some other data and information associated with ENSO and the Warm Pool, such as TOGA-TAO and SCSMEX-A, B, C buoy data, oceanic data of the warm pool and the South China Sea, the oceanic observations of Japan along 137°E, and satellite data such as OLR and TBB, have been widely collected and most of them have been put on to the network. Therefore, a network has been designed, set up and updated with a special emphasis placed on oceanic and meteorological conditions over Warm Pool and the South China Sea, the impact of ENSO events and SSTA of Warm Pool on the weather and climate of APN countries (including tropical cyclones and monsoon), which has been often neglected in previous studies. This is a distributed network for climate monitoring and prediction contributed by APN countries established successfully in the APN region for the first time. The network system in friendly manner provide useful interface and information to meteorologists, publics, and policymakers and greatly build up APN capability to disseminate and exchange monitoring and prediction information of ENSO events and the warm pool for APN countries, which is especially useful for developing countries in APN region to timely receive the information and warning for their preparedness of potential disasters.

在这个项目中，参加国和／或地区(中国、日本、韩国、菲律宾、泰国、马来西亚、越南、印度尼西亚和澳大利亚)主要在以下6个方面进行合作：收集资料和信息、承担科学研究工作、评估ENSO／暖池对天气和气候的影响、改进监测系统和厄尔尼诺／拉尼娜预报系统、建立网络和发布产品、举办国际学术研讨会。其中，中国气象局国家气候中心负责综合项目各参加国提供的资料和信息、改进监测系统和厄尔尼诺／拉尼娜预报系统、建立网络和发布产品。这些信息首先提供给项目参加国和APN国家使用。我们的项目还负责组织ENSO事件和暖池监测和预测以及它们对东亚季风的影响方面的国际研讨会。

In the present project, the participating countries/regions (China, Japan, Korea, Philippines, Thailand, Malaysia, Vietnam, Indonesia, and Australia) have mainly contributed in six aspects: collection of data and information, undertaking scientific research work, assessing effect of ENSO/warm pool on weather and climate, improving monitoring system, improving El Nino/La Nina prediction system setting up the network and issuing products, and holding an international workshop. Among them, CNCC is responsible for integrating data and information provided by various participating countries, improving monitoring system, improving El Nino/La Nina prediction system, integrating and setting up the network and issuing products. First, information has been furnished to participating countries and then APN countries. In addition, our project is also responsible for organizing international workshops on monitoring and seasonal to interannual prediction of ENSO event and the warm pool and their impact on the East Asian monsoon.





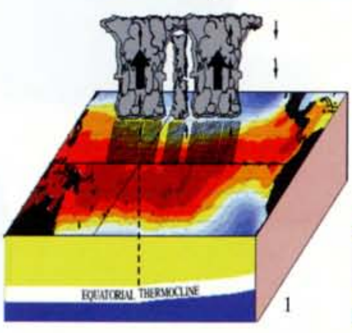
ENSO简介
BRIEF INTRODUCTION OF ENSO

什么是ENSO（厄尔尼诺 和拉尼娜）？
What is ENSO (EL Niño and LA Niña)

ENSO包括厄尔尼诺-南方涛动，科学家们用它来描述伴随着南方涛动的发生、海表面温度(SST)与长期平均值相比的升降现象。南方涛动是指太平洋和印尼-澳大利亚之间的气压呈"翘翘板"现象。厄尔尼诺最初是指秘鲁和厄瓜多尔沿岸的赤道东太平洋地区有时出现暖水的现象，现在科学家们发现厄尔尼诺有4-5年的周期。一次厄尔尼诺事件通常持续1年至1年半时间。拉尼娜是用来描述赤道中、东太平洋 SST比多年平均值偏冷的情况，它是与厄尔尼诺相反的现象。一次拉尼娜过程可能会持续1-2年。

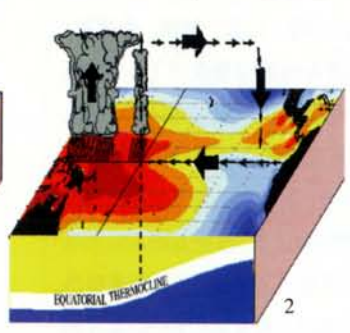
ENSO, which is composed of El Niño-Southern Oscillation, is a term usually used by scientists to describe Southern Oscillation with company of SST increases and decreases when compared to a long-term average. Southern Oscillation is a see-saw of atmospheric pressure between the Pacific and Indo-Australian areas. **El Niño** is a term originally used to describe the occurrent appearance of warm water in the eastern equatorial Pacific region along the coasts of Peru and Ecuador. Currently, it is found by scientist that El Niño has a period of four to five years. When an El Nina event occurs, it typically lasts 12-18 months. **La Niña** is a term describing the central or eastern equatorial Pacific SST colder than the long-term average, which is opposite to El Niño. When a La Niña event occurs, it may persist 1-2 years.

December - February El Niño Conditions



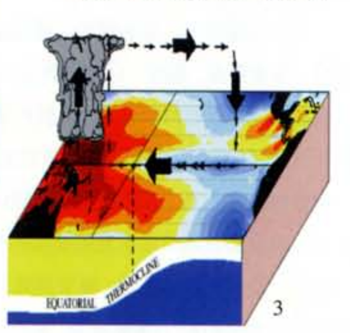
1

December - February Normal Conditions



2

December - February La Niña Conditions



3

图1：与厄尔尼诺有关的风、赤道沃克环流和海洋次表层结构；

图2：热带太平洋平均降水、风和海洋次表层结构；

图3：与拉尼娜有关的风、赤道沃克环流和海洋次表层结构

Fig. 1 EL NINO-RELATED WINDS, EQUATORIAL WALKER CIRCULATION, AND SUBSURFACE OCEAN STRUCTURE;

Fig. 2 MEAN TROPICAL PACIFIC RAINFALL, WINDS, AND SUBSURFACE OCEAN STRUCTURE;

Fig. 3 LA NINA-RELATED WINDS, EQUATORIAL WALKER CIRCULATION, AND SUBSURFACE OCEAN STRUCTURE

大气和海洋的正常状态是什么？

What is normal for atmosphere and ocean?

正常情况下（见第二页中间的示意图），强信风在热带太平洋上沿赤道自西向东吹，推动表面水向西至印度尼西亚，因此西太平洋海面比东太平洋大约高半米。此外，由于冷水自较深层上翻，西太平洋的水较暖、较深，而南美沿岸附近的东太平洋的水较冷、较浅。西部海水表面温度约比南美沿岸附近的海水表面温度高8度左右。海洋次表层结构的特征是西太平洋为较深的暖海水，东太平洋为相对浅的暖海水。海洋温跃层把上层暖水与深层冷水分隔开。温跃层通常从西太平洋到东太平洋向上倾斜。上层海洋温度的东西向变化会引起海表面高度的东西向变化。与海表面温度和赤道降水分布相对应，热带太平洋上低层是东风，高层是西风。不同水温会影响这些地区的天气。在西太平洋，暖空气上升、凝结并形成降雨。在东太平洋，冷空气不易上升成云致雨。因此，通常观测到印度尼西亚和热带西太平洋的降水最大、赤道东太平洋的降水最少。

Normally, middle panel of schematic diagram, strong trade winds blow from the east towards the west across the tropical Pacific along the equator, pushing surface water westward to Indonesia, so the sea level is roughly half a meter higher in the western Pacific than in the east. Moreover, due to an upwelling of cold water from deeper levels, there are warmer, deeper waters in the western Pacific and cooler, shallower waters in the east near the coast of South America. The sea surface temperature is about 8 ℃ higher in the west than in the east near the coast of South America. The characteristics of subsurface ocean structure are a deep layer of warm water in the western tropical Pacific and a relatively shallow layer of warm water in the eastern Pacific. The warm water in upper layer is separated from the cold ocean water in deeper layer by the oceanic thermocline, which normally slopes upward from west to east. The east-west variations in upper-ocean temperatures result in east-west variations in sea level height. The patterns of SST and equatorial rainfall are accompanied by low level easterly winds and upper level westerly winds across the tropical Pacific. The different water temperatures of these areas affect the types of weather over these areas. In the western Pacific, warm air ascends, concretes and forms to rain. However, in the east, the cool air is difficult to rise to produce clouds and rain. Therefore, it is normally observed that there are the heaviest rainfall across Indonesia and the western tropical Pacific but least rainfall across the eastern equatorial Pacific.

厄尔尼诺是什么？ What is El Niño?

在厄尔尼诺期间（第二页左边的示意图），中、西太平洋上的信风张弛，使东太平洋的温跃层下降、西太平洋的温跃层上升。当信风减弱、暖海水自西向东流时，一次厄尔尼诺就发生了。表面暖海水在南美沿岸堆积，东太平洋水温升高。东太平洋上空的低层东风和高层西风均减弱，这说明赤道沃克环流减弱。在厄尔尼诺的发展位相，海洋次表层结构的特征是异常深层暖水和温跃层加深。因此。热带太平洋的温跃层坡度减小、东太平洋的海表面高度比正常偏高。降水区跟着暖水向东移，致使秘鲁多洪水而印尼和澳大利亚干旱。

During El Nino, left panel of the schematic diagram, the trade winds relax in the central and western Pacific, which cause thermocline to depress in the eastern Pacific and elevates in the west. When weakening trade winds allow the warmer water from the western Pacific to flow toward the east, an El Nino event happens. Warm surface water off the coast of South America is piled up and the water temperature in the eastern Pacific is increased. Over the eastern tropical Pacific, both the easterly winds in the lower atmosphere and the westerly winds in the upper atmosphere reduce, which reflect a weakened strength of the equatorial Walker Circulation. During the developing phase of the El Nino, in the subsurface ocean of the eastern tropical Pacific, there is an abnormally deep layer of warm water and the depth of the thermocline increase. Therefore, the slope of the thermocline is reduced across the tropical Pacific and the sea level height is higher than normal over the eastern Pacific. Rainfalls move eastwards following the warm water, with flooding in Peru and drought in Indonesia and Australia.

拉尼娜是什么？ What is La Niña?

在拉尼娜期间（第二页右边的示意图），热带东太平洋的低层东风和高层西风均加强，赤道沃克环流加强。在拉尼娜的发展位相，热带东太平洋次表层暖水层变浅。因此，热带太平洋温跃层坡度增加，东太平洋海面高度比正常值偏低。

During the La Nina, right panel of the schematic diagram, both easterly winds in the lower atmosphere and westerly winds in the upper atmosphere over the eastern tropical Pacific increase, which reflects an enhancement of the equatorial Walker Circulation. During the developing phase of La Nina, there is an abnormally shallow layer of warm water in the subsurface ocean of the eastern tropical Pacific. Therefore, the slope of the thermocline increases across the topical Pacific and the sea level height is lower than normal over the eastern Pacific.

那些年是ENSO年？ What years are ENSO years?

平均每隔3–5年便有厄尔尼诺和拉尼娜发生。尽管如此，历史纪录上历次事件的间隔是2–7年。一次厄尔尼诺后，可能会发生拉尼娜，但不是总会有拉尼娜发生。据统计，1975年以后，拉尼娜的发生频率只有厄尔尼诺发生频率的一半。

El Nino and La Nina occur on average every 3 to 5 years. However, in the historical record, the interval between events varied from 2 to 7 years. A La Nina may but does not always follow an El Nino. Since 1975, the occurrence frequency of La Nina episodes has been only half as high as that of El Nino episodes.

ENSO事件的分类 CLASSIFICATION OF ENSO EVENTS

	ONSET & END	DUR.	PEAK (℃)	PEAK MON.	SSTA INT.	SYN. INT.	ONSET TYPE
WARM	1951.06 - 1952.01	8	1.0	11	W	W	E
	1953.04 - 1953.11	8	0.9	9	VW	W	E
	1957.04 - 1958.07	16	1.4	1	S	M	E
	1963.70 - 1964.01	7	0.8	10	W	W	E
	1965.05 - 1966.03	11	1.3	12	M	M	E
	1968.10 - 1970.01	16	1.1	5	M	M	C
	1972.04 - 1973.02	11	1.9	12	S	S	E
	1976.07 - 1977.01	7	0.9	10	W	W	E
	1979.09 - 1980.02	6	0.9	9	VW	VW	E
	1982.05 - 1983.09	17	2.5	12	VS	VS	C
	1986.09 - 1988.01	17	1.6	9	VS	VS	C
	1991.05 - 1992.07	15	1.4	4	S	S	C
	1993.03 - 1993.11	9	1.1	5	W	M	C
	1994.09 - 1995.02	6	1.2	12	W	W	C
	1997.04 - 1998.05	14	2.8	12	VS	VS	E
COLD	1954.04 - 1956.04	25	-1.7	11	VS	VS	E
	1956.07 - 1956.12	6	-0.7	9	VW	W	C
	1964.03 - 1965.01	11	-1.1	12	M	W	E
	1967.08 - 1968.05	10	-0.7	2	W	VW	E
	1970.06 - 1971.12	19	-1.4	12	S	S	E
	1973.06 - 1974.05	12	-1.4	12	M	S	E
	1974.09 - 1976.03	19	-1.5	12	S	VS	C
	1984.10 - 1985.10	13	-0.9	12	M	W	E
	1988.04 - 1989.05	14	-1.6	12	S	S	E
	1995.09 - 1996.04	8	-0.5	11	VW	VW	E
	1998.10 - 2000.03	18	-1.3	1	S	S	C

Note: VS-very strong; VW-very weak; S-strong; W-weak; M-moderate; E-East onset; C-central onset; Warm Events: SSTA of Nino 1~4 region with 6 months persistently greater than 0.5℃; Cold Events: SSTA of Nino 1~4 region with 6 months persistently smaller than -0.4℃; Intensity Index: Accumulated SSTA of Nino1~4 region during the entire period of ENSO episode. Duration: Total months from beginning to end of ENSO event; Mature Phase: Months with SSTA ≥ 1.0℃ (SSTA ≤ (0.8℃) in Nino 1~4 region for warm (cold) event; Peak Period: The month with SSTA reaches the highest for warm (cold) event; Onset type: The event with anomalous SSTA starting from Nino 1+2 region, or Nino 3 region is called eastern onset type (E), while starting from Nino 4 region is called central onset type (C).

表1 按ΣSSTA 分类的ENSO事件的强度指标

Tab. 1 INTENSITY INDICATOR OF ENSO EVENTS CLASSIFIED BY ΣSSTA OF EACH ENSO EVENT

Class	Very strong	Strong	Moderate	Weak	Very Weak
Warm Event	≥18.0	17.9~14.0	13.9~7.0	6.9~4.6	≤4.5
Cold Event	≤-16.0	-15.9~-12.0	-11.9~-6.0	-5.9~-3.6	≥-3.5

表2 按综合海气指数分类的ENSO事件的强度指标

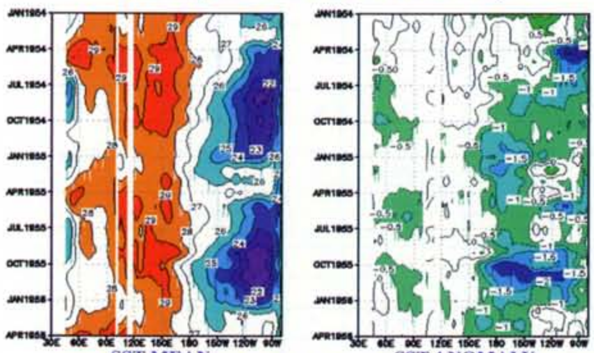
Tab. 2 INTENSITY INDICATOR OF ENSO EVENTS CLASSIFIED BY SYNTHESIZED AIR-OCEAN INDEX

Class	Very strong	Strong	Moderate	Weak	Very Weak
Warm Event	≥2.0	1.9~1.0	0.9~-0.9	-1.0~-1.9	≤-2.0
Cold Event	≤-2.0	-1.9~-1.0	-0.9~0.9	1.0~1.9	≥2.0

Synthesized Air-ocean Intensity of ENSO Episodes: Normalized monthly SSTAs accumulation of Nino1~4 region minus normalized accumulated SOI.

拉尼娜事件 LA NINA EVENTS

Time-longitude Cross Section of SST Anomaly

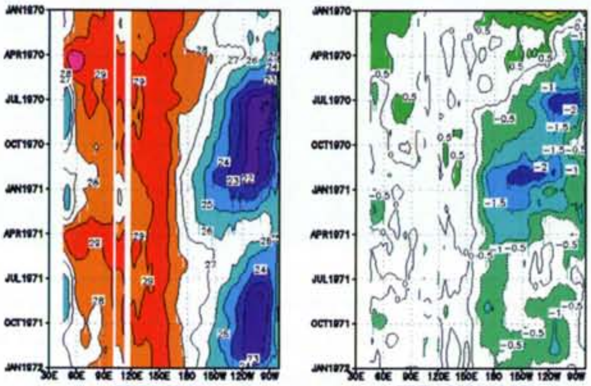


SST MEAN SST ANOMALY

1954.1-1956.4

CMA/NCC/Climate Diagnostics Lab

Time-longitude Cross Section of SST Anomaly

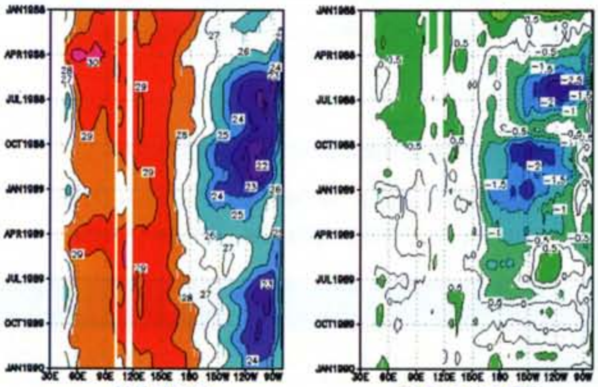


SST MEAN SST ANOMALY

1970.1-1972.1

CMA/NCC/Climate Diagnostics Lab

Time-longitude Cross Section of SST Anomaly



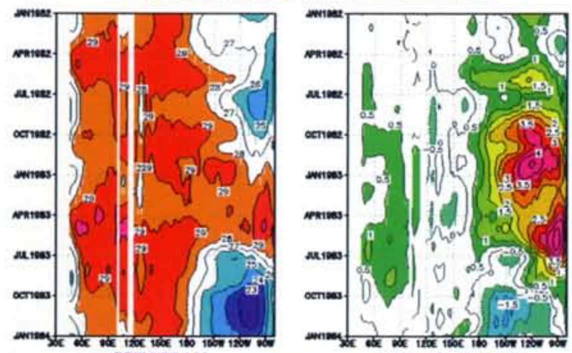
SST MEAN SST ANOMALY

1988.1-1990.1

CMA/NCC/Climate Diagnostics Lab

厄尔尼诺事件 EL NINO EVENTS

Time-longitude Cross Section of SST Anomaly

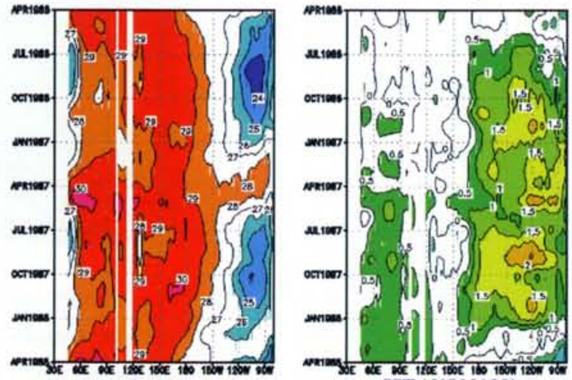


SST MEAN SST ANOMALY

1982.1-1984.1

CMA/NCC/Climate Diagnostics Lab

Time-longitude Cross Section of SST Anomaly

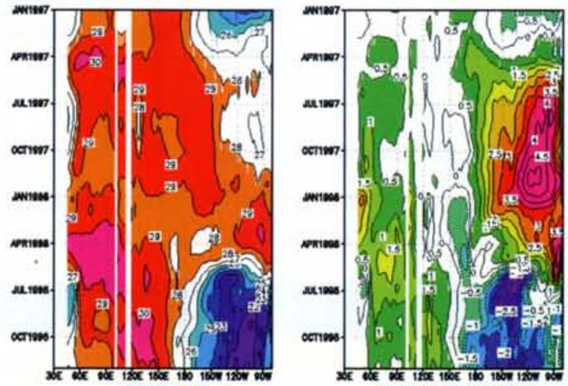


SST MEAN SST ANOMALY

1986.4-1988.4

CMA/NCC/Climate Diagnostics Lab

Time-longitude Cross Section of SST Anomaly

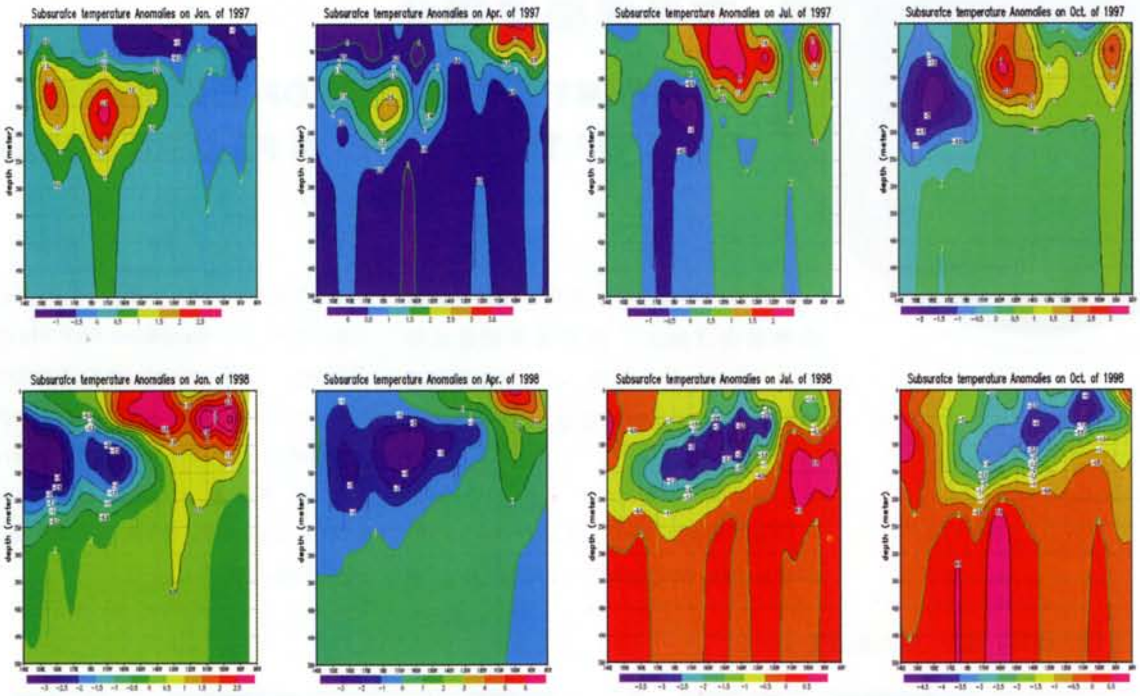


SST MEAN SST ANOMALY

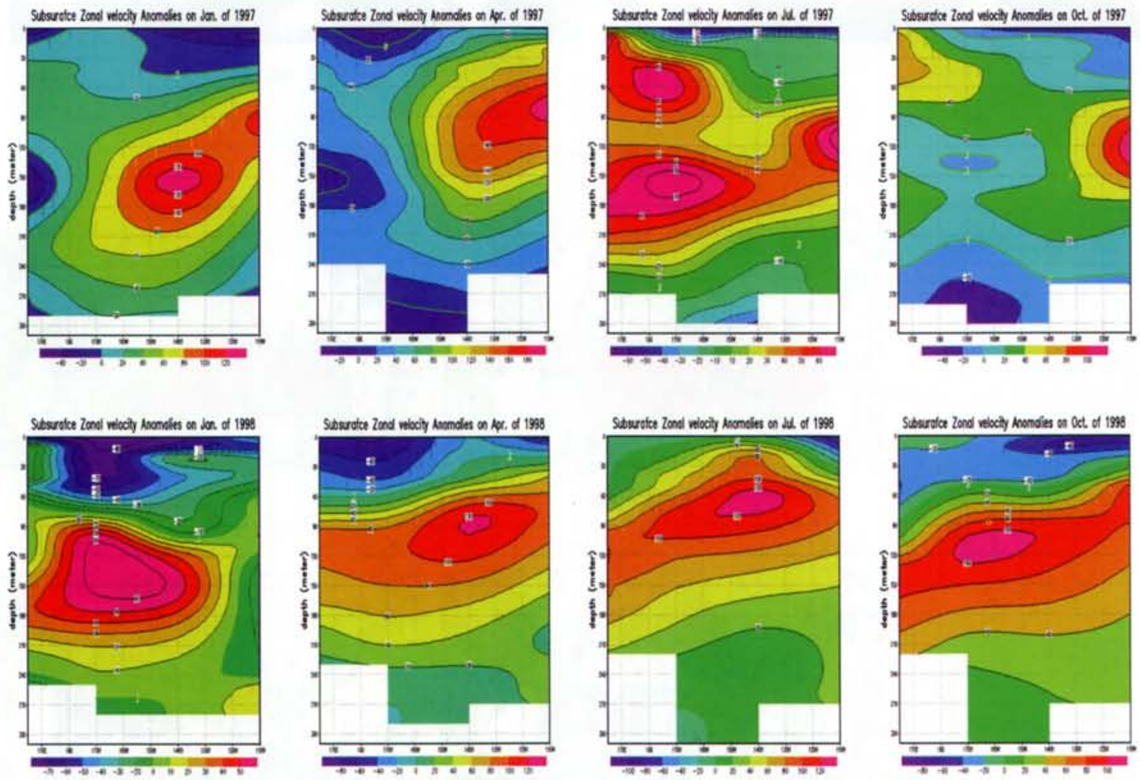
1997.1-1998.12

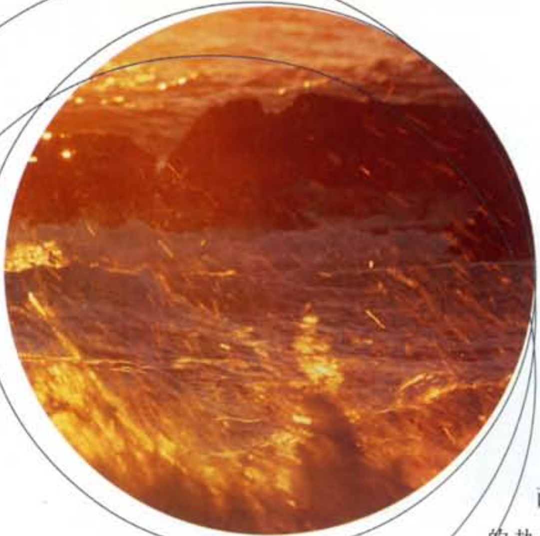
CMA/NCC/Climate Diagnostics Lab

1997–1998年次表层海温距平　SUBSURFACE SEA TEMPERATURE ANOMALY FOR 1997-1998



1997–1998年次表层纬向洋流速度距平　SUBSURFACE ZONAL VELOCITY ANOMALY FOR 1997-1998





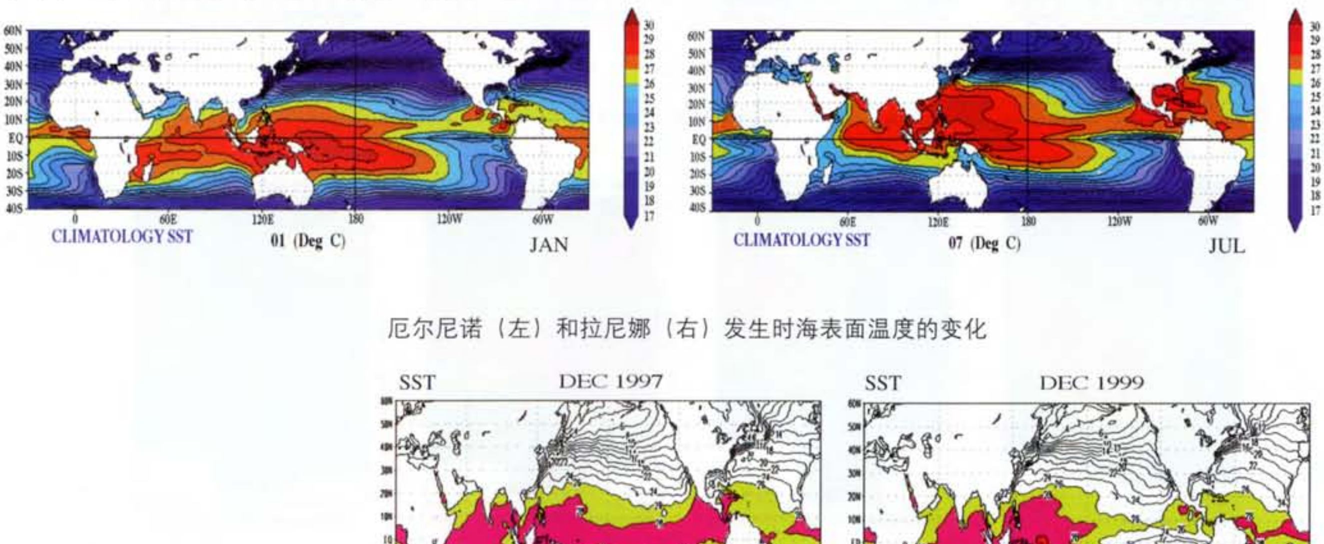
太平洋暖池简介

BRIEF INTRODUCTION OF THE WARM POOL OF THE WESTERN PACIFIC OCEAN

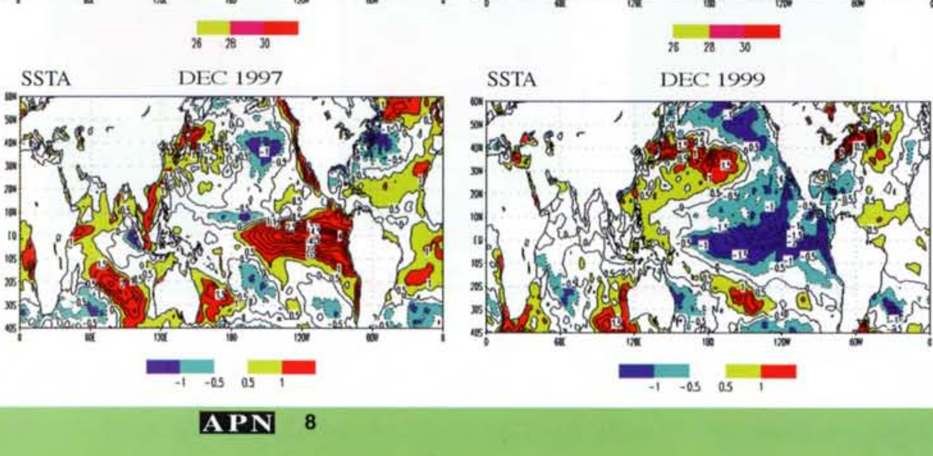
西太平洋暖池位于从菲律宾到日界线的热带海洋地区，那里观测到最高的SST。在厄尔尼诺期间，西太平洋温跃层抬升，暖池海水温度降低；在拉尼娜期间，情况正好相反。

The "warm pool" is located in the extensive tropical oceanic region extending from the Phillipines to the date line, with the maximum SST observed. During a warm episode, the adjustment of thermocline results in enhanced negative anomalies in the western equatorial Pacific. While, during a cold episode, there is a opposite situation in the western equatorial Pacific.

多年平均的1月(左)和7月（右）海表面温度



厄尔尼诺（左）和拉尼娜（右）发生时海表面温度的变化



监测与预测ENSO和西太平洋暖池的重要性

THE IMPORTANCE OF MONITORING AND PREDICTION OF ENSO AND THE WARM POOL OF THE WESTERN PACIFIC OCEAN

众所周知，气候异常与ENSO有密切的关系，它们由此对热带和其它气候带的社会经济产生影响。许多研究表明ENSO循环（包括厄尔尼诺和拉尼娜）与亚洲和西太平洋国家和地区（如印度尼西亚、菲律宾、马来西亚、越南、泰国、澳大利亚、日本、韩国和中国）的气候、环境和社会经济等方面有明显的关系和影响。它可能引起亚洲和太平洋地区的干旱、洪涝、低温冷害、热浪、台风登陆以及森林火灾，并因此给这些地区造成巨大社会经济损失和环境破坏。例如，统计资料表明，由于1997/1998年厄尔尼诺事件的影响，全球和区域气候变化异常，大尺度严重自然灾害造成4,829,884人无家可归，直接经济损失达到3.39亿美元。已经发现，亚洲冬季风和夏季风的强度与ENSO的建立、成熟和衰减有一定的相关关系。另一方面，西太平洋海表面温度异常可以通过PJ（太平洋-日本）型或沃克环流对东亚天气和气候产生遥相关影响。暖池和菲律宾周围地区的对流活动对影响东亚夏季风的季节和年际变率有重要作用。因此，从独特的区域观点出发，迫切需要建立一个监测和预测西太平洋暖池海温及其与夏季风活动关系的系统。改进我们对这些领域的理解和认识，加强对ENSO事件和西太平洋暖池SSTA季节和年际时间尺度的监测和预测，并通过国际互联网把必要的有关信息、产品和数据集分发给APN国家和地区，由此改进该地区对季风活动和重要气候事件的季节和年际预测。

It is well known that there are close relationships between ENSO phenomenon and anomalous climate through which socio-economic impacts in the tropical and other climatic zones have been produced. Numerous investigators have shown that ENSO cycles (consisting of El Nino and La Nina phases) have significant relations with and impacts on climate, environment, and socio-economic aspects in the Asian and western Pacific countries and regions, such as Indonesia, Philippines, Malaysia, Vietnam, Thailand, Australia, Japan, Korea and China. It may cause droughts, floods, cold injuries, heat waves, landfall of typhoons as well as forest fires in the Asian and Pacific region, thus bringing about huge socio-economic losses and deterioration of environment to these regions. For instance, recent statistics data have shown that due to the effect of 1997/1998 El Nino event, global and regional climate changed abnormally, and large-scale severe natural disasters caused 4,829,884 persons to be homeless and direct economic losses up to US$33.9 billions. It has been found that there are some definite correlative relationships between the onset, maturity and decay of ENSO, and the intensity of winter and summer monsoon over Asia. On the other hand, the sea surface temperature anomaly (SSTA) in the western Pacific Ocean may exert a teleconnection effect on the weather and climate in East Asia through PJ (Pacific-Japan) pattern or Walker circulation. The thermal regime of the warm pool and the convection activity in the region around Philippines play important roles in affecting the seasonal and interannual variability of the East Asian summer monsoon. Therefore, from the unique regional view-point, it is an urgent task to set up a network system for monitoring and predicting sea temperature of the warm pool in the western Pacific Ocean and its relationship to the summer monsoon activity. It is very necessary to improve our understanding and knowledge in these fields and very essential to enhance the monitoring and prediction of ENSO events and SSTA on the warm pool over the western Pacific Ocean at the seasonal and interannual time scales with necessary related information, products and data sets distributed to APN countries/regions via an Internet network, thus leading to improvement of seasonal and interannual prediction of monsoon activity and significant climate events in this region.

本项目的目标

THE OBJECTIVES OF THIS APN PROJECT

1999－2000年我们完成了APN资助的“ENSO事件和西太平洋暖池海表面温度异常的监测和预测”项目(APN#99012)。与此同时，1999年，我们又提出了题为“ENSO事件和西太平洋暖池海温结构的监测和预测网络系统”的补充项目建议书，2000年3月得到APN的批准，该项目为期两年（2000－2001年），分别称为APN2000－12和APN2001－12项目。

The APN has funded the project "Monitoring and prediction of ENSO event and SSTA over the warm pool in the western Pacific Ocean" (APN#99012) for 1999/2000. A renewal proposal "The network system for monitoring and predicting ENSO event and sea temperature structure of the warm pool in the western Pacific Ocean"for the next two years (2000-2001) was put forward in 1999, and was approved in March 2000. These projects are referenced as APN 2000-12 and 2001-12.

APN99012项目的主要目标是：

1）监测和预测ENSO事件和西太平洋暖池的SSTA，2）在APN地区建立用于监测ENSO和暖池的国际互联网系统，3）向APN地区发布SSTA预报，4)在APN地区组织国际研讨会。

The major objectives of project APN99012 are: 1) monitoring and predicting ENSO event and SSTA over the warm pool in the western Pacific Ocean, 2) setting up the monitoring Internet system of ENSO event and warm pool in the APN region, 3) releasing SSTA predictions to the APN region, 4) organizing international workshop in the APN region.

APN2000-12项目的主要目标是： 1）收集与ENSO和暖池有关的资料和信息，2）建立和改进网络、发布产品，3）科学研究工作，4）改进ENSO预报系统。

The major objectives of project APN2000-12 are: 1) Collection of data and information relative to ENSO and the warm pool, 2) Setting up and improving the network and issuing products, 3) Scientific research work, 4) Improving El Nino/La Nina prediction system.

PN2001-12项目的主要目标是： 1）监测和预测ENSO事件和暖池海温结构，2）评估对季风、热带气旋以及极端天气、气候事件的影响，3）实现上述信息的网络

The major objectives of project APN2001-12 are : 1) To monitor and predict the ENSO event and the sea temperature structure over warm pool; 2) to assess impact on monsoon activity, tropical cyclone (T.C.) and extreme events; 3) to implement network of above information.

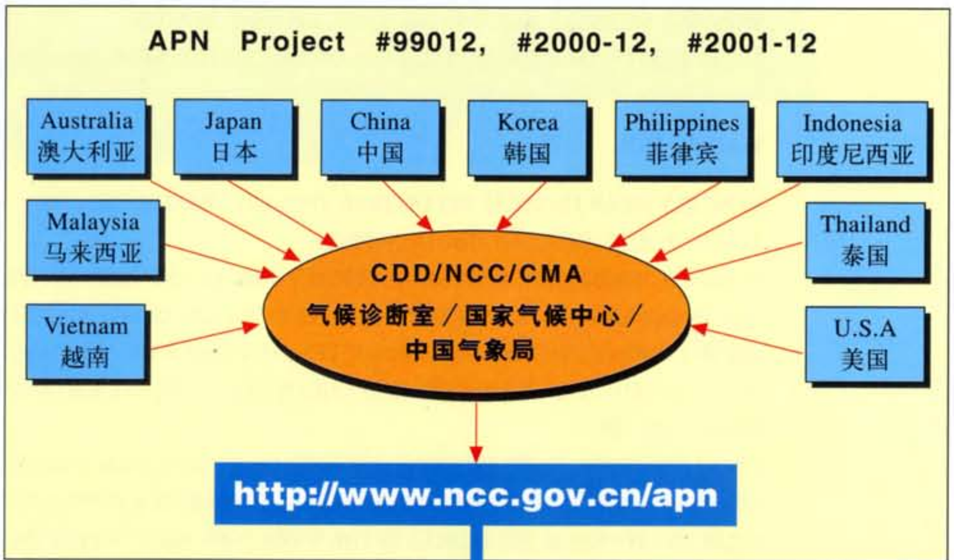
本项目(APN99012、APN2000－12 和APN2001－12)已经建立起来一个网络和网页(http://www.ncc.gov.cn)，其目录和信息保存在一个工作站上。中国气象局国家气候中

心负责这个网络及其国际互联网的维护和改进以及收集和更新必要信息。其他参加国和地区提供信息和数据集。

A network and its web-page (http://www.ncc.gov.cn) of the APN project (#99012, #2000-12 and #2001-12) have been set up, with their catalogues and information residing on a workstation. National Climate Center (NCC), China Meteorological Administration is responsible for maintenance and improvement of this network in the Internet, and collection and updating of the necessary information. Other participating countries/regions furnish information and data sets.

这个网络是专门为APN国家/地区设计的，它特别强调暖池和中国南海的海洋和气象条件以及ENSO事件和暖池对APN国家天气和气候（包括热带气旋和季风）的影响，这些在以前的研究中经常被忽视了。这个网络的重点是更加重视ENSO和暖池通过PJ型遥相关或EAP遥相关对东南亚和东亚的共同影响。这与COLA、CPC和IRI的重点明显不同，他们大多强调ENSO事件及其对北美洲和南美洲的不同影响。

Scientifically, a unique feature is that this network is designed for APN countries/regions, with a special emphasis placed on oceanic and meteorological conditions over Warm Pool and the South China Sea, the impact of ENSO events and SSTA of Warm Pool on the weather and climate of APN countries (including tropical cyclones and monsoon) which has been often neglected in previous studies. The highlights of this network is to pay more attention to combined effects of ENSO events and Warm Pool on Southeast Asia and East Asia, via the so-called PJ pattern teleconnection or EAP teleconnection. This is a marked difference from the focuses placed by COLA, CPC, and IRI that in most of cases stress ENSO events and their impact on North and South America.



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WARM POOL 暖池	EL NINO EVENTS 厄尔尼诺事件	STATISTICAL MODELS 统计模式
TROPICAL CONVECTION 热带对流	LA NINA EVENTS 拉尼娜事件	CLIMATE OUTLOOK 气候展望
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监 测 Monitoring

ENSO SIGNAL ENSO 信号

TIME SERIES OF SSTA INDEX IN NINO 3 + SOI + COI (PRC)
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W. PACIFIC WARM POOL AREA AND INTENSITY INDICES AND POSITION (PRC)
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TIME-LONGITUDE CROSS SECTIONS OF DEPTH OF 20C ISOTHERM AND ANOMALIES IN THE EQUATORIAL PACIFIC (JP)
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SELECTED REGIONAL SST INDICES IN THE WARM POOL AREA (MALAYSIA)

TROPICAL CONVECTION 热带对流

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MONTHLY MEAN HIGH CLOUD AMOUNT (JP)
MONTHLY MEAN VELOCITY POTENTIAL AND DIVERGENT WIND AT 850 AND 200 HPA (PRC)
MONTHLY MEAN VELOCITY POTENTIAL AT 850 AND 200 HPA (JP)

MONSOON (A supporting project- SCSMEX)
季风（南海季风试验资助项目）

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SOUTH CHINA SEA SUMMER MONSOON (PRC)
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850HPA PENTAD MEAN WIND (PRC)
200HPA PENTAD MEAN WIND(PRC)
PENTAD OLR AND OLRA(PRC)
850HPA AND 200HPA MONTHLY MEAN WINDS (AUS)
200HPA MONTHLY MEAN HEIGHT AND WIND AND ANOMALY(JP)
850HPA MONTHLY MEAN HEIGHT AND WIND AND ANOMALY(JP)
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WEATHER SYSTEMS 天气系统

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NW PACIFIC SUBTROPICAL HIGH CHARACTERIZED BY 500 HPA HEIGHT (PRC)
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TRACKS, SUMMERY AND NUMBER OF TROPICAL CYCLONES (JP)
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SST ANIMATION (PRC)
STARTING FROM 2000 ONWARD (PRC)

历史回顾 Historical View

ENSO CLASSIFICATION	ENSO 分类
EL NINO EVENTS	厄尔尼诺事件
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BMRC ENSO MODEL (AUS)
JMA EL NINO PREDICTION MODEL (JP)
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NCC/STI MODEL (PRC)

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ANALOGUE PREDICTION (PRC)
OPTIMUM FILTER ASSEMBLY (PRC)
ENSEMBLE OF MULTI-STATISTICAL MODEL FORECAST (PRC)

CLIMATE OUTLOOK 气候展望

PHILIPPINES
AUSTRALIA
MALAYSIA
KOREA

TYPHOON OUTLOOK 台风展望

TOTAL NUMBER OF NW PACIFIC TYPHOON (HK)
TOTAL NEMBER OF TYPHOONS IN PHILIPPINE AREA OF RESPONSIBILITY (PHILIPPINES)
TOTAL NUMBER OF NW PACIFIC TYPHOON (PRC)

数字资料 Digital Data

JAPAN: SST data; Nino 3 SST index
CHINA: General atmosphere circulation index (diagnose@rays.cma.gov.cn);
Pre-summer rainfall and assimilated atmospheric data (jsxue@grmc.gov.cn)
PHILIPPINES: Mean sea level pressure, temperatures, rainfalls and tropical cyclones (natcruz@philonline.com.ph)
AUSTRALIA: Long-term SOI and SLP of Darwin and Tahiti; SST (p.bate@bom.gov.au)
MALAYSIA: Rainfalls
VIETNAM: Rainfalls,tropical cyclone, disasters caused by ENSO events (nkhieu@imh.ac.vn)
INDONESIA: Rainfalls; data of 11 stations (tien@bppt.go.id)

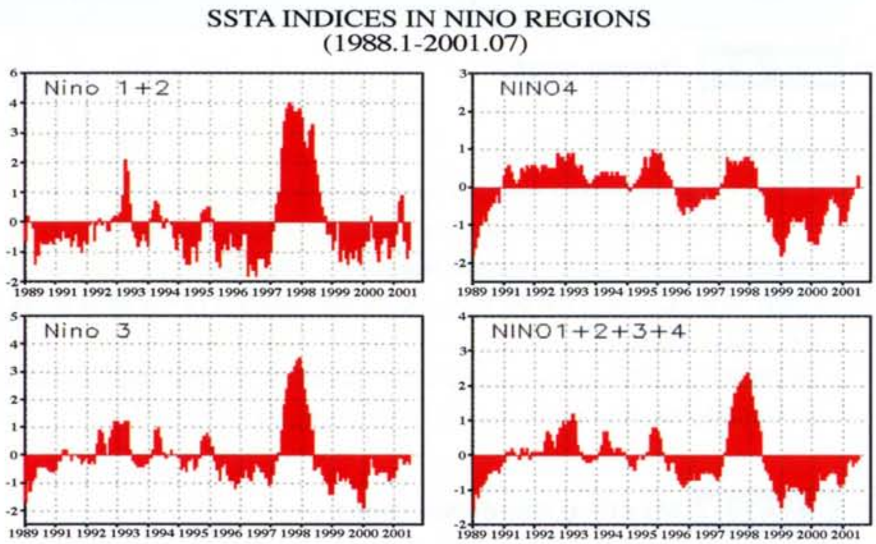
会议公告 Meeting Announcement

ENSO 的监测
MONITORING OF ENSO

一个能够监测和预测ENSO事件和暖池SSTA、能交换有关数据的分布式的网络已经在国家气候中心的二级网页建立起来，通过这个网用户可以链接参加这个项目的每个国家和地区的网页。项目网络页面中包括许多独特的、不同于在其它网页上易于得到的信息。例如，暖池和中国南海附近的监测资料，夏季风建立的预报，季风降水分布的预报，西太平洋热带气旋的发生频率和路径，APN地区的极端天气、气候事件。项目参加国的科学家利用各种方法和技术监测和预报太平洋地区的变化及它们对全球天气的影响。

A distributed network being able to monitor and predict ENSO events and SSTA over Warm Pool and to exchange related data sets has been set up at the second level of the homepage of National Climate Center of China, through which users are able to link to the homepage of each country and region participating at this project. Among the components of the project network, lots of information are unique and different from the existing information easily accessible to users from other networks, for example, the monitoring data around the warm pool and South China Sea, the prediction of summer monsoon onset; the predicted monsoon rainfall distributions, the frequency of occurrence and tracks of tropical cyclones in western Pacific Ocean, and extreme weather and climate events in this region. Scientists from the participated country use a variety of tools and techniques to monitor and forecast changes in the Pacific Ocean and the impact of those changes on global weather patterns.

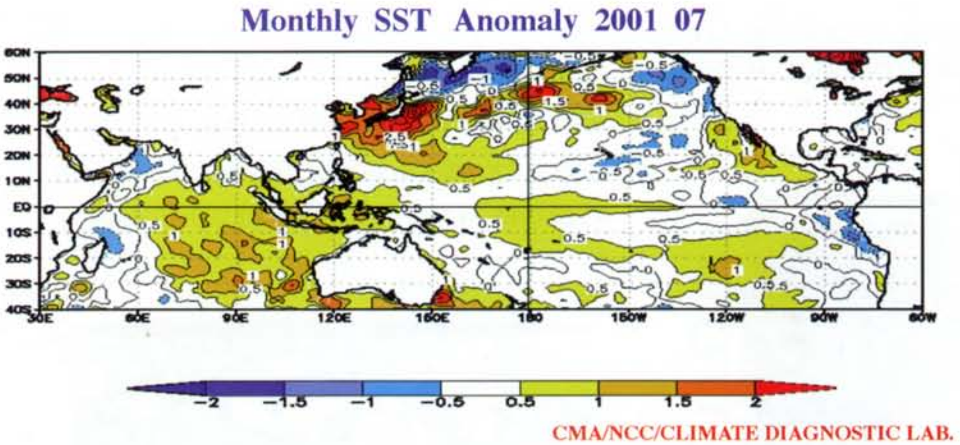
各区异常海表面温度指数（中国）
SSTA INDICES IN DIFFERENT NINO REGIONS (PRC)

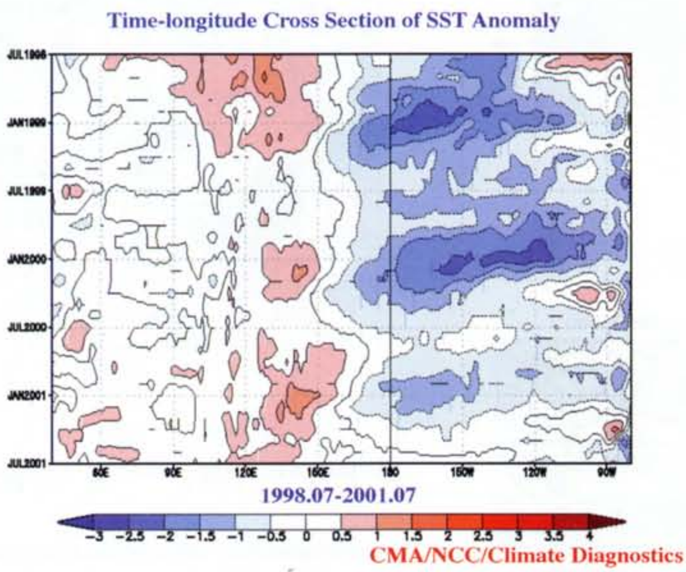


CMA/NCC/CLIMATE DIAGNOSTIC LAB.

月平均热带海洋海表面温度距平分布（中国）

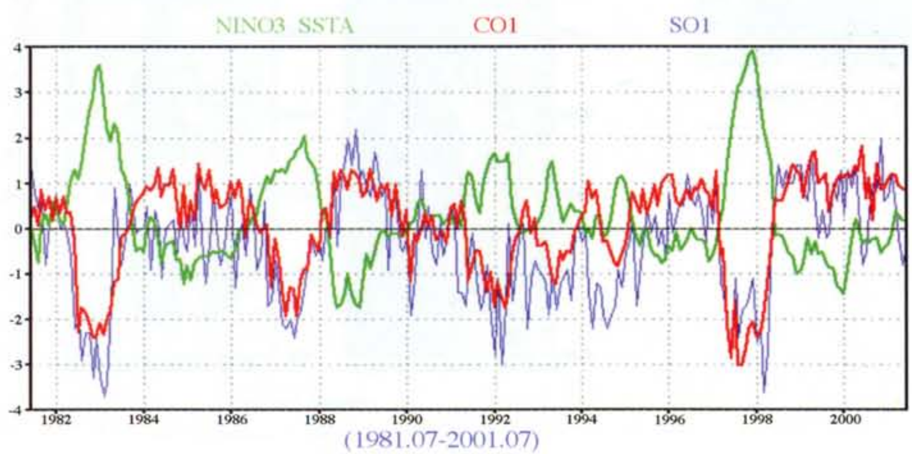
MONTHLY TROPICAL OCEAN SSTA DISTRIBUTION (PRC, JP, AUS)





赤道太平洋尼诺3区海表面温度距平、南方涛动指数和对流活动振荡指数的时间序列（中国）

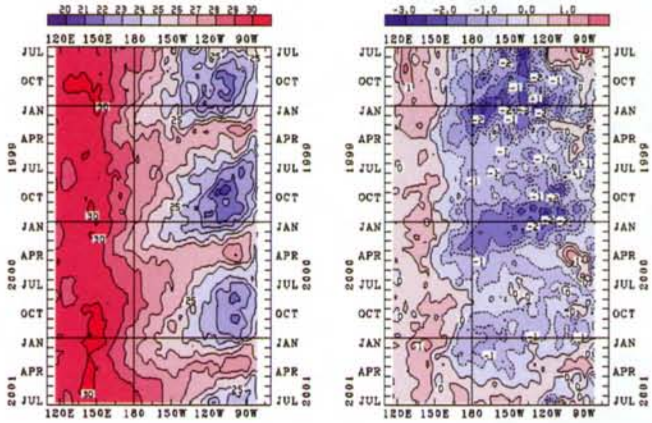
TIME SERIES OF SSTA INDEX IN NINO 3 + SOI + COI (PRC)



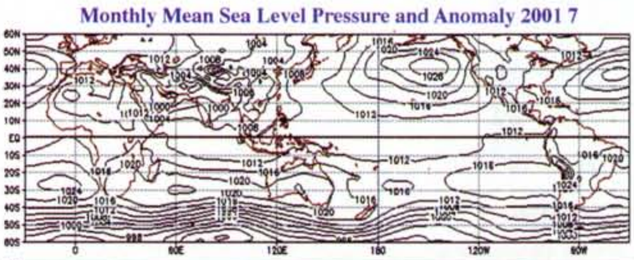
Equatorial Pacific sea surface temperature anomaly index averaged over the area for NINO3 region 90W-150W, 5N-5S(green) COI: Convective activities oscillation index over equatorial Pacific (red), COI=standardized (standized (ECI)-standized (WI)), ECI means OLR anomaly index over the equatorial eastern and central pacific(5N-5S,170E-90W)and WI means OLR anomaly index over the equatorial western pacific (5N-5S,110E-140E).Anomalies are departure from the 1979-1998 base period means. SOI=standardized(standardized(SLPA(TAHTI)-standized (SLPA(DARWIN))

沿赤道热带太平洋海表面温度（左）和距平（右）的时间－经度剖面图（日本）

TIME-LONGITUDE CROSS SECTIONS OF SEA SURFACE TEMPERATURE (LEFT) AND ANOMALIES(RIGHT) ALONG THE EQUATOR IN THE PACIFIC OCEAN(JP)

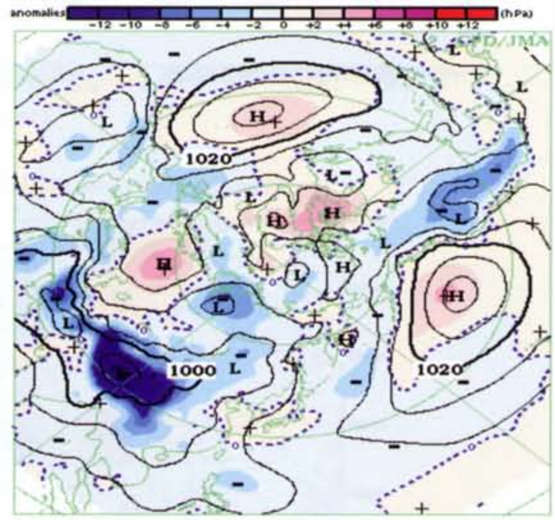


2001 年 7 月的月平均海平面气压（上）和距平（下）（中国）

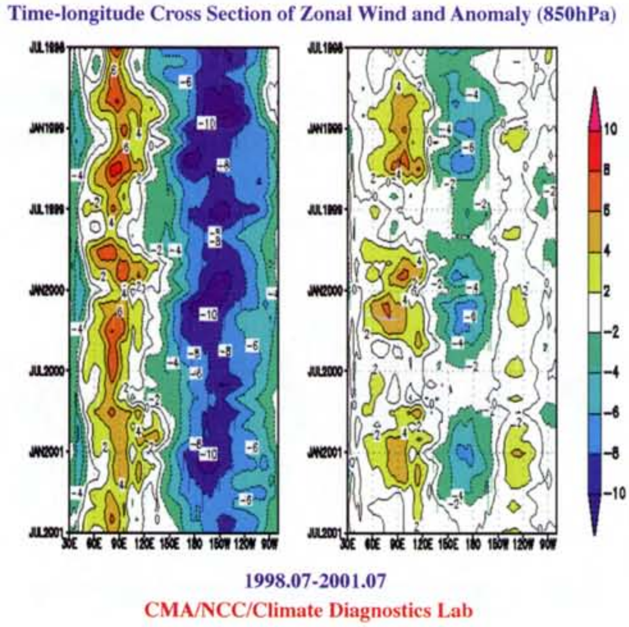


北半球月平均海平面气压和距平（日本）

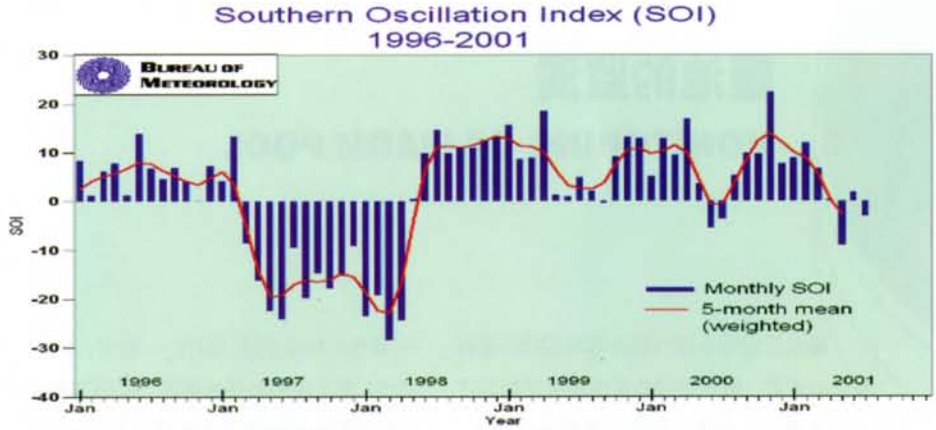
MONTHLY MEAN SEA LEVEL PRESSURE AND ANOMALY IN THE NORTHERN HEMISPHERE(JP)



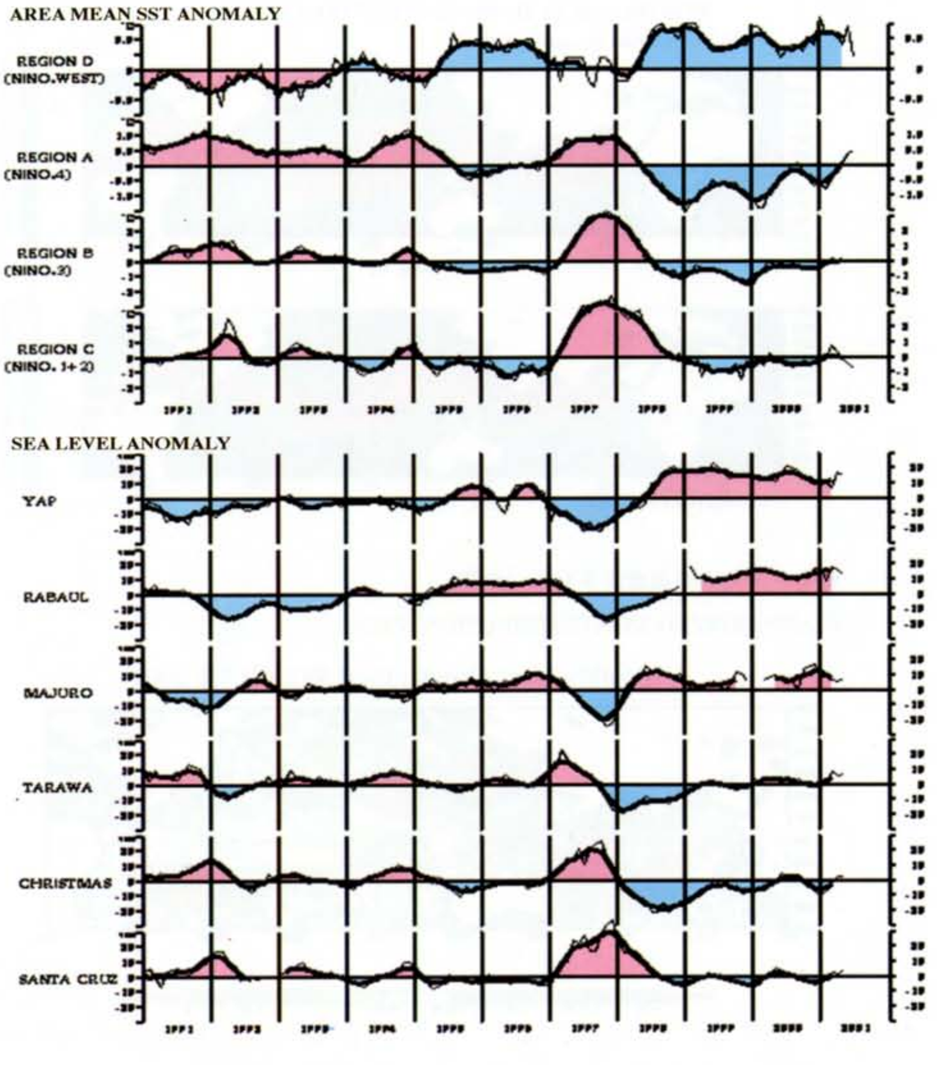
850 百帕纬向风和距平的时间—经度剖面图(中国)



南方涛动指数（澳大利亚）



尼诺3区ENSO指数、海平面高度、南方涛动指数、高云量和纬向风的时间序列（日本）
TIME SERIES OF ENSO INDICES FOR NINO.3, SEA LEVEL, SOI, HIGH CLOUD AMOUNT AND ZONAL WIND (JP)

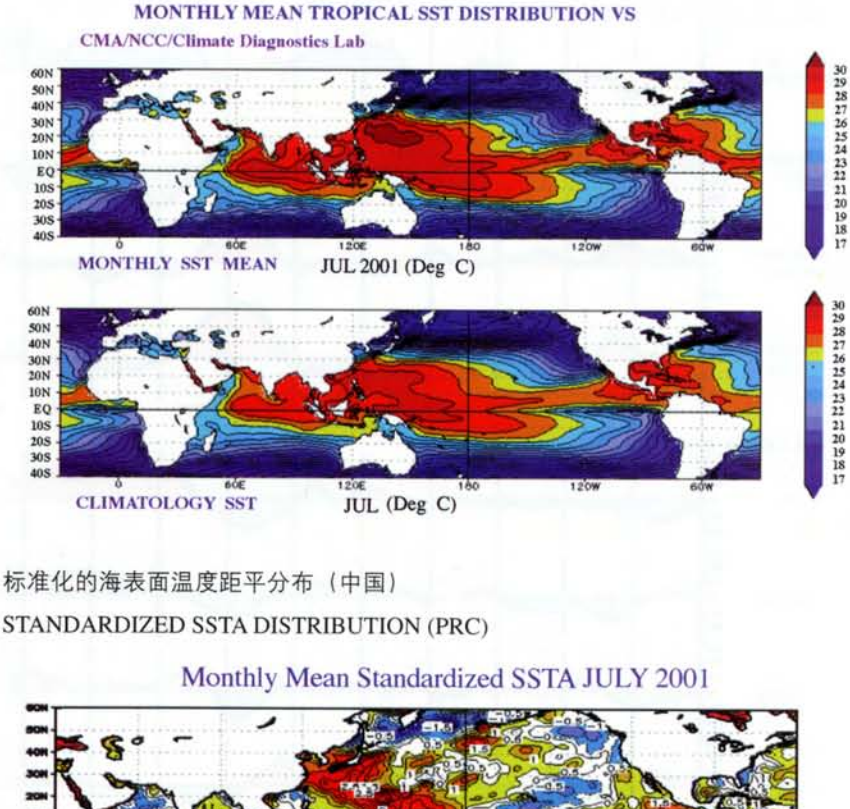


暖池的监测

MONITORING OF WARM POOL

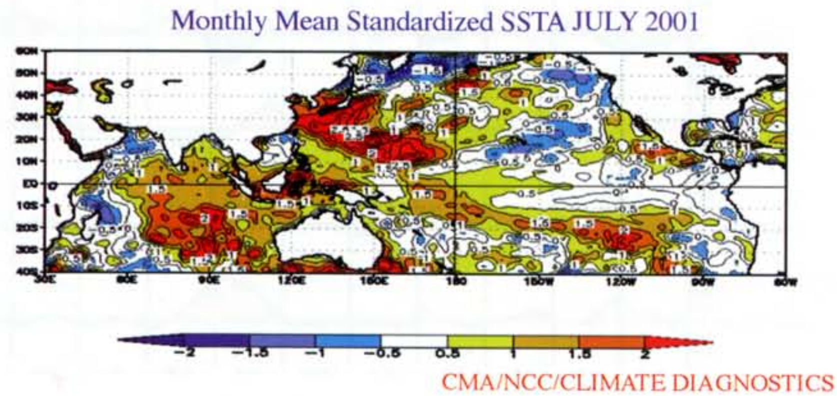
暖池异常对中国气候异常与ENSO循环也十分重要。研究表明热带西太平洋的SST年际变率小，但暖池的覆盖范围变化较大。据此，按照SST(28℃包围的面积和累积值研制了热带西太平洋（120°E－180°E，30°N－30°S）和印度洋（41°E－98°E，30°N－30°S）暖池面积和强度指数、用SST(26℃包围的面积和累积值作为赤道东太平洋(120°E－80°W，10°N－10°S)冷舌面积和强度指数等新的监测指标。

2001年7月（上）和多年平均（下）月平均热带海表面温度分布（中国）

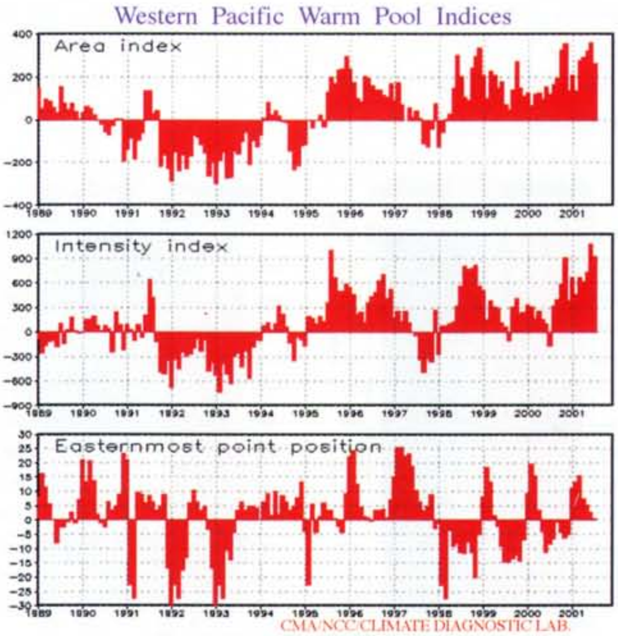


标准化的海表面温度距平分布（中国）

STANDARDIZED SSTA DISTRIBUTION (PRC)



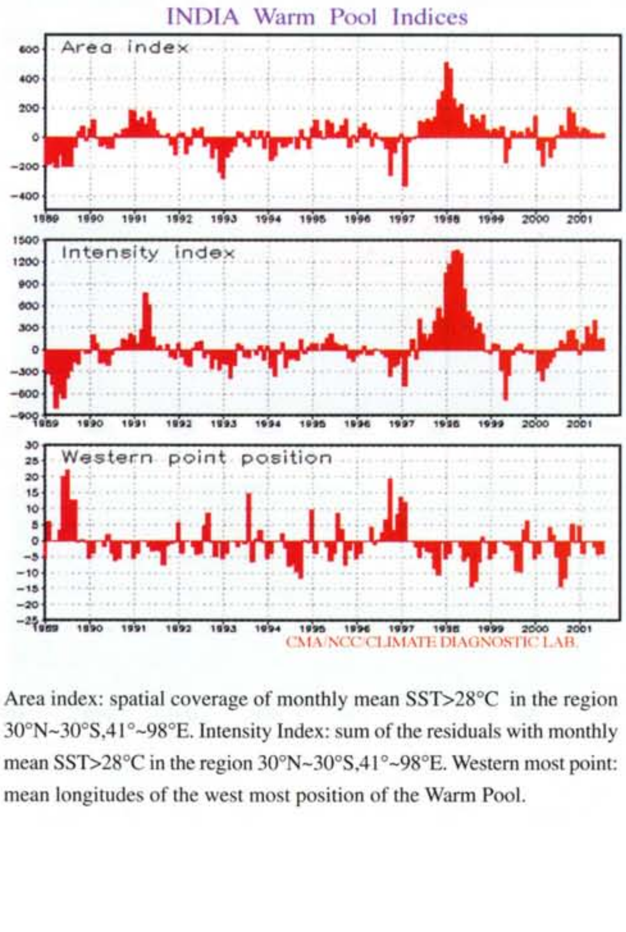
西太平洋暖池的面积、强度和位置指数（中国）
W. PACIFIC WARM POOL AREA AND INTENSITY INDICES AND POSITION (PRC)



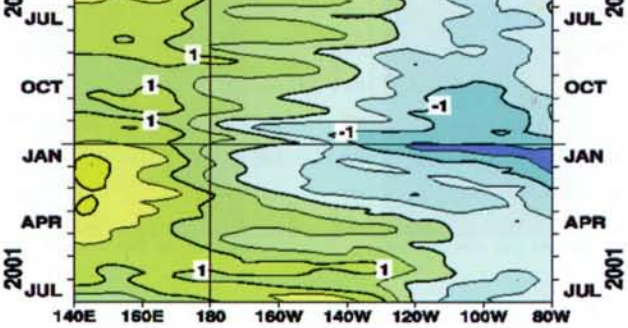
Area index: spatial coverage of monthly mean SST >28°C in the region 30°N~30°S,120°E~180°. Intensity Index: sum of the residuals with monthly mean SST>28°C in the region 30N°~30°S, 120°E~180°. East most point: mean longitudes of east most position of the Pacific Warm Pool.

印度洋暖池的面积、强度和位置指数（中国）

INDIAN OCEAN WARM POOL AREA AND INTENSITY INDICES AND POSITION (PRC)



Area index: spatial coverage of monthly mean SST>28°C in the region 30°N~30°S,41°~98°E. Intensity Index: sum of the residuals with monthly mean SST>28°C in the region 30°N~30°S,41°~98°E. Western most point: mean longitudes of the west most position of the Warm Pool.

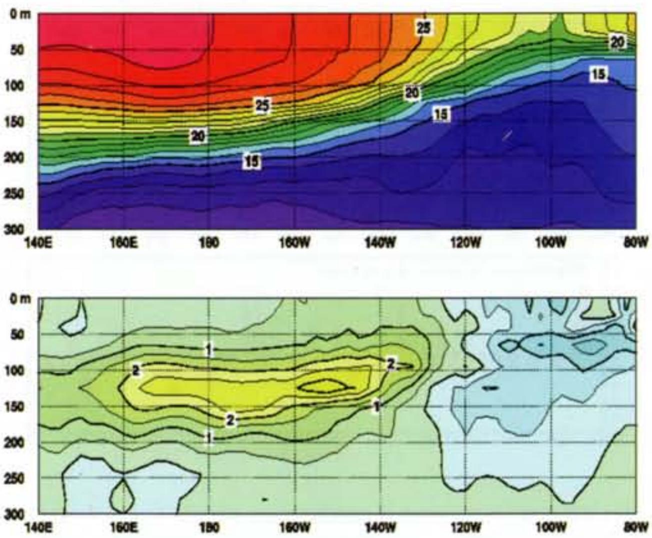


沿赤道热带太平洋热含量距平时间－经度剖面图（日本）

TIME-LONGITUDE CROSS SECTION OF OCEAN HEAT CONTENT (OHC; VERTICALLY AVERAGED TEMPERATURE IN THE TOP 260M) ANOMALIES ALONG THE EQUATOR IN THE PACIFIC OCEAN BY ODAS. BASE PERIOD FOR NORMAL IS 1987-1999. (JP)

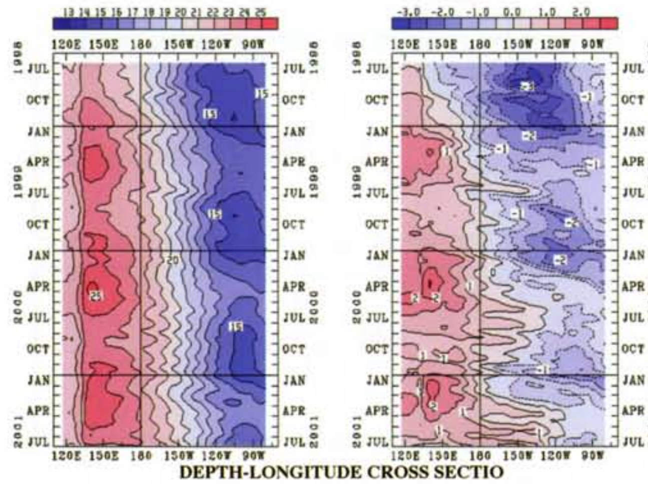
沿赤道热带太平洋温度（上）和距平深度（下）－经度剖面图（日本）

DEPTH-LONGITUDE CROSS SECTIONS OF TEMPERATURE (TOP) AND ANOMALIES (BOTTOM) ALONG THE EQUATOR IN THE PACIFIC OCEAN BY ODAS. BASE PERIOD FOR NORMAL IS 1987-1999 (JP)



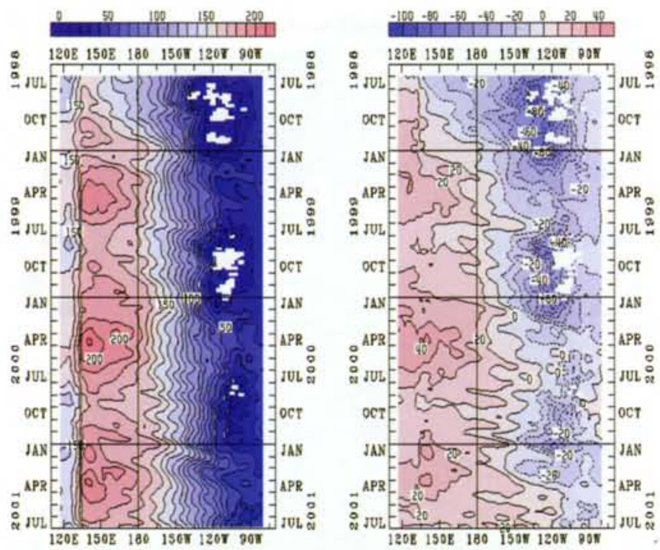
赤道太平洋上层 260 米海洋含量（左）和距平（右）的时间一经度剖面图（日本）

TIME-LONGITUDE CROSS SECTIONS OF OCEAN HEAT CONTENT (LEFT) AND ANOMALIES(RIGHT) IN THE UPPER 260m ALONG THE EQUATOR IN THE PACIFIC OCEAN BY ODAS(JP)



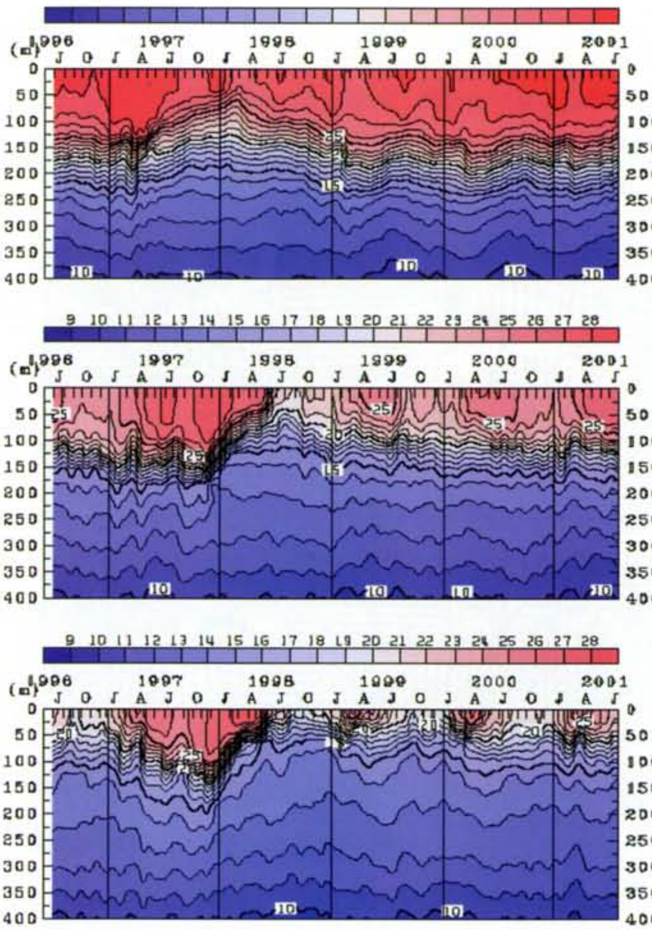
赤道太平洋 20° C 等温线深度（左）和距平（右）时间－经度剖面图（日本）

TIME-LONGITUDE CROSS SECTIONS OF DEPTH OF THE 20°C ISOTHERM (LEFT) AND ANOMALIES (RIGHT) ALONG THE EQUATOR IN THE PACIFIC OCEAN BY ODAS (JP)



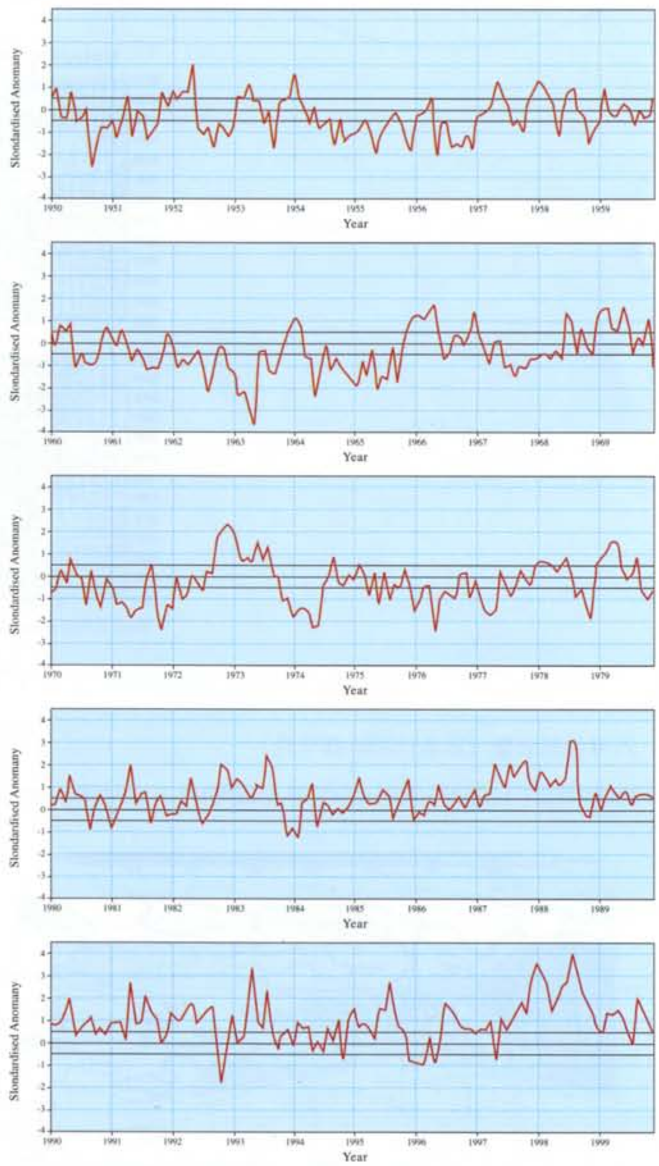
赤道西太平洋（上，160°E）、中太平洋（中，140°W）和东太平洋（下，110°W）的次表层温度深度－经度剖面图（日本）

DEPTH-LONGITUDE CROSS SECTIONS OF EQUATORIAL SUBSURFACE TEMPERATURE FOR THE WESTERN PACIFIC (TOP, 160°E), THE CENTRAL PACIFIC (MIDDLE, 140°W), AND THE EASTERN PACIFIC (BOTTOM, 110°W) BY ODAS



中国南海区域平均海表面温度标准化距平时间序列（马来西亚）

TIME CROSS-SECTION OF THE MONTHLY STANDARDIZED ANOMALY OF THE AREA-AVERAGEG SEA SURFACE TEMPERATURE OVER THE SOUTH CHINA SEA (LATITUDE : 3°N TO 8°N; LONGITUDE : 106°E TO 111°E)
[DATA SOURCE: JAPAN METEOROLOGICAL AGENCY]

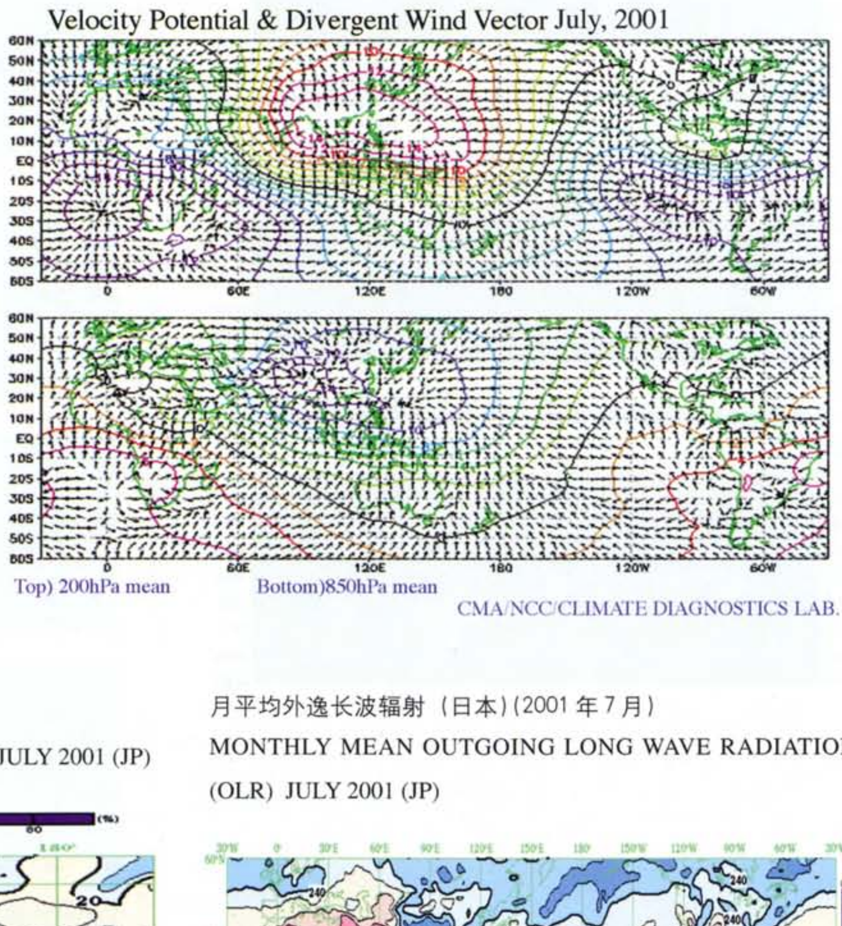


热带对流监测

MONITORING OF TROPICAL CONVECTION

850 百帕和 200 百帕月平均速度势和散度风 （中国）(2001 年 7 月）

MONTHLY MEAN VELOCITY POTENTIAL AND DIVERGENT WIND AT 850 AND 200 HPA (PRC) (JULY, 2001)



月平均高云量 （日本）(2001 年 7 月）

MONTHLY MEAN HIGH CLOUD AMOUNT JULY 2001 (JP)

月平均外逸长波辐射 （日本）(2001 年 7 月）

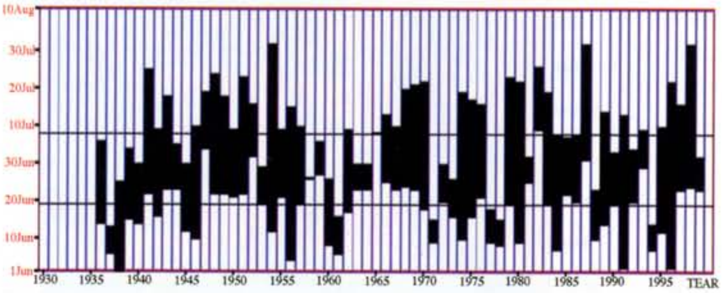
MONTHLY MEAN OUTGOING LONG WAVE RADIATION (OLR) JULY 2001 (JP)

季风监测

MONITORING OF MONSOON (Supported by project- SCSMEX)

中国南海夏季风指数（中国）

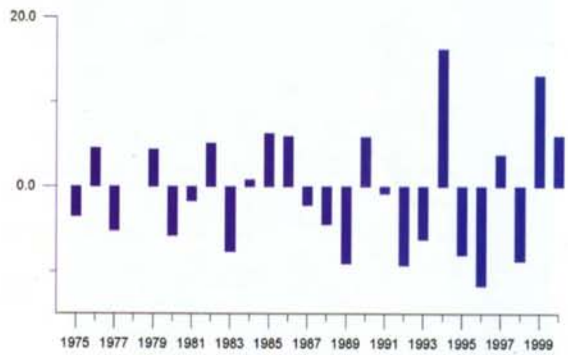
SOUTH CHINA SEA (S.C.S) SUMMER MONSOON (PRC)



Onset and Retreat Dates Evolution for Meiyu in the Mid-lower Reaches of the Yangtze River. The length of the black bar represents the duration of Meiyu, with the bottom end reflecting the onset date and the top end reflecting the retreat date. Two black lines indication the mean onset date and retreat date of the Meiyu (Climatological mean refer to 30 years average during 1961-1900).

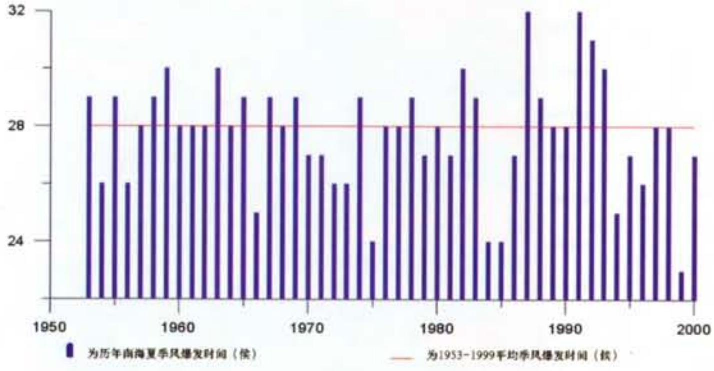
南海夏季风强度指数（中国）

EVOLUTION OF S.C.S SUMMER MONSOON INTENSITY INDEX (1975-2000) (PRC)



中国南海夏季风爆发时间演变图（中国）

EVOLUTION OF ONSET TIME OF S.C.S SUMMER MONSOON (1953-2000) (PRC)



Blue bar means onset time of S.C.S summer monsoon from 1953 to 2000; red solid line means averaged onset time (pentad);y-axes means time (unit:5-day)

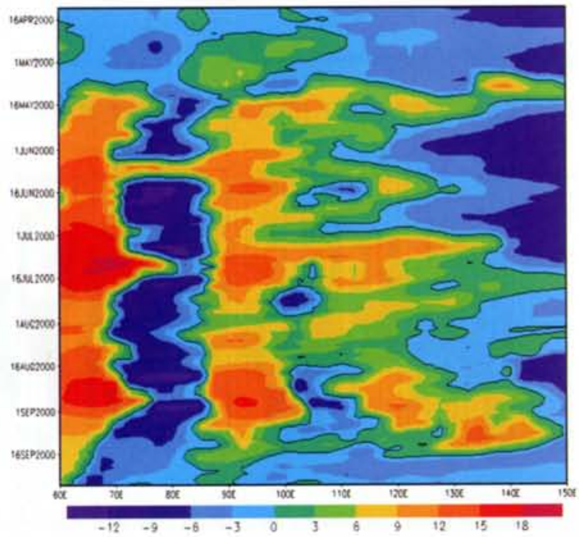
中国南海夏季风建立时间和指数(中国)

ONSET TIME AND INDEX OF SOUTH CHINA SEA SUMMER MONSOON (PRC)

Year	Onset time (pentad)	Index
1953	The 5th of May	
1954	The 2nd of May; The 1st of Jun	
1955	The 5th of May	
1956	The 2nd of May; The 4th of May	
1957	The 4th of May	
1958	The 5th of May	
1959	The 6th of May	
1960	The 4th of May	
1961	The 4th of May	
1962	The 4th of May	
1963	The 6th of May	
1964	The 4th of May	
1965	The 5th of May	
1966	The 1st of May	
1967	The 5th of May	
1968	The 4th of May	
1969	The 5th of May	
1970	The 3rd of May; The 2nd of Jun	
1971	The 3rd of May; The 1st of Jun	
1972	The 2nd of May	
1973	The 2nd of May; The 2nd of Jun	
1974	The 5th of May	
1975	The 3rd of May	34.5
1976	The 4th of May	38.9
1977	The 4th of May	29.0
1978	The 5th of May	
1979	The 3rd of May	38.0
1980	The 4th of May	28.4
1981	The 3rd of May; The 1st of Jun	34.8
1982	The 6th of May	41.0
1983	The 5th of May	28.0
1984	The 6th of Apr; The 6th of May	35.7
1985	The 5th of Apr; The 6th of May	42.4
1986	The 3rd of May	42.3
1987	The 2nd of Jun	35.4
1988	The 5th of May	31.6
1989	The 4th of May	25.6
1990	The 4th of May	42.4
1991	The 2nd of Jun	36.3
1992	The 4th of May	25.6
1993	The 6th of May	32.0
1994	The 1st of May	52.0
1995	The 3rd of May	30.1
1996	The 2nd of May	24.0
1997	The 4th of May	39.7
1998	The 4th of May	41.6
1999	The 5th of Apr; The 5th of May	50.6
2000	The 3rd of May	

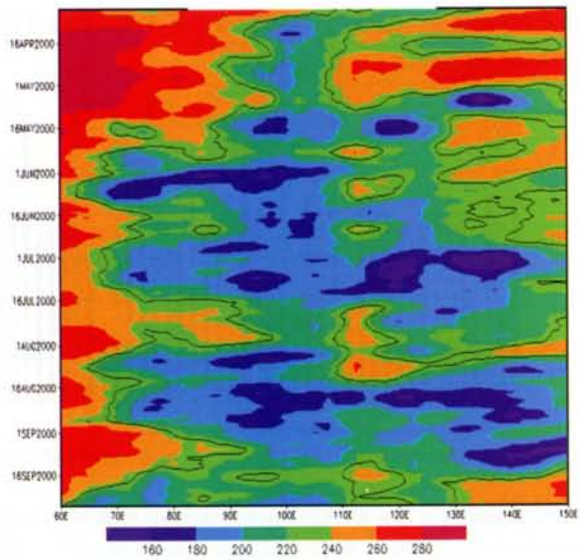
850百帕3天滑动平均西南风时间－经度(7.5－17.5N)剖面图(中国)

TIME-LONGTITUDE CROSS-SECTION OF 3 DAYS RUNNING AVERAGED SOUTHWESTERLIES (PRC)



3天滑动平均外逸长波辐射时间－经度(7.5－17.5N)剖面图(中国)

TIME-LONGTITUDE CROSS-SECTION OF 3 DAYS RUNNING AVERAGED OLR (PRC)



统一季风指数（香港）

UNIFIED MONSOON INDEX (HK)

The Unified Monsoon Index, which is defined as the difference in the meridional winds between 1000 and 200 hPa. Please see the details in the Lu and Chan paper (Lu, E. and J. C. L. Chan, 1999: A unified monsoon index for South China. J. Climate, 12, 2375-2385.

V-wind (1000-200 hPa); 7.5-20.0N ,107.5-120E; u wind

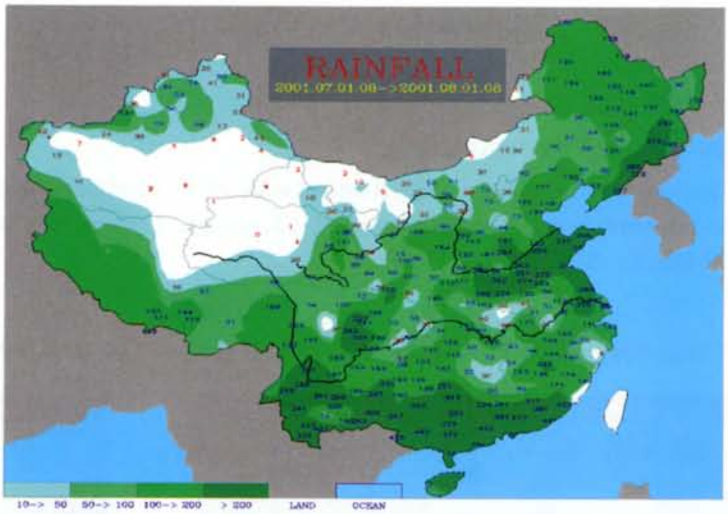
Year	APR	MAY	JUN	JUL	AUG	SEP
1948	2.12	3.07	7.23	6.98	6.04	3.95
1949	-5.51	.80	6.77	4.88	5.68	3.54
1950	-2.73	3.21	6.03	7.16	5.43	3.64
1951	.04	3.69	6.85	5.47	7.84	1.88
1952	1.42	4.68	6.00	7.50	7.54	5.43
1953	-3.47	4.28	5.84	6.89	7.14	6.06
1954	1.00	3.22	6.86	6.93	7.21	5.66
1955	-1.16	4.17	7.69	8.55	5.56	2.86
1956	-1.26	4.32	6.79	5.22	7.02	6.70
1957	-2.44	3.60	6.28	6.19	6.38	4.06
1958	-2.55	4.95	6.57	7.91	5.30	6.18
1959	-1.52	2.20	6.31	6.13	7.18	4.16
1960	-2.64	4.15	7.43	4.00	8.55	4.97
1961	-1.93	5.53	4.97	8.70	8.57	7.10
1962	-1.72	5.82	8.77	8.00	5.43	5.95
1963	-3.08	2.85	6.74	7.89	5.05	5.58
1964	1.22	3.79	6.03	4.40	6.83	4.45
1965	-1.47	3.90	7.56	7.09	4.41	4.33
1966	.80	4.68	6.97	6.70	4.95	.92
1967	-2.19	7.45	6.57	7.16	8.49	5.23
1968	-.49	4.50	6.95	6.64	8.42	5.14
1969	.75	5.99	7.32	7.71	5.50	3.33
1970	-2.63	5.59	5.99	6.25	6.56	5.39
1971	-4.64	4.72	8.06	6.10	6.66	4.39
1972	-.28	5.36	6.45	8.87	8.36	2.52
1973	3.04	5.03	6.31	7.31	6.48	5.24
1974	-2.17	2.01	6.46	5.70	6.13	2.75
1975	-.30	5.88	8.44	6.01	8.22	2.21
1976	-1.30	5.67	8.11	8.11	5.94	4.58
1977	-1.76	4.57	6.94	6.33	5.96	3.49
1978	-2.61	5.16	7.28	4.38	6.85	4.71
1979	.48	4.10	8.06	5.89	8.07	3.64
1980	1.17	3.13	5.31	7.82	6.95	4.51
1981	-.44	3.60	6.48	6.42	8.18	3.12
1982	-1.49	4.54	7.14	8.36	7.75	6.03
1983	1.02	6.23	6.75	6.50	6.72	4.09
1984	3.29	3.23	7.20	5.13	8.13	2.93
1985	-.39	3.44	8.51	4.43	8.38	3.15
1986	-4.21	5.72	6.90	6.23	5.93	3.04
1987	-.88	5.78	6.75	8.26	5.80	3.67
1988	-.66	4.91	6.03	4.86	6.49	2.93
1989	-.67	2.81	5.50	6.22	6.12	5.02
1990	.65	2.98	7.30	5.41	5.64	4.45
1991	.19	1.44	7.07	7.72	6.14	4.41
1992	.22	3.64	6.61	5.72	5.87	3.91
1993	-3.91	5.28	7.22	7.63	8.16	4.09
1994	-1.25	4.96	8.42	9.18	8.05	5.17
1995	-3.49	5.14	7.11	7.23	6.60	3.26
1996	-3.06	3.15	5.48	7.13	5.55	3.79
1997	-2.96	5.62	6.58	8.16	9.06	4.17
1998	1.89	7.46	8.33	6.34	5.34	4.17
1999	-.15	3.94	6.60	8.78	7.75	4.09

V-wind 1000 hPa; 7.5-20.0N ,107.5-120E

Year	APR	MAY	JUN	JUL	AUG	SEP
1948	1.19	2.15	4.54	3.82	3.14	1.68
1949	-.17	1.06	3.74	2.95	3.28	1.62
1950	.25	1.81	3.80	4.47	3.79	1.77
1951	1.43	2.47	4.02	3.17	4.55	1.10
1952	1.18	2.35	4.04	4.76	3.47	2.57
1953	.05	2.94	3.54	3.92	3.90	2.97
1954	1.23	1.60	3.90	3.75	3.68	2.81
1955	-.31	2.21	3.77	4.29	3.00	1.20
1956	.28	2.40	3.22	3.26	3.52	3.00
1957	.17	2.96	3.41	3.01	3.22	1.10
1958	-.04	2.06	3.51	4.03	1.96	2.26
1959	.32	.99	3.63	3.49	4.16	1.82
1960	-.46	1.59	4.09	2.43	4.48	1.44
1961	.10	1.58	3.50	4.68	3.81	2.91
1962	-.52	1.92	4.29	4.02	2.73	2.26
1963	-.69	1.38	3.66	4.14	3.09	2.53
1964	-.43	1.20	3.48	2.50	4.00	1.69
1965	.71	1.58	4.15	4.11	2.26	1.74
1966	.93	1.82	3.65	3.49	2.94	.08
1967	-.32	2.46	4.06	3.84	4.64	1.86
1968	-1.80	2.21	3.48	3.95	4.29	1.49
1969	-.46	2.16	3.42	3.90	2.35	1.05
1970	-1.44	1.75	2.80	3.85	3.44	2.02
1971	-1.44	.85	4.07	3.75	2.61	1.41
1972	-.63	3.17	3.82	5.09	4.16	.55
1973	1.45	2.01	3.49	3.97	3.41	1.32
1974	-.75	1.30	3.88	3.47	3.77	.91
1975	.02	1.88	4.18	2.79	4.49	.92
1976	.04	1.56	3.64	4.19	2.91	2.05
1977	-.15	1.97	3.99	3.62	3.71	1.31
1978	.13	1.20	3.06	2.88	4.03	1.87
1979	-.41	1.95	2.69	3.38	3.89	.71
1980	-.05	1.54	2.04	3.41	3.52	.98
1981	.39	.67	3.27	3.24	4.04	.75
1982	-1.26	1.06	3.25	4.12	3.48	1.64
1983	1.26	2.37	3.25	3.01	3.18	.85
1984	.67	1.40	4.02	2.90	3.94	.50
1985	-.92	.71	4.31	2.70	4.41	.95
1986	-.86	2.27	3.56	3.41	2.70	.52
1987	-.44	1.46	3.13	4.13	2.53	.36
1988	-1.37	1.84	3.29	2.78	3.07	.67
1989	.17	1.21	2.59	2.67	3.26	1.32
1990	.41	.61	3.62	3.37	3.52	1.75
1991	-.75	.43	3.00	3.81	3.46	1.57
1992	1.24	1.72	3.25	2.88	3.41	1.78
1993	-.15	1.62	3.97	3.99	3.68	1.57
1994	.03	1.97	3.92	4.57	4.04	1.42
1995	-.09	1.50	3.83	3.43	2.93	.96
1996	-1.32	1.25	2.40	3.28	2.99	1.48
1997	-.23	2.33	3.81	3.56	4.93	.76
1998	.71	1.53	3.90	3.36	2.25	1.60
1999	.30	.95	3.31	4.68	3.37	1.62

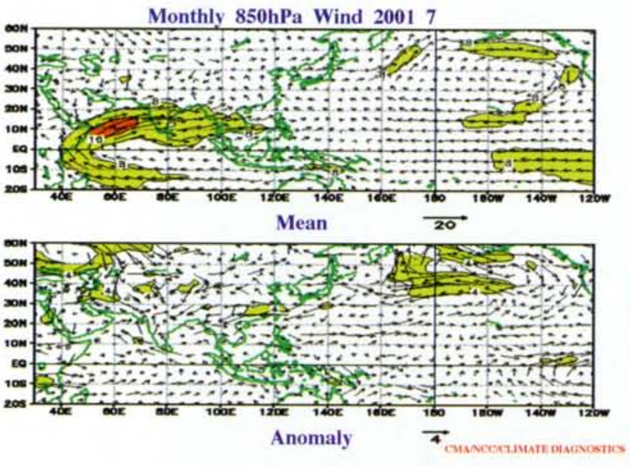
中国月降水量实况（中国・2001 年 7 月）

OBSERVD PRECIPITATION PATTERN FOR JULY, 2001



850 百帕和 200 百帕月平均风和距平（中国）(2001 年 7 月)

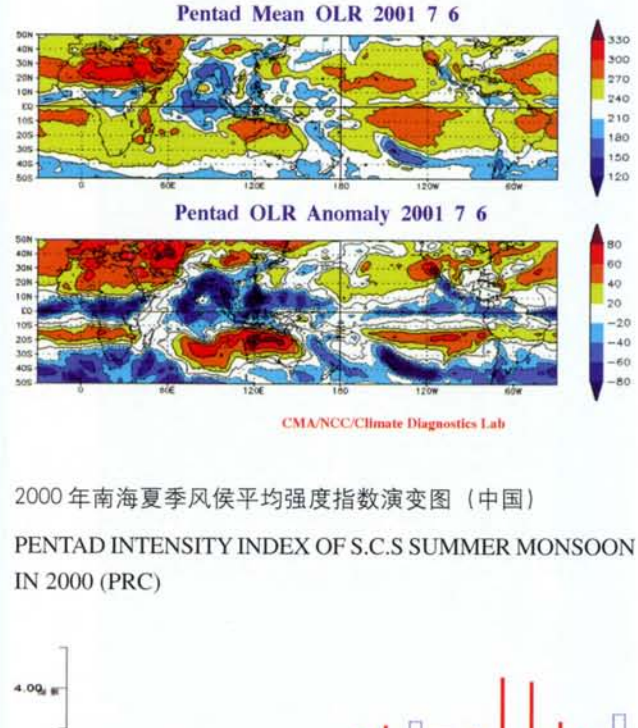
850HP AND 200HPA MONTHLY MEAN WIND AND ANOMALY (PRC) (JULY, 2001)



侯平均外逸长波辐射及其距平（中国）(2001 年 7 月第 6 候)

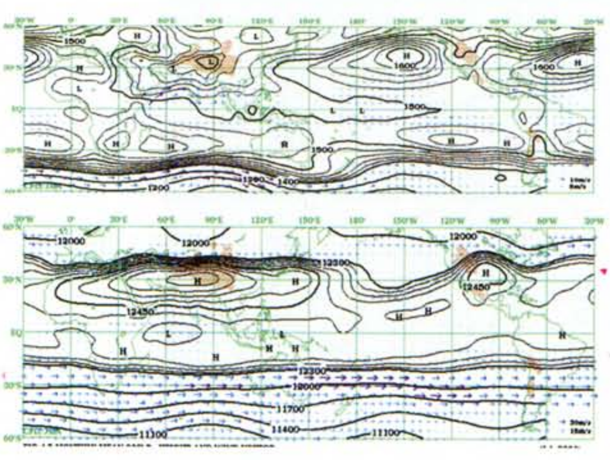
PENTAD OLR AND OLR ANOMALY (PRC)

Pentad OLR anomalies are departures from the 1979-1998 monthly means. (6th pentad of July, 2001)



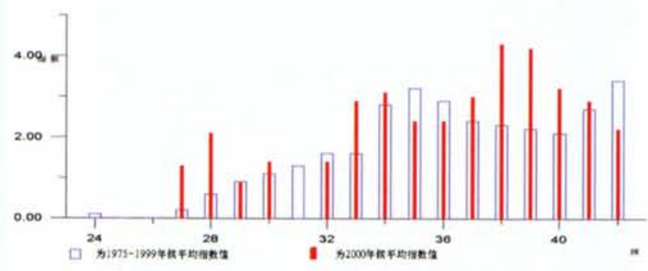
850 百帕和 200 百帕高度场和风矢量场（日本）(2001 年 7 月)

MONTHLY MEAN 850hPa (top) and 200hPa (bottom) HEIGHT AND WIND VECTOR JULY, 2001 (JP)



2000 年南海夏季风侯平均强度指数演变图（中国）

PENTAD INTENSITY INDEX OF S.C.S SUMMER MONSOON IN 2000 (PRC)

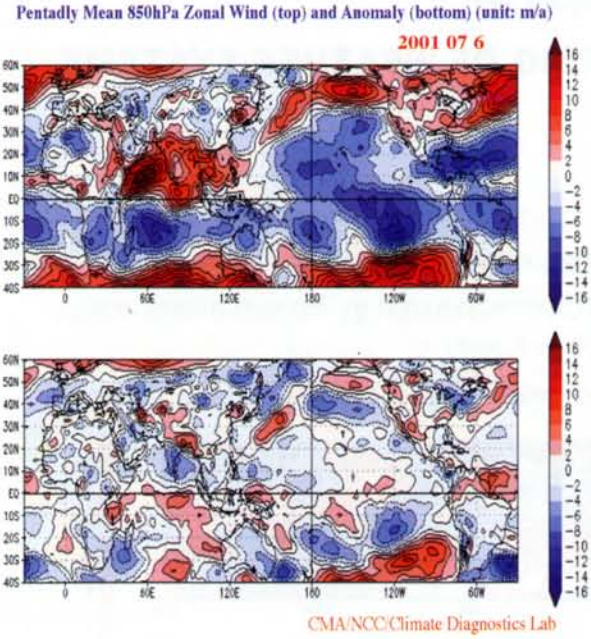


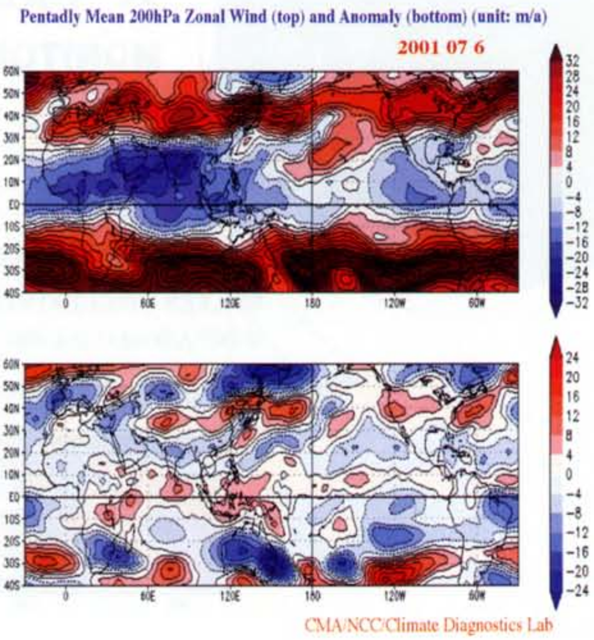
X-axes means time (unit:5 day), Y-axes means intensity; blue pane means 5-day averaged intensity from 1975 to 1999; read bar means 5-day average intensity in 2000

850百帕（左）和200百帕（右）侯平均风及其距平（中国）(2001年7月第6候)

850hPa (LEFT) AND 200hPa (RIGHT) PENTAD MEAN (TOP) AND ANOMALOUS (BOTTOM) WIND

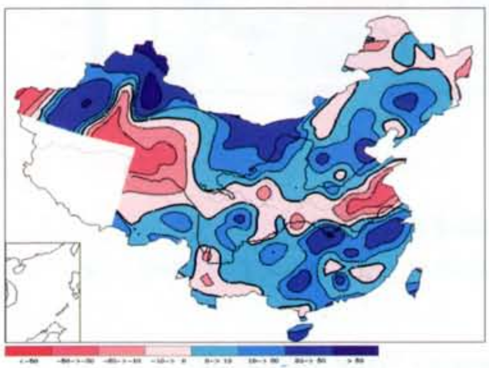
Pentad 850-hPa and 200-hPa zonal winds are departures from the 1979-1995 base period monthly means. (6th pentad of July, 2001)





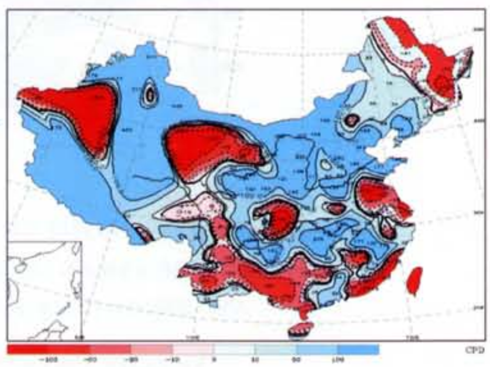
厄尔尼诺次年夏季中国降水距平百分率

PERCENTAGE OF RAINFALL ANOMALY OVER CHINA IN THE SUMMER OF THE YEAR NEXT EL NINO



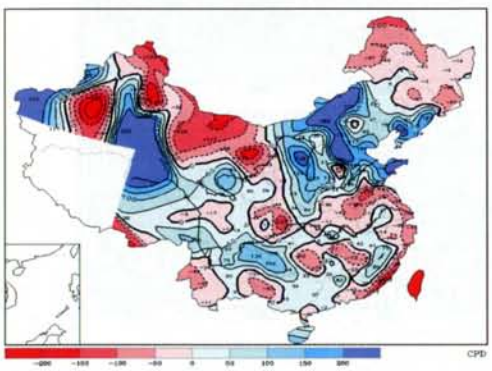
拉尼娜当年夏季中国降水距平百分率

PERCENTAGE OF RAINFALL ANOMALY OVER CHINA IN THE SUMMER OF LA NINA ONSET YEAR



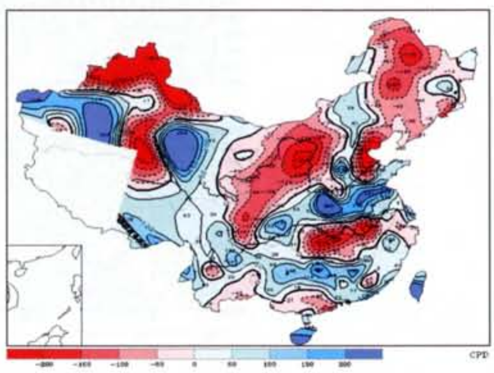
拉尼娜年夏季中国降水距平百分率

PERCENTAGE OF RAINFALL ANOMALY OVER CHINA IN SUMMER OF LA NINA YEAR



拉尼娜次年夏季中国降水距平百分率

PERCENTAGE OF RAINFALL ANOMALY OVER CHINA IN THE SUMMER OF THE YEAR NEXT LA NINA

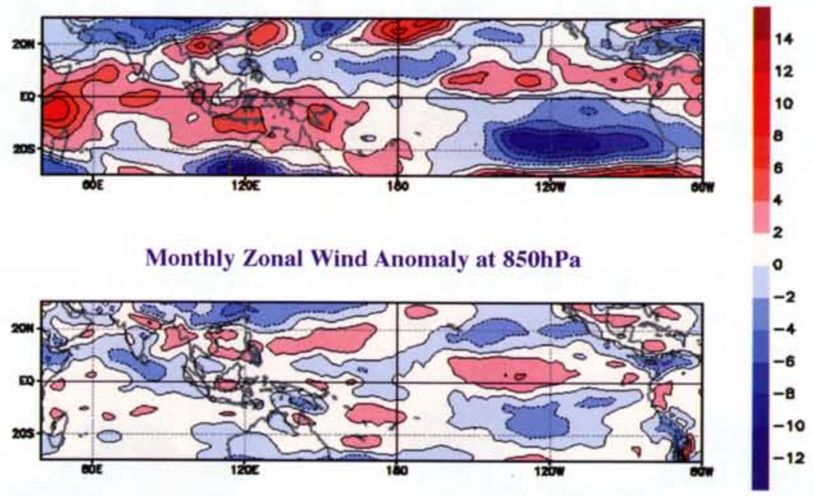


天气系统监测

MONITORING OF WEATHER SYSTEMS

850 百帕和 200 百帕纬向风距平代表的沃克环流（中国）(2001 年 7 月)

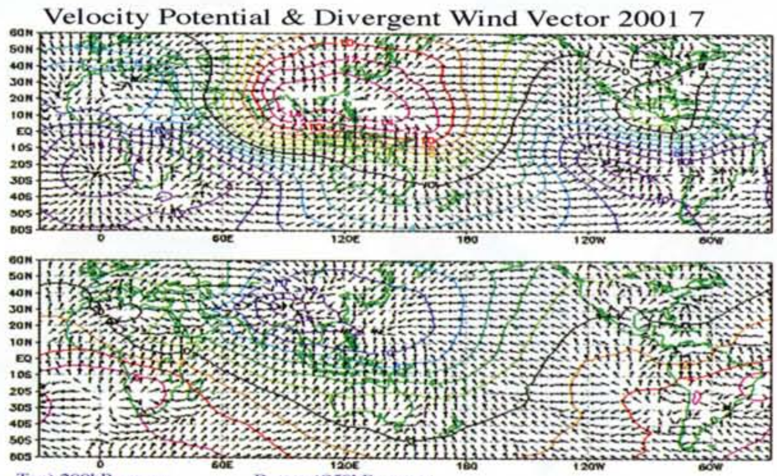
WALKER CIRCULATION CHARACTERIZED BY 850 AND 200HPA ZONAL WIND ANOMALIES (PRC) (JULY, 2001)



CMA/NCC/CLIMATE DIAGNOSTICS LAB.

850 百帕和 200 百帕月平均速度势和散度风（中国）(2001 年 7 月)

MONTHLY MEAN VELOCITY POTENTIAL AND DIVERGENT WIND AT 850 AND 200 HPA (PRC) (JULY, 2001)

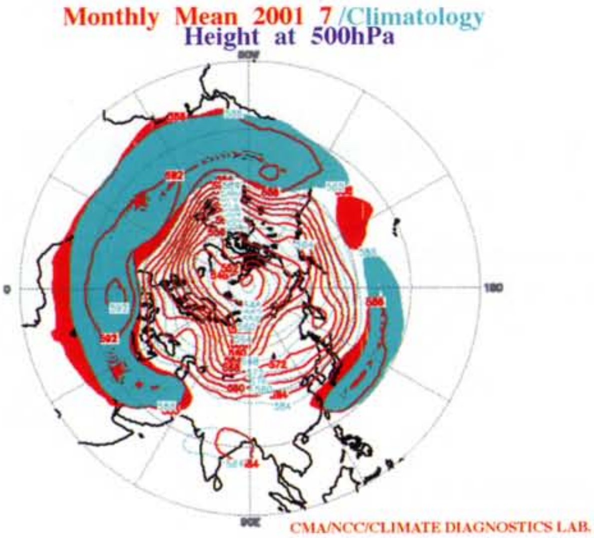


Top) 200hPa mean Bottom)850hPa mean

CMA/NCC/CLIMATE DIAGNOSTICS LAB.

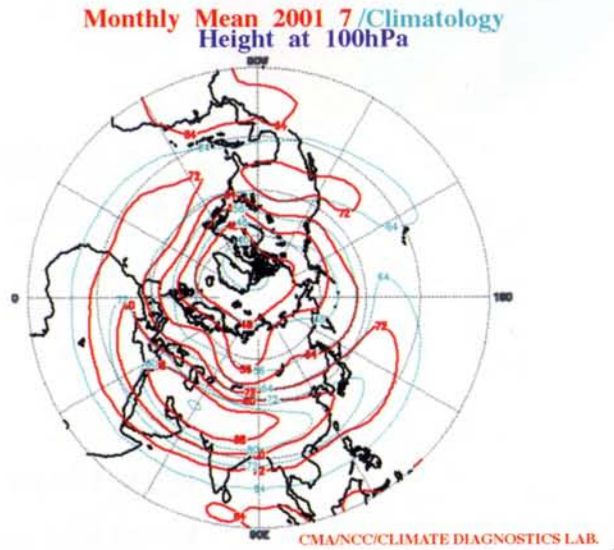
500 百帕月平均高度场表示的西北太平洋副热带高压（中国）(2001 年 7 月)

NW PACIFIC SUBTROPICAL HIGH CHARACTERIZED BY 500 HPA HEIGHT (PRC) (JULY, 2001)



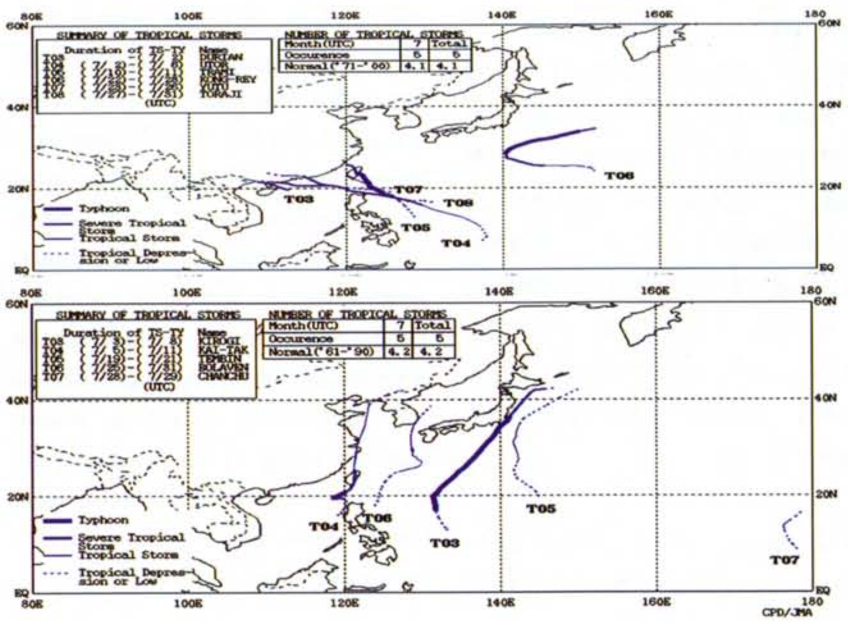
100 百帕月平均高度场表示的青藏高压（中国）(2001 年 7 月)

TIBETAN HIGH REFLECTED BY 100HPA HEIGHT (PRC) (JULY, 2001)



热带气旋路径和数量（日本）(2001 年 7 月)

TRACKS, SUMMERY AND NUMBER OF TROPICAL CYCLONES (JP, JULY 2001)



预报与展望

PREDICTONS AND OUTLOOKS

对气候预测的改进也会带来社会经济的加强，特别是农业、渔业、林业和能源等方面。

Advances in improved climate predictions will also result in significantly enhanced soci-economics, particularly for the national agriculture, fishing, forestry and energy.

ENSO 预测

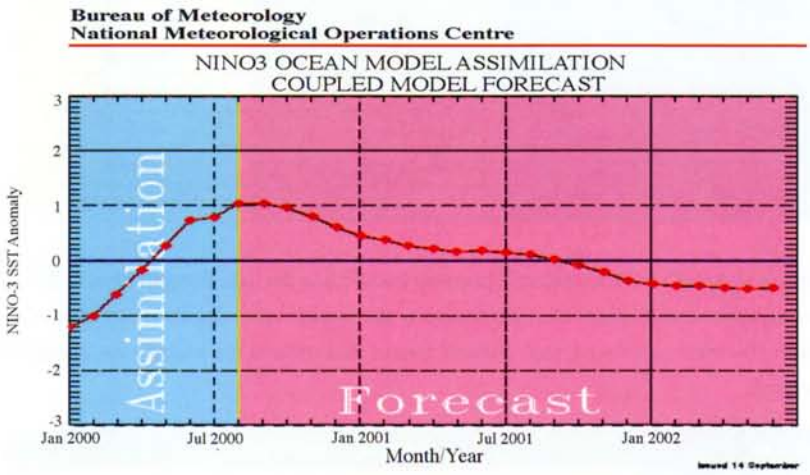
ENSO PREDICTION

预测热带太平洋冷水和暖水事件对水资源管理、能源、运输和牧业、避免和减少损失都非常重要。一些统计和动力模式已经被用来预报热带太平洋海表面温度距平。例如，中国国家气候中心用三种版本的改进ZC模式(1987)、一个改进的Oxford模式（1994）和一个高分辨印度洋－太平洋海洋环流模式预测ENSO年际变化。利用这些海洋－大气耦合模式，成功地预测了1997−2000年的厄尔尼诺和拉尼娜事件。日本气象厅气候预报部用他们的海气耦合模式制作ENSO预测。韩国气象厅长期天气预报部也用一个中等复杂程度的动力海洋－统计大气耦合模式做厄尔尼诺预报。澳大利亚气象局也用海气耦合模式制作ENSO预报。

Better predicting the onset of a warm or cold water event is critical for the managers of water, energy, transportation and farm to avoid or mitigate potential losses. Several statistical and dynamical models have been used to predict the sea surface temperature anomalies over the tropical Pacific Ocean. For example, three versions of improved ZC model (1987), the improved Oxford model (1994) and high-resolution Indian-Pacific oceanic model have been used in CNCC. By utilizing these ocean and atmosphere coupled models, the 1997-1999 El Nino/La Nina events have been successfully predicted. The Division of Climate Prediction of JMA has produced their experimental prediction of ENSO events with the JMA coupled ocean and atmospheric model. Long Range Weather Prediction Division of KMA has also conducted their experimental prediction of El Nino events with an intermediate ocean and statistical atmosphere coupled model system.

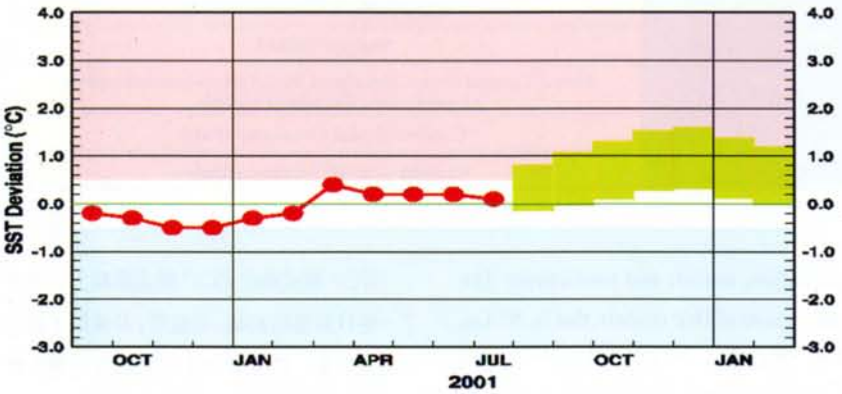
动力模式 DYNAMICAL MODELS

澳大利亚气象局研究中心的ENSO 预报模式
BMRC ENSO MODEL (AUS)



The vertical yellow line indicates when the forecast begins. Ocean thermal data is used up to and including the previous month. Wind data is used up to this month which is the month before the forecast is issued. The assimilation period shows the ingestion of past data while the forecast period shows the coupled model prediction for the next two years.

日本气象厅厄尔尼诺预报模式
JMA EL NINO PREDICTION MODEL (JP)



Outlook of the SST deviation for Region B (Nino.3) by the El Nino forecast model with MOS.This figure indicates a time series of the monthly sea surface temperature (SST) deviation for Region B (4°N-4°S, 150°W-90°W). Thick lines with closed circles show the observed SST deviation and boxes show the predicted for the next six months by the El Nino forecast model with MOS. Each box denotes the range where the SST deviation will be included with the probability of 70%.

澳大利亚气象局总结的 12 个长期 ENSO 预报

TWELVE LONG RANGE ENSO FORECASTS SUMMARISED BY AUSTRILA

Forecast ENSO conditions from august 2001 current conditions are neutral

GROUP	6 MONTHS (Feb 2002)	9 MONTHS (May 2002)
Bureau of Met 1 (NMOC)	Warm	Warm
Bureau of Met 2 (BMRC)	Neutral	Warm
CSIRO	Neutral	Neutral
CCA	Neutral	Warm
COLA	Cold	Cold
ECMWF	Warm	Not Available
LDEO (4)	Neutral	Not Available
NCEP	Neutral	Neutral
NOAA LINEAR INVERSE	Neutral	Neutral
SCRIPPS/MPI	Warm	Neutral
NSIPP/NASA	Neutral	Neutral
JMA	Neutral	Not Available

These terms (warm and cold) refer to eastern equatorial Pacific Sea Surface Temperatures (SSTs). Cold and Warm conditions mean that indices forecast by the models are (roughly) more than one standard deviation below or above normal. Neutral means that indices are within one standard deviation of normal.

GROUP	PREDICTION SYSTEM
NMOC	Intermediate Coupled Ocean Atmosphere Model
BMRC	Coupled General Circulation Model
CSIRO	Coupled General Circulation Model
CCA	Statistical Model (Canonical Correlation)
COLA	Coupled General Circulation Model
ECMWF	Coupled General Circulation Model
LDEO (4)	Intermediate Coupled Ocean Atmosphere Model
NCEP	Coupled General Circulation Model
NOAA (LINEAR INVERSE)	Statistical Model
SCRIPPS/MPI	Hybrid Coupled Ocean Atmosphere Model (Statistical Atmosphere; Ocean General Circulation Model)
NSIPP/NASA	Coupled General Circulation Model
JMA	Coupled General Circulation Model

模式简介：中国气象局国家气候中心的简化海气动力学模式系统由初始化、模式和预报3个部分组成。该系统有五个模式，它们是NCCo，NCCn，NCC/STI，NCC/NIM 和 CAMS/NJU 模式。

Models Description There is a simplified air-sea dynamical model system in NCC/CMA, which includes three parts that are initialization, models and predictions. The system consists of five models, that is, NCCo, NCCn, NCC/STI, NCC/NIM and CAMS/NJU, respectively. (NCC: National Climate Center; STI: Shanghai Typhoon Institute; NIM: Nanjing Institute of Meteorology; NJU: Nanjing University ; CAMS: Chinese Academy of Meteorological Sciences)

NCC 模式是在 ZC87 模式基础上，改变了一些计算函数和前、后处理，并采用了新的初始化方案，用观测 SSTA 和风应力替换模式计算的SSTA 和风应力。(李清泉和赵宗慈等，1996，1997，2000)。NCCn 模式建立在NCCo模式基础上，改进了海洋部分的上翻和平流过程参数化（张祖强和赵宗慈，2000）。

NCC/STI模式建立在NCCo模式基础上，采用了伴随同化方法（端义宏等，2000，梁旭东等，2000）。NCC/NIM模式建立在牛津大学模式(Balmaseda et al.，1994)基础上，改进了大气模式的气候态和热通量项（张勤和丁一汇，1998）。CAMS/NJU模式建立在ZC87模式基础上，将海洋模式扩展到整个热带海洋（太平洋、印度洋和大西洋）（倪允琪等，2000，史力等，2000）

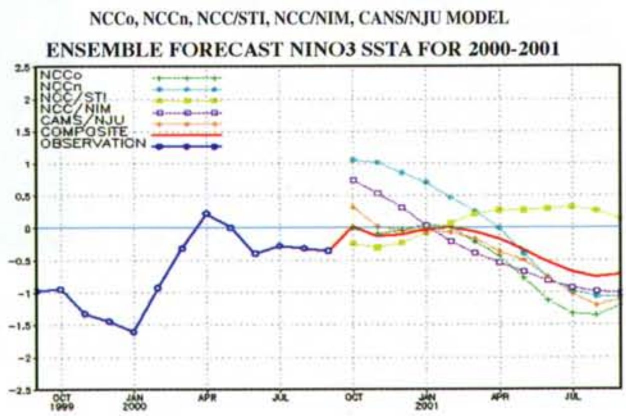
The model NCCo is based on a paper of ZC87 (Zebiak and Cane, 1987). Several computation functions have been changed. Both pre- and post-procedures have been constructed. A new initialization has been used in NCCo. It is that both computational SSTA and wind stress anomalies are replaced by the observed values during the initialization (Li et al., 1996 and 1997; Li and Zhao, 2000). The model NCCn is based on NCCo without initialization. The upwelling and advection in the oceanic component of NCCo have been improved (Zhang and Zhao, 200). The model NCC/STI was based on NCCo without initialization. The adjoint assimilation has been created and used to do the multiple-seasonal predictions (Duan et al., 2000; Liang et al., 2000). The model NCC/NIM is based on an Oxford model (Balmaseda et al., 1994; Zhang and Ding, 1998). Both climate background and heat flux item in the atmospheric component of the model have been improved (Zhang and Ding, 2000). The dynamic network of the model CAMS/NJU is based on ZC87. The model CAMS/NJU has three oceans. It is that the tropical Pacific Ocean, Indian Ocean and tropical Atlantic Ocean. The new parameters in Indian Ocean and Atlantic Ocean have been selected after several experiments (Ni et al., 2000; Shi et al., 2000).

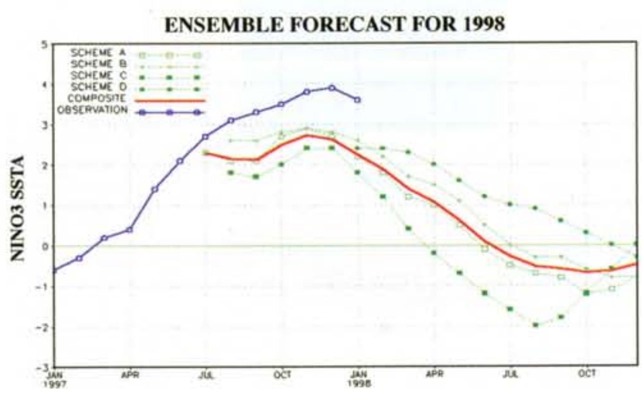
用模式系统自1980–1996年每个月的初始场做超前1–24个月的预报并与观测结果比较进行历史预报检验。对三个厄尔尼诺事件（1982/83，1986/87，1992/93）和三个拉尼娜事件(1984/85，1988/89，1995/96)作了超前1–24个月的预报和检验。结果表明，与持续预报相比，模式系统超前3–12个月有一定的预报热带太平洋SSTA的能力。自1997年起，用该模式系统制作的热带太平洋SSTA多季节预测多次参加中国国家年度和夏季预测会商会。该系统较好地预测了1997/98的厄尔尼诺事件和1998–2000年的拉尼娜事件（李清泉等，1997，1998，1999，2000；赵宗慈，2000）。

Tests of historical prediction by the model system from 1980 to 1996 leading by 1-24 months have been constructed. Three El Nino events (1982/83, 1986/87, 1991/92) and three La Nina events (1984/85, 1988/89, 1995/96) have been forecasted leading by 1-24 months, respectively. It is found from these tests to compare with the persistent prediction that the model system has a certain capability to predict the SSTA over the tropical Pacific Ocean leading by 3-12 months. Since 1997, the multiple-seasonal predictions of SSTA over the tropical Pacific Ocean by the model system have been presented and reported in the National Annual and Seasonal Prediction Workshops. The model system predicted both El Nino (1997/98) and La Nina (1998/2000) events reasonably (Li et al., 1997, 1998, 1999, 2000; Zhao et al., 2000).

动力学简化海气耦合模式系统对热带太平洋海表面温度异常的多季节预测（中国）

MULTIPLE-SEASONAL PREDICTIONS OF SEA SURFACE TEMPERATURE ANOMALIES (SSTA) OVER THE TROPICAL PACIFIC OCEAN BY A SIMPLIFIED AIR-SEA DYNAMICAL MODEL SYSTEM (PRC)



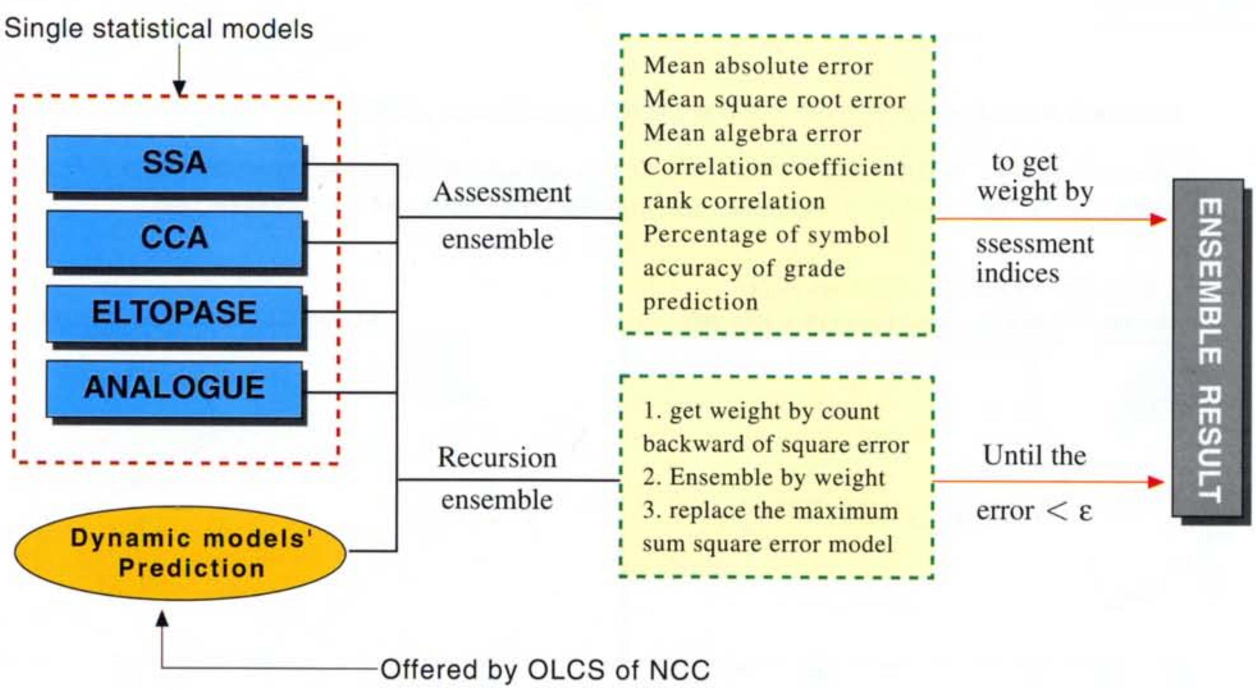


统计模式 STATISTICAL MODELS

模式简介：PC—CCA 模式 是采用EEOF、PRESS原理和集合预报技术建立的主成分典型相关分析模式。SSA 最大熵单谱分析模式是采用单谱分析获得有显著周期的主成分从而重建ENSO循环。利用最大熵AR(p)技术，建立了最大熵单谱分析模式。相似预报法是在 ENSO 循环的动力学分析基础上，建立了原始数列相似、趋势相似和累积相似的10个简单指数。利用这10个简单指数得到一个综合指数，并由此建立相似预报模式。最优滤波集合模式是基于ENSO组成分析理论，利用滤波技术将ENSO 循环分为准两年振荡QBO、3-5年的低频振荡和十年际变化三种时间尺度的振荡。利用4个统计时间序列分析模式，建立了一个新统计ENSO模式—最优滤波集合模式 。这个模式的思想包括两步：首先，利用4个模式中的每一个模式建立12个简单模式预报这三个分量，然后，对于整个ENSO循环预报，用12个简单模式建立64个集合模式并从中挑出最好的一个。

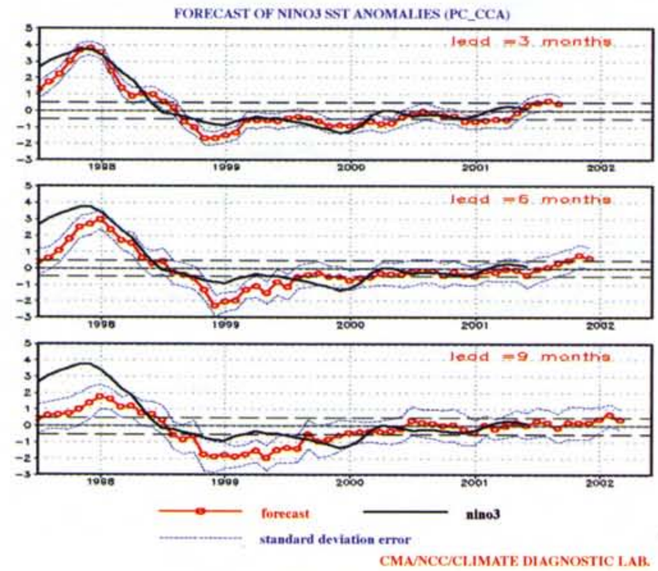
Models Description PC-CCA Applying EEOF, PRESS principle and ensemble forecast technique, a developed CCA, principal component canonical correlation analysis model has been established. SSA Maximum Entropy Singular Spectrum Analysis Model Using singular spectrum analysis, principal components with significant period have been generated and so the ENSO cycle has been reconstructed. After applying the maximum entropy AR(p) technique, this maximum entropy singular spectrum analysis model has been established. ANALOGUE PREDICTION Based on the dynamic analysis of ENSO cycle, 10 simple indices for original series similarity, trend similarity and acceleration similarity have been designed. Then a synthetic index has been generated from the 10 simple indices, and so a so-called analogue forecast model has been established. Optimum Filtering Assembly Model Based on an ENSO component analysis theory, ENSO cycle was separated into three time scale oscillations--QBO, the low frequency mode of 3-5 year and inter-decadal variance using filtering technique. After applying 4 statistical time series analysis models, a new statistic ENSO model, optimum filtering assembly model, has been established. The idea of this model includes two steps. First, 12 simple models are established to forecast each of the three components using each of the 4 models. Then, for the whole ENSO cycle forecast, 64 assembly models have been generated from the 12 simple models and the best one can be selected from them.

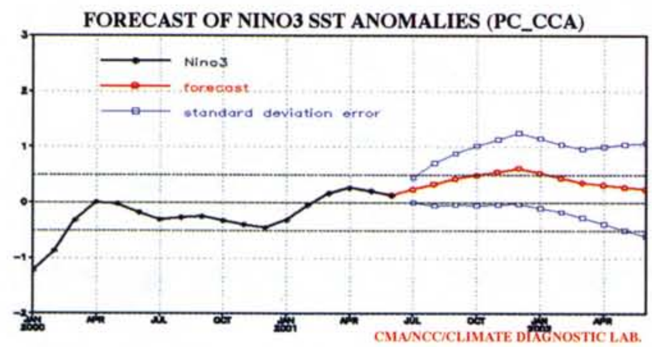
多模式预报集合方法 ENSEMBLE METHODS



典型相关分析模式（中国）

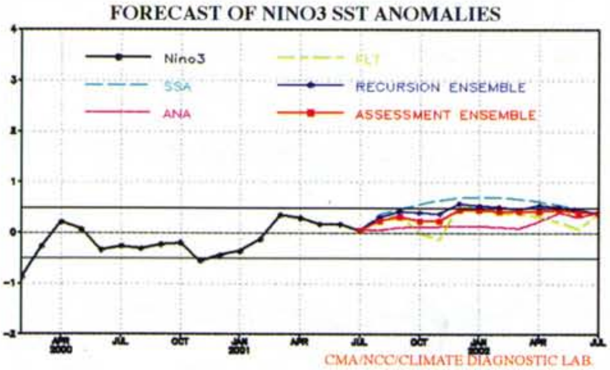
CANONICAL CORRELATION ANALYSIS (PRC)





多个统计模式预报的集合(中国)

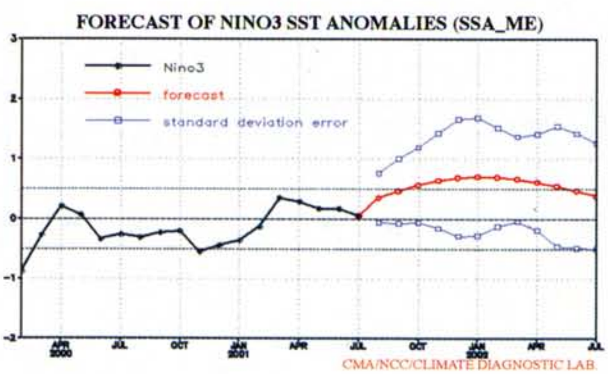
ENSEMBLE OF MULTI-STATISTICAL MODEL FORECAST (PRC)



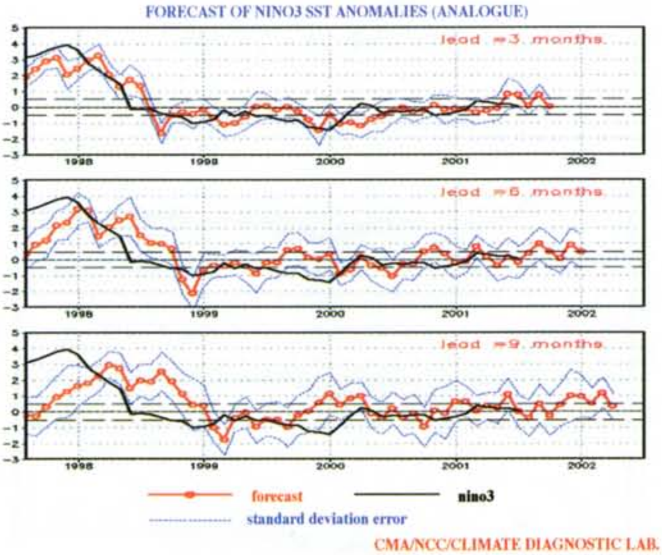
SSA: Singular spectrum analysis ; ANA: analogue prediction; FLT: Optimum filter assembly ; E33: recursion ensemble ; E10: assessment ensmble

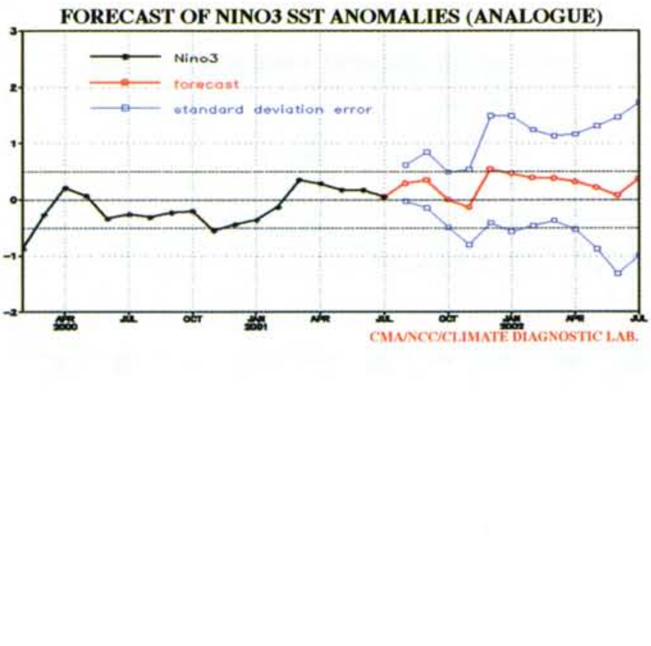
单谱分析模式（中国）

SINGULAR SPECTRAL ANALYSIS (PRC)

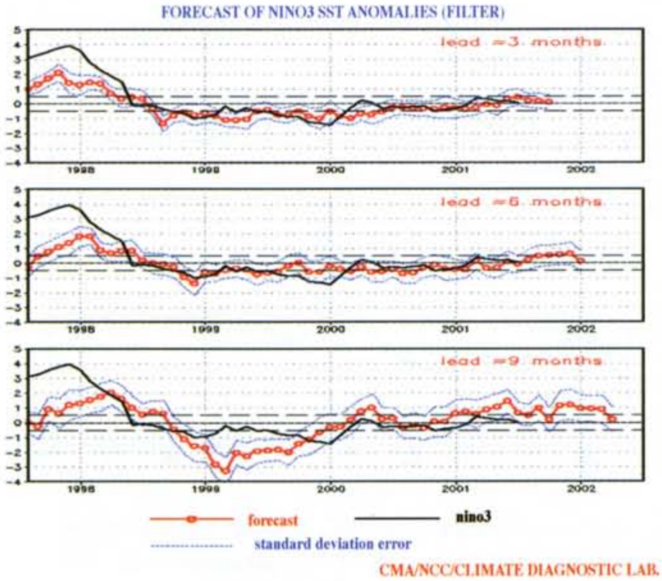


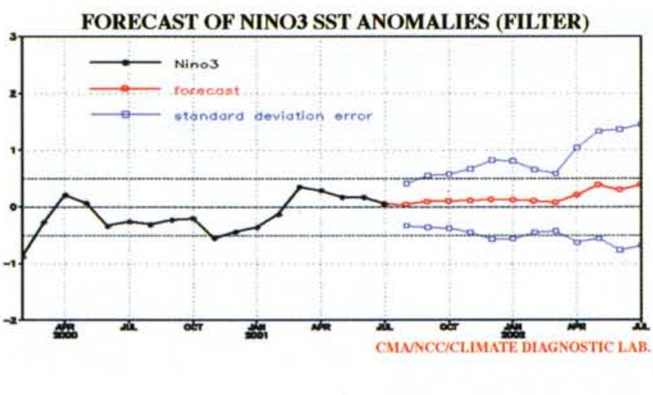
相似预报模式（中国）
ANALOGUE PREDICTION (PRC)





最优滤波集合模式（中国）
OPTIMUM FILTER ASSEMBLY (PRC)





台风预报
TYPHOON OUTLOOK

前 言 Background

陈仲良等（1998，下称CSL）发展了一种预报西北太平洋(WNP)和中国南海(SCS)热带气旋（TC）活动的统计回归方案。在这个方案中，选择了三套预报因子：

- 中、东太平洋海表面温度距平（代表ENSO信号）
- 用来描述从前一年夏季到当年三月的亚洲和西太平洋环流特征的指数
- 热带气旋活动年际变化的趋势（气候态和持续性）

Chan et al. (*Wea. Forecasting*,1998, hereafter CSL) developed a statistical regression scheme to predict tropical cyclone (TC) activity over the western North Pacific (WNP) and the South China Sea (SCS). In their scheme, three sets of predictors were chosen:

- sea-surface temperature anomalies over the central and eastern Pacific (as a proxy for the El Nino/Southern Oscillation (ENSO) signal)
- indices that represent the characteristics of the circulation over Asia and the western Pacific from summer of the previous year to March of the current year, and
- trend of the interannual variations in TC activity (climatology and persistence).

每一套预报因子都通过了统计检验，然后用来做预报。最终预报是这些预报的线性加权合成。权重是根据用"折叠刀(jackknif)"技术估计出每一个预报因子的误差特征确定的。预报量包括整个一年和活跃季节（5-12月）里、整个WNP和南海的热带气旋活动。考虑了三种类型的活动，即考虑所有活动、只考虑热带风暴和台风、只考虑台风。

用CSL方法做了1997和1998年TC季节的实时预报。结果（表1）表明，虽然过高地预报了南海的TC活动，该方法非常好地预报了1997年总的TC活动情况。1998年的预报情况几乎相反（表2）。1997（1998）年是强暖（冷）ENSO年，这些结果表示也许该方法不能捕捉到强冷事件或强暖事件的前兆信号。也可能这些信号在当年的4月不存在。尽管如此，这些结果表明CSL方法能提供一些TC活动水平的指示。

Predictors in each set that pass the statistical tests are then used to make predictions and the final prediction is a linear, weighted combination of these forecasts. The weights are determined from the error characteristics of each predictor estimated through the jackknife technique. The predictands include TC activity over the entire WNP and that over the South China Sea (SCS) for the entire year as well as the active season (May to December). Three types of activity have been considered: all activity, only tropical storms and typhoons, and only typhoons.

Real-time predictions of the 1997 and 1998 TC seasons were made using the CSL scheme. The results (Table 1) show that in 1997, the scheme predicted the total activity quite well although it over-predicted TC activity over the SCS. Almost the reverse is true in 1998 (Table 2). Since 1997 (1998), which was a strong warm (cold) ENSO year, these results suggest that perhaps the scheme could not capture the precursor signal of either a strong cold or warm event. It is also possible that such signals do not exist prior to April of the current year. Nevertheless, these results suggest that the CSL scheme can provide some indication of the level of TC activity.

表 1 对 CSL 方法预报 1997 年 TC 活动的检验

Table 1. VERIFICATION OF THE 1997 TC ACTIVITY FORECASTS MADE BY THE CSL SCHEME

The boundaries are defined as follows: WNP: 100-180°E, 0-40°N; and SCS: 100-120°E, 0-25°N. The observed numbers are from the Joint Typhoon Warning Center and the "normal" is the average for the years 1959-94.

1997	Forecast	Observed	Normal
Annual for the WNP:			
No. of TCs	33 ± 3	33	31
No. of TCs with at least tropical storm intensity	30 ± 3	31	27
No. of typhoons	19 ± 2	21	17
May to December for the WNP:			
No. of TCs	30 ± 3	30	28
No. of TCs with at least tropical storm intensity	27 ± 2	30	25
No. of typhoons	18 ± 2	20	16
Annual for the SCS:			
No. of TCs	12 ± 2	7	13
No. of TCs with at least tropical storm intensity	9 ± 2	7	10

表 2 对 CSL 方法预报 1998 年 TC 活动的检验

Table 2. VERIFICATION OF THE 1998 TC ACTIVITY FORECASTS MADE BY THE CSL SCHEME

THE VERIFICATIONS ARE ALL FOR THE ANNUAL ACTIVITY SINCE NO TC FORMED BEFORE MAY 1998

1998	Forecast	Observed	Normal
WNP:			
No. of TCs	32 ± 3	27	31
No. of TCs with at least tropical storm intensity	28 ± 3	17	27
No. of typhoons	20 ± 2	9	17
SCS:			
No. of TCs	13 ± 2	14	13
No. of TCs with at least tropical storm intensity	11 ± 2	7	10

表 3 2000 年西北太平洋和南海热带气旋个数的预报

Table 3. PREDICTIONS OF THE NUMBER OF TROPICAL CYCLONES OVER THE WESTERN NORTH PACIFIC AND THE SOUTH CHINA SEA IN 2000

2000	Forecast	Normal
WNP:		
No. of TCs	30 ± 3	31
No. of TCs with at least tropical storm intensity	29 ± 3	27
No. of typhoons	22 ± 2	17
SCS:		
No. of TCs	13 ± 2	13
No. of TCs with at least tropical storm intensity	10 ± 2	10

2000年预报

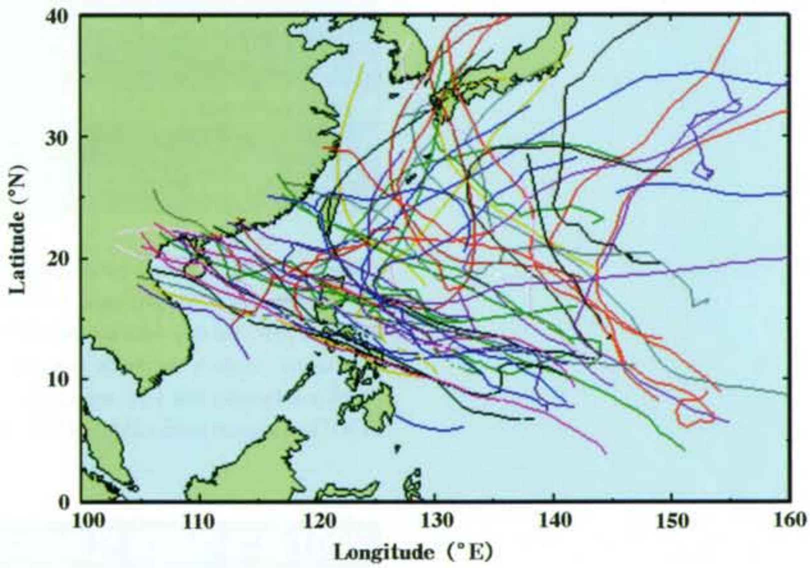
Predictions for 2000

为增加样本个数，增加了1995–1999年的资料以获得单个回归方程的系数。预报(表3)表明，当WNP热带气旋总数接近正常值时，其中的大部分TC将达到至少热带风暴的强度，而且台风的数量可能高于正常值。预计南海的TC活动接近正常值。

To increase the sample size, the coefficients in the individual regression equations are re-derived by including the data in 1995 to 1999. The predictions (Table 3) suggest that while the overall number of TCs in the WNP is close to normal, most of these will reach at least tropical storm intensity and the number of typhoons is likely to be above normal. Tropical cyclone activity over the SCS is predicted to be near normal.

拉尼娜次年5–7月所有热带气旋的路径

ALL TRACKS OF MAY-JULY OF NEXT YEAR AFTER LA NINA



2000年西北太平洋热带气旋活动预报的检验（2001年1月）

Verification of Forecasts of Tropical Cyclone Activity over the Western North Pacific in 2000 (Issued in Jan 2001)

在2000年4月，我们发布了用陈等(1998)发展的方法做的预报，以下称之为原CSL方法。此后，我们通过增加新的预报因子发展了两种对原方案的修正方案。一种是mCSL-4方案，仍然使用前一年4月到当年3月的参数；另一种CSL-6方案，采用前一年6月到当年5月的参数。两种修正方案是为了TC略多于正常值、但台风数略少于正常值（见表4）的季节。2000年6月发布了用CSL-6方案做的预报。预报检验表明，如果被日本热带天气中心（JTWC）认为是热带风暴强度的所有这些TC都被计算在内，mCSL-4和CSL-6方案的预报是正确的。即使扣除3个相对较弱的TC，这些修正方案的预报仍比原来方案的预报为好。特别是，预报的台风个数减少，这与观测一致。

In April 2000, we issued forecasts based on the scheme developed by Chan et al. (1998), which will be labeled as the original CSL scheme (see Table 4). Hereafter, we developed two modifications of the original scheme by incorporating new predictors that appear to be better proxies of the El Nio/Southern Oscillation (ENSO). One modification (the mCSL-4 scheme) still uses parameters from April of the previous year to March of the current year. The other modification (the CSL-6 scheme) makes use of parameters from June of the previous year to May of the current year. Both modifications are for a slightly above-normal season but with slightly below-normal number of typhoons (see Table 4). The predictions from the CSL-6 scheme were issued in June 2000. Verification of the forecasts shows that if all those TCs that were considered by JTWC as having reached tropical storm intensity are counted, the predictions from both the mCSL-4 and CSL-6 schemes are all correct. Even if the three relatively weak TCs (16W, 27W and 28W) are discounted, these revised predictions are still better than the original ones. In particular, the predicted number of typhoons is much reduced, as observed.

表 4　用原 CSL 方法、mCSL–4 和 CSL–6 方法对 2000 年 TC 活动的预报

Table 4. FORECASTS OF TC ACTIVITY IN 2000 USING THE ORIGINAL CSL SCHEME, THE MCSL-4 AND CSL-6 SCHEMES

2000	Forecast			Observed	Normal
	Original	mCSL-4	CSL-6		
Western North Pacific					
No. of TCs (TCA)	30 ± 3	32 ± 3	33 ± 3	34	31
No. of TCs with at least tropical storm intensity (TSYA)	29 ± 3	26 ± 3	28 ± 3	23/26*	27
No. of typhoons (TYA)	22 ± 2	14 ± 2	16 ± 2	14/15#	17
South China Sea					
No. of TCs (TCS)	13 ± 2	11 ± 2	13 ± 2	12	13
No. of TCs with at least tropical storm intensity (TSYS)	10 ± 2	9 ± 2	9 ± 2	7/8**	10

The asterisk in the TSYA row indicates that 3 TCs were classified by JTWC as tropical storms (16W, 27W and 28W) but they were not named by any other center. Similarly, the double asterisks in the TSYS row indicate that 1 TC was classified by JTWC as a tropical storm (28W) but not named by any other center. In the TYA row, the # sign indicates that the 15th typhoon (Soulik) did not intensify to typhoon strength until 3 January 2001(but formed on 29 December 2000). The observed and normal (1959-94) numbers are also included in the last two columns.

2001 年季节热带气旋活动的更新预报（2001 年 7 月发布）

Updated Forecast of Seasonal Tropical Cyclone Activity 2001 (Issued on 12 Jul 2001)

As noted in our forecasts issued on 10 May 2001, updated forecasts will be issued based on the additional information in April and May. The following table gives the various updated forecasts.

2001	Original Forecast	Updated Forecast	Normal
WNP:			
No. of TCs	31 ± 3	32 ± 3	31
No. of TCs with at least tropical storm intensity	27 ± 3	28 ± 3	27
No. of typhoons	18 ± 2	18 ± 2	17
SCS:			
No. of TCs	10 ± 2	11 ± 2	13
No. of TCs with at least tropical storm intensity	9 ± 2	9 ± 2	10
No. of TCs making landfall along the South China coast	3 ± 1	3 ± 1	5

Compared with those issued previously, the changes are minimal. The number of tropical cyclones as well as the number of tropical storms and typhoons are predicted to increase by one while the number of typhoons should remain at 18 as previously predicted. For the South China Sea (0-23°N, 100-120°E), the number of tropical cyclones is also predicted to increase by one but the number of tropical storms and typhoons is expected to be the same as in the previous prediction. The number of tropical cyclones making landfall over the South China coast is forecast to be the same, despite the fact we already had two landfall tropical cyclones (Durian and Utor). We checked the updated predictions and they all consistently give a number between 3 and 4.

ENSO 和暖池的影响

THE EFFECTS OF ENSO AND WARM POOL

海洋的变化会影响全球大气和气候。拉尼娜和厄尔尼诺事件影响高空急流的位置和强度，从而影响风暴的强度和路径．

Changes of ocean impact global atmosphere and climate. For example, La Nina or El Nino event affect the position and intensity of the jet streams, which in turn affect the intensity and track of storms.

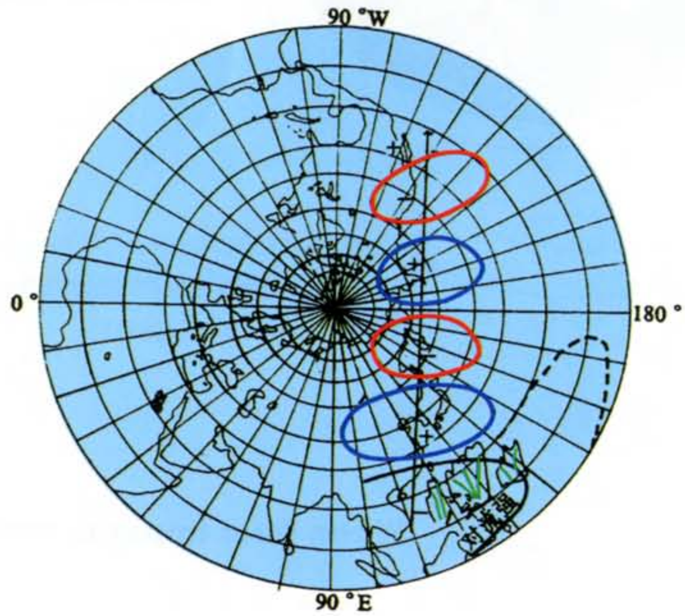
Warm Pool Impacts on Climate

当热带西太平洋海表面温度增高时，由于菲律宾及印度尼西亚一带对流活动增强，造成这个区域上空的热源增强，由于准定常行星波的传播，它引起东亚夏季副热带高压偏北。由图上也可以看到，当夏季菲律宾周围对流活动加强后，在500hPa高度场，一个负距平区域出现在中国南海与菲律宾上空，一个正距平出现在中国江淮流域与日本上空，并且另一个负距平区域与正距平区域分别出现在鄂霍茨克海及阿拉斯加的上空。这种异常距平的分布象一个ROSSBY波列的传播，称为东亚太平洋型或太平洋－日本(PJ)型遥相关（新田；黄荣辉，1990），它对东亚的环流及降水有很大影响。

When the western tropical Pacific SST increases, the enhancement of the convective activity over Philippine and Indonesia results in strengthening of the heat source over these regions. The propagation of the quasi-permanent planetary wave causes the sub-tropical high over East Asia to be located farther to north than normal in summer. As shown in this figure, after convective activity around Philippine enhances in summer, there appears a region of negative anomaly in the 500hPa potential height filed over the South China Sea and Philippine and a positive anomaly over the Yangtze and Huai River Basin of China and Japan. Another negative anomaly region and a positive anomaly region are located in Okhotsk and Alaska respectively. The distribution of the anomalies like the propagation of the ROSSBY waves are named as East Asian-Pacific pattern or Pacific-Japan (PJ) pattern teleconnection (Nitta; Huang, 1990). It has significant influence on the circulation and rainfall over East Asia.

夏季菲律宾周围对流活动加强后北半球大气环流异常距平分布示意图

THE DISTRIBUTION OF ATMOSPHERIC CIRCULATION ANOMALY IN THE NORTHERN HEMISPHERE AS THE CONVECTIVE ACTIVITY AROUND PHILIPPINE ENHANCES IN SUMMER



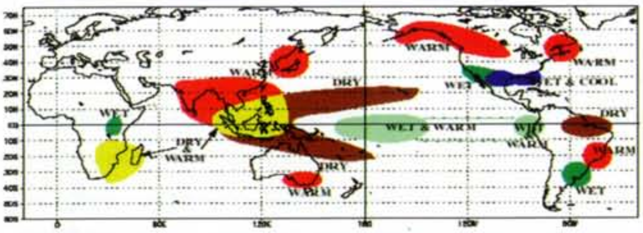
El Nino impact on the global climate

对居住在印度尼西亚、澳大利亚、东南非的人来说，厄尔尼诺意味着严重的干旱和致命的森林火灾。厄瓜多尔、秘鲁、加利福尼亚的人则认为厄尔尼诺会带来暴风雨，然后引发严重洪水和泥石流。而在美洲东北沿岸的居民认为厄尔尼诺会使冬天变得更温暖（可节省取暖费），飓风季节相对平静。在全世界范围内，强厄尔尼诺事件不但造成几千人的丧生，还会使成千上万人流离失所、数十亿美元损失。

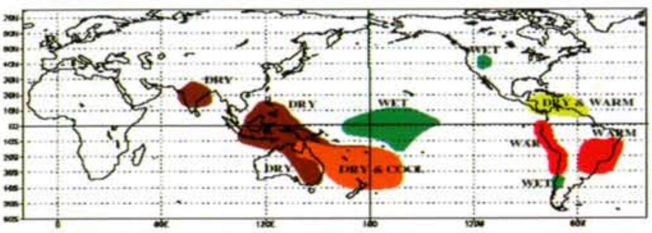
El Nino is a disruption of the ocean-atmosphere system in the tropical Pacific having significant impacts on weather at various locations around the globe. Among these consequences are increased rainfall across the southern tier of the US and in Peru, which has caused destructive flooding, and drought in the West Pacific, sometimes associated with devastating brush fires in Australia. Tropical thunderstorms are fueled by hot, humid air over the oceans. The hotter the air, the stronger and bigger the thunderstorms. As the Pacific's warmest water spreads eastward, the biggest thunderstorms move with it. The clouds and rainstorms associated with warm ocean waters also shift toward the east. Thus, rains which normally would fall over the tropical rain forests of Indonesia start falling over the deserts of Peru, causing forest fires and drought in the western Pacific and flooding in South America. Moreover the Earth's atmosphere reponds to the heating of El-Nino by producing patterns of high and low pressure which can have a profound impact on weather far away from the equatorial Pacific. For instance, higher temperatures in western Canada and the upper plains of the United States, colder temperatures in the southern United States. The east coast of southern Africa often experiences drought during El Nino.

El Nino 对世界各国气候异常的影响

WARM FPISODE RELATIONSHIPS DECEMBER - FEBRUARY

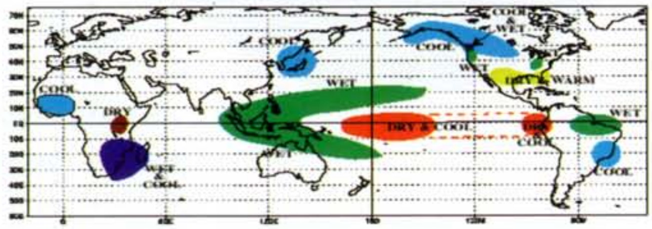


WARM EPISODE RELATIONSHIPS JUNE - AUGUST

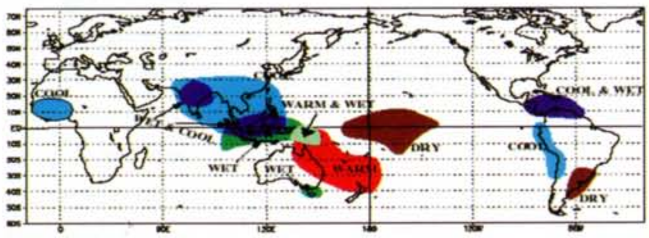


La Nina 对世界各国气候异常的影响

COLD EPISODE RELATIONSHIPS DECEMBER - FEBRUARY

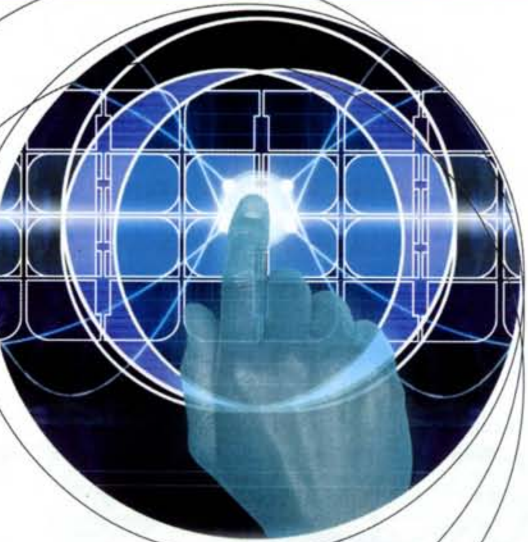


COLD EPISODE RELATIONSHIPS JUNE - AUGUST



La Nina impact on the global climate

Global climate La Nina impacts tend to be opposite those of El Nino impacts. In the tropics, ocean temperature variations in La Nina tend to be opposite those of El Nino. At higher latitudes, El Nino and La Nina are among a number of factors that influence climate. However, the impacts of El Nino and La Nina at these latitudes are most clearly seen in wintertime. In the continental US, during El Nino years, temperatures in the winter are warmer than normal in the North Central States, and cooler than normal in the Southeast and the Southwest. During a La Nina year, winter temperatures are warmer than normal in the Southeast and cooler than normal in the Northwest. In many locations, especially in the tropics, La Nina (or cold episodes) produces the opposite climate variations from El Nino. For instance, parts of Australia and Indonesia are prone to drought during El Nino, but are typically wetter than normal during La Nina.



研究工作
RESEARCH WORK

Expect for the establishment and updating of the network, every participating countries of this project have organized and undertaken their national scientific research activities related to this project. Trough the studies on ENSO, warm pool, monsoon, typhoon, and their impacts on the soci-economic aspects and environments of APN regions/countries, a lot of new scientific findings have been obtained.

In our project, the study on three issues that are closely related to the scientific objectives of our project, i.e., (1) important role of the warm pool in effect on the climate in Asian and Pacific region, (2) the Asian monsoon activity and its relationship to the structure of sea temperature over the warm pool and (3) the socio-economic impact of ENSO event and SSTA over the warm pool, has been greatly enhanced, thus leading to establishment of a more complete and applicable network of ENSO and structures of sea temperature over the warm pool. The enhanced research work has increased the amount of papers and related research papers have been put on the web.

Previously, many efforts have been devoted to study Indian monsoon and their relations to ENSO events, while very few studies have been done of SSTA of Warm Pool and the South China Sea and their impact on climate condition in APN region. In effect, the Southeast Asian and East Asian countries received the combined effect from ENSO and Warm Pool, and in some case the Warm Pool has a greater effect. The research focuses have been placed on: (1) meteorological and ocean-graphical conditions over Warm Pool and the South China Sea; (2) effect of ENSO events and SSTA over Warm Pool on onset of summer monsoon and activity of tropical cyclones; and (3) assessment of impacts of droughts/floods, monsoon, tropical cyclones in Southeast and East Asia under conditions of ENSO event and anomalous SST of Warm Pool. The above studies have been completed with three approaches: (1) summarizing existing scientific achievements; (2) the scientists of CNCC are to study above-mentioned (1) and (2); and (3) the experts of our project is to complete the study associated with (3). Through those studies, the useful relationships between ENSO and SSTA of Warm Pool, and anomalous weather-climate condition in Southern Asia and East Asia will be established and in turn will be used in operational seasonal and interannual prediction, especially for extreme events such as typhoons, monsoon and droughts/floods.

The scientists of the NCC of China have studied the meteorological and oceanographical conditions over Warm Pool and the South China Sea and the effect of ENSO events and SSTA over Warm Pool on onset of summer monsoon and activity of tropical cyclones. Through those studies, the useful relationships between ENSO and SSTA of Warm Pool, and anomalous weather-climate condition in Southern Asia and East Asia have been established and used in operational seasonal and interannual prediction, especially for extreme events such as monsoon and droughts/floods. For instance, by using the subsurface currents and temperature dataset from TOGA-TAO, observational evidence is presented to reveal the formation mechanism and eastward propagation features of subsurface current anomalies driven by the strong westerly wind anomalies over Warm Pool in western Pacific Ocean. Further comparisons suggest that the dominant factor leading to the equatorial sea temperature anomaly within the mixed layer of Pacific is the anomalous upwelling caused by the convergence of subsurface currents rather that the horizontal thermal advections of surface currents. On the basis of the diagnostic study for 1998-2000 cold episode, the main features such as rapid onset, great intensity, quick return to near normal condition of SST, and slow response of the atmospheric condition were revealed. Compared with the other cold episodes, the ocean subsurface temperatures and winds were analyzed as the main triggering factors for the onset cold episode. Results have indicated that the enhancement and eastward development of the subsurface temperatures are the bases of the onset of cold episodes. Change in sea surface winds played a crucial role in the onset and development of cold episodes. The onset season impacts on the duration of the episode. Also, the effects of temporal variation of SSTA in the eastern and central equatorial Pacific Ocean on formation and seasonal predictability of the torrential rainfall over the Yangtze river valley in the Summer of 1998 as simulated by NCAR CCM3 was examined. In order to investigate the formation and seasonal predictability of the torrential rainfall occurring over the Yangtze River Valley in the summer of the following year after onset of El Nino, the effects of temporal variation of SSTA in the eastern and central equatorial Pacific Ocean were studied. It was found that the effect may result from not only the intensity, but also the declining rate of positive SSTA in the eastern and central equatorial Pacific Ocean. NCAR CCM3 and prescribed SSTA in the eastern and central equatorial Pacific Ocean with different declining rates were dedicated to conduct a series of numerical simulation. The comparison between the sensitivity experiments showed that the temporal variation of SSTA exerted great influence on the excessive torrential rainfall over the Yangtze River Valley in the summer of 1998. Moreover, the El Nino/La Nina prediction system of the NCC of China has been improved. We have improved the internal dynamics, data initialization schemes, boundary condition and predictive techniques of ENSO prediction models in order to raise the capability of prediction and simulation.

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He Jinhai, Xu Haimig and Zhou Bin, A discussion on the master-servant relation of air-sea interaction over Nino3 region and the equatorial eastern Indian ocean, Nanjing Institute of Meteorology, China

He Jinhai, Li Feng and Sun Xiurong, East Asian Air-Sea Correlation Characteristics and the Interdecadal Variation, Nanjing Institute of Meteorology, China

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Jose, Aida M. Impact of 1997~1998 EL Nino in the Philippines, Philippine Atmospheric Geophysical and Astronomical Services Administration On Monitoring Sea Surface Temperature Anomalies over the Central and Western Equatorial Pacific and Predicting its Potential Effects on the Philippine Climate and Socio-Economic Environment, Philippine Atmospheric Deophysical and Astronomical Services Administration(PAGASA)

Kazuo Kurihara, Simulated impacts of Westerly burst on an El Nino event using the operational atmosphere ocean coupled model of JMA, "Kookai", El Nino Monitoring and Prediction Center, Climate Prediction Division, Japan Meteorological Agency

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Li Xiaoyan, A Diagnostic Study of 1998/2000 Cold Episode£¨ National Climate Center, Beijing 100081,China

Lian Yi, An Gang, Gao Zongting, Shen Baizhu , A Preliminary Study on the Relationships among East Asia Summer Monsoon, El Nino and Cold Summer in Songliao Plain, China Jilin Meteorological Science Institute, Changchun 130062, China

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Masato Murakami, ENSO monitoring and prediction by Japan Meteorology Agency, Japan Meteorological Agency

Masato Murakami, El Nino and Seasonal Prediction by Japan Meteorological Agency, Climate Prediction Division Japan Meteorological Agency

Park, Chung-Kyu and Jeong-sun Kim, An El Nino Prediction Model with an Intermediate Ocean and Statistical Atmosphere System, Forecast Bureau, Korea Meteorological Administration

Peter Bate, Real-time monitoring of the broad-scale tropical circulation and ENSO in the Australian Bureau of Meteorology, Bureau of Meteorology, Australia

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Tien Sribimawati, Climatological Research for the Indonesia Maritime Continent, Agency for the Assessment and Application of Technology Coordinator, Climate Variability Program, BPPT, Indonesia

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Zhao Zongci, Qingquan Li, Zuqiang Zhang,Lan Yi and Yong Luo, Impacts of the Sea Surface Temperature Anomalies over the Western-Tropical Pacific Ocean and South China Sea on the Climate Change over East Asia, National Climate Center, China

暖池区海气耦合过程（张祖强等，2000）

Air-sea Coupled Process Over Warm Pool (Zhang et al,2000)

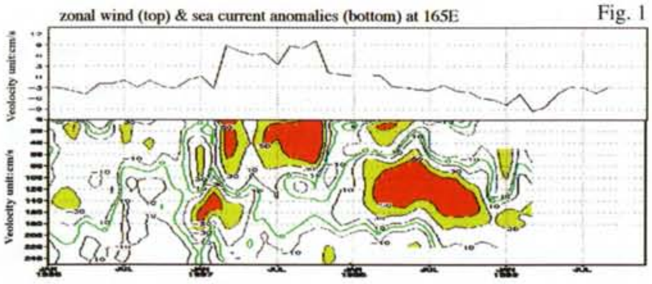

Fig. 1

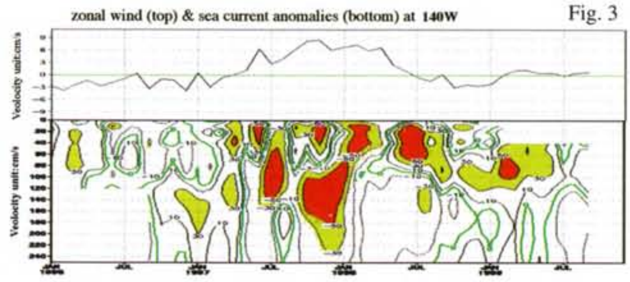

Fig. 3

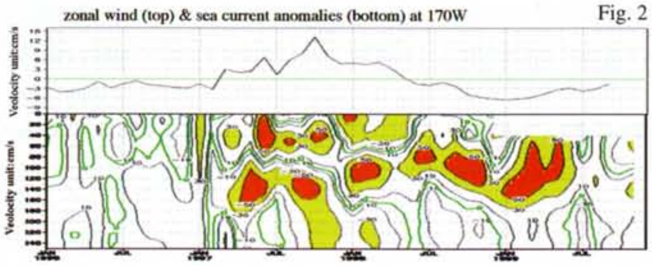

Fig. 2

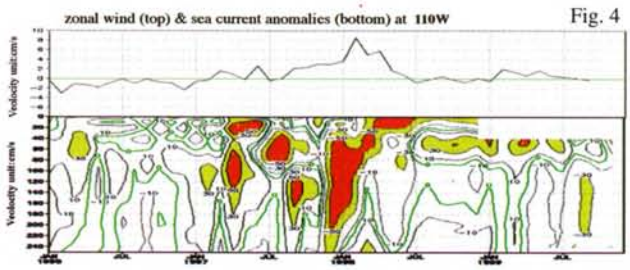

Fig. 4

When the westerlies outburst took place over Warm Pool from late 1996 through early 1997, as shown in Fig.1, the wind-driven sea current anomalies flowed eastward in the shallow layer of 0-100m at equator 165E, while the opposite flow was observed in the deeper layer of 120-200m. The similar pattern of currents also can be found at 170W (Fig.2) but much less obviously at equator 140W (Fig.3) and 110W(Fig.4), which suggests the response of sea current to wind anomalies is most robust over Warm Pool and western central equatorial Pacific.

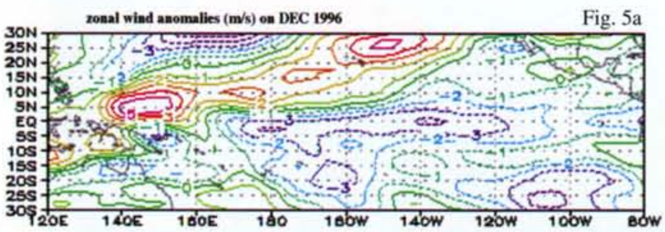

Fig. 5a

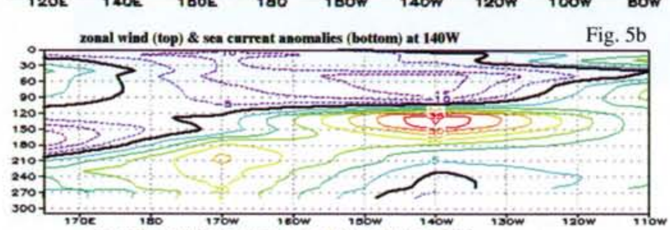

Fig. 5b

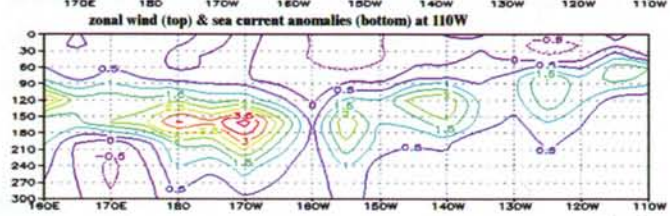

Fig. 5c

During La Nina, for instance, on December of 1996 (Fig.5), the intensified trade wind maintained over the central and eastern equatorial Pacific but the anomalous westerlies appeared over the far western tropical Pacific. Correspondingly, the shallow layer of equatorial Pacific above 100m was characteristic of the convergence of zonal sea currents, but for the lower layer below 120m the opposite condition was found, which will be in favor of the subsidence of water and the associated deeper thermocline as well as the warmer subsurface sea temperature in Warm Pool.

Fig.6 indicates the schematic illustration of the air-sea coupled process over Warm Pool area during the cold phase of ENSO. The convergence of anomalous zonal wind is remarkable over the western Pacific Ocean, so does the related current anomalies. Consequently, the warm water of the shallow layer subsides from the depth of A to the deeper B until to the adjacent region of the thermocline, where its downward momentum (ω) exhausts very quickly. It is due to the fact that the sea temperature of the surrounding background decreases so sharply that the upward buoyancy force(F) on the sinking water increases substantially with depth. In this sense, the thermocline, just like a hard boundary, prevents the water of shallow layer from descending further more and forces it divergence to both sides. So the zonal convergence in the upper layer and divergence in the lower layer will cause the downwelling of water, which reduces the upwelling of cold water below the thermocline and leads to the rise of subsurface sea temperature in Warm Pool. With the eastward propagation of downwelling, the positive sea temperature anomaly, most remarkably near to the thermocline, shifts eastward in such a way that the track of anomaly centers tilts to the shallow layer. When it reaches the eastern pacific, the surface sea temperature rises quickly because of the much shallower thermocline, and then El Nino starts.

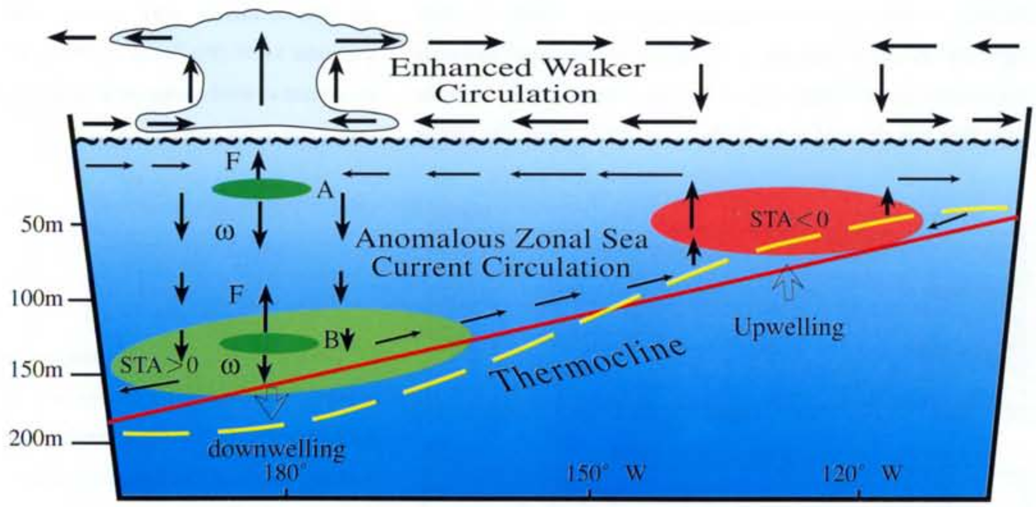

Fig. 6 Schematic illustration of Atmosphere-Ocean Interactions along equatorial Pacific during the mature phase of La Nina. A and B denote the different depth of the same shaded water mass subsiding from the upper layer of ocean. ?F and??? indicate the upward buoyancy force placed on the shaded water mass and its downward velocity. The length of arrows is in proportion to the intensity of physical elements ideally. The solid thick line stands for the climatological depth of themocline along the Equator, and the dashed one is for the condition on the mature phase of La Nina

厄尔尼诺事件对东北温度影响的新研究（廉毅等，2001）

A New reapprasal of impact of El Nino events on temperature in Northeast China (Lian et al, 2001)

The relationships among East Asia summer monsoon in 1951-1995, El Nino in 1909-1999 and temperature from May to Sept. in Songliao Plain, China are analyzed. The result is that the relation between SSTA in the same year of El Nino event and May-Sept. mean temperature of Changchun is of clear periodical and inter-decadescale variations, i.e. a clear negative correlation during cold episode, but a clear positive correlation during warm episode.

In the 1950s-1970s, East Asia summer monsoon was weak, El Nino temperature increase started in the first half a year, the low temperature or cold injury would take place in Changchun summer. During 1980-1995 when East Asia summer monsoon was strong even El Nino temperature increase started in the first half a year, the Changchun's summer temperature was high in the same year, and slight low in the next year but there was no cold injury.

Table 1 Relationship between SSTA in the same year of El Nino events and Changchun's May-Sept. mean temperature anomaly

time		Changchun's Temperature Anomaly positive (years)	Changchun's Temperature Anomaly negative (years)	Changchun Temperature Anomaly in El Nino year positive (years)	Changchun Temperature Anomaly in El Nino year negative (years)
1909-1920	cold period	4	8	1	3
1921-1951	warm period	20	11	6	0
1952-1981	cold period	12	18	1	6
1982-1999	warm period	14	4	5	1

In Table 1, it is clearly indicated that the relationship between SSTA (Nino C region) in the same year of El Nino events and Changchun's May-Sept. mean temperature is of clear stage and a quasi-30-yr (inter-decadescale) variation, i.e. correlation coefficient between El Nino and cold summer at the same year is 9/11(0.82) during cold phases, 1909-1920 and 1952-1981, of negative correlation, but 11/12(0.92), clear positive correlation during warm phases 1921-1951 and 1982-1999.

Fig.1a is a time sequences of region C SSTA and Changchun's monthly-mean temperature anomaly in 1976. The SSTA increased to positive clearly in May, but temperature anomaly continued to January 1977 in negative region except for May-Sept. 1976. This figure is a typical map of long-term negative correlation between El Nino and summer temperature in Songliao Plain during cold period.

Fig. 1b is a time sequence of El Nino SSTA and Changchun's monthly-mean temperature anomaly in 1982-1983. The SSTA increased over 0.5 ℃ in Sept. 1982, and over 1 ℃ in Sept.-Nov. 1982. Changchun's summer temperature is higher in 1982, the same year of the El Nino event, and in 1983 except for lower in June-July 1983. This figure is a typical map of positive correlation between El Nino and summer temperature in Songliao Plain during warm period.

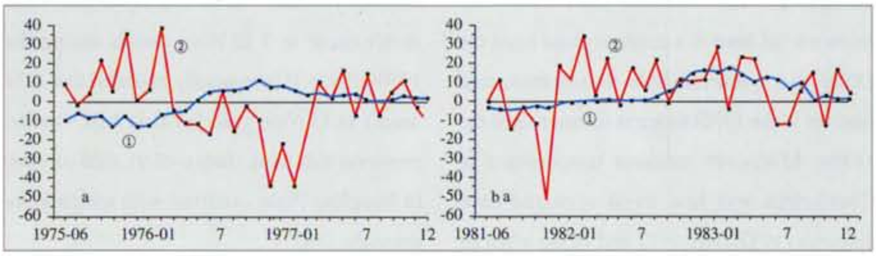

Fig 1 Sea temperature in region C and Changchun's monthly mean temperature anomaly (1 : Sea temperature anomaly; 2 : Changchun's monthly mean temperature anomaly. a: 1975-1977; b: 1981-1983; unit: 0.1° C)

Table 2, which indicates El Nino and East Asia summer monsoon effect on Songliao Plain temperature during crop's growing period, is the relationships among El Nino, East Asia monsoon and Changchun's mean temperature anomaly during crop's growing period (May-Sept.) in 1951-1996. The probability of negative temperature anomaly in Songliao Plain is 86% at the same year of El Nino events. Summer temperature anomaly in 1991, 1993, 1994, the beginning year of El Nino, is high, the relationship is positive. In the next year, temperature is slight low (the absolute value of negative anomaly <0.5° C) such as in 1992 and 1995, but not sever cold summer disasters (the absolute value of negative anomaly 0.7° C) compared with the 1950s-1970s.

Table 2 Relationship among El Nino, East Asia summer monsoon index and Changchun's summer temperature

year		Sea temperature feature		Changchun's May-Sept. Mean Temperature		East Asia
		Beginning month of temperature increase	Temperature increasing pattern	Temperature anomaly	Negative anomaly months	summer monsoon index
1953	El Nino	1	slow	-0.47	4	0.97
1954				-0.97	4	1.04
1957	El Nino	4	slow	-1.2	4	0.98
1963	El Nino	7	slow	+0.8	2	1.26
1965	El Nino	5	slow	-0.2	3	1.66
1966				-0.2	3	1.05
1969	El Nino	2	slow	-1.2	5	0.96
1971				-0.67	5	0.89
1972	El Nino	6	quick	-1.07	4	0.96
1976	El Nino	6	slow	-0.77	4	0.57
1982	El Nino	9	quick	+0.93	0	0.97
1983				+0.13	2	1.27
1986	El Nino	10	quick	-0.27	3	0.85
1987				-0.27	4	1.00
1991	El Nino	5	quick	+0.33	2	1.02
1992				-0.47	4	0.89
1993	El Nino	4	slow	+0.13	3	0.87
1994	El Nino	5	slow	+1.16	0	1.10
1995				-0.27	3	1.12
1996				+0.43	2	

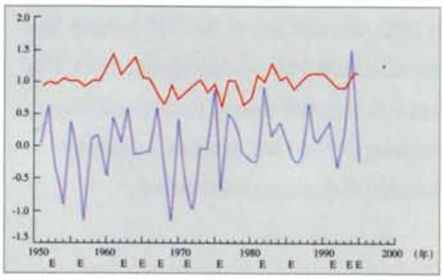

Fig 2 Time sequence of East Asia summer monsoon index, El Nino years and Changchun's May-Sept. temperature anomaly (solid: East Asia summer monsoon index; dash: temperature; E: El Nino year)

Fig 2 is time sequences of East Asia summer monsoon index, El Nino years and May-Sept. temperature anomaly of Changchun. It is found that East Asia summer monsoon index is of a low value phase (<1) during the 1970s, only >1 in 1973, but 5 years indexes <1 from 1980 through 1995. This shows that East Asia summer monsoon has been in a stronger phase since the 1980s, and synchronization in time from cold summer in the 1970s to warm summer since the 1980s. Moreover, summer temperature in Chanhchun was low, even occurred cold disasters (1957,1969,1972 and 1976) when El Nino occurred at the year of weak index of East Asia summer monsoon during the 1950s-1970s. There are two cases of Changchun summer temperature when El Nino occurred at the year of strong index of East Asia summer monsoon. One is higher temperature, such as in 1963, the only one year that cold summer in Songliao Plain didn't occur in 7 El Nino events during the 1950s-1970s. It is especially indicated that 1971 wasn't an El Nino year, but East Asia summer monsoon was weak (index <0.9), cold summer in Songliao Plain occurred with temperature anomaly -0.67° C.

其它方面 OTHERS

区域合作 Regional Collaboration

近年来，中国气象局国家气候中心、美国国家海洋大气管理局、日本气象厅和澳大利亚气象局在ENSO事件的监测和预测方面都取得了相当大的进展。他们每个月分别发布热带太平洋的海洋和大气业务产品，用统计方法和动力模式做海表面温度异常的月、季、年预测。这些产品相当不错，为其他国家提供有益的指导。但是，他们的监测和预测大多集中在赤道中、东太平洋，很少注意西太平洋暖池的监测和预测以及ENSO和暖池海表面温度异常影响方面的监测。1999年，在APN的资助下，中国、日本、韩国、菲律宾、泰国、马来西亚、越南、印度尼西亚和澳大利亚联合提出了和承担了APN合作和研究项目“ENSO事件和西太平洋暖池的海表面温度异常的监测和预测”(1999—2000)。由于参加机构都是受季风影响的APN国家和地区，他们都非常关心ENSO和暖池及其对东亚季风的影响。这是本项目的核心问题。所以，我们在项目目标、分工合作和建设分布式网络等方面意见统一，建立了紧密的区域合作关系。

For the recent years, NOAA of US, JMA of Japan, BOM of Australia and NCC of China have made considerable progresses in the monitoring and prediction of ENSO events. They issue the operational oceanic and atmospheric products over the tropical Pacific Ocean and carry out the monthly, seasonal, annual prediction of SSTA by using both statistical methods and dynamical models in each month respectively. These products are reasonably good and are very useful guidance for other countries. But, most of their monitoring and prediction concentrate on the equatorial central and eastern Pacific Ocean. Less attention is paid to the monitoring and prediction of the western Pacific warm pool as well as the monitoring of the effects resulting from warm pool SSTA and ENSO. In 1999, under the assistance and support of APN, China, Japan, Korea, Philippines, Thailand, Malaysia, Vietnam, Indonesia, and Australia jointly proposed and undertook the APN cooperation and research project " Monitoring and prediction of ENSO event and SSTA over the warm pool in the western Pacific Ocean" (1999-2000). Since the participating institutions are all of APN countries /regions, affected greatly by monsoon, they are of great concern for ENSO events and the warm pool and their impact on the East Asian monsoon. This is the central issue of our project. Therefore, we have made a consensus of the project goal, objectives, respective contributions and distributed network. A close regional cooperative relationship has been established and worked jointly very well.

能力建设
Capacity Building

通过发展和建立国际互联网络，这个项目将大大增加APN向APN国家发布和交换ENSO和暖池监测和预测信息的能力。这种结构建设特别有利于APN地区的发展中国家及时接收信息和警告、为可能发生的灾害做好准备，这些国家的能力也会因此增强。所以，这个项目对增加研究全球环境变化问题的APN区域和国家能力的基本目标做出贡献。

This project will greatly build up APN capability to disseminate and exchange monitoring and prediction information of ENSO events and the warm pool for APN countries through the development and establishment of an international network. This kind of infrastructure building is especially useful for developing countries in this region to timely receive the information and warning for their preparedness of potential disasters. Their national capability building in this regard will be also enhanced. Therefore, this project contributes to the fundamental APN goal of building regional and national capacity (technical expertise) for researching global environmental change issues.

与政策的联系
Links To Policy

本项目的大部分参加者是气象、水文和其它有关机构的各级领导，他们直接或间接地负责为他们国家的各级政府提供必要的信息以制定相应的准备措施。所提供的信息有助于决策者为预防潜在的灾害采取必要的行动。

Most of the participants of this project are the directors, heads or chiefs of meteorological, hydrological or some other related agencies which are directly or indirectly in charge of providing necessary information for the governments of their countries to make contingent preparedness measures. The provided information can assist in policymaker to take necessary action for prevention from potential disasters.

与全球变化研究计划的关系
Relationship to Global Change Research Programmes

本项目与 WCRP的CLIVAR 研究计划和ENSO应用计划以及国际气候预测研究院保持合作关系。

It has a cooperative relationship with CLIVAR of WCRP research programme and ENSO Application Project, International Research Institute for Climate Prediction (IRI/LDEO, Columbia University, USA).

有关的研究工作
Related Research Work

本项目与中国国家重中之重项目“中国短期气候预测系统”的第二、三和四专题互相支持，(国家气候中心承担，中国科技部支持)。

此外，中国气象局国家气候中心与美国国家海洋－大气管理局国家环境预报中心的气候预测中心和国际气候预测研究院一直保持着良好的合作关系，特别是在气候和季风领域，如发展季节预测气候模式、ENSO预测模式、暖池预测和夏季降水预测研究以及交换结果等。中国国家气候中心参加国际气候预测研究院的ENSO应用计划（1994-2000），对方赠送了一台工作站和DSST软件系统。

The second, third and fourth subprojects in the National Key Project " Studies on Short-term Climate Prediction System in China" (1996-2000), undertaken mainly by National Climate Center and financially supported by Ministry of Science and Technology of China.

NCC/CMA has had a good cooperative relationship with Climate Prediction Center (CPC) /NCEP, NOAA and IRI, in particular in the areas of climate and monsoon, development of climate model for seasonal prediction, ENSO prediction, prediction of the warm pool, prediction of summer precipitation patterns and exchange of outputs.CNCC has joined in ENSO Application Project (1994-2000) of International Research Institute for Climate Prediction (IRI/L-DEO, Columbia University, US) , with one workstation and a DSST software system donated to National Climate Center of China.

参加单位
Names of Participating Organizations:

中国气象局国家气候中心，中国科学院大气物理研究所，香港城市大学，日本气象厅气候预报部，东京大学气候系统研究中心，澳大利亚气象局国家气候中心，韩国气象厅，菲律宾大气、地球物理和天文局，印度尼西亚评估和应用技术局；越南气象水文研究所，马来西亚气象局。

National Climate Center (China); Institute of Atmospheric Physics (China); City University of Hong Kong (China); Climate Prediction Division, JMA (Japan); Center for Climate System Research, University of Tokyo (Japan); National Climate Centre (Australia); Meteorological Research Institute (Korea); Philippine Atmospheric, Geophysical and Astronomical Services Administration (Philippines); Agency for the Assessment and Application of Technology (Indonesia); Institute of Meteorology and Hydrology (Vietnam); Malaysian Meteorological Service (Malaysia).

大事记

IMPORTANT ACTIVITIES MEMORANDUM

● 1999年9月16—17日，在北京成功地举办了本项目的预备会议。来自澳大利亚、中国（包括香港）、印度尼西亚、日本、马来西亚、菲律宾和越南等国家的代表参加了这次会议，他们介绍了在监测ENSO和暖池及其对东亚和东南亚气候异常的影响方面和用动力模式和统计方法预测ENSO方面的研究进展。会议讨论和制定了APN 项目(#99012)的实施计划和1999—2000年的具体任务和时间表。

● On 16-17 September 1999, the project successfully held an inception meeting in Beijing. The participants from Australia, China, Hongkong of China, Indonesia, Japan, Malaysia, Philippines and Vietnam reported their recent research progress in the areas of the monitoring of ENSO events, SSTA in the Warm Pool and their impacts on the climate change of East and South-east Asia as well as the prediction of ENSO with coupled models and statistical methods. The implementation plan of APN Project (#99012), the tasks and timetable for 1999-2000 were fully discussed and an agreement was finally made of further actions in the near future.

● 2000年2月27—29日，在上海成功地召开了关于"ENSO和暖池海表面温度异常"的国际研讨会。在这次会议上，中国国家气候中心演示了本项目初步建立起来的网络系统，本项目的其它参加国和地区也展示了自己与监测和预测ENSO和暖池海表面温度异常有关的网页。在此基础上，初步综合形成了一个完整网络系统，其中包含中国国家气候中心网页。此外，与会代表还介绍了各国的研究进展，并就一些关键问题进行了热烈的讨论。

● On February 27-29, 2000, the international workshop on ENSO and SSTA over the warm pool was held successfully in Shanghai, China. During the workshop, the initial network system of this APN project was demonstrated by CNCC, and each of the other contributing countries/regions demonstrated its own homepage related with the monitoring and prediction of ENSO event and SSTA over the Warm Pool, on which basis a full network has been initially integrated with the inclusion of CNCC network system. Moreover, the research progresses made since the inception meeting were reported and some key issues were fully discussed by the meeting participants.

● 为确保项目按计划如期进行，2000年9月27–28日，在北京召开了APN 项目(#2000–12)中期检查会议。项目负责人丁一汇教授主持了会议，参加这个项目的12名中国科学家出席了会议并汇报和检查了前半年的工作进展。这次会议还讨论和安排了未来的工作。

● To ensure the project get along according to the plan, an interim examination meeting for the APN Project 2000-12 (*the network system for monitoring and predicting ENSO event and sea temperature structure of the warm pool in the western Pacific Ocean*) was held in Beijing on September 27-28,2000. The meeting was chaired by the project leader, Prof. Ding Yihui, with 12 Chinese coleaguers of this project attending. The progresses of the APN Project 2000-12 for the first half year were reported and evaluated at the meeting. Then, the future activities have been arranged in order to continuously improve the network.

● 2002年2月5–7日准备在澳门召开关于"监测和预测ENSO事件和暖池及其对东亚季风的影响"的国际研讨会，这是本项目的总结会。

● An international workshop on monitoring and seasonal to interannual prediction of ENSO event and the warm pool and their impact on the East Asian monsoon is prepared to be held in Macau in 5-7 February 2002 (Summary Meeting).

大约40人将应邀参加这次会议，其中包括来自8个APN国家、美国海军研究生院和国际太平洋研究中心的专家们。他们对本项目研究和网络建设方面做出了贡献。这次会议的目标是：(1) 交换研究成果，用新的研究成果更新监测和预测ENSO和暖池海温结构及其对东亚季风、热带气旋和极端事件的网络；(2) 演示更新了的、本项目共同建立的ENSO和暖池监测和预测系统；(3) 增加新的信息，包括暖池对东南亚和东亚天气和气候的影响、东亚季风活动及其与暖池的相互作用和ENSO和暖池对社会经济的影响等方面的信息；(4) 改进和更新现在的网络，加入项目各参加国提供的新内容，特别是新资料集和预报产品；(5) 澳门研讨会可能是我们这个项目三年来的总结会，我们将讨论如何继续维持本项目已经建立起来的这个APN网络系统。

About 40 people including experts from 8 APN countries and US Navy postgraduate school and IPRC, will be invited to attend the workshop. They have been directly involved in our project with their contributions in the aspects of research and development of the network. The goals of the workshop are: (1) to exchange research results and update the achievements and network on monitoring and prediction of ENSO and sea temperature structure over warm pool, and their impact on East-Asian monsoon, tropical cyclones and extreme events;(2) to demonstrate the updated system of the monitoring and prediction of ENSO and the warm pool developed jointly for this project; (3) adding new information, including information of effect of Warm Pool on the weather and climate over Southeast Asia and East Asia, activities of East Asian monsoon and its interaction with Warm Pool, and soci-economic impacts of ENSO events and Warm Pool; (4) improving and updating the existing network, with new inputs from each contributing countries/regions, in particular new accessible data sets and predictive outputs; (5) the Macau workshop will possibly be the summary meeting for our 3-year project. We will discuss how to continuously maintain this APN network.

致　谢

感谢 APN 对本项目的连续支持，也感谢各参加国和地区的大力支持。另外，对于中国科技部与中国气象局的支持也深表感谢。书中摘引了不少图表和材料，也向有关作者致谢，恕不署名。

Acknowledgements

We would like to express our sincere thanks to the APN for their continuous support. Thanks also go to all participating countries and regions as well as MOST and China Meteorological Administration. In this booklet, many diagrams and tables have been taken from varions sources. Their contributions are greatly appreciated.

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