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Predictability of Seasonal Rainfall, Monsoon Onset and Duration in Indonesia, Philippines and Bangladesh

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ABSTRACT: Rainfall variability in the Asia-Pacific region is largely influenced by the El Niño Southern Oscillation (ENSO), the Interdecadal Pacific Oscillation (IPO), the Intertropical Convergence Zone (ITCZ), and the Indian Ocean Dipole (IOD). Of particular interest is the ENSO phenomenon, which provides the basis for seasonal prediction of rainfall using statistical methods employing atmospheric (Southern Oscillation Index or SOI) and sea surface temperature anomaly (SSTa) data as proxies for ENSO. In this paper, we used several derivatives of ENSO-based predictors to assess rainfall forecast skill across the study region and the impact of ENSO on the onset and duration of the monsoon. The results show that ENSO has a significant skill in predicting seasonal rainfall and monsoon onset (and duration) in the Philippines and Indonesia. The strength of relationship in Bangladesh was weak with little potential at present for developing an operational seasonal climate prediction model based on ENSO.

KEYWORDS: *climate variability, ENSO, southeast Asia, seasonal climate forecasts, monsoon onset and duration*

HIGHLIGHTS

- » Impact of ENSO was strong in the Philippines with moderate to high forecasting skill through most of the year with lead times of up to 3 months. Niño 3.4 and SOI had the strongest relationship with rainfall variability across the whole region. Forecasting skill was poor during the peak rainy season (June–August).
- » Onset and duration of monsoon in the Philippines and Indonesia was influenced by ENSO with later onset and shorter duration of monsoon during El Niño years and earlier onset and longer duration during La Niña years. On average, the onset of monsoon was up to 38 days later and up to 35 days shorter in El Niño years compared to La Niña years.
- » Impact of ENSO on Indonesian rainfall is also strong with moderate to high forecasting skill from June to December, particularly in eastern Indonesia.
- » There appears to be little influence of ENSO on the climate of Bangladesh in terms of the predictability of rainfall, onset and duration of the monsoon season.

Introduction

Agriculture is important in the economy of the Philippines, Bangladesh and Indonesia with contributions of 11-16% to GDP. Rice is the main crop grown which provides food security for farmers and their families. However, with a three to four month wet monsoon season, rice can only be grown, once without irrigation. High climate variability coupled with inadequate water distribution systems in this region makes water security for cropping uncertain, which leads to frequent crop failures. ENSO phenomena has a significant impact on rainfall variability and on the timing of the monsoon in the region. In El Niño years, the onset of the monsoon is later than normal, causing delayed planting and reduced yields. Naylor et al. (2007) reported average losses of over 1 million tons of rice in central East Java and West Java from a 30-day delay in monsoon onset. Forecasting of rainfall including the onset and duration of the monsoon would enable better planning of water allocation and cropping decisions leading to less frequent crop failures and maximising planting opportunities during favorable seasons. A key objective of this study was to identify ENSO-based predictors with potential for developing an operational rainfall forecasting system in the region.

Methodology

Prediction of Seasonal Rainfall

Rainfall data for several stations across the three countries were used in the SCOPIC (Seasonal Climate Outlooks for Pacific Island Countries) and FLOWCAST climate prediction software to assess the skill of various predictors (Niño 3.4, SOI and SSTa) in predicting seasonal rainfall. SCOPIC and FLOWCAST uses a linear discriminant analysis to calculate rainfall probability based on different predictor values. Monthly rainfall data ranging from 50 to 100 years were used in the analysis. However, the analysis was limited for SST predictors due to lack of predictor data prior to 1982. The principal measure of forecast repeatability or skill used in this study is a cross-validated hind-cast Linear Error in Probability Space (LEPS) skill score test. The skill of the forecast system is expressed in terms of the LEPS score that is described by Potts et al. (1996). Since forecasting skill depends on lead time, time of the year, predictor value and predictor averaging period, we have derived an overall measure of skill based on the average results of LEPS analyses incorporating:

- Twelve forecasting periods;
- Three lead times (0, 1 and 2 months); and
- Three predictor-averaging periods (1, 2 and 3 months for SST based systems and 2, 3 and 4 months for SOI based systems).

Onset and Duration of Monsoon

To assess the effect of ENSO on the timing and duration of the monsoon, daily rainfall data of at least 30 years across the study region were used. Due to differences in geography and agricultural practices, the definition of the onset and duration of the monsoon varied from country to country but was generally defined as the first (last) date where cumulative rainfall over a specified duration (days) exceeded (not exceeded) a certain threshold. For the Indonesia monsoon, onset was defined as the first date (after October 1) when cumulative rainfall over 10 days exceeded 60 mm. End of the monsoon was defined as the first date (after the start of monsoon) where cumulative rainfall over 14 days was less than 25 mm. For the Philippines, the respective definitions were >25 mm over three days after April 1 for the onset and <25 mm over three successive days for the end of the monsoon. For Bangladesh, the start of the monsoon was defined as the first date (after 1 April) where cumulative rainfall over 15 consecutive days exceeded 60 mm. End of the monsoon was defined as the first date when cumulative rainfall over 10 successive days was less than 30 mm. After calculating these parameters for all years of data at each location, the probability distribution of onset and duration was derived for all years of data and then segregated based on El Niño and La Niña years. Significance testing was carried out using Kruskal–Wallis test at 0.05%. Classification of El Niño and La Niña years were based on Allan (1988).

Results and Discussion

The average annual LEPS scores for three predictor systems (Niño 3.4, SOI and SST1&2) for representative stations across the study region were derived. SST 1 and 2 represent sea surface anomalies in eastern Pacific and Indian Ocean (Drosdowsky and Chambers, 2001). The results show that both SOI and Niño 3.4 have a strong influence on rainfall prediction in the Philippines and eastern Indonesia. In western Indonesia and Bangladesh, the influence of ENSO is less pronounced. The LEPS scores for different predictor systems are not directly comparable due to different length of data used in the analysis. It is also important to note that the LEPS scores are averages of 108 separate analysis and provide an overall level of skill across the year for three lead times and three predictor-averaging periods. As resulted in three representative stations across the region, forecasting skill varies throughout the year and skills are higher with lead time of zero month and for certain parts of year. In Bangladesh, it was found that there is little influence of ENSO on rainfall throughout the year.

The effect of ENSO on monsoon onset and duration for several stations across the region is shown in Table 1. With the exception of Bangladesh, the impact of ENSO on the onset and duration of the monsoon is strong with a median delay of 14 to 35 days for the onset during El Niño years as compared to La Niña years. Duration of the monsoon is also shorter during El Niño years with the median values ranging from 15 to 37 days compared to La Niña years. These results are consistent with earlier studies that show a weak relationship between ENSO and monsoon variability over Bangladesh (Kripalani et al., 1996) but a significant relationship between ENSO and rainfall variability over southeast Asia (Kripalani & Kulkarni, 1997).

Conclusion

Impact of ENSO is strong in the Philippines with moderate to high forecasting skill through most of the year with lead times of up to 3 months. Niño 3.4 and SOI have the strongest relationship with rainfall variability across the whole region. Forecasting skill is poor during the peak rainy season (June–August) in some regions. Onset and duration of the monsoon in the Philippines is influenced by ENSO with later onset and shorter duration of the monsoon during El Niño years and earlier onset and longer duration during La Niña years. On average, onset of the monsoon is up to 38 days later and up to 35 days shorter in El Niño years compared to La Niña years.

Impact of ENSO on Indonesian rainfall is also strong with moderate to high forecasting skill particularly in eastern Indonesia. Over western Indonesia and Java, the effect of ENSO on rainfall variability is less pronounced. Results from eastern Indonesia showed that, on average, the onset of the monsoon tends to be delayed by up to 1 month and they have a shorter duration in El Niño years as compared to La Niña years. There appears to be little influence of ENSO on the climate of Bangladesh in terms of the predictability of rainfall, onset and duration of the monsoon season.

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PROJECT INFORMATION

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		Delay in onset (days)			Duration (days)		
	Probability of Exceedance %	25%	50%	75%	25%	50%	75%
Tagbilaran Philippines	El Niño	59	37	15	109	91	69
	La Niña	25	23	11	118	106	91
	Difference **	34	14	4	9	15	22
Zamboanga Philippines	El Niño	67	56	25	102	73	59
	La Niña	27	21	12	119	110	100
	Difference **	40	35	13	17	37	41
Cox's Bazar Bangladesh	El Niño	51	24	6	174	157	139
	La Niña	41	28	19	163	137	129
	Difference n.s.	10	-4	-13	-11	-20	-10
Ampenan Indonesia	El Niño	56	44	37	172	165	158
	La Niña	31	19	14	196	185	176
	Difference **	25	25	23	24	20	18
Mangkung Indonesia	El Niño	93	75	63	147	140	109
	La Niña	57	44	25	185	168	150
	Difference **	36	31	38	38	28	41

** significant at 0.05% n.s. not significant based on the entire distribution

Table 1. Delay in monsoon onset and monsoon duration at 25, 50 (median) and 75 percentiles for selected stations in the Philippines, Indonesia and Bangladesh.