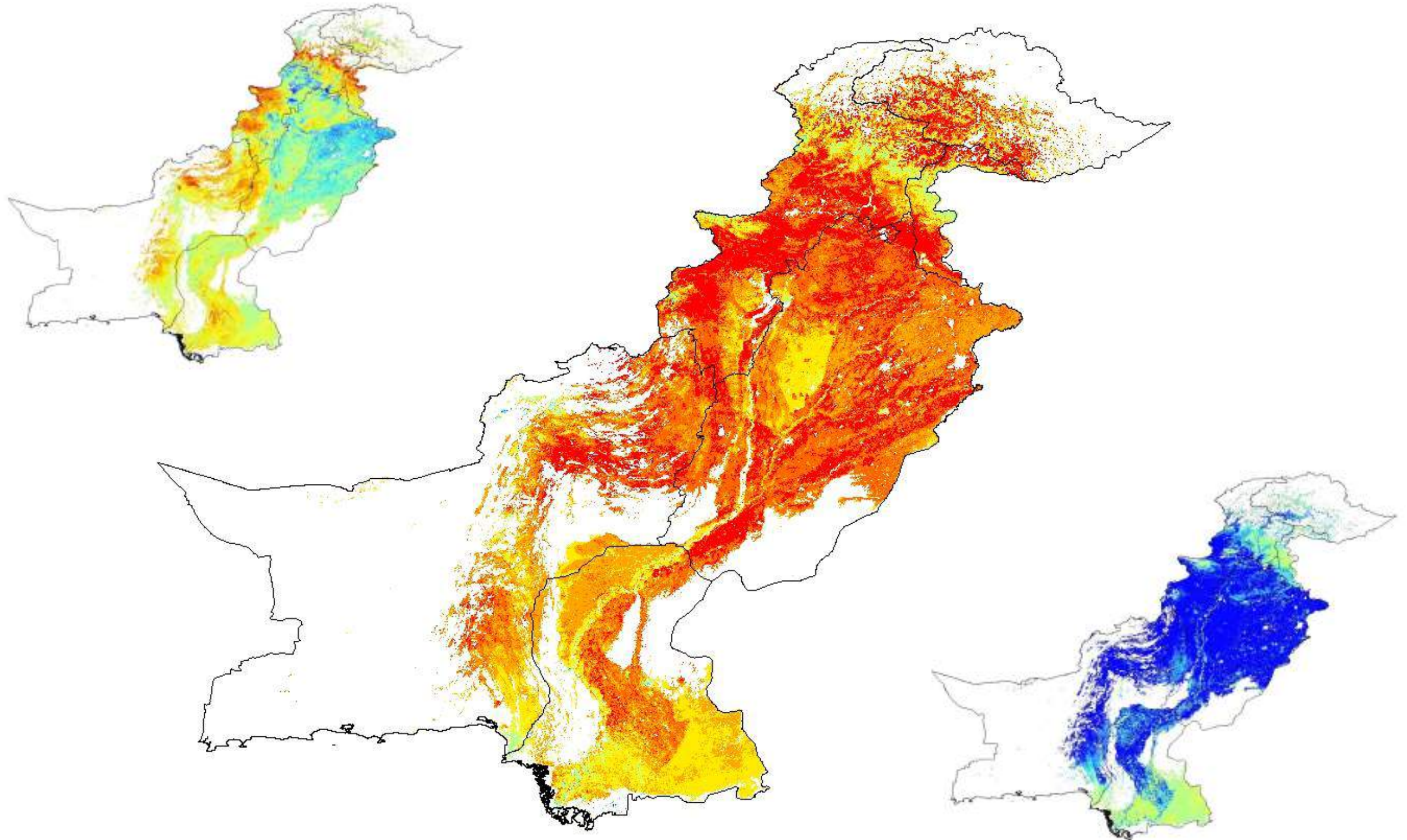


THE DROUGHT ATLAS OF PAKISTAN

Dr. Hemu Kharel Kafle





The Drought Atlas of Pakistan

Dr. Hemu Kharel Kafle

Center for Water and Atmospheric Research



The Drought Atlas of Pakistan

(Historical monthly drought of Pakistan from 2000-2020)

Dr. Hemu Kharel Kafle

Publisher: Kathmandu Institute of Applied Sciences
Bagdol, Lalitpur,
Kathmandu, Nepal.

Figures/Maps: Ms. Soni Khaitu

Edition: First, 2022, January

Price: Rs. 5000.00 (NPR)

ISBN: 978-9937-1-3064-6

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Acknowledgement

The Center for Water and Atmospheric Research (CENWAR) at Kathmandu Institute of Applied Sciences has produced the first edition of the Pakistan Drought Atlas. This Atlas uses a Drought Severity Index (DSI) to highlight the intensity of drought. Descriptive graphs and visuals are used to highlight the drivers and effects of drought in Pakistan.

We would like to thank our collaborator, Prof. Dr. Anjum Rasheed from Centre for Climate Research and Development (CCRD), COMSATS University Islamabad, Pakistan, for her valuable inputs on this atlas.

We are grateful to our technical supervisors Prof. Dr. Yasushi Yamaguchi from Nagoya University and Dr. Shinichi Sobue from GEOGLAM for their advice and inputs in this study. We sincerely thank Asia Pacific Network for Global Change Research (APN) for funding this research work.

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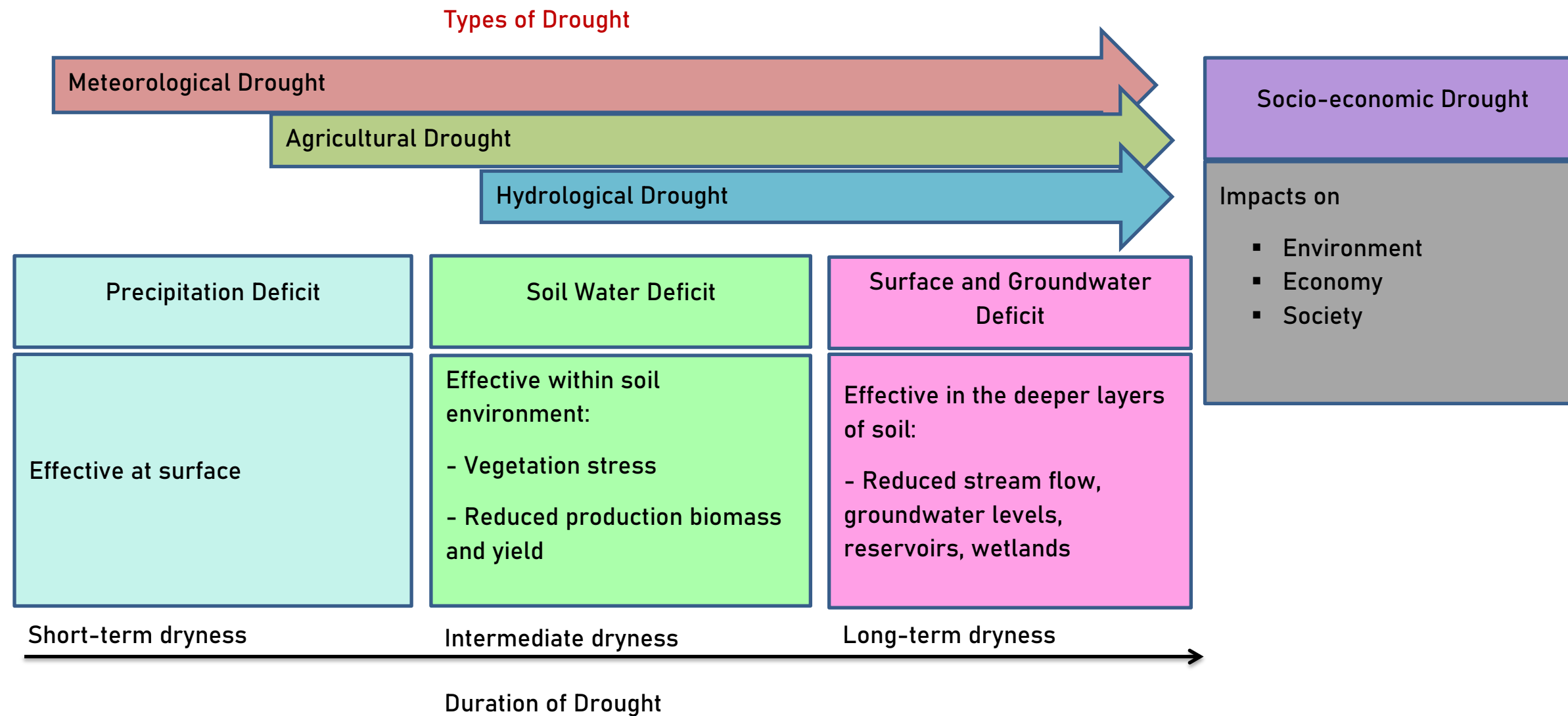


What is Drought?

Drought is a period of time when there is a lack of water on land. Drought mainly results from abnormally low rainfall leading to water scarcity (Wilhite, 2000b). It is defined as “severe water shortage”.

Drought is a complicated phenomenon, yet one of the least understood of all natural hazards impacting more people than any other disaster (Obasi, 1994). Since the demand for water is increasing along with the population in many parts of the world, water supply interruptions caused by drought can be expected to produce greater impacts (Hewitt, 1997).

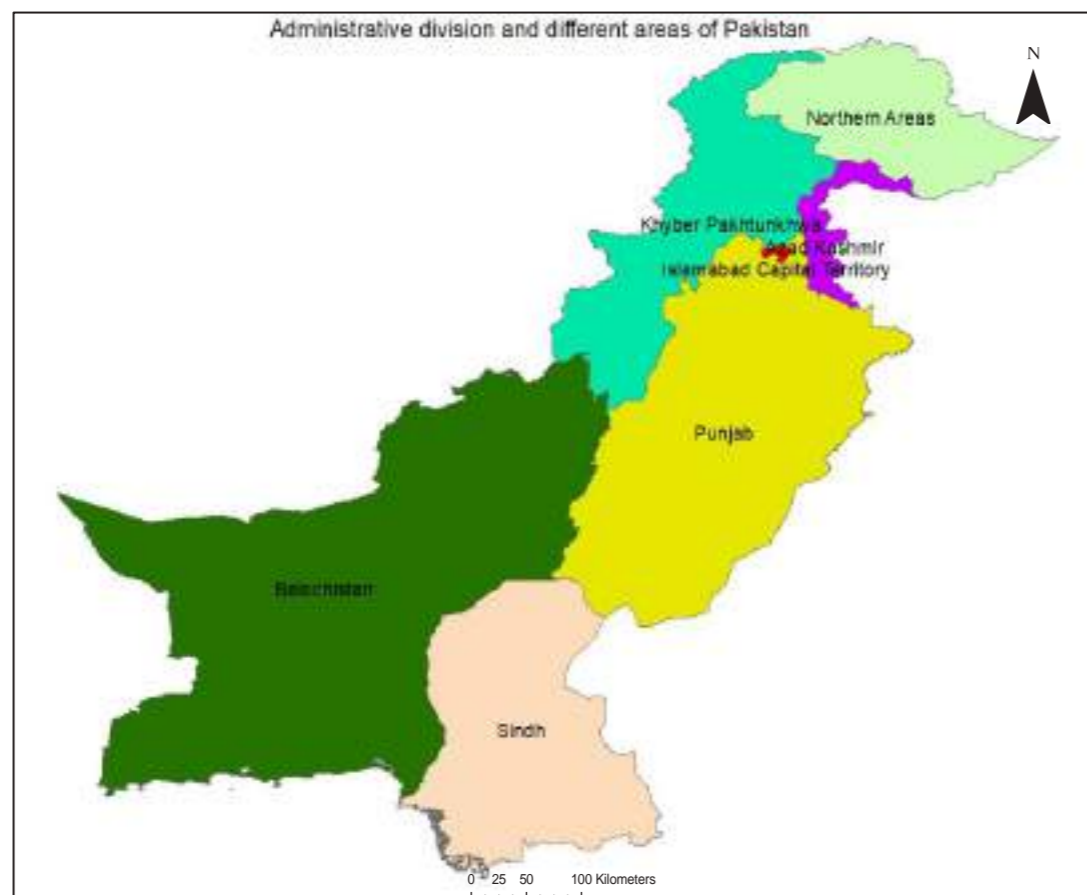
Drought is a global phenomenon; however, their effects are more vulnerable in developing countries because of the lesser potential to mitigate the impacts of such extreme events (Wilhite, 2000).



Pakistan Overview

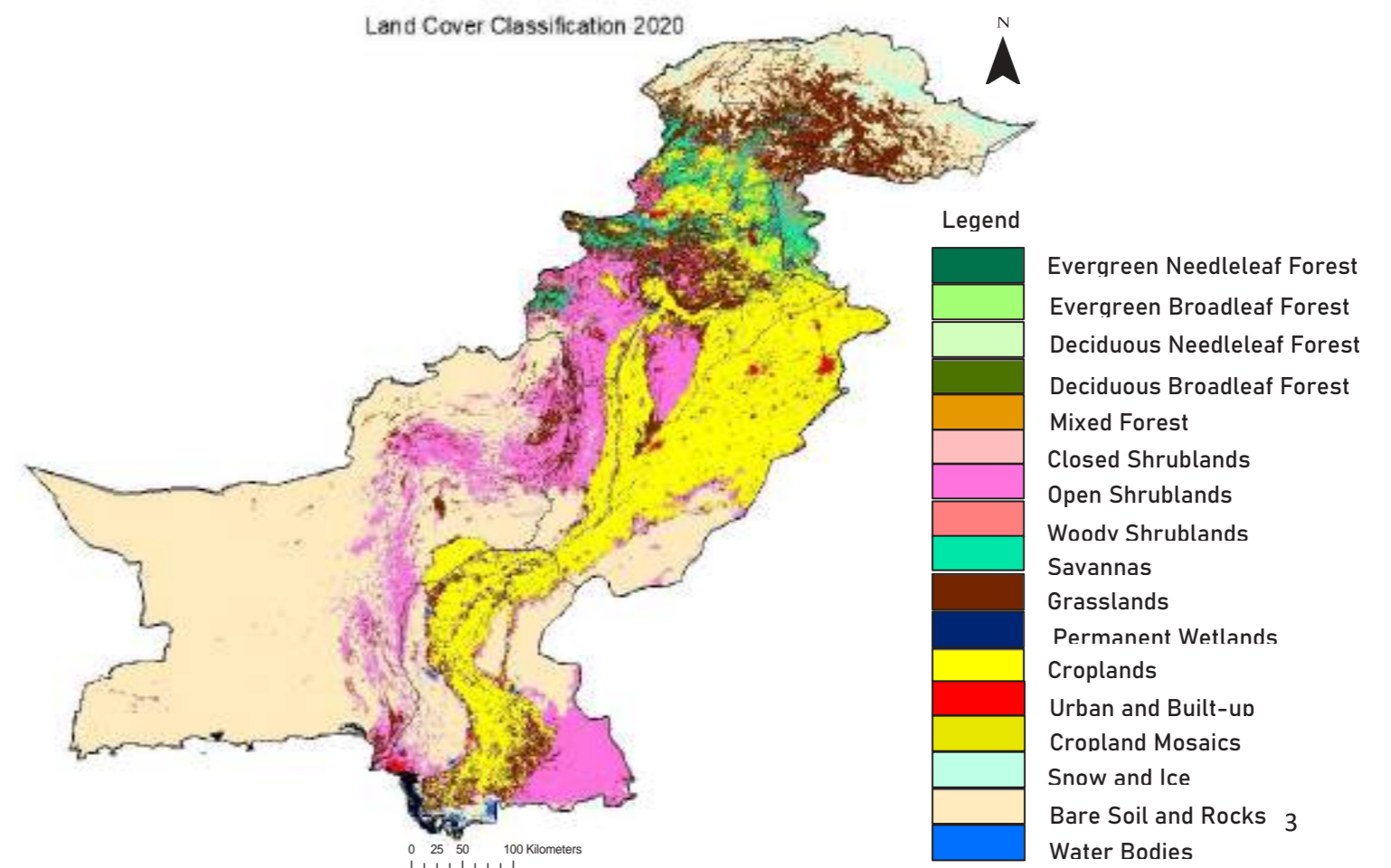
Pakistan is a predominantly arid region with a total land area of 796 096 km² and geographic coordinates of (23°–38°) N latitude and (61°–78°) E longitude. Pakistan has four provinces which include Balochistan, Khyber Pakhtunkhwa, Punjab, and Sindh and one federal territory i.e., Islamabad Capital Territory. In addition, there are two more autonomous territories i.e., the state of Azad Jammu & Kashmir and the Federally administered area of Gilgit Baltistan.

Pakistan has four seasons, which are classified as follows: cold season from December to March, hot season from April to June, monsoon or summer wet season from July to September, and autumn or post monsoon season from October to November. As predicted by Pakistan Meteorological Department (PMD), the country overall received below normal (41.5%) rainfall during October to March. The main thrust was in Balochistan (74.5%) and Sindh (77.3%) while it remained above normal during November throughout the country (FAO, 2021).



Precipitation in the country is divided into two seasons: summer or monsoon precipitation and winter precipitation (Kureshy, 1998). During the months of July and September, monsoon rains enter Pakistan from the east and north east. During this time, the north and northeastern parts of the country receive a significant amount of rain (Khan, 1993). Winter precipitation (December to March) is primarily caused by western disturbances that enter from Iran and Afghanistan (Luo and Lin, 1999).

According to FAO, 22.1 million hectares of the total area of 79.6 million hectares are farmed; the remainder is made up of cultivable waste, densely inhabited forests, and rangelands. Crop land is for 23.3 million hectares, whereas forests account for 4.6 million hectares of total land (GoP, 2010a). Pakistan is also among the top ten producers of wheat, cotton, sugarcane, mango, and dates, and ranks tenth in rice output (GoP, 2010a).



Remotely Sensed Data

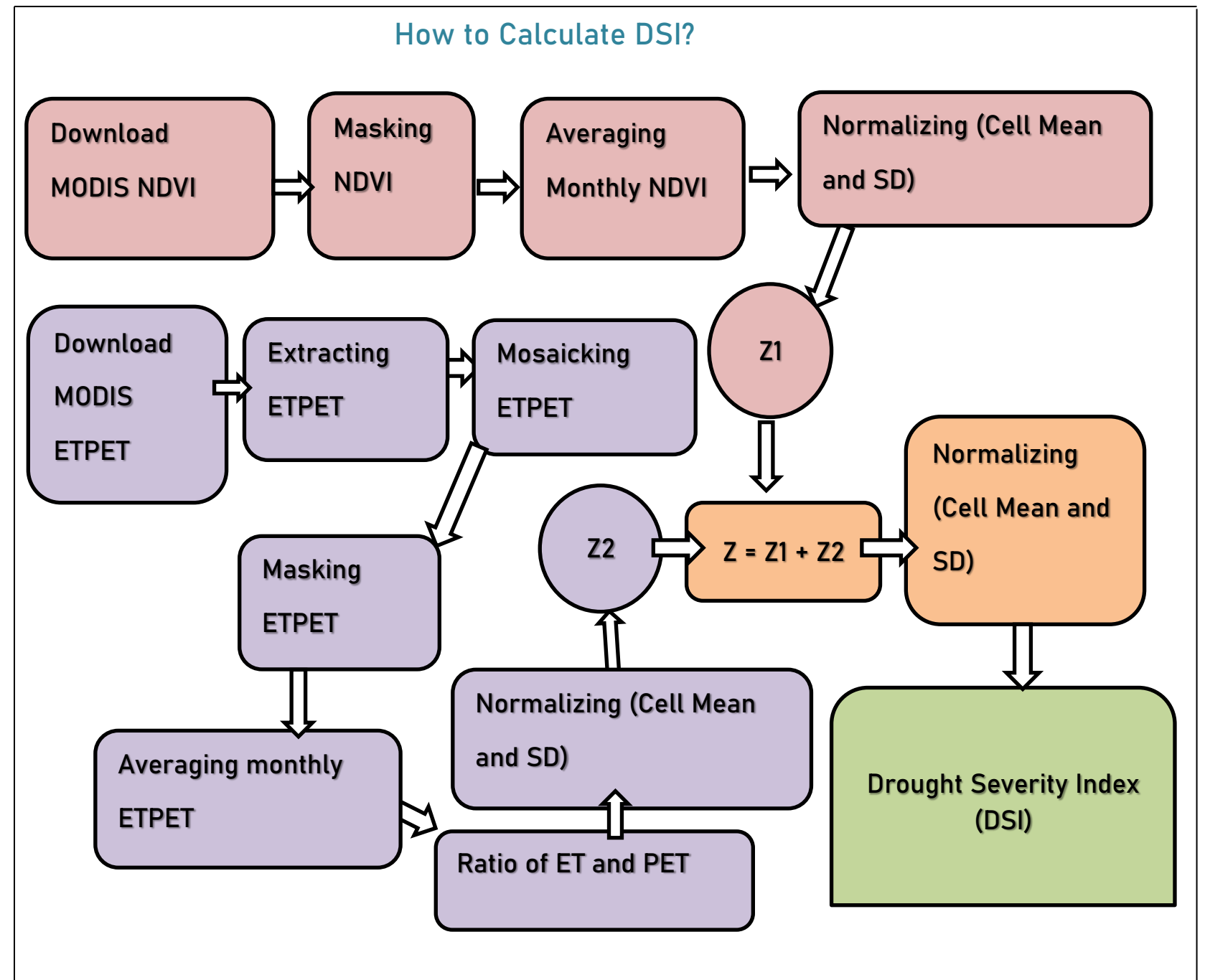
The Moderate-Resolution Imaging Spectrometer (MODIS) is an advanced narrowband-width sensor from which NASA and the USGS allow free composited reflectance data available every eight days via the Earth Resources Observation Systems (EROS) data center (Justice and Townshend, 2002a). MODIS products of Land cover, NDVI and ET/PET have been used for this study.

MODIS NDVI Data

This data includes MOD13A1 (MODIS/Terra Vegetation Indices 16-Day L3 Global 500m SIN Grid) NDVI products at 500m spatial resolution for twenty one years (2000-2020). Global MOD13A1 data are provided every 16 days at 500-meter spatial resolution as a gridded level-3 product in the Sinusoidal projection i.e obtained from NASA Land Processes Distributed Active Archive Center (LP DAAC, <https://lpdaac.usgs.gov/>).

MODIS ET, PET

This data set includes 8-day MOD16A2 Gap-Filled ET/PET (MODIS/Terra Net Evapotranspiration Gap-Filled 8-Day L4 Global 500m SIN Grid V006). The MOD16A2GF Version 6 product is a year-end gap-filled 8-day composite dataset produced at 500 meter (m) pixel resolution. The ET/PET datasets are obtained from Earth Data (<https://earthdata.nasa.gov/>).



Drought Severity Index (DSI)

DSI was chosen to investigate the spatiotemporal variability of droughts across the country using observed satellite products from 2000 to 2020. This newly proposed remote sensing index by Mu et al., 2013 has performed well in many parts of the world. According to Mu et al. (2013), the DSI Index, which combines the NDVI and ET/PET, is calculated as shown in equations (1) to (4). The incorporation of both transpiration and vegetation indicator data in DSI has been regarded as an improvement over other drought index. To study drought in Pakistan, monthly DSI values were calculated over a twenty one year period (2000–2020). Following are the equation systems that were used:

$$Z_{Ratio} = \frac{ET/PET - \overline{ET/PET}}{\sigma_{ET/PET}} \quad (1)$$

$$Z_{NDVI} = \frac{NDVI - \overline{NDVI}}{\sigma_{NDVI}} \quad (2)$$

$$Z = Z_{Ratio} + Z_{NDVI} \quad (3)$$

$$DSI = \frac{Z - \bar{Z}}{\sigma_Z} \quad (4)$$

Where Z_{Ratio} and Z_{NDVI} is the standardized value of ET/PET ratio and NDVI respectively. $\overline{ET/PET}$ and \overline{NDVI} is mean. σ_{Ratio} and σ_{NDVI} is the standard deviation of ET/PET ratio and NDVI respectively. \bar{Z} and σ_Z represents the mean and standard deviation of the sum of Z_{Ratio} and Z_{NDVI} respectively. Drought Severity Index is represented by the DSI calculated in equation (4). Positive DSI value indicates wet condition, while negative values indicate dry conditions, Mu et al. (2013) classified DSI, as shown in table.

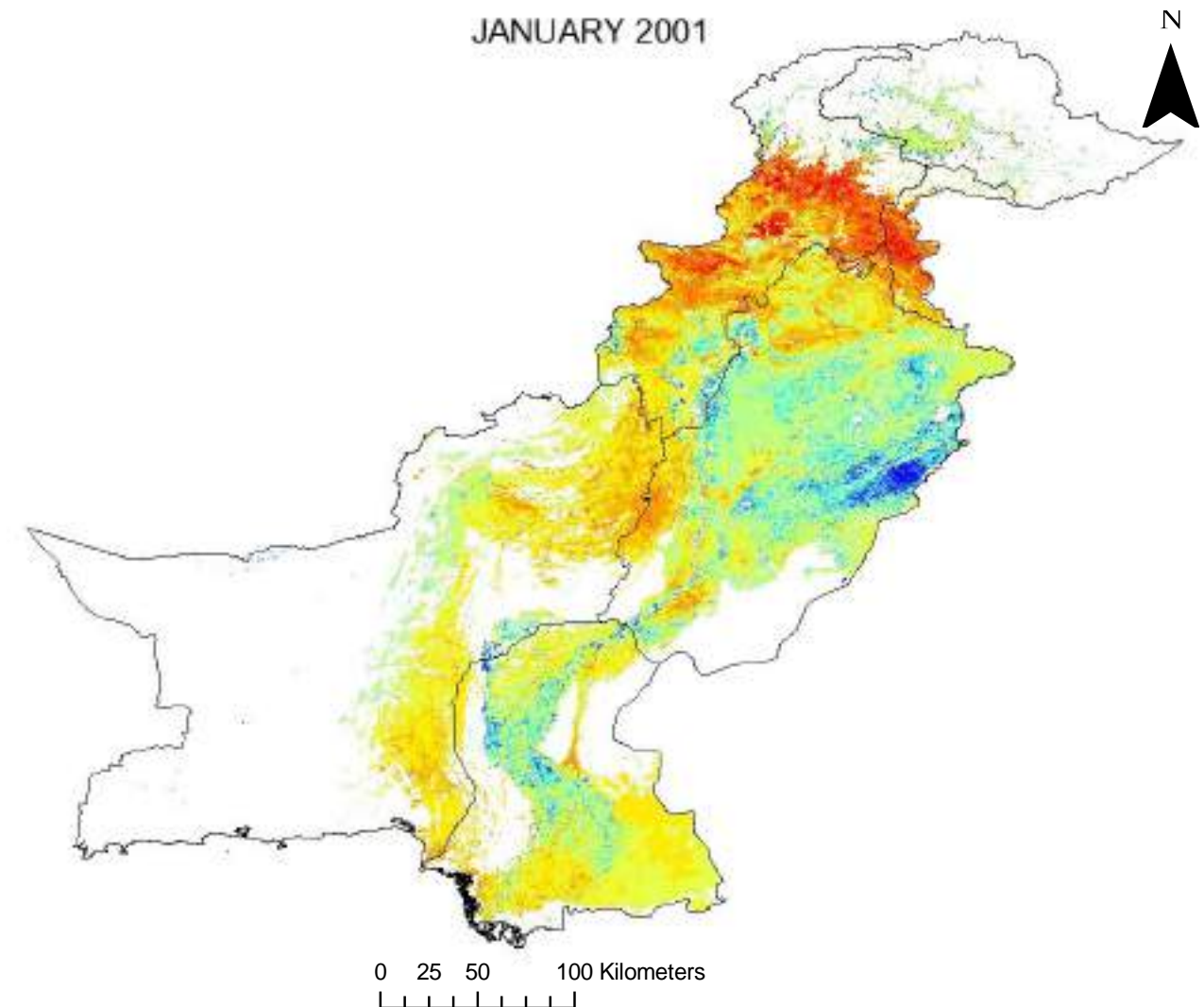
The generate DSI is then imported to ArcGis to export monthly DSI maps i.e displayed in this atlas. In mean monthly DSI maps of Pakistan, extreme dry condition is denoted by Red colour whereas dark blue colour denotes extreme wet condition.

Category	DSI Values	Colour
Extreme Drought	-1.5 or less	Red
Severe Drought	-1.2 to -1.49	Orange
Moderate Drought	-0.9 to -1.19	Yellow-Orange
Mild Drought	-0.6 to -0.89	Yellow
Incipient Drought	-0.3 to -0.59	Light Green
Near Normal	0.29 to -0.29	Green
Incipient Wet Spell	0.3 to 0.59	Light Cyan
Slightly Wet	0.6 to 0.89	Cyan
Moderately Wet	0.9 to 1.19	Blue-Cyan
Very Wet	1.2 to 1.49	Blue
Extremely Wet	1.5 or greater	Dark Blue

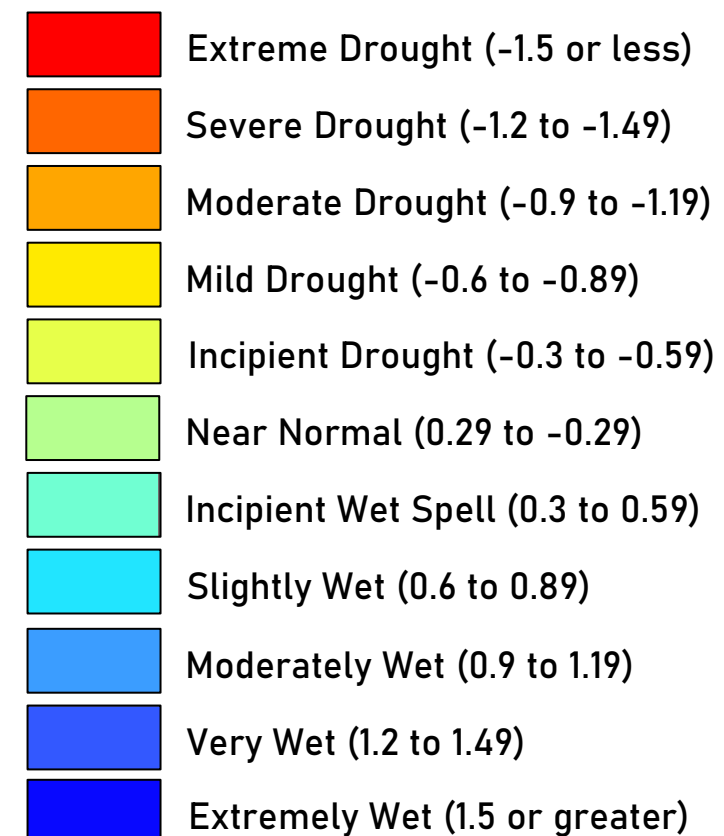
January DSI Maps

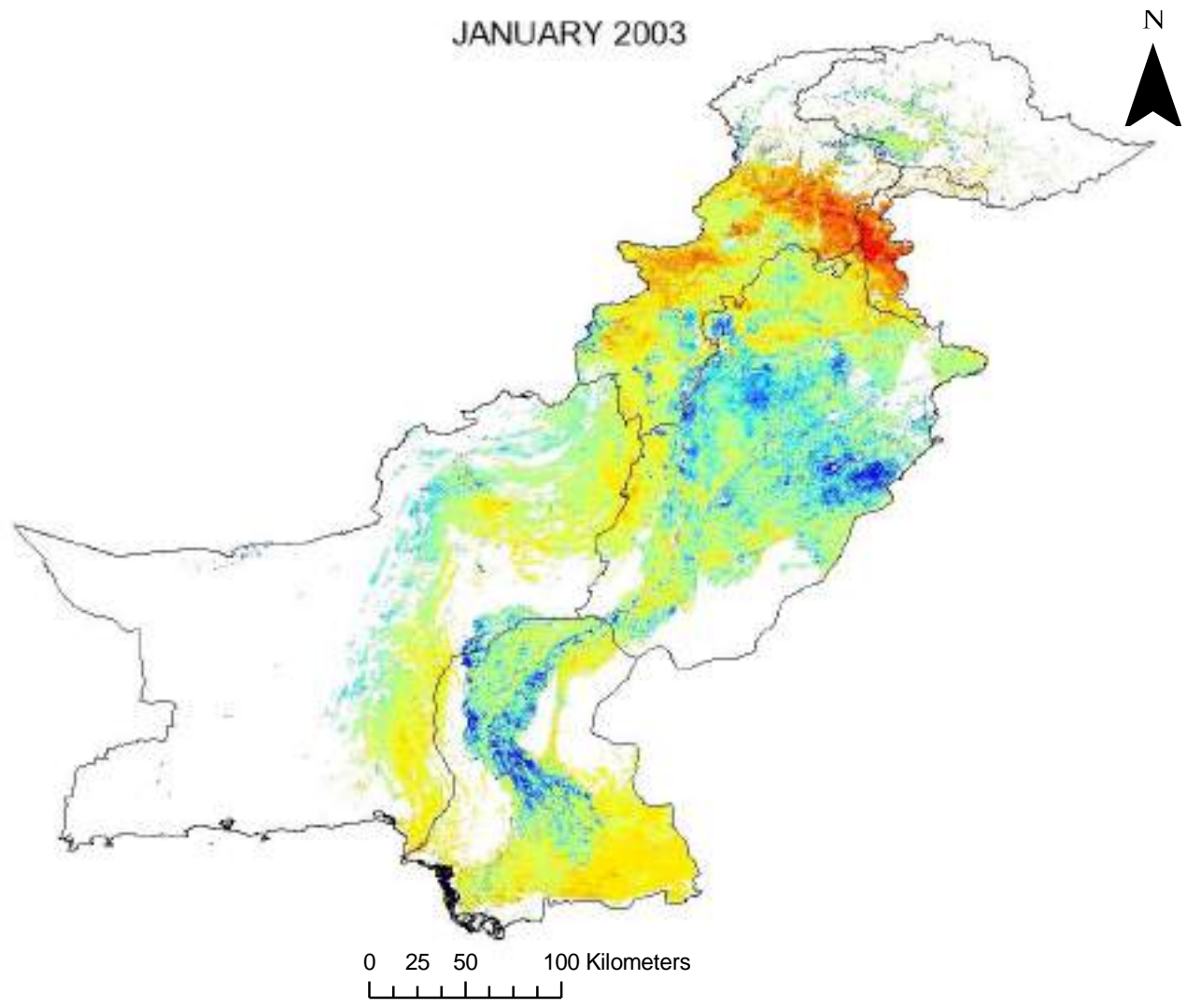
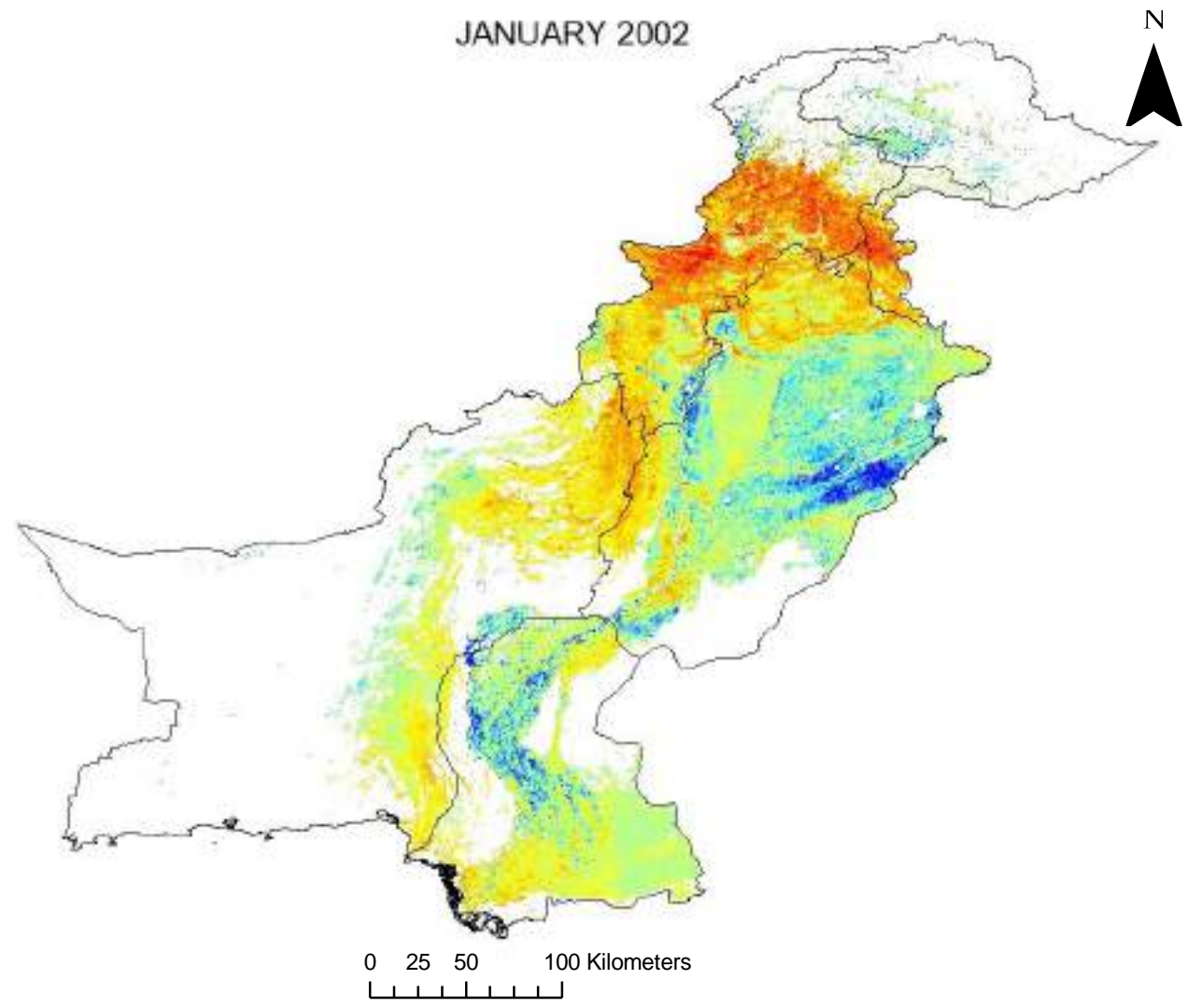
Drought conditions in January typically vary from incipient drought to extremely wet condition. This winter month's characteristics are often marked by near-normal conditions.

Mean January DSI Values		
Years	Values	Drought Condition
2001	-0.51	Incipient Drought
2002	-0.37	Incipient Drought
2003	-0.28	Near Normal
2004	0.65	Slightly Wet
2005	0.84	Slightly Wet
2006	0.10	Near Normal
2007	0.13	Near Normal
2008	0.33	Incipient Wet Spell
2009	0.72	Slightly Wet
2010	-0.31	Incipient Drought
2011	-0.21	Near Normal
2012	0.19	Near Normal
2013	-0.16	Near Normal
2014	0.00	Near Normal
2015	0.09	Near Normal
2016	0.42	Incipient Wet Spell
2017	0.99	Moderately Wet
2018	-0.10	Near Normal
2019	1.06	Moderately Wet
2020	1.53	Extremely Wet














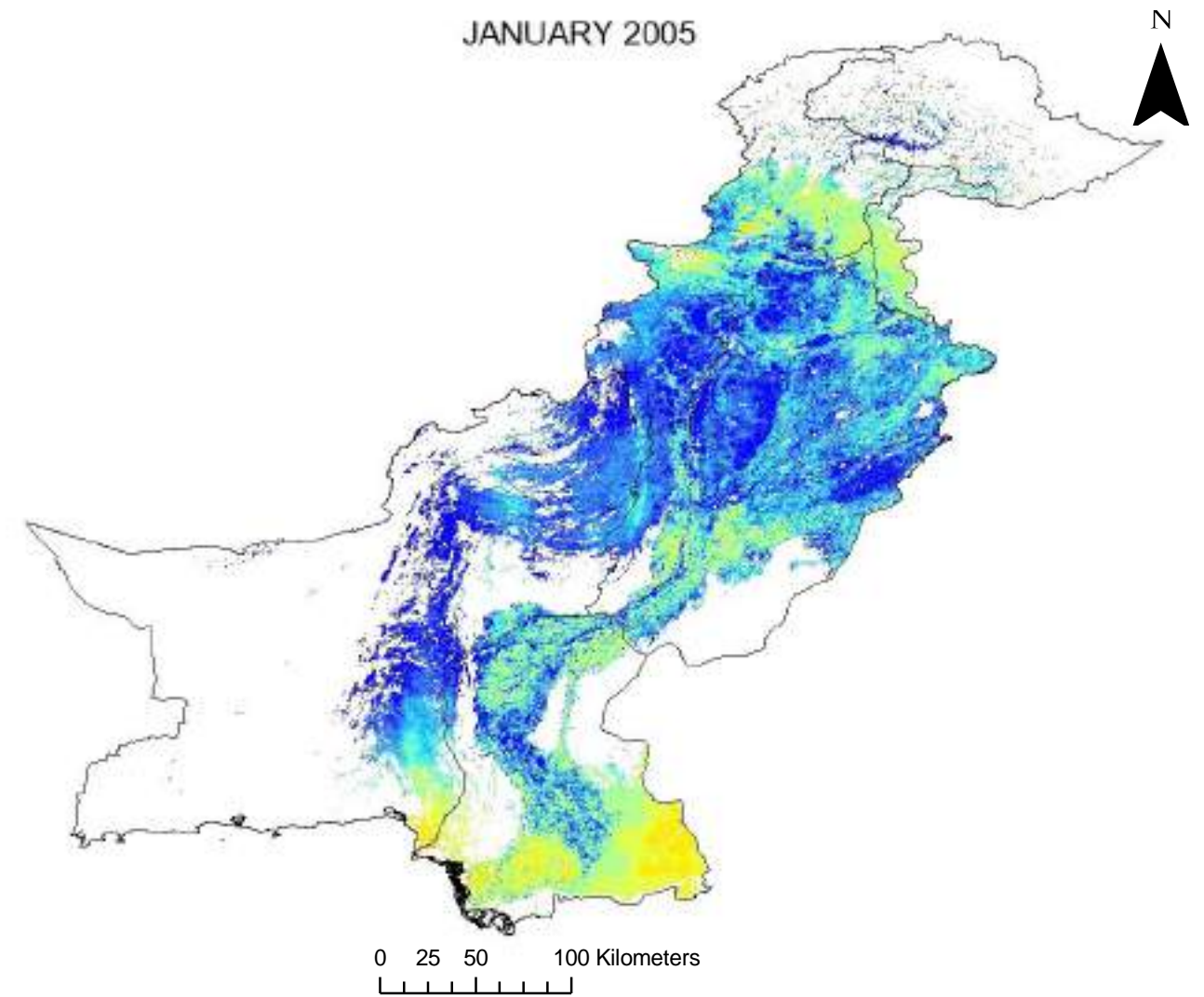
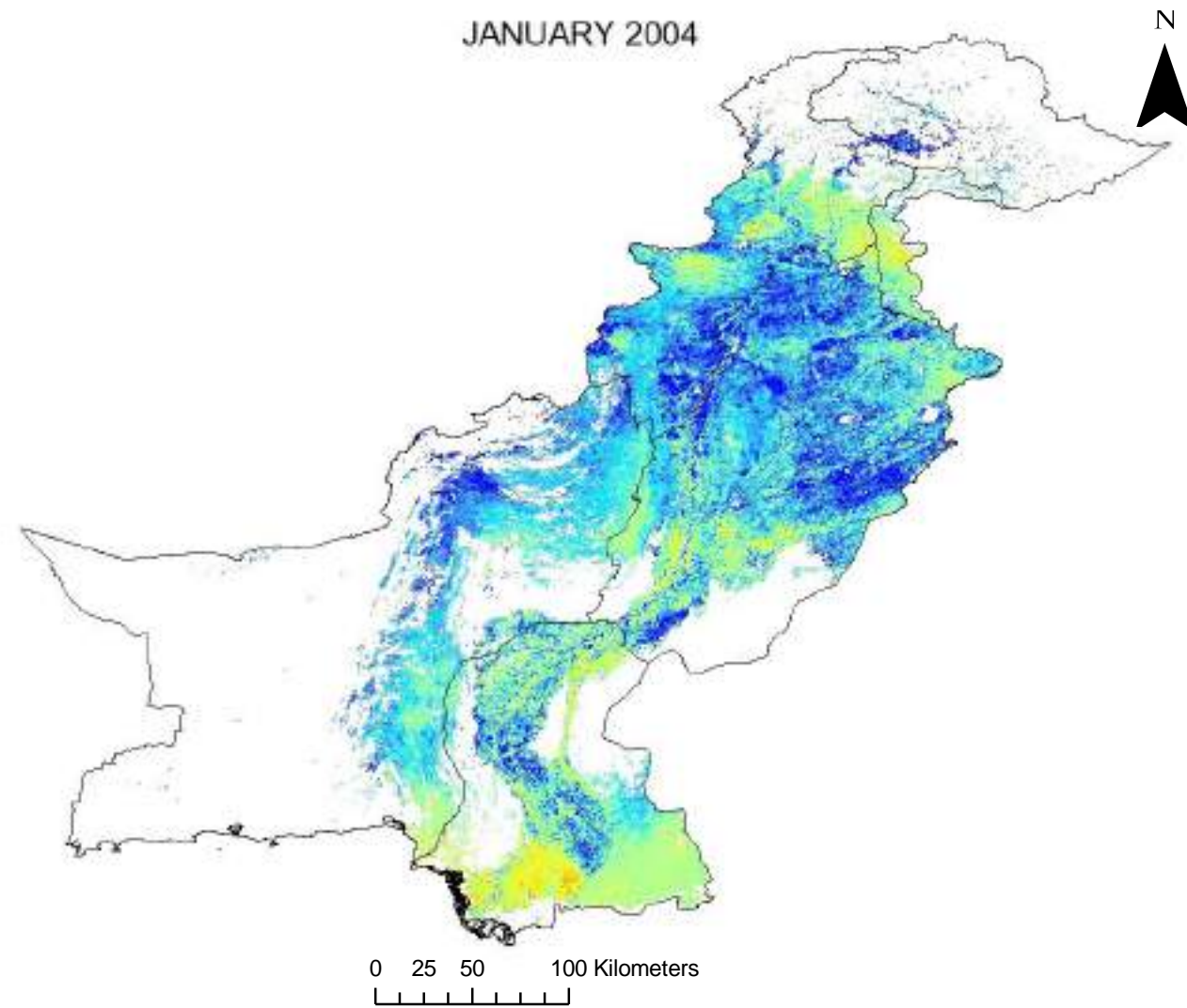
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Legend

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|--|---|--|
|  Extreme Drought (-1.5 or less) |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19) |
|  Severe Drought (-1.2 to -1.49) |  Near Normal (0.29 to -0.29) |  Very Wet (1.2 to 1.49) |
|  Moderate Drought (-0.9 to -1.19) |  Incipient Wet Spell (0.3 to 0.59) |  Extremely Wet (1.5 or greater) |
|  Mild Drought (-0.6 to -0.89) |  Slightly Wet (0.6 to 0.89) | |

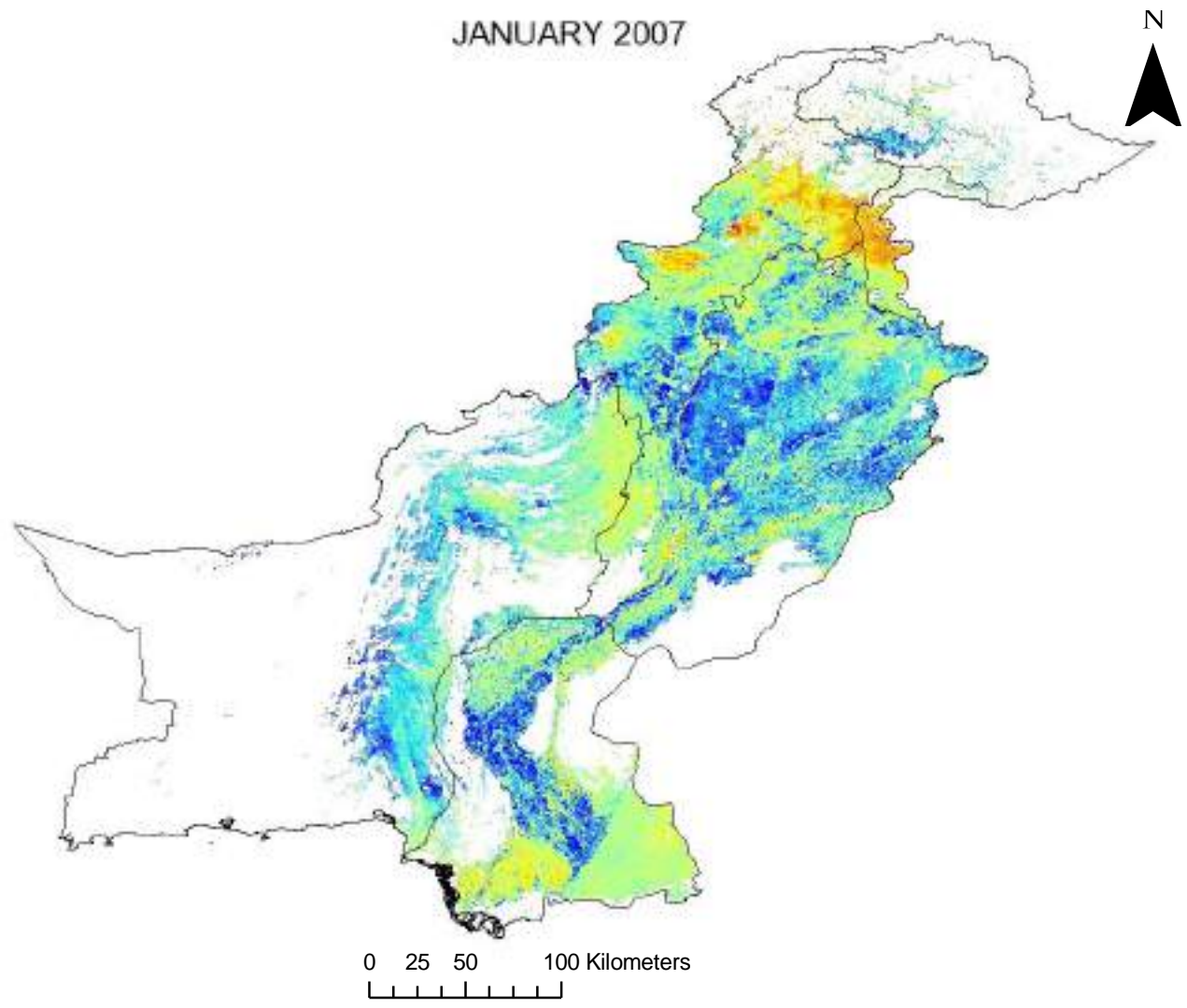
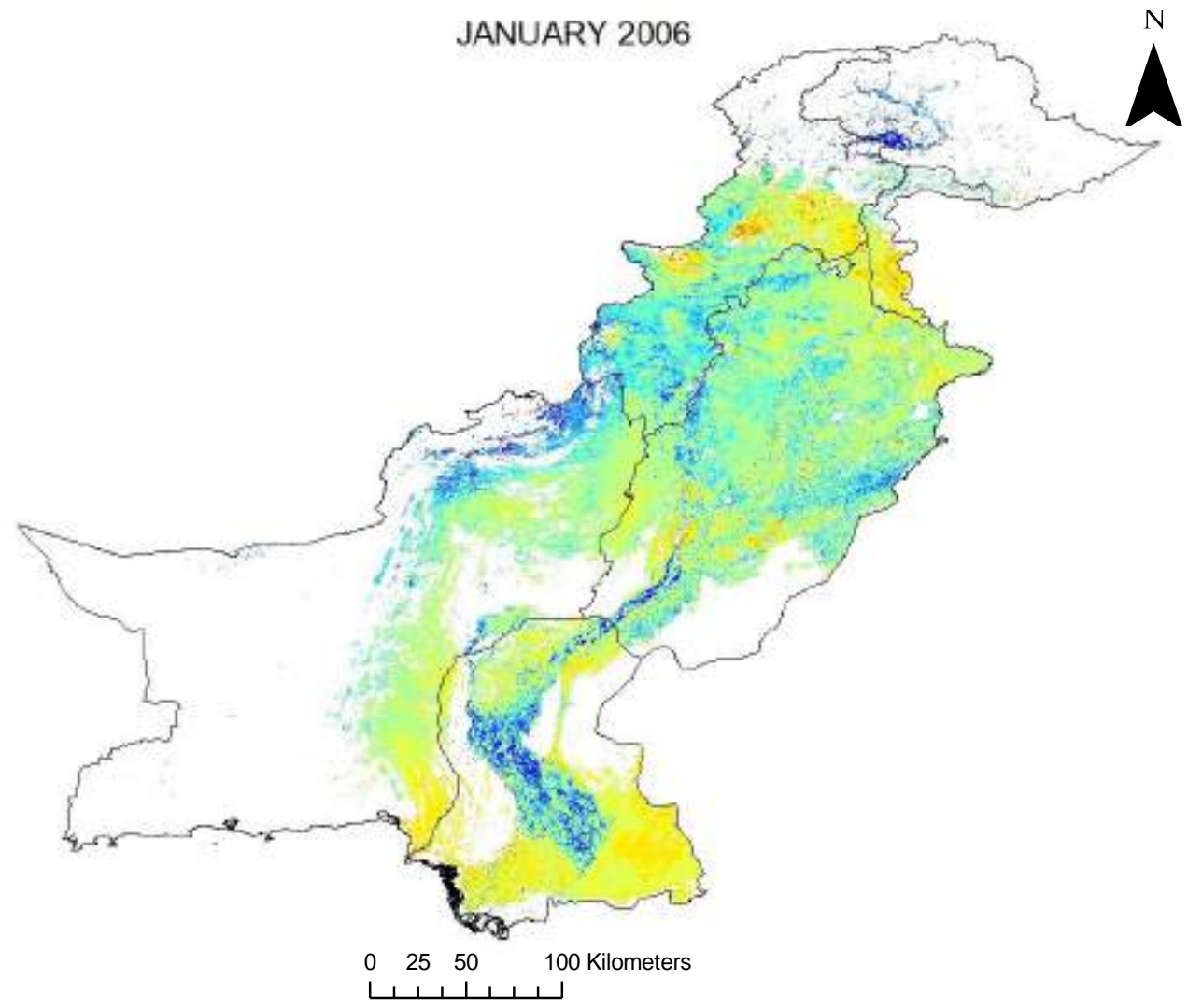


Legend












- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

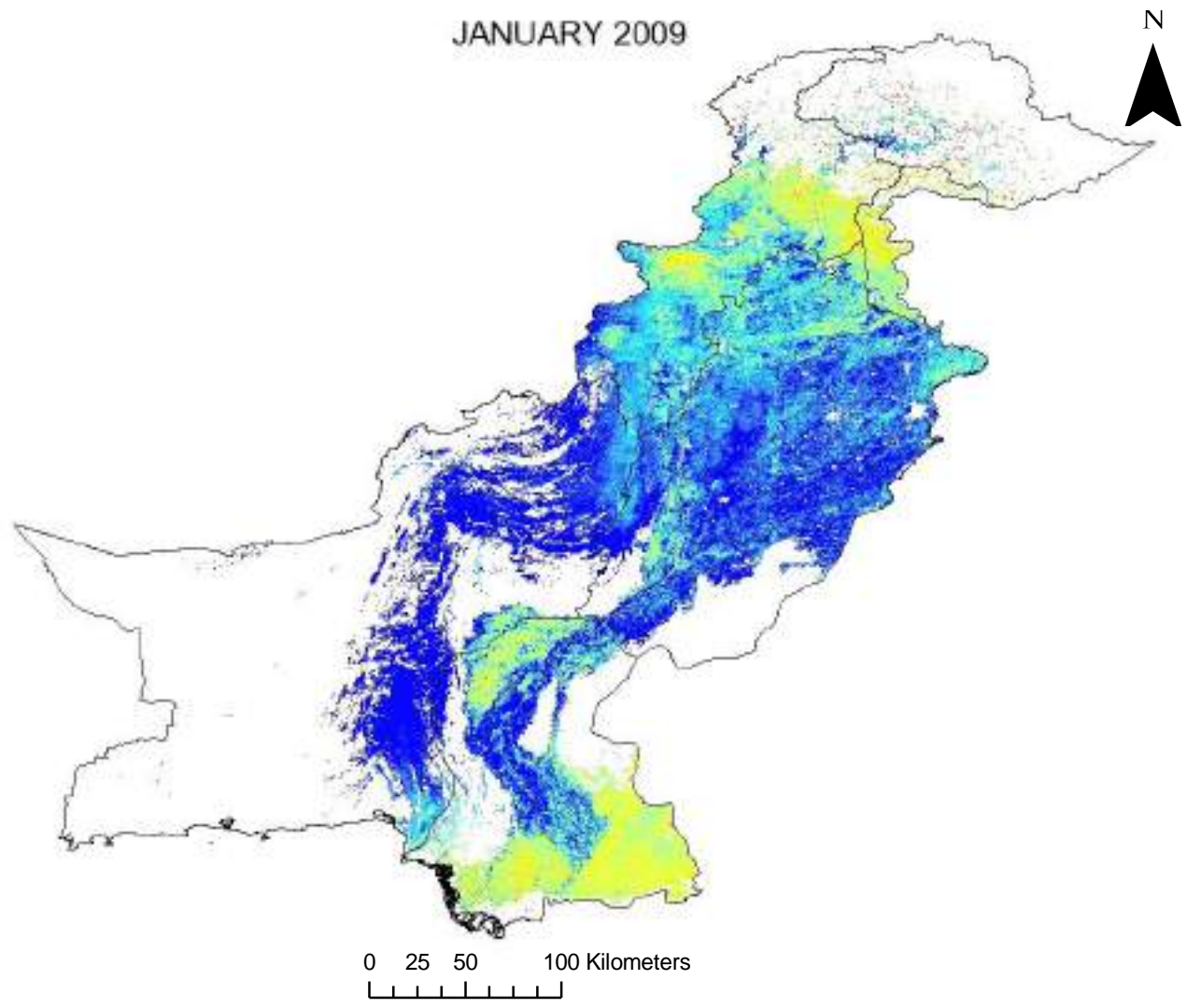
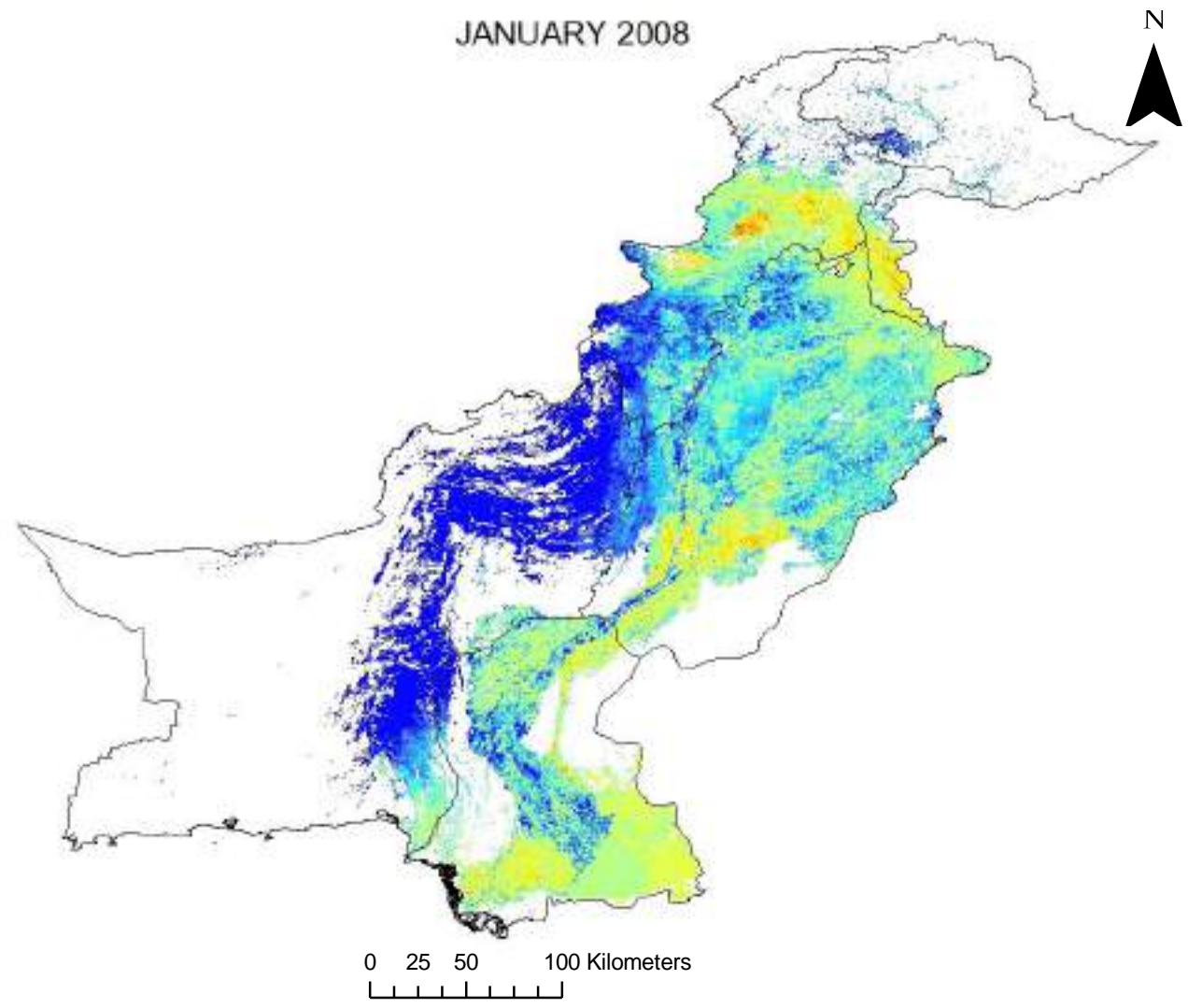
- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)














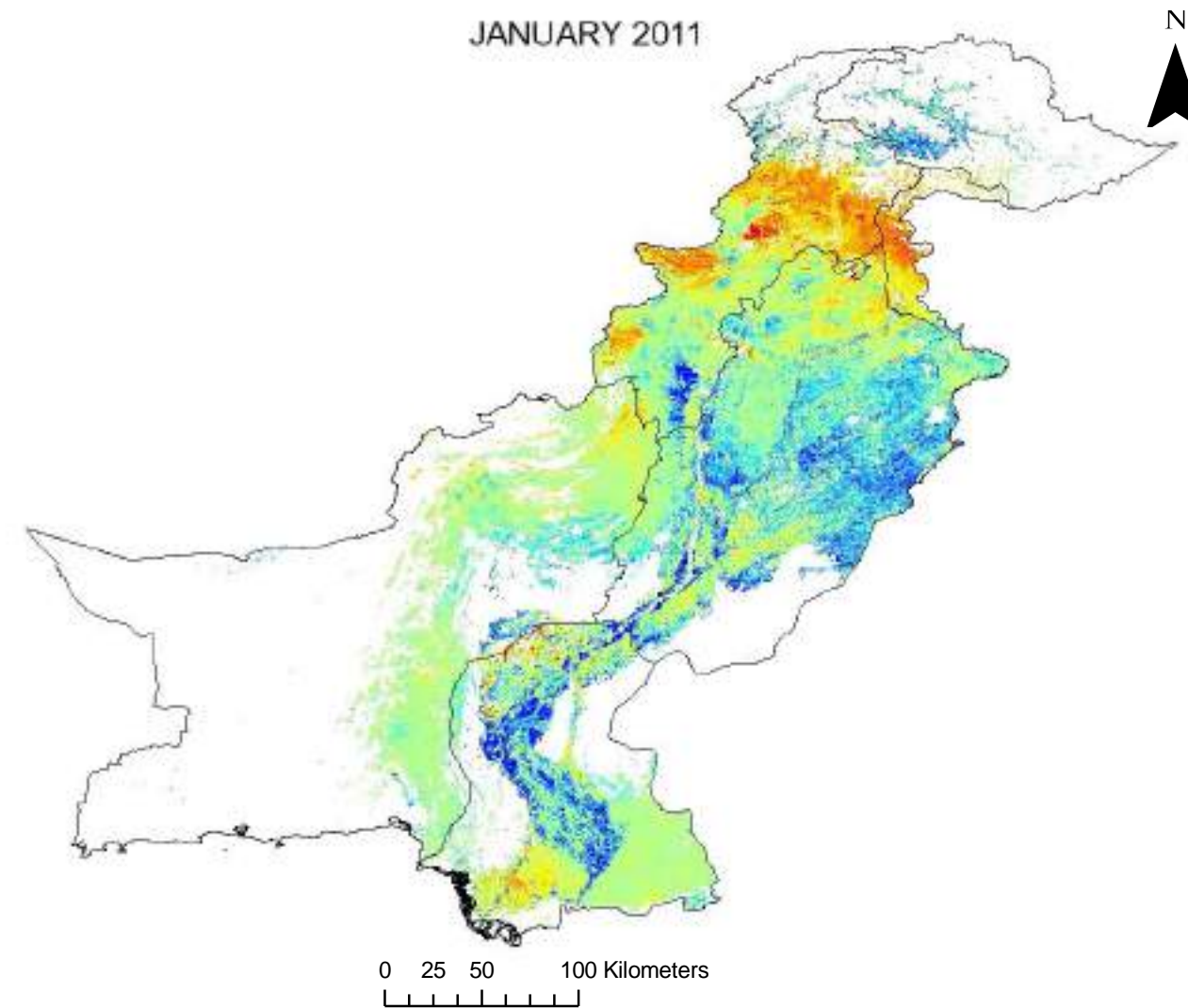
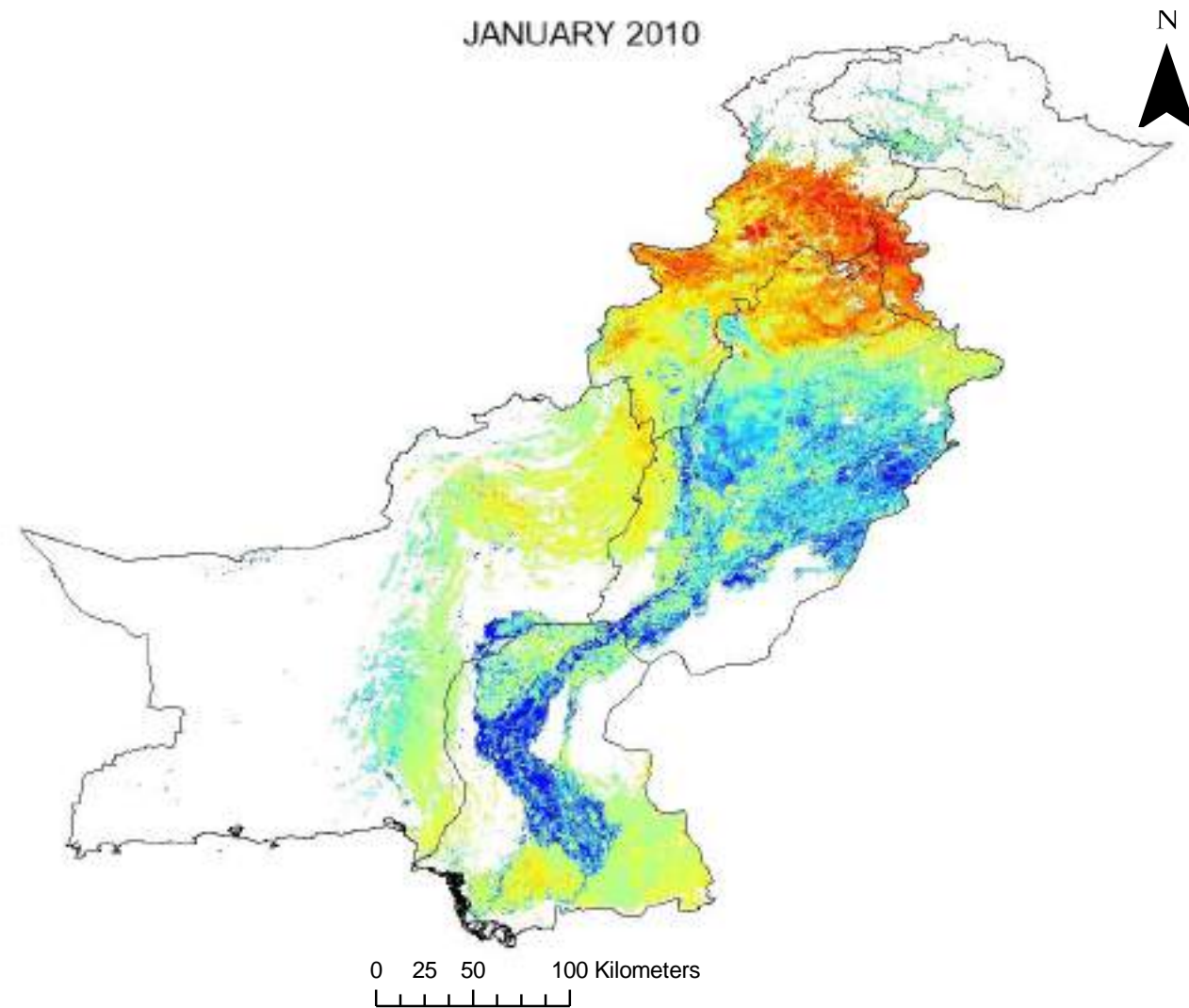
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	Extreme Drought (-1.5 or less)		Incipient Drought (-0.3 to -0.59)		Moderately Wet (0.9 to 1.19)
	Severe Drought (-1.2 to -1.49)		Near Normal (0.29 to -0.29)		Very Wet (1.2 to 1.49)
	Moderate Drought (-0.9 to -1.19)		Incipient Wet Spell (0.3 to 0.59)		Extremely Wet (1.5 or greater)
	Mild Drought (-0.6 to -0.89)		Slightly Wet (0.6 to 0.89)		

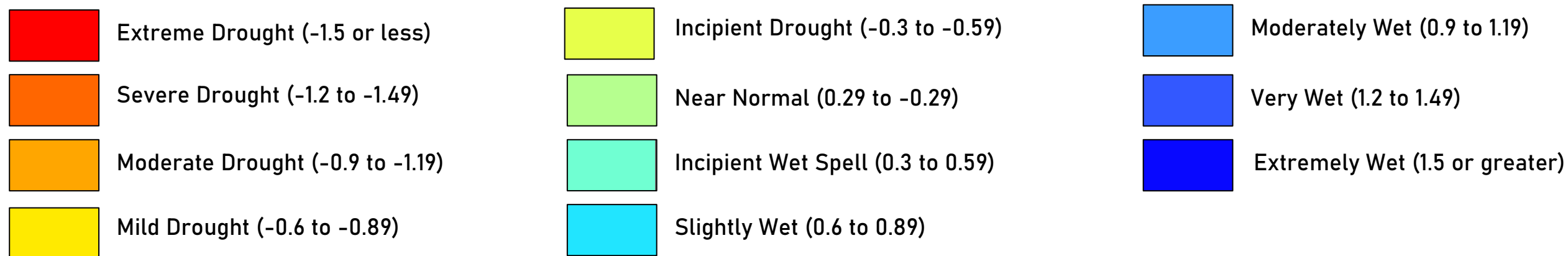


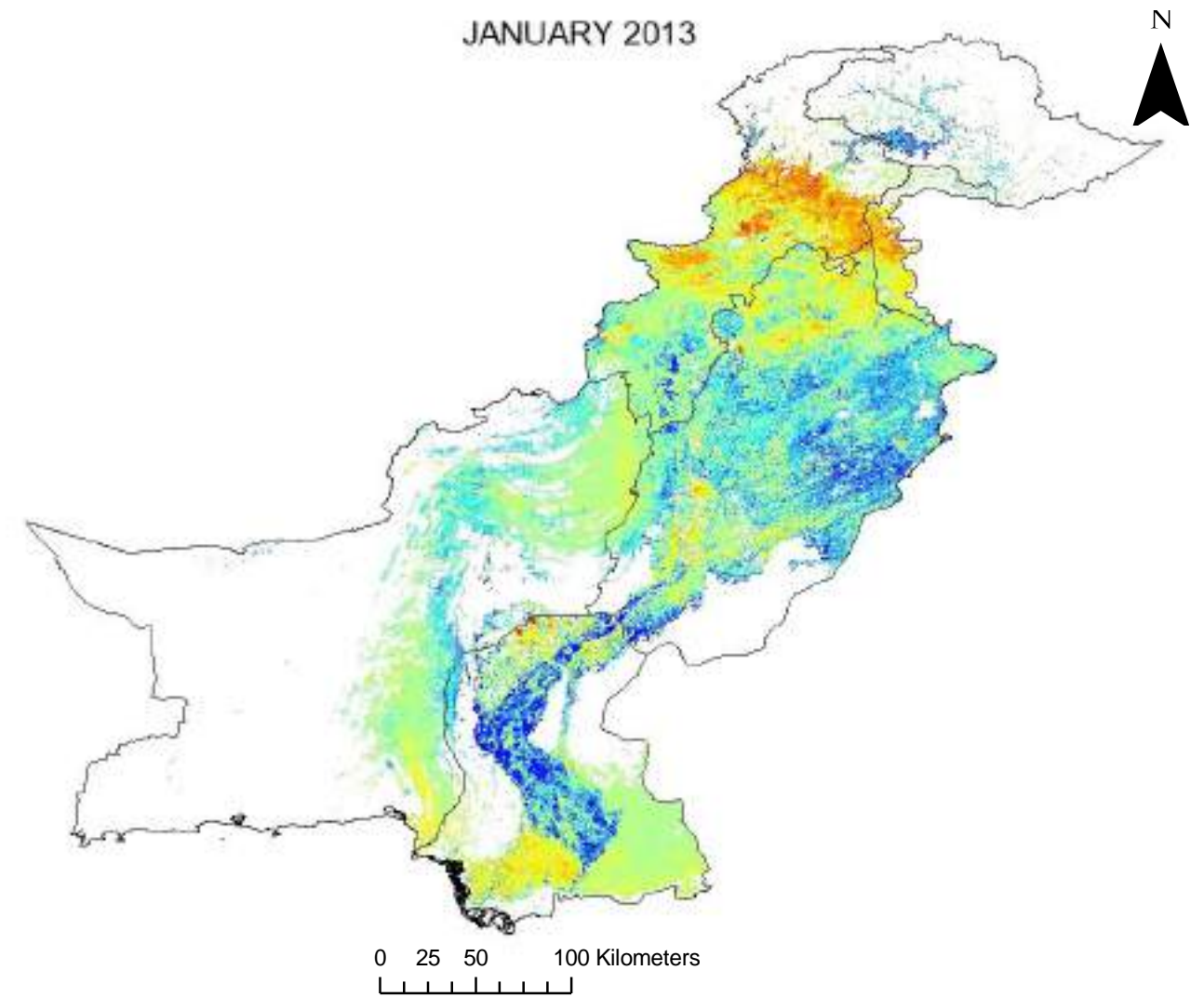
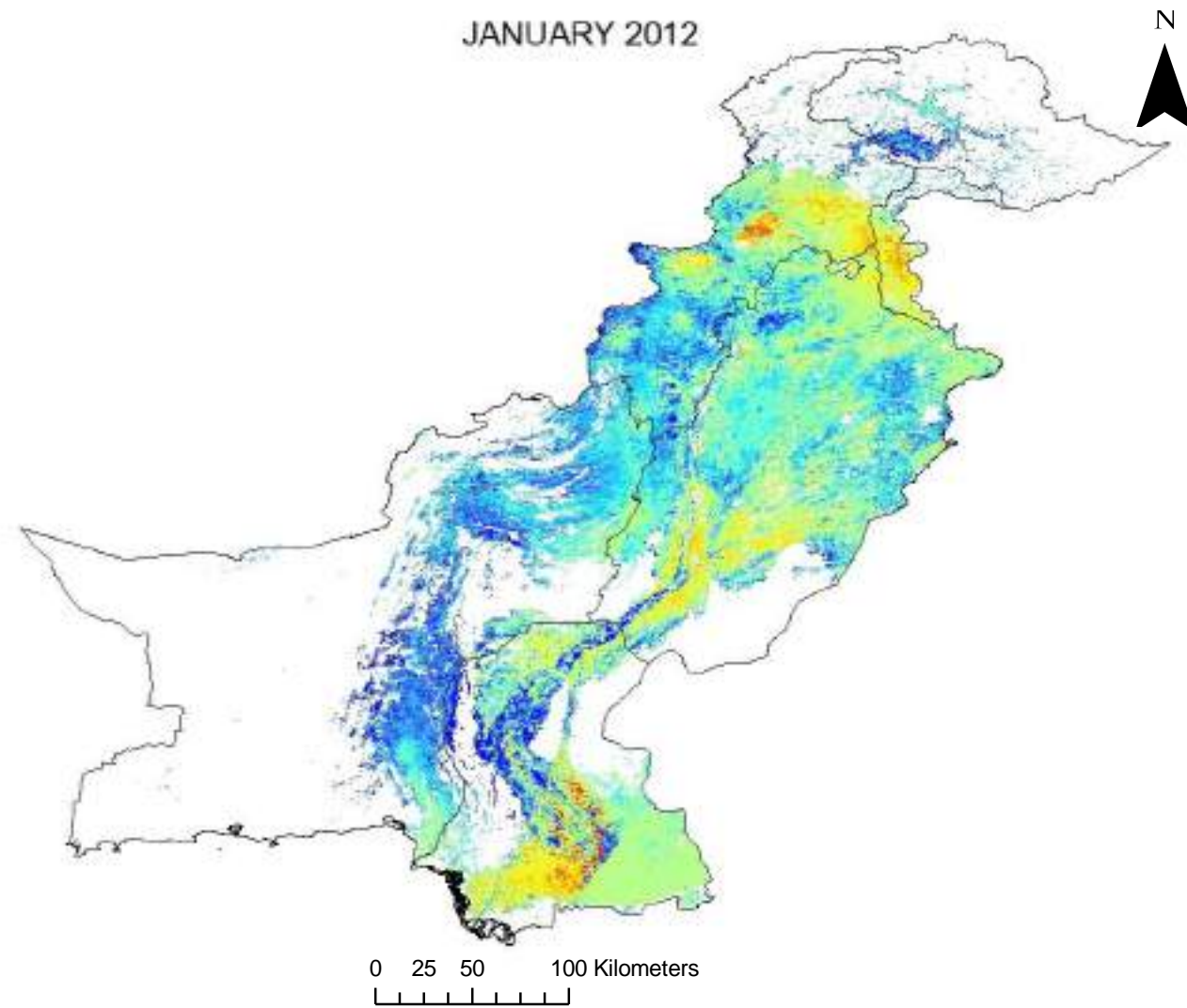
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|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
|  | Severe Drought (-1.2 to -1.49) |  | Near Normal (0.29 to -0.29) |  | Very Wet (1.2 to 1.49) |
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|  | Mild Drought (-0.6 to -0.89) |  | Slightly Wet (0.6 to 0.89) | | |

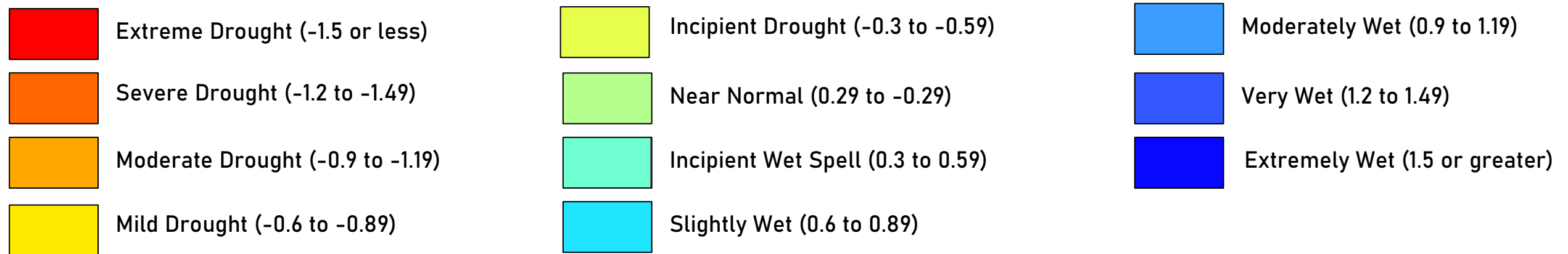


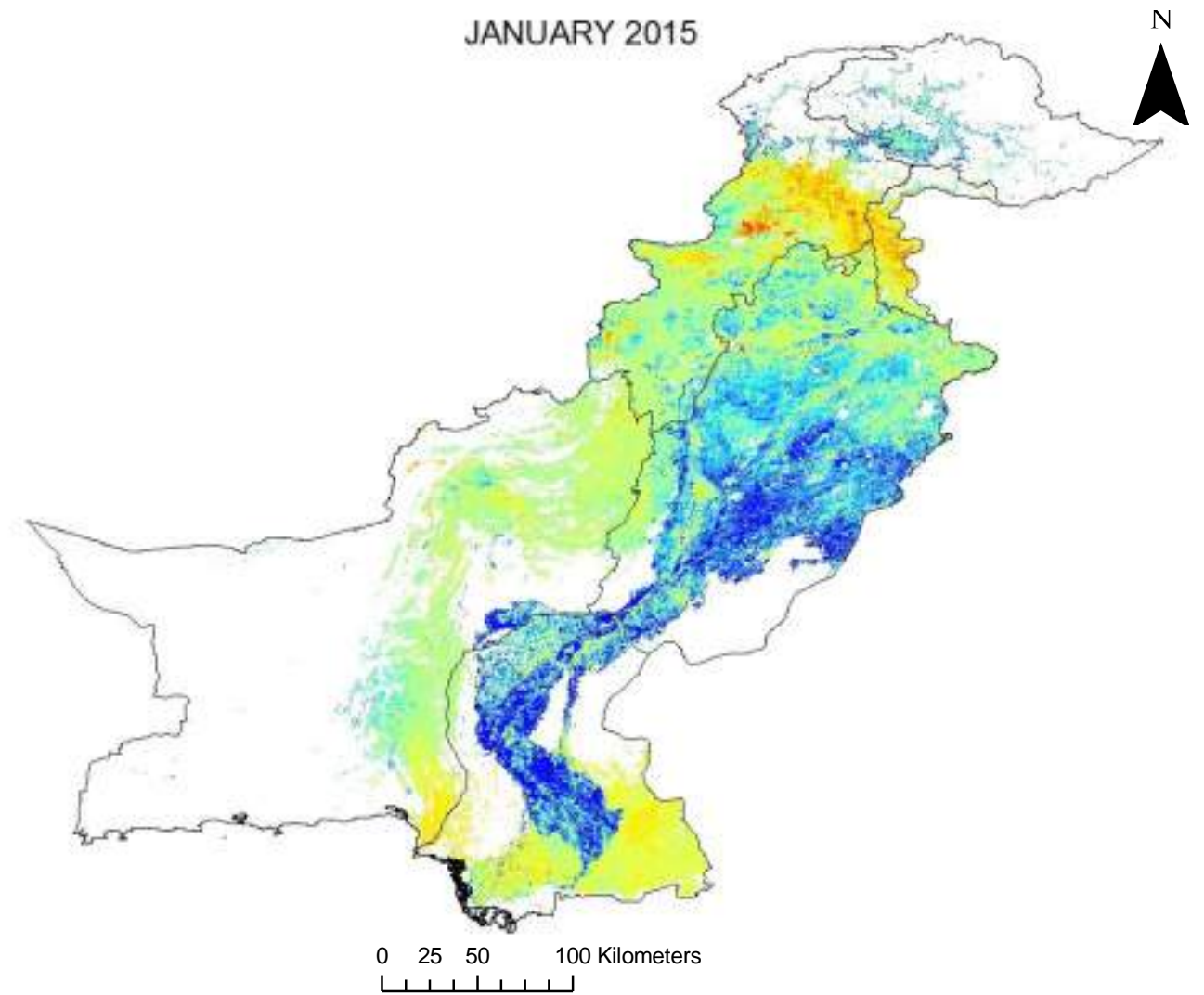
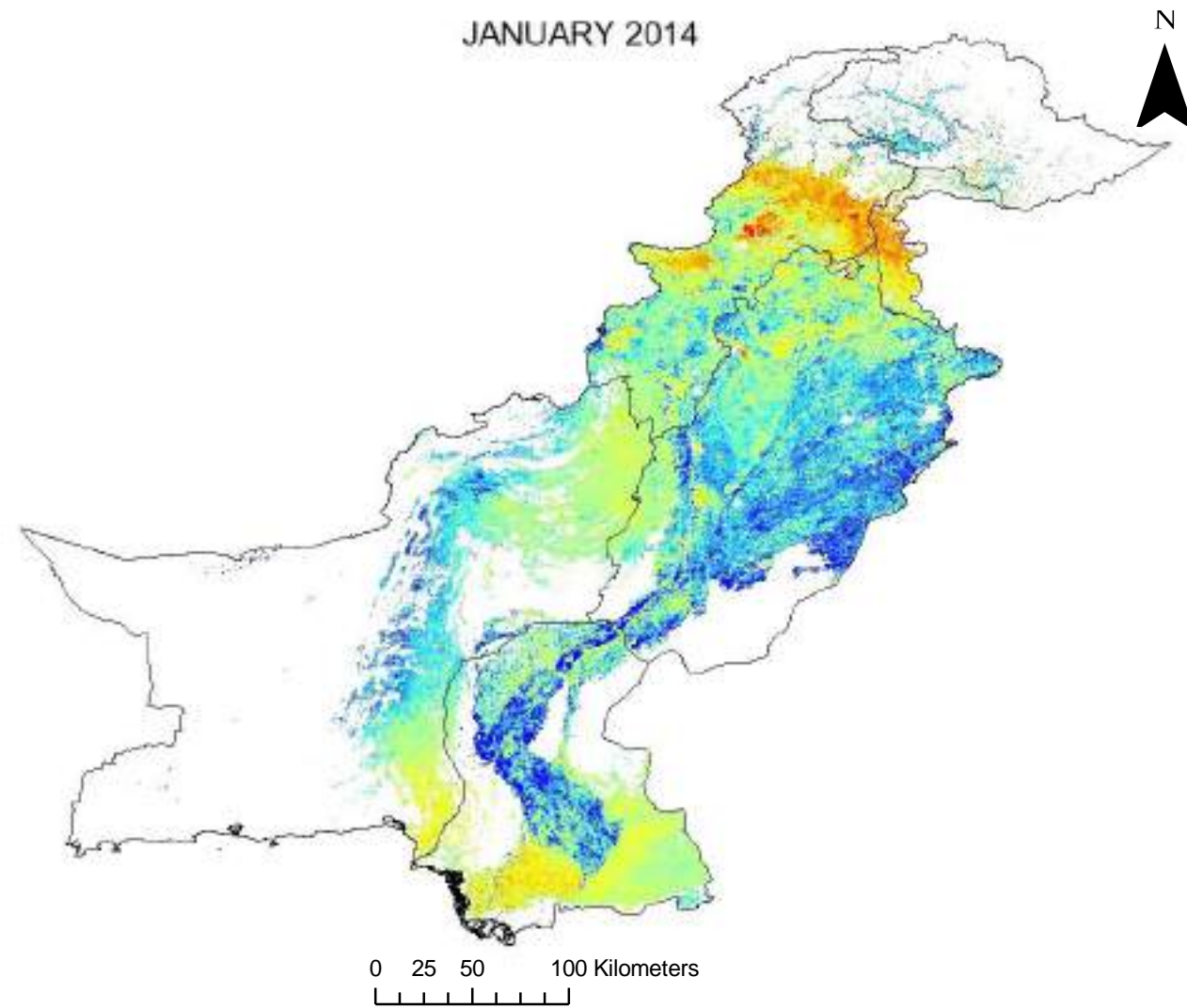
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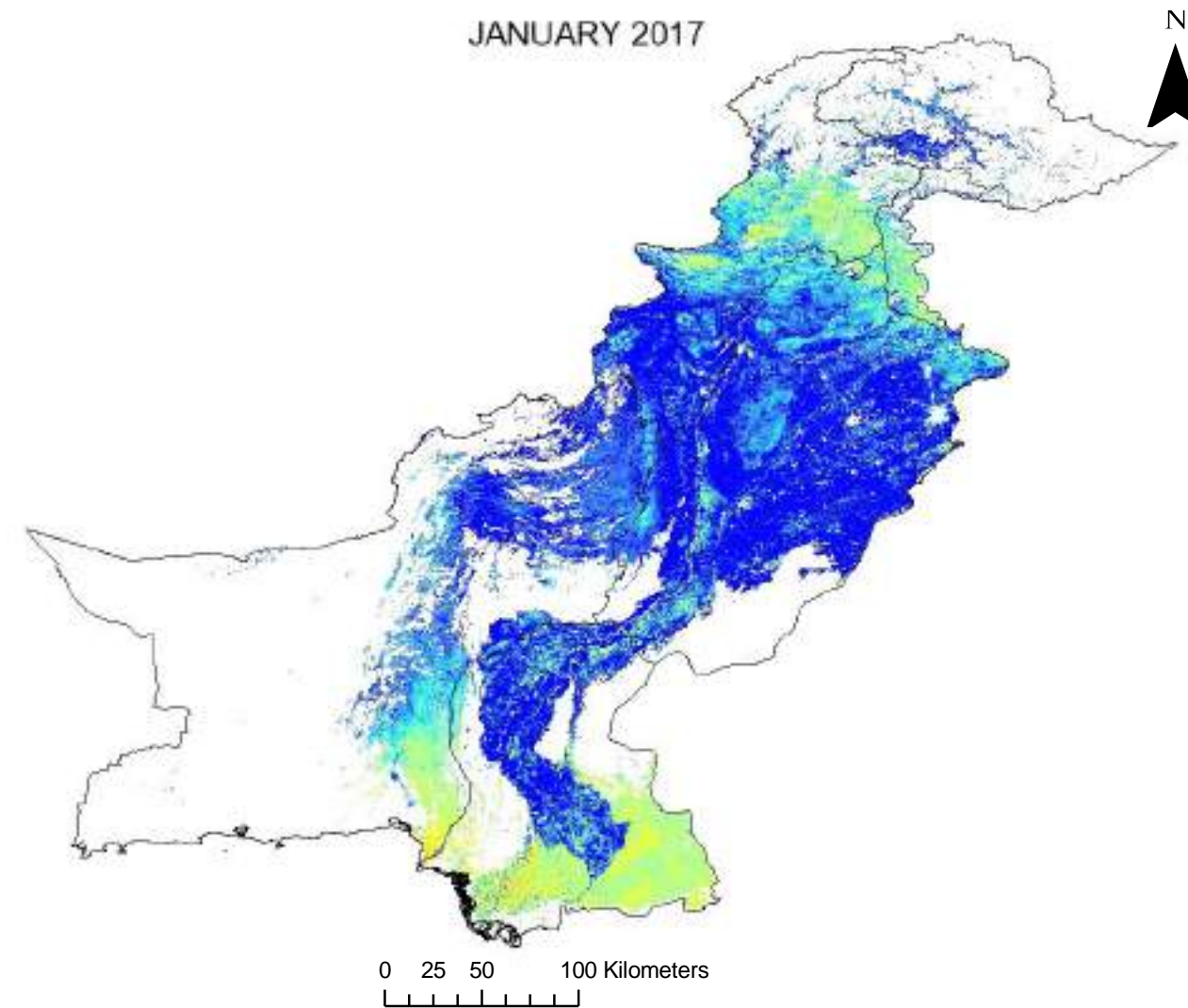
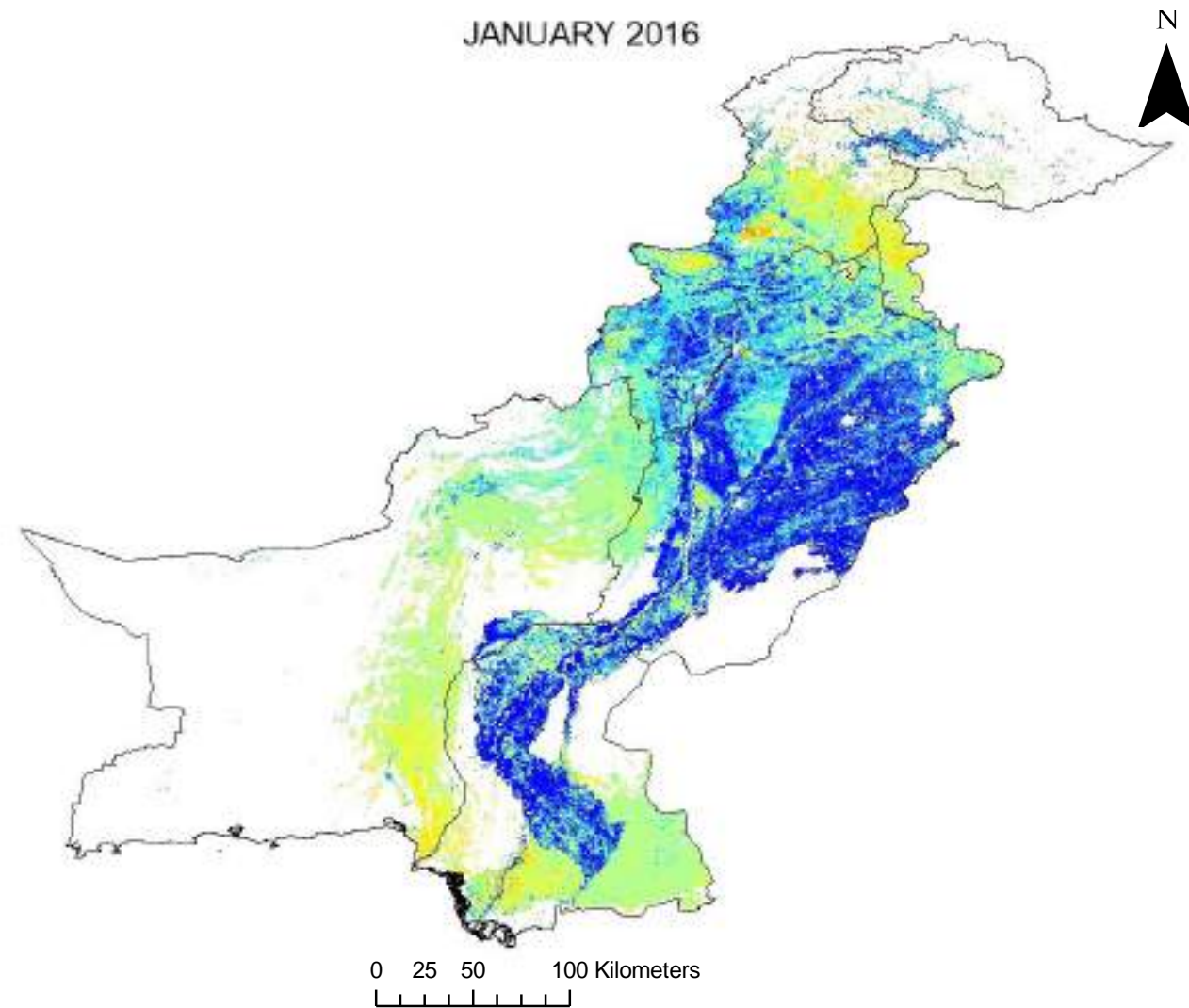


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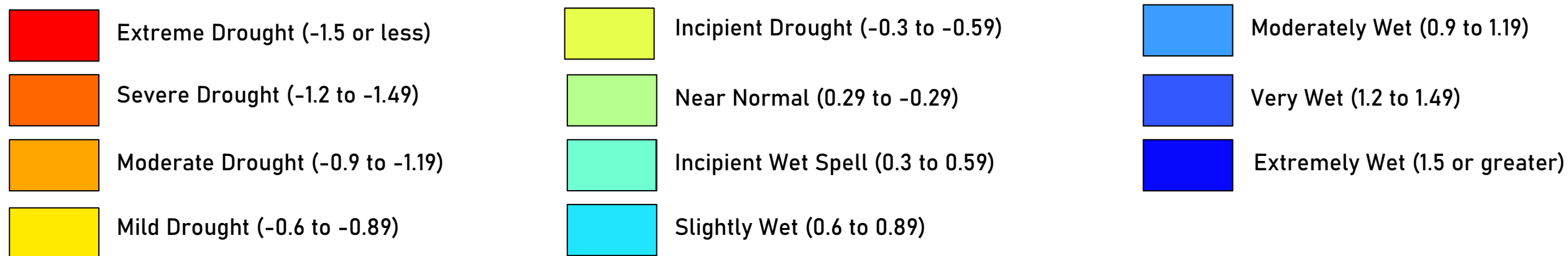
- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

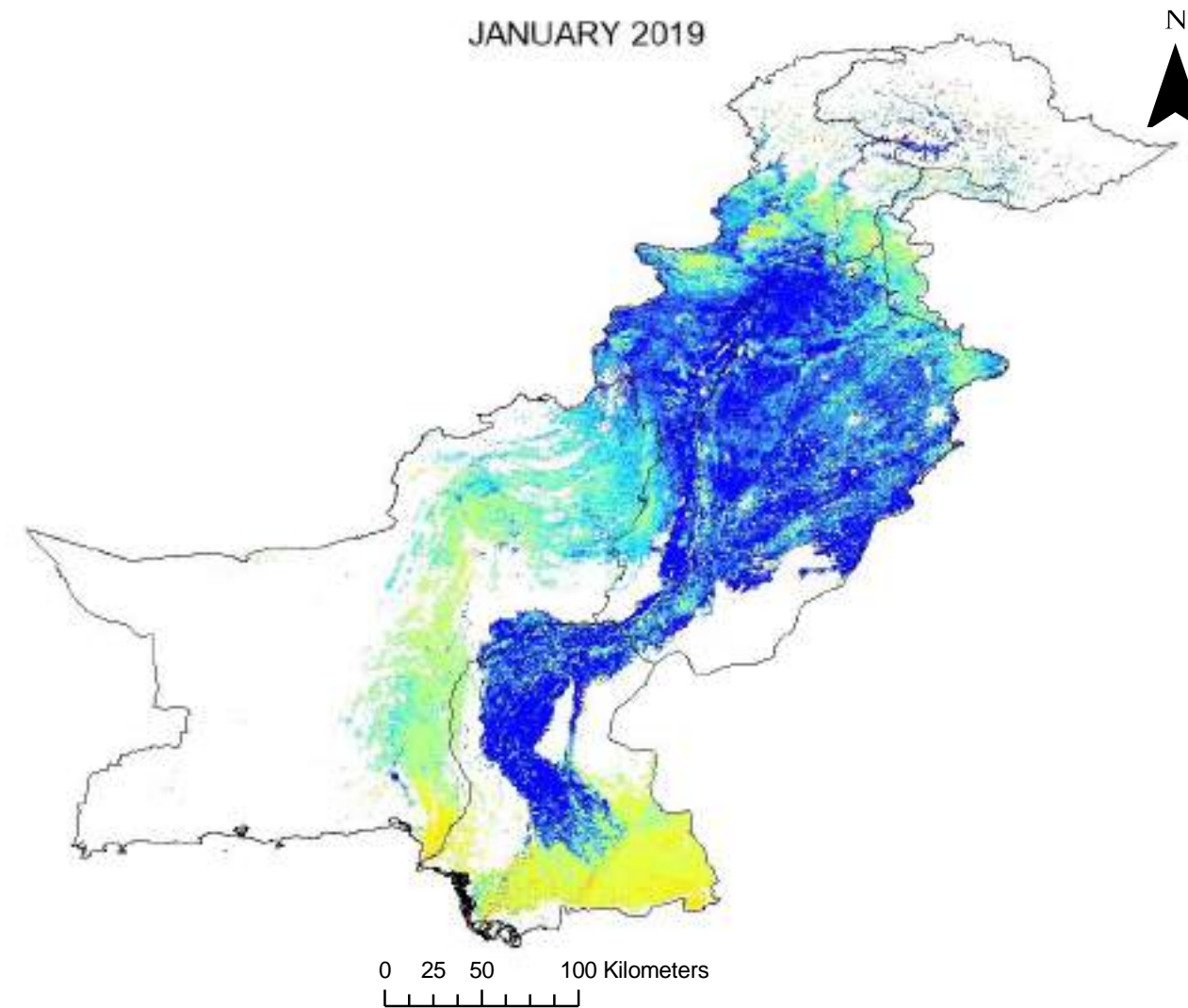
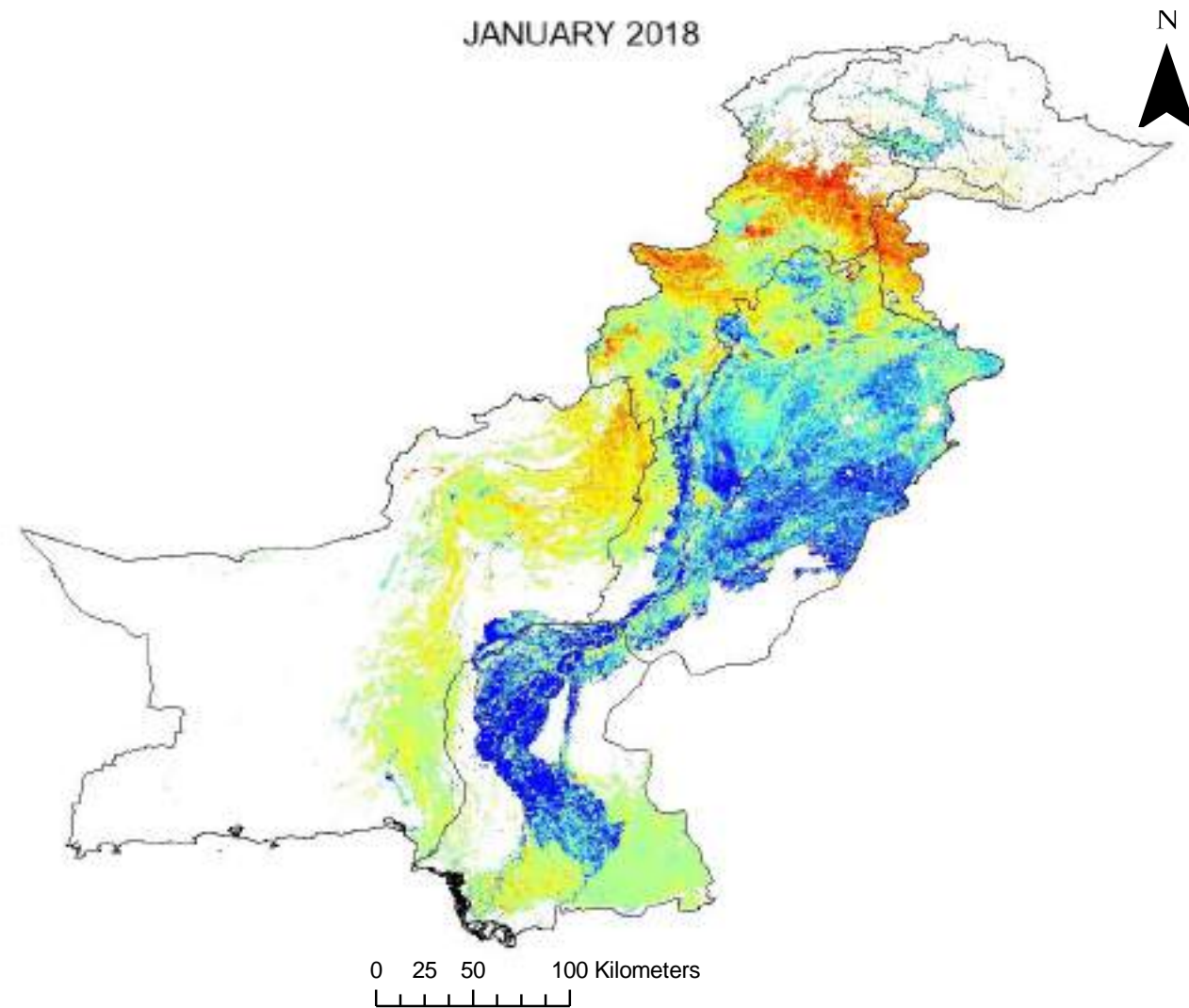
- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)

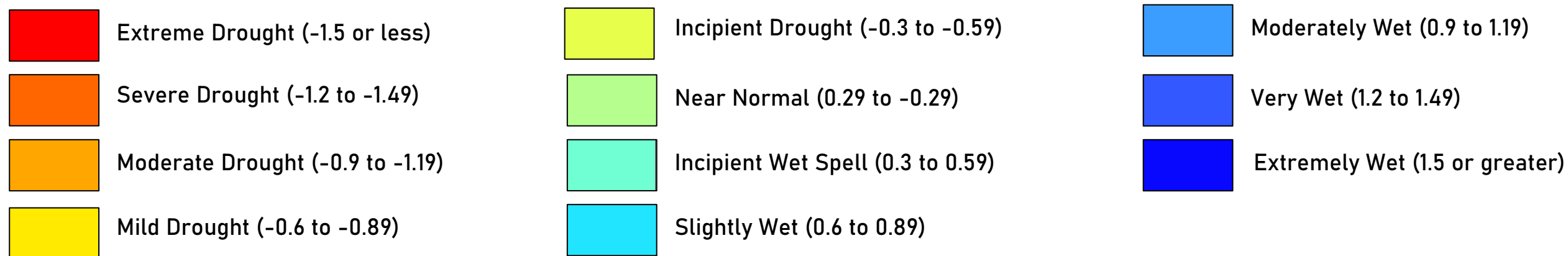


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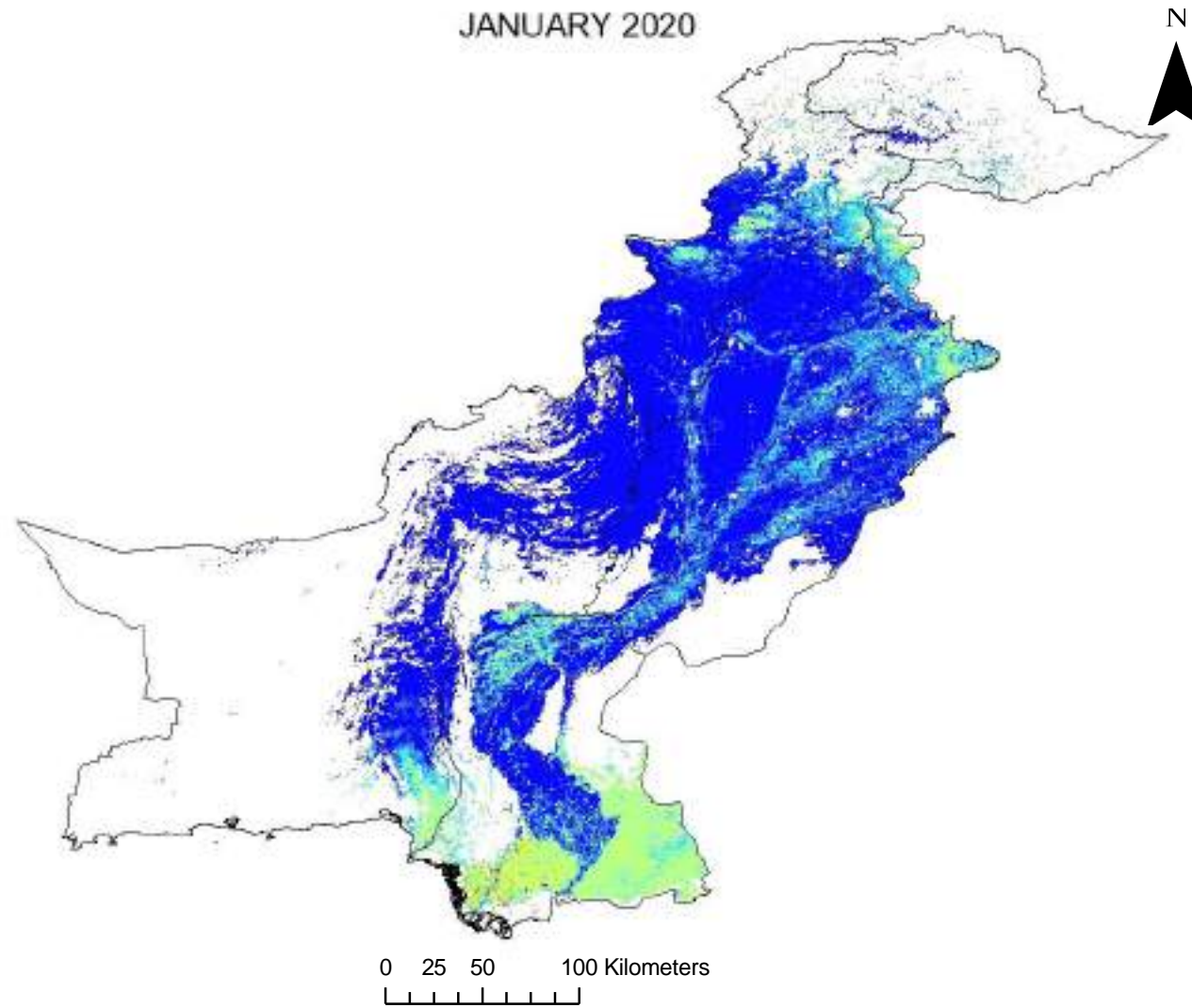








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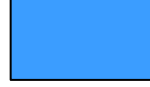


JANUARY 2020



Legend

-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
-  Mild Drought (-0.6 to -0.89)

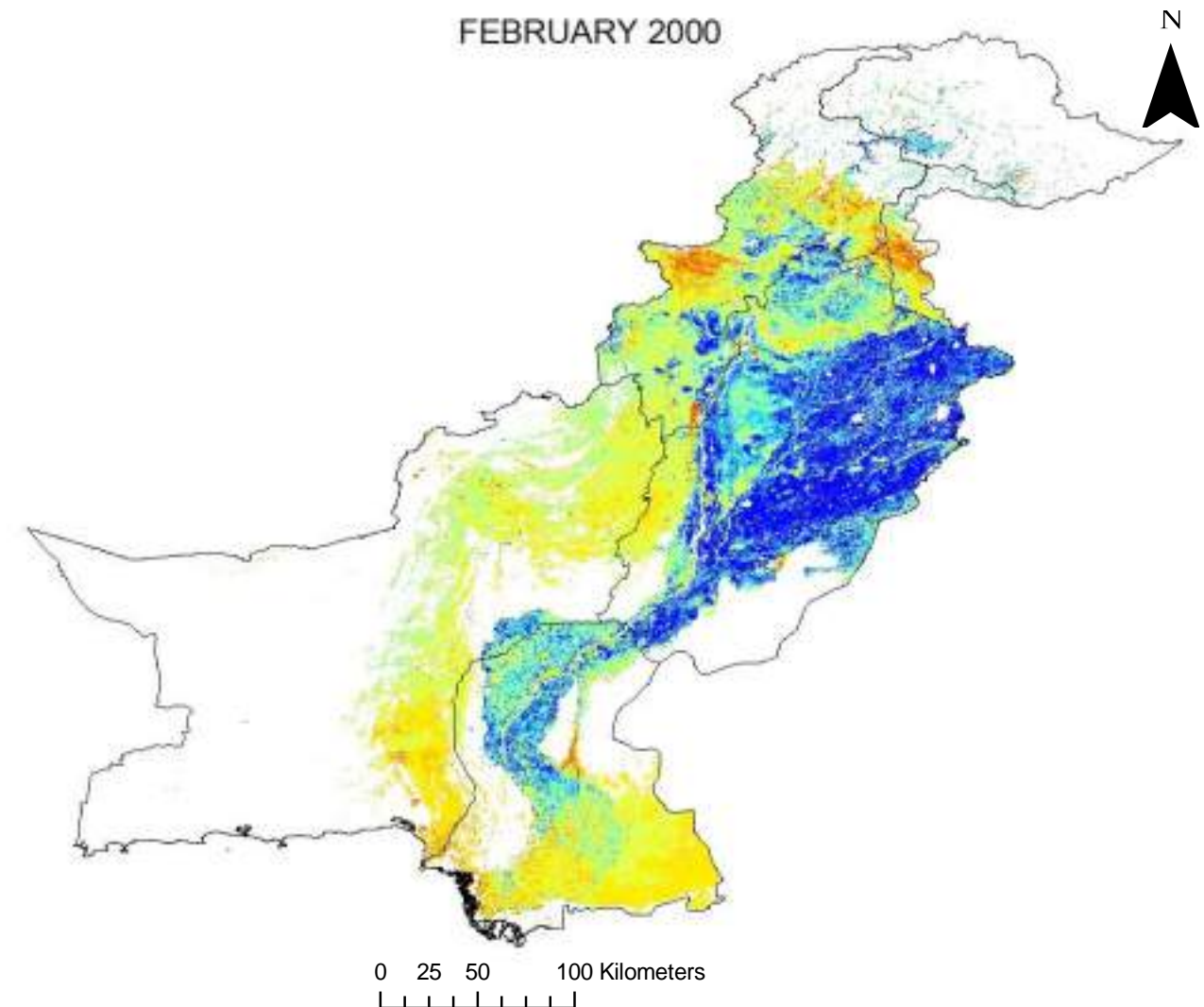
-  Incipient Drought (-0.3 to -0.59)
-  Near Normal (0.29 to -0.29)
-  Incipient Wet Spell (0.3 to 0.59)
-  Slightly Wet (0.6 to 0.89)

-  Moderately Wet (0.9 to 1.19)
-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)

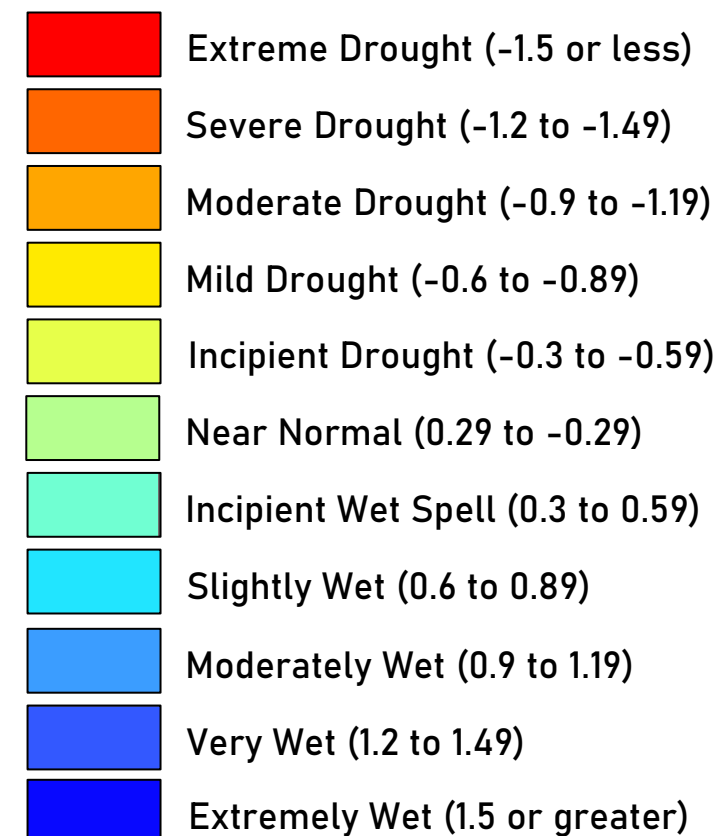
February DSI Maps

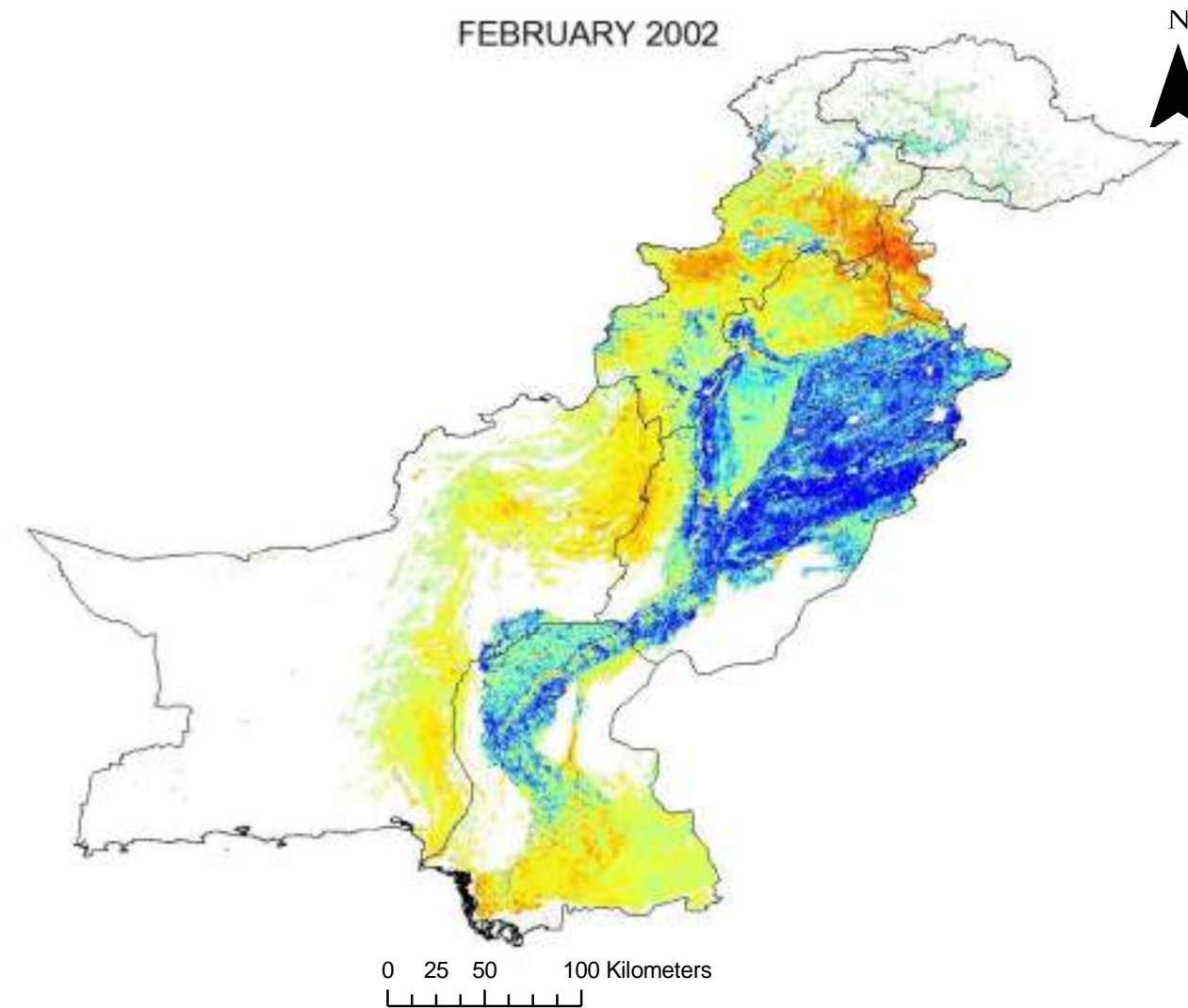
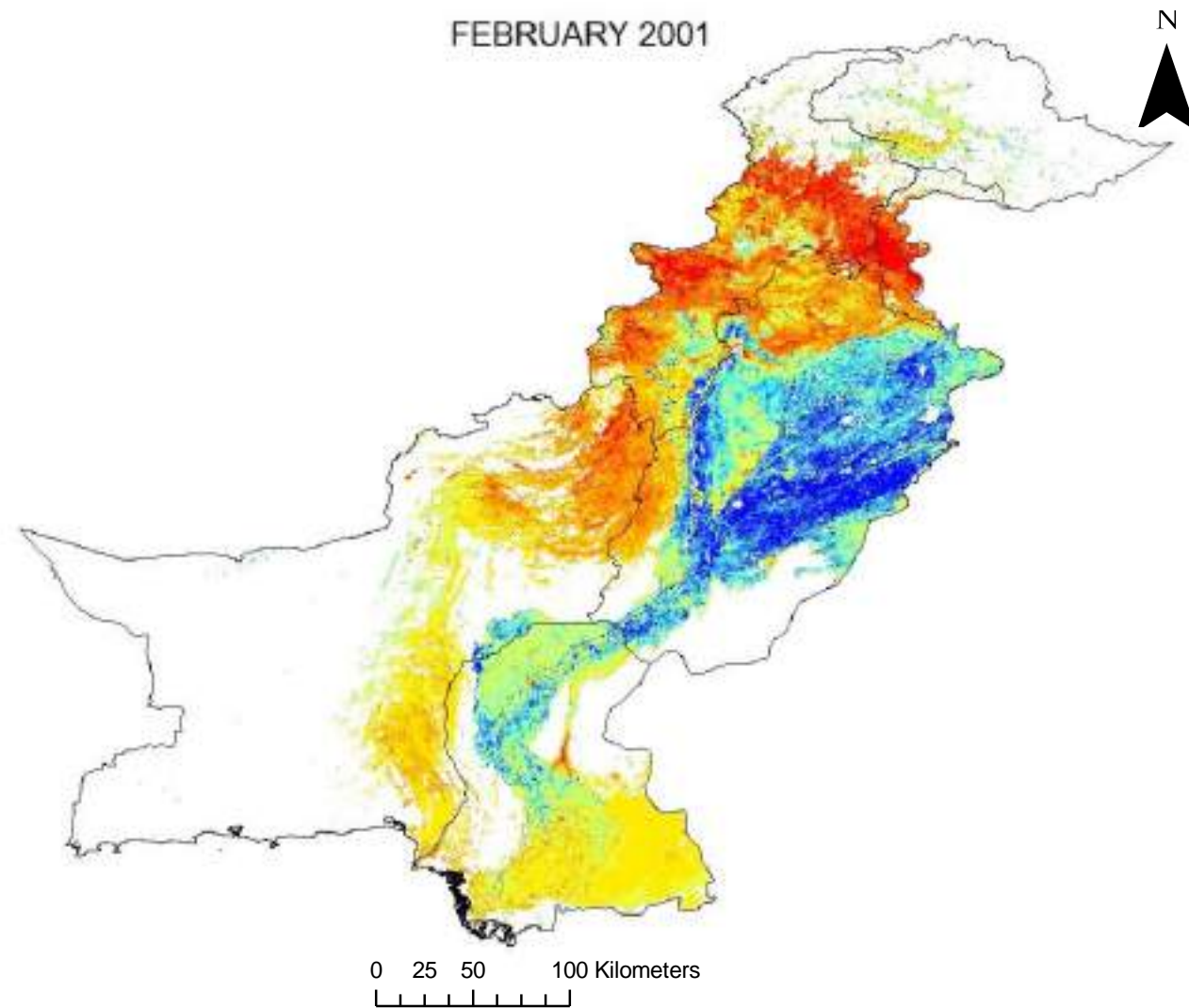
Drought conditions in February can range from incipient drought to extremely wet condition. In 2001, there was a incipient drought, however this winter month is usually wet due to winter precipitation.

Mean February DSI Values		
Years	Values	Drought Condition
2000	0.32	Incipient Wet Spell
2001	-0.49	Incipient Drought
2002	-0.01	Near Normal
2003	0.66	Slightly Wet
2004	0.04	Near Normal
2005	1.89	Extremely Wet
2006	0.30	Incipient Wet Spell
2007	1.42	Extremely Wet
2008	-0.05	Near Normal
2009	0.87	Slightly Wet
2010	0.67	Slightly Wet
2011	1.43	Very Wet
2012	0.29	Near Normal
2013	0.95	Moderately Wet
2014	0.64	Slightly Wet
2015	1.09	Moderately Wet
2016	0.40	Incipient Wet Spell
2017	0.74	Slightly Wet
2018	0.60	Slightly Wet
2019	1.72	Extremely Wet
2020	1.09	Moderately Wet

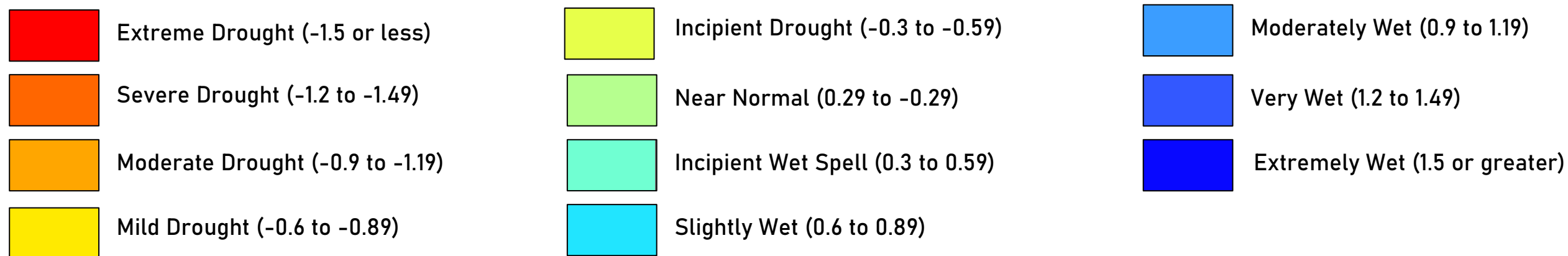


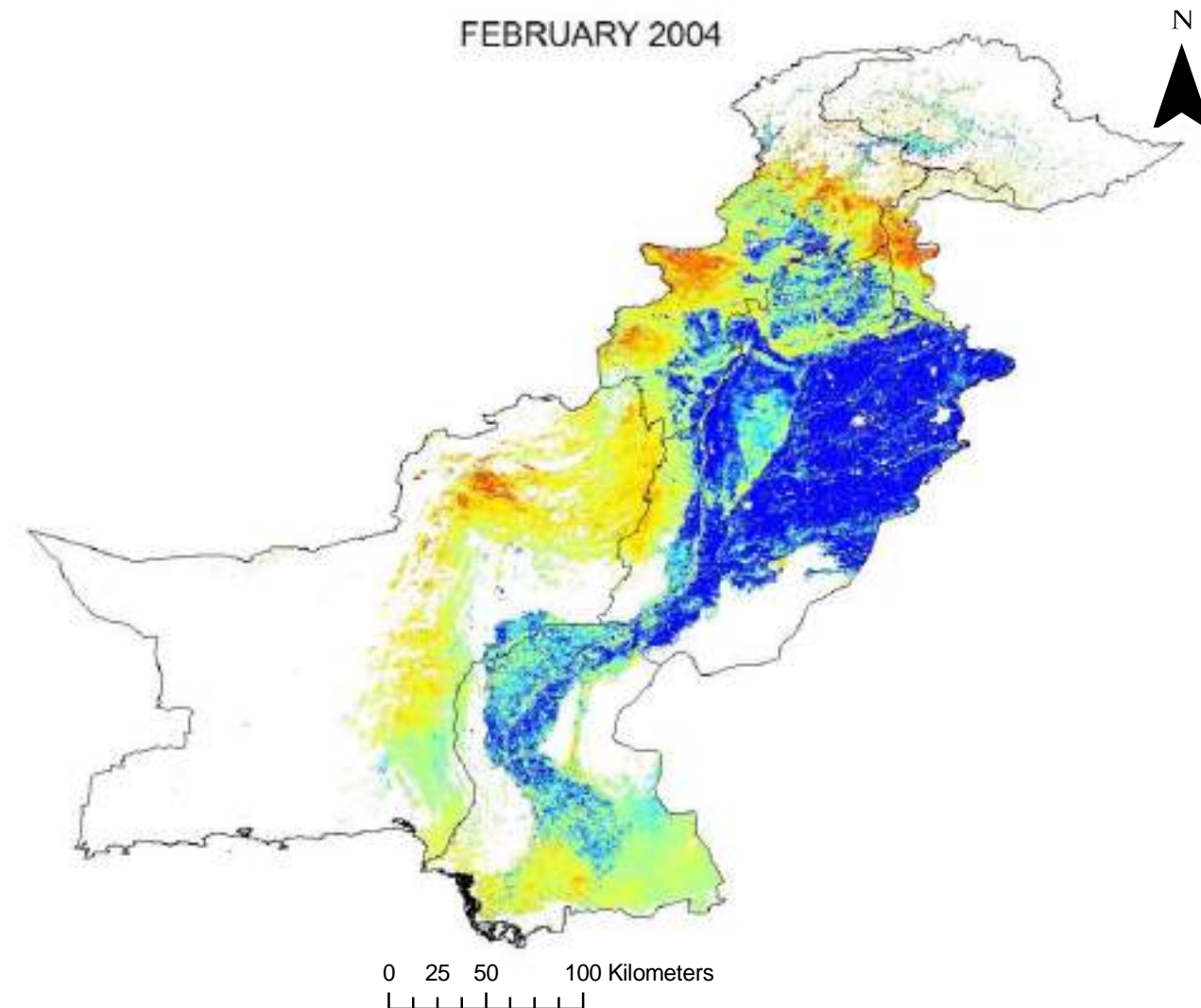
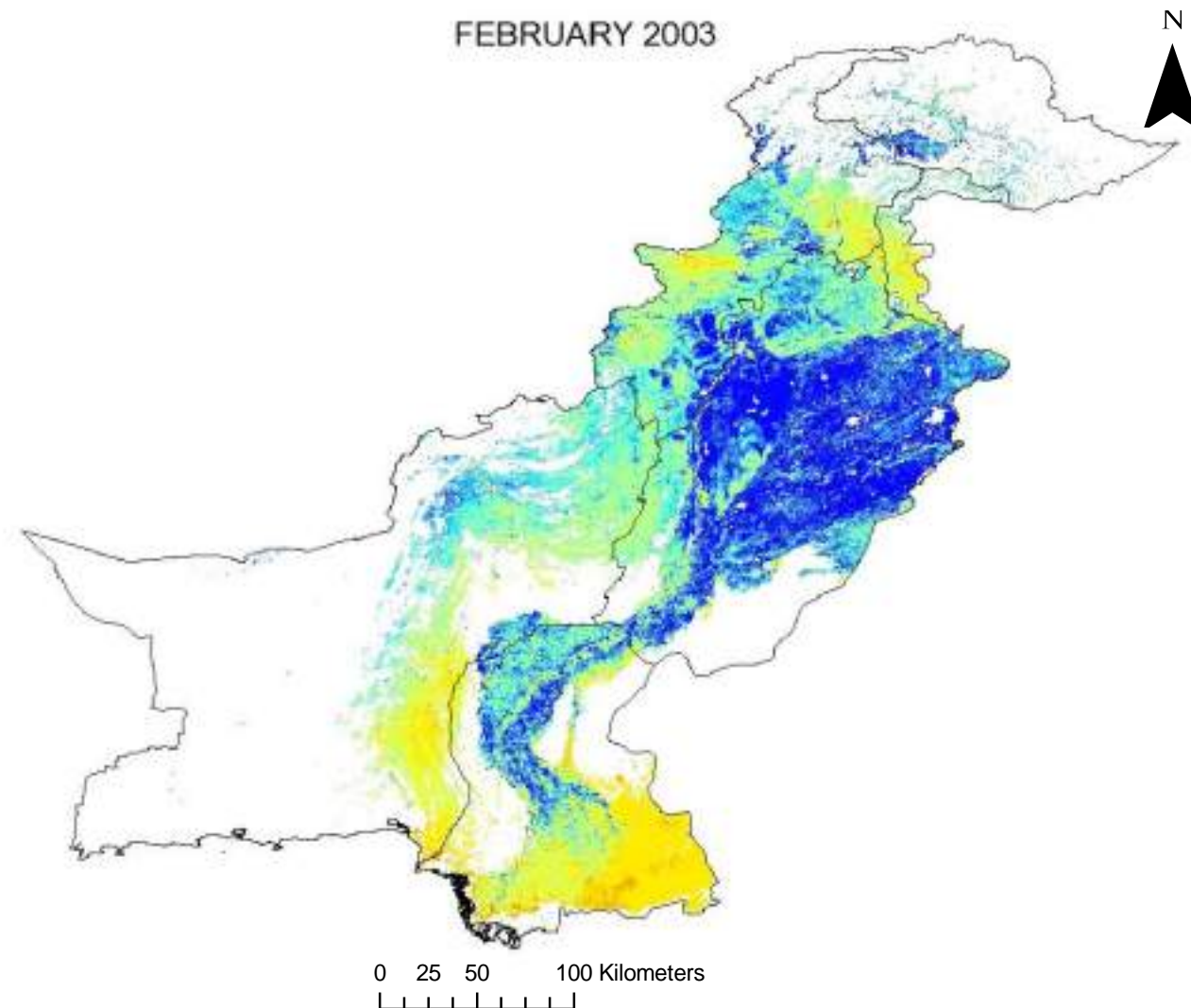
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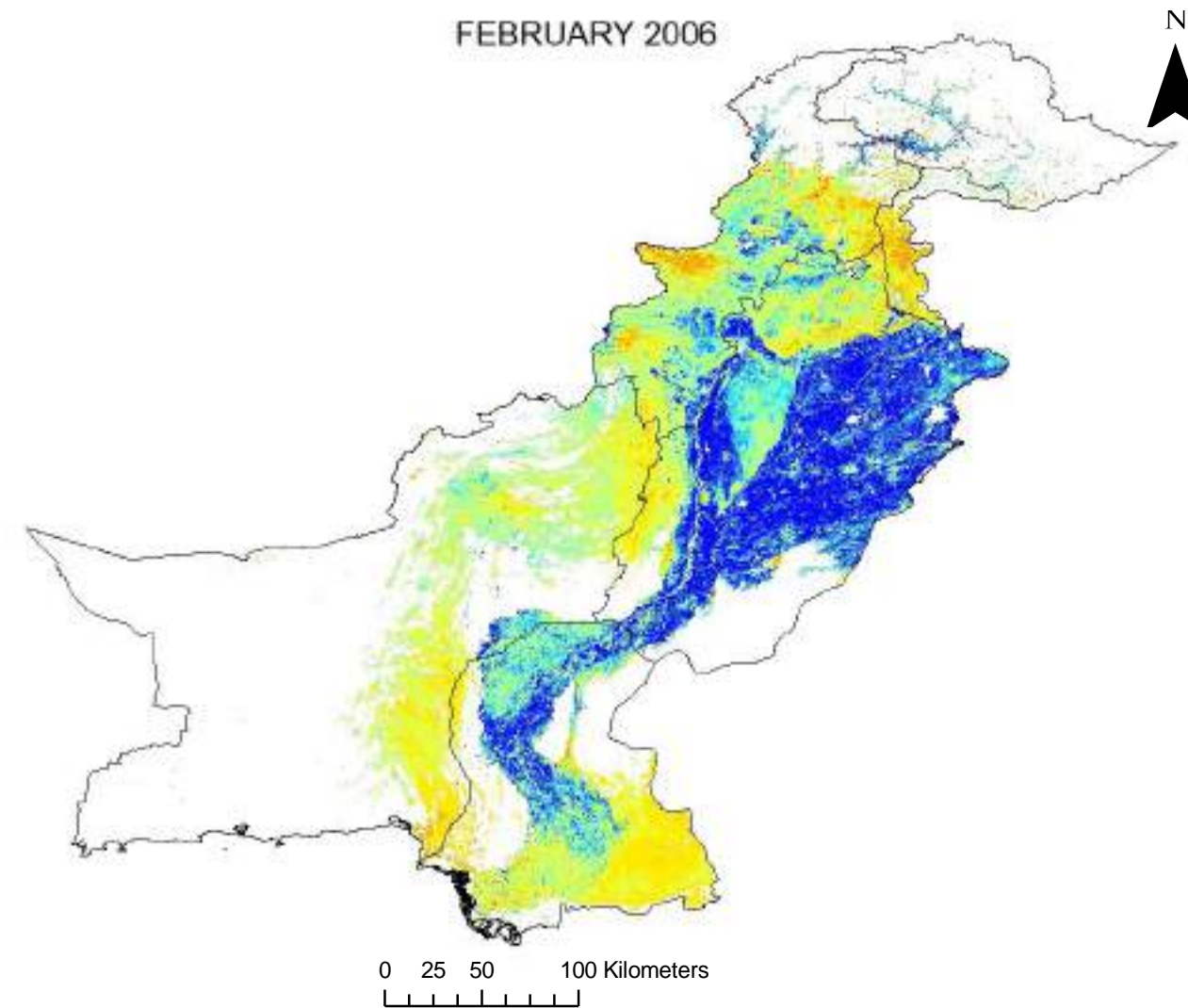
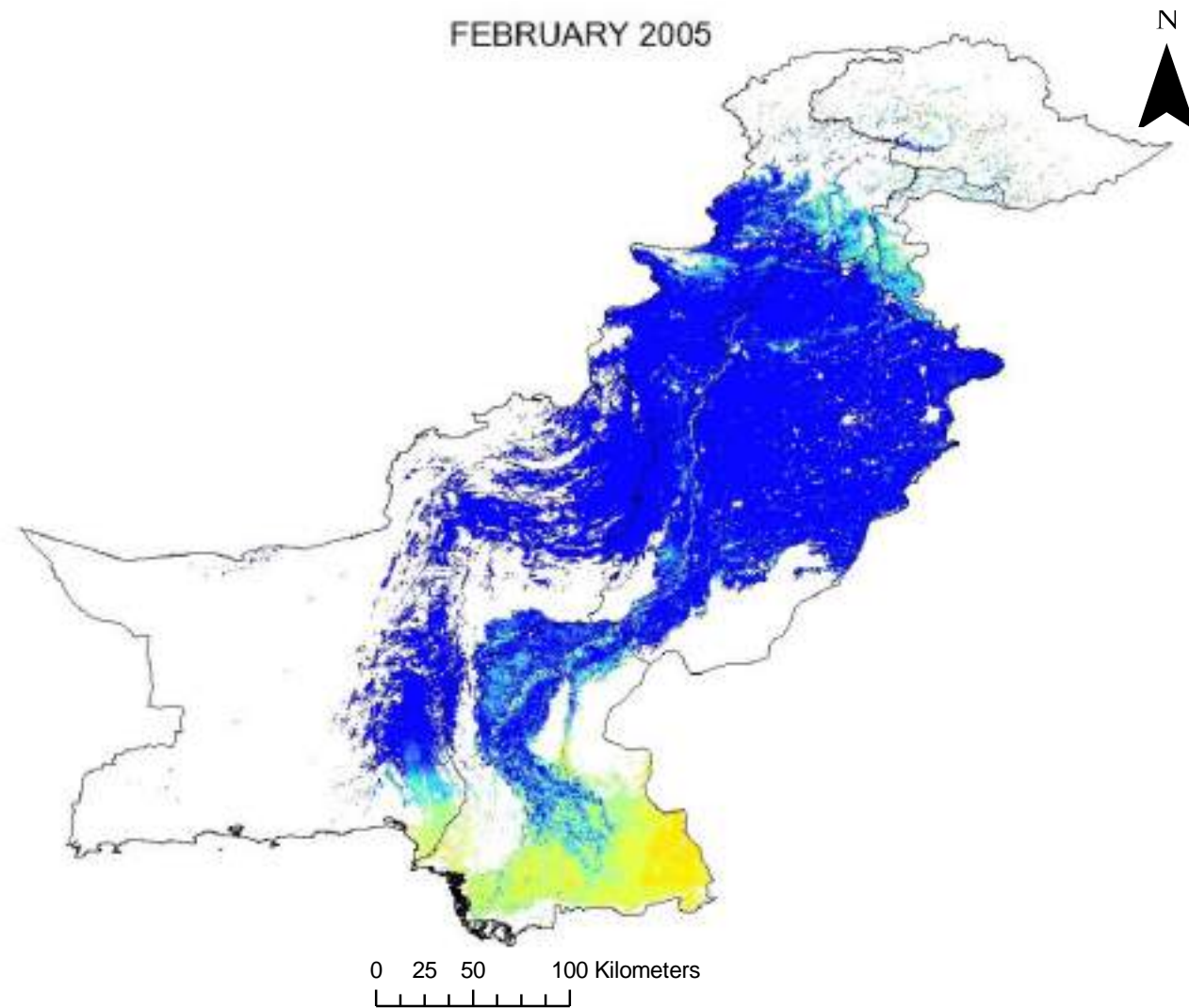
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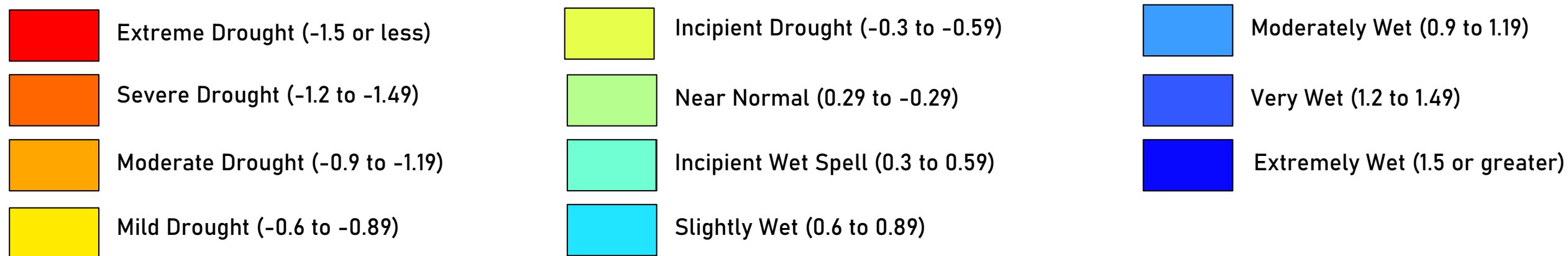


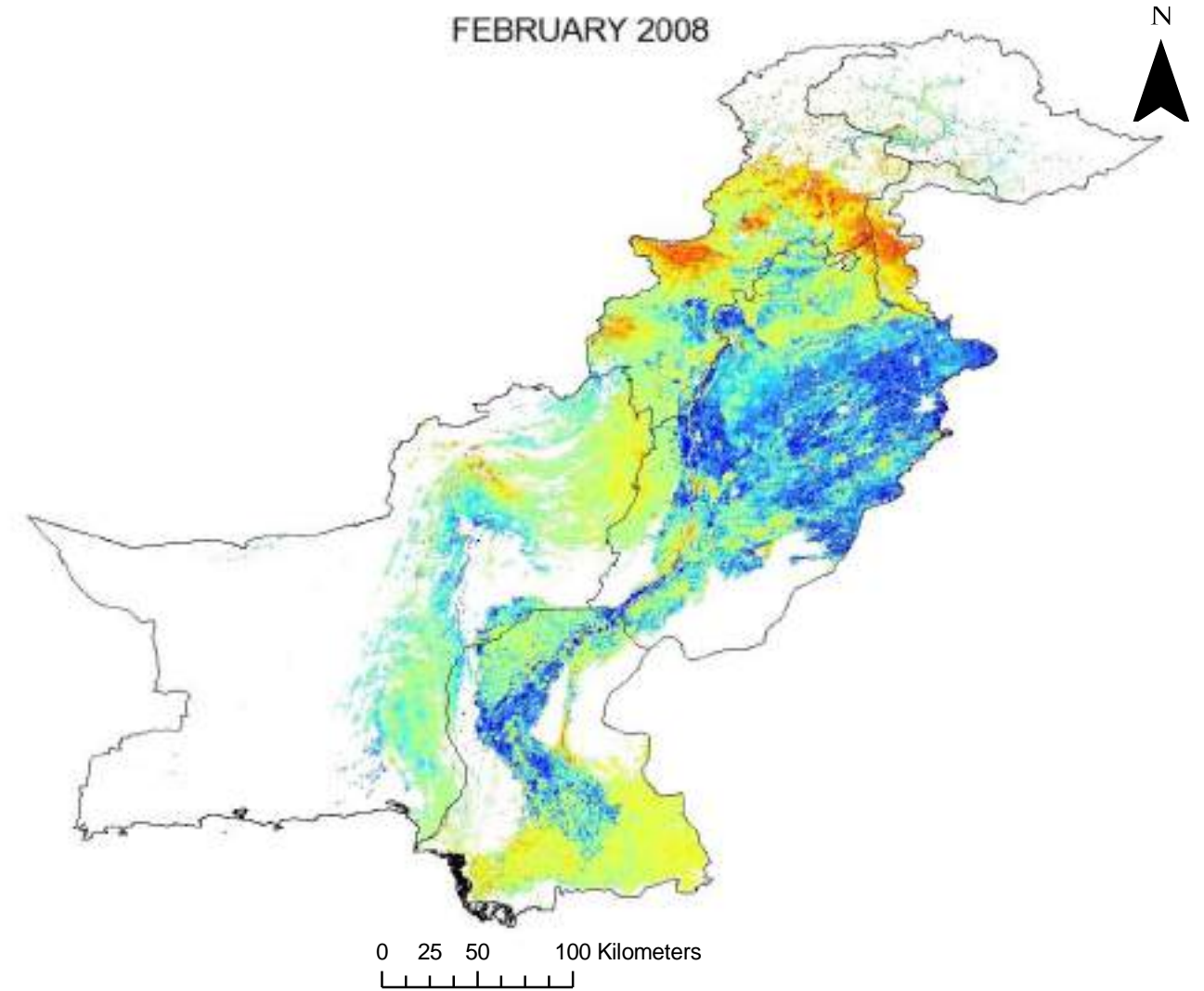
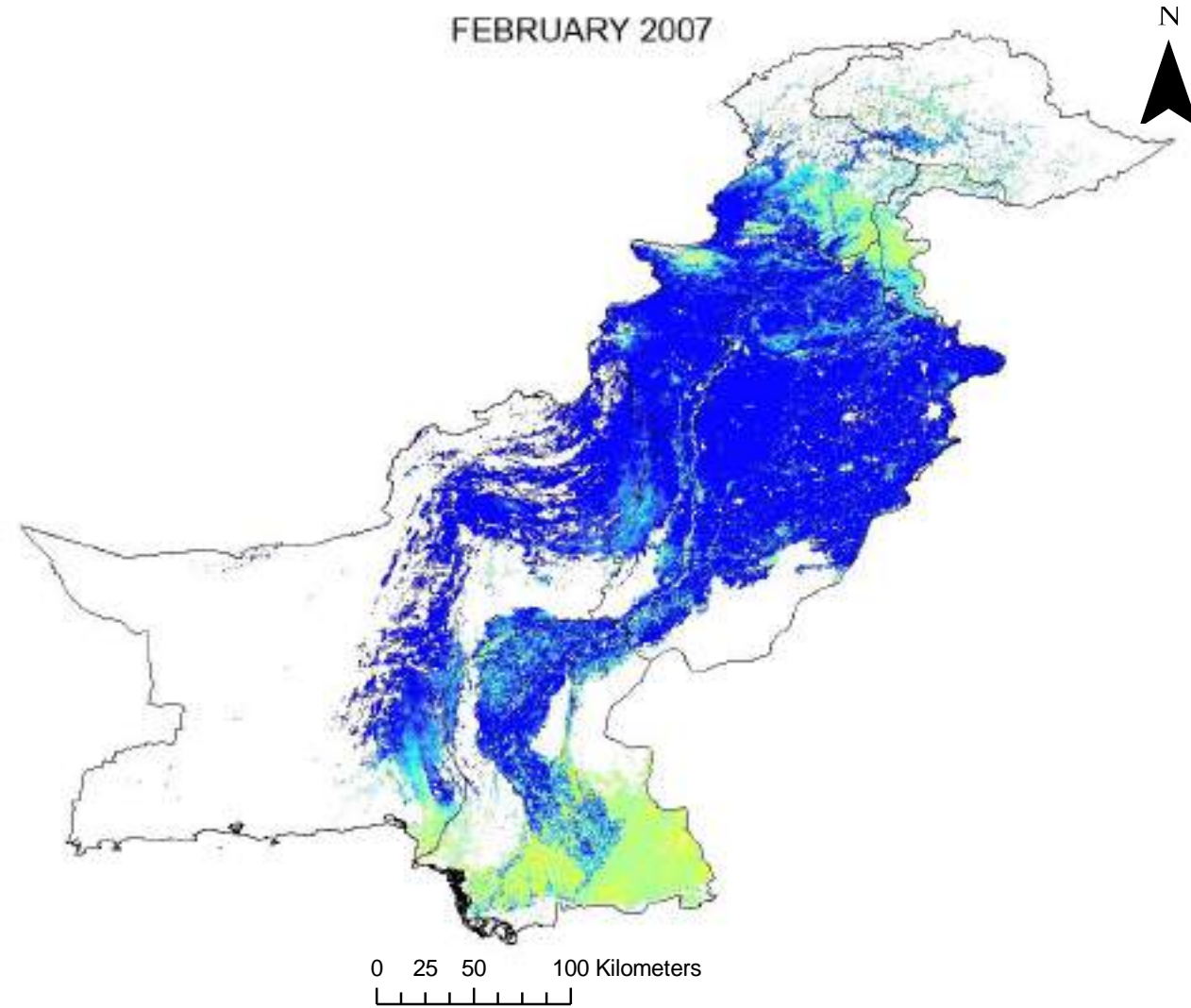
Legend

- | | | |
|--|---|--|
|  Extreme Drought (-1.5 or less) |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19) |
|  Severe Drought (-1.2 to -1.49) |  Near Normal (0.29 to -0.29) |  Very Wet (1.2 to 1.49) |
|  Moderate Drought (-0.9 to -1.19) |  Incipient Wet Spell (0.3 to 0.59) |  Extremely Wet (1.5 or greater) |
|  Mild Drought (-0.6 to -0.89) |  Slightly Wet (0.6 to 0.89) | |

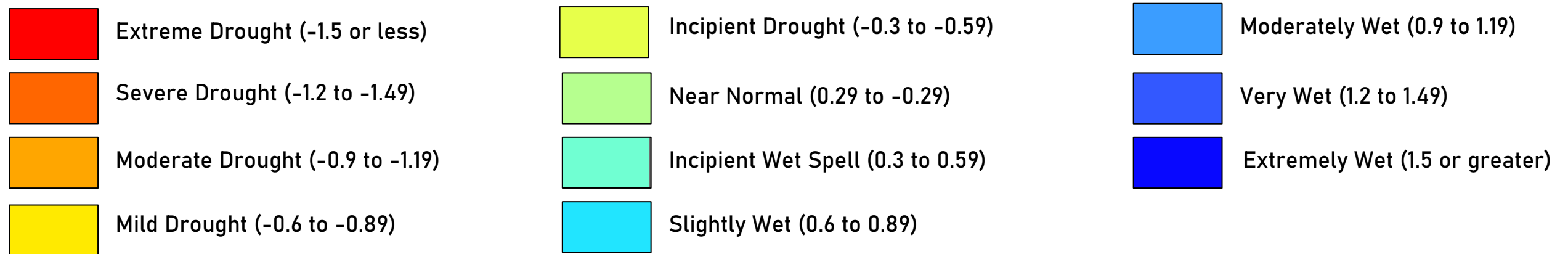


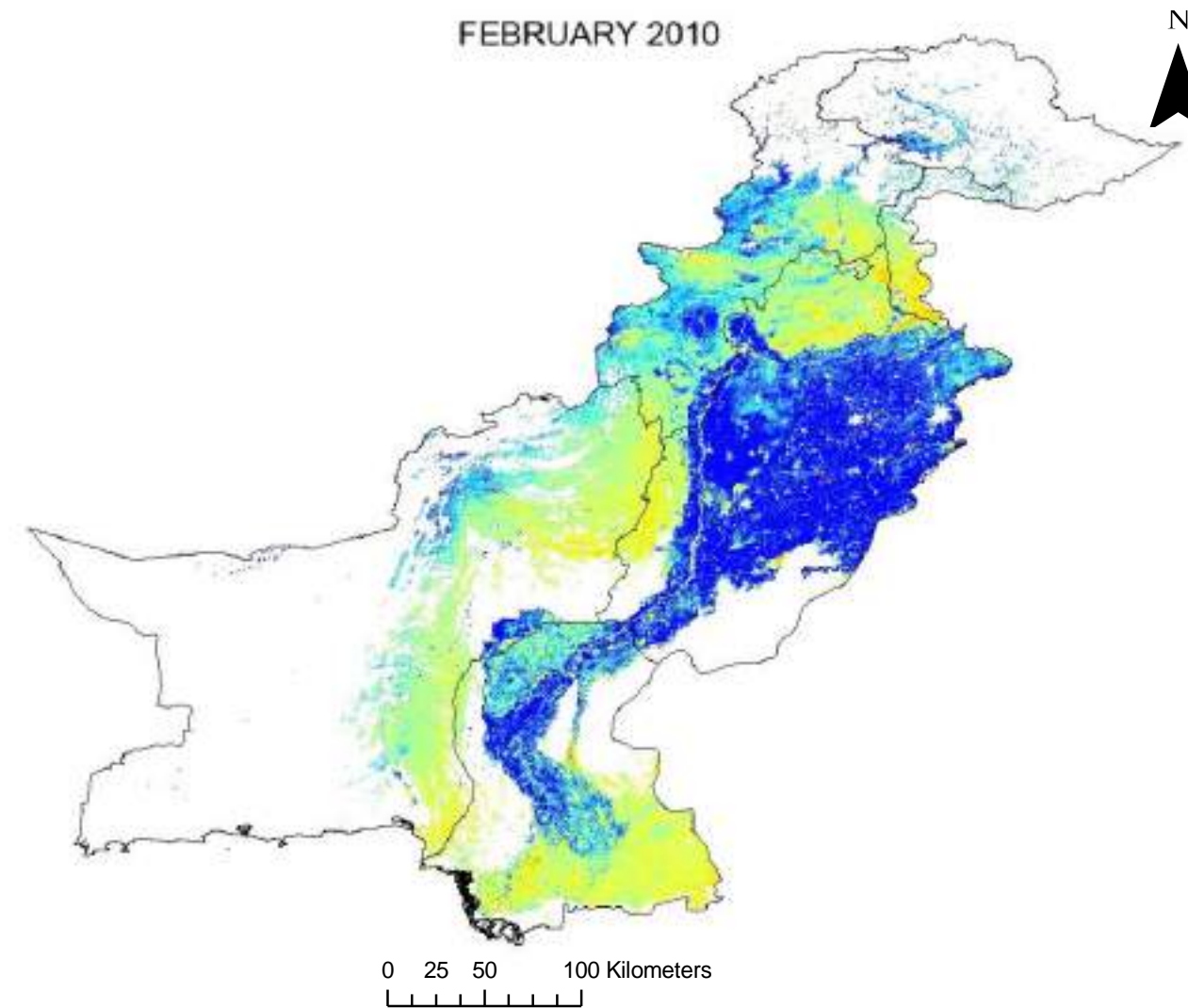
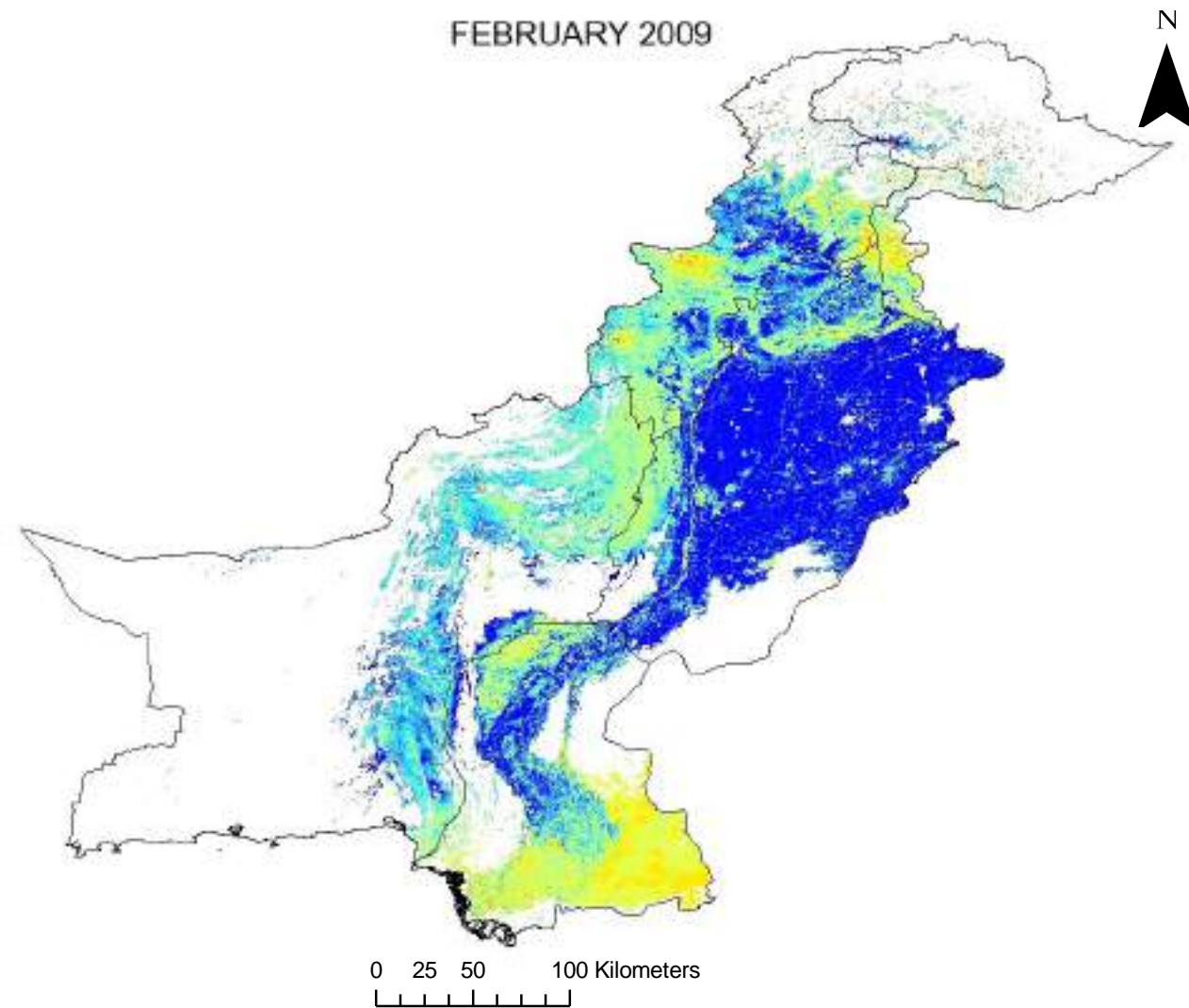
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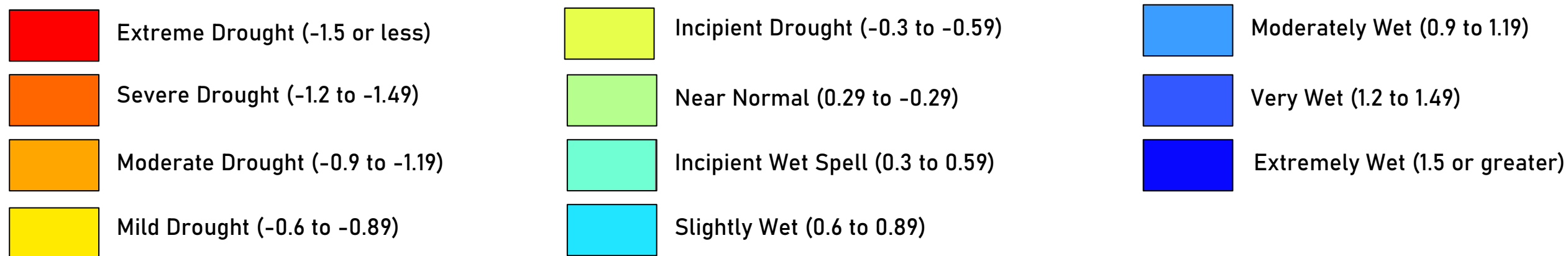


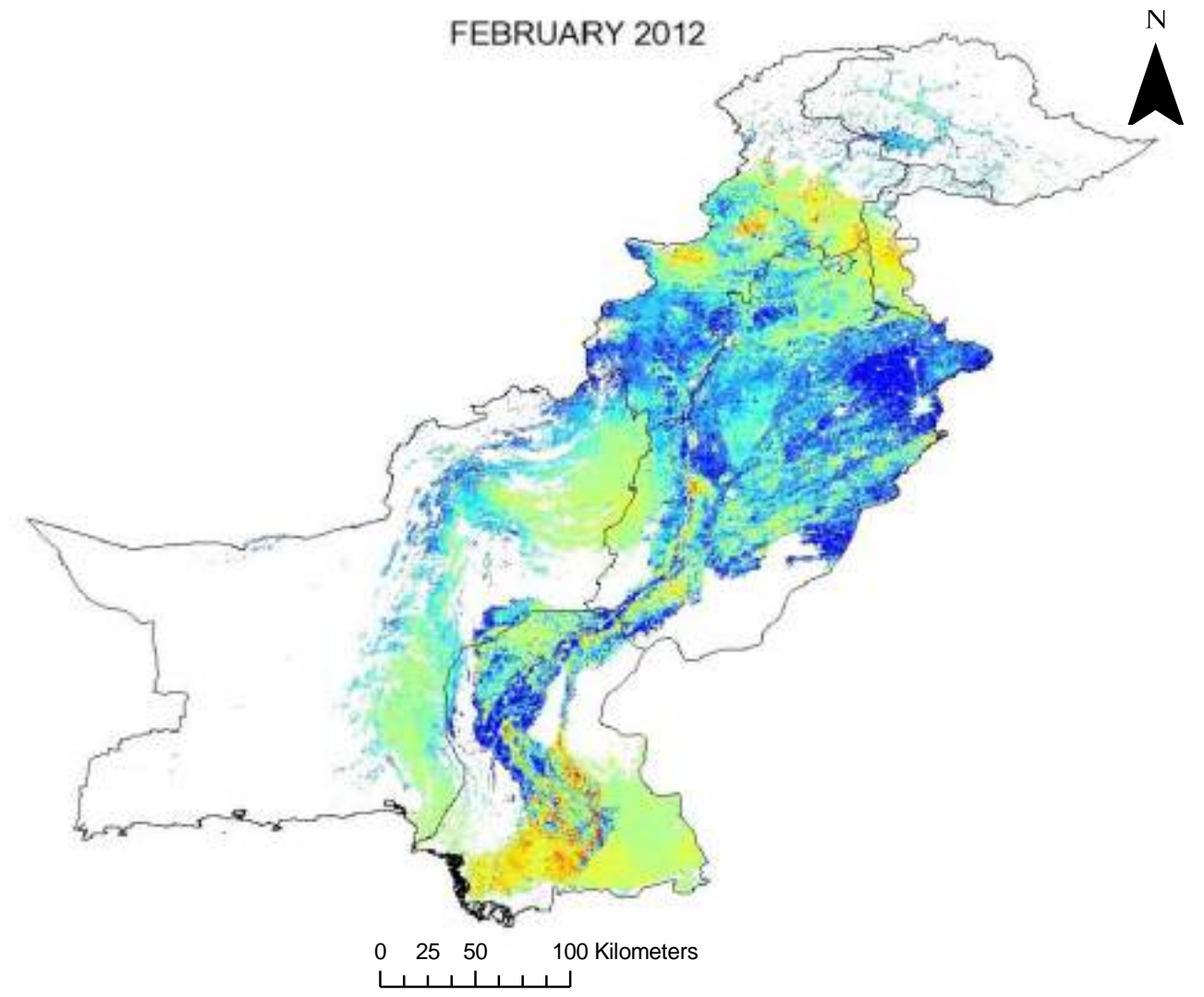
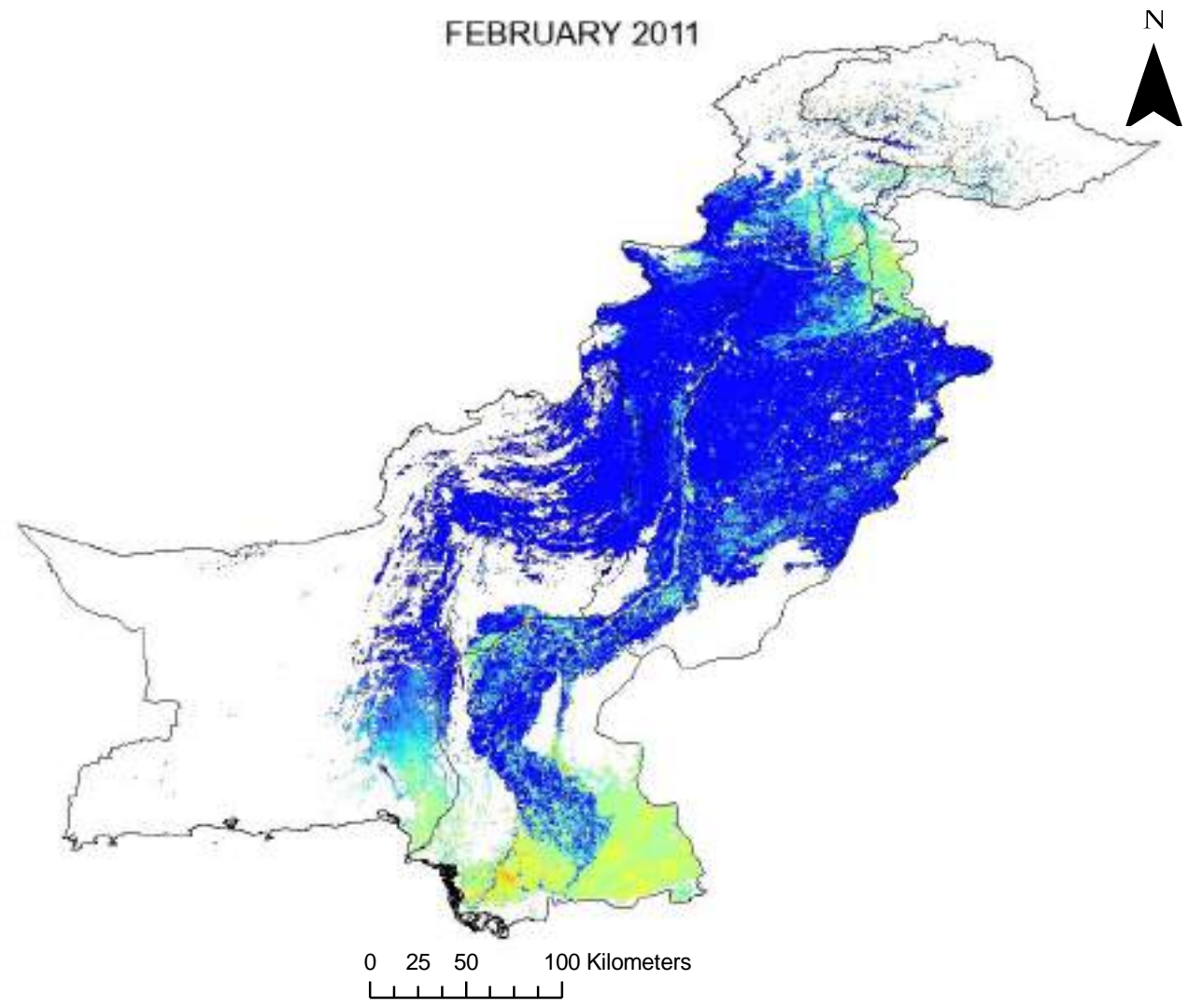
Legend
















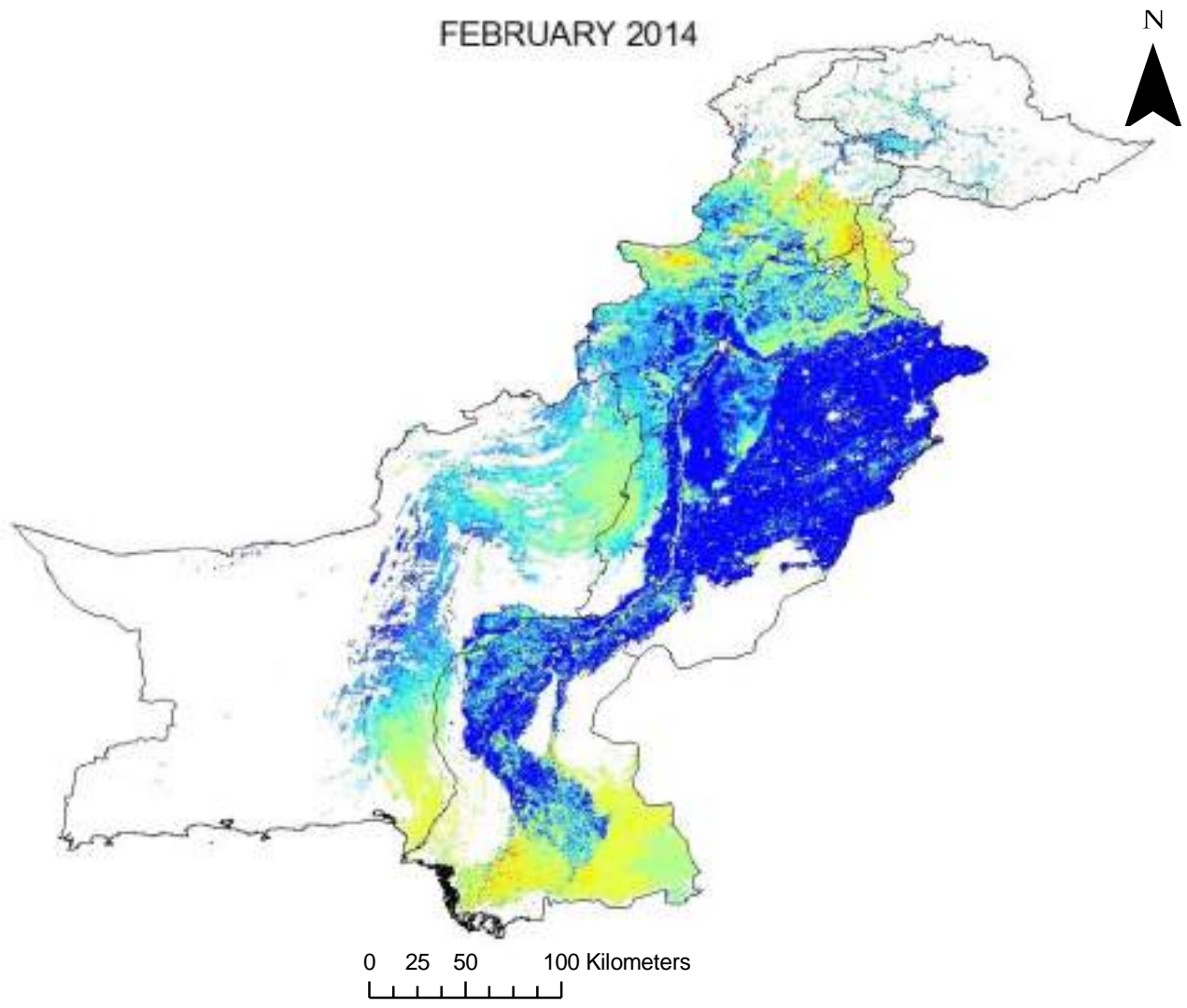
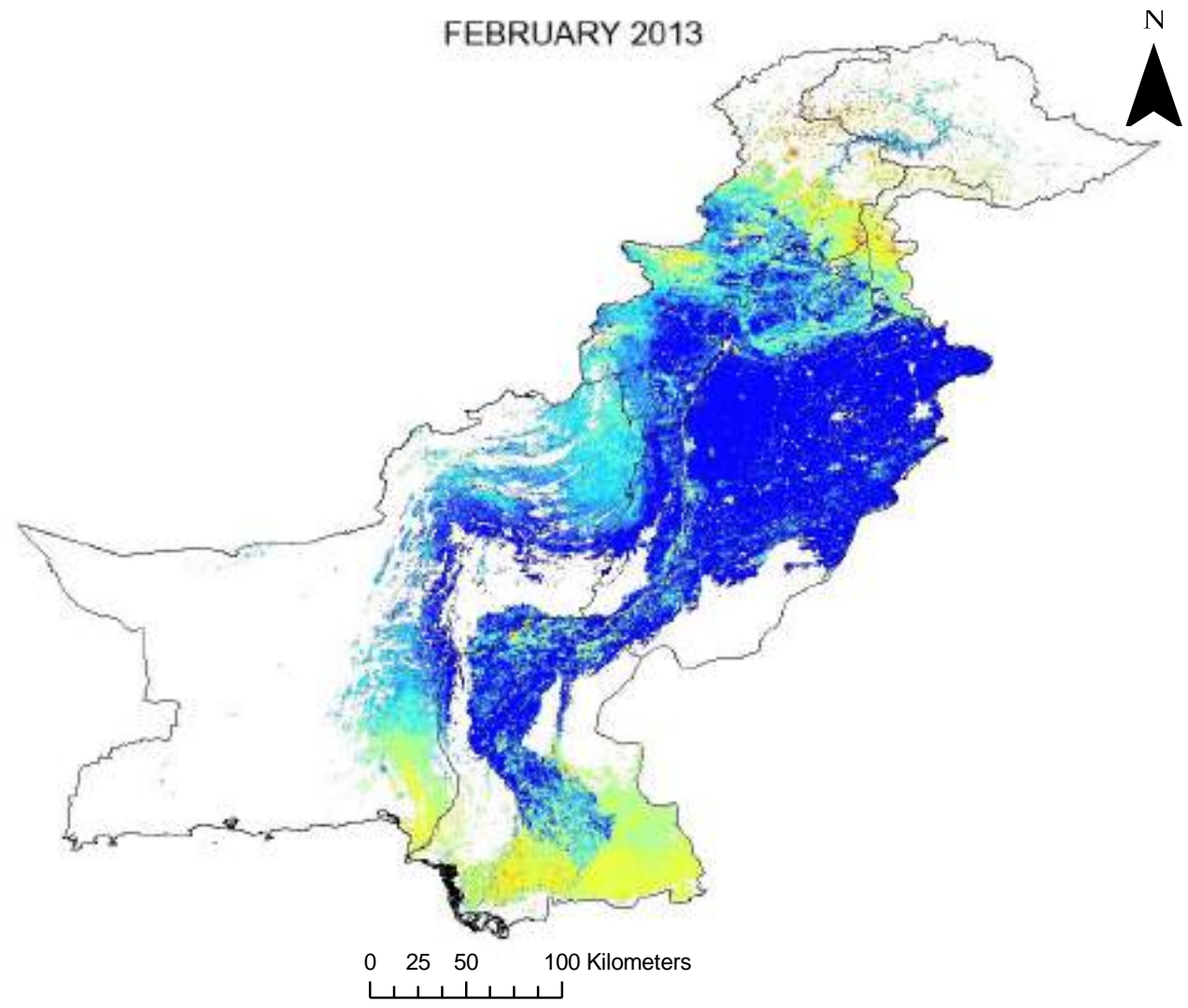
Legend
















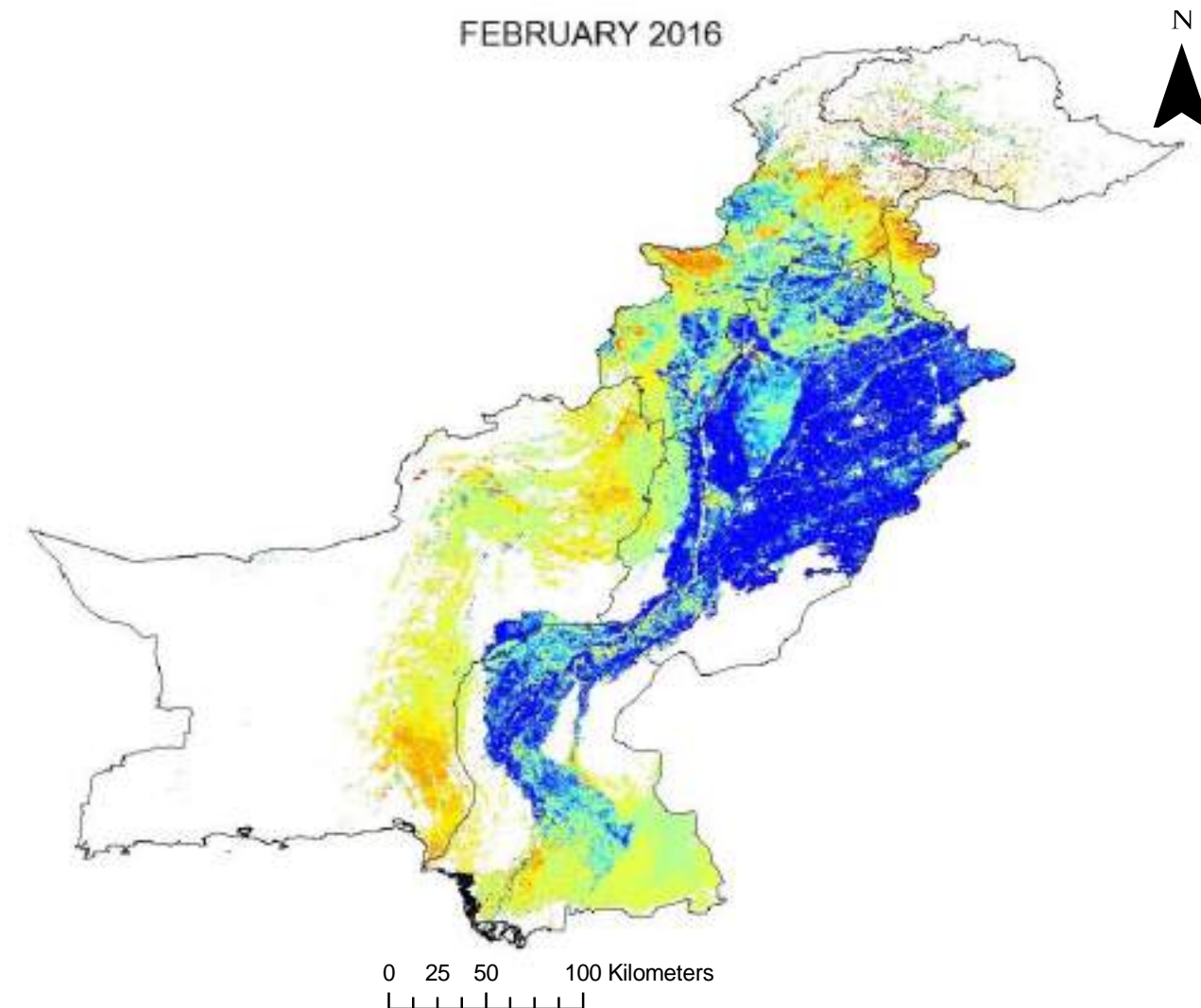
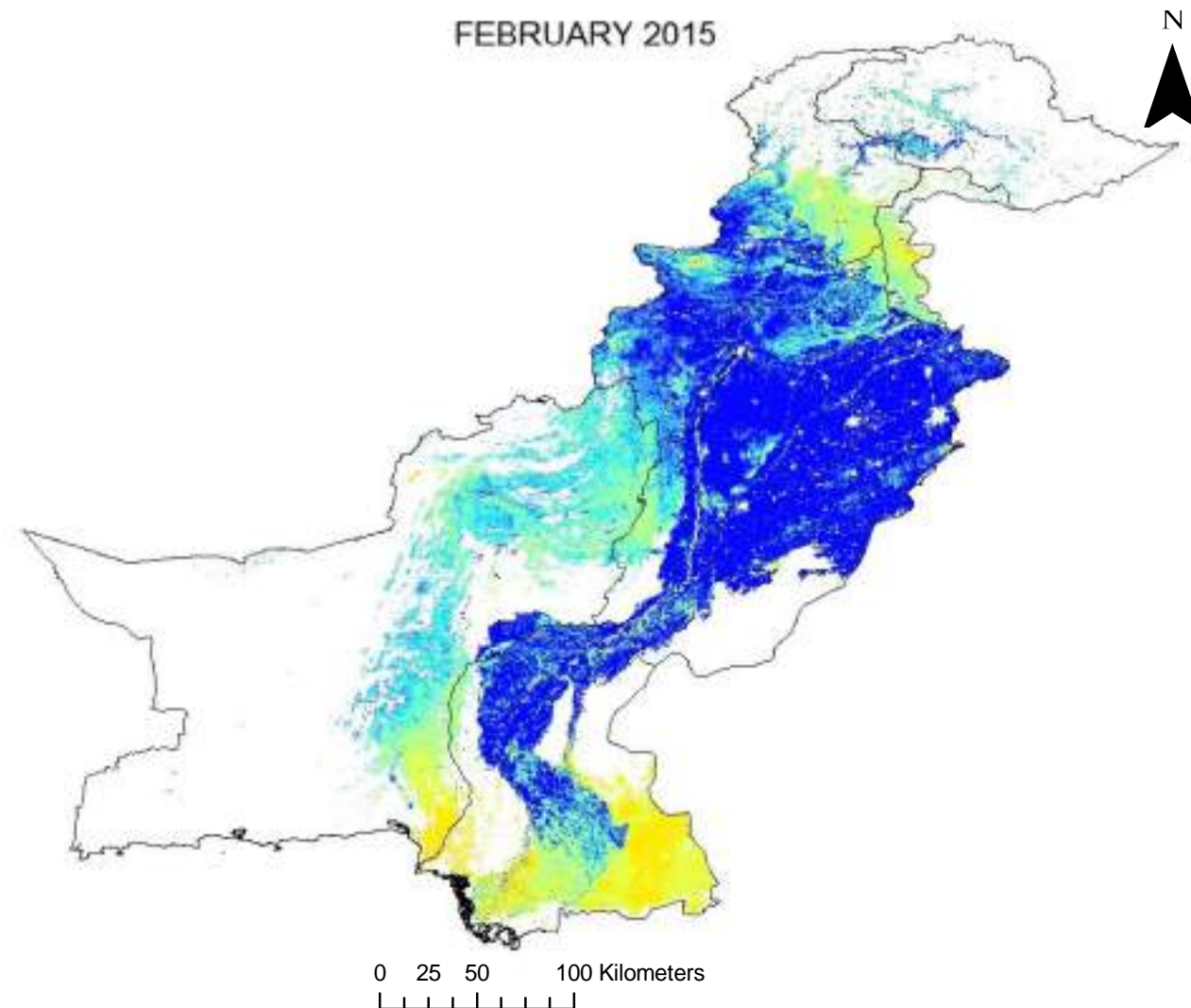
Legend

	Extreme Drought (-1.5 or less)		Incipient Drought (-0.3 to -0.59)		Moderately Wet (0.9 to 1.19)
	Severe Drought (-1.2 to -1.49)		Near Normal (0.29 to -0.29)		Very Wet (1.2 to 1.49)
	Moderate Drought (-0.9 to -1.19)		Incipient Wet Spell (0.3 to 0.59)		Extremely Wet (1.5 or greater)
	Mild Drought (-0.6 to -0.89)		Slightly Wet (0.6 to 0.89)		














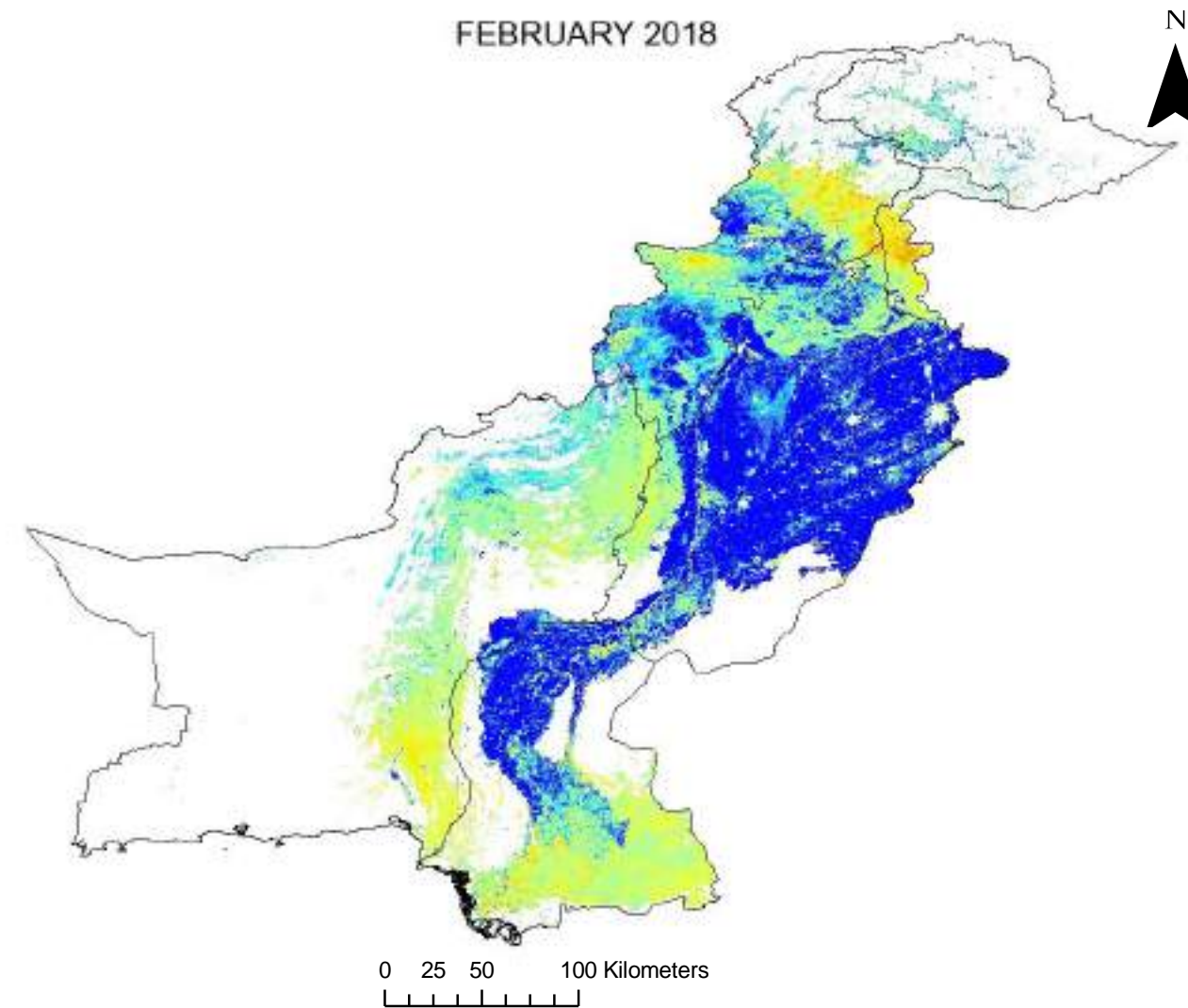
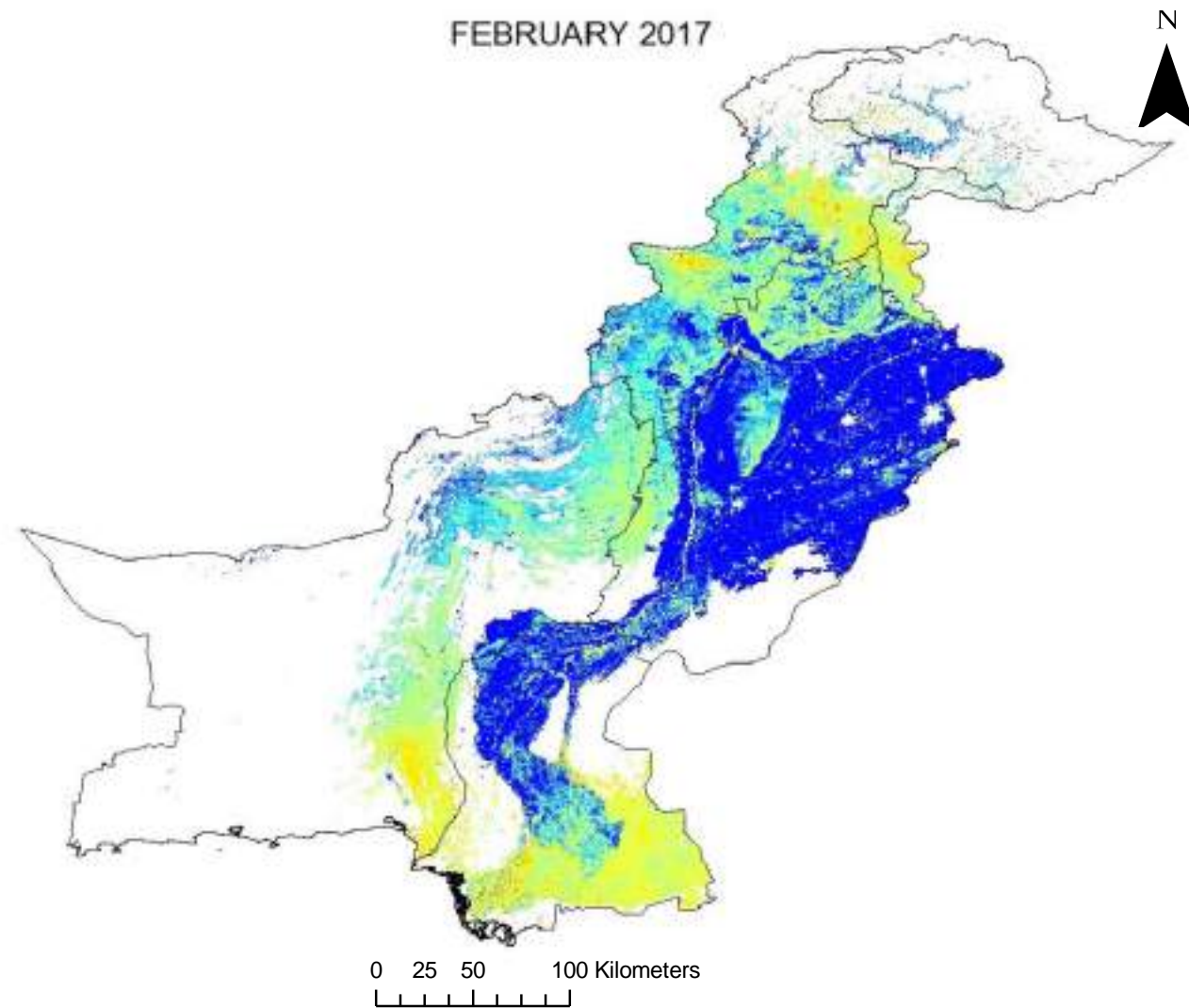
Legend

- | | | | | | |
|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
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|  | Mild Drought (-0.6 to -0.89) |  | Slightly Wet (0.6 to 0.89) | | |








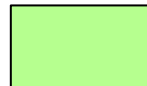


Legend

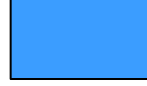


	Extreme Drought (-1.5 or less)		Incipient Drought (-0.3 to -0.59)		Moderately Wet (0.9 to 1.19)
	Severe Drought (-1.2 to -1.49)		Near Normal (0.29 to -0.29)		Very Wet (1.2 to 1.49)
	Moderate Drought (-0.9 to -1.19)		Incipient Wet Spell (0.3 to 0.59)		Extremely Wet (1.5 or greater)
	Mild Drought (-0.6 to -0.89)		Slightly Wet (0.6 to 0.89)		

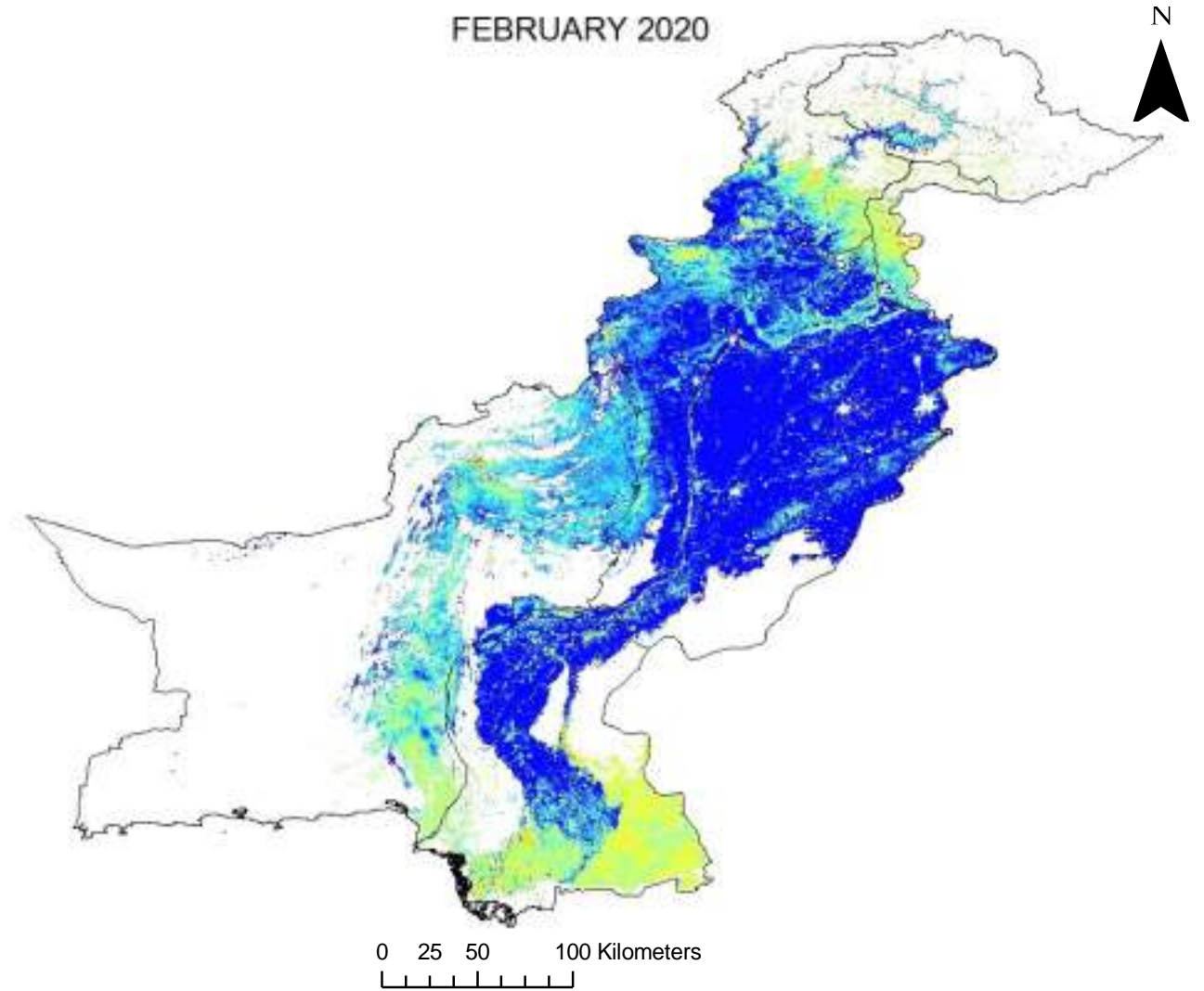
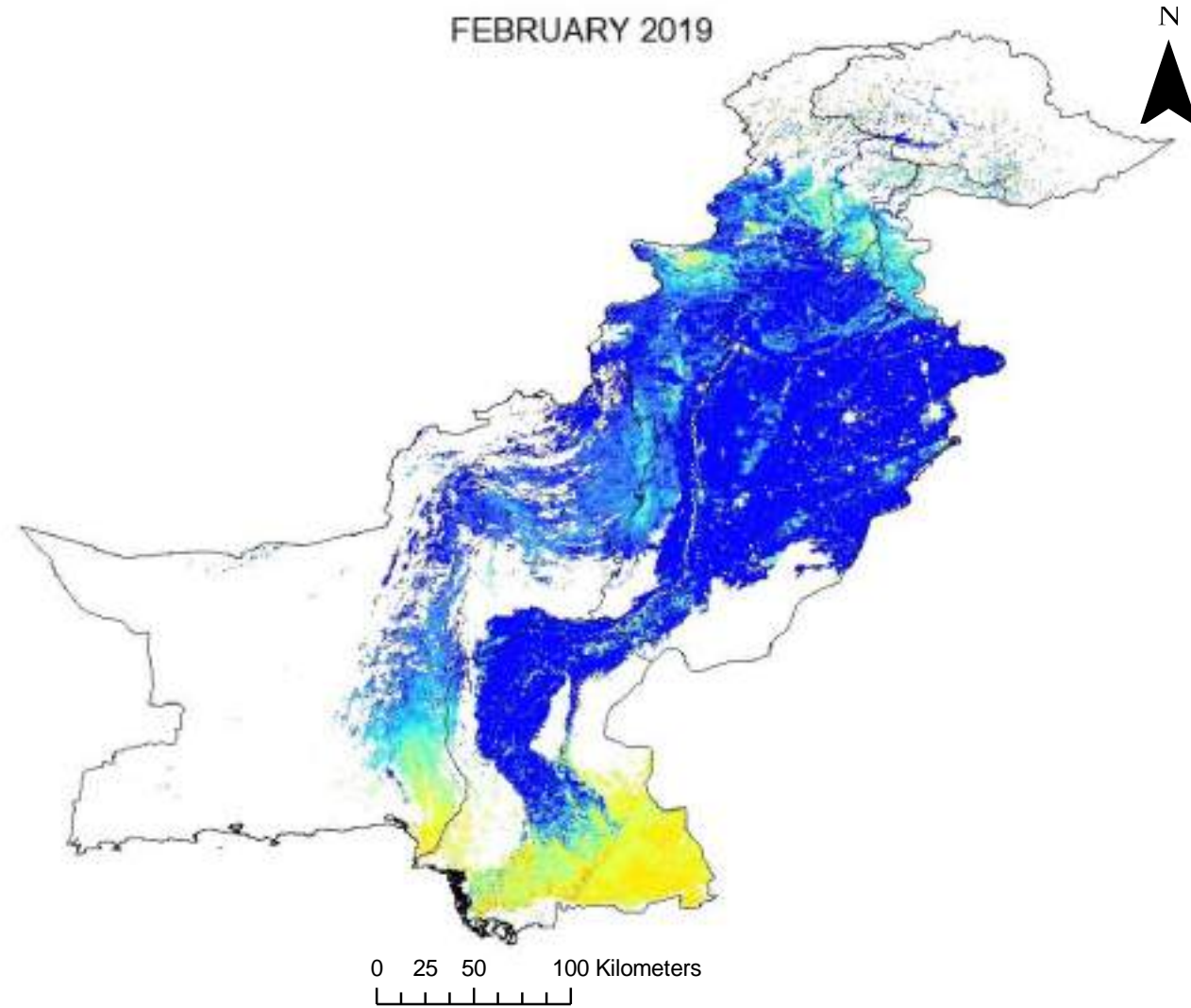


Legend

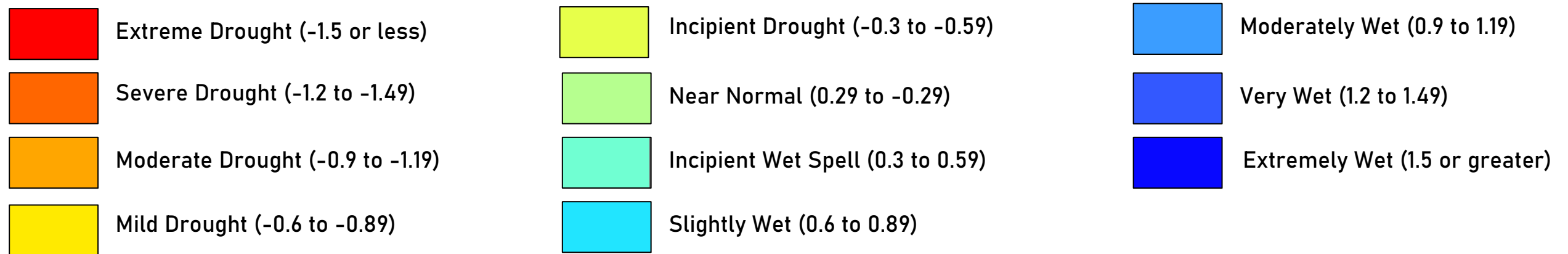
-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
-  Mild Drought (-0.6 to -0.89)

-  Incipient Drought (-0.3 to -0.59)
-  Near Normal (0.29 to -0.29)
-  Incipient Wet Spell (0.3 to 0.59)
-  Slightly Wet (0.6 to 0.89)

-  Moderately Wet (0.9 to 1.19)
-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)



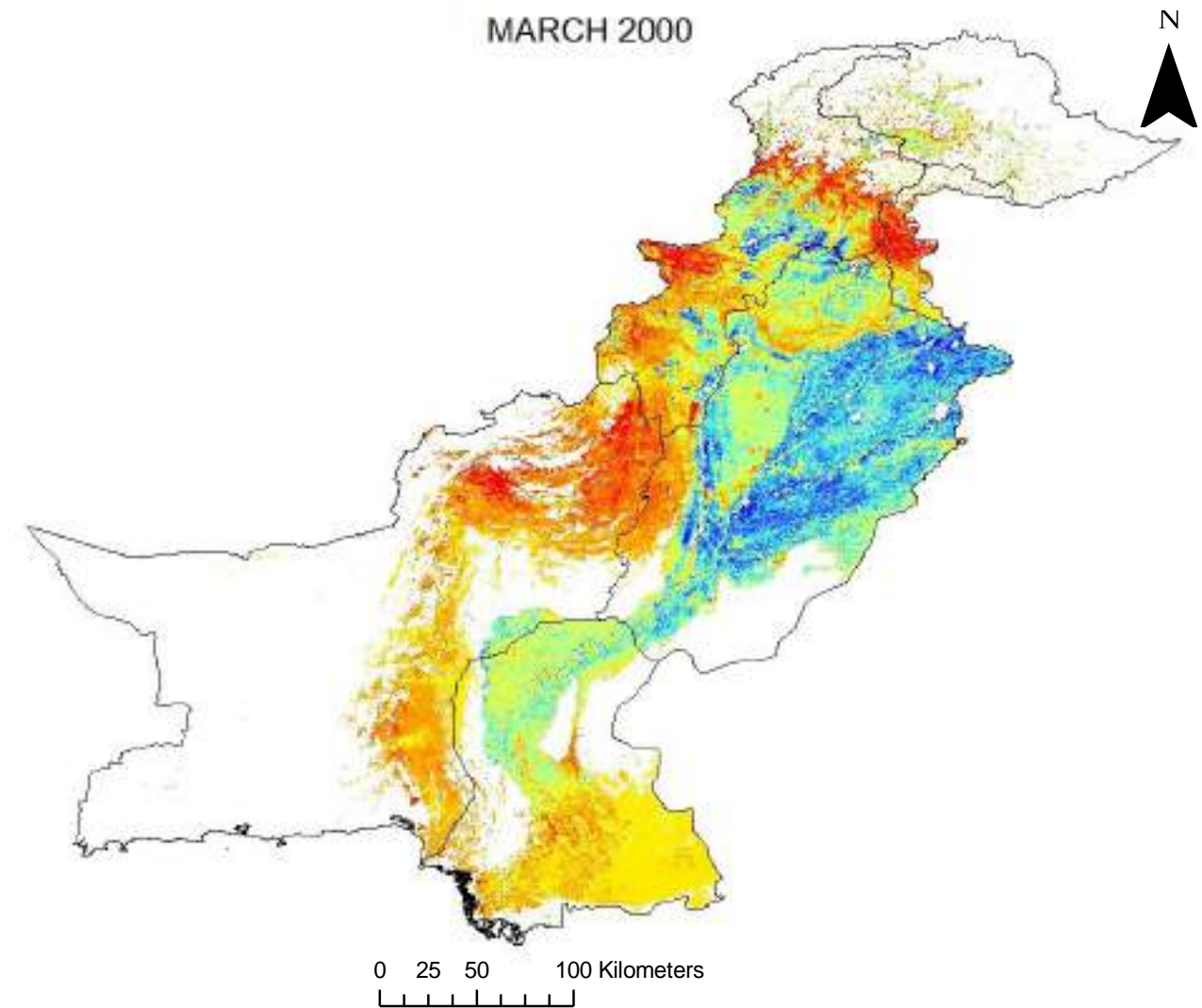
Legend



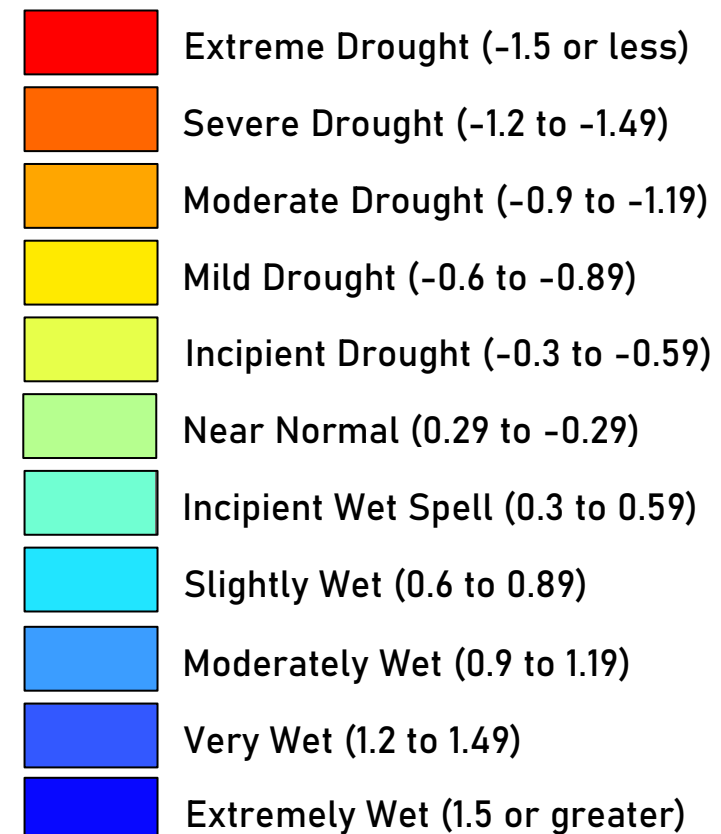
March DSI Maps

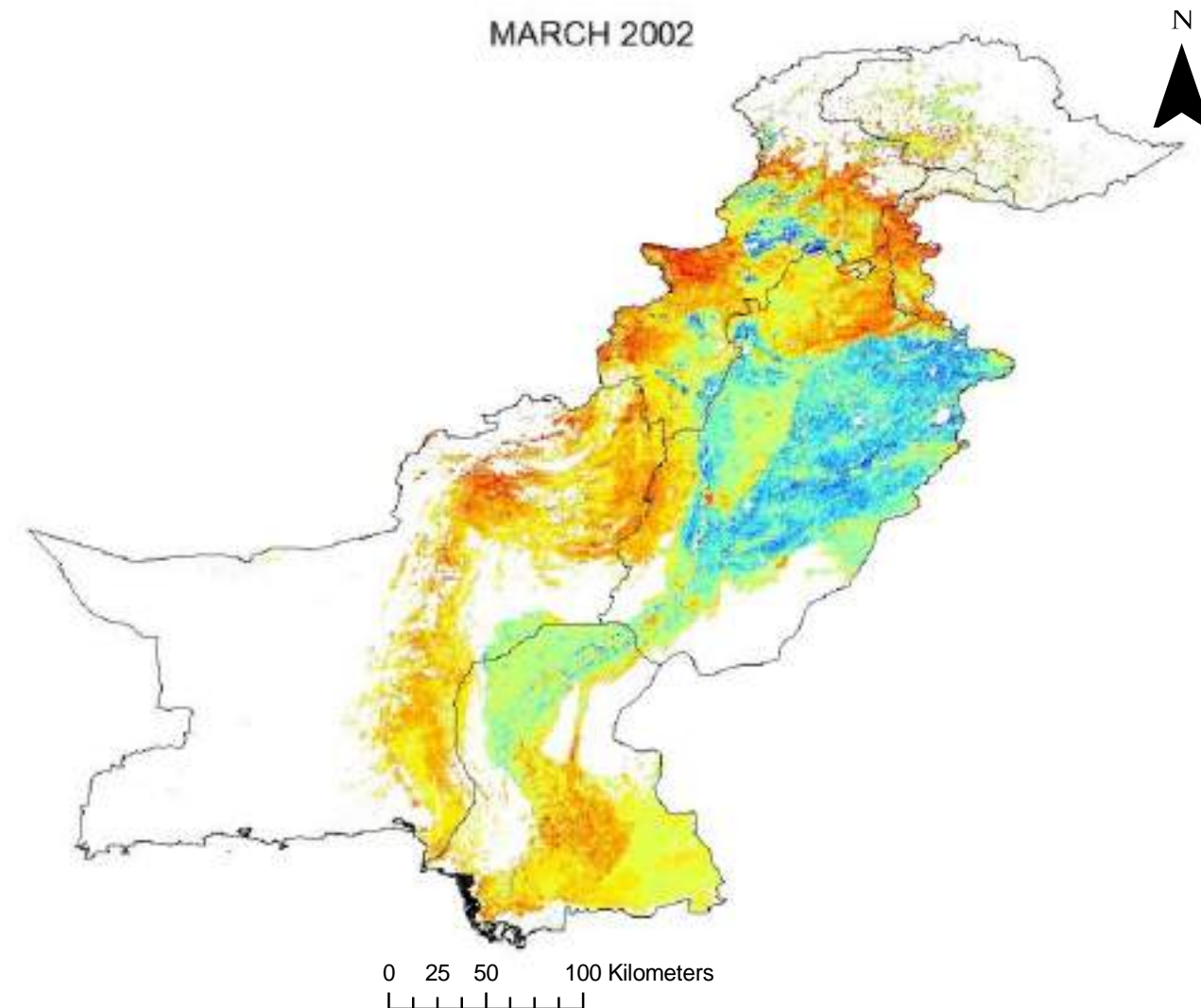
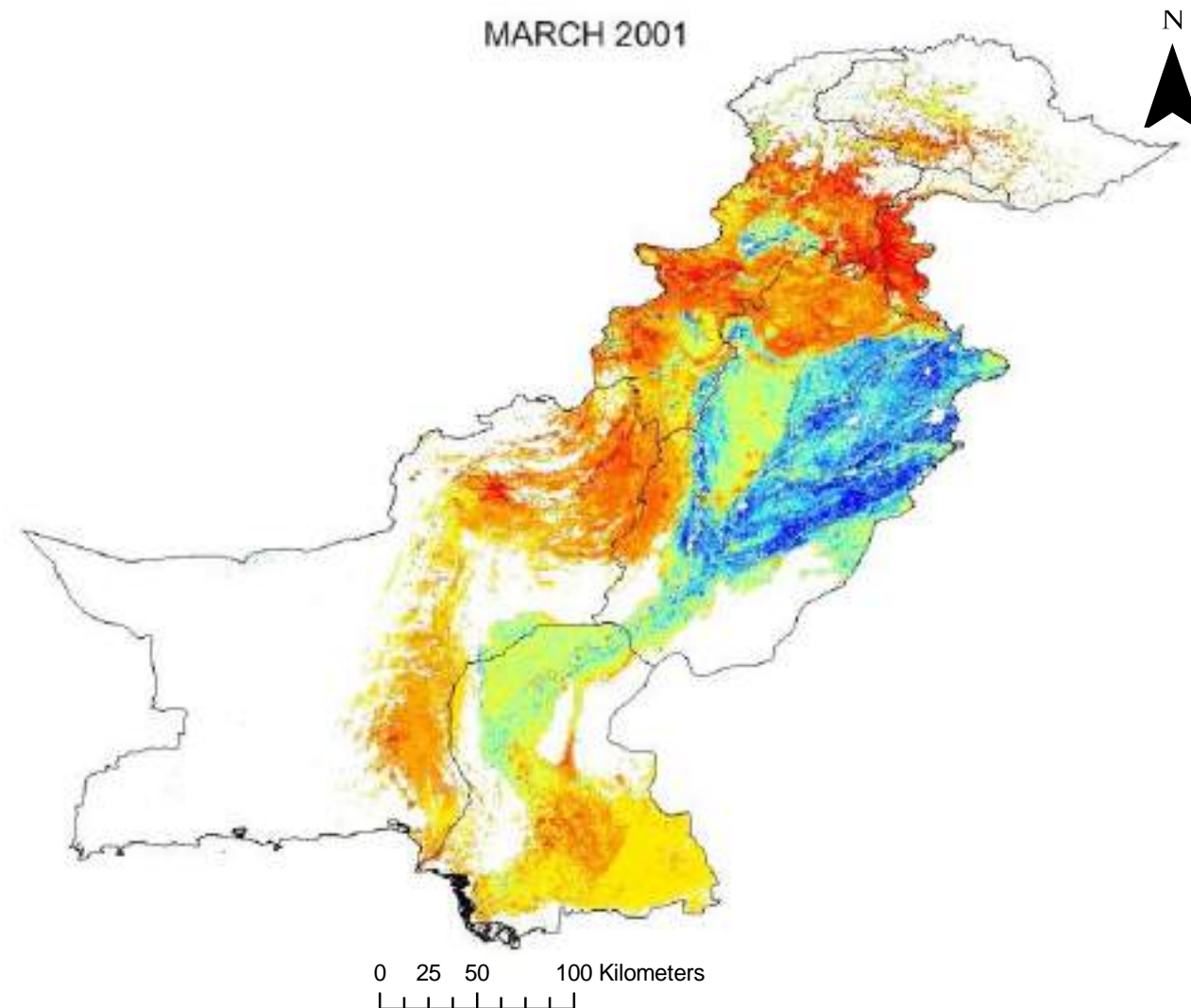
Drought conditions range from incipient drought to extremely wet in March. This month undergoes near normal conditions the most.

Mean March DSI Values		
Years	Values	Drought Condition
2000	-0.43	Incipient Drought
2001	-0.59	Incipient Drought
2002	-0.26	Near Normal
2003	0.22	Near Normal
2004	-0.22	Near Normal
2005	0.78	Slightly Wet
2006	0.21	Near Normal
2007	0.70	Slightly Wet
2008	-0.24	Near Normal
2009	0.25	Near Normal
2010	-0.18	Near Normal
2011	0.18	Near Normal
2012	-0.13	Near Normal
2013	0.68	Slightly Wet
2014	0.75	Slightly Wet
2015	0.93	Moderately Wet
2016	0.79	Slightly Wet
2017	0.41	Incipient Wet Spell
2018	0.17	Near Normal
2019	0.58	Incipient Wet Spell
2020	1.51	Extremely Wet














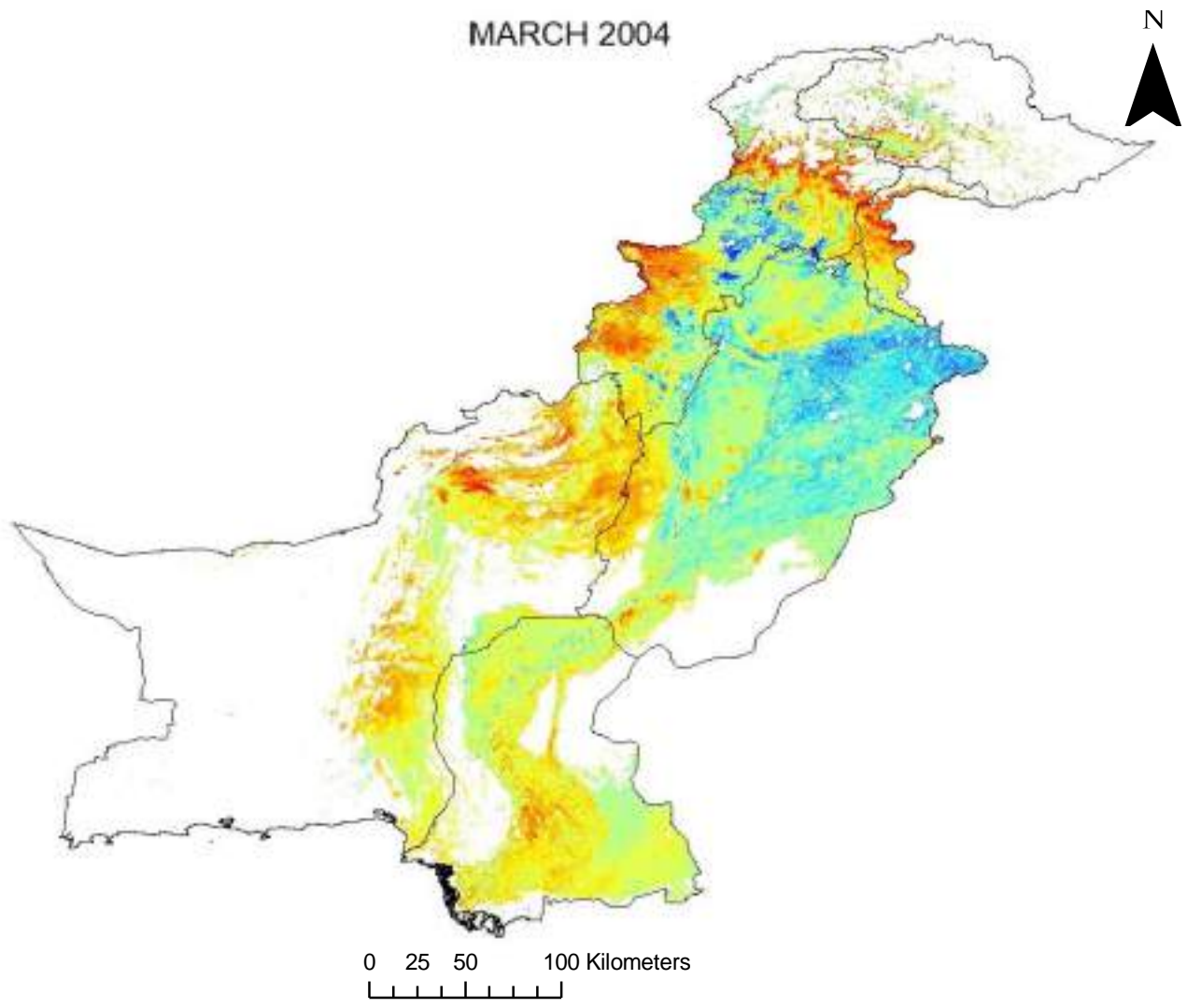
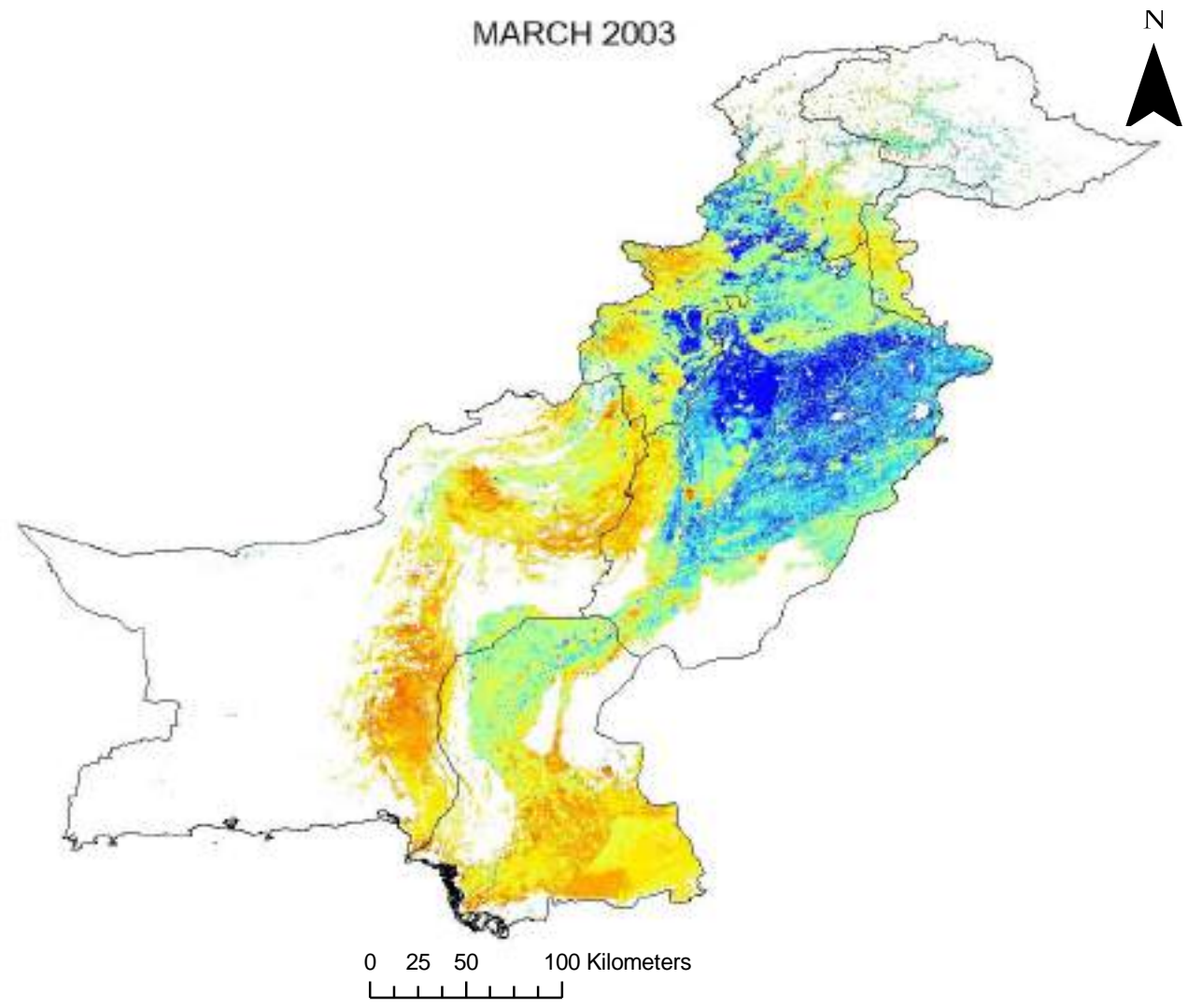
Legend
















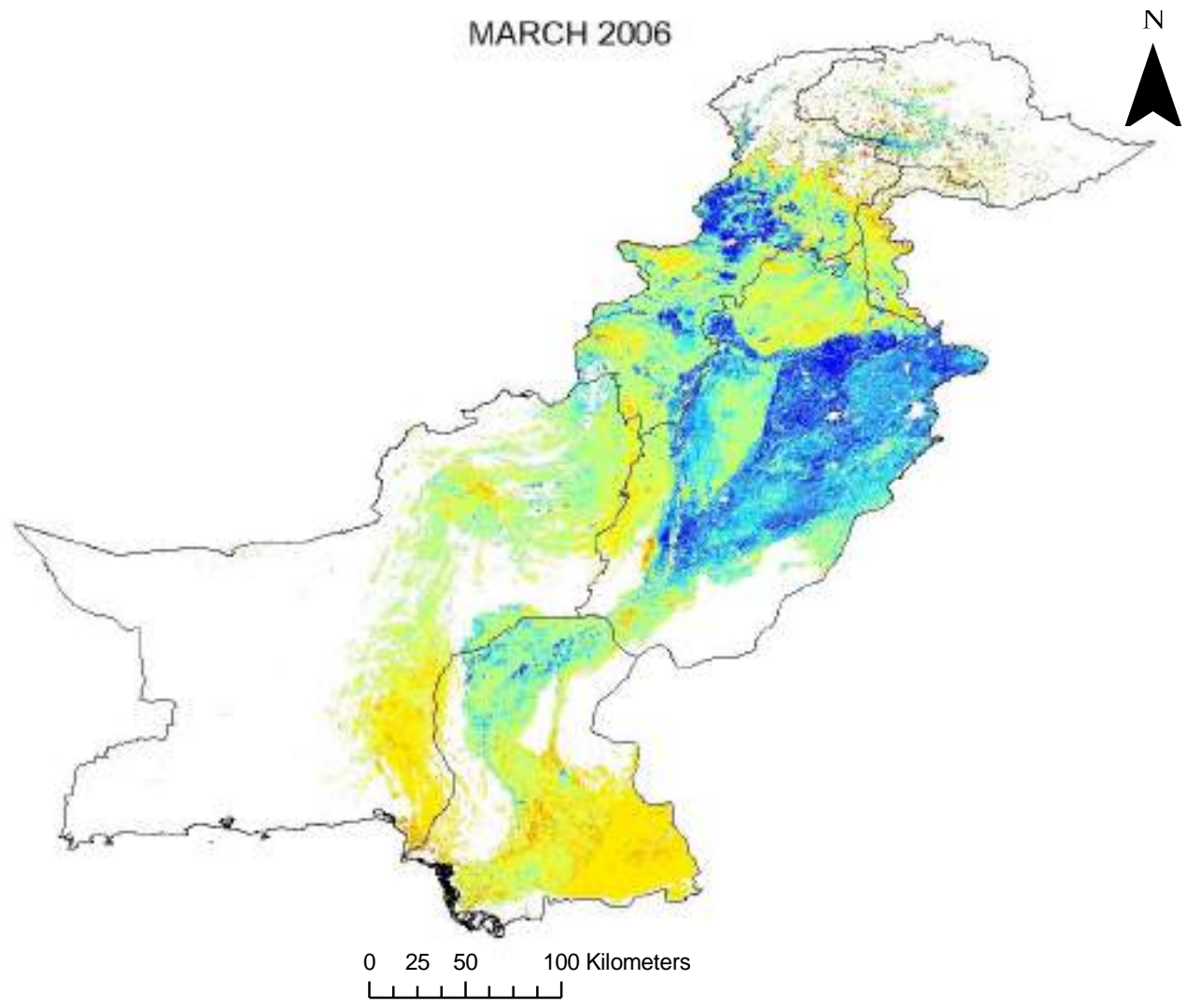
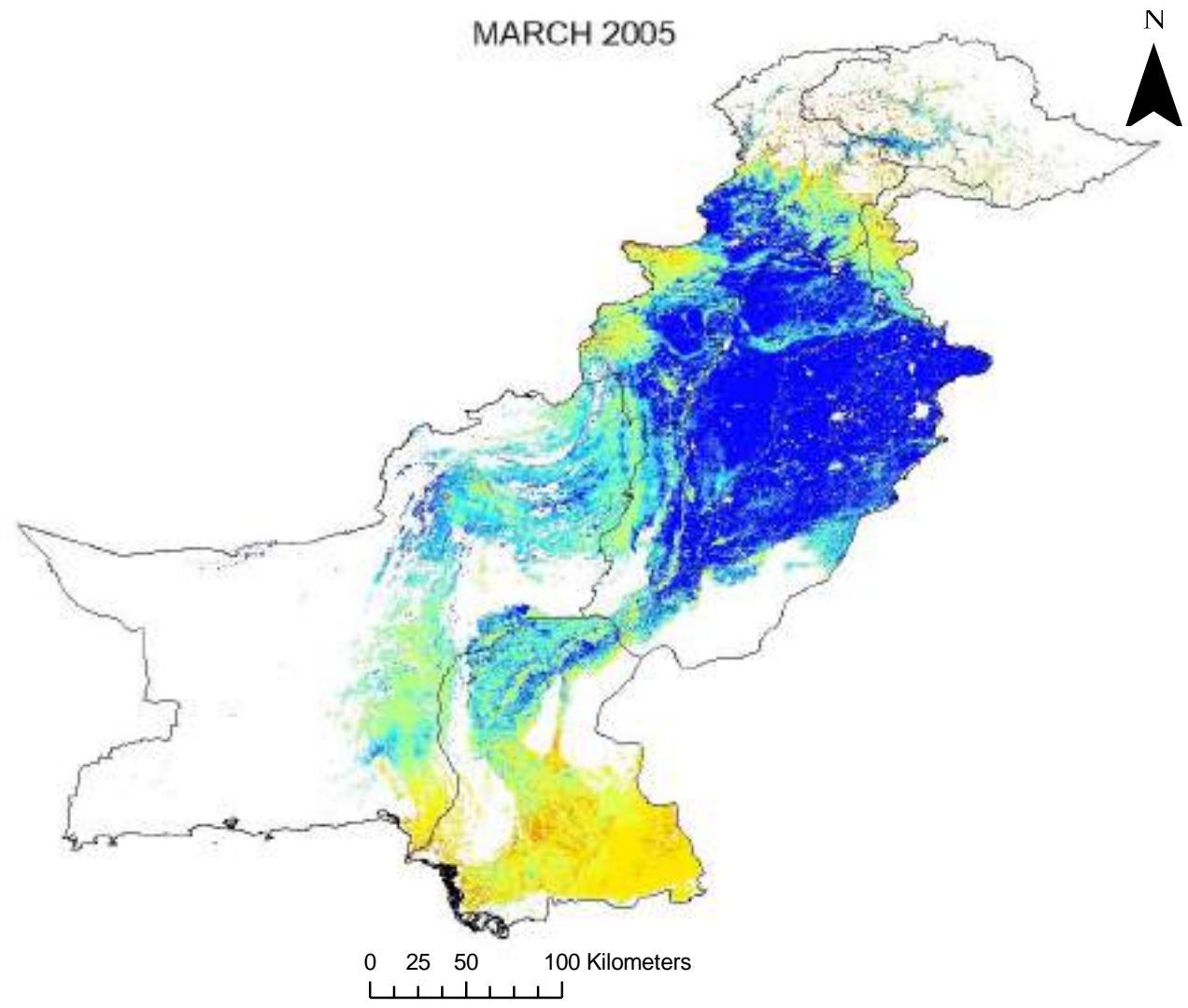
Legend

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|--|---|--|
|  Extreme Drought (-1.5 or less) |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19) |
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|  Moderate Drought (-0.9 to -1.19) |  Incipient Wet Spell (0.3 to 0.59) |  Extremely Wet (1.5 or greater) |
|  Mild Drought (-0.6 to -0.89) |  Slightly Wet (0.6 to 0.89) | |














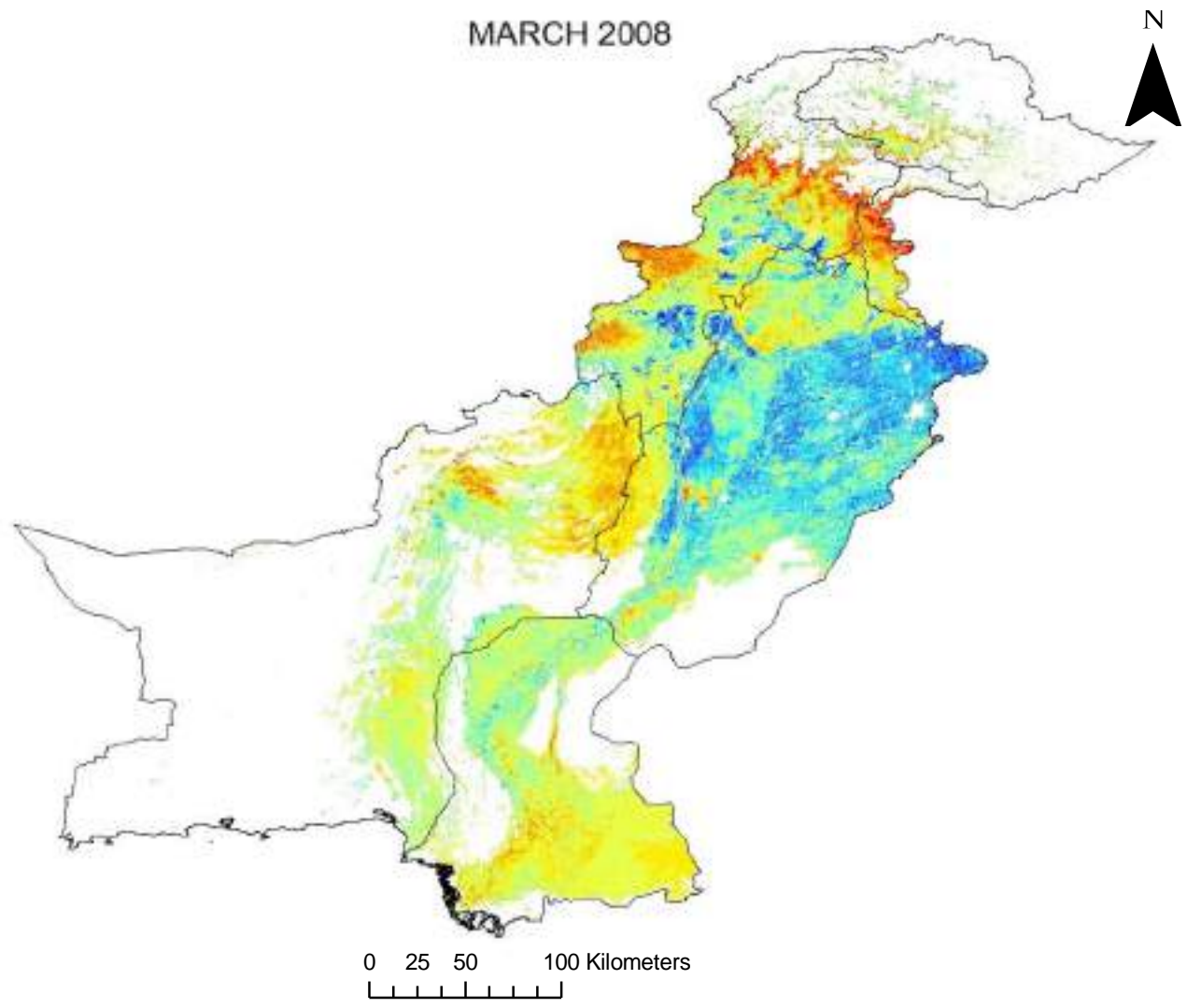
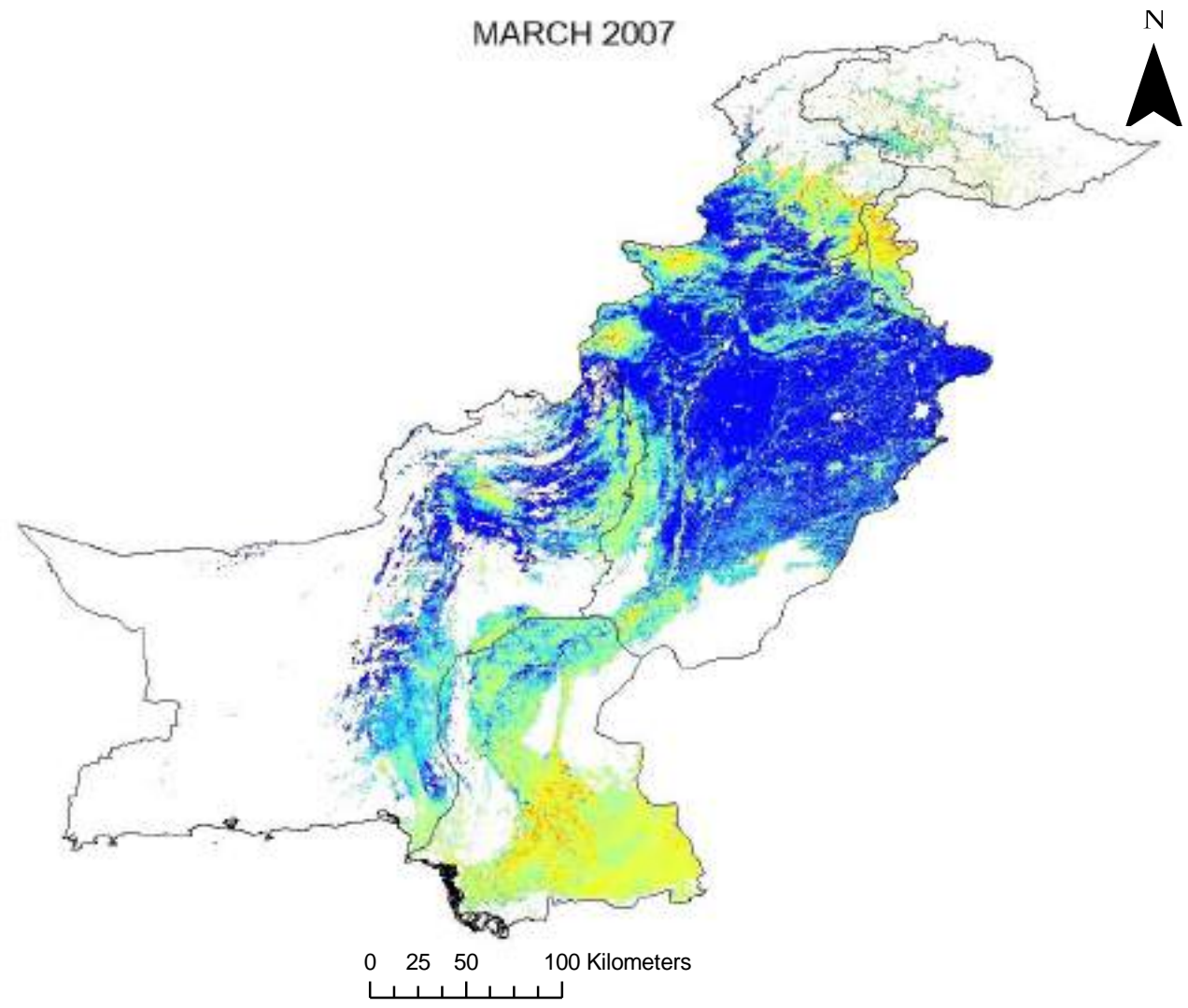
Legend

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|--|---|--|
|  Extreme Drought (-1.5 or less) |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19) |
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|  Mild Drought (-0.6 to -0.89) |  Slightly Wet (0.6 to 0.89) | |

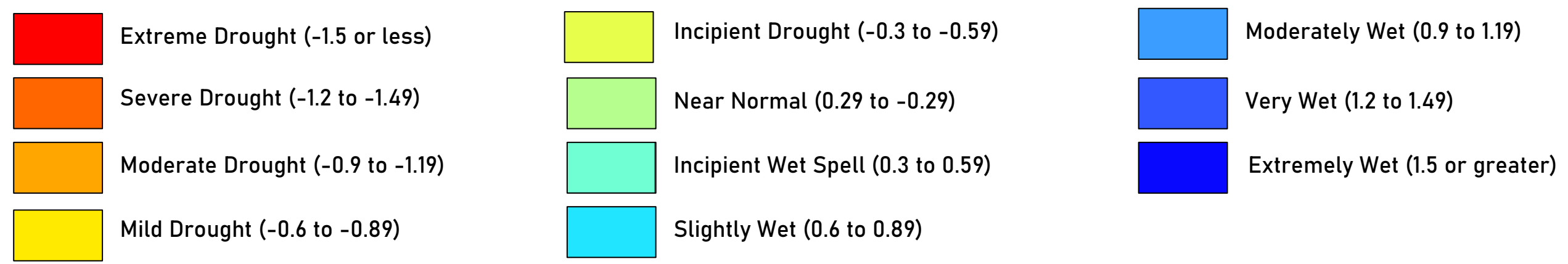


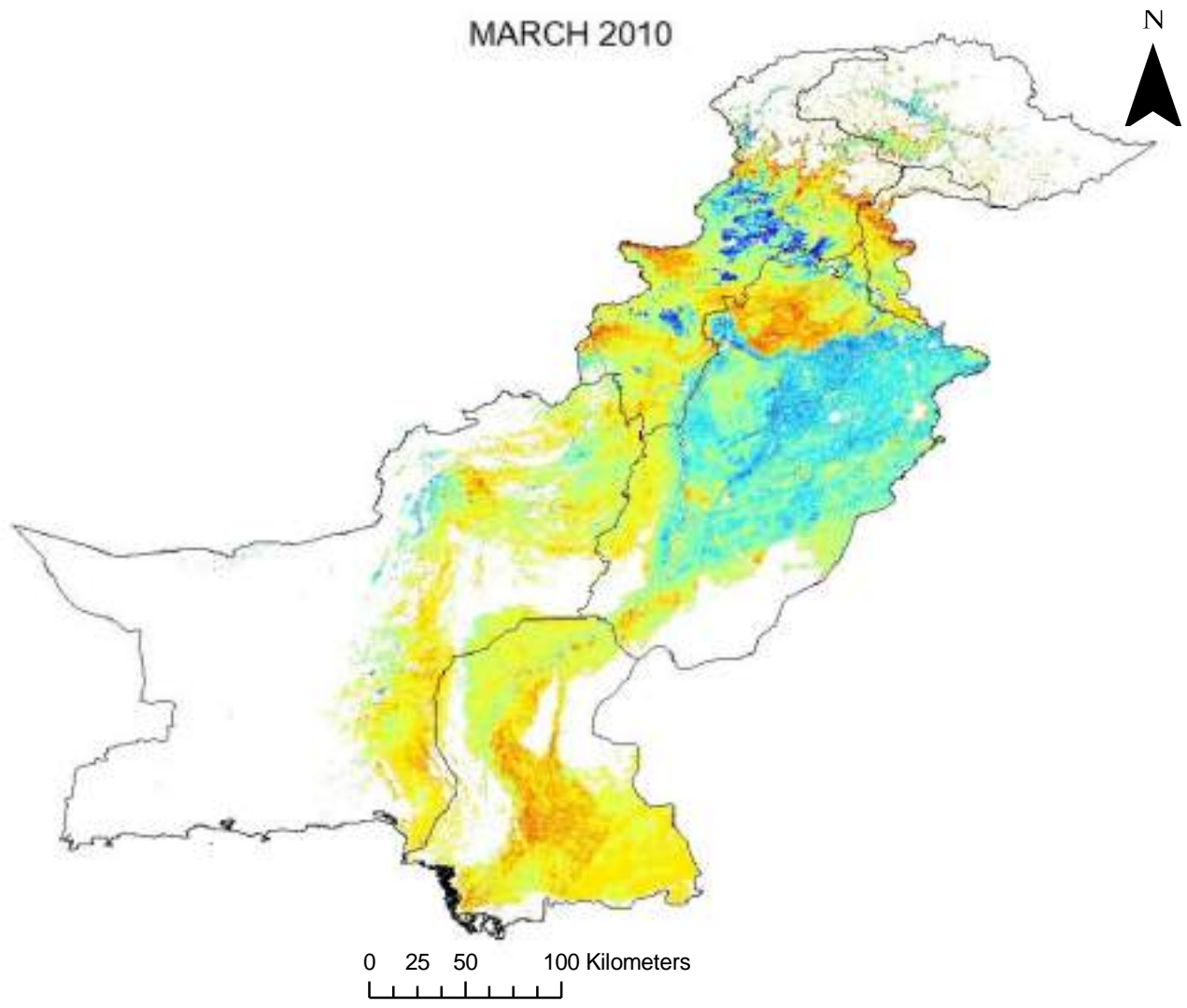
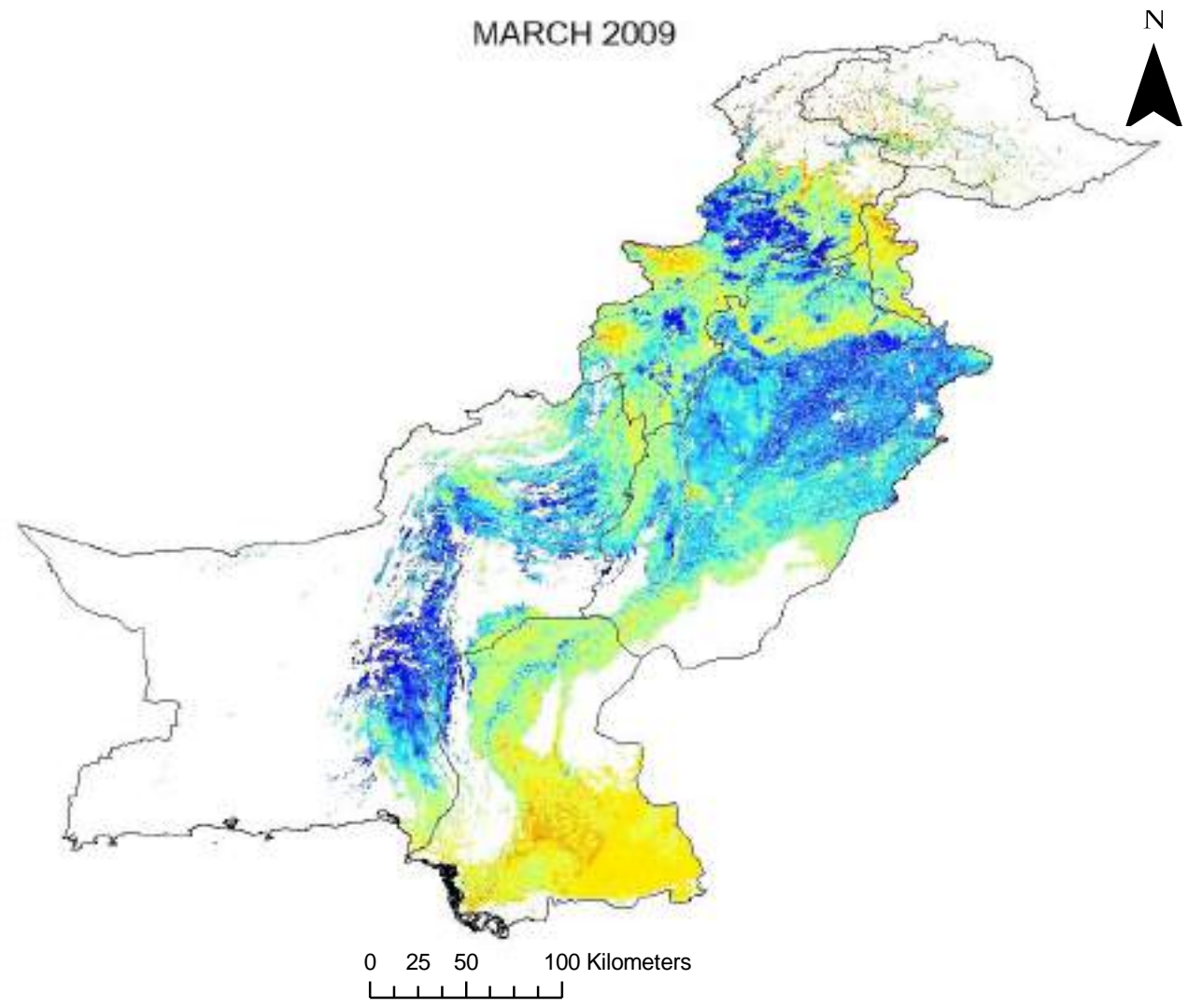
Legend

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|--|---|--|
|  Extreme Drought (-1.5 or less) |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19) |
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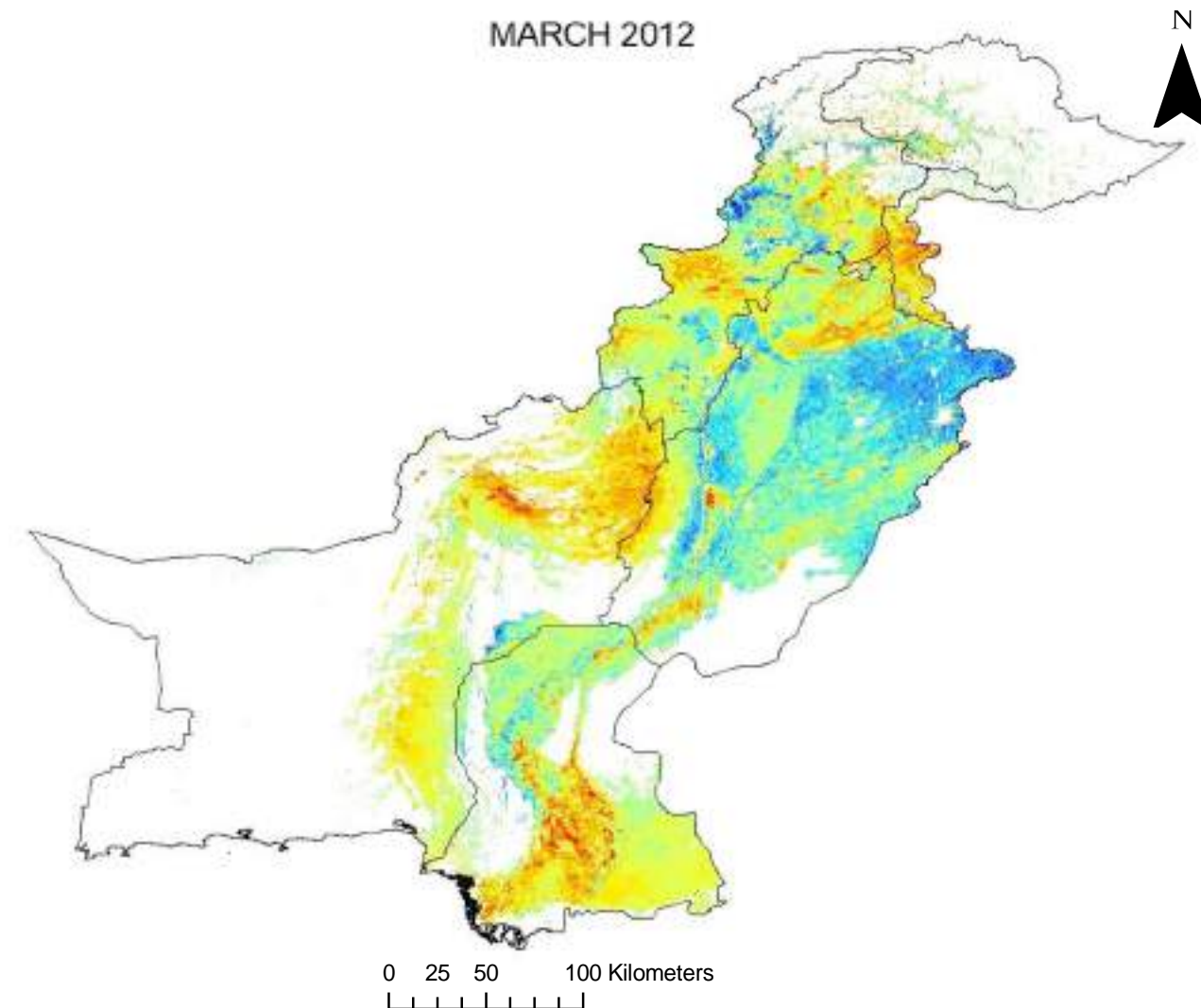
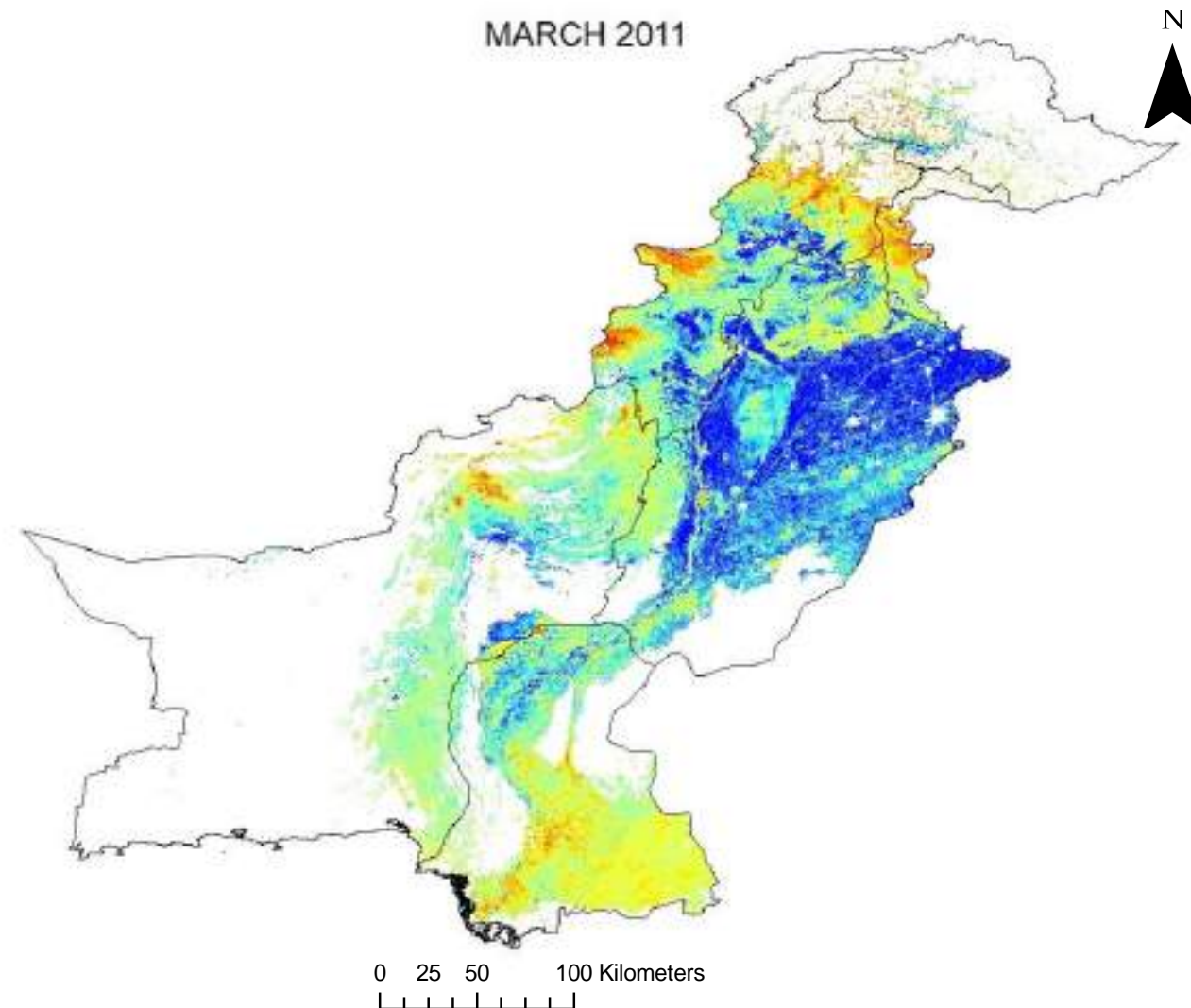
Legend
















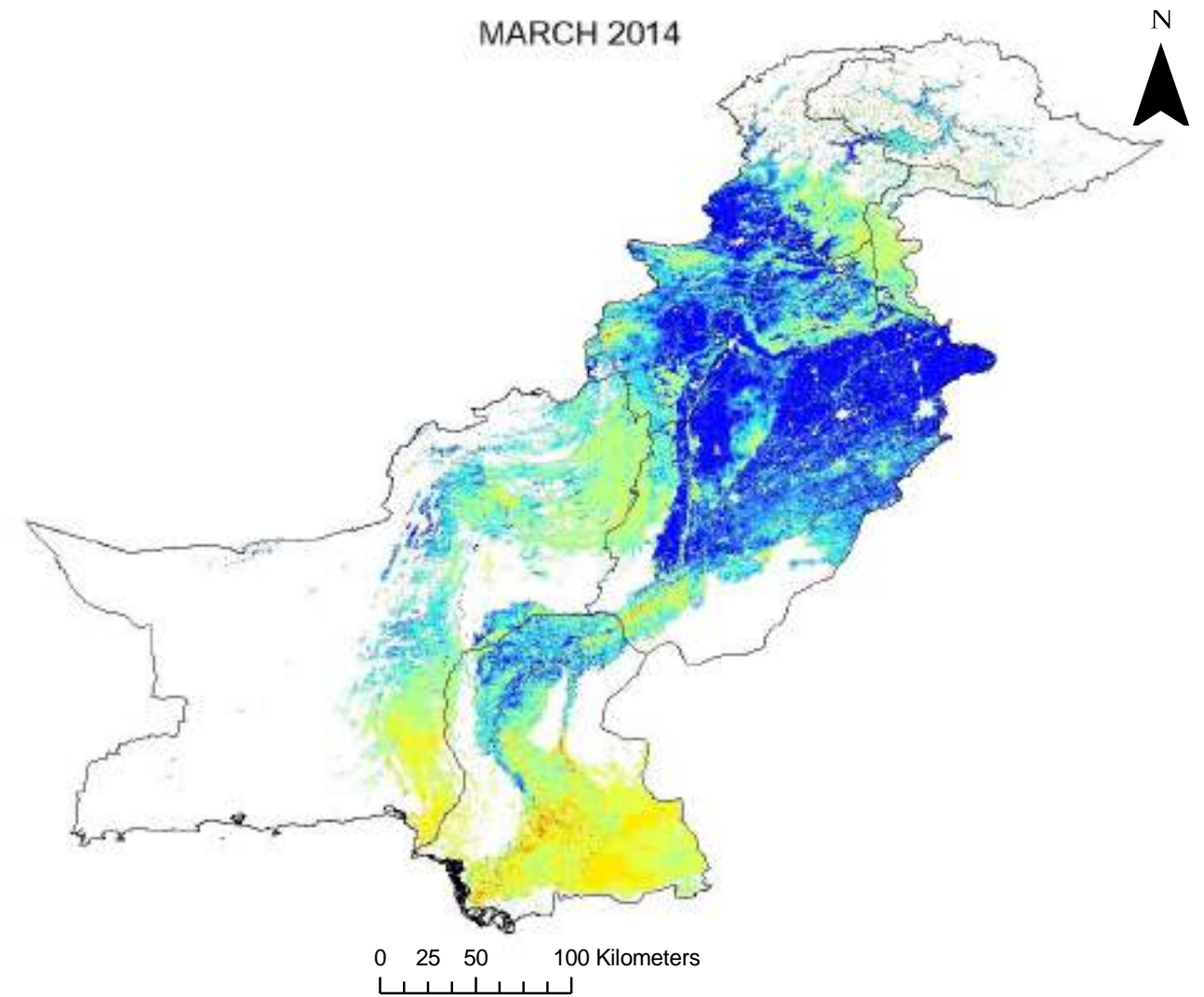
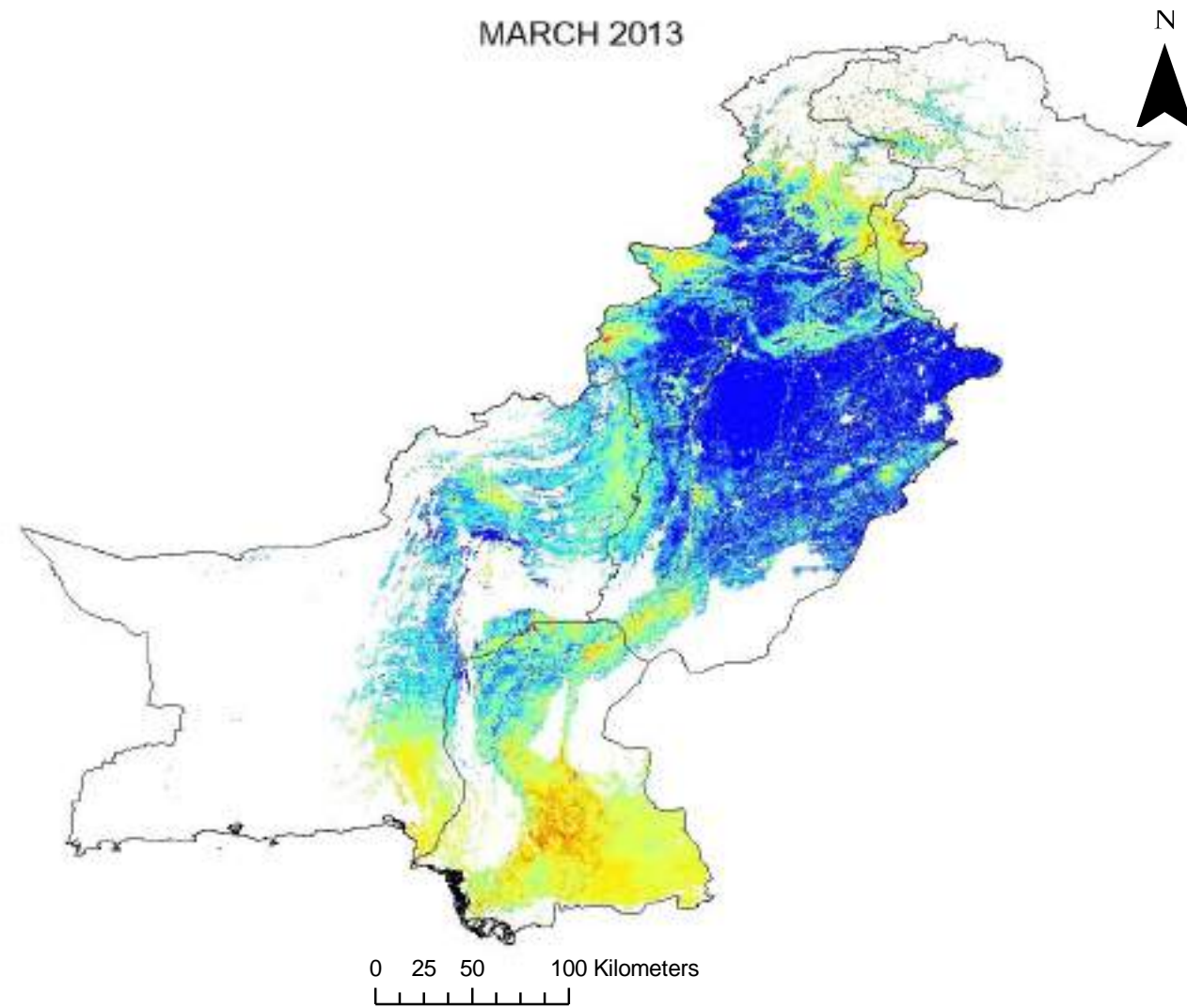
Legend

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|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
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Legend

- | | | |
|--|---|--|
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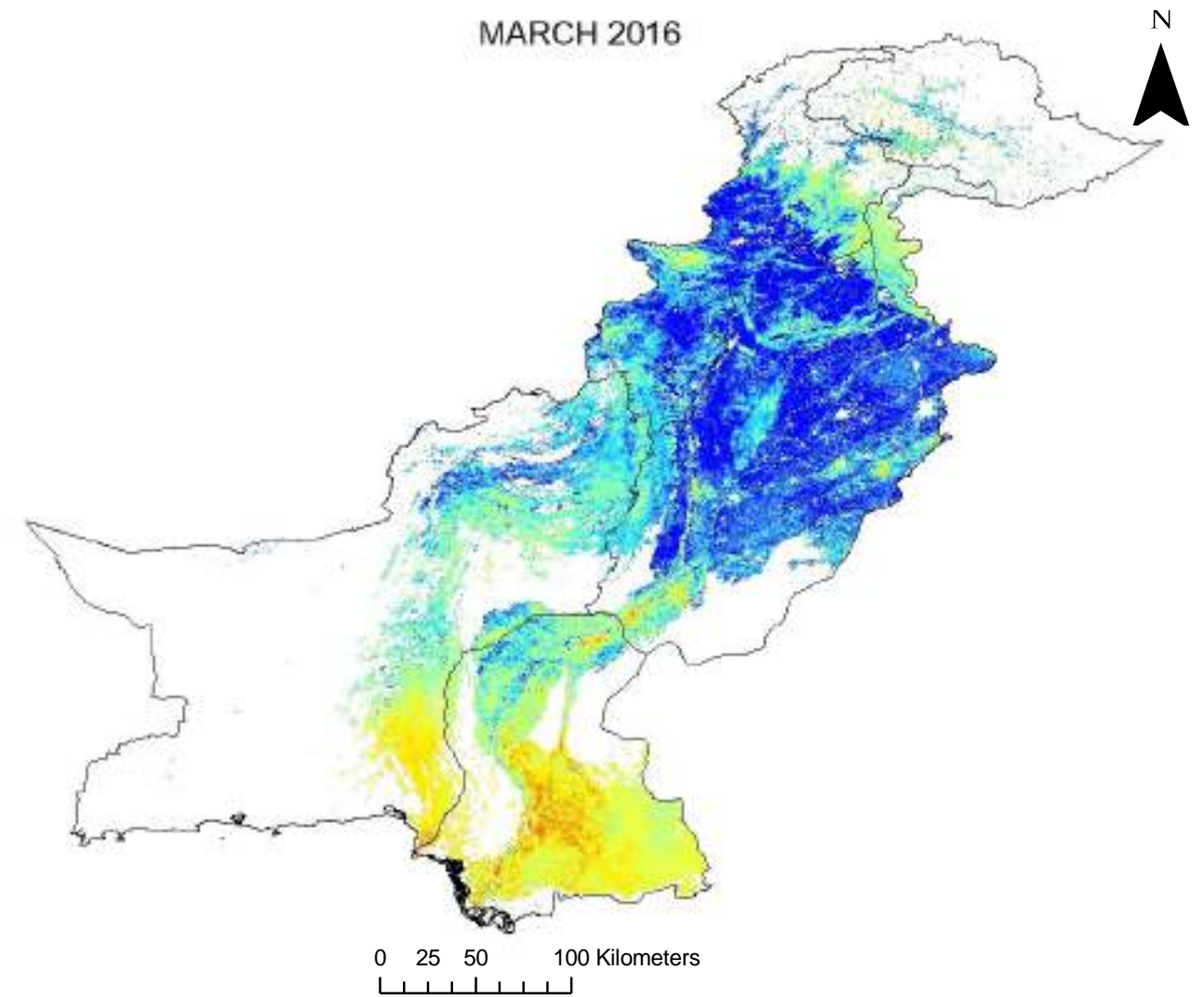
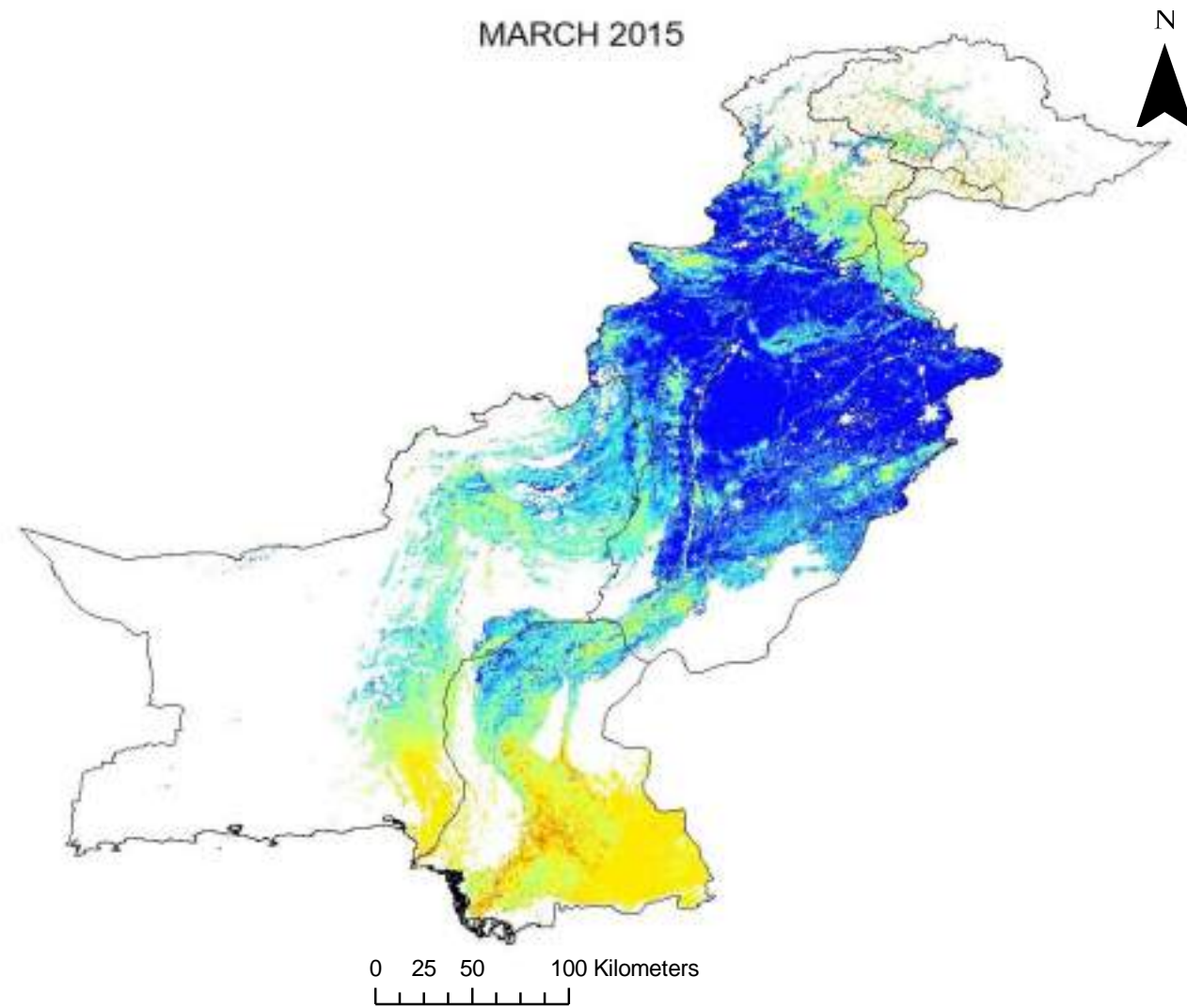


Legend

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

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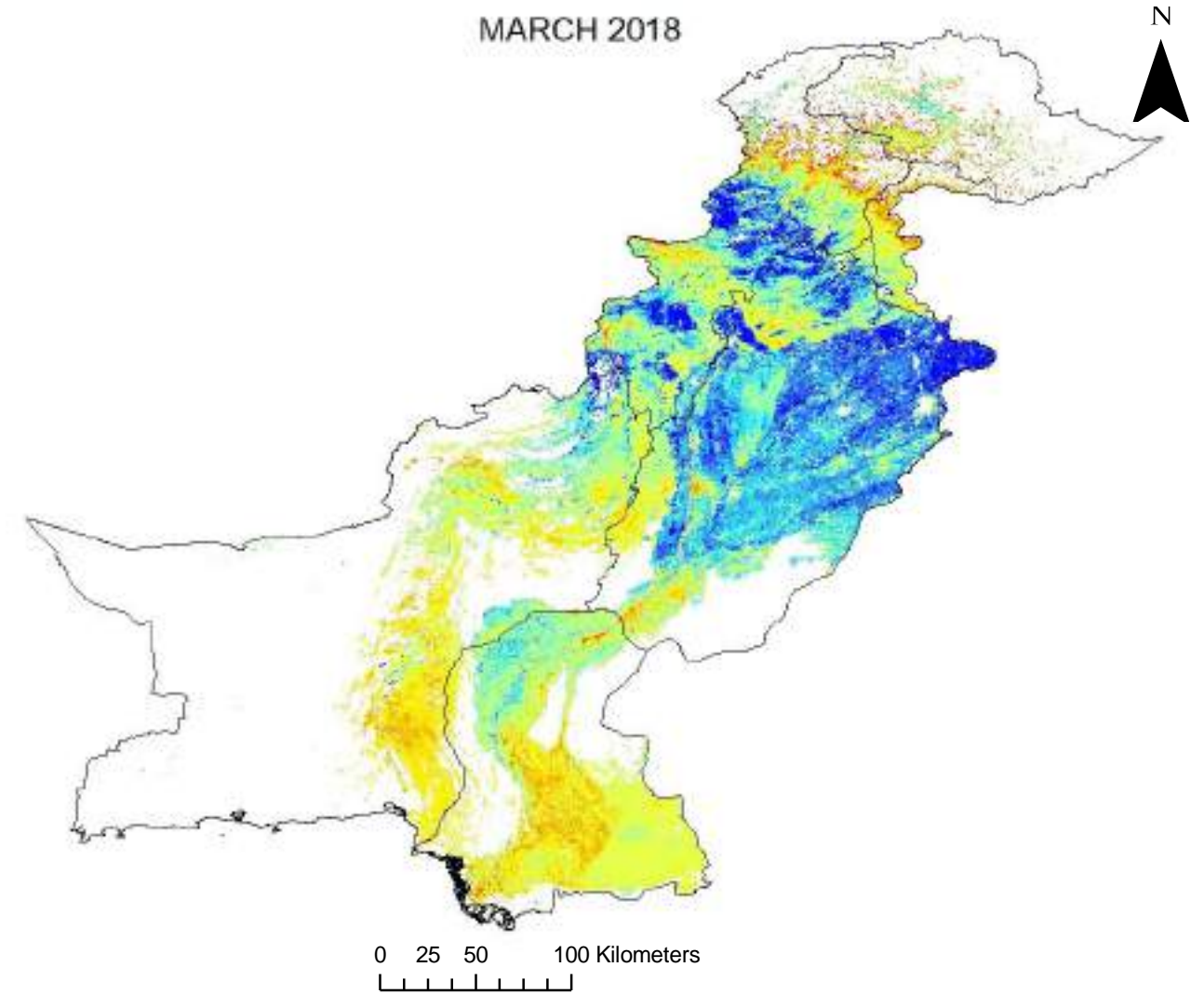
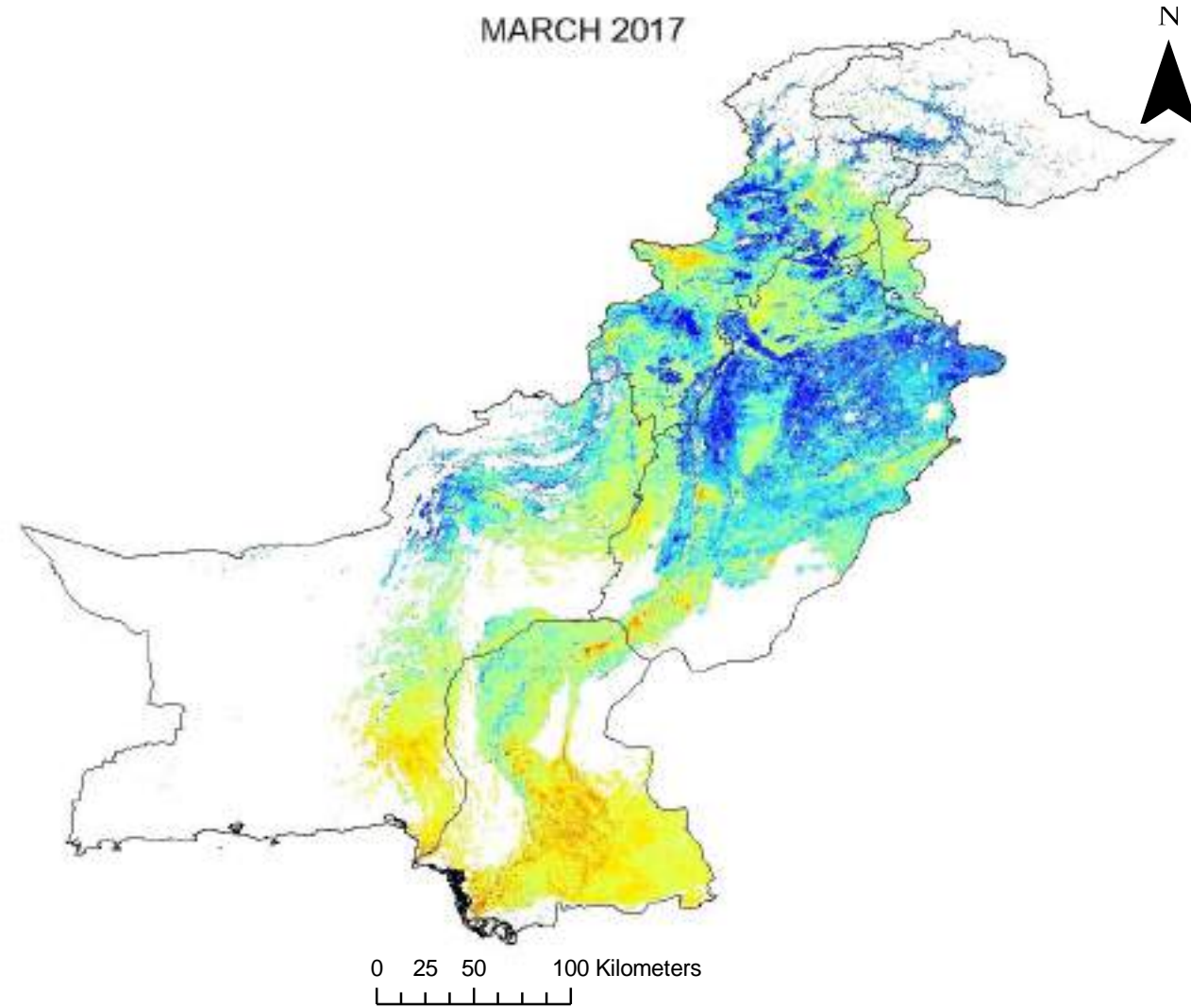


Legend

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
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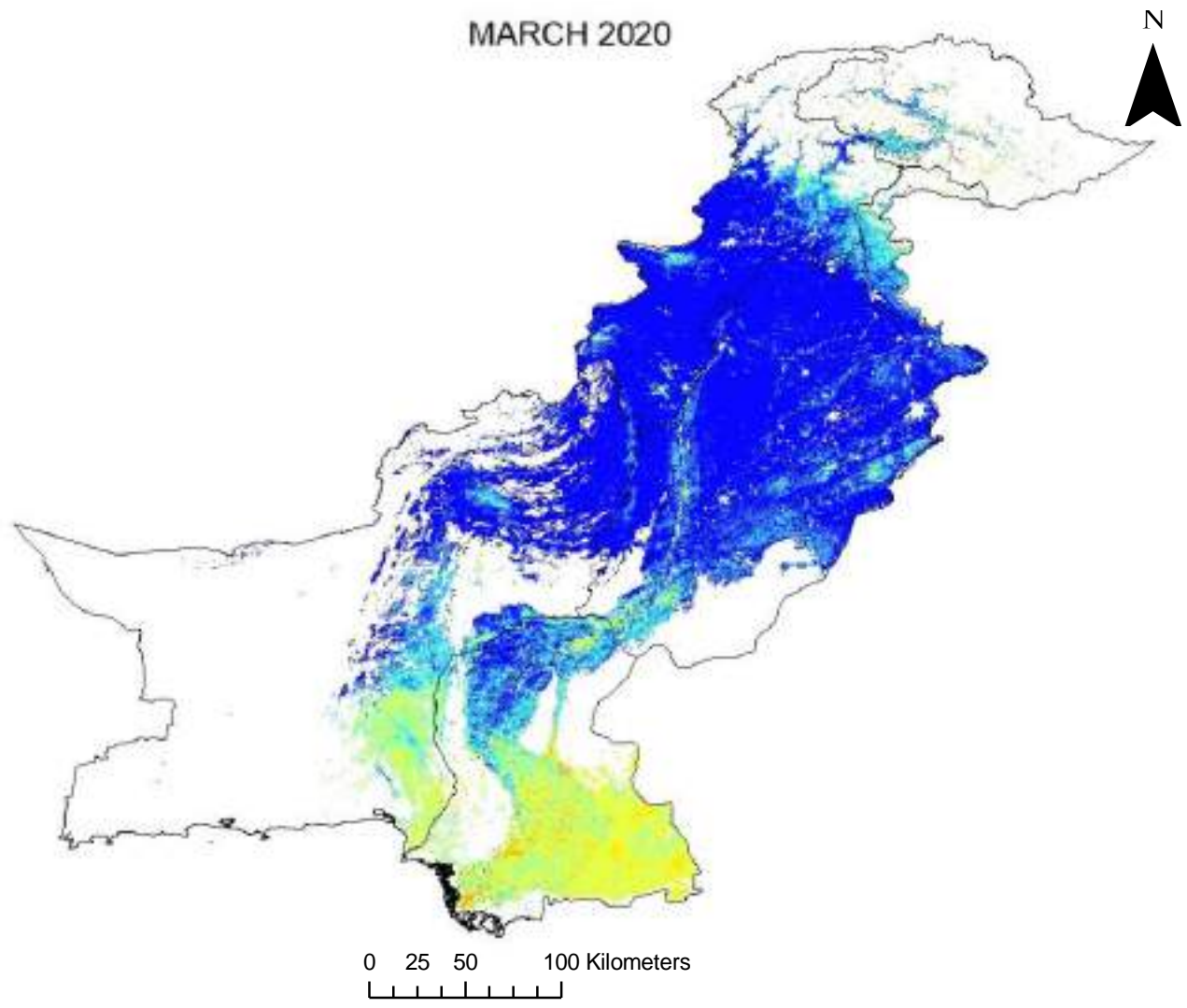
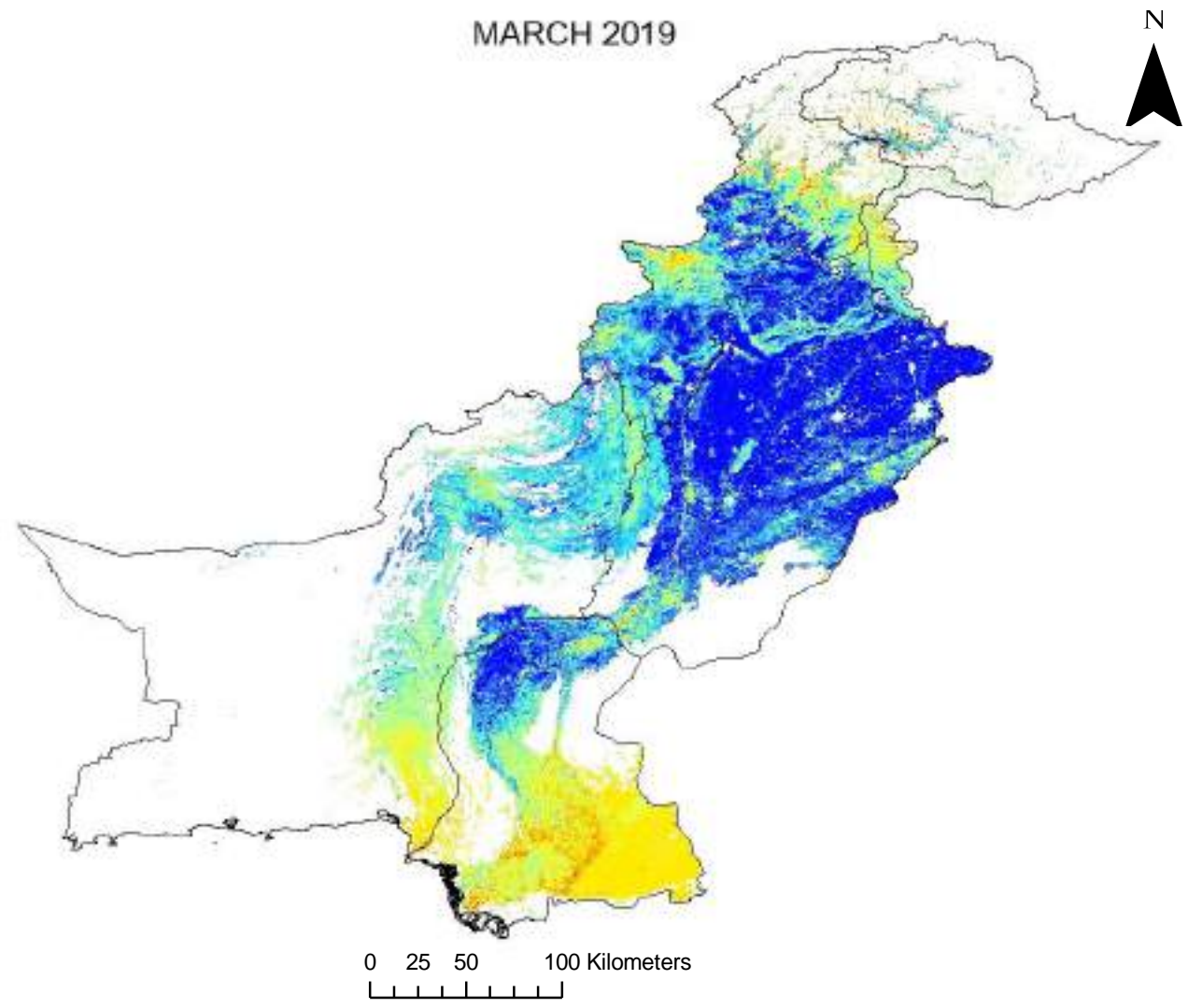


Legend

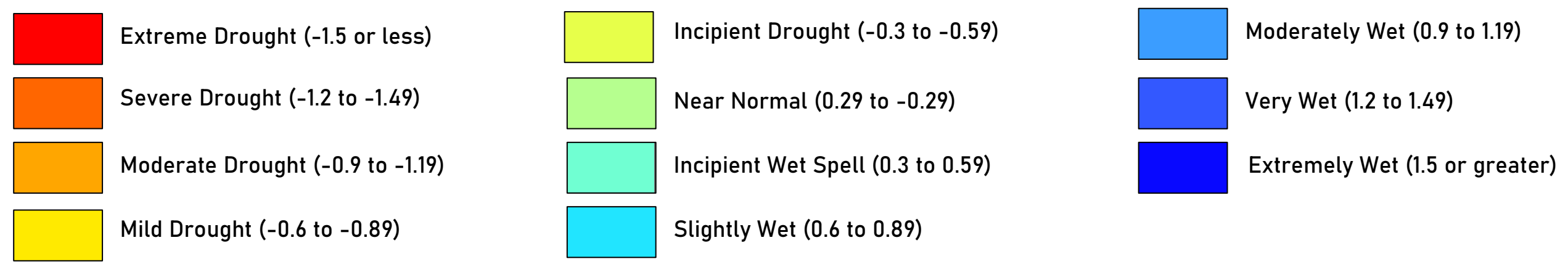
- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

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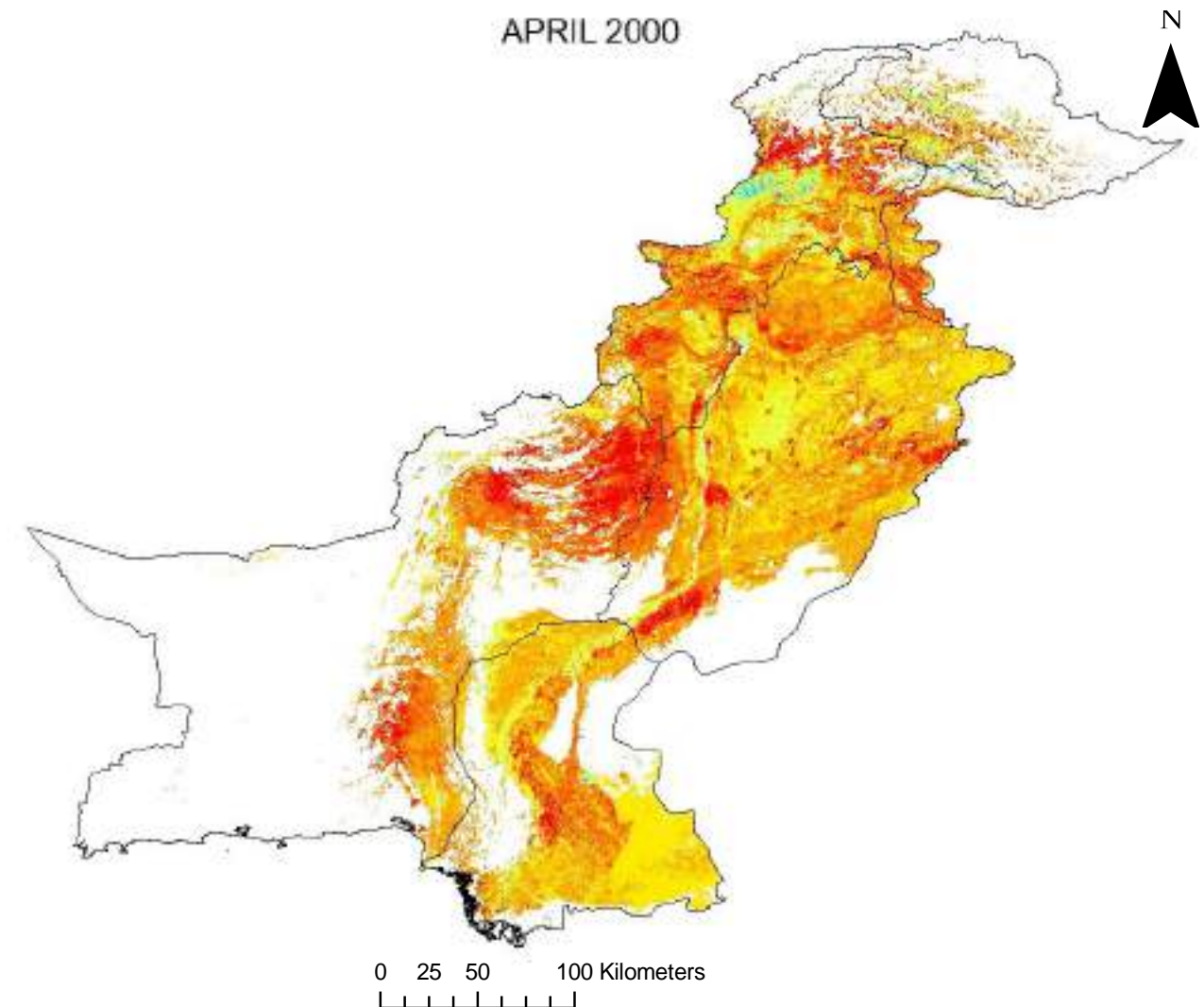
Legend



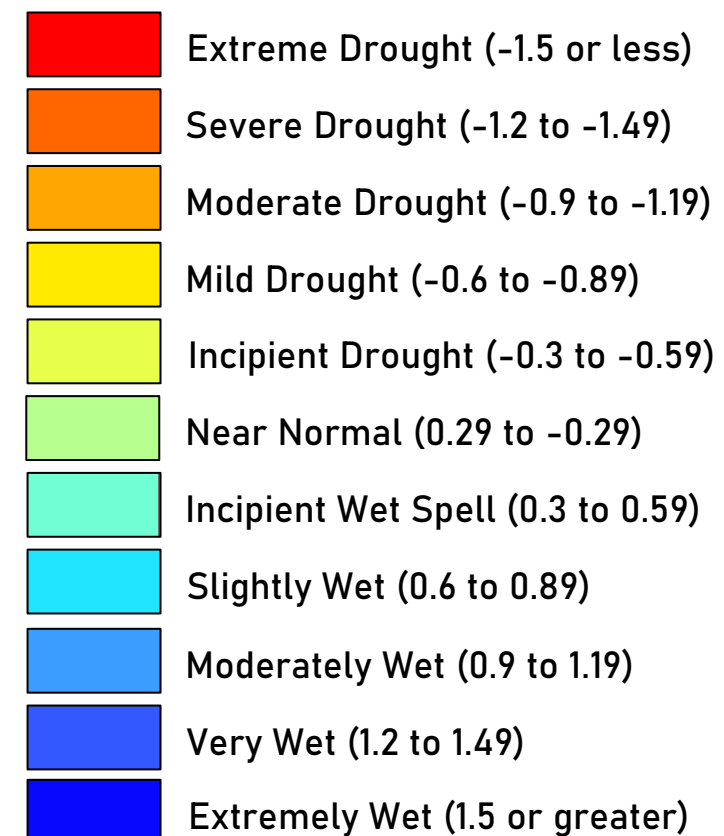
April DSI Maps

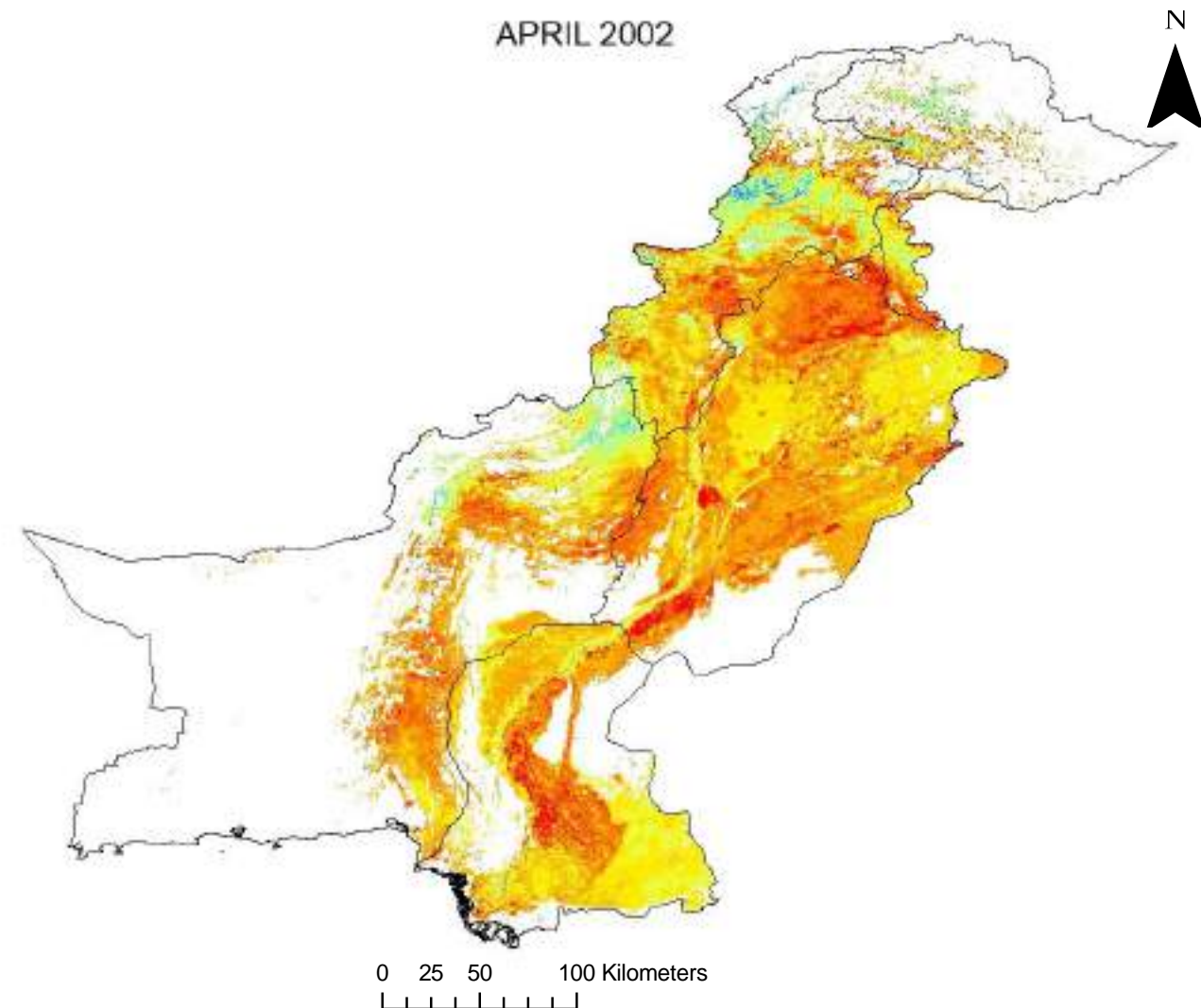
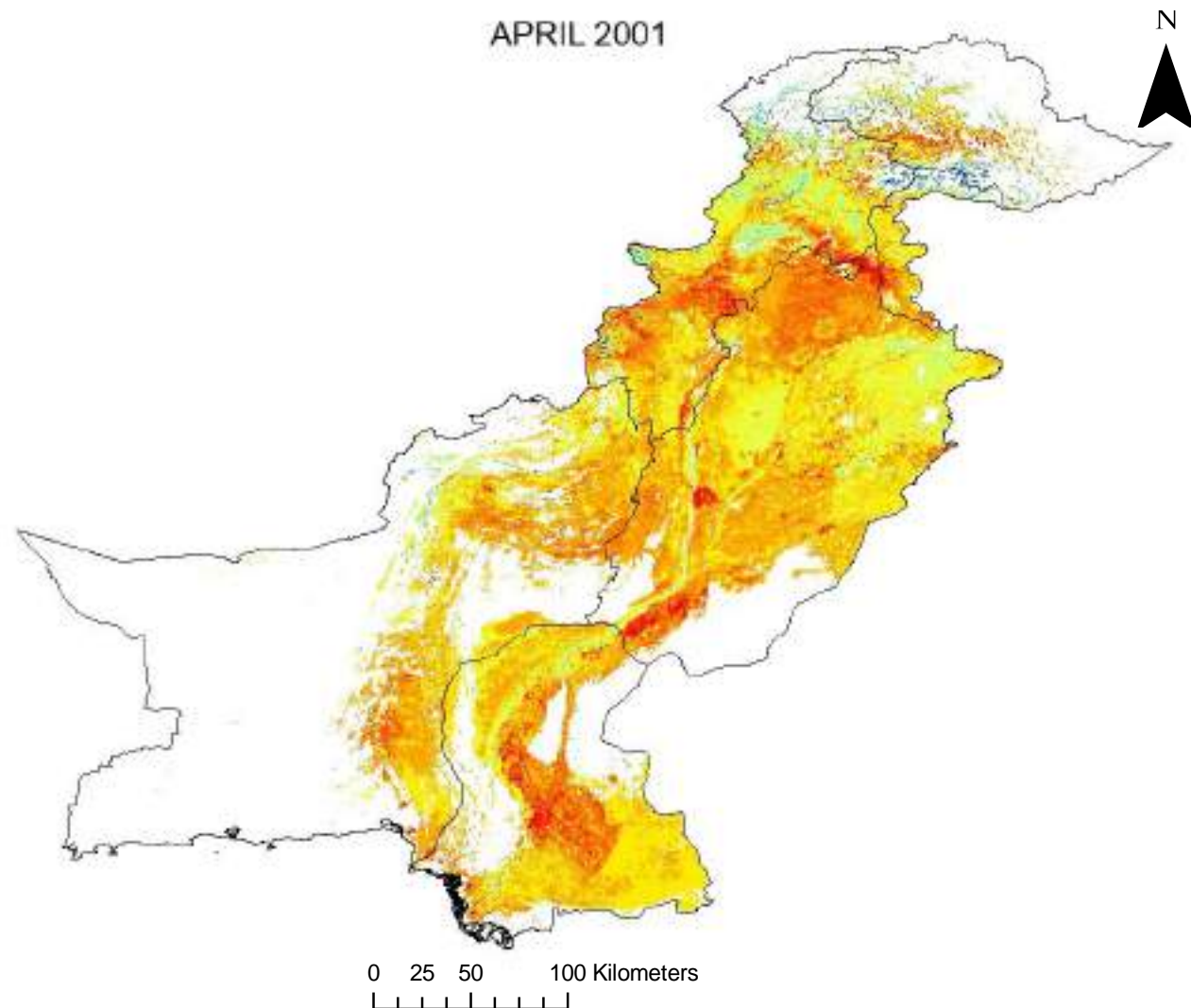
Drought conditions in April typically range from moderate drought to slightly wet condition. In most years, the pre-monsoon month has near normal drought condition.

Mean April DSI Values		
Years	Values	Drought Condition
2000	-0.95	Moderate Drought
2001	-0.65	Mild Drought
2002	-0.68	Mild Drought
2003	-0.19	Near Normal
2004	-0.63	Mild Drought
2005	-0.18	Near Normal
2006	-0.56	Incipient Drought
2007	-0.30	Incipient Drought
2008	-0.41	Incipient Drought
2009	-0.18	Near Normal
2010	-0.34	Incipient Drought
2011	-0.14	Near Normal
2012	-0.12	Near Normal
2013	0.27	Near Normal
2014	0.10	Near Normal
2015	-0.06	Near Normal
2016	-0.12	Near Normal
2017	-0.35	Incipient Drought
2018	-0.20	Near Normal
2019	0.77	Slightly Wet
2020	0.80	Slightly Wet



Legend



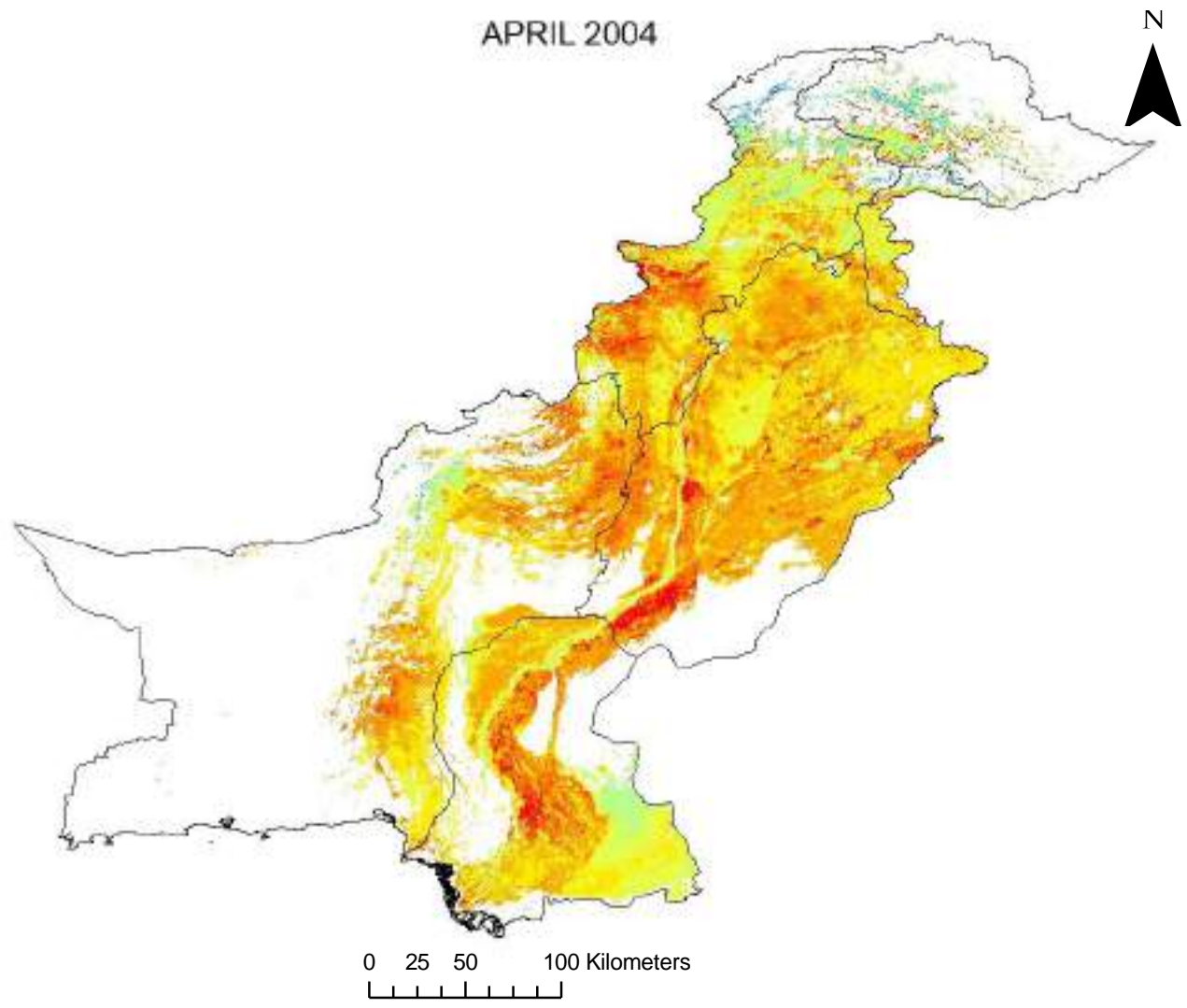
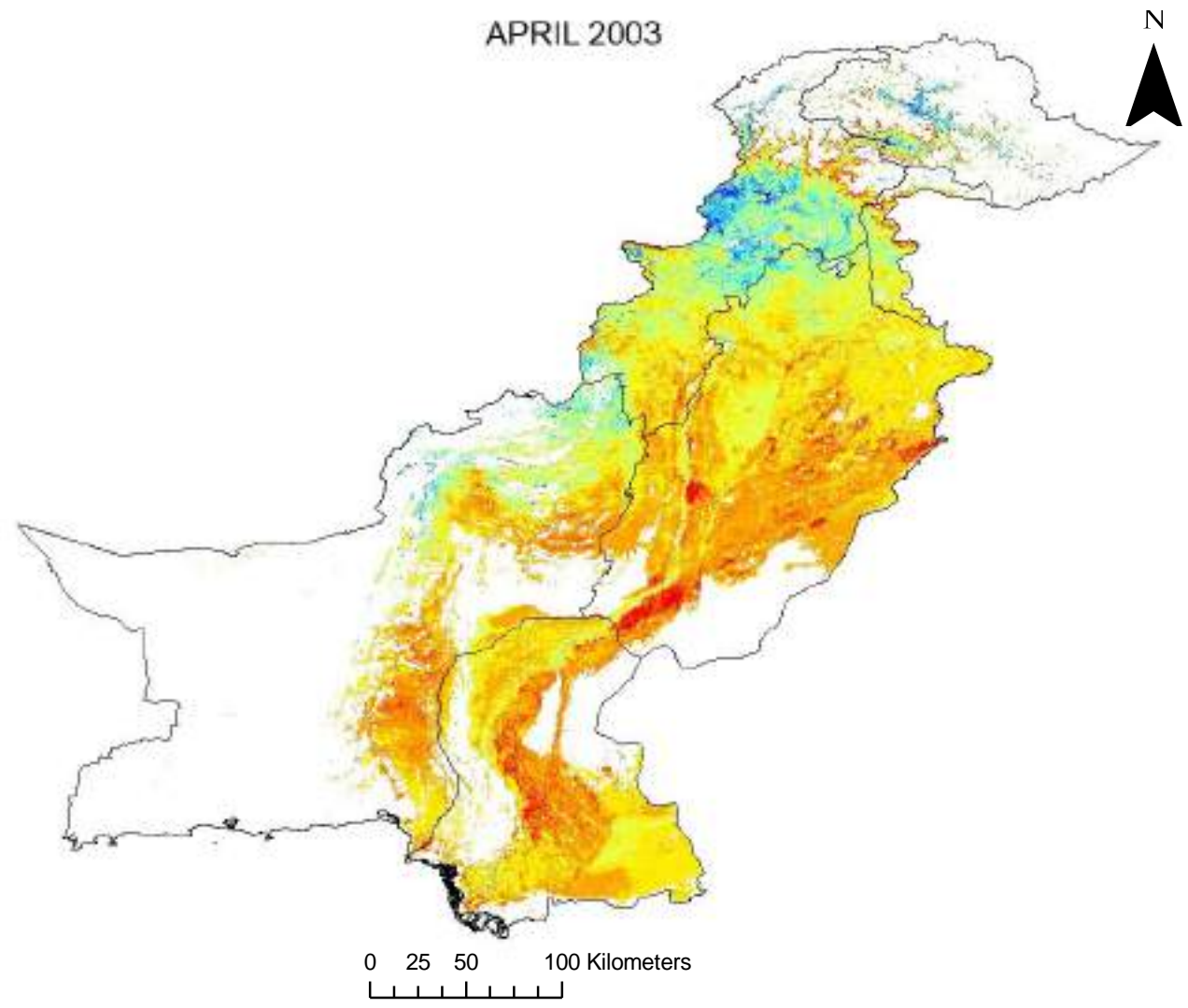


Legend












- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

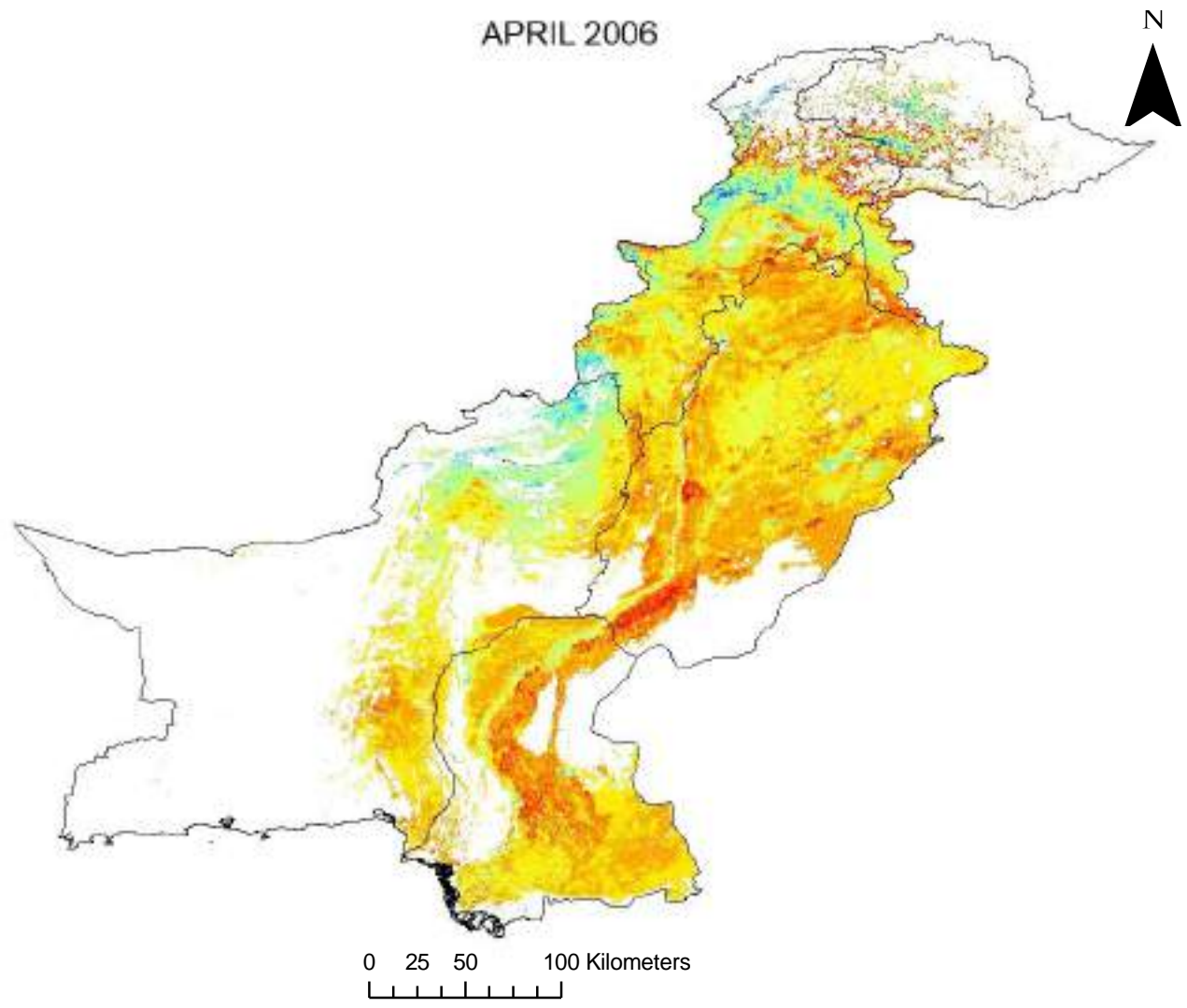
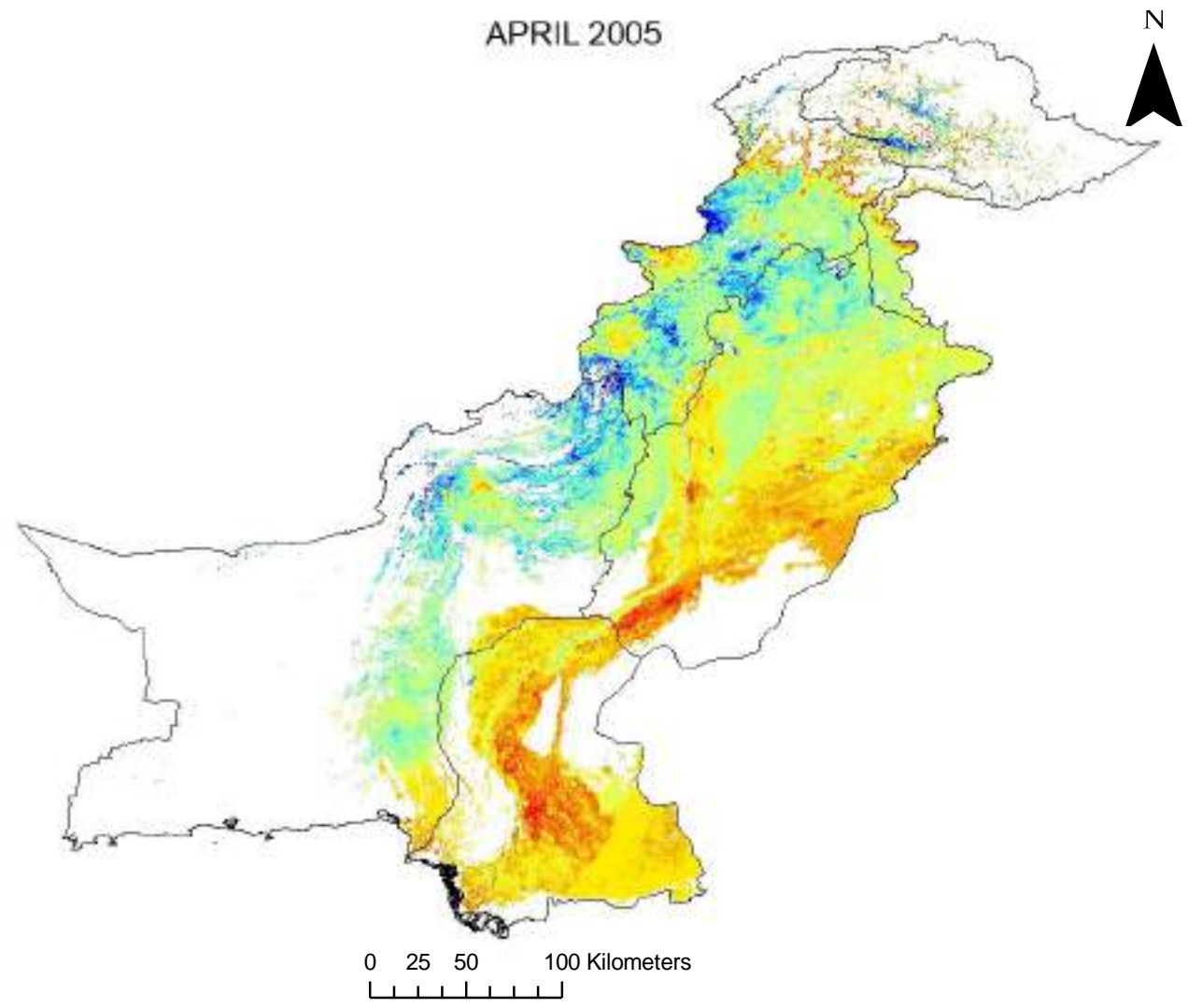
- Incipient Drought (-0.3 to -0.59)
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- Slightly Wet (0.6 to 0.89)

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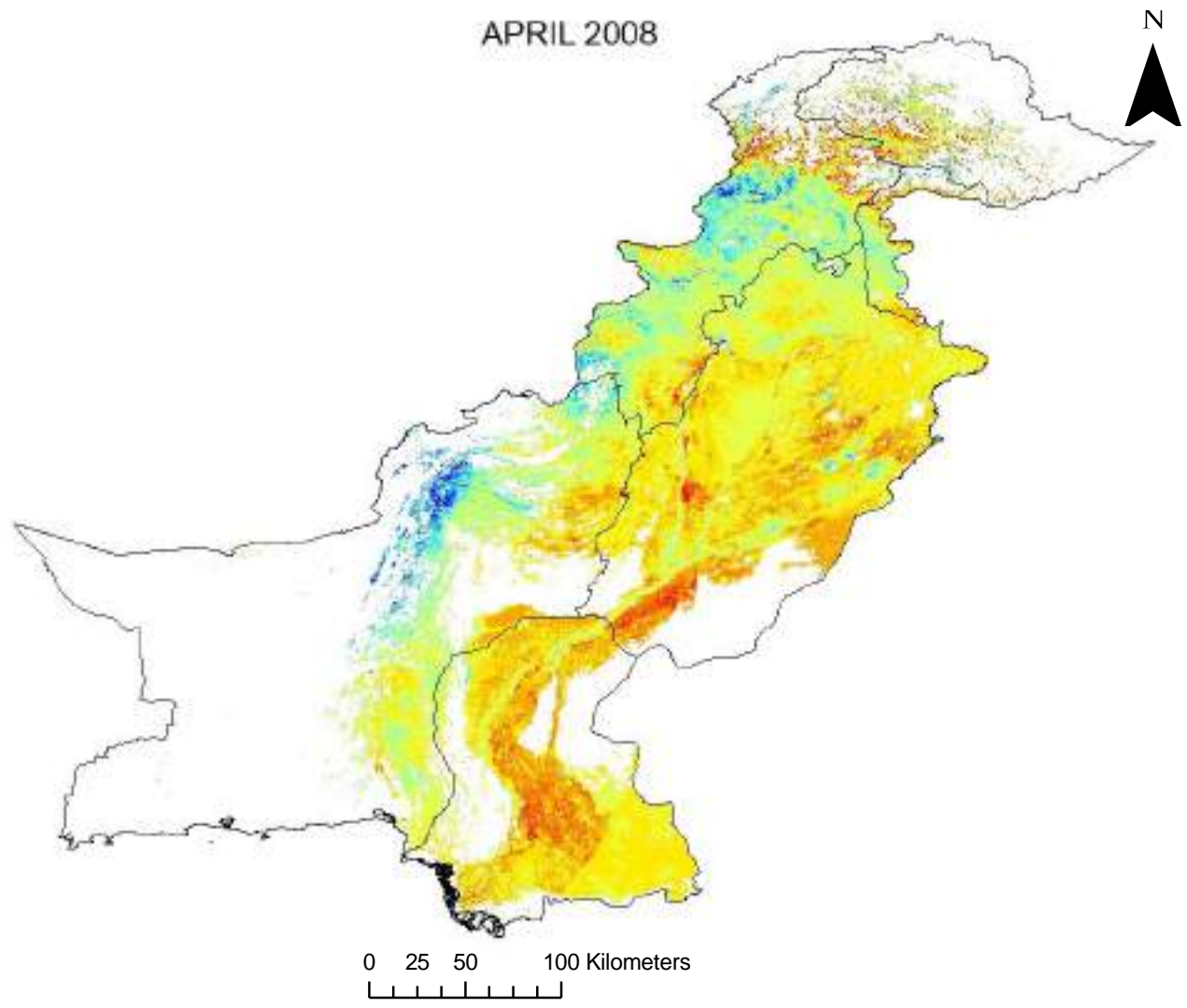
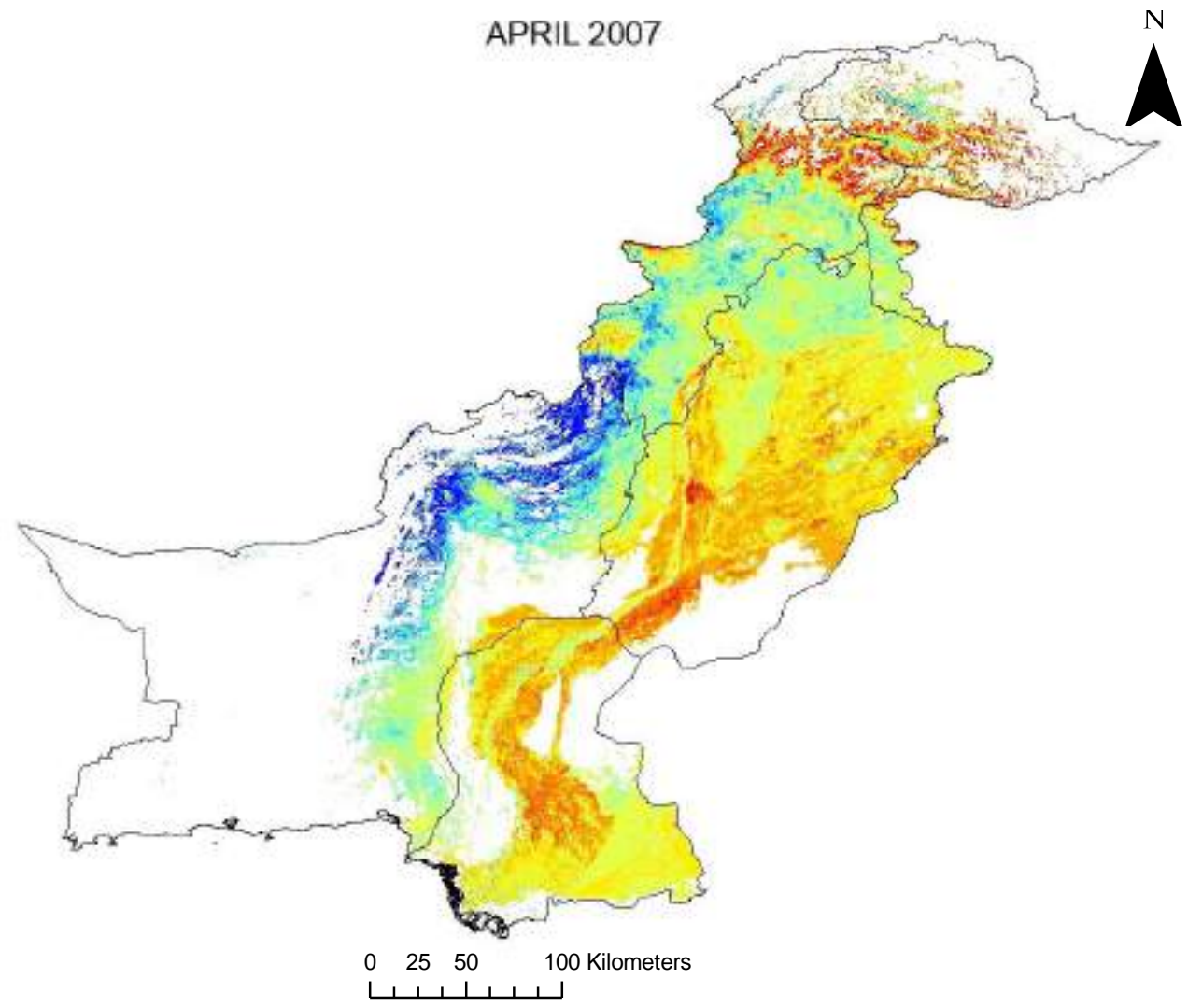
Legend

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|--|---|--|
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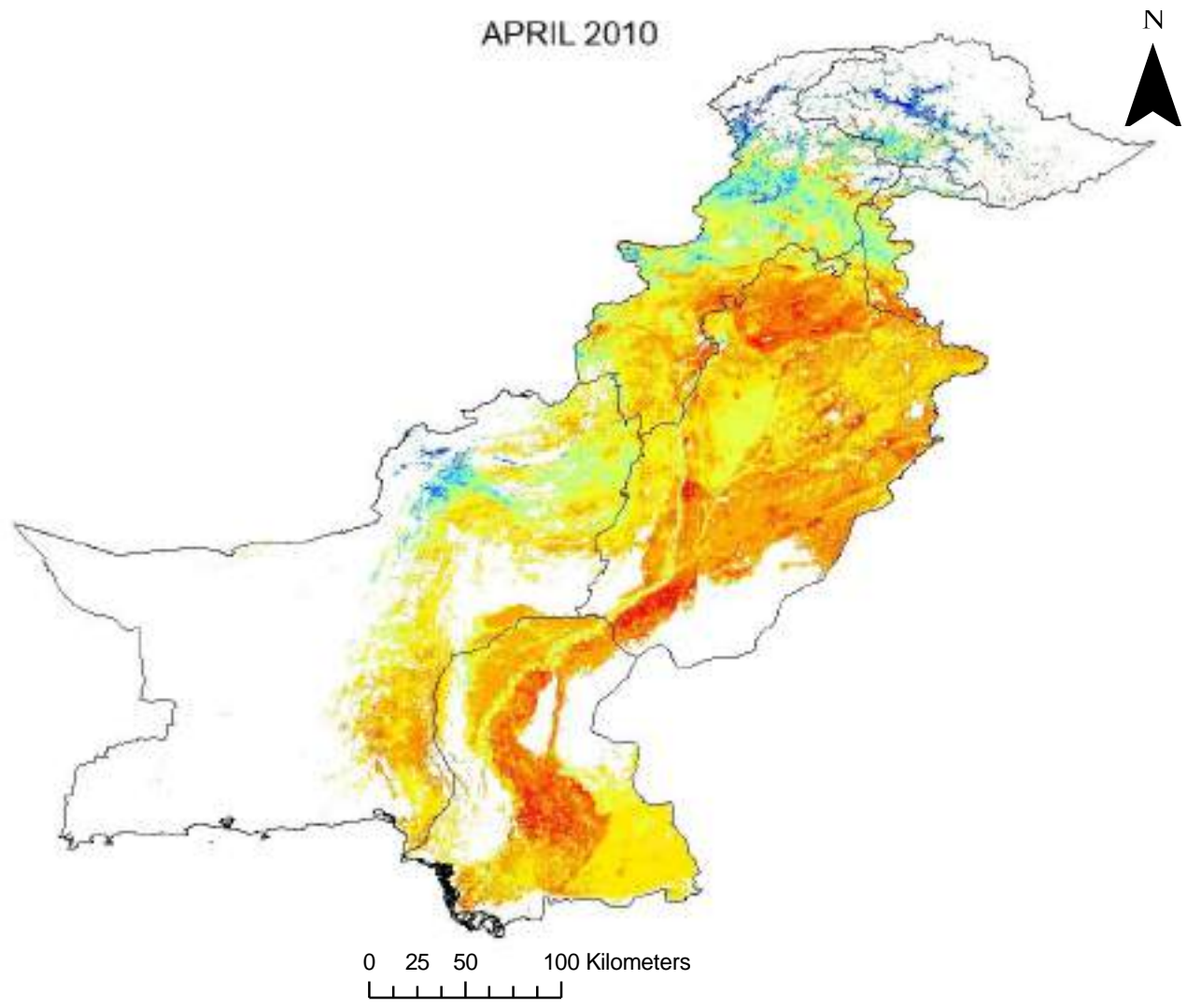
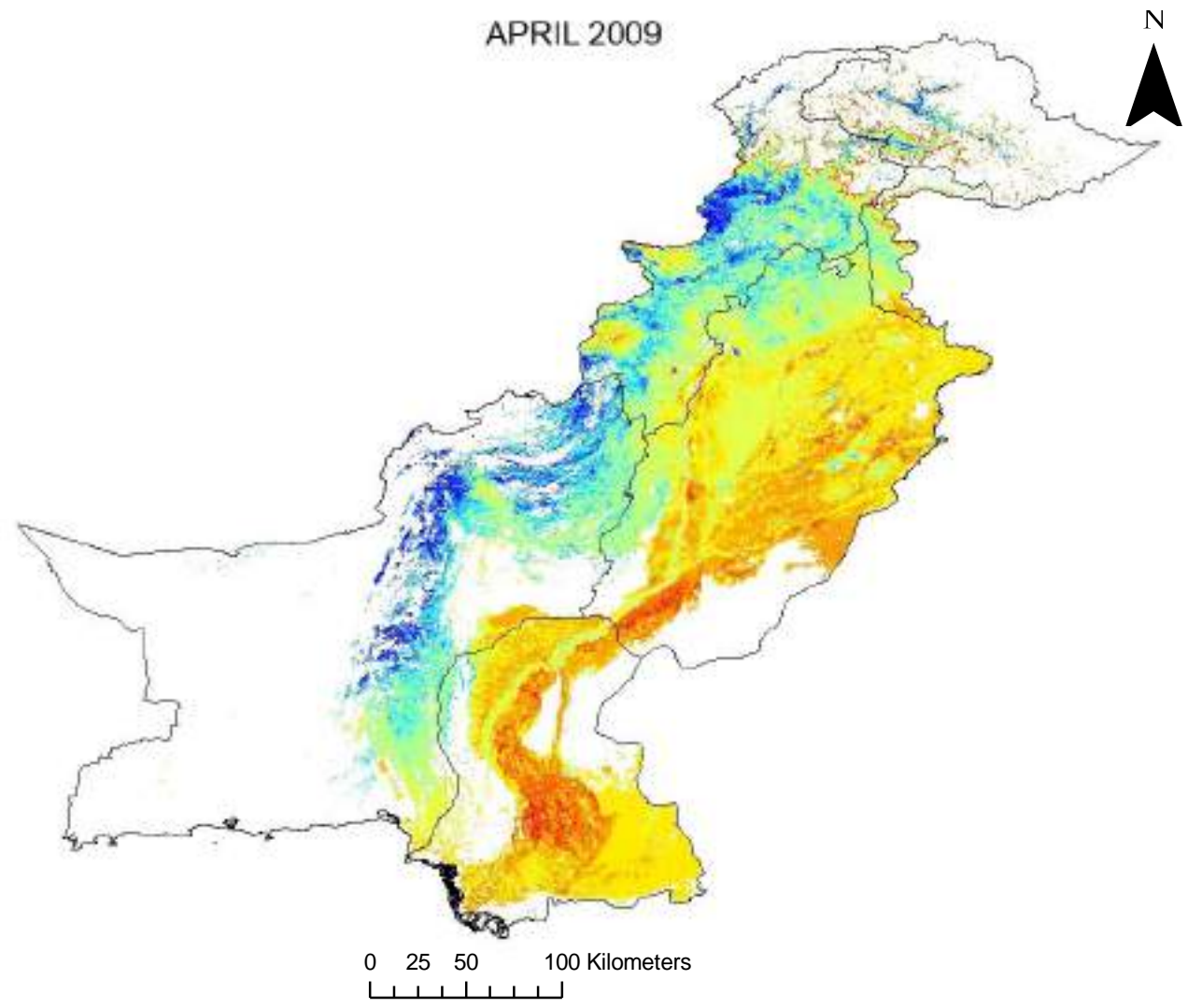
Legend

	Extreme Drought (-1.5 or less)		Incipient Drought (-0.3 to -0.59)		Moderately Wet (0.9 to 1.19)
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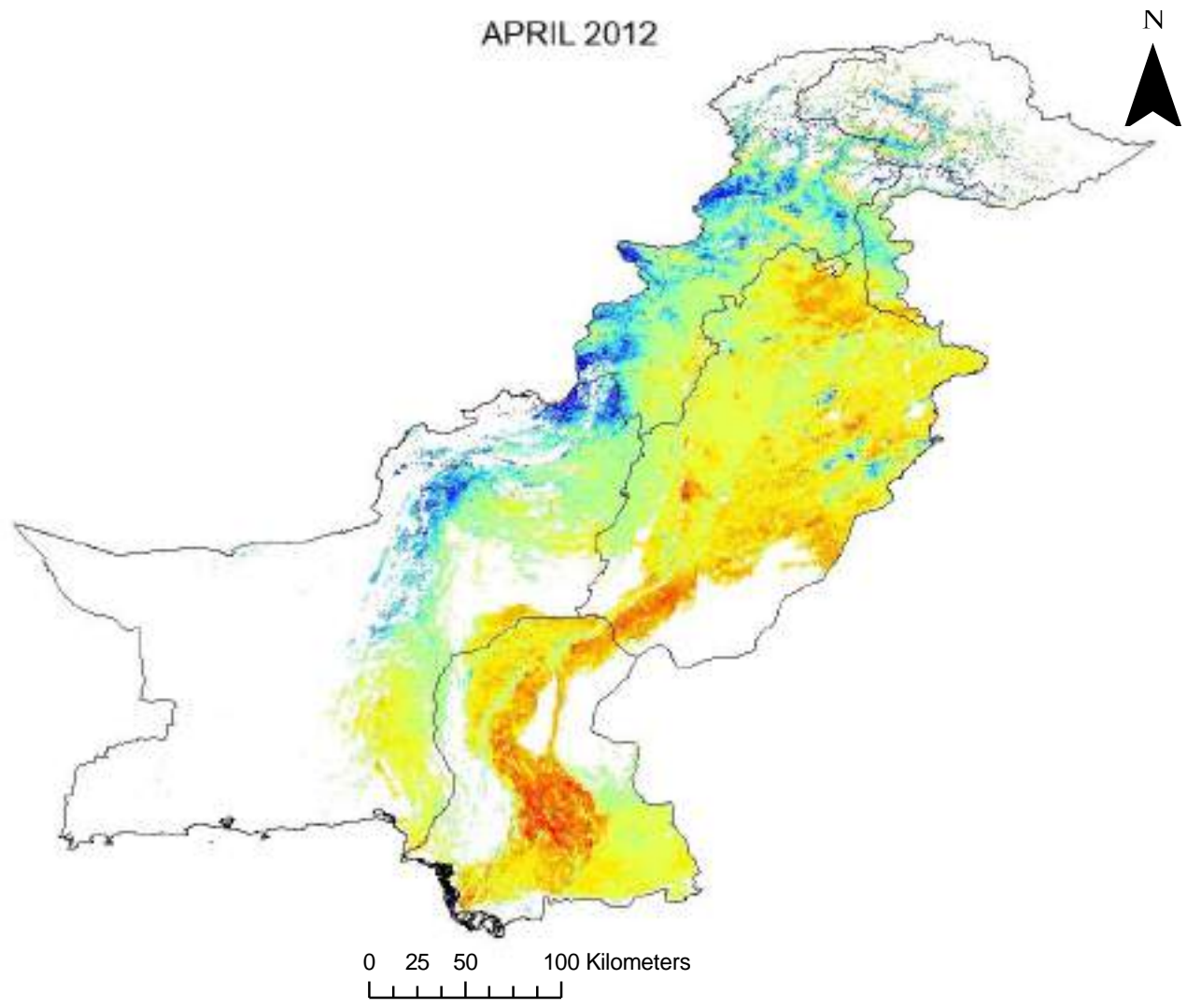
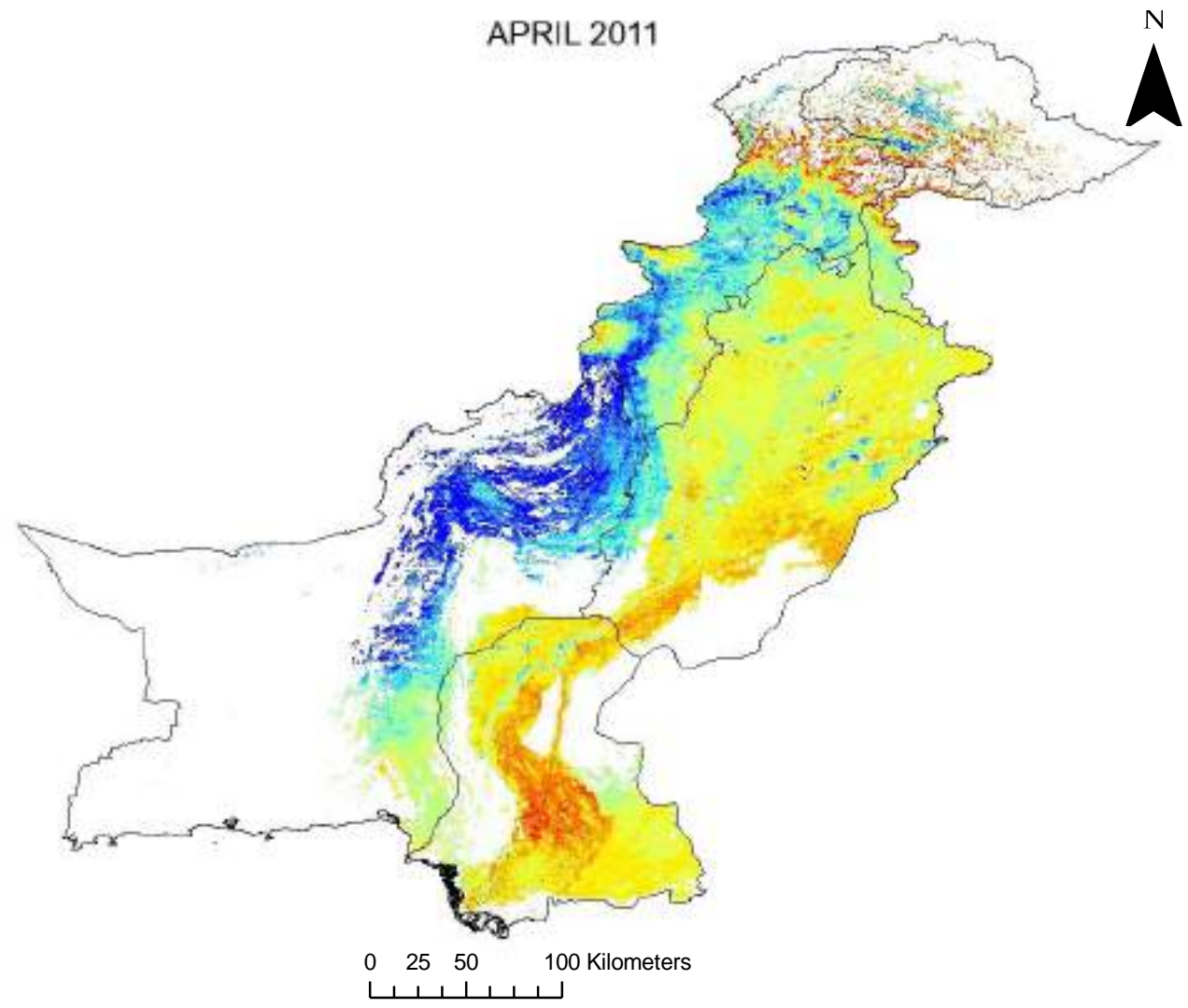
Legend

- | | | | | | |
|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
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|  | Mild Drought (-0.6 to -0.89) |  | Slightly Wet (0.6 to 0.89) | | |














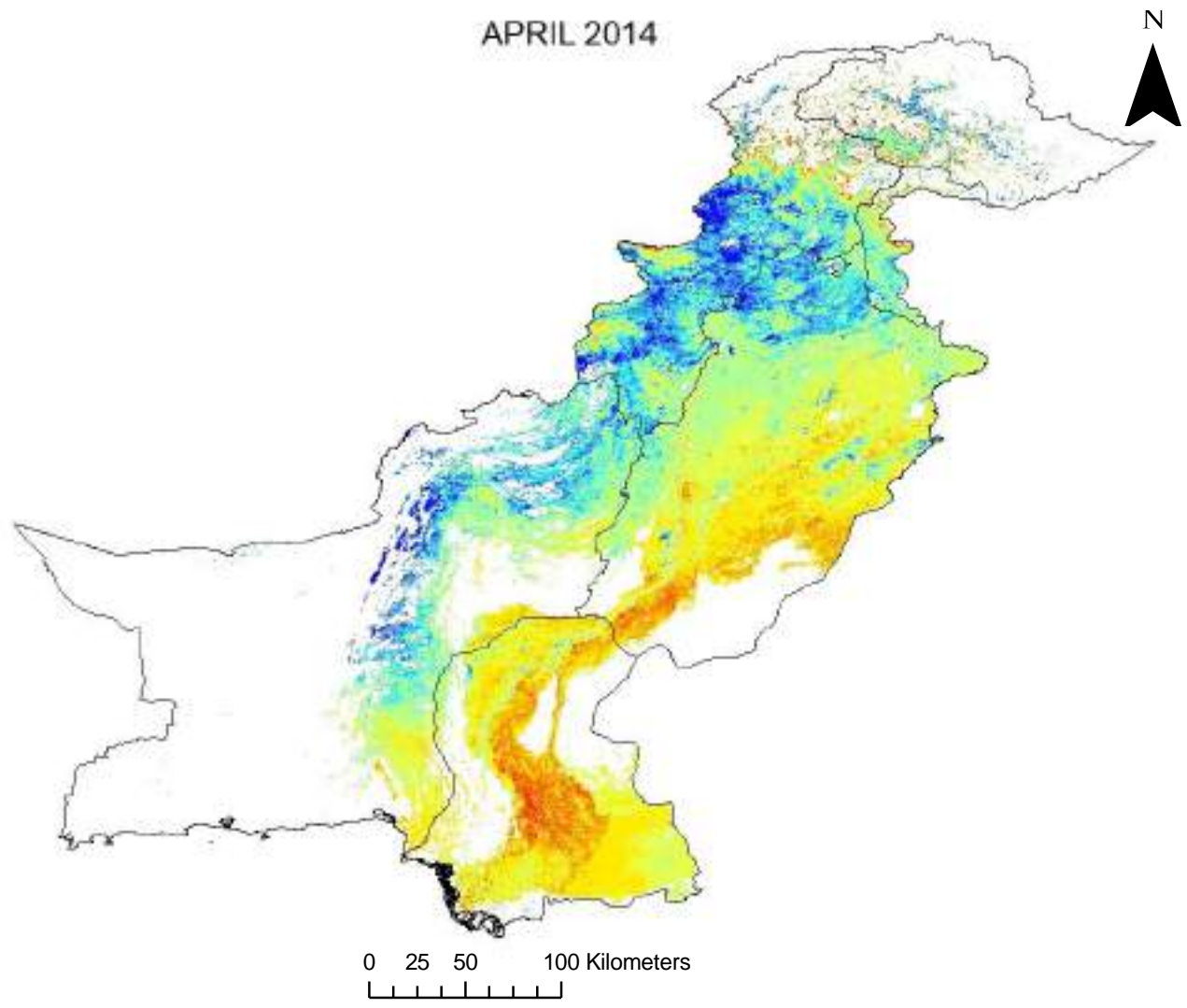
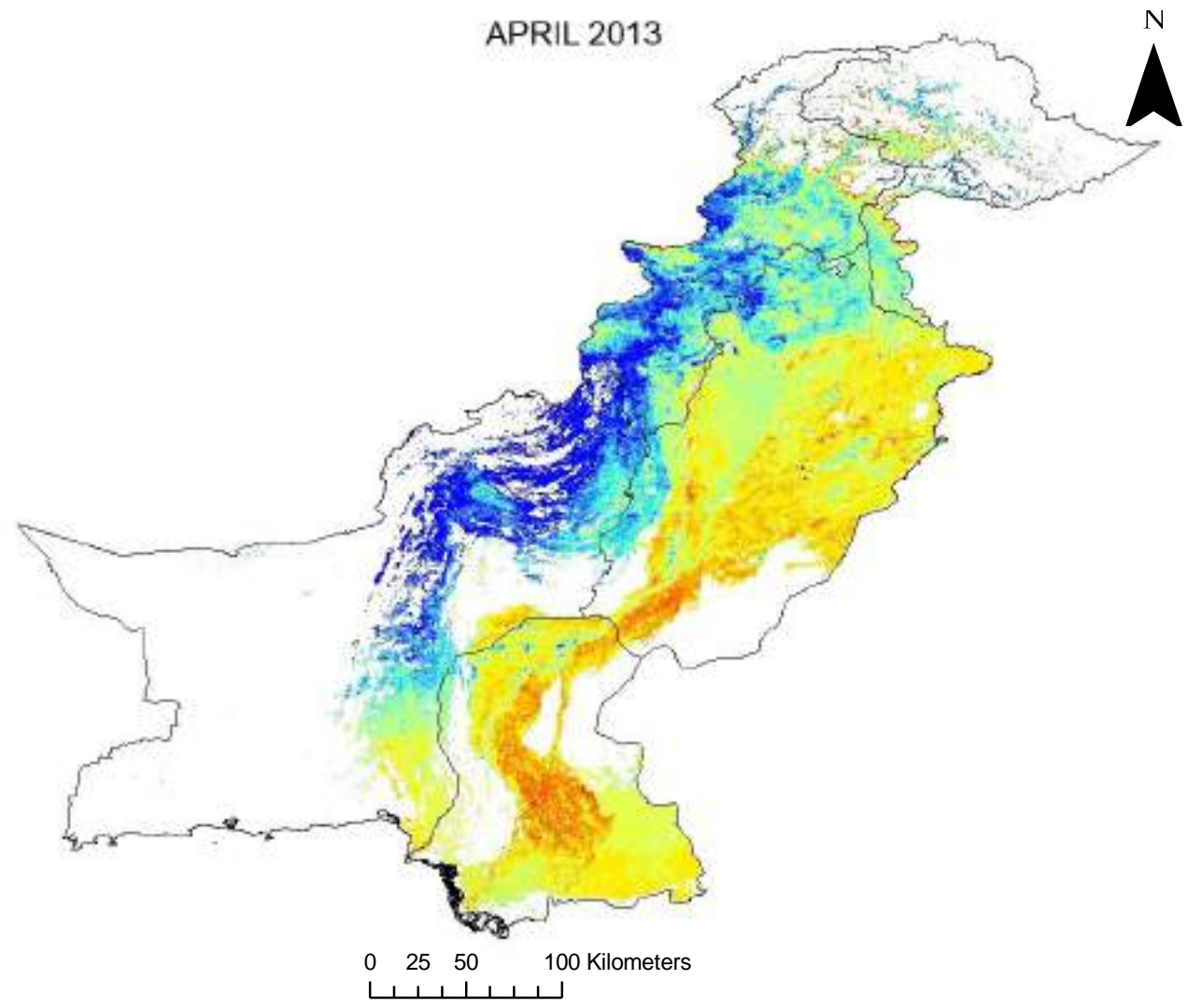
Legend

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|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
|  | Severe Drought (-1.2 to -1.49) |  | Near Normal (0.29 to -0.29) |  | Very Wet (1.2 to 1.49) |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89) |  | Slightly Wet (0.6 to 0.89) | | |














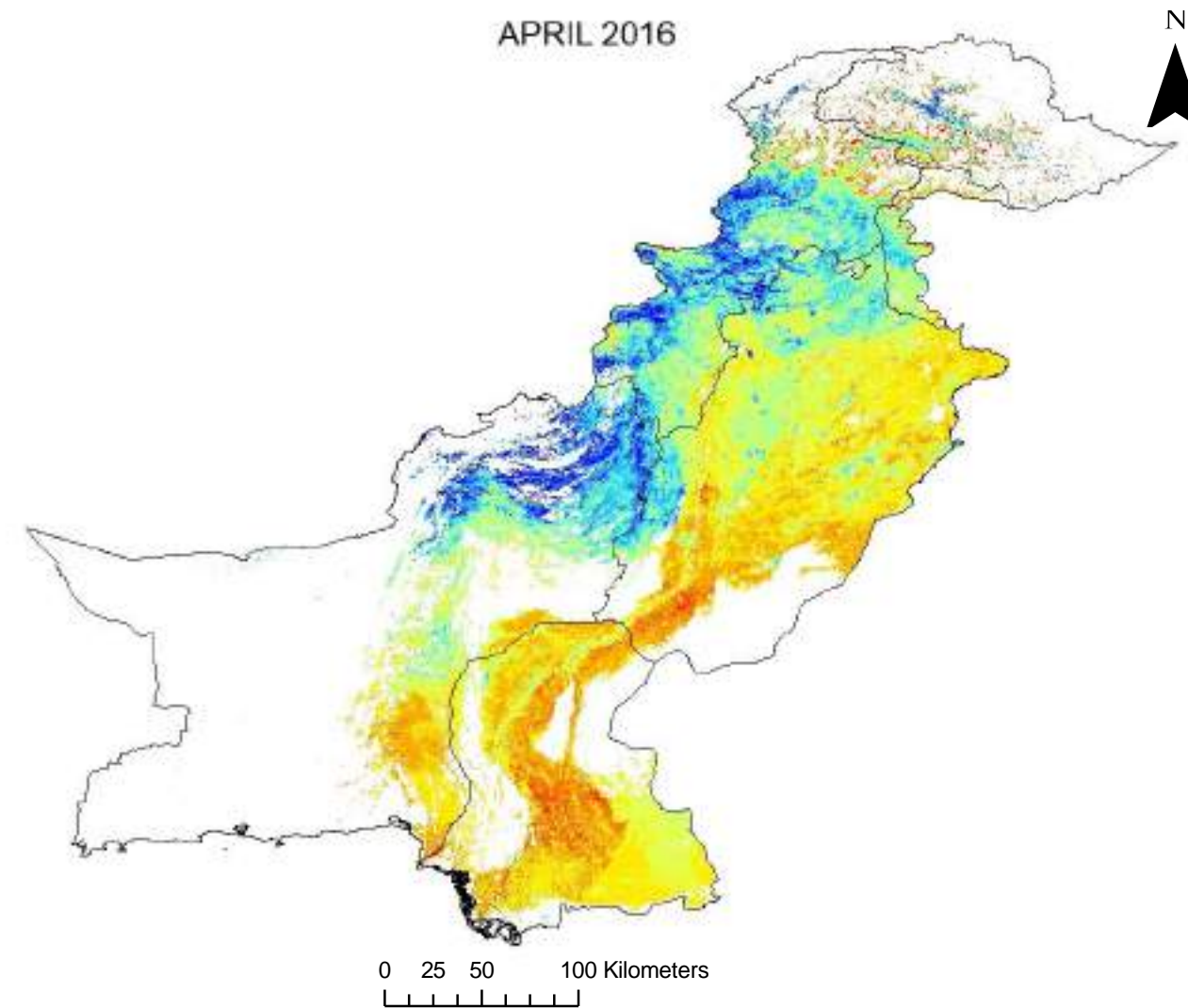
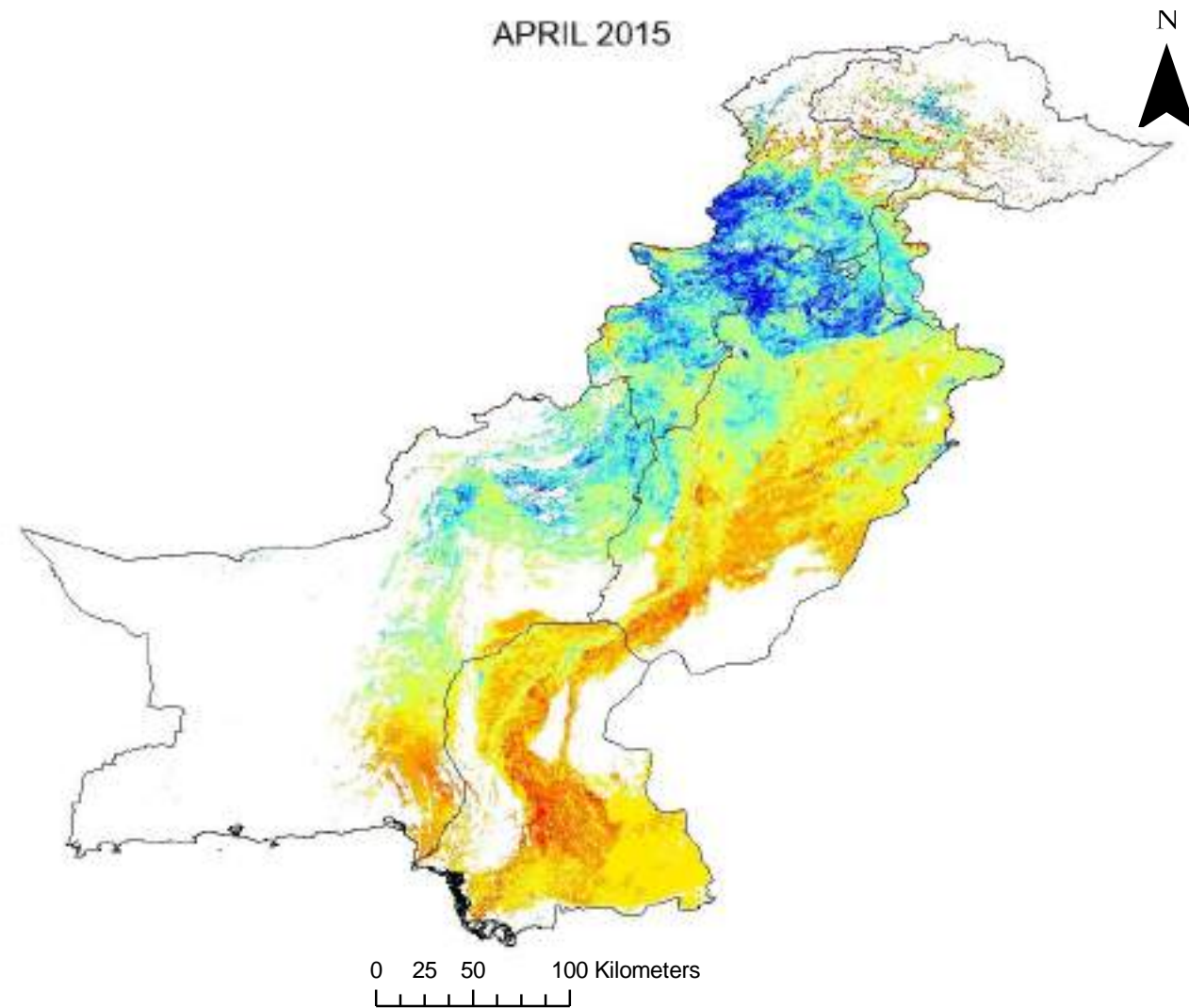
Legend

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|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
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Legend

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|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
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|  | Mild Drought (-0.6 to -0.89) |  | Slightly Wet (0.6 to 0.89) | | |

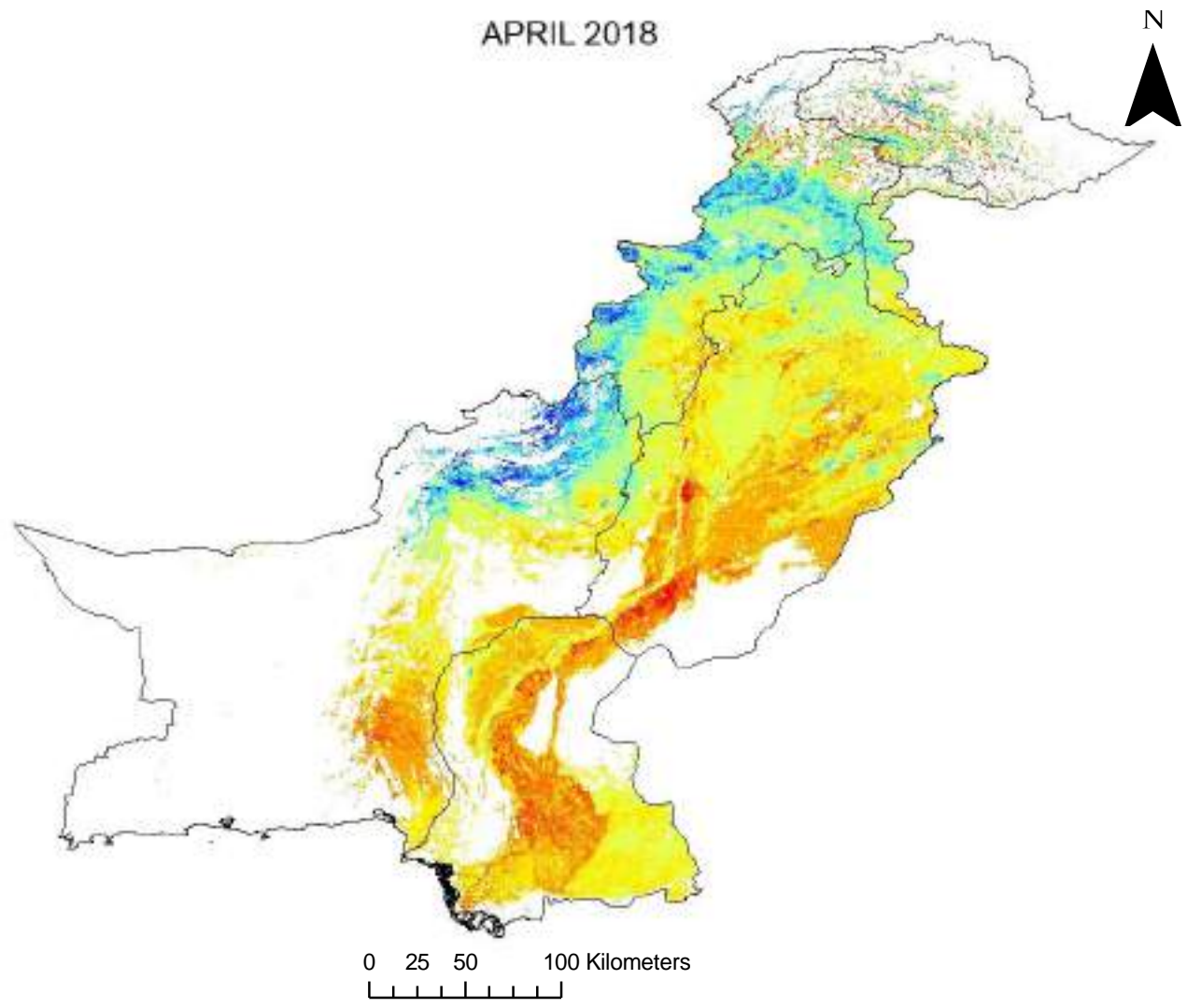
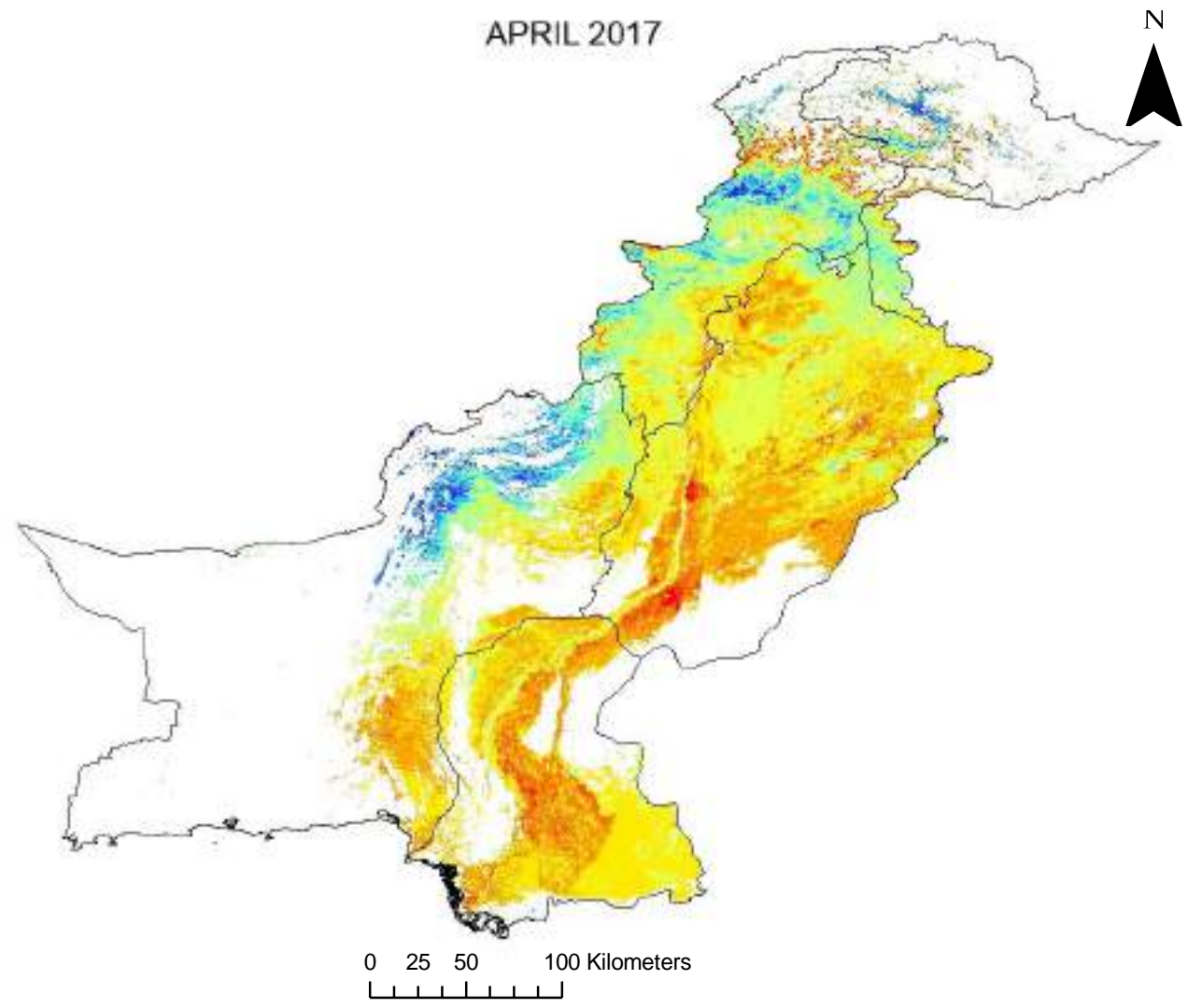


Legend












- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

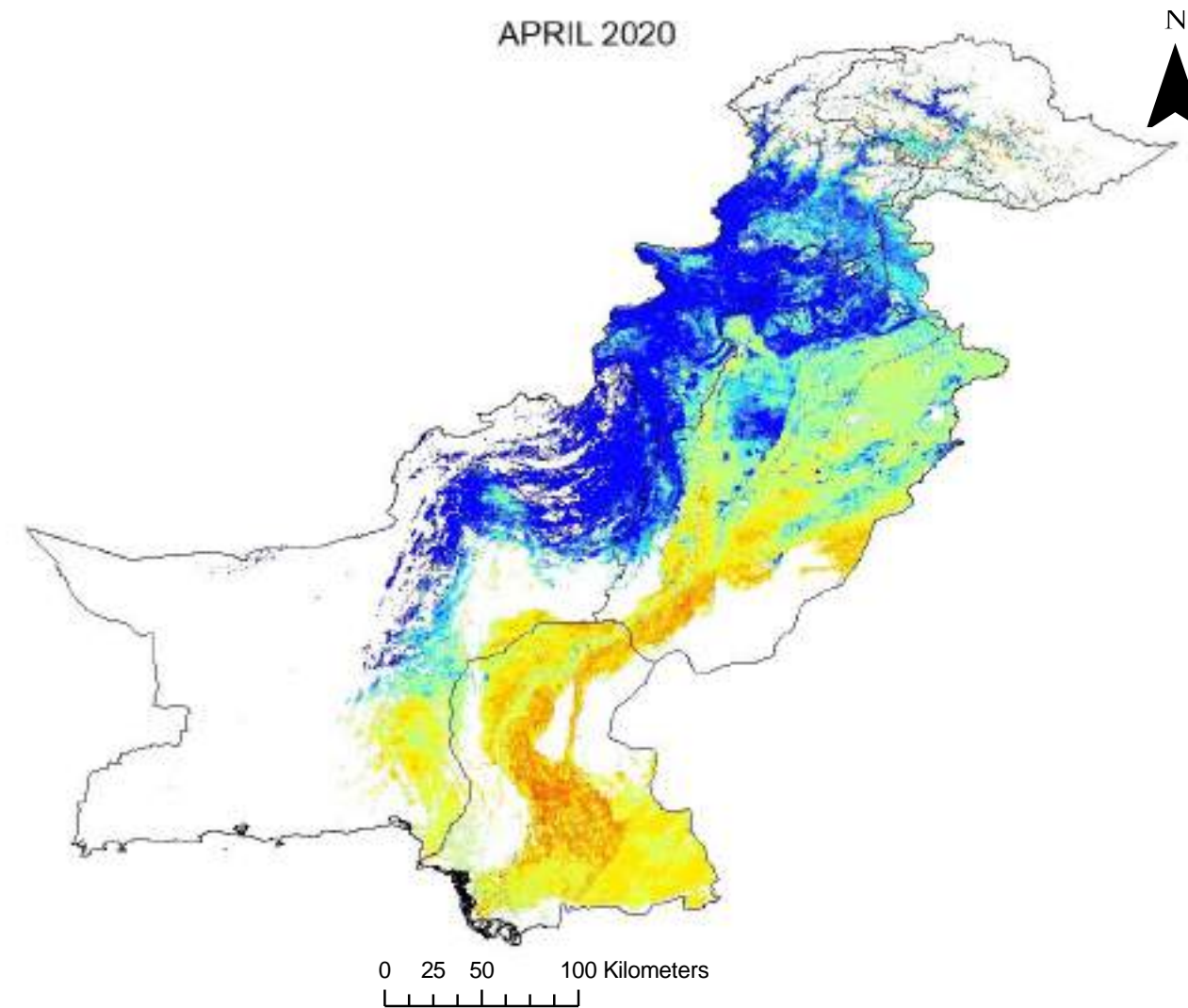
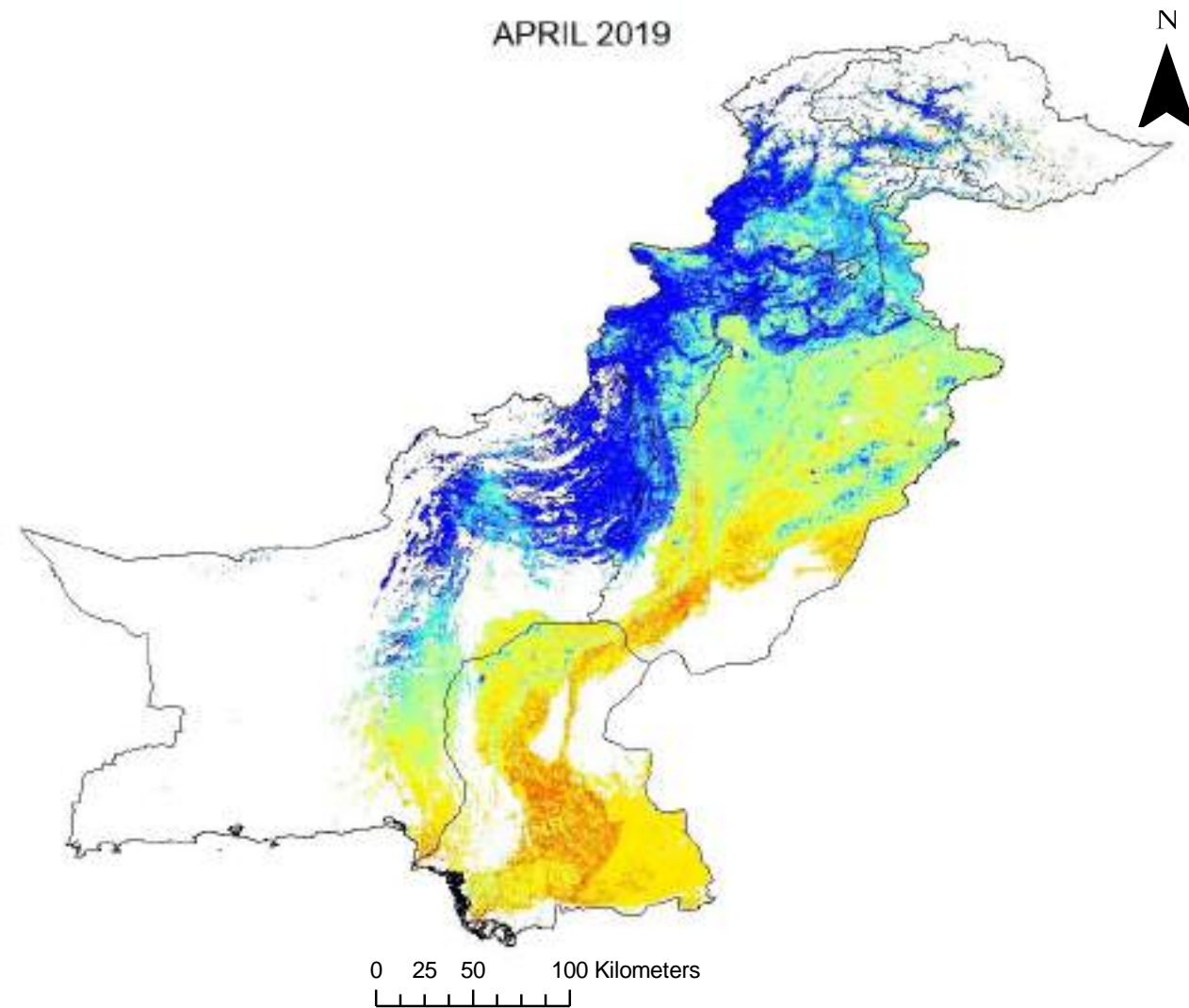
- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



Legend

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|--|---|--|
|  Extreme Drought (-1.5 or less) |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19) |
|  Severe Drought (-1.2 to -1.49) |  Near Normal (0.29 to -0.29) |  Very Wet (1.2 to 1.49) |
|  Moderate Drought (-0.9 to -1.19) |  Incipient Wet Spell (0.3 to 0.59) |  Extremely Wet (1.5 or greater) |
|  Mild Drought (-0.6 to -0.89) |  Slightly Wet (0.6 to 0.89) | |



Legend

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

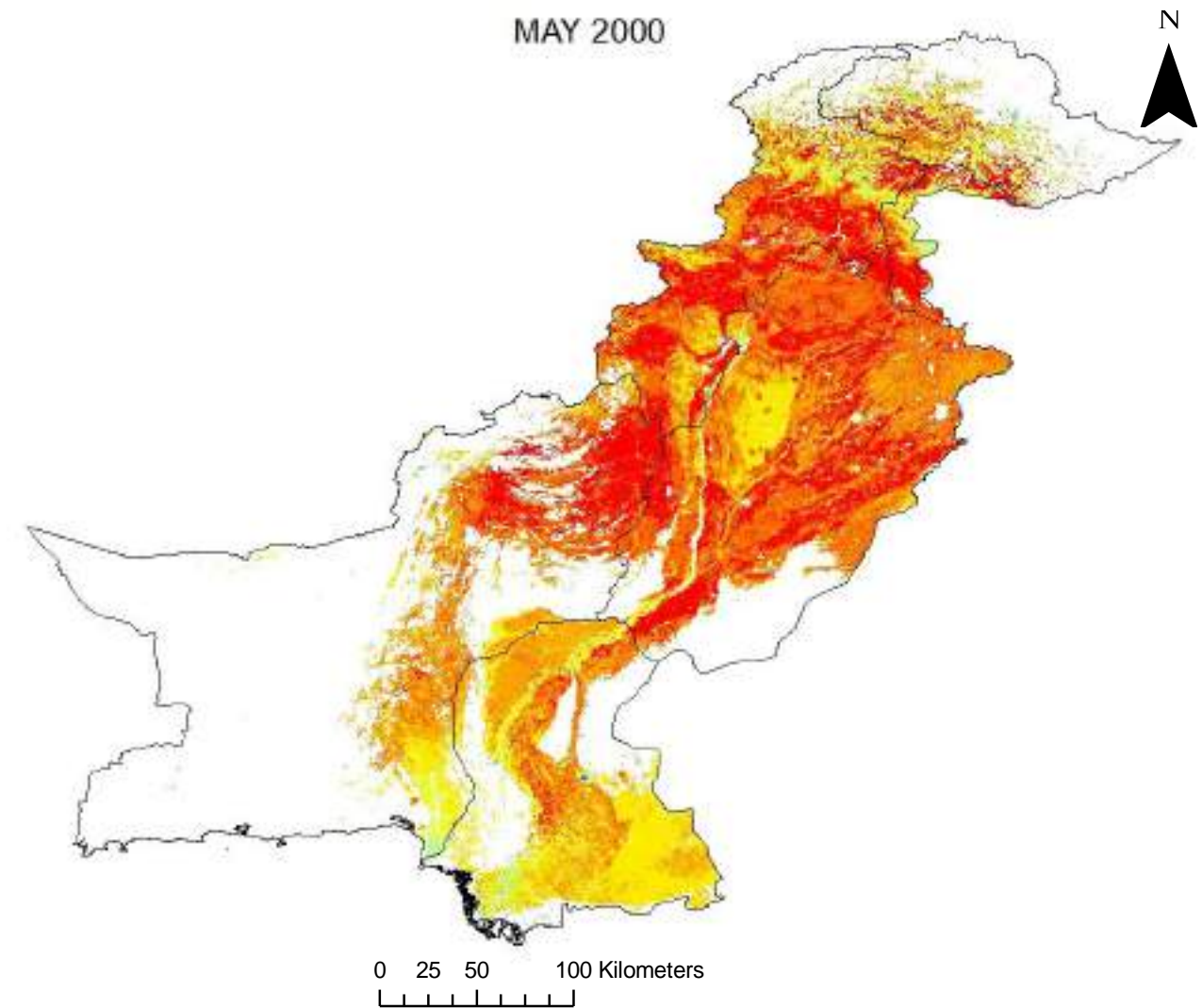
- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
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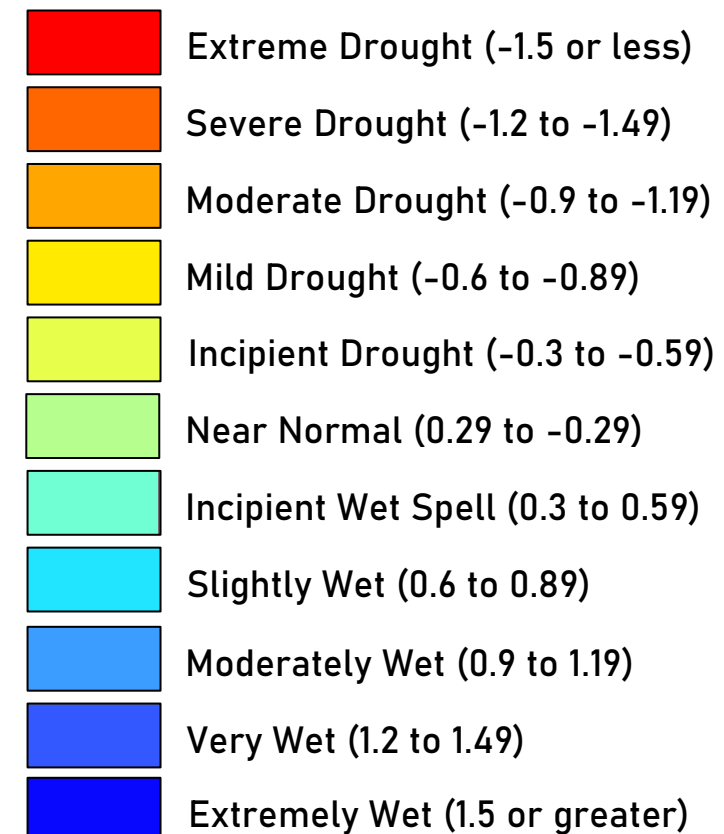
May DSI Maps

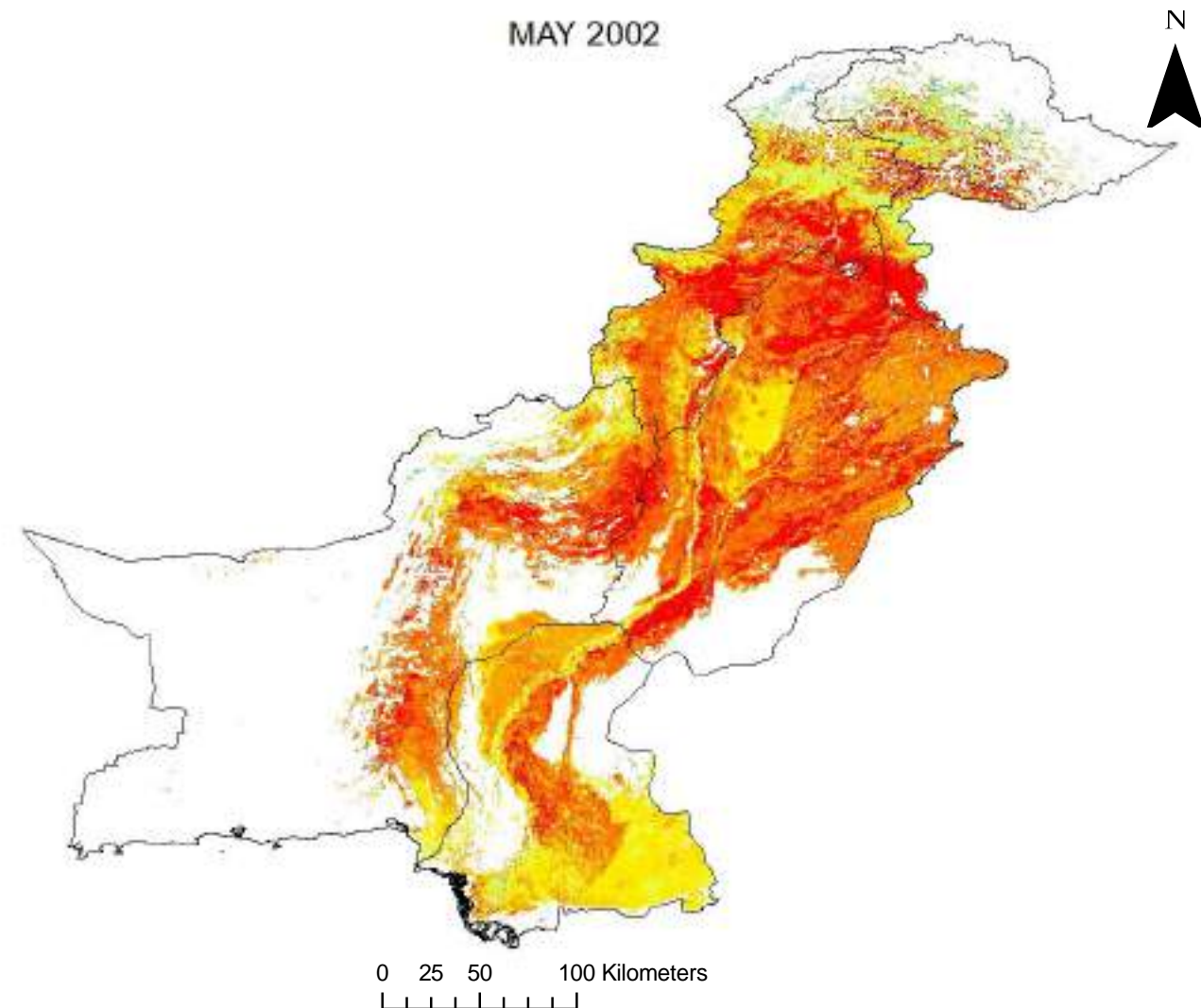
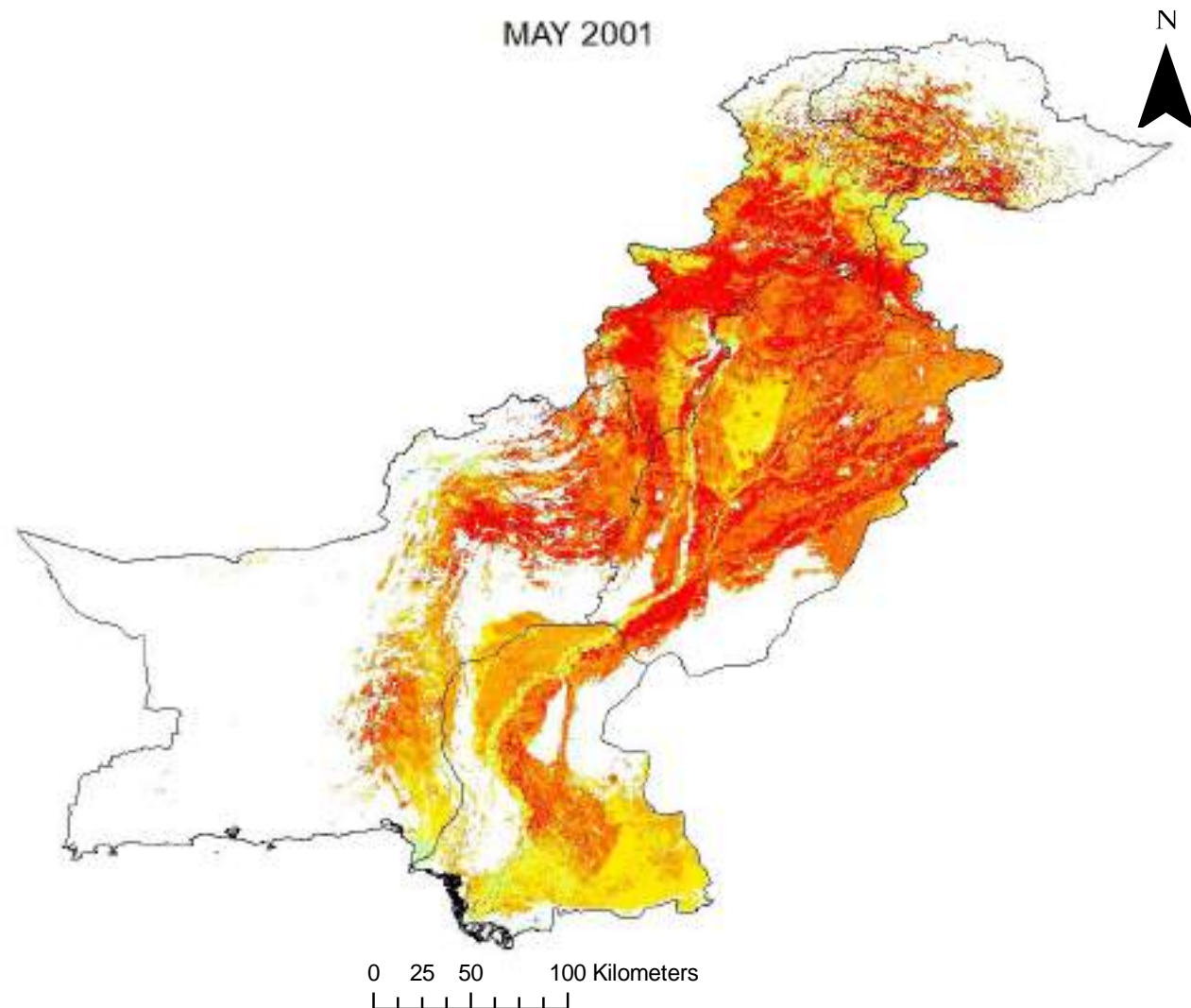
Drought conditions in May can range from moderate drought to near-normal. This hot month is characterized by mild to incipient drought.

Mean May DSI Values		
Years	Values	Drought Condition
2000	-1.11	Moderate Drought
2001	-1.19	Moderate Drought
2002	-1.13	Moderate Drought
2003	-0.70	Mild Drought
2004	-0.97	Moderate Drought
2005	-0.35	Incipient Drought
2006	-0.96	Moderate Drought
2007	-0.65	Mild Drought
2008	-0.76	Mild Drought
2009	-0.55	Incipient Drought
2010	-0.50	Incipient Drought
2011	-0.65	Mild Drought
2012	-0.48	Incipient Drought
2013	-0.58	Mild Drought
2014	0.03	Near Normal
2015	-0.26	Near Normal
2016	-0.45	Incipient Drought
2017	-0.48	Incipient Drought
2018	-0.37	Incipient Drought
2019	0.05	Near Normal
2020	0.22	Near Normal








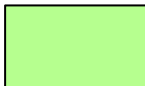


Legend

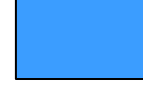




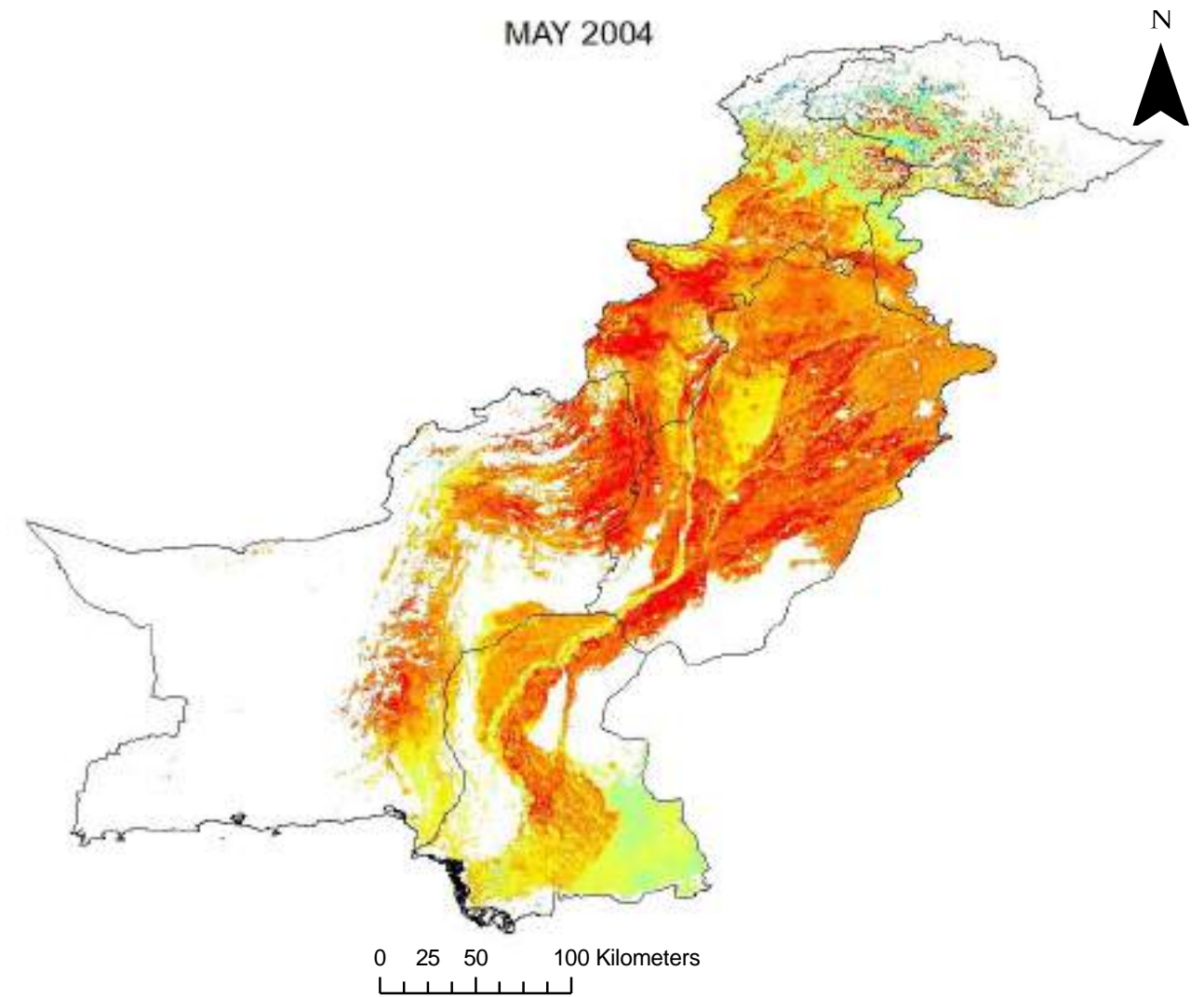
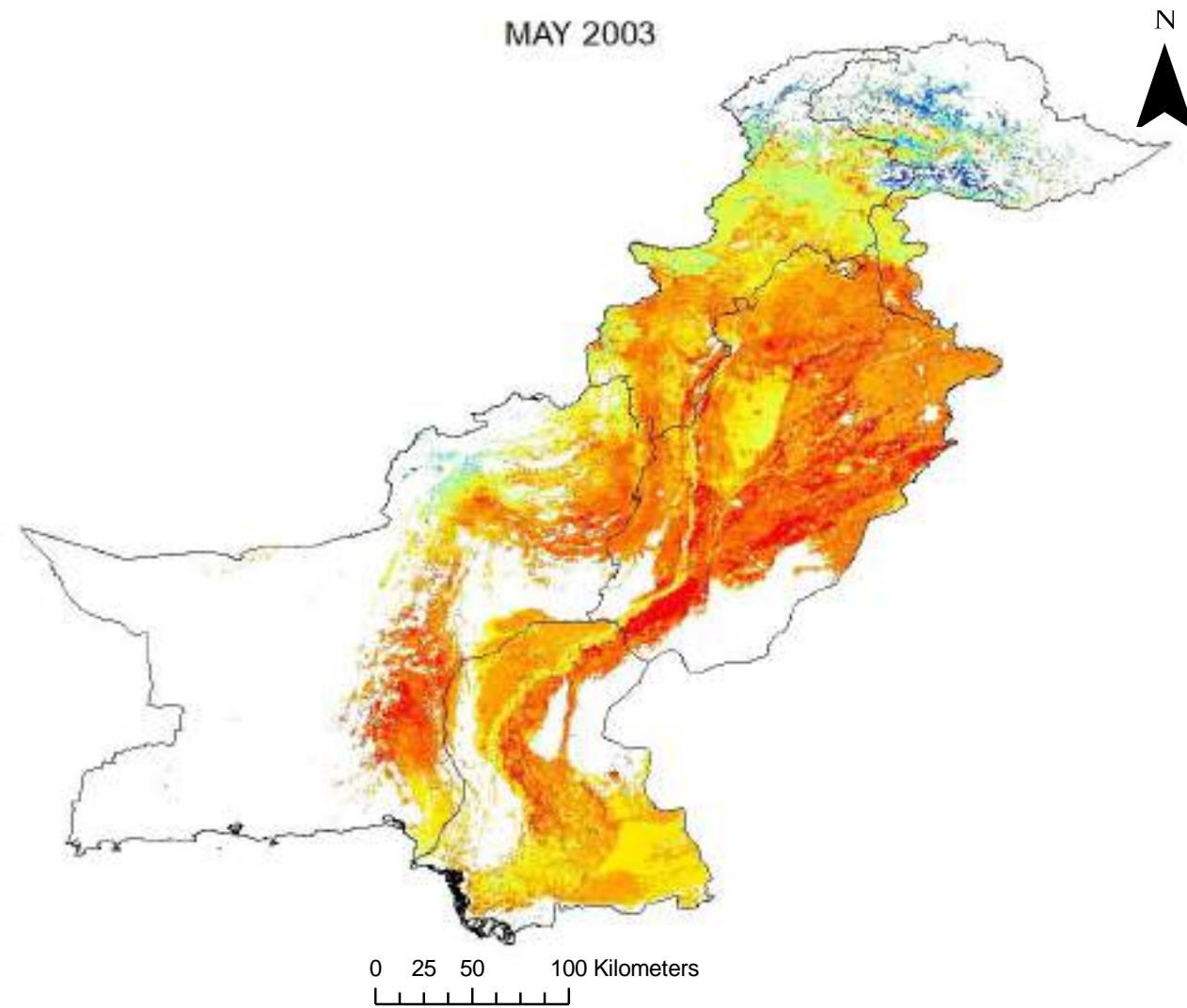


Legend

-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
-  Mild Drought (-0.6 to -0.89)

-  Incipient Drought (-0.3 to -0.59)
-  Near Normal (0.29 to -0.29)
-  Incipient Wet Spell (0.3 to 0.59)
-  Slightly Wet (0.6 to 0.89)

-  Moderately Wet (0.9 to 1.19)
-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)

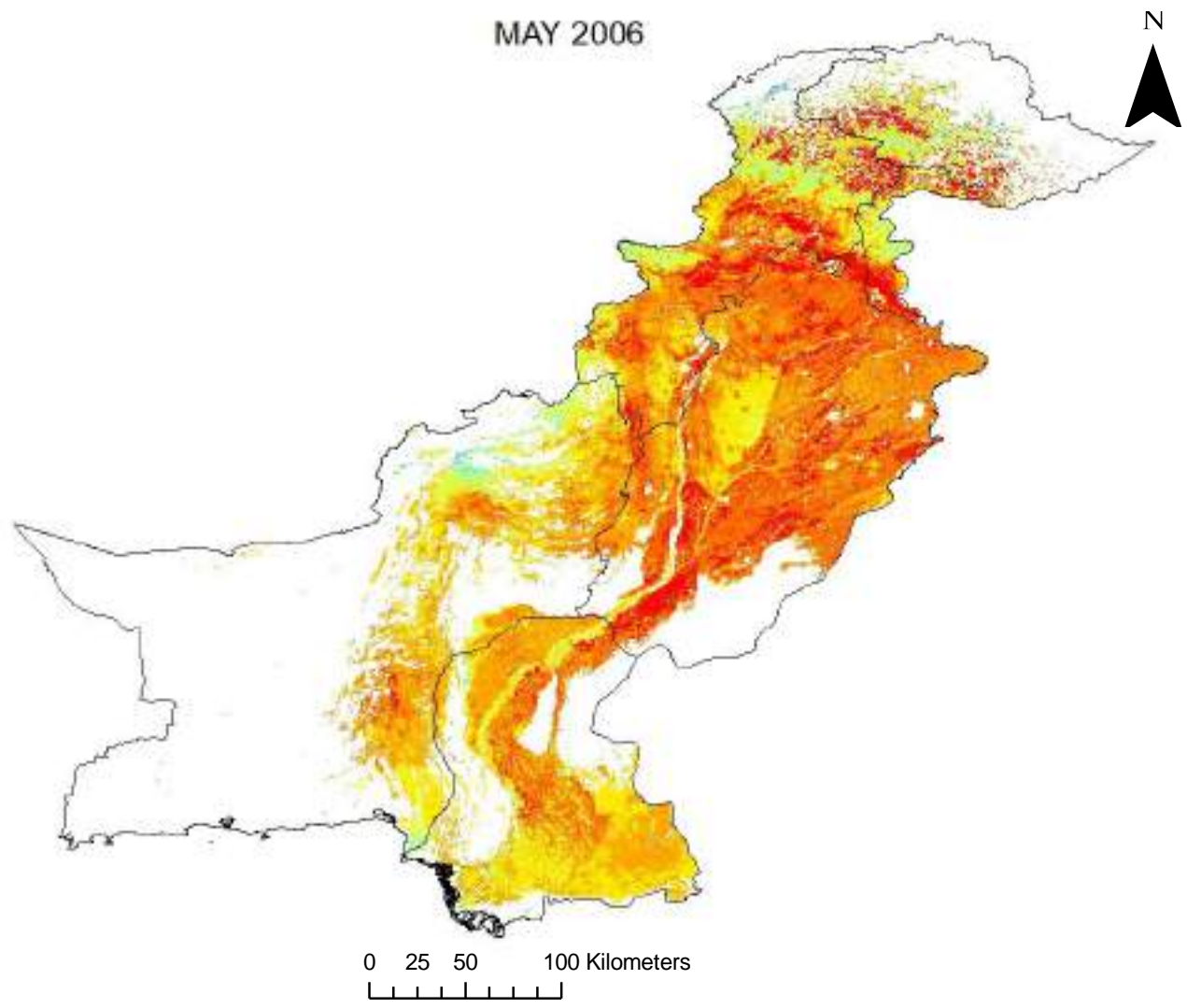
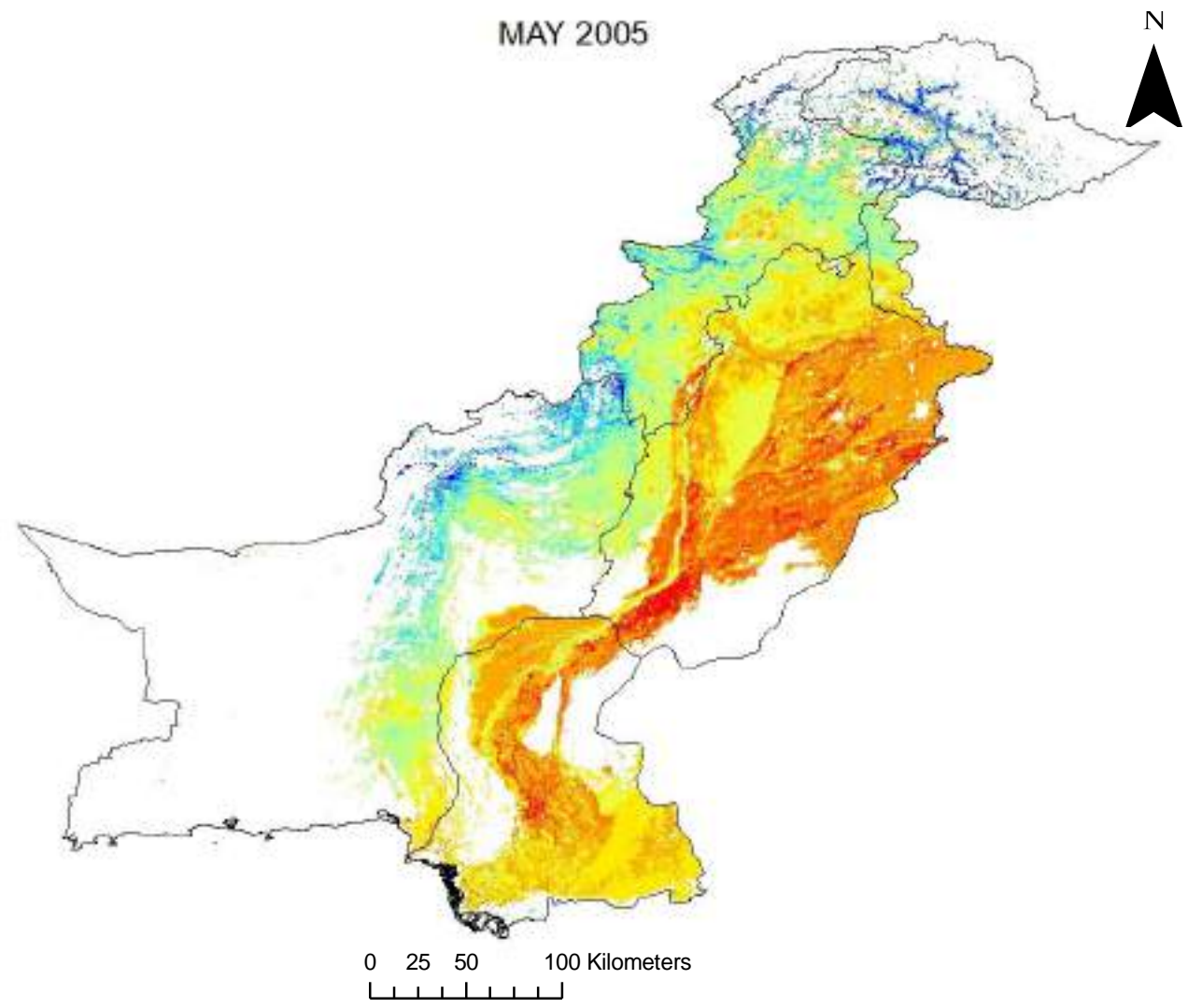


Legend








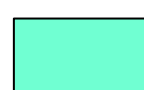



- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

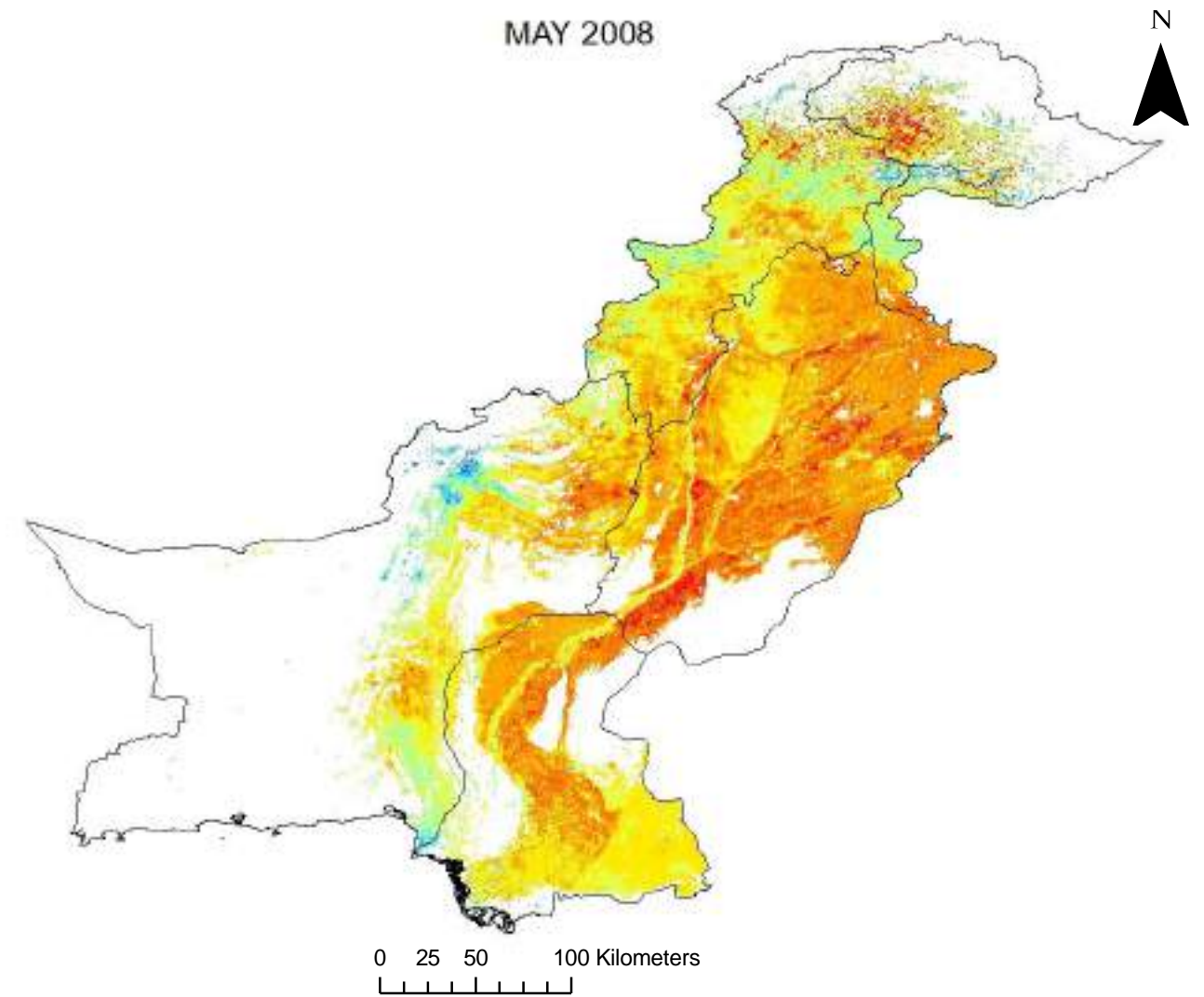
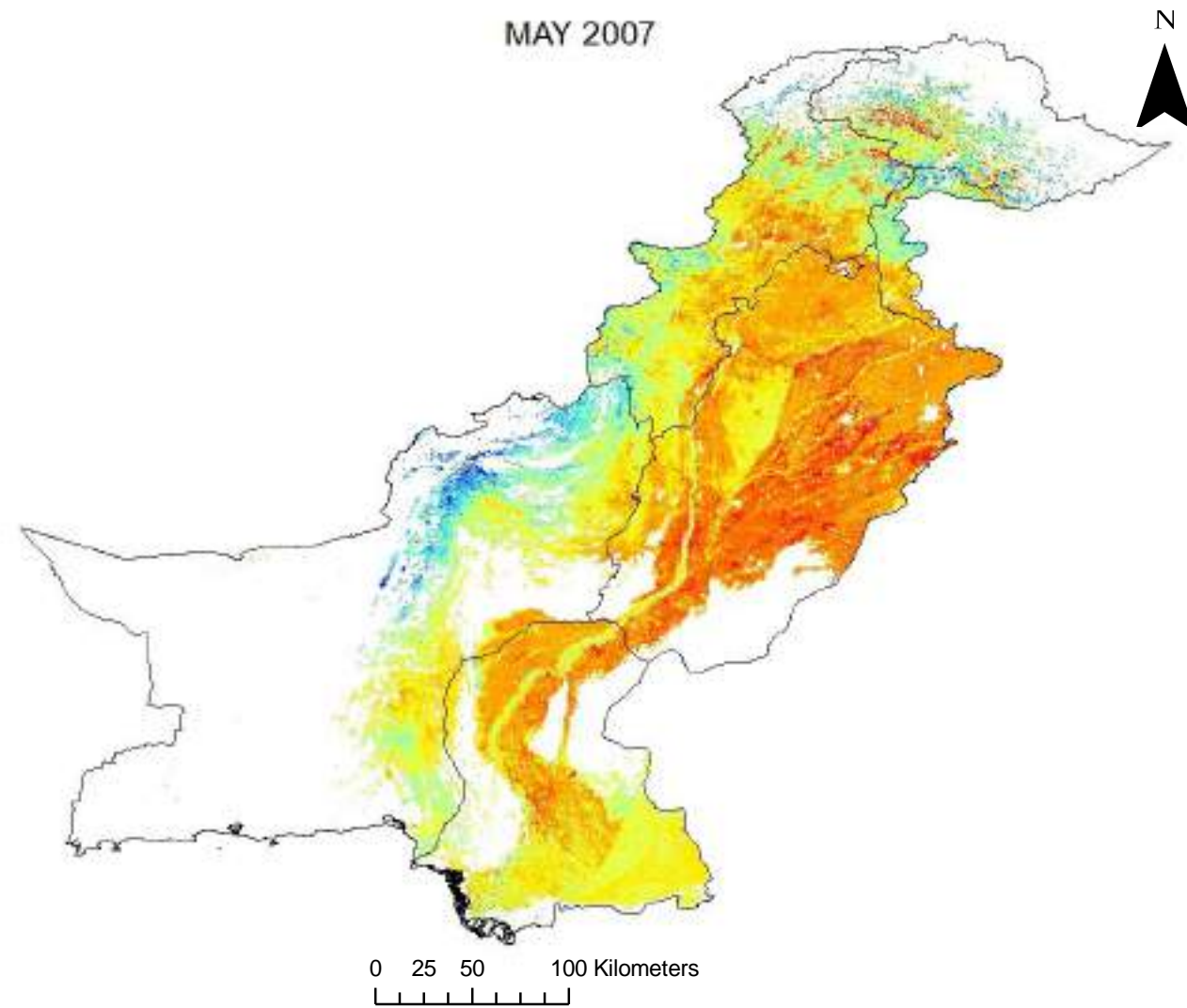
- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
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- Extremely Wet (1.5 or greater)



Legend

	Extreme Drought (-1.5 or less)		Incipient Drought (-0.3 to -0.59)		Moderately Wet (0.9 to 1.19)
	Severe Drought (-1.2 to -1.49)		Near Normal (0.29 to -0.29)		Very Wet (1.2 to 1.49)
	Moderate Drought (-0.9 to -1.19)		Incipient Wet Spell (0.3 to 0.59)		Extremely Wet (1.5 or greater)
	Mild Drought (-0.6 to -0.89)		Slightly Wet (0.6 to 0.89)		

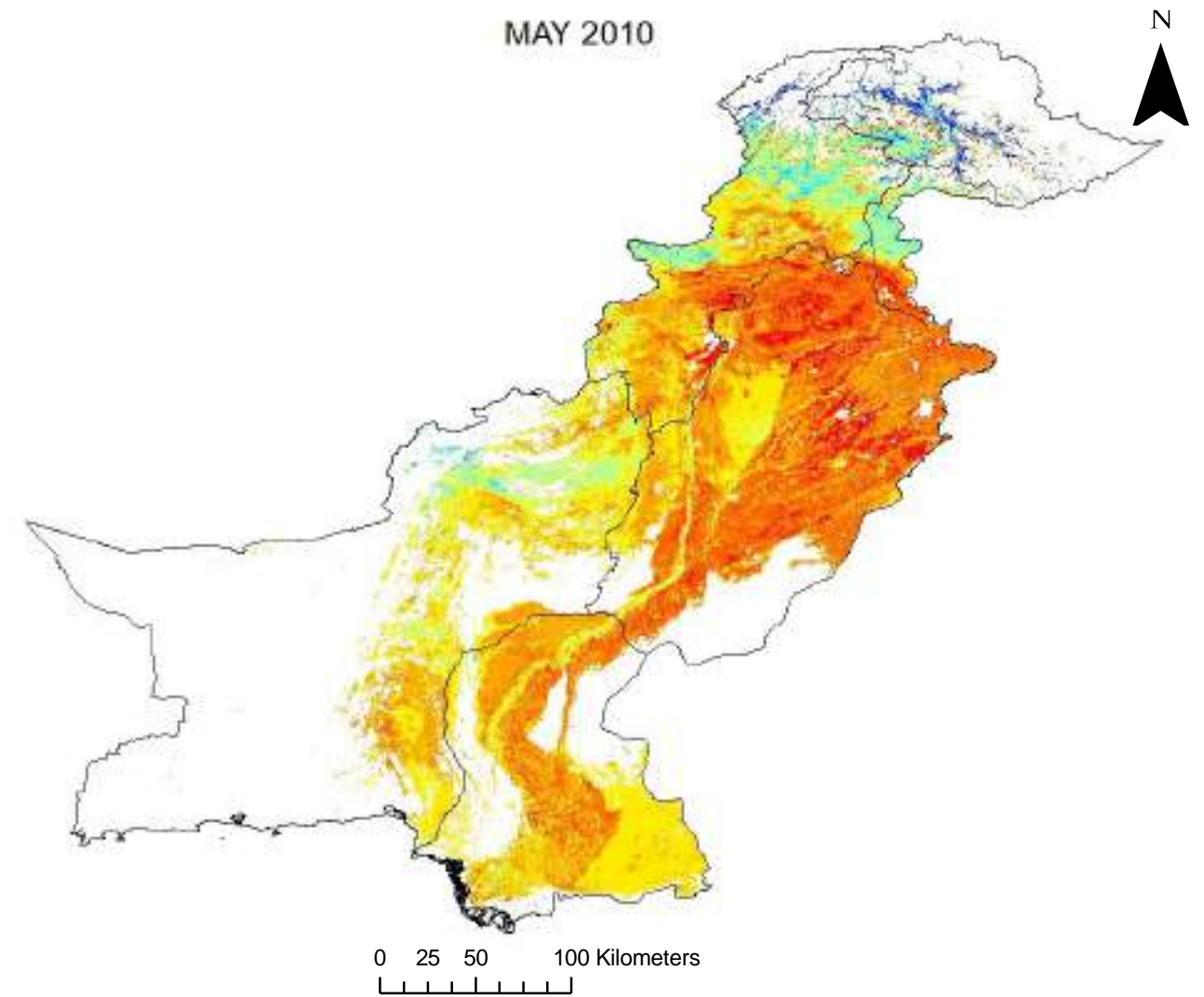
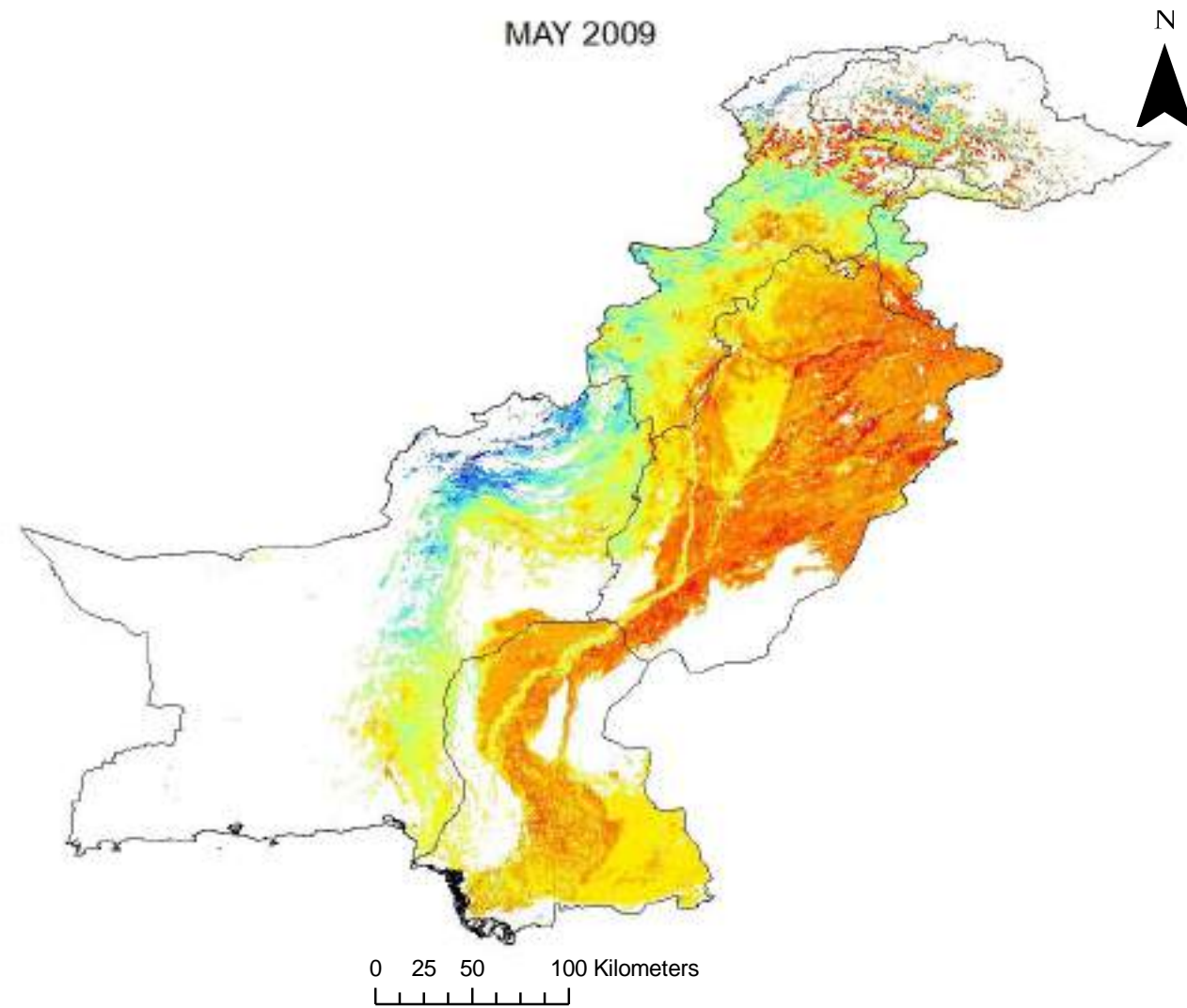


Legend

- Extreme Drought (-1.5 or less)
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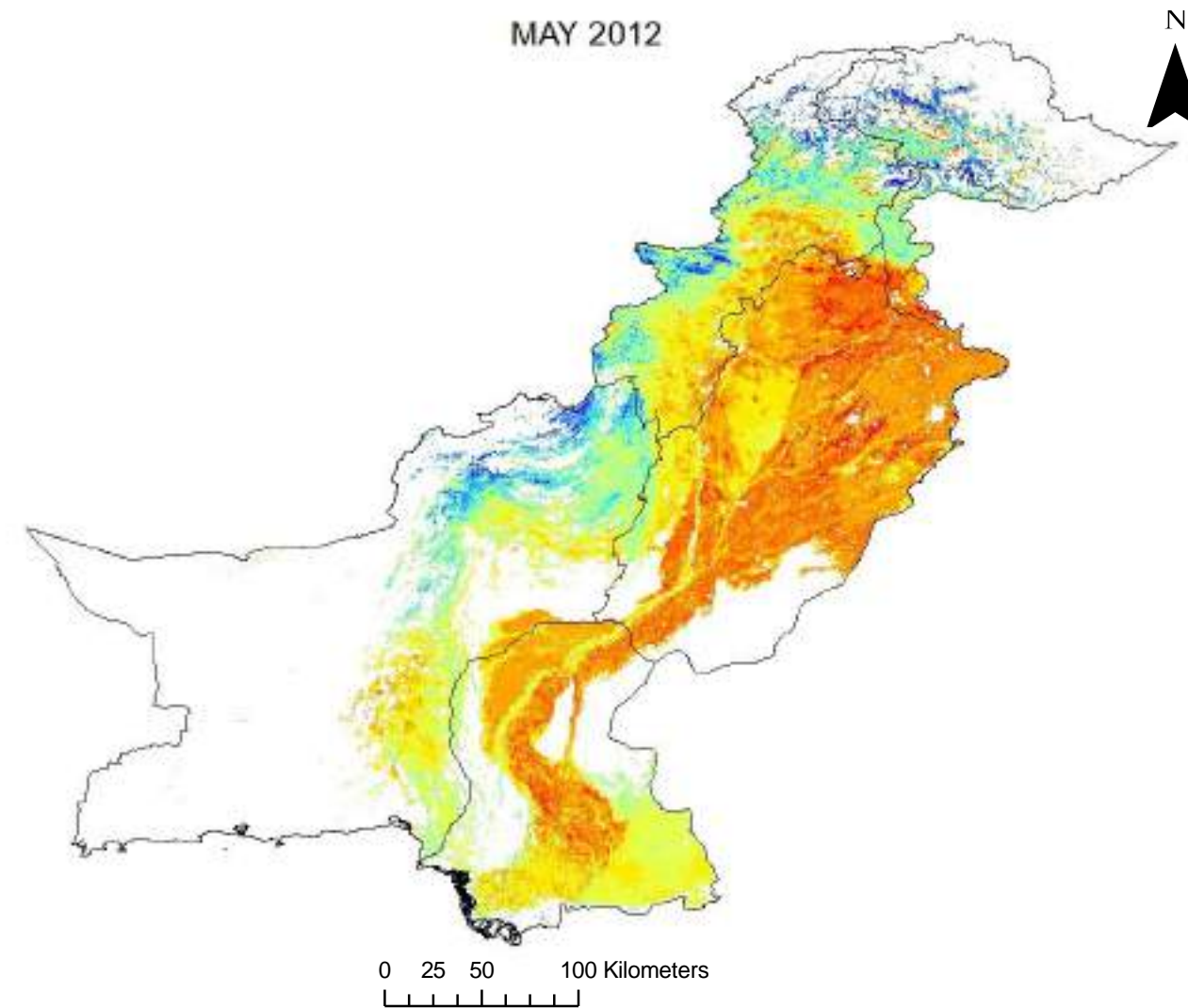
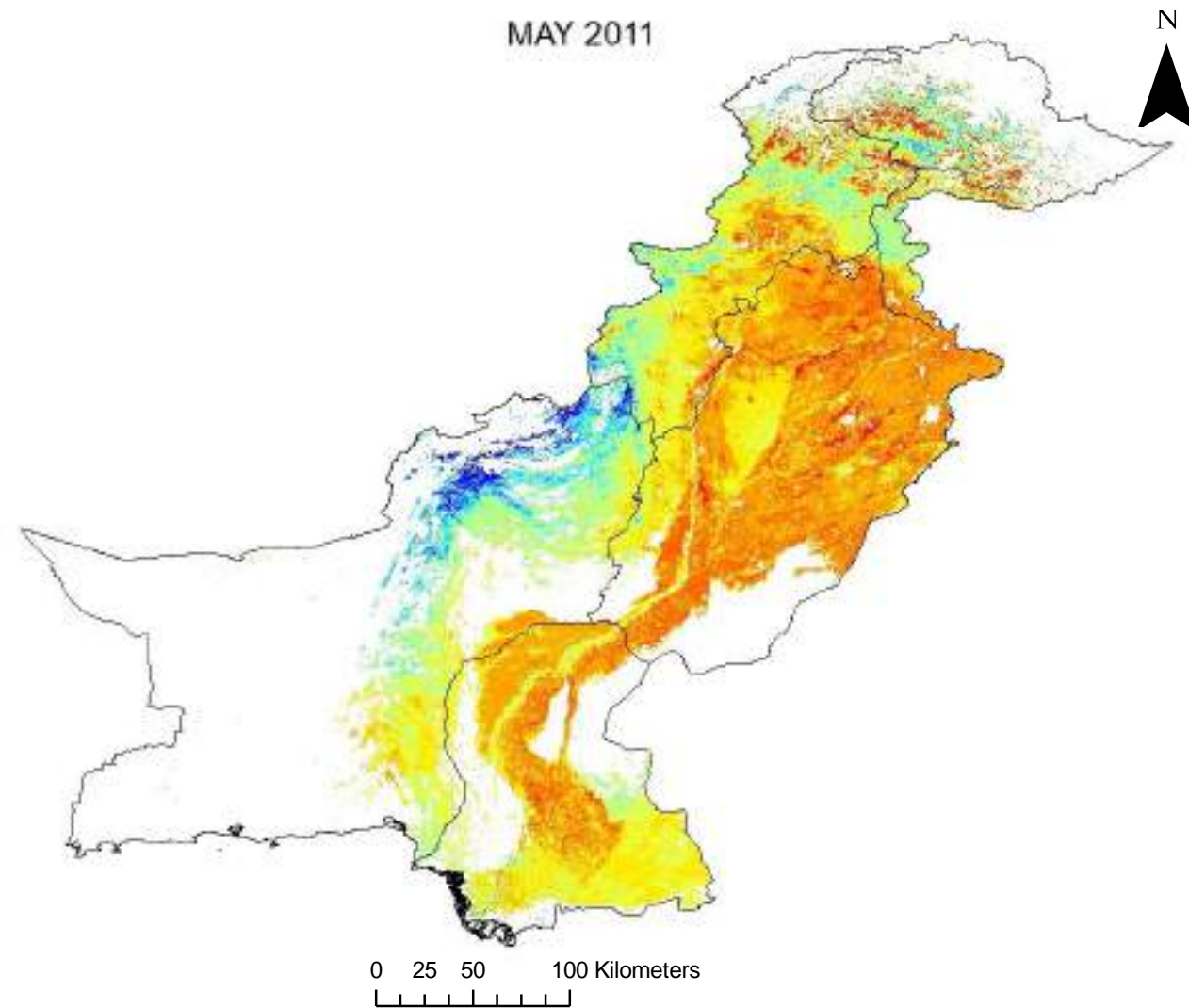


Legend

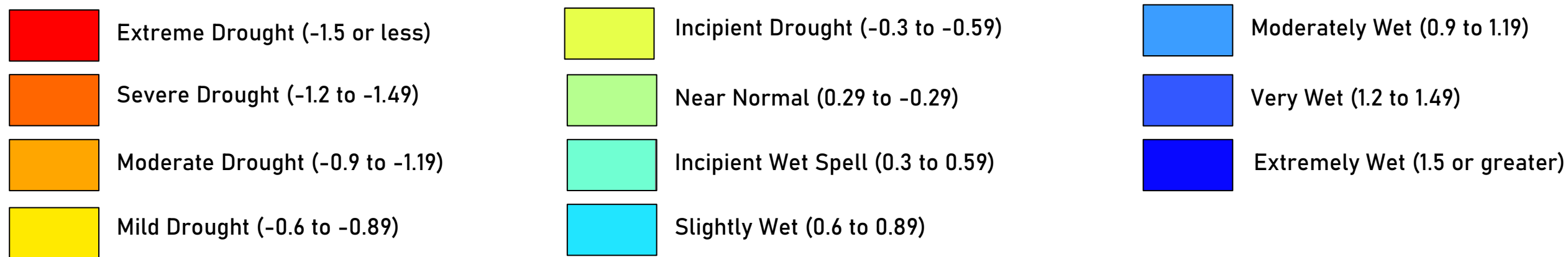
- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

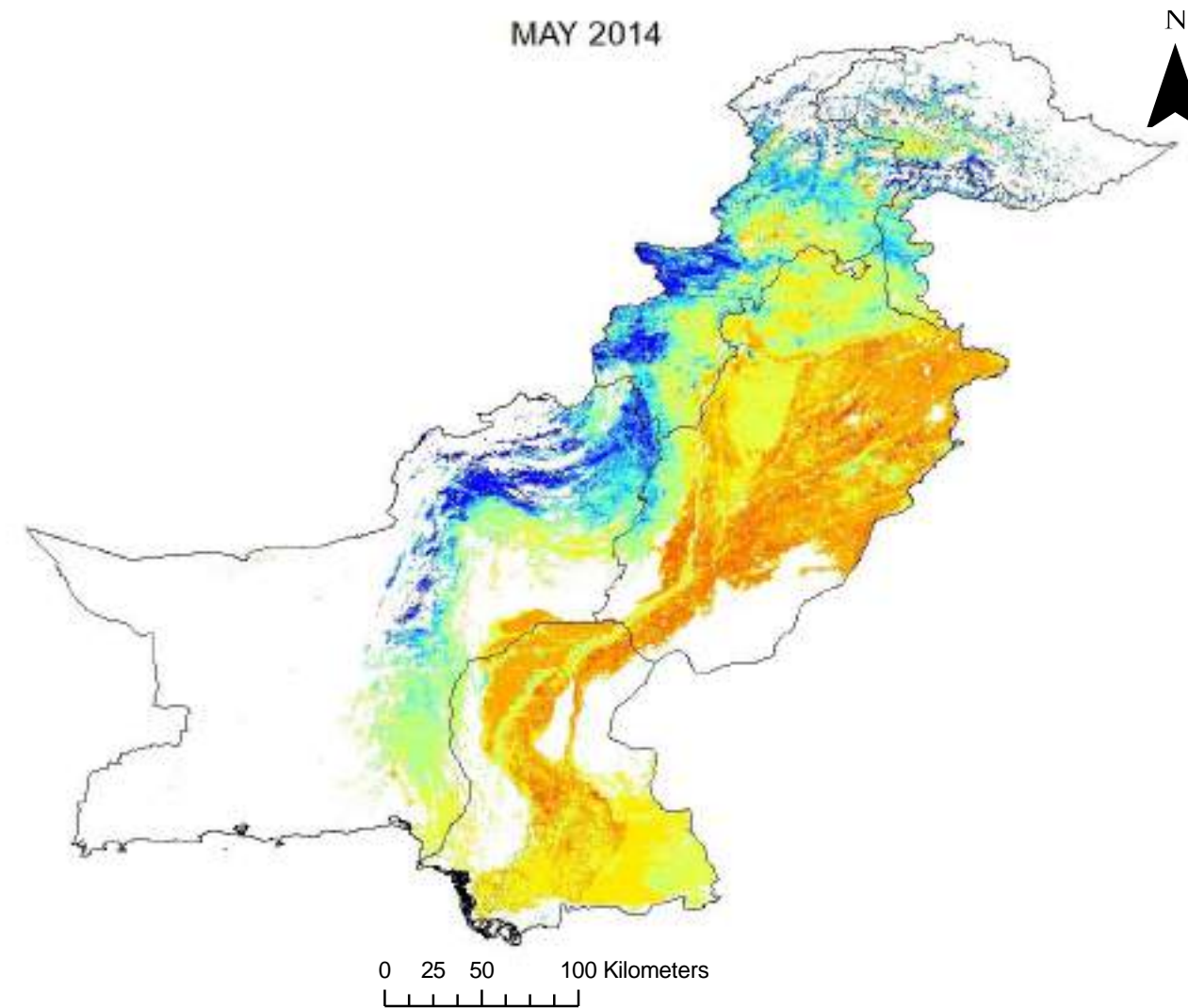
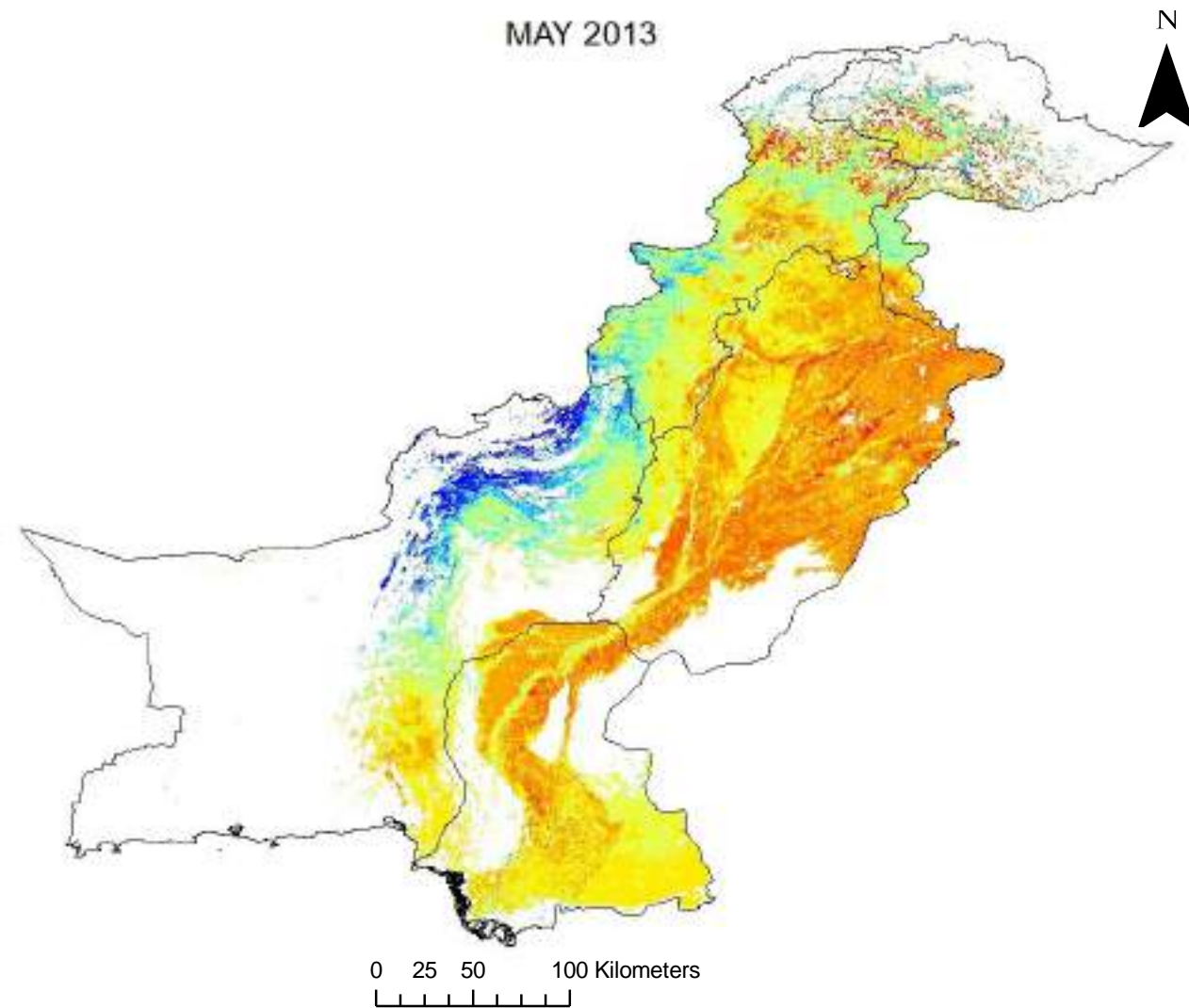
- Incipient Drought (-0.3 to -0.59)
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- Moderately Wet (0.9 to 1.19)
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Legend



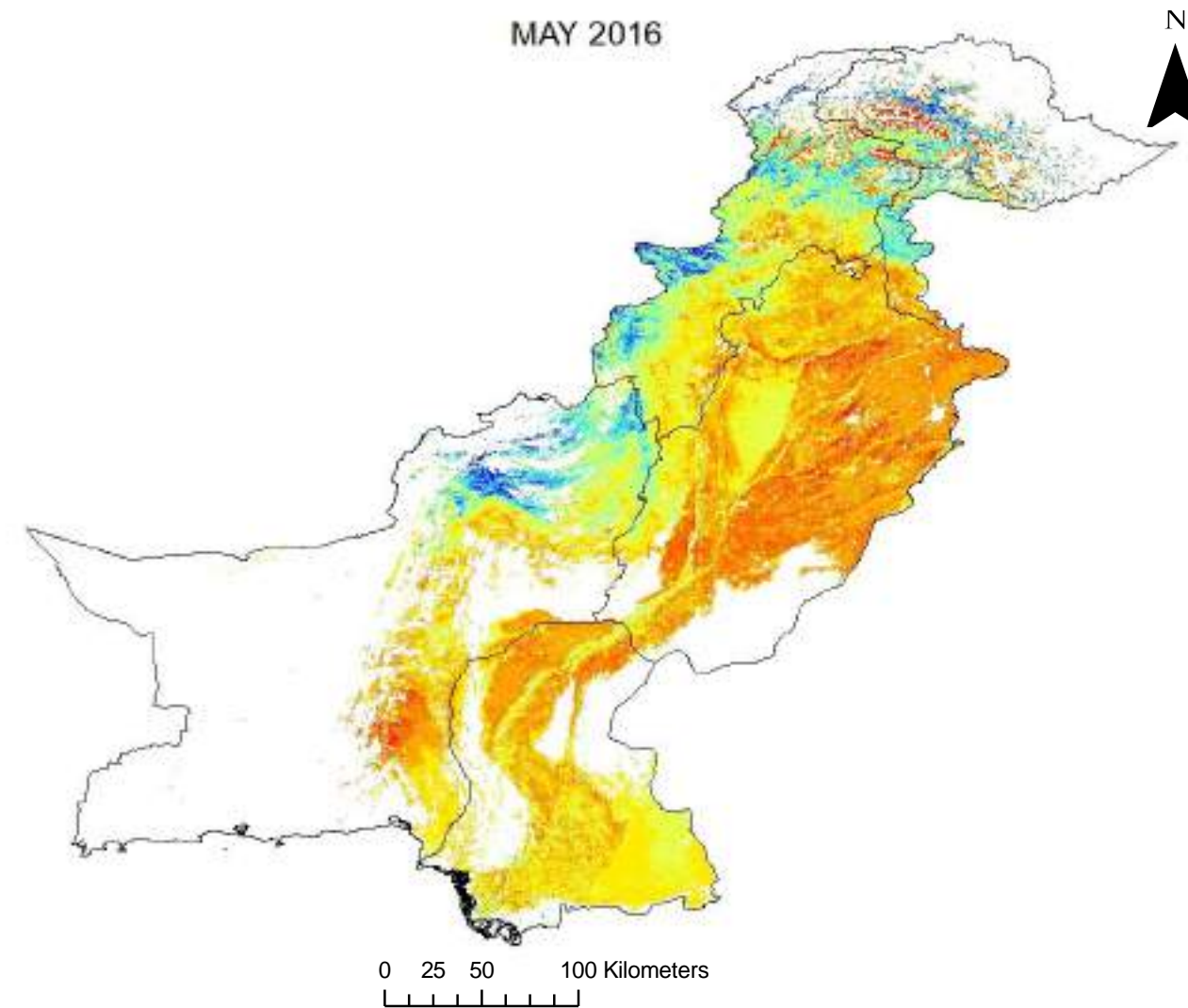
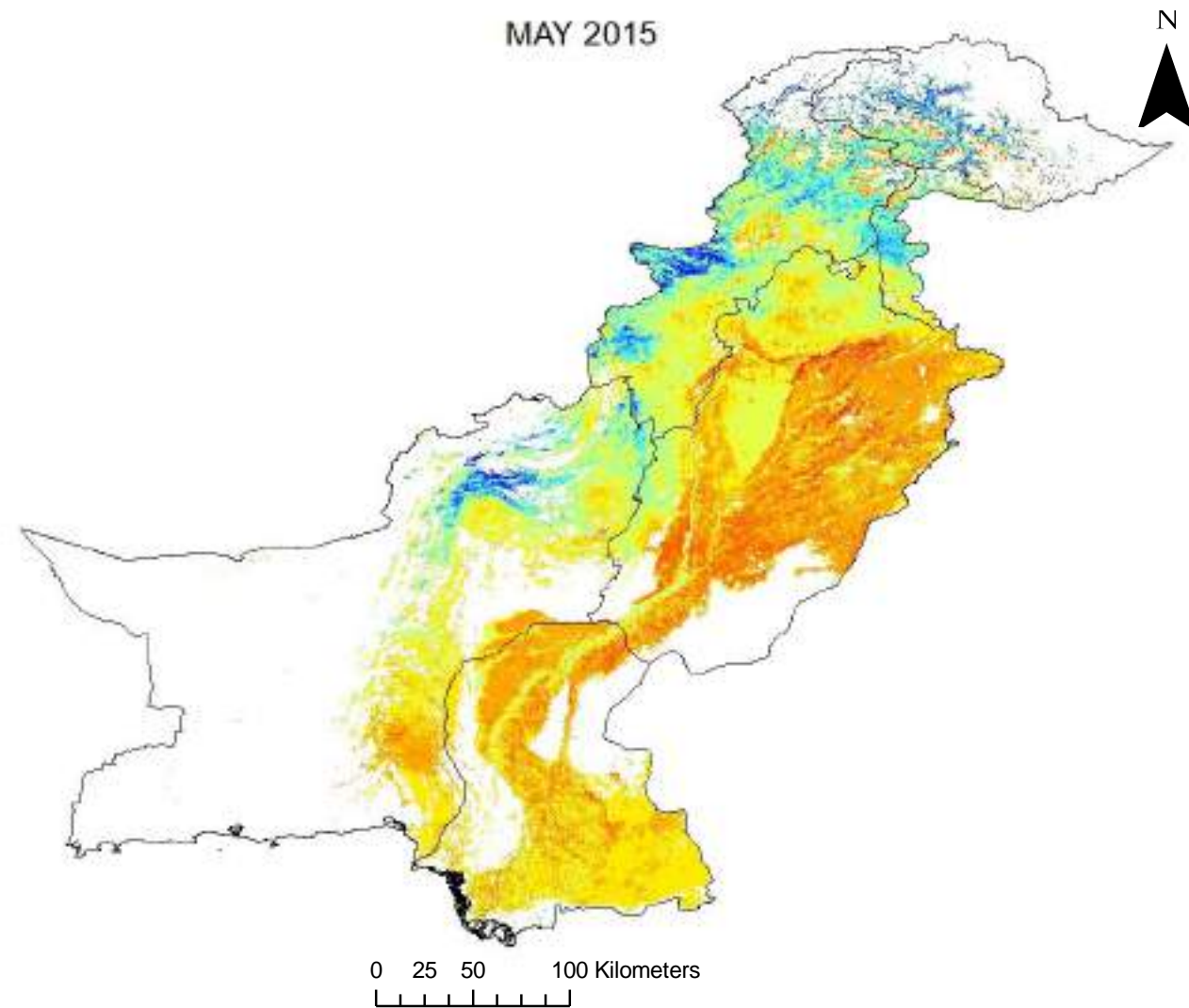


Legend

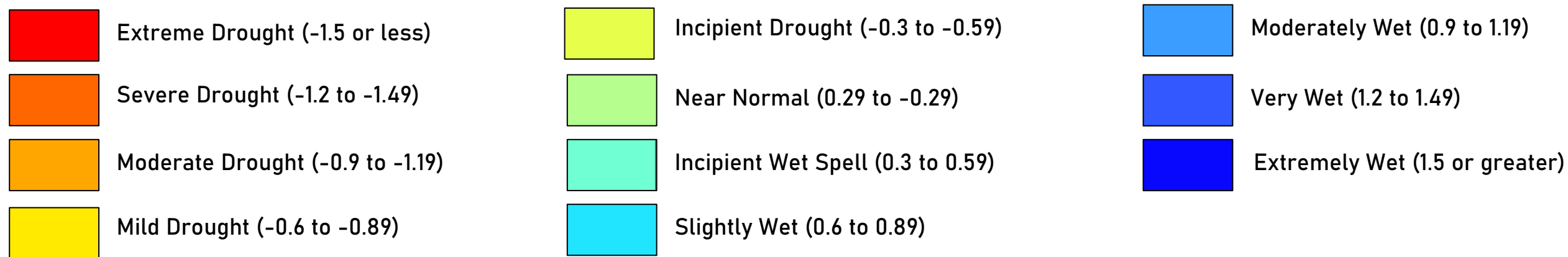
- Extreme Drought (-1.5 or less)
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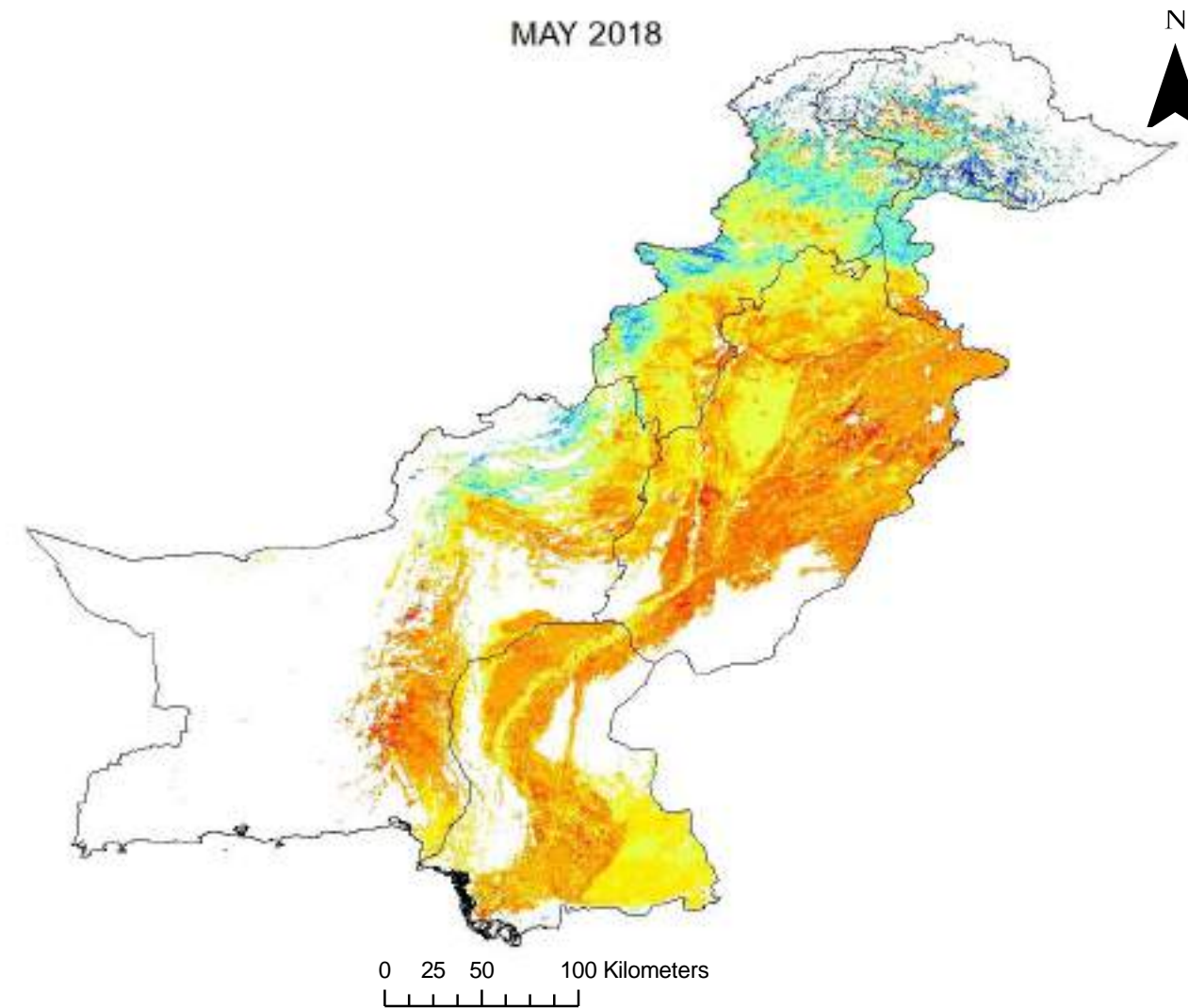
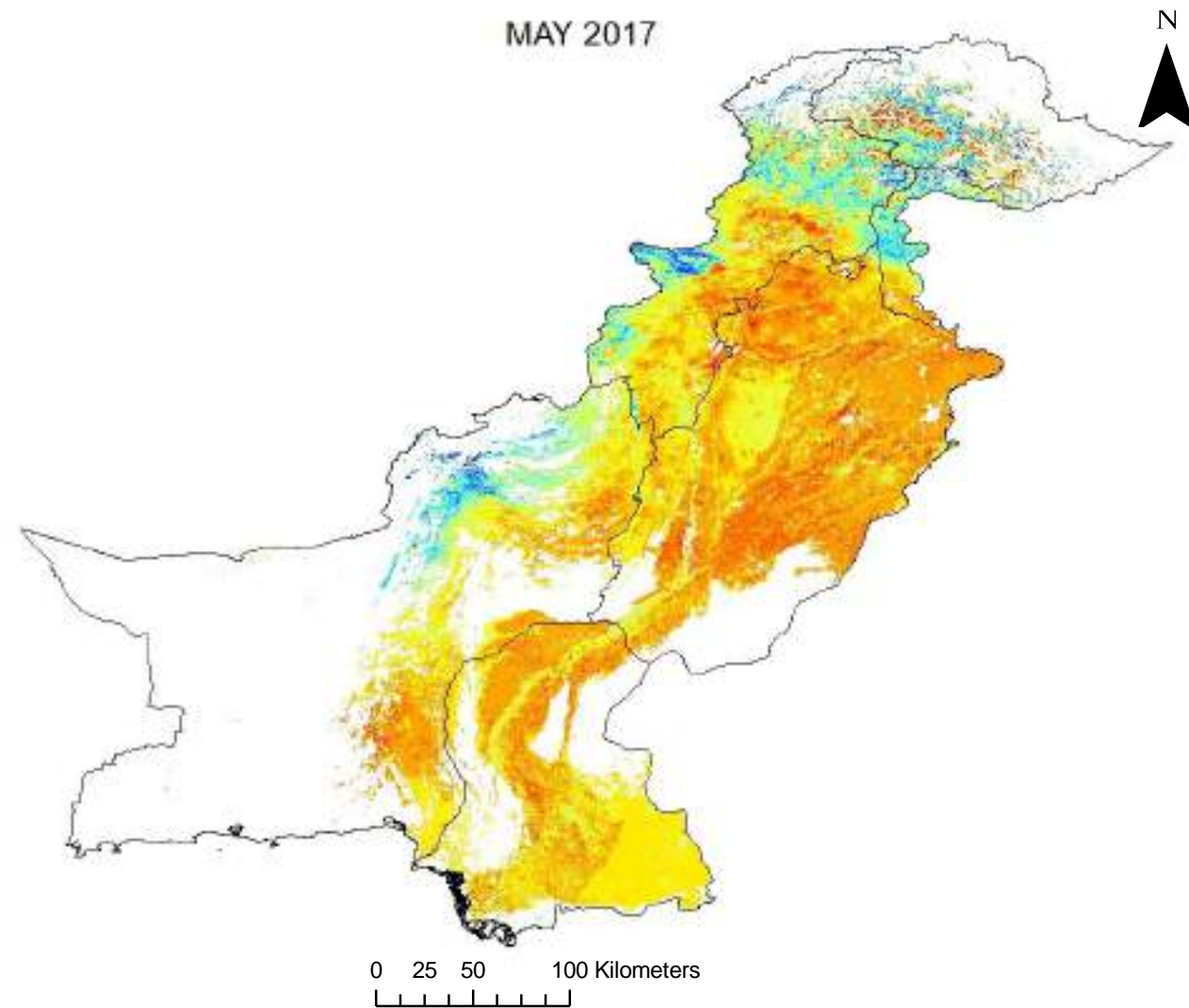
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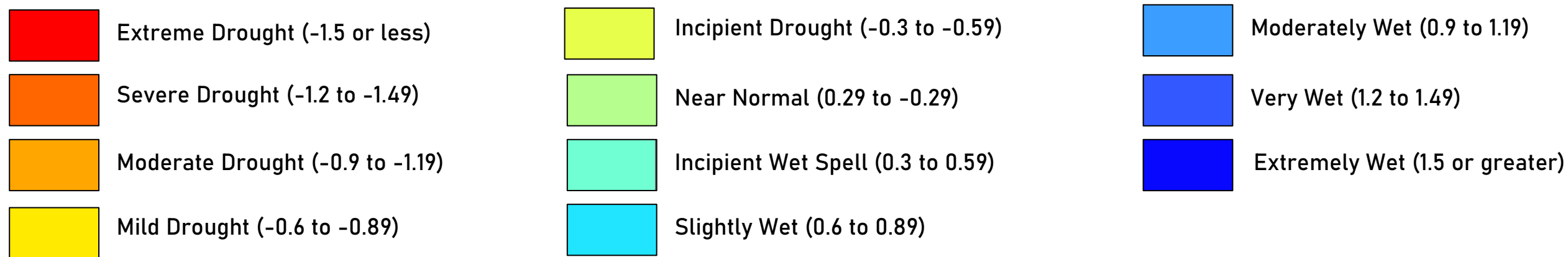


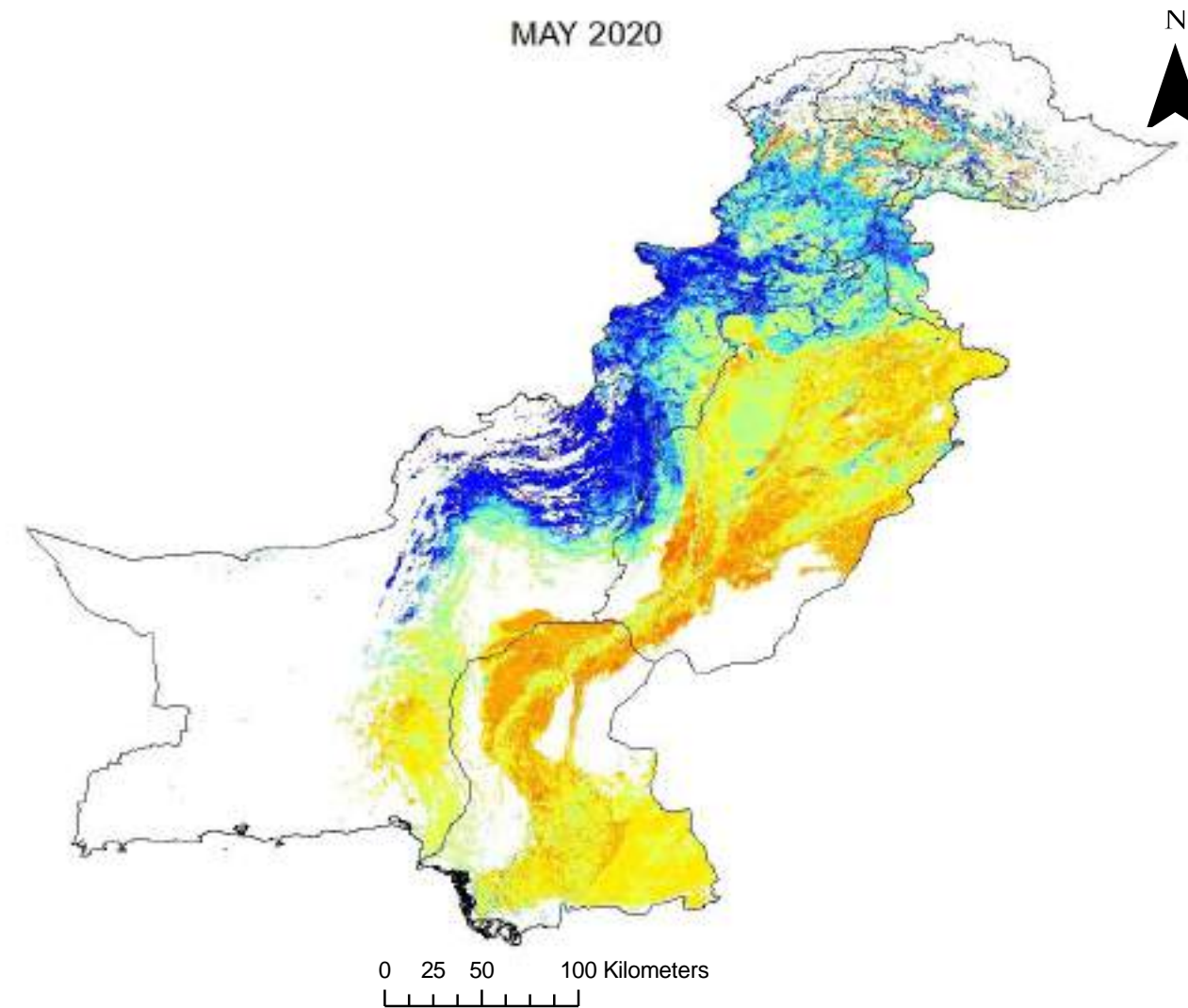
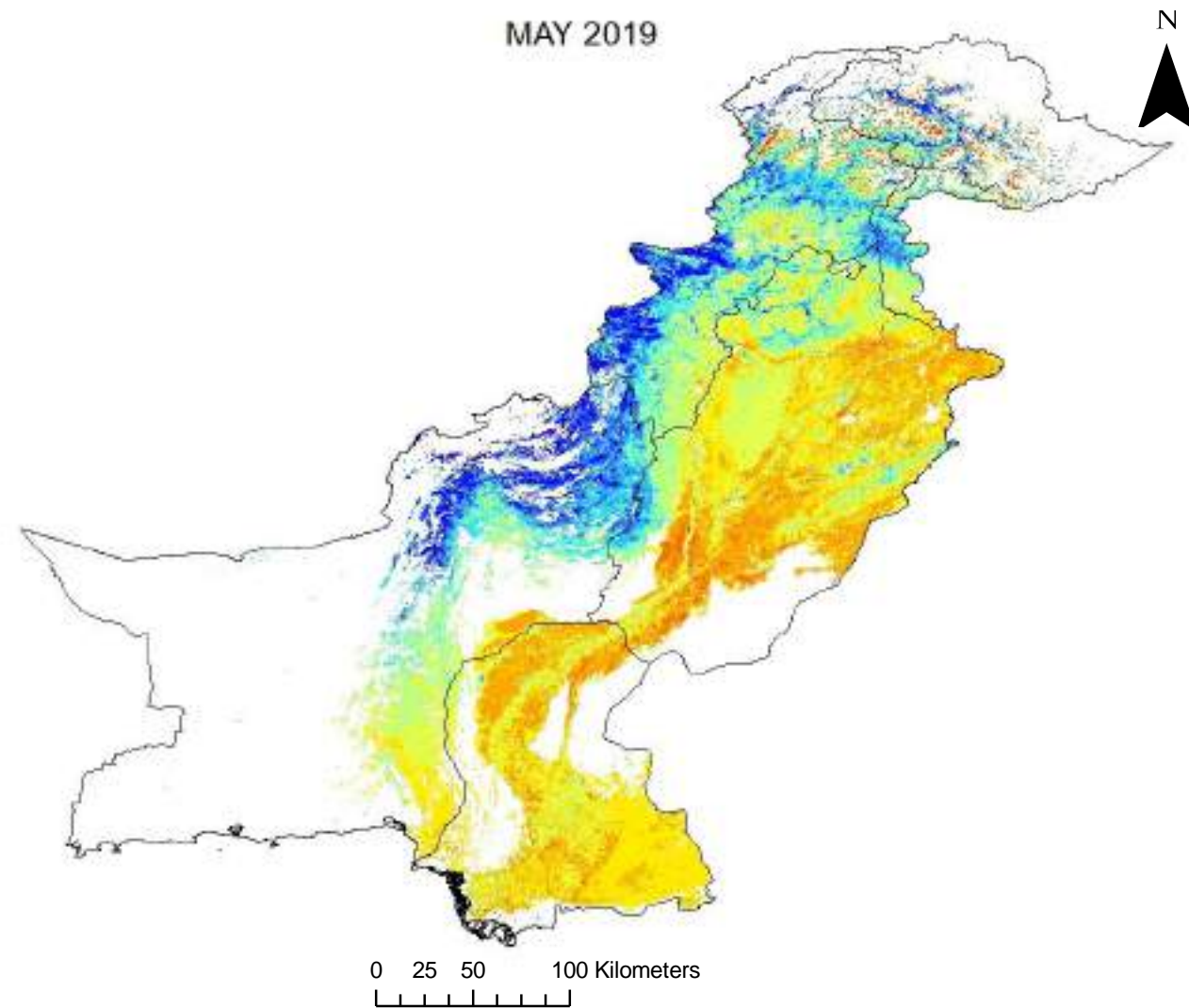
Legend



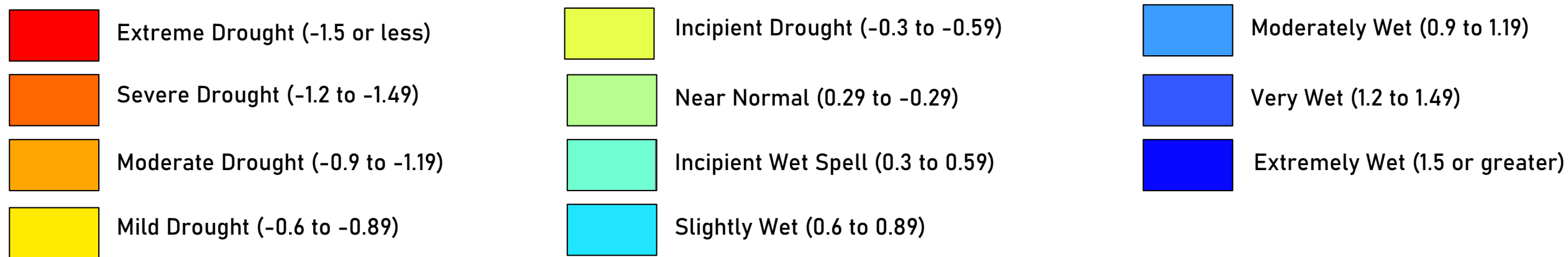


Legend





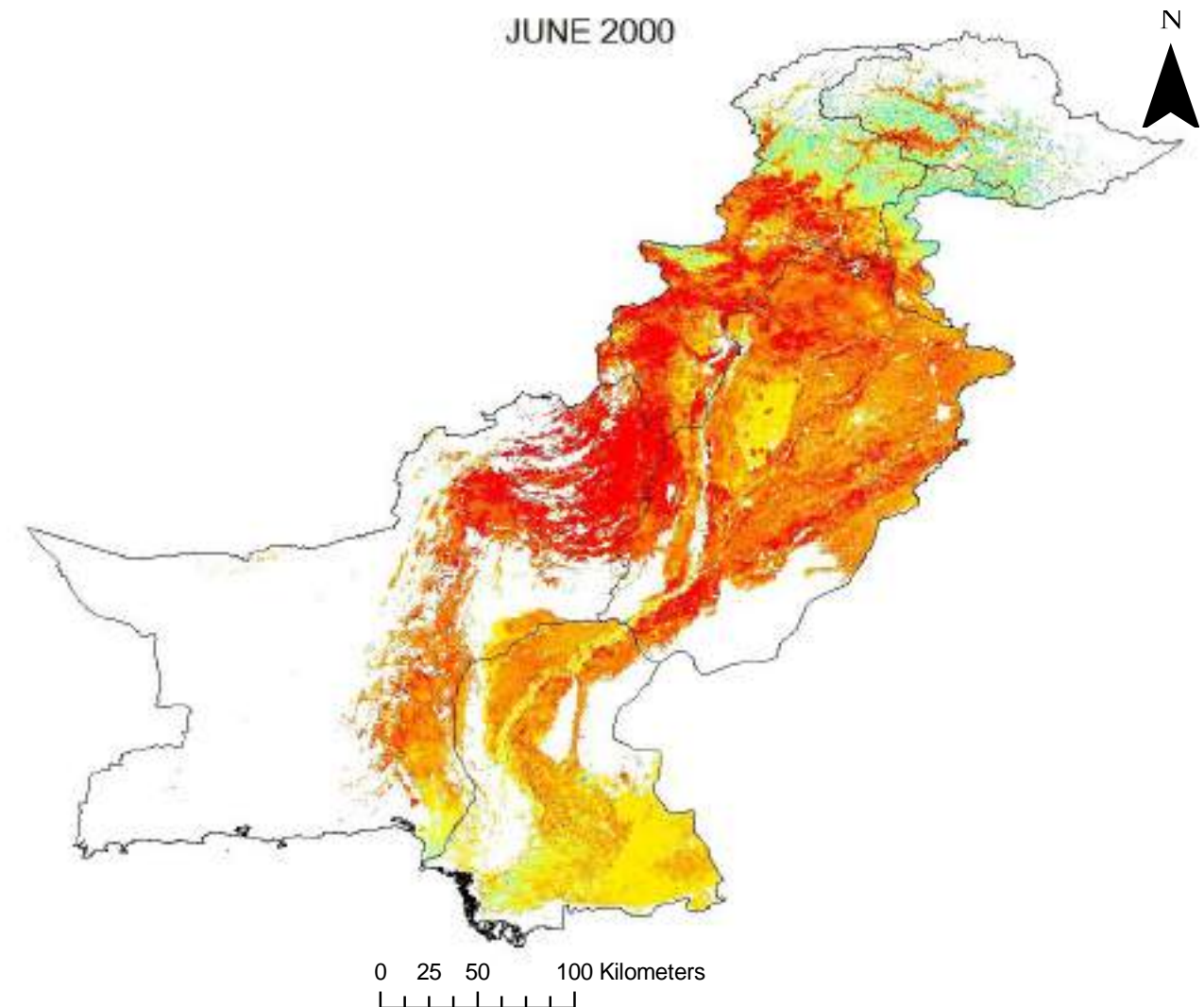
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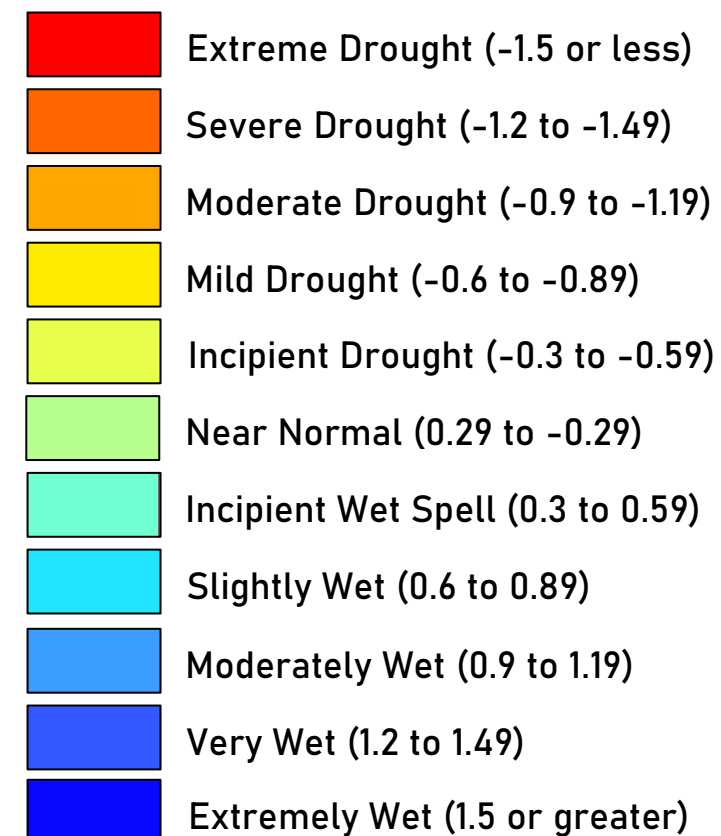
June DSI Maps

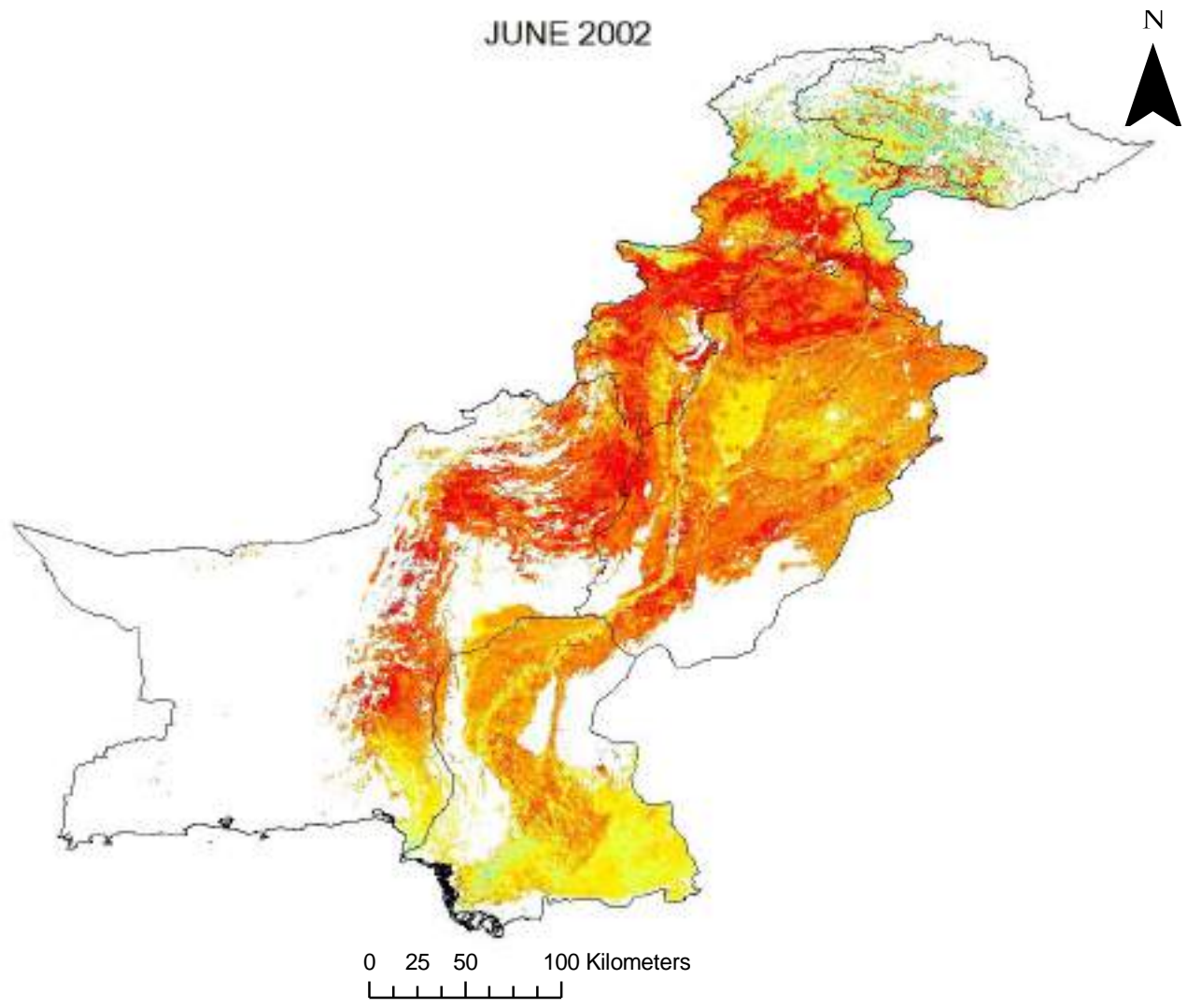
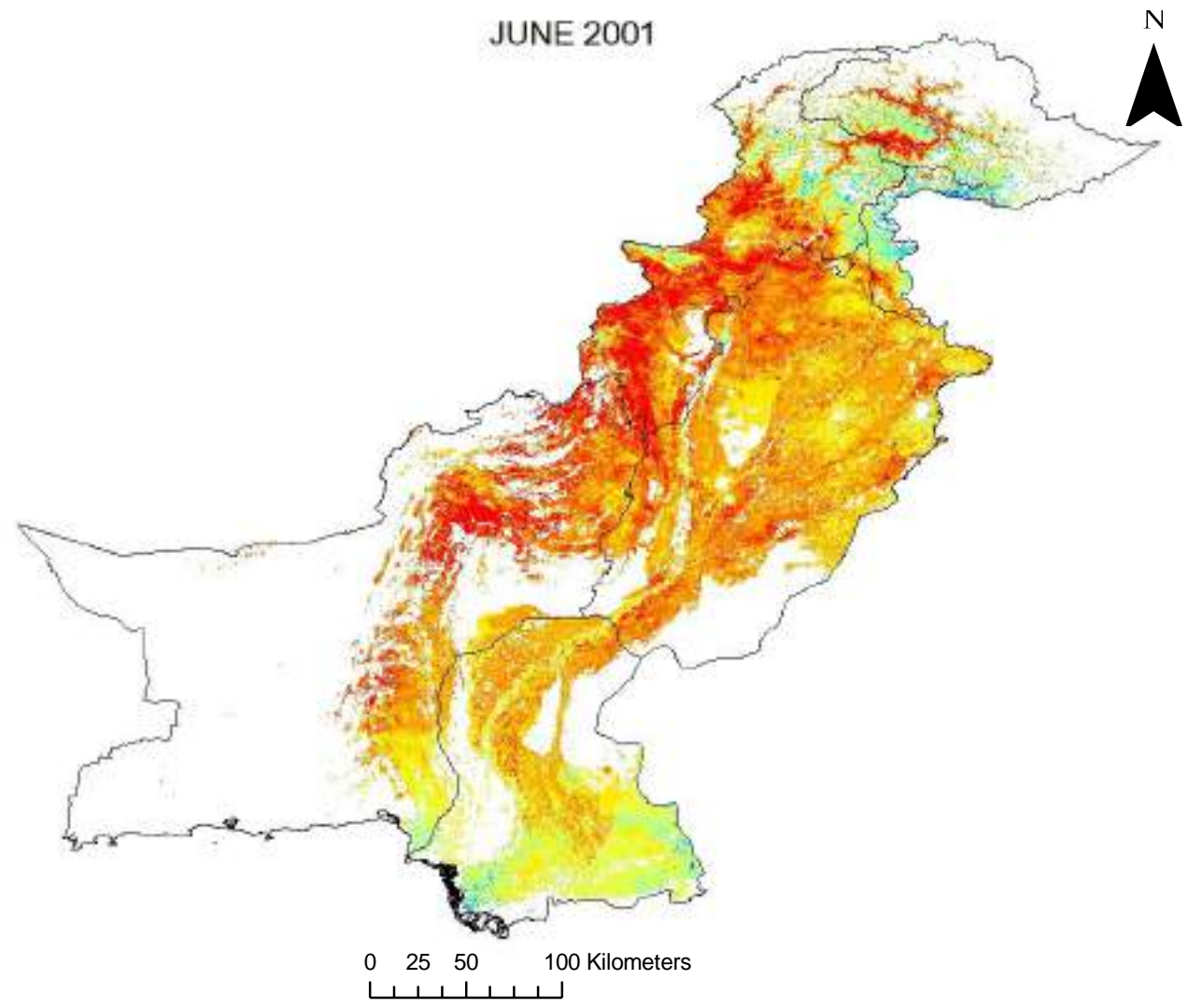
Drought conditions in June typically vary from moderate to near normal. The characteristics of this hot summer month are frequently characterized by mild and incipient drought.

Mean June DSI Values		
Years	Values	Drought Condition
2000	-0.99	Moderate Drought
2001	-0.81	Mild Drought
2002	-0.97	Moderate Drought
2003	-0.67	Mild Drought
2004	-0.88	Mild Drought
2005	-0.73	Mild Drought
2006	-0.87	Mild Drought
2007	-0.33	Incipient Drought
2008	-0.54	Incipient Drought
2009	-0.73	Mild Drought
2010	-0.41	Incipient Drought
2011	-0.62	Mild Drought
2012	-0.76	Mild Drought
2013	-0.37	Incipient Drought
2014	-0.66	Mild Drought
2015	-0.31	Incipient Drought
2016	-0.31	Incipient Drought
2017	-0.36	Incipient Drought
2018	-0.40	Incipient Drought
2019	-0.20	Near Normal
2020	0.12	Near Normal

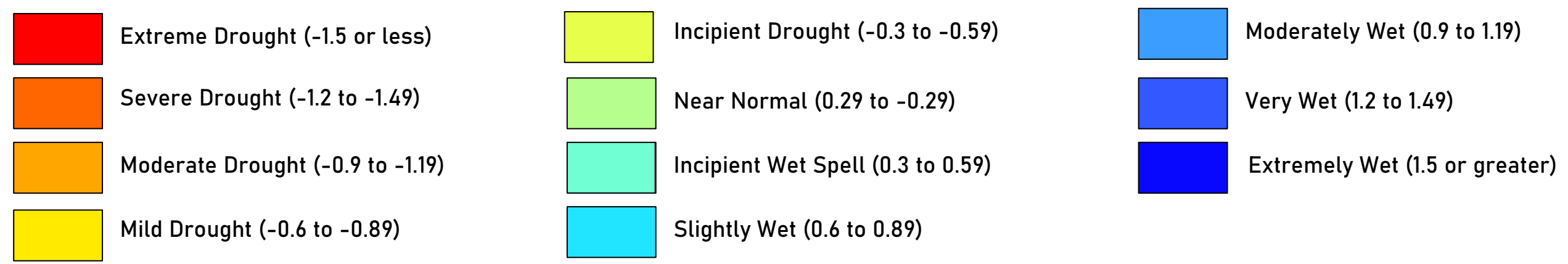


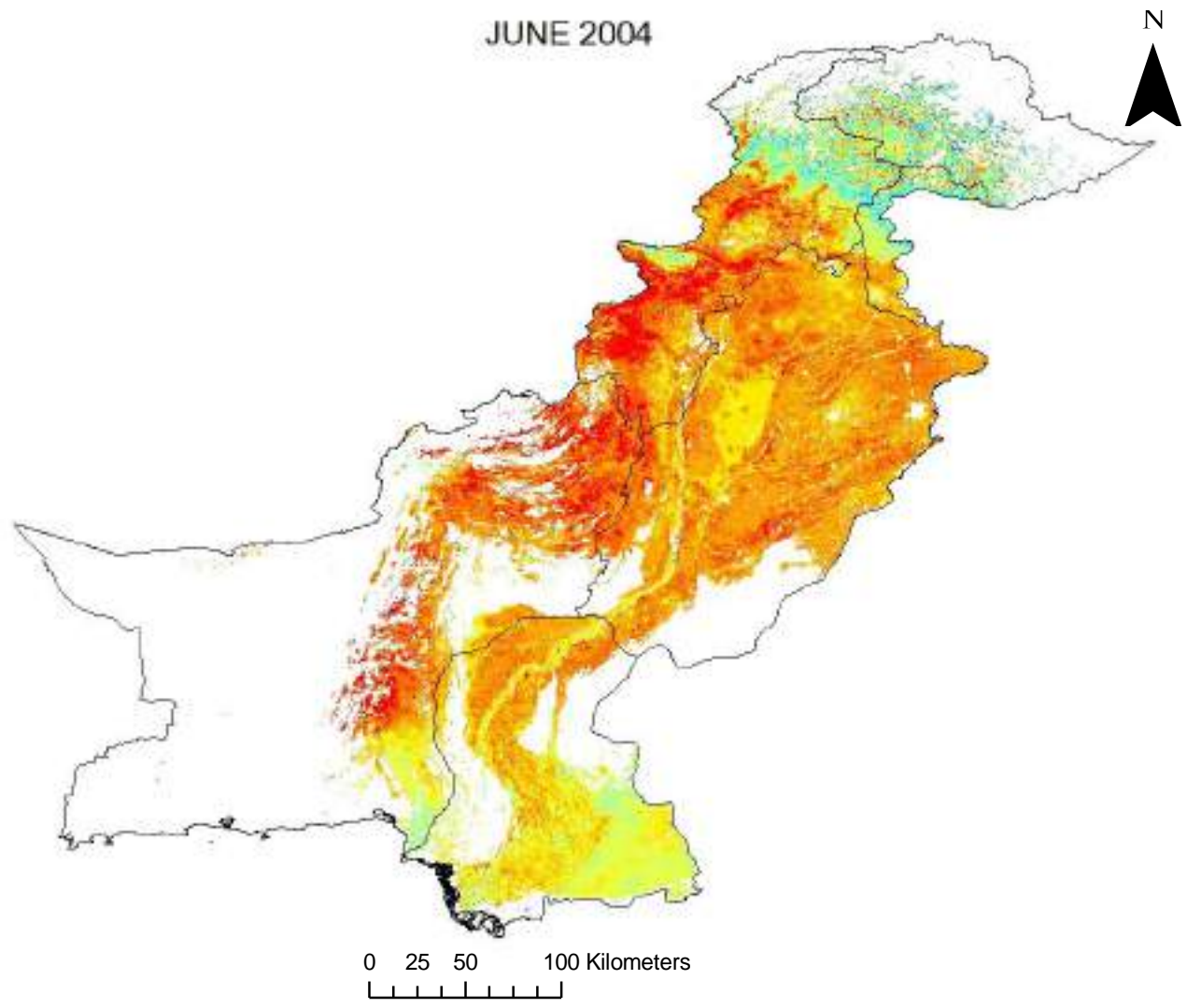
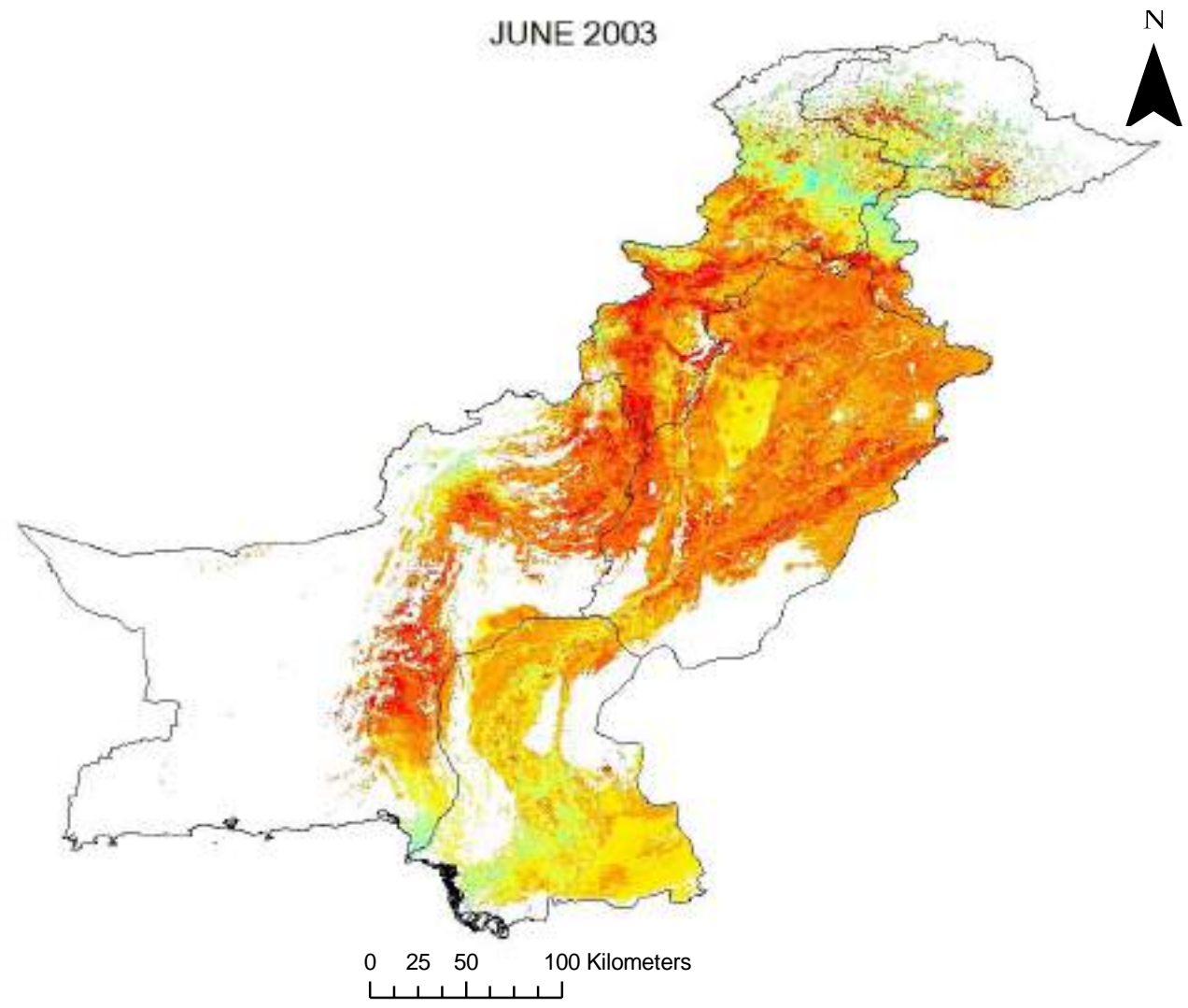
Legend



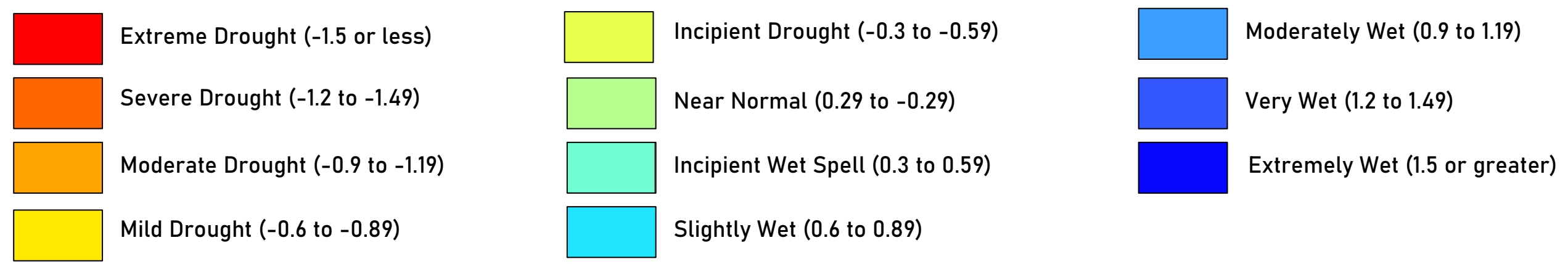


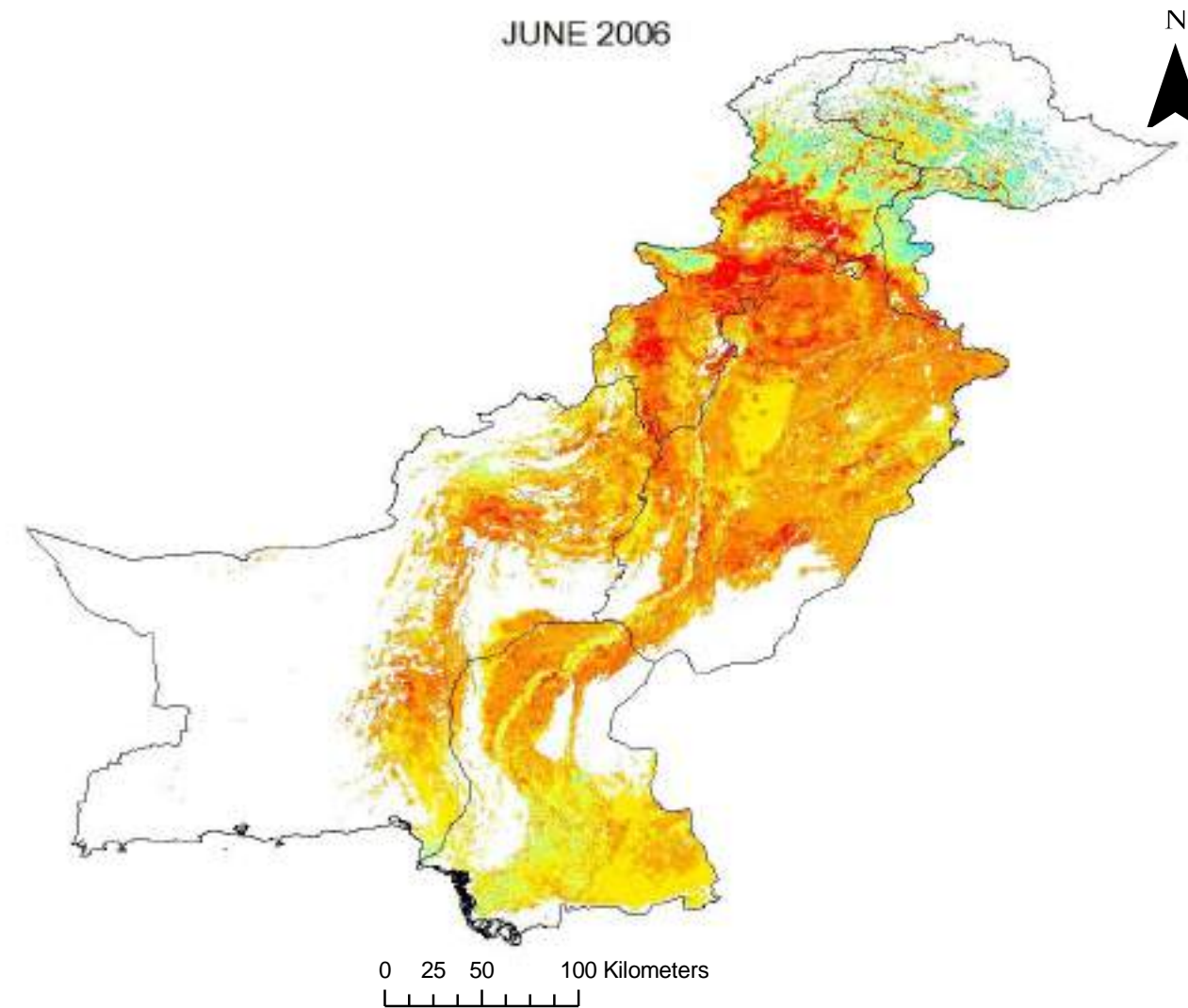
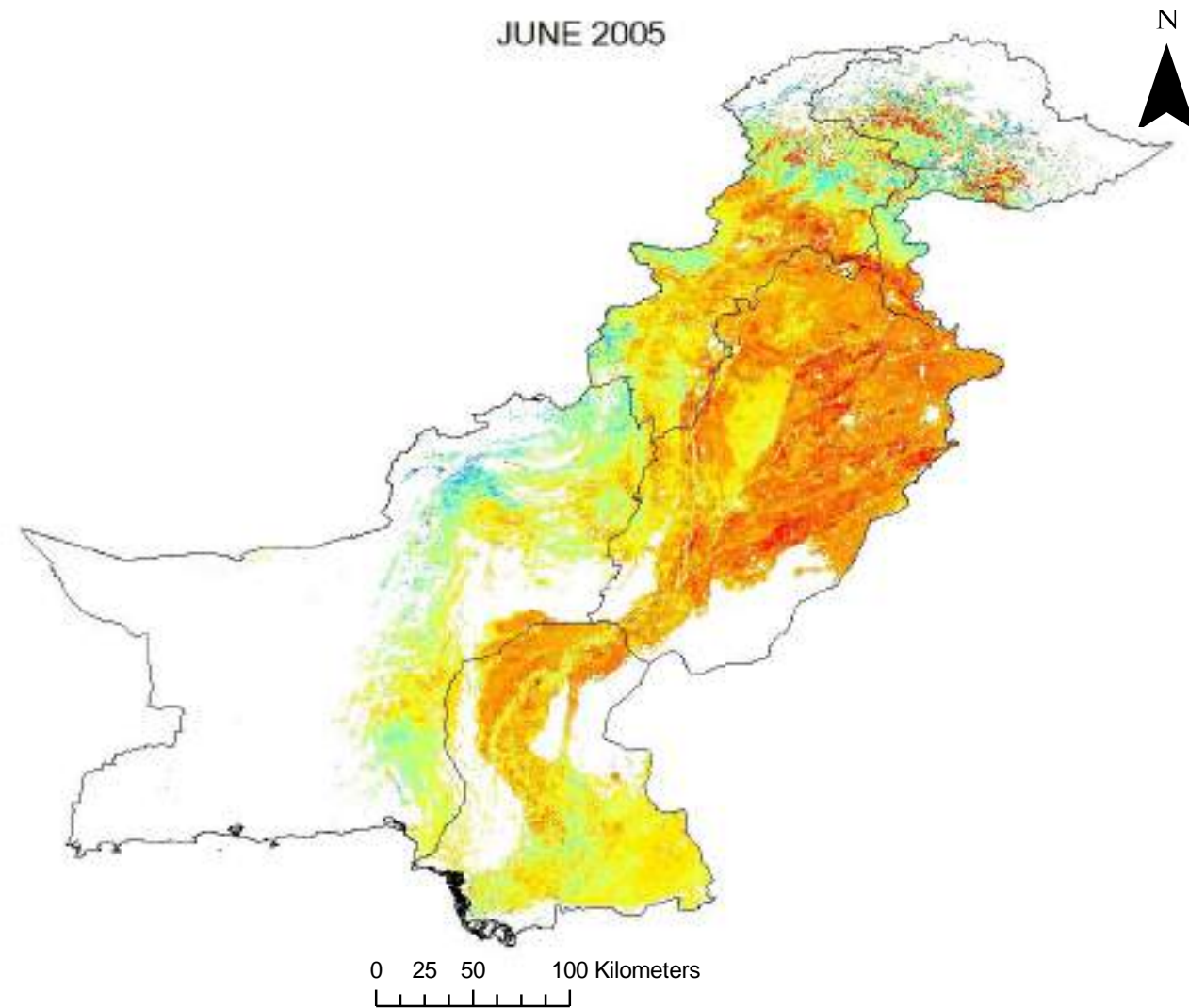
Legend



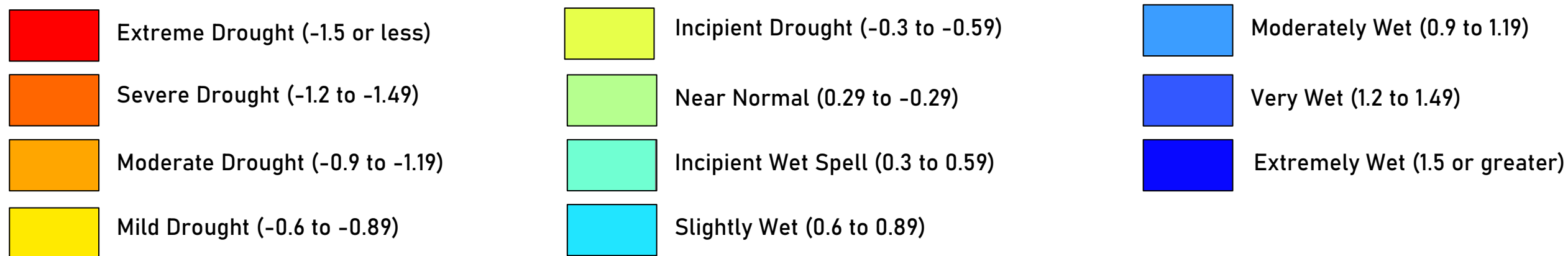


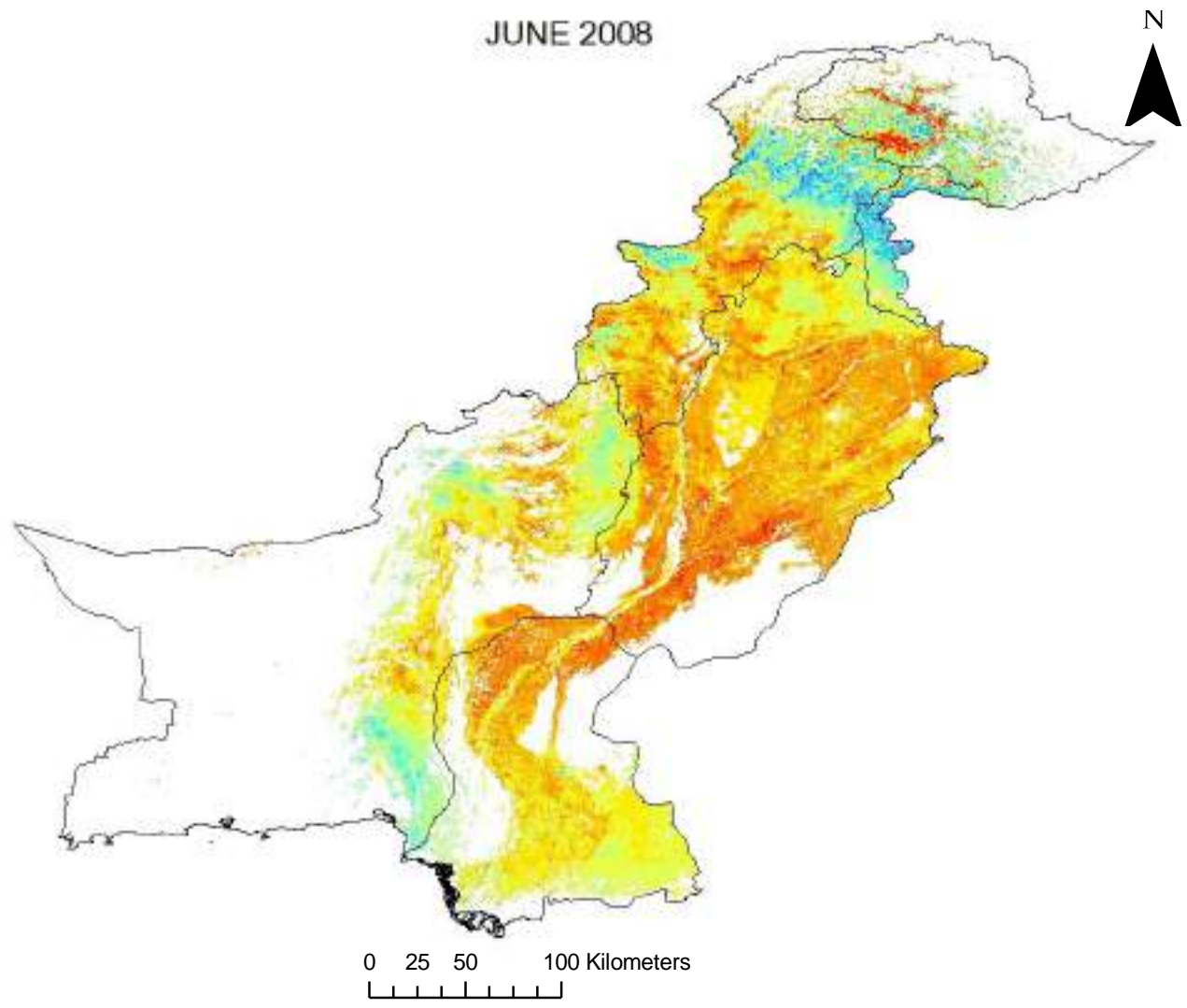
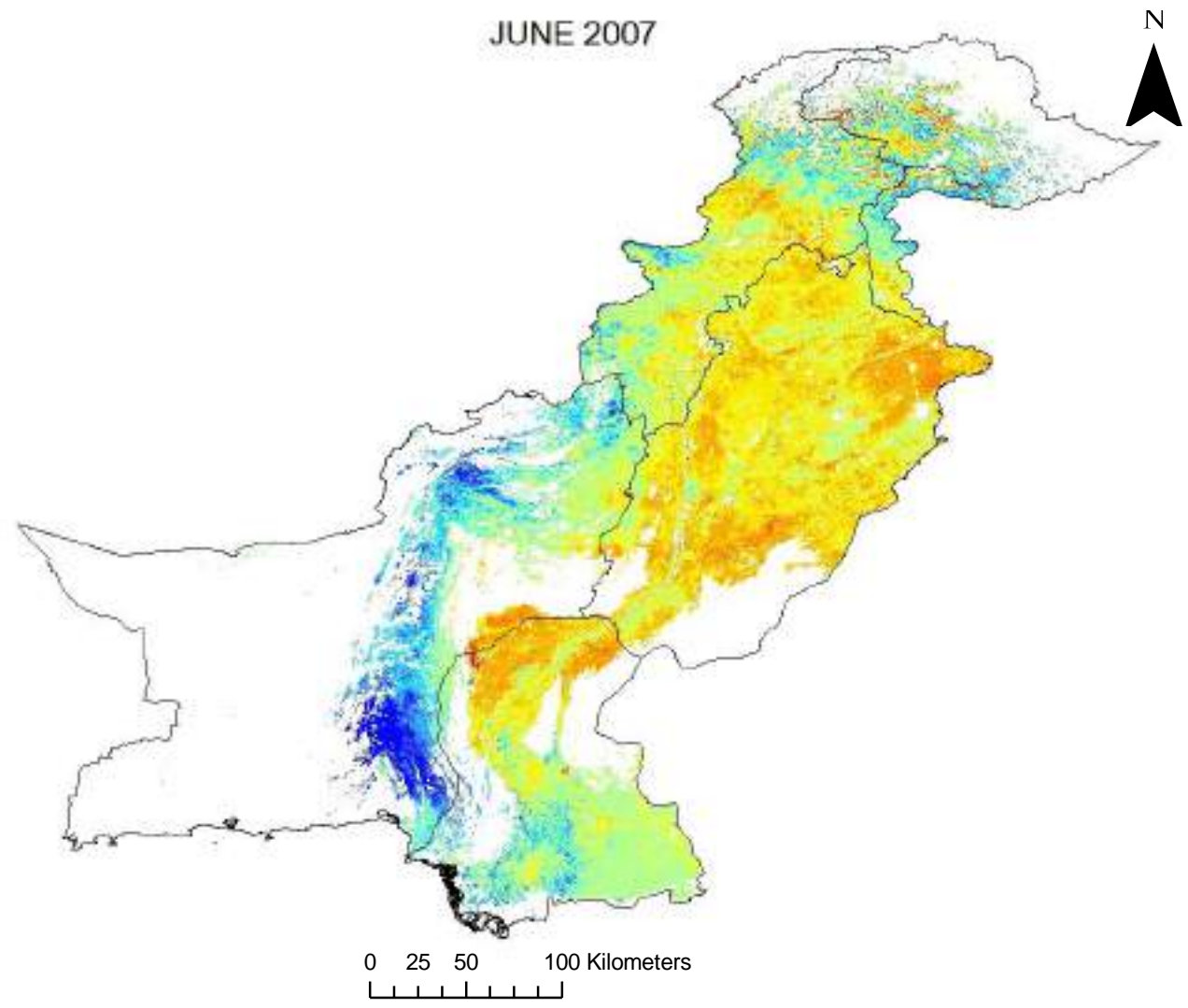
Legend
















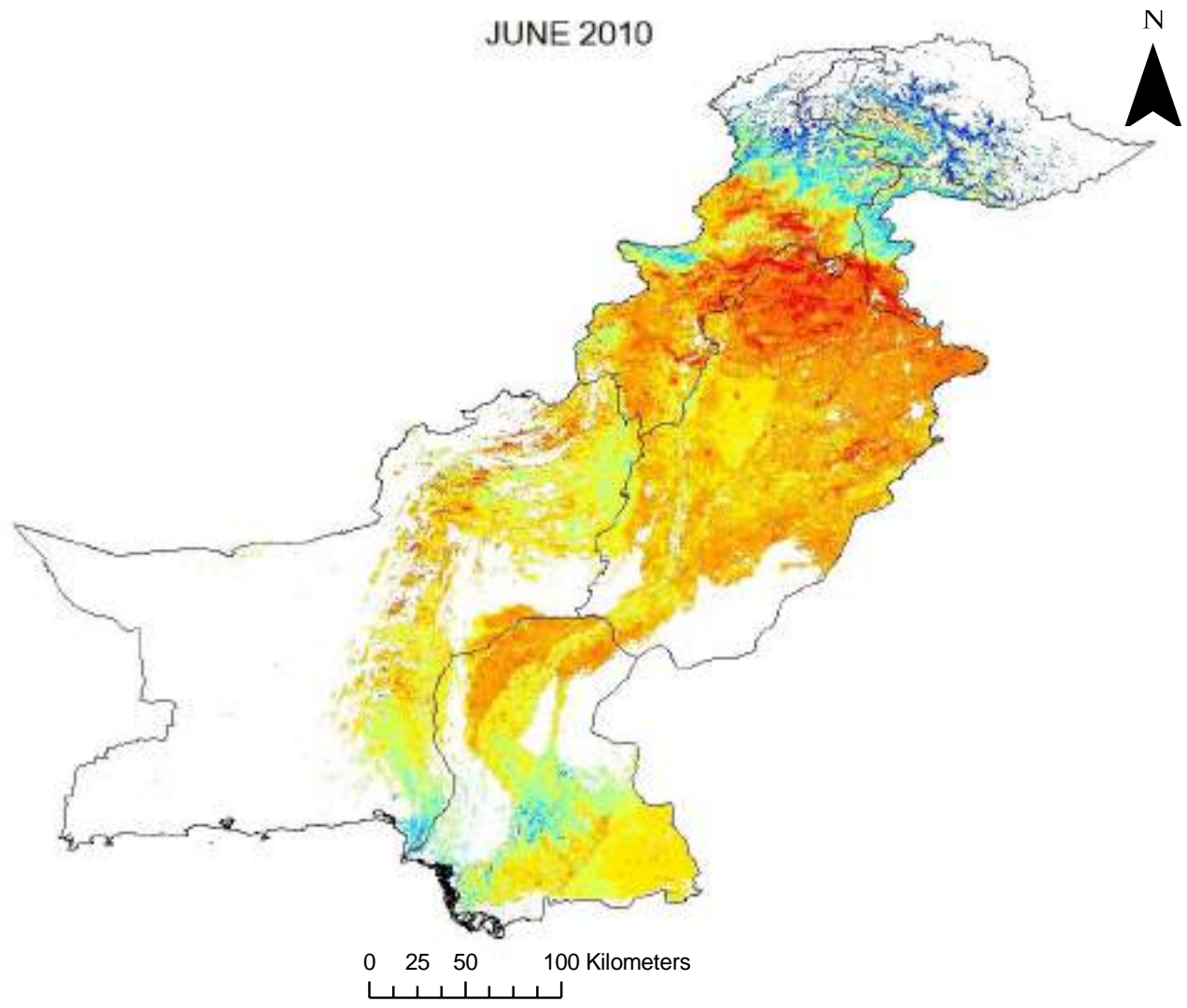
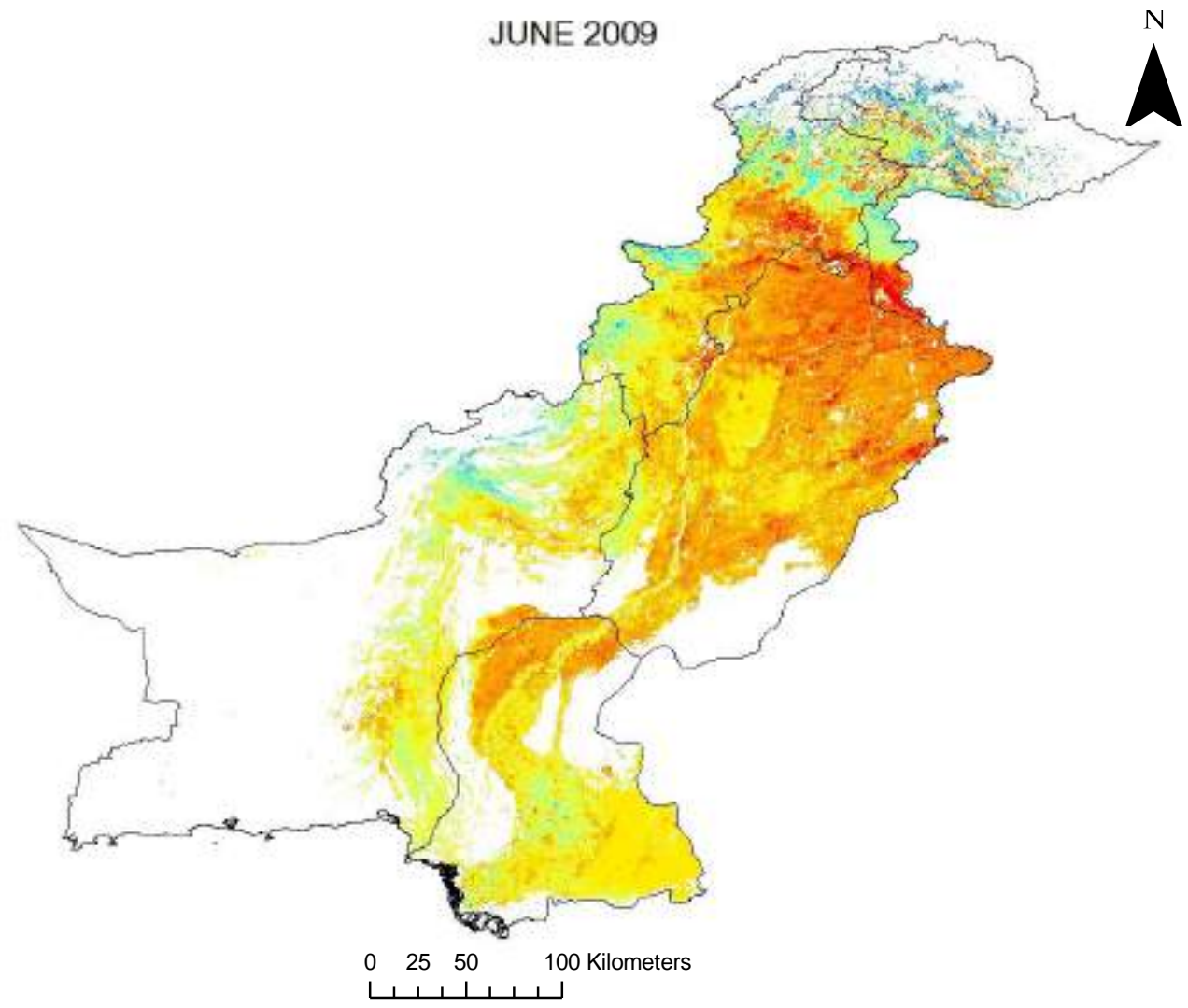
Legend
















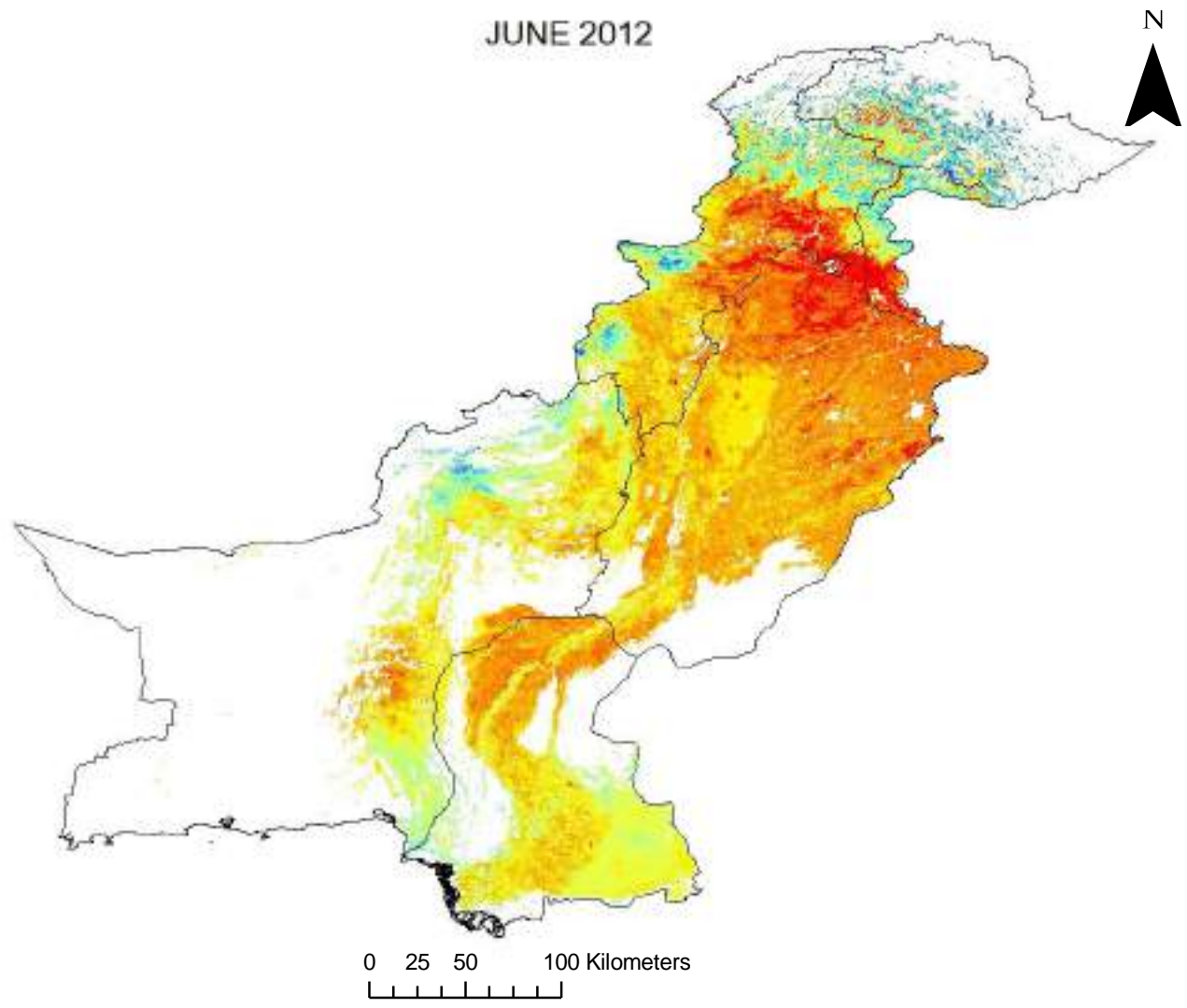
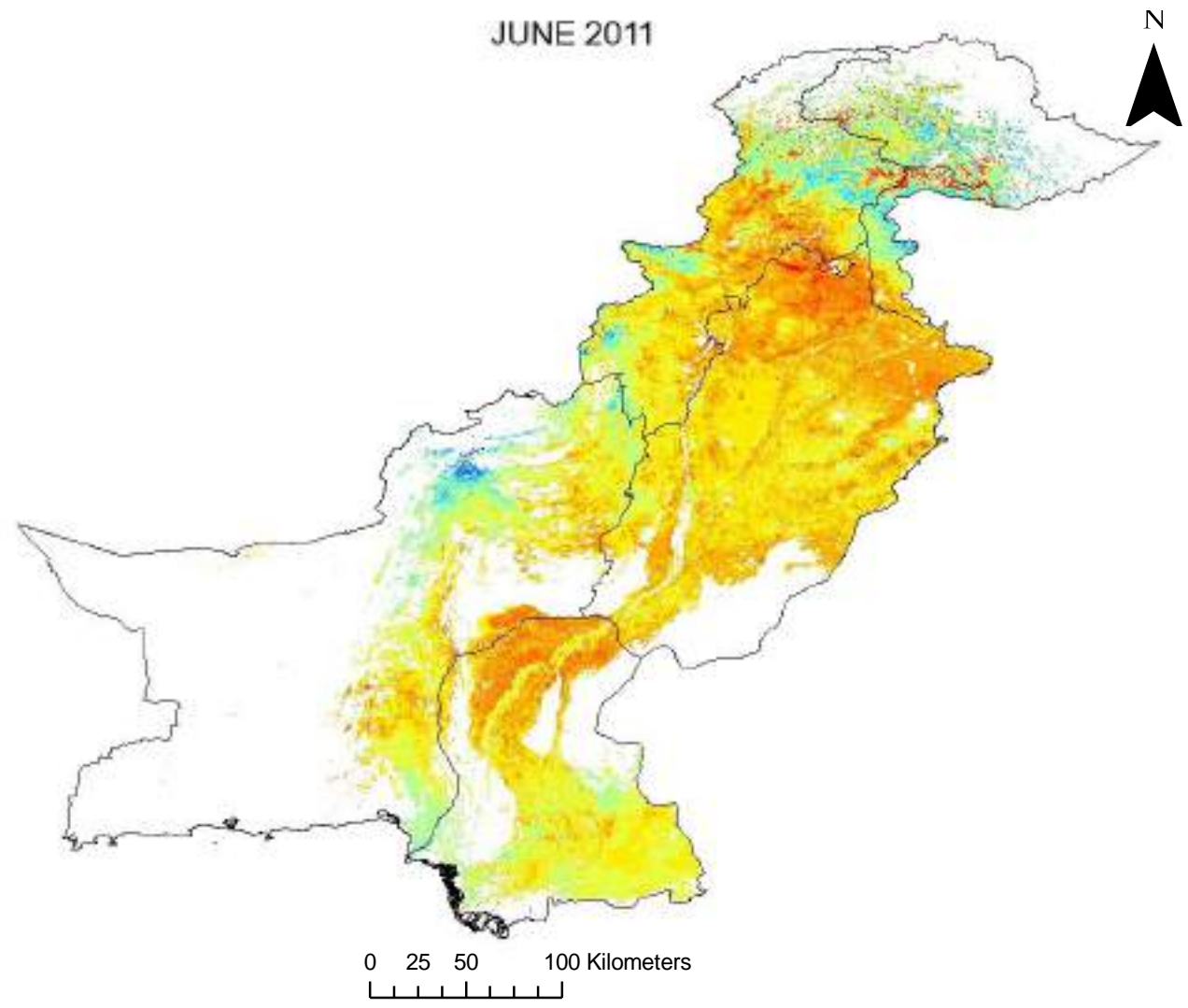
Legend

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|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
|  | Severe Drought (-1.2 to -1.49) |  | Near Normal (0.29 to -0.29) |  | Very Wet (1.2 to 1.49) |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89) |  | Slightly Wet (0.6 to 0.89) | | |














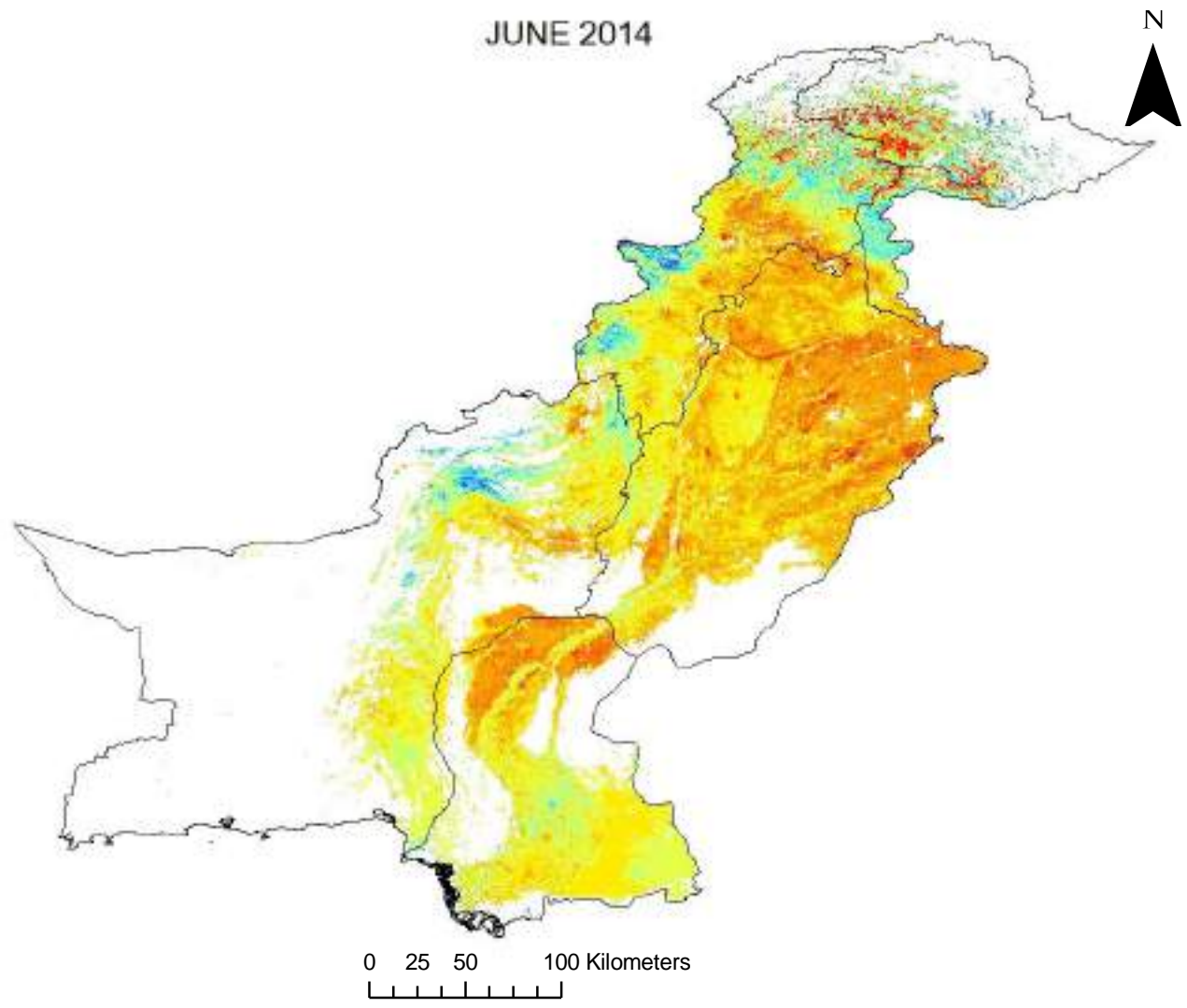
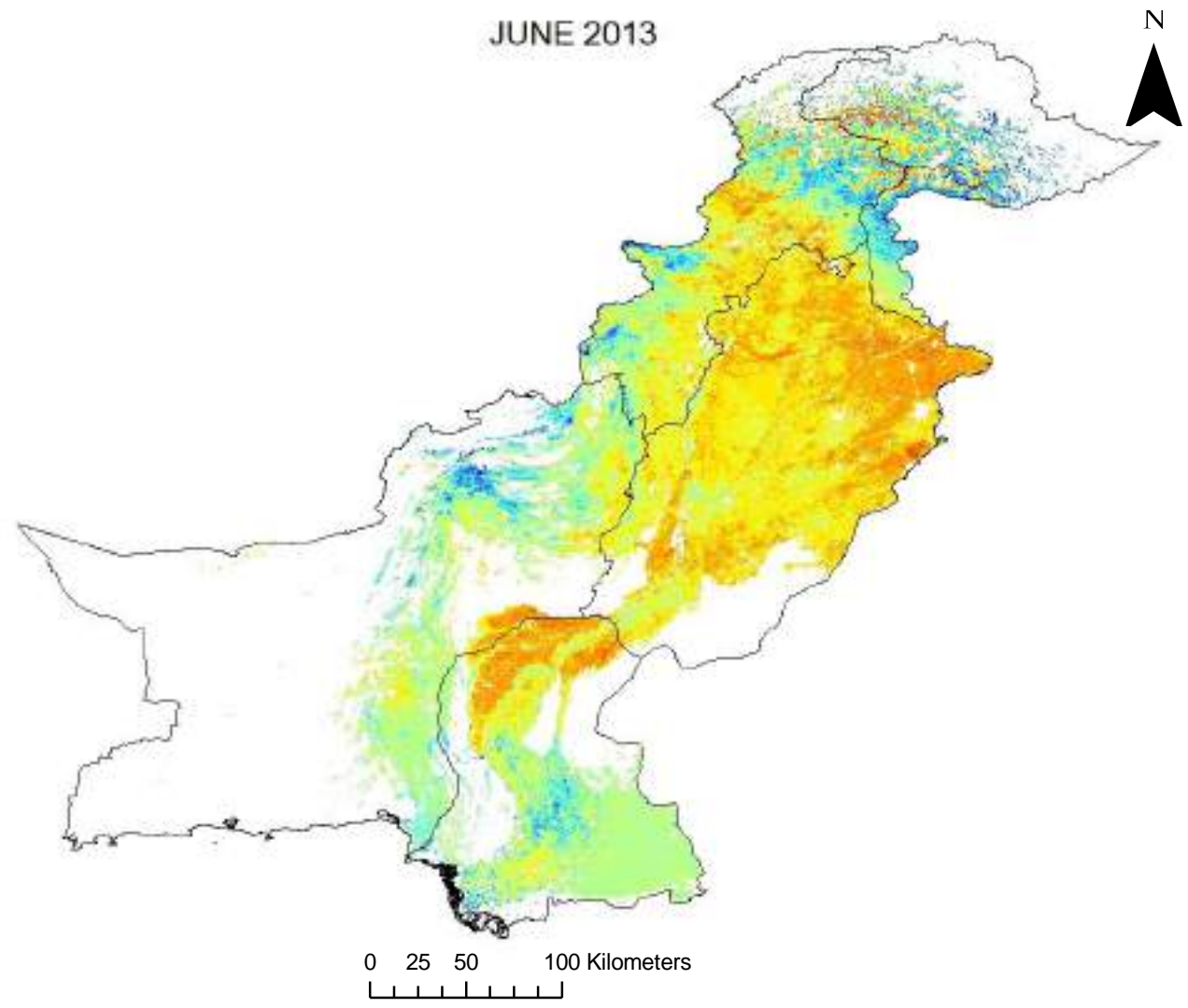
Legend

- | | | | | | |
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|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
|  | Severe Drought (-1.2 to -1.49) |  | Near Normal (0.29 to -0.29) |  | Very Wet (1.2 to 1.49) |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89) |  | Slightly Wet (0.6 to 0.89) | | |














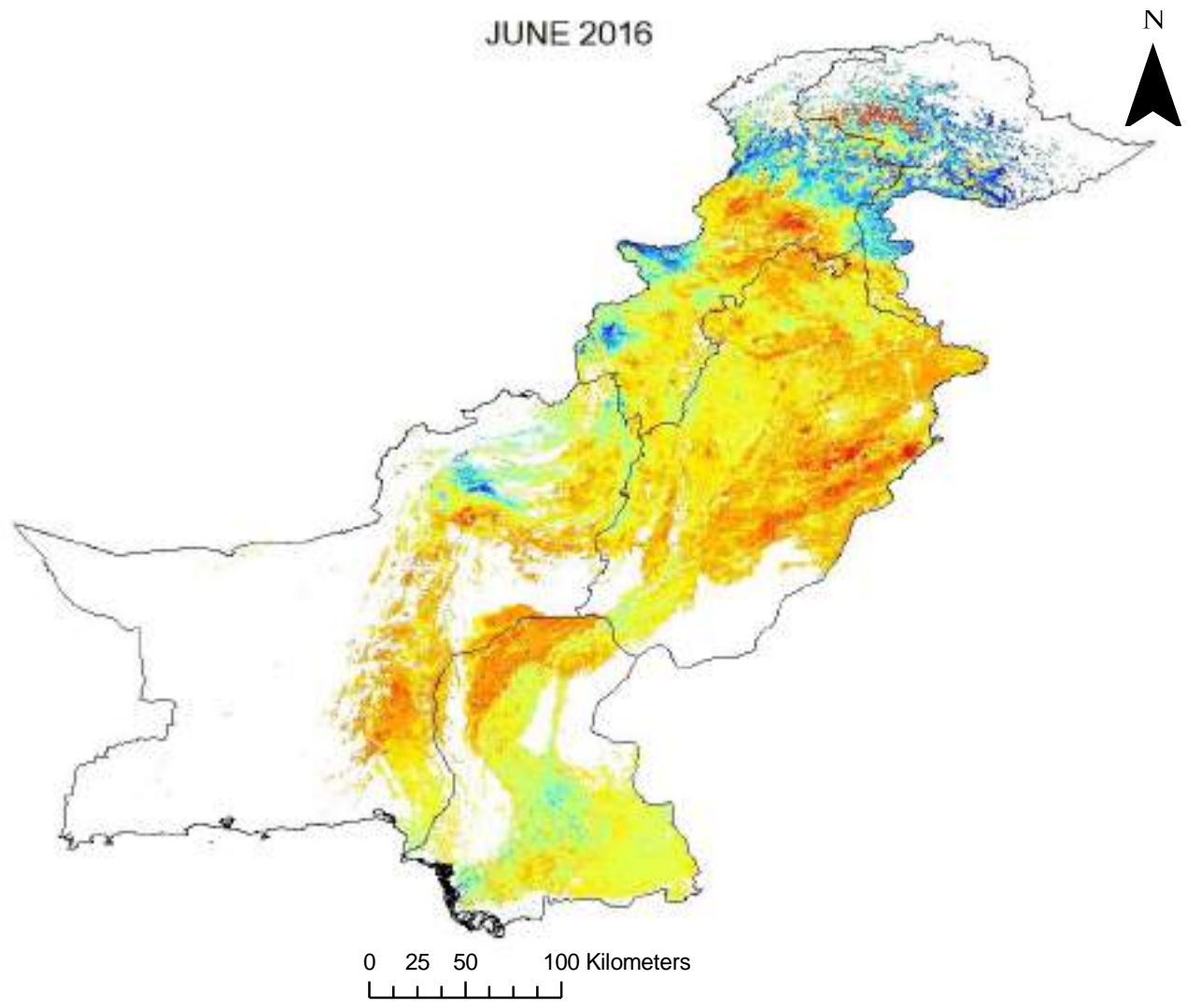
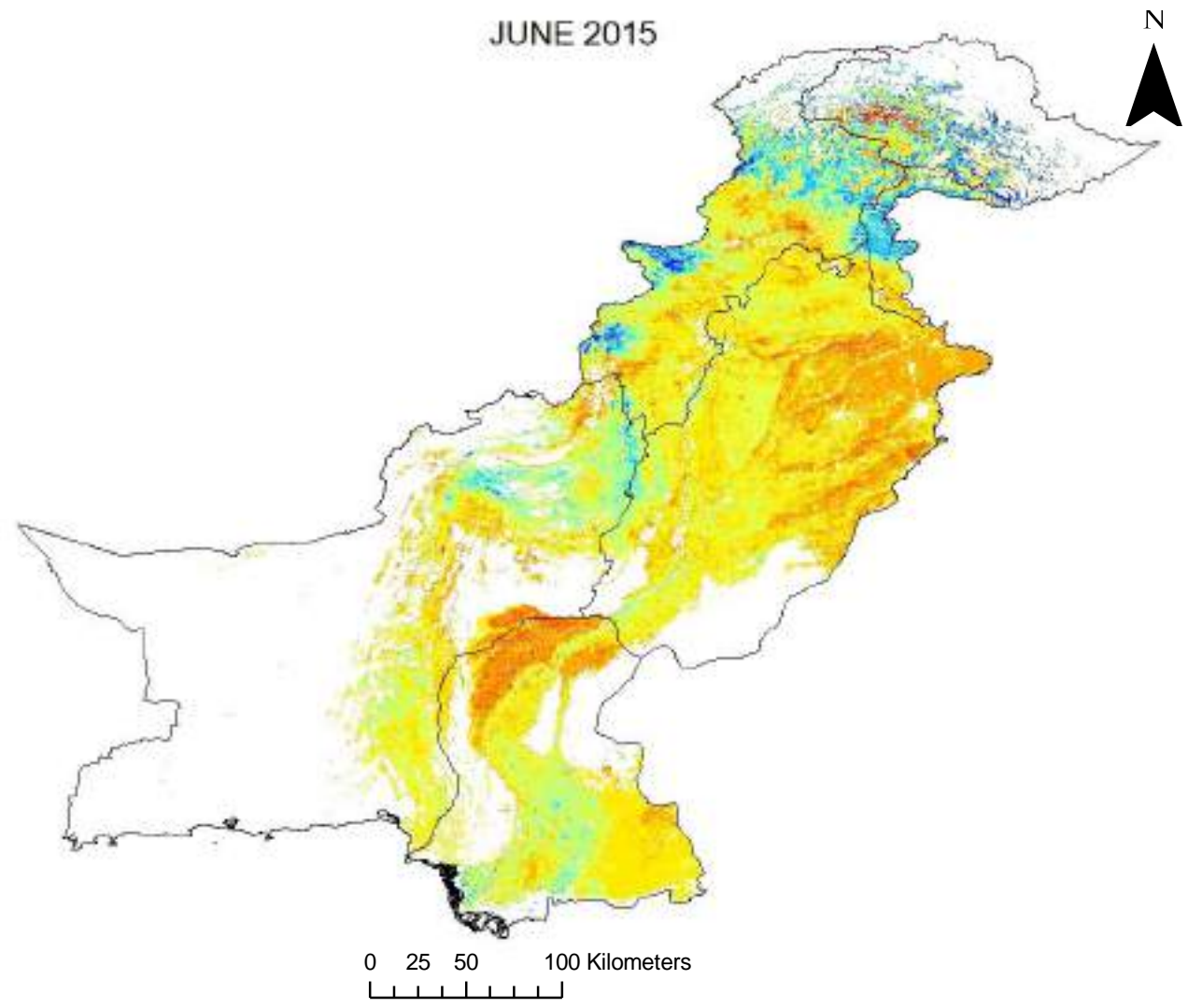
Legend

	Extreme Drought (-1.5 or less)		Incipient Drought (-0.3 to -0.59)		Moderately Wet (0.9 to 1.19)
	Severe Drought (-1.2 to -1.49)		Near Normal (0.29 to -0.29)		Very Wet (1.2 to 1.49)
	Moderate Drought (-0.9 to -1.19)		Incipient Wet Spell (0.3 to 0.59)		Extremely Wet (1.5 or greater)
	Mild Drought (-0.6 to -0.89)		Slightly Wet (0.6 to 0.89)		














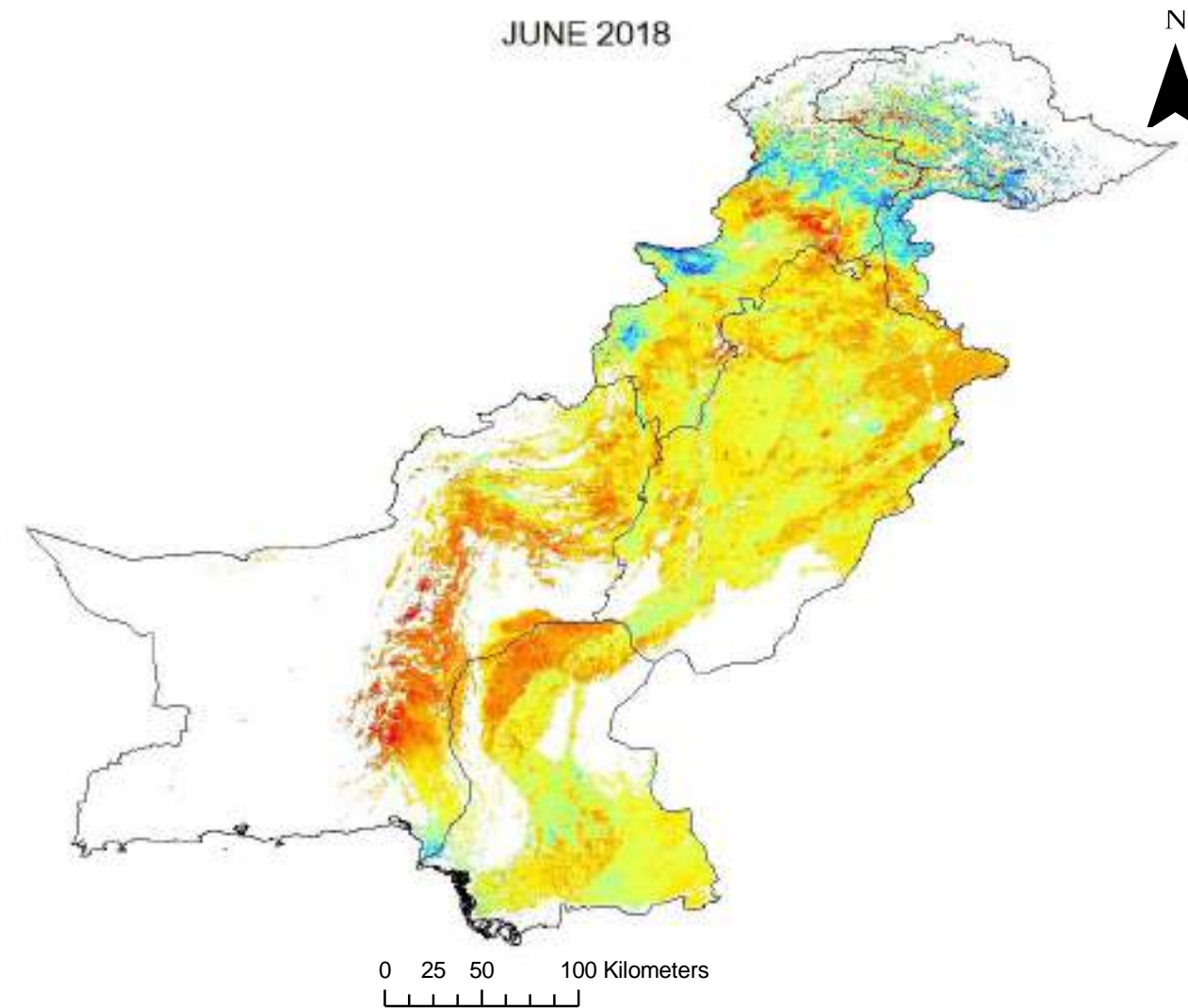
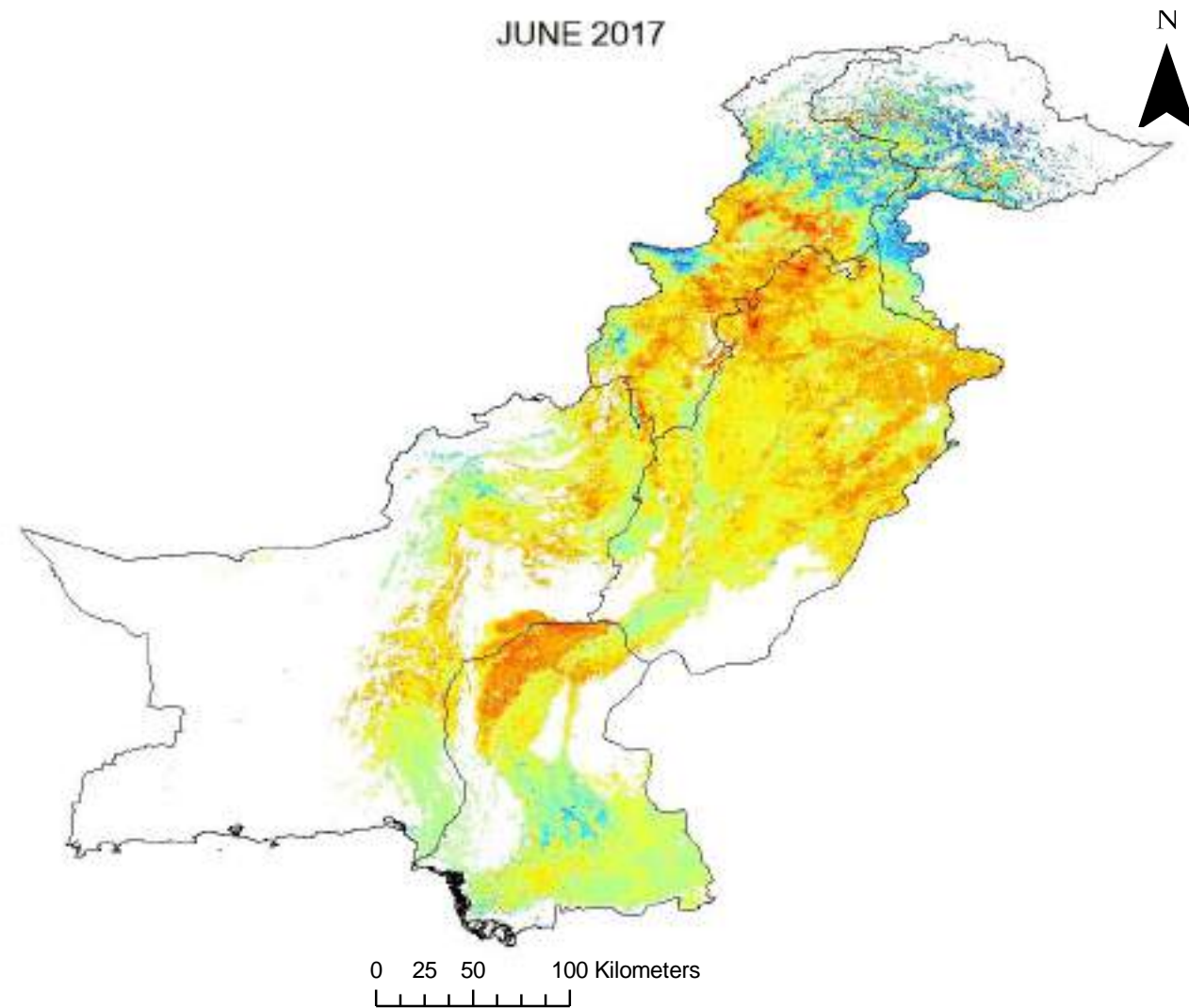
Legend

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|--|---|--|
|  Extreme Drought (-1.5 or less) |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19) |
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|  Mild Drought (-0.6 to -0.89) |  Slightly Wet (0.6 to 0.89) | |

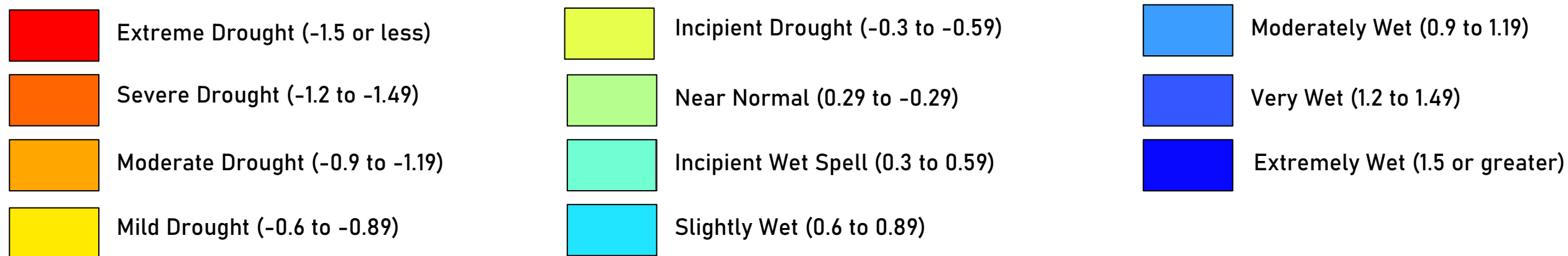


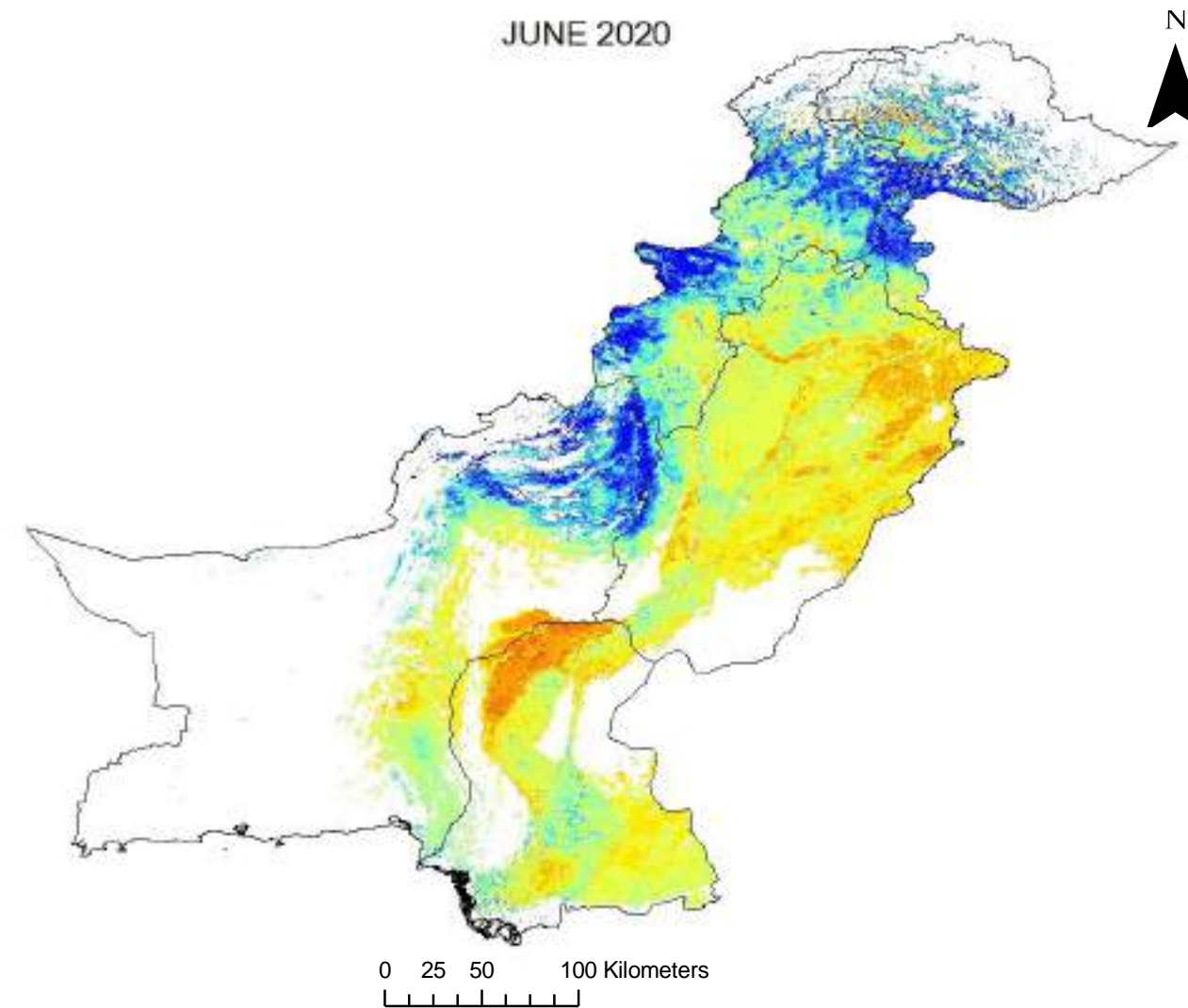
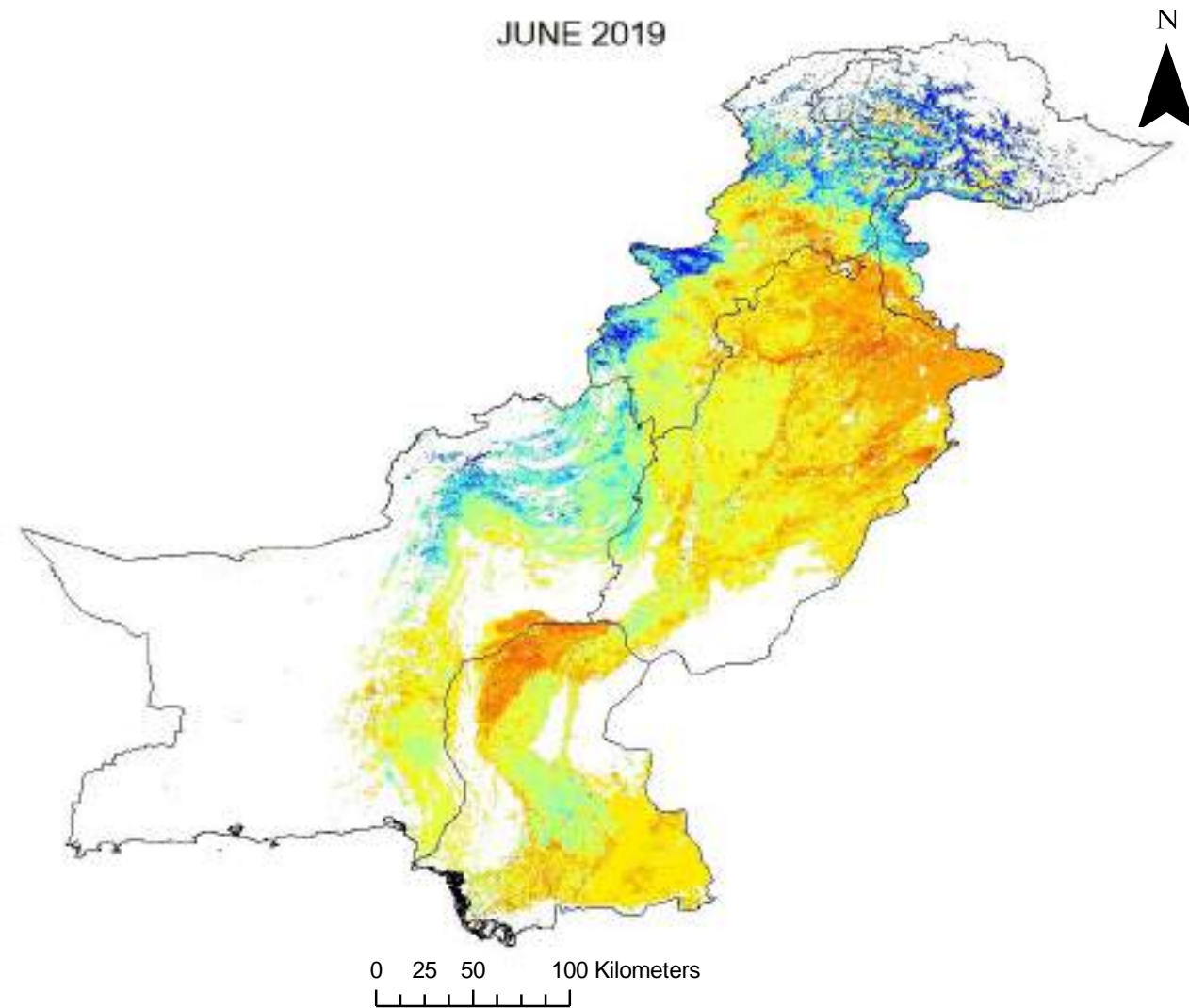
Legend

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|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
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|  | Mild Drought (-0.6 to -0.89) |  | Slightly Wet (0.6 to 0.89) | | |

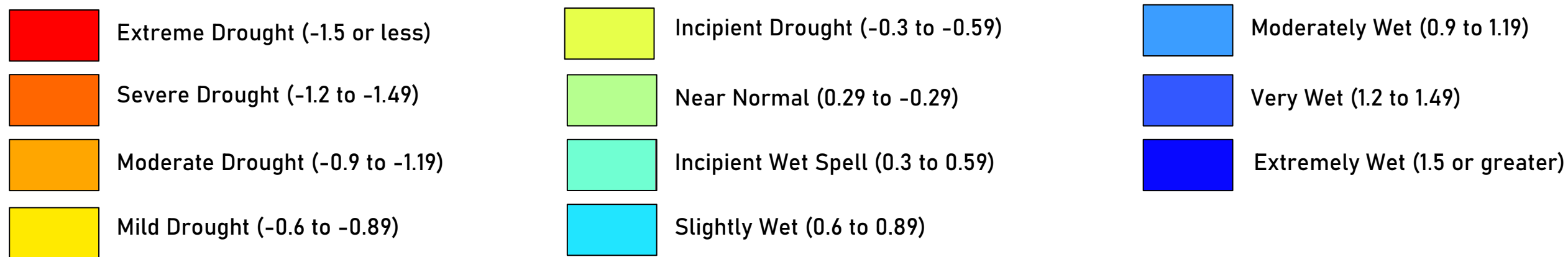


Legend





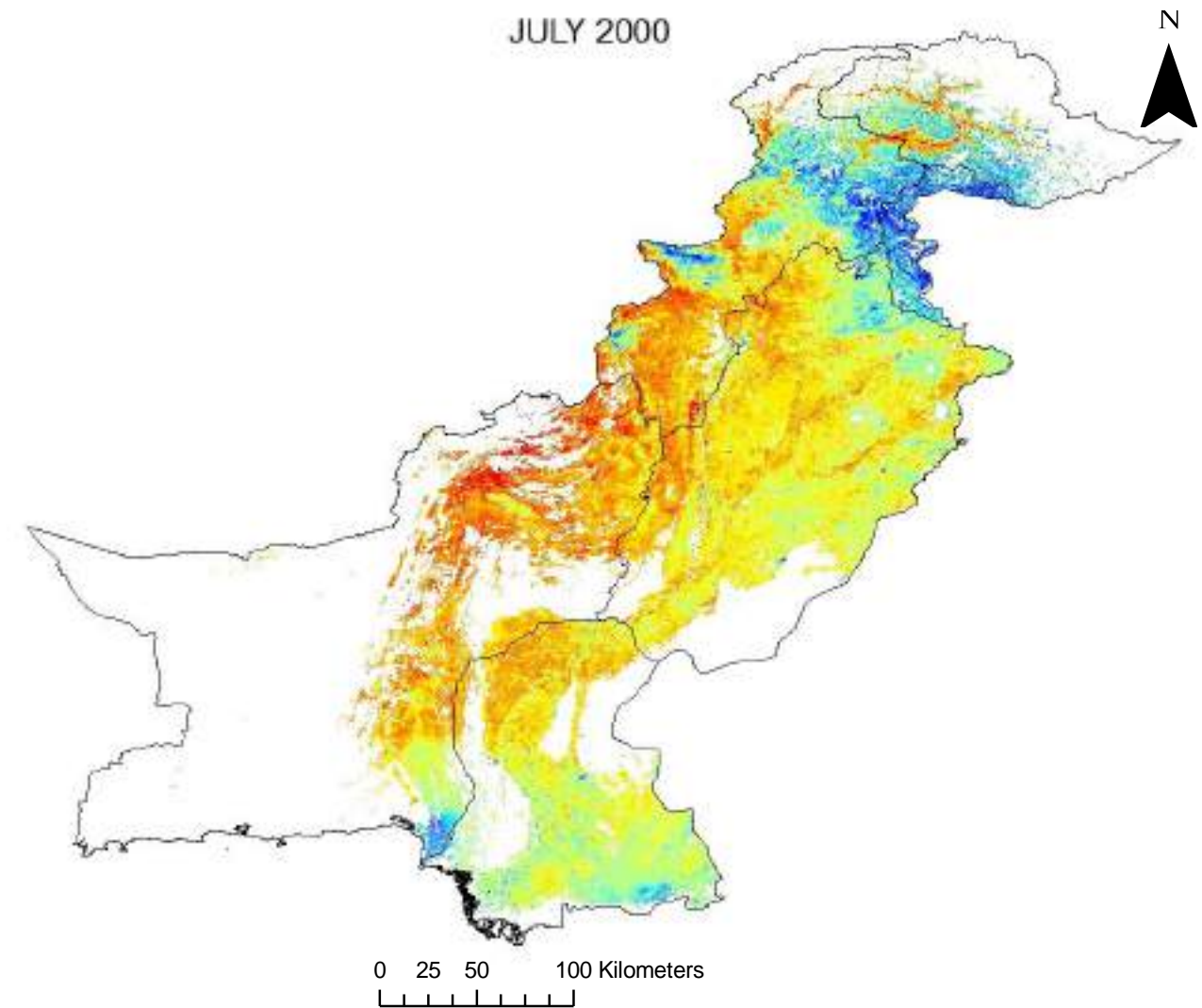
Legend



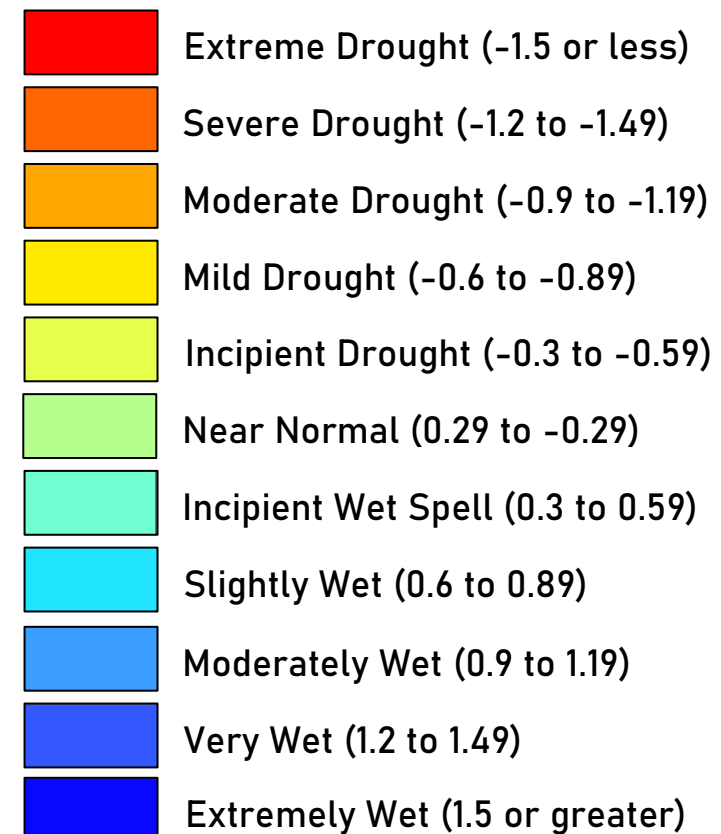
July DSI Maps

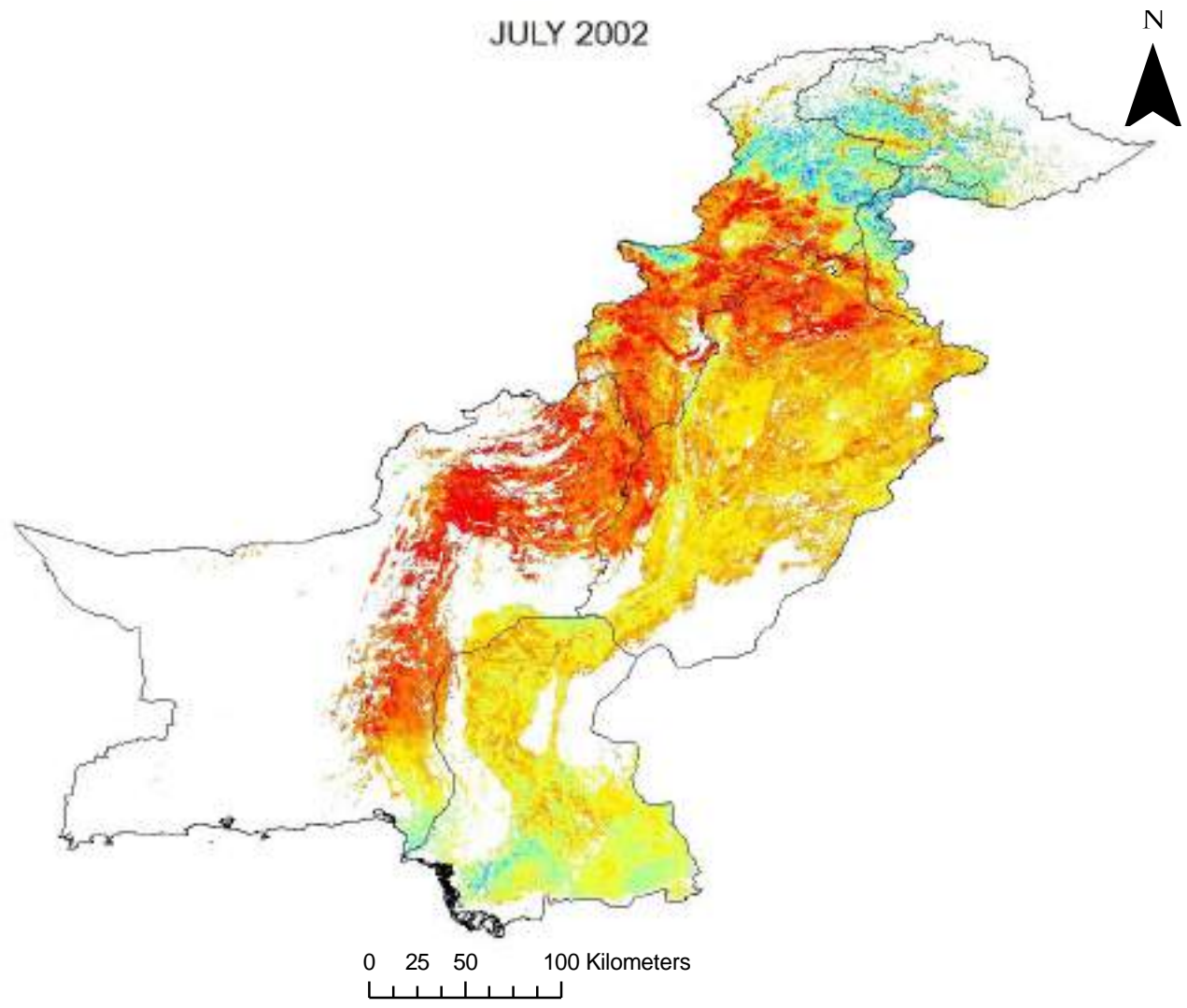
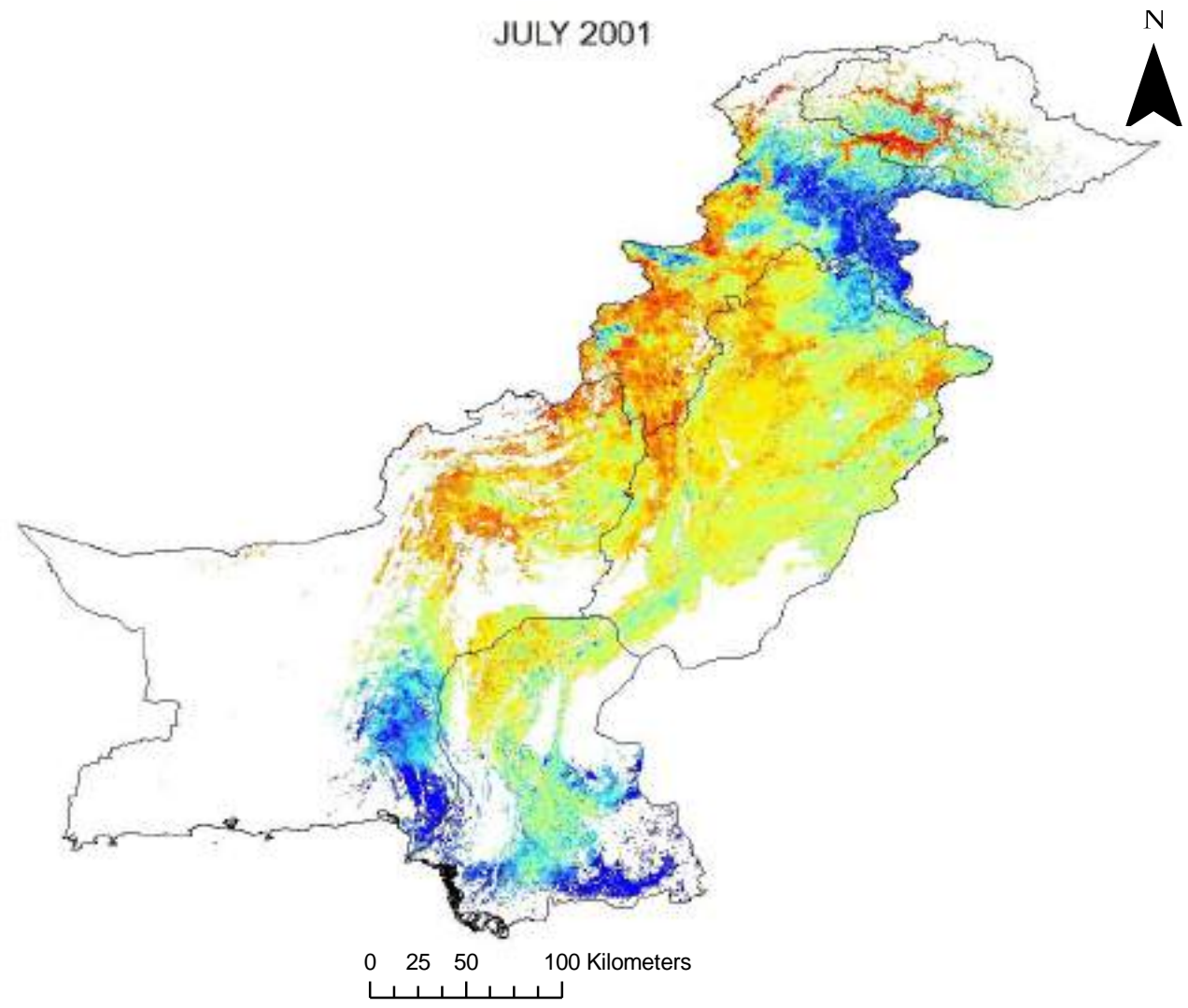
In July, drought condition varies from mild drought to slightly wet condition. July is the monsoon month but mild drought was seen in year 2002.

Mean July DSI Values		
Years	Values	Drought Condition
2000	-0.09	Near Normal
2001	0.07	Near Normal
2002	-0.68	Mild Drought
2003	0.52	Incipient Wet Spell
2004	-0.37	Incipient Drought
2005	-0.01	Near Normal
2006	-0.03	Near Normal
2007	0.27	Near Normal
2008	0.20	Near Normal
2009	-0.25	Near Normal
2010	0.30	Incipient Wet Spell
2011	0.07	Near Normal
2012	-0.44	Incipient Drought
2013	0.40	Incipient Wet Spell
2014	-0.09	Near Normal
2015	0.61	Slightly Wet
2016	0.47	Incipient Wet Spell
2017	0.69	Slightly Wet
2018	0.52	Incipient Wet Spell
2019	0.67	Slightly Wet
2020	0.56	Incipient Wet Spell

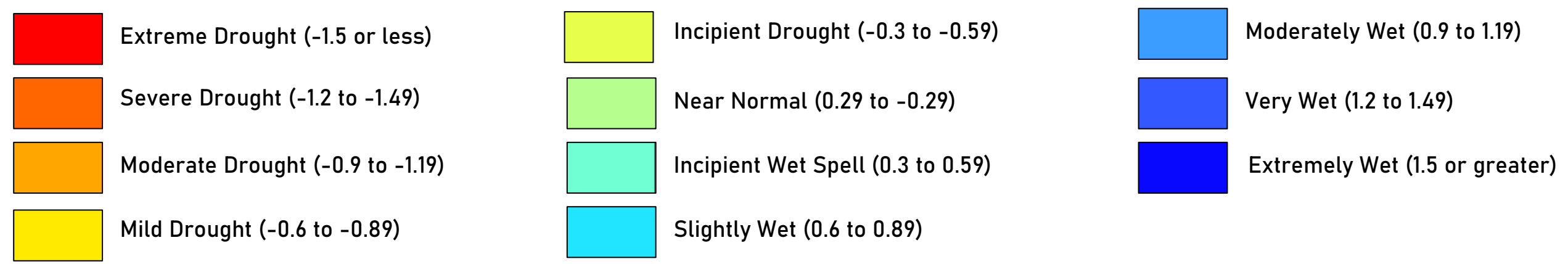


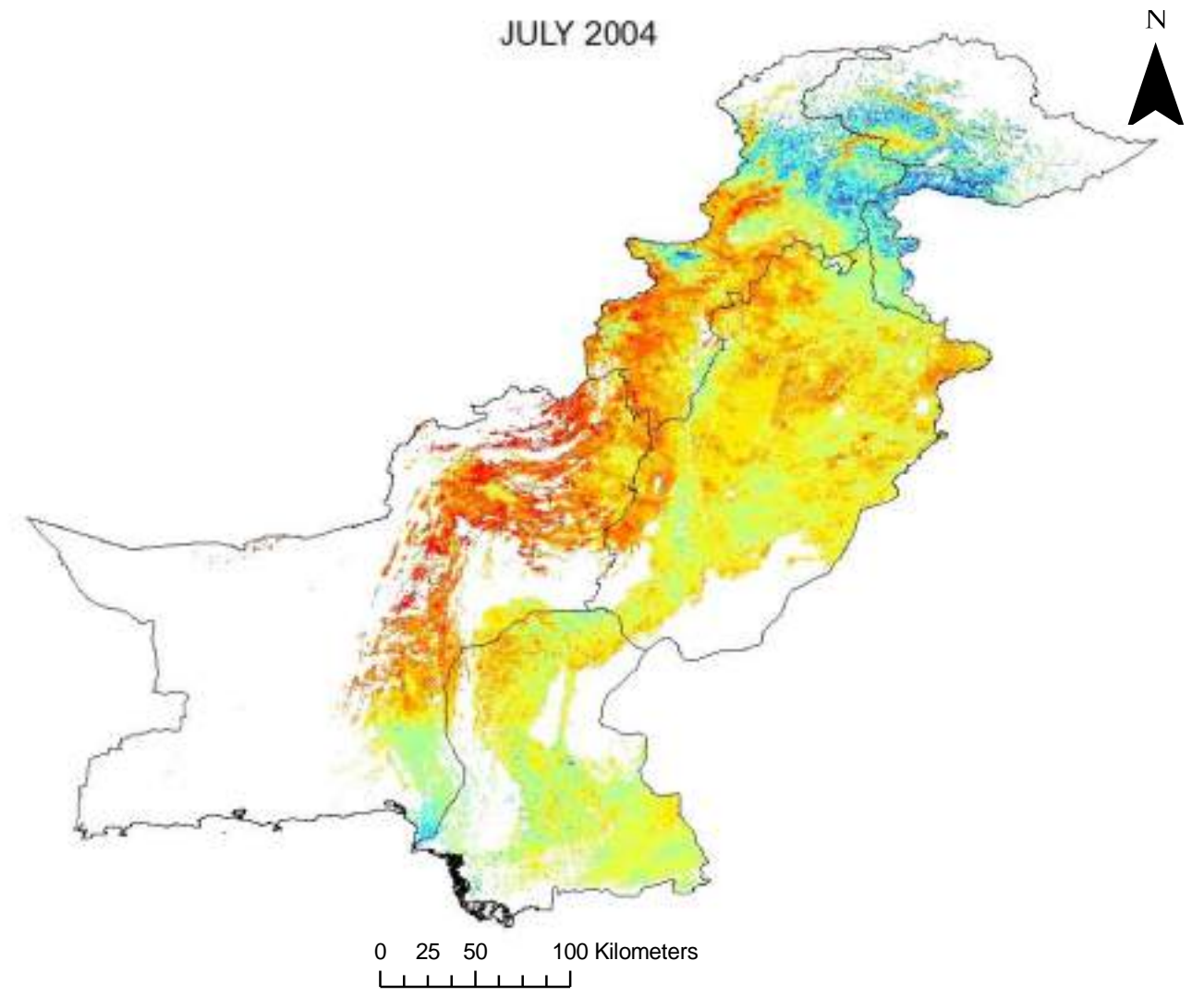
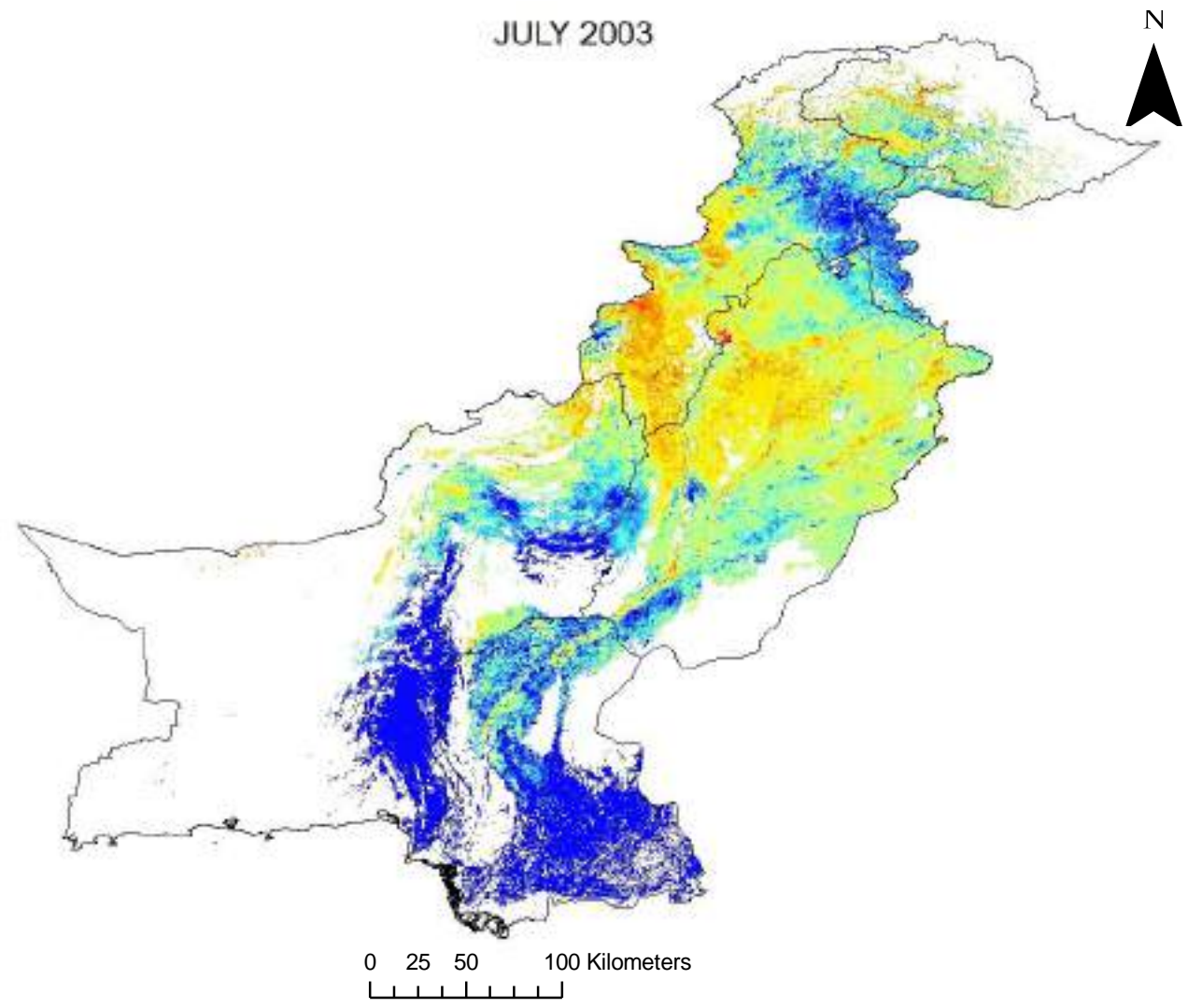
Legend
















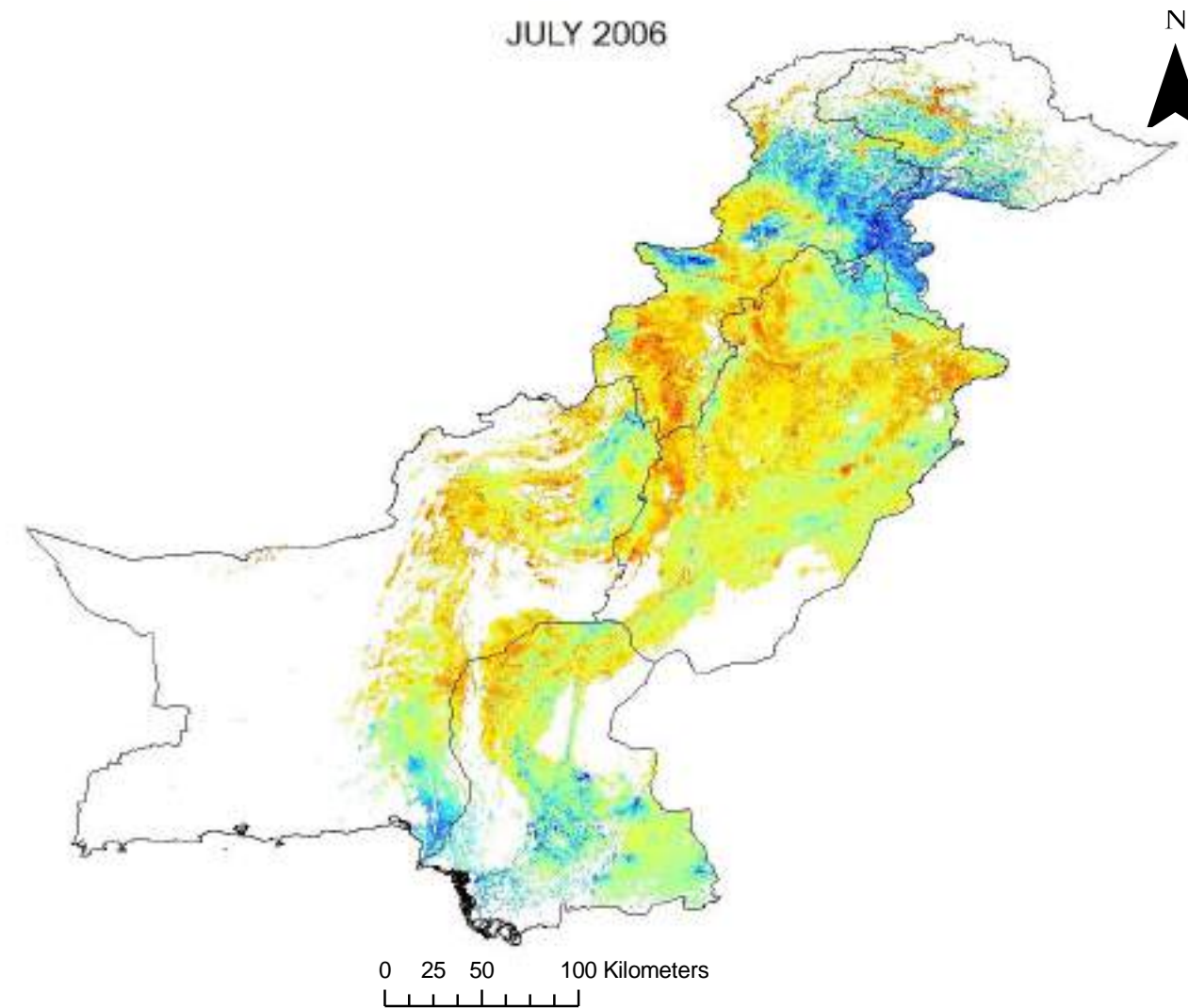
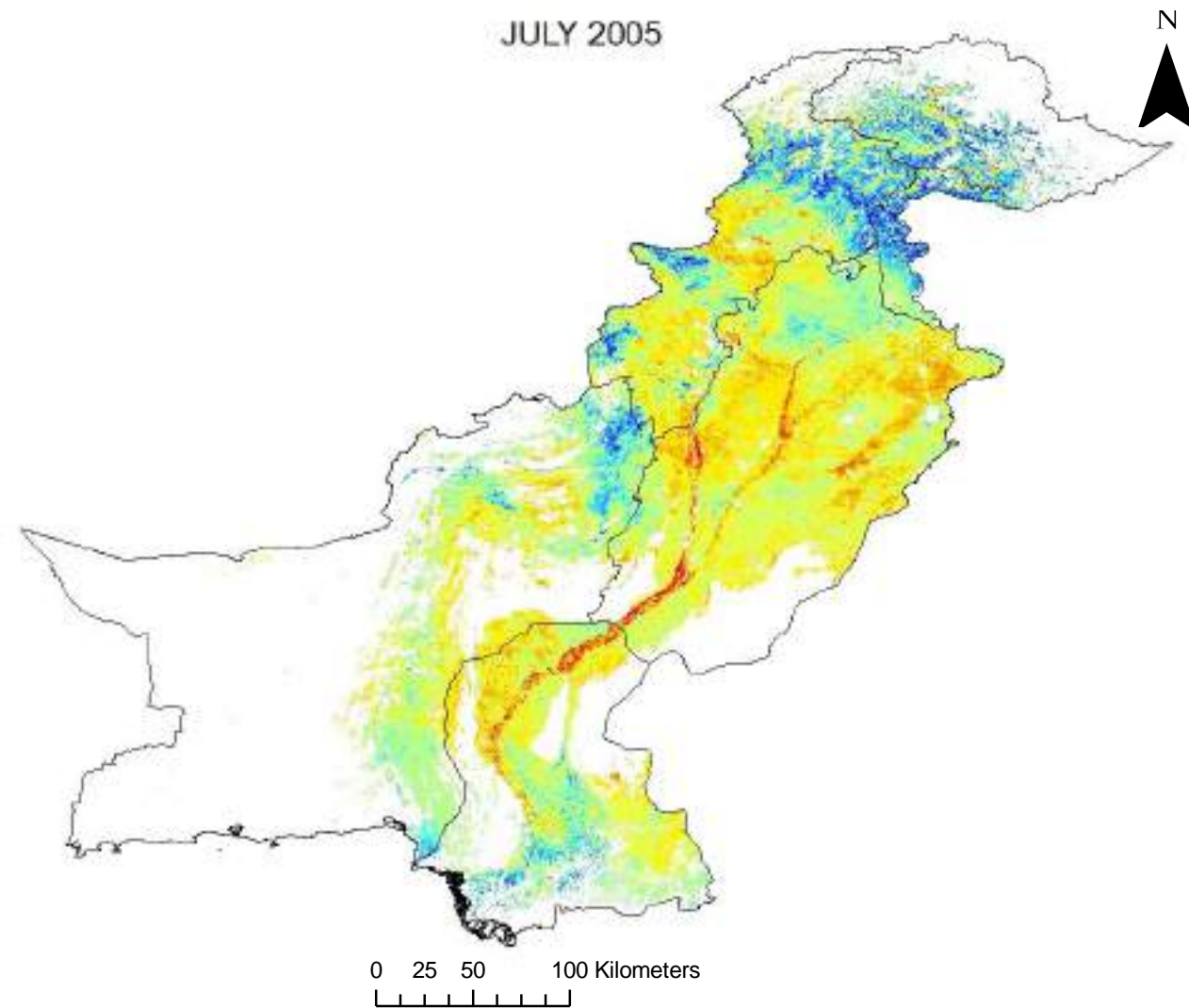
Legend



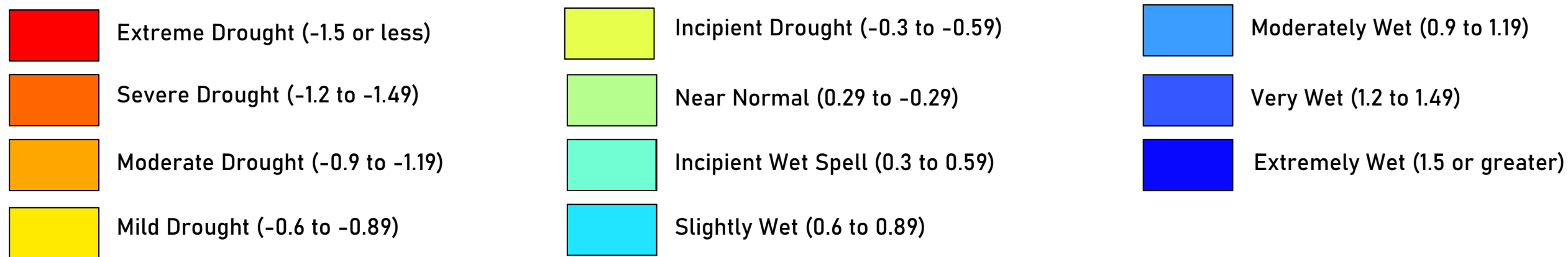


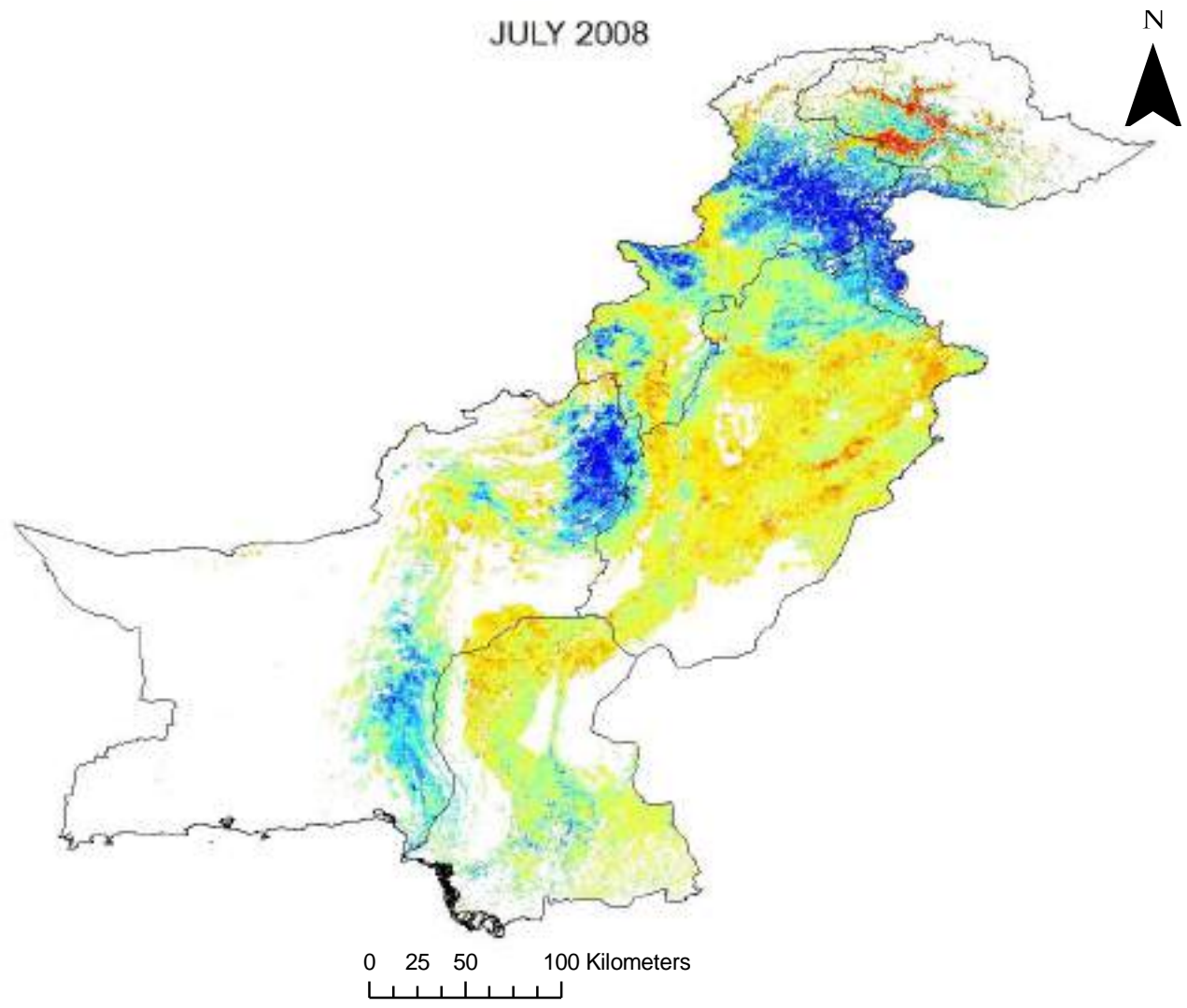
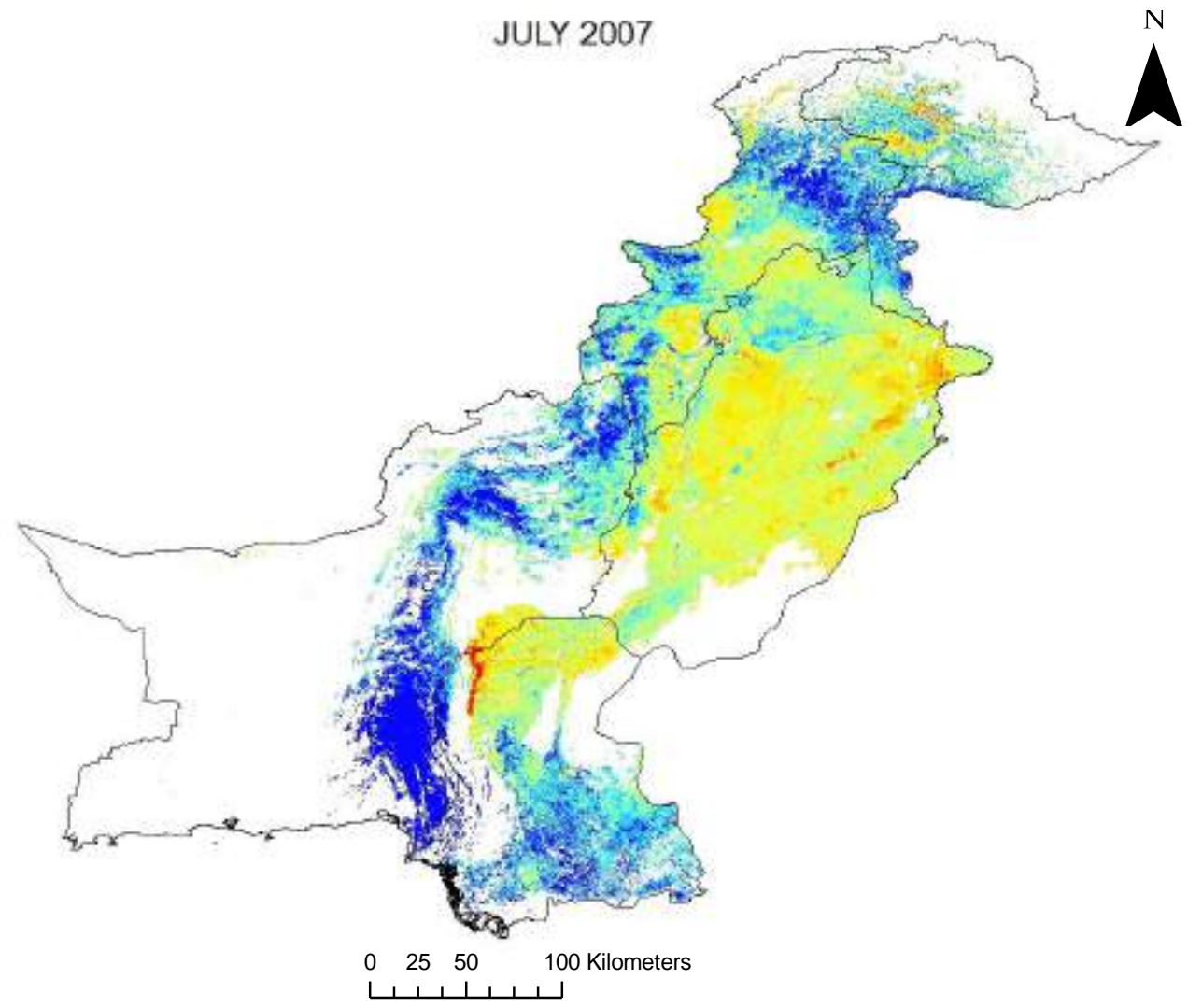
Legend

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|--|---|--|
|  Extreme Drought (-1.5 or less) |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19) |
|  Severe Drought (-1.2 to -1.49) |  Near Normal (0.29 to -0.29) |  Very Wet (1.2 to 1.49) |
|  Moderate Drought (-0.9 to -1.19) |  Incipient Wet Spell (0.3 to 0.59) |  Extremely Wet (1.5 or greater) |
|  Mild Drought (-0.6 to -0.89) |  Slightly Wet (0.6 to 0.89) | |

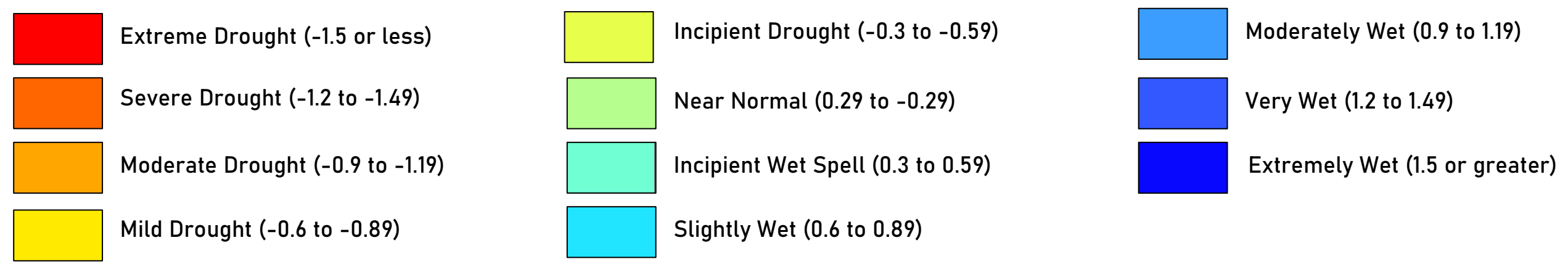


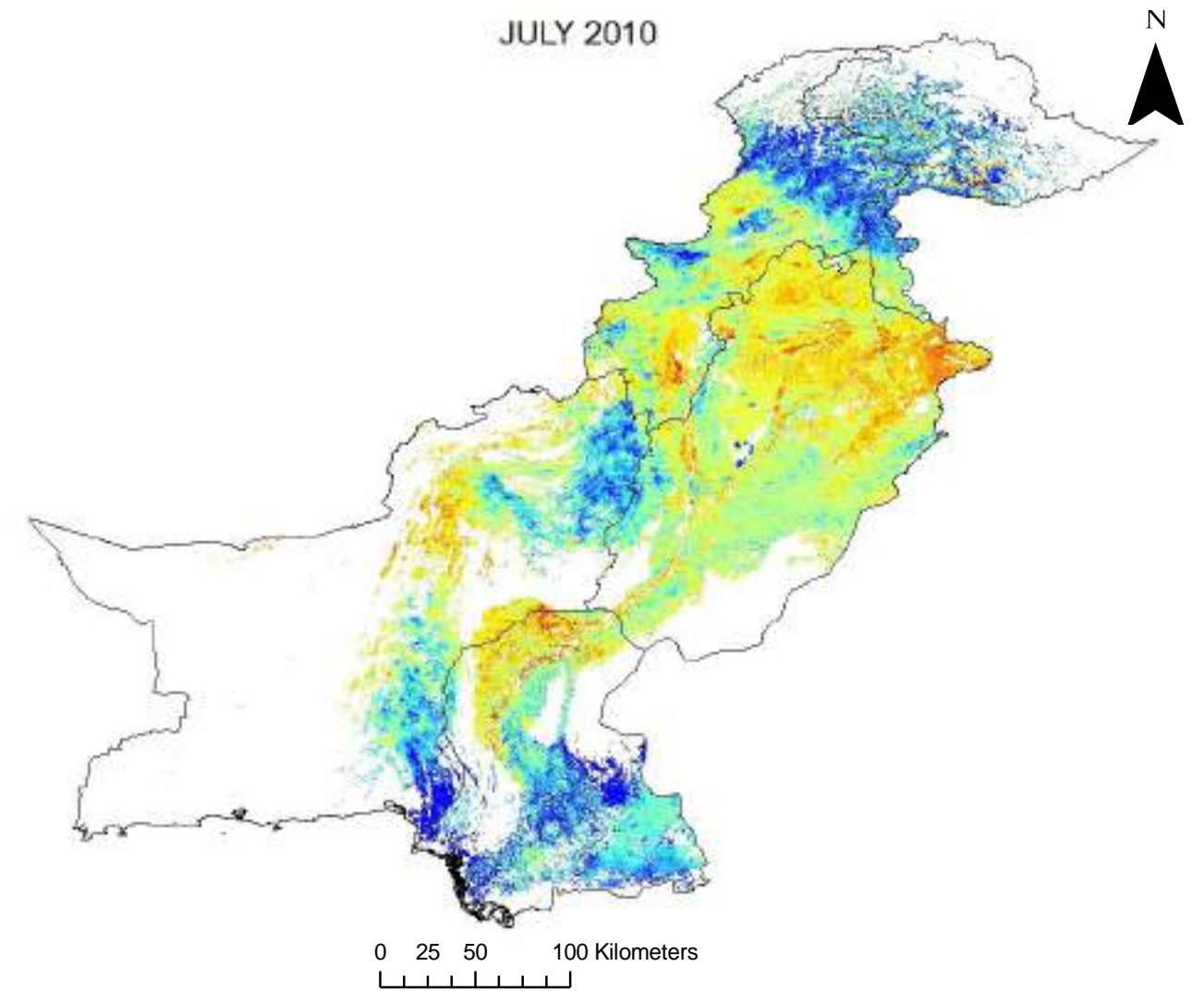
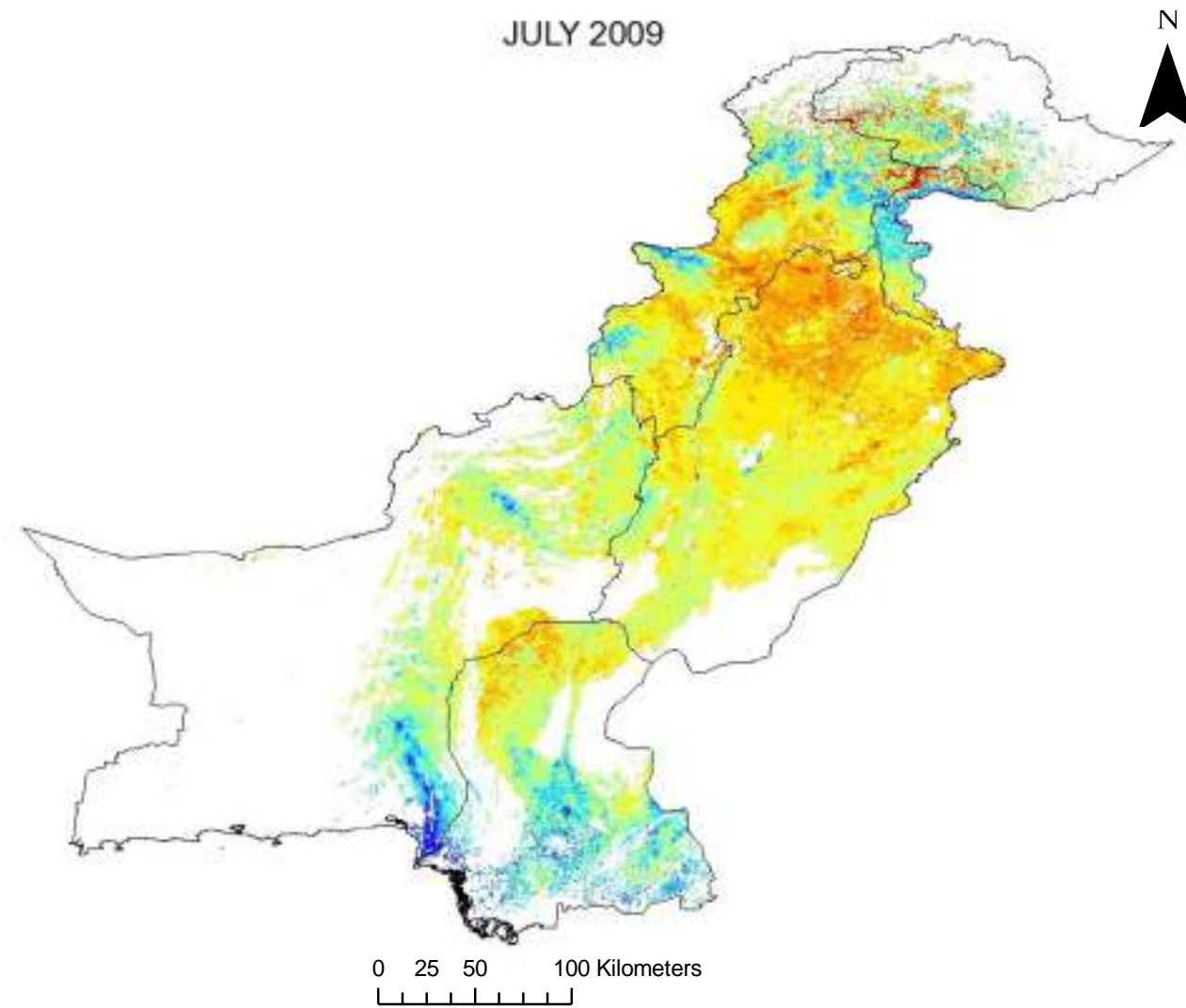
Legend





Legend



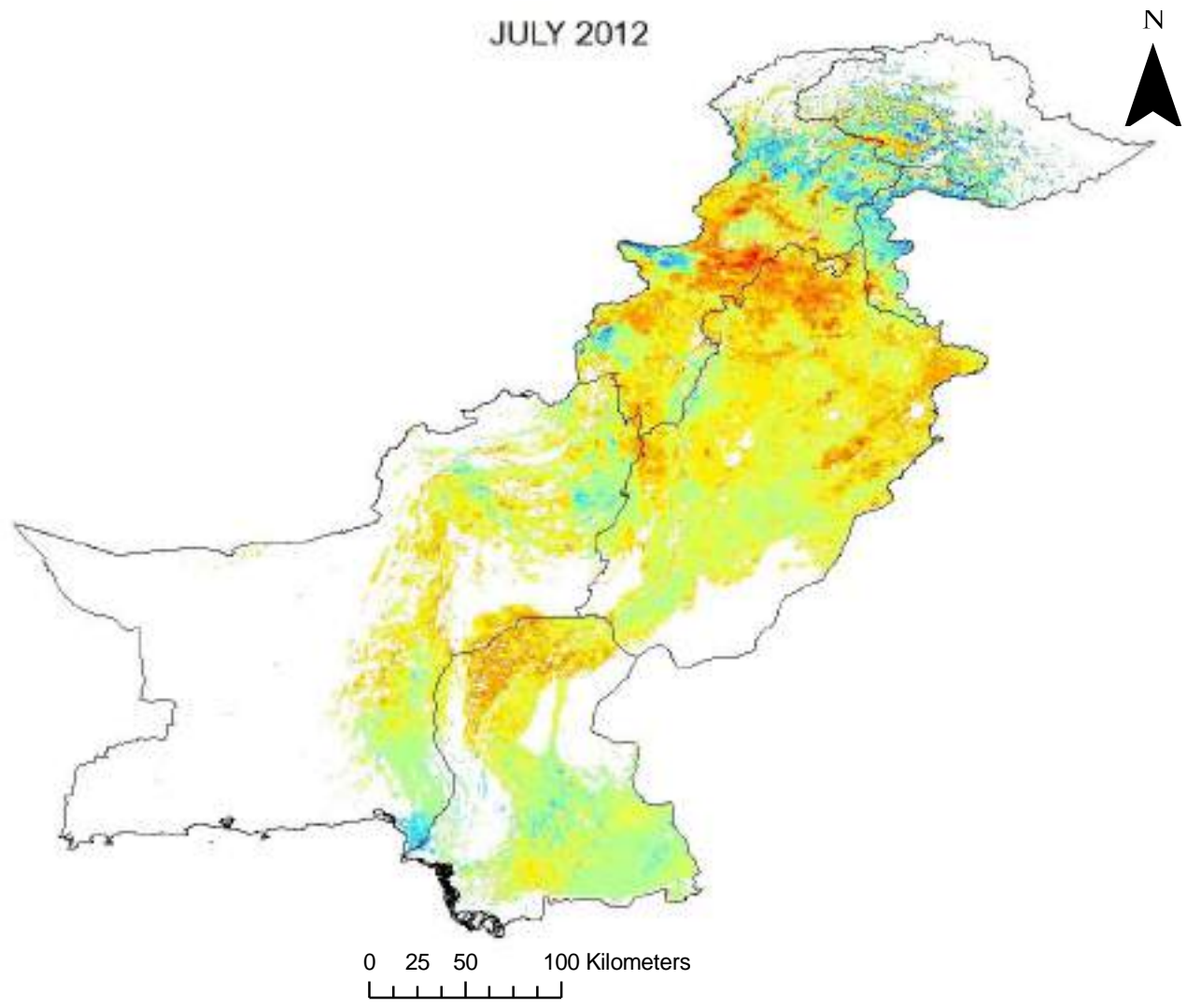
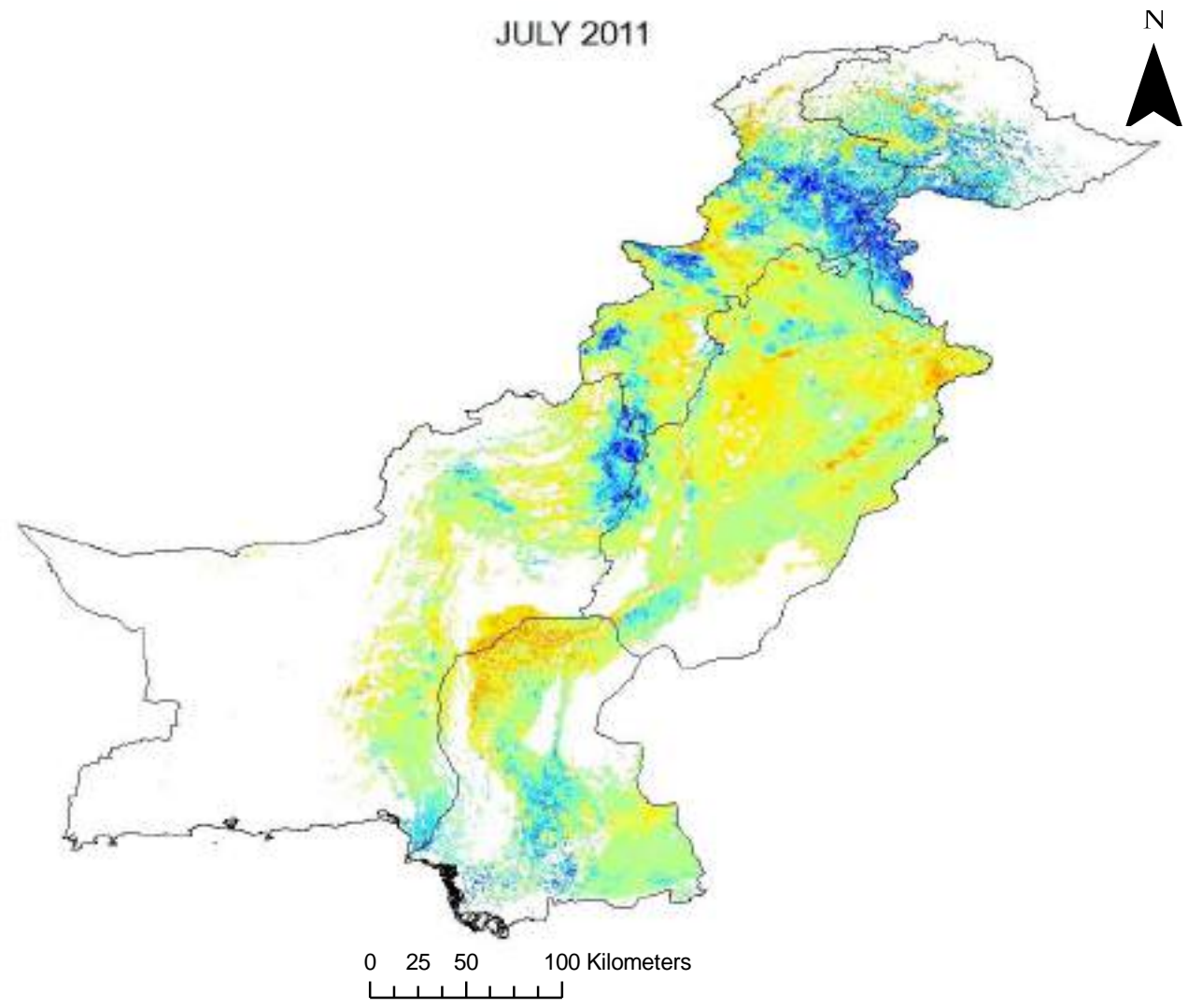


Legend

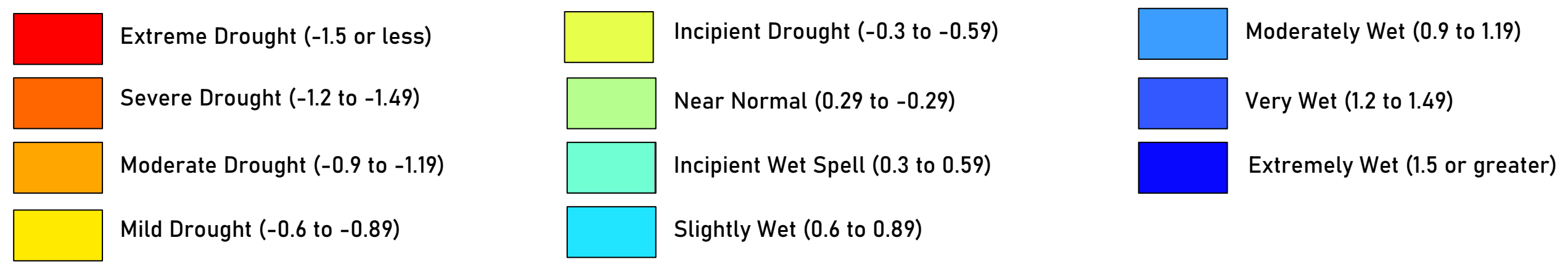
- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

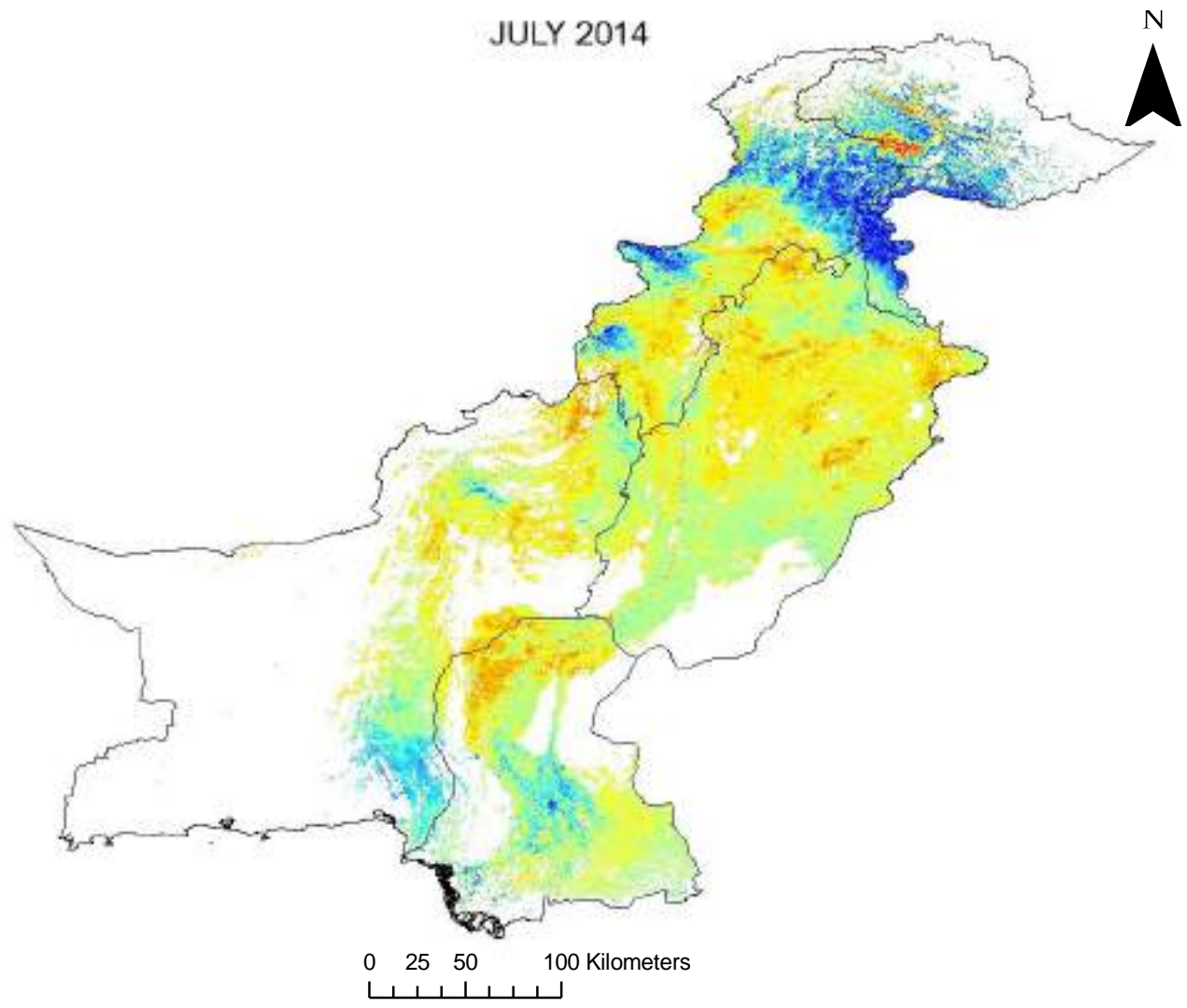
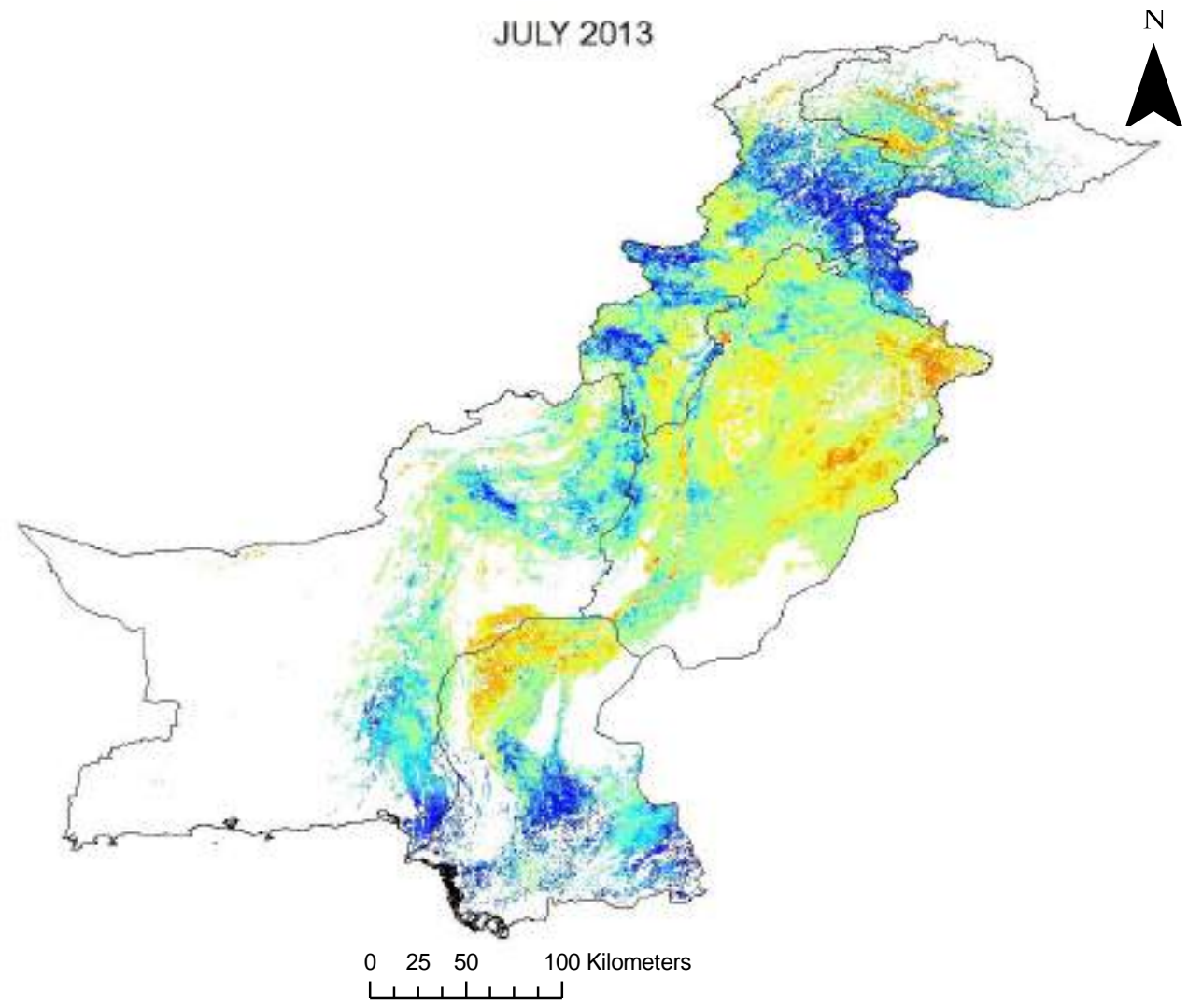
- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)

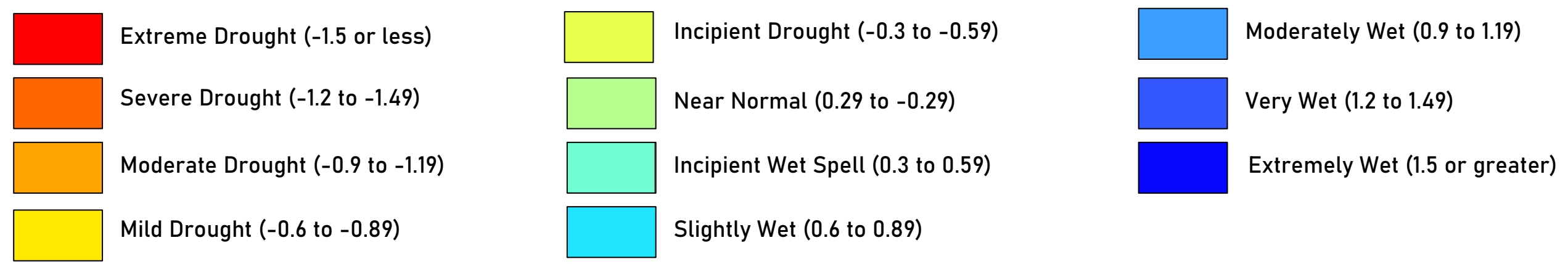


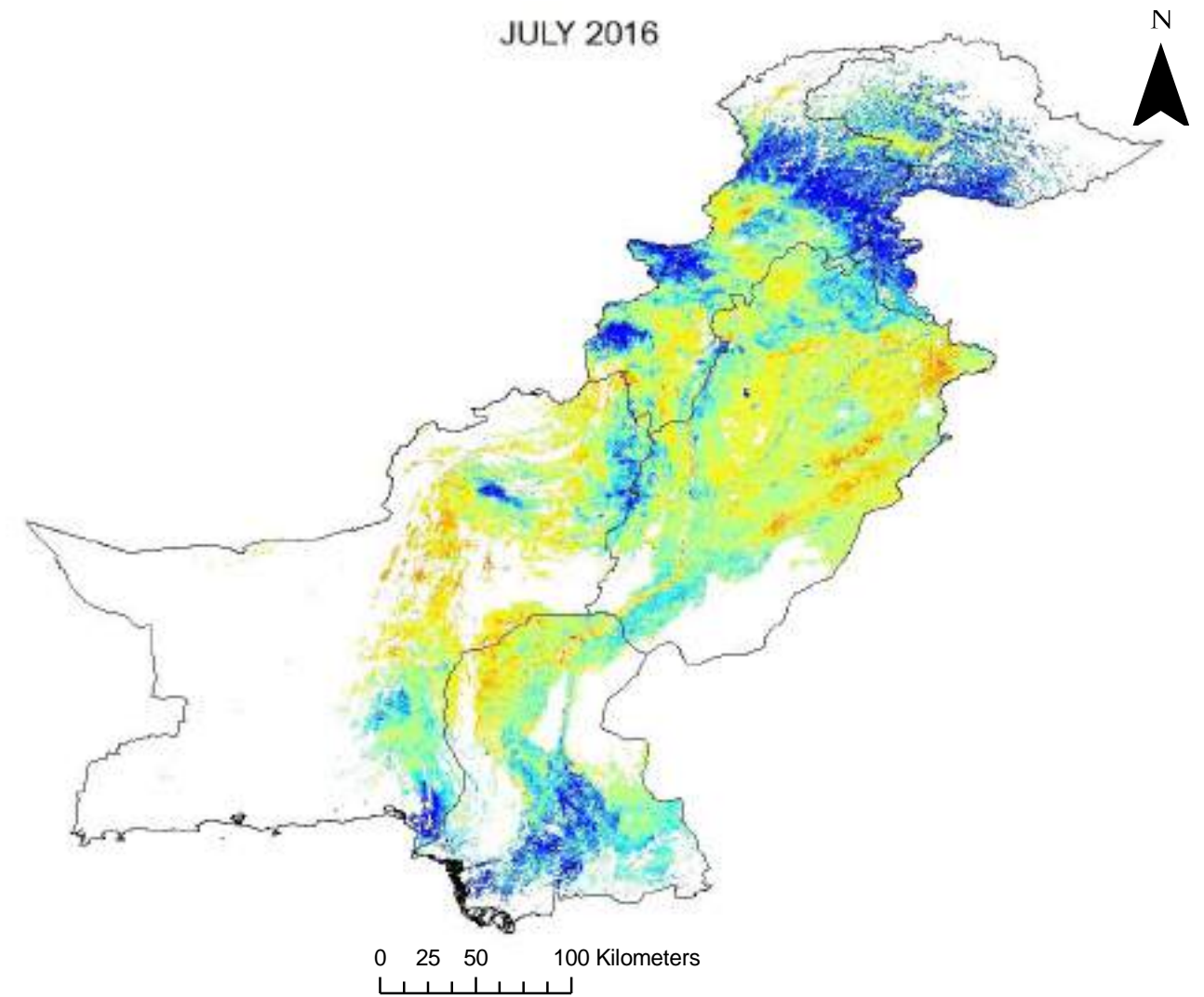
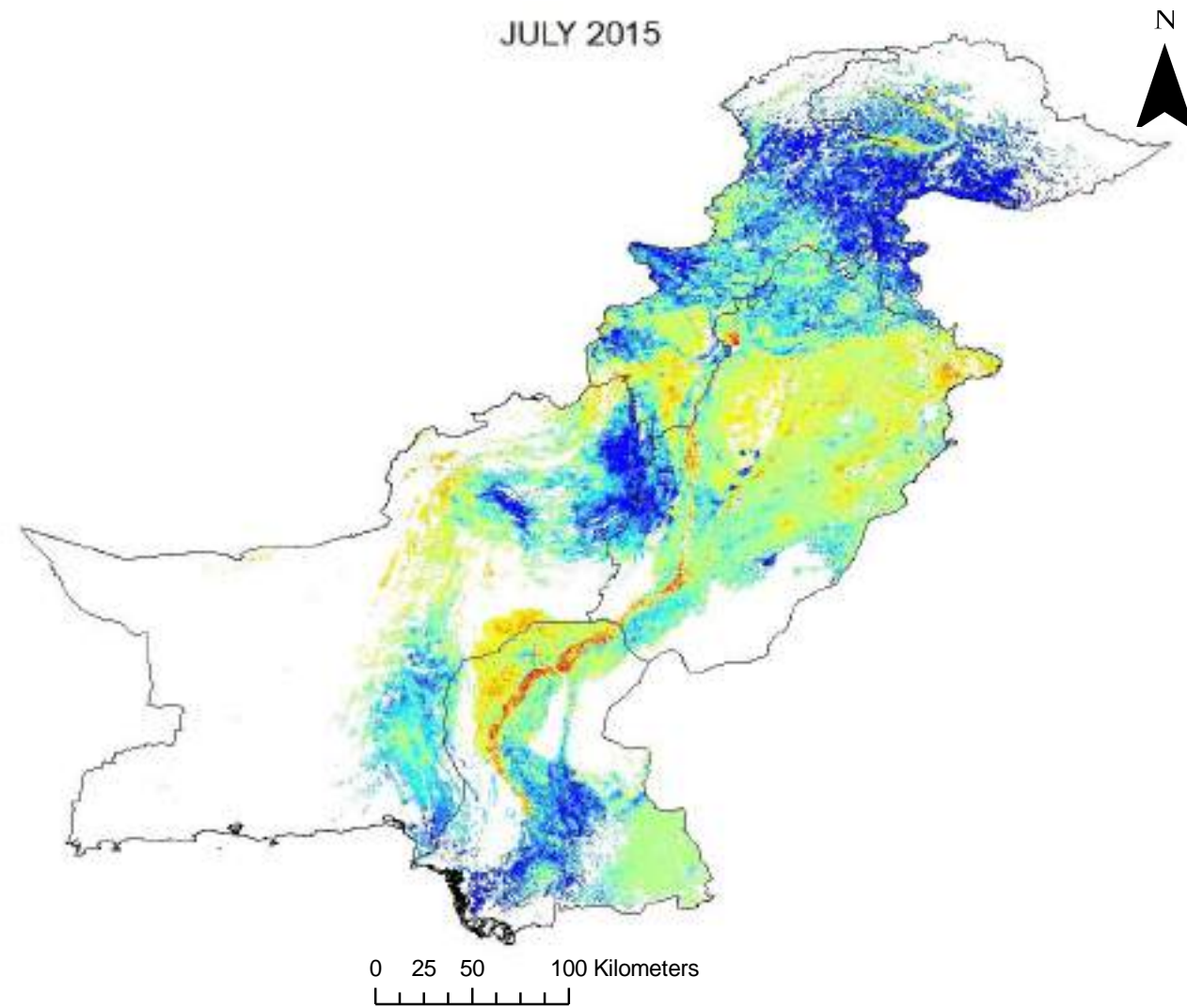
Legend













Legend

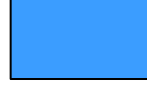




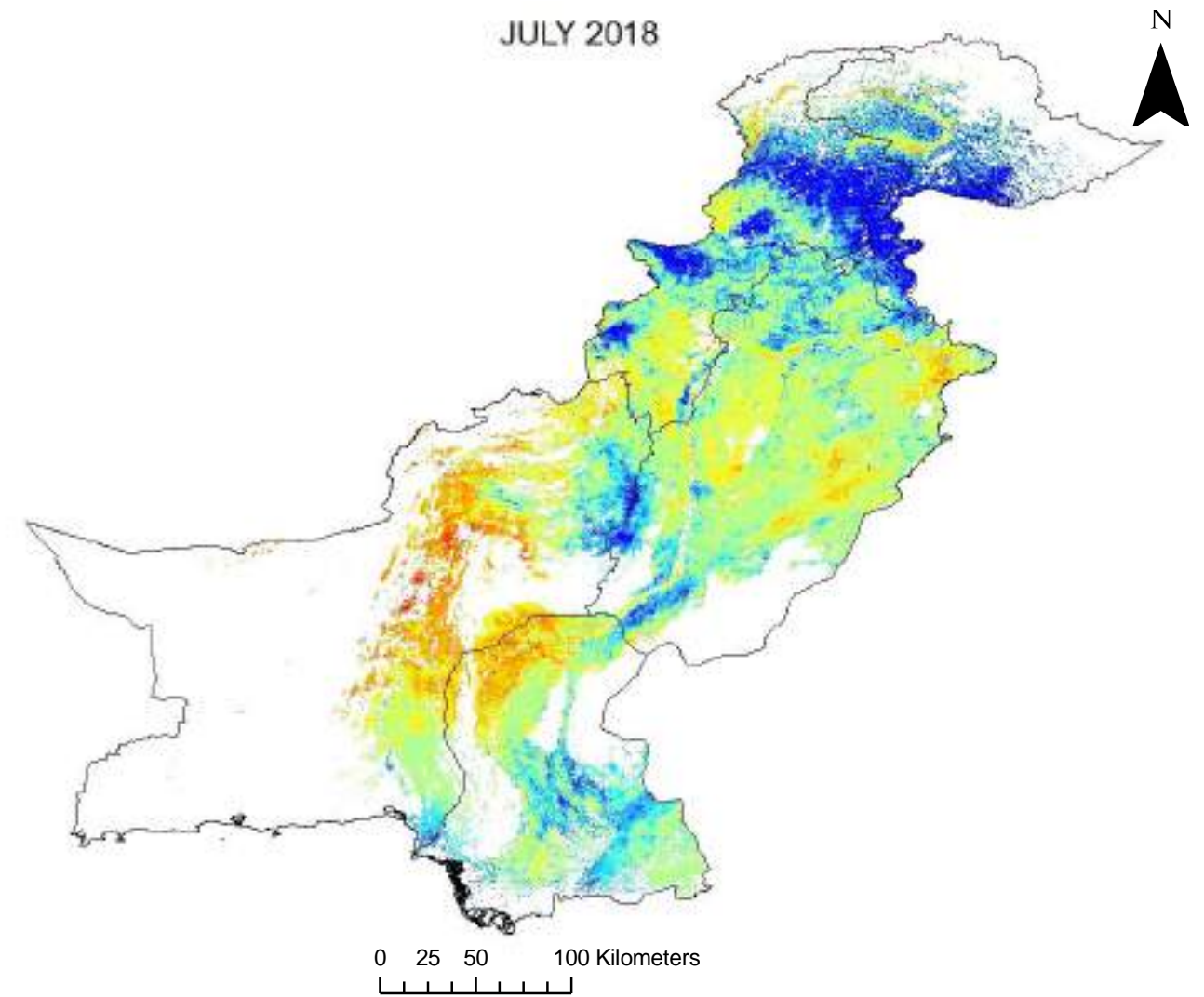
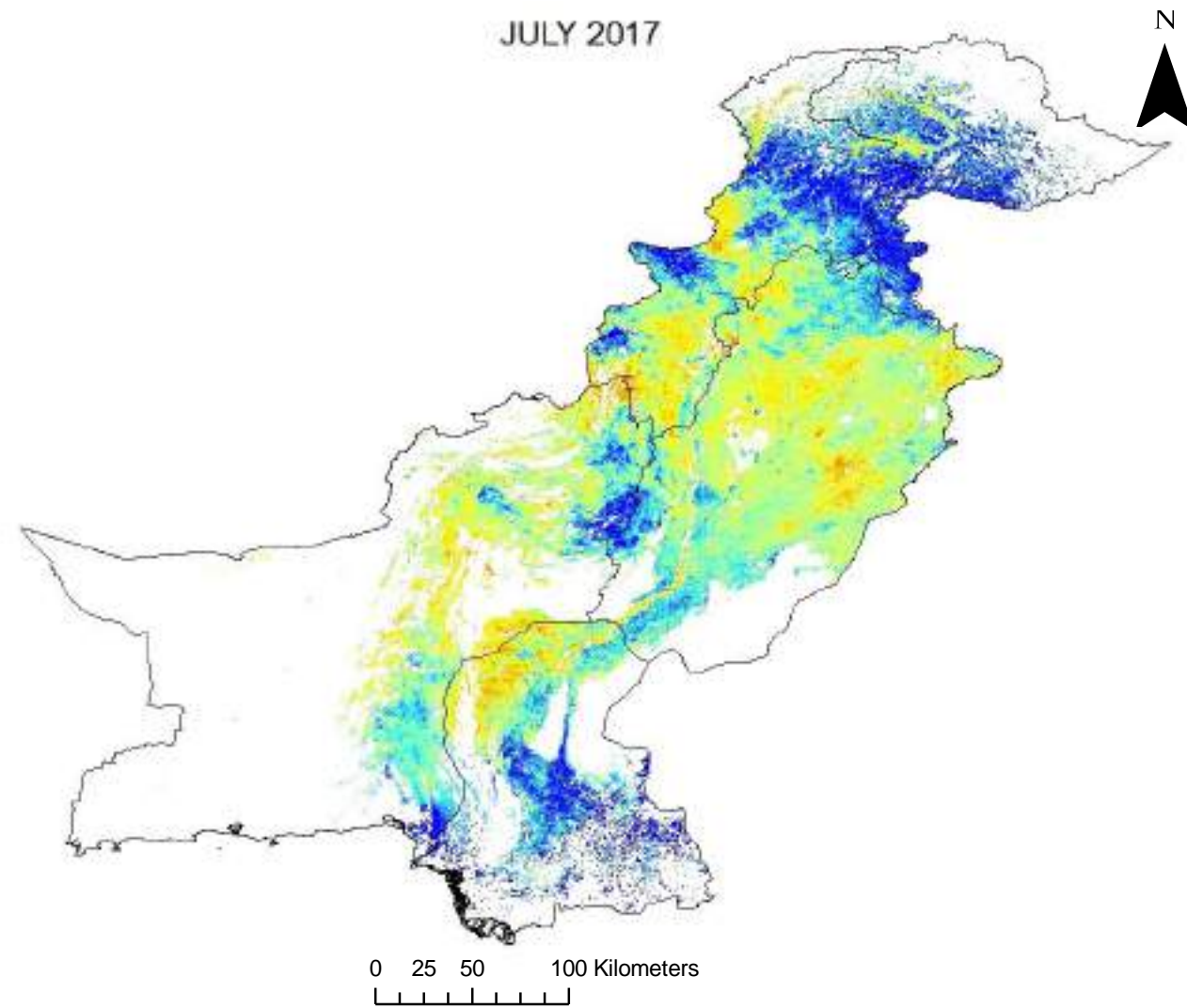


Legend

-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
-  Mild Drought (-0.6 to -0.89)

-  Incipient Drought (-0.3 to -0.59)
-  Near Normal (0.29 to -0.29)
-  Incipient Wet Spell (0.3 to 0.59)
-  Slightly Wet (0.6 to 0.89)

-  Moderately Wet (0.9 to 1.19)
-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)

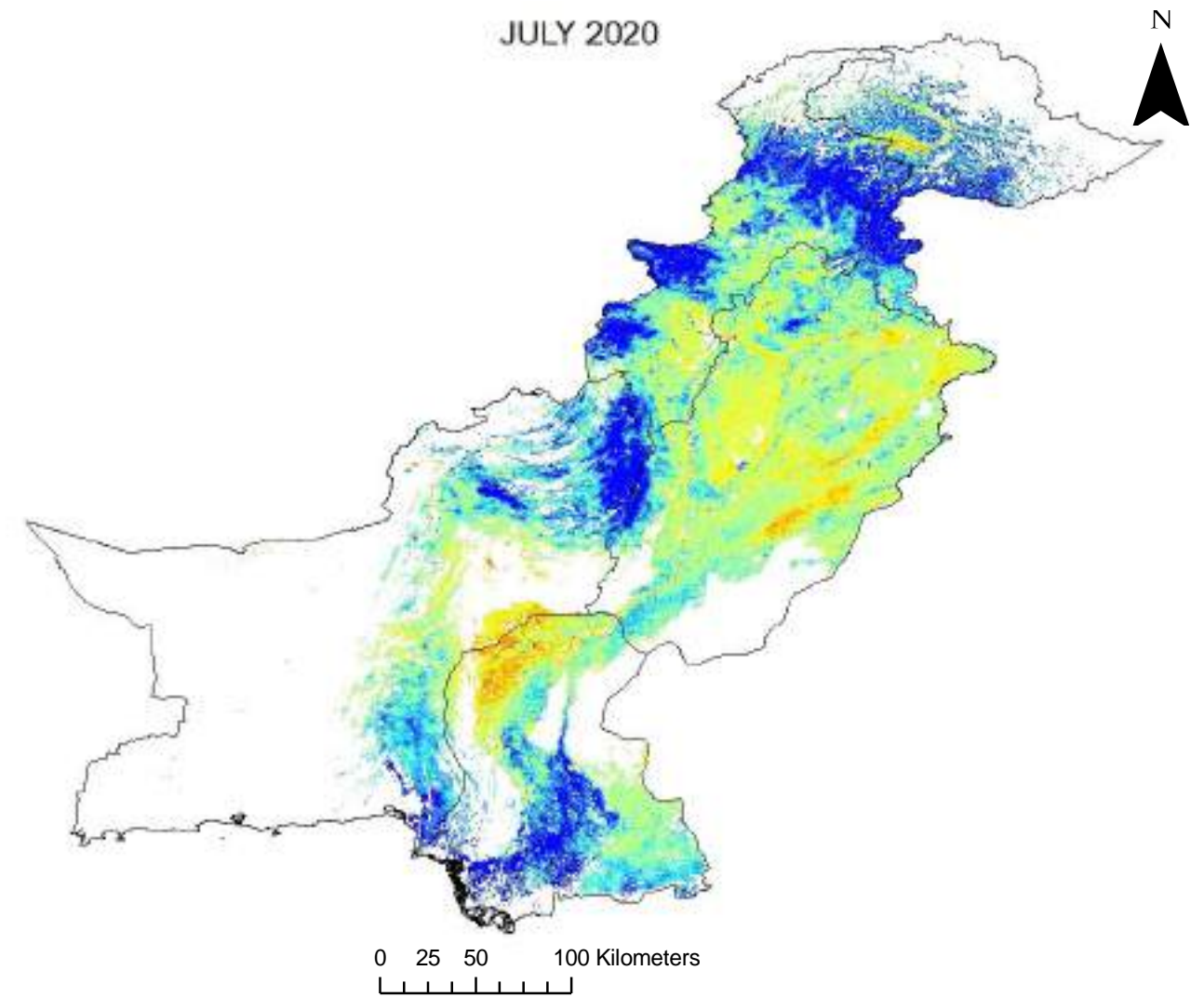
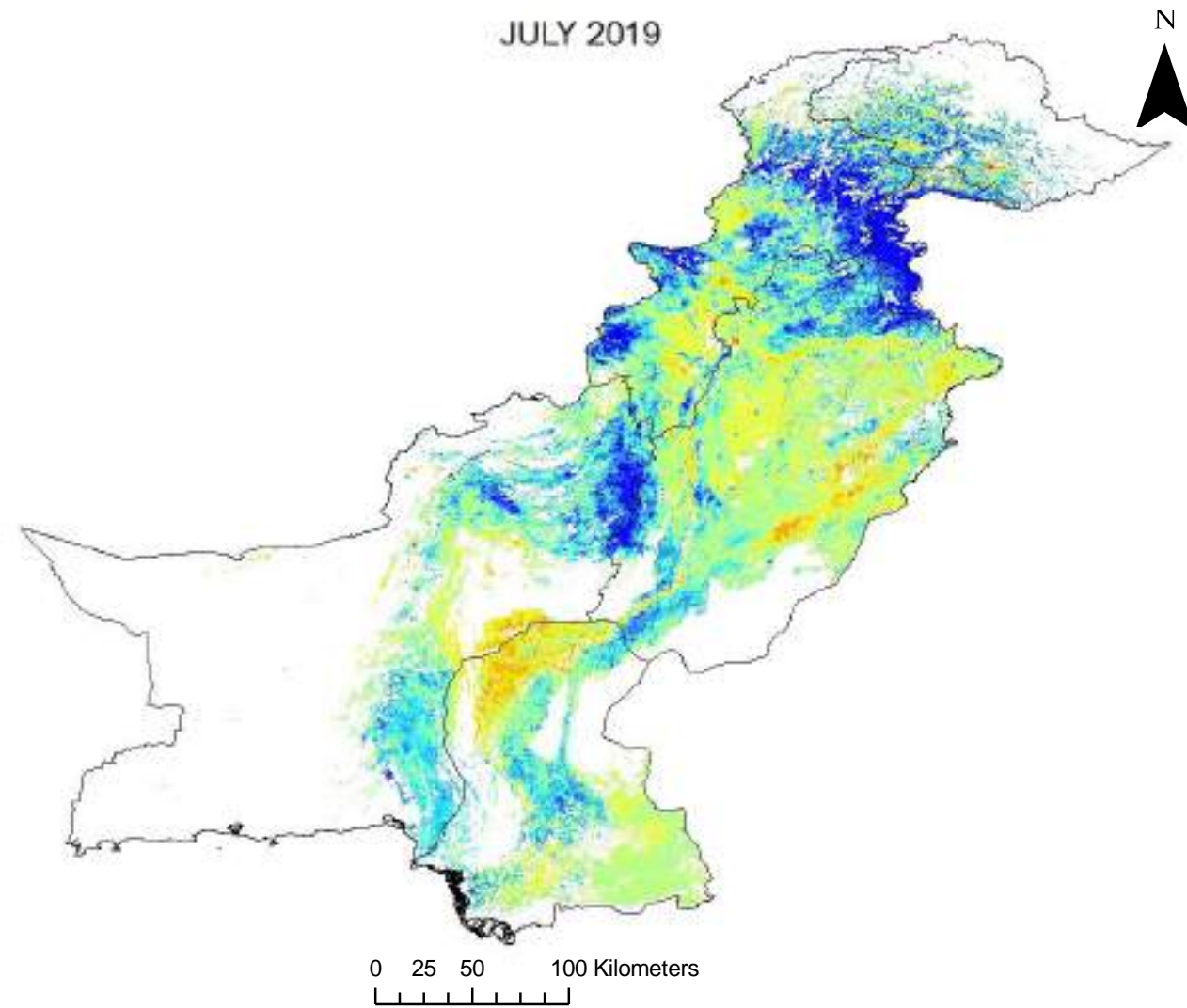


Legend

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

- Incipient Drought (-0.3 to -0.59)
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- Moderately Wet (0.9 to 1.19)
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Legend

- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

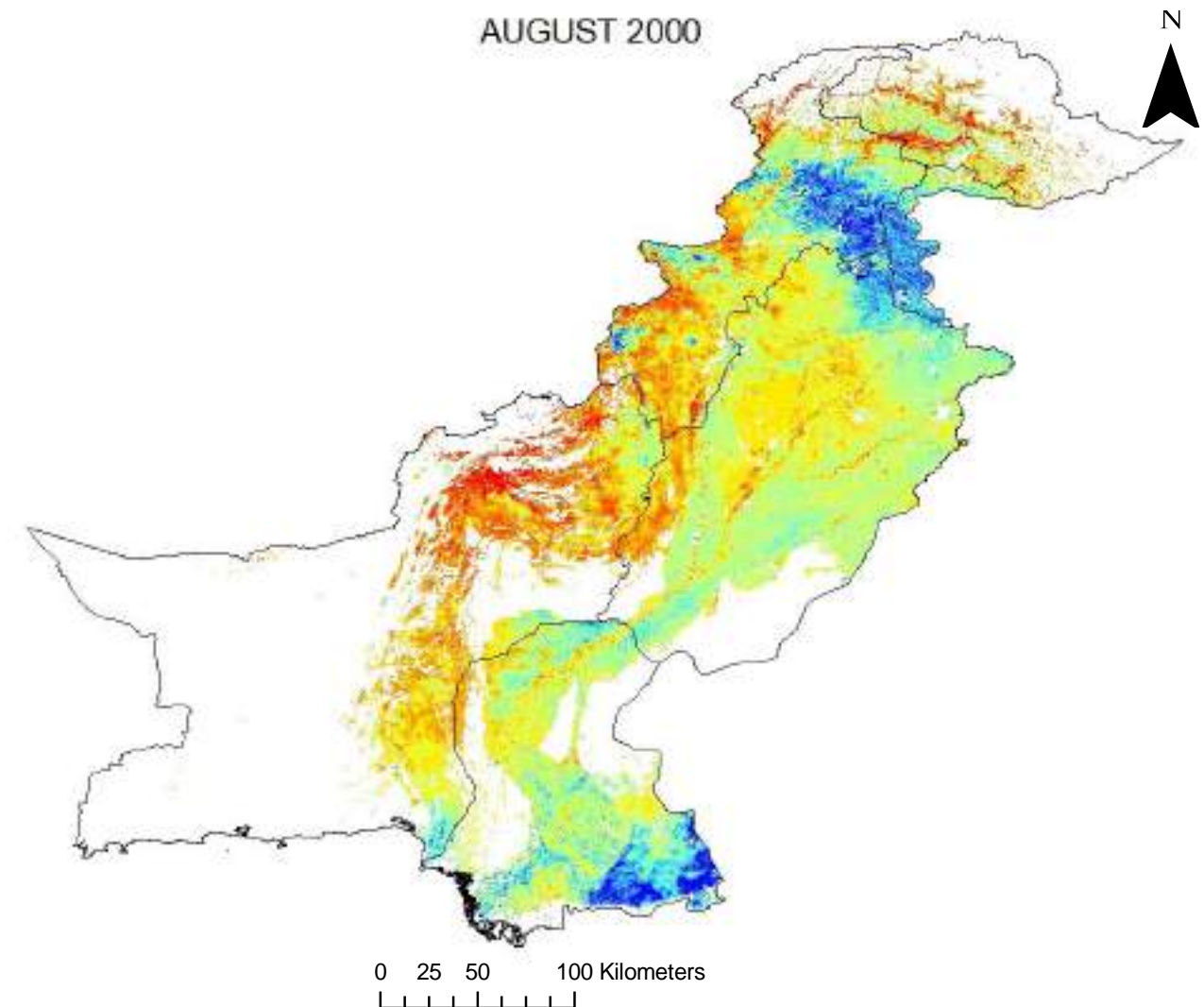
- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)

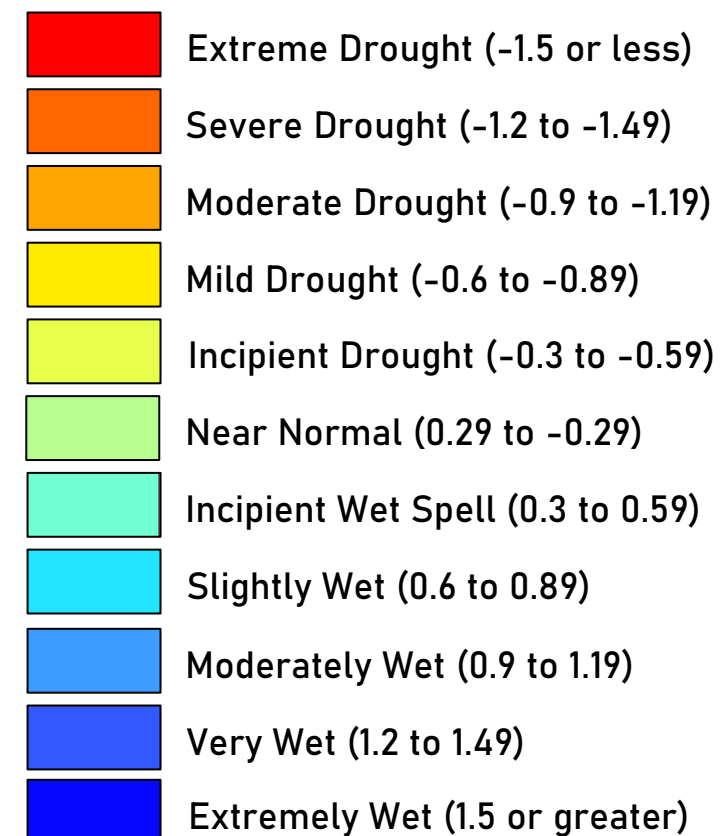
August DSI Maps

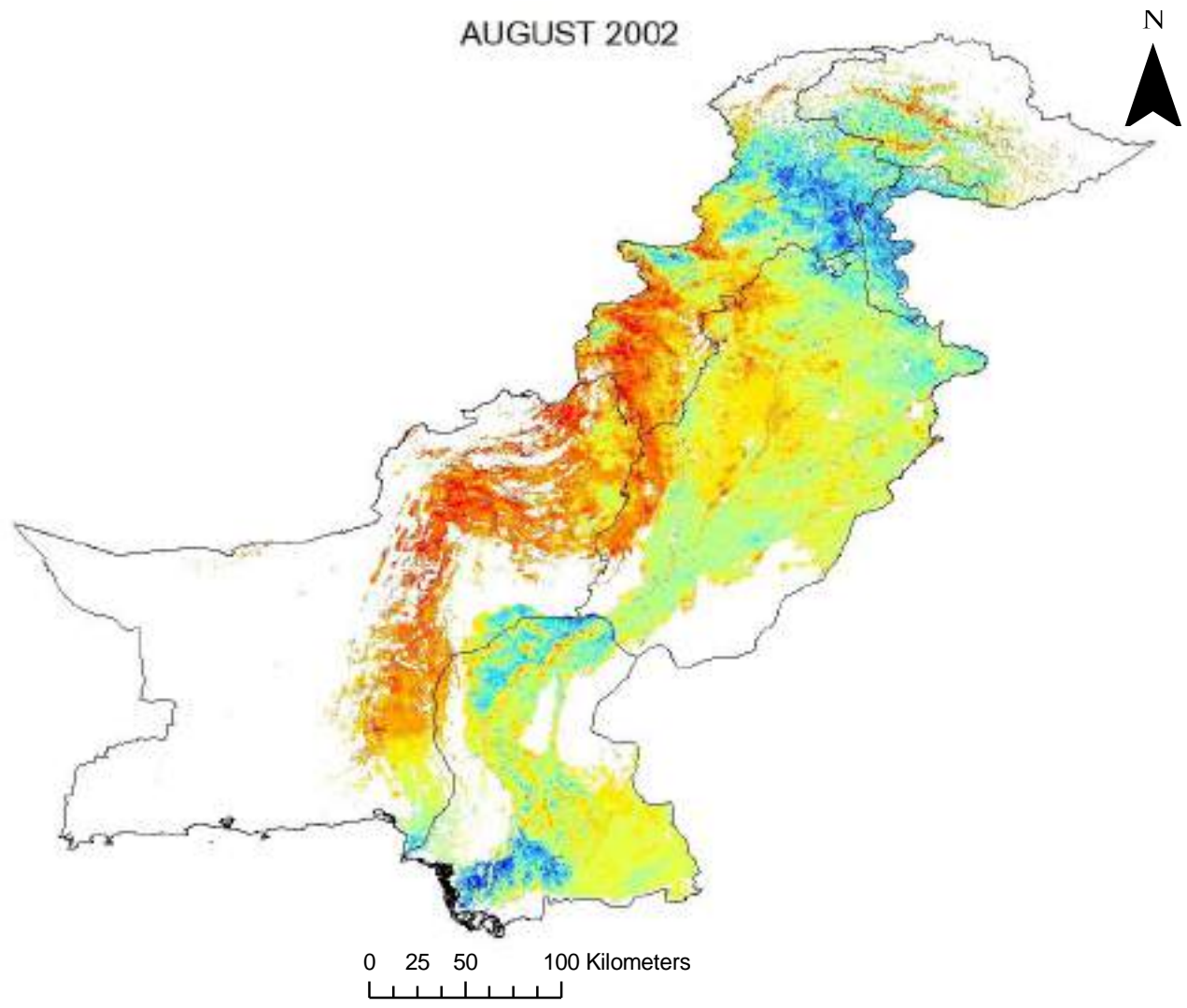
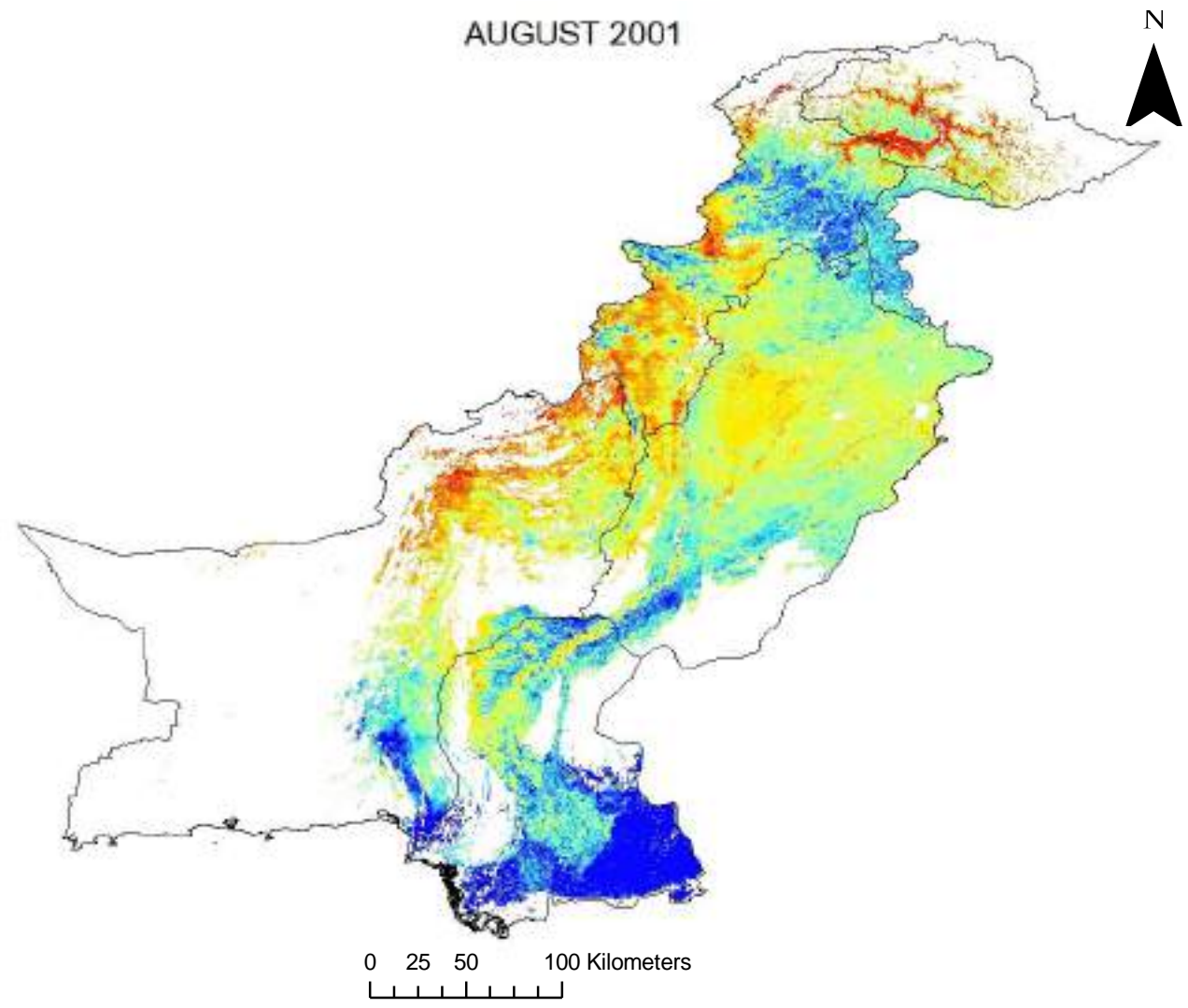
Drought conditions in August vary from near normal to extremely wet condition. This monsoon month is generally wet except in 2000, 2001, 2002, 2004 and 2005.

Mean August DSI Values		
Years	Values	Drought Condition
2000	-0.02	Near Normal
2001	0.21	Near Normal
2002	-0.13	Near Normal
2003	0.71	Slightly Wet
2004	0.07	Near Normal
2005	0.15	Near Normal
2006	1.12	Moderately Wet
2007	0.39	Incipient Wet Spell
2008	0.67	Slightly Wet
2009	0.41	Incipient Wet Spell
2010	1.77	Extremely Wet
2011	1.51	Extremely Wet
2012	0.67	Slightly Wet
2013	1.46	Very Wet
2014	0.48	Incipient Wet Spell
2015	0.64	Slightly Wet
2016	0.70	Slightly Wet
2017	0.71	Slightly Wet
2018	0.76	Slightly Wet
2019	1.53	Extremely Wet
2020	1.92	Extremely Wet














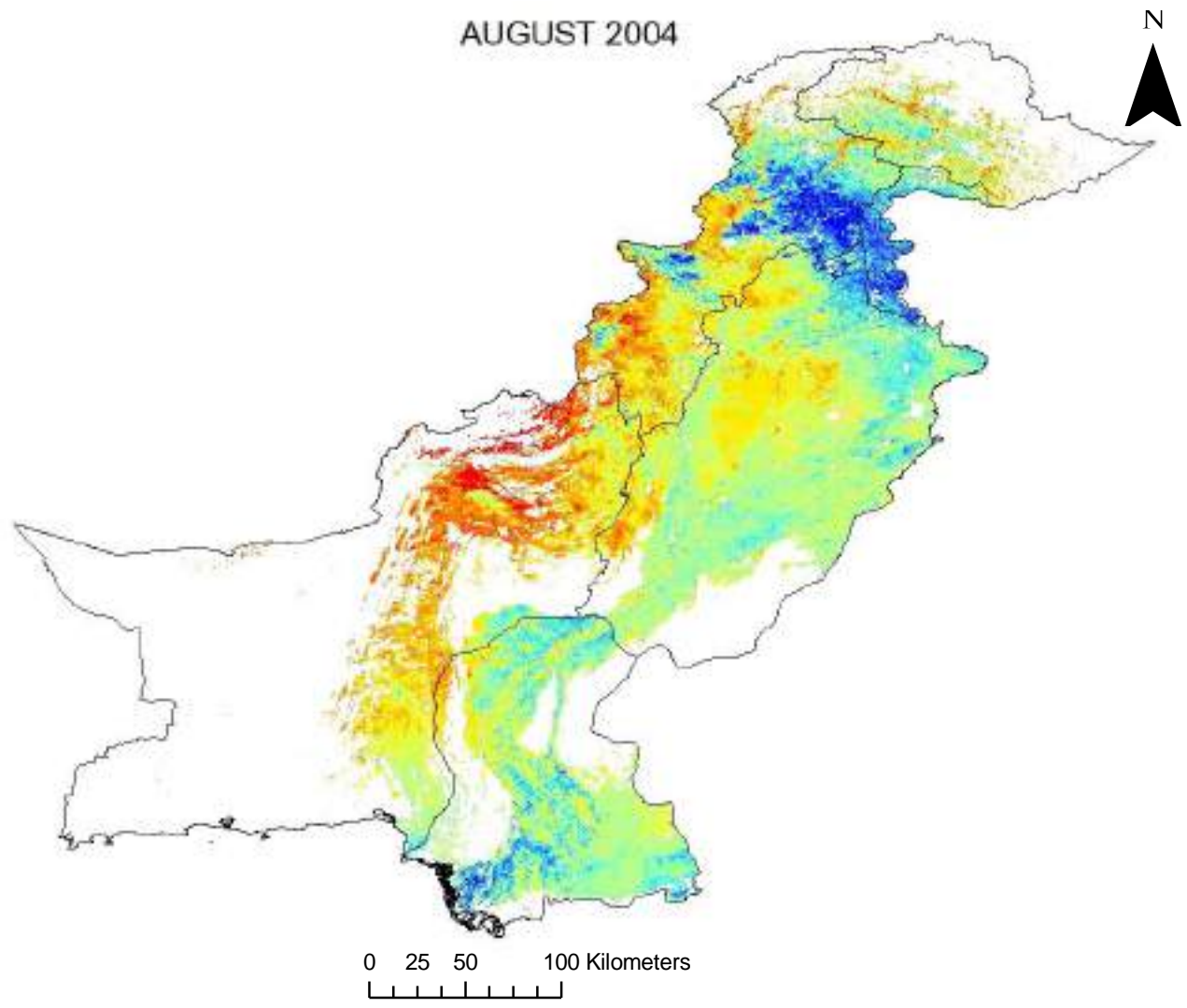
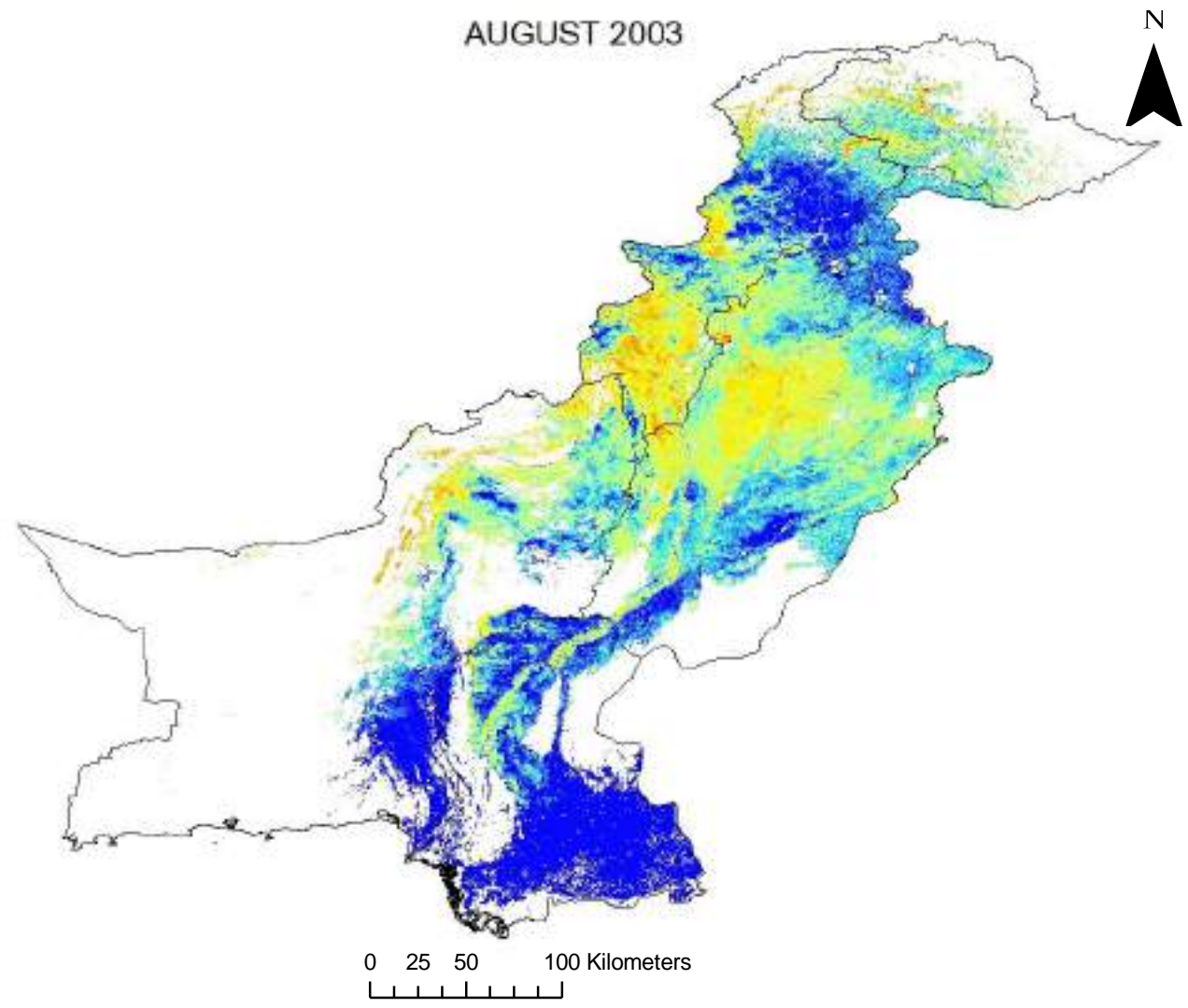
Legend
















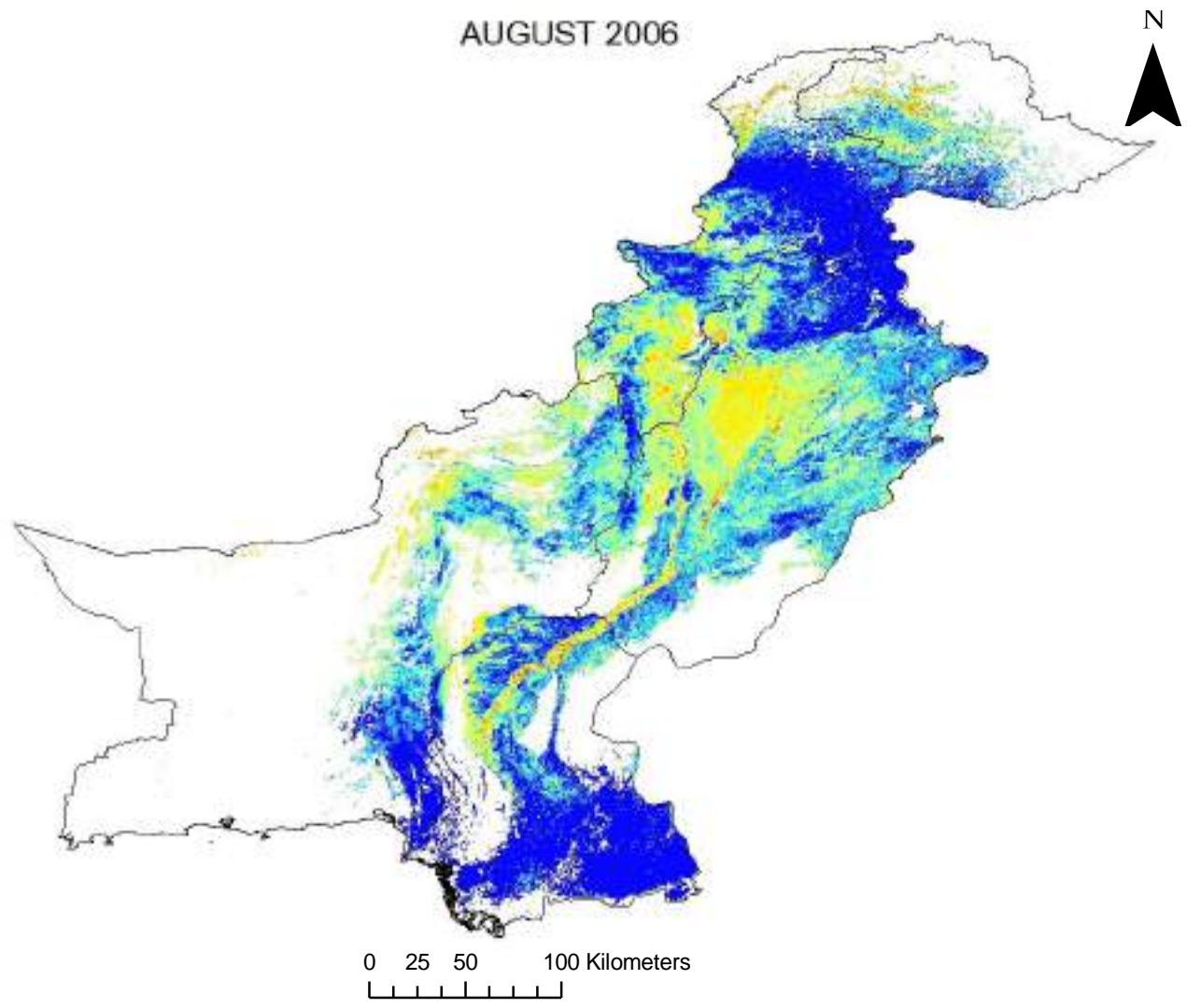
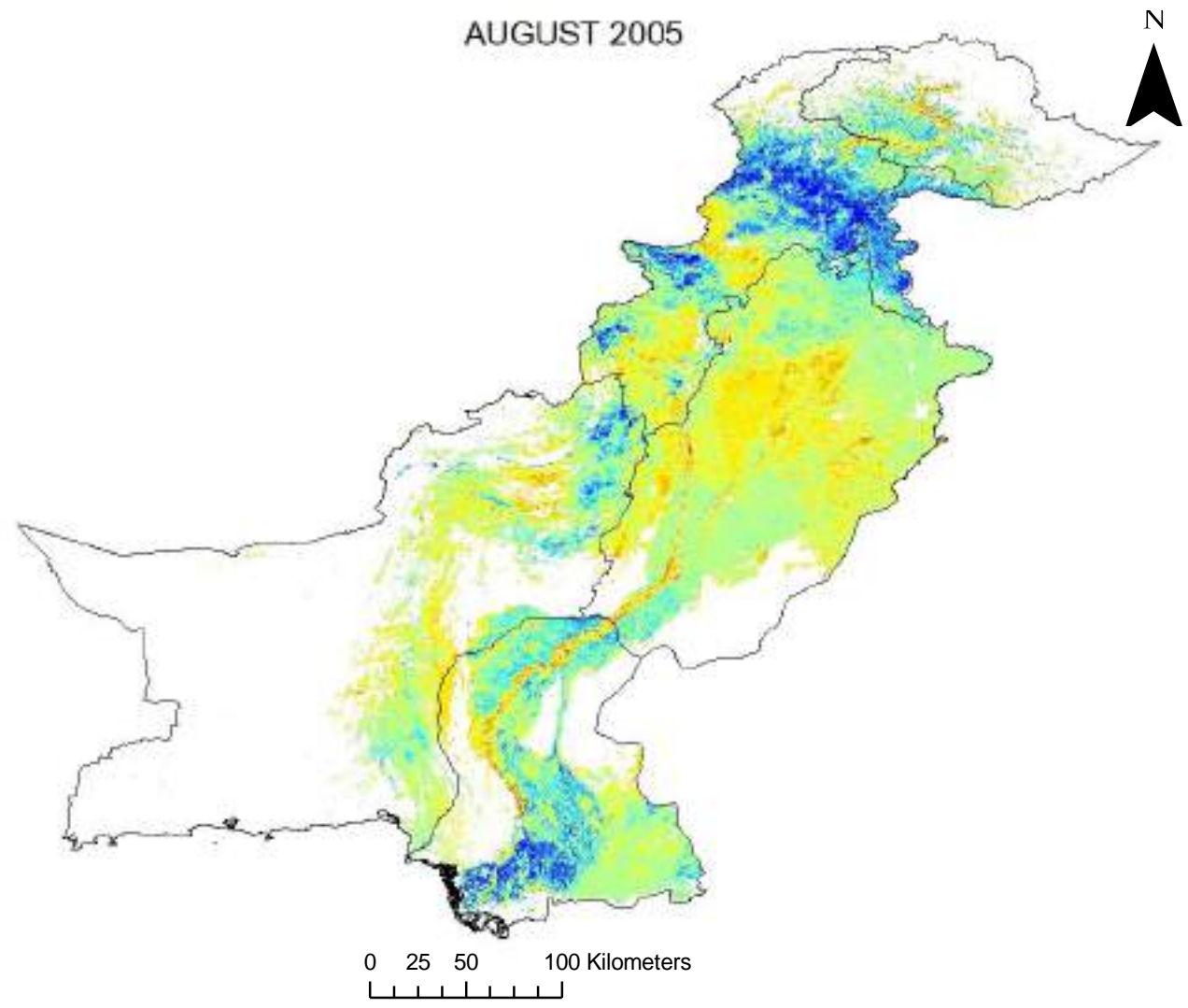
Legend

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|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
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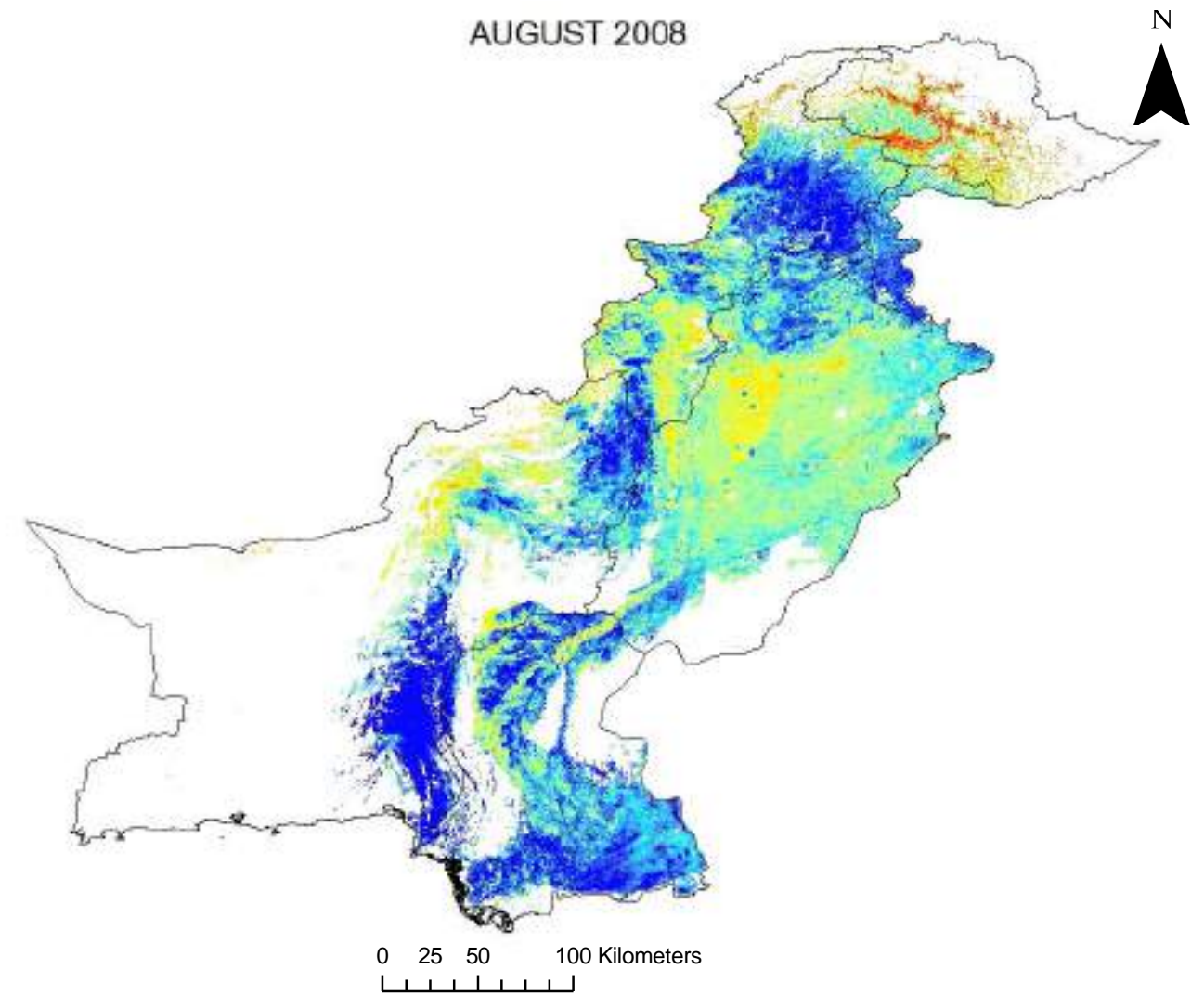
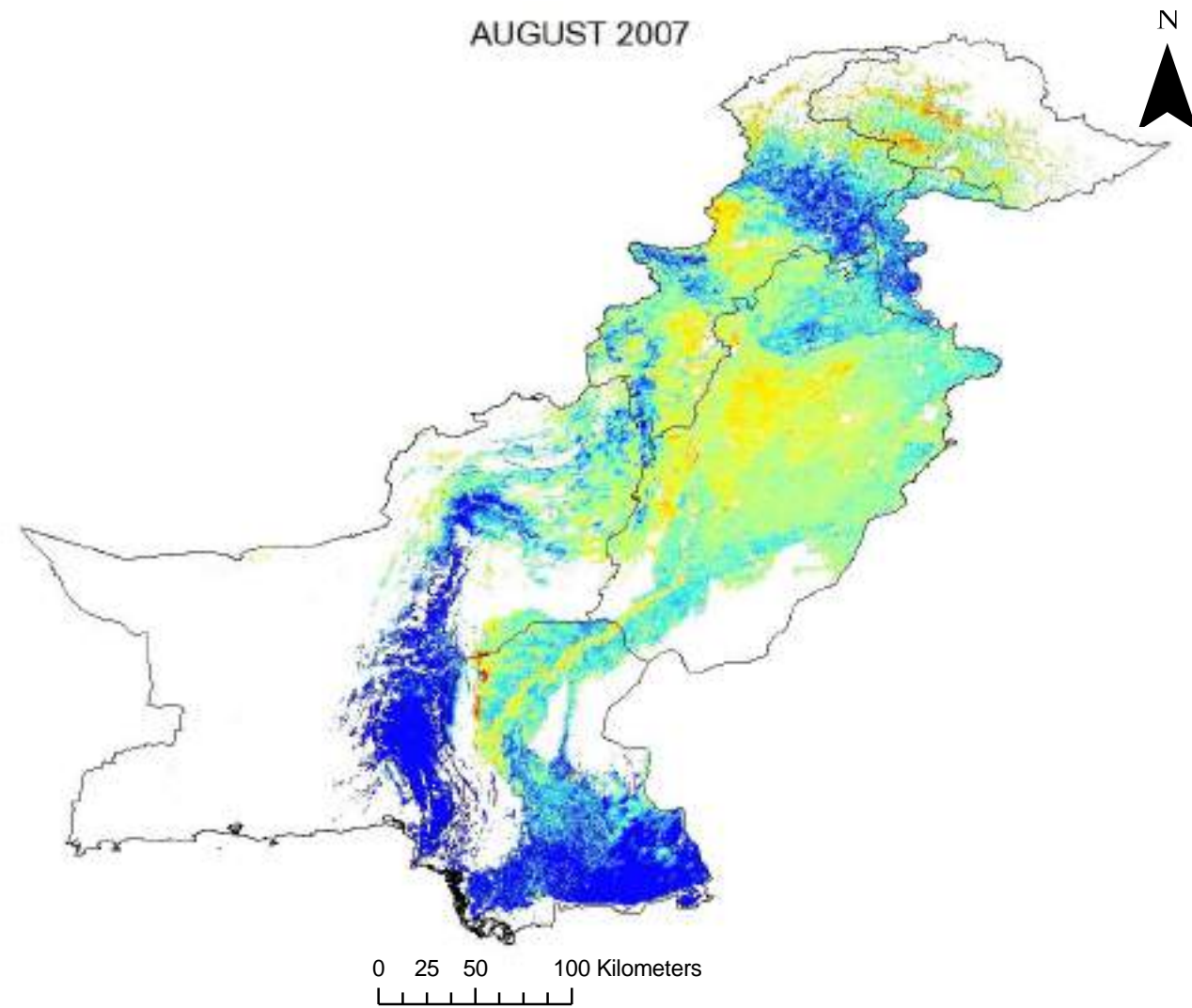
Legend

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|--|---|--|
|  Extreme Drought (-1.5 or less) |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19) |
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|  Mild Drought (-0.6 to -0.89) |  Slightly Wet (0.6 to 0.89) | |

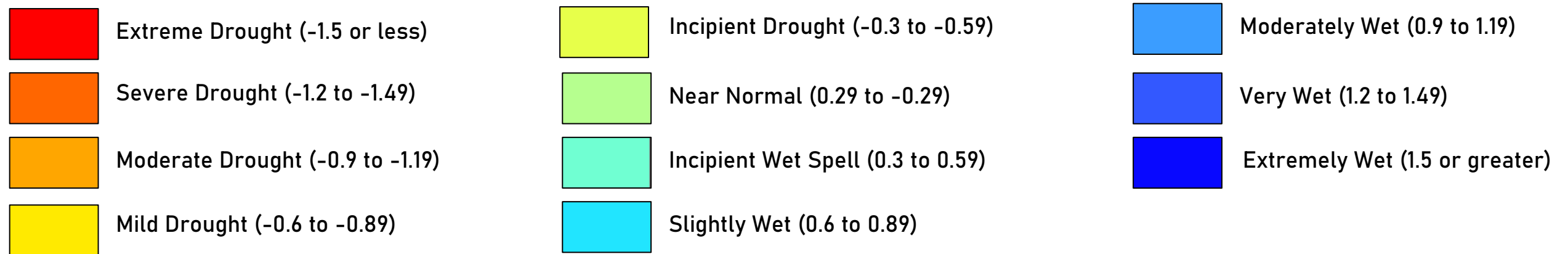


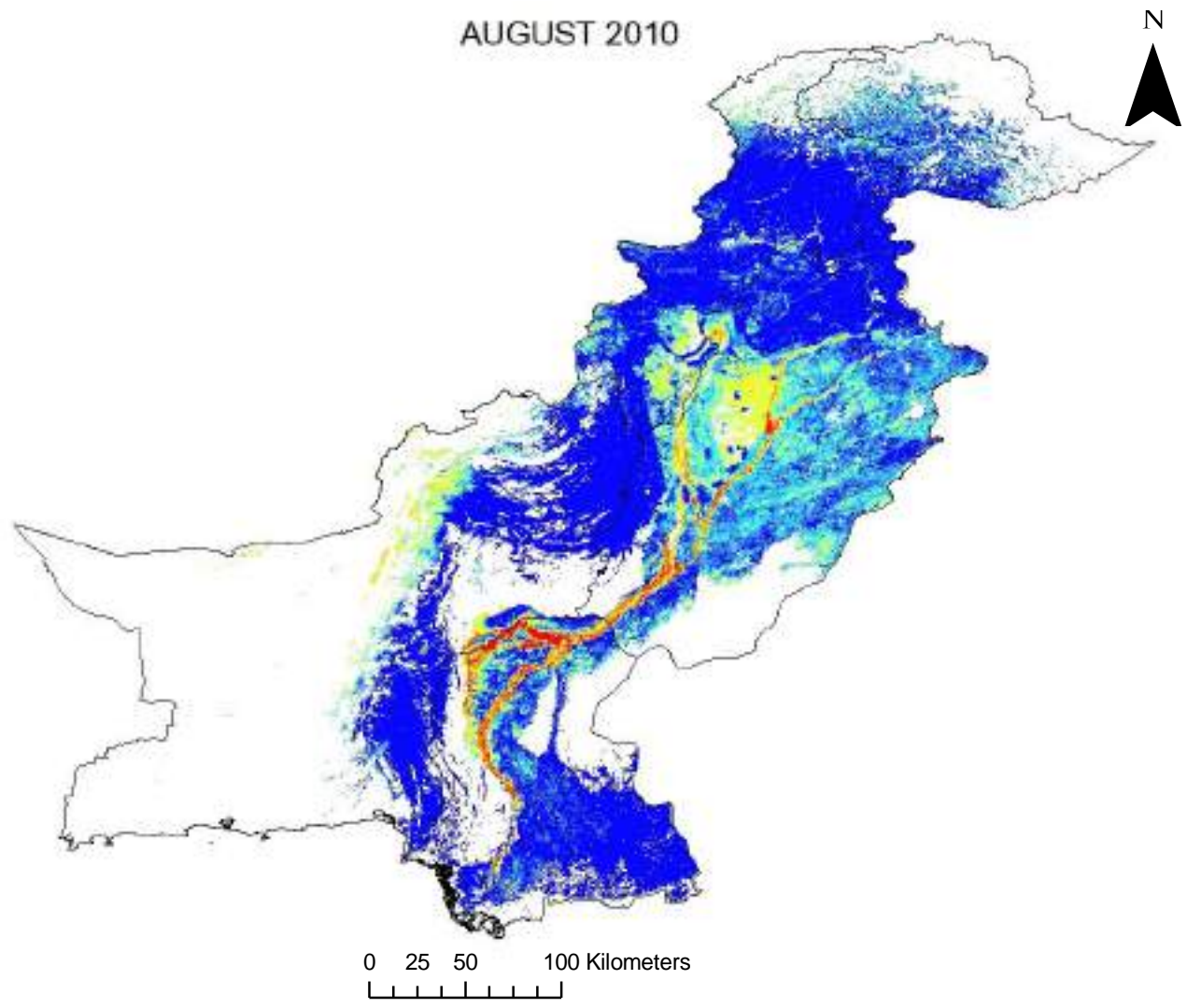
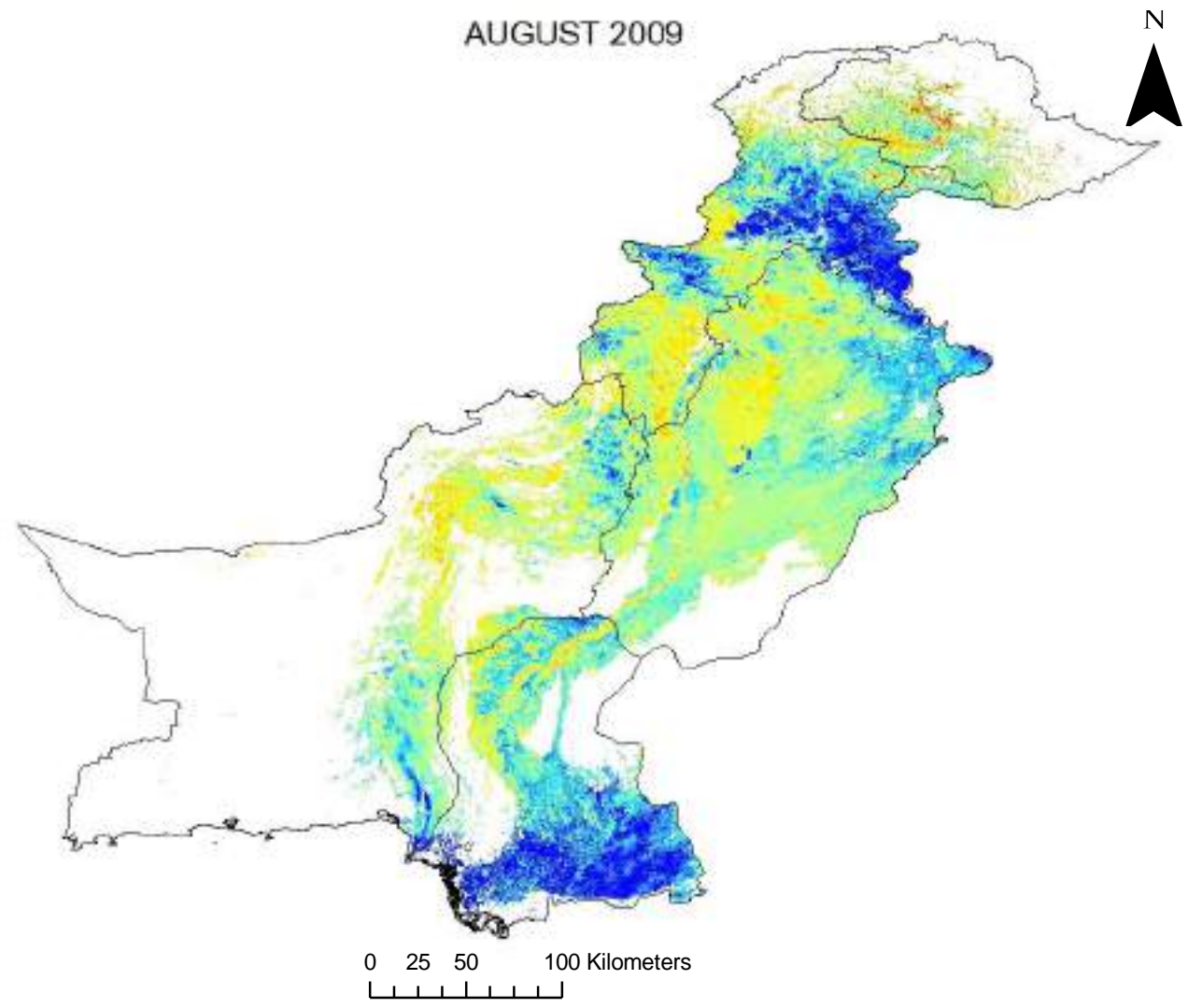
Legend

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|--|---|--|
|  Extreme Drought (-1.5 or less) |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19) |
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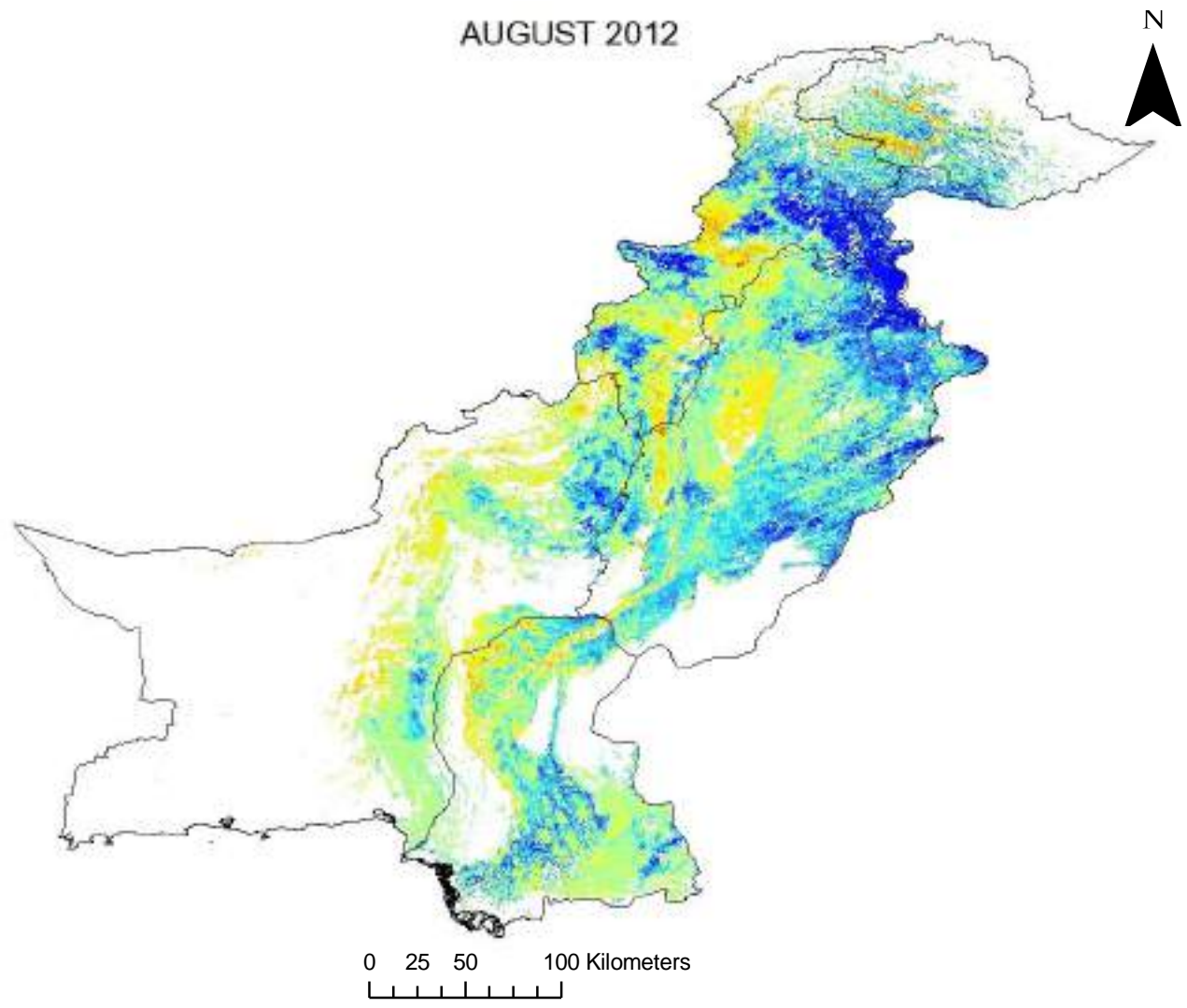
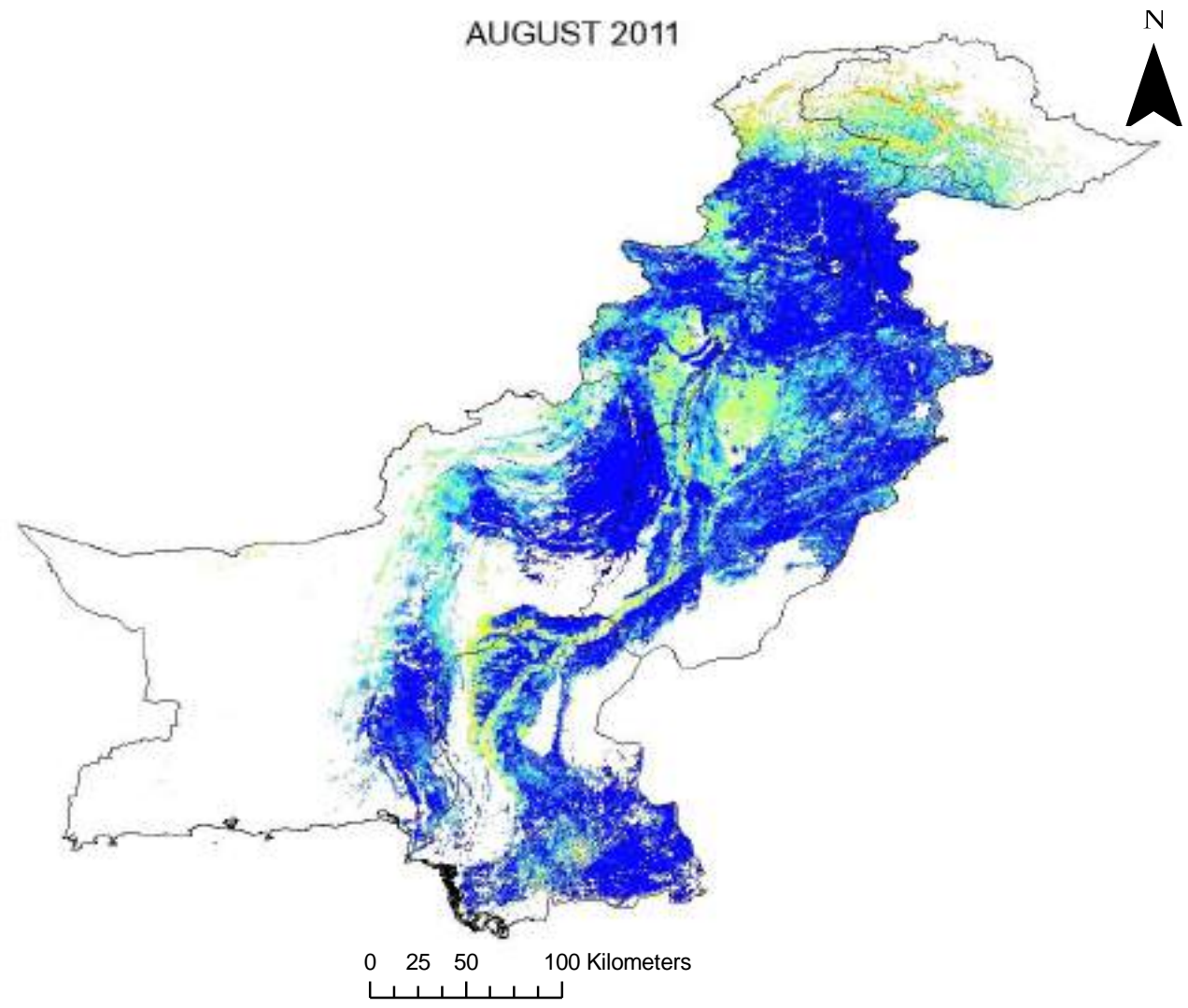
Legend



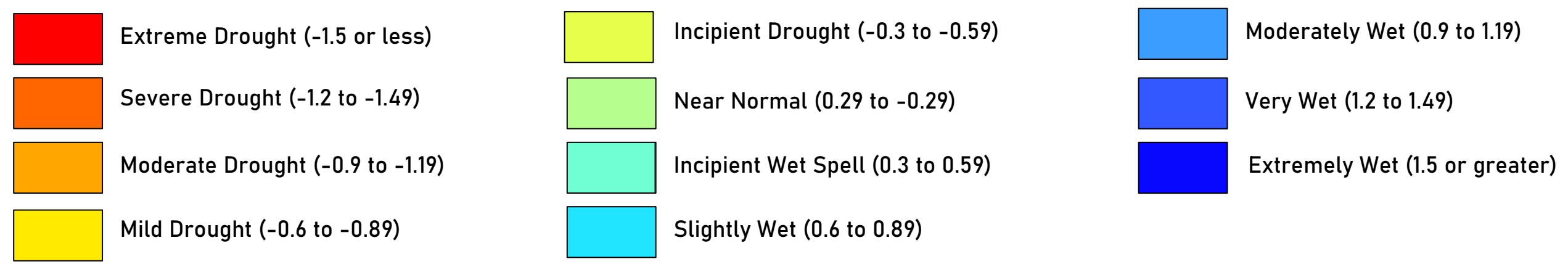


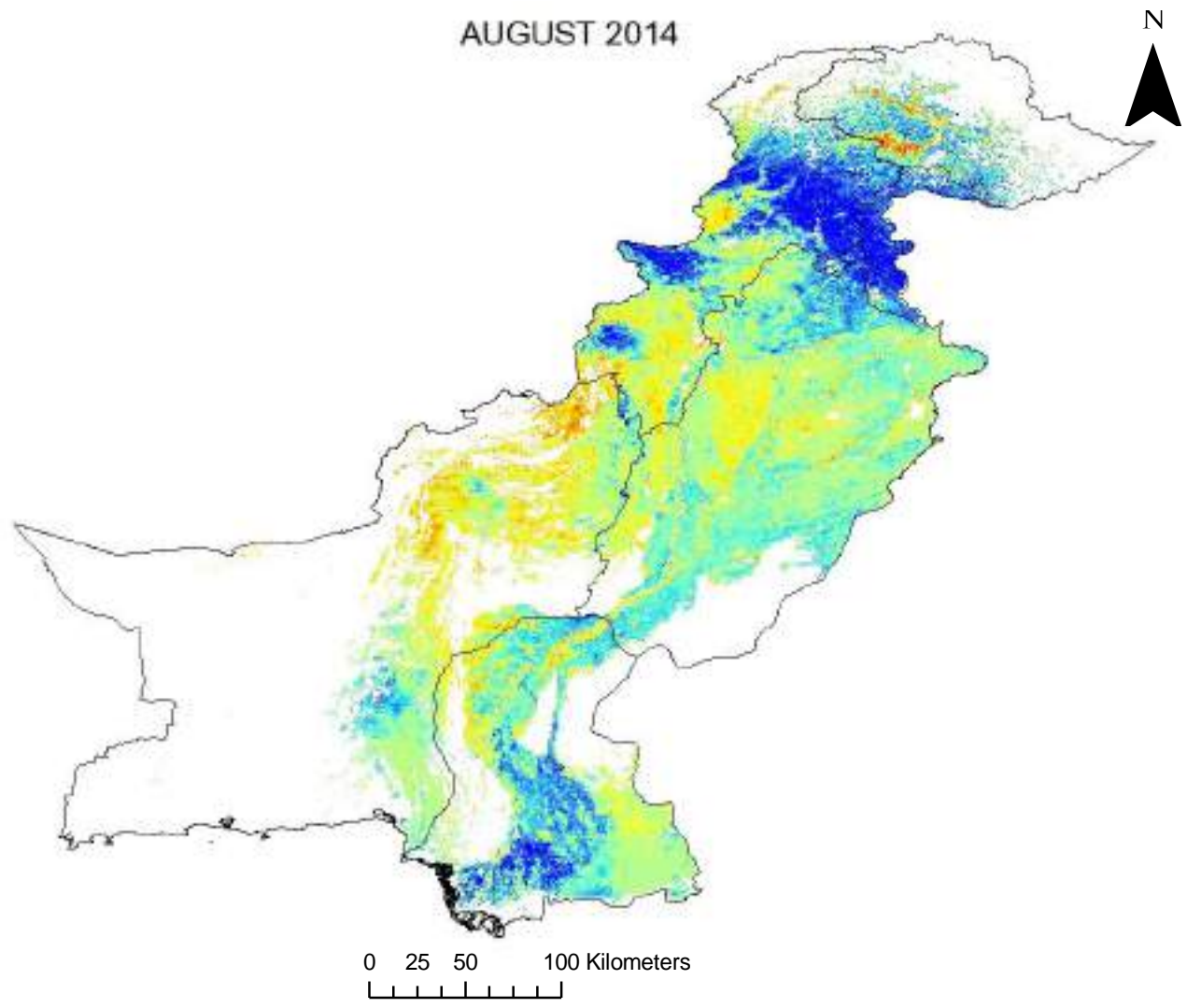
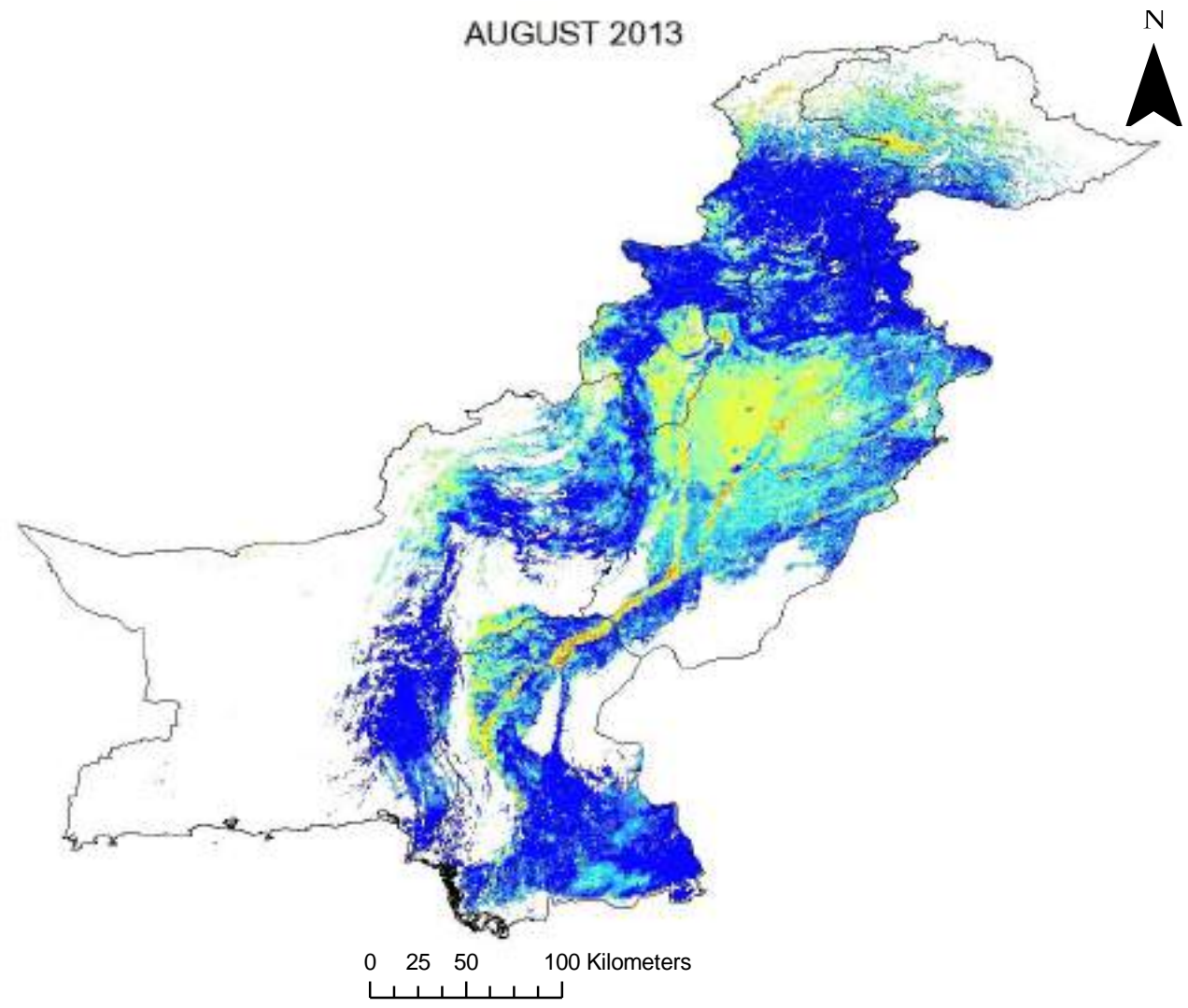
Legend

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|--|---|--|
|  Extreme Drought (-1.5 or less) |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19) |
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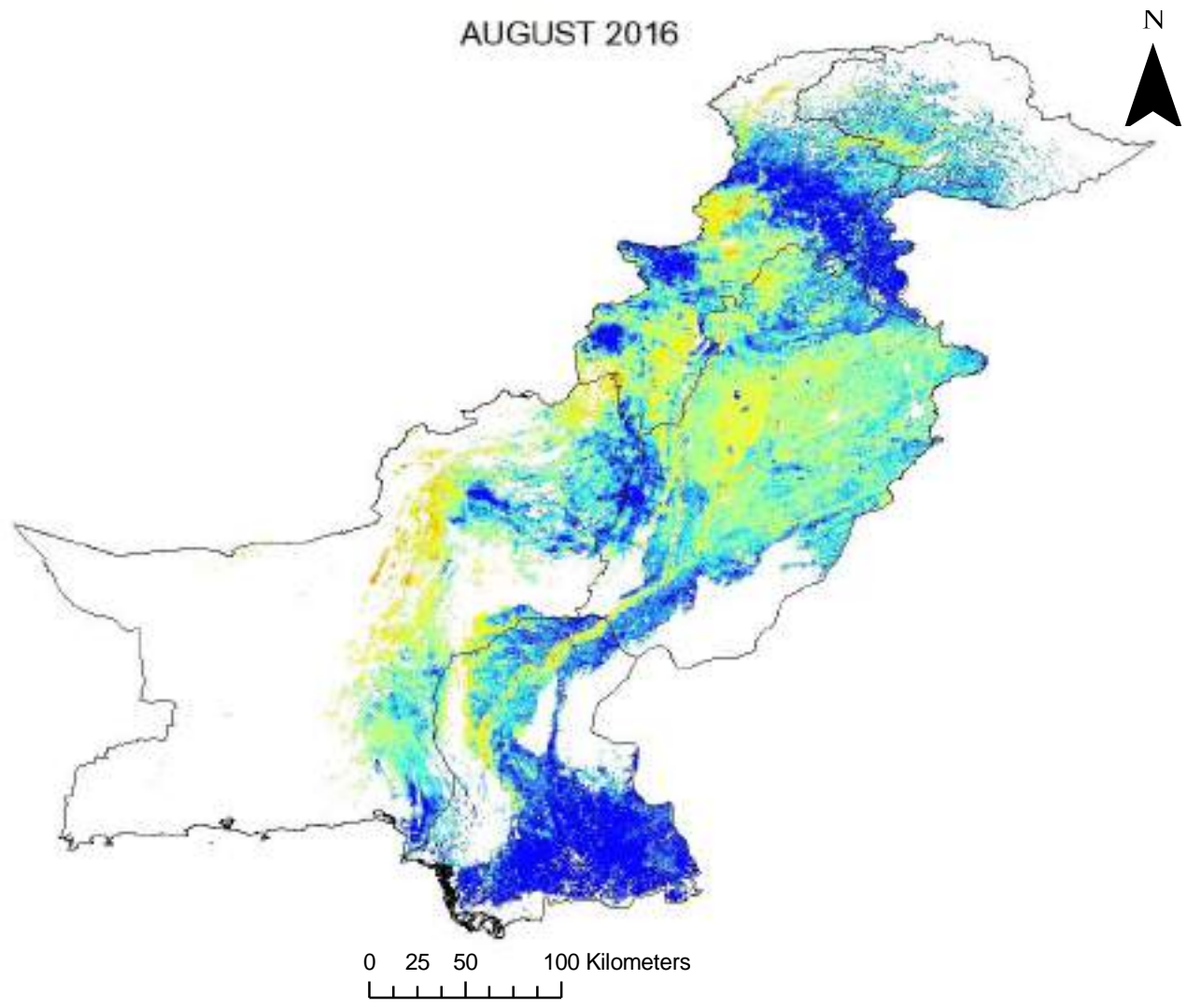
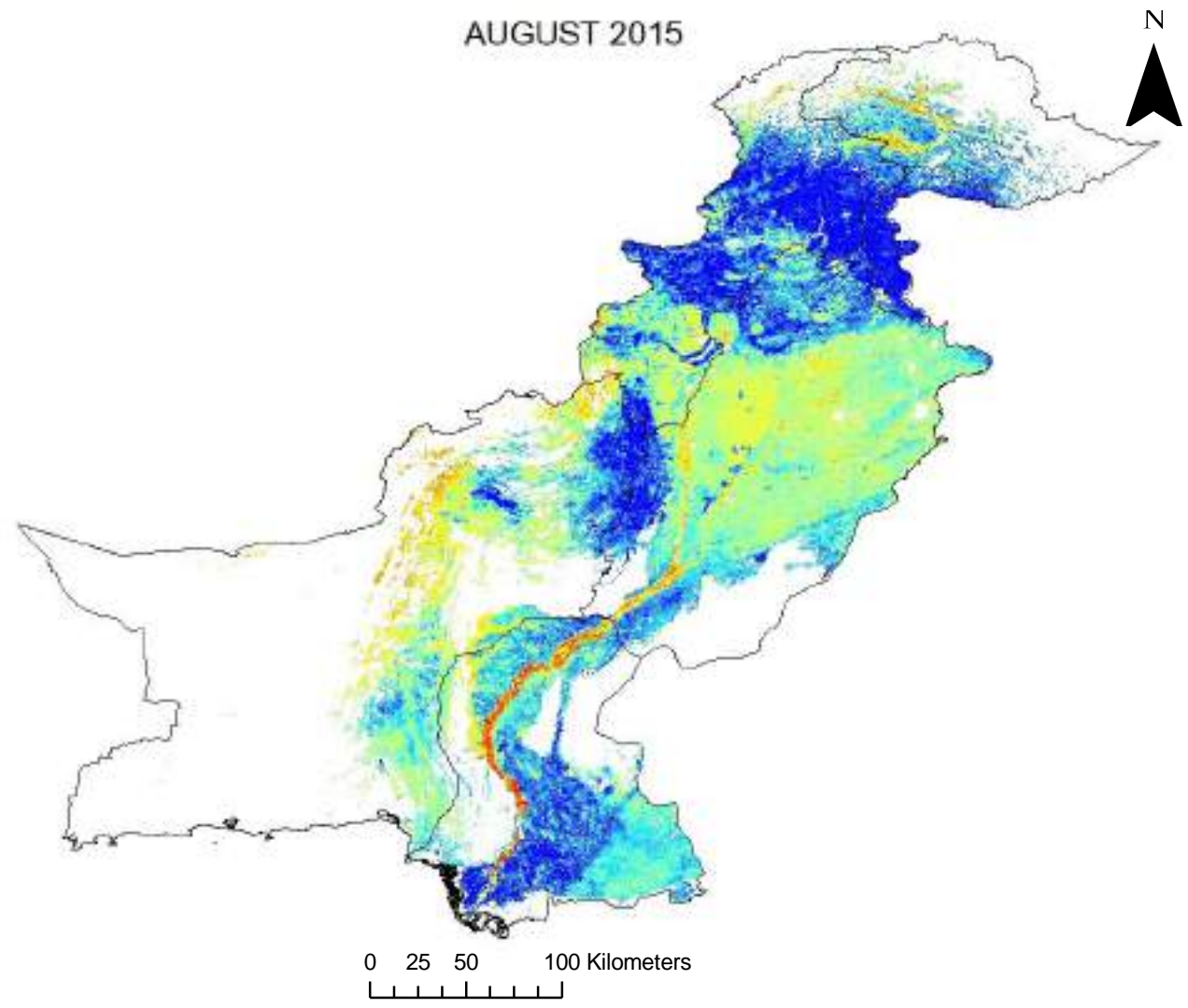
Legend



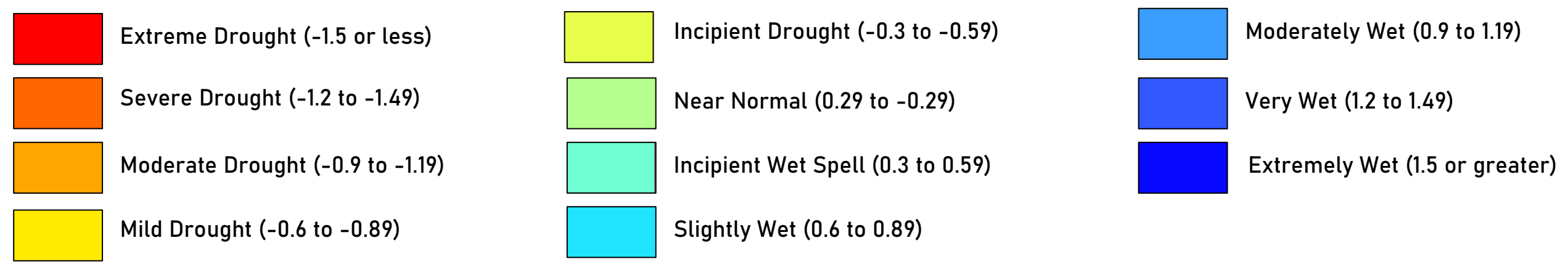


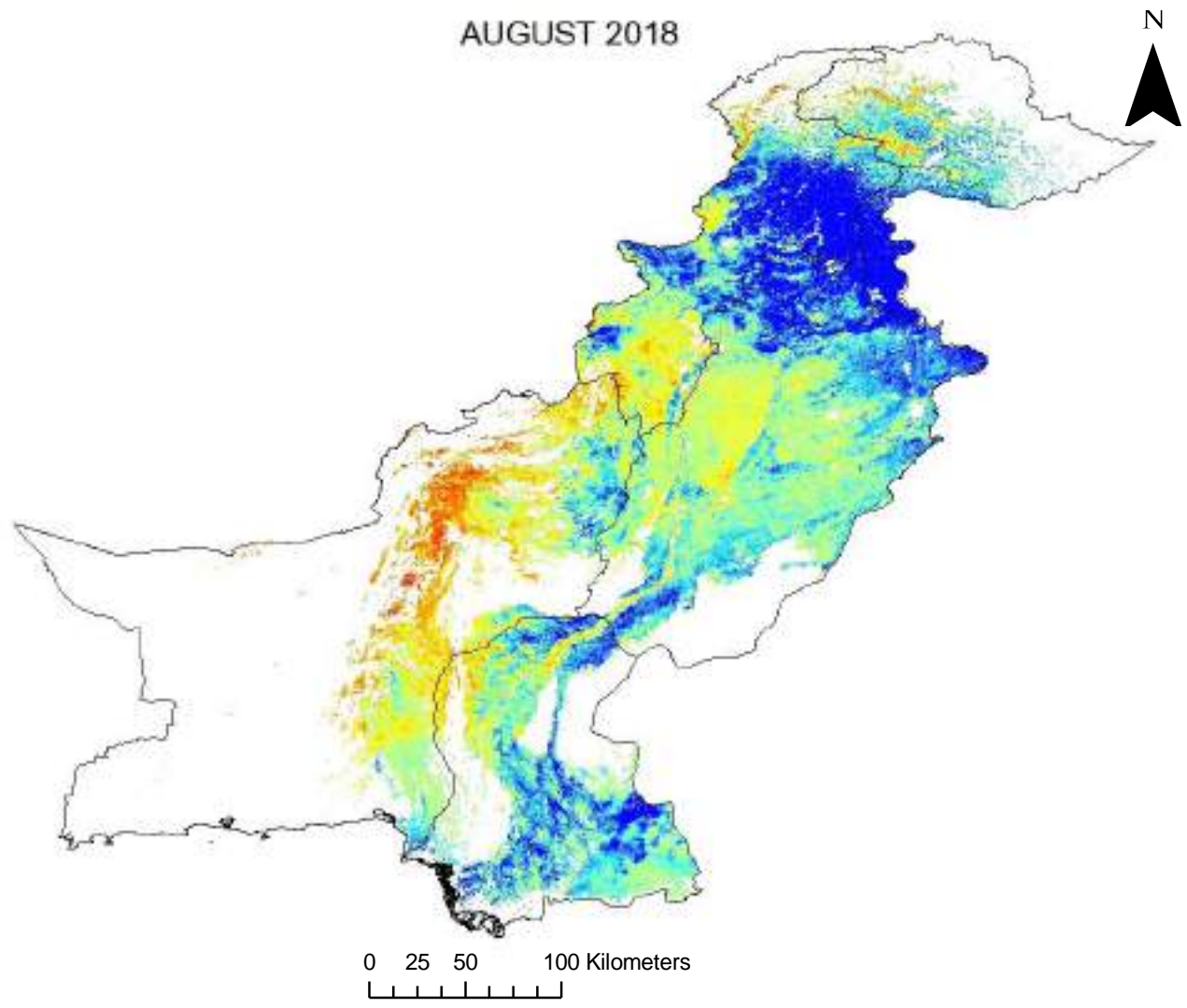
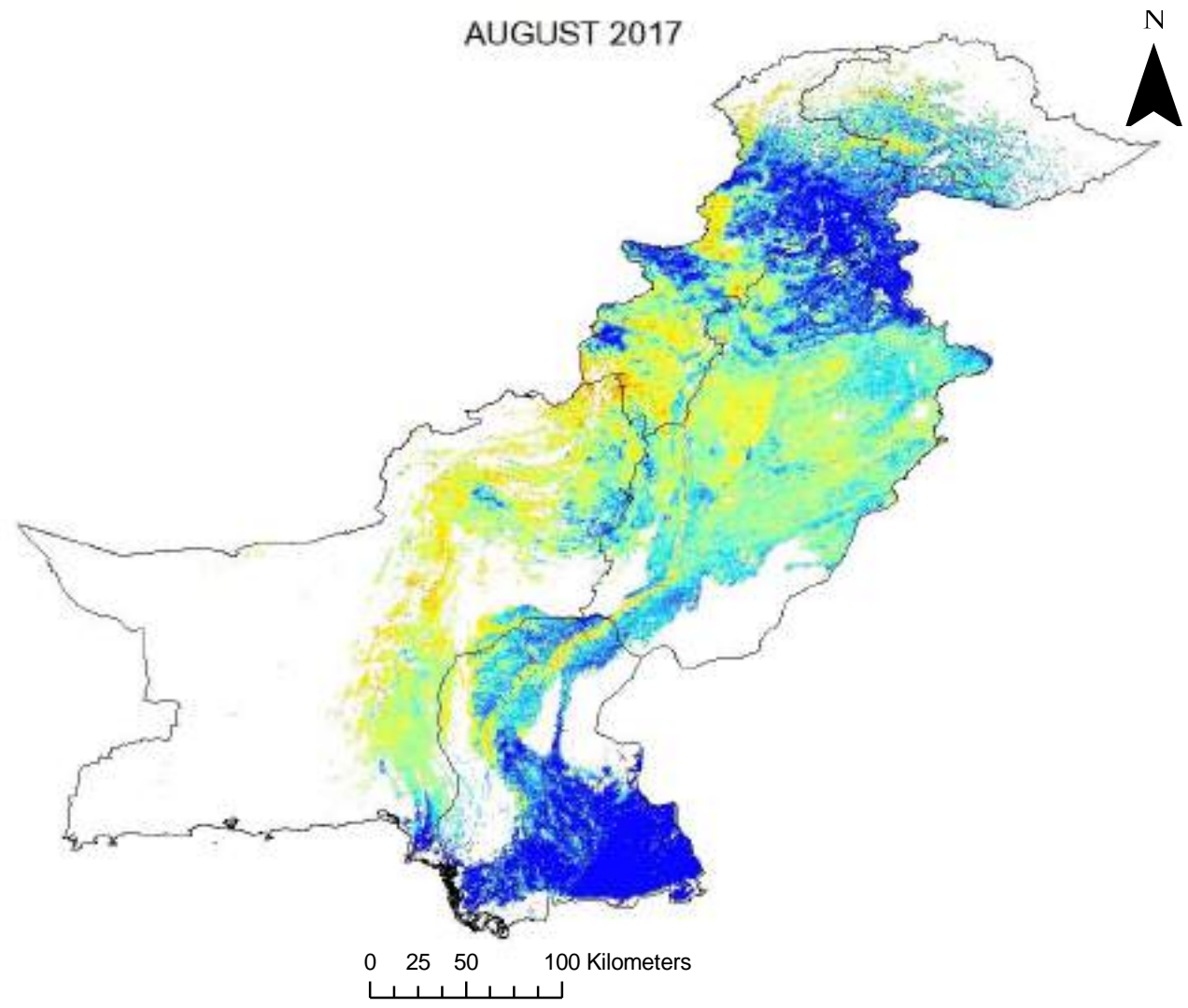
Legend

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|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
|  | Severe Drought (-1.2 to -1.49) |  | Near Normal (0.29 to -0.29) |  | Very Wet (1.2 to 1.49) |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89) |  | Slightly Wet (0.6 to 0.89) | | |

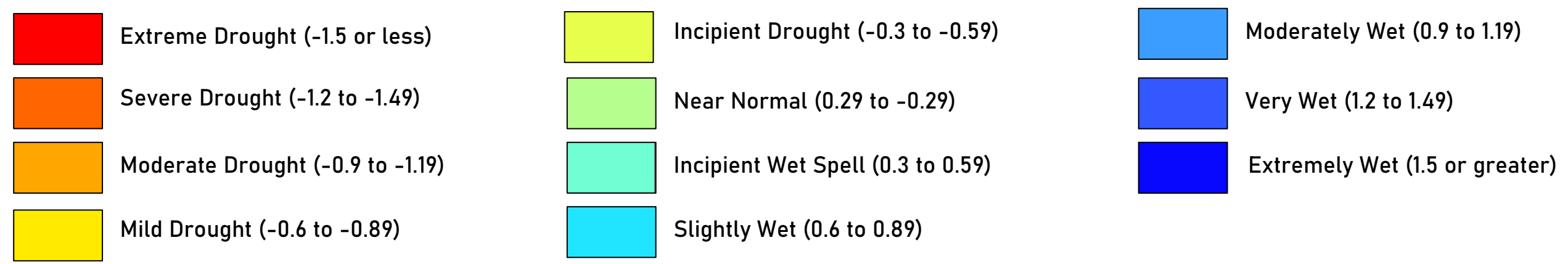


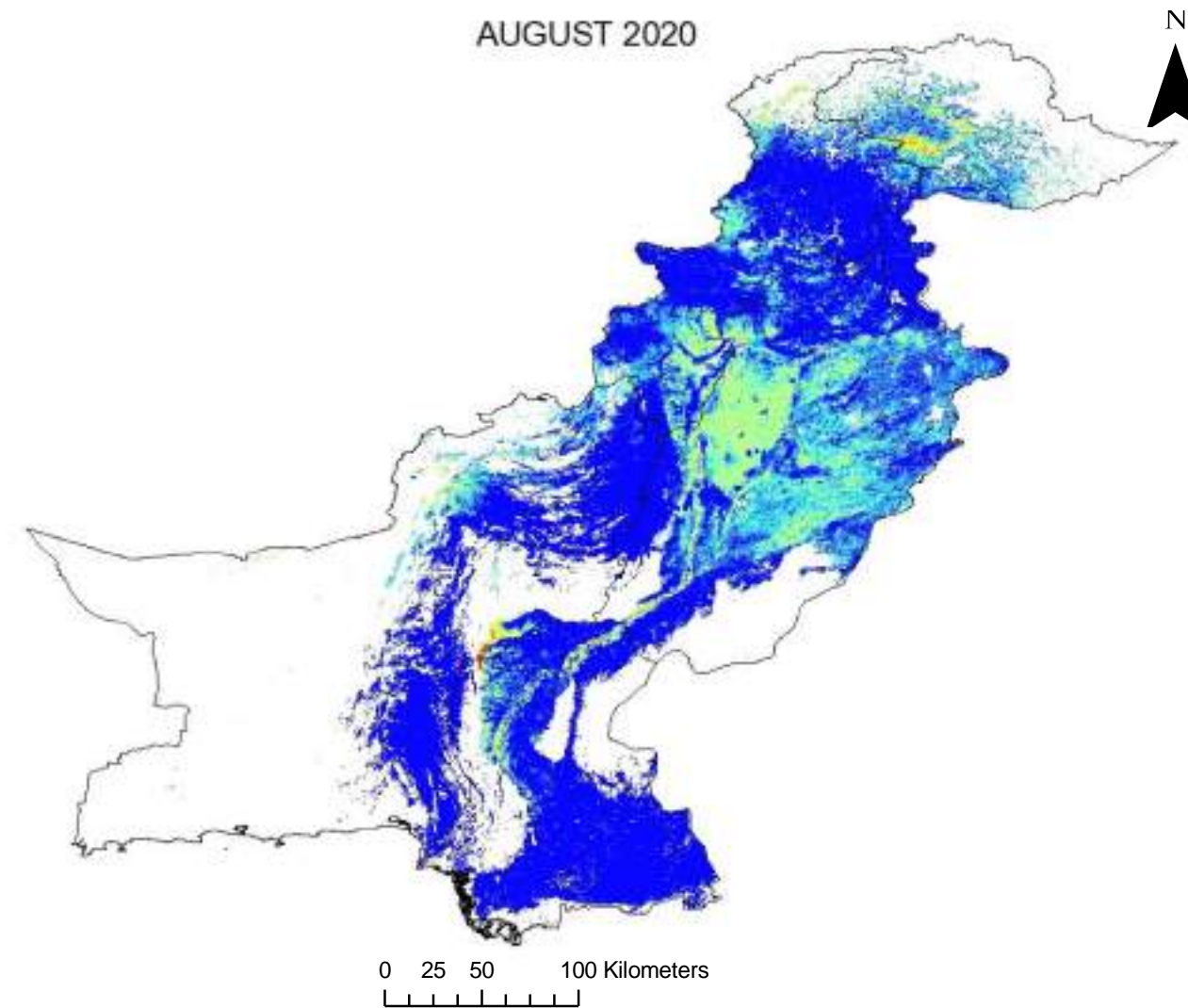
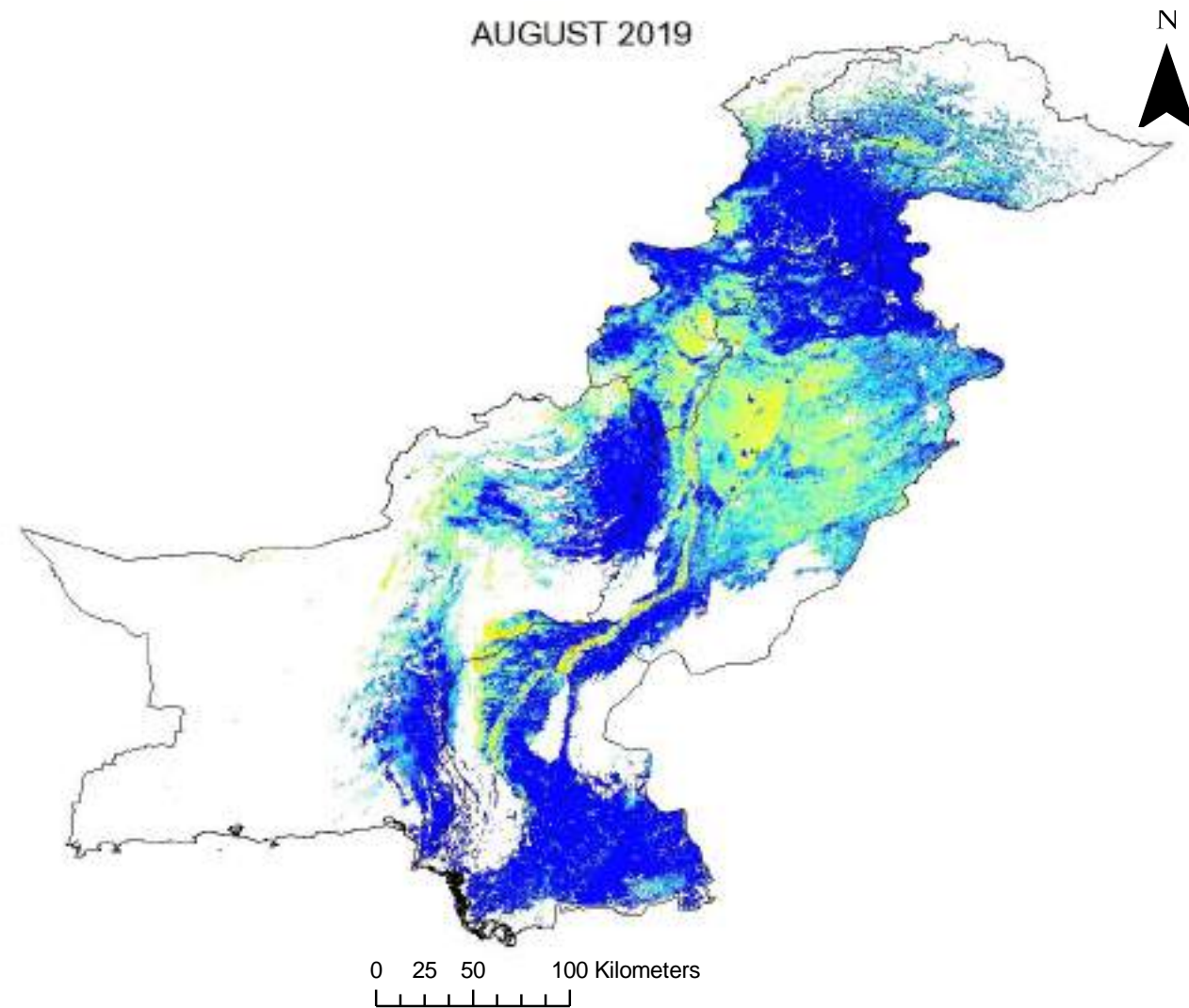
Legend



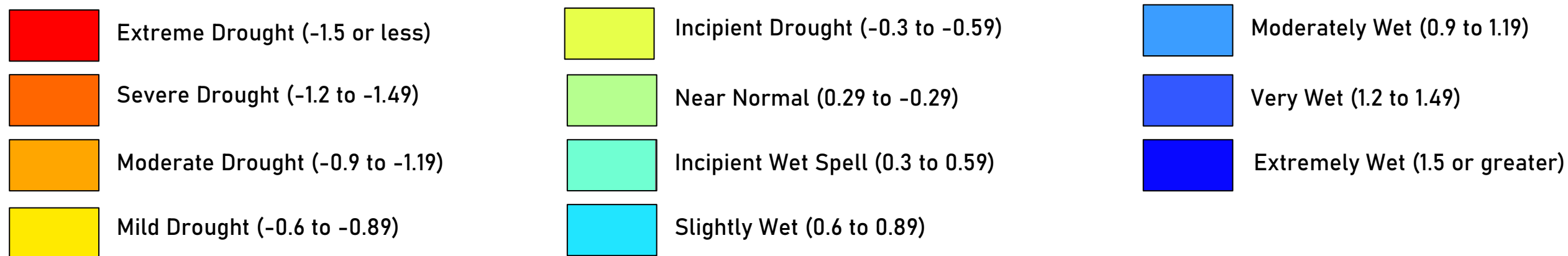


Legend





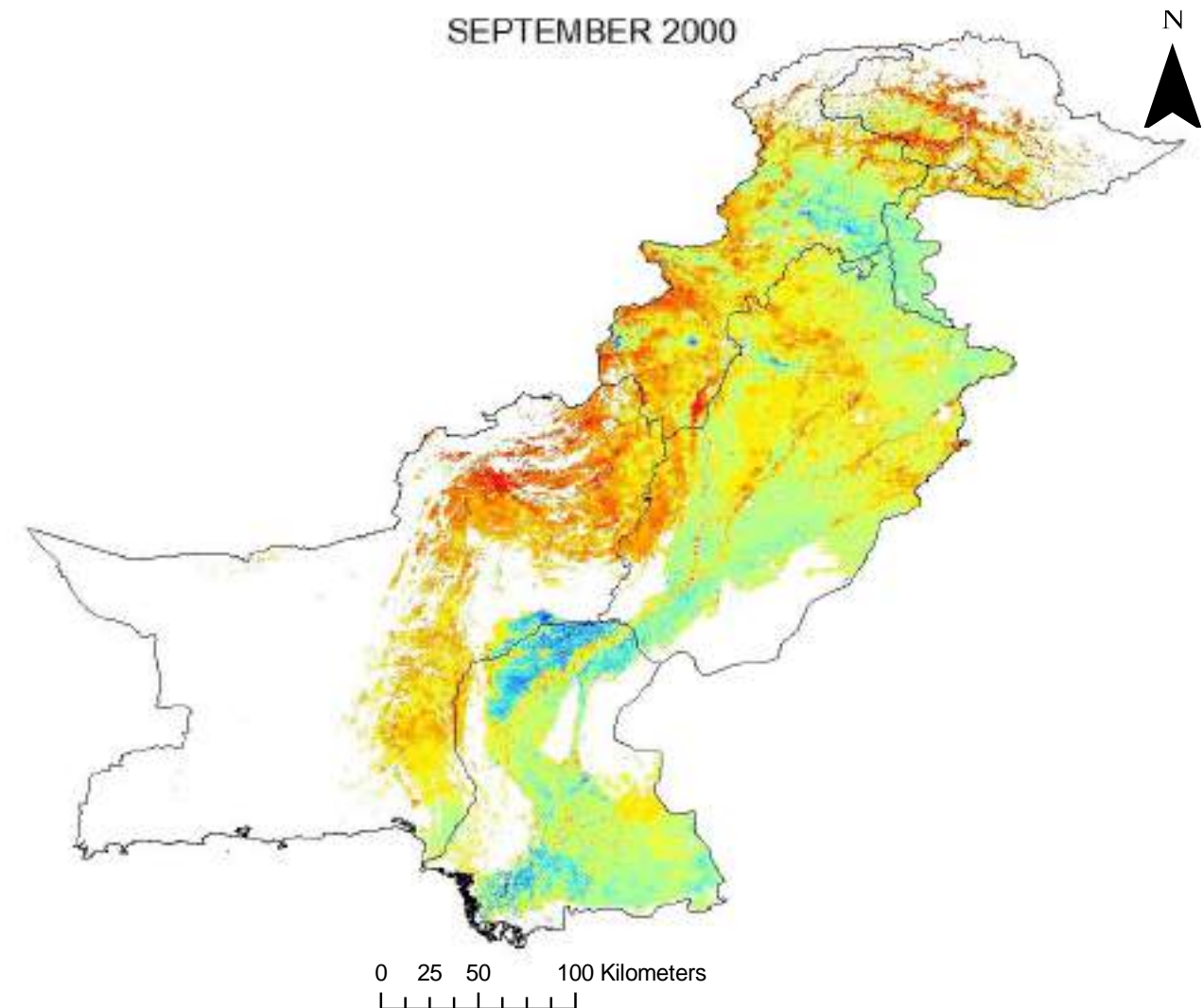
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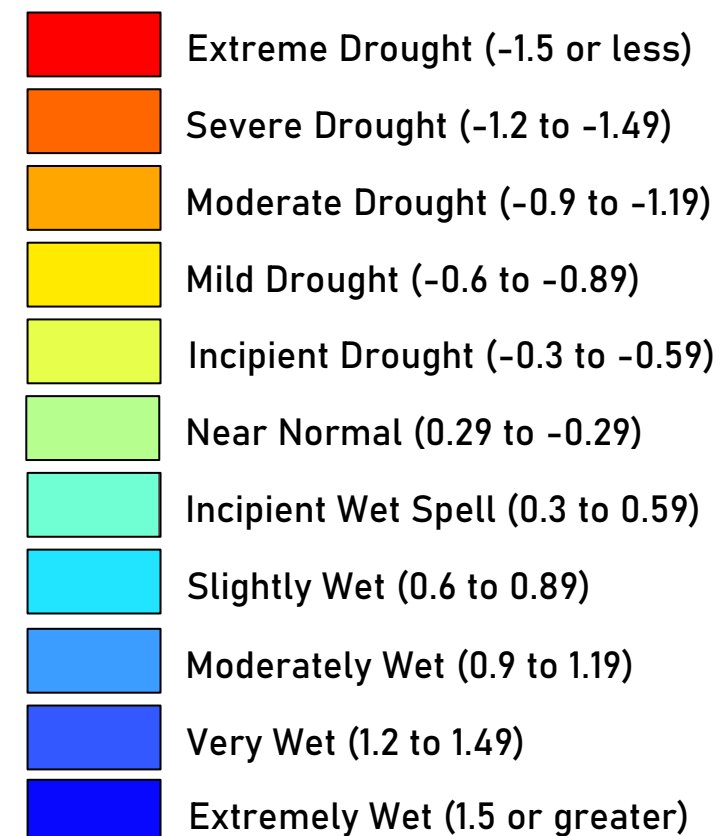
September DSI Maps

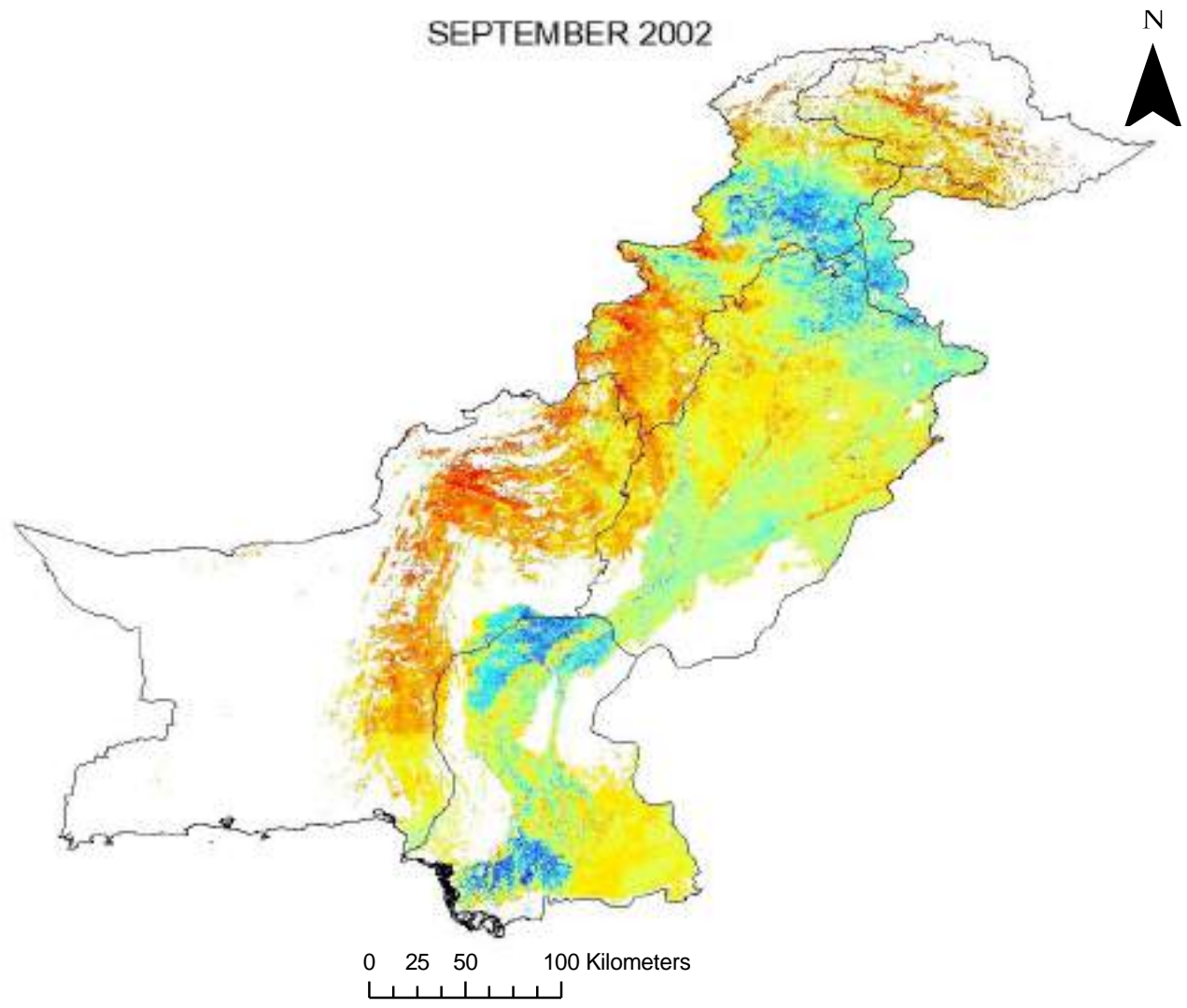
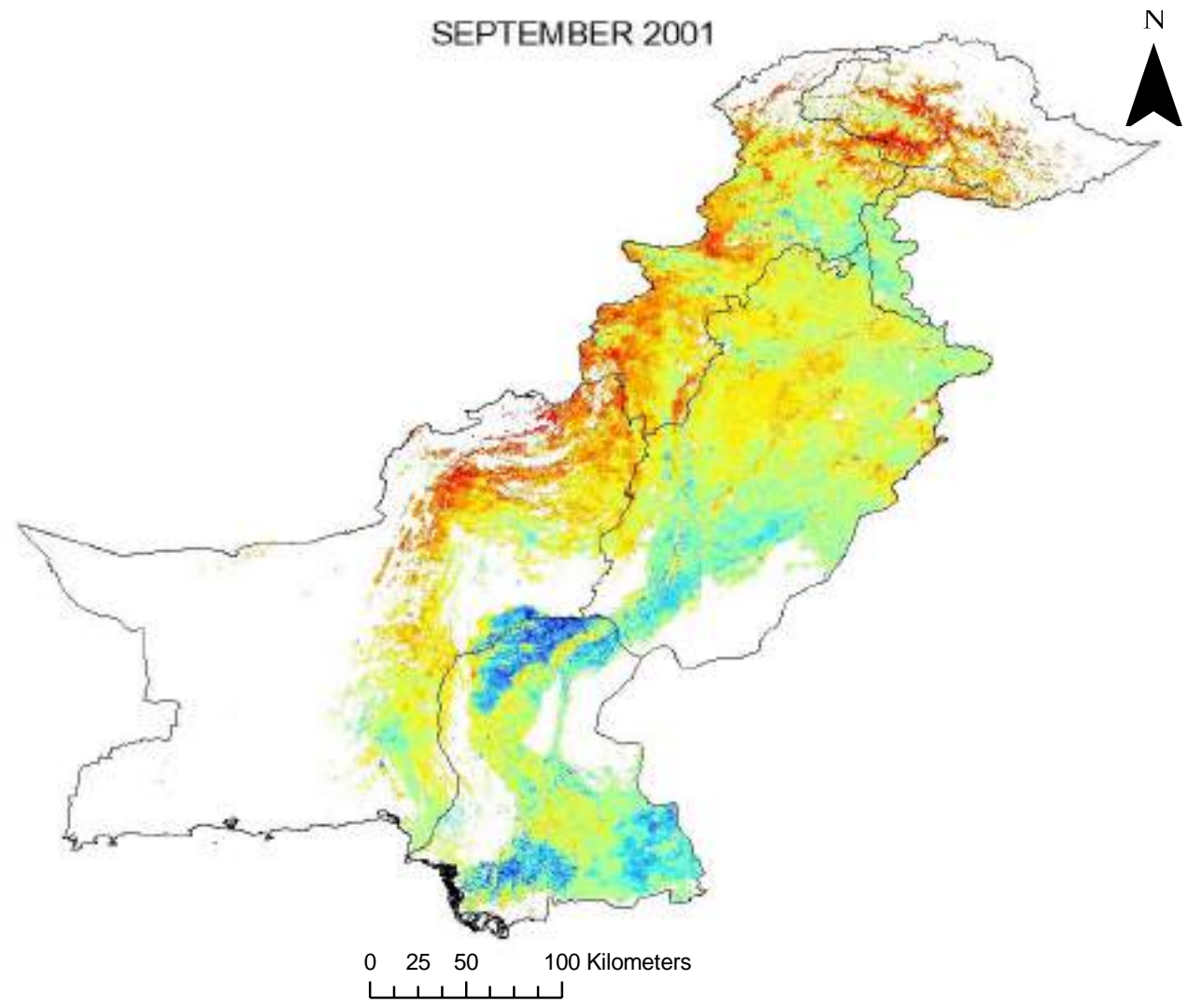
In September, drought conditions are characterized by very wet to extremely wet condition. This monsoon month is extremely wet in all parts of the country.

Mean September DSI Values		
Years	Values	Drought Condition
2000	-0.38	Incipient Drought
2001	-0.42	Incipient Drought
2002	-0.23	Near Normal
2003	0.17	Near Normal
2004	-0.26	Near Normal
2005	0.14	Near Normal
2006	0.09	Near Normal
2007	0.00	Near Normal
2008	-0.07	Near Normal
2009	-0.04	Near Normal
2010	0.56	Incipient Wet Spell
2011	0.95	Moderately Wet
2012	0.69	Slightly Wet
2013	0.31	Incipient Wet Spell
2014	0.29	Near Normal
2015	0.12	Near Normal
2016	0.04	Near Normal
2017	0.16	Near Normal
2018	0.20	Near Normal
2019	0.85	Slightly Wet
2020	1.05	Moderately Wet














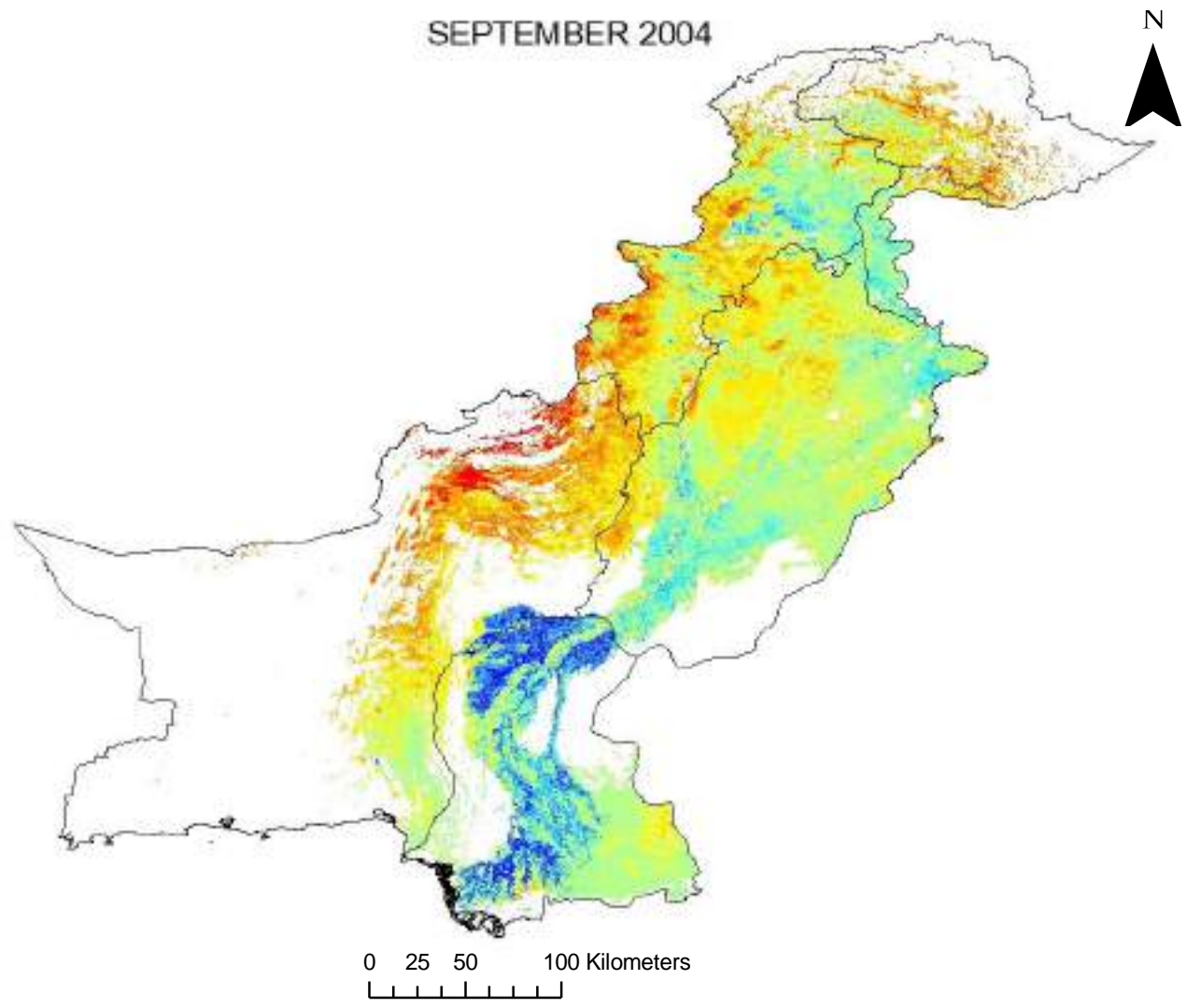
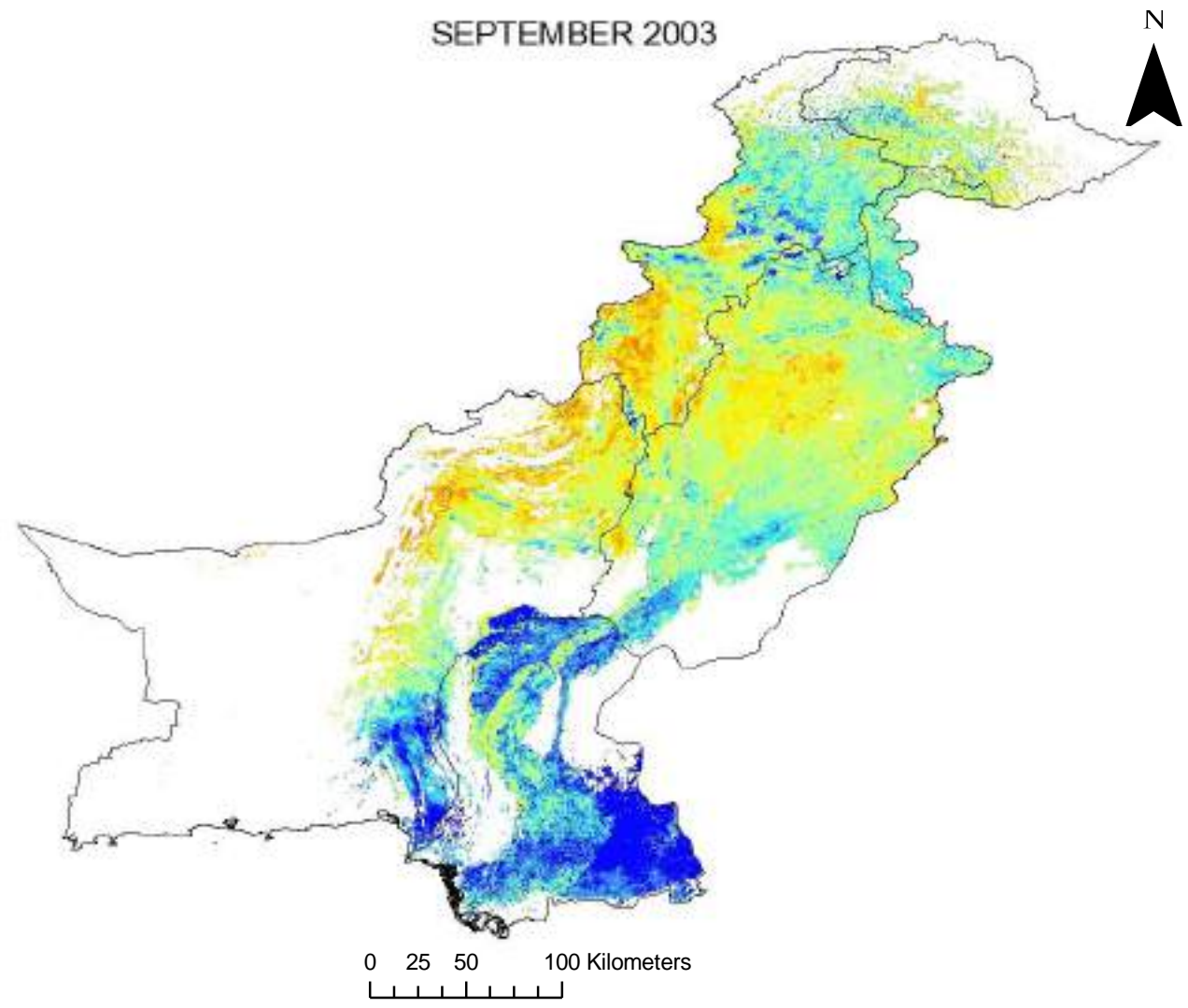
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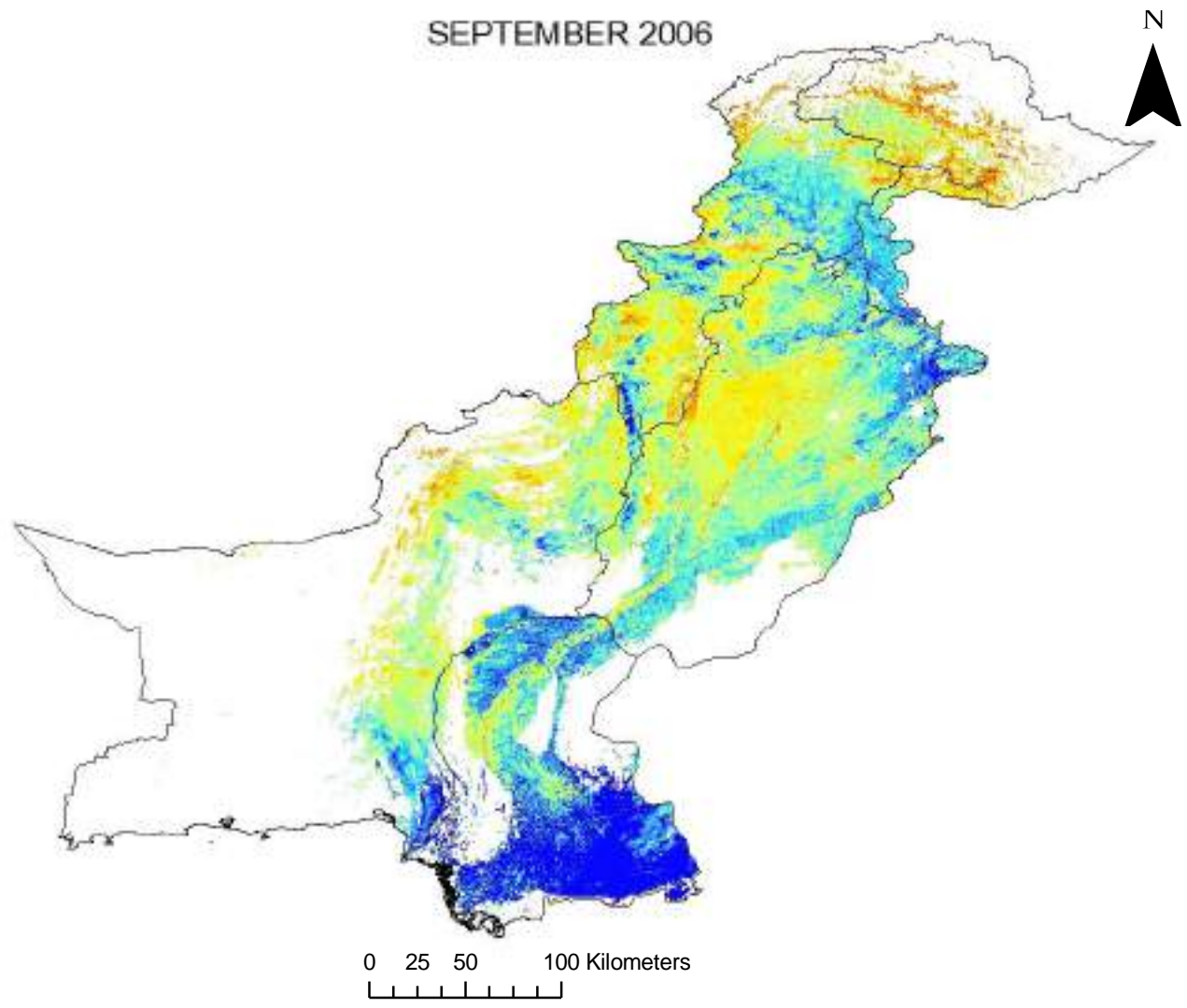
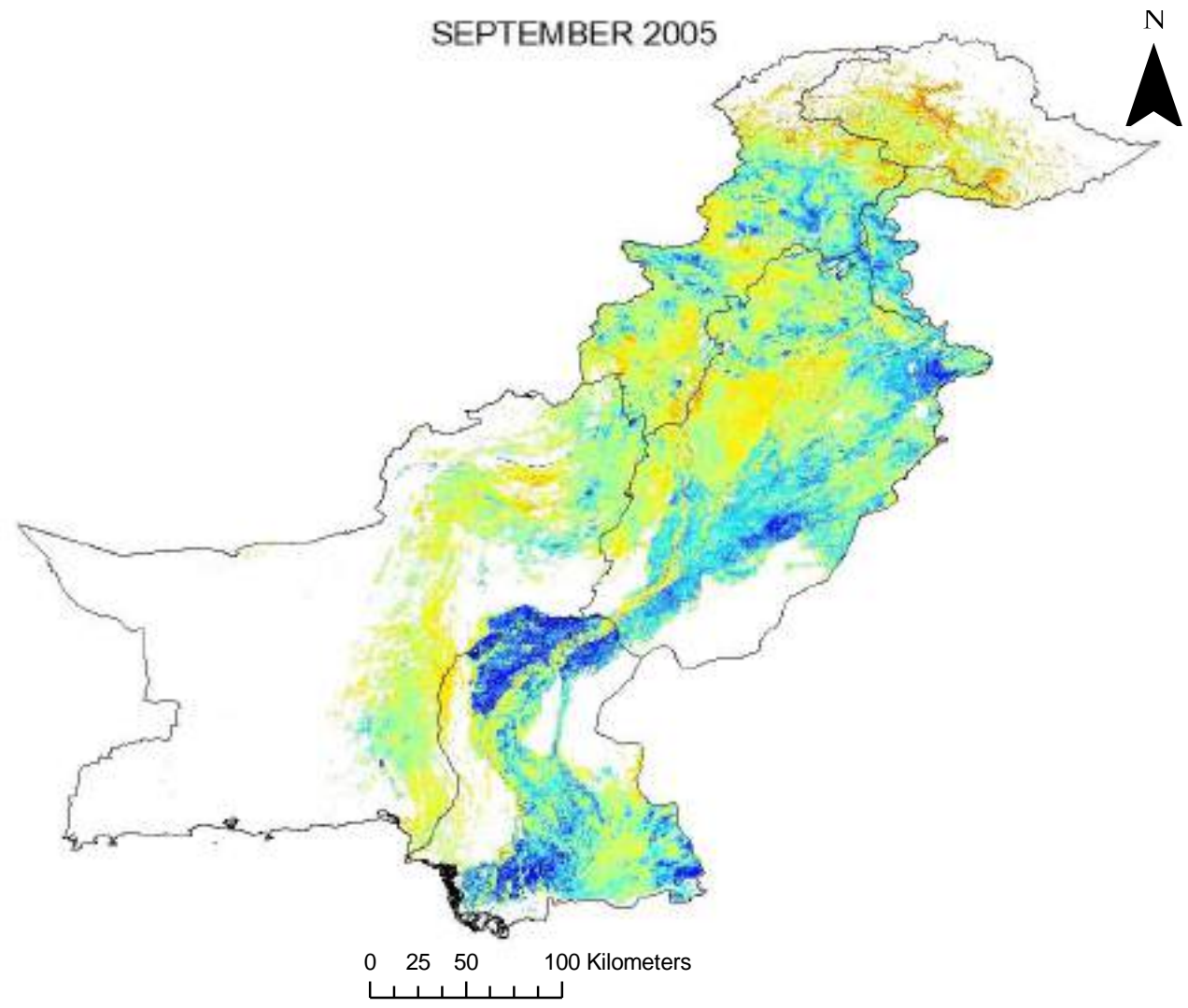
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|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
|  | Severe Drought (-1.2 to -1.49) |  | Near Normal (0.29 to -0.29) |  | Very Wet (1.2 to 1.49) |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89) |  | Slightly Wet (0.6 to 0.89) | | |

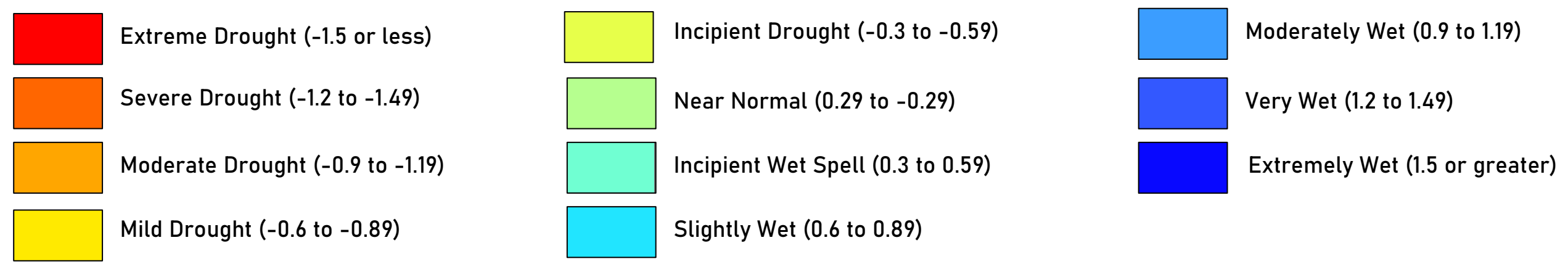


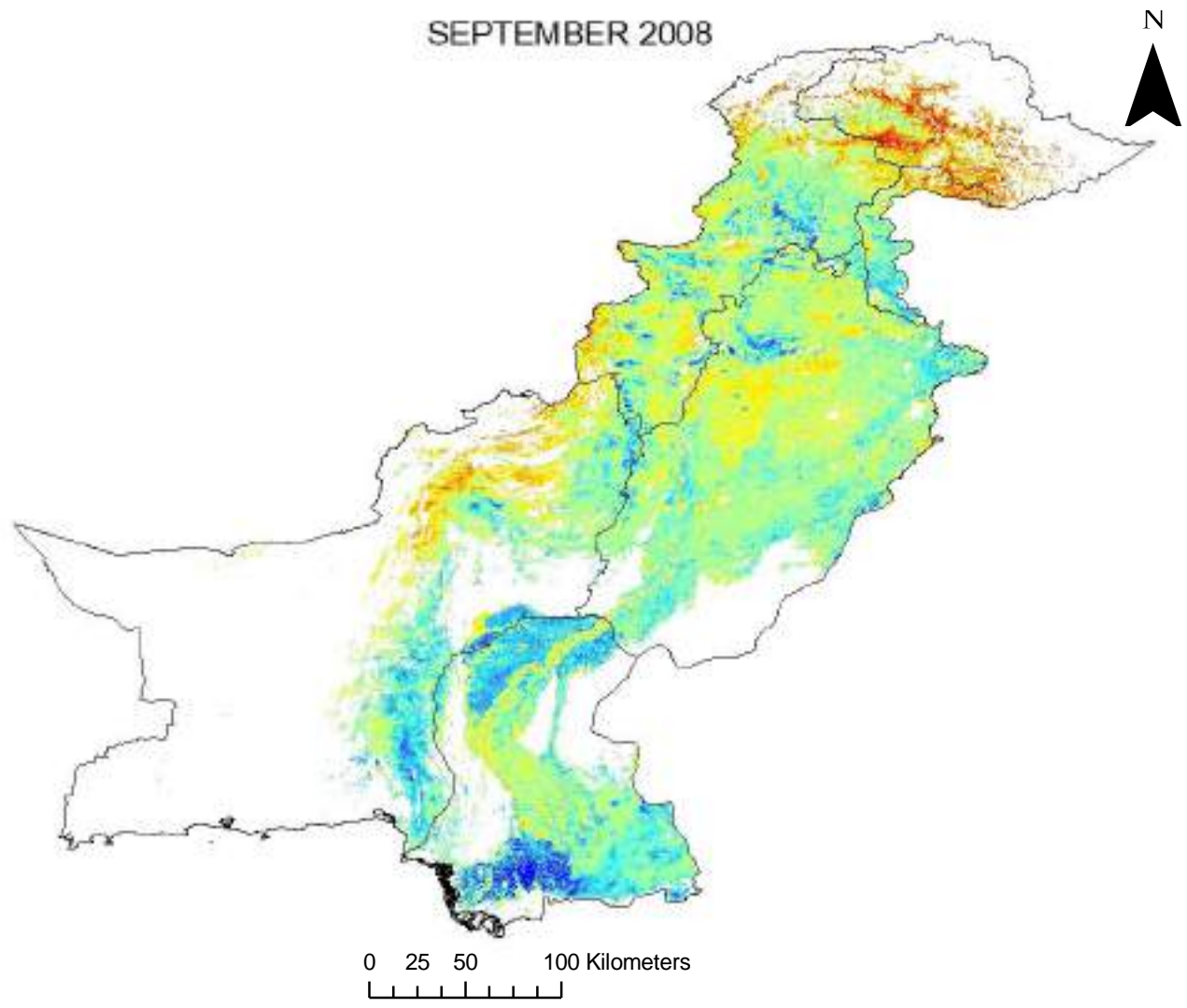
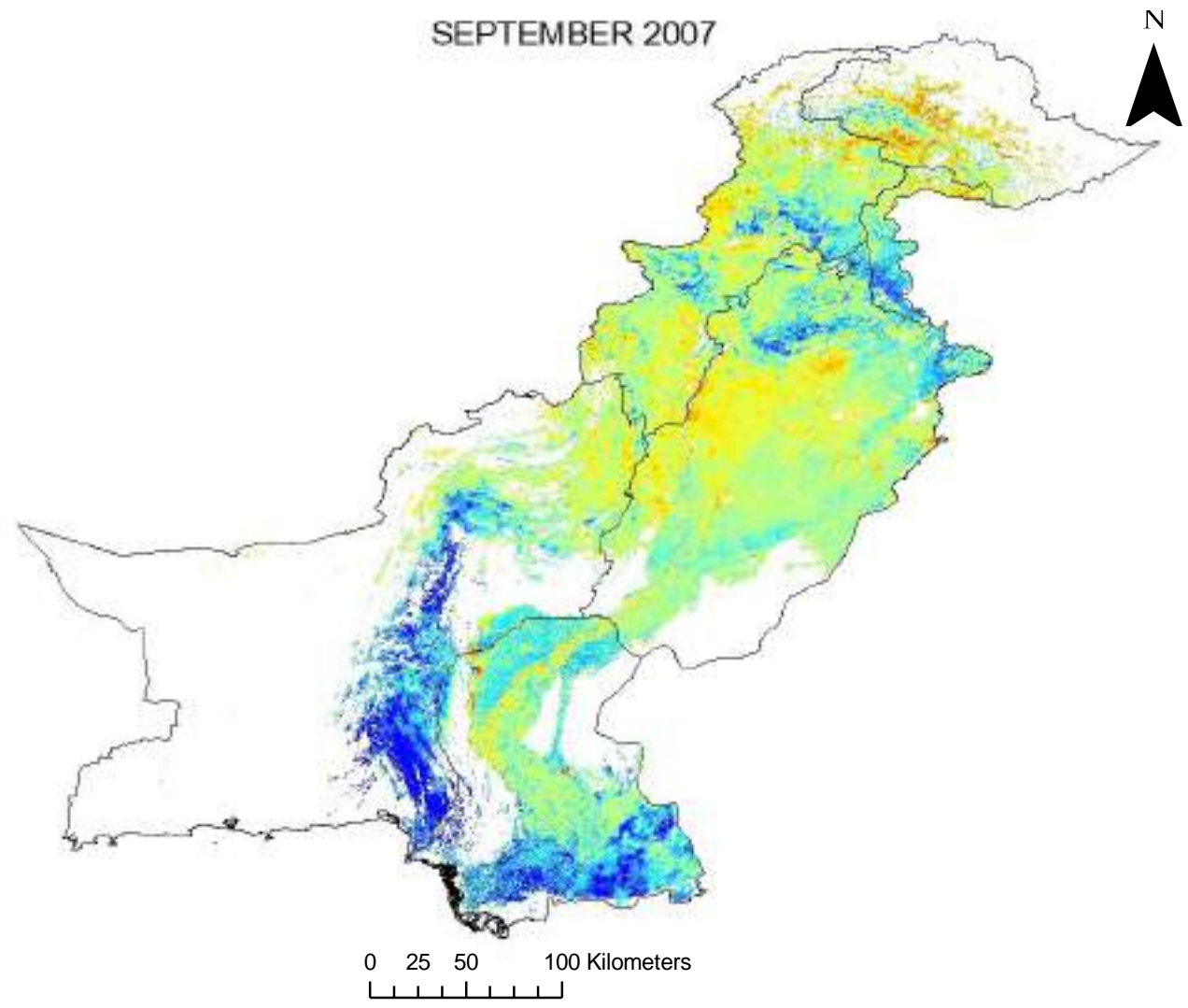
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|  Extreme Drought (-1.5 or less) |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19) |
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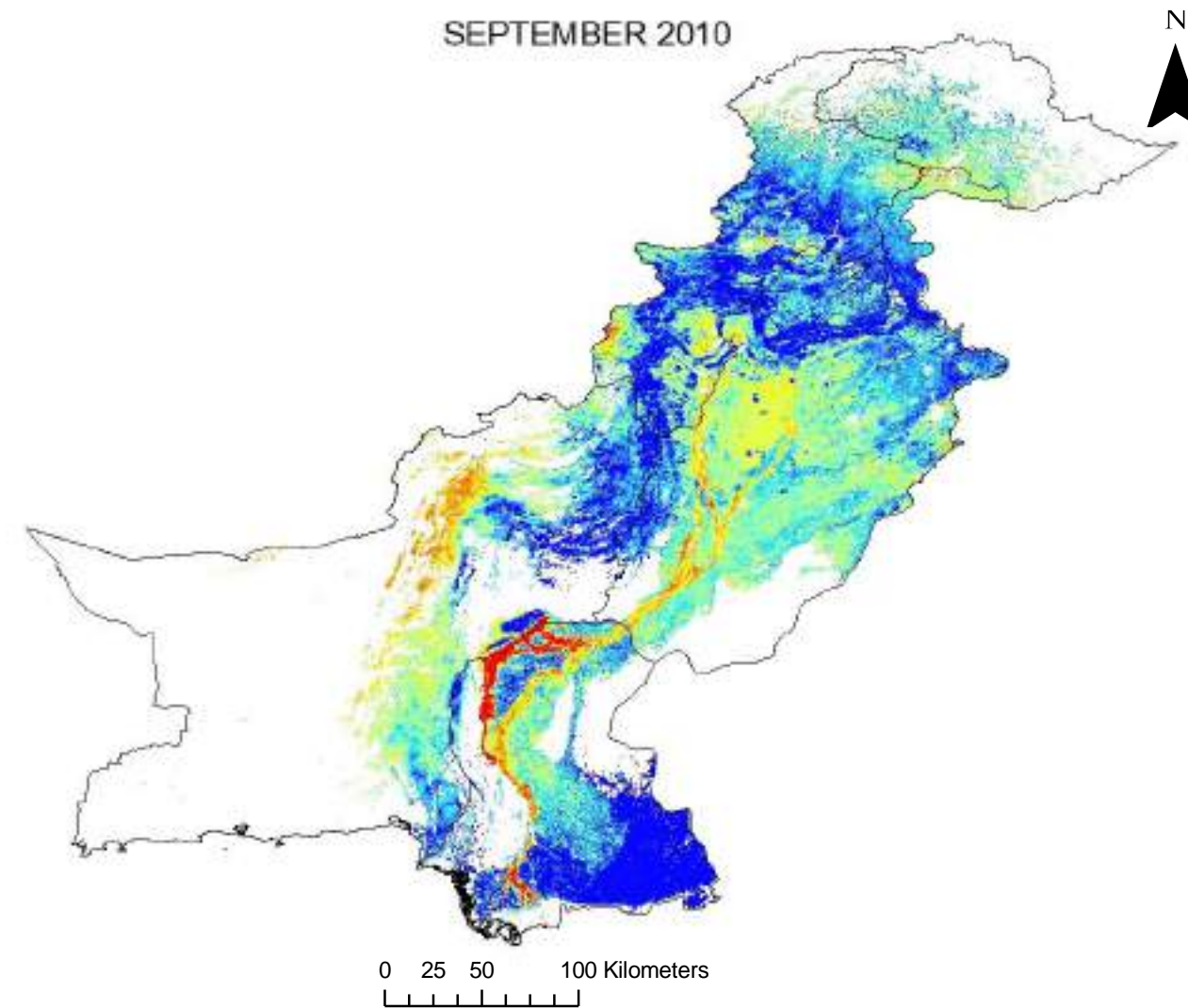
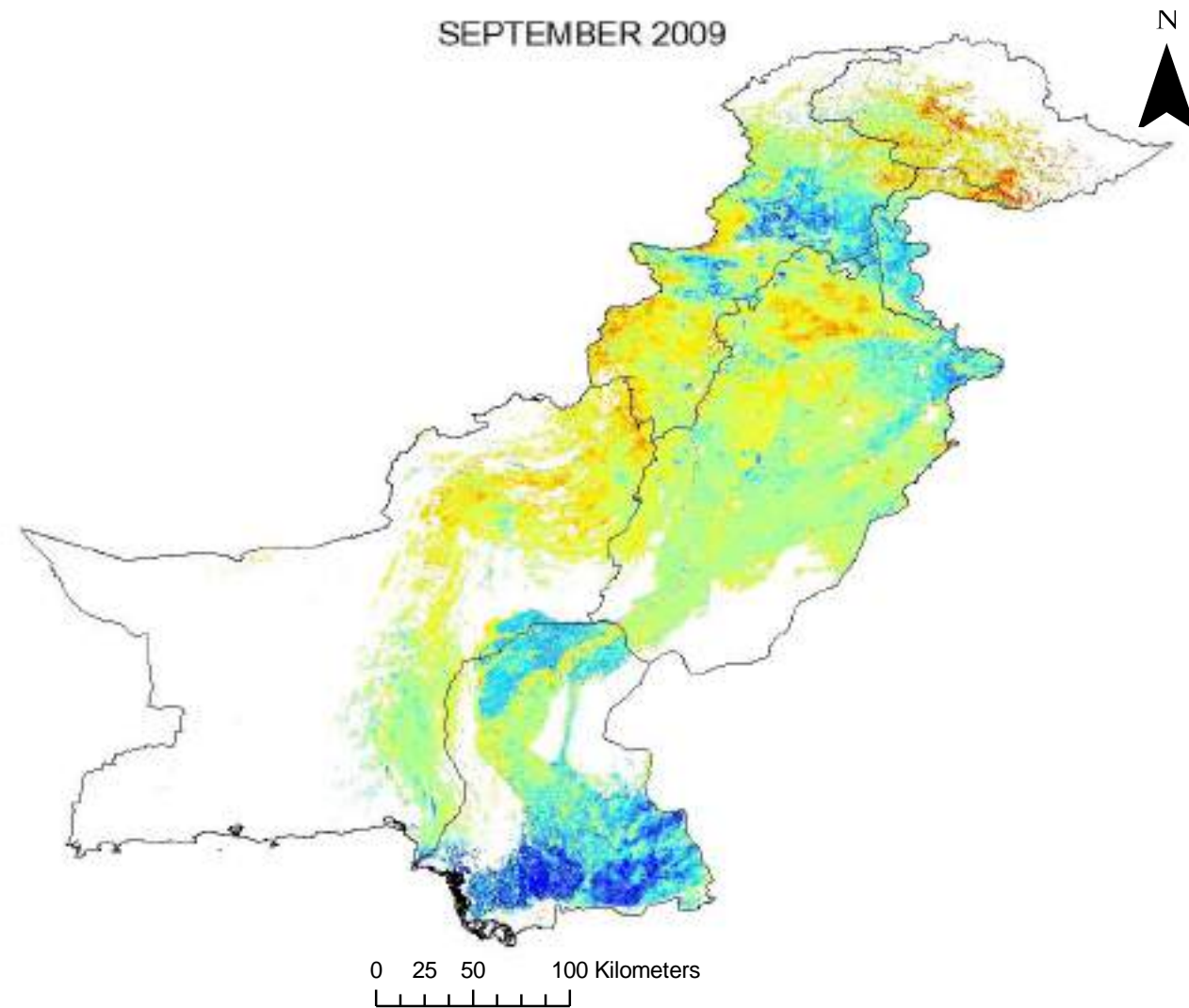
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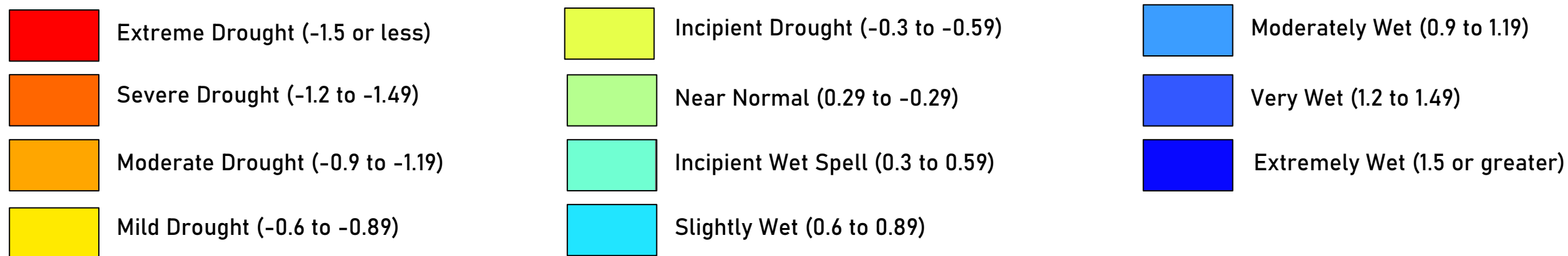


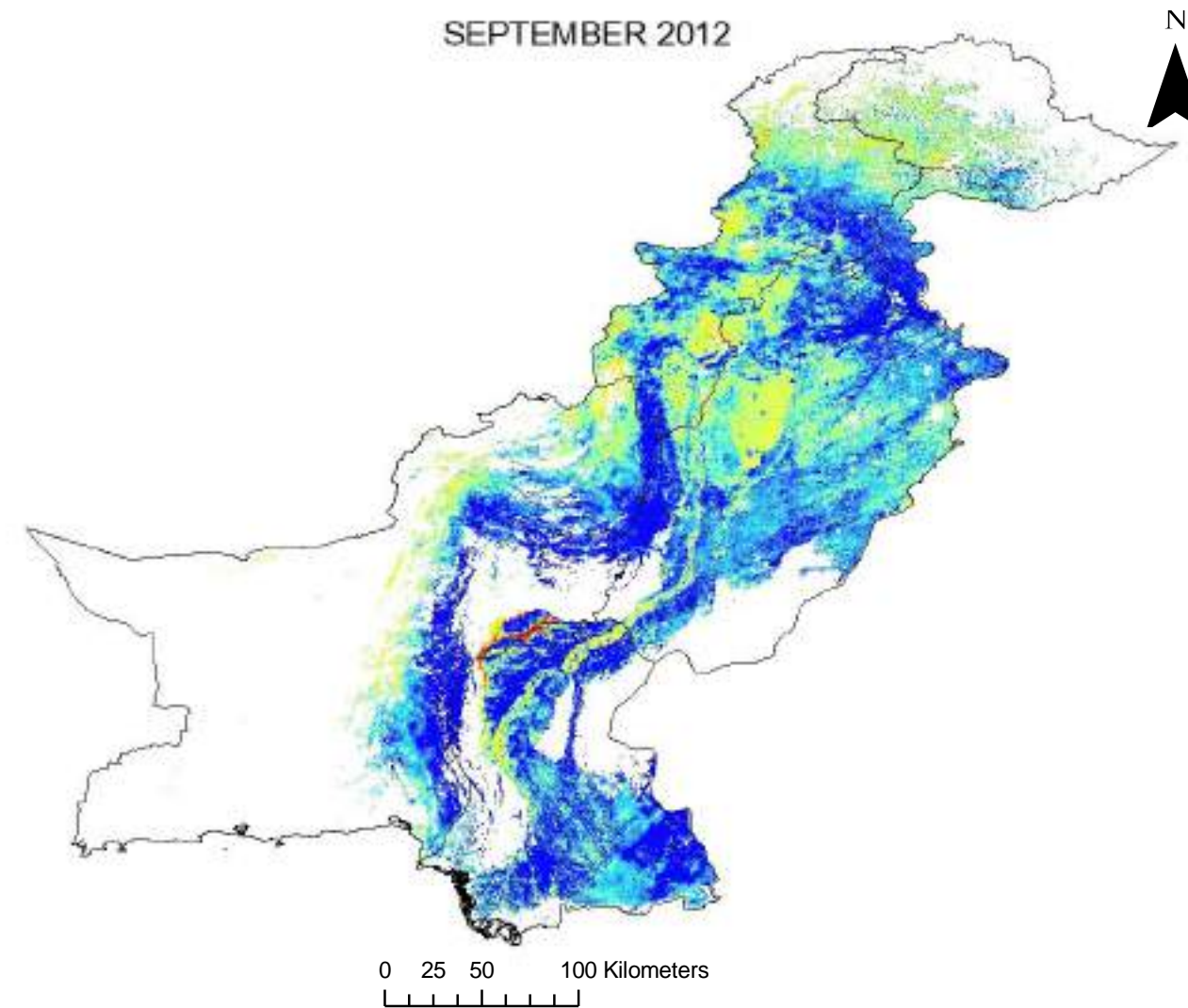
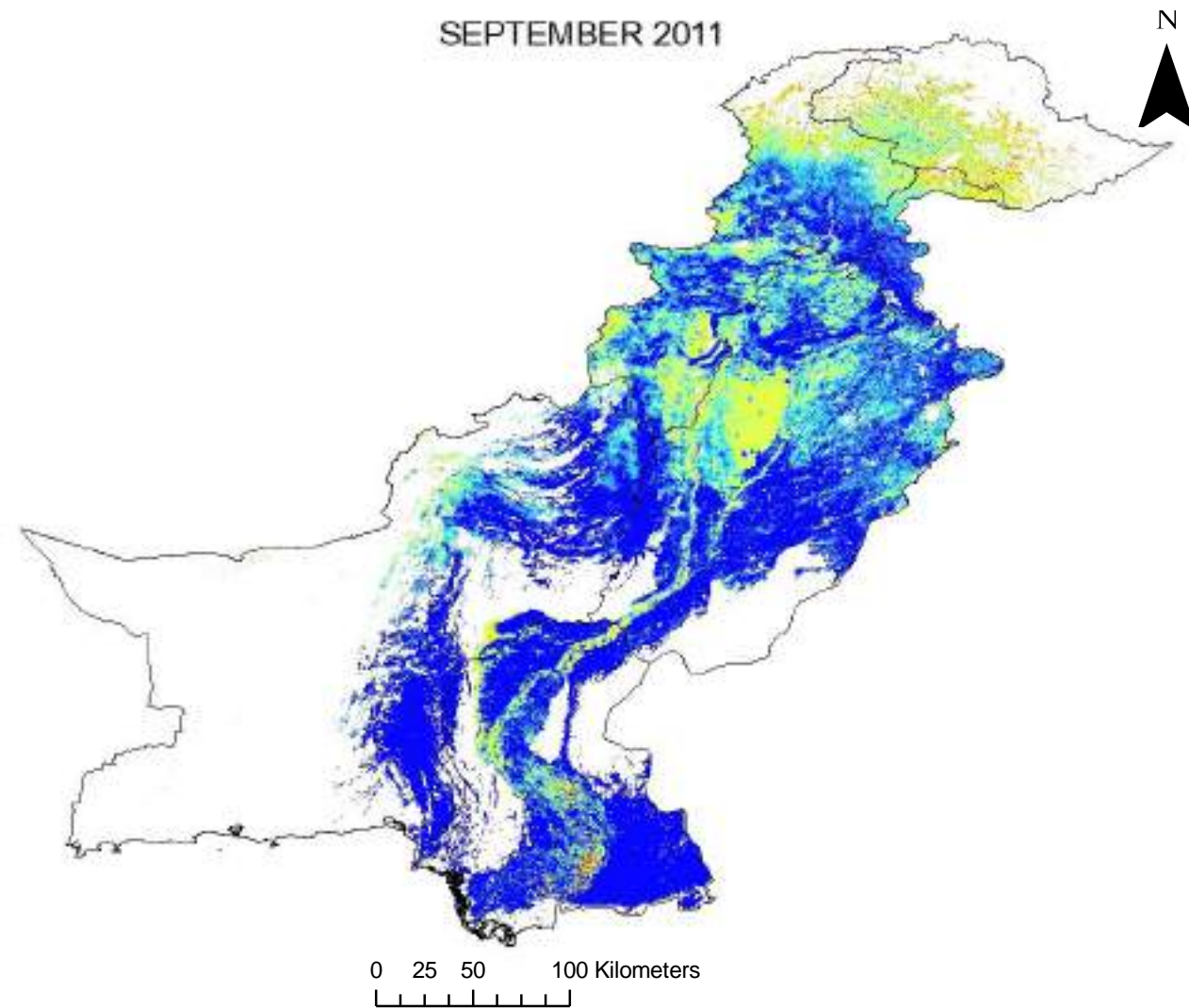
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|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
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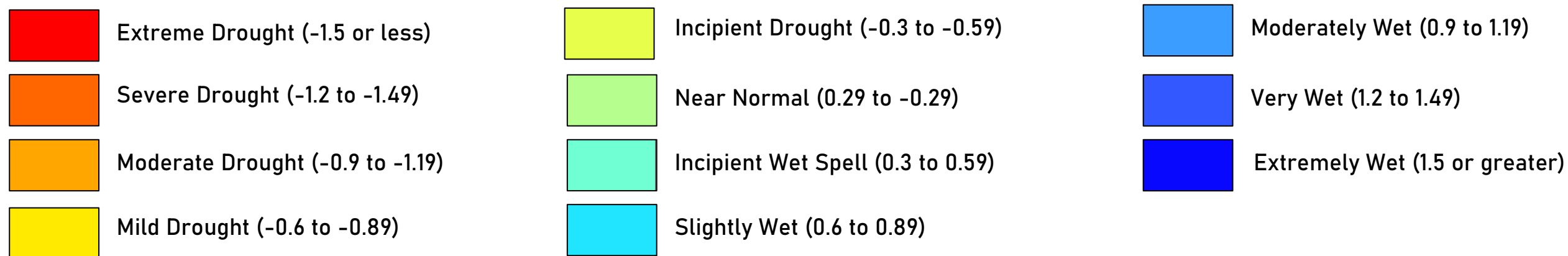


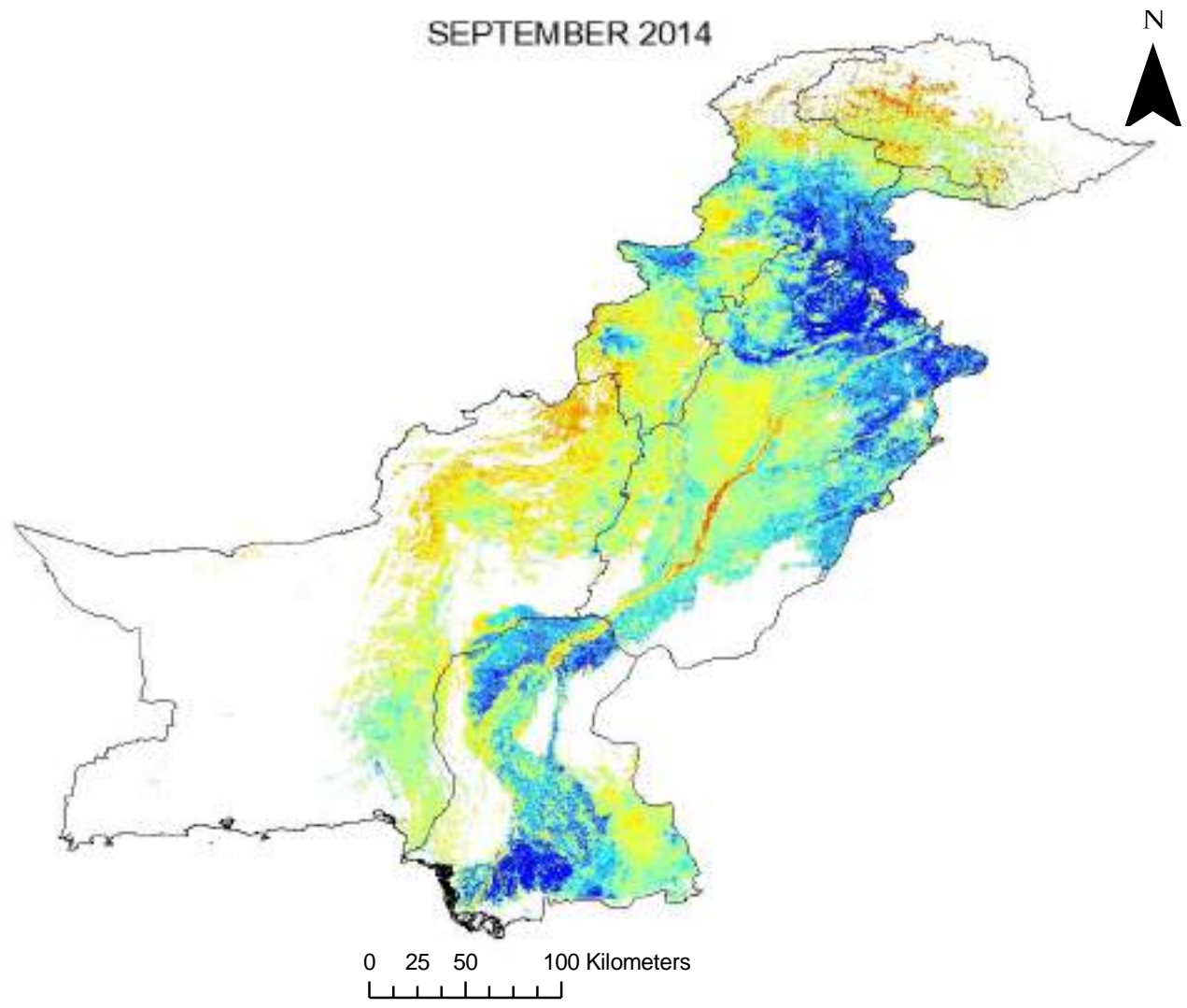
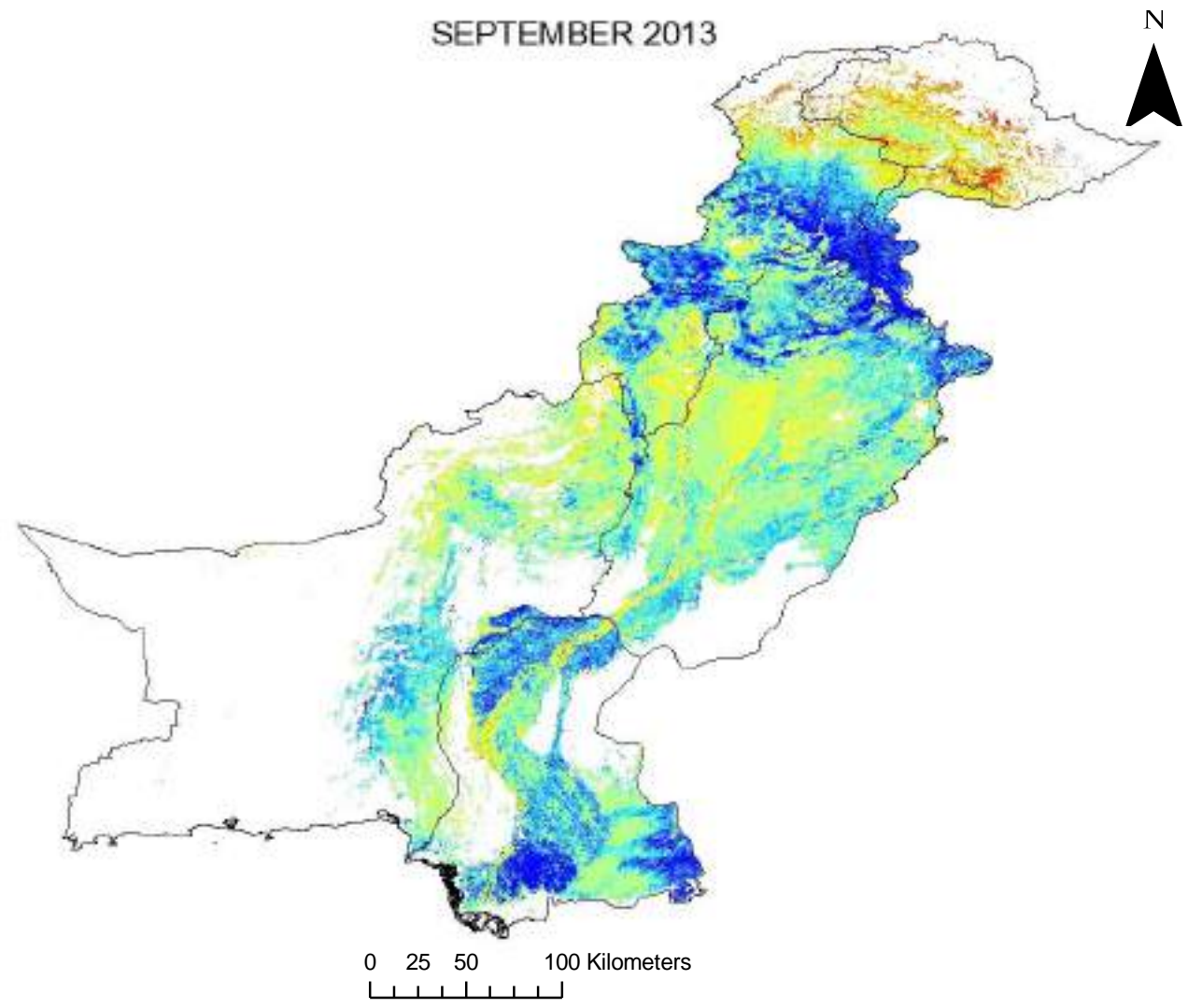
Legend
















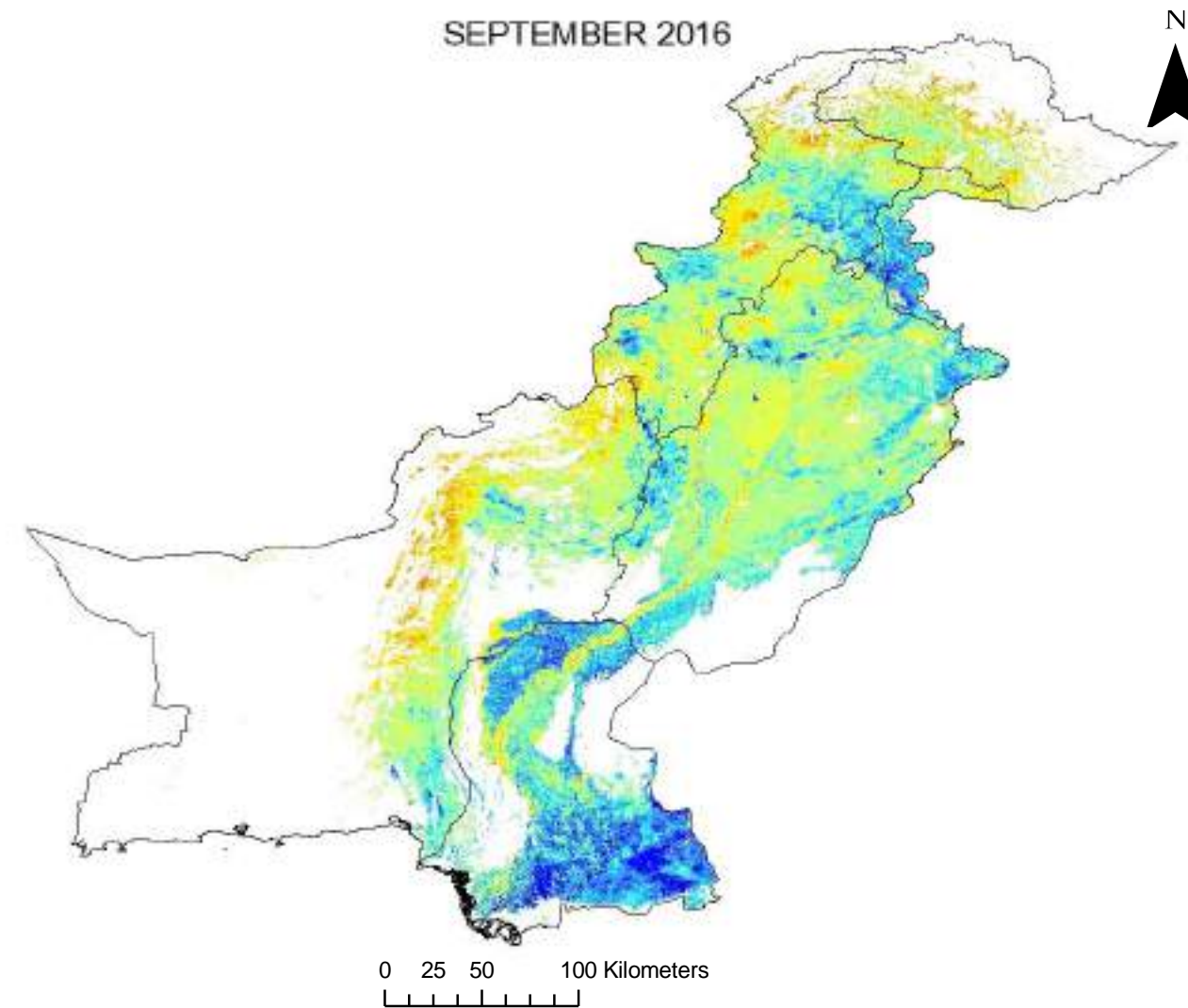
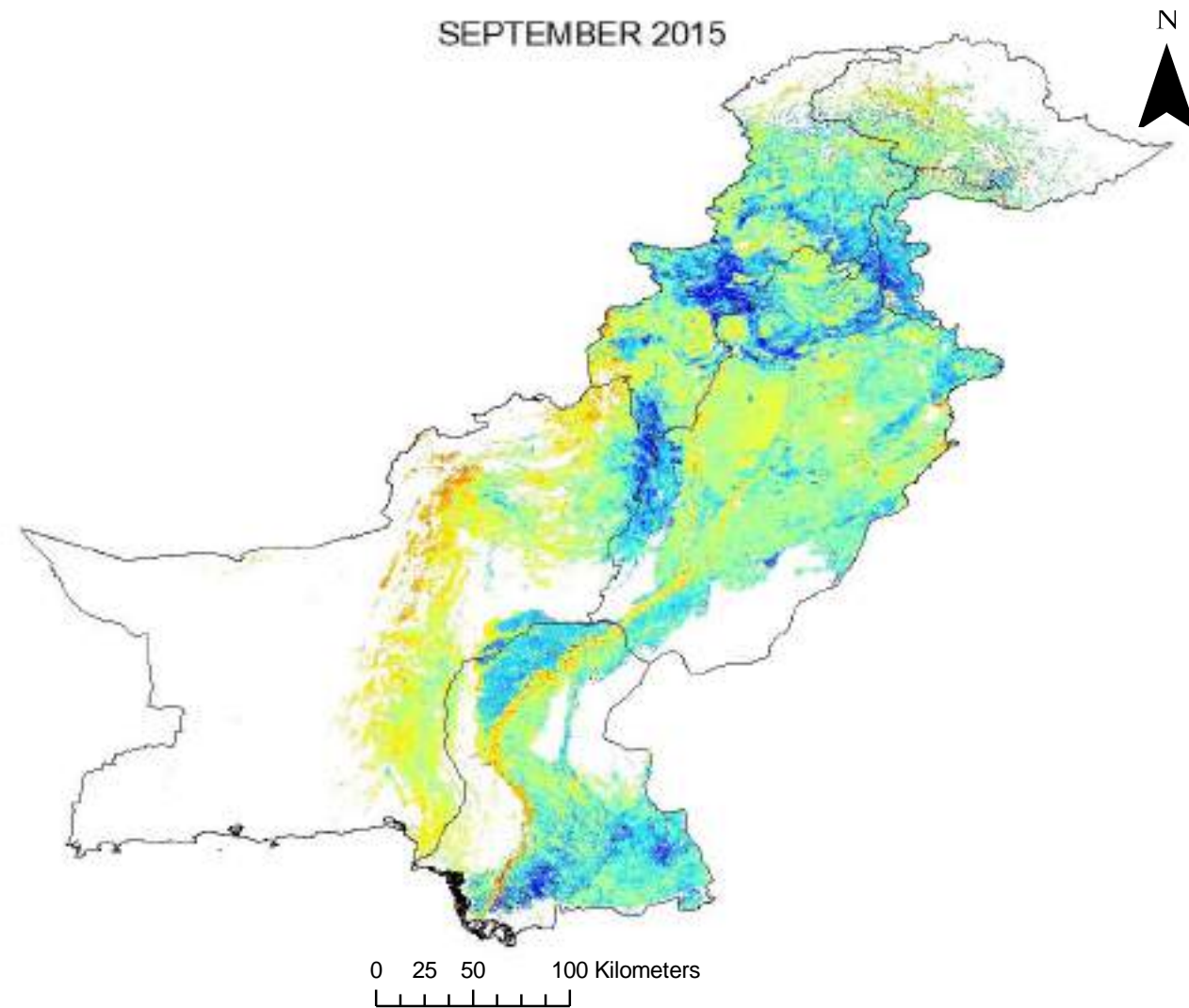
Legend



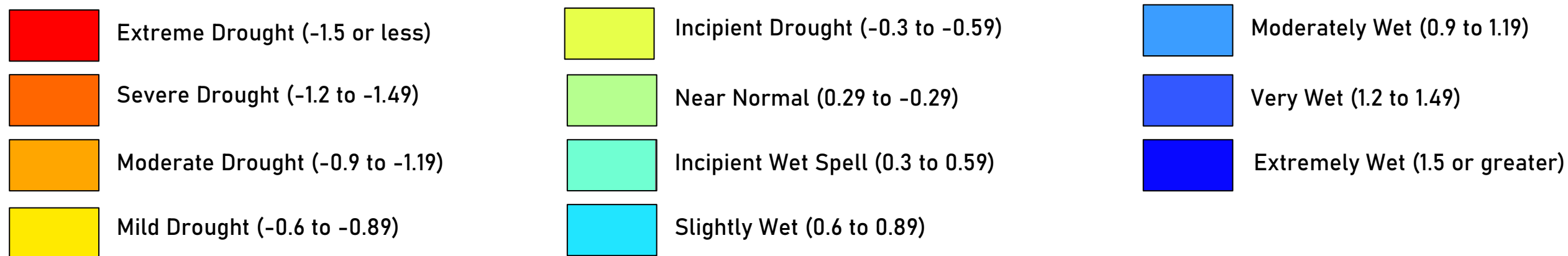


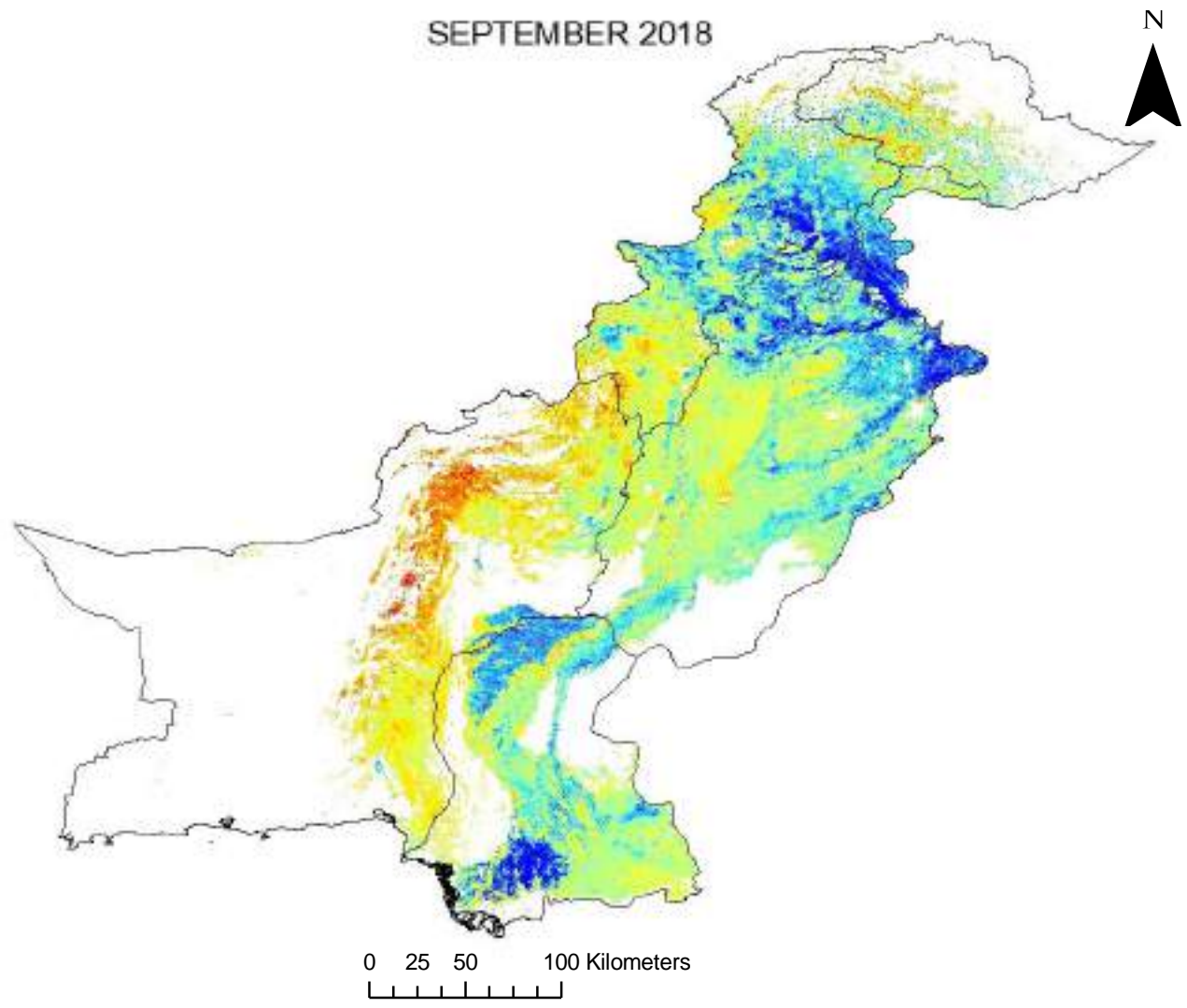
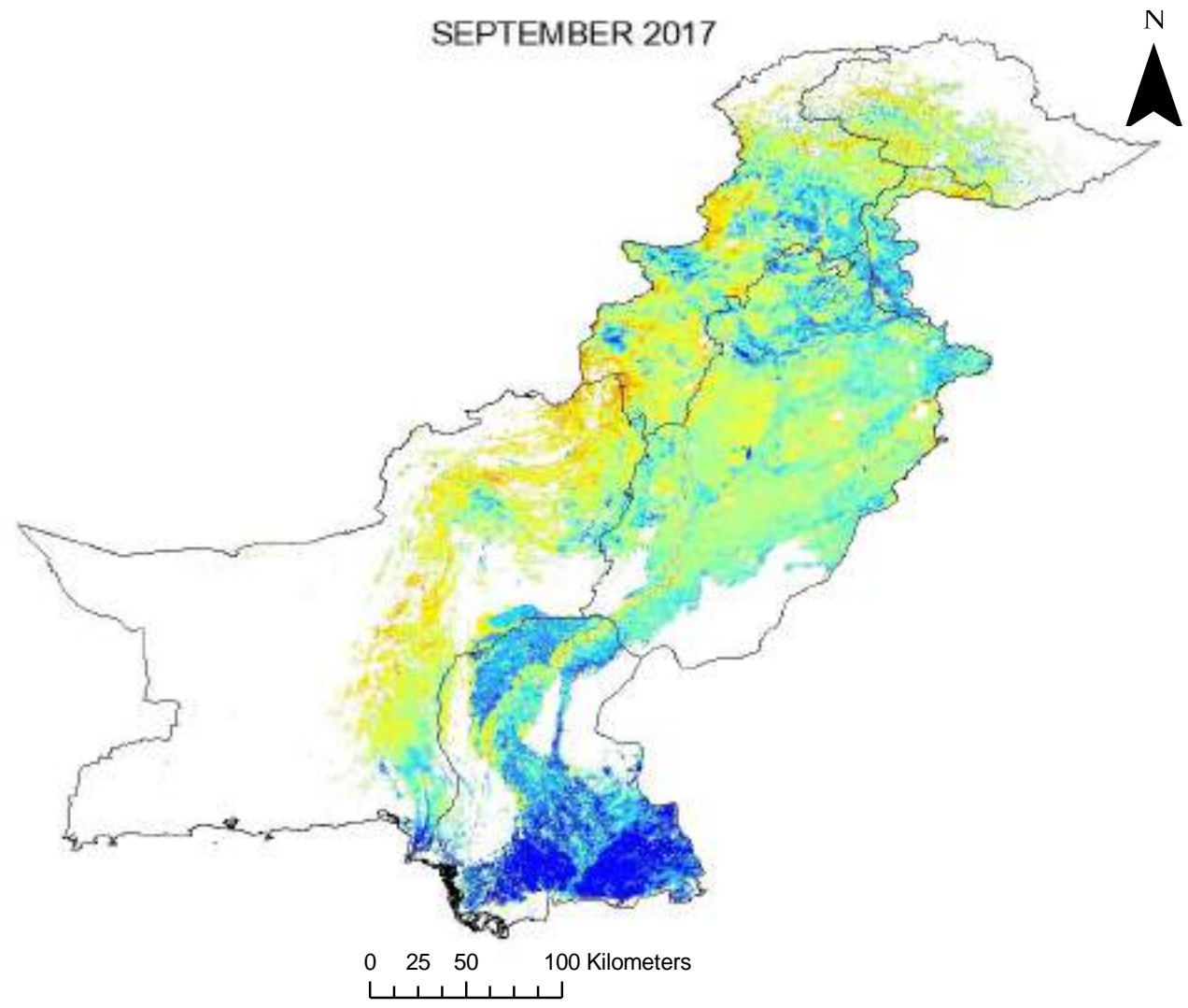
Legend

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|--|---|--|
|  Extreme Drought (-1.5 or less) |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19) |
|  Severe Drought (-1.2 to -1.49) |  Near Normal (0.29 to -0.29) |  Very Wet (1.2 to 1.49) |
|  Moderate Drought (-0.9 to -1.19) |  Incipient Wet Spell (0.3 to 0.59) |  Extremely Wet (1.5 or greater) |
|  Mild Drought (-0.6 to -0.89) |  Slightly Wet (0.6 to 0.89) | |

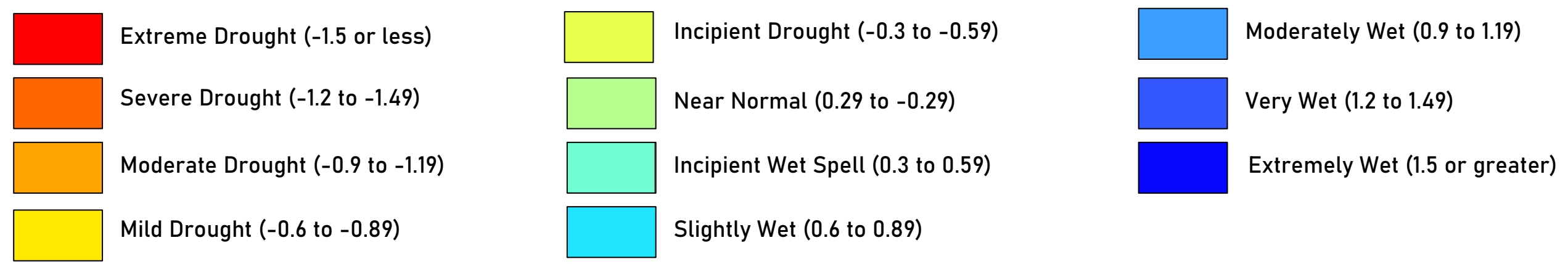


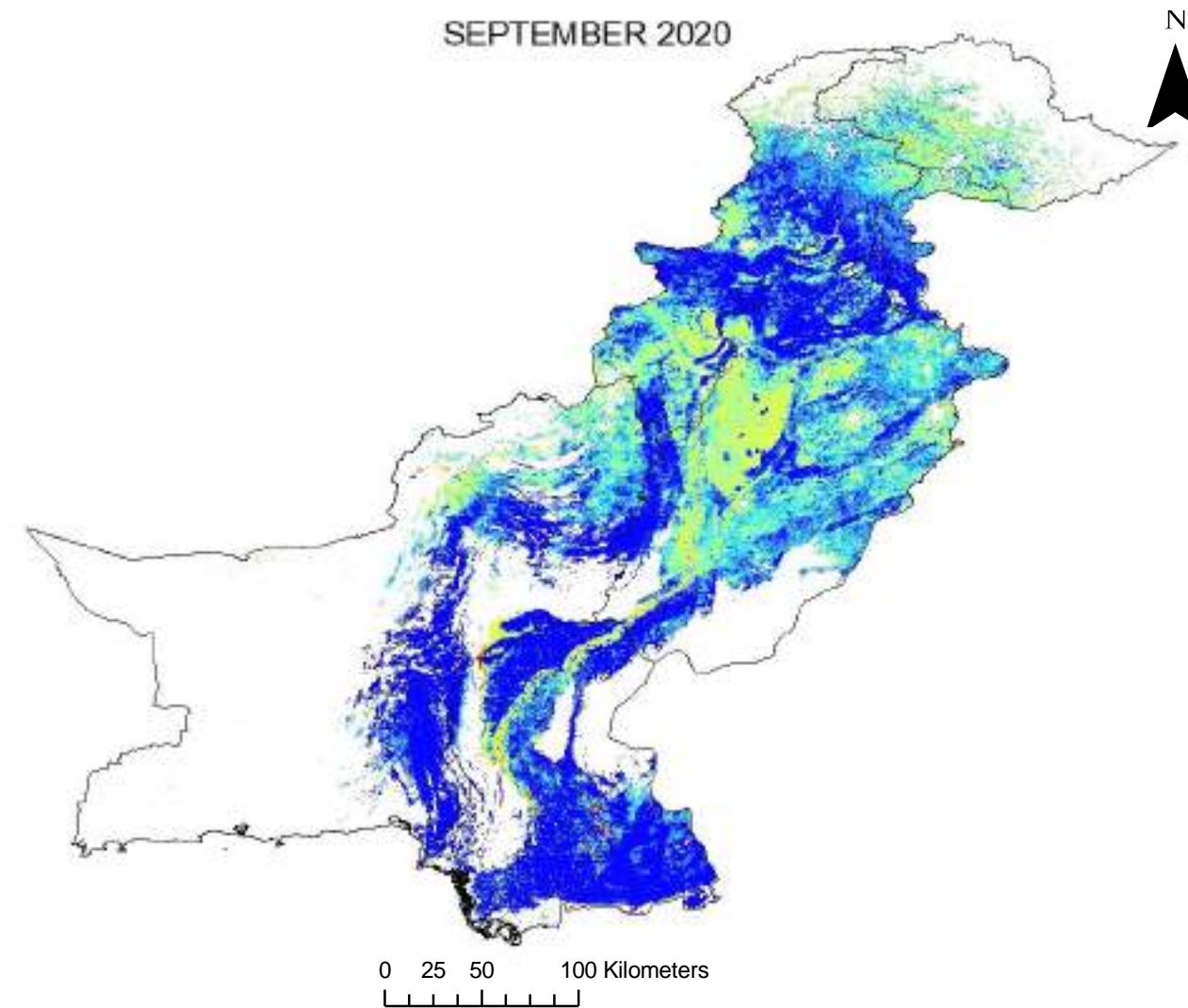
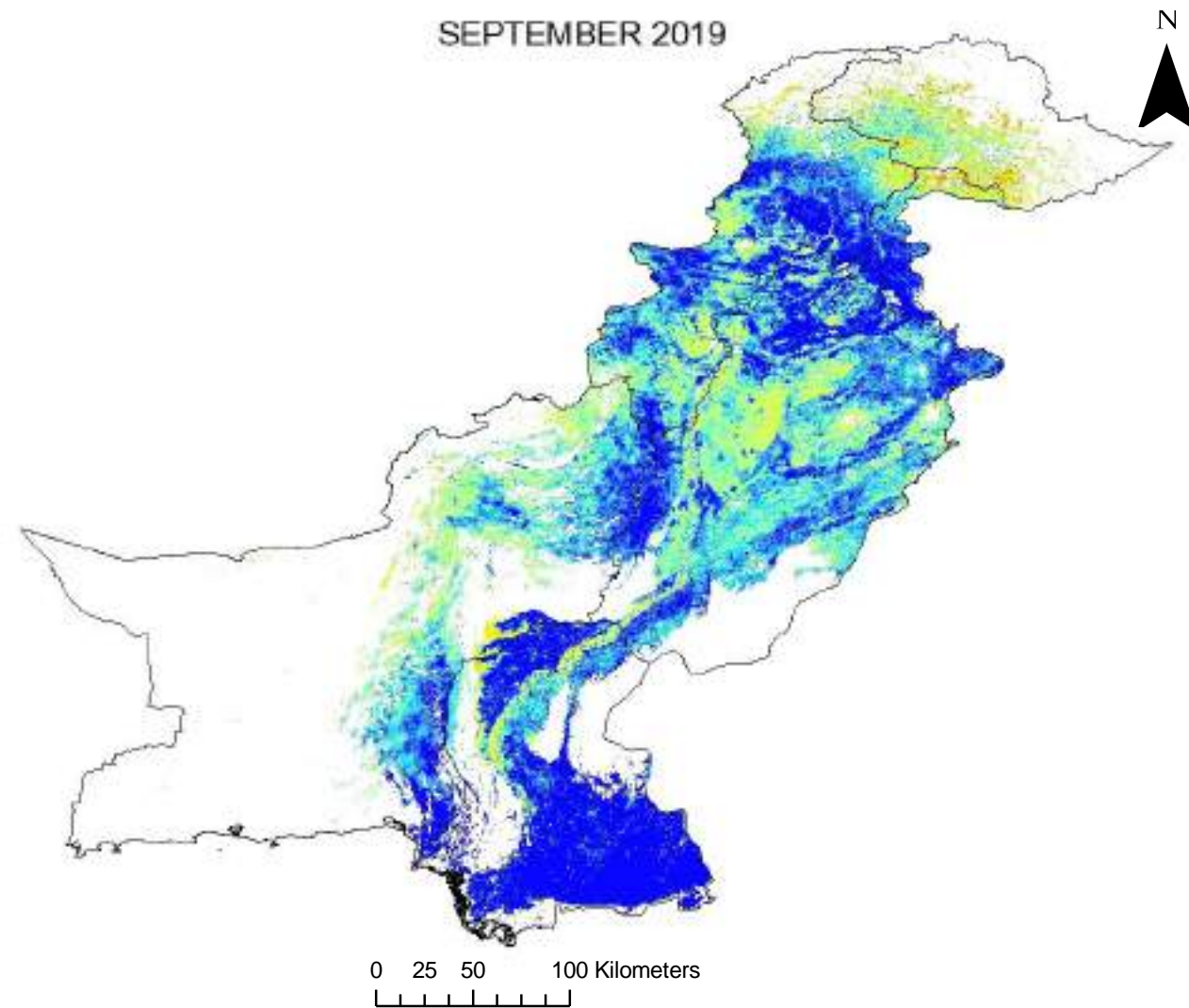
Legend



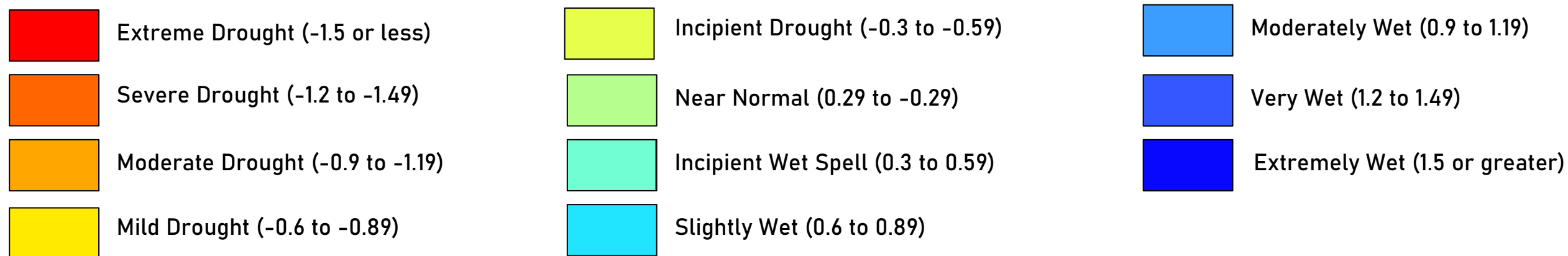


Legend





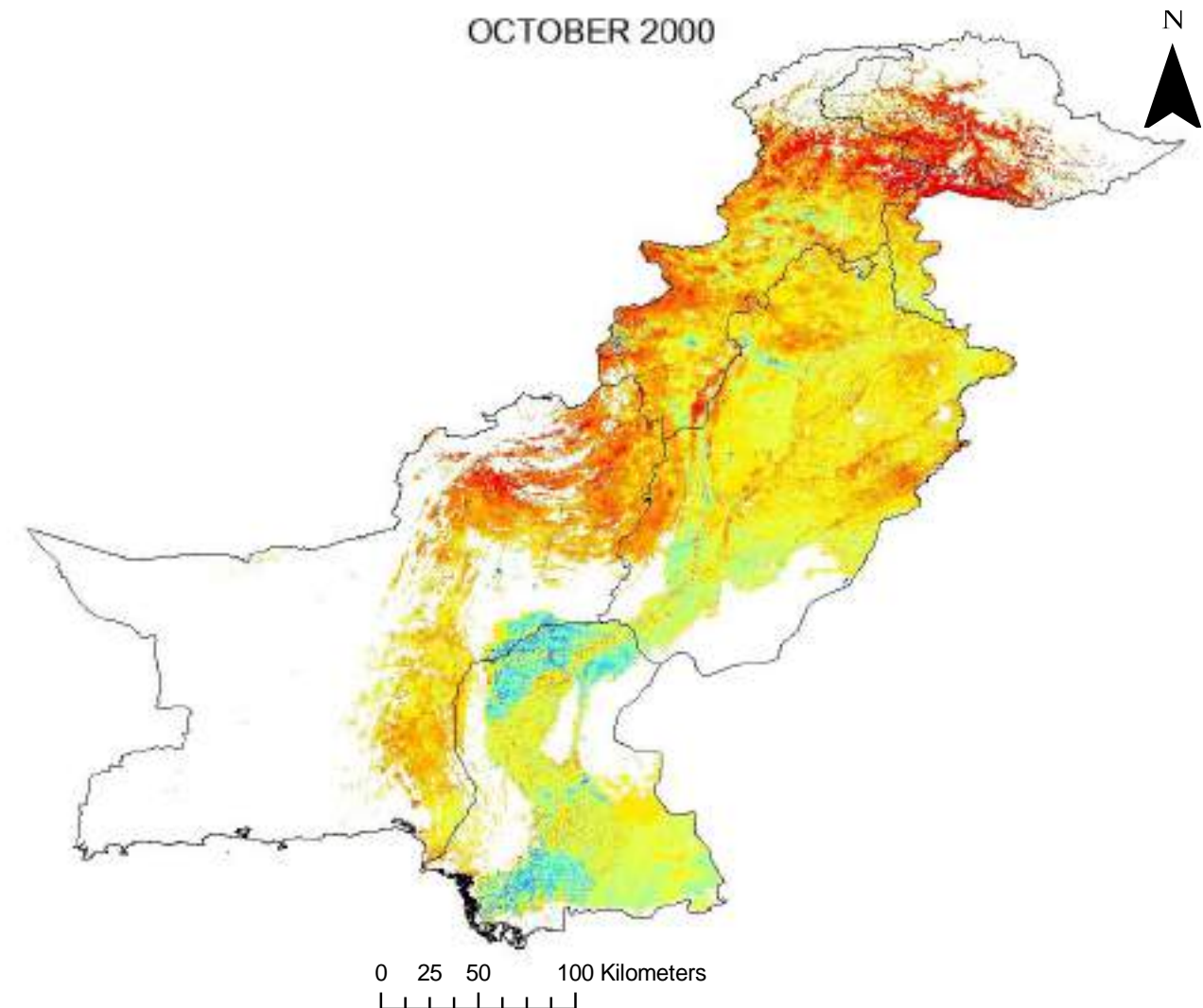
Legend



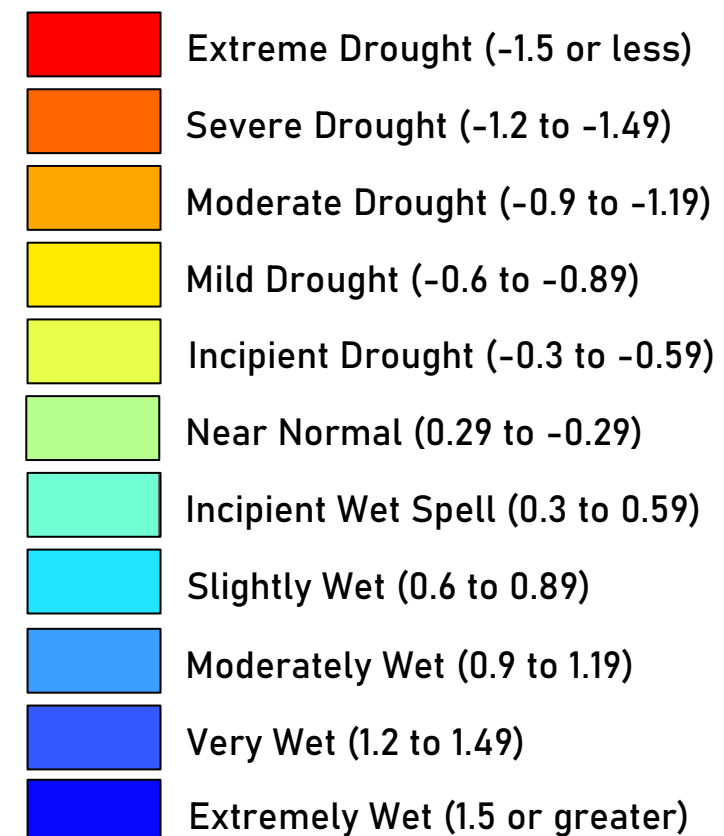
October DSI Maps

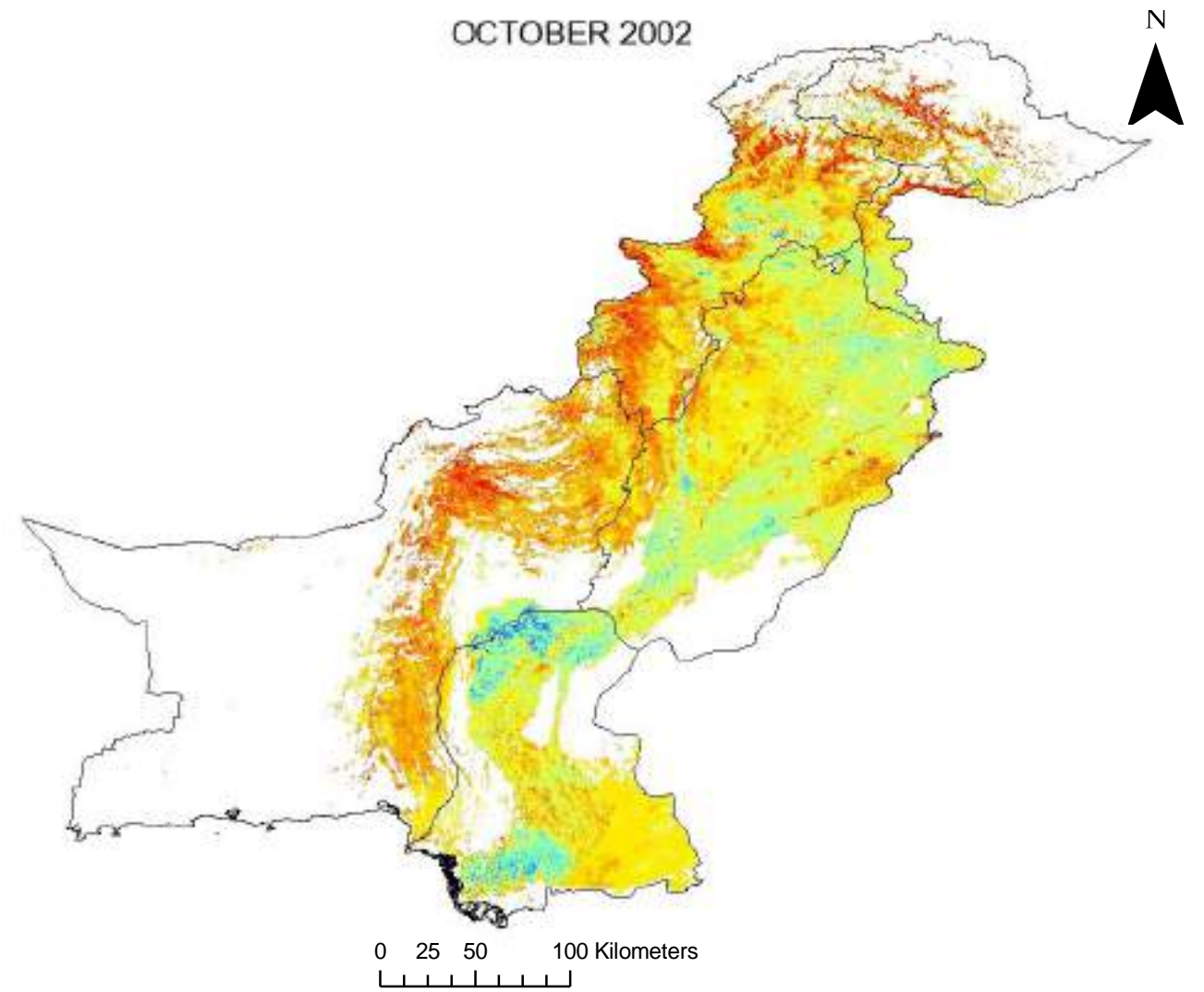
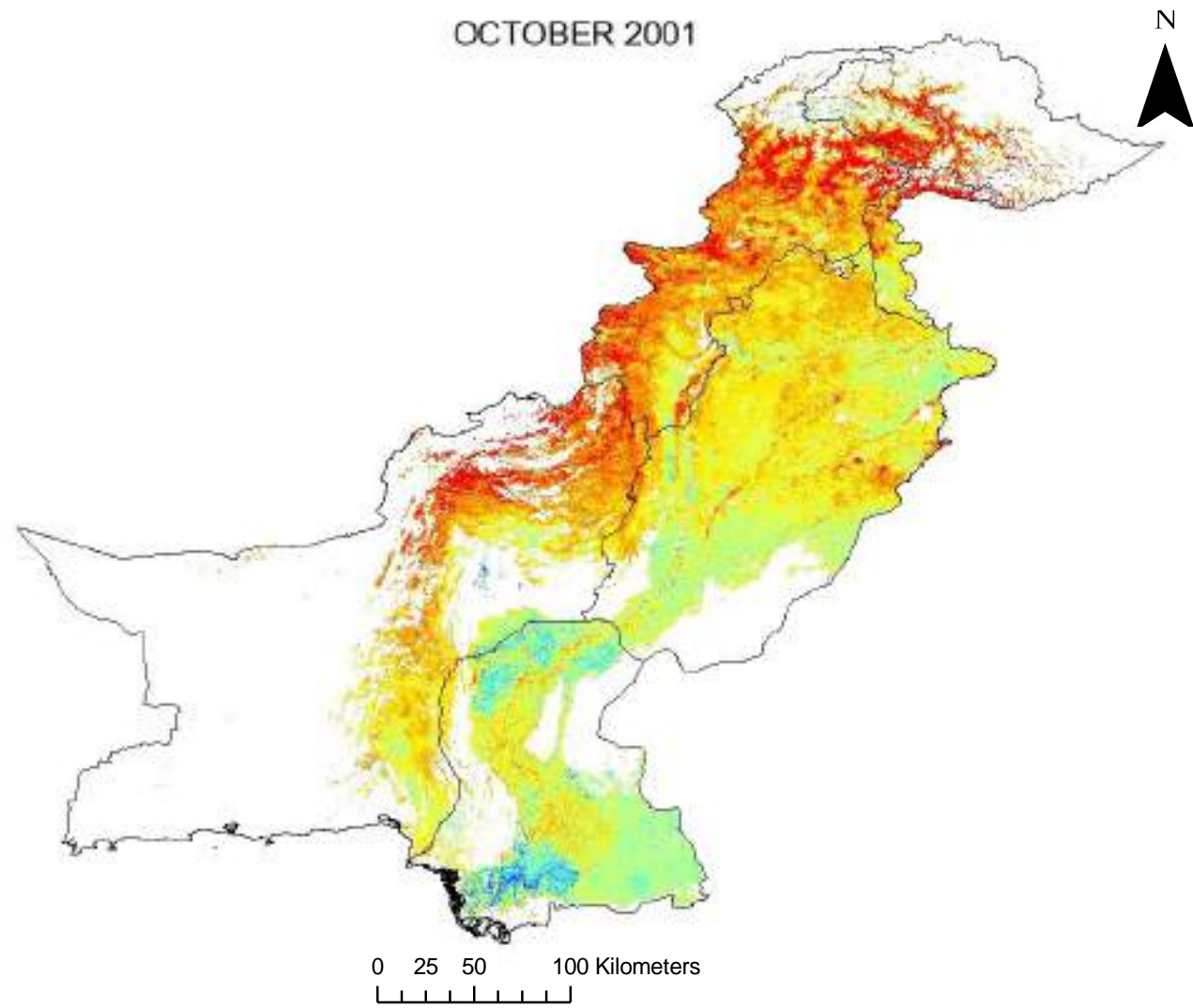
In October (post-monsoon), drought conditions can range from moderate drought to incipient wet spell condition. Near normal condition is majorly identified in October.

Mean October DSI Values		
Years	Values	Drought Condition
2000	-0.94	Moderate Drought
2001	-0.96	Moderate Drought
2002	-0.75	Mild Drought
2003	-0.57	Incipient Drought
2004	-0.31	Incipient Drought
2005	-0.38	Incipient Drought
2006	-0.26	Near Normal
2007	-0.65	Mild Drought
2008	-0.58	Incipient Drought
2009	-0.64	Mild Drought
2010	-0.26	Near Normal
2011	-0.04	Near Normal
2012	-0.25	Near Normal
2013	-0.12	Near Normal
2014	0.06	Near Normal
2015	-0.07	Near Normal
2016	-0.65	Mild Drought
2017	-0.50	Incipient Drought
2018	-0.10	Near Normal
2019	0.32	Incipient Wet Spell
2020	-0.26	Near Normal














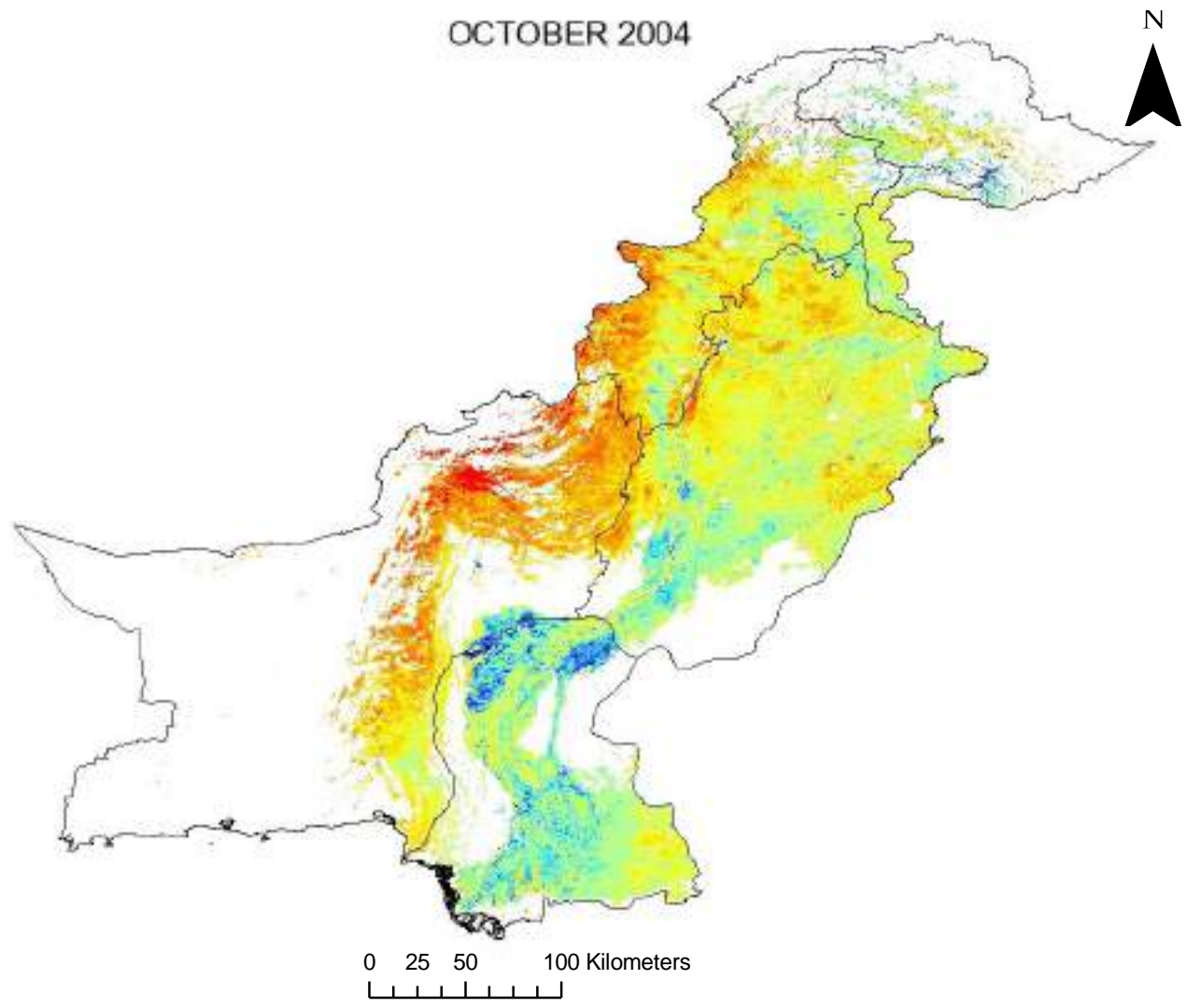
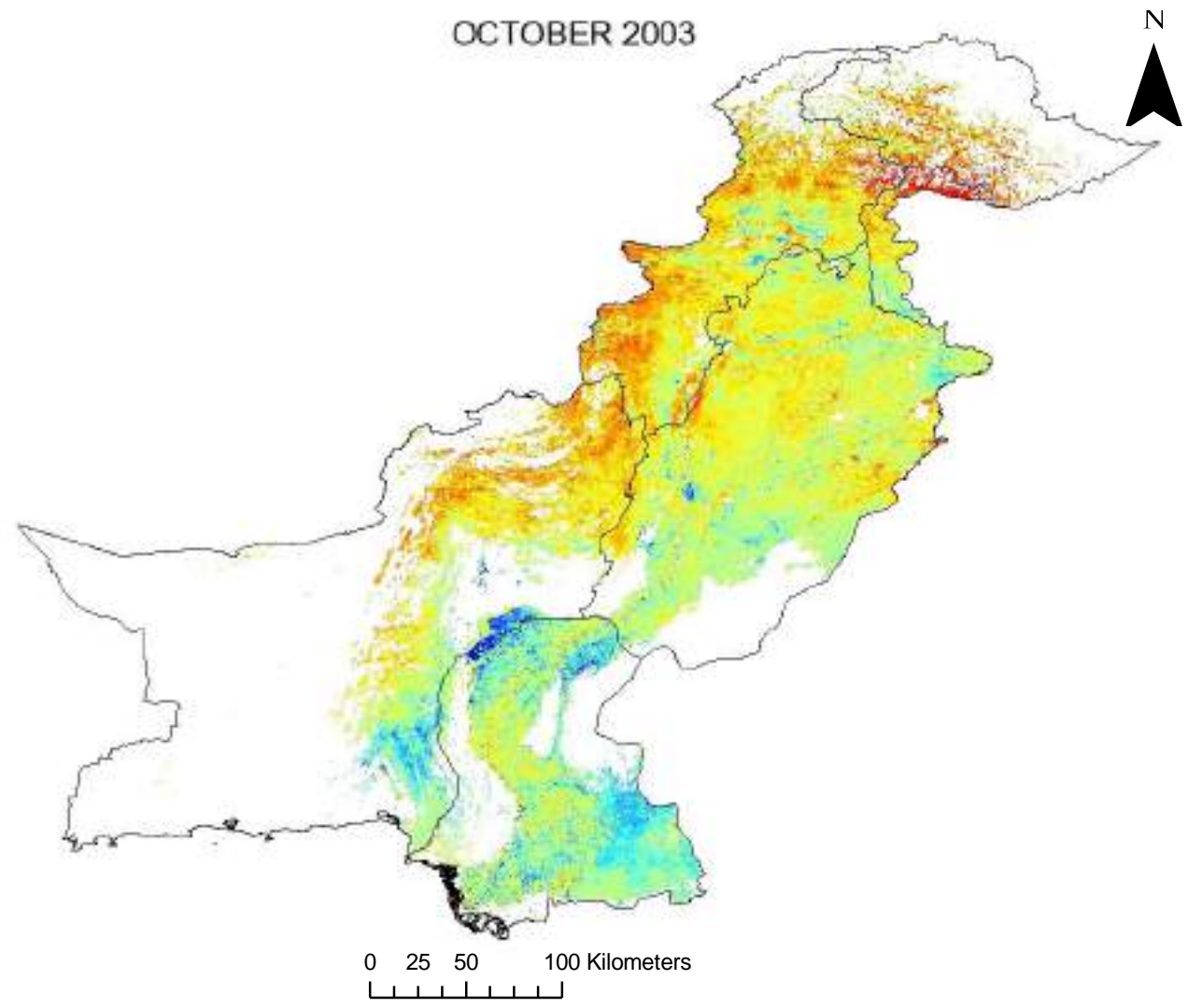
Legend
















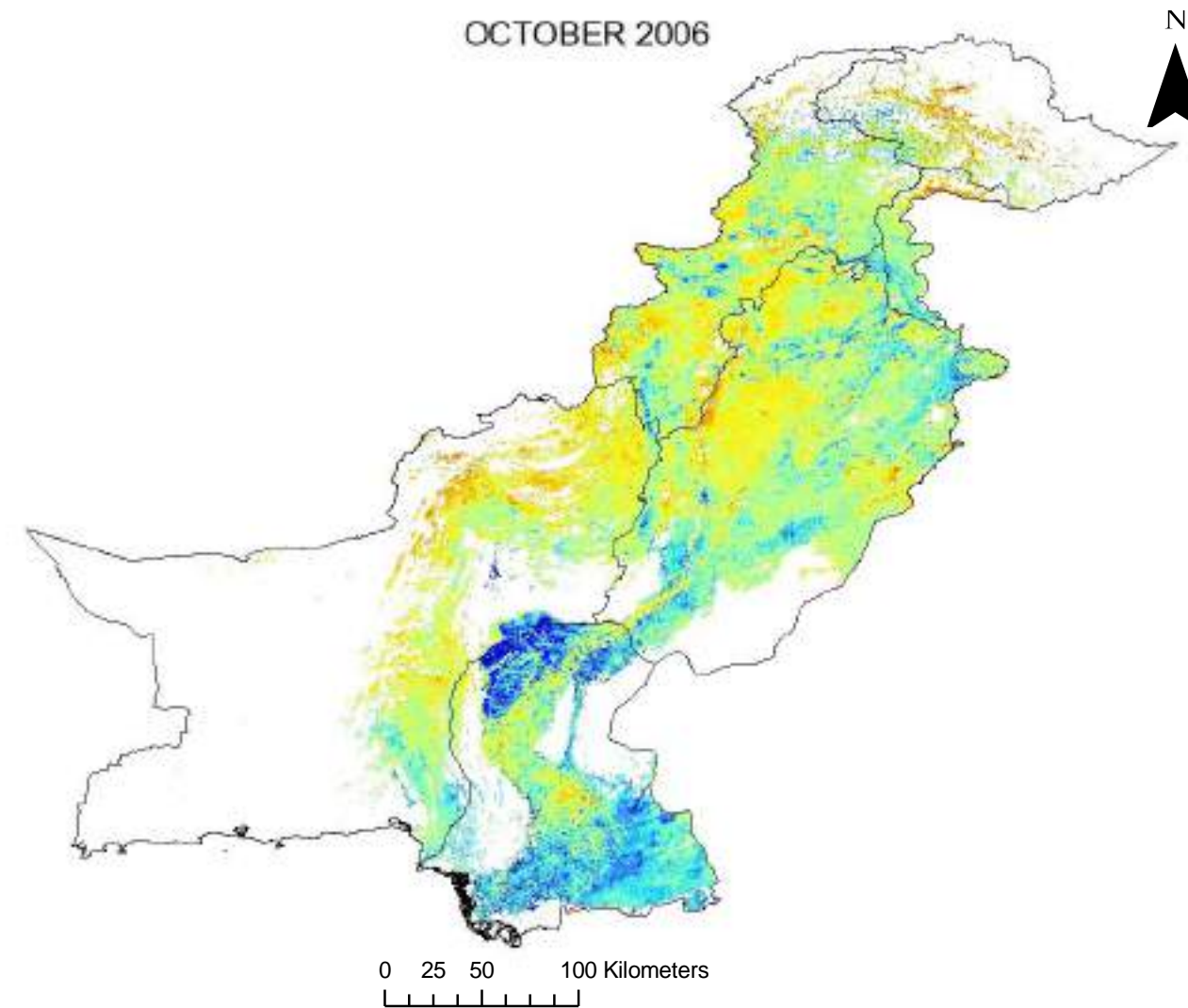
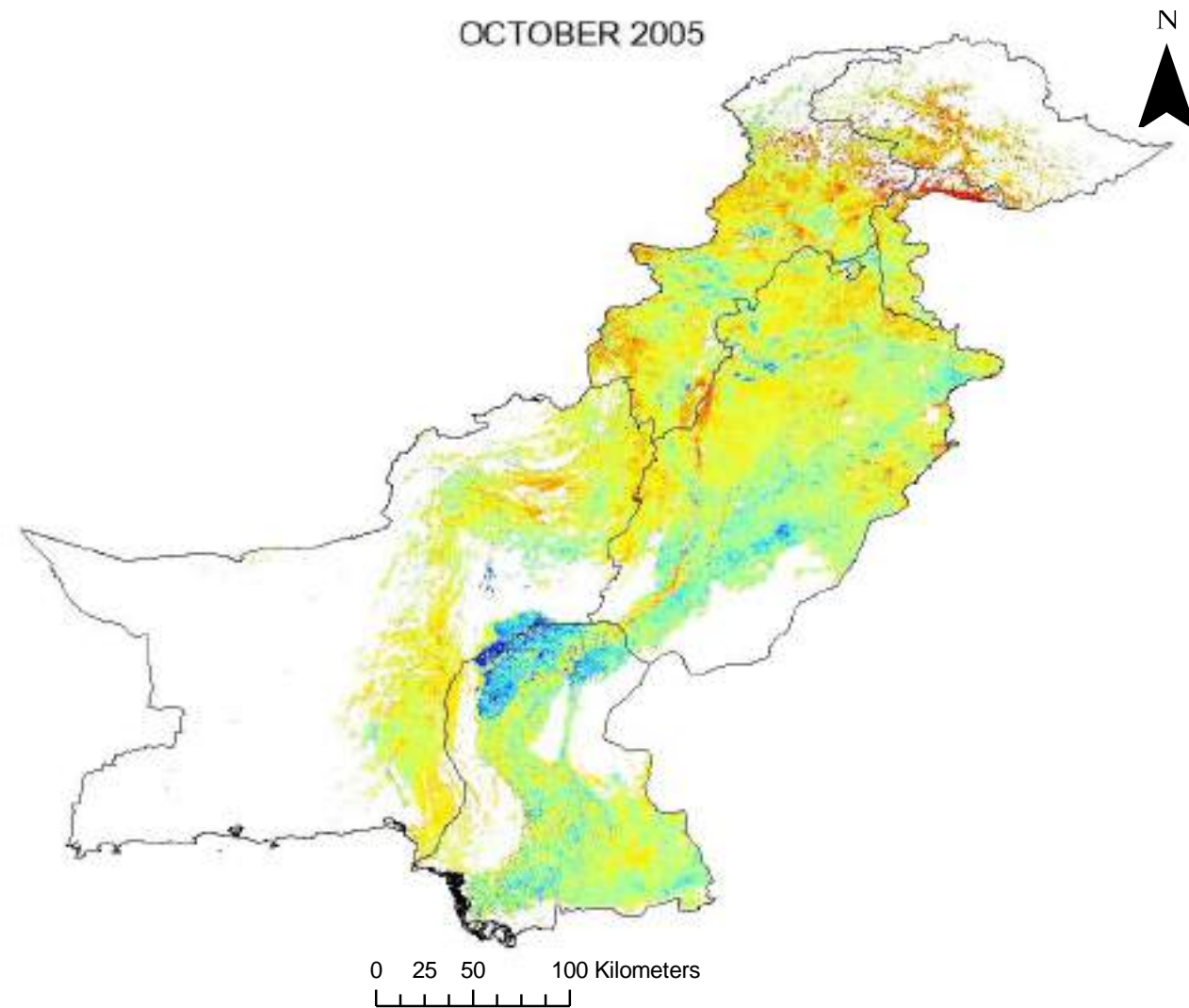
Legend

- | | | | | | |
|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
|  | Severe Drought (-1.2 to -1.49) |  | Near Normal (0.29 to -0.29) |  | Very Wet (1.2 to 1.49) |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89) |  | Slightly Wet (0.6 to 0.89) | | |

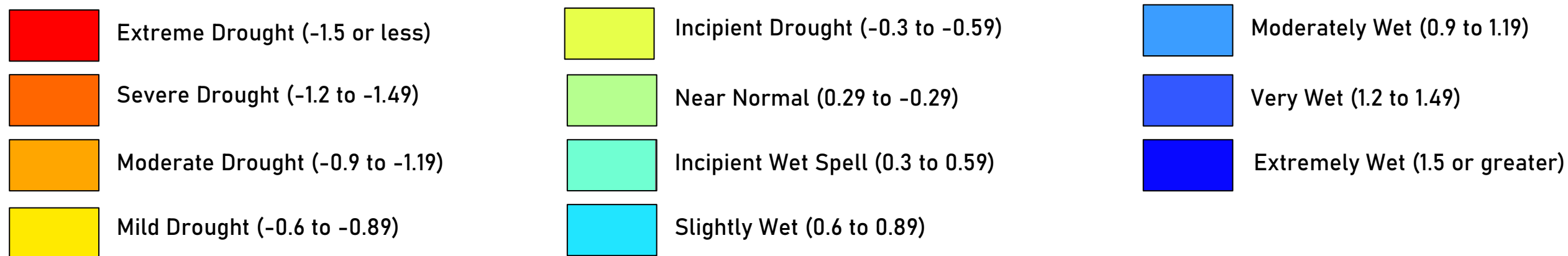


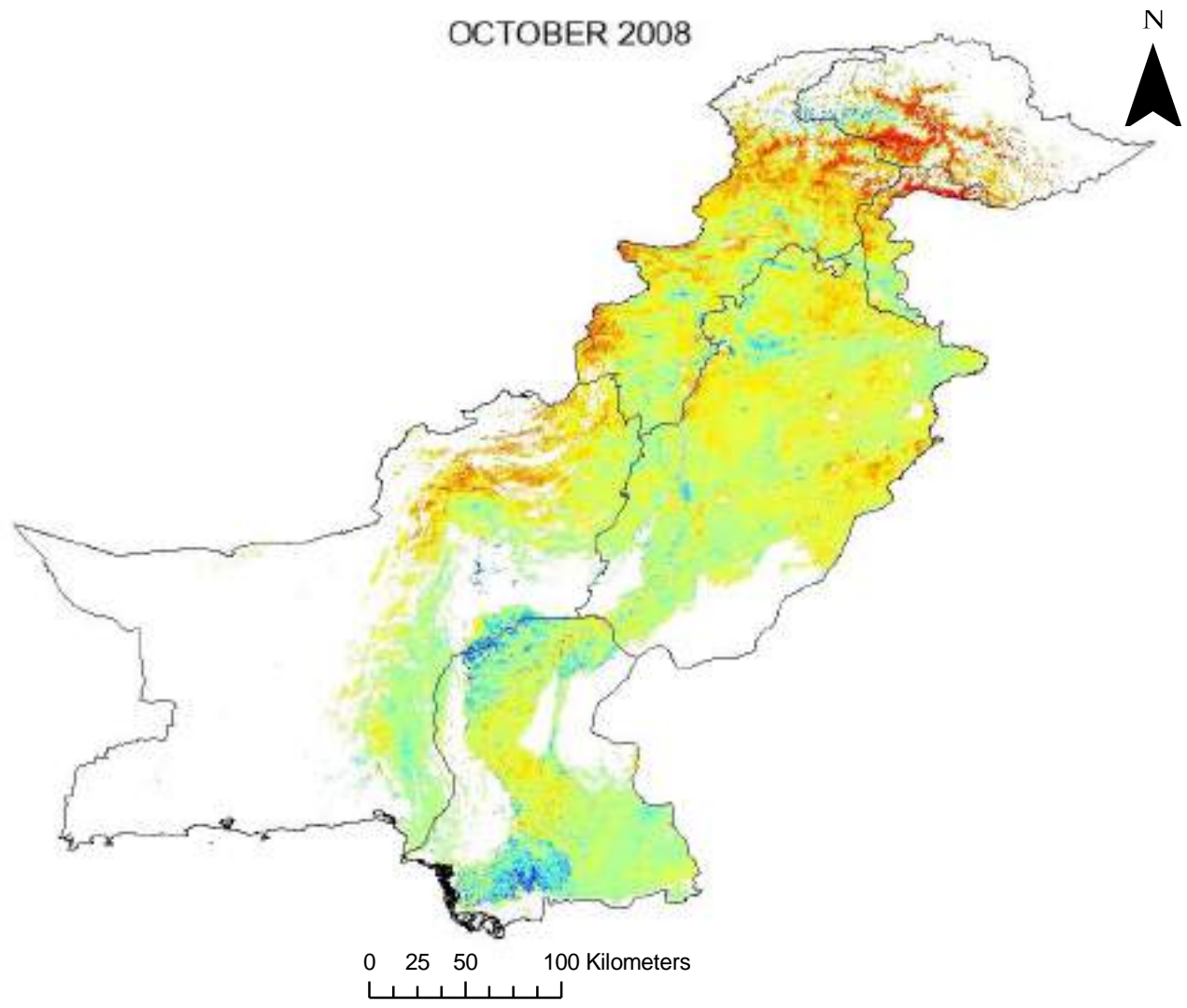
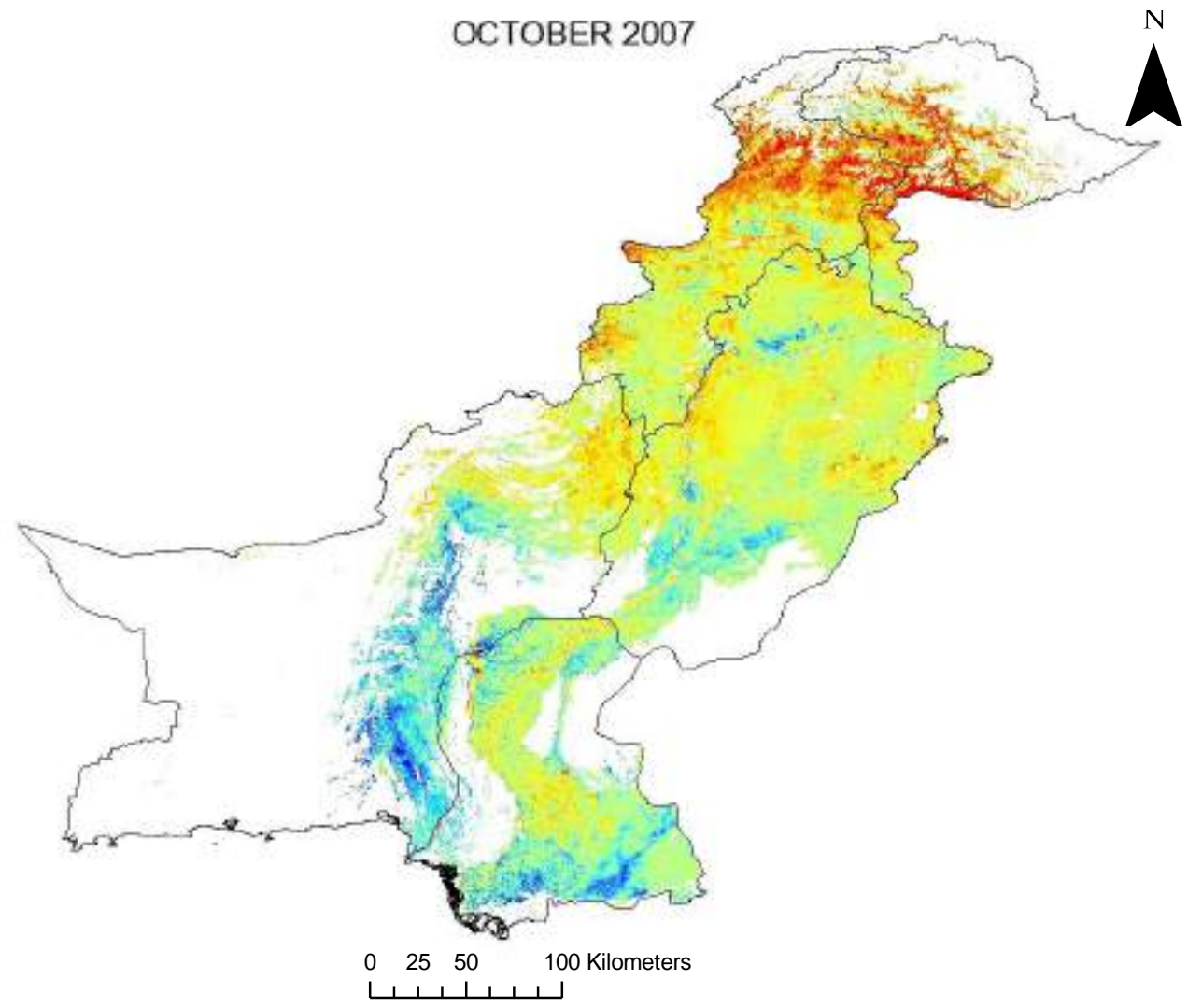
Legend

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|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
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|  | Mild Drought (-0.6 to -0.89) |  | Slightly Wet (0.6 to 0.89) | | |














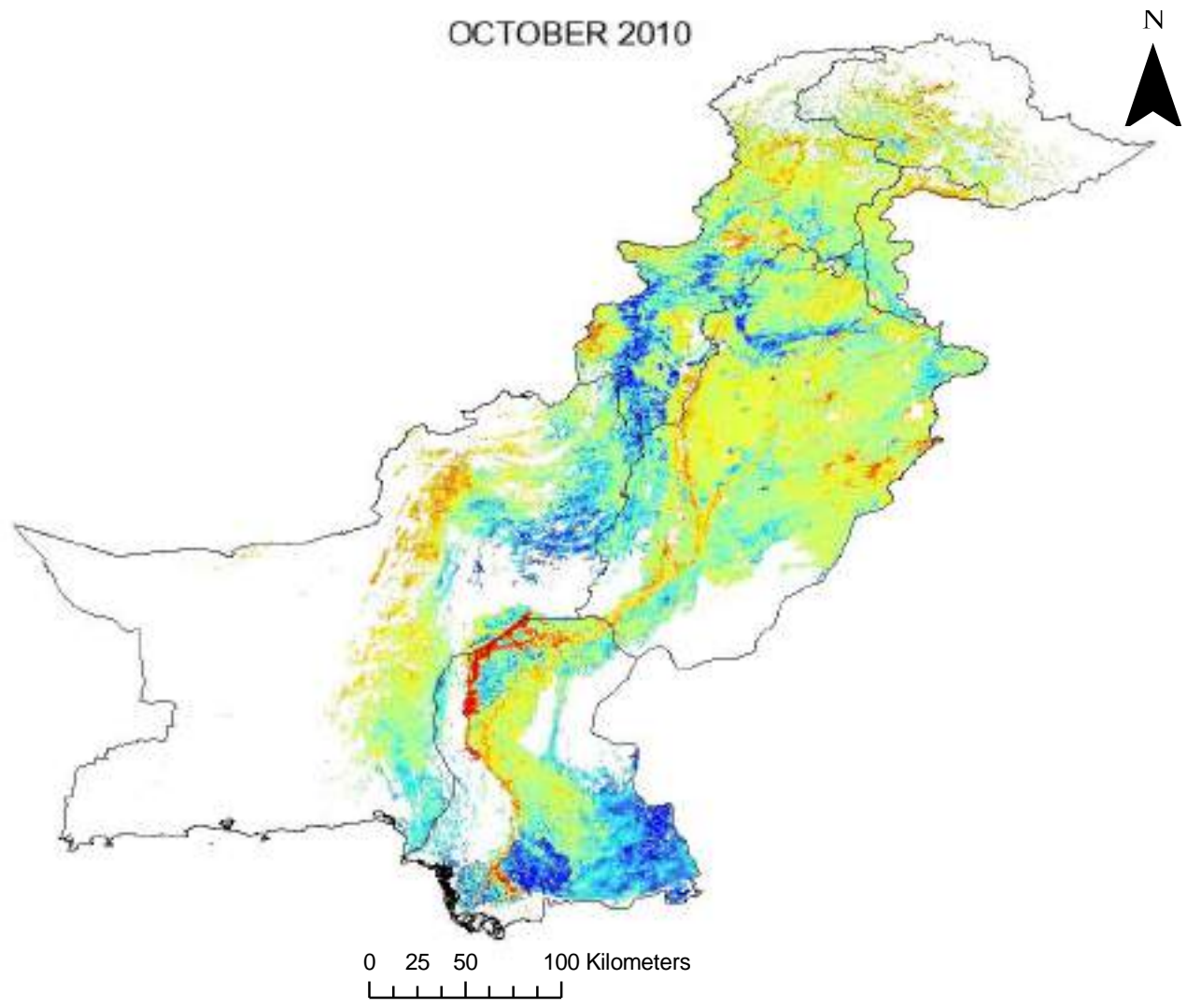
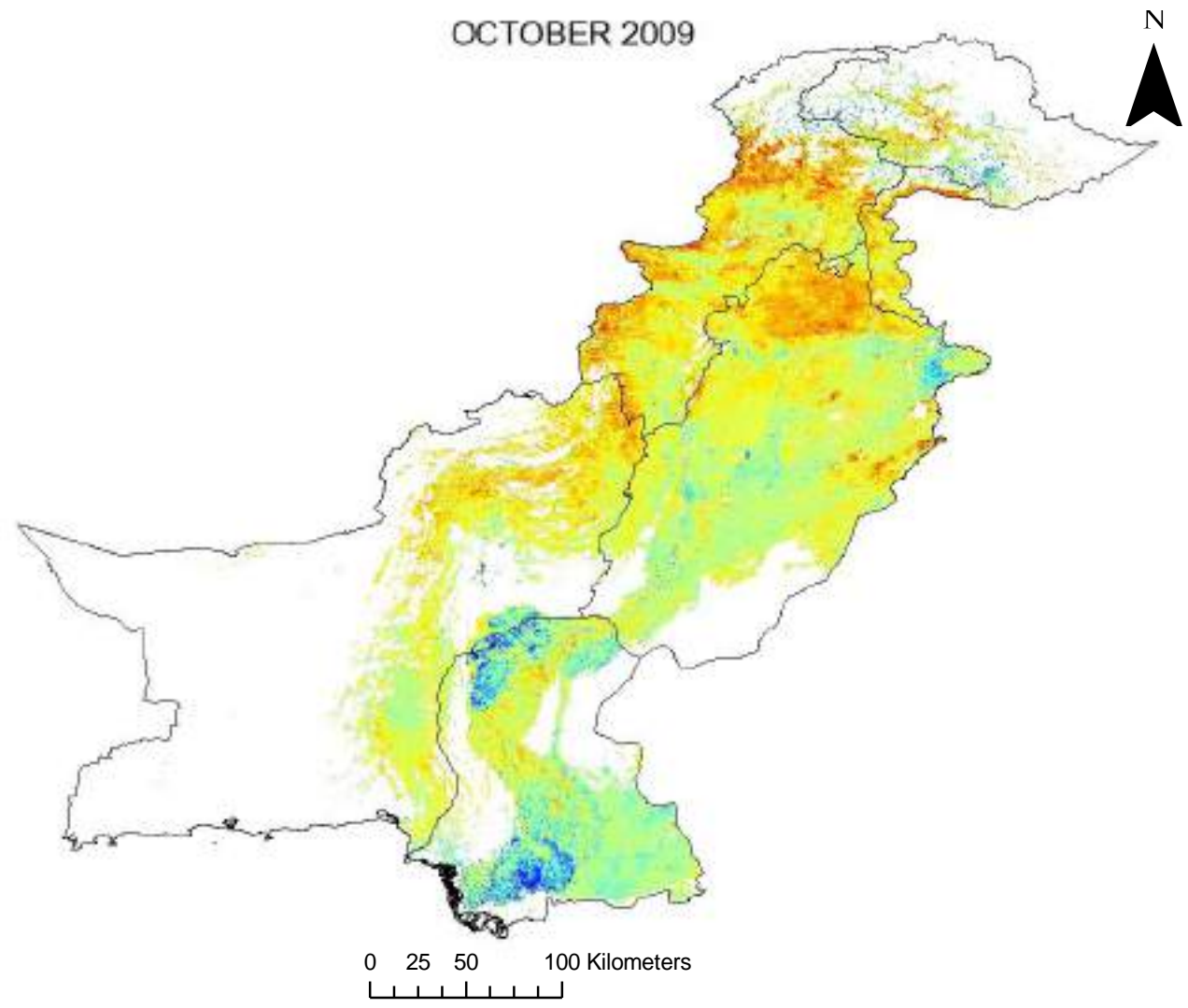
Legend
















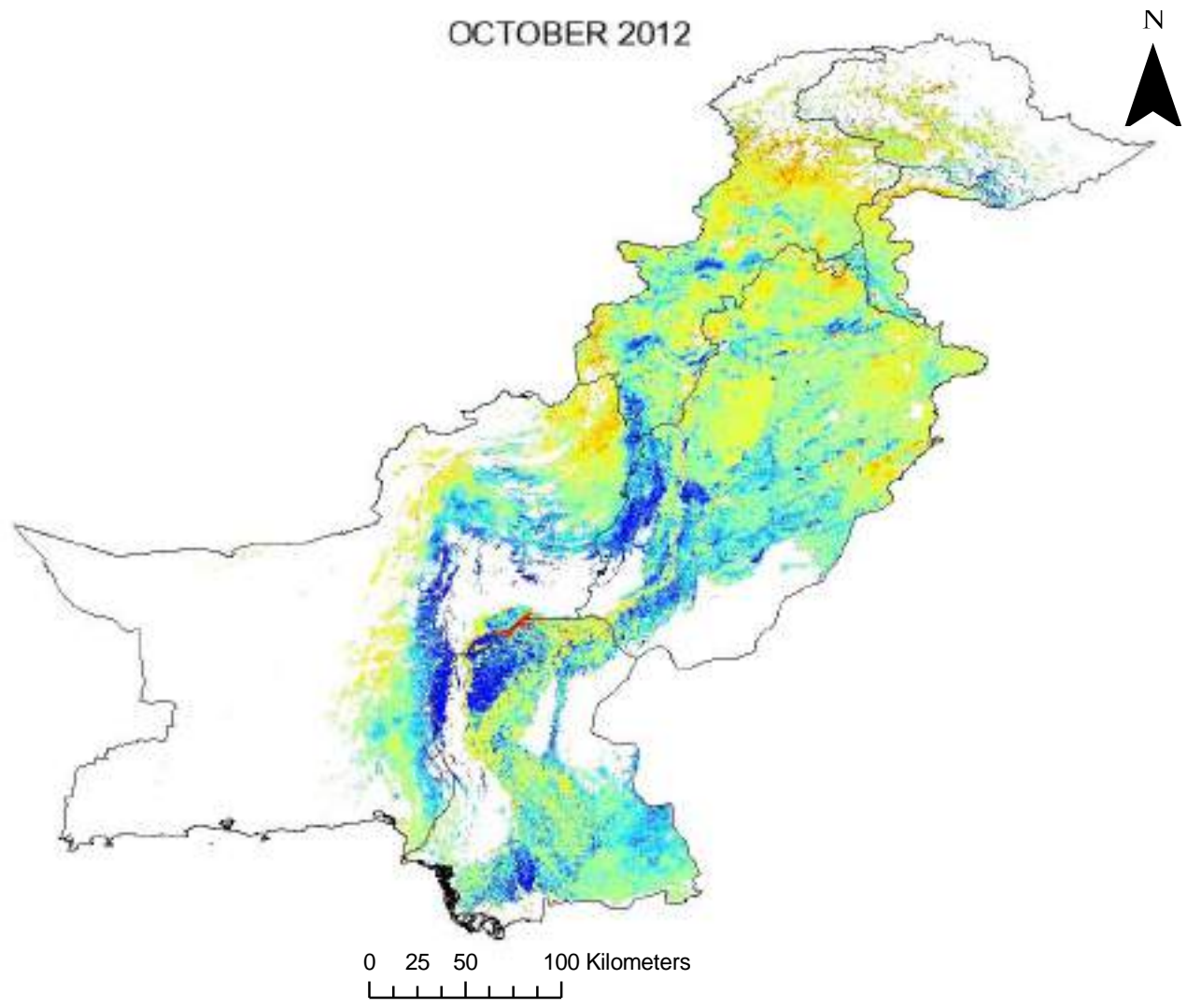
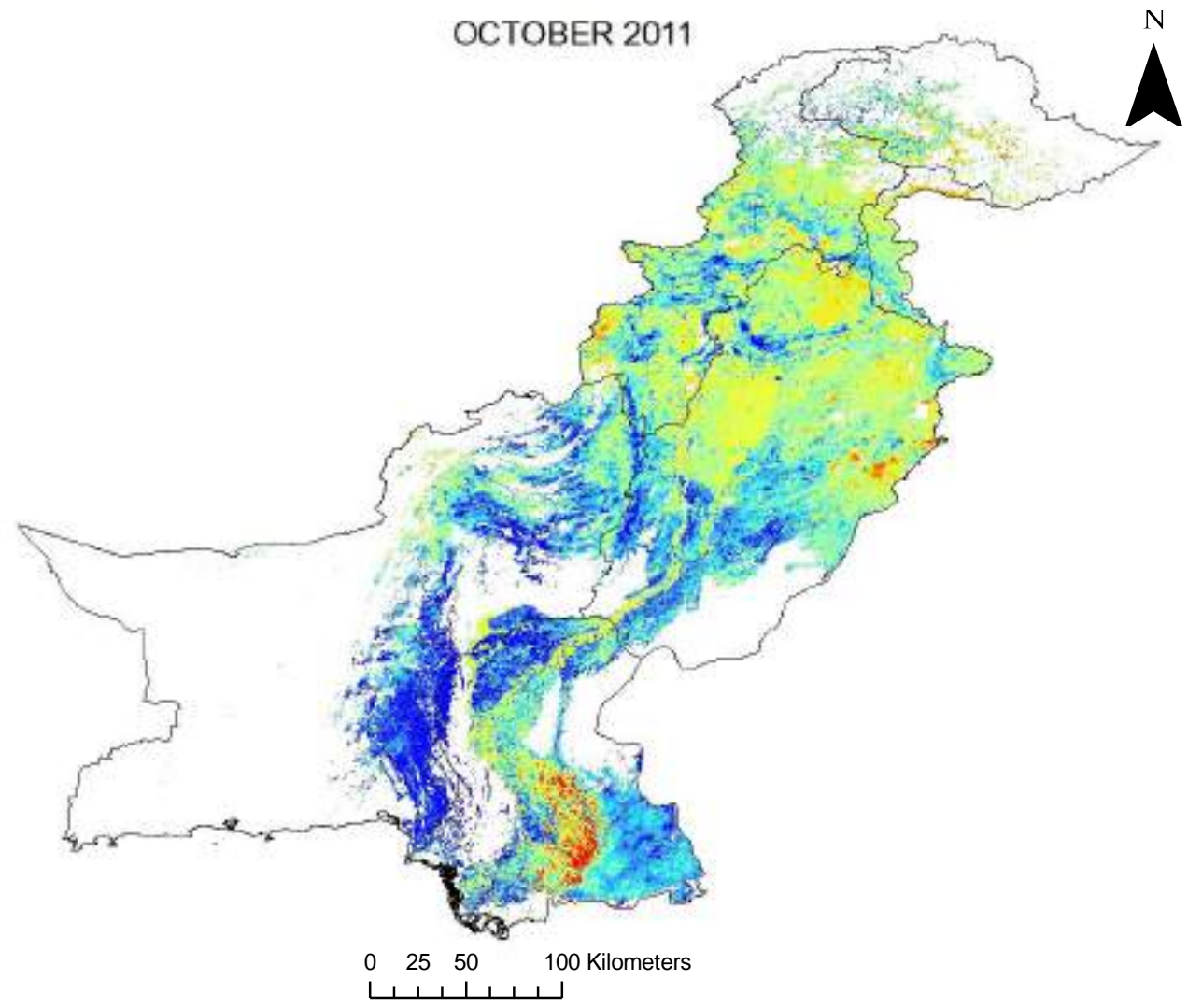
Legend

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|--|---|--|
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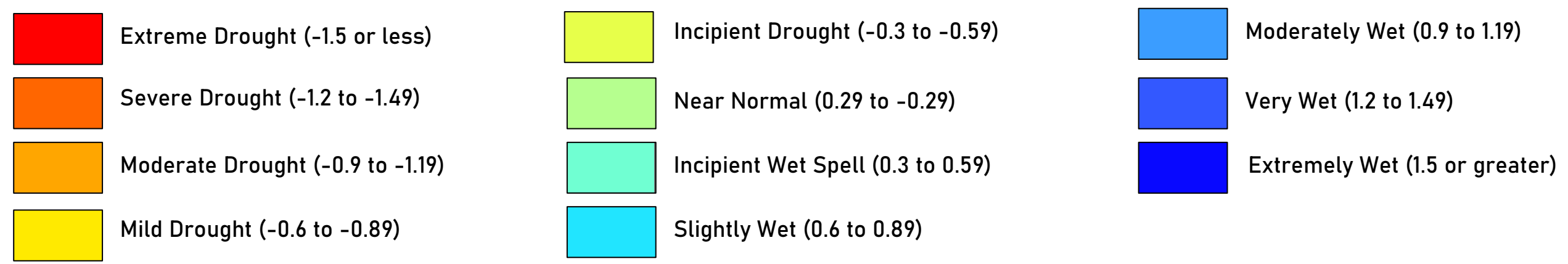


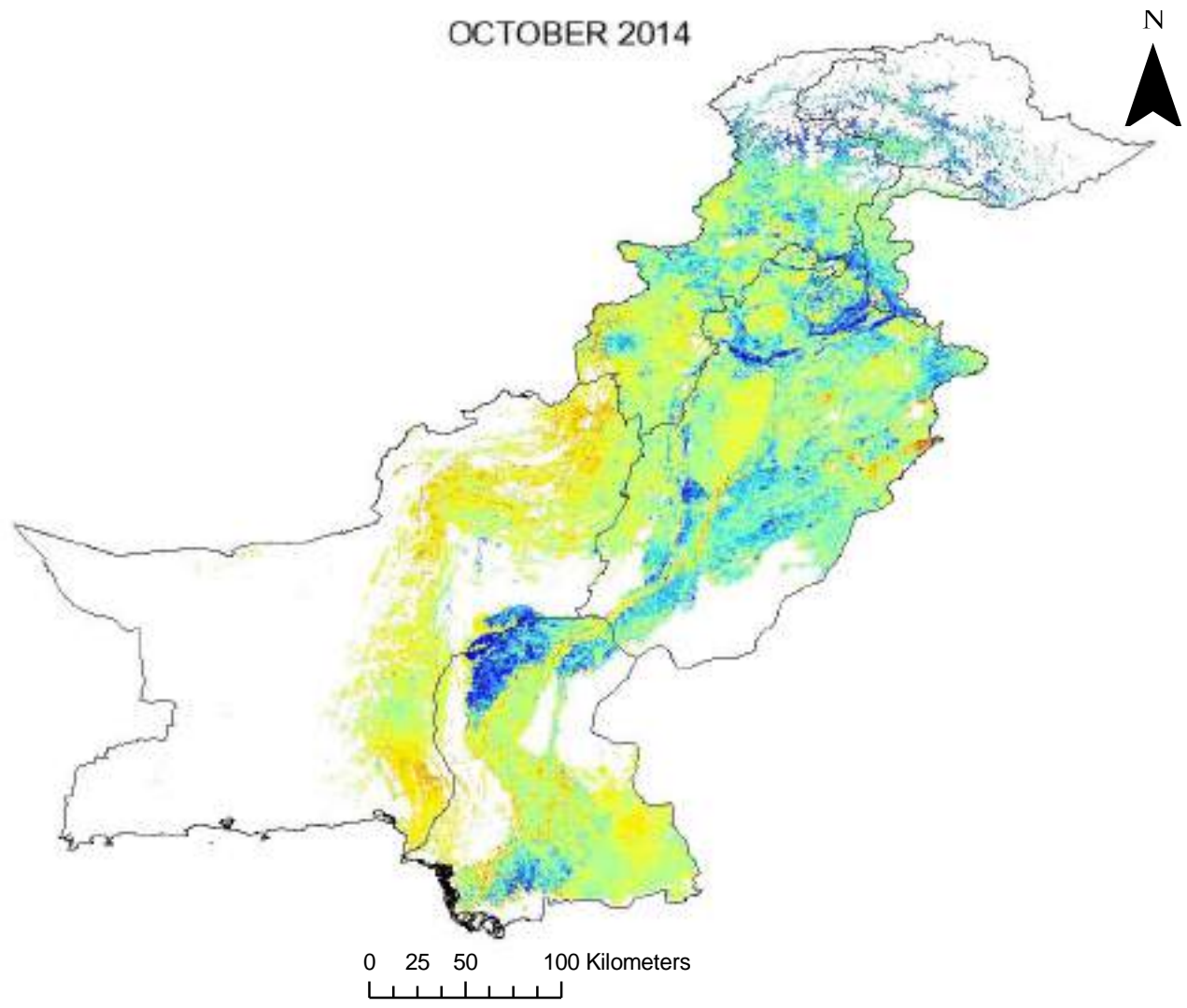
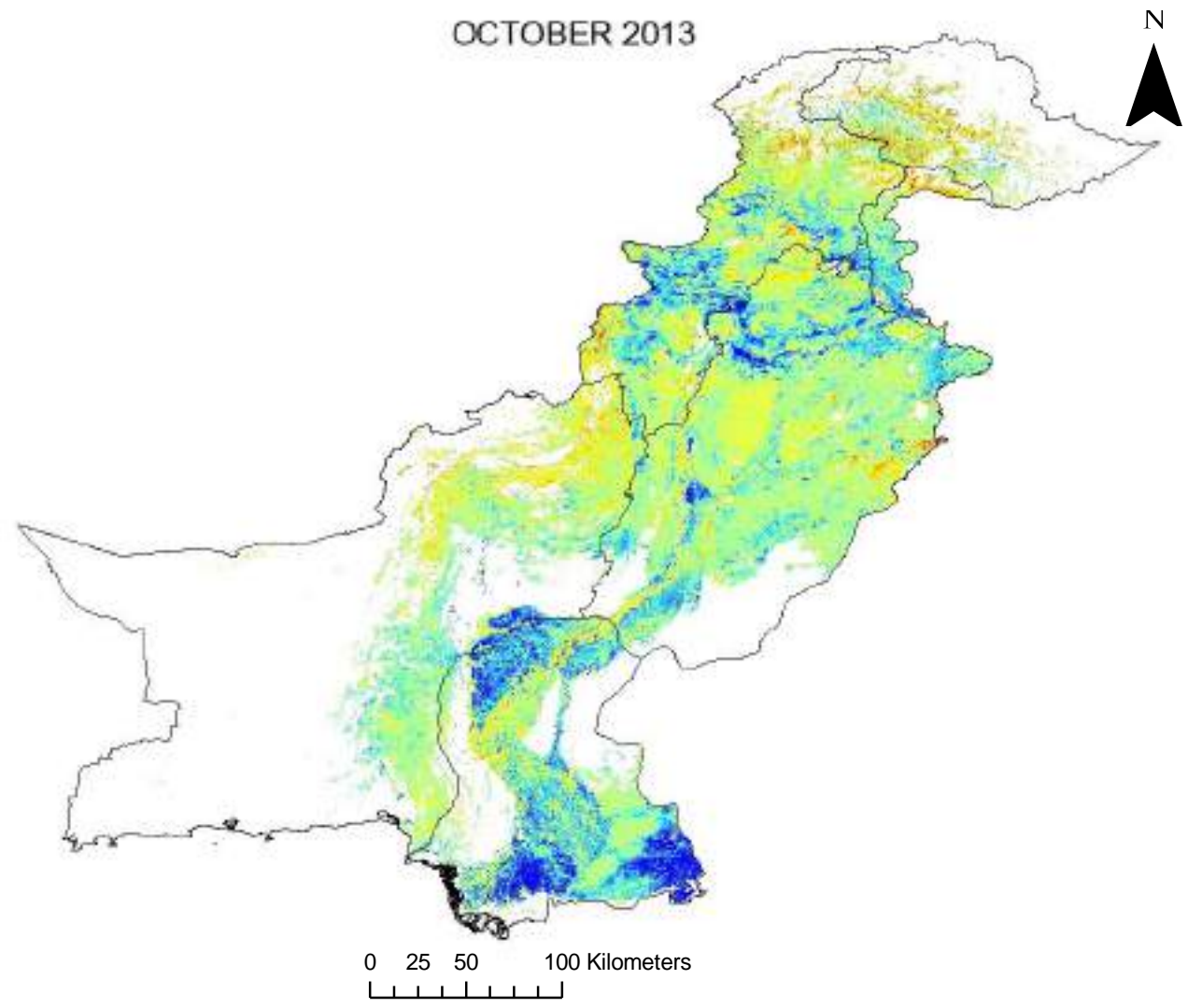
Legend

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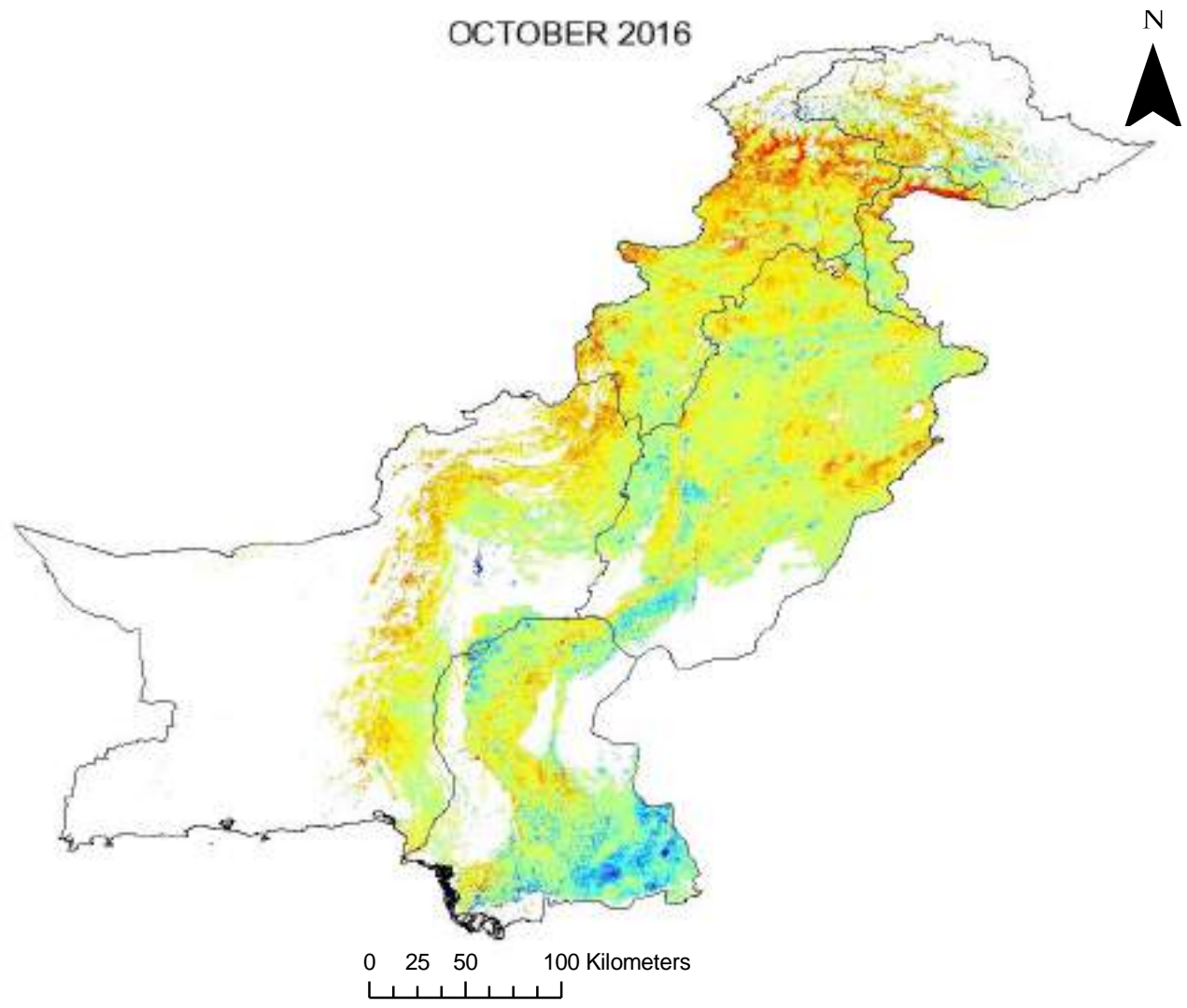
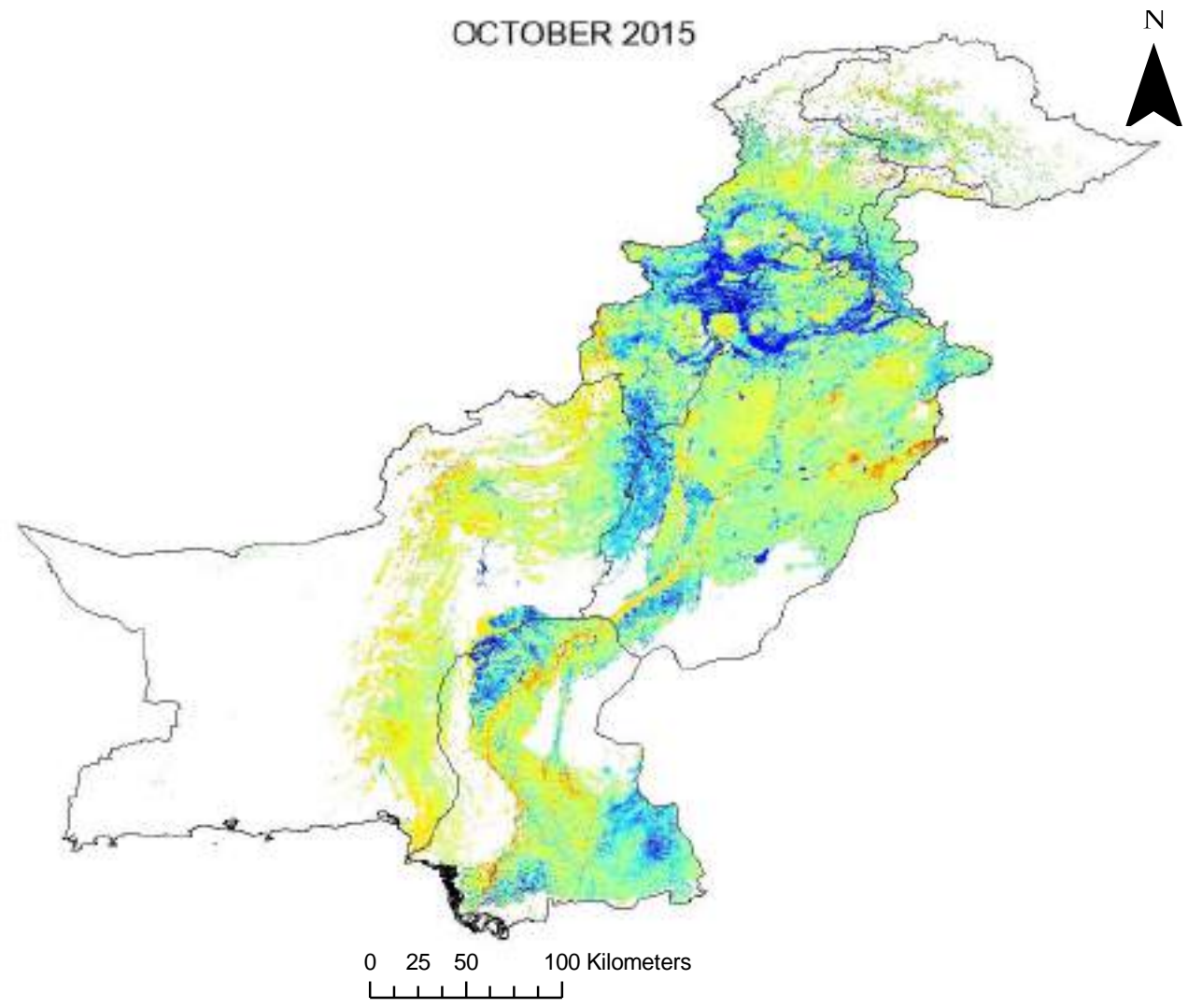
Legend
















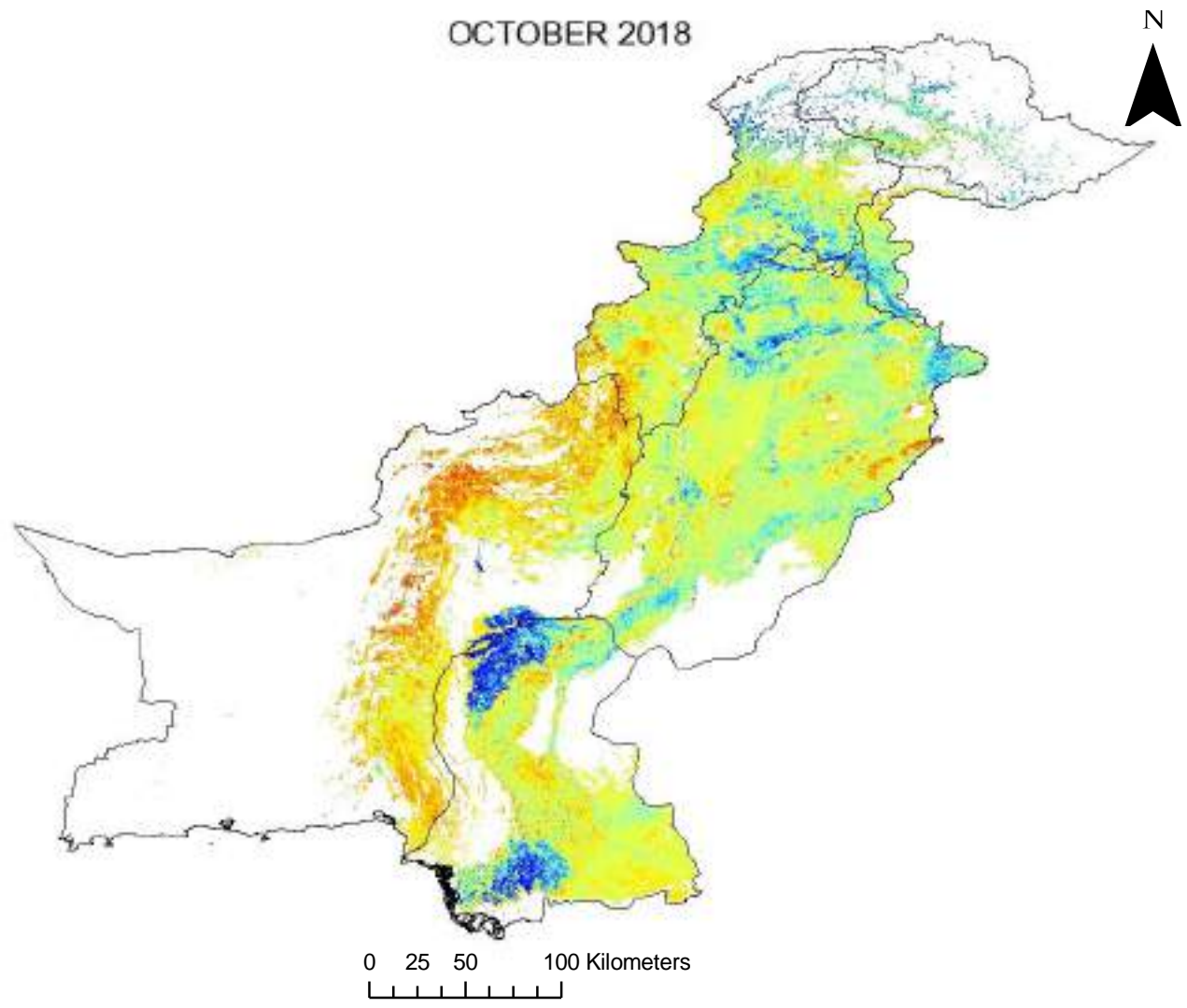
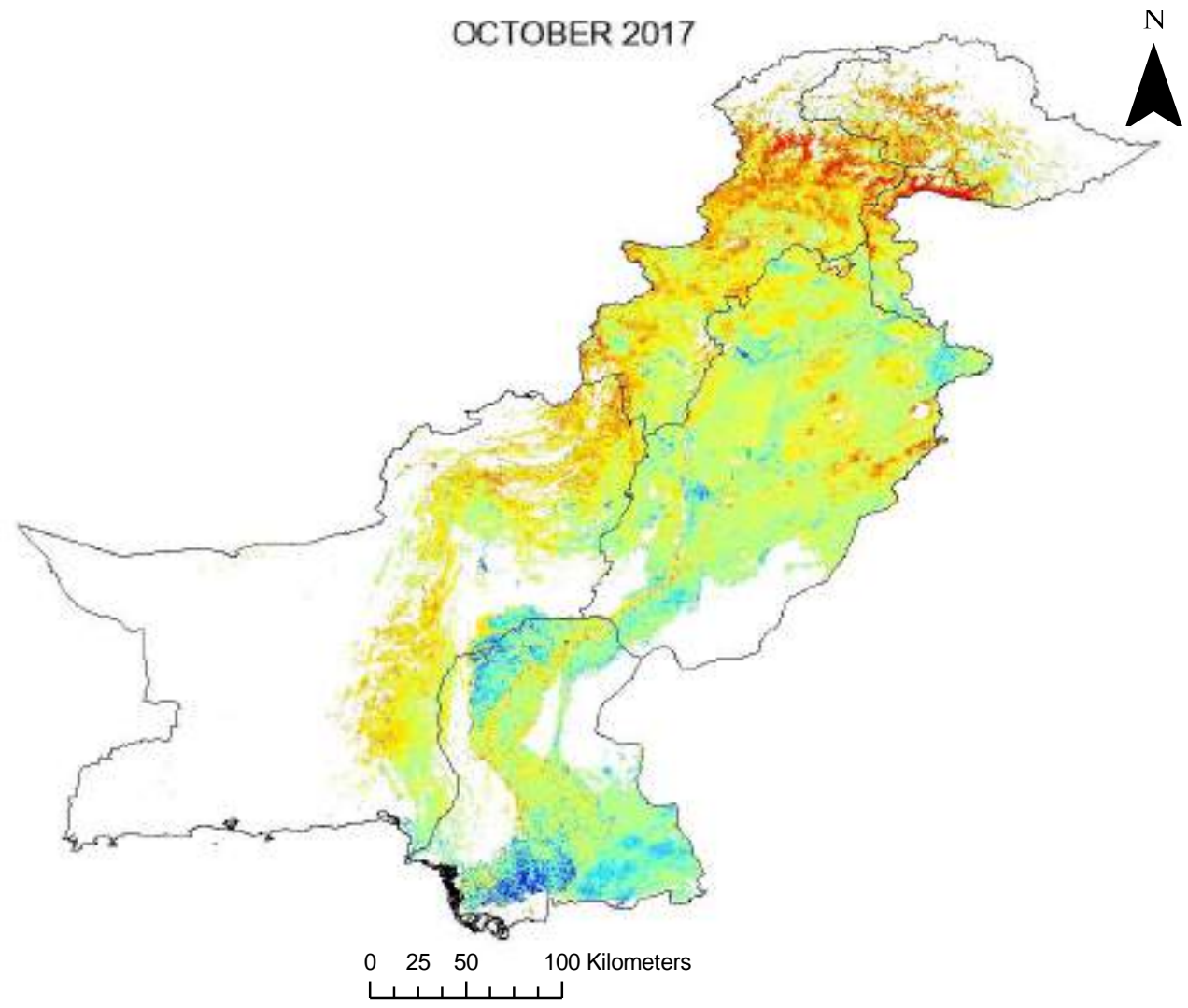
Legend

	Extreme Drought (-1.5 or less)		Incipient Drought (-0.3 to -0.59)		Moderately Wet (0.9 to 1.19)
	Severe Drought (-1.2 to -1.49)		Near Normal (0.29 to -0.29)		Very Wet (1.2 to 1.49)
	Moderate Drought (-0.9 to -1.19)		Incipient Wet Spell (0.3 to 0.59)		Extremely Wet (1.5 or greater)
	Mild Drought (-0.6 to -0.89)		Slightly Wet (0.6 to 0.89)		

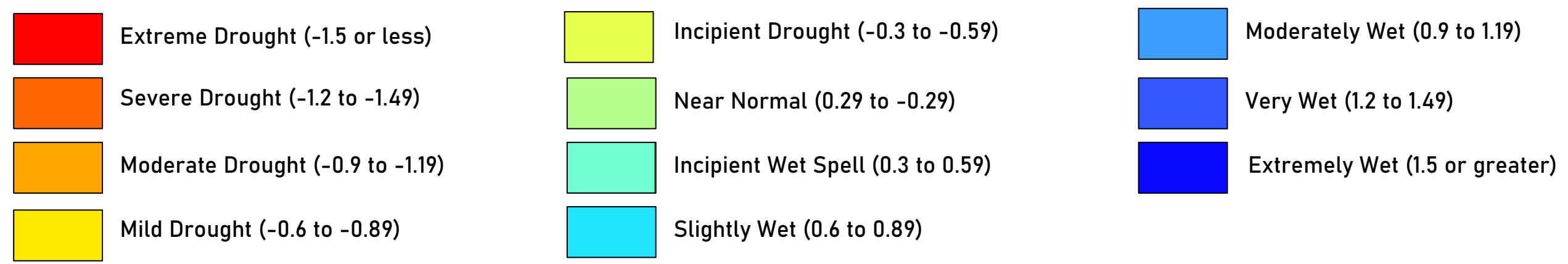


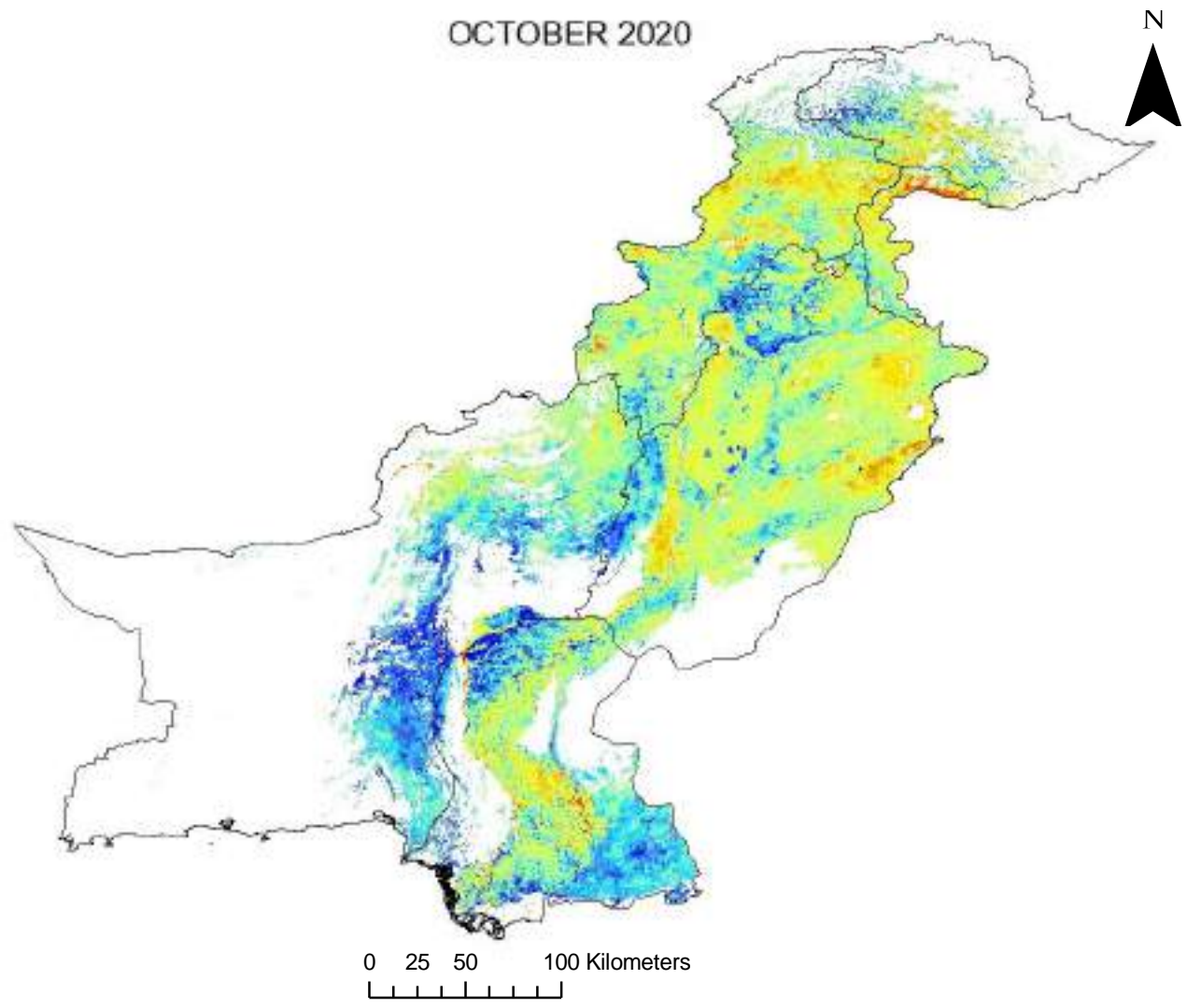
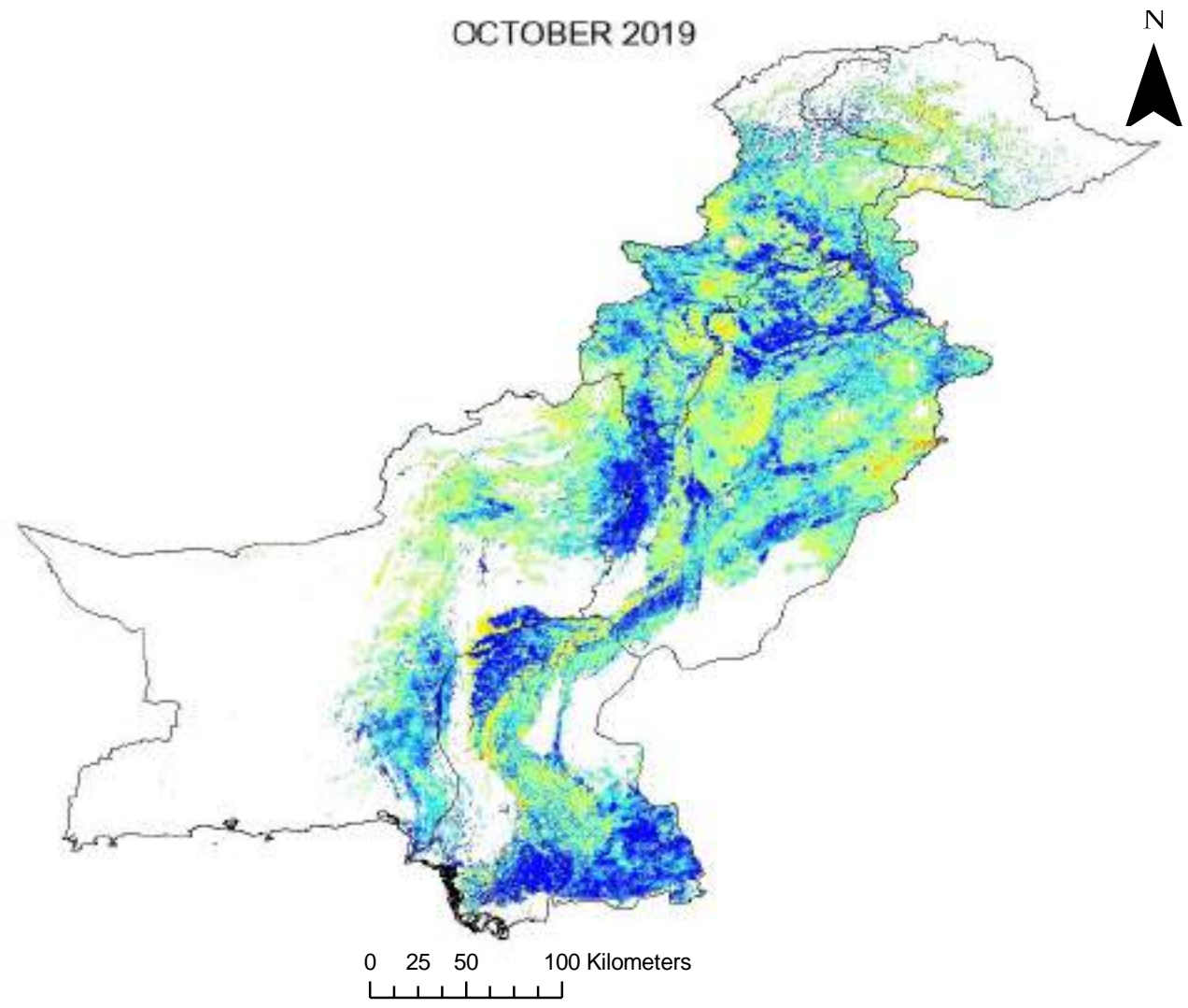
Legend

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|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
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|  | Mild Drought (-0.6 to -0.89) |  | Slightly Wet (0.6 to 0.89) | | |














Legend





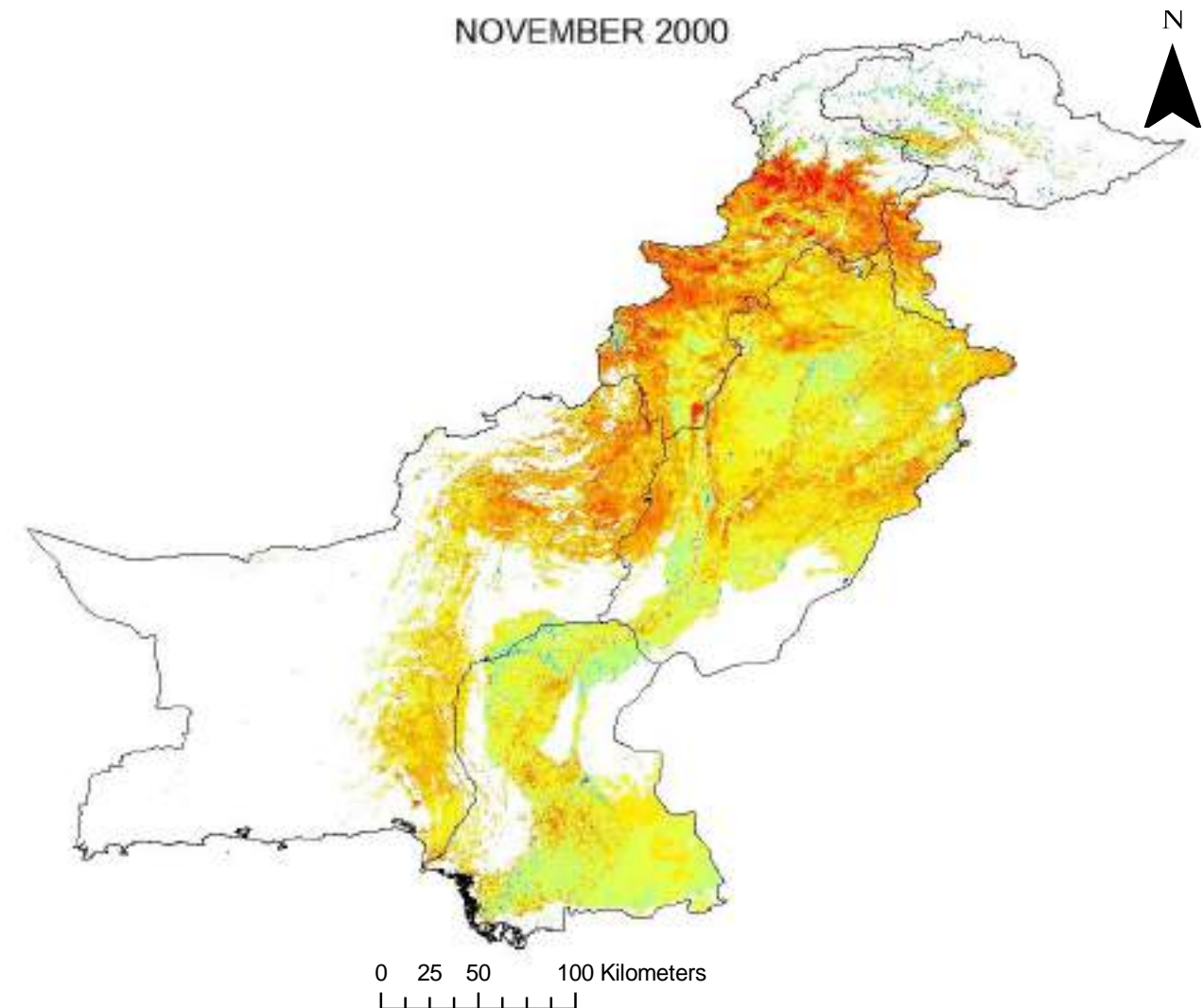
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|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
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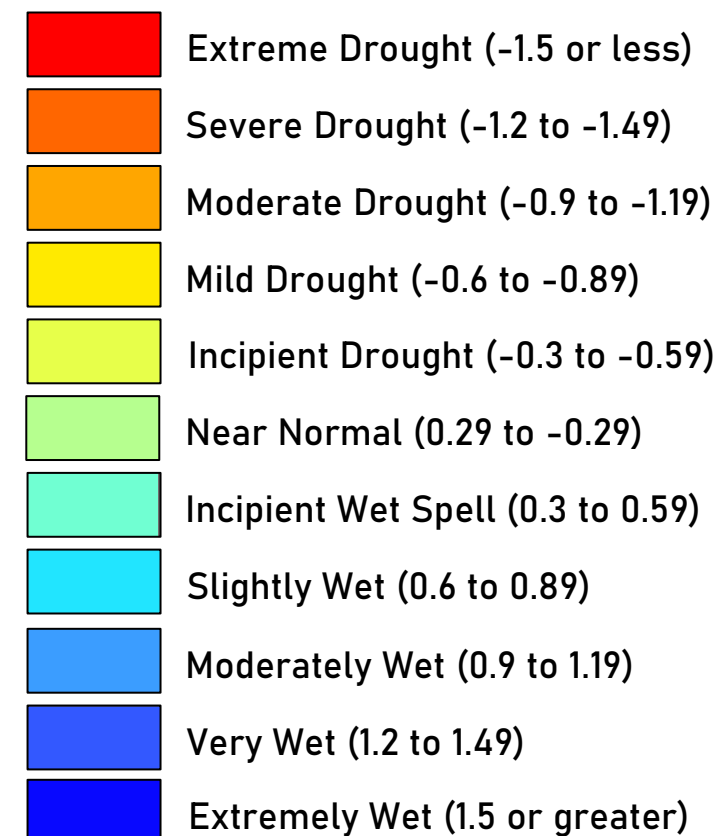
November DSI Maps

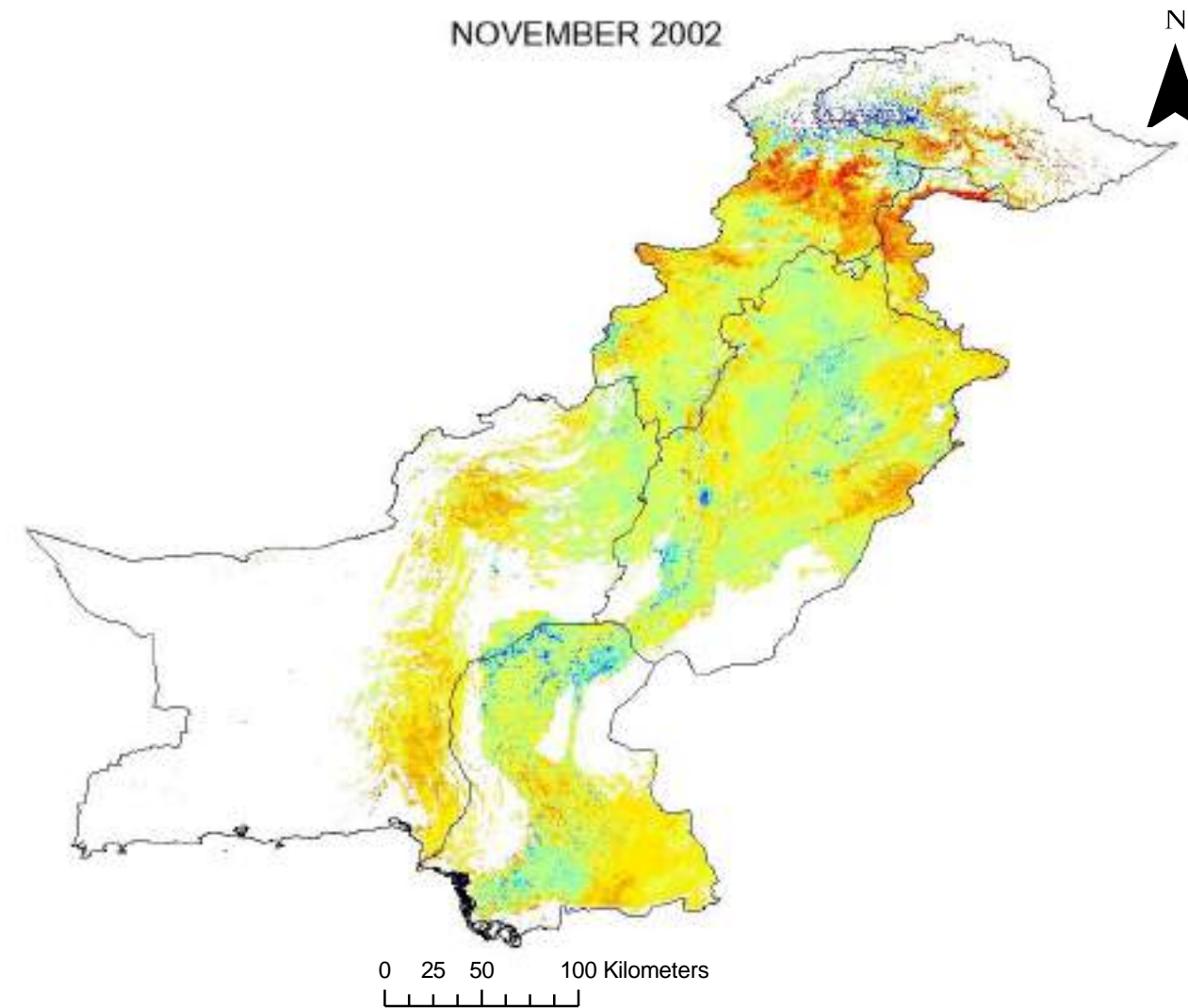
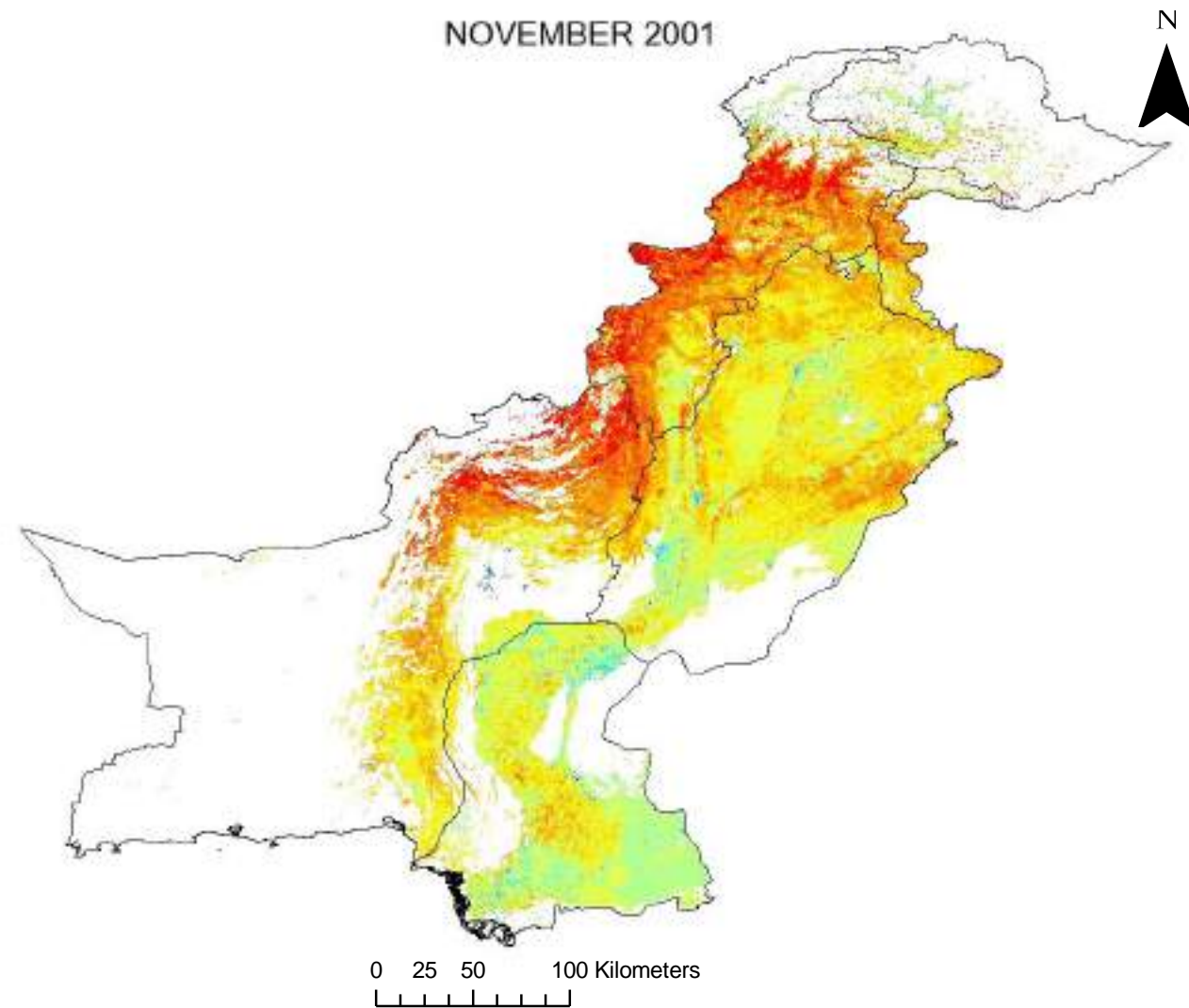
In November, drought normally ranges from mild drought to slightly wet condition. November is post monsoon month in which mild drought and near normal condition is identified.

Mean November DSI Values		
Years	Values	Drought Condition
2000	-0.67	Mild Drought
2001	-0.72	Mild Drought
2002	-0.60	Mild Drought
2003	-0.44	Incipient Drought
2004	-0.51	Incipient Drought
2005	-0.53	Incipient Drought
2006	-0.12	Near Normal
2007	-0.87	Mild Drought
2008	-0.72	Mild Drought
2009	-0.59	Incipient Drought
2010	-0.64	Mild Drought
2011	-0.02	Near Normal
2012	-0.48	Incipient Drought
2013	-0.19	Near Normal
2014	-0.24	Near Normal
2015	0.11	Near Normal
2016	-0.85	Mild Drought
2017	-0.62	Mild Drought
2018	-0.12	Near Normal
2019	0.74	Slightly Wet
2020	0.16	Near Normal

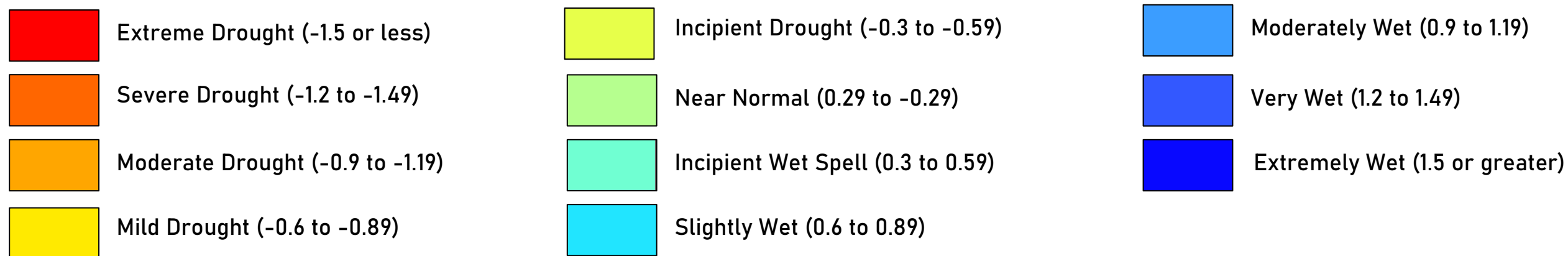


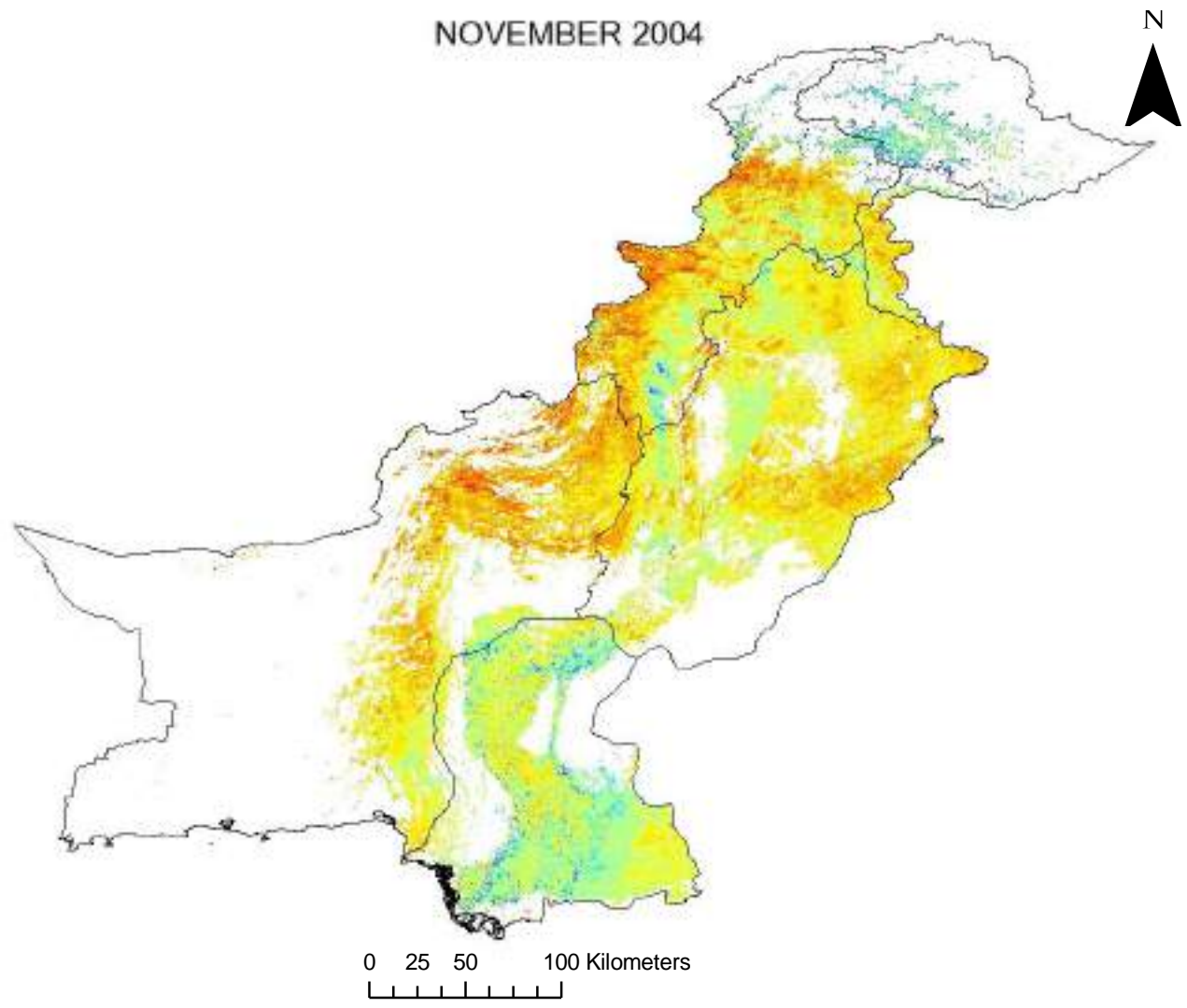
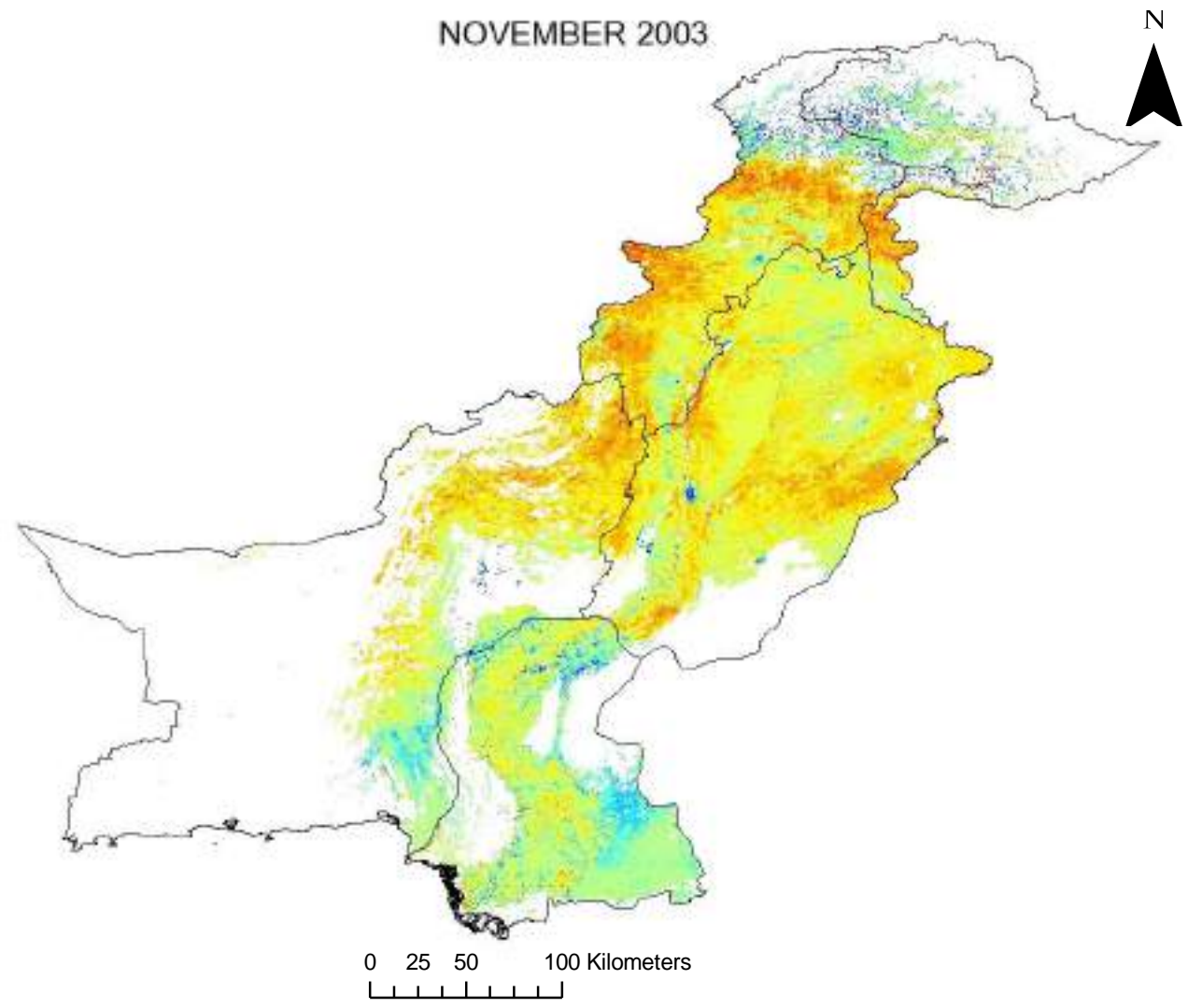
Legend



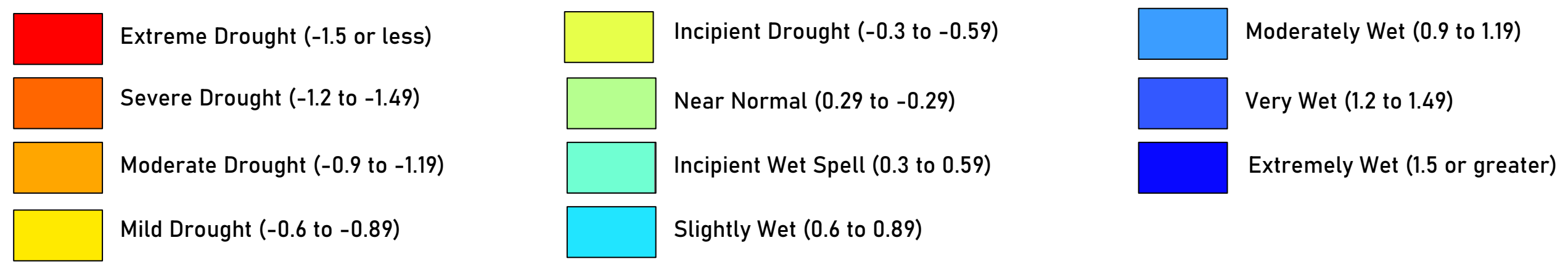


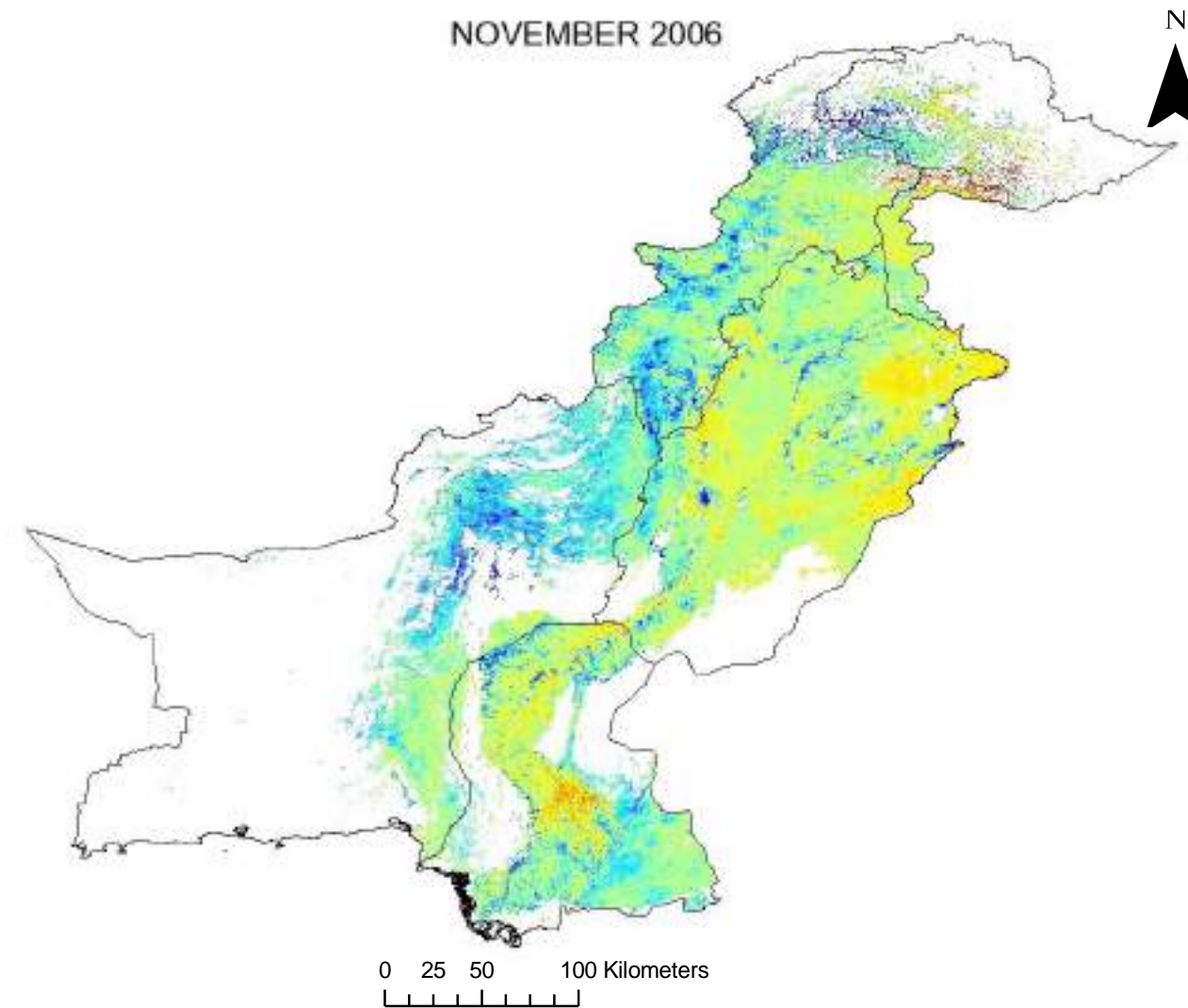
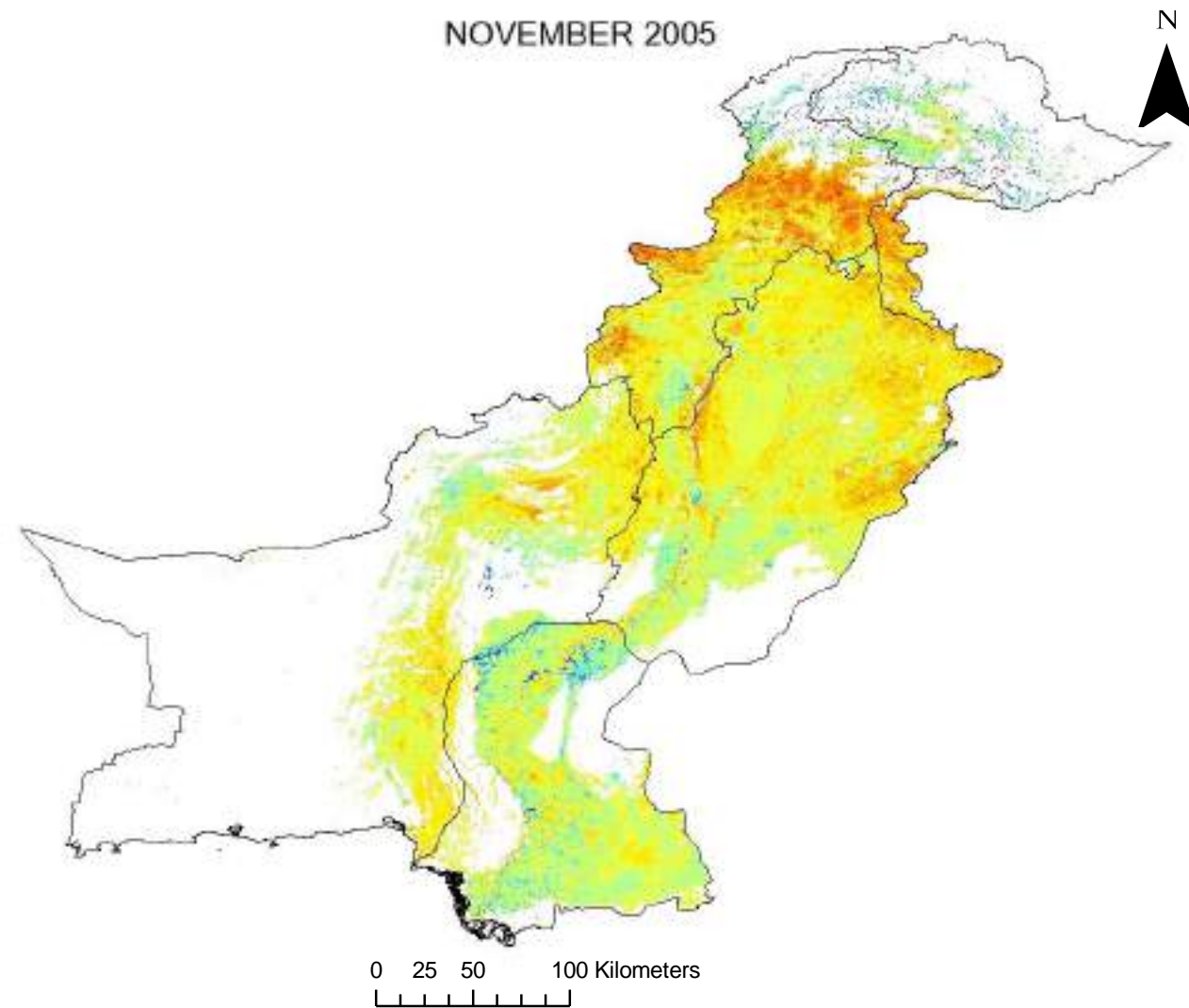
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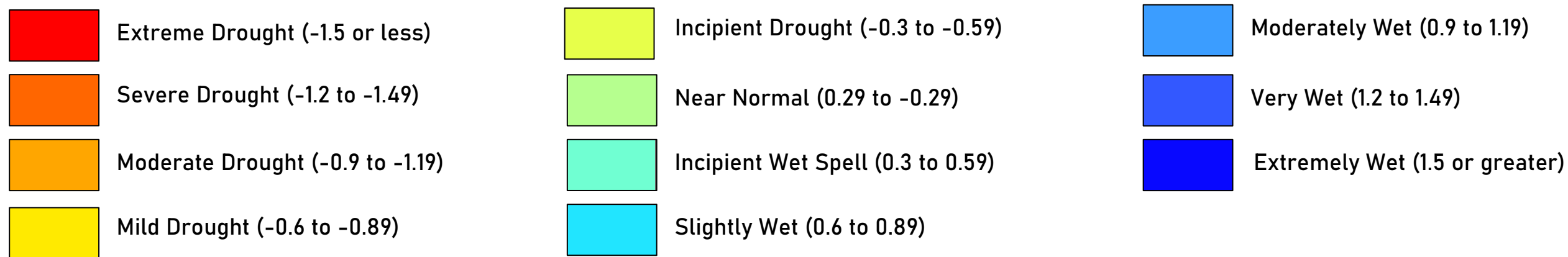


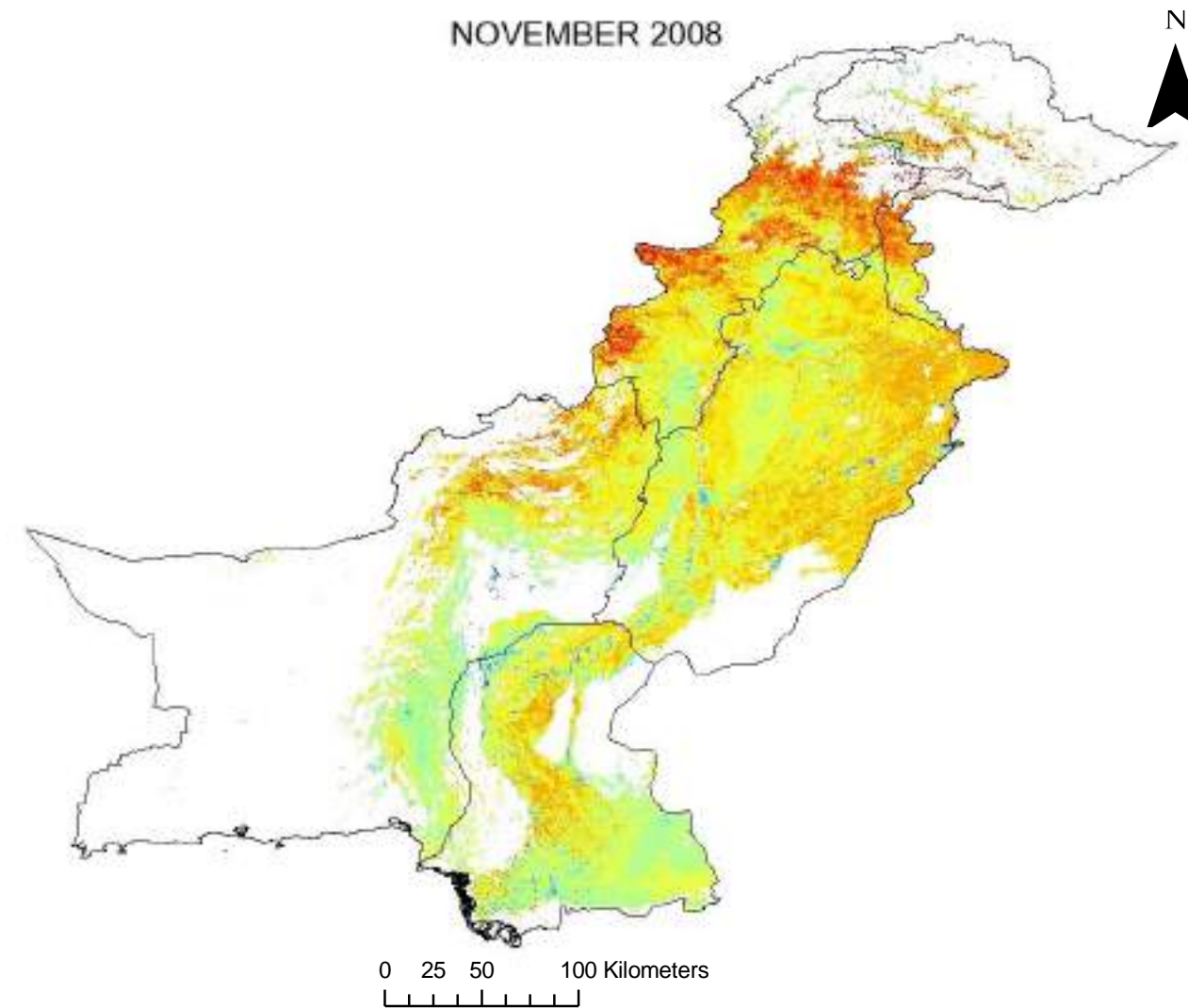
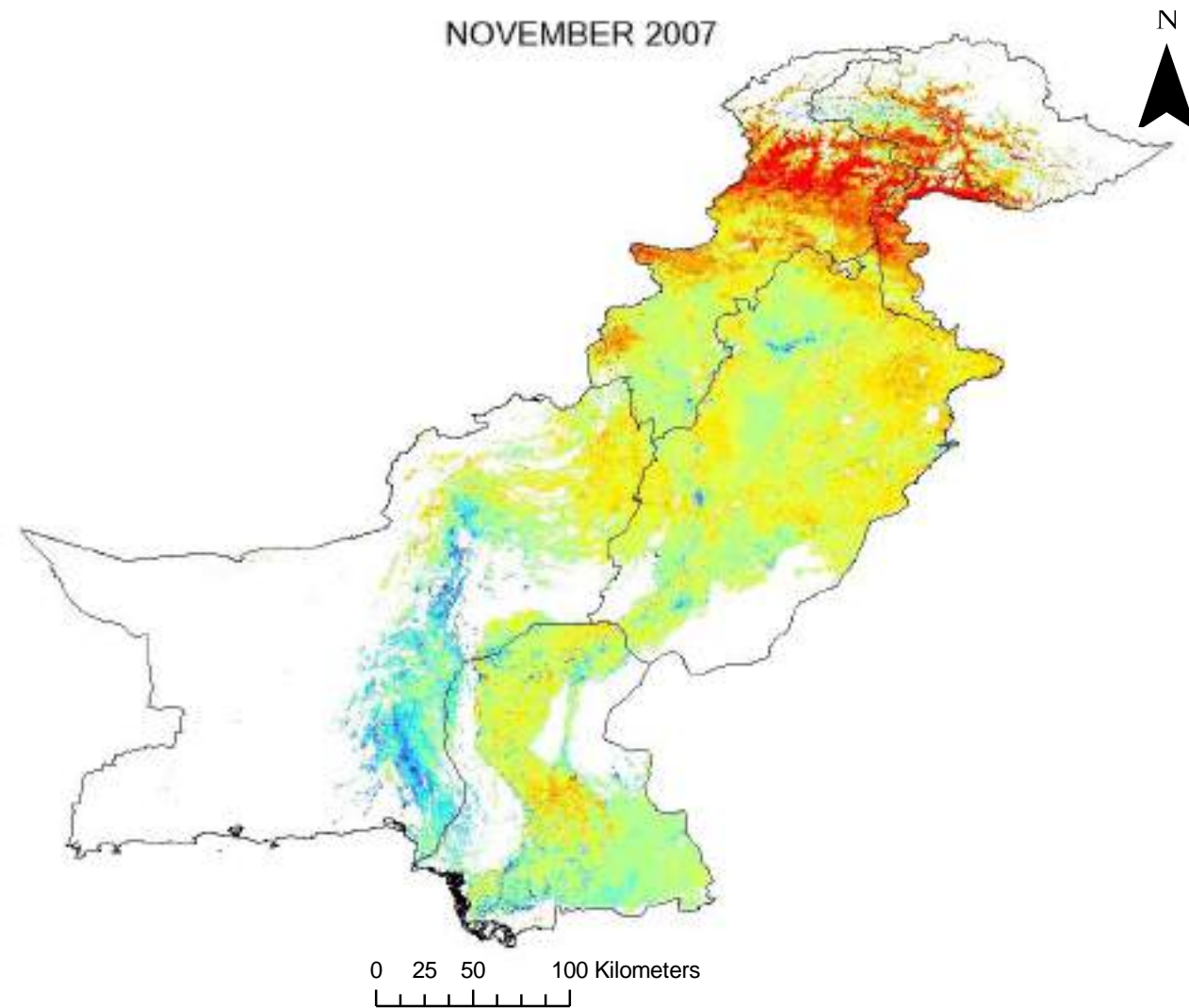
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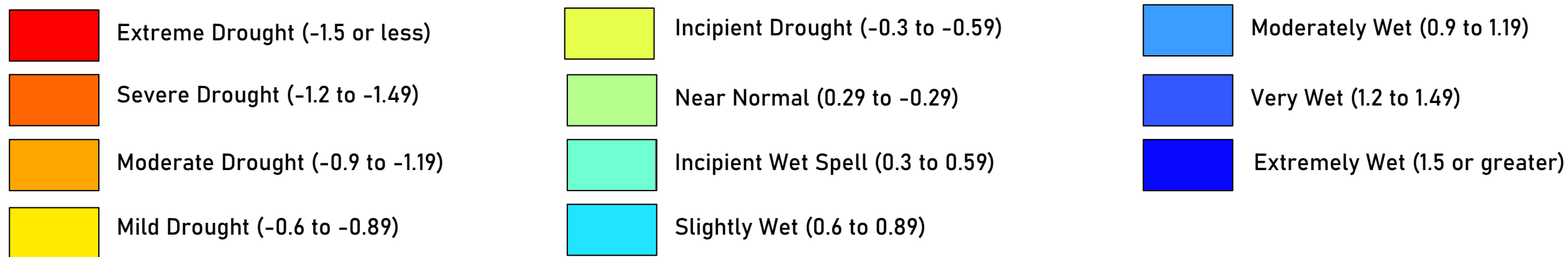


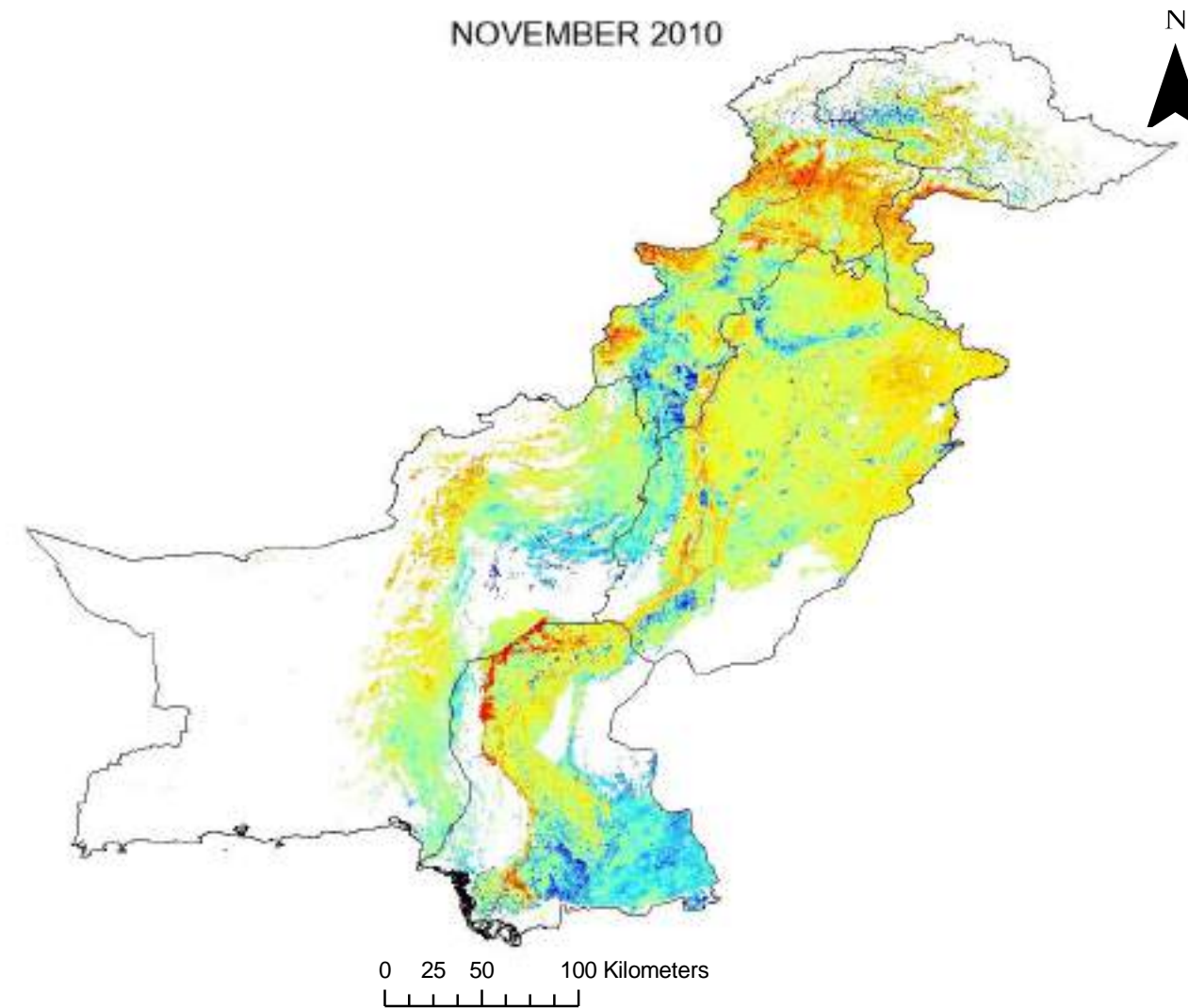
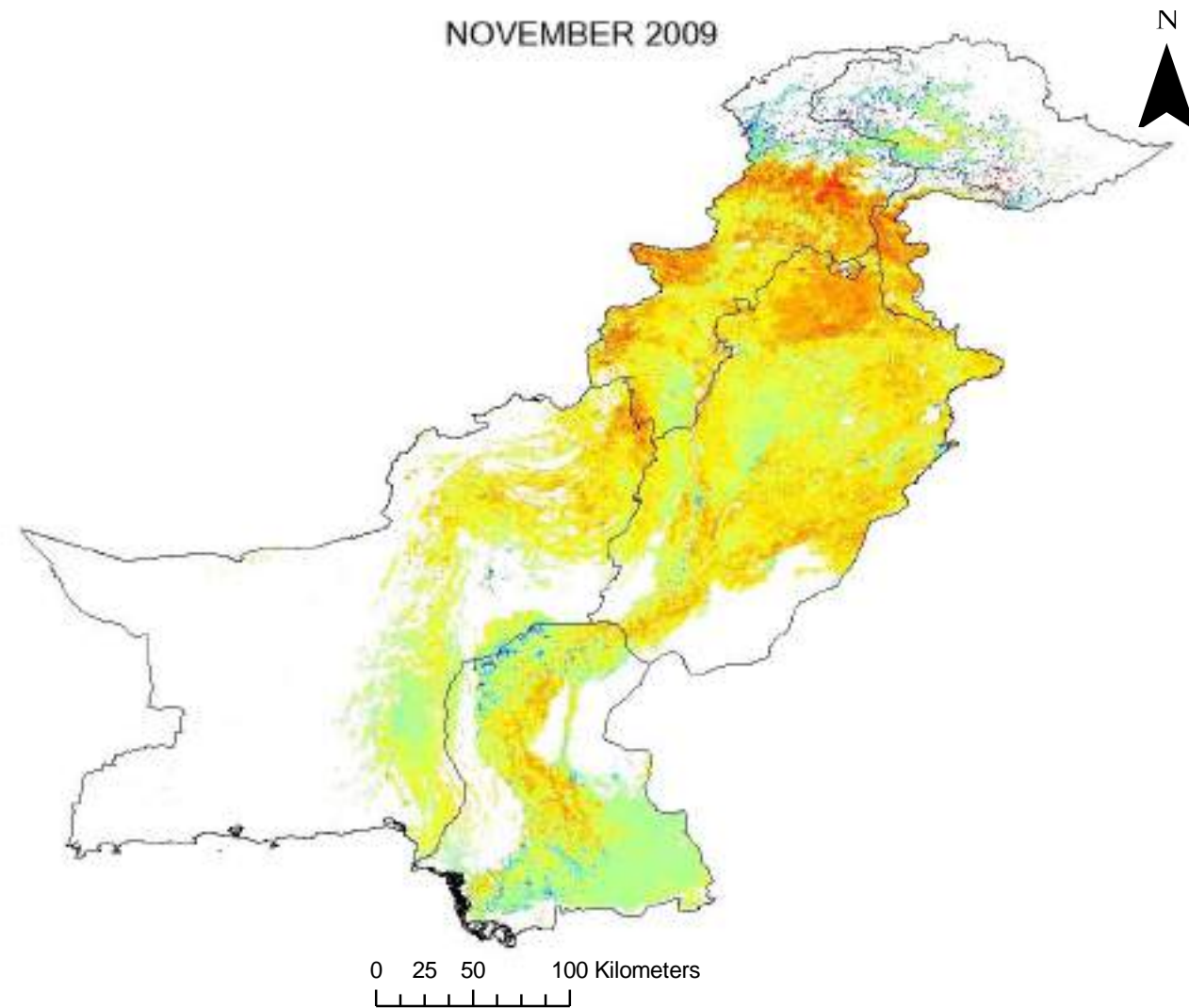
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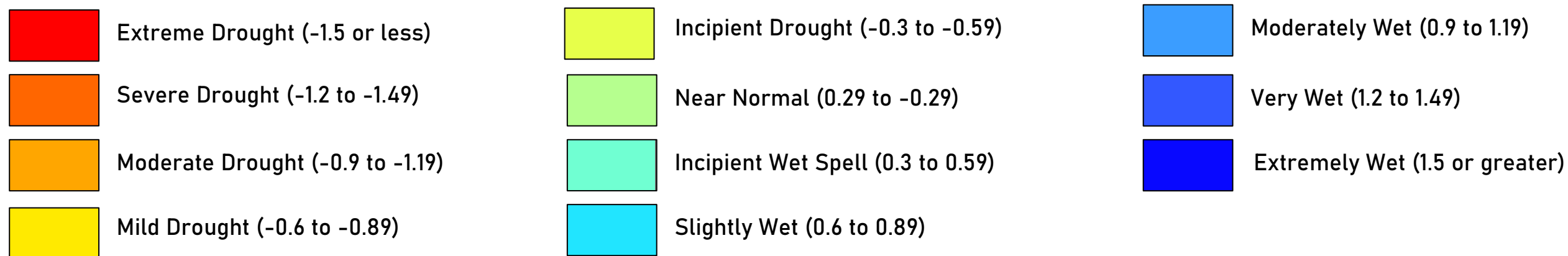


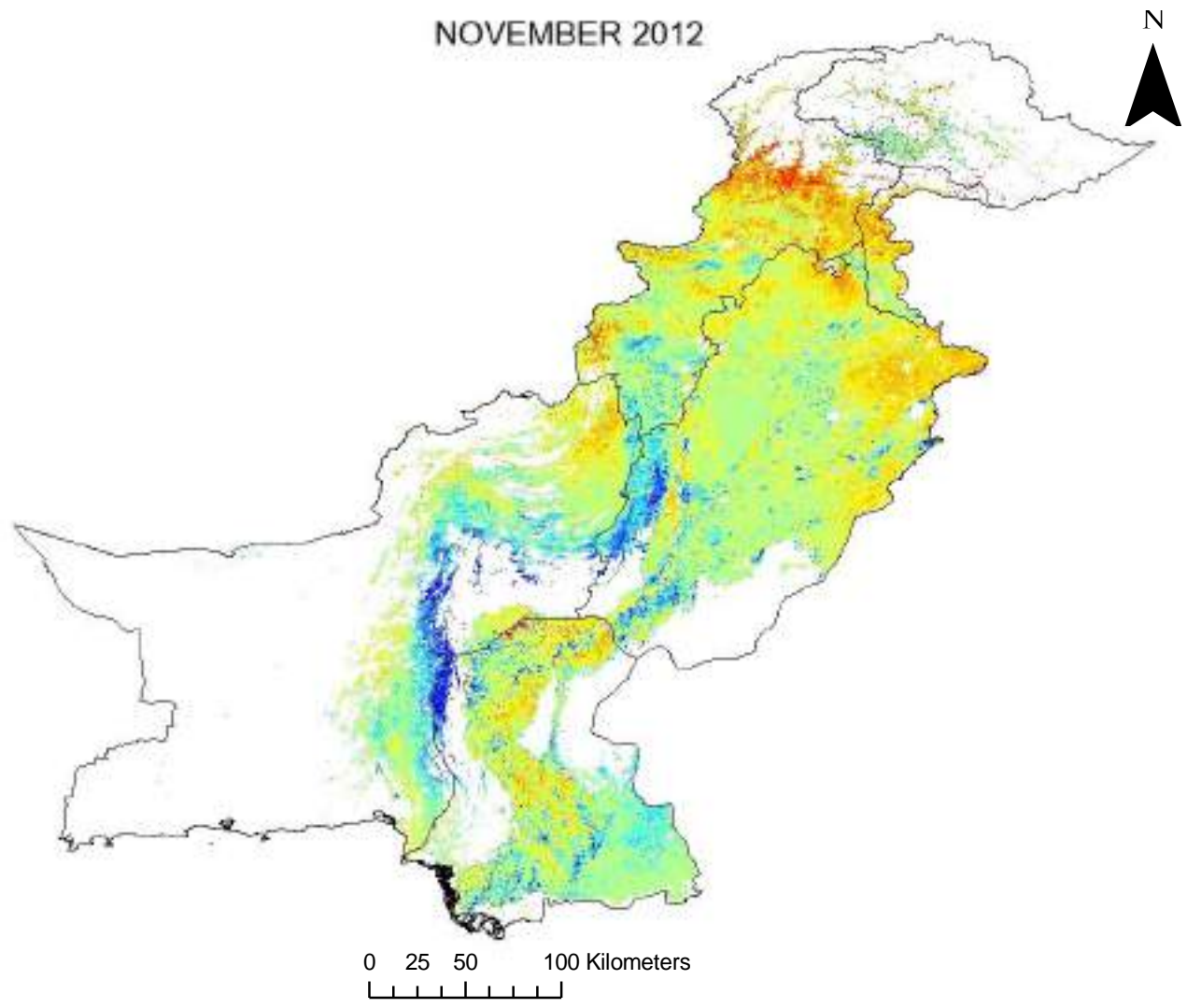
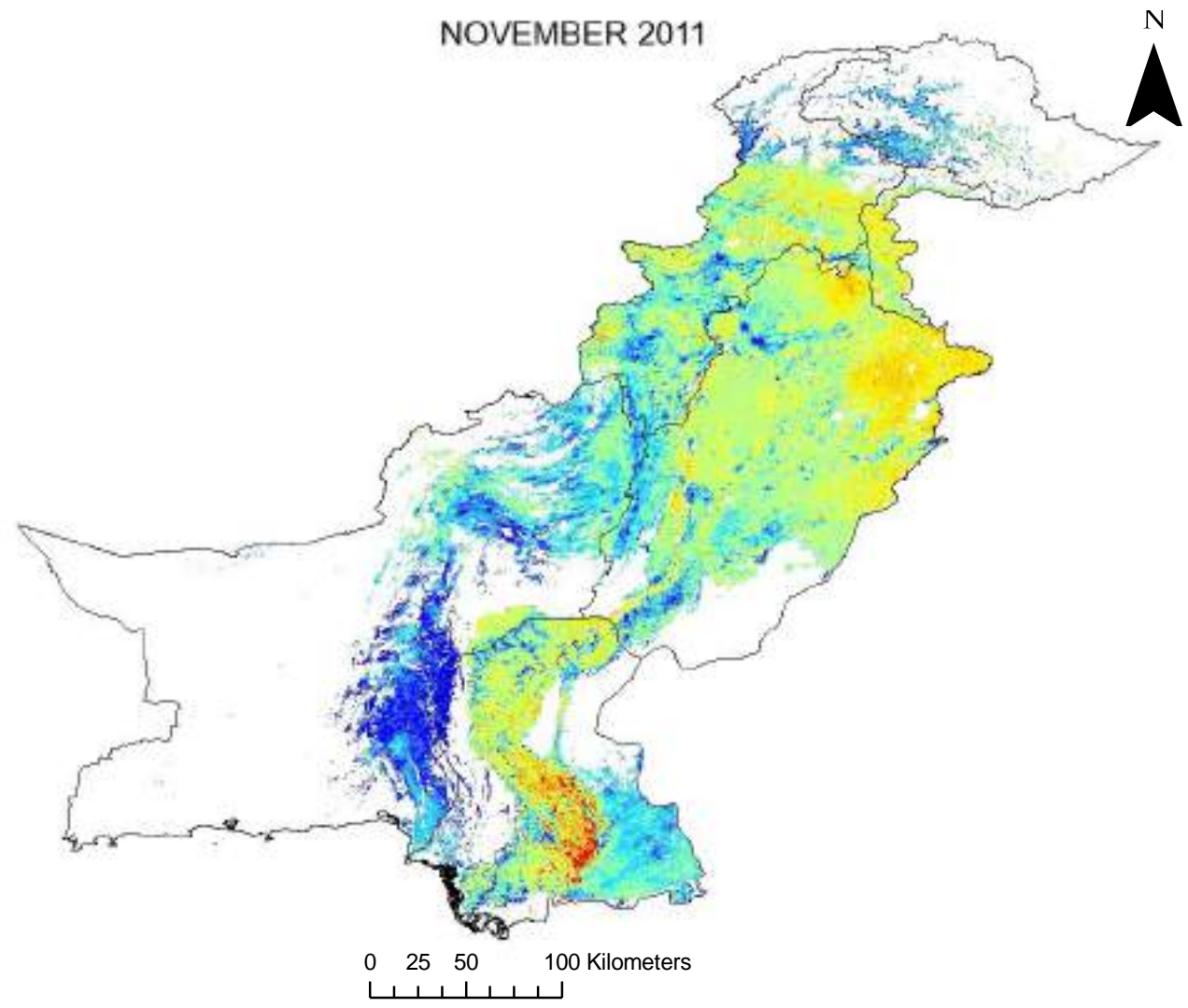
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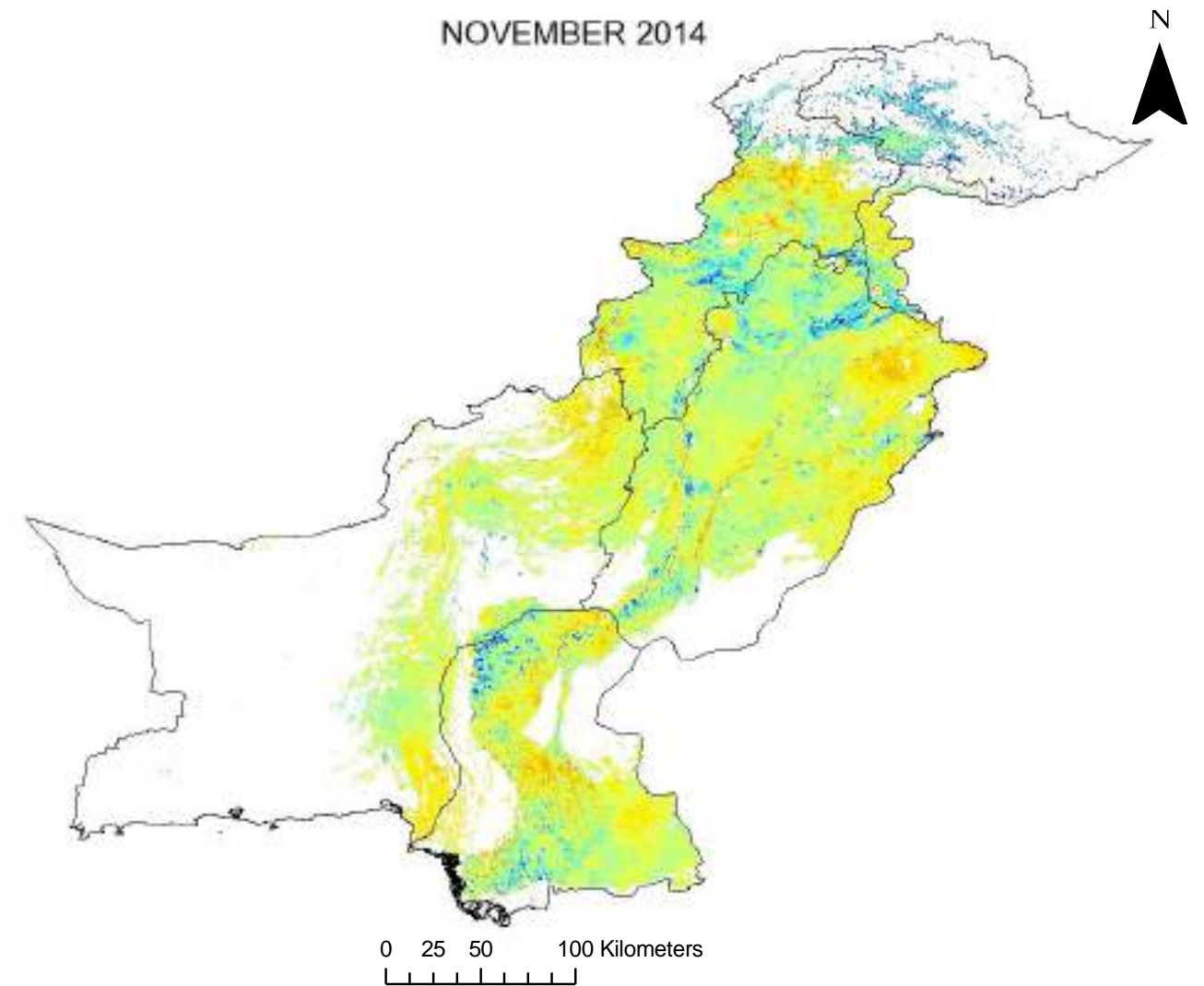
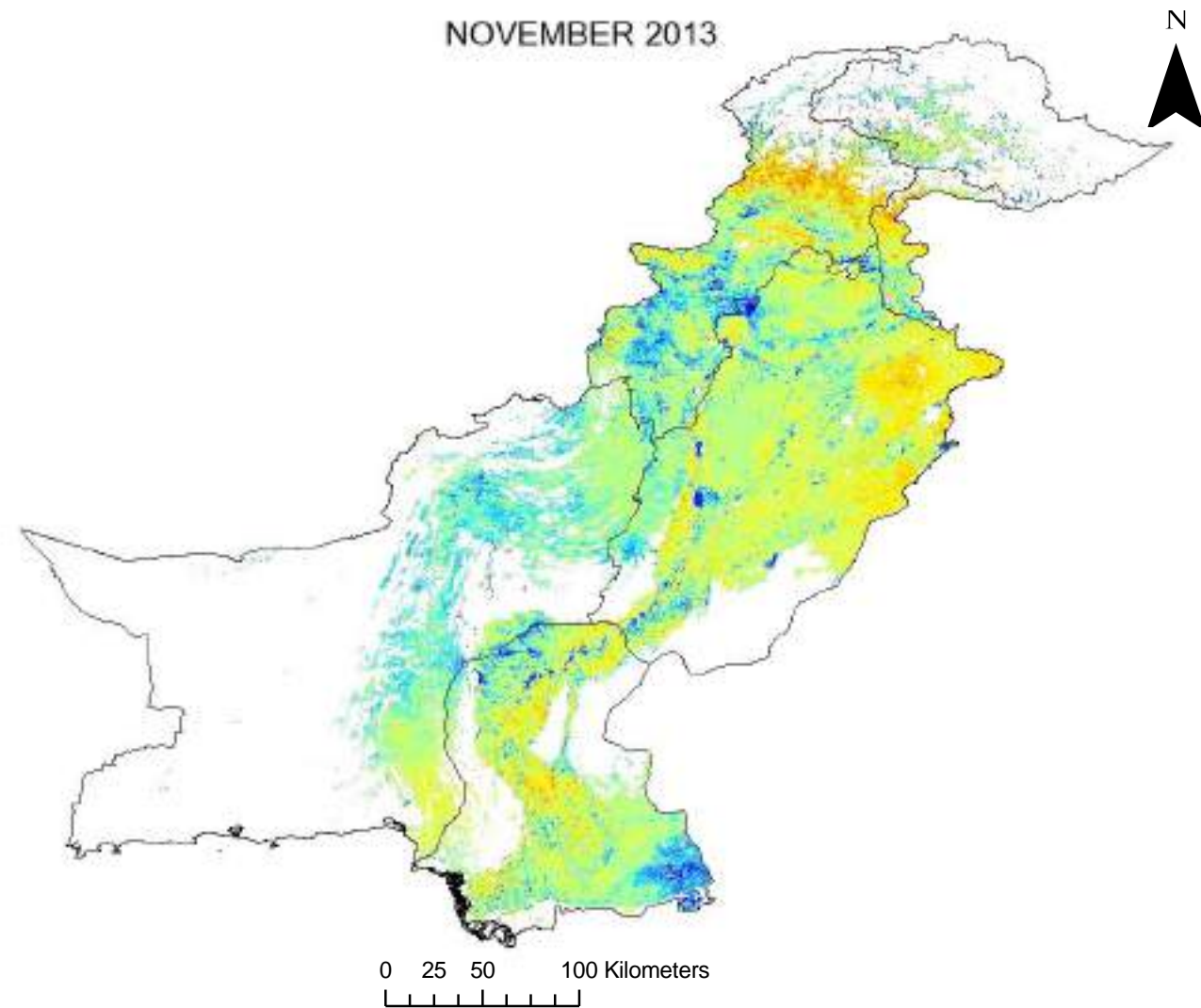
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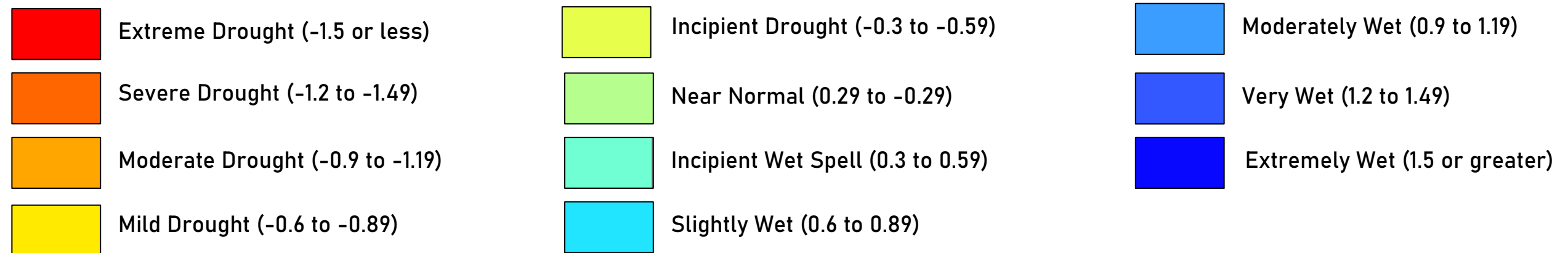


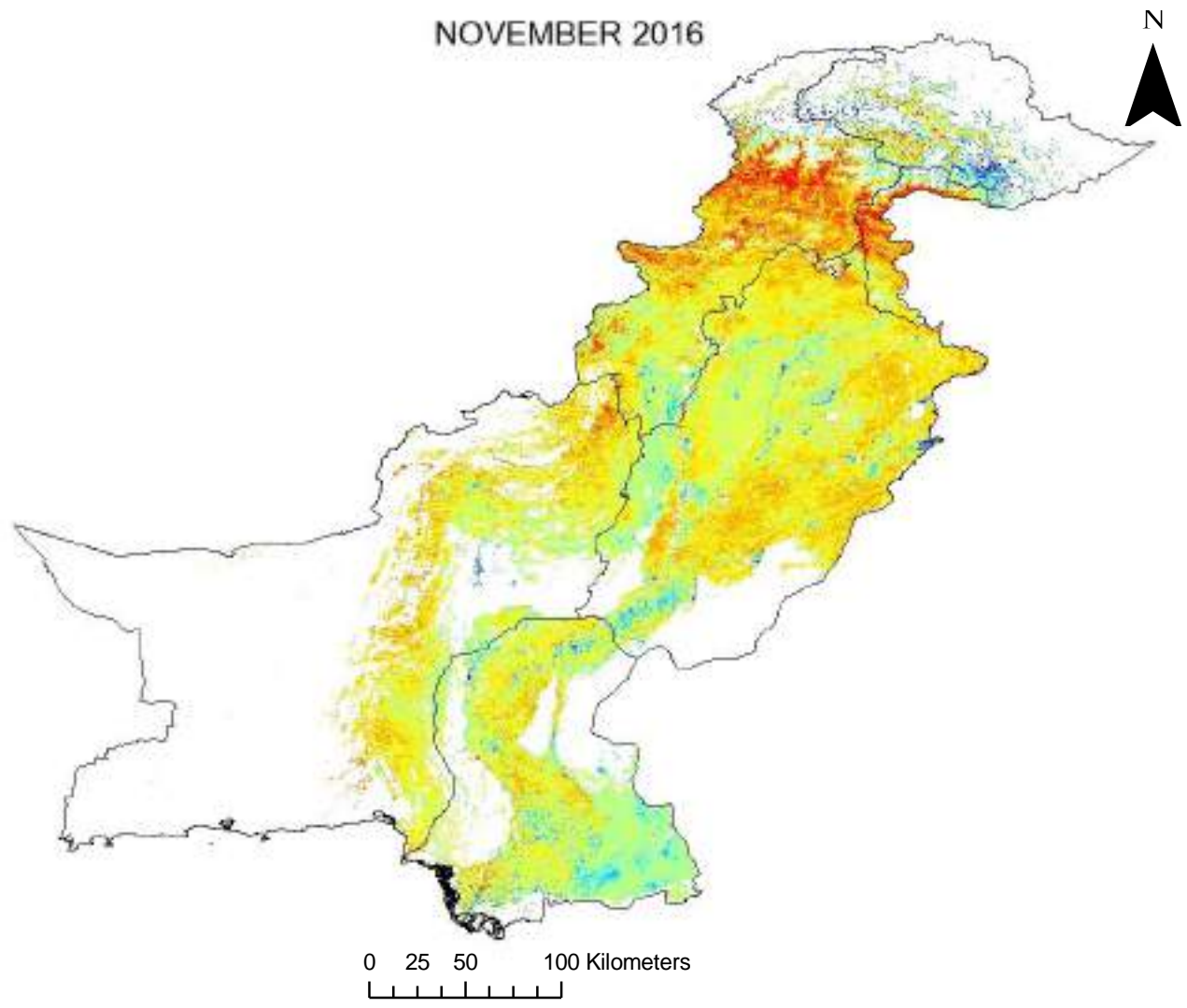
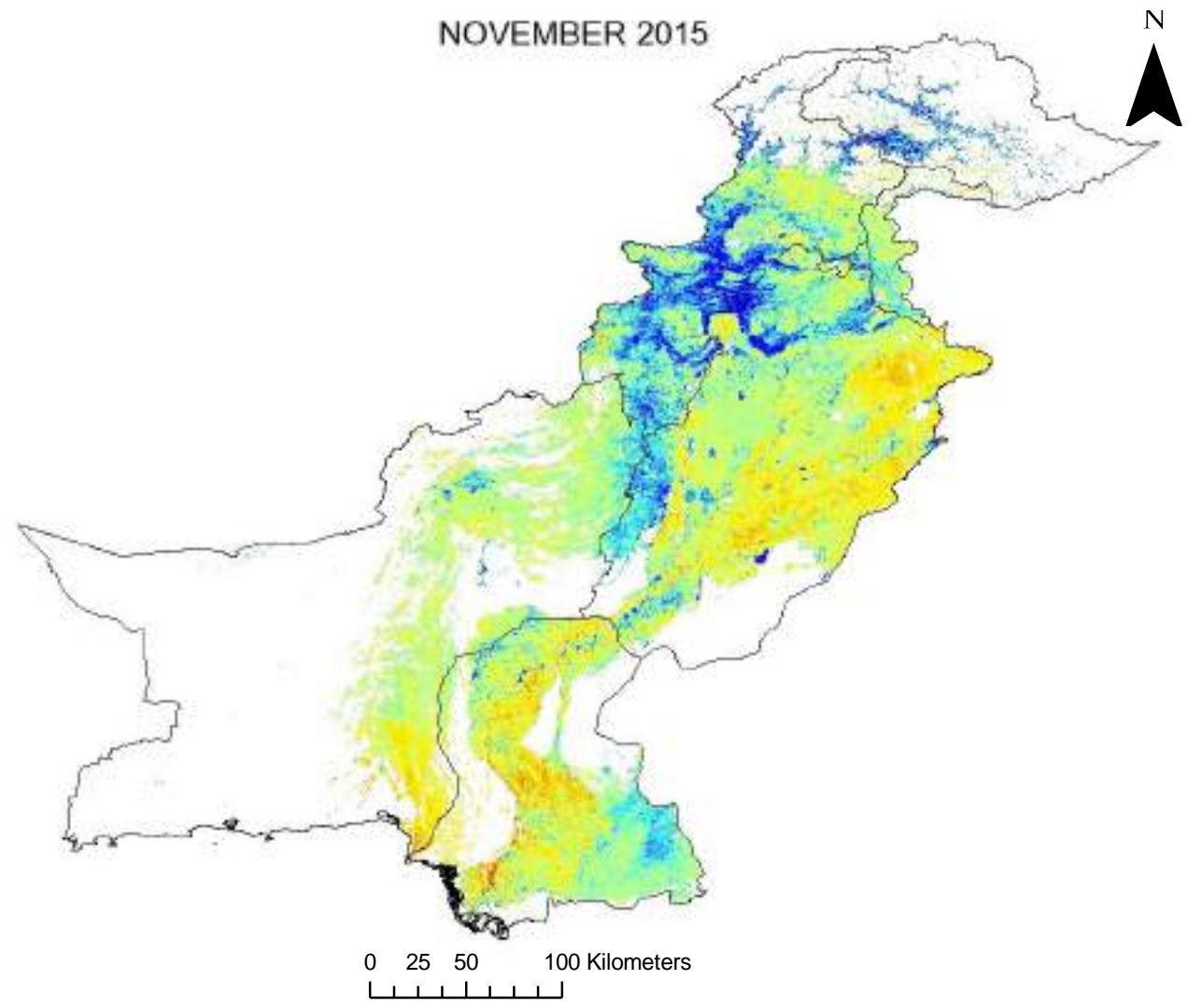
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|--|---|--|
|  Extreme Drought (-1.5 or less) |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19) |
|  Severe Drought (-1.2 to -1.49) |  Near Normal (0.29 to -0.29) |  Very Wet (1.2 to 1.49) |
|  Moderate Drought (-0.9 to -1.19) |  Incipient Wet Spell (0.3 to 0.59) |  Extremely Wet (1.5 or greater) |
|  Mild Drought (-0.6 to -0.89) |  Slightly Wet (0.6 to 0.89) | |














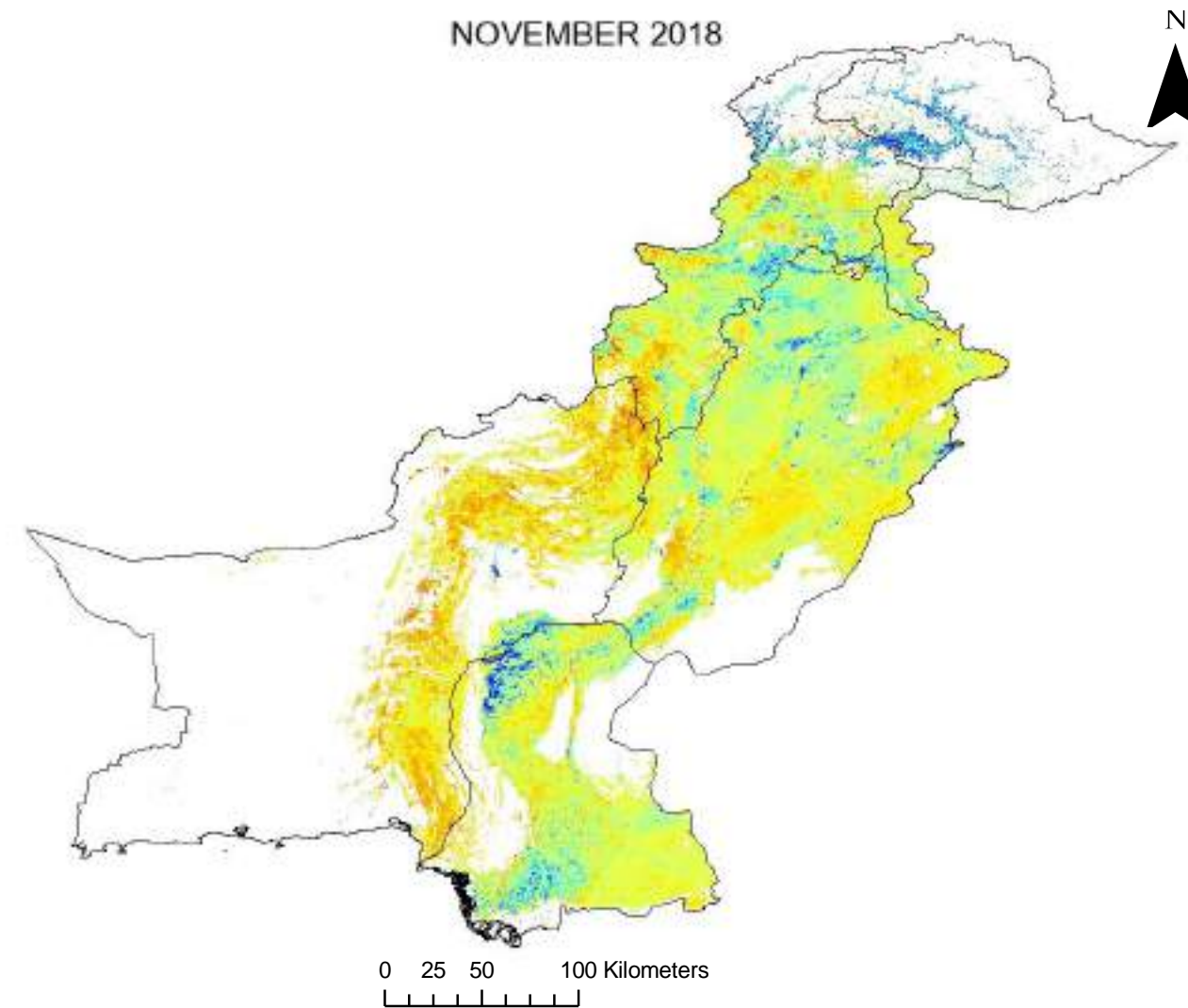
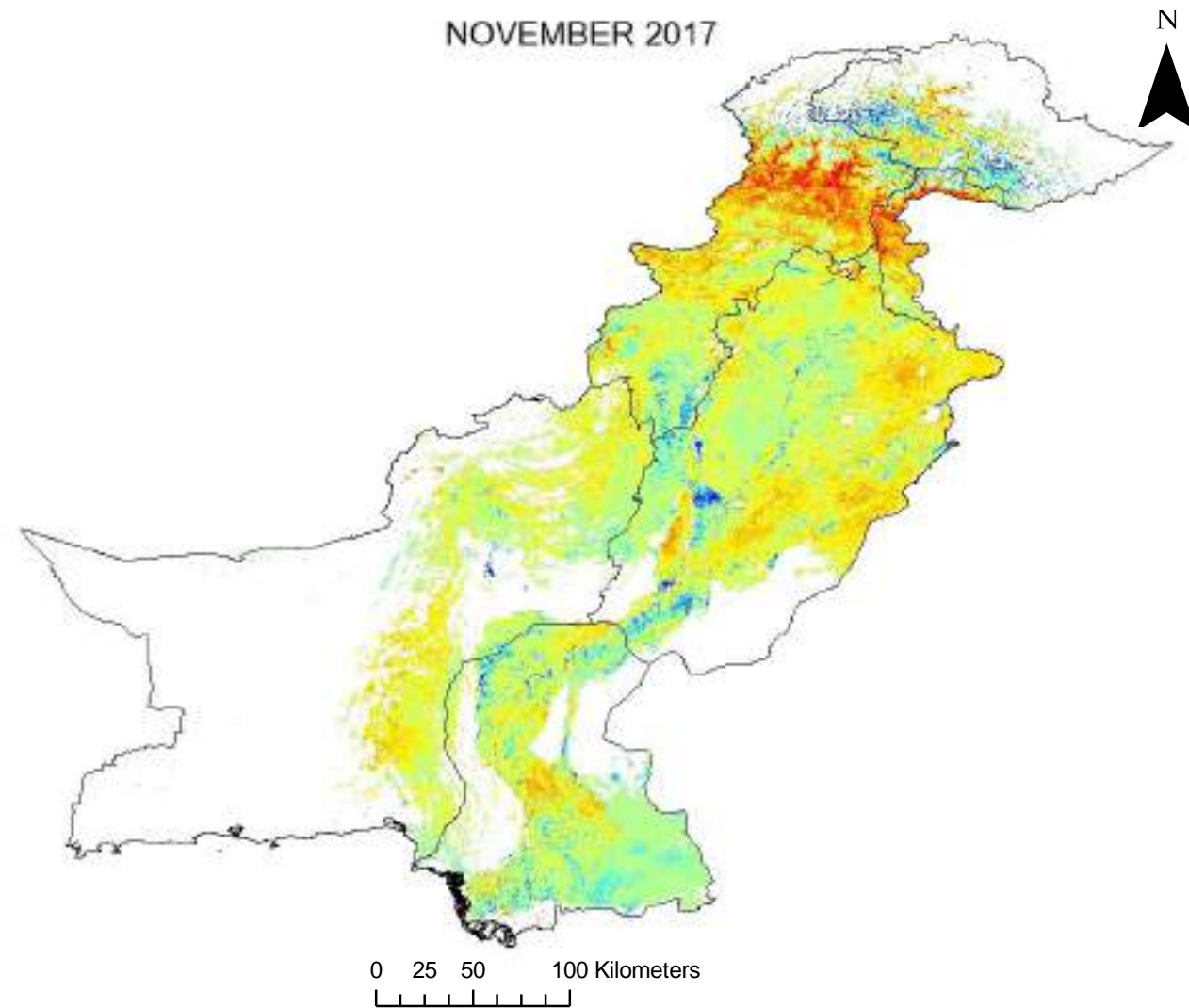
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|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
|  | Severe Drought (-1.2 to -1.49) |  | Near Normal (0.29 to -0.29) |  | Very Wet (1.2 to 1.49) |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89) |  | Slightly Wet (0.6 to 0.89) | | |

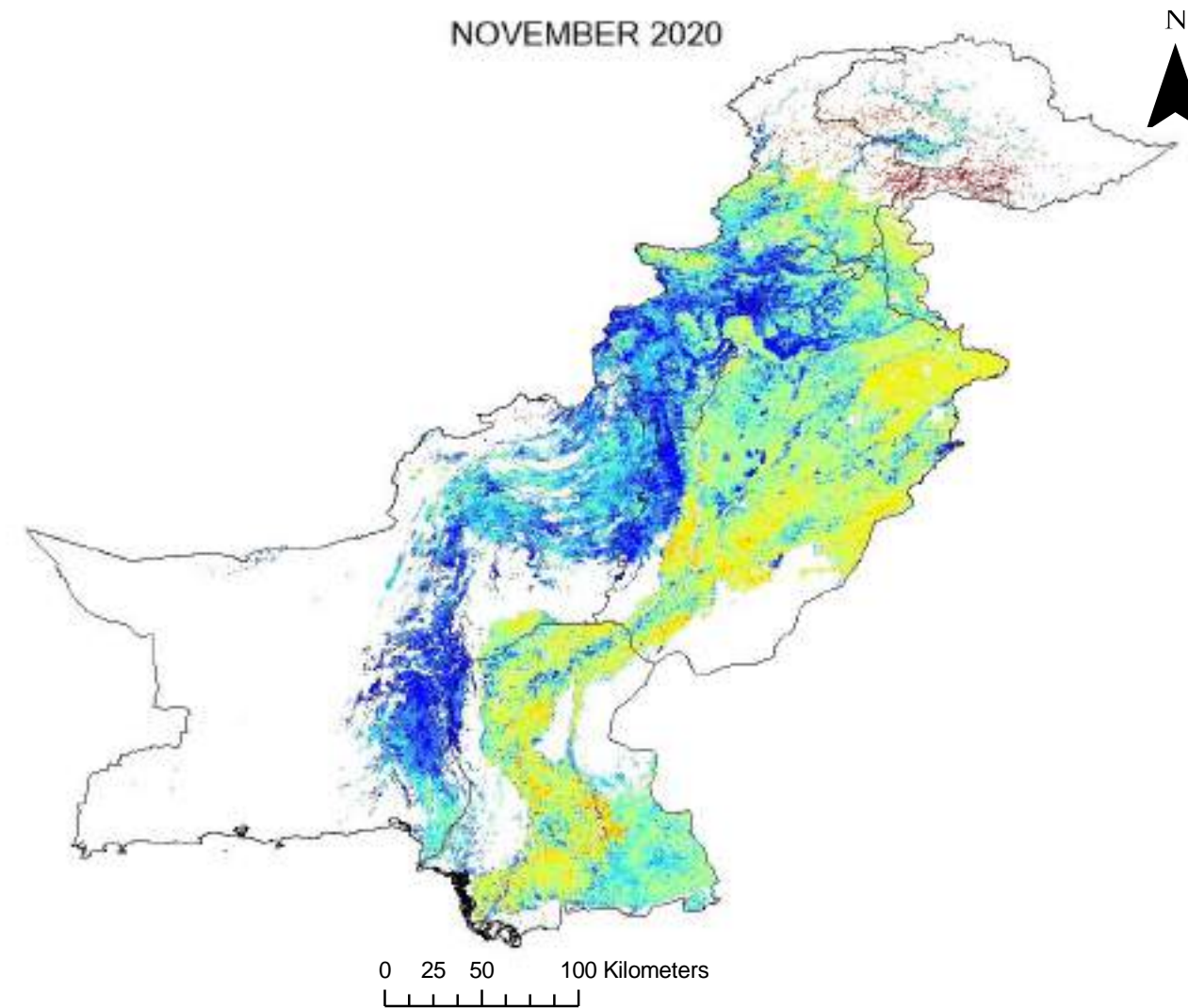
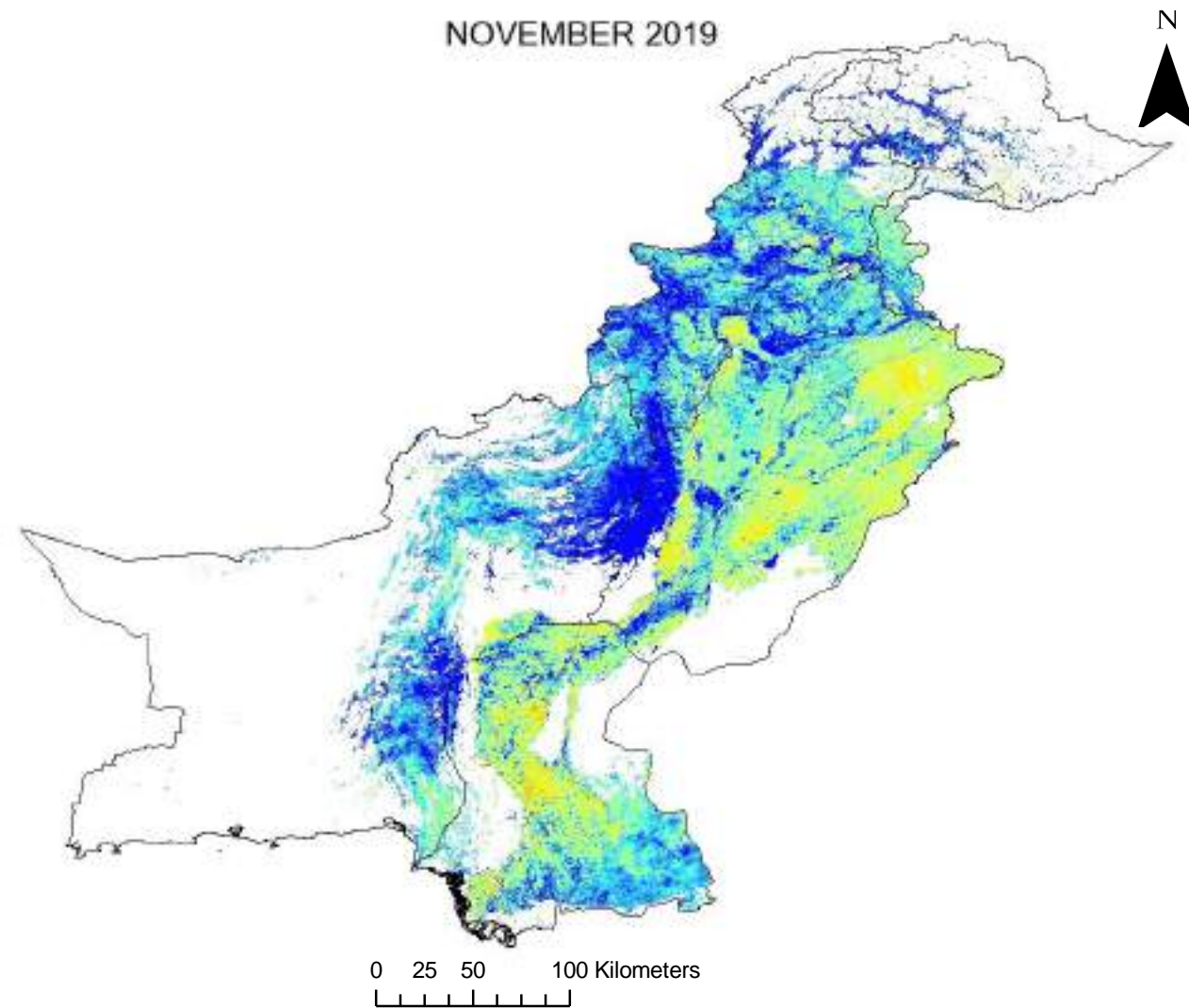


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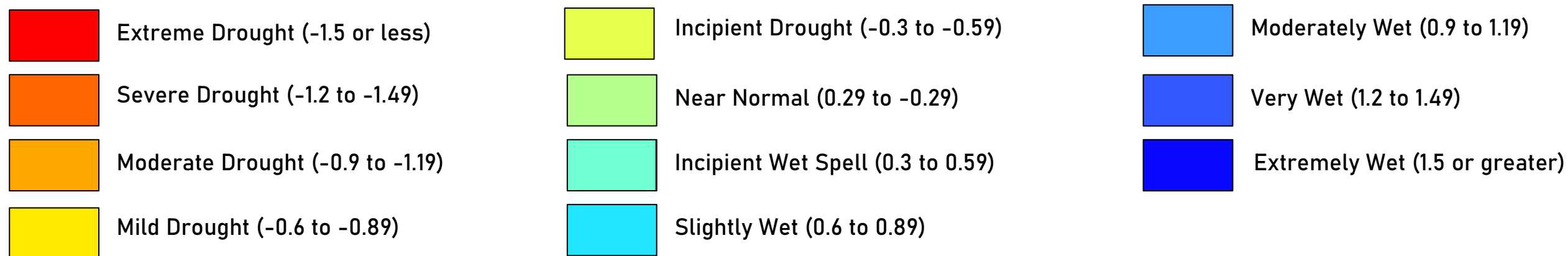
- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)



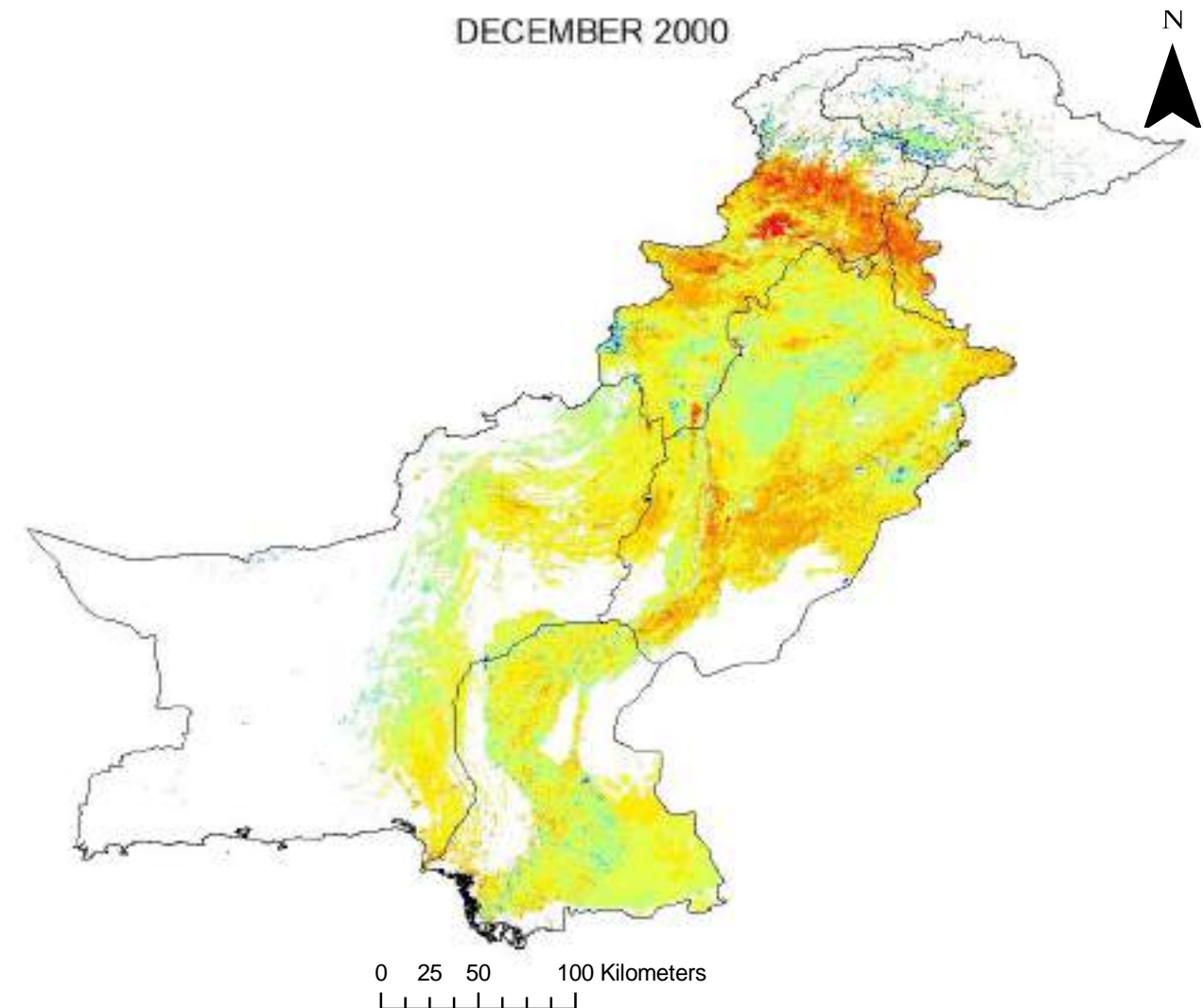
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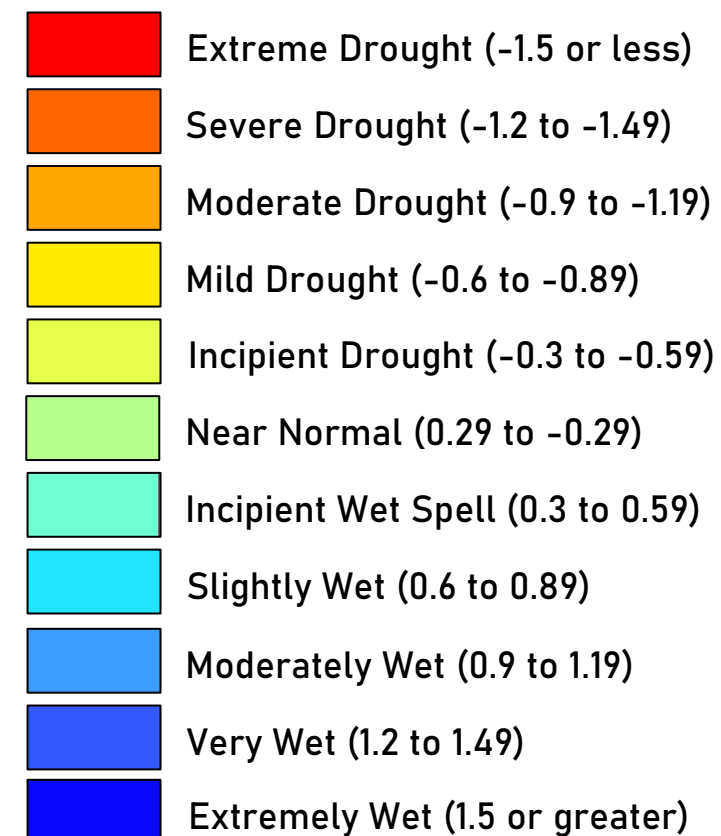
December DSI Maps

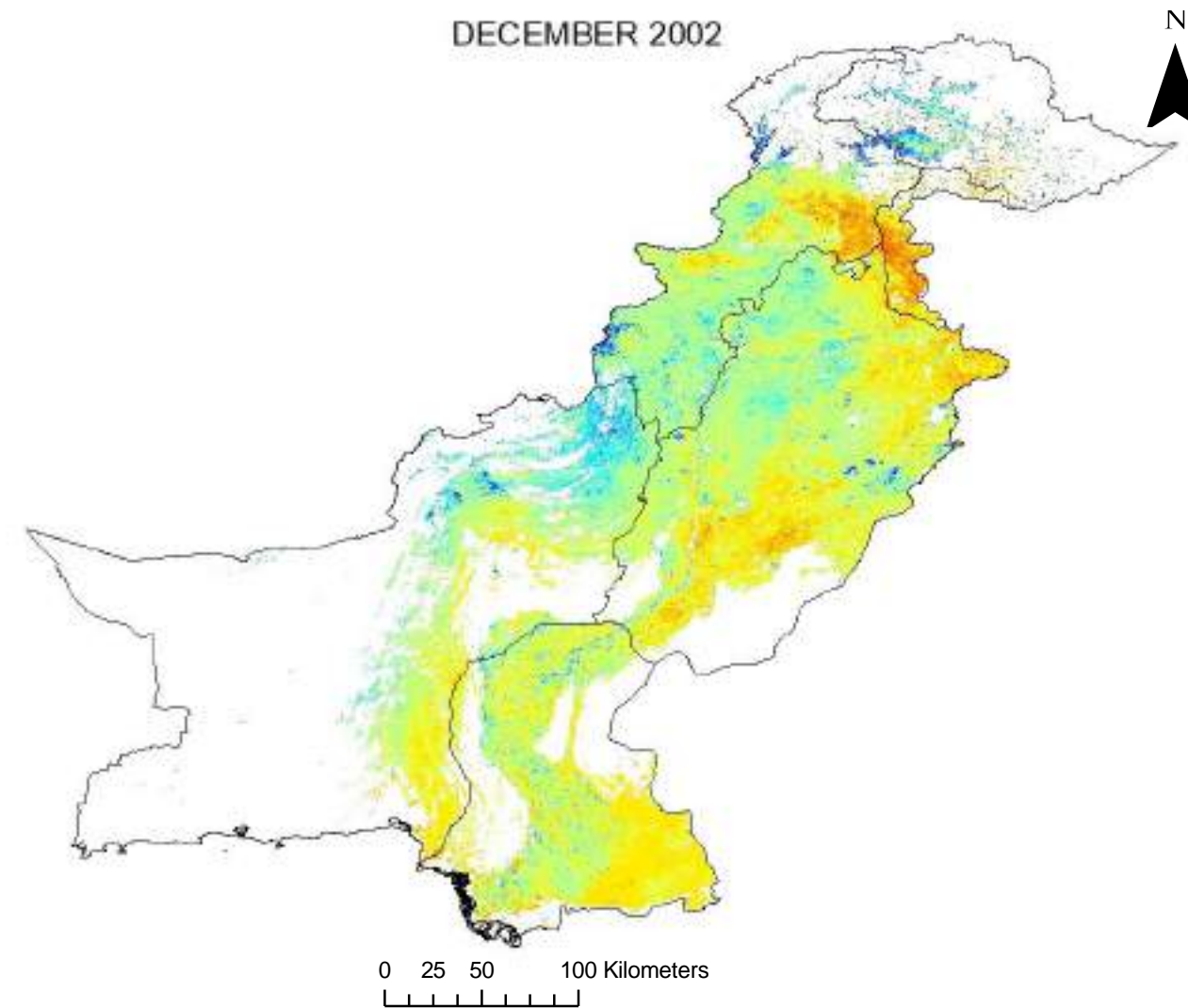
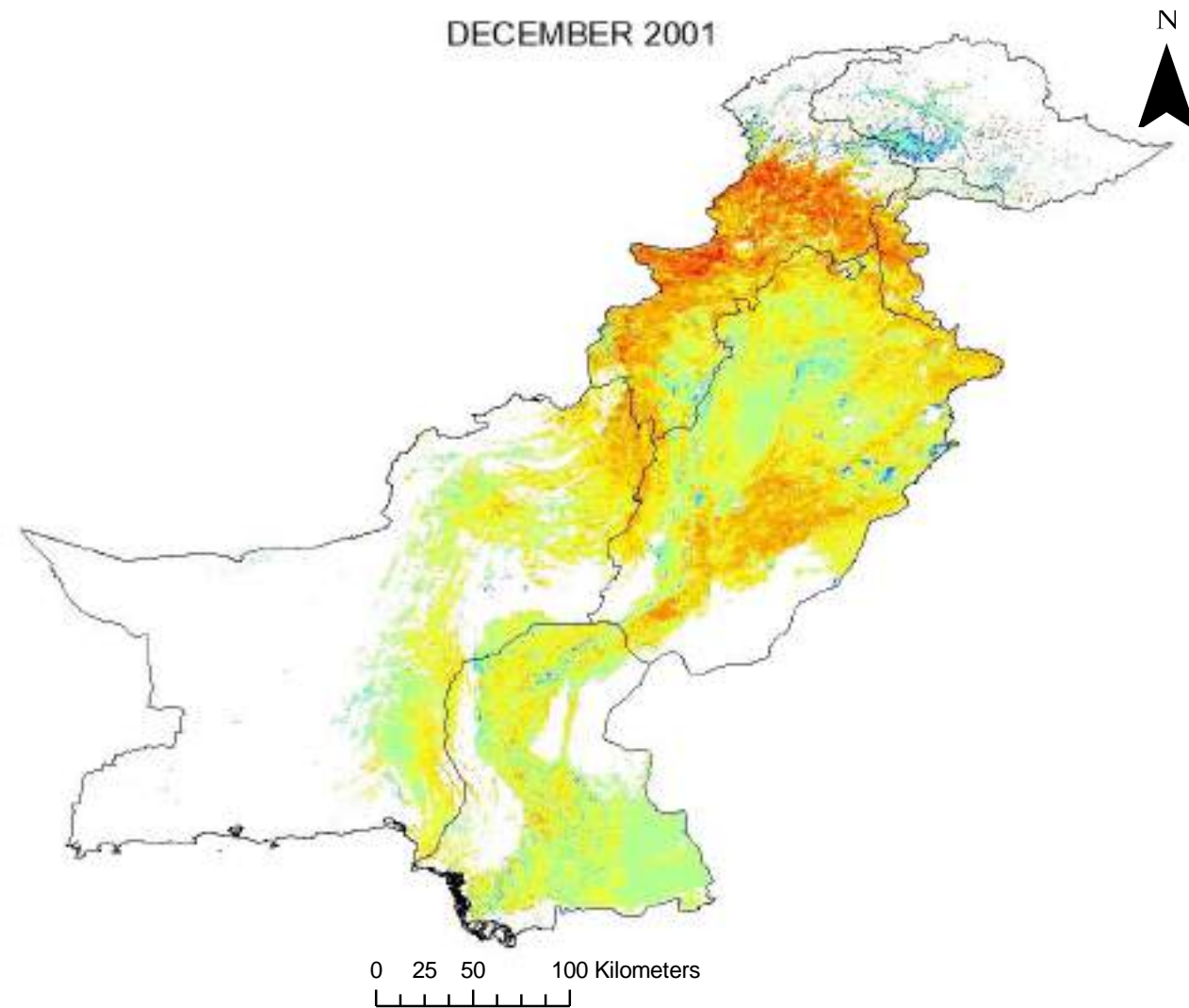
Drought conditions in December typically vary from mild drought to slightly wet condition. The characteristics of this dry and mild winter month are frequently characterized by near normal.

Mean December DSI Values		
Years	Values	Drought Condition
2000	-0.61	Mild Drought
2001	-0.50	Incipient Drought
2002	-0.14	Near Normal
2003	-0.09	Near Normal
2004	-0.24	Near Normal
2005	-0.78	Mild Drought
2006	0.58	Incipient Wet Spell
2007	-0.16	Near Normal
2008	-0.15	Near Normal
2009	-0.33	Incipient Wet Spell
2010	-0.80	Mild Drought
2011	-0.35	Incipient Drought
2012	-0.09	Near Normal
2013	-0.14	Near Normal
2014	-0.46	Incipient Drought
2015	0.10	Near Normal
2016	-0.56	Incipient Drought
2017	-0.24	Near Normal
2018	0.02	Near Normal
2019	0.38	Incipient Wet Spell
2020	0.74	Slightly Wet

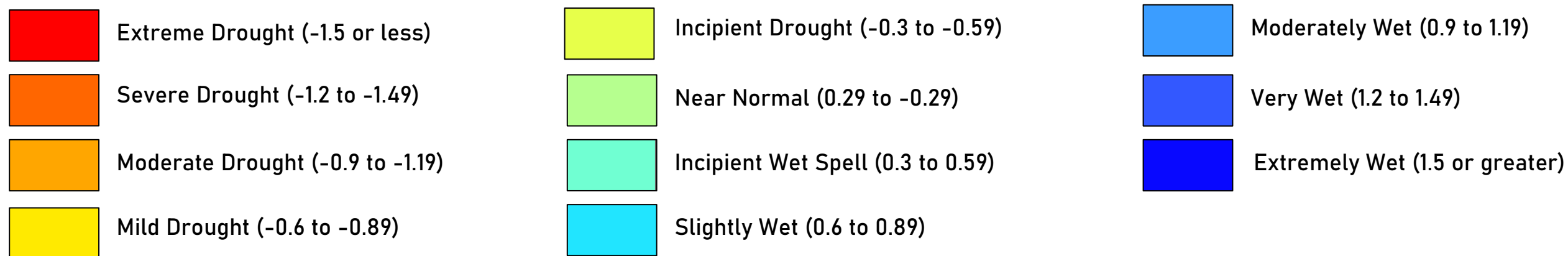


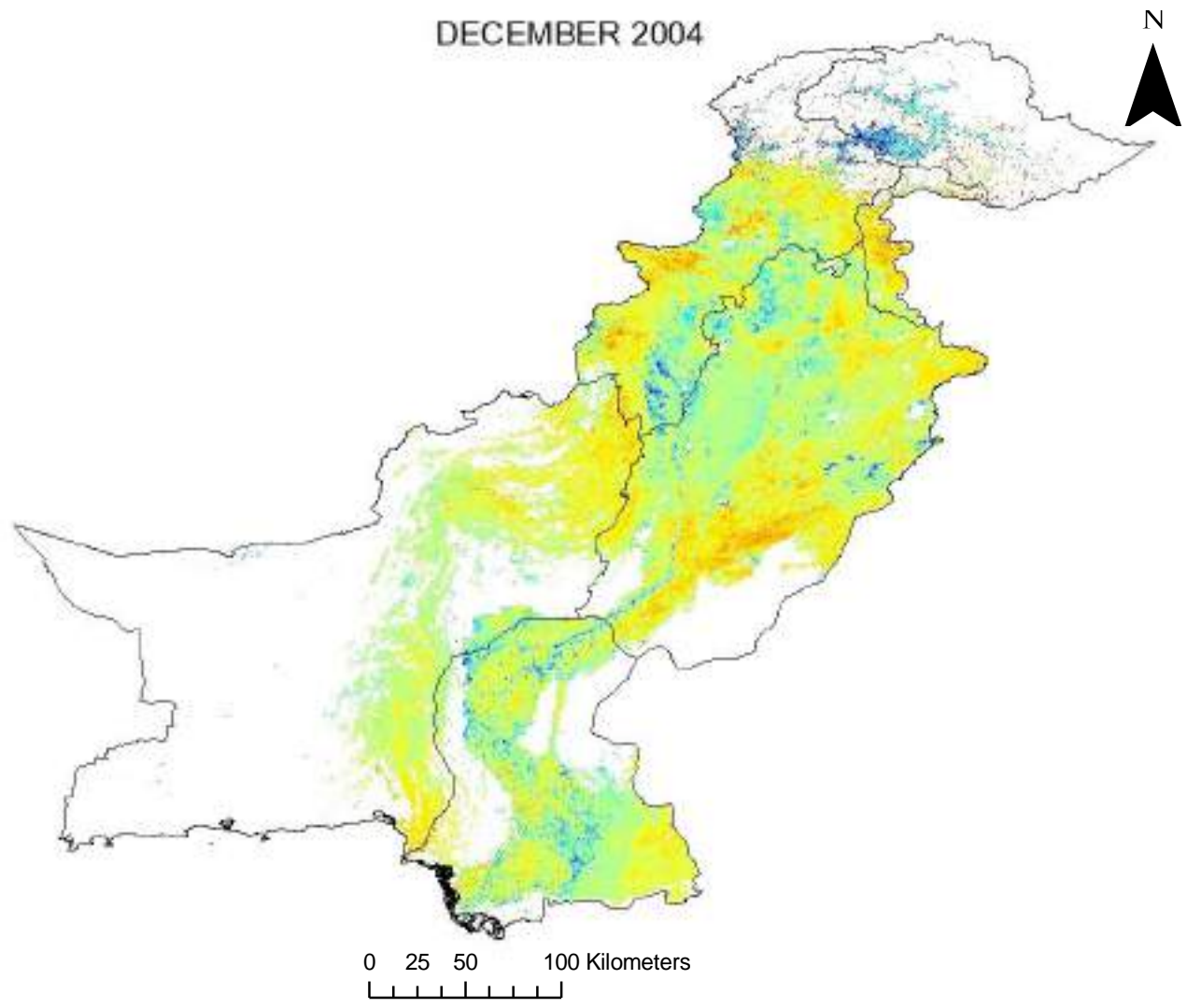
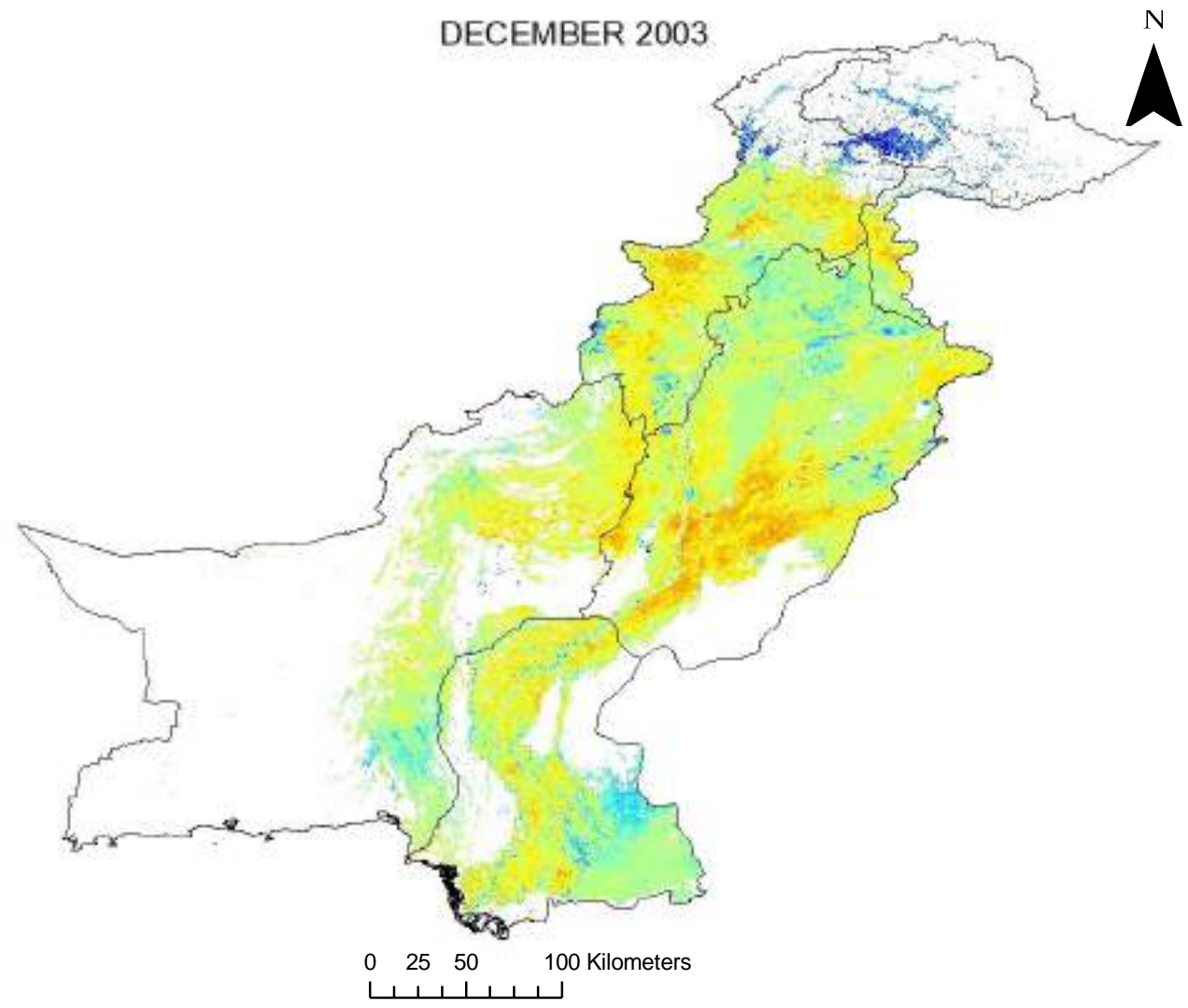
Legend
















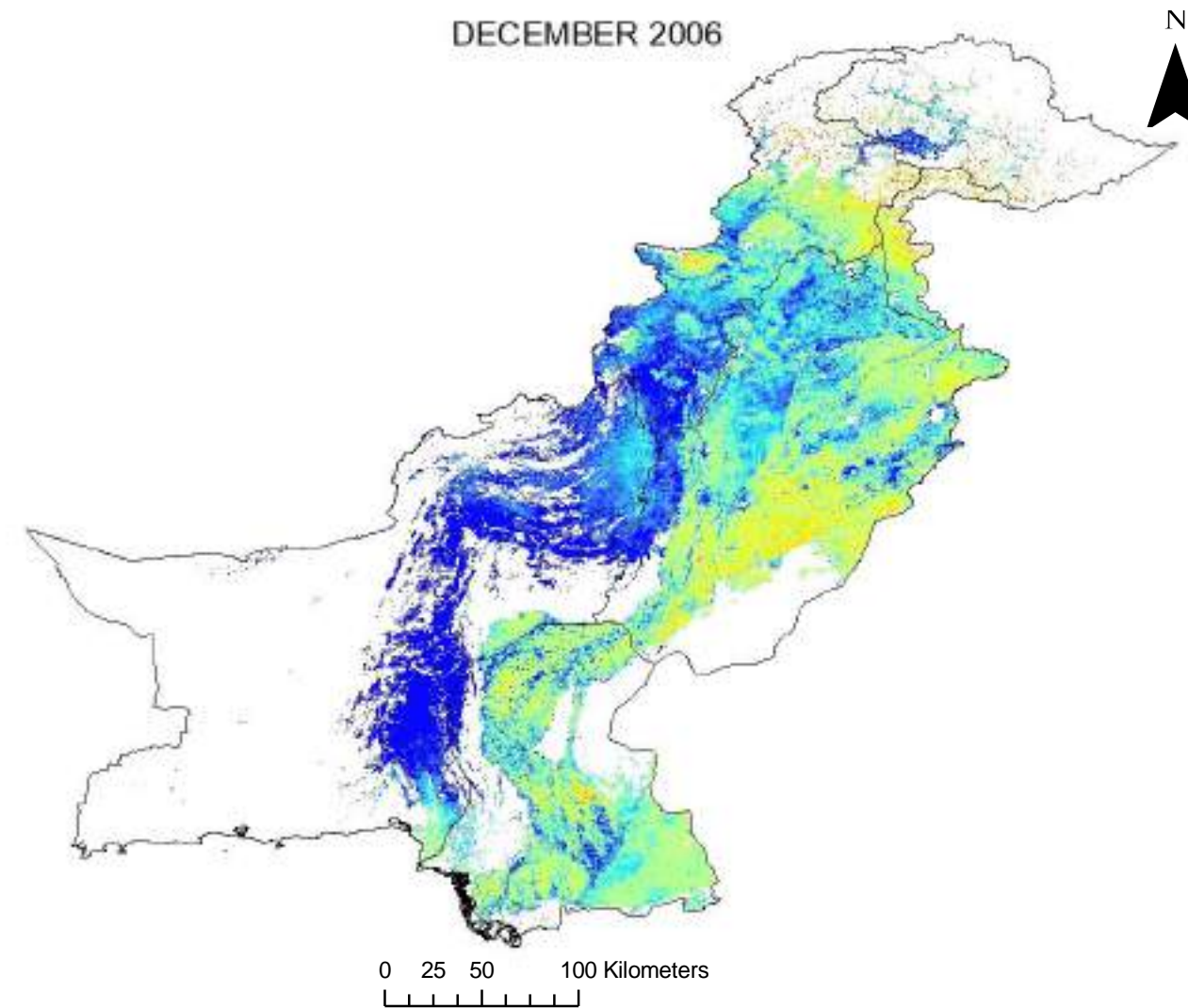
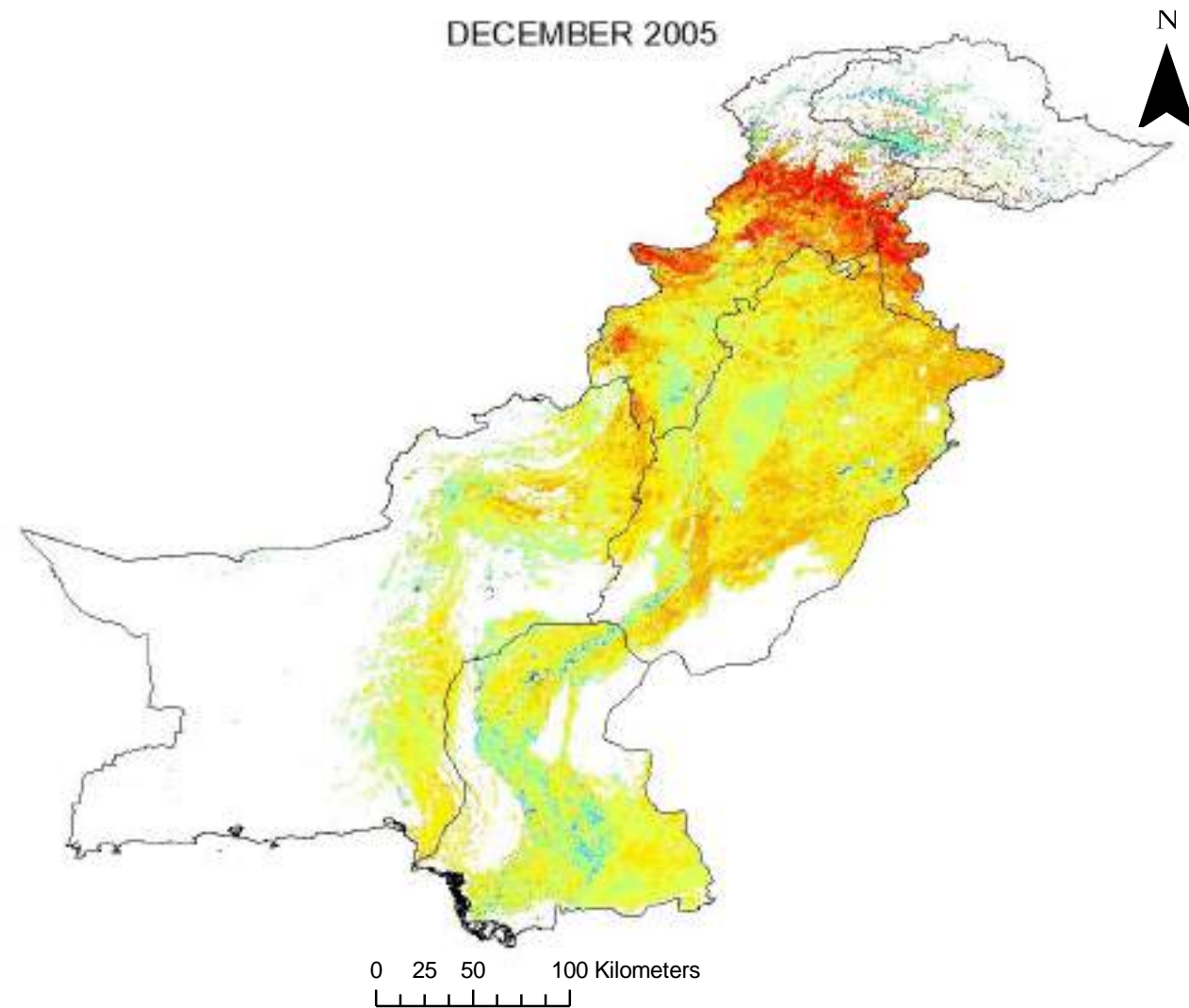
Legend










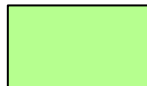


Legend

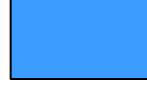


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|---|----------------------------------|---|-----------------------------------|---|--------------------------------|
|  | Extreme Drought (-1.5 or less) |  | Incipient Drought (-0.3 to -0.59) |  | Moderately Wet (0.9 to 1.19) |
|  | Severe Drought (-1.2 to -1.49) |  | Near Normal (0.29 to -0.29) |  | Very Wet (1.2 to 1.49) |
|  | Moderate Drought (-0.9 to -1.19) |  | Incipient Wet Spell (0.3 to 0.59) |  | Extremely Wet (1.5 or greater) |
|  | Mild Drought (-0.6 to -0.89) |  | Slightly Wet (0.6 to 0.89) | | |

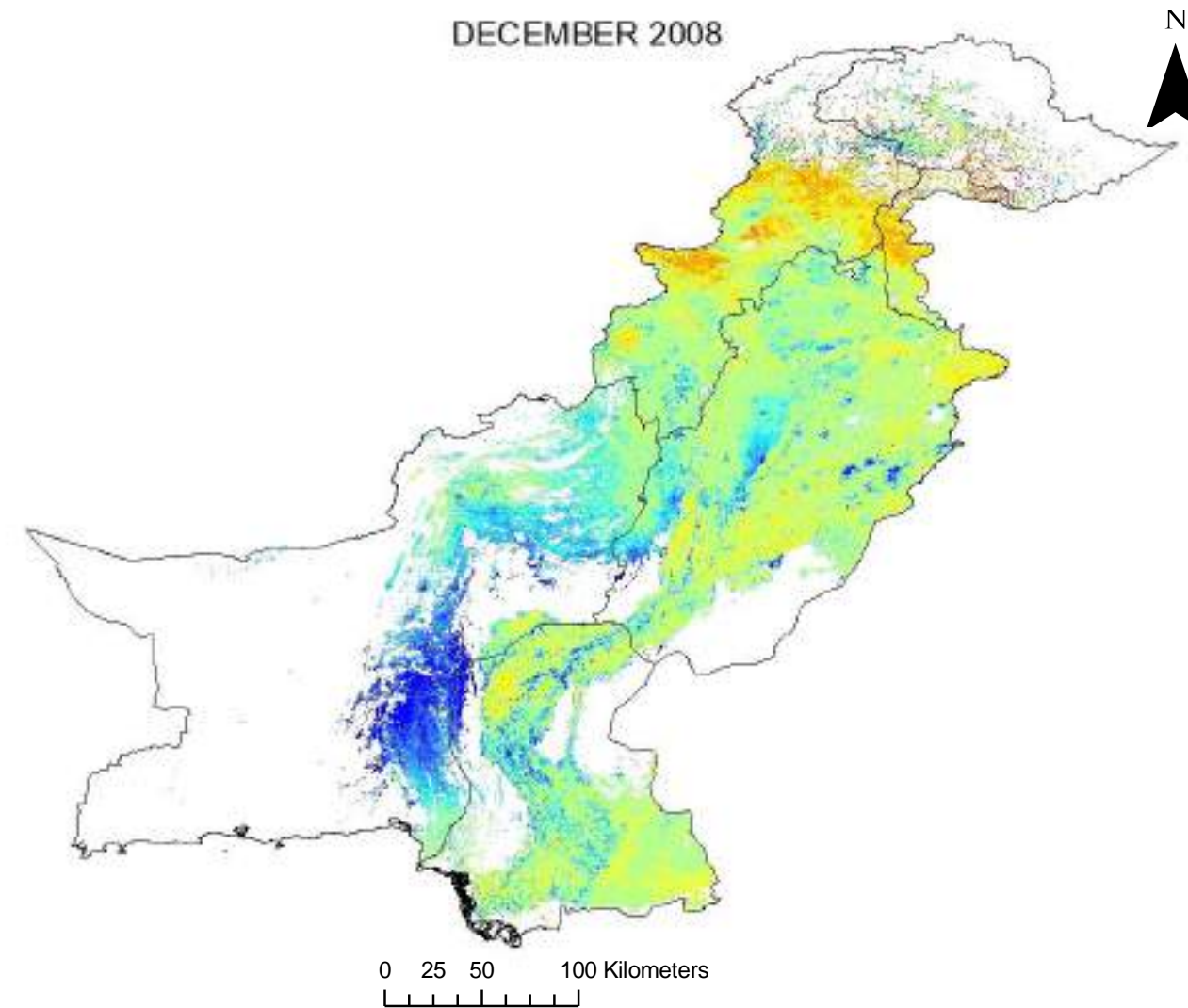
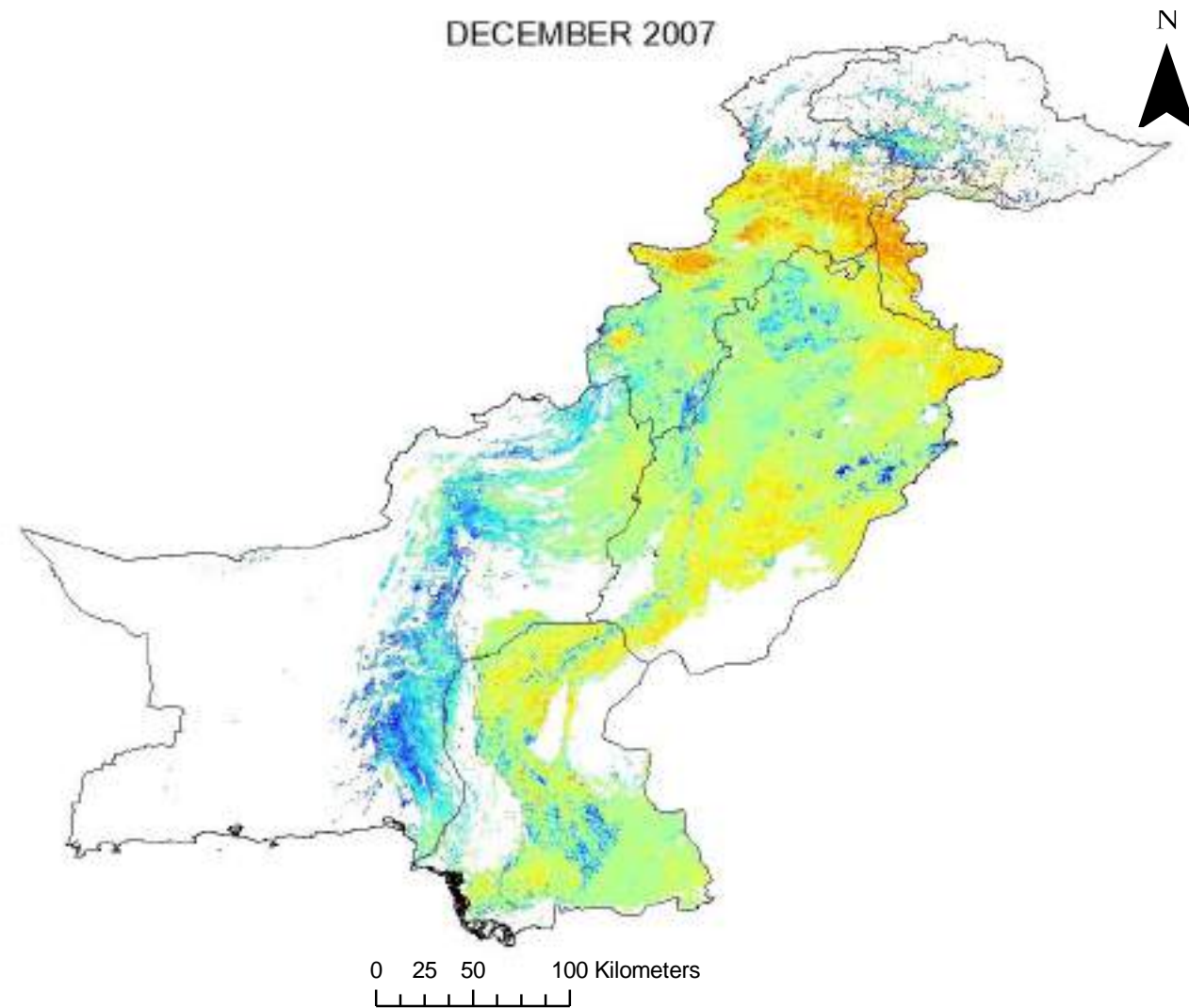


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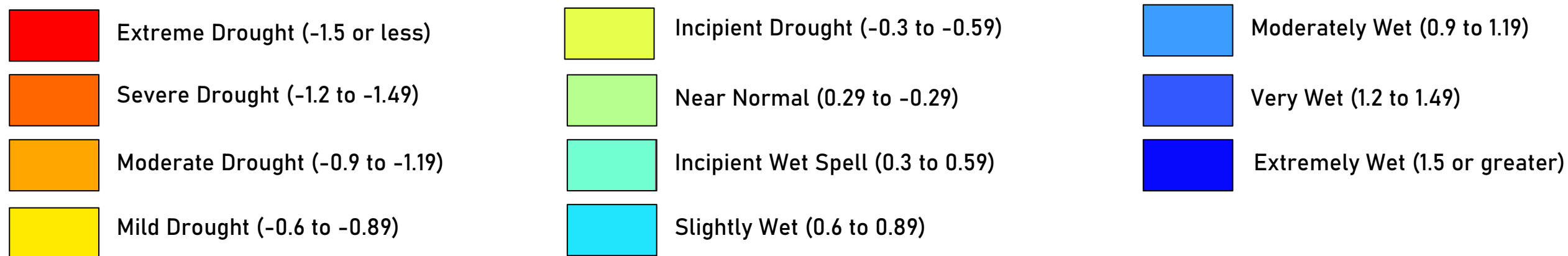
-  Extreme Drought (-1.5 or less)
-  Severe Drought (-1.2 to -1.49)
-  Moderate Drought (-0.9 to -1.19)
-  Mild Drought (-0.6 to -0.89)

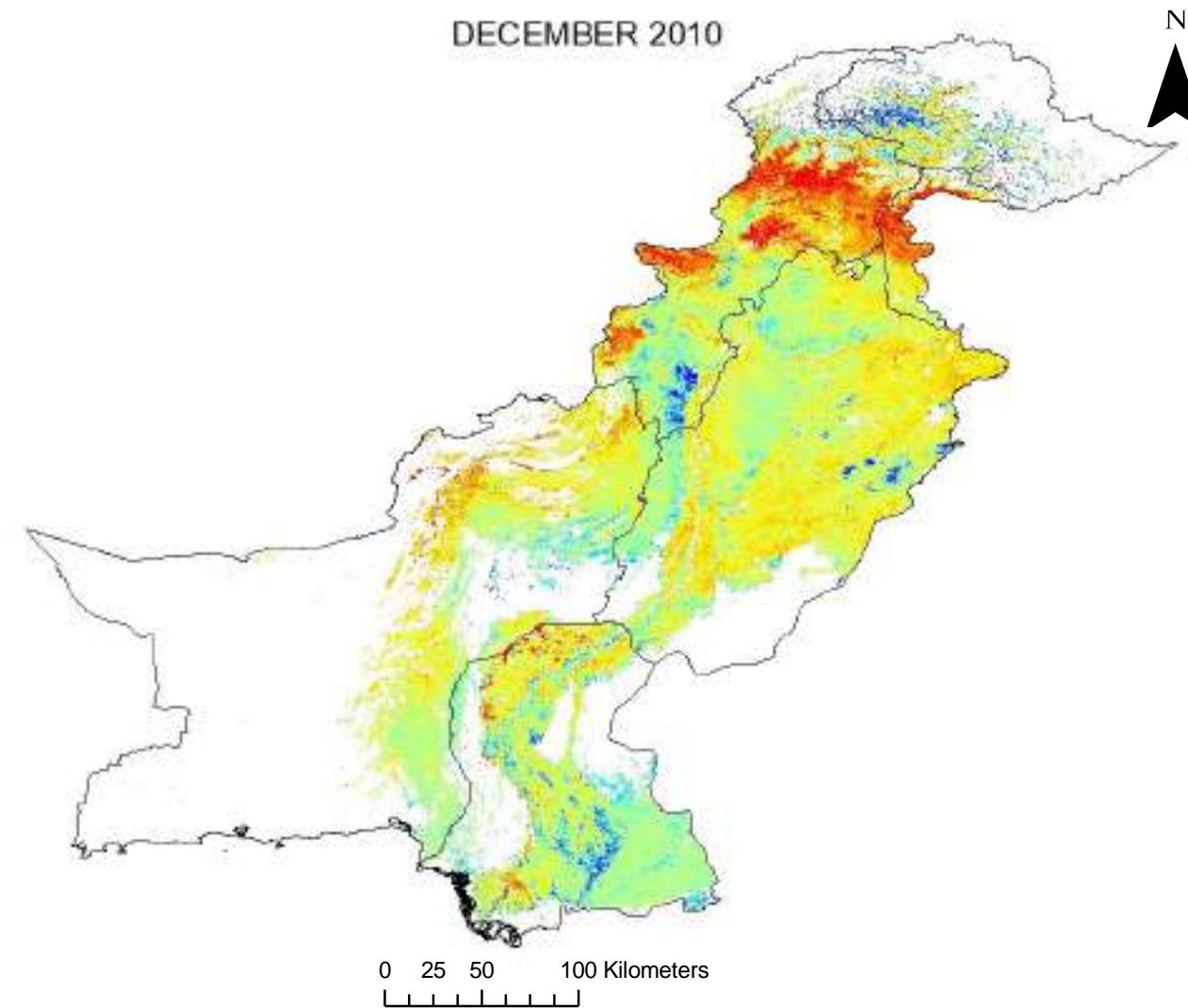
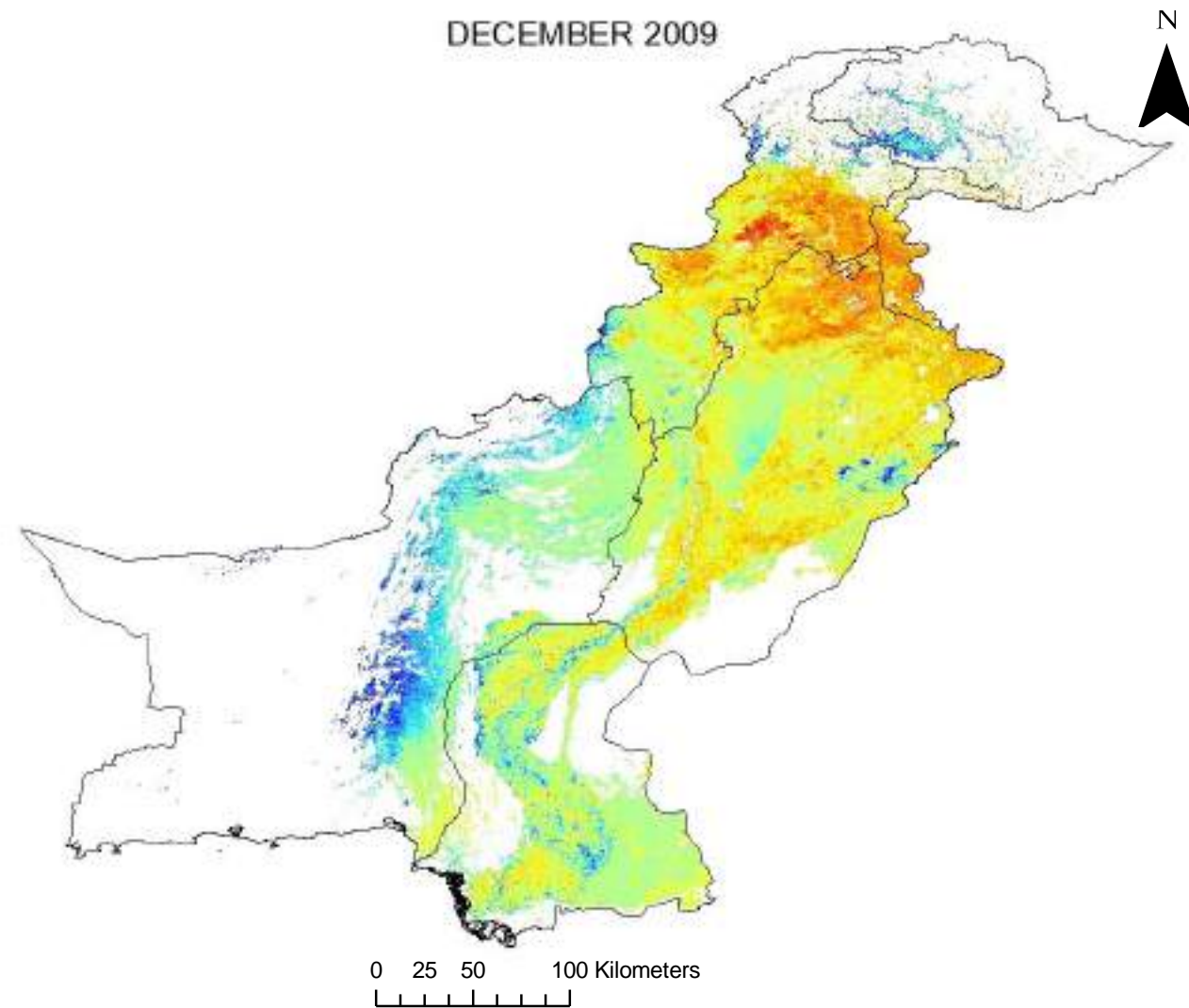
-  Incipient Drought (-0.3 to -0.59)
-  Near Normal (0.29 to -0.29)
-  Incipient Wet Spell (0.3 to 0.59)
-  Slightly Wet (0.6 to 0.89)

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-  Very Wet (1.2 to 1.49)
-  Extremely Wet (1.5 or greater)

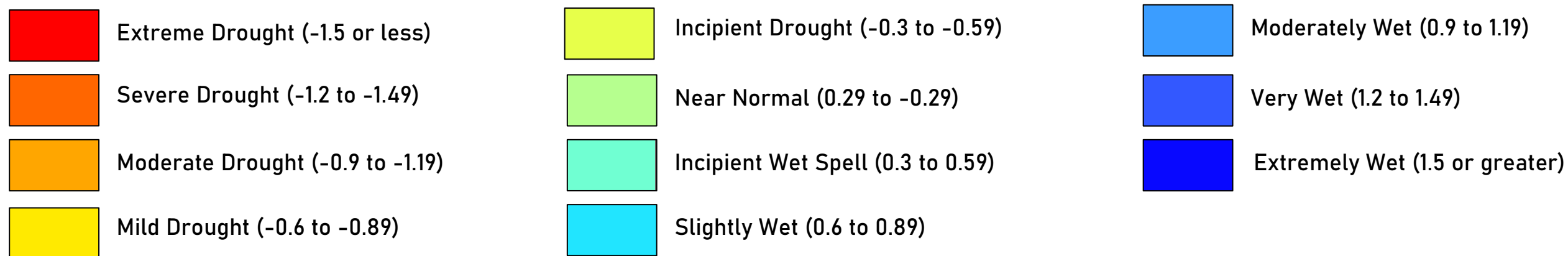


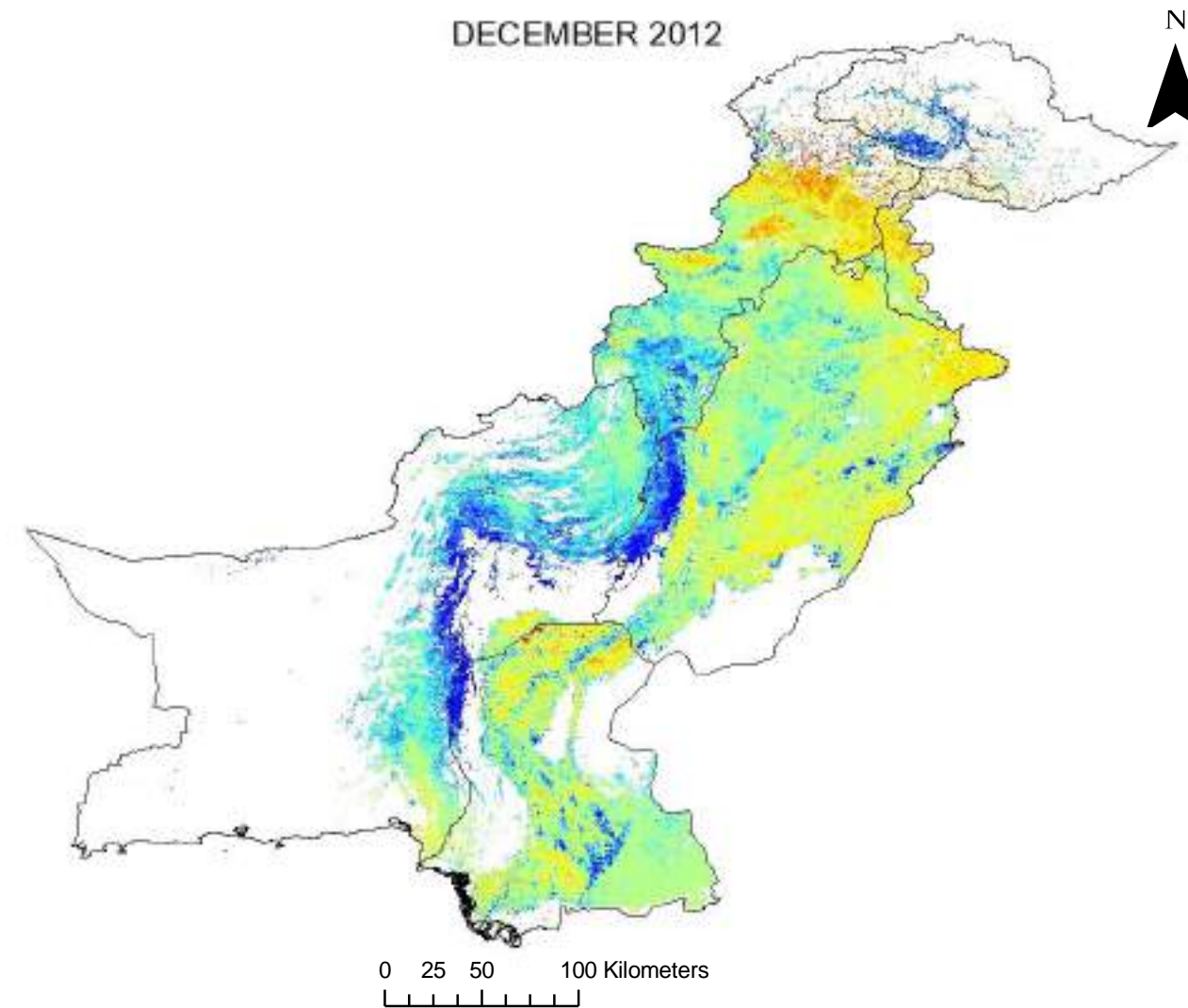
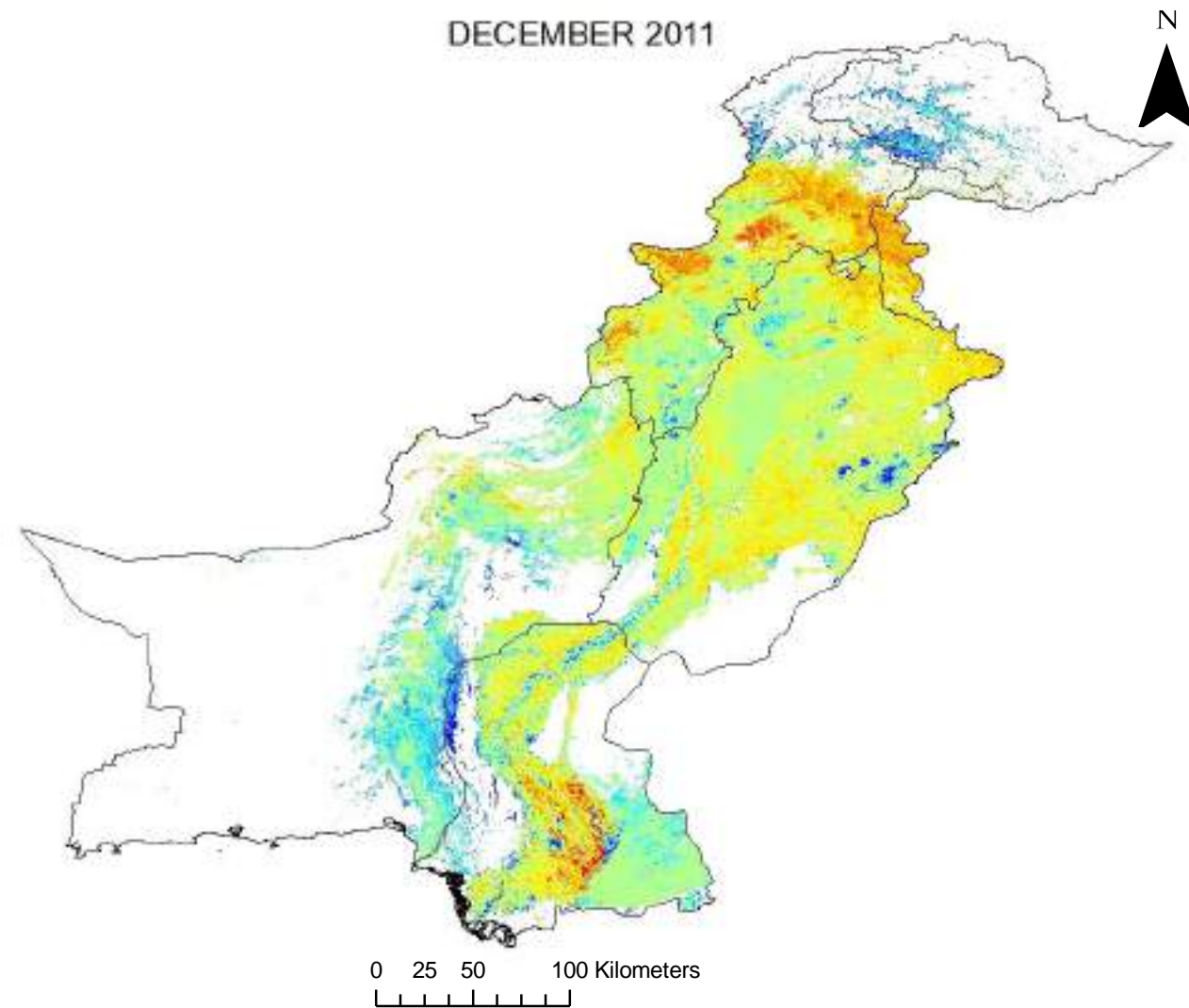
Legend



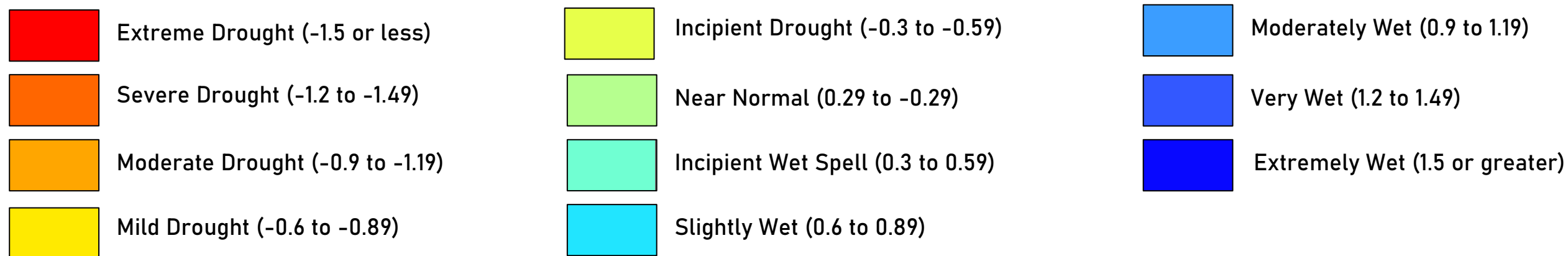


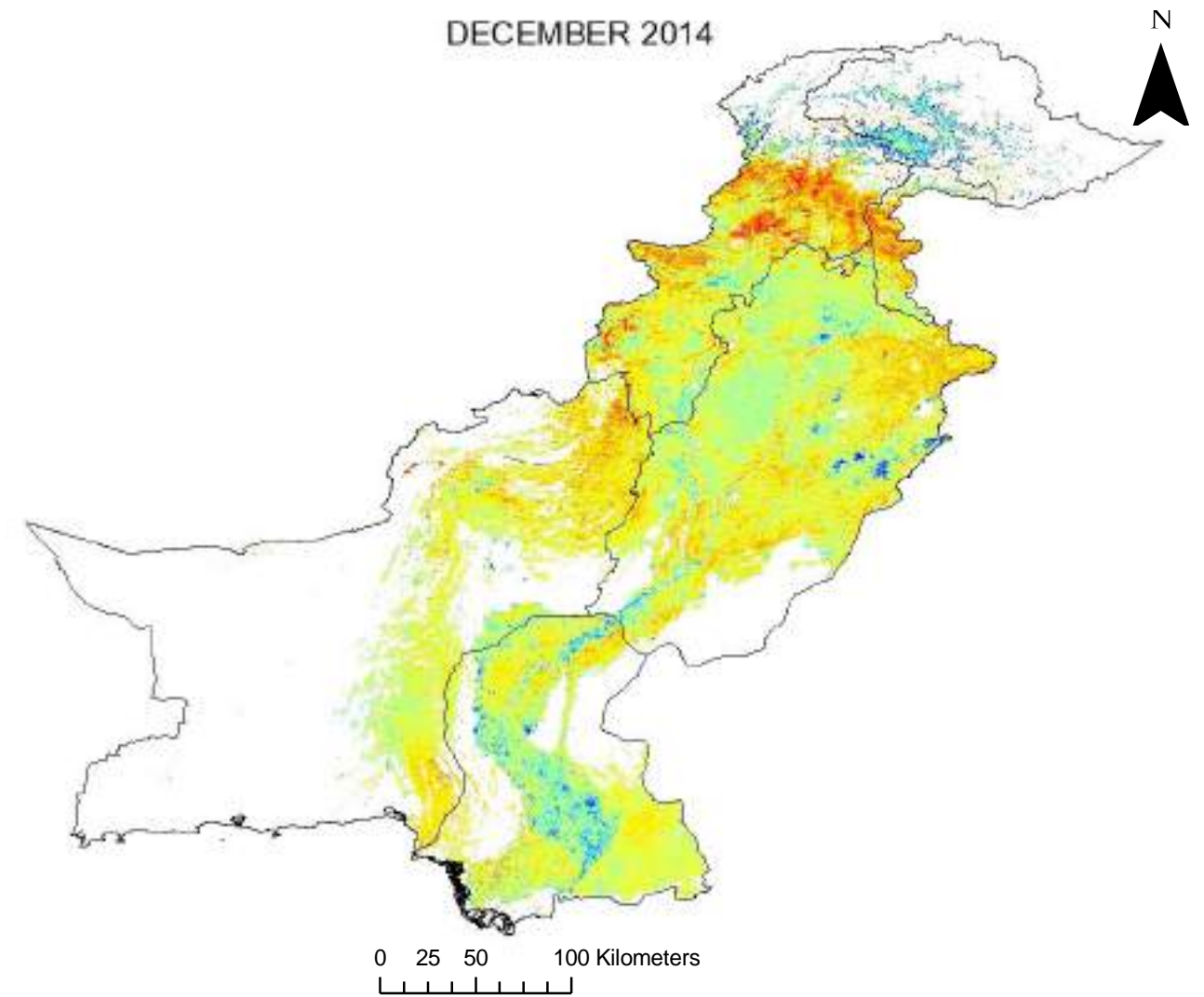
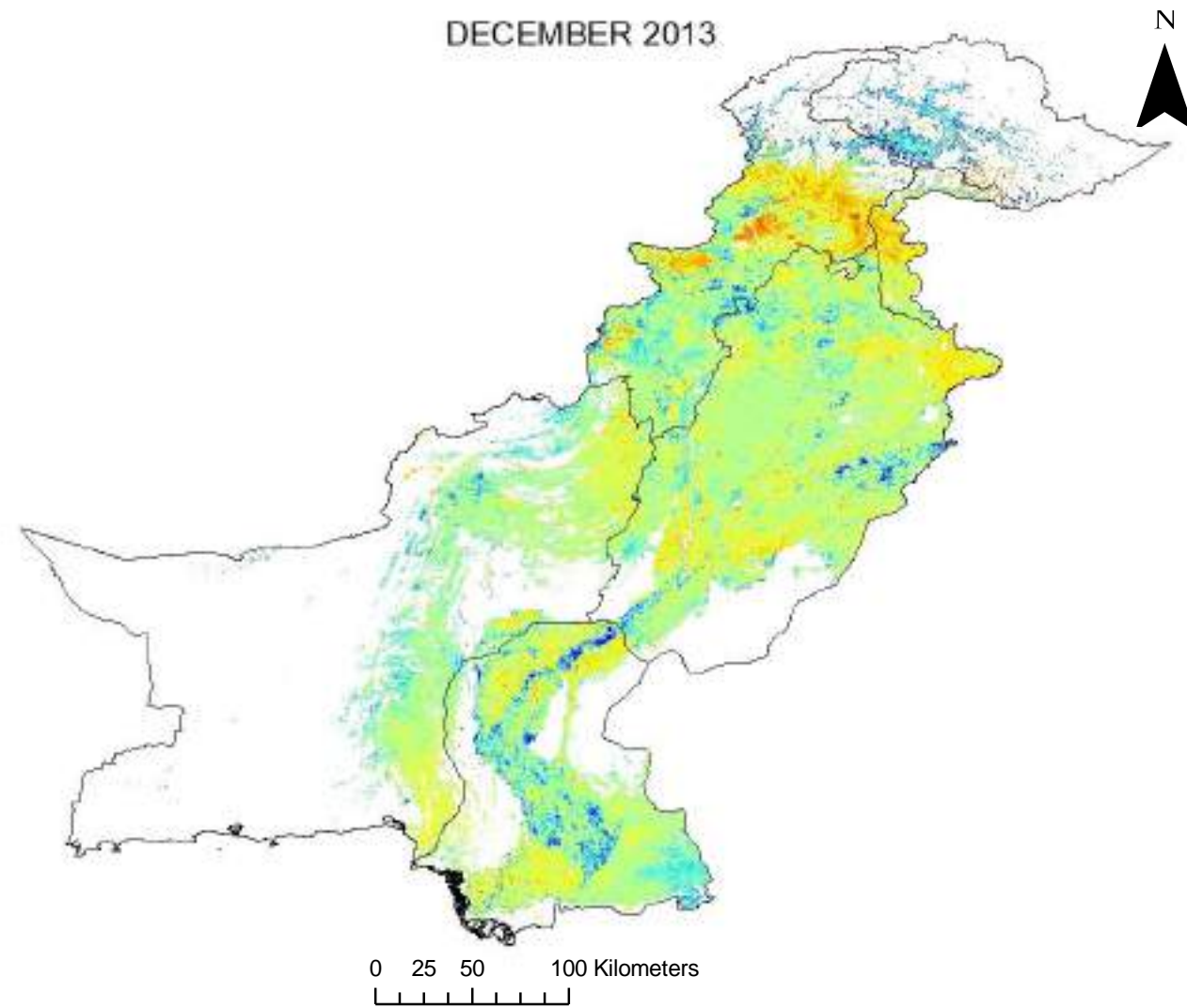
Legend





Legend



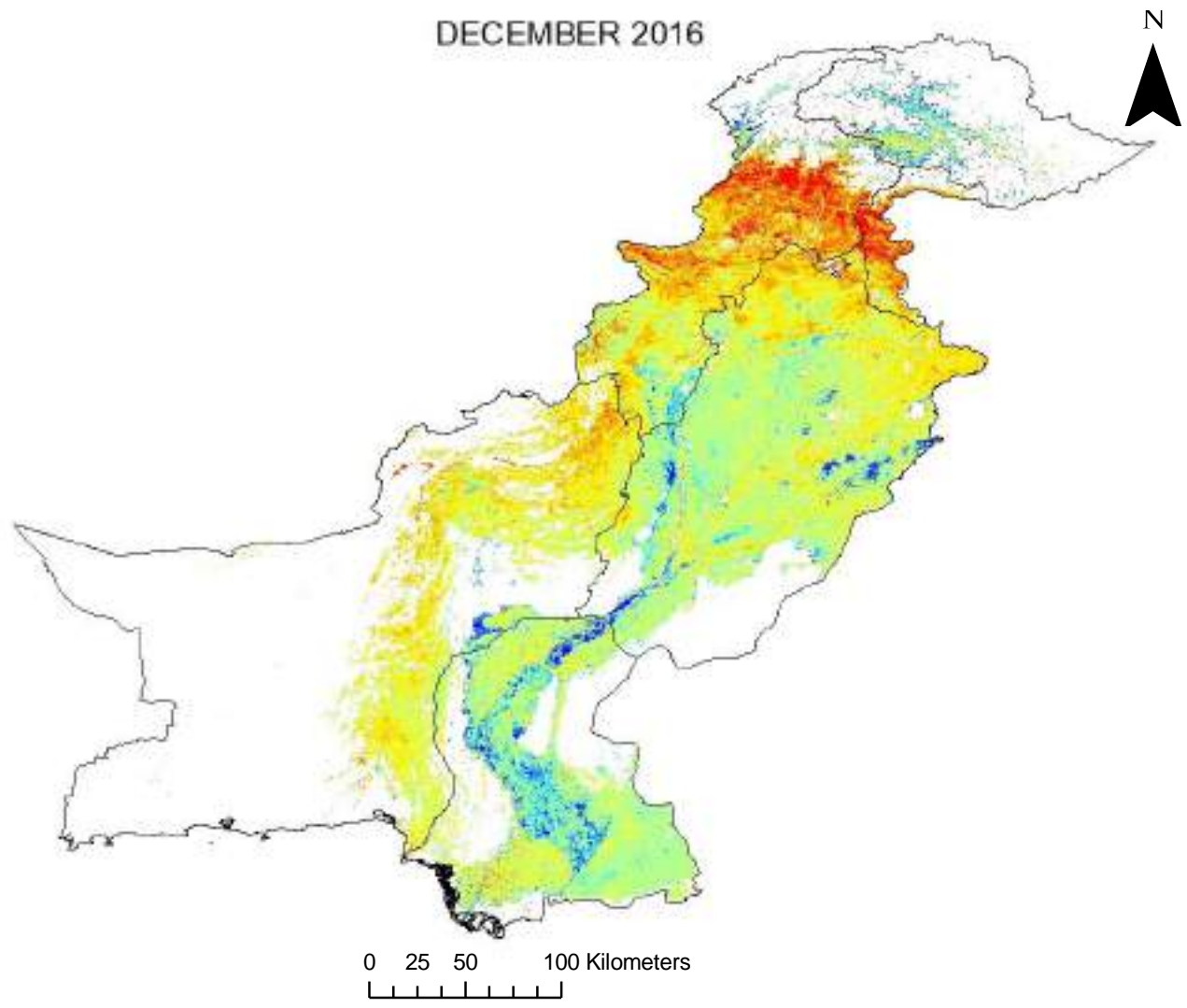
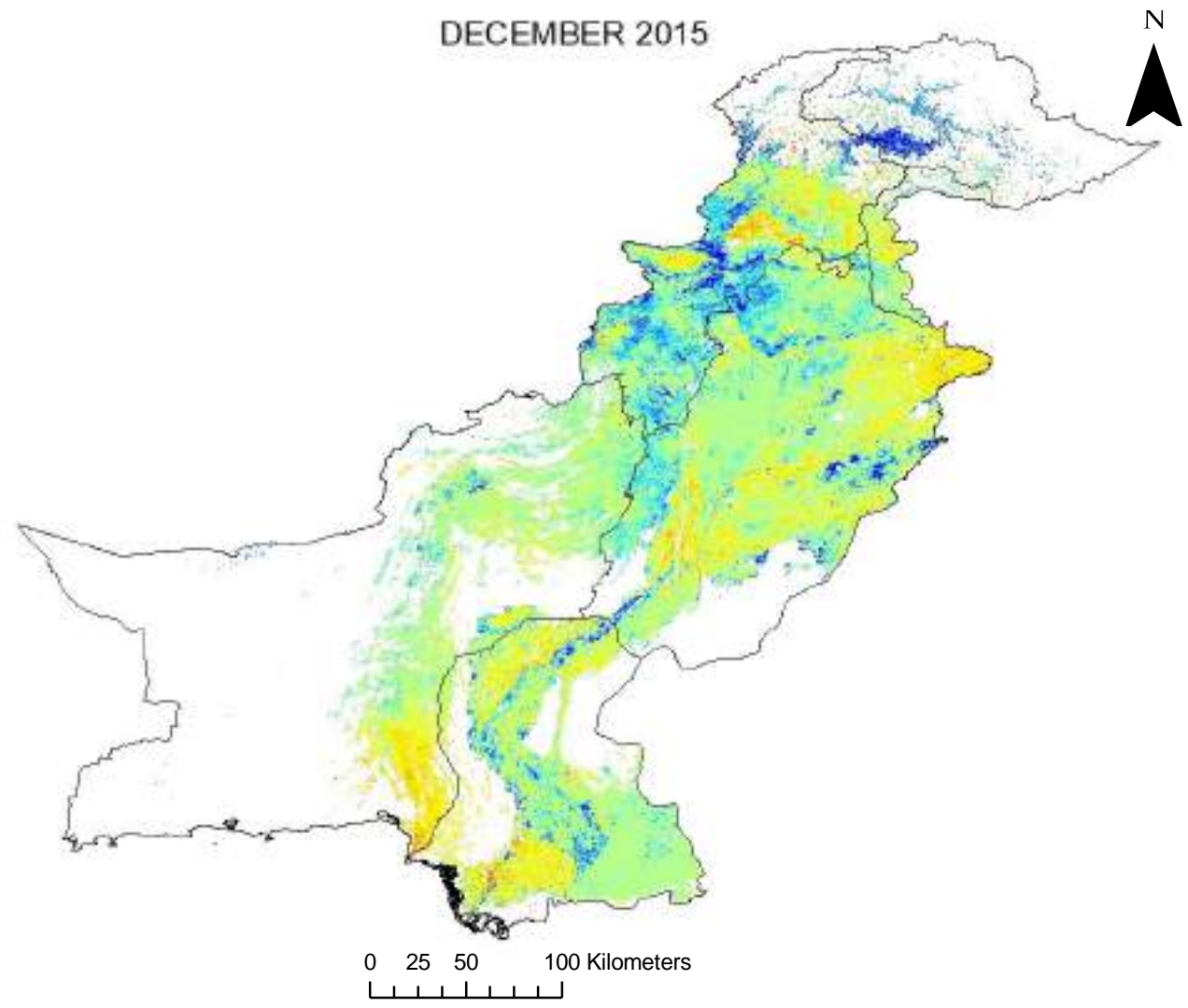


Legend












- Extreme Drought (-1.5 or less)
- Severe Drought (-1.2 to -1.49)
- Moderate Drought (-0.9 to -1.19)
- Mild Drought (-0.6 to -0.89)

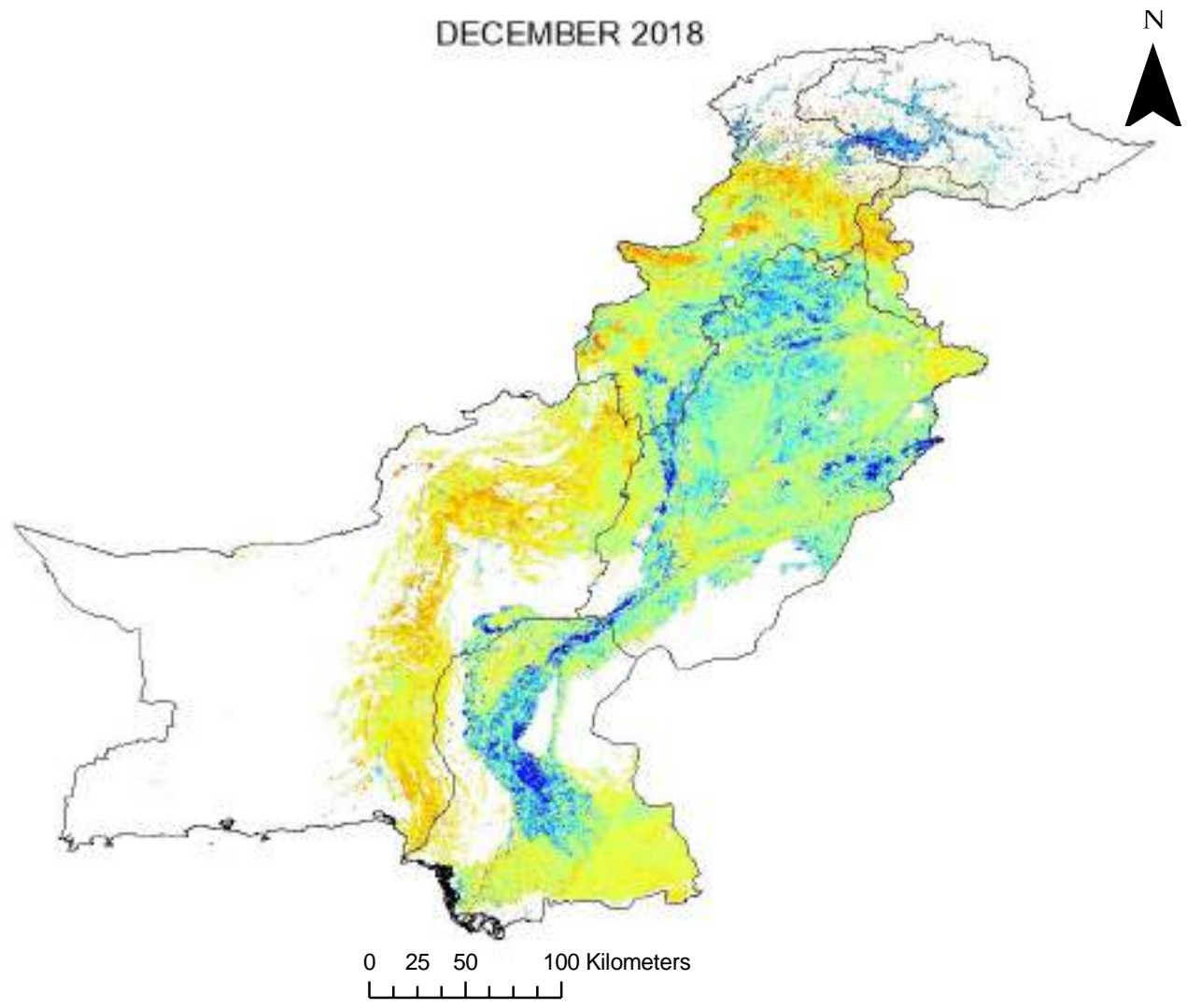
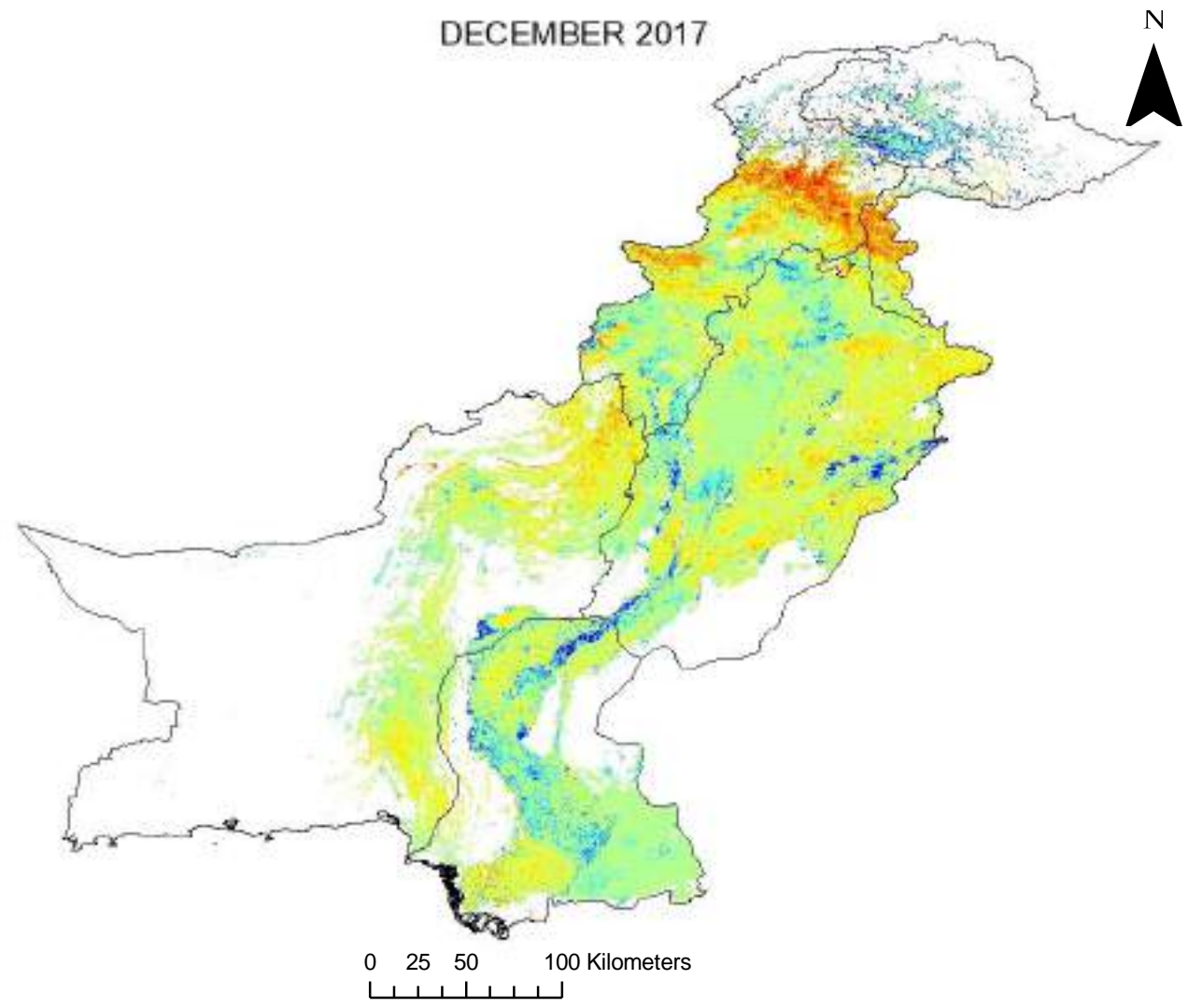
- Incipient Drought (-0.3 to -0.59)
- Near Normal (0.29 to -0.29)
- Incipient Wet Spell (0.3 to 0.59)
- Slightly Wet (0.6 to 0.89)

- Moderately Wet (0.9 to 1.19)
- Very Wet (1.2 to 1.49)
- Extremely Wet (1.5 or greater)














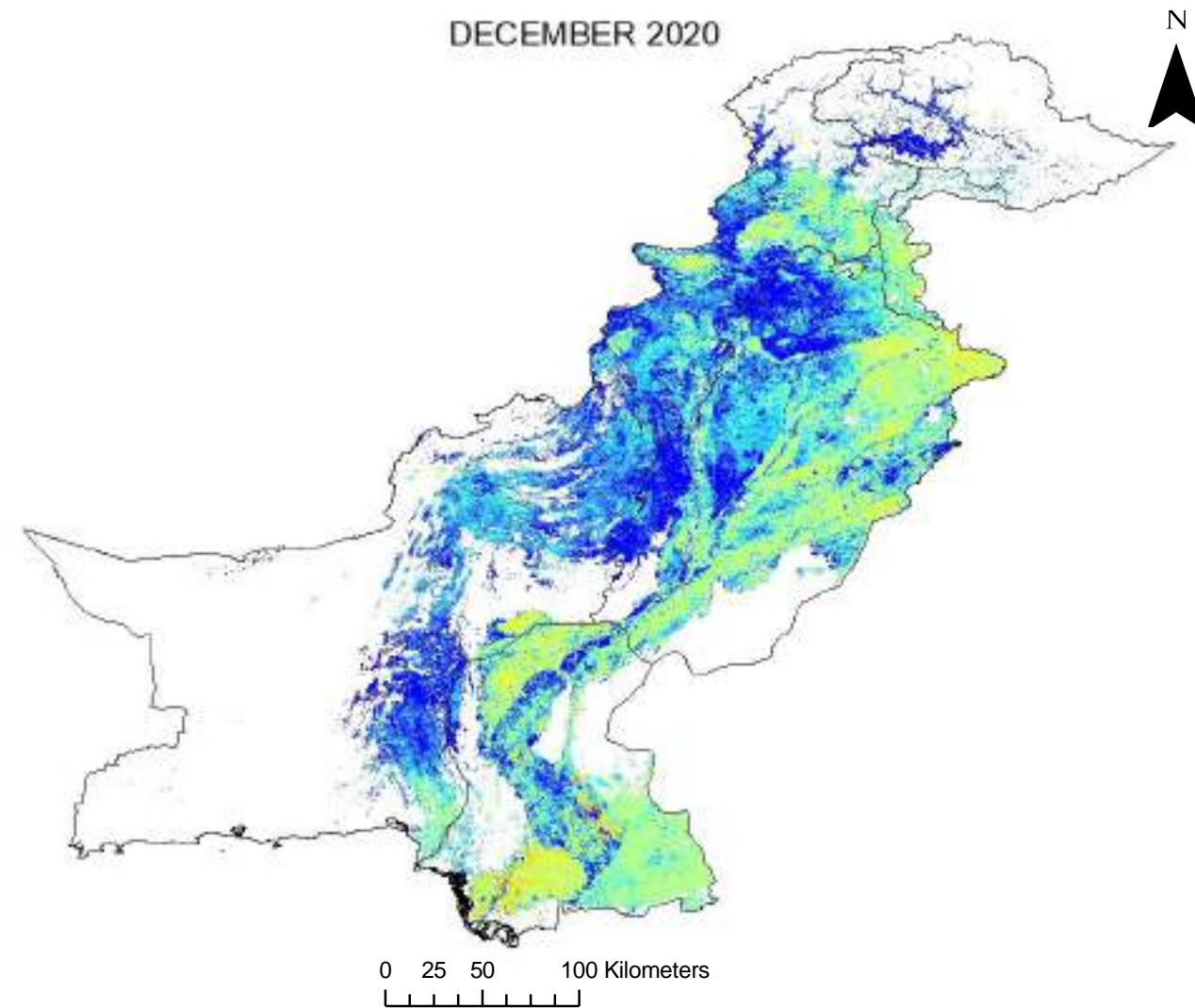
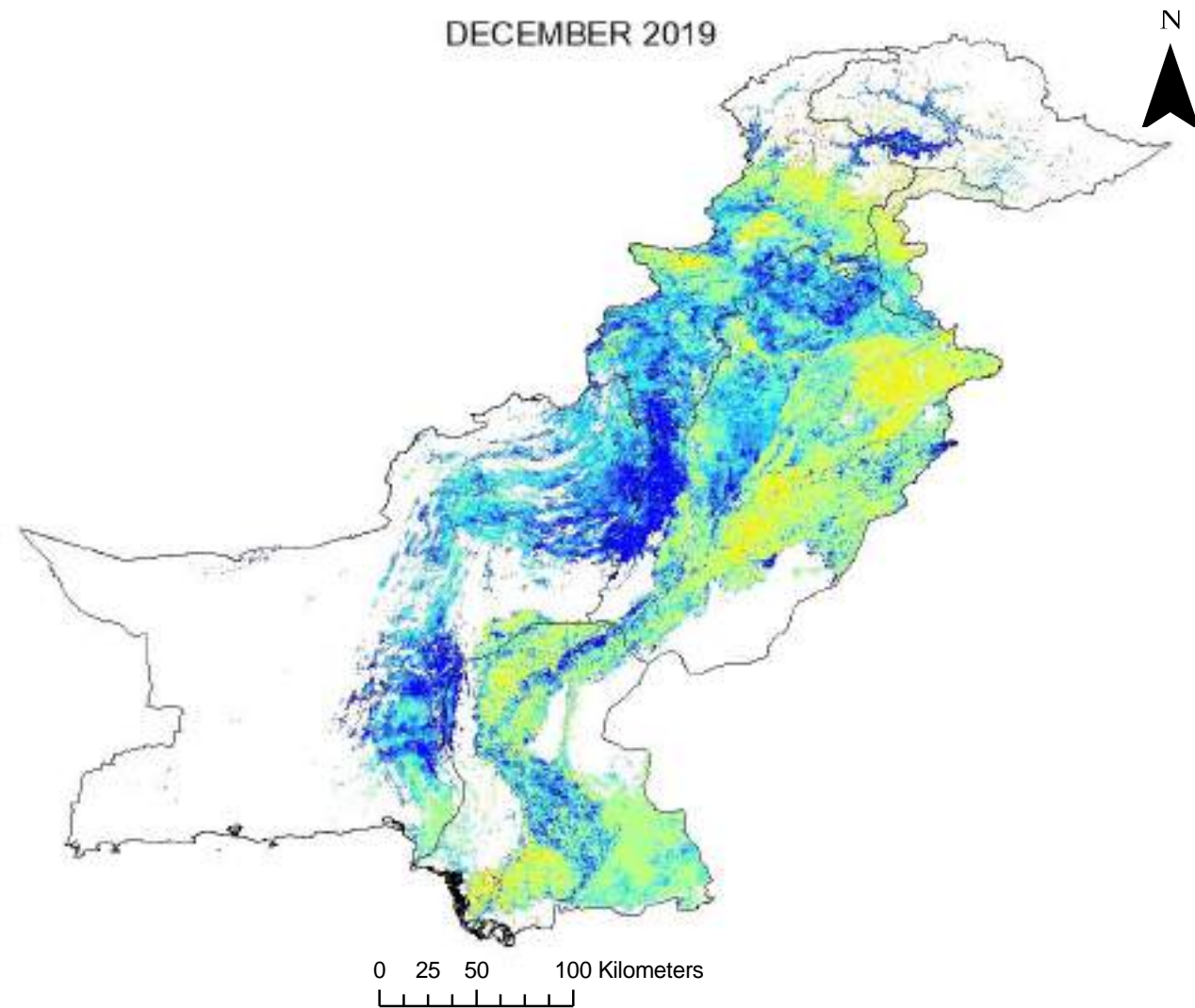
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|--|---|--|
|  Extreme Drought (-1.5 or less) |  Incipient Drought (-0.3 to -0.59) |  Moderately Wet (0.9 to 1.19) |
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|  Mild Drought (-0.6 to -0.89) |  Slightly Wet (0.6 to 0.89) | |








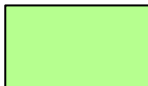


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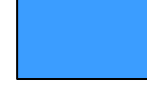


	Extreme Drought (-1.5 or less)		Incipient Drought (-0.3 to -0.59)		Moderately Wet (0.9 to 1.19)
	Severe Drought (-1.2 to -1.49)		Near Normal (0.29 to -0.29)		Very Wet (1.2 to 1.49)
	Moderate Drought (-0.9 to -1.19)		Incipient Wet Spell (0.3 to 0.59)		Extremely Wet (1.5 or greater)
	Mild Drought (-0.6 to -0.89)		Slightly Wet (0.6 to 0.89)		



Legend

-  Extreme Drought (-1.5 or less)
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Drought Severity Index of Pakistan

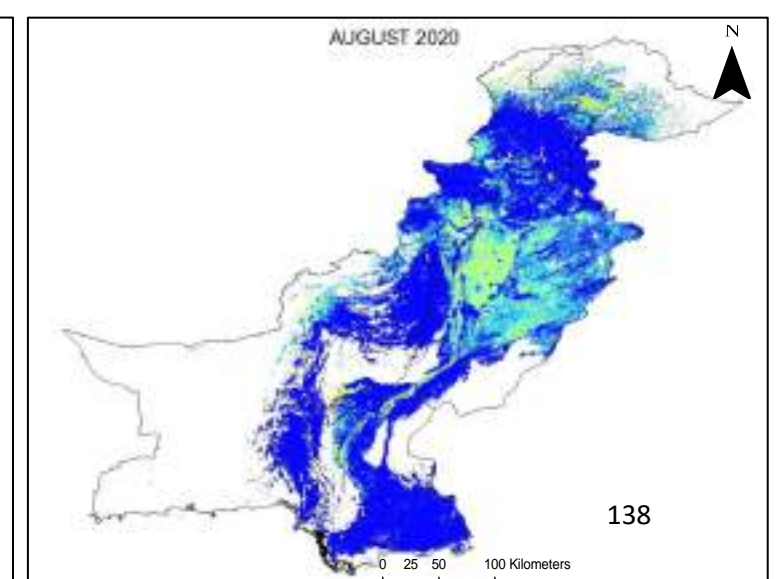
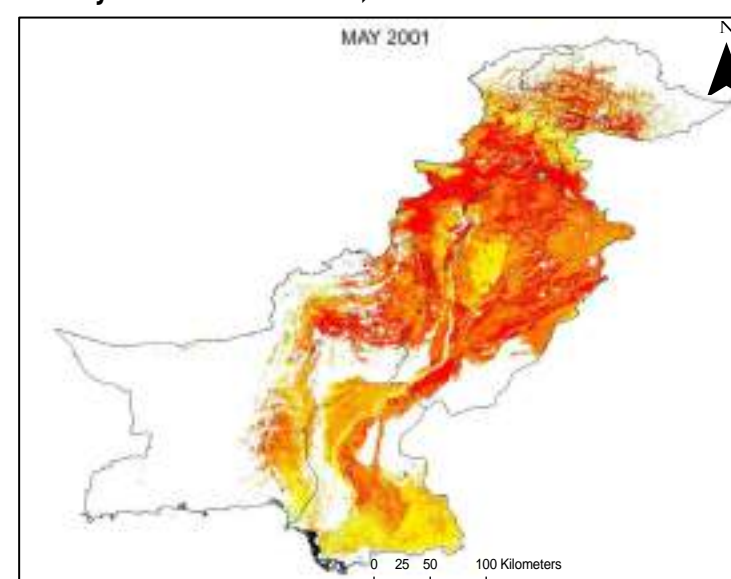
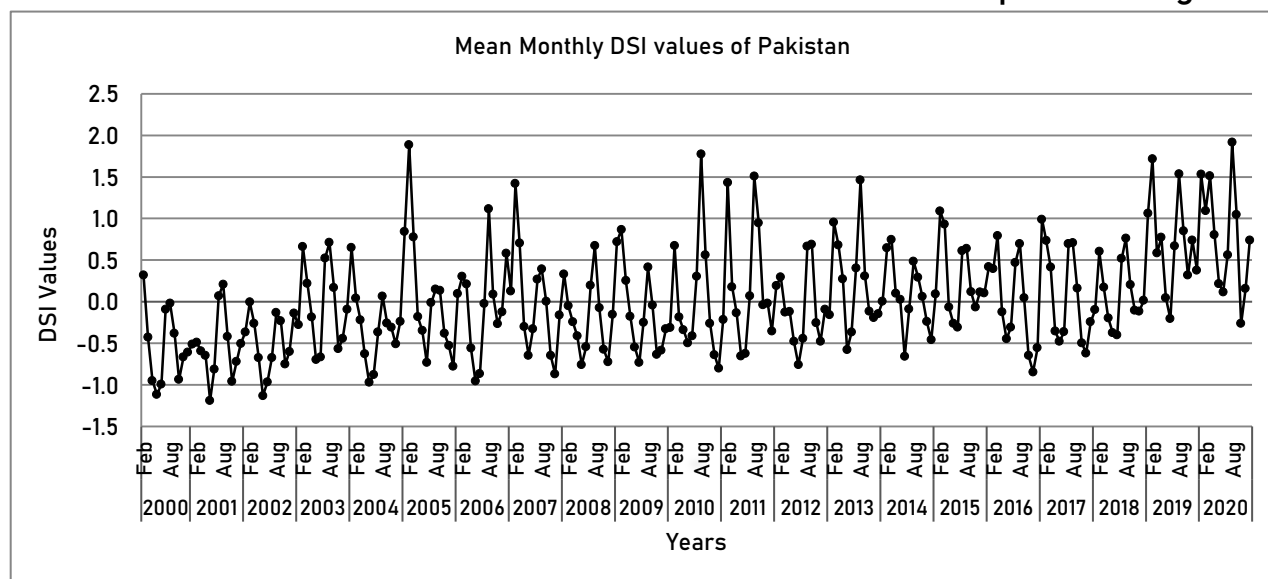
Long term average monthly DSI values of Pakistan from 2000 to 2020 has been shown in figure. X-axis represents time period and Y-axis shows DSI values. Positive numbers of DSI values imply moist conditions, whereas negative values suggest drought conditions (Mu et al., 2013).The lowest mean monthly DSI value of -1.19 was observed in May 2001, indicating severe drought condition and wettest condition in August 2020 with DSI value 1.92, during the entire period (2000 – 2020), followed by May 2000 with a DSI value -1.11. This drought can also be traced back to April 2000, when the comparable mean monthly DSI value was -0.95, indicating moderate drought. Meanwhile, the mean monthly DSI value of July 2000 was -0.09 which indicates near normal conditions. Therefore, the period from April 2000 to June 2000 is referred to as the “drought period” in Pakistan. In the year 2002,

drought lasted from April through July, making it the year with the longest drought periods. Droughts occurred in the months of April and June in the years 2000, 2001 and 2004. Droughts in May and June occurred in 2003, 2006 and 2011.

Summer months of May and June seem to be the driest month in Pakistan according to the average DSI values of whole country. However, the winter months of October, November and December were driest during 2007, 2010, 2016, 2017 and 2020. Similarly, February and August were the wettest months in Pakistan. Mostly the mean monthly DSI values in Pakistan fluctuated between 1 and -1, showing that mild to moderate drought was dominant in Pakistan during the study period. Later years i.,e 2018, 2019 and 2020 received relatively better precipitation in comparison to other years showing mild to incipient drought in these years. Whereas, 2000

and 2001 received less rainfall experiencing severe to moderate drought in the country.

The spatial distribution maps describe the characteristics of drought and its impact on the cropland of various provinces of Pakistan. In most of the study period, severe to moderate drought occurrences were more prevalent in the central and southern regions of the country in April, May, and June. Extreme drought occurrences were observed in May 2000, 2001, and 2002, impacting Balochistan, Punjab, Khyber Pakthunkhwa, and Azad Jammu & Kashmir. Whereas, permanent moderate drought occurrences dominated in Sindh province's south-eastern region from April to June every year throughout the study period, which primarily covers cropland.



References

1. GoP (Government of Pakistan) 2010a. *Agricultural Census*. Islamabad: Agricultural Census Wing, Pakistan Bureau of Statistics.
<http://www.pbs.gov.pk/content/agricultural-census-wing>.
2. Hewitt, K. 1997. *Regions at Risk: A Geographical Introduction to Disasters*. Addison-Wesley Longman, UK.
3. Justice, C.; Townshend, J. 2002a. Special issue on the moderate resolution imaging spectroradiometer (MODIS): A new generation of land surface monitoring. *Remote Sensing of Environment* 83: 1-2.
4. Khan, J. A., 1993; *The Climate of Pakistan*, Rehber Publishers, Karachi.
5. Kureshy, K. U., 1998; *Geography of Pakistan*, National Book Service Lahore, Pakistan
6. Luo, Q. and Lin, E., 1999; Agricultural vulnerability and adaptation in developing countries: the Asia- Pacific region, *Climatic Change*, 43, 729-743.
7. Mu Q, Zhao M, Kimball JS, McDowell NG, Running SW (2013) A remotely sensed global terrestrial drought severity index. *Bull Am Meteorol Soc* 94:83-98
8. National Center for Atmospheric Research Staff (Eds). Last modified 10 Feb 2017. "The Climate Data Guide: CERES: IGBP Land Classification."
Retrieved from: <https://climatedataguide.ucar.edu/climate-data/ceres-igbp-land-classification>
9. Obasi, G.O.P. 1994. WMO's role in the international decade for natural disaster reduction. *Bull. Am. Meteorol. Soc.* 75 (9), 1655-1661.
10. Wilhite, D.A. 2000. Drought as a Natural Hazard: Concepts and Definitions (Chapter 1, 3-18p.). In: *Drought: A Global Assessment* Wilhite, D.A. (ed.) (Volume 1),
Routledge Publishers, London, U.K.
11. Wilhite, D.A. 2000b. Drought as a natural hazard: concepts and definitions. In: *Drought: A Global Assessment* Wilhite, D.A. (Ed.), vol. 1. Routledge, New York, 1-18p.





As a result of changing climatic conditions, alter in precipitation events such as drought have emerged as a source of vulnerability in several South Asian nations, including Nepal, India, Pakistan, and Bangladesh. Recent declines in agricultural productivity have weakened rural economies, encouraging widespread famine and urban migration.

Drought monitoring and assessment techniques are used to forecast drought and identify drought-prone areas, allowing drought mitigation measures to be put in place to lessen the impact of drought on food production and water supplies. To estimate the severity of the drought in Pakistan, we applied the Drought Severity Index (DSI), which combines the Normalized Difference Vegetation Index (NDVI) and the ratio of Evapotranspiration to Potential Evapotranspiration (ET/PET).

This Atlas provides an overview of Pakistan's drought frequency during the last two decades. It portrays the spatiotemporal occurrences of drought in Pakistan's several provinces. I hope this atlas will assist in the creation of policies and plans for timely drought mitigation and forecasting in the agricultural sector.

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ISBN: 978-9937-1-3064-6

