LONG-TERM CLIMATE OUTLOOKS

Issued: 20th April 2018

Valid Period: May – October 2018

South Asian Region:

India

A] Current conditions:

1] El Niño-Southern Oscillation (ENSO)

ENSO Alert System Status: La Niña Advisory

Synopsis: La Niña is expected to transition to ENSO-neutral during April-May, with ENSO-neutral then likely (greater than 50% chance) to continue through the Northern Hemisphere summer 2018.

During March 2018, La Niña continued to weaken, but was still reflected by below-average sea surface temperatures (SSTs) across the east-central and eastern equatorial Pacific Ocean. Convection was suppressed near and east of the Date Line and enhanced over the far western tropical Pacific Ocean. Low-level wind anomalies were easterly over the east-central Pacific, and westerly over the far western Pacific. At upper-levels, winds were anomalously westerly over the eastern Pacific. ***Overall, the ocean and atmosphere system remained consistent with a weak La Niña.***

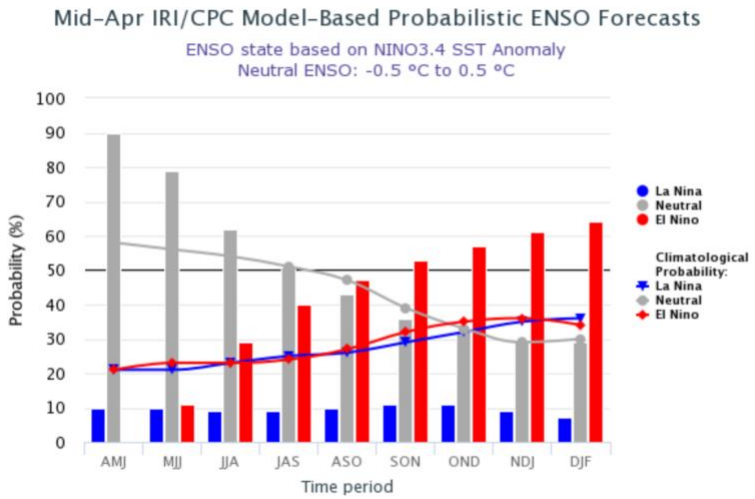


Figure 1a: ENSO Probabilities. (Courtesy: The International Research Institute for Climate and Society).

Figure 1a shows that there is now a 2**9%** chance of ***El Niño*** conditions occurring during the June-July-August season, and a **62%** chance that ***neutral*** conditions will occur. There remains a **36%** chance of ***neutral*** conditions persisting during the September-October-November season, while the chances of ***El Niño*** have increased to **63%.** Most models in the IRI/CPC plume predict La Niña will decay and return to ENSO-neutral during the current March-May season. The forecaster consensus similarly favors a transition to neutral, with a continuation of ENSO-neutral conditions through the summer 2018. Thereafter, there is considerable forecast uncertainty, in part due to the lower prediction

skill for forecasts made at this time of year. ***In summary, La Niña is expected to transition to ENSO-neutral during April-May, with ENSO-neutral then likely (greater than 50% chance) to continue through the Northern Hemisphere summer 2018.***

Local Effects.

Figures 1b and **1c** show the global effects of El Niño (ENSO warm episode). In general, during El Niño events, conditions become warmer and drier over much of India (especially western India) during the monsoon season. Statistical research shows that the **strongest connections between El Niño and India occur during the July-August-September period**, with much *below* average rainfall occurring, especially over Western India. The effects of El Niño will become more apparent as it strengthens through the end of November. **At this stage, there is a 40% chance that that El Niño conditions will occur during the July-August-September period.**

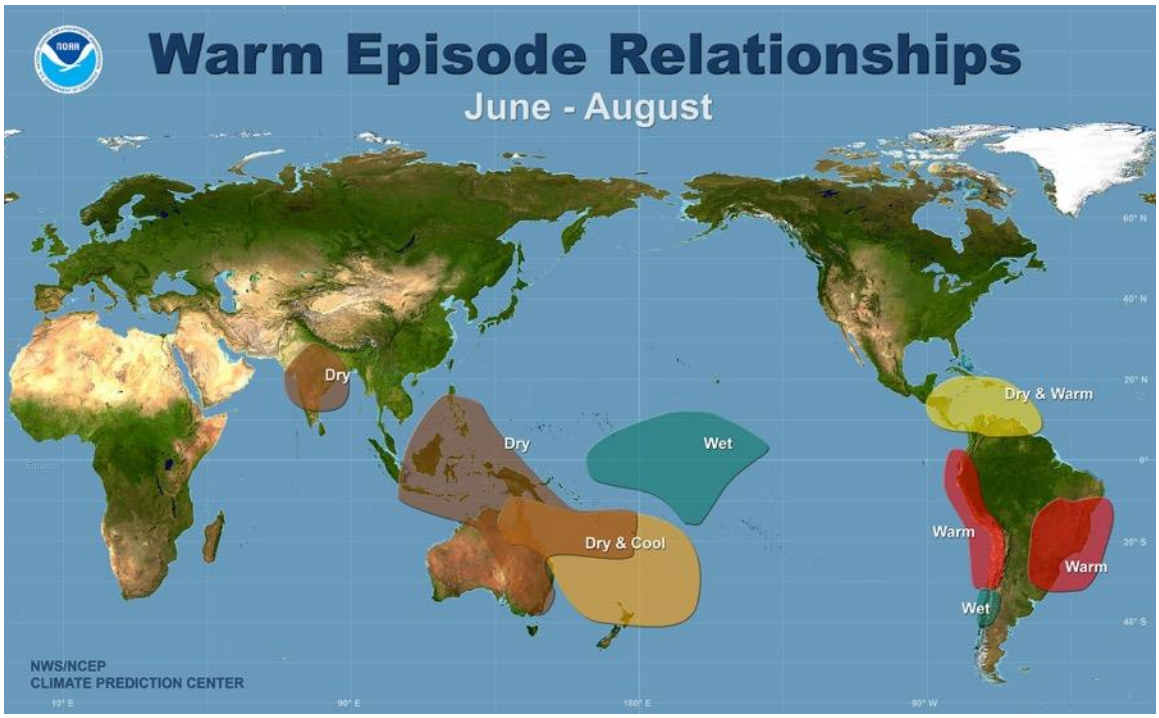


Figure 1b: Global effects of El Nino (ENSO warm episode) during the June-August period. (Courtesy: CPC).

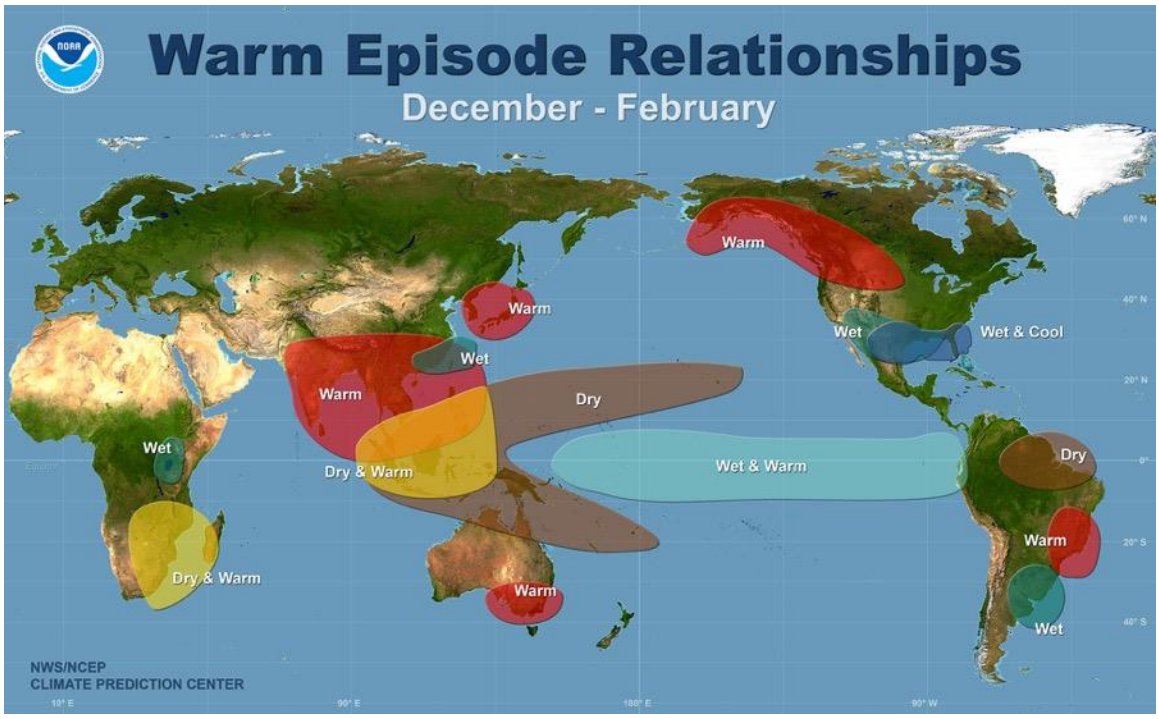


Figure 1c: Global effects of El Nino (ENSO warm episode) during the June-August period. (Courtesy: CPC).

Local Effects of La Niña.

Figures 2b and **2c** show the global effects of La Niña (ENSO cold episode). In general, during La Niña events, conditions become cooler and wetter over much of India (especially western India) during the monsoon season. Statistical research shows that the **strongest connections between La Niña and India occur during the July-August-September period**, with much *above* average rainfall occurring, especially over Western India. With the weakening of the current La Niña***, it is likely that La Niña will have no influence on the upcoming monsoon season****. (~9% chance)*

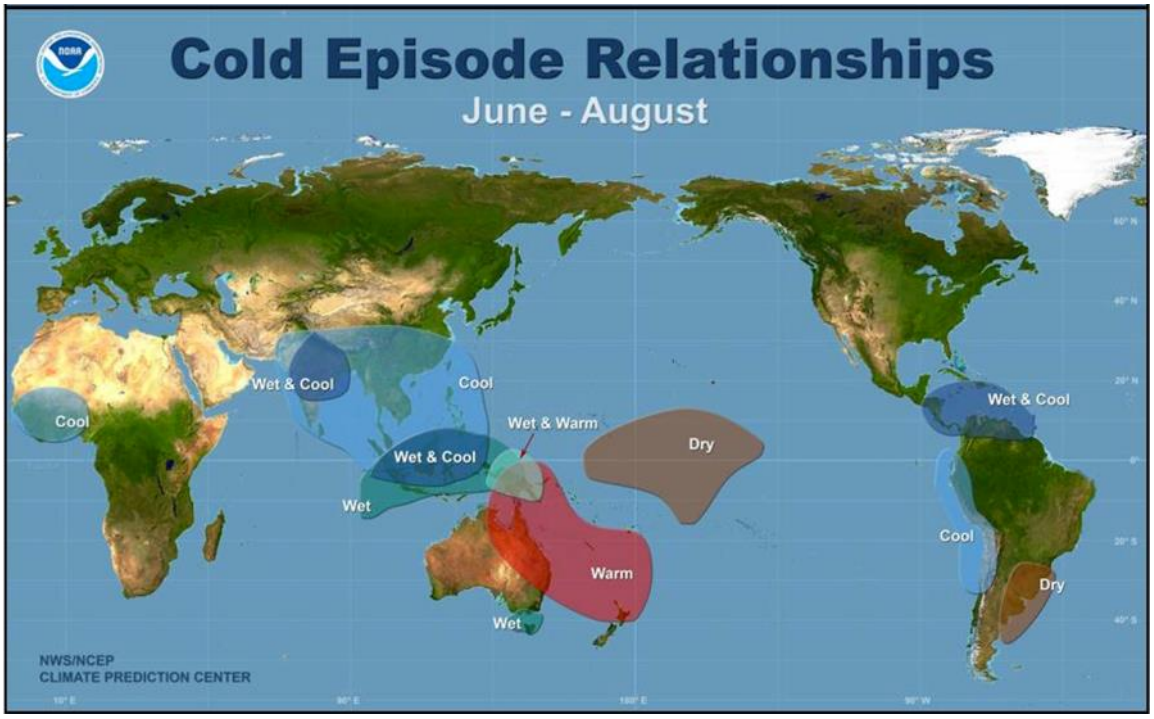


Figure 2b: Global effects of La Niña (ENSO cold episode) during the June-August period. (Courtesy: CPC).

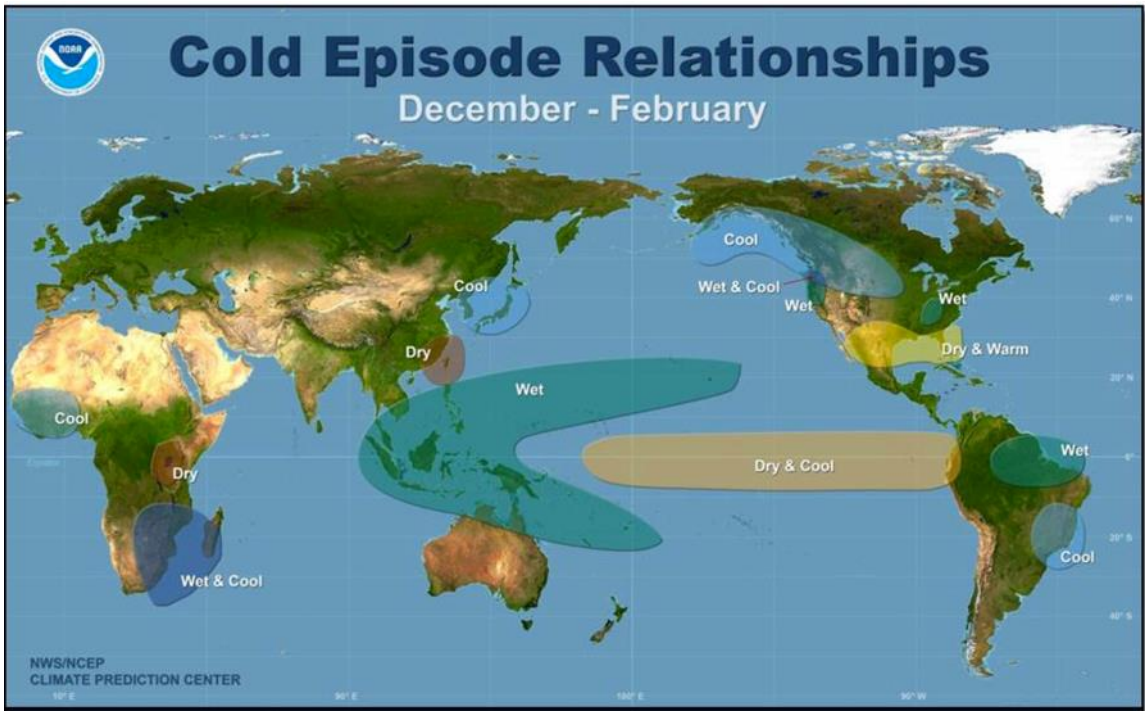


Figure 2c: Global effects of La Niña (ENSO cold episode) during the June-August period. (Courtesy: CPC).

Note:

El Niño or La Niña Watch: Issued when conditions are favorable for the development of El Niño or La Niña conditions within the next six months.

El Niño or La Niña Advisory: Issued when El Niño or La Niña conditions are observed and expected to continue.

The Climate Prediction Center defines "El Niño conditions" as existing when: A one-month positive sea surface temperature anomaly of 0.5°C or greater is observed in the Niño-3.4 region of the equatorial Pacific Ocean (5°N-5°S, 120°W-170°W) and an expectation that the 3-month Oceanic Niño Index (ONI) threshold will be met AND An atmospheric response typically associated with El Niño is observed over the equatorial Pacific Ocean.

The Climate Prediction Center defines "La Niña conditions" as existing when: A one-month positive sea surface temperature anomaly of -0.5°C or less is observed in the Niño-3.4 region of the equatorial Pacific Ocean (5°N-5°S, 120°W-170°W) and an expectation that the 3-month Oceanic Niño Index (ONI) threshold will be met AND an atmospheric response typically associated with La Niña is observed over the equatorial Pacific Ocean.

2] Rainfall

Figure 2 shows actual observed rainfall and rainfall departures for the period 09/04/18 - 15/04/18. Rainfall during this period was generally light with most provinces receiving less than 25mm. However, the western parts of Jammu and Kashmir received between 25mm and 50mm and Kerala and Tamil Nadu provinces received between 25mm and 100mm. The extreme southern areas of Chhattisgarh also received between 25mm and 100mm.

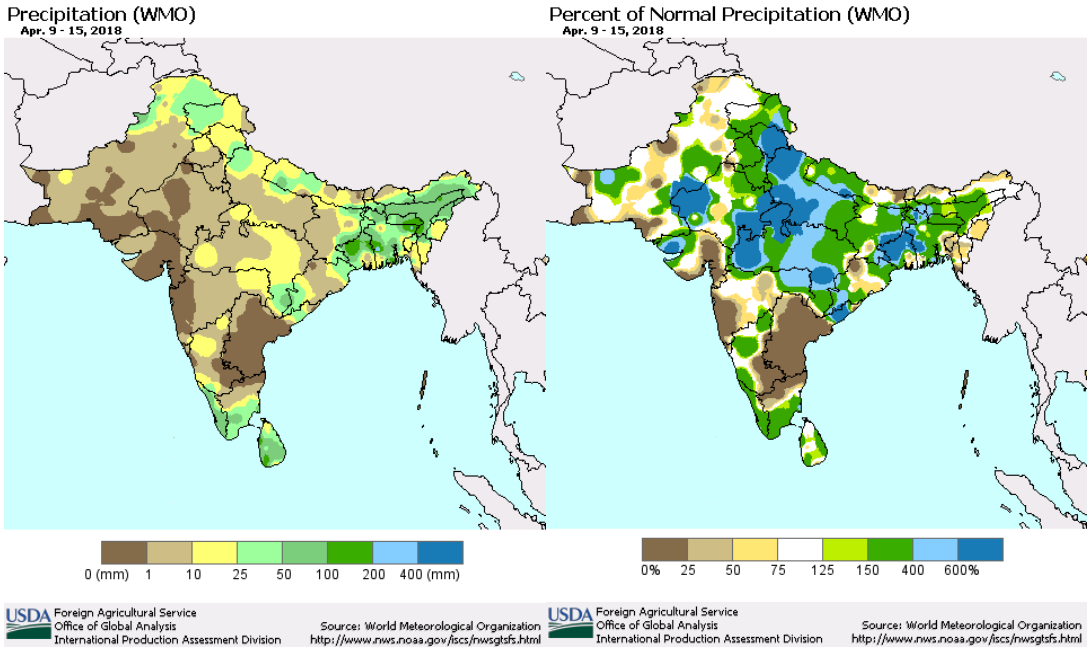


Figure 2: (Left) Observed Rainfall for the period 09/04/18 - 15/04/18& (right) % of WMO normal.

3] Temperature

Figure 3 shows the observed mean temperature and departures from normal for the period 09/04/18 - 15/04/18. Most of the southern provinces of India recorded mostly average temperatures (-1°C to +1°C *above* average). The northwestern provinces recorded mostly *above* average temperatures (+1°C to +5°C), while those in the northeast recorded mostly *below* average temperatures (-1°C to -5°C).

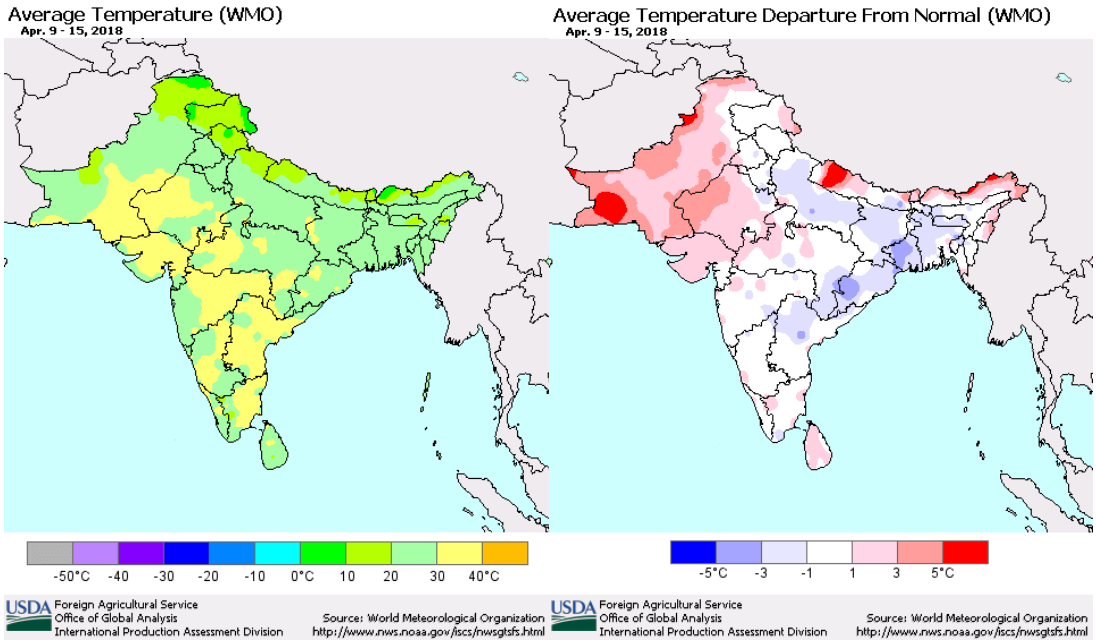


Figure 3: (Left) Observed Mean Temperature for the period 09/04/18 - 15/04/18and (right) departure from WMO normal.

4] Soil Moisture

Figure 4 shows the observed soil moisture percentage for 08/04/18. Low soil moisture values were observed over almost all provinces of India with values ranging between 0% and 10%. The far northeastern provinces had slightly moister soils with values of between 10% and 40%.

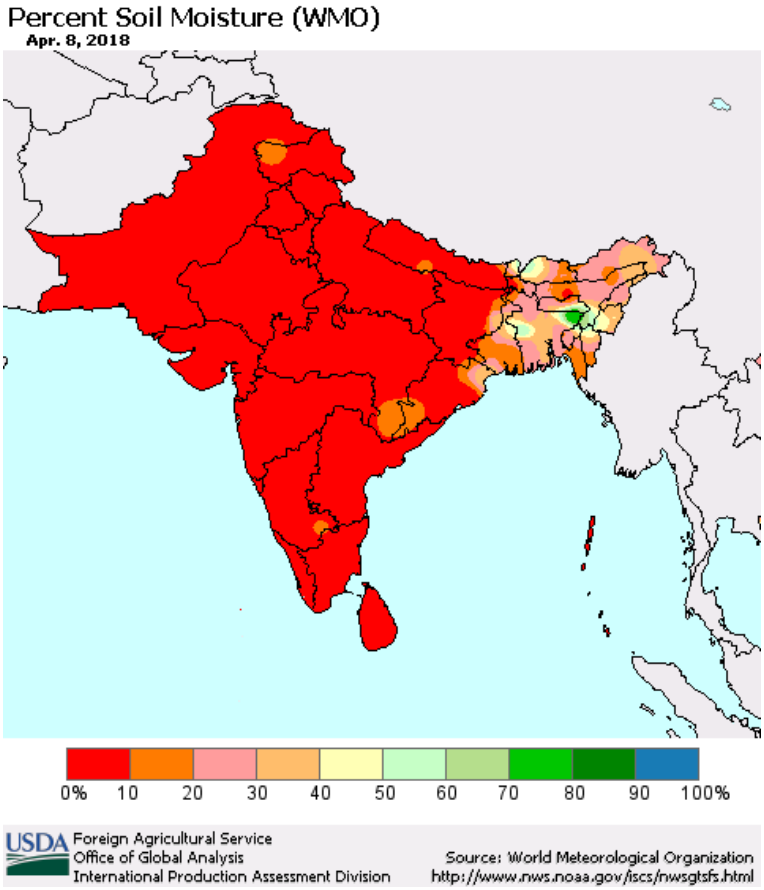


Figure 4: WMO Observed Percent Soil Moisture for 08/04/18.

B] Expected conditions:

MAY 2018: **Rainfall** in general will be average to *above* average over much of India. Specifically, most provinces in the northwest and West Bengal should expect mostly average rainfall (**-12.5mm to +12.5mm**). Parts of Arunachal Pradesh should expect slightly *below* average rainfall (**0mm to -12.5mm**). Almost all the southern states from Maharashtra in the west and Orissa in the east southwards should expect *above* average rainfall (**+12.5mm to +50mm**, especially over Goa and far northwestern coast of Karnataka province). **Temperatures** are expected to be *above* average over Punjab, western Rajasthan, Haryana Provinces and far northern provinces of India (**+0.5°C to +1.5°C**). Except for parts of far eastern Karnataka province, and western Andhra Pradesh province and northeastern Tamil Nadu province where temperatures are expected to be slightly *below* average (**-0.5°C to -1.0°C**), the remainder of the Indian provinces should expect mostly average temperatures (**-0.5°C to +0.5°C**).

JUNE 2018: **Rainfall** in general will be *above* average over much of India and is forecast to be the wettest month of the monsoon season. Specifically, West Bengal is expected to receive mostly average rainfall (**-12.5mm to +12.5mm**). Most provinces in the northwest should expect mostly slightly *above* average rainfall (**+12.5mm to +25mm**). Assam and Arunachal Pradesh should expect *below* average rainfall (**-12.5mm to -50mm**). Almost all the southern states from Gujarat the west and Orissa in the east southwards should expect *above* average rainfall (**+25mm to +125mm**, especially over Goa and from the northern coast of Maharashtra southwards to the northern areas of Kerala province). **Temperatures** are expected to be *above* average over Jammu and Kashmir and over Arunachal Pradesh and far northeastern Assam (**+0.5°C to +1.0°C**). Except for the northwestern and northeastern provinces, where temperatures are expected to be average (**-0.5°C to -0.5°C**), the remainder of the Indian provinces should expect mostly *below* average temperatures (**-0.5°C to -2.0°C**, especially over far eastern Maharashtra).

JULY 2018: **Rainfall** in general will be *above* average over central India and *below* average over much of the western, far northeastern and far southern provinces and mostly average elsewhere. Specifically, most provinces in the west, including Gujarat, western Maharashtra, southern provinces including Kerala and Tamil Nadu and Assam and Arunachal Pradesh should expect *below* average rainfall (**-12.5mm to -50mm**). Central India, including far eastern Maharashtra, southern Chhattisgarh and northern Andhra Pradesh and western Orissa should expect *above* average rainfall (**+12.5mm to +100mm**). The remaining areas should expect mostly average rainfall (**-12.5mm to +12.5mm**). **Temperatures** in general should be mostly average over most of India, but slightly *above* average over the far northern provinces and slightly *below* average over the central parts of India where rainfall is expected to be above average. Temperatures are expected to be *above* average over Jammu and Kashmir and over Arunachal Pradesh and far northeastern Assam (**+0.5°C to +1.0°C**). Except for the northwestern Maharashtra, western Madhya Pradesh provinces where temperatures are expected to *below* average

(**-0.5°C to -1.0°C**), while the remainder of the Indian provinces should expect mostly average temperatures (**-0.5°C to -0.5°C**).

AUGUST 2018: **Rainfall** in general will be *below* average over much of western and southern India and average over much of the northeastern provinces and slightly *above* average over parts of northern Chhattisgarh. Specifically, most provinces in the west, including Rajasthan southwards to Kerala, Tamil Nadu and Andhra Pradesh should expect *below* average rainfall (**-12.5mm to -75mm**). Western Maharashtra and far northern Karnataka provinces will have the largest deficits. Central India, including far eastern Maharashtra, northern Chhattisgarh and parts of southern Assam province should expect *above* average rainfall (**+12.5mm to +50mm**). The remaining areas should expect mostly average rainfall (**-12.5mm to +12.5mm**). **Temperatures** in general should be mostly average over most of India should be average, but slightly *above* average over the far northern provinces. No places should expect *below* average temperatures. Temperatures are expected to be *above* average over Jammu and Kashmir and over Arunachal Pradesh and far northeastern Assam (**+0.5°C to +1.0°C**). The remainder of the Indian provinces should expect mostly average temperatures (**-0.5°C to -0.5°C**).

SEPTEMBER 2018: **Rainfall** in general will be *below* average over much of southwestern and southern India and average over much of the northwestern, northern and northeastern provinces and slightly *above* average over Chhattisgarh and eastern Maharashtra. Specifically, most provinces in the southwest, including Karnataka, Kerala and Tamil Nadu should expect *below* average rainfall (**-12.5mm to -50mm**). Central and eastern Maharashtra, Chhattisgarh and far northern Andhra Pradesh provinces should expect *above* average rainfall (**+12.5mm to +50mm**). The remaining areas should expect mostly average rainfall (**-12.5mm to +12.5mm**). **Temperatures** in general should be mostly average over most of India should be average, but slightly *above* average over the far northern provinces. No places should expect *below* average temperatures. Temperatures are expected to be *above* average over Jammu and Kashmir (**+0.5°C to +1.0°C**). The remainder of the Indian provinces should expect mostly average temperatures (**-0.5°C to -0.5°C**).

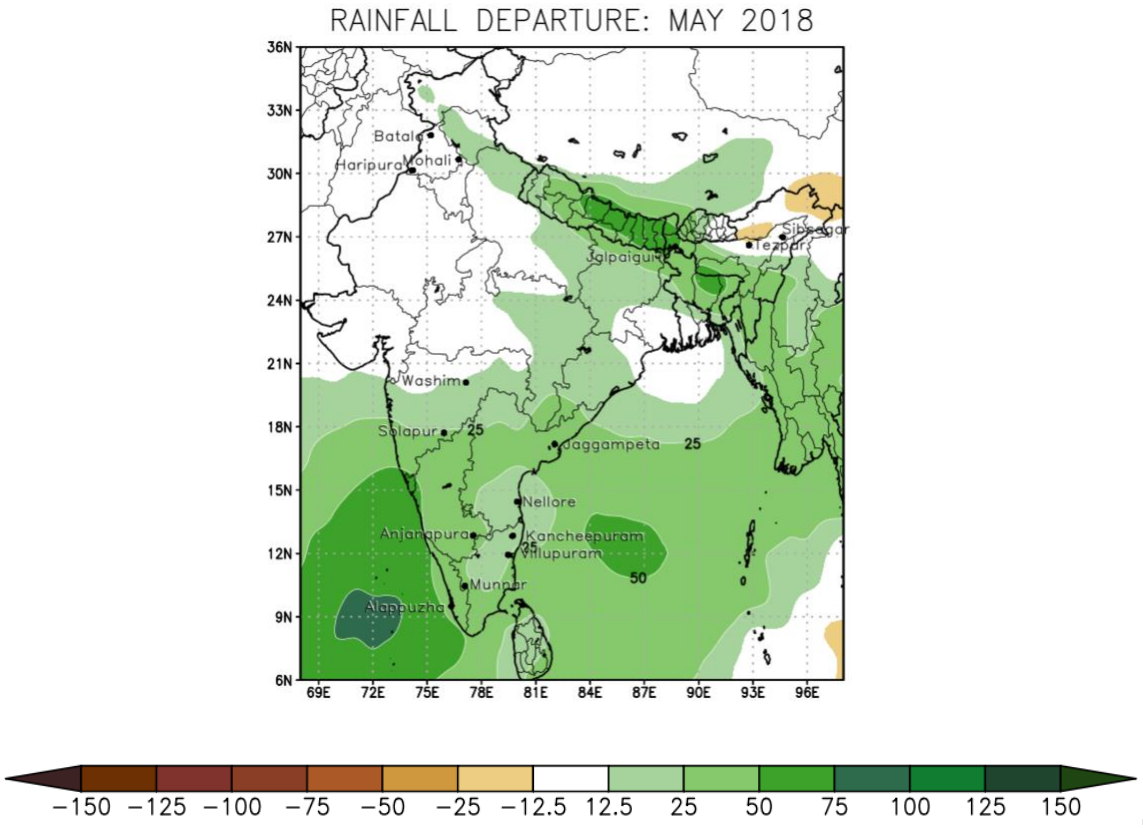
OCTOBER 2017: **Rainfall** in general will be *below* average over Kerala and parts of eastern Tamil Nadu and average over much of the rest of India. Specifically, most provinces in the southwest, including Kerala, eastern Tamil Nadu and the northeastern coat of Andhra Pradesh should expect *below* average rainfall (**0mm to -25mm**). Far northeastern Chhattisgarh province should expect average to slightly *above* average rainfall (**0mm to +12.5mm**). The remaining areas should expect mostly average rainfall (**-12.5mm to +12.5mm**). **Temperatures** in general should be mostly average over most of India should be average, but slightly *above* average over the far northern provinces. No places should expect *below* average temperatures. Temperatures are expected to be *above* average

over Rajasthan and Jammu and Kashmir (**+0.5°C to +1.0°C**). The remainder of the Indian provinces should expect mostly average temperatures (**-0.5°C to -0.5°C**).

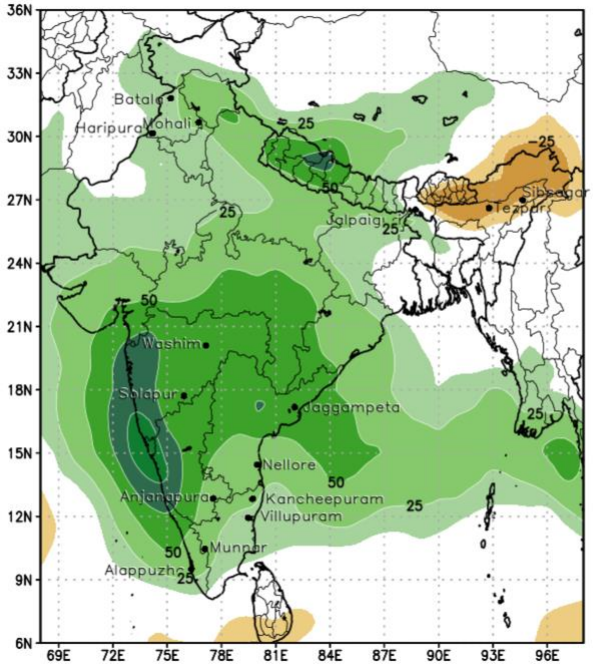
Figure 5 below shows the forecast monthly rainfall (mm) departures from average for India.

Figure 5: Mean monthly North American Multi-Model Ensemble (NMME) rainfall departures (mm) for the months of May - Oct 2018 (based on the forecast on 8th Apr 2018). Anomalies are computed with respect to the 1982-2010 base period monthly means.

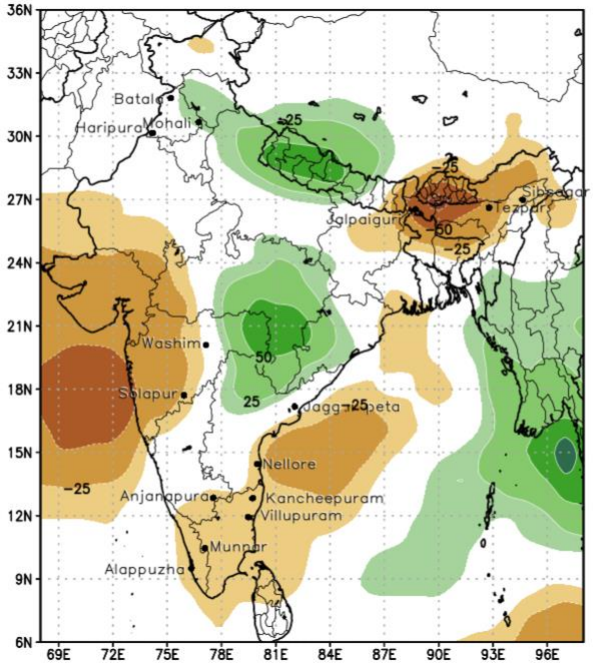
RAINFALL DEPARTURES FROM AVERAGE

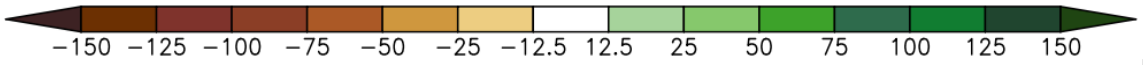


RAINFALL DEPARTURE: JUNE 2018

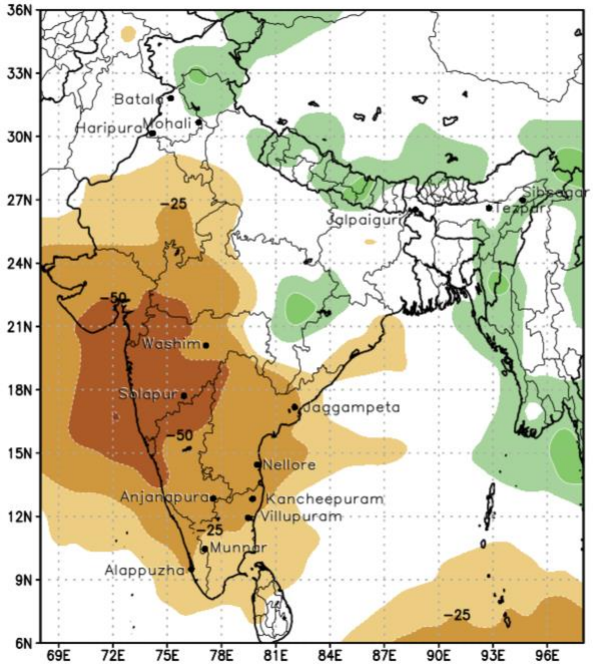


RAINFALL DEPARTURE: JULY 2018

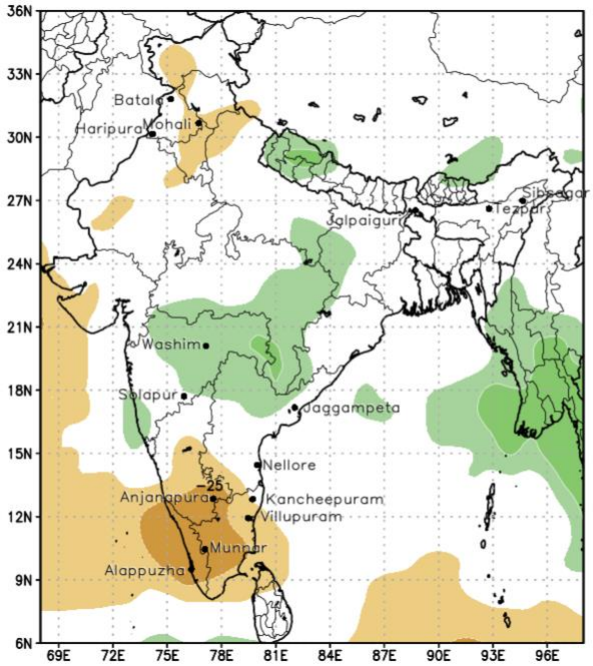


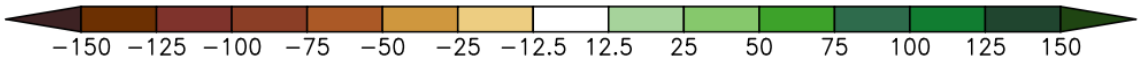


RAINFALL DEPARTURE: AUGUST 2018



RAINFALL DEPARTURE: SEPTEMBER 2018





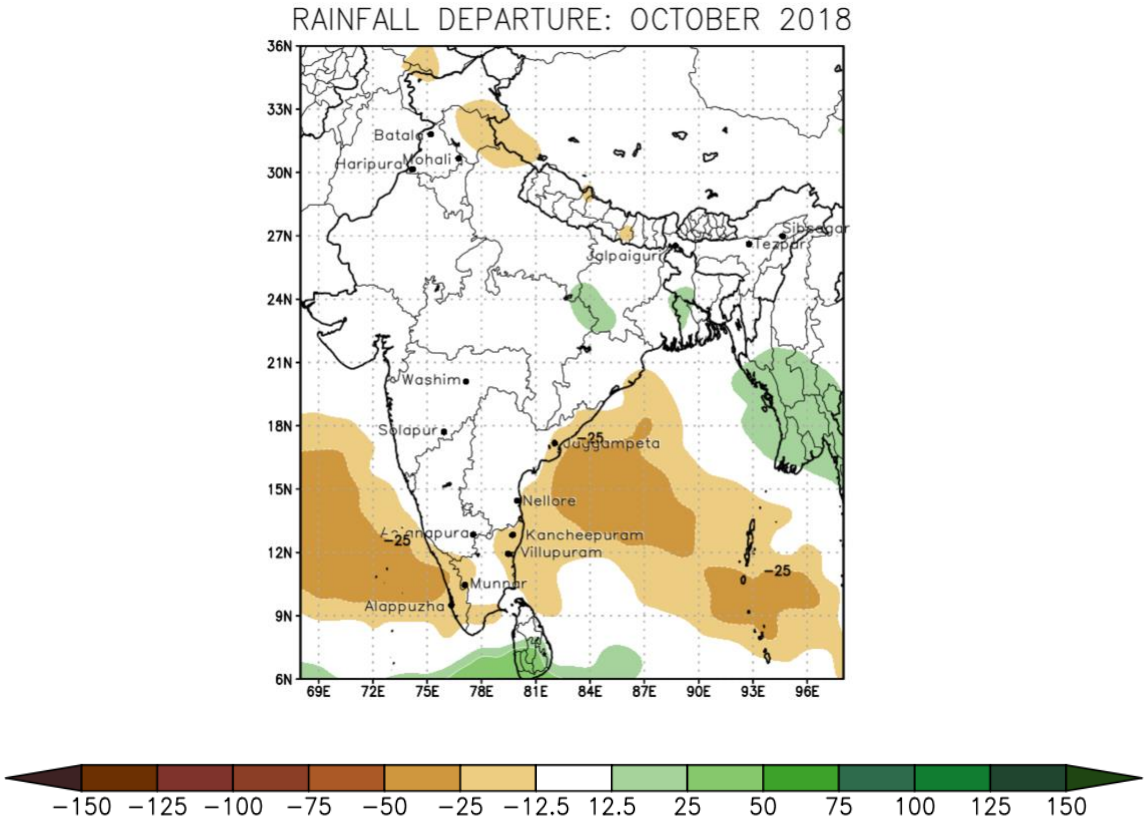
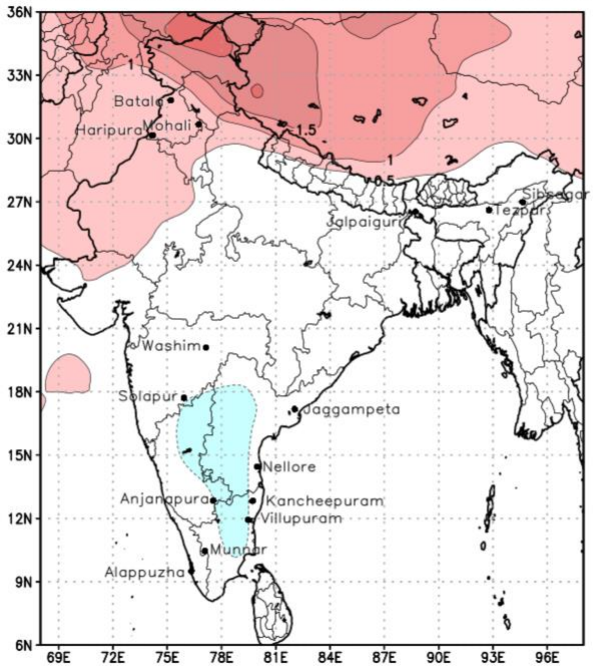


Figure 6 below shows the forecast monthly average temperature (C) departures from average for India.

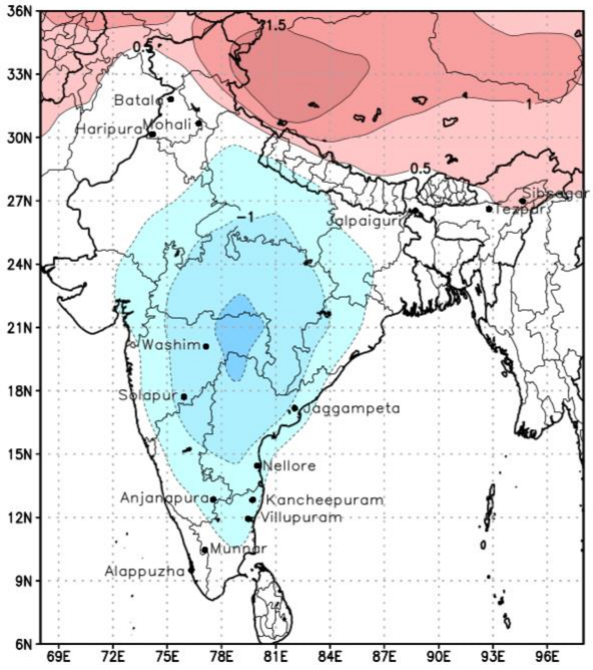
Figure 6: Mean monthly North American Multi-Model Ensemble (NMME) average 2-meter temperature departures (°C) for the months of May - Oct 2018 (based on the forecast on 8th Apr 2018). Anomalies are computed with respect to the 1982-2010 base period monthly means.

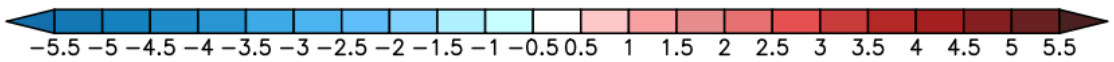
MEAN TEMPERATURE DEPARTURES FROM NORMAL

TEMPERATURE DEPARTURE: MAY 2018

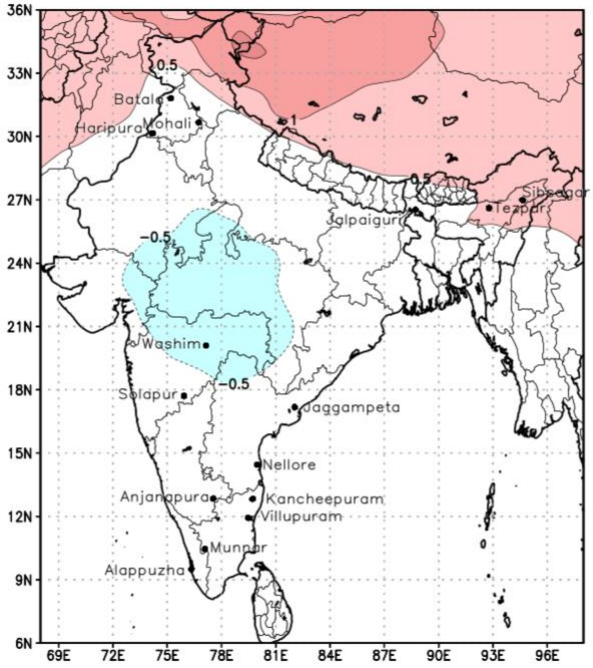


TEMPERATURE DEPARTURE: JUNE 2018

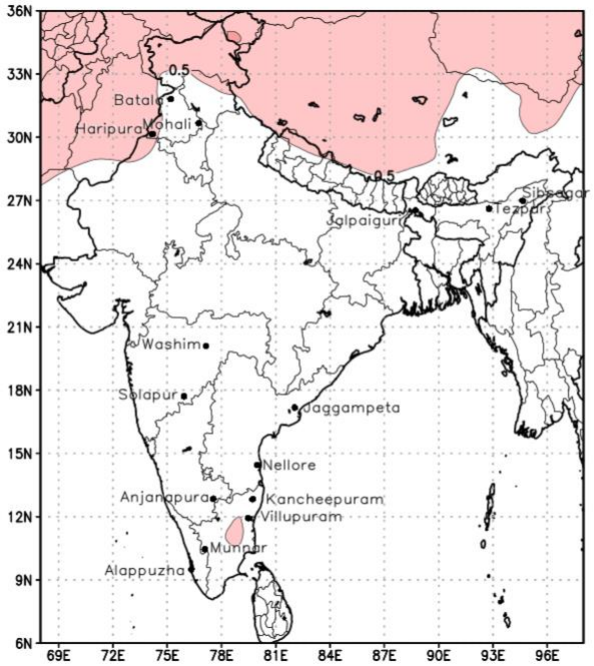


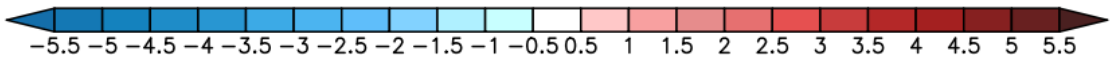


TEMPERATURE DEPARTURE: JULY 2018

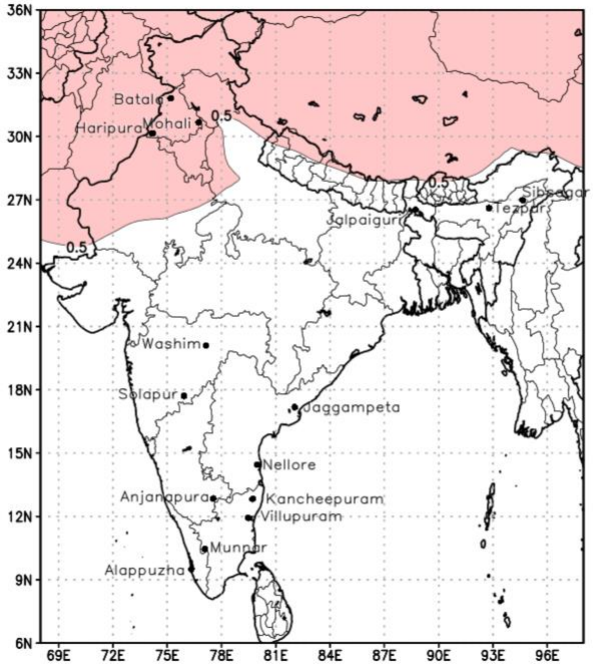


TEMPERATURE DEPARTURE: AUGUST 2018

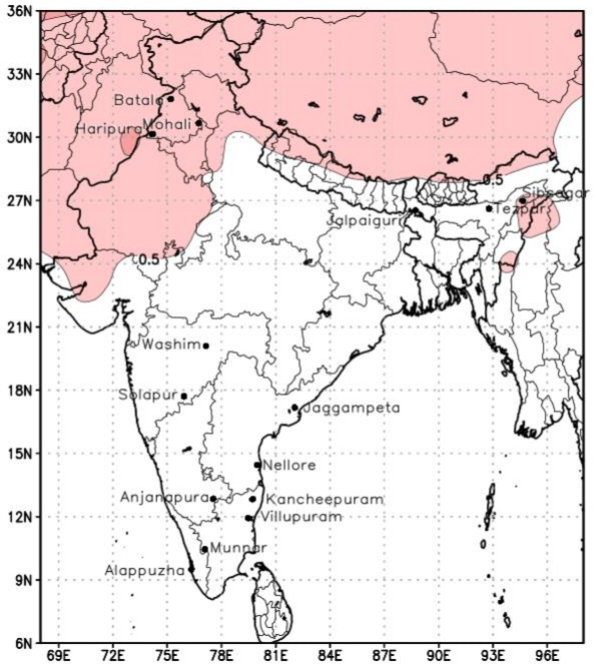


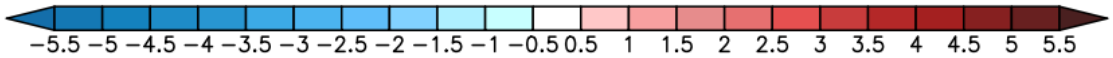


TEMPERATURE DEPARTURE: SEPTEMBER 2018



TEMPERATURE DEPARTURE: OCTOBER 2018



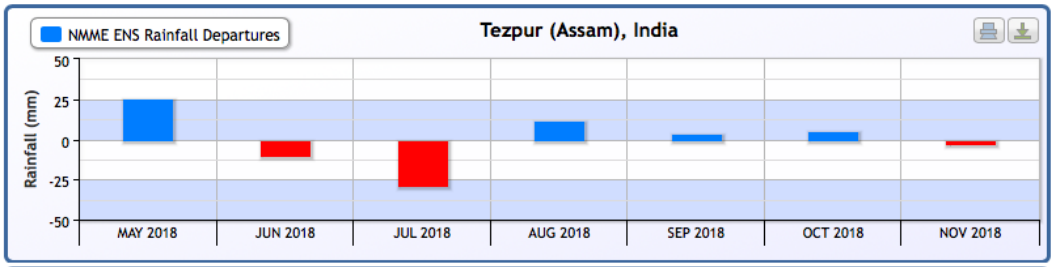


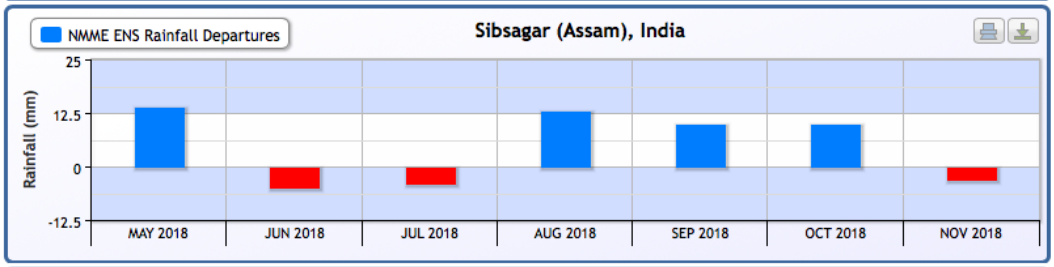
SUMMARY: MAY – OCTOBER 2018

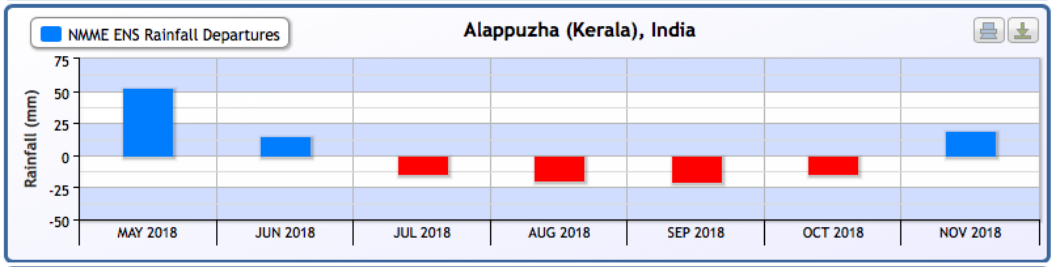
In general, total monsoon rainfall the 6 month forecast period should be mostly average, however, it will not be distributed evenly though the season. Generally May and June is forecast to have *surplus* rainfall over large parts of India, especially the southern and southwestern parts. However, July, and especially, August, are forecast to have moderate rainfall deficits over much of western and southwestern and southern India. Central India is the only area with small rainfall surpluses in September, while most other areas should expect mostly average rainfall, with the exception of far southern India, where moderate deficits should be expected. Average rainfall should be expected over most of India during October. Temperatures are forecast to be mostly average to slightly above average over the far northern provinces throughout the period and mostly average elsewhere. The exception will be over central India during May, June and July when temperatures are expected to be slightly *below* average.

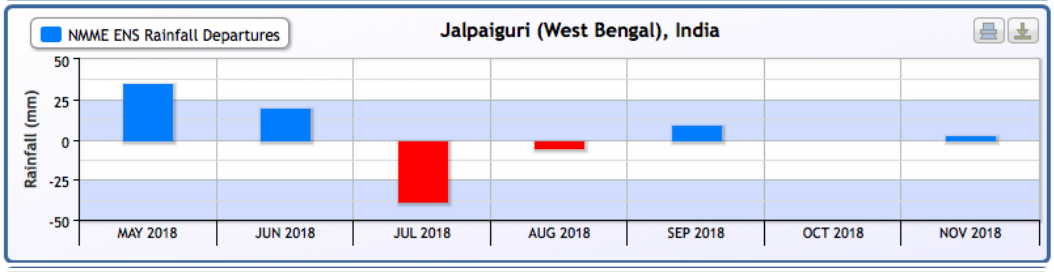
For actual expected monthly rainfall departures for a select listing of fifteen locations in agricultural regions, please see Figure 7 below.

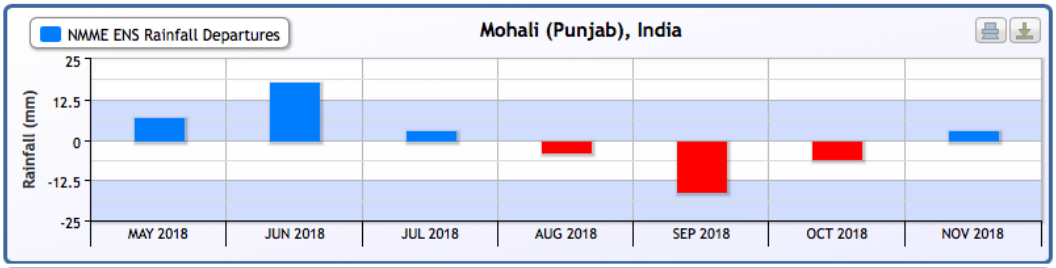
Figure 7 shows the expected rainfall departures from normal for the period **May - November 2018** for locations throughout important agricultural regions of India. (Blue is *above* average, red is *below* average – based on the NMME ensemble).

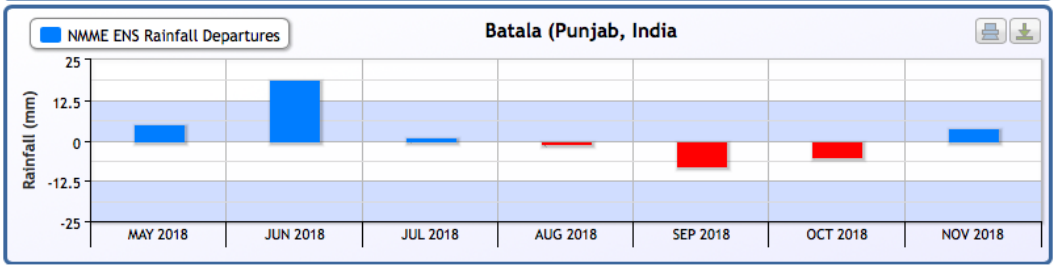

NMME ENS Rainfall Departures
Tezpur (Assam), India
Rainfall (mm)
50
25
0
-25
-50
MAY 2018
JUN 2018
JUL 2018
AUG 2018
SEP 2018
OCT 2018
NOV 2018

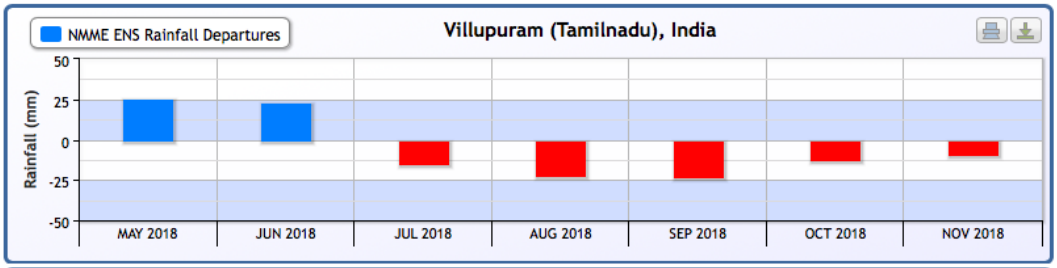

NMME ENS Rainfall Departures
Sibsagar (Assam), India
Rainfall (mm)
25
12.5
0
-12.5
MAY 2018
JUN 2018
JUL 2018
AUG 2018
SEP 2018
OCT 2018
NOV 2018

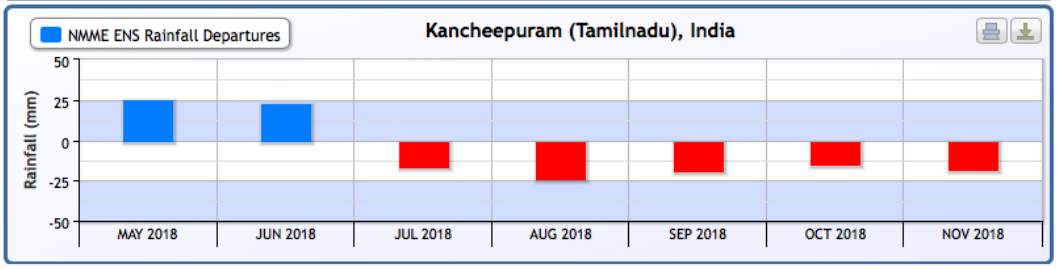

NMME ENS Rainfall Departures
Alappuzha (Kerala), India
Rainfall (mm)
75
50
25
0
-25
-50
MAY 2018
JUN 2018
JUL 2018
AUG 2018
SEP 2018
OCT 2018
NOV 2018

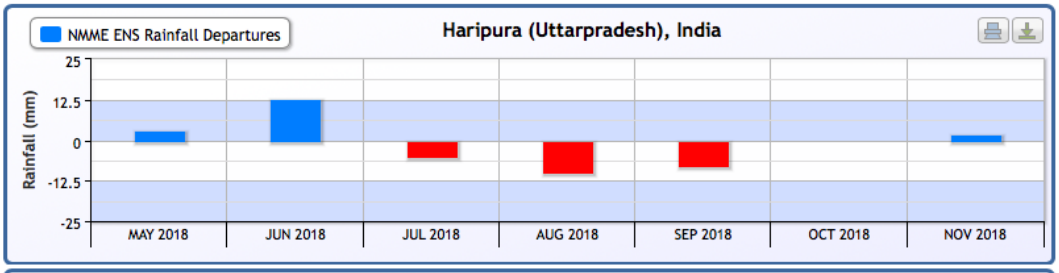

NMME ENS Rainfall Departures
Jalpaiguri (West Bengal), India
Rainfall (mm)
50
25
0
-25
-50
MAY 2018
JUN 2018
JUL 2018
AUG 2018
SEP 2018
OCT 2018
NOV 2018

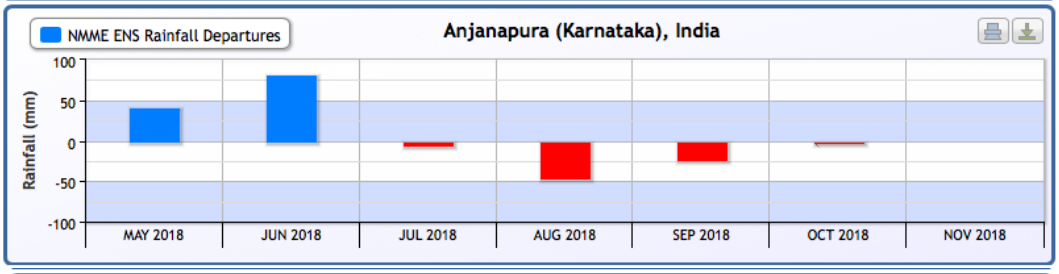

NMME ENS Rainfall Departures
Mohali (Punjab), India
Rainfall (mm)
25
12.5
0
-12.5
-25
MAY 2018
JUN 2018
JUL 2018
AUG 2018
SEP 2018
OCT 2018
NOV 2018

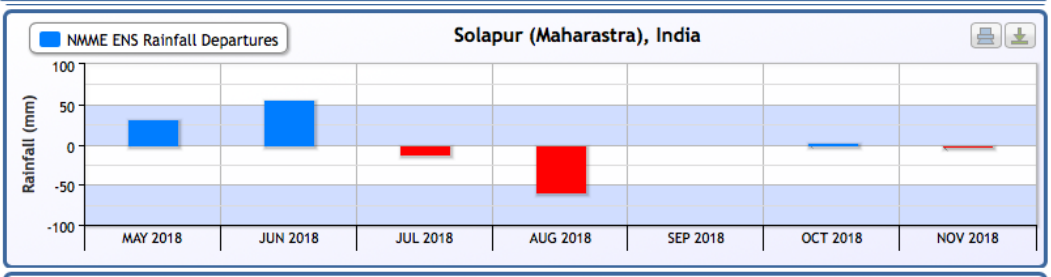

NMME ENS Rainfall Departures
Batala (Punjab, India
Rainfall (mm)
25
12.5
0
-12.5
-25
MAY 2018
JUN 2018
JUL 2018
AUG 2018
SEP 2018
OCT 2018
NOV 2018

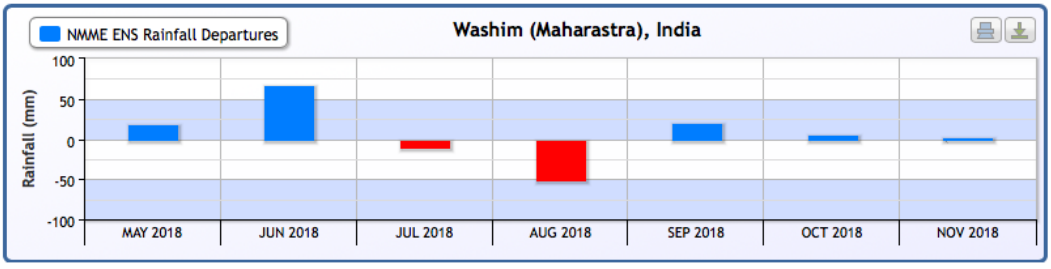

NMME ENS Rainfall Departures
Villupuram (Tamilnadu), India
Rainfall (mm)
50
25
0
-25
-50
MAY 2018
JUN 2018
JUL 2018
AUG 2018
SEP 2018
OCT 2018
NOV 2018

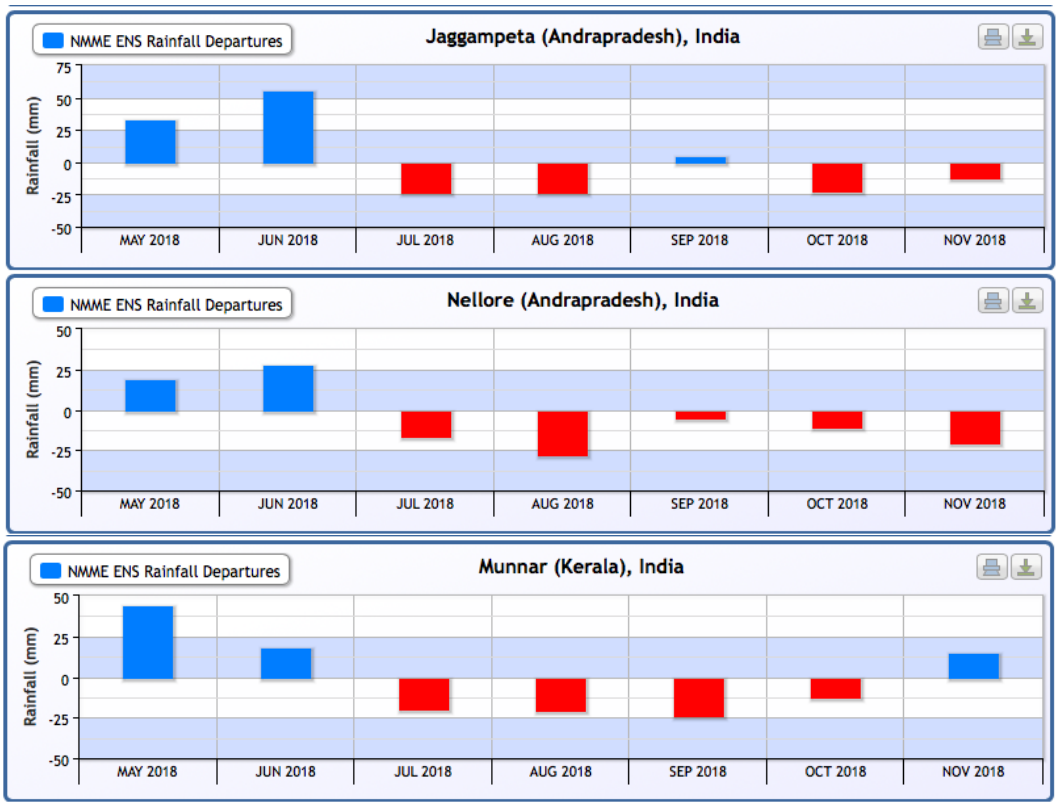

NMME ENS Rainfall Departures
Kancheepuram (Tamilnadu), India
Rainfall (mm)
50
25
0
-25
-50
MAY 2018
JUN 2018
JUL 2018
AUG 2018
SEP 2018
OCT 2018
NOV 2018


NMME ENS Rainfall Departures
Haripura (Uttarpradesh), India
Rainfall (mm)
25
12.5
0
-12.5
-25
MAY 2018
JUN 2018
JUL 2018
AUG 2018
SEP 2018
OCT 2018
NOV 2018


NMME ENS Rainfall Departures
Anjanapura (Karnataka), India
Rainfall (mm)
100
50
0
-50
-100
MAY 2018
JUN 2018
JUL 2018
AUG 2018
SEP 2018
OCT 2018
NOV 2018


NMME ENS Rainfall Departures
Solapur (Maharastra), India
Rainfall (mm)
100
50
0
-50
-100
MAY 2018
JUN 2018
JUL 2018
AUG 2018
SEP 2018
OCT 2018
NOV 2018


NMME ENS Rainfall Departures
Washim (Maharastra), India
Rainfall (mm)
100
50
0
-50
-100
MAY 2018
JUN 2018
JUL 2018
AUG 2018
SEP 2018
OCT 2018
NOV 2018



Appendix:

Definitions and explanations:

WMO Precipitation

Decadal precipitation for each WMO station is calculated by adding the ten daily precipitation records and eliminating any station that reported eight days or less. Maps are then generated by Inverse Distance Weighting interpolation method. Daily ground station data is from the World Meteorological Organization's (WMO) Global Telecommunication System (GTS), which is a global network of more than 6000 stations. However, many of the 6000 stations do not report to the GTS daily, but approximately 3800 stations report each day.

WMO Average Temperature

Average daily air temperature is calculated for each WMO station by averaging the daily maximum and minimum air temperatures. The decadal average air temperature is then

estimated by averaging the ten daily air temperatures for each WMO station. Any WMO station that reported eight days or less is eliminated and maps are then generated by Inverse Distance Weighting interpolation method. Daily ground station data is from the World Meteorological Organization's (WMO) Global Telecommunication System (GTS), which is a global network of more than 6000 stations. However, many of the 6000 stations do not report to the GTS daily, but approximately 3800 stations report each day.

WMO Percent Soil Moisture

Percent soil moisture is the available water for the plant divided by the total water holding capacity of the soil profile. It is useful for determining if the soil profile has enough water for crop development. Available water is calculated by the modified Palmer two-layer soil moisture model, which accounts for the daily amount of water withdrawn by evapotranspiration and replenished by precipitation. The total water holding capacity for each WMO station was derived from the FAO Digital Soil Map of the World and it is dependent on soil texture and depth of the soil profile. For WMO stations overlaying soils with soil depths greater than 1-meter, a maximum soil depth of 1-meter was assumed to approximate the maximum root depth for most plants.

North American Multi-Model Ensemble (NMME)

The North American Multi-Model Ensemble (NMME) is an experimental multi-model seasonal forecasting system consisting of coupled models from United States modeling centers including NOAA/NCEP, NOAA/GFDL, IRI, NCAR, NASA, and Canada's CMC.

The need for the development of NMME operational predictive capability was recommended in the recent US National Academies report "Assessment of Intraseasonal to Interannual Climate Prediction and Predictability". Indeed, the national effort is required to meet the specific tailored regional prediction and decision support needs of a large community of climate information users. The multi-model ensemble approach has proven extremely effective at quantifying prediction uncertainty due to uncertainty in model formulation, and has proven to produce better prediction quality (on average) than any single model ensemble. This multi-model approach is the basis for several international collaborative prediction research efforts, including an operational European system. There are numerous examples of how this multi-model ensemble approach yields superior forecasts compared to any single model.

Source: http://www.cpc.ncep.noaa.gov/products/NMME/about.html