LONG-TERM CLIMATE OUTLOOKS

Issued: 12th March 2019

Valid Period: May – October 2019

South Asian Region:

India

A] Current conditions:

1] El Niño-Southern Oscillation (ENSO)

ENSO Alert System Status: El Niño Advisory

Synopsis: Weak El Nino conditions are present and are expected to continue through the Northern Hemisphere spring 2019 (~55% chance).

El Nino conditions formed during January 2019, based on the presence of above-average sea surface temperatures (SSTs) across most of the equatorial Pacific Ocean and corresponding changes in the overlying atmospheric circulation. Compared to last month, the region of enhanced equatorial convection expanded near the Date Line, while anomalies remained weak over Indonesia. Low-level wind anomalies became westerly across the western Pacific Ocean, while upper-level wind anomalies were mostly westerly over the eastern Pacific. ***Overall, these features are consistent with borderline, weak El Nino conditions.***

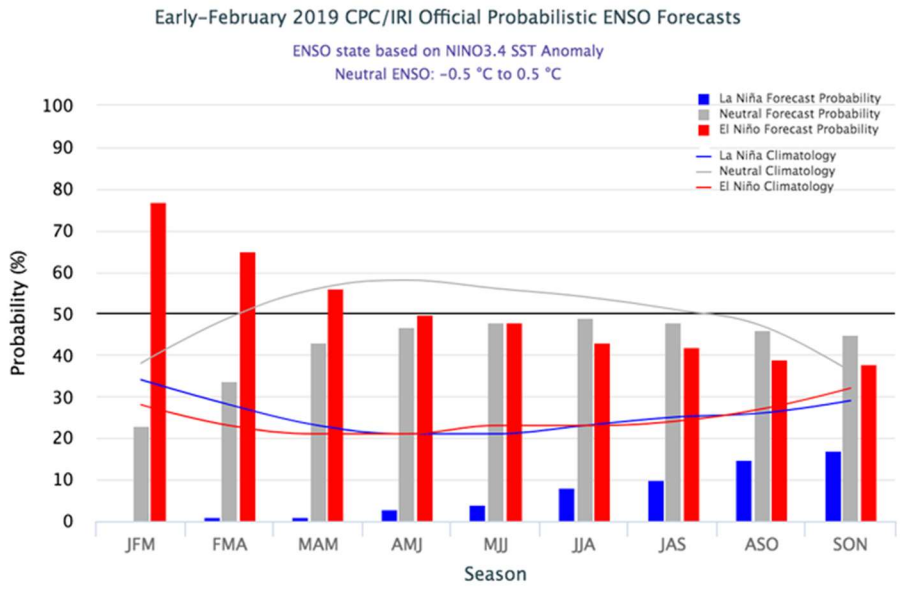


Figure 1a: ENSO Probabilities. (Courtesy: The International Research Institute for Climate and Society).

Figure 1a shows that there is now a **43%** chance of ***El Niño*** conditions occurring during the June-July-August season, and a **49%** chance that ***neutral*** conditions will occur. There remains a **45%** chance of ***neutral*** conditions persisting during the September-October-November season, while the chances of ***El Niño*** have decreased to **38%.** The majority of models predict a Nino 3.4 index of +0.5°C or greater through at least the Northern Hemisphere spring 2019. Most forecasters expect SST anomalies in the east-central

Pacific to increase slightly in the upcoming month or so. Because forecasts through the spring tend to be more uncertain and/or less accurate, the predicted chance that El Nino will persist beyond the spring is 50% or less. ***In summary, weak El Nino conditions are present and are expected to continue through the Northern Hemisphere spring 2019.***

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 42% chance that that El Niño conditions will occur during the July-August-September period.**

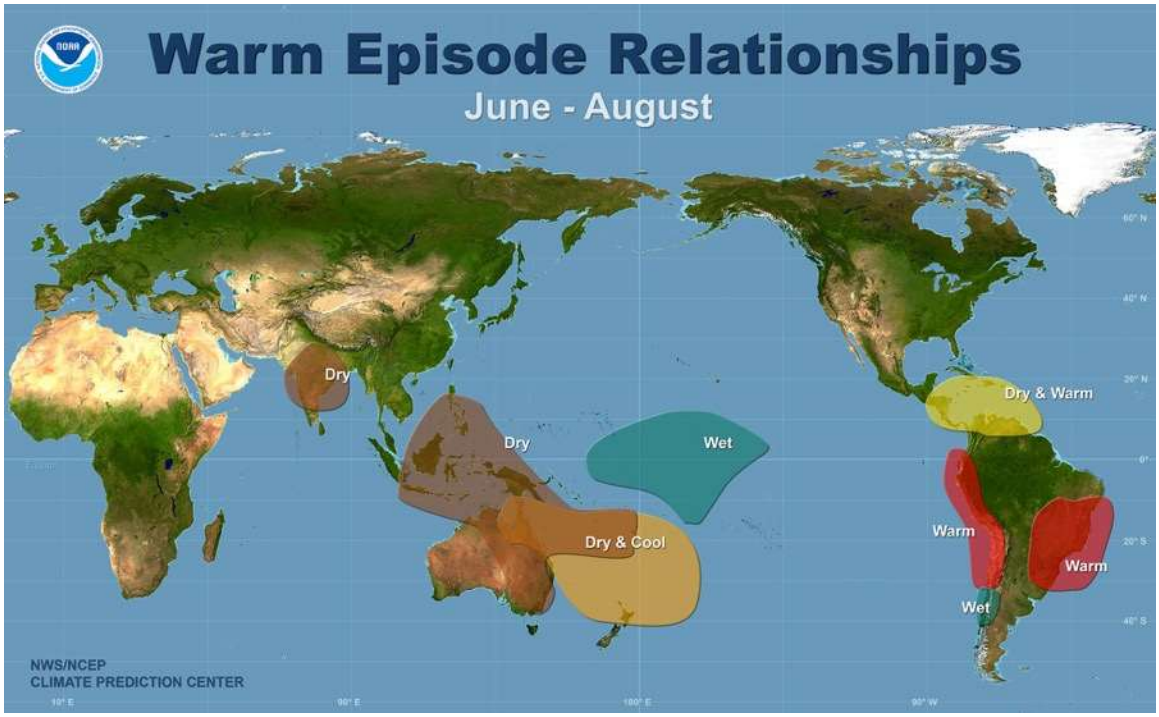


Figure 1b: Global effects of El Nino (ENSO warm episode) during the June-August period. (Courtesy: CPC).

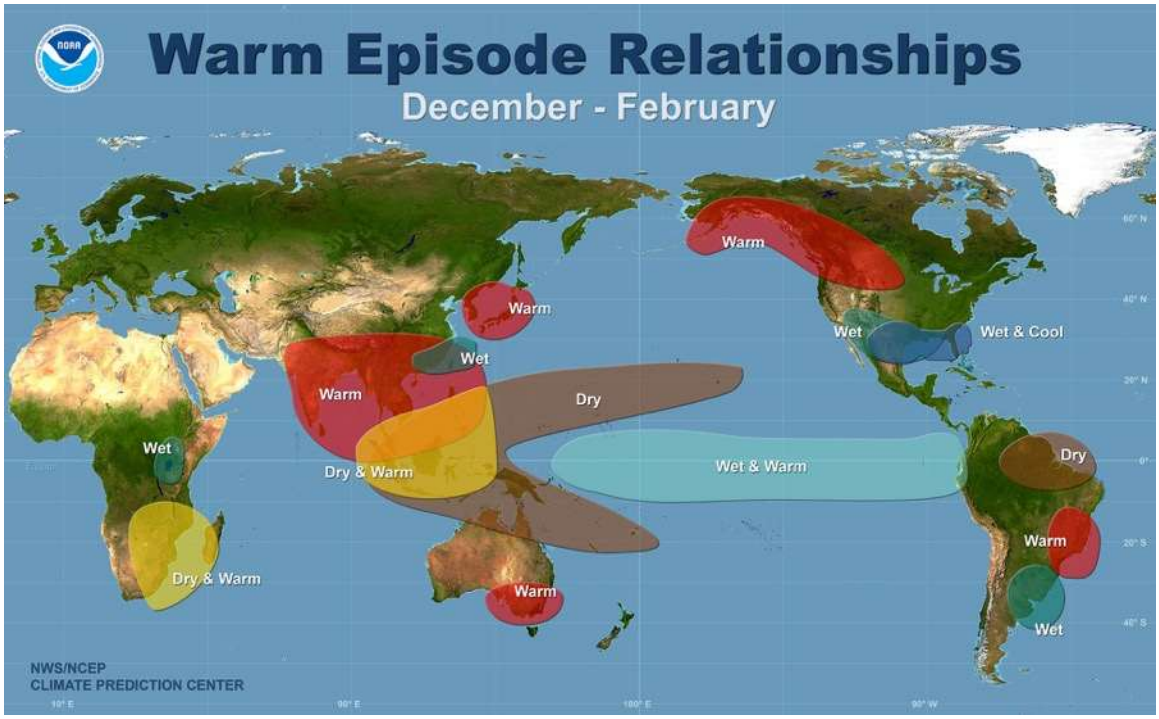


Figure 1c: Global effects of El Nino (ENSO warm episode) during the June-August period. (Courtesy: CPC).

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****. (~10% chance)*

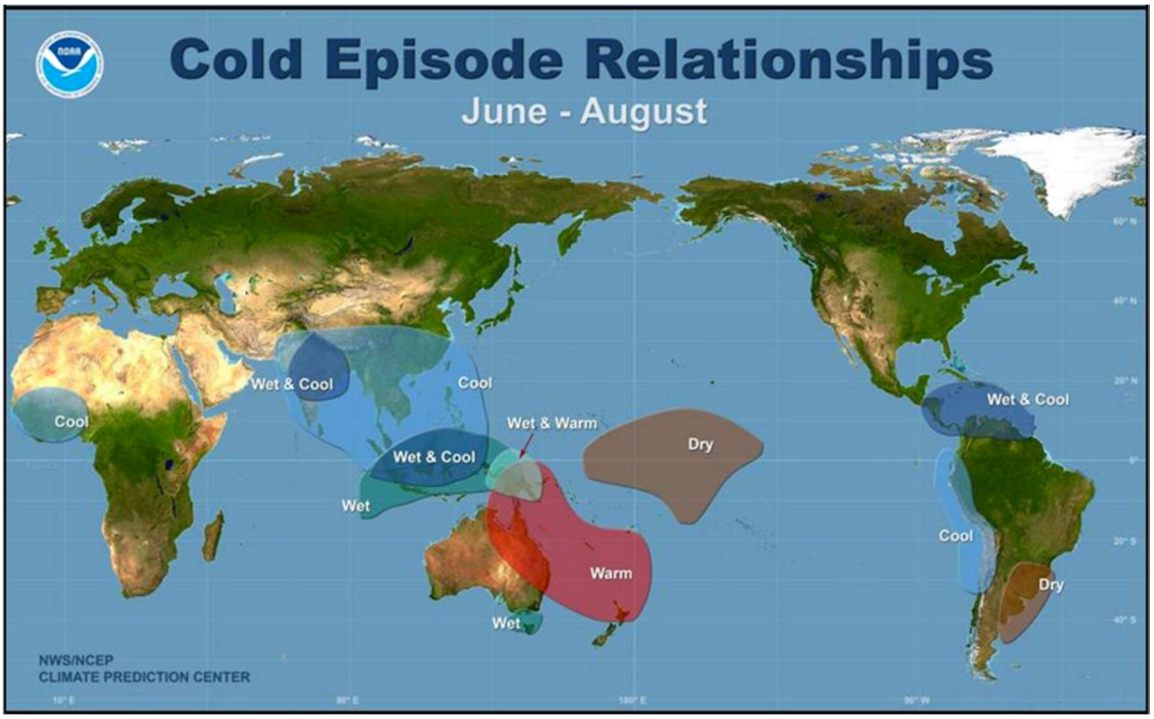


Figure 2b: Global effects of La Niña (ENSO cold episode) during the June-August period. (Courtesy: CPC).

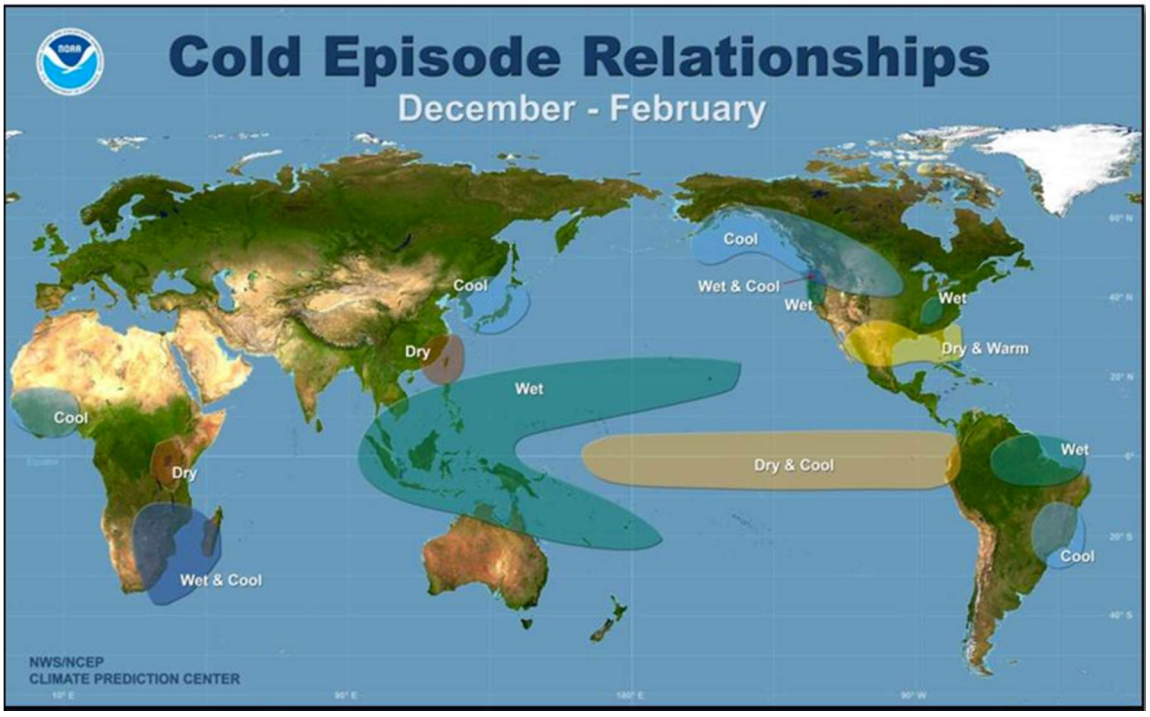


Figure 2c: Global effects of La Niña (ENSO cold episode) during the June-August period. (Courtesy: CPC).

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 04/03/19 - 10/03/19. Rainfall during this period was generally very light with most provinces receiving less than 10mm. However, the far eastern parts of West Bengal received between 25mm and 50mm and areas north of Chennai in Andhra Pradesh received between 25mm and 50mm.

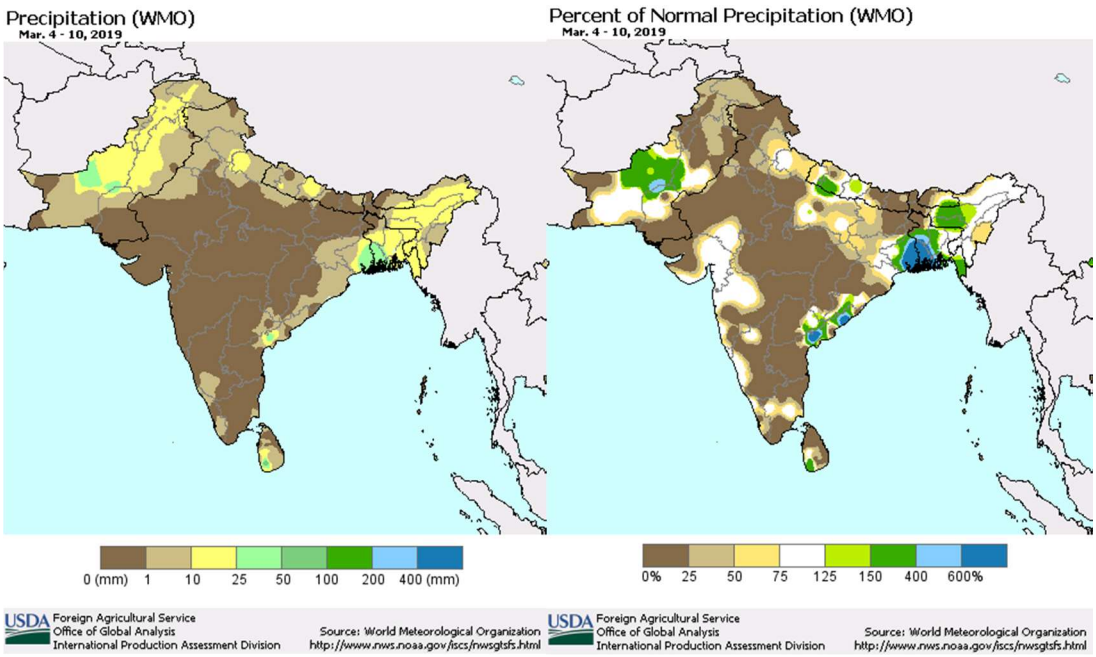


Figure 2: (Left) Observed Rainfall for the period 04/03/19 - 10/03/19 and (right) % of WMO normal.

3] Temperature

Figure 3 shows the observed mean temperature and departures from normal for the period 04/03/19 - 10/03/19. Most of the northern half of India recorded mostly *below* average temperatures (-1°C to -5°C *below* average). The southeastern provinces (especially Tamil Nadu) recorded mostly *above* average temperatures (+1°C to +5°C).

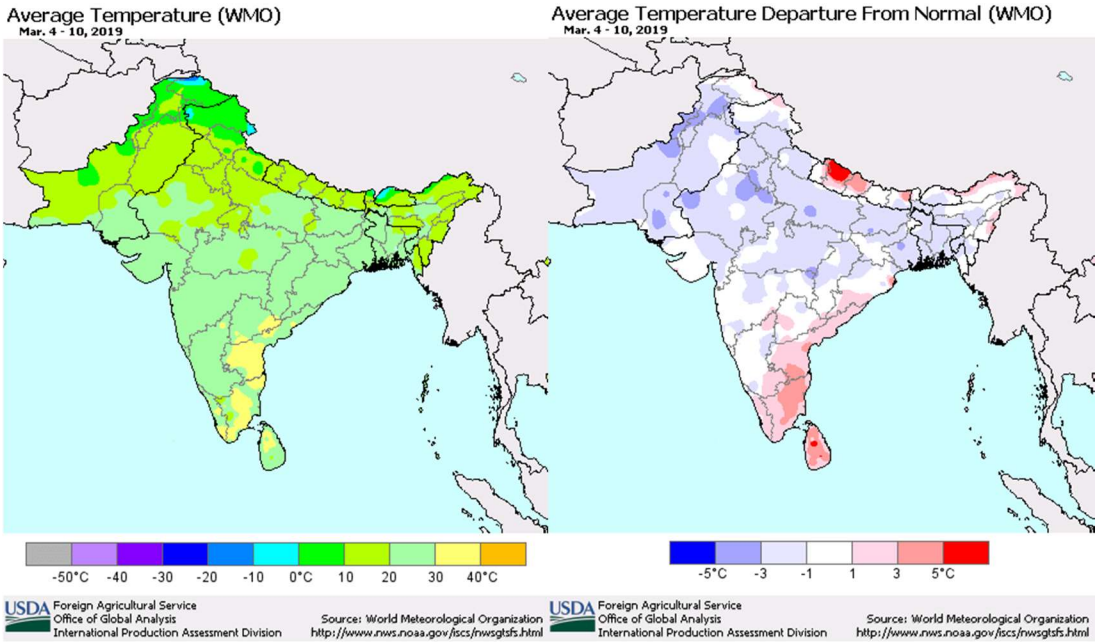


Figure 3: (Left) Observed Mean Temperature for the period 04/03/19 - 10/03/19and (right) departure from WMO normal.

4] Soil Moisture

Figure 4 shows the observed soil moisture percentage for 03/03/19. Low soil moisture values were observed over almost all provinces of India with values ranging between 0% and 10%. The far northern provinces (Jammu and Kashmir) and far eastern provinces(West Bengal) had slightly moister soils with values of between 70% and 100%.

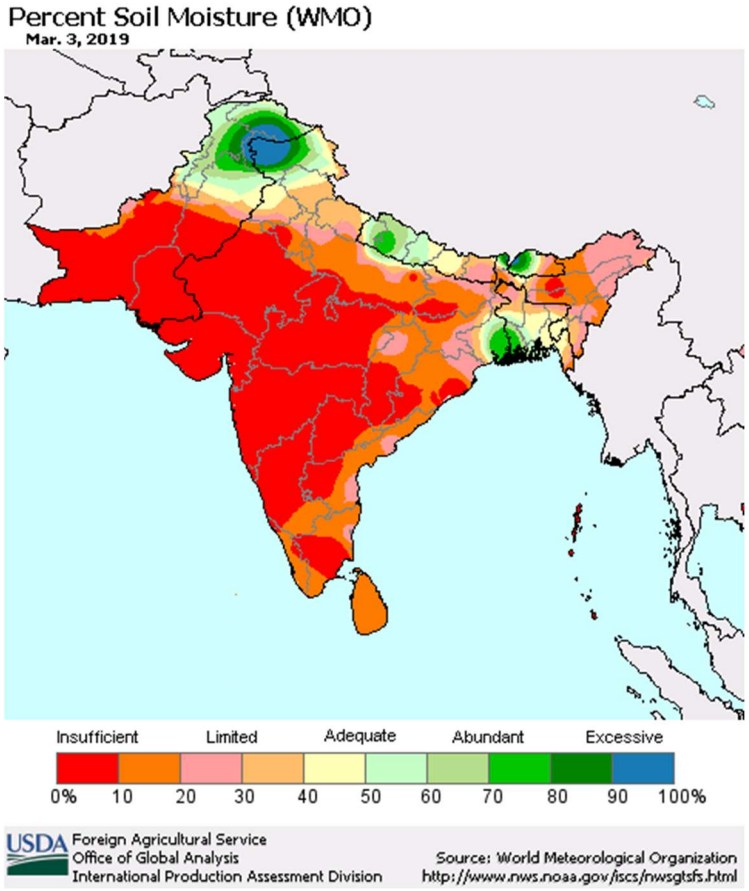


Figure 4: WMO Observed Percent Soil Moisture for 03/03/19.

B] Expected conditions:

MAY 2019 Rainfall in general over most provinces in India should be mostly average (**-12.5mm to +12.5mm**). Kerala and the very southern tip of Tamil Nadu should expect slightly ***below*** average rainfall (**0mm to -12.5mm**). Most of Himachal Pradesh and the southwestern areas of Jammu & Kashmir should expect slightly ***above*** average rainfall (**0mm to +12.5mm**). **Temperatures** are expected to be ***above*** average over the far western areas of Rajasthan, Madhya Pradesh, most of Maharashtra, Telangana, Odisha, Chhattisgarh, Odisha, Karnataka, Andhra Pradesh, Kerala and Tamil Nadu (**+0.5°C to +1.5°C**). The remainder of the Indian provinces should expect mostly average temperatures (**-0.5°C to +0.5°C**).

JUNE 2019: **Rainfall** in general will be average or ***below*** average over much of India and is ***forecast to be the driest month of the monsoon season***. Most provinces in the far northeastern areas (Assam, Meghalaya, Manipur, Nagaland and Manipur) and the very southern areas of Tamil Nadu should expect ***above*** average rainfall (**+12.5mm to +50mm**). Most of Maharashtra, Madhya Pradesh, Chhattisgarh, Odisha, northern areas of Telangana, Andhra Pradesh, eastern Uttar Pradesh, Bihar, Jharkhand and West Bengal should expect ***below*** average rainfall (**-12.5mm to -50mm**). All other provinces should expect mostly average rainfall for June. **Temperatures** are expected to be ***above*** average over most of India (**+0.5°C to +1.5°C**), with the highest departures over the central states (**+1.0°C to +1.5°C**). Jammu & Kashmir should expect mostly average temperatures (**-0.5°C to -0.5°C**).

JULY 2019: **Rainfall** in general will be ***above*** average over most of the southern provinces of India and ***below*** average over a few areas over northwestern and northern India. Specifically, most provinces in the west, including southern Gujarat, western Maharashtra and northwestern Madhya Pradesh and northwestern Uttar Pradesh should expect ***below*** average rainfall (**-12.5mm to -50mm**). The provinces of Telangana, Andhra Pradesh, Karnataka, Kerala, far western Tamil Nadu, far western Bihar and far northeastern Uttar Pradesh should expect ***above*** average rainfall (**+12.5mm to +50mm**). The remaining areas should expect mostly average rainfall (**-12.5mm to +12.5mm**). **Temperatures** are expected to be very similar to June, with ***above*** average temperatures over most of India (**+0.5°C to +1.5°C**), with the highest departures over the Northwestern states (**+1.0°C to +1.5°C**). The eastern coastal areas of Tamil & Nadu should expect mostly average temperatures (**-0.5°C to -0.5°C**).

AUGUST 2019: **Rainfall** in general will be average to ***above*** average over much of central and southwestern and far southern India and average over much of the northern. Specifically, most provinces in the west, including Madhya Pradesh southwards to Kerala, Tamil Nadu, northern Andhra Pradesh, Telangana and Chhattisgarh 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 ***above*** average over most of India (**+0.5°C to +1.0°C**), but average over the southwestern areas of India (**-0.5°C to -0.5°C**). No places should expect ***below*** average temperatures.

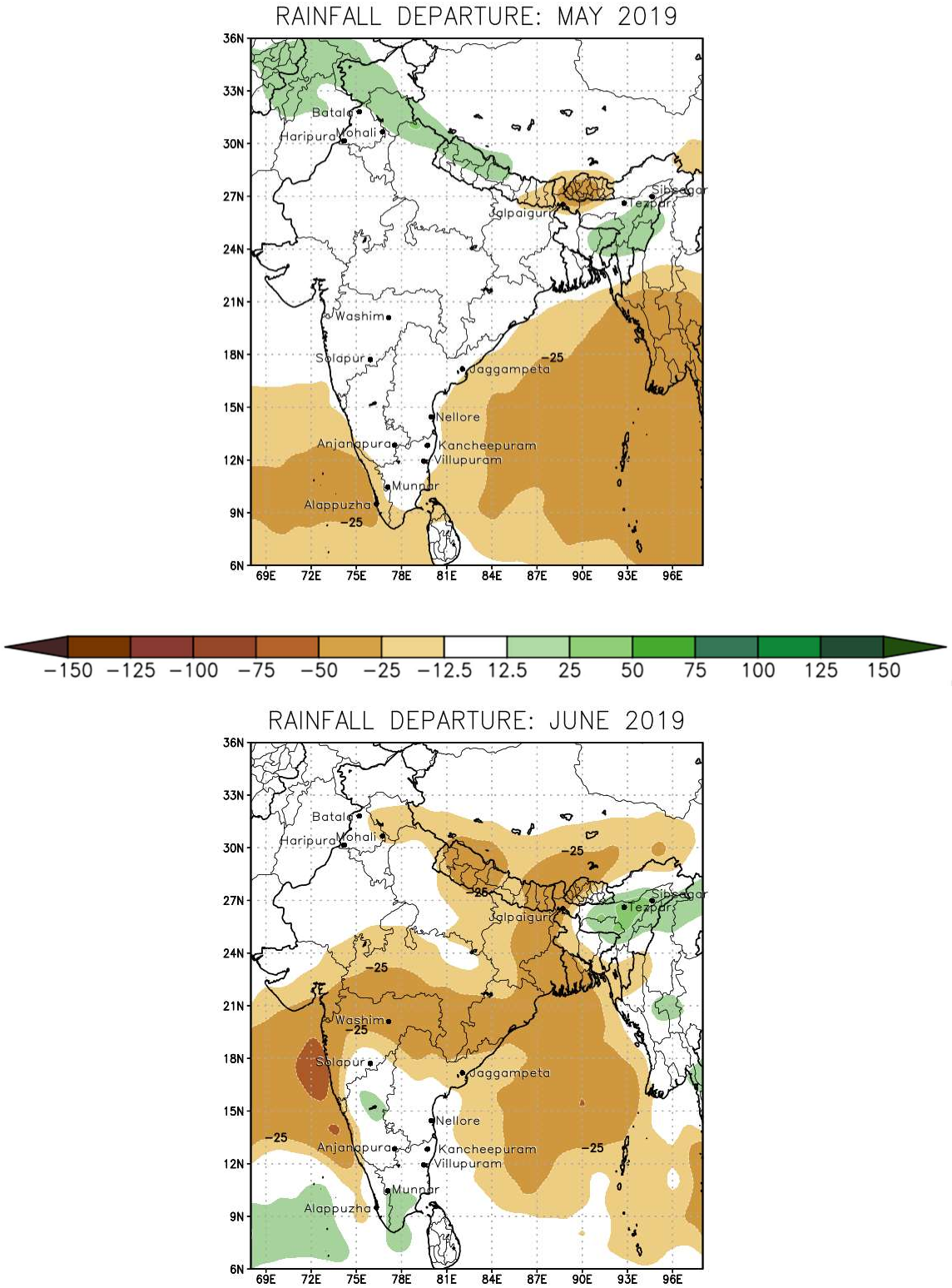
SEPTEMBER 2019: **Rainfall** in general will be mostly average to slightly ***above*** average over India. Specifically, most parts of eastern Bihar, Jharkhand, West Bengal, most of Madhya Pradesh, Chhattisgarh, Odisha, Kerala and far southern Tamil should expect slightly ***above*** average rainfall (**0mm to +12.5mm,** but up to **+25mm** over Odisha). The southeastern areas of Andhra Pradesh should expect slightly *below* 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 slightly ***above*** average over most of India (**+0.5°C to +1.0°C**). No places should expect ***below*** average temperatures. Temperatures are expected to be *above* average over Jammu and Kashmir (**+1.0°C to +1.5°C**).

OCTOBER 2019: **Rainfall** in general will be mostly **average** over almost all of India with a few exceptions. Specifically, most parts of eastern Bihar, southeastern Maharashtra, west coastal areas of Karnataka and far southern Tamil Nadu should expect slightly ***above*** average rainfall (**0mm to +12.5mm**). The extreme coastal areas of far northeastern Tamil Nadu and eastern Andhra Pradesh should expect slightly ***below*** 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 slightly ***above*** average over most of India (**+0.5°C to +1.0°C**). No places should expect *below* average temperatures.

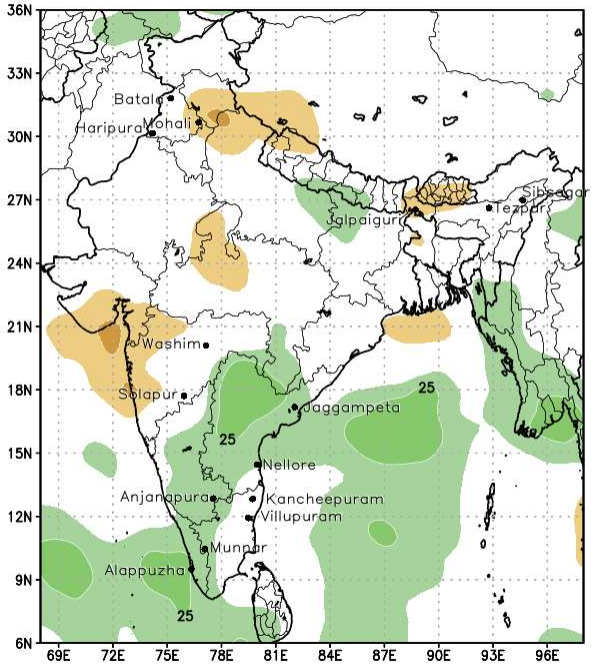
Figure 5 below shows the forecast monthly rainfall (mm) departures from average for India.

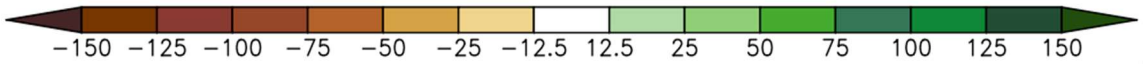
Figure 5: Mean monthly North American Multi-Model Ensemble (NMME) rainfall departures (mm) for the months of May - Oct 2019 (based on the forecast on 8th Mar 2019). Anomalies are computed with respect to the 1982-2010 base period monthly means.

RAINFALL DEPARTURES FROM AVERAGE

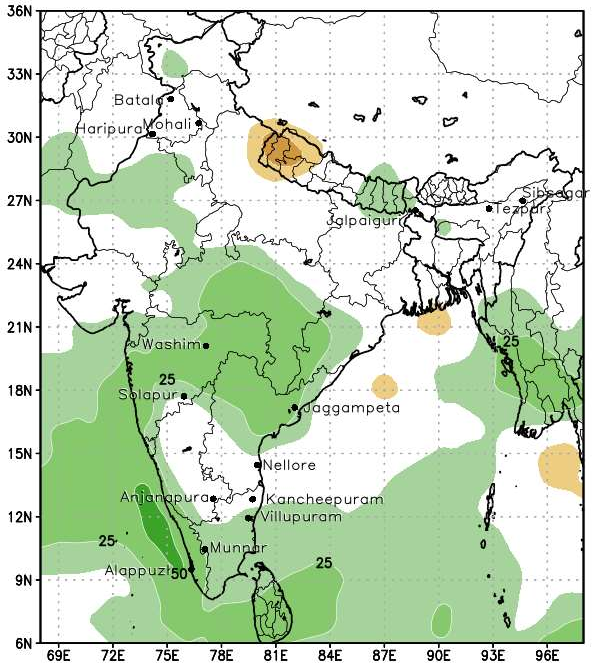


RAINFALL DEPARTURE: JULY 2019

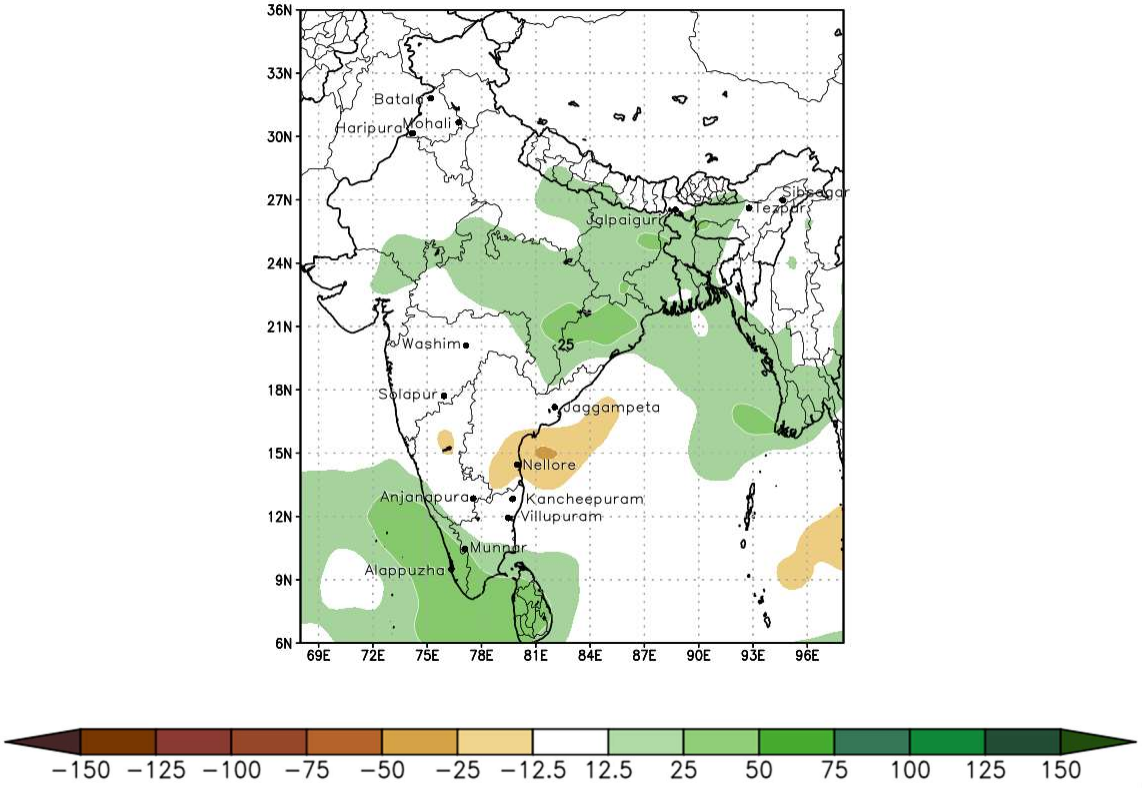




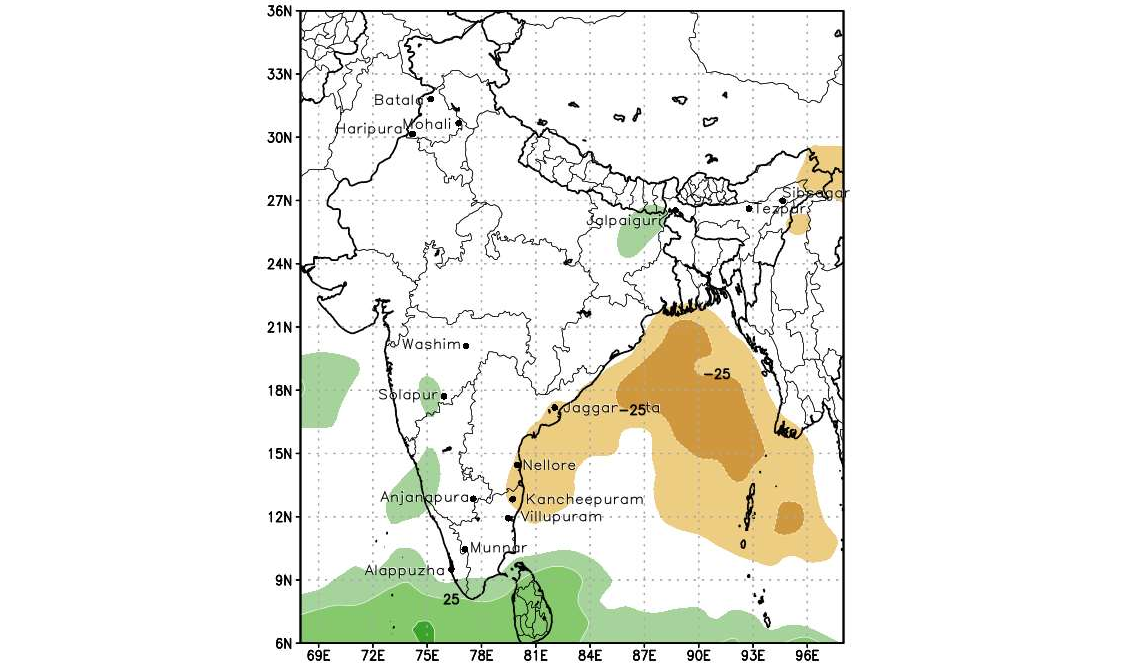
RAINFALL DEPARTURE: AUGUST 2019



RAINFALL DEPARTURE: SEPTEMBER 2019



RAINFALL DEPARTURE: OCTOBER 2019



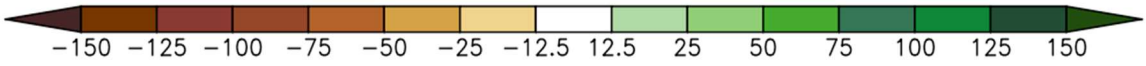
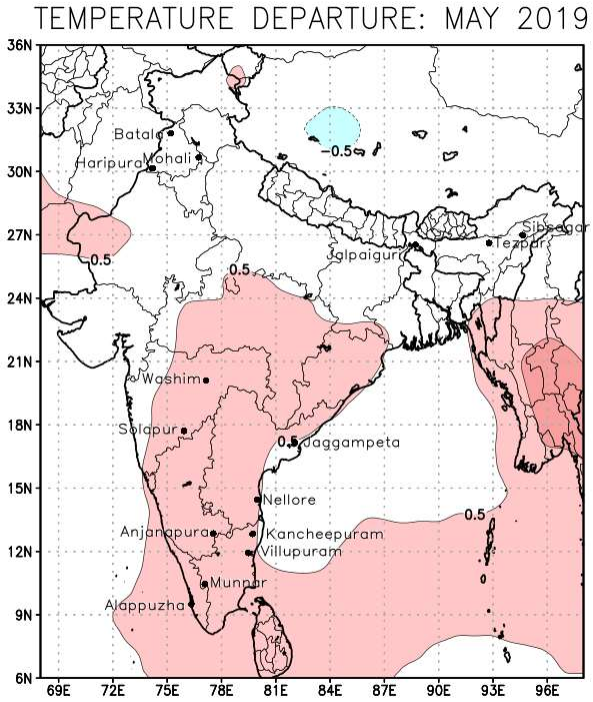


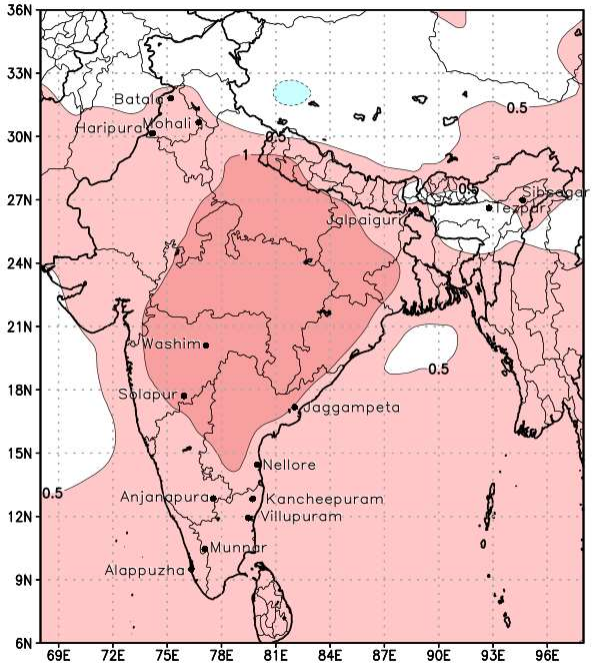
Figure 6 below shows the forecast monthly average temperature (C) departures from average for India.

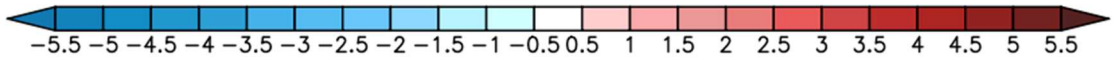
Figure 6: Mean monthly North American Multi-Model Ensemble (NMME) average 2-meter temperature departures (°C) for the months of May - Oct 2019 (based on the forecast on 8th Mar 2019). Anomalies are computed with respect to the 1982-2010 base period monthly means.

MEAN TEMPERATURE DEPARTURES FROM NORMAL

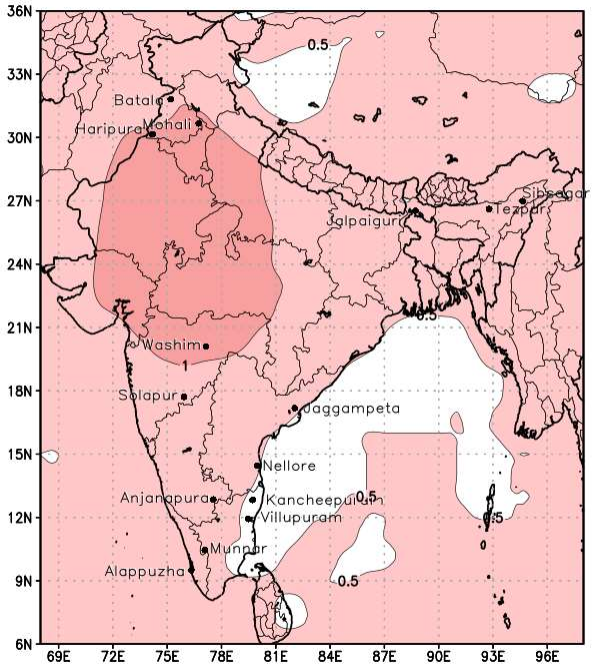


TEMPERATURE DEPARTURE: JUNE 2019

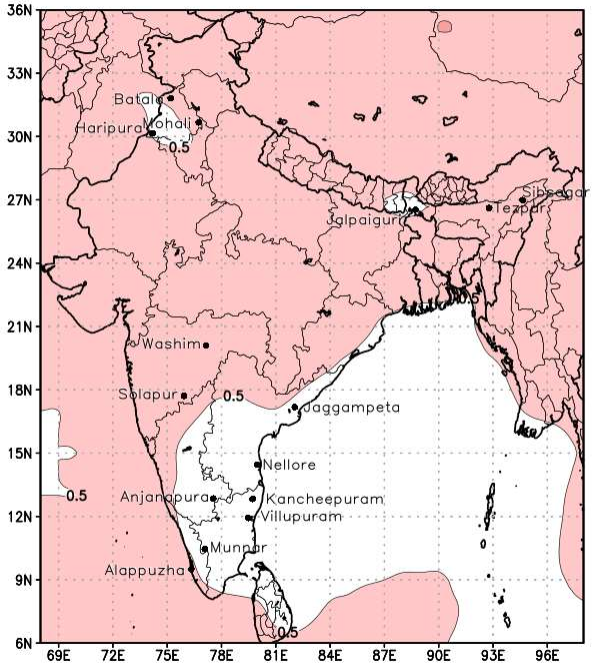


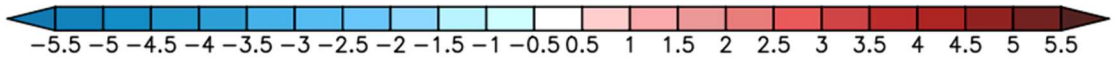


TEMPERATURE DEPARTURE: JULY 2019

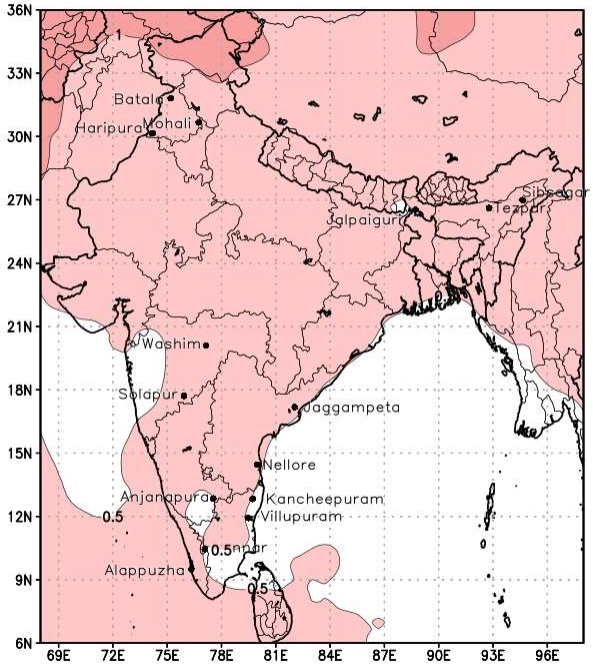


TEMPERATURE DEPARTURE: AUGUST 2019

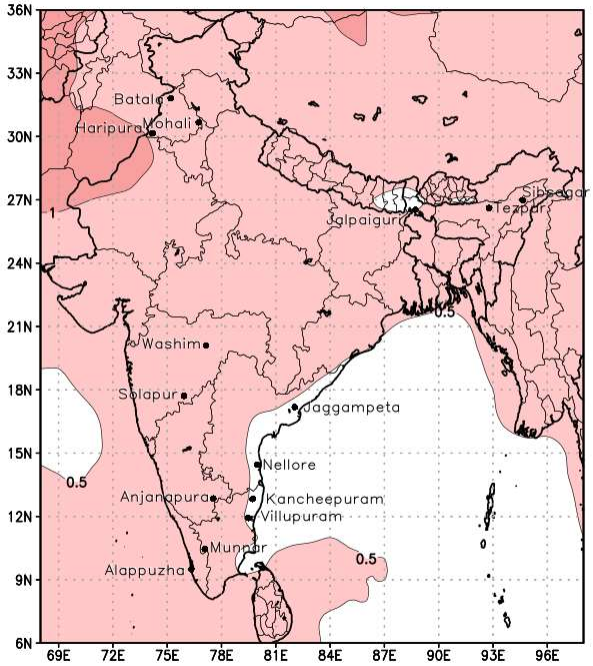




TEMPERATURE DEPARTURE: SEPTEMBER 2019



TEMPERATURE DEPARTURE: OCTOBER 2019

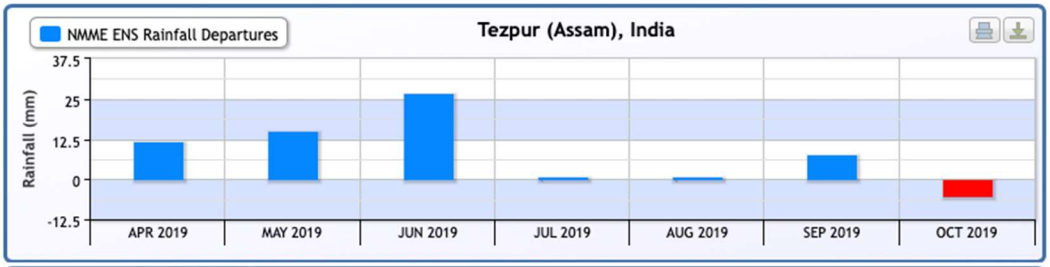


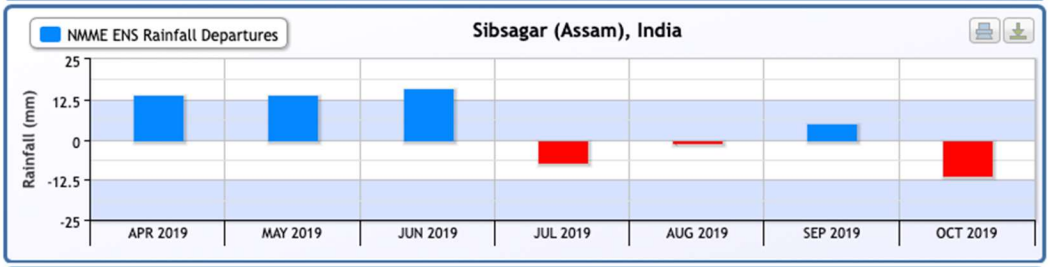
SUMMARY: MAY – OCTOBER 2019

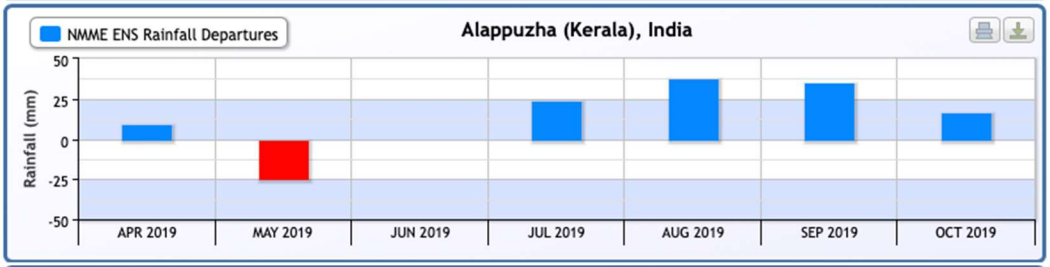
In general, total monsoon rainfall the 6-month forecast period should be mostly average, however, it will not be distributed evenly though the season. Generally, May should see mostly average rainfall, while June is forecast to have a ***deficit*** rainfall over large parts of Central and northeastern India, However, July, and especially, August, are forecast to have small rainfall ***surpluses*** over much of southern India in July and central and southern India in August. Northeastern India is the only area with small rainfall ***surpluses*** in September, while most other areas should expect mostly average rainfall. Average rainfall should be expected over most of India during October. Temperatures are forecast to be mostly average to slightly above average over the most of India throughout the forecast period. The exception will be over southeastern India during August when temperatures are expected to be mostly average. So, with a very much average monsoon season expected, no major rainfall deficits nor surpluses are expected based on the current NMME monthly forecasts!

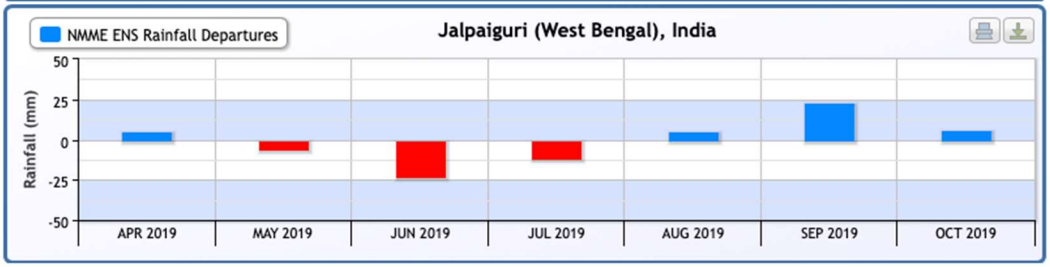
For actual expected monthly rainfall departures for a select listing of fifteen locations in agricultural regions, please see **Figure 7** below.

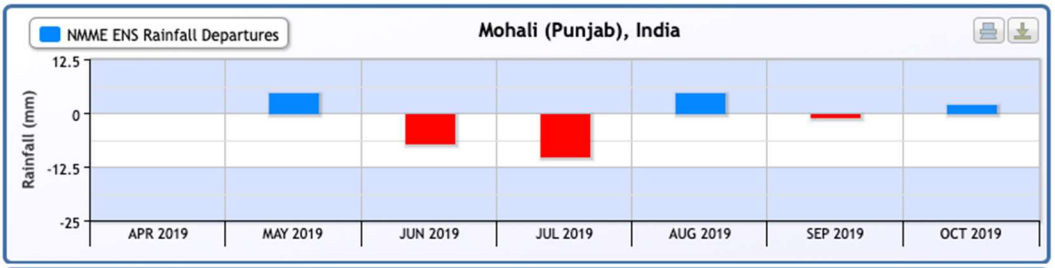
Figure 7 shows the expected rainfall departures from normal for the period **April - October 2019** for locations throughout important agricultural regions of India. (Blue is ***above*** average; red is ***below*** average – based on the NMME ensemble).

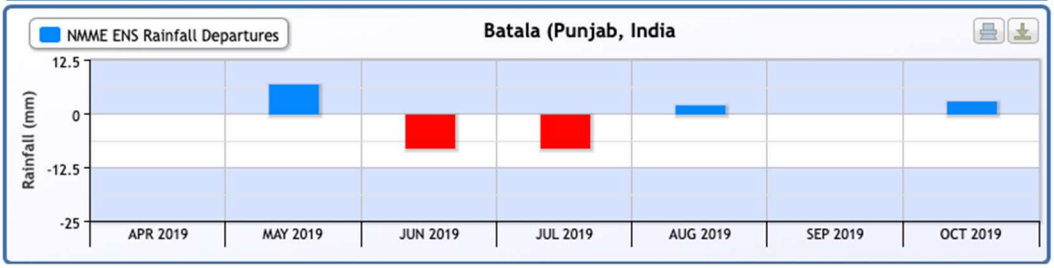

NMME ENS Rainfall Departures
Tezpur (Assam), India
Rainfall (mm)
37.5
25
12.5
0
-12.5
APR 2019
MAY 2019
JUN 2019
JUL 2019
AUG 2019
SEP 2019
OCT 2019

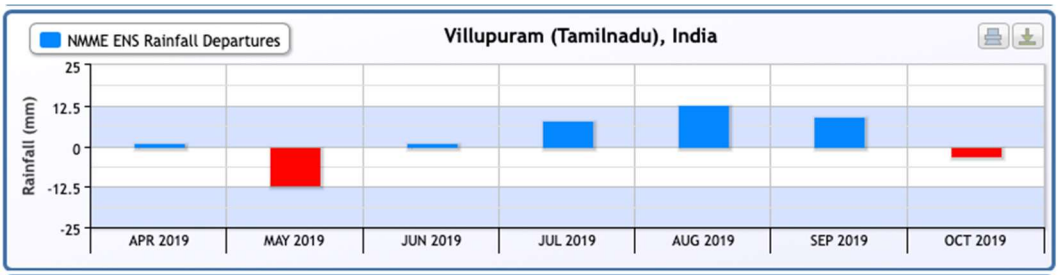

NMME ENS Rainfall Departures
Sibsagar (Assam), India
Rainfall (mm)
25
12.5
0
-12.5
-25
APR 2019
MAY 2019
JUN 2019
JUL 2019
AUG 2019
SEP 2019
OCT 2019

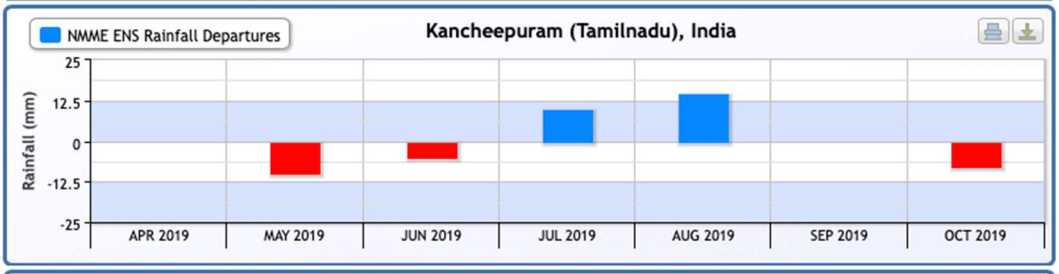

NMME ENS Rainfall Departures
Alappuzha (Kerala), India
Rainfall (mm)
50
25
0
-25
-50
APR 2019
MAY 2019
JUN 2019
JUL 2019
AUG 2019
SEP 2019
OCT 2019

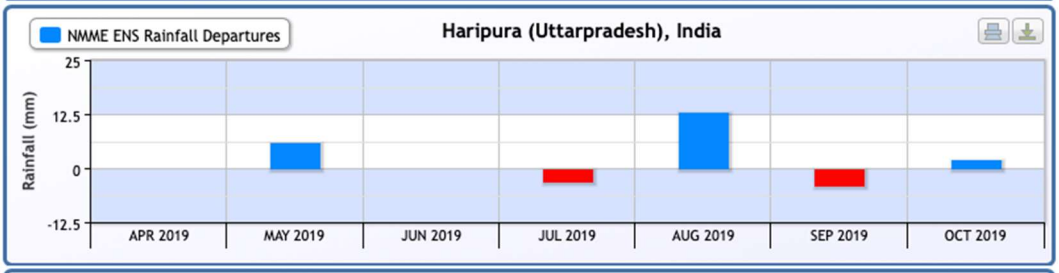

NMME ENS Rainfall Departures
Jalpaiguri (West Bengal), India
Rainfall (mm)
50
25
0
-25
-50
APR 2019
MAY 2019
JUN 2019
JUL 2019
AUG 2019
SEP 2019
OCT 2019

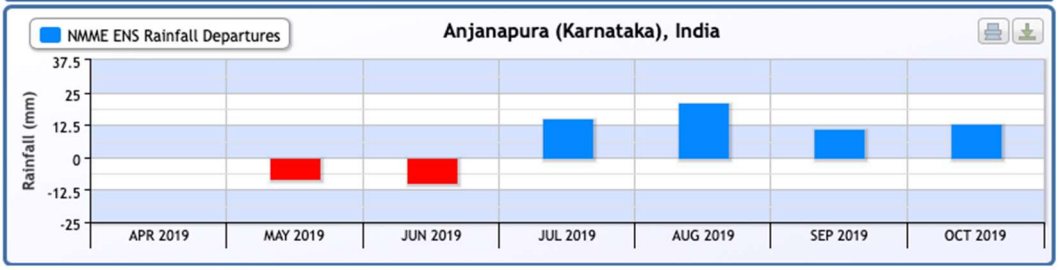

NMME ENS Rainfall Departures
Mohali (Punjab), India
Rainfall (mm)
12.5
0
-12.5
-25
APR 2019
MAY 2019
JUN 2019
JUL 2019
AUG 2019
SEP 2019
OCT 2019

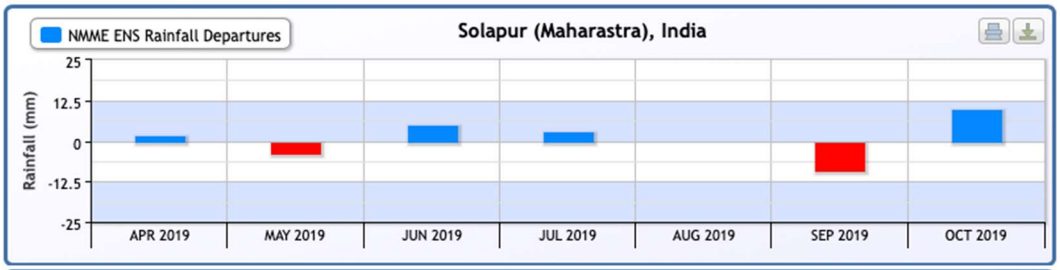

NMME ENS Rainfall Departures
Batala (Punjab), India
Rainfall (mm)
12.5
0
-12.5
-25
APR 2019
MAY 2019
JUN 2019
JUL 2019
AUG 2019
SEP 2019
OCT 2019

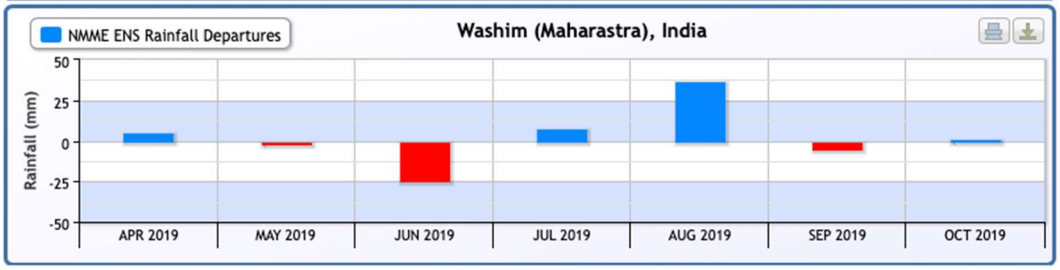

NMME ENS Rainfall Departures
Villupuram (Tamilnadu), India
Rainfall (mm)
25
12.5
0
-12.5
-25
APR 2019
MAY 2019
JUN 2019
JUL 2019
AUG 2019
SEP 2019
OCT 2019

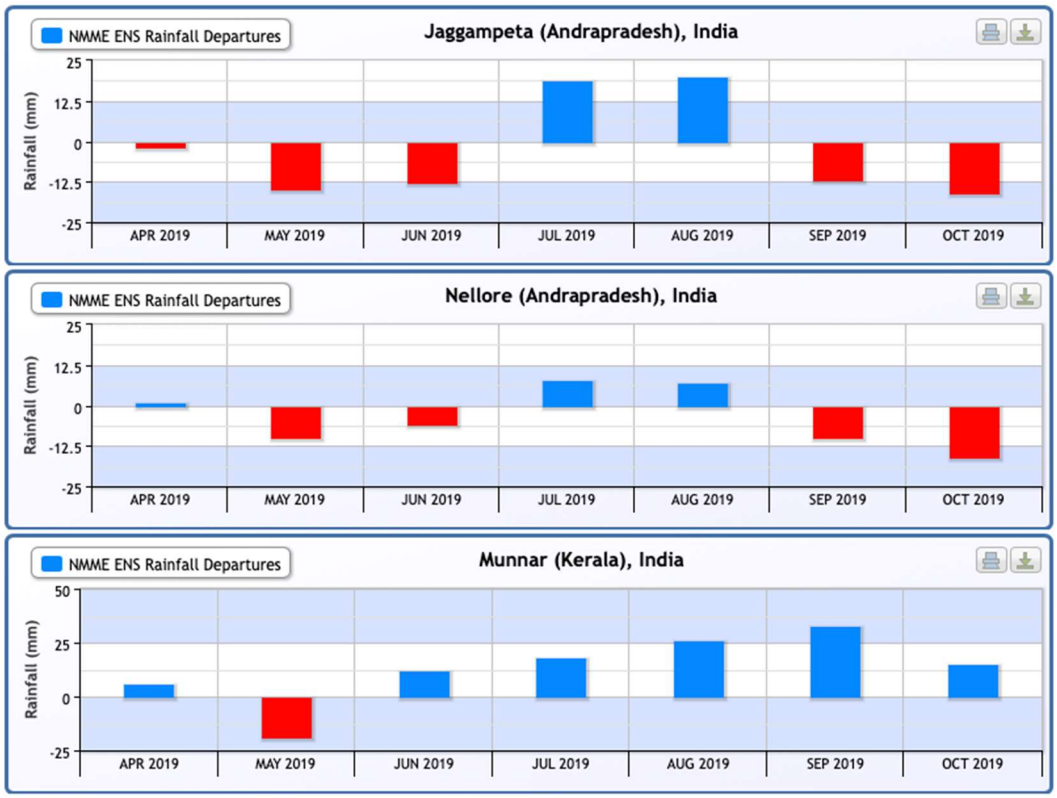

NMME ENS Rainfall Departures
Kancheepuram (Tamilnadu), India
Rainfall (mm)
25
12.5
0
-12.5
-25
APR 2019
MAY 2019
JUN 2019
JUL 2019
AUG 2019
SEP 2019
OCT 2019


NMME ENS Rainfall Departures
Haripura (Uttarpradesh), India
Rainfall (mm)
25
12.5
0
-12.5
APR 2019
MAY 2019
JUN 2019
JUL 2019
AUG 2019
SEP 2019
OCT 2019


NMME ENS Rainfall Departures
Anjanapura (Karnataka), India
Rainfall (mm)
37.5
25
12.5
0
-12.5
-25
APR 2019
MAY 2019
JUN 2019
JUL 2019
AUG 2019
SEP 2019
OCT 2019


NMME ENS Rainfall Departures
Solapur (Maharastra), India
Rainfall (mm)
25
12.5
0
-12.5
-25
APR 2019
MAY 2019
JUN 2019
JUL 2019
AUG 2019
SEP 2019
OCT 2019


NMME ENS Rainfall Departures
Washim (Maharastra), India
Rainfall (mm)
50
25
0
-25
-50
APR 2019
MAY 2019
JUN 2019
JUL 2019
AUG 2019
SEP 2019
OCT 2019



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