The Rainfall Climate over Sri Lanka during 2016

Ruchira Lokuhetti, Lareef Zubair
Foundation for Environment, Climate and Technology,
Digana Village, Rajawella, Sri Lanka.

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Summary

Overall, the accumulated rainfall for the whole island during 2016 was 15% above what is normal. However, this masks, the fact that the island faced 11 dry months and one extremely wet May. In fact, there were 49 dekads (1/3 of a month) that were dry and only two wet dekads and one extremely wet one mid-May.

2016 was unique in that El Nino conditions prevailed till May and after a neutral June, a weak La Nina established itself for the rest of the year with some periods in which it was fully fledged. Such a rapid transition from El Nino to La Nina in two months has happened only rarely and had critical consequences for Sri Lanka.

The Indian Ocean SST behaved in a fashion closer to what is typical for El Nino overall from May 2015 – with warmer conditions and a positive Indian Ocean Dipole. Along with the transition to La Nina, a negative Indian Ocean Dipole established from June to November 2016.

The rainfall modulation during 2016 – reduced January to April rainfall, low Yala rainfall is typical of periods where an El Nino prevailed – and low Maha (October to December) rainfall is typical of La Nina conditions.

At the Intra-Seasonal scale (up to 7-60 days), the Madden Julian Oscillation was active over the Indian Ocean (i.e in phases 2 and 3) with a significant magnitude from Jan (13-20), May (7-17) and Jun (12-21).

The temperature over Sri Lanka dropped to normal levels after June after a record setting 2015 going until Apirl 2016 as the El Nino waned and the Indian Ocean Dipole turned to a negative anomaly.

Further Information

Technical details regards the climate of Sri Lanka are provided in a series of research papers published in the International Journals and available via www.climate.lk. Our weekly climate updates are available at [http://fectsl.blogspot.com.](http://fectsl.blogspot.com)

Data Used

We use ground observations and satellite derived estimates. The satellite data is derived from a 10-km grid resolution estimate from the US NOAA known as RFE (Rainfall Fall Estimate). This combines satellite data and contemparaenously available ground observations and it is produced with a lag of less than a day. Daily, weekly, dekadal, and monthly data were estimated. Note- each month is broken into three dekads of approximately 10 days. Ground obsevations were obtained from a variety of sources including our own weather stations (set up in Digana, Akurana and Aranayaka) and the Departments of Meteorology, Agriculture, Irrigation and private institutions. Ground observations while usually more accurate, are not immediately available and in the case of the Department of Meteorology, prohibilitively expensive.

We have found that satellite derived data approximately follow the ground observations in the past with a systematic under-estimation of about 10-20% in the hill country. Such underestimates are easily corrected.

As a check, we show below a comparison of All Sri Lanka Rainfall (ALSR – see Zubair et al., 2008) based on weekly ground observed data and satellite data in Figure 1. At the national scale, the satellite and ground observed data tracks quite closely. There are some discrepancies in weeks 43 and 44.

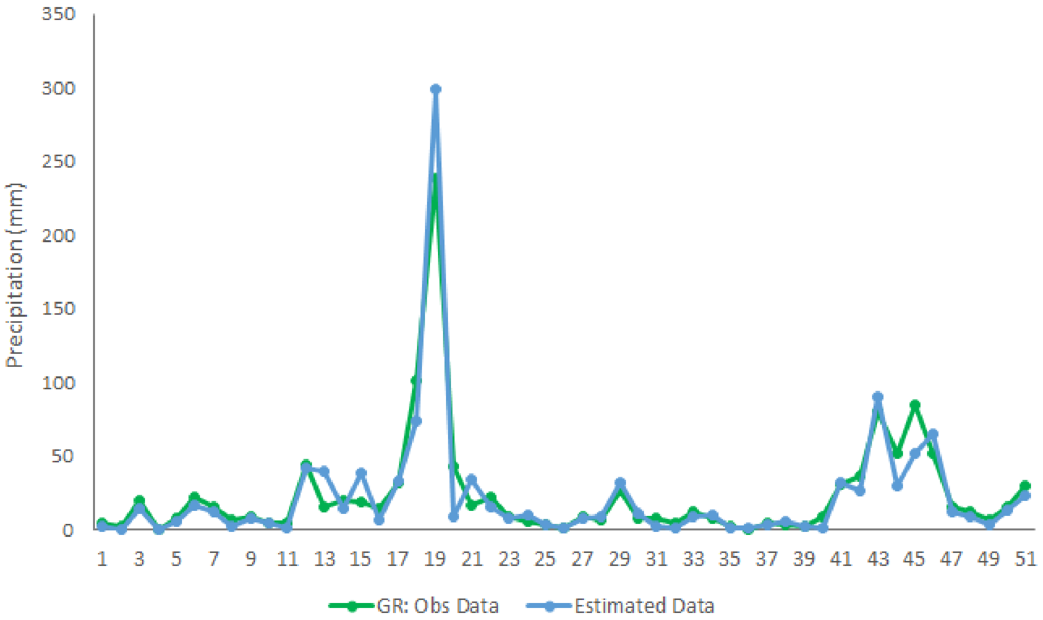


Figure 1: *Comparison between Ground Observed Data and Satellite Estimated data.*

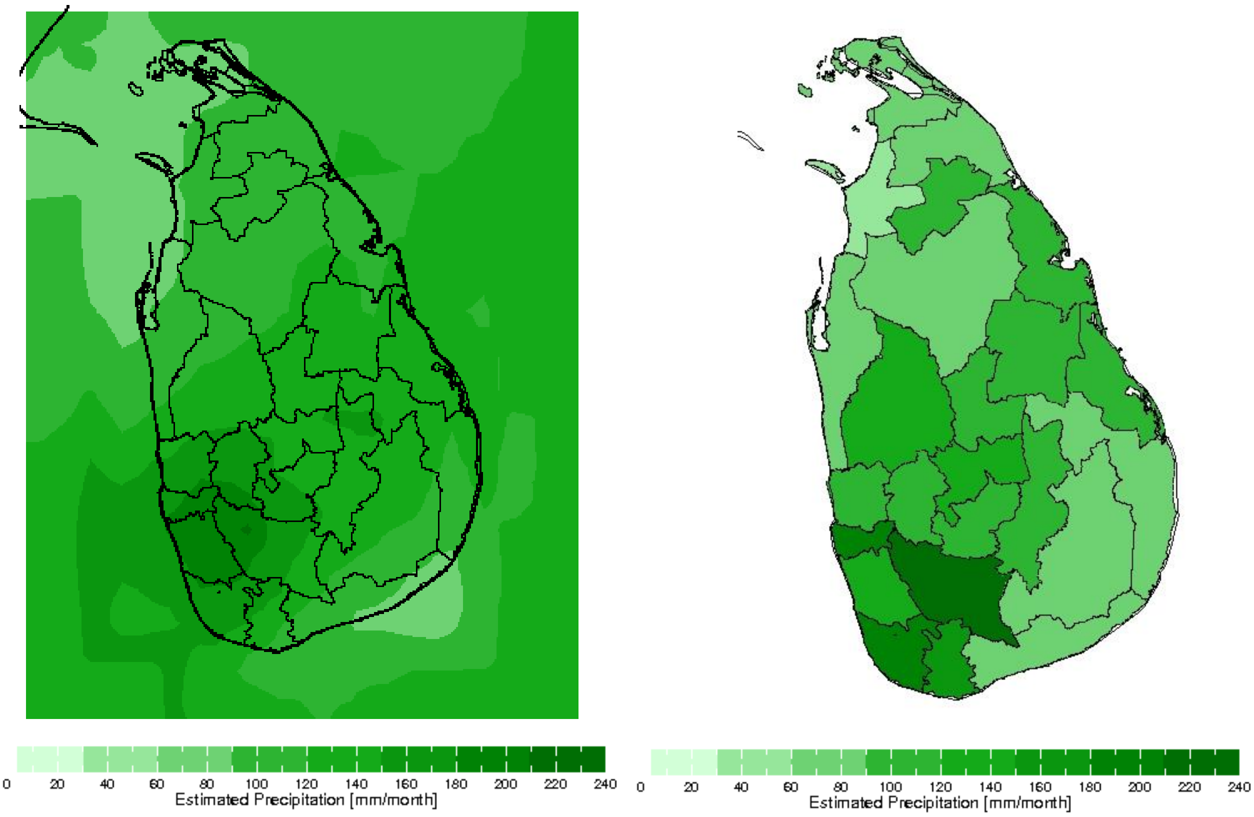


Figure 2: *Left: Annual average precipitation for Sri Lanka estimated from RFE. Right: Annual average precipitation for Sri Lanka from Ground Observations from the Sri Lanka Department of Meteorology, FECT and other observatories.*

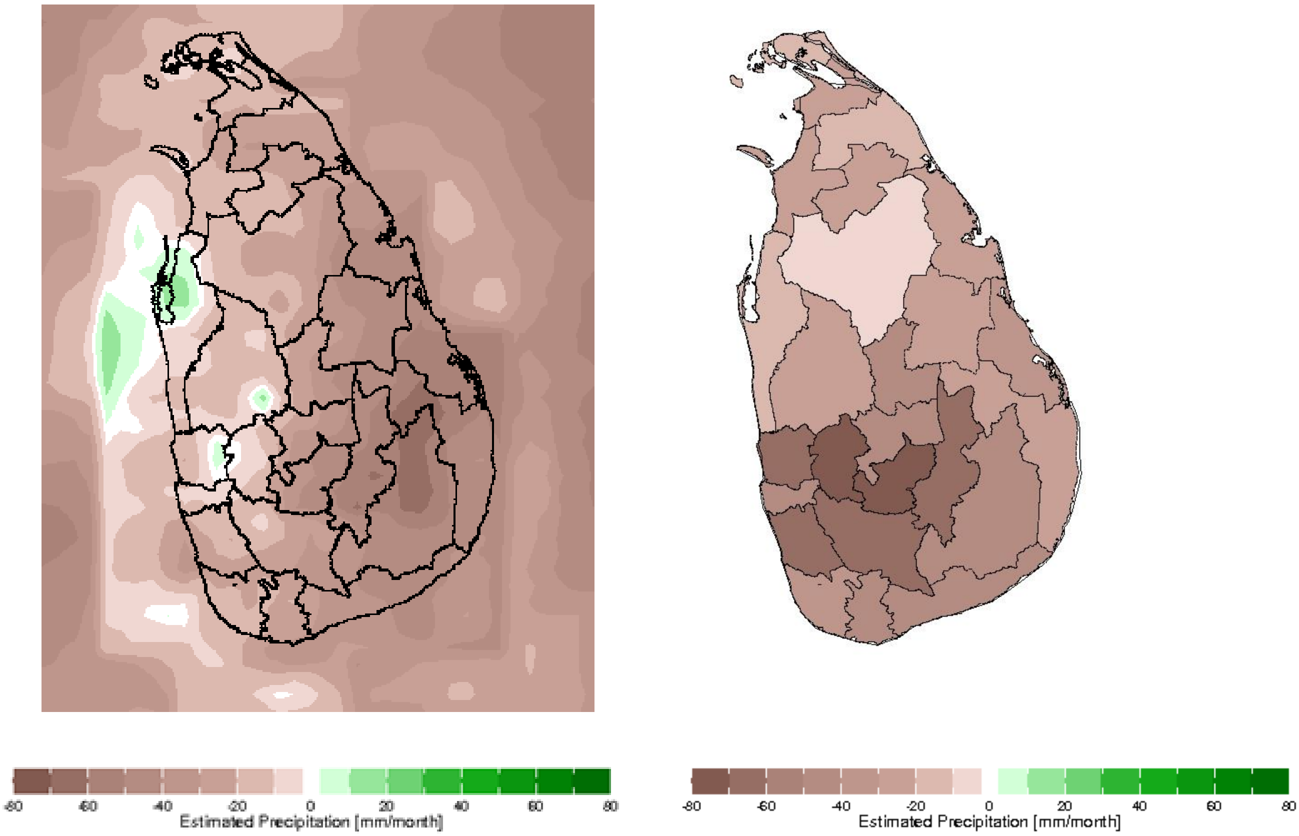


Figure 3: *Left:* ***Yearly precipitation anomaly for Sri Lanka estimated from RFE.*** *The rainfall anomalies are computed from the average since 2002. Right:* ***Yearly precipitation anomaly for Sri Lanka from Ground Observations.*** *The rainfall anomalies are computed from the average since 1980-2010*

Island-Wide Rainfall in 2016

Figure 4 shows that there has been low rainfall in 2016 to what was seen in the previous drought period during 2013.

Figure 5 shows the dekad by dekad departure of rainfall for 2013 up to 2016. It shows that the rainfall was extreme for the second Dekad of May 2016 and above average in the 3rd Dekad of July and 1st Dekad of November. Apart from these 3 dekads, the rainfall has been sustainedly below average rainfall for the rest of the year.

The cumulative rainfall is the total accumulation starting from January 1 of 2016 upto the selected dekad (Figure 6). Sri Lanka received lower than average rainfall until April, a rapid pickup in rainfall in mid-May and then again a lower than seasonable for the rest of the year which still left a 200 mm excess than normal. However, this figure masks the extended drought because the extreme rainfall in May 2016. The heaviest rain received in May was in Western and Sabaragamuwa provinces and all the other provinces had high excesses as well particularly those to the Western half of Sri Lanka.

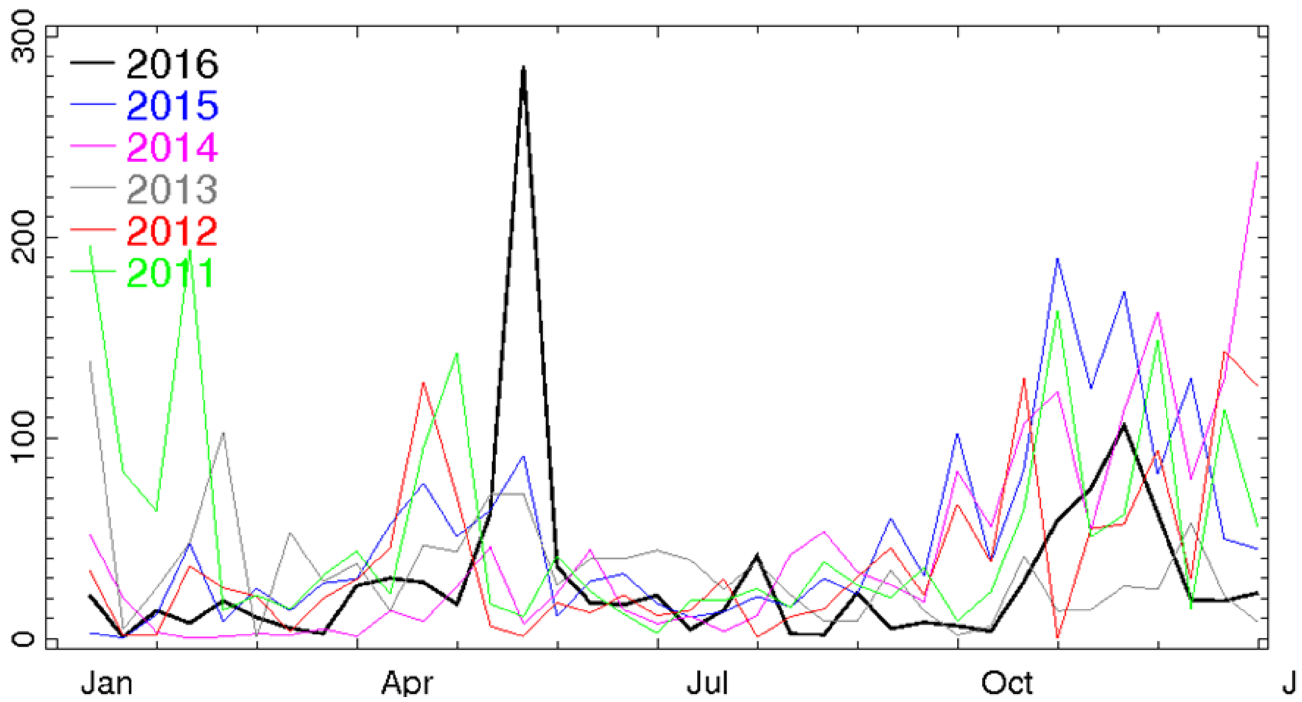


Figure 4:* *Multi-year dekadal (10-day) precipitation comparison for Sri Lanka: *The average rainfall for each dekad (roughly 10 days) over Sri Lanka estimated from satellites and ground observations is shown for the last 6 years as a line in a separate colour over a common January – December axis with 2016 in bold black.*

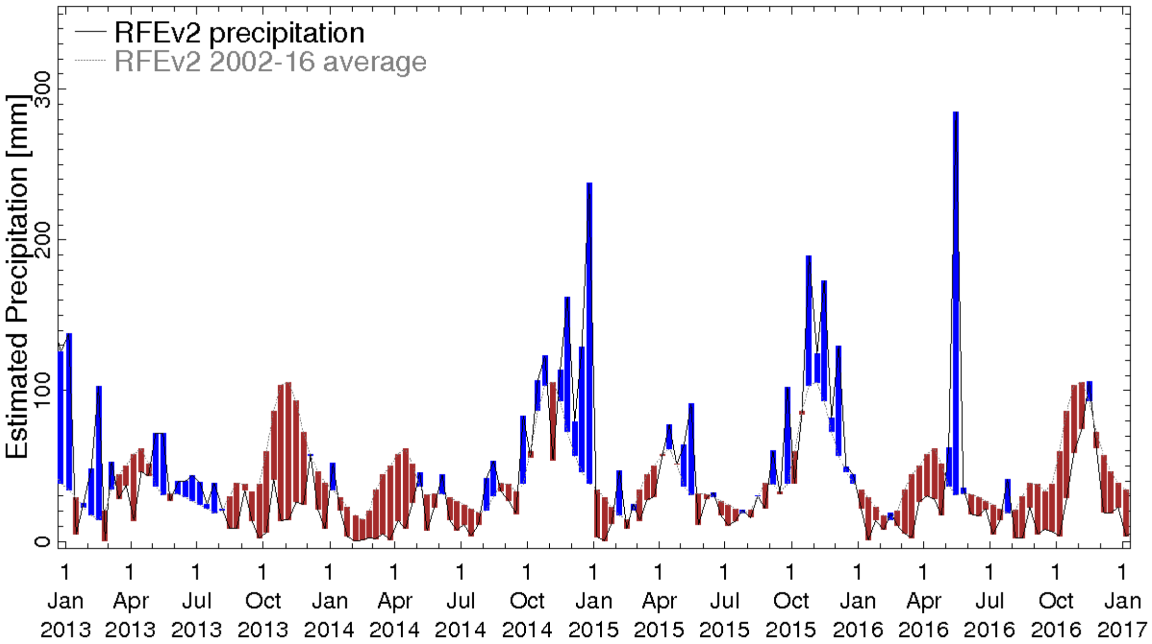


Figure 5:* *Dekadal precipitation of past four years and 2002-2016 average for Sri Lanka: *The smoother curve shows the average over 2002-2016 – this annual cycle is reproduced for each year in the above figure. The departures from this average are shown wetter (blue) and dryer (brown) for each month for the last three years. A dekad refers roughly to 10 days or more accurately as each month divided into three.*

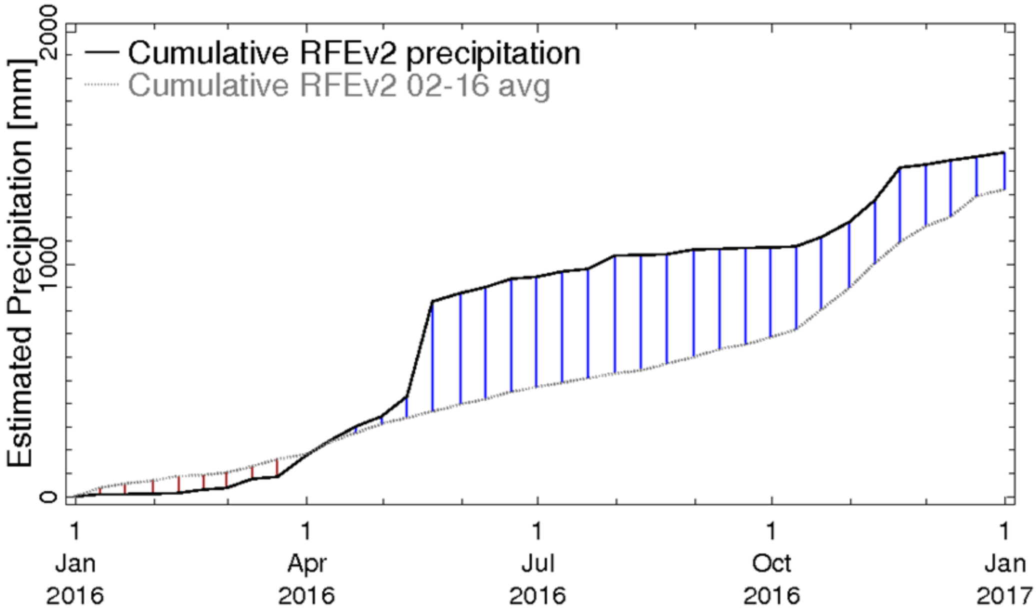


Figure 6: *Cumulative dekadal satellite derived estimates are shown in solid black line and the cumulative recent short term average precipitation is shown in grey dotted line for the most recent 12- months period in the selected region. The blue bars indicate the above average rainfall.*

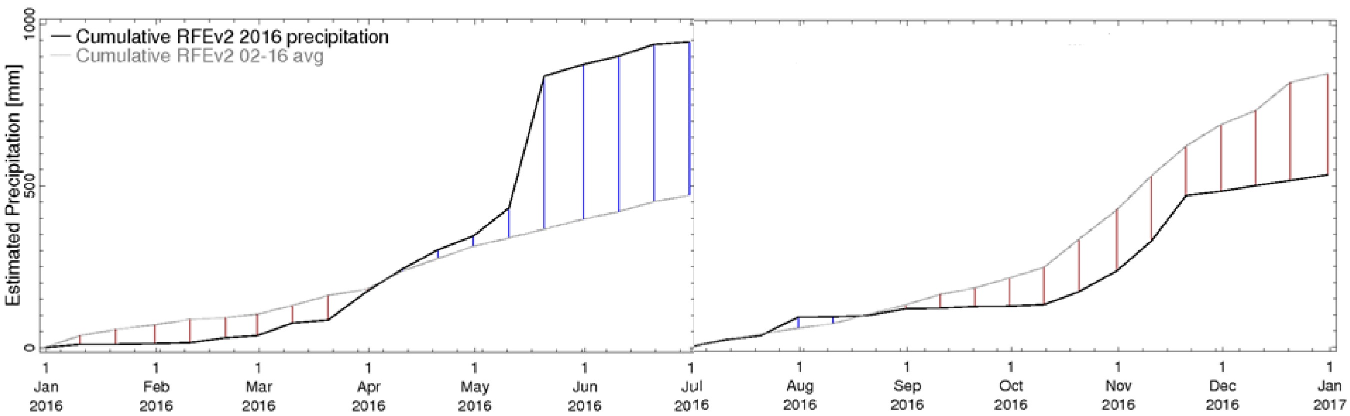


Figure 7: *Cumulative dekadal satellite derived estimates for the first half and for the second half of 2016. The blue bars indicate the above average rainfall.*

Regional Variation in Rainfall during 2016

Annual Rainfall

The map on the left of Figure 2 shows the total rainfall on a 10-km grid as estimated by the RFE. The anomalies (or departure from the long-term average) for each grid cell is computed by subtracting the average for that grid, over the previous 15 years. The anomalies are in Figure 3. Both ground observed and RFE seems to show that the rainfall was consistently below average for the entire island. There are some minor discrepancies as to the districts with the strongest drought and the slight excess in rainfall for the northern regions of Puttalam district. Note, some of these are artefacts arising from the comparison of gridded data with district-wise averages.

Rainfall by Quarter

Rainfall during January-March, April-June, July-September and October-December are shown in Figure 8. These correspond to the latter half of the 2015/2016 Maha, the latter and early halves of the Yala and the early half of the 2015/2017 Maha seasons. The rainfall in late Maha of 2015/2016 was deficient and the rainfall in the early Yala was in excess. The rainfall during late Yala and early Maha of 2016/2017 were significantly deficient.

Monthly Rainfall

The monthly rainfall anomalies shown in Figure 9 shows that apart from extreme rainfall received in May the rainfall largely remained below average throughout the year.

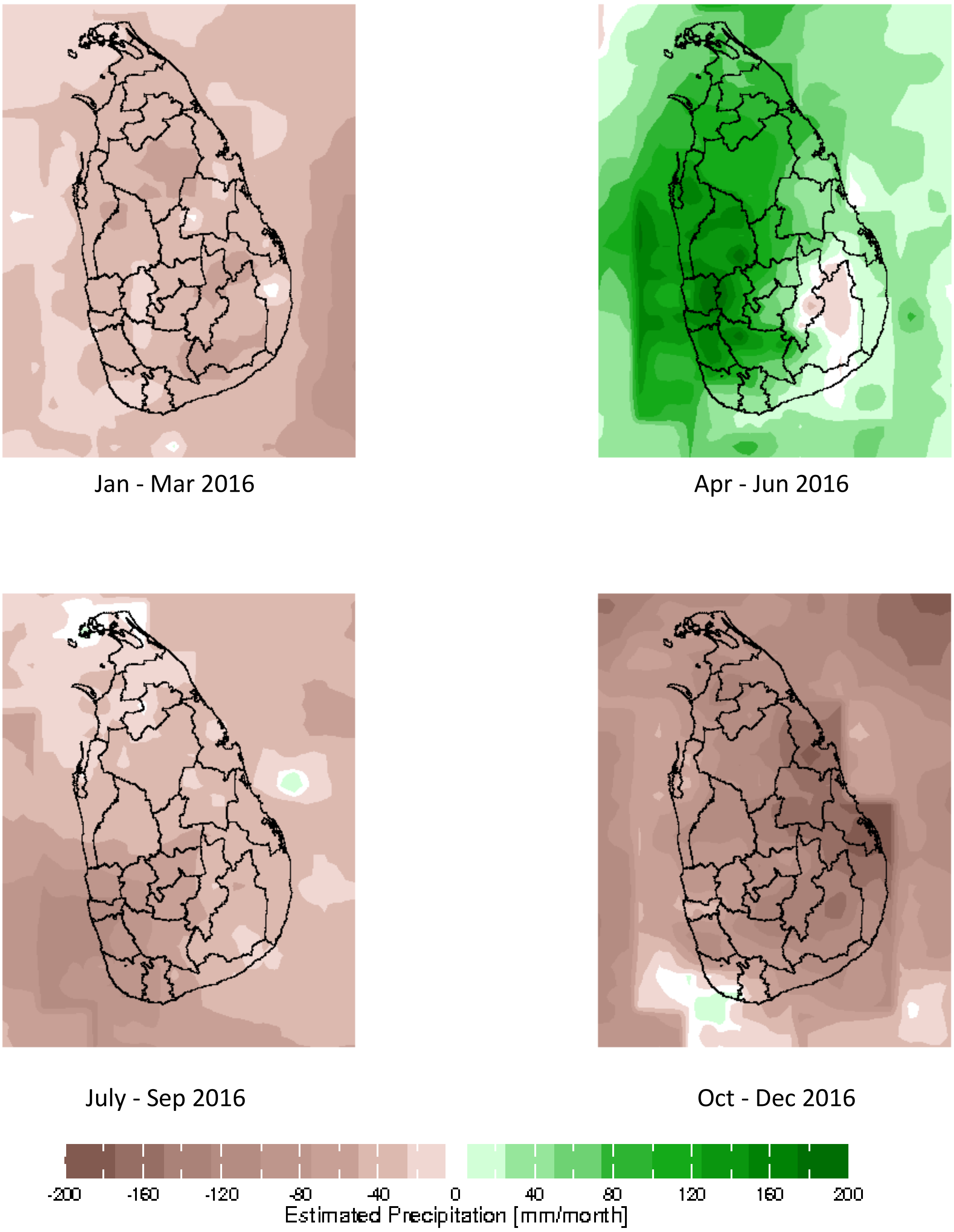


Figure 8: Quarterly seasonal precipitation anomalies for Sri Lanka for 2016. *Rainfall anomalies for January-March (late Maha), and the first (April-June) and second (July-September) half of Yala and October-December (early Maha) are shown. The average rainfall is calculated for January 2002-December 2016*

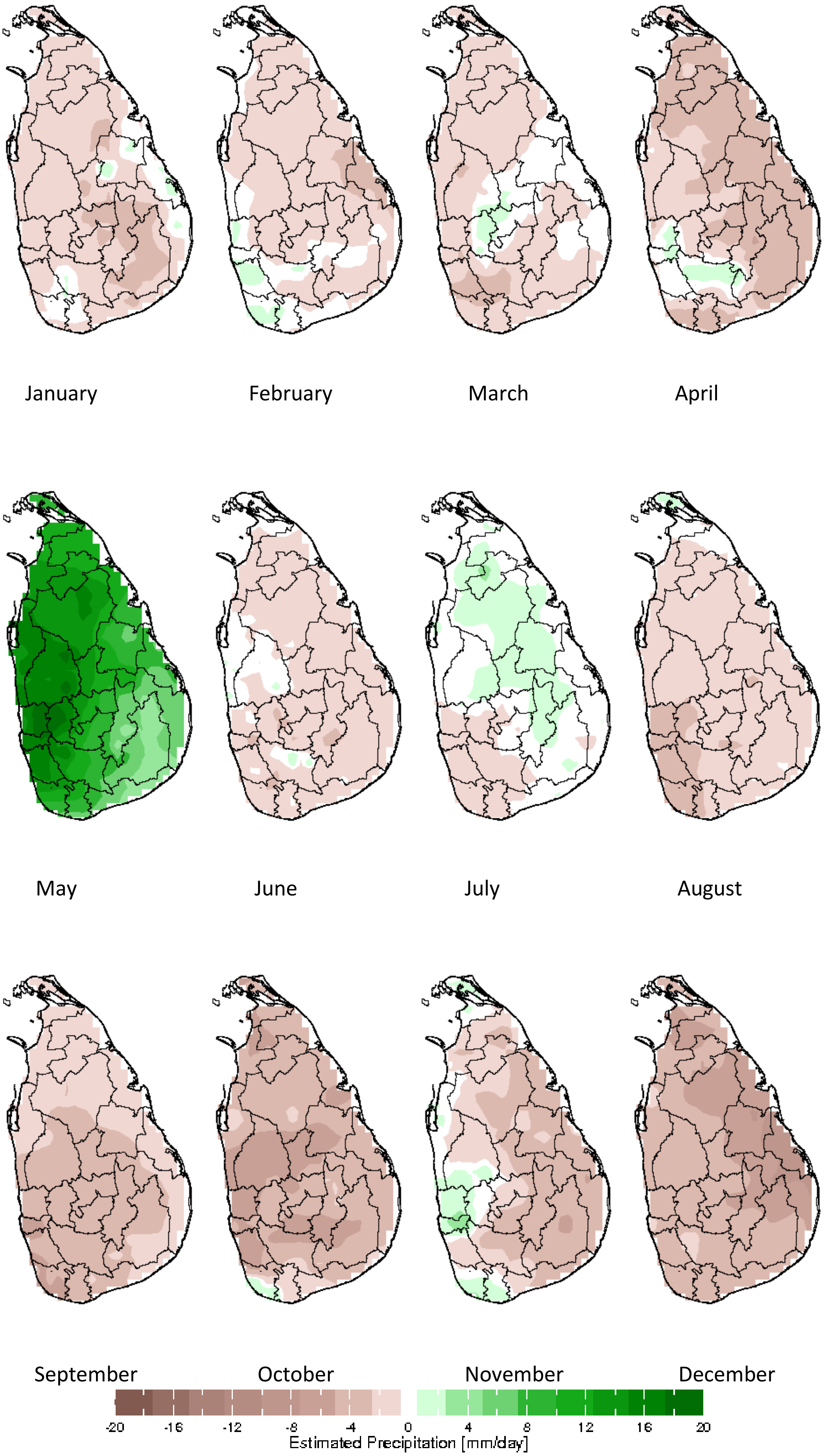


Figure 9: Monthly precipitation anomalies for 2016.

Island-Wide Temperature in 2016

Sri Lanka was much warmer from June 2015 until December 2016 than long-term historical average (1900-2004) but comparable to recent average temperatures (1994-2014). Still the temperatures from January to May 2016 was higher by about 1.5 degrees.

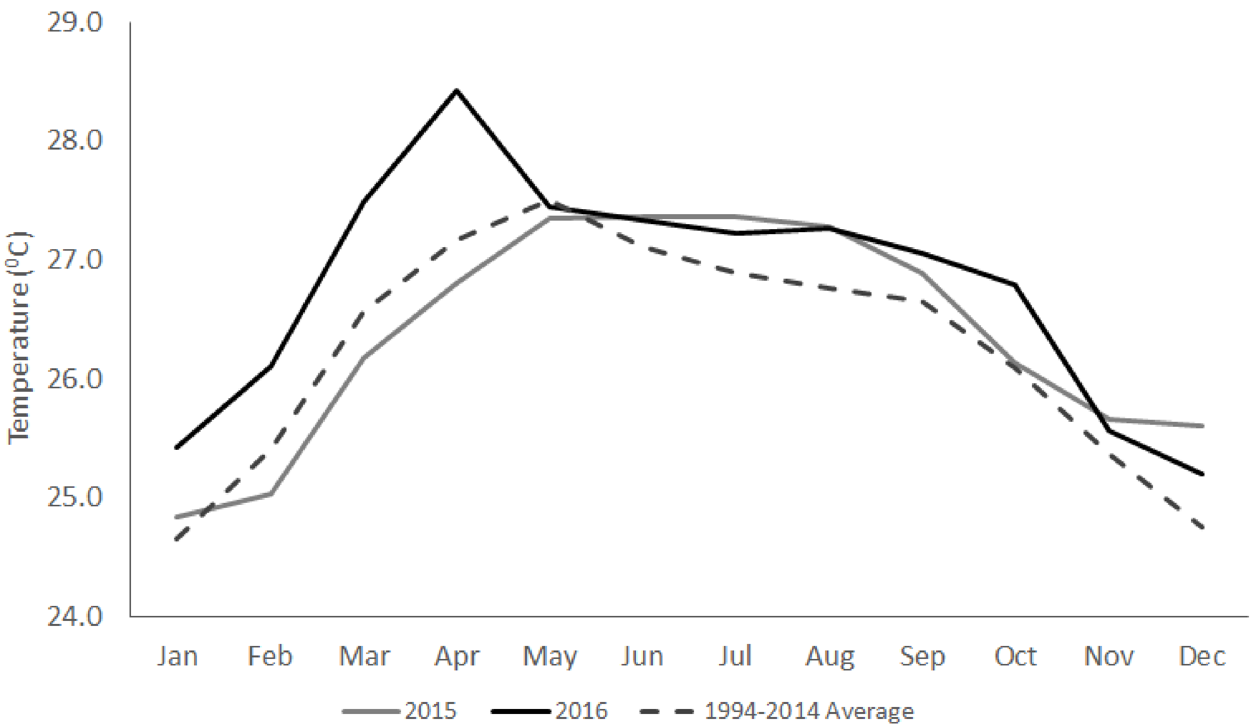


Figure 10: Monthly average temperatures for 2015 and 2016. *The average monthly temperatures is calculated for 1994-2014. The temperature was calculated based on well distributed ground observed stations.*

Major Climate Teleconnections: El Nino, Indian Ocean Dipole Climate Modes during 2016

Climate Indices

Sri Lanka climate is affected by the oceanic conditions. In Eastern Equatorial Pacific region, strong El Nino conditions were observed until mid-2016 and weak La Nina conditions prevailed during the remainder of the year. During La Nina, usually rainfall from September to December is lower than the average.

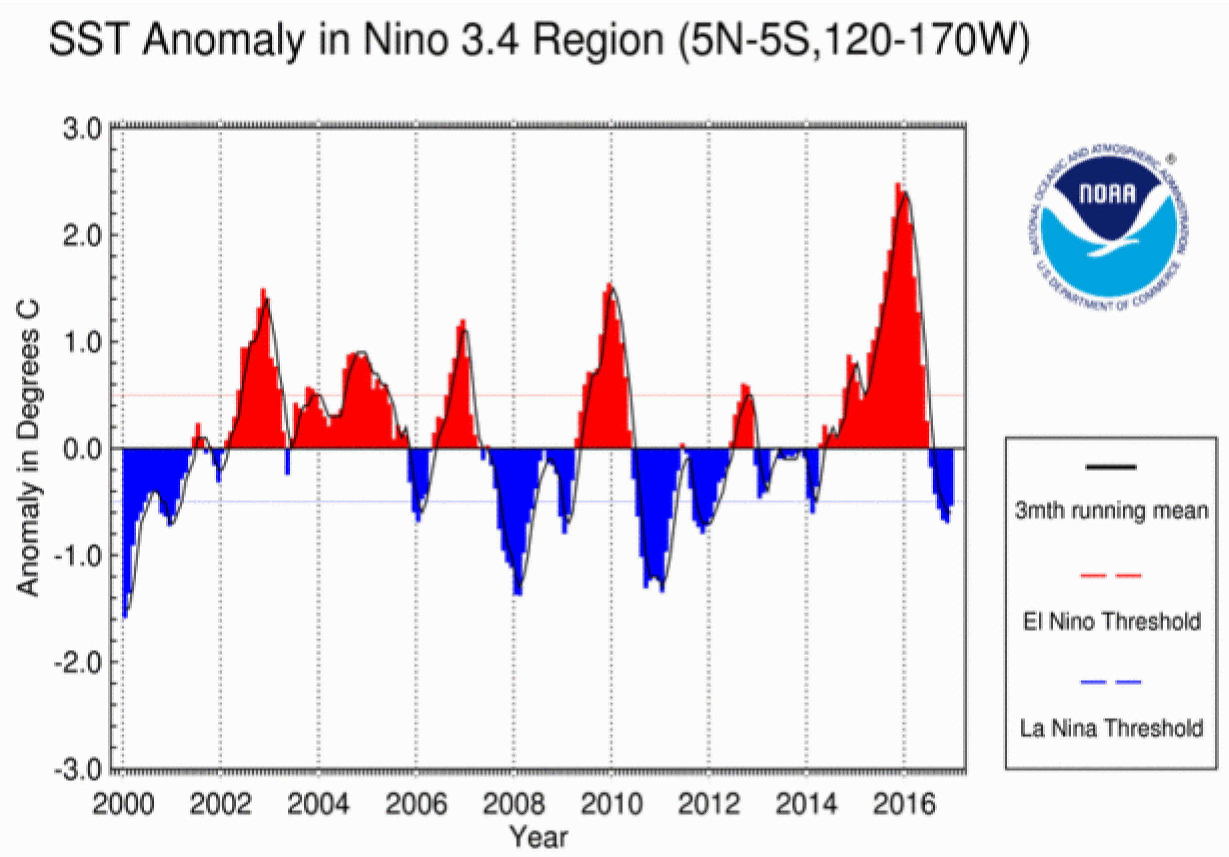


Figure 11: Historical NINO3.4 Sea Surface Temperature Anomaly. Source: NOAA

El Nino conditions developed in June 2015 lasted until June of this year. Weak La Nina conditions were evident for the last quarter of the year.

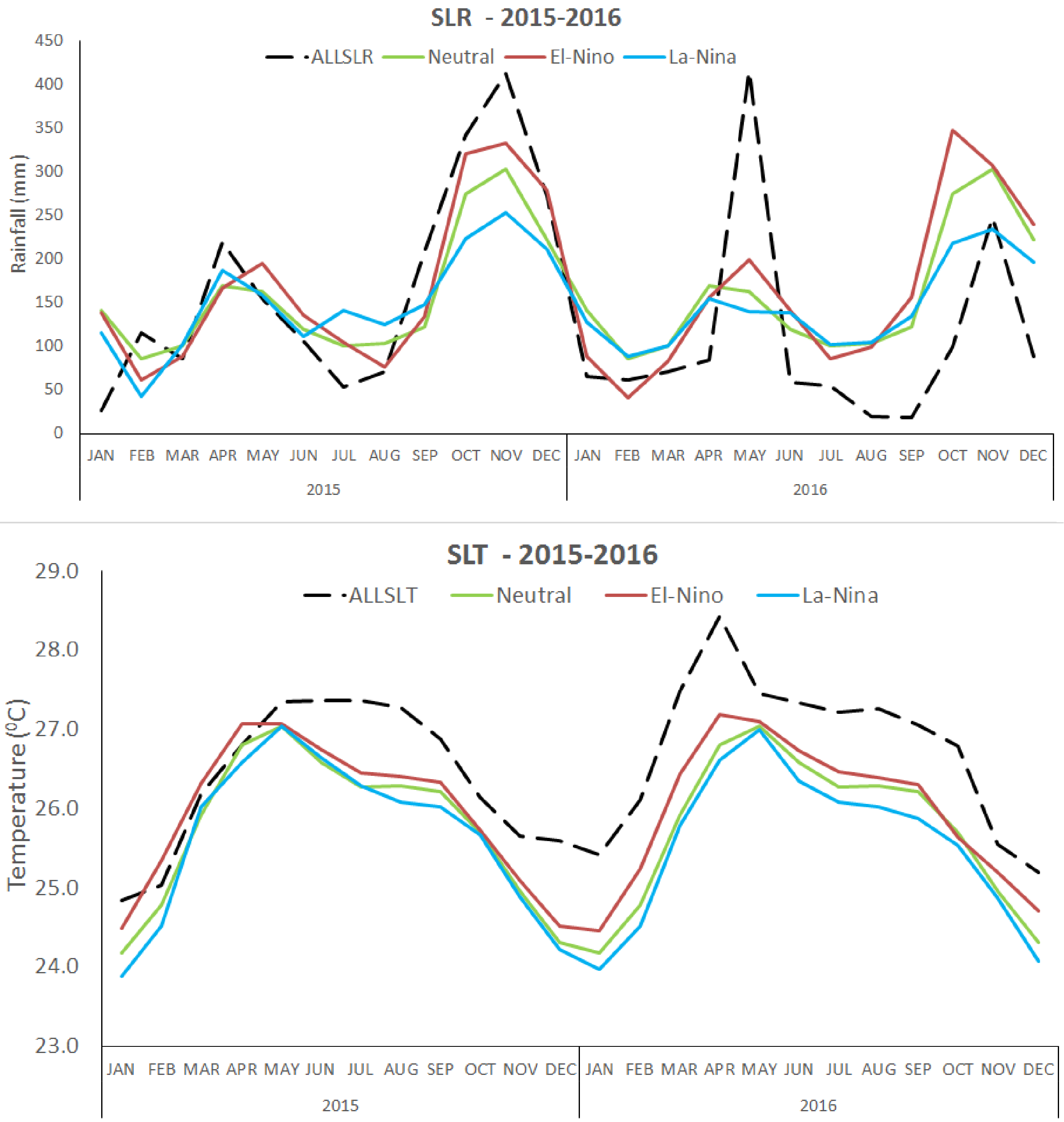


Figure 12: Rainfall climatology for average Rainfall (top panel) and average Sri Lanka Temperature (bottom) during El Niño (red line), Neutral (green) and La Niña (blue) along with Rainfall/Temperature (black) for 2015 and 2016 in the black line.

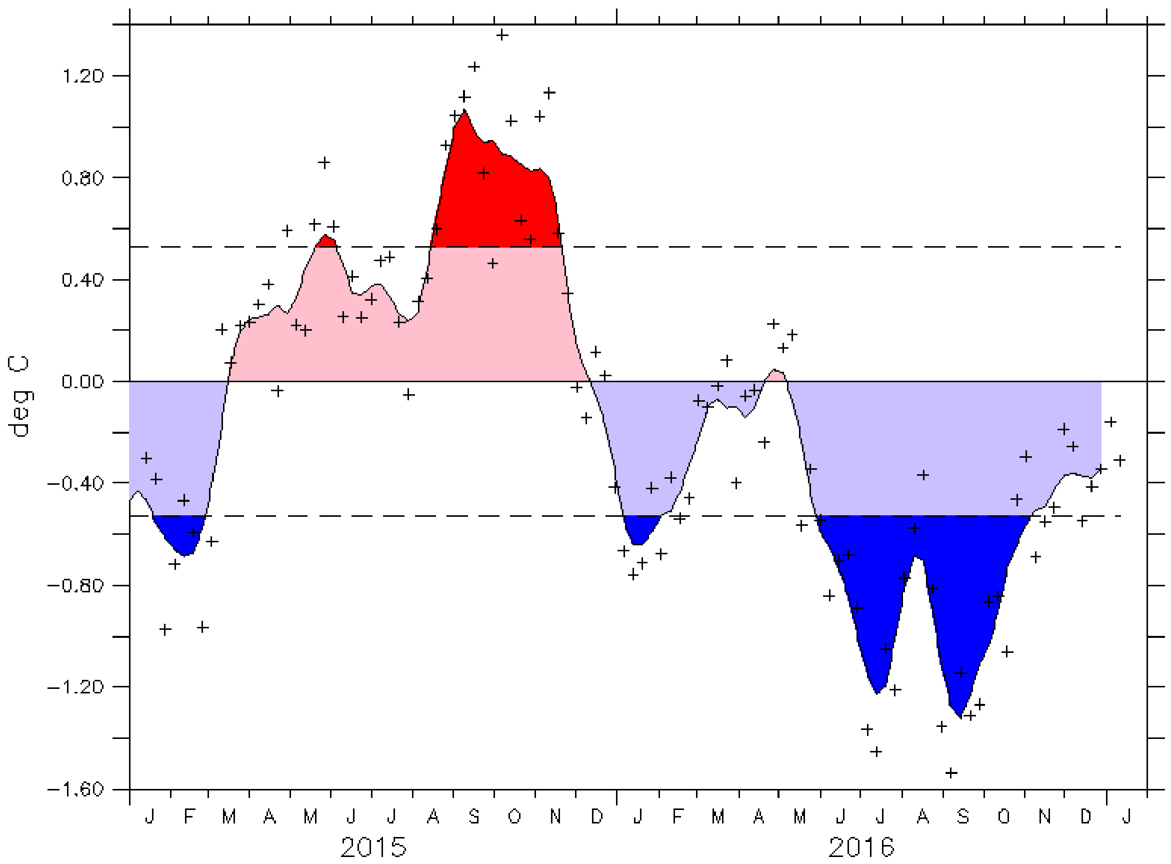


Figure 13: Dipole Mode Index. Source: NOAA

Figure 13 shows that the Indian Ocean Dipole remained negative throughout the year except for a brief rise in April. It was significantly negative from May and stayed so to the end of the year with the May to October period being highly negative. Negative IOD contributes to lower Maha (September to December) rainfall in Sr Lanka.

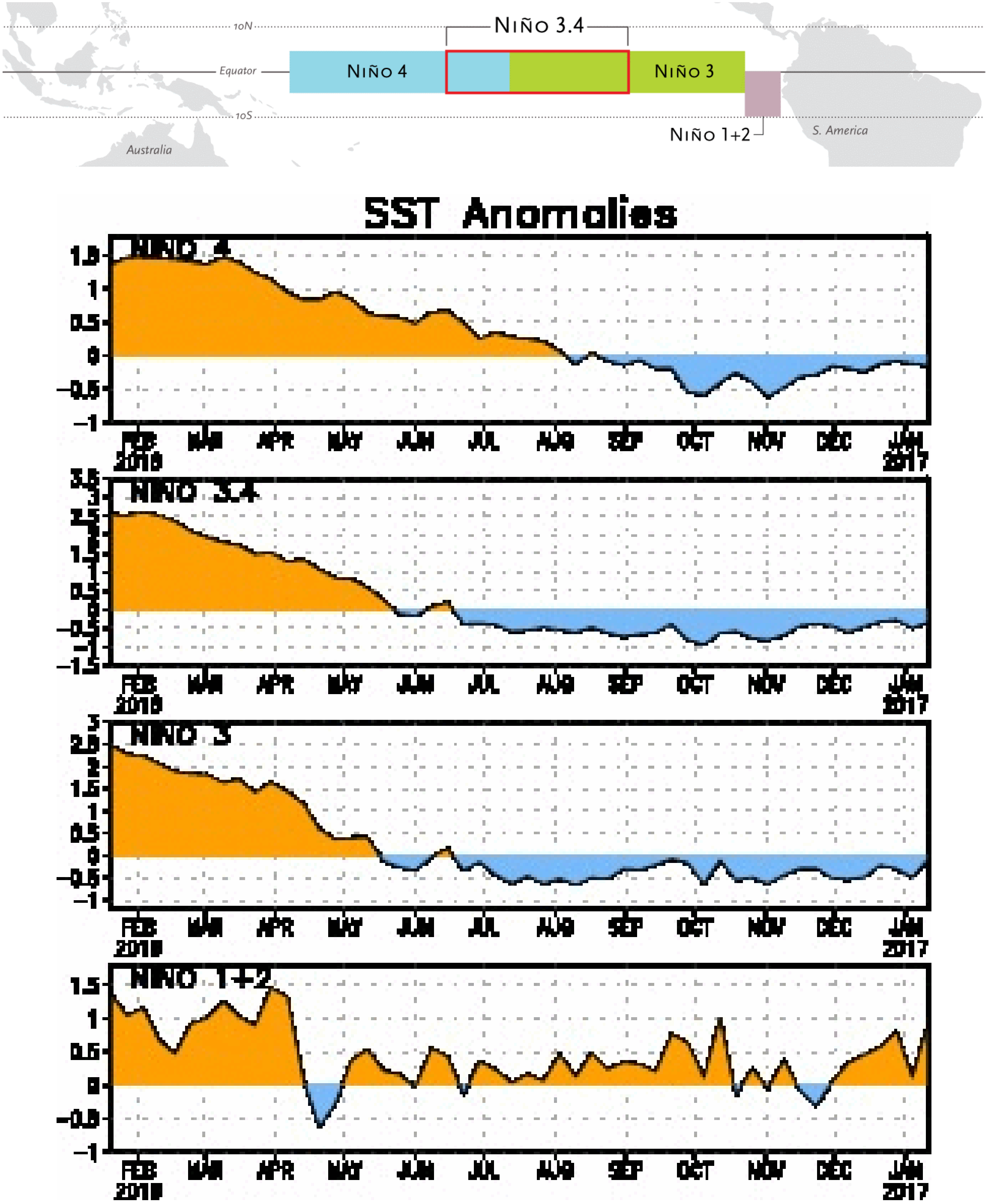


Figure 14: Sea Surface Temperature Anomalies by NINO Regions. Source: NOAA

Positive Sea Surface Temperature Anomaly was seen in every NINO region in the first quarter of 2016. Weak La Nina conditions started to develop during July to August, and continued till the end of 2016.

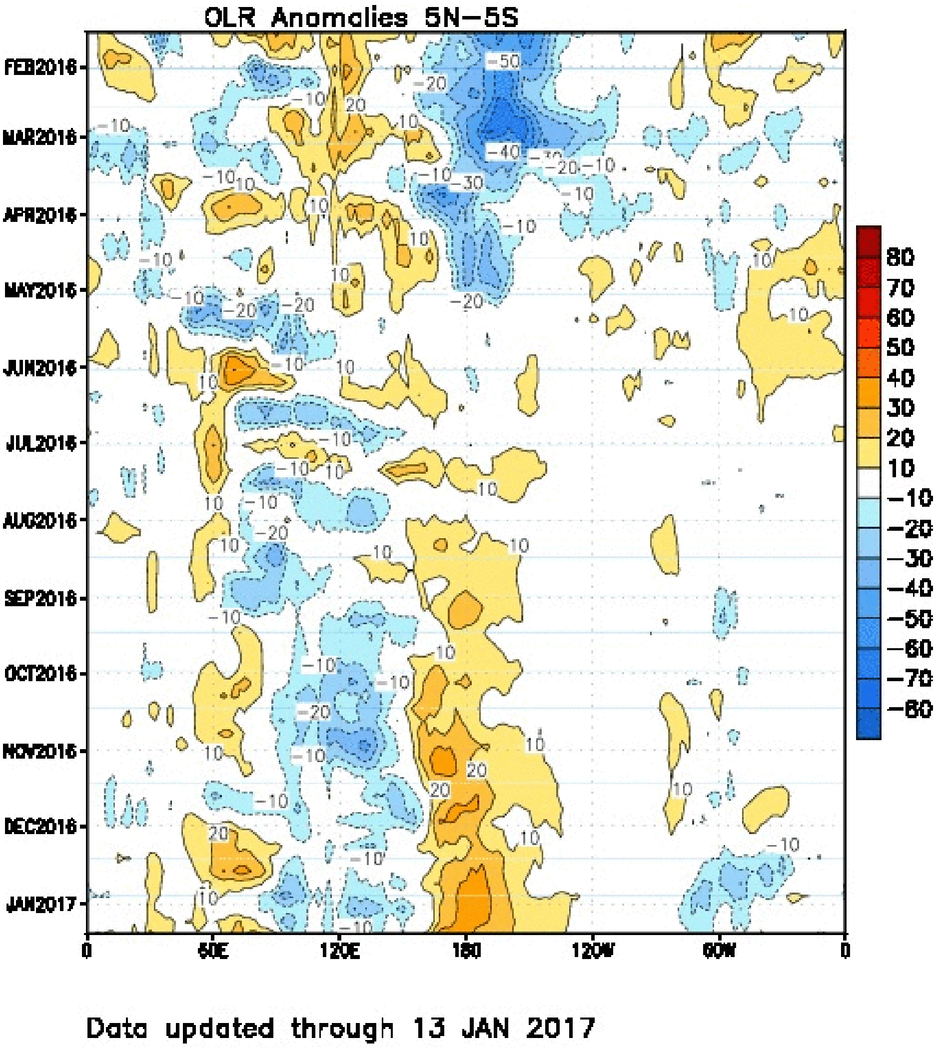


Figure 15: Outgoing Longwave Radiation Anomaly (W/m^2). Source: NOAA

Monitored Outgoing Long-Wave Radiation (OLR) over the equatorial latitudes – OLR is a proxy for rainfall at large scale. The impact of MJO at Sri Lanka's longitude of 80 ºE can be interpreted.

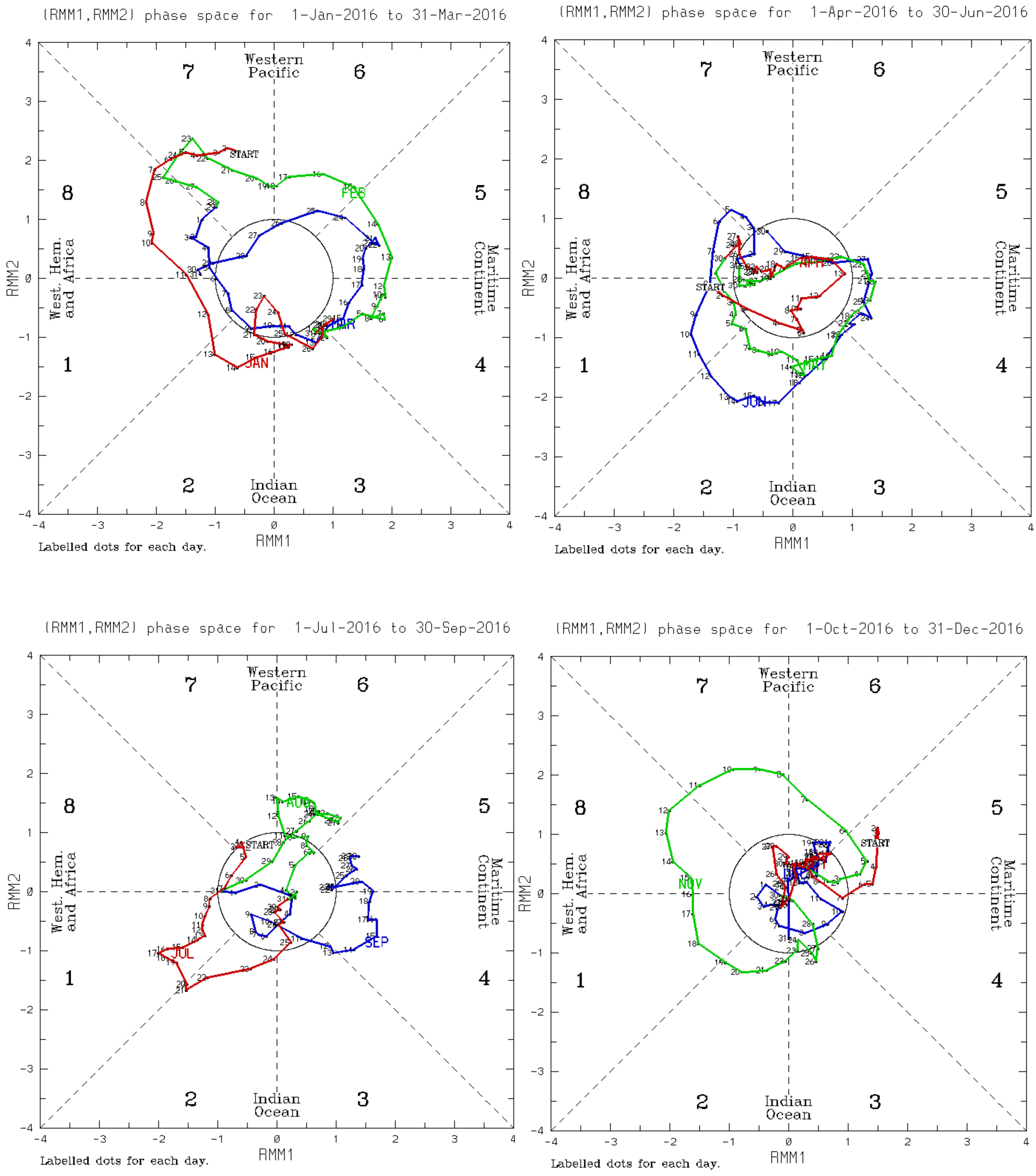


Figure 16: Madden Julian Oscillation phase Diagram for 2016. Source: Australia Bureau of Meteorology.

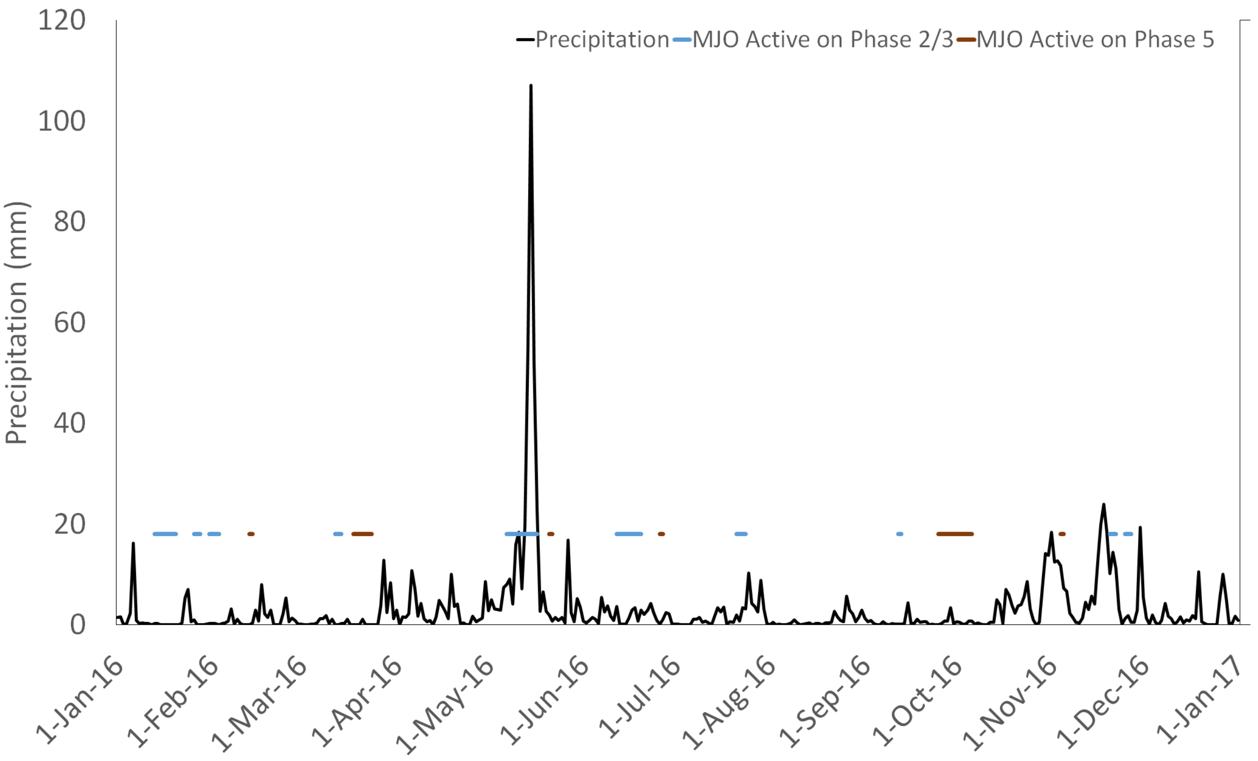


Figure 17: Daily rainfall and MJO active (blue) and suppression (brown) phases of 2016

The periods during which the MJO is in a phase which augments Sri Lanka rainfall is shown in blue in the dashed line above and those in brown shows the periods during which MJO suppresses rainfall. We can see that there is no consistent suppression of rainfall for the year. MJO is active during the flood event of May 2016 and worthy of further analysis.

To be discarded

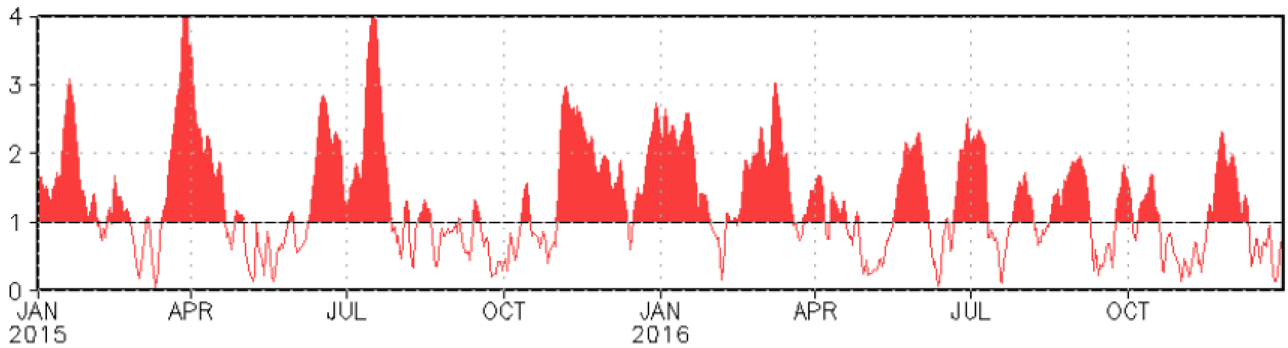


Figure 18: Magnitude of the Intra-Seasonal Climate Mode – Madden Julian Oscillation Source: NOAA

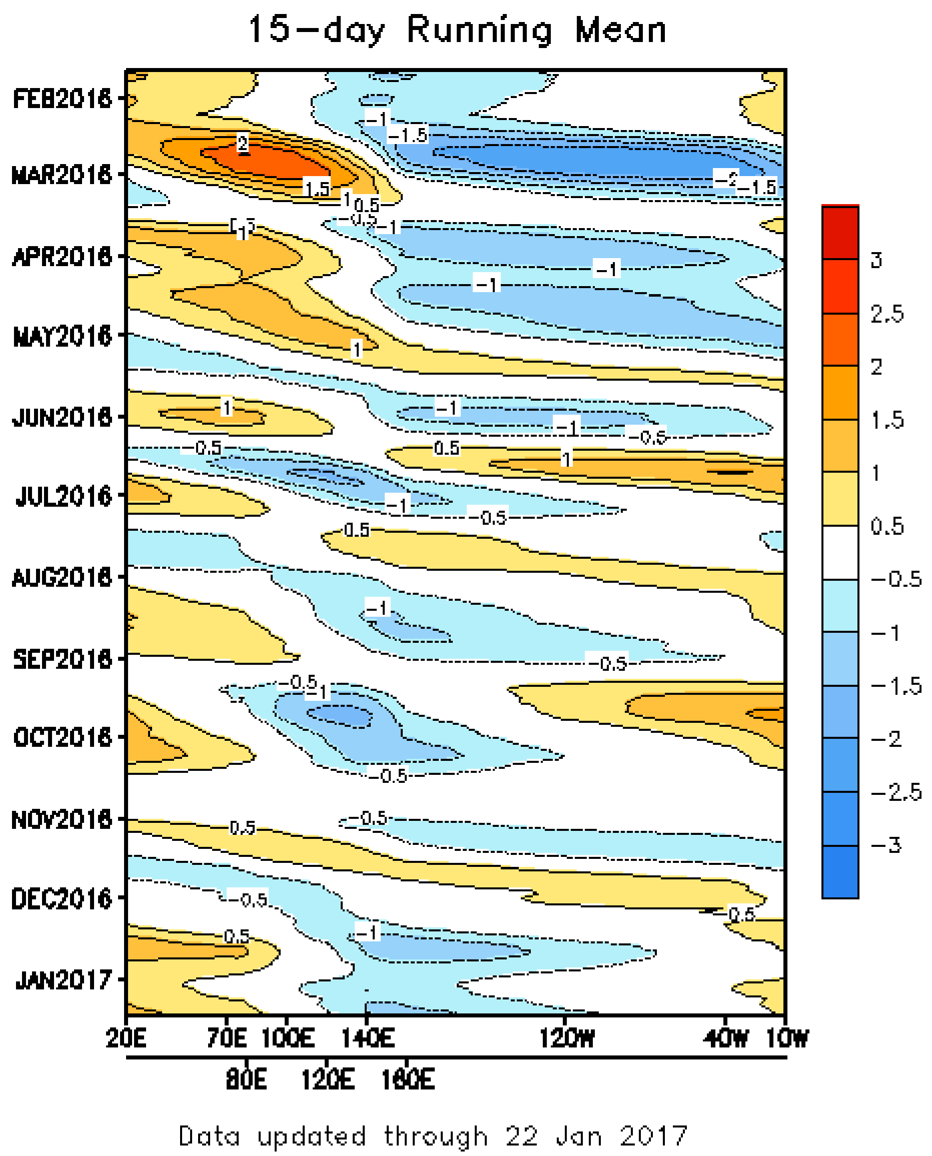
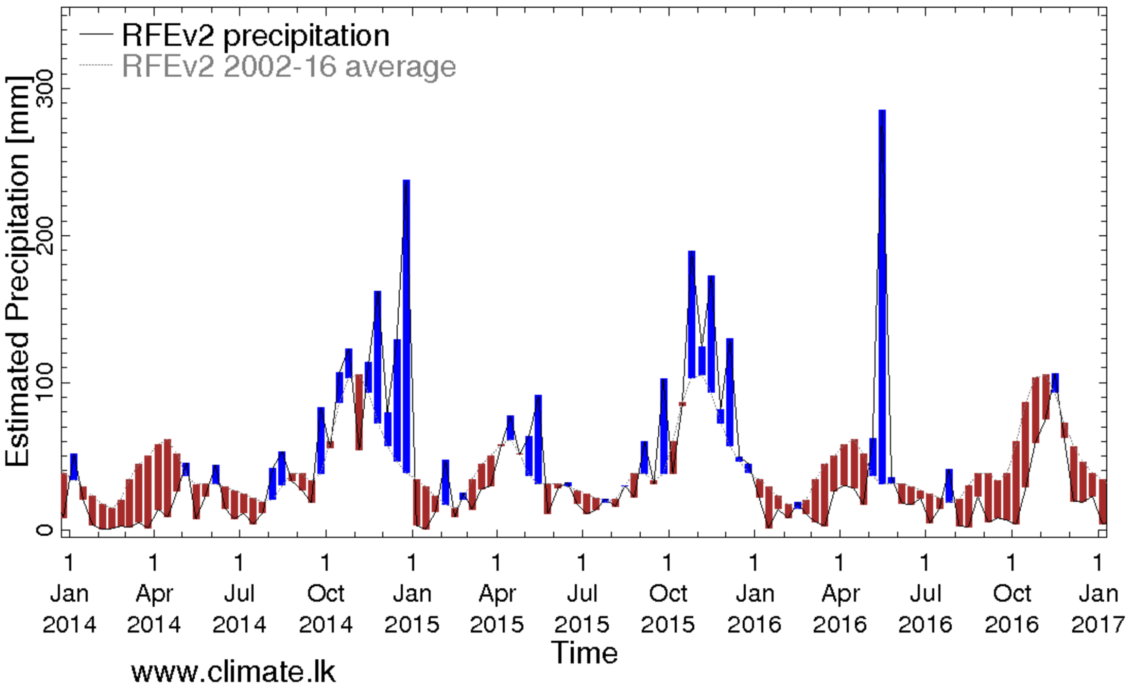


Figure 19: 3-Pentad running mean of MJO Amplitude in 2016. Source: NOAA

MJO is considered weak if the Amplitude is within -1 and 1. Blueish color represents the enhanced convection while reddish color represents suppressed convection. Thus, the amplification was only during a few periods in the longitudes of Sri Lanka (79-82ºE).

We see that the rainfall was suppressed in February significantly and augmented in the months of May, June, July, September and November.



RFEv2 precipitation
RFEv2 2002-16 average
Estimated Precipitation [mm]
0
100
200
300
1 Jan 2014
1 Apr 2014
1 Jul 2014
1 Oct 2014
1 Jan 2015
1 Apr 2015
1 Jul 2015
1 Oct 2015
1 Jan 2016
1 Apr 2016
1 Jul 2016
1 Oct 2016
1 Jan 2017
Time
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