Interannual variability of ENSO indices and cloud amount over India

Sujata K. Mandke [1,*] and Amita Prabhu[1]
[1]Indian Institute of Tropical Meteorology, Ministry of Earth Sciences, India
*amin@tropmet.res.in, amitaprabhu@tropmet.res.in

Introduction

The present study analyses the interannual variability and trends in El Niño Southern Oscillation (ENSO) indices as well as cloud amount averaged over India, for the period 1984-2009. The low-level and mid-level clouds are considered. Trends in cloud cover over different regions of the world examined by several researchers indicated that trends are neither uniform everywhere, nor same across different time periods over some regions (Jaswal, 2017 and references therein). Annual and seasonal trends in total cloud cover over India based on the period 1951-2010 are decreasing (Jaswal, 2017), the mechanism for which is still unknown**.** Trends in cloud cover over some of the regions are linked to factors such as ENSO (Warren et al. 2007) and aerosols (IPCC, 2007). The relationship between ENSO and cloud amount averaged over India is still not adequately clear and thus examined in the present study.

2. Data

The following datasets are used in this study: (i) Cloud amount from the International Satellite Cloud Climatology Project (ISCCP) D2 data (Rossow and Schiffer, 1999), provided for each 280-km grid cell over the globe, for the period from July 1983 to December 2009. The cloud amount (%) is the fractional area covered by clouds observed from the satellites. Low-level and mid-level clouds are classified using their radiance-derived cloud top pressure as per ISCCP cloud classification (http://isccp.giss.nasa.gov/cloudtypes.html). (ii) ENSO indices are obtained using optimally interpolated monthly global SST (1°×1°) version 2, from National Oceanic and Atmospheric Administration (Reynolds et al., 2002).

Results

The nature of ENSO is commonly quantified using sea surface temperatures (SST) anomalies in the different parts of equatorial Pacific Ocean. The indices of ENSO computed from the standardised SST anomalies averaged over four Niño regions (Trenberth and Stepaniak, 2001), namely Niño1+2 (0-10°S, 90°W-80°W), Niño3 (5°N-5°S, 150°W-90°W), Niño3.4 (5°N-5°S, 170°W-120°W) and Niño4 (5°N-5°S, 160°E-150°W), for the period 1984–2009 are considered in this study and hereafter referred as ENSO indices. Year-to-year variations (solid line with marker) along with the trend (red dashed line) of these four ENSO indices for the period 1984–2009 are illustrated in Figure 1(a-d) respectively. Likewise, cloud amount variations averaged over Indian region [8°-38°N,68°-98°E] (solid line with marker) is depicted with trend (red dashed line) for low-level and mid-level clouds for the period 1984–2009 in Figure 1(e-f) respectively. Small decrease in the year-to-year variability of ENSO indices after 2000 is apparent over all four Niño regions (Figure 1(a-d)) **.** Statistical significance of trend is checked using F-test statistic (Kendall and Stuart, 1979). Trend in four ENSO indices is insignificant (Figure 1(a-d)). An increasing trend in both low-level and mid-level cloud amount averaged over India is significant at 95% confidence level (Figure 1(e-f)). Next, correlation coefficient (CC) between each of the ENSO indices (Niño1+2, Niño3, Niño3.4 and Niño4) is evaluated separately with detrended low-level cloud (green) and also with the mid-level cloud (maroon) amount averaged over the Indian region [8°-38°N,68°-98°E], for summer monsoon season (June-September), based on the period 1984-2009 (Figure 1(g)). Significant inverse relation between four ENSO indices with mid-level cloud amount (Figure 1(g)) suggests that ENSO may be one of the factors causing its increasing trend. The relation between four ENSO indices with low-level cloud amount over India is insignificant. Further efforts are needed to investigate the mechanisms pertaining to increasing trend in low-level cloud amount over India.

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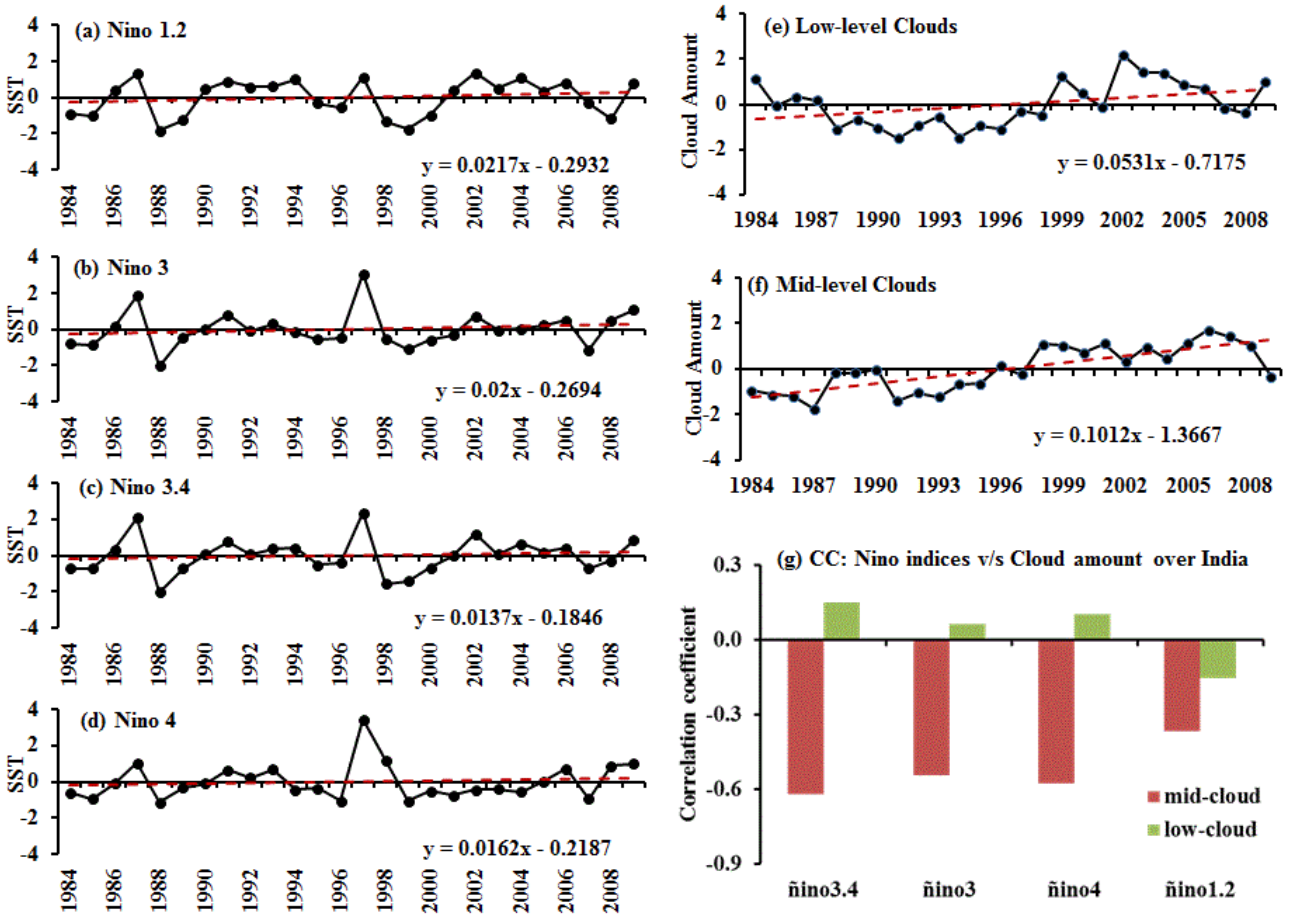

Figure 1: (a) Inter-annual variability of Niño1+2 SST index (solid line with marker) along with the linear trend (red dashed line) for the period 1984-2009 . **(b)-(d)** same as Figure 1(a) except for Niño3, Niño3.4 and Niño4 SST indices respectively. **(e)** Inter-annual variability of low-level cloud amount (%) (solid line with marker) averaged over the Indian region [8°-38°N,68°-98°E] along with the trend (red dashed line) for the period 1984-2009. **(f)** same as Figure 1(e) except for mid-level cloud amount. **(g)** Correlation coefficient between each of ENSO indices (Niño1+2, Niño3, Niño3.4 and Niño4) separately with detrended low-level cloud (green) and mid-level cloud (maroon) amount averaged over the Indian region [8°-38°N,68°-98°E], based on the period 1984-2009.