Low-level Cloud trends and its relationship with Indian Summer Monsoon

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1. Introduction

India Summer Monsoon Rainfall is one of the prime phenomena having a profound impact on the socio-economic growth of the country (Gadgil, 2003). Clouds typically cover almost two third of the global surface and are responsible for rainfall. Clouds are generally produced over the warm and moist regions assisted by atmospheric motions, wherein its vertical structure is particularly indicative of the motions producing the clouds, in addition to most of the cloud properties that are generally produced by the same event (Rossow and Schiffer, 1999). Implications of external remote forces on the distribution of clouds and summer monsoon rainfall have been studied earlier employing International Satellite Cloud Climatology Project (ISCCP) dataset (Prabhu et al., 2018). This study elucidates trends in Low-level clouds and its relationship with summer monsoon rainfall over India.

2. Data and methodology

Gridded Rainfall data (0.25° x 0.25°) developed by India Meteorological Department (IMD) (Pai et al., 2014), from a finely distributed network of 6955 rain gauges spread across the entire Indian landmass is utilised for the period 1984-2009. ISCCP D2 data, has been employed for the period 1984-2009 for observing the distribution of large-scale low-level cloud features. As per ISCCP cloud classification (Rossow and Schiffer, 1999), low-level clouds are estimated from the Cloud Top Pressure (CTP), which is in the range of 1000 to 680 hPa, while the Cloud Optical Thickness (COT) is in the range of 0–379. The cloud amount estimation is done by evaluating each pixel of 5 km across for a particular level by counting the number of pixels that are marked as cloudy and dividing by the total number of pixels in a region of about 280 km across and this dataset is available online (http://isccp.giss.nasa.gov/products/products.html). Further, trend for the inter-annual time series of low-level cloud amount index constructed by averaging over the Indian region [8°-38°N, 68°-98°E] during June through September (JJAS) based on the period 1984-2009 is examined by using a standard *F* test statistic that assesses the null hypothesis of zero slopes (Kendall and Stuart, 1979). Furthermore, correlation coefficients (CC) are computed to determine the spatial relationship between the low-level cloud amount index over the Indian region and rainfall at each grid during JJAS based on the above period, and checked for its significance at 95% confidence level, employing student's T test statistic (Kendall and Stuart, 1979). Both the time series are detrended and standardised prior to calculation of CC.

3. Results

Following inferences are drawn considering the connection between ISCCP's low-level clouds and summer monsoon rainfall over India as shown in Figure 1:

1) A significant increasing trend in standardised Low-level cloud amount index is observed over the period 1984-2009.

2) Spatial plot of trend for Low-level cloud amount during JJAS based on the period 1984-2009 depicts significant decreasing trend over the western parts of India and significant increasing trend over the southeast peninsular India along with adjoining regions of southwest Bay of Bengal.

3) CC of low-level cloud amount averaged over the Indian domain with that of rainfall at each grid point over India during JJAS season depicts larger spread of negative relationship between the two, implying deficit summer monsoon rainfall for excessive Low-level clouds.

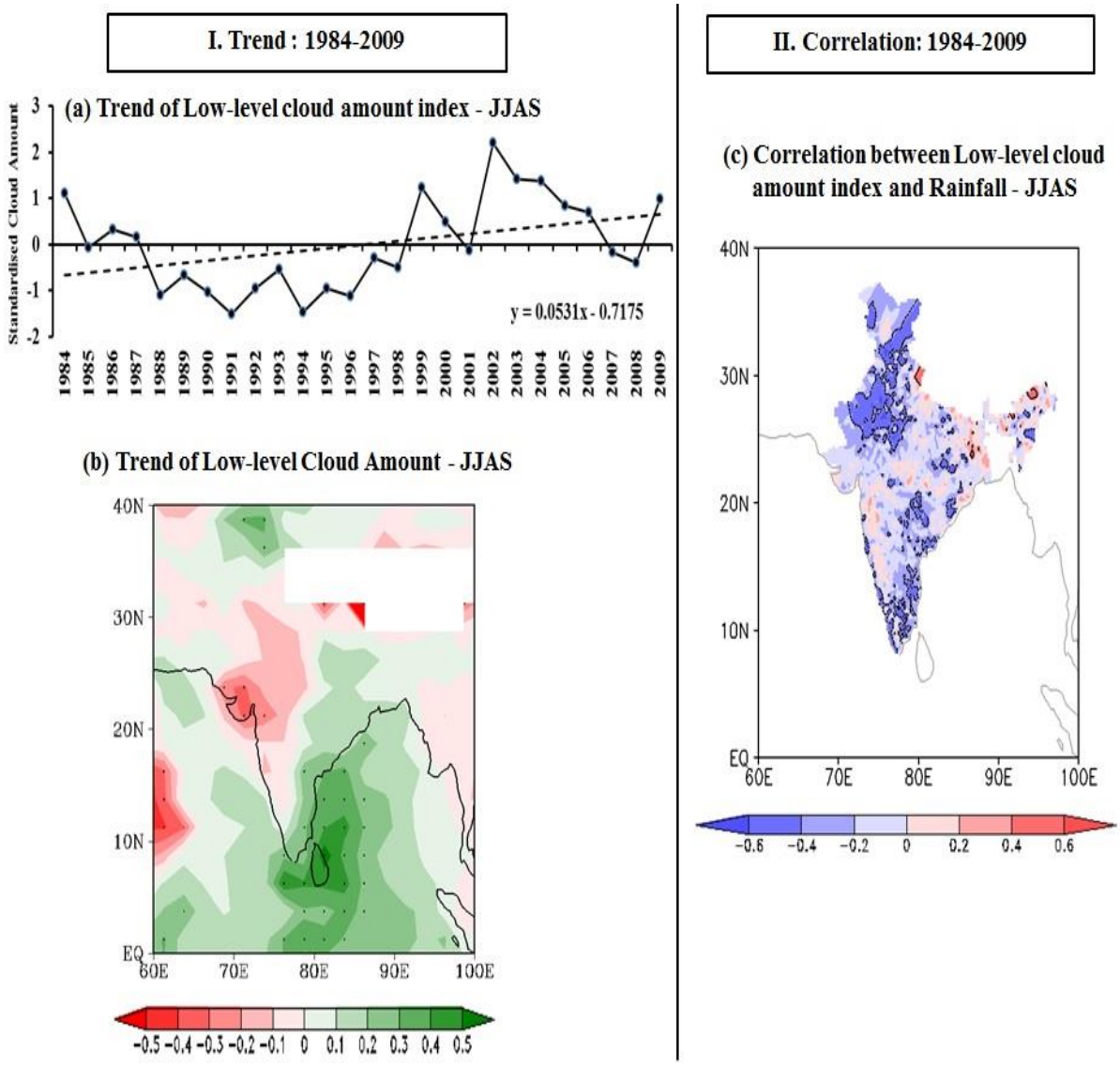

Figure 1. Set I. (a) Inter-annual variability of Low-level cloud amount index during JJAS averaged over the Indian region [8°-38°N, 68°-98°E] over the period 1984-2009, wherein dotted line indicate its trend; (b) Spatial plot of trend of Low-level cloud amount during JJAS based on the period 1984-2009; Set II. (c) Spatial Correlation (shaded) of Low-level cloud amount index with that of rainfall at each grid point over the Indian region during JJAS based on the period 1984-2009, whereas contours in black indicate significance of correlations at 95% confidence level.

References

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