Supplementary Material

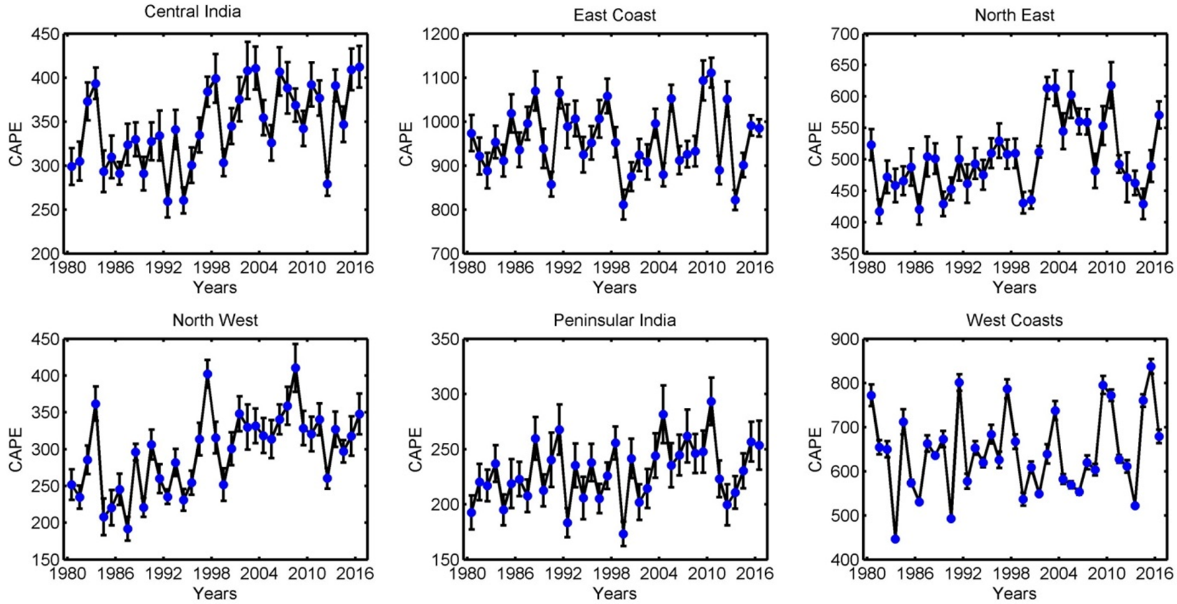

Figure S1: Climatic trends of CAPE for all six Indian Regions using ERA Interim monthly average datasets

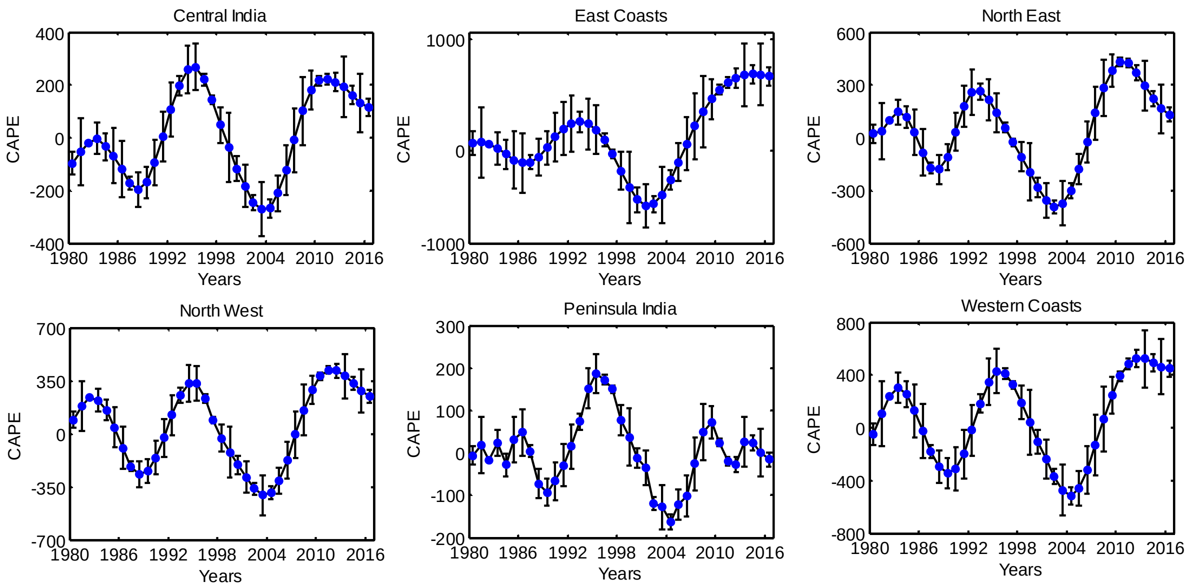

Figure S2: MCO periodicities of CAPE for all Indian regions.

Text S1: Breif Description of the parcel and instability parameters used

(a) Lifted Condensation level (LCL): It is the height at which an air parcel would attain condensation if it is raised dry adiabatically from the surface. This is because at that height, the air parcel mixing ratio becomes equal to saturation mixing ratio. Lower values of it indicate presence of tall clouds reaching the surface during convective events.

(b) Level of Free condensation (LFC): It is defined as that level of atmosphere above the LCL where the parcel of air lifted moist adiabatically would for the first time be warmer than its surrounding. Lower heights of LFC indicate more probability of moist air parcels to be lifted upwards leading to more convective strength in the system.

(c) Equilibrium Level (EL): It is the level of atmosphere where a parcel would attain same temperature as of surroundings and would cease its upward motion. Higher the EL, more the energy contained within the convective system.

(d) Lifted Index (LI): It is the difference between the temperature of the environment with that of an air parcel lifted adiabatically to 500 mbar pressure. Negative or near negative value of LI reflects condensation of saturated vapour parcel to liquid indicating instability and severe weather conditions. LI generally indicate the intensity of the convective activities like CAPE.

(e) Vertical Totals Index (VT): It represents the instability component of TTI. It is calculated as the temperature gradient between 850 and 500 hPa pressure levels. This parameter is a sensitive measure of atmospheric instability.

(f) Convective Available Potential Energy (CAPE): CAPE indicates the buoyant energy available to accelerate an air parcel vertically and is calculated using the summation of positive buoyant energy from LFC to EL. Higher CAPE provides more energy for convective growth; hence CAPE should be high in convective conditions and less in normal conditions. According to some standard research attempts, the values of CAPE > 1500 J kg^{-1} are essential to have super cell formation.

(g) Mixed Layer CAPE (MLC): This parameter is similar to CAPE, but this one is mostly used to assess the atmospheric instability during well mixed conditions in a better way than surface based CAPE. The main difference between CAPE and MLCAPE is that, this parameter constitutes the total positive energy attained by the parcel when lifted from the LFC to the lowest 100 mb of the troposphere. However, it may be noted that in this paper, the effect of UTLS on CAPE and thunderstorm severity has been shown in a focussed way. Also in clear weather conditions, EL mostly resides along ~300 hPa over all Indian regions. Hence to separate the effect of UTLS near 100 hPa during intense convection, here the summation is taken only upto 300 hPa levels.

(h) Convective Inhibition Energy (CINE): This is the summation of negative buoyant energy from surface level to LFC. Being the opposite of CAPE, higher values of CINE produce strong hindrance to convective genesis.

(i) Precipitable Water Vapor (PWV): This is the total column water vapour present per unit area. High values indicate higher moisture favouring convective processes.

(j) Precipitable Water Vapour at Lower troposphere (PWL): Lower level moisture contents particularly upto the boundary layer height (maximum 700 hPa) are also useful for controlling all rainfall occurrences and hence they are taken additionally. Again, if both PWL and PWV are taken, then the contribution of the middle and upper troposphere can be clearly understood for all Indian regions.

(k) Horizontal Wind Shear (WSH): This is a common parameter which is calculated as th gradient of horizontal winds between the surface and the 6 km height level. Large values of this prevent convective updrafts and hence it reduces thunderstorm severity.

(l) Temperature at 100 hPa Pressure levels (T100): This represents the atmospheric temperatures present at the 100 hPa pressure level and it is recorded from the radiosonde profiles. This parameter is taken to investigate whether at all there are any reliable relationships between UTLS cooling and CAPE as already hinted earlier in previous resaerch attempts over India.

(m) Ordinary Thunderstorm Frequency (TSO): This parameter is calculated for each station as the number of radiosonde launches per year at 00Z where the colocated surface wind speed values as obtained from base radionde data (obtained by Woyming Portal is between 31-62 km/hr as already cited out by IMD reports and Saha et al. 2018.

(n) Severe Thunderstorm Frequency (TSS): This is similar to TSO, only here the number of radiosonde launches at 00Z are counted for which the surface wind speed is above 62 km/hr as again cited out by IMD reports and Saha et al. 2018.

(o) Weak Rainfall Frequency (WRF): This parameter is calculated for each station as the number of radiosonde launches or days per year at 00Z when the obtained one day rainfall accumulation is very low (below 7.5 mm) as specified by IMD reports.

(p) Severe Rainfall Frequency (SRF): This parameter is similar to WRF; the only difference is that this parameter is calculated for each station as the number of radiosonde launches or days per year at 00Z when the obtained one day rainfall accumulation is very high (above 124.5 mm) as again cited by the IMD reports.