Absorbing aerosol modulation of mesoscale summertime temperature maxima over India: a causality based approach

Prashant Dave, Mani Bhushan, Chandra Venkataraman

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Temperature maxima and absorbing aerosols over India

- Large anomalies in summer time temperature maxima (Ratnam et al., 2016)
- An increase in duration, frequency and intensity of heatwave events (Rohini et al., 2016).
- Attribution: large scale atmospheric anomalies connecting sub-tropical persistent high, quasi-stationary, depleted soil moisture and clear skies etc.
- The effect can extend several hundred kilometers around source (Bond et al., 2007).
- India, in particular Indo-Gangetic belt, has witnessing increasing emissions of absorbing aerosols (Habib et al., 2006)

Objectives
- To investigate link between local and distant absorbing aerosols with temperature extremes.
- Identification and quantification of pathways of temperature interaction.
Data and Methodology

Data description

- Maximum surface temperature ($T_{\text{max}}$): Indian Meteorological Department
- Absorbing aerosol index (AAI): TOMS and OMI
- Lapse rate: ERA-interim reanalysis (derived from layerwise temperature)
- AAOD: OMI 2004-2013
- Time period: March-June, 1979-2013
- Region: 6.5N-38.5N, 66.5E-100.5E
- ~ 900 pixels

Flowchart:

- AAI daily anomaly
- $T_{\text{max}}$ daily anomaly

Identification of “Coincident (<10 kms)” and “Distant (>300 kms)” pixels using cross-correlation; ~900$^2$ cross-correlations

Cluster average time series

Granger causality for identification of lag

Extreme events ($T_{\text{max}}$ anomaly > 0.8; 6 consecutive days)

Path analysis for segregation of overall effect into pathways
Results

- Dark red shows positive while blue shows negative correlation.
- Tmax cluster (Local region) matches with Ratnam et al. (2016) box used for studying heat waves.
- Using cluster average, causality of upto 3-days was found from AAI anomaly (Distant region) to Tmax anomaly (Local region)
- Regions distant and local were selected for further analysis.
- If causality exits at multiple lags, lag with maximum correlation was selected for the analysis.
Implications on heat wave

- Using Tmax daily anomaly, extreme maximum temperature days of local region were identified for every year.

- For every year using causality was tested, and lag between AAI anomaly (distant region) and Tmax anomaly (local region) were identified.

- Similar to all years together results, causality was found from AAI to Tmax anomalies and not other way around.

- Lag order varied from 1-11 days.
Path analysis

Normal conditions

Extreme conditions
- Increase in AAI at distant region increases $T_{\text{max}}$ at local region.
- Increased $T_{\text{max}}$ at distant region decreases Lapse Rate at distant region and increases $T_{\text{max}}$ at local region.
- Increase in $T_{\text{max}}$ at local region contributes to decrease in Lapse Rate at local region.
- Decreased Lapse Rate at distant region also contributes to decrease in Lapse Rate at local region.
- AAI at distant region contributes to increase in $T_{\text{max}}$ as well as in decrease in Lapse Rate while AAI at local region does not contribute.
Composite of AAOD

For the period of 2004-2013.

Higher AAOD absolute and anomaly was found in Extreme distant region.

Supporting the arguments of presence of high absorbing aerosol in distant regions during extreme conditions.
Conclusions and future direction

- **Non-local aerosols** play role in affecting distant temperature.

- Plays prominent role in effecting extreme heat events.

- Correlation between layer wise temperature and winds, with AAI can help in revealing the complete mechanisms.

- Identification of days with high relative humidity along with temperature extreme can further help in understanding the heat wave mechanisms.

Thank you.