NCAP-COALESCE
CarbOnaceous AerosoL Emissions, Source apportionment & ClimatE impacts
Understanding scientific complexities related to carbonaceous aerosols focussing on issues underlying their origin and fate, and their role as drivers of regional climate change over India.

Research BRIEFS

Exacerbation of Indian Summer Monsoon Breaks by the Indirect Effect of Regiona Dust Aerosols

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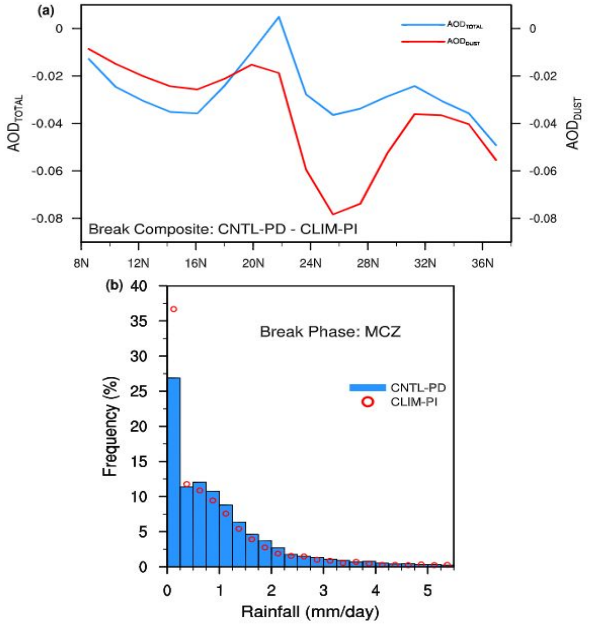

a) Latitudinal variation of the difference in aerosol optical depth (AOD) of total aerosols (AOD TOTAL) and dust aerosols (AODDUST) averaged over the longitudinal range of the monsoon core zone (MCZ), between the break composites from CNTL-PD and CLIM-PI simulations (top panel). (b) Frequency distribution (number of grids as a % of total grids) of rainfall in each 0.25 mm/day rain bin for MCZ from Community Earth System Model (CESM) control simulation with present-day emissions (CNTL-PD) and CESM simulation with pre-industrial aerosol emissions (CLIM-PI) during all the break days (bottom panel).

Key highlights:

- Dust builds up over India during break spells due to the dust transport by anomalous winds and the trapping of dust emitted from Thar-desert
- The breaks exhibit reduced cloud effective radius and enhanced lower atmospheric warming as evidence for the dust-induced indirect effect
- Indirect effect of dust in warming the atmosphere and exacerbating severity of breaks is conspicuous in Community Earth System Model runs with increased loading of dust.

Summary of your Research:

Century-long climate simulation experiments using the state-of-the-art climate model, Community Earth System Model (CESM), reveal the model fidelity in capturing the characteristics of aerosols, cloud, convection, rainfall and circulation over India associated with the active and break spells having excess and deficit rainfall over central India within the summer monsoon season.

During break spells, the aerosols build up over India due to the transport of desert dust from the west to central India by lower-level atmospheric winds, the abundance of desert dust emitted from the Thar desert and the increased lifetime of aerosols in dry conditions.With the accumulation of dust aerosols which absorb solar radiation and cause warming of the clouds, break spells exhibit reduced cloud effective radius and increased lower atmospheric warming as potential evidence for the indirect effect of dust aerosols. Consistently, the severity of break spells is exacerbated with enhanced loading of dust aerosols over central India in CESM simulation..

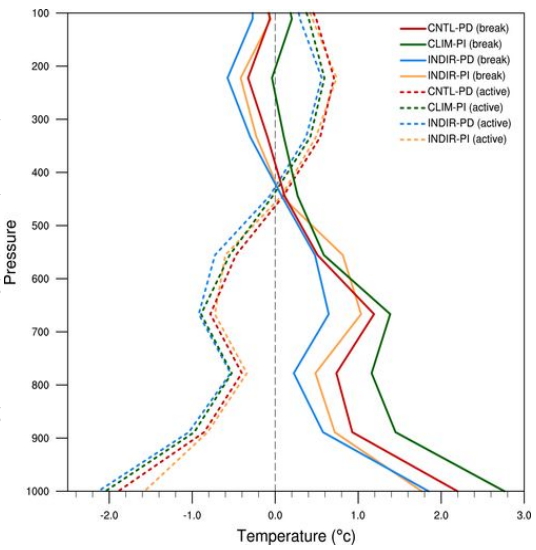

Fig: Vertical profiles of composite anomalies of air temperature over the monsoon core zone for active (dashed lines) and break (solid lines) spells from Community Earth System Model (CESM) control simulation with present-day emissions (CNTL-PD) along with the corresponding simulation with direct effect of anthropogenic aerosols turned off (INDIR-PD) and CESM simulation with pre-industrial aerosol emissions (CLIM-PI) along with the corresponding simulation with direct effect of anthropogenic aerosols turned off (INDIR-PI).

Take away/conclusion :

- Break spells with drier than average rainfall are observed to have increased lifetime of aerosols and are associated with buildup of absorbing aerosols over central India. Such aerosol buildup can change atmospheric heating through indirect impacts of aerosols.
- Assessment of CNTL-PD reveals model fidelity in capturing seasonal mean ISM and the characteristics of AOD, winds, CER, CWP, CAPE and rainfall over India associated with the active/break phase within the summer monsoon season.During the breaks, aerosols build up over central India mainly due to desert dust transported from the west by the anomalous circulation, besides the trapping of dust emissions from the Thar Desert and the increased aerosol lifetime in dry conditions. Break spells exhibit reduced cloud effective radius and enhanced lower atmospheric warming over central India as potential evidence for the indirect effect induced by dust aerosols.
- Consistently, break spells intensify in CESM simulation with increased loading of dust aerosols. The strong correlation between intraseasonal anomalies of rainfall and AOD when AOD leads rainfall by 1–3 days over India, reaffirms the role of dust induced indirect effect in intensifying breaks.
- The indirect effect of dust aerosols in warming the atmosphere and exacerbating the severity of breaks is conspicuous in simulations forced with the indirect effect of aerosols alone, both for present-day and pre-industrial periods.

Research Article citation

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