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

# Aerosol influences rainfall spatial patterns on fast timescales.

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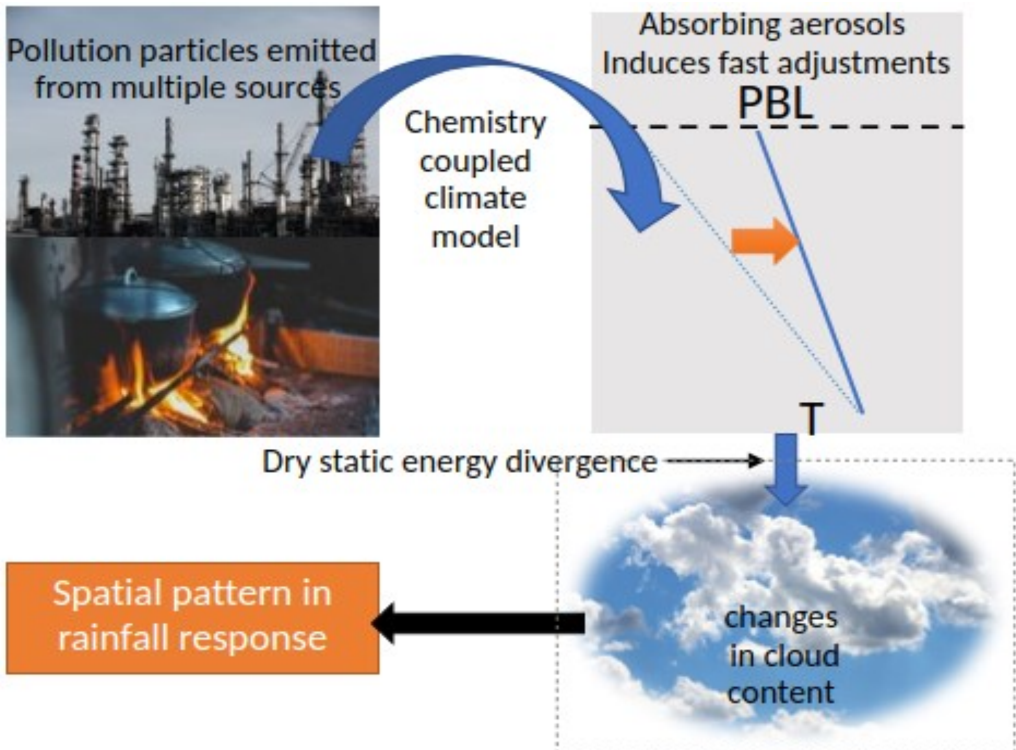


### *Key highlights:*

- ECHAM6-HAM2 with varying anthropogenic aerosol emissions with prescribed SSTs are used to investigate stratiform and convective precipitation rapid adjustments.
- Increased absorbing aerosols over Northern India caused shortwave heating triggering a moisture feedback thereby increasing stratiform precipitation processes.
- Changes in the precipitation response on the fast timescales are coincident with the dynamical changes to dry static energy divergence.
- The large spatial pattern changes in dry static energy divergence underpins the regional circulation induced changes in moisture and rainfall formation processes.
- The nature of the prescribed SST simulations capture the aerosol influence on timescales of hours to few months.

### *Summary:*

The aerosol lifecycle was evaluated over India in simulations (2005-2014) with three GCMs in the COALESCE project (Carbonaceous aerosol emissions, source apportionment and climate impacts, Venkataraman et al., 2020). The ECHAM6.3-HAM2.3, CAM5.3 and NICAM-SPRINTARS were input with identical emissions from the Speciated Multi-pollutant generator (SMoG-India-v1) emission inventory, nested globally in CEDS. Good agreement was found among models and with observations of spatially and seasonally averaged meteorological variables and aerosol species columnar loading, wet and dry deposition. Sea-salt and dust exhibit a W-E horizontal gradient, while anthropogenic aerosols exhibit a N-S and E-W horizontal gradient, consistent with emission distributions over India. Improved estimation of aerosol optical depth was obtained from

Larger wintertime (DJF) under-prediction (-30-60%) indicated improvements needed in seasonal boundary layer height and anthropogenic inorganic aerosol simulation, especially ammonium nitrate. Steep vertical profiles of aerosol extinction across models, in disagreement with CALIPSO measurements, imply needs for improved model vertical dispersion. Regarding carbonaceous aerosols, a larger species AOD (15-40% of total), strong spatial N-S gradients and larger regional residence times, than global mean values, result from enhanced regional emissions from residential biofuel cooking, agricultural stubble burning and traditional informal industry like brick production.

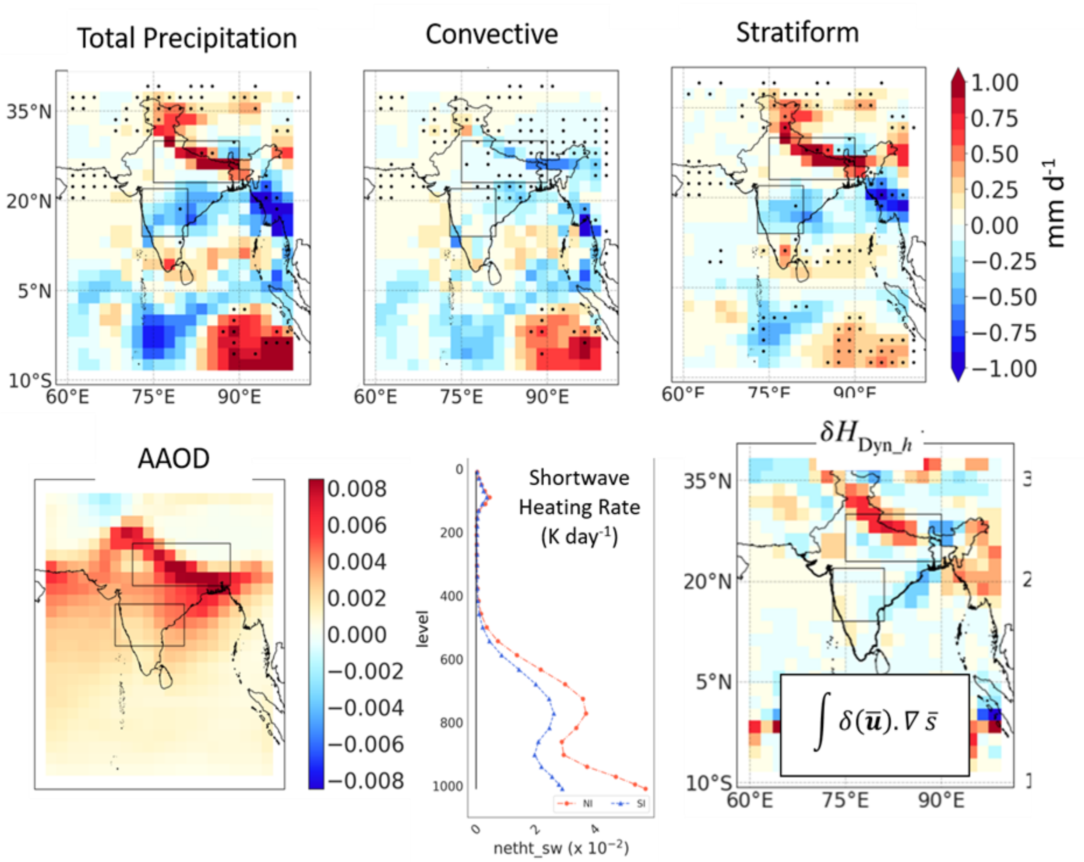


Figure 1: The peak monsoon (July–August) precipitation (mm d−1) climatology for 40 years (1971–2010) difference between HA and LA experiments is shown for total precipitation, convective precipitation, and stratiform precipitation. The boxes represent the two study regions NI (North India) and PI (peninsular India). The differences in Absorbing AOD (AAOD), vertical profile of the differences in shortwave heating rate and dynamical component of the dry static energy divergence. The dots represent 90% significance in the differences between HA and LA climatology.

## *Major findings :*

- Changes in season mean rainfall spatial patterns impact agricultural practices, water storage and management, economic policies, and near-term hazard management. The season mean rainfall changes in the near-term are linked to aerosol emission changes over India.

- The main pathway identified for the increases over North India has been linked to absorbing aerosol induced regional circulation changes. These changes in circulation increased moisture transport towards North India leading to efficient rainfall formation processes.

## *Research Article*

## *Citation*

Muduchuru, K., Venkataraman, C. Spatial heterogeneity of aerosol induced rapid adjustments on precipitation response over India: a general circulation model study with ECHAM6-HAM2. Clim Dyn 58, 293–304 (2022).

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