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

Wintertime radiative effects due to black carbon (BC) over Indo-Gangetic Plain as modeled with new BC emission inventories in CHIMERE

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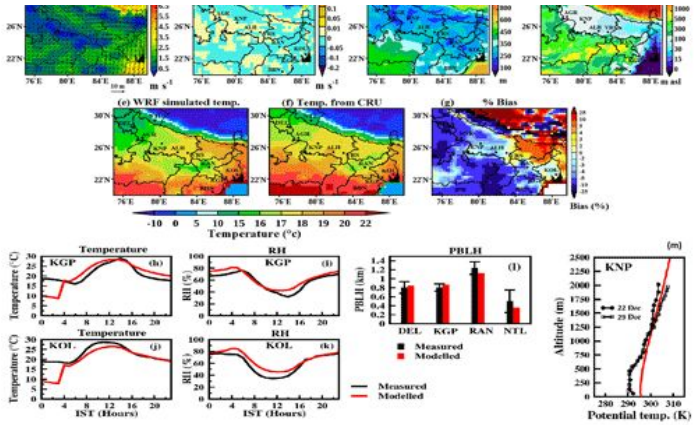

Figure: Spatial distribution of the WRF-simulated (a–c) winter monthly mean (a) horizontal wind field (note that the colour scale is for wind speed in m s−1 and the arrows indicate the direction of the mean field), (b) vertical wind speed at 1000 hPa, (c) planetary boundary layer height (PBLH in metres), and (d) topography (metres above sea level, m a.s.l.) (e–g) Spatial distribution of winter monthly mean surface temperature from (e) WRF simulations, (f) observations from CRU, and (g) percentage bias in WRF estimates. (h–k) Comparison of the hourly distribution of winter monthly mean (h, j) surface temperature and (i, k) relative humidity from WRF simulations with observations at stations (Kharagpur, KGP; Kolkata, KOL). (l) Comparison of winter monthly mean PBLH during day hours between measured and simulated values at the stations under study. The error bars represent the standard deviation (σ) in the measured PBLH. (m) Comparison of the vertical profile of potential temperature obtained from WRF (winter monthly mean) and measurements (2 d).

Key highlights:

- The atmospheric radiative warming due to BC was about 50–70 % larger than surface cooling.
- Compared to the atmosphere without BC, for which a net cooling at the top of the atmosphere was exhibited, enhanced atmospheric radiative warming by 2–3 times and a reduction in surface cooling by 10–20 % were found due to BC.

Summary of your Research:

Wintertime direct radiative perturbation due to black carbon (BC) aerosols was examined over the Indo-Gangetic Plain (IGP) by evaluating the efficacy of the fine grid-resolved (0.1◦ × 0.1◦) BC aerosol transport in a chemical transport model (CHIMERE) offline coupled with the WRF regional meteorological model.A strong association of the winter monthly mean BC concentration between modelled and measured values for stations under study corresponding to each of the five simulations was noticed. The efficacy to simulate the magnitude of the observed wintertime BC distribution was found to be moderate to poor for the bottom up simulation

The BC-AOD fraction (10 %–16 %) from the Constrained simulation was noted to be about twice as large as the BC mass fraction (6 %–10 %) over most of the IGP region. Five hotspots with a large BC load (surface concentration > 16 µg m–3 from the Constrained simulation) were identified in and around megacities (Delhi and Kolkata) and the surrounding semi-urban area as well as urban spots over the central and mid-eastern IGP Prayagraj–Allahabad–Varanasi, Patna), including the rural spot over the lower mid-eastern IGP (Palamu).

Analysis of direct radiative perturbations due to BC aerosols showed that winter time BC aerosol over the IGP enhances atmospheric warming by 2–3 times more and reduces surface cooling by 10 %–20 % less than considering atmosphere-eliminating BC aerosols. The BC-induced net warming effect at the top of the atmosphere (TOA) from the Constrained simulation was estimated as 10–17 W m–2 over most of the IGP, in contrast to a net cooling at the TOA considering the atmosphere without BC.

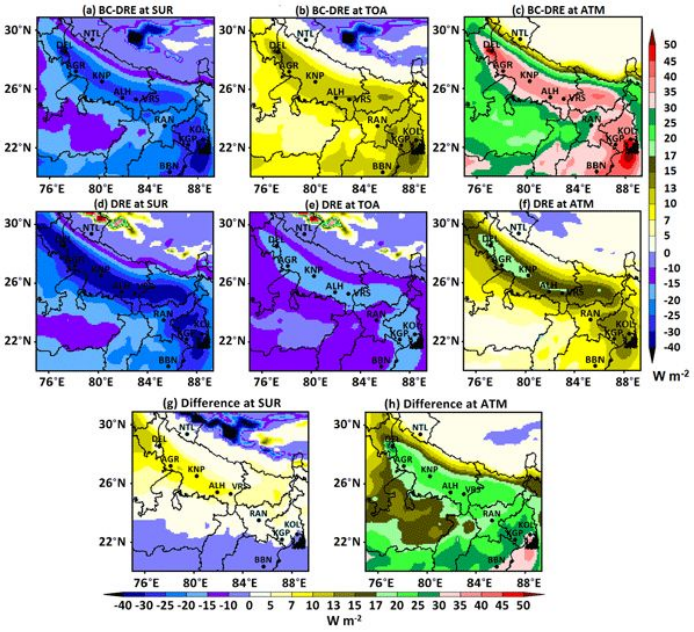

Figure (a–c) Spatial distribution of wintertime direct radiative perturbation due to BC aerosols from the Constrained simulation at (a) SUR, (b) TOA, and (c) ATM. (d–f) Same as (a–c) but with atmosphere-eliminating BC. (g–h) Difference in radiative perturbation due to BC and atmosphere-eliminating BC at (g) SUR and (h) ATM

Take away/conclusion :

- The wintertime direct radiative perturbation due to BC aerosols from the Constrained simulation estimated the atmospheric radiative warming (+30 to +50 W m−2) to be about 50 %–70 % larger than the surface cooling.
- A widespread enhancement in atmospheric radiative warming due to BC by 2–3 times and a reduction in surface cooling by 10 %–20 %, with net warming at the top of the atmosphere (TOA) of 10–15 W m−2, were noticed compared to the atmosphere without BC, for which a net cooling at the TOA was exhibited.
- These perturbations were the strongest around megacities (Kolkata and Delhi), extended to the eastern coast, and were inferred to be 30 %–50% lower from the bottom up than the Constrained simulation.

Research Article citation

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