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

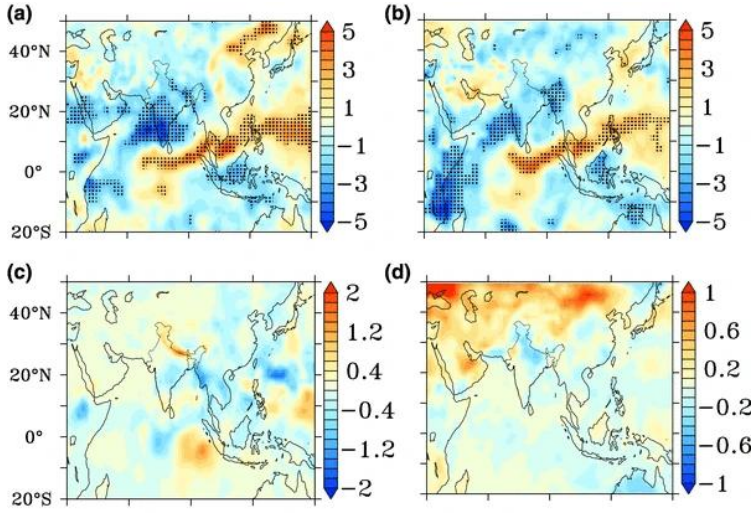
Disentangling sea-surface temperature and anthropogenic aerosol influences on recent trends in South Asian monsoon rainfall

Author List: Nitin Patil[1], Chandra Venkataraman[1,2] , Kaushik Muduchuru[1], Subimal Ghosh[1,3], Arpita Mondal[1,3]

[1]Interdiciplinary Program in Climate Studies, Indian Institute of Technology Bombay, Powai, Mumbai, India

[2]Department of Chemical Engineering, Indian Institute of Technology Bombay, Powai, Mumbai, India

[3]Department of Civil Engineering, Indian Institute of Technology Bombay, Powai, Mumbai, India



Trend [mm day−1 (40 years−1)] in precipitation a) ESST+GHGHaero, b) ESST+GHGLaero (Stipples indicates significant at 90%), and difference between ESST+GHGHaero and ESST+GHGLaero in c) Precipitation (mm day−1), d) 2-m temperature (°C)

Key highlights:

- Recent changes in anthropogenic aerosol levels (1971 versus 2010), when imposed on SST changes, were linked to an intensification of drying in the peninsular Indian region, with prominent decreases over the Western Ghats.
- Overall increase in atmospheric stabilization, decrease in vertical velocity, along with reduced evaporation flux, thus reducing convective rainfall.
- Changes in stratiform cloud processes tend to enhance rainfall formation processes like autoconversion and accretion.

Summary of your Research:
Recent studies point to combined effects of changes in regional land-use, anthropogenic aerosol forcing and sea surface temperature (SST) gradient on declining trends in the South Asian monsoon (SAM). This study attempted disentangling the effects produced by changes in SST gradient from those by aerosol levels in an atmospheric general circulation model. Two pairs of transient ensemble simulations were made, for a 40-year period from 1971 to 2010, with evolving versus climatological SSTs and with anthropogenic aerosol emissions fixed at 1971 versus 2010, in each case with evolution of the other forcing element, as well as GHGs. Evolving SST was linked to a widespread feedback on increased surface temperature, reduced land–sea thermal

contrast and a weakened Hadley circulation, with weakening of cross-equatorial transport of moisture transport towards South Asia. Increases in anthropogenic aerosol levels (1971 versus 2010), led to an intensification of drying in the peninsular Indian region, through several regional pathways. Aerosol forcing induced north–south asymmetries in temperature and sea-level pressure response, and a cyclonic circulation in the Bay of Bengal, leading to an easterly flow, which opposes the monsoon flow, suppressing moisture transport over peninsular India. Further, aerosol induced decreases in convection, vertically integrated moisture flux convergence, evaporation flux and cloud fraction, in the peninsular region, were spatially congruent with reduced convective and stratiform rainfall. Overall, evolution of SST acted through a weakening of cross-equatorial moisture flow, while increases in aerosol levels acted through suppression of Arabian Sea moisture transport, as well as, of convection and vertical moisture transport, to influence the suppression of SAM rainfall.

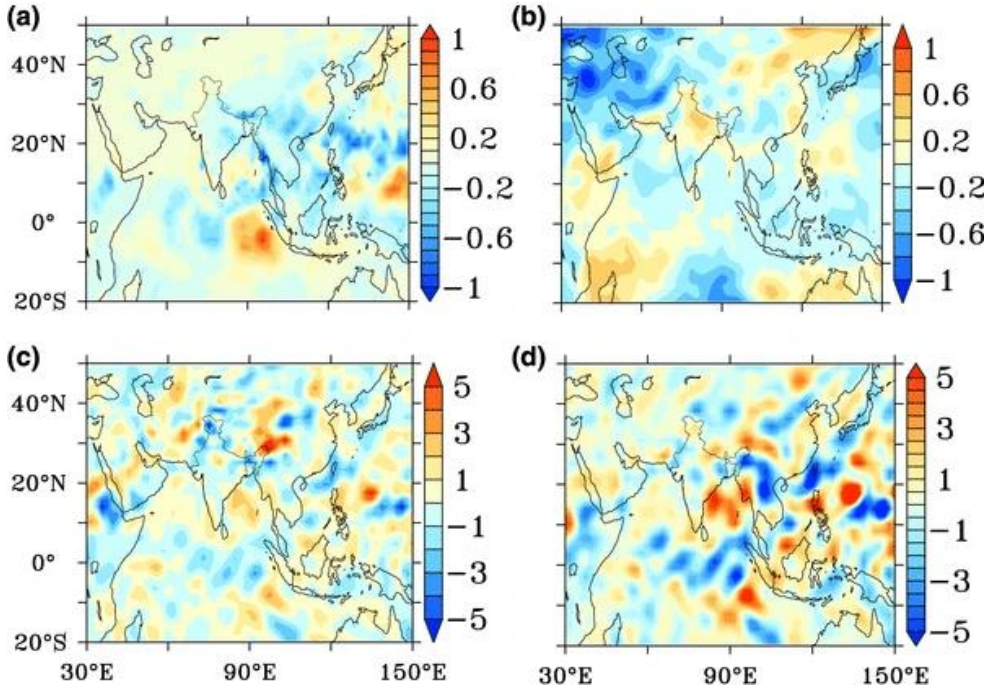


Figure: Difference between ESST+GHGHaero and ESST+GHGLaero for a Convective rainfall (mm day−1), b Lower Tropospheric Stability (LTS, K), c ω850 (× 10−3 m s−1) and d Vertically Integrated Moisture Flux (VIMFC, Kg m−1 s−1) during

Take away/conclusion :

Transient simulations in a GCM with an interactive aerosol scheme that includes indirect effect parameterizations, with use of a mix of scattering and absorbing anthropogenic aerosols, at emission levels of 2010 and 1971, allowed investigation of several pathways through which aerosol effects are manifested. Overall, it is found that SST gradient changes act through a weakening of cross-equatorial moisture flow, while aerosol level increases act through weakening of Arabian Sea moisture transport, as well as, of convection and vertical moisture flux, in the peninsula, to influence the suppression of SAM rainfall.

Research Article citation

Patil, N., Venkataraman, C., Muduchuru, K. et al.(2019) Disentangling sea-surface temperature and anthropogenic aerosol influences on recent trends in South Asian monsoon rainfall. Clim Dyn

Link:

https://doi.org/10.1007/s00382-018-4251-y

Contact

Prof. Chandra Venkataraman
National Co-ordinator
(NCAP-COALESCE Project)
Interdisciplinary Programme in Climate Studies

Indian Institute of Technology, Bombay Powai, Mumbai-400076, India

Phone: 91-22-2576-5141

https://ncapcoalesce.iitb.ac.in/

Consortium partners in the NCAP-COALESCE network