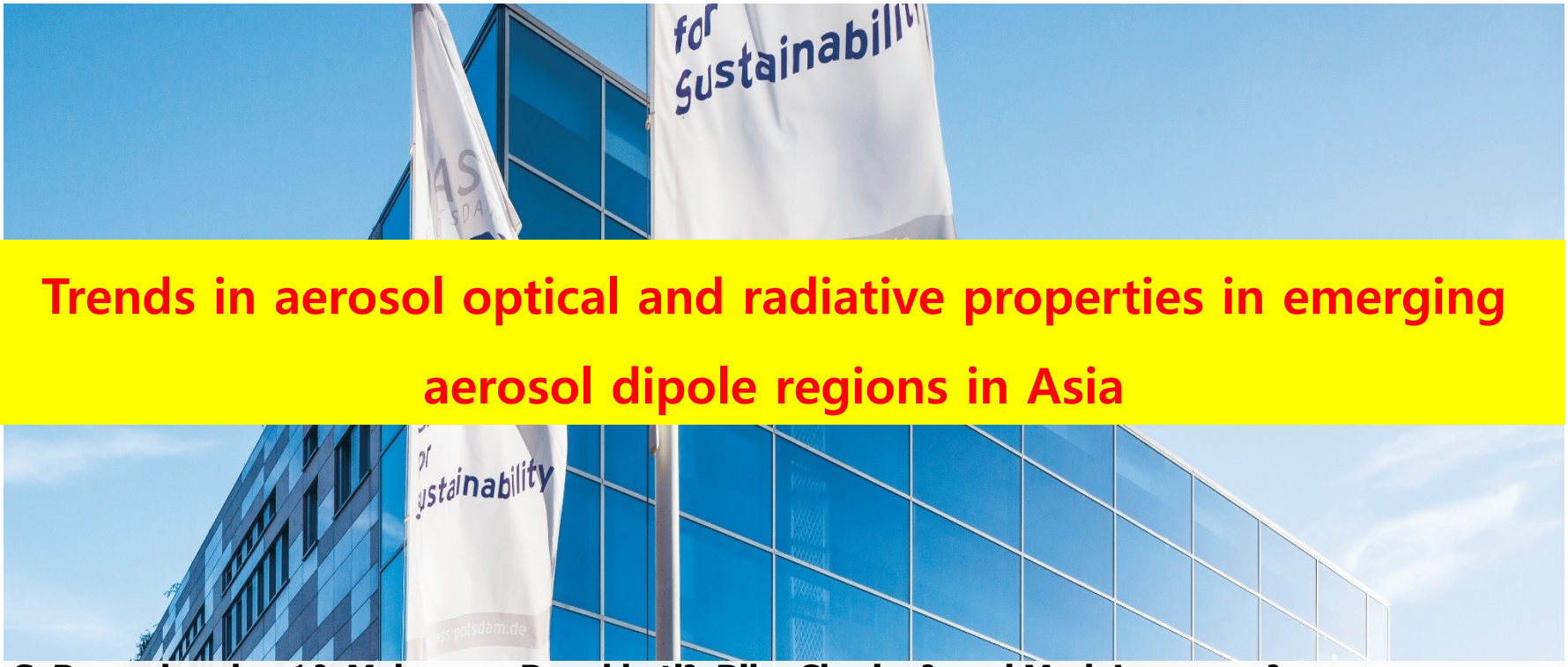


Trends in aerosol optical and radiative properties in emerging aerosol dipole regions in Asia

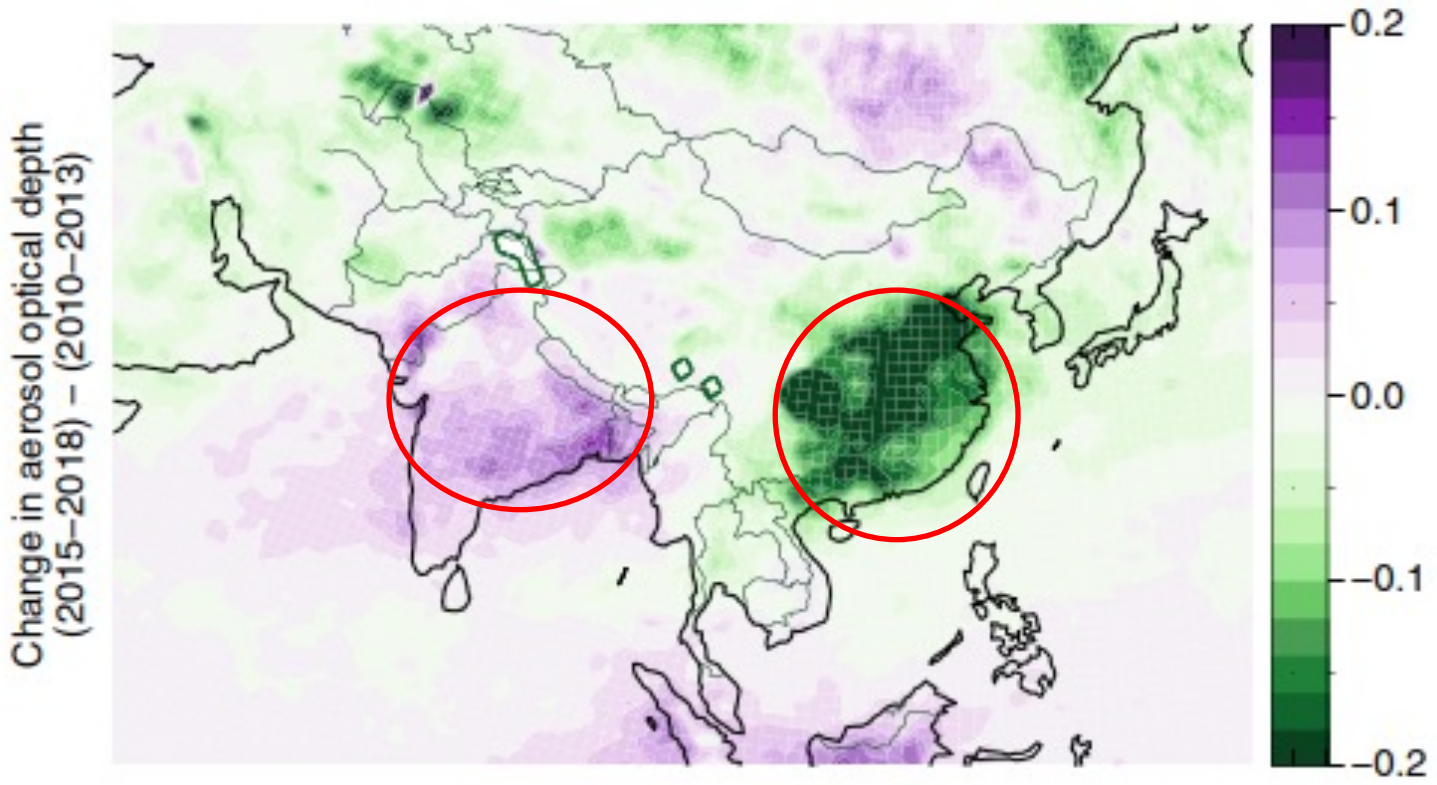
S. Ramachandran[1,2], Maheswar Rupakheti[2], Ribu Cherian[3], and Mark Lawrence[2]

[1]Physical Research Laboratory (PRL), Ahmedabad, India
[2]Research Institute for Sustainability – Helmholtz Centre Potsdam (RIFS), Potsdam, Germany
[3]Leipzig Institute for Meteorology, University of Leipzig, Leipzig, Germany

5th Workshop
Dhaka, 8-10 June 2023

Asian Aerosol Dipole

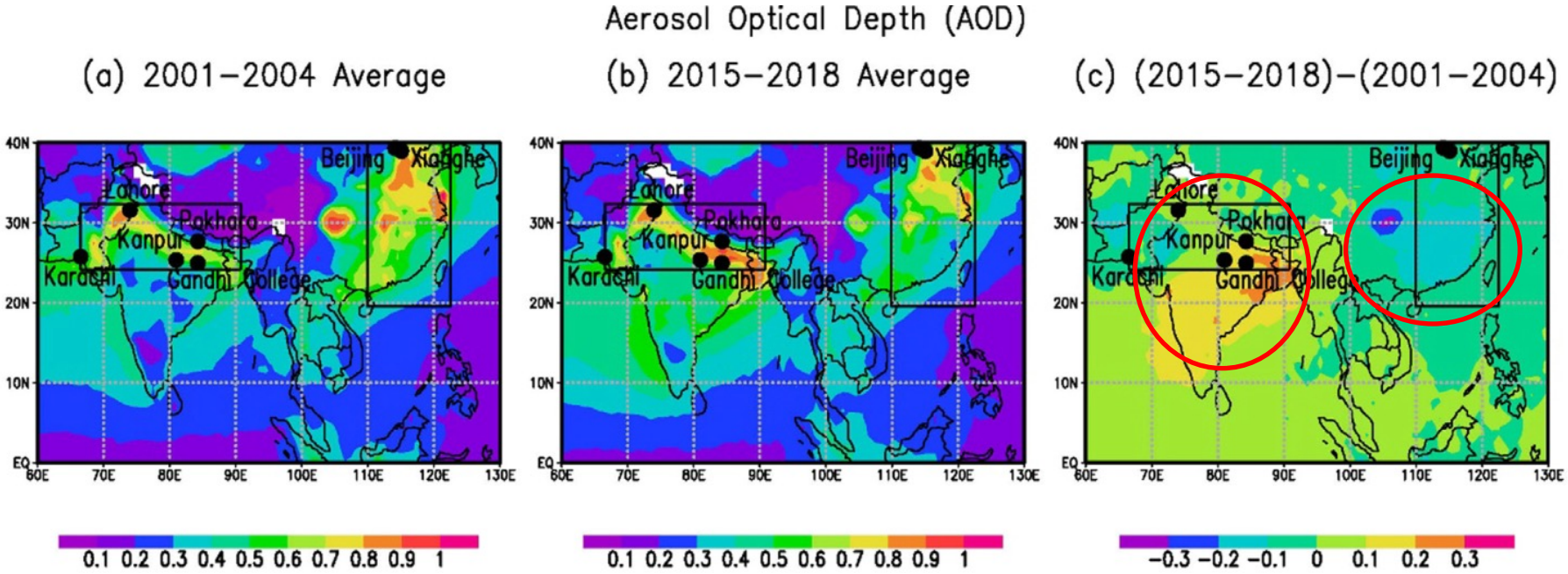
- Recent increase in aerosol emissions in South Asia and a significant decrease in East Asia (notably in China since 2010) has resulted in a marked reduction in total AOD_{550} (MODIS) over China and increase over India creating an Asian aerosol dipole (*Samset et al., 2019*)



Samset et al., Nature Geosci., 2019)

Asian Aerosol Dipole

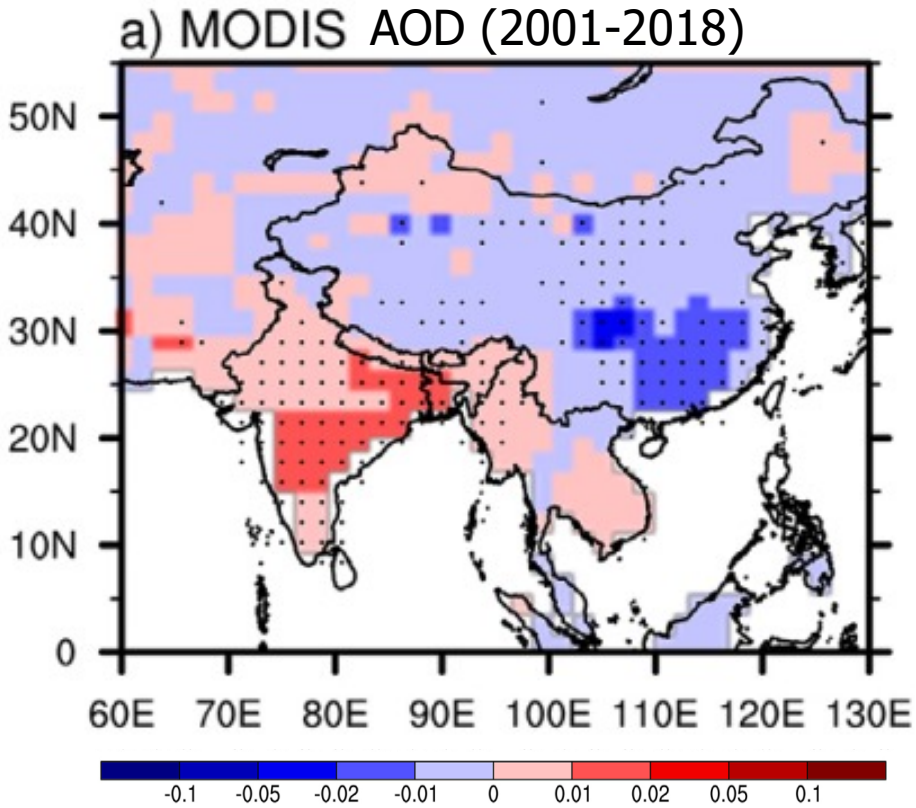
- Asian aerosol dipole is evident in both ground-based measurements (AERONET) in South Asia and East Asia and satellite observations (MODIS) of AODs during 2001-2018.



Ramachandran and Rupakheti, Gondwana Research 2022

AOD trends over the aerosol dipole regions

- Our inadequate understanding of magnitudes and trends in atmospheric aerosols, particularly over Asia, is a major source of uncertainty in climate change (*IPCC AR6 WG1, 2021*)



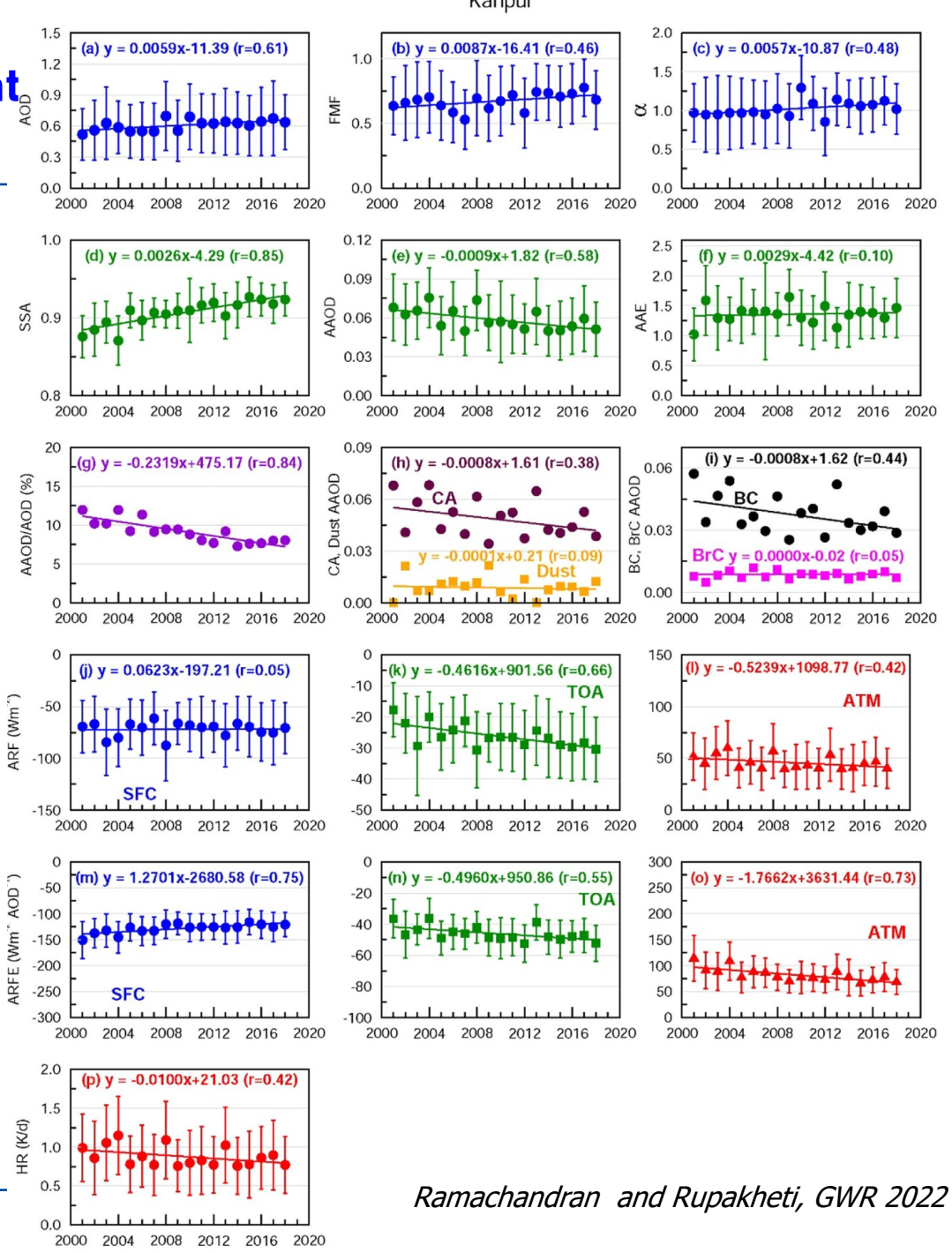
Black dots correspond to points (0.5°x0.5°) where the trend (linear) is significant at the 95% confidence level.

Ramachandran et al, Sci. Total. Environ. 2022a

Trends in aerosol optocal and radiative properties (AERONET) at Kanpur, India during 2002–2018

Key highlights:

- Aerosols are becoming more scattering in nature (increasing SSA, decreasing AAOD, decreasing AAOD/AOD, decreasing BC AAOD, decreasing heating rate).
- Aerosol size distributions may also be changing and hence affecting the optical and radiative properties (which is yet to be studied).

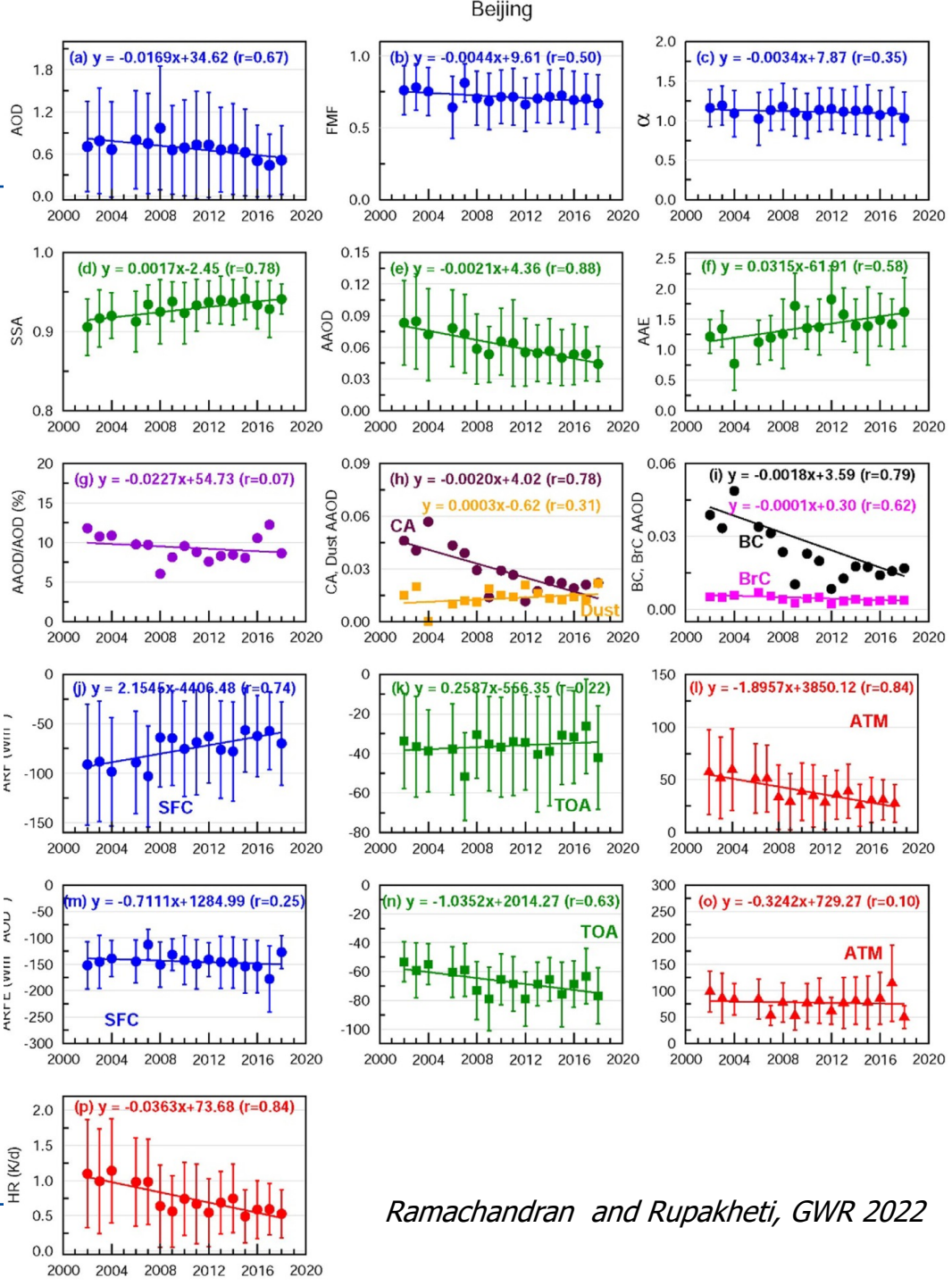


Ramachandran and Rupakheti, GWR 2022

Trends in aerosol optocal and radiative properties (AERONET) at Beijing, China during 2002-2018

Key highlights:

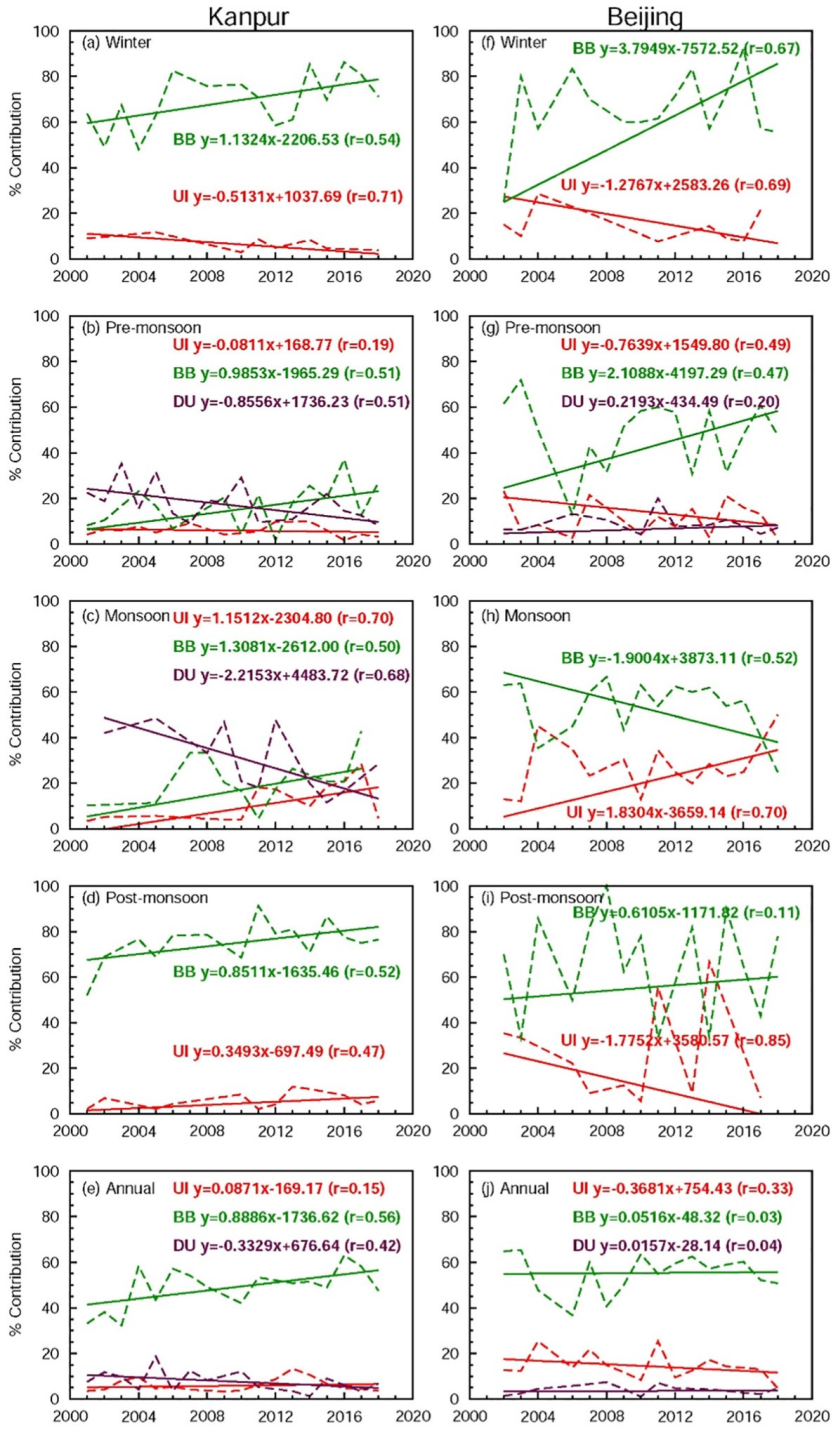
- Aerosols are becoming more scattering in nature (increasing SSA, decreasing AAOD, decreasing AAOD/AOD, decreasing BC AAOD, decreasing heating rate).
- Aerosol size distributions may also be changing and hence affecting the optical and radiative properties (which is yet to be studied).



Ramachandran and Rupakheti, GWR 2022

Trends in aerosol optocal and radiative properties (AERONET) at Beijing, China and Kanpur, India during 2002–2018

BB: Biomass burnig aerosols
UI: Urban and Industrial aerosols
DU: Dust aerosols



Key highlights:

- BB aerosol type is increasing in Kanpur in all seasons while it is increasing in Beijing during Winter and Pre-monsoon only.
- UI aerosol type is increasing over both sites during Monsoon season.

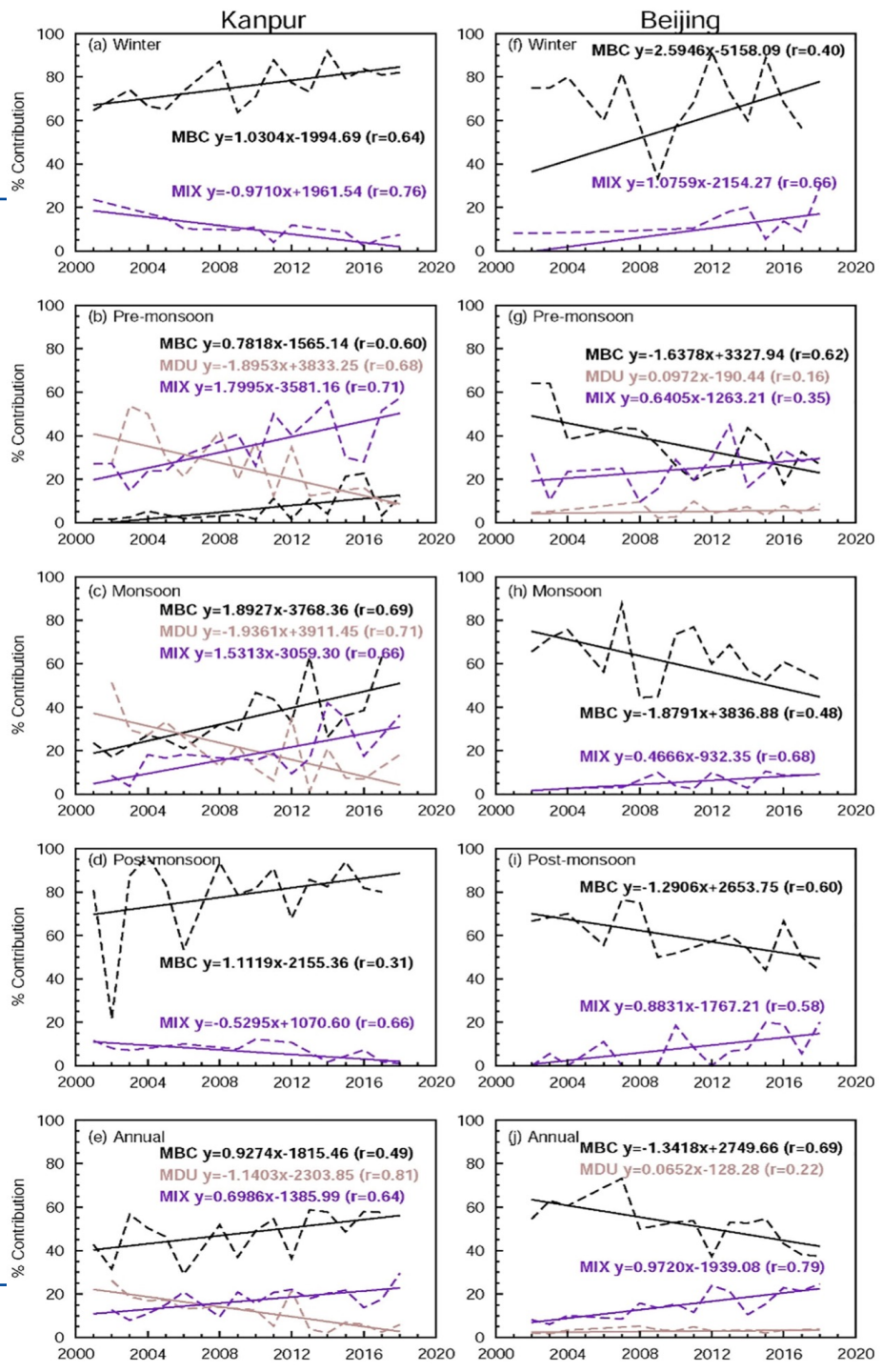
Ramachandran and Rupakheti, Sci. Total Environ, 2022b

Trends in aerosol optocal and radiative properties (AERONET) at Beijing, China and Kanpur, India during 2002–2018

MBC: Mostly BC aerosols
MIX: BC and Dust mixed aerosols
MDU: Mostly Dust aerosols

Key highlights:

- MBC type is increasing in Kanpur in all seasons while it is increasing in Beijing during Winter only.
- MDU aerosol type is decreasing over Kanpur in all seasons while it is slightly increasing over Beijing during pre-monsoon

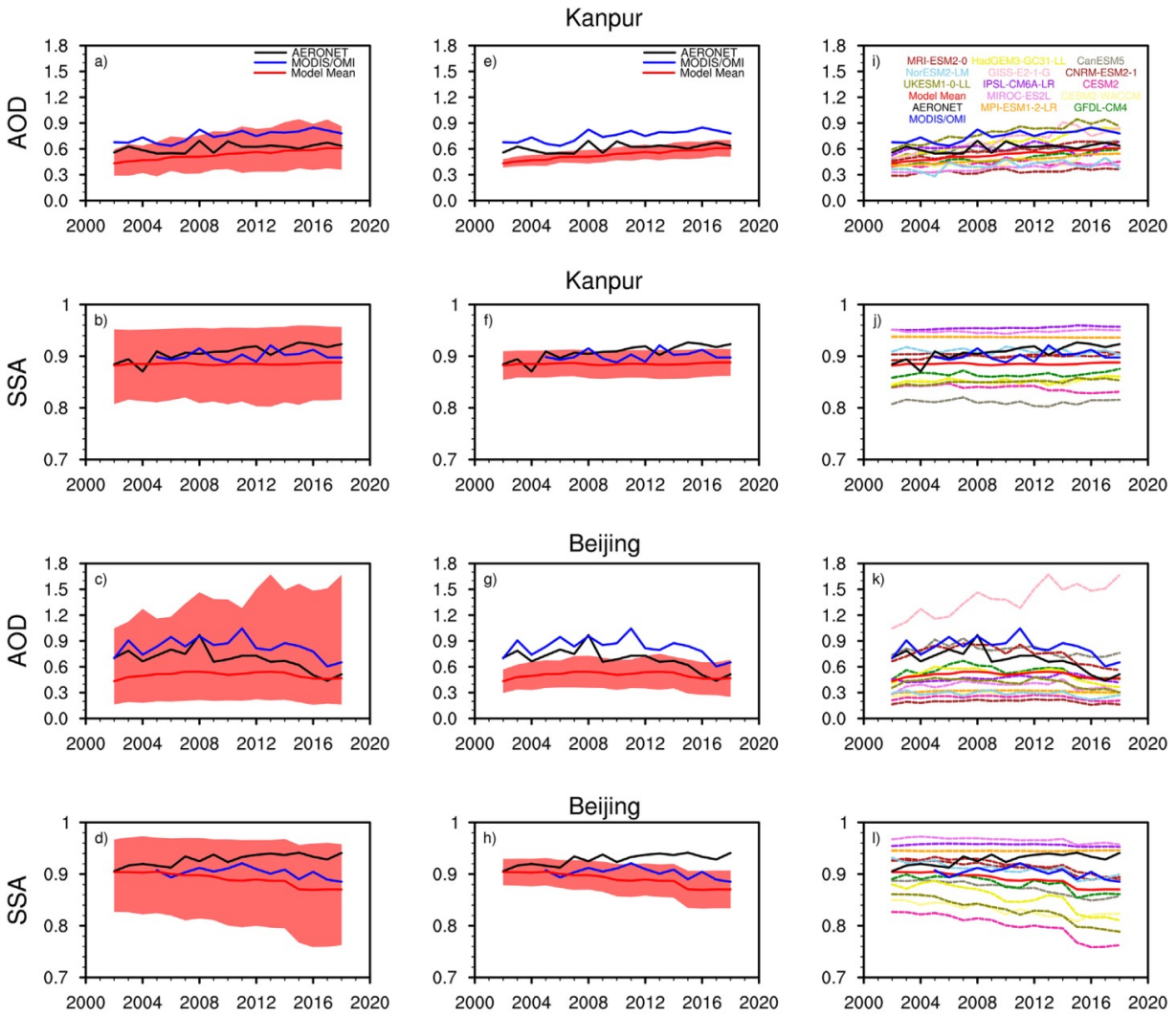


Ramachandran and Rupakheti, Sci. Total Environ, 2022b

Trends in AOD and SSA from observations (AERONET) and model simulations (CMIP6) at Beijing, China and Kanpur, India during 2002-2018

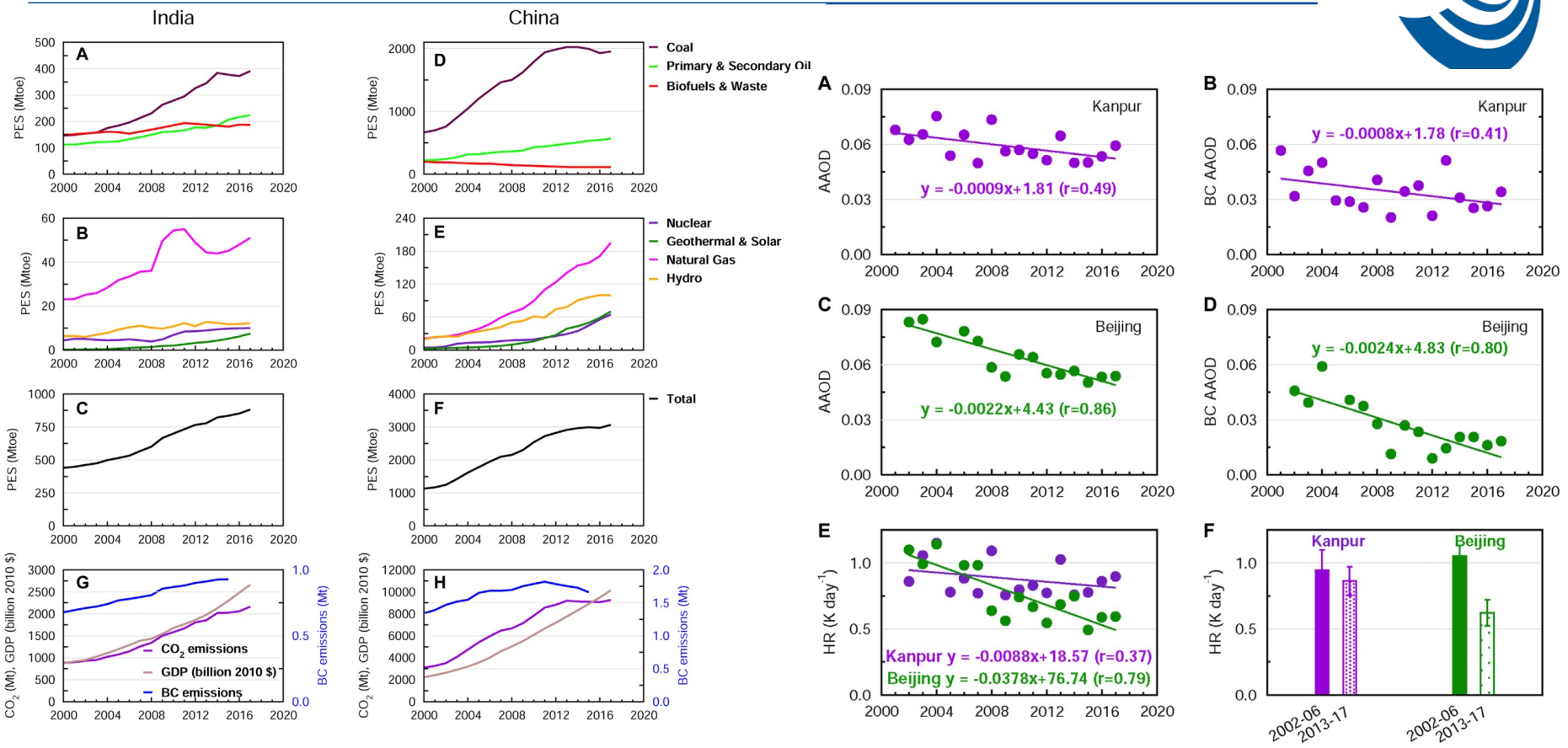
Key highlights:

- Many CMIP6 models are unable to simulate AOD and SSA over Kanpur and Beijing (notably magnitudes)



Ramachandran et al, Scii. Total Environ., 2022c

Changing energy mix in India and China and resultant climate benefits through BC reduction



- Aerosol-induced atmospheric heating rate is decreasing over both South and East Asia as a result of energy mix and resultant changing aerosol content and composition. However, annual average HR of 0.5-1.1 K/day is still high.

Ramachandran et al, Front. Env. Sci, 2022

For further Information on trends

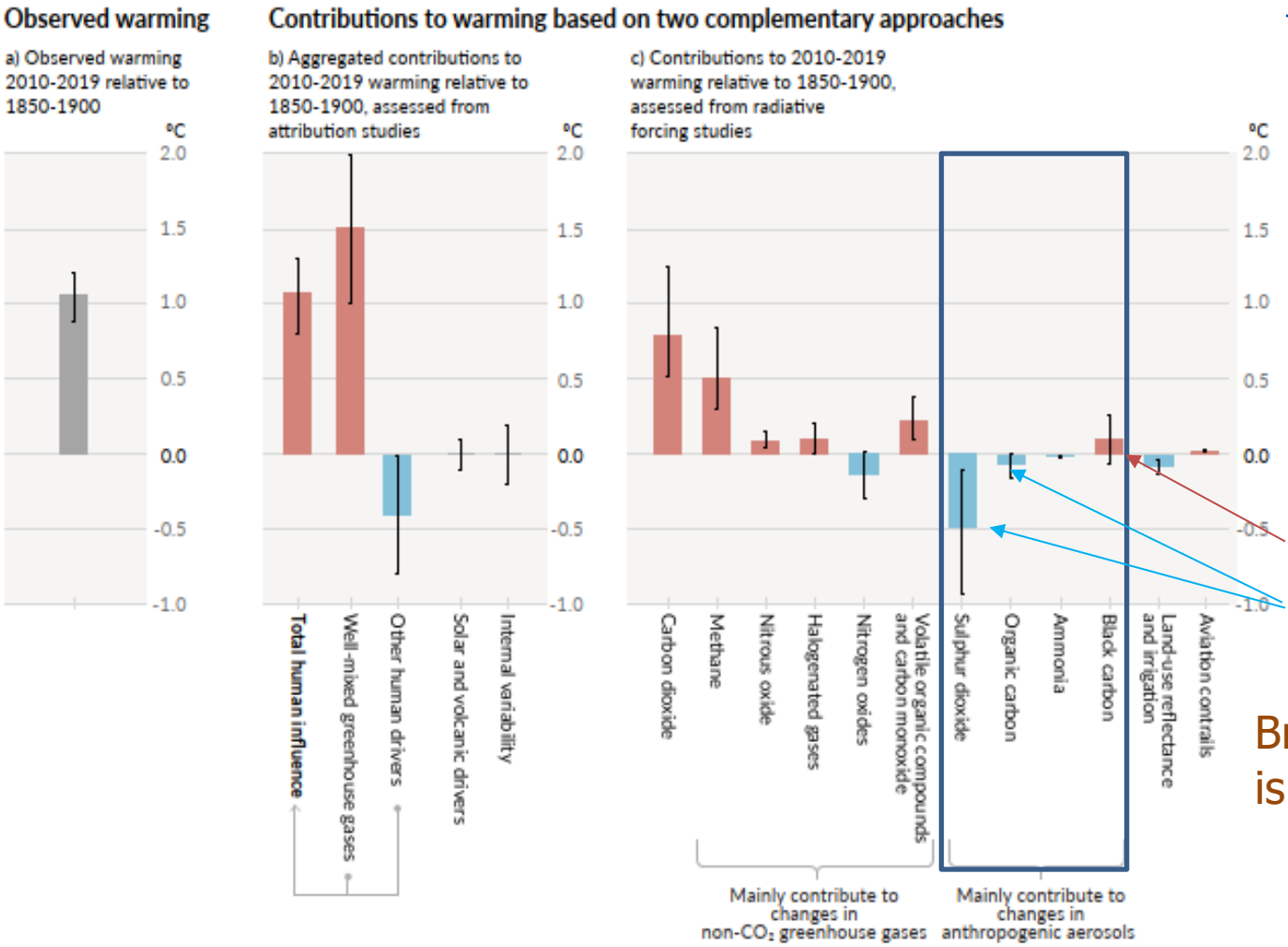
- Ramachandran, S., Rupakheti, M., and Lawrence, M.G.: Aerosol-induced atmospheric heating rate decreases over South and East Asia as a result of changing content and composition, *Scientific Reports,* 10(1), 20091, 2020
- Ramachandran, S., Rupakheti, M. and Cherian, R.: Insights into recent aerosol trends over Asia from observations and CMIP6 simulations, *Science of the Total Environment,* 807(1), 150756, 2022
- Ramachandran, S. and Rupakheti, M.: Trends in physical, optical and chemical columnar aerosol characteristics, and radiative effects over South and East Asia: Satellite and ground-based observations, *Gondwana Research,* 105, 366-387, 2022
- Ramachandran, S., Rupakheti, M., Cherian, R., and Lawrence, M.G.: Climate benefits due to cleaner energy transitions in East and South Asia through black carbon reduction, *Frontiers in Environmental Science,* 10, 842319, 2022
- Ramachandran, S. and Rupakheti, M.: Trends in types and absorption characteristics of aerosols over Indo-Gangetic Plain and North China Plain in last two decades, *Science of the Total Environment,* 831, 154867, 2022
- Ramachandran, S., Rupakheti, M., Cherian, R., and Lawrence, M.G.: Aerosols heat up the Himalayan climate*, Science of the Total Environment,* in press, 2023

Thank You

maheswar.rupakheti@rifs-potsdam.de

Air pollution (Aerosols) impacts on climate:
Global Temperature Change

IPCC AR6, SPM, 2021



Observed: +1.09°C
Anthropogenic: +1.07°C
GHGs: +1.5°C [1-2°C]
Aerosols: -0.4°C [0.0 to -0.8°C]
Uncertainty: Factor of 2.

Warming

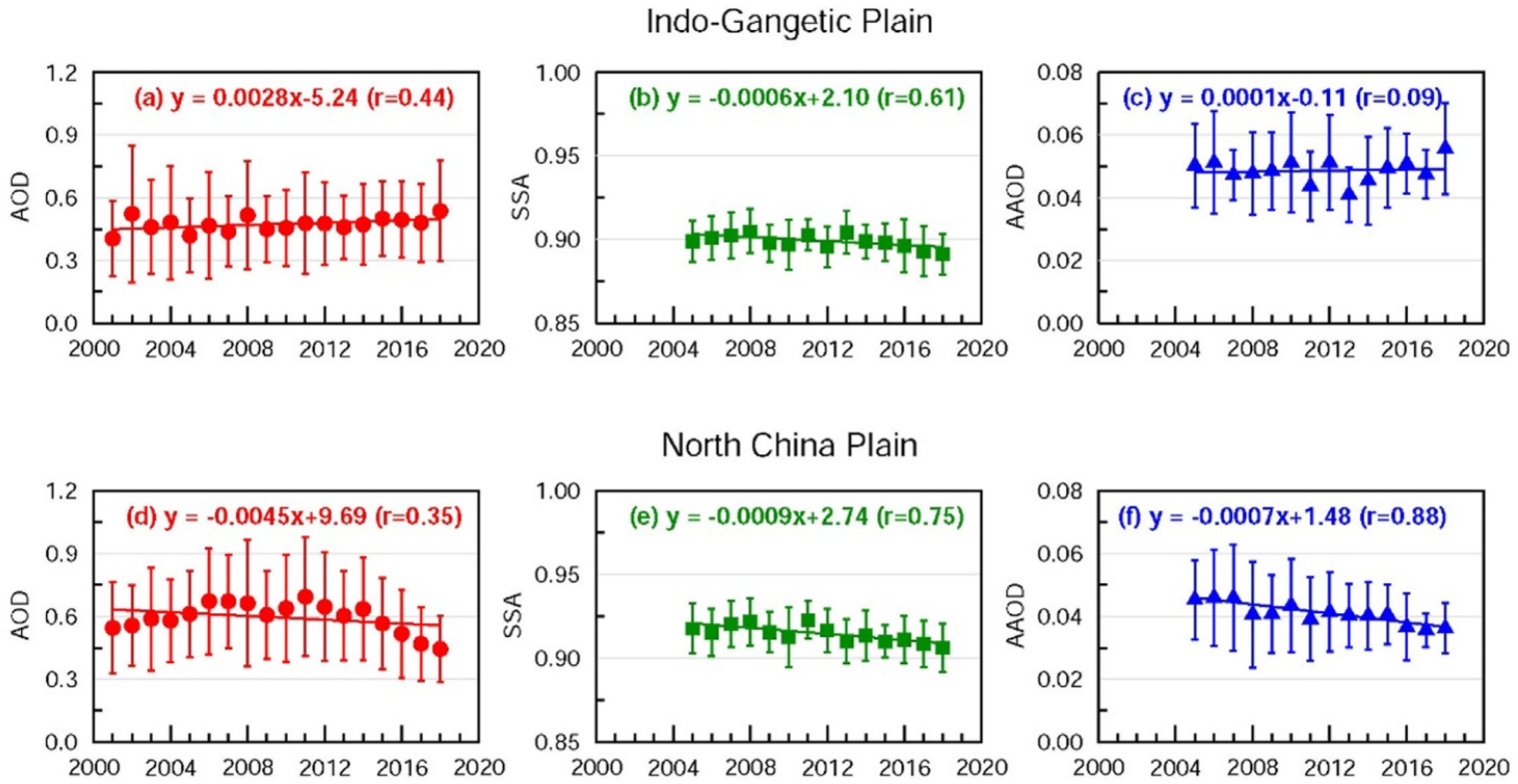
Cooling

Brown Carbon (warming) is not considered yet.

- Observed warming is driven by emissions from human activities, with GHG warming partly masked by aerosol cooling.
- Because of the spatial and temporal non-uniformity of aerosol forcing, the net effect is not simply a fractional offset.

Trends in AOD, SSA and AAPD over IGP and NCP

Area averaged trends in satellite-retrieved AOD, SSA and AAOD during 2001-2018.

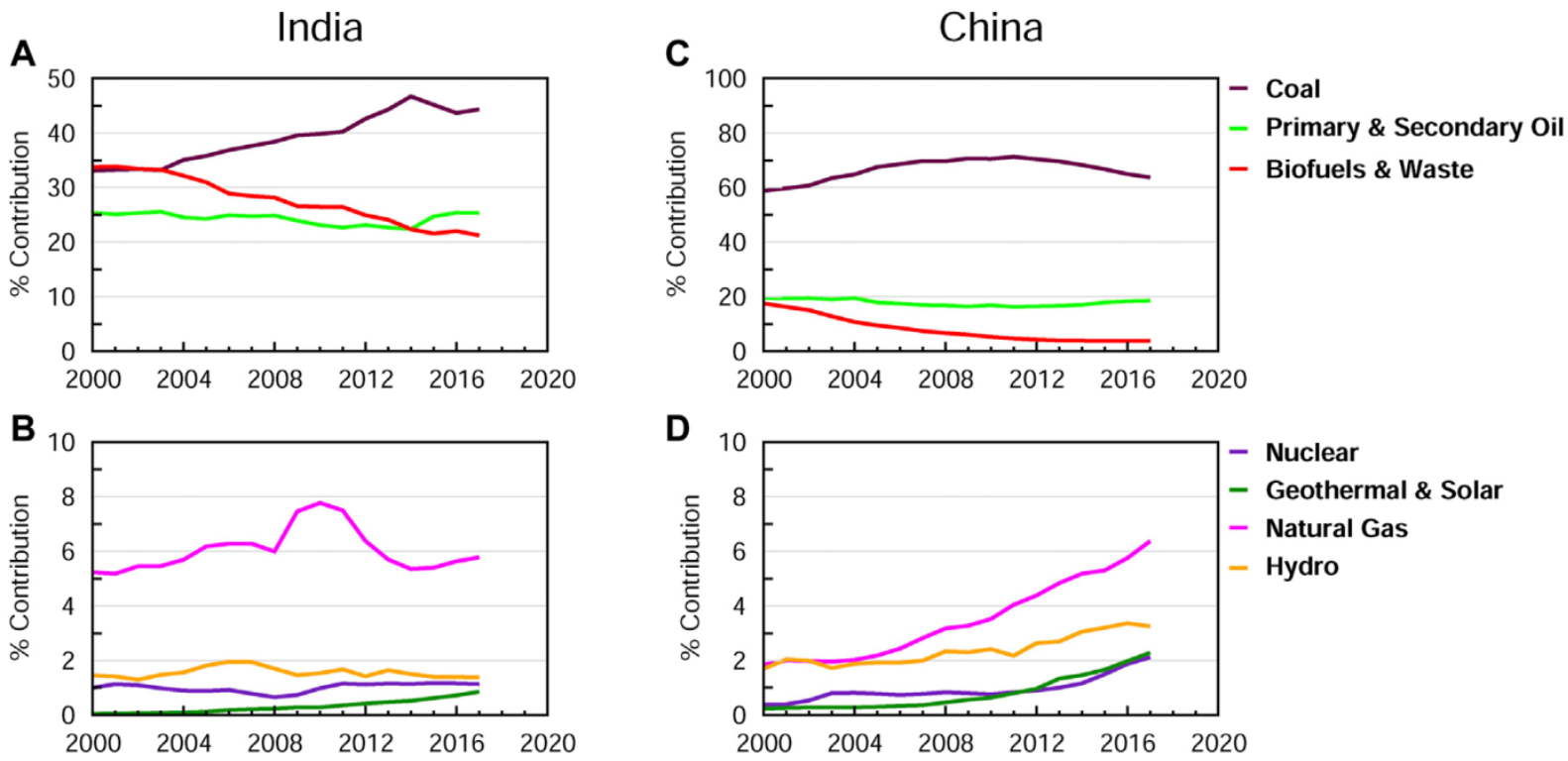


AOD from MODIS, and SSA and AAOD from OMI.

Ramachandran et al, Sci. Total. Environ. 2022c

Trends in AOD, SSA and AAPD over IGP and NCP

Contributions of energy sources to total energy production



Ramachandran et al, Front, Env. Science. 2022