Asian summer monsoon response to a future dipole in aerosol emissions across India and China

- using an intermediate-complexity GCM

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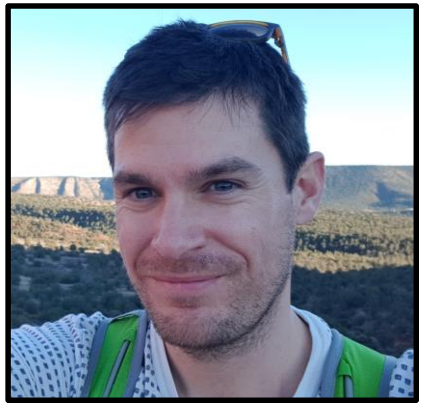

AeroCom 2020

Aerosol impacts the Asian summer monsoon

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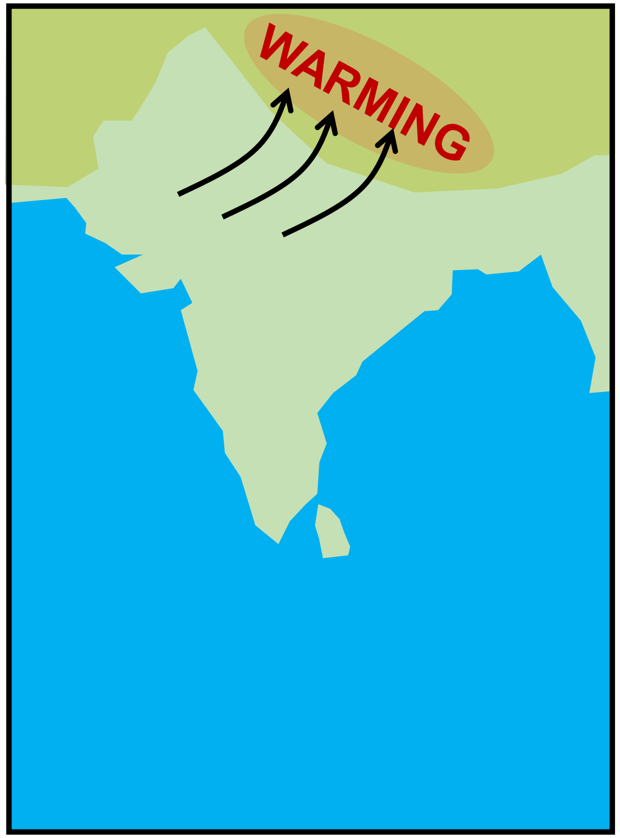
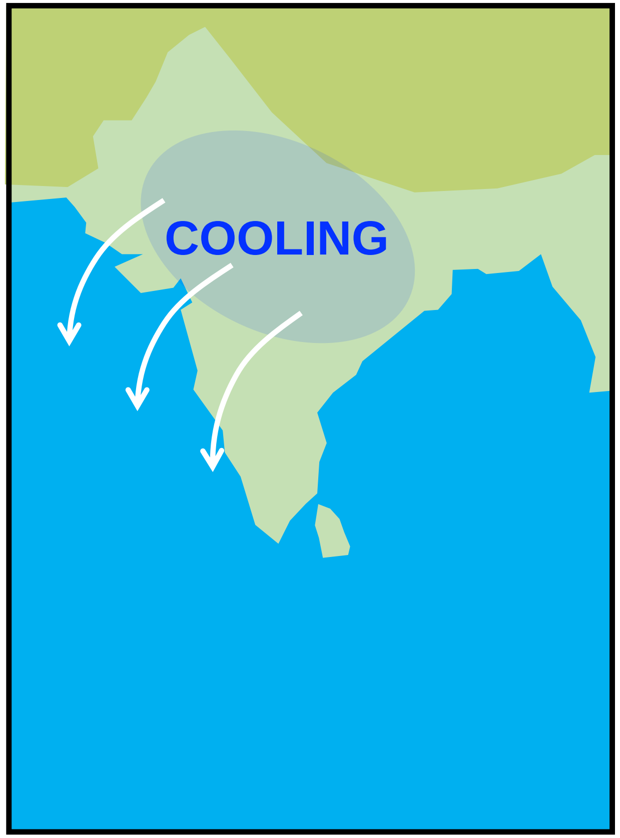
ABSORBING AEROSOL IN PRE-MONSOON =

ELEVATED HEAT PUMP ADVANCES MONSOON ONSET

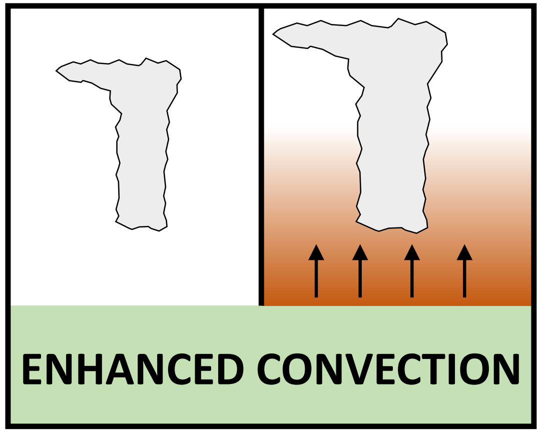


AEROSOL EXTINCTION = SURFACE COOLING

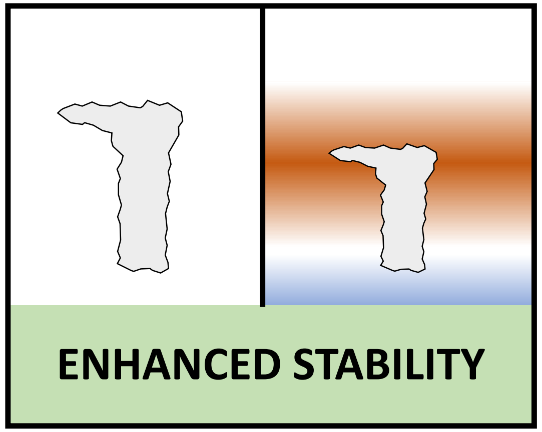
WEAKENED MERIDIONAL T GRADIENT



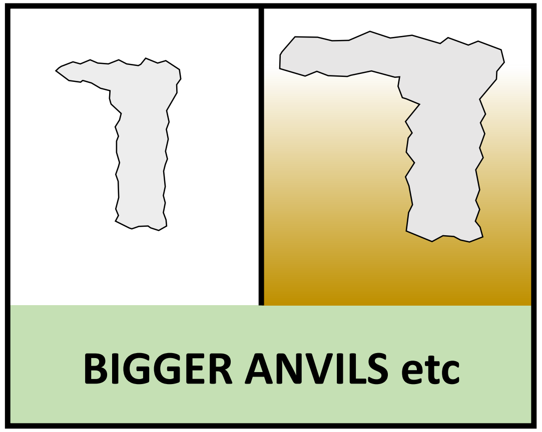
ABSORBING AEROSOL PERTURBS STABILITY



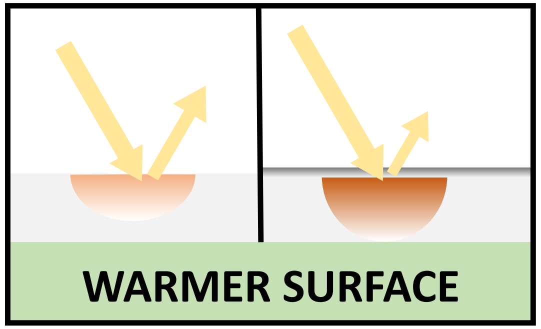
SENSITIVE TO VERTICAL PROFILE



AEROSOL ENHANCES CLOUD DROPLET NUMBER



DARK AEROSOL INCREASES SNOW ALBEDO



Future dipole in emissions projected

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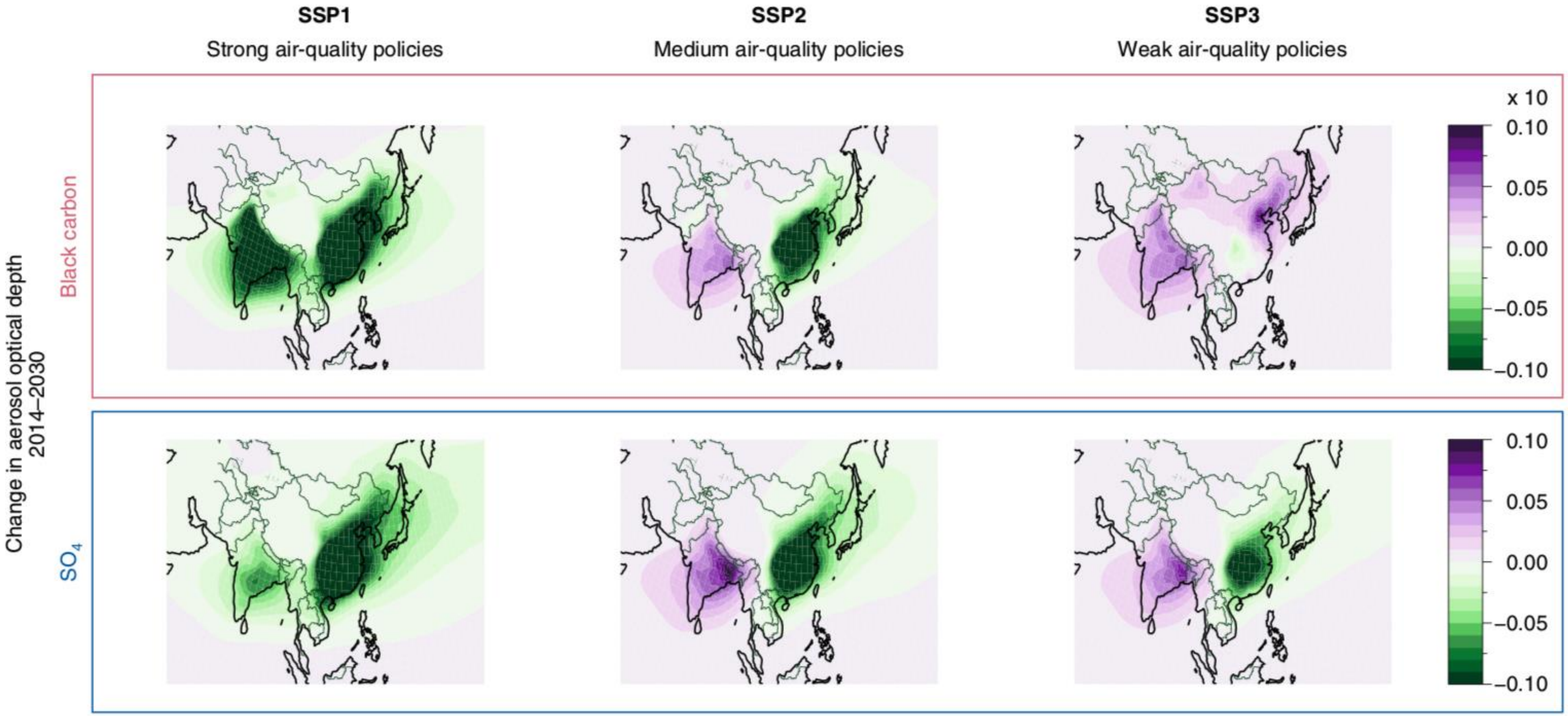
⇩ BC everywhere
⇩ SO_4 mainly in China

⇩ BC & SO_4 in China
⇧ BC & SO_4 in India

⇧ BC everywhere
⇩ SO_4 in China
⇧ SO_4 in India



Samset et al., Nature Geoscience, 2019

IGCM4 – a speedy model that packs a punch

University of Reading

IGCM4 – Intermediate Global Circulation Model 4

- spectral primitive equations climate model based on the baroclinic model of Hoskins and Simmons (1975)
- includes representation of:
  - radiation (2 SW, 5 LW bands)
  - land-surface properties
  - surface topography
  - dry and moist convection
  - clouds (+ parameterized marine stratocumulus)
  - stratospheric processes
  - SST climatology, mixed-layer ocean, or coupled to MOMA (FORTE)
- T42 (2.8°) standard resolution – but also configured for T170 (0.7°)
- 35 levels (20 for troposphere, 15 for stratosphere)
- Computing time for 100 years: IGCM4 (T42L35) = 30hr on 32 processors; FORTE 2.0 (T42L35) = 24hr on 28 cores
  - also possible to run on desktop computer in serial (IGCM4 T42L35: 5 year integration in 24hr)

from Joshi et al. (2015):

> [this type of model] *enables process-level understanding to become more tractable because of (a) computational speed enabling long integrations or large ensemble members, and (b) flexibility and ease of use enabling the examination of idealized scenarios*

Geosci. Model Dev., 8, 1157–1167, 2015
www.geosci-model-dev.net/8/1157/2015/
doi:10.5194/gmd-8-1157-2015

Geoscientific Model Development
Open Access

IGCM4: a fast, parallel and flexible intermediate climate model

M. Joshi[1,2], M. Stringer[3], K. van der Wiel[1,2], A. O'Callaghan[1,2], and S. Fueglistaler[4]

IGCM4 coupled with MOMA ocean model

https://doi.org/10.5194/gmd-2020-43
Preprint. Discussion started: 5 March 2020

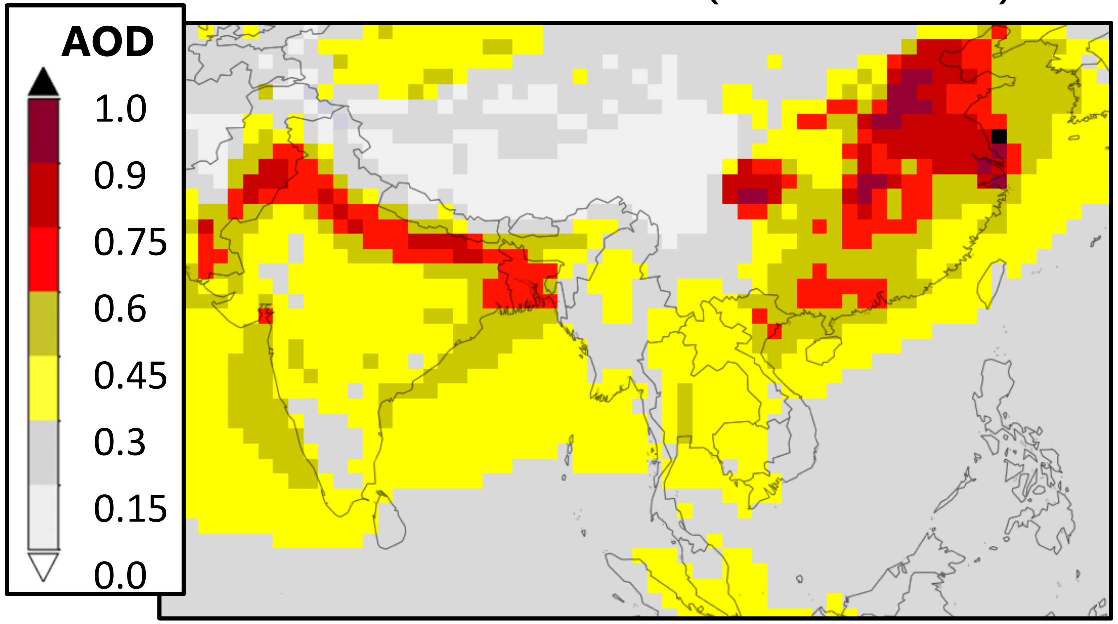
Geoscientific Model Development
Discussions
Open Access

FORTE 2.0: a fast, parallel and flexible coupled climate model

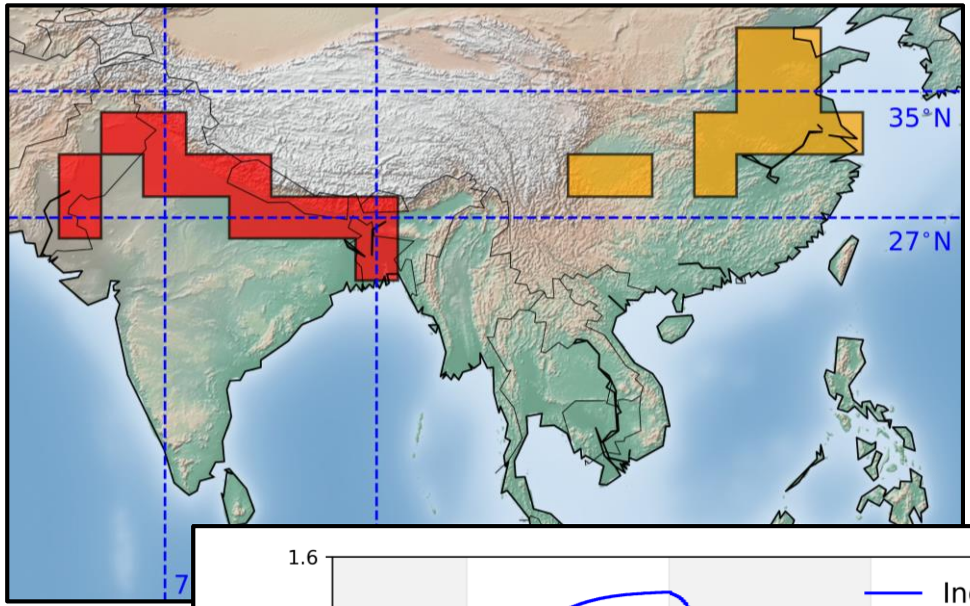
Adam T. Blaker[1], Manoj Joshi[2], Bablu Sinha[1], David P. Stevens[3], Robin S. Smith[4], and Joël J.-M. Hirschi[1]

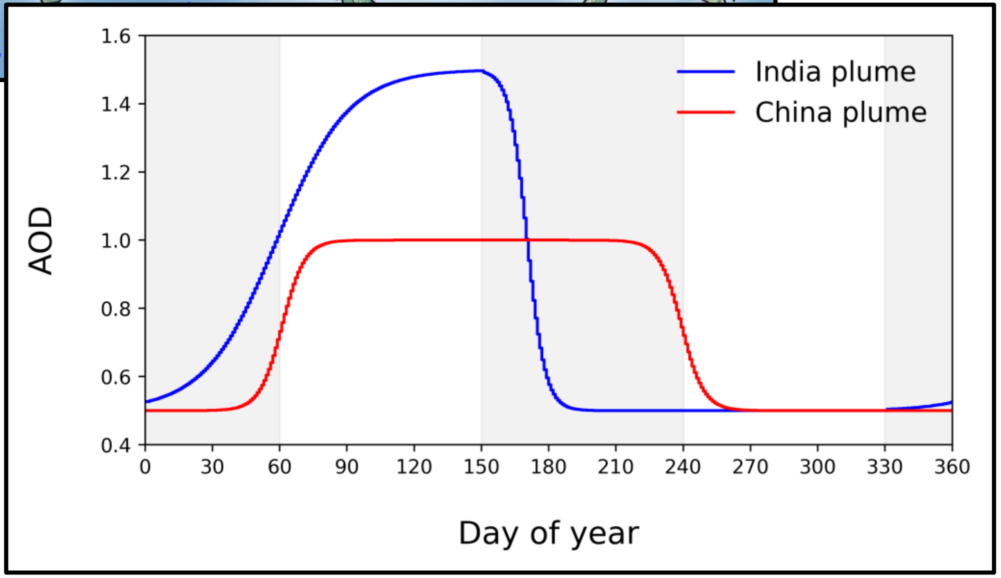
Treatment of aerosols in radiation scheme

mean MODIS AOD (2000 to 2019)



Spatial distribution in experiments





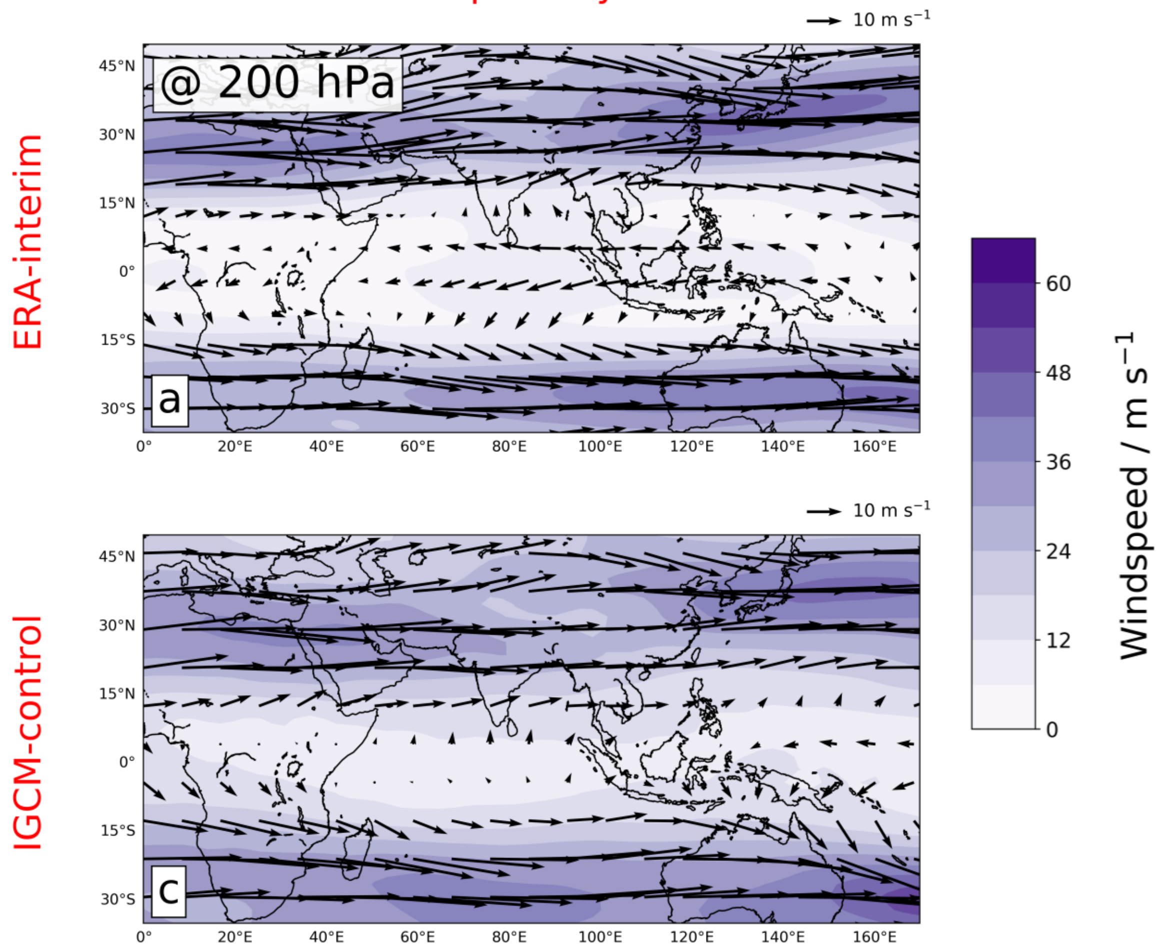
- India plume = elevated up to 600 hPa (4km)
- China plume = surface to 800 hPa (2km)

40 year simulations using SST climatology

IGCM4 reproduces monsoon circulation

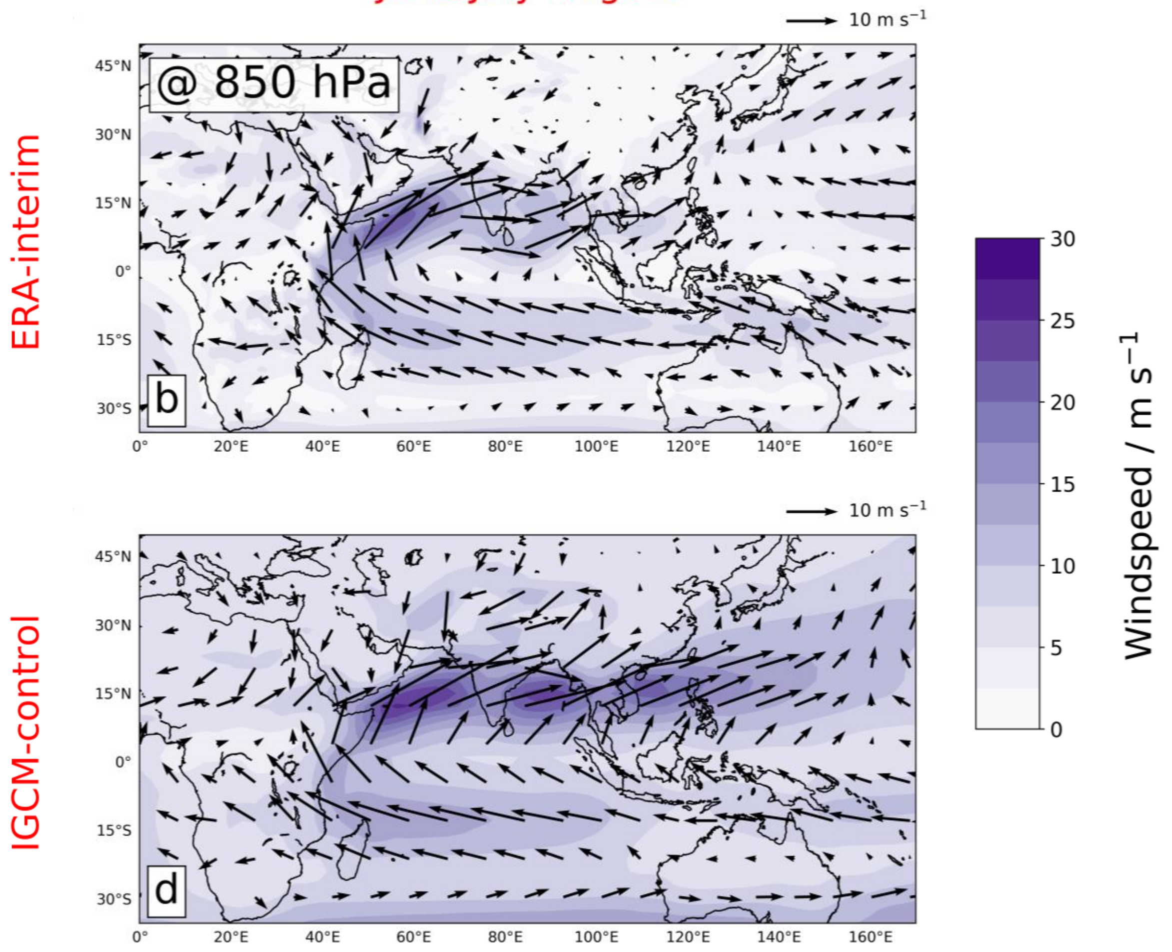
focusing on subtropical jet during pre-monsoon

April-May

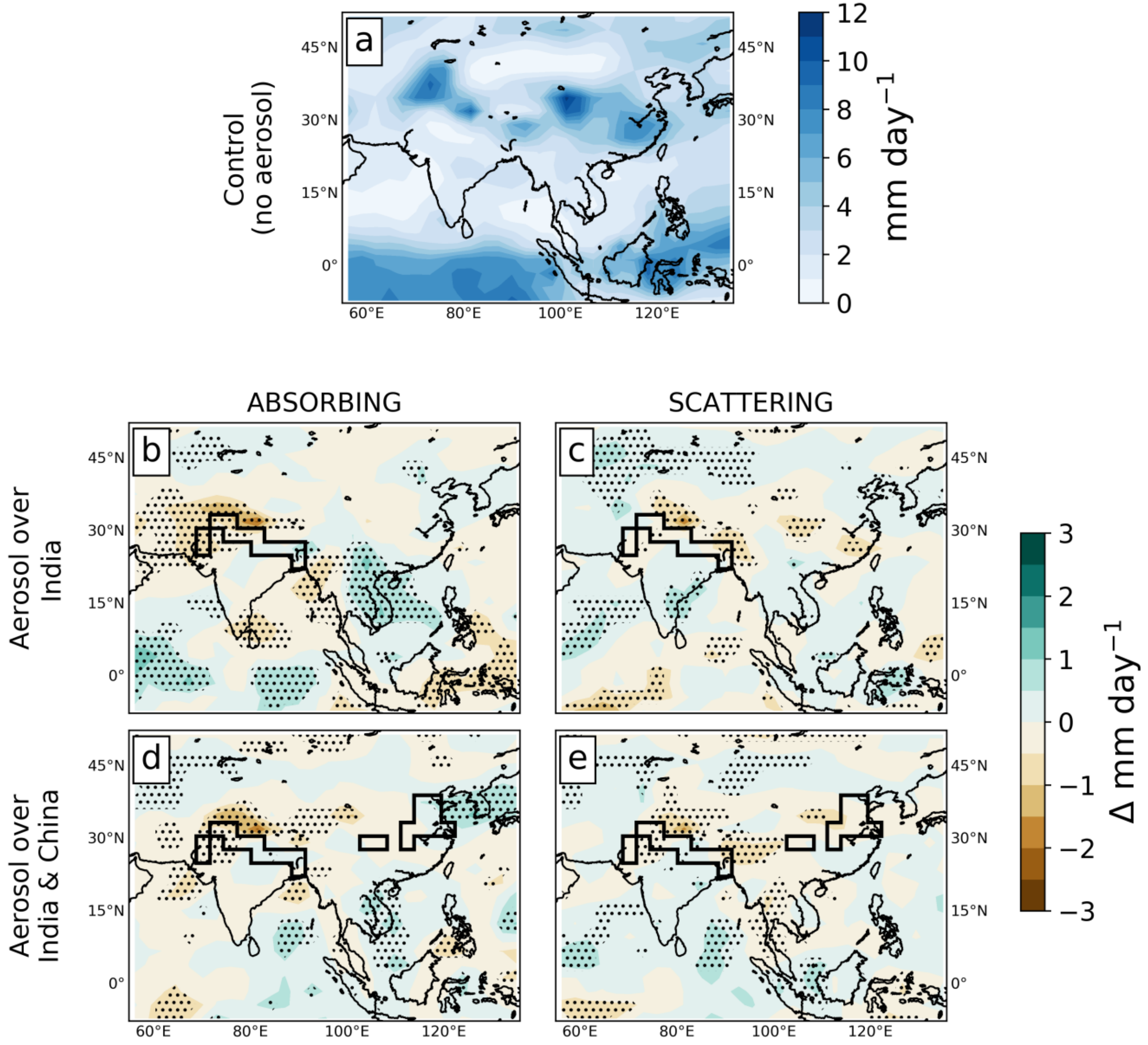


focusing on low-level jet during monsoon

June-July-August

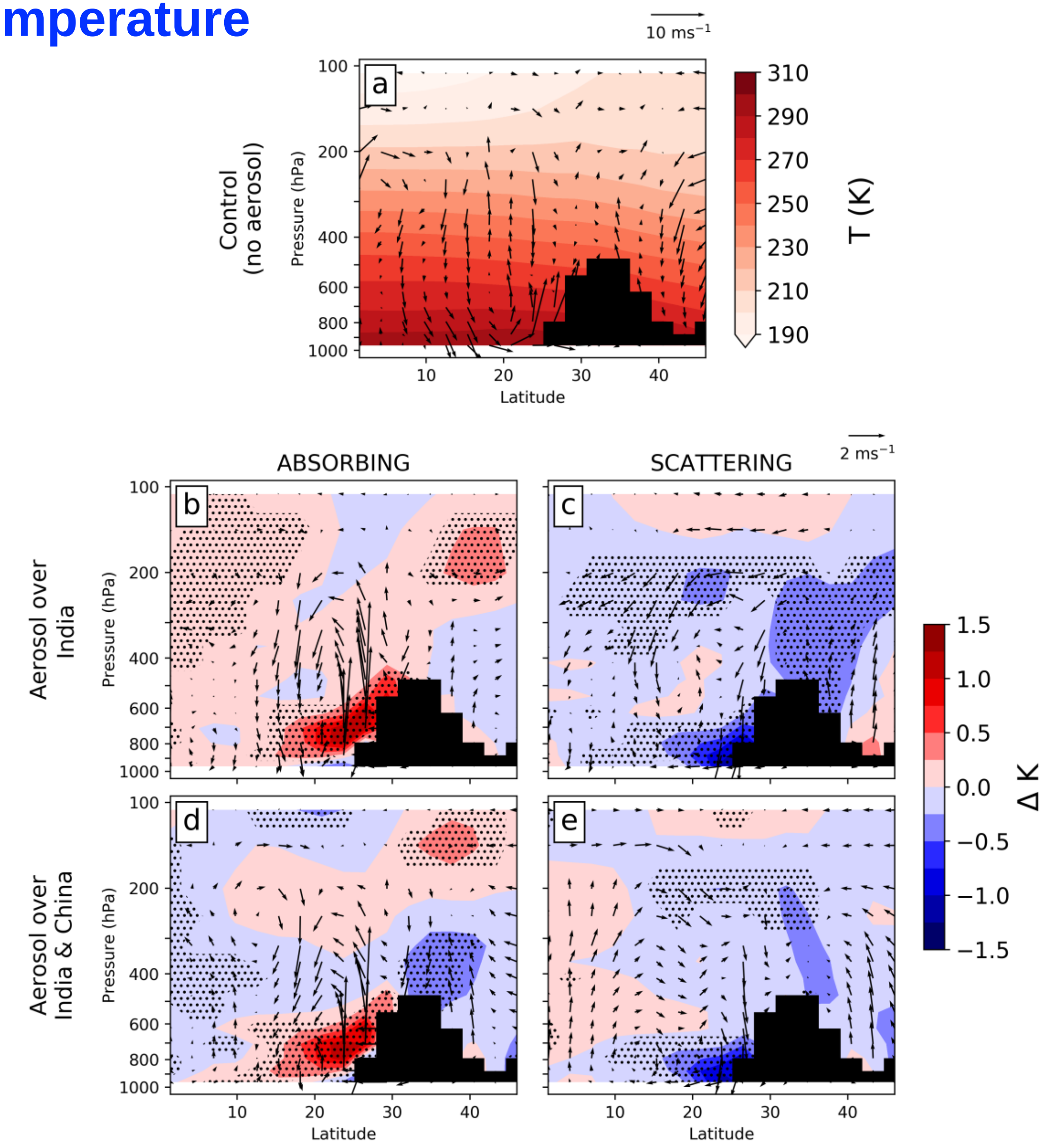


Pre-monsoon: precipitation response

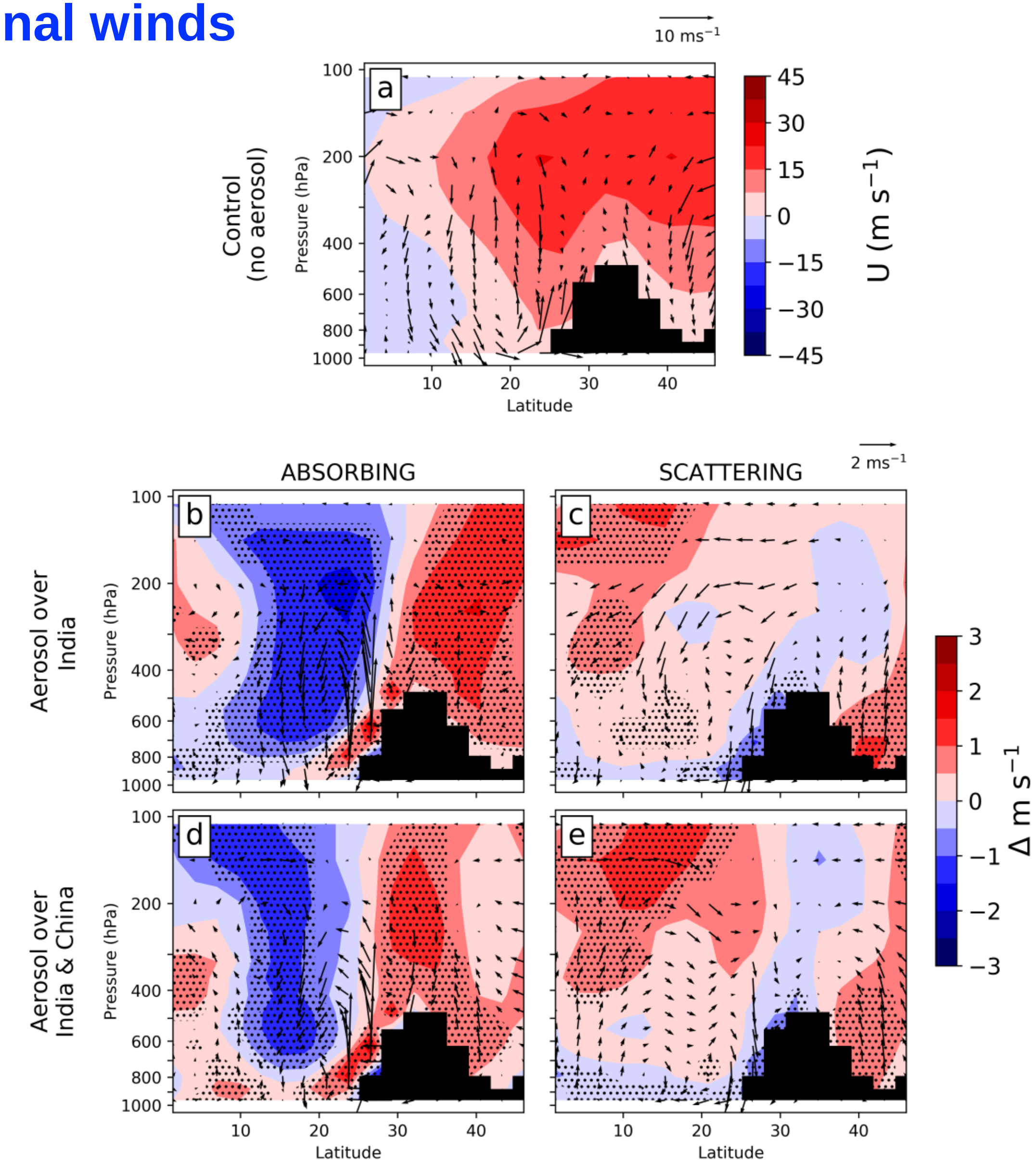


Pre-monsoon: Vertical cross sections at 90E

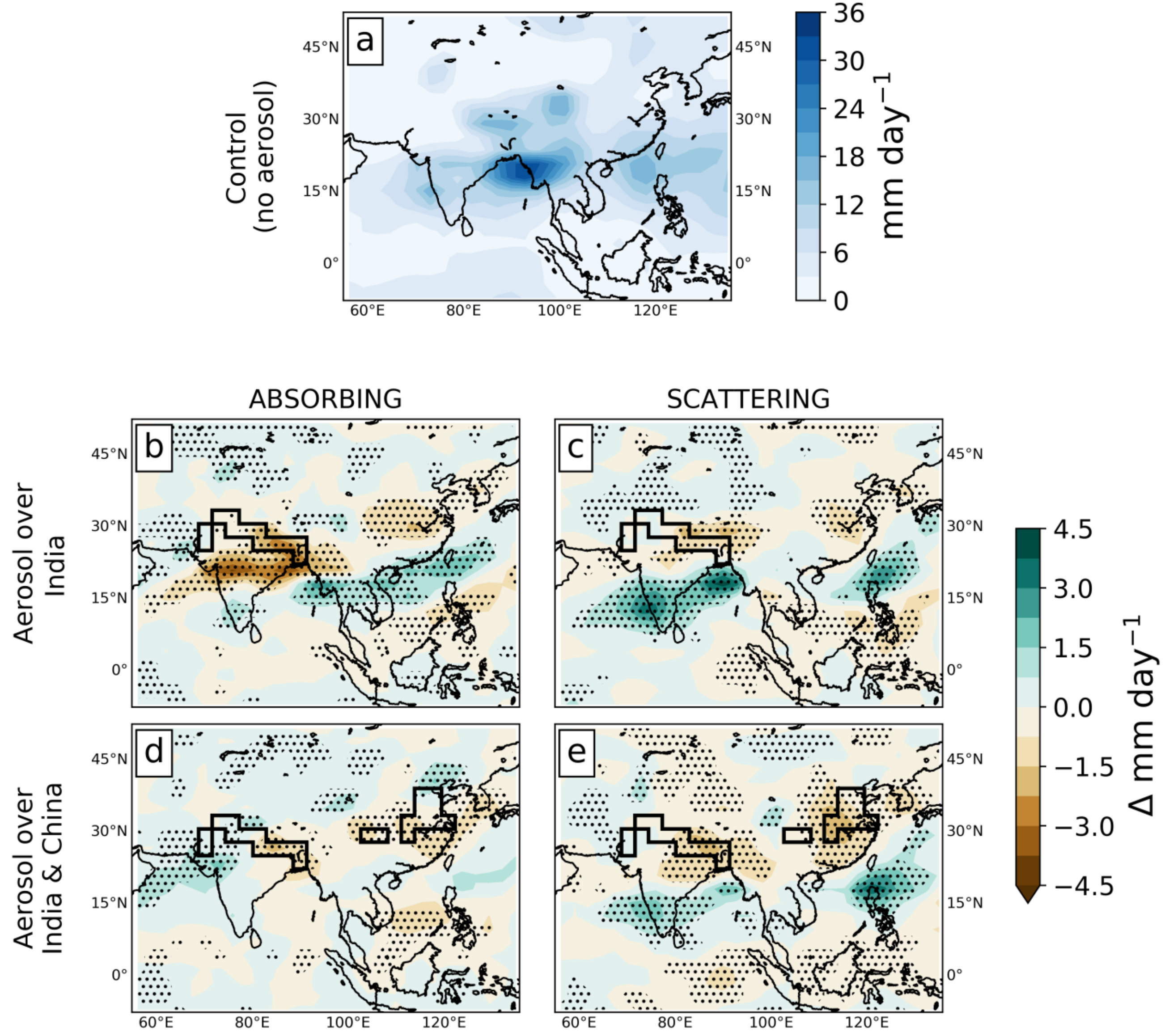
Temperature



Zonal winds

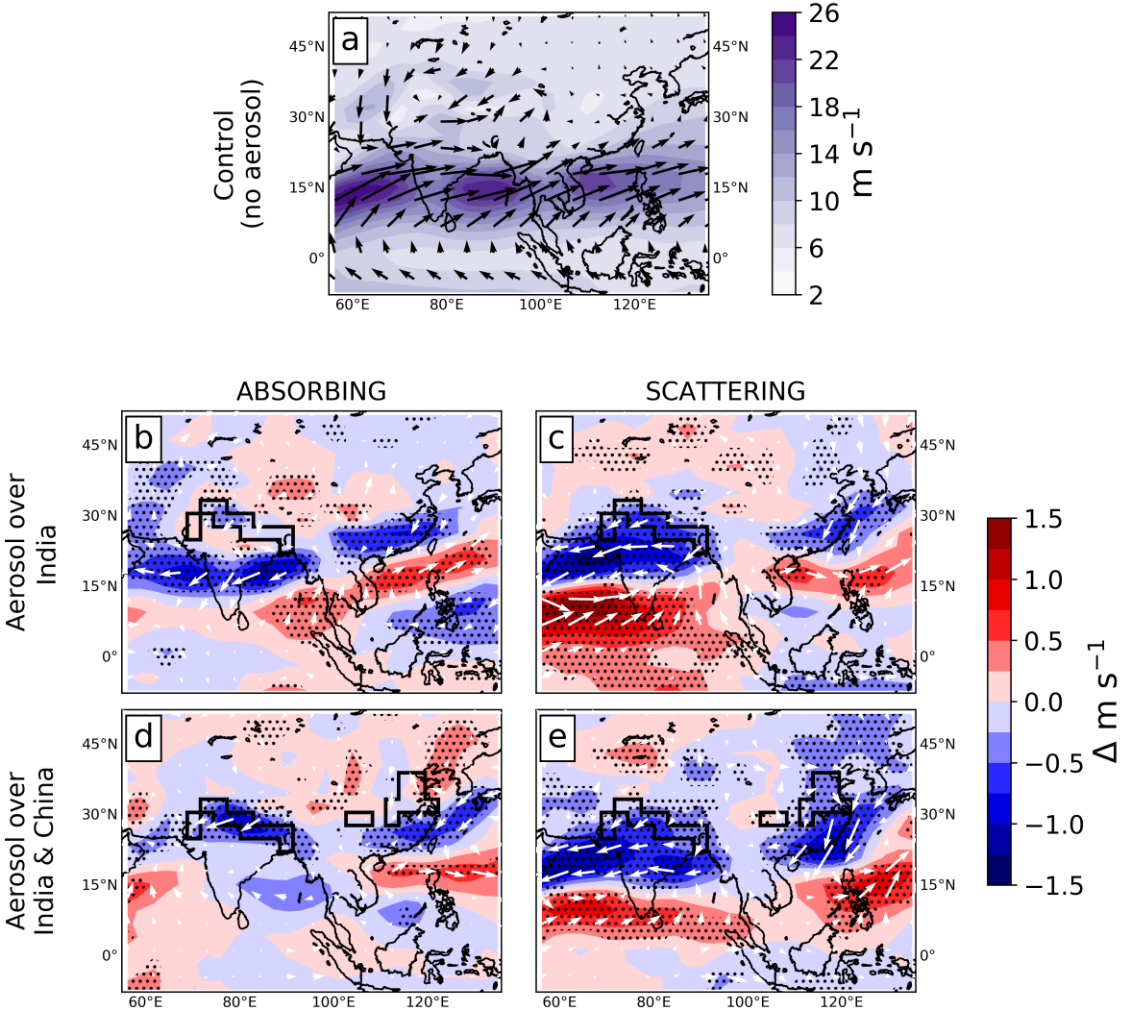


Monsoon: precipitation response

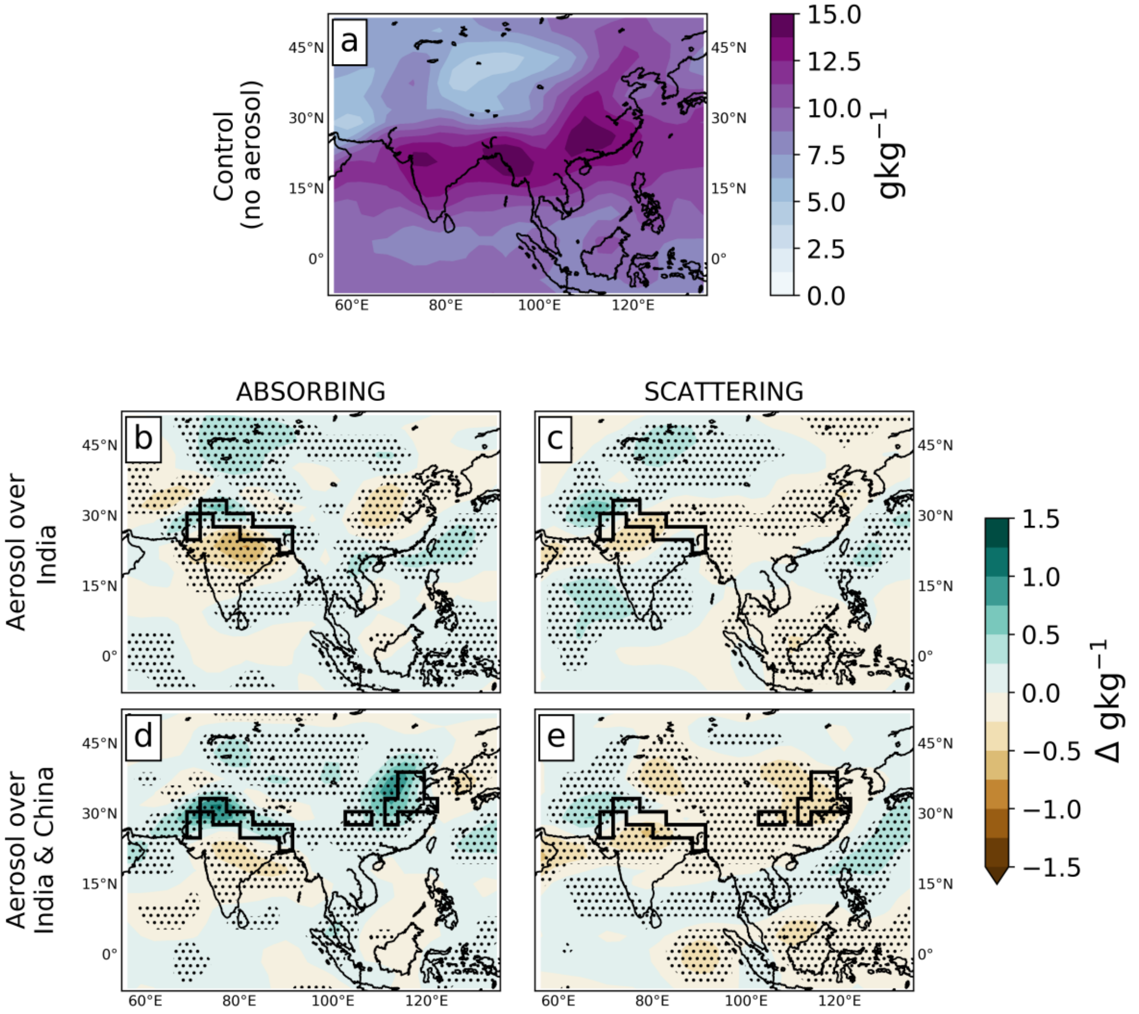


Monsoon: response of BL winds and Q_{vapor}

850 hPa horizontal windspeed



850 hPa water vapor



Summary

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- IGCM4 with prescribed aerosol used to investigate projected dipole in aerosol emissions from South and East Asia and impact on the Asian Summer Monsoon

- Increases in India emissions causes widespread decrease in precipitation
- Increases in China emissions enhance this effect locally, but also perturb the response upstream in India

- SSP1 = strong decrease in BC and SO_4 over India and China
  - increased monsoon precipitation over much of China and India
- SSP2 = strong dipole (decrease of BC and SO_4 in China, increase in India)
  - small increase in monsoon precipitation over China
  - enhanced drying over India
- SSP3 = increased BC in China, increased BC and SO_4 in India
  - enhanced drying over India and China