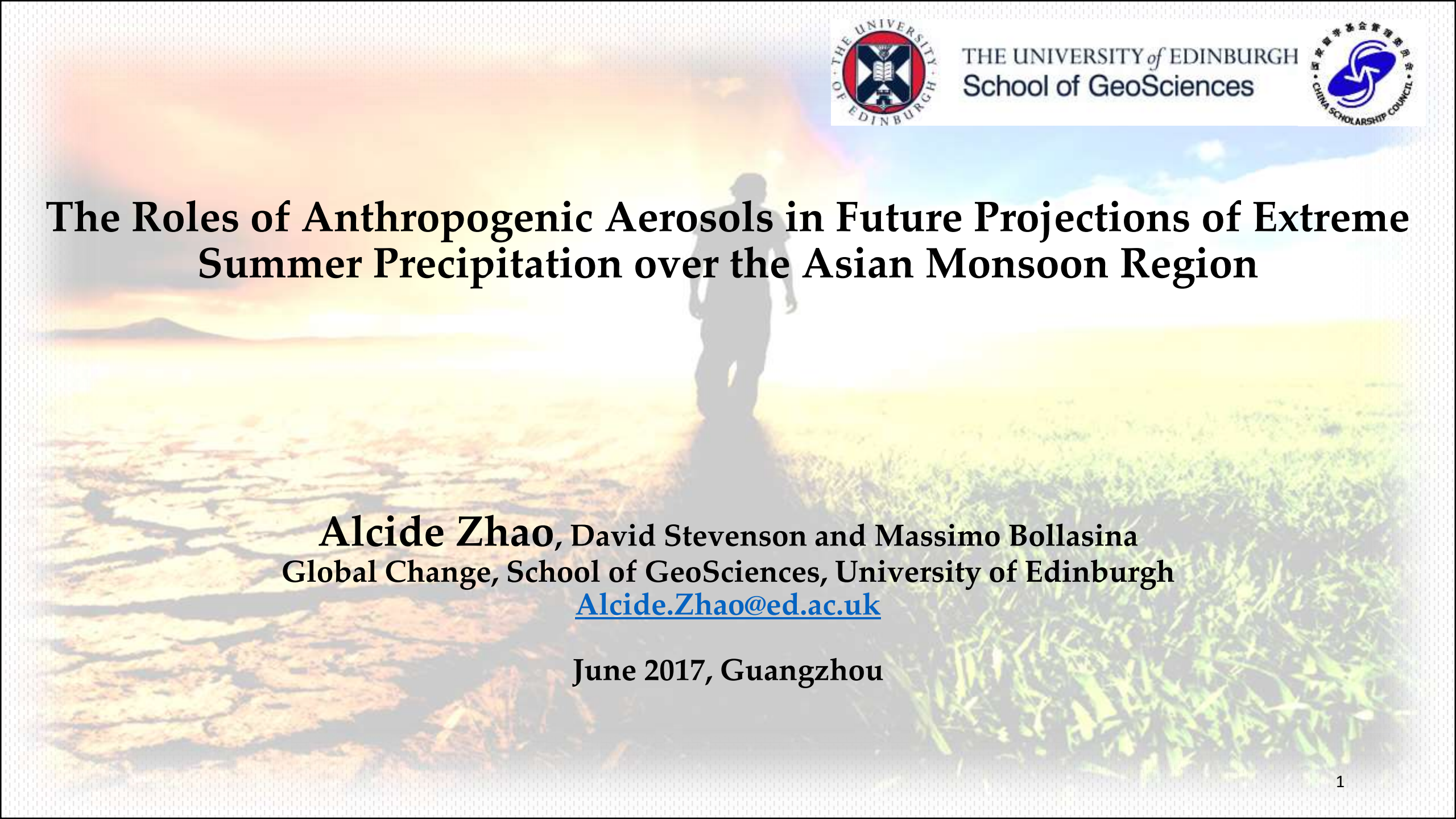

THE UNIVERSITY of EDINBURGH
School of GeoSciences

The Roles of Anthropogenic Aerosols in Future Projections of Extreme Summer Precipitation over the Asian Monsoon Region

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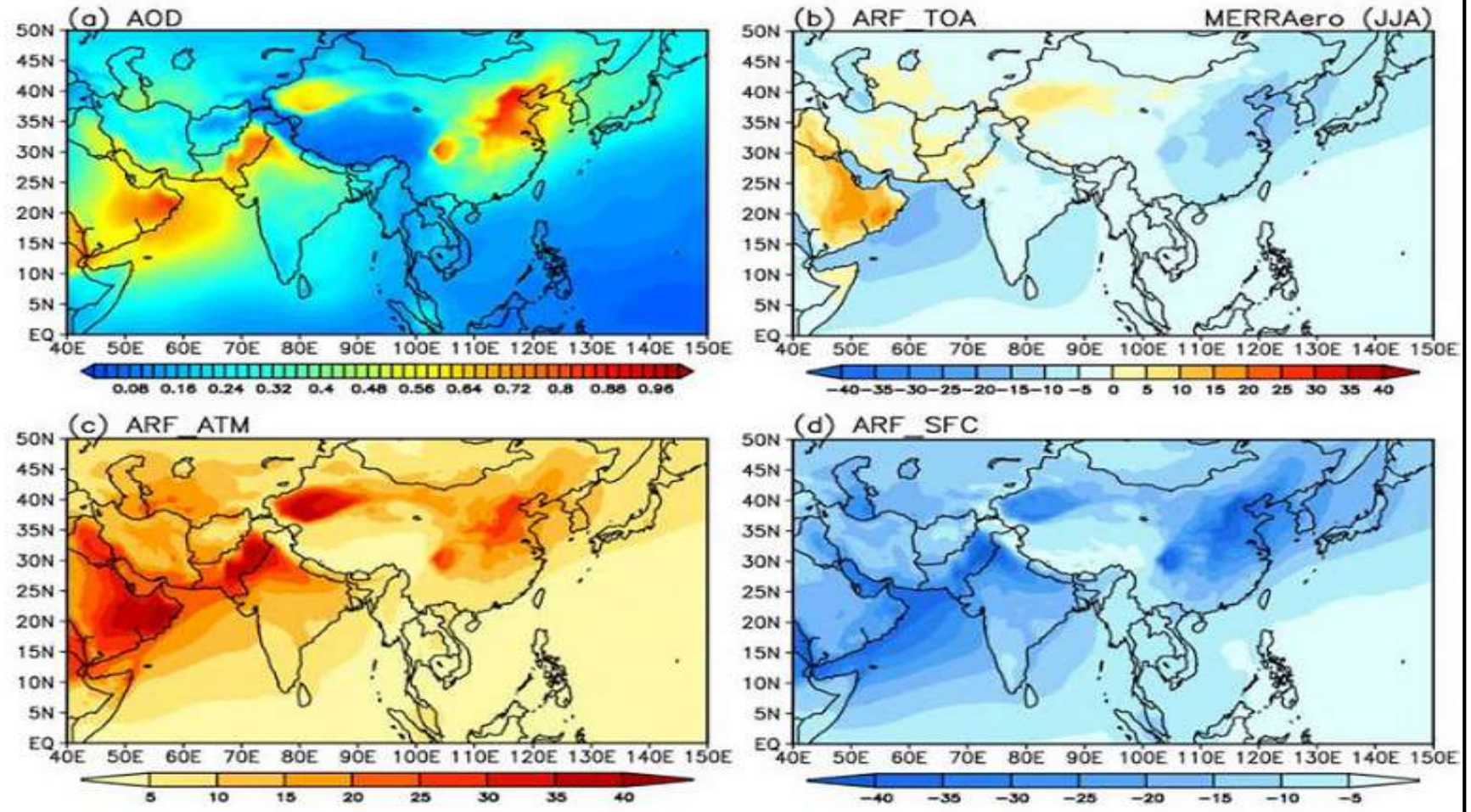
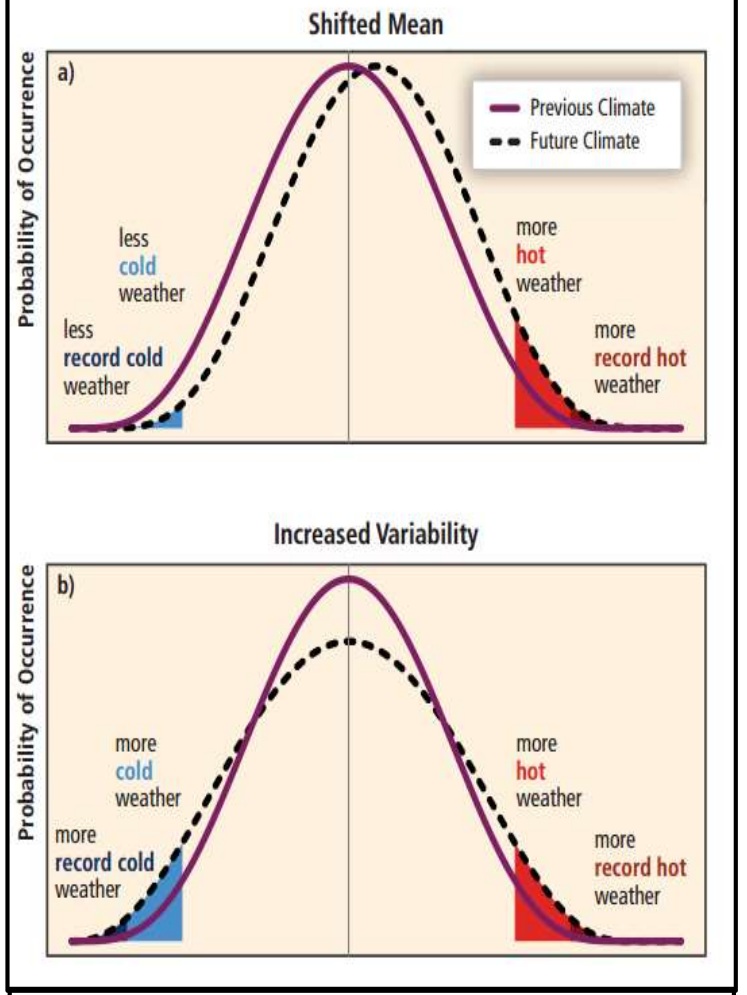
Anthropogenic Aerosols and Climate Extremes

- Forcing agents: GHGs, Land use, aerosols
- Dust, sea salt, volcanic , Sulfate, BC, OC, nitrates
- Diverse and complicated effects
- Aerosol-radiation-cloud-climate interactions
- Climate and weather Extremes: Upper/lower ends of the range of observations

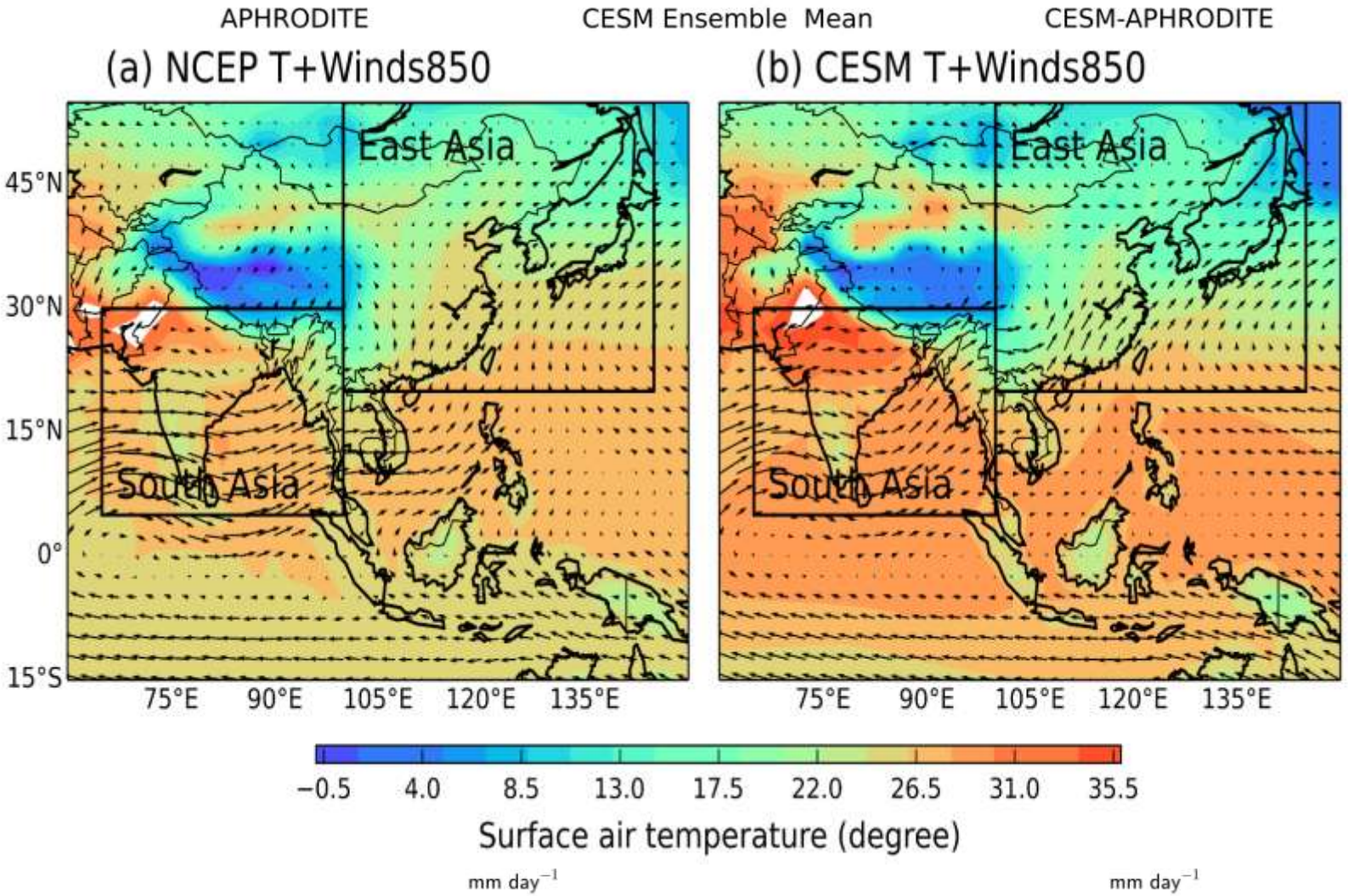




A small increase in average temperature leads to extensive changes in climate and weather extremes

Model and Methodology

- The Atmosphere-Land–Ocean–Sea ice fully coupled Community Earth System Model (CESM1)
- 30 ensembles under the RCP8.5, while 15 under RCP8.5 with aerosols fixed at 2005 levels, with different initial condition
- APHRODITE daily precipitation over the Asian Monsoon (1ºS-55ºN, 60ºE-15ºE) region; NCEP/NCAR reanalysis

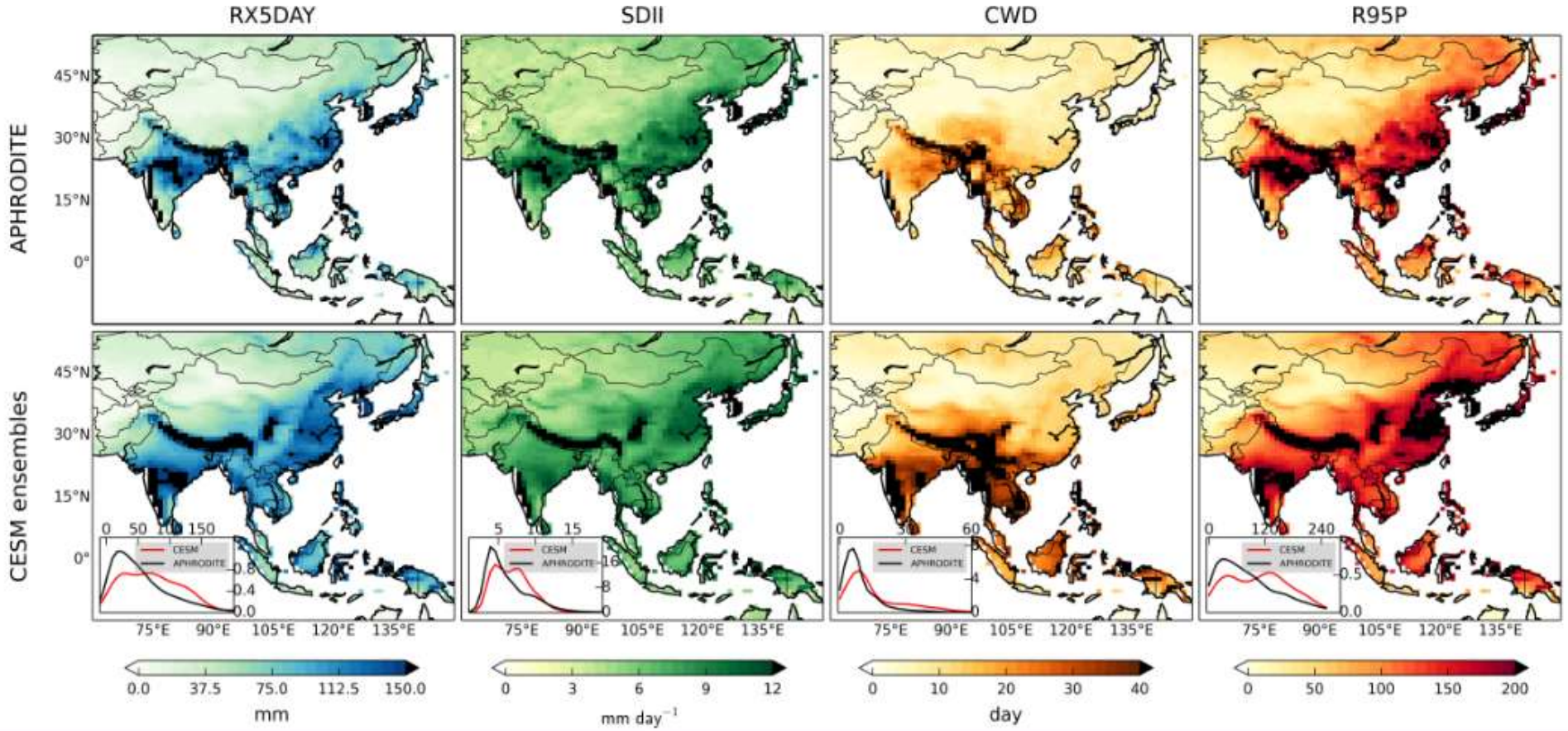


Asia	1.40 (37%)
East Asia	1.06 (22%)
South Asia	1.5 (21%)

- Climatological means are captured well by the model, although the model tends to produce overstimulation comparing to the APHRODITE
- Skilful also in representing the dynamic and thermodynamic aspects of the climate

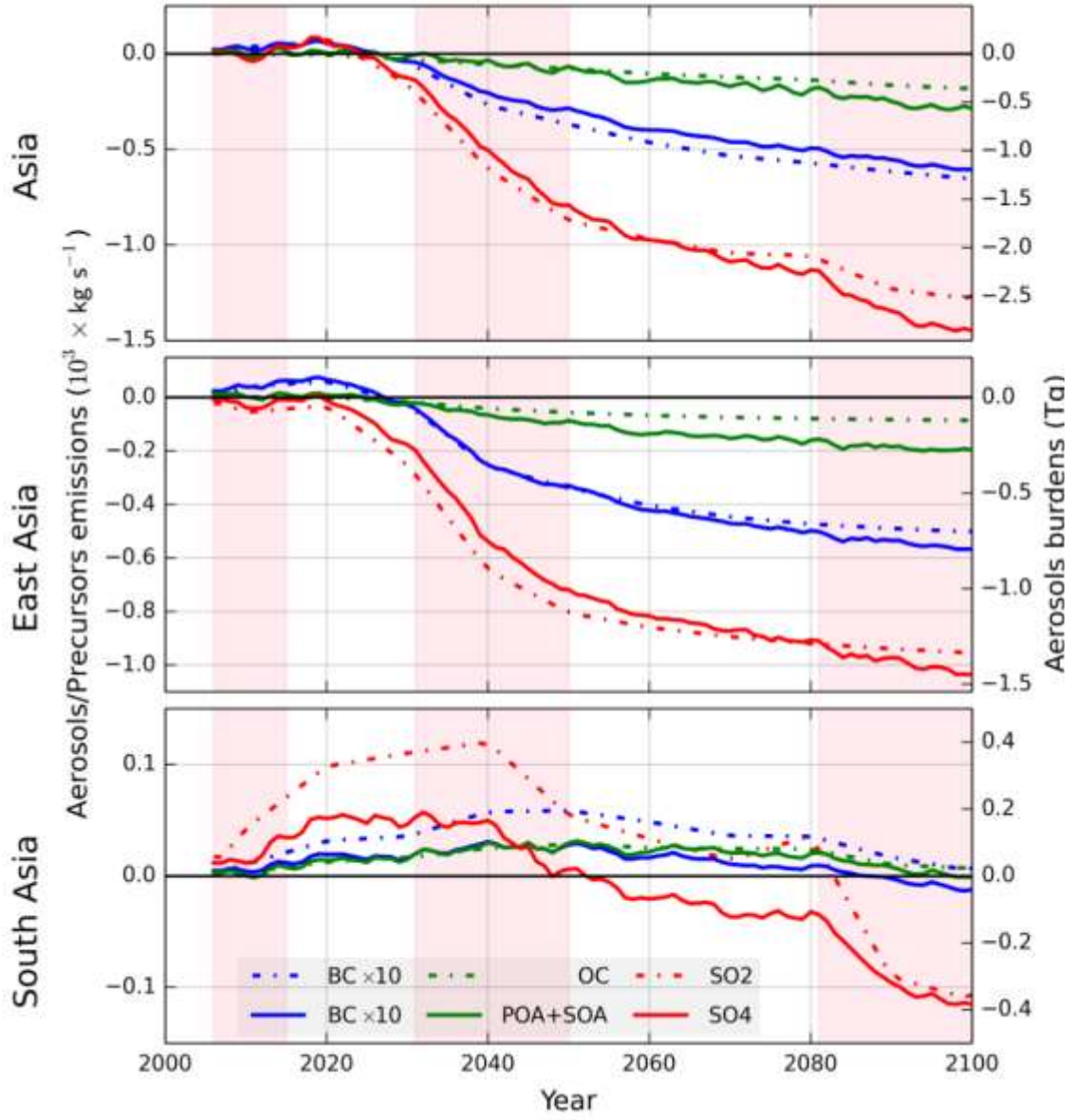
Model evaluation: Present-day Precipitation Extremes

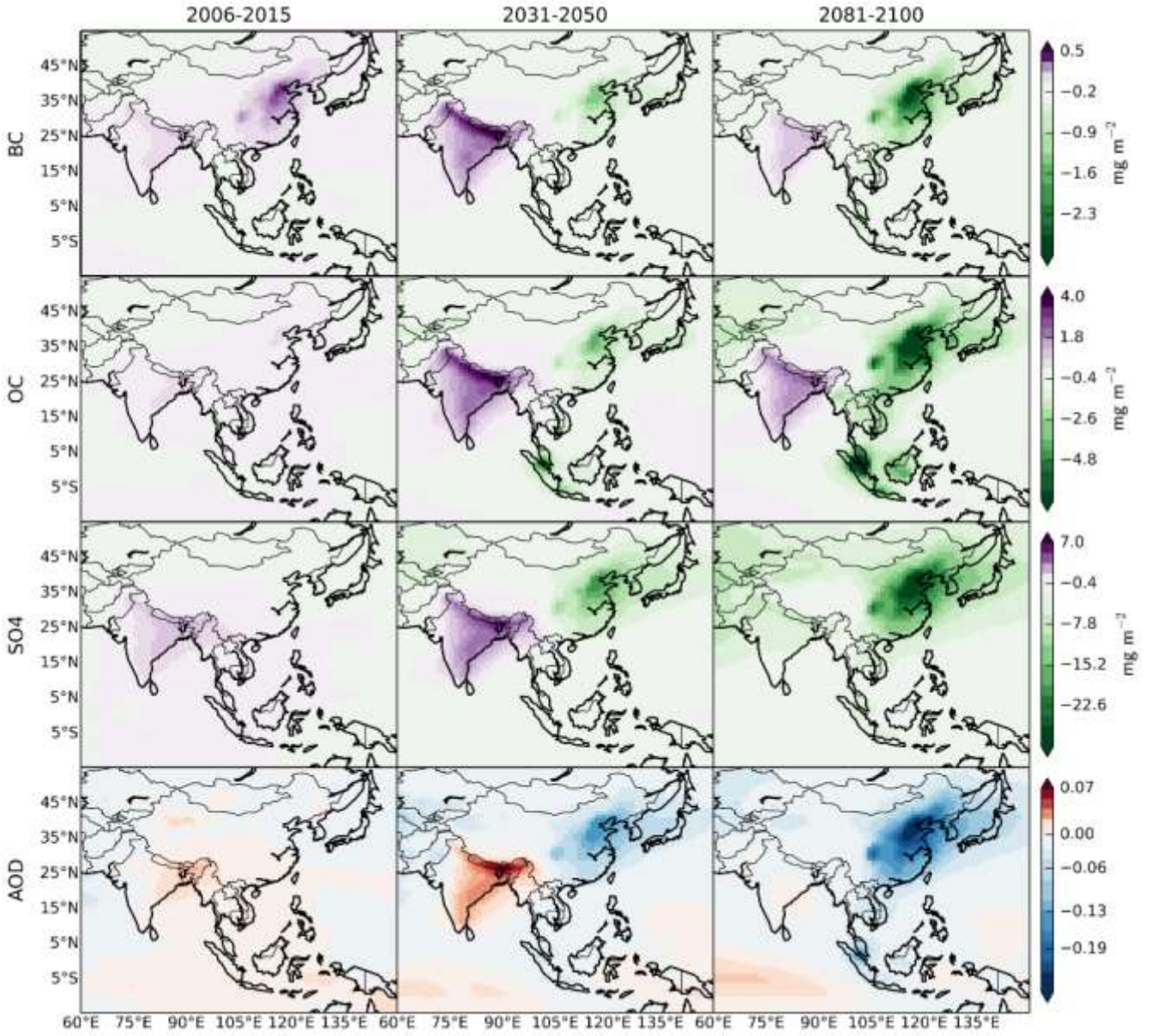
Indices	Name	Brief definition	Units
RX5DAY	Maximum 5-day Precipitation	Maximum consecutive 5-days precipitation	mm
SDII	Precipitation Intensity Index	Mean precipitation amount over wet days	mm/day
CWD	Consecutive Wet Days	Maximum number of consecutive days when precipitation ≥ 1mm	days
R95PR	Ratio of intense precipitation	Ratio between the total amount of intense and moderate/light precipitation	-



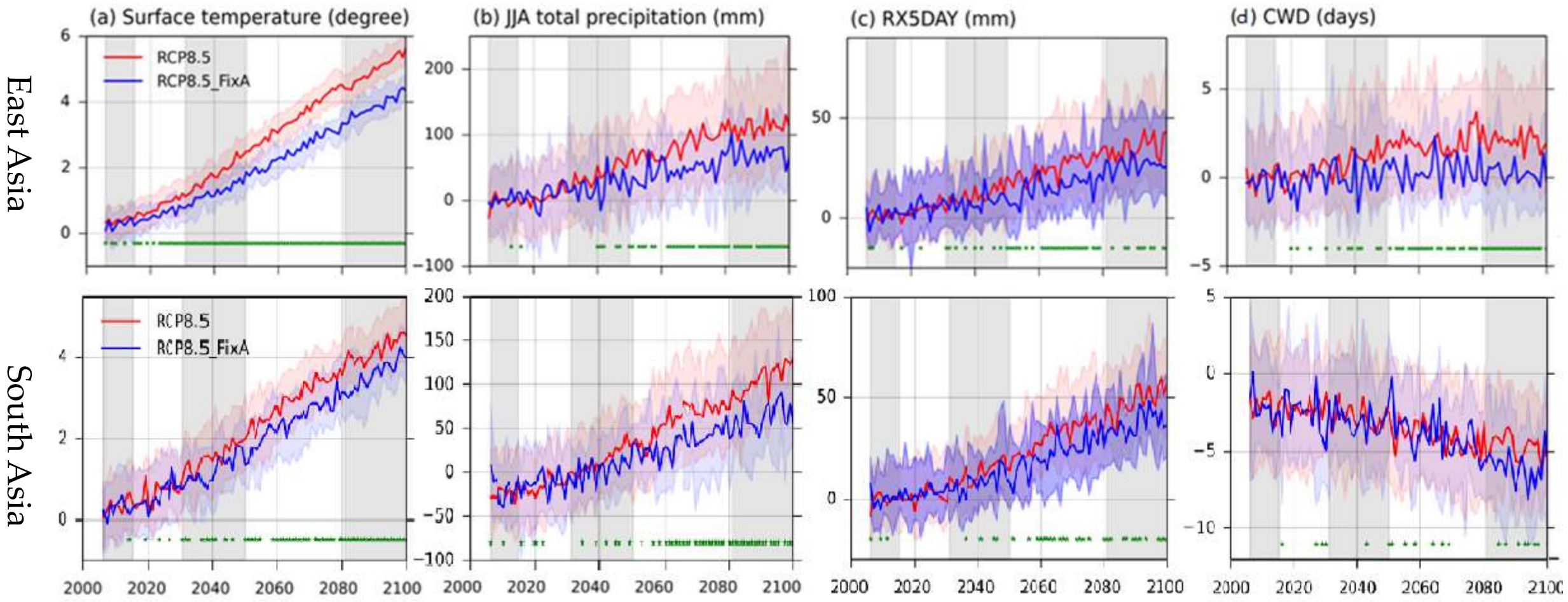
The model shows **good agreement** with observations in terms of all the four indices although the model tends to produce **slight overestimations** which are mainly resulting from the overestimation of daily precipitation

Aerosol Scenarios Under the RCP8.5 Pathway



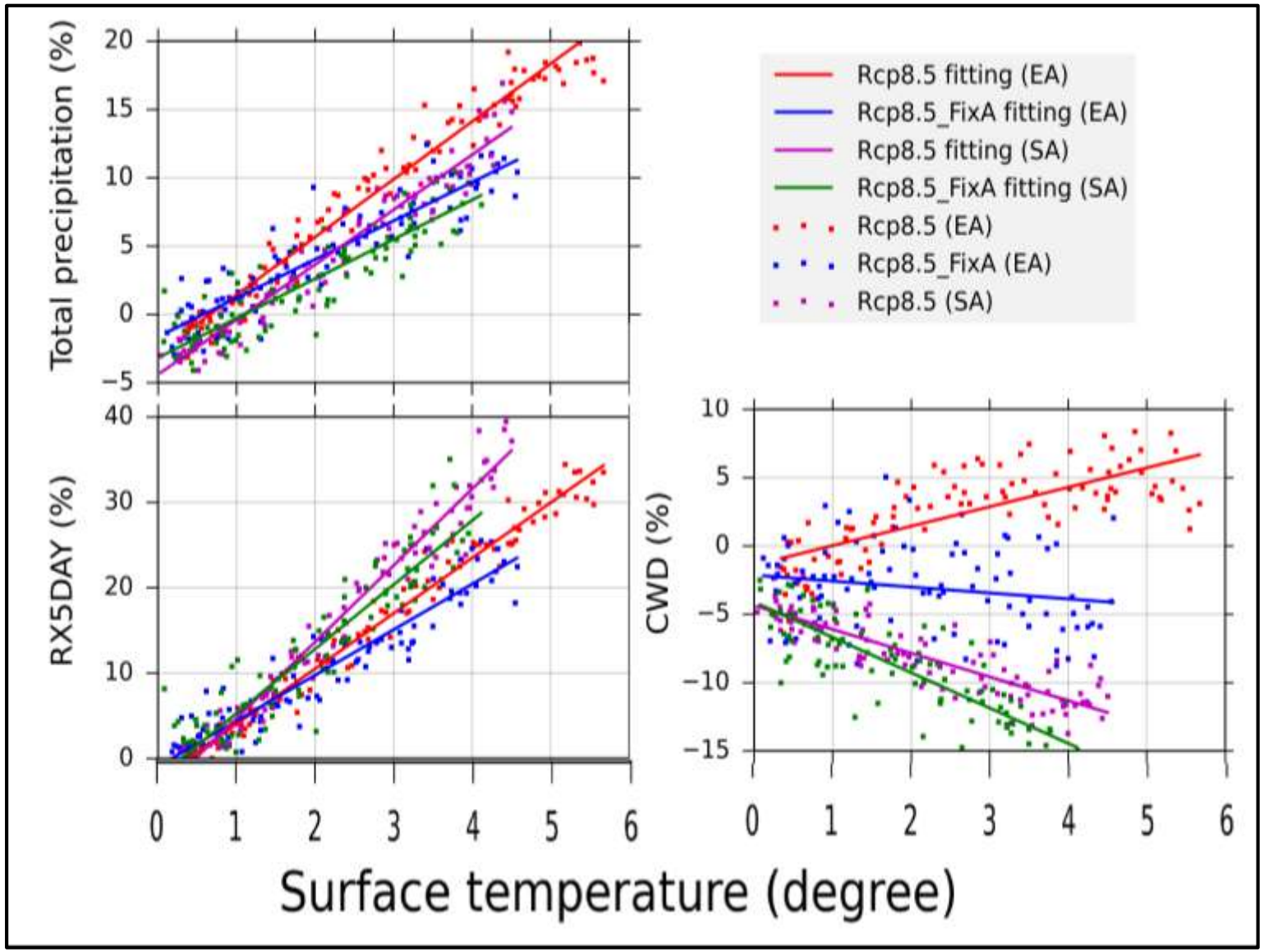


Extreme Precipitation Projections : Temporal Evolution



- Total precipitation increase in association with warming, of which aerosols overweigh GHGs
- EA see differences form SA in CWD and other indices (not shown)
- Precipitation Extremes are sensitive to aerosols, and the sensitivity vary with indices and regios

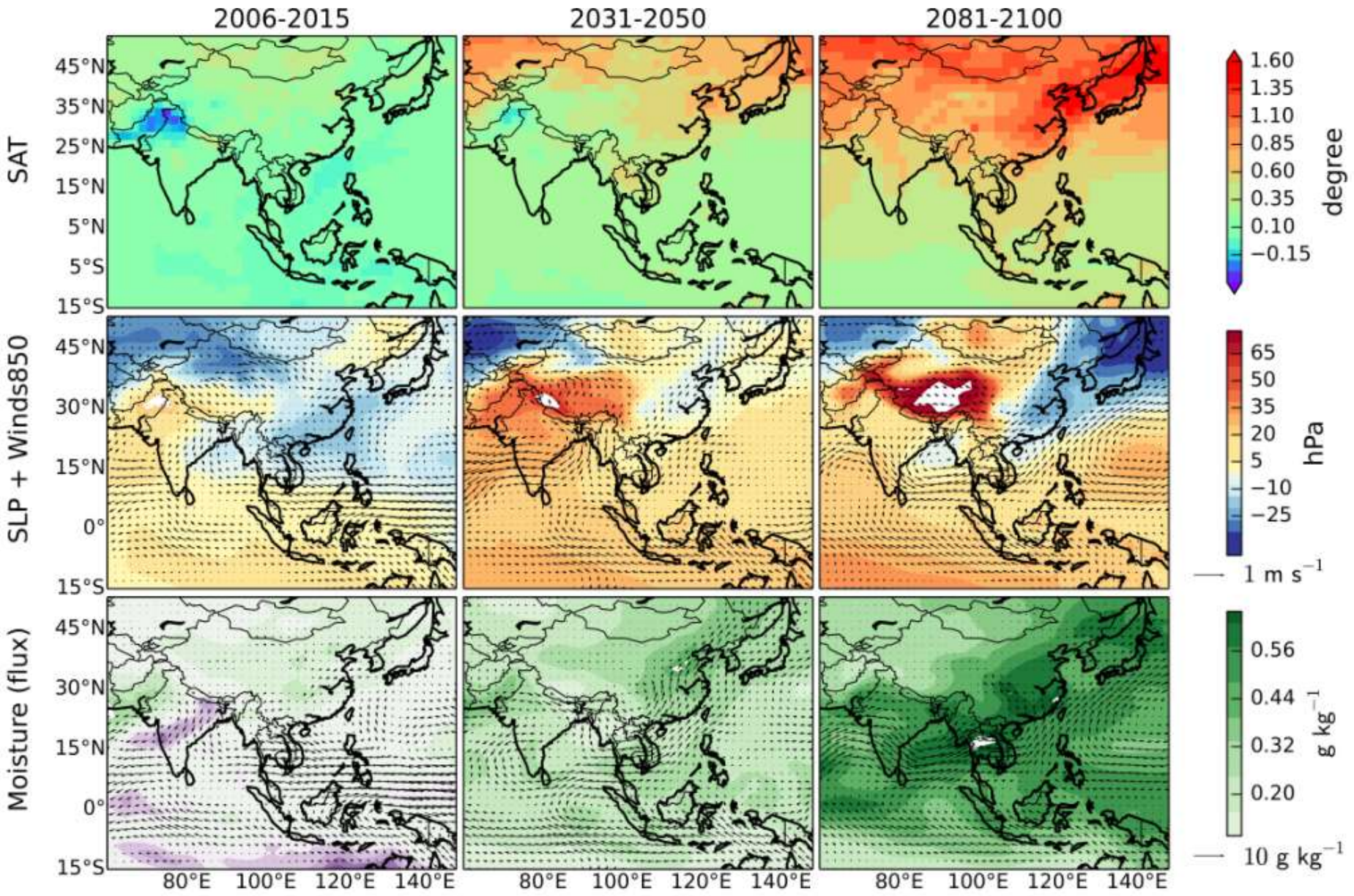
Sensitivity to Warming



	East Asia	South Asia
Total precipitation (%)	4.23 (2.83)	4.02 (2.89)
RX5DAY (%)	6.48 (5.33)	8.965 (7.52)
SDII (%)	3.11 (2.66)	4.74 (3.83)
CWD (%)	1.42 (-0.43)	-1.74 (-2.59)
R95PR (%)	1.52 (2.61)	11.03 (10.77)

- Compare to the aerosol varying runs, the fixed aerosol run shows a different sensitivity of the index to T changes
- EA behaves differently from the SA
- Extremes indices do not linearly related to warming and warming associated mean precipitation increases
- Other effects of aerosols,, including Cloud properties and large-scale circulations should also be highlighted on top of radiative forcing

Responses of Dynamic and Thermodynamic Fields



- **Radiative budget, Cloud properties and large-scale circulations are all modulated which, as a turn, affect total precipitation and precipitation extremes**
- **Detectable signals show that aerosols can supress monsoon circulation, moisture flux transport, due to aerosols resulted in changes in sea-land temperature gradients, SLP, et.al**

Summary and Conclusion

- It is very likely that we will face much more severe precipitation extremes in the future with more stringent controls on aerosols emissions being adopted
- The model suggest that anthropogenic aerosols play a much more significant role in modulating precipitation extremes over the GHGs
- Changes in intense precipitation would be significant with aerosol, but moderate/light rainfall might be more sensitive and show larger variations.
- Aerosols are important through their diverse and complicated effects on radiation budget, cloud physics/dynamics, and dynamics/thermodynamics
- Floods or droughts? It is a question and we need to think hard before answering

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Questions & comments?

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