Climate Change and Precipitation Extremes over South Asia

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1. Background

- Changes to the amount of rainfall can have a damaging effect on the population of South Asia (> 2 billion), with too much or too little rainfall leading to events such as flooding, landslides, droughts, and crop failure [1].
- There has been an increase in extreme precipitation over most of India in the past 120 years, with urbanization correlating to an increase in the intensity of these extreme events [2].
- The Asian Monsoon shows a higher sensitivity to global warming when compared to other monsoon domains [3] meaning an increase in greenhouse gas (GHG) emissions could lead to a more intense South Asian monsoon in the future.

2. Experimental Framework

- CMIP6 models (Table 1) are used in investigating the precipitation over South Asia, with a specific focus over India and its 6 homogeneous precipitation regions (Fig. 1).
- Analysis for each year only considers the months June, July, August and September (JJAS).
- Historical analysis is from 1984-2014 and future analysis is from 2015-2100. This has been split into near-future [NF (2030-2060)] and far-future [FF (2070-2100)].
- Shared-Socioeconomic Pathways (SSPs) SSP1-2.6, SSP2-4.5 and SSP5-8.5 [4] were used to assess future changes in precipitation.

3. Results

- The multi-model mean (MME) captures the general precipitation trend over this region. Mostly dry bias is seen over India (Fig. 2).
- MME captures the movement of the southwesterly wind, however there are biases in windspeed magnitude over the region (increase of ~3-4ms-1 over India; Fig. 3).
- During the NF all SSP scenarios show a similar increase in extreme wet days (Fig. 4).
- FF-SSP5 shows a noticeable increase in extreme wet days when compared to FF-SSP1 and FF-SSP2, reaching over 20% in some areas. The most affected areas are South of PR, West of WC and East of NE regions (Fig. 4).
- All SSPs show an increase in precipitation when compared to historical values. FF-SSP5 shows the largest shift (59 mm/JJAS) in precipitation and all other scenarios show a shift of around 28 mm/JJAS when compared to present values (Fig. 5).

Models	Country	Horizontal Resolution (lon and lat)	Model Vertical Levels (km)
CanESM5	Canada	128 x 64	49
CESM2	USA	288 x 192	32
CMCC-ESM2	Italy	288 x 192	30
CNRM-CM6-1	France	362 x 294	75
EC-Earth3	Europe	512 x 256	75
GFDL-ESM4	USA	360 x 180	49
HadGEM3-GC31-LL	UK	192 x 144	85
INM-CM5-0	Russia	180 x 120	73
KACE-1-0-G	South Korea	192 x 144	85
MIROC6	Japan	256 x 128	81
NorESM2-MM	Norway	288 x 192	40
UKESM1-0-LL	UK	192 x 144	85

Table 1 – Earth System Models (ESMs) used in present work.

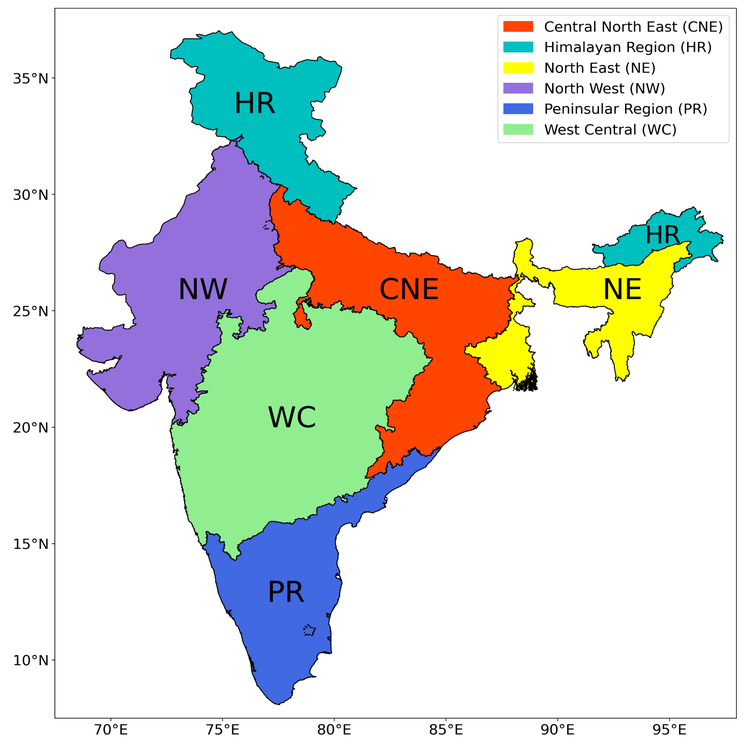

Fig. 1 - Six precipitation homogenous regions over India (Population of 1.4 billion)

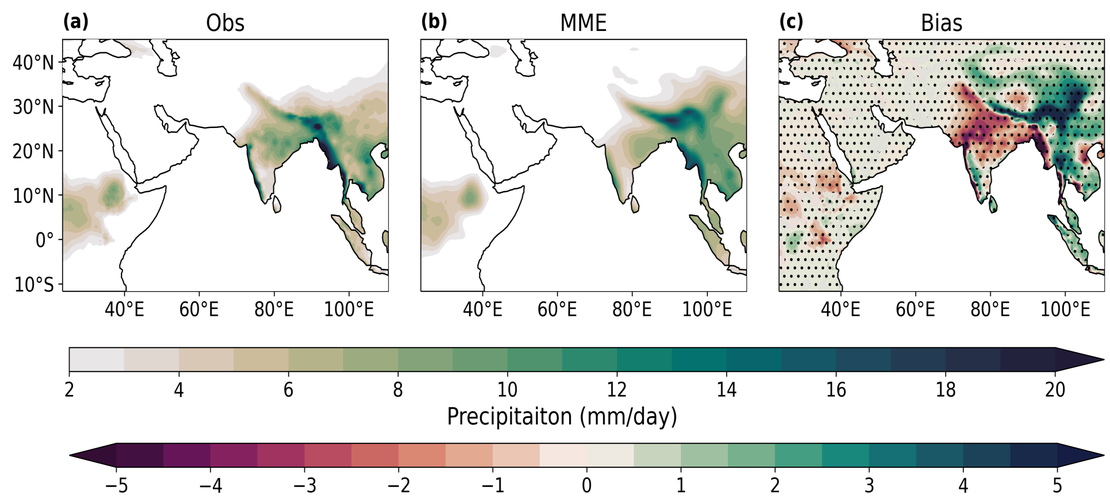

Fig. 2 - JJAS precipitation changes (mm/day) for 31 years (1984-2014); (a) Observed, (b) MME and (c) bias of MME. The dots show areas of 95% significance.

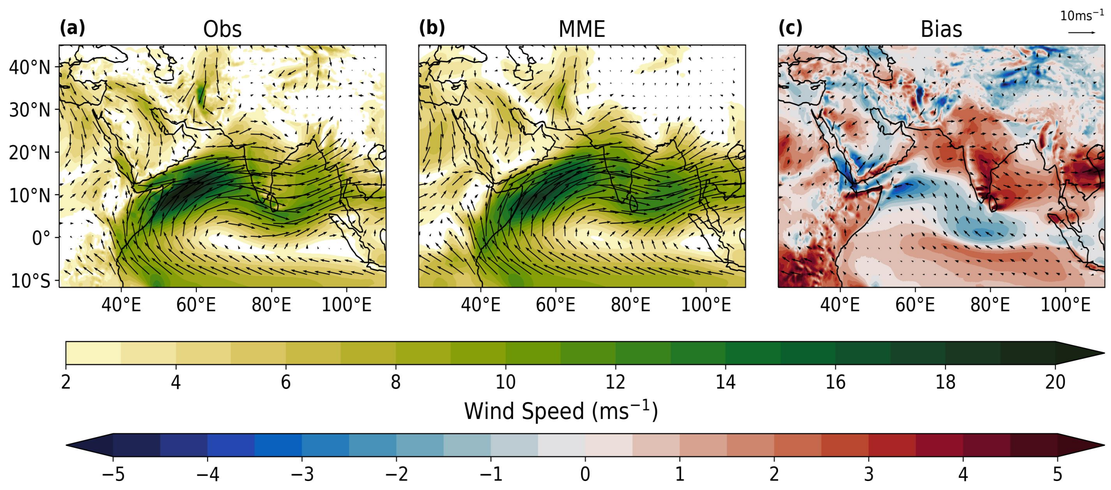

Fig. 3 - JJAS windspeed (ms^{-1}) for 31 years (1984-2014) at 850hPa; (a) Observed, (b) MME and (c) MME bias.

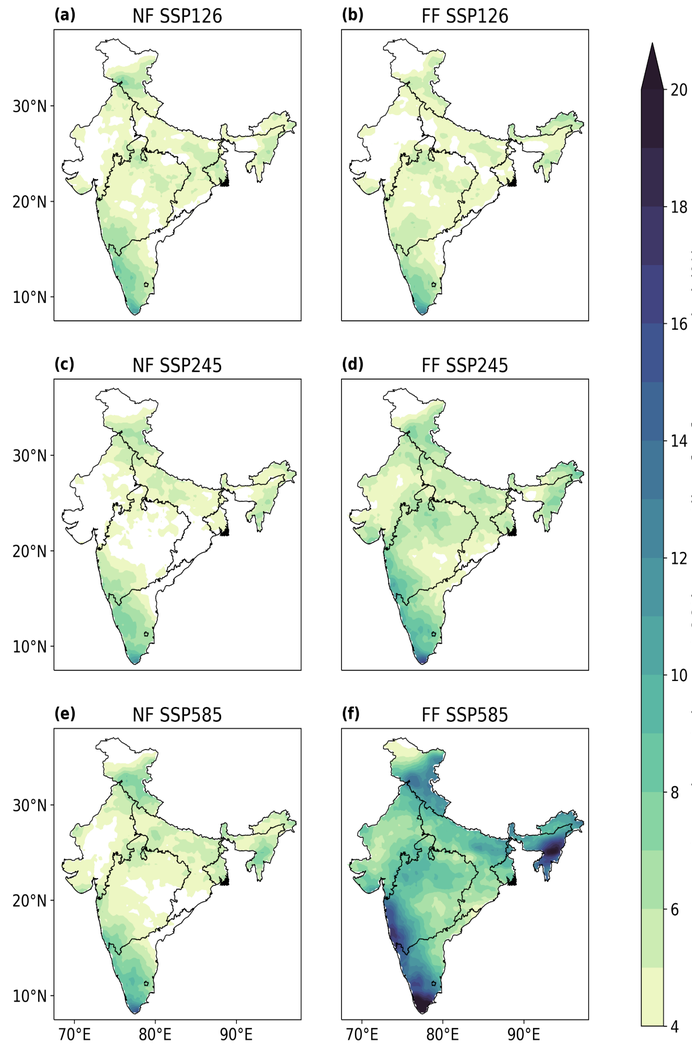

Fig. 4 – Extremely wet days where the percentage of daily precipitation amount > 99th percentile of the daily precipitation for the reference period 1984-2014.

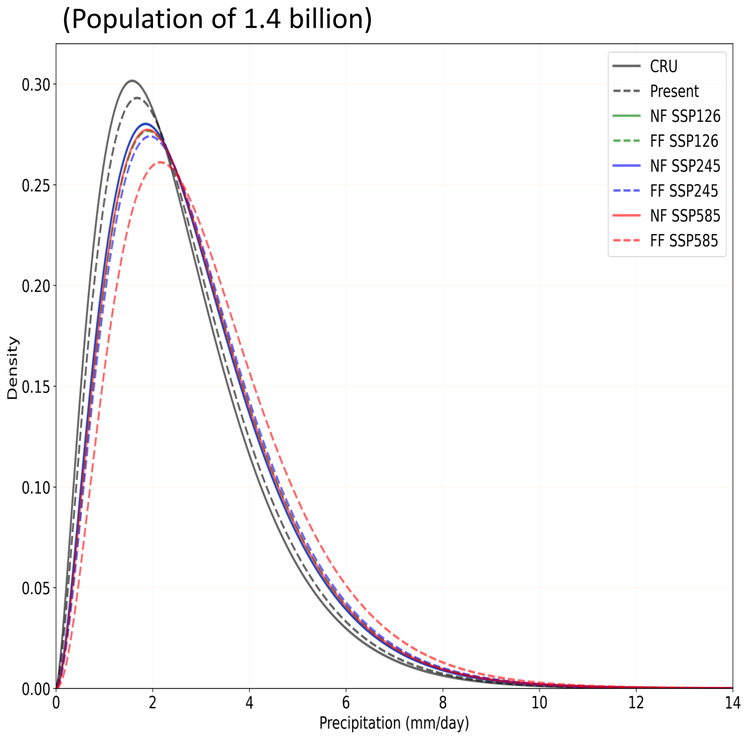

Fig. 5 – Probability density function of the JJAS mean precipitation over the South Asia land mass. Grey lines represent the historical period. For the SSPs, solid lines show the NF and dashed lines show the FF.

4. Conclusion and Future Scope

- CMIP6 models capture the precipitation trend over South Asia, although there are wet and dry biases over parts of the region.
- Findings suggest that continuing fossil-fueled development will lead to an increase in precipitation during the South Asian monsoon by the end of the century.
- Extreme precipitation events are also shown to be more frequent under the higher fossil-fueled scenario when compared to other scenarios.
- Ongoing effort using high resolution climate modelling to study local changes in precipitation extremes and associated impacts.

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REFERENCES

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