The Indian monsoon in a changing climate

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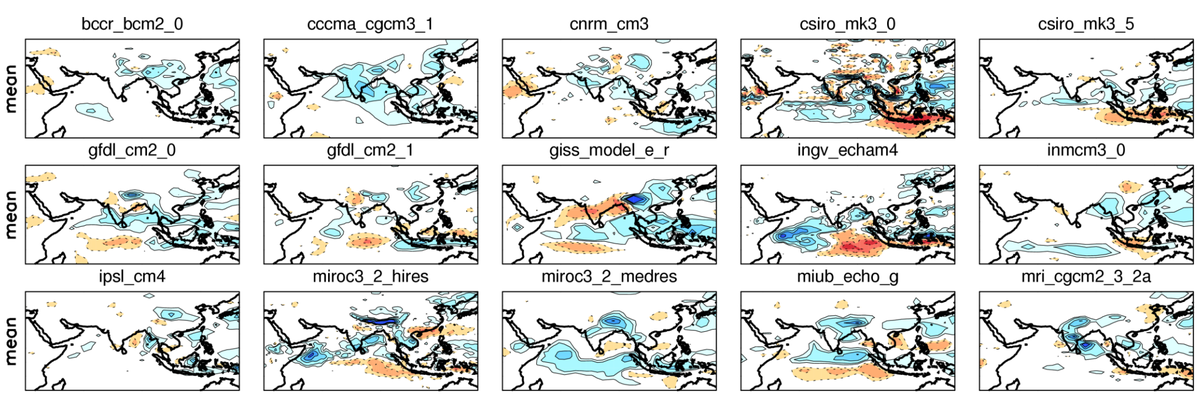
Key results

- Indian rainfall is likely to increase in the future but with much uncertainty in spatial distribution.
- Seasonal prediction of the Indian monsoon depends on changes to ENSO which may be independent of anthropogenic warming.
- Monsoon active and break cycles could become more intense under elevated CO_2.
- The heaviest extremes of monsoon rainfall are very uncertain in the future, but may be predictable based on temperature change.

Mean monsoon changes

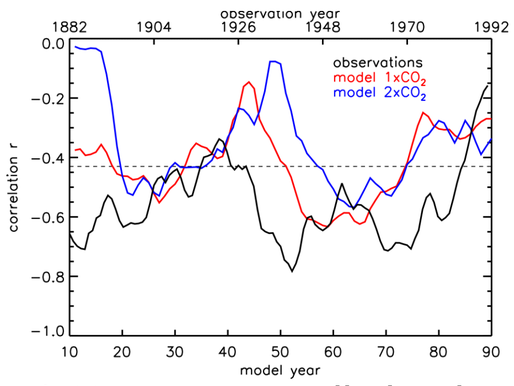


Changes in mean summer (JJA) precipitation under climate change. Blue/orange areas indicate wetter/drier.

[Data are: control and 1pctto2x integrations from the IPCC AR4 (CMIP3) database for 15 models].

- Most models suggest an increase in Indian monsoon rainfall.
- Considerable diversity among spatial patterns of change.
- Mechanisms involve strengthened land-sea temperature contrast and increased moisture from warmer Indian Ocean.

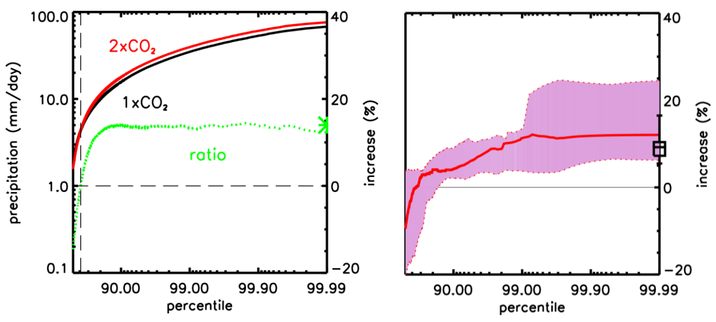
Seasonal prediction



21-year moving correlations of JJAS all-India rainfall with Niño-3 SST in HadISST vs. AIR observations and integrations of HadCM3 under control and doubled CO_2 conditions. JJAS rainfall is measured over all-India, east Pacific SST measured over the Niño-3 region.

- Monsoon prediction is strongly dependent on ENSO.
- How ENSO will change in the future is uncertain.
- The monsoon-ENSO teleconnection can vary independent of changes in greenhouse gas forcing.

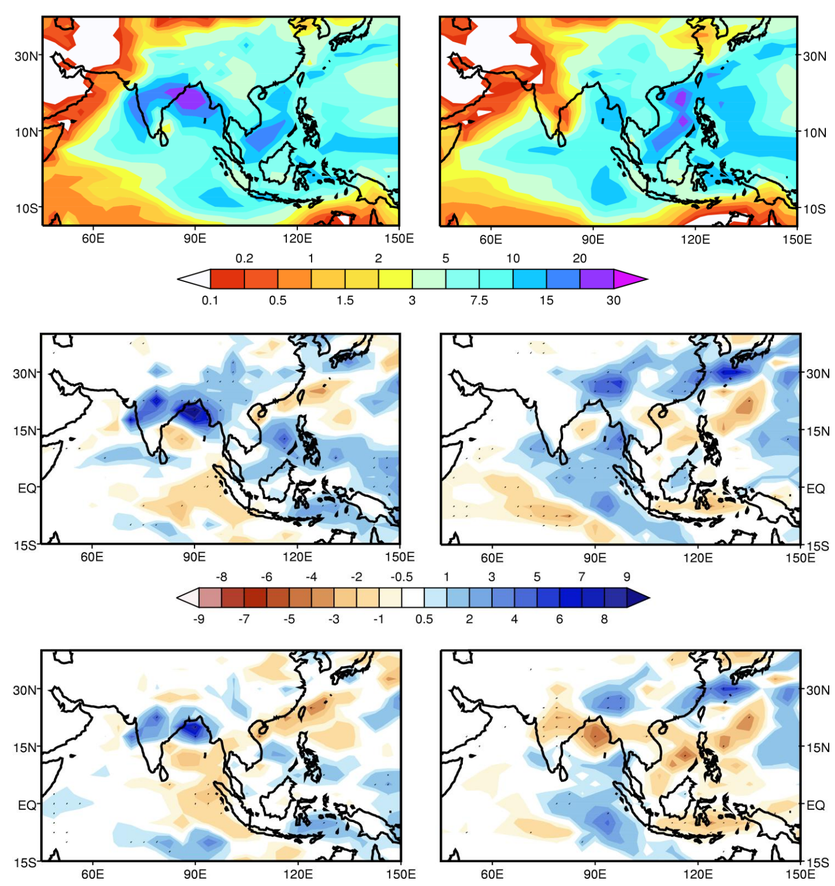
Monsoon rainfall extremes



(left) Extreme precipitation over India in HadCM3: Increase of heaviest rainfall is comparable with prediction based on surface warming and Clausius-Clapeyron relation (asterisk), and (right) spread of increases in the IPCC models.

- Extremes are damaging to crops and infrastructure.
- The IPCC AR4 models show considerable uncertainty in future projections of monsoon rainfall extremes.
- In some models, there is a suggestion that changes to the heaviest extremes may be predictable based on local surface temperature changes.

Active-break cycles



Composites of active (left) and break (right) events in HadCM3 at 1xCO_2 (top) and the change at doubled CO_2 (middle). When the effects of the wetter seasonal cycle are taken into account, break events are found to intensify (bottom).

- Timing, duration and intensity of monsoon active-break events (intraseasonal variability) are particularly important for agriculture.
- Using the HadCM3 model we demonstrate more intense active events at doubled CO_2 (consistent with wetter extremes).
- Removing the effect of the wetter seasonal cycle due to enhanced greenhouse warming shows break events also to intensify at doubled CO_2.

Find out more...

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