Simulation of monsoons and their variability in the HadGEM2 model family

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A – Introduction

A model "family" comprises a range of specific model configurations incorporating different levels of complexity but with a common physical framework. This approach has several benefits for climate change modelling, including the use of models with common processes for a wide range of science questions.

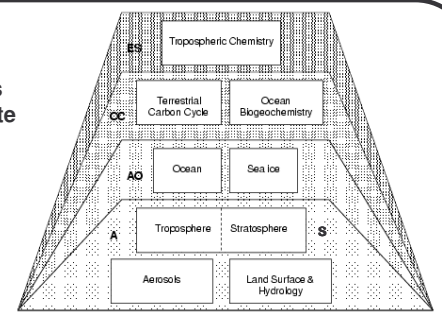
We compare the present-day monsoon performance in the Asian and African regions between members of the HadGEM2 family of MetUM configurations, and examine the impact of their different functionality on the monsoon simulation.

B – The HadGEM2 Family

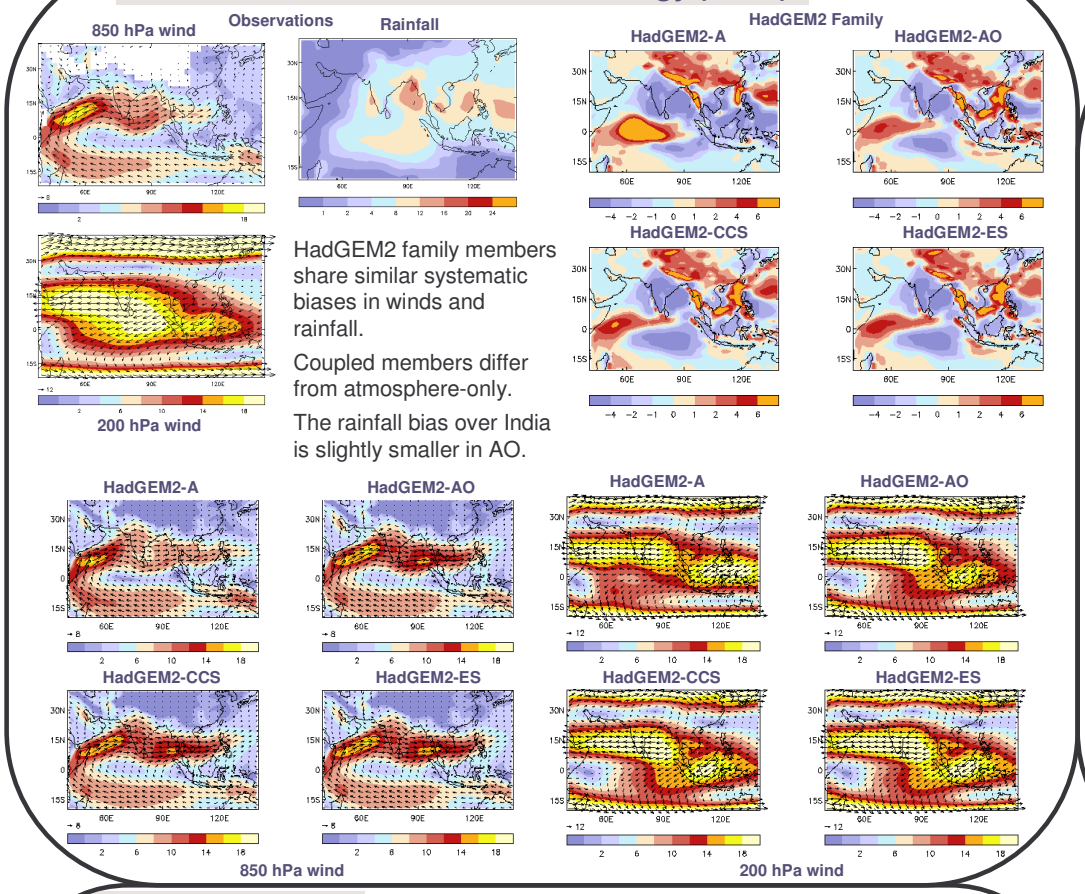
The HadGEM2 model family comprises configurations made by combining model components which facilitate the representation of many different processes within the climate system.

The components include atmosphere, ocean and sea ice, terrestrial and oceanic carbon cycle and tropospheric chemistry *(The HadGEM2 Development Team, 2011).*

Clearly, many of the processes are interdependent.



C – Asian summer monsoon climatology (JJAS)

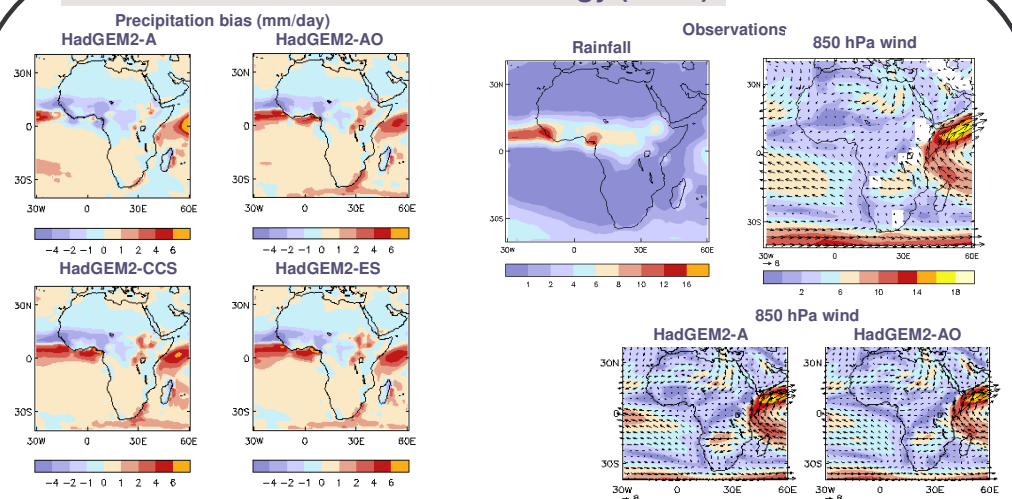


HadGEM2 family members share similar systematic biases in winds and rainfall.

Coupled members differ from atmosphere-only.

The rainfall bias over India is slightly smaller in AO.

D – West African monsoon climatology (JJAS)



HadGEM2 family members tend to underestimate West African summer monsoon rainfall and to overestimate it over the Gulf of Guinea and the equatorial Atlantic. This is particularly evident in the coupled configurations.

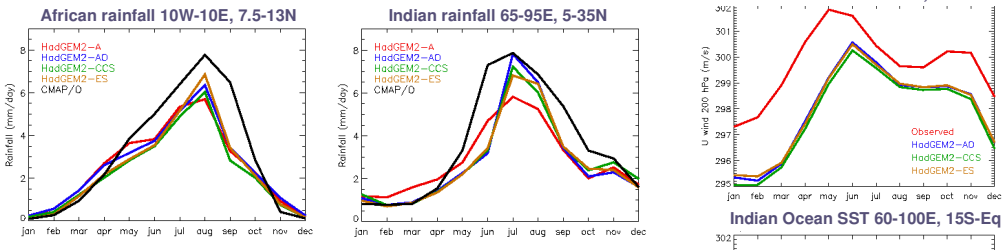
Rainfall biases over land are associated with poor distribution of rainfall intensity (too much light rain) and poor diurnal cycle.

Rainfall biases over the sea are associated with a warm SST bias in the Gulf of Guinea and weaker monsoon winds across the Guinea coast.

E – Seasonal cycle

The timing of the seasonal cycle of African rainfall is correct although the amplitude is underestimated.

The amplitude of the seasonal cycle of Indian rainfall is also underestimated, particularly by HadGEM2-A. The coupled configurations exhibit a delayed onset due to an Arabian Sea SST bias in spring (Levine and Turner, 2011), but have better peak rainfall. The latter is associated with a negative feedback between the rainfall and SSTs in the equatorial Indian Ocean region, with the reduced rainfall bias and colder SSTs both promoting increased rainfall over India.

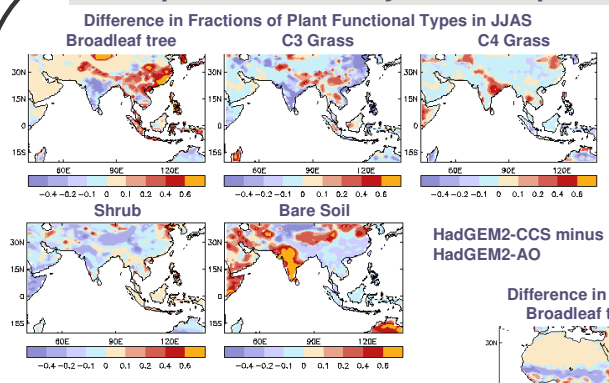


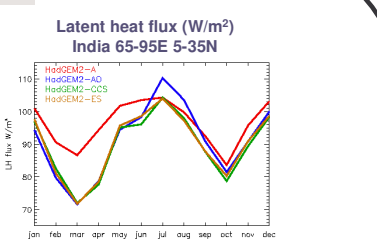
Coupled configurations all show cold SST biases in the Arabian Sea and equatorial Indian Ocean.

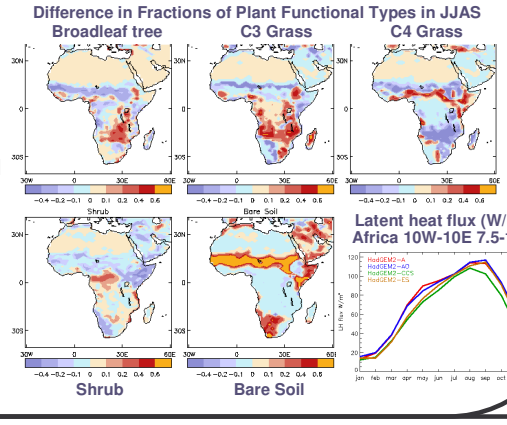
The biases in the Arabian Sea develop during winter due to excessive latent heat fluxes and strong low-level north-easterly flow, but are reduced during summer.

The biases in the equatorial Indian Ocean persist throughout the year and are associated with excessive rainfall in this region driven by the atmosphere component.

F – Impacts of Earth System components







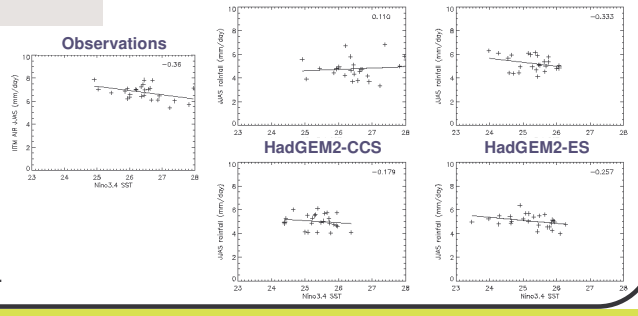
The ES and CCS configurations, which both include the terrestrial carbon cycle, have much more bare soil over India and the Sahel than the A or AO configurations, replacing grass, shrubs and broadleaf trees.

Over India, this is associated with smaller latent heat fluxes in ES and CCS in summer as evaporation and transpiration from vegetation is reduced. This may contribute to the larger Indian rainfall bias in ES and CCS.

G – Interannual variability

Observed Indian monsoon rainfall shows a negative correlation with Nino3.4 SSTs.

The HadGEM2 coupled configurations show similar negative correlations, whereas HadGEM2-A shows a weak positive correlation. This is associated with the larger underestimation of Indian monsoon rainfall in HadGEM2-A.



H – Summary

The members of the HadGEM2 model family share common systematic biases in monsoon rainfall and circulation.

Rainfall biases over India are slightly larger in HadGEM2-ES and HadGEM2-CCS. This may be partly related to the presence of a rather different, and varying, vegetation distribution in these configurations which both include the terrestrial carbon cycle.

However, the influence of Earth system processes on the monsoon simulation appears to be much smaller than that of the systematic biases, particularly in rainfall and SST, that are present in all configurations.

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References
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RC Levine, AG Turner (2011) Dependence of Indian summer monsoon rainfall on moisture fluxes across the Arabian Sea and the impact of coupled model sea surface temperature biases. Climate Dynamics, doi:10.1007/s00382-011-1096-z