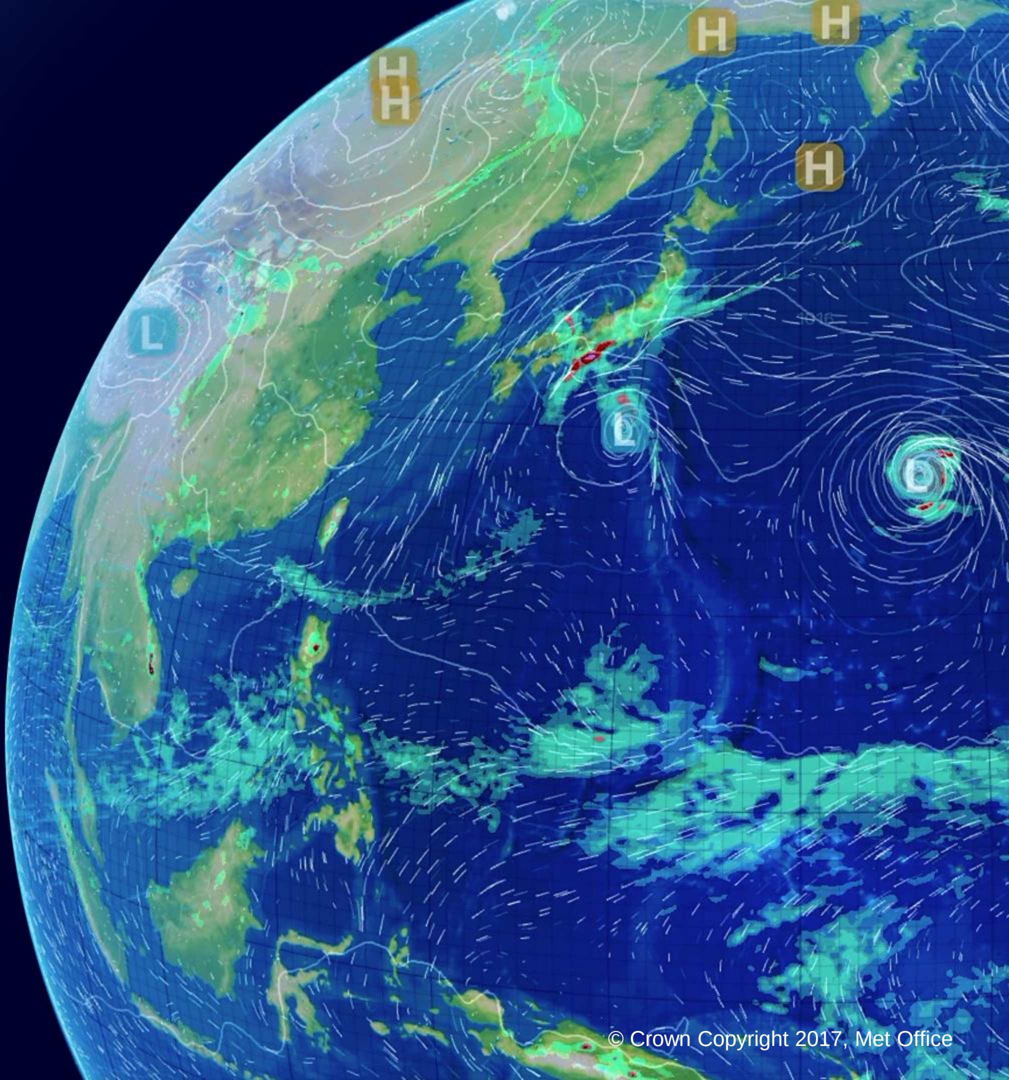
Processes and predictability in the Asian monsoon

Gill Martin

With contributions from:

Rajib Chattopadhyay, Amulya Chevuturi, Jennifer Fletcher, Susmitha Joseph, Richard Keane, Richard Levine, Arathy Menon, James Mollard, Ankur Srivastava, Andy Turner and many others.



Introduction

- We all know that we need models in order to make predictions, but also that models have errors and biases.
- Bias correction is used routinely e.g. in seasonal forecasting but it is still essential to understand the drivers, and effects on monsoon predictions, of model errors and to try to reduce them.
- Many researchers around the world use observations, reanalyses and models to study monsoon processes, accompanied by idealised modelling and sensitivity studies.
- This talk will outline various studies in which we are doing this in order to motivate and inform future model development.

Model Intercomparison

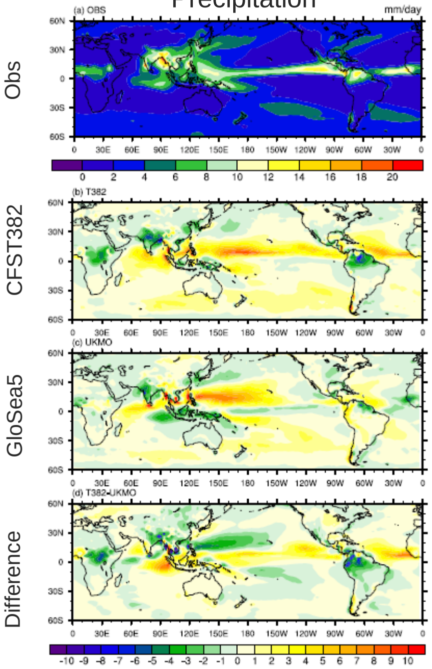
Met Office

Newton Fund

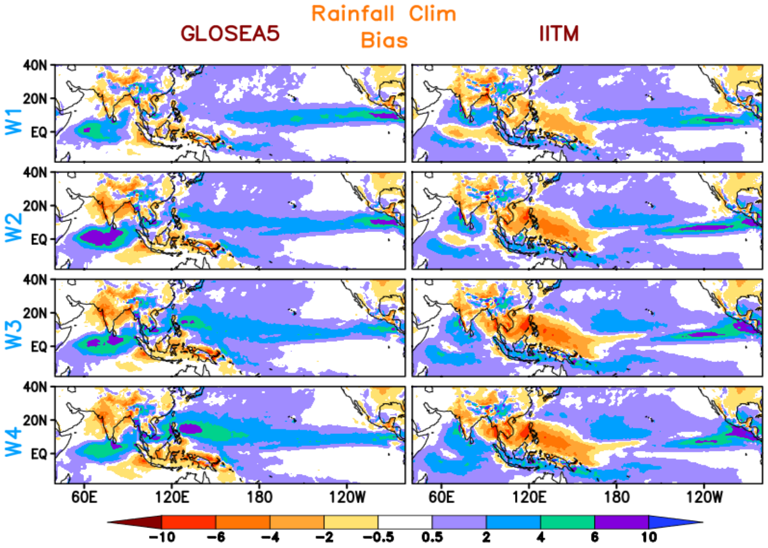
सत्यमेव जयते
Ministry of Earth Sciences

As part of a joint project (supported by the Newton Fund and MoES), we are carrying out intercomparisons of our various model configurations in order to identify common and differing biases on a range of timescales.

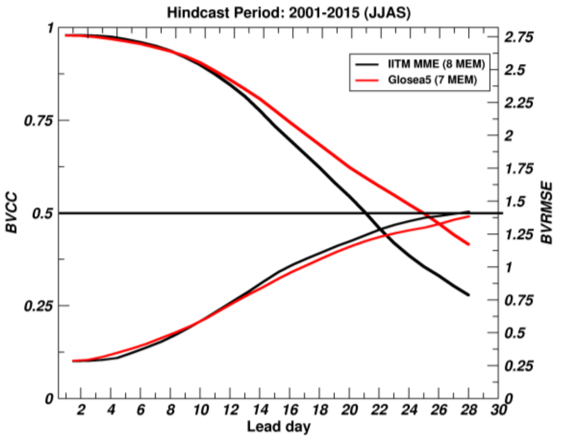
Seasonal hindcasts GloSea5 vs MMCFS



Extended-range GloSea5 vs IITM-MMEPS



MISO analysis GloSea5 vs IITM-MMEPS



Gill Martin, Susmitha Joseph, Rajib Chattopadhyay, Ankur Srivastava

Amulya Chevuturi

Indian summer monsoon onset seasonal forecast skill

- Hindcasts from Met Office GloSea5 and ECMWF SEAS5 seasonal forecasting systems.
- Hindcasts show significant skill at forecasting dynamical features of the large-scale monsoon onset one month in advance
- Models have higher skill for monsoon features calculated using large-scale indices compared to those at smaller scales
- Accurate forecasts for local-scale monsoon onset tercile category over majority of Indian landmass

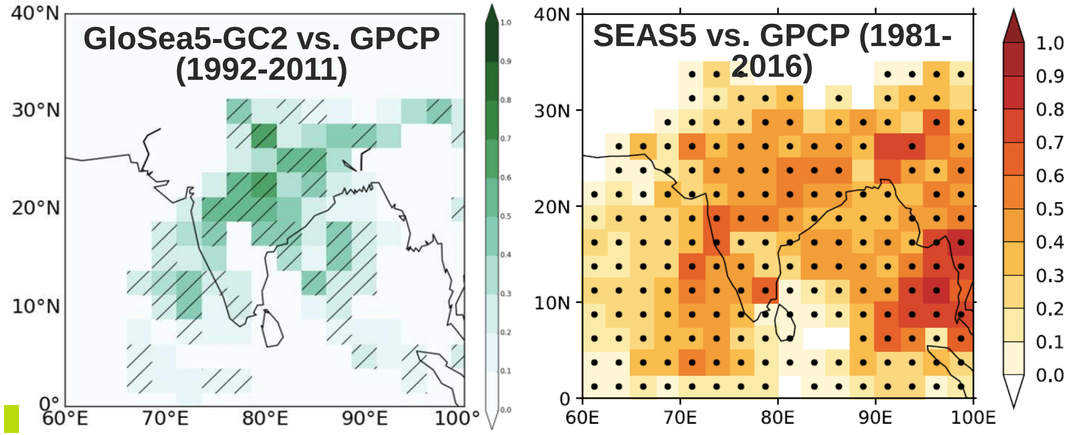
1st of May initialization hindcast		TTGI	WYI	WFI
GloSea5-GC2 vs. ERA-Interim (1992-2011)#	**Correlation**	0.7*	0.8*	0.6*
	Ratio of Predictable Components	1.0	1.0	0.7
SEAS5 vs. ERA5 (1981-2016)+	**Correlation**	0.7*	0.7*	0.6*
	Ratio of Predictable Components	1.0	1.0	0.9

TTGI: Tropospheric temperature gradient

WYI: Vertical shear of zonal wind

WFI: Horizontal shear of zonal wind

*significant at the 5% level

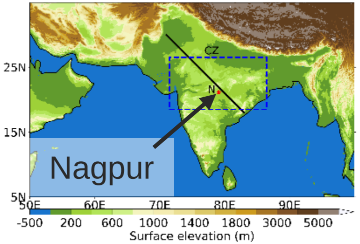


Fraction of forecasts of local rainfall onset predicting the correct tercile category (early/neutral/late)

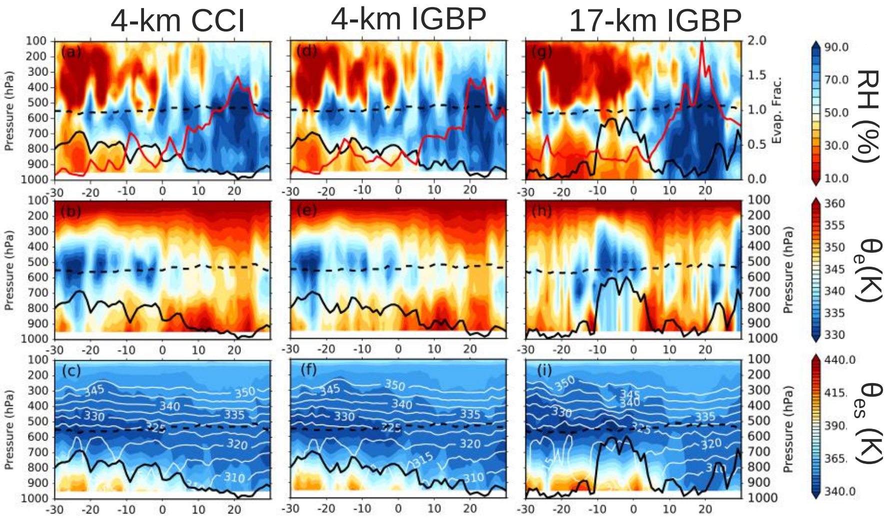
Chevuturi et al. (2019), https://doi.org/10.1007/s00382-018-4536-1
Chevuturi et al. (2021), https://doi.org/10.1007/s00382-020-05624-5

Role of mid-tropospheric moistening and land surface in the progression of 2016 monsoon

Arathy Menon



(a) Dry air intrusion

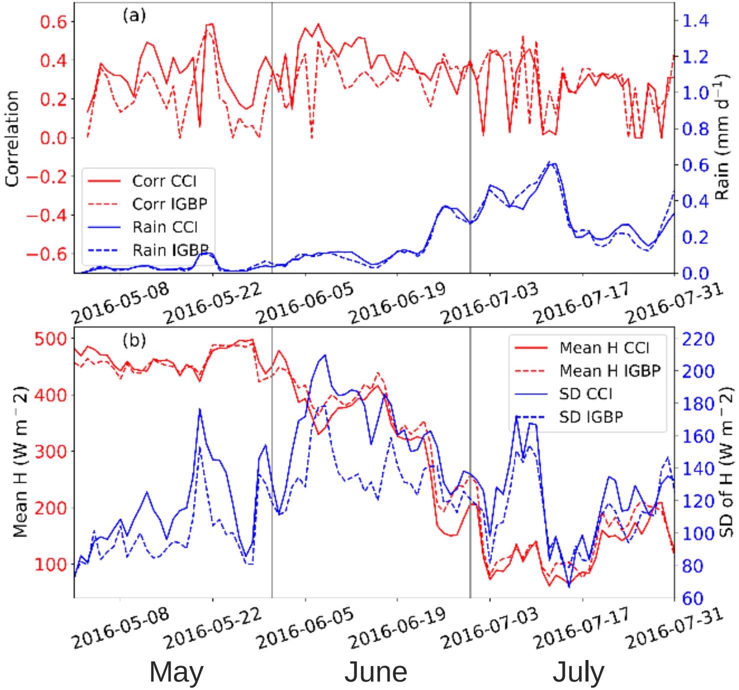


Time-Pressure section at Nagpur
CCI, IGCP = different land cover representations

(b) Land surface wetting

Corr of past 3-day rain with 11 am frac

3-day mean rain



Mean SH flux over core zone

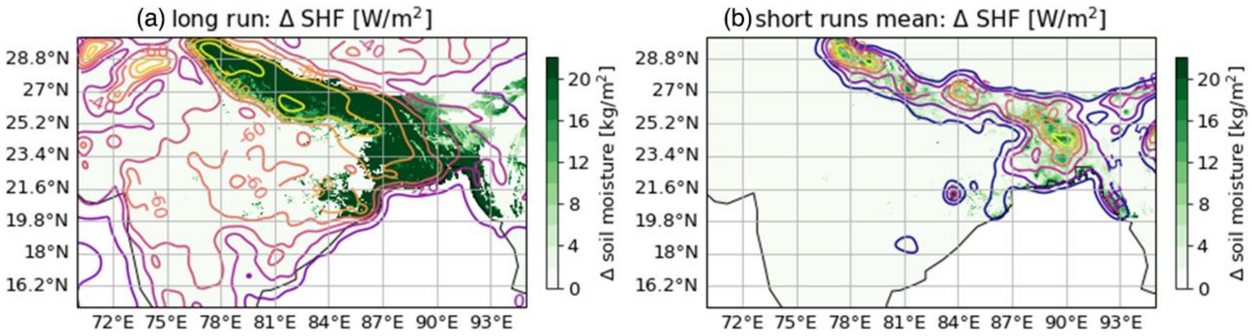
S.d. of SH flux over core zone

- Mid-tropospheric moistening plays a major role in the progression of the monsoon.
- Land surface wetting moistens the boundary layer and helps in the initial progression of the onset rains.

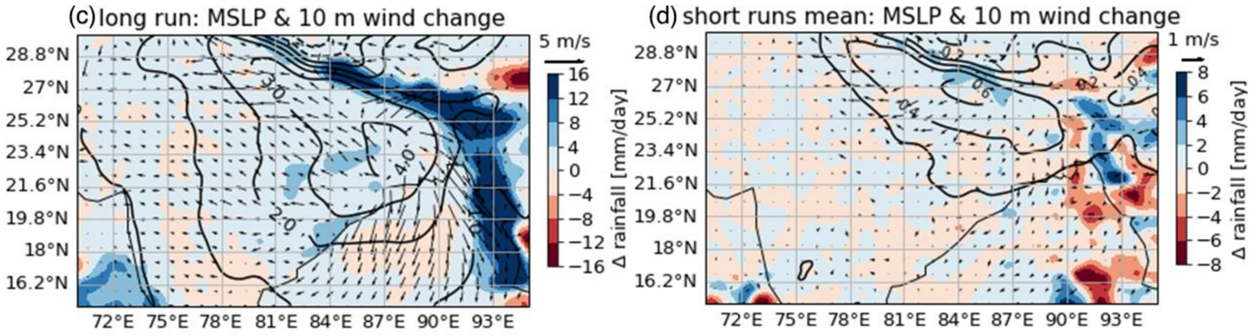
Effect of irrigation on monsoon onset

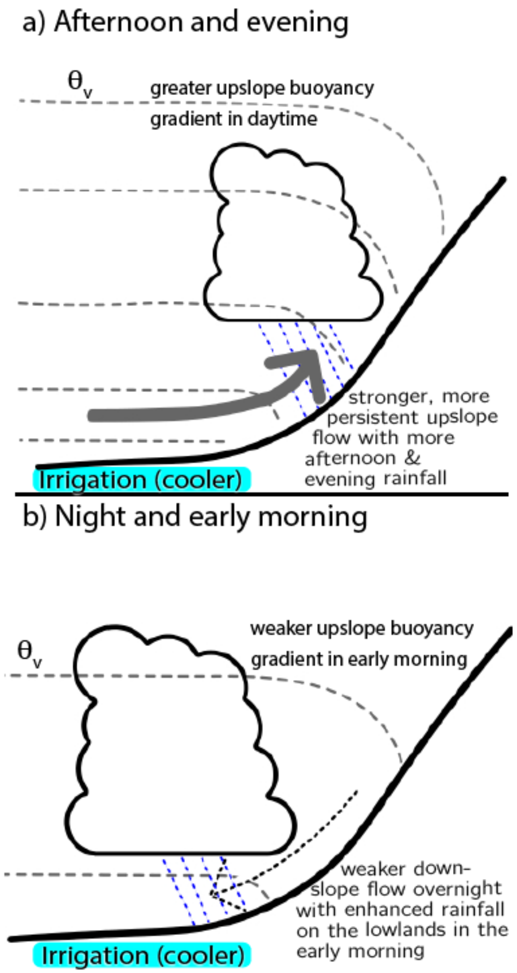
Jennifer Fletcher, Richard Keane
Met Office
UNIVERSITY OF LEEDS

Changes in soil moisture (shaded) and SH flux (contours)



Changes in rainfall (shaded), MSLP (contours) and 10m winds (vectors)

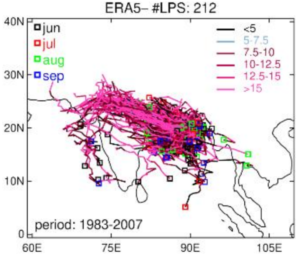




Fletcher, J.K., C.E. Birch, R.J. Keane, C.M. Taylor and S.S. Folwell (2021), *submitted to QJRMS*

Roles of air-sea coupling and resolution on Indian monsoon low pressure systems

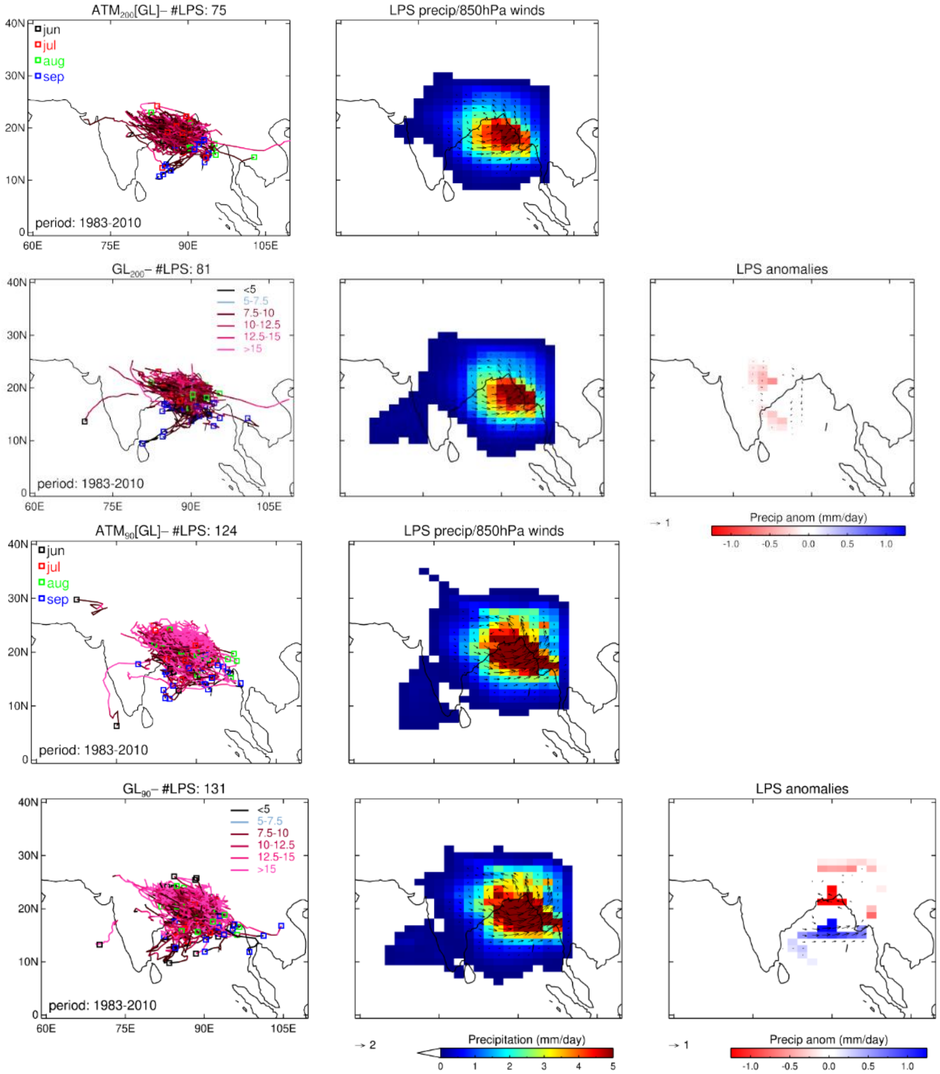
MetUM-GOML2 simulations at different resolutions and with global or regional air-sea coupling provide idealised decomposition into isolated impacts from coupling and resolution



Levine, R.C. et al. (2020), *Clim. Dyn., doi: 10.1007/s00382-020-05526-6.*

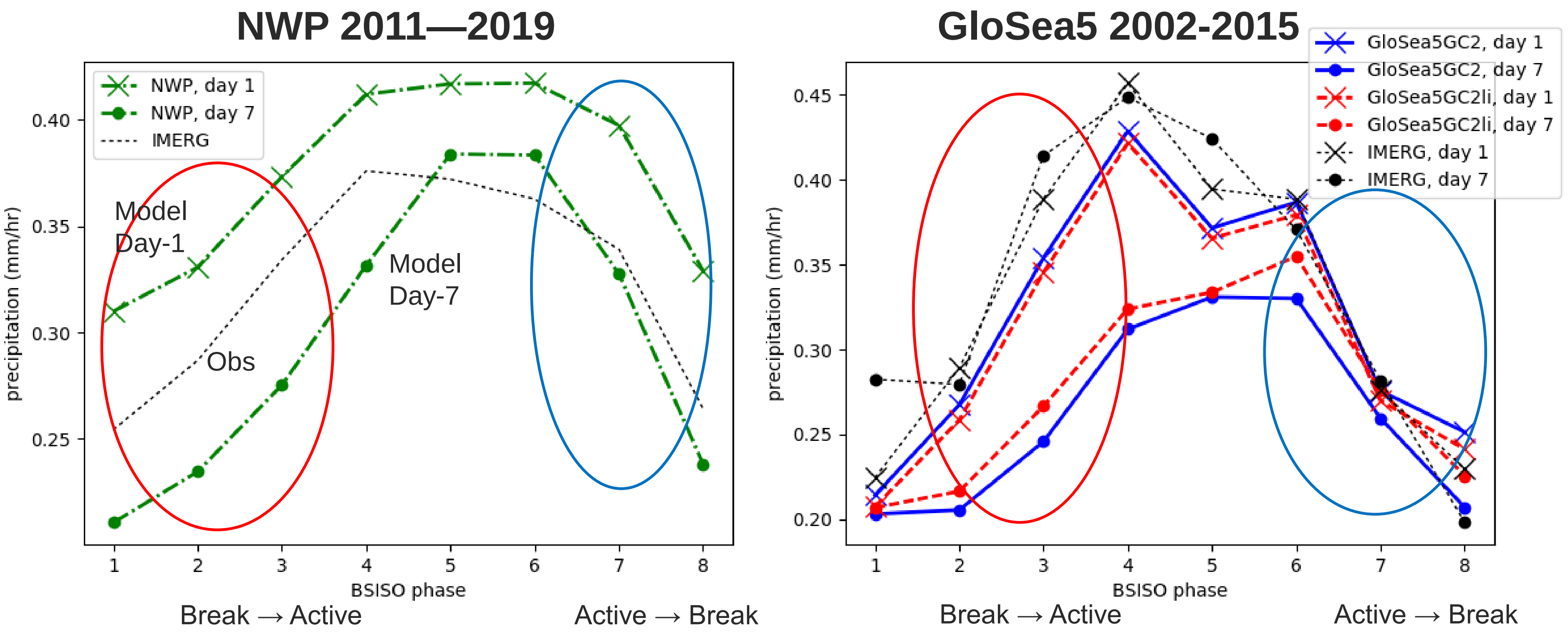
➡ **Global coupling has neutral-negative effect on monsoon LPS, with reduced rainfall from individual systems due to negative air-sea feedback on atmospheric convection.**

➡ **Increased horizontal resolution has large positive effect on number of LPS and associated rainfall.**



Richard Levine

Effect of BSISO index on Indian summer monsoon precipitation bias in the MetUM

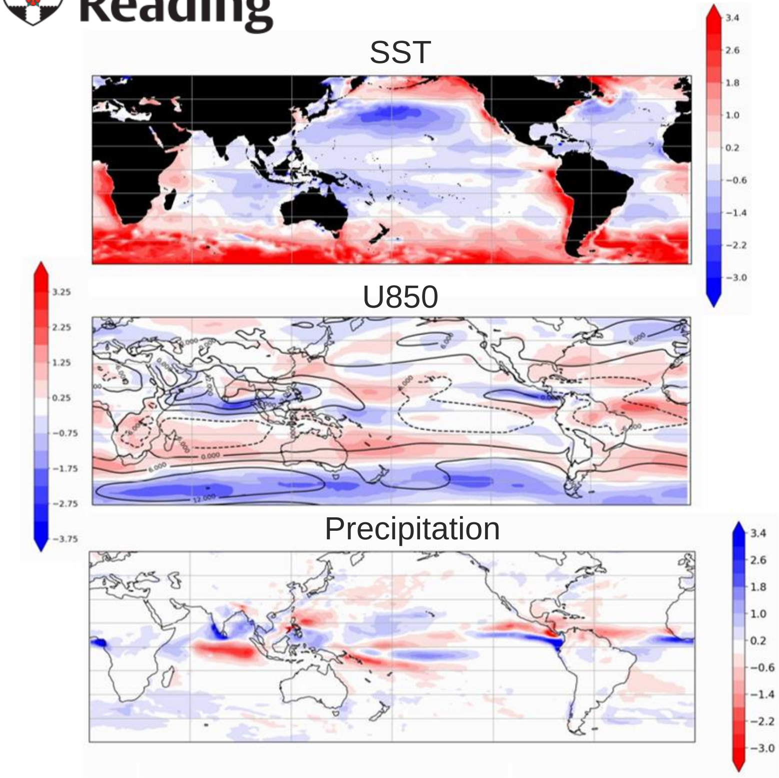


Richard Keane

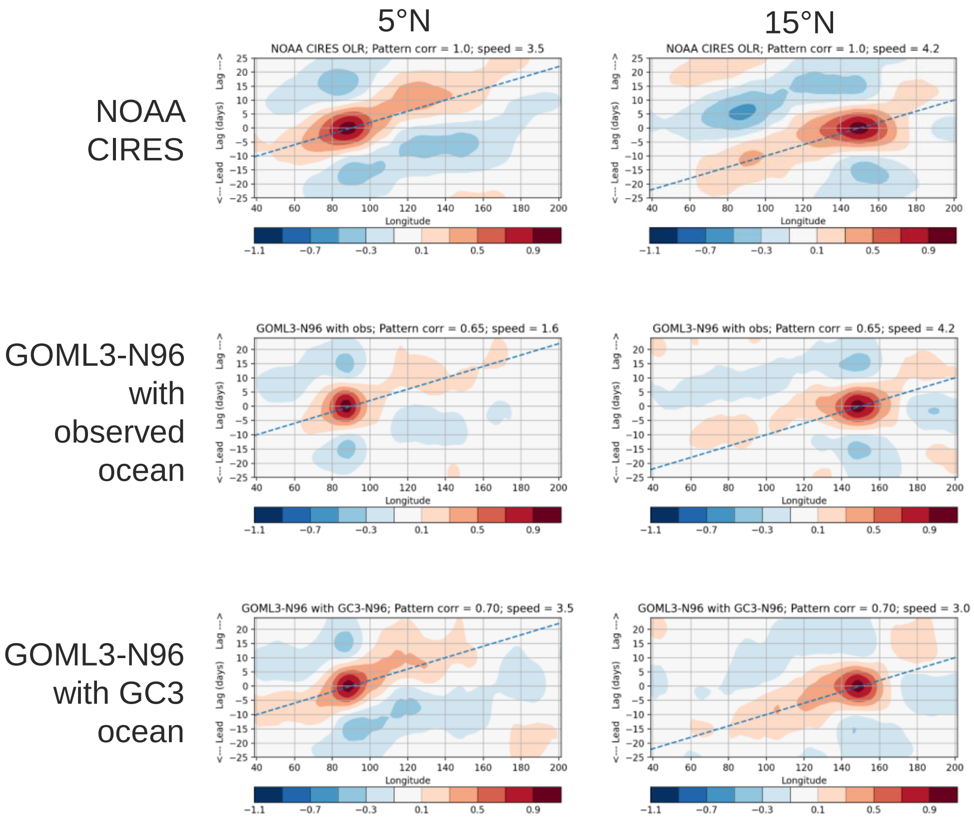
Keane, R.J., D.J. Parker and J.K. Fletcher (2021), *accepted for Geophys. Res. Lett.*

Effects of model SST biases on sub-seasonal oscillations

James Mollard, Andy Turner



Differences between GOML3-N96 with GC3 ocean and GOML3-N96 with observed ocean states for JJAS



Northward propagation of the BSISO between 70-100°E longitude

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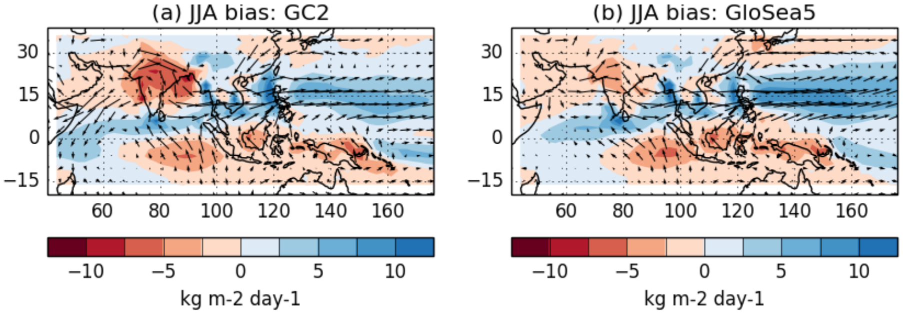
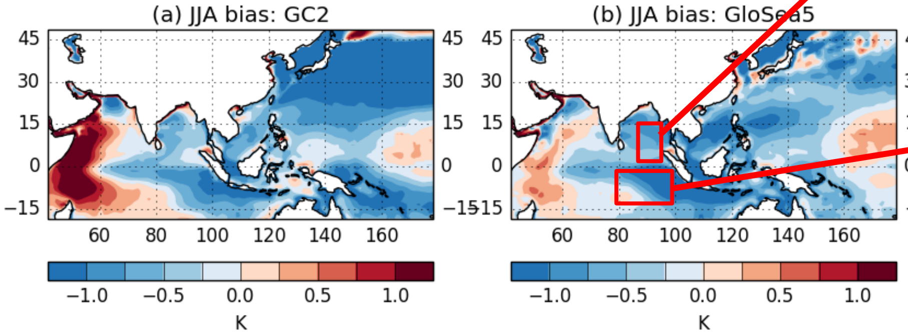
Understanding the development of systematic errors in the ASM

Multi-decadal climate runs

850 hPa wind & rainfall errors

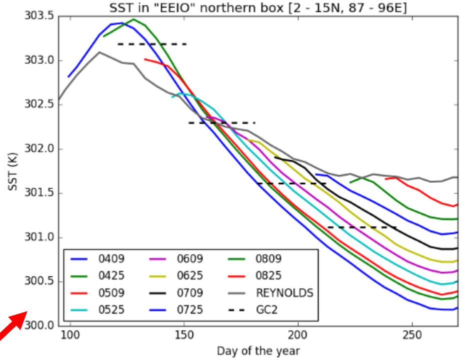


Sea surface temperature errors

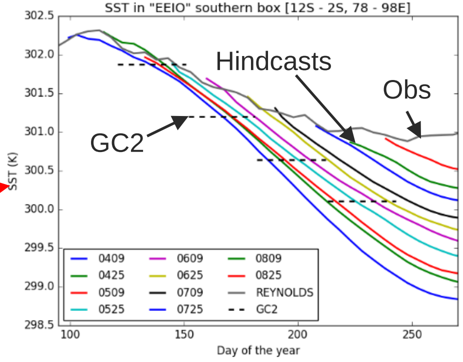


Seasonal hindcasts

SST in EEIO (N)

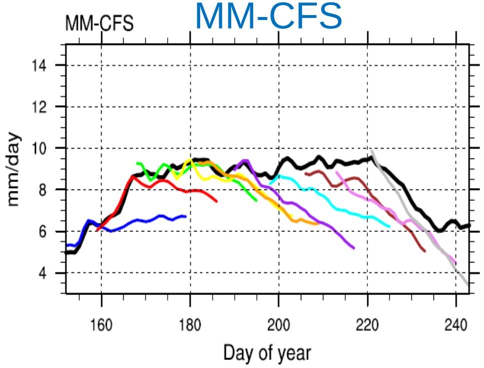


SST in EEIO (S)

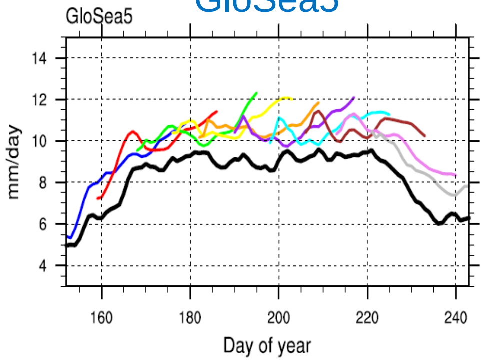


ISM Rainfall 60-100E, 10-25N

MM-CFS



GloSea5



Gill Martin, Ankur Srivastava

Martin, G.M., R.C. Levine, J.M. Rodriguez & M. Vellinga (2021), *accepted for Geosci. Model Dev*

Met Office

Final comments

- Understanding monsoon processes and improving their representation in models is essential research towards improving forecasts on a range of time and space scales.
- Joint research and intercomparison between different modelling systems can accelerate this process.
- We can make use of seamless modelling systems to examine how monsoon errors develop over time and space, and how they affect forecasts on different timescales.
- While joint parametrisation development is difficult when modelling systems differ, shared knowledge and understanding can have mutual benefits.

Thank you for your attention!