Impact of ocean observation systems on ocean analyses and subseasonal forecasts

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with

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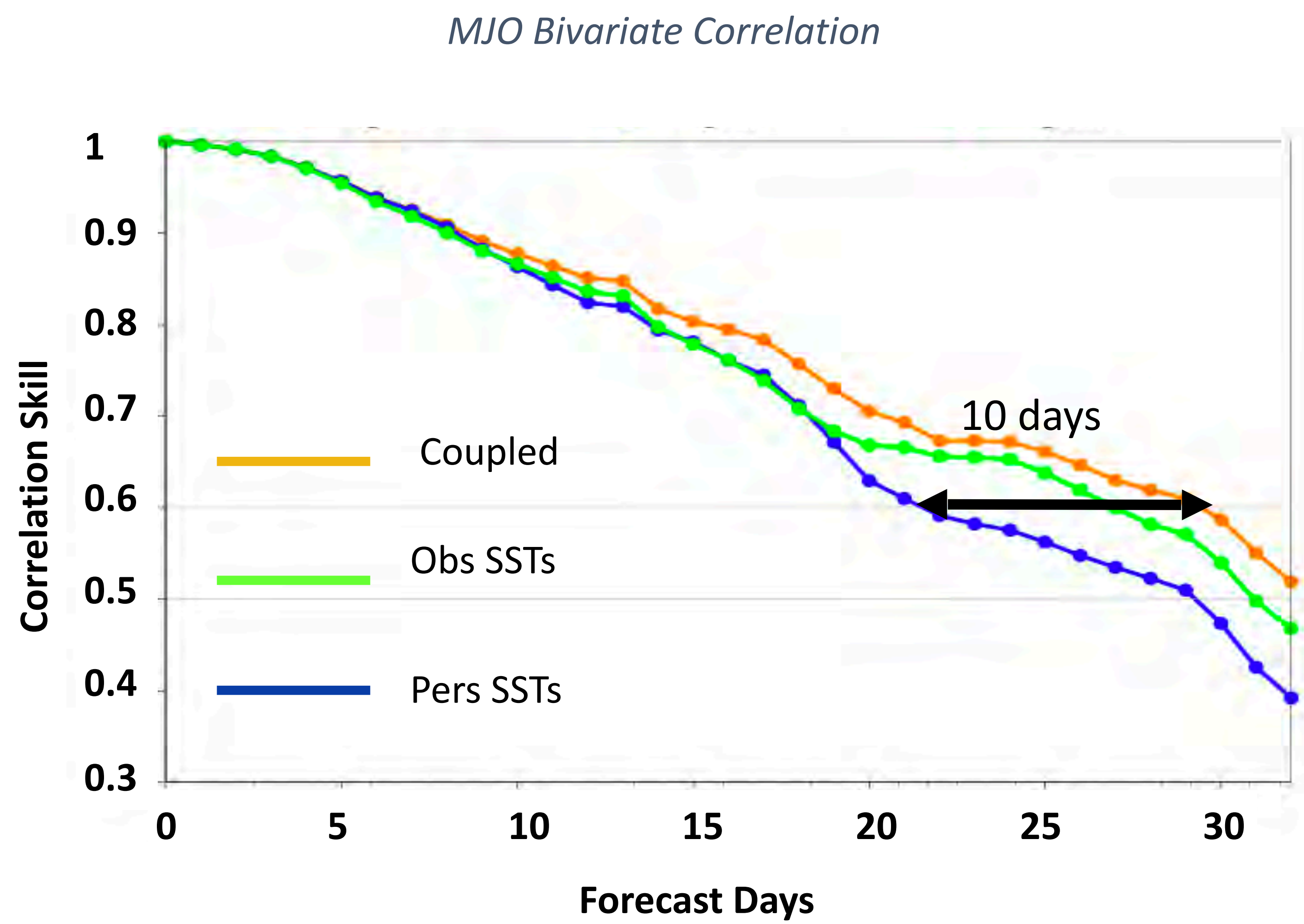
source: nasa.gov/ISS

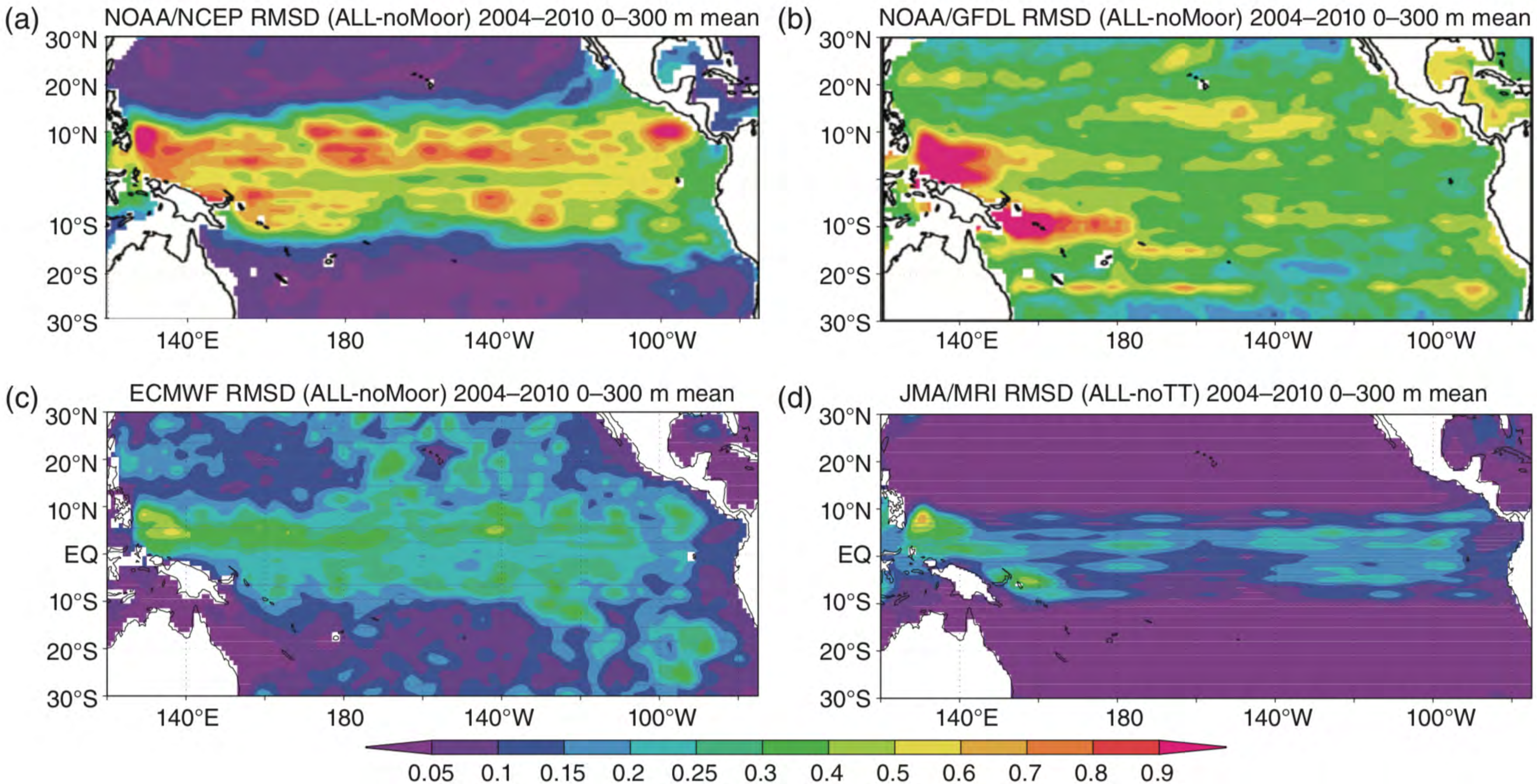
Ocean coupling improves MJO predictability

- Subseasonal forecasts of the MJO benefit significantly from coupling to the ocean (20 years of initialized forecasts)
- Ocean-atmosphere phase locking of anomalies and feedback act as a source of predictability on S2S timescales
- Understand coupled processes better to improve models and predictions on sub seasonal timescales



Subramanian, A., F. Vitart, C. Zhang, A. Kumar and M. A. Balmaseda 2018

Impact of assimilating Tropical Pacific observations

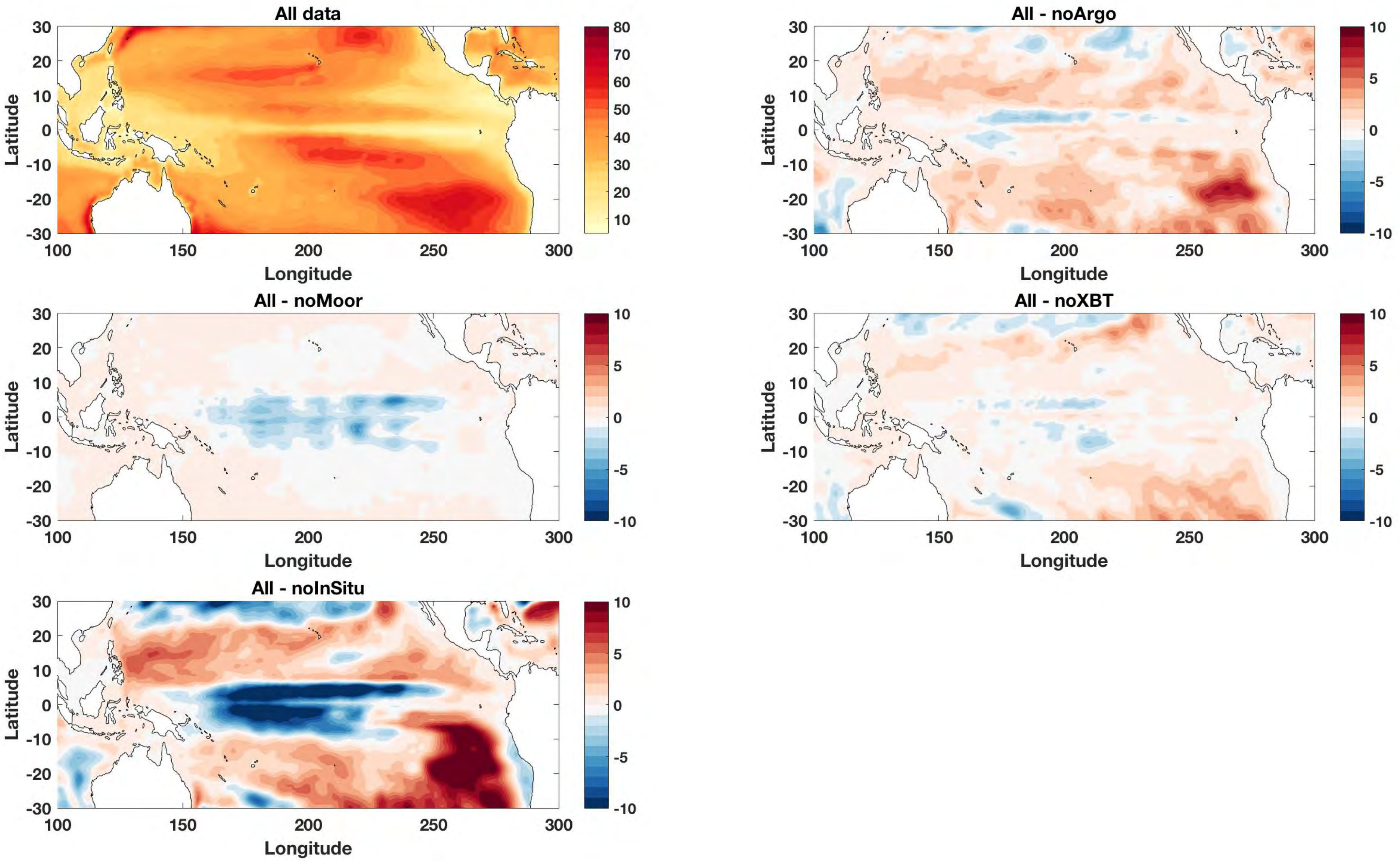


RMS difference of temperature (°C) in upper ocean

Statistics from 2004-2011 **Fujii et al., (2015)**

Impact on the mean mixed layer depth

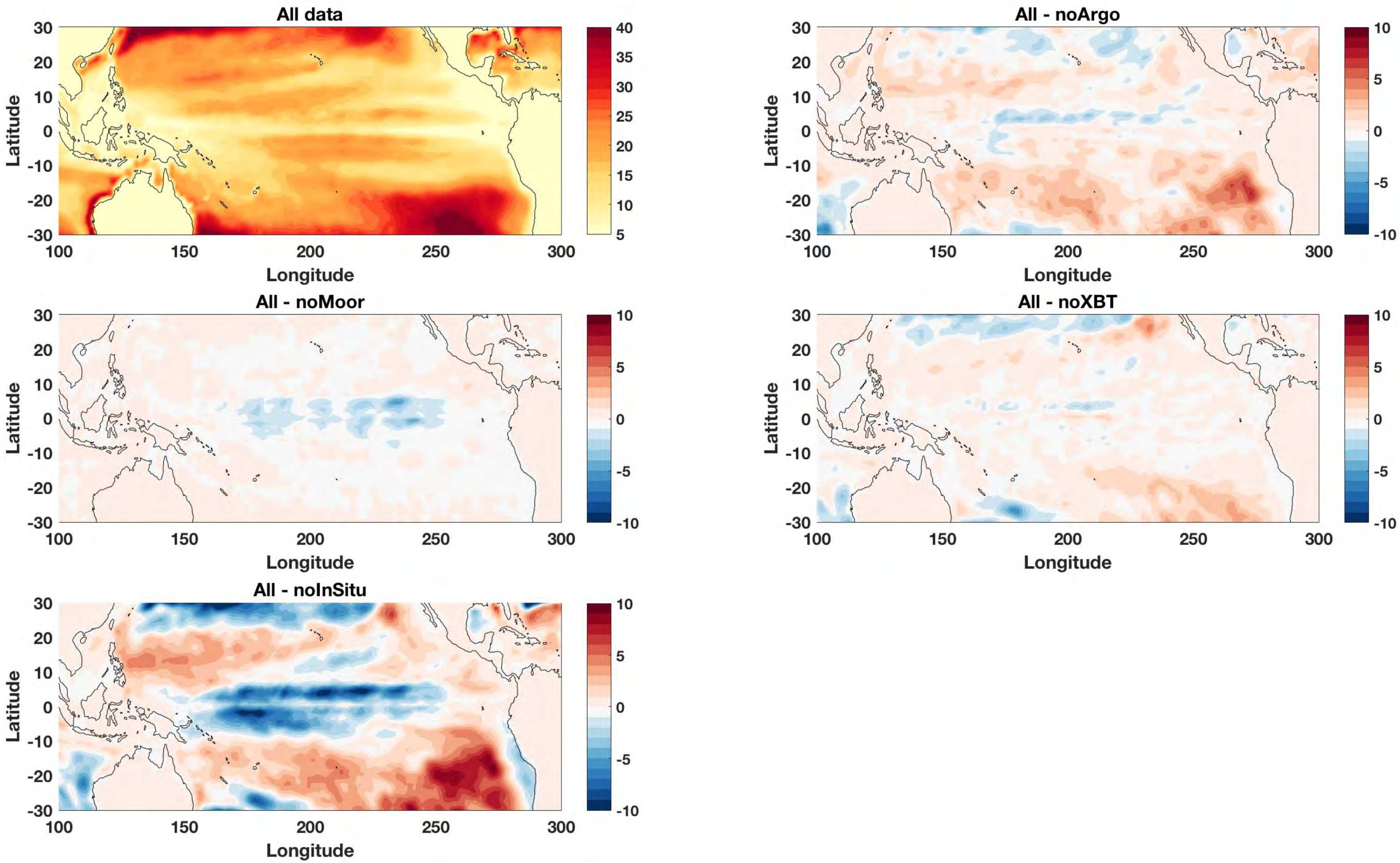
ECMWF ocean DA system (same as ORAS5)



Assimilating in-situ observations in the ocean has a significant impact on the Tropical Pacific mean mixed layer depth. Assimilating TAO moorings reduces mean MLD.

Impact on the variability in mixed layer depth

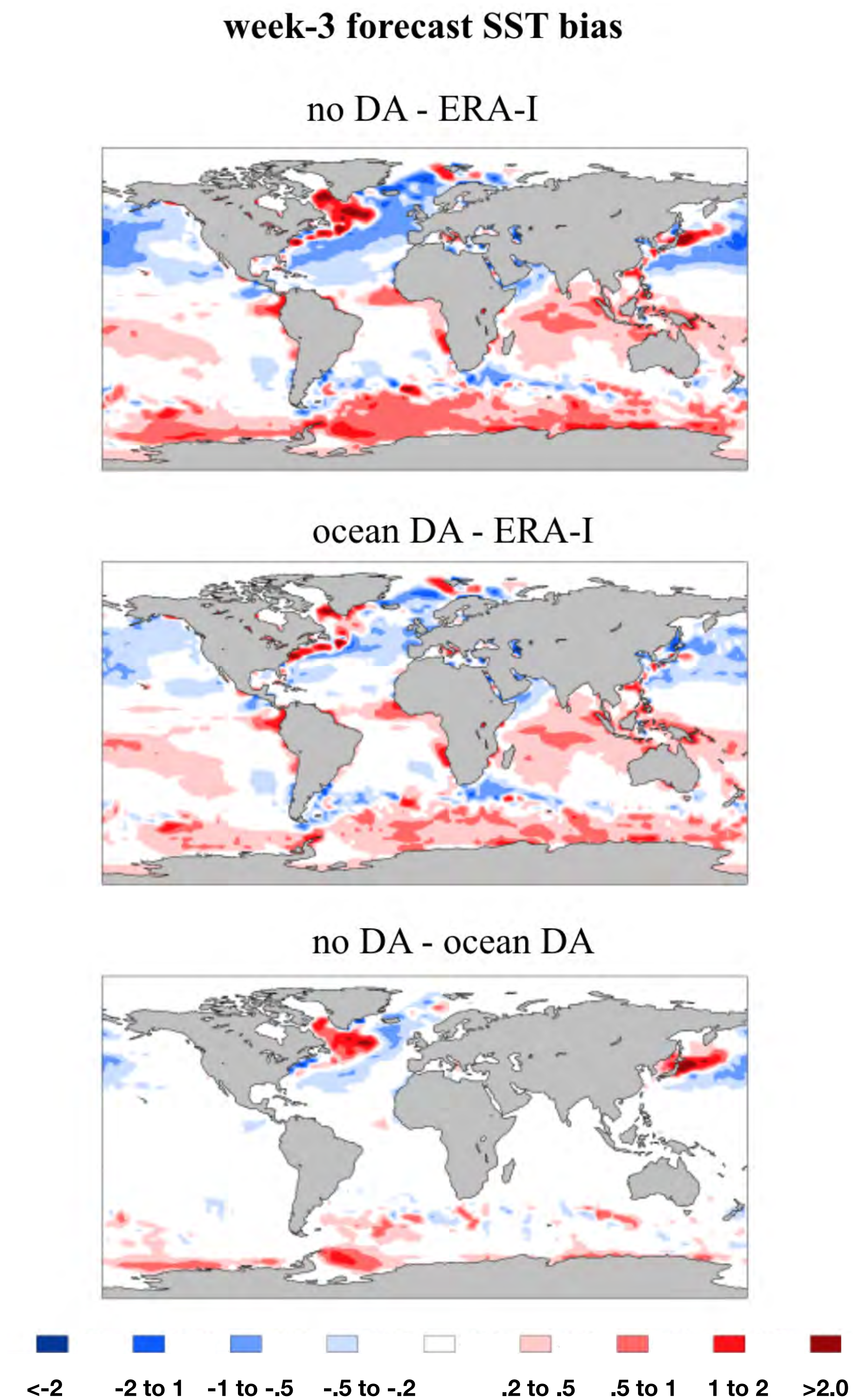
ECMWF ocean DA system (same as ORAS5)



TAO moorings mainly impact mixed layer depth locally by reducing the variance in MLD compared to not assimilating mooring data

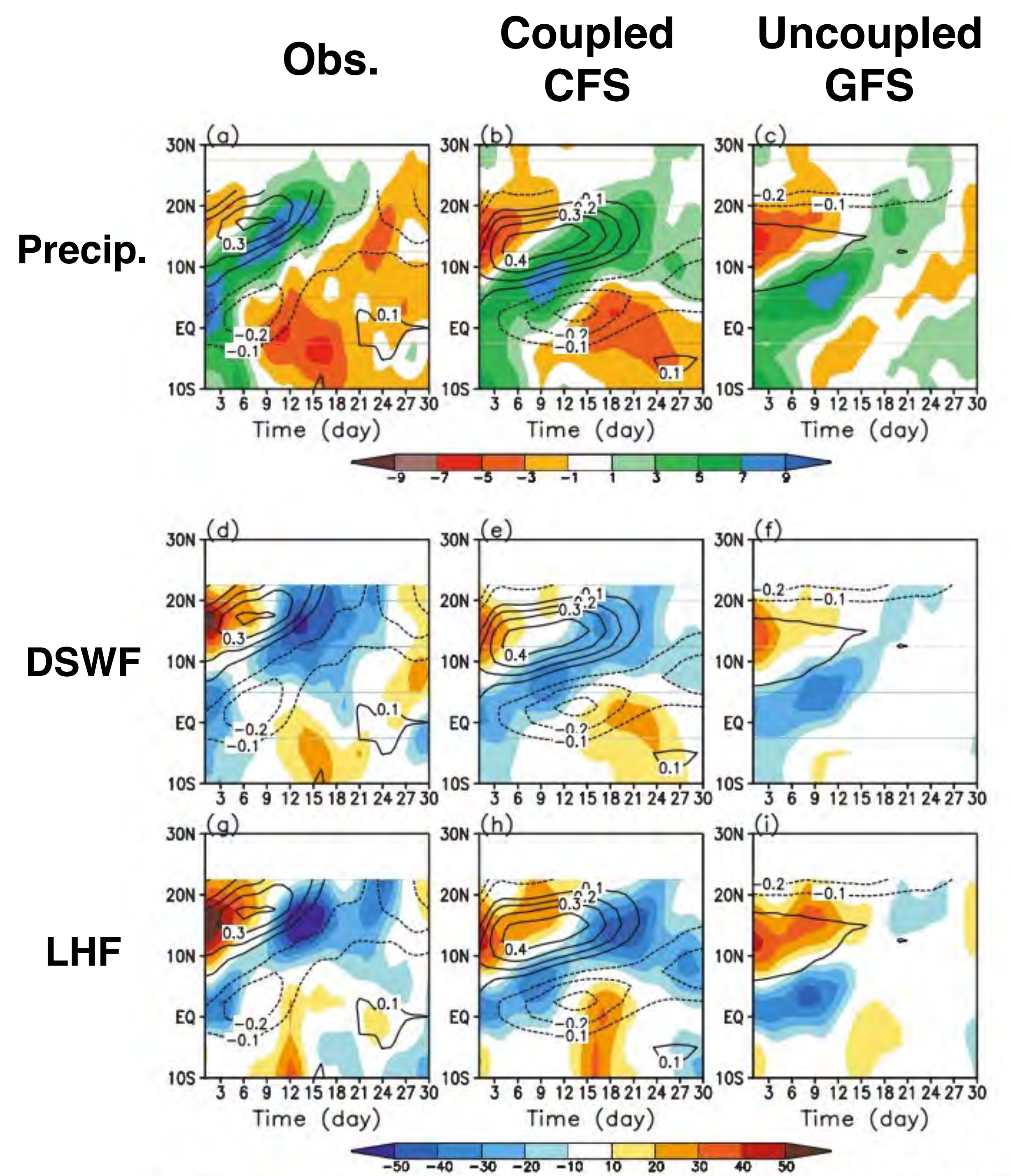
SST bias in subseasonal forecasts with OSEs

- Subseasonal forecasts
  - starting on 1st of each month,
  - 5 ensemble members,
  - 32 day forecasts
- Control forecasts starting from Ocean data assimilation (**ocean DA** experiments)
- Forecasts starting from ocean analysis without Data assimilation (ocean model is run forced only from re-analysis + relaxation of SSTs) - **no DA**
- Reduced SST bias in the mid-latitudes for week-3 forecasts in **ocean DA experiments**



Air-sea interaction for MISO forecasts

During MISO propagation, the observed phase relation between latent heat flux, SST and SW radiation is better represented in coupled NCEP forecasts compared to uncoupled forecasts.



Composite anomalies. (top) Precipitation (shaded starting at 1 mm day^{-1}, with a 2 mm day^{-1} contour interval) and SST (contours starting at ±0.1 K, with a 0.1-K contour interval, negative values dashed) averaged between 65° and 95°E. (middle) Same as the top row, except that the shading is for downward surface solar radiation (starting at ±10 W m^{-2}, with a 10 W m^{-2} contour interval). (bottom) Same as the middle row, except that shading is for downward latent heat flux. (left) Observation, (middle) CFS forecast, and (right) GFS forecast.

Wang et al. 2009

Ocean data assimilation impact: Precipitation in MISO predictions

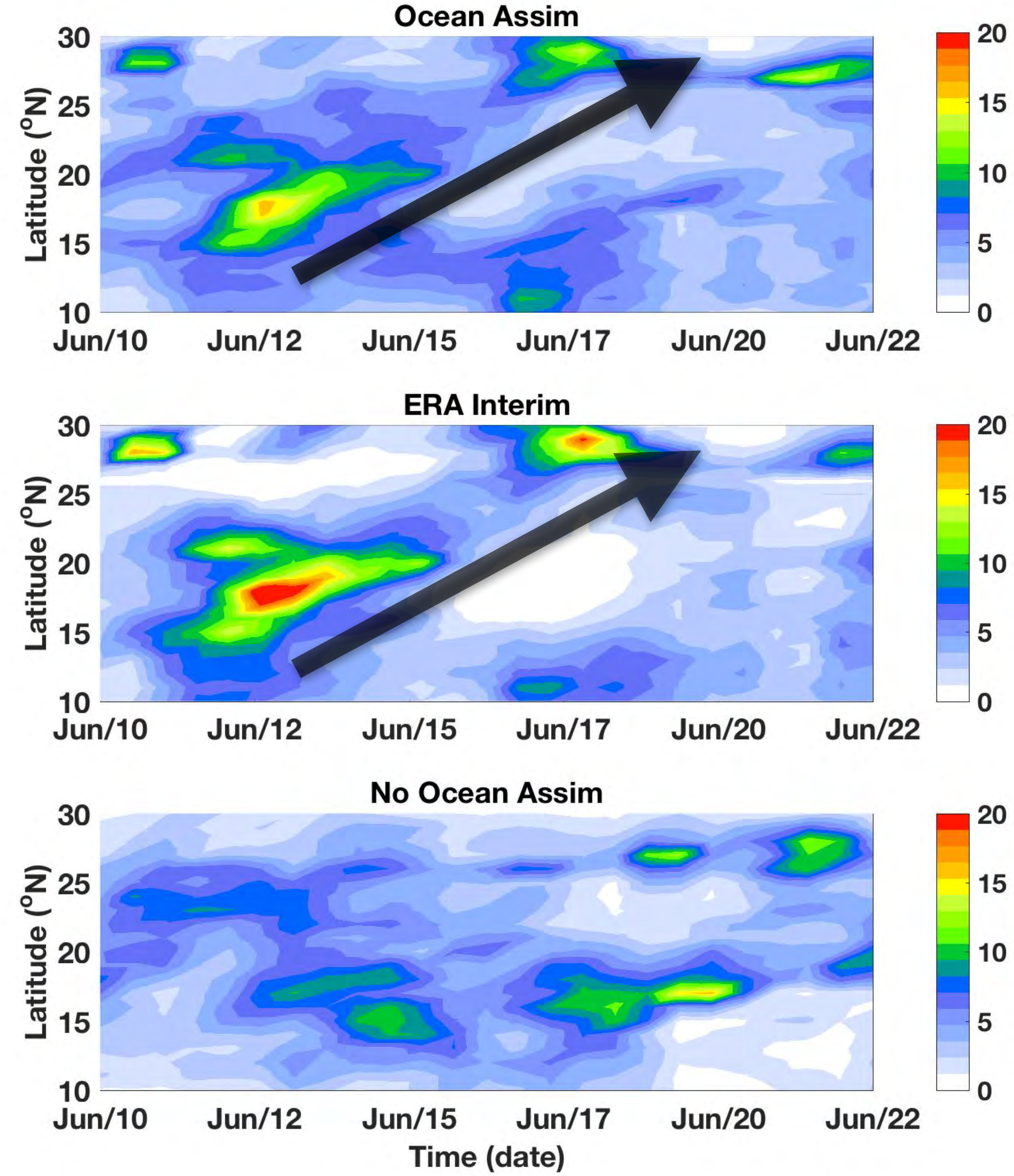
ECMWF sub seasonal forecast system

All ocean observations assimilated prior to hindcast initialization ⇒ **more coherent MISO propagation**

Reanalysis

No ocean DA prior to hindcast initialization

2013 June: Precipitation Hovmöller



Subramanian et al. (2018, In Prep.)

Zonal mean precipitation [85 E - 90 E]

Ocean data assimilation impact: LH Flux anomalies in MISO predictions

ECMWF sub seasonal forecast system

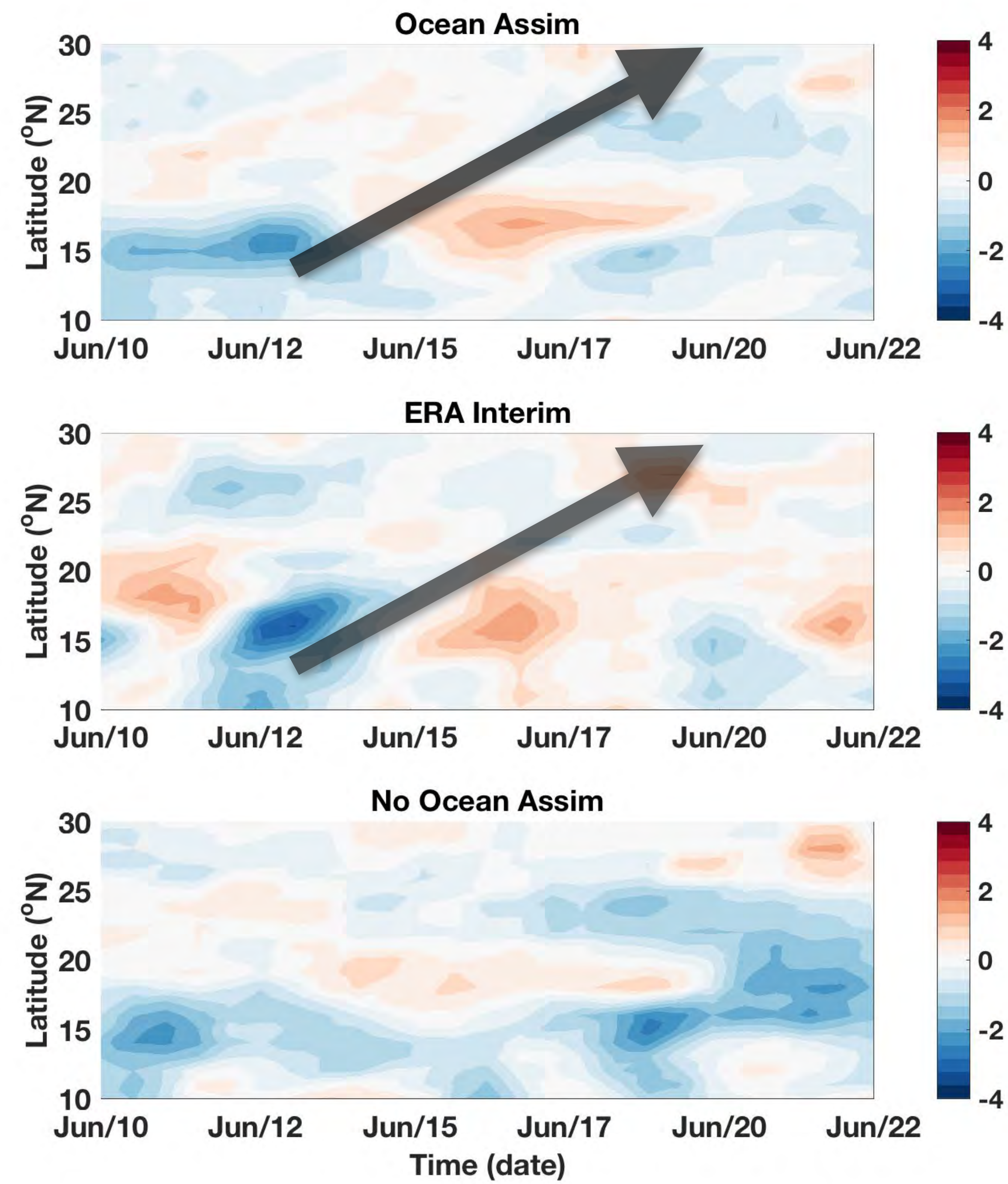
All ocean observations assimilated prior to hindcast initialization ⇒ **more consistent surface flux anomalies**

Reanalysis

No ocean DA prior to hindcast initialization

Subramanian et al. (2018, In Prep.)

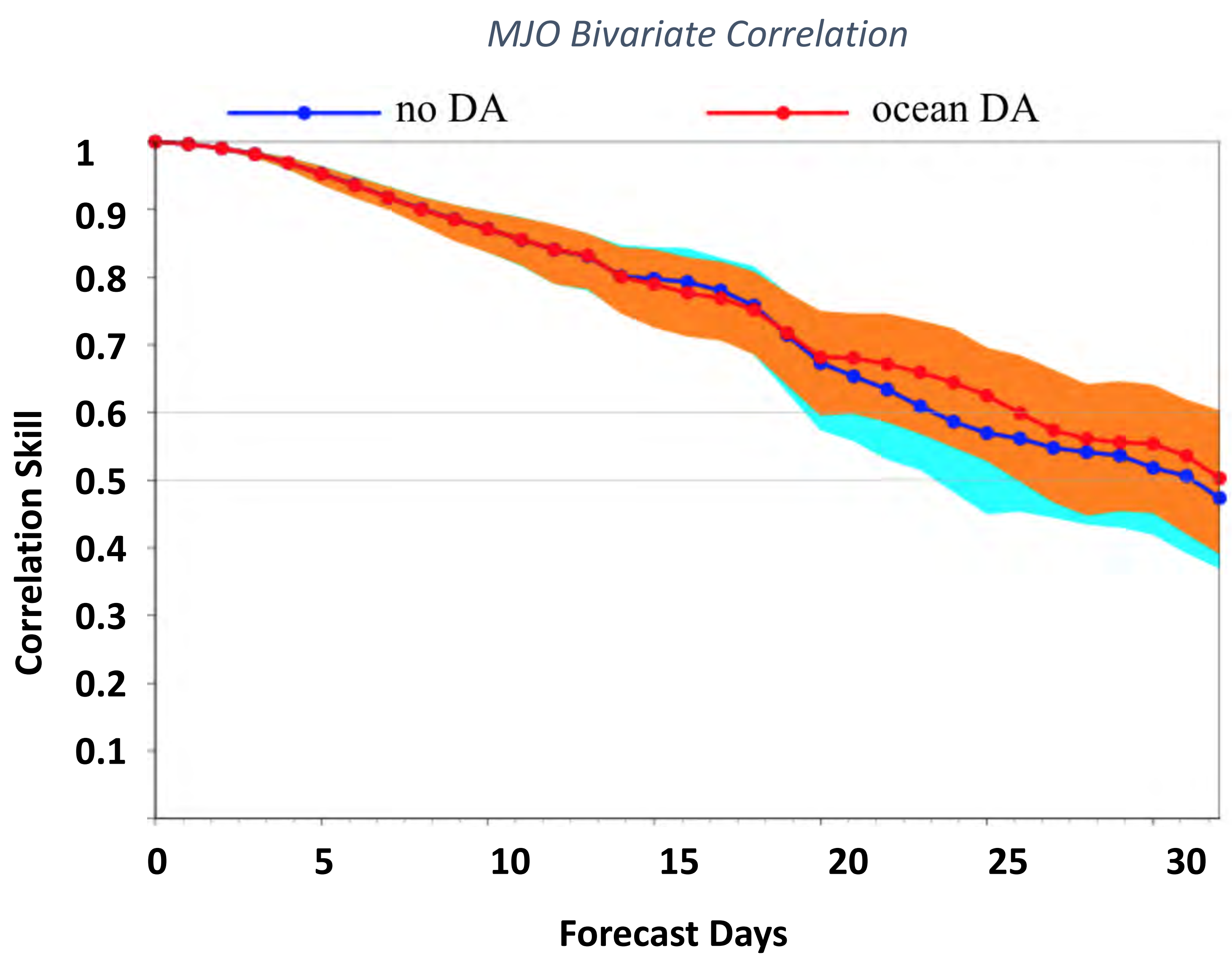
2013 June: Latent Heat Flux (x10^3 kJ m^{-2})



Zonal mean LH Flux [85 E - 90 E]

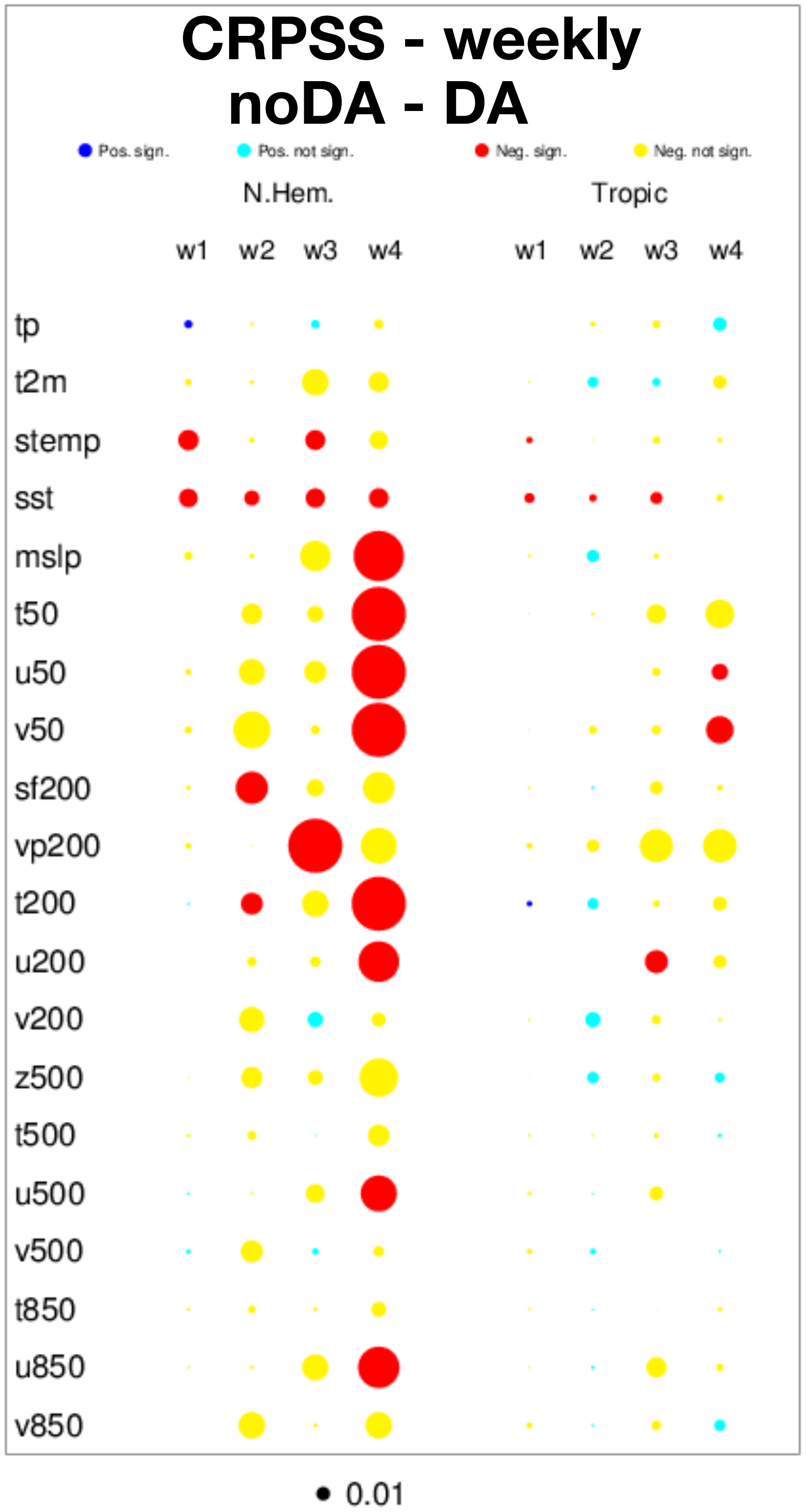
Ocean DA and MJO forecast skill

- Subseasonal forecasts of the MJO benefit modestly from ocean initialization in coupled forecasts
- Week-3 and beyond show improved skill of a day or two
- Forecast skill improvement is within uncertainty and more diagnostics need to be performed to understand the differences

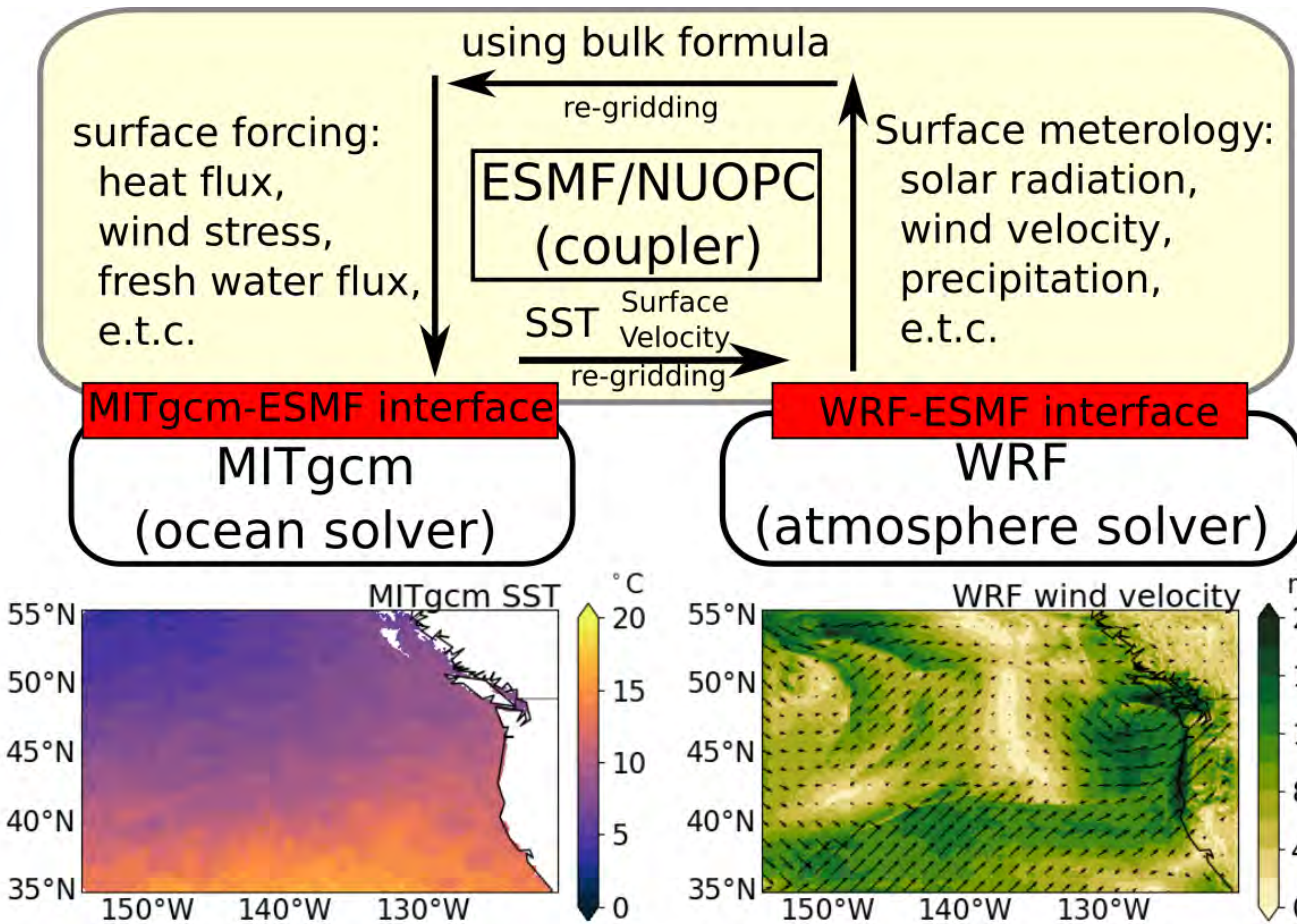


Ocean DA and forecast skill scorecard

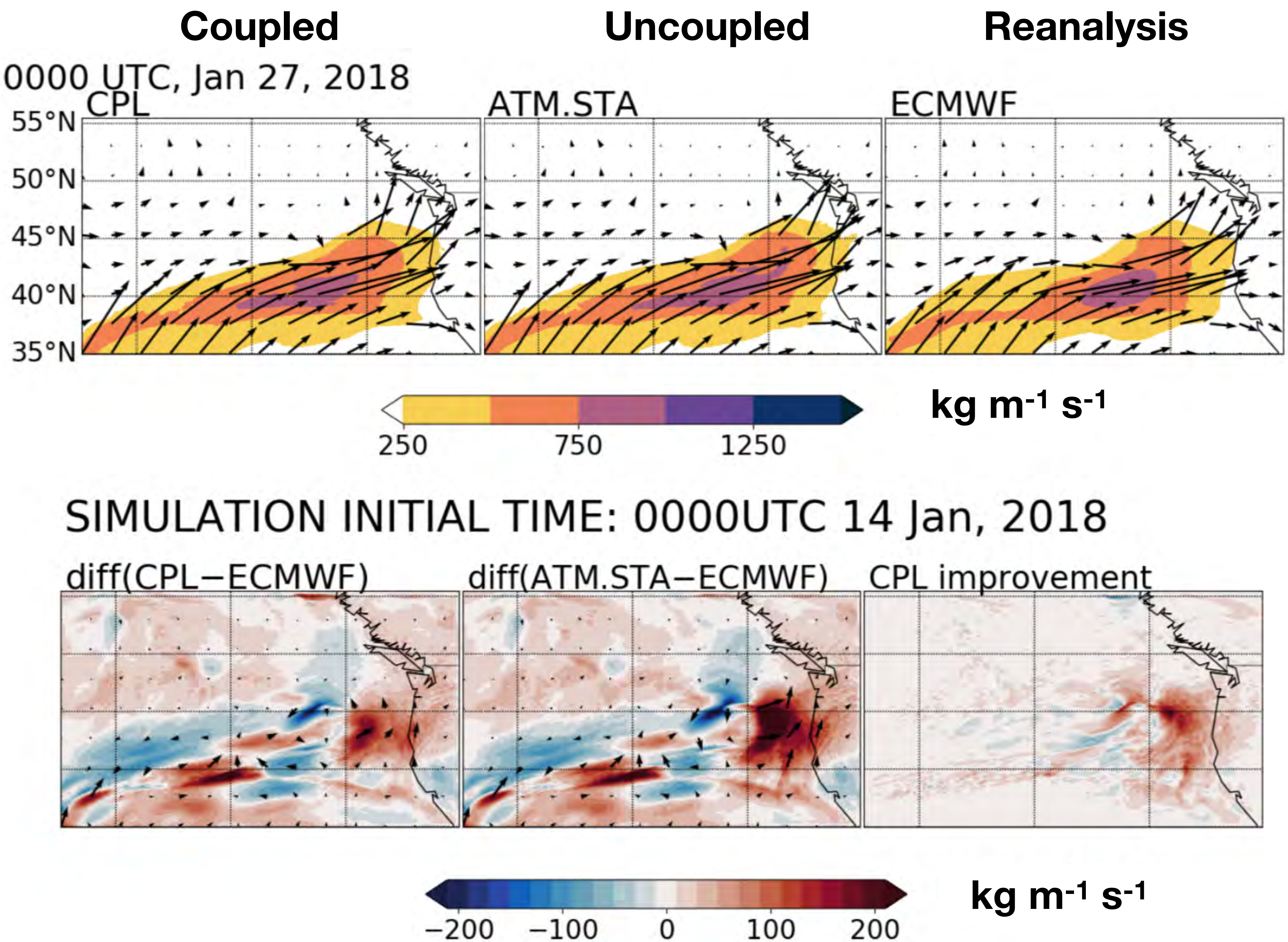
- Difference of weekly CRPSS skill scores
- Skill improvements are much larger in the Extratropics, with a clear degradation in the no DA experiments
- Upper atmosphere as well as surface skill scores are better in ocean DA experiments



Regional coupled model development



Atmospheric River 2-week forecast: Jan 2018



Ocean coupling improves integrated vapor transport (IVT) week-2 forecast during the AR event on Jan 27, 2018. The simulation initial time is 0000 UTC 14 Jan, 2018.

Sun et al., 2018 (In Prep.)

Process Studies

BoBBLE

BoBBLE
Bay of Bengal Boundary Layer Experiment

ASIRI-OMM and MISO-BOB

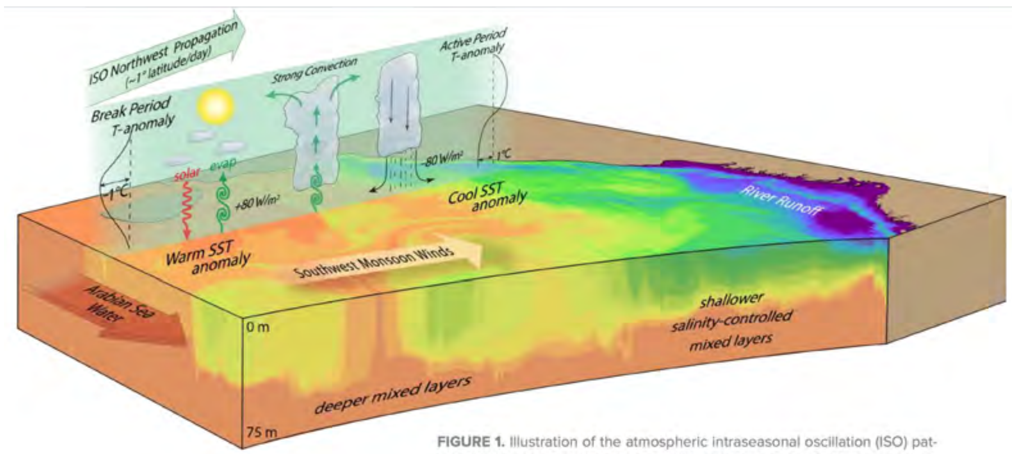
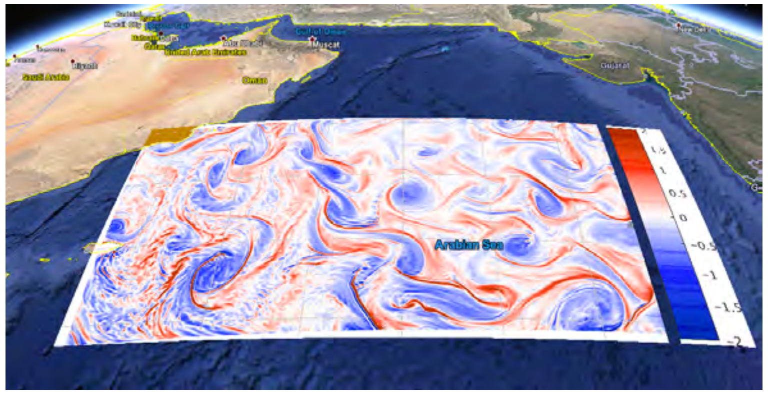


FIGURE 1. Illustration of the atmospheric intraseasonal oscillation (ISO) pattern that propagates over the Bay of Bengal during the southwesterly monsoon season. Color in the ocean represents salinity, and was produced using the HYbrid Coordinate Ocean Model, or HYCOM (Cummings and Smedstad, 2013, http://dx.doi.org/10.1007/978-3-642-35088-7_13). *Schematic drawing by Emily Shroyer and produced by David Reinert, Oregon State University.*

TPOS 2020
Tropical Pacific Observing System

DYNAMO 2011-2012
dynamics of the madden-julian oscillation

NASCar



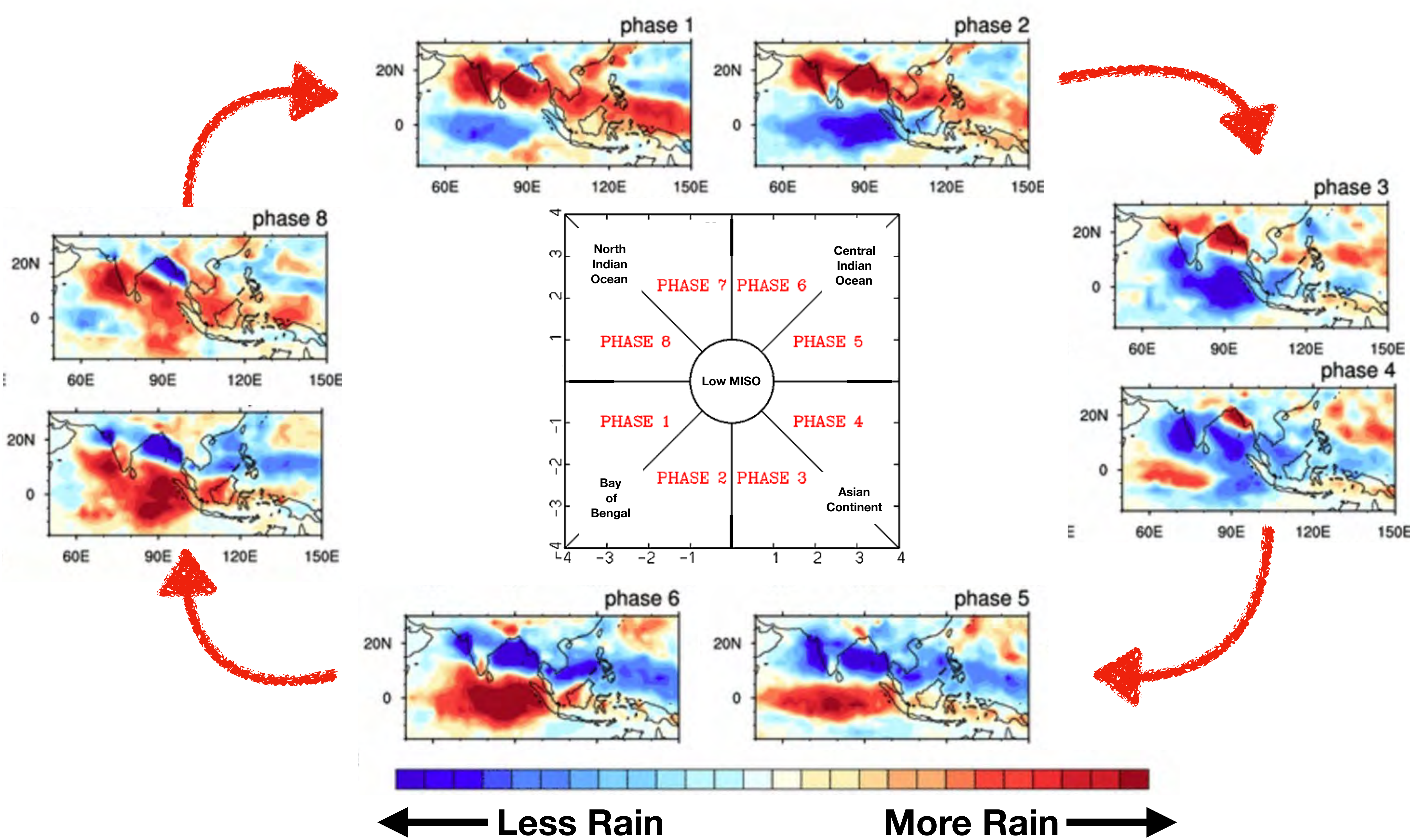
Years of Maritime Continent

Summary

- Preliminary results from new ocean DA system at ECMWF shows overall positive impact from assimilation of TAO mooring and Argo (in-situ) data in ocean analyses
- Ocean in-situ observations have significant impact on mean and variability representations of subsurface ocean variables
- Ocean DA helps improve forecast skill of some atmospheric variables on sub seasonal timescales
- Further analysis is required (including with other modeling systems) to understand the systematic impact of ocean observations on improved process understanding and forecast skill for S2S timescales

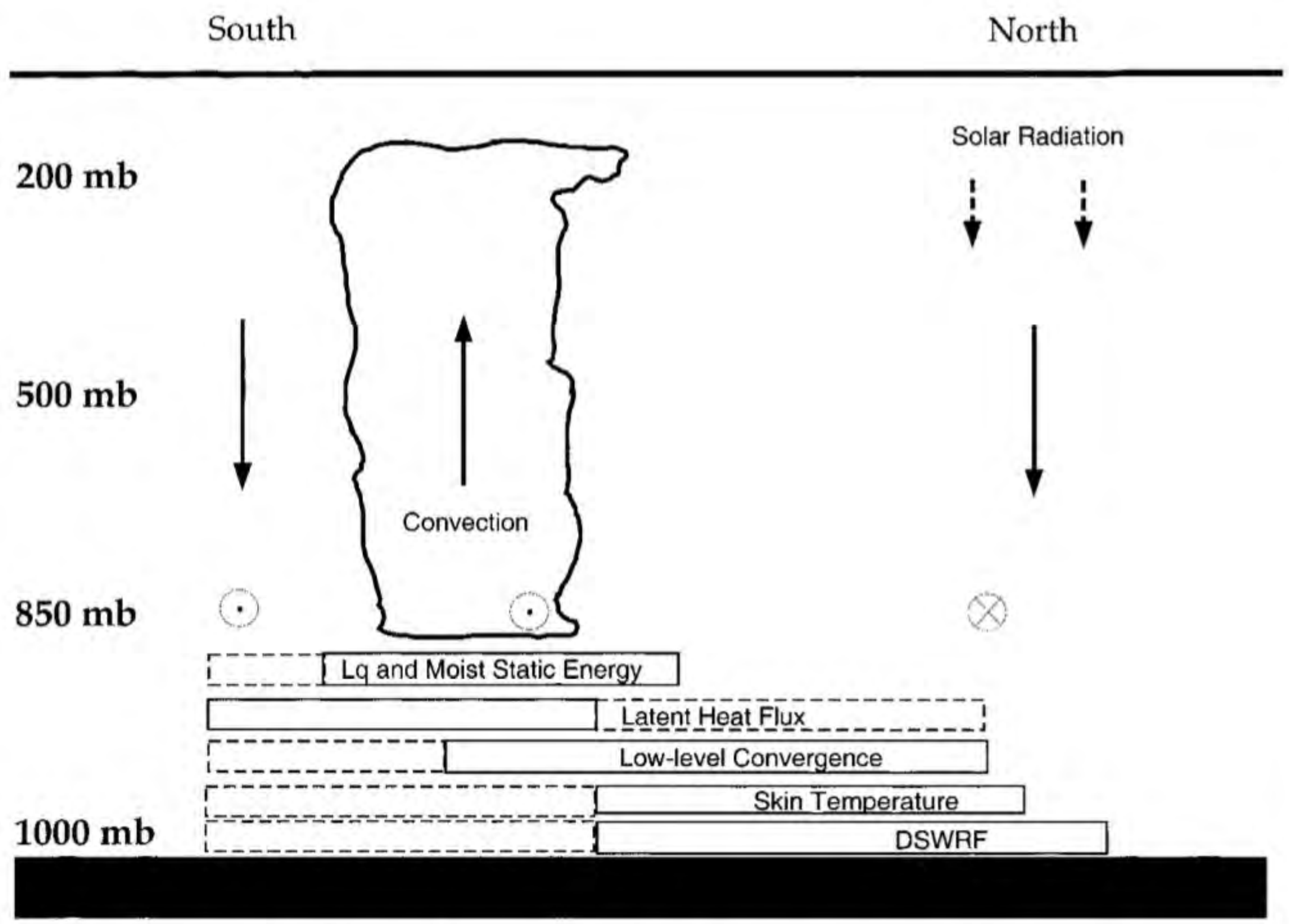
Monsoon clouds over Bangladesh. Courtesy: NASA

Monsoon Intraseasonal Oscillation



Based on an EEOF analysis of precipitation in the Tropics.
Neena et al., 2017

Air-sea interaction is key

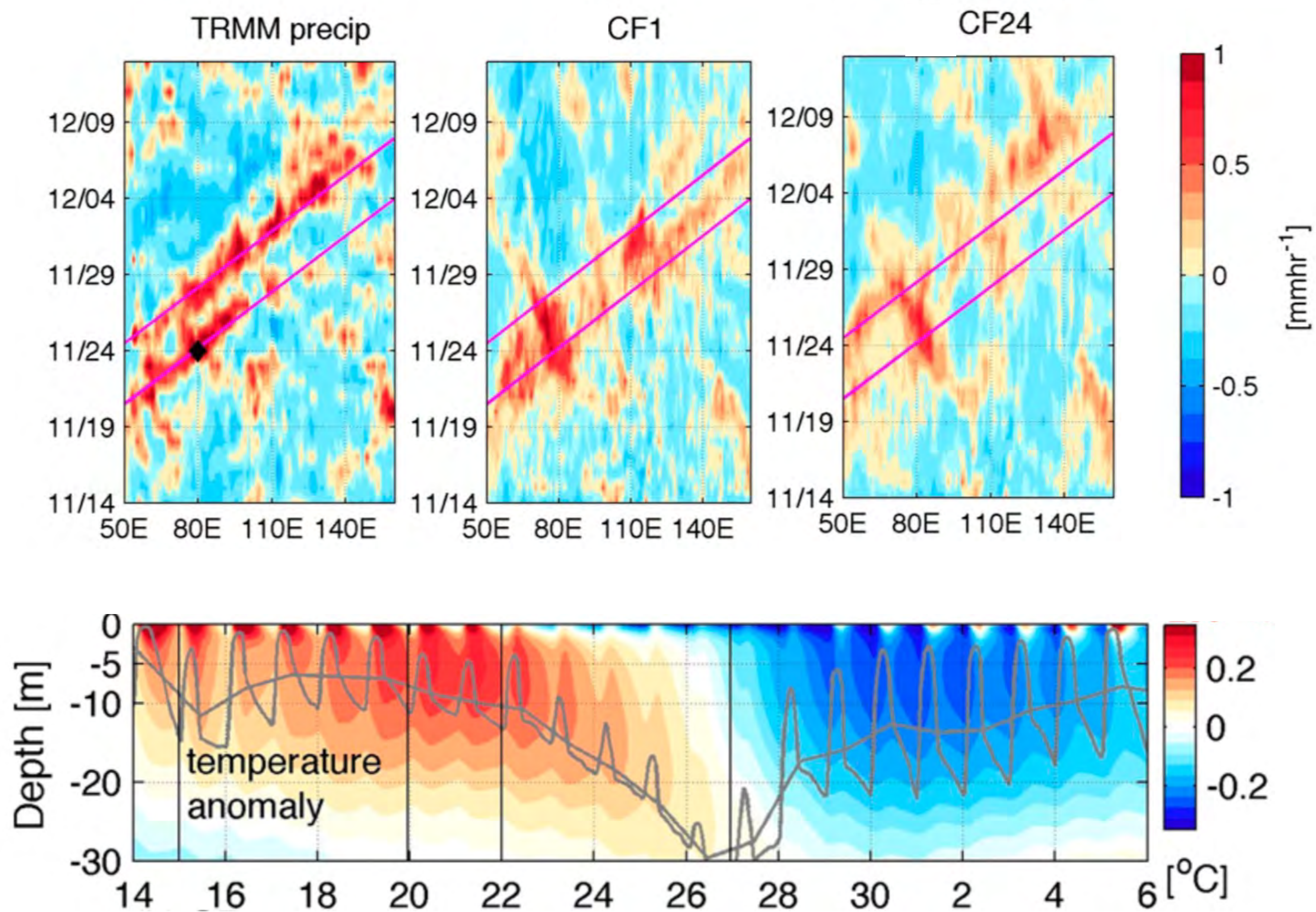


Schematic of air–sea interaction in the northward propagation of convective anomalies associated with the BSISO in the Indian and western Pacific Oceans. Dark vertical lines indicate the ω(500 mb) anomaly. The cloud indicates deep precipitating convection. The boxes represent the approximate locations of anomalies relative to the convection. Solid box indicates a positive anomaly, and dashed box indicates a negative anomaly. Circles indicate direction of 850-mb zonal wind anomaly with the ⊗ (⊙) representing easterlies (westerlies).

PBL convergence maximum north of the convection maximum leads to feedbacks that propagate the system poleward. Kemball-Cook and Wang (2001)

Impact of high-frequency air-sea interactions on MJO

Diurnal coupling in a regional model improves MJO due to rectification of shallow moistening.



Seo, Subramanian, Miller, Cavanaugh, J. Clim. 2014

MJO and the Maritime Continent

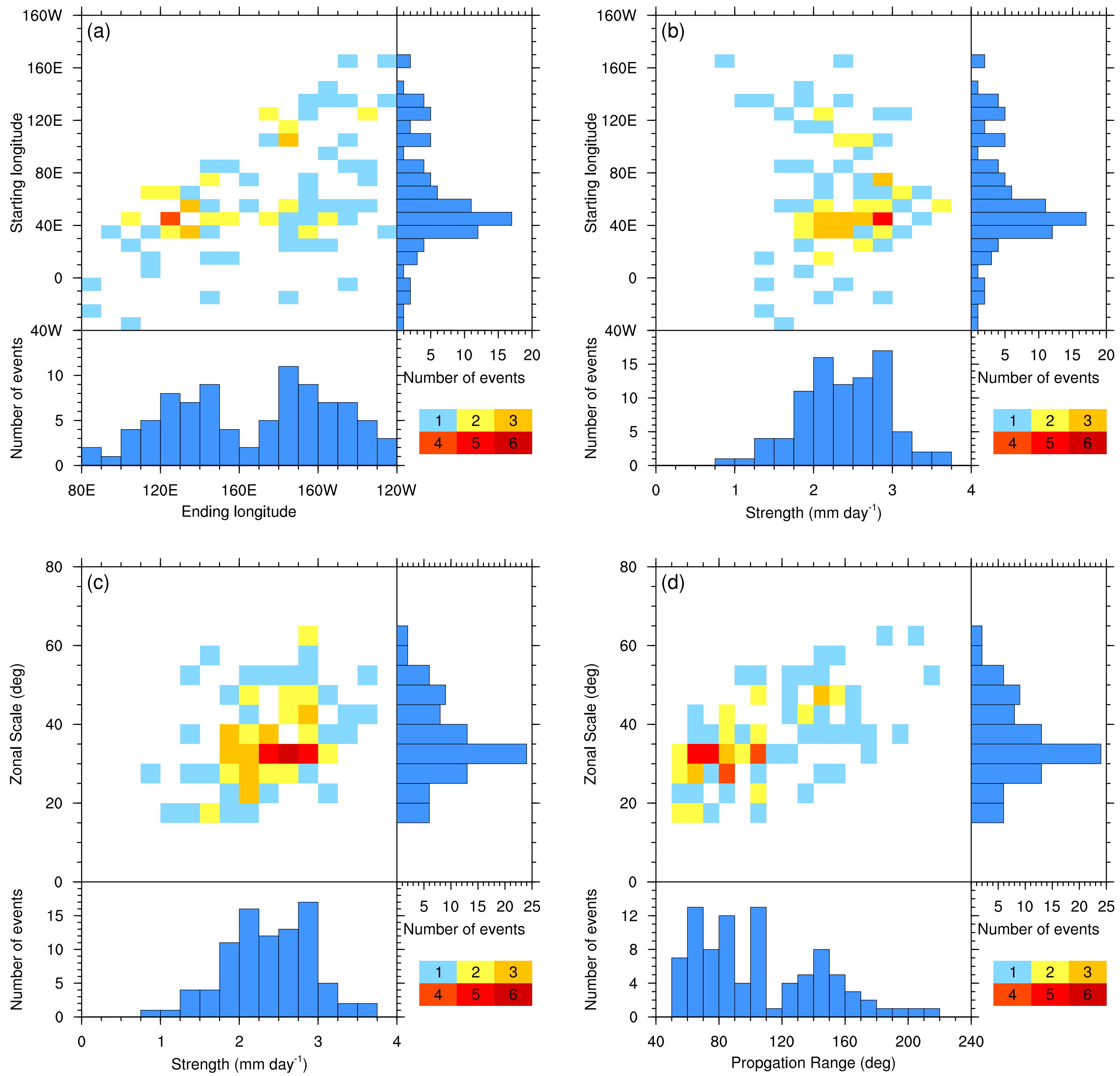
Individual and joint number distributions of

(a) starting vs ending longitudes

(b) starting longitudes vs mean strength

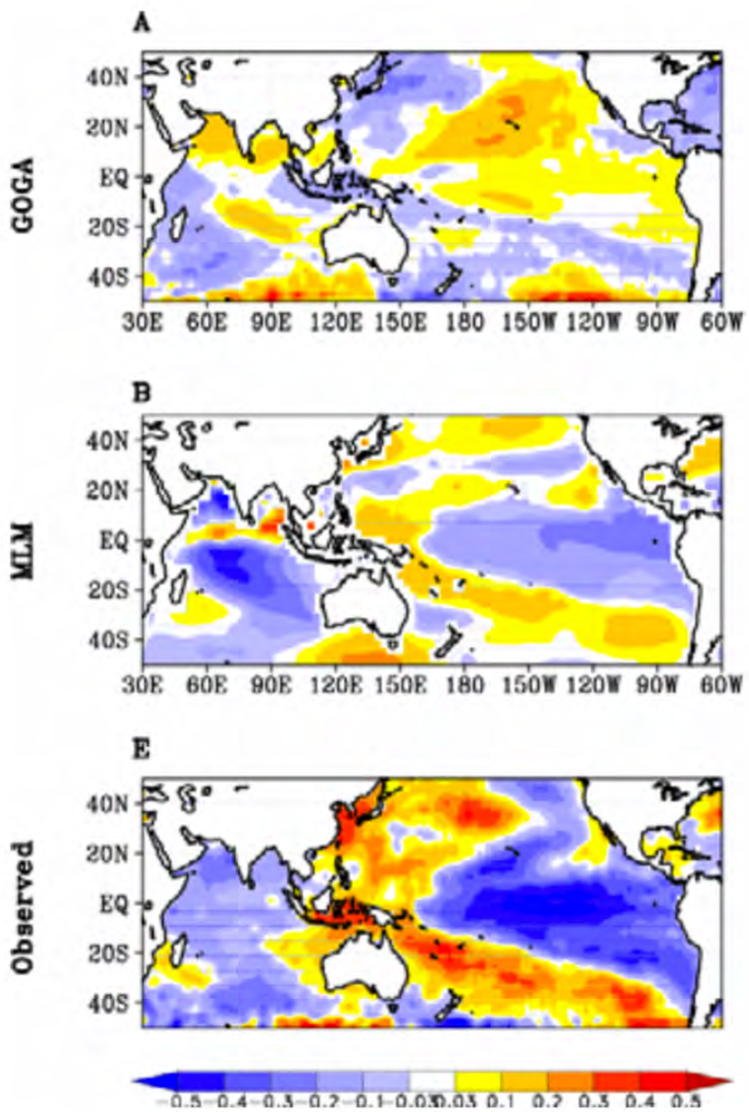
(c) mean zonal scales vs mean strength

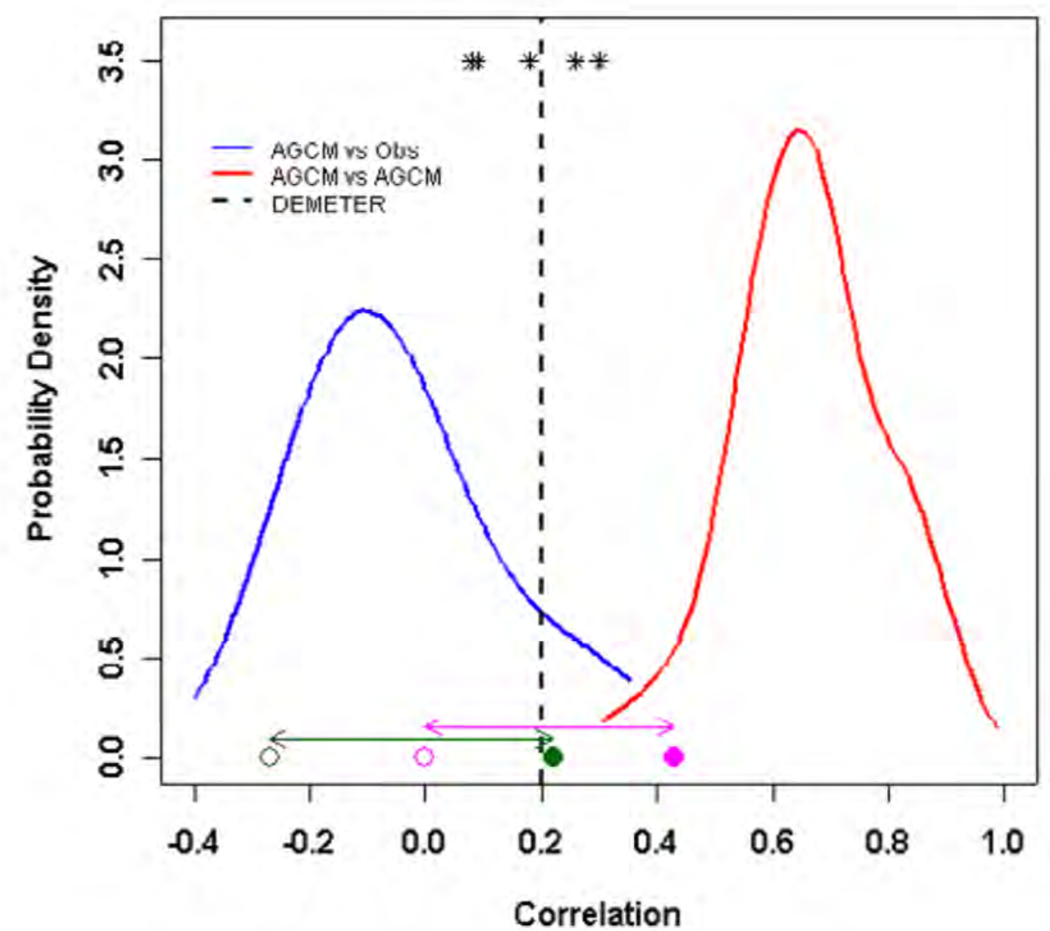
(d) mean zonal scales vs propagation ranges of tracked MJO events using the TRMM precipitation data.



Zhang and Ling (2017)

Air-sea interaction and seasonal monsoon forecasts





Correlation maps of

(a) observed SSTs and monsoon rainfall simulated from uncoupled model,

(b) simulated SSTs and monsoon rainfall from the coupled model.

(c) observed SSTs and observed monsoon rainfall

PDFs of correlation skill of June – September Indian monsoon rainfall

(red) ‘perfect model’

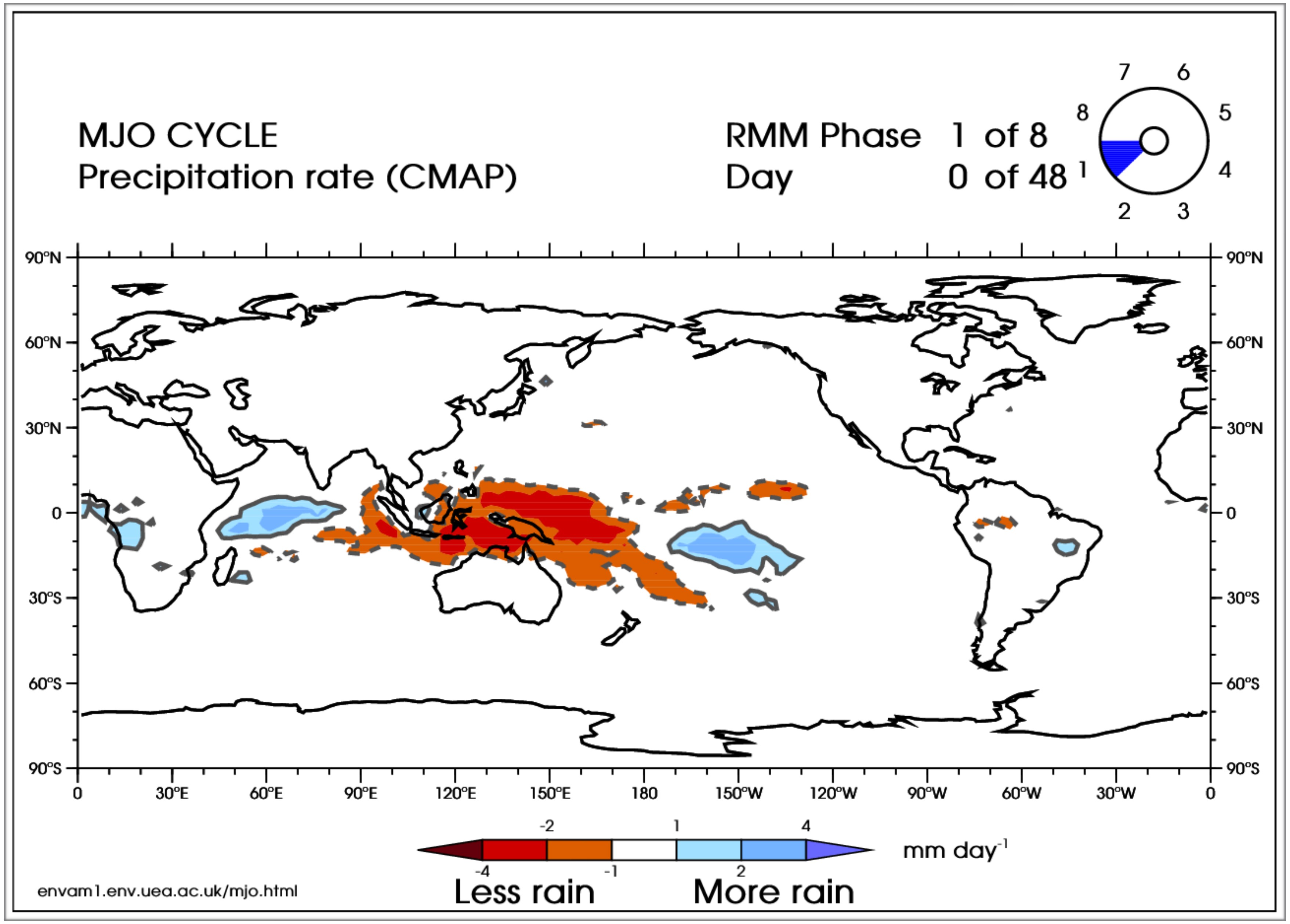
(blue) actual skill

Closed coloured circles - skill of two of AGCM coupled ML model.

Krishna Kumar et al., 2005

Madden-Julian Oscillation

Largest signal in tropical precipitation on timescales shorter than a year

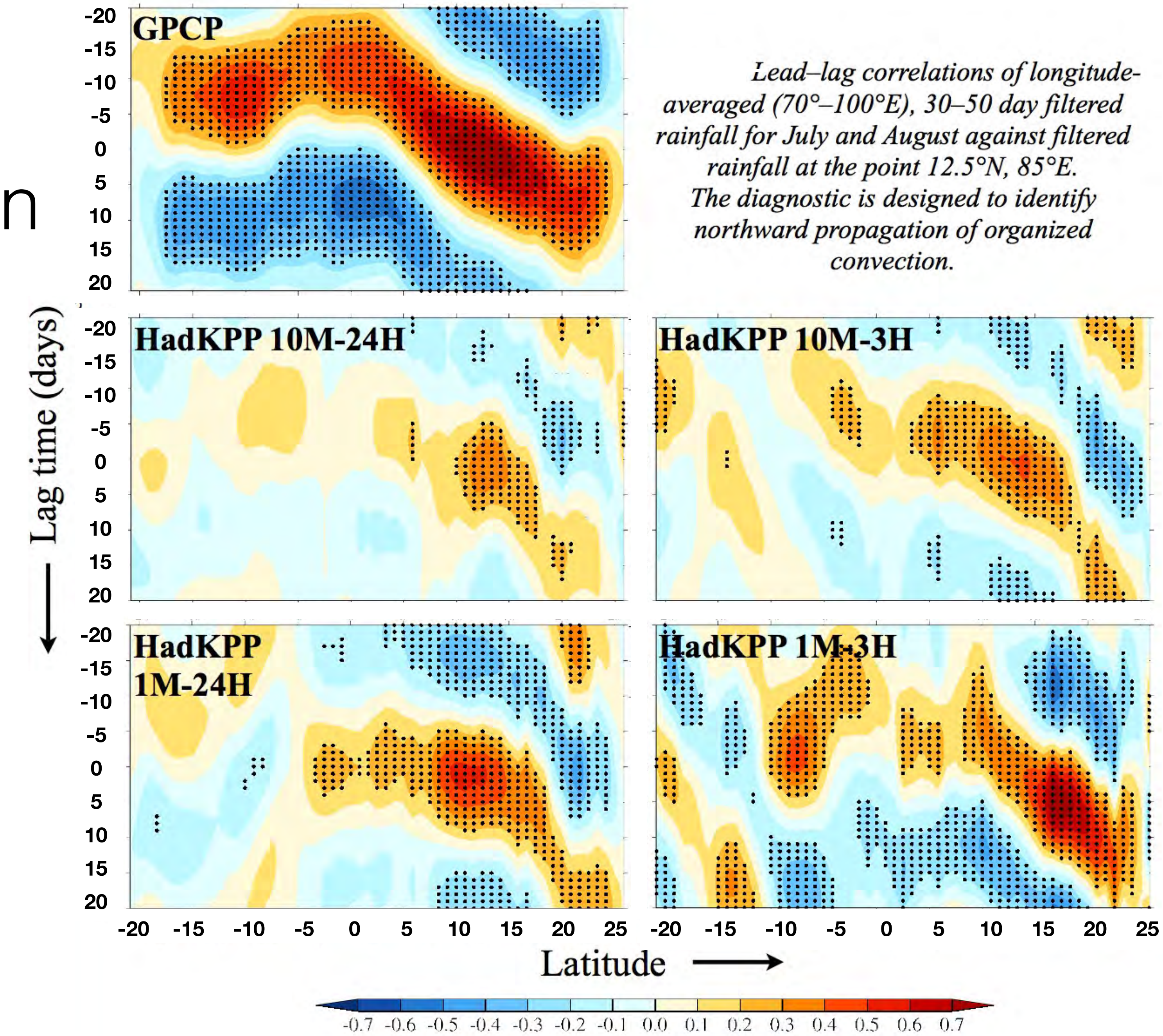


source: Prof. A. Matthews, Univ. of E. Anglia

Impact of high-frequency air-sea interactions on MISO

Higher vertical resolution in the upper ocean and resolving the diurnal cycle in coupling helps improve the representation of MISO.

Klingaman et al., 2010



Lead–lag correlations of longitude-averaged (70°–100°E), 30–50 day filtered rainfall for July and August against filtered rainfall at the point 12.5°N, 85°E. The diagnostic is designed to identify northward propagation of organized convection.