WGNE MJO Task Force:
Current Activities and Next Steps

Steve Woolnough
on Behalf of the WGNE MJO Task Force

MJO Task Force: Background

- Renewed in early 2013 for a term of 3 years, extend in Dec 2015 for a further 3 years
- Sponsor: Working Group on Numerical Experimentation (WGNE)
- Follow on from the WCRP-WWRP/THORPEX/YOTC MJOTF and US CLIVAR MJO Working Group
- Website: http://www.wmo.int/pages/prog/arep/wwrp/new/MJO_Task_Force_index.html

Members

Steve Woolnough	University of Reading **(co-chair)**
Daehyun Kim	University of Washington **(co-chair)**
Charlotte DeMott	CMMAP/Colorado State Univ
Hyemi Kim	Stoney Brook University
Nick Klingaman	University of Reading
Tieh-Yong Koh	Singapore University of Social Sciences
June-Yi Lee	Pusan National University
Eric Maloney	Colorado State University
Adrian Matthews	University of East Anglia
Tomoki Miyakawa	AORI/ University of Tokyo
Richard Neale	National Center for Atmospheric Research
Camille Risi	IPSL/Laboratoire de Météorologie Dynamique
Ken Sperber	PCDMI/Lawrence Livermore National Laboratory
Matthew Wheeler	Bureau of Meteorology
Prince Xavier	UK Met Office

Important others and former members

X. Jiang, D. Waliser, J. Petch, F. Vitart, J. Benedict, H. Hendon, D. Raymond, Xiouhua Fu, Chidong Zhang, Augustin Vintzileos, Masaki Satoh, Hai Lin, Mitch Moncrieff, Min-Seop Ahn, Hae-Jeong Kim, Surya Rao, Jerome Vialard, Jon Gottschalck

Overall Goal: Facilitate improvements in the representation of the MJO in weather and climate models in order to increase the predictive skill of the MJO and related weather and climate phenomena.

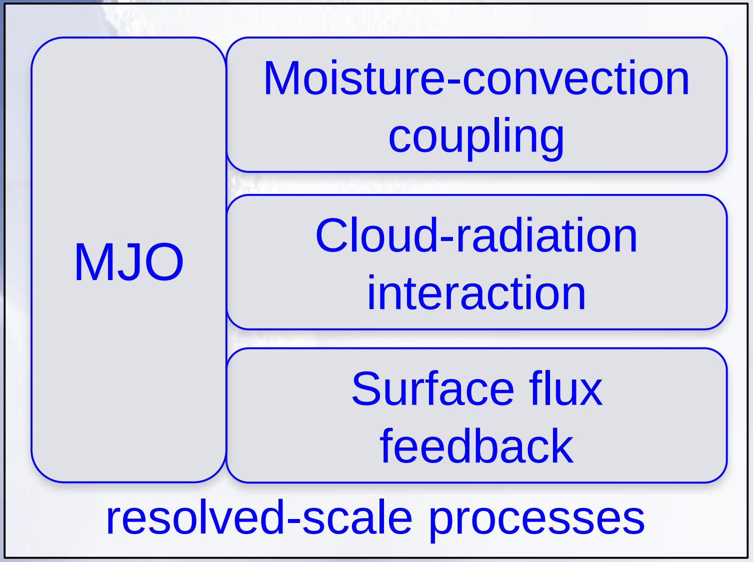
Organized into 5 Subprojects

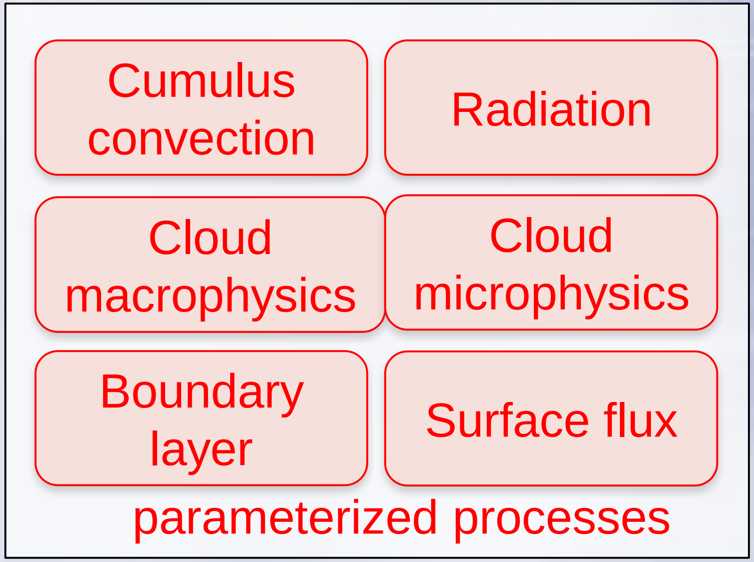
- **Development of process-oriented diagnostics/metrics for MJO simulation**
- **Ongoing evaluation of real-time forecasts and hindcasts of tropical intraseasonal variability, including assessment of hindcasts in the S2S model database**
- **Develop, coordinate, and promote analyses of MJO air-sea interaction**
- **Advance understanding of MJO interactions with the Maritime Continent**
- **Develop, coordinate, and promote analyses of MJO interactions with the extratropics**

Process Orientated Diagnostics

Goal: Provide insight into how parameterizations should be improved to enhance MJO simulation for the correct physical reason

- Diagnostics should be relevant to:
  - resolved-scale processes that are important in MJO dynamics
  - unresolved-scale processes (i.e. parameterizations) in GCMs
- Activity is ongoing with a focus on the moist static energy budget and contributions to its evolution (dynamical and physical)
- Developing ideas around linking to particular theoretical models





Role of the mean state on MJO simulation and prediction

- A number of observational analysis and “moisture mode” theoretical view of MJO suggests that horizontal moisture (mse) advection is important for MJO propagation
- Dominant term in observations is advection of mean state moisture by anomalous flow

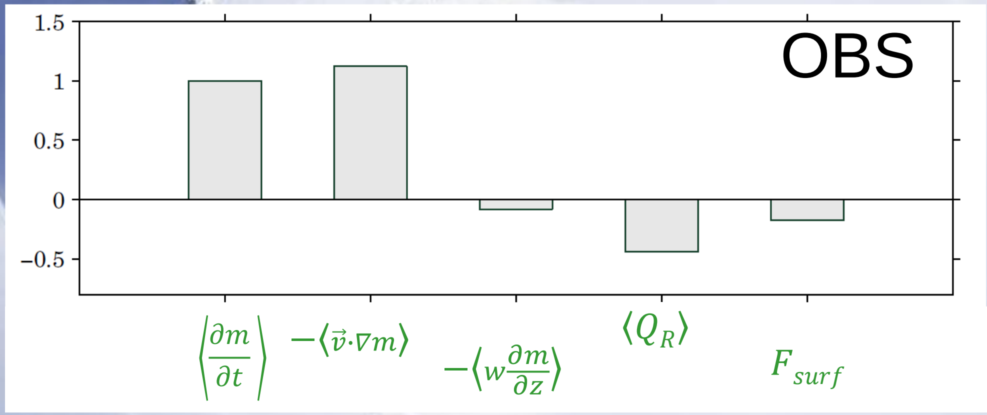


Figure from Jiang (2017)

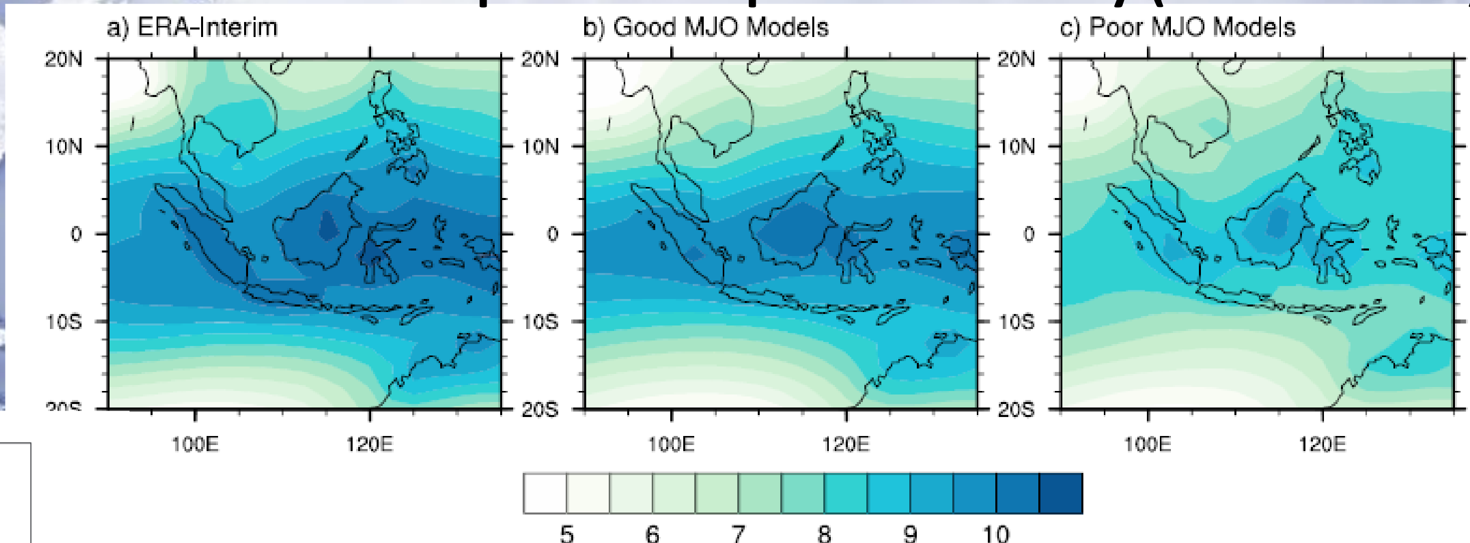
Role of the mean state on MJO simulation and prediction

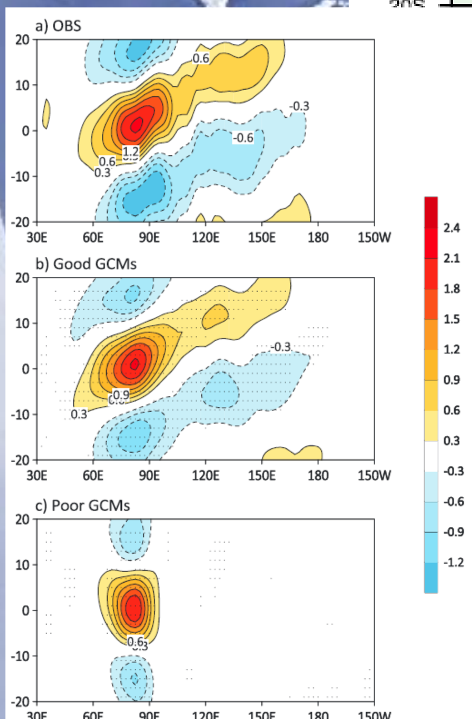
- Recent studies collectively evidence that the horizontal distribution of the basic state low-tropospheric humidity is crucial to a successful simulation and prediction of the MJO.
- Simulated horizontal gradients of the mean low-tropospheric humidity determine the magnitude of the moistening (drying) to the east (west) of the enhance MJO, thereby enabling or disabling the eastward propagation of the MJO.
  - Many MJO-incompetent GCMs exhibit biases in the mean humidity that weaken the horizontal moisture gradient
  - MJO prediction skill of the S2S models is tightly related to the biases in the mean moisture gradient.

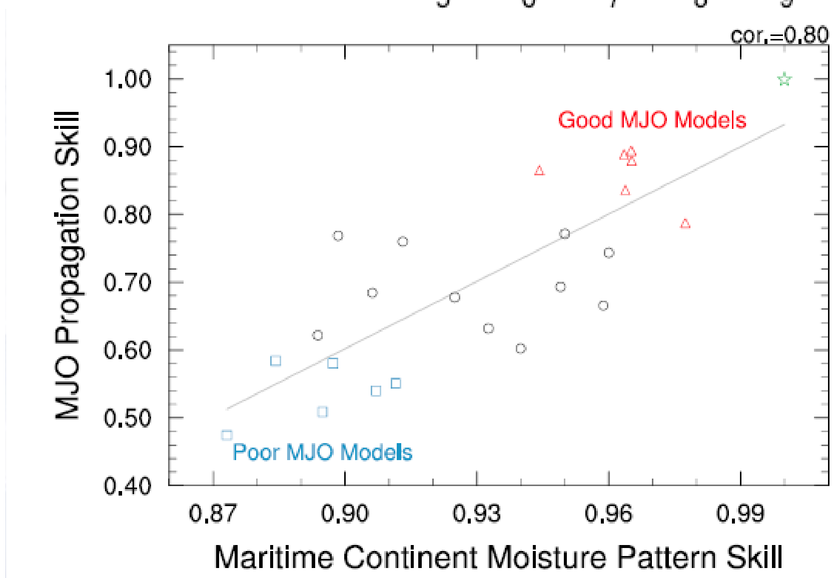
Jiang (JGR, 2017); Gonzalez and Jiang (GRL, 2017), D. Kim (in prep), Lim et al. (submitted), H. Kim (QJRMS, 2017)

Mean Moisture Bias and MJO simulation skill

Nov-April mean specific humidity (650-900 hPa)



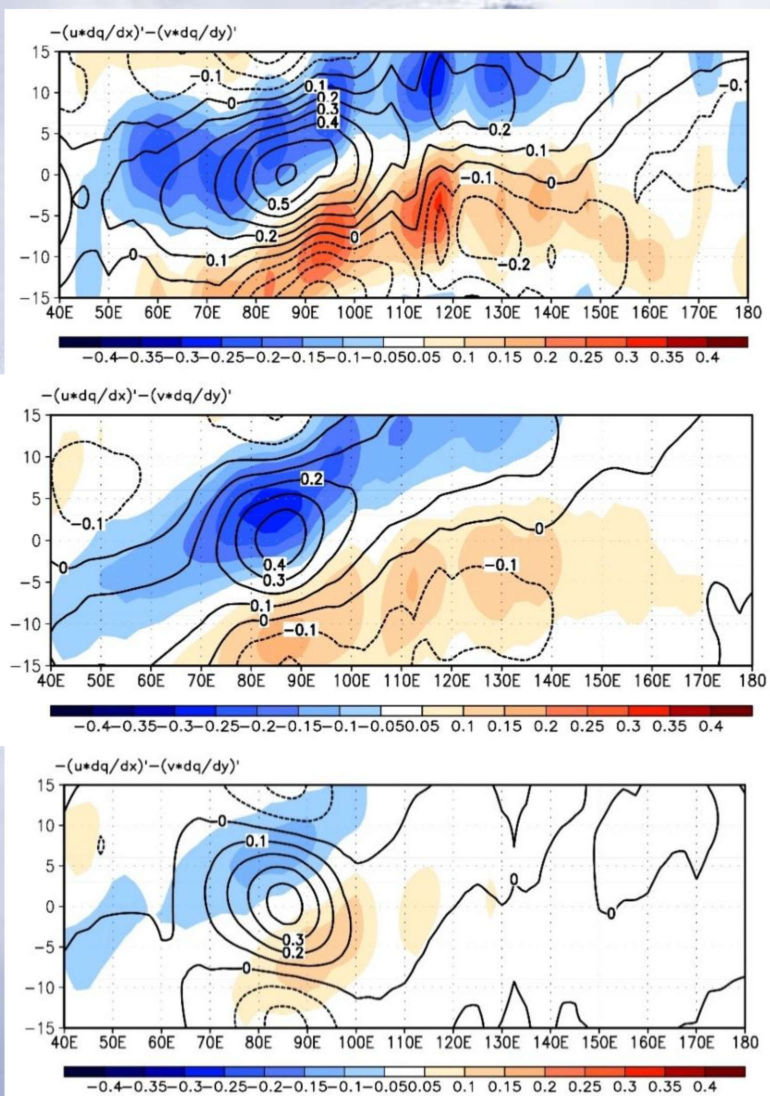




GASS-MJO Task Force GCM intercomparison Project models

Gonzalez and Jiang (2017)

Mean Moisture Bias and MJO simulation skill

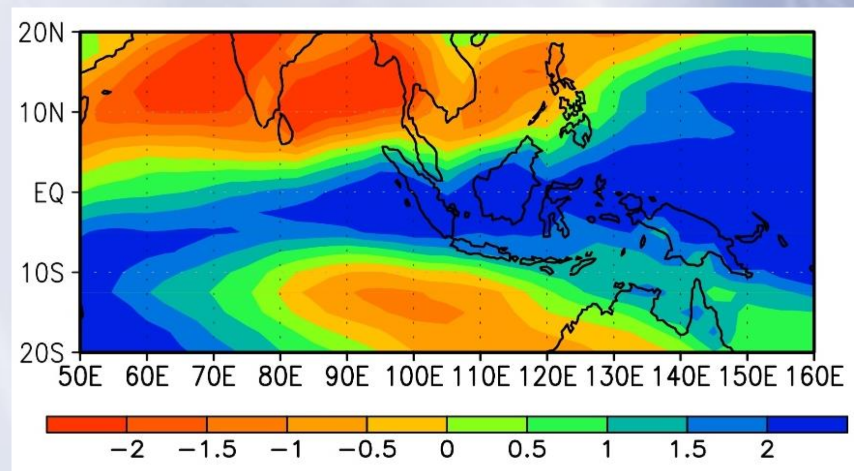


OBS

Good-MJO

Poor-MJO

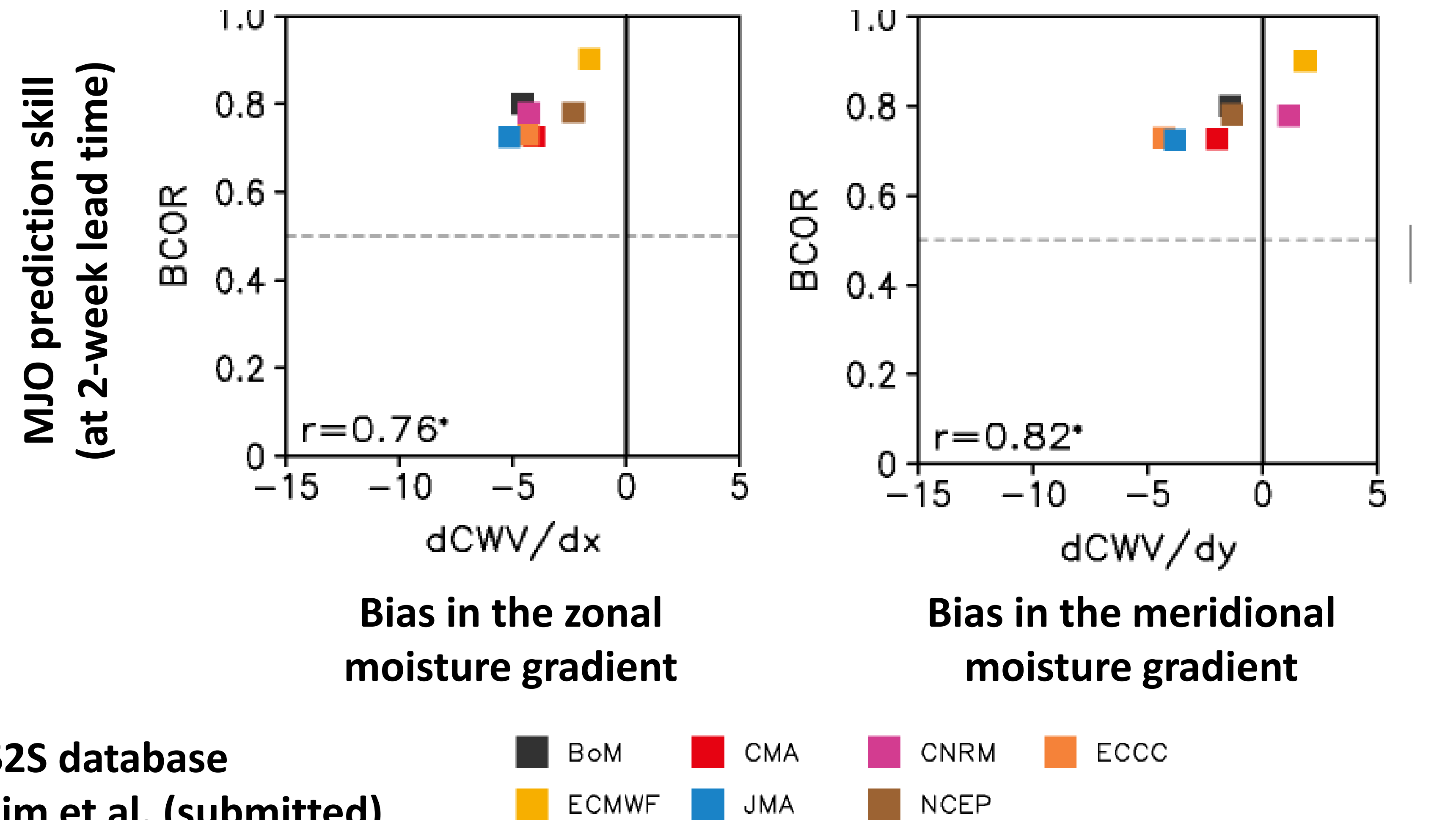
Nov-April mean specific humidity (600-850 hPa, g/kg): Good-MJO minus Poor-MJO models



CMIP5 models
D. Kim et al. (in preparation)

MJO-associated precipitation (contour) and horizontal moisture advection (shaded) anomalies

Mean Moisture Bias and MJO prediction skill



Bias in the zonal moisture gradient

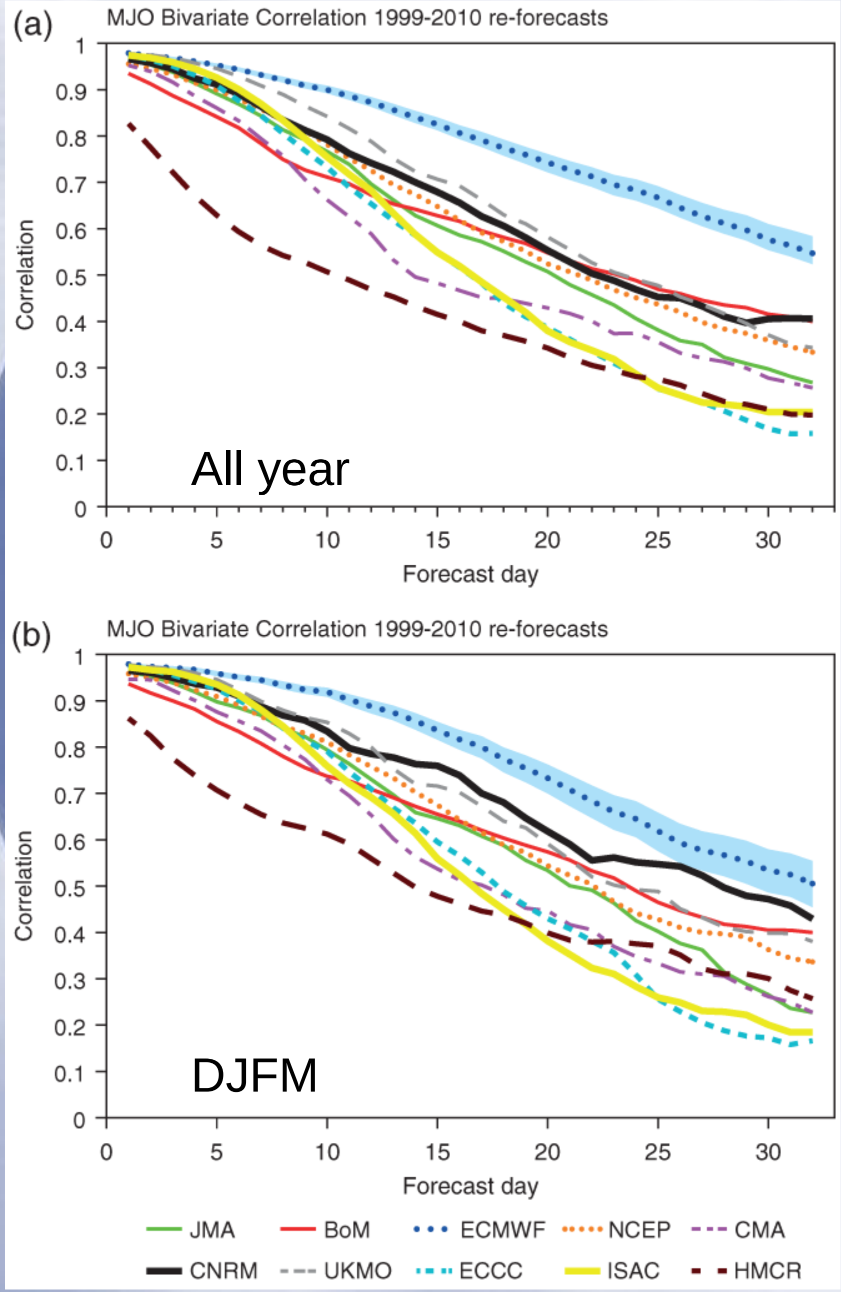
Bias in the meridional moisture gradient

S2S database
Lim et al. (submitted)

Evaluation of real-time forecasts and hindcasts of tropical ISV, including assessment of hindcasts in the S2S model database

- Real-time monitoring of operational MJO and BSISO forecasts ongoing at NCEP, APCC
  - http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CLIVAR/clivar_wh.shtml
  - http://www.apcc21.net/ser/casts.do?lang=en
- Ongoing discussions with S2S on
  - Real-time production and sharing of MJO, BSISO metrics
  - assessment of MJO/BSISO forecast skill
  - Analysis and Assessment of MJO/BSISO as a source of predictability and/or skill in the tropics
  - What is the spread/skill relationship in sub-seasonal forecasts for MJO/BSISO?
  - Relationships between forecast skill of large-scale ISV indices and forecast skill local “weather”

MJO skill in S2S database



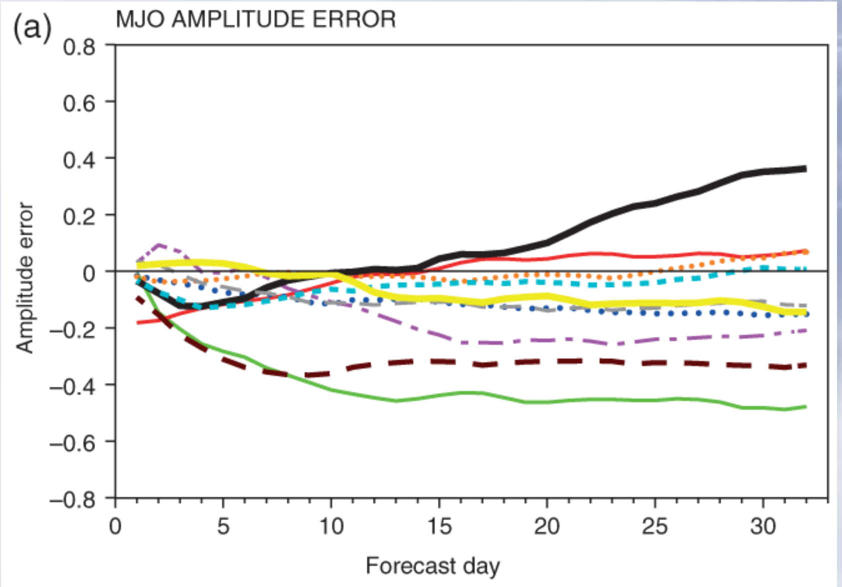
Skill of ensemble (Bivariate correlation for RMM >0 6) for 5-28 days depending on model (10-25 for DJFM)

Most most models have skill out to about 12-18 days

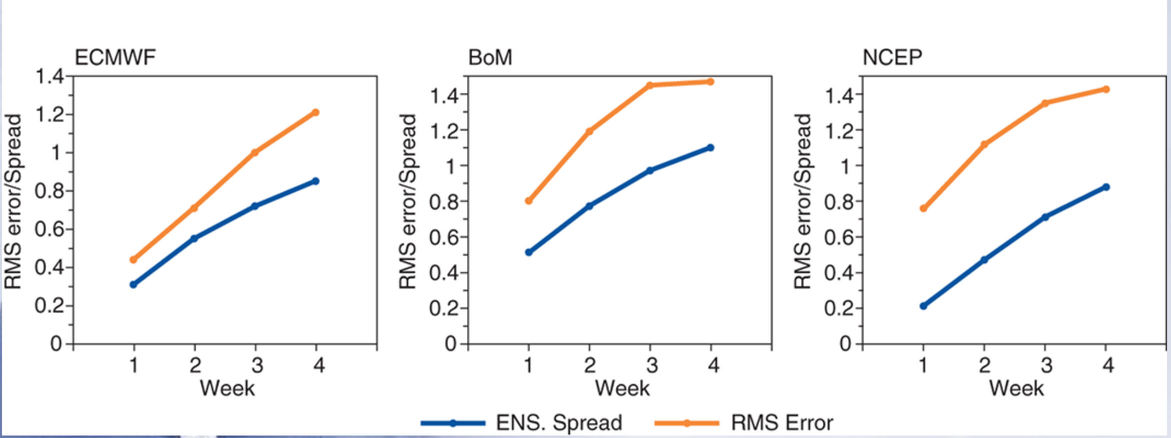
Most models underpredicted MJO amplitude, but not as bad as ~10 years ago

Models have too many events which don't make it through the Maritime Continent (20-45% cf 10% in observations)

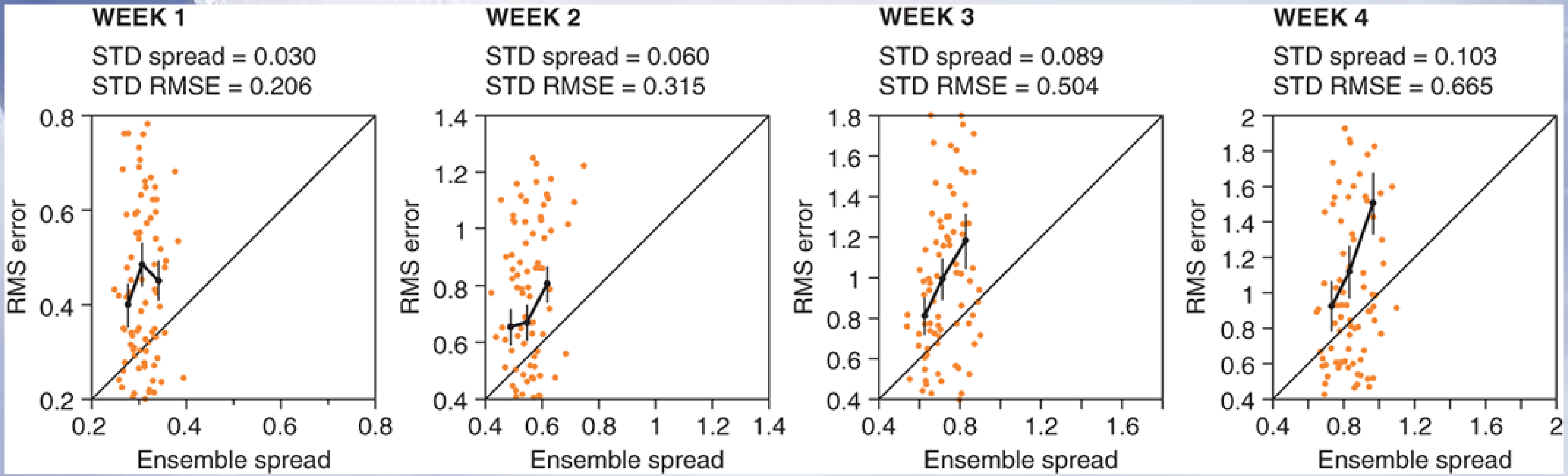
Vitart (QJRMS, 2017)



MJO skill in S2S database



- Models are underdispersive
- No evidence of spread-skill relationship at early lead times, some indication at longer lead times
- Spread is not flow dependent enough
- Need for better ensemble generation strategies to improve spread and its flow dependence



Air-sea interaction in the MJO

Goal: To develop, coordinate, and promote analyses of MJO air-sea interaction, including development of diagnostics that relate MJO simulation capability to fidelity in simulating key air-sea interaction processes.

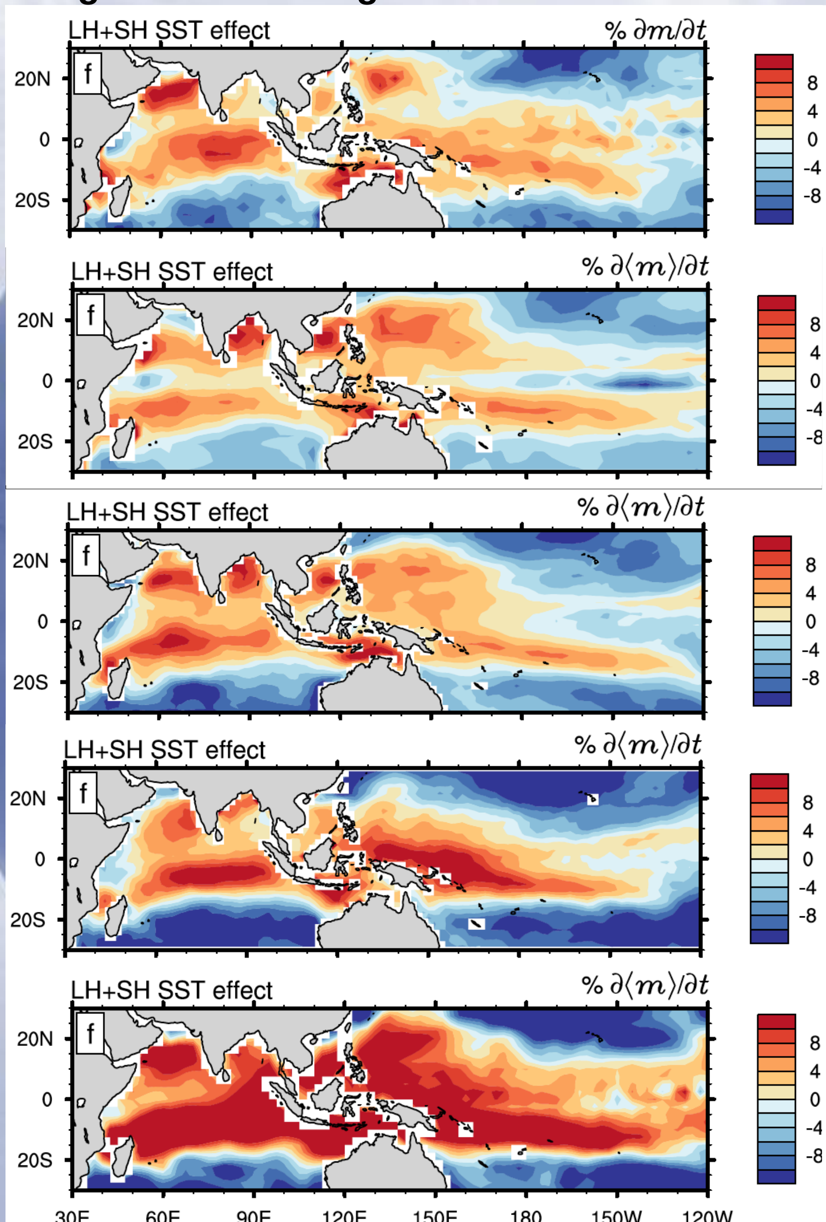
- Comprehensive review of air-sea interaction in the MJO (DeMott et al., *Rev. Geophys.,* 2015)
  - Impact of atmospheric tropical intraseasonal variability on ocean relatively well understood, except in and around Maritime Continent region
  - Feedback of oceanic variability on tropical atmospheric very much less well understood, need for new diagnostics
    - How important are SST feedbacks
    - What are the mechanisms through which the SST variability influences the MJO
  - Modelling experiments often complicated by combined impacts of coupling and basic state changes
  - Strong recommendation against the use of experiments with daily evolving prescribed SSTs

Air-sea interaction in the MJO

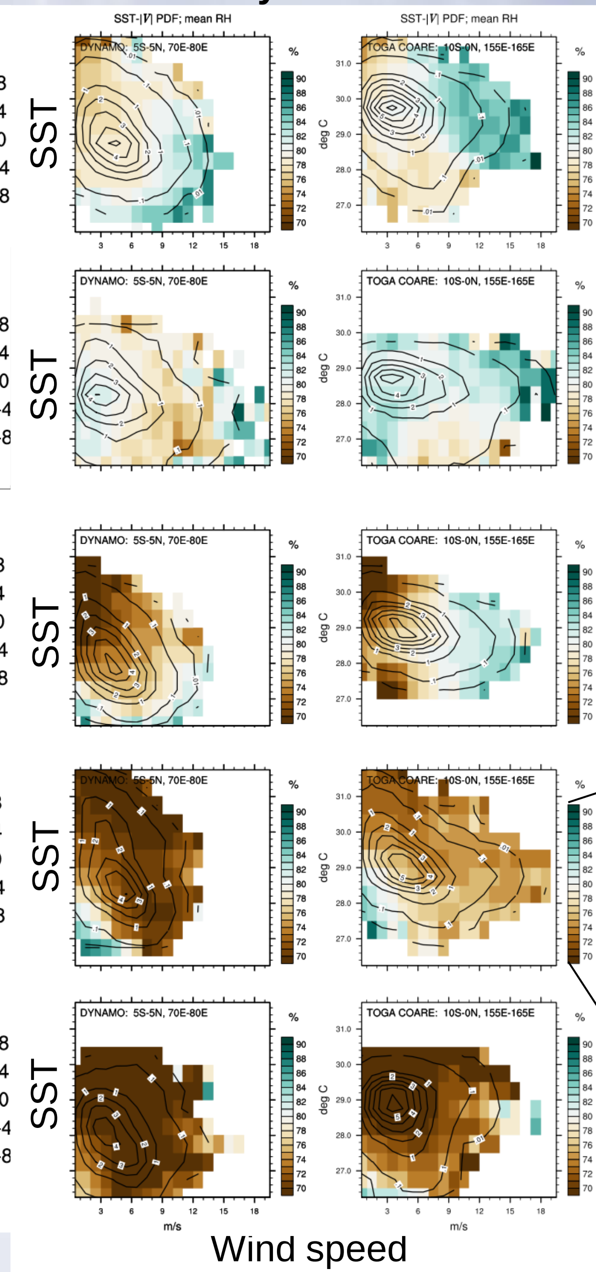
- Development of Air-sea interaction diagnostics (De Mott et al., 2016)
  - Set of diagnostics to describe tropical intraseasonal variability in key surface and atmospheric/ocean fields and their relationship to the MJO
  - Development of diagnostics to highlight the influence of SST variability on the MJO through a moist static energy budget framework
    - Currently address influence of SST variability on surface turbulent flux contribution to the MSE budget (we might consider this a local effect)
    - Does not currently address the impact of non-local effects e.g. changes in SST gradients influencing large-scale circulation and e.g. moisture convergence
  - Diagnostics coded in ncl and will be made publically available in the future (c.f. MJO simulation diagnostics)
- Application of these diagnostics to a set of models (De Mott, Klingaman ongoing activities)

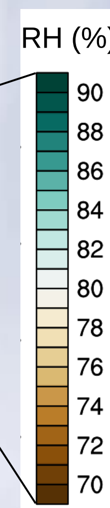
Ocean feedback strength vs Boundary Layer Humidity

%age of MSE change from SST effects



BL Humidity vs wind and SST





Boundary layer **dry biases** can inflate ocean feedbacks to the MJO*

**Hyemi Kim finds moist bias in ECMWF*

Interactions of the MJO with the Maritime Continent

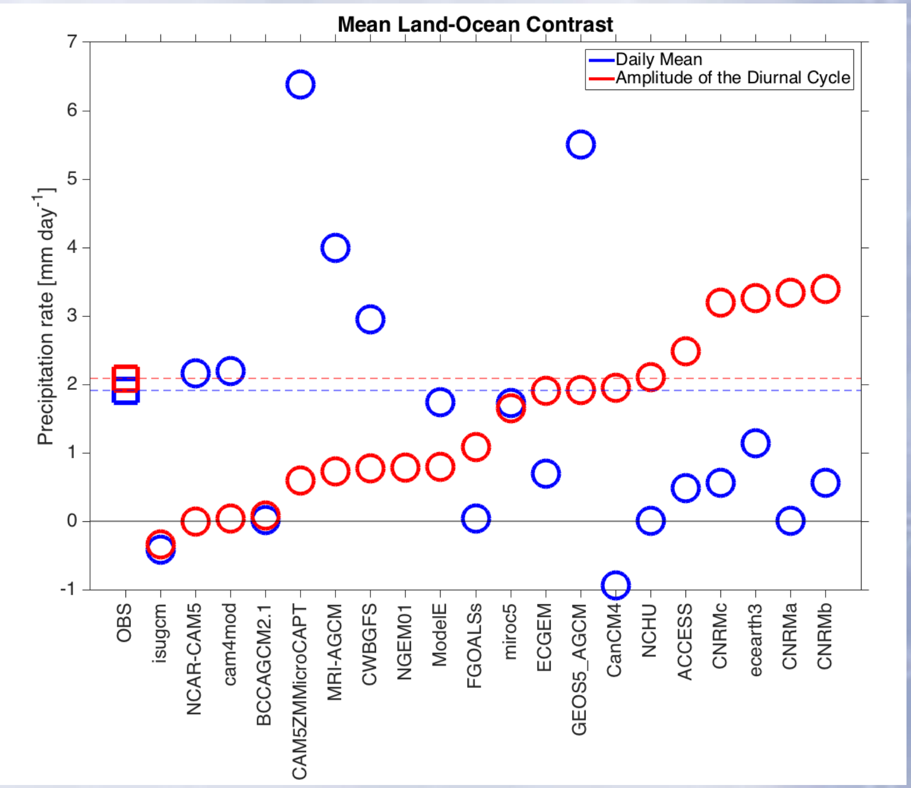
Goal: To improve our understanding of the MJO with Maritime Continent, its influence on the propagation of the MJO, its modulation of the local "weather"; and the capability of our weather and climate models to capture these interactions

- Jointly organized activity with the S2S project
- Possibility to interact with the efforts for an internationally coordinated observational and modelling programme (YMC)
- Joint MJOTF/S2S Workshop on "Interactions between the MJO and Maritime Continent", Singapore, 11-13 April, 2016,
  - hosted by the Meteorological Service of Singapore and the National Environment Agency

Models' performance over MC: mean precipitation, amplitude and phase of the diurnal cycle

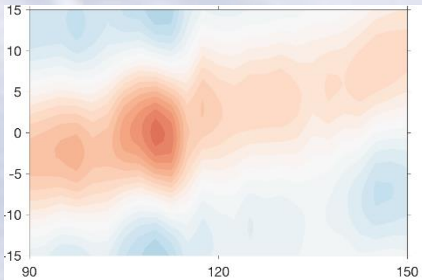
- Most models underestimate both relative amplitude of precipitation and mean precipitation, especially over land. Phase of diurnal cycle worse over land
- Only few models show realistic land sea contrast in amplitude of the diurnal cycle or daily mean precipitation. Only MIROC5 gets both correct.

(Baranowski et al, JGR submitted)



Diurnal cycle variability over MC during MJO propagation

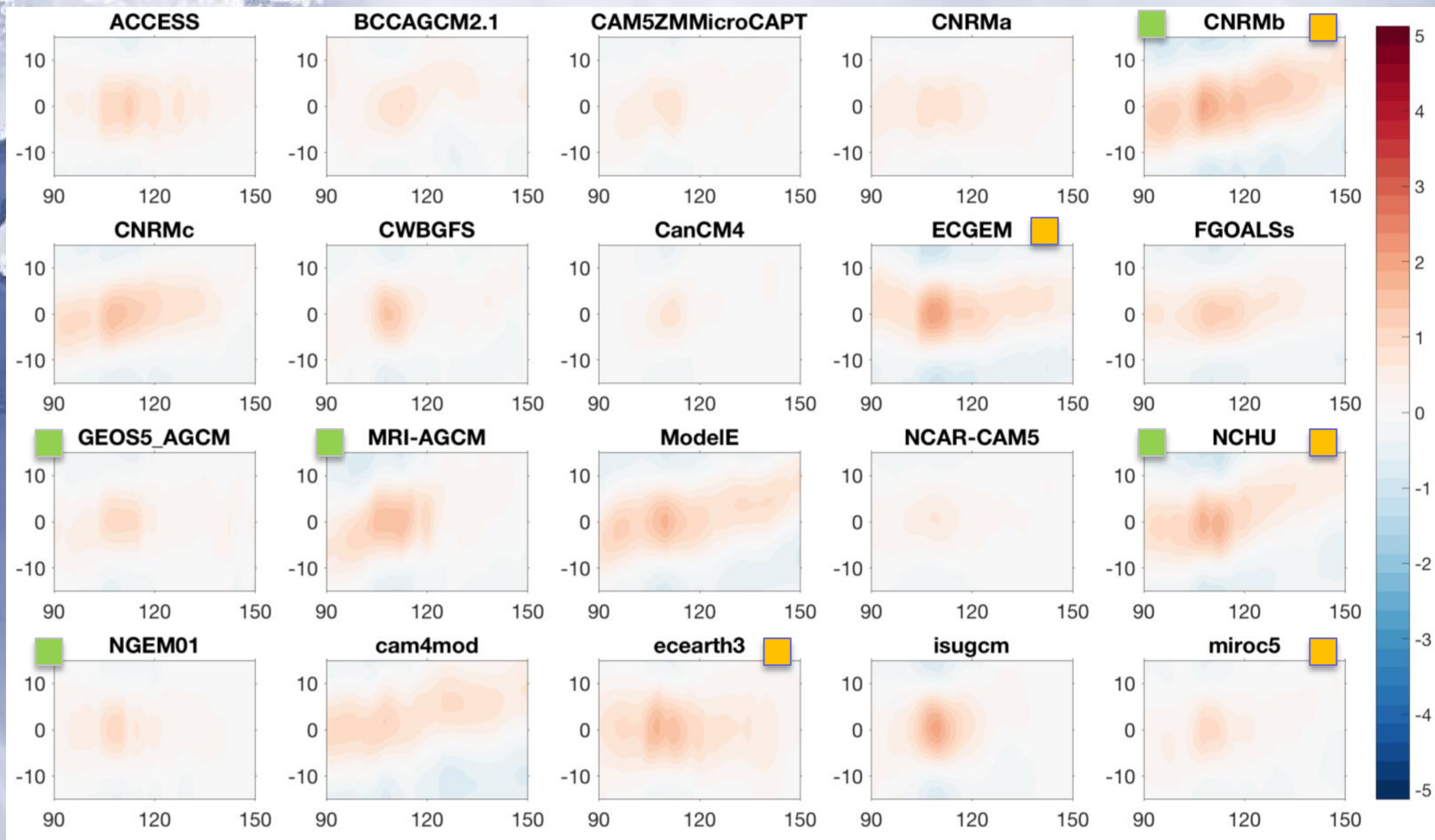
TRMM reference



Baranowski et al, JGR in prep

Good MJO propagation

Good Diurnal Cycle



mm/day

Enhanced DC

Suppressed DC

Diurnal cycle variability driven by model's ability to realistically represent eastward propagation of MJO pattern, best when combined with good DC representation

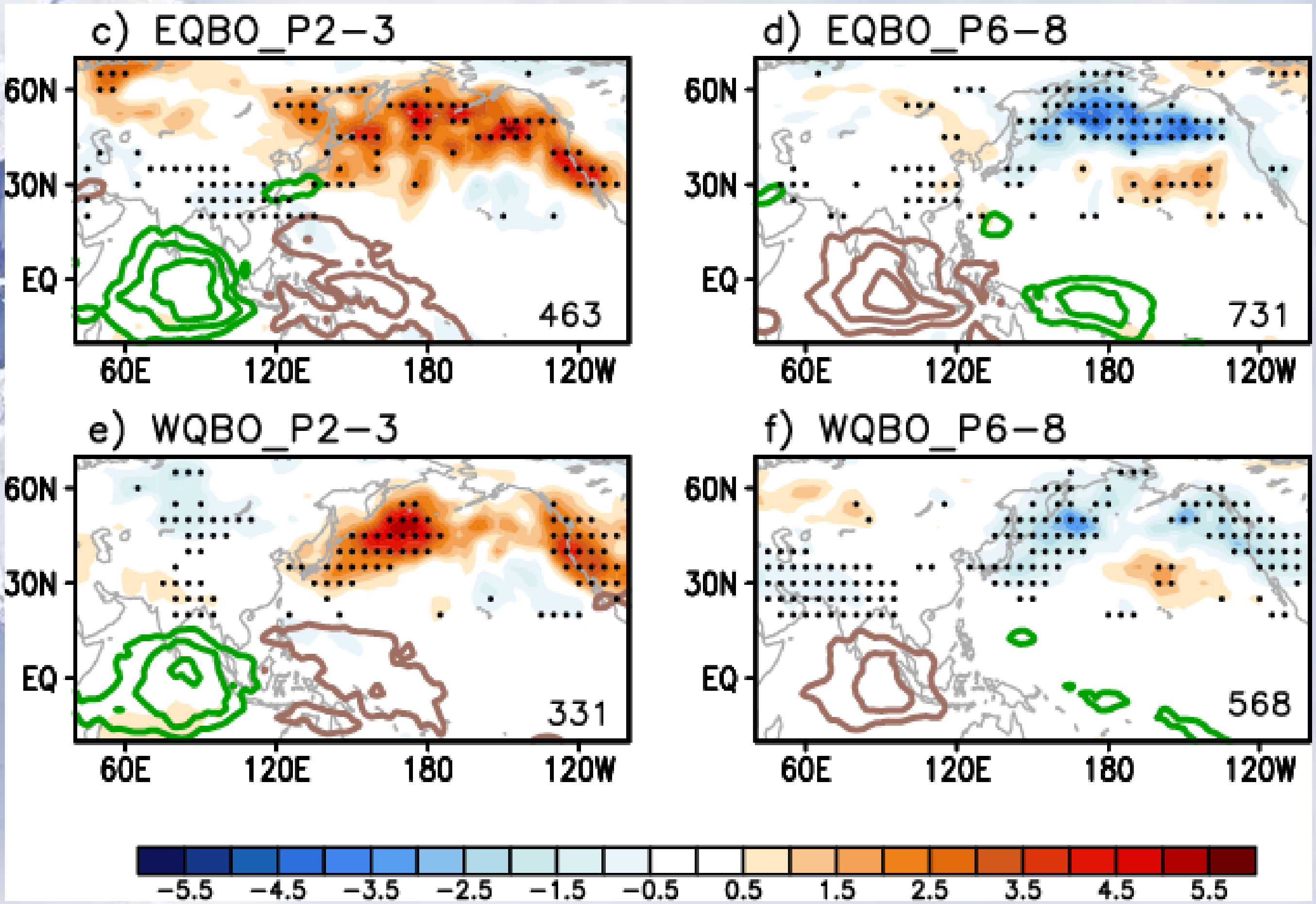
Analysis of MJO interactions with the extra-tropics

Goal: To improve our understanding of the interactions between the MJO and the extratropics, their dependence on the slowly varying background state; and their representation (and the source of errors in this representation) in weather and climate models

- New activity still under development
- Joint activity with new S2S teleconnections sub-project
- Review paper published in led by S2S teleconnections but with contributions from MJOTF
  - Stan et al., 2017 "Review of Tropical-Extratropical Teleconnections on Intraseasonal Time Scales" *Rev Geophys.* DOI: 10.1002/2016RG000538
- A number of TF members have funded projects to address aspects of this questions.

MJO Teleconnections to the North Pacific

MJO-Storm Track modulation by the QBO

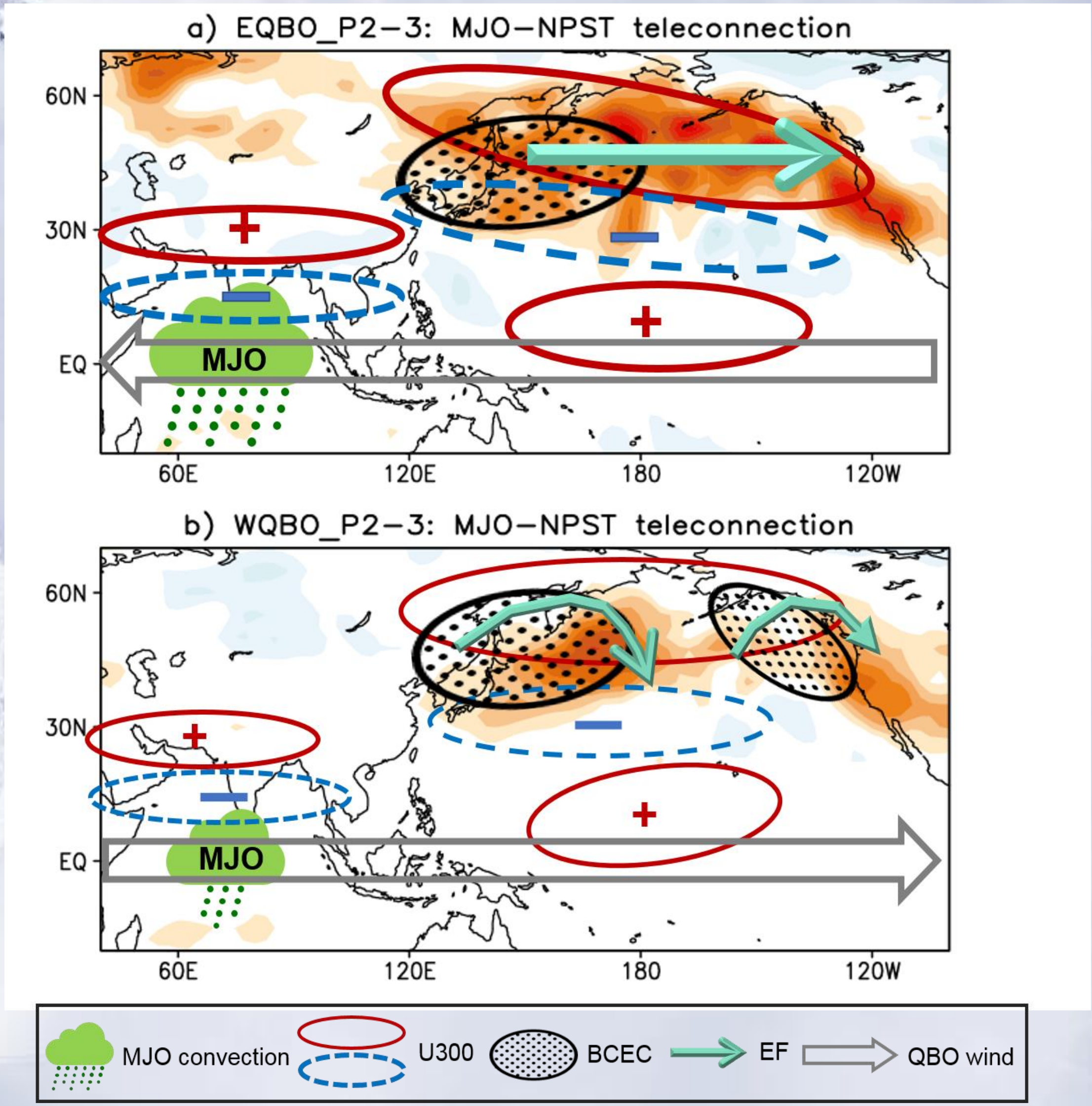


Contour: 25-90d filtered OLRa (W/m^2)
Shading: 2-10d filtered Eddy Kinetic Energy (Storm Track) (m^{2}s^{-2})

Wang, Kim, Chang, Son (JGR, submitted)

MJO Teleconnections to the North Pacific

MJO-Storm Track modulation by the QBO



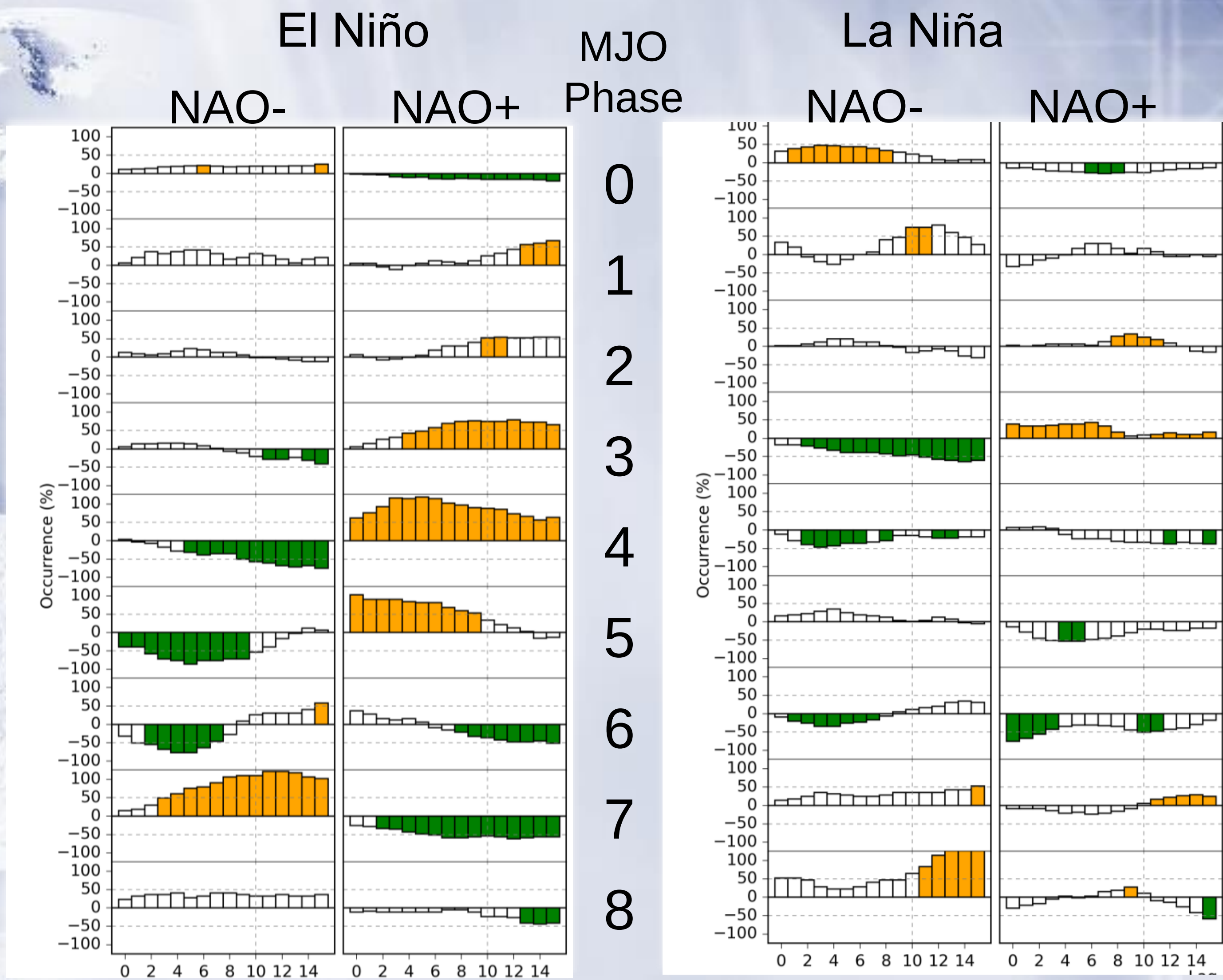
BCEC: Baroclinic Energy Conversion
EF: Energy Flux

Wang, Kim, Chang, Son (JGR, submitted)

MJO Teleconnections to the North Atlantic

Repeat Analysis of Cassou (2008) but sub-sampling by ENSO phase

Also looking at the dependence on initial N Atlantic Regime



Lee, et al. in prep