WGNE MJO Task Force:

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
- Website: http://wgne.meteoinfo.ru/activities/on-going-activities/wgne-mjo-task-force/

Members

Steve Woolnough	University of Reading **(co-chair)**
Daehyun Kim	University of Washington **(co-chair)**
Charlotte DeMott	CMMAP/Colorado State Univ
Hyemi Kim*	Stony Brook University
Nick Klingaman	University of Reading
Tieh-Yong Koh	Singapore University of Social Sciences
Eric Maloney	Colorado State University
Adrian Matthews	University of East Anglia
Tomoki Miyakawa	AORI/ University of Tokyo
Richard Neale	National Center for Atmospheric Research
Matthew Wheeler	Bureau of Meteorology
Prince Xavier	UK Met Office
Samson Hagos*	PNNL
Xianan Jiang*	UCLA

* *Joined since 2015*

Stepped down since 2015: Camille Risi, Ken Sperber, Jon Gottschalck, June-Yi Lee

We're looking to recruit and additional member from a SE Asia Met Service

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

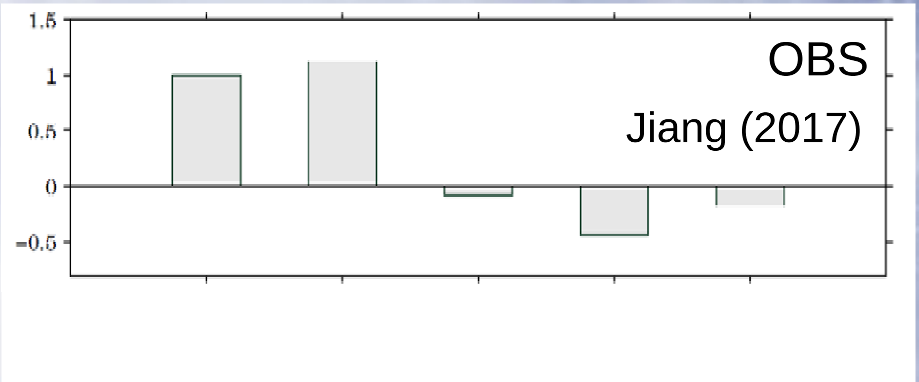
- **Development of process-oriented diagnostics/metrics for MJO simulation**
- **Ongoing evaluation of real-time forecasts and hindcasts of tropical intraseasonal variability, including assessment of hindcasts in the S2S model database**
- **Develop, coordinate, and promote analyses of MJO air-sea interaction**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

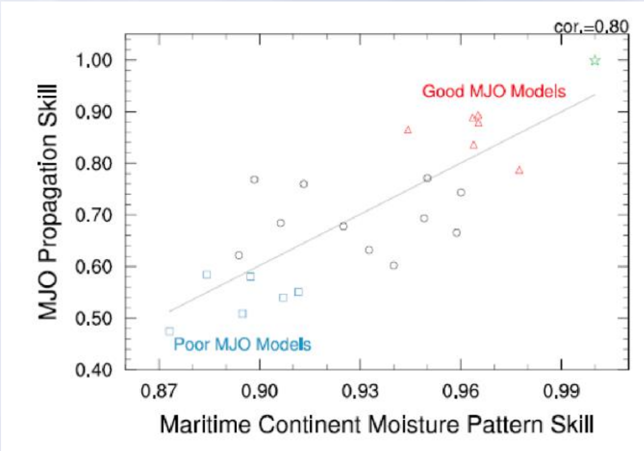
Process Orientated Diagnostics

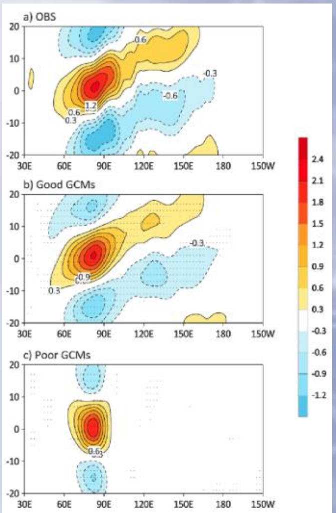
- Body of work highlighting the relationship between background mean moisture state and MJO simulation/prediction skill (e.g. Jiang, 2017; Gonzalez and Jiang, 2017; Lim et al., 2018; Kim, H. 2017)
  - Relation to moist static energy budget of the MJO and “moisture mode” theories for the MJO
  - Importance of horizontal advection of the mean moisture by the MJO winds in MSE budget
- Studies identifying the importance of radiative feedbacks (e.g. Wolding et al. 2016) and convective moisture adjustment timescale (Jiang et al. 2016) in the amplitude of the MJO
- Experiments to diagnose relative contributions of changes in basic state vs changes in wave-moisture interactions in sensitivity of equatorial waves to convective mixing (Peatman et al. 2018)
- Led model analysis of MJO in CMIP5 models including application of MJO process diagnostics (Ahn et al. 2017)
- Led review of MJO simulation and process oriented diagnostics for “The Global Monsoon System” (Jiang et al, under review)
- Led the development of the MJO Diagnostics for the NOAA MAPP Model Diagnostics Task Force to develop and implement a process oriented model national modeling center diagnostics package

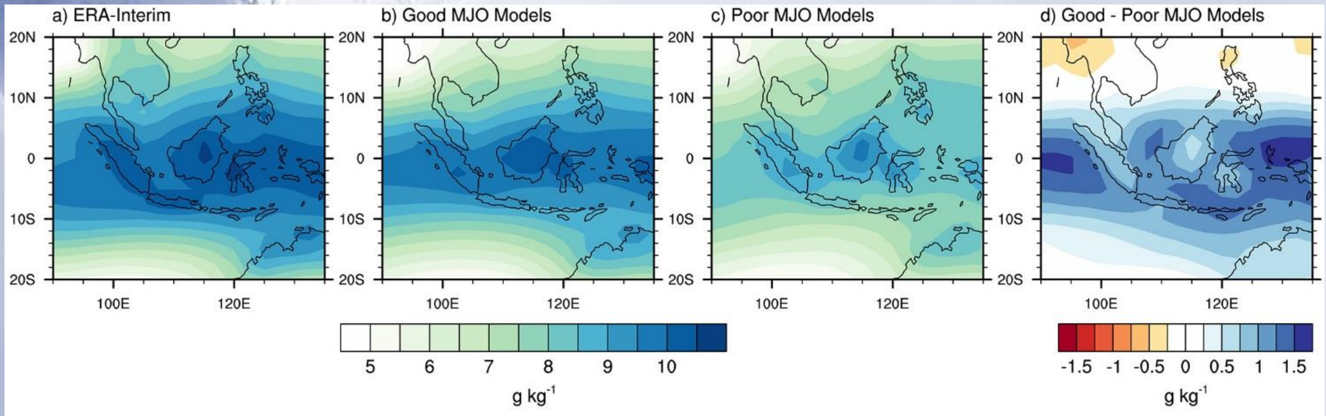
Role of the mean state on MJO simulation

- 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
- Models with a good representation of the mean moisture (gradients) tend to have a good simulation of the MJO
- Similar sensitivity to the moisture basic state in prediction models









GASS-MJO Task Force GCM intercomparison Project models Gonzalez and Jiang (2017)

MJO Prediction

- Assessment of the MJO prediction skill in the S2S database (Lim et al 2018) and SubX (Kim, H et al. in prep)
- Led analysis of the relationship between prediction skill and the mean moisture and cloud long-wave feedback (Kim, H. 2017, Lim et al 2018)
- Analysis of MJO propagation across the Maritime Continent in ECMWF monthly forecasting system (Kim, H et al 2016)
  - High skill forecasts have initial conditions with strong OLR dipole and strong SST-convection relationship
  - Low skill forecasts have initial conditions with weak convective signal in West Pacific and weak coupling
- Led a review paper and book chapter on MJO prediction and predictability (Kim, H. et al 2018; and under review)
  - Variable MJO prediction skill across models
  - MJO predictions are under-dispersive
  - Better skill for initially strong MJO events
  - Maritime Continent is probably a prediction barrier rather than predictability barrier
- Participated in the development of global cloud resolving model and led its evaluation in terms of prediction skill (Satoh et al, 2017)
- Development and evaluation of WRF tropical channel model for potential application for SE Asia regional S2S prediction (Fonseca, et al. 2015, Koh & Fonseca, 2016, Fonseca et al. 2018)

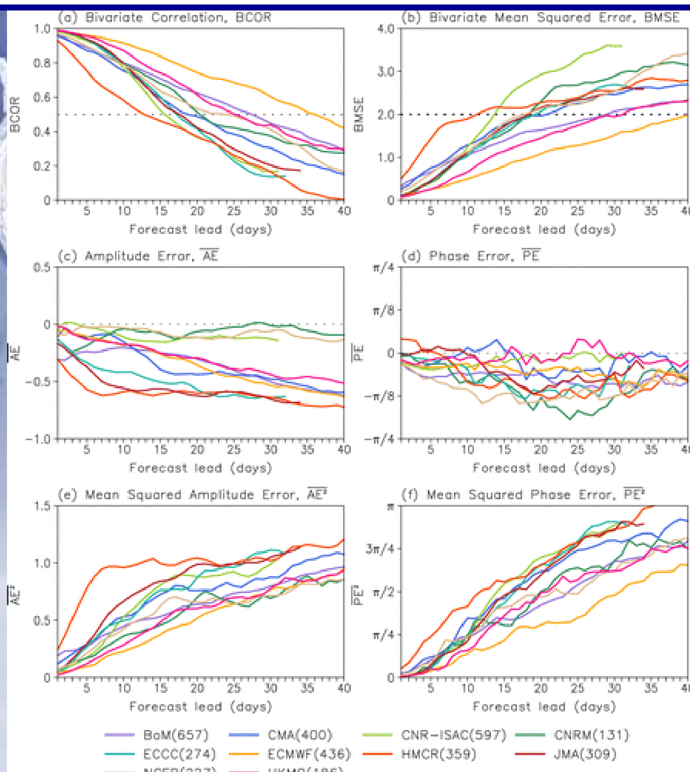
MJO prediction skill in S2S hindcasts

- Range of “skill” from 2-5 weeks
- Most models biased weak and slow
- ECMWF’s better skill likely comes mainly from smaller phase errors
- Models with good representation of mean moisture gradients tend to have better skill particular for phase 6-7 initialization
- Models with better cloud longwave feedback to have better skill particularly for phase 2-3 initializations

BCOR

AE

MSAE



BMSE

PE

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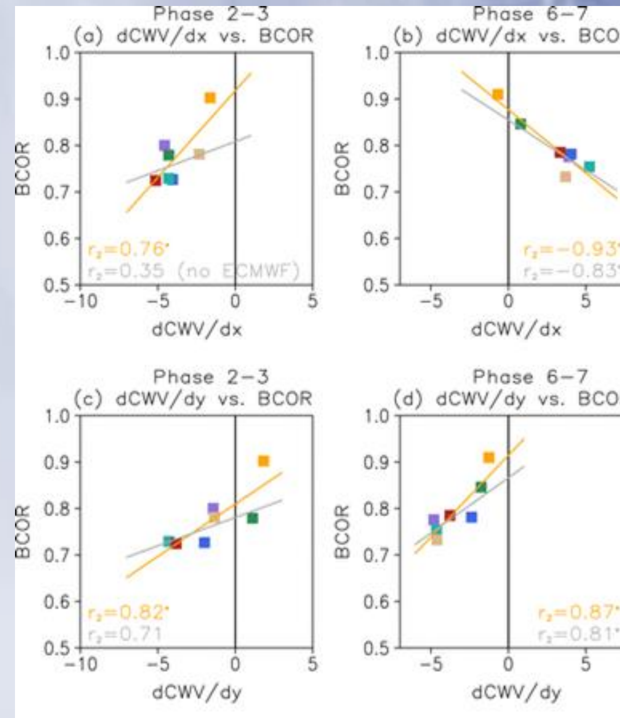
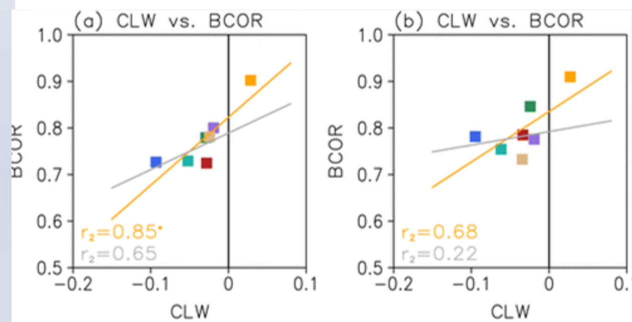




S2S database , Lim et al (2018)

Air-sea interaction in the MJO

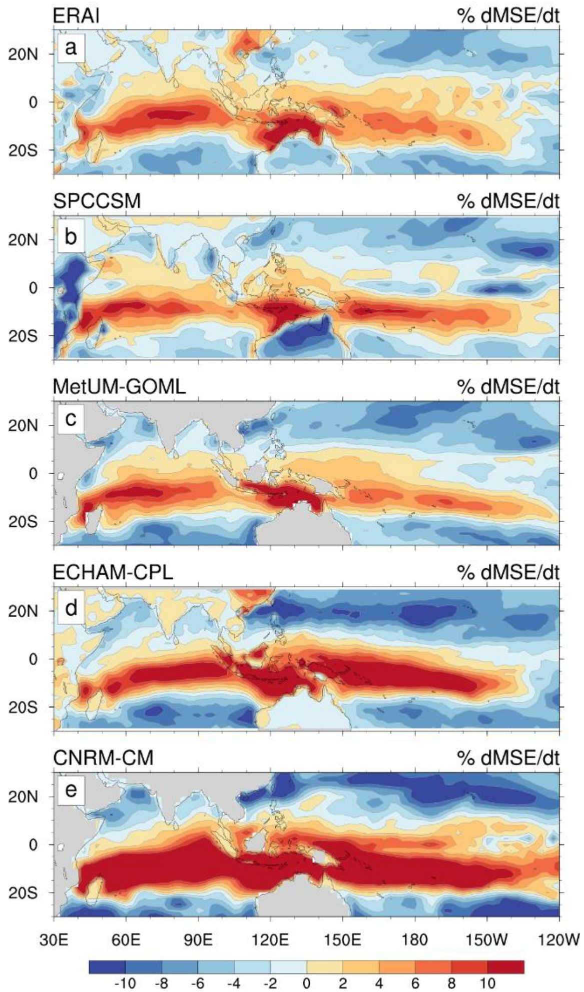
- Developed a set of intraseasonal air-sea interaction diagnostics to quantify the contribution of intraseasonal SST perturbations to the MSE budget of the MJO (DeMott et al. 2016)
  - Intraseasonal SST perturbations account for ~10% of MSE tendency across the Warm Pool
- Leading analysis of MJO simulation fidelity in coupled and uncoupled simulation pairs of 4 GCMs (De Mott et al., in prep)
  - Coupling improves MJO eastward propagation
  - Some changes in basic state moisture (despite same monthly SSTs)
  - Stronger zonal pressure gradient enhancing MJO easterlies (cause or effect?)
- Analysis of MJO in coupled an uncoupled simulations with UM and role of basic state (Xavier et al, in preparation)
- Participated in the development of a full ocean-coupled global cloud resolving/permitting model (NICOCO) and evaluated the impact of coupling to model MJO reproducibility. (Miyakawa et al. 2017)
- Led book chapter summarizing air-sea interactions in the MJO for “The Global Monsoon System” (DeMott and Klingaman, under review)
- Leading NOAA MAPP S2S Task Force activity project to assess oceanic sources of predictability for the MJO

Air-sea interaction in the MJO

Diagnostics

"Coupling strength": Intraseasonal SST fluctuations account for ~10% of MSE tendency. Exaggerated in some models.

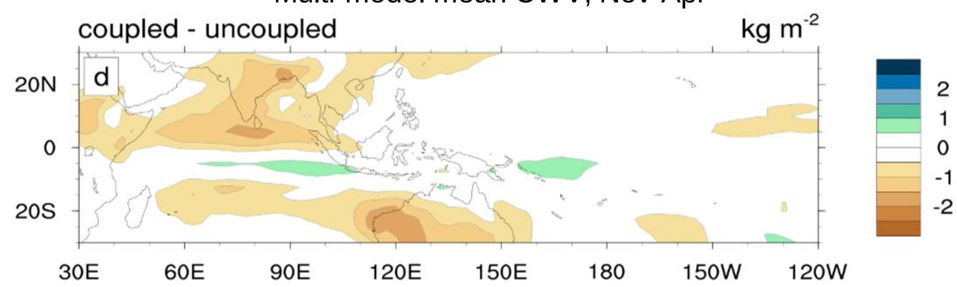
SST effect on dMSE/dt, Nov-Apr



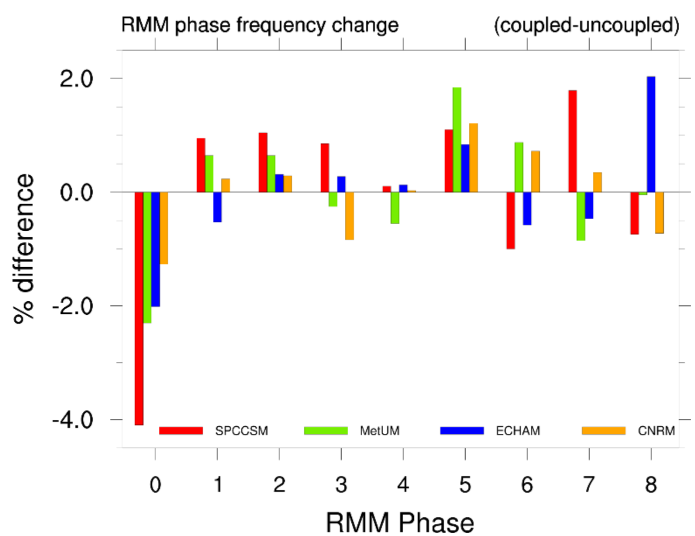
Modeling study

Coupled vs uncoupled simulations with same SST climatology, low-frequency variability. Mean state moisture changes, despite same mean state SST.

Multi-model mean CWV, Nov-Apr



Uniform reductions in Phase 0, increases in Phases 2 and 5 with coupling. Greater spread when convection is in western Pacific.

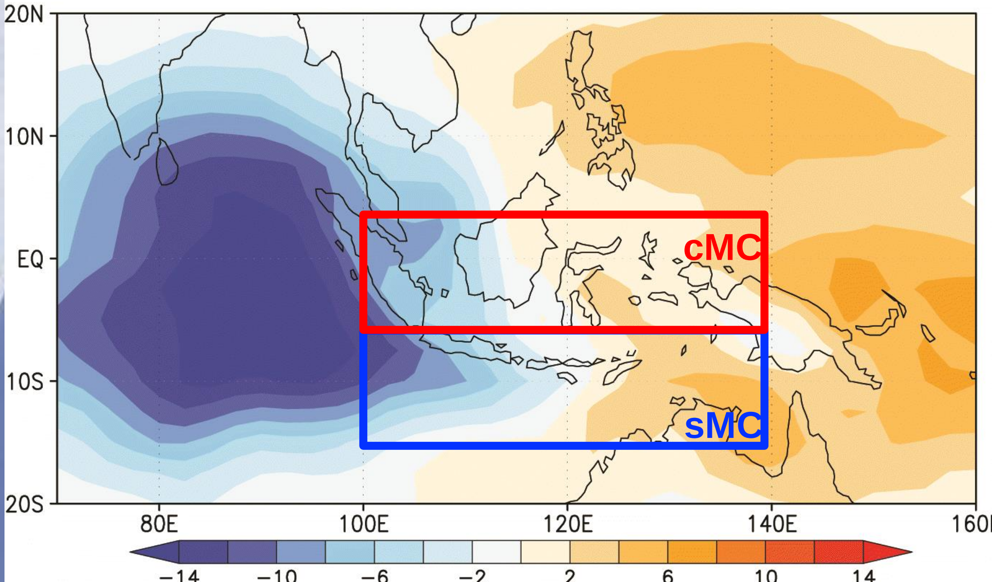


Interactions of the MJO with the Maritime Continent

- 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
- Led successful proposals to contribute to YMC field campaigns
  - Propagation of Tropical Intraseasonal Oscillations (PISTON) field experiment (Maloney et al.)
  - TerraMaris (Matthews, Woolnough, Klingaman et al)
  - RV Investigator Cruise (Wheeler, Matthews et al)
- Mechanistic Analysis and Experiments of MJO propagation through Maritime Continent
  - MSE budget perspective to understand MJO detour (Kim, D et al, 2017)
  - Sensitivity to strength of MC land convection in a GCM and relationship to mean moisture basic state (Ahn et al, in prep)
- Analysis of multi-scale interactions between the diurnal cycle, MJO, ENSO&IOD (Fonseca et al, 2018)
- Interaction of the MJO with seasonal cycle and NE cold surges in the Maritime Continent (Lim et al, 2017; Xavier et al, in prep),
- Led a review book chapter on MJO interactions with the Maritime Continent for "The Global Monsoon" (Kim, D et al, under review)

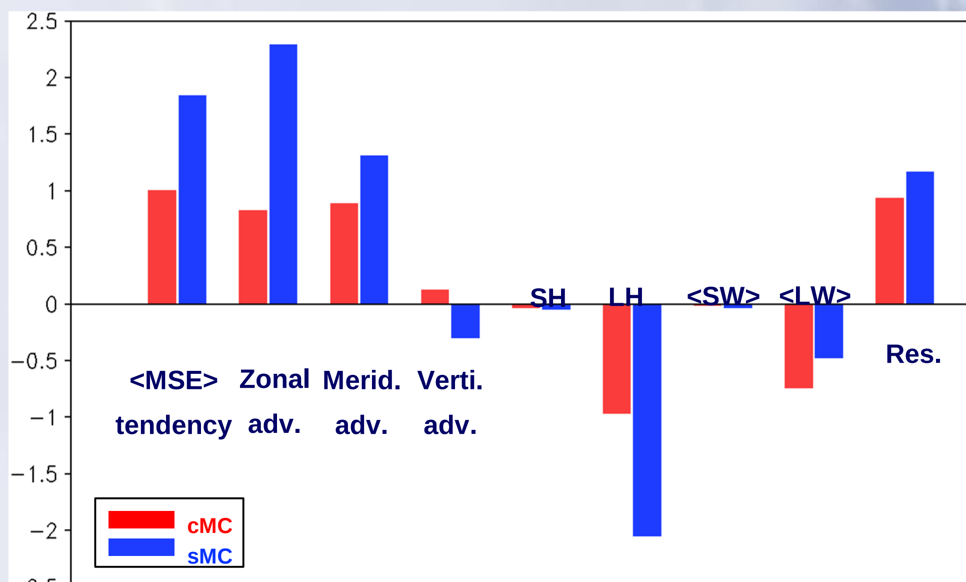
Interactions of the MJO with the Maritime Continent

OLR anomalies after an onset over the IO



MJO convection detours the MC area southward during boreal winter (i.e. main convection center passes through the sMC)

MSE budget during the recharging period shows that horizontal advection terms (esp. advection of mean moisture by MJO perturbation wind) are responsible for the "detouring"

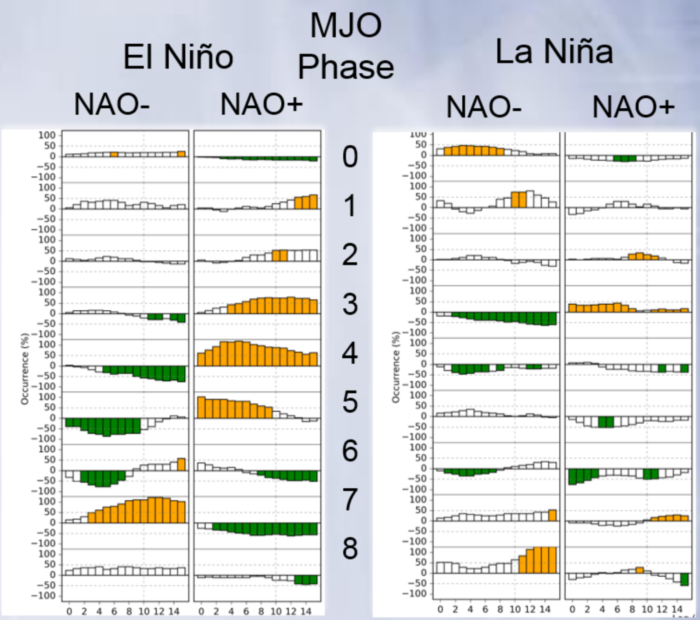


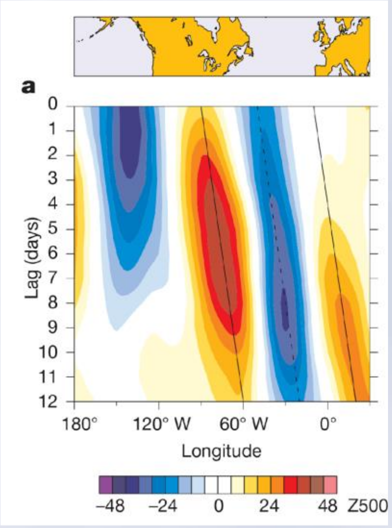
Analysis of MJO interactions with the extra-tropics

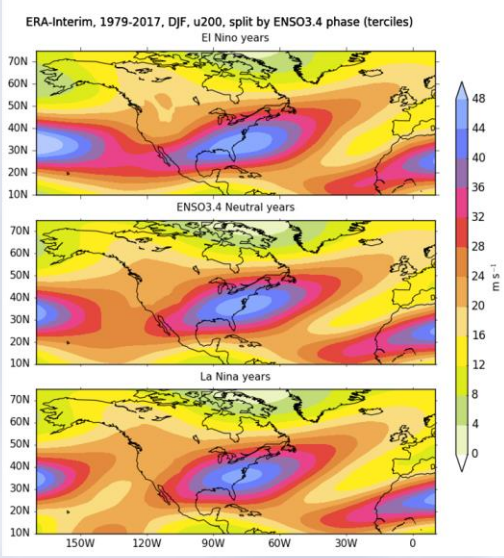
- Joint activity with new S2S teleconnections sub-project
- Contributed to a review of tropical-extratropical teleconnections on intraseasonal timescales joint with S2S (Stan et al. 2017)
- A number of studies looking at MJO teleconnections to the Northern Pacific, N America and Northern Atlantic and the dependence on the slowly varying background state
  - MJO-NAE regimes MJO-NAO+ teleconnection stronger in El Niño and barely present in La Niña (Lee et al, in prep)
  - Northern Atlantic and Pacific Blocking modulated by MJO, influence of MJO modulated by ENSO (Henderson et al, 2016; Henderson and Maloney 2018)
  - Modulation of Atmospheric Rivers by MJO (Mundhenk et al., 2016)
  - Modulation of MJO-Atmospheric River teleconnection by QBO and application to statistical sub-seasonal forecasting (Baggett et al, 2017; Mundhenk et al., 2018)
  - Modulation of MJO-N Pacific teleconnection by QBO (Wang et al, 2018)
  - Impact of MJO on N America surface temperature, precip and storm tracks (Zheng et al, 2018)
- Development of MJO teleconnection metrics for Climate Models and S2S models highlighting importance of both basic state and MJO heating (Henderson et al, 2017)
- Analysis of phase dependent robustness of MJO-mid-latitude teleconnections and implications for S2S predictions (Tseng et al, 2018)

ENSO modulation of MJO Teleconnections to the N Atlantic

- Repeat Analysis of Cassou, but sub-sampled by ENSO
  - MJO-NAO+ teleconnection following phase 4 enhanced during El Niño years and barely apparent in La Niña years
  - MJO-NAO- teleconnection strongest in ENSO neutral years and delated in La Niña years
  - MJO-AR teleconnection opposite sign in El Niño vs La Niña
- Possible mechanisms include
  - Changes in location of Pacific Jet
  - Changes in influence on influence of MJO on N Atlantic jet entrance region
- Possible rectification onto seasonal mean
  - El Niño years have increase NAO+ occurrence but reduced occurrence during phase 0 when no active MJO







Lee, et al., in prep

Plans for future activities

- Propose continuation of MJO-TF activity focused in broadly similar areas but with a slight re-organization
  - Keep sub-projects on Maritime Continent, MJO-Extratropics Interactions and MJO Prediction
  - Subsume POD and Air-sea interaction into new sub-project on “Mechanisms and Simulations”, (which will also cut across other sub-projects)
- **MJO Mechanisms and Simulations**
  - Continue to develop diagnostics to elucidated key mechanisms for MJO and its simulation in models, including
    - Sensitivity to parametrized physics (including impact of explicit representations)
    - Role of air-sea interaction including biases in “coupling strength)
  - Develop diagnostics and methodologies for separating impact of changes in model configuration (physics/coupling/resolution) on basic state vs impact on MJO “physics”
  - Understanding interannual variability in MJO
    - Role of interannual modes of variability (ENSO, QBO)
    - Impact of simulated interannual variability on metrics of MJO activity
  - Application of existing and new Process Oriented Diagnostics, Air-sea interaction diagnostics to CMIP6

Plans for future activities

- **MJO Prediction** (in collaboration with S2S)
  - Continued analysis of MJO Prediction skill and its dependence on variability of e.g. MJO, basic state; and model configuration
  - Explore relationships between ensemble spread and skill
  - Representation of MJO impacts in prediction systems

- **MJO and the Maritime Continent**
  - Continued analysis of representation of key physical processes for simulation of MJO propagation in Maritime Continent
  - Exploit observations and modelling efforts from YMC

- **MJO Extratropics interactions** (in collaboration with S2S)
  - Continued analysis of sensitivity of MJO teleconnections to details of MJO and basic state
  - Develop and apply metrics for MJO teleconnections and sources of error in their representation in models
  - Impact of MJO teleconnections on predictability and prediction skill for Extra-tropics

MJO TF Publications (2016-2018): total 40

Ahn, M.-S., **D. Kim**, **K. R. Sperber**, I.-S. Kang, **E. Maloney**, D. Waliser, and H. Hendon, 2017: MJO simulation in CMIP5 climate models: MJO skill metrics and process-oriented diagnosis. Clim. Dyn., 49, 4023–4045.

Ahn, M.-S., **D. Kim**, et al. Examination of the Maritime Continent barrier effect on MJO propagation in a GCM, In preparation.

Baggett, C. F., E. A. Barnes, **E. D. Maloney**, and B. D. Mundhenk, 2017, Advancing Atmospheric River Forecasts into Subseasonal Timescales. Geophys. Res. Lett., 44, 7528-7536.

Baranowski D., D. Waliser, **X. Jiang**, J. Ridout, and M. Flatau, 2018: Contemporary GCM Fidelity In Representing the Diurnal Cycle of Precipitation over the Maritime Continent. *Journal of Geophysical Research - Atmosphere*, under review.

DeMott, C. A., J. J. Benedict, **N. P. Klingaman**, **S. J. Woolnough**, and D. A. Randall, 2016: Diagnosing ocean feedbacks to the MJO: SST-modulated surface fluxes and the moist static energy budget. JGR, 121, 8350-8373.

DeMott, C. A., and **N. P. Klingaman**, 2018: Air-sea interactions in the Madden-Julian oscillation. Under review.

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Fonseca, R.M., **T.-Y. Koh,** and C.-K. Teo, 2018: Multi-Scale Interactions in a High-Resolution Tropical-Belt Experiment using WRF Model. Clim. Dyn. (in press).

Gonzalez, A. O. and **X. Jiang**, 2017: Winter Mean Lower-Tropospheric Moisture over the Maritime Continent as a Climate Model Diagnostic Metric for the Propagation of the Madden-Julian Oscillation. Geophys. Res. Lett., 10.1002/2016GL072430.

Henderson, S. A., **E. D. Maloney**, and E. A. Barnes, 2016: The influence of the Madden-Julian oscillation on Northern Hemisphere winter blocking. J. Climate, 29, 4597-4616.

Henderson, S. A., **E. D. Maloney**, and S.-W. Son, 2017: Madden-Julian oscillation teleconnections: The impact of the basic state and MJO representation in general circulation models. J. Climate, 30, 4567–4587.

Henderson, S. A., and **E. D. Maloney**, 2018: The impact of the Madden-Julian Oscillation on high-latitude winter blocking during El Niño-Southern oscillation events. J. Climate, 31, 5293–5318.

Jiang, X., M. Zhao, **E. D. Maloney**, and D. E. Waliser, 2016: Convective Moisture Adjustment Time-scale as a Key Factor in Regulating Amplitude of the Madden-Julian Oscillation. Geophys. Res. Letters, 43, 10,412–10,419.

Jiang, X., 2017: Key processes for the eastward propagation of the Madden-Julian Oscillation based on multi-model simulations. Journal of Geophysical Research: Atmospheres, 10.1002/2016JD025955.

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Jiang, X., **D. Kim,** and **E. Maloney**: Progress and status of MJO simulation in climate models and process-oriented diagnostics, Under review.

Kim, D., M.-S. Ahn, **C. DeMott**, **X. Jiang**, **N. Klingaman**, **H. Kim**, J. Lee, Y. Lim, S.-W. Son, **S. Woolnough**, **P. Xavier**, Basic state lower-tropospheric humidity distribution: key to successful simulation and prediction of the Madden-Julian oscillation, 2017 AGU fall meeting, New Orleans

Kim, D., H. Kim, and M.-I. Lee, 2017: Why does the MJO detour the Maritime Continent during austral summer? Geophys. Res. Lett., 44, 2579–2587.

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Kim, H. M., 2017: The impact of the mean moisture bias on the key physics of MJO propagation in the ECMWF reforecast, JGR-Atmospheres, 122, 7772–7784

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MJO TF Publications (2016-2018): total 40

Kim, H. M., F. Vitart, D. E. Waliser: MJO Prediction: Current status and future challenges, Book chapter in "The Multi-Scale Global Monsoon System" (under review)

Kim, H. M., K. Pegion, M. Janiga, D. Achuthavarier: Process-based MJO hindcast evaluation in SubX (in preparation)

Koh, T.-Y. and R.M. Fonseca, 2016: Rainfall-Based Convective Cloud Scheme applied to the BMJ Scheme in WRF Model. Q. J. R. Meteorol. Soc., 142, 989-1006.

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Miyakawa, T., H. Yashiro, T. Suzuki, H. Tatebe, M. Satoh, 2017: A Madden-Julian Oscillation event remotely accelerates ocean upwelling to abruptly terminate the 1997/1998 super El Nino. Geophys. Res. Lett., doi:10.1002/2017GL074683.

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Wang, J., **H. M. Kim**, E. K. M. Chang, S. W. Son, 2018: Modulation of the MJO and North Pacific Storm Track relationship by the QBO, JGR-Atmospheres, 123, 3976–3992.

Wolding, B. O, **E. D. Maloney**, and M. Branson, 2016: Vertically Resolved Weak Temperature Gradient Analysis of the Madden-Julian Oscillation in SP-CESM. J. Adv. Modeling. Earth. Sys., 8, doi:10.1002/2016MS000724.

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