WMO WGNE

MJO Task Force

Mechanism | Simulation | Prediction | Impact

Daehyun Kim

on behalf of the task force

WGNE-36

November 4, 2021

Major accomplishments

- **Review articles** on the MJO-MC interaction, MJO process-oriented diagnostics, moisture mode theory, and the MJO-QBO connection.

- Significant progress on the potential use of **Artificial Intelligence (AI)/Machine Learning (ML)** for modeling and prediction of the MJO.

- Development and application of various **process-oriented diagnostics**, especially those for MJO teleconnections.

Terms of references

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.

- Develop/promote process-oriented diagnostics/metrics
- Evaluation of real-time forecasts and hindcasts of tropical intraseasonal variability
- MJO air-sea interaction
- MJO interactions with the Maritime Continent
- MJO interactions with the extratropics
- Artificial Intelligence (AI)/Machine Learning (ML): Explore and identify areas where Artificial Intelligence (AI)/Machine Learning (ML) can help advance modeling and prediction of the MJO and its associated high-impacts weather and climate events.

Membership

Charlotte DeMott, Co-chair, Colorado State University
Daehyun Kim, Co-chair, University of Washington
Matthew Janiga, Naval Research Laboratory
Xianan Jiang, UCLA
Samson Hagos, Pacific Northwest National Laboratory
Yoo-Geun Ham, Chonnam National University
Stephanie Henderson, University of Wisconsin-Madison
Hyemi Kim, Stony Brook University
Tieh-Yong Koh, Singapore University of Social Sciences
Zane Martin, Colorado State University
Tomoki Miyakawa, AORI/ University of Tokyo
Richard Neale, NCAR
Donaldi Permana, BKMG
Steve Woolnough, Uni. of Reading
Prince Xavier, UK Met Office

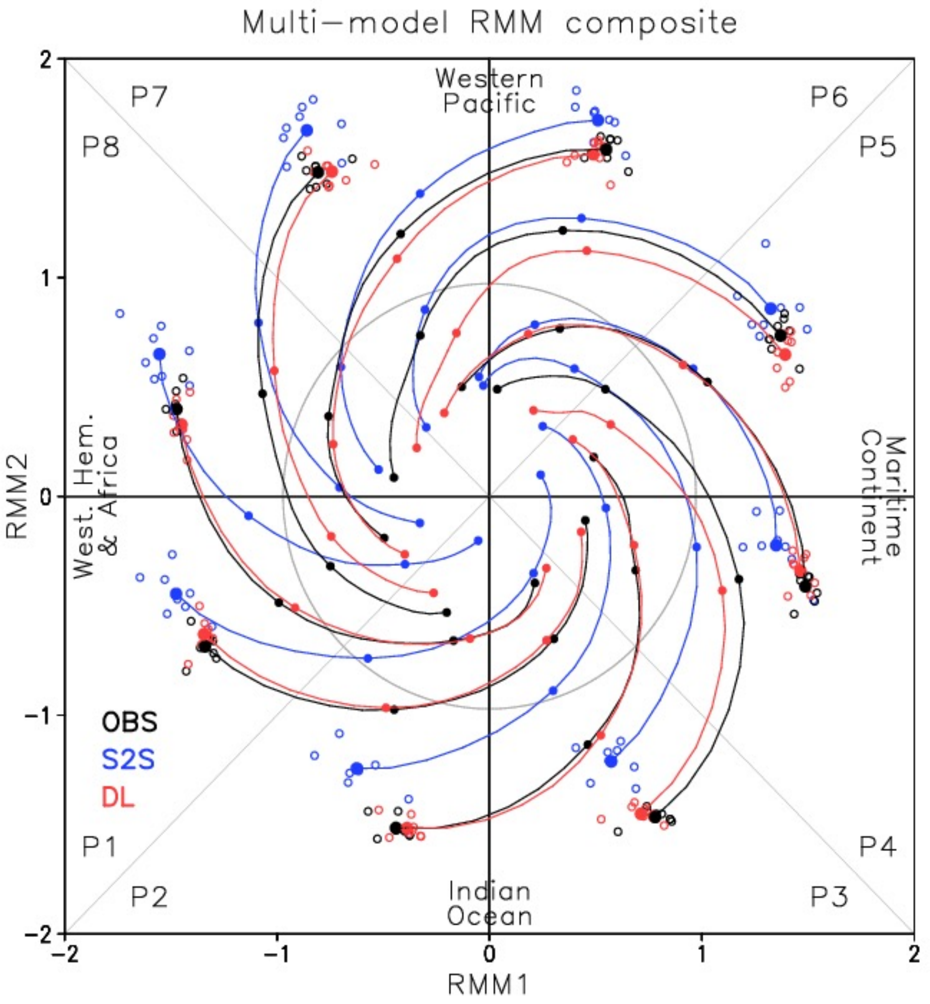
Research highlights

Explore and identify areas where **Artificial Intelligence (AI)/Machine Learning (ML)** can help advance modeling and prediction of the MJO and its associated high-impacts weather and climate events.

MJO prediction: Deep Learning bias correction

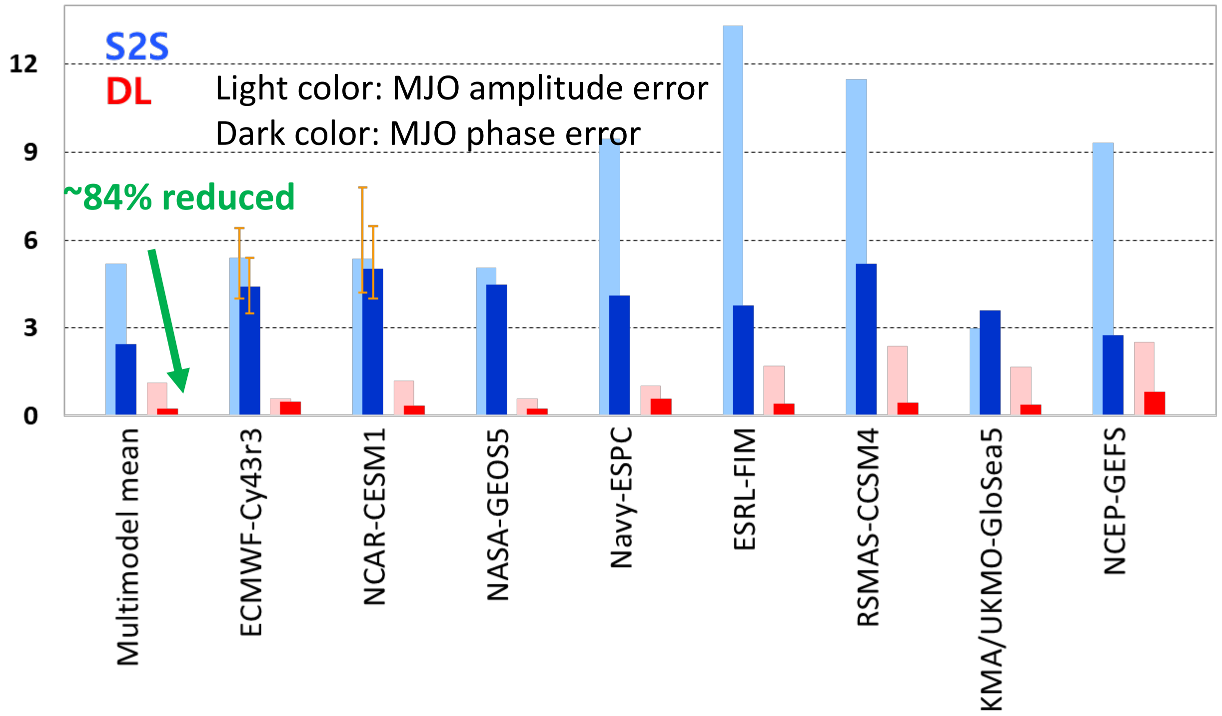
Hyemi Kim
Yoo-Geun Ham

Improved forecast of MJO phase and amplitude



H. Kim et al. (Nature Comms, 2021)

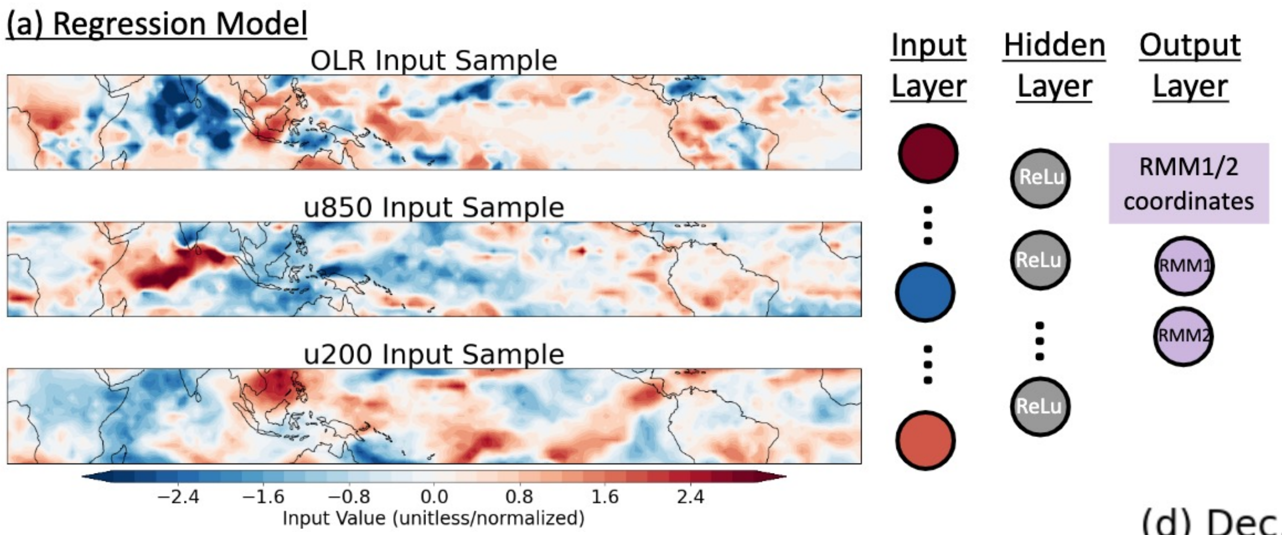
Reduced MJO Forecast Errors (4-weeks average)

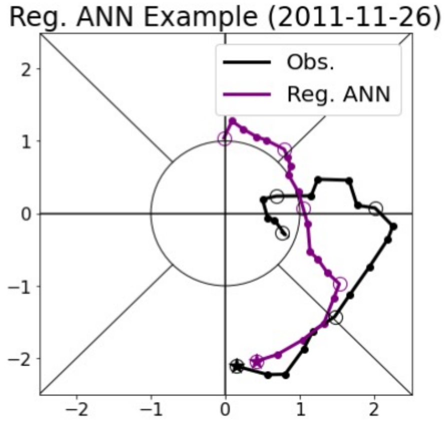


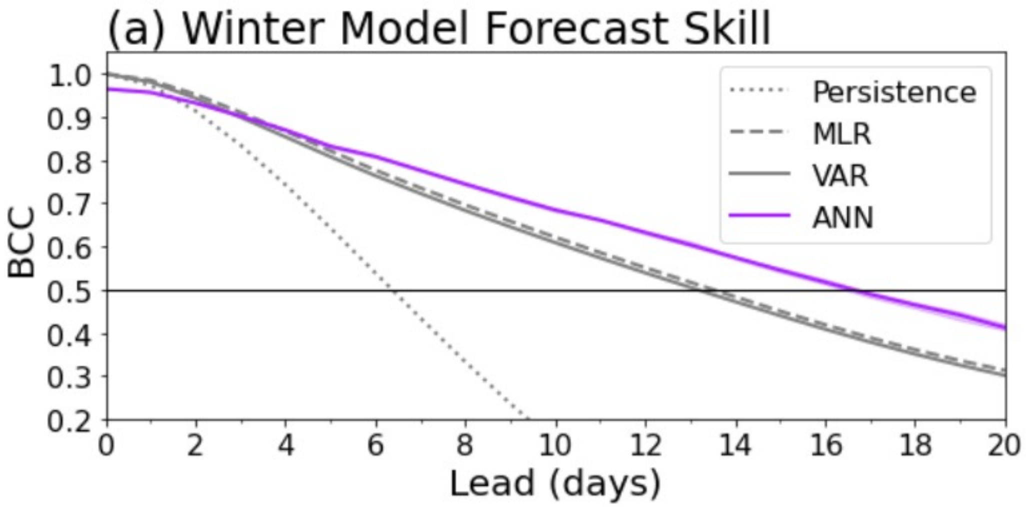
- Systematic MJO forecast errors in S2S/SubX reforecasts can be reduced via Deep Learning (DL) techniques.
- MJO prediction skill and propagation is improved with DL bias correction.

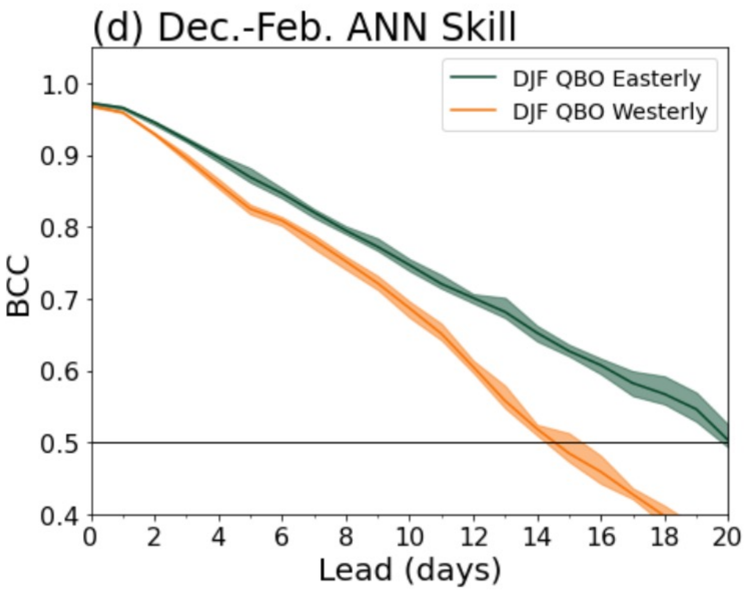
Zane Martin

Machine learning-based MJO prediction









Martin et al. (2021b)

Characterizing MJO variability and Predictability Using Machine Learning

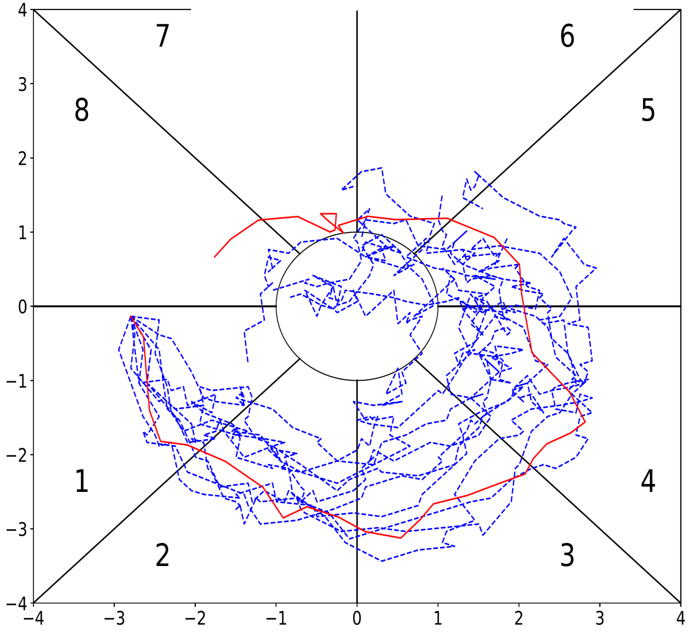
Samson Hagos

The Question: How does the background state influence the initiation, variability and predictability of MJO events

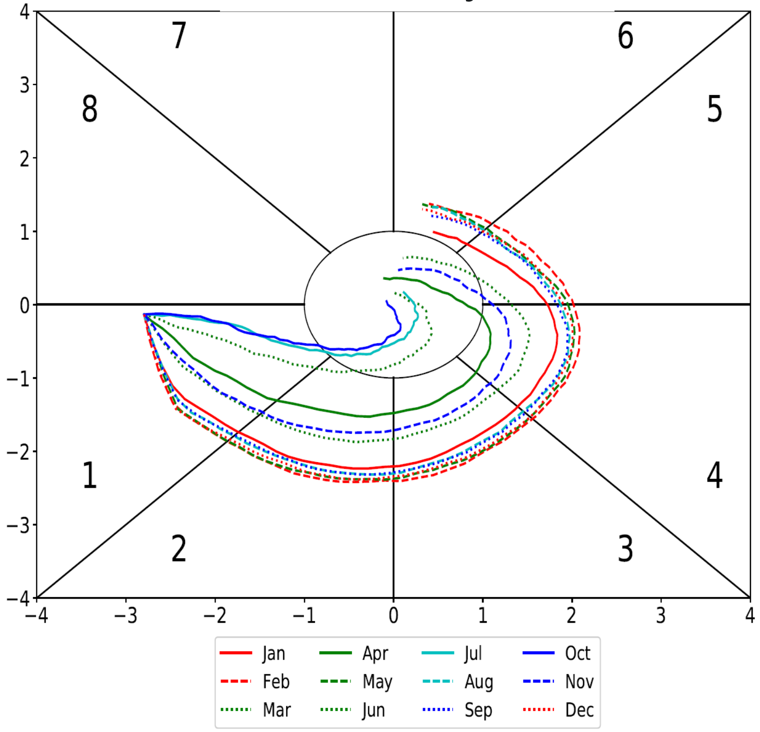
Approach: Develop, train and run a Markovian surrogate stochastic model

The model P($\Delta rmm = \Delta RMM_i | S_t$) where $S_t = [rmm, SC, ENSO, QBO, IOD]$

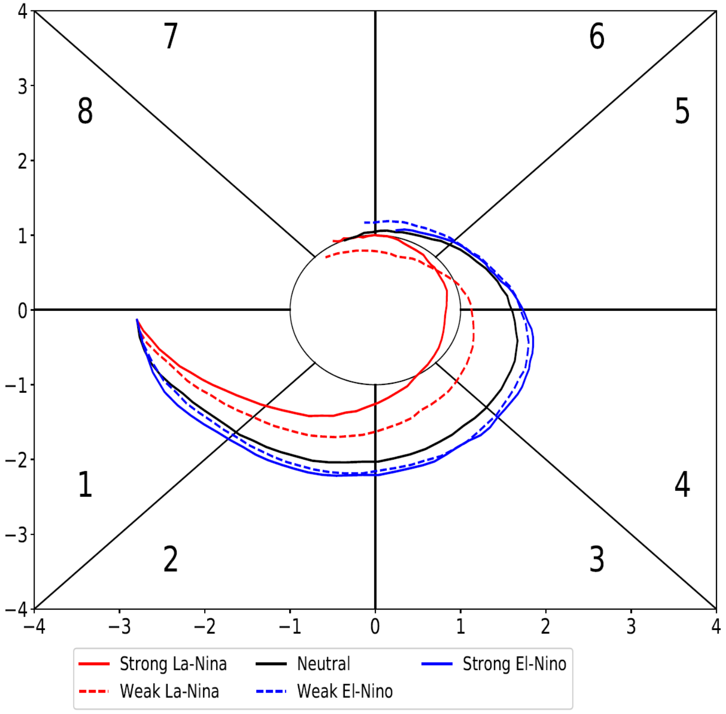
Example



Seasonality



ENSO



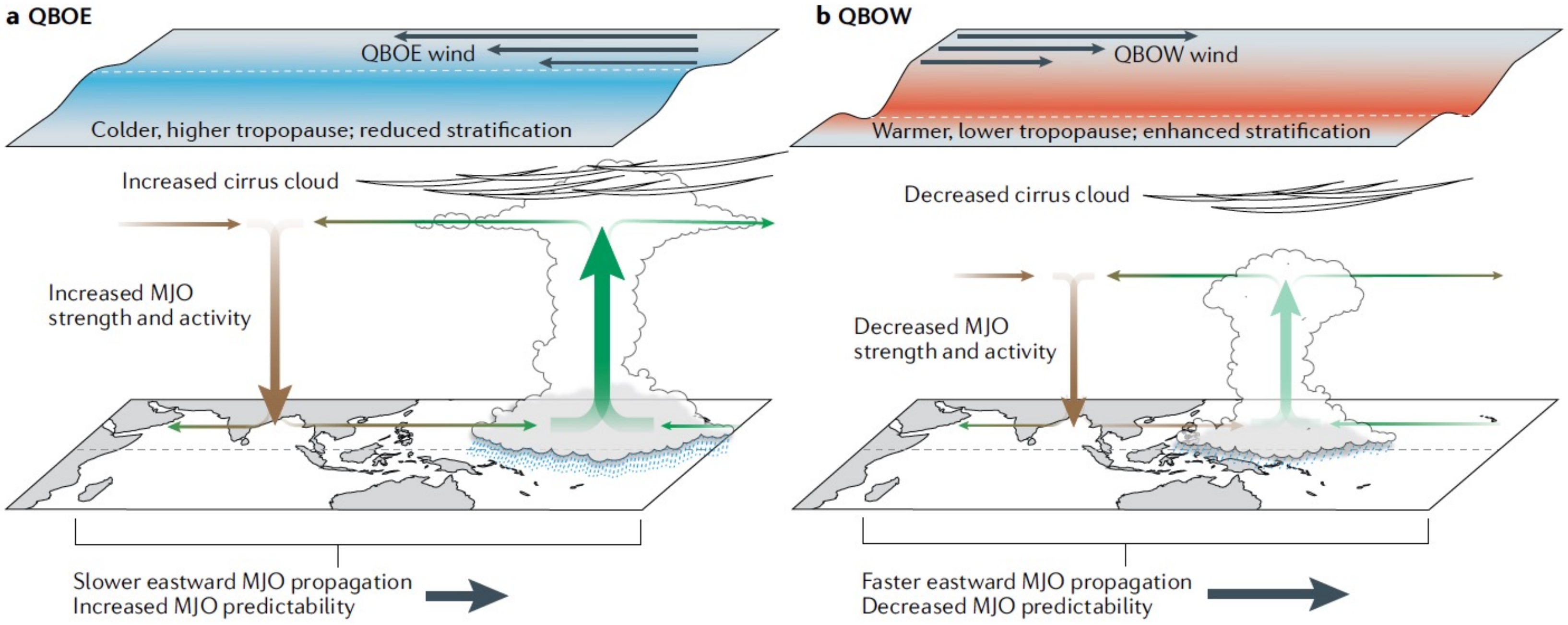
Research highlights

Further development and promotion of **process-oriented diagnostics/metrics** that improve insight into the physical mechanisms for robust simulation/prediction of the MJO and that facilitate improvements in convective and other physical parameterizations relevant to the MJO.

Jiang, X., D. Kim, E. D. Maloney, 2021: Progress and Status of MJO Simulation in Climate Models and Process-Oriented Diagnostics, Chap. 25 in The Multiscale Global Monsoon System, Eds: C.P. Chang, K.J. Ha, R. H. Johnson, D. Kim, G.N. Lau, B. Wang. World Scientific Series on Asia-Pacific Weather and Climate, Vol. 11. World Scientific, Singapore, https://doi.org/10.1142/11723.
Adames, Á. F., **D. Kim**, E. D. Maloney, and A. H. Sobel, 2021: The moisture mode framework of the Madden-Julian Oscillation, Chap. 22 in The Multiscale Global Monsoon System, Eds: C.P. Chang, K.J. Ha, R. H. Johnson, **D. Kim**, G.N. Lau, B. Wang. World Scientific Series on Asia-Pacific Weather and Climate, Vol. 11. World Scientific, Singapore, https://doi.org/10.1142/11723.
Martin, Z., S. W. Son, A. Butler, H. Hendon, **H. Kim**, A. Sobel, S. Yoden, C. Zhang, 2021: The influence of the Quasi-Biennial oscillation on the Madden-Julian oscillation, Nature Reviews - Earth & Environment, https://doi.org/10.1038/s43017-021-00173-9

Zane Martin

Advancing understanding of the QBO-MJO connection



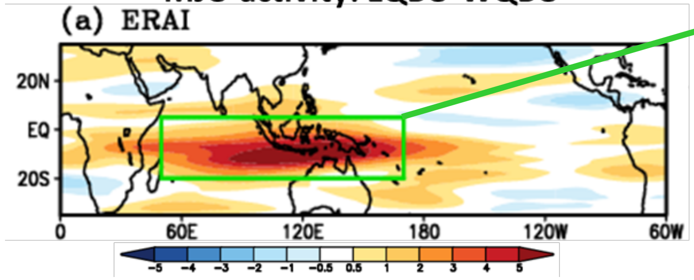
Adapted from Martin et al. (2021a) Fig. 5

- Research continues to focus on understanding and modeling the connection between the stratospheric quasi-biennial oscillation and the MJO
- A review paper summarizing the state of the science appeared in *Nature*
- Modeling studies have shown continued difficulties capturing the QBO-MJO connection in climate models, suggesting important biases or missing processes that must continue to be explored

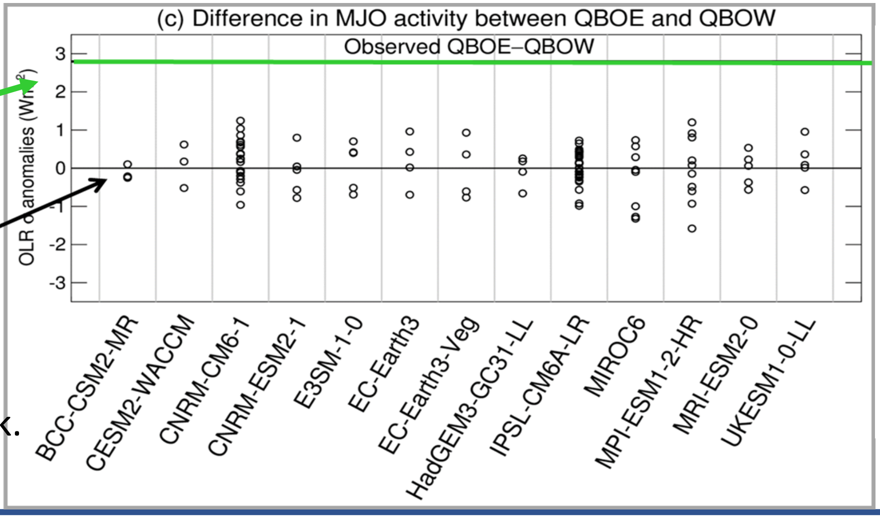
- MJO prediction and simulation: QBO-MJO link in S2S and CMIP6

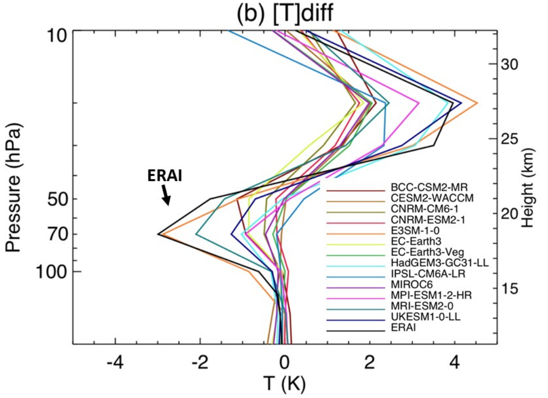
QBO-MJO connection in CMIP6

MJO activity: EQBO-WQBO



Individual ensemble member





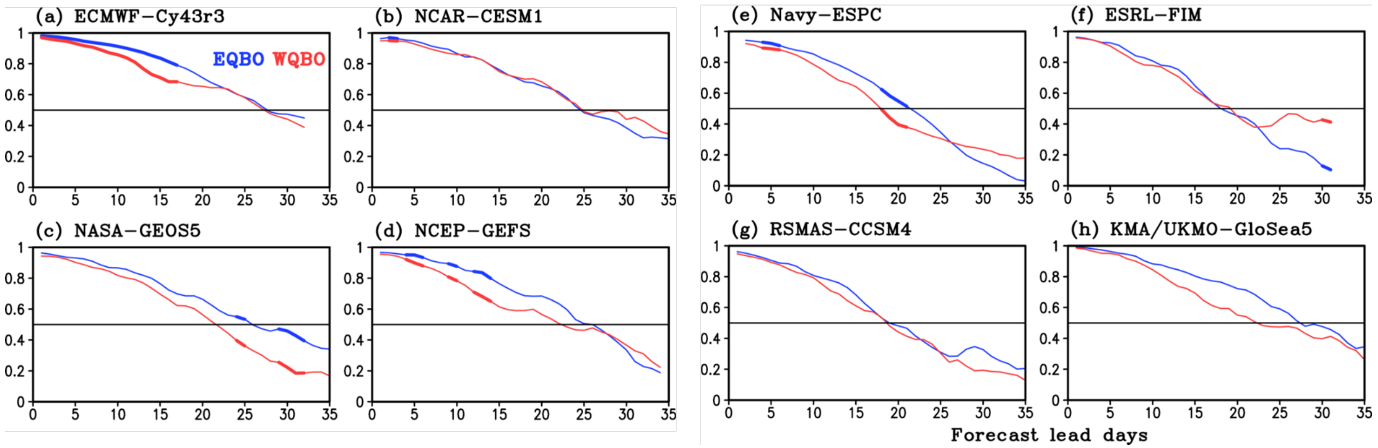
Kim et al. (GRL, 2020)

- None of the CMIP6 models simulate an observed QBO-MJO link.
- CMIP6 models have weaker QBO amplitude than observed.

QBO-MJO connection in S2S/SubX

Kim et al. (JGR, 2019)

MJO prediction skill (RMM)



* **Thick lines:** MJO skill difference is statistically significant at 95% confidence level (100,000 sample bootstrap).

- MJO is more predictable in EQBO.
- But, MJO skill difference between QBO phase is NOT statistically significant.

- The QBO modulates the MJO in observations, but it does not significantly influence MJO prediction skills and simulation in a multi-model assessment.

Hyemi Kim

Investigating the QBO-MJO relationship using linear inverse modeling

Stephanie Henderson

Observed

Internal to stratosphere

Coupled to troposphere and SST

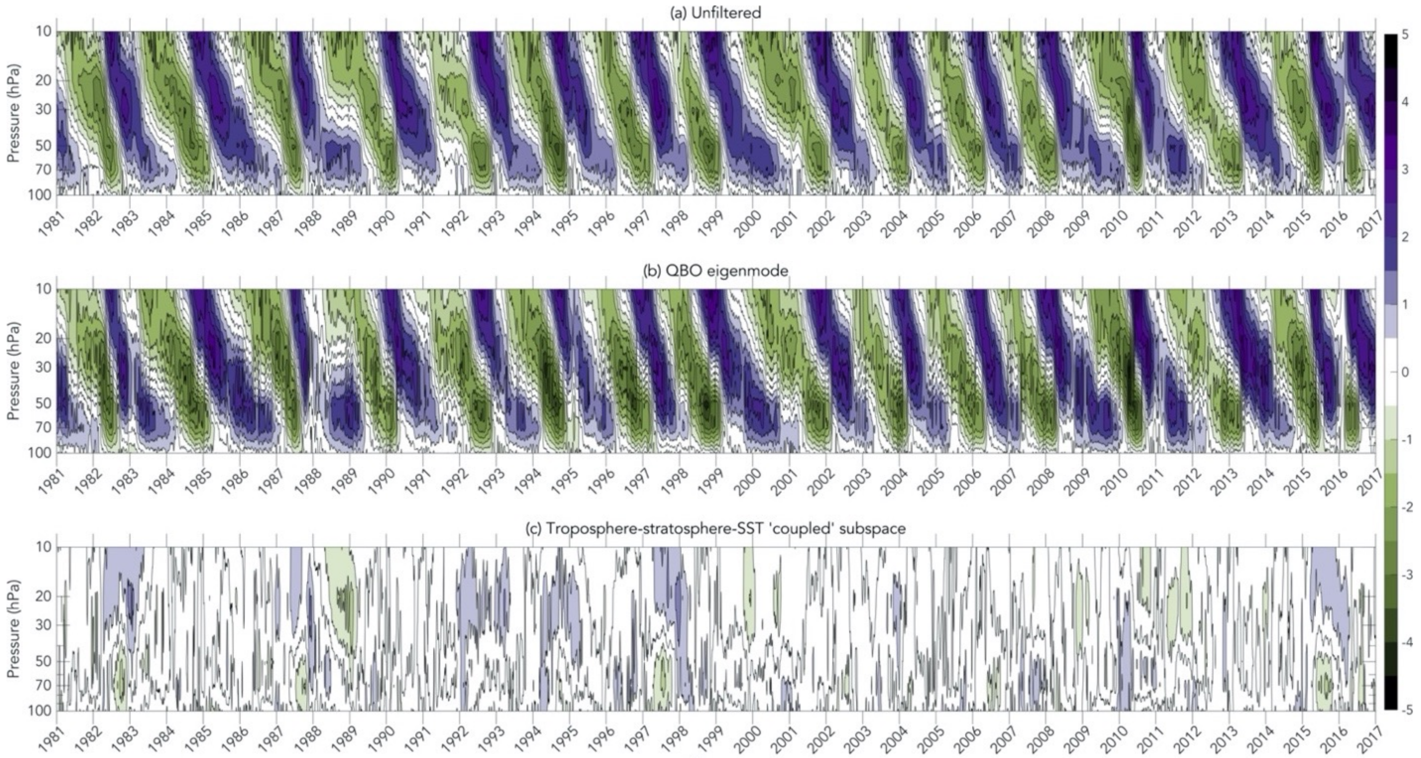


Fig.: Tropical zonal mean zonal wind (ms^{-1}) (a) observed (from raw JRA-55 reanalysis) composite and composites with a LIM nonnormal filter applied to show contributions from the (b) QBO eigenmode (purely internal to the stratosphere) and (c) coupled eigenmodes (component coupled to the troposphere and SST).

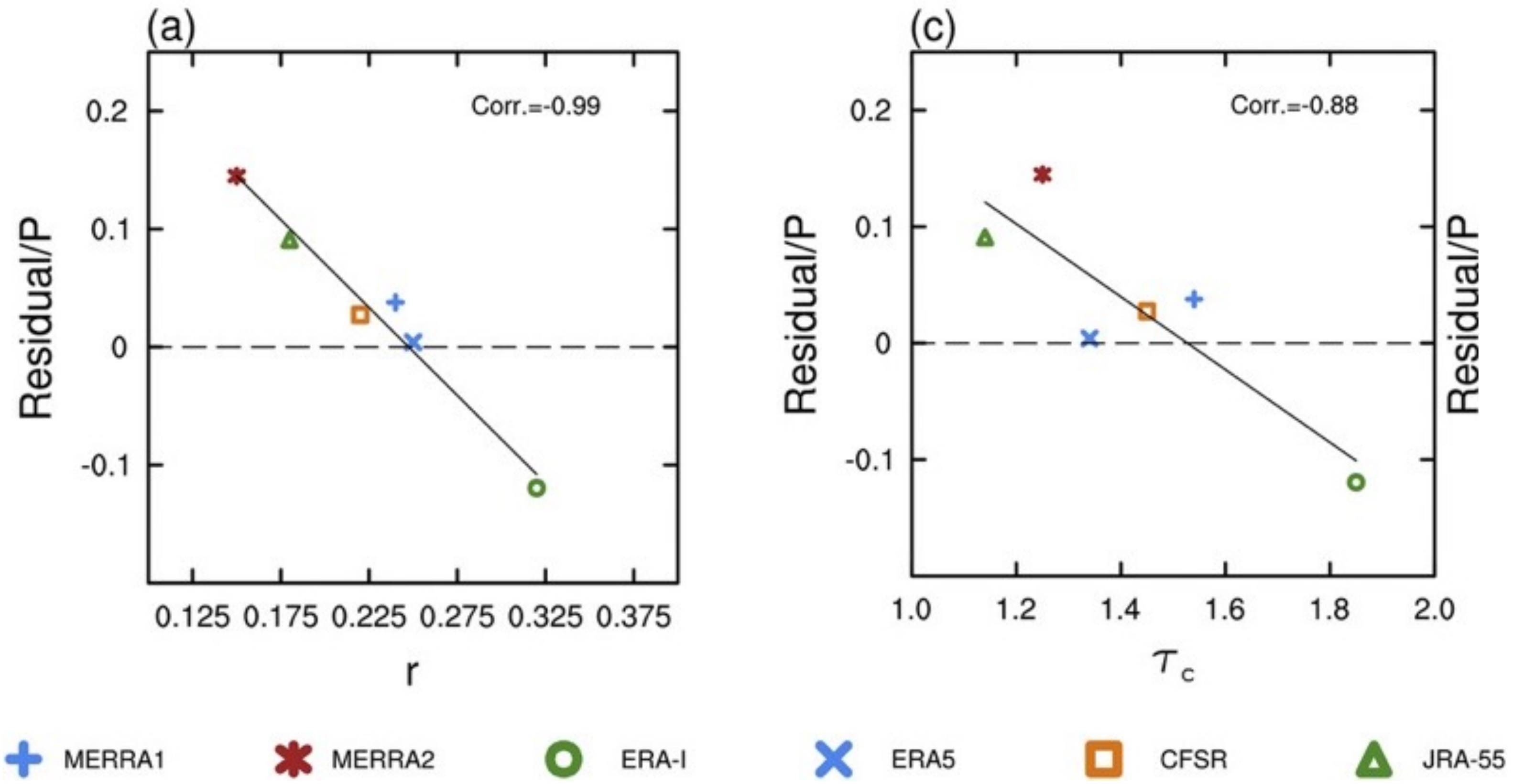
- We are employing LIM to investigate the dynamical links between the tropical stratospheric zonal wind with ENSO and MJO.
- This includes LIM climate runs (integrates LIM forward to obtain thousands of years of data based on current statistics and noise to increase sampling) and time-period specific LIMs to investigate the time dependence of these relationships.

(ongoing work)

Intercomparison of the Column Moist Static Energy and Water Vapor Budget of the MJO among Six Modern Reanalysis Products

Daehyun Kim

- A multi-reanalysis comparison of MJO MSE and moisture budget using six modern reanalysis products: MERRA1, MERRA2, ERA-I, ERA5, CFSR, JRA-55.
- A noticeable inter-RA spread in the MSE budget terms, especially those that are directly affected by the model parameterization schemes.
- RAs that underestimate (overestimate) the strength of cloud–radiation feedback and the convective moisture adjustment time scale tend to have positive (negative) MJO CWV budget residual (Figure), indicating the critical role of these processes in the maintenance of MJO CWV anomalies.

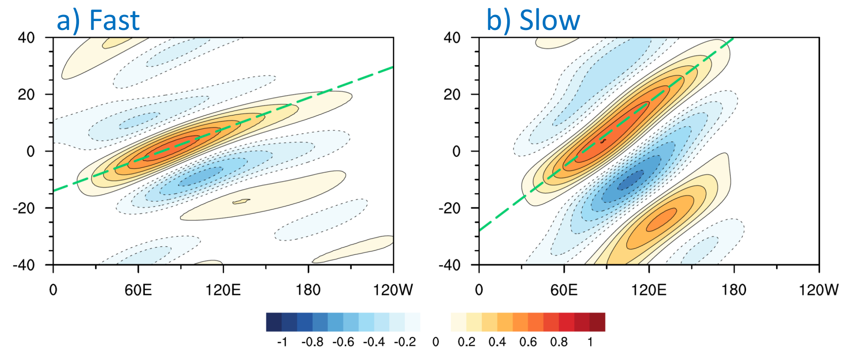


Ren, P., **D. Kim**, M.-S. Ahn, D. Kang, and H.-L. Ren, 2021: Intercomparison of MJO column moist static energy and water vapor budget among six modern reanalysis products. *J. Clim.* **34**, 2977–3001. https://doi.org/10.1175/JCLI-D-20-0653.1

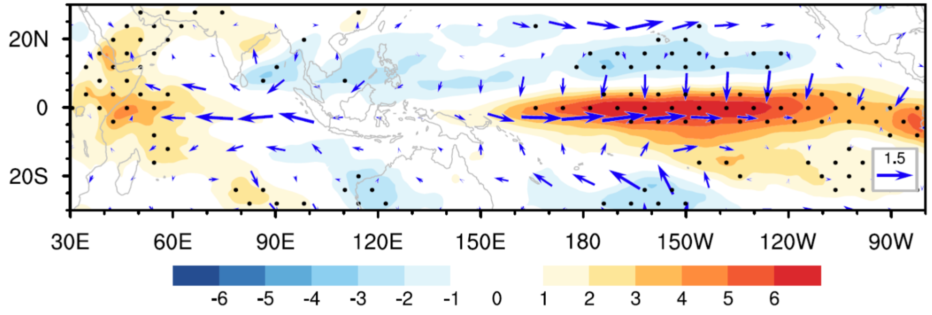
Zonal-scale of the MJO and its propagation speed on the interannual time-scale

Mengxia Lyu, **Xianan Jiang** , Zhiwei Wu, **Daehyun Kim**, and Ángel F. Adames

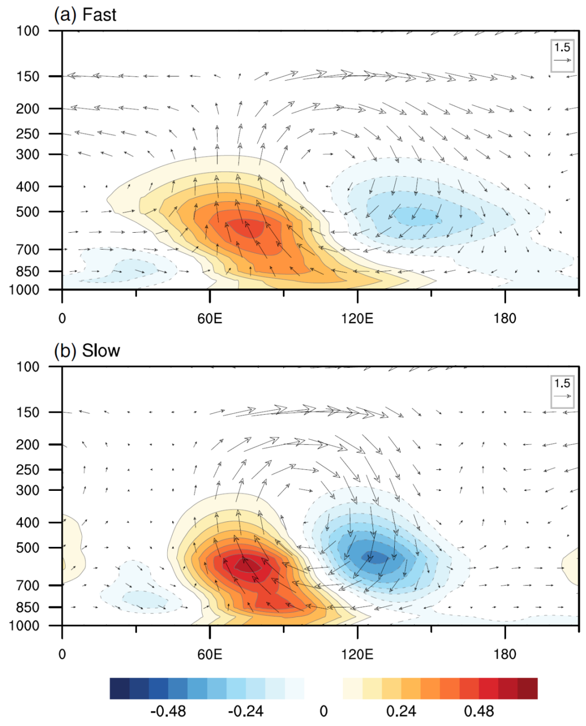
MJO propagation during winters with fast and slow eastward propagation



Mean state differences between fast and slow MJO winters (Fast-Slow)
(Shading: precipitable water; Vectors: 10m winds)



MJO vertical structure during fast and slow winters
(Shading: precipitation; Vectors: u-w winds; 10ºS-10ºN)



- During the winters with fast MJO propagation, the MJO exhibits a much larger zonal-scale than that during the winters with slow propagation, which induces stronger and broader moistening (drying) to the east (west) of MJO through horizontal moisture advection, prompting a faster MJO phase speed.
- The larger MJO zonal-scale during the fast MJO propagation winters is coincident with an expansion of the Indo-Pacific warm pool.

Lyu, M., X. Jiang, Z. Wu, D. Kim, and A. F. Adames, 2021: Zonal-Scale of the Madden-Julian Oscillation and Its Propagation Speed on the Interannual Time-Scale. *Geophys. Res. Lett.*, **48**, e2020GL091239, 10.1029/2020GL091239.

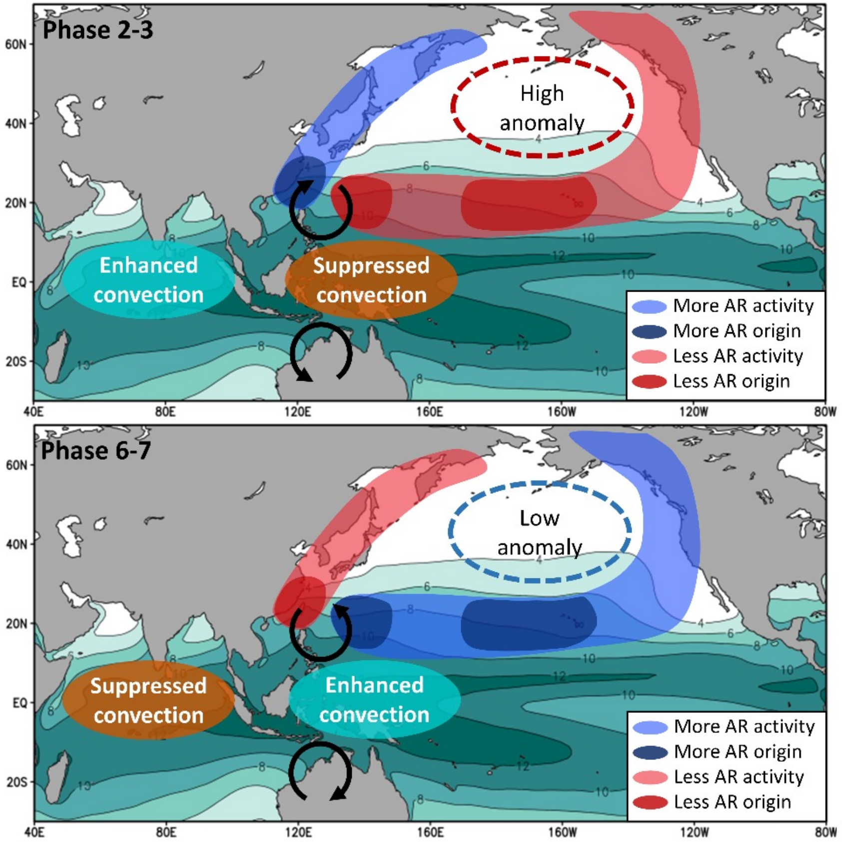
Research highlights

Develop, coordinate, and promote analyses of **MJO interactions with the extratropics**, including an assessment of model ability to accurately simulate such interactions and the consequences for prediction of the midlatitude circulation and extreme events.

- MJO teleconnections

Hyemi Kim

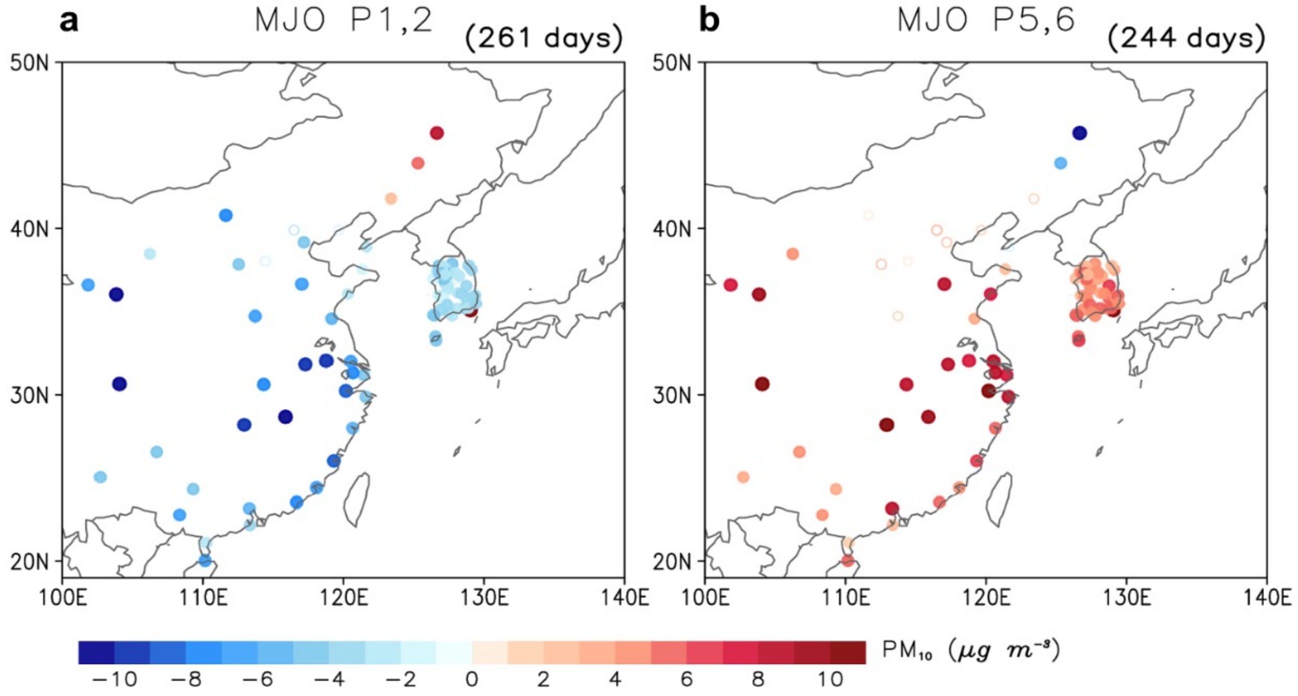
MJO-Atmospheric Rivers



- The MJO significantly influences the number, lifetime, and propagation of North Pacific ARs
- More Atmospheric Rivers (ARs) with longer lifetime occur over the subtropical North Pacific when MJO is in phase 6-7
- Dynamical processes are the dominant factors in the MJO-ARs connection

(Zhou et al. 2021, GRL)

MJO-Air pollution (PM10)



- MJO is a primary source of wintertime subseasonal variability of East Asia PM10 concentration.
- PM10 becomes significantly high (low) in MJO phases 5–6 (MJO phase 1–2).

(Jung et al. in revision, Nature Comms)

Investigating the impact of MJO heating structure on MJO teleconnections

Stephanie Henderson

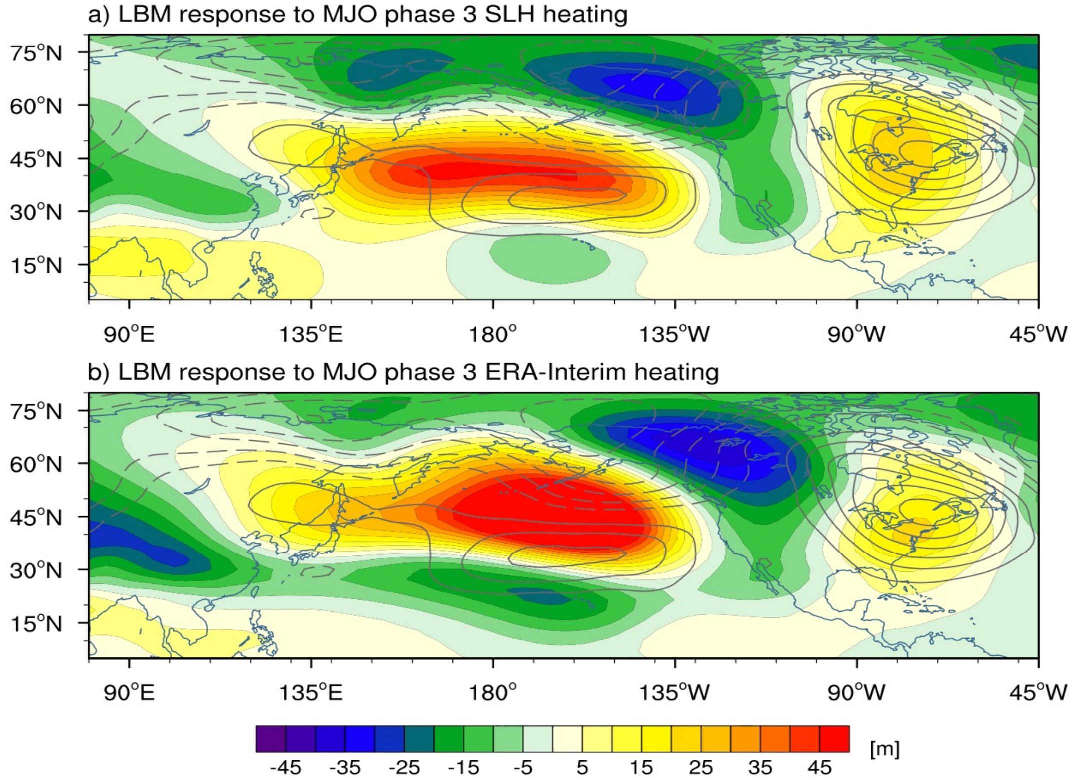


Fig: Anomalous 250-hPa geopotential height linear baroclinic model (LBM) response to MJO phase 3 heating (shading) from a) TRMM SLH and b) ERA-Interim. For reference, the corresponding height composite from ERA-Interim (5-9 days after MJO phase 3) is in gray contours every 10 m. The zero contour is omitted.

- Reanalysis MJO heating varies greatly depending on which reanalysis dataset is used.
- Using the linear baroclinic model, we are examining the impact of heating structure using satellite observations and reanalysis.

(ongoing work)

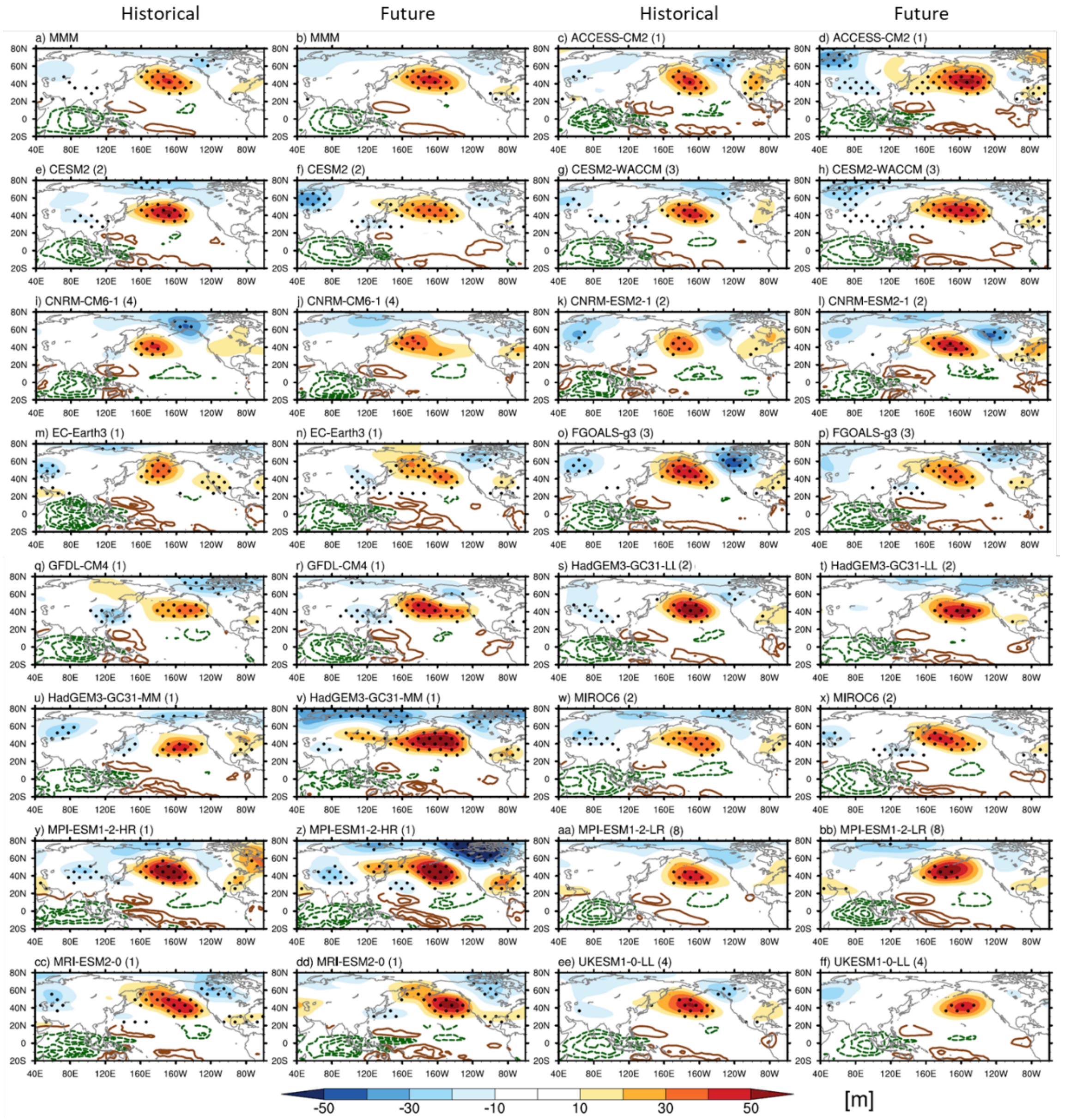
Other work:

- MJO impacts on March-June extratropical cyclone tracks (MS Thesis – Angelica Soria)
- The role of the MJO and ENSO on Northeast Pacific blocking

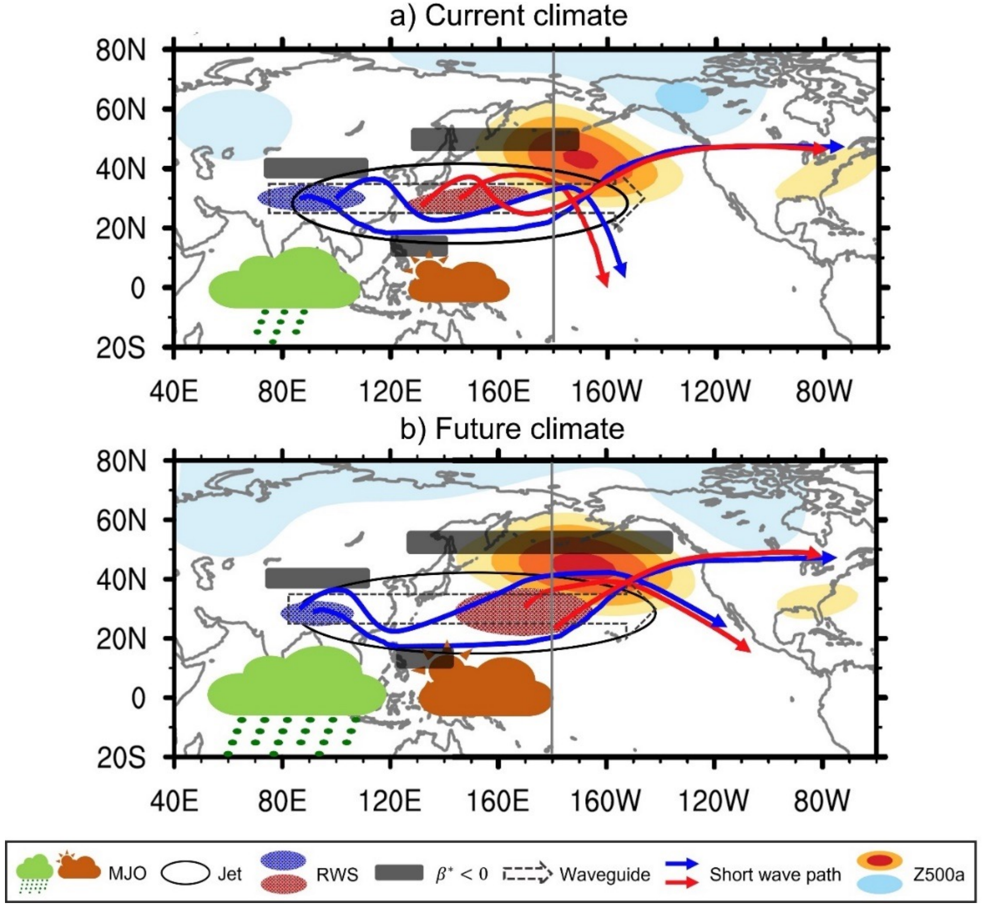
- MJO teleconnections: Future change in CMIP6

Hyemi Kim

Historical vs. Future Z500 anomaly (MJO phase 3)



Mechanism



- Future change in MJO-PNA relationship is assessed with 15 CMIP6 historical and SSP585 runs. Dynamical mechanisms (wave generation and propagation) are investigated with LBM.
- The most robust and significant change is an eastward extension of MJO teleconnections.

Wang et al. (J Climate, submitted)

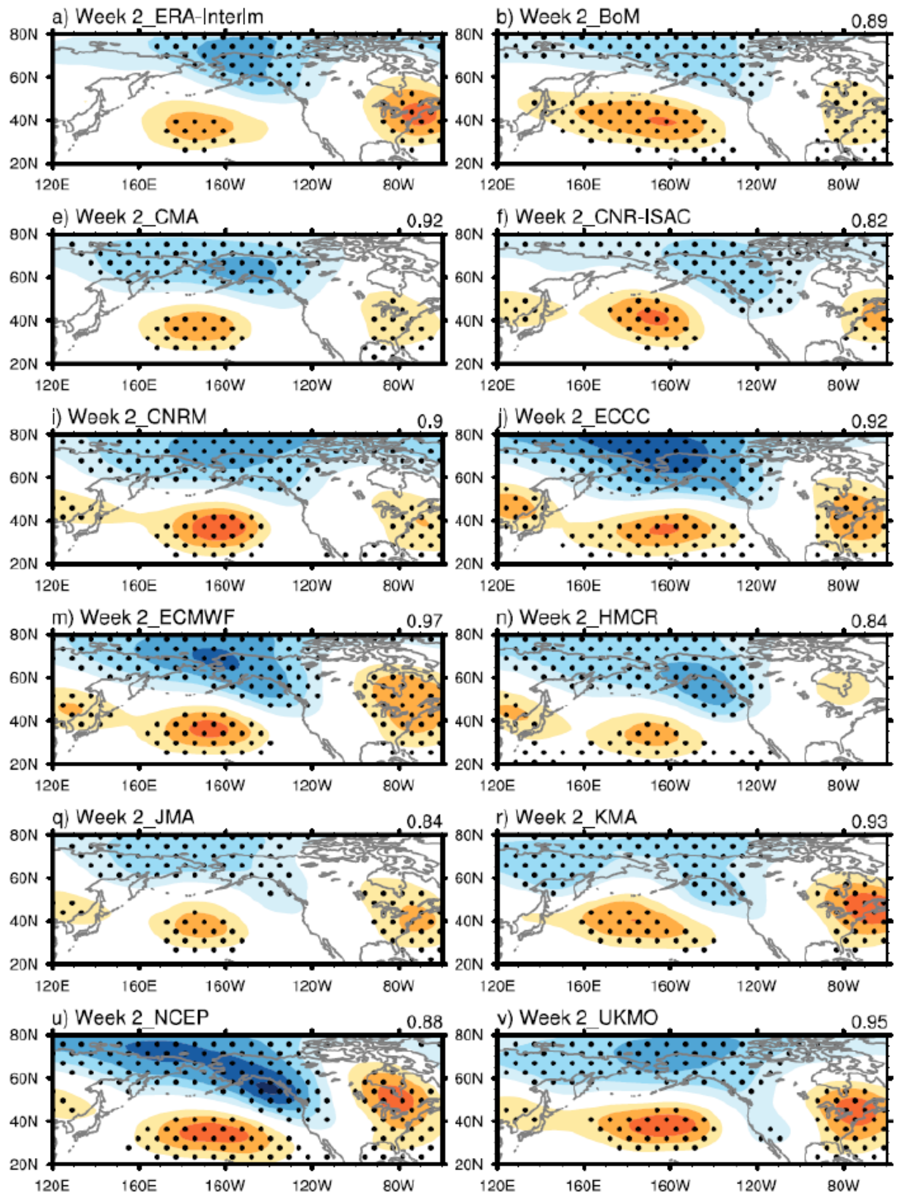
Research highlights

Promote the ongoing **evaluation of real-time forecasts and hindcasts of tropical intraseasonal variability**, including assessment of hindcasts in the Subseasonal to Seasonal Prediction Project (S2S) model database. Coordinate with WGNE to implement new forecast metrics within the operational forecast centers.

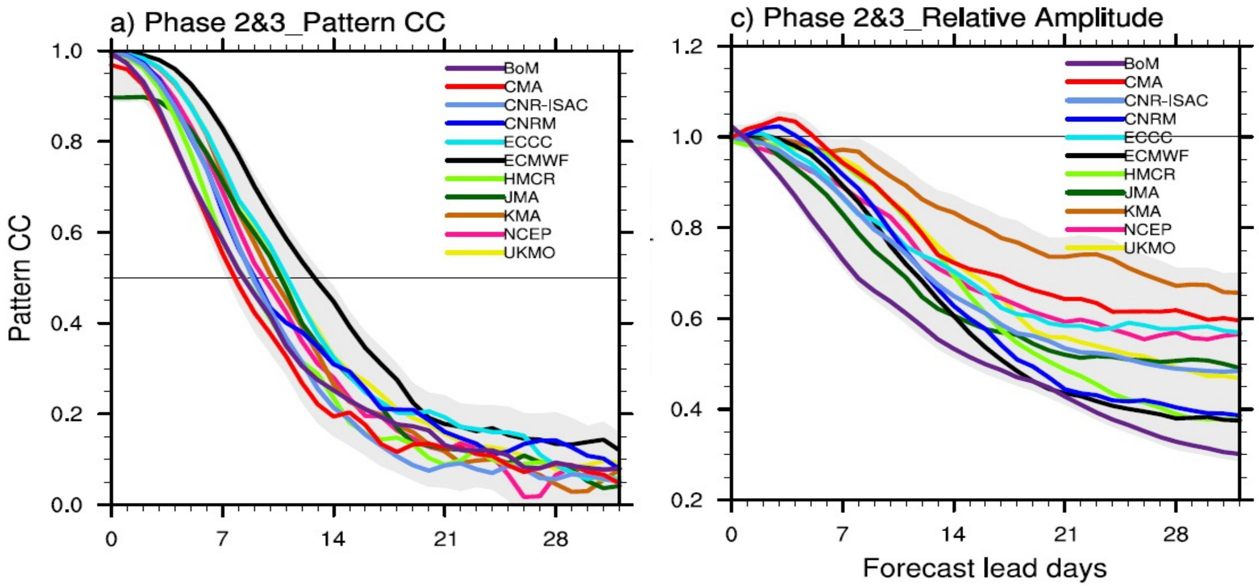
- MJO teleconnections: Prediction in S2S

Hyemi Kim

Week-2 Z500 forecasts (MJO phase2&3)



Application of MJO-teleconnection metrics to S2S forecasts



(Stan et al, BAMS, submitted)

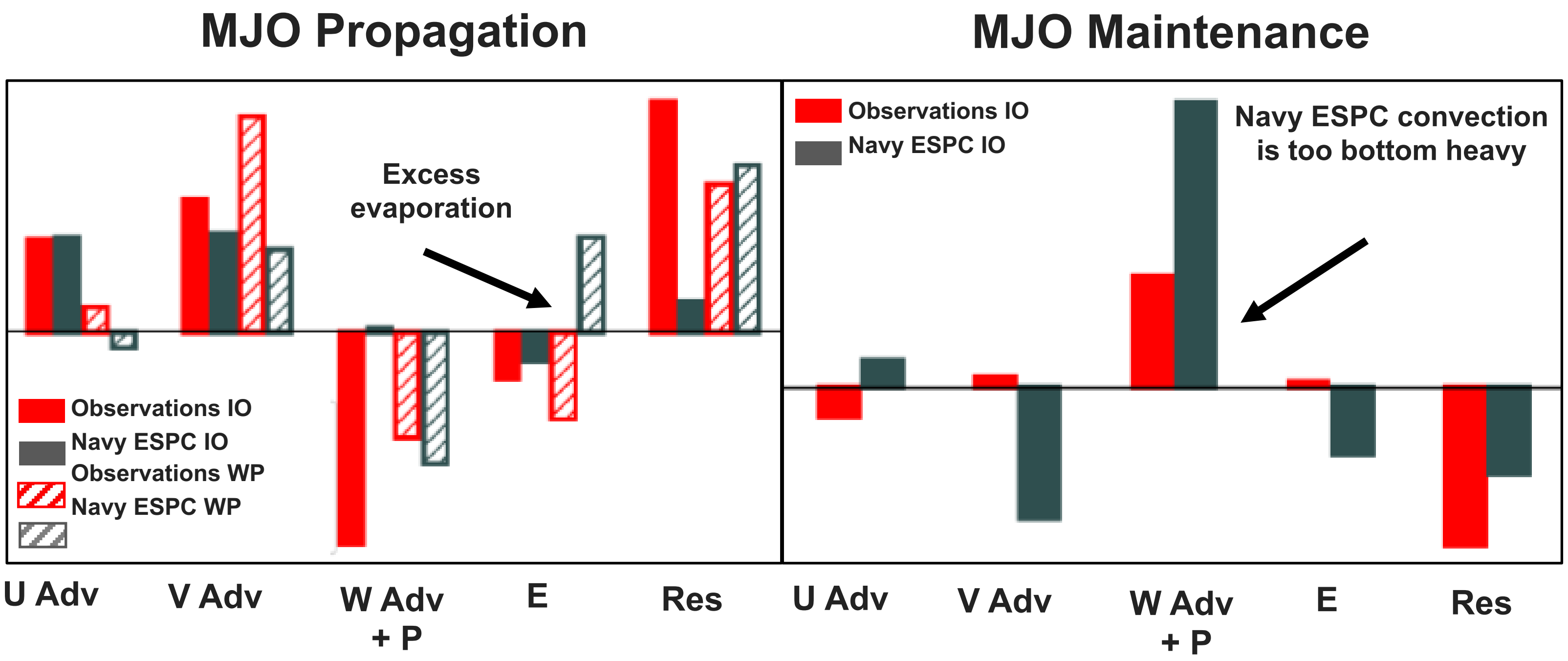
- The MJO teleconnection metrics developed with MJO TF members are applied to S2S reforecasts.
- MJO influence on the prediction of TCs, storm tracks, 2m temperature via tropospheric and stratospheric pathways are evaluated in 11 S2S reforecasts.

Other related research:

- MJO-Storm Track forecast in SubX models (Zheng et al. 2021)

MJO prediction in Navy ESPC

Matthew Janiga



- The Navy ESPC 16-member ensemble has now been running operationally since May 2020. Navy ESPC v2 is targeted for completion at the end of FY22.

- Examinations of the moisture budget in Navy ESPC forecasts performed for the Subseasonal eXperiment (SubX) show that the too-fast propagation is due to excess evaporation and the too-strong amplitude is due to excess vertical moisture advection. **Moisture budget terms for DJF 2009-2015 forecasts (Top Figure).**

Rushley et al. (submitted)

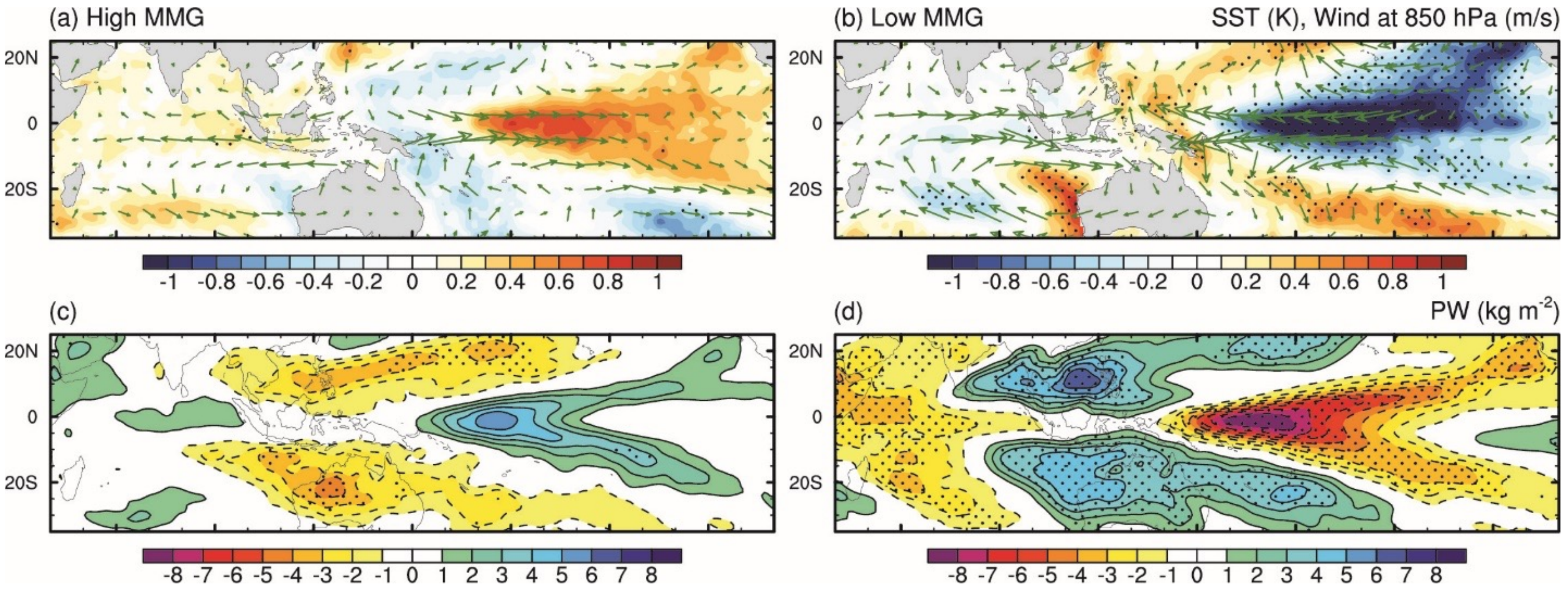
Research highlights

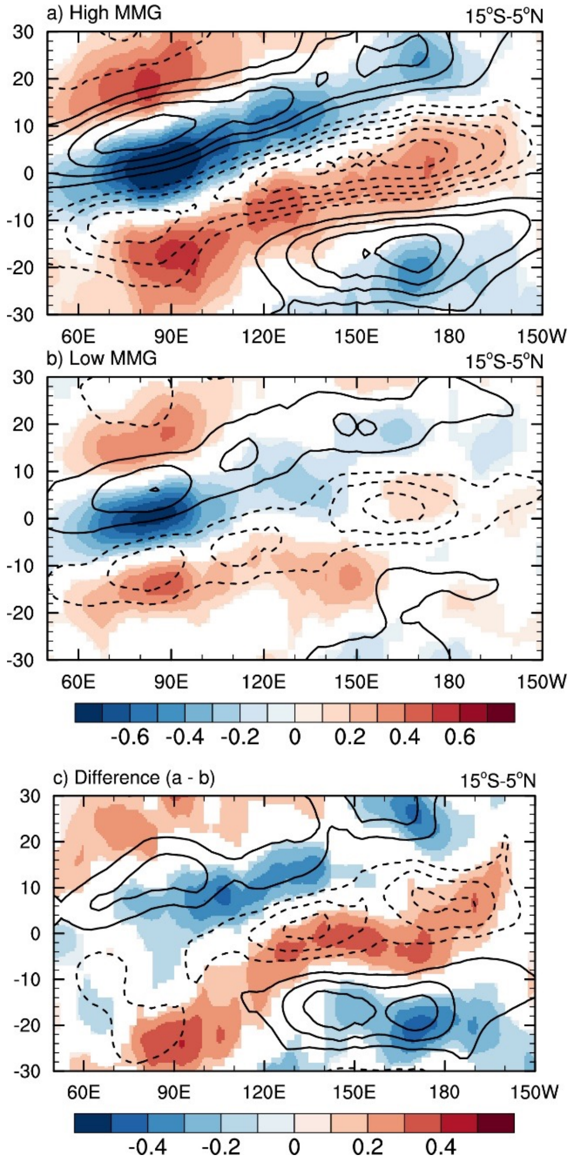
Advance understanding of **MJO interactions with the Maritime Continent** to facilitate improvements in model bias and foster better subseasonal predictions across the Maritime Continent and the globe.

Kim, D., E. D. Maloney, and C. Zhang, 2021: Review: MJO propagation over the Maritime Continent, Chap. 21 in The Multiscale Global Monsoon System, Eds: C.P. Chang, K.J. Ha, R. H. Johnson, D. Kim, G.N. Lau, B. Wang. World Scientific Series on Asia-Pacific Weather and Climate, Vol. 11. World Scientific, Singapore, https://doi.org/10.1142/11723.

Role of the mean state moisture gradient on the propagation of the MJO across the Maritime Continent

Daehyun Kim





- The interannual variability of the seasonal mean meridional moisture gradient (MMG) over the southern MC area is associated an ENSO-like SST anomalies.
- MJO propagation through the MC is enhanced (suppressed) in years with higher (lower) seasonal mean MMG, which modulating the meridional advection of the mean moisture via MJO wind anomalies.
- The background moisture distribution has a strong control over the propagation characteristics of the MJO in the MC region

Kang, D., **D. Kim**, M.-S. Ahn, and S.-I. Ahn, 2021: The role of background meridional moisture gradient on the propagation of the MJO over the Maritime Continent, *J. Climate*, **34**, 6565-6581, https://doi.org/10.1175/JCLI-D-20-0085.1.

BMKG

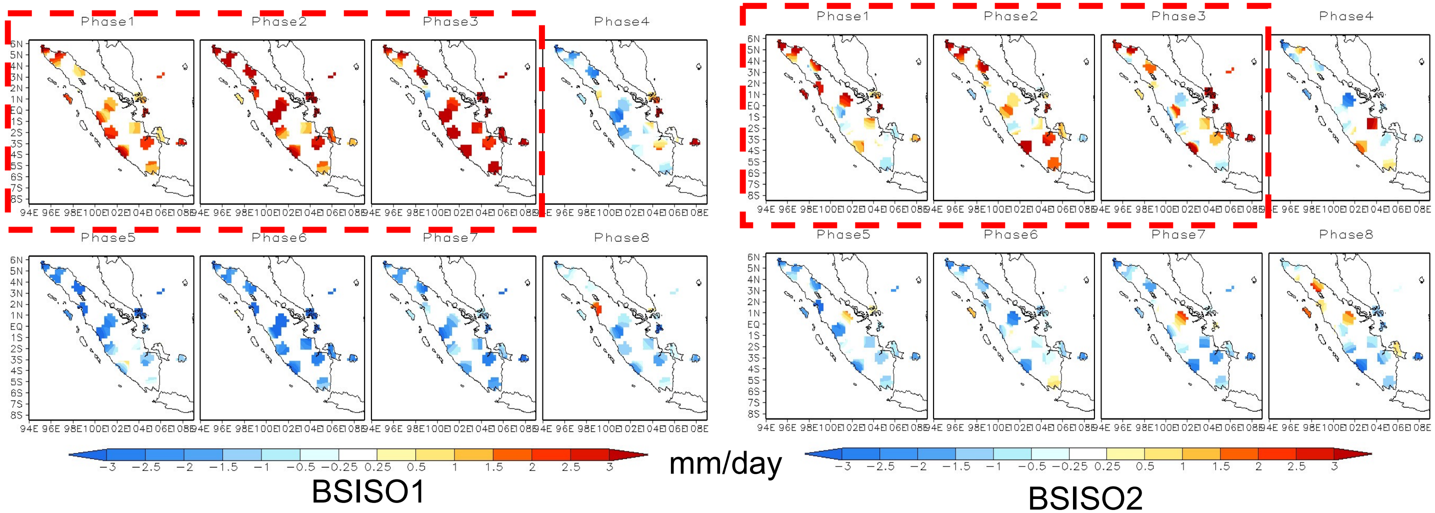
Donaldi Permana

MJO/BSISO, observed impact on observation in the Maritime Continent

- Sagita, N., **Permana., D.S.**, Supriyadi, S (2021). Impact of boreal summer intraseasonal oscillation (BSISO) on in-situ rainfall in Sumatera, Indonesia (in Indonesian, published in National Conference Proceeding)

- **Permana., D.S**, Supari. Impacts of the MJO on Rainfall at Different Seasons in Indonesia. Presented in 2nd International Conference on Tropical Meteorology and Atmospheric Sciences (ICTMAS, March 2021). This paper discusses the impact of MJO on rainfall in Indonesia using in-situ and satellite data

- As part of WCSSP Southeast Asia,
  - Collaborating with Simon Peatman (Univ. Reading, UK) and Prince Xavier on a project Mesoscale Convective Scale (MCS) Tracking over Southeast Asia and its relationship with tropical waves.
  - Weather regimes for SE Asia (including links to modes of variability) and sub-seasonal predictability (project led by Oscar Martinez Alvarado, Univ. Reading, UK)



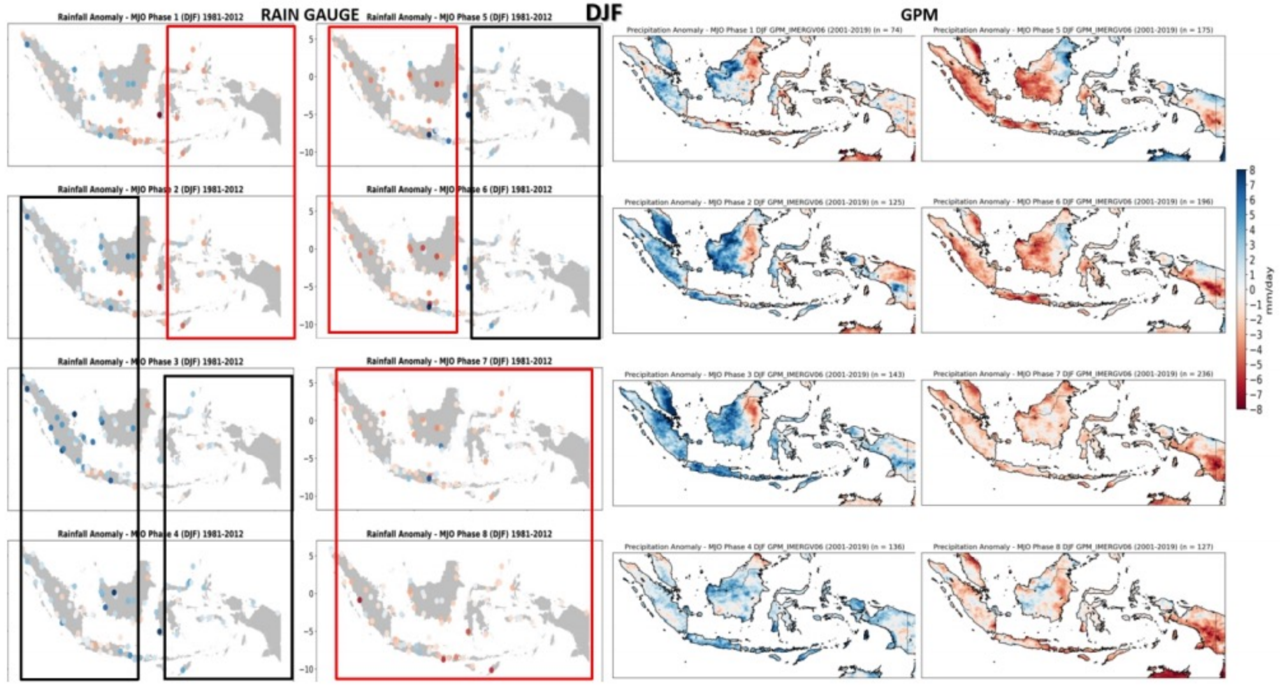


Figure 4. (Left panel) Rainfall anomalies for each MJO phase from station data during DJF. Black (Red) boxes indicate the region with dominant positive (negative) rainfall anomalies. (Right panel) Rainfall anomalies for each MJO phase from GPM IMERGV06 data during DJF.

BMKG

Indonesia Agency for Meteorology,
Climatology and Geophysics

Donaldi Permana

MJO, equatorial waves triggering extreme rainfall and floods in Indonesia

- Paski, J. A. I., **Permana, D. S**., Alfuadi, N., Handoyo, M. F., Nurrahmat, M. H., & Makmur, E. E. (2021, March). A multiscale analysis of the extreme rainfall triggering flood and landslide events over Bengkulu on 27th April 2019. In AIP Conference Proceedings (Vol. 2320, No. 1, p. 040019). AIP Publishing LLC. https://doi.org/10.1063/5.0037508. This paper discusses the combination of tropical waves triggering the flood and landslide events in South Sumatra.

- J A I Paski, E E S Makmur, **D S Permana**, A S Praja, M H Nurrahmat, N F Riama, W Fitria, Hartanto. Analysis of Multi-Scale Hydrometeorological Triggering Flash Flood Event of the 13 July 2020 in North Luwu, South Sulawesi. Presented in 2nd International Conference on Tropical Meteorology and Atmospheric Sciences (ICTMAS, March 2021). This paper discusses the combination of tropical waves triggering the flood and landslide events in South Sulawesi

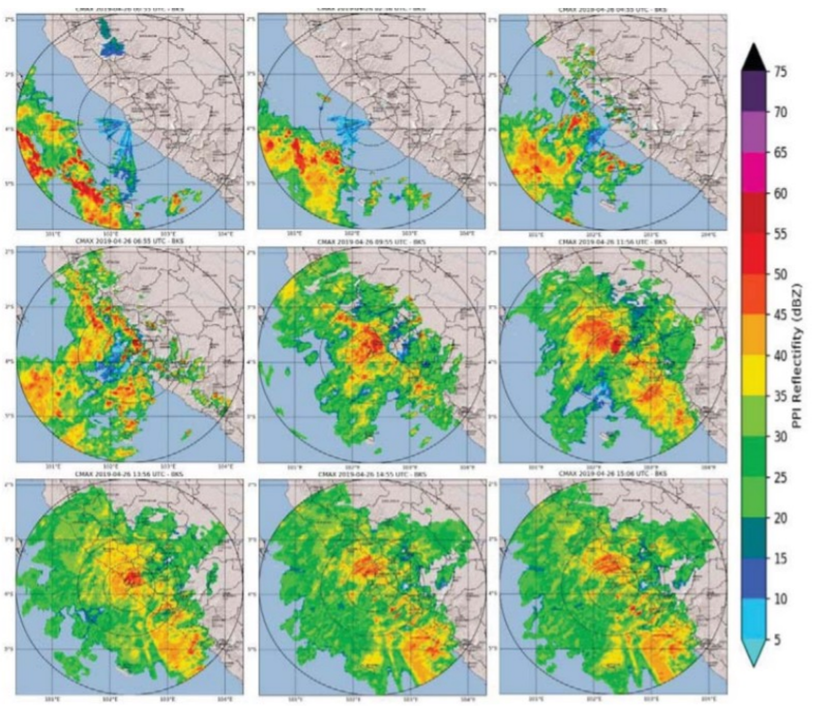


FIGURE 7. The hourly column maximum CMAX reflectivity product of BMKG Bengkulu weather radar indicates MCS moving from Ocean to Bengkulu Province on 26 April 2019 at 00:55 UTC (07.5 LT) until 26 April 2019 at 15:06 UTC (22.06LT)

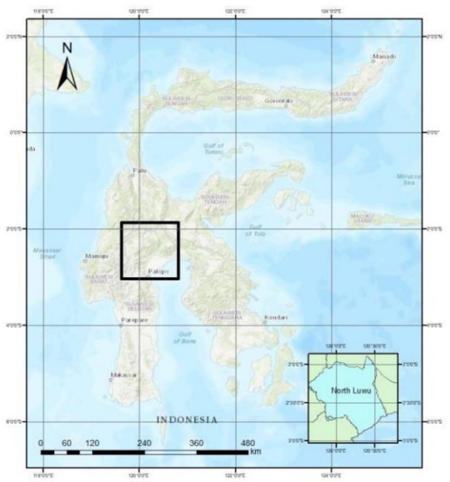


Figure 1. North Luwu regency as the research area.

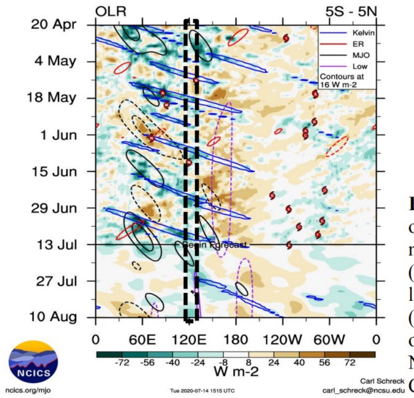
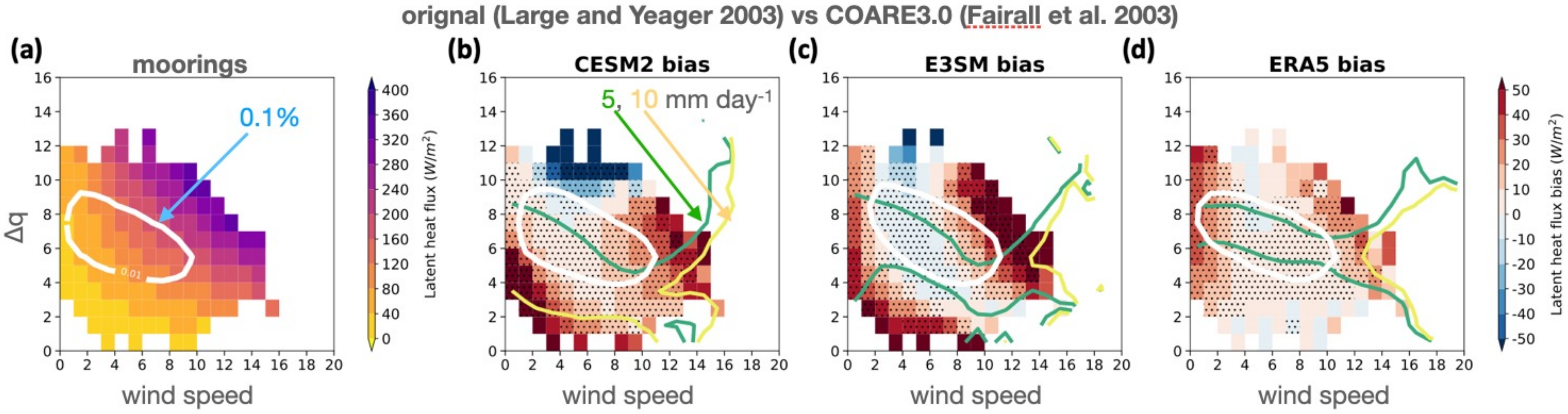


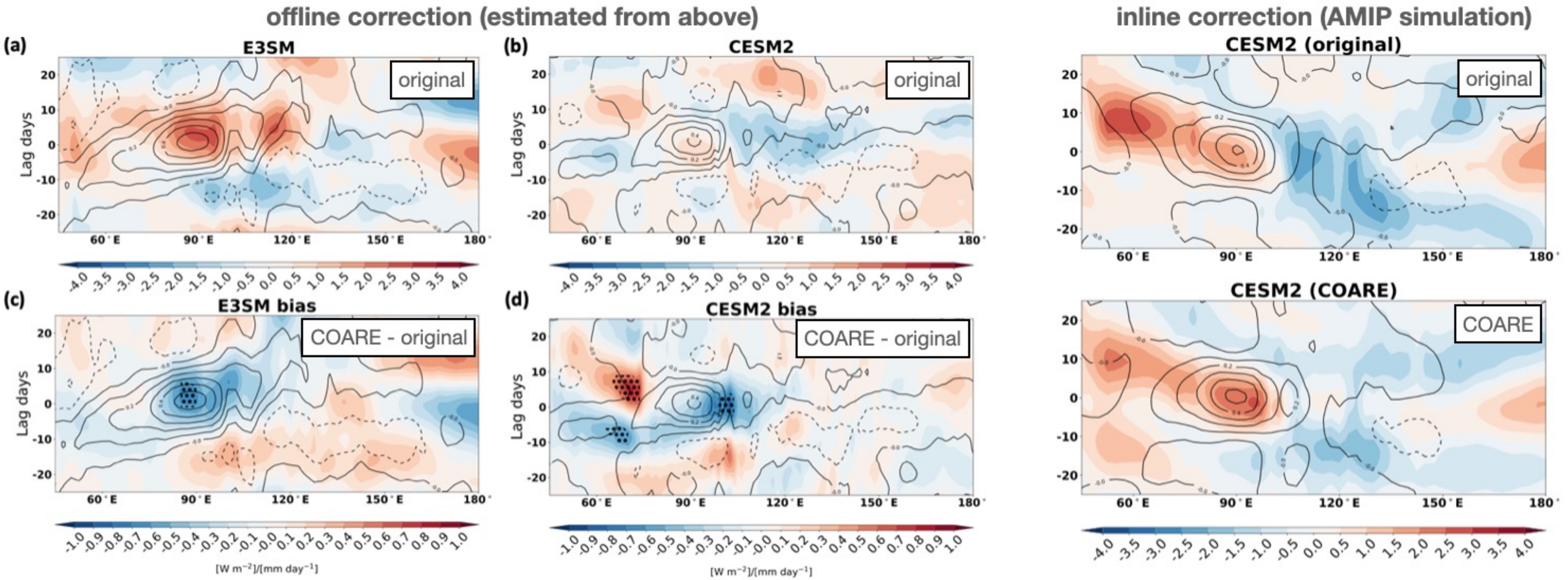
Figure 8. Hovmöllers diagrams of OLR anomalies for monitoring the tropical waves (MJO, ER, and Kelvin) in latitudinal averaging of 5S-5N (with black box is the location of North Luwu regency) from North Caroline Institute for Climate Studies (NCICS)

Research highlights

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.

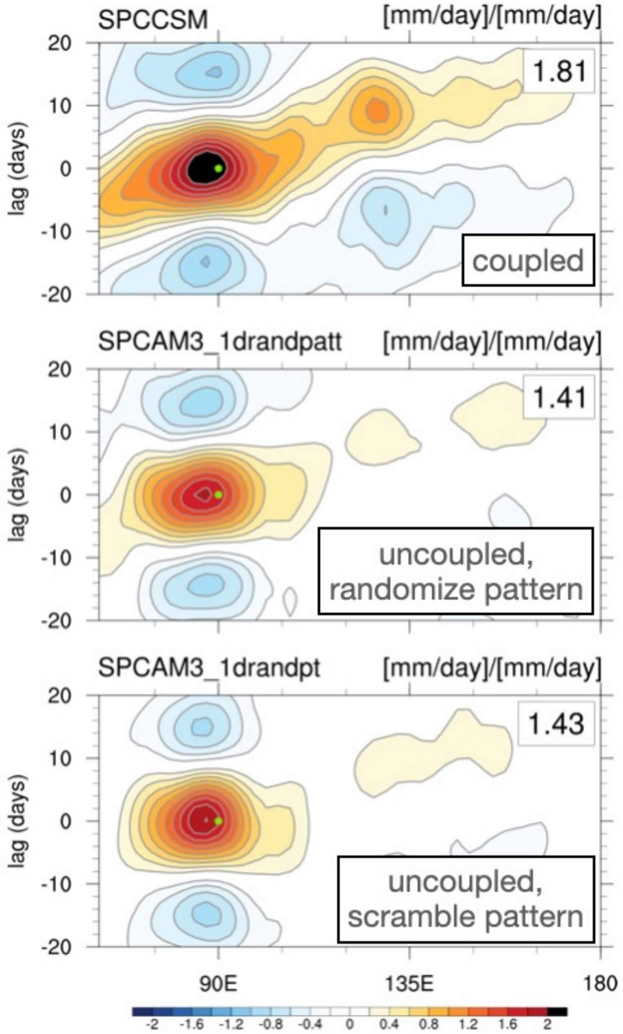
DeMott and Chia-Wei Hsu (CSU): bulk flux algorithms and the MJO

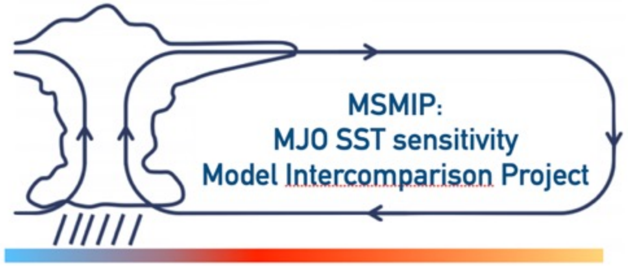




MJO SST sensitivity Model Intercomparison Project (MSMIP)

Coupled SSTAs have phasing, patterns, and persistence.
Which is most important for coupled feedbacks to MJO?





EXPERIMENTS

- CGCM with daily SST output
- AGCM_mon: prescribe monthly mean SSTs (remove all sub-monthly SSTA variability)
- AGCM_1drandpt: prescribe shuffled daily SSTA (scramble patterns)
- AGCM_1drandpatt: prescribe shuffled daily SSTA (retain pattern)
- AGCM_5drandpatt: prescribe shuffled 5-day SSTA blocks (retain pattern, persistence)

- project provides code to perform SSTA shuffling
- output to be stored at NCAR
- interest to date: CESM2, E3SM, GISS, KIOST-ESM
- will advertise project at AGU 2021
- project website under development

MJO Task Force publications

Adames, Á. F., D. Kim, E. D. Maloney, and A. H. Sobel, 2021: The moisture mode framework of the Madden-Julian Oscillation, Chap. 22 in The Multiscale Global Monsoon System, Eds: C.P. Chang, K.J. Ha, R. H. Johnson, D. Kim, G.N. Lau, B. Wang. World Scientific Series on Asia-Pacific Weather and Climate, Vol. 11. World Scientific, Singapore, https://doi.org/10.1142/11723.

Barton, N. P., and Co-Authors: The Navy's Earth System Prediction Capability: A new global coupled atmosphere-ocean-sea ice prediction system designed for daily to subseasonal forecasting. Earth and Space Sci.

Domeiesen, D. I. V. and Co-Authors: Advances in the subseasonal prediction of extreme events. (B.A.M.S. / Major Rev.)

Hansen, K. A., S. J. Majumdar, B. P. Kirtman, and M. A. Janiga. Testing vertical wind shear and nonlinear MJO/ENSO interactions as predictors for subseasonal Atlantic tropical cyclone forecasts. (Wea. Forecasting / Major Rev.)

Janiga, M. A., C. A. Reynolds, S. Rushley, S. Chen, and C. J. Schreck III. Subseasonal tropical prediction skill in the Navy Earth System Prediction Capability. (In Prep.)

Jiang, X., D. Kim, E. D. Maloney, 2021: Progress and Status of MJO Simulation in Climate Models and Process-Oriented Diagnostics, Chap. 25 in The Multiscale Global Monsoon System, Eds: C.P. Chang, K.J. Ha, R. H. Johnson, D. Kim, G.N. Lau, B. Wang. World Scientific Series on Asia-Pacific Weather and Climate, Vol. 11. World Scientific, Singapore, https://doi.org/10.1142/11723.

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Kim. H., J. M. Caron, J. H. Richter, and I. R. Simpson, 2020: The lack of QBO-MJO connection in CMIP6 models, Geophys. Res. Lett. https://doi.org/10.1029/2020GL087295

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Kim H., Y. G. Ham, Y. S. Joo, S. W. Son, 2021: Deep Learning for bias correction of MJO prediction, Nature Communications, 12, 3087, https://doi.org/10.1038/s41467-021-23406-3

Kodama, C., and coauthors, 2020: The Nonhydrostatic Cosahedral Atmospheric Model for CMIP6 HighResMIP simulations (NICAM16-S): experimental design, model description, and impacts of model updates. Geosci. Model Dev., 14, 795–820, doi:10.5194/gmd-14-795-2021.

Lyu, M., X. Jiang, Z. Wu, D. Kim, and A. F. Adames, 2021: Zonal-Scale of the Madden-Julian Oscillation and Its Propagation Speed on the Interannual Time-Scale. Geophys. Res. Lett., 48, e2020GL091239, 10.1029/2020GL091239.

Martin, Z., E. Barnes, and E. Maloney: Using simple, explainable neural networks to predict the Madden-Julian oscillation, submitted to JAMES, preprint at ESSOAR

Martin, Z., C. Orbe, S. Wang, and A. Sobel, 2021: The MJO-QBO relationship in a GCM with stratospheric nudging, J. Clim., 34(11), 4603-4624

Martin Z., S. W. Son, A. Butler, H. Hendon, H. Kim, A. Sobel, S. Yoden, C. Zhang, 2021: The influence of the Quasi-Biennial oscillation on the Madden-Julian oscillation, Nature Reviews - Earth & Environment, https://doi.org/10.1038/s43017-021-00173-9

Meehl G. et al., 2021: Initialized Earth system prediction from subseasonal to decadal timescales, Nature Reviews - Earth & Environment, https://doi.org/10.1038/s43017-021-00155-x

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Richter J., K. Pegion, L. Sun, H. Kim, J. Caron, A. Glanville, S. Yeager, W. Kim, A. Tawfik, 2021: Subseasonal prediction with and without a well-represented stratosphere in CESM1. Wea. Forecasting, doi: https://doi.org/10.1175/WAF-D-20-0029.1

Rushley, S. S., M. A. Janiga, J. A. Ridout, C. A. Reynolds. The impact of mean state moisture biases on MJO skill in the Navy ESPC. (Sub. to Mon. Wea. Rev.)

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Xavier, P., and coauthors, 2020: Seasonal Dependence of Cold Surges and their Interaction with the Madden–Julian Oscillation over Southeast Asia, J. Climate (DOI: 10.1175/JCLI-D-19-0048.1)

Zheng, C., E. K. M. Chang, H. Kim, M. Zhang, W. Wang, 2021: Subseasonal Prediction of Wintertime Northern Hemisphere Extratropical Cyclone Activity by SubX Models, Wea. Forecasting, 36(1), 75-89

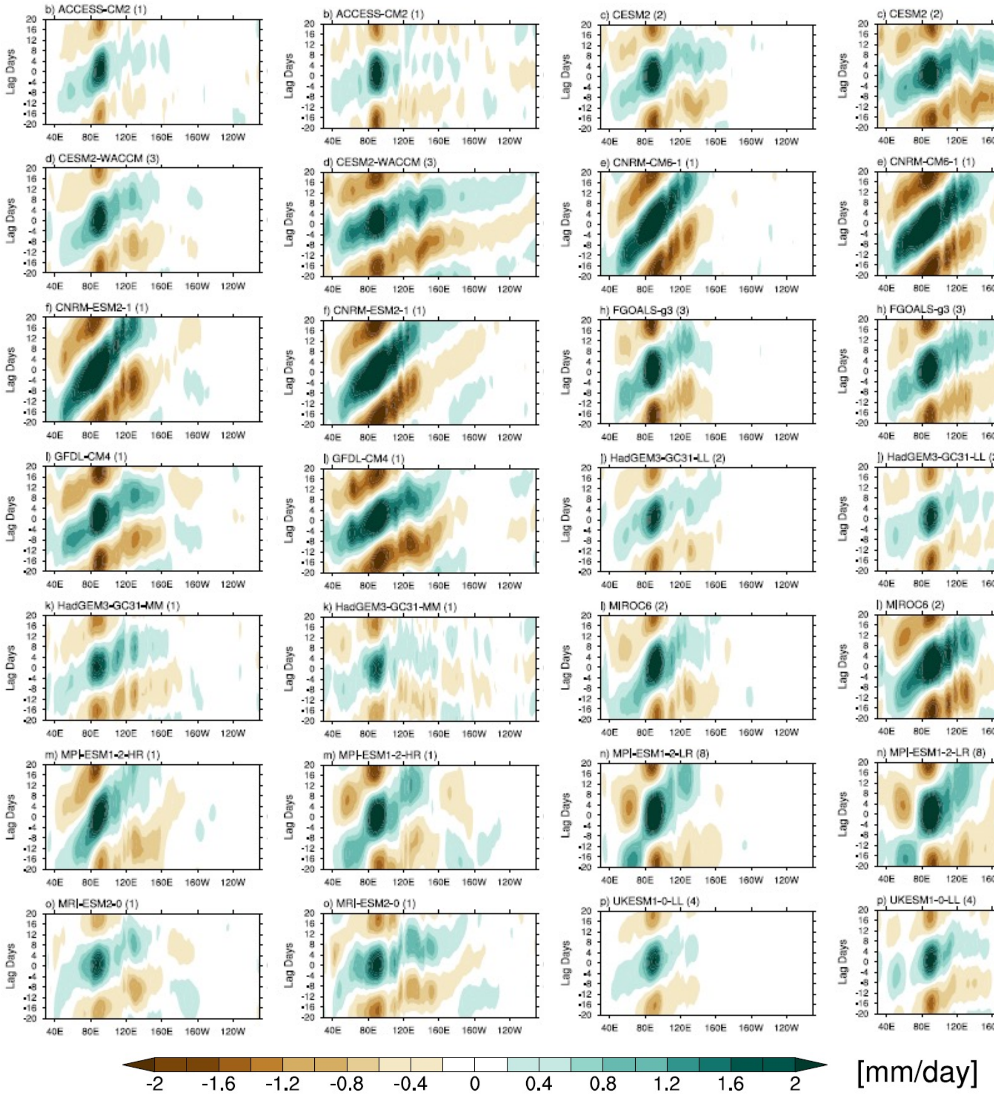
Zhou Y., H. Kim, D. E. Waliser, 2021: Atmospheric River lifecycle responses to the Madden Julian Oscillation, Geophys. Res. Lett. 48, e2020GL090983.

MJO simulation: Future change in CMIP6

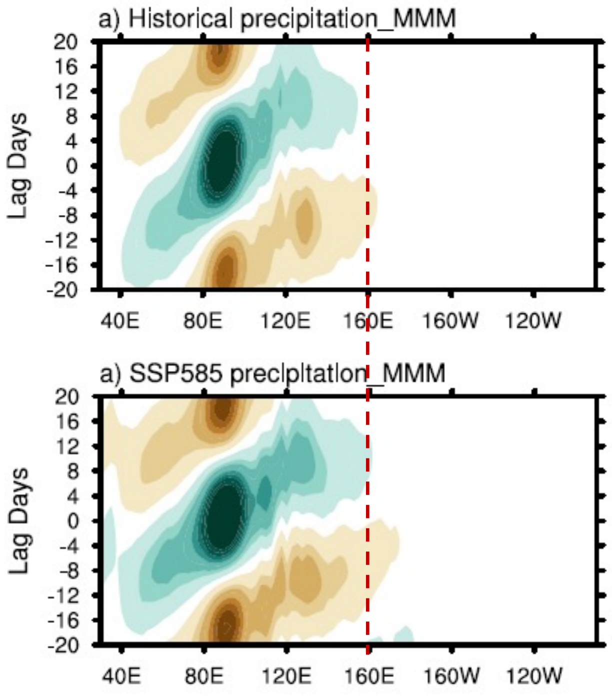
Hyemi Kim

MJO propagation: Historical vs. Future (14 CMIP6 models)

Historical | Future | Historical | Future

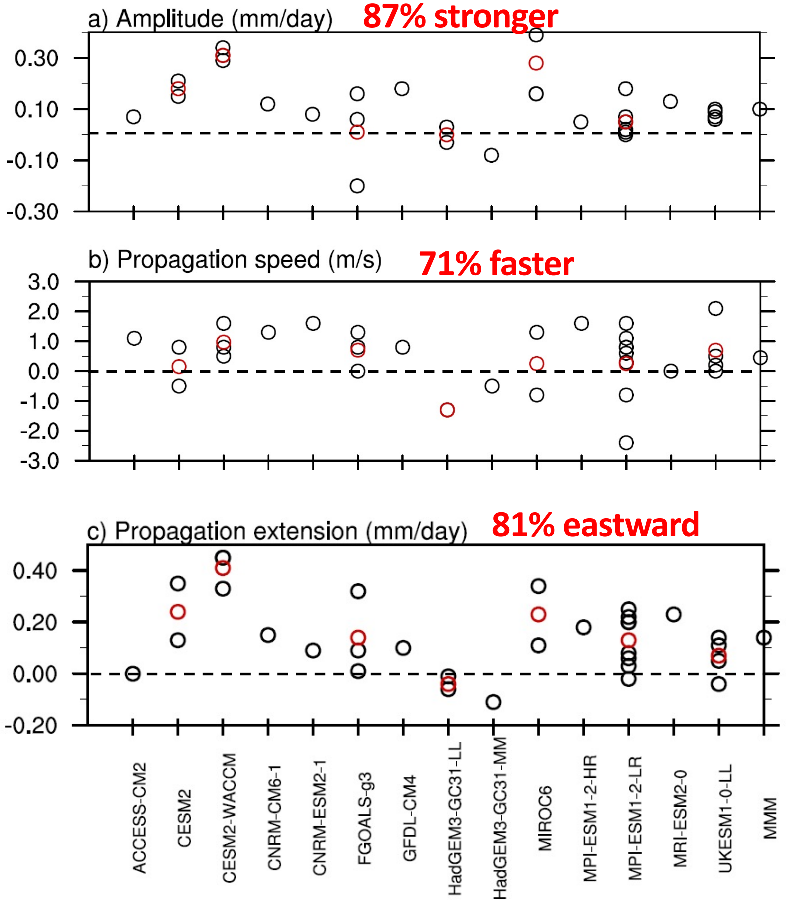


Multi-model mean



Wang et al. (in prep)

MJO activity change



- 14 CMIP6 models' historical and SSP585 simulations are assessed.
- Future MJO convection in boreal winter: Stronger amplitude, faster propagation speed, more eastward extension.

Characterizing MJO variability and Predictability Using Machine Learning

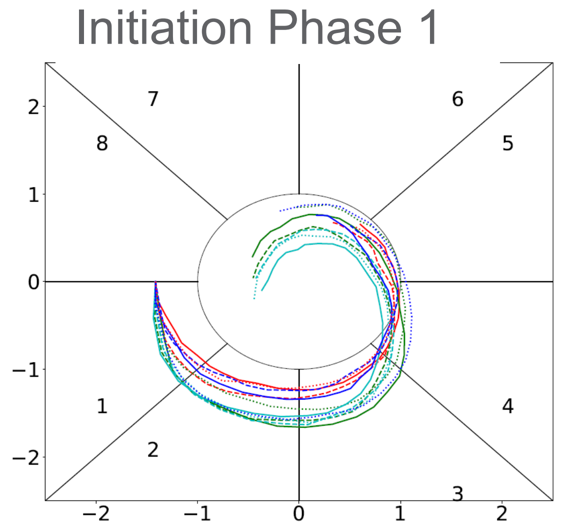
Samson Hagos

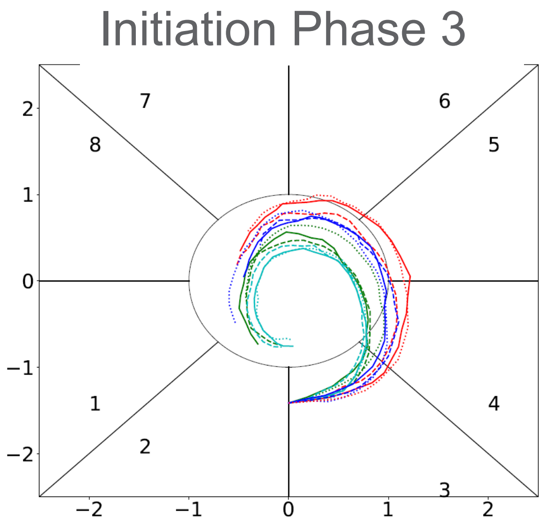
The Question: How does the background state influence the initiation, variability and predictability of MJO events

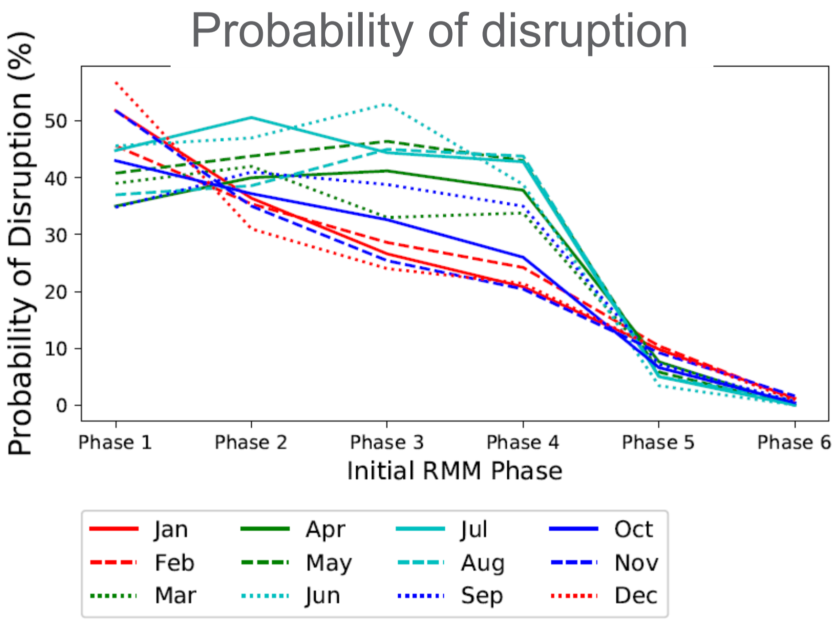
Approach: Develop, train and run a Markovian surrogate stochastic model

The model $P(\Delta rmm = \Delta RMM_i | S_t)$ where $S_t = [rmm, SC, ENSO, QBO, IOD]$

The effect of seasonality on the probability of disruption

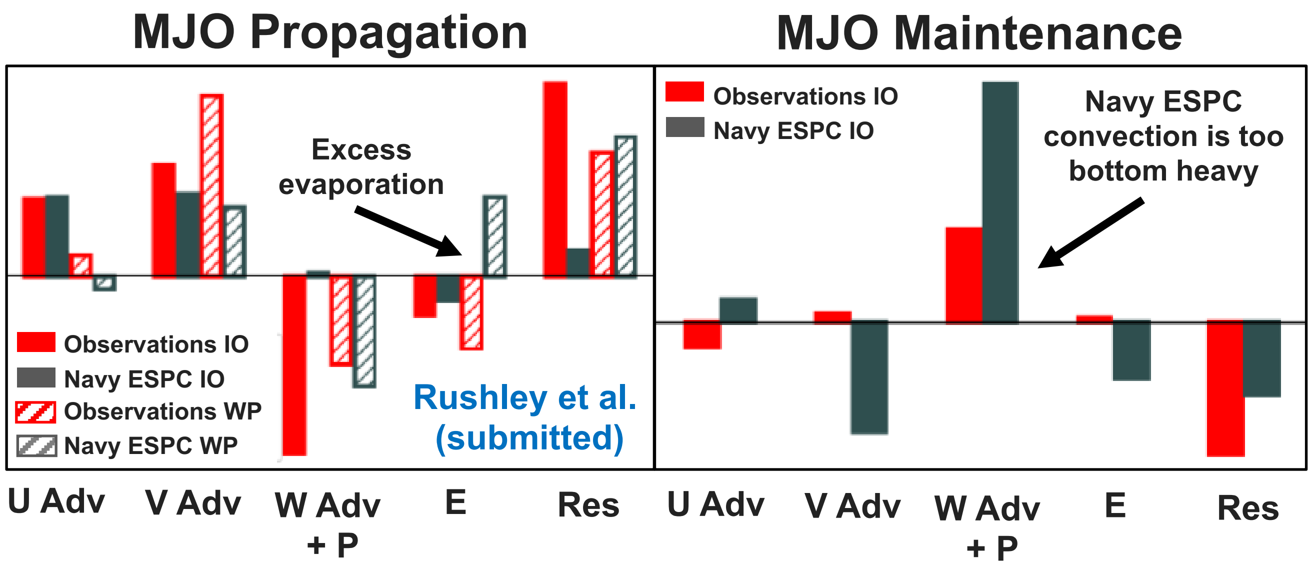






- As found in Hagos et al. (2019 GRL) because of zonal component of seasonality MJO events propagate from one "season" to another. Thus, the probability of their disruption depends on which "direction" they are propagating

Matthew A. Janiga: Science Highlights

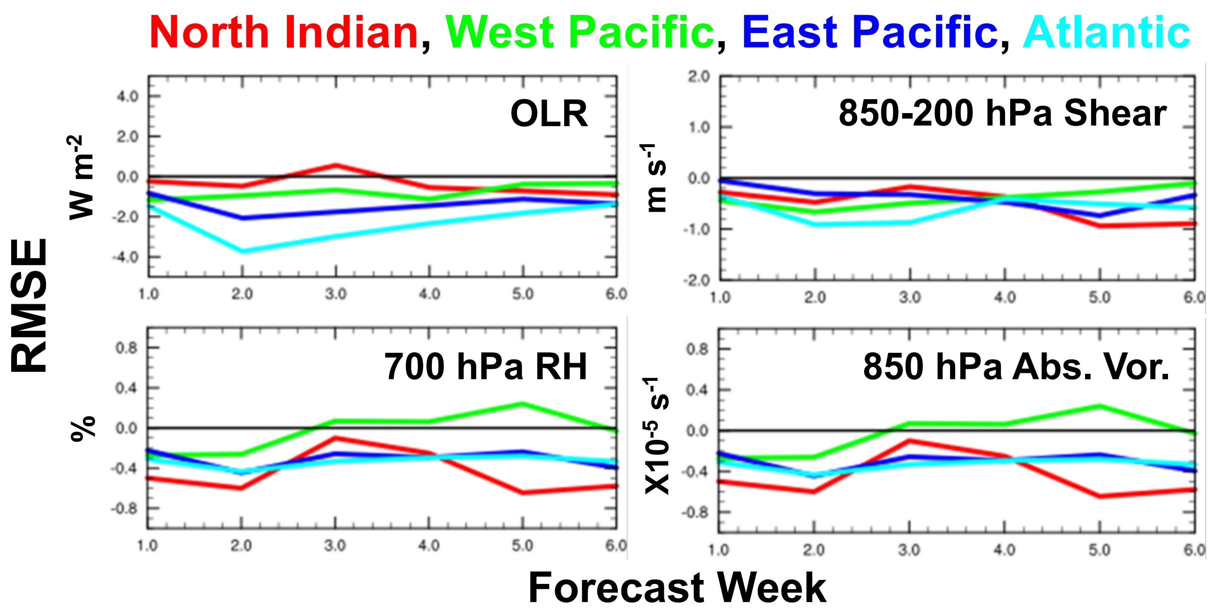


- The Navy ESPC 16-member ensemble has now been running operationally since May 2020. Navy ESPC v2 is targeted for completion at the end of FY22.
- Examinations of the moisture budget in Navy ESPC forecasts performed for the Subseasonal eXperiment (SubX) show that the too-fast propagation is due to excess evaporation and the too-strong amplitude is due to excess vertical moisture advection. **Moisture budget terms for DJF 2009-2015 forecasts (Top Figure).**

- Navy ESPC experiments performed with Analysis Correction-based Additive Inflation (ACAI) (Crawford et al. 2020), wherein analysis-derived tendencies are applied during model integration, yield broad improvements in model biases including the MJO and TC-related fields. **Navy ESPC RMSE (ACAI-Control) for JJASON 2020 forecasts (Bottom Figure).**

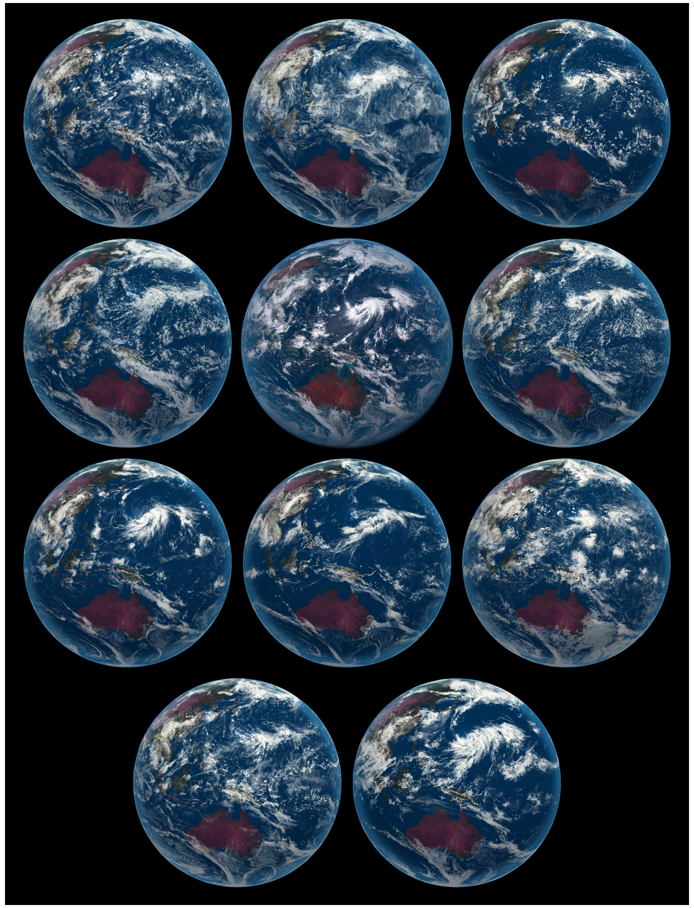
Other Research:

- Examining the role of the MJO in statistical-dynamical subseasonal TC prediction (Hansen et al. *In Review*).
- Relating MJO performance to TC genesis potential index skill in Navy ESPC and S2S database models (Janiga et al. *In Prep.*)



Tomoki
Miyakawa

The Phase 2 of DYAMOND targets EUREC4A intensive observation campaign (2020 JAN-FEB) and the winter MJO.



DYAMOND, a collection of sub-5km mesh "global storm resolving" models.
(Stevens et al., 2019)

Participating models for **DYAMOND2**

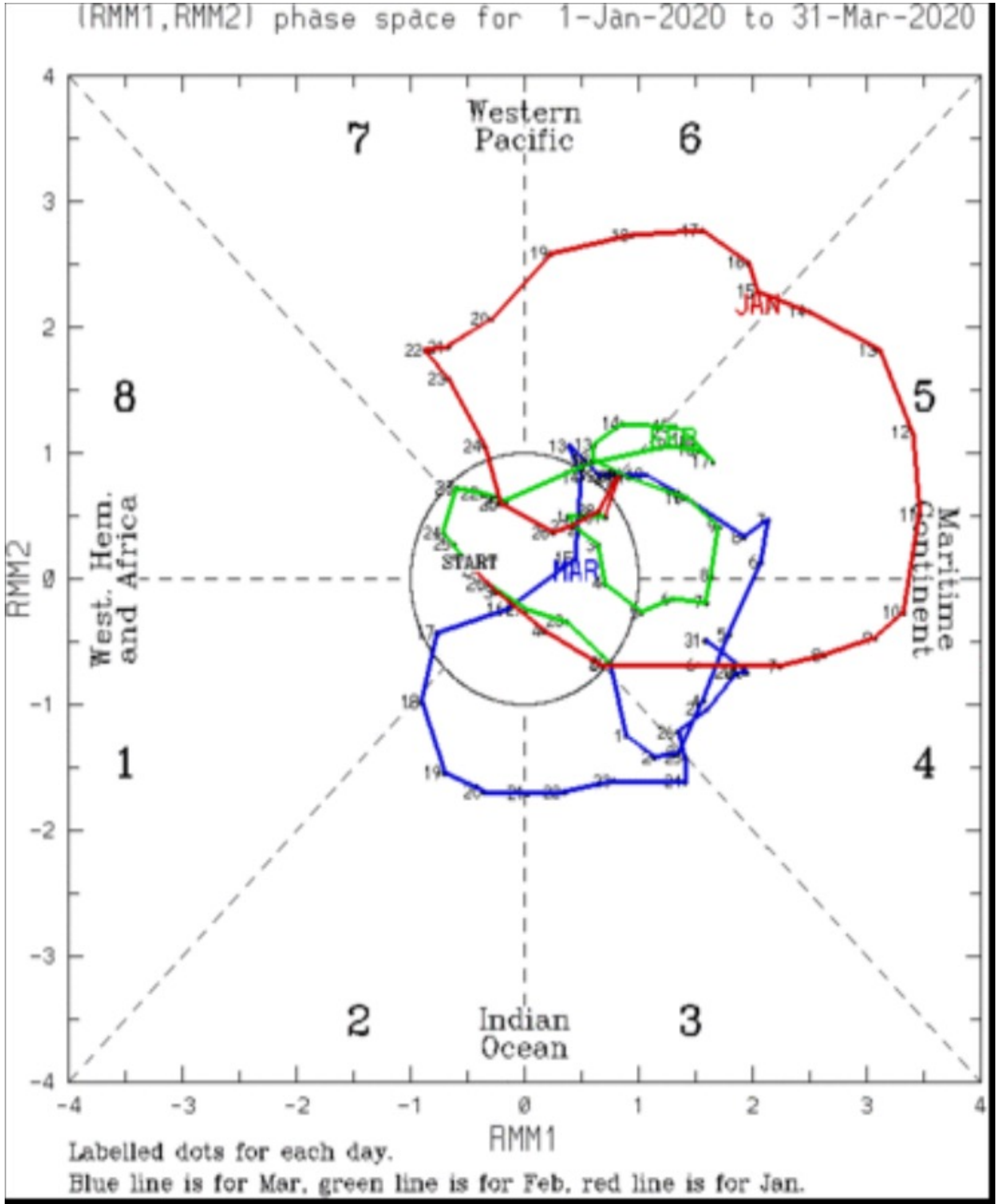
NICAM, ICON, IFS, ARPEGE, GEM, GEOS, MPAS, NEPTUNE, SHiELD, SAM, SCREAM, UM

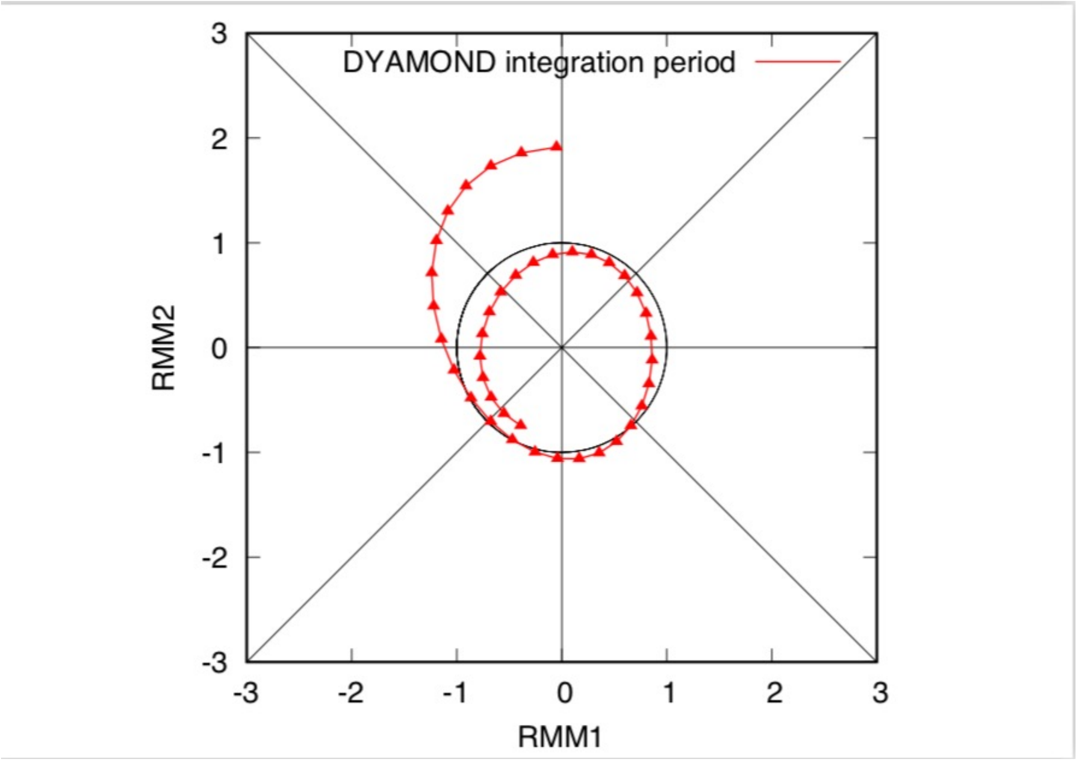
Most of the data now at DKRZ, thanks to Florian Ziemen and participants.

lead by Daniel Klocke (MPI) and
Tomoki Miyakawa (Univ. Tokyo, **MJO-TF**)

Supplementary info for Daehyun

Tomoki Miyakawa

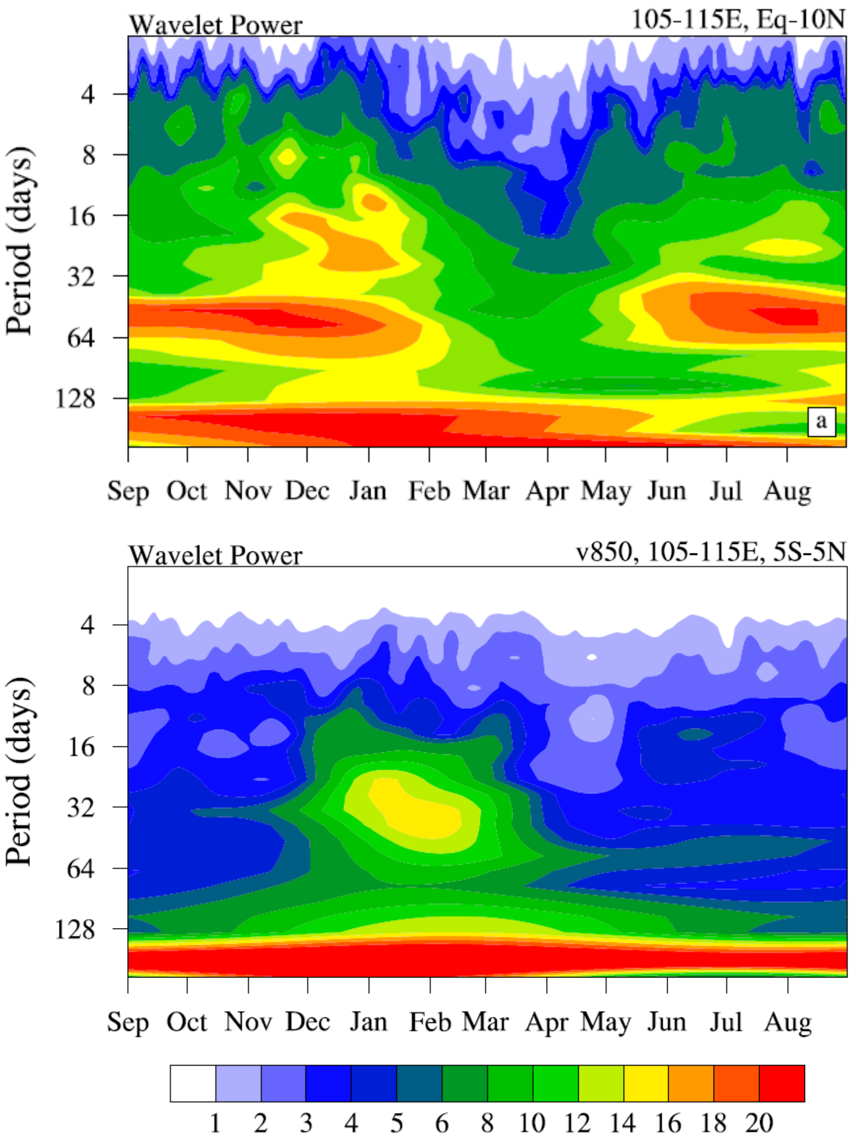




Observed RMM indices show a pretty good MJO signal during EUREC4A after filtering (right figure, by Suematsu).
(Filtering not available for the DYAMOND2 simulations.)
(Messy in real time calculation, 40days from JAN20.)

Seasonal interactions of MJO and cold surges over Maritime Continent

- Both the cold surges and the MJO undergo seasonal variations with well-defined regional features.
- Wavelet analysis shows that MJO amplitude and high-frequency rainfall variations over Southeast Asia peak in November–December.
- MJO amplitude is suppressed during February and March. This is associated with high-frequency surges of meridional winds that are prominent during the early part of the season, but February–March is dominated by low-frequency (20–90 days) cross-equatorial monsoon flow



Xavier et al (2020) Seasonal Dependence of Cold Surges and their Interaction with the Madden–Julian Oscillation over Southeast Asia, J. Climate (DOI: 10.1175/JCLI-D-19-0048.1)