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MJO Predictive Skill and Impacts in the Navy Earth System Model

Climate Diagnostics and Prediction Workshop 10/24/2018

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NRL[1], NC State[2]

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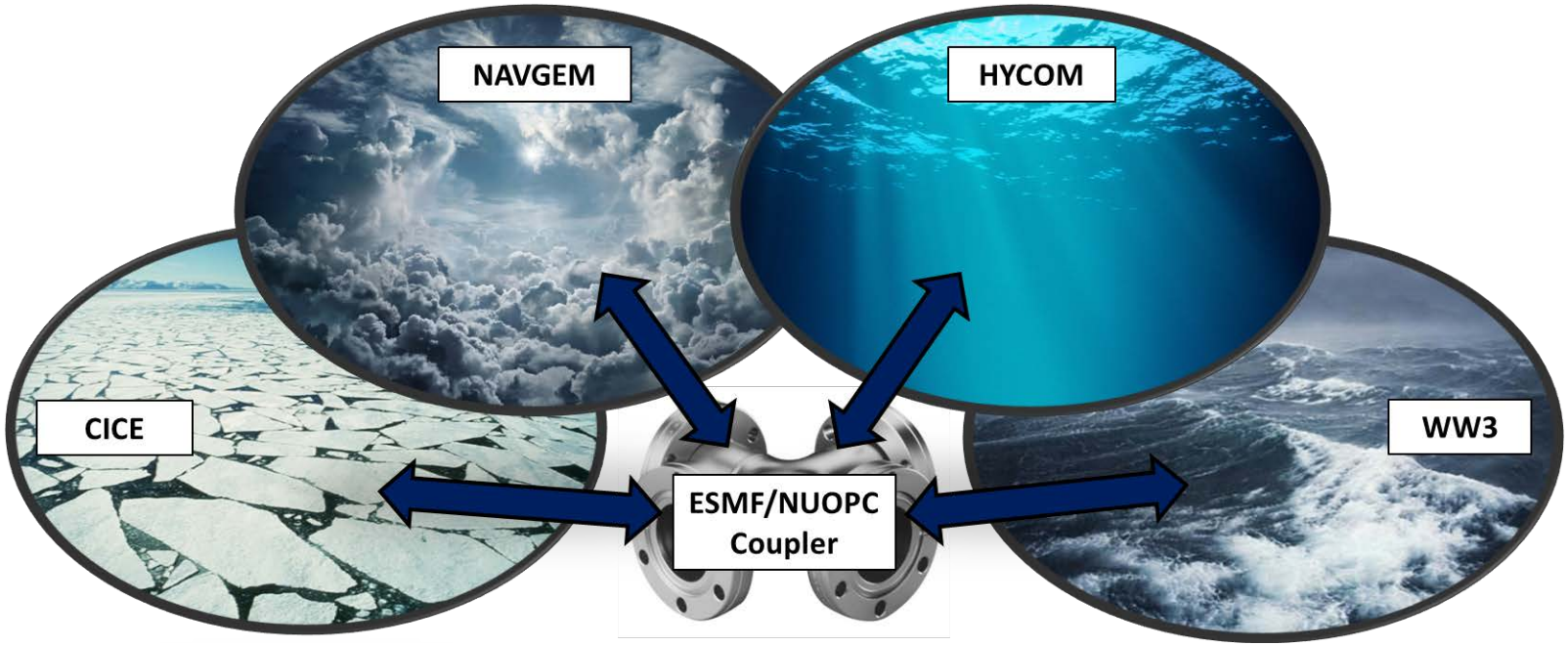
Navy Earth System Model



The Navy Earth System Model (NESM) is a global coupled model being developed for subseasonal-to-seasonal (S2S) sea ice, atmosphere, ocean, and wave prediction.

Overview

1) Wavenumber-frequency filtering diagnostics for subseasonal forecasts (Janiga et al. 2018).
2) Composite structure and evolution of the Madden-Julian Oscillation (MJO) in NESM.
3) Comparison of NESM to other models in the Subseasonal Experiment (SubX) archive.

Datasets

Observations:

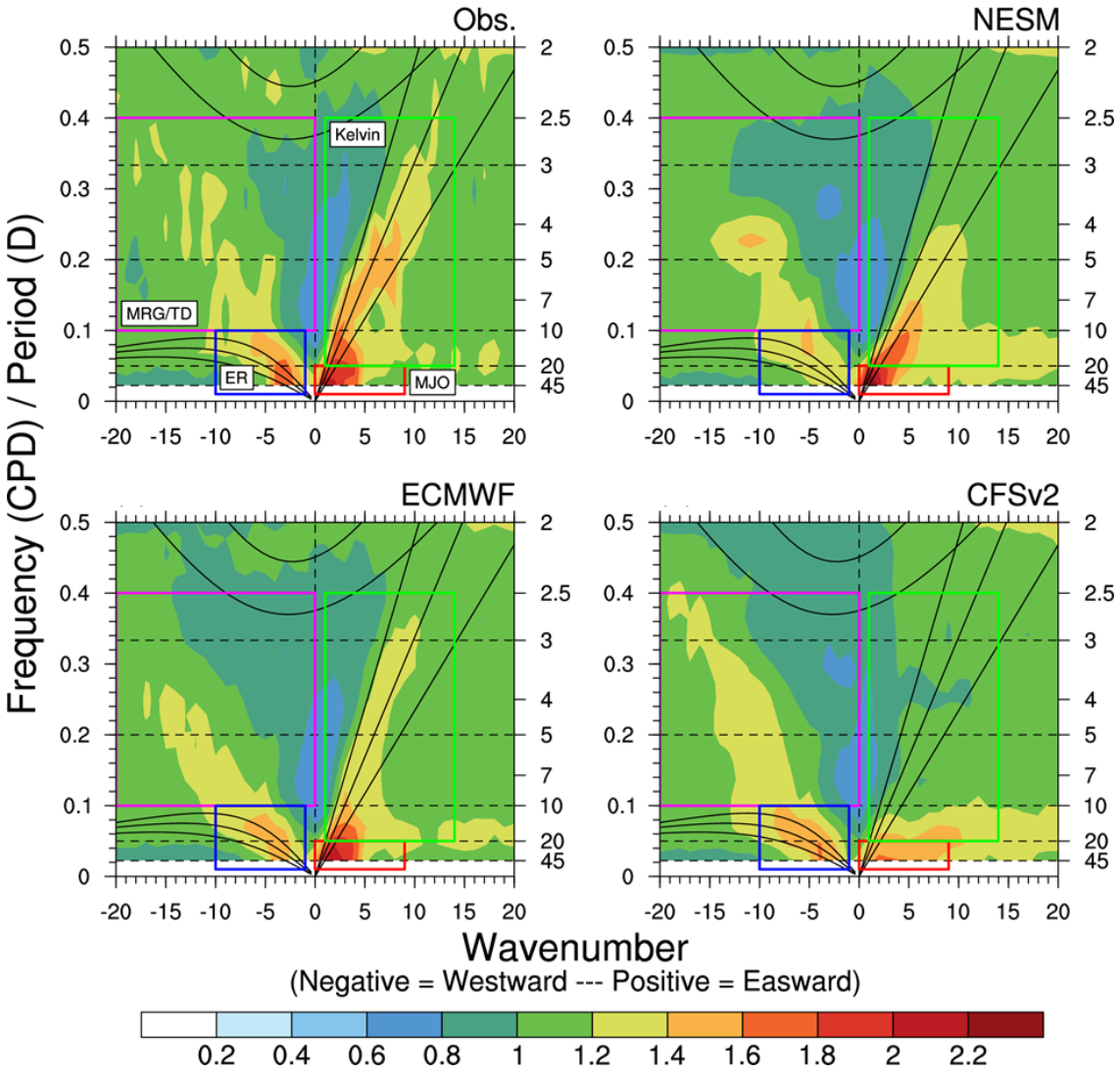
- NOAA OLR (Lee 2014): 2.5°x2.5° daily averages.
- ERA-Interim reanalyses (Dee et al. 2011): 2.5°x2.5° at 00Z and 12Z.

Models:

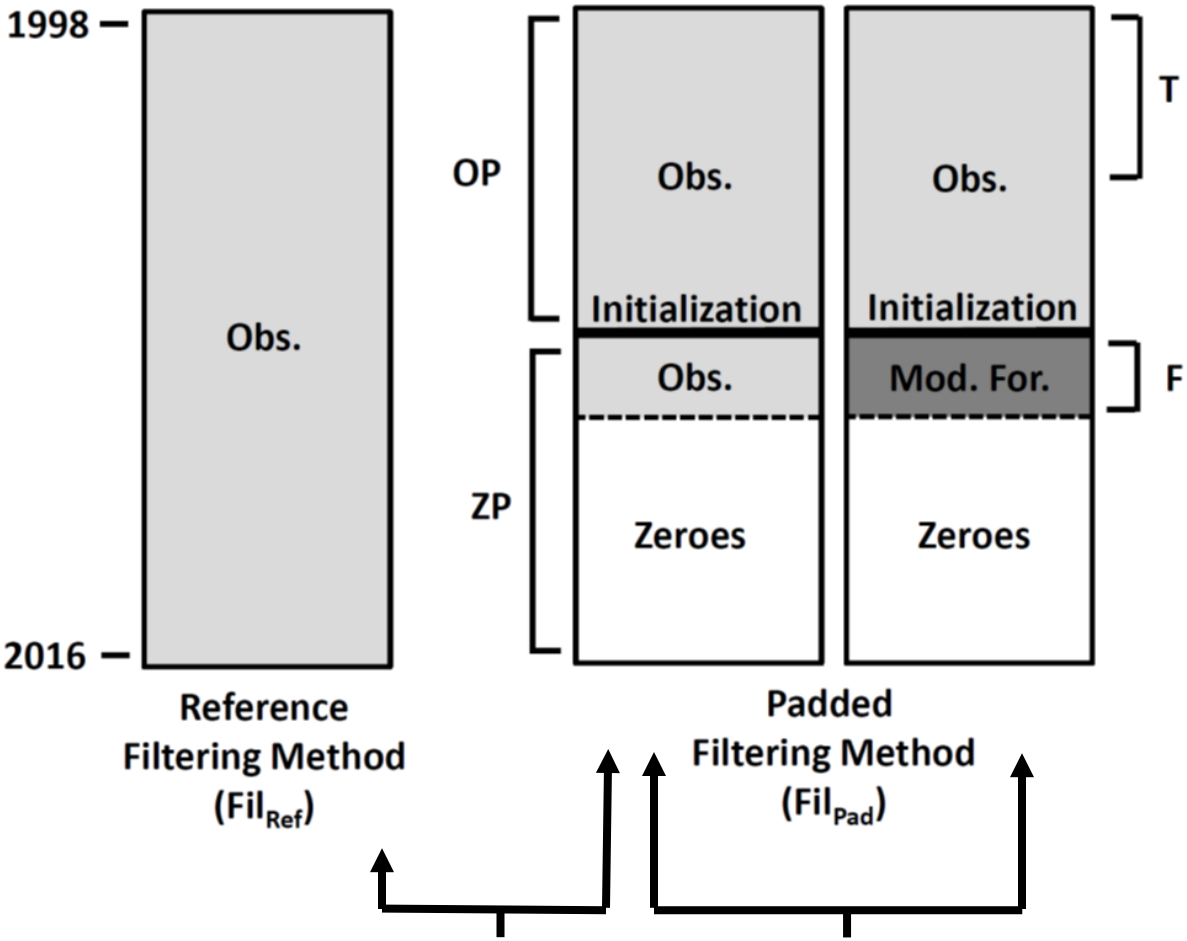
- NRL (NESM): 4x weekly initialization at 12Z.
- ECMWF (CY41R1): 2x weekly initialization 00Z.
- NCEP (CFSv2): Initializations at 00Z on every 5th day used.
- **Plus additional models from the Subseasonal Experiment (SubX)…**

Wavenumber-Frequency Filtering Methodology

Wavenumber-Frequency Spectra



Methodology



Where is filtering reliable?

How do the model and observations compare?

Janiga et al. (2018): Subseasonal Forecasts of Convectively Coupled Equatorial Waves and the MJO: Activity and Predictive Skill. *Mon. Wea. Rev.*

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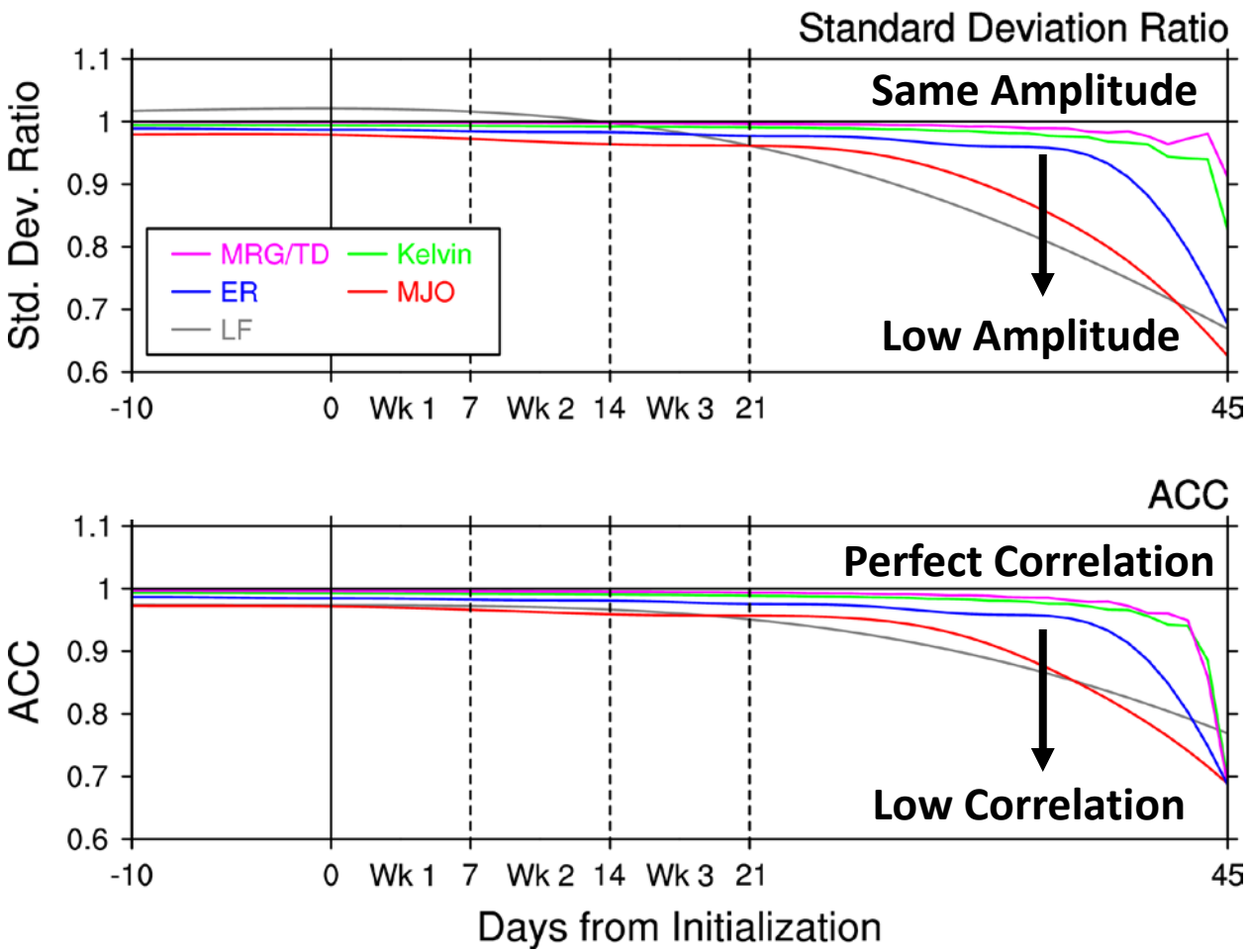
Methodology Evaluation



The padded filtering method is a good approximation for the reference filtering method over the first three weeks.

(top) Standard deviation ratio and (bottom) anomaly correlation between the padded and reference filtering methods over 30°S-30°N 1999-2015.

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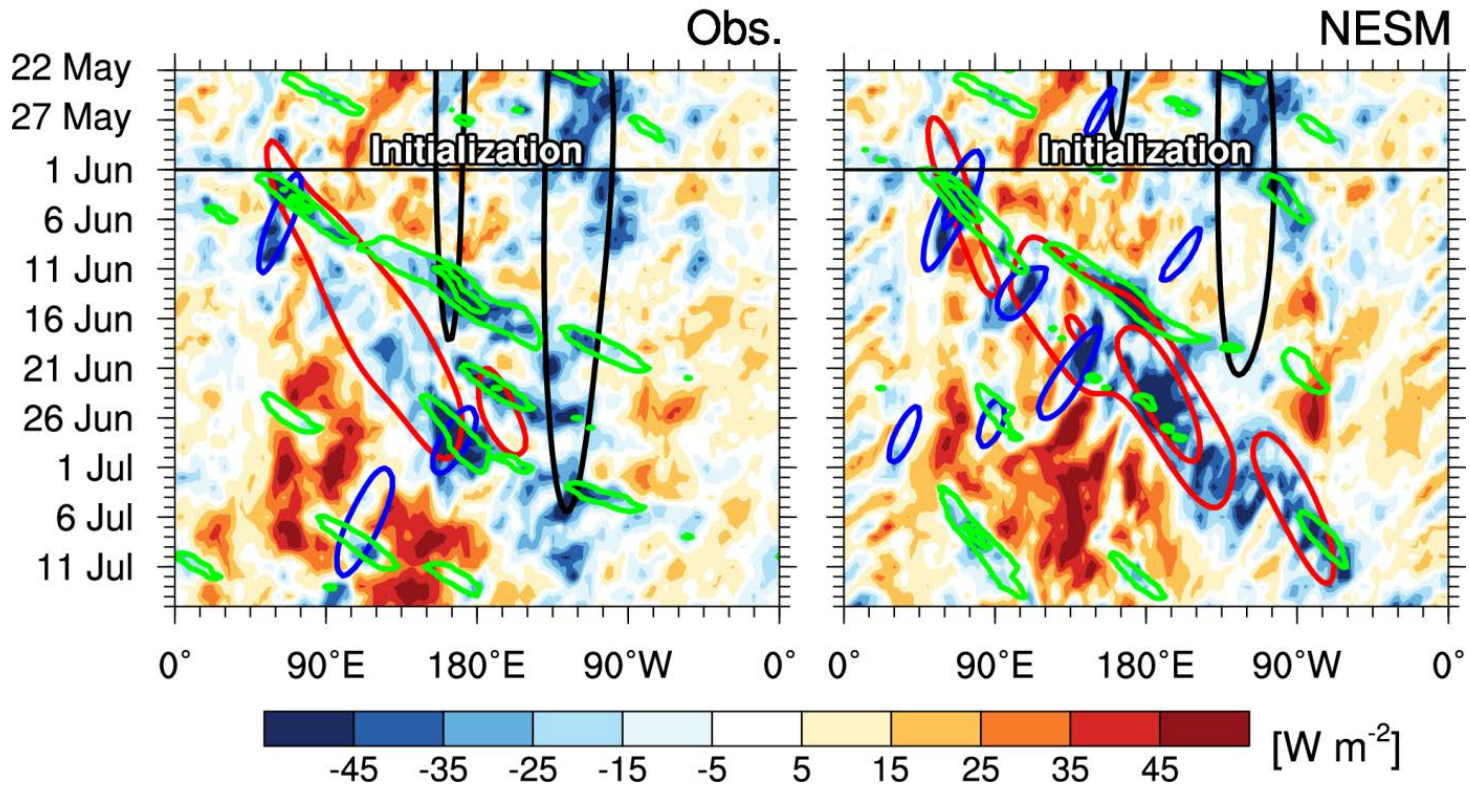
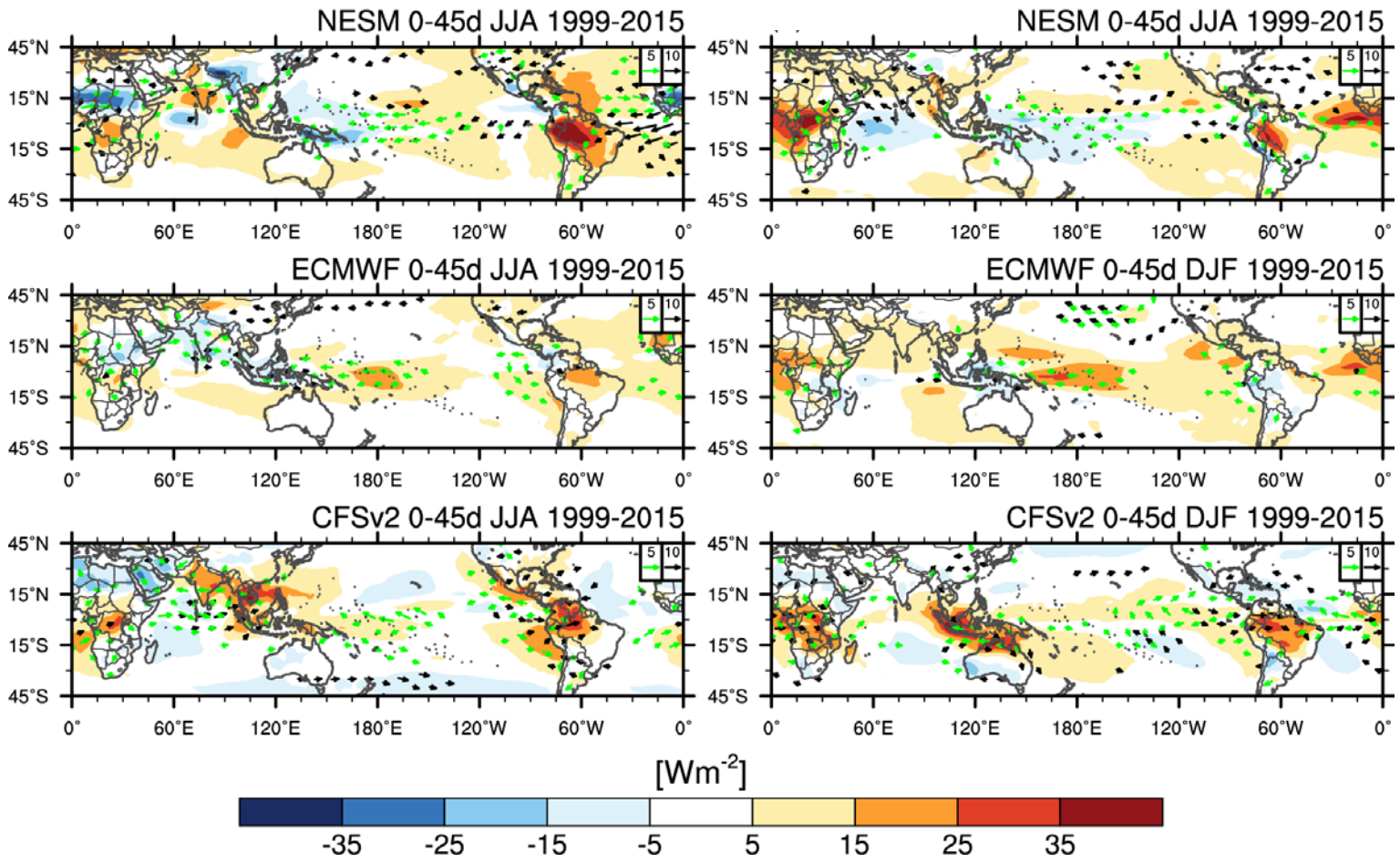
Example



OLR anomalies (10°S-10°N) from (a) satellite observations and (b) NESM. **>100 d,** **MJO**, **Kelvin**, and **ER** anomalies are contoured every 15 W m^{-2} and unfiltered OLR anomalies are shaded.

Mean Biases



Means biases of OLR (shaded, Wm^{-2}) and 850 hPa (green vectors, ms^{-1}) and 200 hPa (black vectors, ms^{-1}) winds integrated over F0-45 d during (left) JJA and (right) DJF.

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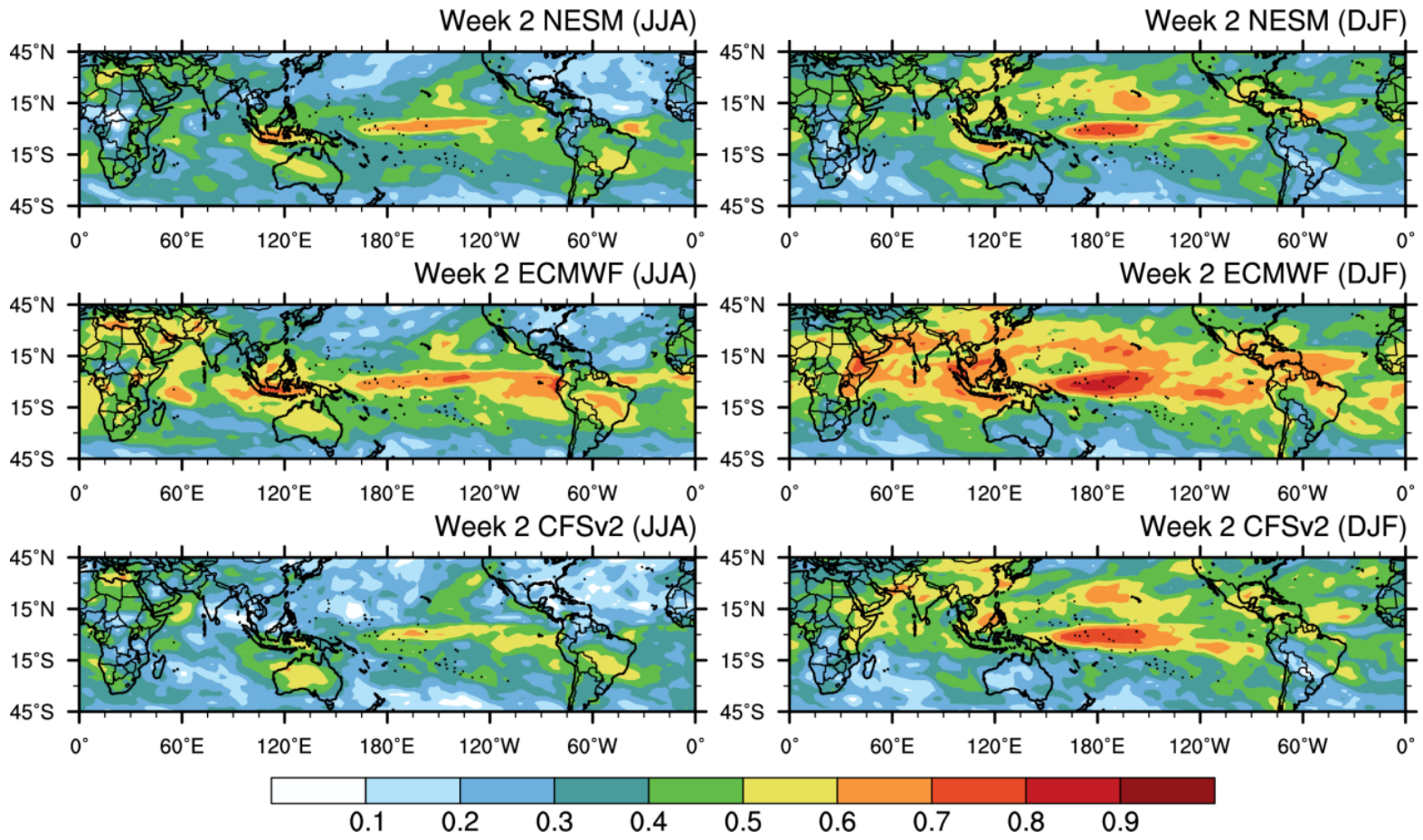
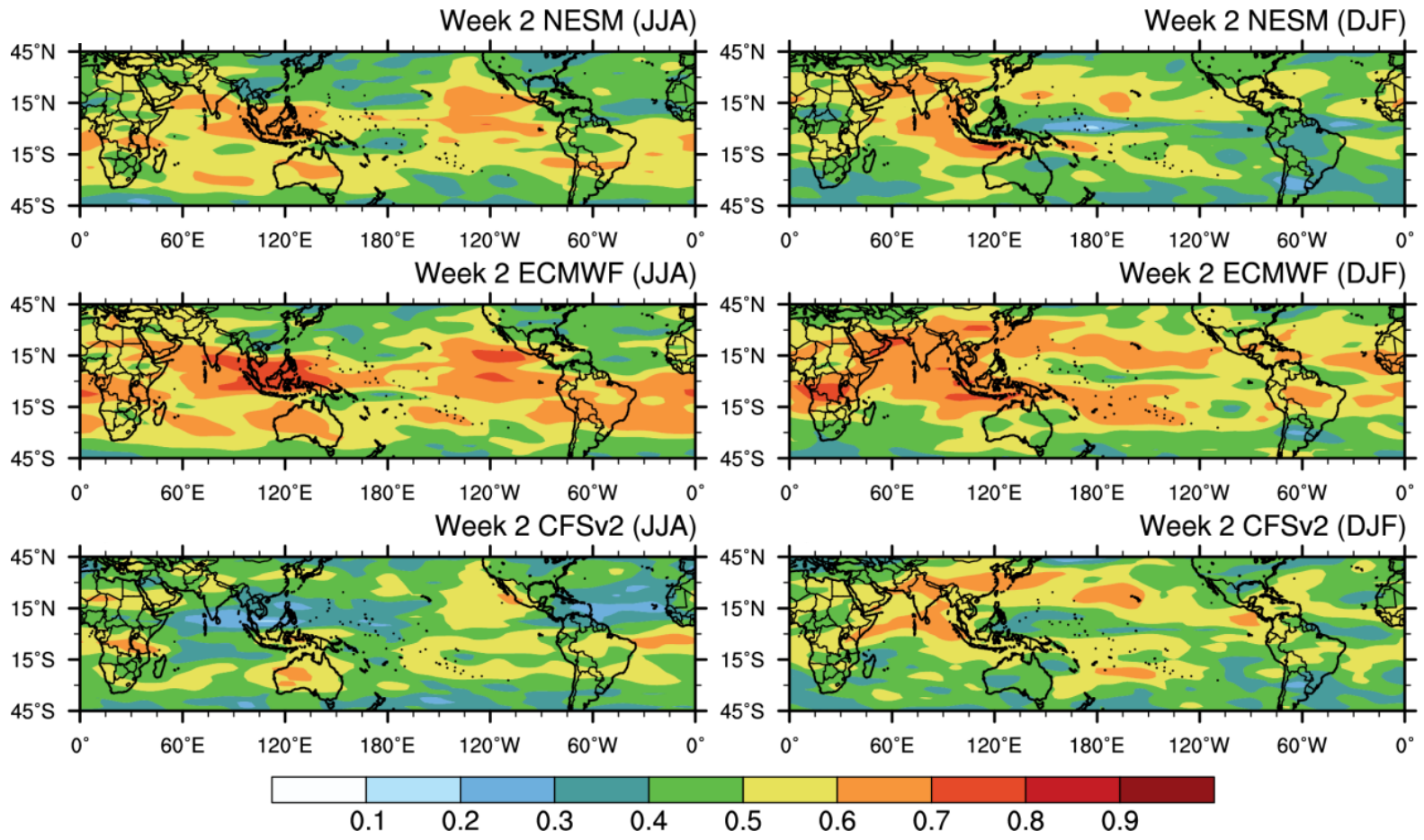
Correlation of Unfiltered OLR



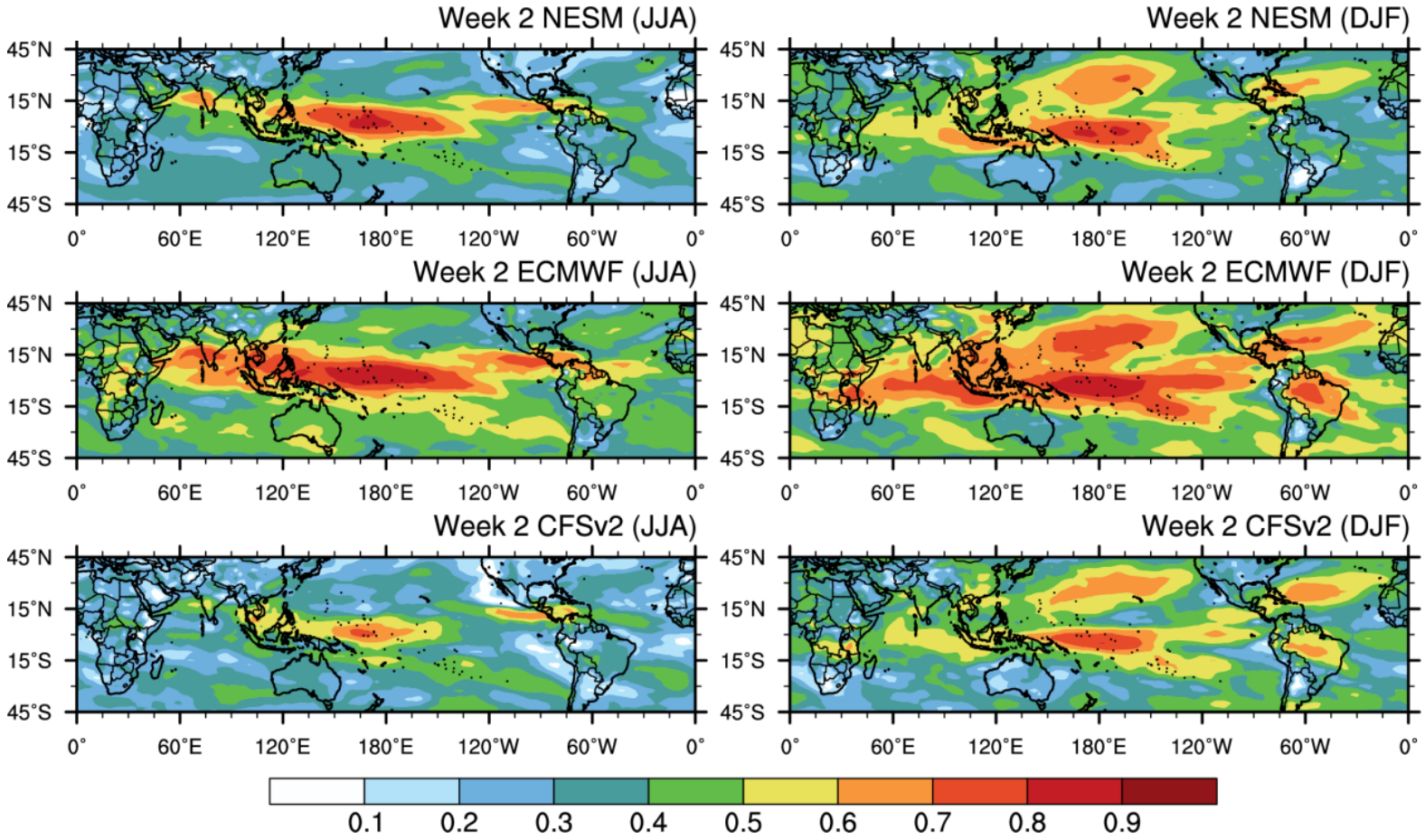
Anomaly correlation (shaded) between forecasted and observed **unfiltered OLR** at week 2 (F7-14d) during (left) JJA and (right) DJF.

Correlation of MJO-Filtered OLR



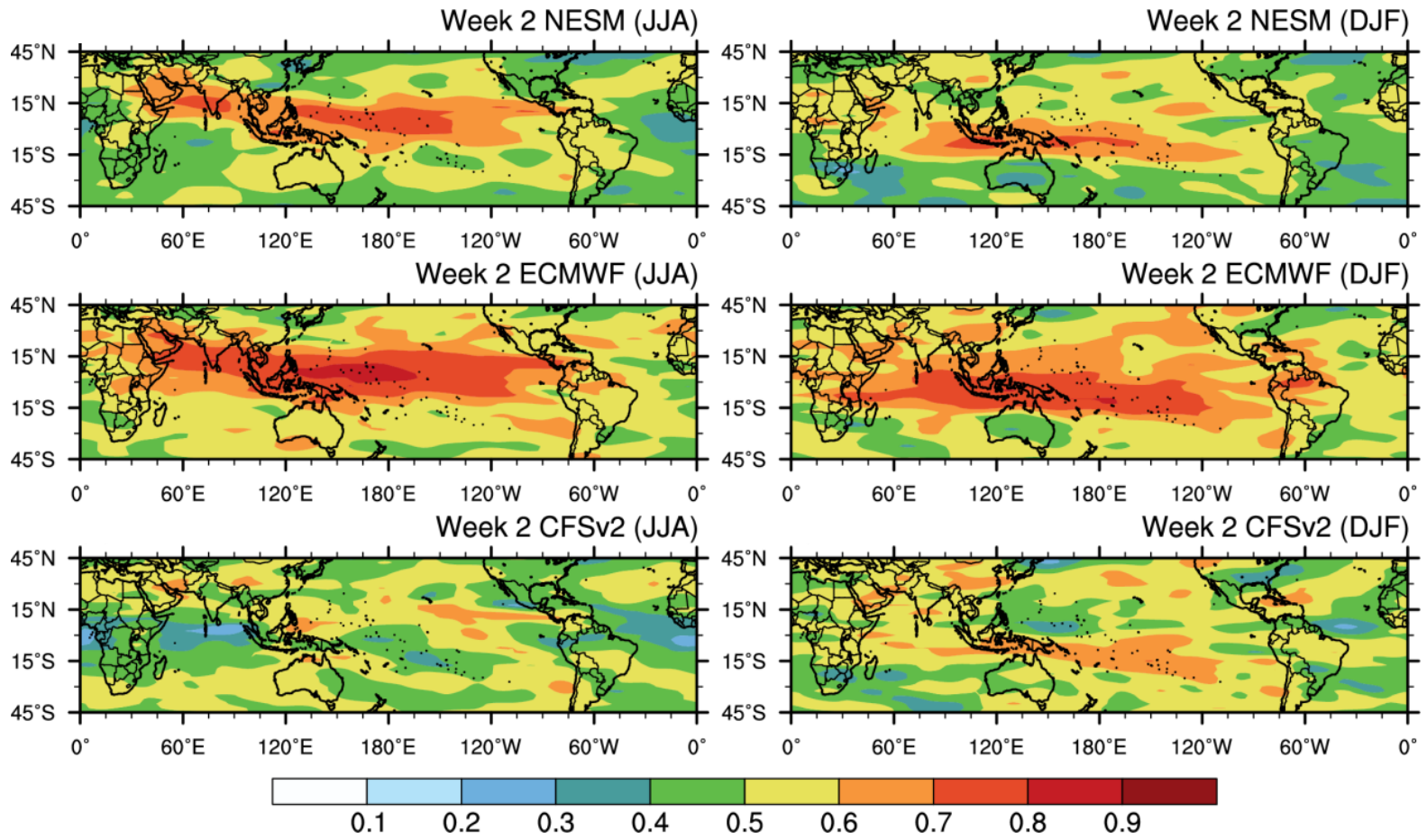
Anomaly correlation (shaded) between forecasted and observed **MJO-filtered OLR** at week 2 (F7-14d) during (left) JJA and (right) DJF.

Correlation of Unfiltered U850



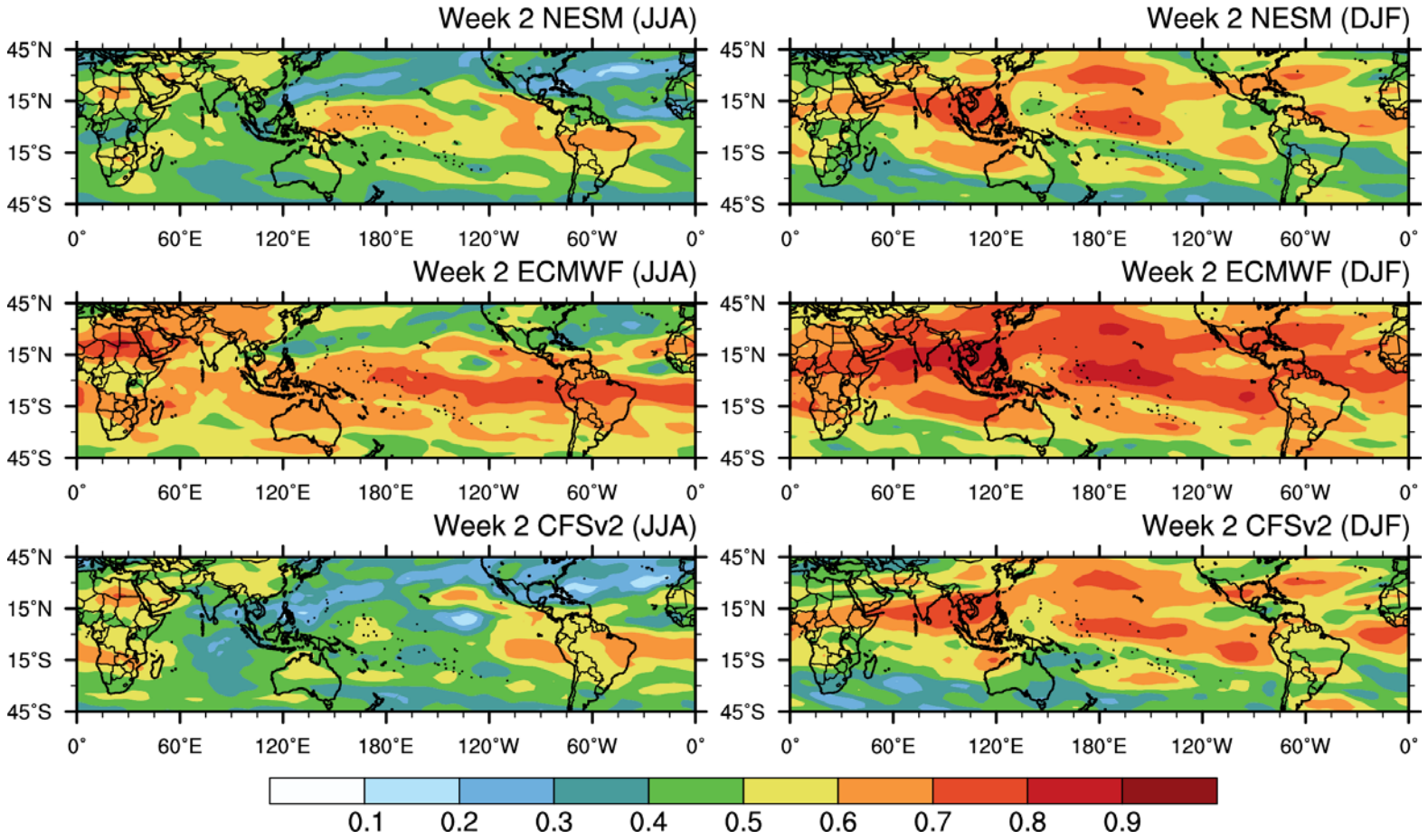
Anomaly correlation (shaded) between forecasted and observed **unfiltered U850** at week 2 (F7-14d) during (left) JJA and (right) DJF.

Correlation of MJO-Filtered U850



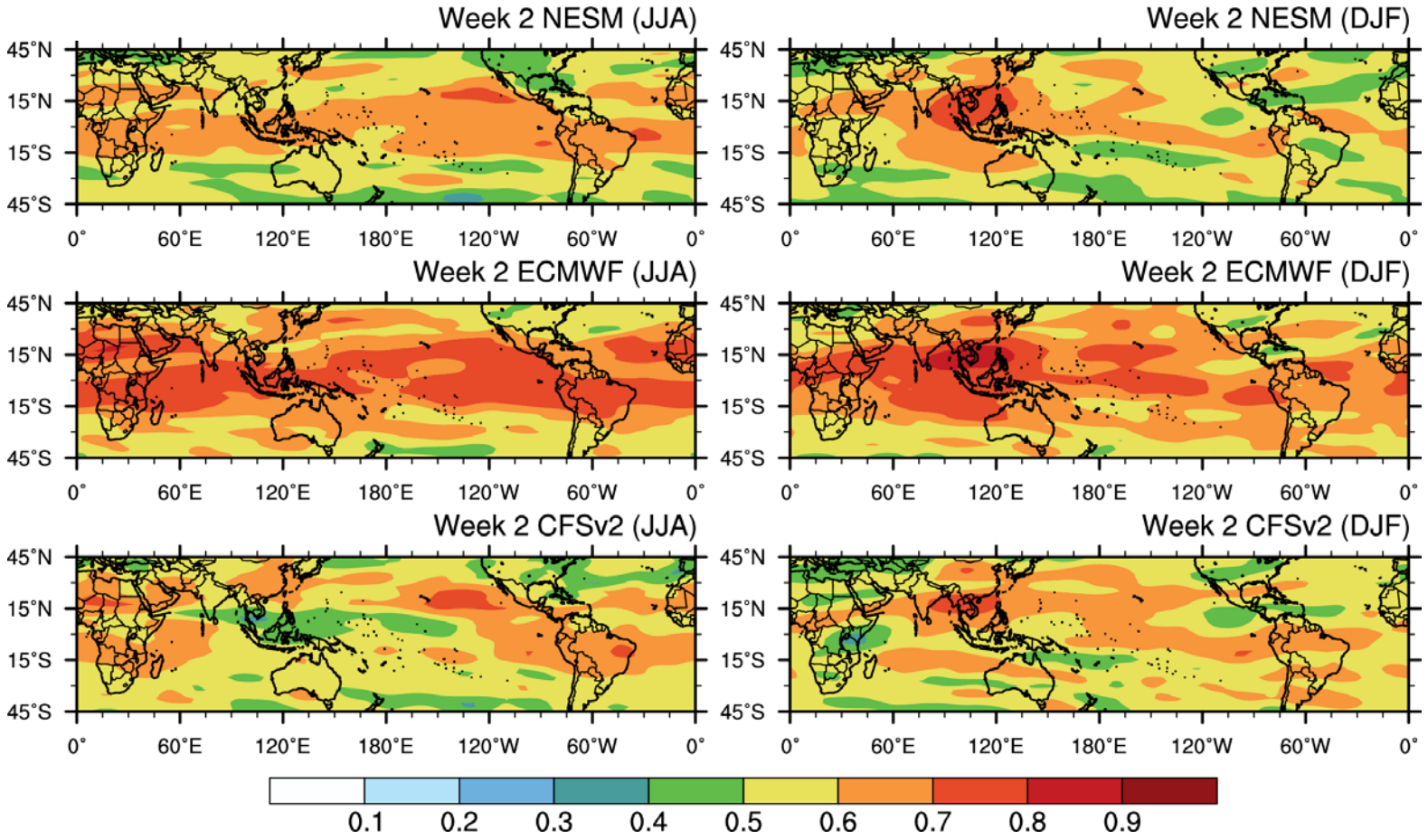
Anomaly correlation (shaded) between forecasted and observed **MJO-filtered U850** at week 2 (F7-14d) during (left) JJA and (right) DJF.

Correlation of Unfiltered U200



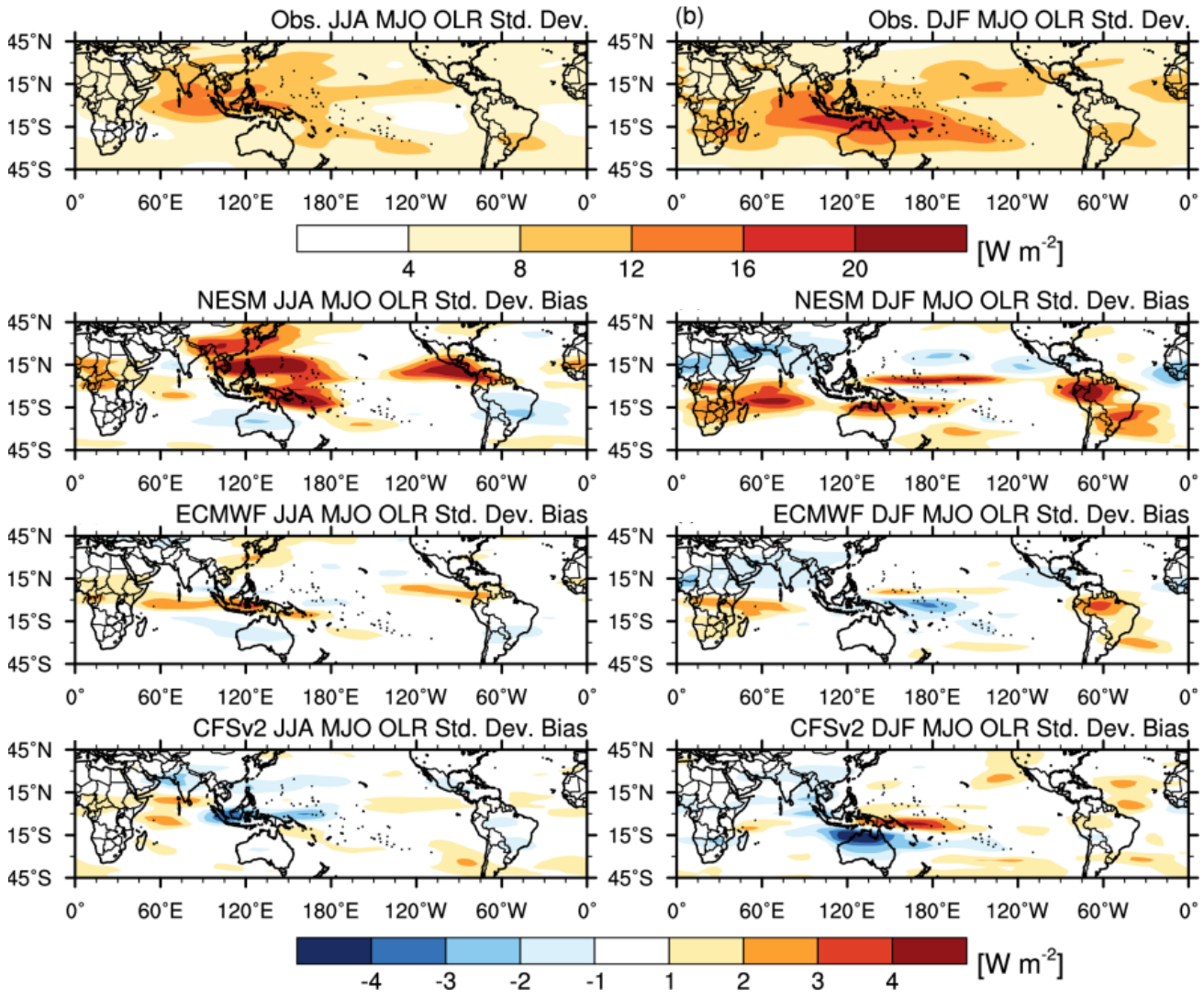
Anomaly correlation (shaded) between forecasted and observed **unfiltered U200** at week 2 (F7-14d) during (left) JJA and (right) DJF.

Correlation of MJO-Filtered U200



Anomaly correlation (shaded) between forecasted and observed **MJO-filtered U200** at week 2 (F7-14d) during (left) JJA and (right) DJF.

MJO-Filtered OLR Activity Biases



(top) MJO-filtered OLR standard deviation during week 2-3 (W m^{-2}, shaded).

(bottom) Standard deviation biases during week 2-3 from NESM, ECMWF, and CFSv2. (W m^{-2}, shaded).

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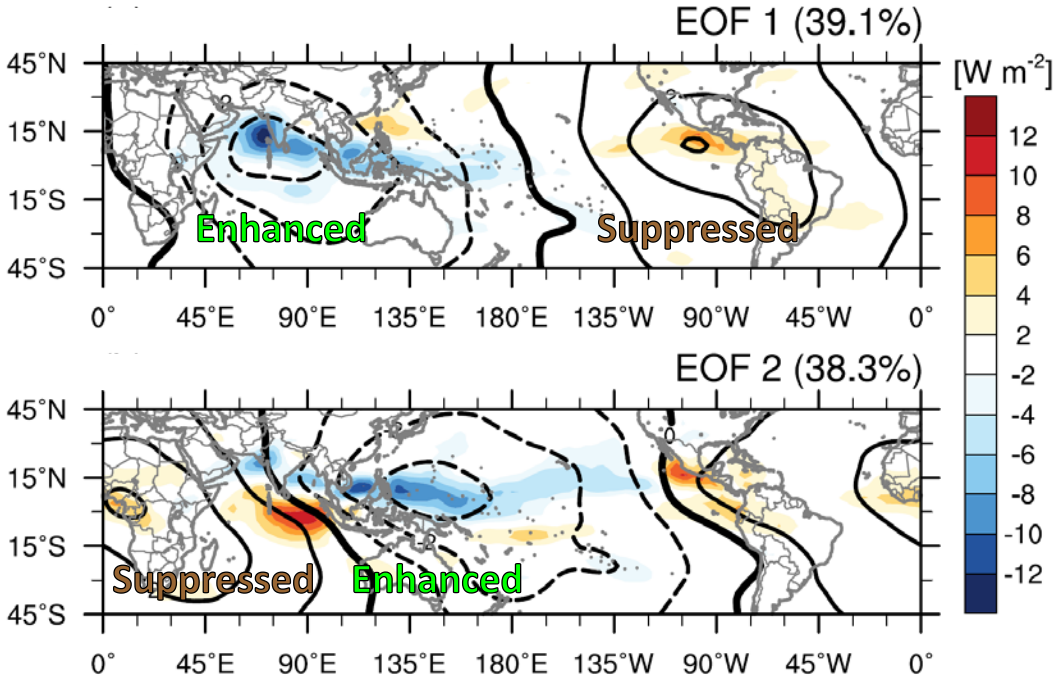
MJO Index - Methodology



Regression between OLR (W m^{-2}, shaded) and 200 hPa velocity potential (x10^6 m^2 s^{-1}, contours) and the PCs of the two leading EOFs of MJO-filtered 200 hPa velocity potential.

Step 1:
Calculate leading 2 EOFs (2D lat-lon) of global MJO-filtered 200 hPa velocity potential.

Step 2:
Project model forecasts of MJO-filtered 200 hPa velocity potential onto the 2 EOFs to get a time-series of each EOF.

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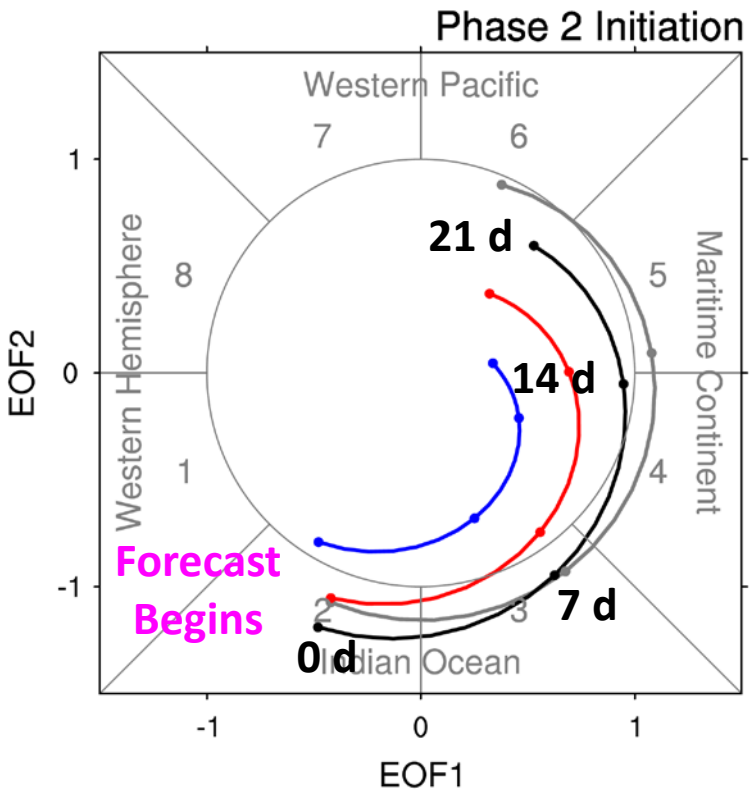
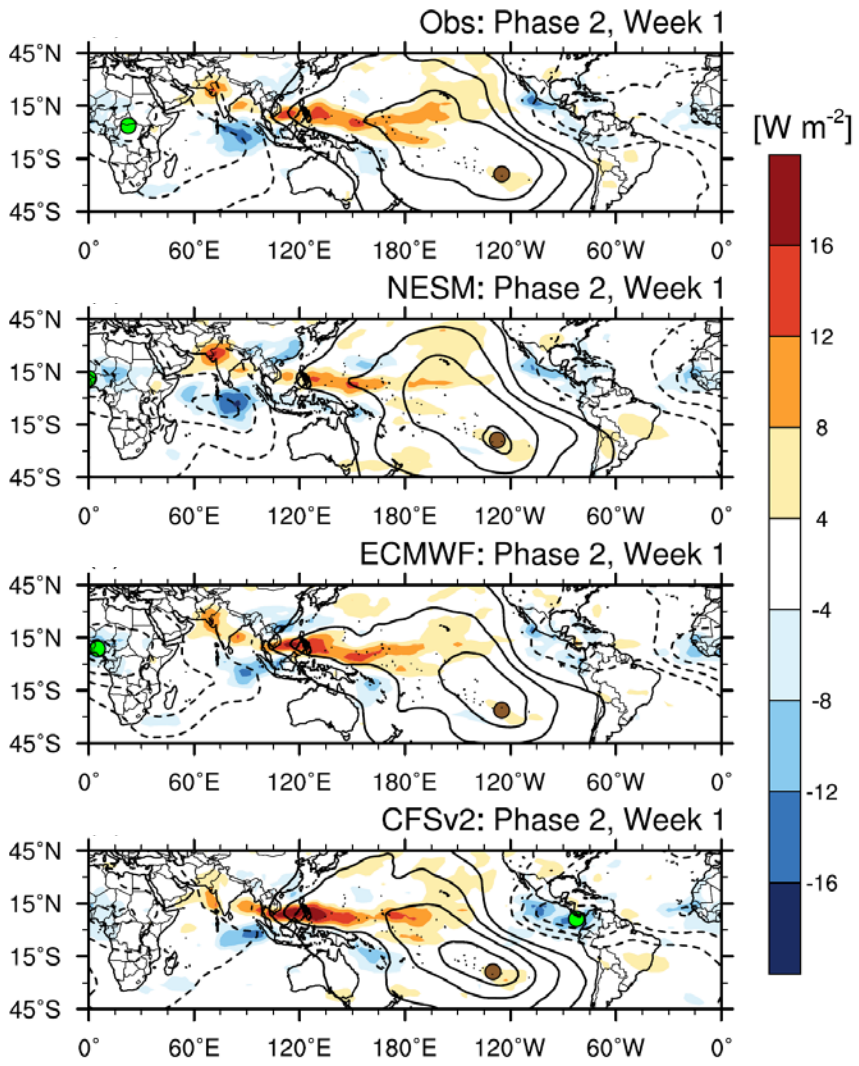
MJO Composite Evolution (Week 1)

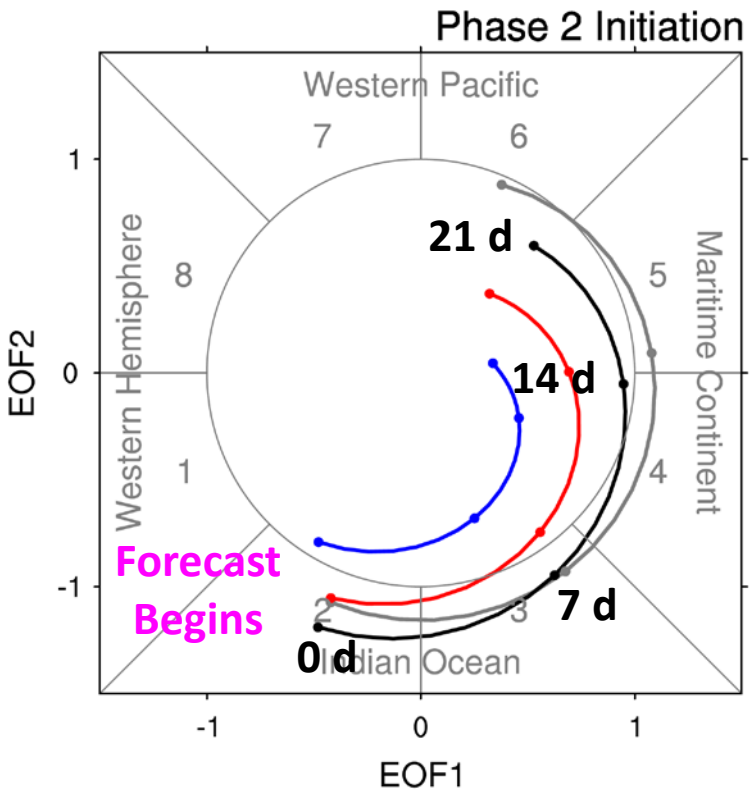


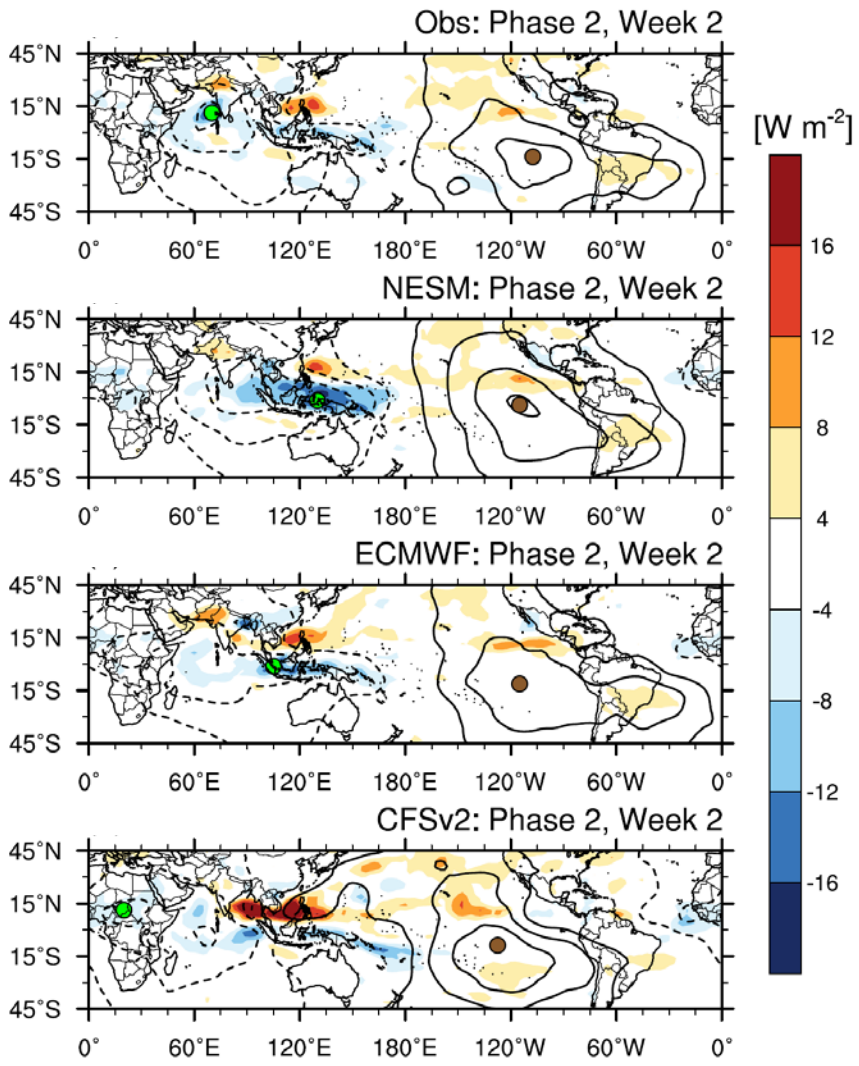
Composite evolution of the two EOFs for an initial state over the Indian Ocean (Phase 2) from JJA 1999-2015 reforecasts.

Obs., NESM, ECMWF, CFSv2



MJO Composite Evolution (Week 2)

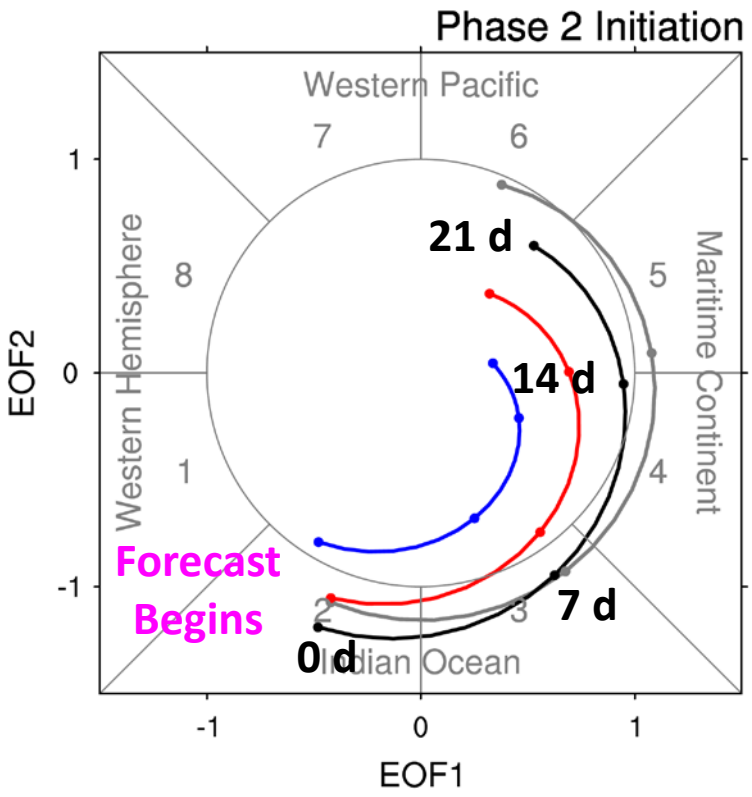


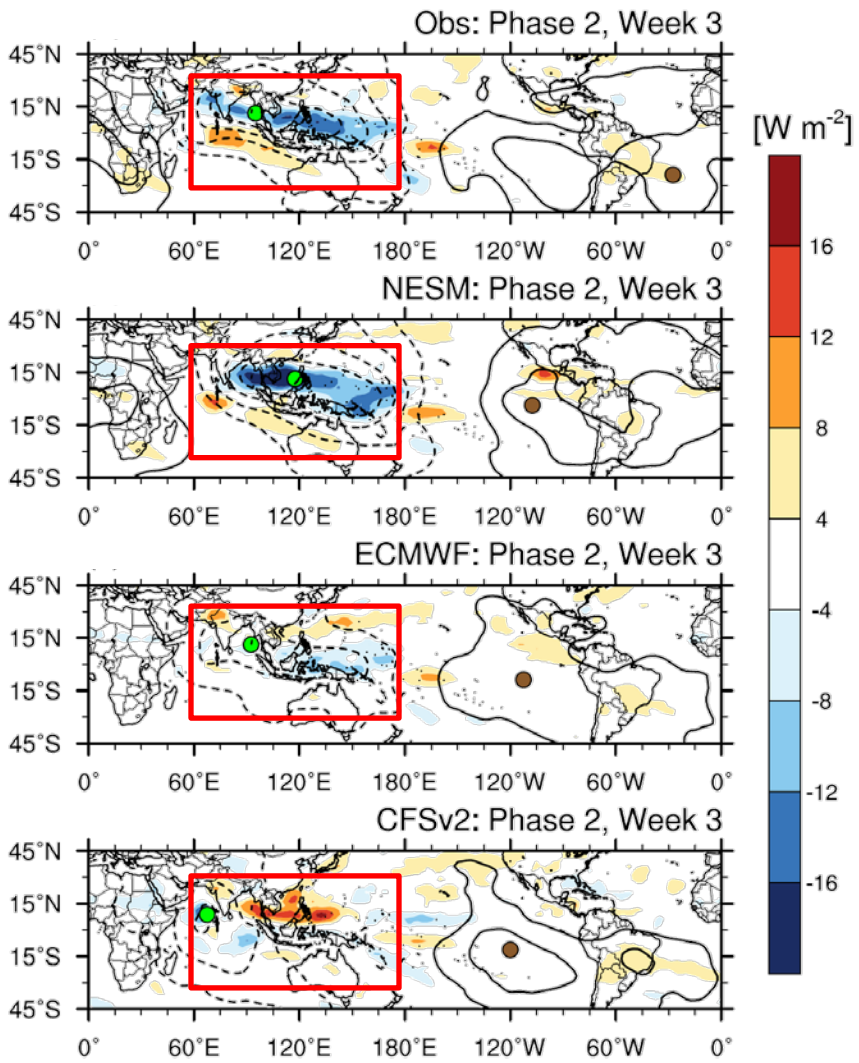


Composite evolution of the two EOFs for an initial state over the Indian Ocean (Phase 2) from JJA 1999-2015 reforecasts.

Obs., NESM, ECMWF, CFSv2

MJO Composite Evolution (Week 3)

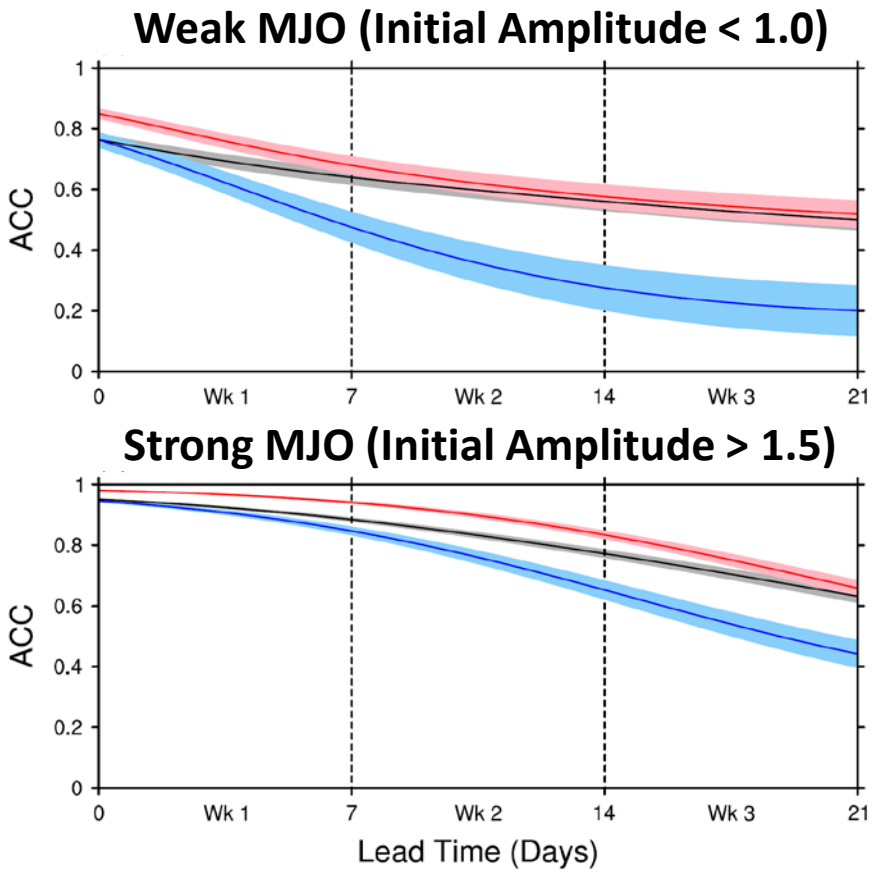




Composite evolution of the two EOFs for an initial state over the Indian Ocean (Phase 2) from JJA 1999-2015 reforecasts.

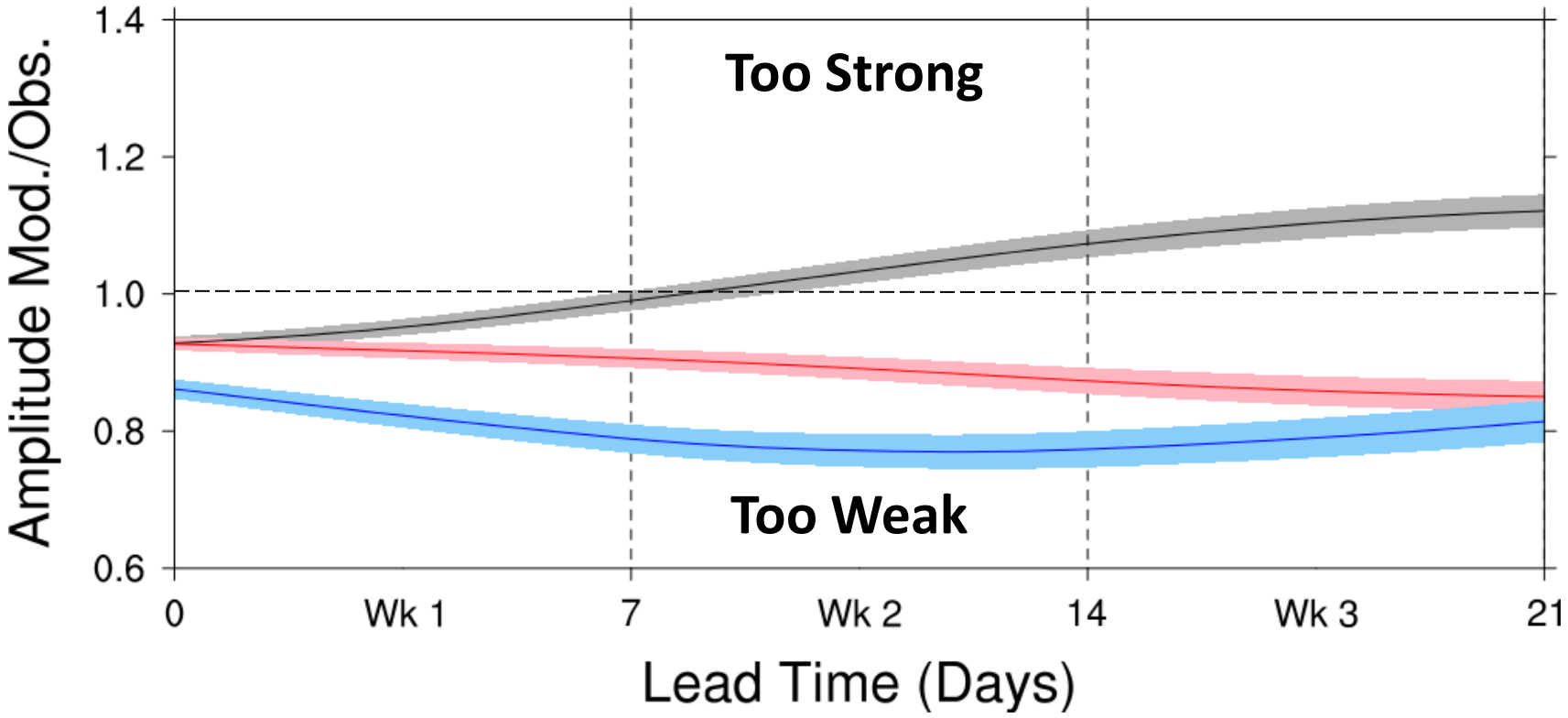
Obs., NESM, ECMWF, CFSv2

MJO Index Anomaly Correlation



NESM, ECMWF, CFSv2

MJO Index – Amplitude Bias



NESM, ECMWF, CFSv2

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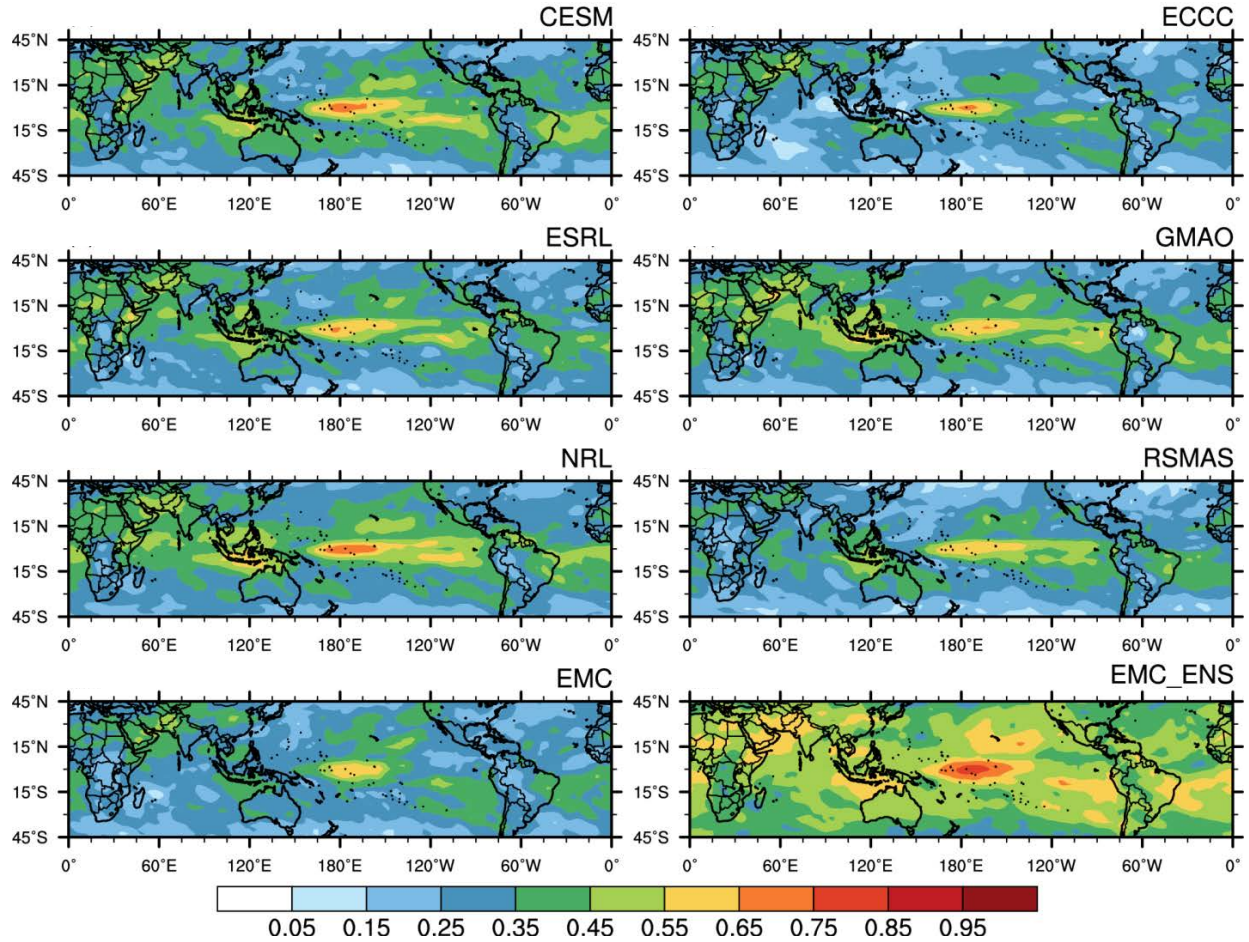
SubX Comparisons

Correlation of Unfiltered OLR



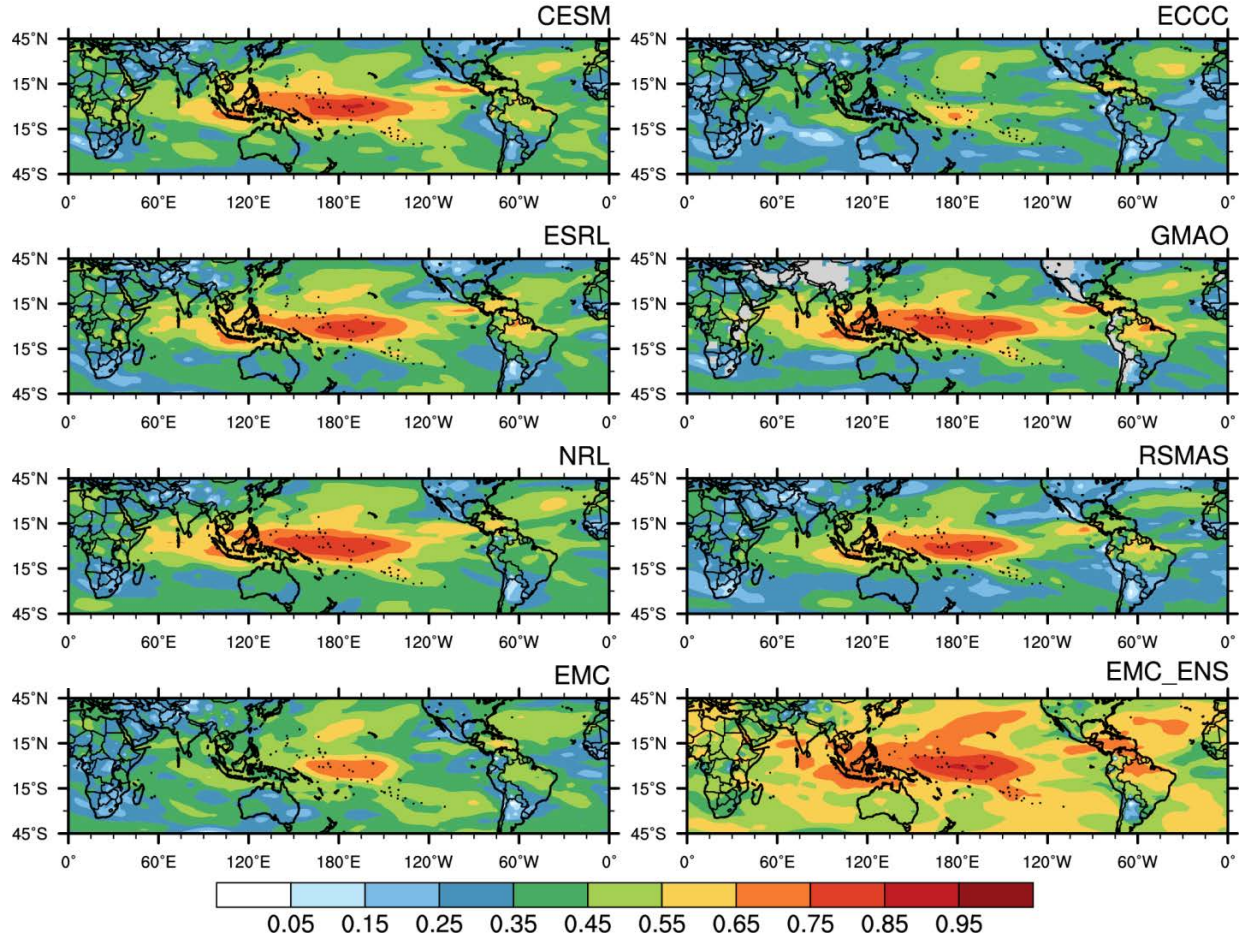
NRL (NESM) →

EMC (GEFS) →

← **EMC (GEFS 11 Member Ensemble)**

Anomaly correlation (shaded) between forecasted and observed **unfiltered OLR** at week 2 (F7-14d) during all months.

Correlation of Unfiltered U850



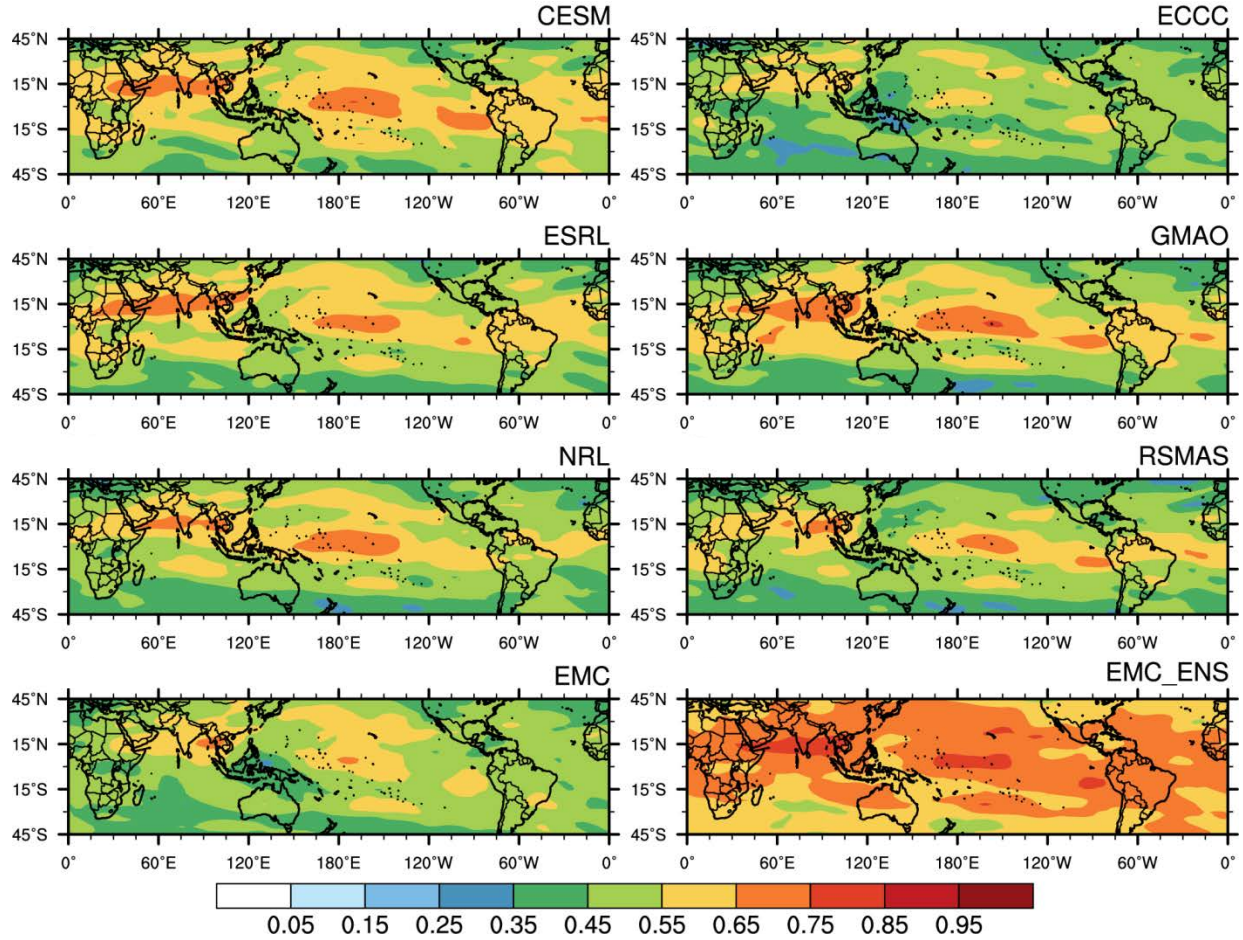
NRL (NESM) →

EMC (GEFS) →

← **EMC (GEFS 11 Member Ensemble)**

Anomaly correlation (shaded) between forecasted and observed **unfiltered U850** at week 2 (F7-14d) during all months.

Correlation of Unfiltered U200



NRL (NESM) →

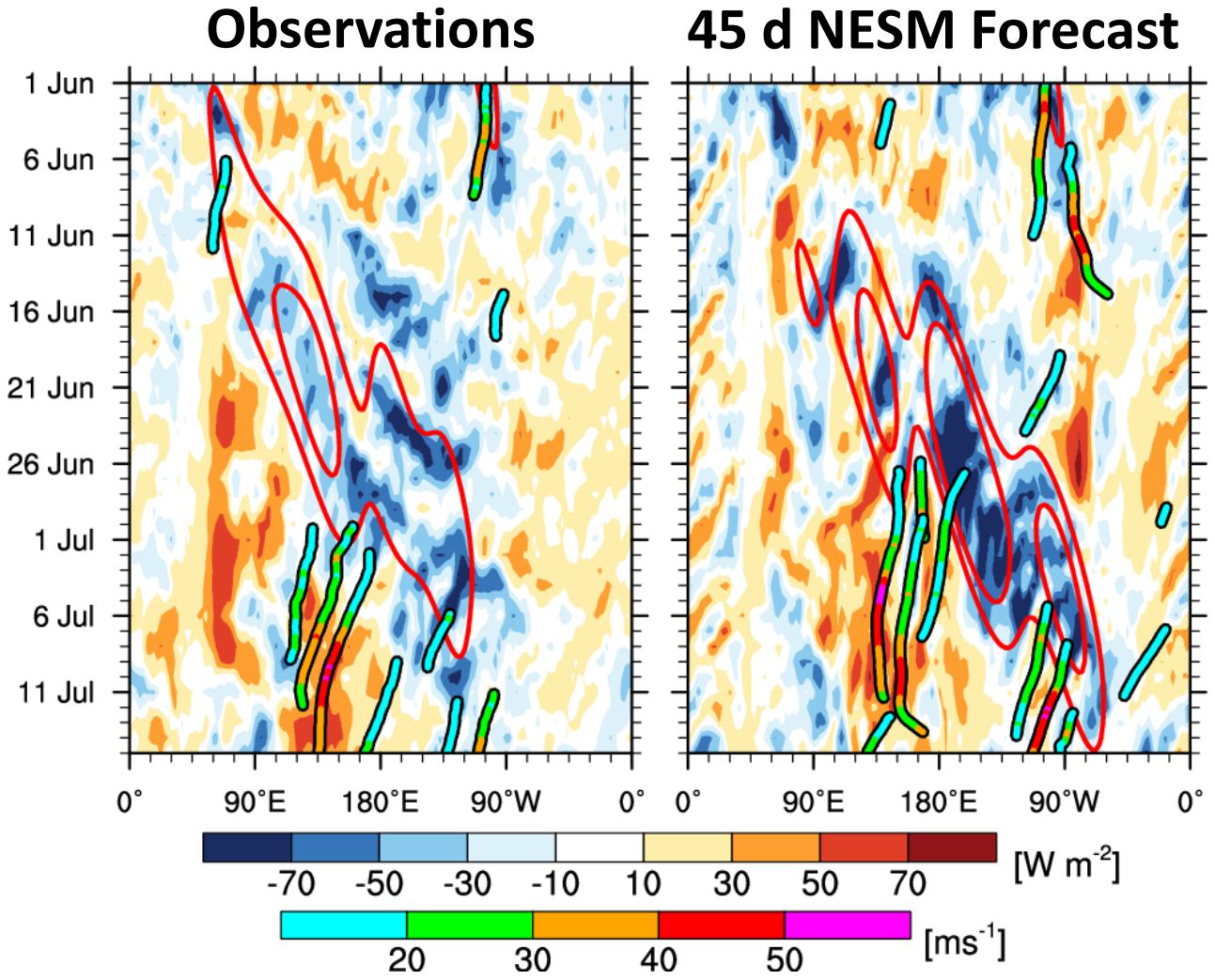
EMC (GEFS) →

← **EMC (GEFS 11 Member Ensemble)**

Anomaly correlation (shaded) between forecasted and observed **unfiltered U200** at week 2 (F7-14d) during all months.

Tropical Cyclones

Tropical Cyclone Case Study



Forecast Initialization (June 1, 2015)

0-10°N OLR anomalies shaded from (left) NOAA observations and (right) a 45 d NESM forecast. MJO-filtered OLR anomalies are contoured in red every 15 W m^{-2} .

TC tracks are colored by 10 m max windspeed.

Summary and Future Work

Summary:

- The ability of a model to predict the position of the MJO convective envelope may be a more relevant test of MJO predictive skill than global MJO indices.
- The NESM has fairly unique MJO biases (too fast and too strong).
- Preliminary looks at tropical cyclone forecasting indicate that extreme events may have predictive skill beyond 1 month.

Future Work:

- Examinations of the performance of the NESM 15 member ensemble.
- A closer look at tropical cyclone skill at S2S time scales.

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