MJO Predictive Skill and Impacts in the Navy Earth System Model

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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.
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
How do the model and observations compare?
Where is filtering reliable?
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.
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.
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.
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).
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.

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.
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

Weak MJO (Initial Amplitude < 1.0)

Strong MJO (Initial Amplitude > 1.5)

NESM, ECMWF, CFSv2
MJO Index – Amplitude Bias

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SubX Comparisons
Correlation of Unfiltered OLR

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

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Correlation of Unfiltered U850

Anomaly correlation (shaded) between forecasted and observed unfiltered U850 at week 2 (F7-14d) during all months.
Correlation of Unfiltered U200

Anomaly correlation (shaded) between forecasted and observed unfiltered U200 at week 2 (F7-14d) during all months.
Tropical Cyclones
Tropical Cyclone Case Study

Observations

45 d NESM Forecast

Forecast Initialization (June 1, 2015)

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

TC tracks are colored by 10 m max windspeed.
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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