Using the S2S Database to Evaluate the Performance of the Navy Earth System Prediction Capability (ESPC) Ensemble

Workshop on Predictability, Dynamics and Applications Research Using the TIGGE and S2S Ensembles

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The Navy Earth System Prediction Capability (Navy ESPC) 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 prediction skill of the Madden-Julian Oscillation (MJO) in the Navy ESPC.

3) Preliminary look at ensemble performance and subseasonal tropical cyclone prediction in the Navy ESPC.
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 (Navy ESPC): Weekly initialization.
- ECMWF: 2x weekly initialization.
- NCEP (CFSv2): Initializations on every 5th day used.

Results are for control member forecasts from 1999-2015 and 2017 ensemble forecasts.
Wavenumber-Frequency Spectra

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How do the model and observations compare?

Where is the 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) Navy ESPC. >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.

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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.

Navy ESPC (JJA)

ECMWF (JJA)

CFSv2 (JJA)

Navy ESPC (DJF)

ECMWF (DJF)

CFSv2 (DJF)

Anomaly correlation (shaded) between forecasted and observed MJO-filtered OLR 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.

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

(bottom) Standard deviation biases during week 2-3 from Navy ESPC, ECMWF, and CFSv2. (W m\(^{-2}\), shaded).
Regression between OLR (W m\(^{-2}\), shaded) and 200 hPa velocity potential (\(\times 10^6\) 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.

Results shown for JJA 1999-2015 reforecasts.
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., Navy ESPC, ECMWF, CFSv2
MJO Composite Evolution (Week 2)

Observed (Week 2)

Navy ESPC (Week 2)

ECMWF (Week 2)

CFSv2 (Week 2)

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

Obs., Navy ESPC, 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., Navy ESPC, ECMWF, CFSv2
MJO Index Anomaly Correlation

Weak MJO (Initial Amplitude < 1.0)

Strong MJO (Initial Amplitude > 1.5)

Navy ESPC, ECMWF, CFSv2
MJO Index – Amplitude Bias

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Anomaly correlation (shaded) between forecasted and observed week 2 (F7-14d) OLR (left) and U850 (right). First 16 members used.
OLR anomalies averaged over 0-10°N from (left) observations and (right) a 45 d Navy ESPC forecast are shaded. Negative 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 Navy ESPC has fairly unique MJO biases (too fast and too strong).
- Preliminary looks at active tropical cyclone periods indicate that extreme events may have predictive skill beyond 1 month.

Future Work:

- Closer examination of the performance of the Navy ESPC ensemble.
- Multi-year analyses of the predictability of tropical cyclone genesis and track density at S2S time scales.

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