Multi-Model Comparisons of Subseasonal Tropical Prediction Skill and Real-Time Applications

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Outline

1. Background and Motivation
2. Subseasonal Prediction Using Navy ESPC
3. Real-Time S2S Project
4. Future Opportunities

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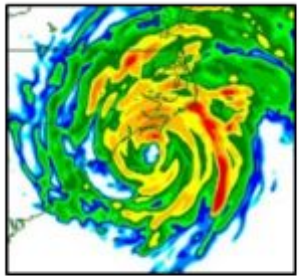
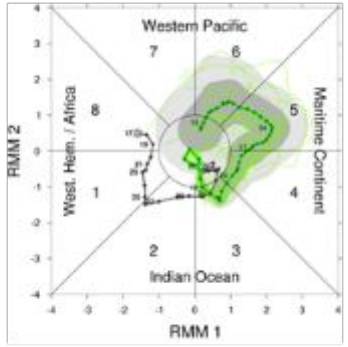
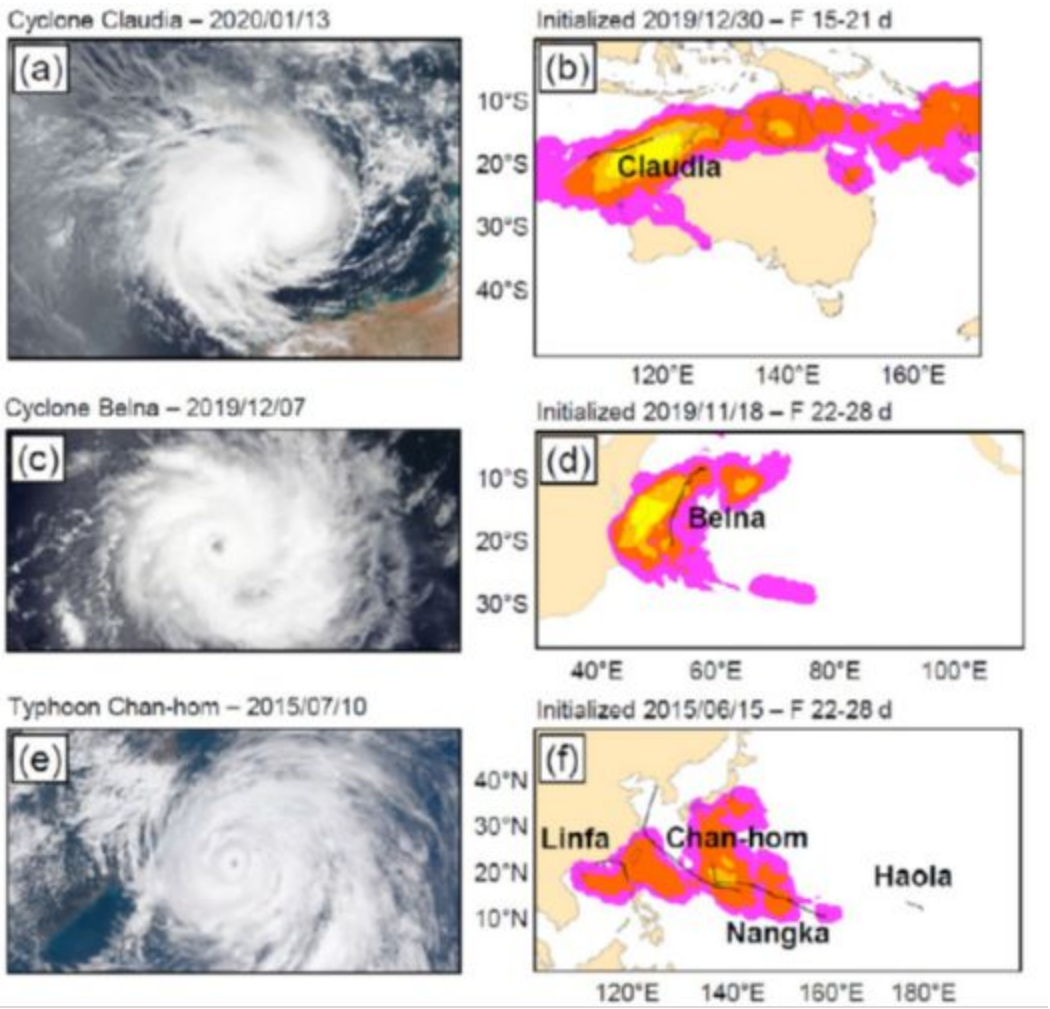
Sub-Seasonal to Seasonal Tropical Cyclone Prediction and the Navy

	Prediction Time-Scale: Hours to Days	Prediction Time-Scale: Weeks to Months
Need	 Tactics, Fleet Safety, and Operational Readiness	Force Positioning, Preparedness, Situational Awareness 
Capability	Limited-Area and Global Atmospheric Models Provide Information About Individual Weather Events  Forecast of Irene (2011) Radar Reflectivity	Earth System Models Provide Information About Slowly Varying Modes (e.g. MJO, ENSO) that Influence Weather and the Ocean 

Case Studies of Extended-Range TC Prediction Skill

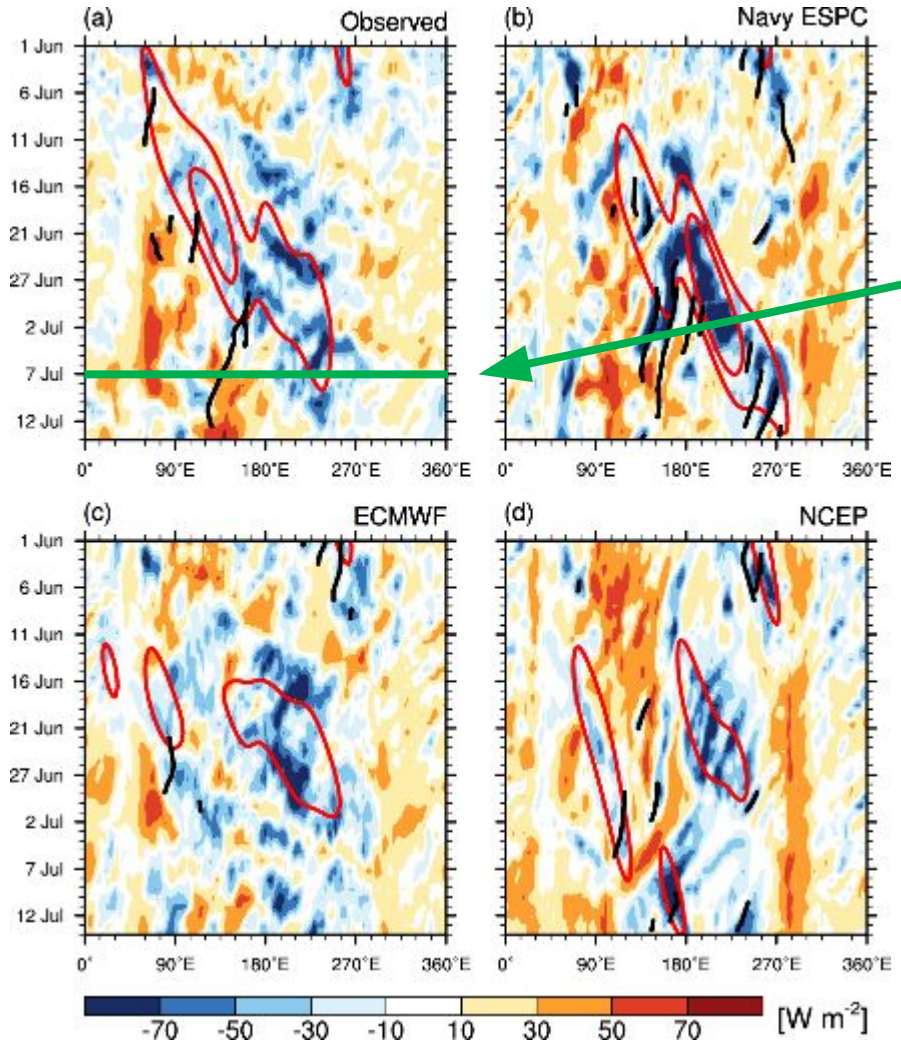


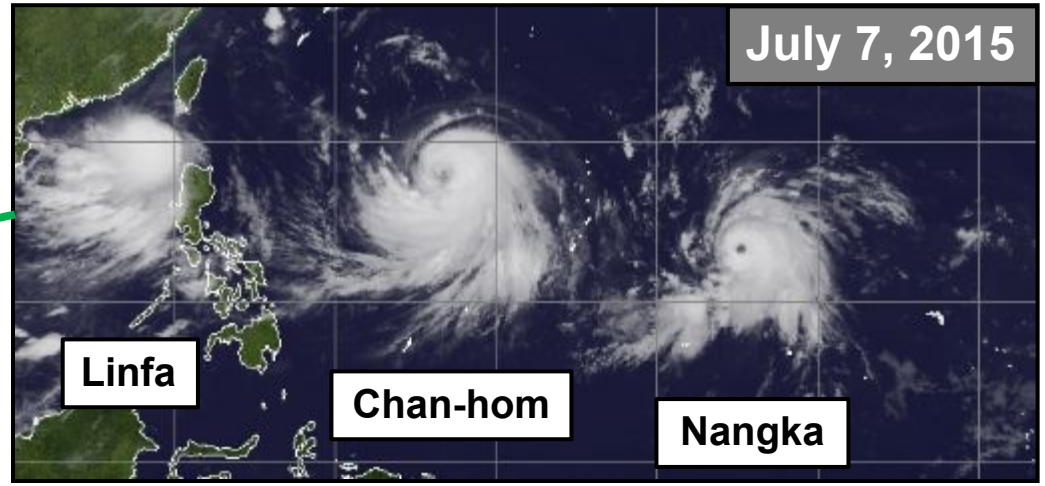
Probability of TC Occurrence

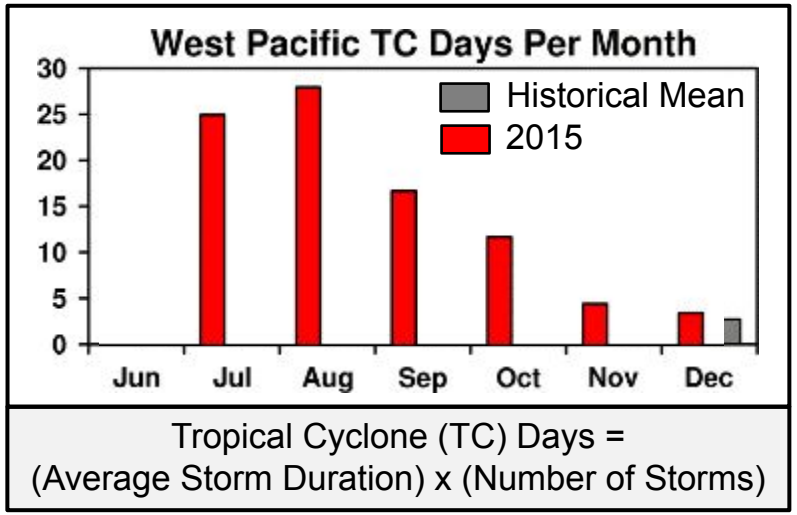
- 5-10%
- 10-20%
- 20-30%
- 30-40%

Case studies using the ECMWF S2S ensemble indicate that high TC predictability is attributed to strong and well predicted MJO events Domeisen et al. (2022).

MJO and TC West Pacific TC Outbreak of Summer 2015







Tropical Cyclone (TC) Days =
(Average Storm Duration) x (Number of Storms)

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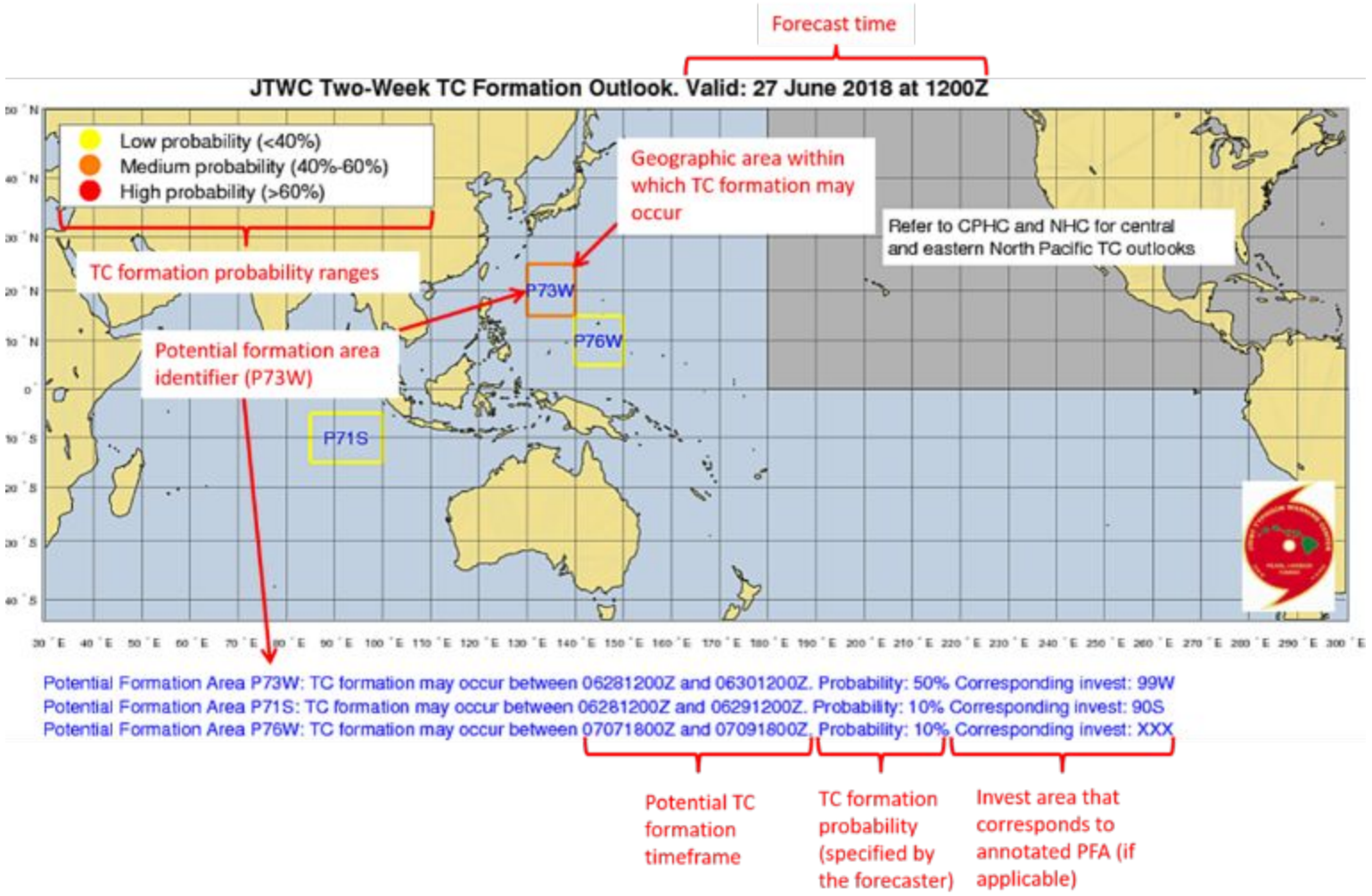
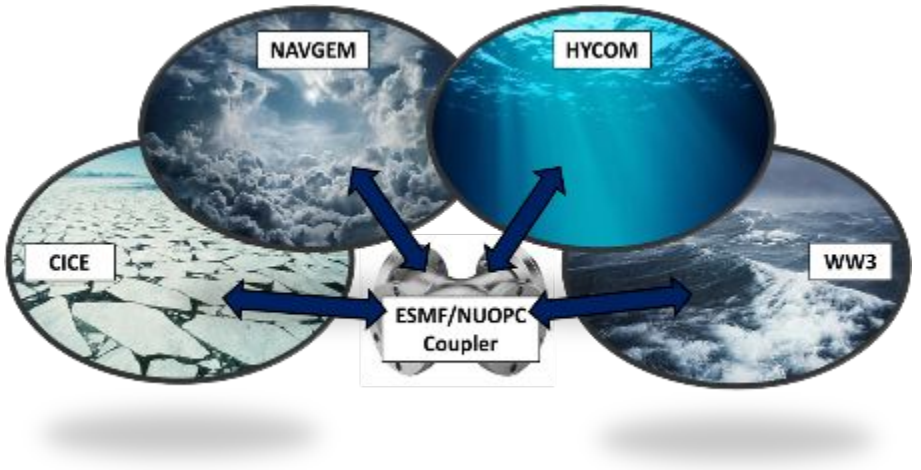
Joint Typhoon Warning Center Extended-Range TC Outlooks

The Joint Typhoon Warning Center (JTWC) is producing subjective two-week and three-week genesis forecasts using both public and Navy ESPC forecasts.



Operational Subseasonal Prediction Using Navy ESPC

Operational Navy ESPC Configuration



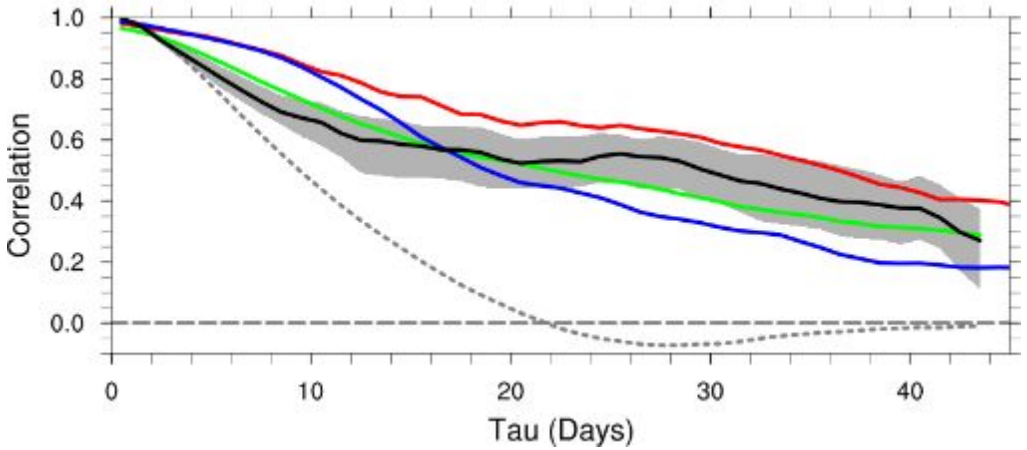
Navy ESPC:

Forecast	Time Range, Frequency	Atmosphere (NAVGEM)	Ocean (HYCOM)	Ice (CICE)
Ensemble Long-Term (S2S)	0-45 days 16 Members each Sunday	T359L60 (37 km) 60 levels	1/12° (9 km) 41 layers	1/12° (9 km)
Deterministic Short-Term	0-16 days, Daily	T681L60 (19 km) 60 levels	1/25° (4.5 km) 41 layers	1/25° (4.5 km)

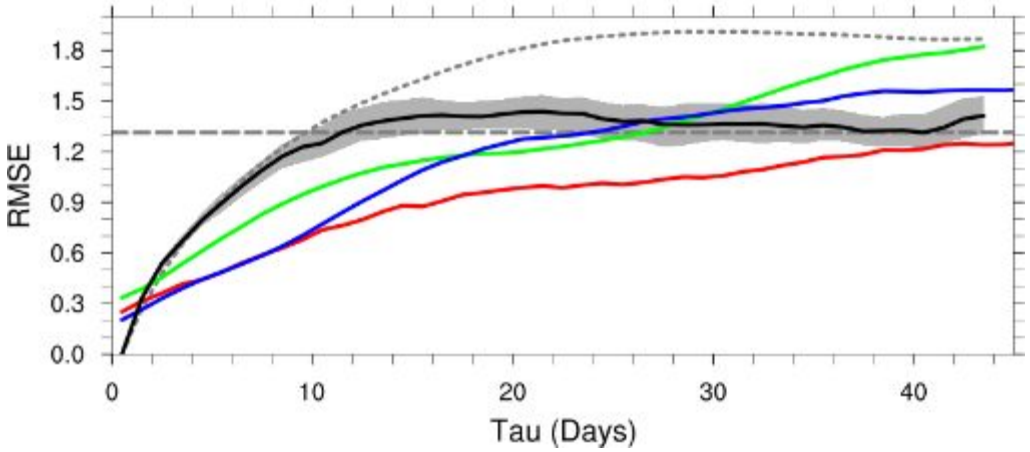
The Navy ESPC ensemble has been run operationally since August 2020.

Navy ESPC MJO Prediction Skill

Bivariate Correlation of RMM PCs



Bivariate RMSE of RMM PCs



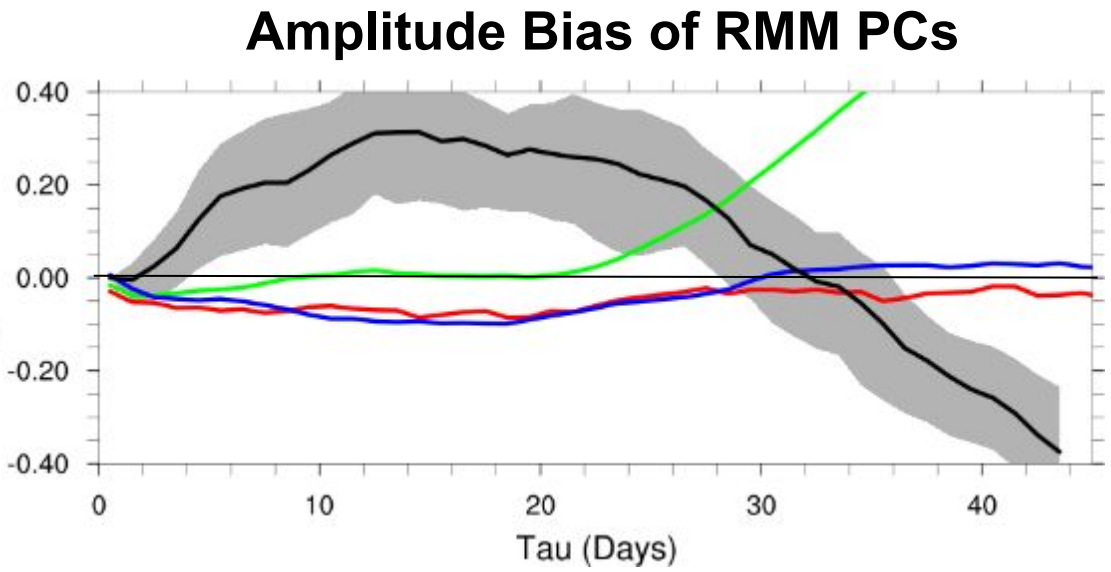
Navy ESPC and S2S Models MJO Verification
Jul 2020 – Apr 2022 Initializations

Key:

- Navy ESPC (16)
- 2 σ Uncertainty
- Navy ESPC Deterministic
- Climatology
- Persistence
- ECMWF (51)
- NCEP (16)
- UKMO (4)

(# Members)

Navy ESPC MJO Amplitude Bias



Navy ESPC and S2S Models MJO Verification
Jul 2020 – Apr 2022 Initializations

Key:

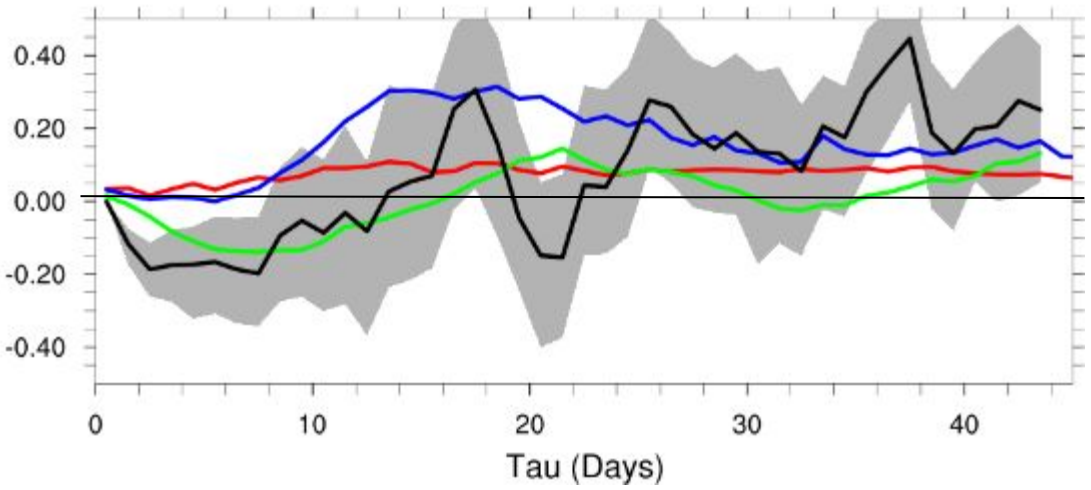
- Navy ESPC (16)
- 2 σ Uncertainty
- ECMWF (51)
- NCEP (16)
- UKMO (4)

(# Members)

Amplitude Bias = Distance from origin (σ).

Navy ESPC MJO Phase Bias

Phase Bias of RMM PCs



Navy ESPC and S2S Models MJO Verification
Jul 2020 – Apr 2022 Initializations

Key:

Navy ESPC (16)
2 σ Uncertainty
ECMWF (51)
NCEP (16)
UKMO (4)

(# Members)

Phase Bias = Distance between model and observations in RMM space (phases at amplitude = 1).

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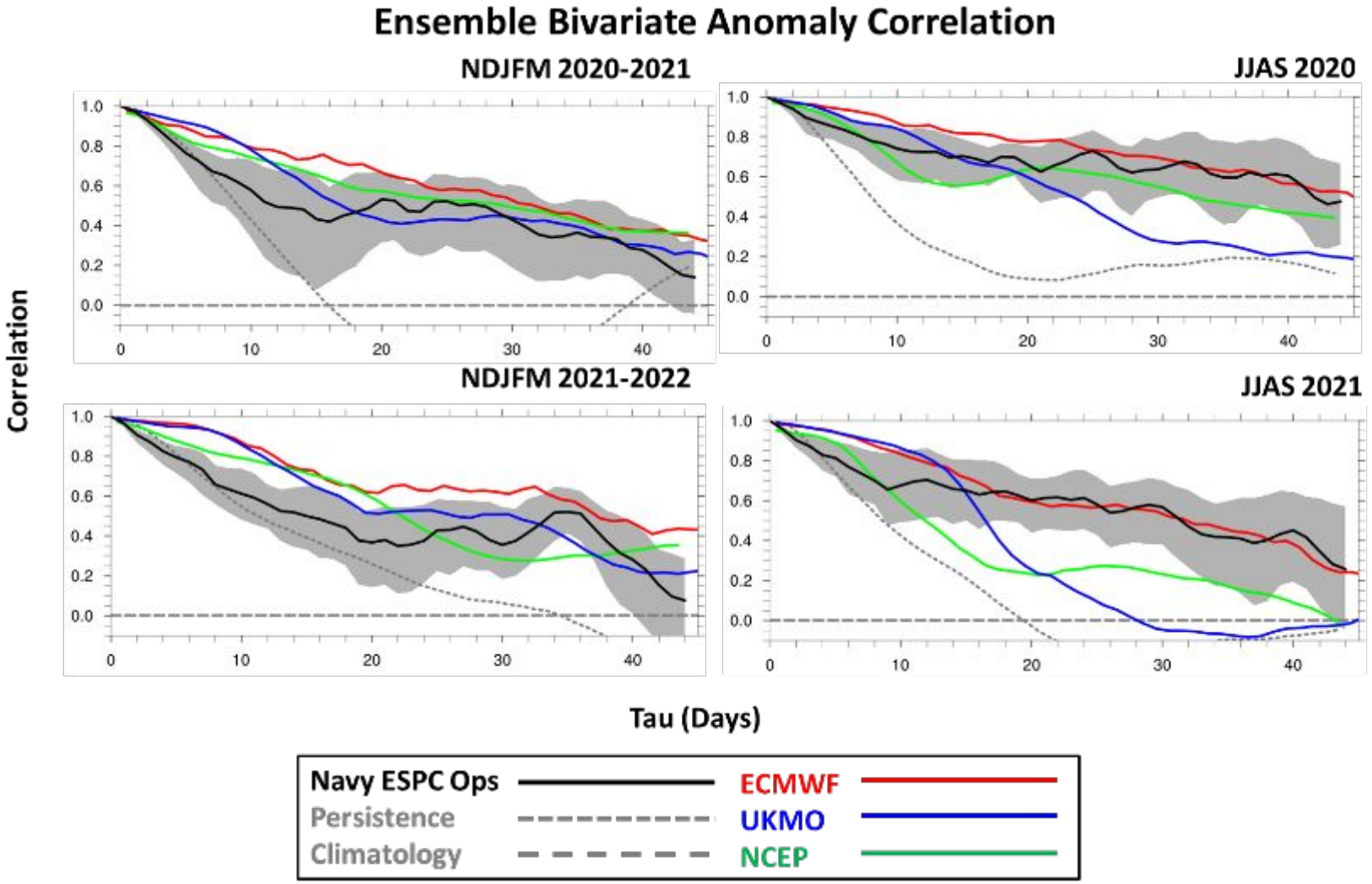
Seasonal Dependence of MJO Skill



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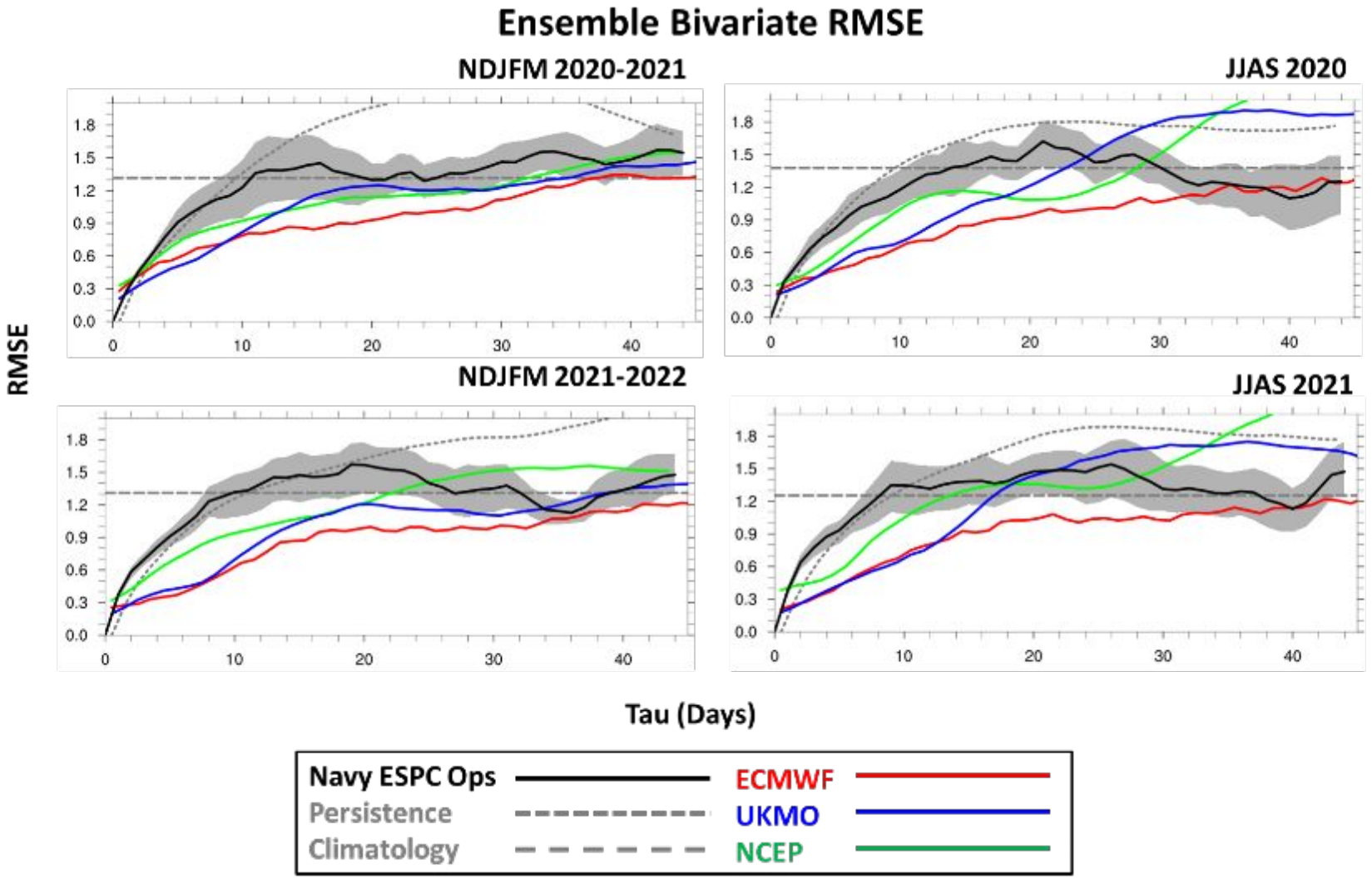
Seasonal Dependence



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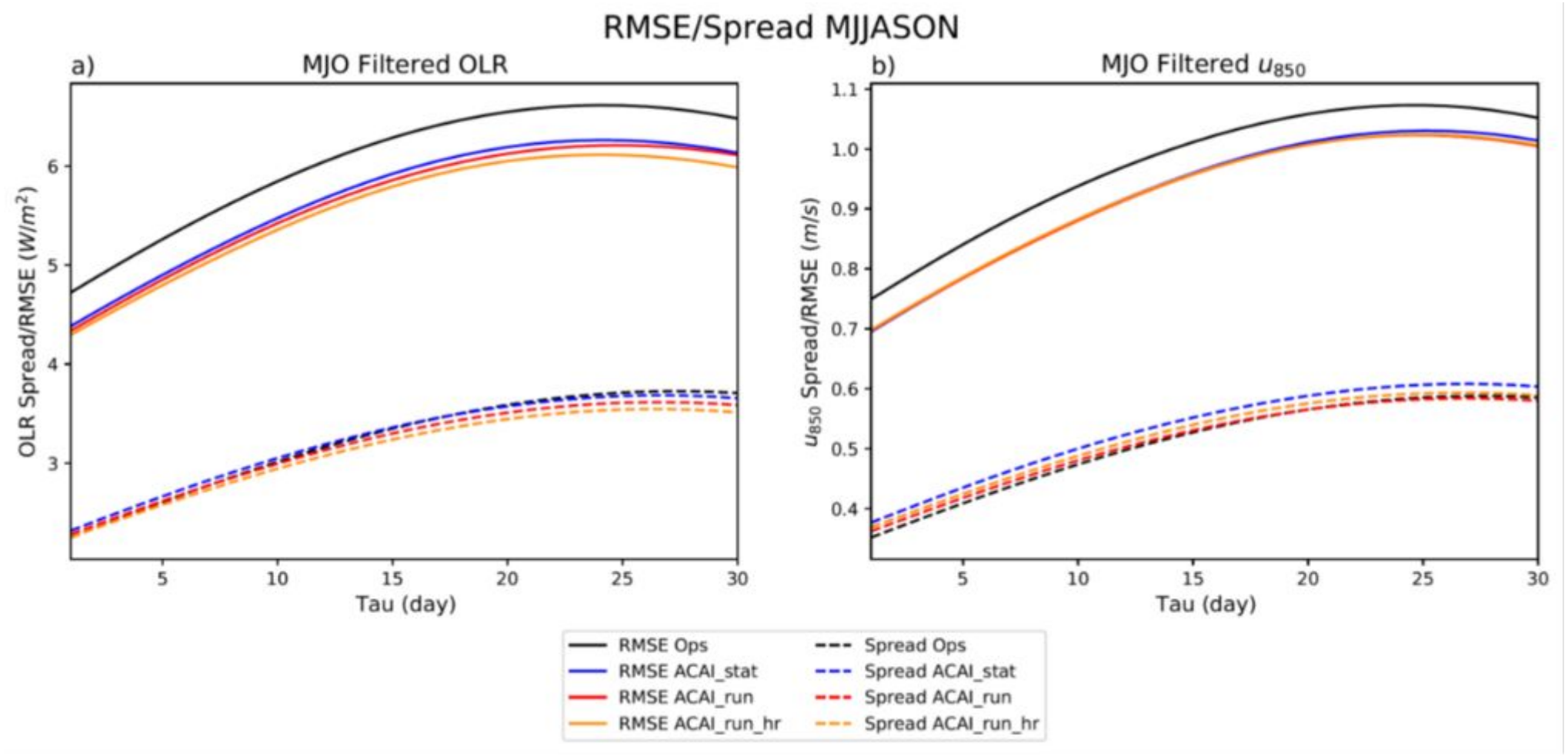
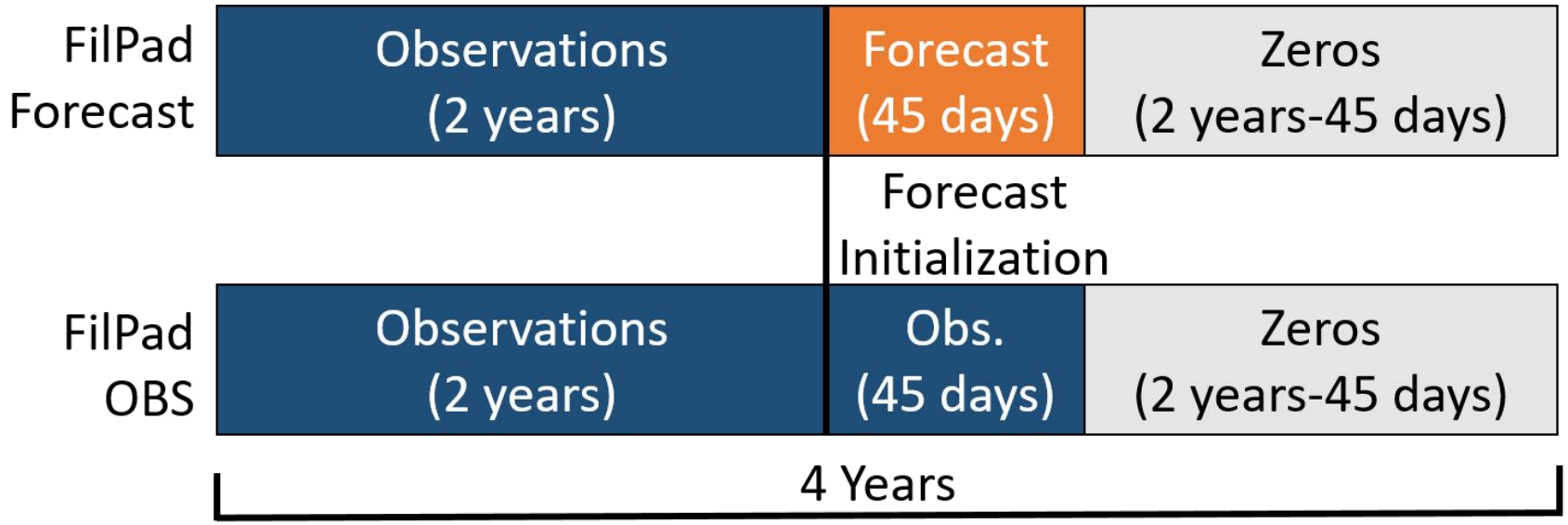
Future Upgrades to Navy ESPC



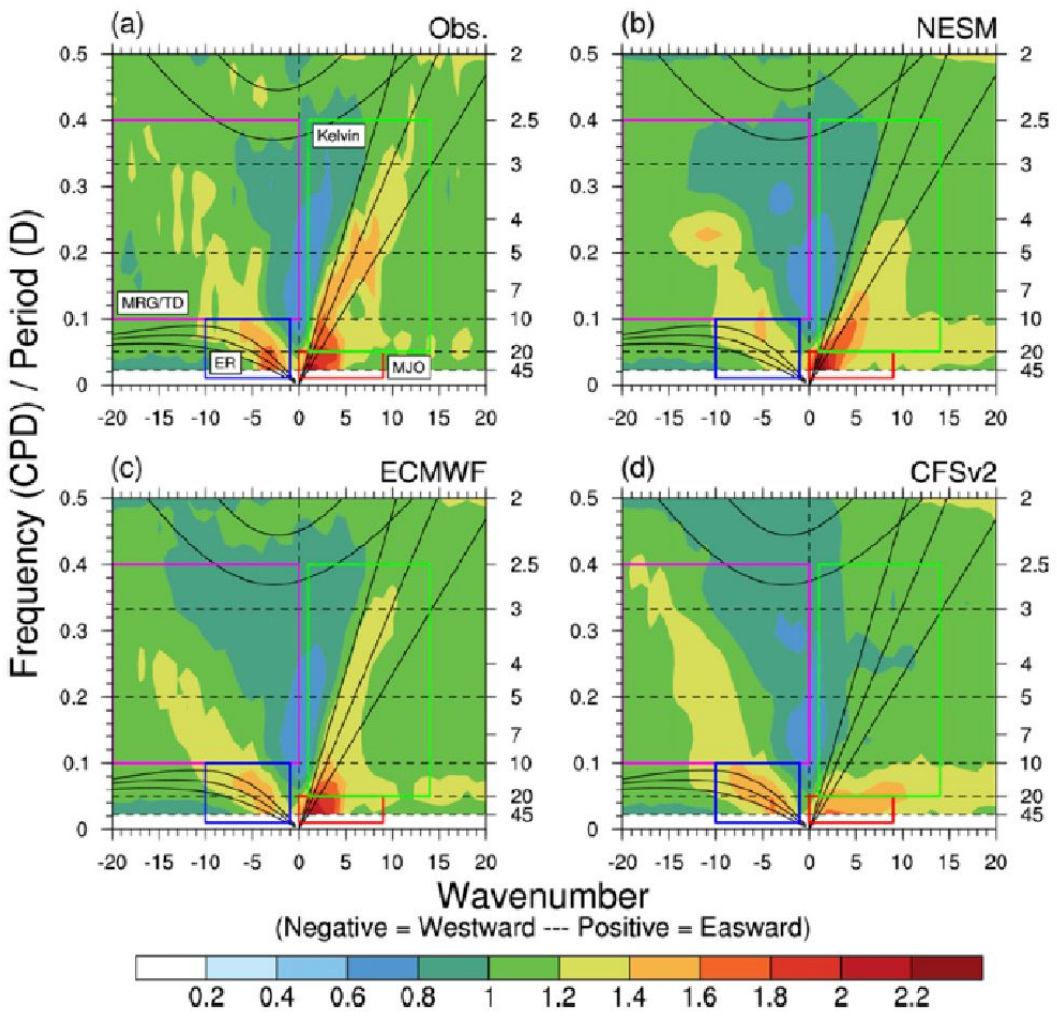
Real-Time S2S Project

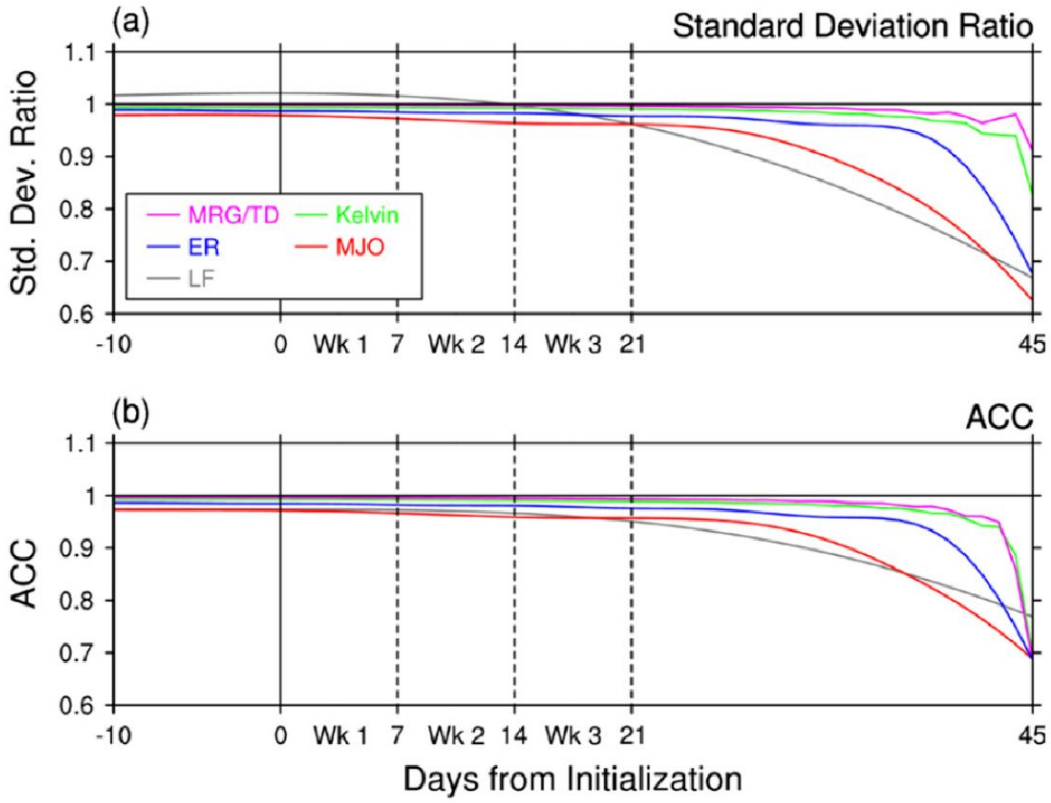
Real-Time Wavenumber-Frequency Filtering Methodology



Following Janiga et al. (2018), wavenumber-frequency filtering was applied to real-time S2S model forecasts.

Real-Time Wavenumber-Frequency Filtering Methodology





The padded filtering method does a good job approximating the reference method (filtering a multi-decade continuous dataset) for observations (Janiga et al. 2018).

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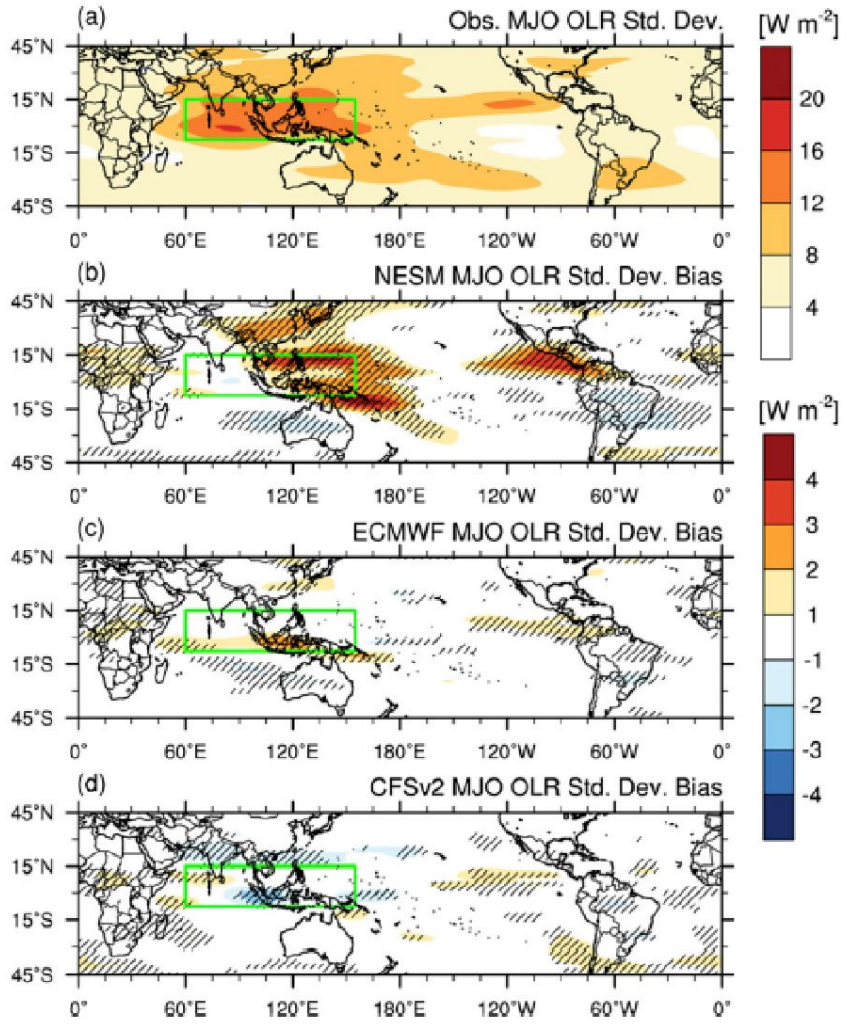
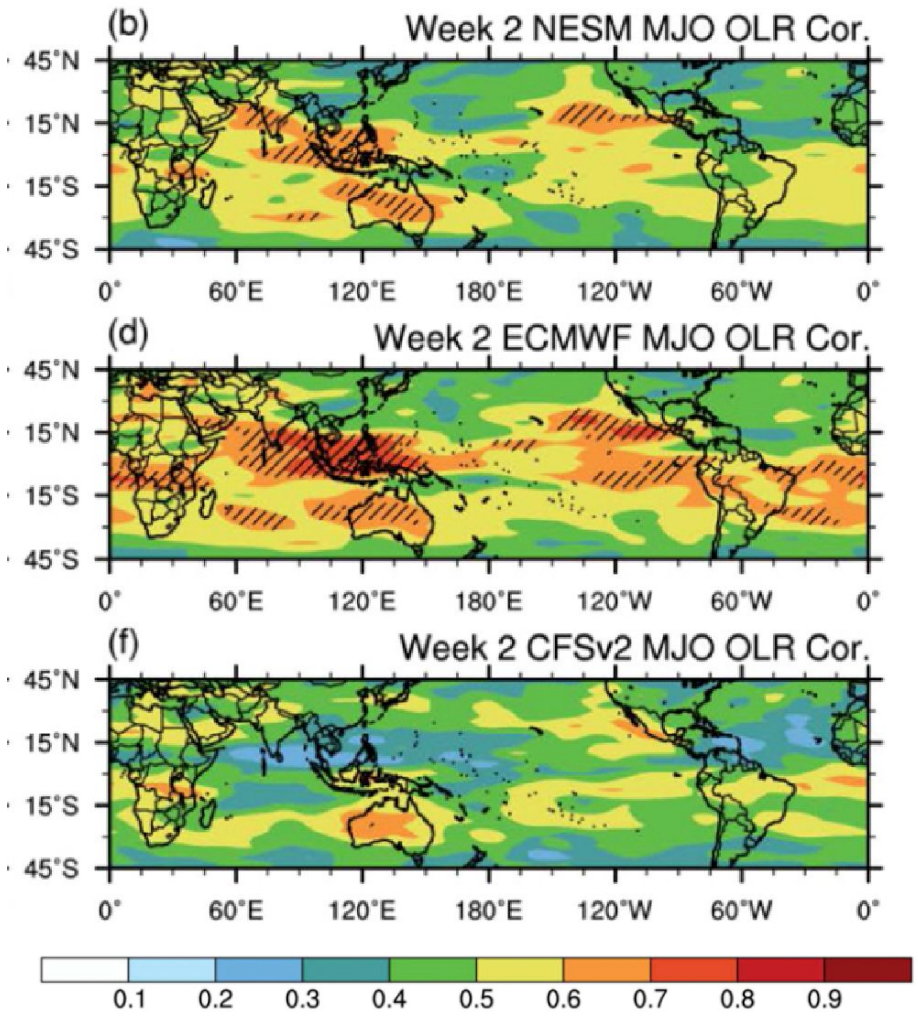
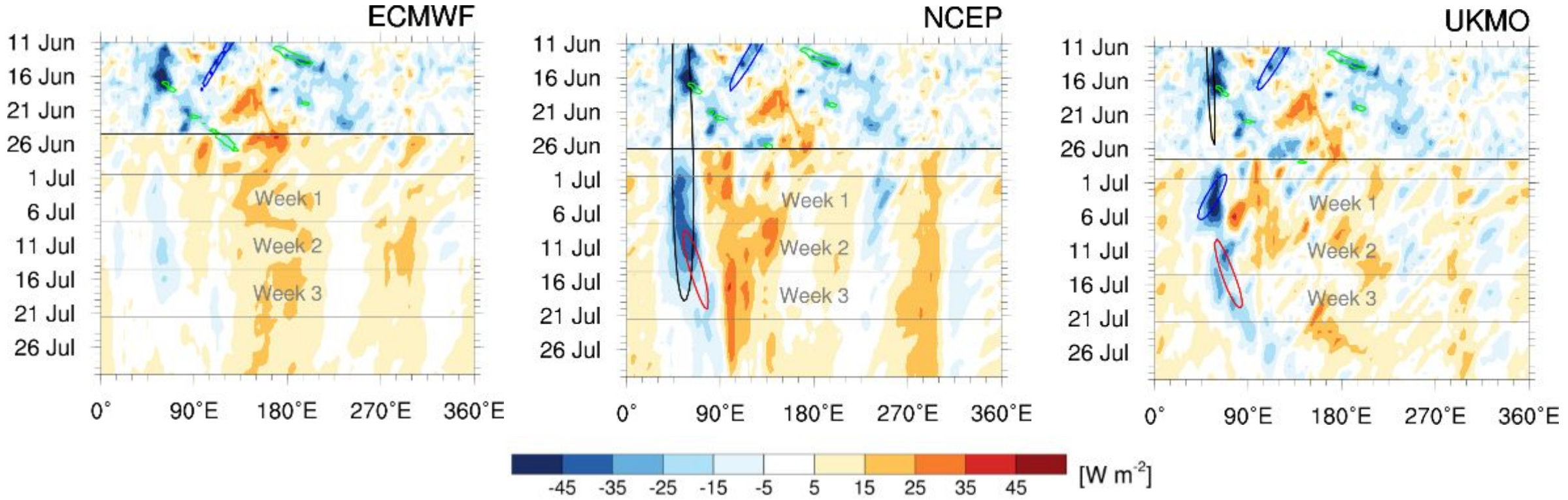
Verification for JJA 1999-2015 Forecasts





Example of Wavenumber-Frequency Filtered OLR Forecast



Low-Frequency
MJO
ER
Kelvin

15°S-15°N averages. Filtered fields contoured every -15 W m^{-2}.

- ECMWF (51 members) initialized 2020-06-24
- NCEP (16 Members) initialized 2020-06-26
- UKMO (4 Members) initialized 2020-06-27

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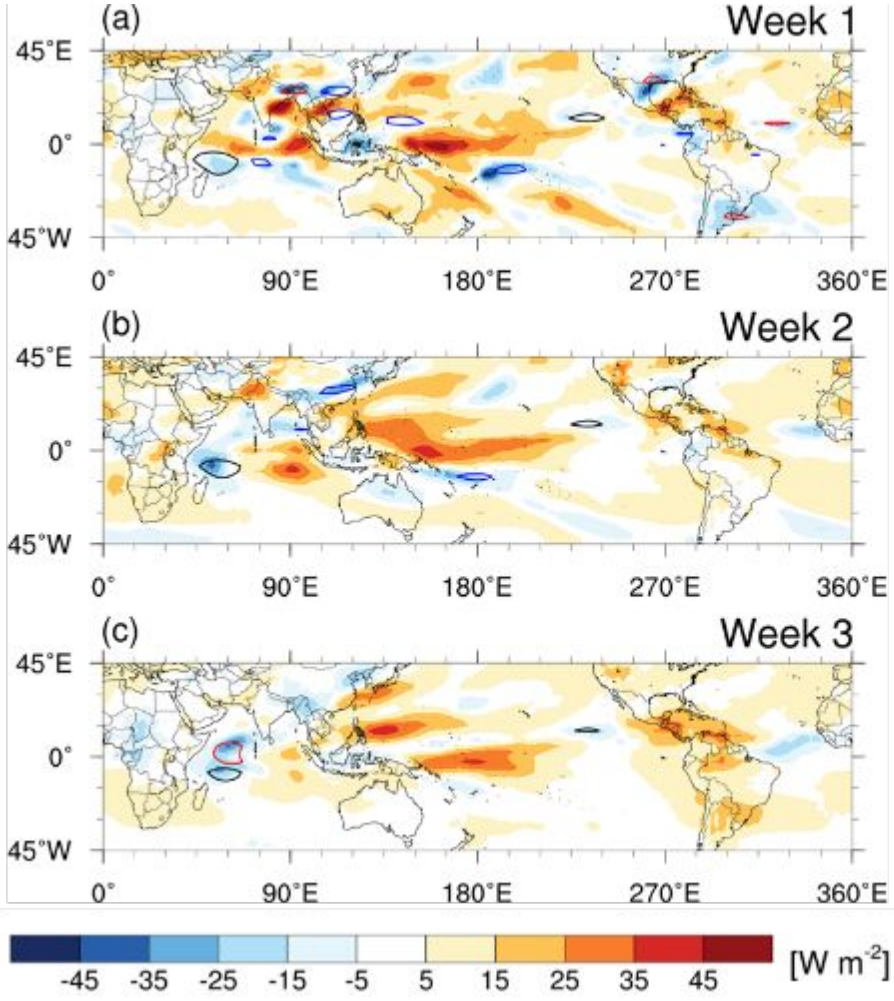
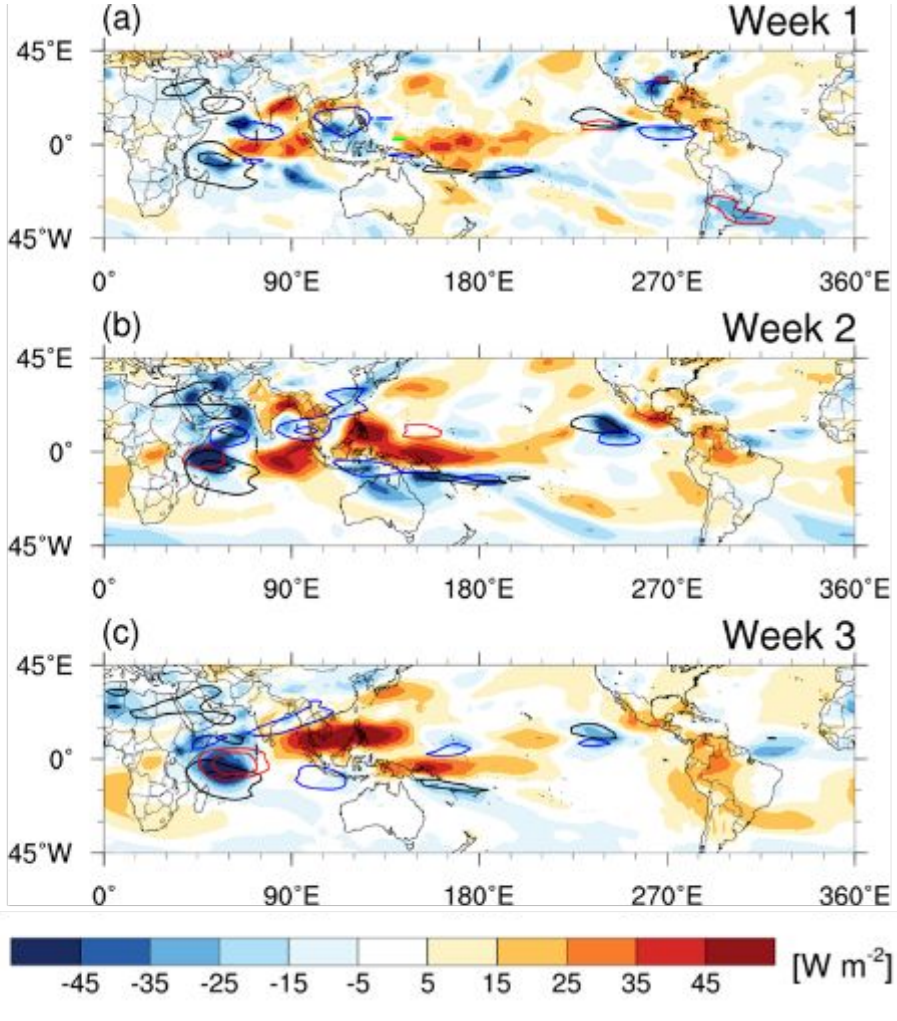
ECMWF



Valid 07/01 - 07/07

Valid 07/08 - 07/14

Valid 07/15 - 07/21

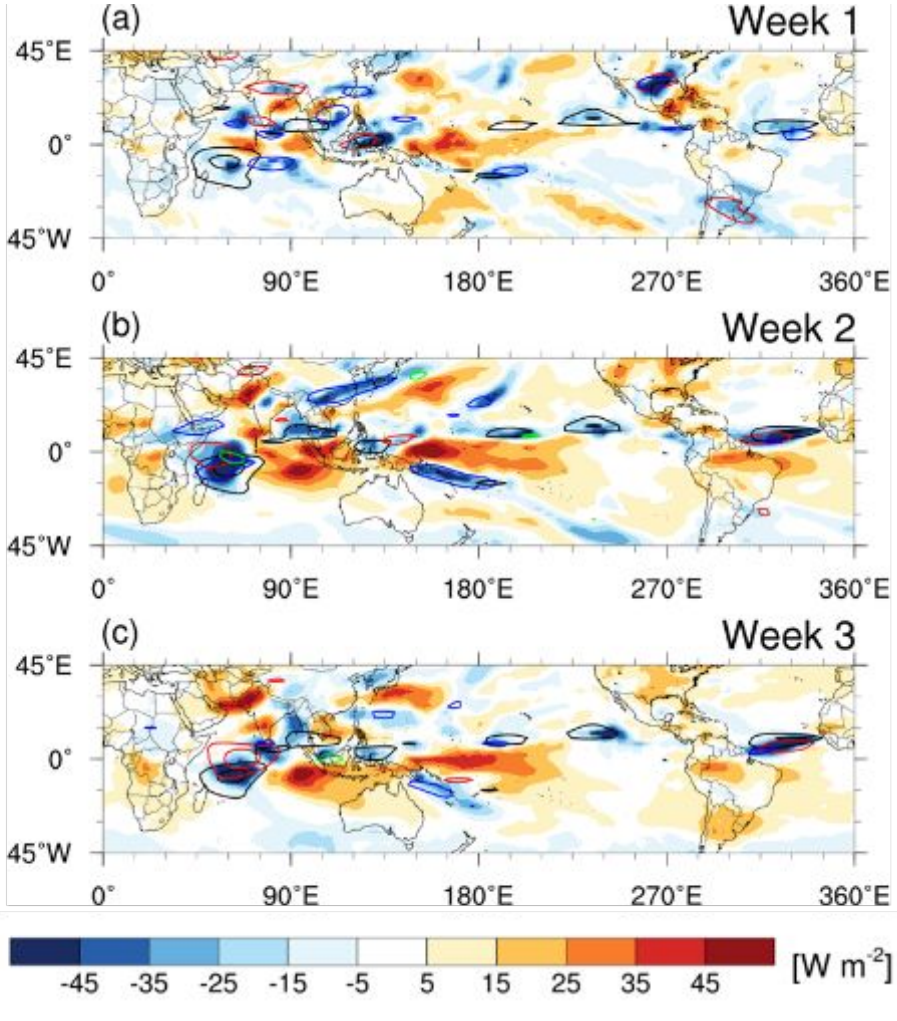


Valid 07/01 - 07/07

Valid 07/08 - 07/14

Valid 07/15 - 07/21

UKMO

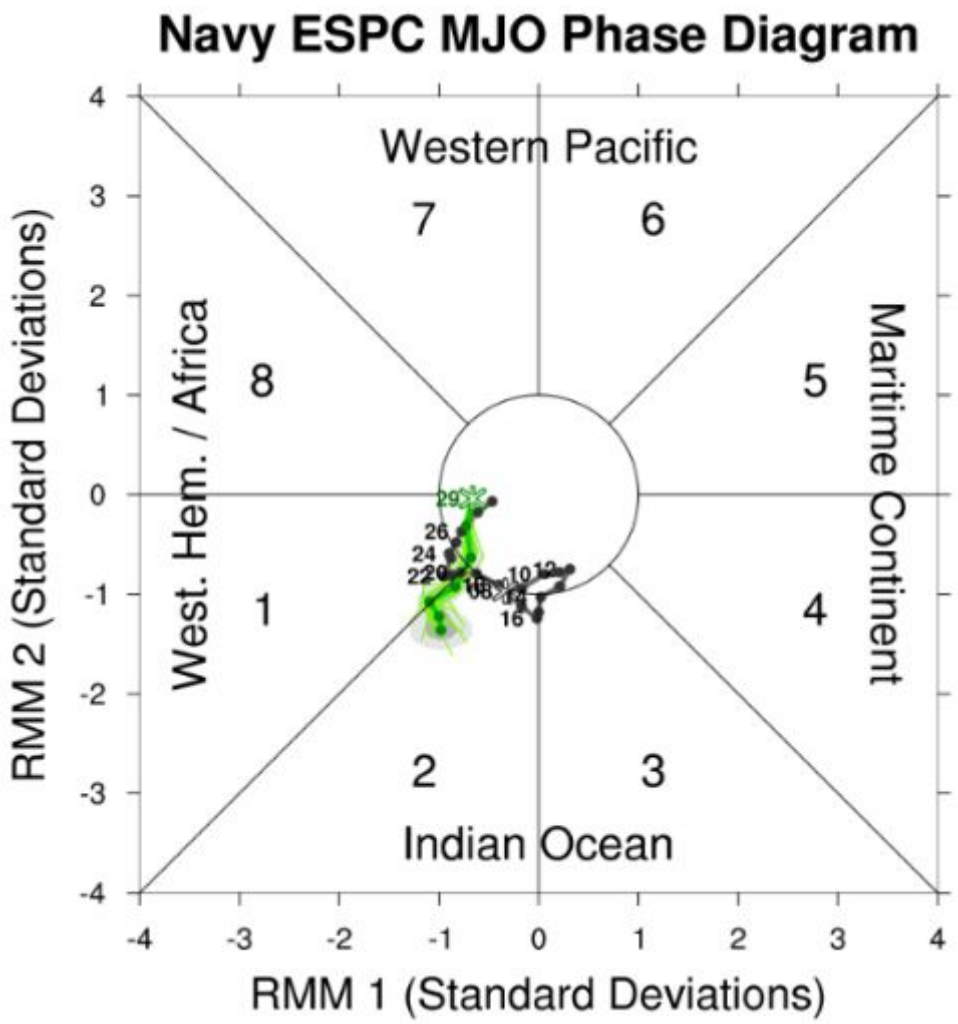


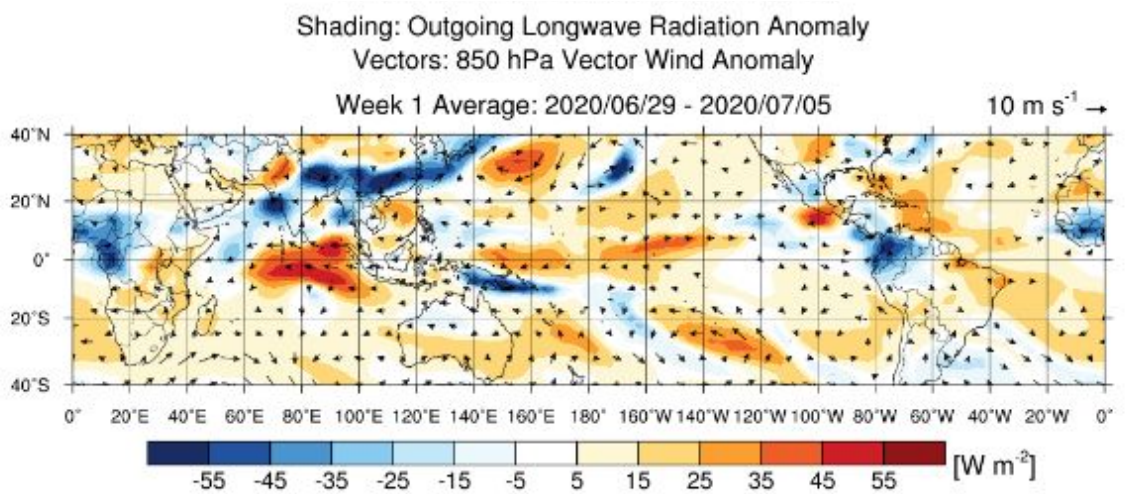
Valid 07/01 - 07/07

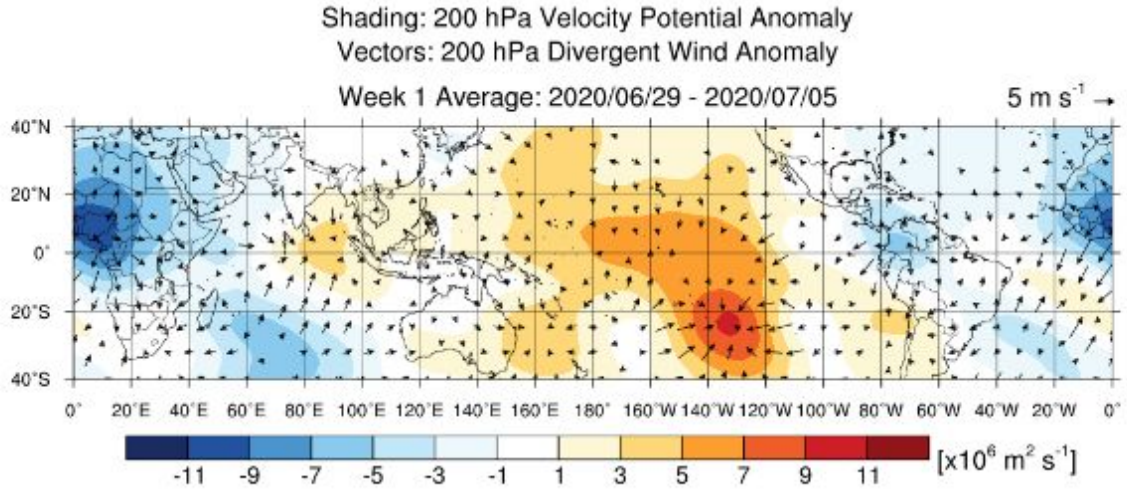
Valid 07/08 - 07/14

Valid 07/15 - 07/21

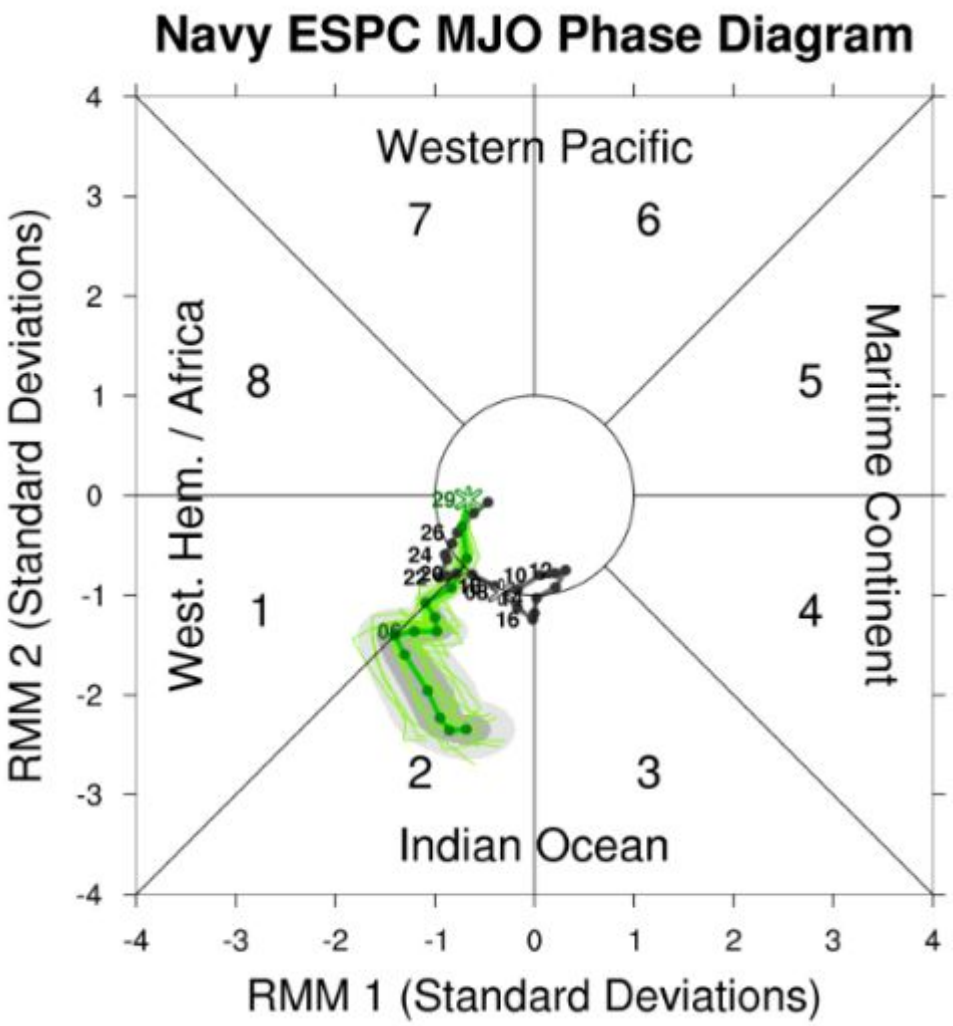
Navy ESPC Products
2020/06/28 Initialization – Week 1

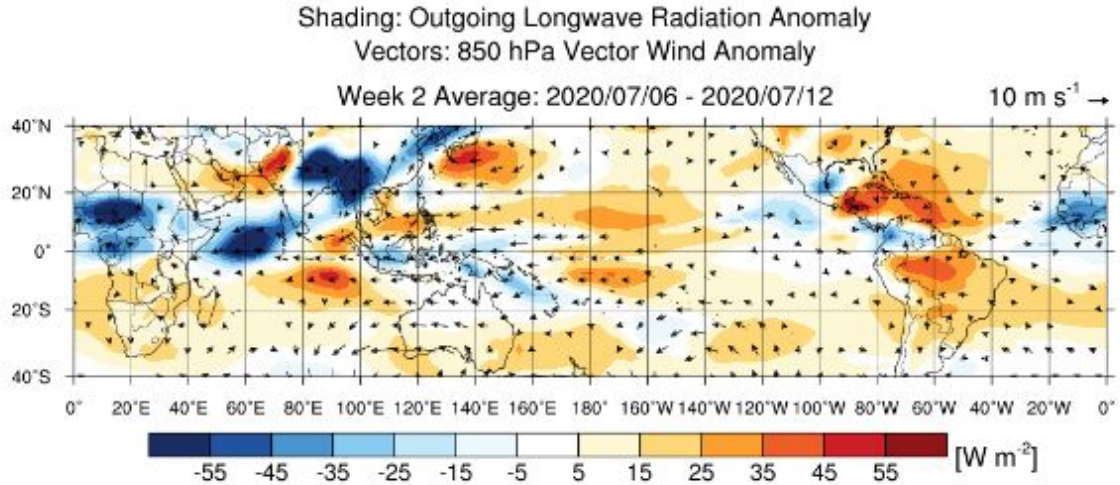


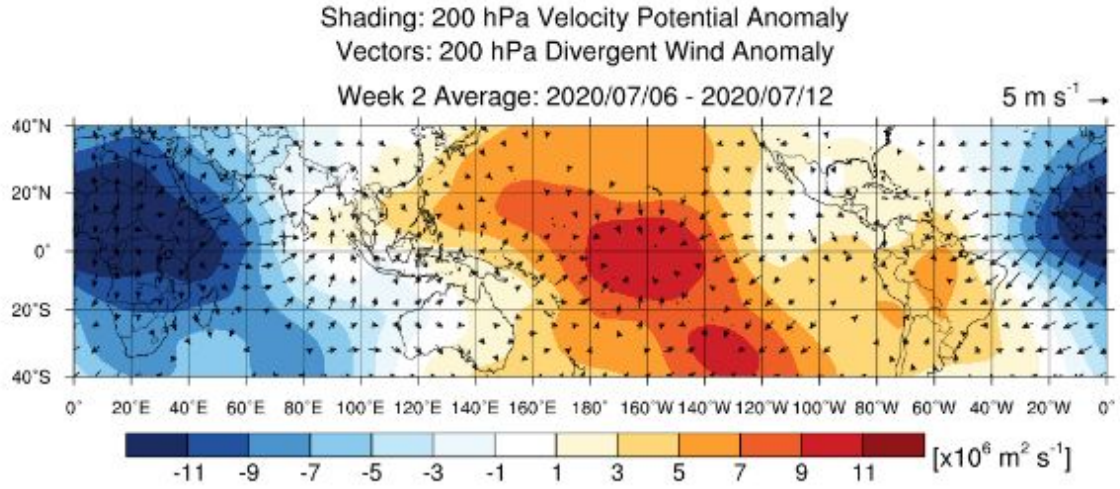




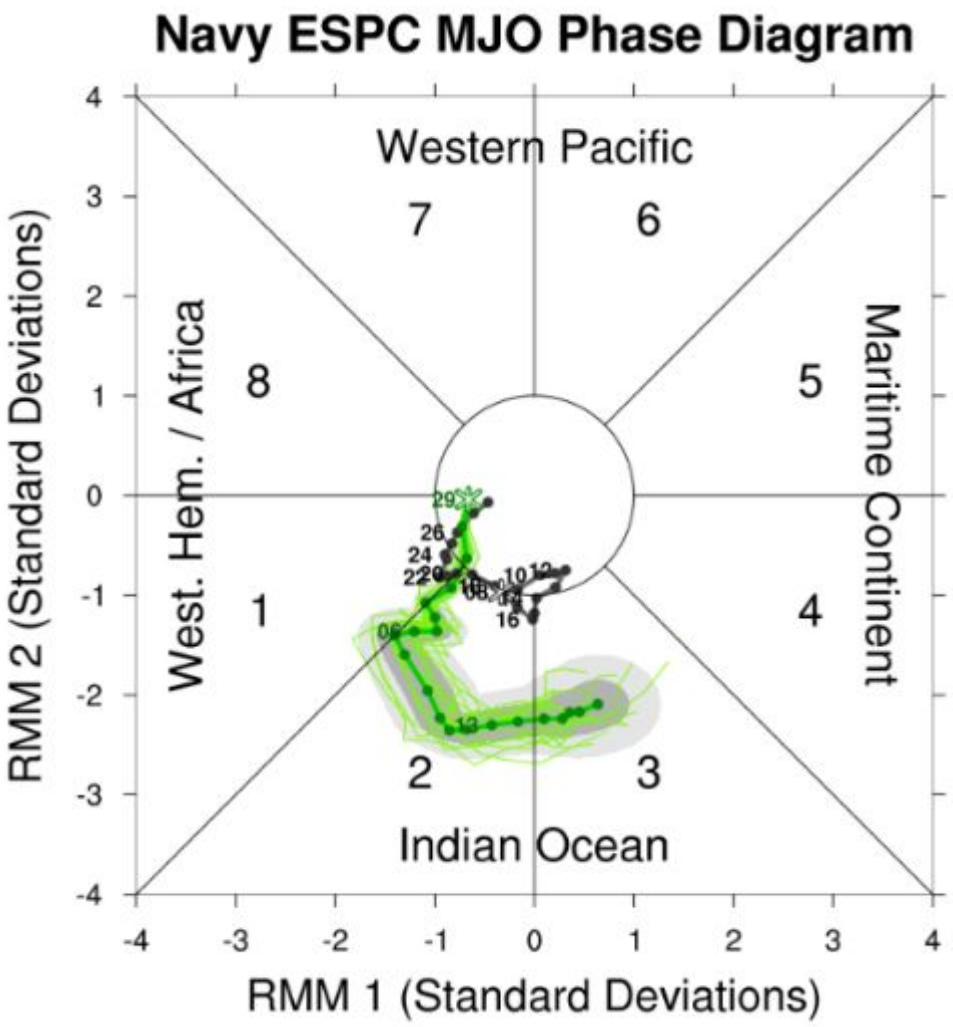
Navy ESPC Products
2020/06/28 Initialization – Week 2

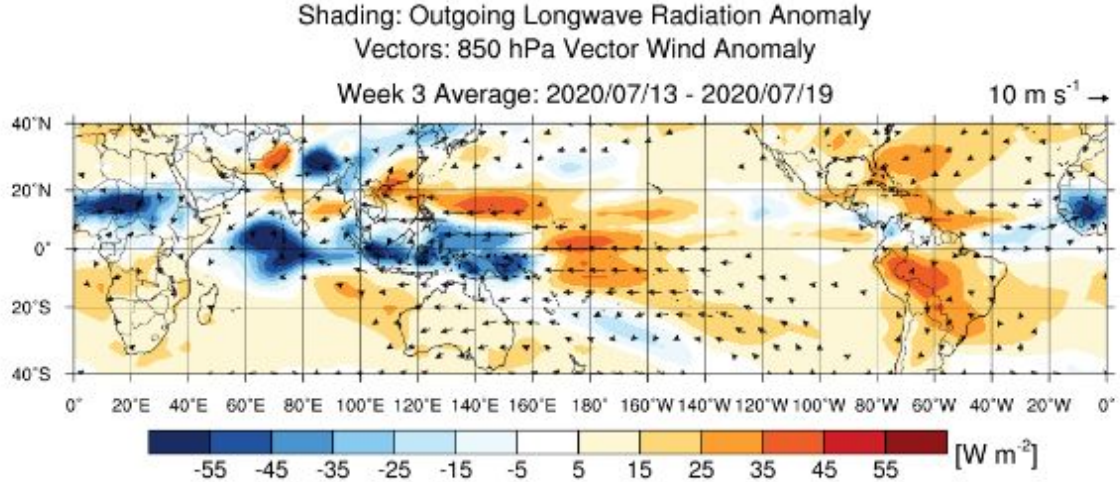


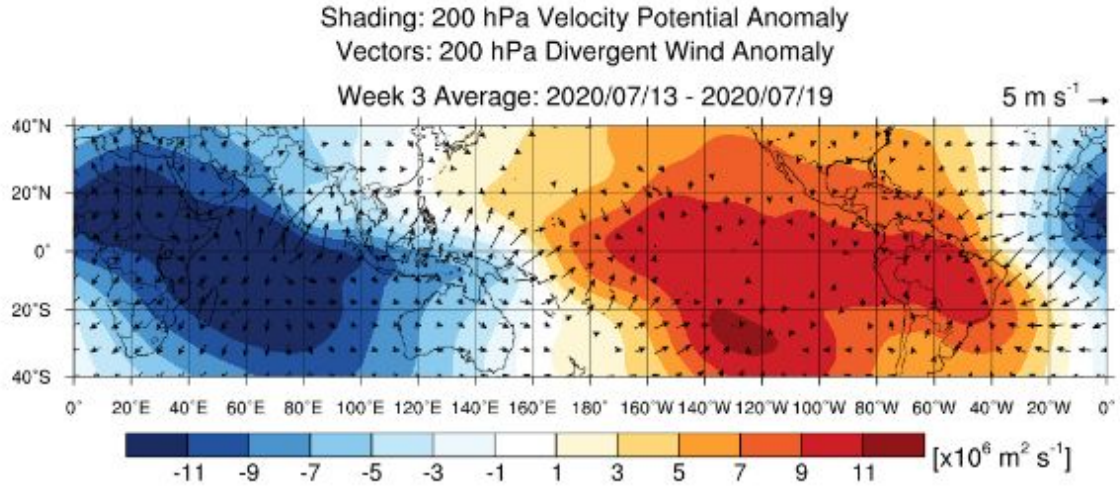




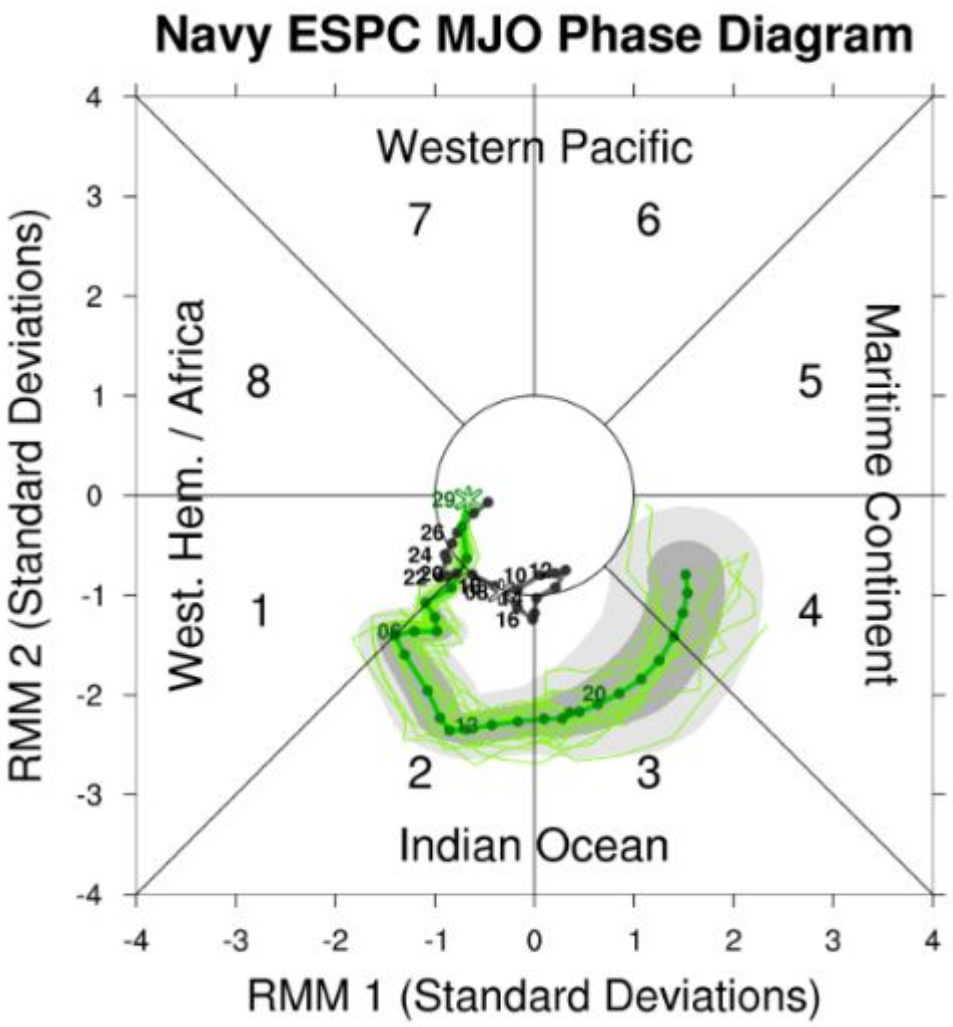
Navy ESPC Products
2020/06/28 Initialization – Week 3

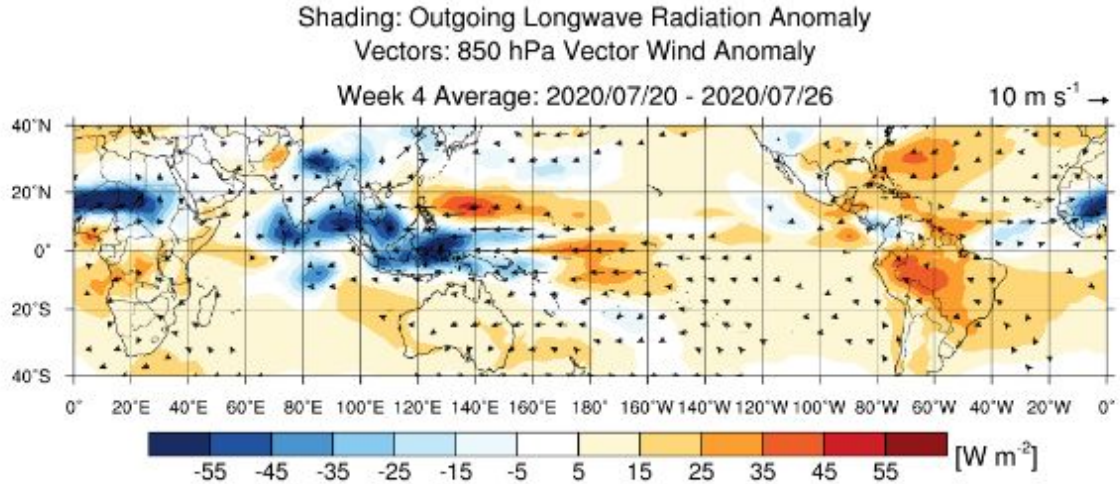


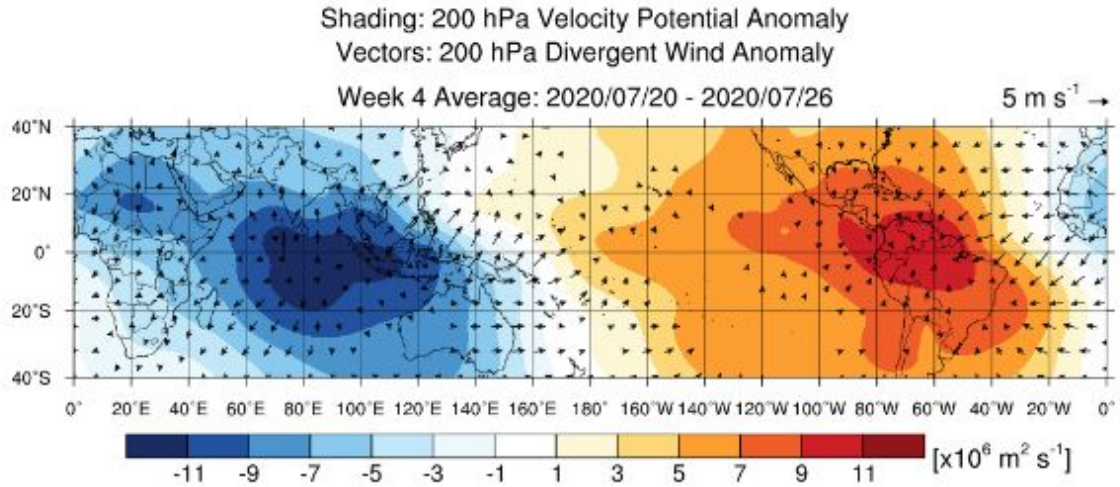




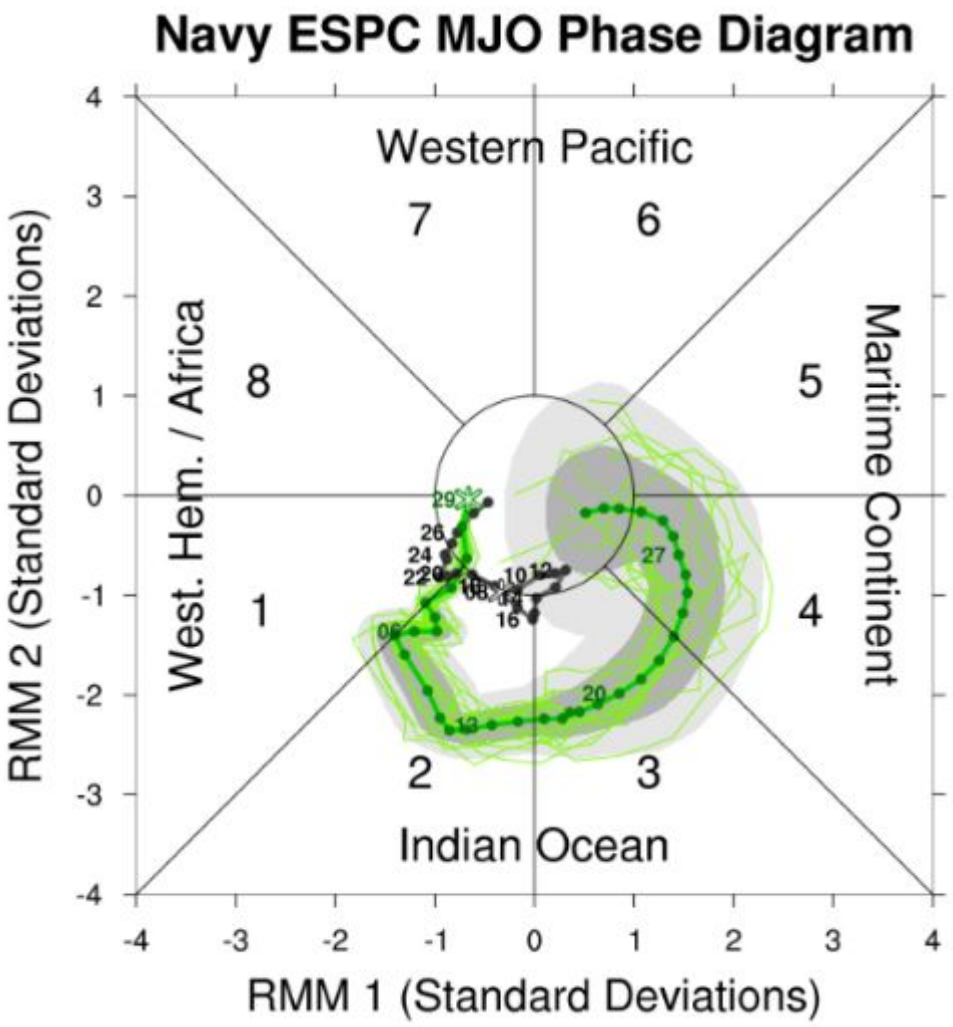
Navy ESPC Products
2020/06/28 Initialization – Week 4

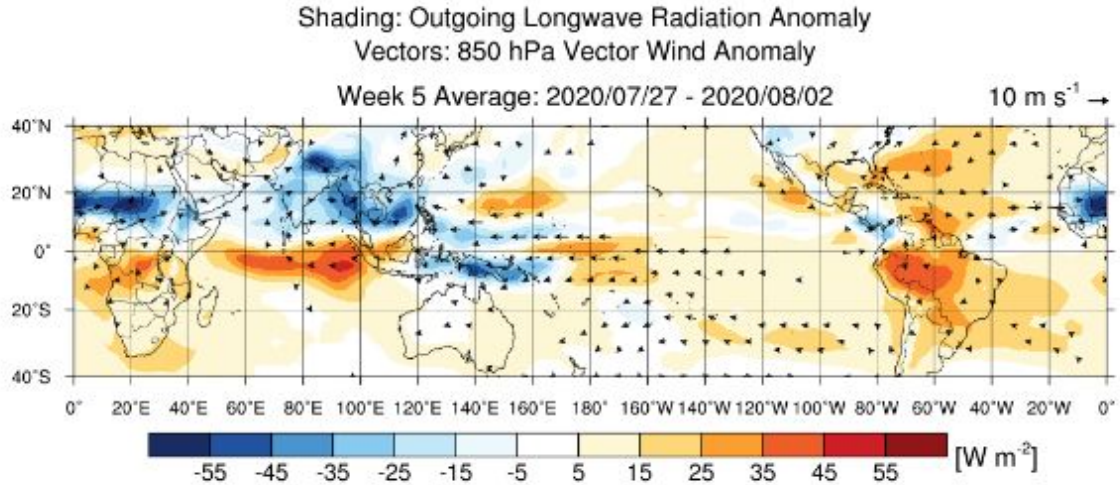


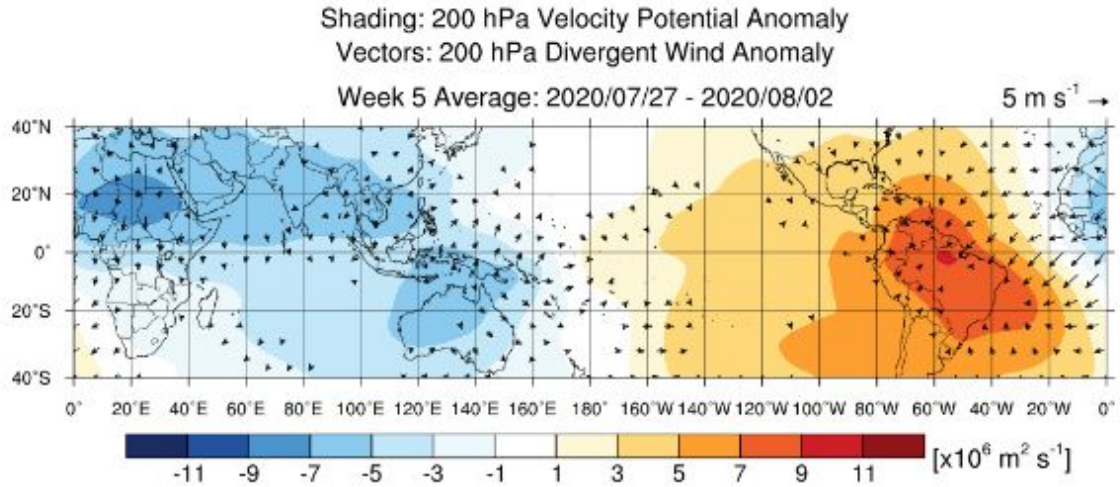




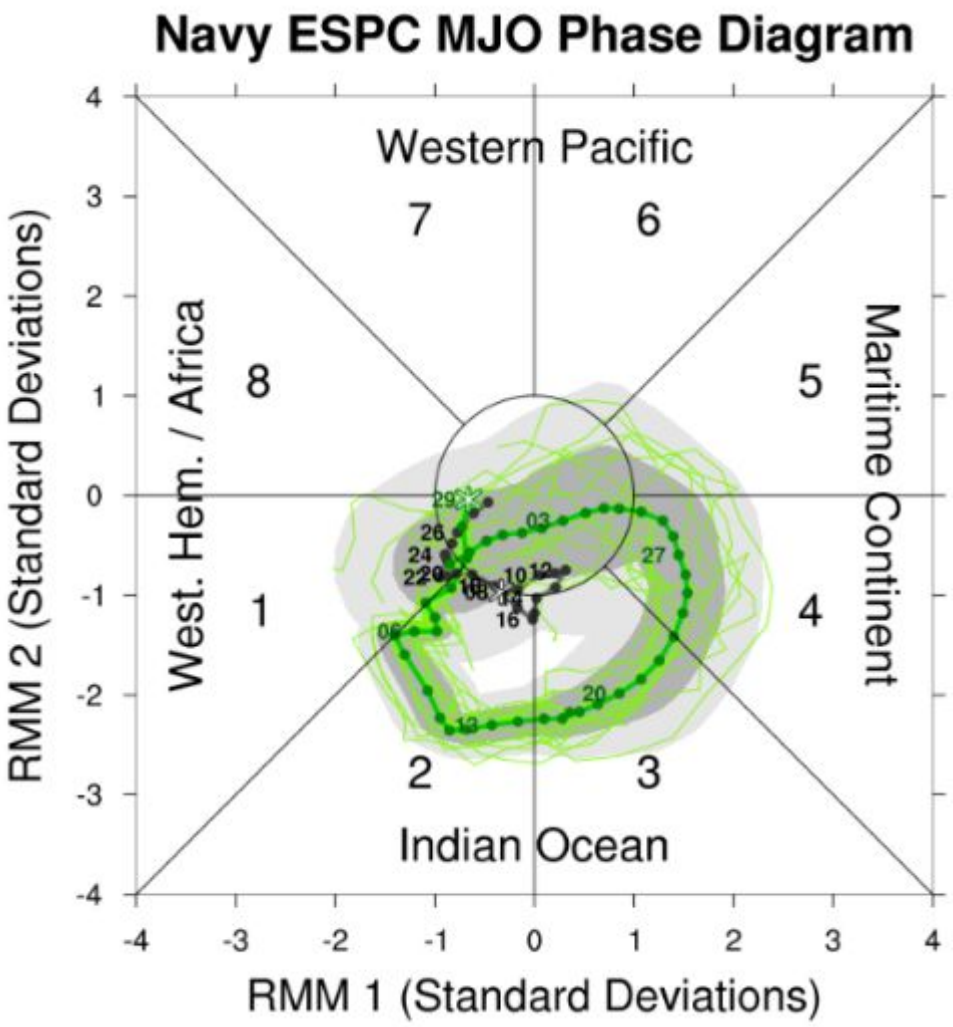
Navy ESPC Products
2020/06/28 Initialization – Week 5

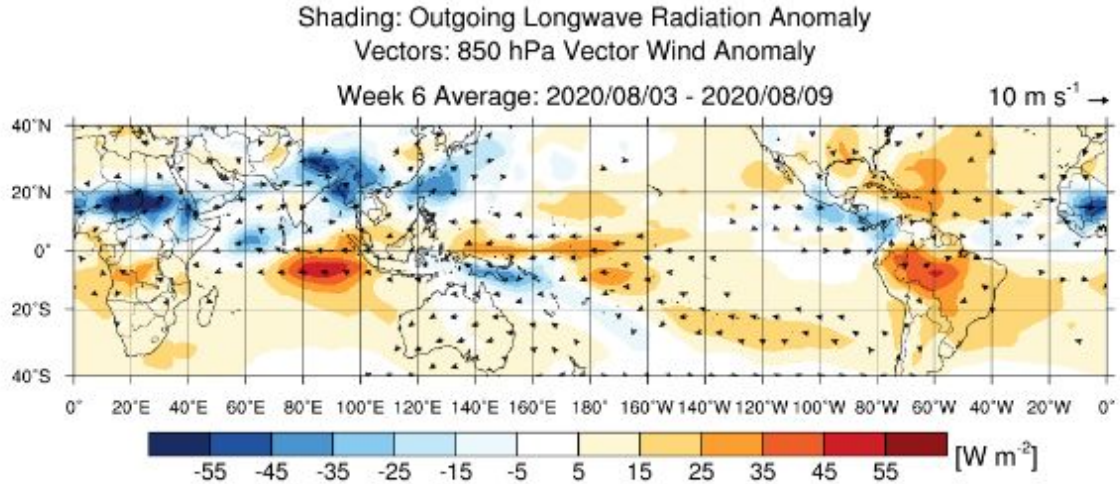


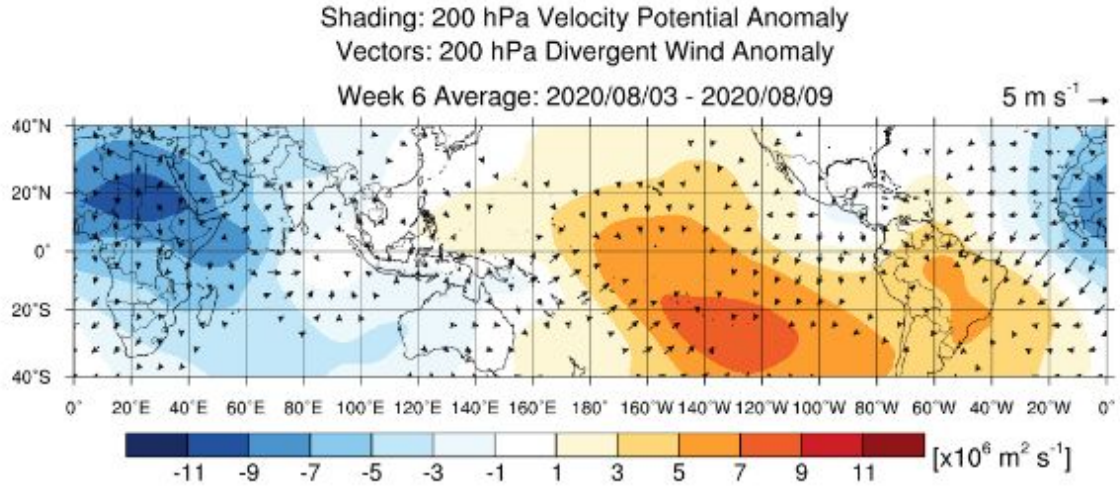




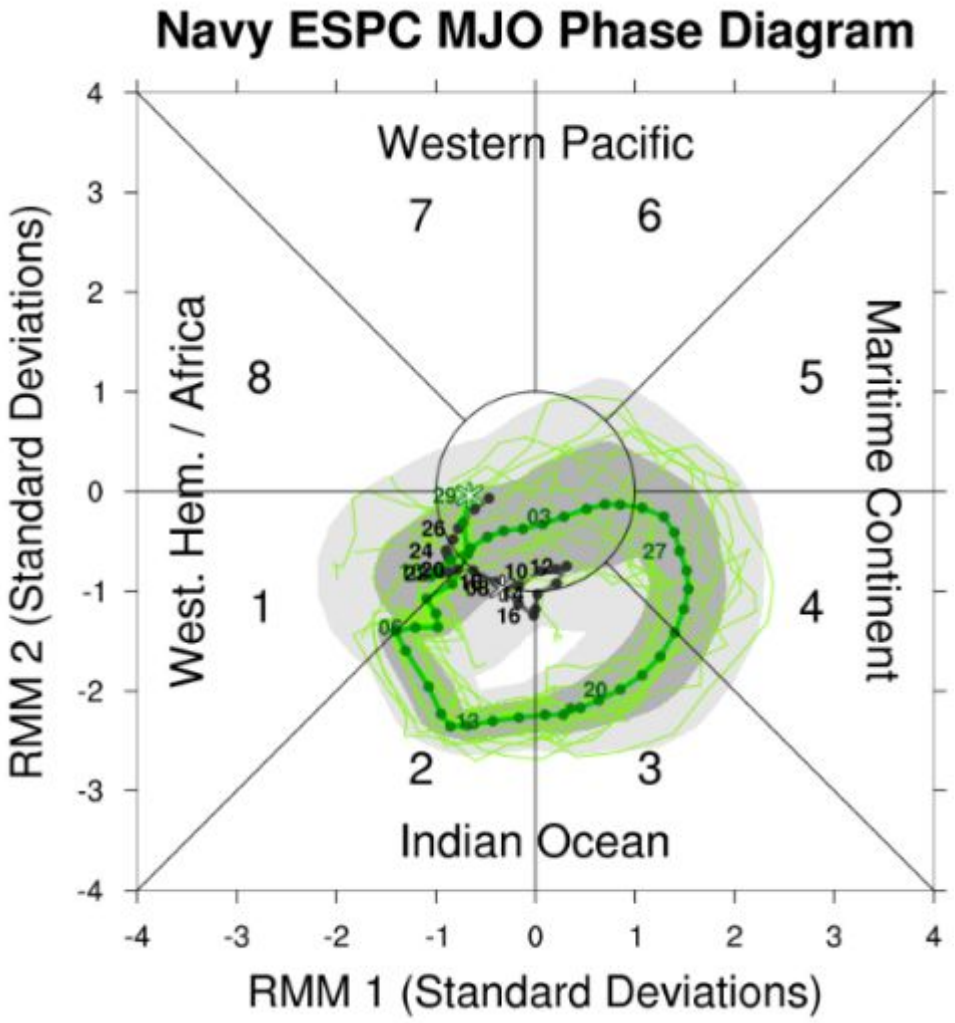
Navy ESPC Products
2020/06/28 Initialization – Week 6

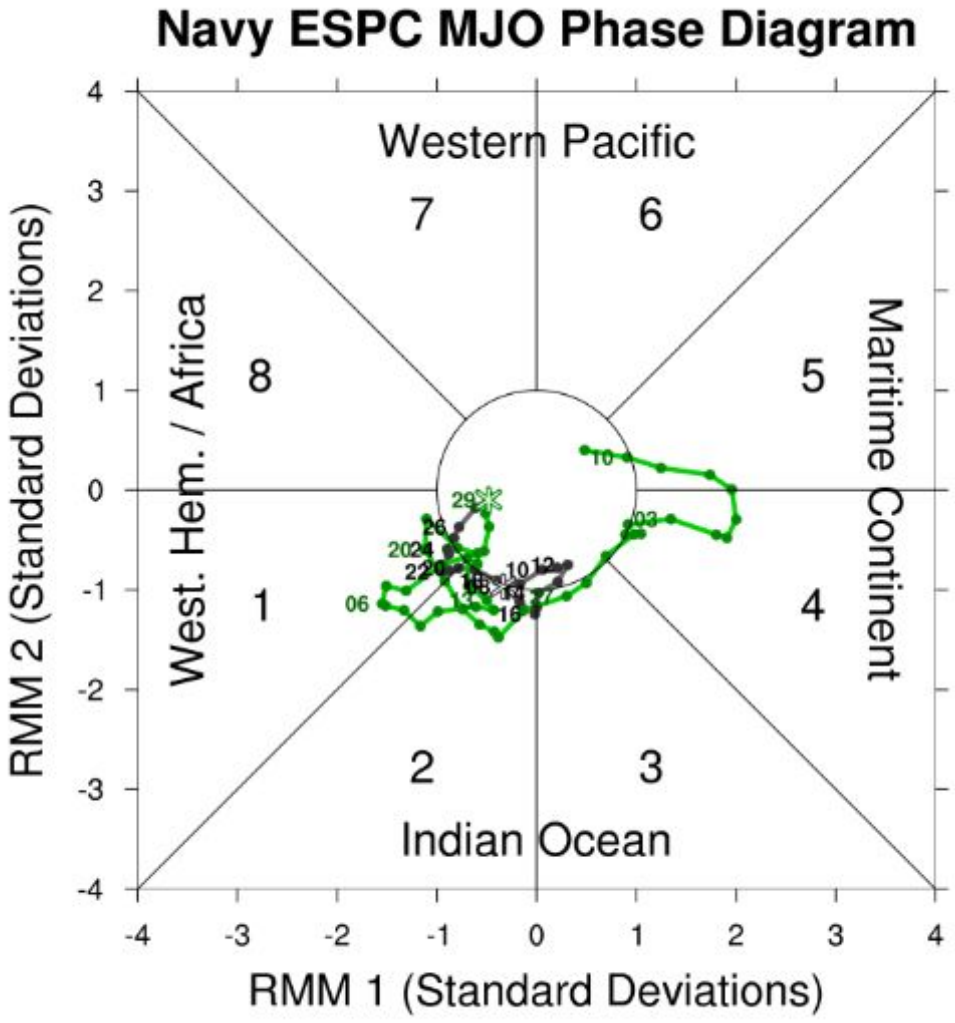






Navy ESPC Products
2020/06/28 Initialization – Verification





Future Opportunities

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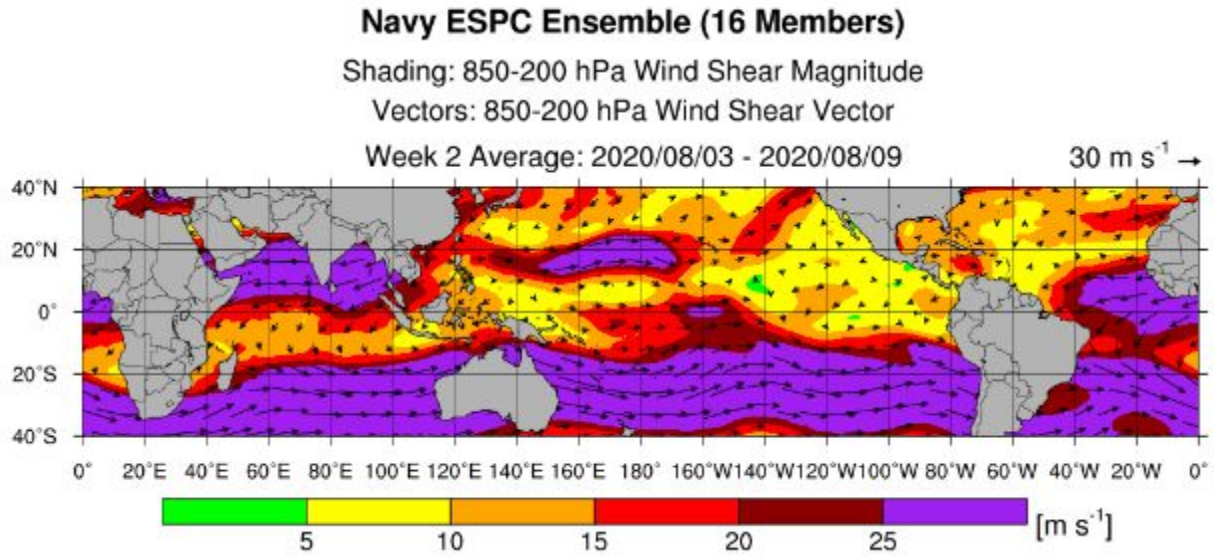
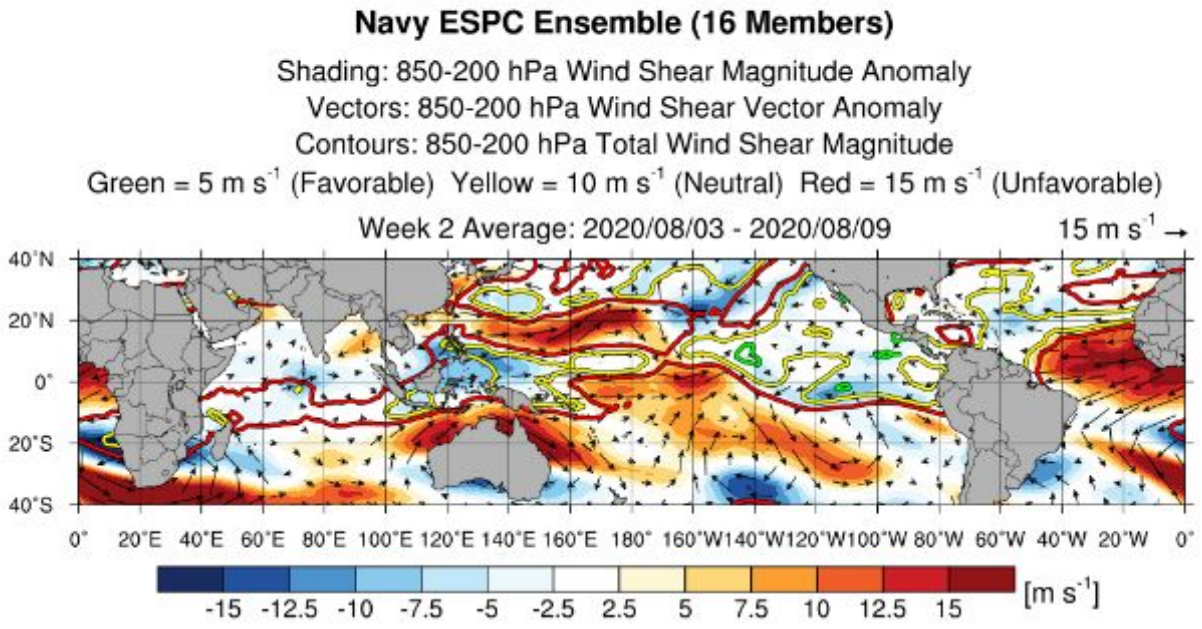
New Wind Shear Products

Total 850-200 hPa Wind Shear Vector and Magnitude



Anomalous 850-200 hPa Wind Shear Vector and Magnitude and Total Shear at Specific Levels



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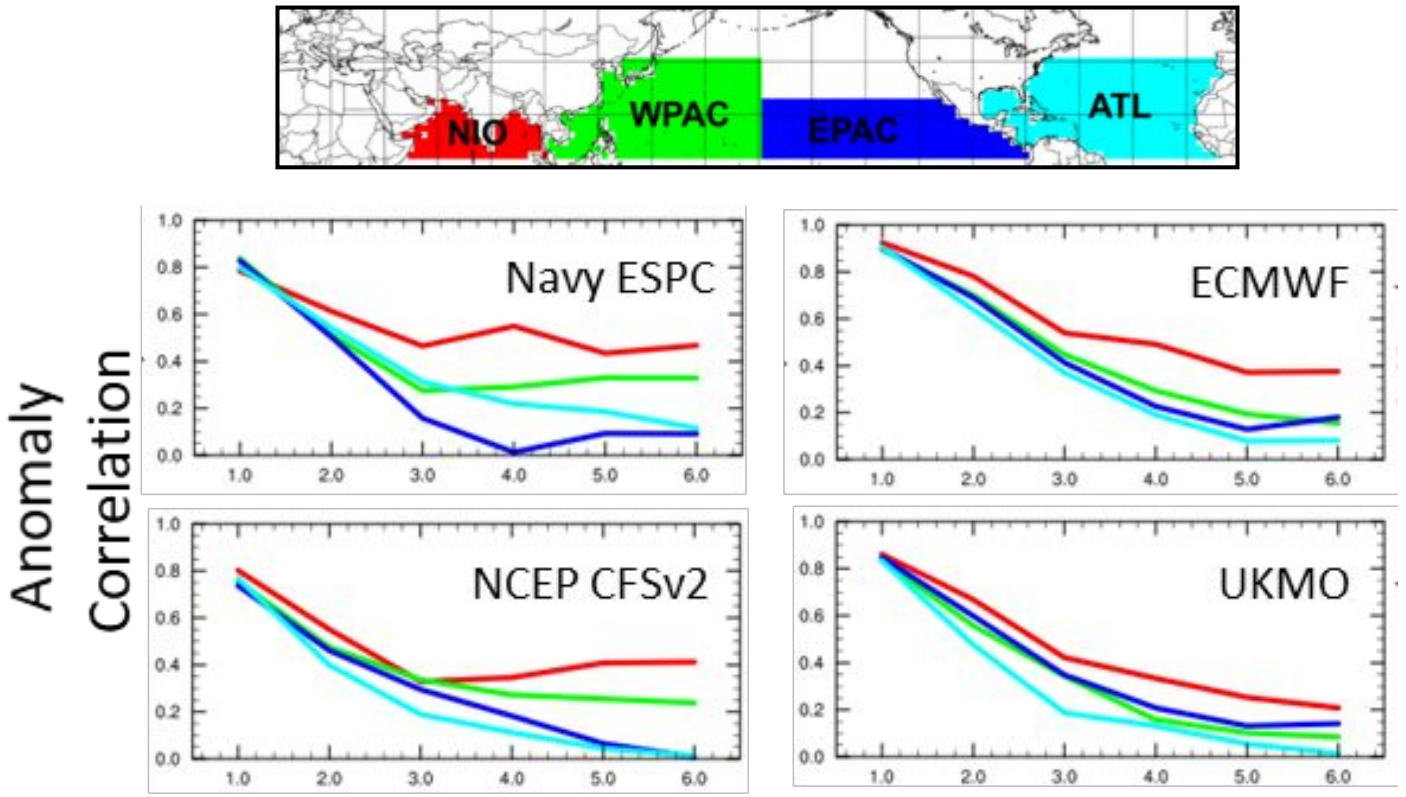
Wind Shear Product Validation



Verification of weekly-averaged wind shear magnitude for different models as a function of forecast lead time for Jun-Nov 2020 Forecasts.

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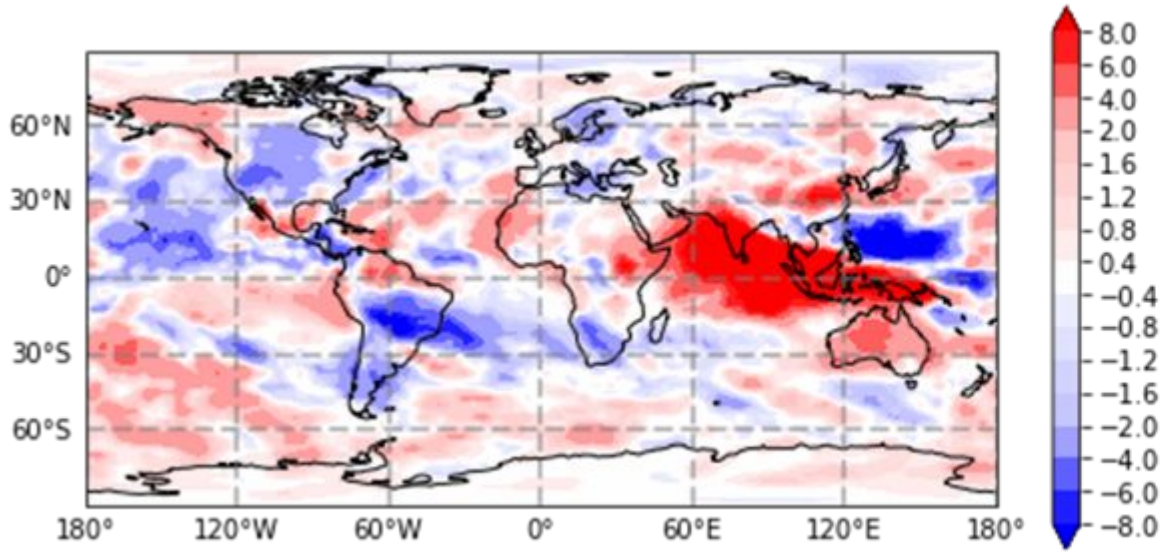
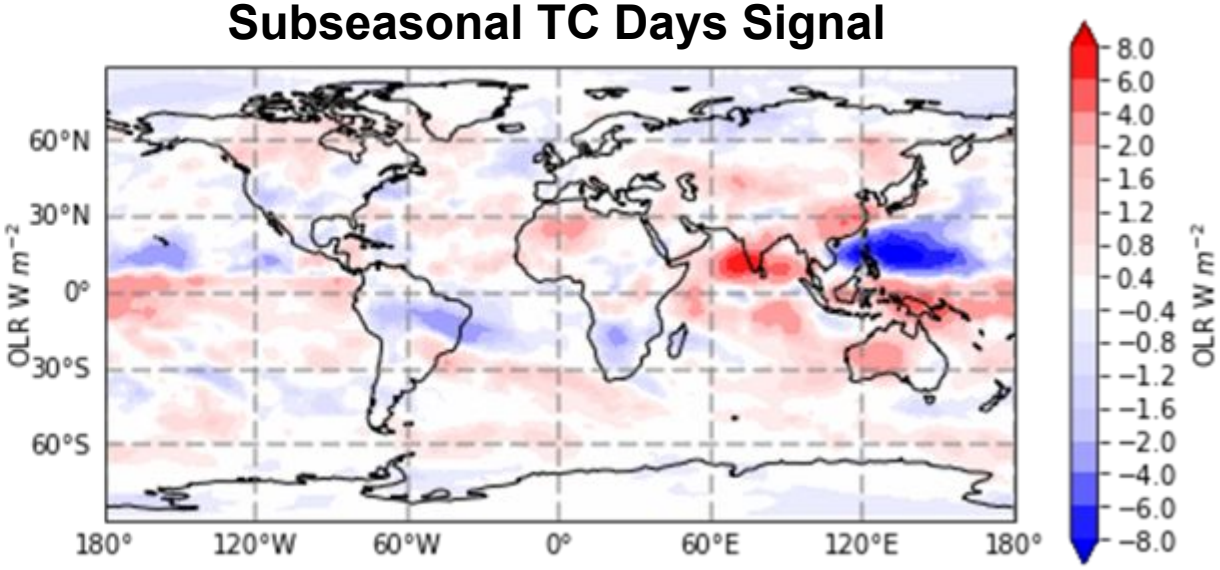
Statistical-Dynamical TC Prediction

OLR Anomalies MJO Phase 6

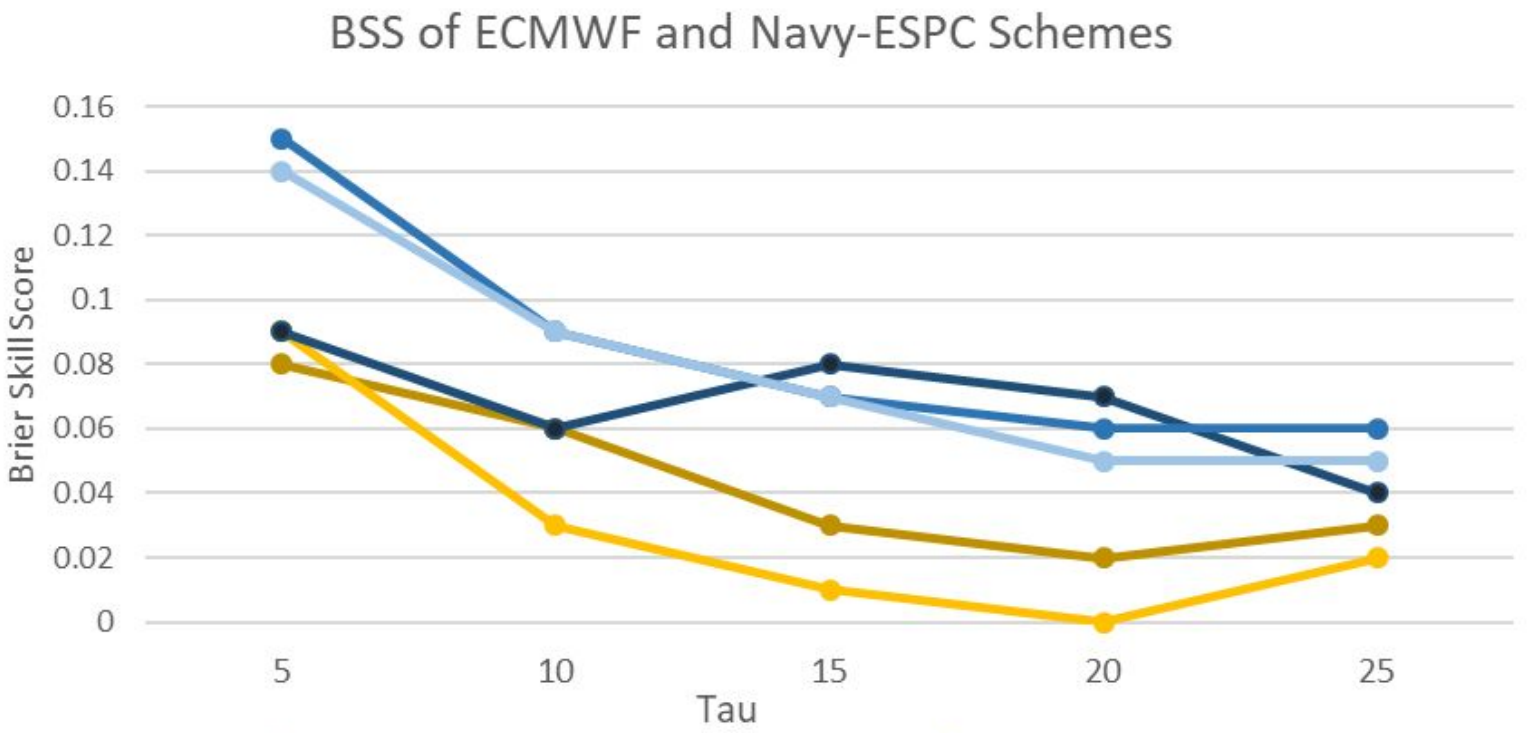


OLR Anomalies Enhanced Subseasonal TC Days Signal



Statistical-Dynamical TC Prediction

Statistical-Dynamical Models of West Pacific TC Days



ESPC [MJO, SST]
ESPC [TCD OLR, SST]

ECMWF [MJO, SST]
ECMWF [TCD OLR, SST]
ECMWF [TCD OLR, TCD Shear, SST]

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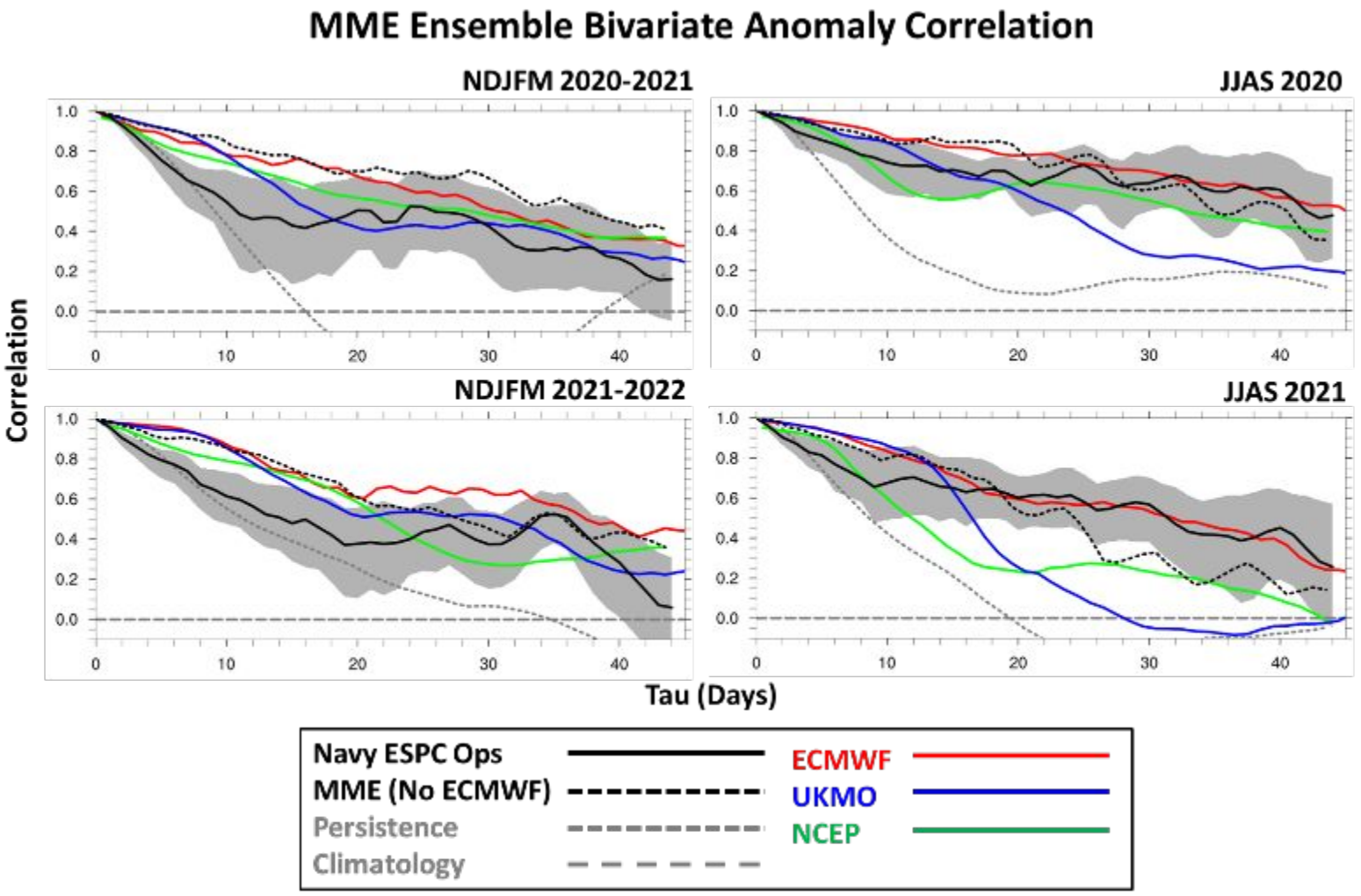
Multi-Model Ensembles



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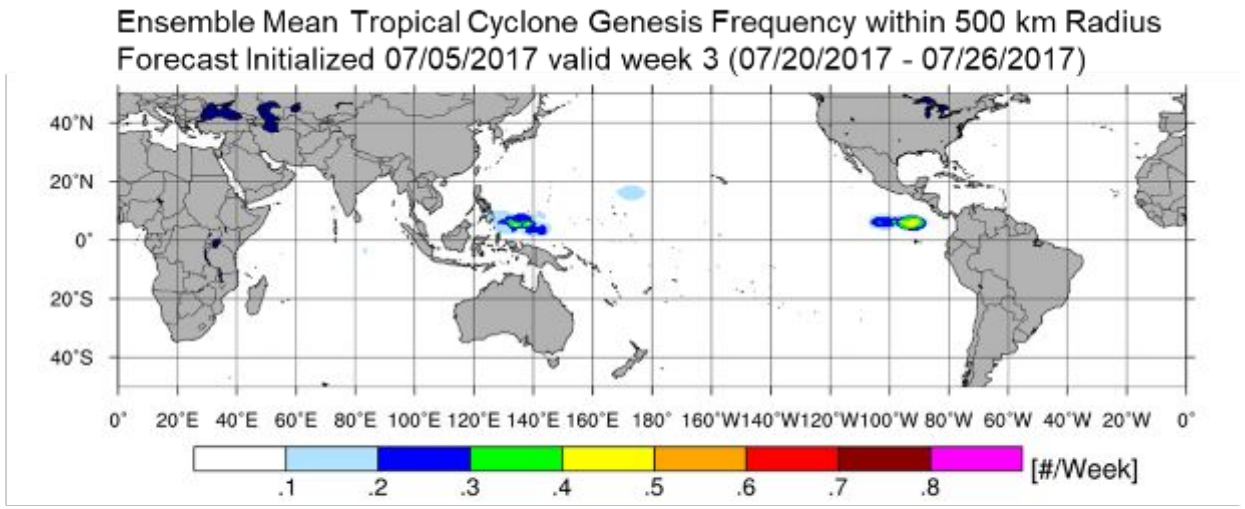
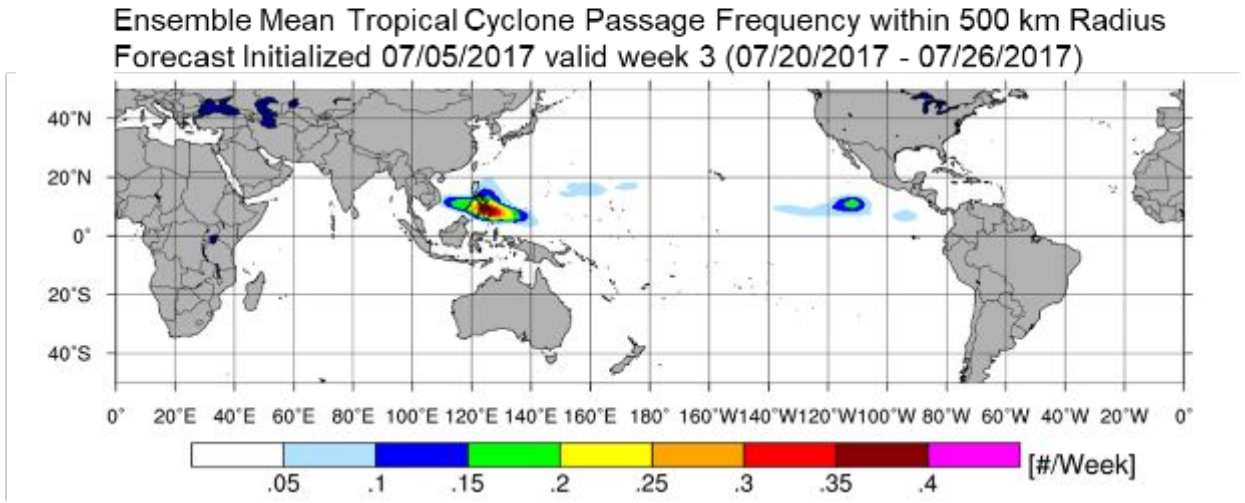
Extended-Range TC Track Products





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Summary

Real-Time Project:

- Filtering OLR for the MJO provides a more detailed view of the position of the MJO envelope than MJO indices.
- Given large biases in MJO behavior, multi-model guidance can provide valuable context for forecasters and in model evaluation.

Future Opportunities:

- Other large-scale indices.
- Wind shear and other tropical cyclone environment products.
- TC tracks and statistical-dynamical TC predictions.
- Multi-model ensembles.