Prediction skill of the eastward propagating Madden-Julian Oscillation and associated dynamics in Version 2 of NASA's GEOS-S2S forecast system

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Introduction / Motivation

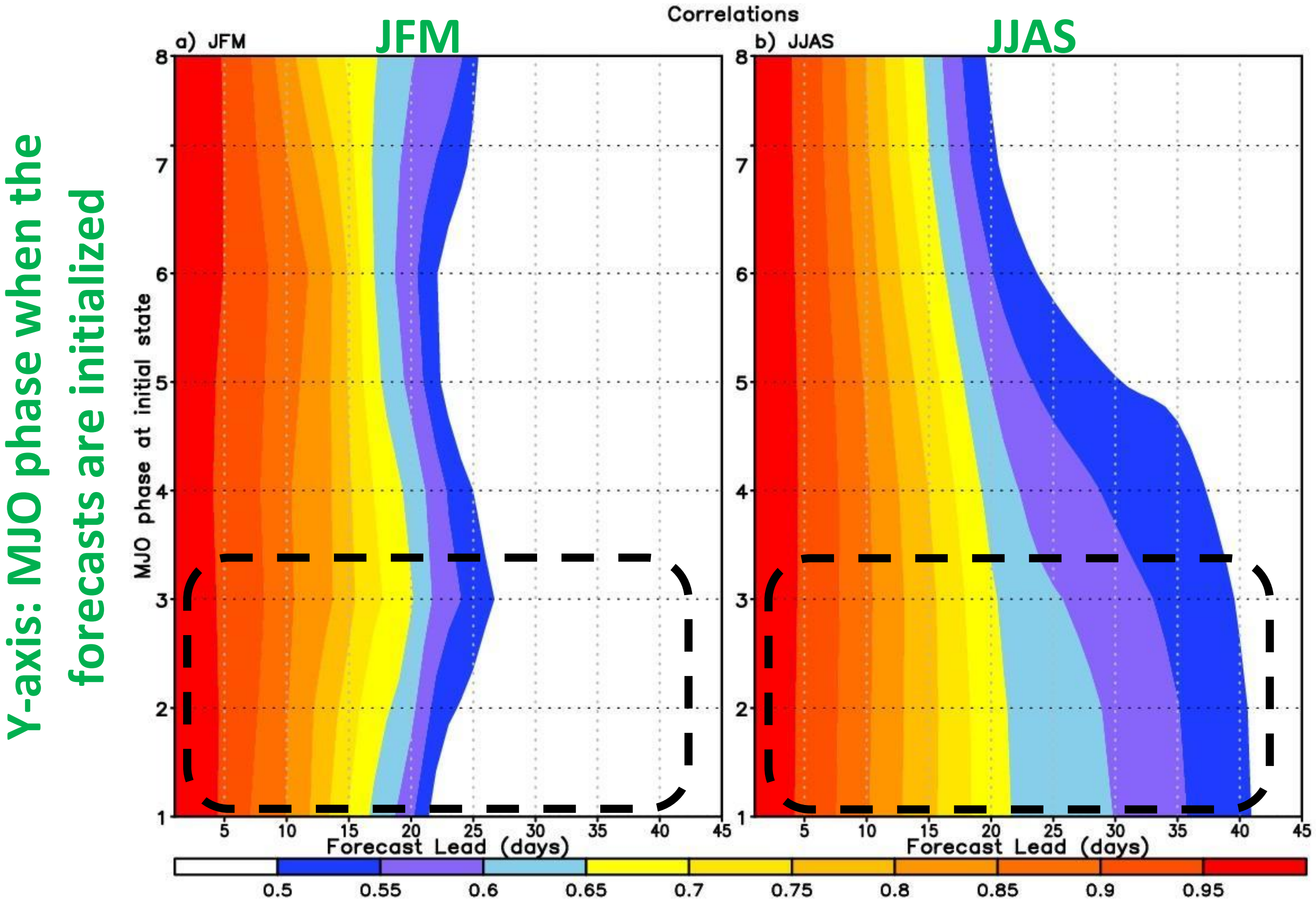
The annual bivariate correlation of the Real-time Multi-variate MJO time series between GEOS-S2S forecast and observation is shown to be greater than ~0.50 at 30-day forecast lead.

Correlation displays a seasonality: Correlation at long-leads (>30 days) is noticeably higher for boreal summer initial conditions (June-September), with correlations remaining above 0.5 at 35-40 day leads, and lower for boreal winter initial conditions from January through March, dropping to ~0.5 at 25-day lead, still comparable to the skills in the other reliable S2S forecast systems.

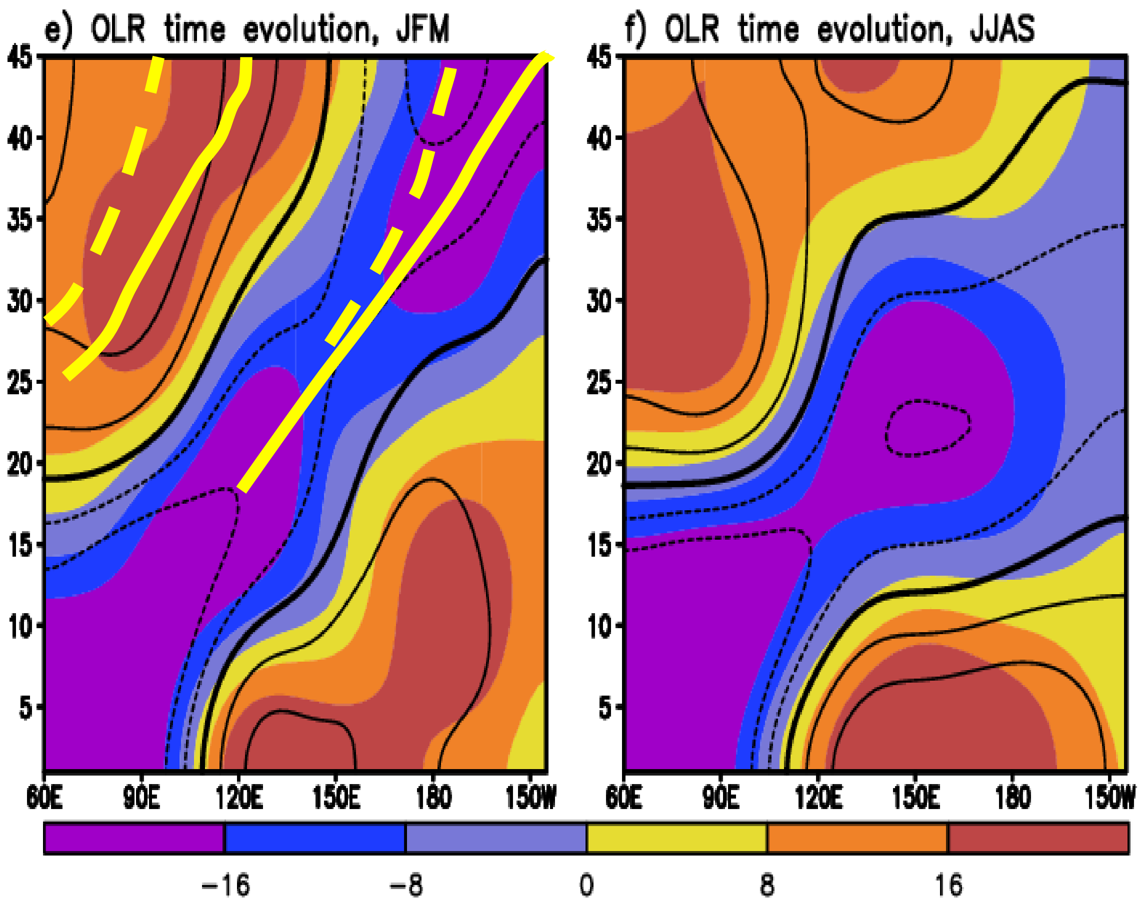
This study investigates the 1) moistening process based on moist static energy budget and 2) circulation response to the MJO convective heating around the Maritime Continent to understand this seasonality in skill.

MJO prediction skill in GEOS-S2S and time evolution of OLR in two seasons

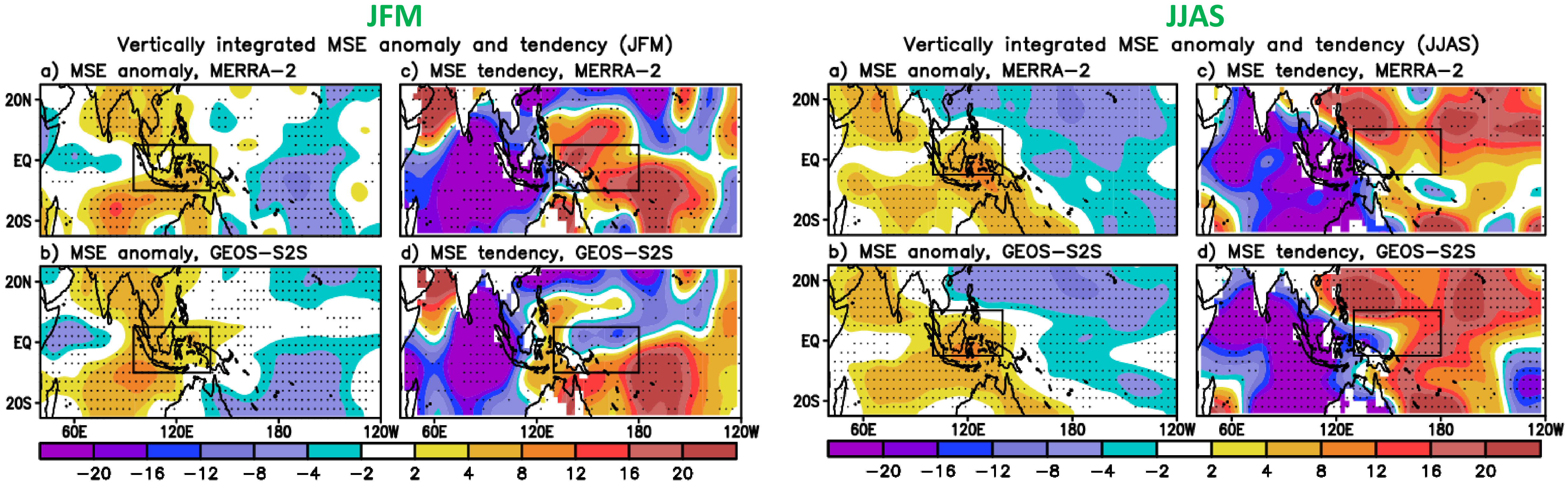
Seasonal difference (JFM vs. JJAS) in prediction skill: Bivariate correlations of the MJO time series between obs. and forecasts drop much less slowly with lead time when the MJO phases at initial state are 1, 2, 3 in JJAS, compared to JFM.



Eastward propagating OLR. The predicted OLR anomalies (*black contour*) in JFM are somewhat west of observed (*shaded*) at 25–45 day leads, indicating slower propagation than observed.

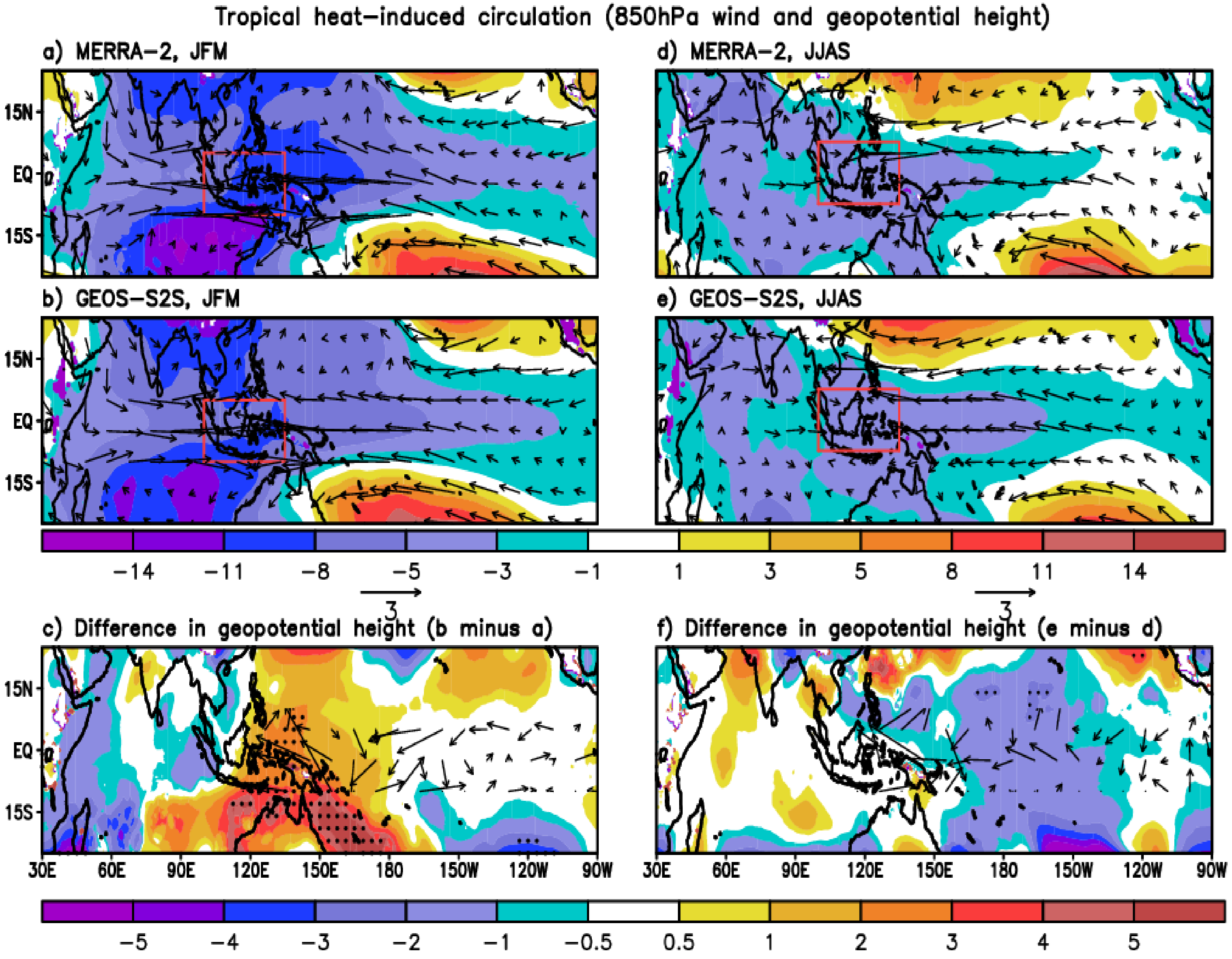


Moist static energy (MSE) tendency from the MSE budget equation

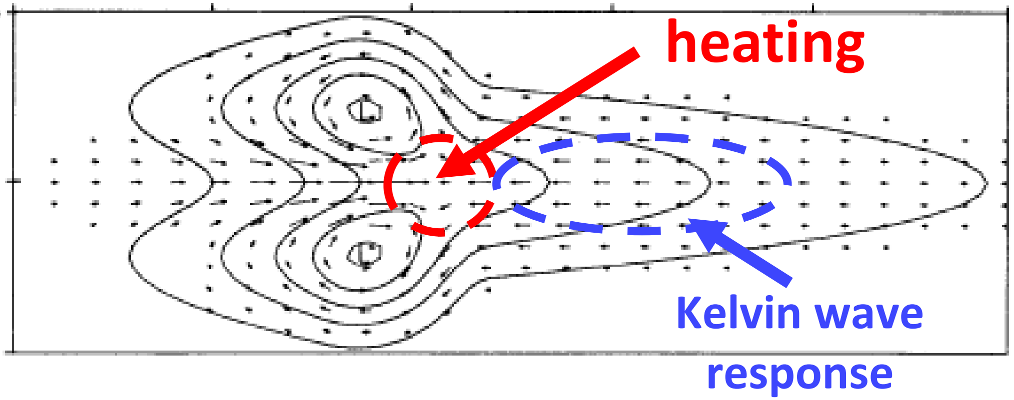


Premoistening (=MSE tendency) ahead of the MJO convection (=MSE anomaly) is realistic in the model in summer, helping the eastward propagation of the MJO to the western Pacific. However, this moistening is underestimated in the boreal winter. (Weaker vertical advection of MSE is responsible for this underestimated moistening.. not shown here)

Circulation & height response to MJO heating (JFM (left), JJAS (right))



Diff. maps: Negative height anomaly and equatorial Kelvin wave response over the MC and W. Pacific is stronger than observed in summer (=> Large zonal scale of response with strong Kelvin wave response is necessary for active MJO propagation to the Pacific). Negative height response is underestimated in winter.



Concluding remarks

- MJO prediction skill in the GEOS-S2S forecast system Version 2 displays a seasonality: higher in boreal summer initial condition (when the MJO phases are 1, 2, or 3: Correlation remains above 0.5 at 35-40 day forecast lead) and lower in boreal winter initial condition (correlations close to ~0.5 at 25 day lead). (Note: this assessment is based on RMM index-based metrics)

- Eastward propagation of OLR is as fast as observed in summer, but slower than observed in winter, clearly at 25-45 day forecast leads.

- Dry bias in the tropics, underestimated total moisture advection near Maritime Continent, and underestimated moistening process (due to underestimated vertical MSE advection) ahead of the MJO convective anomaly is found from the GEOS-S2S in winter, while they are captured well in summer.

- Atmospheric circulation (Kelvin wave) / pressure response to the MJO convective heating is more realistic in summer, while underestimated in winter.

- The realistic representation of moistening process is crucial for better prediction of the eastward propagating MJO activity.

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