NASA GEOS Model for Sub-Seasonal to Seasonal Predictions: The Major Teleconnections, Tropical Cyclone Activity, and ENSO

Young-Kwon Lim[1,2], Siegfried D. Schubert[1], and Andrea M. Molod[1]

[1]NASA Goddard Space Flight Center (GSFC), Global Modeling and Assimilation Office (GMAO), Greenbelt, MD, USA; [2]Goddard Earth Sciences Technology and Research / I.M. Systems Group, Greenbelt, MD, USA

GMAO
Global Modeling & Assimilation Office

Abstract

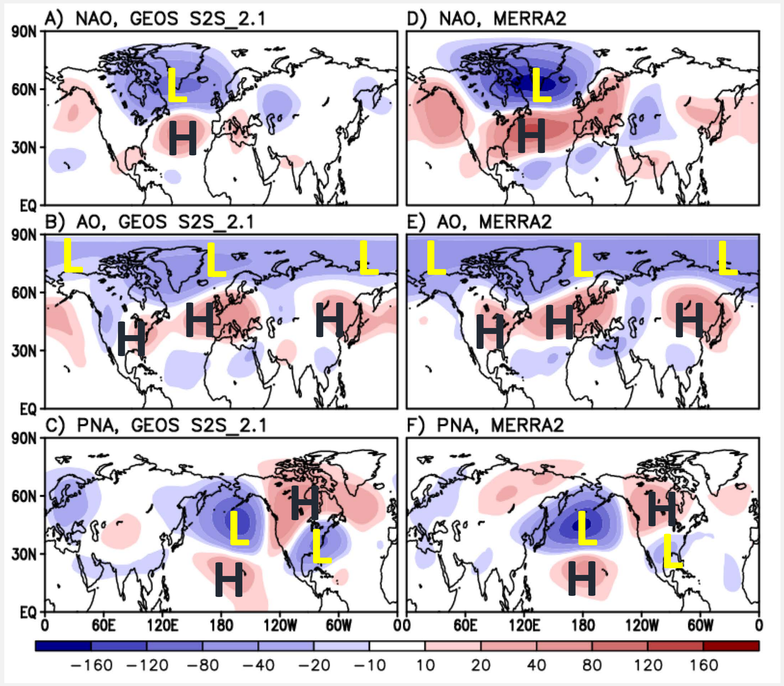
Ability of the NASA GEOS seasonal prediction model system (the latest version) in predicting the large-scale teleconnections, tropical cyclone (TC) activity, and ENSO are validated. The major large-scale teleconnections include the North Atlantic Oscillation (NAO), the Arctic Oscillation (AO), and the Pacific North American (PNA) that span vast geographical area across the North Pacific/Atlantic and North America. Predictive skill of TC activity is assessed by Genesis potential index (GPI). Anomaly correlations are greater than 0.5 for winter teleconnections at up to 2 month lead and for the first four month (June-July-August-September) GPIs over the North Atlantic and the Western Pacific. Correlation for the long-range prediction of the ENSO (Niño3.4 SST) maturity reaches 0.9 at 6 month lead and 0.8 at 9 month lead.

Model system: 1) Full coupling of the atmosphere, ocean, land, and sea-ice, and 2) atmosphere-ocean coupled data assimilation.

Atmosphere: FV dynamics, cubed-sphere horizontal discretization, physical patameterizations (details in Molod et al. 2015), Ocean: MOM5-based, Land: catchment LSM (Koster et al. 2000), Sea ice: CICE4.1

Major Teleconnections

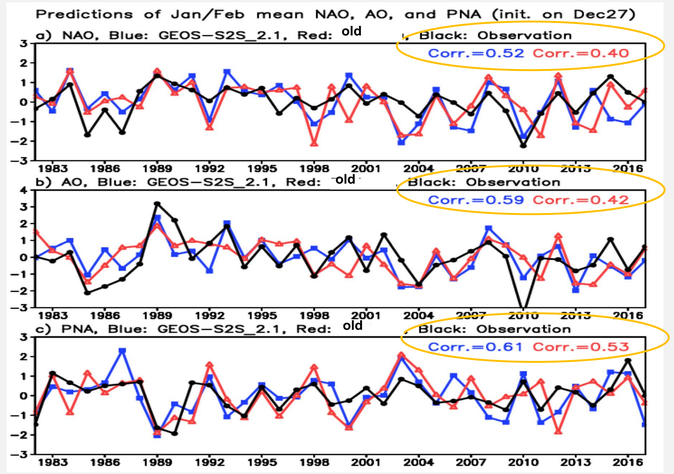
Identification of the patterns



GEOS model MERRA2

The GEOS model quite realistically produces the observed major teleconnection patterns of the NAO, the AO, and the PNA. However, the magnitude of the observed anomalies is slightly underestimated by the model.

Predictions of the Phase/Magnitude of the Teleconnections

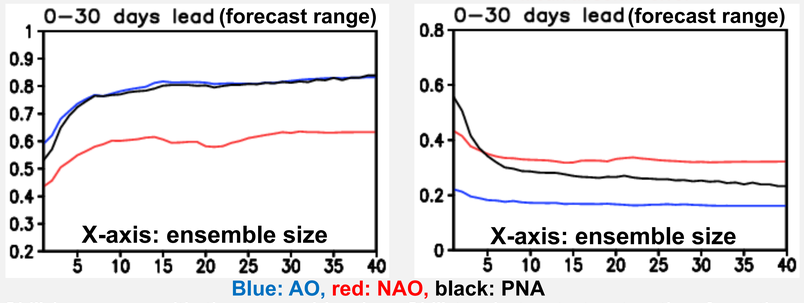


NAO
AO
PNA

Blue: new version, red: old, black: MERRA2

Predictive skill is assessed for 1982-2016 Jan/Feb winters (initialized in late December each year). Correlations are 0.5–0.6, with the highest from the PNA (followed by AO and NAO).

Skills as a Function of Ensemble Size (Daily Teleconnections)



Blue: AO, red: NAO, black: PNA

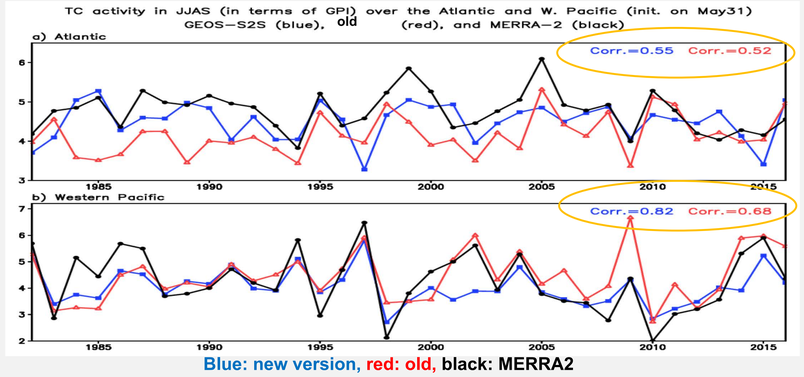
Skill increases with the ensemble size. Skill tends to start saturation from the ensemble size 10–15.

TC Activity: Genesis Potential Index

$$\text{GPI} = |10^5\eta|^{3/2}\left(\frac{RH}{50}\right)^3\left(\frac{V_{pot}}{70}\right)^3(1+0.1V_s)^{-2}\left(\frac{-\omega+0.1}{0.1}\right)$$

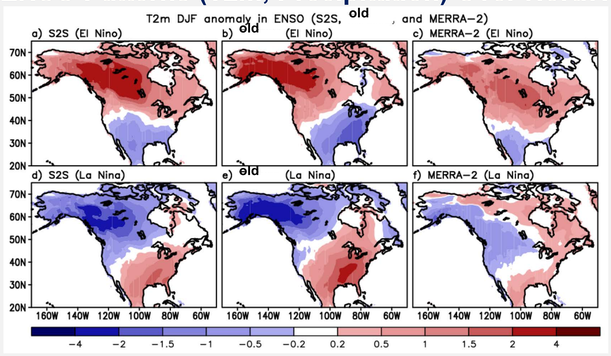
$$V_{pot}^2 = \frac{C_k T_s}{C_d T_0}(CAPE^* - CAPE^b)$$

Prediction of the JJAS GPI, Initialized in late May



Blue: new version, red: old, black: MERRA2

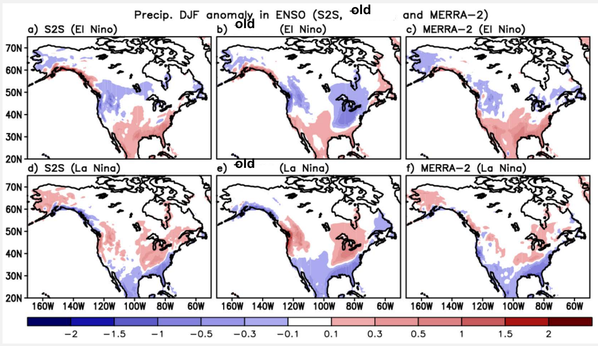
ENSO Patterns (T2m, Precipitation) Over North America



T2m
ENSO warm
ENSO cold

Left: new version, middle: old, right: MERRA2

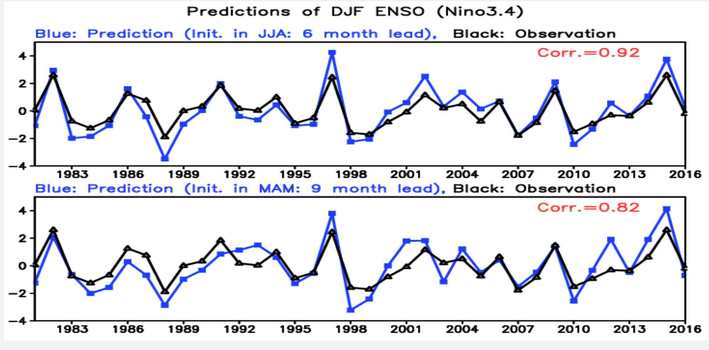
Overestimation of the anomaly amplitude, along with the warmest/coldest anomaly across Alaska and the Western Canada in the old system is partly improved by the new system. Center of the observed cold anomaly in Mexico during El Niño is also better recognized in the new system. Accurate reproduction of the La Niña pattern is relatively more difficult, consistent with other seasonal forecast models.



precipitation
ENSO warm
ENSO cold

Excessive dry bias over the Mid-West surrounding the Great Lakes and underestimated wet condition over the SE US in the old system is improved. During La Niña, overestimated wet condition over the NW US, and the Mid-West, and poor detection of the wet condition over Alaska, is improved by the new system.

Long-range Prediction of ENSO (Niño3.4 SST) Maturity



6 month lead
9 month lead

E-mail: Young-Kwon.Lim@nasa.gov | *Web:* gmao.gsfc.nasa.gov

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