GEOS-5 Seasonal Forecast System: ENSO Prediction Skill and Bias

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Model, data, experiment

The GEOS-5 AOGCM known as S2S-1.0 has been in service from June 2012 through January 2018 (Borovikov et al. 2017). The atmospheric component of S2S-1.0 is Fortuna-2.5, the same that was used for the Modern-Era Retrospective Analysis for Research and Applications (MERRA), but with adjusted parameterization of moist processes and turbulence. The ocean component is the Modular Ocean Model version 4 (MOM4). The sea ice component is the Community Ice CodE, version 4 (CICE). The land surface model is a catchment-based hydrological model coupled to the multi-layer snow model.

The AGCM uses a Cartesian grid with a 1° × 1.25° horizontal resolution and 72 hybrid vertical levels with the upper most level at 0.01 hPa. OGCM nominal resolution of the tripolar grid is ½°, with a meridional equatorial refinement to ¼°.

In the coupled model initialization, selected atmospheric variables are constrained with MERRA. The Goddard Earth Observing System integrated Ocean Data Assimilation System (GEOS-iODAS) is used for both ocean state and sea ice initialization. SST, T and S profiles and sea ice concentration were assimilated.

Observed SST 1982-1998 vs 1999-2016

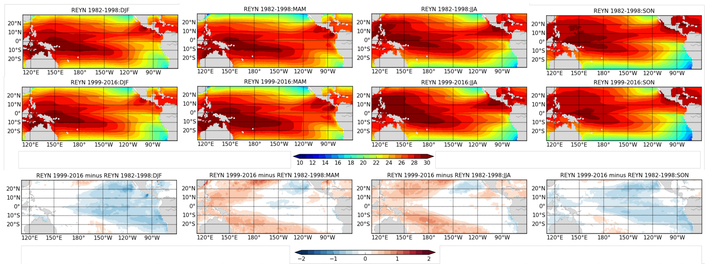

Fig. 1. Reynolds SST used as ODAS observations for the initialization of the seasonal hindcasts/forecasts, and as SST validation. Shown here are the mean SST values over 1982-1998 and 1999-2016 periods for 4 seasons (Boreal winter, spring, summer and autumn), and the difference between these two fields.

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For 35 years, every 5 days, a 9-month coupled seasonal hindcast has been initialized. In this study we included 4 mid-month hindcasts, concurrent with the hindcasts for the new forecast system S2S-2.1 (in production mode since December 2017).

Tropical Pacific Ocean SST S2S-1.0 forecasts in 1982-1998 and 1999-2016

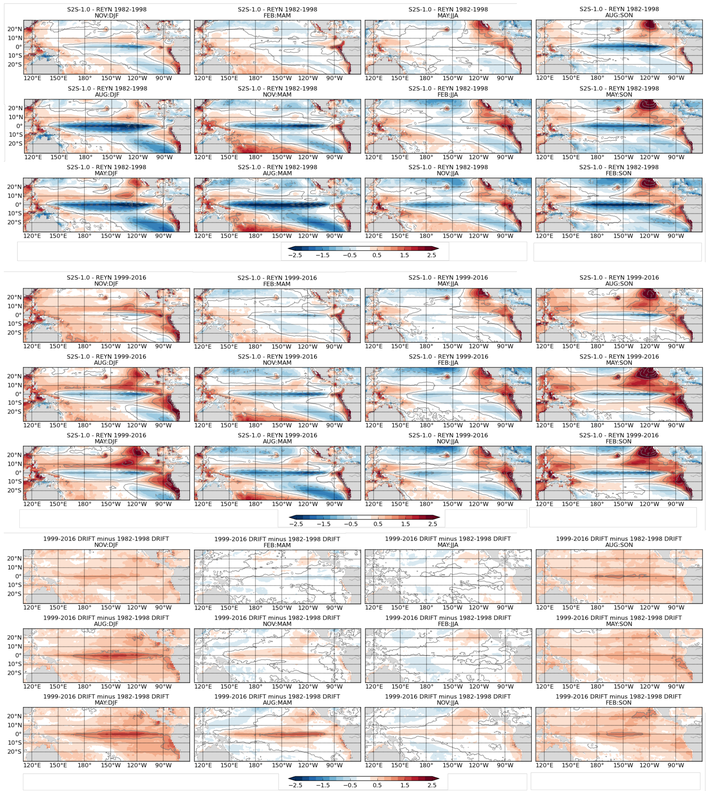

Fig. 2. Spatial pattern of seasonal mean SST forecast departure from Reynods SST for the 1982-1998 and 1999-2016 periods and their difference (top, middle and bottom panels of 3 rows). Within each panel the plots are organized as following: SST values shown are averaged over 1-3 (top), 4-6 (middle) and 7-9 (bottom) months lead for 4 target seasons (DJF in 1st, MAM in 2nd, JJA in 3rd and SON in the 4th column); the months containing the corresponding initial conditions are labeled as well, i.e. NOV:MAM means forecasts initialized during November, averaged over March, April, May.

Seasonal cycle bias for Equatorial Pacific Ocean SST indices

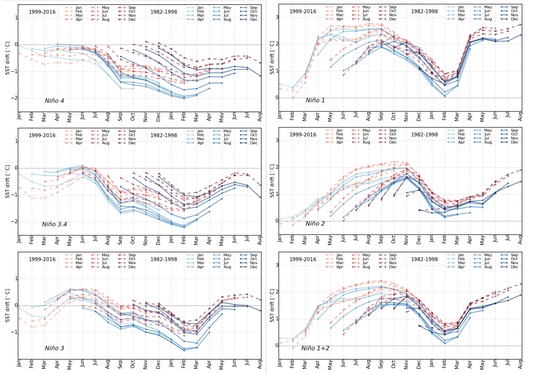

Fig. 3. Monthly mean SST forecast drift with respect to Reynolds. Solid lines show the 1982-1998 period, dashed lines correspond to the 1999-2016 period.

Forecast Skill

Anomaly Correlation Coefficient (ACC) is used as a measure of potential skill and Mean Square Skill Score (MSSS) as a measure of actual skill. MSSS is computed with respect to climatology.

$$MSSS_{clim} = \frac{MSE_{clim} - MSE_{fcst}}{MSE_{clim}}, \; where \; MSE_{\substack{fcst \\ [clim]}} = \frac{1}{n}\sum_{i=1}^{n}\left(T_{\substack{fcst \\ [clim]}}(i) - T_{obs}(i)\right)^2$$

Here $T_{fcst}(i)$ is the temperature anomaly of the i-th hindcast and $T_{clim}(i) \equiv 0$.

Potential predictability P computed as the anomaly correlation for a case of one of the ensemble members treated as observations, averaged over all possible combinations of ensemble members.

$$P = \langle AC(T_i, \langle T_{N \setminus i} \rangle) \rangle \qquad ACC = \langle AC(\langle T_N \rangle, T_{obs}) \rangle$$

ACC, MSSS, predictability skills

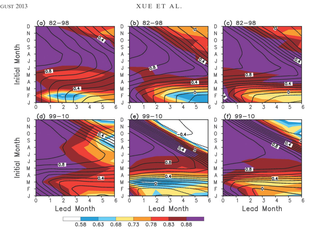

Fig. 8. The ACC of the CFSv2 (shading) and persistence-forecast SST anomaly (contours) in the (left) Niño-4, (middle) Niño-3, and (right) Niño-3.4 regions for the periods (top) 1982–98 and (bottom) 1999–2010 as functions of lead months (*x* axis) and initial months (*y* axis). The contour interval is 0.1. Only values with >95% significance were shown.

Fig. 4. The paper by Xue et al. (2013) was an inspiration for this study. Similar characteristics of ACC skill were for the CFSv2 and S2S-1.0 SST forecasts.

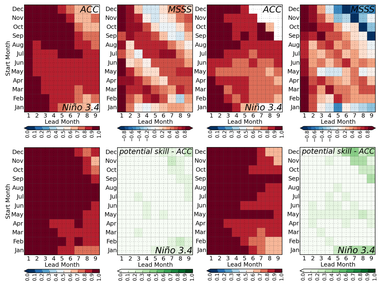

Fig. 5. Top row: SST ACC and MSSS for the Niño 3.4 index. The Pearson correlation significance test with *p*-value at 0.01 is applied to the ACC. Bottom row: potential predictability P, and the difference with the ACC, shown in the top row.
The left columns are for the 1982-1998 period, the right for the 1999-2016. Forecast start months are along the y-axis and lead months are along the x-axis.
Please flip the pages to see skills for other SST indices.

References

Borovikov, A., Cullather, R., Kovach, R. et al. 2017: GEOS-5 seasonal forecast system. Clim Dyn 1-27 DOI 10.1007/s00382-017-3835-2

Xue, Y., M. Chen, A. Kumar, Z. Hu, and W. Wang 2013: Prediction Skill and Bias of Tropical Pacific Sea Surface Temperatures in the NCEP Climate Forecast System Version 2. J. Climate, 26, 5358–5378, https://doi.org/10.1175/JCLI-D-12-00600.1

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