Toward integrated seasonal predictions of land and ocean carbon flux: lessons from the 2015-16 El Niño

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Seasonal Forecasts Beyond Climate

Coupled atmosphere-ocean GCMs increasingly provide skillful forecasts of climate 3-9 months into the future (**Fig. 1**). With advances in the complexity of model components, skillful seasonal predictions of carbon cycle flux may oone day be possible.

Seasonal Forecasting System

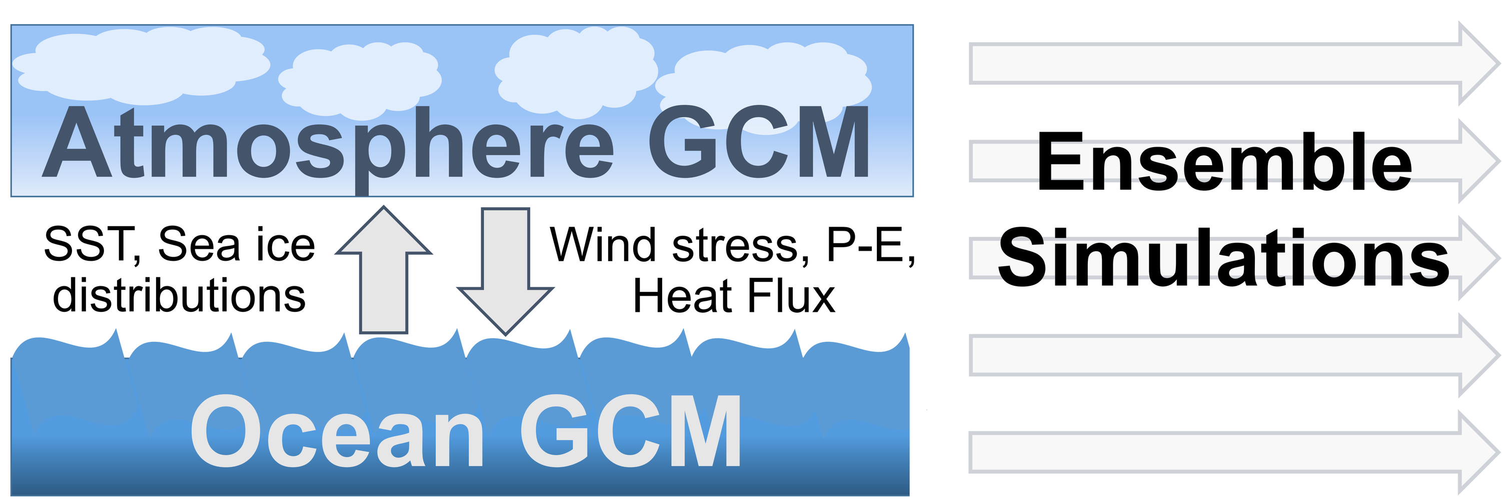

Fig. 1. Seasonal forecasts of climate anomalies are produced by coupled atmosphere-ocean general circulation models. Ensembles of forecasts are launched monthly, initialized from a ocean-atmosphere analysis.

GEOS Forecast Niño 3.4 Index

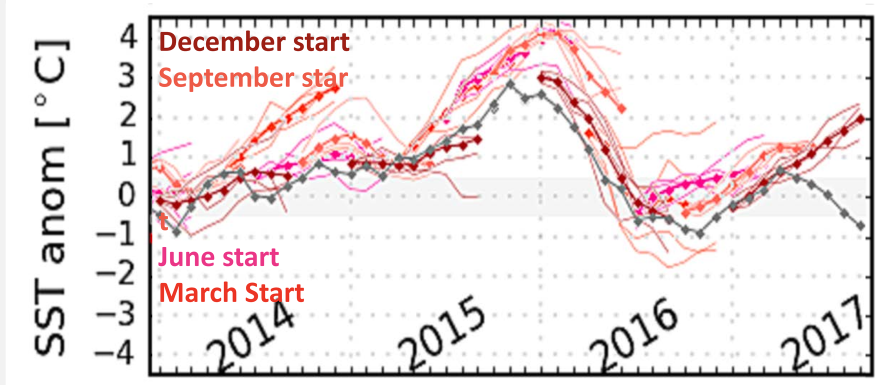

Fig. 2. GEOS forecast SST anomaly in the Niño 3.4 region. Forecasts tend to overpredict the strength of the SST anomaly and its duration.

GEOS Predictions of the 2015-16 El Niño

We examine the predictability of the carbon cycle response to the 2015-16 El Niño using NASA's GEOS modeling system. **Figure 2** shows SST anomaly forecasts while **Figure 3** shows temperature and precipitation z-scores for forecasts beginning in Dec., 2015.

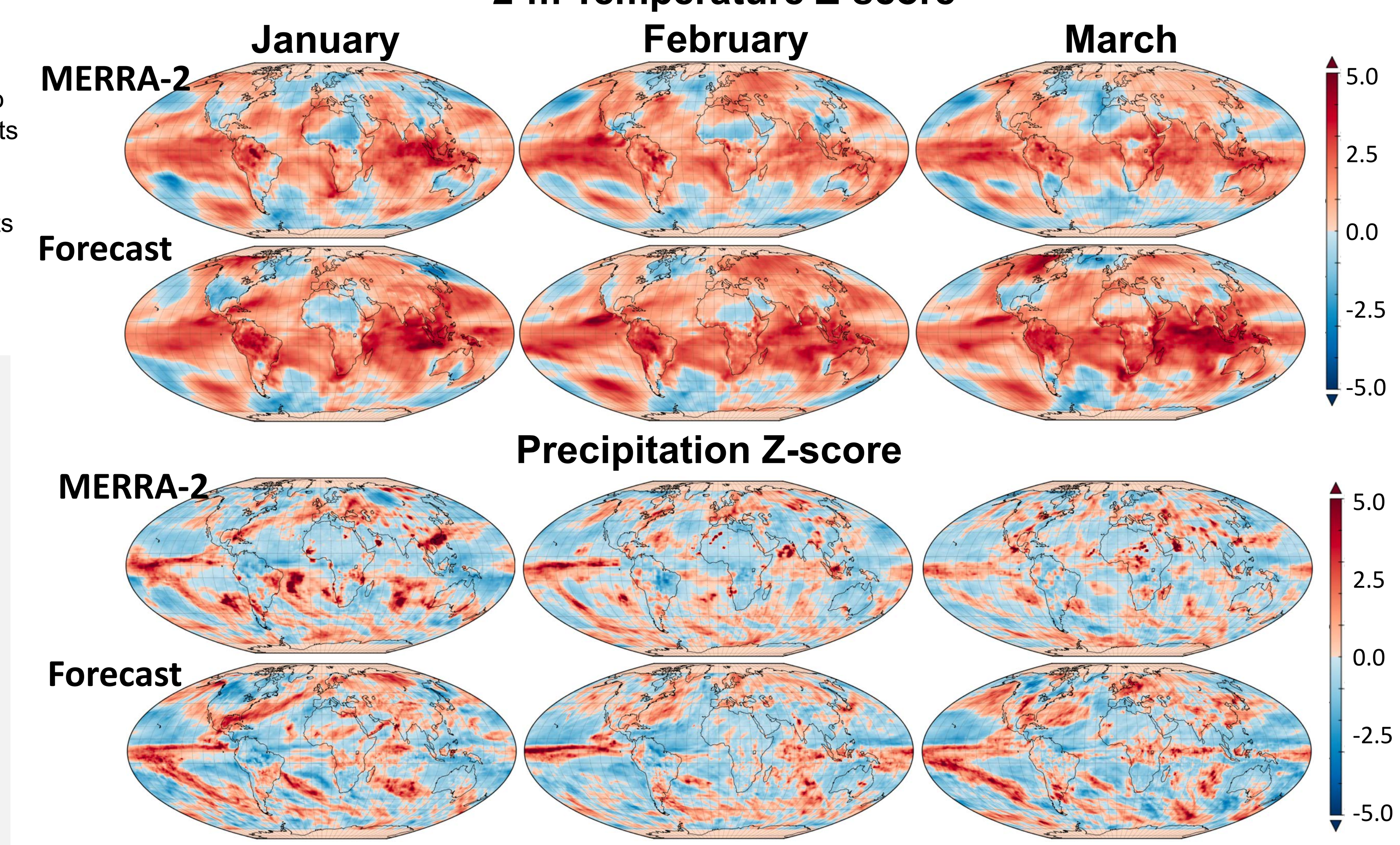

Fig. 2. MERRA-2 and GEOS seasonal forecast 2-m temperature and precipitation z-scores (standard deviation relative to mean). Forecasts with lead times of 1-3 months are able to predict general patterns of tropical temperature anomalies with precipitation forecasts showing less skill.

Prediction of the 2016 Carbon Flux Anomalies

Next, we use the predicted climate anomalies to estimate land and ocean carbon flux anomalies. Ocean flux anomalies (**Fig. 4**) were calculated by the NASA Ocean Biogeochemical Model (NOBM) driven by forecast meteorology. Land flux anomalies (**Fig. 5**) were computed using a statistical model of NBP trained using a 38-year simulation by the Catchment-CN terrestrial biosphere model and driven by 9-month forecast meteorology

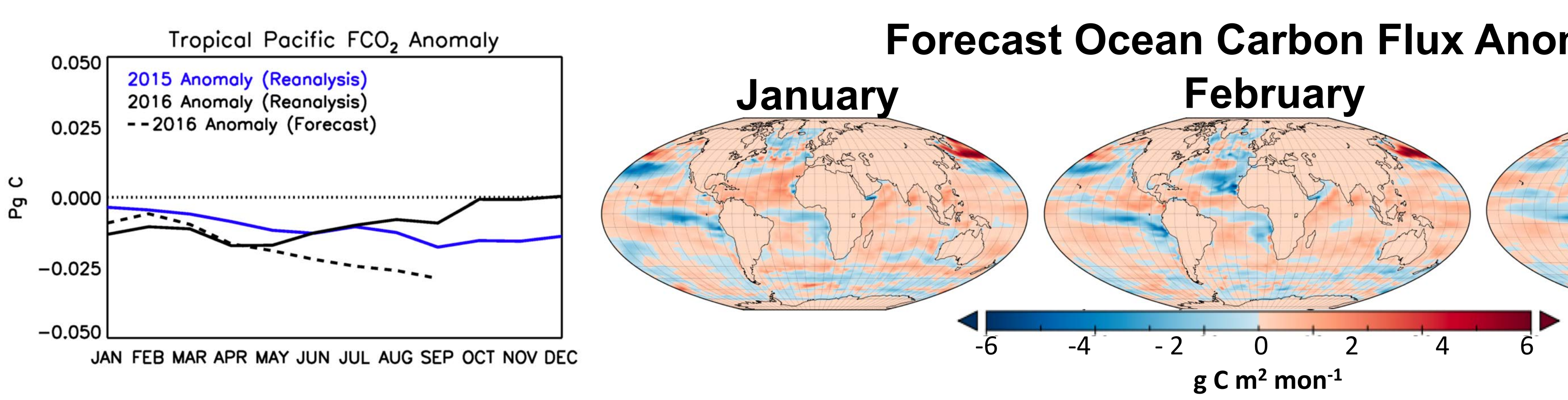

Fig. 4. NOBM estimates a ~0.2 Pg C sink for the equatorial Pacific during 2015-16. Flux forecasts perform reasonably out to month 4, but are unable to capture the return to normal SST conditions.

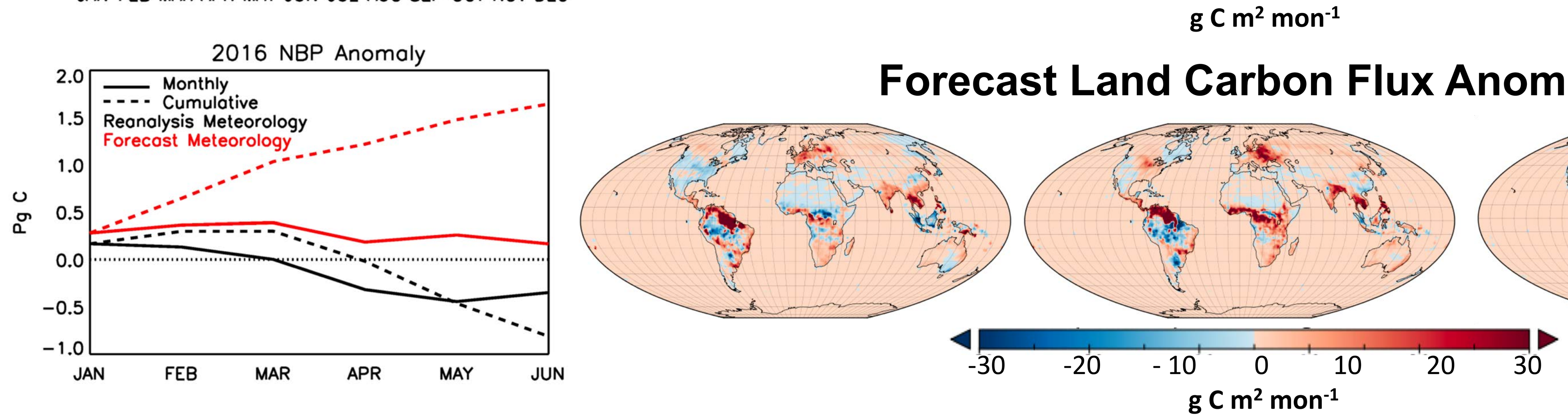

Fig. 5. The statistical flux model predicts a strong global source (~0.2-0.3 Pg C per month) focused in the tropics. While spatial patterns of the reanalysis-driven flux are reproduced well, the accumulated flux becomes unreasonably large after several months.

Atmospheric CO_2 Impact

Finally, we integrate the predicted climate anomalies in the GEOS AGCM and compare to observed anomalies from OCO-2 (**Fig. 6**).

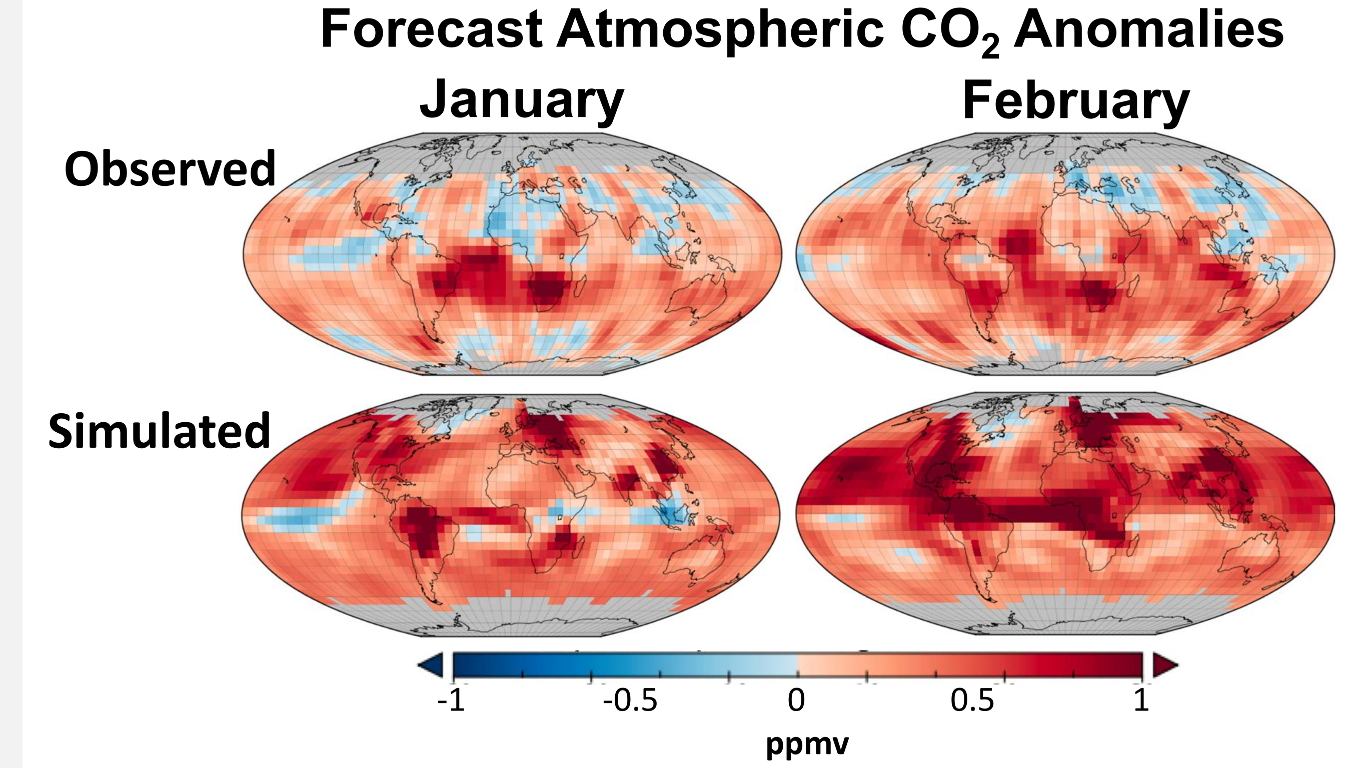

Fig. 6. The forecast flux anomalies tend to overestimate atmospheric CO_2 anomalies. The greatest skill is found in months 1-2 in the tropics.

Next Steps

Ongoing work is focused on: developing bias correction techniques for forecast meteorology; defining skill metrics; quantifying skill in other initialization months and time periods (neutral, La Niña); and better understanding the potential user needs of such forecasts.

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