GEOS S2S-2_1: The GMAO High Resolution Seasonal Prediction System

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GMAO
Global Modeling & Assimilation Office

Motivation

NASA/GSFC's Global Modeling and Assimilation Office (GMAO) uses coupled Earth-System models and analyses, in conjunction with satellite and *in situ* observations, to study and predict phenomena that evolve on seasonal to decadal timescales. A central motivation for GMAO is the innovative use of NASA satellite data to improve forecast skill.

GMAO's GEOS S2S system Version 2 was released in October 2017, and included a major upgrade, with substantial changes in models and assimilation.

S2S Version 2 Description: Models and Assimilation

Model

- AGCM: Post MERRA-2 generation, cubed sphere grid at ~0.5º, 72 hybrid sigma/pressure levels; GOCART interactive aerosol model, cloud indirect effect (2-moment cloud microphysics); MERRA-2 generation cryosphere;
- OGCM: MOM5, ~0.5º, 40 levels;
- Sea Ice: CICE-4.0.

Coupled Ocean Data Assimilation System

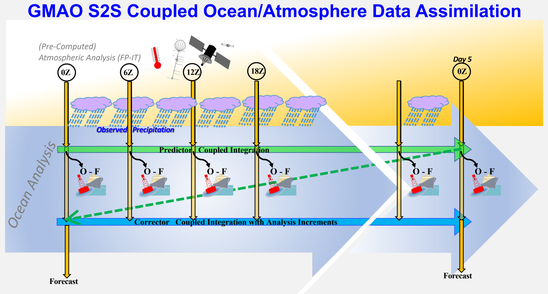
- atmosphere is "replayed" to "FPIT" (like MERRA-2); precipitation correction over land;
- NCEP-like LETKF code/system, set here to behave as Ensemble OI;
- Forecasts: initialized from ODAS, perturbations from analysis differences;
- Hindcasts: re-initialized from 5-day run of ODAS, perturbations from analysis differences;

Observations

- nudging of SST and sea ice fraction from MERRA-2 boundary conditions;
- assimilation of in situ Tz and Sz including Argo, XBT, CTD, tropical moorings;
- assimilation of satellite along-track ADT (Jason, Saral, ERS, GEOSAT, HY-2A, CryoSat-2);
- sea ice concentration from the National Snow and Ice Data Center (NSIDC).

S2S Forecast Production

GMAO S2S Coupled Ocean/Atmosphere Data Assimilation



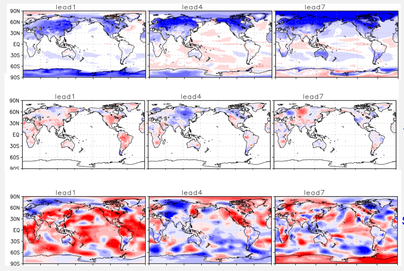
GMAO's GEOS S2S sub/seasonal forecastsand Coupled Data Assimilation are run in near real time, running consistently since 1998.

	Subseasonal	Seasonal
Length of Forecast	45 days	9-12 months
Frequency of forecasts	Every 5 days	Every 5 days
Number of Ensembles	4 per start date	Total of 10 per month
Frequency of submission	Once per week	Once per month
Availability	~3 days after real time	Once per month
Initial Conditions from	GEOS ODAS	GEOS ODAS
Hindcasts	1999-2016	1981-2016

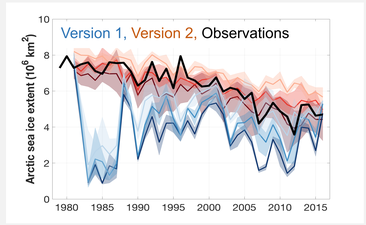
Sub/Seasonal Forecasts: Skill

Absolute Difference (blue → new system has less bias)

Anomaly Corr. Difference (red → new system has higher corr.)



Version 2 forecast bias and skill are clearly improved at one month to one season lead times, bias is improved at all leads

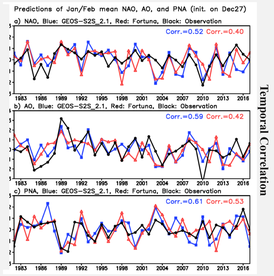


The S2S Version 2 hindcast system can explain up to 80% of September sea ice extent variance over the hindcast period.

Sub/Seasonal Forecasts: Variability

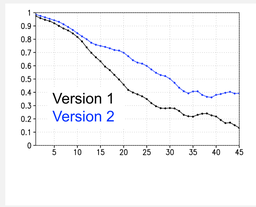
Prediction skill of these modes is shown here as time series correlations of mode eigenvalues.

Version 2 correlations are higher for NAO, AO and PNA



MJO skill is evaluated with the Real-Time Multivariate Madden-Julian Oscillation Index (RMM), which involves winds at the top and bottom of the troposphere and OLR

Version 2 RMM is substantially improved relative to Version 1

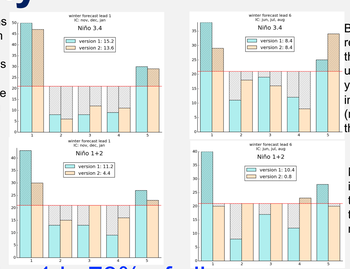


Sub/Seasonal Forecasts: Reliability

We assume that the probability that the observation lies within each bin is equal. Deviation from this uniform distribution is a metric of the ensemble reliability.

The mean absolute difference between the forecast rank histogram and the ideal one (red horizontal line) is shown. The smaller this score the better is the ensemble reliability.

Both versions have a warm bias (observations tend to fall outside of the envelope on the colder side).



Better ensemble reliability in terms of the deviation from the uniform distribution, yet not enough spread in either version (many observations in the outer bins).

Marked improvement in version 2 compared to version 1 for all lead times (tan histogram nearly uniform).

Version 2 had better rank histograms than Version 1 in 73% of all cases.

Future Directions

GEOS S2S Version 2 is being used with coupled chemistry to study the impacts of a large volcanic eruption on seasonal prediction, and to examine predictability in seasonal air quality

GEOS S2S Version 3 (2019 release), includes upgrades targeted to known issues:

- Advances in atmospheric physics
- Ocean resolution increase to ~0.25 deg, 50 levels
- Assimilation of sea surface salinity and sea ice thickness
- Atmosphere/ocean interface layer
- Increase in ensemble size and modification of ensemble perturbations

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GEOS S2S file Specification: https://gmao.gsfc.nasa.gov/pubs/docs/Nakada1033.pdf