Advantages of the 25 km resolution ocean model in GEOS Seasonal Prediction System Version 3

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GEOS-S2S-2 was released in November, 2017 (Molod et al., 2020)
GEOS-S2S-3 due for release December 2021 (System to be "frozen" late 2020)

GEOS-S2S-3 System Characteristics

Model

- AGCM: Current GMAO NWP (including aerosol model) + two-moment cloud microphysics
- OGCM: **MOM5, ~0.25 deg, 50 levels**; **Ice Sheet runoff to proper location**
- **New "atmosphere-ocean interface layer" - diurnal warming and cool layer**
- Sea Ice: CICE-4.0

Coupled Ocean Data Assimilation System

- atmosphere is "replayed" to **MERRA-2 and** "FPIT" (like MERRA-2); precipitation correction over land, **modified "replay" methodology**
- NCEP-like LETKF code/system, set here using **(updated)** static background error statistics;
- Forecasts: **initialized from "MERRA-2 Ocean" reanalysis, new perturbation/ensemble strategy;**
- Hindcasts: **initialized from "MERRA-2 Ocean" reanalysis, new perturbation/ensemble strategy;**

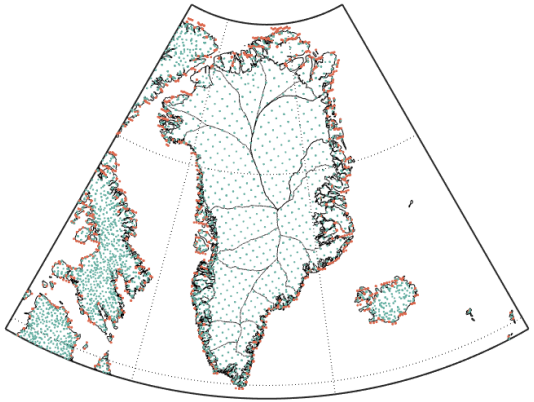
Observations

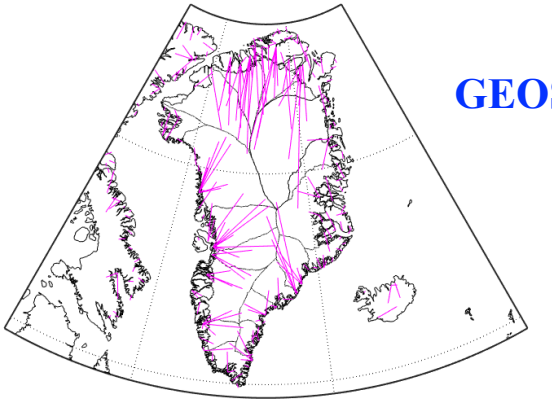
- nudging to MERRA-2 SST and sea ice fraction **with "dual ocean" method, new technique for sea ice;**
- assimilation of *in situ* Tz and Sz including Argo, XBT, CTD, tropical moorings;
- assimilation of satellite along-track ADT (Jason, Saral, ERS, GEOSAT, HY-2A, CryoSat-2);
- sea ice concentration from the National Snow and Ice Data Center (NSIDC).
- **assimilation of SMAP, Aquarius sea surface salinity**

GEOS-S2S-2 → GEOS-S2S-3
Model Upgrades with Large Impact:

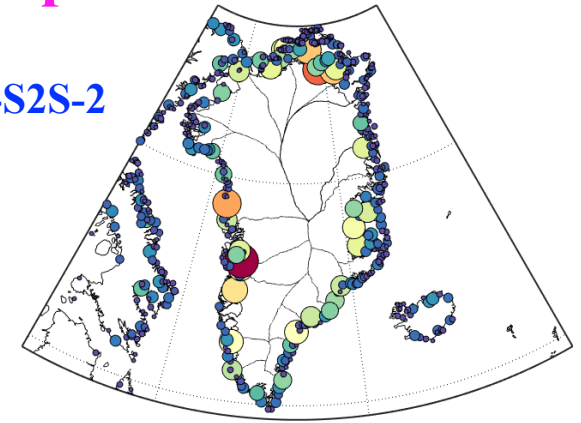
- Ice Sheet Runoff to Proper Location
- Atmosphere-Ocean Interface Layer
- Ocean Resolution
- New Ensemble Strategy – Forecasts

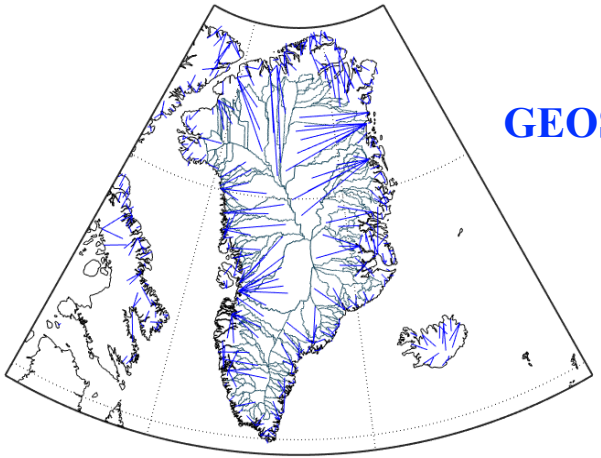
GEOS-S2S-3: Ice Sheet Runoff to Proper Location



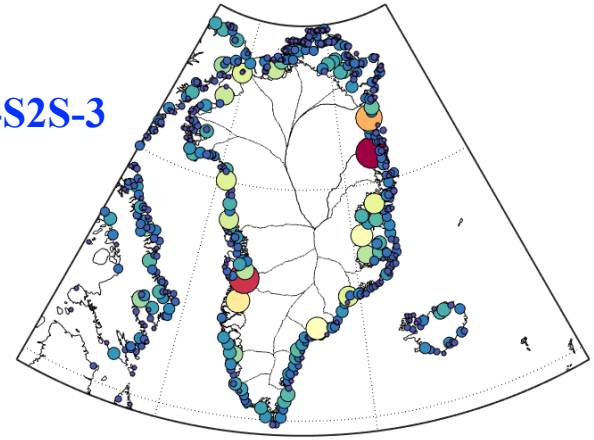


GEOS-S2S-2





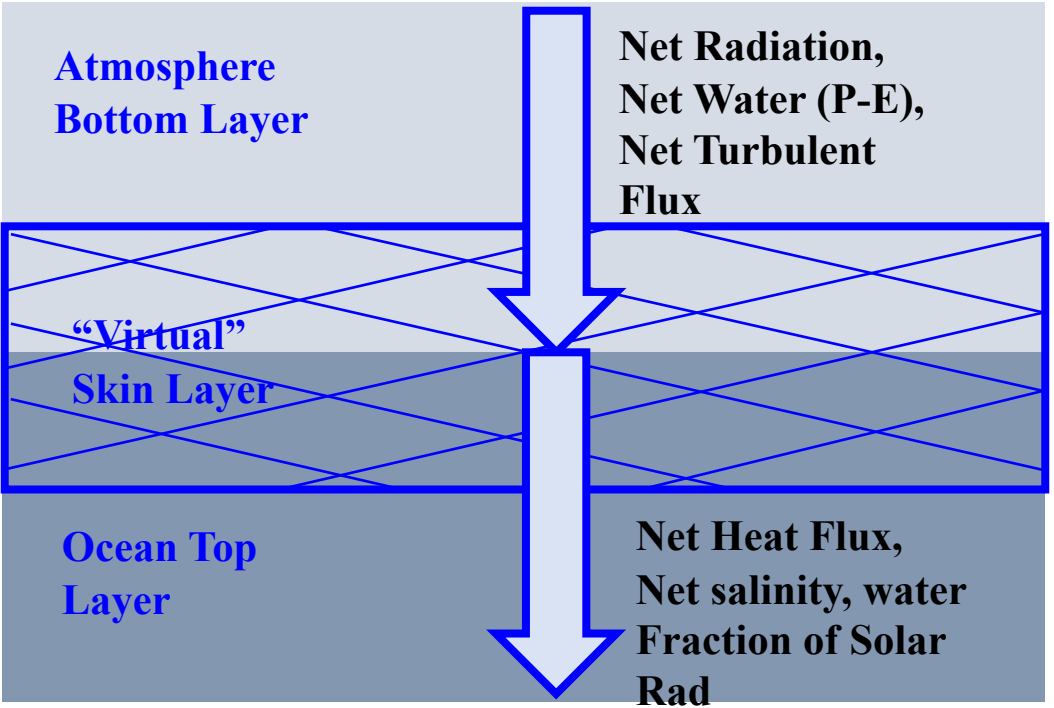
GEOS-S2S-3



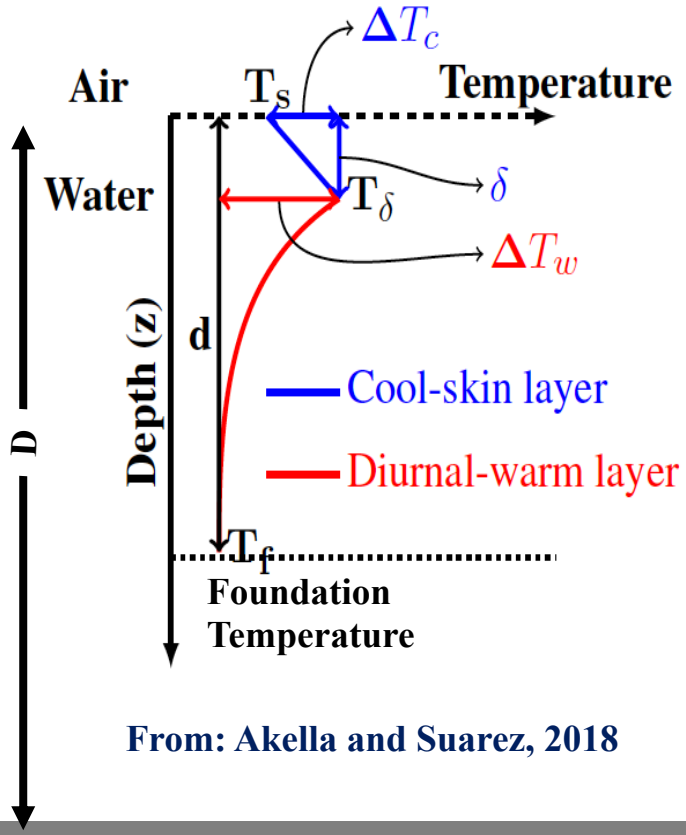
Courtesy of: Lauren Andrews. GMAO

GEOS-S2S-3: Atmosphere-Ocean Interface Layer

GEOS-S2S-2



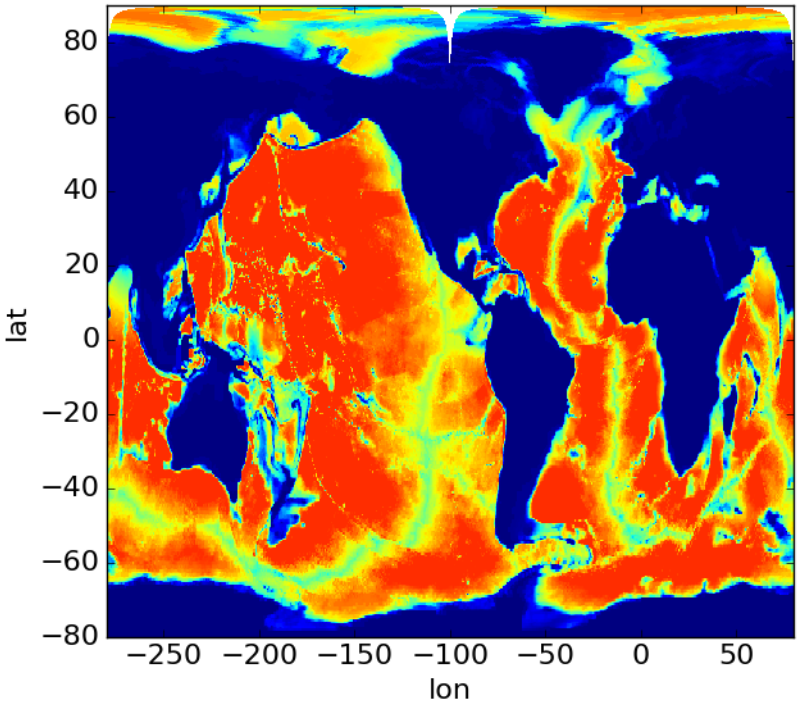
GEOS-S2S-3



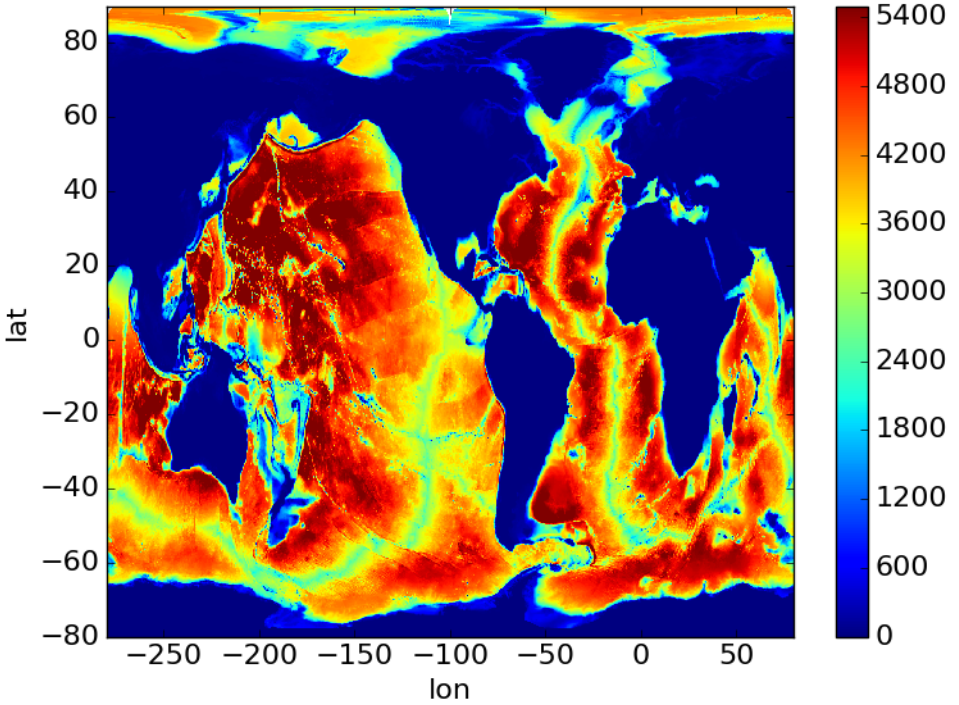
From: Akella and Suarez, 2018

Ocean Resolution – Bathymetry

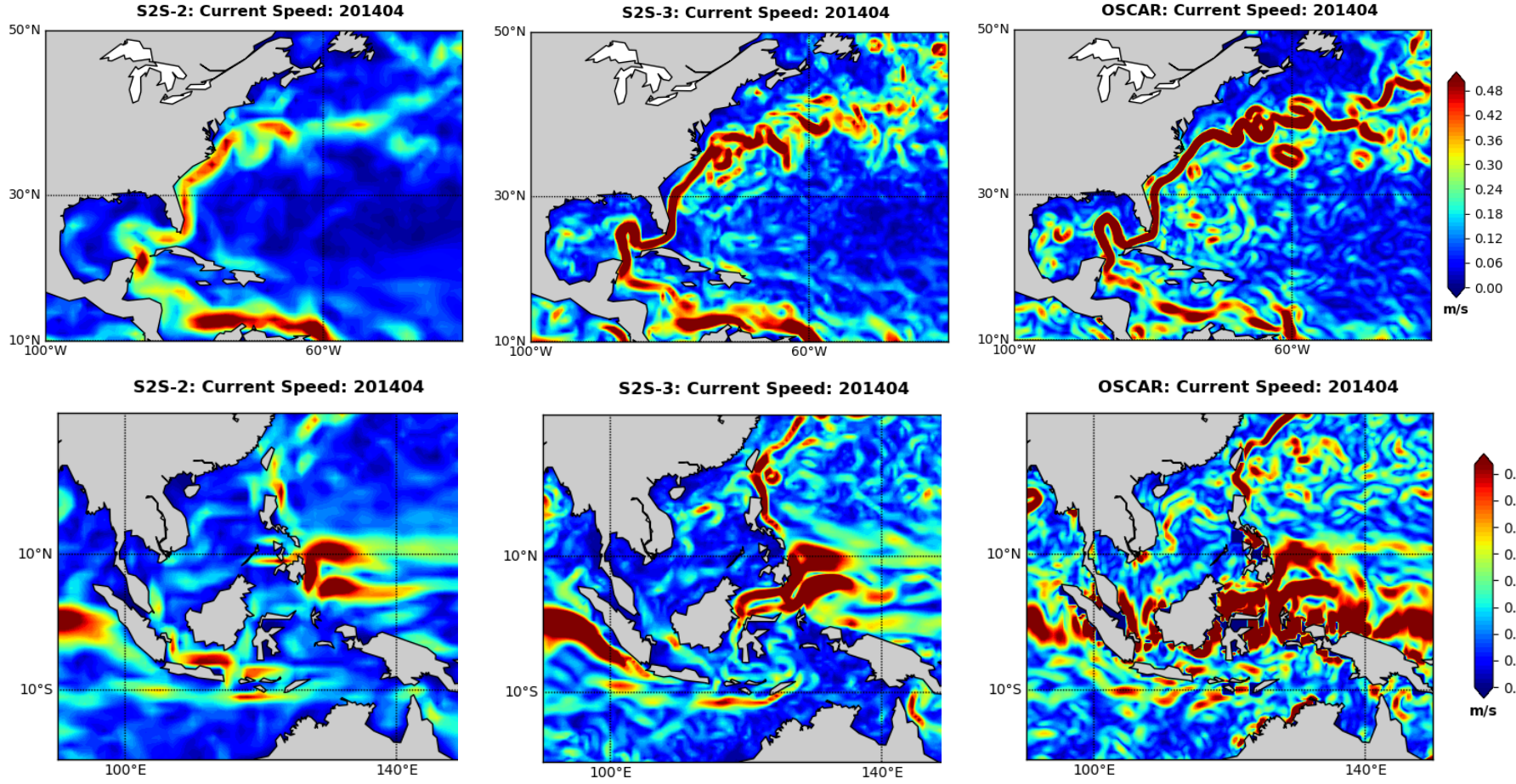
GEOS-S2S-2: 0.5º, 40L



GEOS-S2S-3: 0.25º, 50L

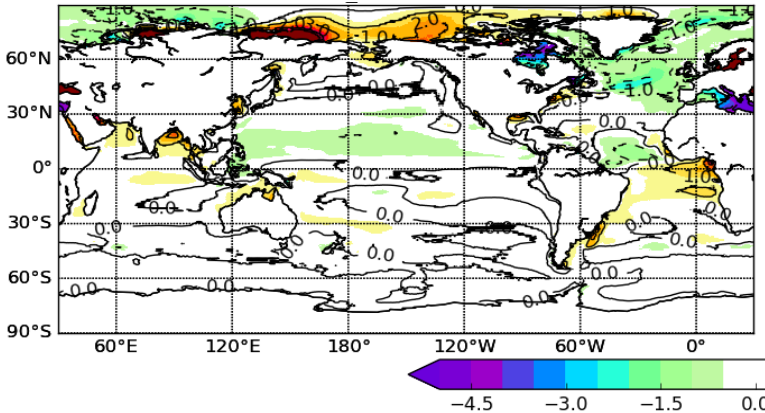


Ocean Resolution – Surface Currents

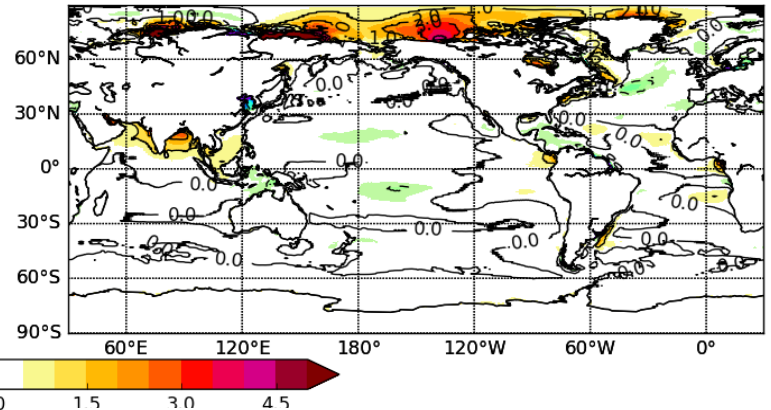


Ocean Resolution – Impact on Transport

GEOS-S2S-2

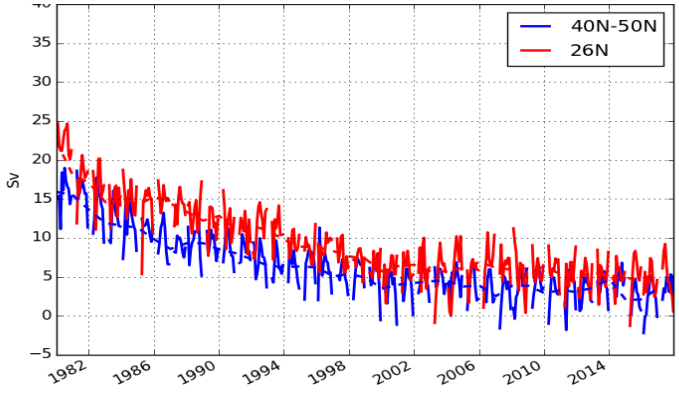


GEOS-S2S-3

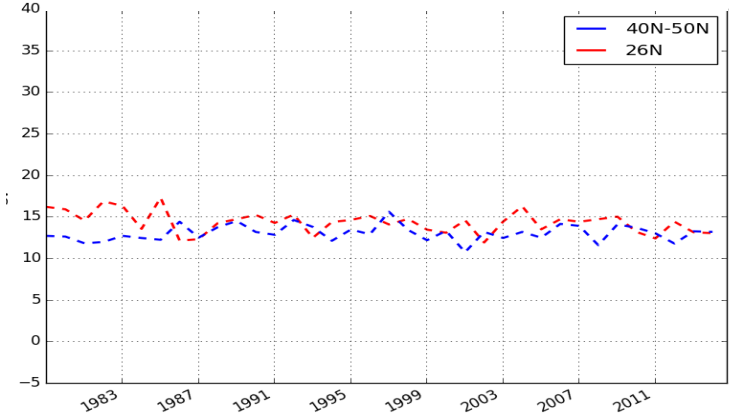


GEOS-S2S-3 has smaller bias in salinity relative to the World Ocean Atlas Version 13

GEOS-S2S-2



GEOS-S2S-3



GEOS-S2S-3 has Stronger Atlantic Meridional Overturning Circulation AMOC) in Sv

Forecast Ensemble Strategy

Motivation for Change in Ensemble Strategy:

GEOS-S2S Tropical Pacific SST was found to be under-dispersive early in the forecast and over-dispersive later (Molod et al., 2020). This prompted the change in the ensemble perturbation strategy.

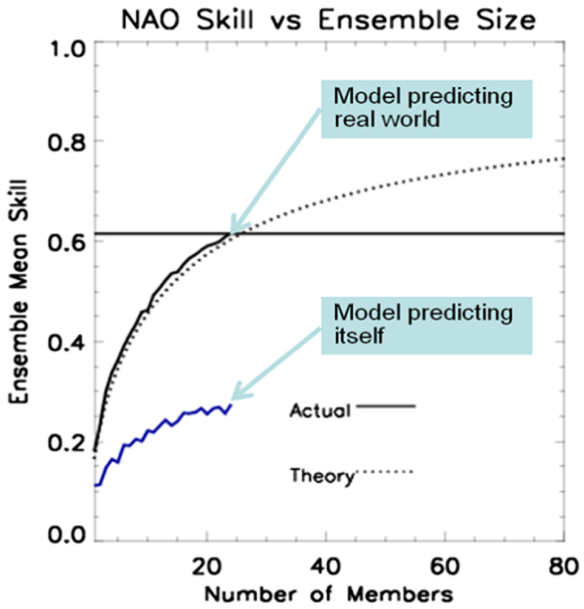
Extratropical skill was lower than the best state-of-the-art systems because of the small ensemble size (eg., Scaife et al., 2018). This prompted the change in ensemble size and the new approach to the number of ensembles.

Little evidence of additional skill from ensemble size beyond a few months. This prompted the sub-sampling strategy for extending selected ensemble members

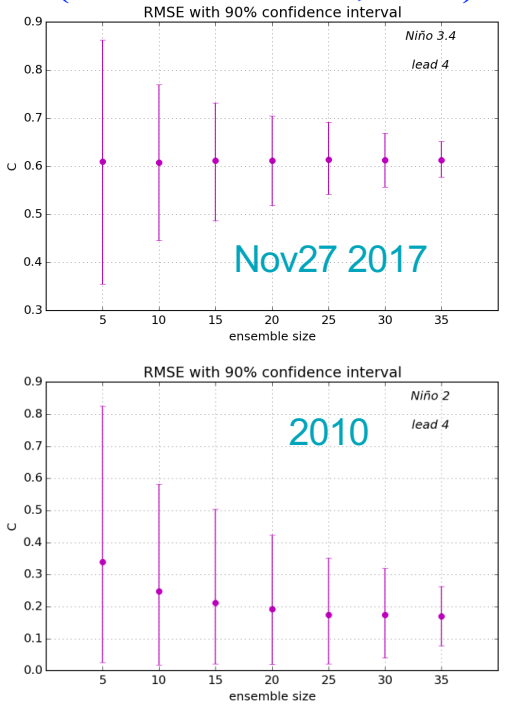
Retained from GEOS-S2S-2: “Lag-Burst” ensemble

Forecast Ensemble Strategy – Ensemble Size

NAO at 1 month lead (Scaife & Smith, 2018)

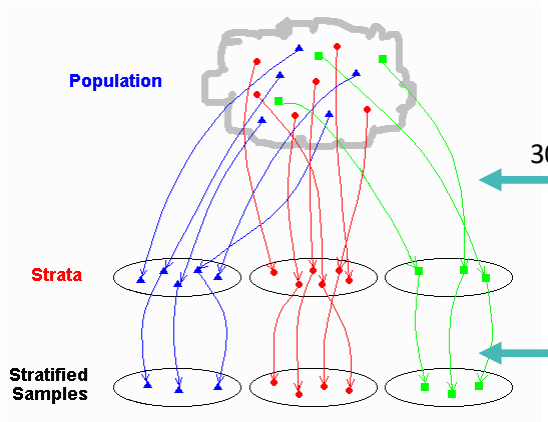


ENSO at 4 months lead (Borovikov et al., 2019)



We need lots of ensemble members for short lead, but not for long leads.

Stratified sampling. KMEANS.



A) t_0

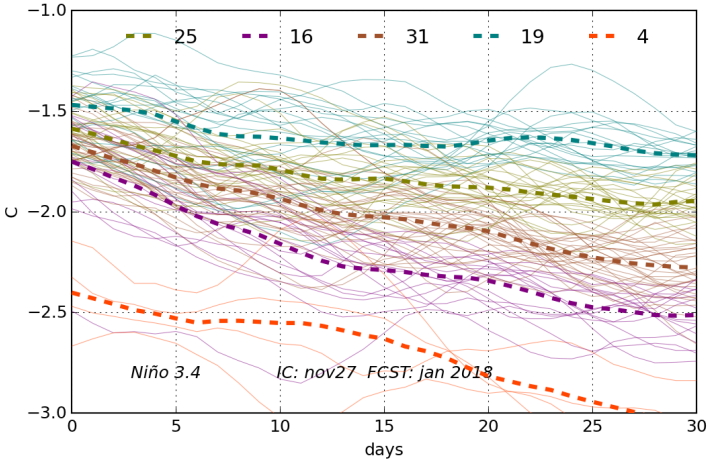
30 day forecasts

B) t_0+30 days

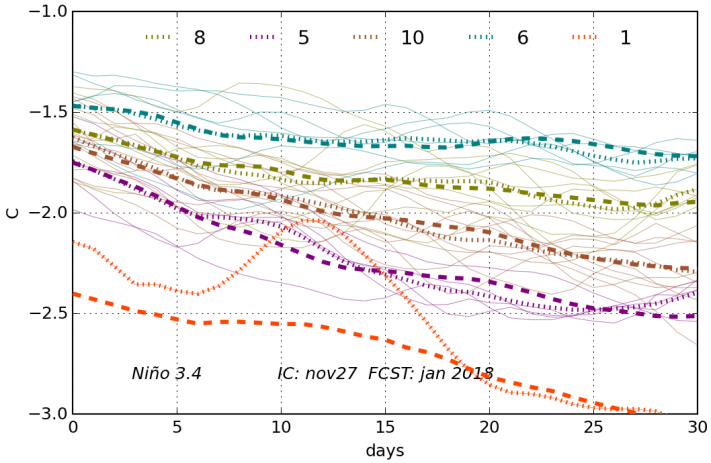
extend forecasts with smaller sample

C) t_f (6 mons)

We take advantage of the information about the early error growth that can be obtained from the relatively large initial ensemble, in a way that ensures the capture the leading directions (in phase space) of error growth (Schubert et al. 1992).



EXAMPLE: original clusters and means



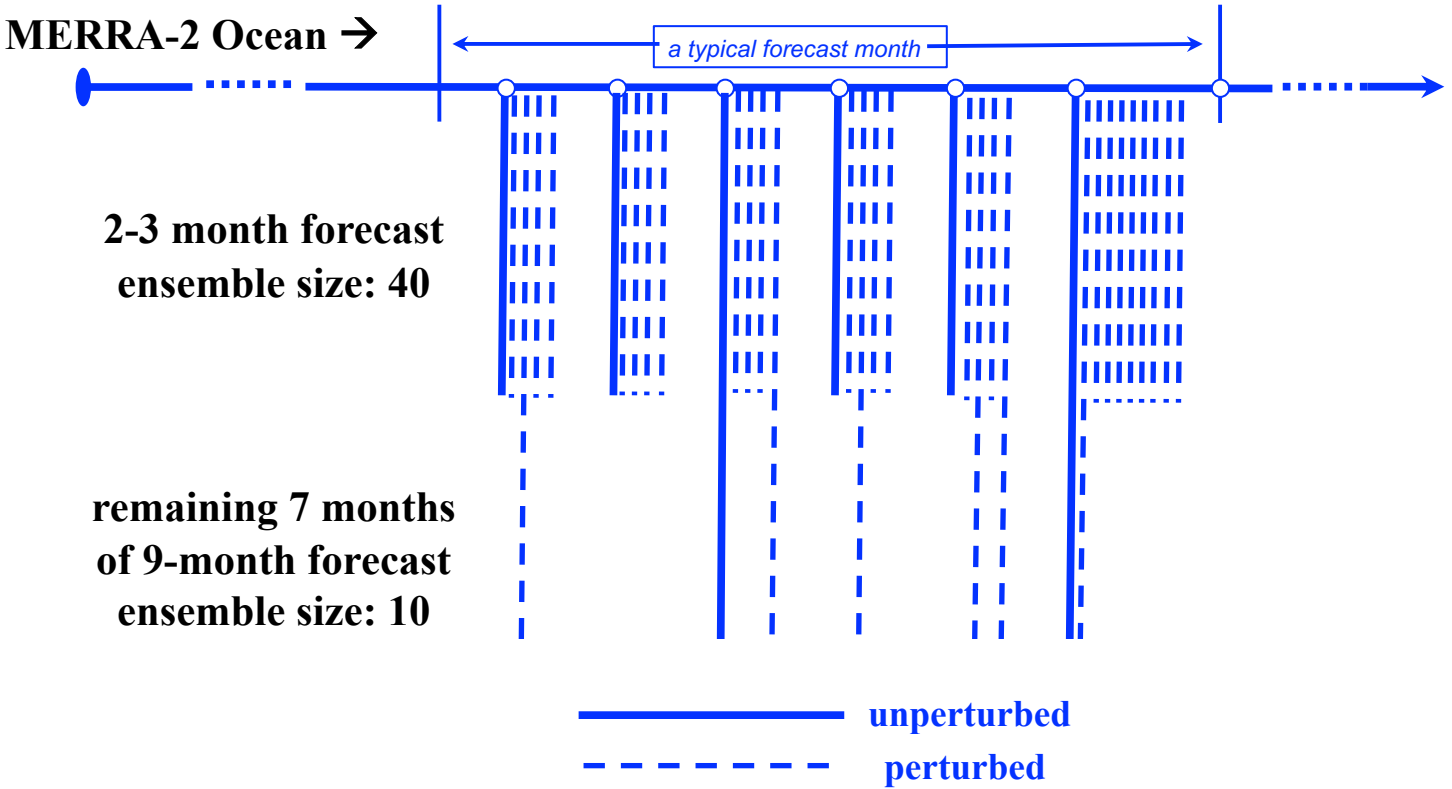
EXAMPLE: sub-sampled clusters and means (dotted lines) original means (dashed lines)

See Borovikov et al. Wednesday Poster: Designing an optimal strategy for GMAO S2S ensemble forecast

GEOS-S2S-3 Near Real-Time Sub/Seasonal Prediction Suite Initialized from the (Weakly) Coupled AODAS

	Sub/Seasonal
Length of Forecast	9 months
Frequency of forecasts	Every 5 days
Number of Ensembles	40 member lag/burst for first two months, selection of 10 members for remaining 7 months
Frequency of submission	Once per week OR once per month (as needed)
Initial Conditions from	"MERRA-2 Ocean" GEOS-S2S-3 AODAS
Retrospective Forecasts	1981-2019

Forecast Ensemble Strategy – "Lag/Burst"



Summary

- GEOS-S2S-3 and "MERRA-2 Ocean", NASA/GMAO's coupled atmosphere-land-ocean seasonal forecast system and weakly coupled atmosphere-ocean reanalysis is due for public release late 2020
- Model upgrades include proper glacial runoff and improved diurnal cycle with atmosphere-ocean interface layer
- Upgrade of ocean resolution in the GEOS-S2S-3 system resulted in improved surface currents, ocean mass transport and surface salinity
- Forecast Strategy: Many ensemble members for short-range, fewer for longer range. Preliminary results show improved teleconnection skill