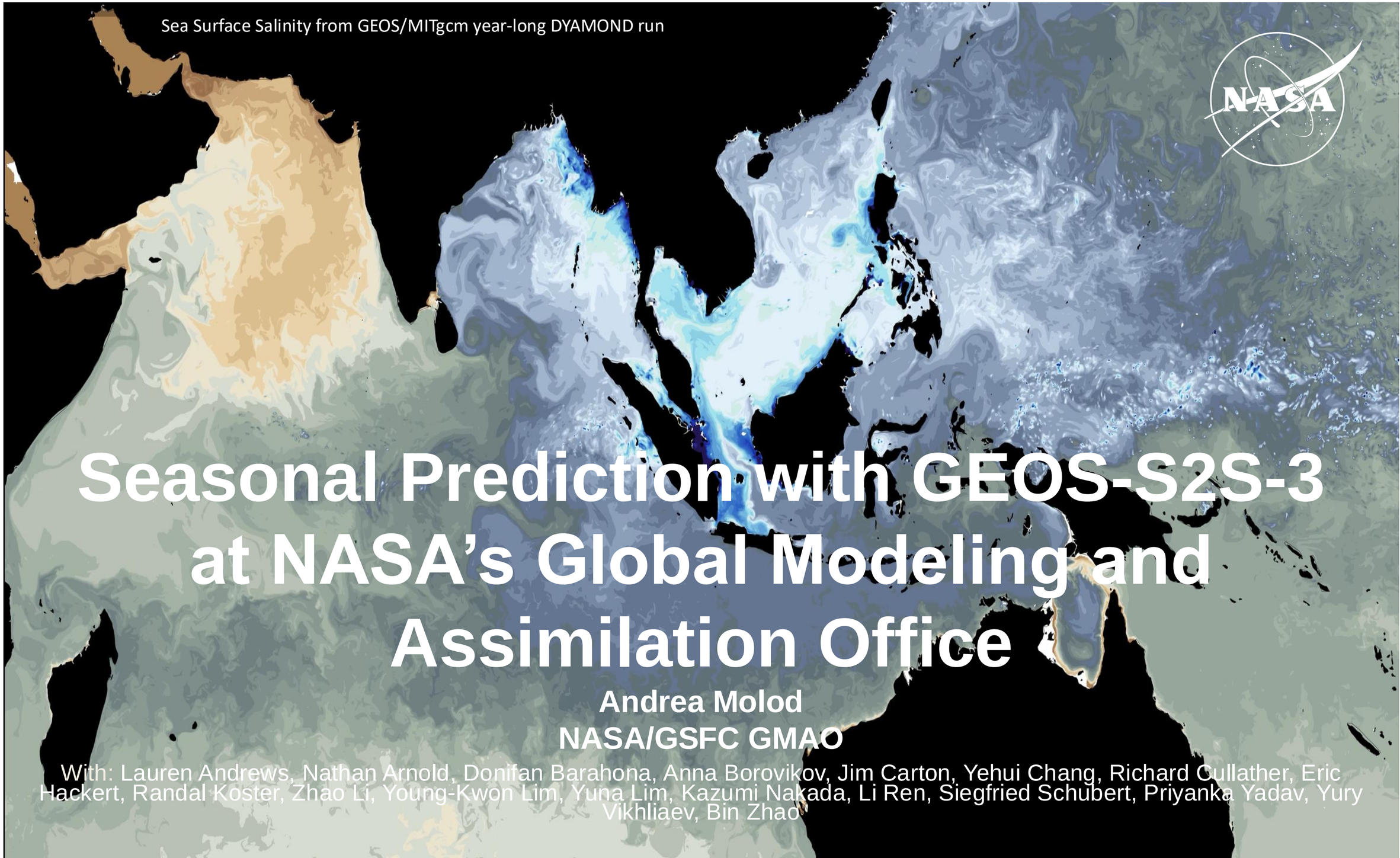

Seasonal Prediction with GEOS-S2S-3 at NASA's Global Modeling and Assimilation Office

Andrea Molod

NASA/GSFC GMAO

With: Lauren Andrews, Nathan Arnold, Donifan Barahona, Anna Borovikov, Jim Carton, Yehui Chang, Richard Cullather, Eric Hackert, Randal Koster, Zhao Li, Young-Kwon Lim, Yuna Lim, Kazumi Nakada, Li Ren, Siegfried Schubert, Priyanka Yadav, Yury Vikhliaev, Bin Zhao

GEOS-S2S

GMAO Seasonal Prediction group uses coupled Earth-System models and analyses, in conjunction with satellite and *in situ* observations, to study and predict phenomena that evolve on sub/seasonal to decadal timescales. A central motivation for GMAO is the innovative use of NASA and other satellite data to improve forecast skill

- **Atmosphere/Ocean Coupled Model Development**
- **Ocean Analysis Development**
- **Development of Initialization/Perturbation Strategy for ensembles of Sub/Seasonal Forecasts**
- **Coupled Assimilation Strategy Development**

- **Production/Dissemination of Coupled Data Assimilation (Re)Analysis**
- **Production/Dissemination of Sub/Seasonal Forecasts**

- **Evaluation/Assessment of Forecast Fidelity**
- **Evaluation/Assessment of Assimilated Ocean State**

- **Predictability Studies**

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GEOS-S2S-3 System Characteristics

Model

- AGCM: Recent 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
- Forecasts: **initialized from "GiOcean-NRT" assimilation, new perturbation/ensemble strategy;**
- Retrospective Forecasts: **initialized from "GiOcean" reanalysis, new perturbation/ensemble strategy;**

Coupled Ocean Data Assimilation System – Coupled Reanalysis "GiOcean" and "GiOcean-NRT"

- Atmosphere is "replayed" to **"GEOS_IT"**; precipitation correction over land, **modified to "regular replay"**
- **Aerosol is "replayed" to GEOS_IT analyzed aerosol optical depth using GAAS (Goddard Aerosol Assimilation System)**
- Penny et al. (2013) LETKF code/system, set here using **(updated)** static background error statistics;

Observations

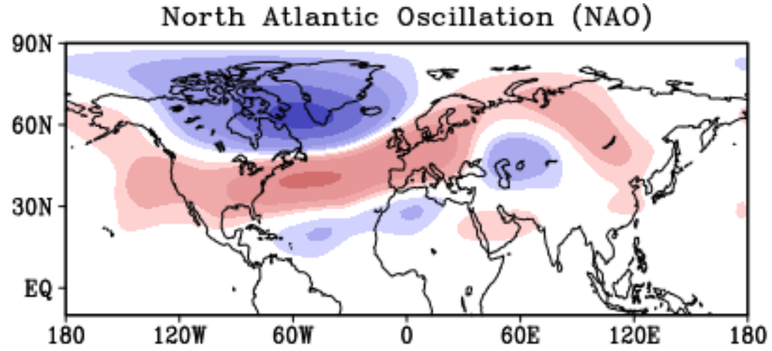
- nudging/assimilating SST and sea ice fraction from GEOS-IT (OSTIA/Reynolds), **new technique for sea ice;**
- assimilation of *in situ* Tz and Sz including Argo, XBT, CTD, tropical moorings;
- assimilation of satellite along-track ADT (Jason, Saral, ERS, GEOSAT, HY-2A, CryoSat-2);
- sea ice concentration from the National Snow and Ice Data Center (NSIDC).
- **assimilation of SMOS, SMAP, Aquarius sea surface salinity**

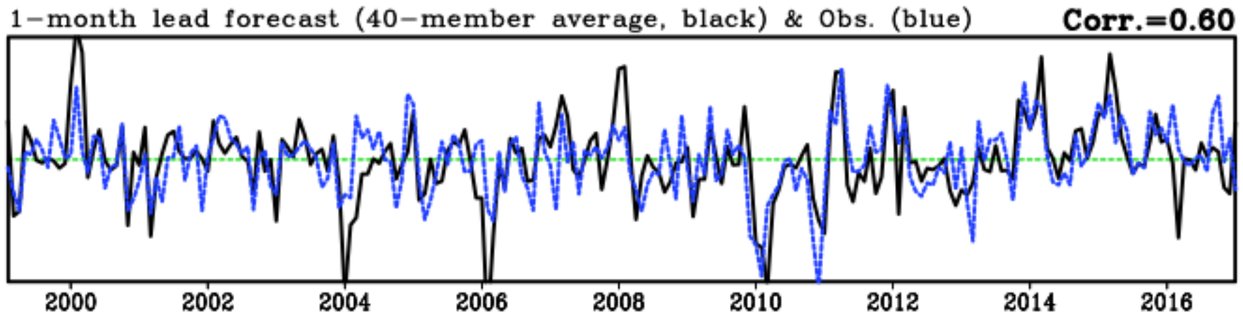
GODDARD EARTH SCIENCES

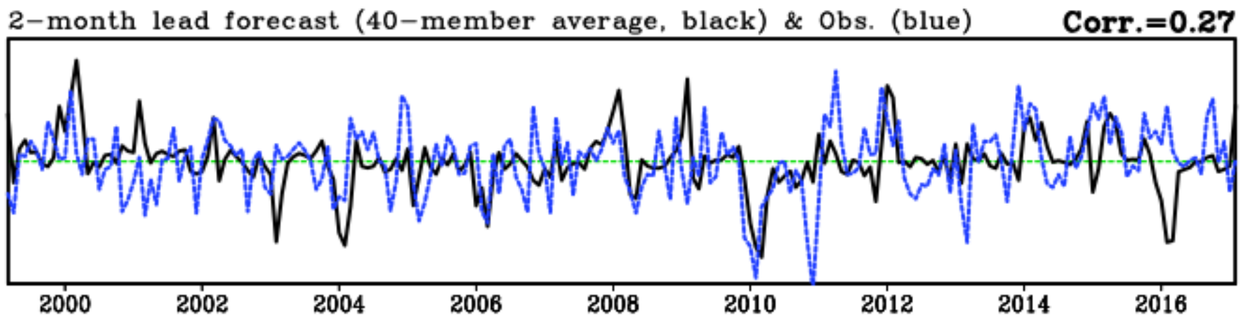
GEOS-S2S-3 System Characteristics

	Sub/Seasonal
Length of Forecast	9 months
Frequency of initialization	Every 5 days
Number of Ensembles	40 member lag/burst for first three months, selection of 10 members for remaining 6 months
Frequency of submission	Once per week OR once per month (as needed)
Retrospective Initial Conditions from	“GiOcean” GEOS-S2S-3 AODAS
Retrospective Forecasts	1991-2024
Near-real time Initial Conditions from	“GiOcean-NRT” GEOS-S2S-3 AODAS

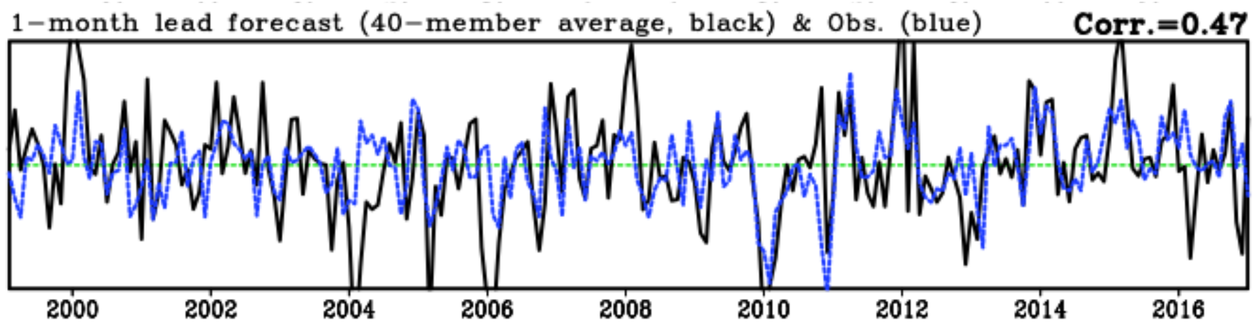
GEOS-S2S-3: Forecast Evaluation - NAO

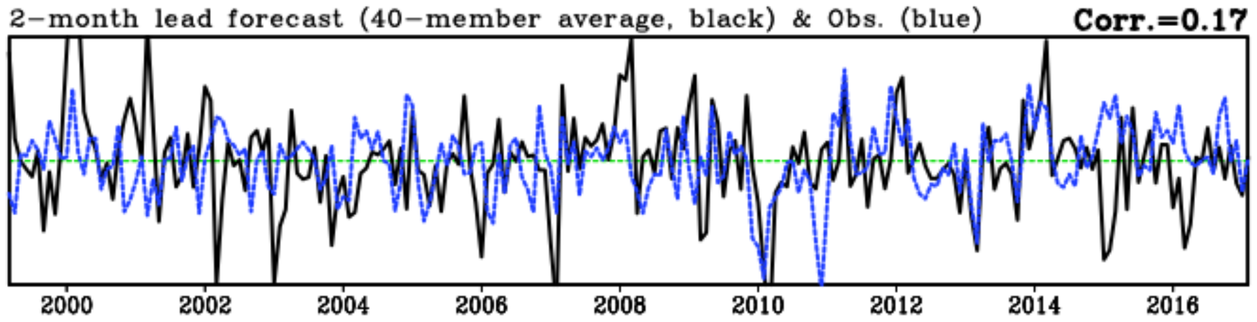






Analysis of Young-Kwon Lim





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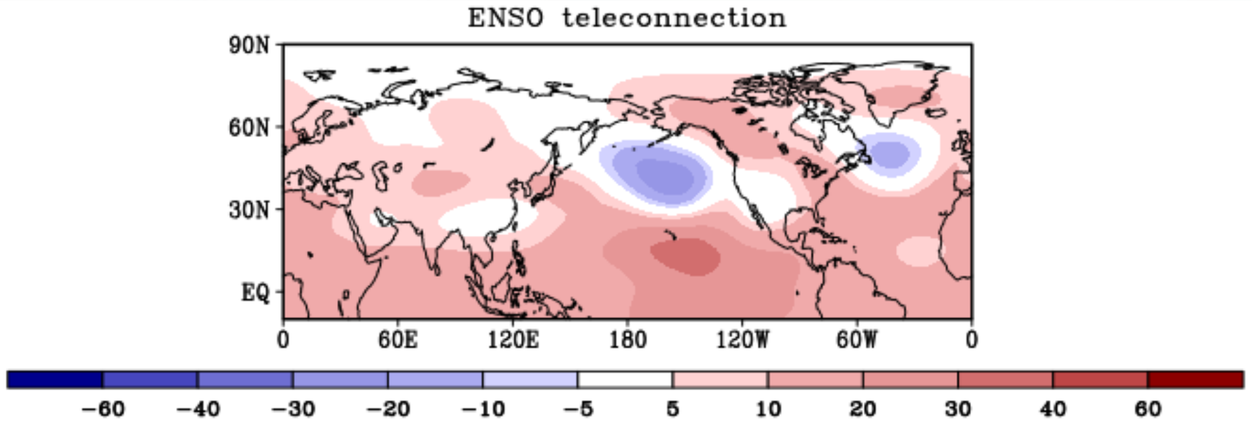
GEOS-S2S-3: Forecast Evaluation – ENSO Teleconnection



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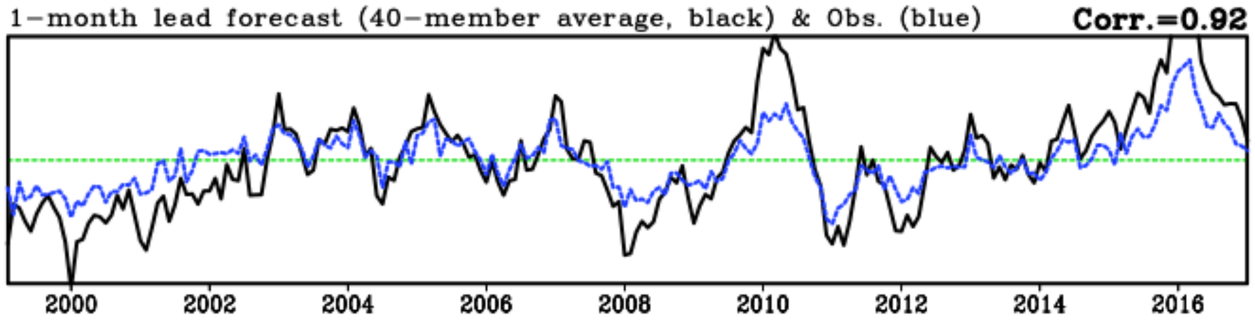

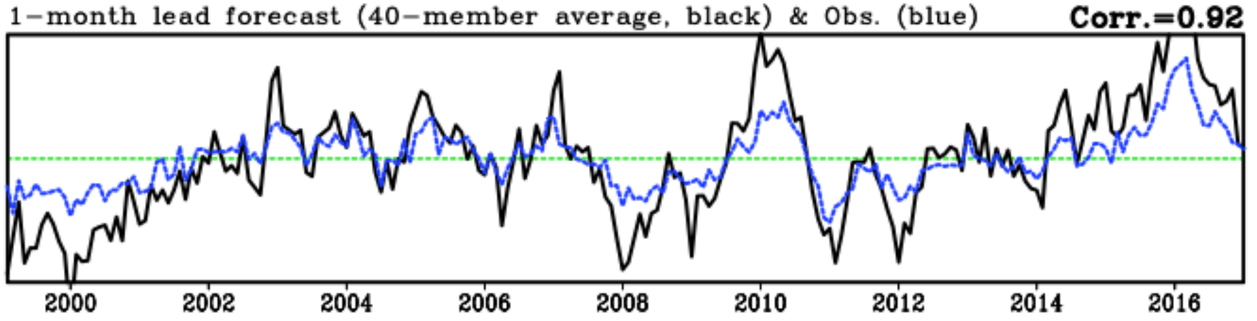

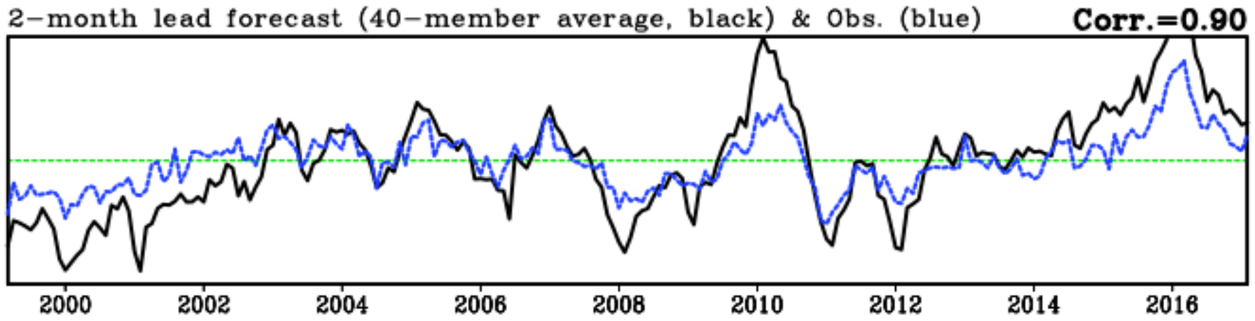

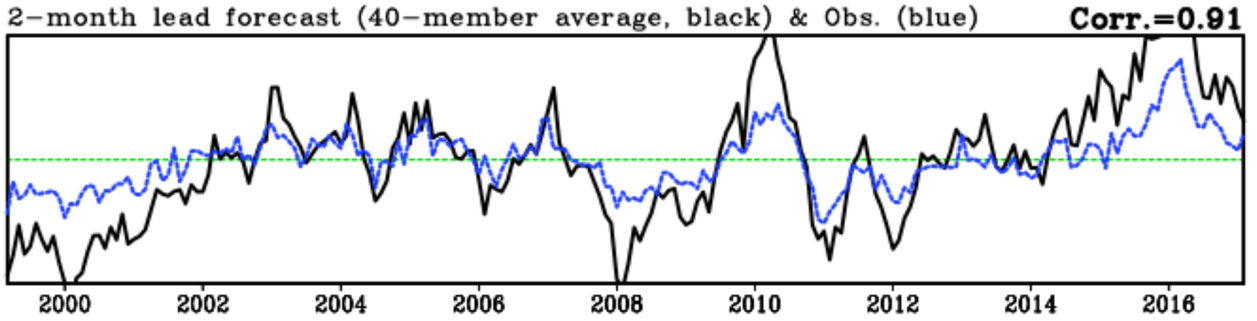

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GEOS-S2S-3: Forecast Evaluation – T2M Anomaly Correlation

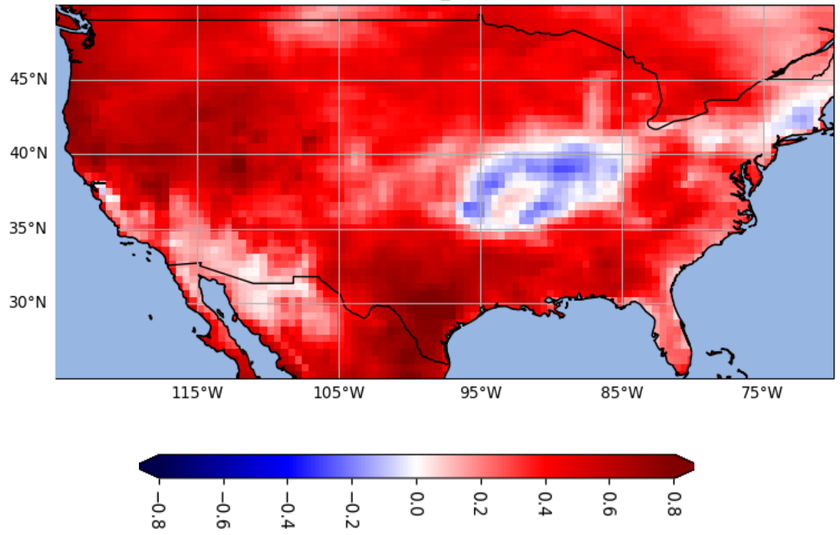
June AC

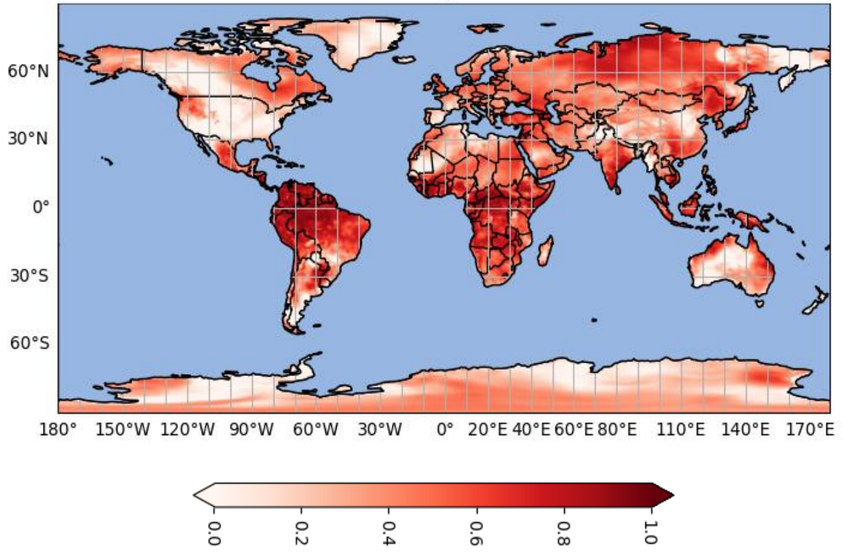
January AC

June 1-month lead

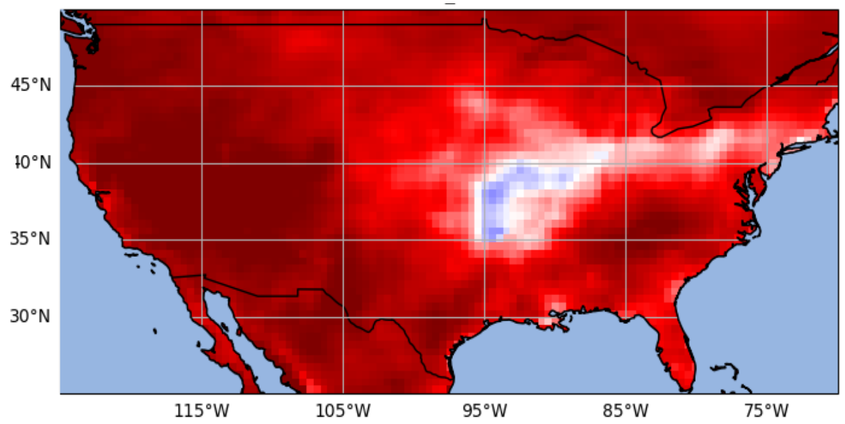
January 1-month lead

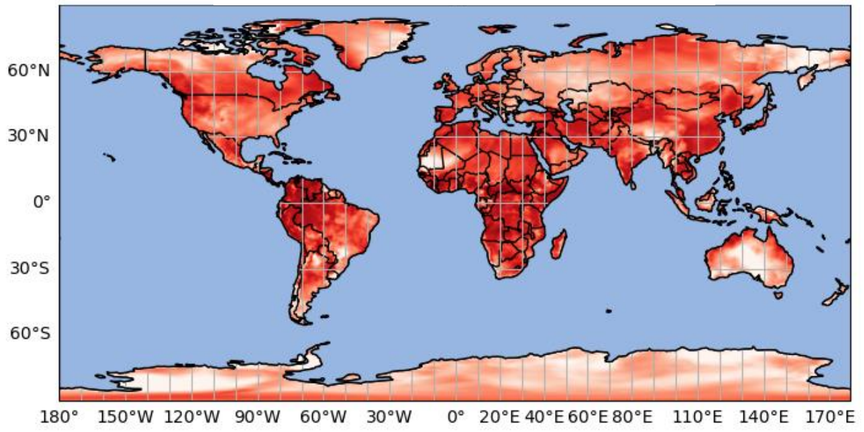
GEOS-S2S-2





GEOS-S2S-3





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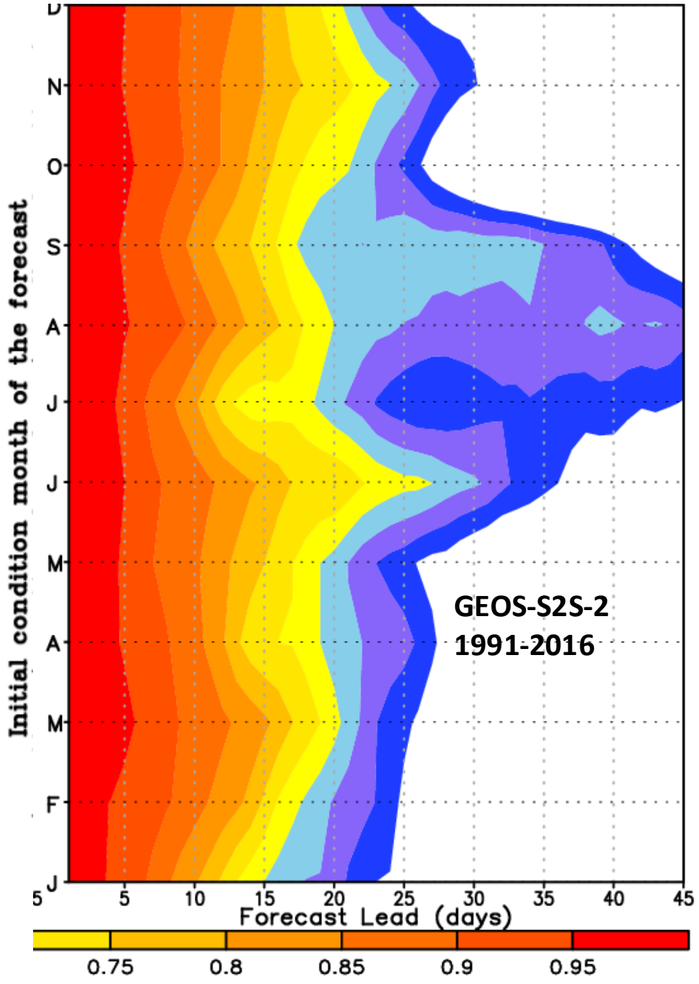
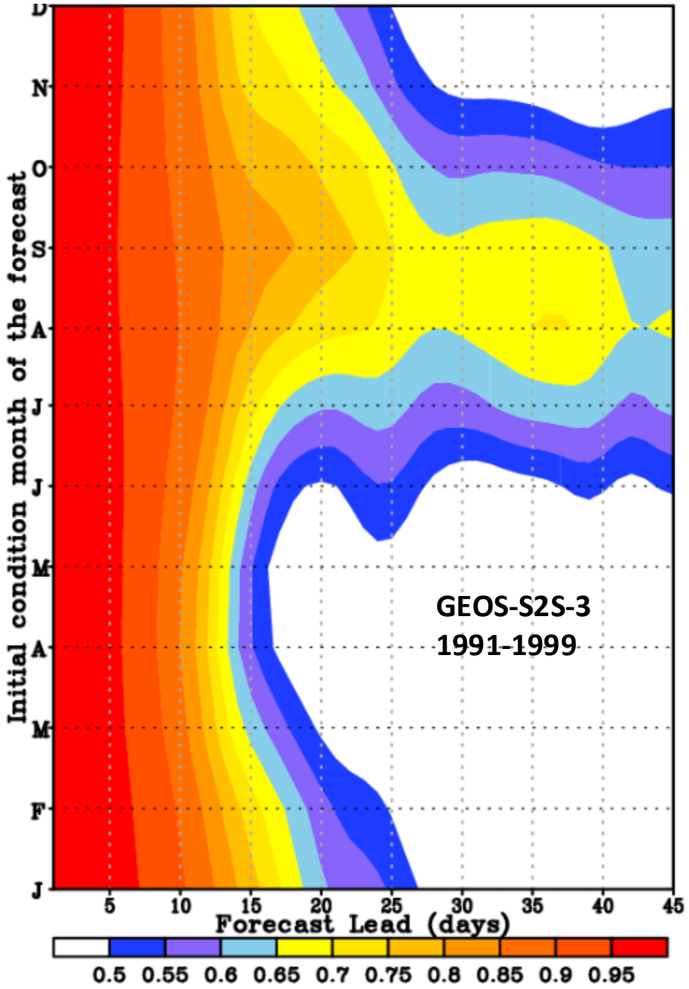
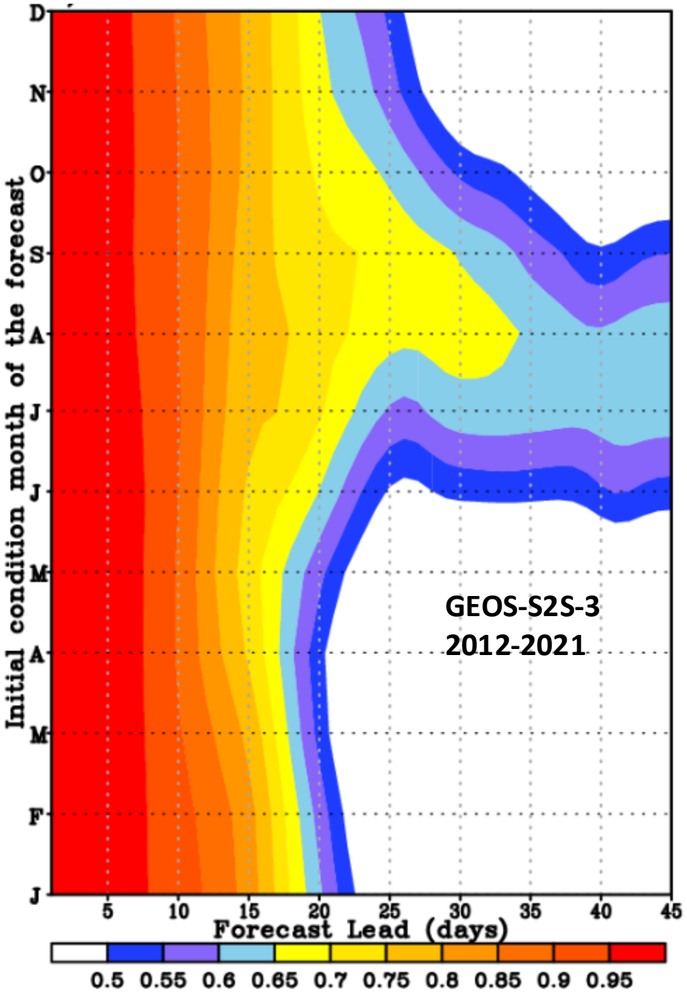
Analysis of Zhao Li

MJO Forecast Skill: RMM



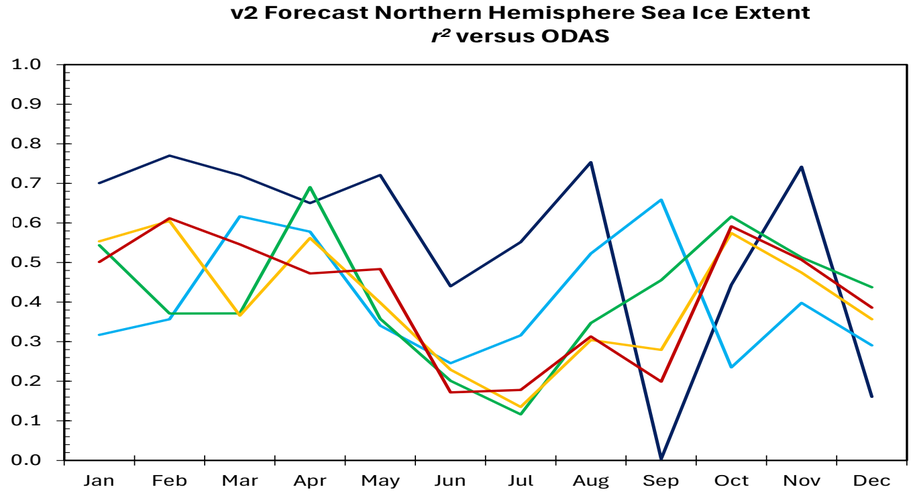


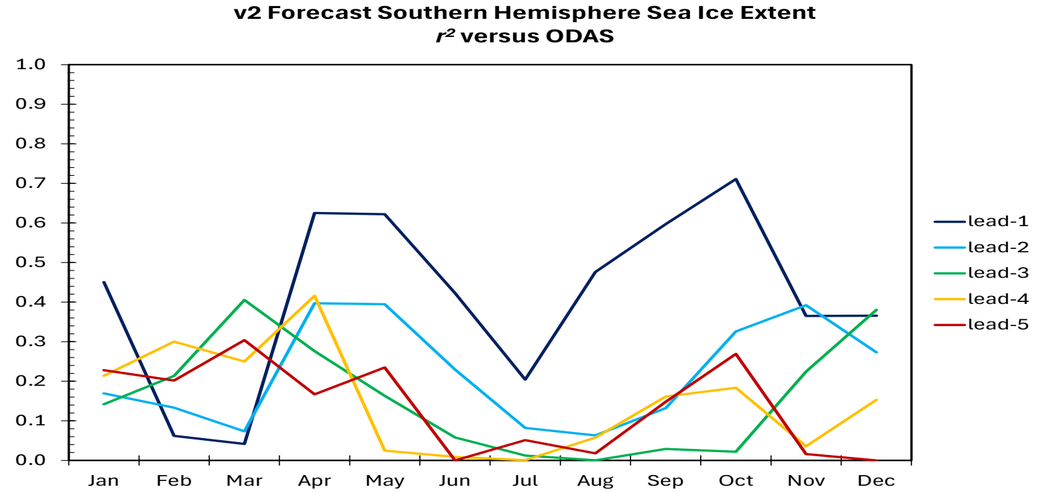


Analysis of Young-Kwon Lim

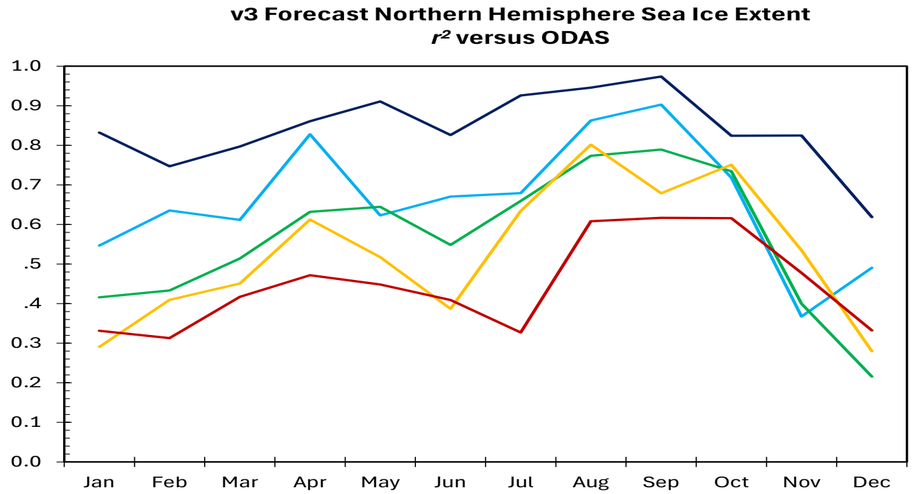
GEOS-S2S-3: Forecast Evaluation – Sea Ice Extent

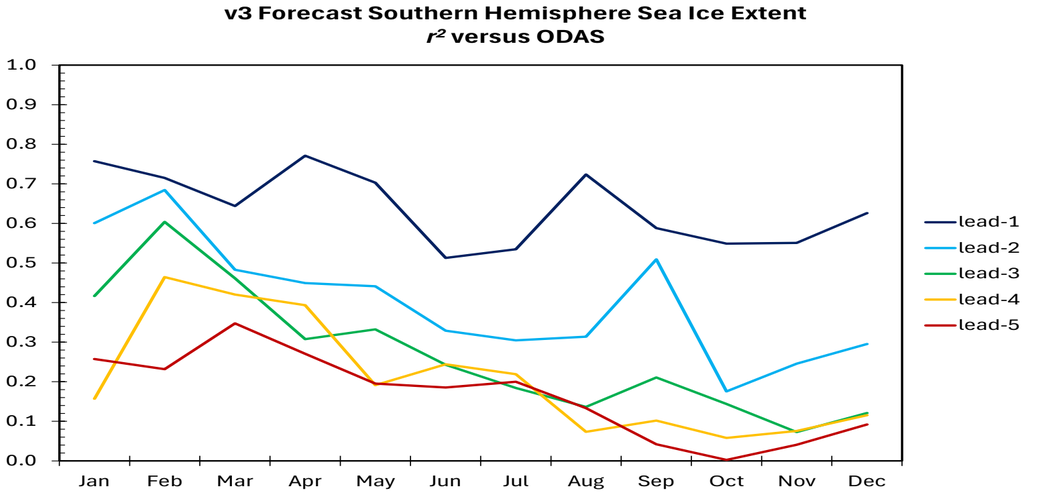
GEOS-S2S-2





GEOS-S2S-3





Analysis of Richard Cullather

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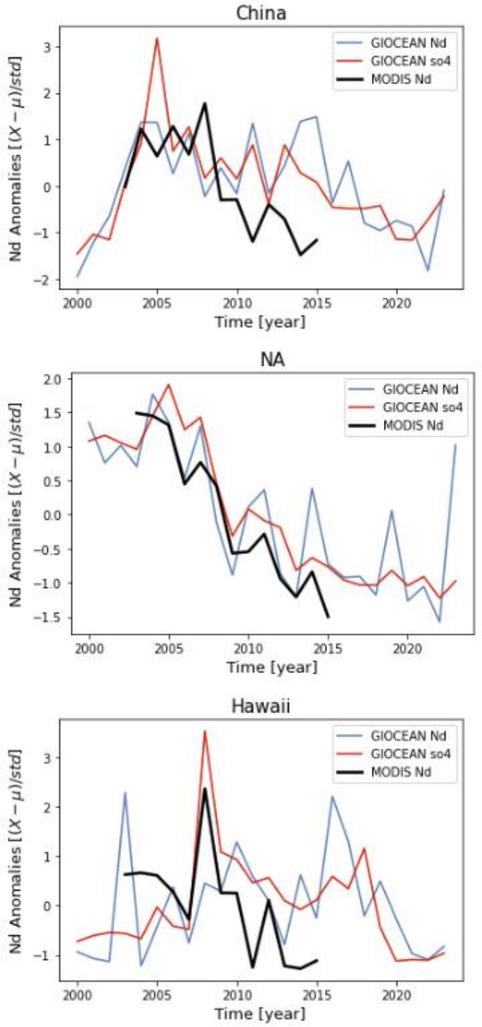
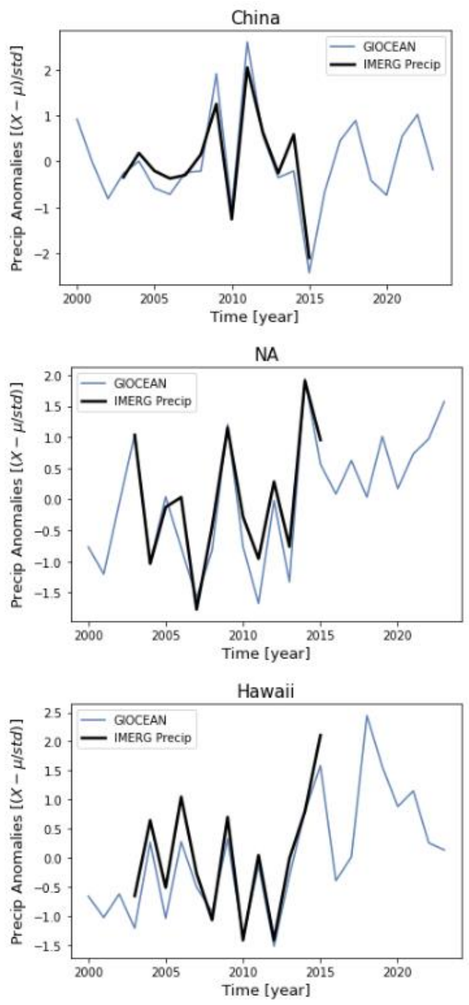
GEOS-S2S-3 AODAS: Aerosol and Cloud Drop Number Trends

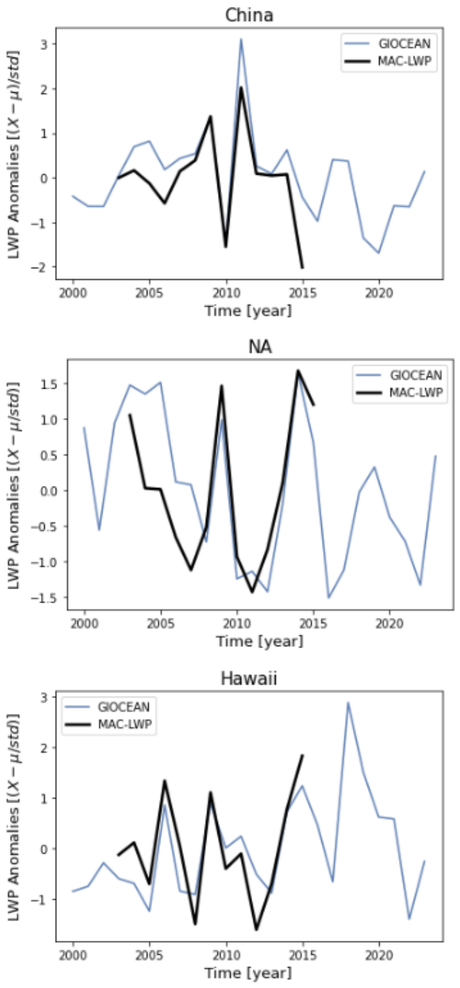
N_d and SO4 Anomaly



Precipitation Anomaly



LWP Anomaly



Decadal trends in:

- Cloud Drop Number (N_d)
- Sulfate (SO4)
- Liquid Water Path (LWP)
- Precipitation

are well simulated by GiOCEAN over different regions.

(Reminder, GiOCEAN includes replay to AOD and water vapor)

Song C., McCoy D., and Barahona D. In preparation

Thank you for your attention:

Contact info: andrea.molod@nasa.gov

New/Ongoing Research related to prediction and predictability

1. Land surface - Boundary Layer feedbacks and their roles in S2S Predictability and Prediction
2. Seamless Prediction and Predictability from Weather to Subseasonal to Seasonal Scales
3. GEOS/MITgcm coupled model and data assimilation system for decadal prediction
4. Understanding of the role of the ocean surface salinity in MJO behavior over the Maritime Continent
5. “Tendency Bias correction” – Existing studies at GMAO with “bias corrected” atmosphere in a coupled model, being extended to an ML-based state dependant correction, also now investigating impact of “bias corrected” ocean as well.

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