NASA Earth System Modeling Town Hall

American Geophysical Union Annual Meeting, San Francisco CA: Dec 11-15, 2023

Global Modeling and Assimilation Office (GMAO)

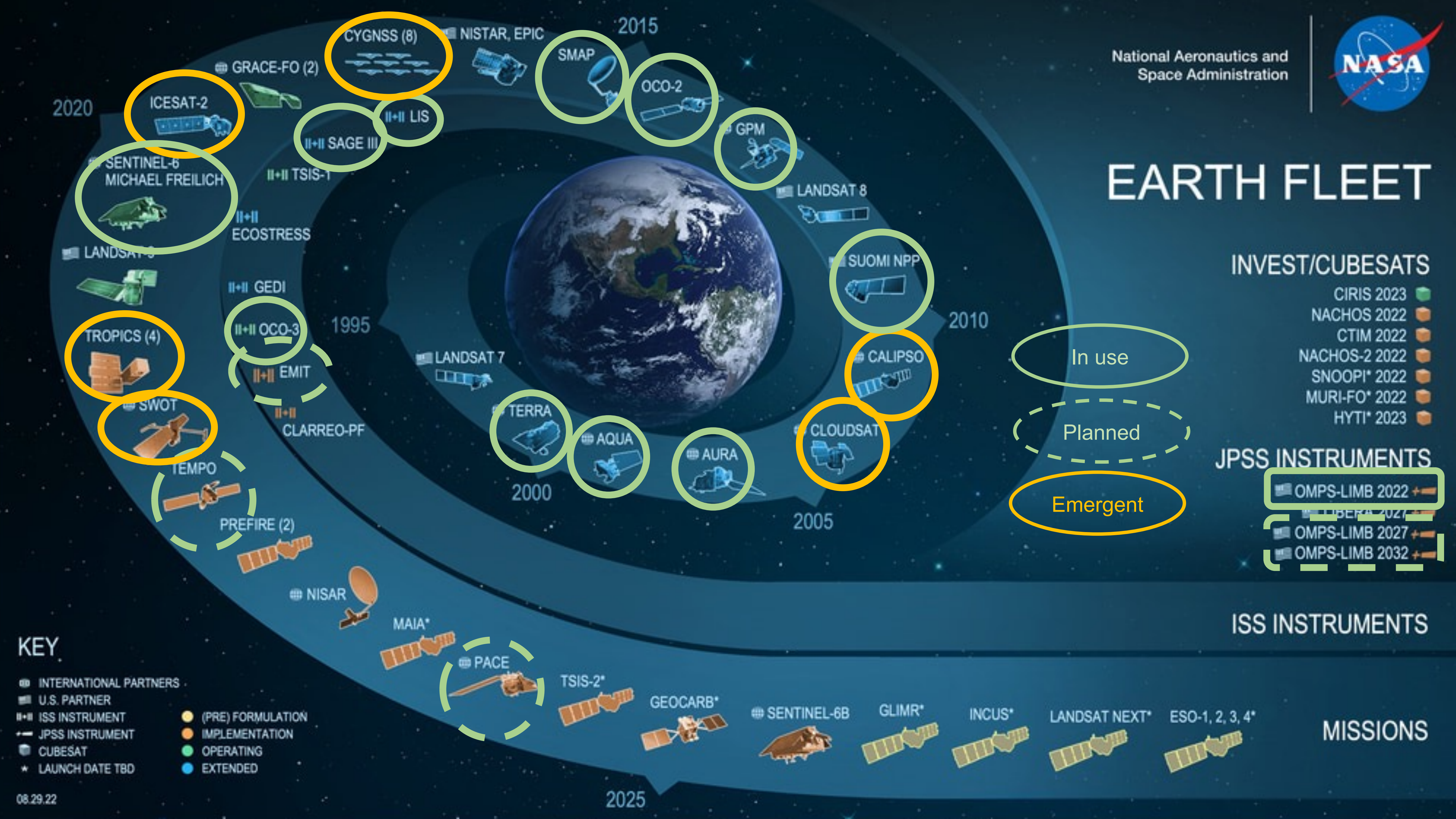
Steven Pawson
NASA Goddard Space Flight Center

Mission Statement

GMAO's core mission is to enhance the value of NASA's observations to understand, analyze and predict changes in the physics, chemistry and biology of the Earth system

Global Modeling and Assimilation Office (GMAO)

The "Goddard Earth Observing System" (GEOS) suite of modeling and data assimilation tools targets the use of NASA observations, alongside operational and commercial data, to advance the state of Earth system analysis and prediction


National Aeronautics and Space Administration
NASA
EARTH FLEET
INVEST/CUBESATS
CIRIS 2023
NACHOS 2022
CTIM 2022
NACHOS-2 2022
SNOOPI* 2022
MURI-FO* 2022
HYTI* 2023
JPSS INSTRUMENTS
OMPS-LIMB 2022
OMPS-LIMB 2027
OMPS-LIMB 2032
ISS INSTRUMENTS
MISSIONS
In use
Planned
Emergent
2015
2020
1995
2010
2000
2005
2025
CYGNSS (8)
NISTAR, EPIC
SMAP
OCO-2
GPM
LANDSAT 8
SUOMI NPP
CALIPSO
CLOUDSAT
AURA
AQUA
TERRA
LANDSAT 7
GRACE-FO (2)
ICESAT-2
LIS
SAGE III
TSIS-1
SENTINEL-6 MICHAEL FREILICH
ECOSTRESS
LANDSAT 9
GEDI
OCO-3
EMIT
TROPICS (4)
SWOT
CLARREO-PF
TEMPO
PREFIRE (2)
NISAR
MAIA*
PACE
TSIS-2*
GEOCARB*
SENTINEL-6B
GLIMR*
INCUS*
LANDSAT NEXT*
ESO-1, 2, 3, 4*
KEY
INTERNATIONAL PARTNERS
U.S. PARTNER
ISS INSTRUMENT
JPSS INSTRUMENT
CUBESAT
LAUNCH DATE TBD
(PRE) FORMULATION
IMPLEMENTATION
OPERATING
EXTENDED
08.29.22

GEOS Systems/Products

GEOS-FP (Forward Processing)
Real-time weather prediction, with a slant towards including NASA observations

GEOS-CF (Composition Forecasting)
Real-time prediction of atmospheric composition with complex chemistry

GEOS-IT (Instrument Teams)
Historical and real-time meteorological analyses, support >30 science teams

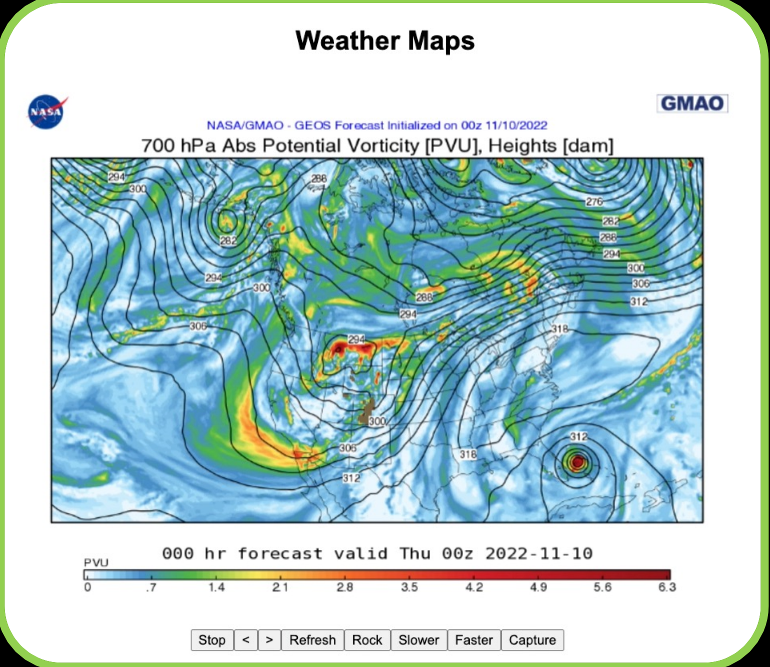
SMAP-Level 4
Root-zone soil moisture and carbon fluxes, as part of the SMAP mission

MERRA-2 (Climate Reanalysis)
With a focus on data from NASA's EOS mission, including aerosol and ozone, for 1980-2025

MERRA-21C (21^{st} Century)
21^{st} Century reanalysis, with all-sky microwave, examines transition to post-EOS and commercial observations

GEOS-S2S (in the NMME)
Sub-seasonal to seasonal predictions using coupled model systems

GEOS Predictions

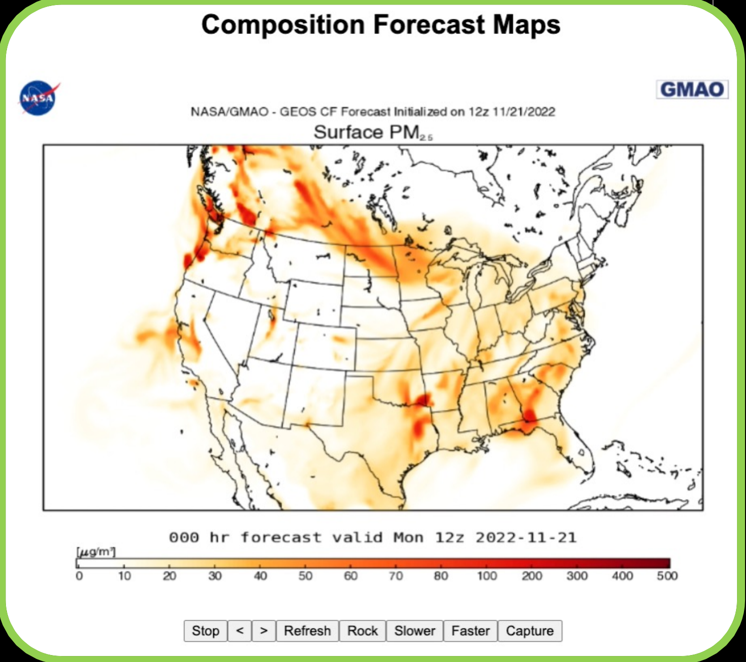


GEOS-FP

Support space and suborbital missions

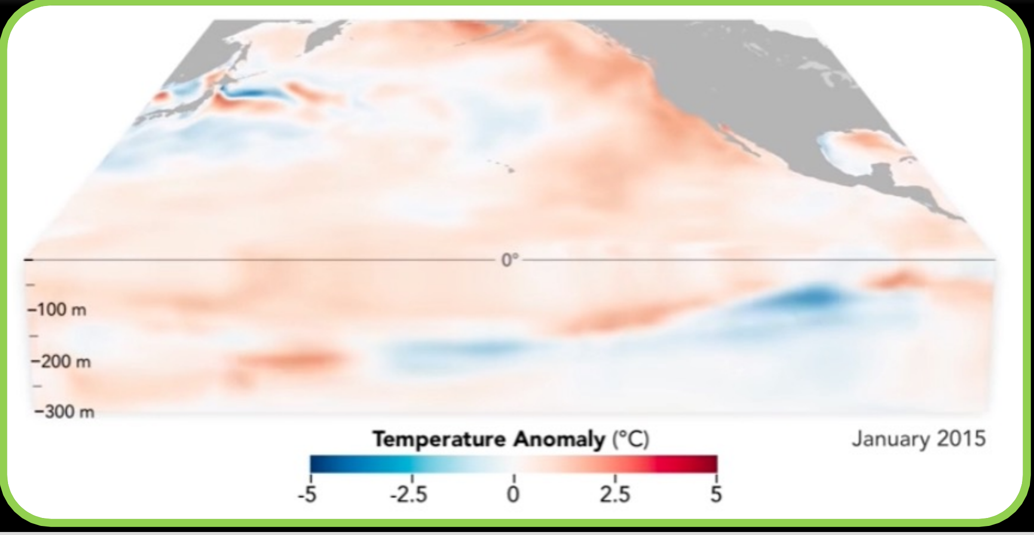
Observation impact studies (metrics)

Basis for interagency collaborations



GEOS-CF

GEOS-S2S



Supports NASA research and development

Opportunities to develop new applications

The GMAO Core Effort in the NASA Context

Where does the GMAO's core effort fit in this pyramid?

The GMAO Core Effort in the NASA Context

Improving the integrity and capability of the GEOS modeling and analysis systems for Earth system science

- Coupled assimilation (JEDI)
- Impacts of new observations
- Spatio-temporal resolution
- Coupling of Earth System components
- Complexity of processes

Example: A Machine Learning Approach for Improving Cloud Parametrization

Problem

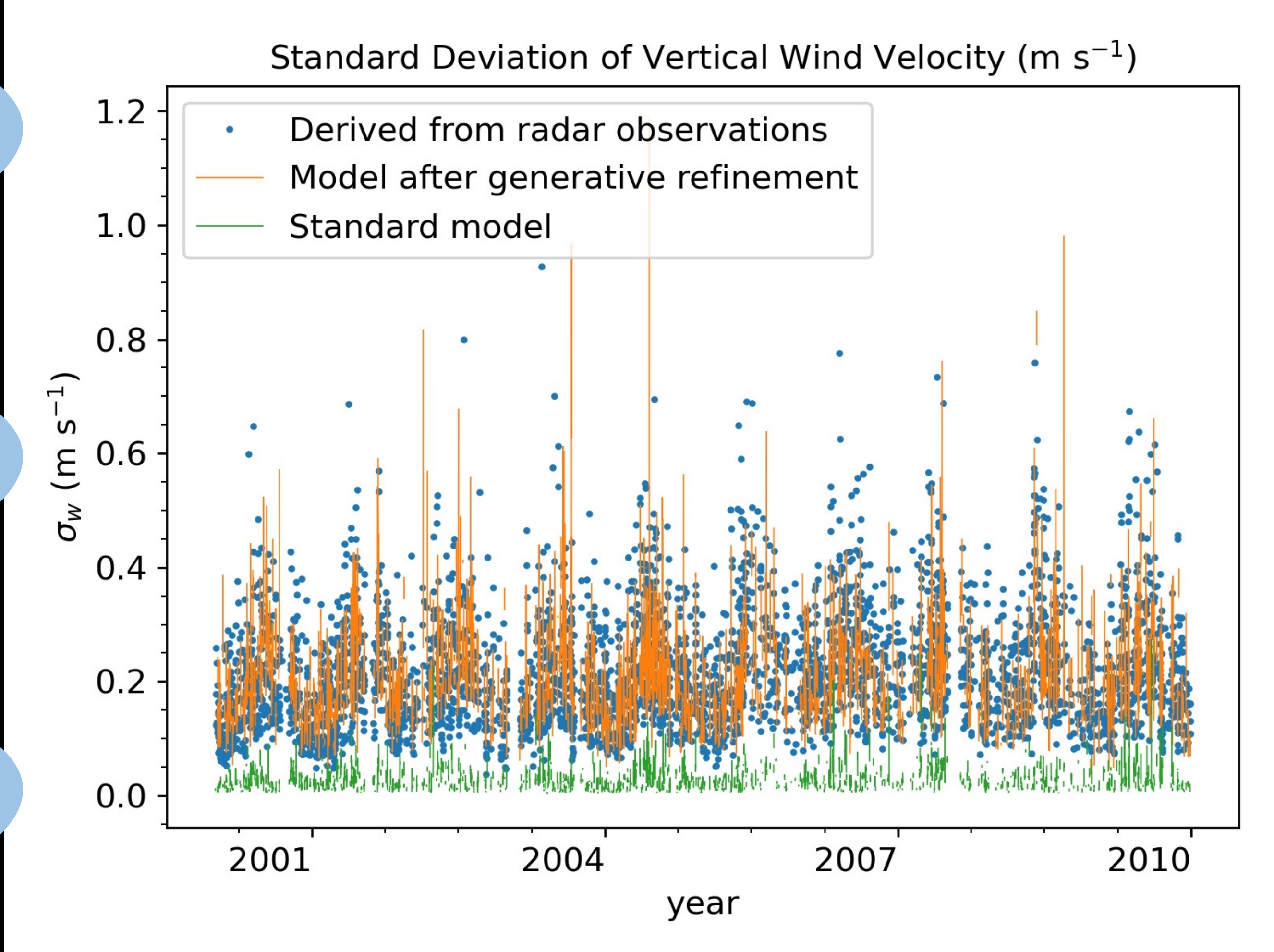
Vertical air motions (w) vary on scales too small to capture in weather and climate models

Objective

Develop a sub-grid representation of the w spectrum, using the fine-scale model and the radar observations

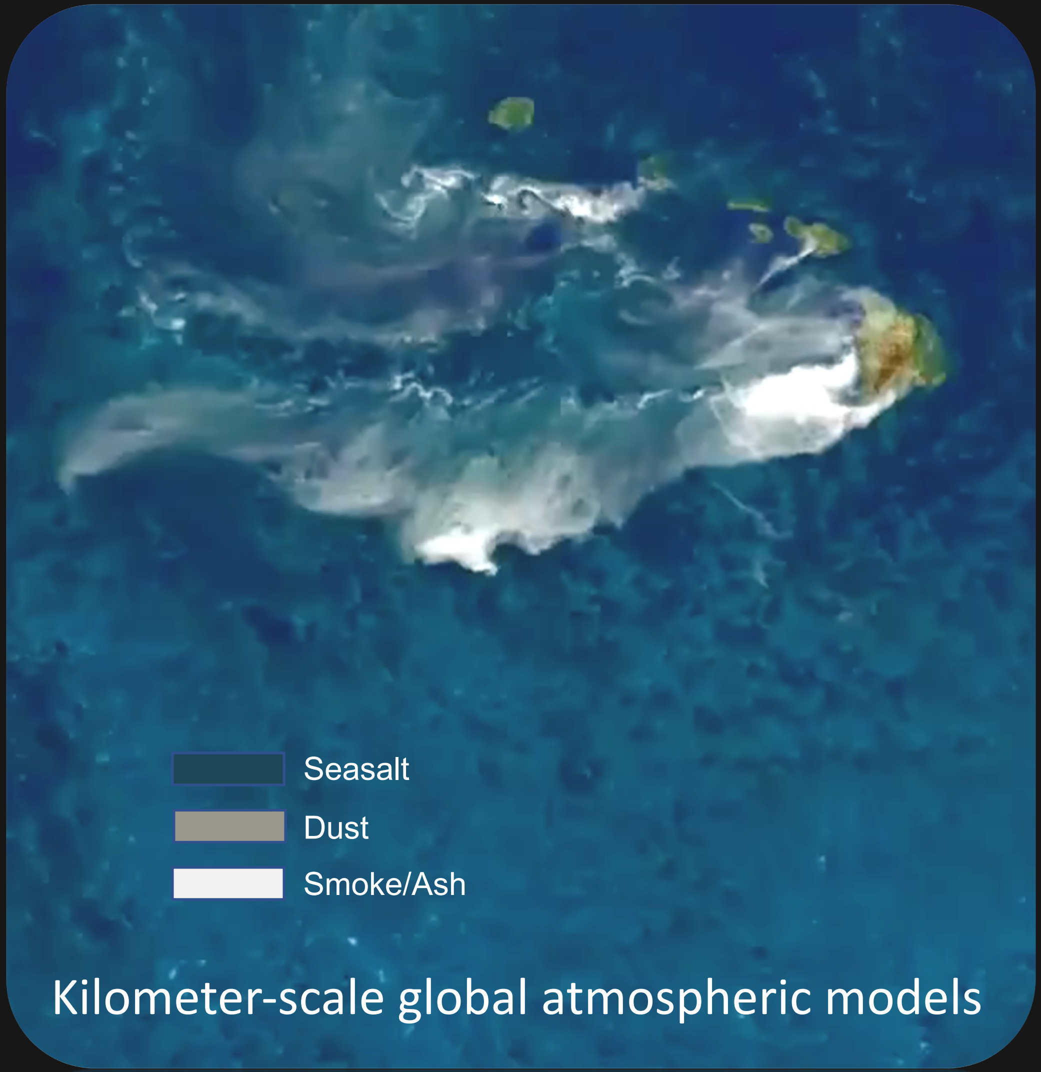
Outcome

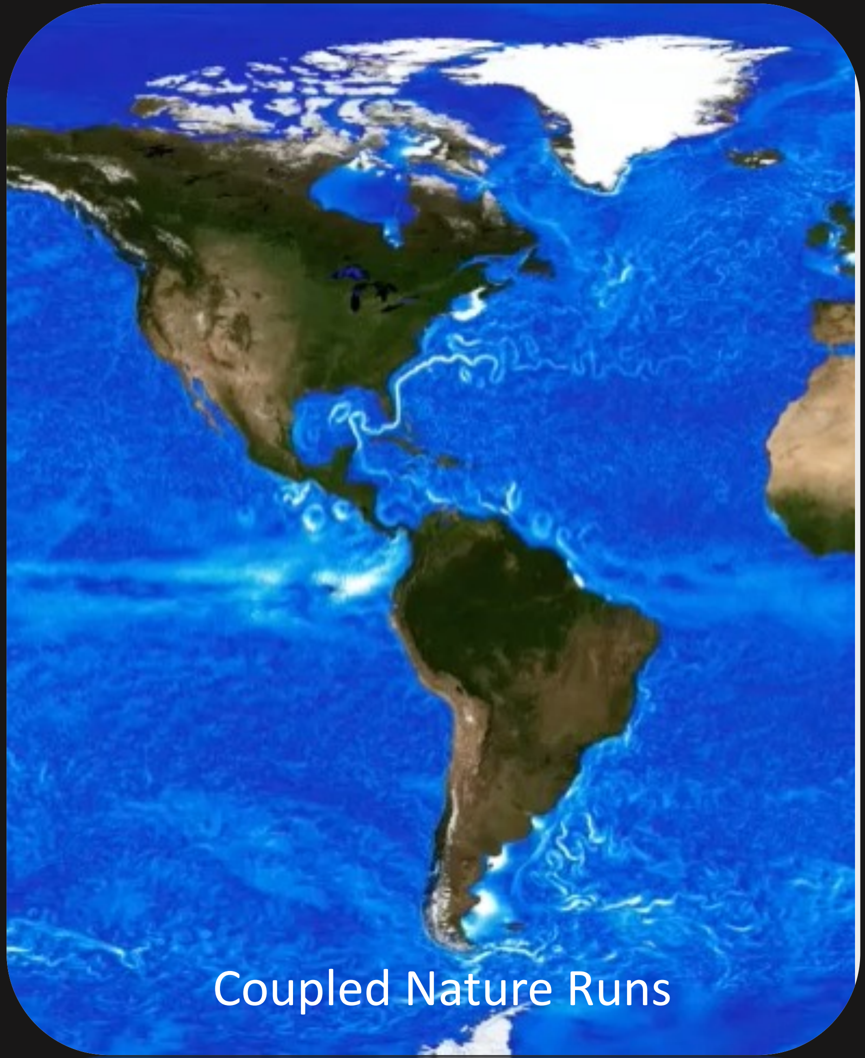
Subgrid w variance is well captured by using the observations to refine the km-scale model estimate



Barahona, D., Breen, K. H., Kalesse-Los, H., & Röttenbacher, J. (2023). Deep Learning Parameterization of Vertical Wind Velocity Variability via Constrained Adversarial Training. *Artificial Intelligence for the Earth Systems*. https://doi.org/10.1175/AIES-D-23-0025.1

High-Resolution GEOS Models





Example: GeoXO Hyperspectral IR Sounder using the GEOS OSSE CapabiliX

OSSE Problem

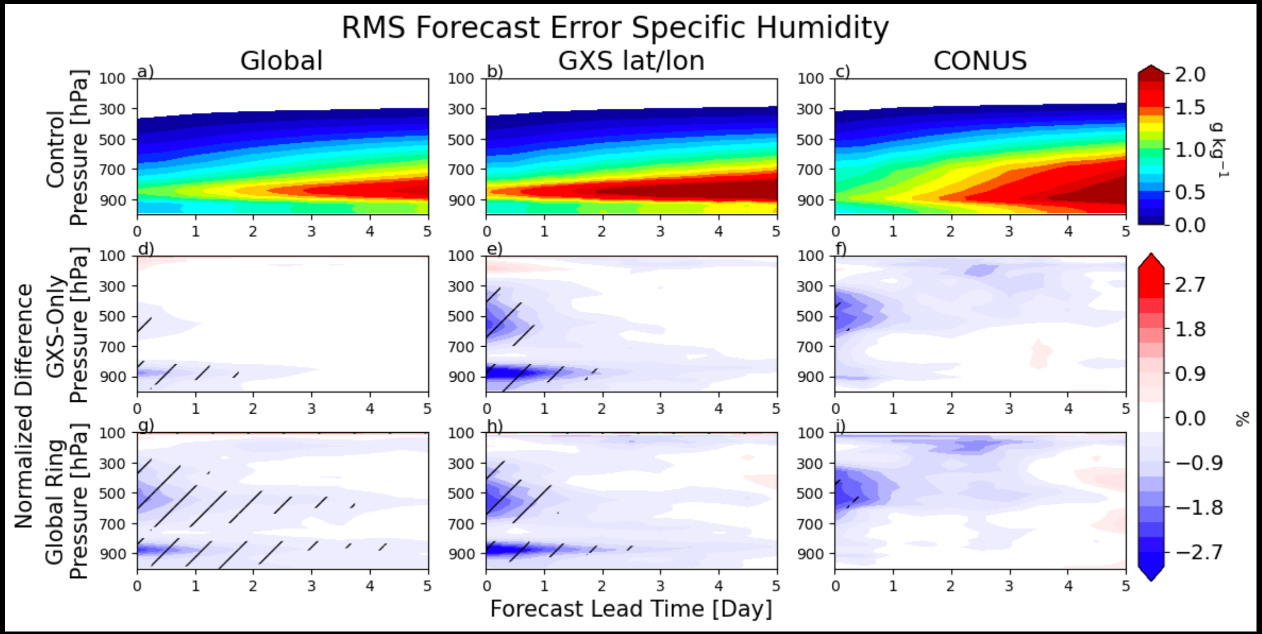
How do new observations impact the quality of meteorological analyses?

Experiment

Use baseline (2020) observing system and add GeoXO and a "Geo Ring" that include hyperspectral IR sounders

Outcome

Geostationary hyperspectral sounders will be beneficial for weather foecasting, regionally and globally



Top: five day RMS forecast error for q (2020 baseline obs)
Middle: improvements (blue shade) after adding GeoXO
Bottom: improvements (blue shade) after adding Geo ring

Work by Nikki Prive, Erica McGrath-Spangler, Bryan Karpowicz, Yanqiu Zhu

Opportunities Abound