



Toward coupled data assimilation in NASA's GEOS: Developments in the ocean context

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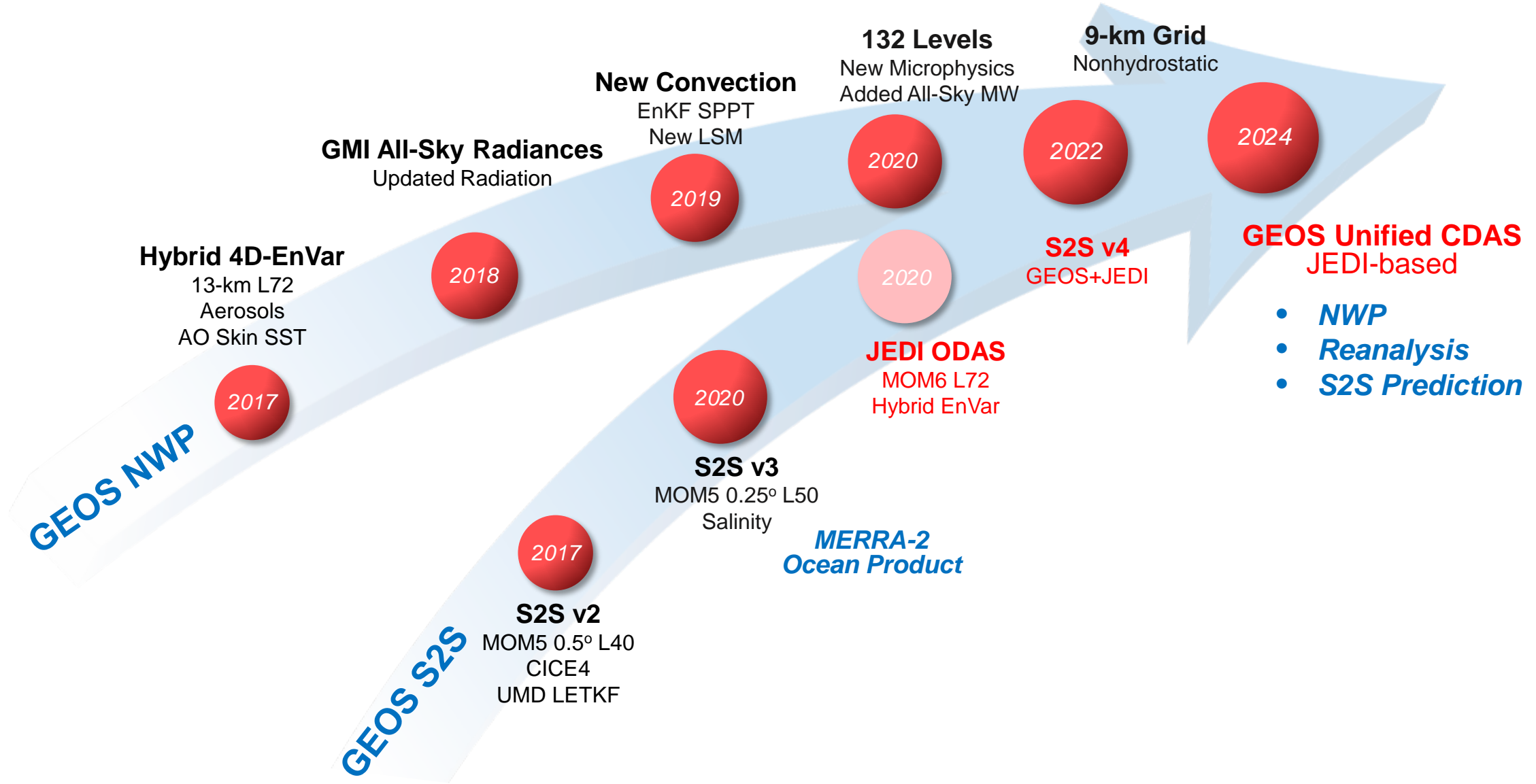
¹NASA/GMAO

²JCSDA/UCAR

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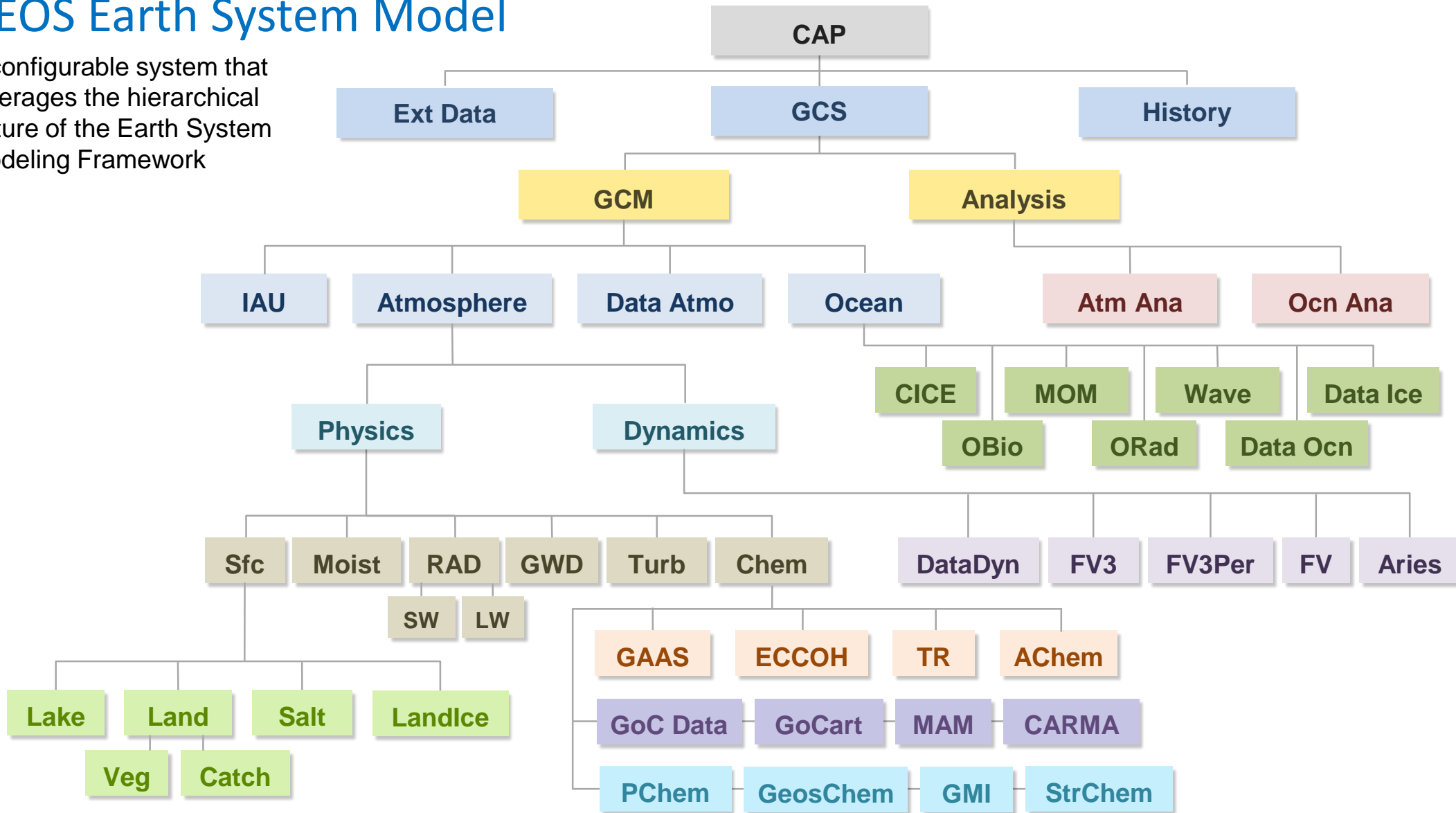
Moving toward a JEDI-based GEOS system for coupled DA



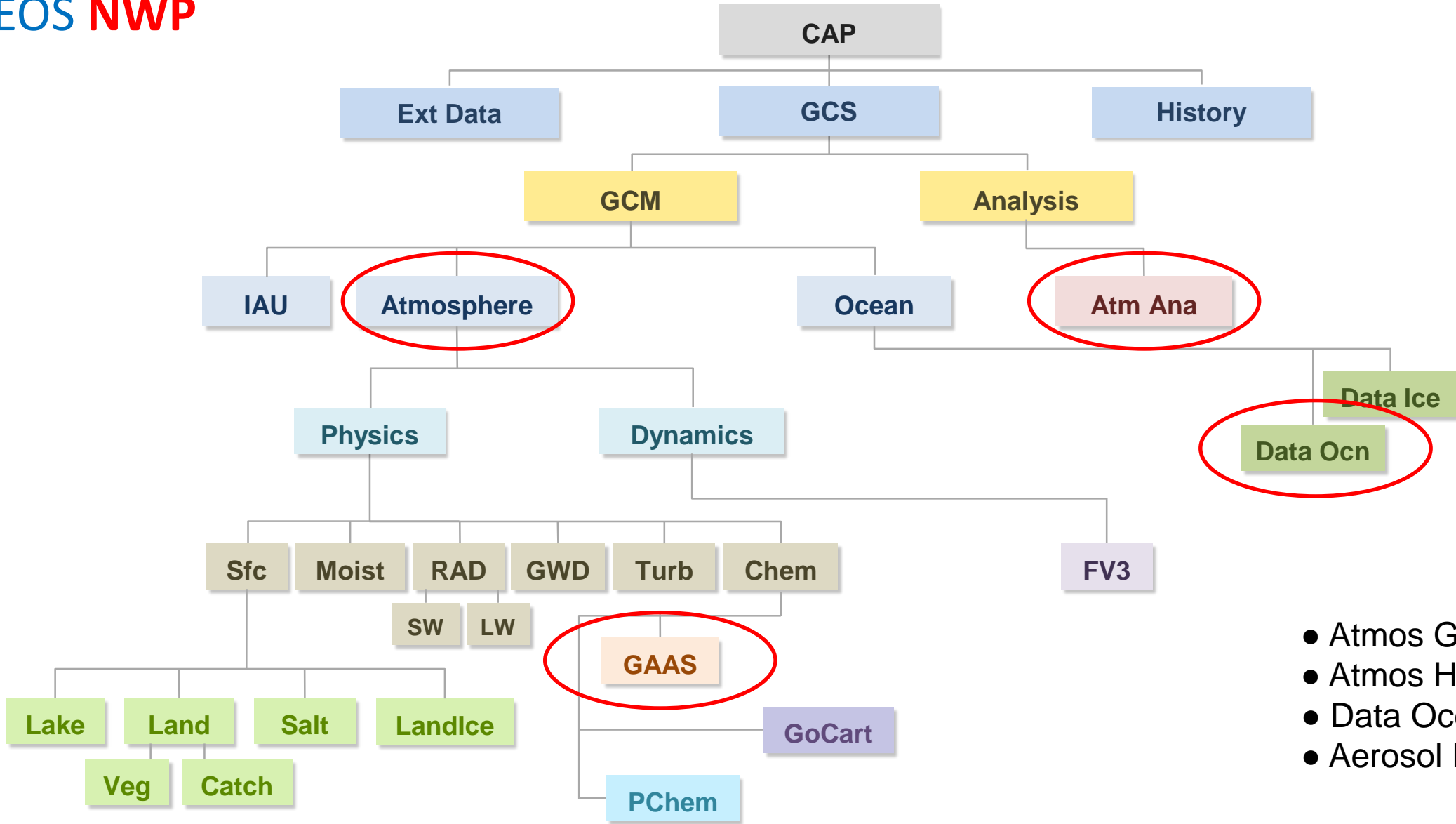


GEOS Earth System Model

A configurable system that leverages the hierarchical nature of the Earth System Modeling Framework



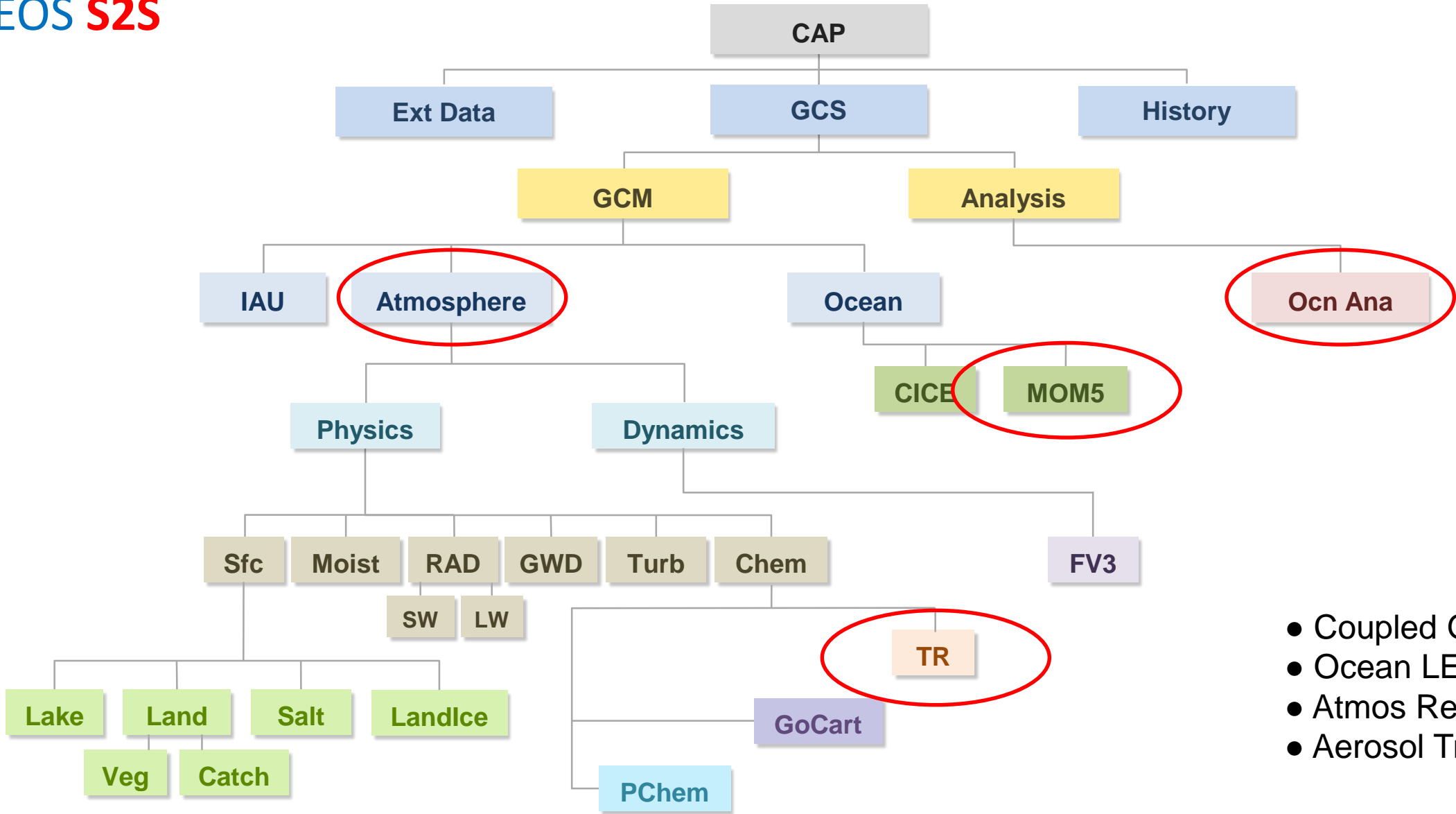
GEOS NWP



- Atmos GCM
- Atmos H4D-EnVar
- Data Ocean
- Aerosol DA



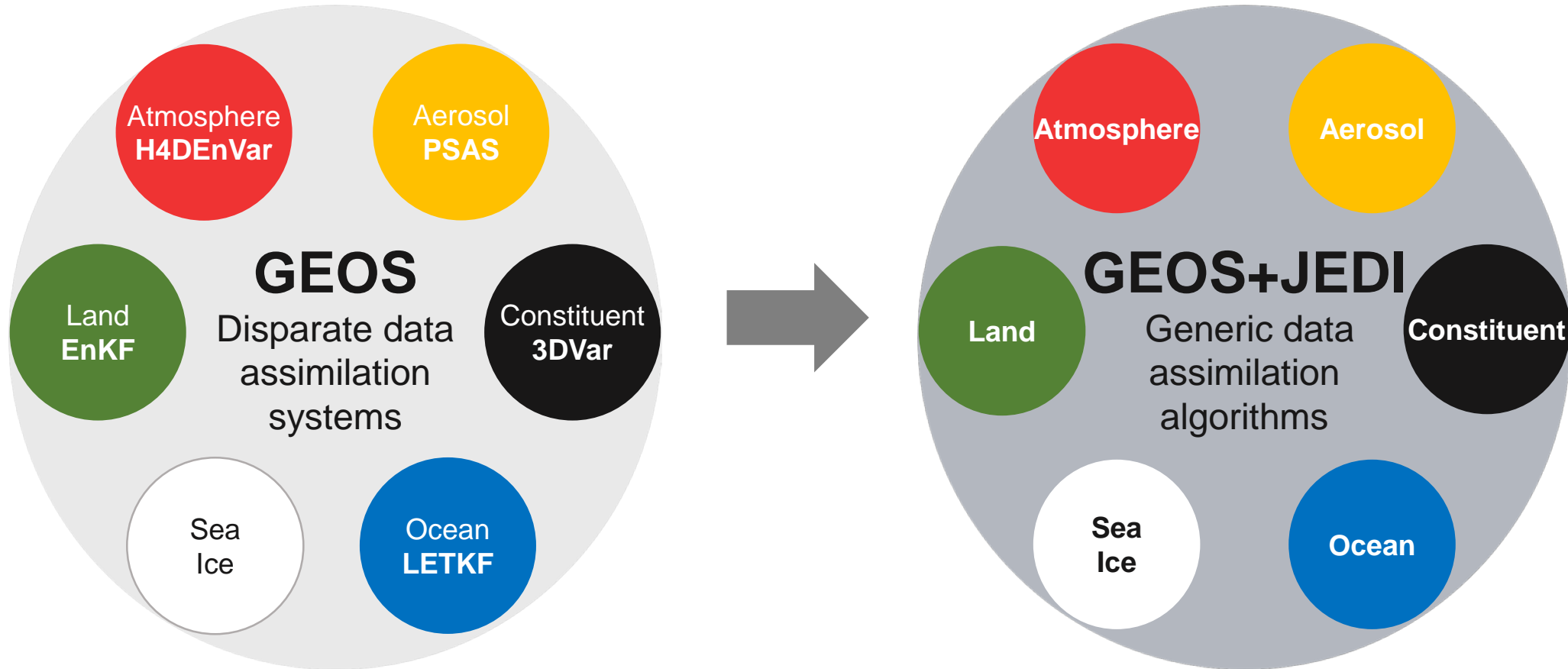
GEOS S2S



- Coupled GCM
- Ocean LETKF
- Atmos Replay
- Aerosol Transport

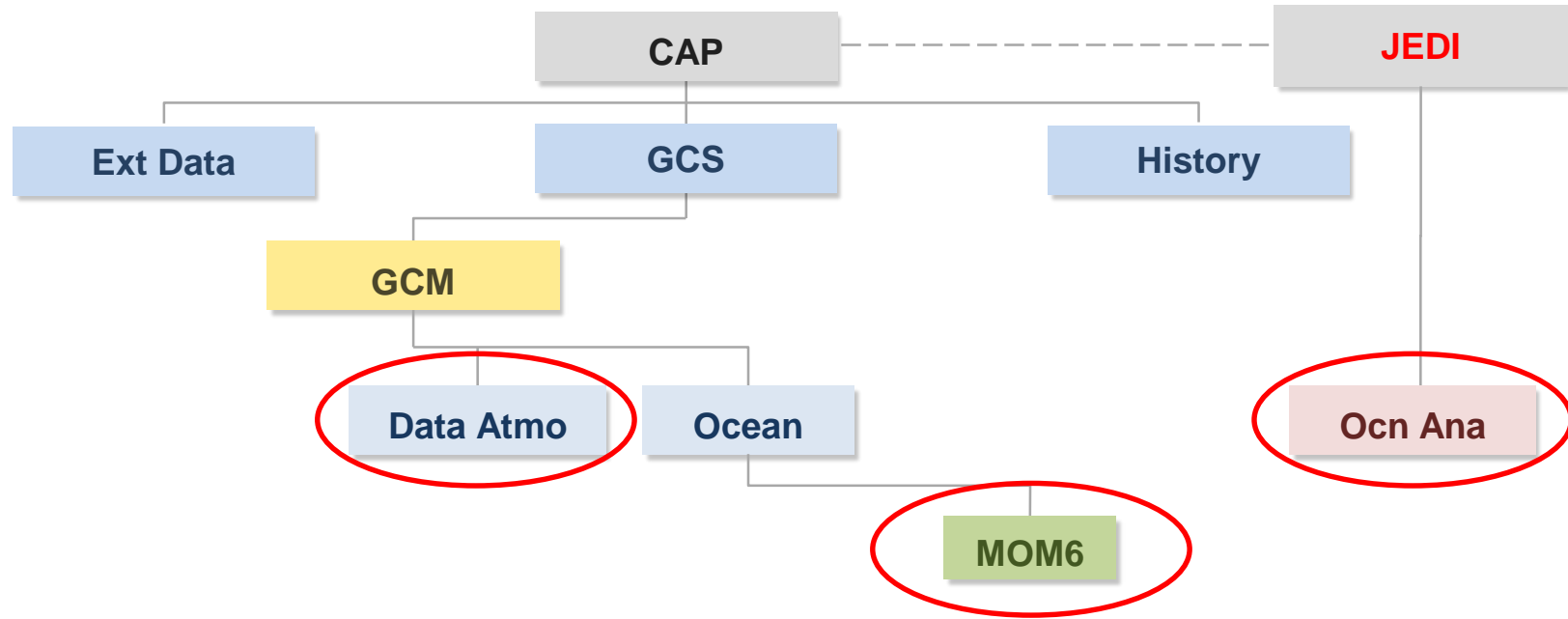
Building a GEOS unified data assimilation system

Up to now GMAO's data assimilation systems have been developed for individual GEOS components as disparate entities.





GEOS+JEDI ODAS



- Ocean GCM
- **JEDI DA**
- Data Atmos



Experimental setup

Not a toy system...

- GFDL MOM6 at 1° L72
- Full suite of observations
- 24-h assimilation window
- JEDI-SOCA 3D-Var
 - Balance operators for variable transforms
 - Vertical correlations parameterized based on model mixed layer depth
 - Horizontal correlations using B-Matrix on an Unstructured Mesh Package (**BUMP**)
- 1 Nov 2015 – 30 April 2016

Also...

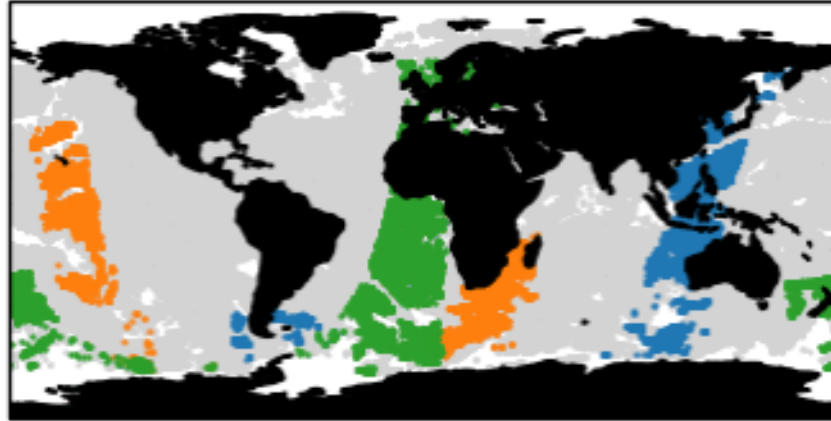
- Two sets of atmospheric forcings:
 - CFSR
 - MERRA-2
- Two sets of observations:
 - NCEPObs (HGODAS)
 - GMAOObs (GEOS S2S)

(GMAOObs do not include satellite SST)

Sample observation counts in a 24-h assimilation window

SST (IR)

AVHRR (Metop-A, NOAA 19) VIIRS (SNPP)



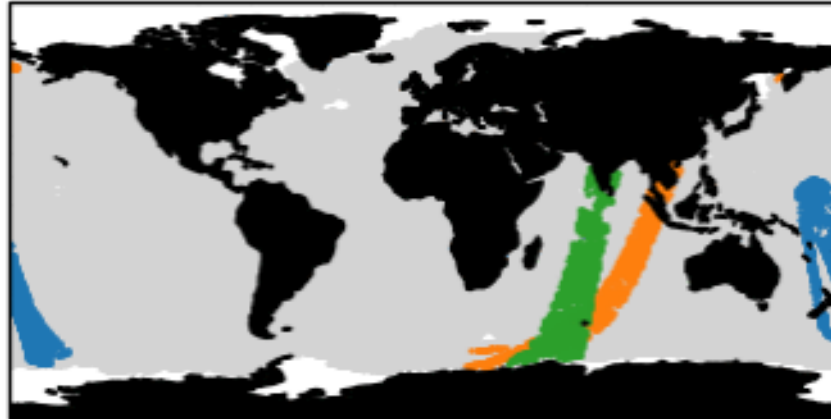
Salinity

SMAP



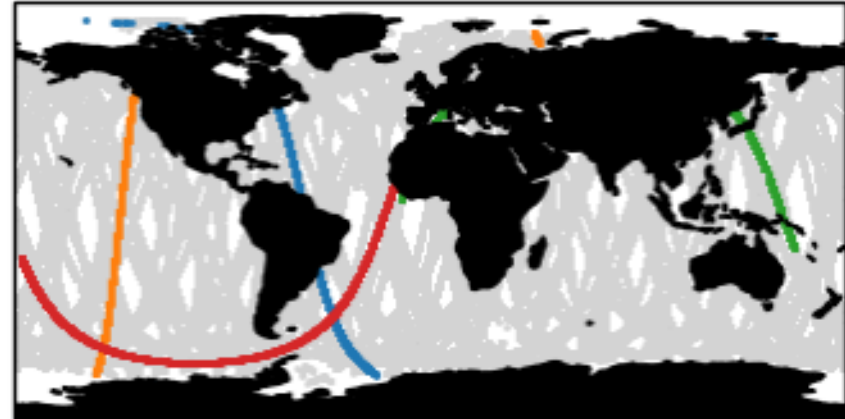
SST (MW)

GMI, AMSR-2, WindSat



Altimetry

Jason-2/-3, Sentinel-3a, Cryosat-2, SARAL



SST (IR) - 486,923

SST (MW) - 337,773

Salinity - 458,886

Ice Fraction - 93,157

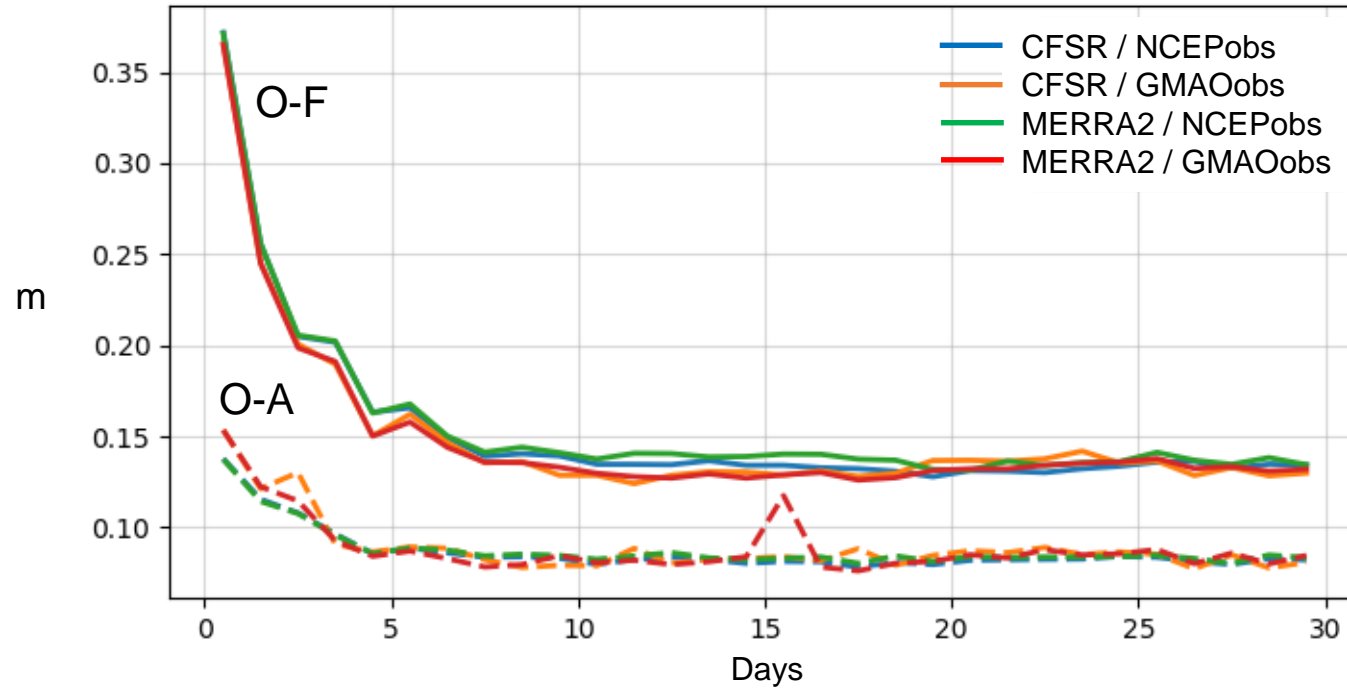
Altimetry - 240,017

1,616,756



Assimilation sanity check

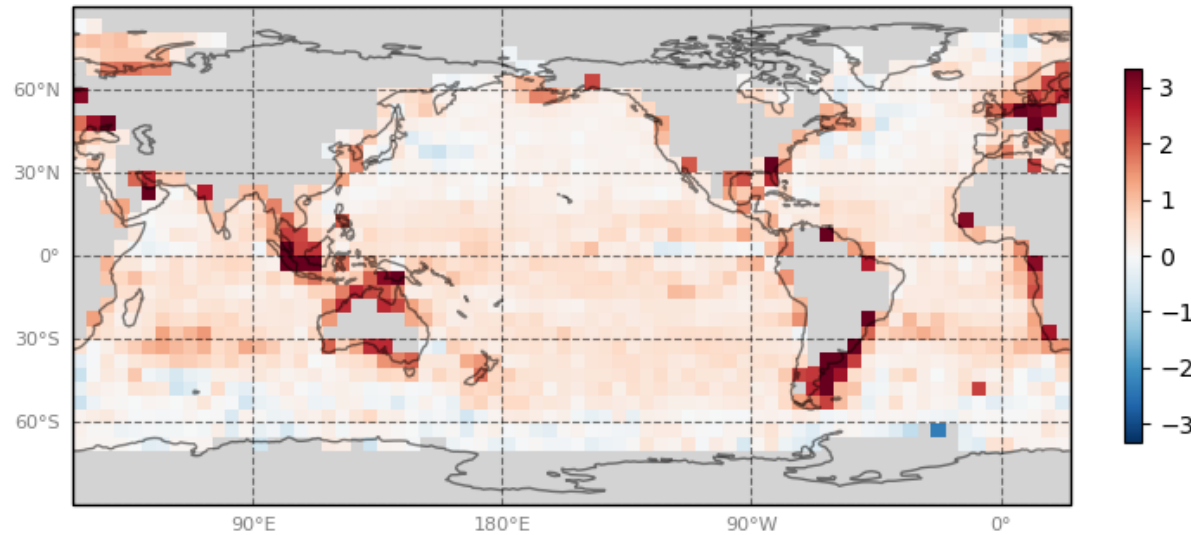
ADT rms departures



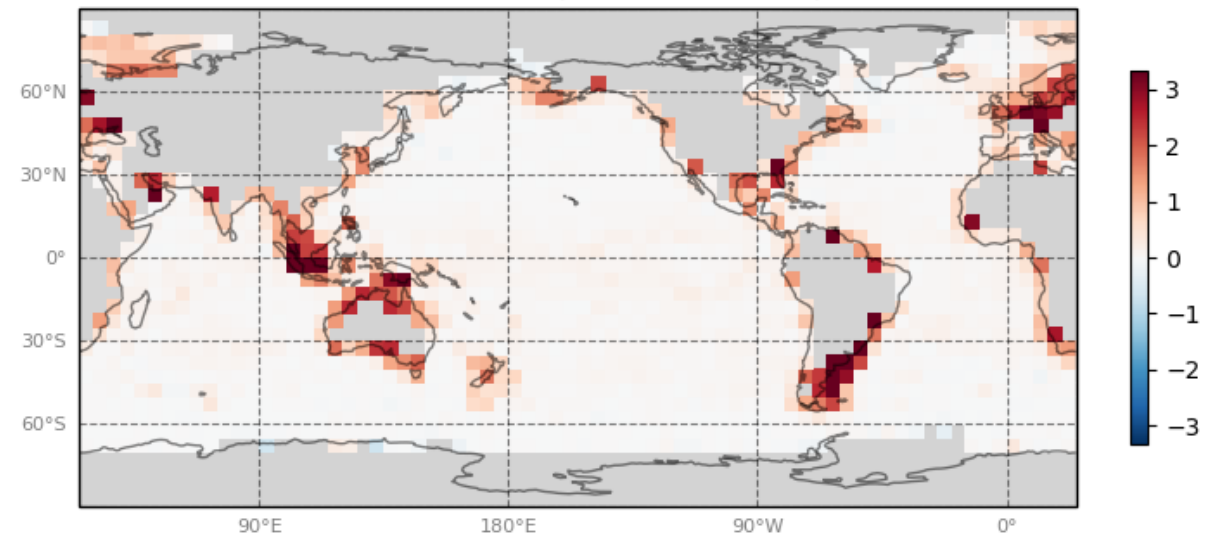
Atmospheric forcing effects

Departure differences between MERRA2 / NCEPobs and CFSR / NCEPobs

Difference in SST rms O-F



Difference in SST rms O-A

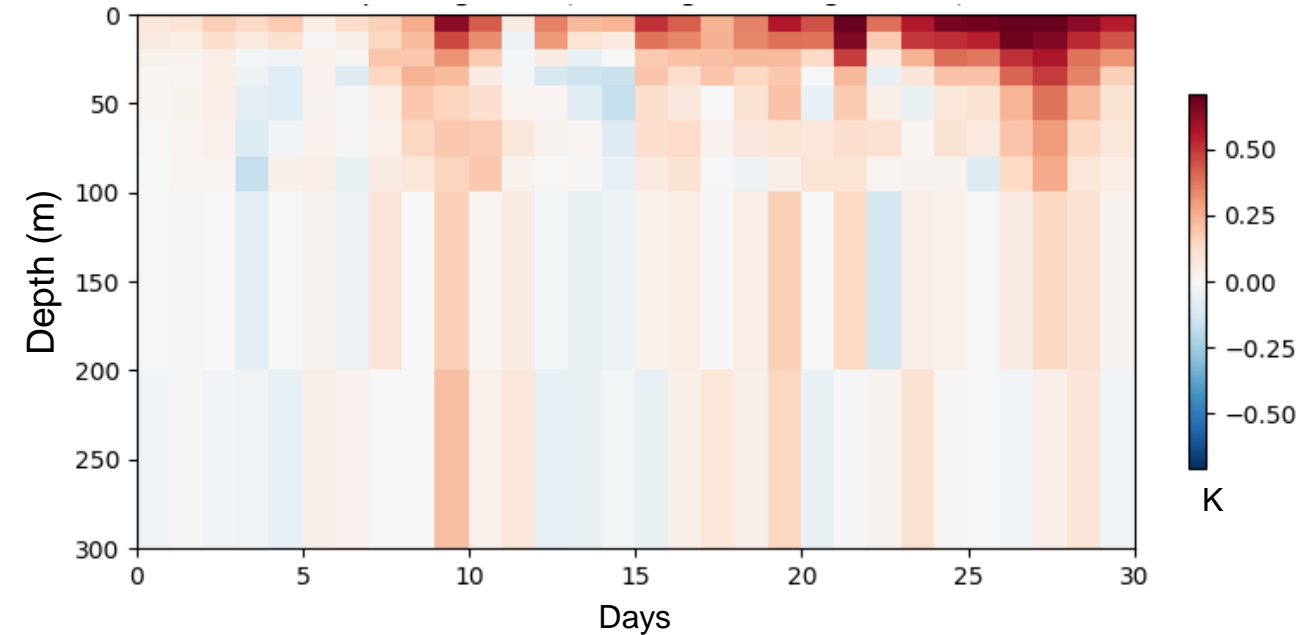


Red shades imply MERRA2 forcing drives the SST away from the observations compared with CFSR forcing, which is reduced somewhat after the assimilation.

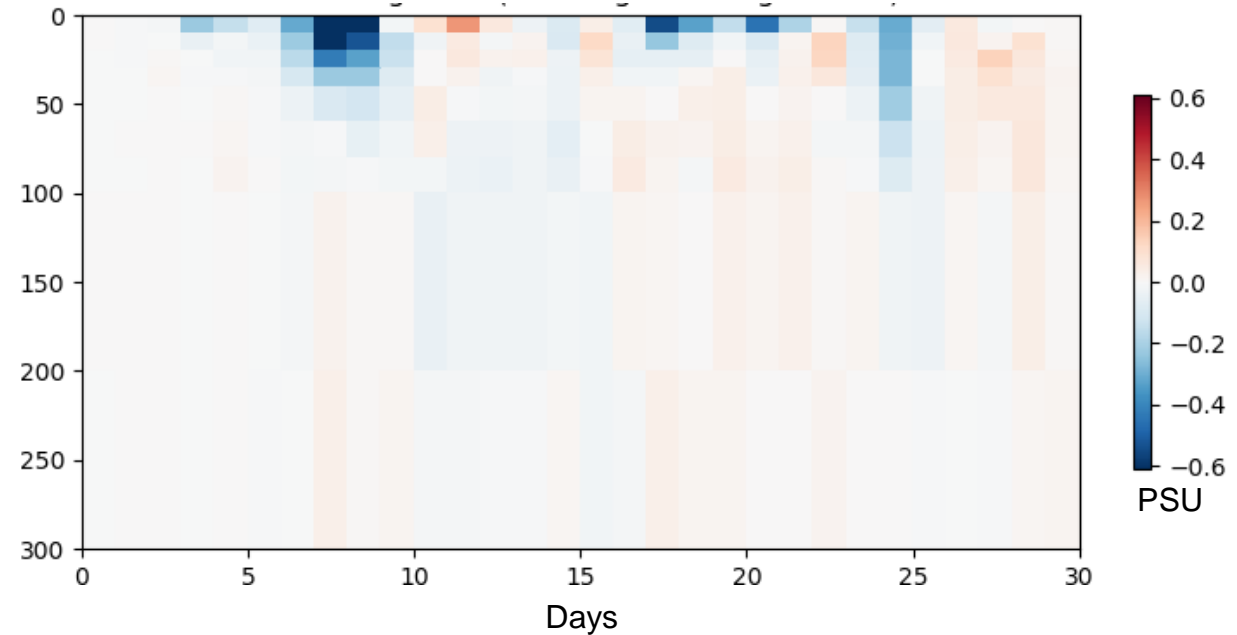
Atmospheric forcing effects

Departure differences between MERRA2 / GMAOobs and CFSR / GMAOobs

Difference in Temp rms O-F



Difference in Salinity rms O-F



Temperature error with MERRA2 forcing grows with time and shows some deepening; Salinity error shows no obvious trend.

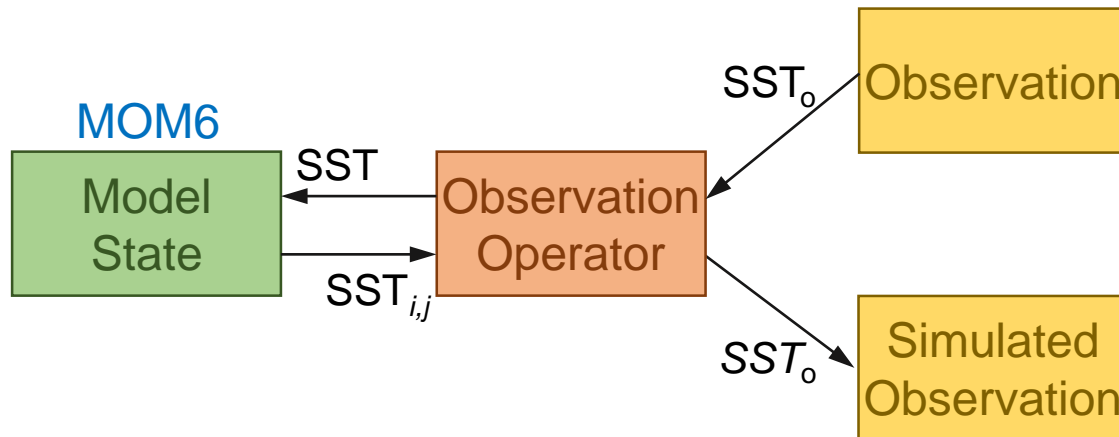


Animation of SSH: 2 panels TBD

Future work

- A key component of JEDI is the Unified Forward Operator (UFO), which introduces standard interfaces for **observation operators** that link the model and observation worlds.
- The UFO accommodates the assimilation of observations for coupled or uncoupled models in an analogous (unified) manner.

Uncoupled Ocean Only



Coupled Ocean-Atmosphere

