The GMAO Development Path: Looking toward a new FPIT data stream

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GMAO Near Real Time Support

GEOS Product Identifier	GEOS Version Used	Periods Covered
GEOS FP	5.22	3/13/2019 - on-going
	5.21	7/11/2018 - 3/13/19
	5.17	11/01/2017 - 7/11/018
	5.16	1/24/2017 - 11/01/2017
	5.13.1	5/1/2015 - 1/23/2017
	5.13.0	8/20/2014 - 5/1/2015
	5.11.0	6/11/2013 - 8/20/2014
GEOS FP-IT	5.12.4	1/1/2000 - on-going
	5.9.1	1/1/2000 - 1/1/??
G5.7.2	5.7.2	8/18/2011 - 6/10/2013
G5.2.0	5.2.0	8/14/2008 - 6/2/2013
G5.1.0	5.1.0	10/1/2003 - 10/2/2008
G5.0.1	5.0.1	8/1/2004 - 1/3/2008
G5-YOTC	5.3.0	1/1/2008 - 4/20/2010
	5.4.0	
	5.4.1	
G5.4.1-CERES	5.4.1	12/01/1997 - present
G5-CERES	5.2.0	12/1/2007 - 3/1/2016

- Forward Processing (FP) represents the latest system, including promoted updates to the model and analysis
- Before promotion to FP, a candidate system is tested in parallel with FP (FPP)
- Before a candidate for FPP is chosen, a series of experiments is conducted to validate science updates (X00…)

Recent Forward Processing Updates

5.22	3/13/2019 - on-going
5.21	7/11/2018 - 3/13/2019
5.17	11/01/2017 - 7/11/2018
5.16	1/24/2017 – 11/01/2017

5.16

- Analysis
  - **3-D to 4-D Data Assimilation**
  - Assimilation Algorithms
- GCM
  - Resolution to 12.5km
  - GEOS model processes

5.21

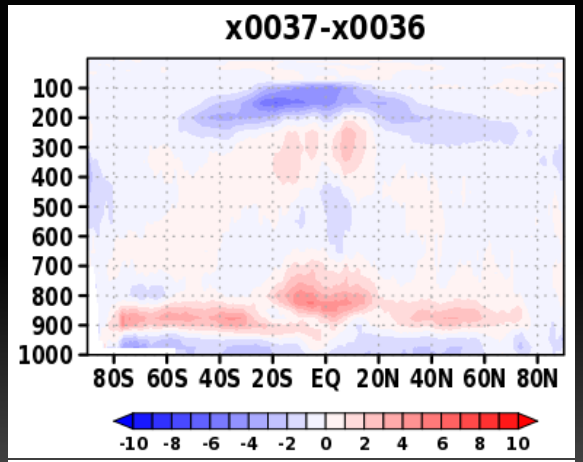
- Analysis
  - GMI all-sky radiance assimilation
  - IAU allows larger corrections
- GCM
  - RRTMG LW and improved cloud ice and liquid effective radii
  - NOAA Virtual Lab Dynamical Core v0 (FV3)

5.22

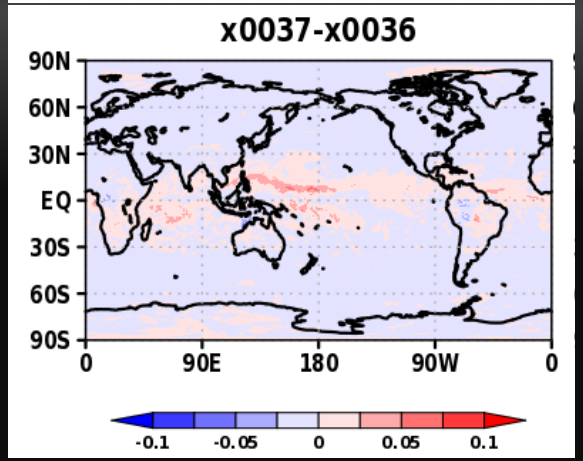
- Analysis
  - NOAA-20 CrIS and ATMS
  - SNPP OMPS ozone
  - **Inter-channel correlated obs errors** for AIRS and IASI
  - Retuned obs errors for polar AMVs
- GCM
  - Sponge layer, cube to lat lon updated – no significant diffs

Latest Experiment – X0037

- RRTMG shortwave
- Grell–Freitas deep convection
- UW shallow convection
- Turbulence retuned (consistent with new physics)
- Dycore updated to latest NOAA release
- Stochastically perturbed physics in EnKF
- X0038 – Adds updated Land Model
- X0039 – Adds new AO interface layer, with coupled model capability



RH
Dec 2017



RH
250 hPa

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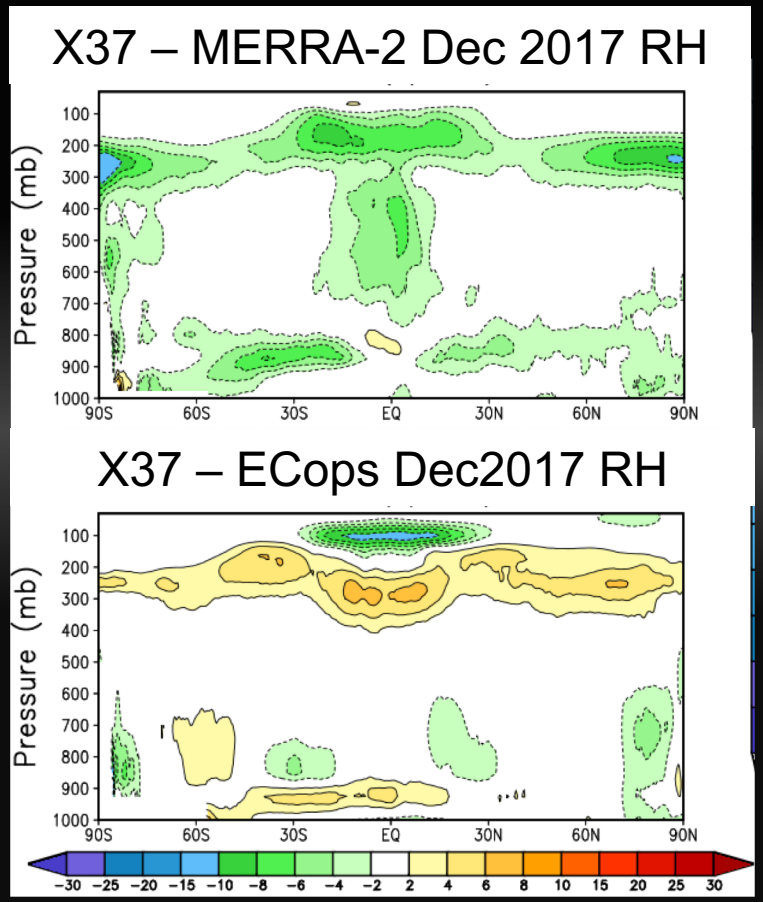
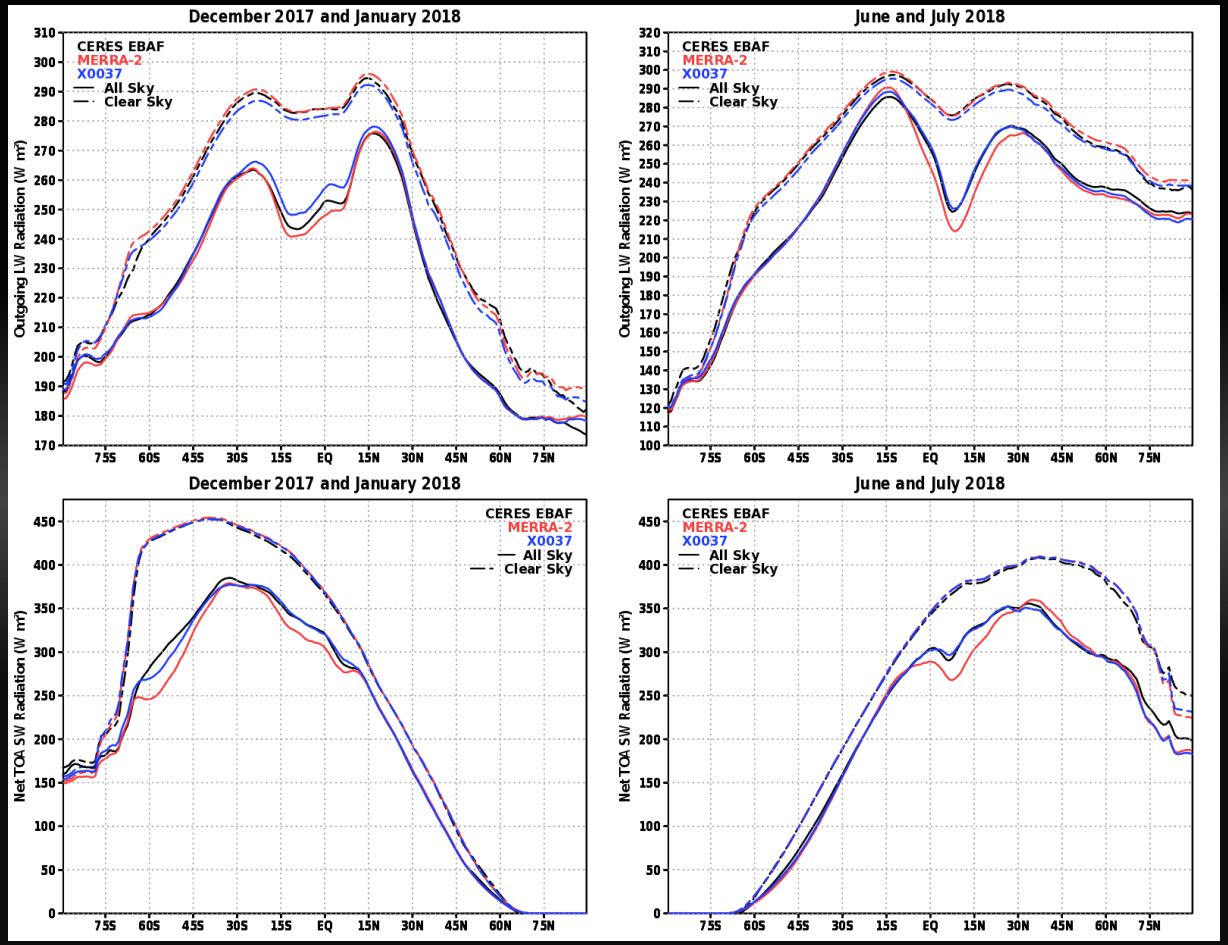
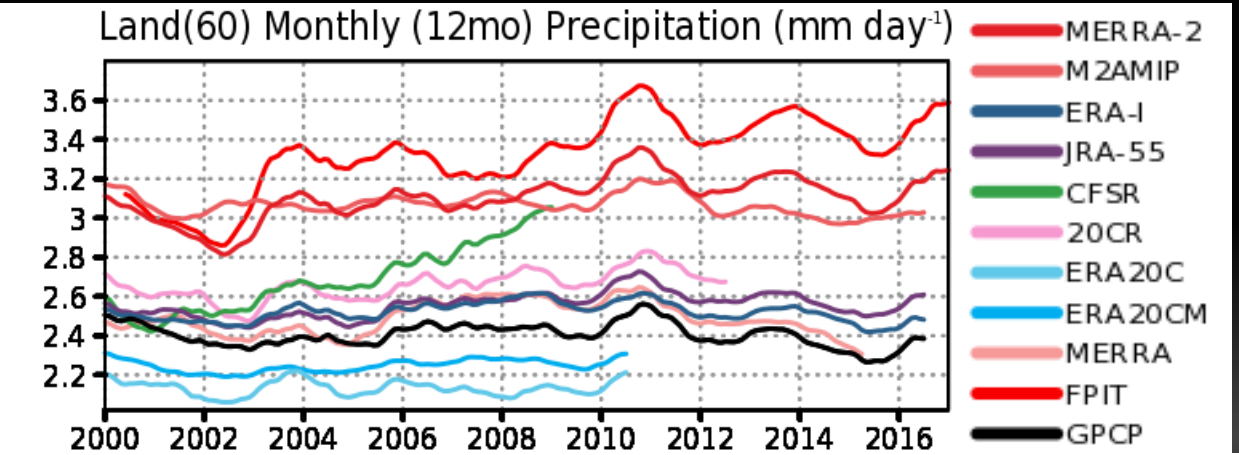


MERRA-2, X37 and CERES CLDREM

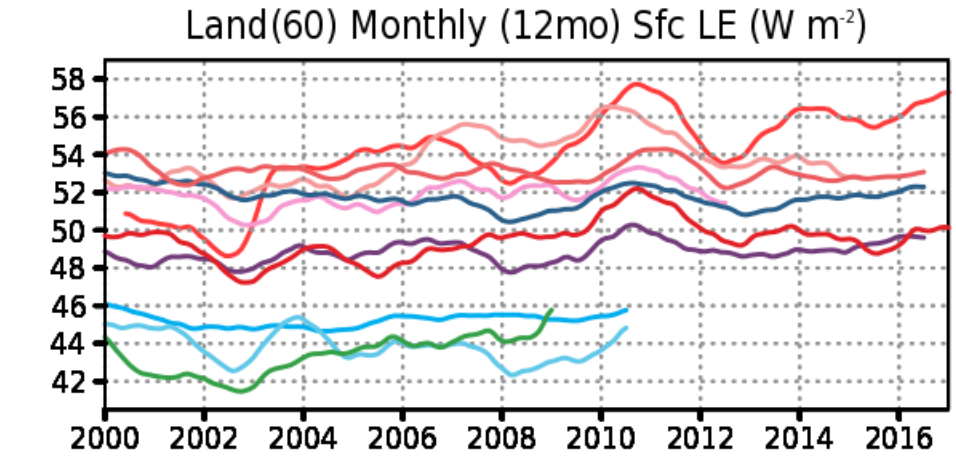
- X37
  - SW Clear generally comparable
  - LW Clear low biased
  - Winter All sky tropical high bias
- MERRA-2
  - Clear appear reasonable
  - All sky tropical biased

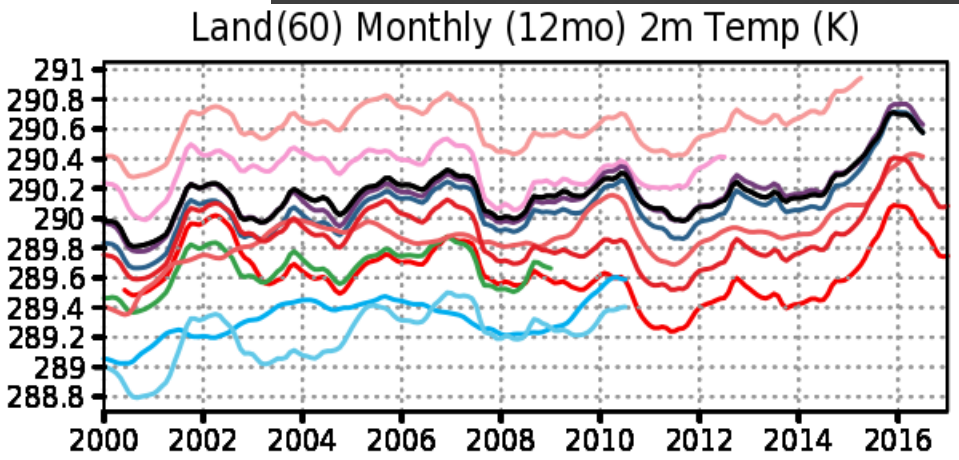


FPIT Biases

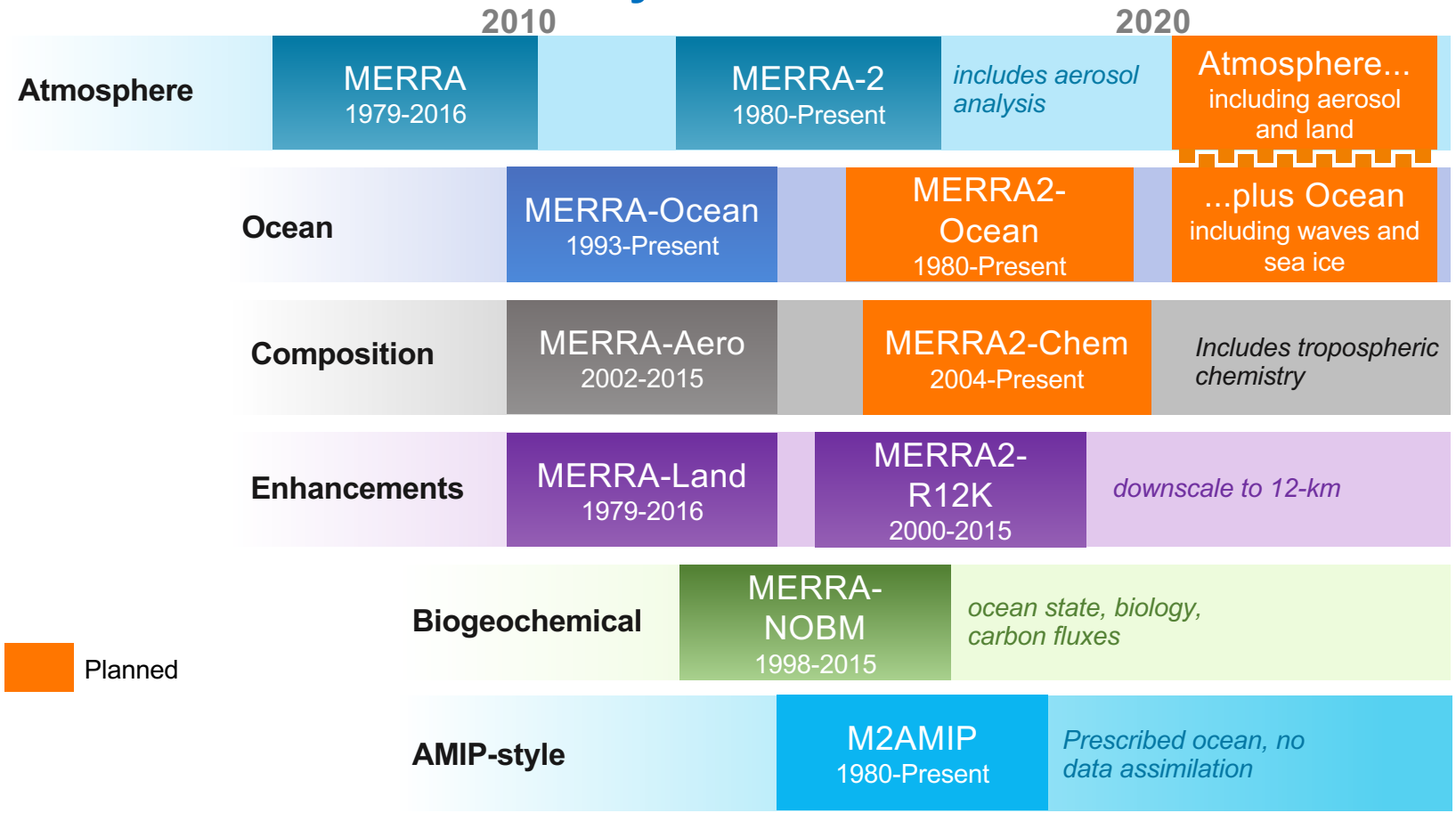


- MERRA Systems run cold with high Evap
- This is amplified in FPIT without precip corrections





GMAO Reanalyses and Derivative Products



GMAO coupled data assimilation development

GEOS ADAS
Hybrid 4D-EnVar
13-km L72
Aerosols
AO Skin SST

Jan 2017

GEOS ADAS
Updated LSM, Radiation, and Convection
All-sky Radiances
Other GSI Updates

July 2018

GEOS ADAS
AOGCM MOM5
Updated Microphysics
EnKF Perturbed Physics

July 2019

GEOS ADAS
AOGCM MOM6

Jan 2020

Jan 2021

Jan 2022

GEOS CDAS
A:H4DEnVar (JEDI)
O:H4DEnVar (JEDI)
L: EnKF (JEDI)

GEOS CDAS
A:H4DEnVar (GSI)
O:H4DEnVar (JEDI)

Jan 2020

S2S v4
MOM6 L72
O:H4DEnVar (JEDI)

MERRA-2 Ocean

July 2019

S2S v3
MOM5 0.25° L50
Catchment-CN
Salinity

Oct 2017

S2S v2
MOM5 0.5° L40
CICE4
UMD LETKF

Atmospheric DAS

Seasonal Prediction System

Atmosphere-Ocean-Land Coupled DAS

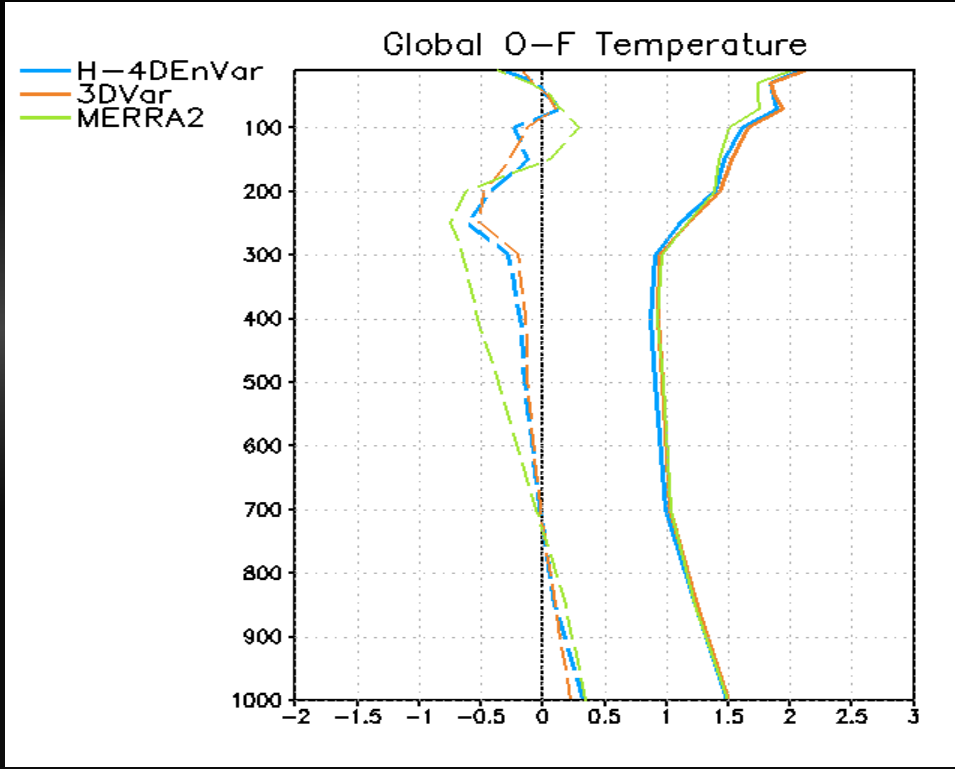
NWP, S2S Prediction, Reanalysis

Reanalysis Groundwork

- A small group at GMAO has been evaluating and prioritizing specific work needed for a new reanalysis (or FPIT)
  - Update History output
  - Update Corrected Precipitation
  - Test and update the error covariance matrix
  - Chemistry passive tracers
  - Testing period 2004-5 (interesting upper trop discontinuity in MERRA-2)
- Benchmark testing new system
- Sensitivity testing data assimilation configurations (e.g. hybrid ensemble, resolution)

Comparison of MERRA-2 3DVAR with more recent Hybrid Ensemble 4DVAR

- Testing various configurations of the data assimilation
  - DA is the largest computational burden in the reanalysis
  - Both 3d/4d var methods showing similar statistics and improvements over MERRA-2



New Instrument Team Support System: A Proposal

- **What best serves instrument team needs?**
- Physics – Land Surface, RRTMG, GF, UW etc
- Observing system requirements
- Resolution – Does the MERRA-2 resolution satisfy the goals of the instrument teams? C180/50Km
- Data Assimilation – 3DVar not 4DVar? (and including ensemble variance)
- Sensitivity Experiments - gauge Instrument team needs (e.g. 3D/4D, resolution)
- Timeframe – 1 year to produce the sensitivity experiments?

CERES-GMAO Evaluation Group

- Routine Telecons (~3 weeks)
- Relate status and updates on physics/model/analysis
- *Aiming to coordinate the next GMAO FPIT reanalysis with the next CERES reprocessing*
- Review GEOS FP versions in the ***Algorithm sensitivity*** (Seung-Hee) and detailed statistical comparisons (Xianglei Huang)
- Evaluate new FP-IT reanalysis sensitivity test, and eventually the next atmospheric reanalysis

Summary

- GMAO is working toward an integrated Earth system analysis capability to advance its activities in S2S, reanalysis and NWP
  - M2-Ocean begins processing in the Summer – **closed Earth energy**
- A reanalysis with coupled physical components of the atmosphere, ocean, land and cryosphere is **planned for 2022 (duration/period and exact system configuration TBD)**
- Given GMAO's focus on the use of NASA observations, ongoing research is aimed at the representation of aerosols, chemical, and biogeochemical
- Continue production of MERRA-2 (and FP-IT and 5.4), and MERRA-2-driven component reanalyses that serve as test environments for emerging capabilities
  - GEOS v5.4 survived a recent upgrade to new CPU and continues