Planning for GEOS-IT

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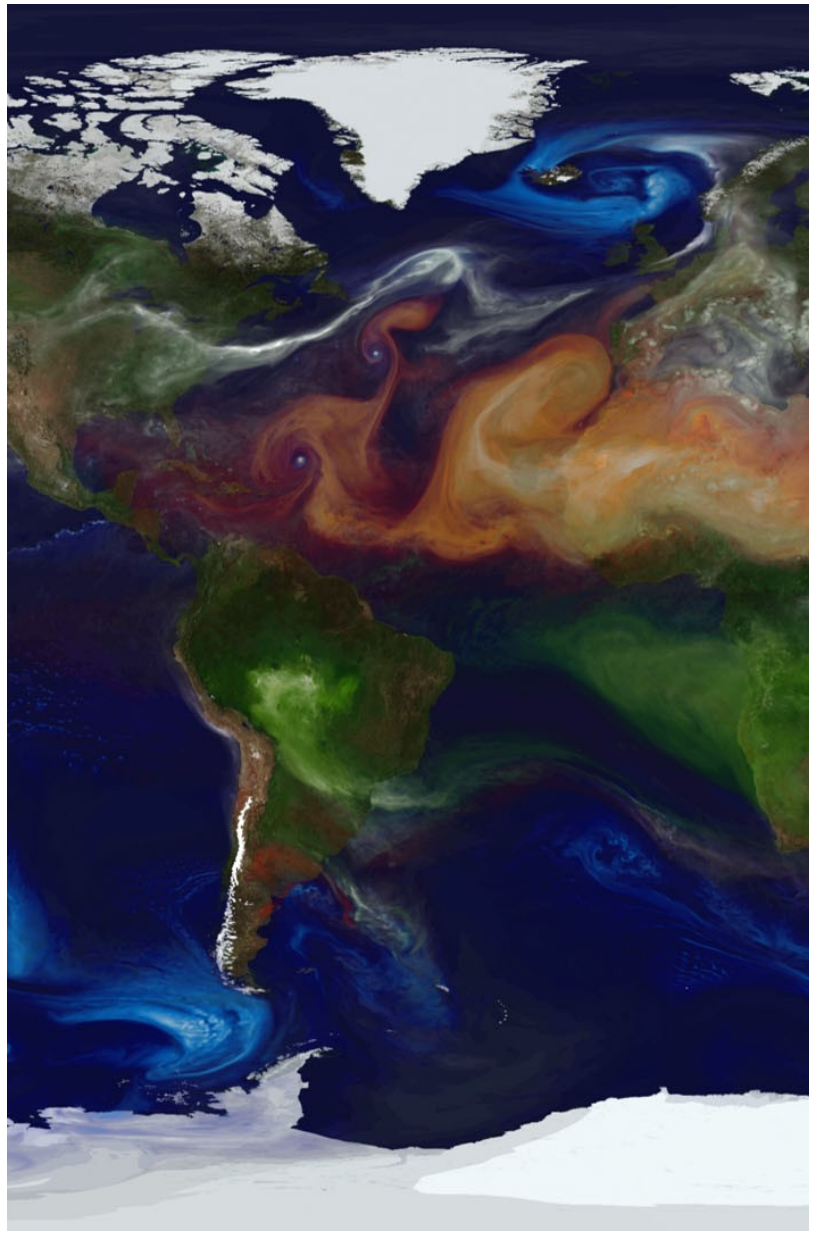
A presentation for discussion with the user community about an upgrade for GEOS-FPIT

July 16, 2020



Plan for the Meeting

Overview of GMAO's main GEOS systems and upgrade strategies

Technical details of GEOS-IT, the upgrade of GEOS-FPIT/RPIT

Logistical details: product generation and timelines

Data distribution: presentation by the DAAC

Input from representatives of each Instrument Team

Discussion

Summary of Major GMAO Products

GMAO's current products that are documented both technically and through robust file specifications, well validated, and released to the broad community for research and applications

System	Focus	Customers/Applications
GEOS-FP "weather prediction"	Impacts of NASA observations on NWP: forefront resolution and complexity	NASA Field Missions (weather, aerosols) Multiple Agencies: NOAA/FAA; NOAA field stations; NRL
GEOS-CF "air quality"	Pioneering global system for atmospheric composition using multiple NASA assets	Health/Air Quality studies (via NASA Applied Sciences) Multiple agencies: NIH, Army, NOAA
GEOS-S2S "seasonal prediction"	Ensembles of coupled Earth System predictions, emphasizing NASA observations	National ensembles (NMME, SubX), drought/sea-ice prediction Multiple Agencies and international linkages
MERRA-2 "reanalysis"	Stable product for climate studies, emphasizing NASA data	Only current national reanalysis: USGCRP/NCA applications Interagency use: DoE, DoT, NOAA, …
GEOS-FPIT "mission support"	Stable, well validated, low-latency product for use by NASA instrument teams	More than 20 NASA Instrument Teams
GEOS-Nature Run "mission planning"	Complex Earth System simulations at fine resolution with obs. simulators	Planning for new space-based missions NOAA and broad community; DoE/Smithsonian; NSF

Proposed Transition from GEOS-FPIT to GEOS-IT

Commitment to NASA's Earth Science Mission means GMAO wants to provide the best-possible products

GEOS-FPIT uses a ~2015-era version of the GEOS model and assimilation system

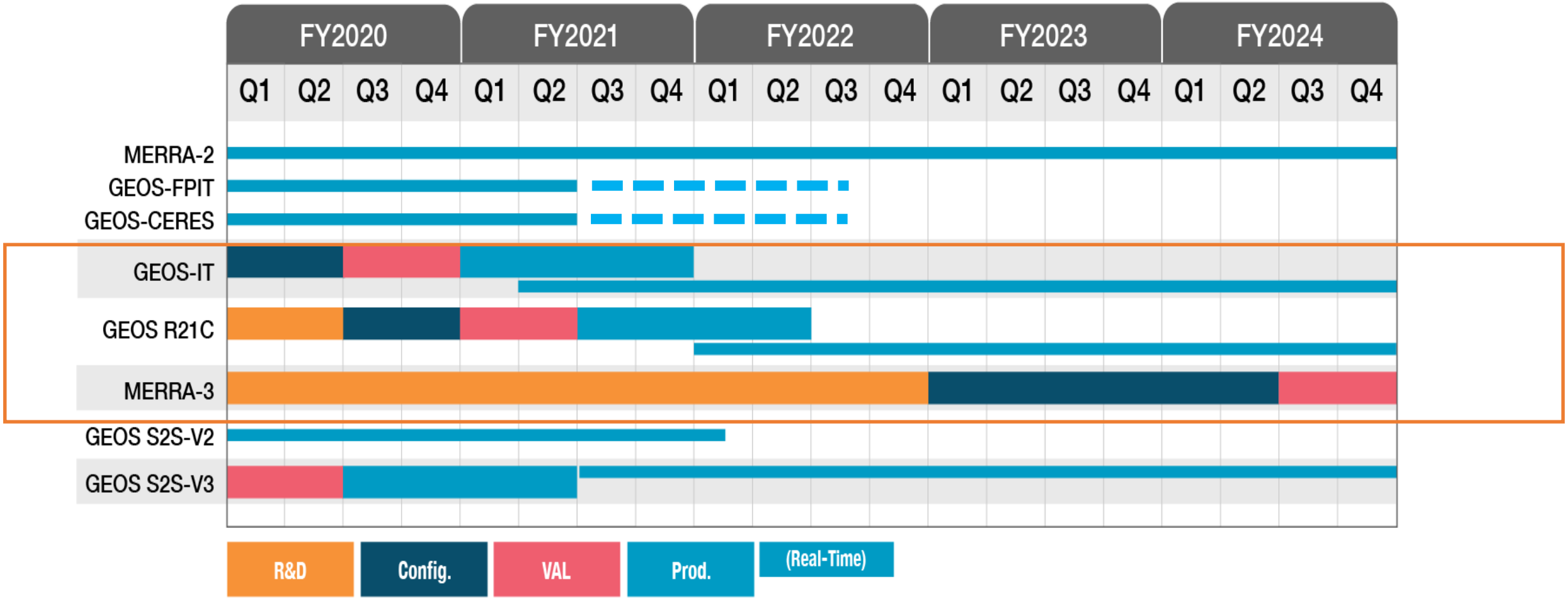
- model enhancements lead to more realistic moisture, temperature, land surface, … analyses
- older models become hard to maintain in modern computing environments
- new observations typically cannot be assimilated in older systems
- opportunity to use reprocessed versions of older operational observations (e.g., AMSU)

Planning to retain the 50-km resolution of GEOS-FPIT (time-to-completion and data volumes)

Continue use of the "3DVar" assimilation technique (HPC cost and data volumes)

Continue the "subscription only" access via the GES-DISC

Timeline of GMAO Projects



~2015

GEOS-FP

Atmosphere

50km,L72

3D-Var

Near-real time NWP

MERRA-2

Atmosphere

50km,L72

3DVar

1980-onwards

GEOS-FPIT

Atmosphere

50km,L72

3DVar

EOS-period

~2020

GEOS-FP

Atmosphere

12.5km,L72

Hybrid 4DEnVar

Near-real time NWP

GEOS-IT

Atmosphere

50km,L72

3DVar

EOS to post-EOS period

Based on current GEOS-FP

GEOS-R21C

Atmosphere

25km,L72

Hybrid 4DEnVar

EOS to post-EOS period

~2025

GEOS-FP

MERRA-3

Coupled Atmosphere-Ocean

Higher vertical resolution

JEDI-based DA

Multi-decade

FPIT (GEOS-5.12.4)

GEOS-5.13.0

GEOS-5.13.1

GEOS-5.16.5

GEOS-5.17.0

GEOS-5.21.0

GEOS-5.22.0

FP (GEOS-5.25.1)

Capability to process additional input observation types, such as METOP-B AMSUA, METOP-B IASI, METOP-B MHS, CRIS, SSMIS, and GOES sounder.

Hybrid 3D-Var data assimilation.
Enhancement to the forecast model **parameterization of surface drag**

Hybrid 4D-EnVar DA.
Increase spatial **resolution to 12.5km**.

Updated topography data set;
Retuning of the gravity-wave drag and turbulence parameterizations. Changes to the moist physics to improve the representation of intense precipitation events.

FPIT (GEOS-5.12.4)

GEOS-5.13.0

GEOS-5.13.1

GEOS-5.16.5

GEOS-5.17.0

GEOS-5.21.0

GEOS-5.22.0

FP (GEOS-5.25.1)

Change to model physics (RRTMG longwave radiation + improved representation of cloud ice and liquid effective radii). Dynamical core update. **All sky assimilation** of GPM GMI radiances. **Updated variational bias-correction scheme.** Update to 4DIAU.

Assimilation of radiances from **Cris and ATMS from NOAA-20**. Addition of **total column ozone measurements from the OMPS nadir mapper instrument**. NEXRAD velocity-azimuth display (VAD) winds disabled. Retuned Observation errors for all polar AMVs from MODIS and AVHRR. Update added to account for inter-channel correlations in the specification of the observation error matrix for AIRS and IASI hyper-spectral IR radiances.

FPIT (GEOS-5.12.4)

GEOS-5.13.0

GEOS-5.13.1

GEOS-5.16.5

GEOS-5.17.0

GEOS-5.21.0

GEOS-5.22.0

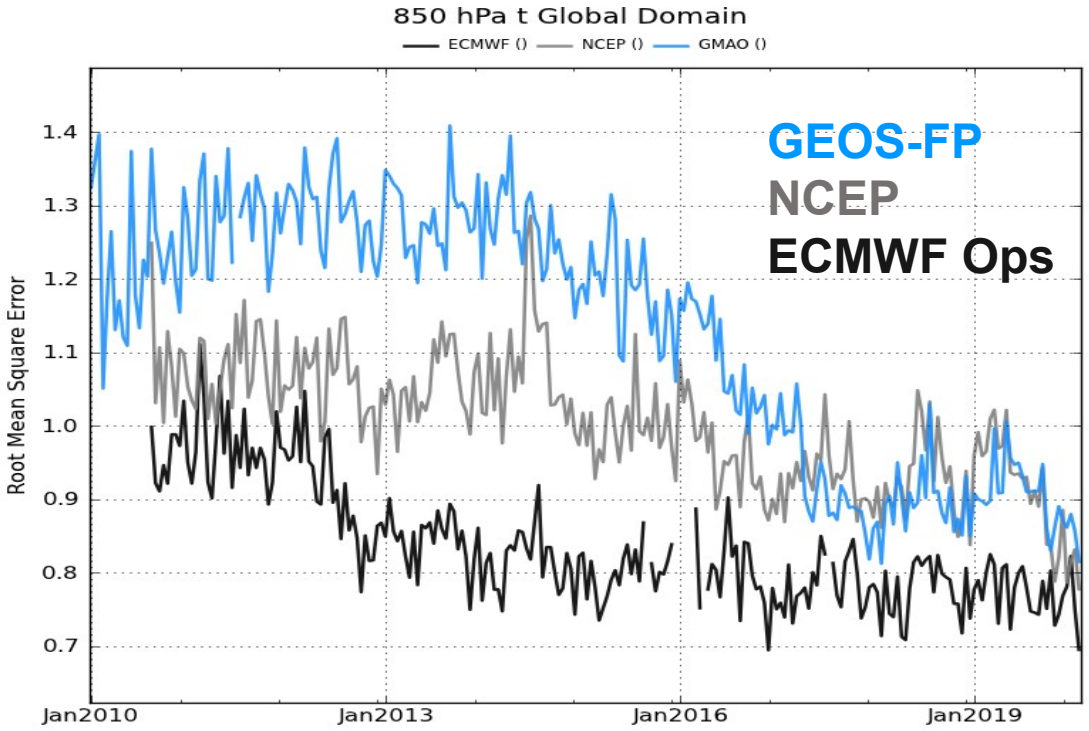
FP (GEOS-5.25.1)

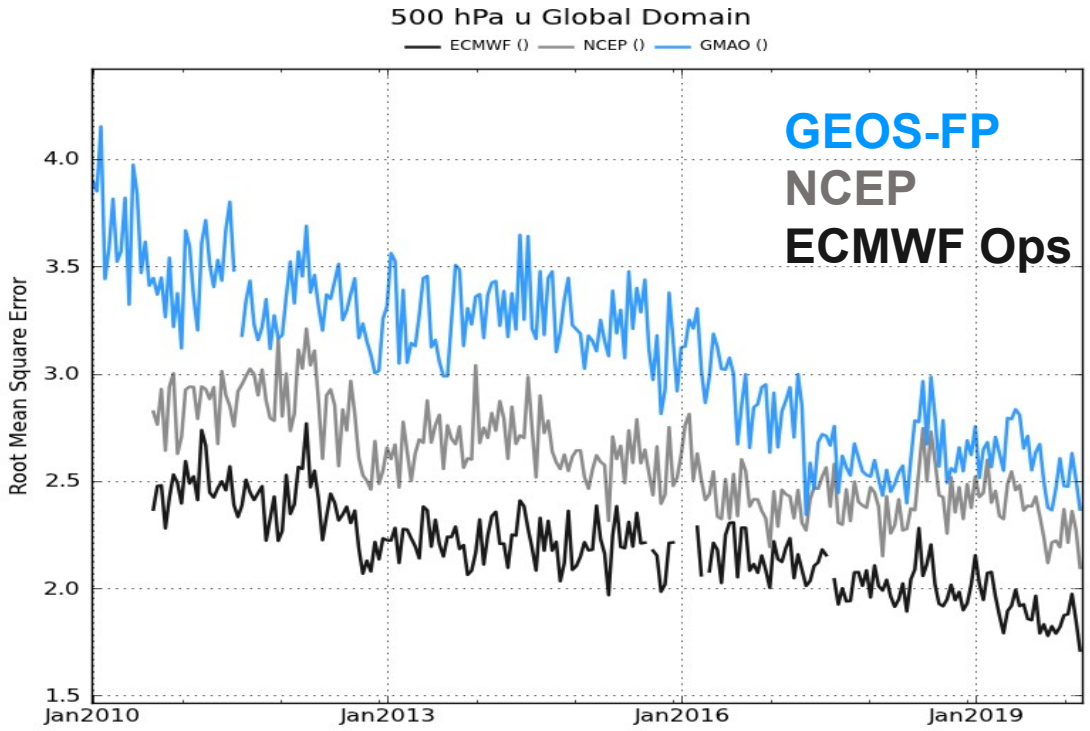
Deep convective parameterization (RAS) replaced with a combination of the **Grell-Freitas scale-aware deep and congestus parameterization** combined with the Park and Bretherton shallow convection scheme.

New **RRTMG shortwave radiation scheme**. Update to cloud liquid and ice radiative properties in the single-moment microphysics.

Catchment land model now includes **updated hydrology features** making GEOS systems consistent with operational GMAO production of SMAP Level 4 soil moisture products. This includes extensive updates of model BC (soil textures, vegetation phenology) and **improved physical treatments of soil moisture diffusion and surface thermodynamics**.

Impact on forecast skill





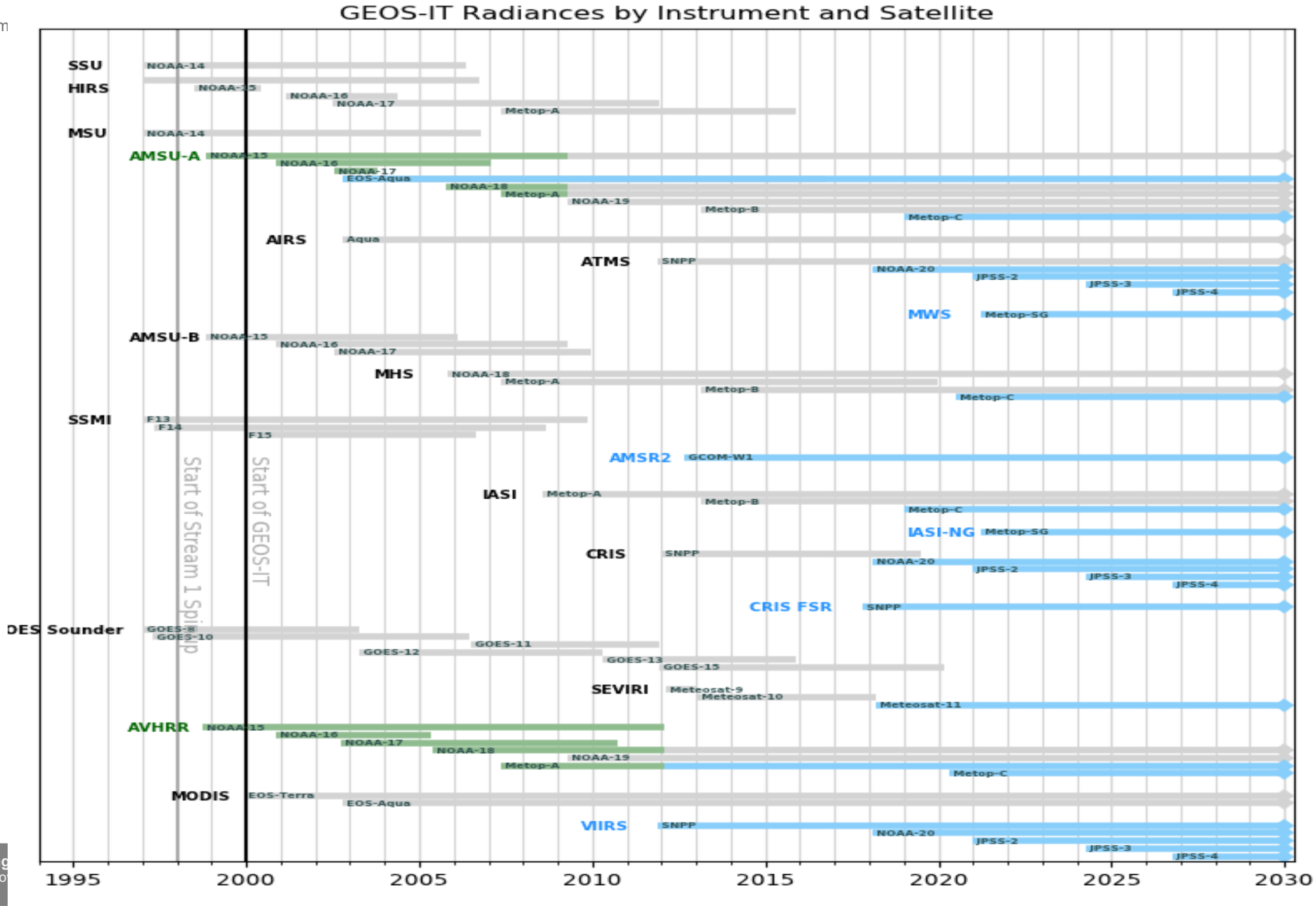
Time series of 48h forecast rms error for 850hPa temperature and 500hPa zonal wind

Observing system

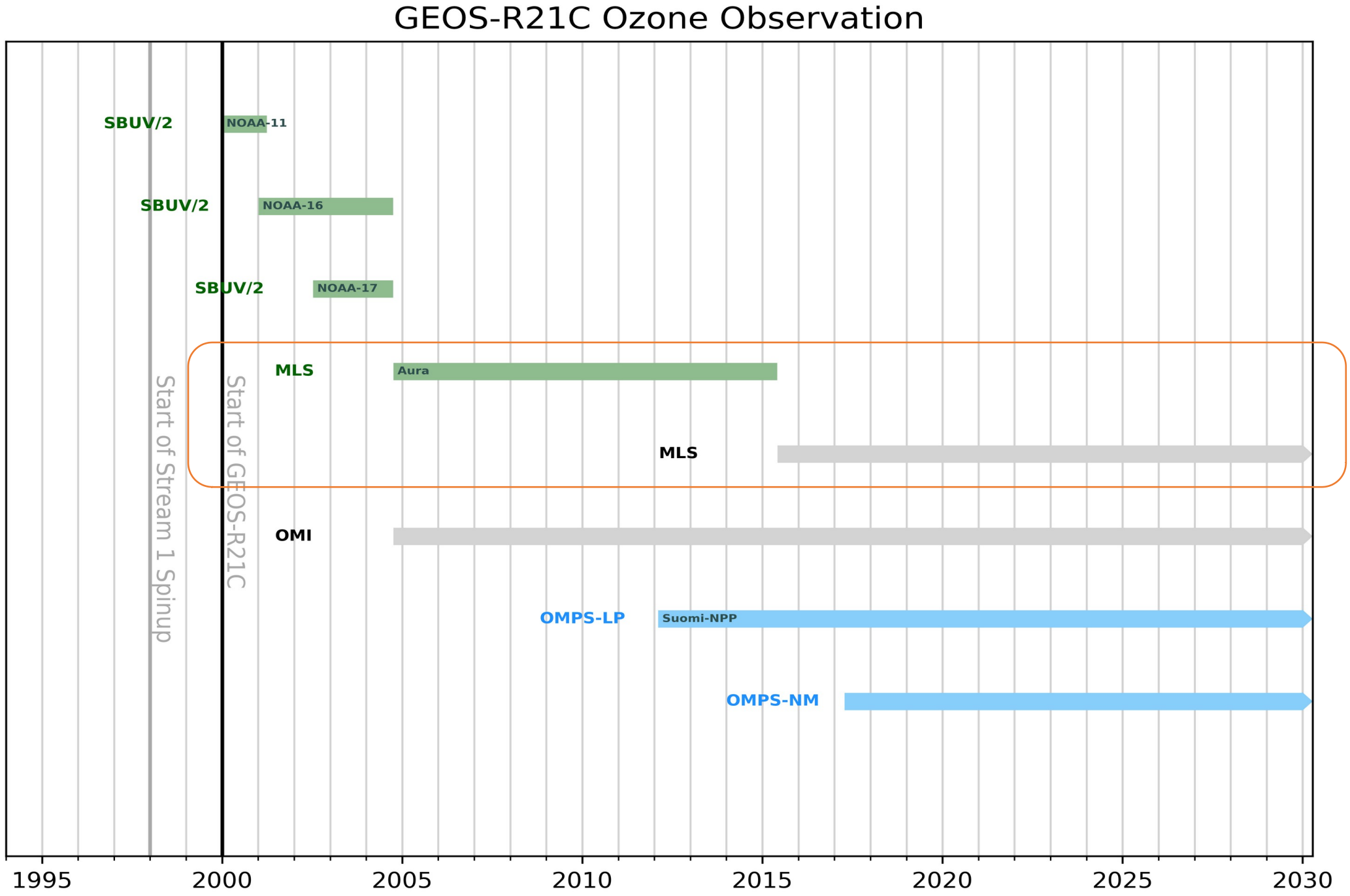
Reprocessed

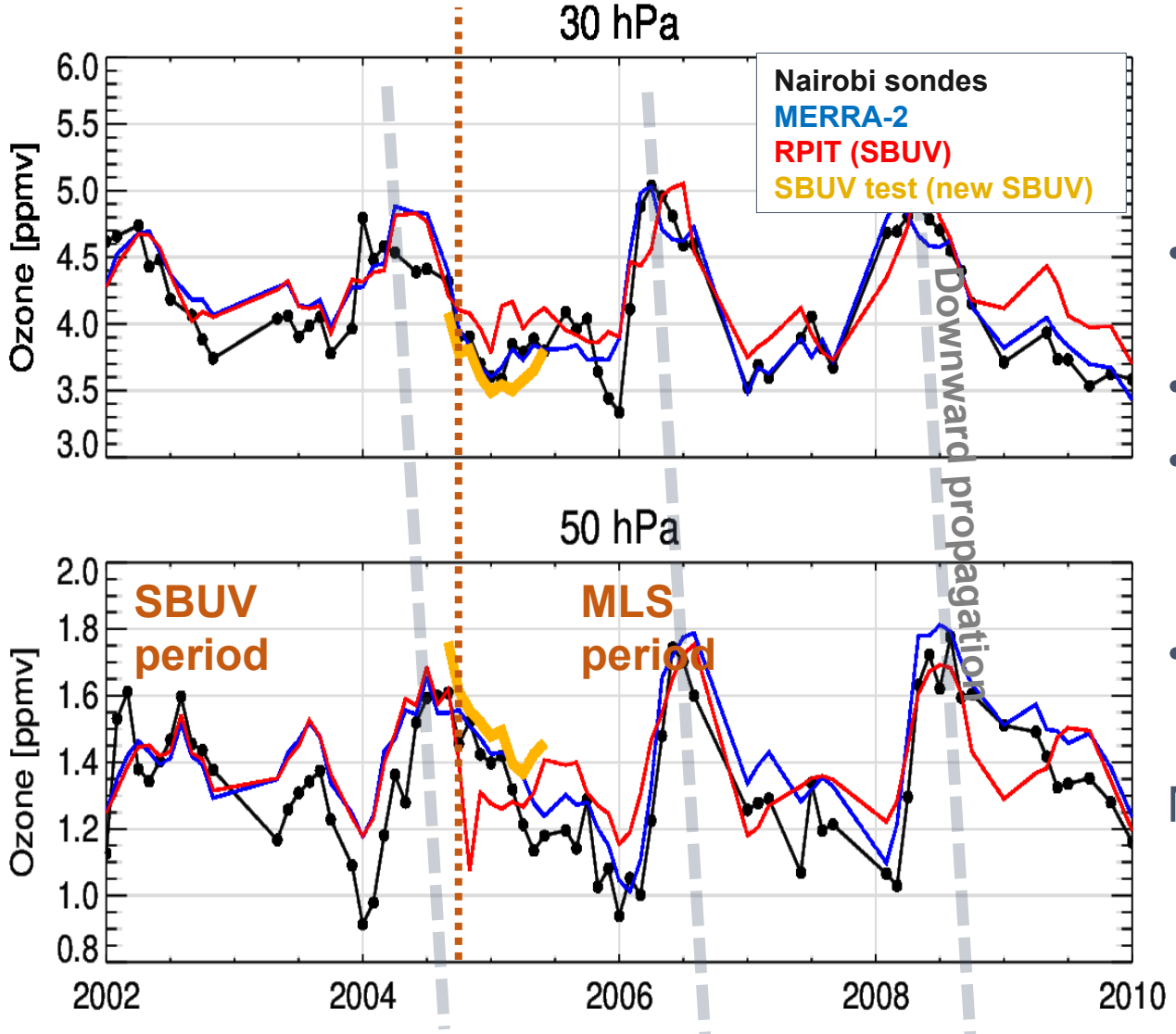
Used in FPIT

NEW



Ozone data


GEOS-R21C Ozone Observation
SBUV/2
NOAA-11
SBUV/2
NOAA-16
SBUV/2
NOAA-17
MLS
Aura
MLS
OMI
OMPS-LP
Suomi-NPP
OMPS-NM
Start of Stream 1 Spinup
Start of GEOS-R21C
1995
2000
2005
2010
2015
2020
2025
2030



Monthly averaged data from ozonesondes and three analyses at Nairobi

- New version of SBUV ozone data: dynamical priors account for the QBO
- Observation errors retuned
- Test analysis in better agreement with ozonesondes and MERRA-2 than RPIT ("old" version of SBUV data)
- Improvements of SBUV analysis:

MERRA (previous slide) ▭ RPIT ▭ new SBUV test

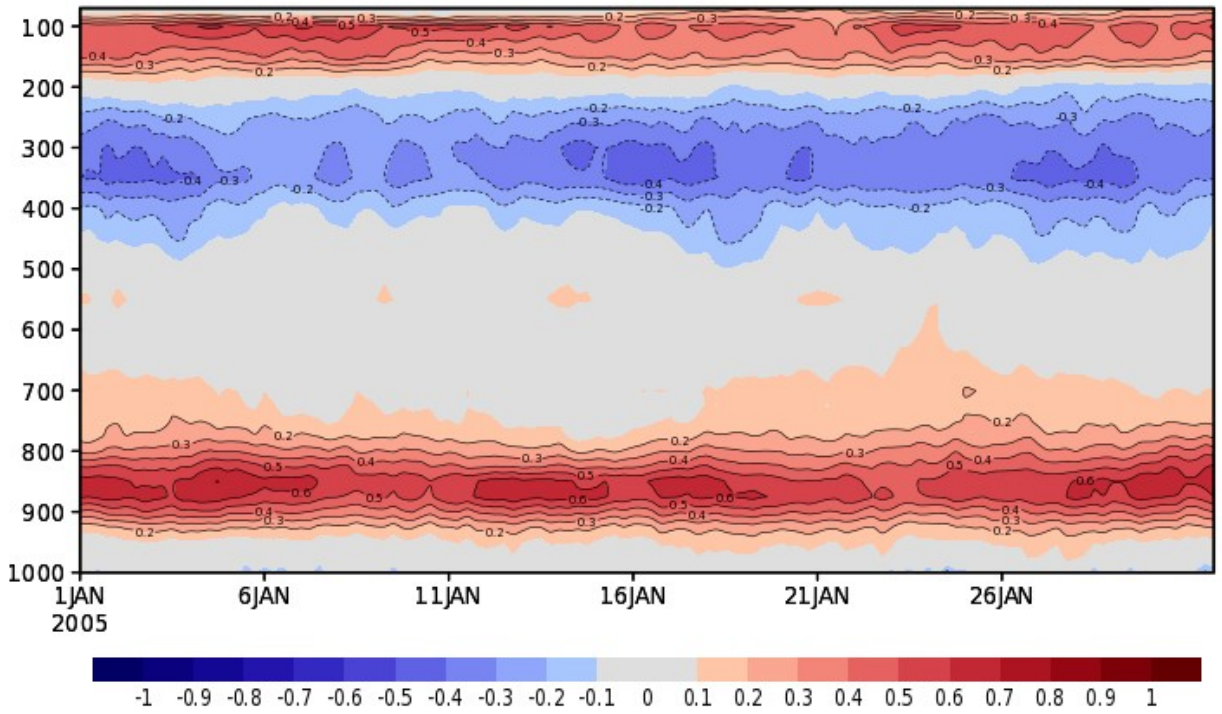
Preliminary evaluation of T and Q: "candidate" GEOS-IT system compared with current GEOS-FPIT system

Candidate system = 3dVar test with new SBUV/2 and no MLS

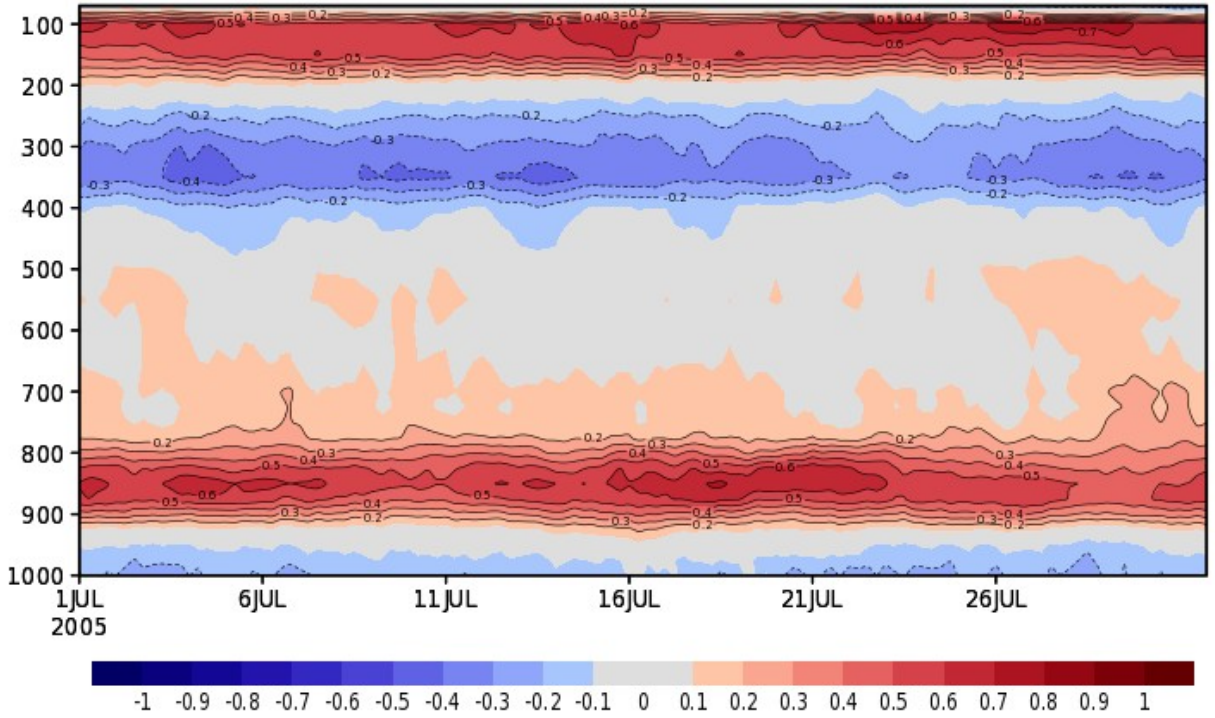
Current system = d5124_rpit_jan12 (GEOS-FPIT)

There are substantial differences in the global (60N,S) temperature between the candidate-IT and the current GEOS-FPIT systems

Candidate minus current FP-IT TEMP; January 2005

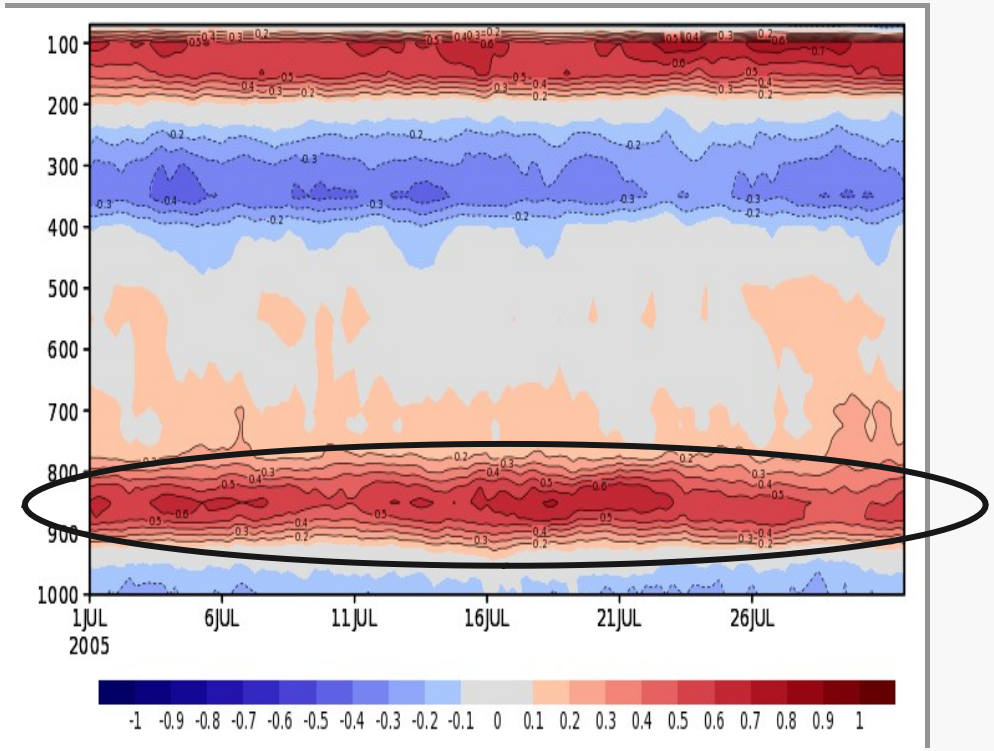


Candidate minus current FP-IT TEMP; July 2005

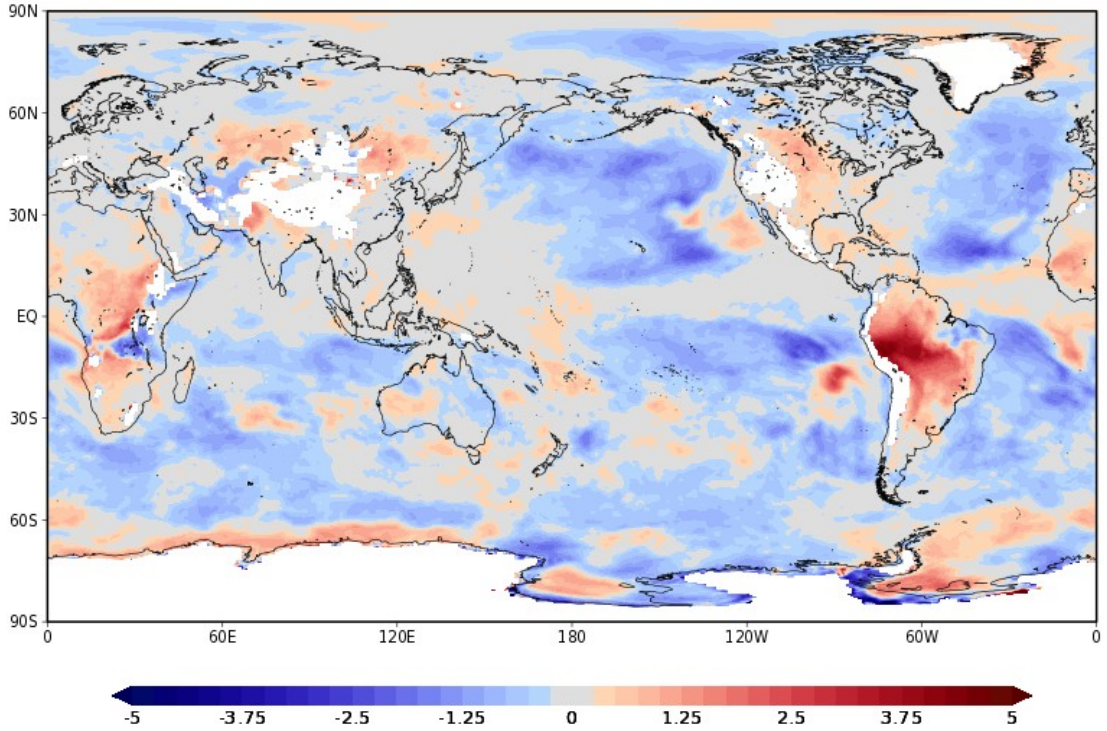


How do these differences compare with ERA-5 Reanalysis temperatures?

Test minus current FP-IT TEMP; July 2005

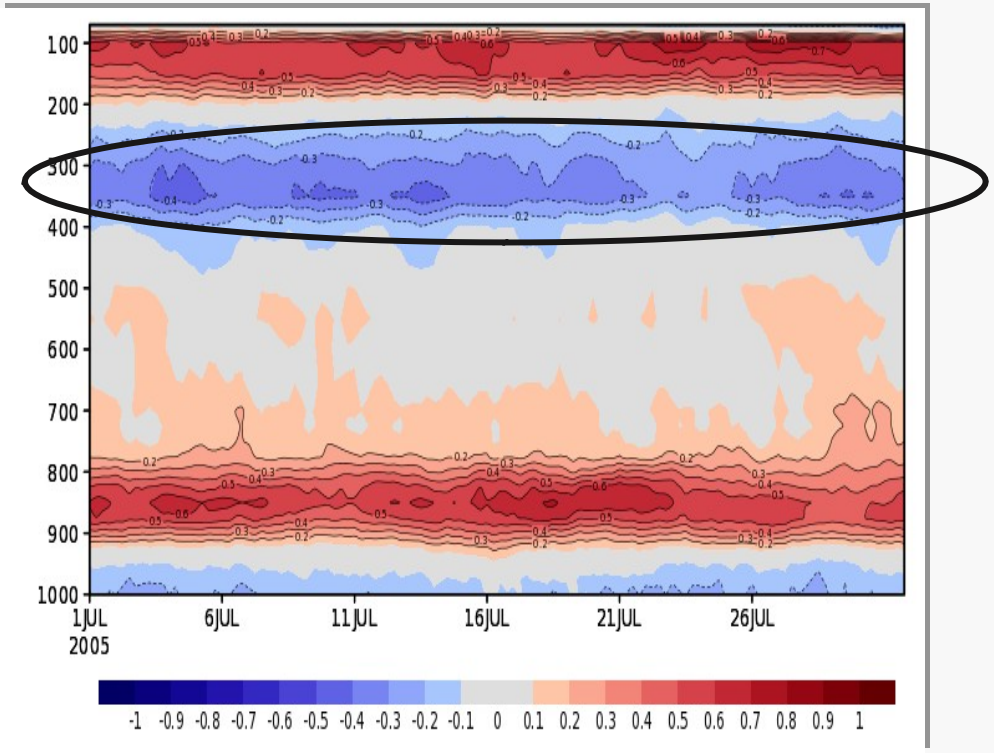


850T Closeness to ERA5
Blue = Candidate, Red = Current

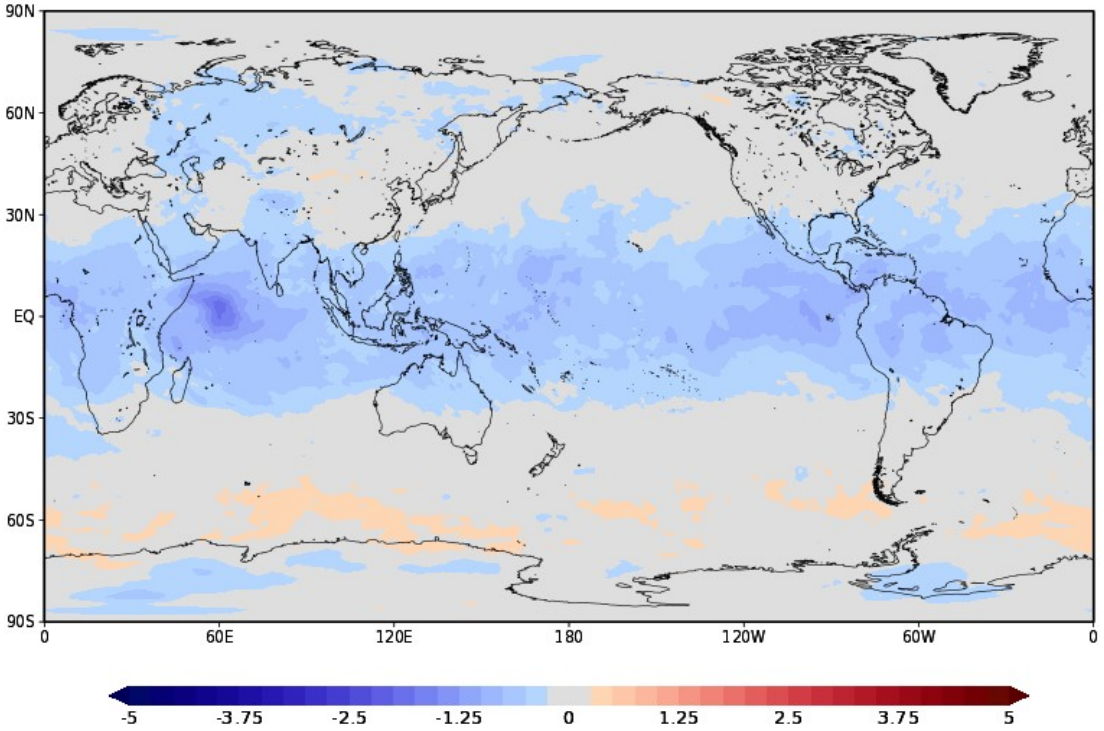


Substantial improvement over most ocean surface, and some degradation over land (especially over South America)

Test minus current FP-IT TEMP; July 2005

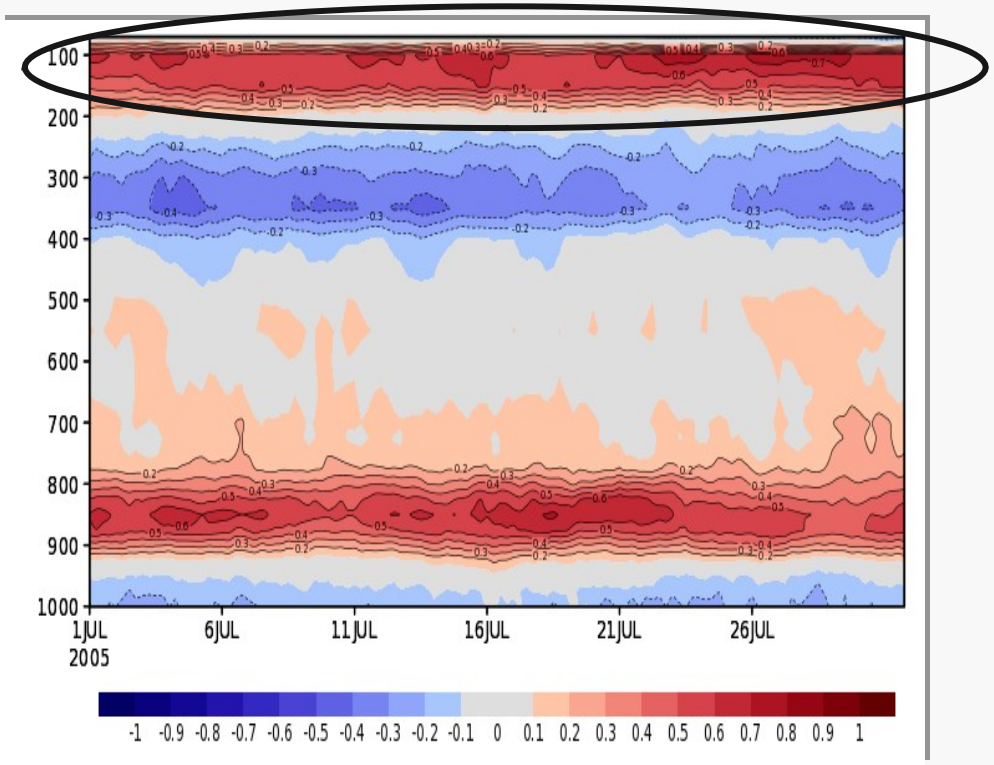


300T Closeness to ERA5
Blue = Candidate, Red = Current

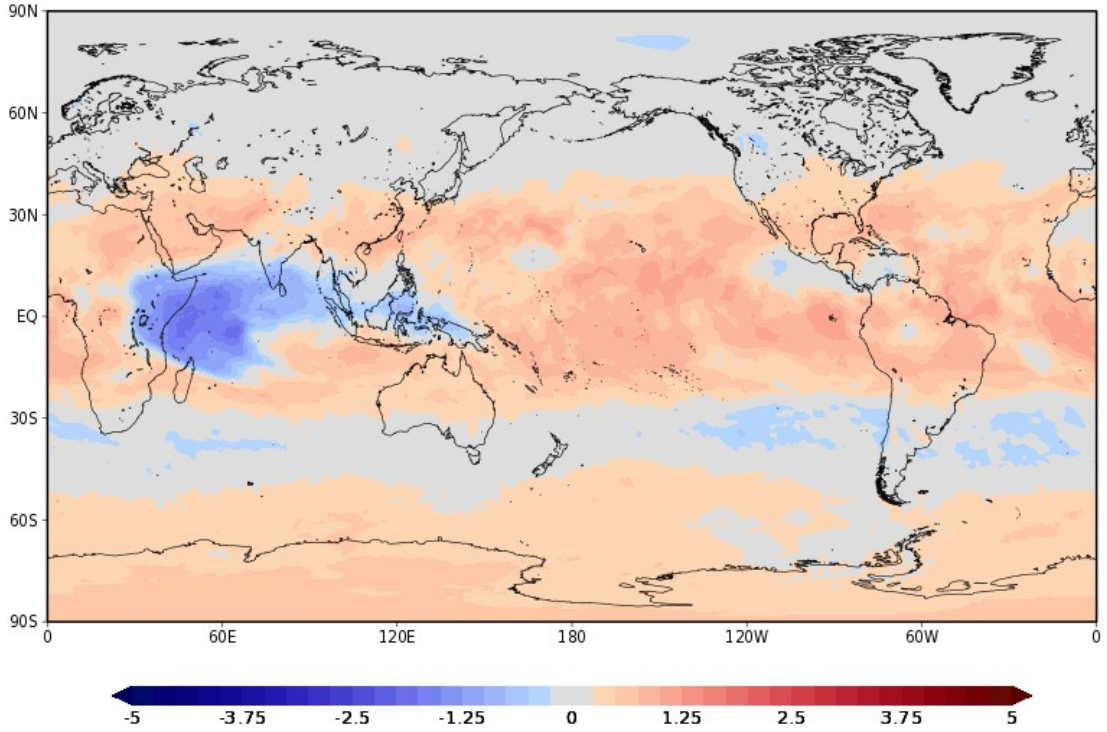


Near-universal substantial improvement (except for a sliver of degradation along 60S)

Test minus current FP-IT TEMP; July 2005



150T Closeness to ERA5
Blue = Candidate, Red = Current



Candidate system is warmer and further away from ERA-5. But compared with NCEP (not shown) the warmer 150mb temperatures in the candidate system are closer in candidate than in the current FP-IT

Summary

Proposed GEOS-IT:

- Based on a recent GEOS-FP system (GEOS-5.25)
- Retain the 50km horizontal resolution used in present GEOS-FPIT
- Use a 3D-Var configuration for the assimilation
- Updated observing system compared to GEOS-FPIT:
  - reprocessed input data: AMSU-A , SBUV/2, AVHRR…
  - new input data: Metop-C, NOAA-20, JPSS, including OMPS-NM and OMPS-NP
- Not using all-sky radiances (microwave), GMI/TMI, or limb ozone (MLS, OMPS-LP)


NASA

GEOS-IT Data Collections

- GEOS-FPIT file specification includes 30 collections plus the constant collection. Daily size is ~22 GB. Data resolution is not changing.
- No change to the NetCDF-4 file format, except perhaps some metadata adjustment.
- Filenames will change, but probably only the 2nd and 5th nodes: GEOS.fpit.asm.inst3_3d_asm_Np.GEOS5124.20101201_0000.V01.nc4
- An updated file specification document will be released and posted on the GMAO products web page: https://gmao.gsfc.nasa.gov/GMAO_products/
- Consideration will be given to dropping collections that are not being used.

GEOS-IT Data Collections

Table 6-1 - List of standard collections

Name	Description	Approx. Daily Size (MB)
const_2d_asm_Nx	Constant fields	
inst3_3d_asm_Nv	Basic assimilated fields from IAU corrector	1,800
inst3_3d_asm_Np	Basic assimilated fields from IAU corrector	974
inst3_2d_asm_Nx	Miscellaneous 2D assimilated fields from IAU corrector	57
tavg3_3d_asm_Nv	Basic assimilated fields from IAU corrector	1,700
tavg3_3d_cld_Nv	Upper-air cloud related diagnostics	596
tavg3_3d_mst_Nv	Upper-air diagnostics from moist processes	207
tavg3_3d_mst_Ne	Upper-air diagnostics from moist processes at layer edges	186
tavg3_3d_trb_Ne	Upper-air diagnostics from turbulence at layer edges	1,300
tavg3_3d_rad_Nv	Upper-air diagnostics from radiation	657
tavg3_3d_tdt_Nv	Upper-air temperature tendencies by process	1,600
tavg3_3d_udt_Nv	Upper-air wind tendencies by process	2,100
tavg3_3d_qdt_Nv	Upper-air humidity tendencies by process	1,100
tavg3_3d_odt_Nv	Upper-air ozone tendencies by process	774
tavg3_3d_lsf_Nv	Upper-air large-scale flux	454
tavg3_3d_lsf_Ne	Upper-air large-scale flux at layer edges	297
tavg1_2d_slv_Nx	Single-level atmospheric state variables	320
tavg1_2d_flx_Nx	Surface fluxes and related quantities	285
tavg1_2d_rad_Nx	Surface and TOA radiative fluxes	183
tavg1_2d_lnd_Nx	Land related surface quantities	218
tavg1_2d_lfo_Nx	2D time-averaged land surface forcings	65
inst1_2d_lfo_Nx	2D instantaneous land surface forcings	65
tavg1_2d_ocn_Nx	Ocean related surface quantities	100
tavg3_2d_aer_Nx	2D time-averaged aerosol diagnostics	137
tavg3_2d_adg_Nx	2D time-averaged aerosol diagnostics (extended)	187
tavg3_2d_chm_Nx	2D time-averaged chemistry diagnostics	14
inst3_3d_aer_Nv	3D instantaneous aerosol diagnostics	3,100
tavg3_3d_aer_Nv	3D time-averaged aerosol diagnostics	3,100
inst3_3d_chm_Nv	3D instantaneous chemistry diagnostics	441
tavg3_3d_nav_Ne	3D time-averaged navigation files (layer edges)	148
tavg3_3d_nav_Nv	3D time-averaged navigation files	147

Estimated total 22.6 GB

GEOS-IT Production and Delivery

- Products are delivered to end users by GES DISC.
- These are assimilation products only. No forecast products for GEOS-IT.
- In NRT mode, products generated 4X/day: 00 UTC (21-03); 06 UTC (03-09); 12 UTC (9-15); 18 UTC (15-21)
- Delivery latency (to GES DISC): typically 1-16 hours after completion. Longer delays are possible.
- Production will run with 3 parallel streams with starting dates TBD. The last stream will start in mid-2018. Estimate of production start is 2021 Q1.
- Delivery of products to the GES DISC should begin in 2021 Q2.
- At least 6 months of near real-time overlap before GEOS-FPIT stops production at the end of 2021.

GEOS-IT: Questions and Discussion

- MLS
- OMPS LP
- CERES Flash Flux
- CERES
- Ocean Color
- AMSR
- GPROF
- CESM/WACCM @ NCAR
- MODIS Deep Blue
- OMI
- TES
- GEDI
- OCO-2/3
- USGS Landsat
- GEOCARB
- CALIPSO
- MPLNET
- DSCOVER-EPIC
- TCCON