Status and plans for reanalysis at NASA/GMAO

Ron Gelaro
on behalf of the GMAO

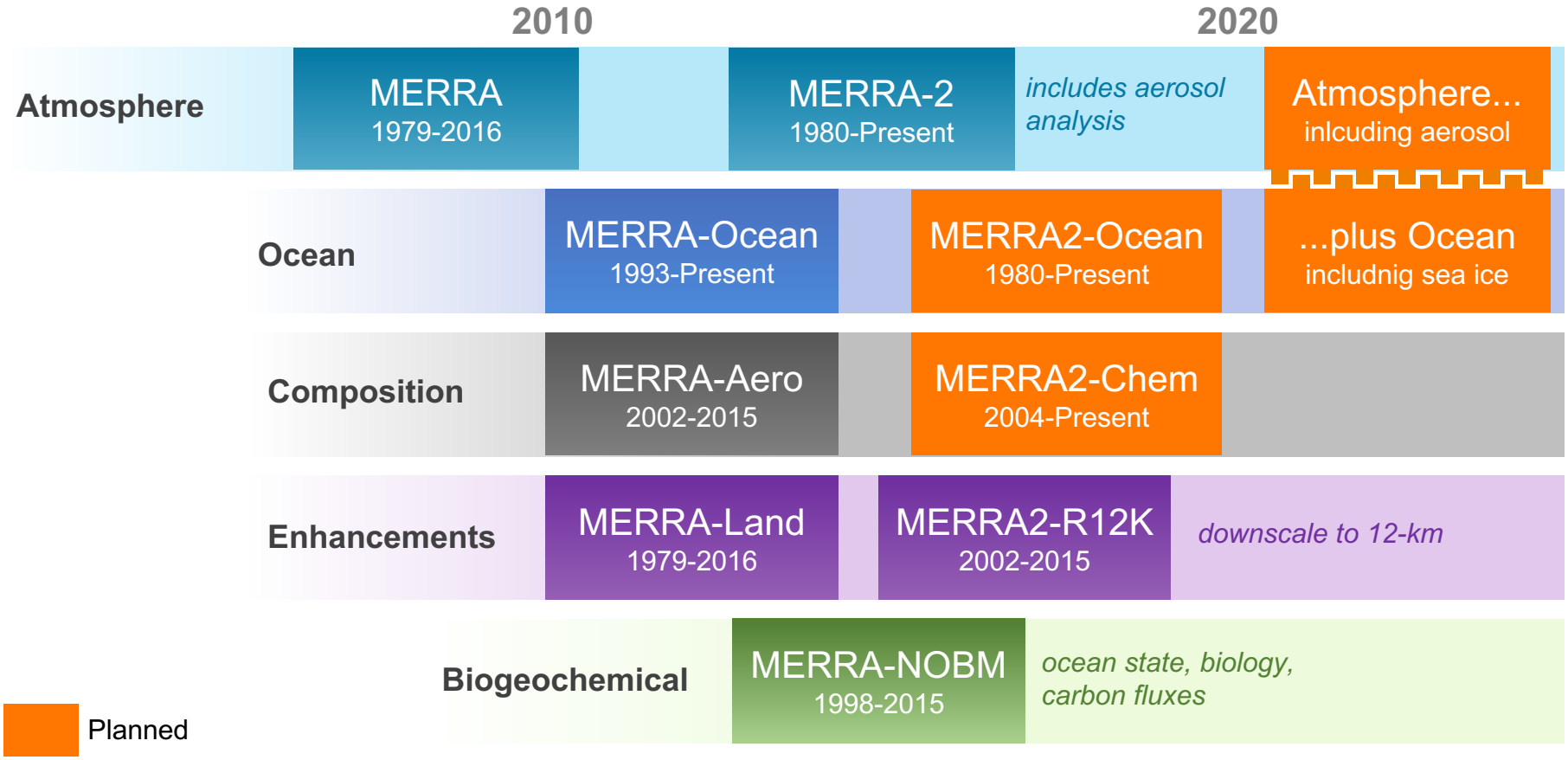
5th International Conference on Reanalysis (ICR5), Rome, Italy, 13 – 17 November 2017

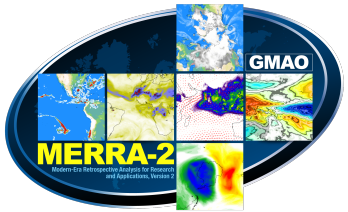
Toward an Earth system (re)analysis capability

- GMAO is active in extending its GEOS system to encompass many aspects of the Earth system
- Progress incrementally through a combination of systems with increased levels of coupling, plus offline component reanalyses
- GMAO's work links strongly to NASA's Earth observations
  - Use of GEOS products by instrument teams
  - Ingest of NASA data to demonstrate their value in Earth system analyses
  - Planning for new NASA missions

This talk focuses on a few examples that illustrate current capabilities and are steps on the pathway to future growth

GMAO reanalyses and derivative products





Some aspects of MERRA-2

- GMAO's most recent atmospheric reanalysis of the modern satellite era
- Advances over its predecessor, MERRA (terminated 29 Feb 2016)
  - Many more observations
  - Model and analysis updates
- **Focus on non-meteorological aspects as a pathway to a more complete Earth system reanalysis**
  - Aerosol data assimilation
  - Representation of cryospheric processes
  - Use of NASA observations in the stratosphere, especially ozone
- Well documented, including a special collection in *J. Climate*

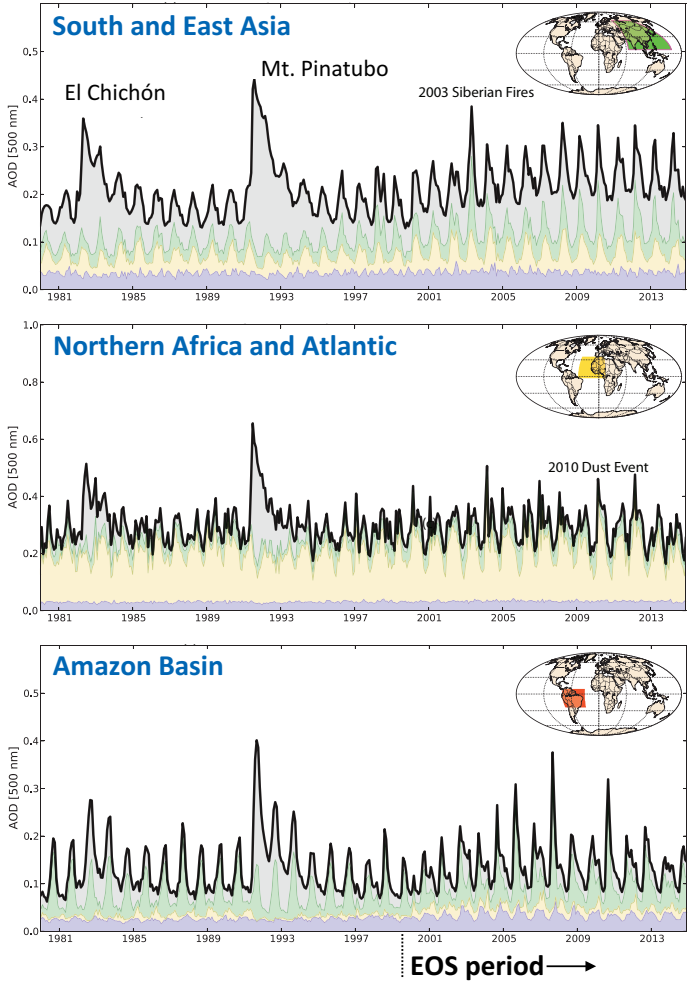
Several oral and poster presentations at this conference

MERRA-2 aerosol analysis

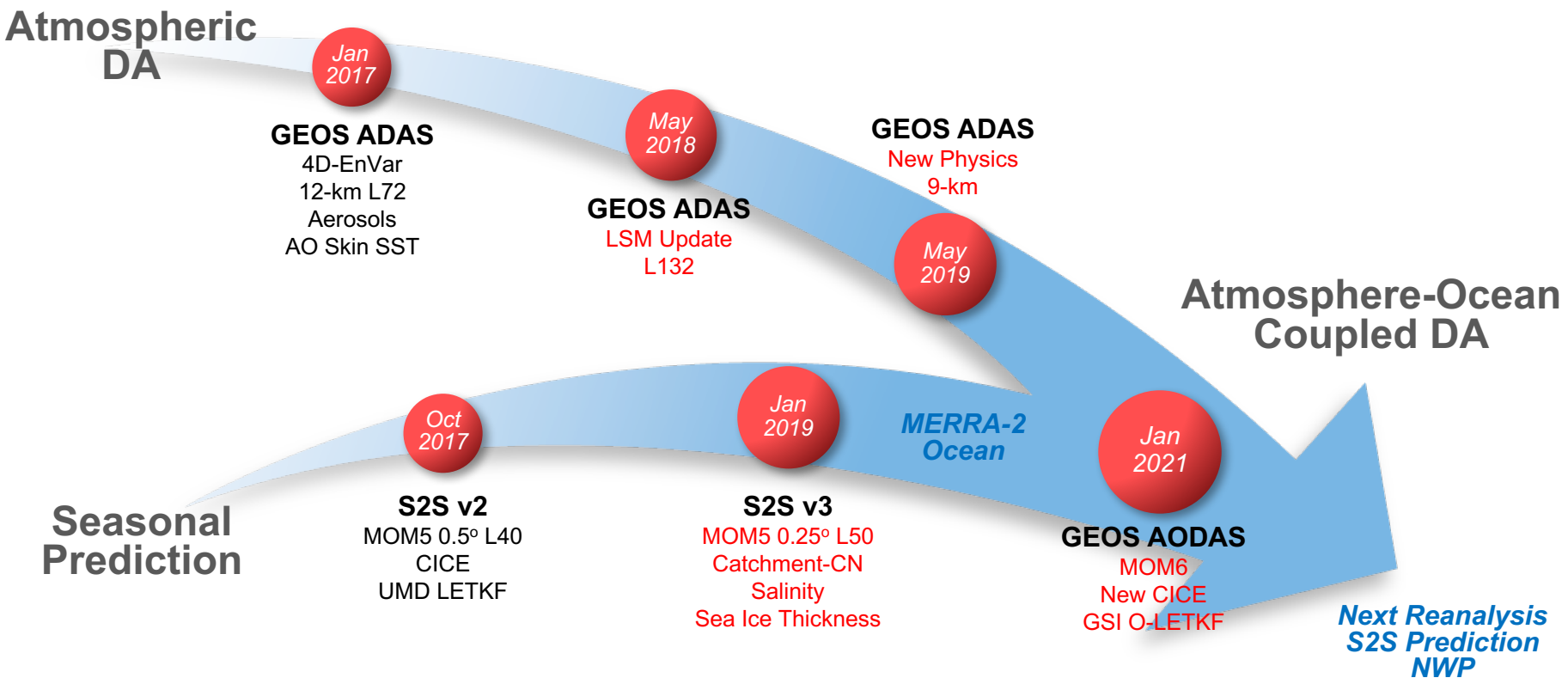
Time series of AOD in MERRA-2 averaged over major aerosol source regions (1980 – 2014)

Seasonal cycles of dust and biomass burning apparent in all regions, as are large increases in sulfate after El Chichón and Mt. Pinatubo eruptions

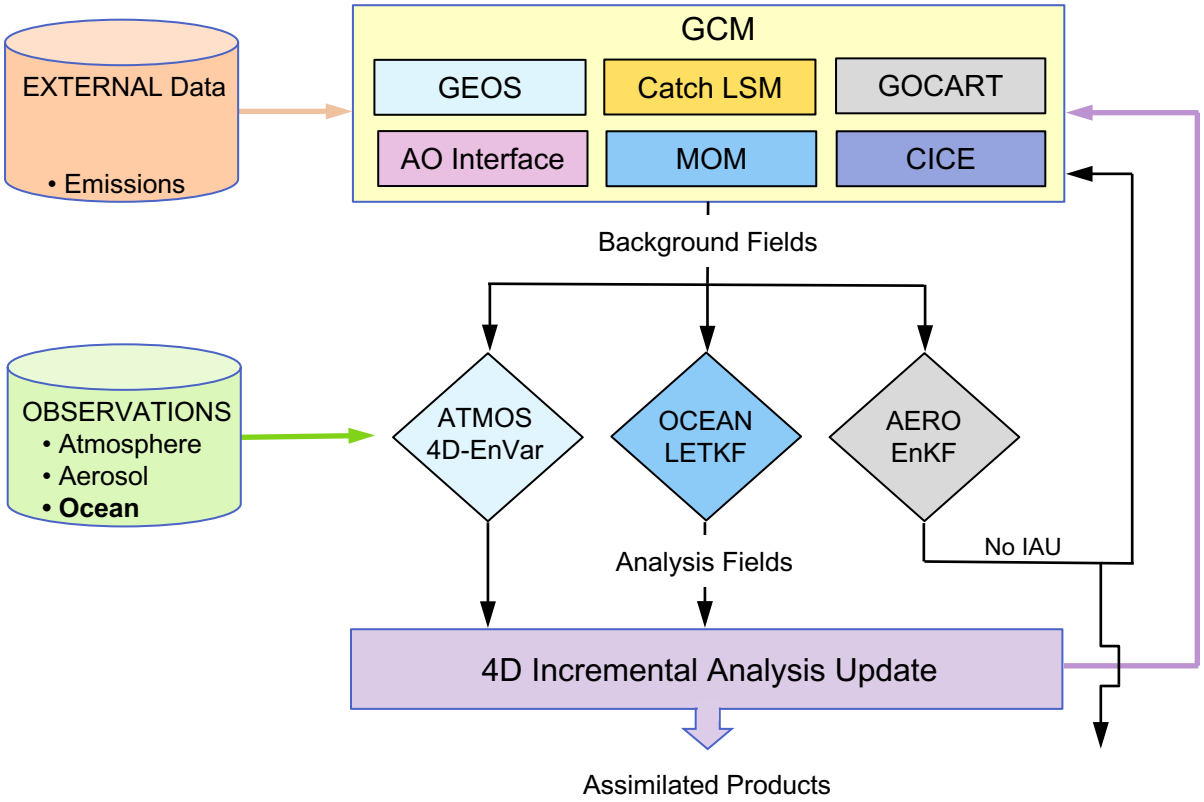
Dominant aerosol types generally differ by region, e.g. dust over Africa, carbon from biomass burning over Amazon



GMAO coupled atmosphere-ocean assimilation development



GEOS coupled atmosphere-ocean assimilation system



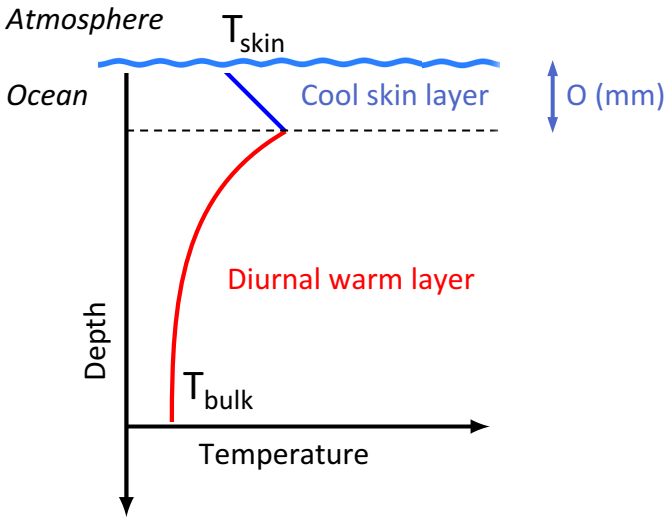
Coupled DA for the atmosphere and ocean

Background fields from the coupled GEOS AOGCM

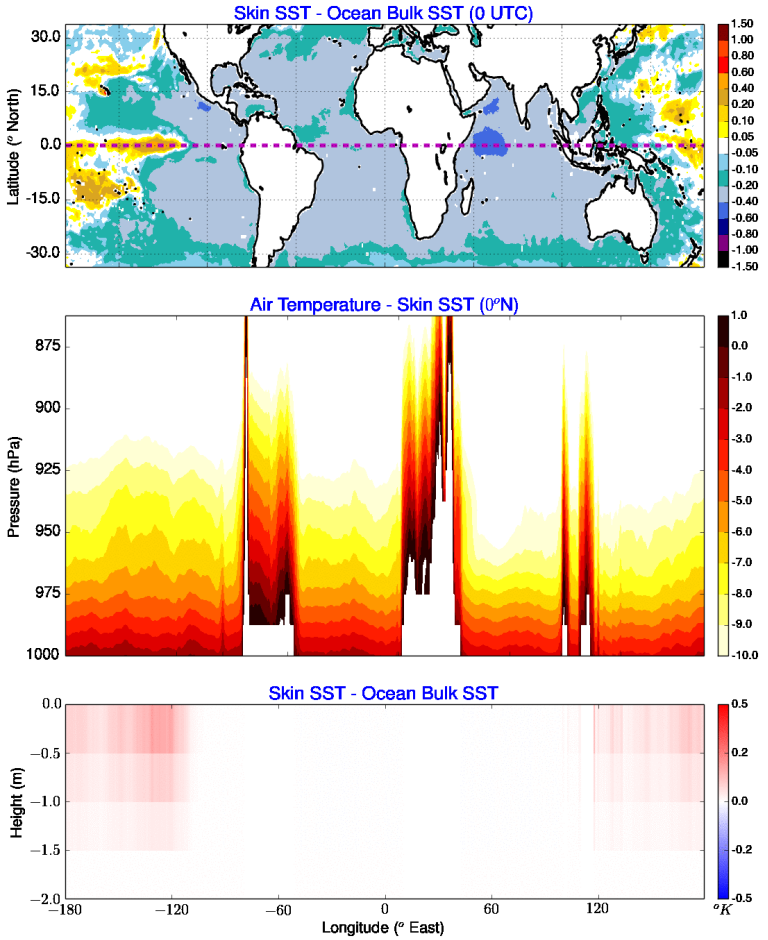
Separate analyses for the ocean and atmosphere (and aerosols)

Information exchange between components occurs through IAU model integration

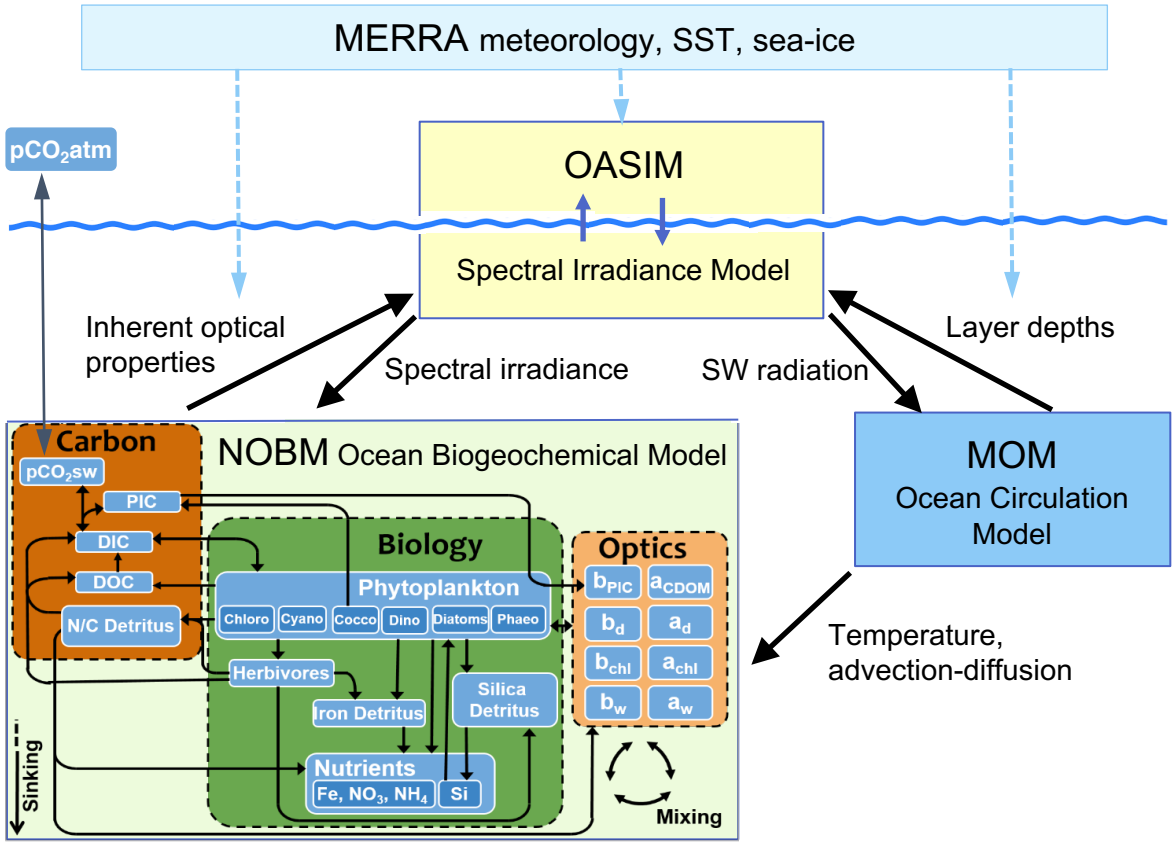
GEOS semi-coupled skin SST analysis (AO interface)



- Model diurnal cycle, with cool skin plus diurnal warming in 2-meter mixed layer
- Assimilates SST-sensitive IR radiances plus all other data in the atmospheric analysis
- Eventually, T_{bulk} from coupled ocean model



Ocean biogeochemical assimilation



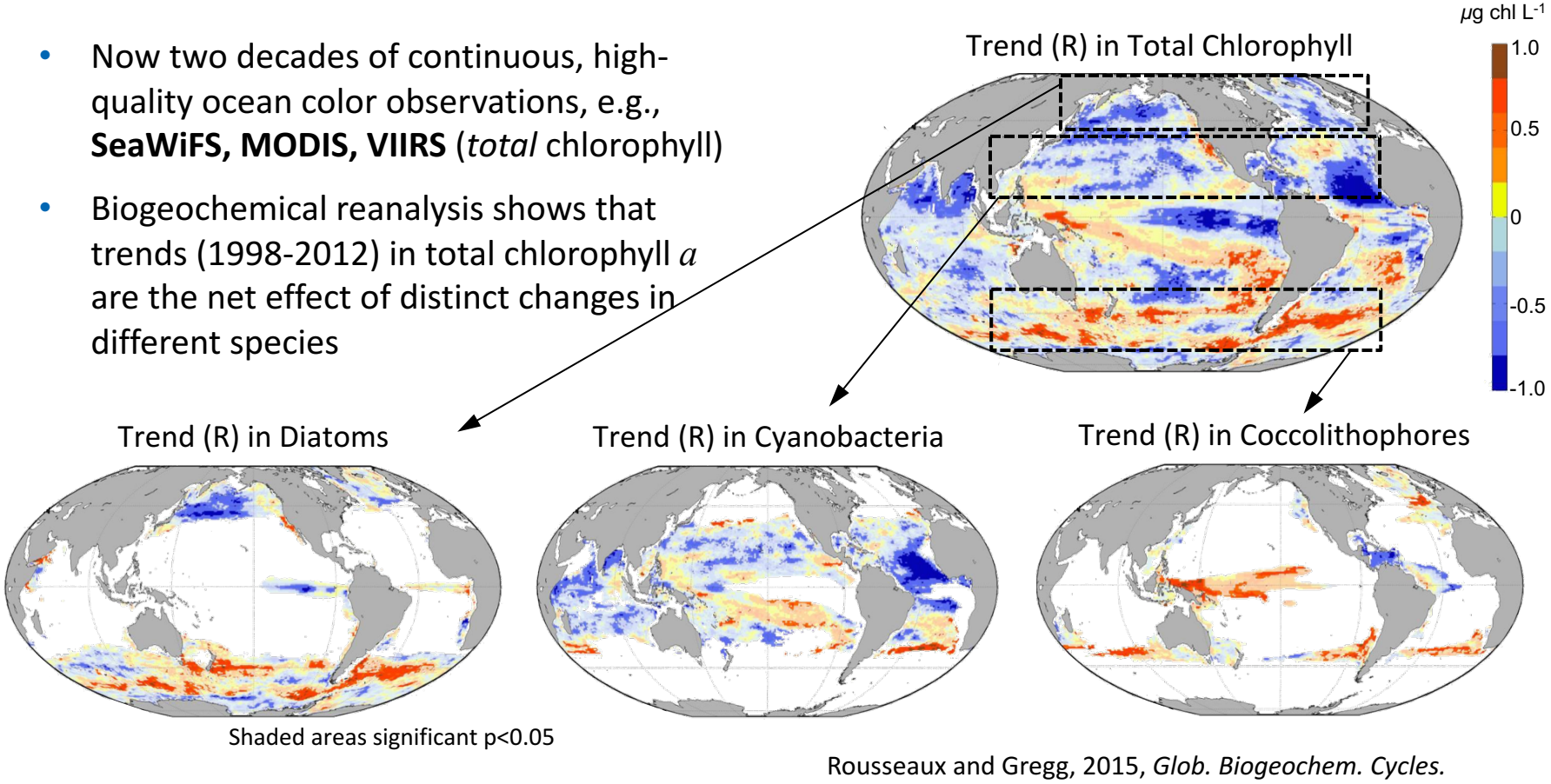
NASA Ocean Biogeochemical Model (NOBM)

Assimilates chlorophyll, absorption of colored dissolved organic matter (CDOM), and particulate inorganic carbon (PIC)

Outputs chlorophyll, nutrients, phytoplankton groups, primary production, nutrients, carbon components and fluxes, spectral irradiance/radiance

MERRA-NOBM global decadal trends in ocean phytoplankton

- Now two decades of continuous, high-quality ocean color observations, e.g., **SeaWiFS, MODIS, VIIRS** (*total* chlorophyll)
- Biogeochemical reanalysis shows that trends (1998-2012) in total chlorophyll *a* are the net effect of distinct changes in different species

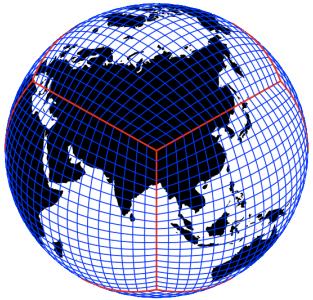


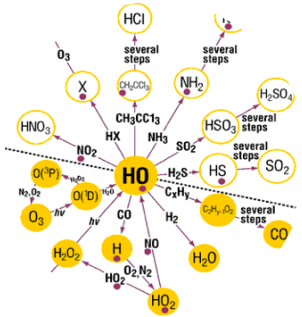
Shaded areas significant p<0.05

Rousseaux and Gregg, 2015, *Glob. Biogeochem. Cycles.*

Three-dimensional chemistry

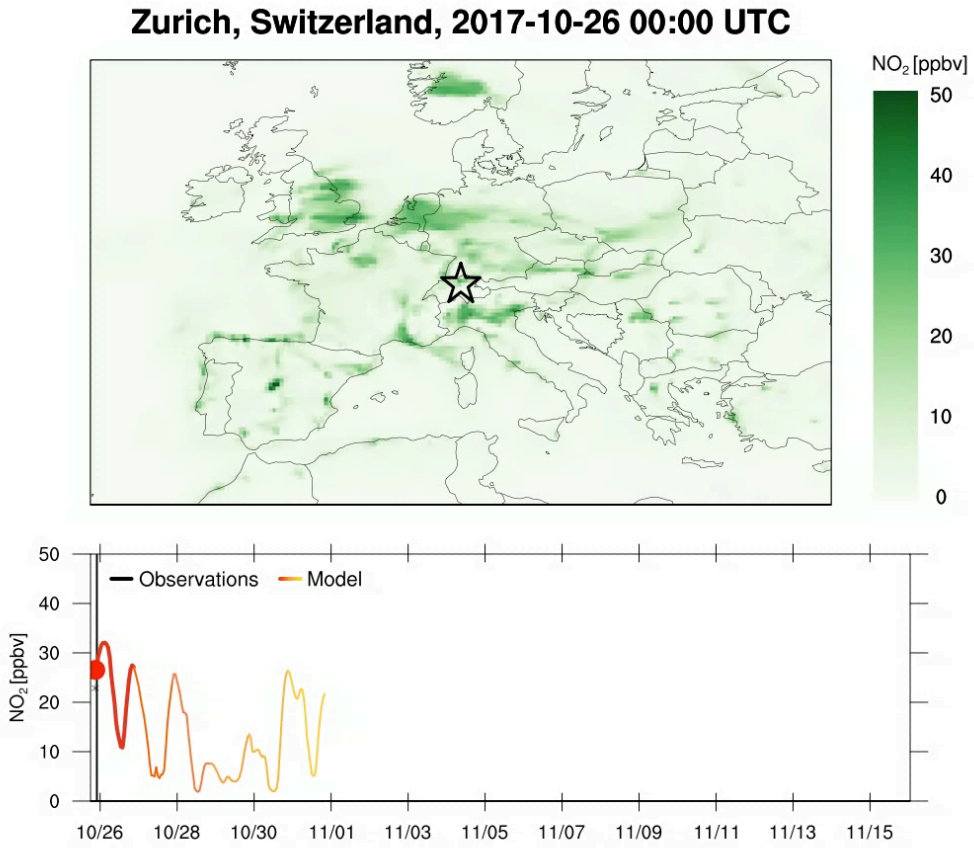
Long-standing collaboration with Harvard to develop **GEOS-Chem** for use in GEOS

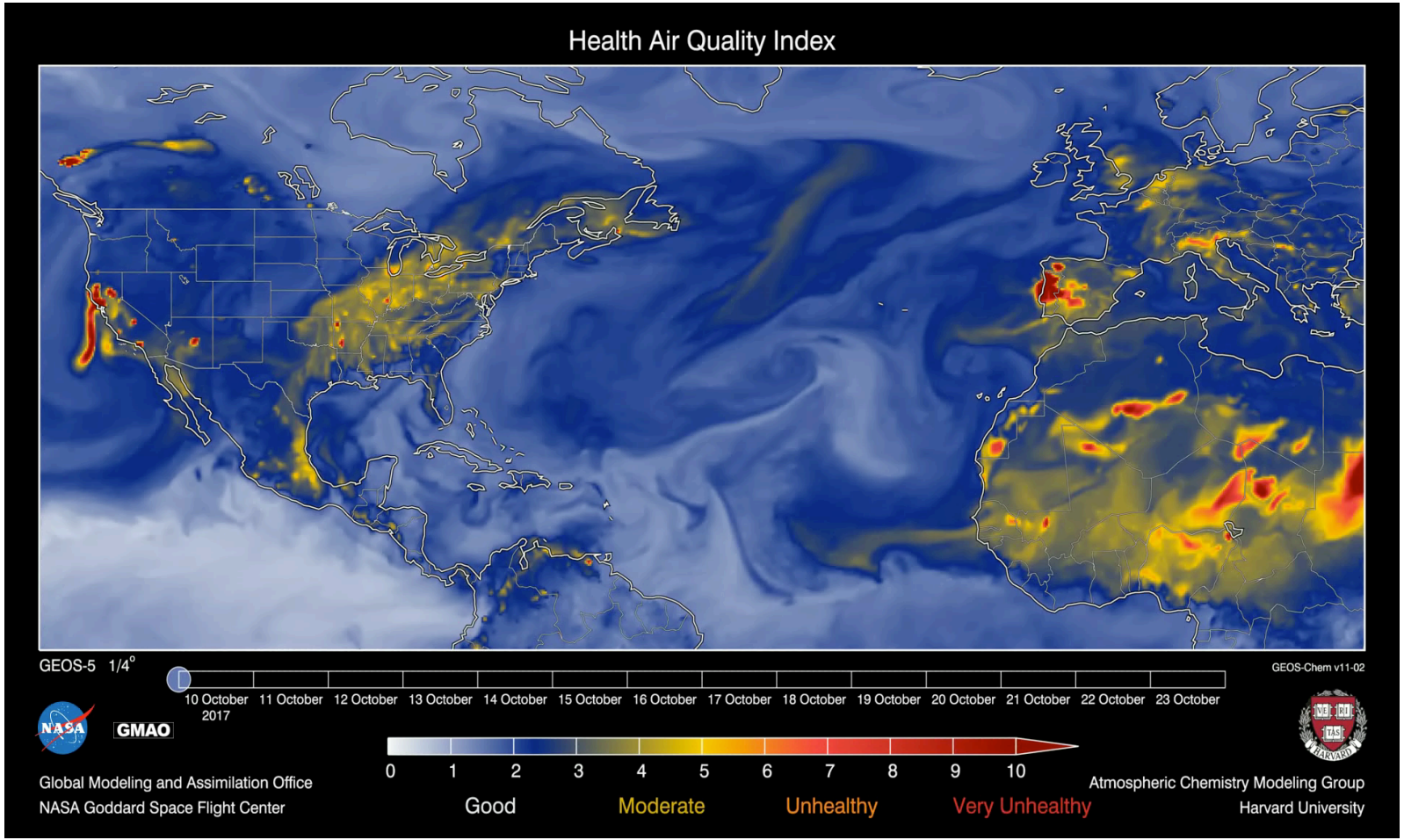




As a research project, recently began daily full chemical forecasts at 25-km resolution, forced by GEOS real-time meteorology

Currently, no assimilation of chemical species, but this will be worked in slowly as a separate optimization from the met state (**OMI**, **MOPITT**, ...**TEMPO**, **Sentinel**, **GEMS**)





HAQI shown here combines O_3, NO_2 and $PM_{2.5}$

Summary

- GMAO is working toward an integrated Earth system analysis capability to advance its activities in S2S, reanalysis and NWP
- A reanalysis with coupled physical components of the atmosphere, ocean, land and cryosphere is planned for 2021 (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 processes
- Continue production of MERRA-2, and MERRA-2-driven component reanalyses that serve as test environments for emerging capabilities