A Brief Summary of Plans for the GMAO Core
Priorities and Initiatives for the Next 5 years

Provided as information for ROSES 2012 A.13 – MAP

Developments in the GMAO are focused on the next generation systems, GEOS-6, and an Integrated Earth System Analysis and the associated modeling system that supports that analysis.

GEOS-6 and IESA

(1) The GEOS-6 system will be built around the next generation, non-hydrostatic atmospheric model with aerosol-cloud microphysics (advances upon the Morrison-Gettelman cloud microphysics and the Modal Aerosol Model (MAM) aerosol microphysics module for the inclusion of aerosol indirect effects) and an accompanying hybrid (ensemble-variational) 4DVar atmospheric assimilation system.

(2) IESA capabilities for other parts of the earth system, including atmospheric chemical constituents and aerosols, ocean circulation, land hydrology, and carbon budget will be built upon our existing separate assimilation capabilities.

The GEOS Model

Our modeling strategy is driven by the need to have a comprehensive global model valid for both weather and climate and for use in both simulation and assimilation. Our main task in *atmospheric modeling* during the next five years will be to make the transition to GEOS-6. This direction is driven by (i) the need to improve the representation of clouds and precipitation to enable use of cloud- and precipitation-contaminated satellite radiance observations in NWP, and (ii) the research goal of understanding and predicting weather-climate connections. Development will focus on 1km to 10km resolutions that will be needed for the data assimilation system (DAS). Climate resolutions (10-100km) will not be ignored, but developments for resolutions coarser than 50 km will have lower priority.

	2012	2016
RT Met analysis	1/4°	5 km
Reanalysis	1/2°	10 km
GGMS*	10 km	1-3 km
Climate simulations	1/2-1°	10-50 km

**GGMS: GEOS Global Mesoscale Simulations*

The above table shows the planned evolution of the AGCM's horizontal resolution from the current implementations to 2016 and thus reflects developments that will take place during the period covered by the ROSES announcement. Currently, all versions of GEOS-5 use a vertical grid with 72 levels with a top at 0.01 hPa (~80 km). By 2016 we plan to roughly double the number of levels, at least for NWP and reanalysis applications, and will be using a somewhat higher model top (~100 km). These details are still TBD.

Atmospheric modeling issues that need to be addressed at higher resolutions include:

- Double counting, throttling/activating parameterizations, particularly deep convection.
- Shallow convection and turbulent processes, which will continue to be parameterized, but will be embedded in resolved meso-scale and even cloud-scale circulations.
- Representation of other fast processes, such as large scale condensation and cloudiness prediction and their dependence on resolution, microphysics of cloud condensates, aerosol microphysics and interactions with cloud and chemical processes, precipitation microphysics, etc.
- Computational performance. Achieving these higher resolutions will require codes capable of running on 10^4 to 10^5 processors and of using new "accelerator" technologies, such as GPGPUs and MICs.

In addition to these developments in the atmospheric GCM itself, there will also be significant updates to the way atmosphere-surface interactions are treated.

Over continental regions these will be driven by developments in the Catchment Land Surface Model. These will include:

- Improved catchment boundary definition
- Full river routing model (Pfafstteter-based)
- More extensive catalogue of vegetation types
- Separate canopy energy budget
- Dynamic vegetation phenology and explicit representation of land carbon budgets.

Over open ocean and sea-ice developments will focus on the air-sea interface, with the inclusion of an updated diurnal warming layer module and also the WaveWatch3 Model and its interface with both the ocean and atmospheric boundary layer parameterizations. The current ocean model configuration is at 1/2° resolution. With the focus on higher atmospheric resolution and the IESA, the resolution used for the ocean model will be increased to at least 1/8°.

Developments in the OGCM will focus on reducing biases in climate simulations and completing the integration of the NASA Ocean Biogeochemistry Model (NOBM) into GEOS-5.

The GEOS Assimilation Systems

We will continue our focus on the atmospheric data assimilation system – to contribute to NASA missions and the JCSDA and to make advances in reanalyses – but also to increasingly link the systems to prepare for an IESA.

Atmospheric assimilation priorities:

- Implement the hybrid 4DVar system in GEOS-6 and develop the field of observing system science, utilizing advanced adjoint-based tools and infrastructure for simulating future observing systems.
- Expand utilization of satellite data, including cloud-affected radiances.
- Continue the aerosol assimilation coupled to the meteorological analysis.
- Couple the CO and CO_2 assimilation to the meteorological analysis.
- Continue to improve atmospheric reanalysis of moisture.

Ocean assimilation priorities

- Develop the assimilation of sea surface salinity and surface wave height.
- Improve the representation of climate variability in ocean reanalyses.
- Develop the assimilation of ocean color in MOM4.

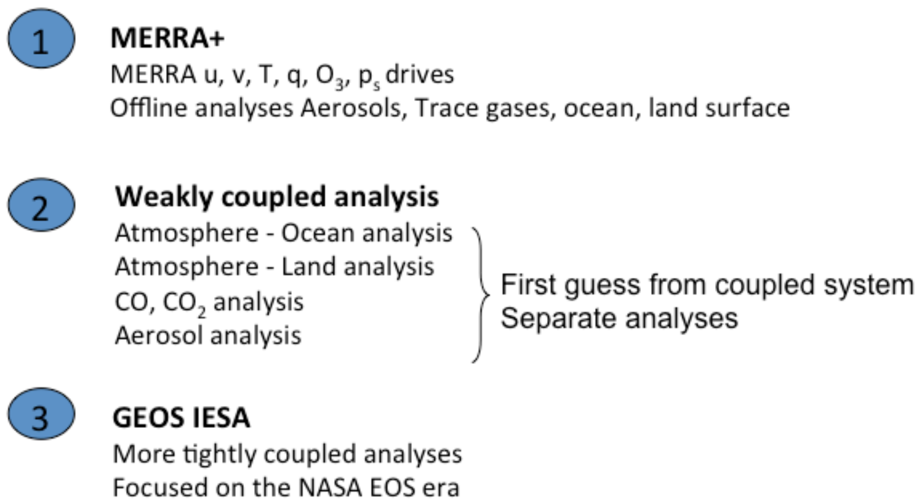
Land surface assimilation priorities

- Continue development with a special focus on surface temperature, soil moisture and snow water equivalent.

Integrated Earth system analysis:

- Link the *ocean and land data assimilation* systems to the ADAS – in a weakly coupled system through the skin/surface temperature.

Our strategy for building an Integrated Earth System Analysis is to take a phased approach, building on the GEOS-5 ADAS and our existing/emerging assimilation systems for other components. For a reanalysis of the integrated earth system we are building on MERRA, with either MERRA-forced (ocean and MERRA-Land, with a precipitation correction for the latter) or MERRA replay (MERRA-Aero). Most of these have already been implemented. MERRA-Land, in particular, is already being distributed along with MERRA at the GES DISC (see http://gmao.gsfc.nasa.gov/merra/news/merra-land_release.php). We are now proceeding with the second phase of weakly coupled analyses (see the figure below), with most progress made for the aerosol and ocean analyses. The focus for more tightly coupled analyses will be on the NASA EOS period with its comprehensive observation suite.



GMAO's Phased approach to an Integrated Earth System Analysis (IESA).

Our goal is to begin the next generation GEOS atmospheric reanalysis for the satellite era in 2016. The target is a 4D system at 10-14 km with sea surface temperature (SST), Land skin temperature (LST), and soil moisture included. Coincident ocean and land reanalyses will be generated from a weakly coupled system.

Other GMAO Priority Efforts

We will continue other efforts to use our systems in areas that help to evaluate the model performance and also to guide development priorities. These include:

- Near-real-time weather forecasts. These are important for the assimilation system evaluation as well as for the support of NASA field campaigns and other external applications.
- Seasonal and decadal prediction. These are important for the ocean and land assimilation system evaluations as well as coupled model evaluations. We contribute these forecasts to the National Multi-Model Ensemble (NMME) and also CMIP5. We will continue to explore initialization strategies to ameliorate the influences of model biases; reduce model drift, etc.
- Observing system science investigations, expanding our collaborations on design of future missions (GEOS Global Mesoscale Simulations as a Nature Run, OSSEs).
- Development of Level-4 products for SMAP and GPM.
- Contribute to NASA's Carbon Cycle and Ecosystem Science by further development of model components, including dynamic vegetation and integration of NOBM into the GEOS modeling suite.