Modeling WG Update
Objectives for this meeting

• Review some ongoing or developing integration activities
• Develop ideas for integration papers
• Revise and redefine the objectives of this working group

Short meeting – concise goals
Fluxes in cyclones represent an important contribution to basin-wide estimates.

Reanalyses exhibit a wide range of results and bias
- MERRA low wind bias; NCEP resolution too coarse
- Observations not complete cover, some obscured locations

Model development needs to benefit from NEWS studies like this

The red dot indicates the center of the cyclone near the time of the satellite overpasses, and the black line shows the cyclone track. The gaps in the images are due to gaps between satellite tracks and rainfall that is too great for accurate retrievals.
Surface turbulent fluxes of energy (latent heat and sensible heat) associated with warm seclusions (strong extra-tropical cyclones) were found to be important for basin-wide budgets of energy and moisture. Satellite estimates of these surface fluxes are determined from satellite observations, and compared to four reanalyses and the SeaFlux (v0.75) interpolated product. The reanalysis products are ERA40, NCEPR2, CFSR, and MERRA. The model representations of surface wind, temperature, and humidity were also examined in an effort to explain differences in magnitude. These variables were used in a bulk flux algorithm to determine the turbulent surface fluxes. Care was taken to treat the satellite winds (equivalent neutral winds) in a manner physically consistent with traditional winds.

The ERA40, CFSR and MERRA product had relatively good spatial representation of the trailing cold front; however, the low MERRA wind speeds were a large factor in underestimating the fluxes. NCEPR2 lacks the resolution needed to represent the cyclone, and blurs the cold front. The SeaFlux v0.75 interpolated fluxes have more variable accuracy. The bias adjusted satellite-derived fluxes in the lower right are considered the standard for comparison.

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Figure 1. The diurnal evolution of $T_{2m}$ and $q_{2m}$ can be used to diagnose the land surface and PBL heat and moisture budgets (dashed), reflecting the balance reached for a particular LSM + PBL scheme coupling in LIS-WRF during the a) July 2006 and b) June 2007 extremes study.

Figure 2. The total heat and moisture budgets derived from the mixing diagrams in Fig. 1 for the Dry (July 2006) case, for different Land-PBL scheme coupling (LSMs labeled) in LIS-WRF vs. observed.

- New Developments
  - Coupled LIS-WRF; Diagnostics suite; Assessment of the coupled component (Santanello et al. 2009-2011)
  - Experiments for 2006-7 case studies have been performed – Multiple LSMS and PBL param.
  - Looking to expand integration collaborations with the Extremes and Evaporation groups
  - Address gaps in NEWS model validations and L-A interaction

Integration of NEWS Model and Diagnostic Products with the 2006-7 Dry/Wet Extremes Study
Joseph A. Santanello, Jr. and Christa D. Peters-Lidard (PI), NASA-GSFC Code 614.3

Assets Developed Under NEWS Phase-1
A comprehensive framework for addressing local land-atmosphere coupling ('LoCo') at the process-level and its impact on water and energy cycles, including:

- **LIS-WRF coupled system** established as a community modeling testbed for local and regional applications
- **A suite of diagnostics** that can be applied to any model, scale, or observation (in-situ or satellite); e.g. Figs. 1-2
- **Assessment of coupled model components** and the impacts of each on the feedbacks governing soil moisture-PBL-clouds/precip interaction

**Santanello, J. A. et al., 2009:** A modeling and observational framework for diagnosing local land-atmosphere coupling on diurnal time scales. *J. Hydromet.*, 10, 577-599.

**Santanello, J. A. et al., 2011:** Diagnosing the Sensitivity of Local Land-Atmosphere Coupling via the Soil Moisture-Boundary Layer Interaction. *J. Hydromet.*, in press.

**Experiments Completed**
Application of above assets to provide a systematic exploration of LoCo and impacts on the water and energy cycle during dry and wet extreme periods in the U.S. SGP:

- **LIS-WRF Case Studies**
  - 14-20 July 2006 (Dry Regime)
  - 14-20 June 2007 (Wet Regime)
- 500x500 domain @ 1km spatial resolution w/hourly output
- 3 LSMs (Noah, CLM, TESSEL) coupled with 3 PBLs (YSU, MYJ, MRF)

**Integration Plans & Results**
Analysis of 2006-7 case studies to produce the following:

- Evaluation of LSM-PBL scheme couplings under dry and wet regimes
- Assessment of the strength and drivers of LoCo during extreme events
- Analysis of extremes across range of model products from local/regional (LIS-WRF) to continental (NARR; Dong et al.) to global (MERRA, MMF)
- Incorporation of MERRA data into global mapping of L-A coupling metrics performed by the GEWEX-GLASS LoCo working group

**Expanding Integration Efforts**

- **Extremes Study:** Utilize the flexibility (physics) and resolution (process-level) of LIS-WRF to establish the physical basis for evaluating and improving other NEWS data and model products
- **WEC and E&LH Working Groups:** Assess how L-A coupling is a factor (explicitly or inherently) in the products they are producing (e.g. ET)
- **Bridge gaps:** from local-to-global analysis of L-A coupling by identifying behavior and limitations of NEWS models and data (for different regimes (inc. extremes)
- **Closer link to data:** What can AIRS provide in terms of global observation of relevant LoCo variables (e.g. PBL properties) vs. what is modeled
Delivered

- Coupled MMF-LIS
- Sensitivity of circulation related to both land and cloud
- Developing 2 yr integrations for large scale model comparisons
- Characterizing the uncertainty of model and data products


Figure 1. (below) A schematic of the coupling of the three MMF-LIS components. Arrows indicate input and output of atmospheric and land surface states among components.

Figure 2. (right) Global mean daily precipitation for June to August 2007 with map views and latitudinal cross sections of CMORPH, MERRA, and two free-running simulations of MMF-LIS using different versions of the Common Land Model. A singular advantage of MMF-LIS is the ability to use multiple land surface models to study land-atmosphere interactions.

Priority Work for Next Phase

- Provide MMF-LIS output (2006-2008) across NEWS working groups.
- Determine if differences between MMF-LIS and observational datasets are attributable to model physics, particularly in areas known to be problematic in large-scale models (e.g., diurnal cycles, precipitation intensity spectra, tropical and extra-tropical waves).
- Identify improvements and capabilities needed, based on the analysis by our group and from feedback from Working Groups.
Precipitation intensity spectrum

(2005 JJAS vs. 2006 JJAS)

(lon: 0 to 360, lat: -45 to 45)

Note: Y-axis in logscale

- Precipitation intensity spectrum
  - MMF 1.25*1.0 (3-hourly)
  - MERRA 1.25*1.0 (3-hourly)
  - CFSR T62 (3-hourly)
  - CMORPH 0.25*0.25 (3-hourly)
  - TRMM 0.25*0.25 (3-hourly)
Project Successes and Deliverables for NEWS Phase-1

The Multi-scale Modeling Framework (MMF) replaces the cumulus parameterization in a finite-volume GCM (GEOS-4) with a cloud-resolving model (GCE) to explicitly resolve cumulus clouds. This work included:

- Coupling the MMF to the Land Information System (LIS), a multi-model land data assimilation system to create the MMF-LIS;
- Assessing the sensitivity of regional and global atmospheric circulations to the integrated impact of cloud and land surface processes;
- Conducting 2-year global simulations (2007-2008) and comparing MMF-LIS results to global gridded datasets and reanalysis.

Importance of MMF-LIS Research Continuity under NEWS

NEWS and other community-based efforts have shown that current data and model products have significant uncertainty and spread in precipitation and other water and energy budget terms, particularly across global scales. The MMF-LIS enhances our ability to investigate the integrated impact of small-scale cloud microphysics and soil and vegetation states on regional to global-scale circulations, cloud patterns, and precipitation. This work demonstrated the value of:

- The use of a cloud-resolving model as a GCM “super-parameterization”, capable of resolving convection globally;
- Integrating and coupling three complex model components to achieve a computationally efficient global model framework that can be run at resolutions ranging from 0.5° to 2° and
- The multi-model capability of LIS in understanding the sensitivity to land surface processes at regional and global scales.

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MERRA – Regional Climate and Extremes crosscut

• Motivated both by TRACE and NCA
• April 2011 – drought in W TX, flooding in the Ohio, So. Miss basins
• Reasonable location of anomalies; magnitude seem weak
Model Integration Paper

• It should....
  – Address at least one major objective of NEWS strategy
  – Have participation on the scale of the EWC effort
    • Which implies that there exists a common thread(s)
  – Have a champion: the PI who takes ownership and responsibility for sheparding the process

• It cannot...
  – Alter or add undue activities on contributing Pis (likely whose budgets have already been cut)
  – Be so broad to catch all “modeling” efforts
Possible Model Integration Paper

• NEWS Strategy: Addressing the need to improve water and energy cycle representation in models; Includes evaluation and metrics derived from NASA observed data products

• An example of a common thread: MERRA
  – Several PIs have used MERRA to varying degrees in their work, so, a broad NEWS evaluation of the WEC in MERRA, aimed at strengths and weaknesses
If you recall, Tasks and Gaps

- Resources to examine *climate models and their hydrological cycle* in comparison with these observed results.
- **Water vapor transport estimates** will likely receive more attention with the start of the GPM mission as we resolve discrepancies between the annual mean and seasonal cycles of precipitation over the northern and southern hemisphere extratropics.
- Ice sheet monitoring and modeling; *cold region processes* are still the major gap for water and energy cycle.
- **Expertise** in regional/global modeling/data assimilation is needed in order to convert new knowledge of dynamical mechanisms into prediction capability, and *evaluation of feedback mechanisms*.
- The impact of land data assimilation (e.g. soil moisture) on the coupled system during extreme events.
- Development of parameterized processes requires *multi-scale observations for validation* at fine to coarse resolutions.
- GCM output *insufficient diagnostics* for certain evaluations.
- Fine scale *ability of reanalyses* to represent *extreme events*.
- **Uncertainty of reanalyses**, regarding WEC remains an issue.
- Need recommended *baseline data for metrics of model validation*; new metrics needed in many cases, NEWS could document metrics.
Model Group Discussions, today

• Review model “Gaps” to define both determine scope of group, near and long term objective

• Model working group objectives: Many projects are up, new PI’s will join soon, update the objectives of the group. Should a broad group continue, or not, or be redefined to something more specific?

• Model Integration Paper(s)
  – Thoughts on a MERRA-centric paper
  – Brain storming other paper ideas
Model Group Discussions, tomorrow

• Review current cross-group integration activities, and identify new activities
• Perhaps a broad model group takes away from other groups needs
• Redefining the model group? What makes most sense with existing (new?) projects and working groups. Or, what gaps exist?
  – Objectives needs to make sense, with the projects/PIs that we have
  – Hope to leave here with clear objective beneficial to NEWS and complementary to the other groups