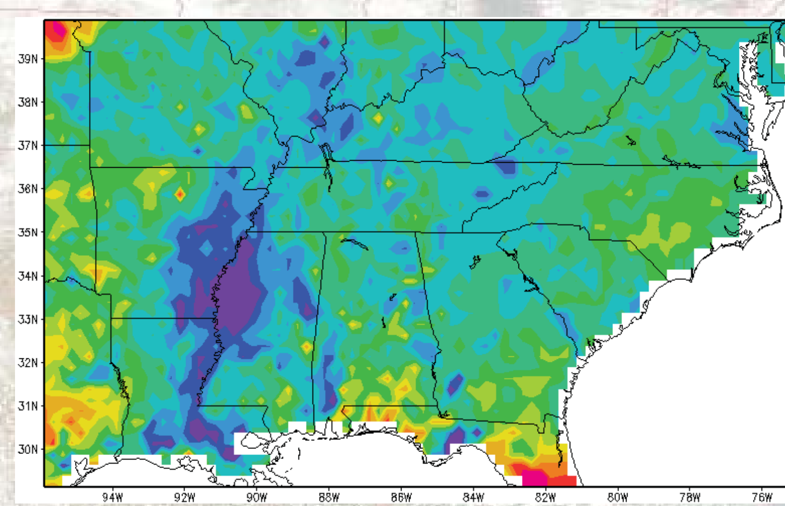
Assimilation of SMOS Retrieved Soil Moisture into the NASA Land Information System



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Goals

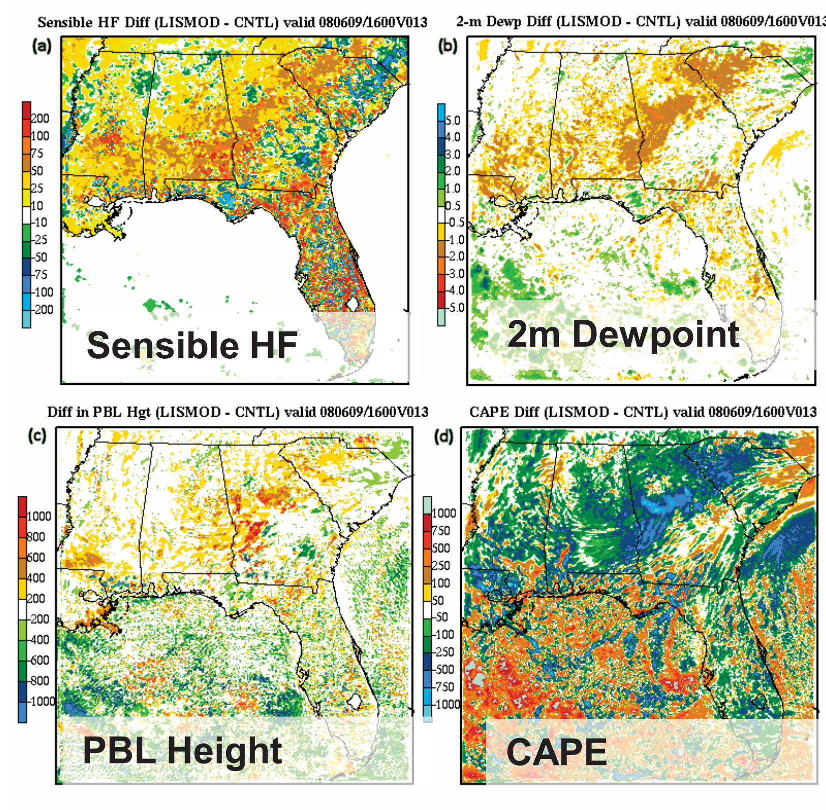
Soil Moisture Data Assimilation

Forecast Challenge

- Available moisture affects humidity, sensible/latent heating, diurnal heating rate, and convection

Objective

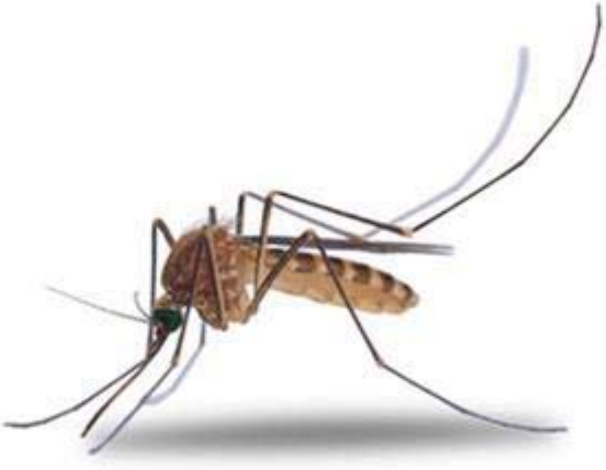
- Improve soil moisture estimates for regional NWP applications and situational awareness
  - Improve LIS soil moisture by assimilating satellite retrievals
  - Use LIS output to initialize NWP



Impact of using high-resolution LIS boundary conditions in WRF (rather than NAM fields). From Case et al. 2008

Other Applications

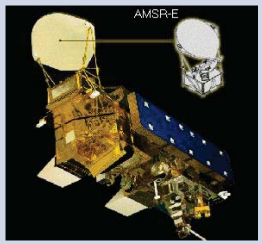
– Drought Monitoring
– Flood Forecasting
– Streamflow prediction
– Public health



SMOS and SMAP

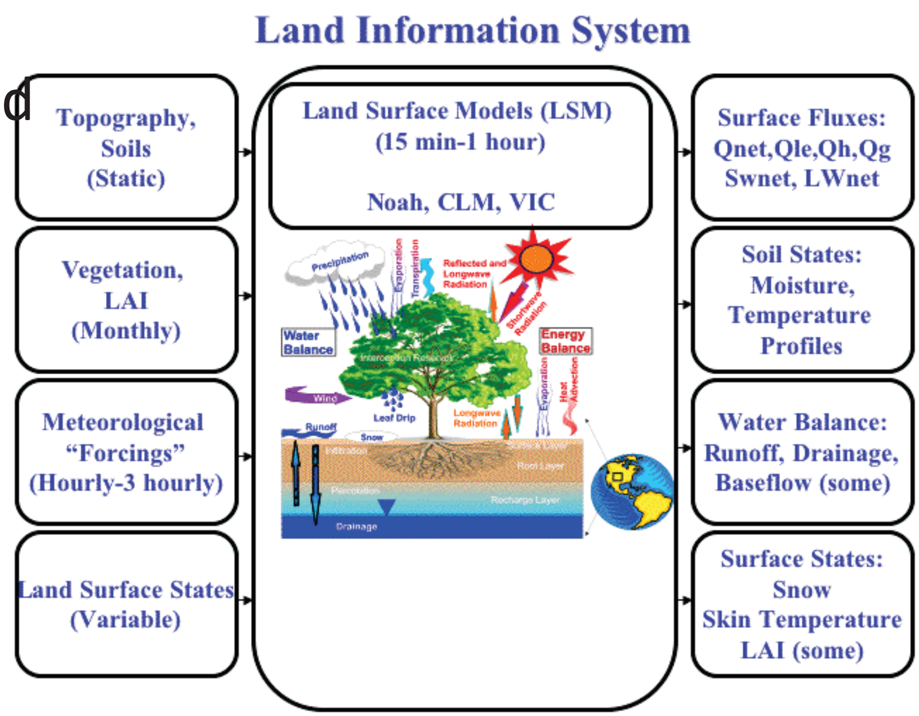
- L-band radiometers (and radars) can be used to estimate soil moisture in the top layer (~5 cm) of soil.
  - L-band (1.4 GHz) sees deeper in the soil, and performs better in dense vegetation than higher frequency instruments like AMSR-E (6-10 GHz).
- Currently assimilating retrievals from European Space Agency's Soil Moisture and Ocean Salinity (SMOS) satellite
- Preparing for assimilation of NASA Soil Moisture Active/Passive (SMAP) retrievals
  - Launch in early 2015
  - Combined (radar/radiometer) product available at a higher resolution (9 km)
  - We are members of the SMAP Early Adopters team

Soil Moisture Instruments

Name	AMSR-E	**SMOS** Soil Moisture and Ocean Salinity	**SMAP** Soil Moisture Active/Passive		
					
Agency	NASA/JAXA	ESA	NASA		
Launch		2009	Nov. 2014		
Orbit	Polar	Polar	Polar		
Sensor Type	Passive	Passive	Passive	Active	Combined
Frequency	6.9 GHz (C-band)	1.4 GHz (L-band)	1.41 GHz	1.2 GHz	
Resolution	56 km	35-50 km	36 km	**3 km**	9 km
Accuracy	6 cm^3/cm^3	**4 cm^3/cm^3**	**4 cm^3/cm^3**	6 cm^3/cm^3	**4 cm^3/cm^3**

Soil Moisture Assimilation in LIS

- Noah LSM (in LIS) produces "operational" soil moisture/temperature states and surface fluxes of water and sensible/latent heat.
- Use data assimilation of SMOS/SMAP soil moisture retrievals to improve model states
- We plan to implement this in near-real-time SPoRT LIS to improve product for end users

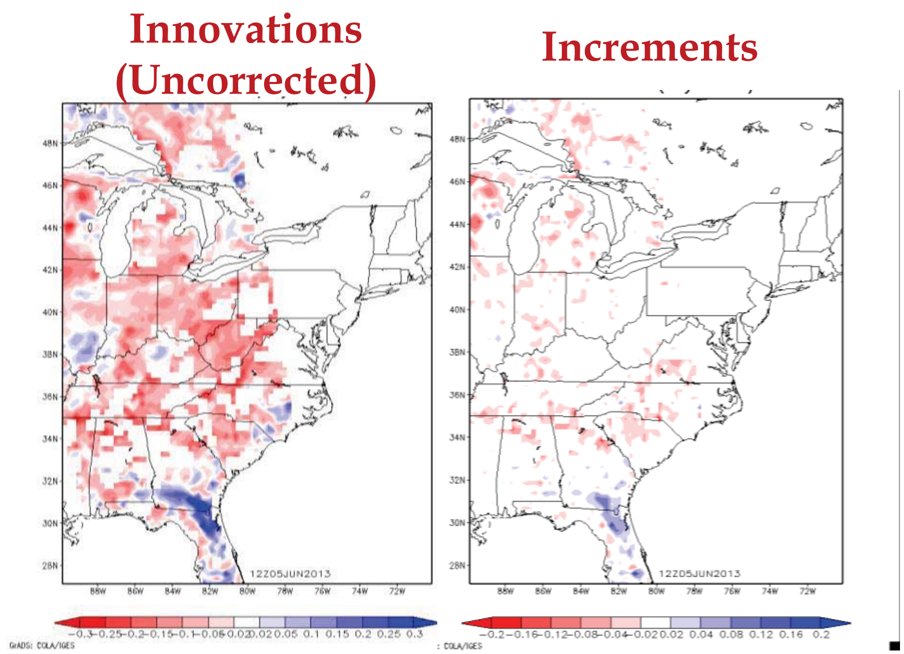


Data Assimilation with EnKF

- LIS has a built in Ensemble Kalman Filter
- EnKF combines the model **background** and **observations** to make **analyses**
  - Relative weighting is controlled by the specified **observation error** and by the **ensemble spread**
- Implemented EnKF assimilation of SMOS data
  - Read SMOS data files
  - QC based on model state and data flags for precipitation, RFI, data quality, frozen soil, snow cover, and high vegetation
  - Ongoing experiments to tune run-time settings including perturbations, number of ensemble members
  - Bias correction by CDF Matching
  - Capability of implementing landcover-dependent correction.

Bias Correction

- Initial tests had large dry bias in observations, so that only extreme rain events had correct sign.
- Discussions with other researchers confirmed need for bias correction

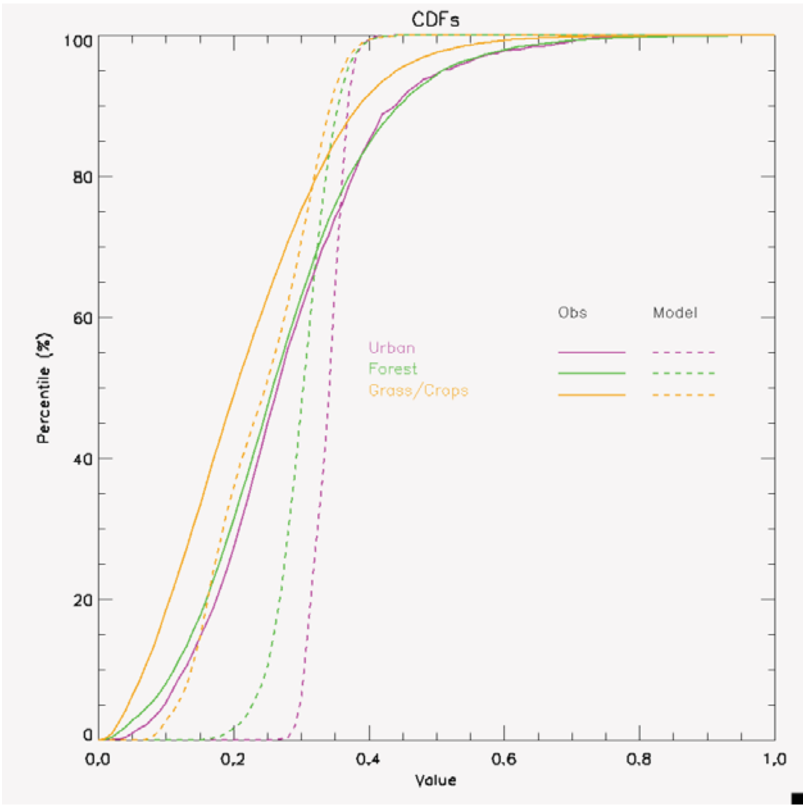


Uncorrected innovations (observations minus model) and increments. Red=dry bias in retrievals.

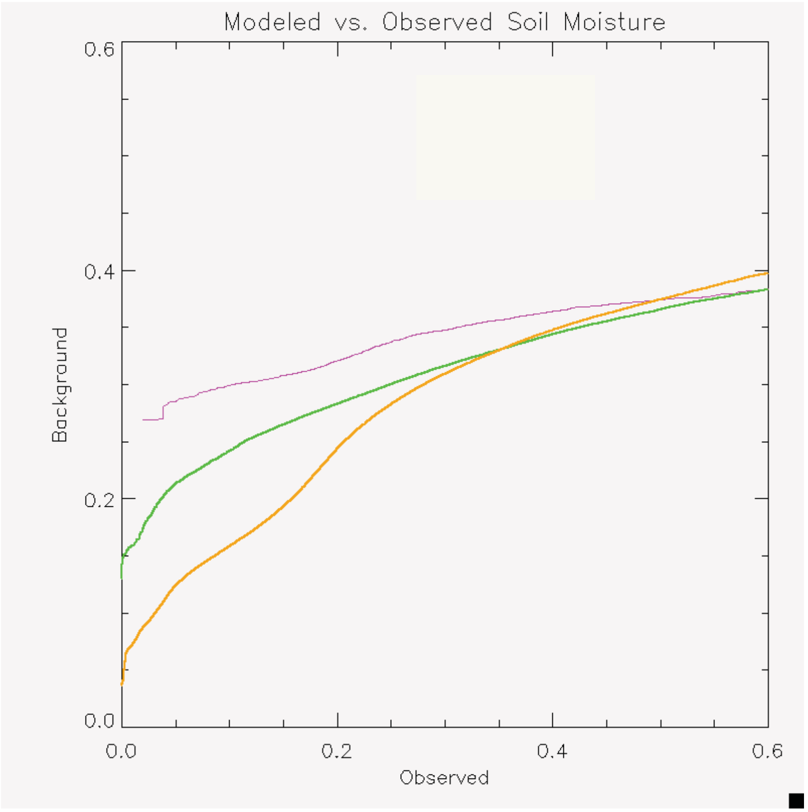
- Implemented CDF matching correction for SMOS retrievals.
- Assimilating retrievals (not radiances) lets us use established methodology

Bias Correction

CDFs of Soil Moisture Observations and Model

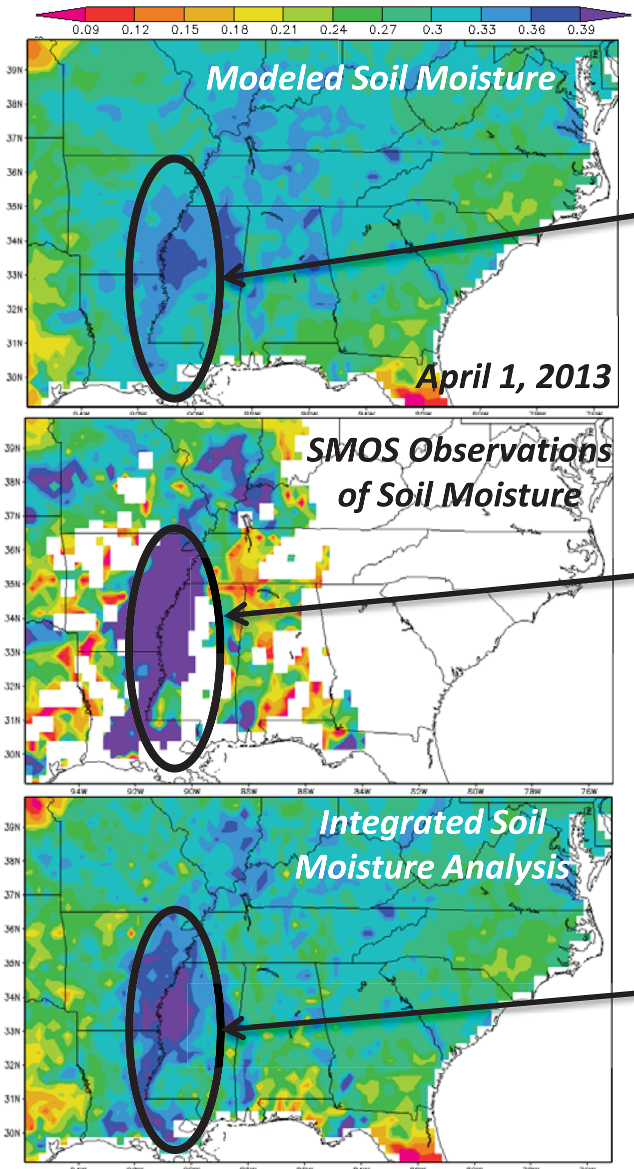


Correction Curves for 3 vegetation categories



- **LIS can apply point-by-point correction curves. To increase the background dataset size, we are aggregating points by landcover type. We will also explore correction at each point and aggregating by soil type.**

Irrigation Case Study

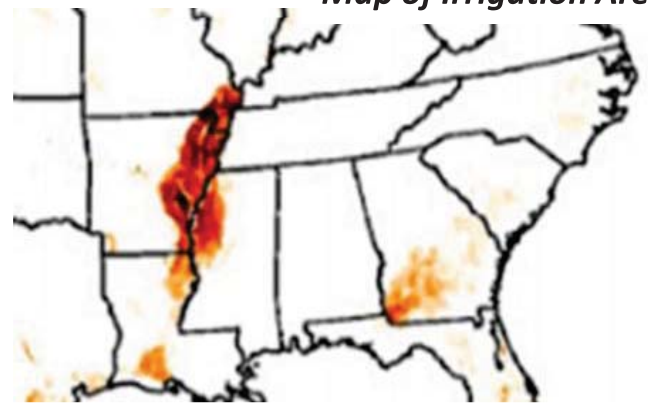


Model soil moisture concentration forced only by precipitation and misses magnitude of irrigation-saturated MS Valley

SMOS observes irrigated fields

Blended analysis of model and observations better represent irrigated area and should result in improved weather and hydrologic modeling

Map of Irrigation Areas



From U. of Frankfurt-FAO (Ozdogan 2001)

- Test Impact on NWP using coupled LIS-WRF
- Implications for regional climate modeling
  - Impacts of changing land-use, precipitation patterns

Current and future plans

- Testing DA for higher resolutions (grid cells << observation size)
  - Use in SPoRT high-resolution LIS runs.
- Validate analyses
  - TAMU North American Soil Moisture Database
- Test Impact of assimilating SMOS retrievals on NWP using coupled runs in NU-WRF
  - Impact on boundary layer for a quiescent day
  - Active convection case
  - Validation over a longer time period
  - Look at both sensitivity and forecast accuracy
- Implement with SMAP retrievals

Questions?

Perturbation Tests