Soil Moisture Data Assimilation in the Land Information System

Clay Blankenship (USRA)

Jonathan Case (ENSCO, Inc.), Bradley Zavodsky (NASA/MSFC)

SMAP Early Adopters' Telcon

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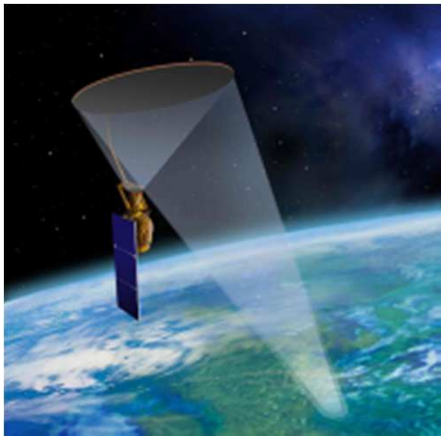
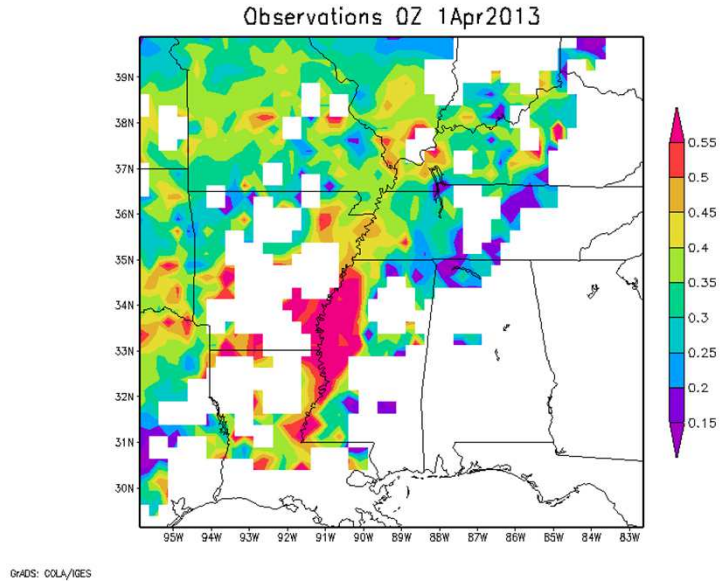
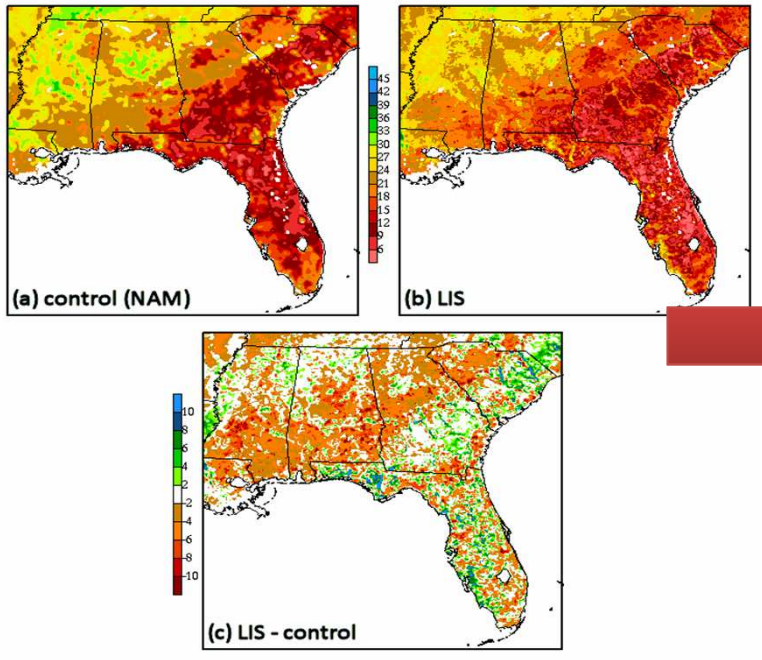
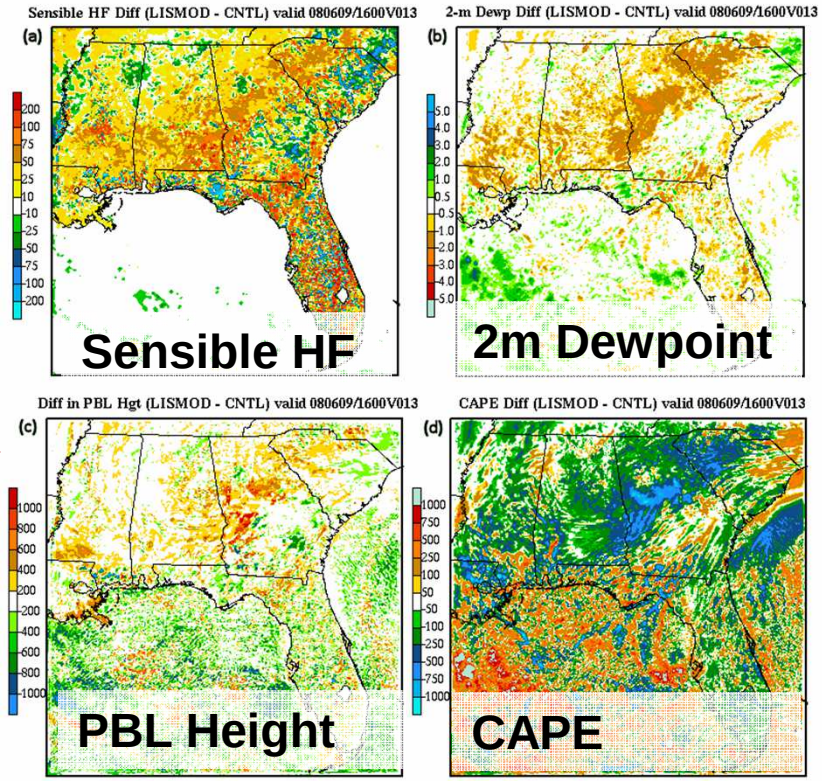




Motivation: Impact of Soil Moisture Fields on NWP

Volumetric 0-10 cm soil moisture





Previous work by our group and others shows that changes in soil moisture initial conditions for NWP have a significant impact on forecast variables.

- **Gradients in soil moisture and heat fluxes can generate differential heating boundaries that initiate convection in weakly-forced regimes**
- **Initializing models with higher-resolution LIS data result in more accurate fields used to predict convection (figure at left)**
- **Convective summer storms can generate heavy rain (flash flooding), strong winds, and lightning (fires)**

Objective

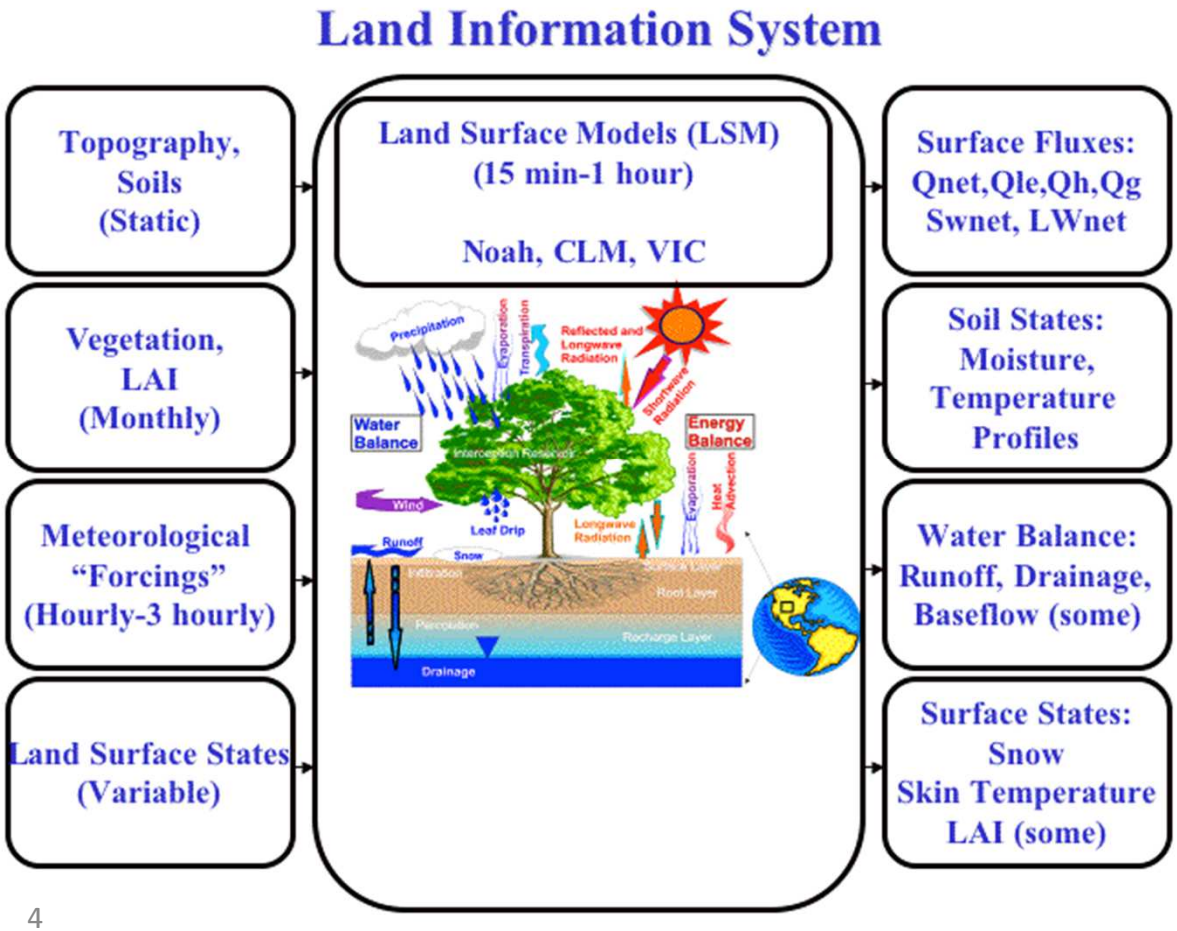
- Improve soil moisture estimates for regional NWP applications and situational awareness

Methodology

- Assimilate SMOS and SMAP soil moisture retrievals into the Noah LSM within LIS.
  - Implemented SMOS data assimilation in LIS
- Targeted Applications
  - Improved land surface initialization for regional WRF forecasts
  - Better situational awareness for drought monitoring and assessing flood potential

Land Information System (LIS)

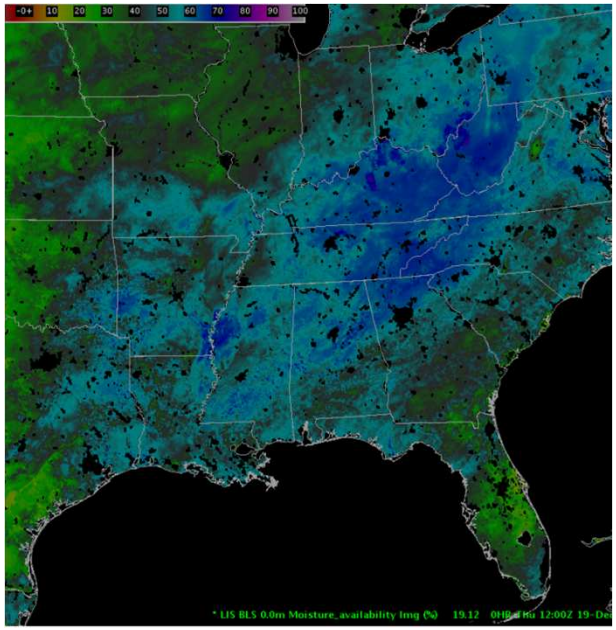
LIS is a modular modeling and data assimilation system from NASA-GSFC with the capability to run several different LSMs, ingest a variety of forcing and parameter data, and interface with NWP models.

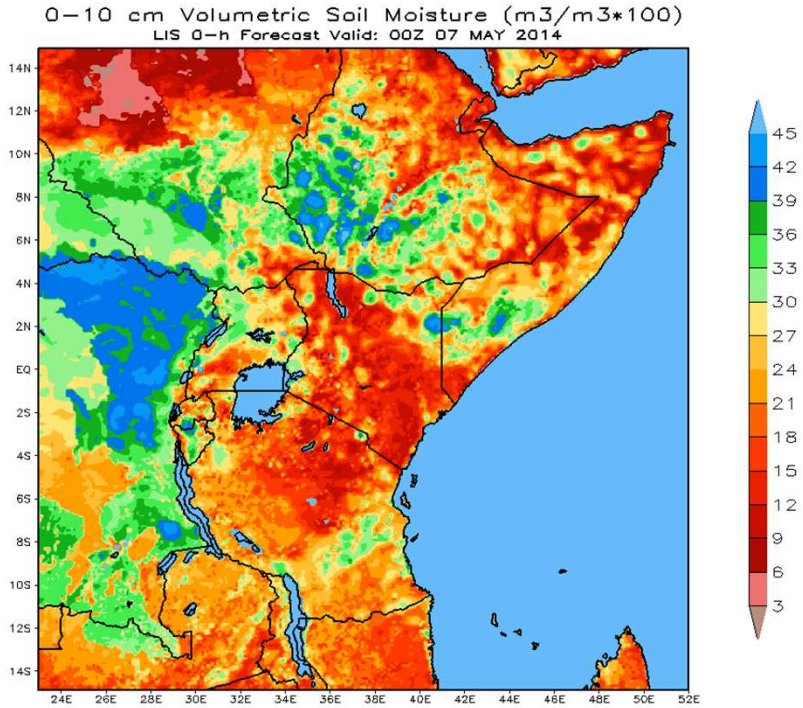


LSMS
VIC, Noah, CLM, Catchment, SiB2, Hyssib
Base Forcings
ECMWF, GDAS, NLDAS...
Supplemental Forcings
TRMM 3B42, Agrrad, Cmap, Cmorph, Stg4...
Parameters (Landcover, soils, greenness, albedo, LAI, topography, tbot)
Data Assimilation
(observation types, perturbation method)

Real-time SPoRT Land Information System

Soil moisture from SPoRT-LIS in NWS AWIPS II Decision Support System





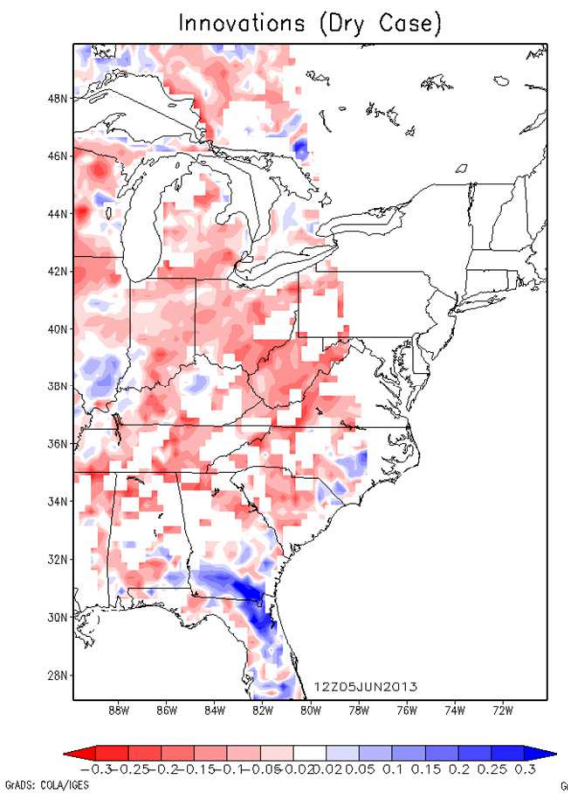
- **We run LIS in real-time for Southeast US and East Africa**
  - **Products provided to NWS and Kenya Meteorological Service**
- **Long-term integration of Noah Land Surface Model (LSM)**
  - **Forcing: NLDAS-2, Stage IV/MRMS/CMORPH Precip, and GDAS/GFS forecast**
  - **Vegetation coverage/health: Green Vegetation Fraction (GVF) from MODIS (VIIRS 2014)**
- **Used for situational awareness and local modeling**

Data Assimilation in LIS

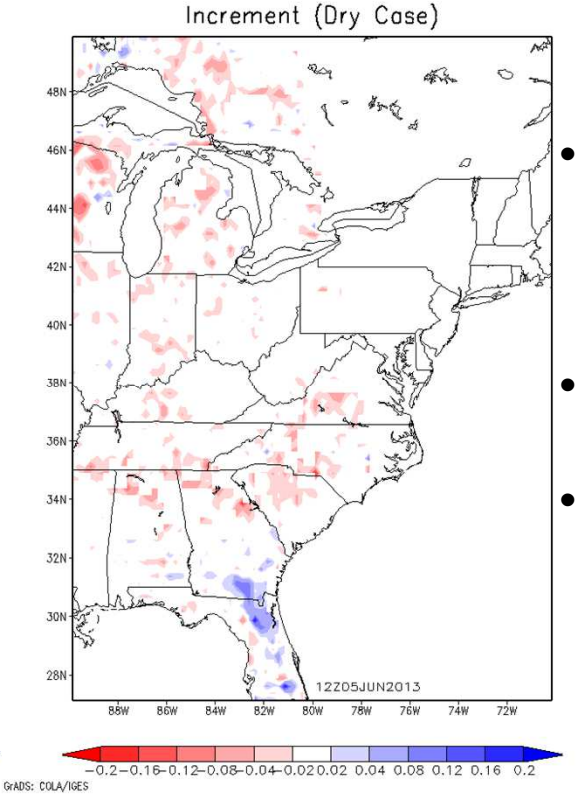
- LIS includes an Ensemble Kalman Filter (EnKF) algorithm
- Comes prepackaged with AMSR-E and other observation types
- We have implemented SMOS soil moisture data assimilation
  - Reads ESA binary files (SMUDP2 product) and puts observations on LIS domain
  - QC based on data flags (RFI, quality), and for frozen soil, high vegetation, snowcover, falling precipitation
  - Implemented bias correction

SMOS DA: First attempt

Innovations



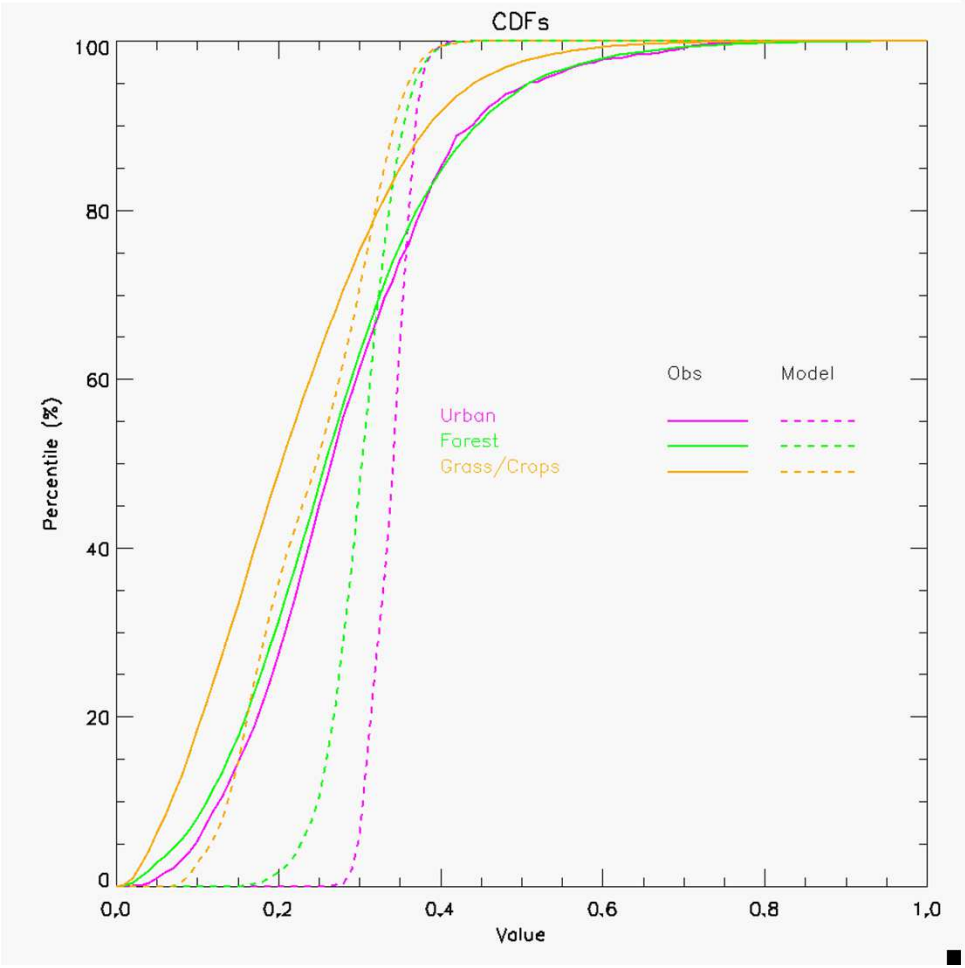
Increments



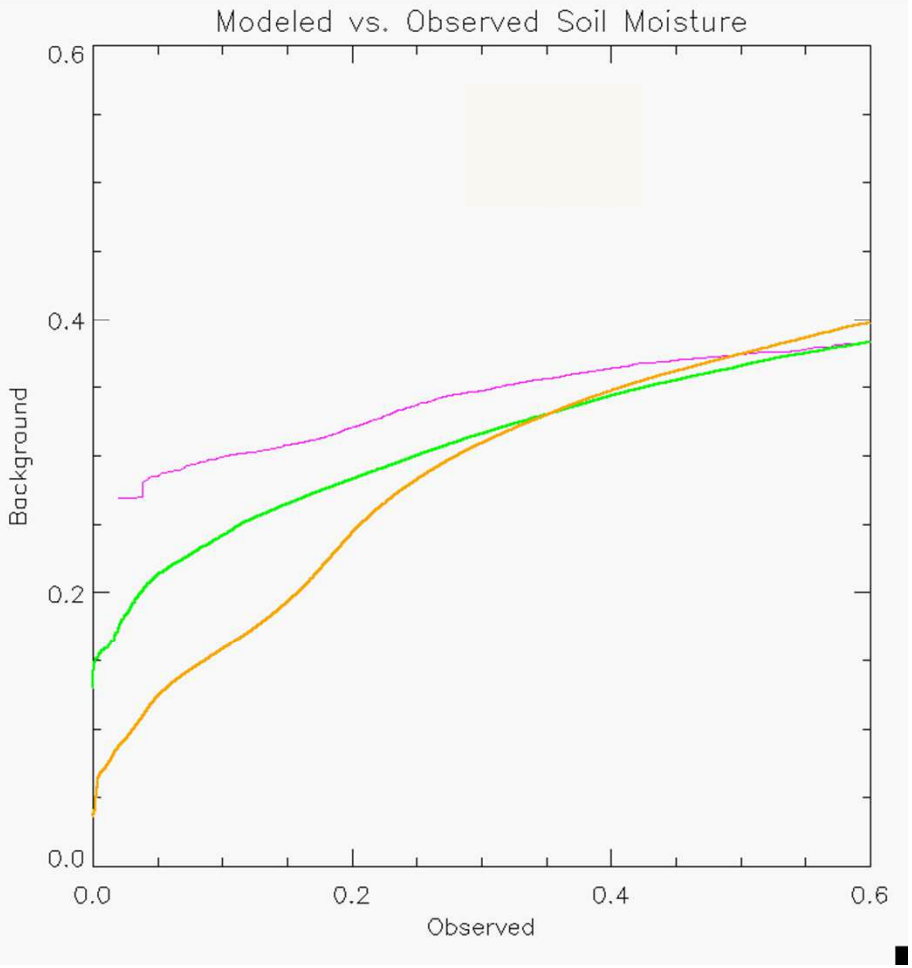
- Running LIS/Noah with SMOS Level 2 soil moisture observations
- Modified precipitation forcing by -50% to test impact of different scenarios (presented at left)
- Large dry bias in observations overwhelms the signal
- Led us to implement bias correction

SMOS DA: Bias Correction

CDFs of Soil Moisture Observations and Model

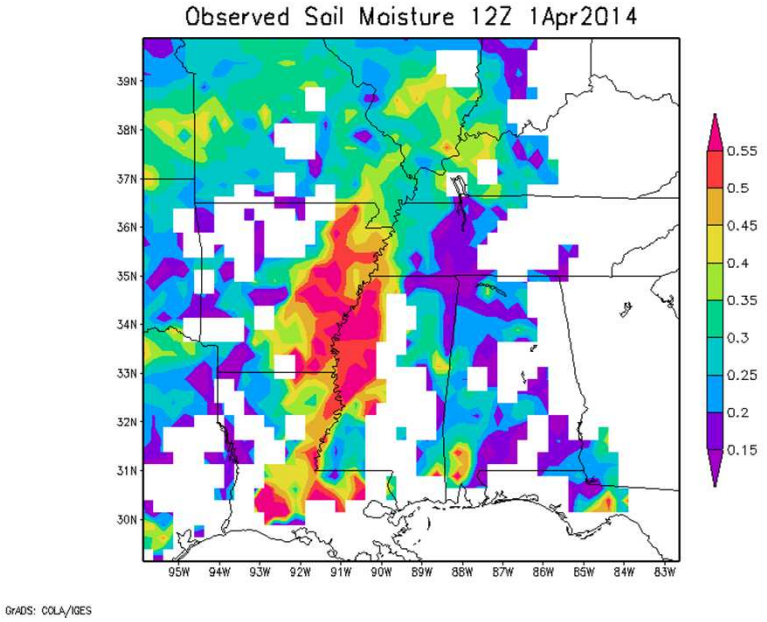


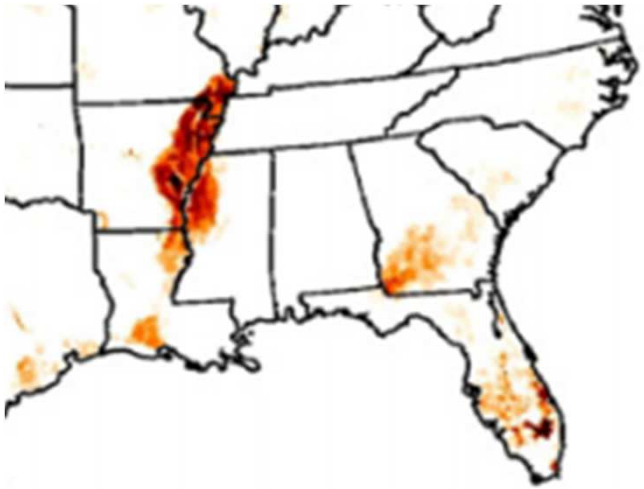
Correction Curves for 3 vegetation categories



- **Breaking down by vegetation type instead of point by point due to limited amount of observation data; but will look at longer period of time and also analyze by soil type**

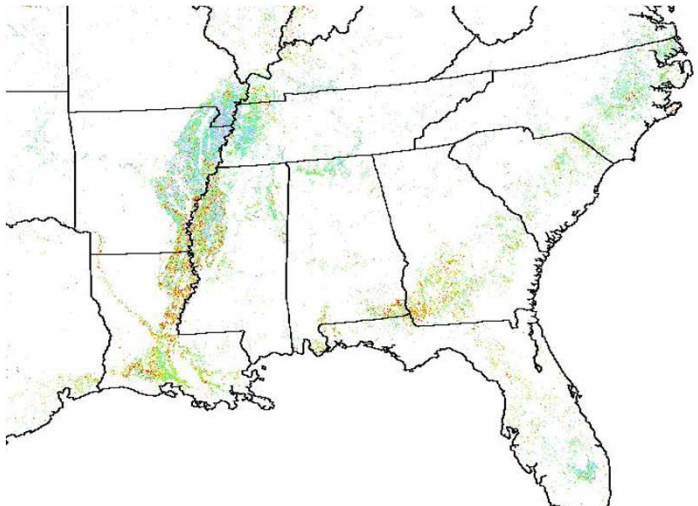
Case Study: Irrigated rice fields





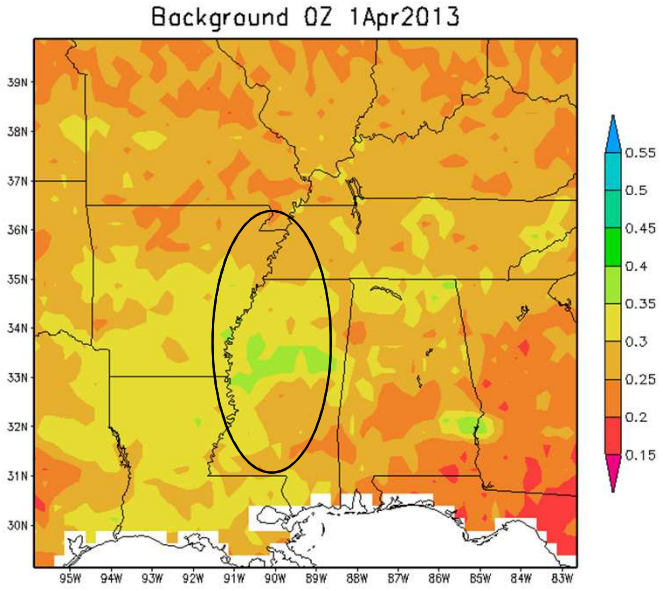
U. of Frankfurt-FAO map of areas equipped for irrigation (from Ozdogan 2001)

- Large signal in the SMOS observations for flooded rice fields.
- Irrigation is not captured in the standard LIS data.
- Test the impact of increased surface moisture (surface water) on weather forecasts.
- Previous research (Case et al. 2008) shows improved weather forecast when using LIS fields for boundary conditions

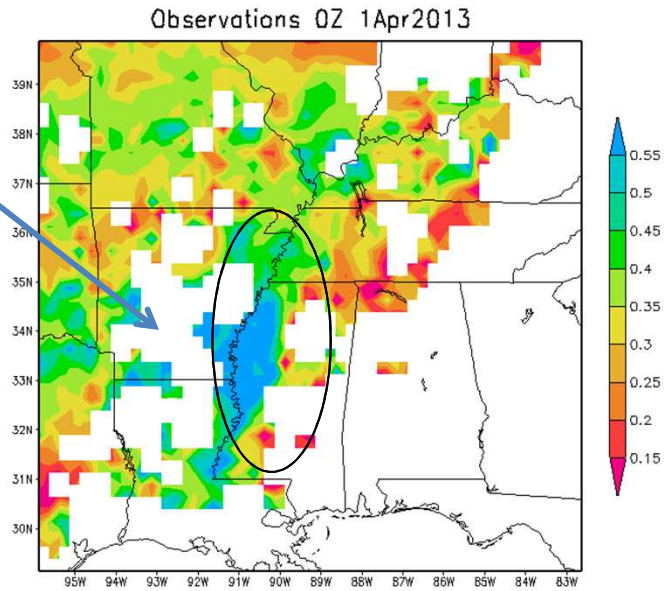


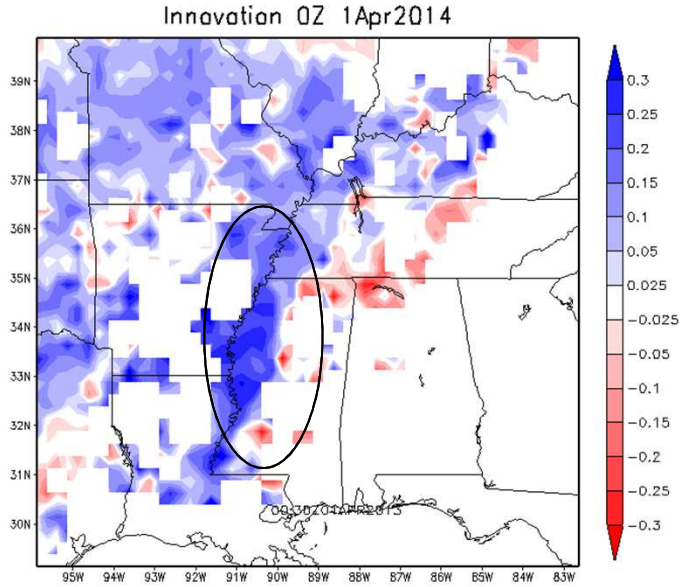
MODIS-derived irrigation (Ozdogan 2001)

Data Assimilation Results

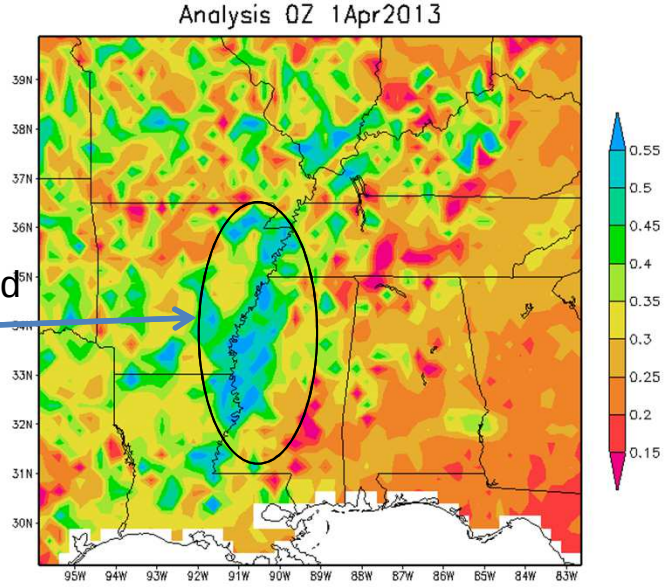


Most rejects (white space) due to high retrieval uncertainty





Analysis fields capture the irrigated area better



Continuing Work

- Validation of soil moisture analyses
  - TAMU North American soil moisture database
- Test impact of LIS DA fields on WRF forecasts
  - Impact on boundary layer for a quiescent day
  - Severe weather case
- Assessment of real-time LIS by forecast offices
- Test assimilation of SMAP data
  - GSFC is developing assimilation module for SMAP 9 km combined product
  - First test with sample data
  - Then operational data when available