The Utility of the Real-Time NASA Land Information System for Drought Monitoring Applications

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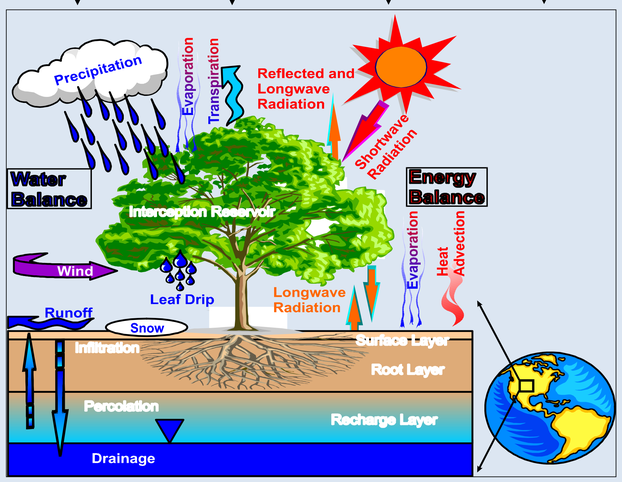
I. Background

The NASA Land Information System (LIS)

Inputs

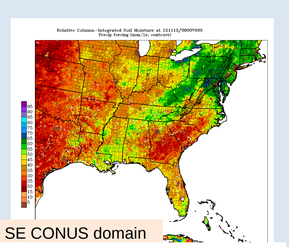
Topography, Soils | Land Cover, Vegetation Properties | Meteorology (Atmospheric Forcing) | Snow, Soil Moisture, Temperature



Outputs

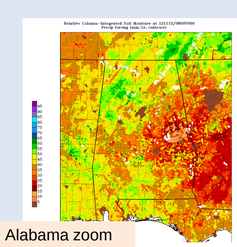
Soil Moisture & Temperature | Evaporation | Runoff | Snowpack Properties

- LIS running Noah version 3.2 on SPoRT's "weather-in-a-box" cluster:
  - 910 x 800 dimensions with 3-km grid spacing (see Figures below)
  - Restarted every 6 hours; originally initialized at 0000 UTC 1 June 2010
  - Static parameters:
    - ✓ MODIS/IGBP 20-class land use; STATSGO 16-class soil type
    - ✓ MODIS 5-km maximum snow albedo
  - Time-varying input:
    - ✓ SPoRT/MODIS daily 1-km Green Vegetation Fraction (GVF)
    - ✓ Surface albedo based on input real-time SPoRT/MODIS GVF
  - Atmospheric forcing:
    - ✓ Hourly 0.125° NLDAS-2 and 4.8-km NCEP Stage IV precipitation from initialization to t – 4 days, based on ~4 day latency of NLDAS-2 analyses in real-time
    - ✓ Global Data Assimilation System (GDAS) 0.205° analyses / short-term forecasts and NCEP Stage IV precipitation from t – 4 days to t_0, based on ~6-9 hour latency of GDAS in real-time
    - ✓ Global Forecast System (GFS) model 0.205° short-term forecasts to provide continuous availability of LIS-Noah output for end-users
- SPoRT end-user applications
  - Initialize LSM variables at resolution consistent with local models (typically ~3 km grid spacing)
  - Use hourly LIS output for diagnostic purposes:
    - ✓ Assessing drought/flood risk based on antecedent soil moisture,
    - ✓ Identifying differential heating zones that could contribute to warm-season convective initiation



SE CONUS domain

3-km SPoRT-LIS relative column integrated (0-200 cm) soil moisture (%)

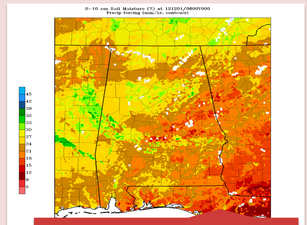


Alabama zoom

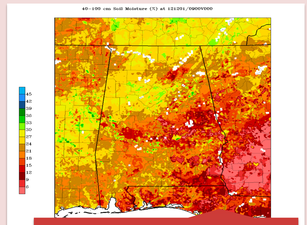
3-km SPoRT-LIS relative column integrated (0-200 cm) soil moisture (%)

II. Data/Imagery Output and Advantages

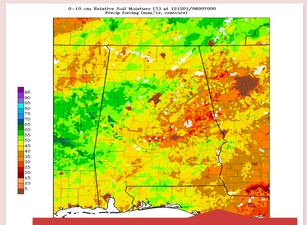
The Alabama 3-km Domain and associated soil moisture and GVF products



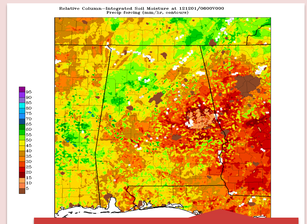
0-10 cm Soil Moisture (%)



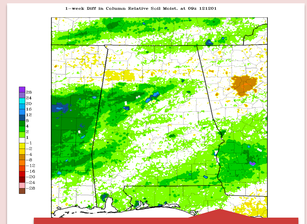
40-100 cm Soil Moisture (%)



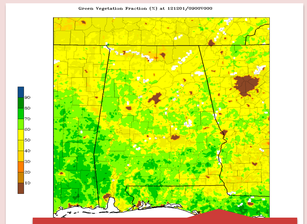
0-10 cm Relative Soil Moisture (%)



0-200 cm Relative Soil Moisture (%)



0-200 cm Relative Soil Moisture Weekly Difference (%)



Green Vegetation Fraction (%)

The real-time LIS is output in 3 km resolution and restarted four times daily at 00Z, 06Z, 12Z, and 18Z. Graphics are generated for Alabama (shown left) and the Southeast CONUS (section I). Data are output in Grib2 format and can be ported into the Advanced Weather Interactive Processing System (AWIPS I, II) for use in NWS offices. This is one of the advantages of the NASA LIS, enabling zooming and sampling of data at 3 km resolution, and overlay with other data sets. Hourly output imagery are also generated each day in .gif format to the following webpage: http://weather.msfc.nasa.gov/sport/case_studies/lis_AL.html.

Weekly Difference plots of 0-200 cm Relative Soil Moisture were generated by SPoRT beginning in winter 2012 based on NWS feedback. Since input to the United States Drought Monitor (USDM) takes place on a weekly basis, weekly difference plots in soil moisture offer temporal relevancy and a quick analysis of the most significant changes over a given area.

Existing soil moisture data sets (below) offer parameters such as soil moisture rankings and departures from normal, which are necessary for drought analysis. However, the LIS 3 km resolution allows for analysis on sub-county scales, which complements existing common soil moisture data sets, and is important for input to the USDM.

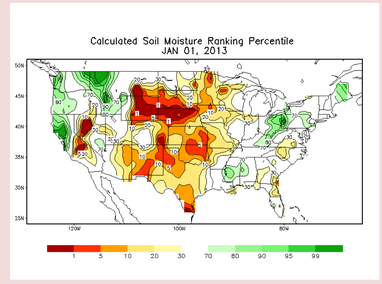


Image courtesy of the Climate Prediction Center http://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

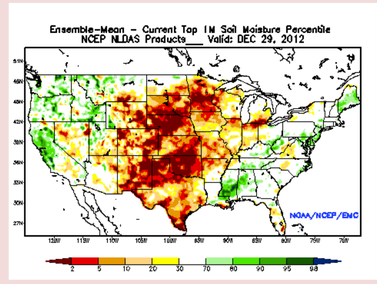
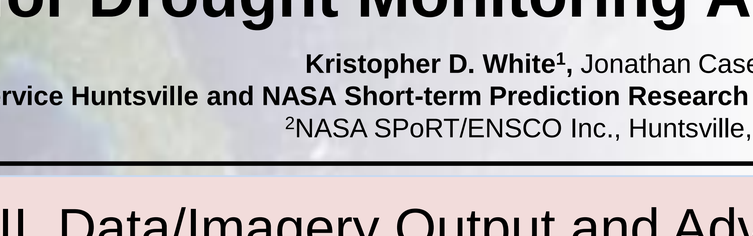


Image courtesy of the National Center for Environmental Prediction's Environmental Modeling Center http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

III. Drought Monitoring Examples

Mid Summer 2011

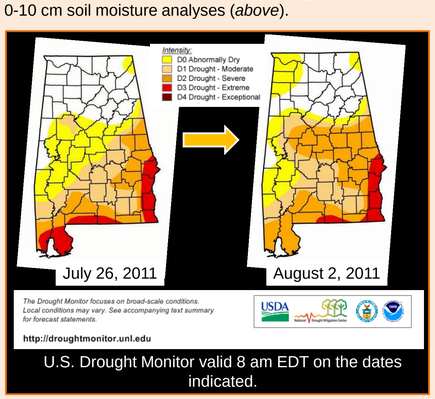


NASA LIS 1-km 0-10 cm soil moisture (%), valid at 0900Z on the dates indicated. Degraded areas are circled in white.

Hot and relatively dry weather (chart below) in mid summer 2011 lead to the rapid degradation of soil moisture conditions, as indicated by LIS 1 km 0-10 cm soil moisture analyses (*above*).

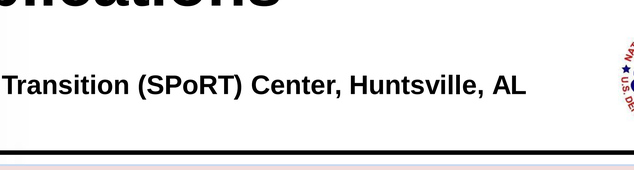
	Muscle Shoals		Russellville	
Date	High Temperatures	Precip	High Temperatures	Precip
07/27	97	0.00	93	0.00
07/28	92	0.16	91	0.00
07/29	91	0.01	88	0.03
07/30	96	0.01	97	0.00
07/31	98	0.00	98	0.00
08/01	98	0.00	99	0.00
08/02	99	0.00	101	0.22

Soil moisture (%) in the 0-10 cm layer decreased about 10% from July 26 to August 2, 2011 in portions of northwest Alabama and central Alabama (above). Corresponding stress to agriculture was noted in the weekly USDA Crop Progress and Conditions report for the state of Alabama. As a result of these impacts, suggestion was made to introduce D0 conditions in northwest Alabama.



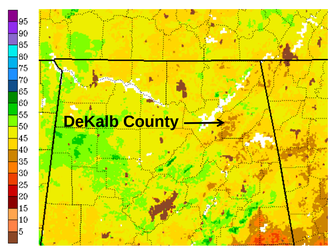
U.S. Drought Monitor valid 8 am EDT on the dates indicated.

Early May 2012

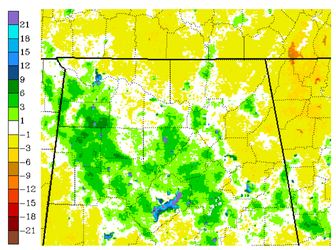


USDM valid May 1, 2012

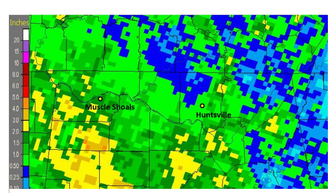
USDM valid May 8, 2012



LIS 0-200 cm Relative Soil Moisture (%) May 8, 2012 0600Z



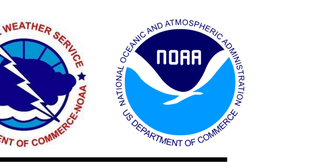
LIS 0-200 cm Relative Soil Moisture (%) Weekly Difference May 8, 2012 0900Z



Stage III Precipitation Week Ending May 8th, 2012 1200Z

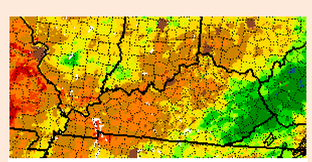
LIS data showed low relative soil moisture values in southern DeKalb County, AL by May 8th. Stage-IV precipitation showed a similar lack of rainfall during the previous week, but the main question is how does the lack of rainfall input affect soil moisture and potential impacts to agriculture. The LIS allows for focus to drought analyses. Communications with USDA agricultural extension agents verified dry soils and impacts to corn crops, resulting in changes to the May 8th USDM.

November 2012

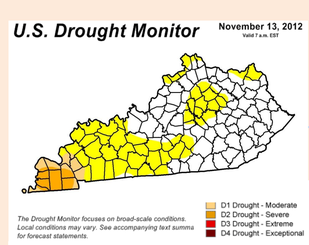


Stage III precipitation totals for the 24 hours ending 1200Z November 8, 2012

Despite rainfall amounts around one to two inches in portions of southwestern Kentucky (above), deep layer relative soil moisture (0-200 cm) was still low, with values generally below 35%. The Kentucky Division of Water recommended keeping the existing severe (D2) drought designation based partly on LIS soil moisture evidence.



LIS 0-200 cm Relative Soil Moisture (%) November 13, 2012 0600Z



IV. Future Work

Work is ongoing to expand the LIS from its current SE CONUS domain (Section I) to a full CONUS domain. This presents some challenges, both with respect to quality of precipitation forcing data sets in the Intermountain West and adjacent portions of Canada and Mexico. The NASA SPoRT modeling team is working to incorporate other CONUS-scale precipitation data sets, which can be seen in poster 69 in the Tuesday morning Hydrology session. Additional work is ongoing to assimilate L-band soil moisture data from the European Soil Moisture Ocean Salinity mission. The upcoming NASA Soil Moisture Active-Passive mission will offer superior soil moisture retrievals as compared to the legacy AMSR-E mission. The SPoRT modeling team also plans to develop soil moisture climatology products with the standard LIS 3 km spatial resolution, which will better enable sub-county scale monitoring of drought conditions over the Southeast CONUS.