P69 Comparison of Four Precipitation Forcing Datasets in Land Information System Simulations over the Continental U.S.

Jonathan L. Case[1], Sujay V. Kumar[2], Robert J. Kuligowski[3], and Carrie Langston[4]

[1]ENSCO, Inc./Short-term Prediction Research and Transition (SPoRT) Center; [2]SAIC/NASA Goddard Space Flight Center, Greenbelt, MD;

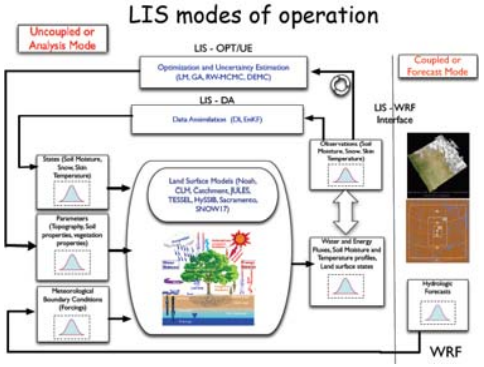
[3]NOAA/NESDIS/Center for Satellite Applications and Research, Camp Springs, MD; [4]Cooperative Institute for Mesoscale Meteorological Studies, Norman, OK

Introduction and Objectives

- **SPoRT runs the NASA Land Information System in real-time to support local modeling and diagnostics at NOAA/National Weather Service (NWS) weather forecast offices (WFOs)**
  - Domain covers only the Southeastern half of the U.S. due to limitations in the Stage IV precipitation analysis driving the Noah land surface model integration in LIS
  - SPoRT would like to expand the real-time LIS to the Conterminous U.S. (CONUS) and Alaska to support additional NWS WFOs and River Forecast Centers, which requires improved precipitation analyses
- **Experiment objectives**
  - Run LIS-Noah for one year using different precipitation forcing datasets to inter-compare accumulated precipitation and resulting land surface model fields (e.g. soil moisture in various layers)
  - Develop an optimal blend of atmospheric and precipitation analyses to produce high-quality land surface depictions over the CONUS

Modeling System and Datasets

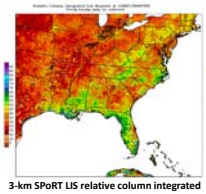
- **NASA Land Information System (LIS)**
  - High-performance land surface modeling & data assimilation framework
  - Can run a variety of land surface models (we ran Noah version 3.2)
  - Supports several static databases for land use and soil classification
  - Able to run up to global domains at 1-km grid spacing

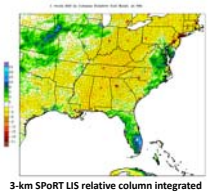


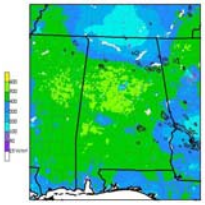
- **Precipitation datasets being tested in LIS**
  1. North American Land Data Assimilation System-phase 2 (NLDAS-2)
     - ✓ 0.125°grid over northern Mexico, CONUS, and southern Canada
     - ✓ Precipitation analysis uses 3-h NARR + daily CPC gauges + 0.5-h CMORPH + 1-h Stage II + PRISM topographical adjustment
     - ✓ Temporally disaggregates gauge precip based on Stage II radar
     - ✓ Limitations: 3-4 day lag in real-time; fairly coarse-resolution grid
  2. NCEP Stage IV precipitation analysis
     - ✓ 4.8-km grid over much of CONUS
     - ✓ Radar rain rates + gauge product produced hourly
     - ✓ Limitations: Odd-shaped polygon grid cuts off Pacific NW, Canada, & northern Mexico, leading to artificial gradients in LIS soil moisture
  3. NSSL National Mosaic QPE (NMQ product)
     - ✓ High-resolution analysis [0.01° (~1 km) grid spacing] over CONUS+
     - ✓ Radar rain rates + gauges similar to Stage IV product
     - ✓ Limitations: Apparent zero values assigned in data-void regions
  4. NESDIS/STAR GOES QPE
     - ✓ High-resolution analysis [~ 4km grid spacing] over western hemisphere
     - ✓ GOES / microwave satellite-based product
     - ✓ Official GOES-R algorithm working group product
     - ✓ Limitations: Like any satellite-based precipitation product, has challenges in stratiform precipitation regions

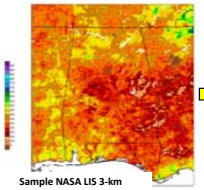
Real-time LIS-Noah at SPoRT over the Southeastern U.S.

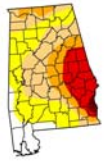
- **LIS running Noah version 3.2 on SPoRT's "weather-in-a-box" cluster:**
  - 910 x 800 dimensions with 3-km grid spacing (see Figures below)
  - Continuously-restarted every 6 hours; originally initialized at 0000 UTC 1 June 2010
  - Static parameters:
    - ✓ MODIS/IGBP 20-class land use; STATSGO 16-class 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: (see diagram at right)
    - ✓ 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


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


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


LIS-Noah sample latent heat flux with overlay of precipitation areas

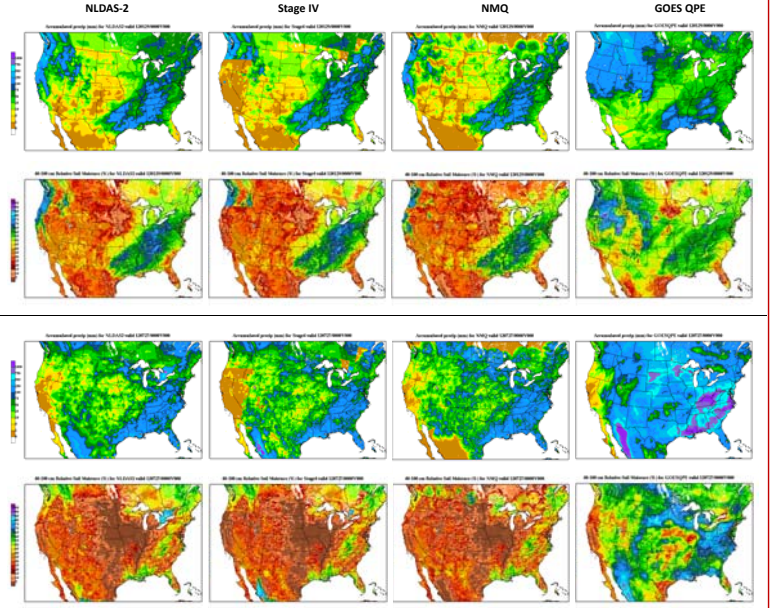

Sample NASA LIS 3-km 0-10 cm soil moisture plot.


U.S. Drought Monitor for the state of Alabama

LIS Configuration for 1-year offline Noah LSM Simulations

- **LIS-Noah version 3.2 simulation from 1 September 2011 to 1 September 2012**
  - Cold-start simulation to inter-compare impacts of different precipitation forcing datasets on 3-km Conterminous U.S. domain
  - First-guess volumetric soil moisture / temperature of 20% and 290 K, respectively, in all Noah LSM layers (0-10, 10-40, 40-100, and 100-200 cm)
- **Atmospheric forcing datasets**
  - 2-m T/q, 10-m winds, surface pressure, downward short- & long-wave radiation:
    - ✓ Background data from GDAS for whole domain
    - ✓ Over-ridden by NLDAS-2 variables from 25 to 52°N latitude and -125 to -67°E longitude
  - Precipitation forcing experiments:
    - (1) Control LIS: GDAS 3-hourly precipitation + hourly NLDAS-2 precipitation
    - (2) Stage IV run: Same as (1) , except replacing precipitation with Stage IV where available
    - (3) NMQ run: Same as (1), except replacing precipitation with NMQ where available
    - (4) GOES QPE run: Same as (1), except replacing precipitation with GOES QPE where available
- **Parameters common to all LIS simulations**
  - Soil/land-use type: STATSGO 16-class soil and MODIS/IGBP 20-class land use
  - Green Vegetation Fraction: SPoRT/MODIS real-time 1-km CONUS data, updated daily

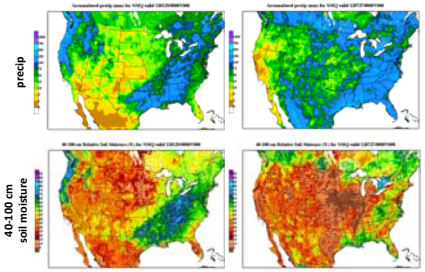
Comparison of Monthly Accumulated Precipitation and LSM Fields



Discussion Points

- Radar / gauge-based analyses have similar precip patterns east of Rockies in CONUS
  - NLDAS-2 analysis is too wet in southern Ontario in July, related to NARR analyses and is currently under investigation
  - Stage IV has problem areas in southeastern Canada and in the western U.S. where the grid cuts off and/or has missing data contributing to erroneously low precip values
  - NMQ appears to improve precip over the intermountain West, but clearly has radar beam blockage issues and data cut-off problems in Mexico and Canada
  - The GOES QPE product results in over-representation of precip in both coverage and intensity
- Precipitation analyses directly translate to root-zone soil moisture patterns
  - NLDAS-2, Stage IV, & NMQ capture Midwest Drought
  - GOES QPE soil moisture result is much more moist except over California
- Some type of blended precip forcing needed
  - Retain strengths of individual precipitation analysis
  - Fill gaps and remove discontinuities

Special NMQ Experiment: NLDAS-2 background precip ; NMQ only if > 0



Replacing NLDAS-2 with NMQ only when NMQ > 0 helps to eliminate the data gaps in Mexico and Canada, as well as the radar beam blockage in the intermountain West. Solution is slightly wetter than original NMQ run, but has better spatial continuity and preserves major features in soil moisture fields. Compare to images above at the same two times in the LIS run.

Poster Summary and Future Work

- **Summary and Conclusions**
  - Configured LIS to run with four different precipitation forcing datasets for a 1-year integration period
    - ✓ NLDAS-2, Stage IV, NMQ, and GOES QPE
    - ✓ Col-started Noah LSM within LIS from 1 Sep 2011 to 1 Sep 2012
  - Radar+gauge based products were similar to one another in the eastern U.S. (due to good radar and gauge coverage)
    - ✓ NLDAS-2, Stage IV, and NMQ
    - ✓ NMQ showed most detail due to highest product resolution
    - ✓ All three depicted Midwest drought well in root-zone soil moisture
  - Like most satellite products, GOES QPE over-represented precip coverage & intensity, making soil too moist
- **Follow-on efforts**
  - Validate LIS-Noah analyses against available soil moisture observations (e.g. Soil Climate Analysis Network) by computing error statistics such as RMSE and anomaly correlation
  - Expand real-time SPoRT-LIS runs to CONUS+ domain using optimal blend of precipitation forcing
  - Seek further improvements in SPoRT-LIS by assimilating satellite-based soil moisture, snow, and/or skin temperature retrieval products, as available in real time
  - Ultimate solution may be a combination of improved precip forcing and data assimilation methodologies