Using the NASA Land Information System for Improved Water Management and an Enhanced Famine Early Warning System

Christa Peters-Lidard

Chief, Hydrological Sciences Laboratory, NASA/GSFC

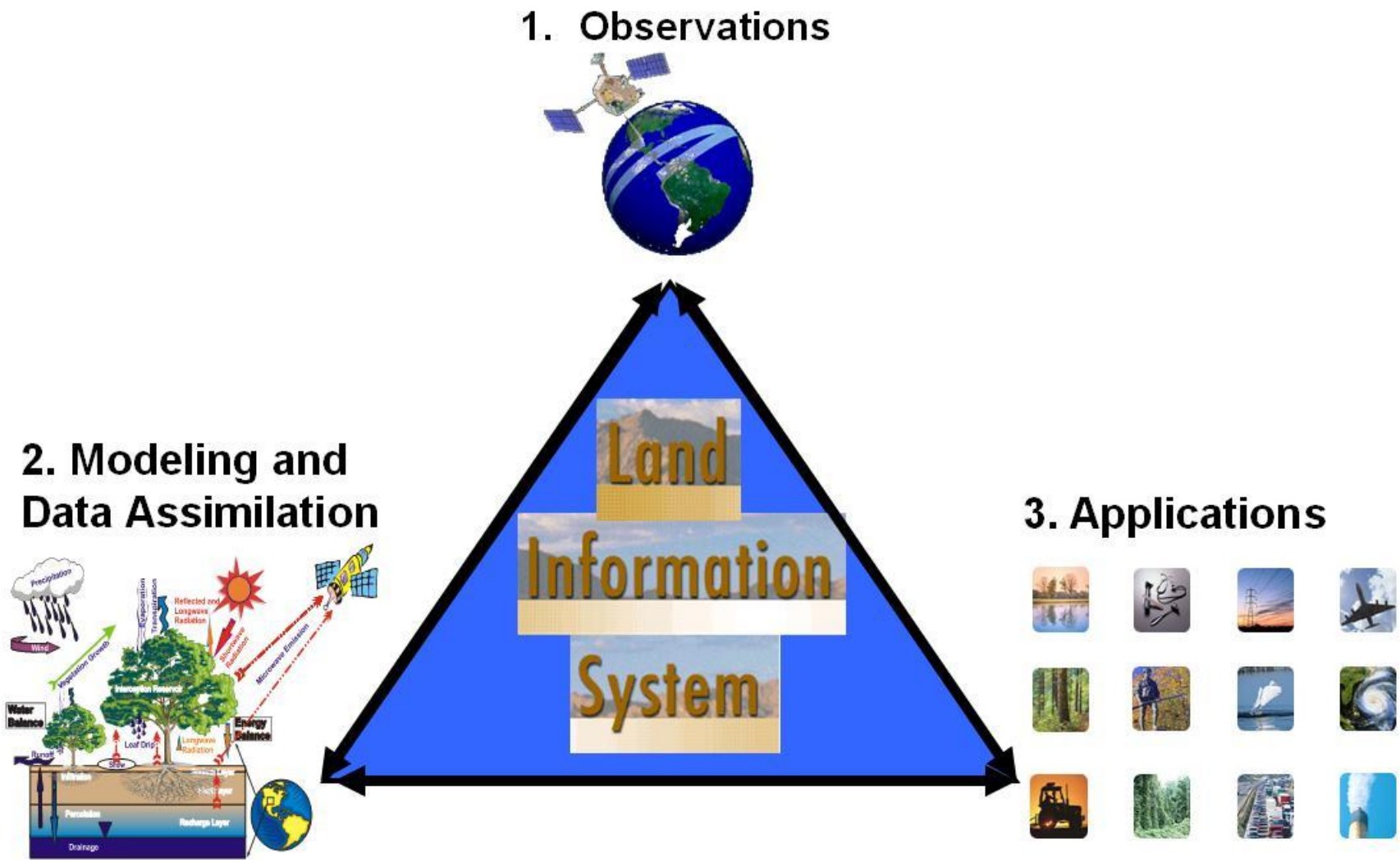
World Bank "Ignite" Talk: 29 February 2012

Acknowledgements:

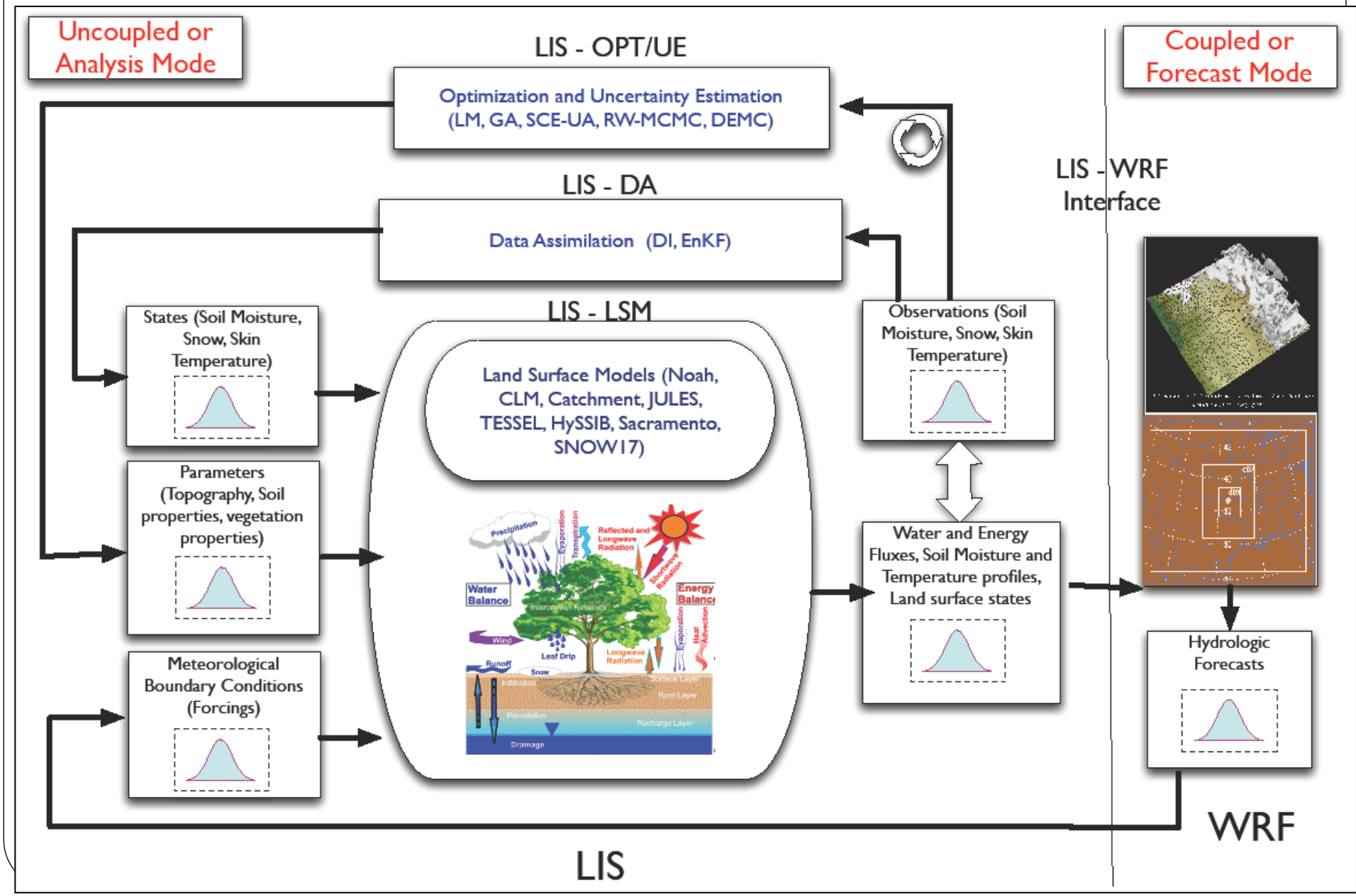
The LIS Team

Collaborators at AFWA, USACE/CRREL, NOAA/NCEP and USGS/EROS

The Land Information System (LIS; http://lis.gsfc.nasa.gov) Integrates Observations, Models and Applications to Maximize Impact



LIS Capabilities



Developing LIS Land Data Assimilation Capabilities

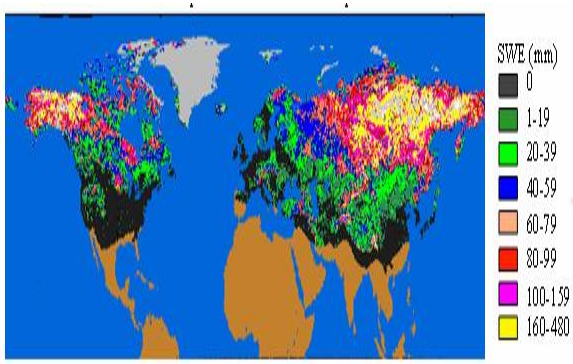
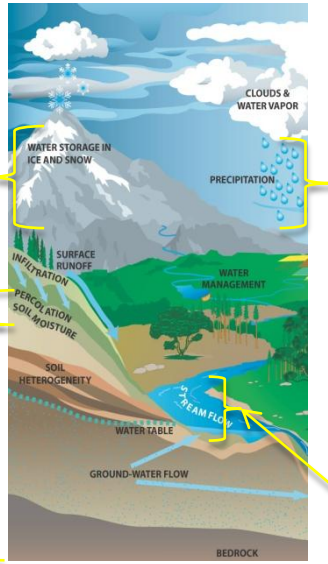


Figure 1: Snow water equivalent (SWE) based on Terra/MODIS and Aqua/AMSR-E. Future observations will be provided by JPSS/VIIRS and DWSS/MIS.



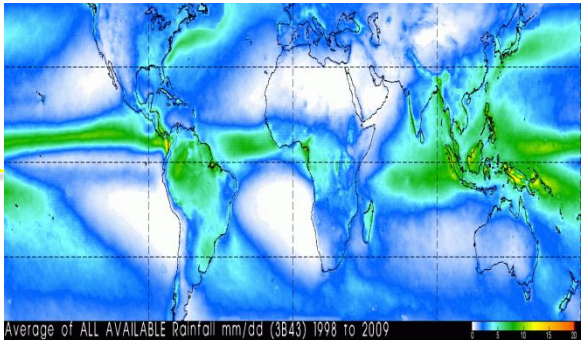


Figure 2: Annual average precipitation from 1998 to 2009 based on TRMM satellite observations. Future observations will be provided by GPM.

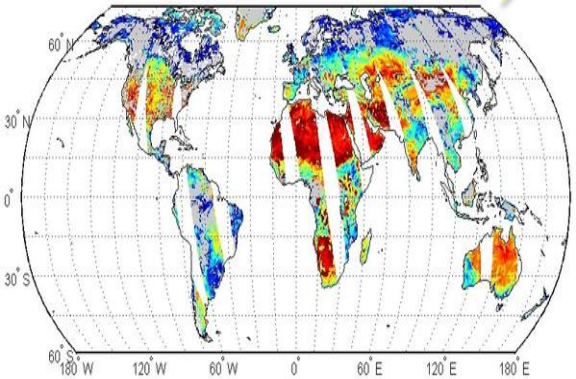


Figure 3: Daily soil moisture based on Aqua/AMSR-E. Future observations will be provided by SMAP.

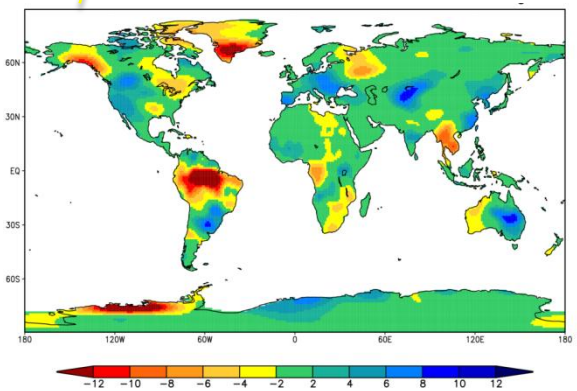


Figure 4: Changes in annual-average terrestrial water storage (the sum of groundwater, soil water, surface water, snow, and ice, as an equivalent height of water in cm) between 2009 and 2010, based on GRACE satellite observations. Future observations will be provided by GRACE-II.

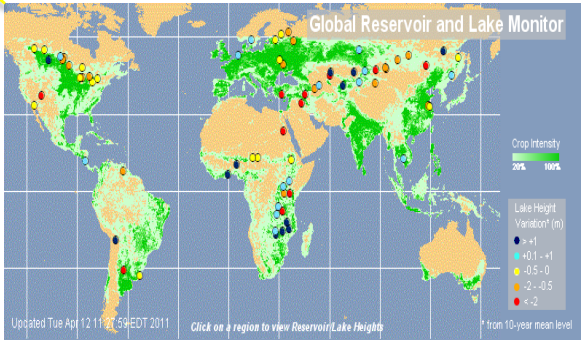
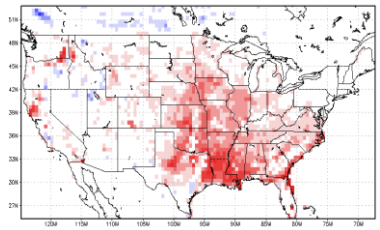


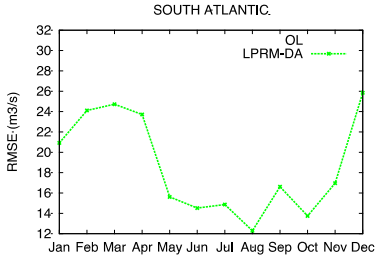
Figure 5: Current lakes and reservoirs monitored by OSTM/Jason-2. Shown are current height variations relative to 10-year average levels. Future observations will be provided by SWOT.

NASA Observations, LIS, and Impacts

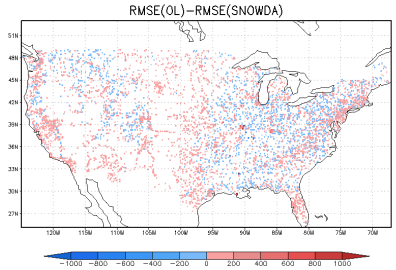
- AMSR-E Surface Soil Moisture ->
  - Root Zone Soil Moisture
  - Evapotranspiration
  - Streamflow
    - Downstream Impact: Agricultural, Meteorological Droughts

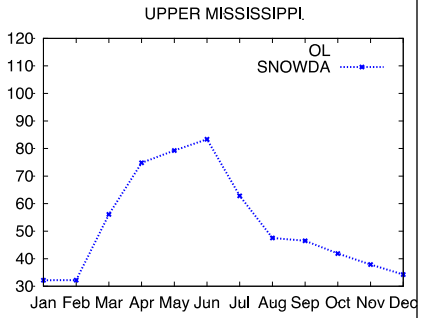
MAM



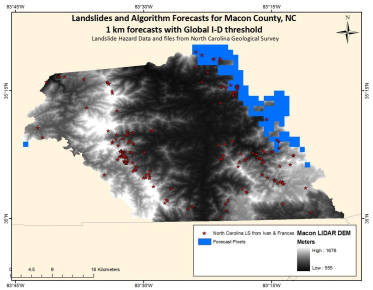


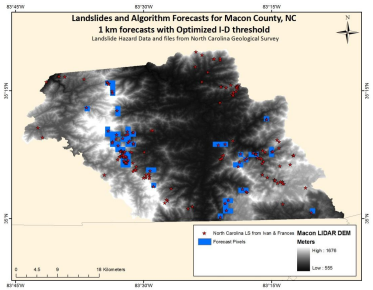
- AMSR-E Snow Water Equivalent ->
  - Snow Depth
  - Streamflow
    - Downstream Impact: Floods





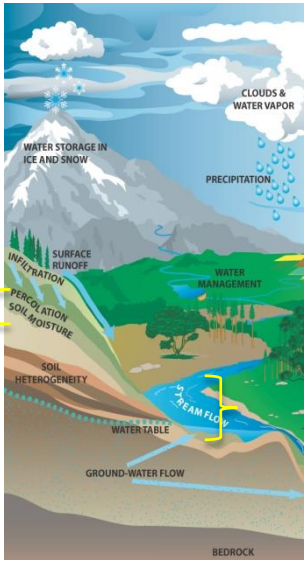
- TRMM-based precipitation ->
  - Slope Instability
    - Downstream Impact: Landslides





Backup

Soil Moisture Data Assimilation



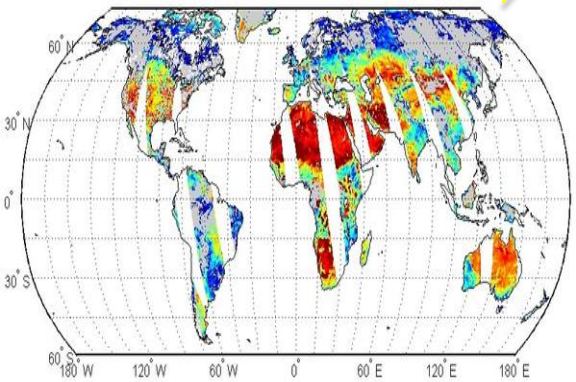


Figure 3: Daily soil moisture based on Aqua/AMSR-E. Future observations will be provided by SMAP.

Impact Assessment:

- Drought

Variables Analyzed:

- Soil Moisture
- Steamflow
- Evapotranspiration

Experimental Setup:

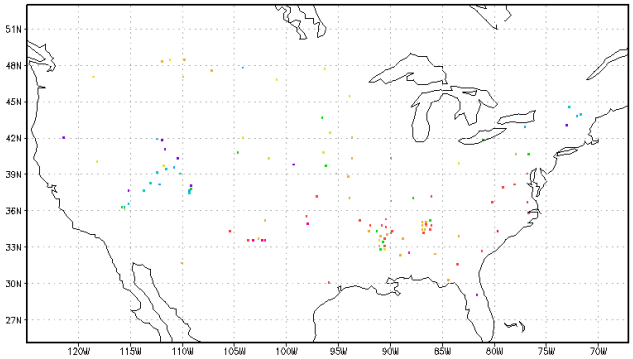
- Domain: CONUS, NLDAS
- Resolution: 0.125 deg.
- Period: 2002-01 to 2010-01
- Forcing: NLDASII
- LSM: Noah 3.2

Data Assimilation:

- AMSR-E LPRM soil moisture
- AMSR-E NASA soil moisture

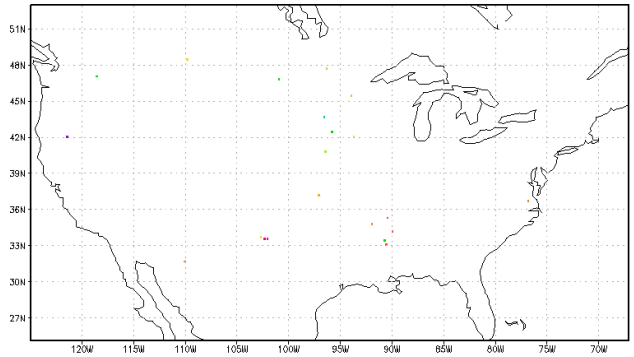
Soil moisture Assimilation -> Soil moisture (Evaluation vs SCAN)

ALL available stations (179)



Anomaly correlation	OL	NASA-DA	LPRM-DA
Surface soil moisture (10cm)	0.55 +/- 0.01	0.49 +/- 0.01	0.56 +/- 0.01
Root zone soil moisture (1m)	0.17 +/- 0.01	0.13 +/- 0.01	0.19 +/- 0.01

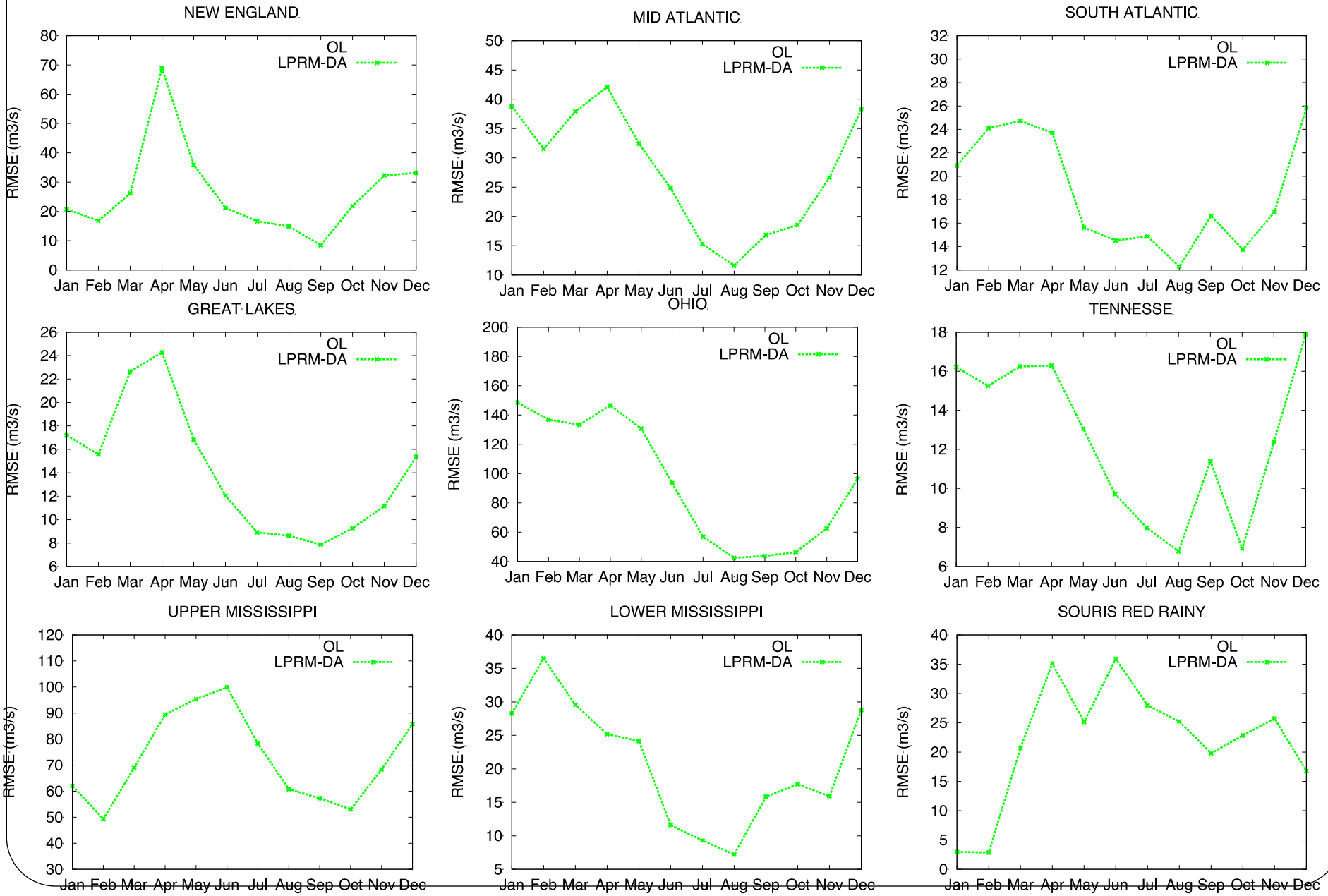
(21) Stations listed in Reichle et al.



Anomaly correlation	OL	NASA-DA	LPRM-DA
Surface soil moisture (10cm)	0.62 +/- 0.05	0.53 +/- 0.05	0.62 +/- 0.05
Root zone soil moisture (1m)	0.16 +/- 0.05	0.13 +/- 0.05	0.19 +/- 0.05

Soil Moisture Assimilation -> Streamflow Evaluation vs. USGS gauges – by major basins

Soil Moisture Assimilation -> Streamflow
(average seasonal cycles of RMSE– using Xia et al. (2011) stations)



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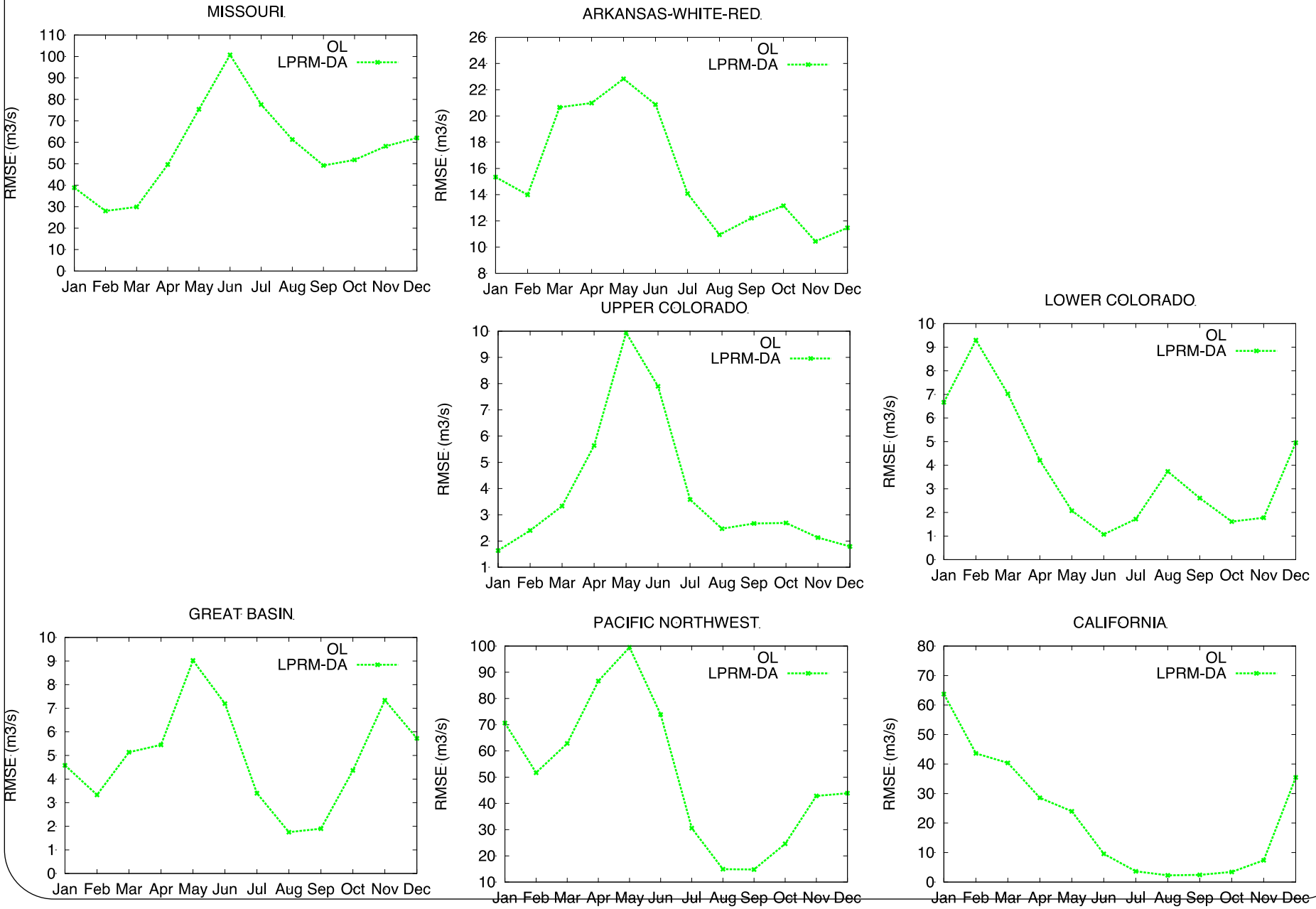
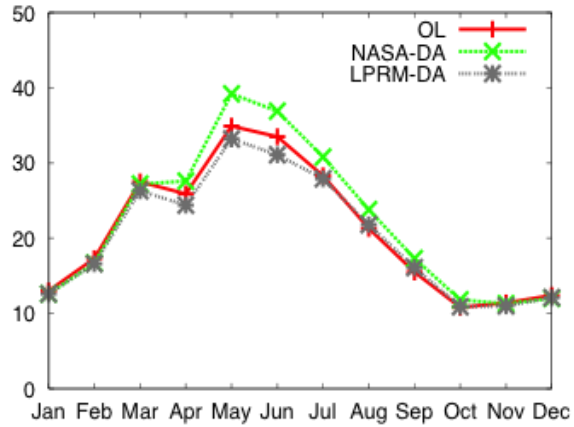
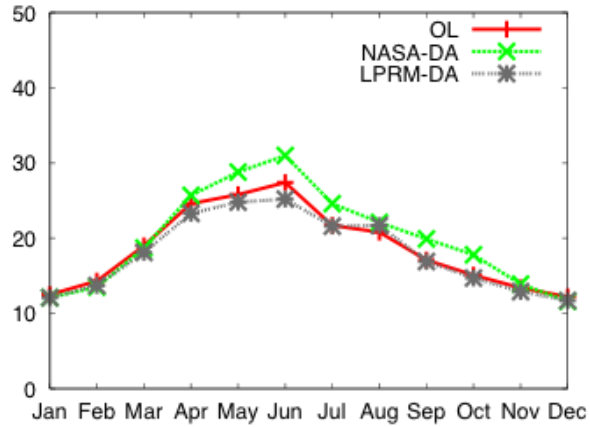


Soil Moisture Assimilation -> Latent Heat Flux

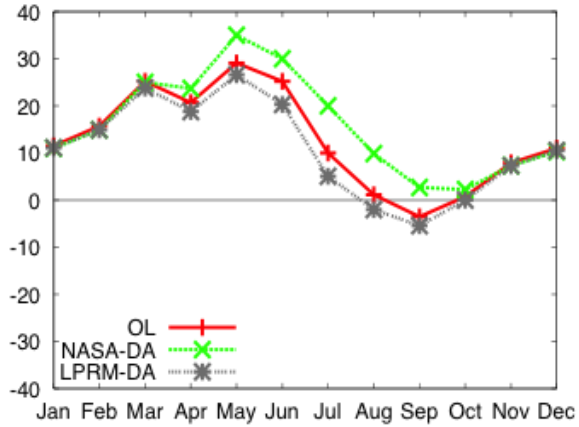
FLUXNET **MOD16**

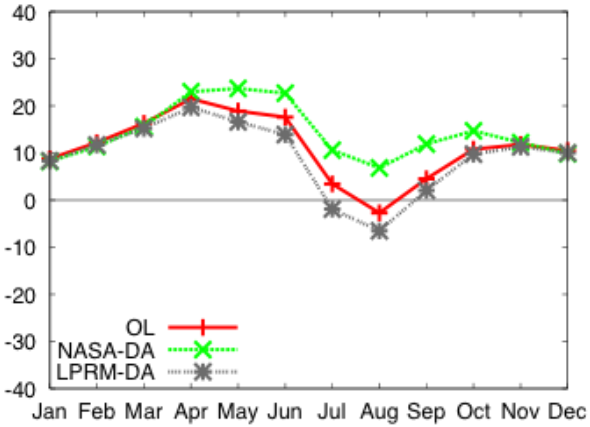
RMSE





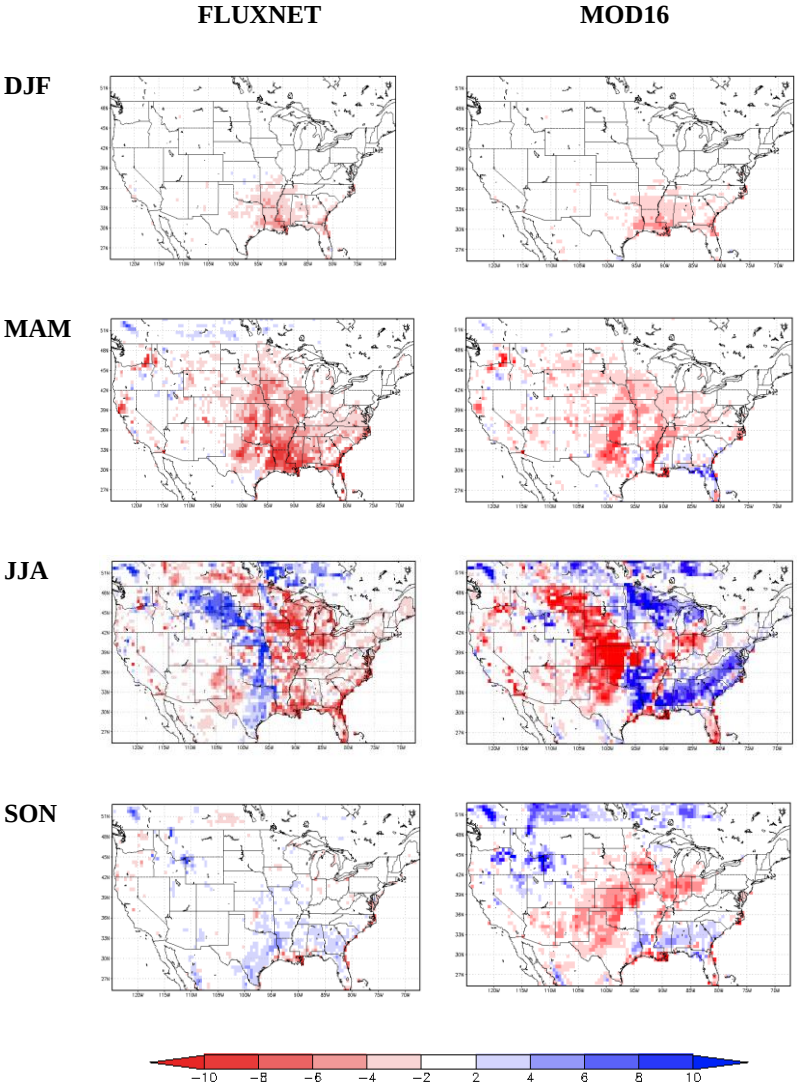
Bias



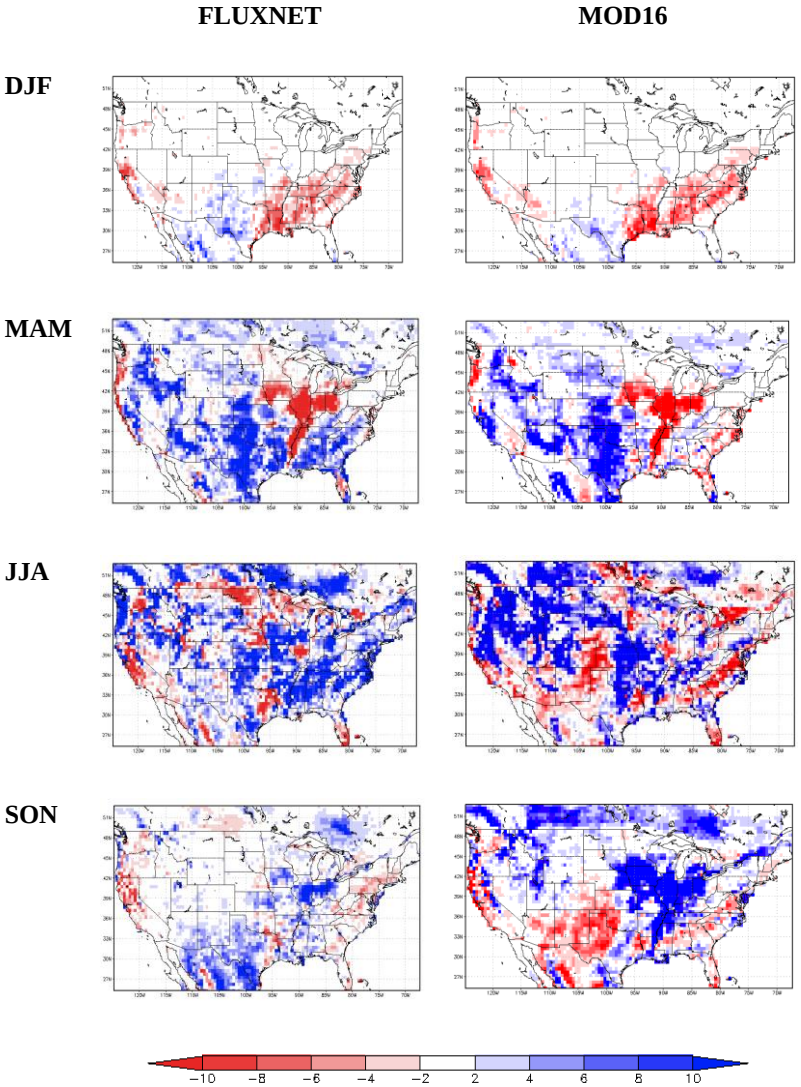


Peters-Lidard, Christa D., Sujay V. Kumar, David M. Mocko and Yudong Tian, (2011), Estimating Evapotranspiration with Land Data Assimilation Systems, In press, *Hyd. Proc*.

Where Does Soil Moisture Assimilation Help Improve Qle (i.e. Reduce RMSE) ?

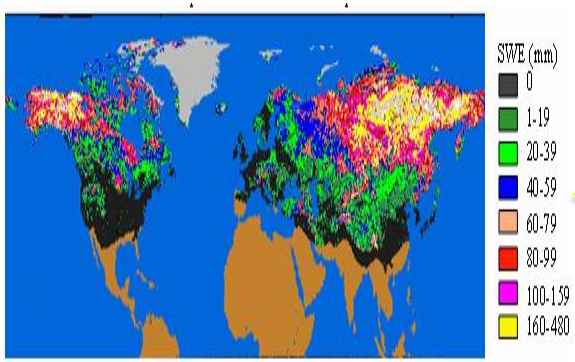


LPRM-DA



NASA-DA

Snow Data Assimilation



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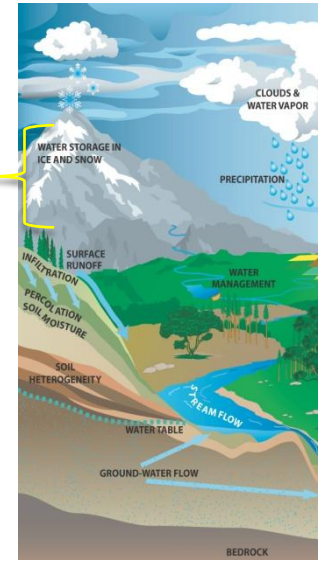

Impact Assessment:

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Experimental Setup:

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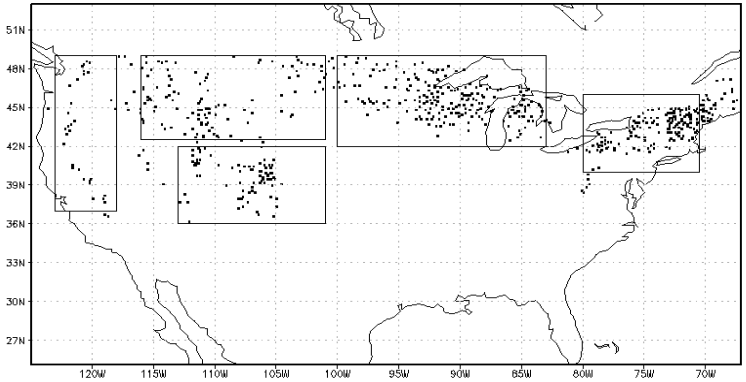
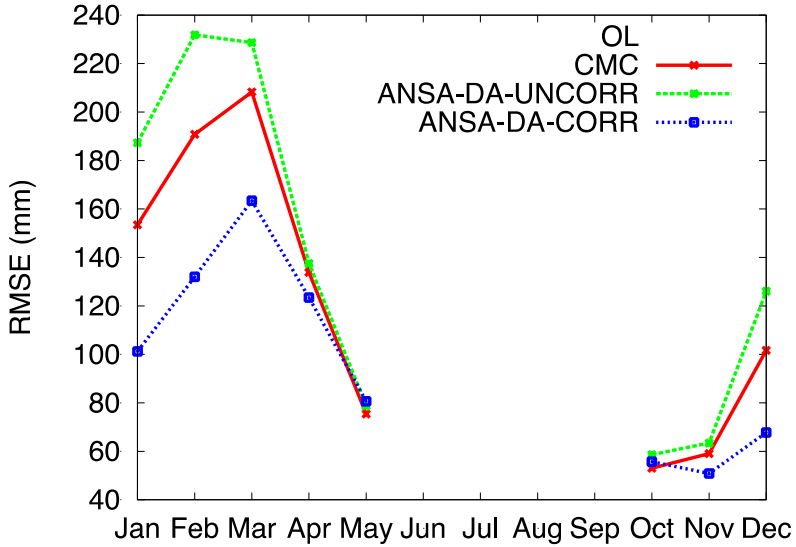
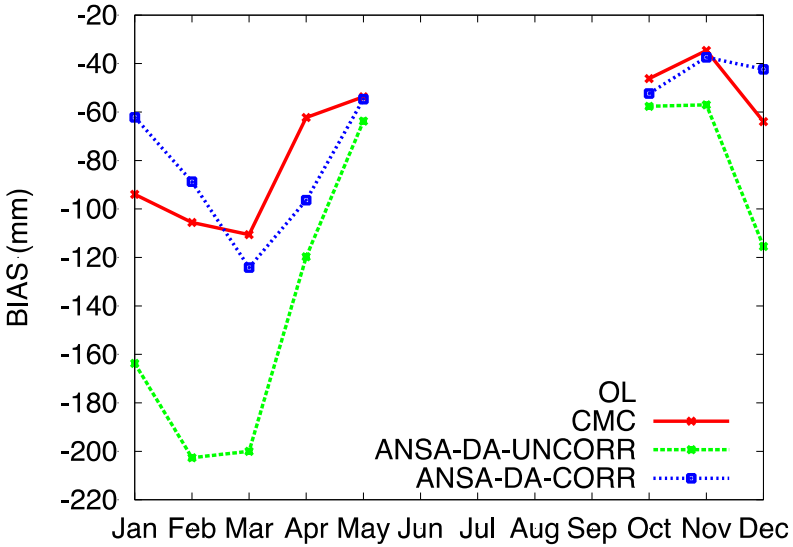
Data Assimilation:

- AMSR-E snow depth
- AMSR-E bias corrected
- snow depth



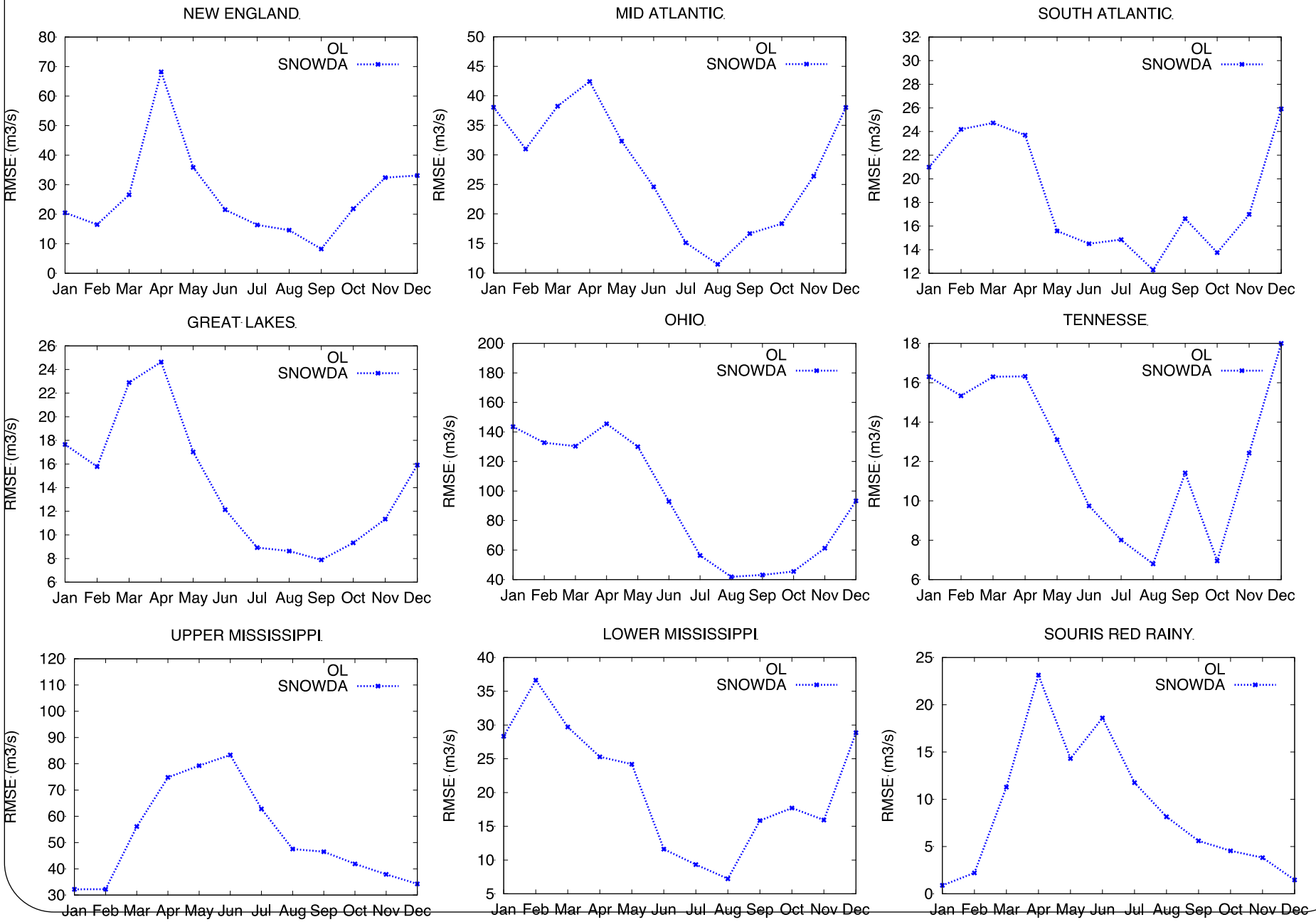
Snow Assimilation -> Snow Depth (Evaluation vs COOP)





	RMSE(mm)	Bias (mm)	R
OL	212 +/- 10.0	-130.0 +/- 11.0	0.63 +/- 0.01
CMC	197 +/- 8.0	-85.9 +/- 8.0	0.70 +/- 0.01
ANSA-DA-UNCORR	233 +/- 10.0	-159 +/- 10.0	0.53 +/- 0.01
ANSA-DA-CORR	152 +/- 9.0	-77.6 +/- 8.0	0.77 +/- 0.01

Snow Assimilation -> Streamflow
(average seasonal cycles of RMSE– using Xia et al. (2011) stations)



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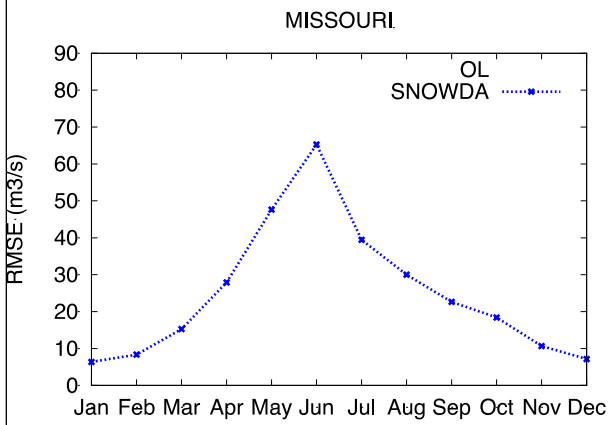
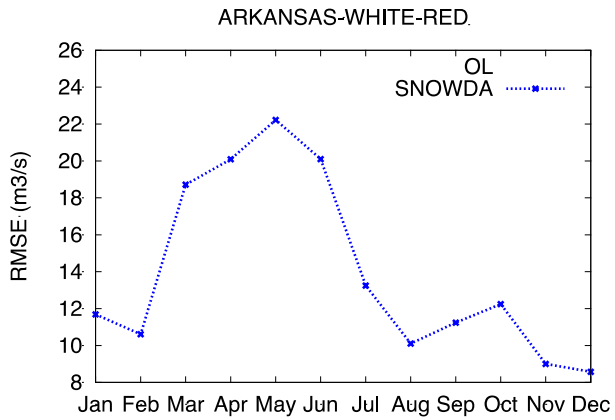
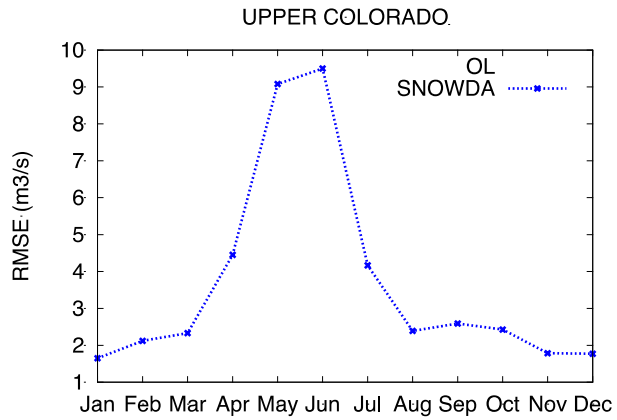
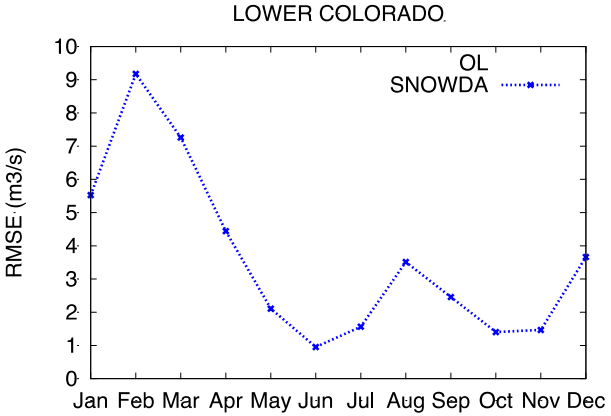
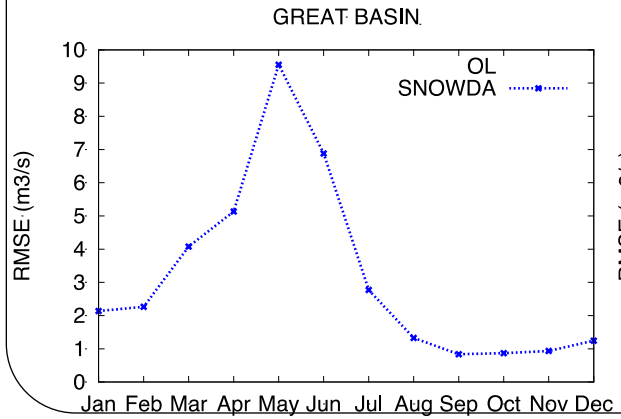


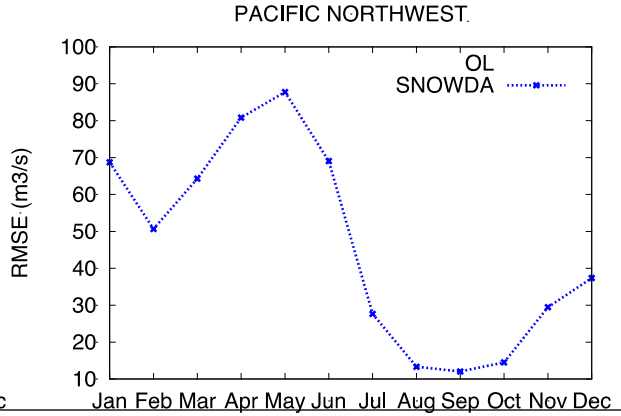


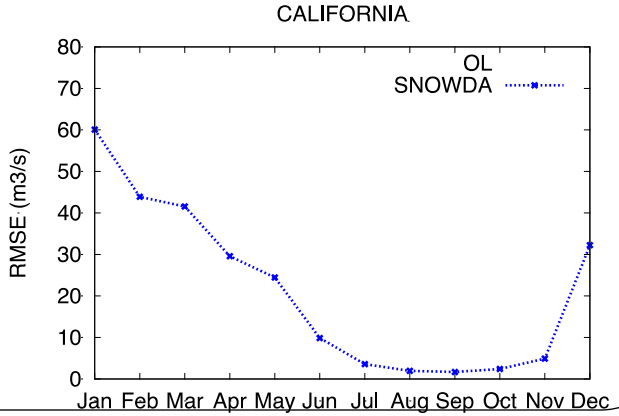
Snow DA shows improvements during the melt periods
-E.g., New England, Upper Mississippi, Souris Red Rainy, Missouri, Arkansas



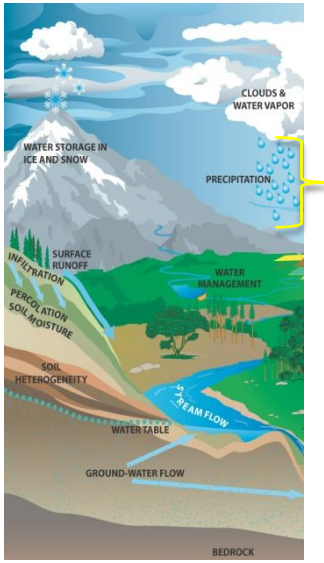








TRMM Precipitation -> Landslides



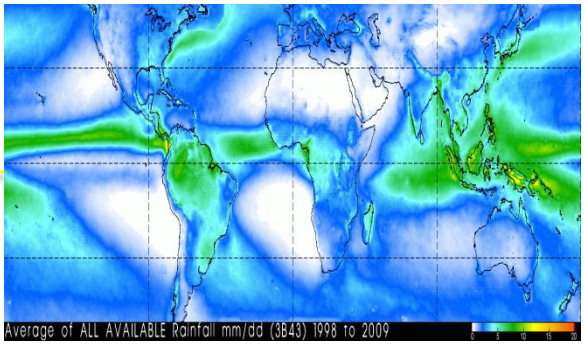
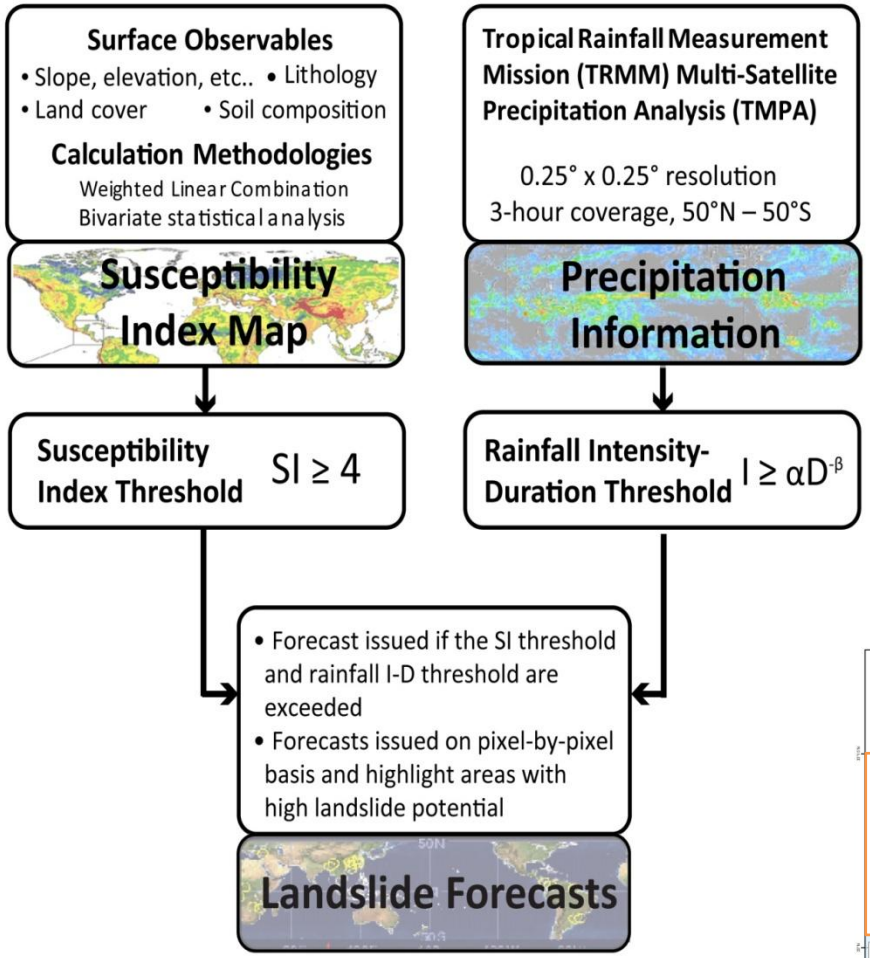


Figure 2: Annual average precipitation from 1998 to 2009 based on TRMM satellite observations. Future observations will be provided by GPM.

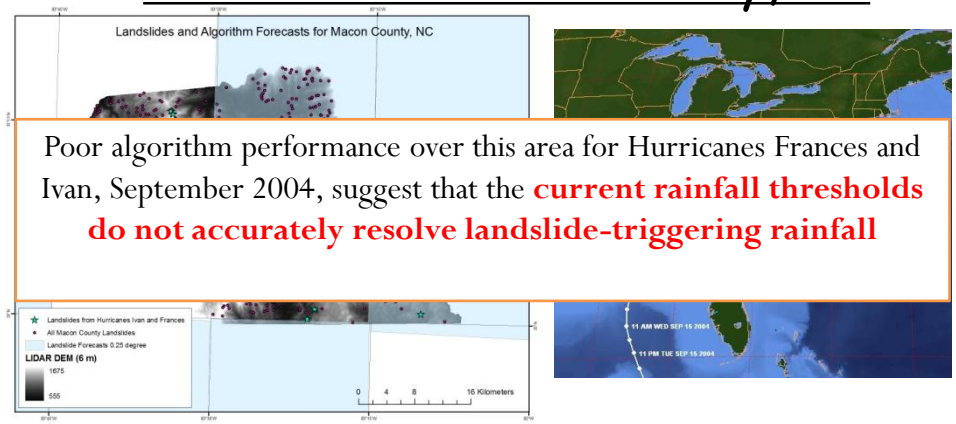
Remotely Sensed Precipitation -> Landslides
Rainfall threshold-based landslide prediction model



Algorithm currently running in near real-time at following website:
http://trmm.gsfc.nasa.gov/publications_dir/potential_landslide.html

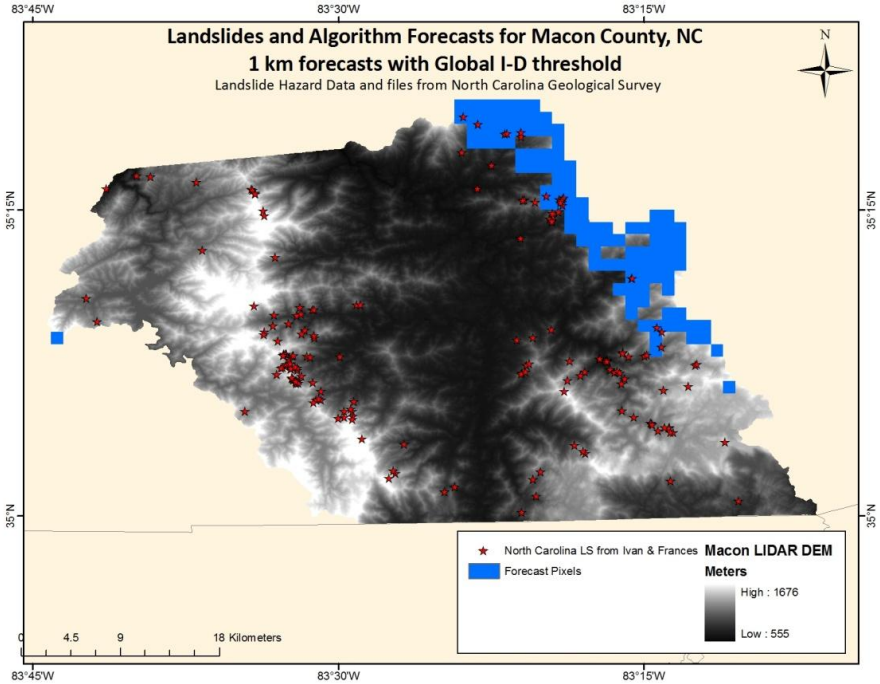
- Couples a static susceptibility map with precipitation real-time forcings from Tropical Rainfall Measuring Mission (TRMM)
- When both susceptibility and rainfall intensity-duration thresholds are exceeded, a forecast is issued indicating landslide potential

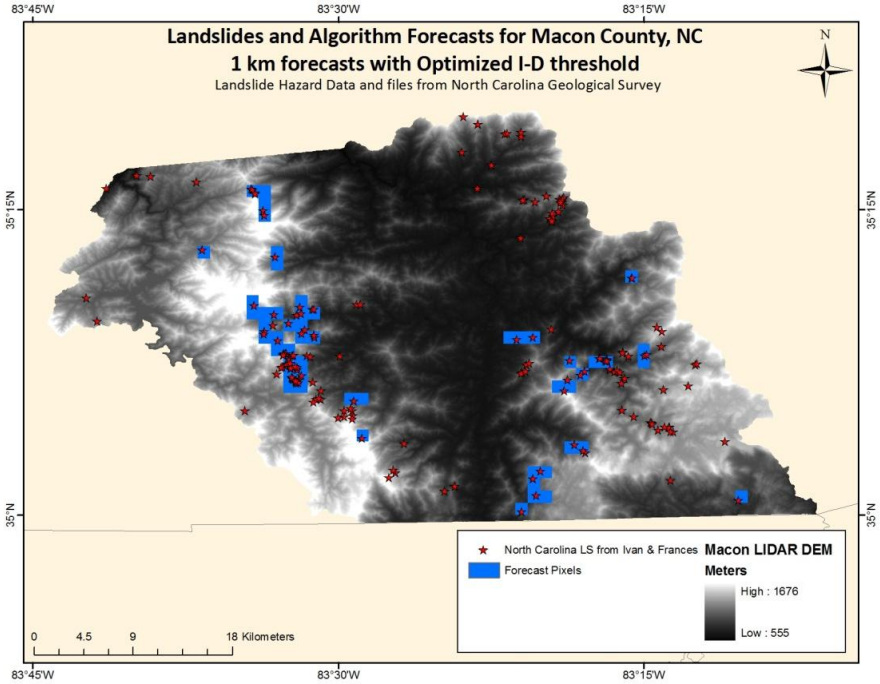
Test Case: Macon County, NC



Poor algorithm performance over this area for Hurricanes Frances and Ivan, September 2004, suggest that the **current rainfall thresholds do not accurately resolve landslide-triggering rainfall**

Improved landslide model performance with optimized rainfall thresholds





	Probability of detection (POD)	False Alarm Ratio (FAR)
Default model	4.2 %	99.1 %
Optimized model	20.8 %	88.7 %

★ Landslide inventory from Hurricanes Frances and Ivan in September, 2004

Summary

- Remotely sensed soil moisture, snow and precipitation can be useful for hazard assessment

- LPRM AMSR-E Soil moisture assimilation can improve soil moisture, streamflow and evapotranpiration -> Drought

- Bias-corrected AMSR-E Snow depth assimilation improves snow depth and streamflow-> Floods

- TRMM-based precipitation inputs can be useful for landslide detection, given calibrated thresholds ->Landslides