US National Cropland Soil Moisture Monitoring using SMAP

Zhengwei Yang, Rick Mueller
UDSA/NASS/RDD
Genong Yu, Liping Di
CSISS, George Mason University

Purpose

- This project "US national cropland soil moisture monitoring using SMAP" is
  - To study the feasibility of using SMAP mission results to support US national crop condition monitoring and other NASS operational data needs, such as crop yield modeling needs;
  - To improve NASS cropland soil moisture monitoring results in consistency, reliability, objectivity and efficiency;
  - To reduce survey cost and burden.

Planed NASS Project Task

- Engage in pre-launch research that will enable integration of SMAP data after launch in their application as described in MOA;
- Complete the project with quantitative metrics prior to launch;
- Join the SMAP Applications Team to participate in discussions of SMAP mission data products related to application needs;
- Participate in the implementation of the SMAP Mission Applications Plan by taking lead roles in SMAP applications research, meetings, workshops, and related activities.

Project Goal

- Based on the feasibility of application of SMAP data products, we will explore to build a remote sensing based soil moisture monitoring system prototype. This system may utilize
  - SMAP data products, such as L3SM_A/P, L4_SM, or L1C-S0_HiRes;
  - Derived weekly high spatial resolution soil moisture data products – SMAP data fused results with other remote sensing data such as MODIS products.
- The calibrated and validated soil moisture product will be published and disseminated to end users via web service based application system for NASS operations

NASS Crop Condition Monitoring

- NASS publishes weekly crop progress and condition report; soil moisture condition is part of crop condition report.
- NASS currently monitors crop soil moisture condition by weekly field observations for counties in 45 states.
- State-level estimates of observed topsoil and subsoil moisture are published weekly during the growing season.
- Soil moisture reports are:
  - Subjective and qualitative measurement;
  - Not precise in measurement and geospatial;
  - Not consistent, unreliable and inefficient;
  - Field observation is from volunteers;
  - Operational cost expensive and survey burden;
  - Descriptive report.

NASS Soil Moisture Condition Report

Days Suitable & Soil Moisture Condition as of September 25, 2011

Item	Districts									State
	NW	NC	NE	WC	C	EC	SW	SC	SE	
	(Days)	(Days)	(Days)	(Days)	(Days)	(Days)	(Days)	(Days)	(Days)	(Days)
Days suitable	6.2	5.7	5.4	6.7	6.5	6.0	5.9	6.5	6.9	6.2
	(Percent)	(Percent)	(Percent)	(Percent)	(Percent)	(Percent)	(Percent)	(Percent)	(Percent)	(Percent)
Topsoil moisture										
Very short	23	13	12	8	23	5	0	21	42	16
Short	42	40	24	39	31	26	7	49	42	34
Adequate	35	46	59	52	44	69	87	29	16	48
Surplus	0	1	5	1	2	0	6	1	0	2
										14
										34
										51
										1

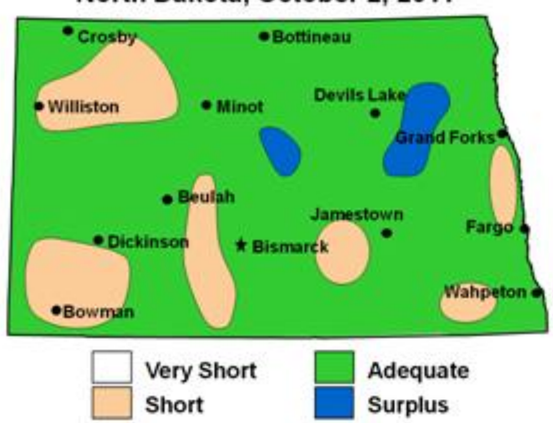
NORTH DAKOTA CROP WEATHER REPORT, Week Ending October 2, 2011 — Page Two

Soil Moisture Supplies – North Dakota

Item	Oct 2, 2011	Sept 25, 2011	Oct 2, 2010	2006-2010 Average
	(percent)	(percent)	(percent)	(percent)
Topsoil				
Very Short.....	2	1	-	8
Short..........	19	15	4	23
Adequate......	72	74	82	63
Surplus.........	7	10	14	6
Subsoil				
Very Short	1	1	-	13
Short	10	9	5	24
Adequate......	75	73	80	57
Surplus.........	14	17	15	6

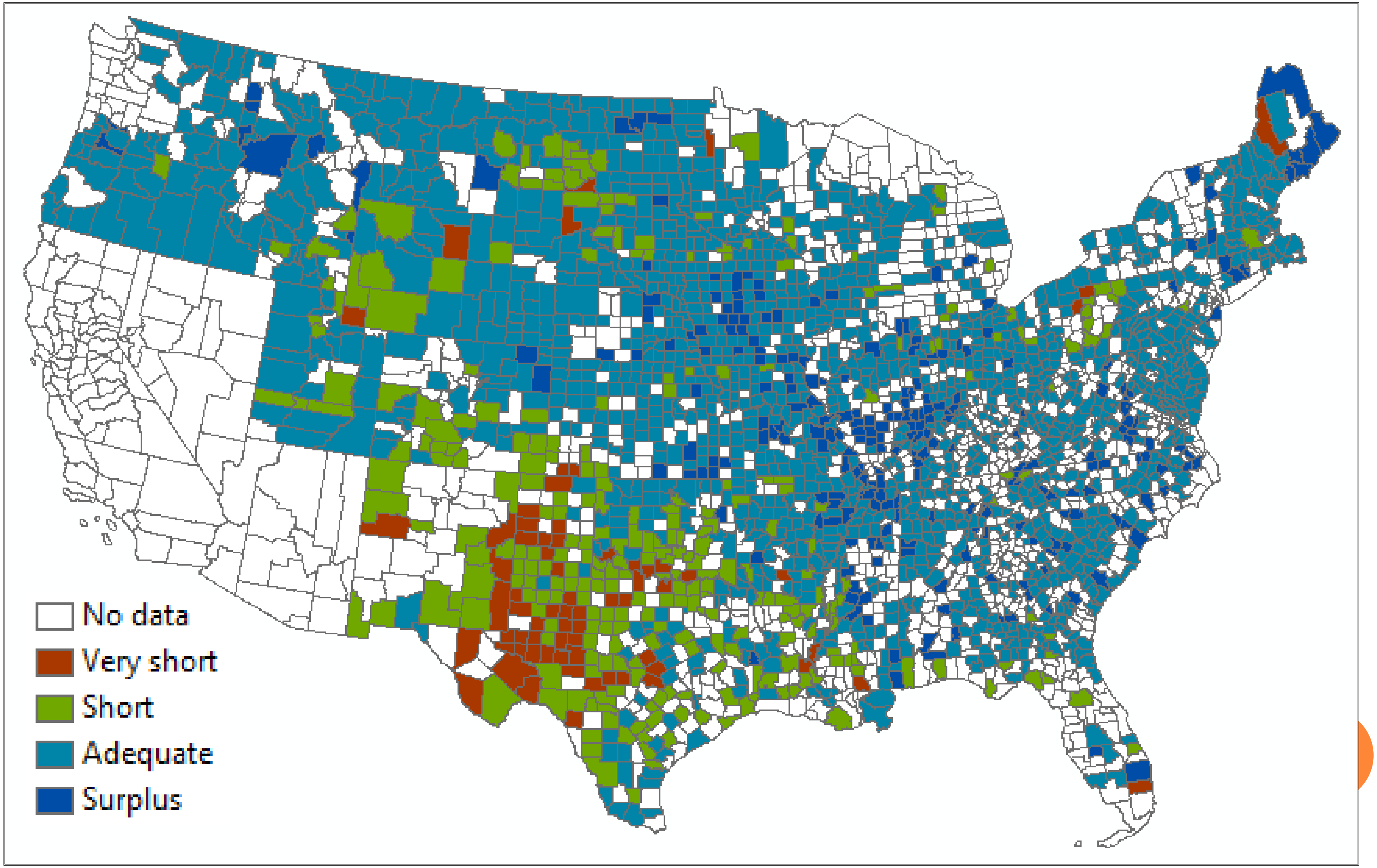
- Represents zero.

Topsoil Moisture Supplies
North Dakota, October 2, 2011



Subsoil Moisture Supplies
North Dakota, October 2, 2011

NASS Survey Based Soil Moisture (Week of May 4, 2003)



NASS' REQUIREMENTS

- Objective and quantitative soil moisture measurement;
- High resolution national geospatial coverage;
- Georeferenced monitoring;
- At least Sub-county resolution monitoring;
- Automatic data collection, processing and publishing;
- Online visualization and dissemination;
- Consistent, reliable, efficient and low cost;
- ALL these requirements can be achieved by a **remote sensing based monitoring system**!

Challenges

- How to produce higher spatial resolution products for surface and root-zone soil moisture monitoring;
- Large scale ground truth calibration – quantify NASS' soil moisture condition and correlate it with sensor's measurement;
- Large scale ground truth Validation.

Our Approach

- The possible solutions include:
  - Use data fusion and assimilation to down-scale the SMAP product;
  - New quantitative metrics will be developed and correlated with SMAP's measurements under various conditions to improve the current qualitative descriptions of soil moisture.
  - Establish a large scale sensor network on crop land to continuously collect ground truth data.
- NASS National Cropland Data Layer(CDL) will be utilized to identify specific agricultural areas.
- A web service based geospatial application system will be developed to publish and disseminate the calibrated and validated soil moisture product to end users.
- Collaboration partners such as The Center for Spatial Information Science and Systems (CSISS) of George Mason University and the Hydrology and Remote Sensing Lab in USDA's Agricultural Research Service will be sought if funding support becomes available.

Foreseeable requirements for pre-launch data products and plans for field experiment demonstration

- Develop our capacity to ingest SMAP data products in their native format;
- Plan the required SMAP downscaling and calibration research;
- Facilitate the design of a potential ground truth network.

PLANED MILESTONES AND QUANTITATIVE METRICS

Phase 1: June 2011 – Dec 2011

1) Establish data retrieval, converting utility to test the SMAP data accessibility and format compatibility.
2) Examining SMAP simulated data or SMOS for possible processing capability including hardware, software and functional processing utility development.

Phase 2: Dec 2011 – Dec 2012

1) Developing quantitative metrics for qualitative USDA NASS soil moisture survey data.
2) Using SMOS to cross-examine the soil moisture against USDA NASS survey based county level soil moisture data.
3) Seek funding for ground truth data collection.
4) Evaluating the impacts of 3km and 10km resolution SMAP data on the accuracy of the county level soil moisture assessment.

PLANED MILESTONES AND QUANTITATIVE METRICS (CONT. I)

Phase 3: Dec 2012 – Dec 2013

1) Collecting business requirements for US National Cropland Soil Moisture Monitoring System (NCSMMS).
2) Developing US National Cropland Soil Moisture Monitoring System design specification and system architecture.
3) Prototyping NCSMMS including data visualization and dissemination.
4) Evaluating the existing methods for SMAP data spatial resolution downscaling.
5) Developing method(s) for producing higher spatial resolution SMAP based surface and root-zone soil moisture products by using data fusion and assimilation to down-scale the SMAP products.

PLANED MILESTONES AND QUANTITATIVE METRICS (CONT. II)

Phase 4: Dec 2013 – Dec 2014

1) Continuing the spatial resolution method development and implementation.
2) Developing a ground truth network prototype, if funding is available, including topsoil and subsoil (root zone) moisture measurements.
3) Developing the plan and procedure for large scale ground truth calibration and validation of remotely sensed data and assessing the added utility of SMAP soil moisture estimates above and beyond our current baseline monitoring capability.
4) Planning after launching research and possible operational implementation.

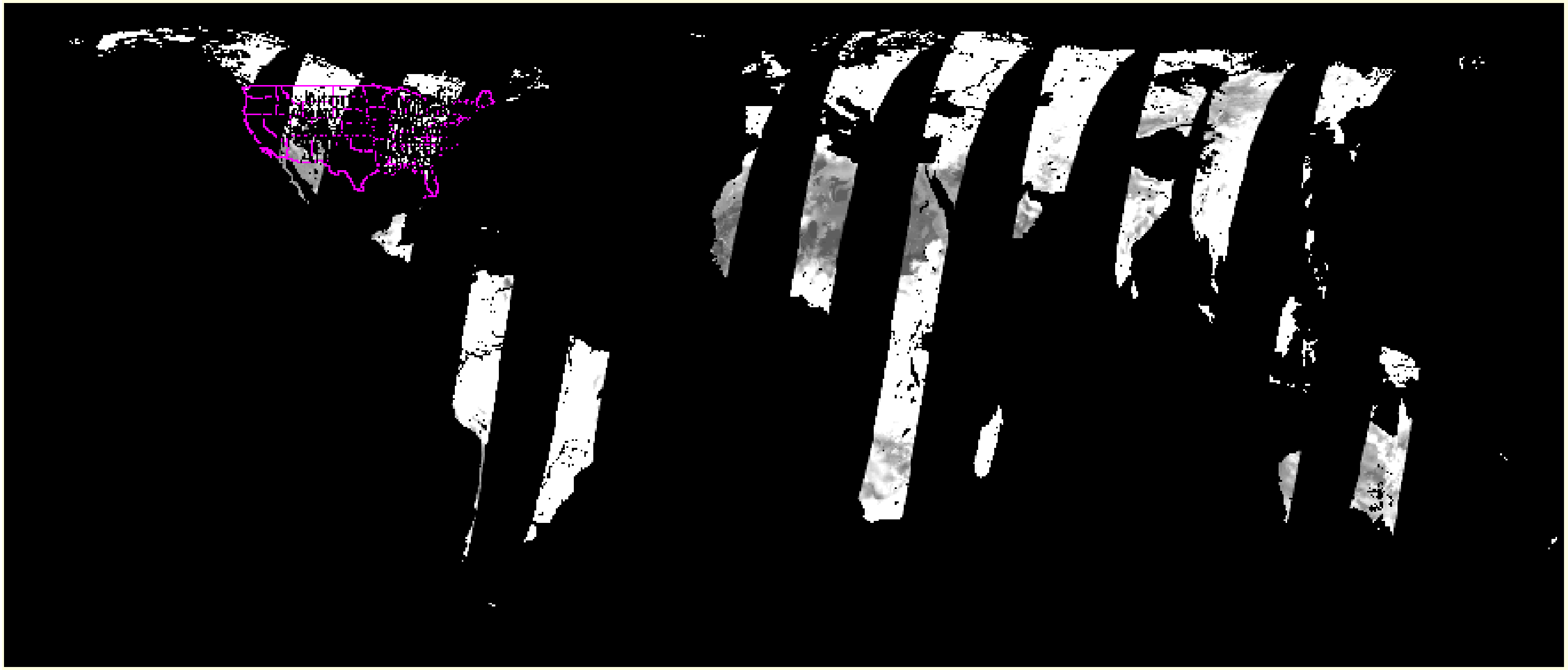
Post-launch implementation strategy

- Large scale validation network will be established before full implementation;
- Comprehensive assessment of the post-launch SMAP data will be conducted;
- Plans will be made to fully develop the prototype with a regional scale into an operational environment jointly with a NASS Crop Progress, Condition, and Natural Disaster Assessment program;
- Appropriated funding will be pursued to allow implementation of this program.

SMAP Level 3 Data

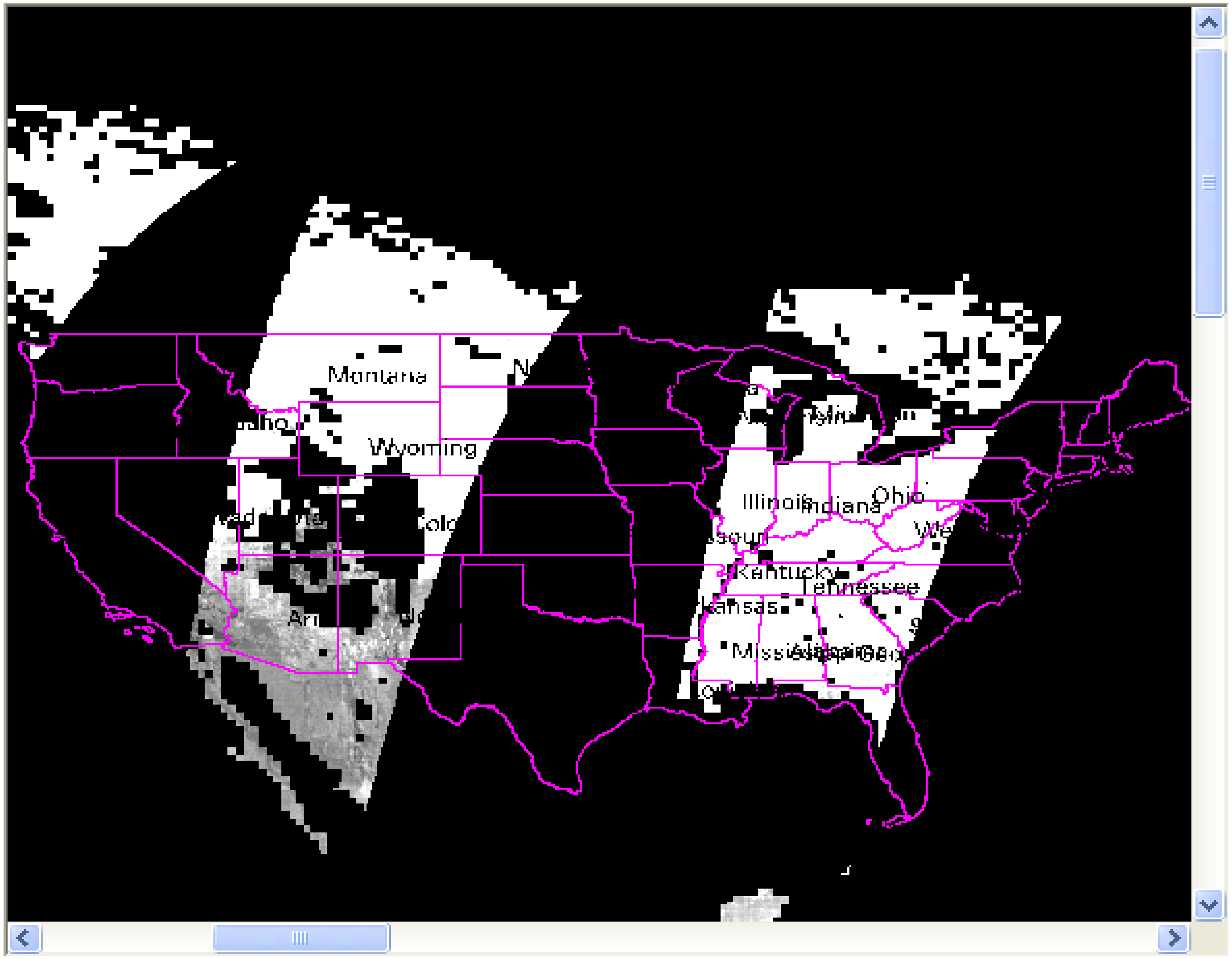
- Level 3 Active Soil Moisture data
  - 3km resolution;
  - Half-orbital swaths;
  - Algorithm was trained for a bare surface, the errors are large when vegetated surfaces attenuate and scatter the radar signal.
- **Level 3 Active/Passive Soil Moisture data**
  - 9km resolution;
  - Half-orbital swaths;
- Level 3 Passive Soil Moisture data
  - 36 km Equal Area Scalable Earth (EASE) grid
  - Half-orbital swaths;

SMAP Level 3 AP Data -Global

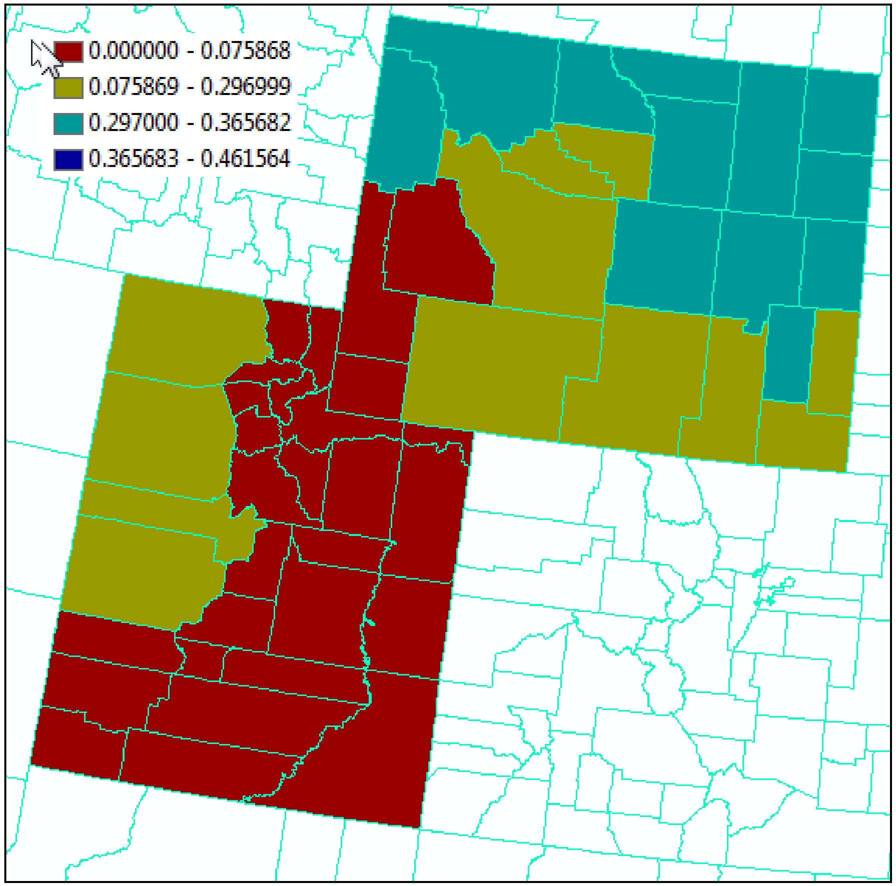


- ❑ Only one simulated data set is currently on line.
- ❑ Simulated data are for May 1, 2003.

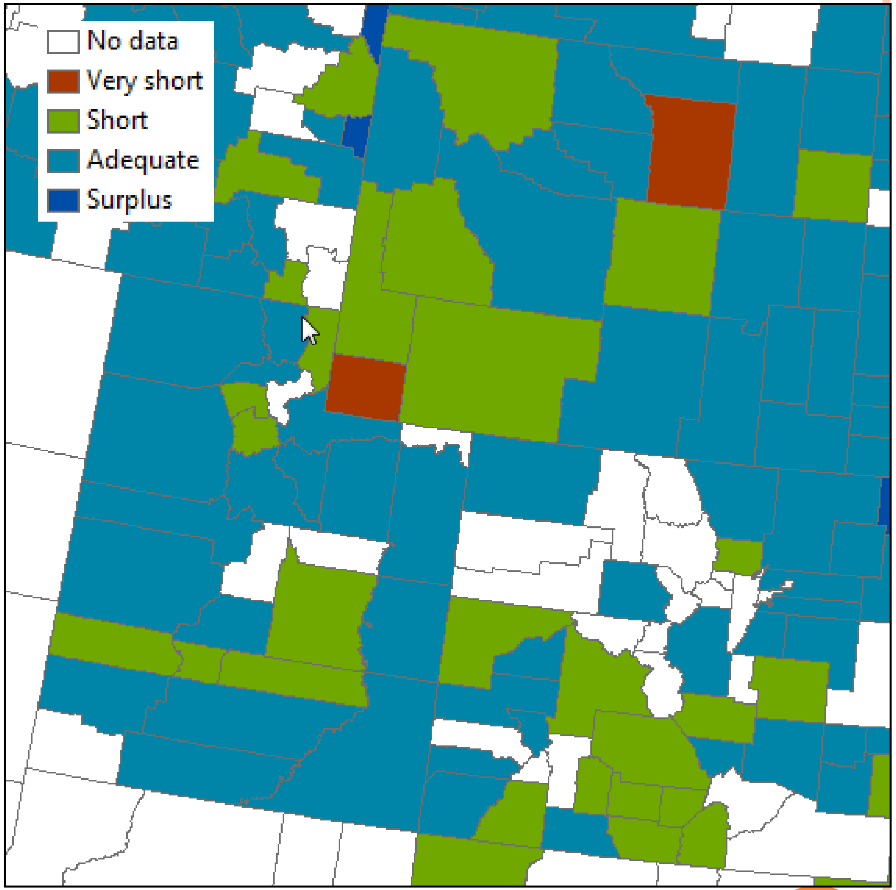
Study Area – United States



SMAP-AP Soil Moisture vs. NASS Survey Topsoil Moisture – UT and WY

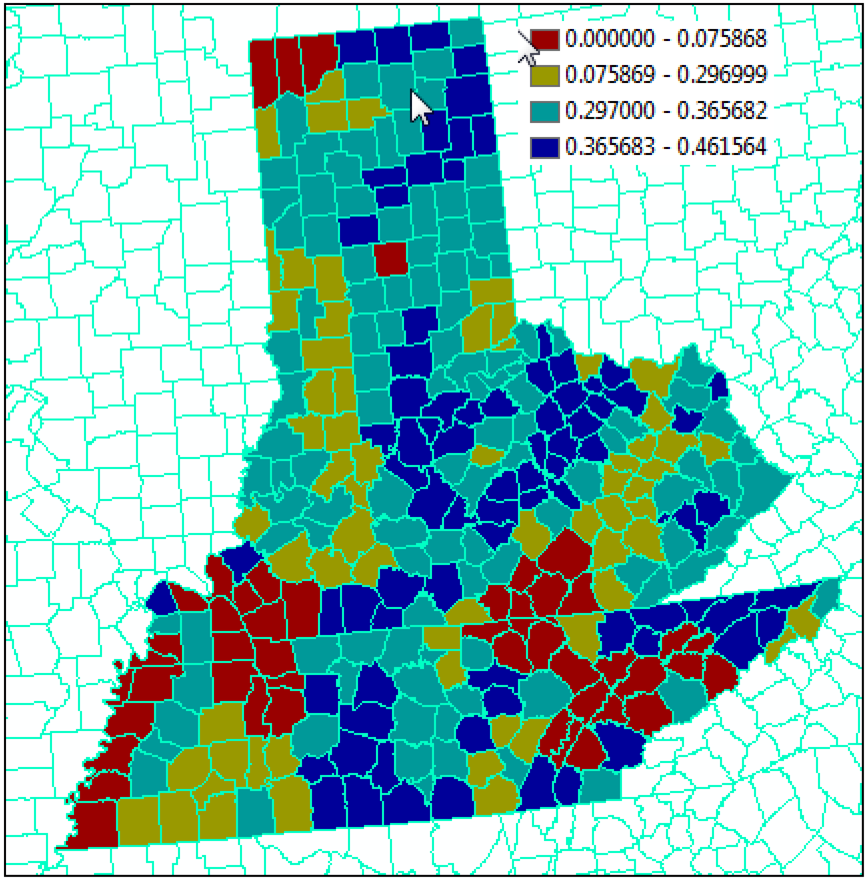


SMAP L3 AP Soil moisture

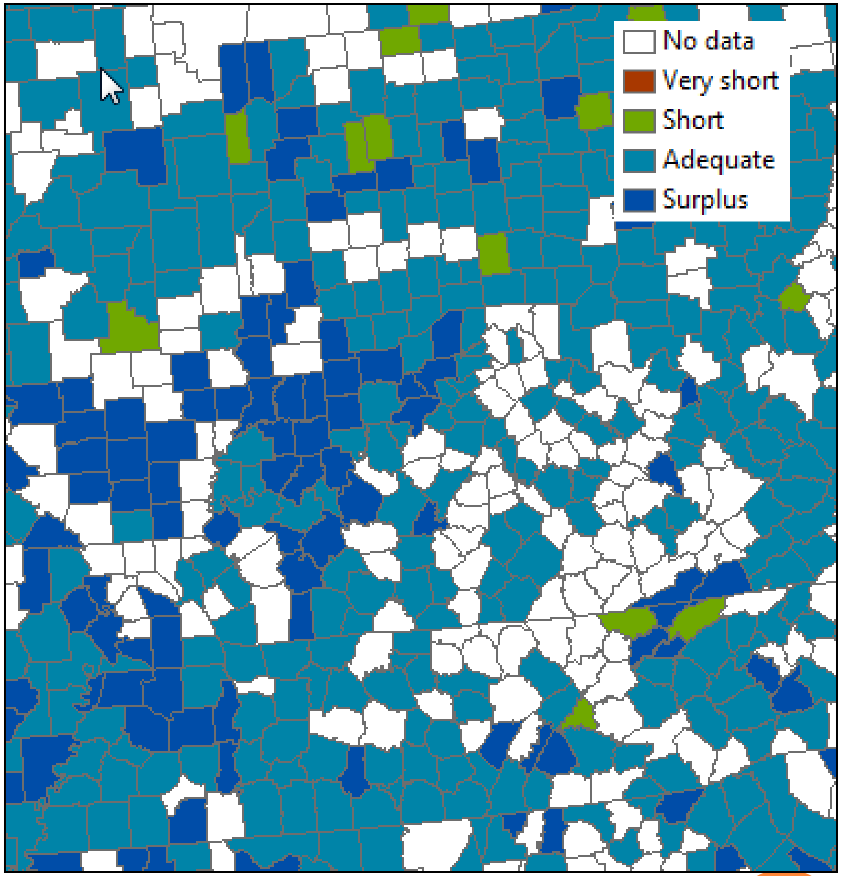


NASS Top soil survey

SMAP-AP Soil Moisture vs. NASS Survey Topsoil Moisture – IN, KY, TN

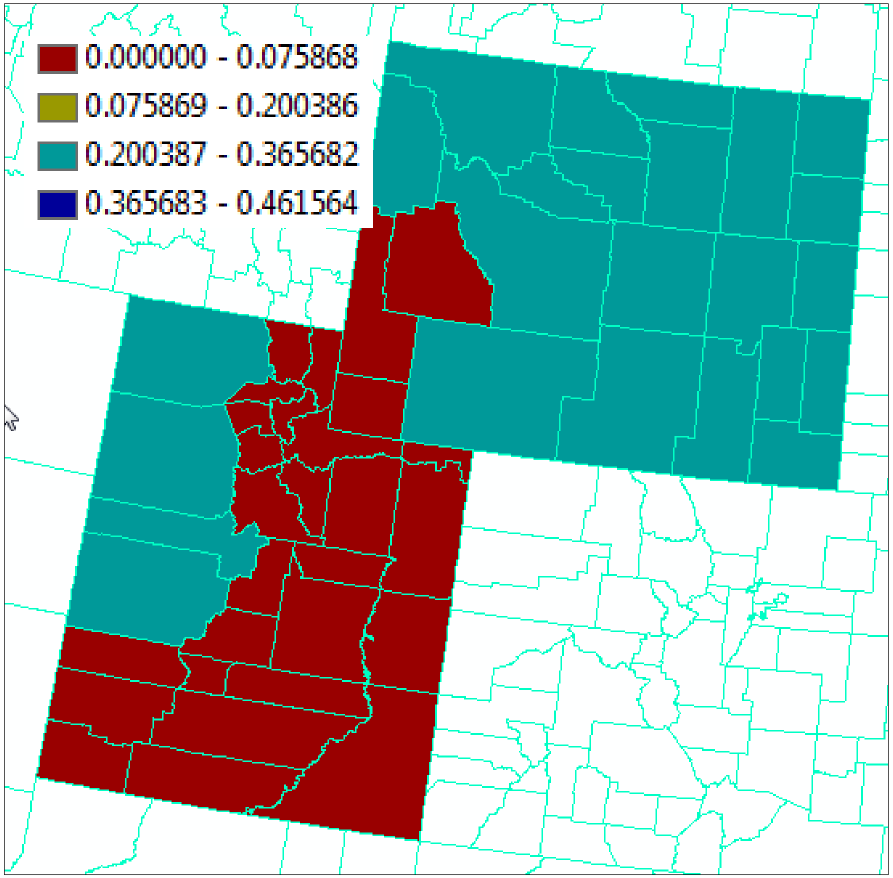


SMAP L3 AP Soil moisture

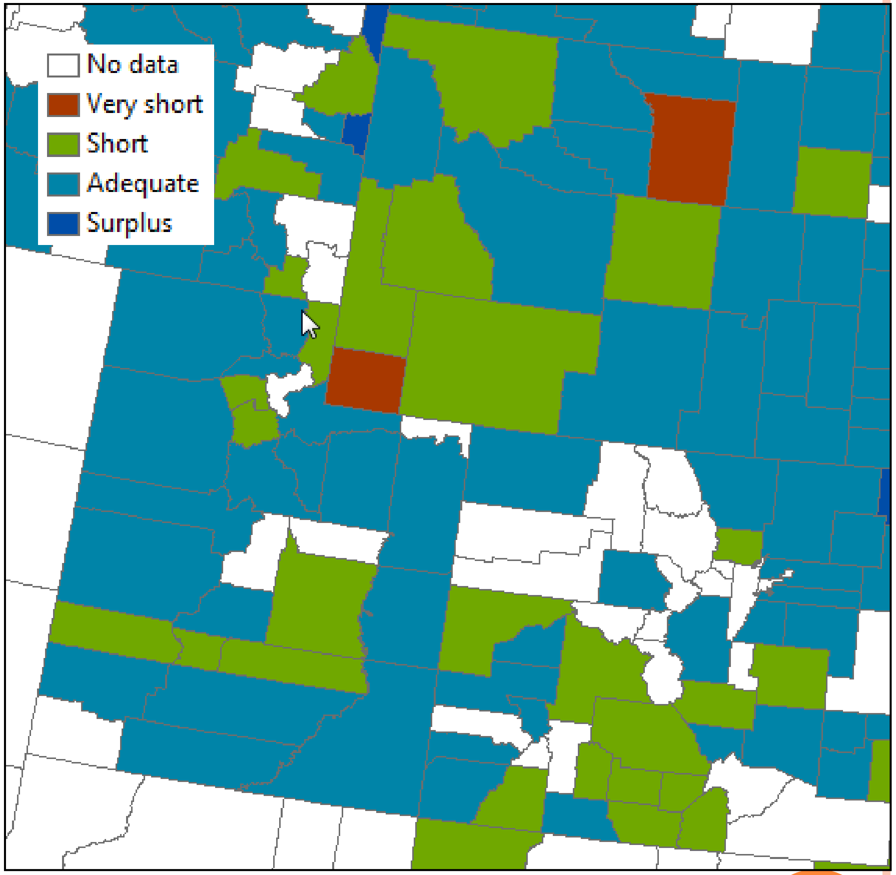


NASS Top soil survey

SMAP-AP Soil Moisture vs. NASS Survey Topsoil Moisture – Different Threshold



SMAP L3 AP Soil moisture



NASS Top soil survey

Conclusions

- The preliminary comparison results demonstrated big inconsistencies between SMAP L3 AP soil moisture product and NASS topsoil survey results. The possible reasons include:
  - Inconsistency in NASS survey results;
  - Inappropriate correlation between SMAP's soil moisture measurement and qualitative descriptions of soil moisture;
  - Vegetation impact on SMAP results;
  - Errors caused by low 9km resolution
- Different SMAP's soil moisture measurement cluster threshold will significantly change the monitoring result. Further systematic study is needed.

THANK YOU…

Zhengwei_yang@nass.usda.gov