Development of Global High Resolution Soil Moisture Product from the SMAP mission

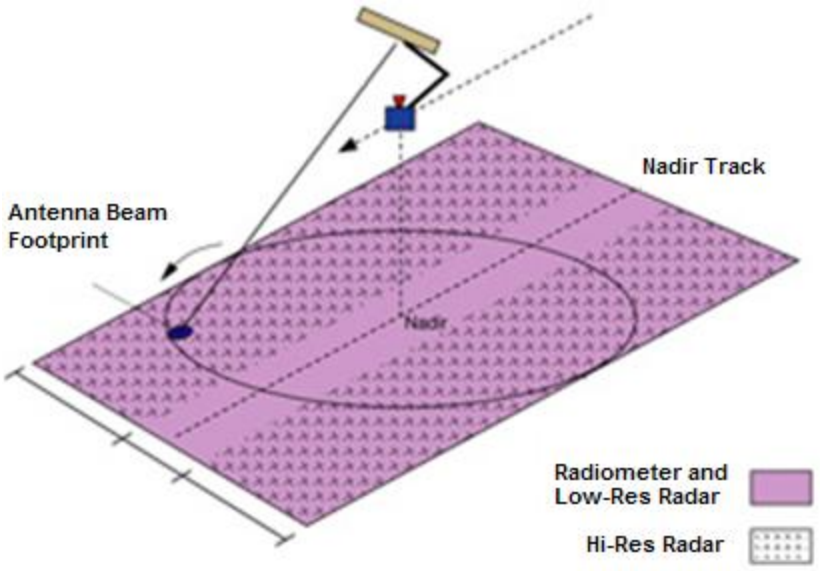
Narendra N. Das[a]
Dara Entekhabi[b]
Eni Njoku[a]

[a]Jet Propulsion Laboratory, California Institute of Technology
[b]Massachusetts Institute of Technology

AGU Fall Meeting, 2009

Date: 12/14/2009

SMAP Overview



INSTRUMENT CONFIGURATION

Radar
- Frequency: 1.26 GHz
- Polarizations: VV, HH, HV
- Data collection:
  - High-resolution/high-rate data for ground SAR processing
  - Low-resolution real-aperture data collected continuously

Radiometer
- Frequency: 1.41 GHz
- Polarizations: H, V, U
- Relative accuracy: 1.3 K
- Data collection: Continuous over full scan

Antenna
- Configuration: Conically-scanning reflector
  - Forms 1000 km wide swath
  - Shared by both radar and radiometer
- Diameter: 6 meters
- Resolution:
  - 40 km radiometer
  - 1-3 km SAR
- Rotation rate: 14.6 RPM
- Beam efficiency: 90%

SMAP Level 1 Science Requirements Summary

Requirement	Baseline Mission		Minimum Mission	
	Soil Moisture	Freeze/ Thaw	Soil Moisture	Freeze/ Thaw
Resolution	10 km	3 km	10 km	10 km
Refresh Rate	3 days	2 days(1)	3 days	3 days(1)
Accuracy	0.04 m^3/m^3(2)	80%(3)	0.06 m^3/m^3(2)	70%(3)
Duration	36 months		18 months	

(1) North of 45° N Latitude
(2) % volumetric water content, 1-sigma
(3) % classification accuracy (binary: Freeze or Thaw)

3

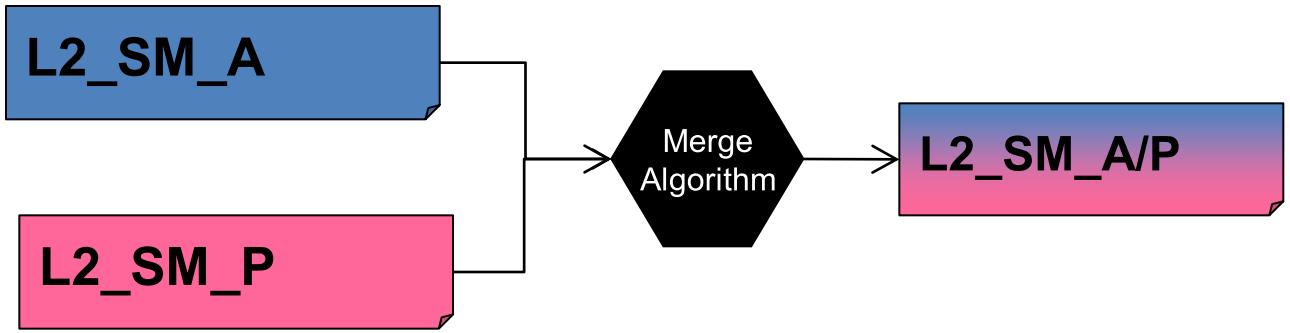
Expected Suite of Products from the SMAP Mission

Data Product Short Name	Description	Data Resolution
L1B_S0_LoRes	Low Resolution Radar σ_o in Time Order	5x30 km (10 slices)
L1C_S0_ HiRes	High Resolution Radar σ_o on Swath Grid	1-3 km
L1B_TB	Radiometer T_B in Time Order	36x47 km
L1C_TB	Radiometer T_B on Earth Grid	36 km
L2_SM_P	Radiometer Soil Moisture	36 km
L2_SM_A/P	**Active-Passive Soil Moisture**	**9 km**
L2_F/T_HiRes	Daily Global Composite Freeze/Thaw State	1-3 km
L3_SM_P	Daily Global Composite Radiometer Soil Moisture	36 km
L3_SM_A/P	**Daily Global Composite Active-Passive Soil Moisture**	**9 km**
L4_SM	Surface & Root Zone Soil Moisture	9 km
L4_C	Carbon Net Ecosystem Exchange	1 km

Approaches

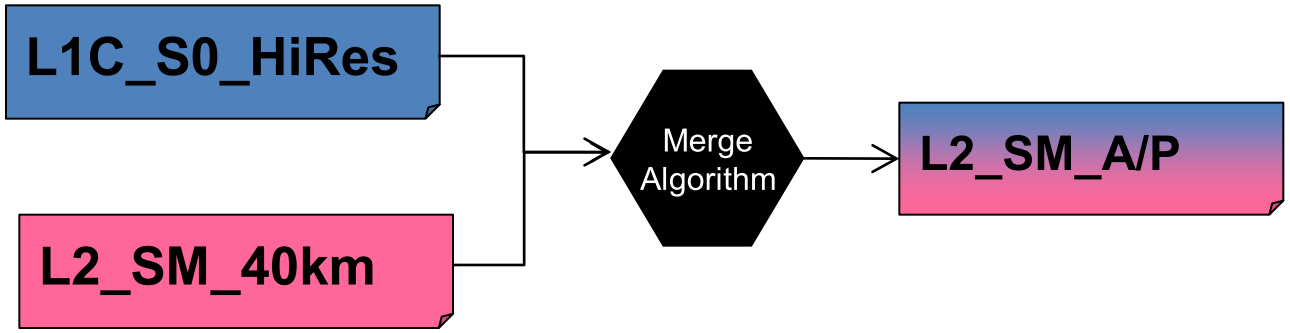
Approach 1:

Begins with L2 Retrieved Soil Moisture Products



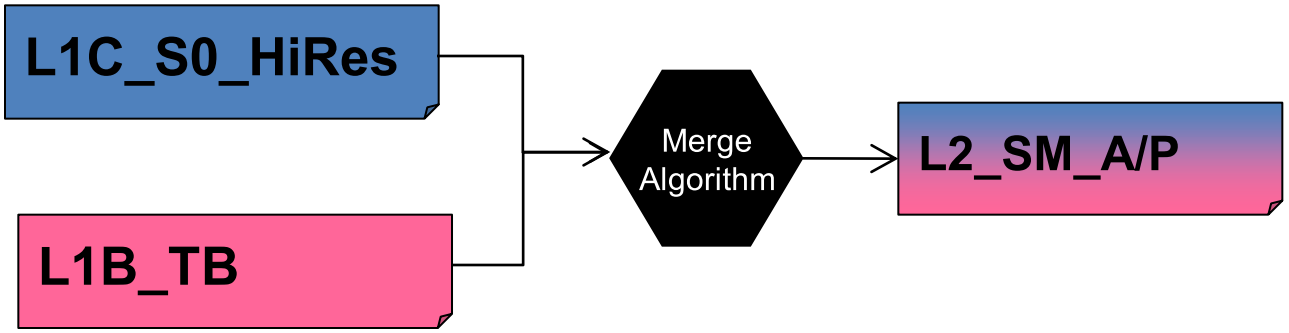
Approach 2:

Begins with L2 Retrieved Soil Moisture Products and HiRes radar data



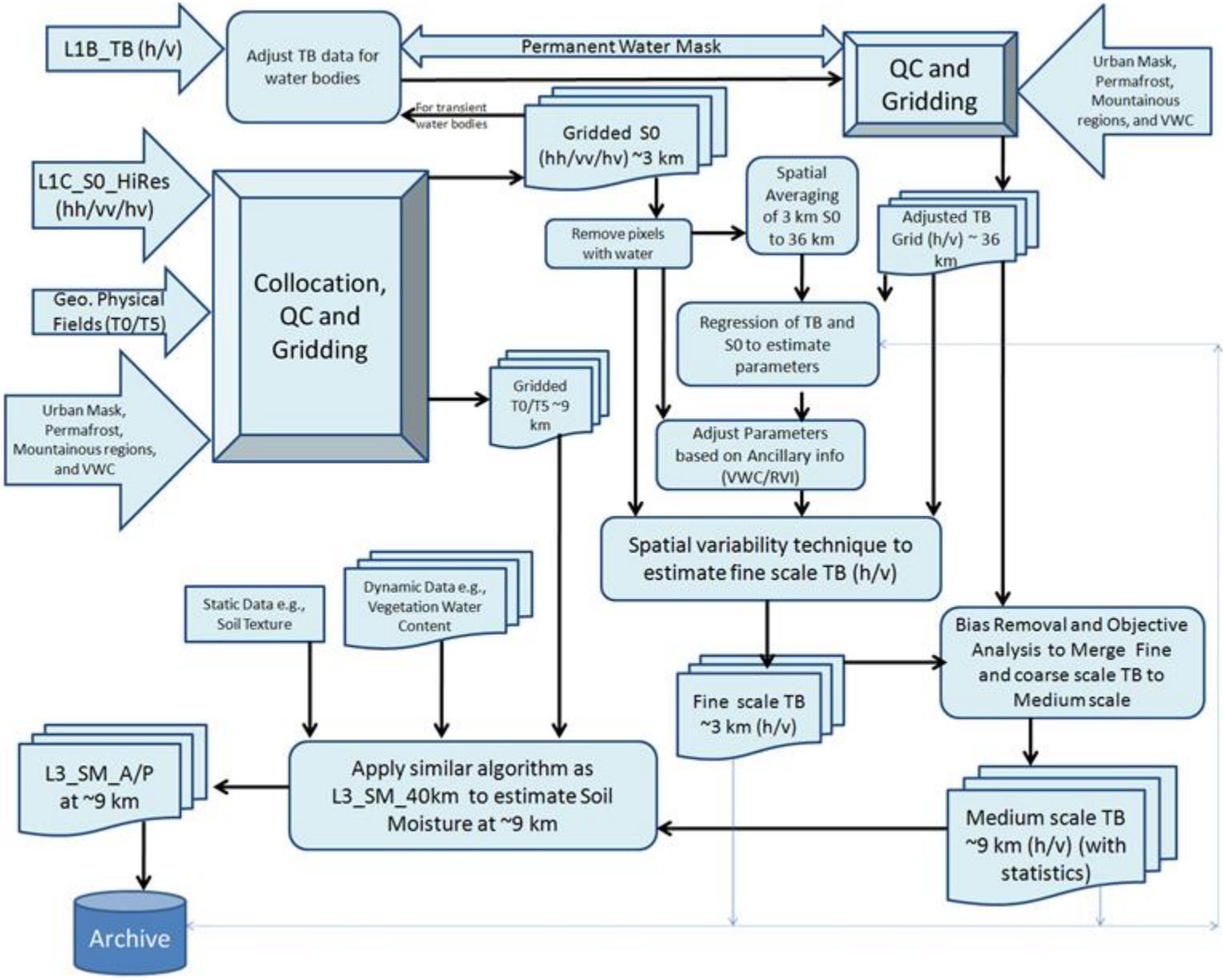
Approach 3:

Begins with L1 Brightness Temperature and HiRes radar data



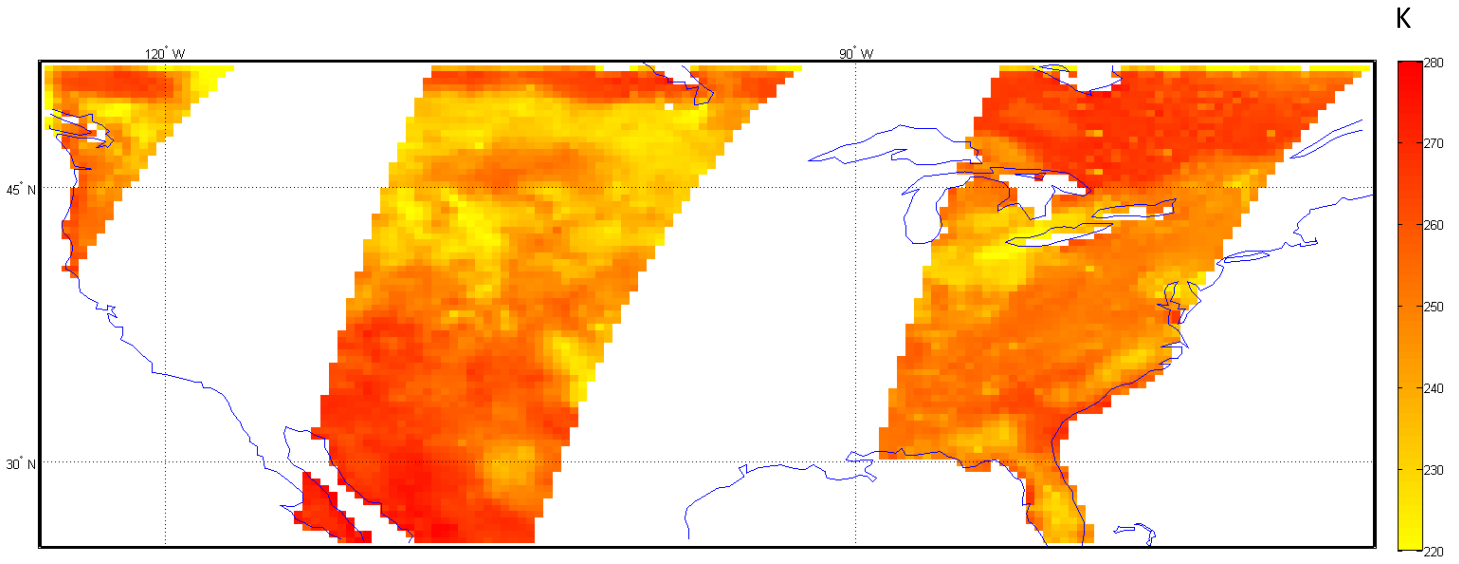
Flow Diagram of L2_SM_A/P Algorithm

Based on Approach 3



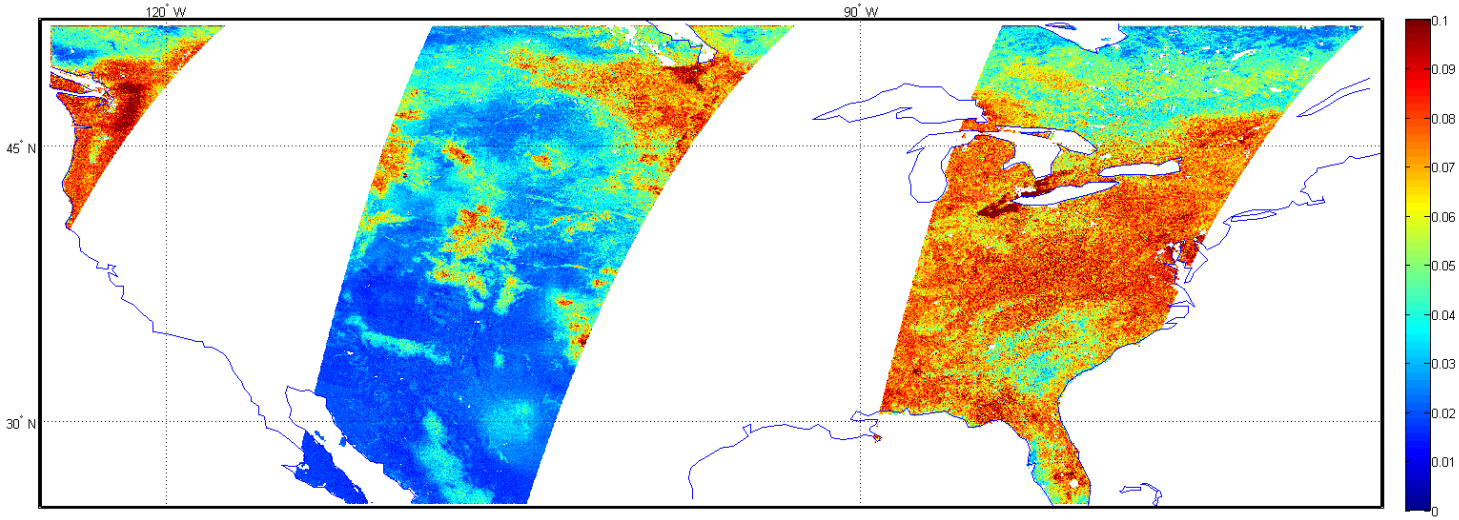
Simulation of L2_SM_A/P Algorithm

Gridded TB-hpol (~36 km) for June 06, 2004



Introduced 1.3 K (1 sigma) noise while gridding L1B_TB data

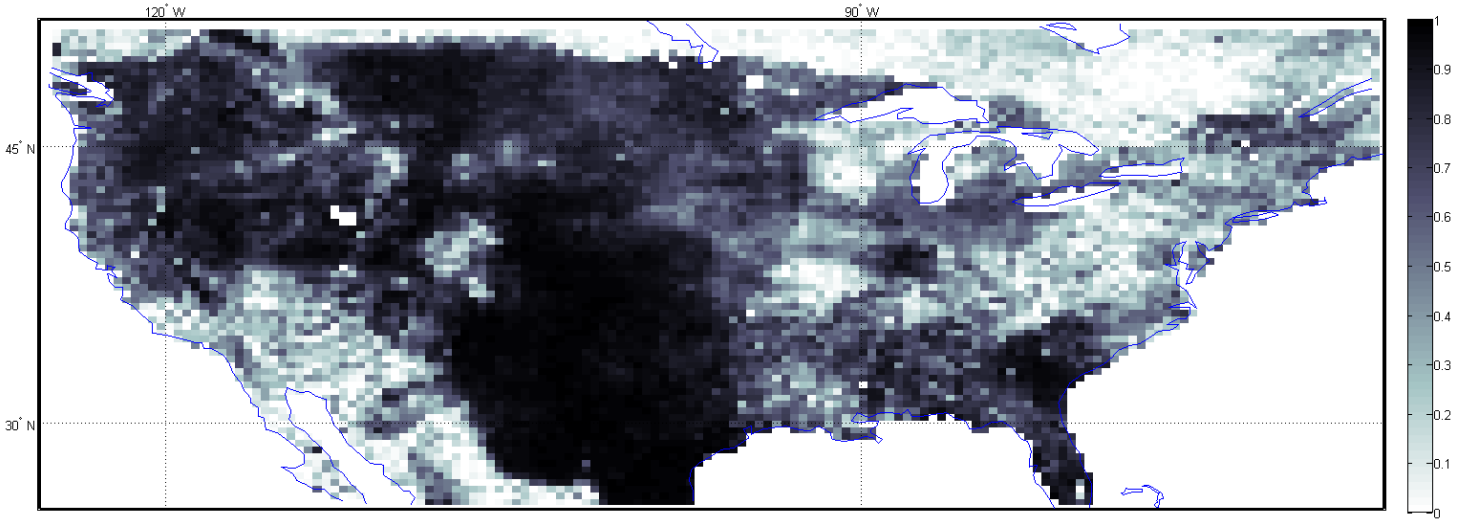
Gridded S0-vv (~3 km) for June 06, 2004



Introduced 0.6 dB (1 sigma) noise in outer edge of the swath and nearly 1 dB (1 sigma) noise at the nadir

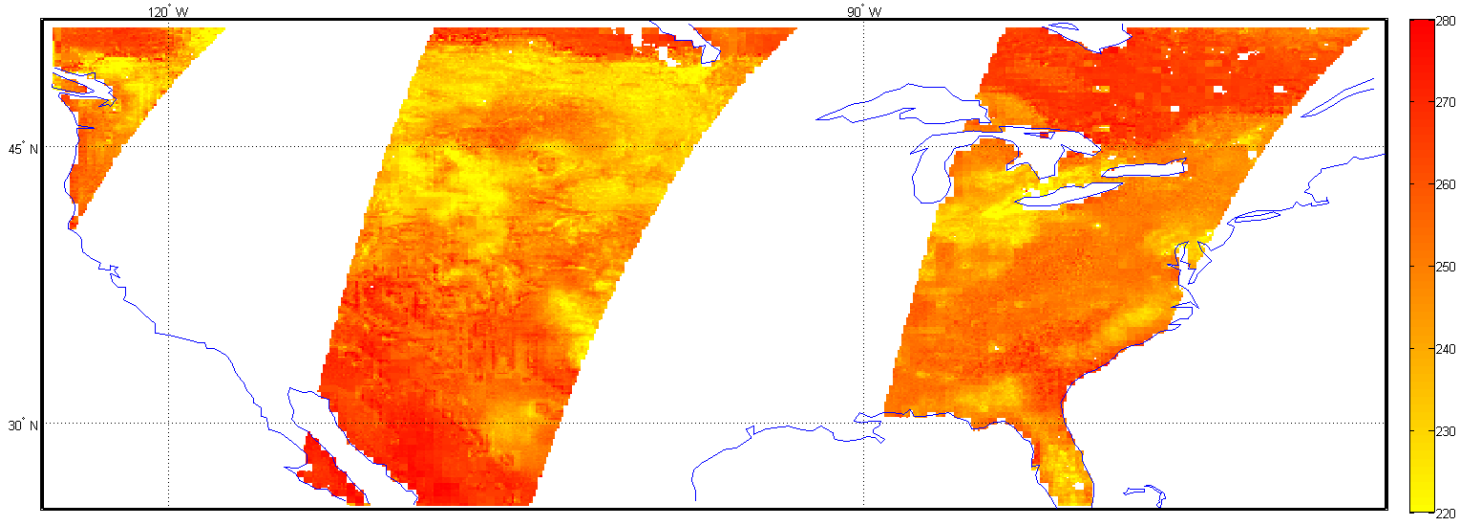
Simulation of L2_SM_A/P Algorithm

Correlation (R^2) between Tb-hpol (~36 km) and mean(S0-vv) at ~3 km



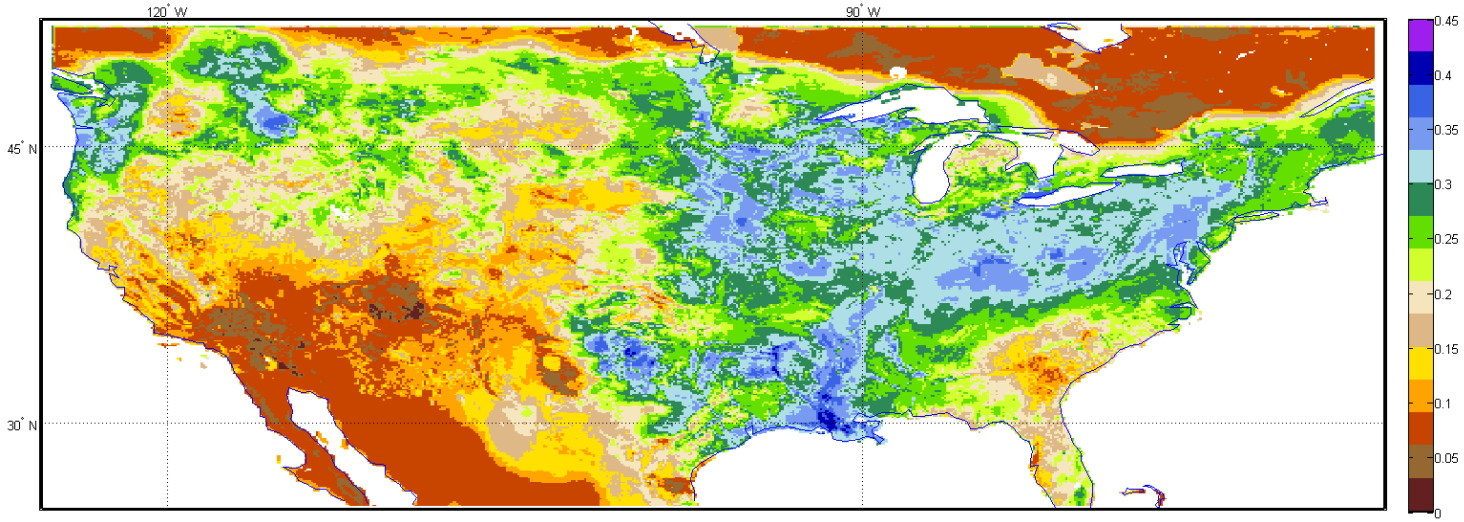
Disaggregated TB (~9 km) for June 06, 2004

K

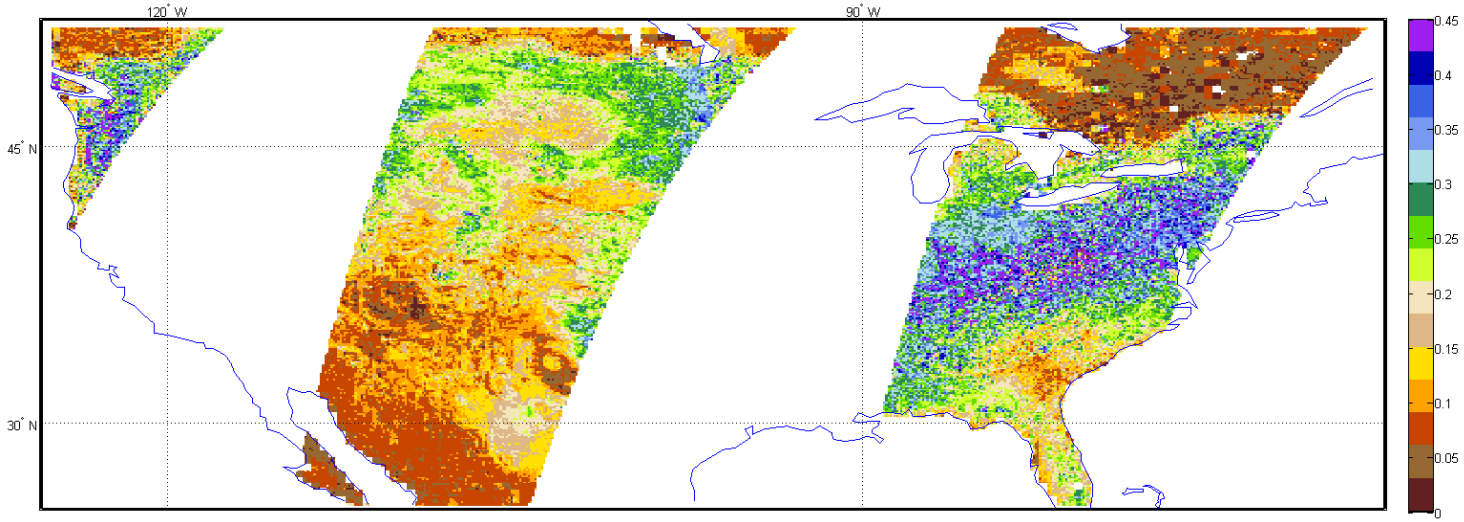


Simulation of L2_SM_A/P Algorithm

Soil Moisture Truth June 06, 2004 cm^3/cm^3

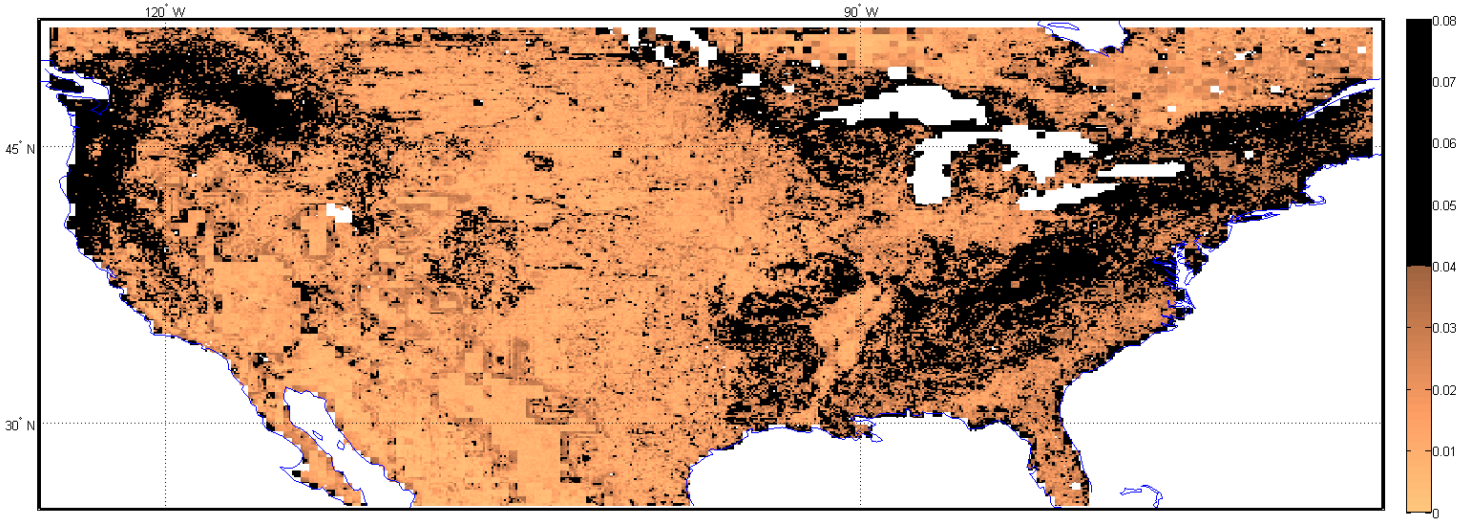


Soil Moisture from Algorithm June 06, 2004 cm^3/cm^3

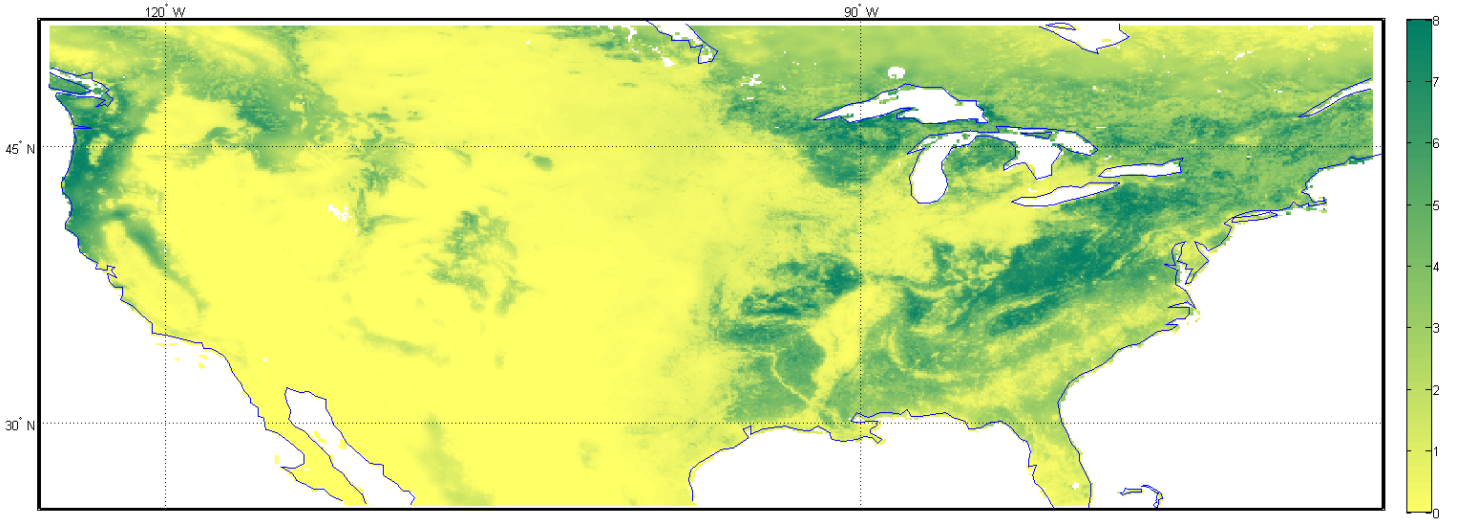


Simulation of L2_SM_A/P Algorithm

RMSE in Soil Moisture (~9 km) observed for one month period (June, 2004) cm^3/cm^3

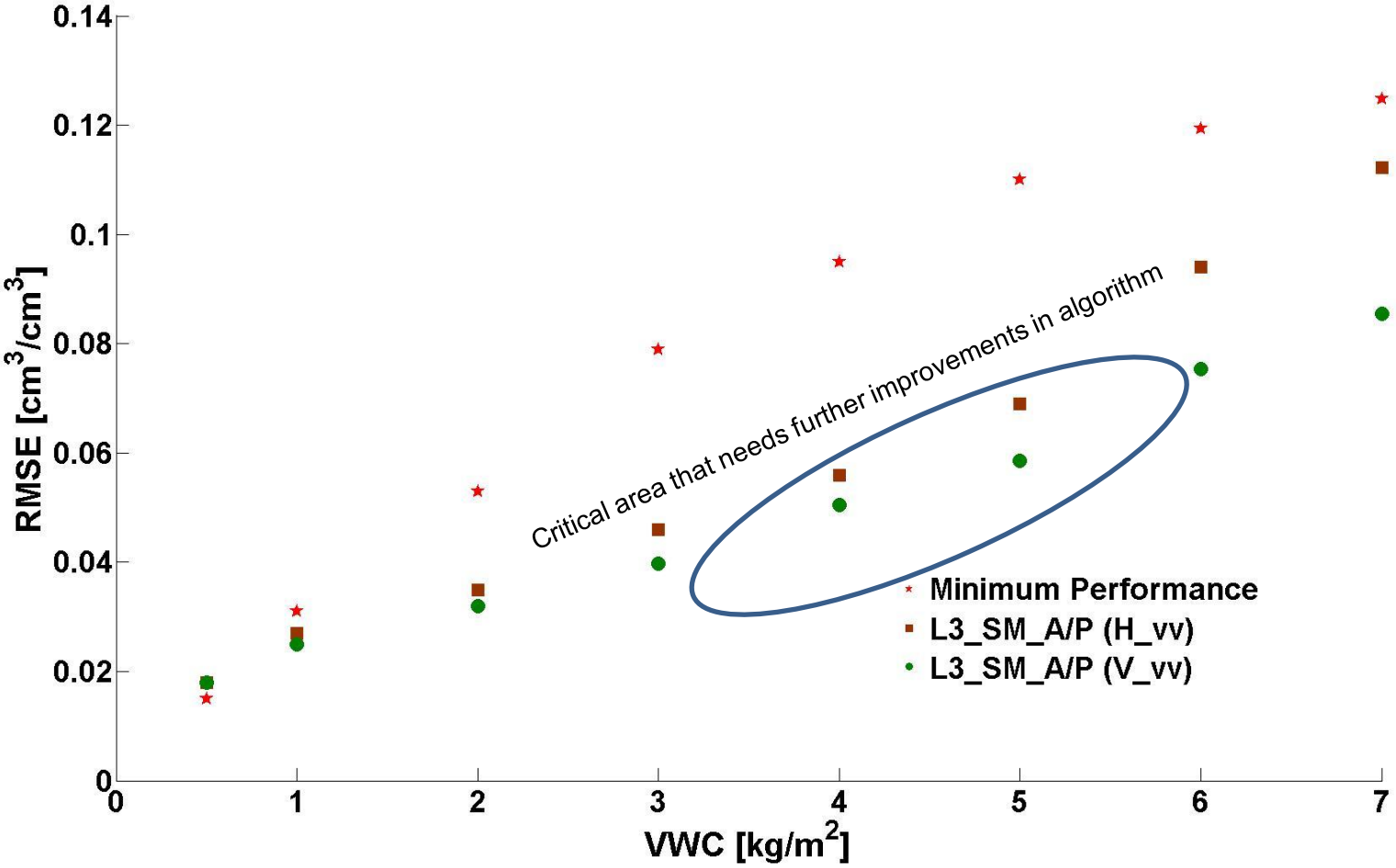


VWC for June 15, 2004 kg/m^2



Simulation of L2_SM_A/P Algorithm

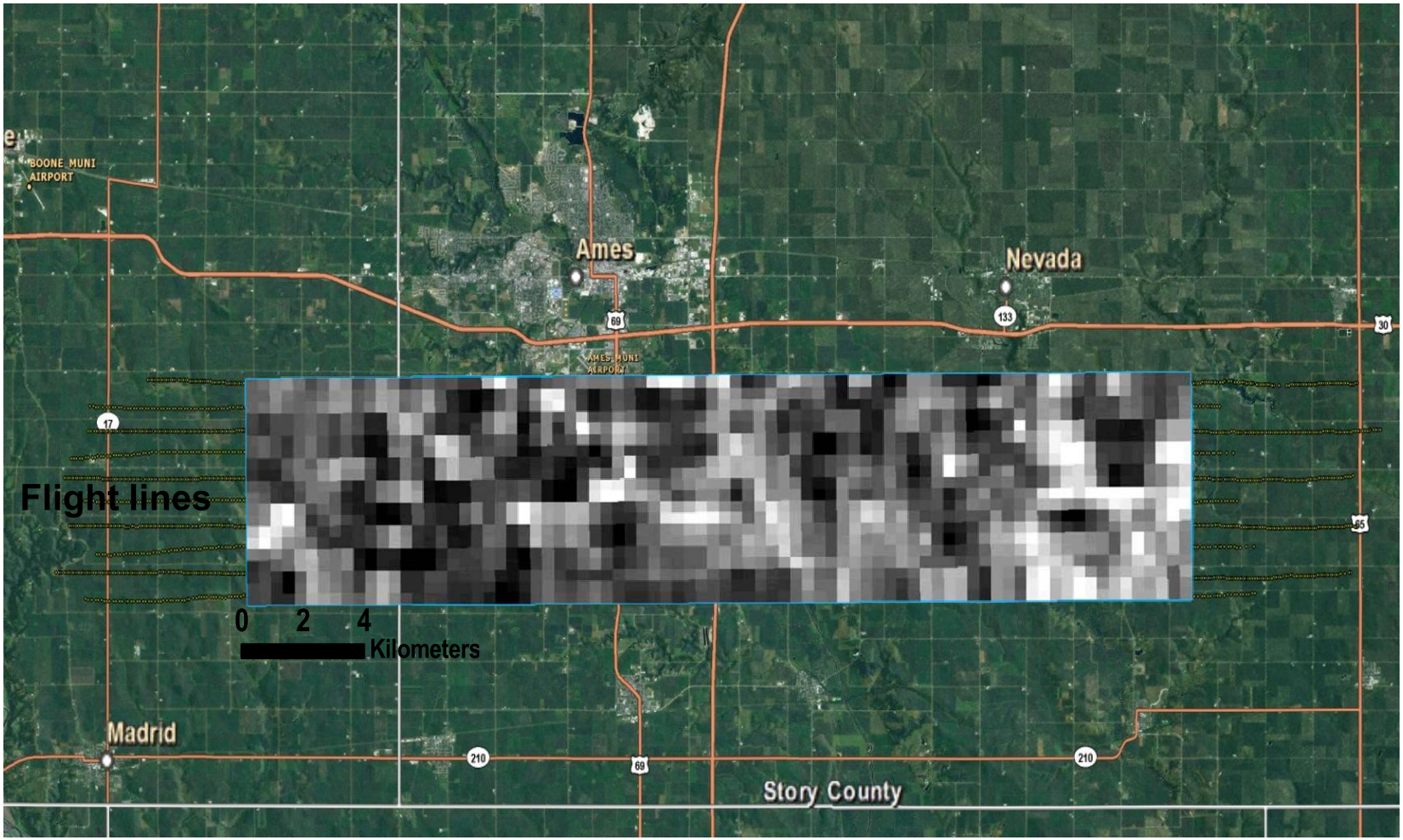
Performance of L3_SM_A/P algorithm for one month study period over the CONUS domain



Assessment of L2_SM_A/P Algorithm Using PALS

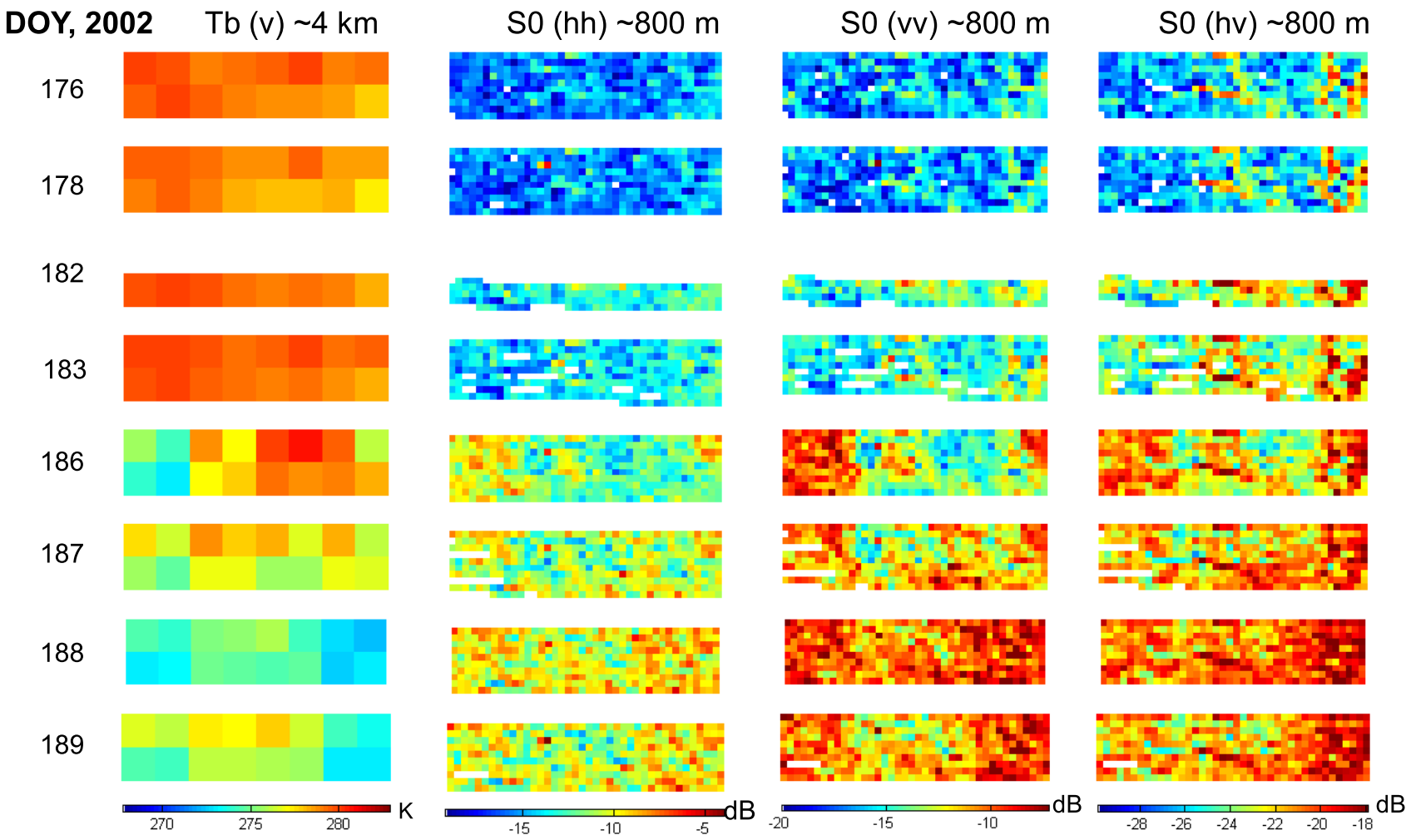
Gridding of PALS Flight lines Data

PALS: Passive and Active L- and S-band Microwave Sensor

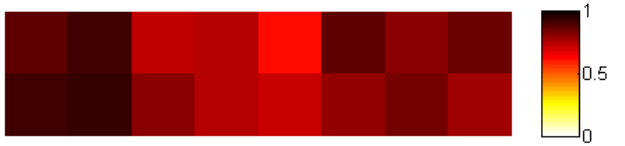


TB data gridded at 4 km, and Sigma0 gridded at 0.8 km

Assessment of L2_SM_A/P Algorithm Using PALS

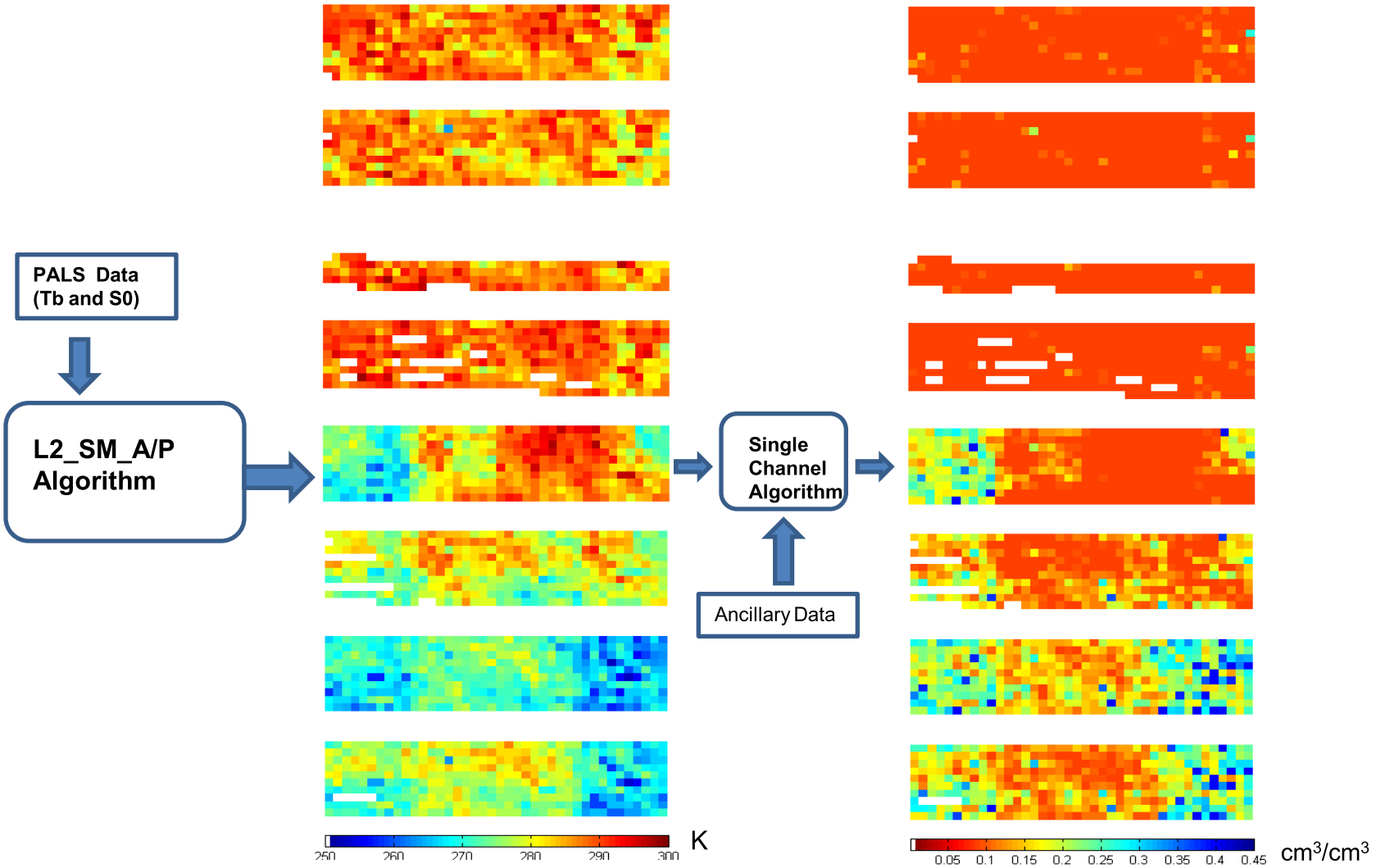


Gridded PALS Radiometer and Radar data



R^2 values (Low: 0.65, High: 0.93)
observed between Tb (v) and co-pol S0 (vv)

Assessment of L2_SM_A/P Algorithm Using PALS

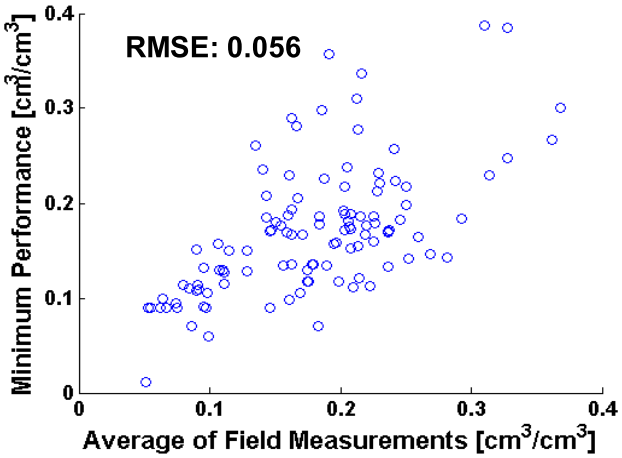


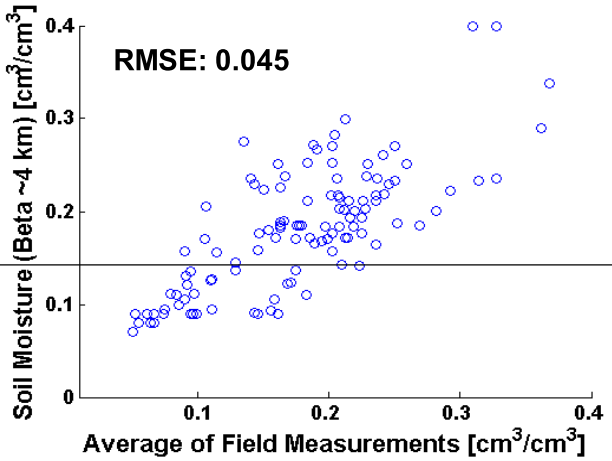
Disaggregated Tb (800 m)

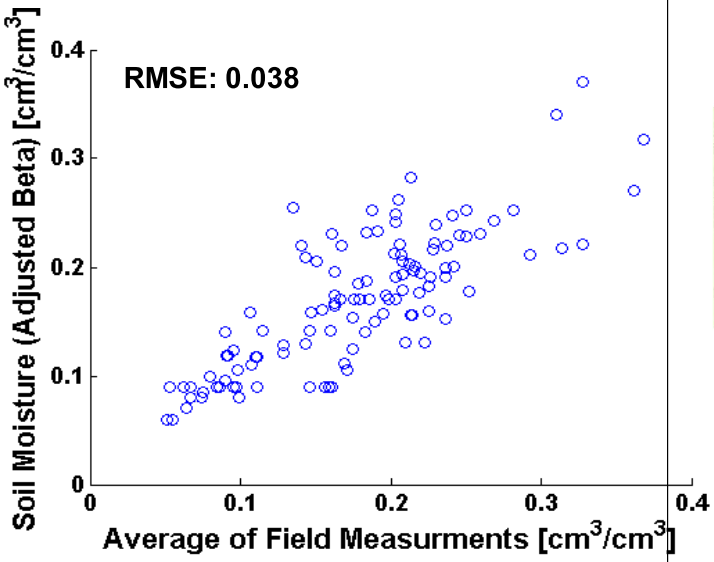
Estimated Soil Moisture (800 m)

Assessment of L2_SM_A/P Algorithm Using PALS

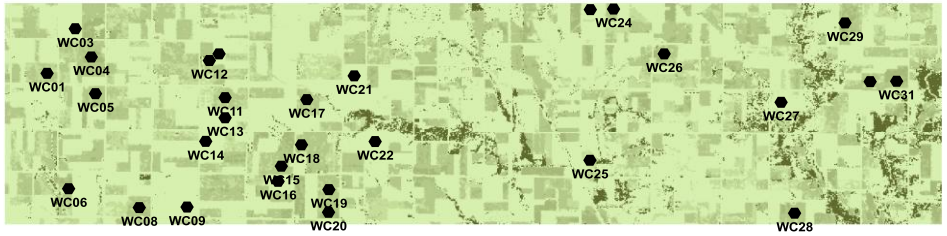
Algorithm Performance







Soil Moisture Sampling Sites within the Study Region



Conclusion

Results from the simulation over the CONUS domain show that the algorithm is capable to meet the L1 requirements

The algorithm overestimates (i.e., positive bias) soil moisture for regions having high VWC. Adjustment/fix in the algorithm is required to improve the performance for regions having VWC >3 kg/m^2

PALS data verifies that the assumption (linear *TB*-log[σ] relationship) hold well to retrieve soil moisture from the L2_SM_A/P algorithm

THANKS