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

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AGU 2009 Fall Meeting

Objective

SMAP Instrument Configuration

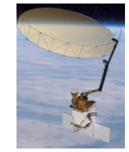
Radar
Frequency: 1.26 GHz
Polarizations: VV, HH, HV
Resolution: 3 km
Relative Accuracy: 1.0 dB (HH and VV)

Radiometer
Frequency: 1.41 GHz
Polarizations: H, V, U
Resolution: 40 km
Relative Uncertainty: 1.3 K

Shared Antenna
Constant Incidence Angle: 40°
Wide Swath: 1000 km

- ***Radiometer*** - High accuracy (less influenced by roughness and vegetation) but coarser spatial resolution (40 km)
- ***Radar*** - High spatial resolution (1-3 km) but more sensitive to surface roughness and vegetation
- **Combined Radar-Radiometer** product provides optimal blend of resolution and accuracy to meet science objectives

SMAP Level 1 Science Requirements



Requirement	Soil Moisture	Freeze/ Thaw
Resolution	**10 km**	3 km
Refresh Rate	3 days	2 days(1)
Accuracy	**4%** $[m^3/m^3]$ (2)	80% (2)
Duration	36 months	

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

Product Short Name	Description	Data Resolution
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

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L2_SM_A/P Algorithm Outline

Take advantage of SMAP constant incidence angle

Assumption #1: Time-fluctuations in T_B and σ are correlated, i.e.

$$T_B = \alpha + \beta \cdot \log_{10}[\sigma]$$

Dissaggregated $T_B\,(3\text{ km}) = T_B\,(36\text{ km}) + \delta\{\beta \cdot \log_{10}[\sigma(3\text{ km})]\}$

where δ{·} is spatial anomaly within 36 km

Assumption #2: β is homogeneous over 36 km
(or whose pattern can be inferred from ancillary data on vegetation or σ_{hv})

Essentially brightness temperature disaggregation using parameters inferred from time-series of radar and radiometer measurements.

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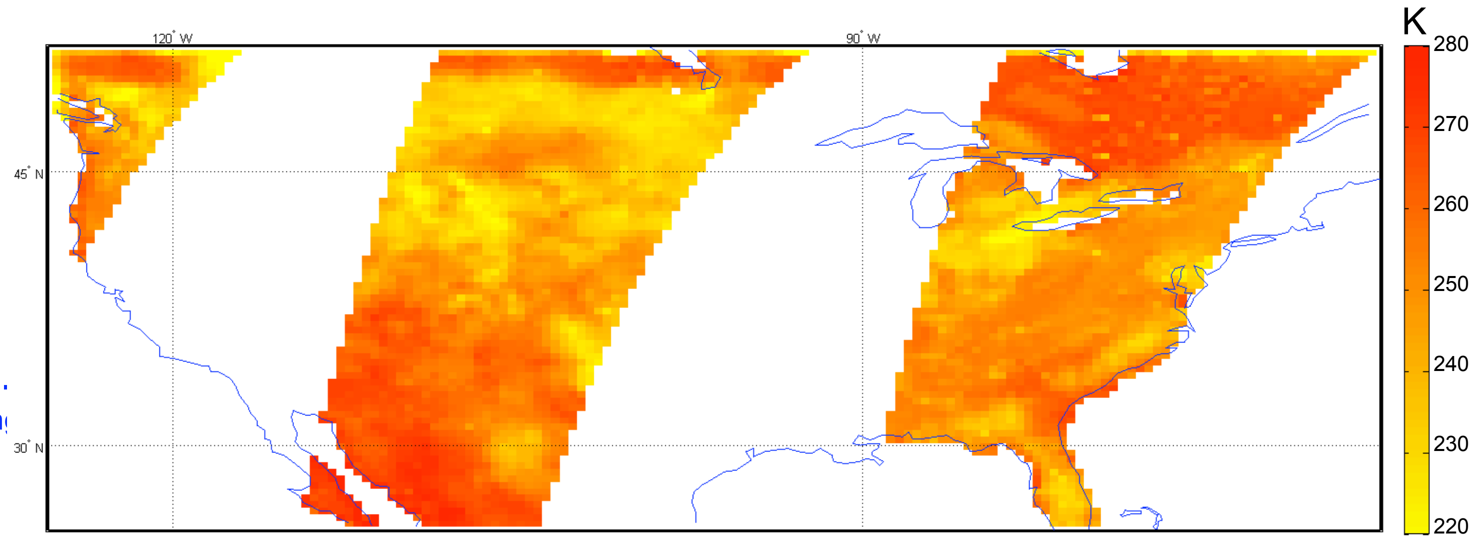
SMAP Algorithm Testbed

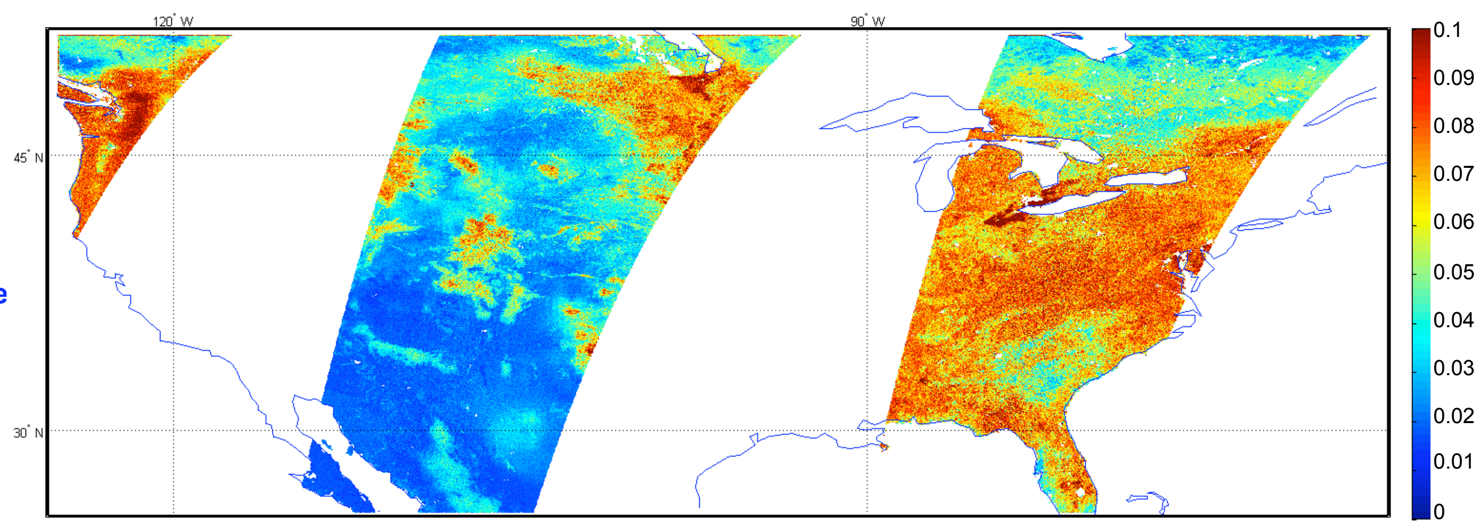
T_B-H (~36 km)
June 06, 2004

Introduced 1.3 K (1-
noise while griddin
L1B_TB data



σ_{vv} (~3 km)
June 06, 2004

Introduced 0.6 dB
(1-σ) noise in oute
edge of the swath
and nearly 1 dB
noise at nadir

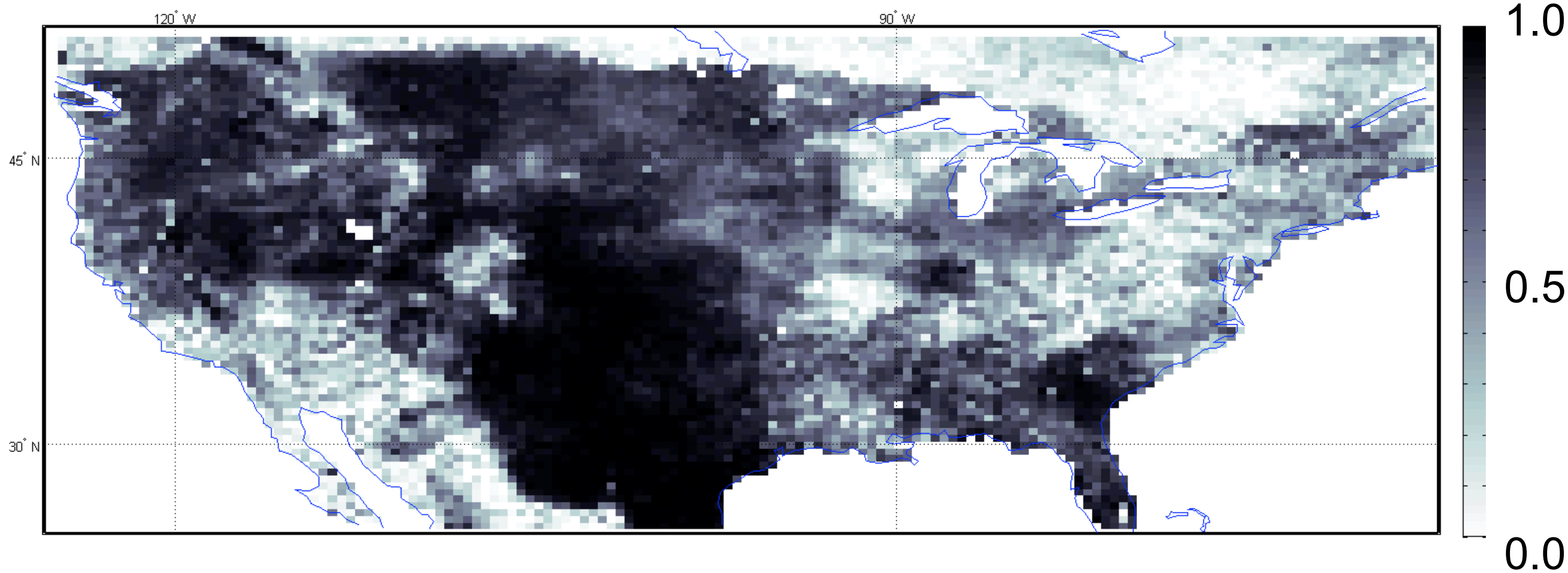


Time-Series Correlation Between Measurements

A key assumption of the algorithm is that time-fluctuations in T_B-H and σ_{vv} are correlated (constant incidence angle).

<u>Test using Algorithm Testbed</u>

Correlation between T_B-H (~36 km) and mean(σ_{vv}) at ~3 km



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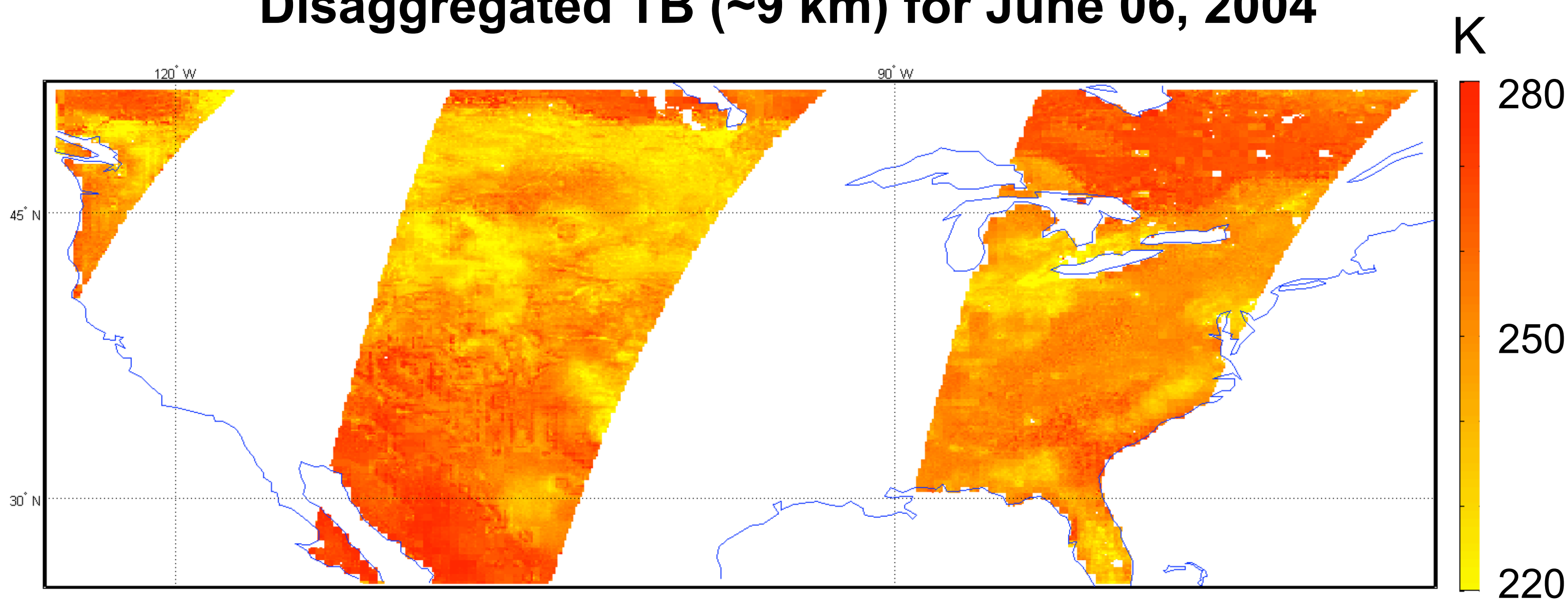
L2_SM_A/P in the SMAP Algorithm Testbed

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



Next apply radiometer retrieval algorithm (single-channel) with ancillary data at ~9km to retrieve soil moisture (L2_SM_A/P).

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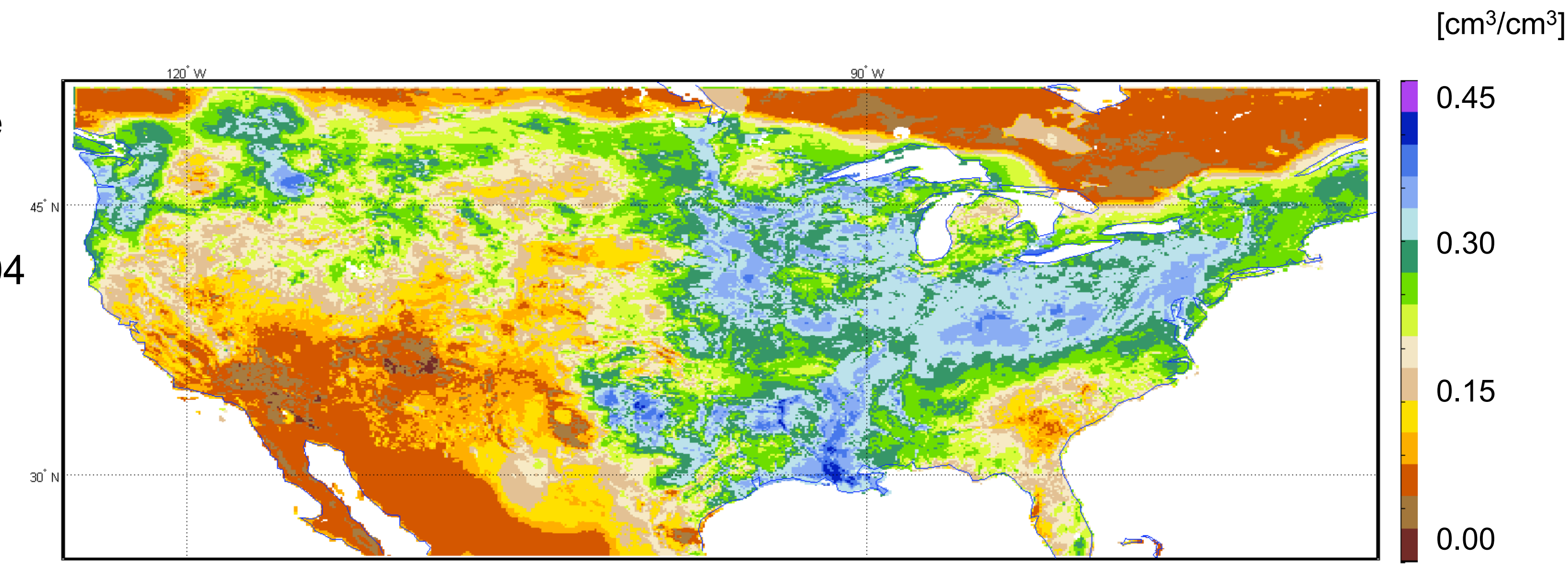
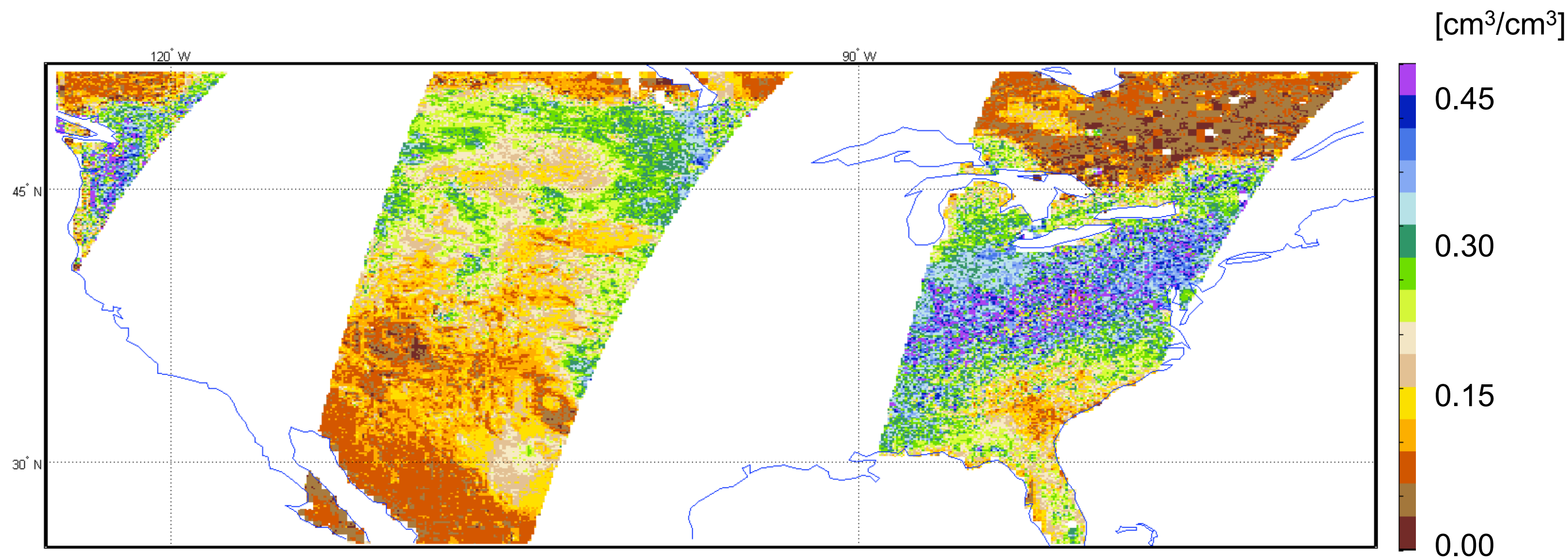
Sample L2_SM_A/P

Soil Moisture
Truth

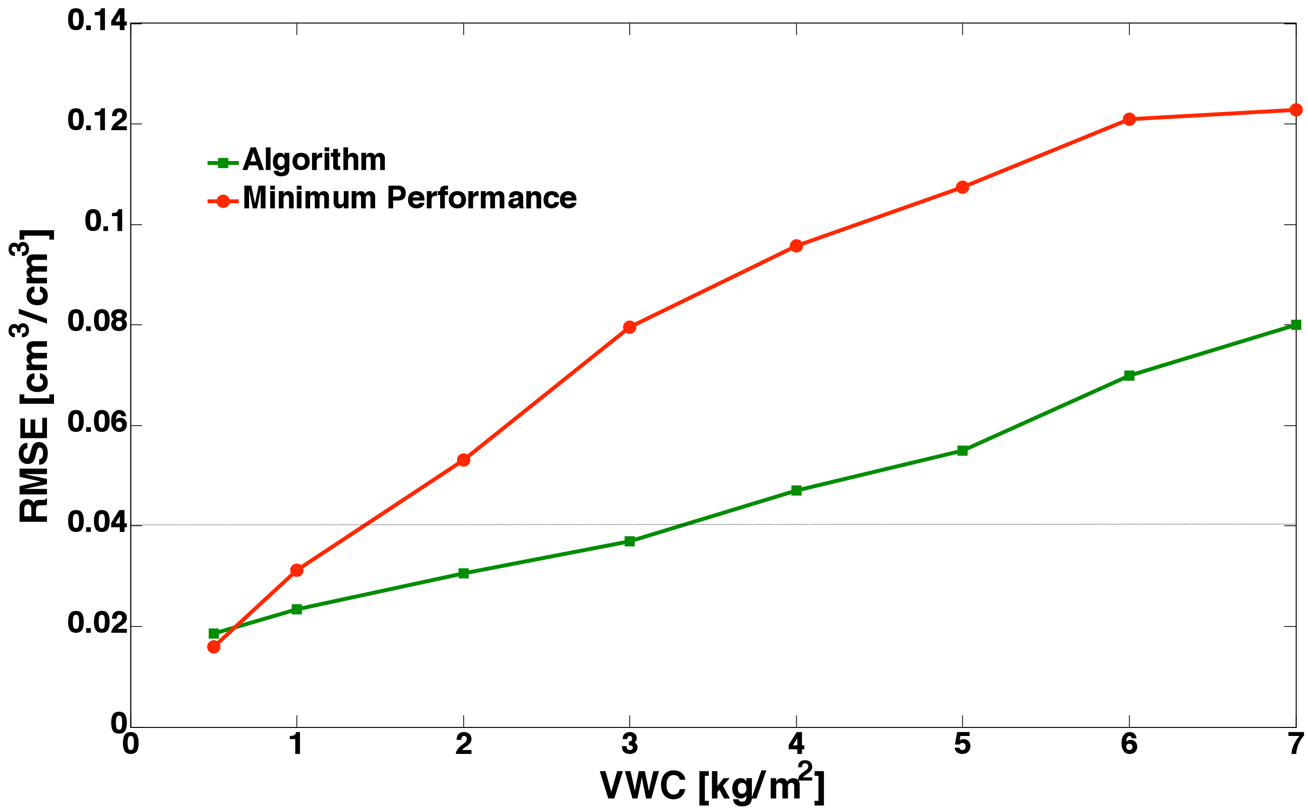
June 06, 2004



Soil Moisture
Algorithm



Performance Statistics (1 month, CONUS)



Minimum Performance is defined as radiometer bightness temperature resampled at 9 km, i.e. no radar information used.

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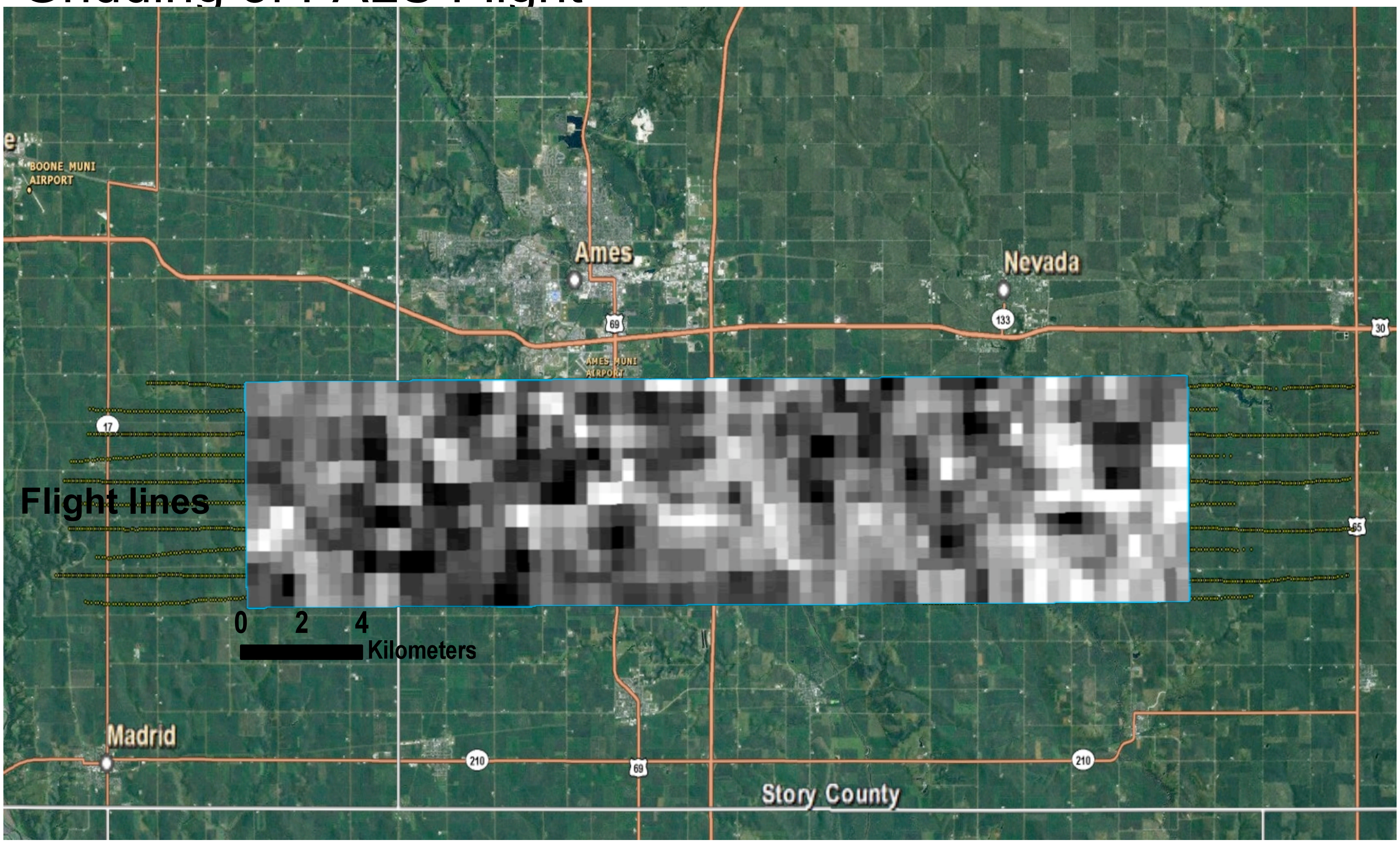
Assessment of Assumption Using PALS

Gridding of PALS Flight

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



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

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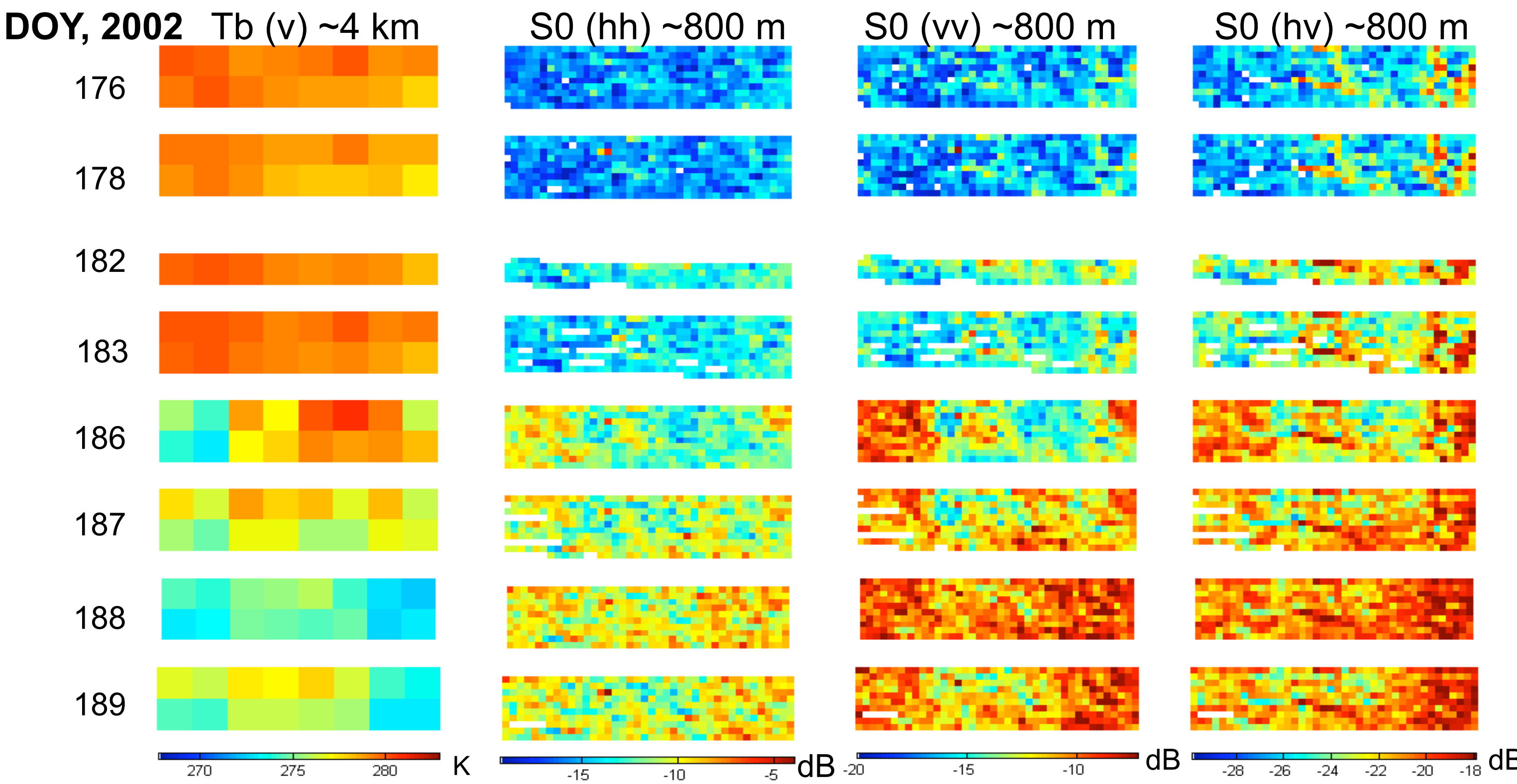
Assessment of Algorithm Using PALS



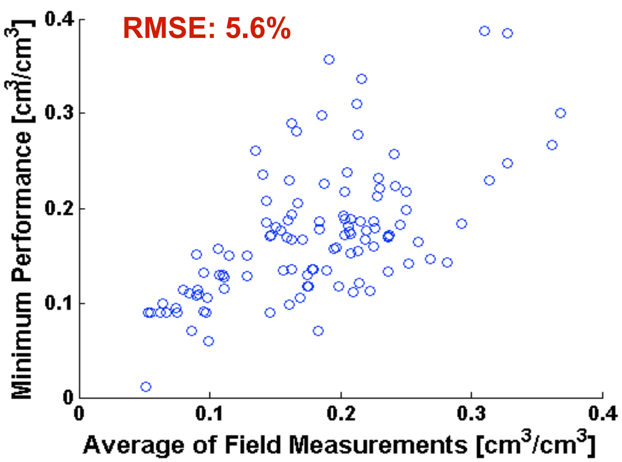
Gridded PALS Radiometer and Radar data

R^2 values between TB_v and σ_{vv}

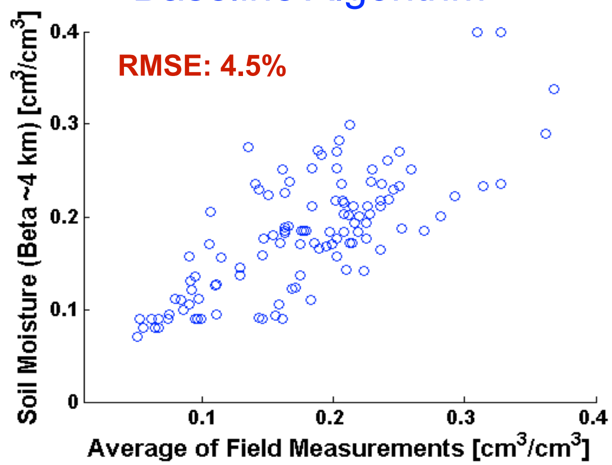
(Low: 0.65, High: 0.93)

Assessment of Algorithm Using PALS

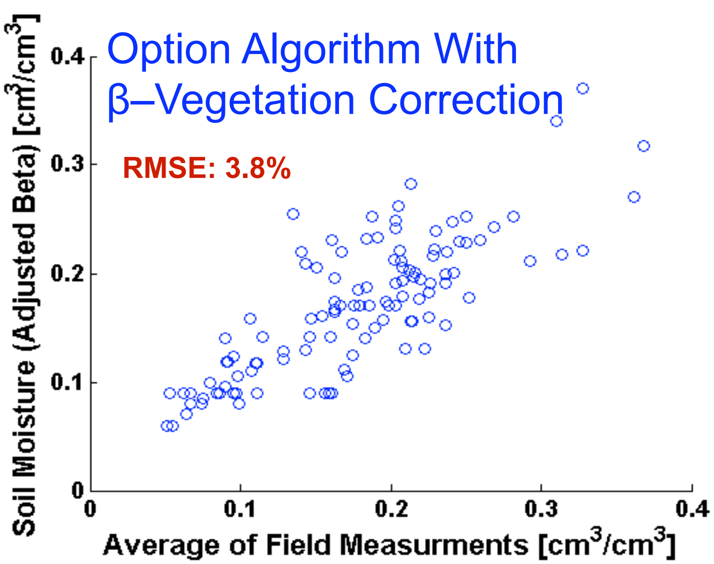
Minimum Performance



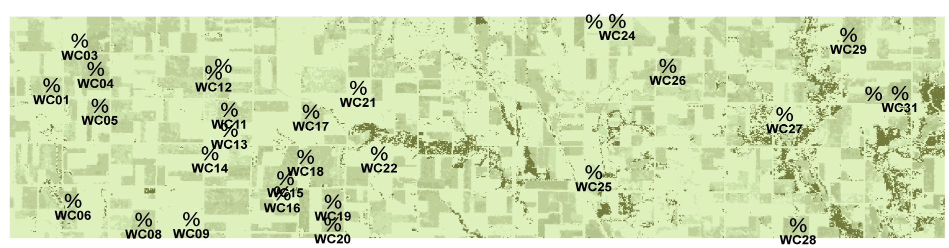
Baseline Algorithm



Option Algorithm With β–Vegetation Correction



Soil Moisture Sampling Sites within the Study Region



Conclusion

Simulation results over the CONUS domain show that the algorithm is capable to meet the SMAP L1 requirements

The algorithm overestimates (i.e., positive bias) soil moisture for regions having high VWC. Adjustment 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