Land Surface Modeling Studies in Support of AQUA AMSR-E Validation

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Project Goal:

To provide modeling support to the AMSR-E validation activities through a combination of soil moistures retrievals (using the Princeton (PU) Land Surface Microwave Emission Model (LSMEM) and process-based hydrological modeling.

Recent Activities:

1. Validation using SMEX02/03, NAME, and OK-mesonet data
2. Comparisons between AMSR-E and TMI over OK region

Today Focus

Intercomparison of two AMSR-E soil moisture retrievals algorithms and their validation.

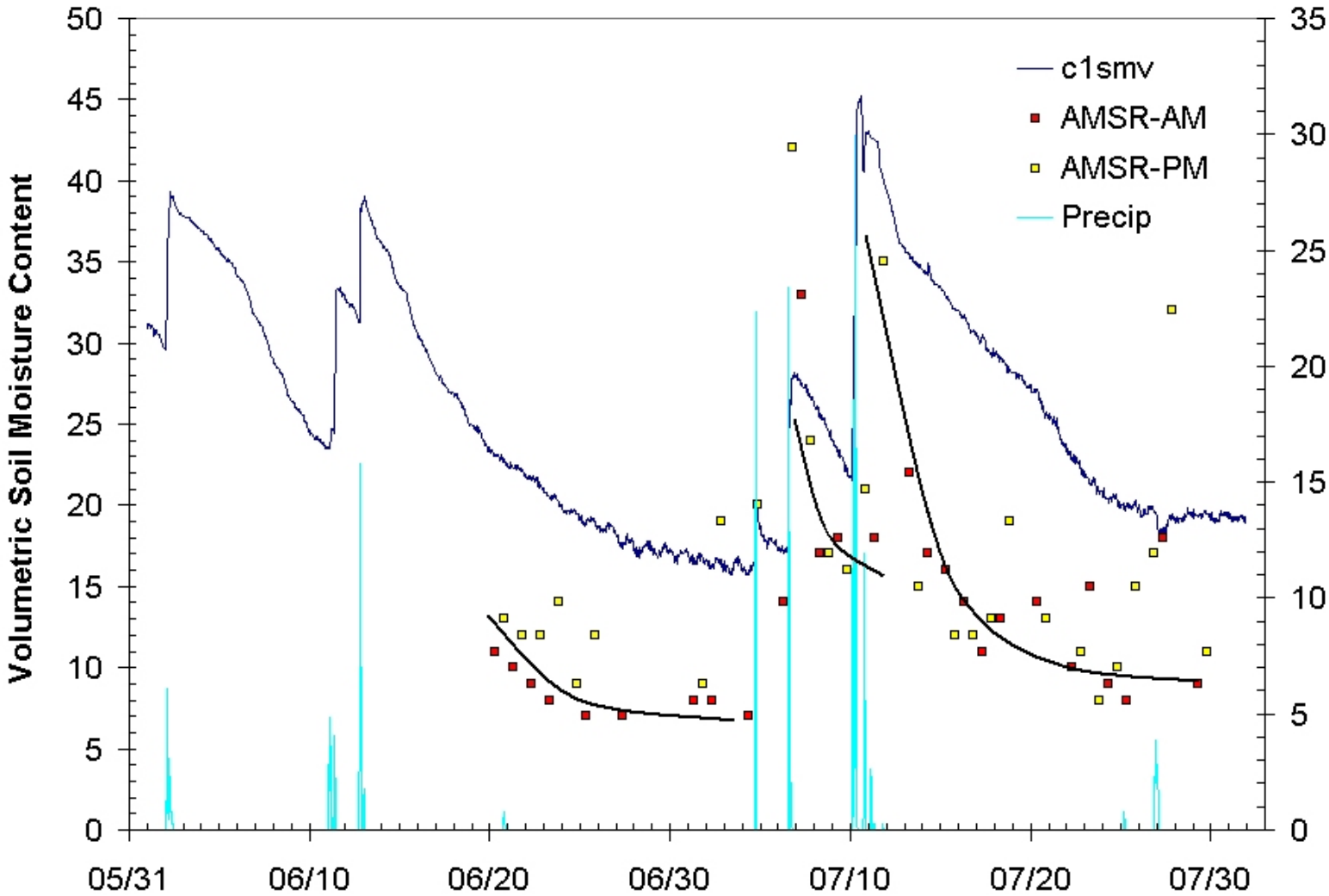
Basis of the validation research

1. Soil moisture retrievals used the Princeton (PU) Land Surface Microwave Emission Model (LSMEM) and 10.7 GHz brightness temperatures from the TRMM Microwave Imager (TMI) and AMSR-E. LSMEM is based on Tb(H) and Ts, plus ancillary land surface data (soil, vegetation, etc.)

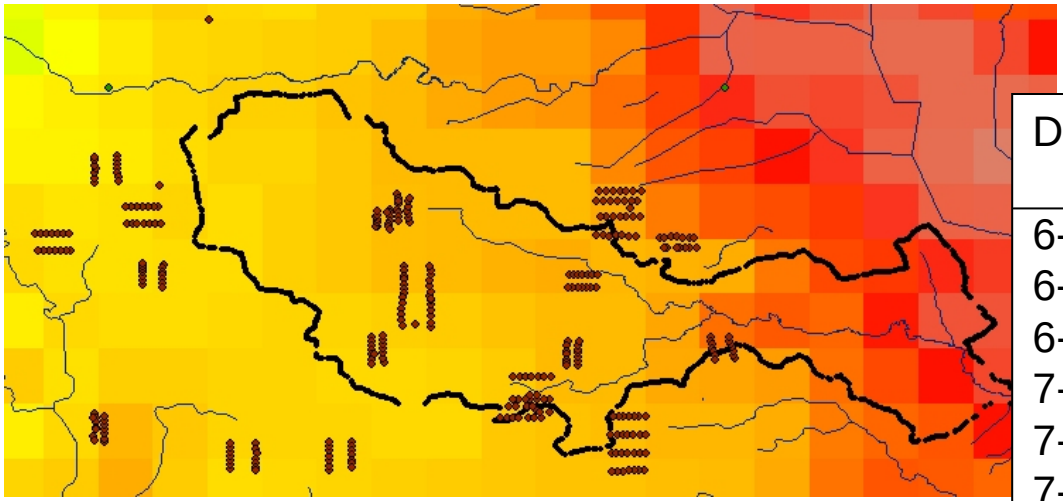
2. Retrieval comparisons were with a JPL-version of the AMSR-E retrieval algorithm for TMI and the NASA/AMSR-E 10.7 GHz retrievals; these use a polarization ratio approach and empirical parameters.

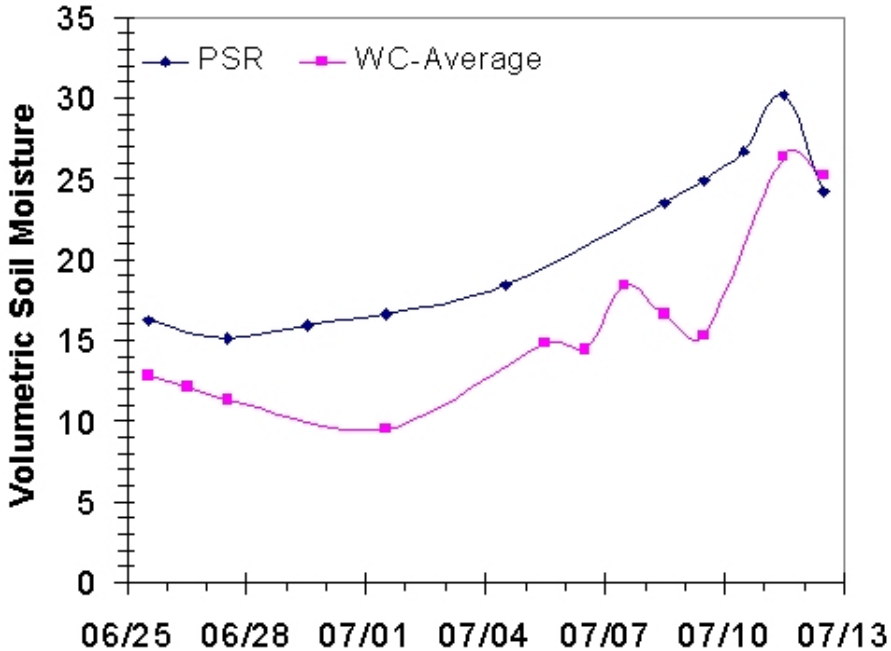
3. Comparisons were also made to SMEX field data, 5-cm soil moisture from 30 Oklahoma mesonet data sites, and to 10-cm soil moisture from a land surface model.

SMEX02: PU/AMSR-E X-Band Soil Moisture Comparison with the ARS SCAN Soil Moisture Monitoring Site



SMEX02: PU/AMSR-E 10.7 GHz Soil Moisture Comparison with the Theta Probe Field Data

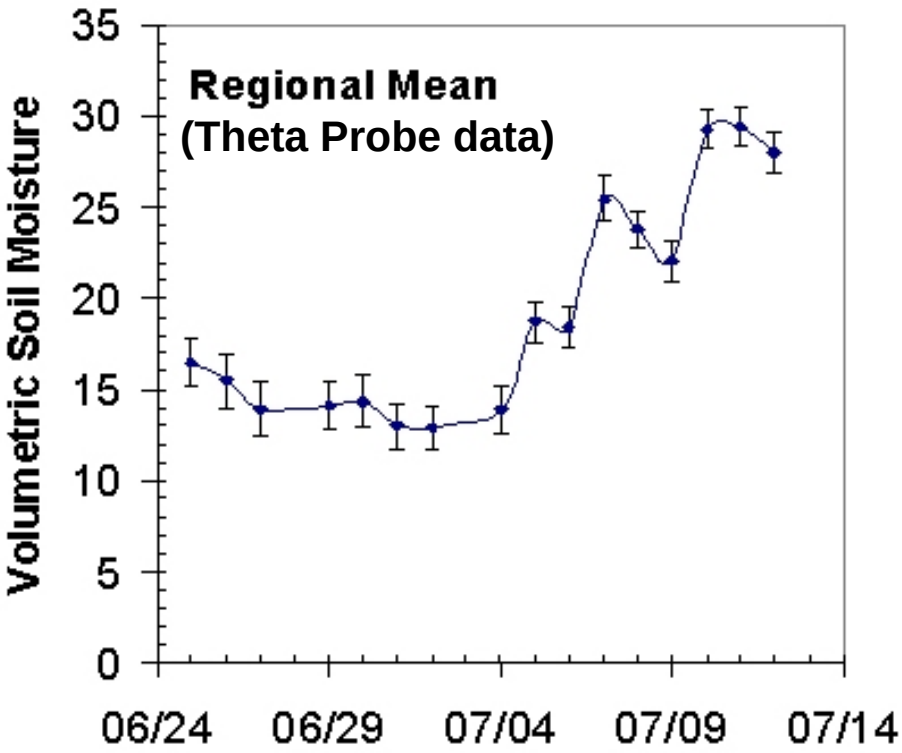


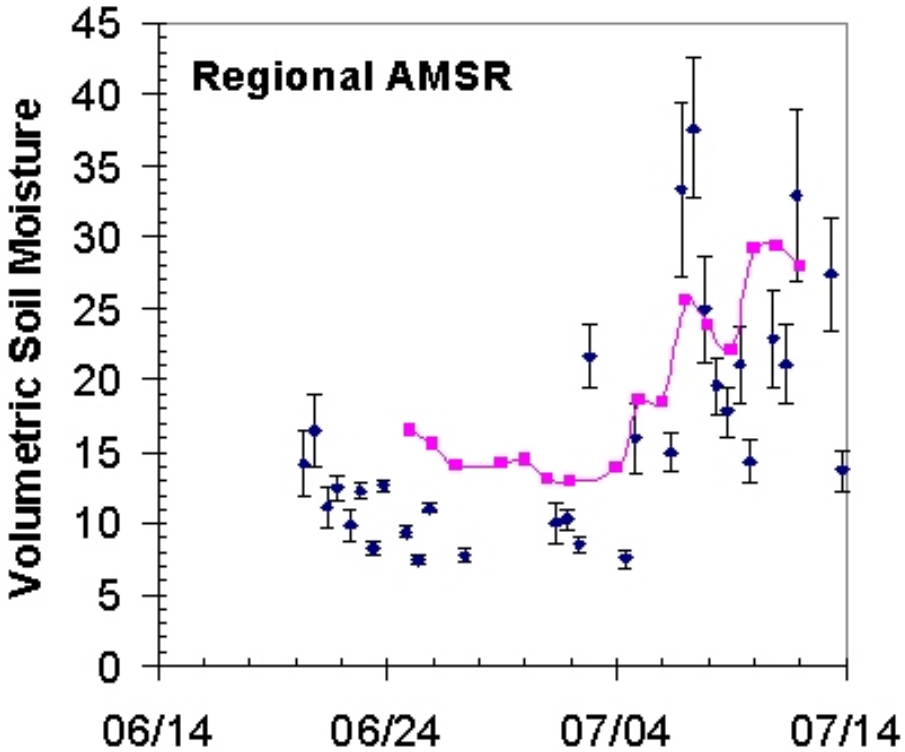


Date	Samples	Soil Moisture Avg	Soil Moisture Std dev	PU/ AMSR*
6-25	272	12.8	2.6	9.5
6-26	273	12.1	2.8	
6-27	273	11.3	2.3	7.0
7-1	103	9.5	1.6	8.5
7-5	271	14.8	2.4	
7-6	273	14.4	2.2	14.0
7-7	273	18.4	2.7	28.5
7-8	273	16.6	2.3	17.0
7-9	273	15.3	2.4	17.0
7-11	260	26.4	1.8	26.5
7-12	273	25.2	2.1	

*AMSR-E values indicate the resampled pixel that encompasses the Walnut Creek catchment ~65% of the pixel

SMEX02: PU/AMSR-E X-Band Soil Moisture Comparison with the Field Theta Probe Measurements

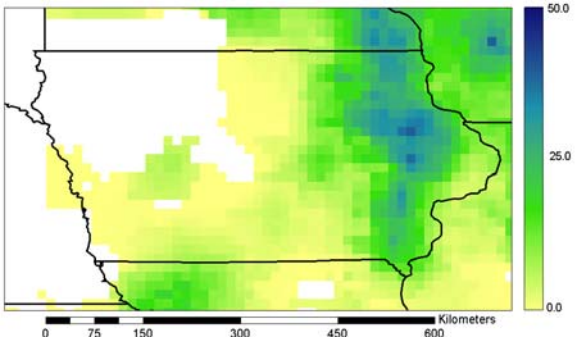


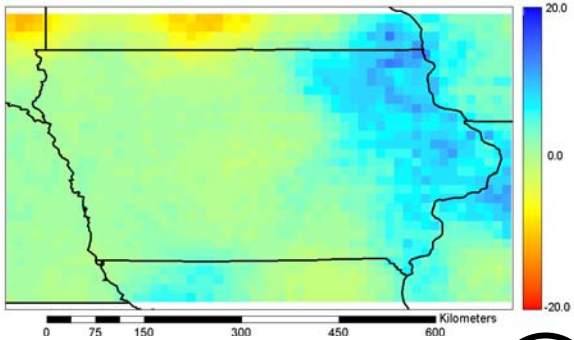


(Notice how PU/AMSR-E has more realistic variability after rain events)

Rainfall and Retrieved PU/AMSR soil moisture patterns

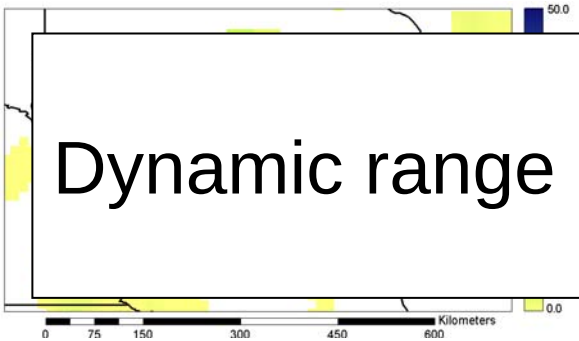
June 26



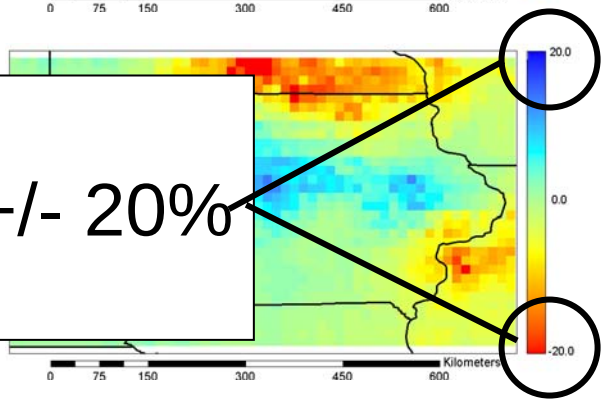


June 27 - 25

July 5

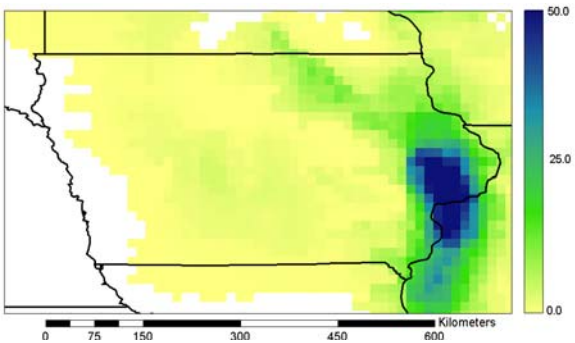


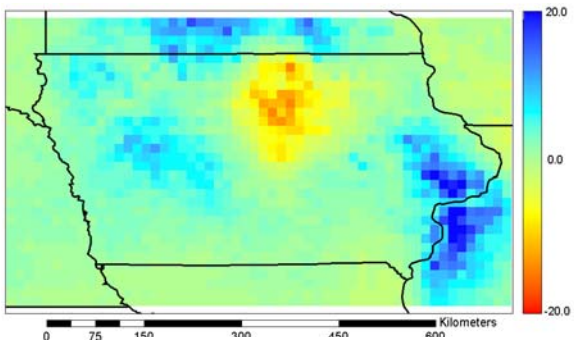
Dynamic range +/- 20%



July 6 – 4

July 19

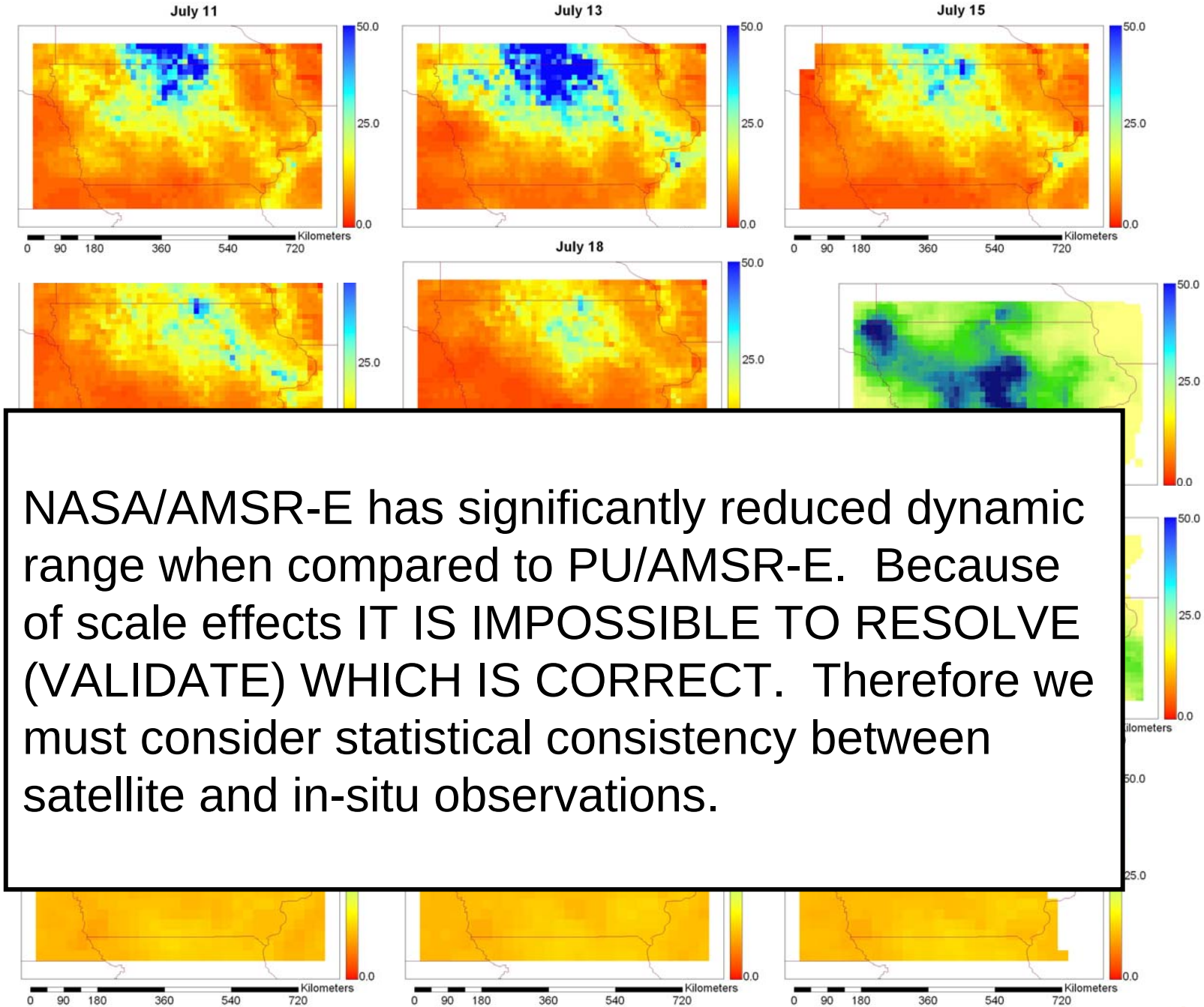




July 20 – 18

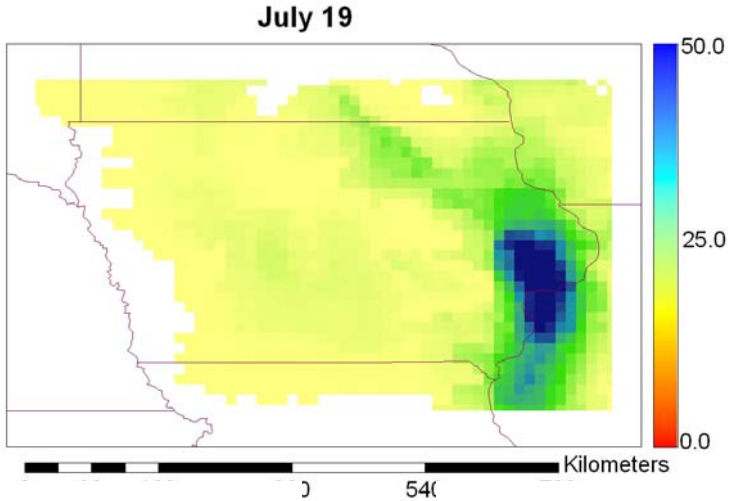
PU/
AMSR

NASA/
AMSR

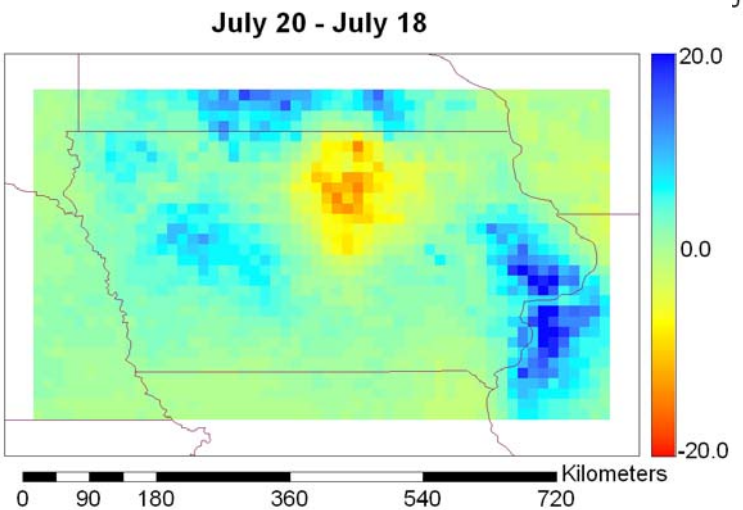


NASA/AMSR-E has significantly reduced dynamic range when compared to PU/AMSR-E. Because of scale effects IT IS IMPOSSIBLE TO RESOLVE (VALIDATE) WHICH IS CORRECT. Therefore we must consider statistical consistency between satellite and in-situ observations.

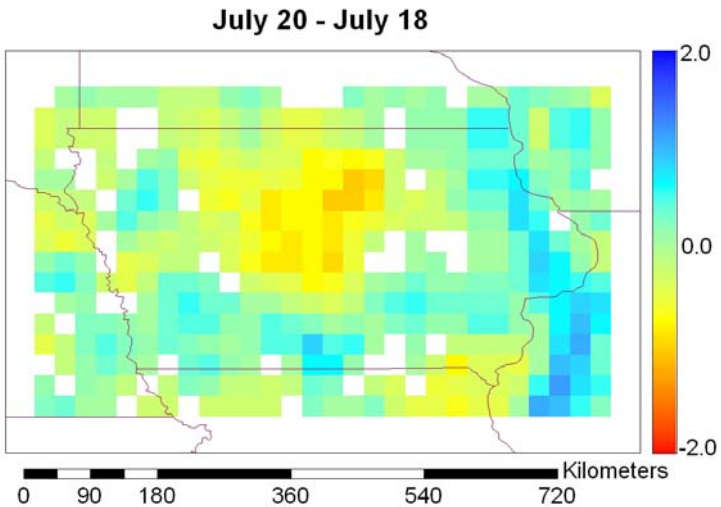
Looking at soil moisture differences between pre- and post-rain days



Rainfall (mm)



PU/AMSR-E differences % soil moisture

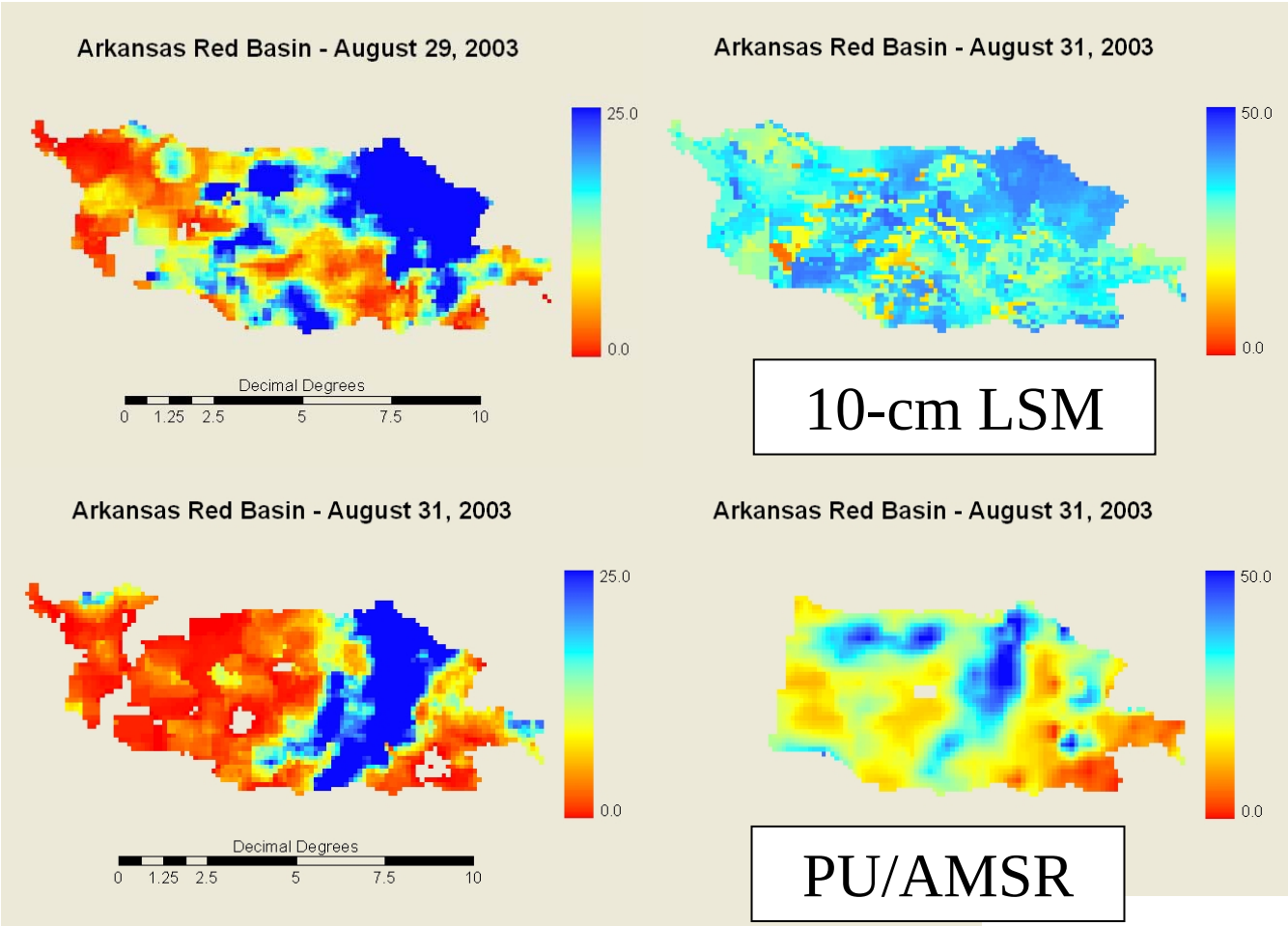


NASA/AMSR-E differences – reduced range

Soil Moisture – Rainfall Comparison

Precipitation Aug 29/31:

Soil moisture



…strong influence on soil storage in both the VIC and AMSR responses.

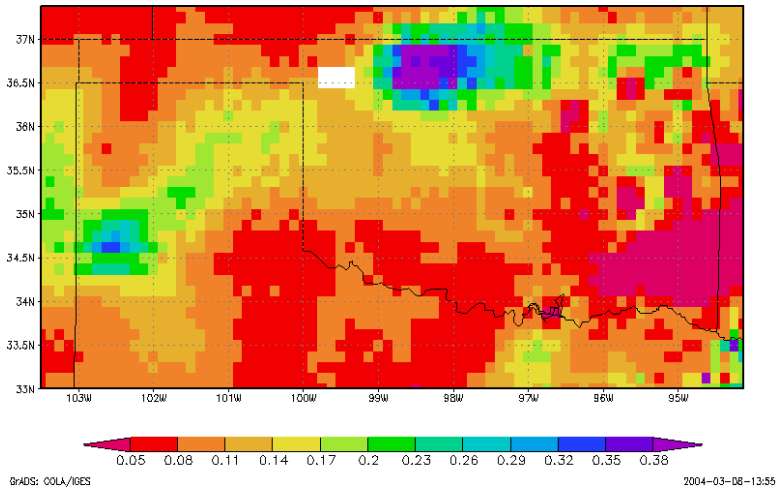
Delayed response evident in VIC estimates.

Algorithm Validation/Comparisons over the SGP

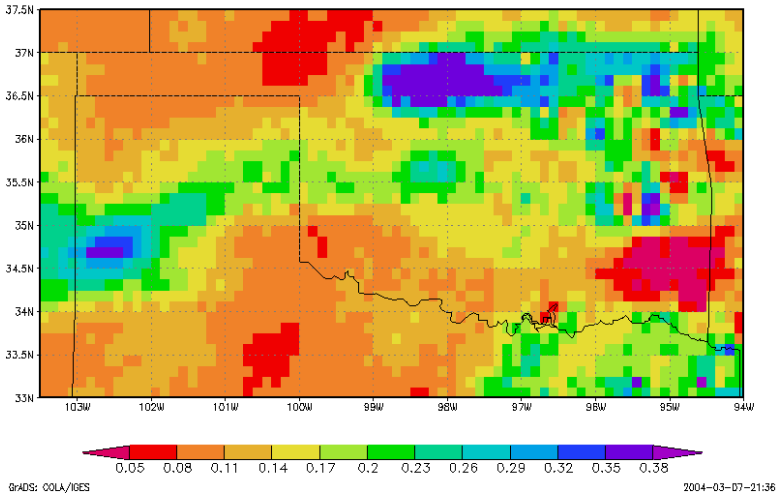
Used 6 years of TMI 10.7 GHz data (1998-2003) and 2 years of AMSR-E data (2003-2004).

With TMI, used JPL/TMI algorithm from Eni Njoku. With AMSR-E, used retrieved soil moisture from the NASA DAAC.

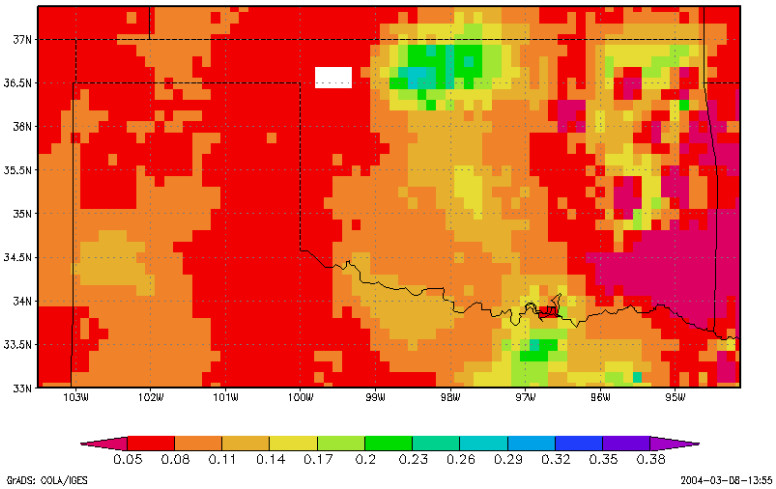
PU/AMSR-E 10.7 GHz Soil Moisture Comparisons with PU/TMI-based Soil Moisture



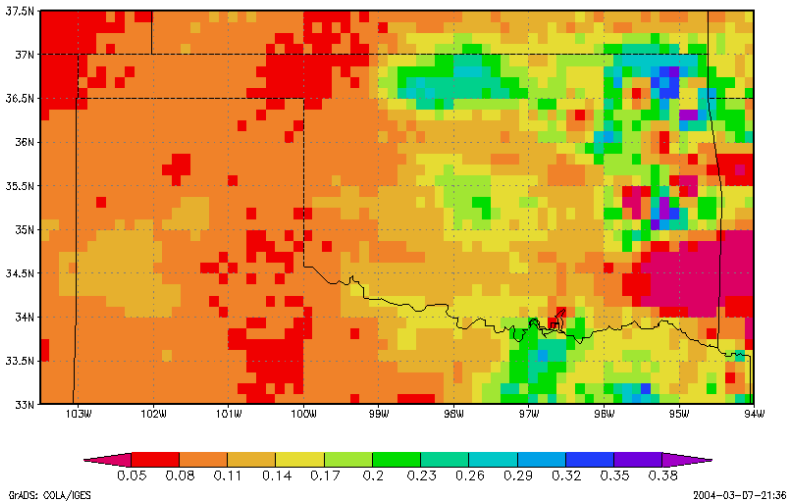
AMSR-E retrieved soil moisture July 23, 2002



TMI retrieved soil moisture July 23, 2002

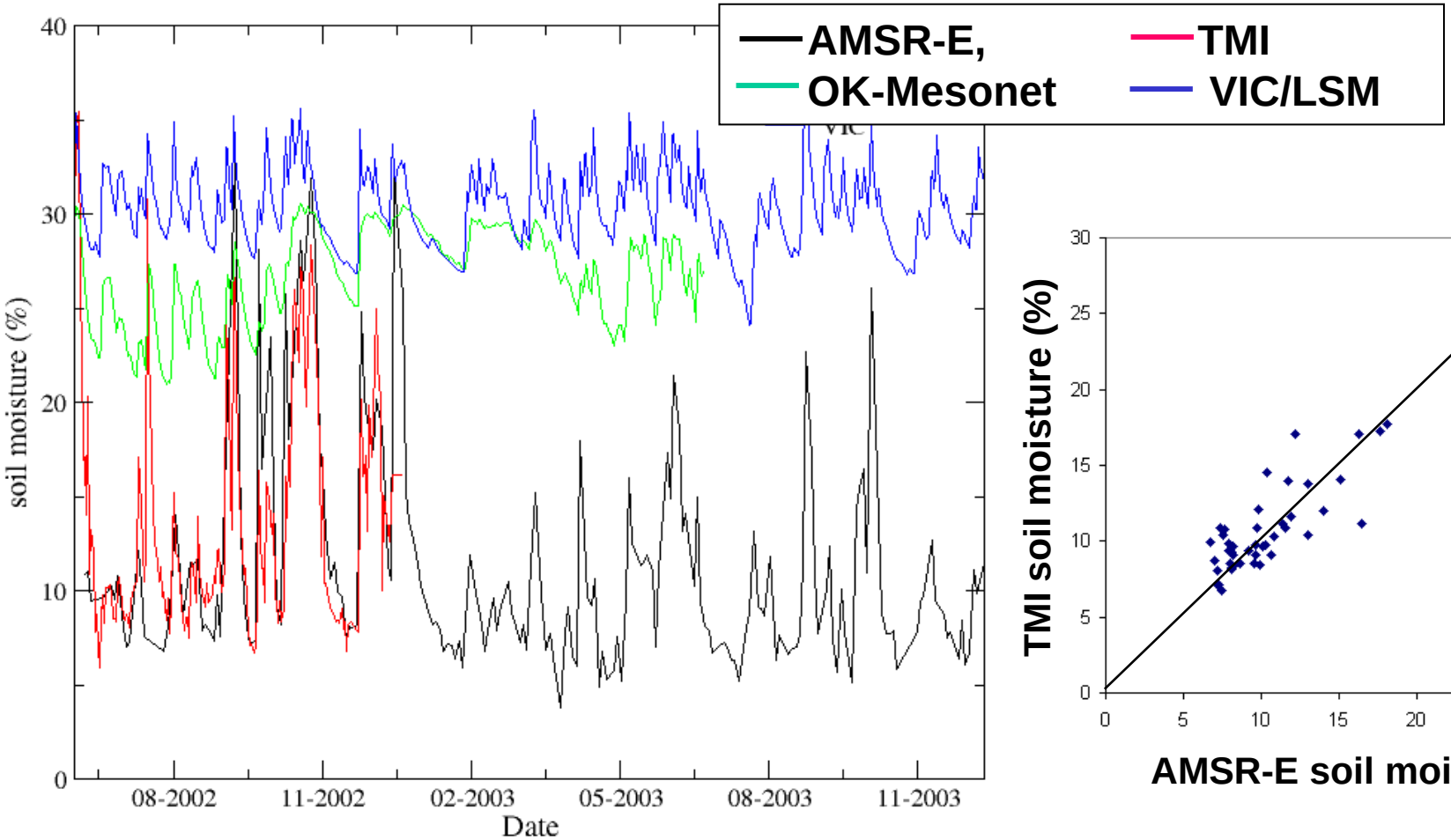


AMSR-E retrieved soil moisture July 25, 2002



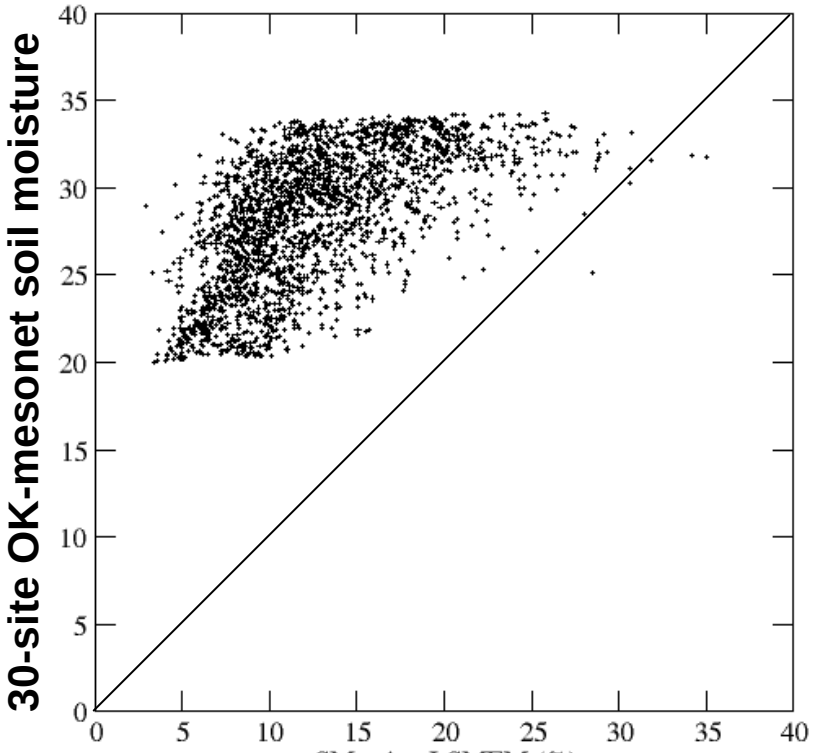
TMI retrieved soil moisture July 25, 2002

PU/AMSR-E X-Band Soil Moisture Comparisons with PU/TMI X-Band Soil Moisture

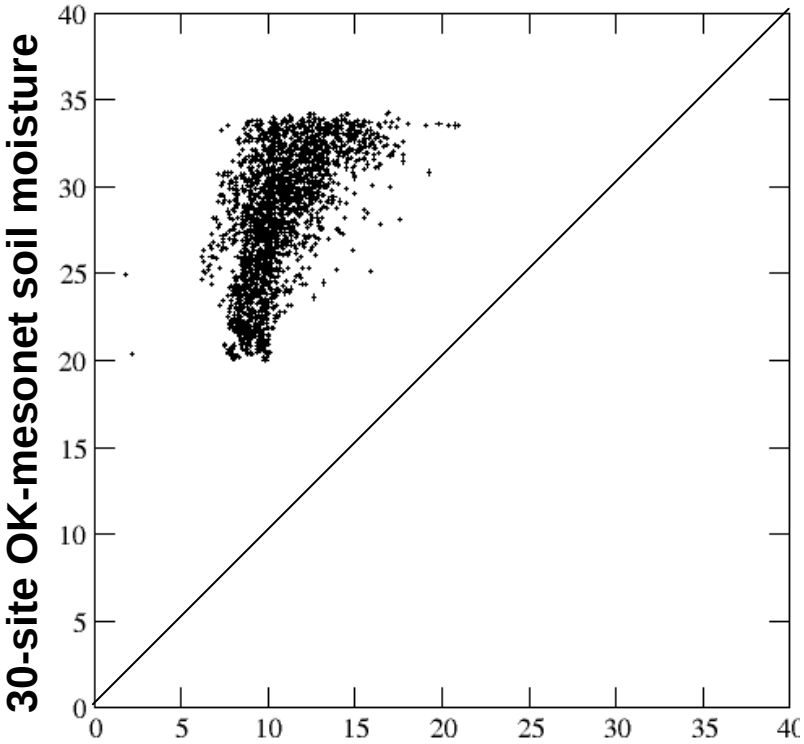


Lesson: Retrievals consistent across sensors, but different from *in-situ*

Retrieved soil moisture averaged over 30 Oklahoma mesonet sites

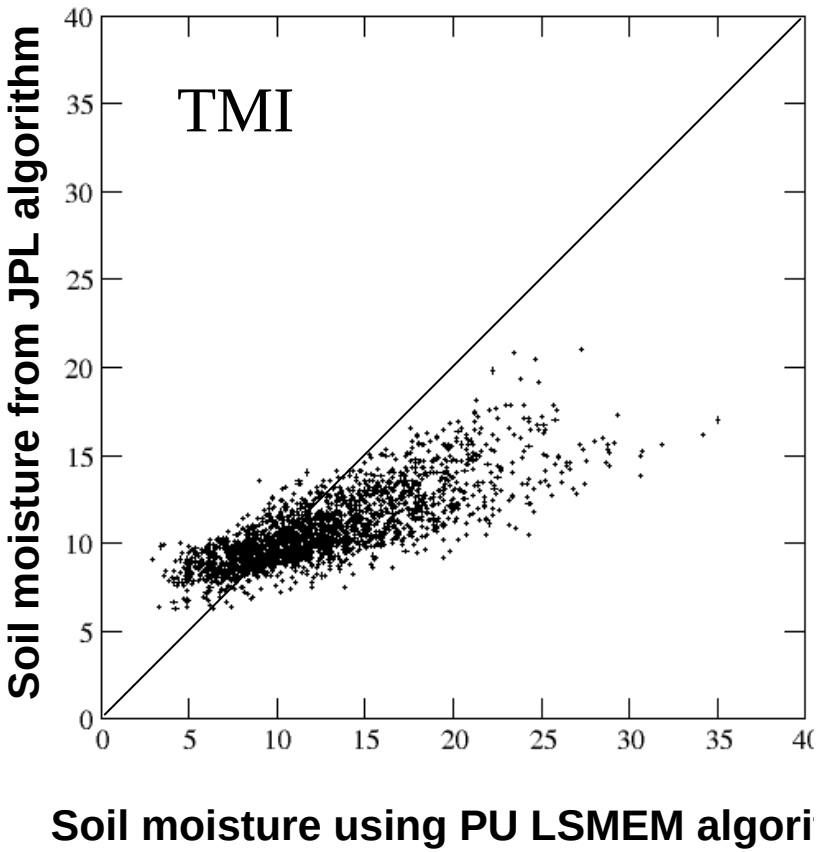


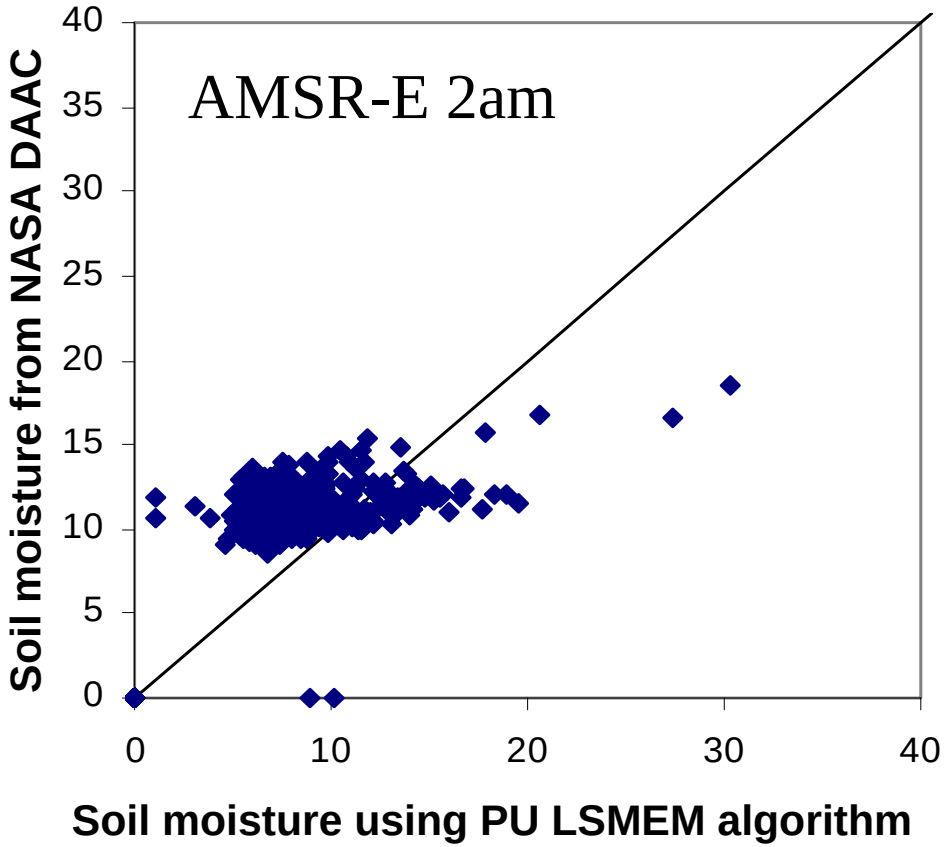
Soil moisture using PU LSMEM algorithm



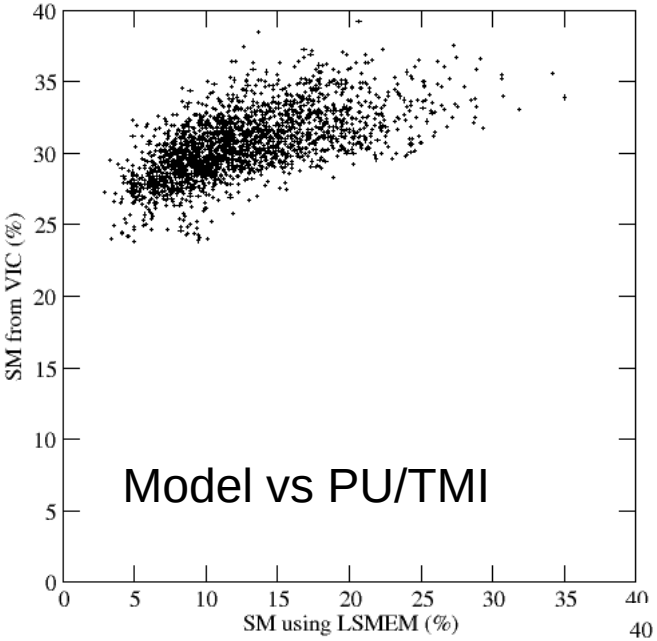
Soil moisture using NASA/JPL algorithm

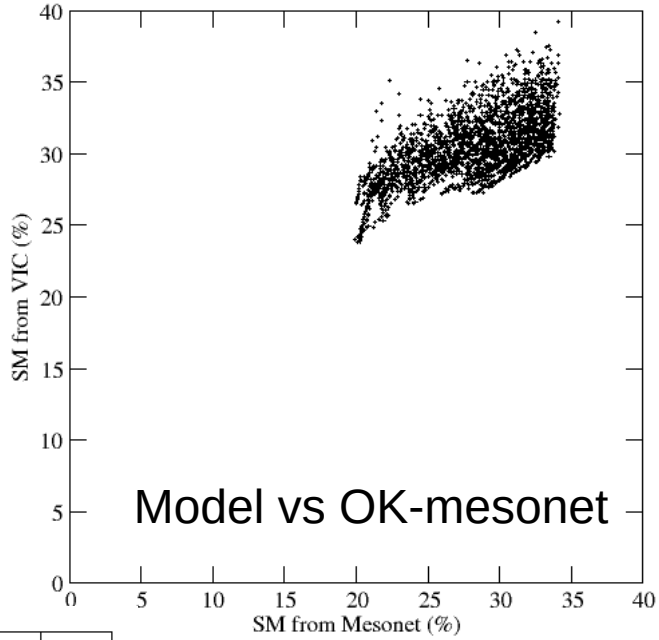
Algorithm comparison for retrieved soil moisture averaged over 30 Oklahoma mesonet sites

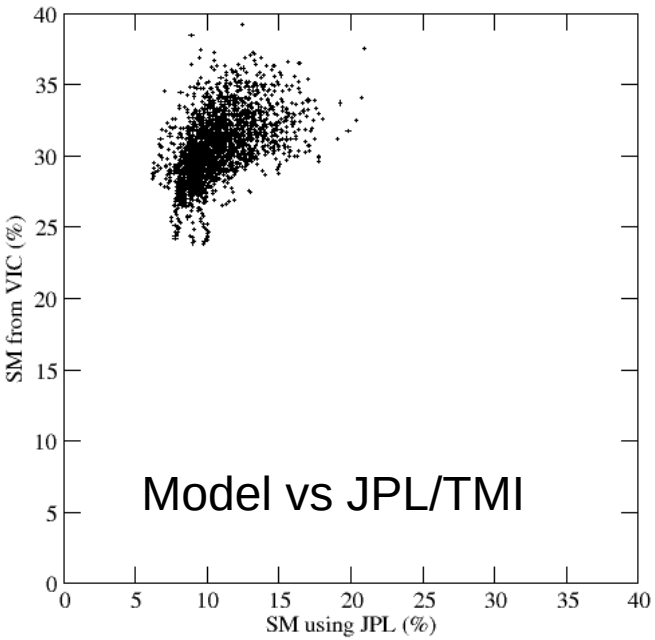




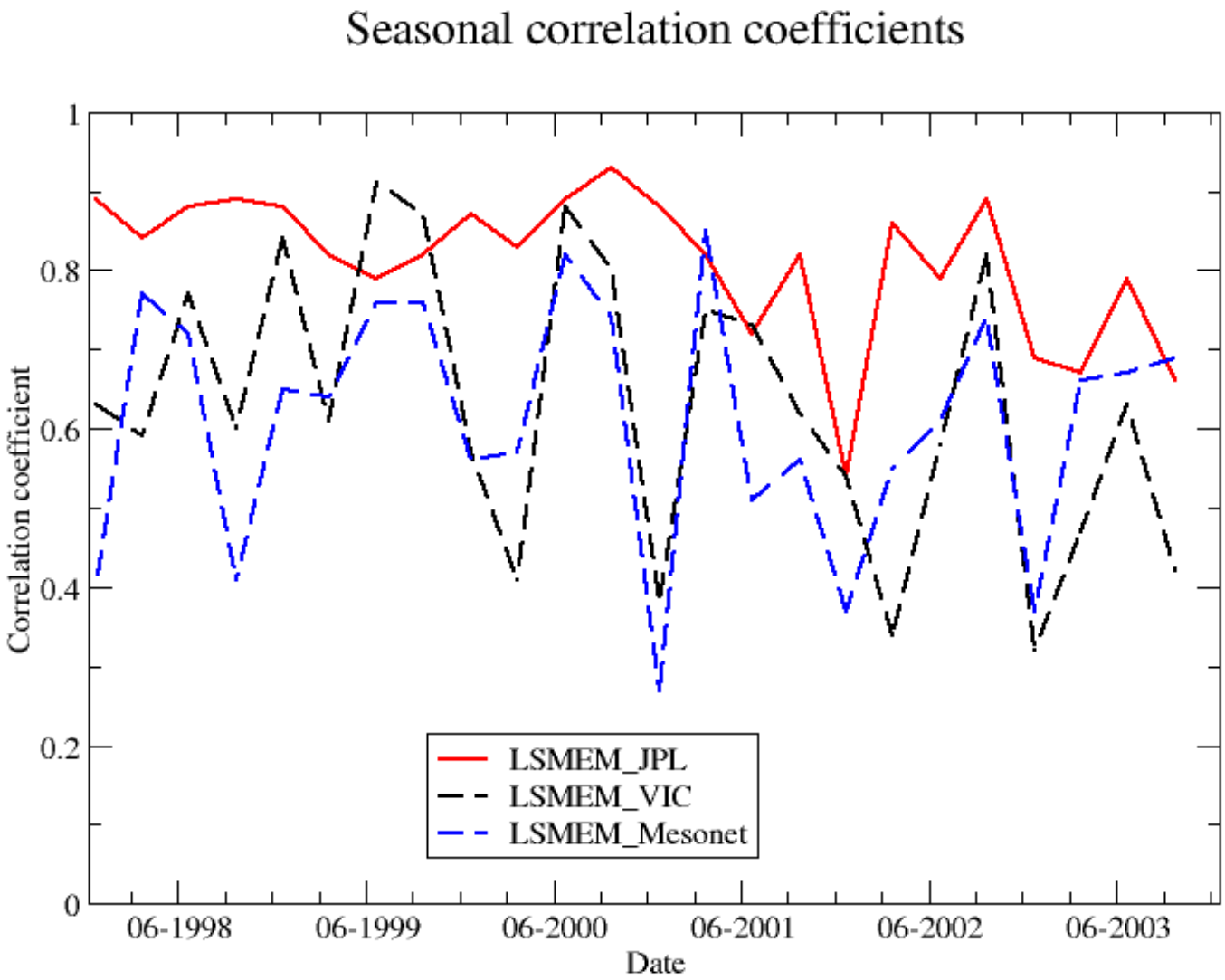
Comparisons between LSM and retrieved soil moistures



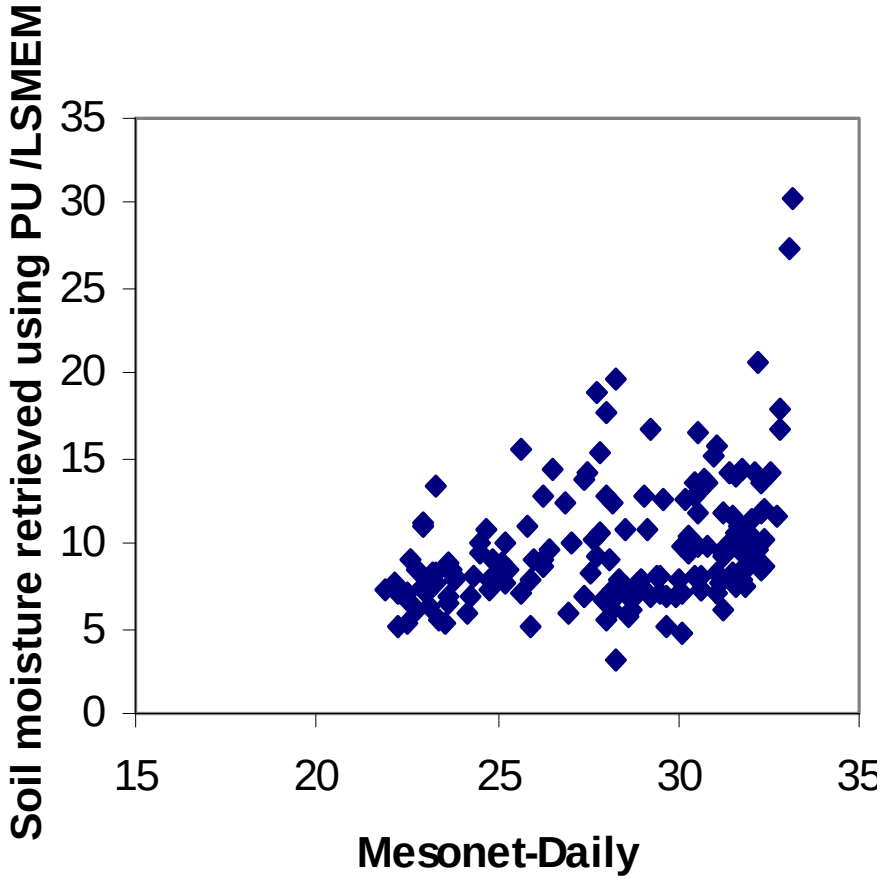


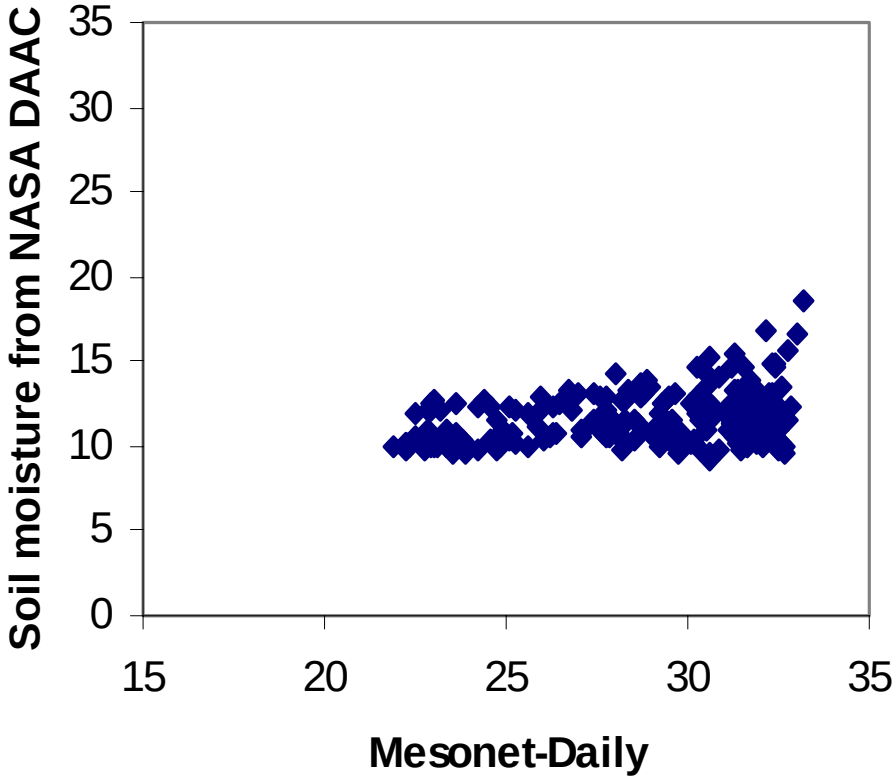


Statistical consistency between LSM and retrieved soil moistures

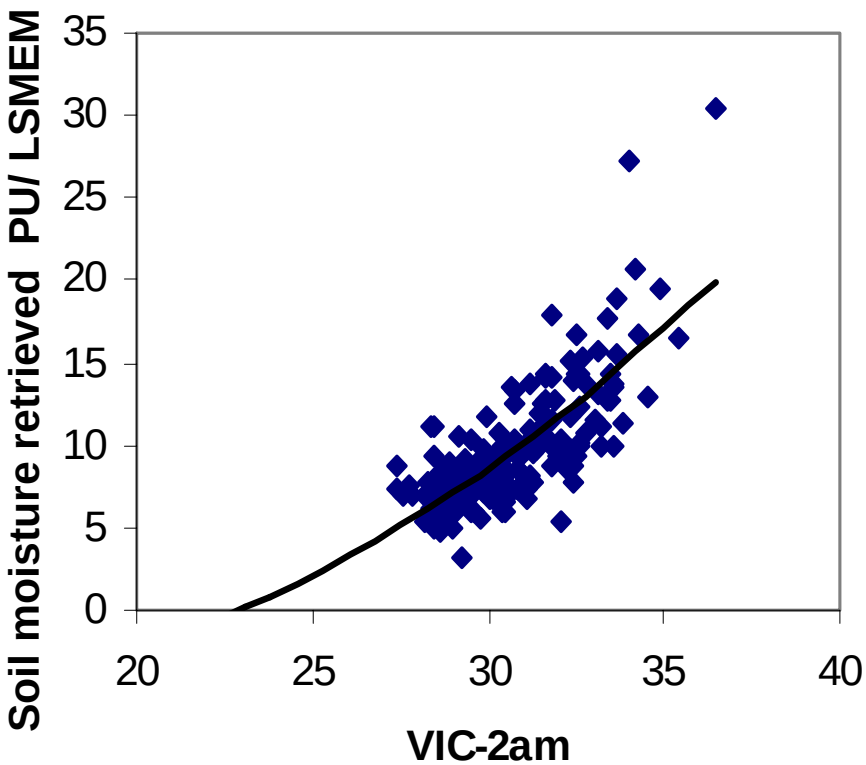


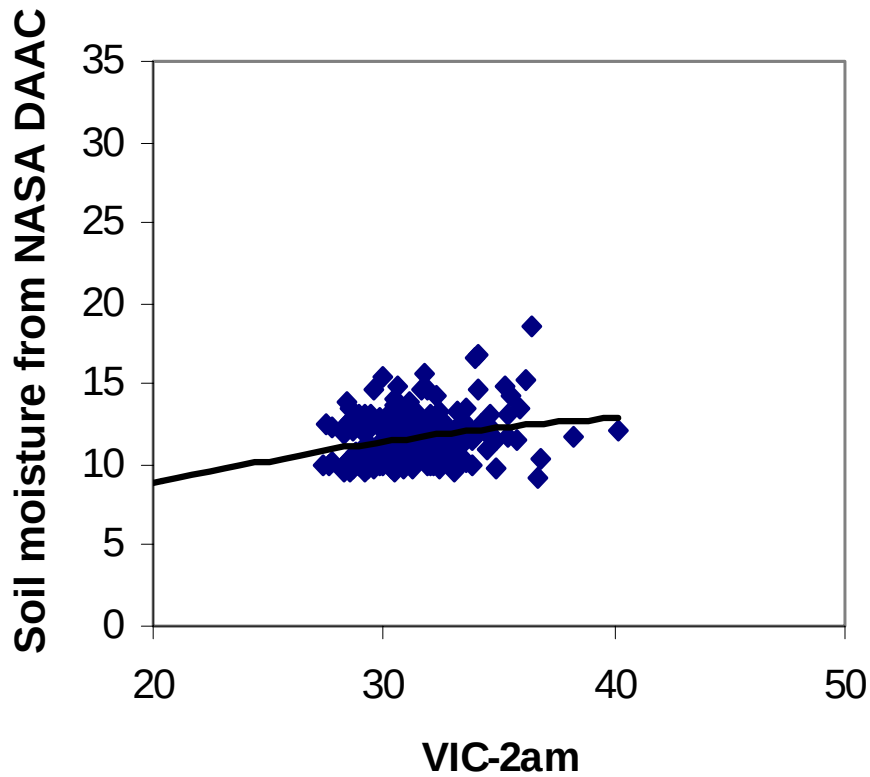
AMSR-E results from PU/LSMEM (left) and NASA/DAAC (right) for 2004 AMSR-E am overpasses over the 30 OK-mesonet sites, compared to the 30 mesonet sites





AMSR-E results from PU/LSMEM (left) and NASA/DAAC (right) for 2004 am overpasses over the 30 OK-mesonet sites compared with the same sites from VIC 2am LSM output. Parabolic trend line has been fitted to both; Note that rainfall has been filtered out of the LSMEM result but not the NASA/DAAC

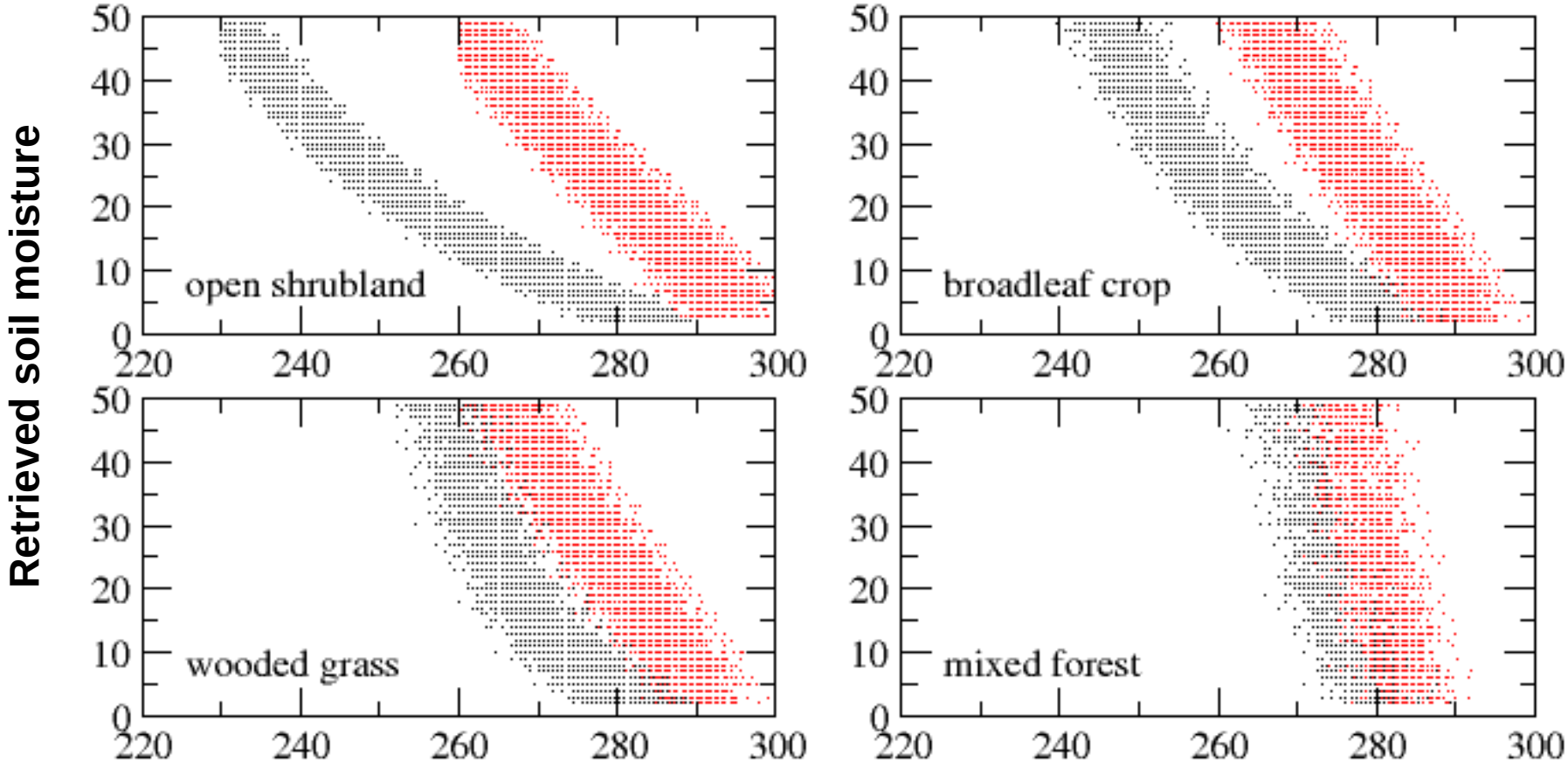




Implications for retrieval error estimates and use in assimilation

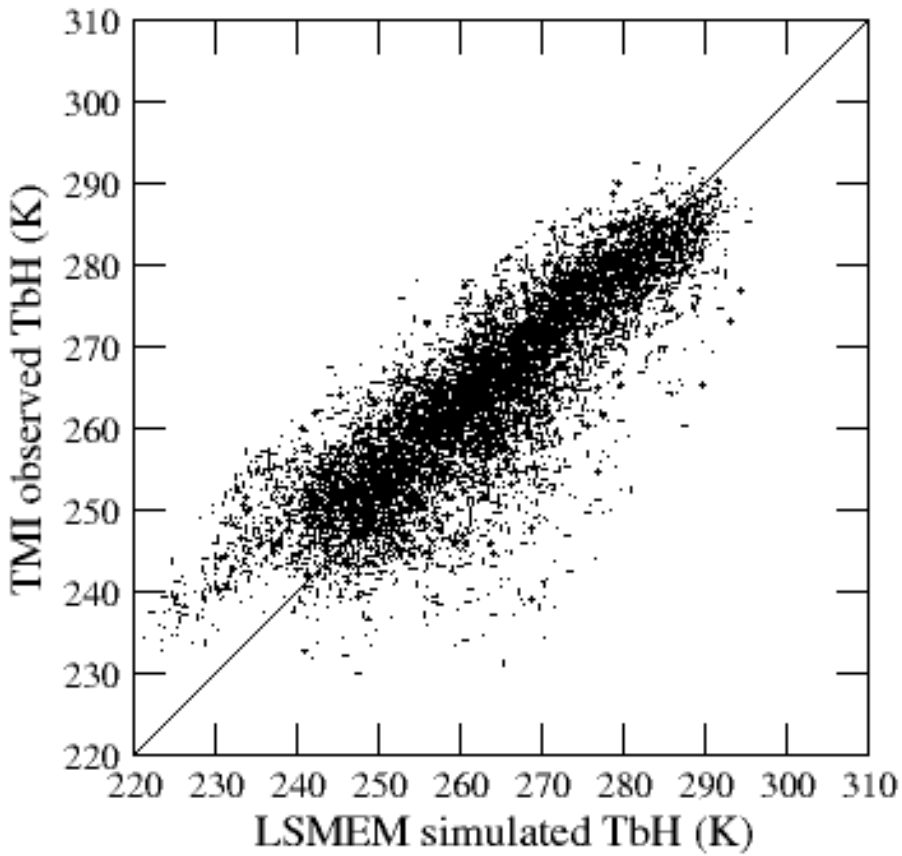
1. The reality that retrieved soil moistures have different mean values and dynamic ranges implies that new, innovative statistical approaches are needed for validation: “statistical consistency” – this is currently being developed at Princeton.
2. The lack of a dynamic range in the NASA/JPL DAAC algorithms is problematic, but the two products are well correlated.
3. Sensitivity analysis for the algorithms are underway. For the PU LSMEM, errors in Ts appear to result in high frequency noise in SM during dry periods.
4. For individual (validation) points, the errors between satellite retrievals (at 25-40 km scales) can be very large.

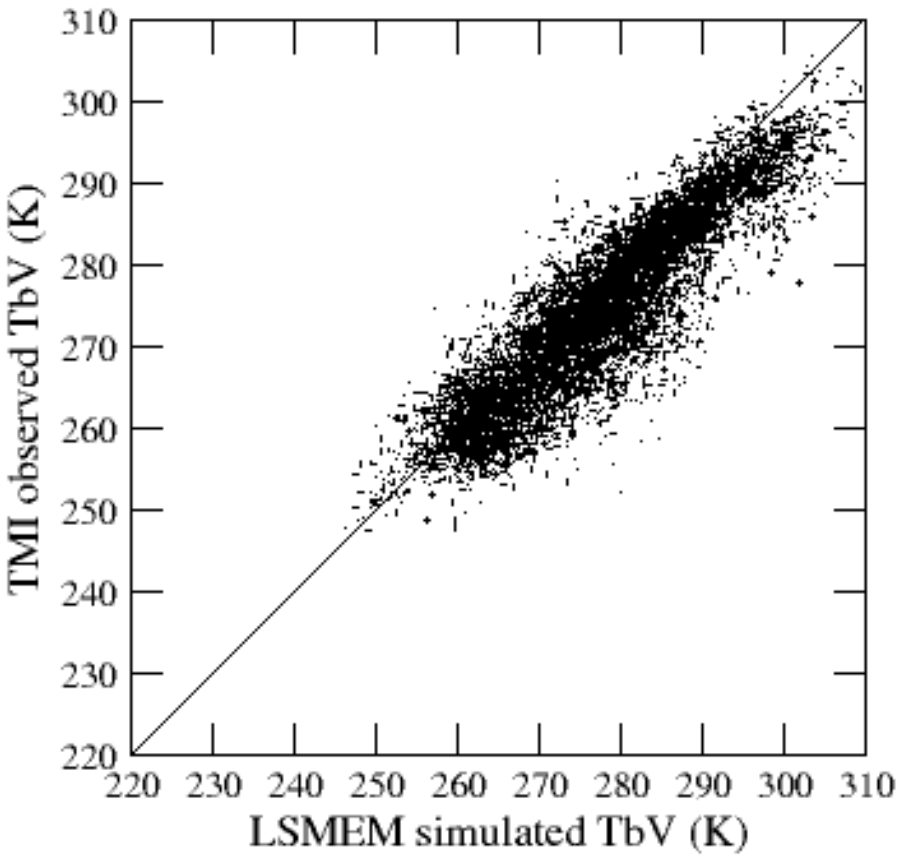
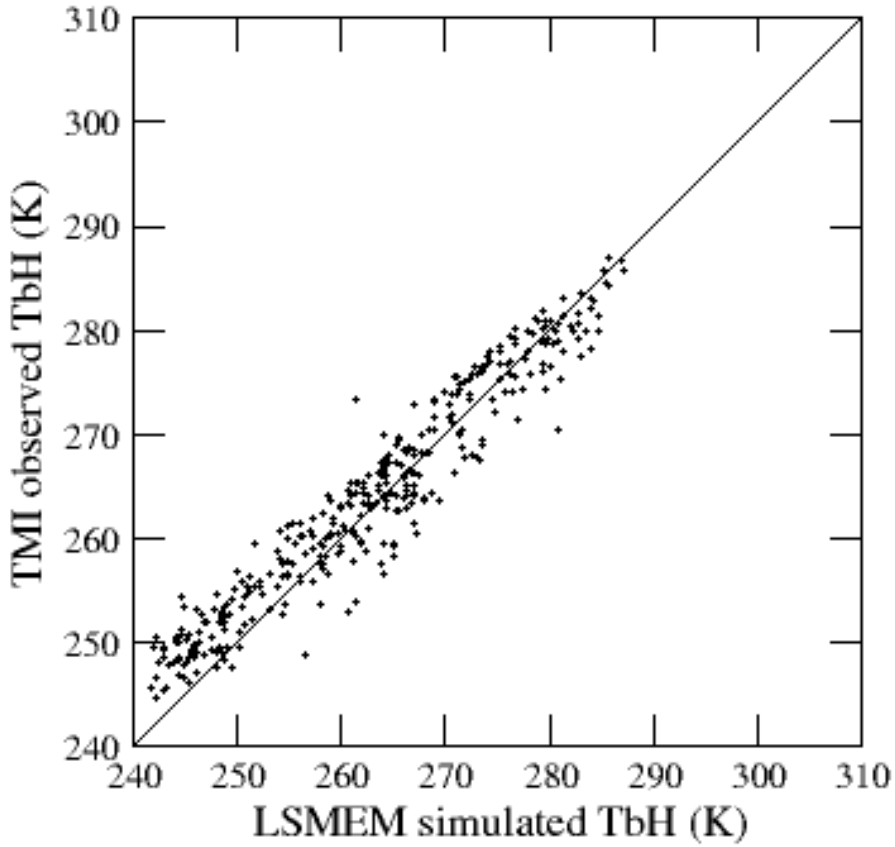
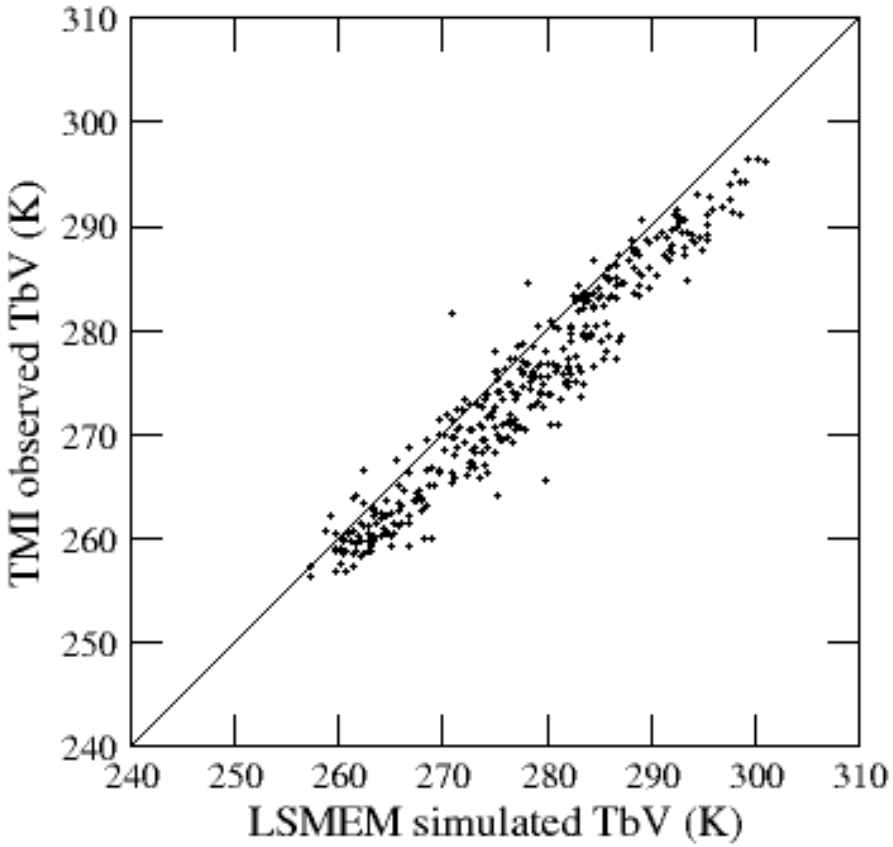
Sensitivity of retrieved soil moisture using the PU LSMEM uncertainty in Ts (RMS error 3K) for four OK-mesonet sites (i.e. soil, vegetation, roughness characteristics from the sites)



'Observed' 10.7 GHz brightness temperatures: Tb(V)—red; Tb(H)—black (results from 100 Monte Carlo simulations)

Comparisons between observed and simulated Tb, over 23 OK-mesonet sites, for 363 TMI orbits from 2003





Comparisons between observed and simulated Tb, averaged over 23 OK-mesonet sites, for 363 TMI orbits from 2003