Soil moisture measurements and modeling for validating AMSR-E soil moisture and brightness temperatures

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Objectives of overall project:

- **Provide best estimates of soil moisture and C- and X-band brightness temperatures (T_B) with associated confidence limits to validate AMSR-E products at the footprint scale (~ 50 km) and on the 25 km EASE grid**
- **Soil moisture and T_B estimates will be generated using a coupled hydrologic/ radiobrightness model with data assimilation from aircraft-borne microwave sensors.**
- **Validation will be performed using data from regional field experiments such as SMEX '02 in Iowa.**

Today's presentation:

- **Describe validation strategy and models**
- **Present preliminary results comparing AMSR-E C-band T_B with best model estimates**

AMSR-E T_B Validation Strategy

AMSR-E Soil Moisture

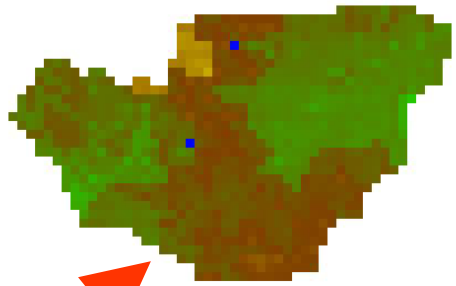
Assimilation of aircraft microwave data

Land surface/ hydro model

Soil temperature, moisture profiles

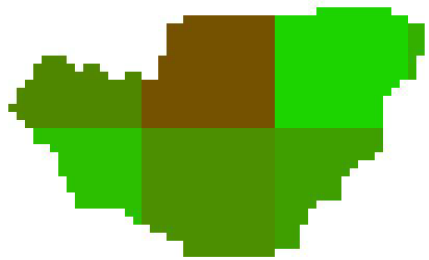
Radiobrightness model

Model-scale T_B



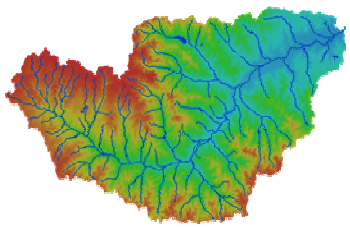
Aggregation

AMSR-scale T_B for validation



Evaluate scaling errors

Soils, vegetation, topography



Advanced Microwave Scanning Radiometer-EOS (AMSR-E)

AMSR-E Soil Moisture

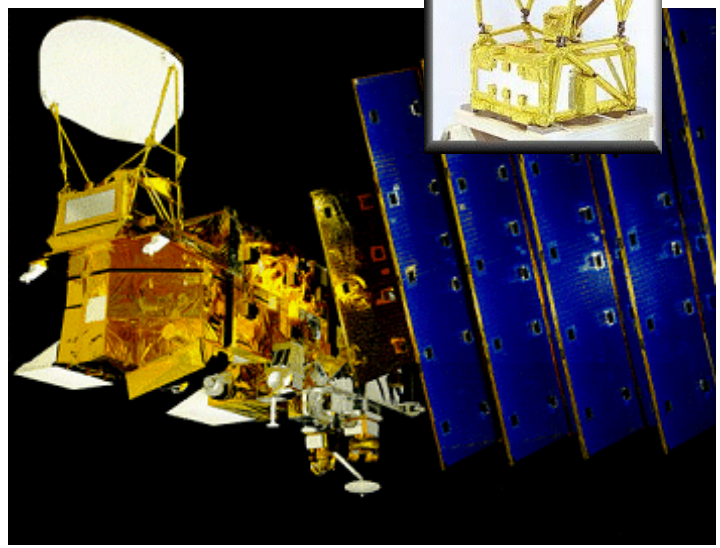
Sensor Specifications:

Frequency (GHz)	Polarization	Sensitivity (K)	Mean Spatial Resolution (km)	Swath (km)
6.925	V, H	0.3	56	1445
10.65	V, H	0.6	38	1445
18.7	V, H	0.6	21	1445
23.8	V, H	0.6	24	1445
36.5	V, H	0.6	12	1445
89.0	V, H	1.1	5.4	1445

- 12 channel, 6 frequency conically scanning passive microwave radiometer
- Built by NASDA

AMSR-E

Aqua



Launch:

- AMSR-E launched on Aqua on May 4, 2002
- AMSR launched on ADEOS-II on Dec. 14, 2002

Orbit:

- Sun-synchronous orbit
- Equatorial crossing at 1330 LST for AMSR-E and 1030 LST for AMSR
- Earth incidence angle of 55°

Soil Moisture Experiments in 2002 (SMEX '02)

AMSR-E Soil Moisture

Location: Near Ames, Iowa
Time: 24 June – 13 July 2002

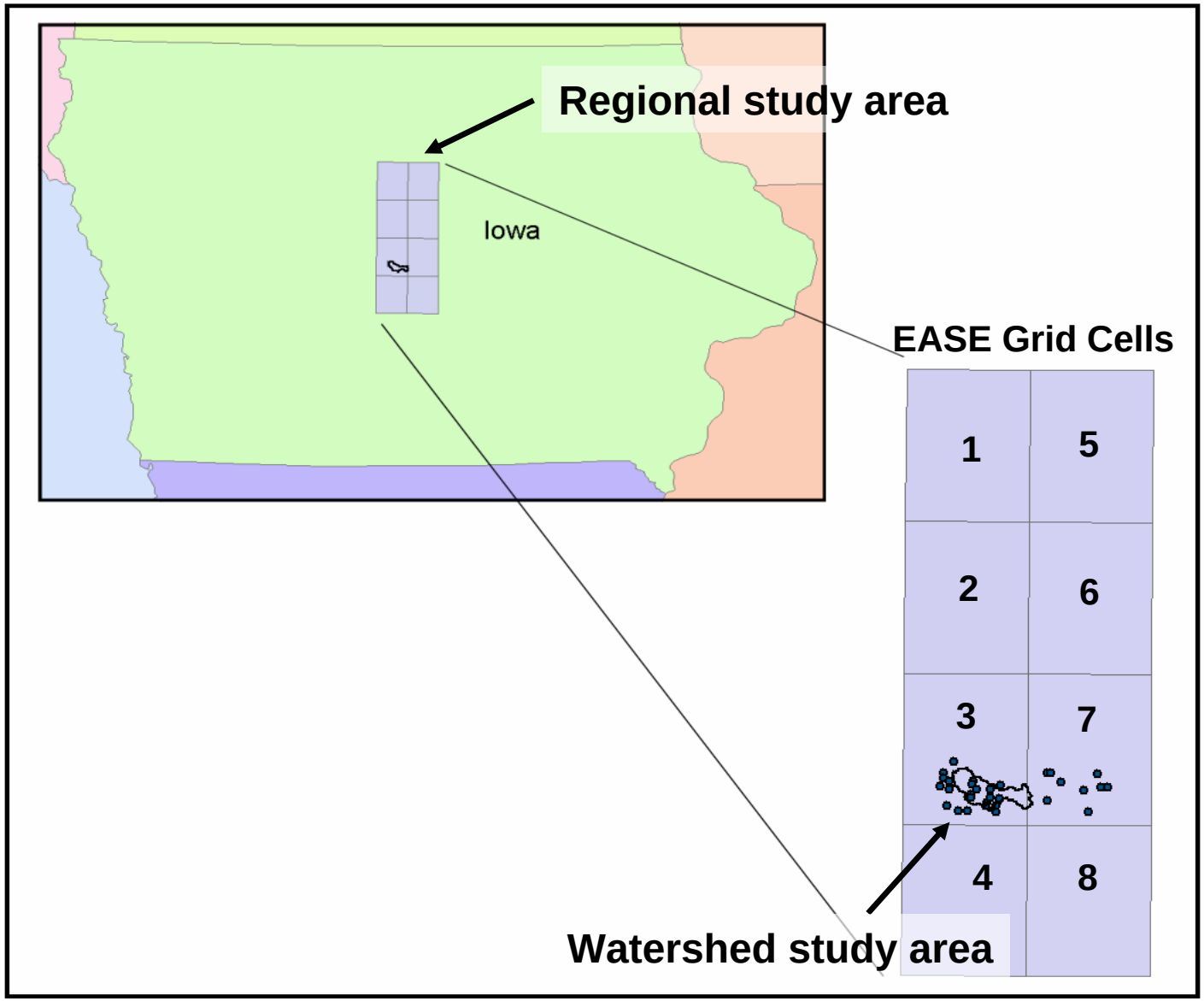
Walnut Creek watershed area:
- ~ 400 km^2
- 31 ground sampling sites for measuring gravimetric soil moisture, surface and soil temperatures (daily, AM), and vegetation properties (~weekly)
- Surface energy flux stations, lidar, and radiosonde measurements

Regional area:
- ~5000 km^2
- 48 ground sampling sites for measuring gravimetric soil moisture (daily, PM)

Corn (50% of area)

Soybeans (40% of area)

EASE Grid Cells in SMEX '02



T_B Validation Methodology

Characterize errors in AMSR-E T_B relative to model estimates at the EASE grid scale:

- **Tune SHEELS by adjusting soil and vegetation parameters to match the 0-6 cm gravimetric soil moisture at the 31 sampling sites in the Walnut Creek watershed study area**

- **Tune the RTM by adjusting surface roughness and vegetation parameters to match C-band Polarimetric Scanning Radiometer (PSR) T_B**

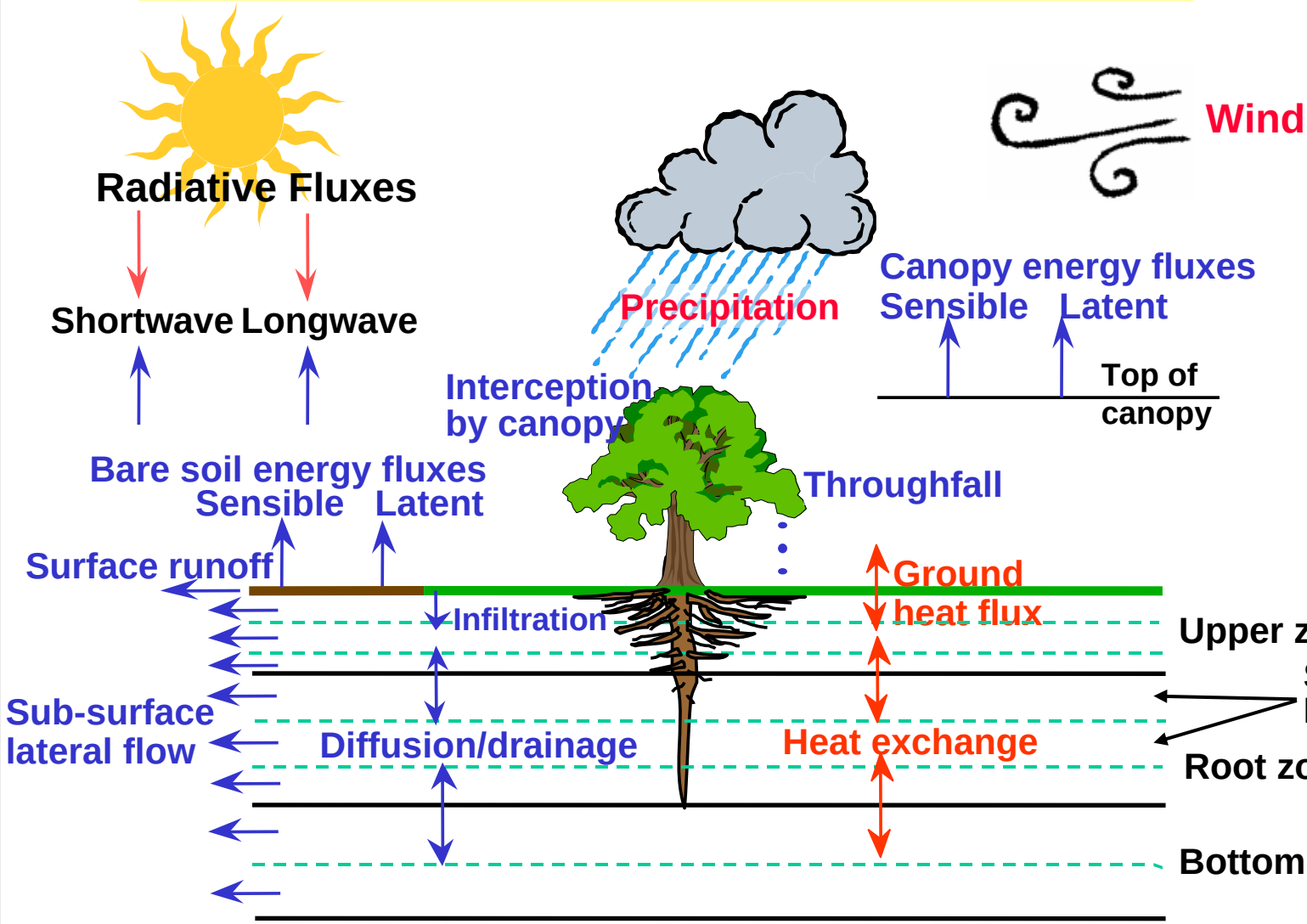
- **Validate AMSR-E C-and X-band T_B at the EASE grid scale within the SMEX '02 regional study area**

- **Estimate errors in T_B associated with sampling from footprint measurements to the EASE grid**

AMSR-E Soil Moisture

SHEELS:
Simulator for Hydrology and Energy Exchange at the Land Surface

AMSR-E Soil Moisture



Microwave Radiative Transfer Model

Forward coherent wave radiative transfer model of Njoku and Kong, 1977

- **Determines microwave brightness temperatures at given frequencies based on soil moisture and temperature profiles**
- **Soil moisture and temperature profiles are supplied by SHEELS or *in situ* observations**
- **Includes parameterizations for effects of surface roughness and vegetation**
- **Using Dobson dielectric mixing model in this study**

AMSR-E Soil Moisture

SHEELS/RTM Modeling Procedure

- Initialize soil moisture profile based on antecedent precipitation on day 161 (10 June)

- Run SHEELS at hourly time step, forcing with NWS North Central River Forecast Center Multi-sensor Precipitation Estimates (MPE)

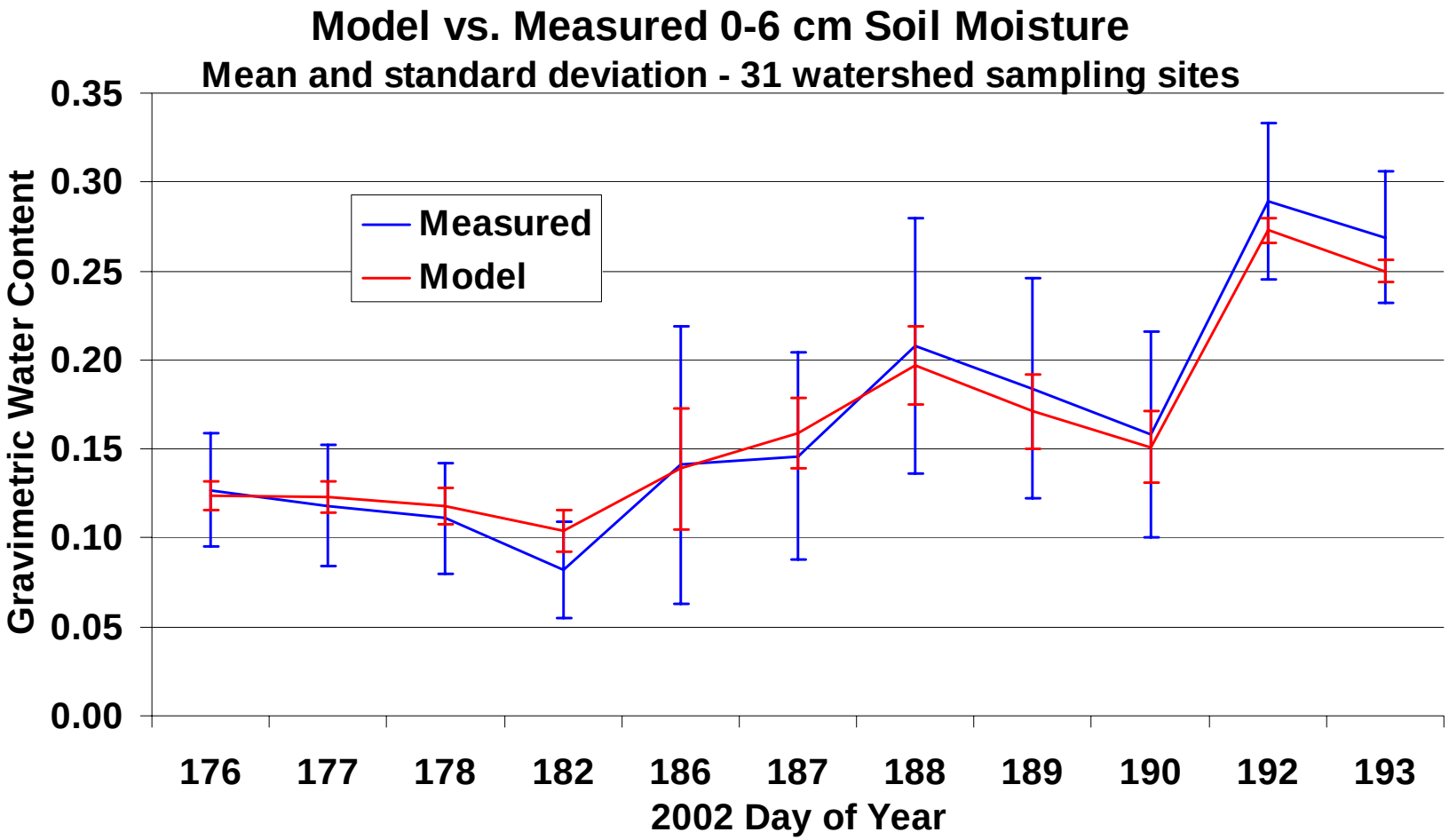
- Other meteorological forcing obtained from USDA Soil Climate Analysis Network (SCAN) site at Ames, Iowa

- SHEELS soil layer configuration:

Zone	Thickness (cm)	No. layers
Upper	6	6
Root	94	9
Bottom	50	2

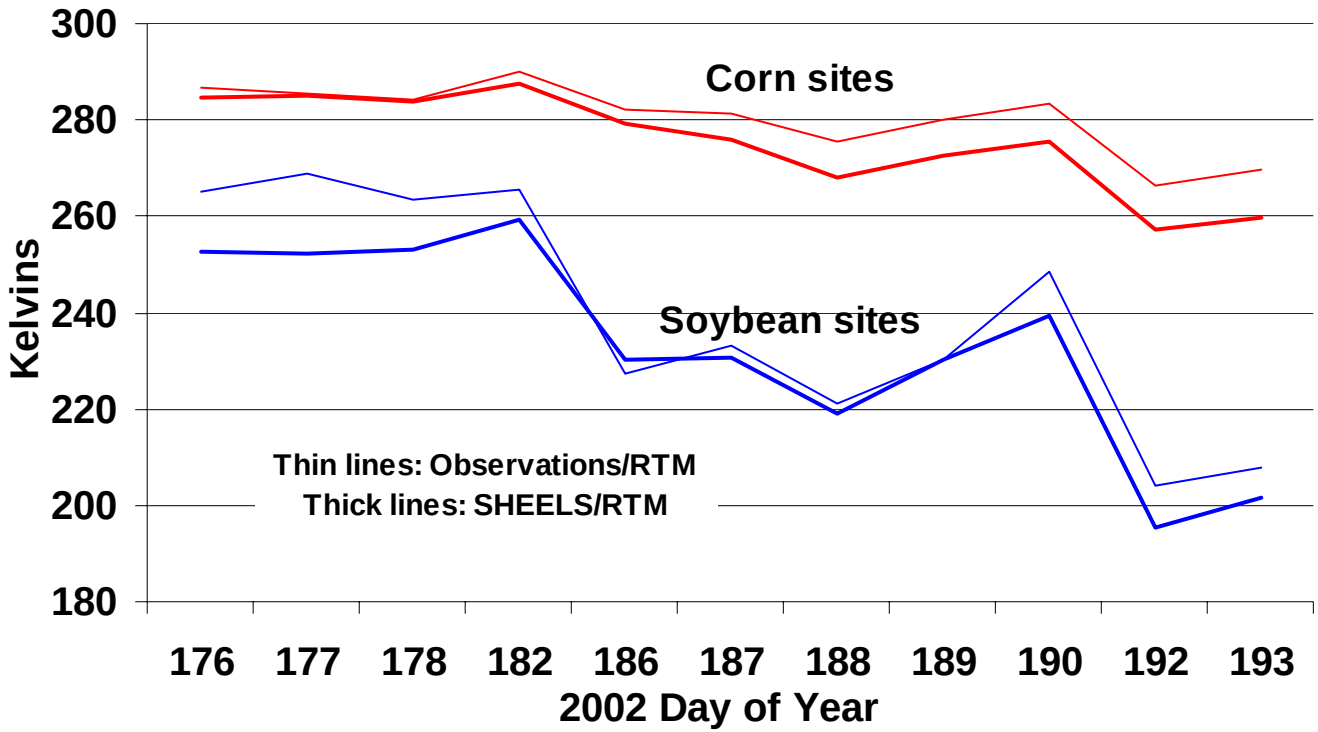
Model vs. Measured Gravimetric Soil Water Content

AMSR-E Soil Moisture



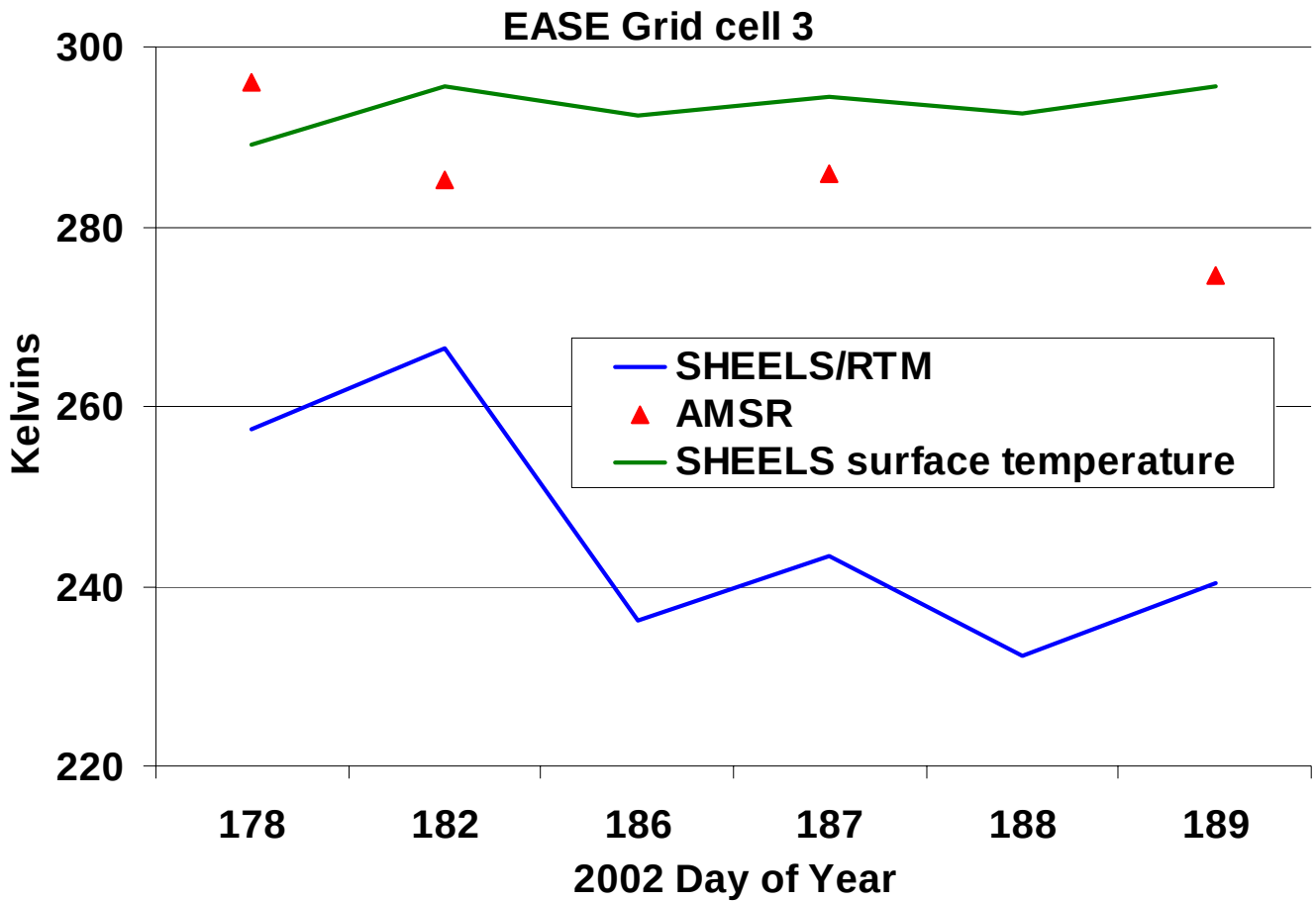
- Gravimetric measurements made each day at ~ 11:00 CDT
- Excellent overall agreement for mean of all sampling sites

RTM-Estimated C-band T_B Corn and Soybean Sites



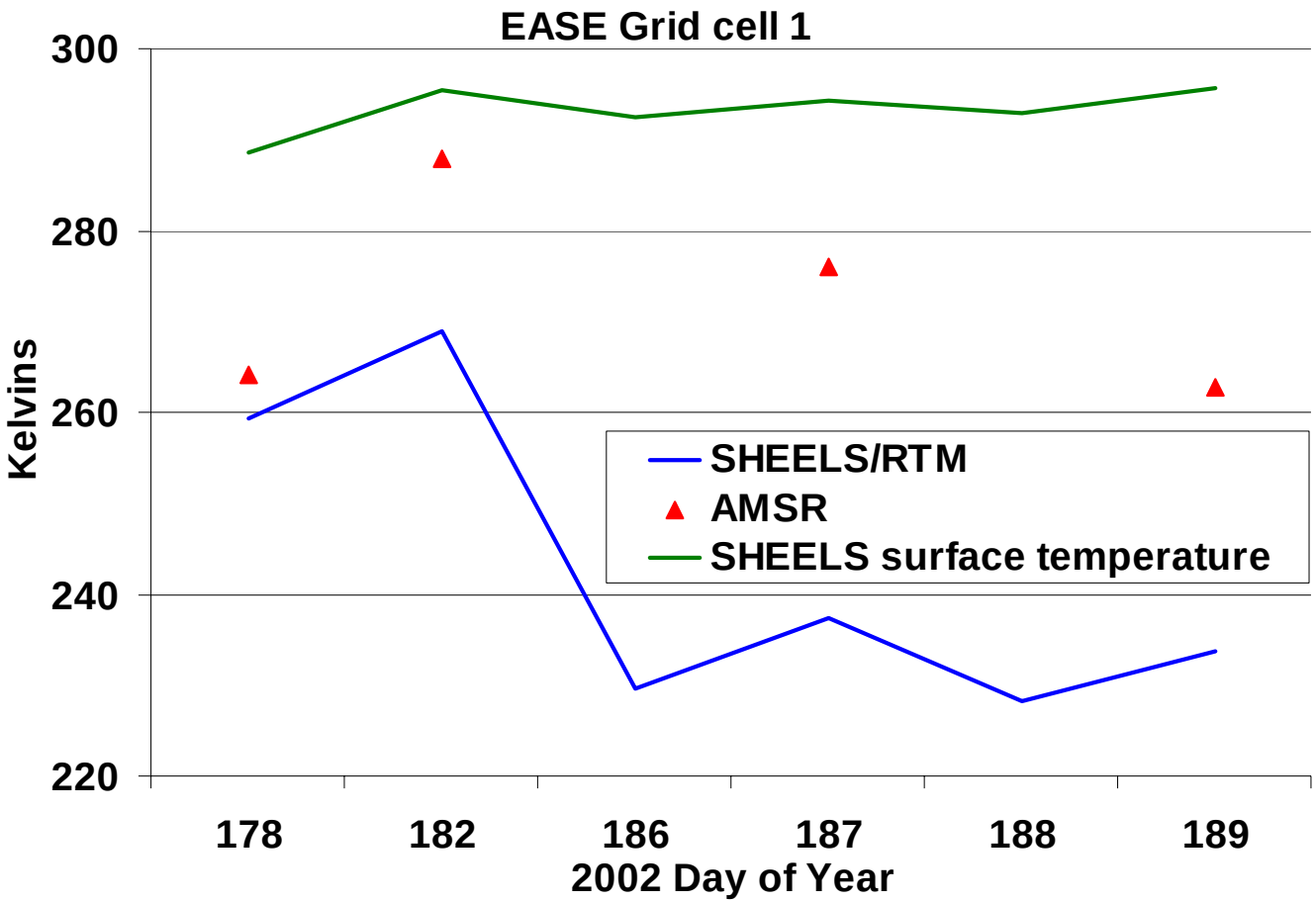
- T_B estimated by RTM using soil moisture and temperatures from observations or from SHEELS
- Observations: 0-1 and 1-6 cm soil moisture
- SHEELS: full soil moisture profile
- Results are for horizontally-polarized 6.9 GHz frequency at 11:00 CDT
- Values for corn sites are much higher with less sensitivity compared to soybean sites

AMSR-E vs. SHEELS/RTM C-band T_B



- Results for horizontally-polarized 6.9 GHz frequency
- Data are for ~ 1:30 AM local time
- Coincident SHEELS surface temperatures are shown for comparison
- AMSR T_B appears to be anomalously high – RFI problems?

AMSR-E vs. SHEELS/RTM C-band T_B



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AMSR-E Soil Moisture

Summary and Conclusions

- A modeling/data assimilation system is in place to generate 'best estimates' of microwave brightness temperatures and near-surface soil moisture with which to validate AMSR-E data products.
- Uncertainties in these estimates will be estimated using an ensemble simulation approach.
- Model 0-6 cm soil moisture estimates agree well with observations at the watershed scale (400 km^2).
- Model T_B for corn sites are much higher and show lower sensitivity than for soybean sites.
- AMSR-E T_B values for EASE Grid (25 x 25 km) are significantly (up to 40 K) higher than model values for the 4 days analyzed.
- Some of the differences may be due to RFI contamination.