AMSR-E Soil Moisture

# Soil Moisture Remote Sensing and AMSR-E Validation


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*Huntsville, Alabama, USA*



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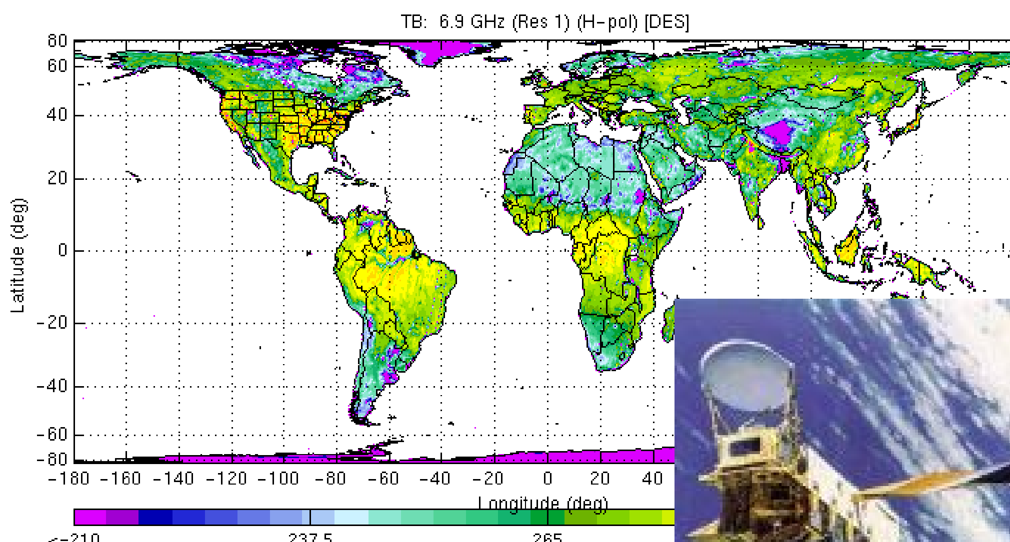



# Scope of Work

*OBJECTIVES*:

Provide “best estimates” of footprint-scale mean brightness temperatures and EASE-grid scale soil moisture with associated confidence limits.

*APPROACH*:

Utilize a coupled hydrologic/radiobrightness model to estimate brightness temperatures with data assimilation from *insitu* observations and airborne radiometers.

*ACCOMPLISHMENTS*:

- Participated in data collection efforts associated with SMEX02 and SMEX03.
- Have coupled the hydrologic and radiobrightness models and tuned these models for the SMEX02 study domain.
- Acquired and processed MODIS land surface temperature data to estimate emissivities for five homogeneous regions around the globe. This was a contribution to on-going efforts to address concerns about AMSR-E C band calibration.
- Analyzed PALS brightness temperature data. Have compared methods of spatially interpolating among PALS observations.
- Analyzed the effect that near-surface soil moisture profiles have on brightness temperatures and quantified the extent to which not accounting for this effect is a component of validation errors.

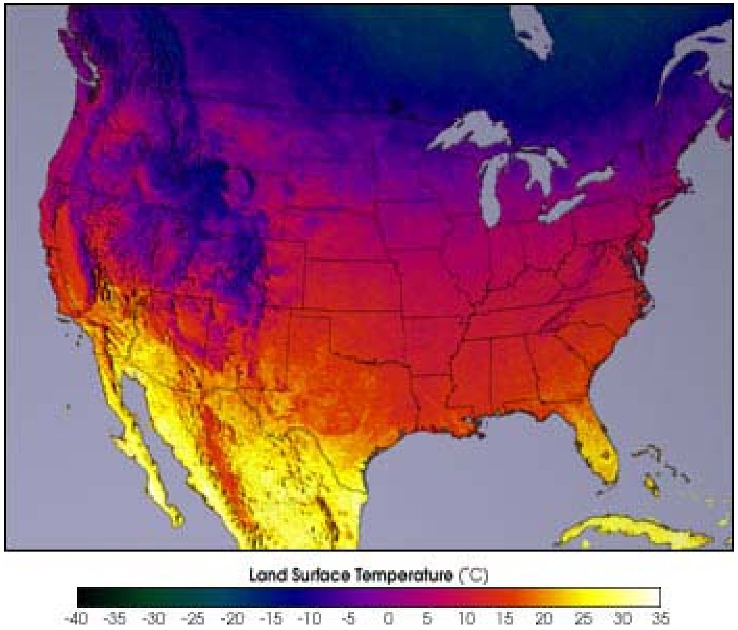
# Analysis of MODIS Land Surface Temp.

As part of an investigation into anomalies noted in AMSR-E C band calibration, we used MODIS land surface temperatures to calculate AMSR-E emissivities for 6.9 GHz and 10.7 GHz (V and H pol).

Daytime and nighttime overpasses were used.

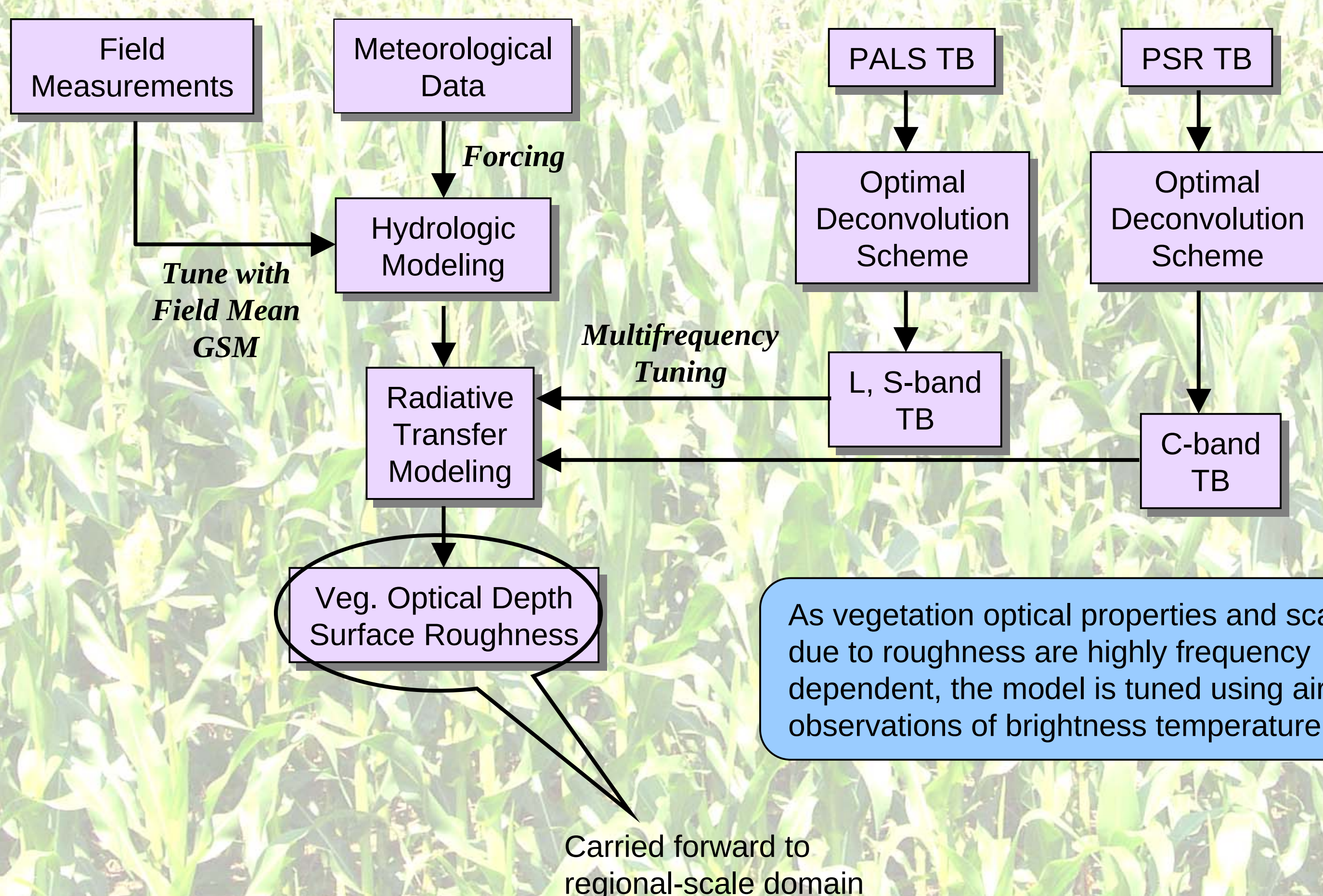
Emissivities were determined for 5 “homogeneous” sites.

Means, minima, maxima and standard deviations were calculated for areas encompassing 9 EASE-grid cells (3x3), or 5625 km$^2$. Boxes were defined by E. Njoku.



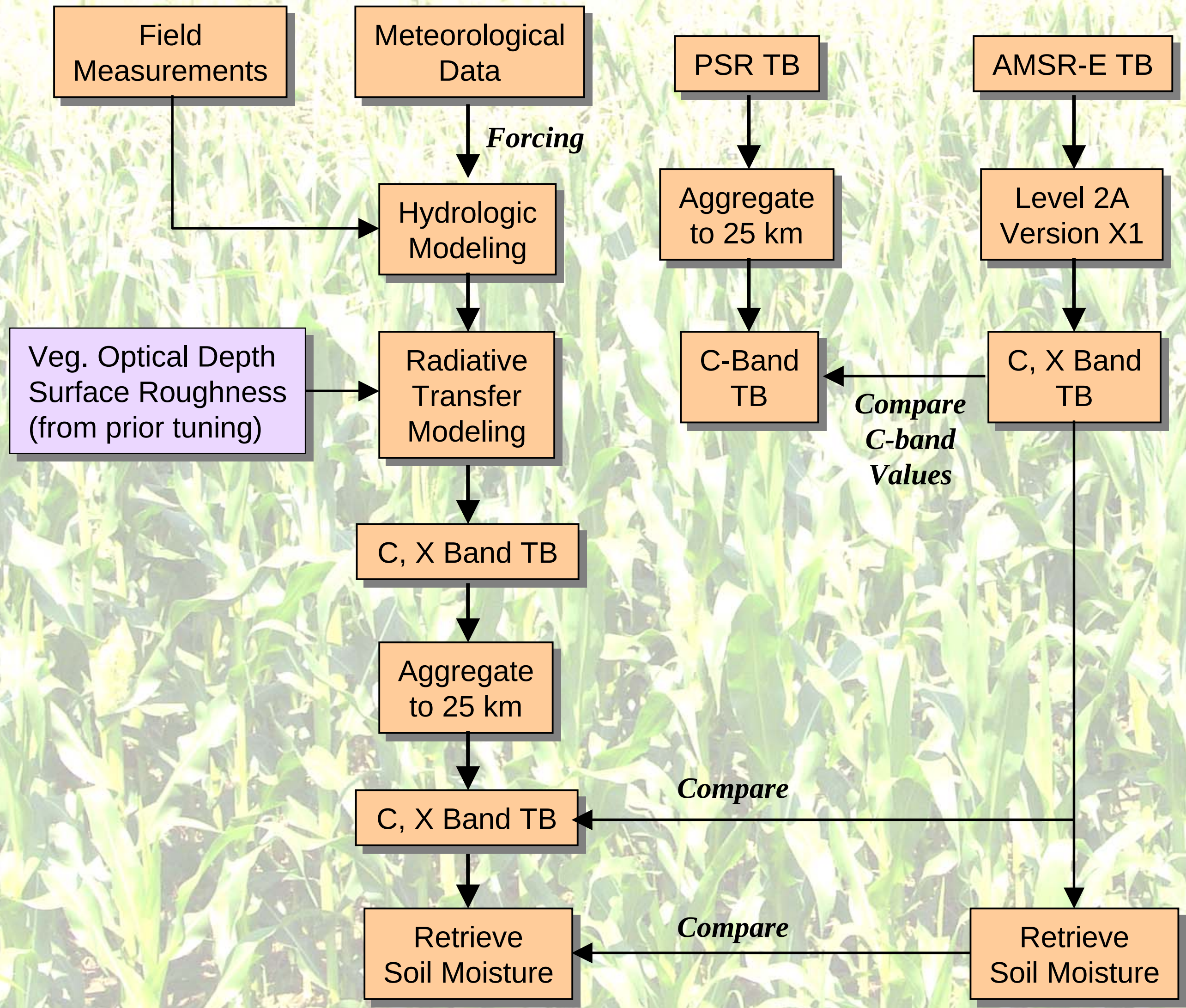

| **Sites:** | **Dates:** |
| --- | --- |
| Western Egypt (desert) | 25 June 2002 – 28 February 2003 |
| Central Zaire (tropical forest) | 25 June 2002 – 7 May 2003 |
| Mali/Senegal (Sahel) | 25 June 2002 – 28 February 2003 |
| Alaska (tundra) | 25 June 2002 – 7 May 2003 |
| Saskatchewan (boreal forest) | 25 June 2002 – 7 May 2003 |
| Iowa (SMEX02; agricultural) | 25 June 2002 – 3 September 2002 |

# Multifrequency Model Tuning




As vegetation optical properties and scattering due to roughness are highly frequency dependent, the model is tuned using aircraft observations of brightness temperature.

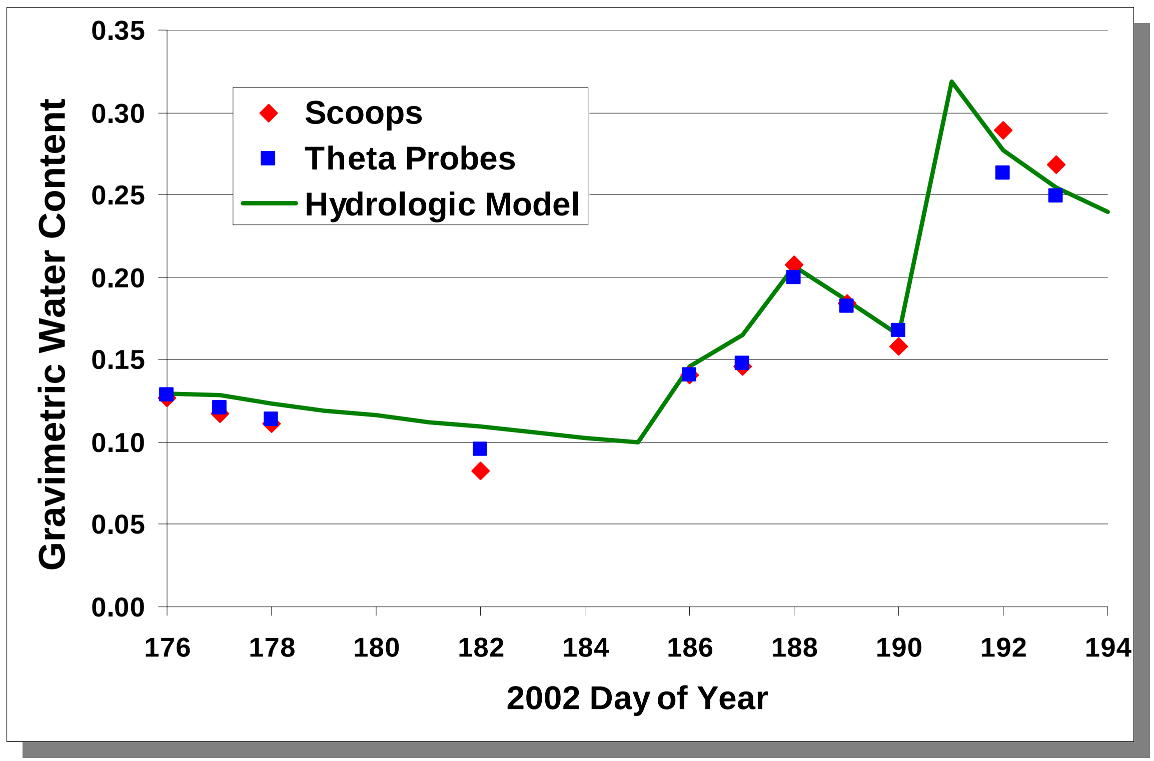
# AMSR-E Validation Approach



# Hydrologic Model Tuning

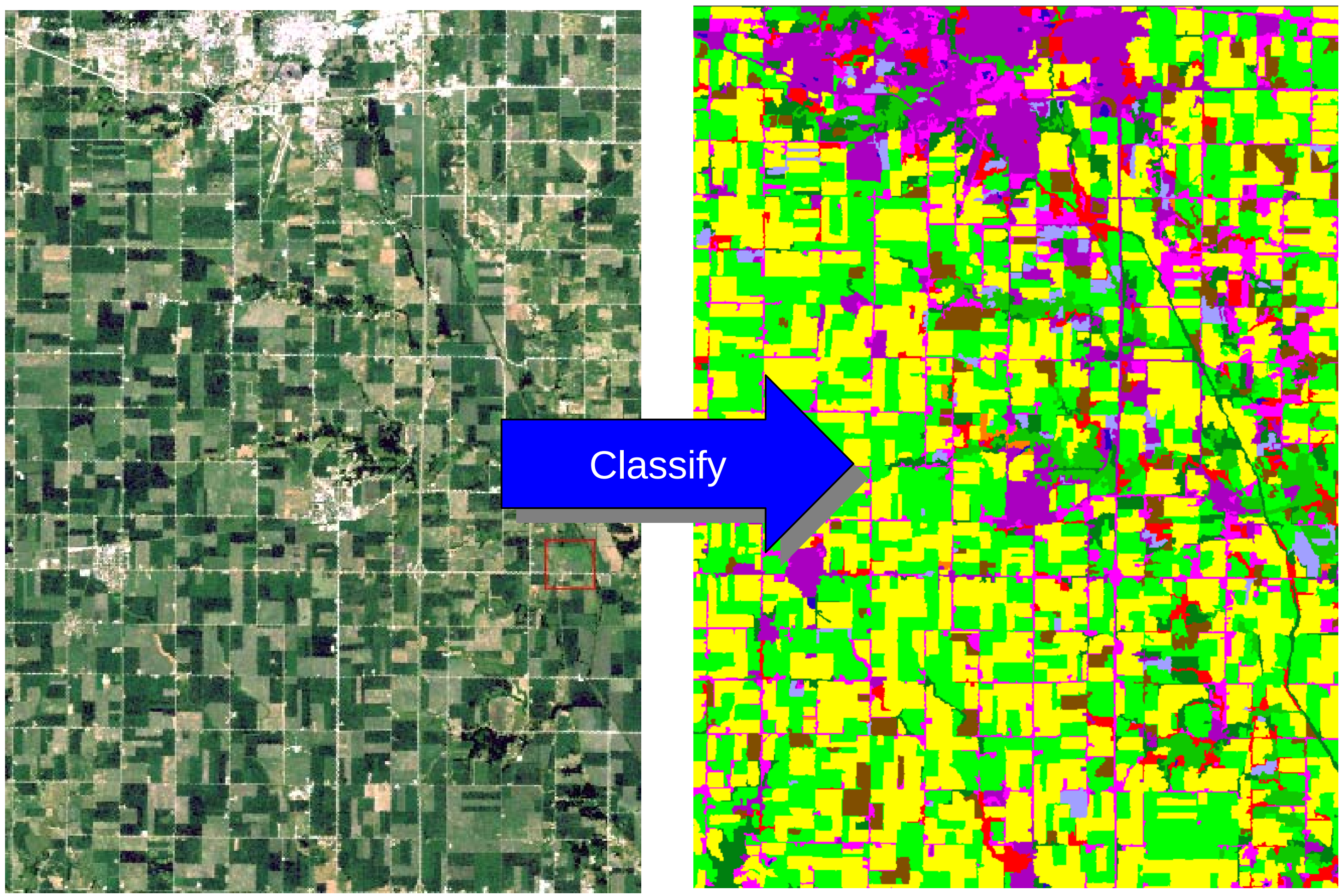
## Watershed-scale Area

Our hydrologic model has been tuned over the Walnut Creek watershed. This plot shows modeled mean 0-6 cm gravimetric soil moisture over the watershed compared with mean observations.



# Land Cover Classification

Land cover was classified using Landsat Enhanced Thematic Mapper scenes from May 14, July 1 and July 17, 2002.  Preprocessed image data were used in a segmentation-based supervised classification with 11 classes.



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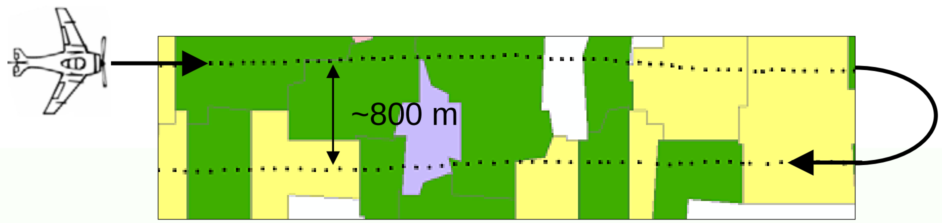
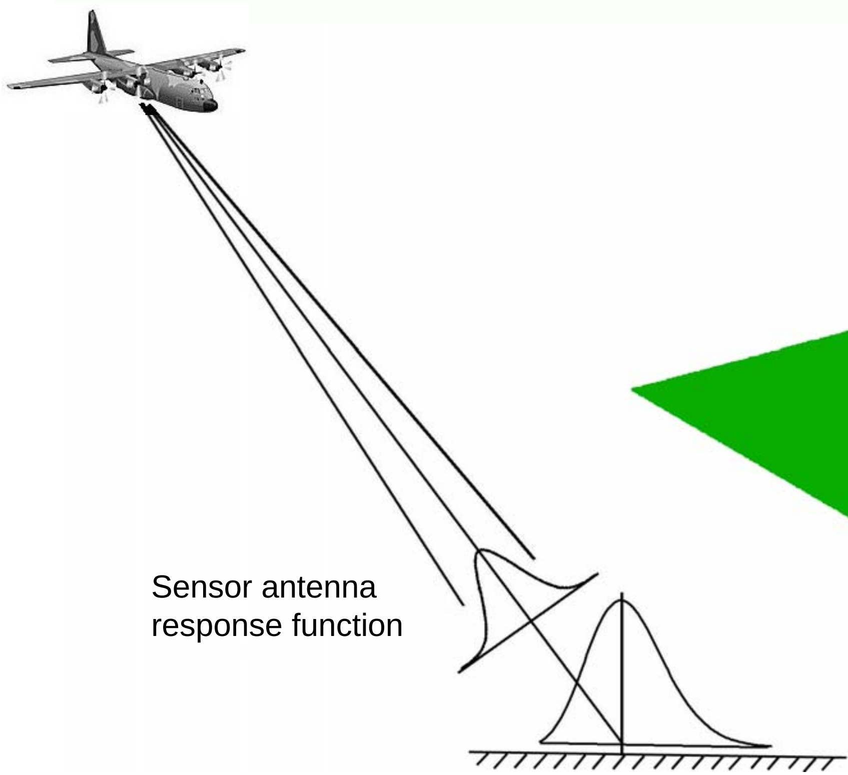
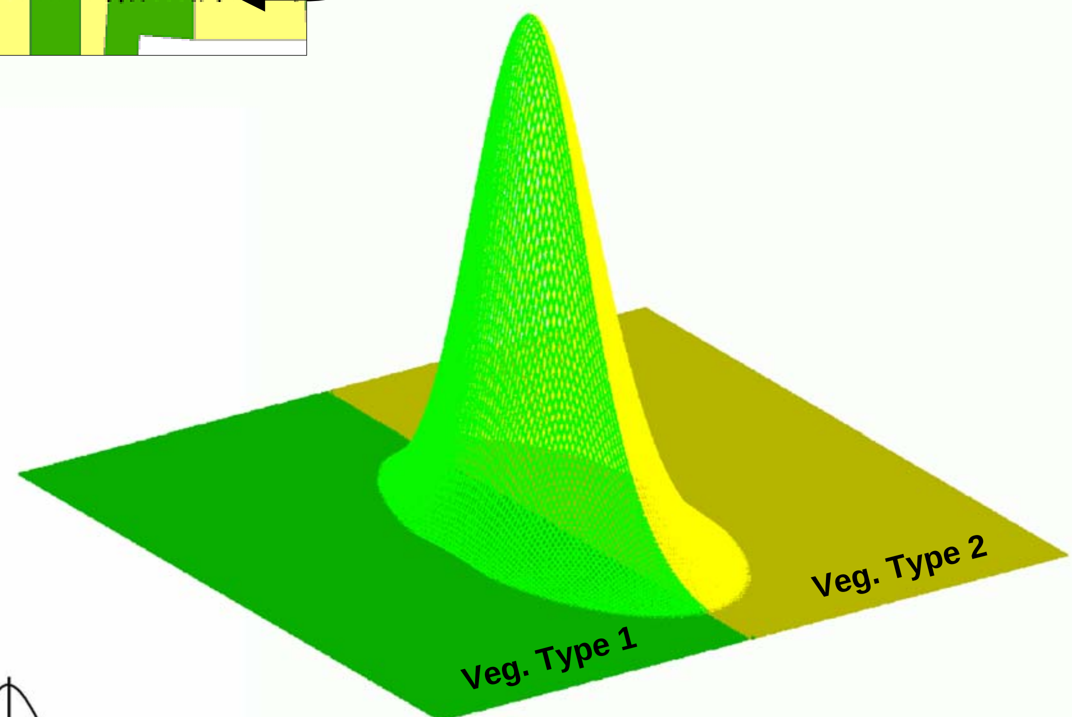
# Optimal Deconvolution of Remotely Sensed Brightness Temperature




Airplane travels along flightlines making observations about every 100 m. Flight lines are spaced about every 800 m.

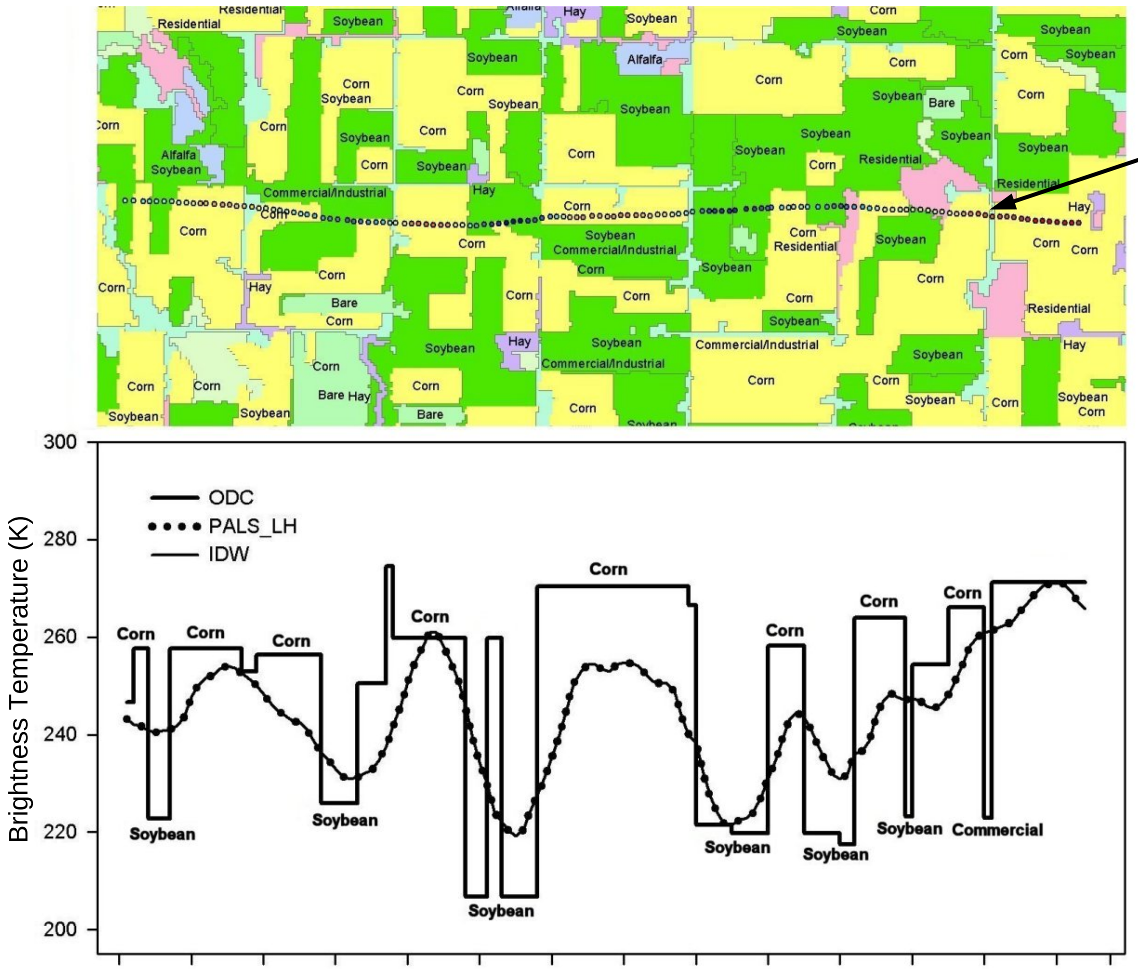



Sensor response function is projected onto a horizontal plane




With a high degree of oversampling, an optimization routine is used to deconvolve the observed $T_B$ into field-mean values based on the land cover segmentation.

# Comparison of Interpolation Methods




Discrete observations along a flightline

Comparison among methods used to spatially interpolate between $T_B$ observations.

The inverse distance-weighted (IDW) method--or other interpolation methods--reproduces the observations and results in considerable smoothing, whereas the optimal deconvolution (ODC) method estimates field-mean values and reconstructs sharp contrast between land cover types.

Note that the IDW technique underestimates the maximum and overestimates the minimum $T_B$ values.

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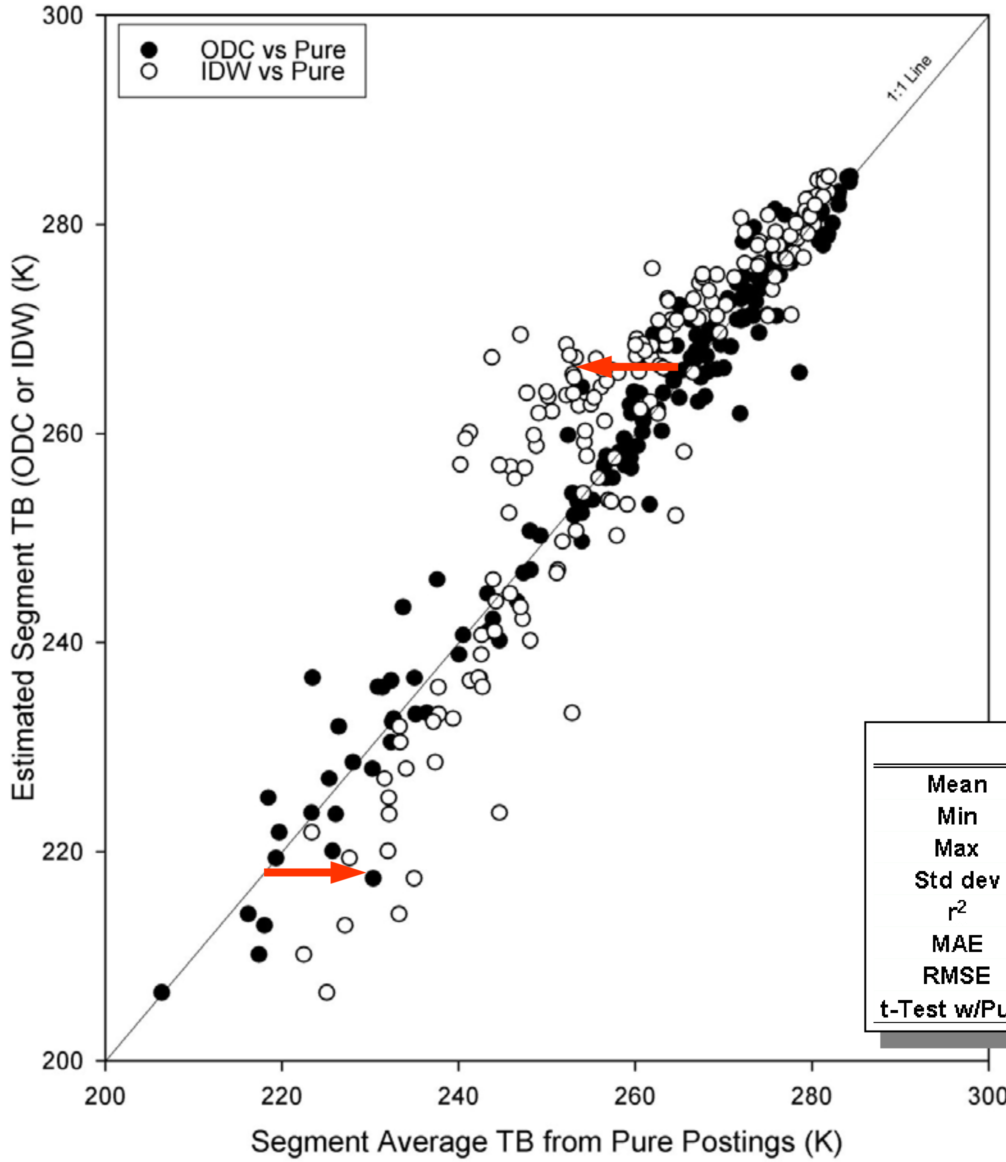
# Comparison of Interpolation Methods



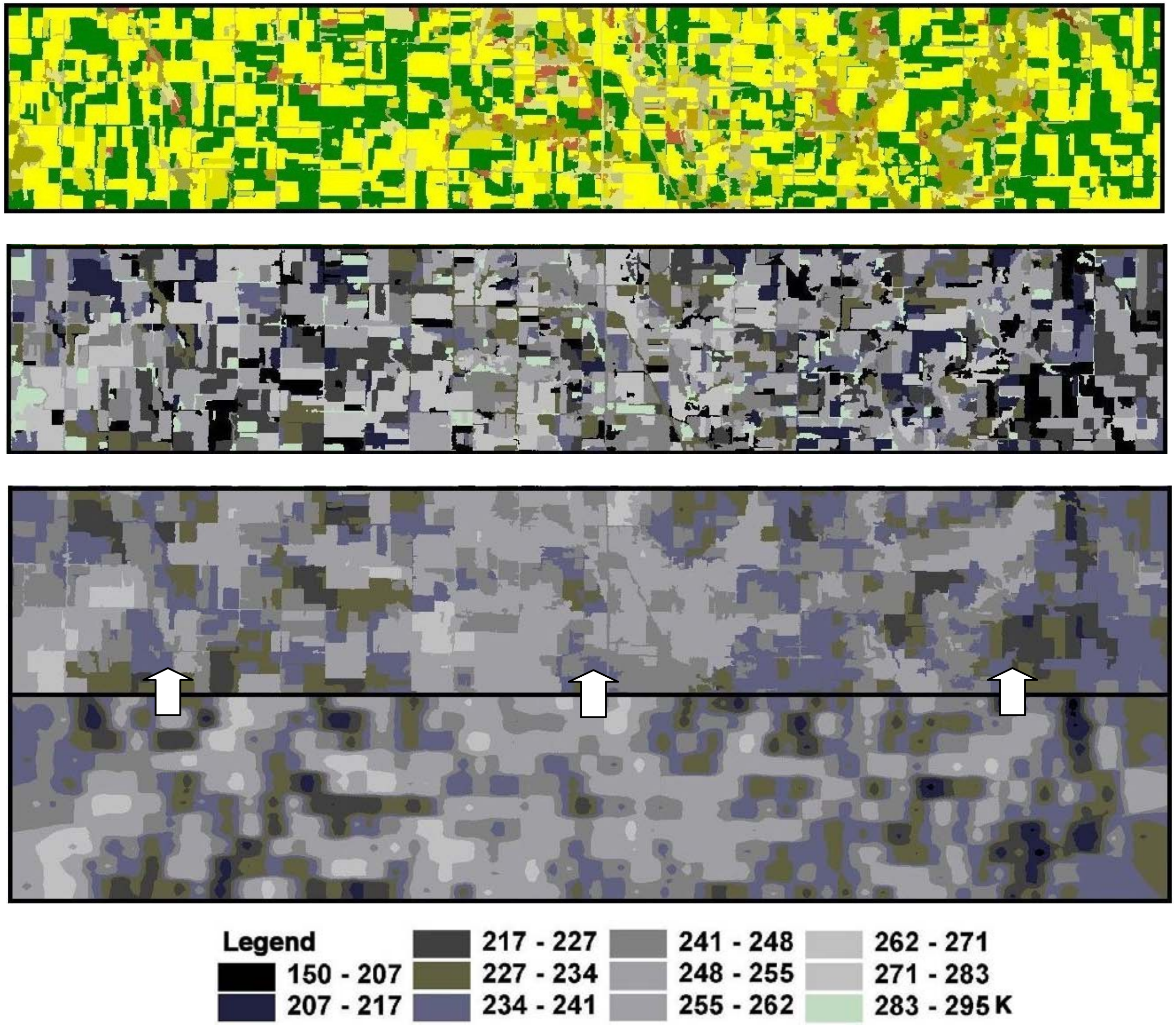

For validation of the method, we isolate “pure” postings as observations in which the entire signal is derived from a single segment.

Brightness temperatures estimated using the ODC method, excluding “pure” postings, are more highly correlated with segment $T_B$ estimated with pure postings than are segment-mean $T_B$ derived using the inverse distance-weighted method.

Note that the IDW method tends to overestimate the “true” $T_B$ (derived from pure postings) at low $T_B$ (soybean) and underestimate true $T_B$ at higher TBs (corn) (red arrows).

| | ODC W/o Pure | IDW | Pure |
|---|---|---|---|
| Mean | 261.42 | 259.11 | 261.72 |
| Min | 206.38 | 223.88 | 206.52 |
| Max | 284.35 | 281.71 | 284.58 |
| Std dev | 18.03 | 14.88 | 18.18 |
| $r^2$ | 0.96 | 0.70 | |
| MAE | 2.41 | 6.18 | |
| RMSE | 3.53 | 8.01 | |
| t-Test w/Pure | Failed | Passed | |

# Spatial Interpolation of $T_B$ by Two Methods




Segmentation-based land cover classification:
yellow = corn
green = soybean

Spatial interpolation of PALS $T_B$ data by ODC method

Compare

IDW converted to segment mean values for comparison purposes

Spatial interpolation of PALS $T_B$ data by inverse distance-weighted interpolation (IDW) (10 m grid).

Note that the dynamic range of $T_B$ values from the IDW technique is not as large as from the ODC technique.

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# Soil Moisture Profile Sampling

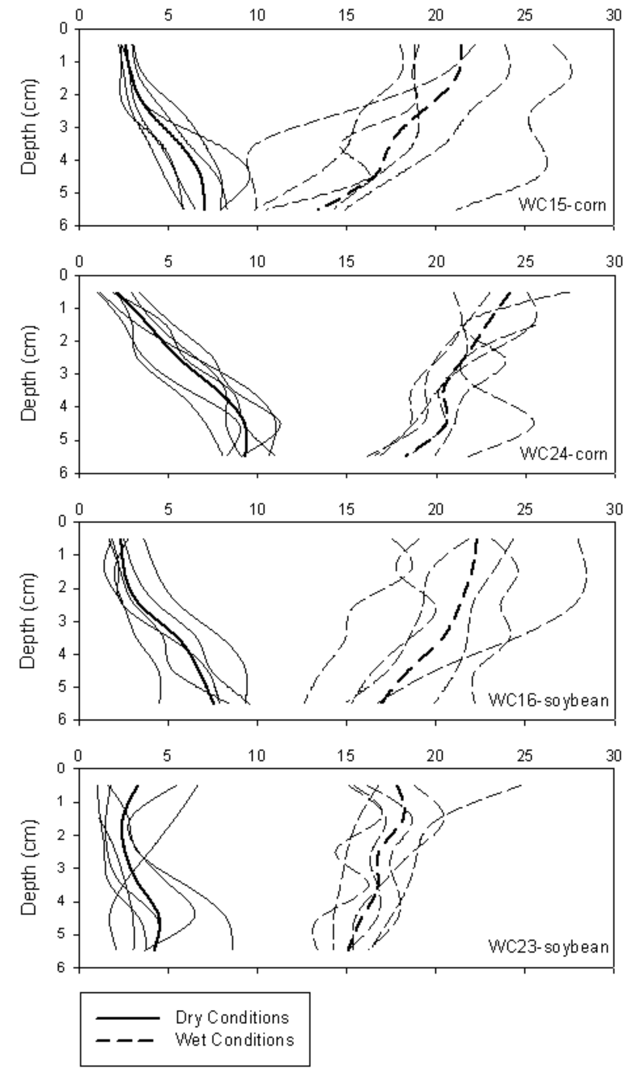
Sliced cores were collected during SMEX02 to evaluate the contribution to “error” in validation studies by not accounting for the effect of the near-surface moisture profile on $T_B$.

## Core sampling

0-6 cm profiles from sliced cores collected daily at 4 points on each of four study sites.

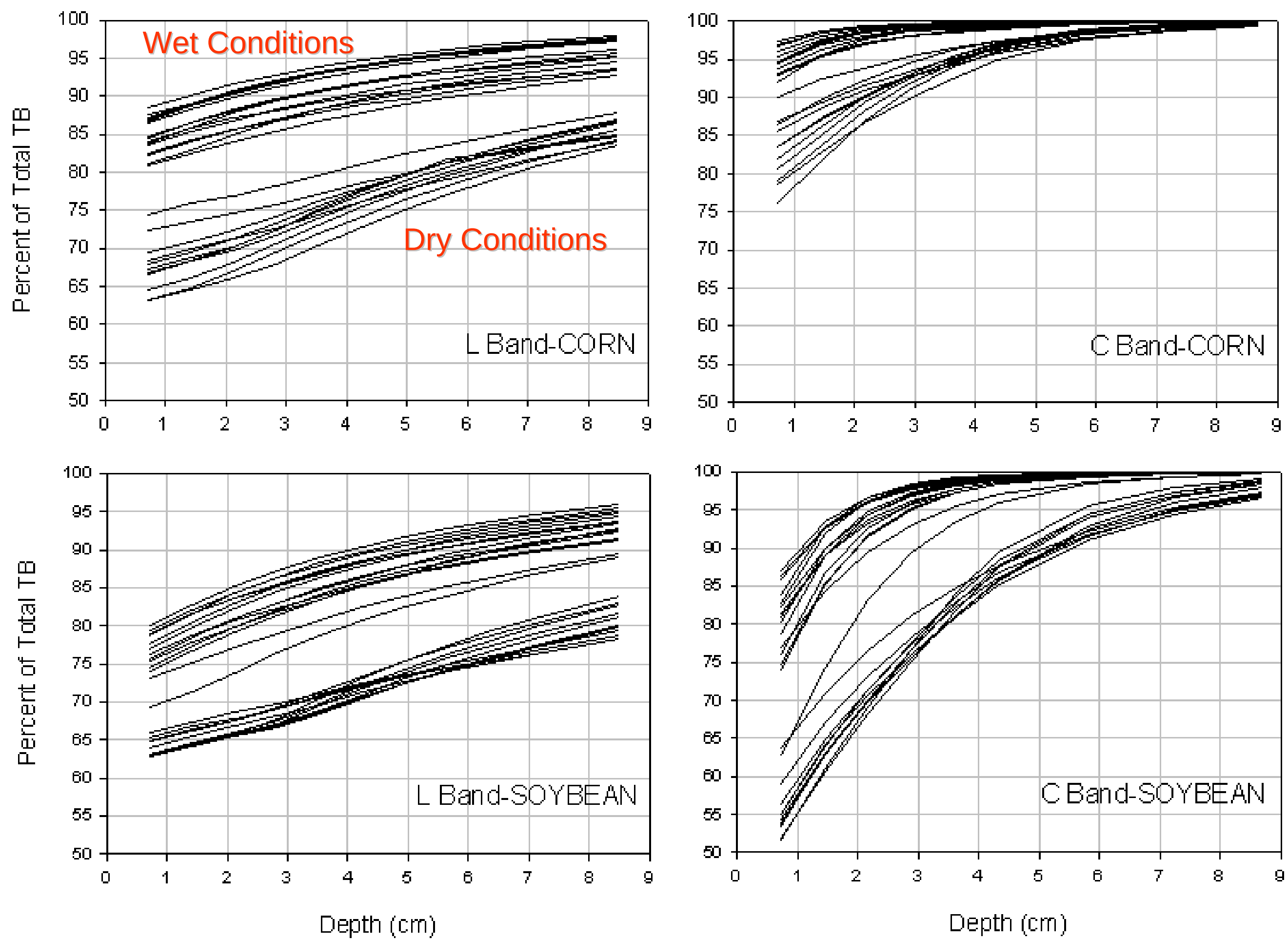
## Slicing the core

Observed profiles from four study sites under dry conditions and wet conditions.



# L and C Band Emitting Depth

A radiative transfer model was run using all near-surface moisture profile observations to determine the emitting depth at L and C band under wet and dry conditions.  At least 75% of the energy at L band is emitted from the 0-6 cm layer, and more than 90% of the radiation emitted at C band is from the 0-6 cm layer.



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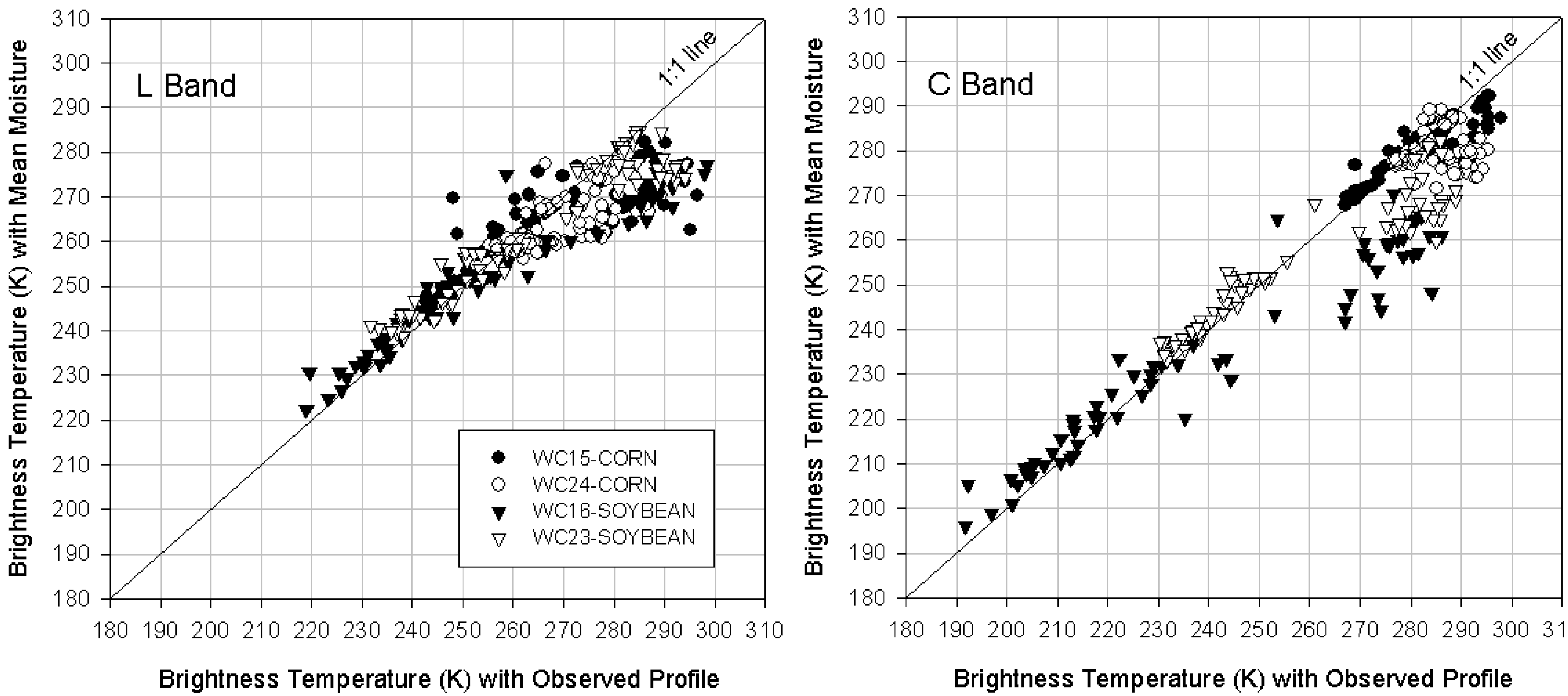
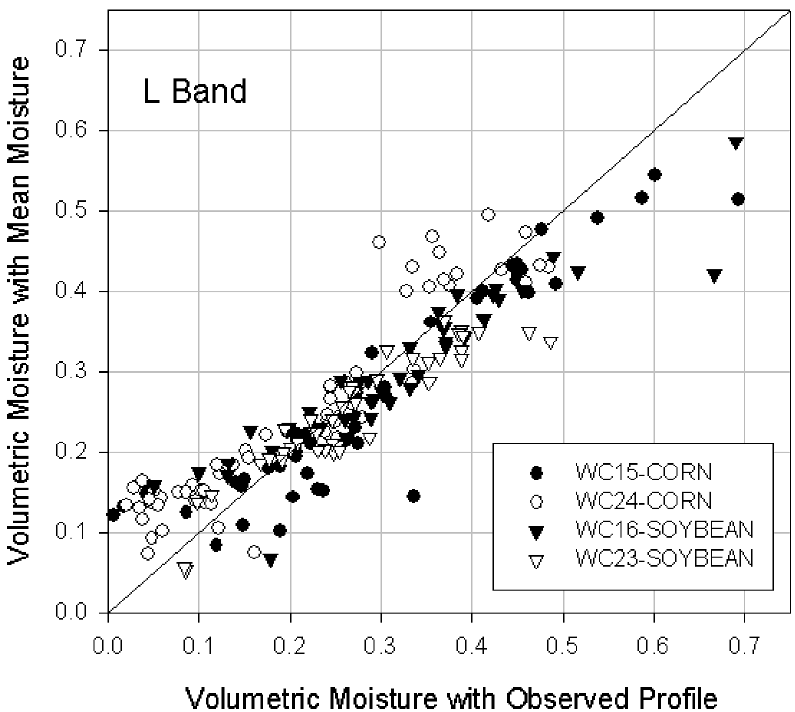
# Estimated $T_B$ with Different Profiles

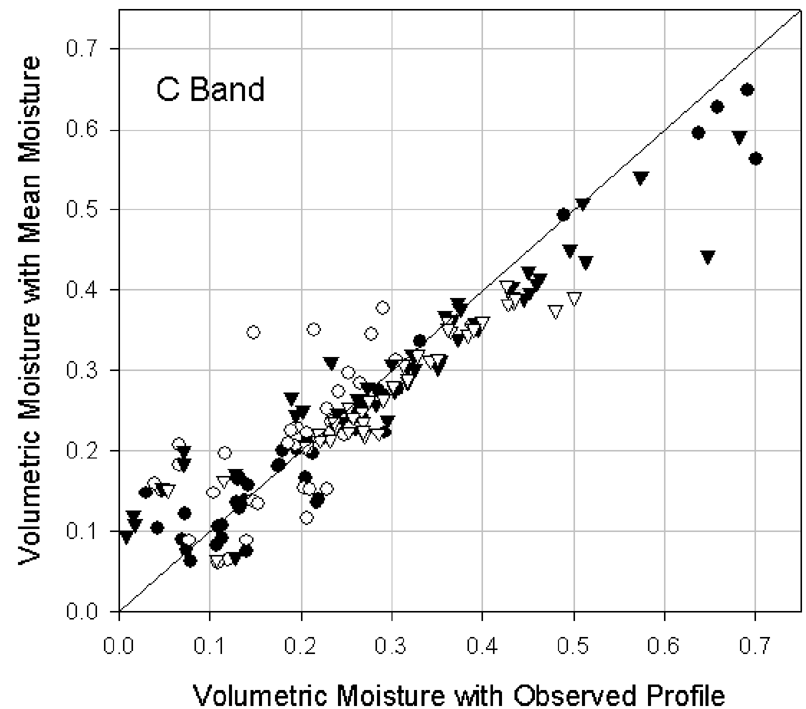
Comparison in L and C band $T_B$ computed with our radiative transfer model using observed near-surface moisture profiles and a mean profile for the 0-6 cm layer. With the mean profile, $T_{Bs}$ are biased slightly high by a few degrees at low temperatures, but are biased low at higher $T_{Bs}$ --in some cases by as much as 30 K.



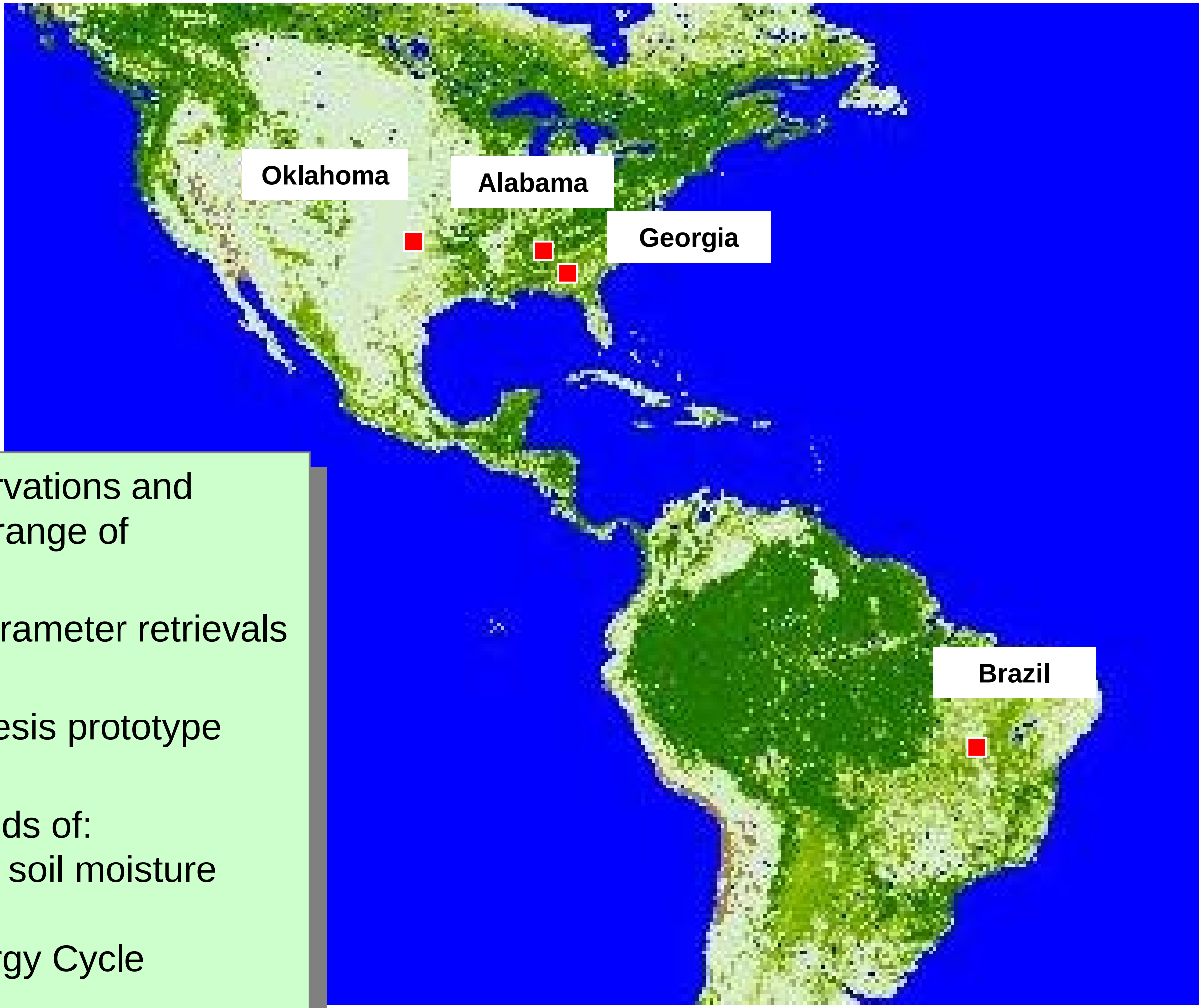
# Inverse Retrieval of Soil Moisture with Estimated $T_B$

Brightness temperatures estimated with different near-surface moisture profile attributes (previous slide) were applied to an inverse retrieval algorithm to determine how the TB biases translate in terms of volumetric soil moisture given fields with different vegetation cover. For the SMEX02 study sites, neglecting the near-surface moisture distribution imposes a wet bias on the order of 5-10% on retrieved soil moisture under dry conditions and a dry bias on the order of 5-15% under wet conditions.



# Soil Moisture Experiments in 2003 (SMEX03)




## Objectives

1. Extend instrument observations and algorithms to a broader range of vegetation conditions
2. Validate land surface parameter retrievals from AMSR data
3. Test 2-D aperture synthesis prototype sensor
4. Support the science needs of:
   - HYDROS and future soil moisture missions
   - Global Water & Energy Cycle program

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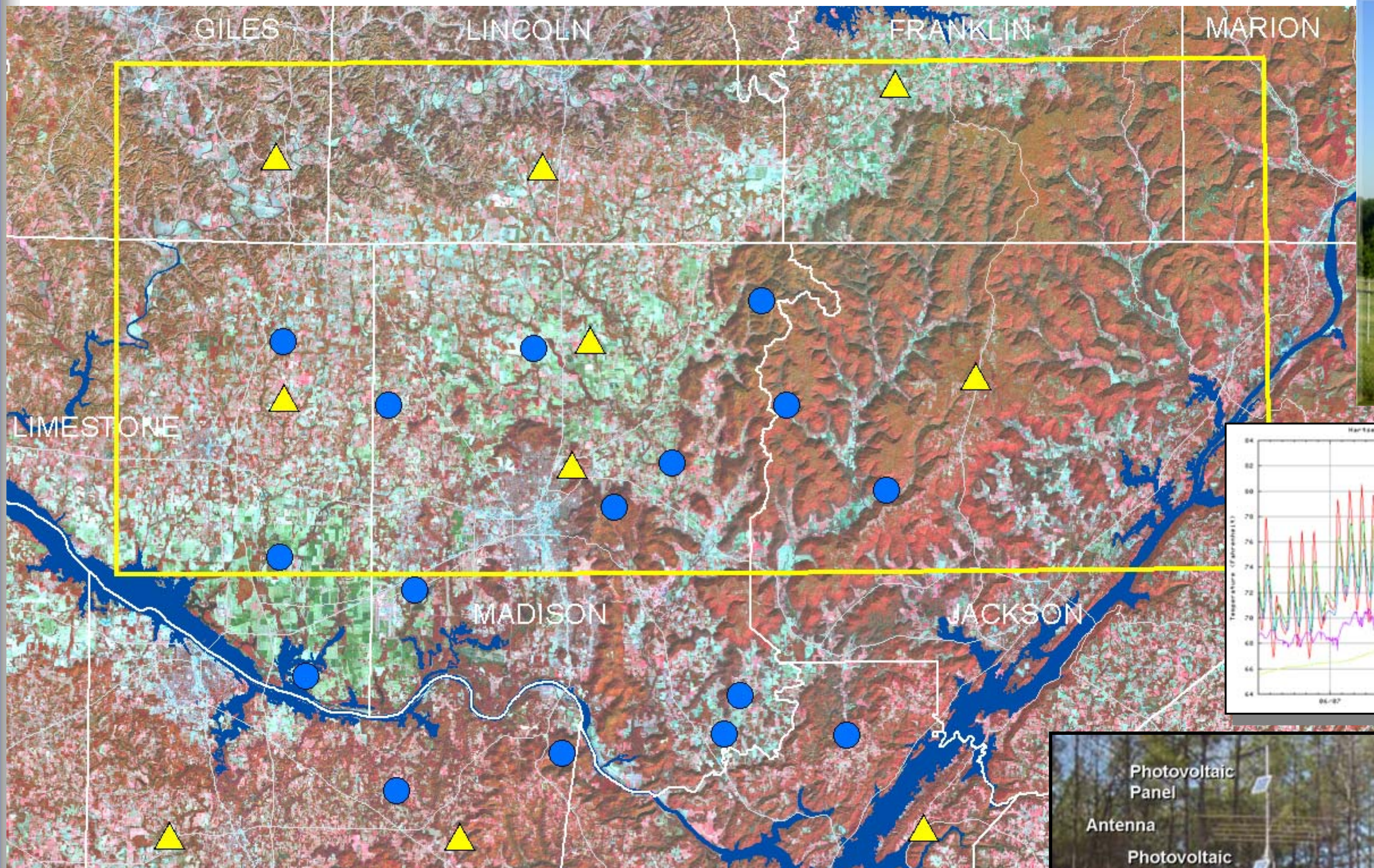
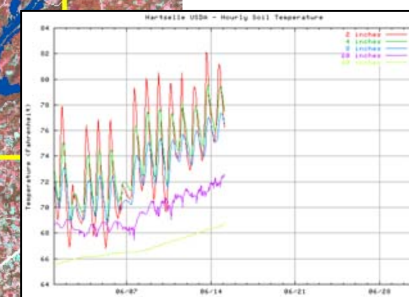
# Meteorological and Soil Profile Stations




10 USDA SCAN Stations
16 AAMU Soil Profile Stations

# SMEX03-Alabama Sampling Strategy

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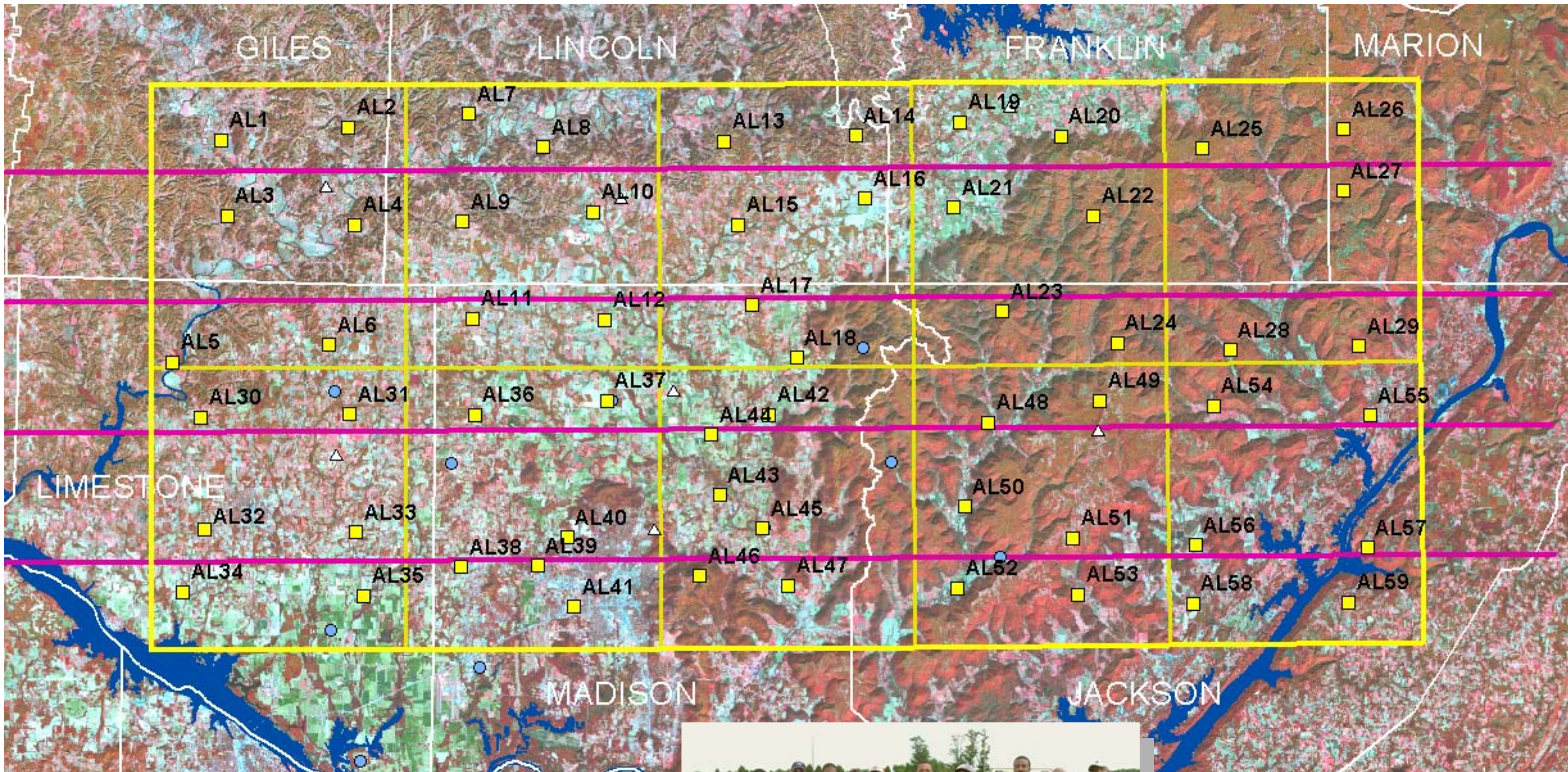


- 6250 sq. km, 2380 sq. mi.
- portions of 7 AL and TN counties
- 10 EASE-grid cells (25 x 25 km)
- 5 Flight lines
- 58 ground validation sites

*National Space Science and Technology Center, Huntsville, AL*

# Future Research

- After release of the SMEX02 PSR data, we will complete the multi-frequency tuning of the radiative transfer model at the watershed scale.
- Run the coupled model over the SMEX02 regional domain in ensemble mode to generate products for AMSR validation.  Analyze results.
- Validation of the RFI-suppression algorithms generated by other investigators will be ongoing.
- Quality assessment and documentation of SMEX03-Alabama data are nearing completion.
- Validation activities will be duplicated to some extent with data sets generated during SMEX03.