

# AIRS Land Surface Temperature and Emissivity Validation

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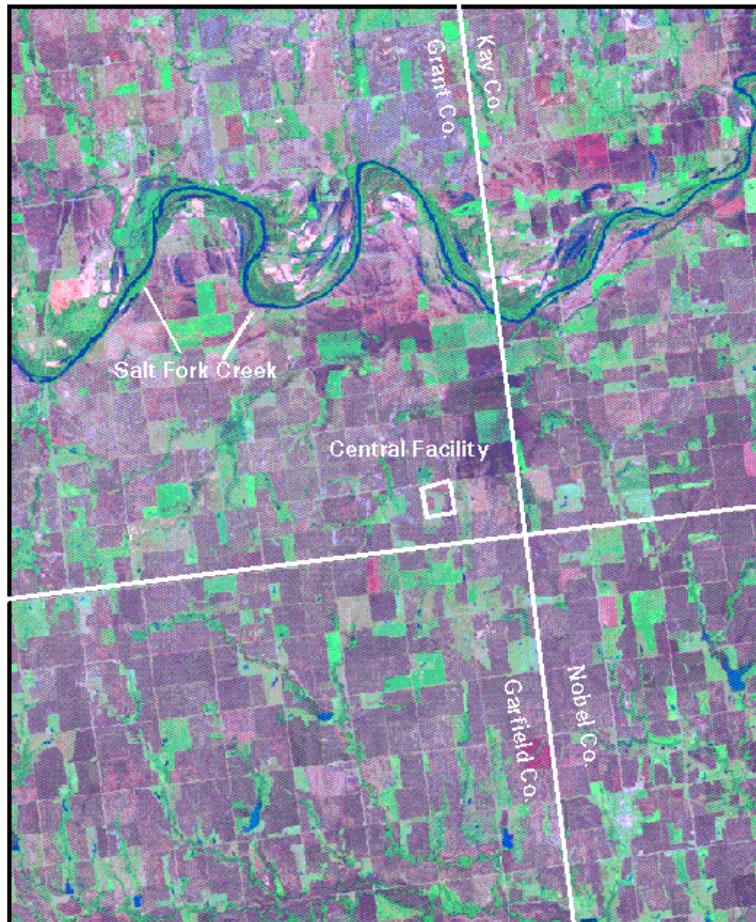
# Project Description

- **Land Surface Characterization Using High Spectral Resolution AIRS and Moderate Spatial Resolution MODIS Observations from the EOS Aqua Platform**
- R. Knuteson - PI
- NASA Aqua Validation
- Funded by NASA Terrestrial Ecosystems
- Three year grant (one year remaining)
- Themes:
  - (1) Improve the use of sounder data over land.
  - (2) Assess land surface changes in regions sensitive to climate variations, e.g. semi-arid.

# Topics

- AIRS Temperature Validation
  - ground truth sites (ARM SGP)
  - MODIS inter-comparison
- AIRS IR Emissivity Validation
  - ARM SGP Matchup project (joint).
  - Selected granule files for case studies.
  - Daily “clear” analysis.
  - Collaboration with JCSDA activities.

# AIRS Temperature Validation: Ground Truth



Landsat TM Scene 28/35

Scene date: 970927

Bands 7,4,2



Red, Purple: Cropland

Lt. Green: Pasture, Grass, etc.

Dark Green: Trees, shrubs, etc.

Blue: Water

Landsat TM scene provided by R. Cahalan, NASA-Goddard

Map by Alice Ciaella 2/05/98

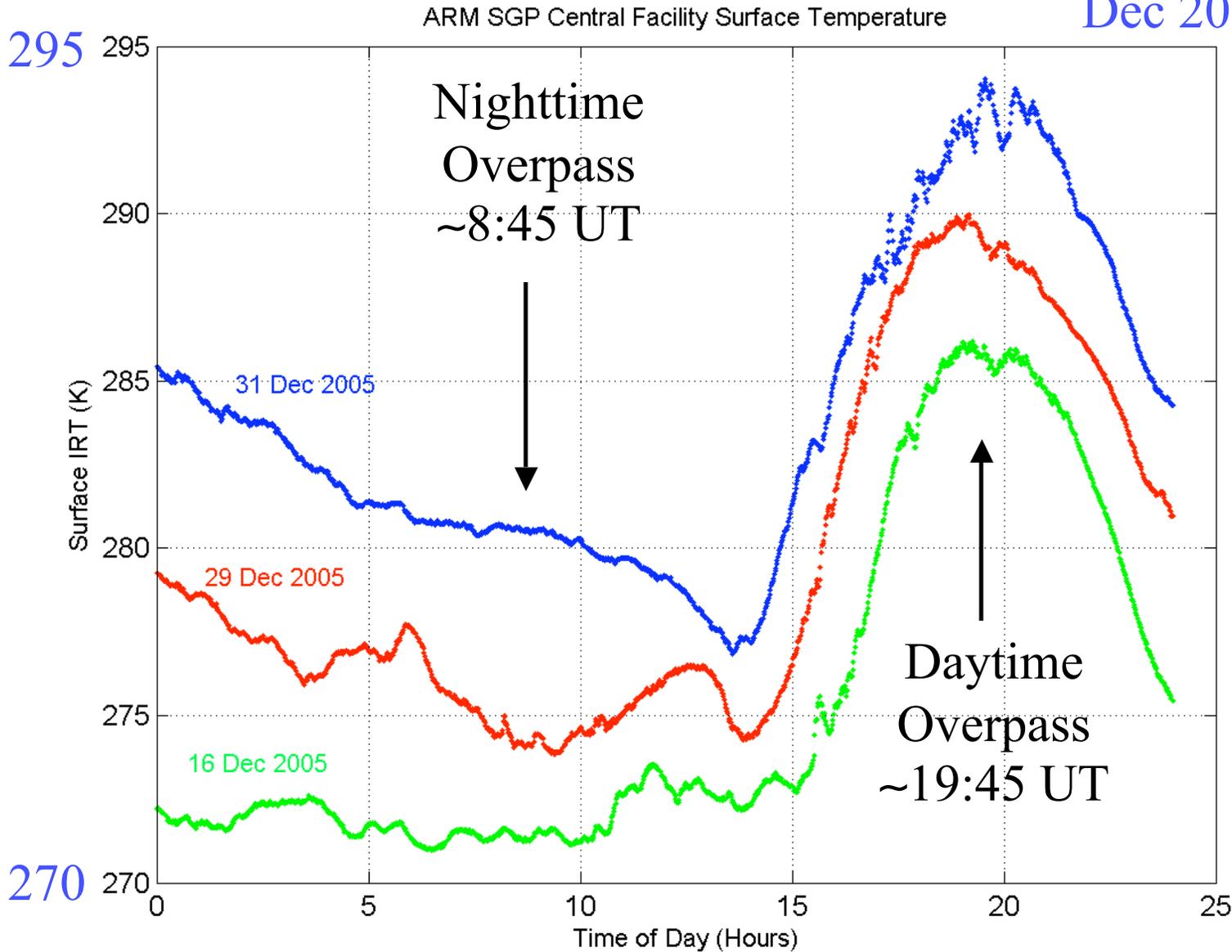
## ARM SGP Site

- Mid-Continental (Oklahoma)
- Provides **surface and atmospheric** profiling measurement accuracy
- Long-term **continuous** observations are ideal for comprehensive satellite validation



# AIRS Temperature Validation: Ground Truth

Dec 2005 Oklahoma



## Comments

Hourly variability is ~1 K

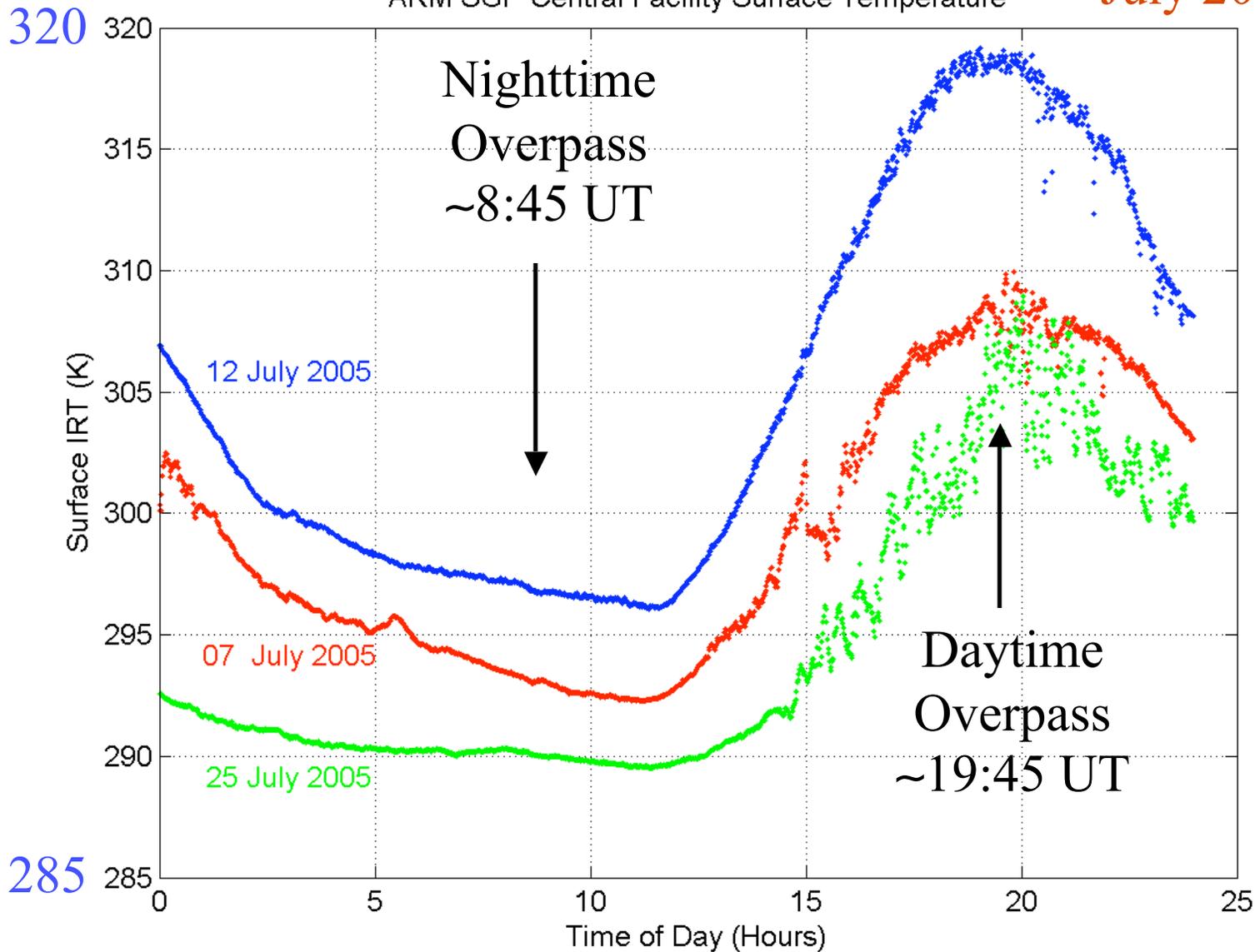
Day-Day variability is ~5 K

Day/Night variability is ~15 K

# AIRS Temperature Validation: Ground Truth

ARM SGP Central Facility Surface Temperature

July 2005 Oklahoma



## Comments

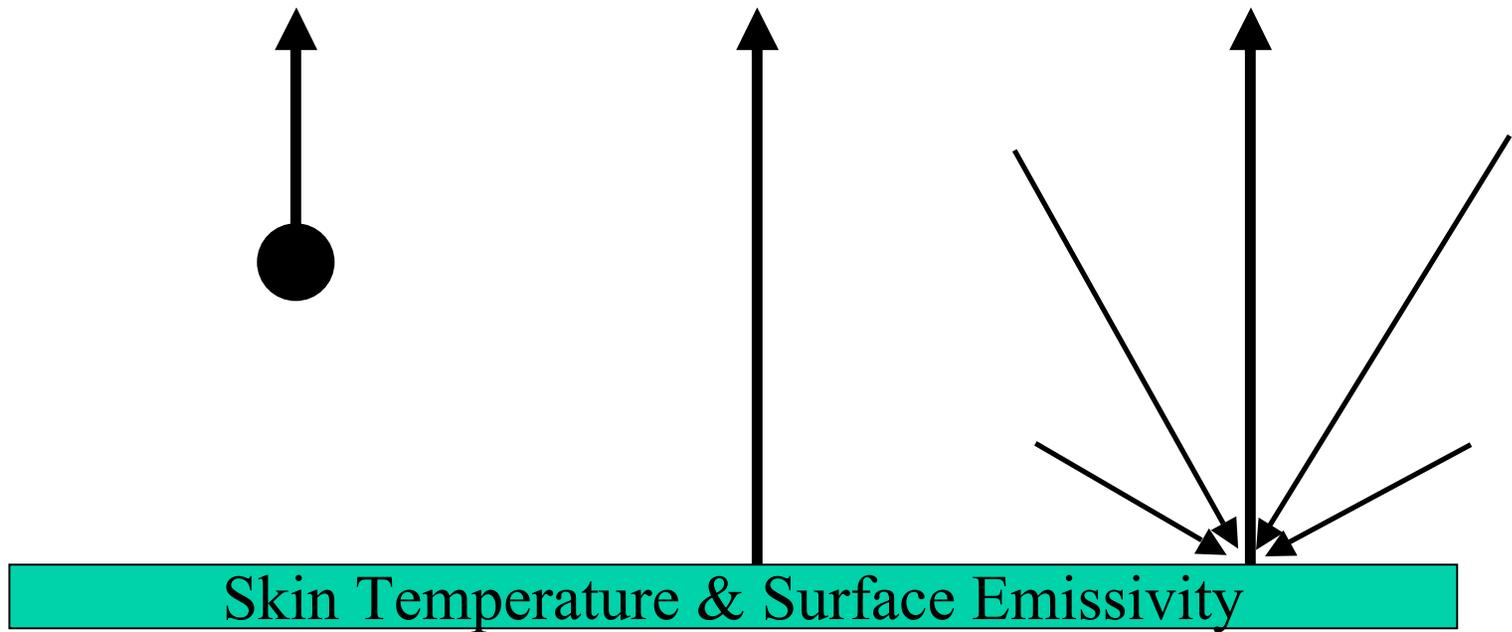
Hourly variability is ~5 K (day)

Day-Day variability is ~5 K

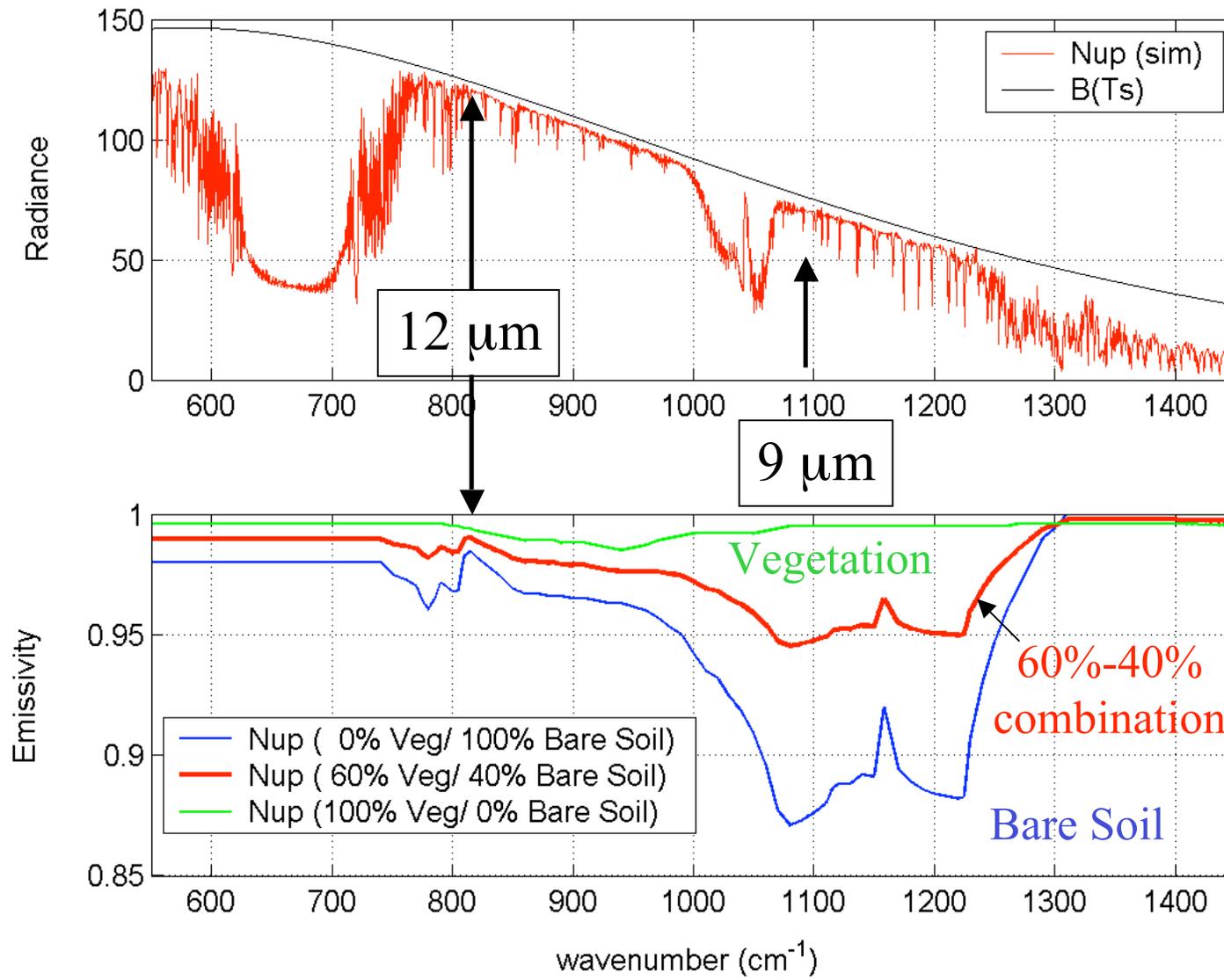
Day/Night variability is ~15 K

## Infrared Radiative Transfer Equation (Lambertian surface)

$$N_v^\uparrow = \underbrace{\int B_v(T(P)) d\tau_v}_{N_v^{atm\uparrow}} + \underbrace{\tau_v^{tot} \cdot e_v \cdot B_v(T_S)}_{\text{Surface Emission}} + \underbrace{\tau_v^{tot} \cdot (1 - e_v)}_{\text{Surface Reflection}} \cdot \overline{N_v^\downarrow}$$



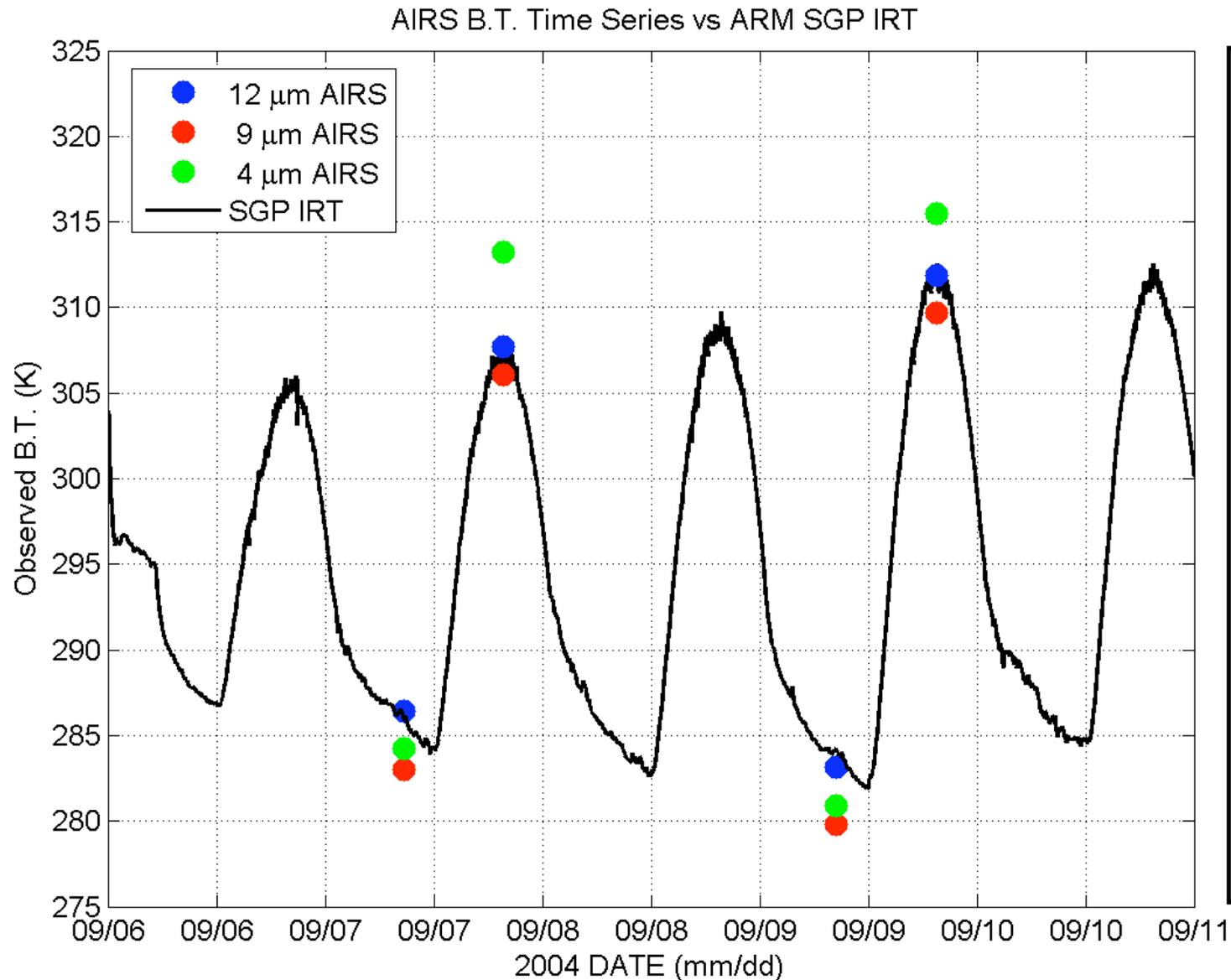
# AIRS Temperature Validation: Ground Truth



## Comments

SGP Site Emissivity has a **maximum** in a narrow region at 12  $\mu\text{m}$ : (830  $\text{cm}^{-1}$  - 832  $\text{cm}^{-1}$ )

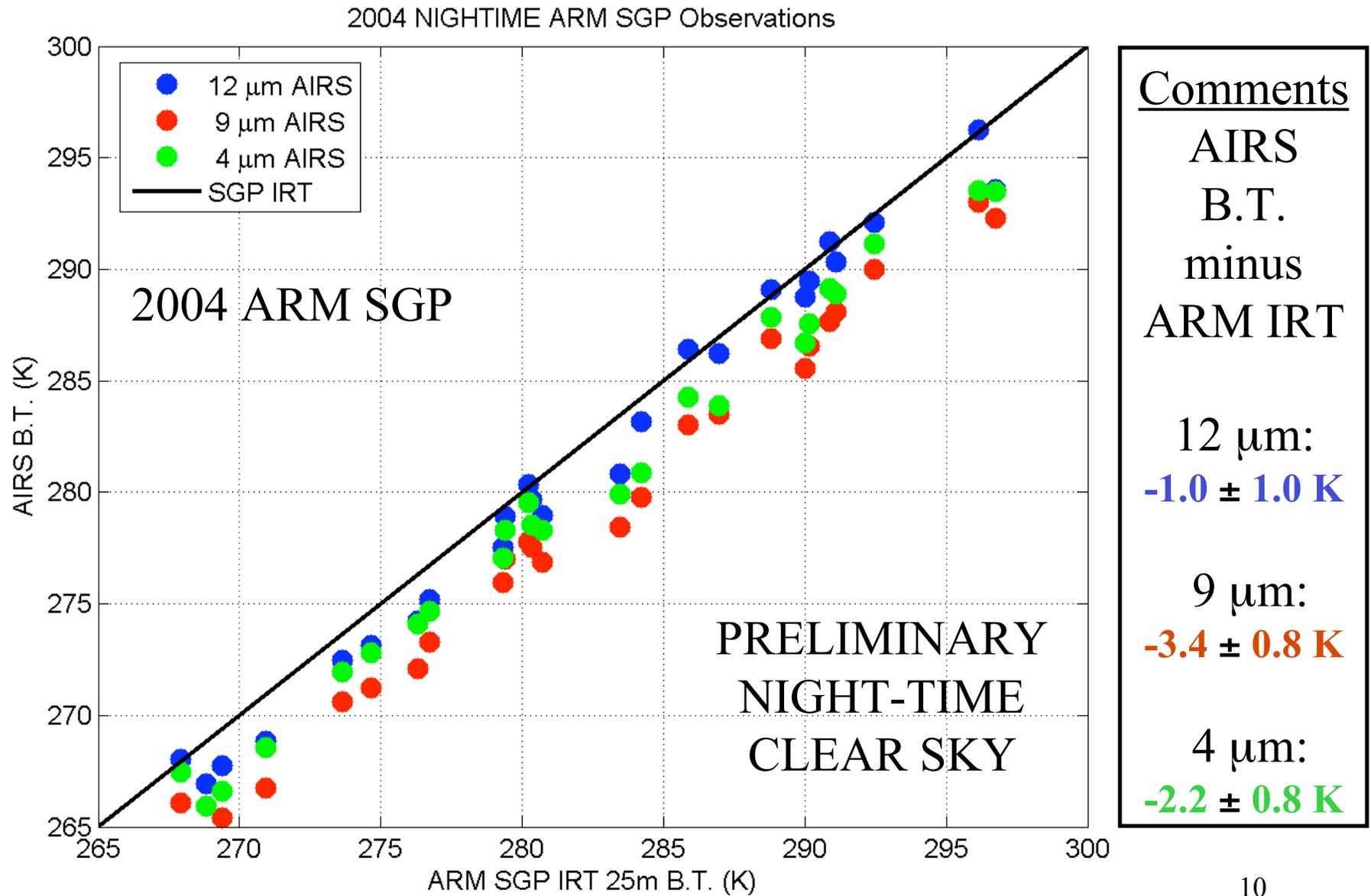
# AIRS Temperature Validation: Ground Truth



## Comments

Using an AIRS validation database developed with Dave Tobin using ARM measurements.

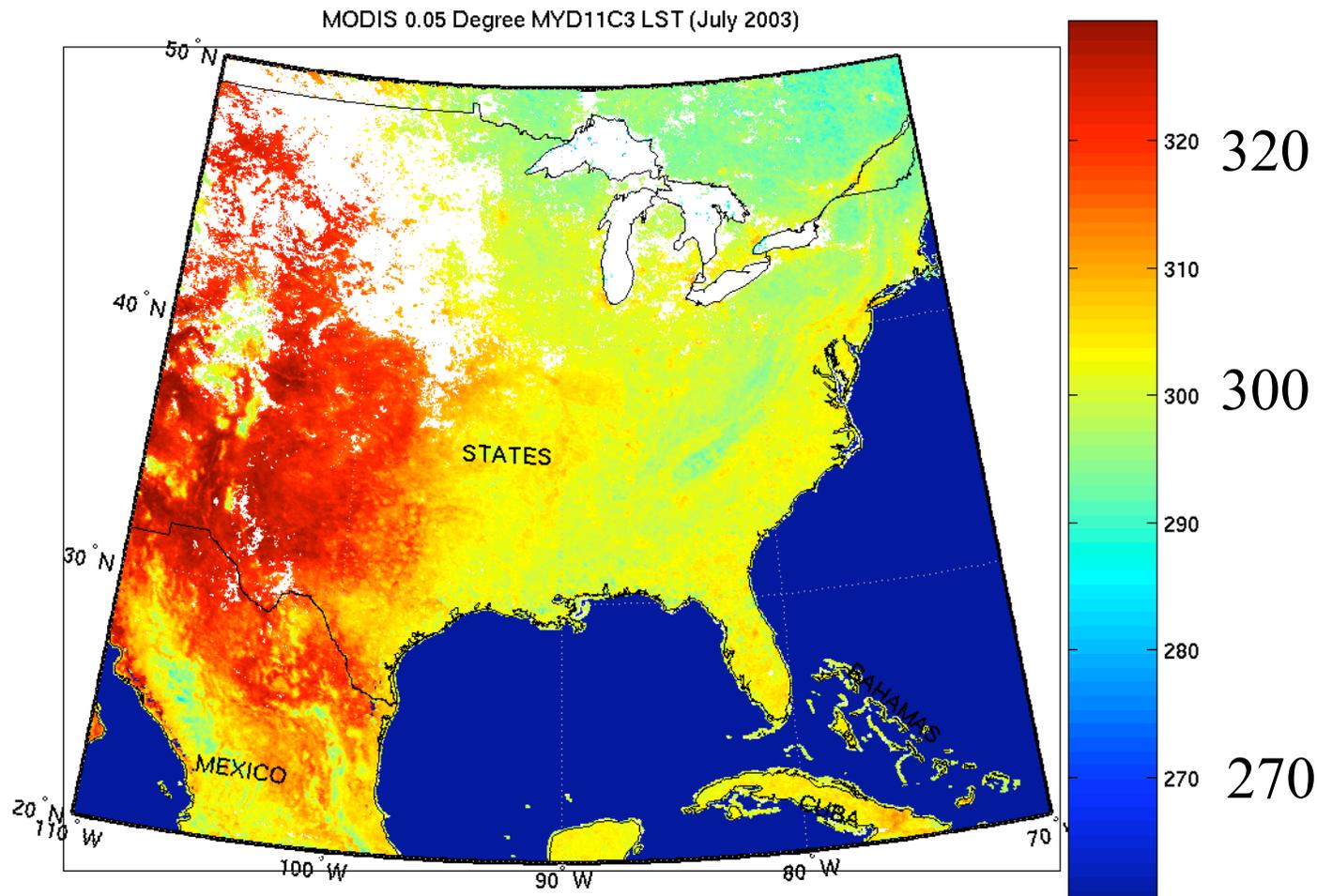
# AIRS Temperature Validation: Ground Truth



# Topics

- AIRS Temperature Validation
  - ground truth sites
  - AIRS/MODIS inter-comparison  
(Monthly Composite Level 3 Products)
- AIRS IR Emissivity Validation
  - ARM SGP Matchup project (joint).
  - Selected granule files for case studies.
  - Daily “clear” analysis.
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# AIRS Temperature Validation: MODIS Comparison



## Comments

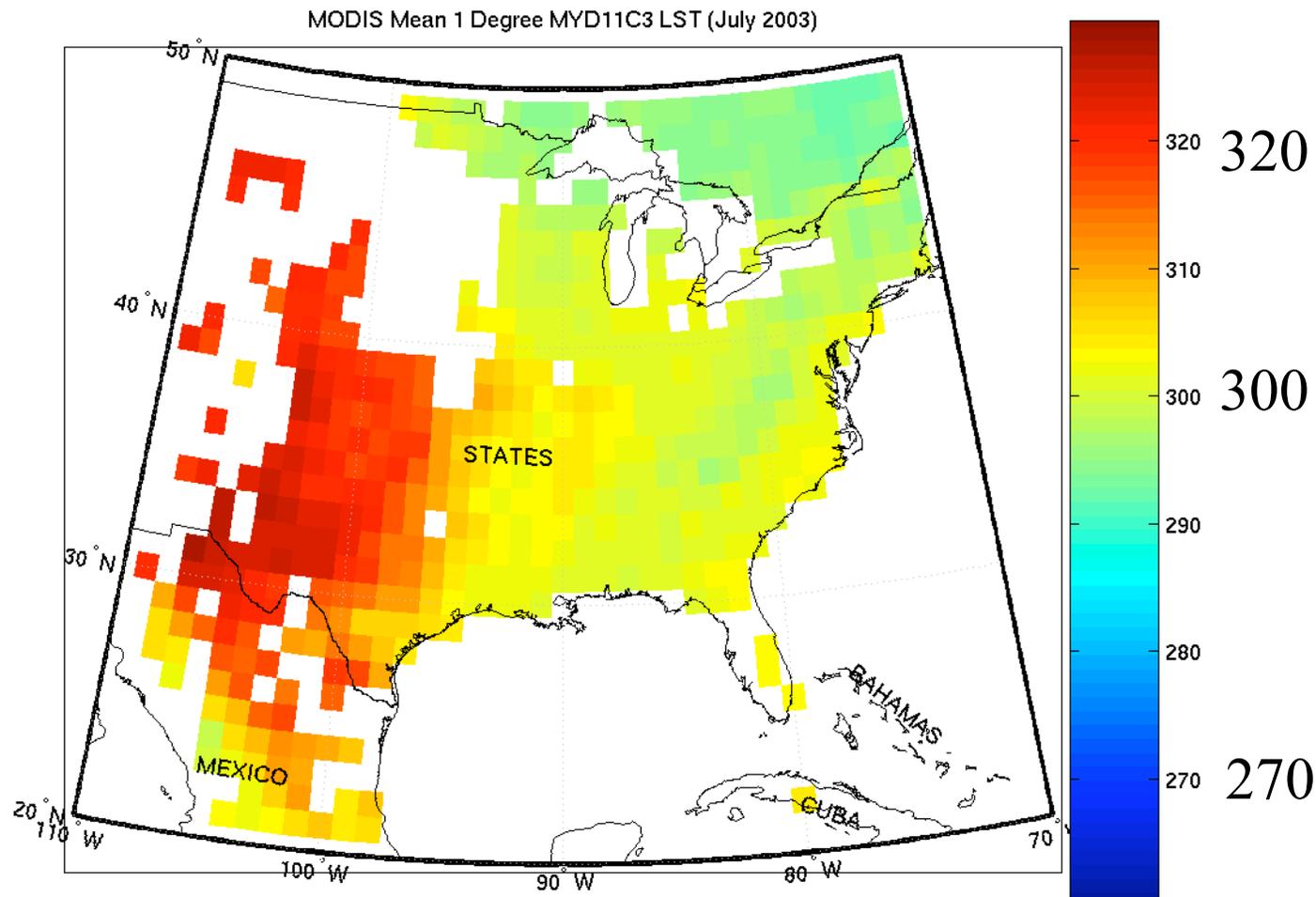
Day/Night  
algorithm

5 km  
spatial  
resolution

MOD11C  
product

JULY 2003 MODIS (MOD11C) – DAY-TIME

# AIRS Temperature Validation: MODIS Comparison



## Comments

MODIS  
Good Data  
Flag Used.

Reduced  
from 0.05  
degree to 1  
degree  
resolution

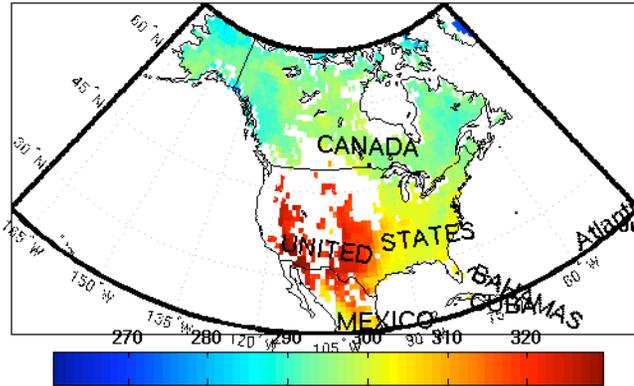
Within Std  
Dev. < 1 K

JULY 2003 MODIS Averaged to 1 degree Grid

# AIRS Temperature Validation: MODIS Comparison

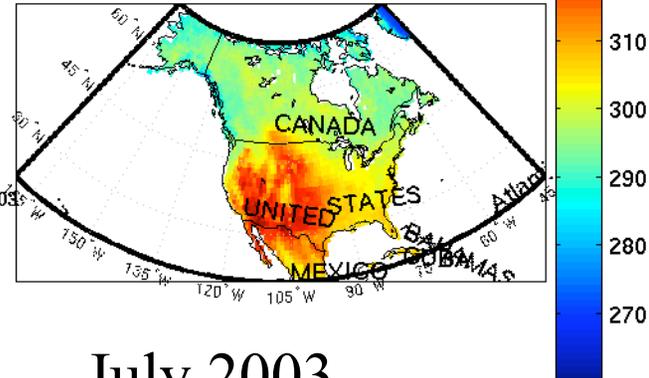
## MODIS (v. 4)

MODIS (v4) Surface Skin Temperature (1 degree resolution)



## AIRS (v. 4)

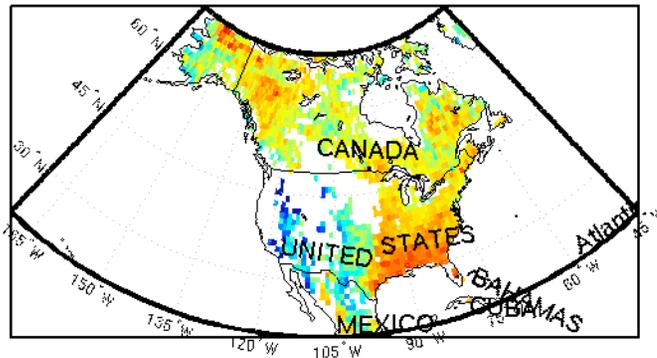
AIRS Level 3 Surface Skin Temperature (v4.0.8 Test)



July 2003

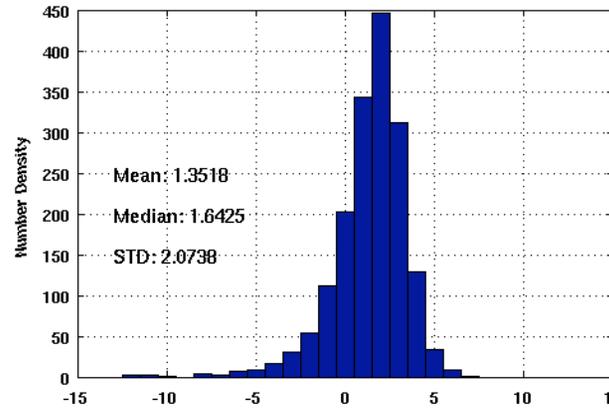
## AIRS - MODIS

AIRS minus MODIS Surface Skin Temperature



-6      0      6

AIRS L3 minus MODIS Land Surface Skin Temperature Distribution



Created at UW-SSEC on 28-Nov-2005

-5      0      5

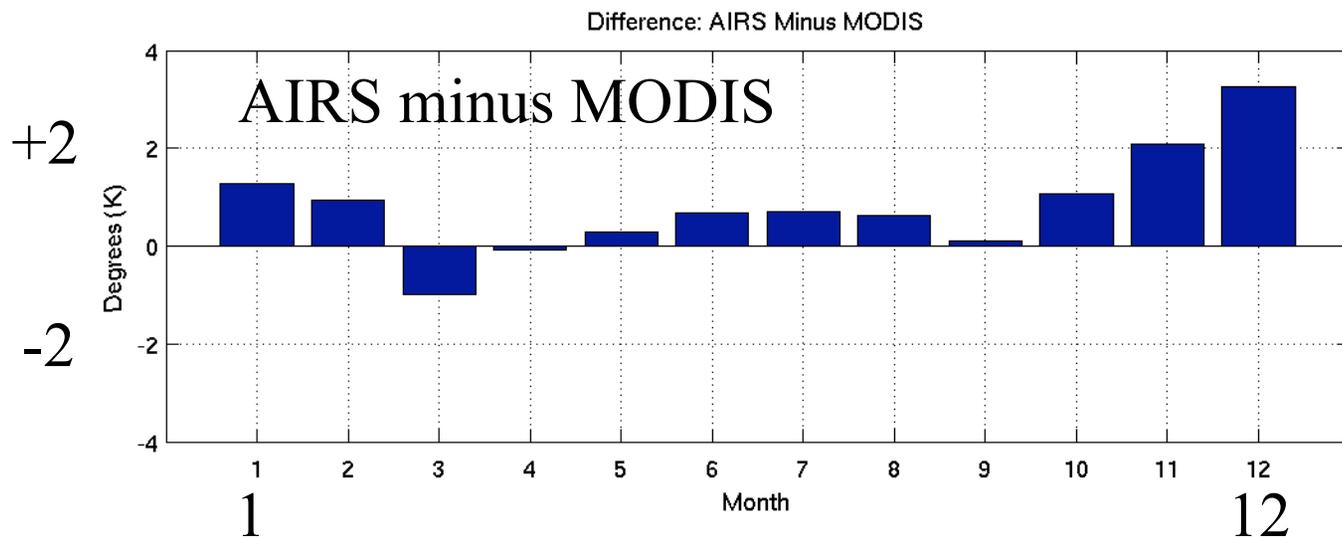
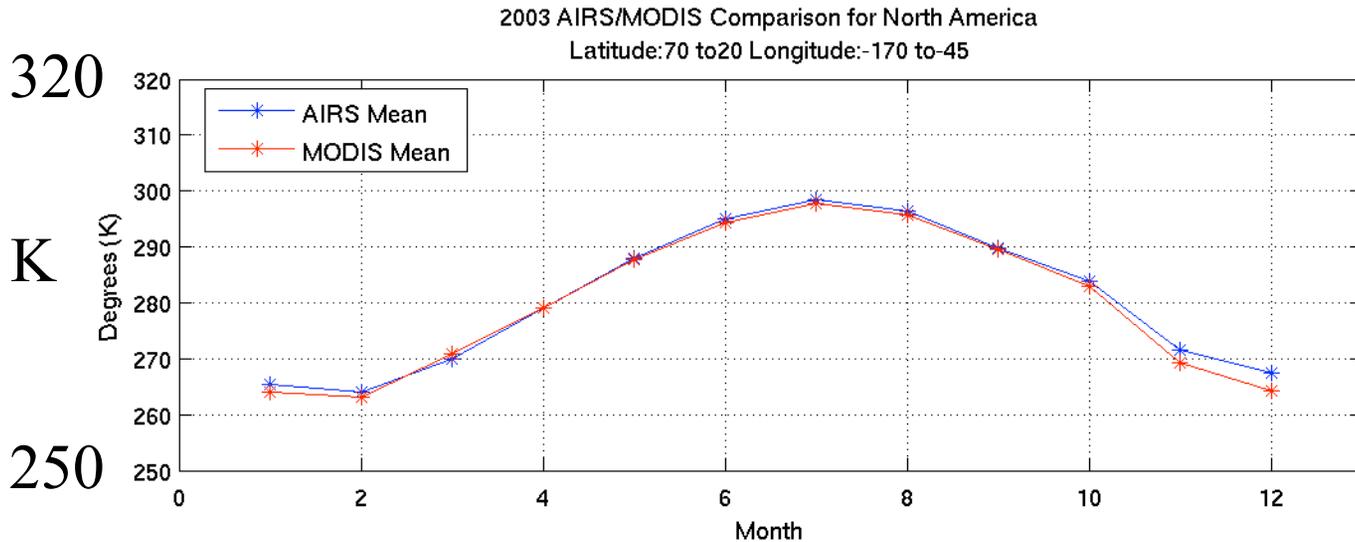
## Comments

AIRS  
minus  
MODIS

Mean:  
**+1.4 K**

Std Dev:  
2.1 K

# AIRS Temperature Validation: MODIS Comparison

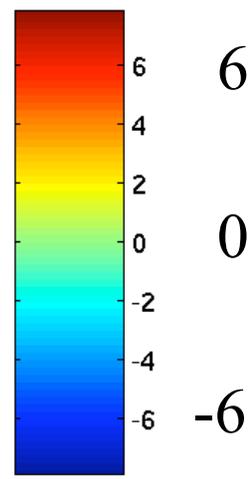
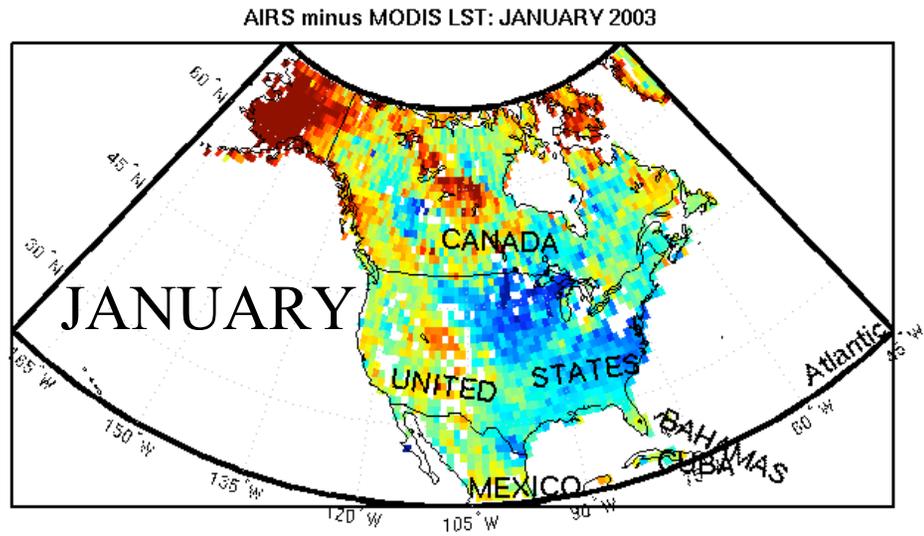


MONTH of 2003

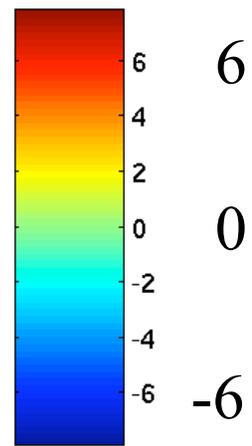
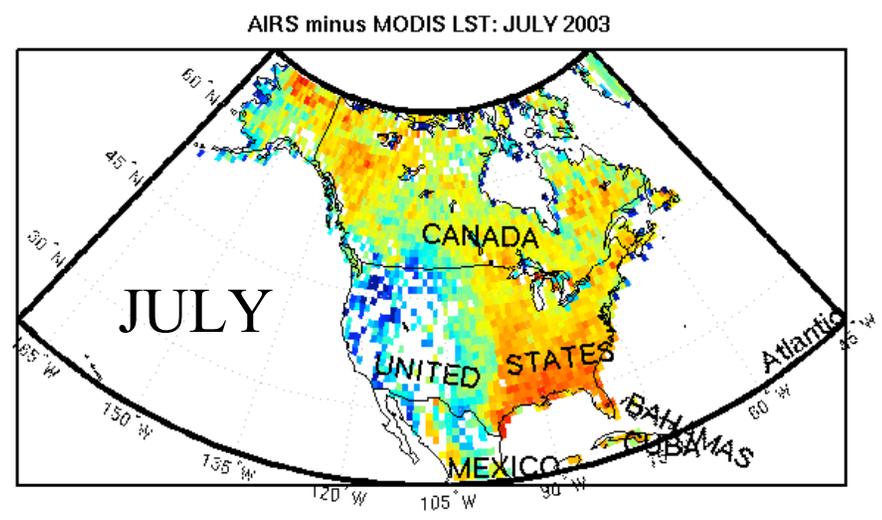
## Comments

North American Day-Time Mean  $T_{\text{surface}}$  Bias within  $\pm 1$  K except during Winter

# AIRS Temperature Validation: MODIS Comparison



2003 AIRS minus MODIS



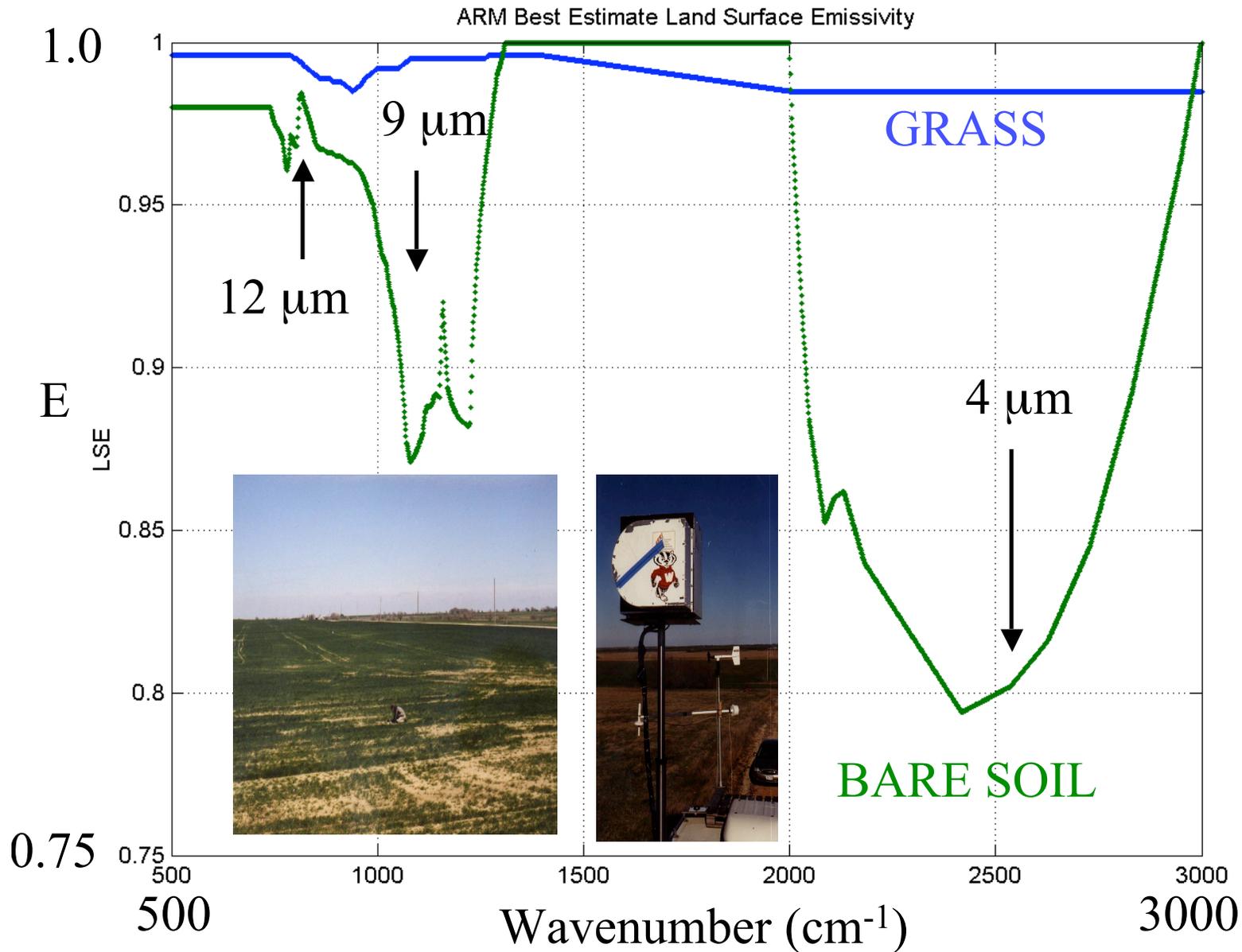
Comments

Indication of a Winter Polar Surface Temp. Bias in the AIRS gridded L3 product

# Topics

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  - **ARM SGP Matchup project (with Tobin).**
  - Selected granule files for case studies.
  - Daily “clear” analysis.
  - Collaboration with JCSDA activities.

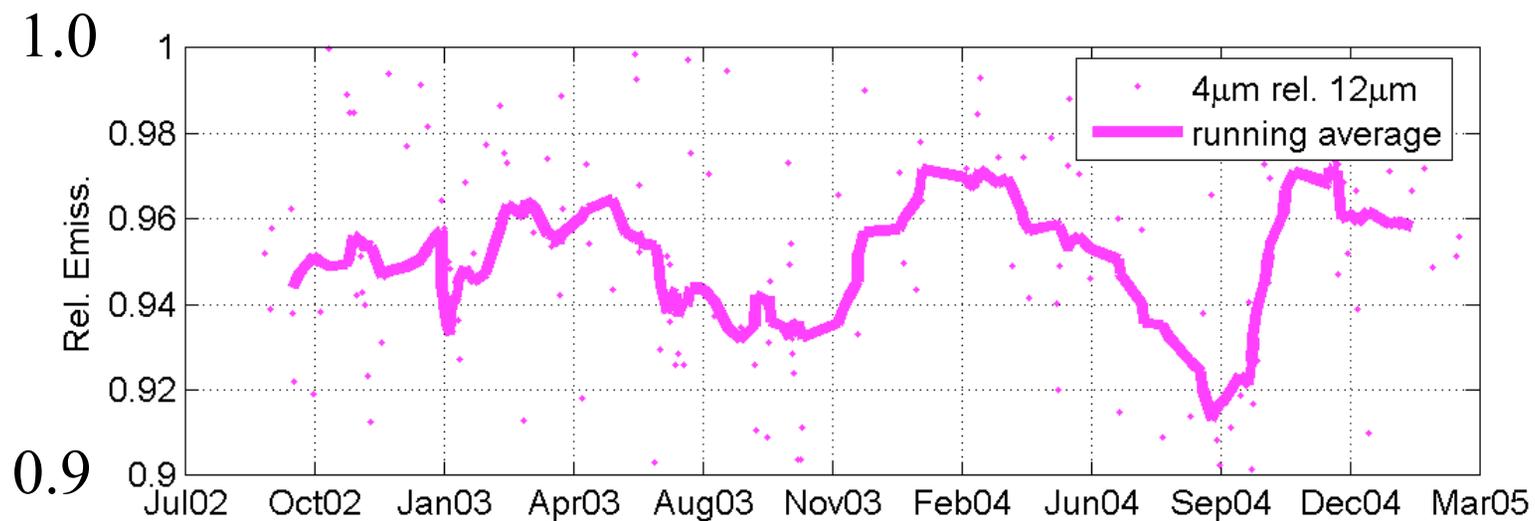
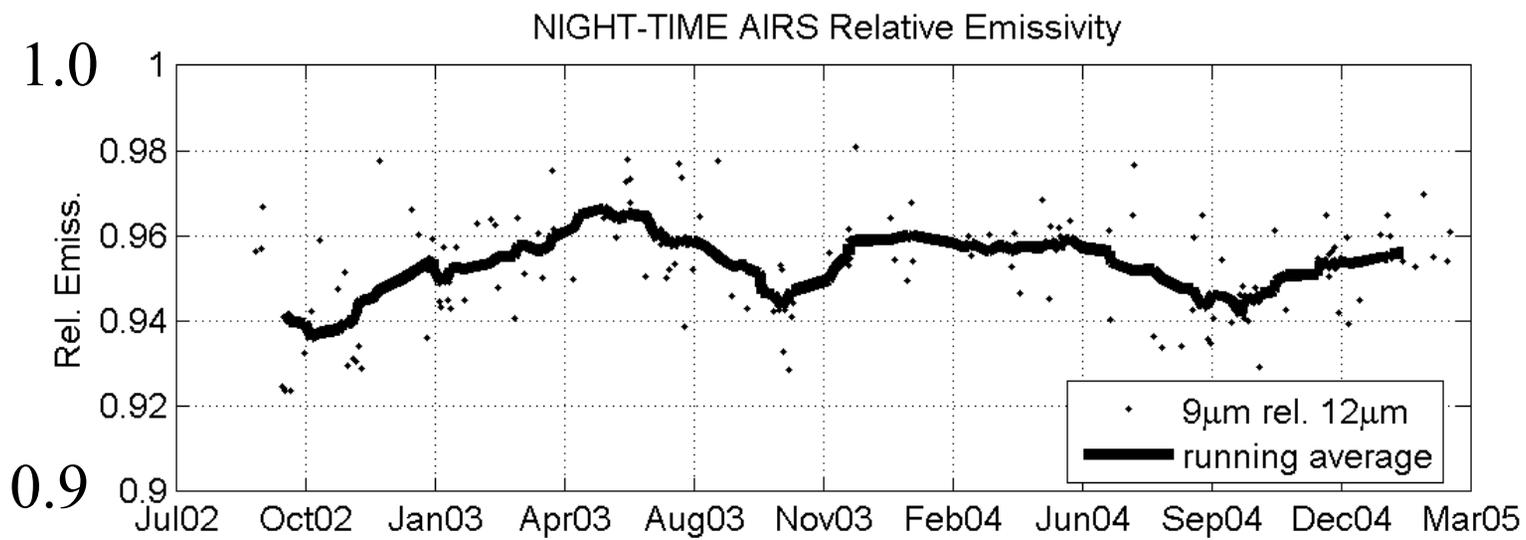
# AIRS IR Emissivity Validation: ARM SGP Matchup



Comments

AIRS  
FOV  
contains  
weighting  
of Pasture  
or Wheat  
(Grass)  
and  
Exposed  
Bare Soil  
(Silicates)

# AIRS IR Emissivity Validation: ARM SGP Matchup



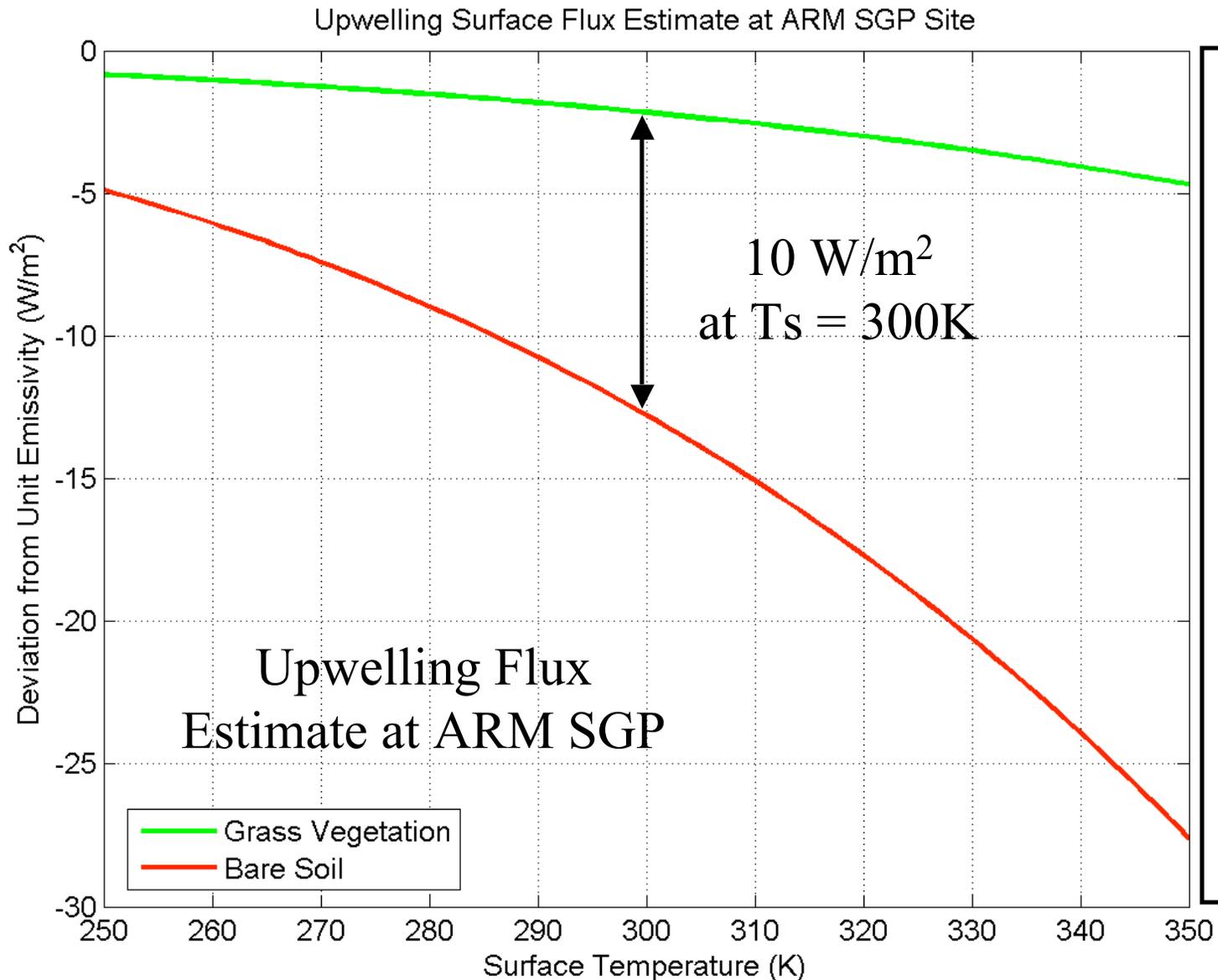
## Comments

Seasonal variation due to exposure of soil after **WHEAT** harvest.

9 µm:  
2-3 %

4 µm:  
4-6 %

# AIRS IR Emissivity Validation: ARM SGP Matchup



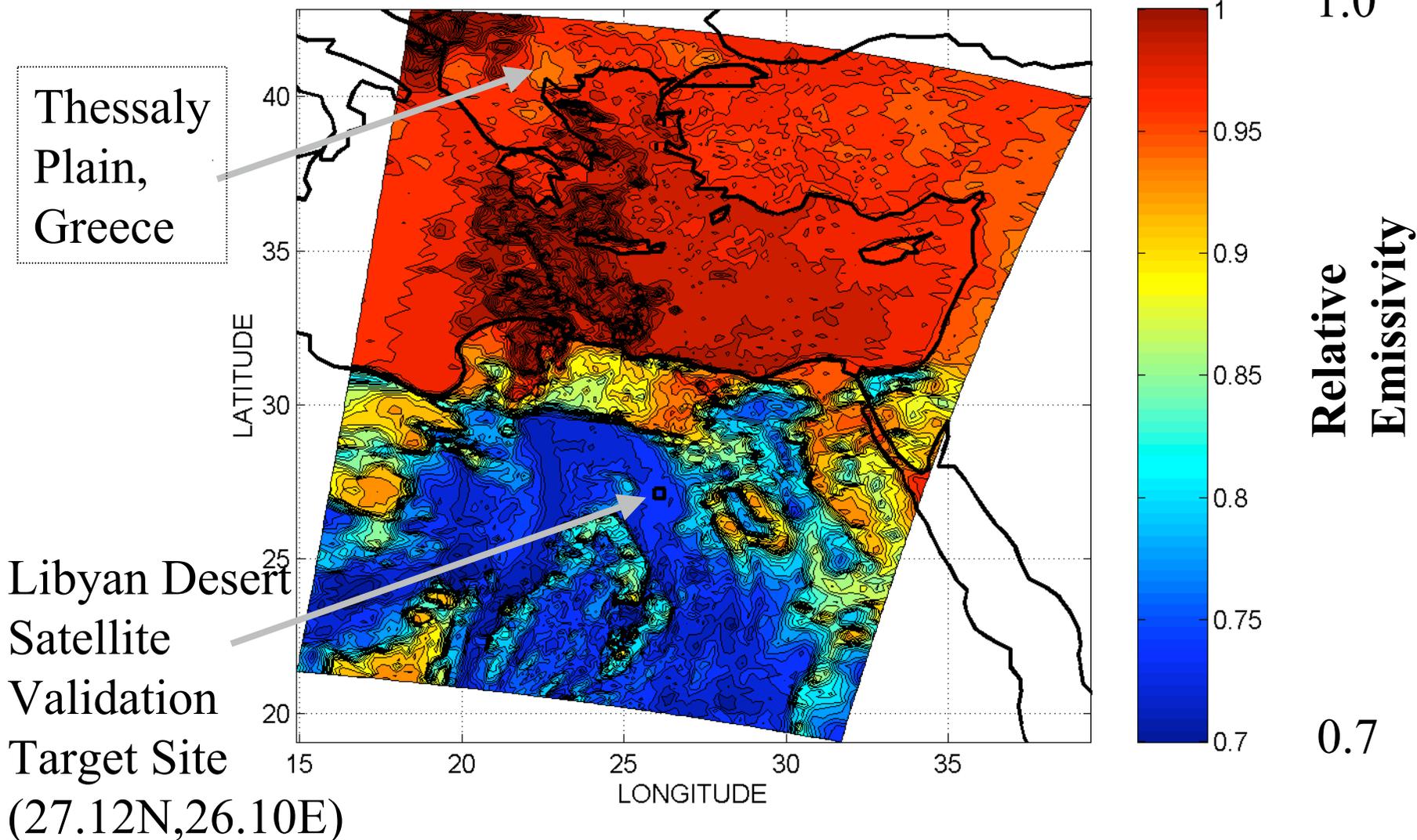
Comments  
A 50%  
vegetation  
fraction  
implies an  
**anthropogenic**  
**affect of**  
**about**  
**5  $W/m^2$**   
with a  
seasonal  
variation of  
2 to 3  $W/m^2$ .

# Topics

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# AIRS IR Emissivity Validation: Case Studies

AIRS Raw Relative Emissivity (9  $\mu\text{m}$ ): 16 Nov 2002 00:00-00:06 UTC



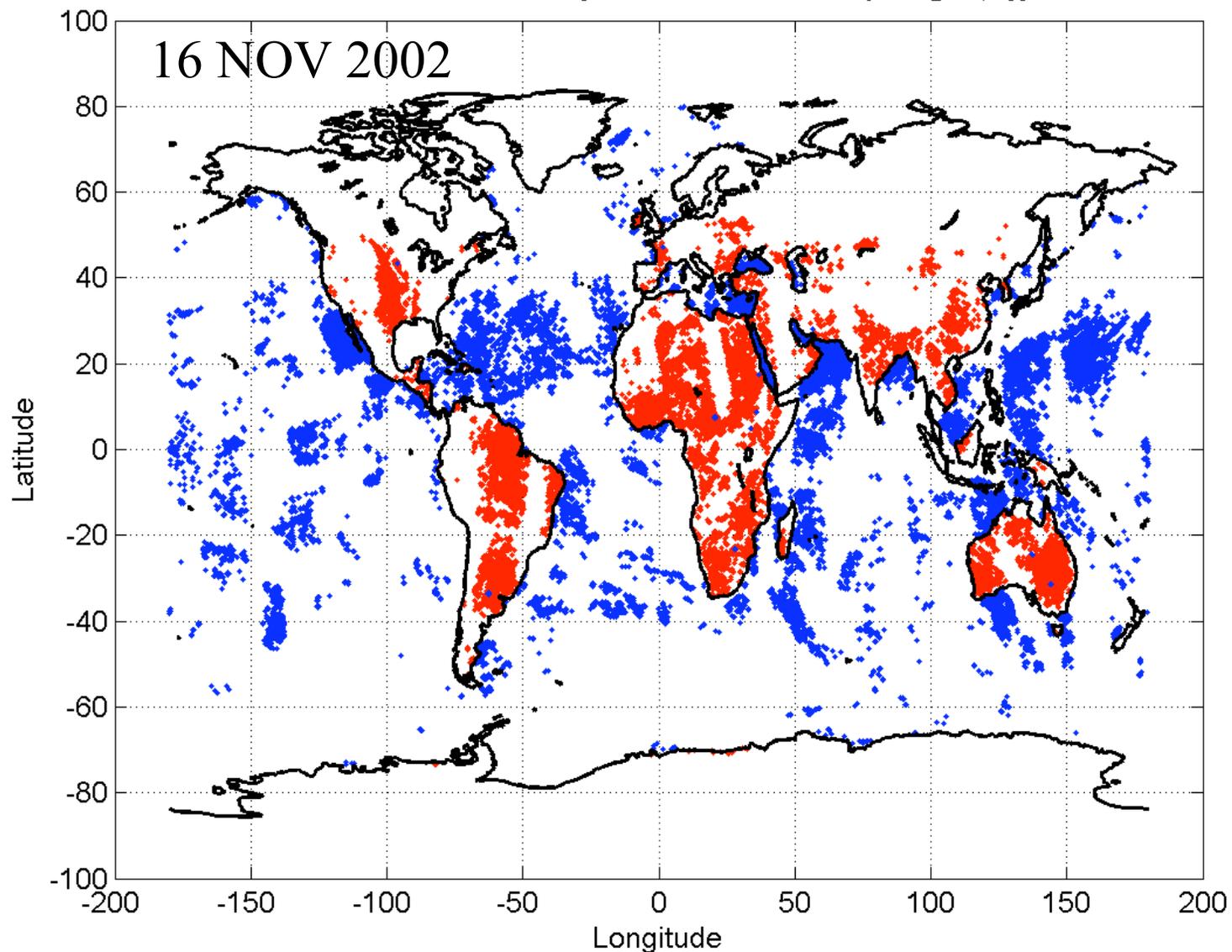
16 November 2002 00:00-00:06 UTC (15-km F<sub>2</sub>V)

# AIRS IR Emissivity Validation: Daily “Clear” File Analysis

- AIRS Temperature Validation
  - ground truth sites
  - MODIS inter-comparison
- AIRS IR Emissivity Validation
  - ARM SGP Matchup project (joint).
  - Selected granule files for case studies.
  - **Daily “clear” analysis.**
  - Collaboration with JCSDA activities.

# AIRS IR Emissivity Validation: Clear Match

Clear FOVs: AIRS.2002.11.16.L1B.Match\_clear.a.v4.0.16.0.PGE\_verify\_L1B\_v00.T05103225453.hdf



## Comments

Clear  
Ocean  
(Blue)

Clear  
Land (Red)

Using  
Aumann  
Clear Tests

# AIRS IR Emissivity Validation: In Collaboration with the JCSDA (LeMarshal)

- Polar ( $|\text{latitude}| > 75$  degrees)
  - Arctic, Antarctic
- Snow covered land ( $|\text{lat}| > 45$  degrees)
  - Siberia, Alaska, Canada, Scandinavia
- Deserts
  - Sahara, China, Australia
- Semi-Arid Regions
  - Sahel, Western U.S..

# Progress Summary

- Continental ARM SGP site is being used for Temperature and IR Emissivity validation.
- Global AIRS L3 are compared with MODIS L3 products for monthly composites.
- Case Studies are being used to assess L2 products on a granule basis (Working Group).
- AIRS “clear” daily data stream will be used to create a global single field of view emissivity database for use by the AIRS ST and JCSDA.