AIRS Land Surface Temperature and Emissivity Validation

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Topics

• IR Emissivity for Clear AIRS FOVs
  *(Algorithm provided to JPL and JCDA.)*

• AIRS Temperature Validation
  *(AIRS/MODIS Level 3 comparison.)*
Infrared Radiative Transfer Equation (lambertian surface)

\[ N_v^\uparrow = \int B_v(T(P))d\tau_v + \tau_v^{tot} \cdot e_v \cdot B_v(T_S) + \tau_v^{tot} \cdot (1 - e_v) \cdot \overline{N}_v \]

- \( N_v^{atm}\uparrow \)
- Surface Emission
- Surface Reflection

Skin Temperature & Surface Emissivity
Approximate Solutions:

\[
N_v^\uparrow = \int B_v(T(P))d\tau_v + \tau_v^{\text{tot}} \cdot e_v \cdot B_v(T_S) + \tau_v^{\text{tot}} \cdot (1 - e_v) \cdot \overline{N}_v
\]

\[
e_v = N_v^\uparrow / B_v(T_S)
\]

(spectral relative)

\[
e_v = (N_v^\uparrow - \int B_v(T(P))d\tau_v) / (\tau_v^{\text{tot}} \cdot B_v(T_S))
\]

(atmospheric corrected spectral relative)

\[
e_v = [(N_v^\uparrow - \int B_v(T(P))d\tau_v) - \tau_v^{\text{tot}} \cdot \overline{N}_v] / [\tau_v^{\text{tot}} B_v(T_S) - \tau_v^{\text{tot}} \cdot \overline{N}_v]
\]

(formal solution - known atmosphere - unknown skin temperature)
AIRS Relative Emissivity and Temperature

16 November 2002
Focus Day
MODIS Image of Egypt & Nile River

Daytime Overpass: 11:03 UTC on 16 Nov. 2002
Desert observations show strong Quartz restrahlung features.
Relative emissivity contains atmospheric absorption lines.

- Relative emissivity contains atmospheric absorption lines.
NIGHT -- 9 μm relative to 12 μm

Thessaly Plain, Greece

Libyan Desert Satellite Validation Target Site (27.12N, 26.10E)

16 November 2002  00:00-00:06 UTC (15-km FOV)
NIGHT -- 4 µm relative to 12 µm

Thessaly Plain, Greece

Libyan Desert Satellite Validation Target Site (27.12N, 26.10E)

16 November 2002  00:00-00:06 UTC (15-km FOV)
AIRS Absolute Emissivity and Surface Temperature (including Surface Reflection)

16 November 2002 Focus Day

• Square symbol marks Egypt One site in Libyan Desert
ECMWF Analysis: 16 Nov. 2002  12 UTC

- ECMWF profile over Egypt One site in Libyan Desert
• LBLRTM calculations reduced to AIRS spectral resolution.
**Constraint:** Emissivity solution should be smoothly varying across atmospheric absorption lines!

- Minimum Std. Deviation is at the true skin temperature!!
AirS Absolute Emissivity

EGYPT-One Libyan Desert: 16 Nov 2002 11:03 UTC

- Squares are using 281 Select AIRS channels only. It Works!!!
How Good Does RTE Need to Be?

Online/Offline Signal is 0.05K for a 1% reflectivity !!!
Clear Sky IR Emissivity from AIRS Summary

- Demonstrated ability to determine RELATIVE emissivity to within about 2% using ECMWF atmospheric state as input to a line-by-line RTE correction.
- Demonstrated ability to determine ABSOLUTE emissivity to about 1% using AIRS observations + ECMWF atmospheric temperature and water vapor profiles using Online/Offline technique. *(Assuming an accurate RTE model for reflection.)*
- Demonstrated that a 10% error in total water vapor leads to a 1% error in absolute emissivity with the On/Offline method.
- Demonstrated a FORTRAN implementation that gives consistent results using only the 281 channel subset. (!!!)
- Delivered FORTRAN code to JPL and JCDA for evaluation and possible routine implementation.
AIRS Surface Temperature and IR Emissivity Validation

AIRS/MODIS L3 Comparison (Preliminary !!!)
MOD11 Monthly Composite

MODIS 0.05 deg (5 km) Land Surface Temperature
MOD11 Monthly Composite

MODIS Band 29 Surface Emissivity (.05 degree resolution)

MODIS 0.05 deg (5 km) IR Emissivity at 8.5 µm
*** The AIRS L3 Product shown here is based on Release Version 3, which has NOT been validated over land. ***
(See Stephanie Granger’s Talk Friday AM for more details.)

January 2003    Global Monthly Composite

AIRS 1 deg (100 km) Land Surface Temperature
AIRS Validation Against MODIS Products (or vice versa)

Method:
1. Degrade MOD11 product from 5 km (0.05 deg) to 100 km (1 degree) bins by taking the median value.
3. Display difference maps and histograms for
   a) Land Surface Temperature
   b) IR Emissivity (12, 8.5, and 3.9 μm)

This comparison method is suggested for future evaluation of AIRS land surface temperature products since it can be used to identify potential problem areas in either the AIRS or MODIS products.
January 2003

Skin Temperature

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

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

AIRS minus MODIS Surface Skin Temperature

AIRS L3 minus MODIS Land Surface Skin Temperature Distribution

Mean: 1.5573
Median: 0.91562
STD: 4.2038

Created at UW-SSEC on 22-Apr-2005
Skin Temperature

July 2003

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

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

AIRS minus MODIS Surface Skin Temperature

AIRS L3 minus MODIS Land Surface Skin Temperature Distribution

Mean: 0.85988
Median: 1.152
STD: 3.3351

Created at UW-SSEC on 22-Apr-2005
January 2003

12 μm Emissivity

MODIS (v4) Band 32 Surface Emissivity (1 degree resolution)

AIRS Level 3 12 μm Surface Emissivity (v4.0.8 Test)

AIRS minus MODIS Surface Emissivity

AIRS L3 minus MODIS Global Surface Emissivity Distribution

Mean: 0.022272
Median: 0.018699
STD: 0.028926

Created at UW-SSEC on 22-Apr-2005
12 µm Emissivity

July 2003

MODIS (v4) Band 32 Surface Emissivity (1 degree resolution)

AIRS Level 3 12 µm Surface Emissivity (v4.0.8 Test)

AIRS minus MODIS Surface Emissivity

AIRS L3 minus MODIS Global Surface Emissivity Distribution

Created at UW-SSEC on 22-Apr-2005
Skin Temperature

July 2003

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

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

AIRS minus MODIS Surface Skin Temperature

AIRS L3 minus MODIS Land Surface Skin Temperature Distribution

Mean: 0.51611
Median: 1.0492
STD: 2.7396

Created at UW-SEC on 22-Apr-2005
12 μm Emissivity

January 2003

MODIS (v4) Band 32 Surface Emissivity (1 degree resolution)

AIRS Level 3 12 μm Surface Emissivity (v4.0.8 Test)

AIRS minus MODIS Surface Emissivity

AIRS L3 minus MODIS Global Surface Emissivity Distribution

Mean: 0.022272
Median: 0.018699
STD: 0.028926

Created at UW-SSEC on 22-Apr-2005
12 µm Emissivity

MODIS (v4) Band 32 Surface Emissivity (1 degree resolution)

AIRS Level 3 12 µm Surface Emissivity (v4.0.8 Test)

AIRS minus MODIS Surface Emissivity

AIRS L3 minus MODIS Global Surface Emissivity Distribution

Mean: 0.022552
Median: 0.022676
STD: 0.017097

Created at UW-CSC on 22-Apr-2005
Skin Temperature

AIRS minus MODIS Surface Skin Temperature for February 2003
AIRS Monthly Composite Missing
for May 2003
Skin Temperature

AIRS minus MODIS Surface Skin Temperature for September 2003

Legend:
- Blue: Lower temperatures
- Red: Higher temperatures

Note: The map shows the difference in skin temperature between AIRS and MODIS data for September 2003.
AIRS / MODIS Land Product Summary

• The AIRS “test” L3 products using software release version 3.X level 2 products was obtained from JPL.
• The Aqua MODIS MOD11 (collection 4) product was obtained from the Goddard DAAC for this analysis.
• Demonstrated the utility of comparing AIRS L3 products to spatially degraded MODIS L3 products for land surface temperature and IR emissivity validation.
• Complete set of graphics for all geographic regions and all spectral regions is available for the year 2003 at http://gi.ssec.wisc.edu/~airs/knuteson
• A corresponding set of graphics will be added as Goddard begins producing AIRS L3 products based on the data reprocessing using PGE version 4 software.