June 9, 2009

2st Workshop on Remote Sensing and Modeling of Surface Properties

Global Monthly Surface Emissivity Datasets Derived from the Hyperspectral Instruments

Fengying Sun: Surface emissivity datasets
Lihang Zhou: AIRS emissivity regression retrieval
Zhouhui Cheng: IASI emissivity regression retrieval
Haibing Sun: IASI regression training datasets
Walter Wolf: Near real time processing & gridding system
Mitch Goldberg and Chris Barnet: AIRS and IASI PIs
Thomas King: Near real time processing

Outline

- AIRS and IASI surface emissivity Datasets (seasonal variation, day/night and viewing angle effects).
- Comparisons with the UW/CIMSS Baseline fit (BF) global emissivity database (MODIS)
- Comparisons with the laboratory measured hyper-spectral emissivity database (ICESS/UCSB)
- Summary and future Work

Two sets of surface emissivity products from AIRS/IASI near-real time systems

- **Regression Emissivity Approach** (REG, *Zhou et al., 2008)*:
  - Estimation of surface emissivity at 39 hinge points (ranging from 3.7 to 15.4 μm) by using 20 window channel radiances.
  - The regression relationship is based on clear radiances simulated from the ECMWF forecast and a surface emissivity training dataset.
  - Three land surface types: non-frozen land, snow and ice.
- **Physical Retrieval Approach** (RET, *Susskind et al., 2003*):
  - Use regression emissivity as a first guess over land (*Goldberg et al., 2003*).
  - Iterated regularized least squared minimization of the differences between measured and calculated radiances in 25 longwave (15) and shortwave (10) window channels.

Monthly Surface Emissivity Datasets

- Build the global monthly surface emissivity datasets from the **AIRS** (*since August 2003*) and IASI (*since September 2008*) global daily gridded radiance datasets.
- Spatial resolution: **3 ° longitude x 3° latitude** (both REG and RET, 45 km FOR) and 0.5° x 2° (REG, 15 km FOV).
- Two kinds of surface emissivity products: regression (REG, clear sky) and physical retrieval (RET, 'best' retrieval).

Criteria for 'Best' Retrieval

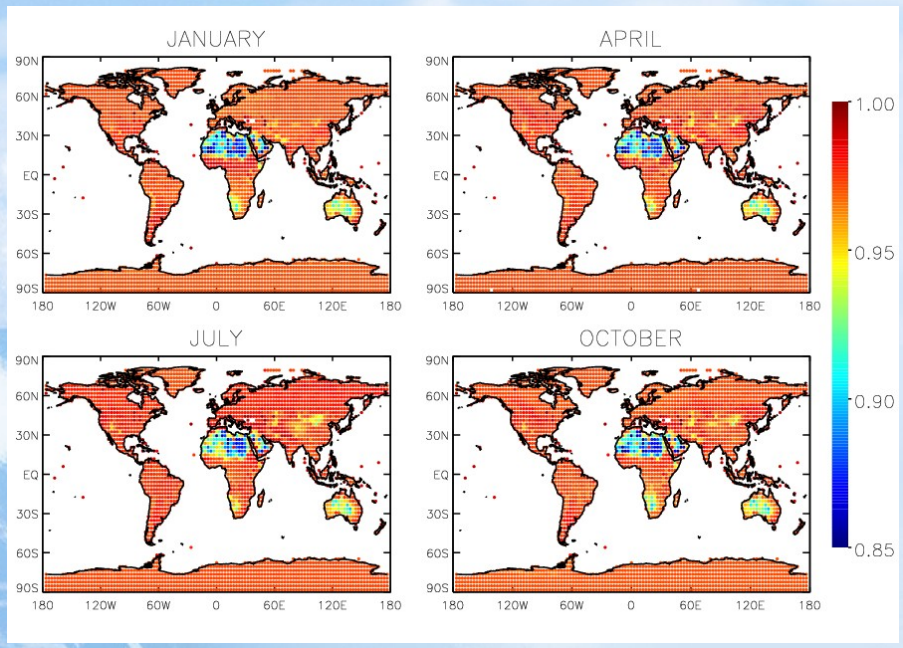
- Accepted by AIRS NOAA retrieval algorithm.
- Thresholds of quality control:
  - Amplification factor from cloud-clearing ≤ 1 (~1/3 for clear scenes).
  - Liquid water content estimated from AMSU measurements ≤ 0.001 gm/cm^2.
  - Principle components score from NOAA regression ≤ 1.5.

➢ 3% clear, 65% accepted, 45% 'best' retrieval

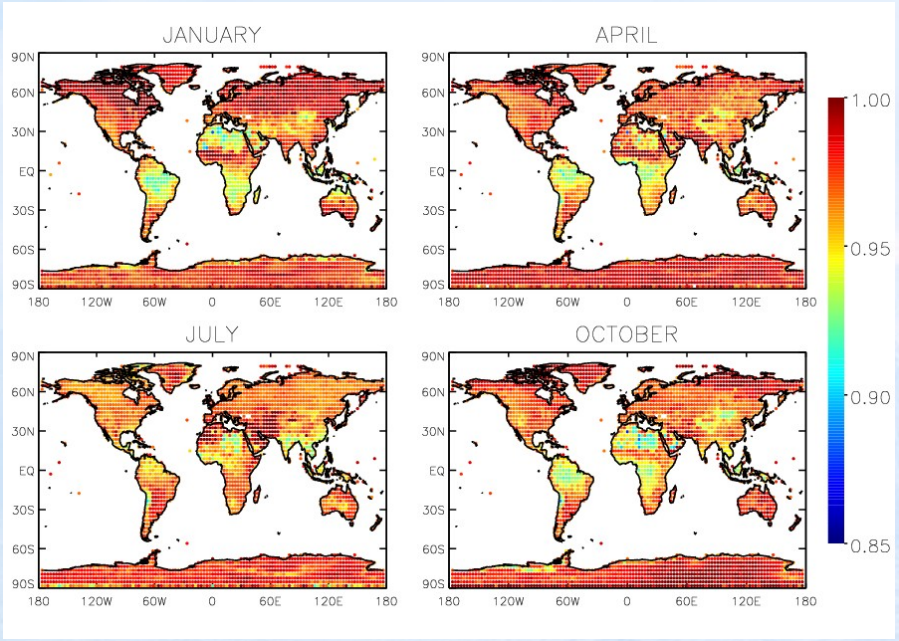
Seasonal Variation:

AIRS monthly surface emissivity at 847.46 cm^{-1} (11.8 μm)

REG

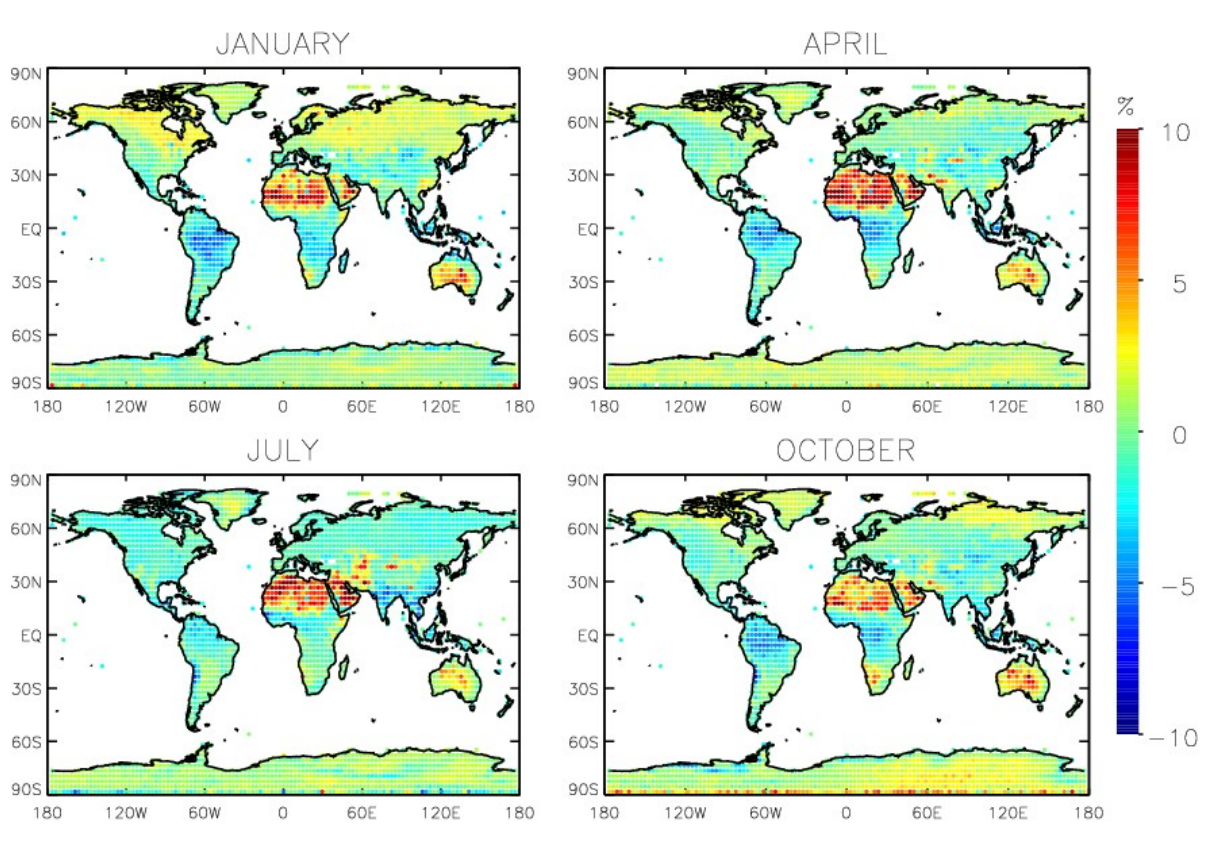


RET



Built from monthly gridded data from August 2003 to January 2008 excluding July 2007 (53 months)

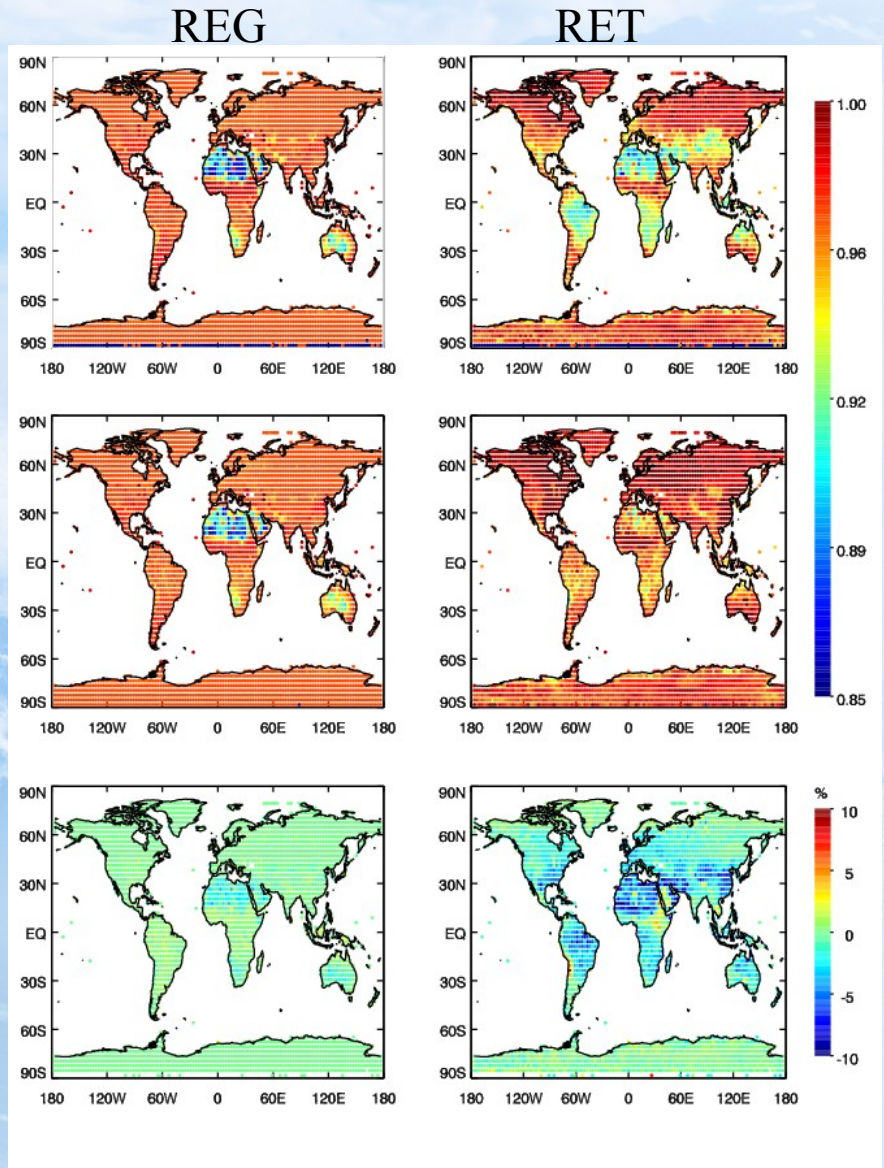
Percent difference between AIRS RET and REG monthly surface emissivity at 847.46 cm^{-1} (11.8 μm)



➢RET emissivity increases greater than 5% over desert

Day/night effect

AIRS monthly surface emissivity at 847.46 cm^{-1} (11.8 μm)



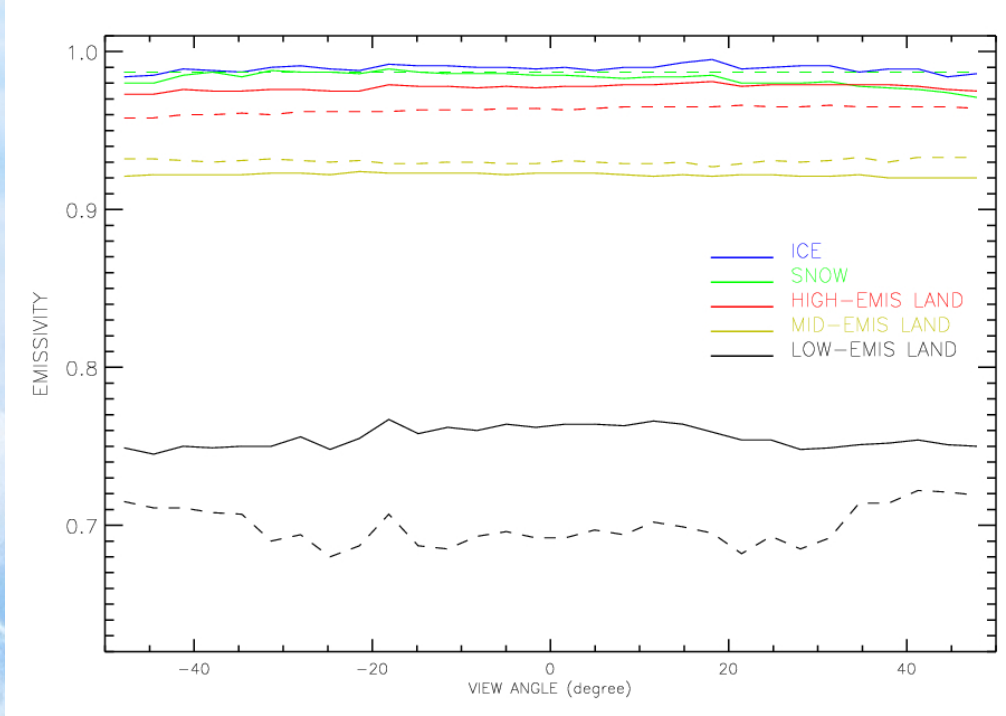
Built from monthly gridded data from January in the years from 2004 to 2008 (5 months).

View angle dependence

Stratify AIRS daily surface emissivity in 2006 according to MW surface types and AIRS RET emissivity at 8.3 μm:

- Ice: MW surfclass=3&4.
- Snow: MW surfclass=5, 6&7.
- Low-emissivity land: MW surfclass=1 and AIRS RET ε at 8.3 μm < 0.85.
- Mid-emissivity land: MW surfclass=1 and 0.85 < AIRS RET ε at 8.3 μm < 0.95.
- High-emissivity land: MW surfclass=1 and AIRS RET ε at 8.3 μm > 0.95.

1210 cm^{-1} (8.3 μm)

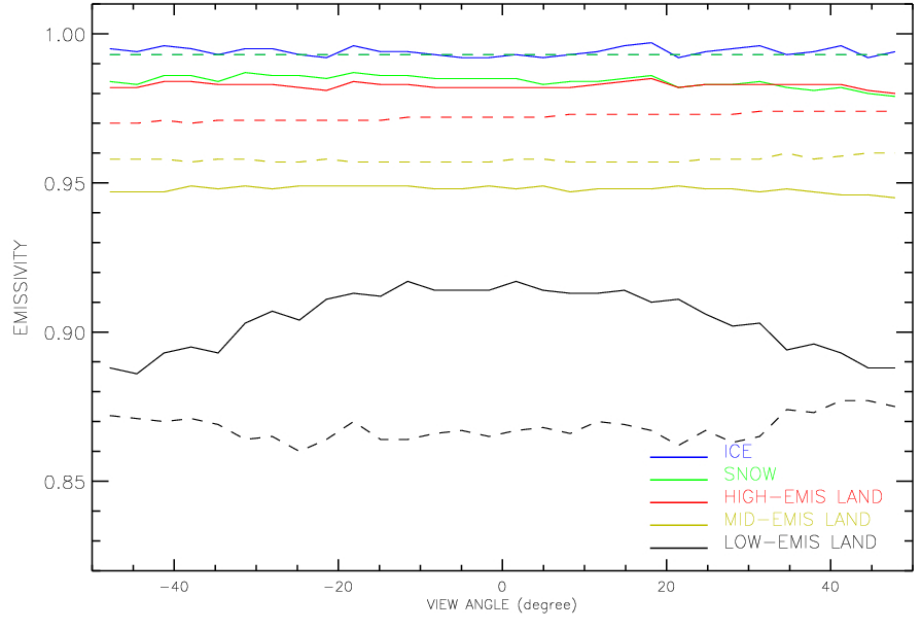


(Dashed – REG Solid – RET)

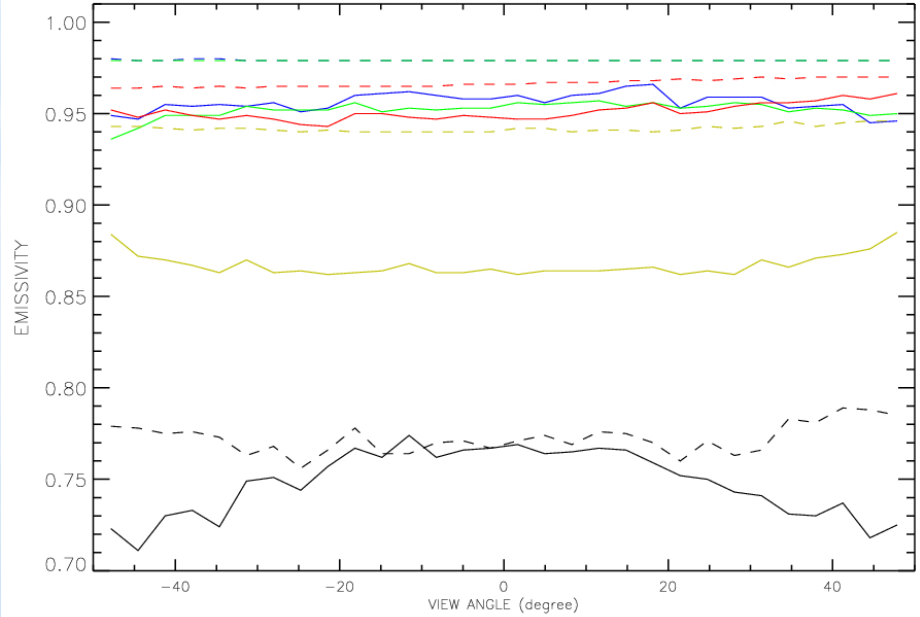
For low-emissivity land (AIRS RET):

- Small viewing angle dependence in quartz reststrahlen band

980 cm^{-1} (10.2 μm)



2600 cm^{-1} (3.85 μm)



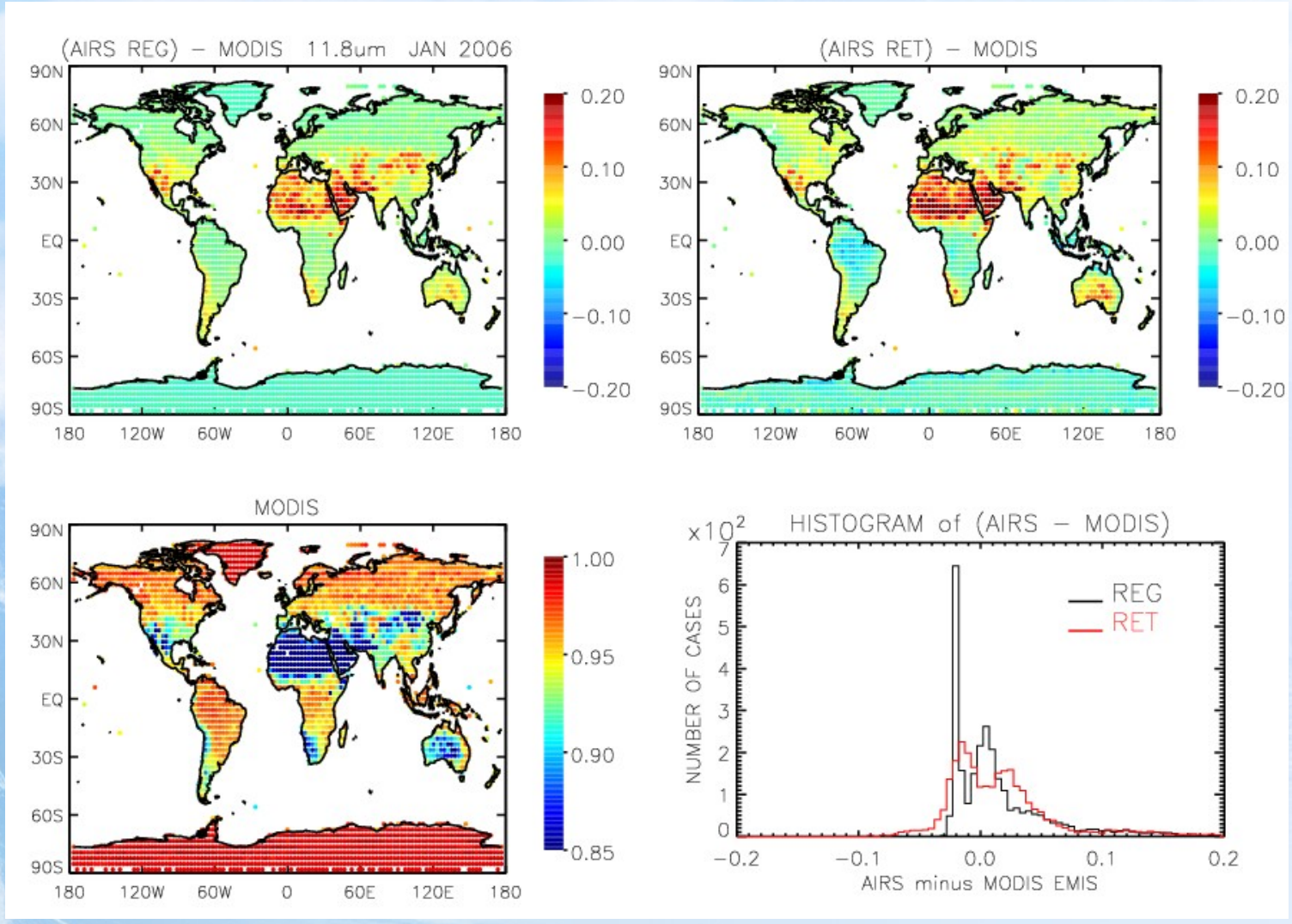
For low-emissivity land (AIRS RET):

- Thermal infrared window: 2.5% difference from nadir to 45 °
- Shortwave bands: 5% difference from nadir to 45 °

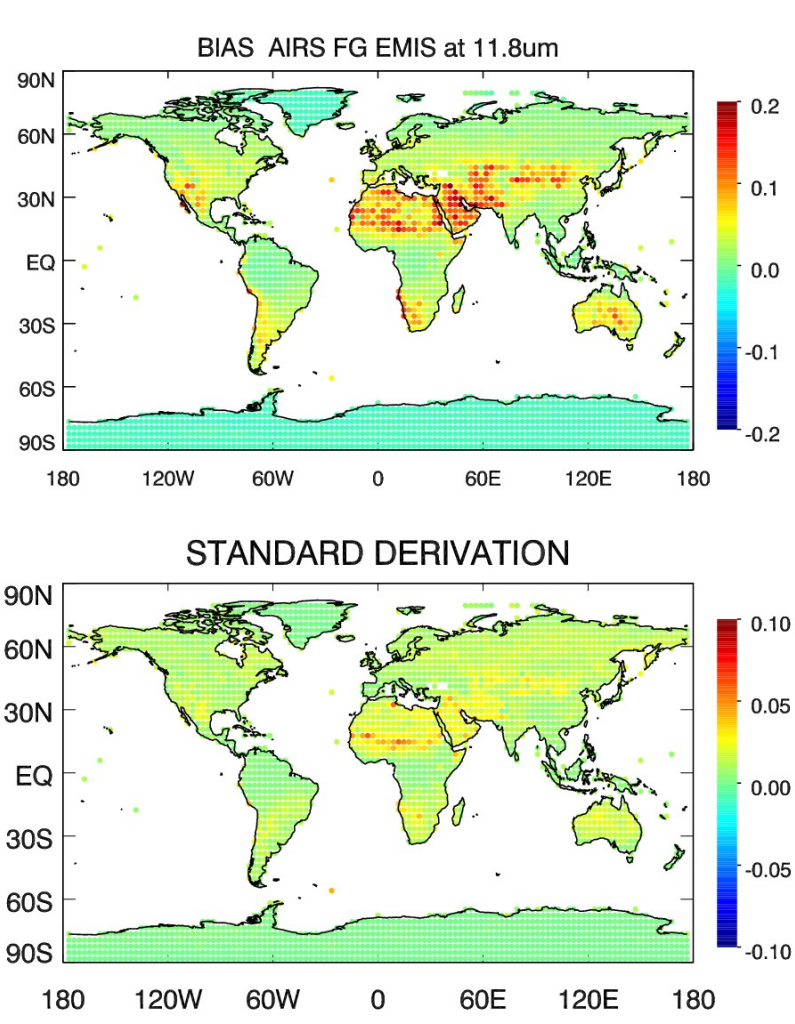
Comparisons with the UW/CIMSS Baseline fit (BF) global emissivity database

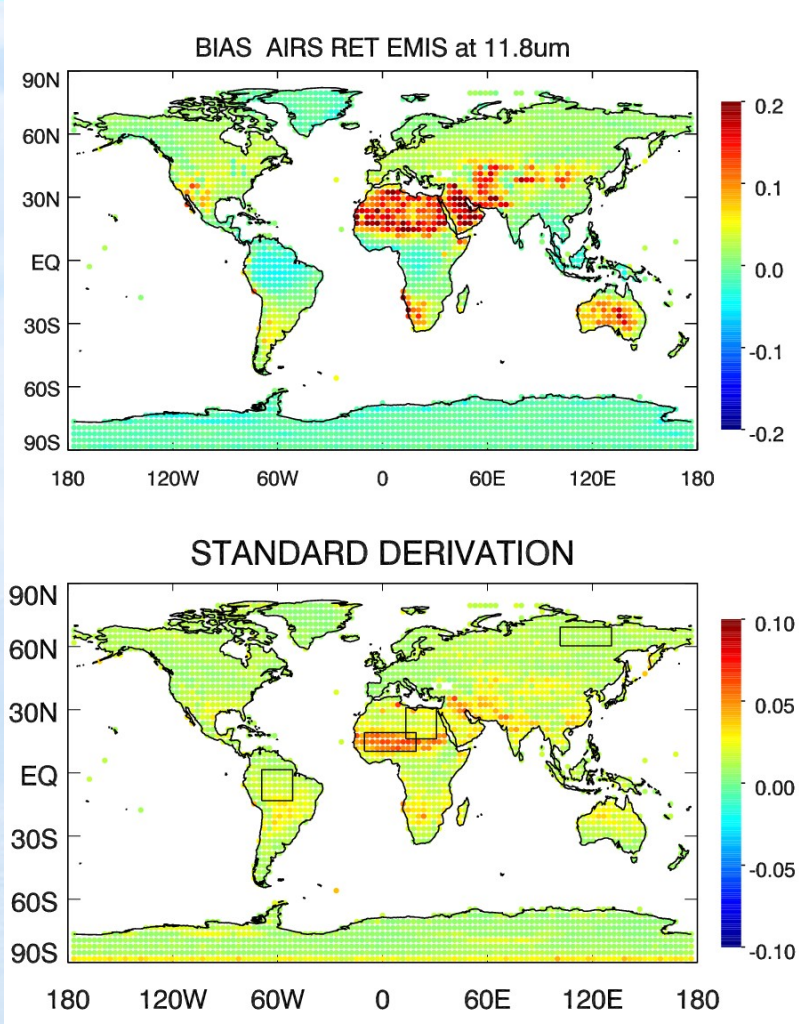
- Interpolated MODIS BF emissivities onto AIRS wavebands .
- Averaged MODIS BF emissivities that fell within 26 km of AIRS grids (MODIS BF's gridding is 7200x3600, AIRS's is 120x61).
- Data source: http://cimss.ssec.wisc.edu/iremis/

AIRS and MODIS monthly surface emissivity at 847.46 cm^{-1} (11.8 μm) in January, 2006



Bias and standard deviation of AIRS and MODIS monthly surface emissivity at 847.46 cm^{-1} (11.8 μm)

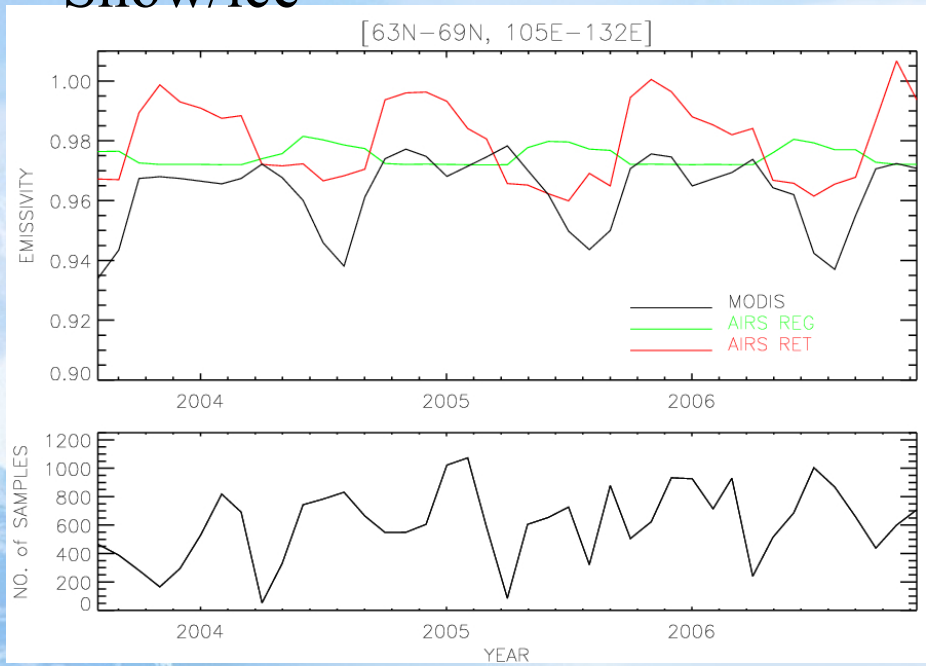




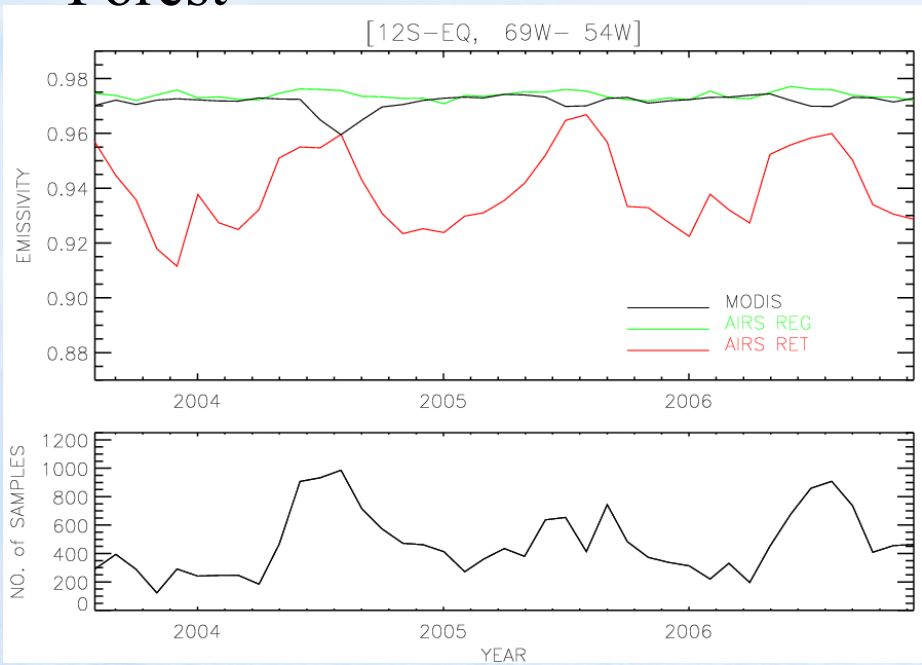
Built from AIRS and MODIS (version 4) monthly surface emissivity from August 2003 to December 2006 excluding January 2004 (40 months)

Time series of AIRS and MODIS monthly surface emissivity at 847.46 cm^{-1} (11.8 μm)

Snow/ice

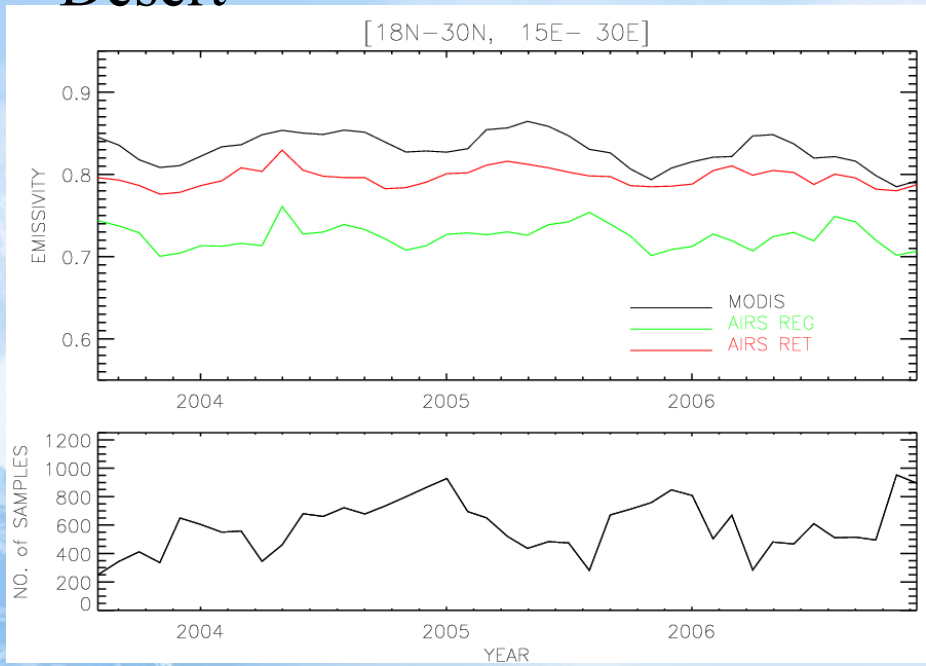


Forest

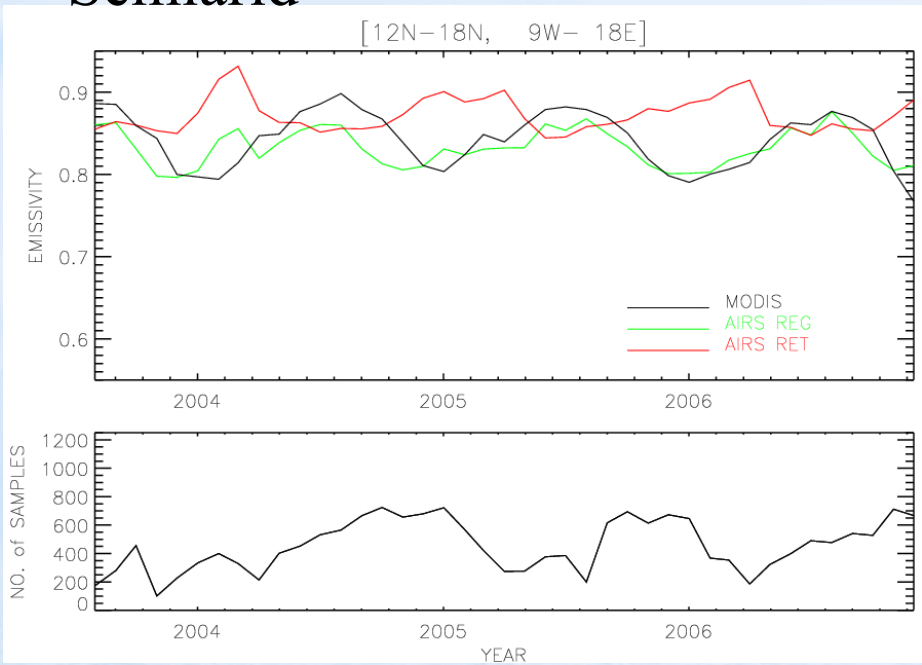


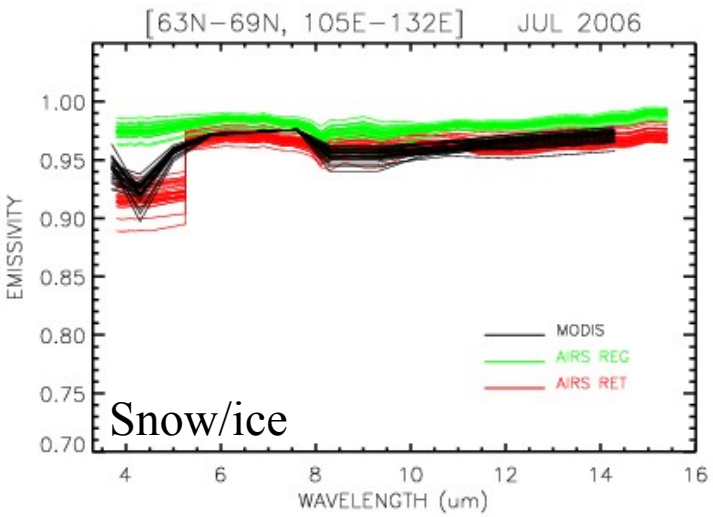
Time series of AIRS and MODIS monthly surface emissivity at 1162.8 cm^{-1} (8.6 μm)

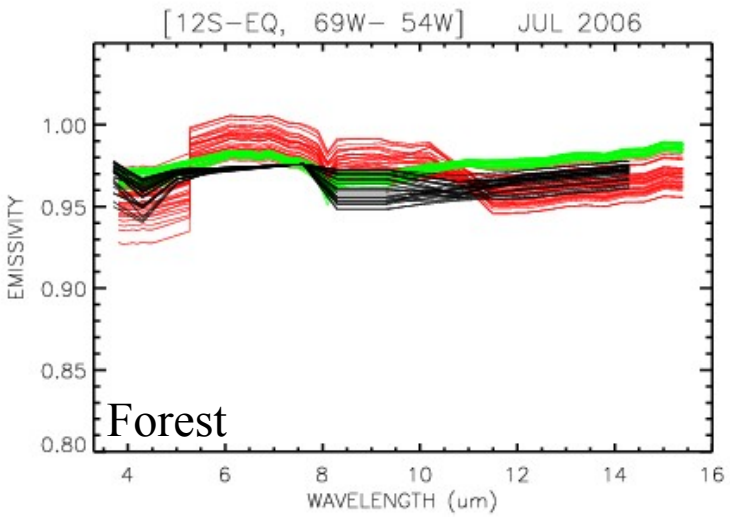
Desert

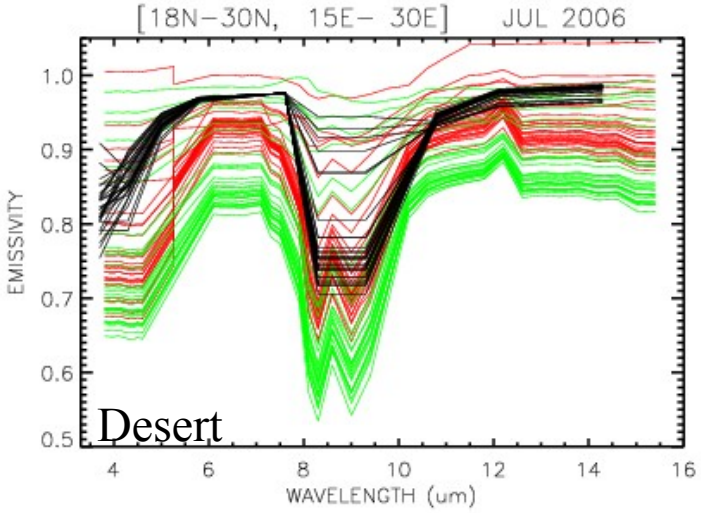


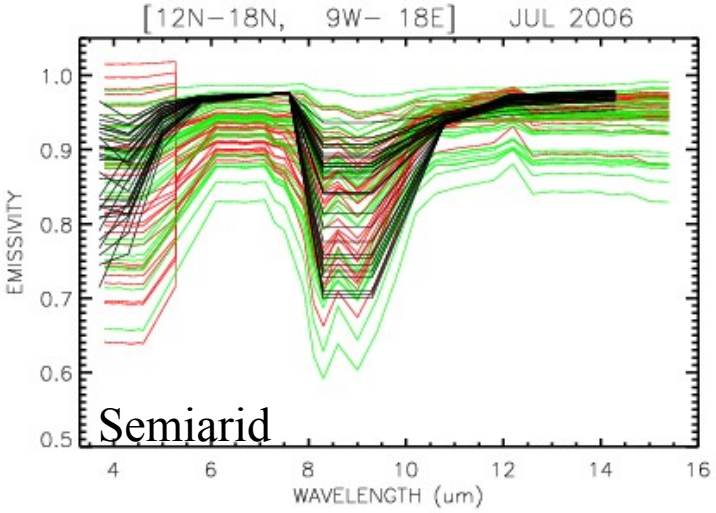
Semiarid




[63N–69N, 105E–132E] JUL 2006
EMISSIVITY
WAVELENGTH (um)
MODIS
AIRS REG
AIRS RET
Snow/ice


[12S–EQ, 69W– 54W] JUL 2006
EMISSIVITY
WAVELENGTH (um)
Forest


[18N–30N, 15E– 30E] JUL 2006
EMISSIVITY
WAVELENGTH (um)
Desert


[12N–18N, 9W– 18E] JUL 2006
EMISSIVITY
WAVELENGTH (um)
Semiarid

Comparisons with the laboratory measured hyper-spectral emissivity database (ICESS/UCSB)

- UCSB data source: http://www.icess.ucsb.edu/modis/EMIS/html/em.html.

- Interpolated UCSD emissivity onto AIRS wavebands.
- Averaged UCSD emissivity by kinds of surface materials: ice (3), snow(2), soil (71) and vegetation (28).

- AIRS emissivities in 2006 are averaged according to microwave surface type and AIRS RET infrared surface emissivity at 8.3 μm.

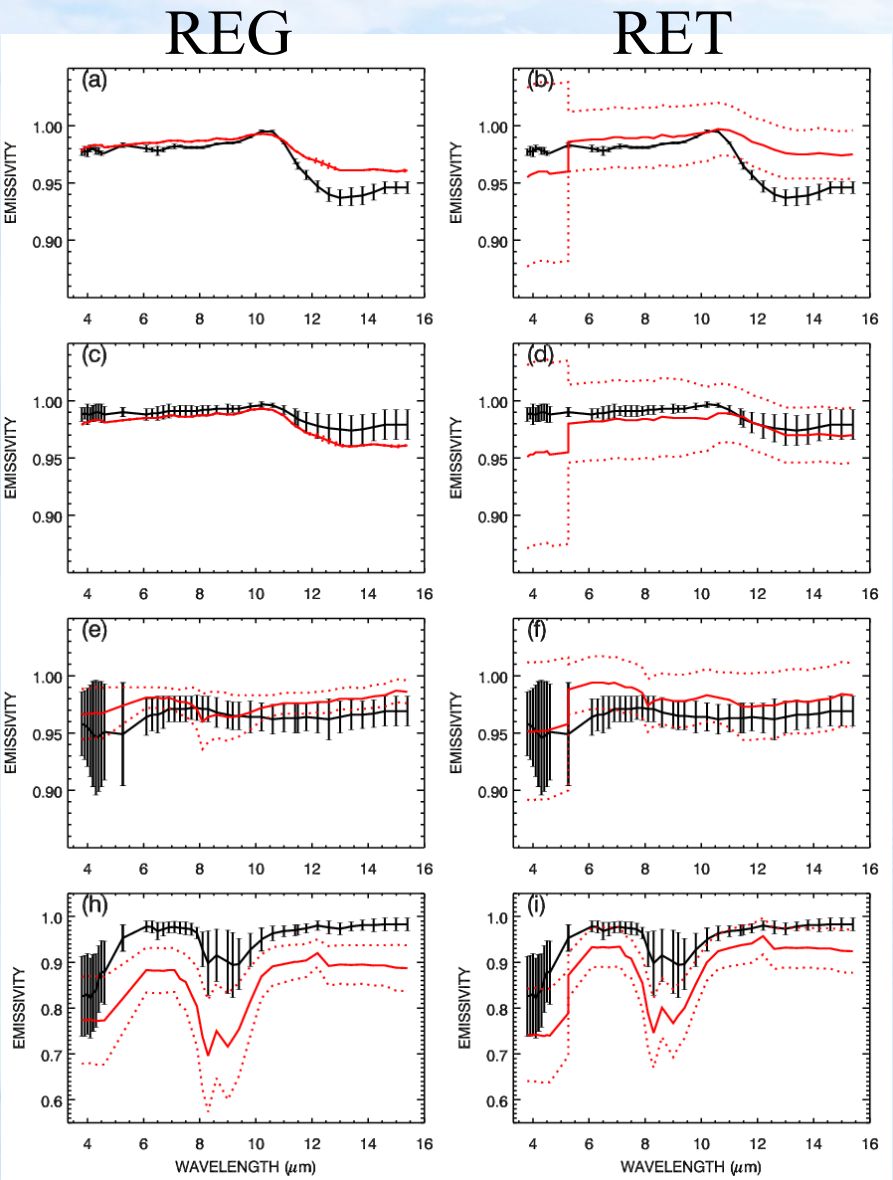
Bias and standard deviation of AIRS and UCSD emissivity stratified by surface types

Ice

Snow

Veg / High-emis land

Soil / Low-emis land



Summary

- AIRS REG monthly emissivity are ready to deliver to user community.
- AIRS RET monthly emissivity may need to wait for AIRS version 6 update. Main issues:
  - Low values in shortwave bands.
  - Uncertainties in cloud-clearing and water vapor.
  - Large day/night difference and viewing angle dependence.

Future Activities

- Apply to IASI physical retrieval of surface emissivity by using MODIS and AIRS monthly emissivity as first guess.
- Assess the uncertainties in surface skin temperature, cloud fraction and water content.
- Upgrade to land surface emissivity regression:
  - Simulation with the latest RTAs.
  - Experiment with adding more surface types and shortwave window channels.
  - Experiment with using laboratory measured hyper-spectral emissivity database as surface emissivity training dataset.
- Development of new algorithms: principal components regression and optimal optimization approach.