Infrared Hyperspectal Surface Emissivity Retrieval Using IASI

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[2] **STAR/NESDIS/NOAA**

Outline

- **Algorithm development for Land Surface Infrared Emissivity Retrieval & Simulation in IOSSPDP.**

- **Hyperspectral Infrared Land Emissivity retrieval — Algorithms**
  - **« Multi channel radiance regression algorithm**
  - **« Principle component retrieval algorithm**

- **Validation and discussion.**

Hyper spectrum Infrared Land Emissivity Retrieval — IASI Multi-channel Regression Algorithms

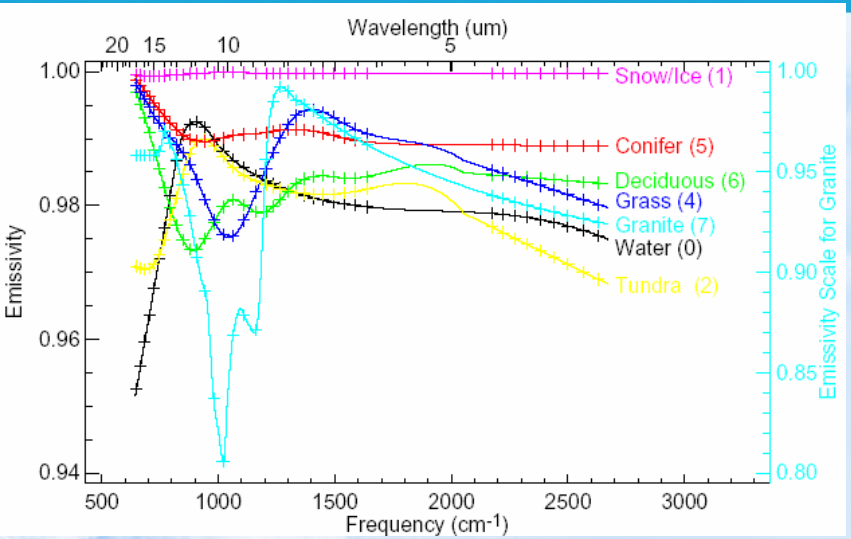
- **The NOAA regression emissivity approach is based on clear radiances simulated from the GDAS forecasts and a surface emissivity.**

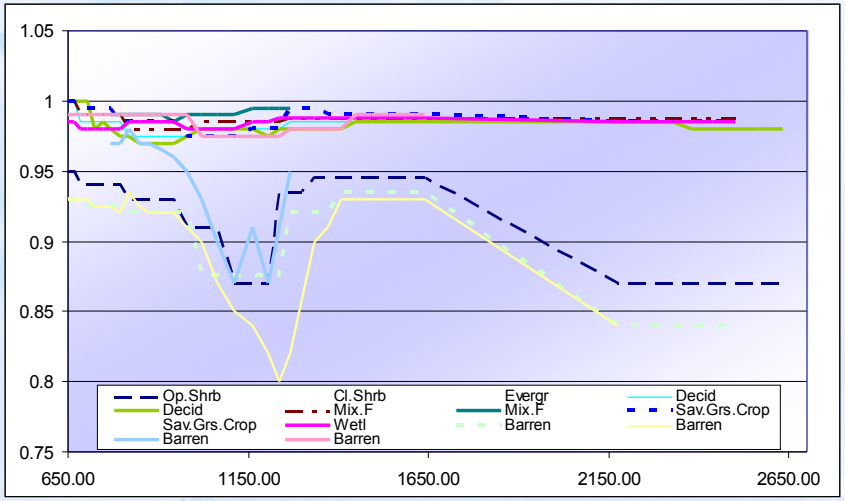
- **Training Dataset: IASI Radiance & Surface Emissivity**
  - IASI radiance: Cloud free atmosphere. IASI observation simulated with RTA model
    Atmosphere: Provide by GDAS forecast data
    RTA model: SARTA (from UMBC)
    Profile: Temperature H20 CO2 O3 CH4 CO
    Observation/Instrument Noise
  - Surface emissivity:
    Based upon the physical model
    Based upon the physical model + Statistic Model
    Based upon the Lab measurement

- **Variability in Training dataset:**
  - Random combination of different surface type and disturb the composing percentage.
  - Random combination the land surface atmosphere profile with surface emissivity .

- **The training dataset provides representative and high resolution emissivity data to establish the relation between the high resolution observations and the high resolution emissivity**

Surface Emissivity Physical Model





- (0) sea water (nadir), (1) snow/ice, (2) tundra or wet snow, (4) grass, (5) conifer forest, (6) deciduous forest and (7) granite. The scale on the right side applies to granite..

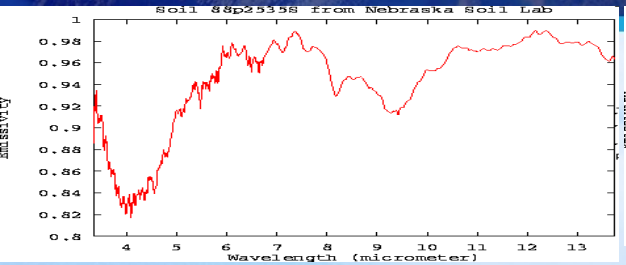
Two sets of surface emissivity model used before: Low spectral resolution.
(* AIRS :14 land Surface Model+ 12 Snow/ice models)

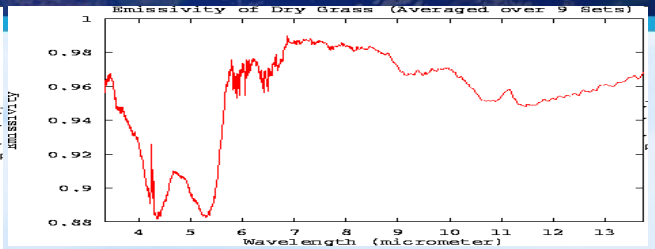
Not suitable for the IASI/AIRS problem.

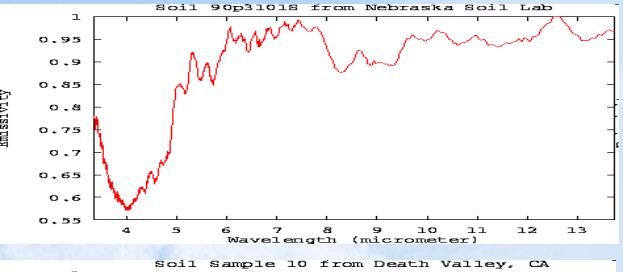
Static Model: Based upon the Lab Measurement statistics: Low spectral to High spectral: (**Suzanne Wetze; Seemann,Eva borbas.. 2007)**

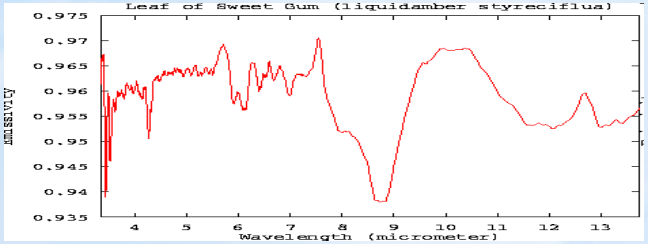
Lab Measurements (UCSB)

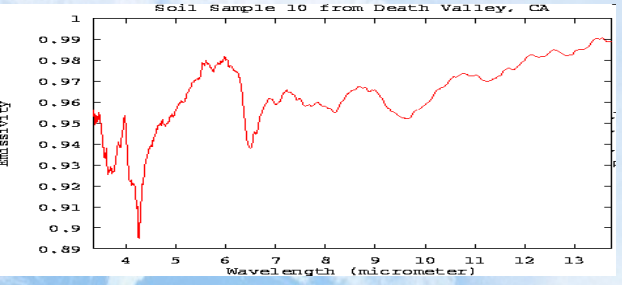
http://www.icess.ucsb.edu/modis/EMIS/html/em.html

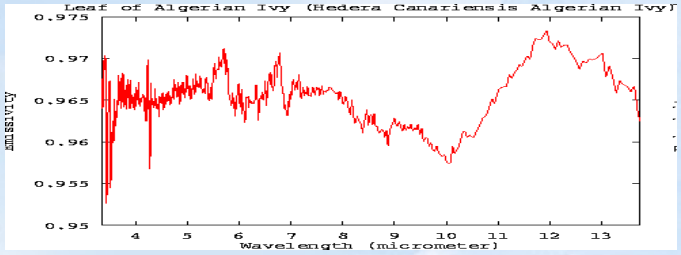


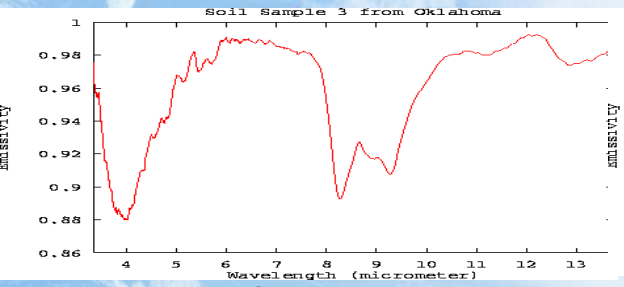


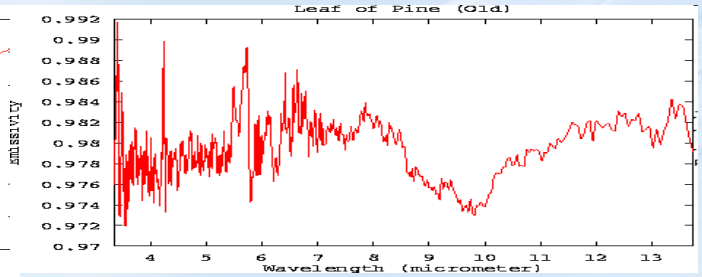












Soil

Vegetation

Lab Measurements:

UCSB (University of California, Santa Barbara)

- High spectral Resolution: 3.8/1.9(cm -1)
- Truth

But

- Point Measurement
- Single component: significant difference

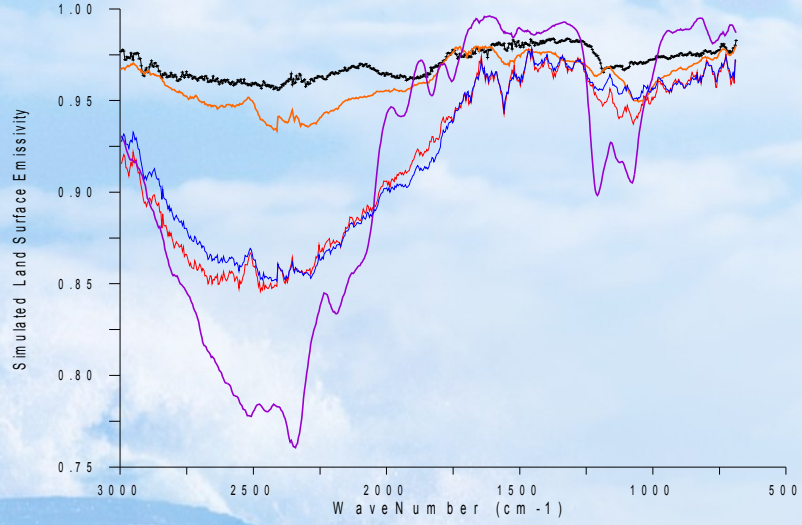
IASI Pixel Level Surface Emissivity:

- 20x 30 km average
- Include different components
- Surface condition/moisture

Lab Measurements are not enough

New Training Emissivity Dataset for Regression

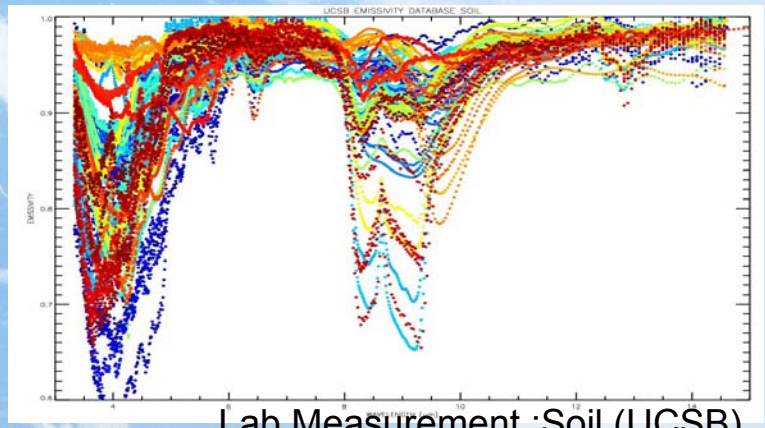
Close to real Surface Statistic Feature:



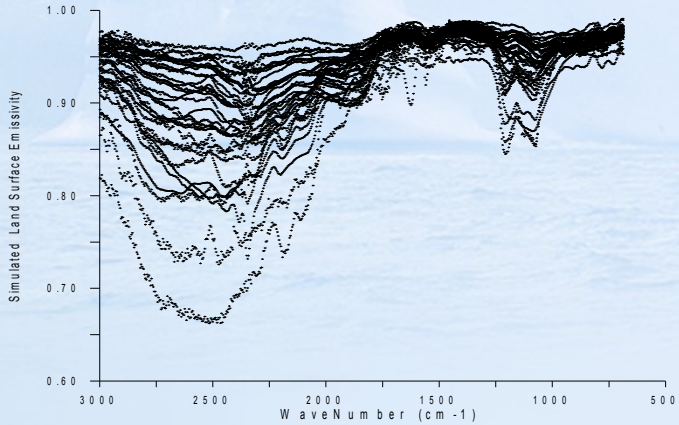
Cover the variability of the real surface pattern

- 70 soil type + 24 tree Type + 3 grass Type
- Combination: three soil types+ One tree + one grass

High Spectral resolution.
3.85882 cm-1 686.869cm-1-2998.3cm-1
Interpolated to IASI channel



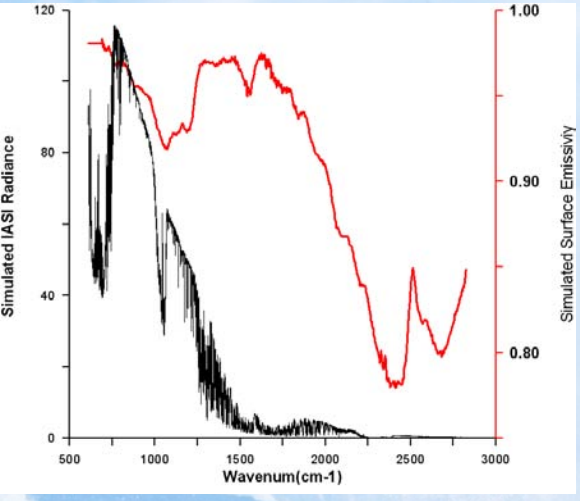
Lab Measurement :Soil (UCSB)

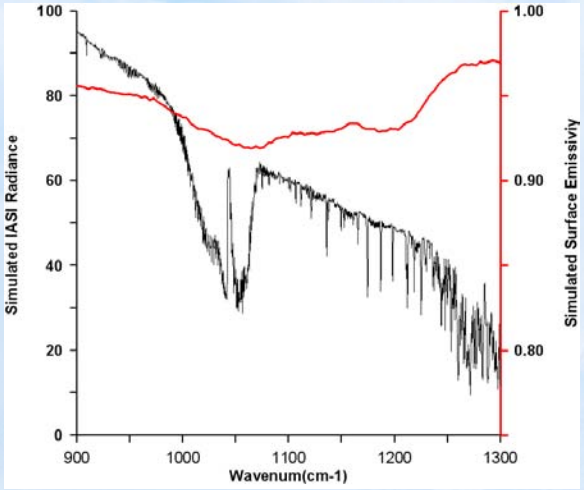


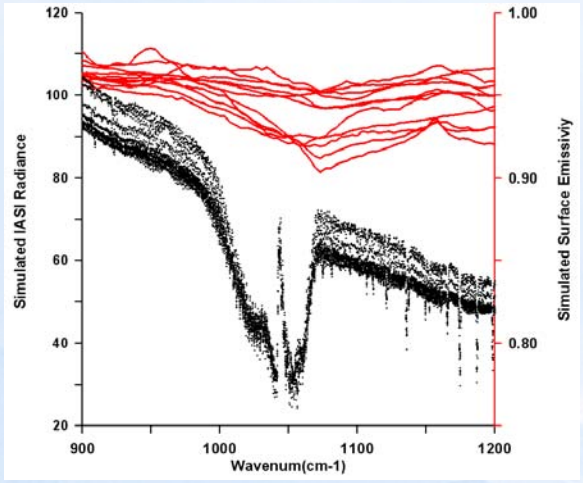
100 Emissivity Spectrums from Training Data

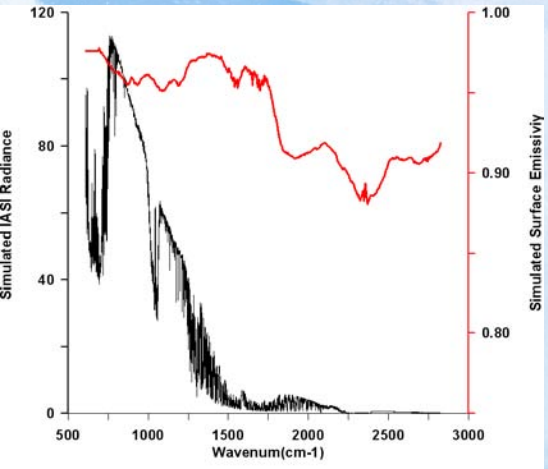
Training dataset — IASI Radiance Simulation

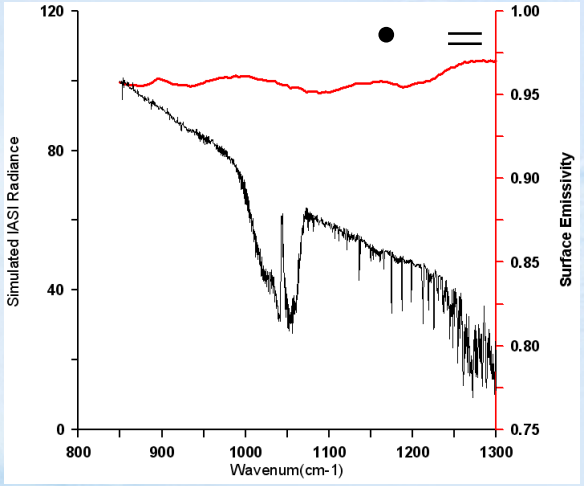
Using High Resolution dataset/RTA to extract more information

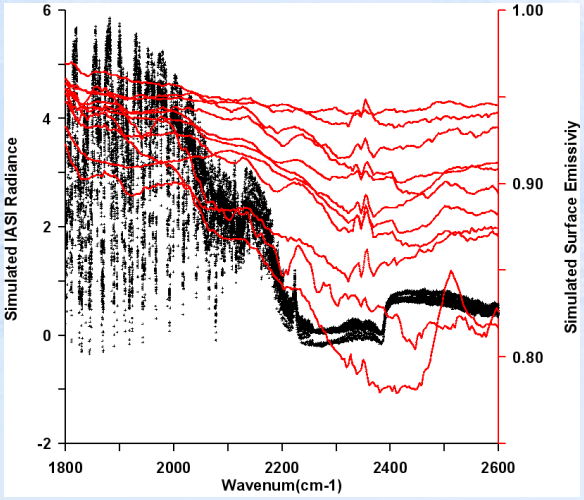












Black-Radiance spectrum Red-Emissivity spectrum 8um-10um SiO_2 4um Signal,/Noise

IASI Multi-channel Regression Algorithms

Regression algorithms.

Selection of the Channel : Emissivity be retrieved:

Represent the emissivity spectral information

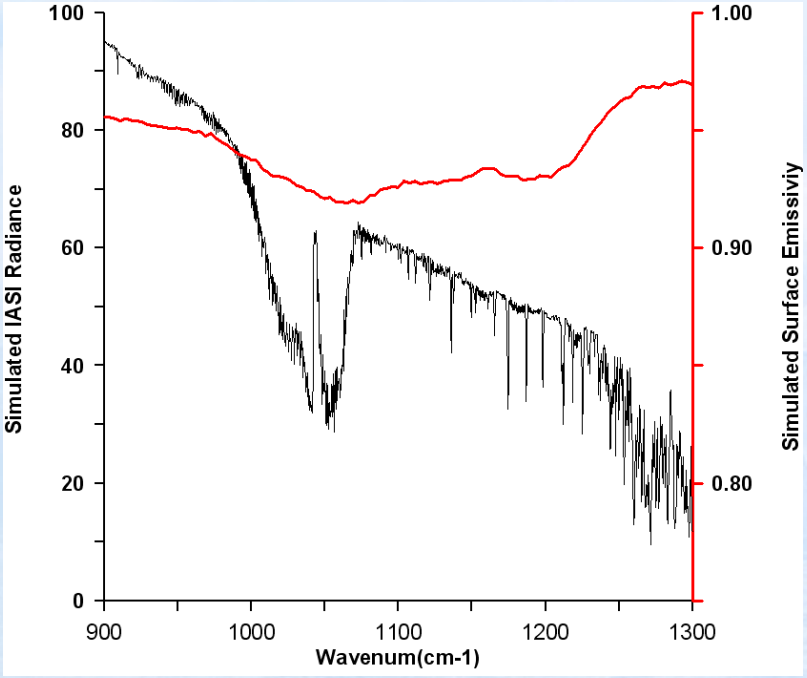
- 39 Hinge point set: Extend to high resolution (AIRS IASI)
- 10 MOD11 Hinge Points, Extend with Static Model
- Principle Component of the Emissivity

Select of the IASI channels used to retrieve the emissivity:

- **AIRS: 20 window channels regression algorithm**
- **IASI: 20+ windows channels**
  Regression based upon reconstruction radiances
- **Regression based upon principle components**
- **Present IASI retrieval operation algorithms: 20 Windows Channels + 39 Hinge Point Regression**

Selection of the Channel

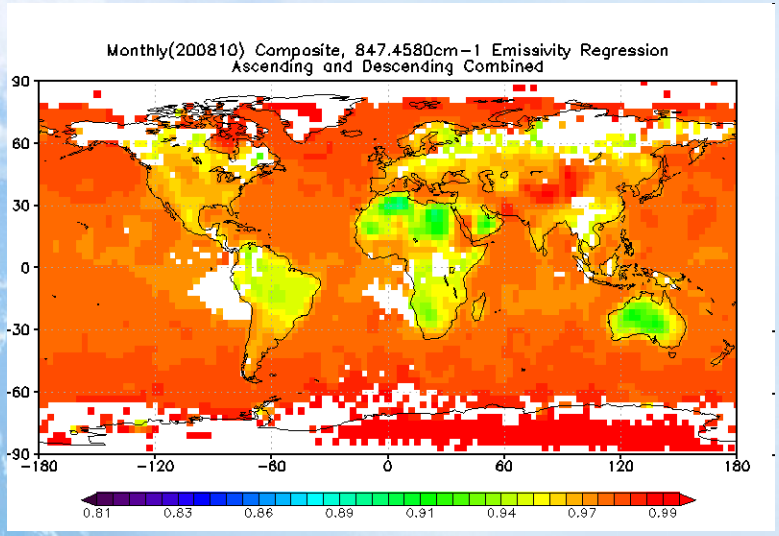
649.35	666.67	684.93	704.22	724.64
746.27	769.23	793.65	819.67	847.46
877.19	909.09	943.40	980.39	1020.4
1063.8	1111.1	1162.8	1204.8	1234.6
1265.8	1298.7	1333.3	1369.9	1408.4
1449.3	1492.5	1538.5	1587.3	1639.3
2173.9	2222.2	2272.7	2325.6	2380.9
2439.0	2500.0	2564.1	2631.6	



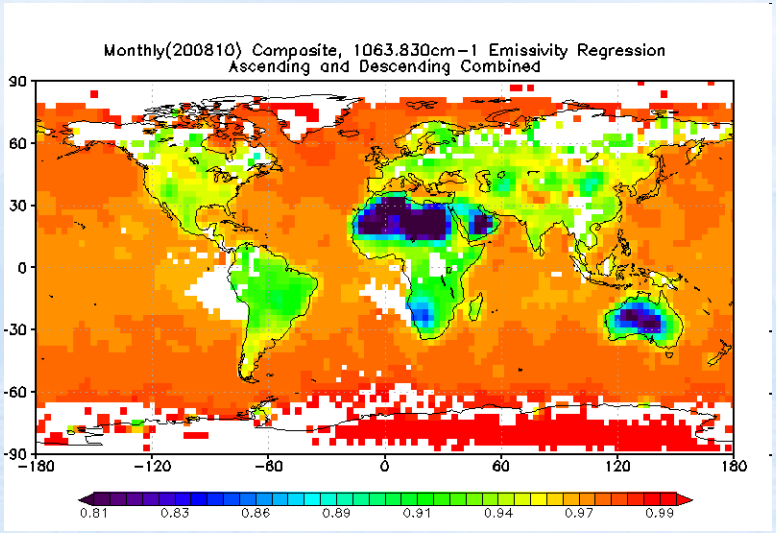
IASI Multi-channel Regression Results: Monthly Maps from IASI

- The Updated IASI Multi-channel retrieval algorithms is developed based upon the new surface emissivity training data.

Global monthly maps are derived by applying the regression technique on the IASI daily global gridded datasets



11.8μm



9.4μm

IASI Principal Components (PCs) In the Regression Algorithm

Apply Principle Components in the Emissivity Retrieval

- Reduce noise more effectively while still retaining the most important information from the 8461-channel IASI observations
- Training dataset: 200 PCs computed by using IASI simulated data & surface emissivity data

New Elements In the Regression algorithms:

- 1: Applied the improved land emissivity surface dataset.

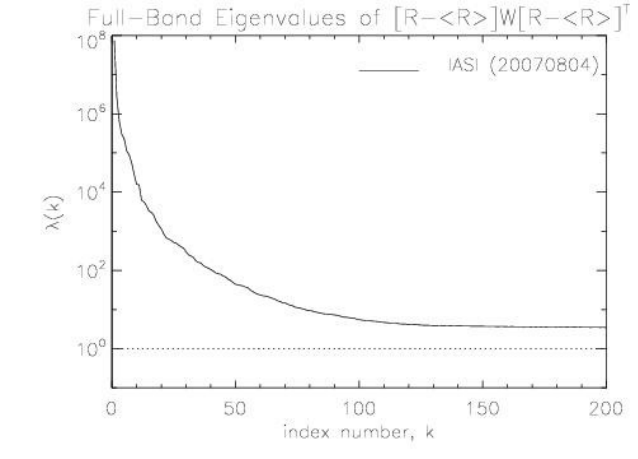
- 2: Applied the principle components

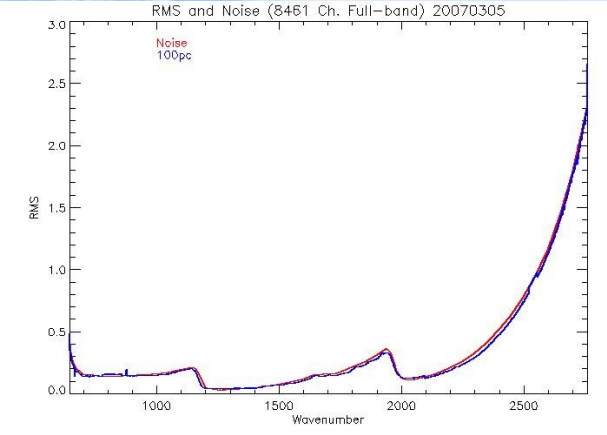
Two Retrieval algorithms are being developed and tested

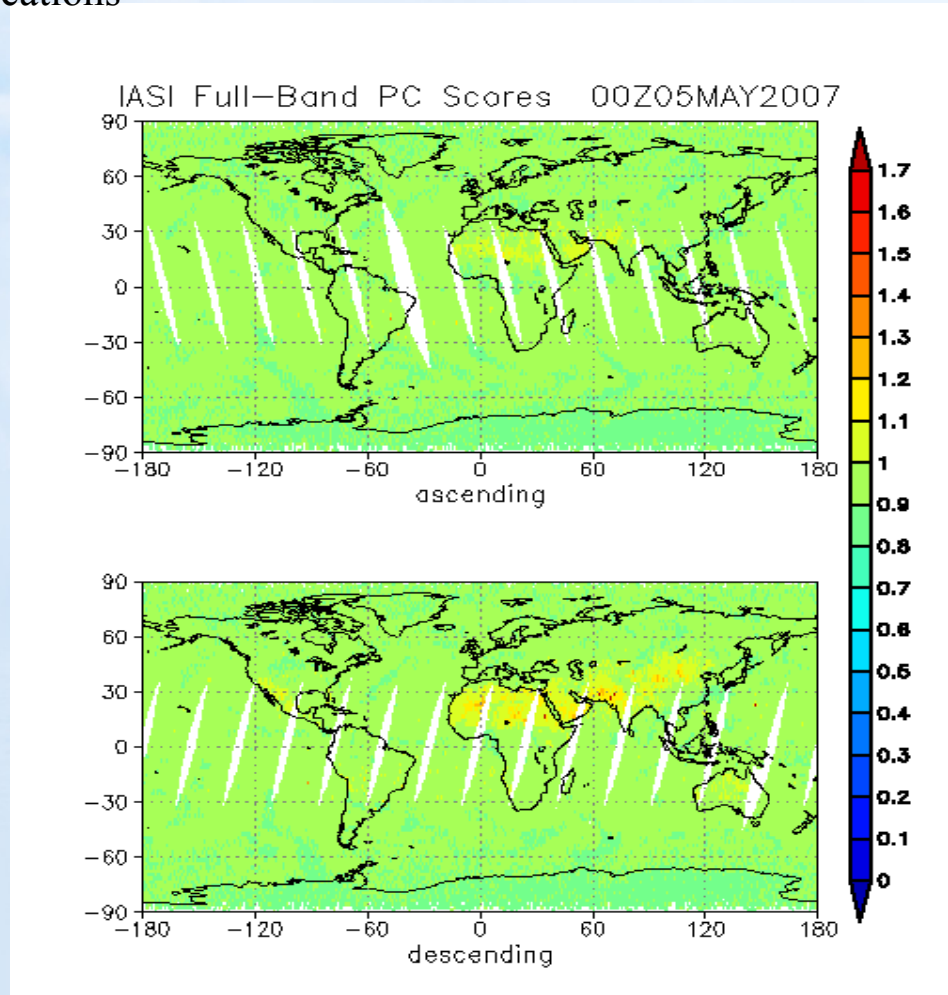
1. Retrieval algorithm basing upon the reconstructed window channel radiances
2. Retrieval algorithm basing upon IASI radiance PCs

IASI Principal Component (PCs) Regression Algorithm

- Benefits: Noise filtering / data compression.
  shortwave IR window channels for applications

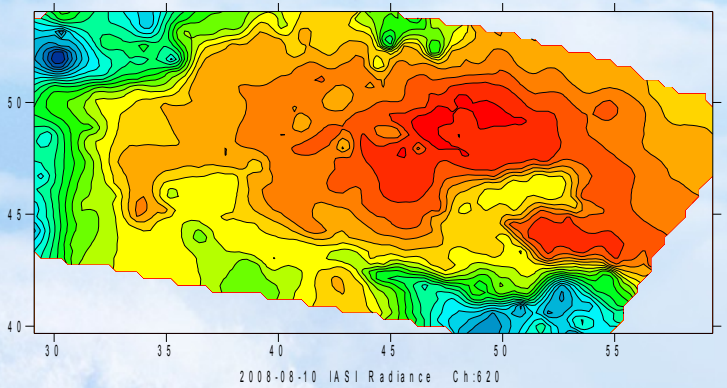


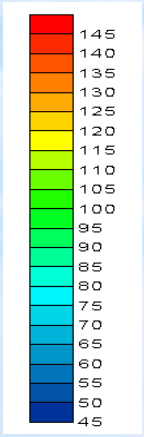


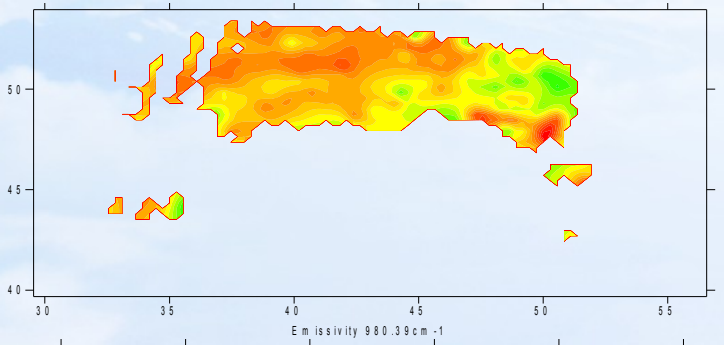


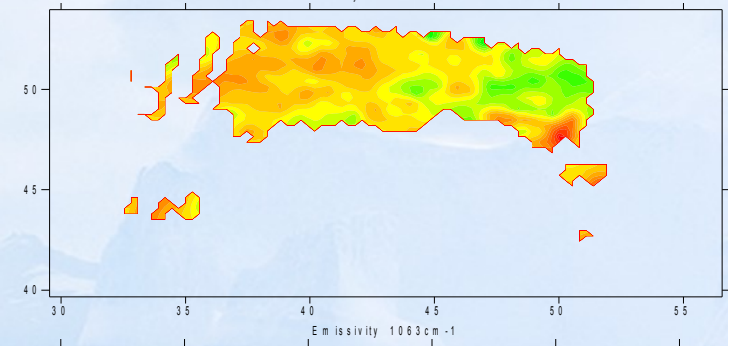
IASI PCs Regression Algorithm — Results for Real IASI observation

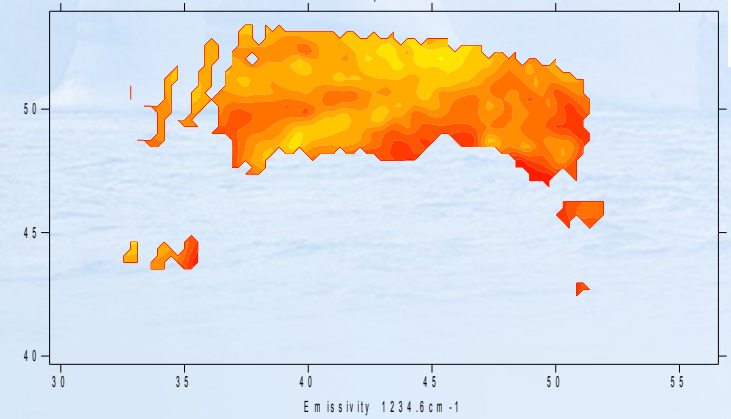
Middle ASIA

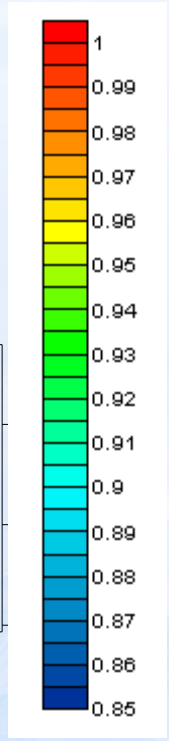


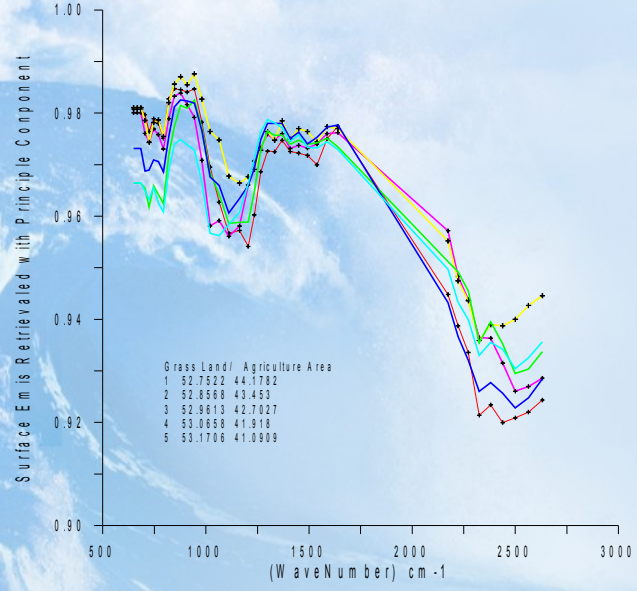






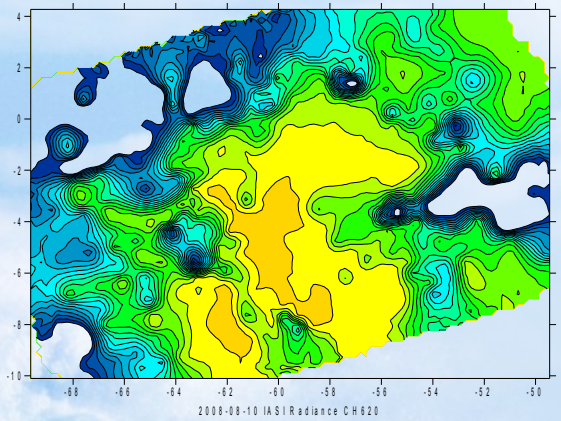


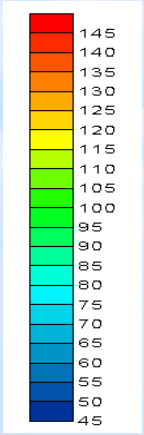


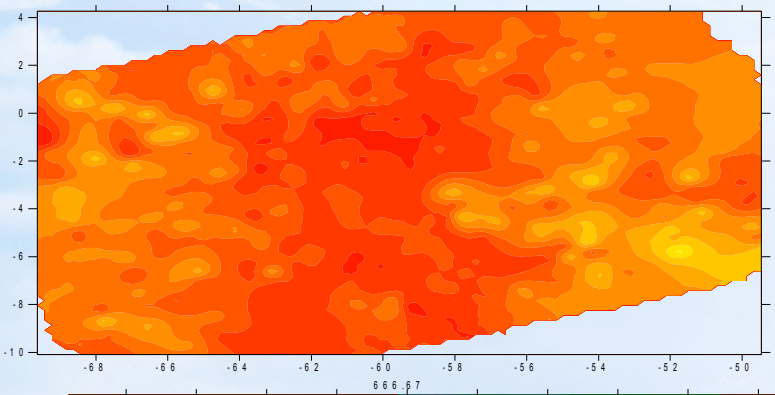


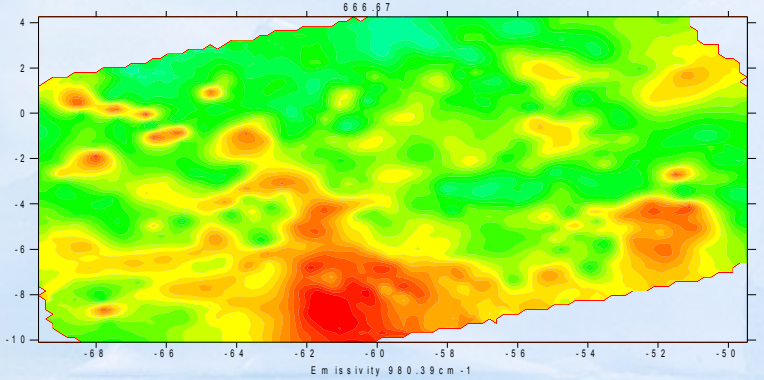
IASI PCs Regression Algorithm — Results

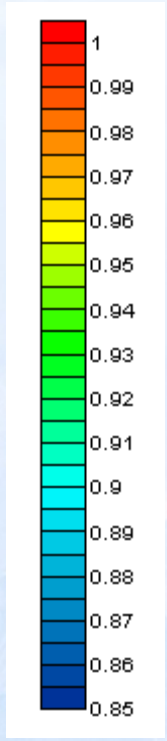
Brazil

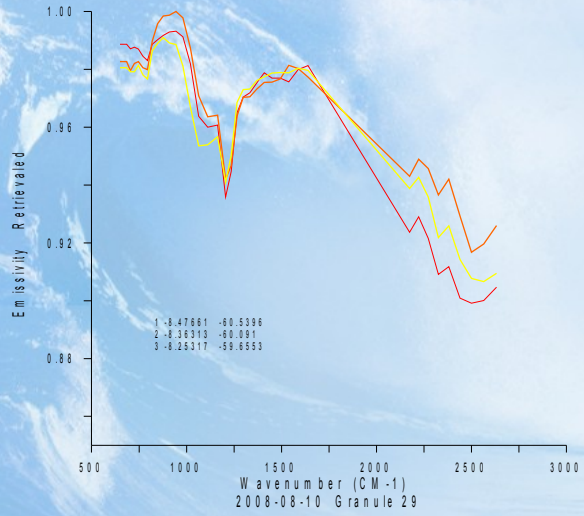


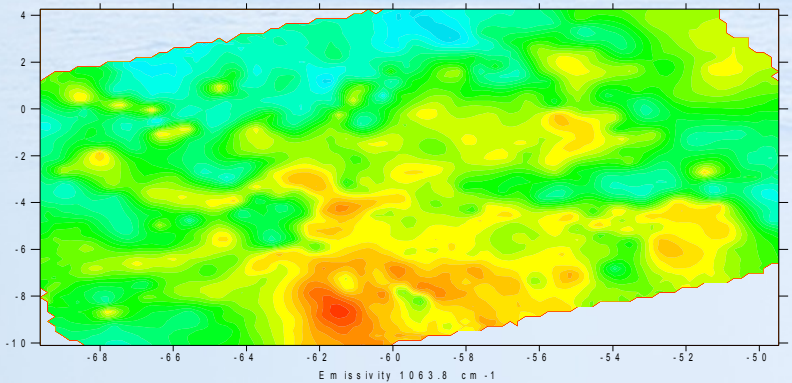












Validation Method

Requirement: Same time/location/target . Reasonable validation dataset

Lab Measurement:

- High spectral Resolution: 3.8/1.9 -- Point Measurement/Single Component

IASI Pixel Level Surface Emissivity: 20 km x 30 km average

Include different components – Surface condition/Moisture

MODIS retrieval :

MOD11: 6 band (20 22 23 29 31 32) emissivity product with day-night algorithms

Suzanne W. Seemann, Eva E. Borbas et al: High spectral resolution emissivity from low resolution 6 band emissivity (0.05 *0.05), 416 channels, monthly

Validation dataset: Collocated IASI/MODIS clear sky dataset is generated at STAR

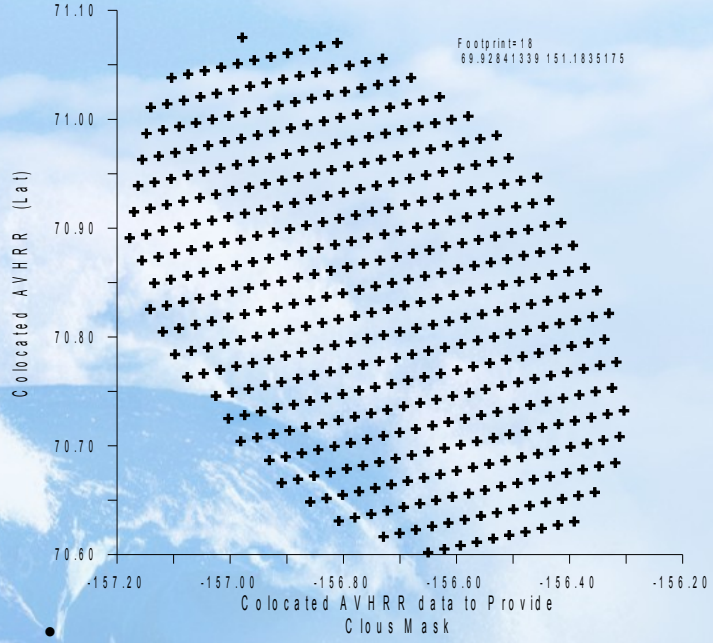
This dataset will be used for algorithm validation and further development.

Validation Dataset:

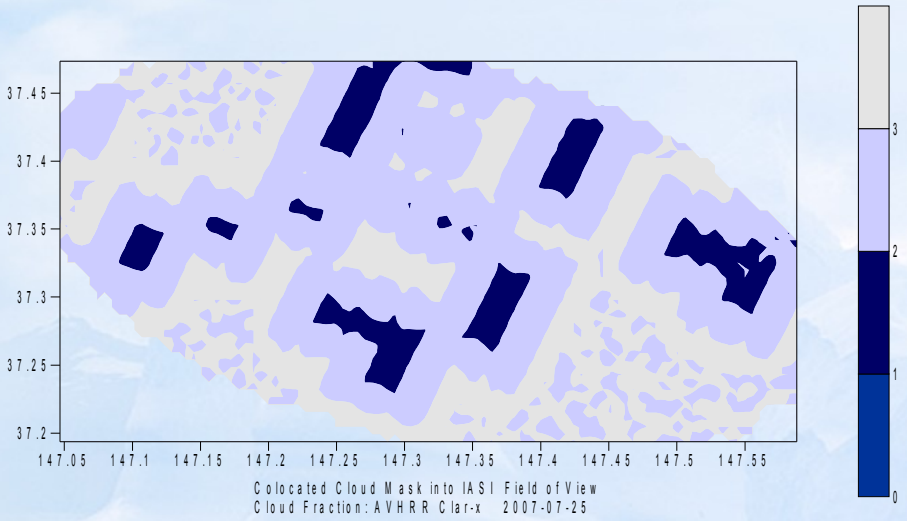
Integrated Dataset from AVHRR/MODIS/IASI

A satellite data integration system is developed in STAR.

The collocated data from different instruments covers the same field of view



- The IASI interferometer field of view is square, seen under an angle of 3.33 x 3.33°. Information matrix of 2 x 2 circular pixels seen under an angle of 1.25°. The overall swath is ± 48.3° with respect to the nadir direction, corresponding to 30 mirror positions.



Regression Dataset quality control: 1: IASI Data: Clear Sky

Cloud Mask: Co-locate AVHRR (on board of METOP) data onto IASI FOV (CLAVR-x)

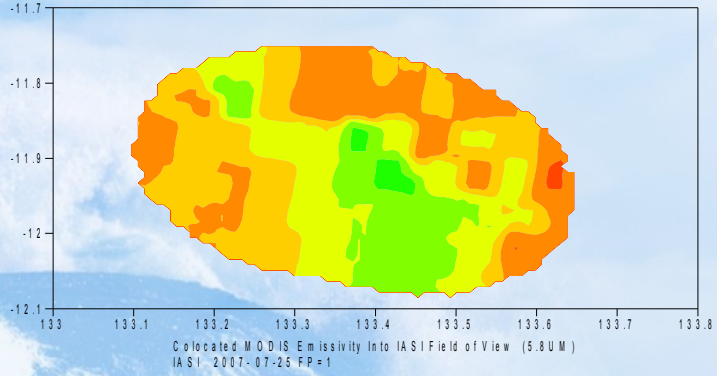
Validation Dataset: Integrated Dataset from AVHRR/MODIS/IASI

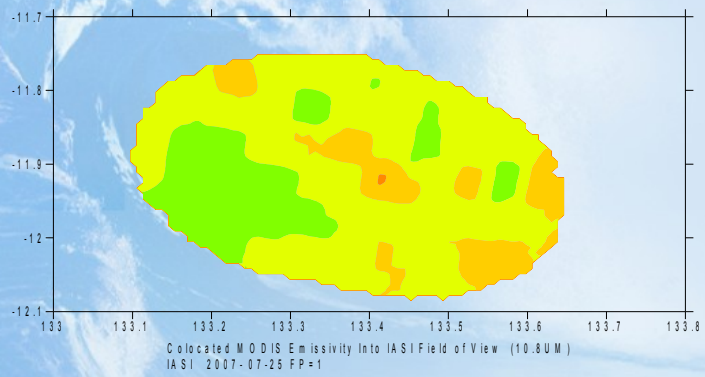
At present, the monthly averaged surface dataset used is:

1 : MODIS 10 channel data collocated to the IASI field of view

2: 10 channel dataset is co-located and extended to the IASI high spectral resolution dataset. (See Suzanne Wetze Seemann, Eva Borbas.. 2007)

3: Interpolate it to the 8641 IASI channel.





Spatial / Spectral

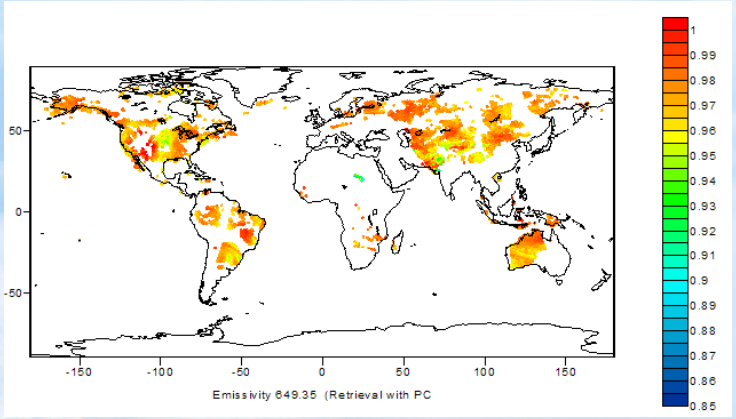
Basing on the analysis of the high spectral resolution laboratory measurements of selected materials, the PCs (eigenvectors) of laboratory spectra are regressed against 10 measured frequency points.

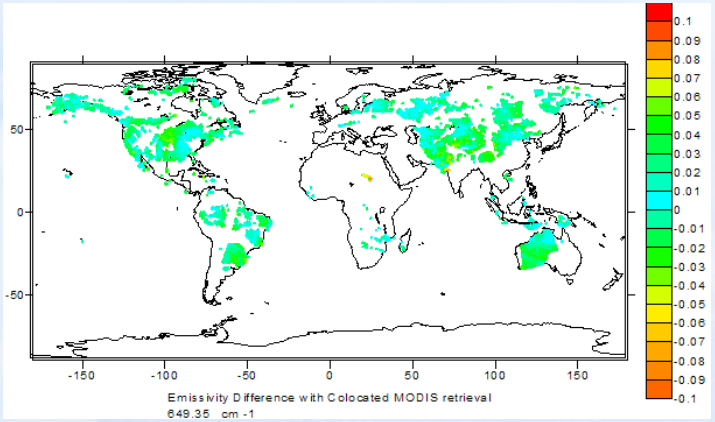
This result in PCA transfer algorithms to obtain high resolution spectra with wave number resolution between 2-4 cm^{-1}.

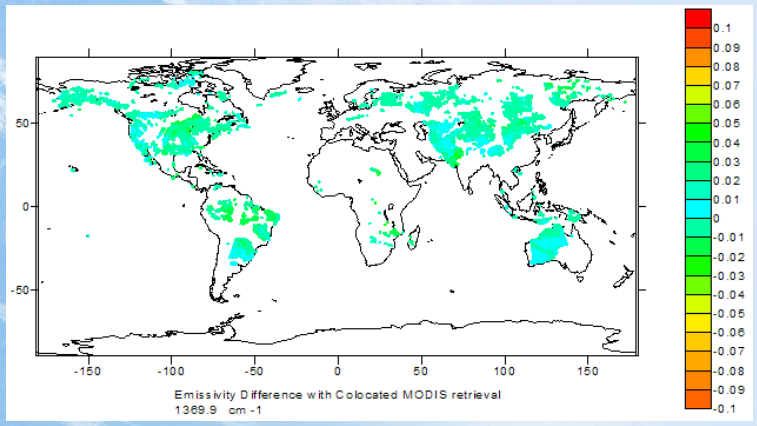
A linear interpolation is applied to obtain IASI channel emissivity from the MODIS retrieval

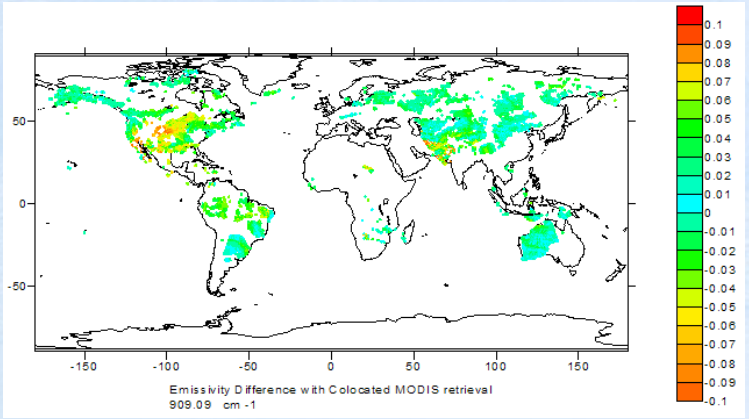
Validation: Comparing with Collocated MODIS Data 2008-07-25

Testing with Co-located dataset









IASI Multi-channel Regression Algorithm

Summary :

- 1: The IASI emissivity regression algorithm is upgraded with a new surface emissivity algorithm

- 2: The regression algorithm between IASI radiance principle components and surface emissivity is established . The initial test show that PC based regression, developed with the RTA model, can generate reasonable results. The regression between IASI principle component reconstructed radiances and surface emissivity is established . Both algorithms are in the testing period.

- 3: The difference between real observations and RTA simulated observations will introduce biases when the regression is used with real data. An adjustment matrix will be required.

Next step: Optimize the PC retrieval, increase information and control noise

- Apply more PC reconstructed channels in the reconstructed radiance based retrieval.
- Adjust PC numbers in the retrieval algorithms based upon the PCs

- Problem:
- Fixed trace gas: such No2.. The PC eigenvector Matrix different with truth
- Training dataset: Model data , lesst extra value.
- The IASI view angle processing: The difference between train dataset and real dataset