Land Surface Temperature and Infrared Emissivity at High Latitudes from Advanced Infrared Sounder Observations

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Objective

Provide a methodology for the successful assimilation of infrared advanced sounder data over high latitude snow/ice (day and night).

Approach:

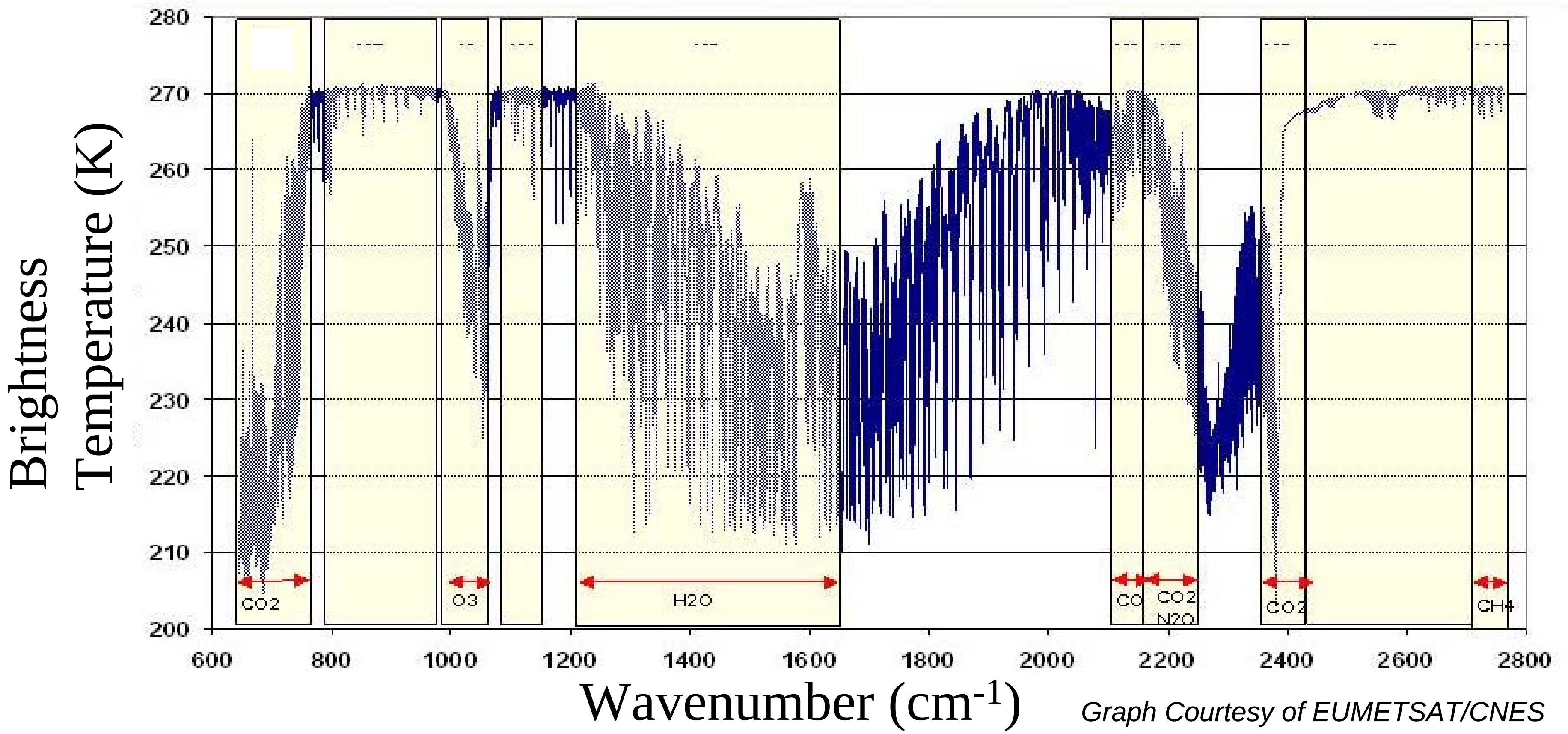
1. Identify clear sounder fields of view (using IR imager)
2. Accurate estimation of snow/ice skin temperature.
3. Estimation of snow/ice infrared emissivity for all sounding channels.

Work is IN PROGRESS !

Advanced Sounders Schedule

- AIRS – NASA EOS AQUA (2002 – 2006+)
- IASI – METOP (2006 – 2020+)
- CrIS – NPP/NPOESS (2008 – 2025+)
- Other countries are in planning stages.

METOP IASI:
Infrared Atmospheric Sounder Interferometer

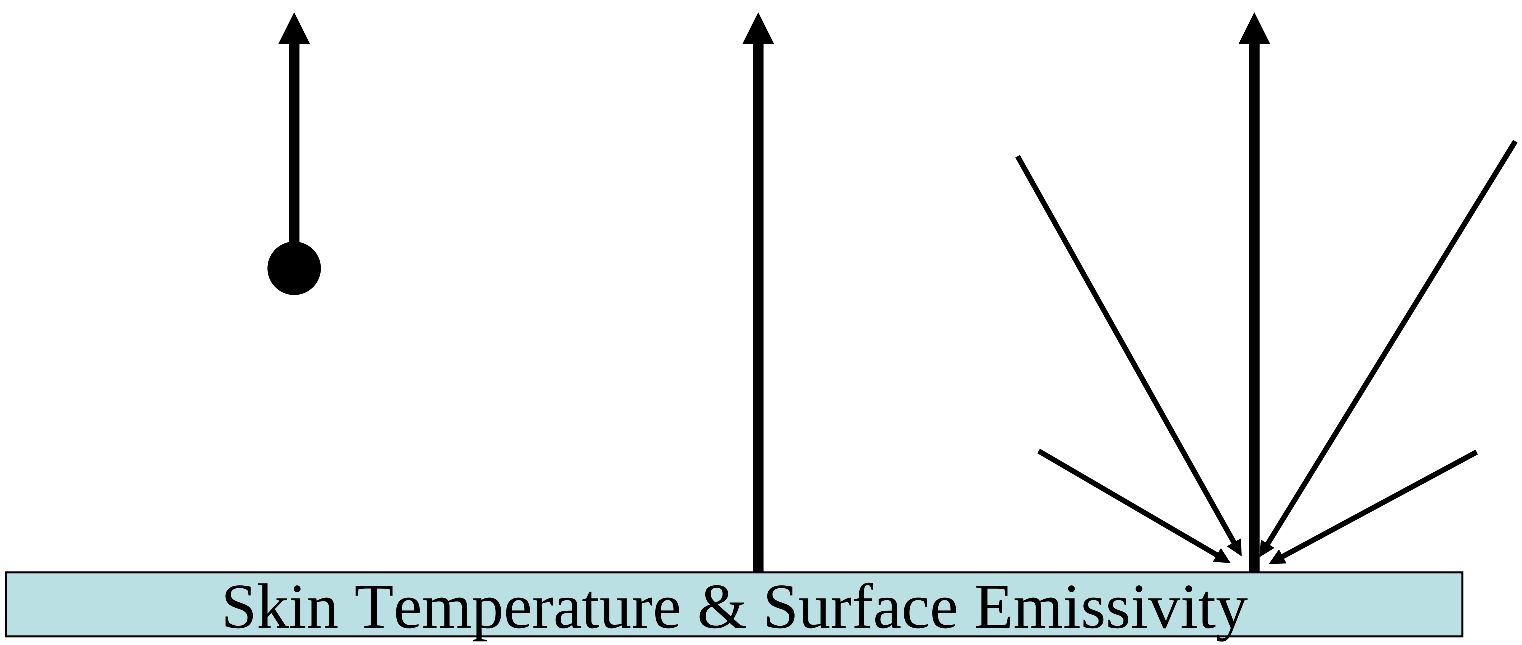


Graph Courtesy of EUMETSAT/CNES

IASI continous spectral coverage from 3.5 – 15 μm and high spectral resolution provides a unique opportunity for land surface and atmospheric remote sensing.

Infrared Radiative Transfer Equation (lambertian surface)

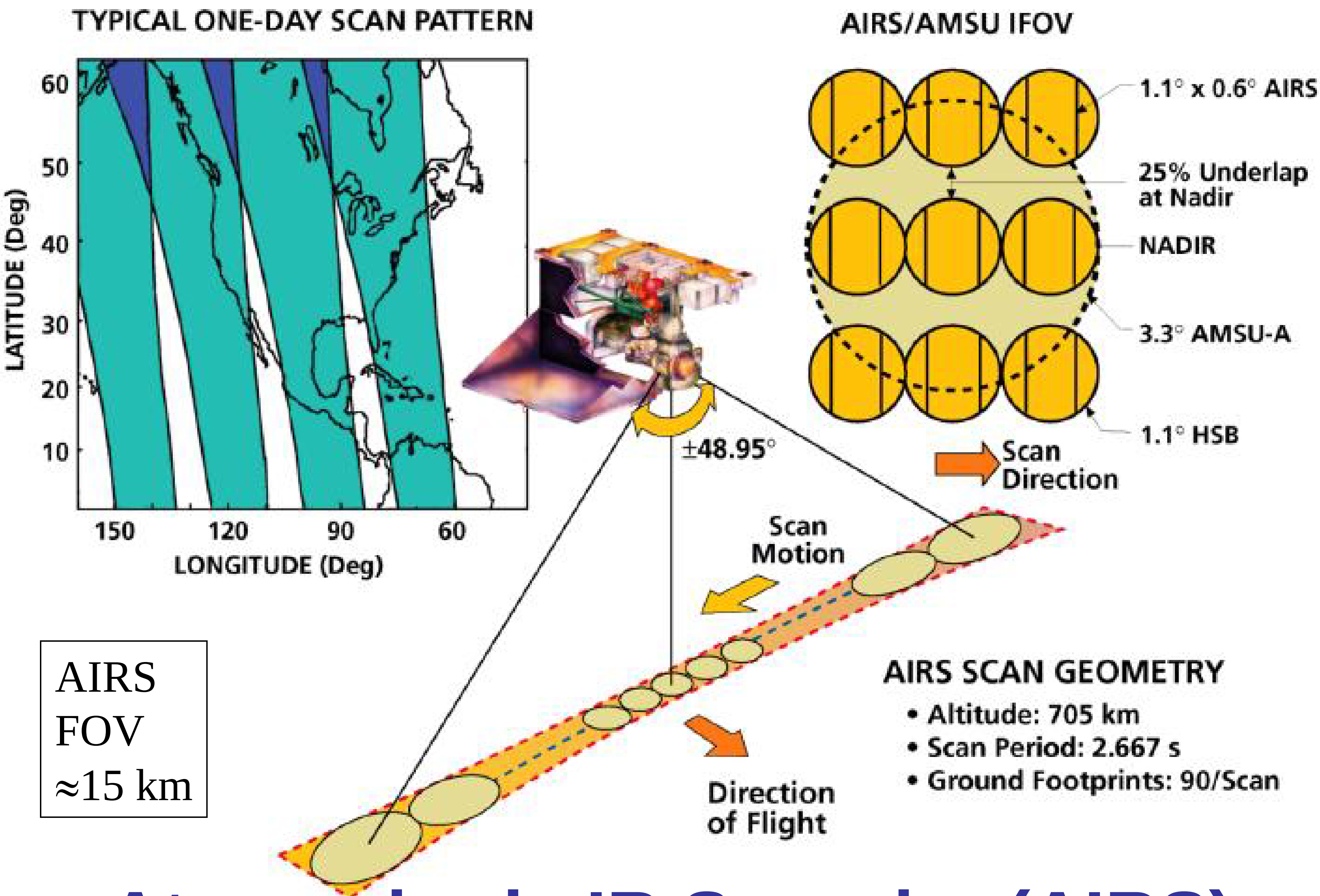
$$N_\nu^{\uparrow} = \underbrace{\int B_\nu(T(P))\, d\tau_\nu}_{N_\nu^{atm\uparrow}} + \underbrace{\tau_\nu^{tot} \cdot e_\nu \cdot B_\nu(T_S)}_{\text{Surface Emission}} + \underbrace{\tau_\nu^{tot} \cdot (1 - e_\nu) \cdot \overline{N}_\nu^{\downarrow}}_{\text{Surface Reflection}}$$



CASE STUDY

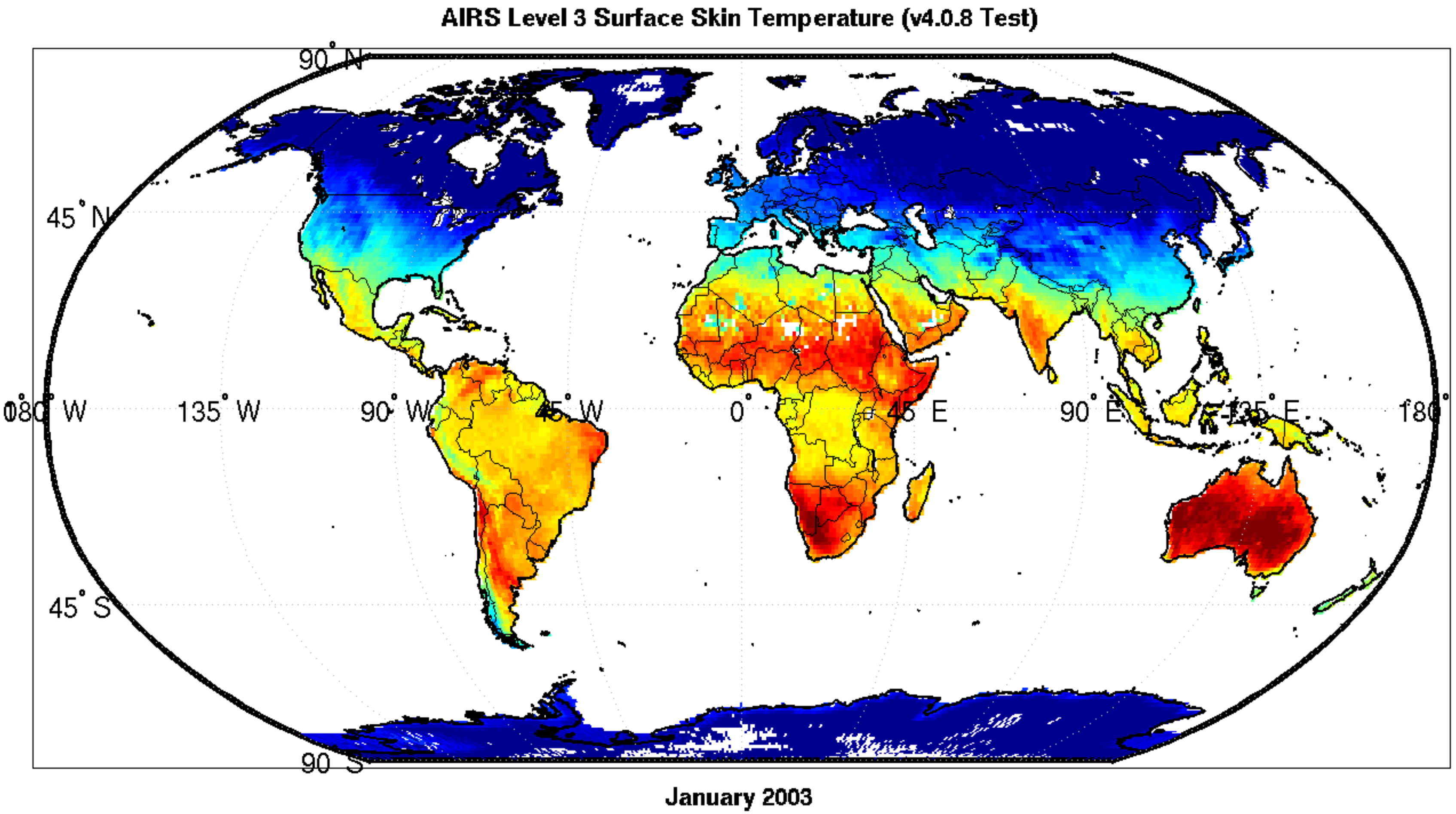
High-Latitude Winter

Greenland Ice Sheet
Using AIRS and MODIS

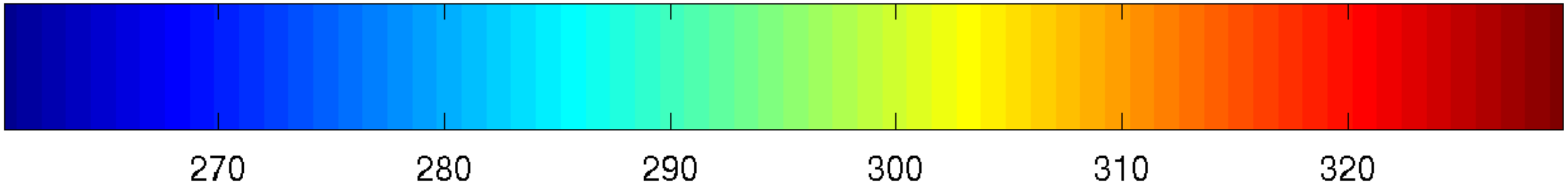


AIRS
FOV
≈15 km

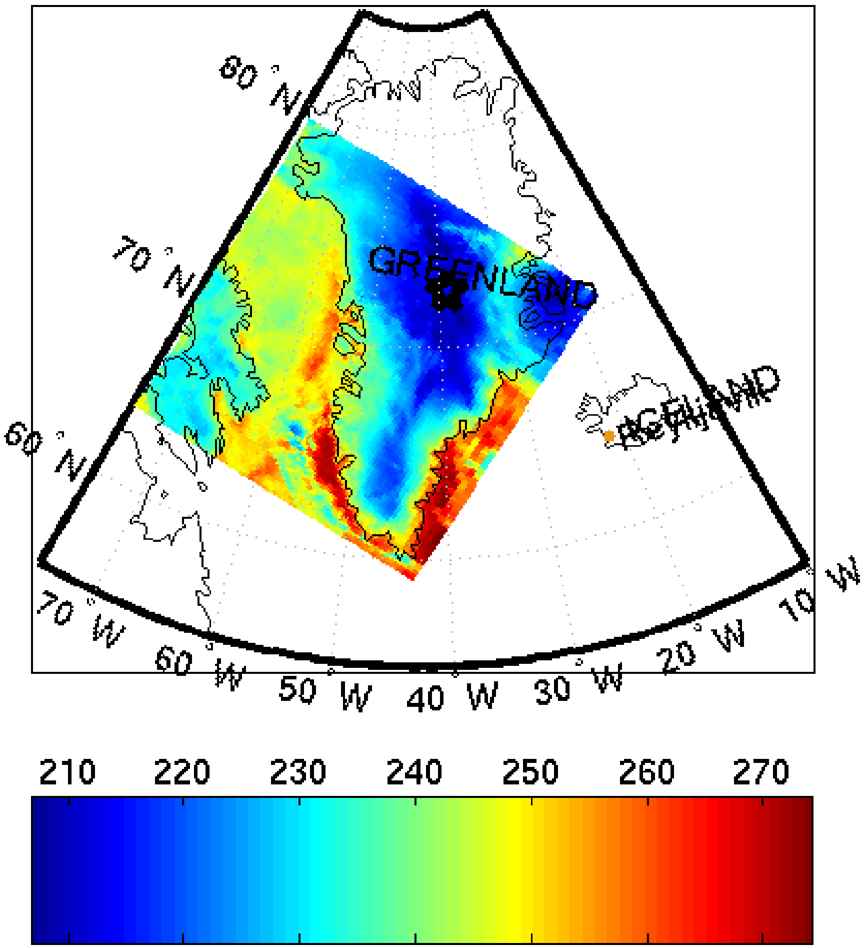
Atmospheric IR Sounder (AIRS)



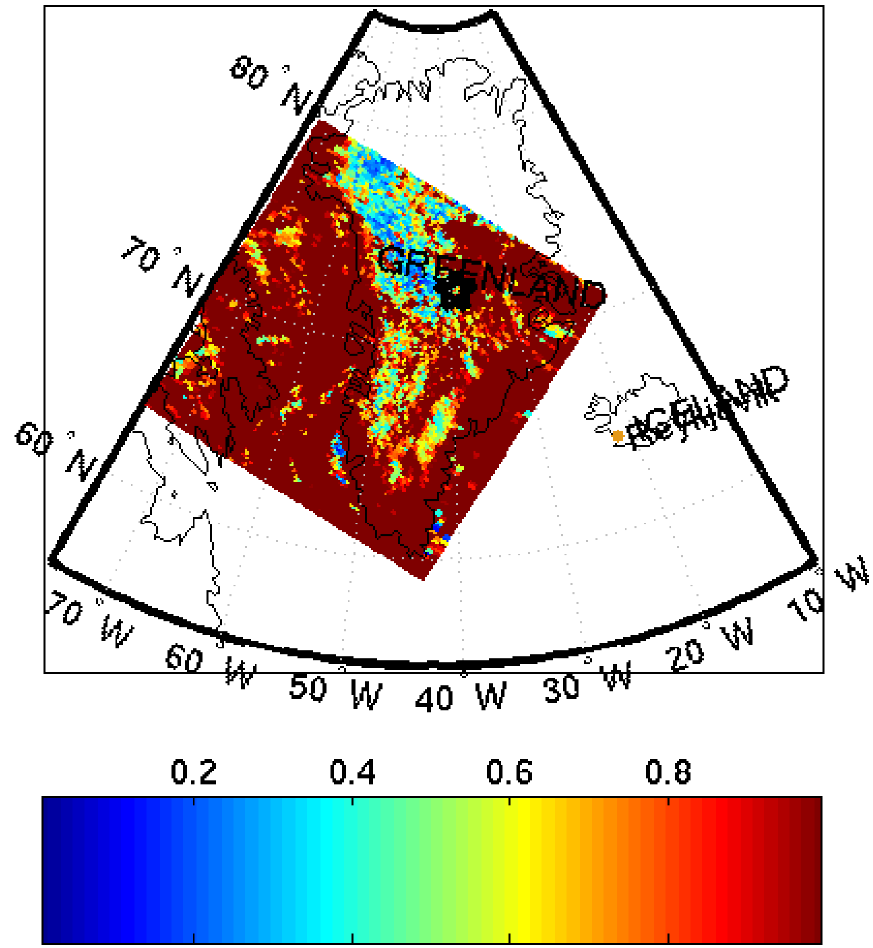
High latitude Regions Include Antarctica, Siberia, Alaska, Canada, and Greenland



Collocated MODIS MEAN



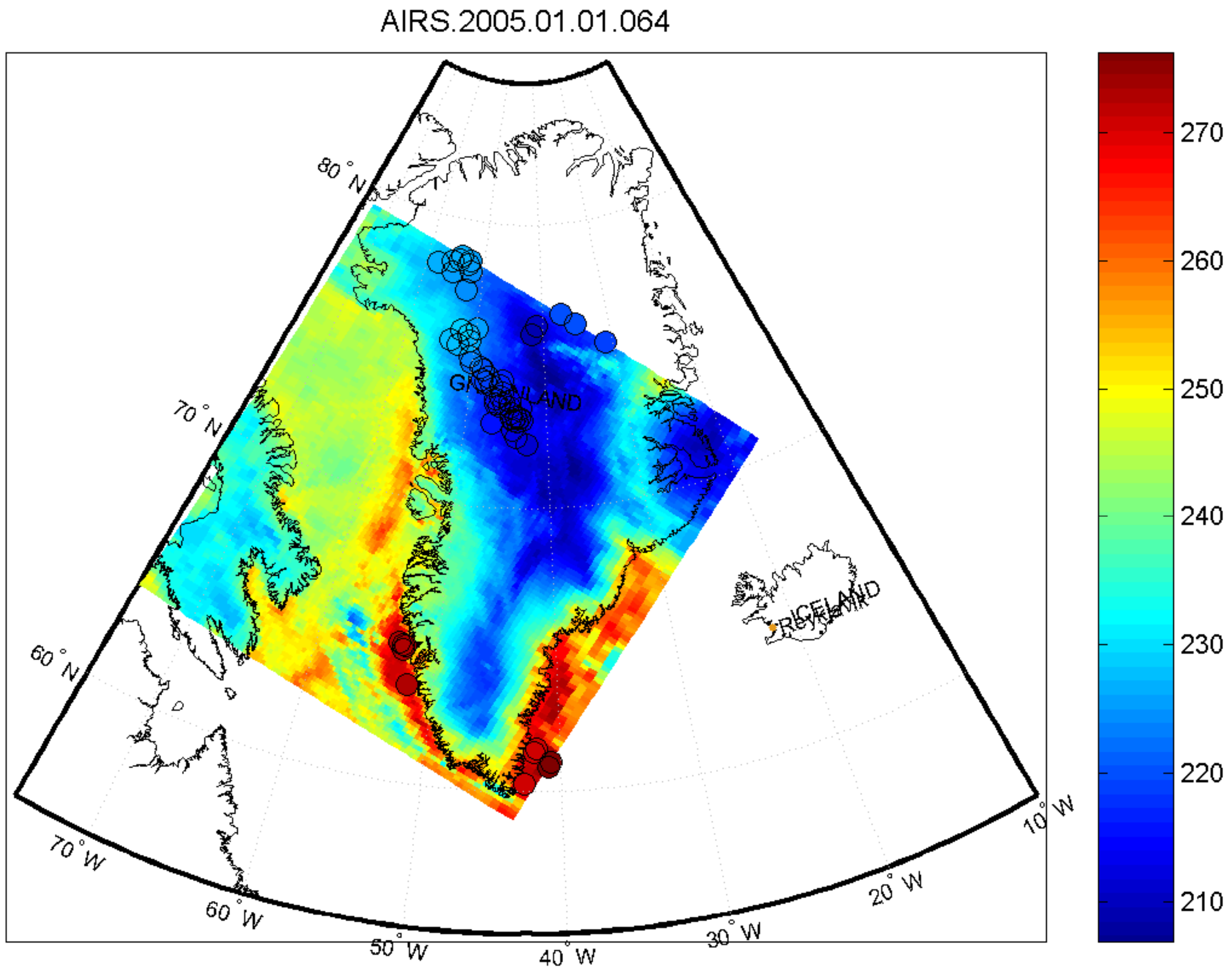
Collocated MODIS Std Dev.



- Compute MODIS 12 micron mean and standard deviation within AIRS FOVs.
- Use infrared subpixel scene uniformity as a simple clear test.

AIRS Uniform Fields of View

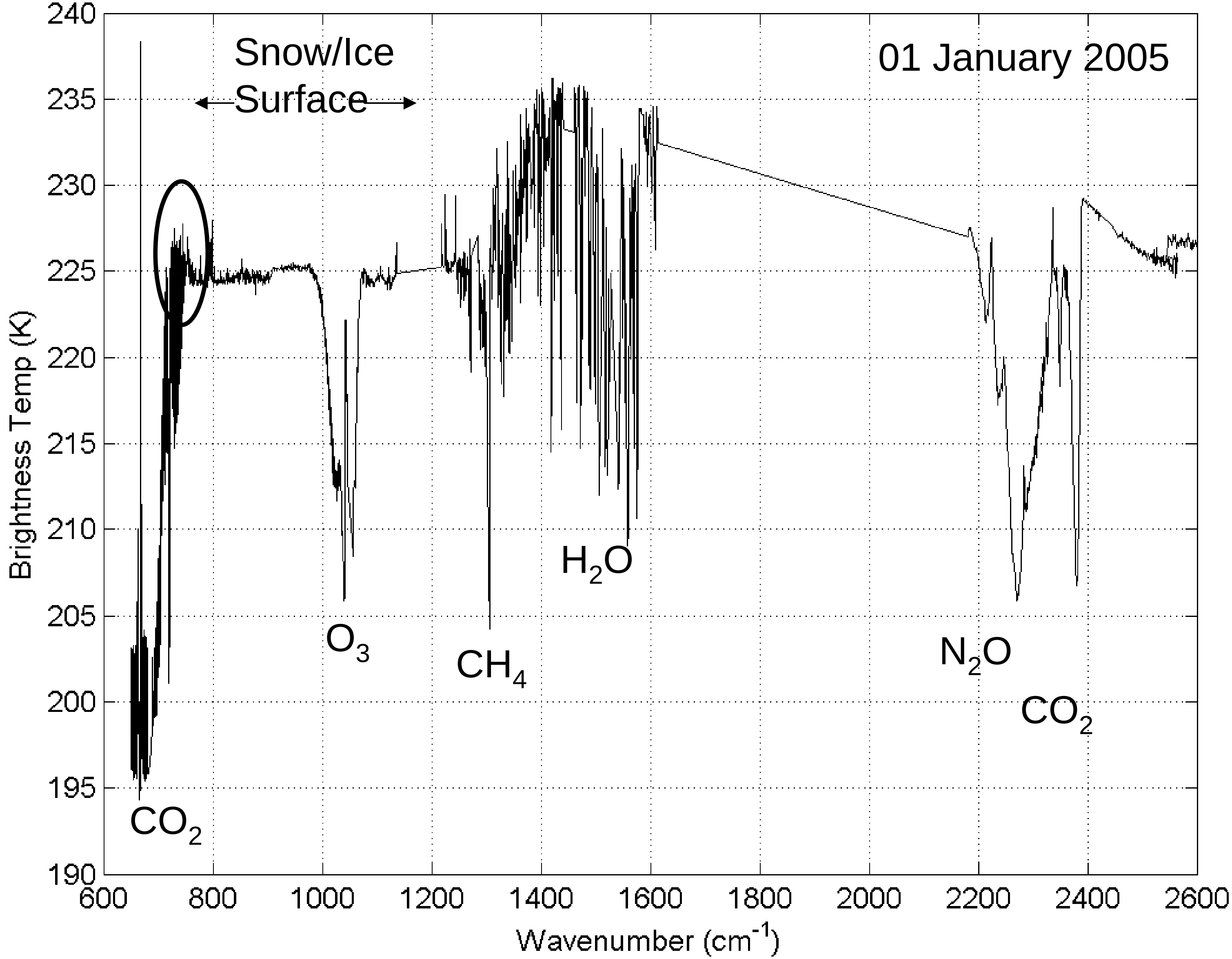
01 January 2005
Overpass at
06:24 UTC



Circles indicate AIRS FOVs where MODIS 12 micron channel is uniform to < 0.2 K.

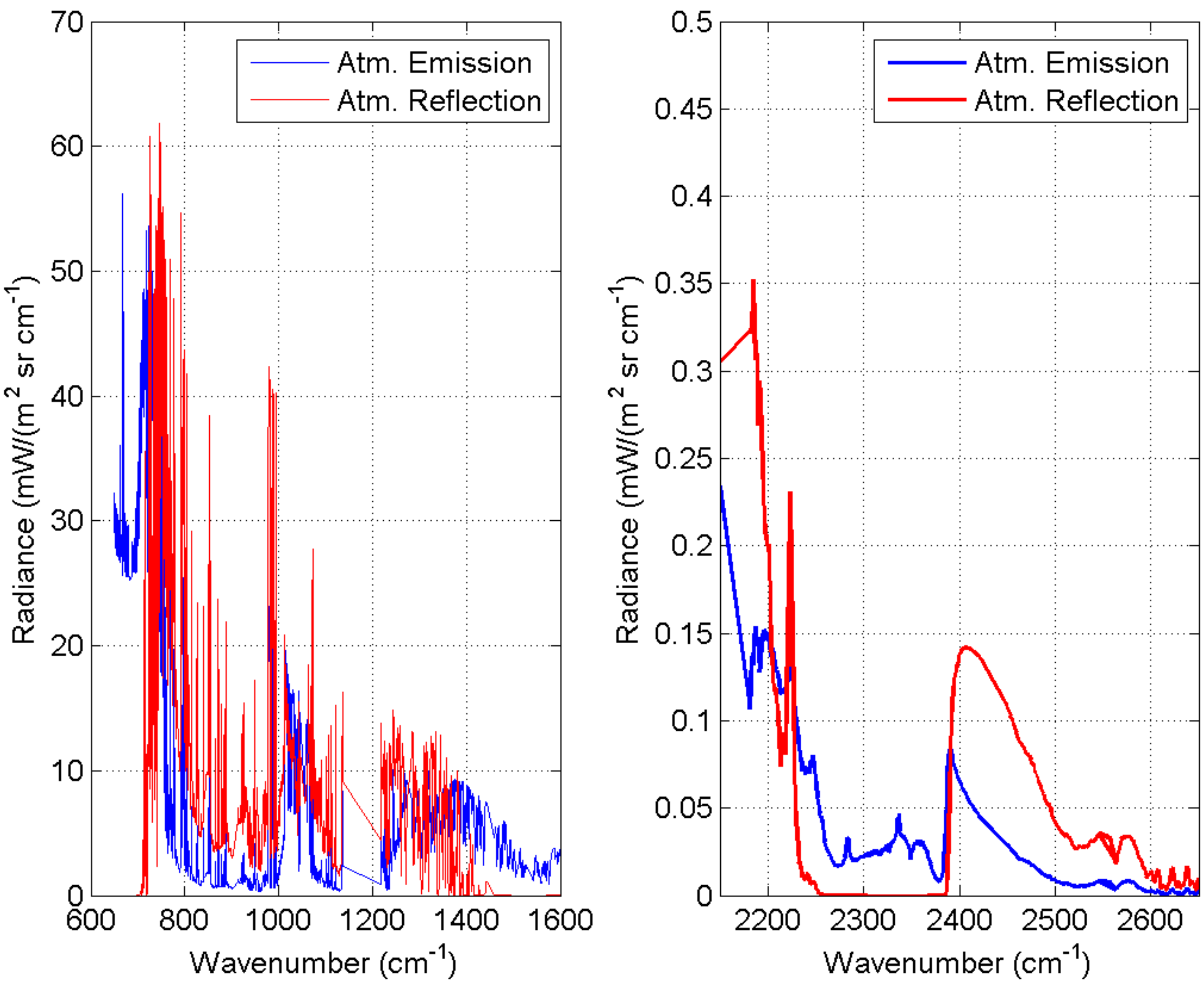
- Select AIRS scenes where MODIS 12 micron channel is < 0.2 K standard deviation.

Example "Clear" AIRS Spectrum Over Greenland Ice Sheet



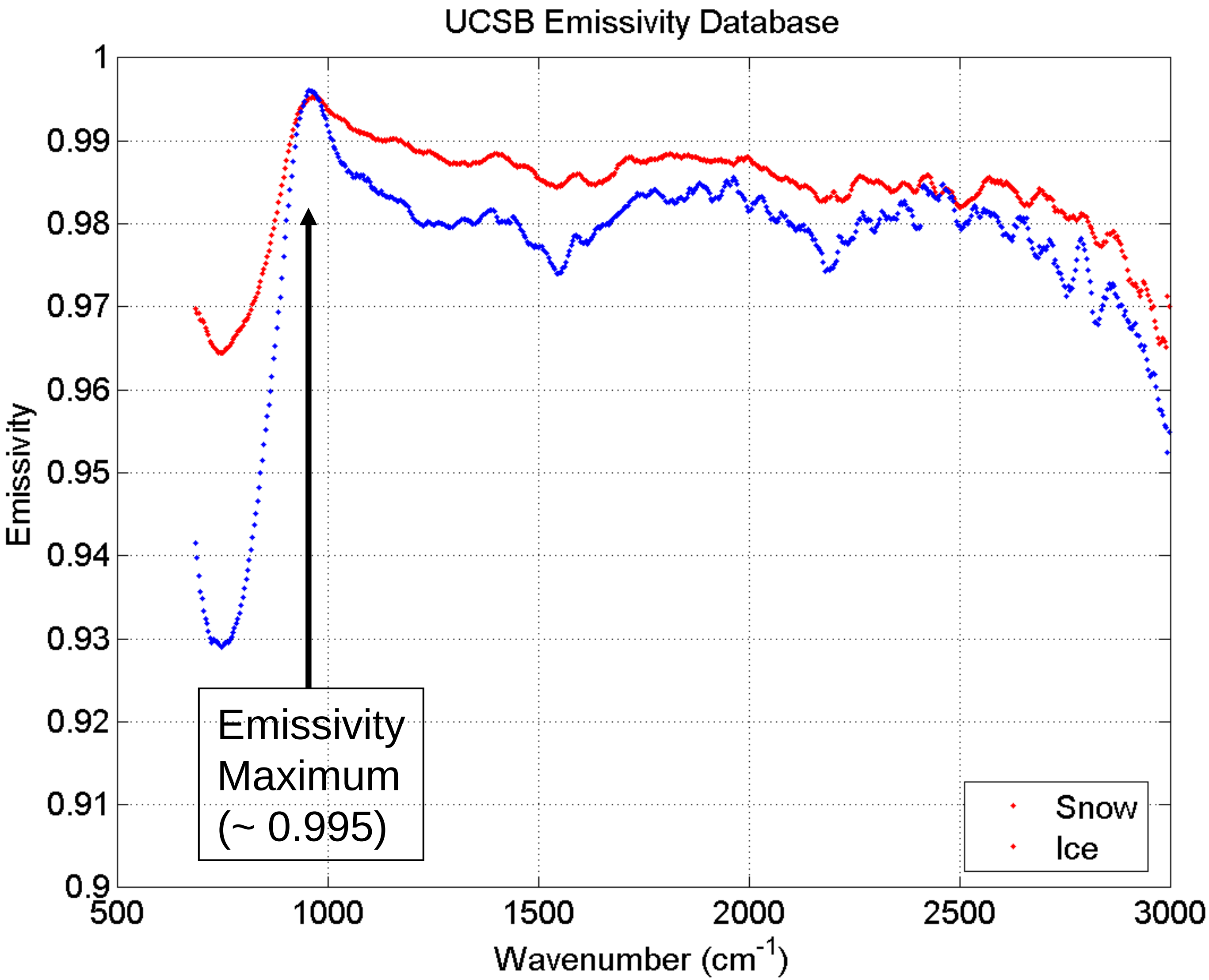
- Surface skin is colder than air above the surface (temperature inversion).

Atmospheric Emission and Reflection Calculated



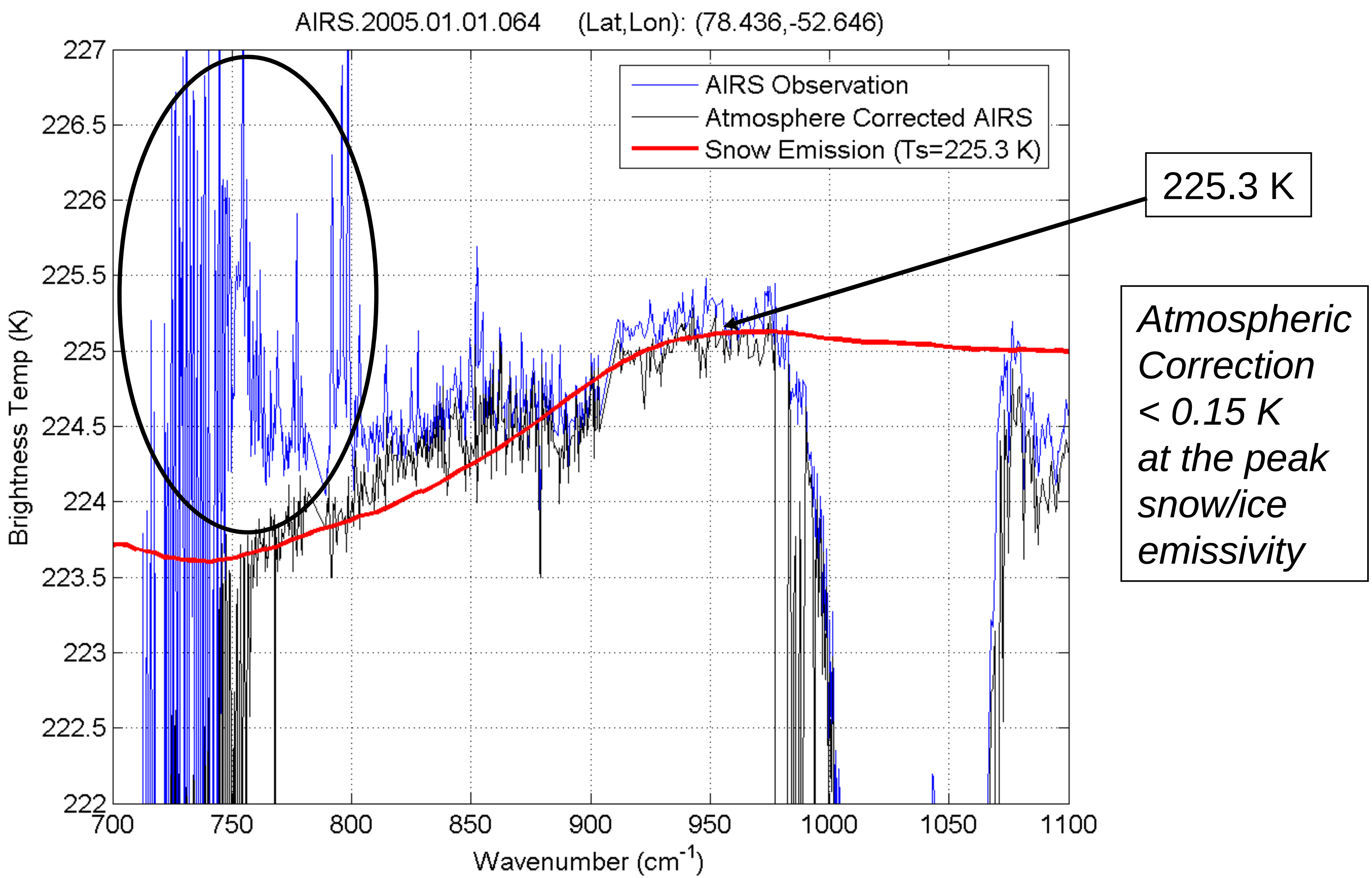
- Use ECMWF and SARTA RTE for atmospheric correction.

Laboratory Measurements of Snow and Ice Emissivity Spectra



- Take advantage of the peak in the snow/ice emissivity at 960 cm^{-1} skin temperature estimation (Emissivity is about 0.995).

Retrieved Surface Emission Over Greenland Ice Sheet



- Surface emission is CONSISTENT with Snow Emission at a skin temperature determined using snow/ice emissivity peak at 960 cm^{-1}.

Frequency of Clear Soundings (Greenland, January 2005)

- Consider all AIRS overpasses of Greenland for January 2005

- Find collocated MODIS pixels within AIRS fields of view.

- Compute 12 micron MODIS standard deviation and mean within AIRS fields of view.

- Apply tight uniformity test
 (MODIS Std. Deviation < 0.02 K)

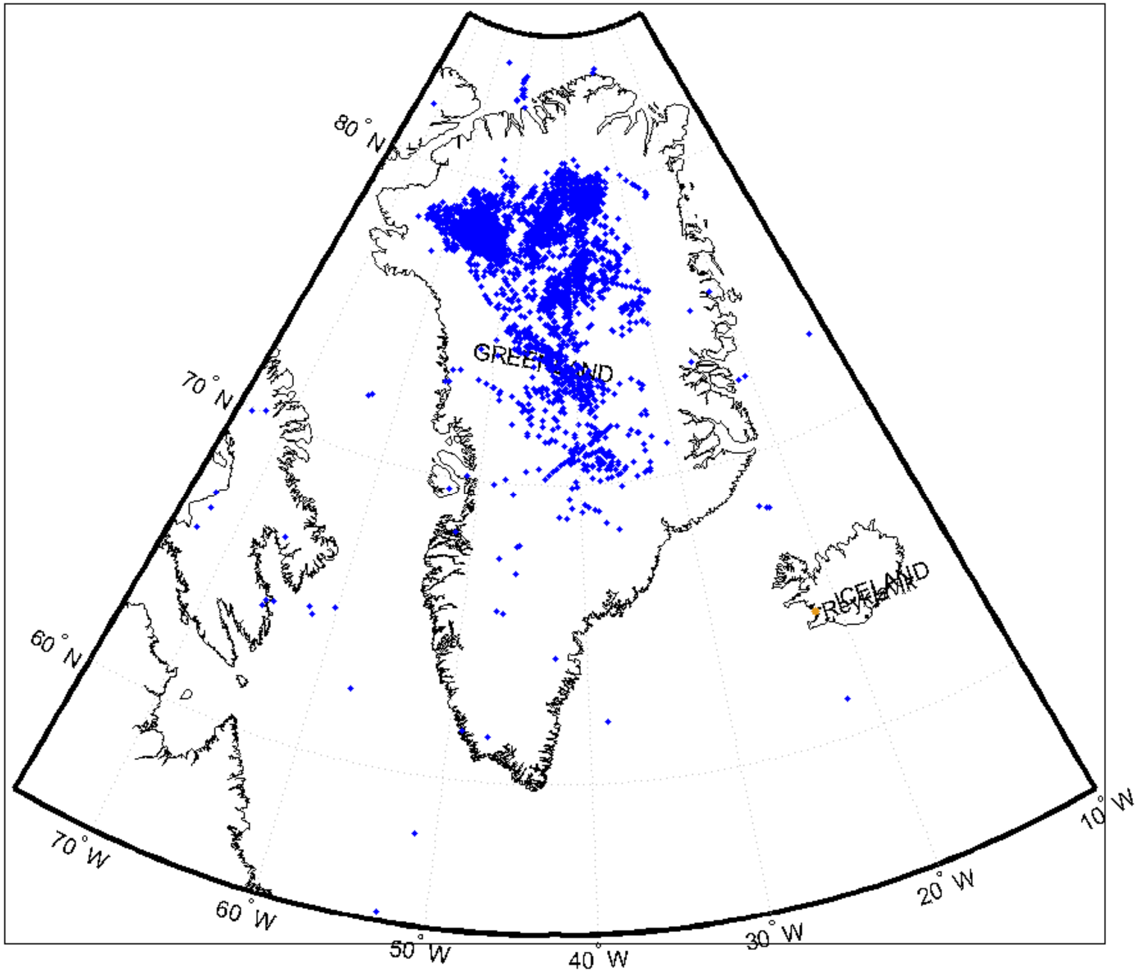
- Compute number of potential soundings per day in the area surrounding the Greeland continent.

MODIS Mean 12 μm BT: 200 K – 230 K

JAN 2005

MODIS Std Deviation Within AIRS FOV < 0.2 K

104 AIRS FOVs per Day on Average for January



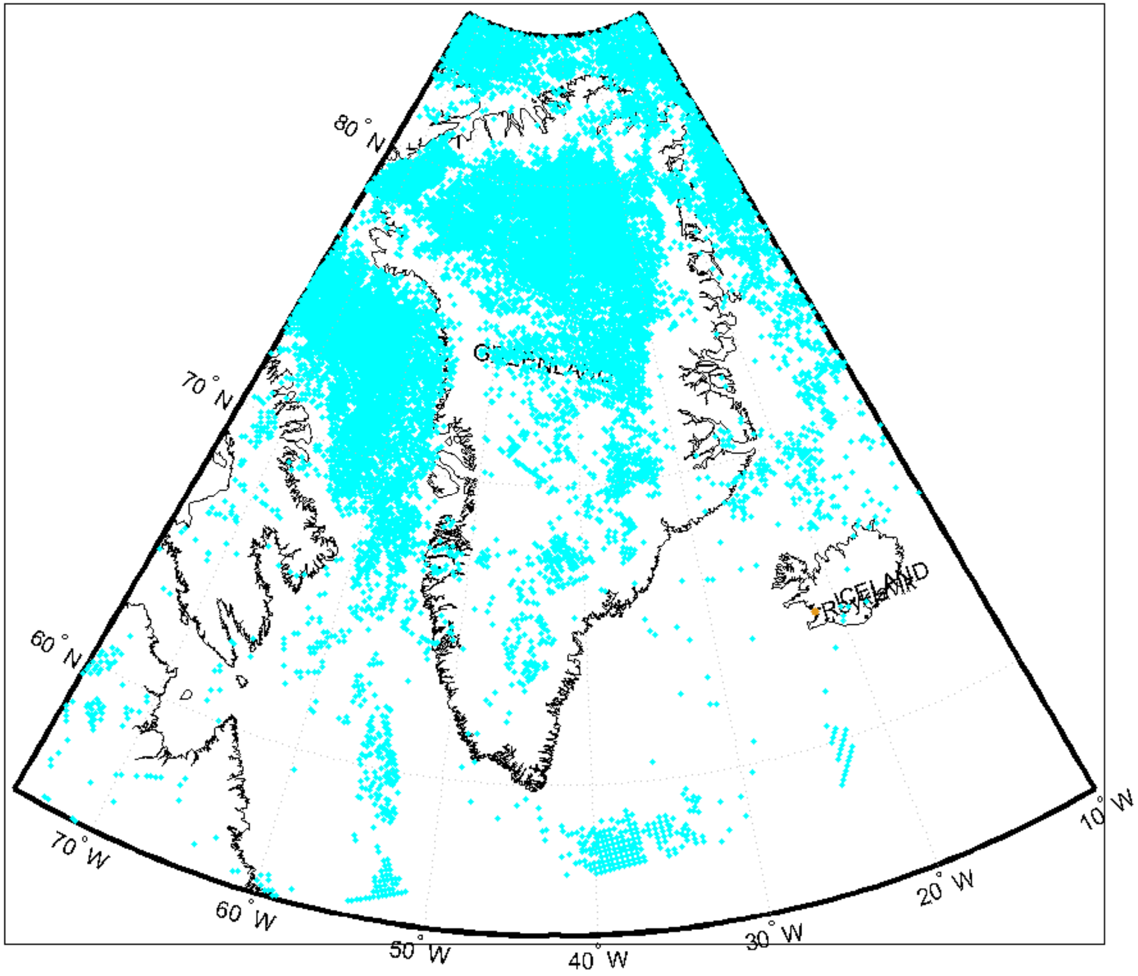
- Average of 100 “Clear” Soundings per Day

MODIS Mean 12 μm BT: <u>230 K – 260 K</u>

JAN 2005

MODIS Std Deviation Within AIRS FOV < 0.2 K

1344 AIRS FOVs per Day on Average for January



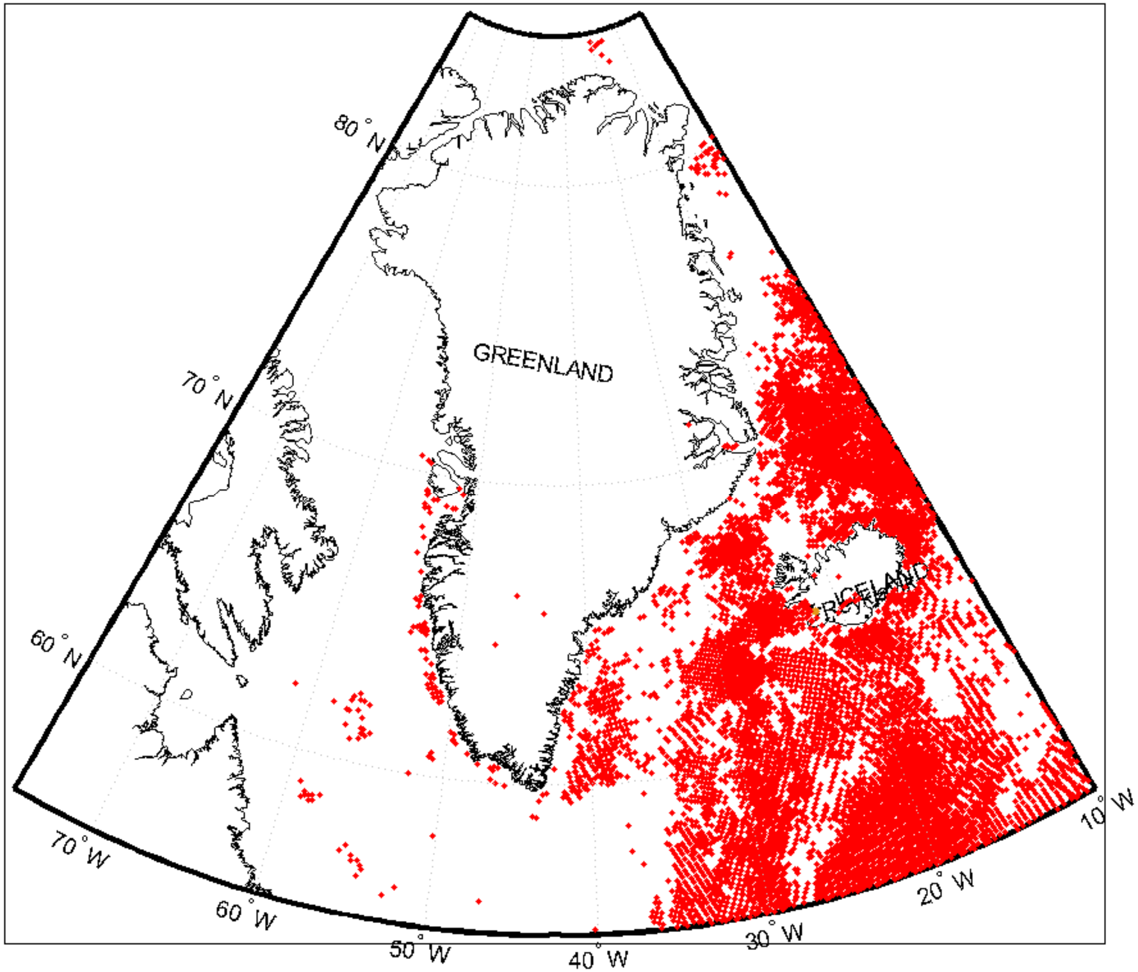
- Average of 1000 “Clear” Soundings per Day

MODIS Mean 12 μm BT: <u>260 K – 290 K</u>

JAN 2005

MODIS Std Deviation Within AIRS FOV < 0.2 K

515 AIRS FOVs per Day on Average for January



- Average of 500 "Clear" Soundings per Day

Preliminary Conclusions

1. Assimilation of advanced sounder radiances during high latitude winter requires 1) the identification of clear sounder fields of view, and 2) the correct estimation of surface skin temperature and infrared emissivity.

2. Infrared imager data collocated within sounder fields of view can be used to identify uniform scenes as a simple cloud test (effective when Std. Dev. < 0.2).

3. A linear combination of snow and ice laboratory emissivity measurements are proposed for use in snow/ice covered regions. Surface skin temperature meaurements can be accurately estimated from the 960 cm^{-1} region of sounder observations.

Future Work

Collaboration with John LeMarshall (and Jim Jung) at the Joint Center for Satellite Data Assimilation is in progress for evaluating the impact of this approach on NWP for a case study.

International TOVS Study Conference, 15th, ITSC-15, Maratea,Italy, 4-10 October 2006
Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center,
Cooperative Institute for Meteorological Satellite Studies, 2006.

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