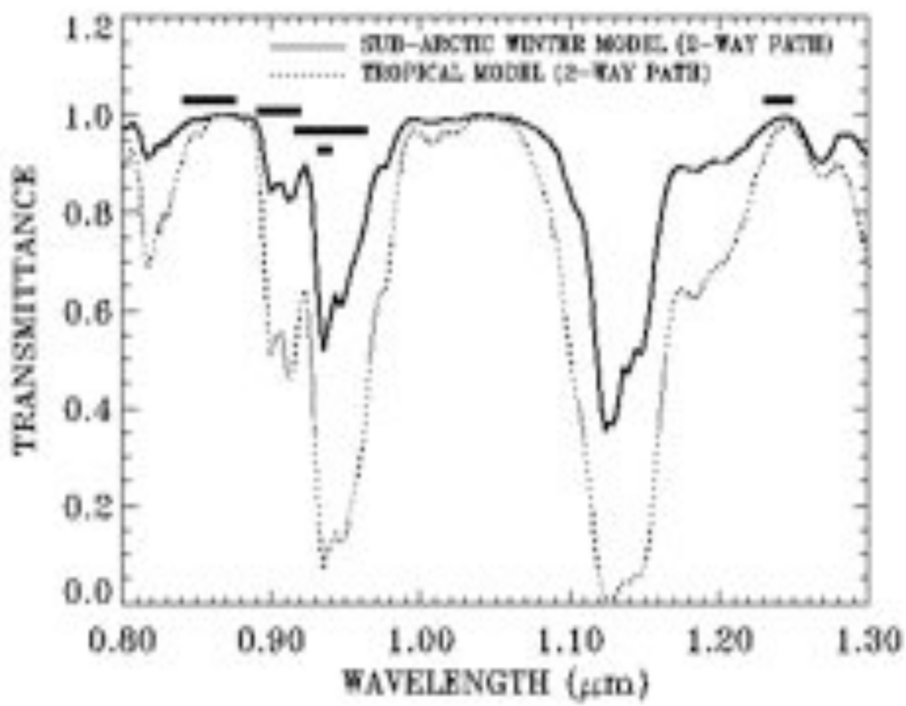
Upgrades to the MODIS near-IR Water Vapor Algorithm and Cirrus Reflectance Algorithm For Collection 6

Bo-Cai Gao & Rong-Rong Li

Remote Sensing Division, Code 7232, Naval Research Laboratory, Washington, DC

The Near-IR Water Vapor Algorithm



MODIS has 3 water vapor absorption channels near 0.94 micron, and 2 atmospheric window channels near 0.865 and 1.24 micron.

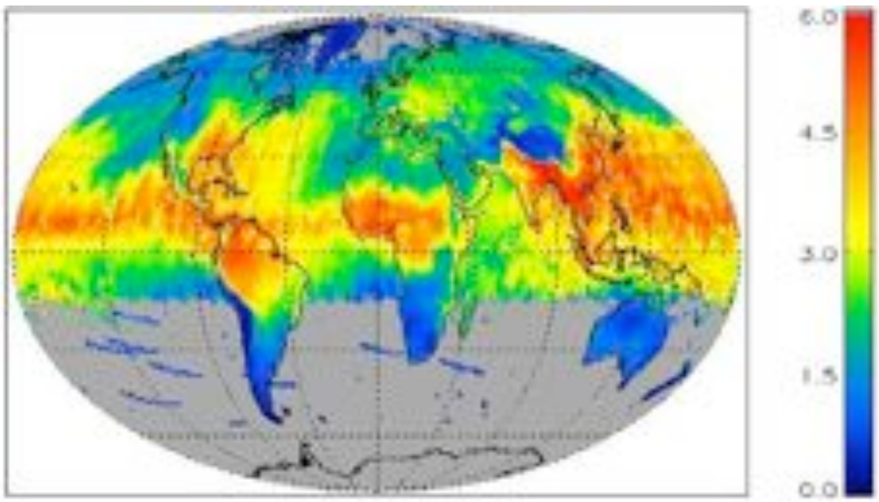
At present, the MODIS near-IR water vapor algorithm works fine for clear land surfaces.

Over bright clouds, the 5 channels used in the algorithm can saturate. The algorithm didn't handle properly the saturated pixels.

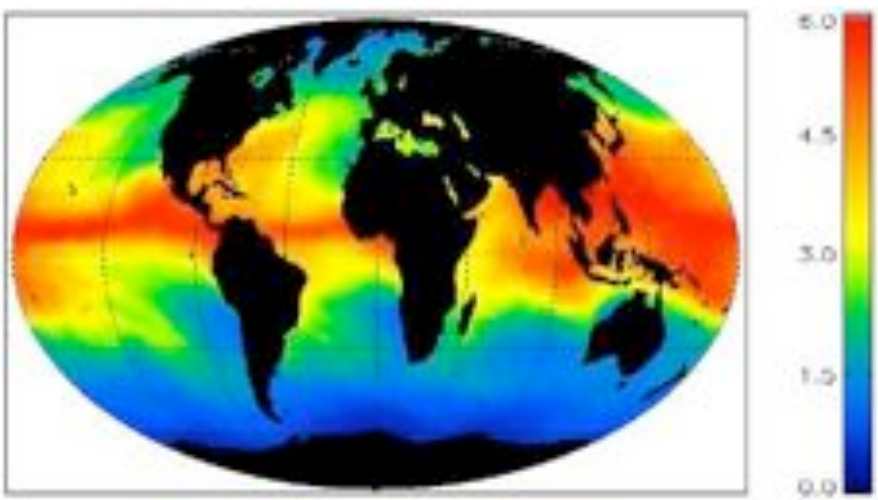
Minor upgrades to the QA routines used in the algorithm are needed.

Water Vapor Image (MODIS + SSMI)

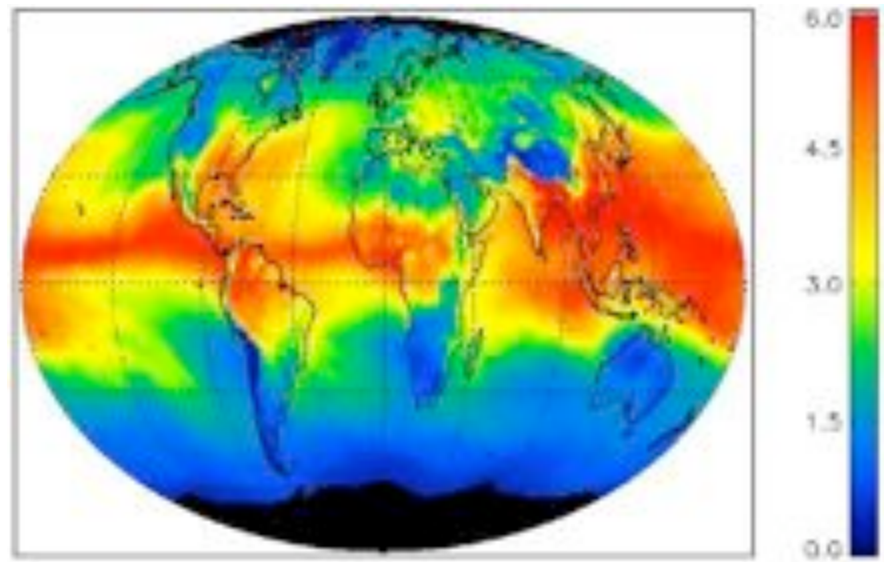
MODIS Vapor (7/2002)



SSMI Vapor (7/2002)

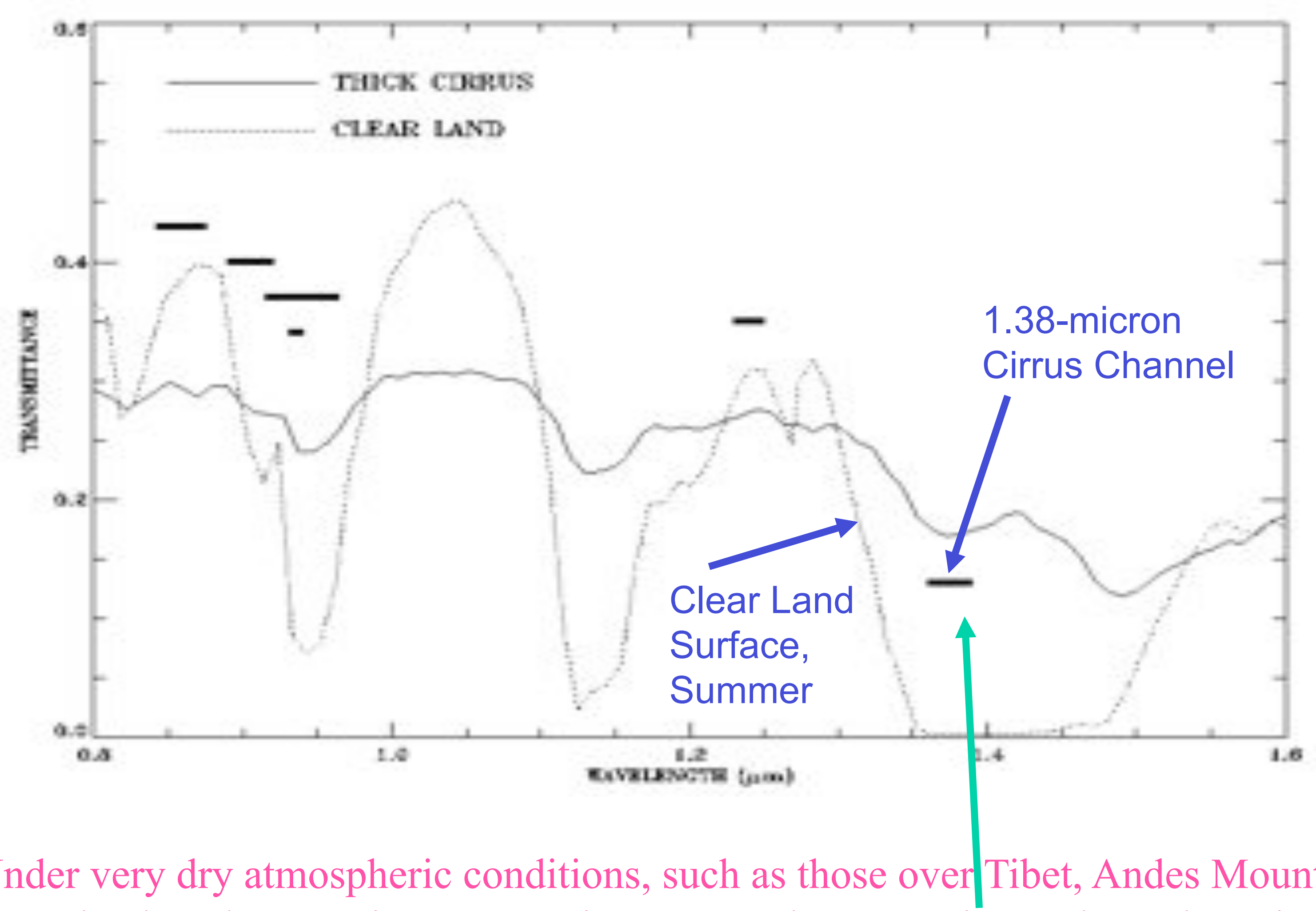


Vapor (MODIS + SSMI)



By merging the MODIS near-IR water vapor over land and SSMI water vapor over ocean, a nearly global TWP data set can be produced for climate research.

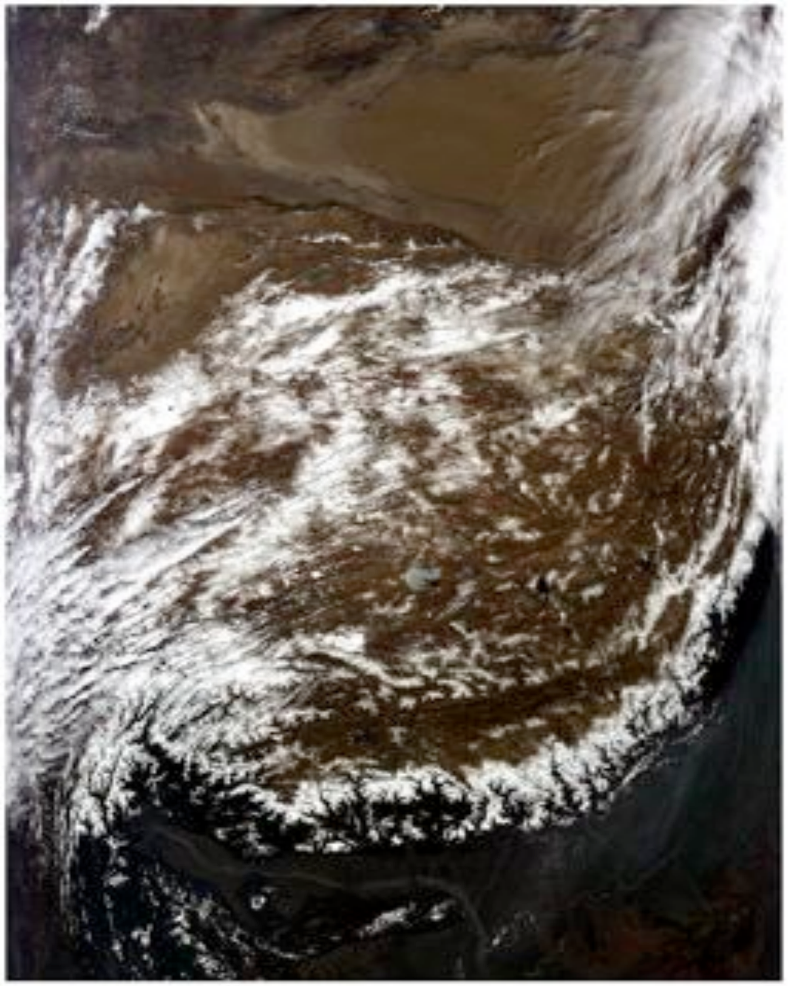
The MODIS Cirrus Reflectance Algorithm



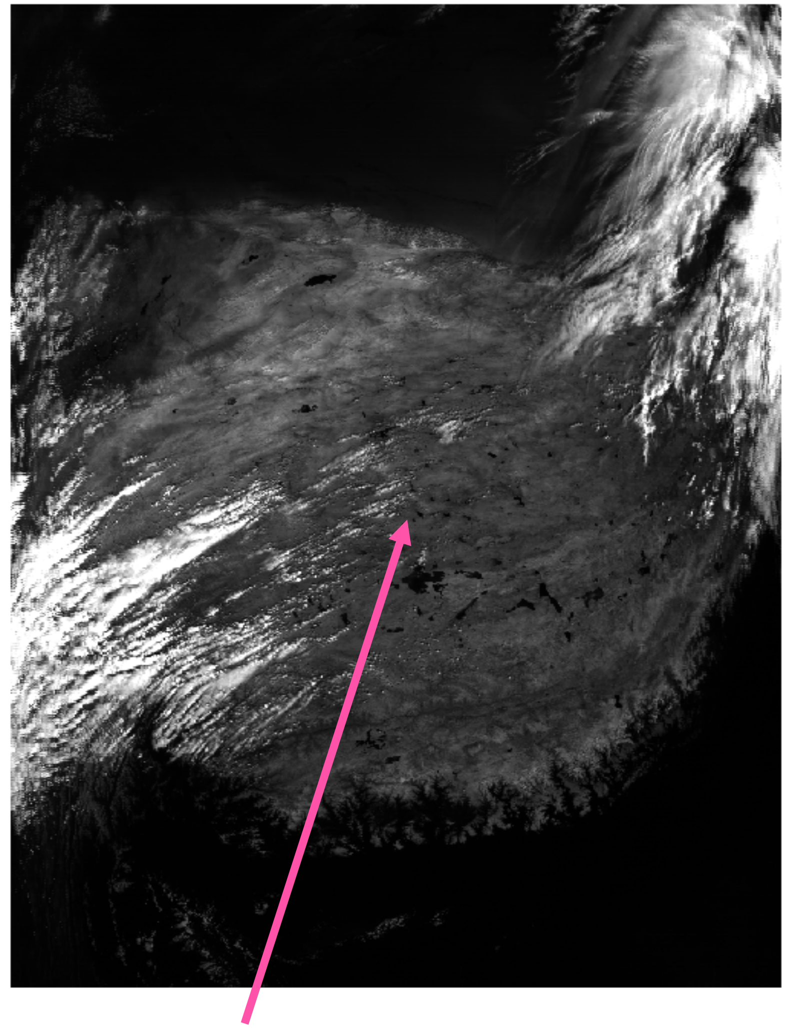
Under very dry atmospheric conditions, such as those over Tibet, Andes Mountains, Greenland, and Antarctic over certain seasons, the 1.38-micron channel receives small amount of solar radiation reflected by Earth's surfaces. As a result, the surface signals can contaminate the cirrus signals near 1.38 micron.

Examples of MODIS Images Over Tibet

RGB Image



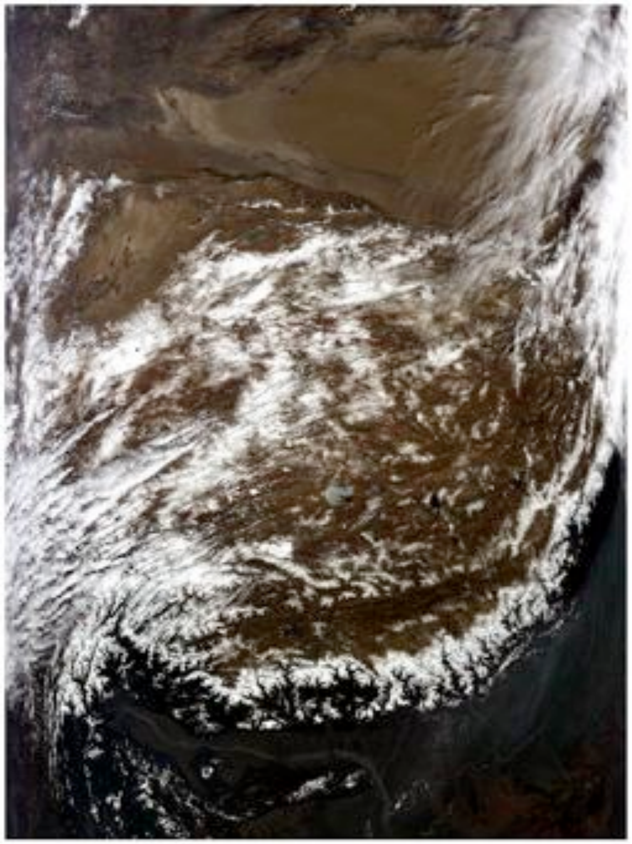
1.38-micron Image



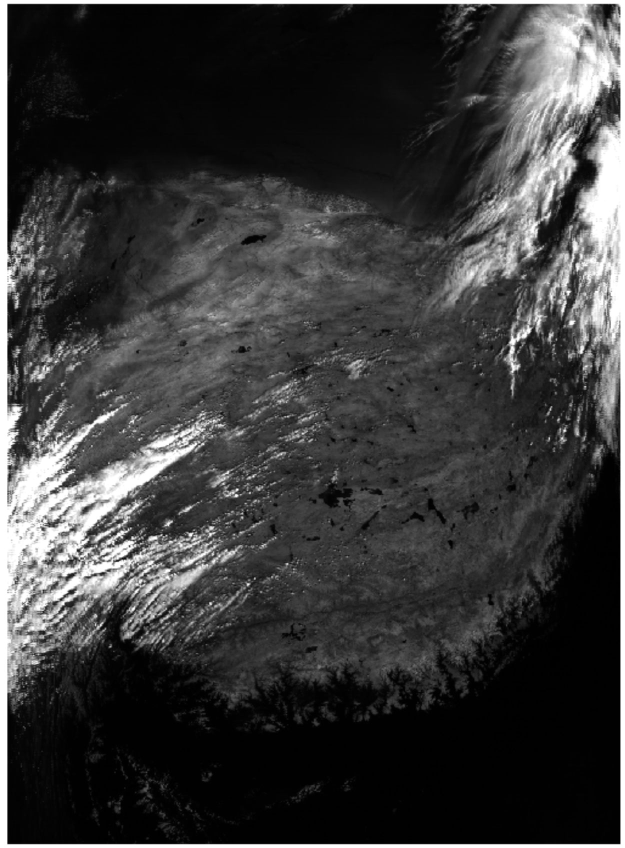
Although cloud features are seen dominantly in the 1.38-micron channel image, weak surface features are also seen.

Examples of Surface Masking Over Tibet

(A) RGB IMAGE



(B) 1.38-μm IMAGE

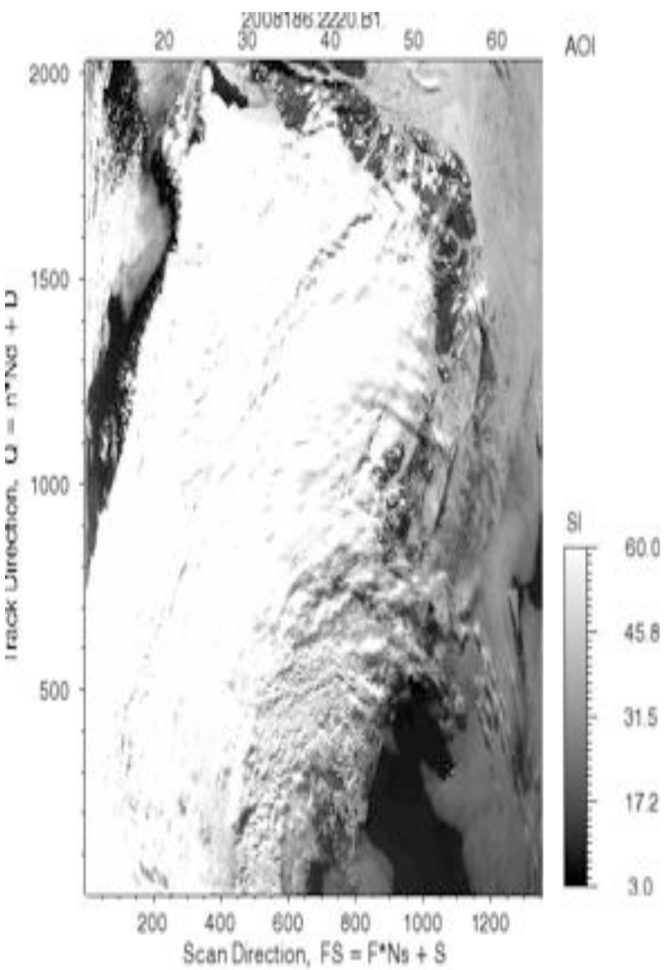


(C) 4.51-μm IMAGE

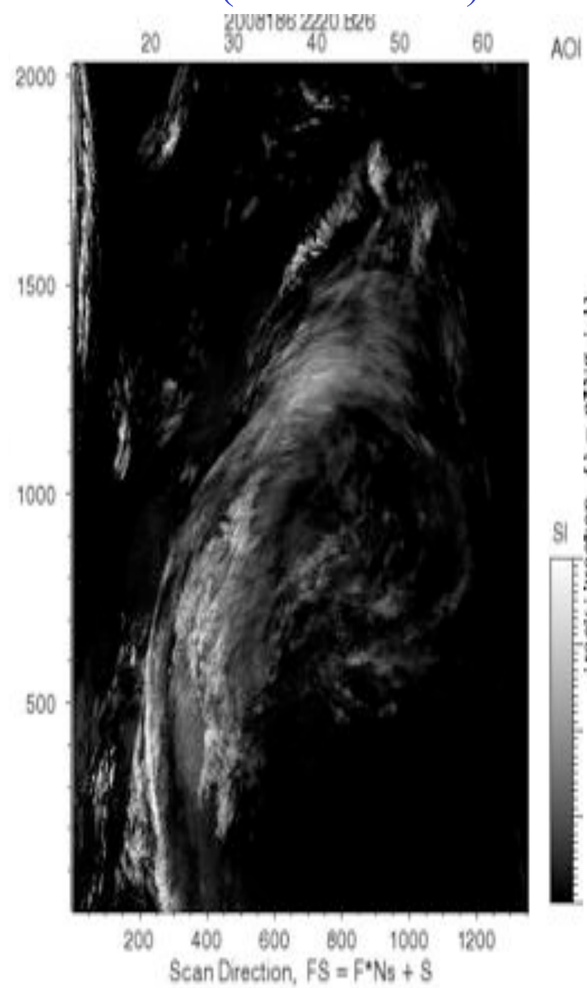
A number of masking schemes, including the MODIS operational cloud masking algorithm and different ratio and BT difference techniques, have been tested with the help from Dr. Aisheng Wu. We have found that the CO2+N2O absorption channel centered at 4.51 micron is very effective for separating clouds from clear surfaces over Tibet and Andes Mountains. Further tests of the technique with explicit consideration of surface elevations are still needed.

Examples of Surface Masking Over Greenland

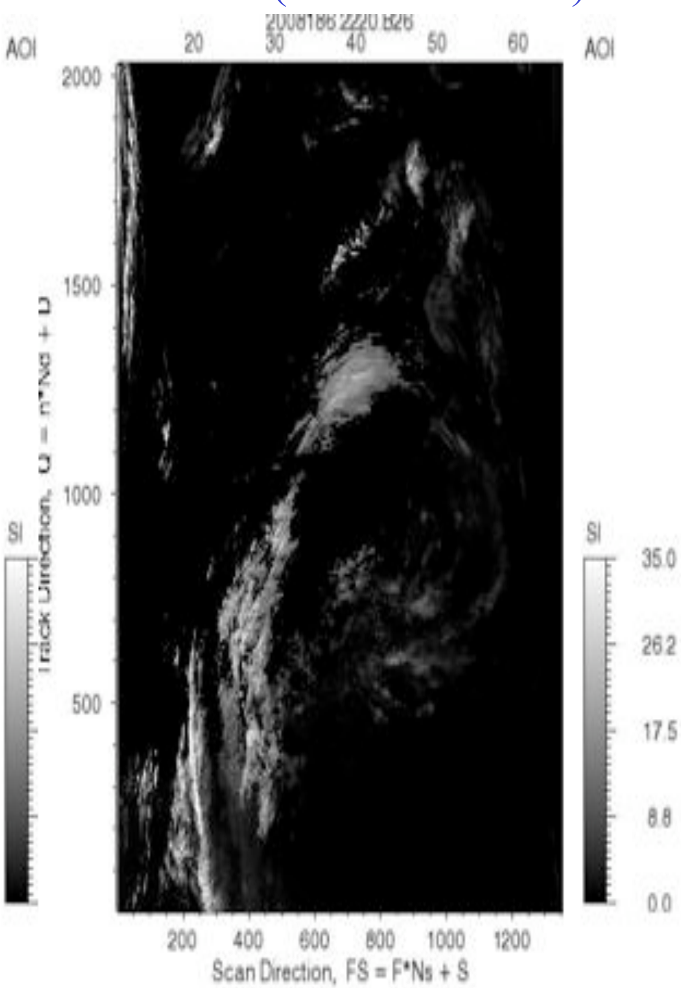
B1 (0.66 micron)



B26 (1.38 micron)

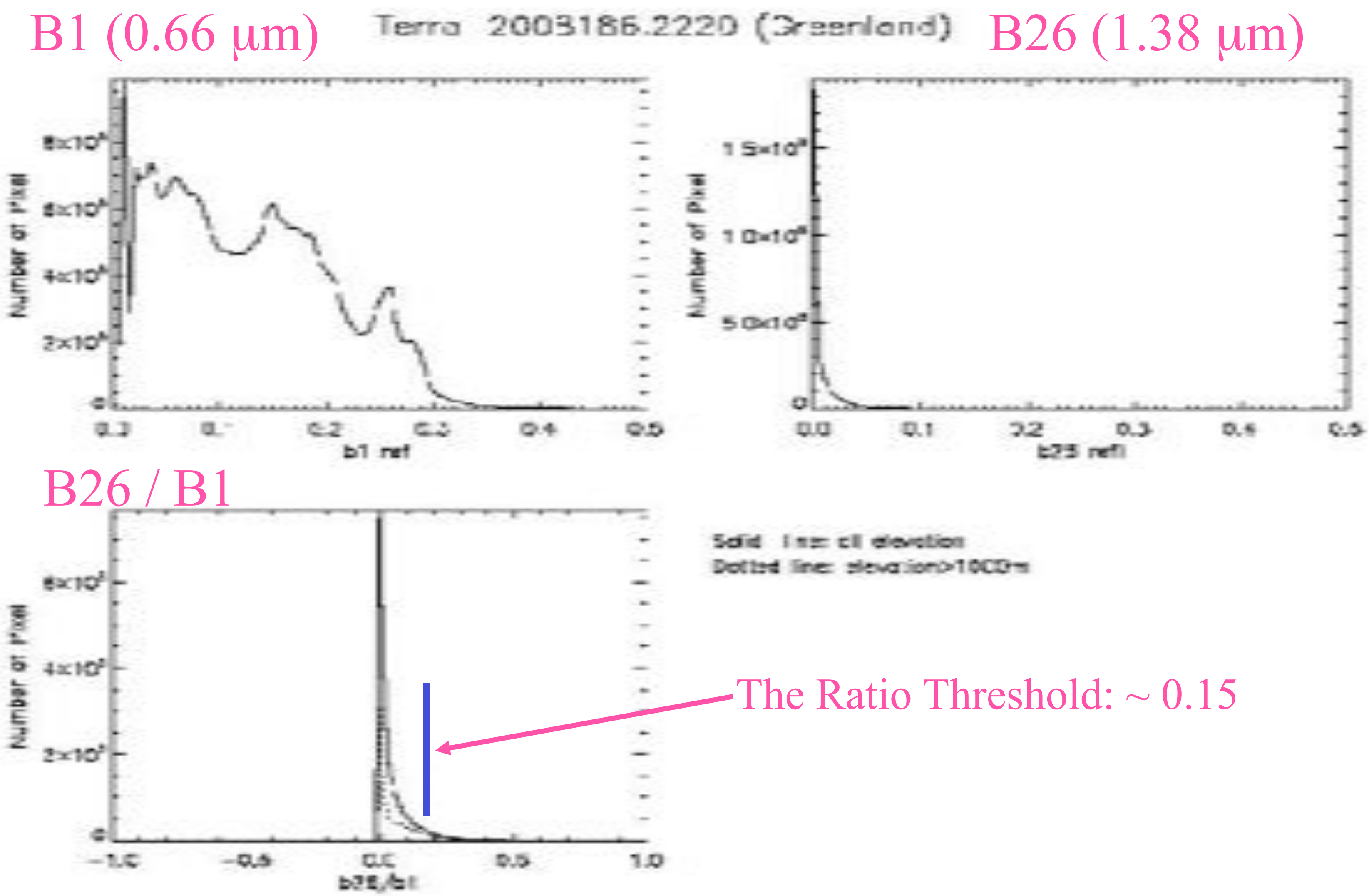


Masked (B26/B1 > 0.15)



(The images were generated by Dr. Aisheng Wu of SSAI)

Histograms For The Sample Greenland Images

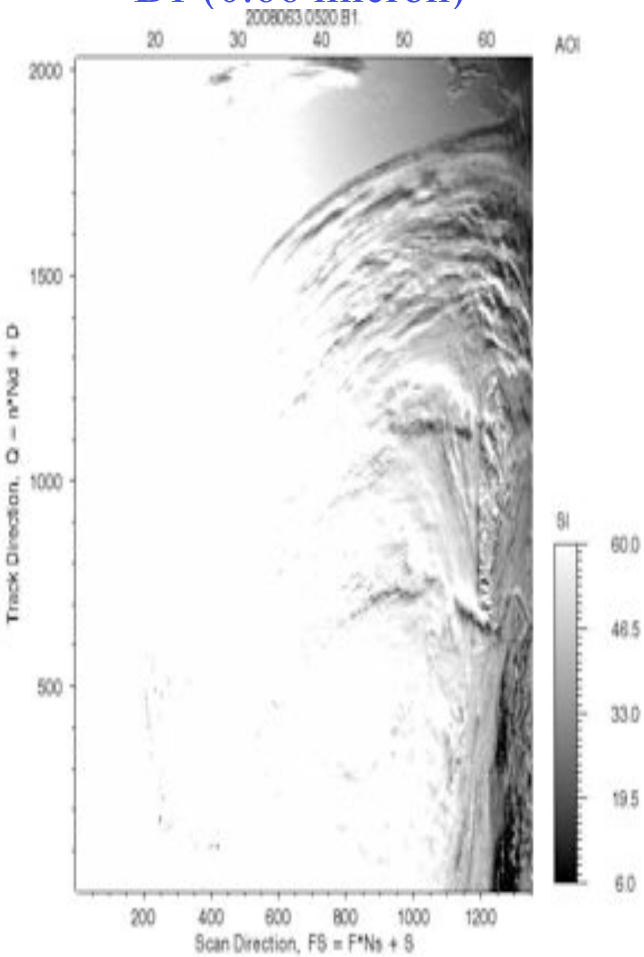


(The plots were generated by Dr. Aisheng Wu of SSAI)

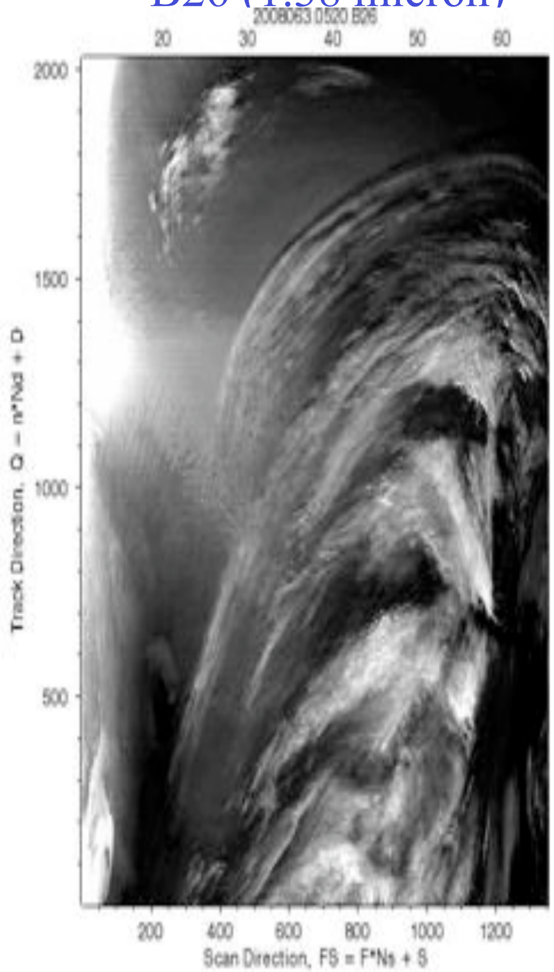
Examples of Surface Masking Over Antarctic

(Most difficult, further analysis of MODIS + CALIPSO Lidar Data is needed)

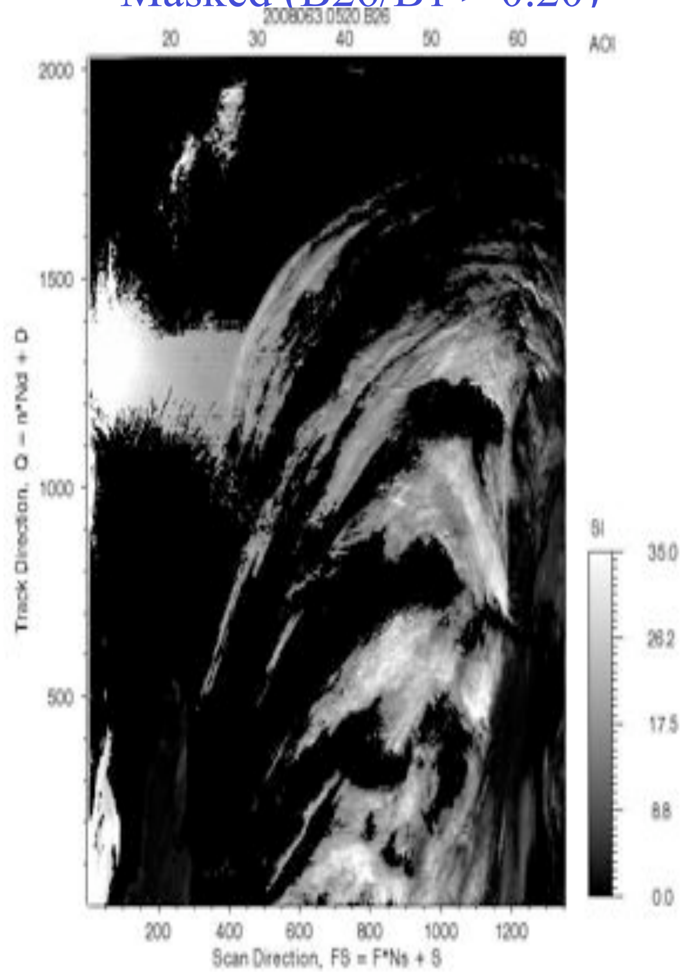
B1 (0.66 micron)



B26 (1.38 micron)



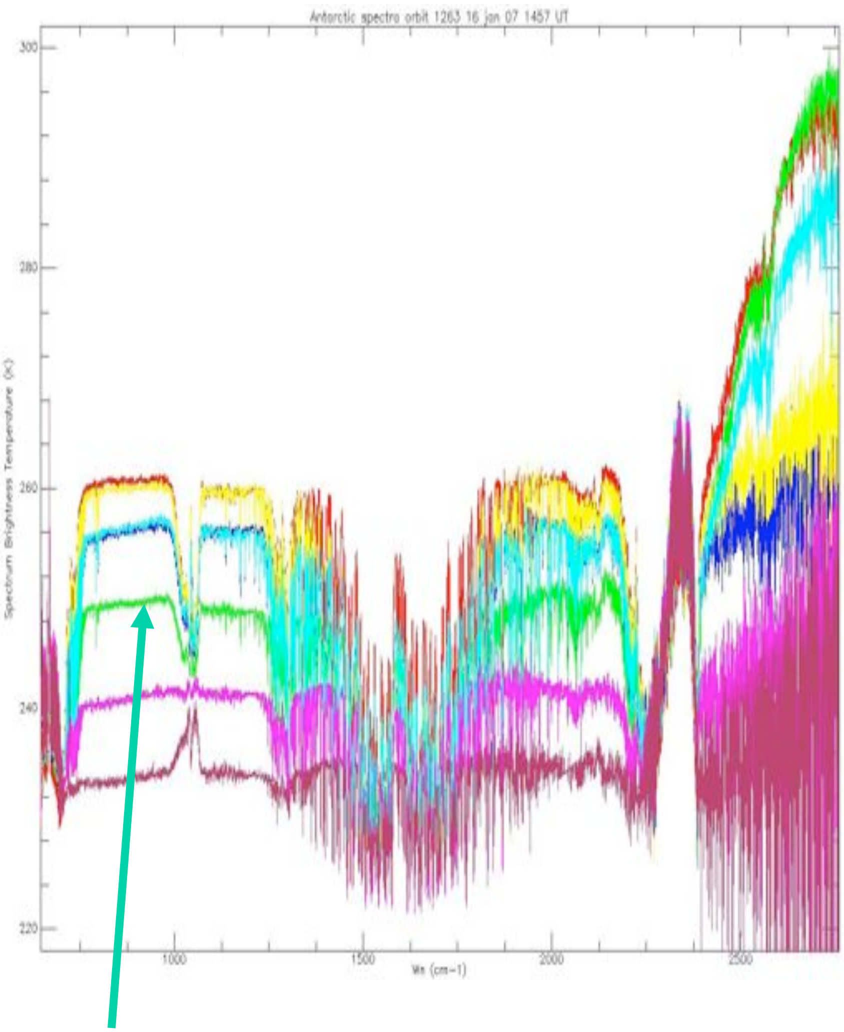
Masked (B26/B1 > 0.20)



(The images were generated by Dr. Aisheng Wu of SSAI)

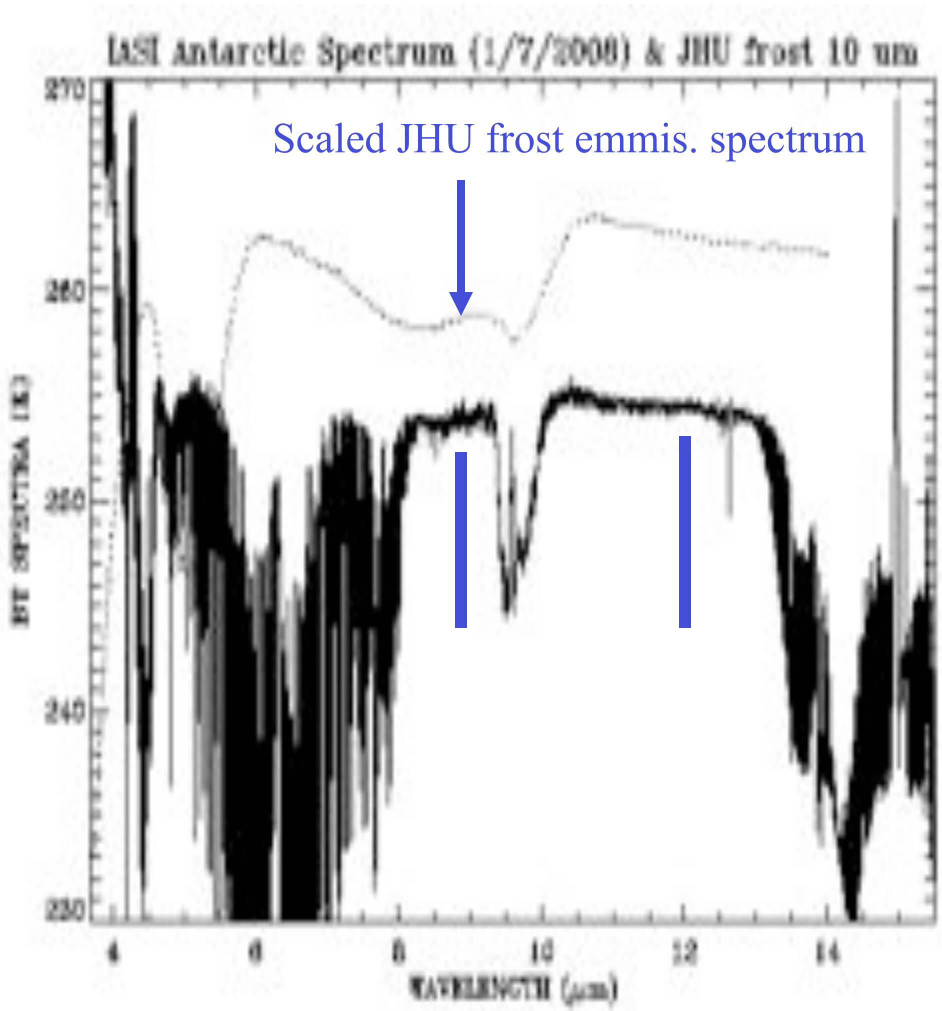
A Possible New Method For Cloud Detection Over Antarctic

[BT(8.6 µm) – BT(12 µm) < 0 Based Analysis of IASI and MODIS data]



An IASI cloud spectrum over Antarctic 1/2007

BT(8.6 µm) – BT(12 µm) < 0

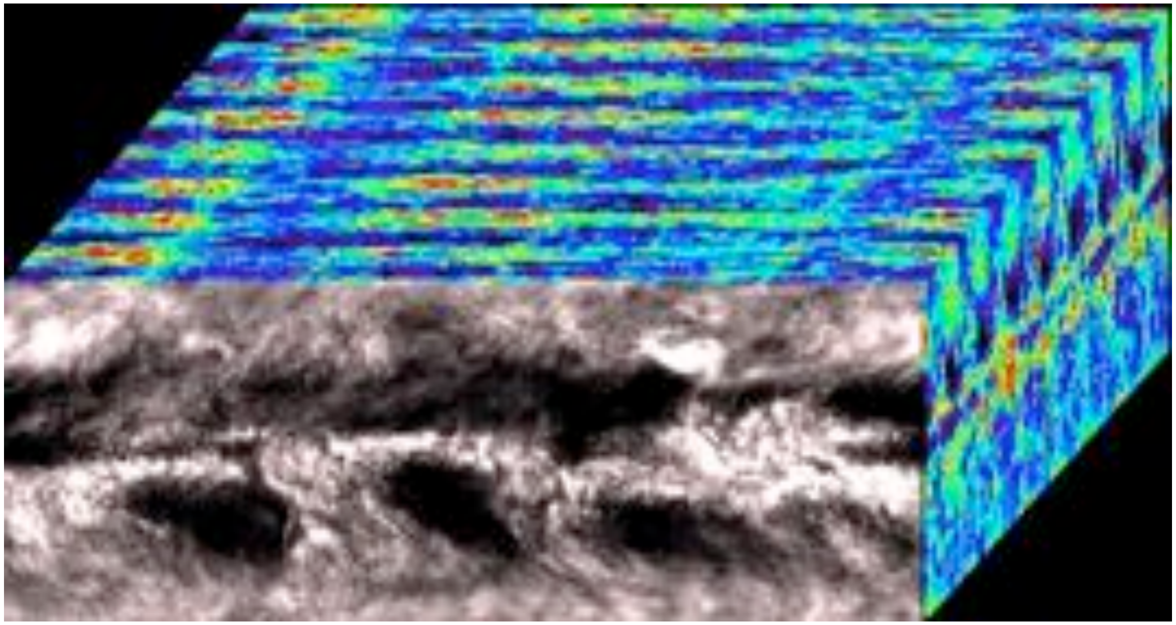


Another IASI cloud spectrum over Antarctic 1/2008

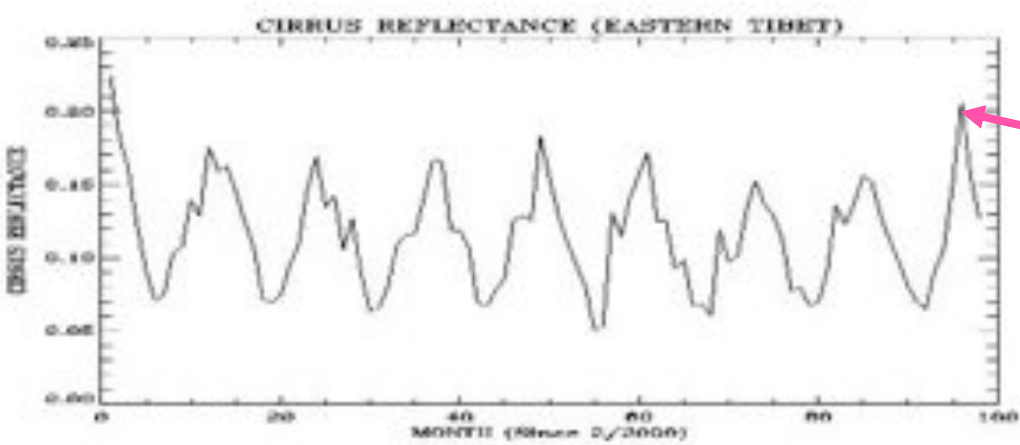
BT(8.6 µm) – BT(12 µm) < 0

Cirrus Reflectance Imaging Cube For Climate Research

(with minor surface contaminations over high elevation areas)



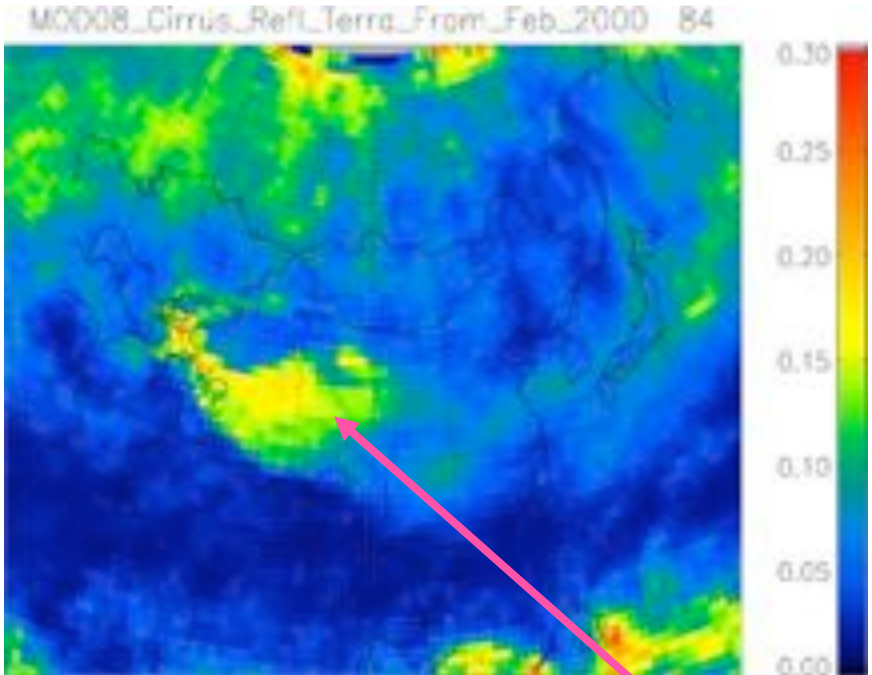
We stacked a total of 98 monthly-mean MODIS cirrus reflectance images (2/2000 – 3/2008) together to form a 3-D image cube (Lon, Lat, time (month)).



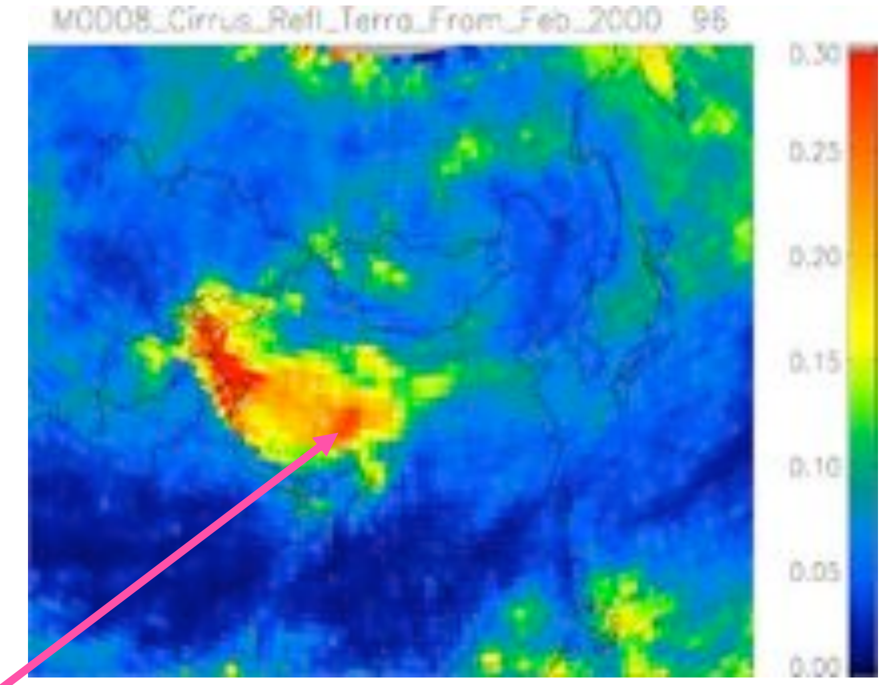
An example of time series of cirrus reflectance data over eastern Tibet of China is shown here. A **spike** is observed for January 2008, which corresponds to the severe weather conditions in the region.

Examples of Monthly-Means Cirrus Reflectance Data

Asia (January 2007)



Asia (January 2008, La Nina)



Large differences are observed between
January 2007 & January 2008

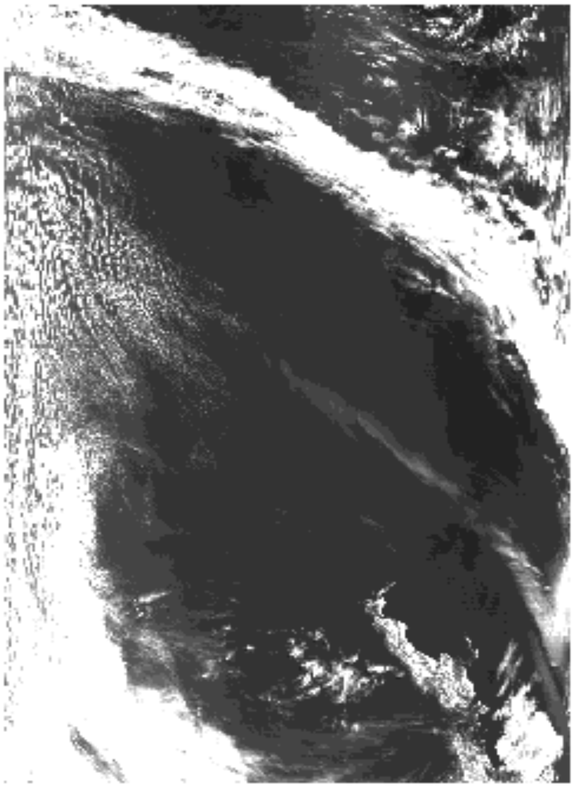
DISCUSSIONS

In late 1992, the NASA MODIS Project decided to implement the 1.38-micron channel on MODIS for improved detection of thin cirrus clouds.

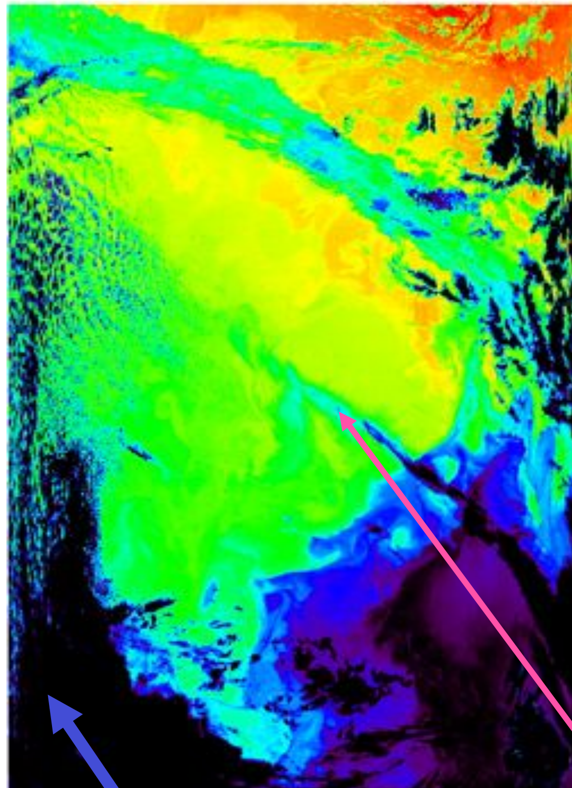
At present, many operational MODIS data products, such as aerosols and sea surface temperatures (SSTs), are still contaminated by thin cirrus clouds. Cirrus corrections have not been performed. The usefulness of these data products for climate research can be questioned.

A Case of Thin Cirrus Contamination to SSTs

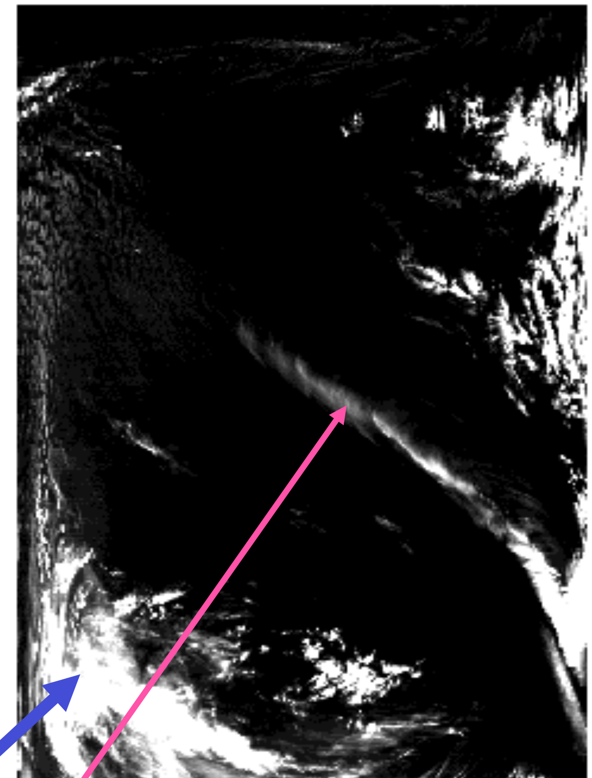
0.55 mm Image



SST Image (0 – 25 C)



Cirrus Image (1.38 μm)

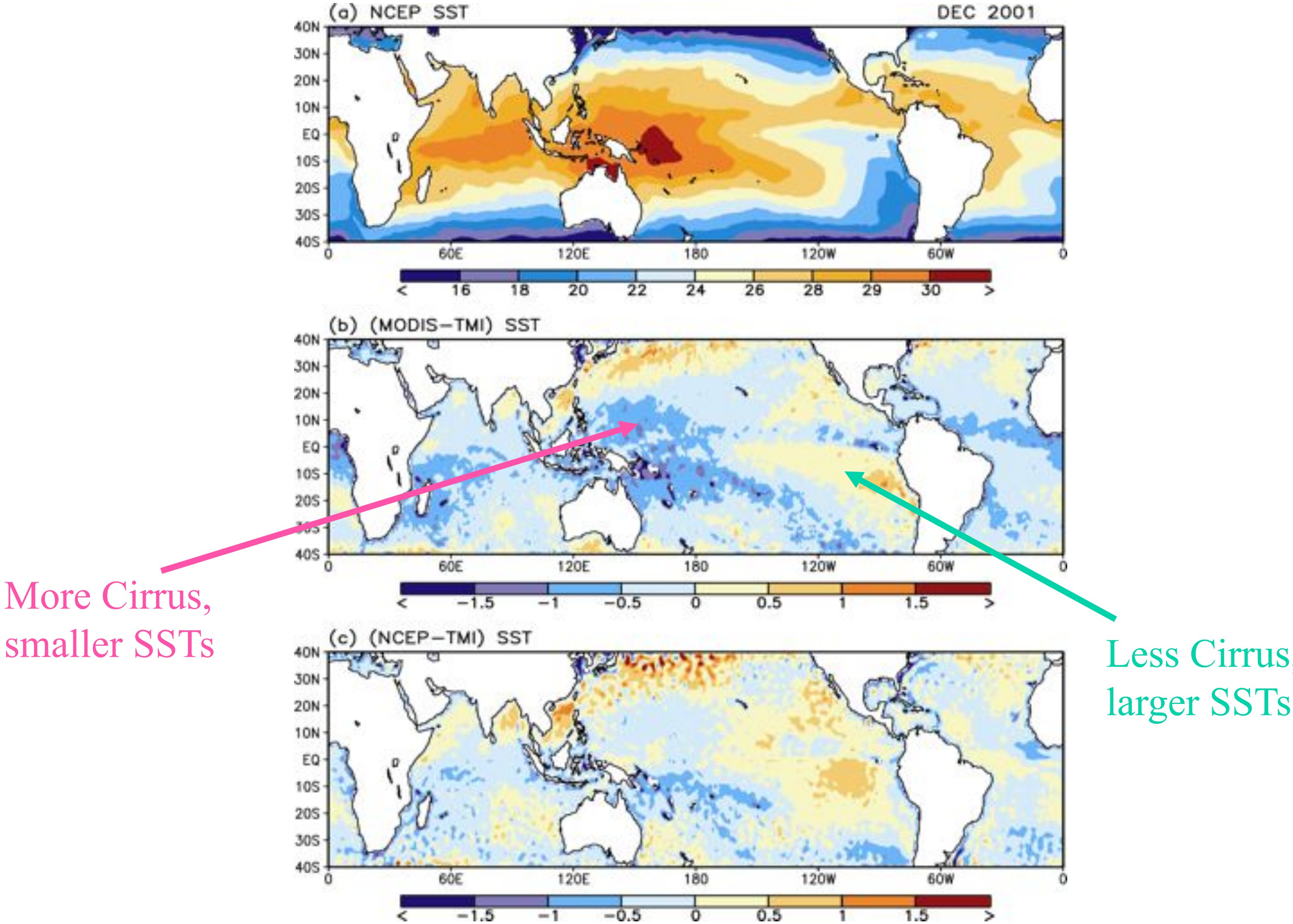


Smaller SST values are reported over thin cirrus areas.

The errors are propagated to the L2 and L3 SST data products

Very small SST values are derived over thicker cirrus covered areas

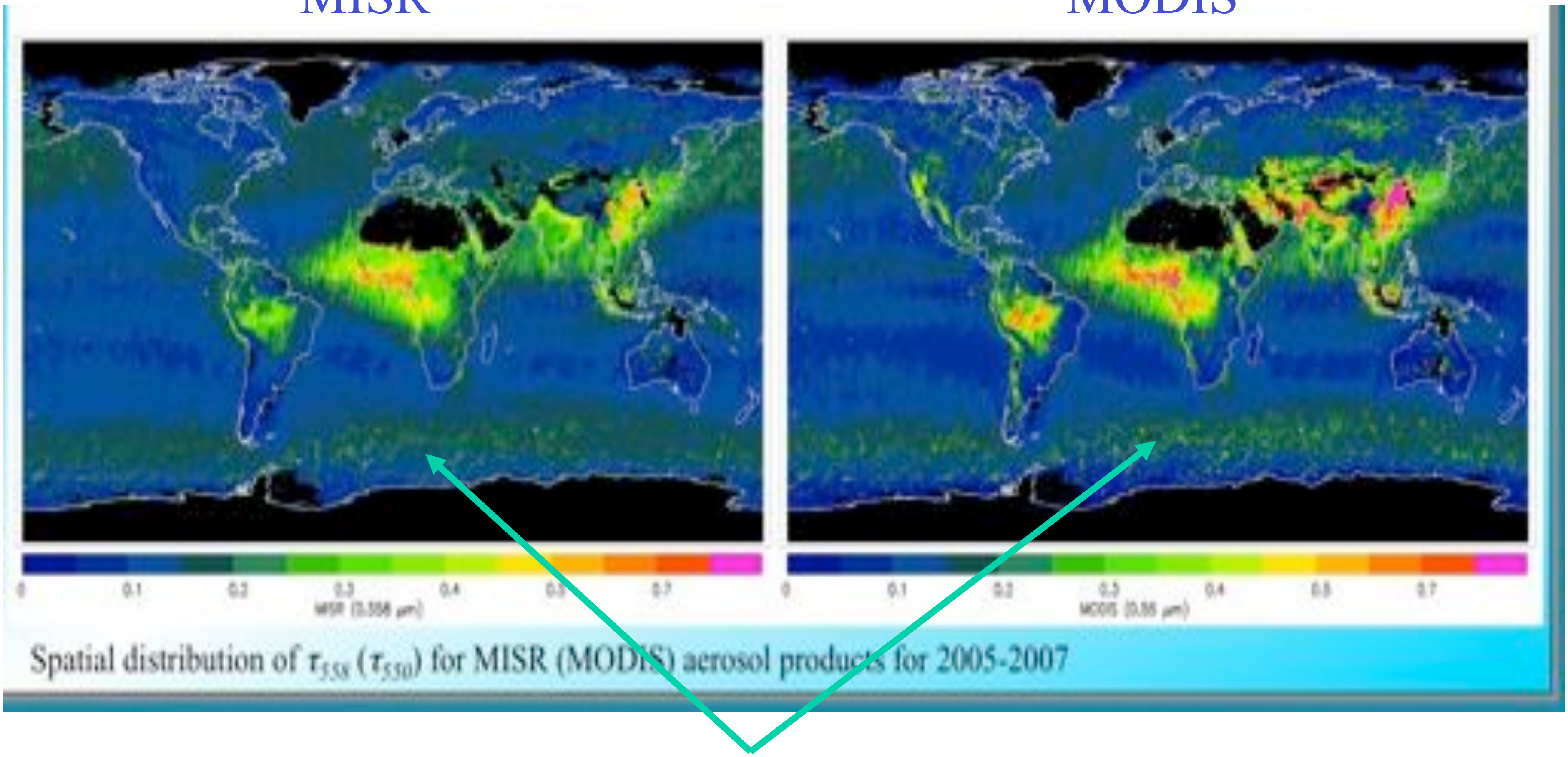
Comparison of Monthly-Mean SSTs from MODIS, TMI, & NCEP



Examples of MISR & MODIS Aerosol Images

(From Dr. J. Zhang's research group at U. of North Dakota)

MISR MODIS



Spatial distribution of τ_{558} (τ_{550}) for MISR (MODIS) aerosol products for 2005-2007

Thin cirrus clouds & bubbles near the ocean surfaces may have contributed to the large optical depths in this latitude belt. We also believe that the MODIS ocean color products & SSTs over the latitude belt are not quite correct.

Summary

- Global near-IR water vapor and cirrus reflectance products have been derived from MODIS channels in the near-IR spectral region. These data products are suitable for climate studies, although improved cirrus reflectance retrievals over dry and high elevation areas, such as Tibet Plateau, Andes Mountains, Greenland, and Antarctic are still needed.

- So far, the data sets have hardly been used by the modeling communities to study, for examples, El Nino and La Nina phenomena.

- We believe that a number of MODIS operational data products are somewhat contaminated by thin cirrus clouds. Cirrus corrections are needed in order to have improved retrievals of these data products for climate research.