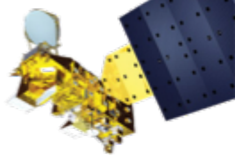


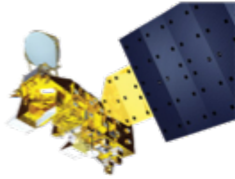
Comparing AIRS and CrIS under mean and extreme conditions

Hartmut H. Aumann

Evan M. Manning

AIRS & CrIS

- AIRS and CrIS are hyperspectral infrared sounders in similar 1:30 PM sun-synchronous orbits.
- AIRS on EOS-Aqua has been flying since 2002.
- CrIS-1 on SNPP has been flying since 2012.
- More CrIS instruments will fly on JPSS-1, 2, 3 for decades to come.
- We need to characterize the instruments very carefully before we can make a merged record.



A distinction between forecast utilization and climate applications is important

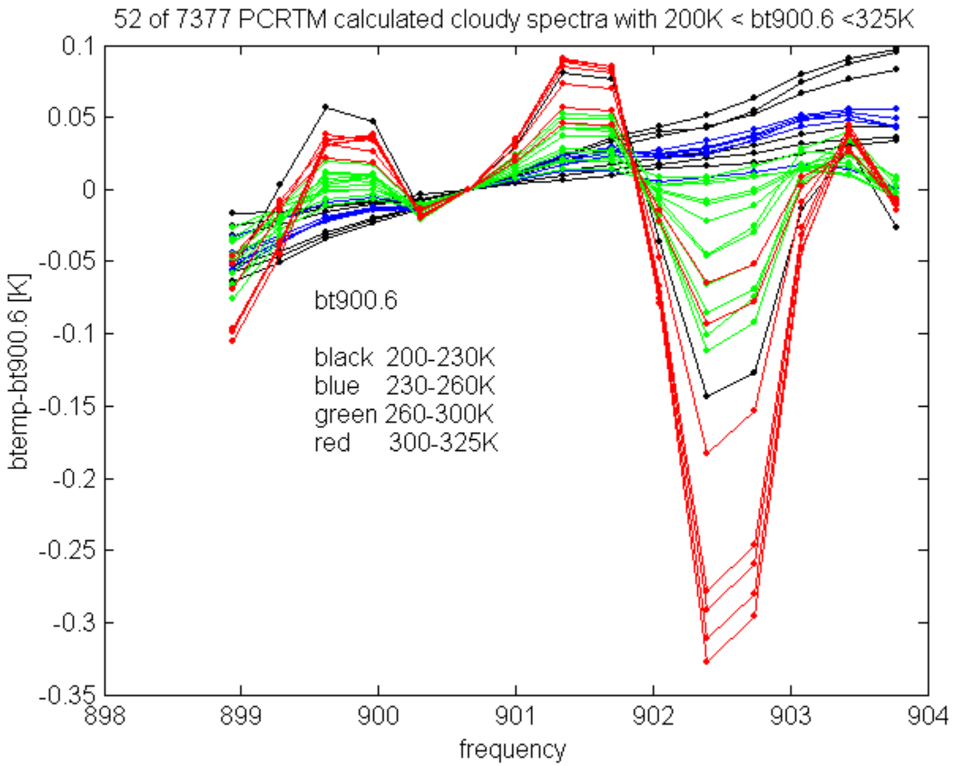
- For direct assimilation and L2 retrievals the requirements are very lenient.
  - In direct assimilation data were the difference between the observed and the expected disagree by more than 1K are rejected as “cloudy”.
  - If a L2 retrieval does not converge, the data are rejected because “the clouds are too difficult”.
  - Both methods apply a bias correction. L2 V6 uses a flat time independent bias correction. ECMWF uses a zonal and dynamic bias correction.

- For climate applications the requirements are much harder
  - All data which pass the instrument quality control are accepted
  - Clear and cloudy data are analyzed in large area and/or time ensembles.
  - Data which differ significantly from the mean can not be rejected as outliers
  - Difference of 100 mK are taken serious as potential indicators of climate change

- We focus on climate analysis of 5 years of AIRS and CrIS data

There are Spectral Response Function differences between the AIRS and CrIS

- We deal with this by limiting the analysis to the broad window area at 900 cm^{-1}
- For channels between 900 and 901 cm^{-1} the difference relative to 900.6 cm^{-1} is less than 0.05K for spectra with 200K < bt900.6 <325K.



We use Random Nadir Sampling (RNS)

Each day AIRS/ CrIS and IASI create 3 million spectral.
The bottle neck for effectively using that much data is data access time.

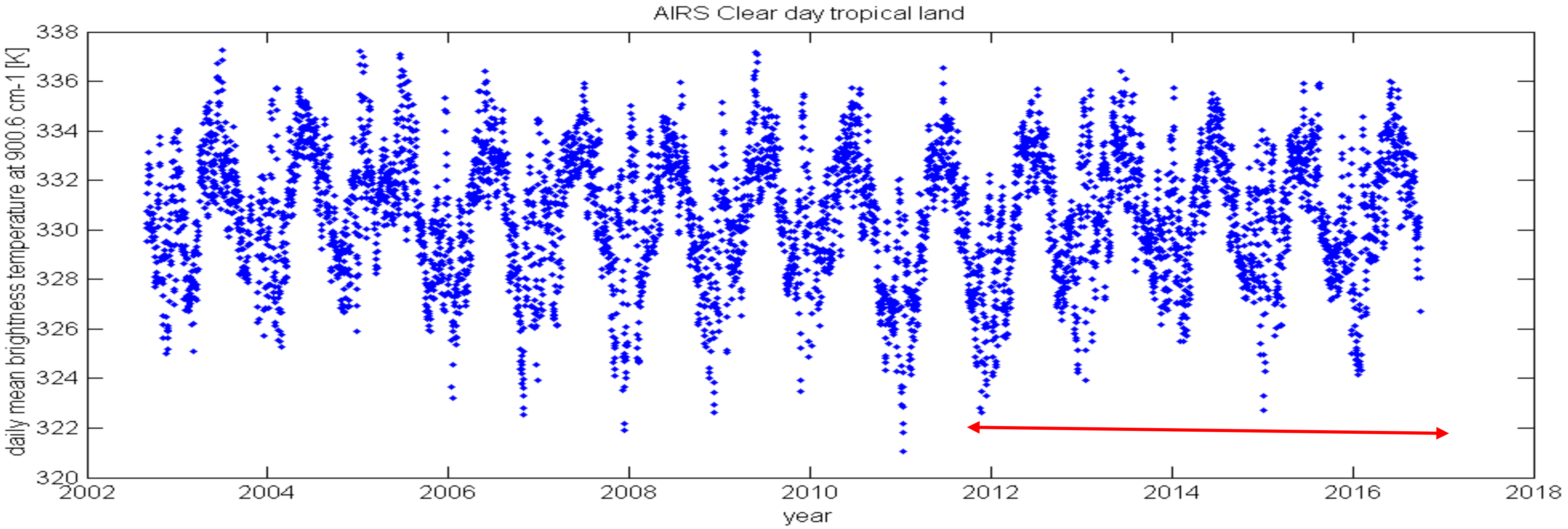
For climate analysis using all data is not necessary.
Removing the redundant high latitude coverage reduces the data to 2 million spectra.

RNS the 2 million spectra to typically 22,000 randomly, globally uniformly sampled data per day.

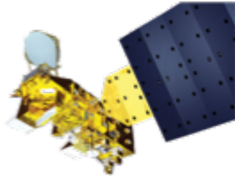
The 22,000 can be further subsetted. We then analyze the time series of the daily mean values

Example: Maximum bt900 for day tropical land

Each day we find typically 1000 RNS from day tropical land.
Select the maximum and plot the time series.
15 year mean = 330.61 K. trend -0.03K/year, trend uncertainty 0.02 K/year



Do this for the 5 years where we have overlap between AIRS and CrIS.



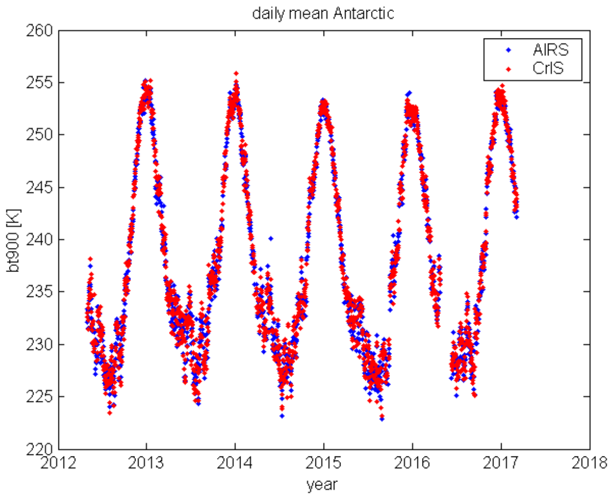
Data

- We use Random Nadir Samples (RNS) from AIRS and CrIS between May2012 and March 2017 from the AIRS and CrIS Calibration Data Subsets.

- The AIRS data use the L1B V5, which is based on the pre-launch calibration 1998.

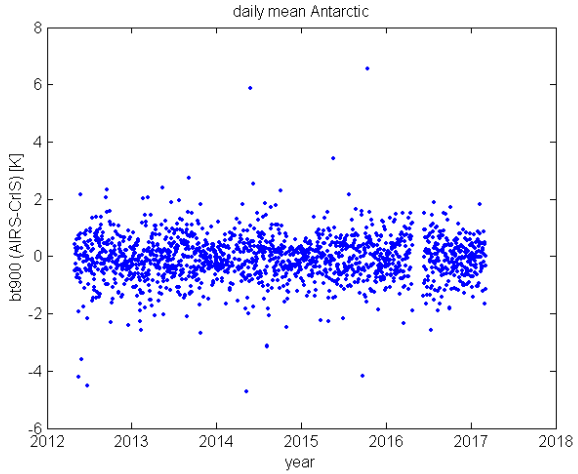
- The CrIS data use the NOAA (CCAST) calibration using the recommended quality control. We do not distinguish between which of the 9 CrIS detector elements is selected.

CrIS is 0.07K warmer than AIRS in the Antarctic Zone (lat<-60). Excellent.



AIRS 5 year mean
239.522±0.259K

CrIS 5 year mean
239.653±0.260K



AIRS –CrIS 5 year mean

-0.071±0.016K

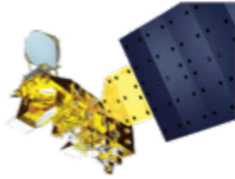
No trends. High common mode signal cancellation. High outliers from daily mean

These are the differences between the daily mean values calculated from 1000 daily observations.

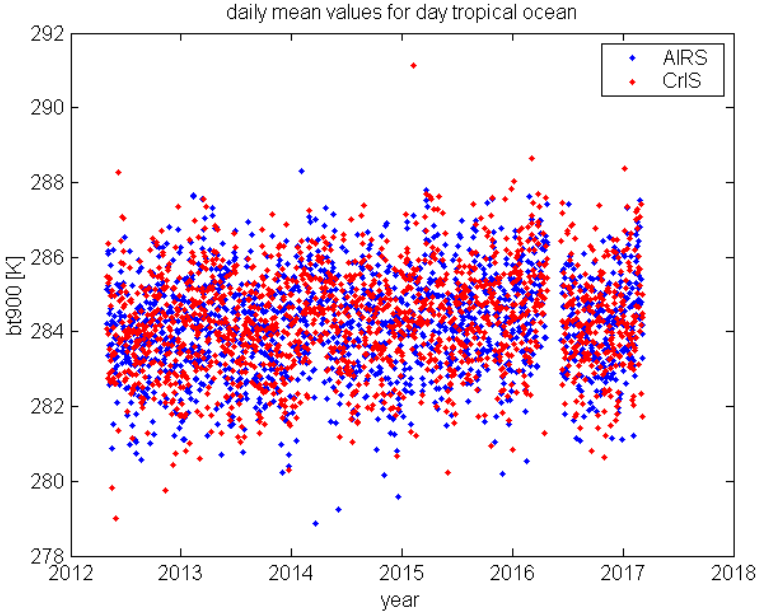
Note that for several days the mean of AIRS of 1000 points was 4K warmer than CrIS!

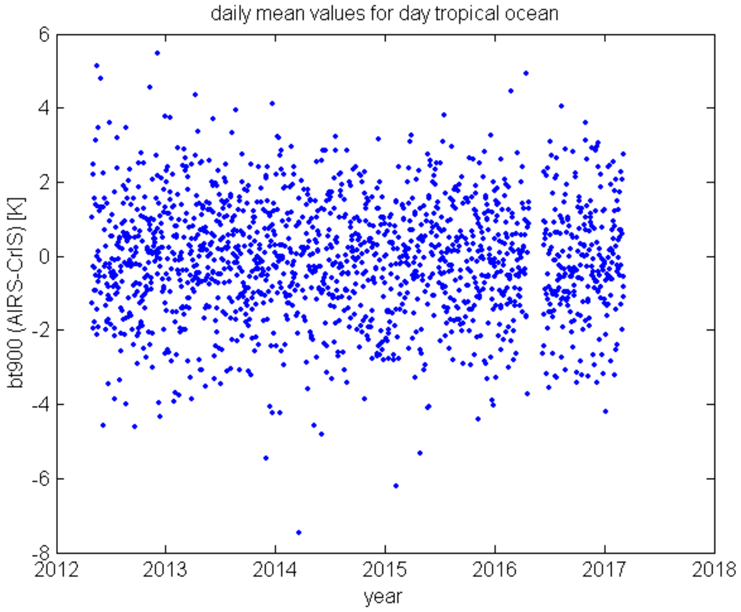
This is not a simple data dropout.

But this does not degrade the good value of the 5 year mean.



CrIS is 0.1K warmer than AIRS for RNS from day tropical ocean. Excellent.





These are the differences between the means calculated from 4000 daily observations.

The +/- 4K difference is surprisingly large, but maybe due to the presence of clouds

AIRS 5 year mean
284.17±0.032K

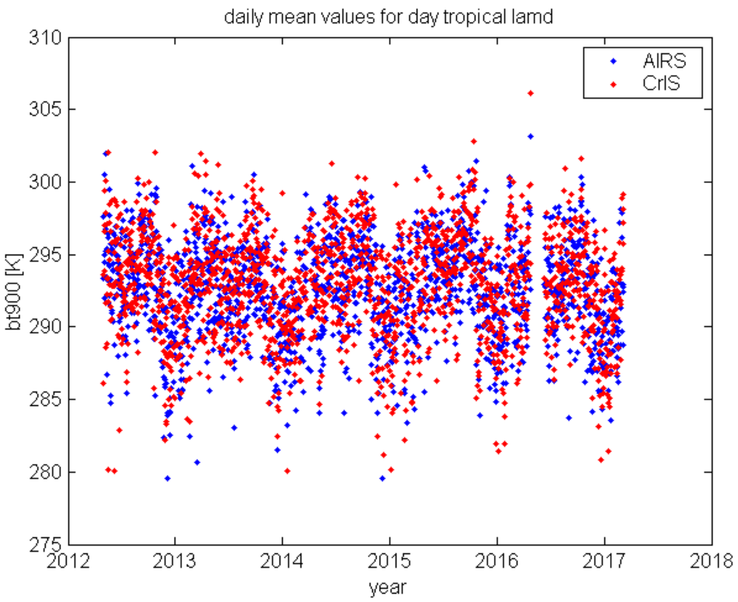
CrIS 5 year mean
284.25±0.036K

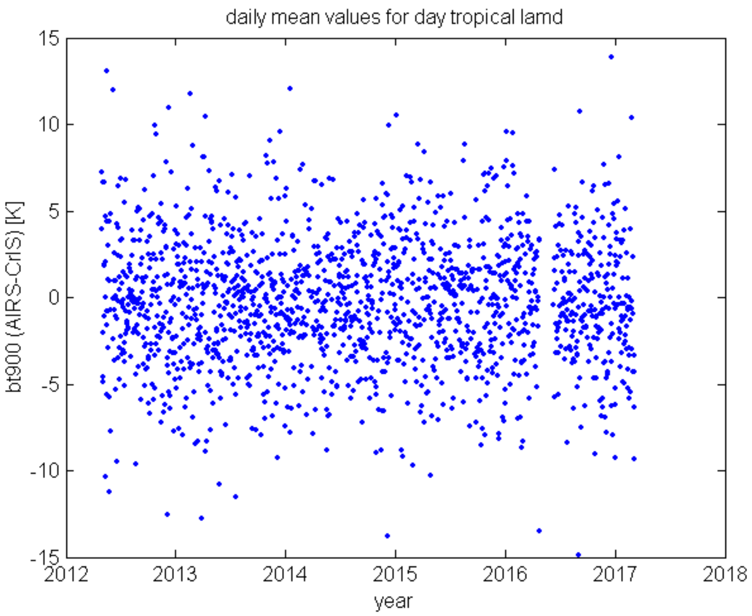
AIRS –CrIS 5 year mean

-0.098±0.037K

No trend in the difference.

The warm CrIS bias relative to AIRS increases for day tropical land to 0.25K





These are the differences between the daily mean values calculated from 1000 daily observations.

The difference are surprisingly large, but maybe are due to the presence of clouds

AIRS 5 year mean 291.51±0.082K

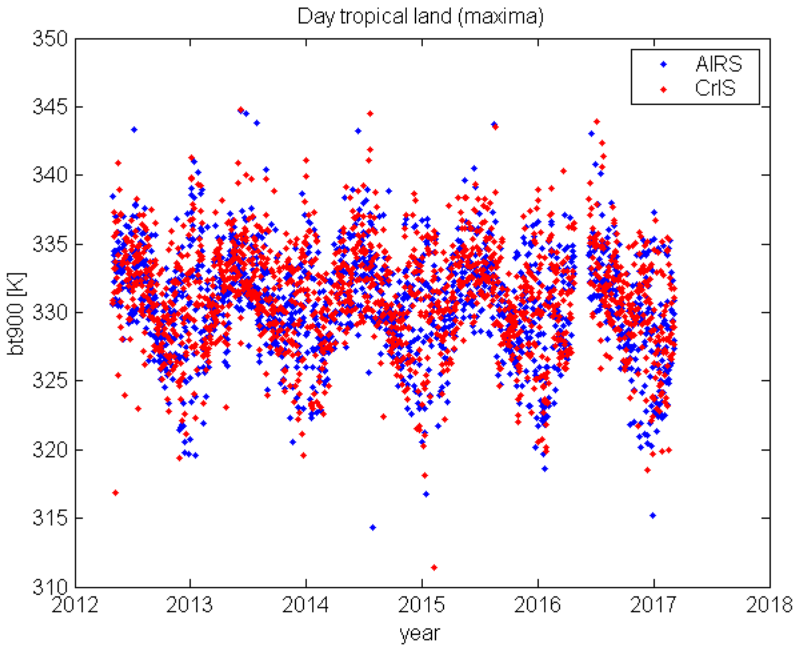
CrIS 5 year mean 292.81±0.082K

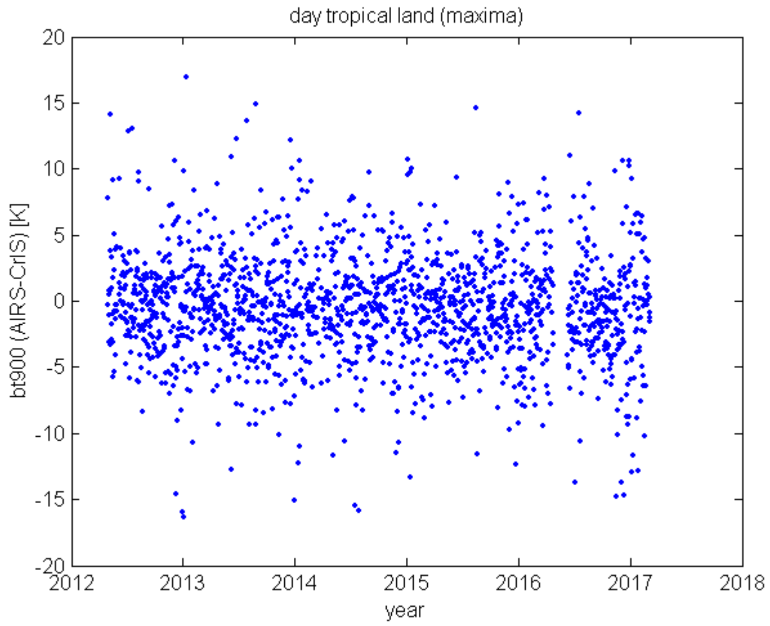
AIRS –CrIS 5 year mean -0.2462±0.082K

No trends. High common mode signal cancellation.

For RNS max day tropical land the warm bias of CrIS increases to 0.46K

Day clear land is interesting for climate change of desertification.





CrIS is on average 0.46K warmer than AIRS under extreme warm cases.

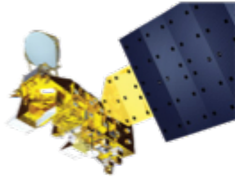
Note that the AIRS 5 year mean was 330.612K

AIRS 5 year mean 330.612±0.086K

CrIS 5 year mean 330.988±0.088K

AIRS –CrIS 5 year mean

-0.461±0.083K

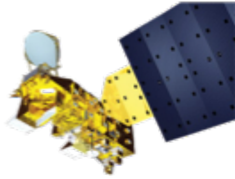


The CrIS bias relative to AIRS shifts from
+0.07K at 240K (polar)
+0.10K at 284K (day tropical ocean)
+0.25K at 291K (tropical day land)
+0.46K at 330K (clear day tropical land)

The differences seen for day tropical land are far in excess of the 0.1K thresholds accepted for climate change evaluations.

If AIRS and CrIS data were not taken at the same time, the differences would be interpreted as climate change

What could cause this warm CrIS bias under warmer than 300K conditions?



Why is CrIS warmer than AIRS at temperatures above 300K?

- **The AIRS and CrIS orbits have the same ascending nodes, but the orbit inclinations are slightly different. In the tropical zone the Sun is about 6 minutes closer the local noon than for AIRS. This will not credibly explain the 0.25K warmer mean, 0.46K warmer max from CrIS during the day.**

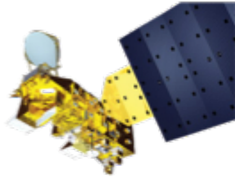
  A sun-angle difference effect could be corrected if the diurnal cycle is accurately known.

  Very difficult.

- **AIRS and CrIS have nominally the same footprint size of about 14 km at ½ peak, but CrIS stares, while AIRS scans in cross track.**

  This subtle difference is may be an explanation for the warmer CrIS footprints. Not clear if there is a unique software fix possible.

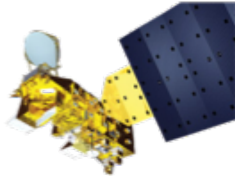
- **This may be a non-linearity issue. This requires verification, but a fix in a new calibration release is possible.**



Summary

- Under average conditions AIRS and CrIS agree at the +/-100 mK level.
- Under warmer than 300K conditions CrIS is up to 0.46K warmer than AIRS .

  This is far in excess of the 0.1K thresholds accepted for climate change applications.
- This difference complicates the desired “seamless” transition between AIRS and CrIS.
- Sun-angle differences, footprint size differences and residual non-linearity are possible causes
- If the subtle footprint size difference between AIRS and CrIS is the reason for the difference, then plans to “improve” the next generation CrIS spatial resolution from the current 14 km (9x9 array) to 6 km will further complicate the interpretation of the time series of hyperspectral data started in 2002.



Thanks for your attention