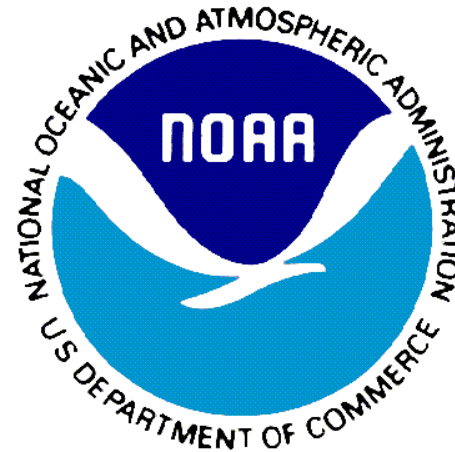


# Characterization of Infrared Imager/Sounder and Infrared/Microwave Sounder Synergistic Cloud-Cleared Infrared Radiances

*H.-L. Allen Huang, Li Guan, Kevin Baggett, Jun Li, Chian-Yi Liu, Xuebao Wu*  
Cooperative Institute for Meteorological Satellite Studies, UW-Madison  
*Timothy J. Schmit, W. Paul Menzel*  
Office of Research and Applications, NOAA/NESDIS



**ITSC-14**

**Beijing, China**

**25 May 2005**

# Characterization of Infrared Imager/Sounder and Infrared/Microwave Sounder Synergistic Cloud-Cleared Infrared Radiances

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Cooperative Institute for Meteorological Satellite Studies, UW-Madison  
&

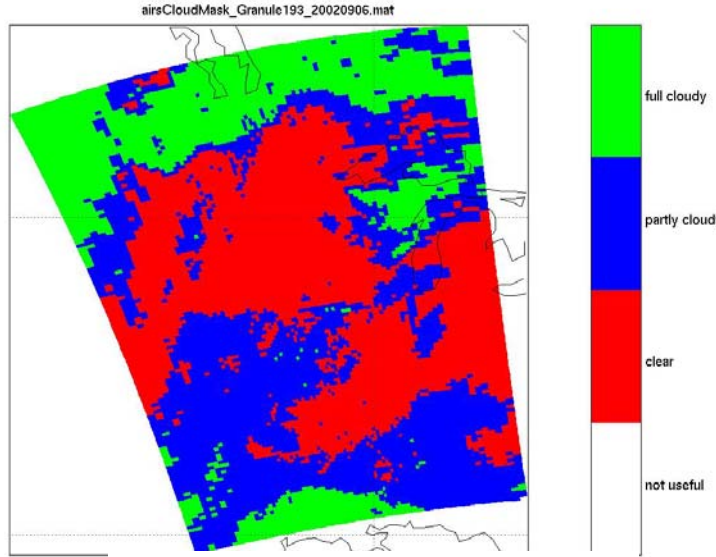
*Timothy J. Schmit, W. Paul Menzel*  
Office of Research and Applications, NOAA/NESDIS

## ABSTRACT

- To evaluate the characteristics of these cloud-cleared radiances and their potential for improvements of numerical weather prediction and cloudy sounding applications.
- Preliminary results have shown that these two approaches, though quite different in character, and processing methodology, are both effective and have certain unique characteristics and deficiencies.

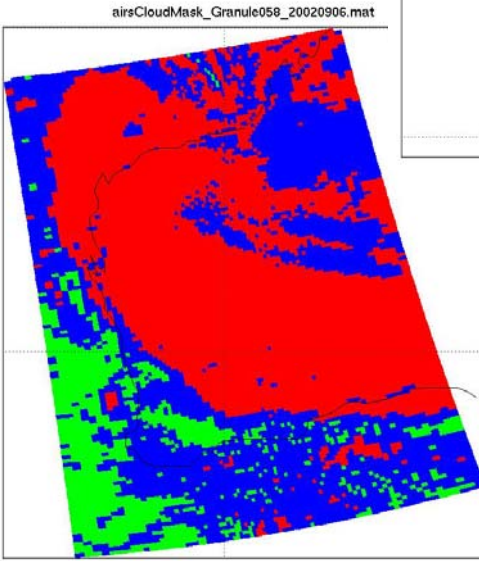
# Case Granule Dataset Used

2 Sep. 2002  
AIRS  
Focus Day

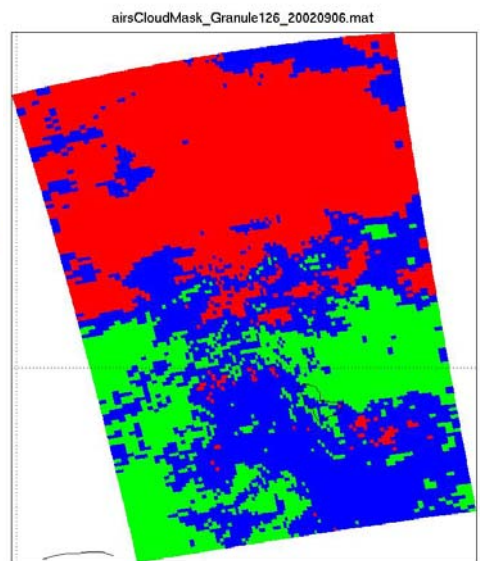


Wisconsin Granule

- 4 Granules of Collocated AIRS & MODIS Data
- MODIS 1-km Cloud Mask
- AIRS C.M. (from MODIS)
- No ancillary data used

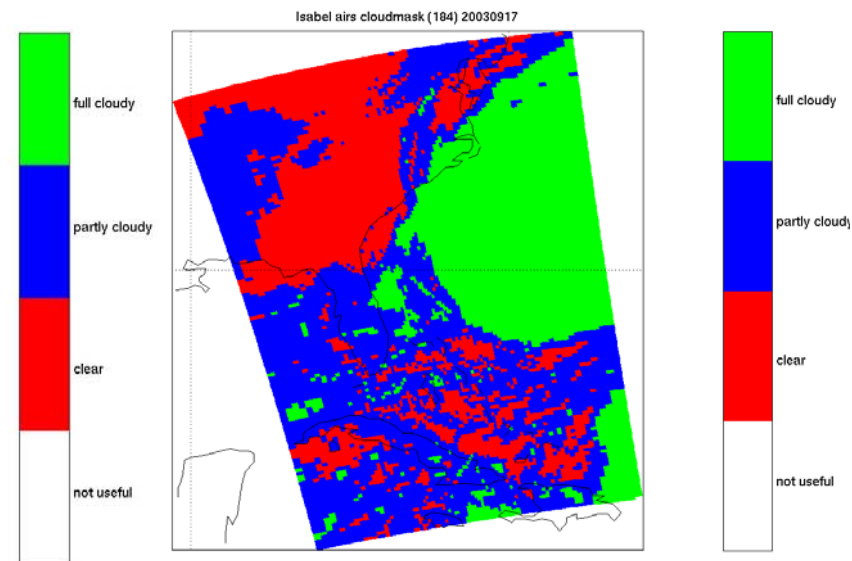


Australia Granule



South Africa Granule

17 Sep. 2003

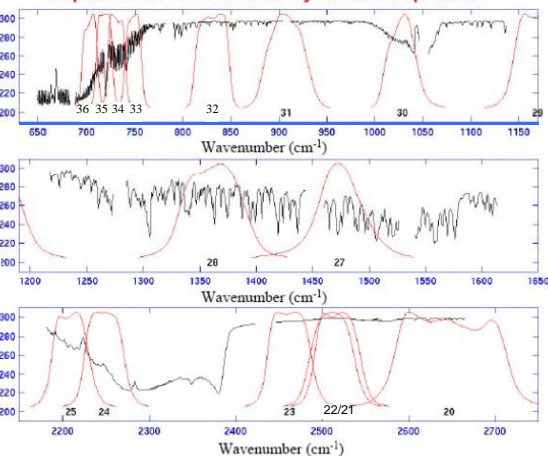


Hurricane Isabel Granule

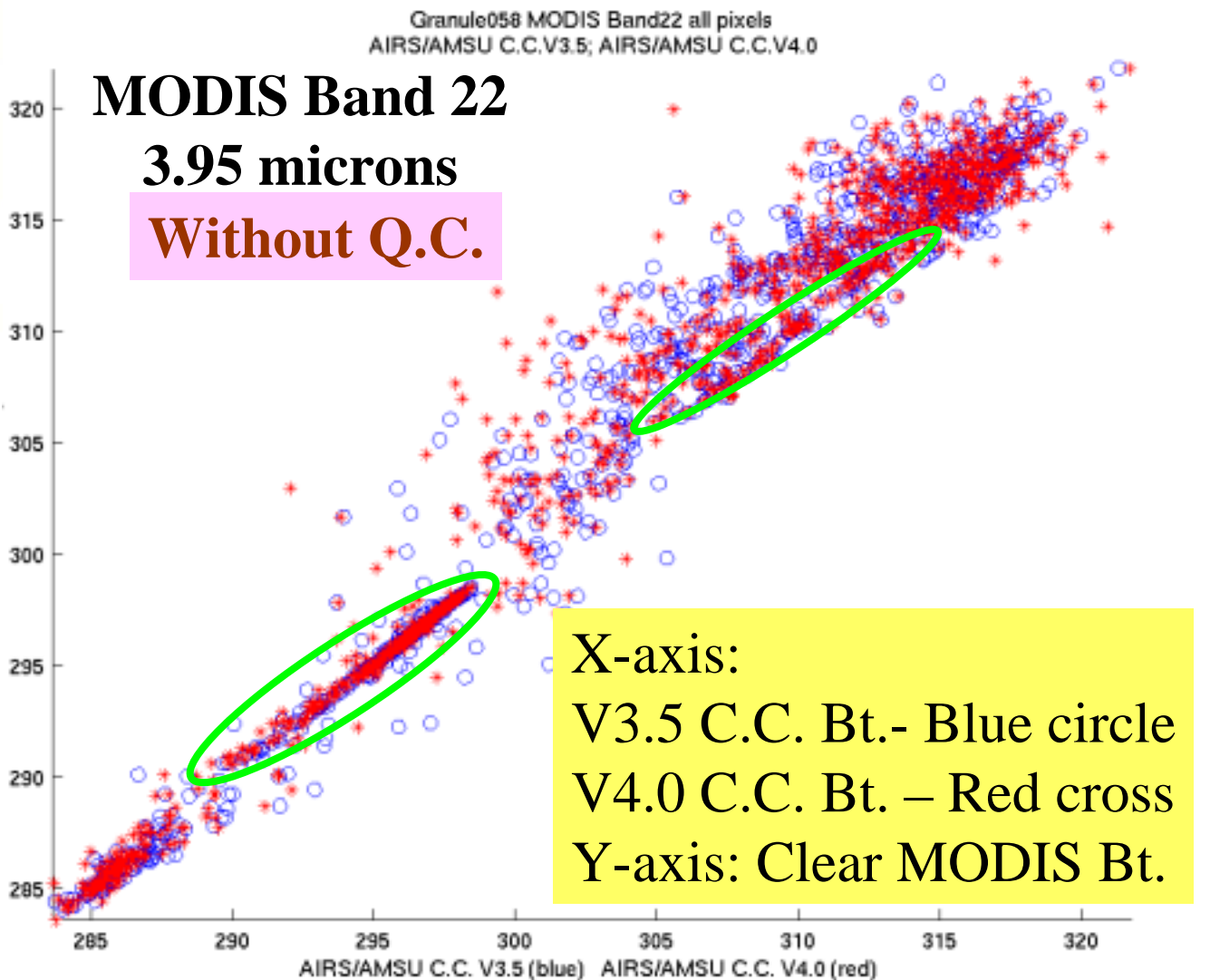
# AIRS/AMSU (3 by 3 AIRS FOV) V3.5 Vs V4.0 C.C. Comparison

58\_20020906 MODIS Band22 JPL C.C. V3.5-V4.0

Aqua MODIS IR SRF Overlay on AIRS Spectrum

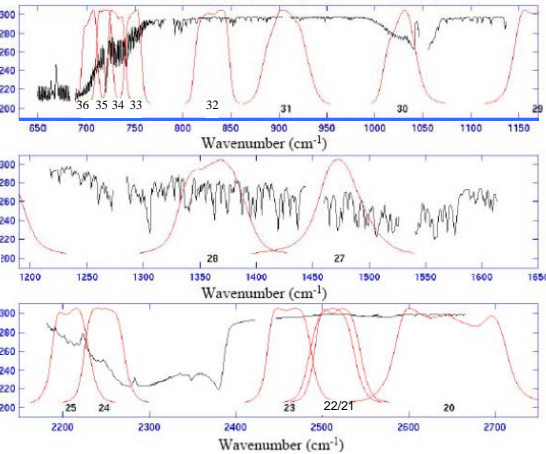


**MODIS Band 22**  
**3.95 microns**



# AIRS/AMSU (3 by 3 AIRS FOV) V3.5 Vs V4.0 C.C. Comparison

Aqua MODIS IR SRF Overlay on AIRS Spectrum



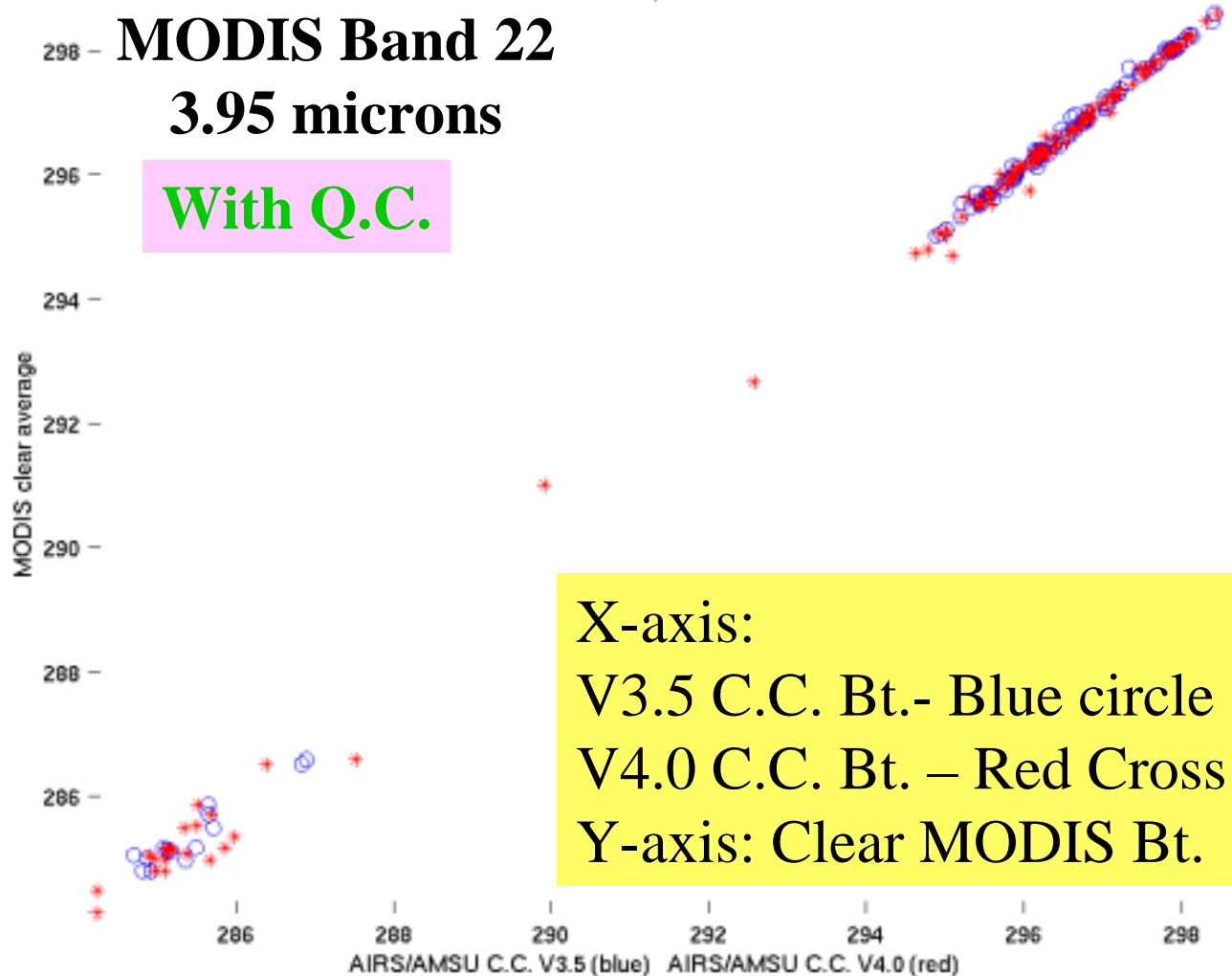
Q.C. filtered most of the unreliable data as well as some good data.

Granule058 MODIS Band22 (JPL Q.C.successful pixels)  
AIRS/AMSU C.C.V3.5; AIRS/AMSU C.C.V4.0

298 – MODIS Band 22

3.95 microns

With Q.C.



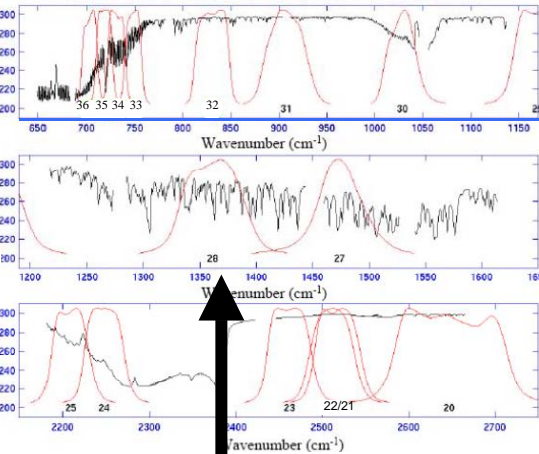
X-axis:  
V3.5 C.C. Bt.- Blue circle  
V4.0 C.C. Bt. – Red Cross  
Y-axis: Clear MODIS Bt.

AIRS/AMSU C.C. V3.5 (blue) AIRS/AMSU C.C. V4.0 (red)

# AIRS/AMSU (3 by 3 AIRS FOV) V3.5 Vs V4.0 C.C. Comparison

058\_20020906 MODIS Band28 JPL C.C. V3.5-V4.0

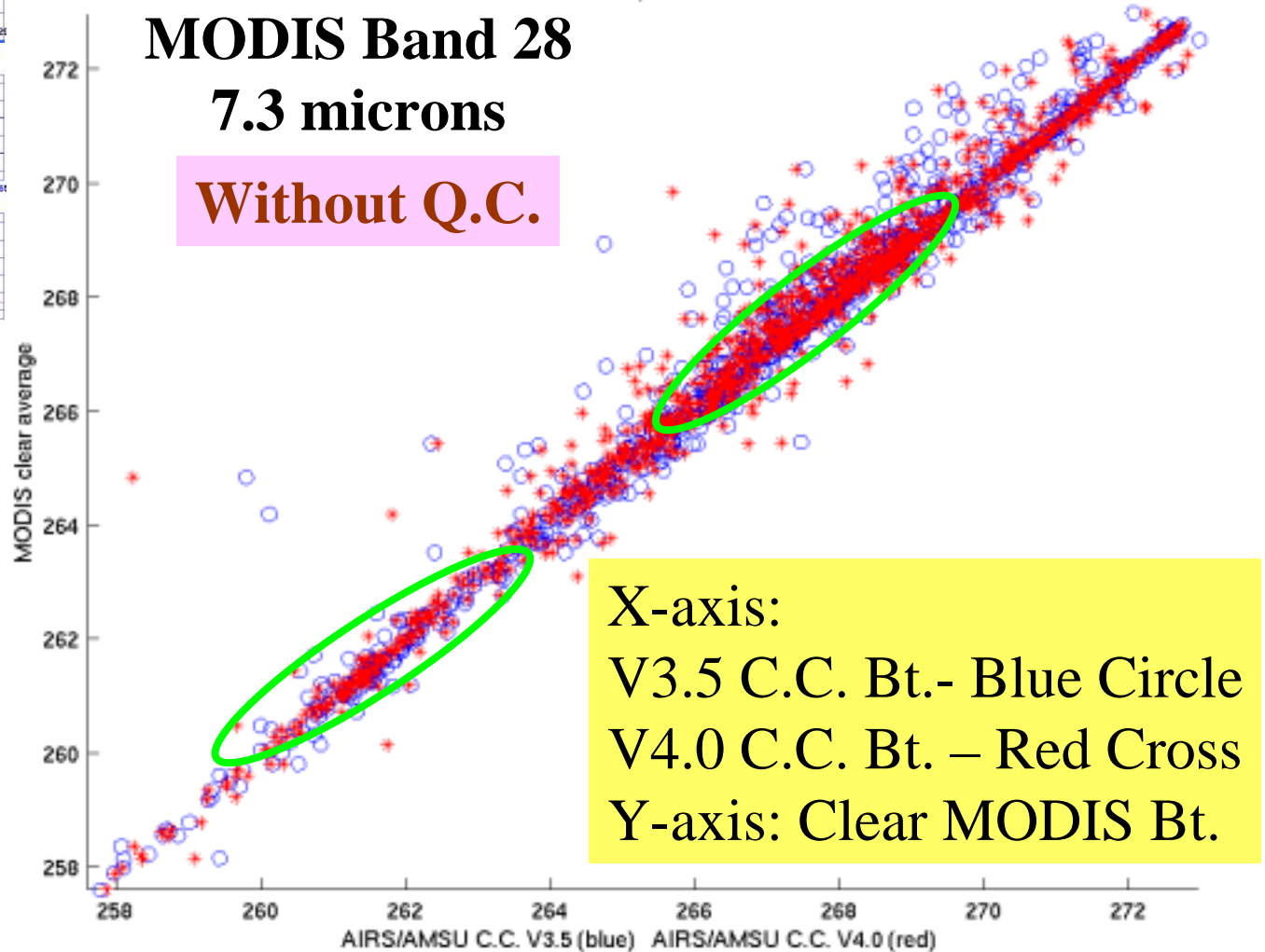
Aqua MODIS IR SRF Overlay on AIRS Spectrum



**MODIS Band 28**  
**7.3 microns**

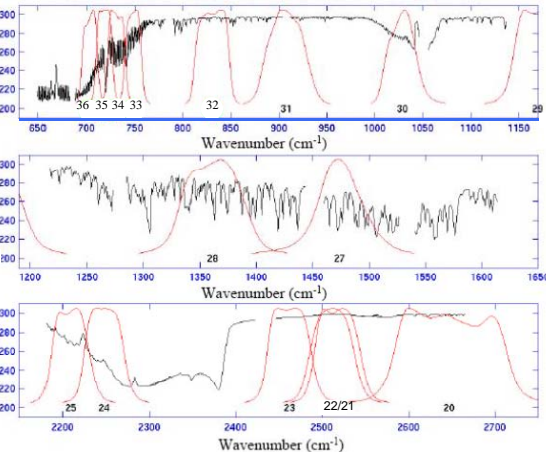
Granule058 MODIS Band28 all pixels  
AIRS/AMSU C.C.V3.5; AIRS/AMSU C.C.V4.0

**MODIS Band 28**  
**7.3 microns**  
**Without Q.C.**



# AIRS/AMSU (3 by 3 AIRS FOV) V3.5 Vs V4.0 C.C. Comparison

Aqua MODIS IR SRF Overlay on AIRS Spectrum



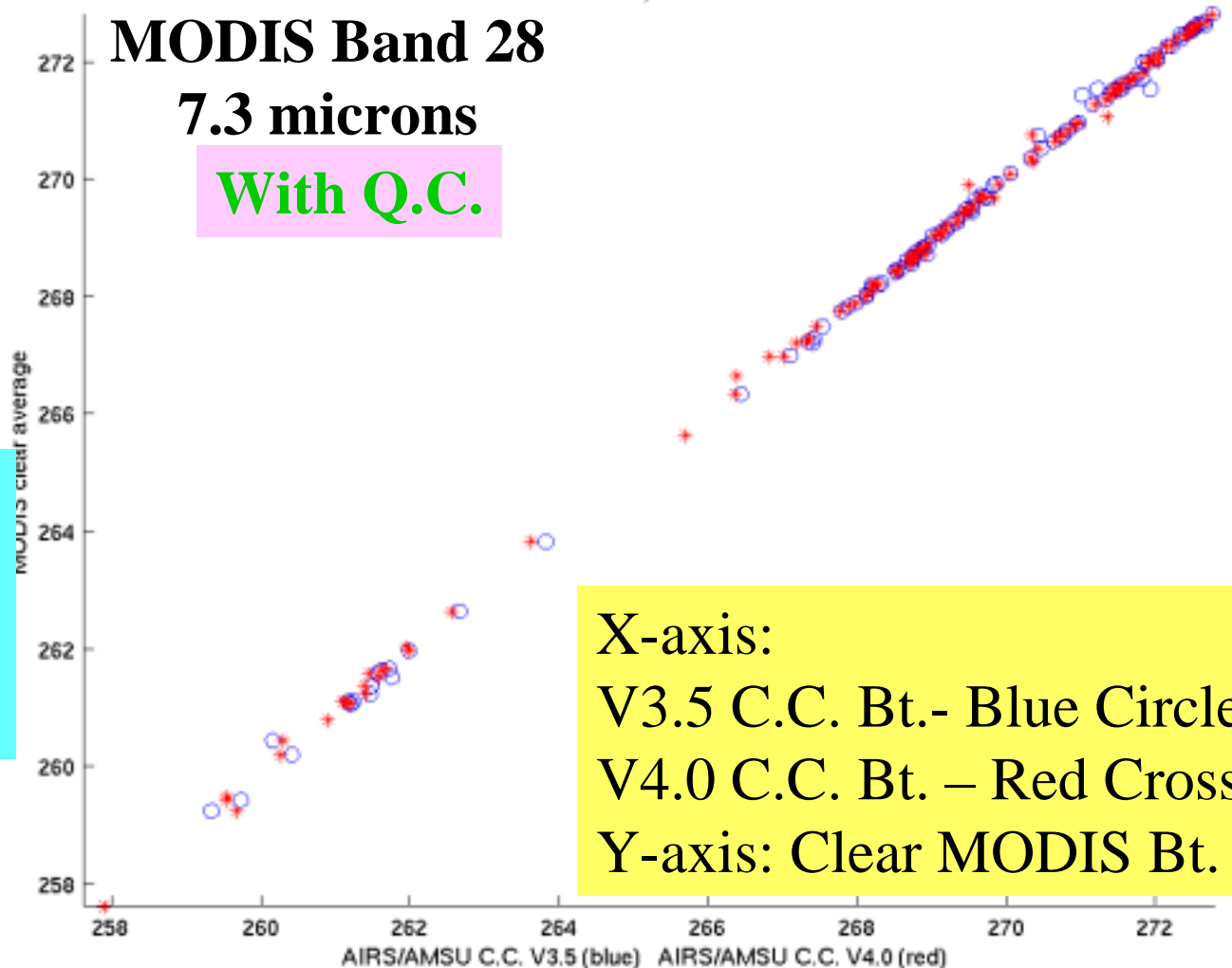
Q.C. filtered most of the unreliable data as well as some good data.

Granule058 MODIS Band28 (JPL Q.C.successful pixels)  
AIRS/AMSU C.C.V3.5; AIRS/AMSU C.C.V4.0

## MODIS Band 28

### 7.3 microns

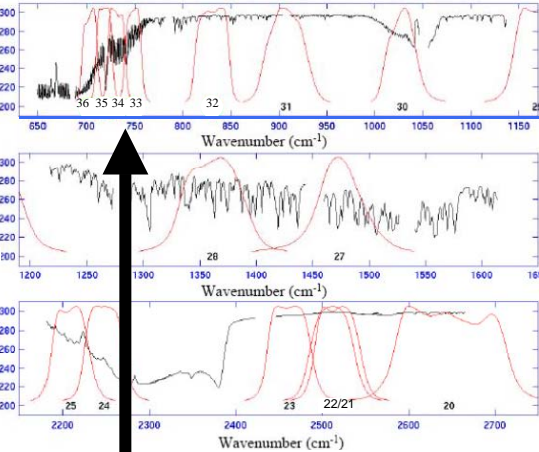
With Q.C.



# AIRS/AMSU (3 by 3 AIRS FOV) V3.5 Vs V4.0 C.C. Comparison

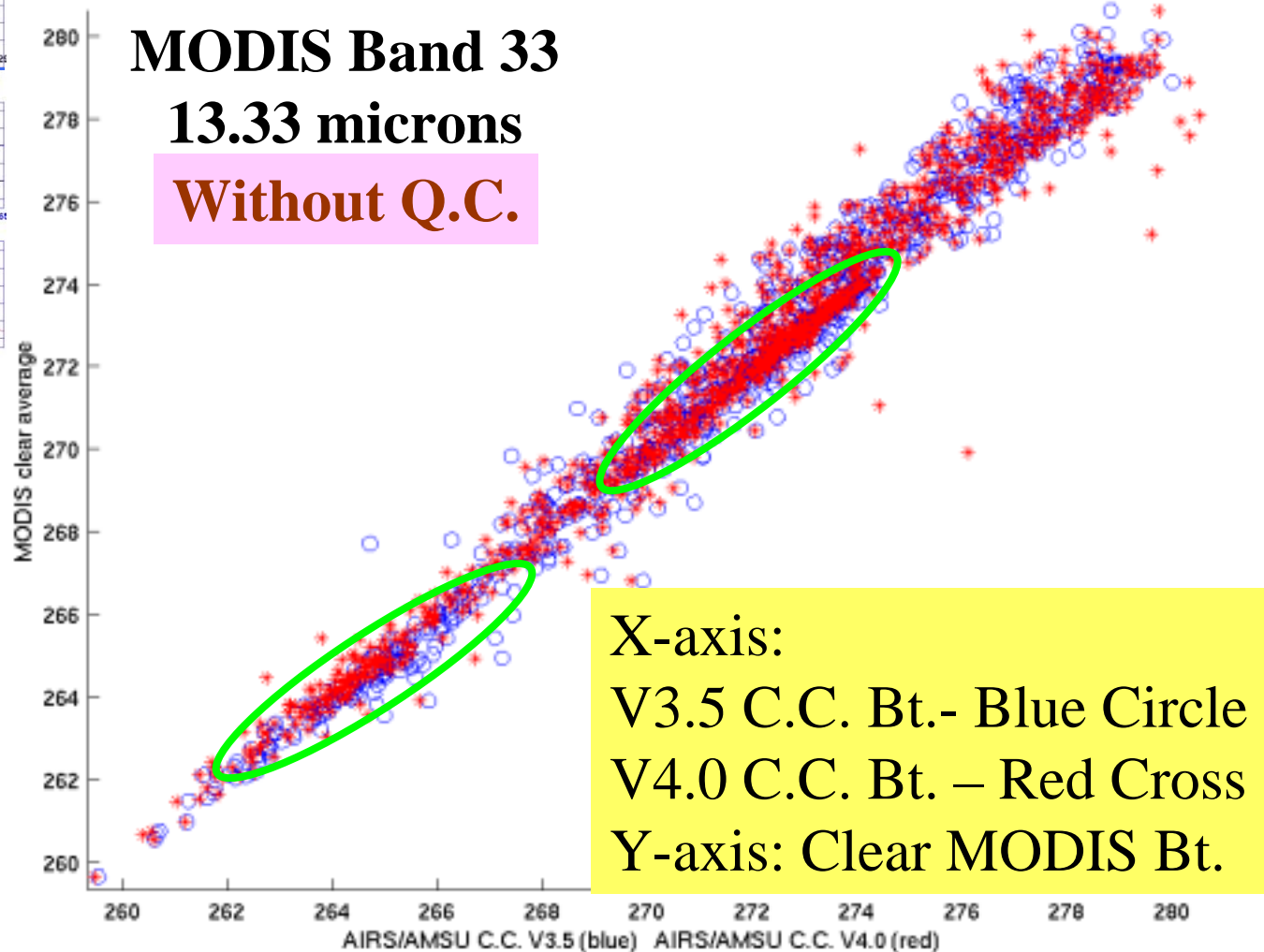
058\_20020906 MODIS Band33 JPL C.C. V3.5-V4.0

Aqua MODIS IR SRF Overlay on AIRS Spectrum



**MODIS Band 33**  
**13.33 microns**

Granule058 MODIS Band33 all pixels  
AIRS/AMSU C.C.V3.5; AIRS/AMSU C.C.V4.0



**MODIS Band 33**  
**13.33 microns**  
**Without Q.C.**

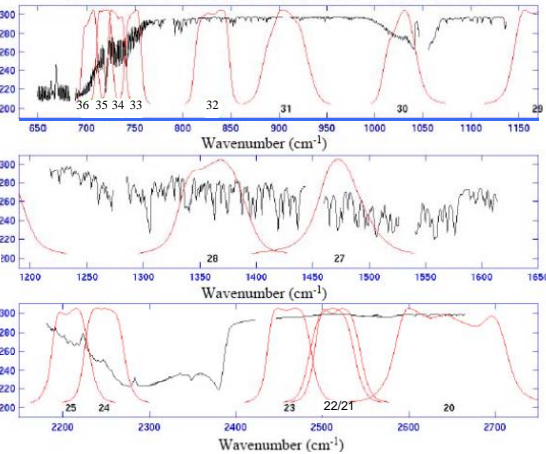
X-axis:  
V3.5 C.C. Bt.- Blue Circle  
V4.0 C.C. Bt. – Red Cross  
Y-axis: Clear MODIS Bt.

AIRS/AMSU C.C. V3.5 (blue) AIRS/AMSU C.C. V4.0 (red)



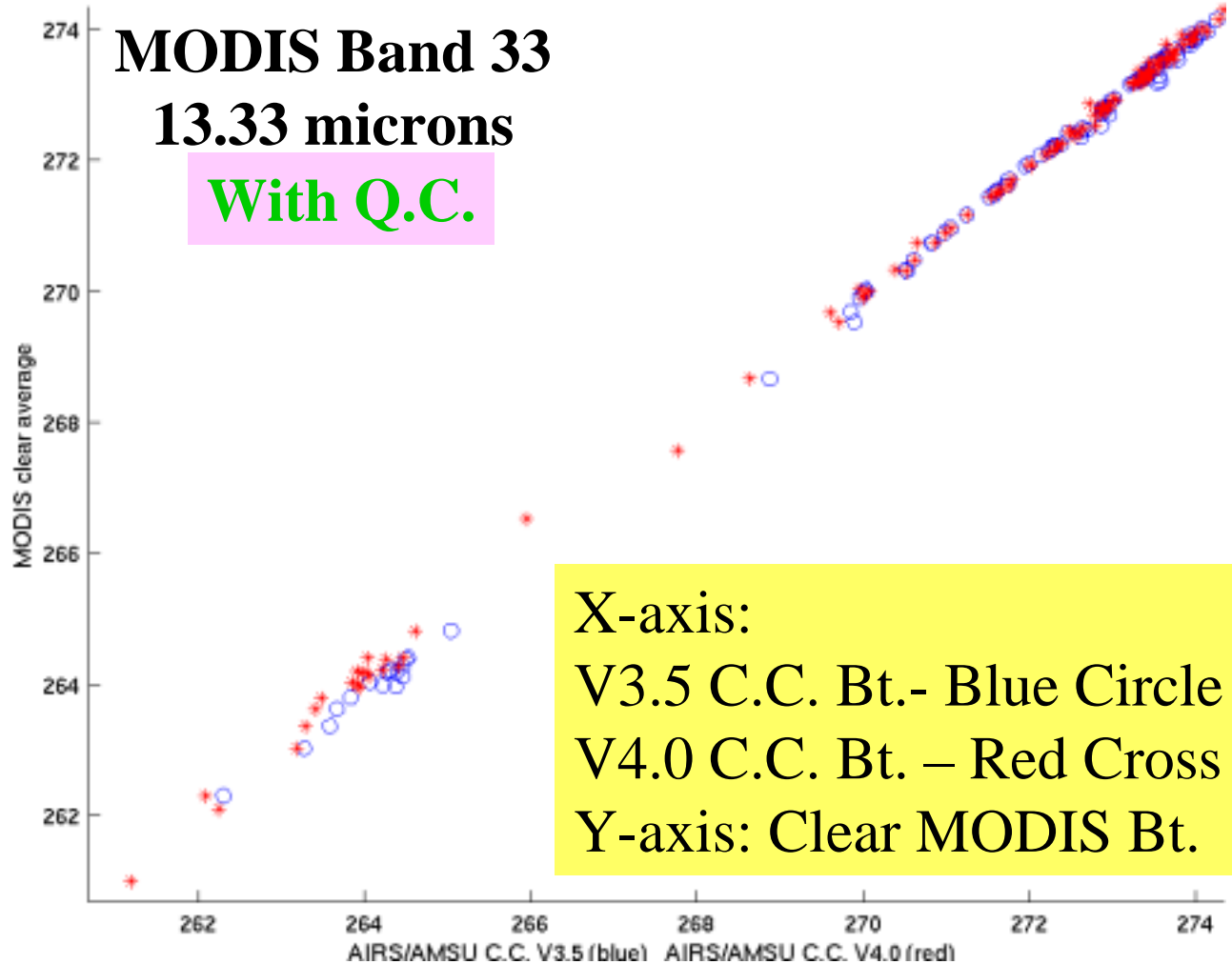
# AIRS/AMSU (3 by 3 AIRS FOV) V3.5 Vs V4.0 C.C. Comparison

Aqua MODIS IR SRF Overlay on AIRS Spectrum



Q.C. filtered most of the unreliable data as well as some good data.

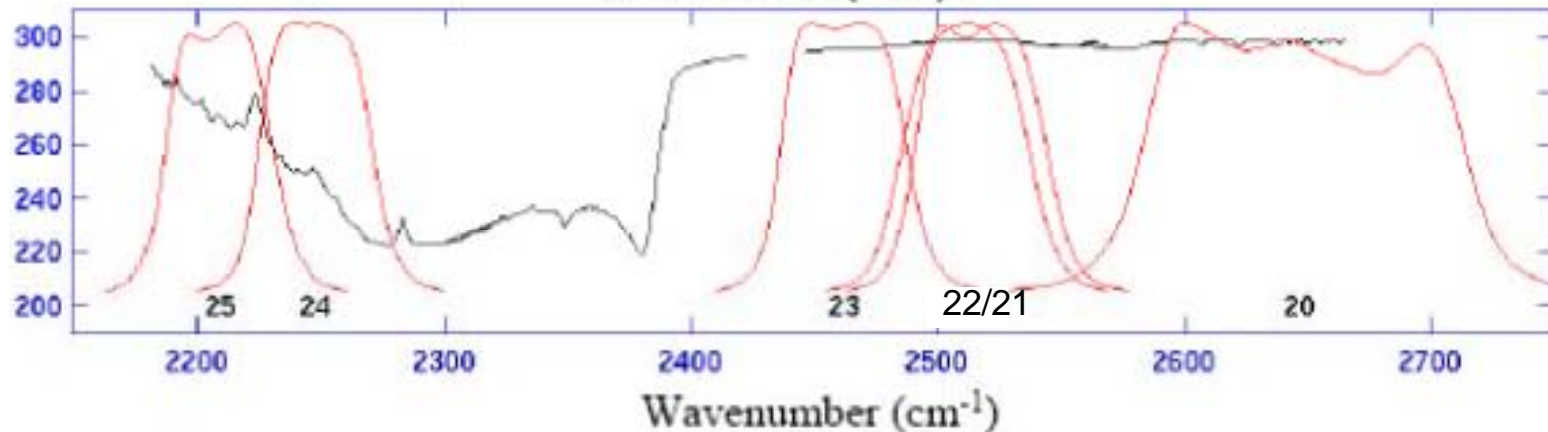
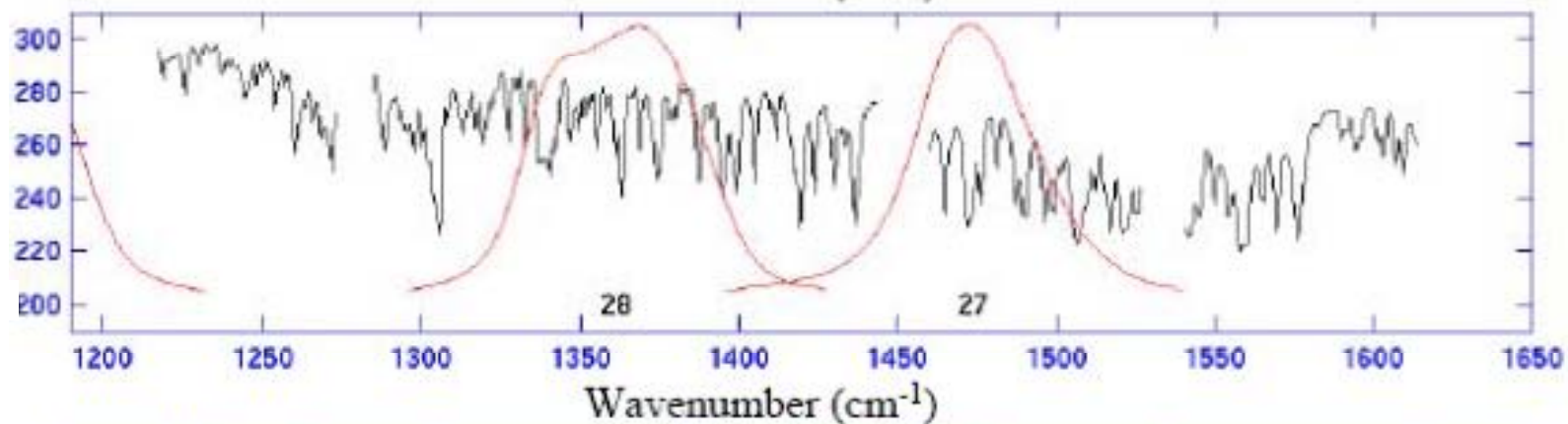
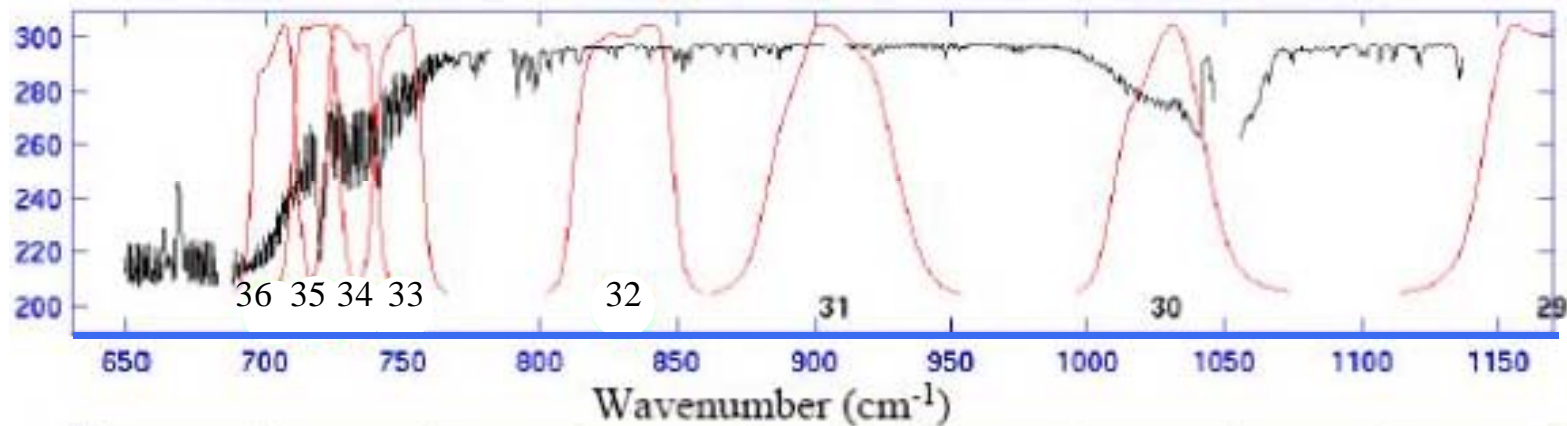
Granule058 MODIS Band33 (JPL Q.C.successful pixels)  
AIRS/AMSU C.C.V3.5; AIRS/AMSU C.C.V4.0



**MODIS Band 33**  
**13.33 microns**  
**With Q.C.**

X-axis:  
V3.5 C.C. Bt.- Blue Circle  
V4.0 C.C. Bt. – Red Cross  
Y-axis: Clear MODIS Bt.

# Aqua MODIS IR SRF Overlay on AIRS Spectrum



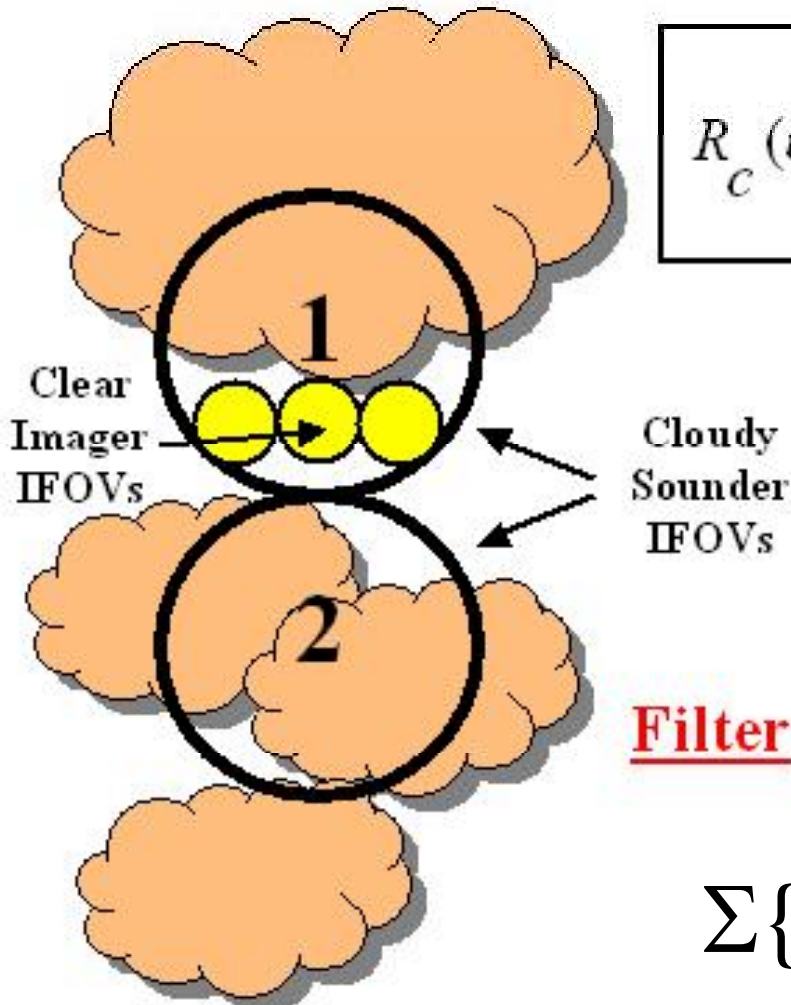
# MODIS/AIRS Synergistic N\* Cloud Clearing

	MODIS Bands Used in C.C.	MODIS Bands Used in Q.C.
Multi-band N*	22 24 25 28 30 31 32 33 34	22 24 25 28 30 31 32 33 34
Single-band N*	31 or 22	22 24 25 28 30 31 32 33 34

## Threshold for AIRS Pair C.C. Retrieval:

Each AIRS footprint within the C.C. pair (2 by 1 ) must have at least 15 MODIS confident clear (P=99%) pixel (partly cloudy)

# MODIS/AIRS Synergistic Single-Channel $N^*$ Cloud-Clearing General Principal



$$R_c(\nu) = \frac{R_1(\nu) - N^* R_2(\nu)}{1 - N^*}$$

Where;  
 $N^* = N_1/N_2$ .

$$N^* = \frac{\text{srf}[R_1(w)] - R_c(w)}{\text{srf}[R_2(w)] - R_c(w)}$$

$$\text{srf}[R_i(w)] = \int \theta(w, \nu) R_i(\nu) d\nu$$

**Filter:** Or Q.C.

$$\Sigma \{ \text{srf}[R_c(\delta\nu_j)] - R_c(\delta\nu_j) \}^2 \leq \epsilon$$

# MODIS/AIRS Synergistic Multi-Channel N\* Cloud Clearing

## General Principal

$$J(N^*) = \sum_i \frac{1}{\sigma_i} [(R_{M_i}^{clr} - f_i(R_v^{cc}))]^2$$

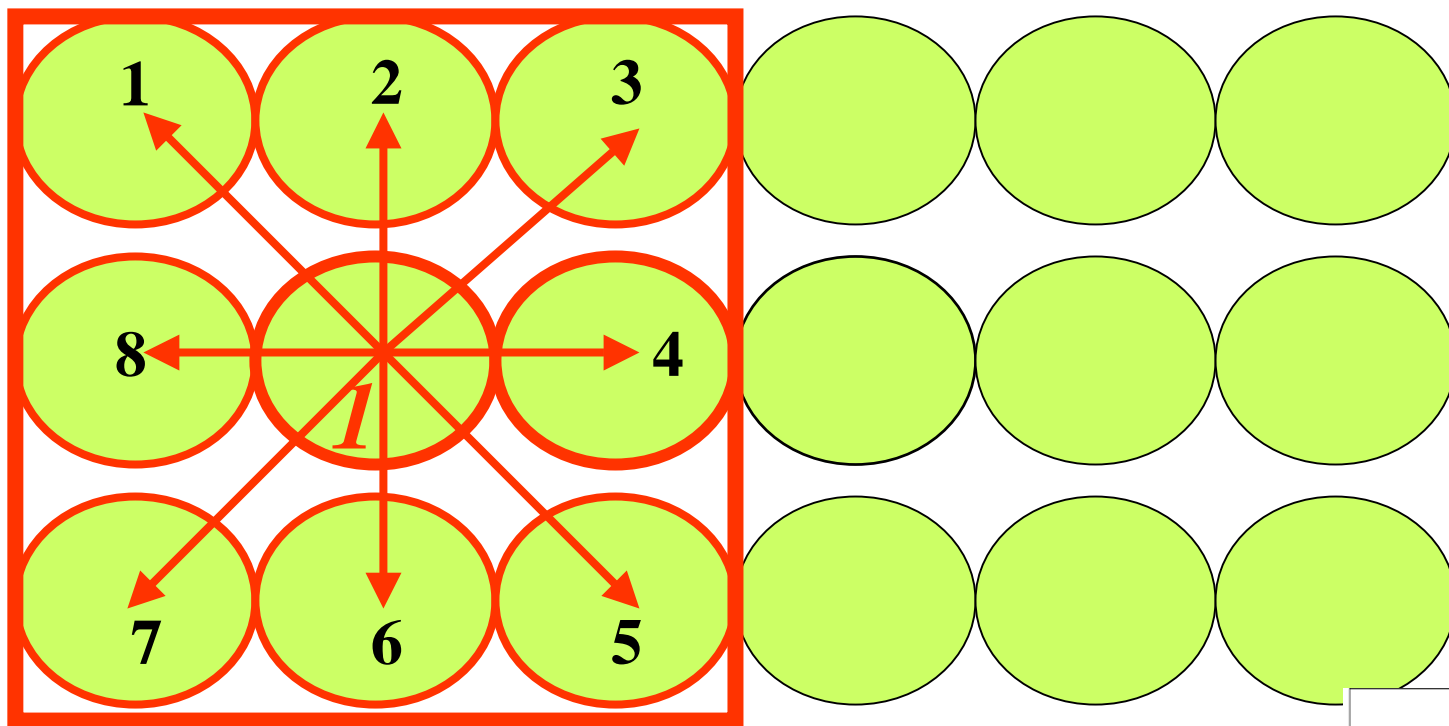
$$J(N^*) = \sum_i \frac{1}{\sigma_i} [(R_{M_i}^{clr} - f_i(\frac{R_v^1 - R_v^2 N^*}{1 - N^*}))]^2$$

$$\frac{\partial J(N^*)}{\partial N^*} = 0$$

$$N^* = \frac{\sum_i \frac{1}{\sigma_i^2} [f_i(R_v^1) - R_{M_i}^{clr}] [f_i(R_v^1) - f_i(R_v^2)]}{\sum_i \frac{1}{\sigma_i^2} [f_i(R_v^2) - R_{M_i}^{clr}] [f_i(R_v^1) - f_i(R_v^2)]}$$

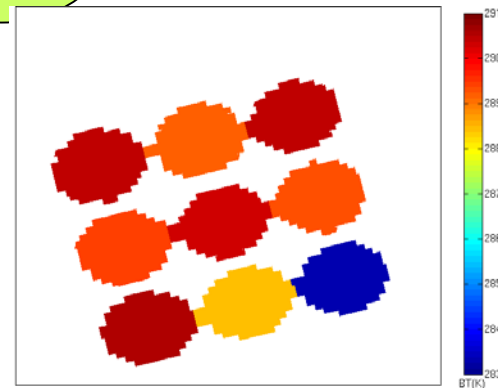
# MODIS/AIRS Synergistic N\* Cloud Clearing Over Sampling Strategy

8 possible AIRS pairs (2 FOVs)



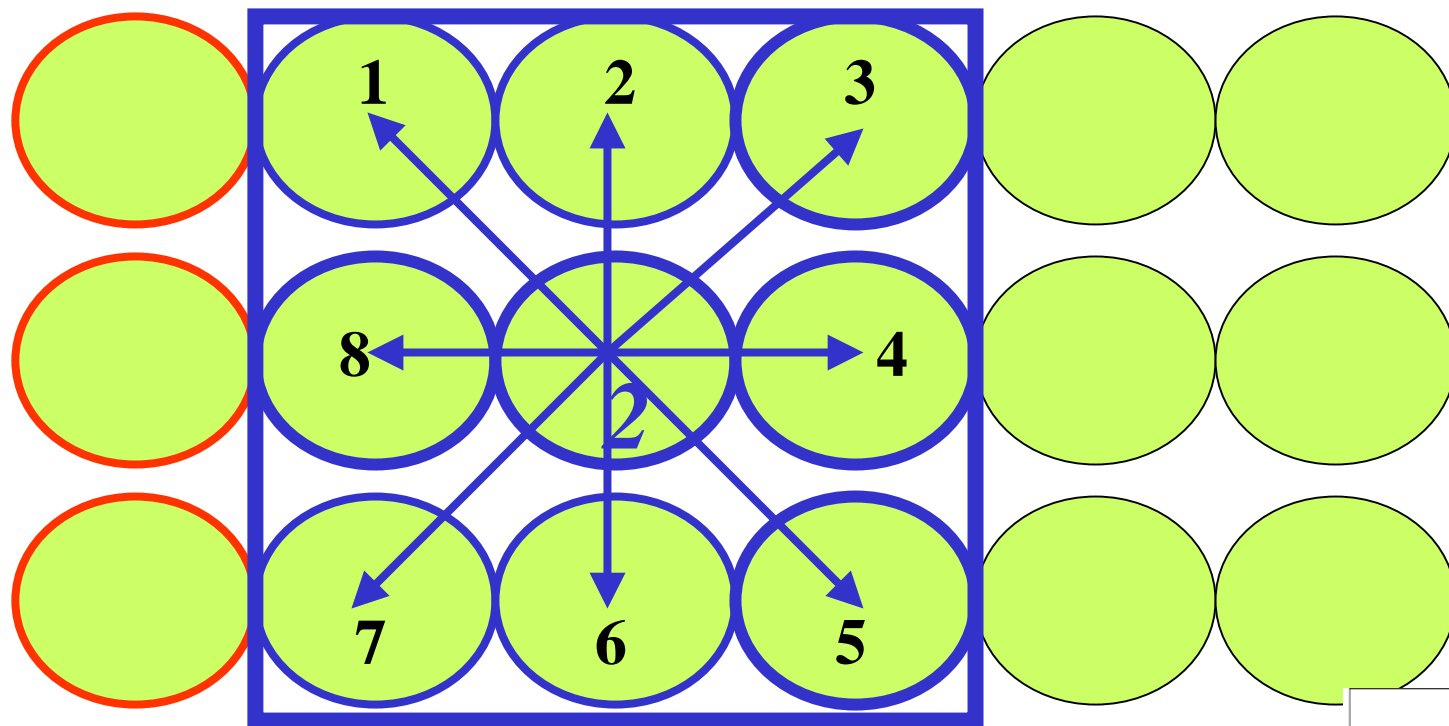
1

Pseudo Single AIRS FOV

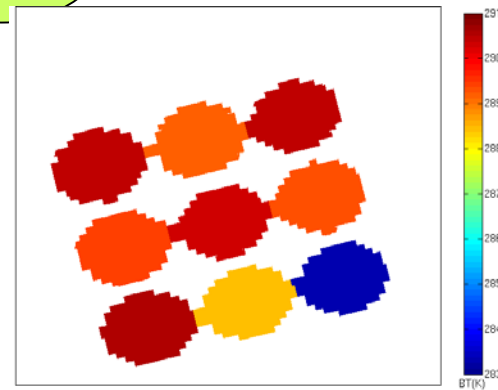


# MODIS/AIRS Synergistic N\* Cloud Clearing Over Sampling Strategy

8 possible AIRS pairs (2 FOVs)

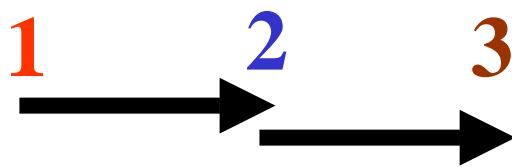
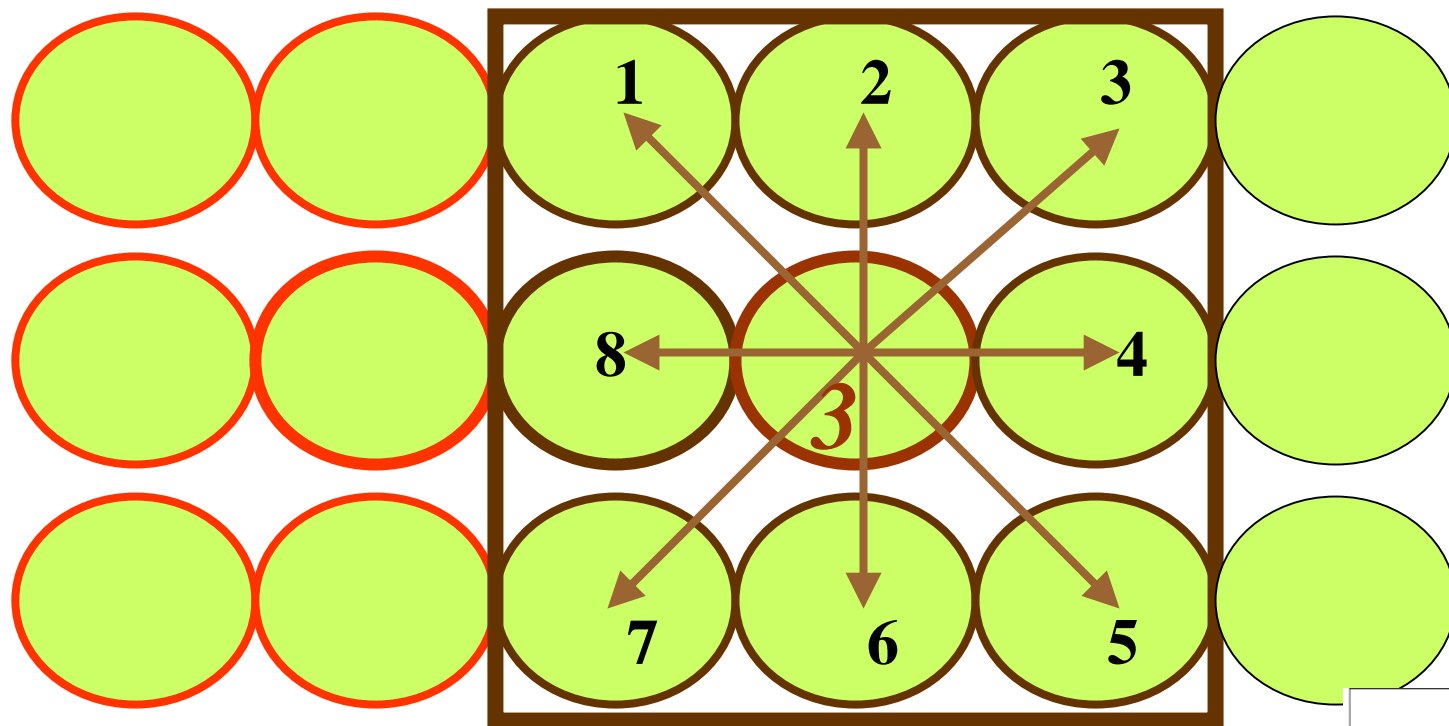


**Pseudo Single AIRS FOV**

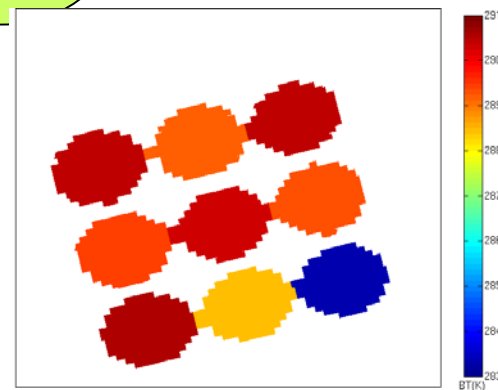


# MODIS/AIRS Synergistic N\* Cloud Clearing Over Sampling Strategy

8 possible AIRS pairs (2 FOVs)



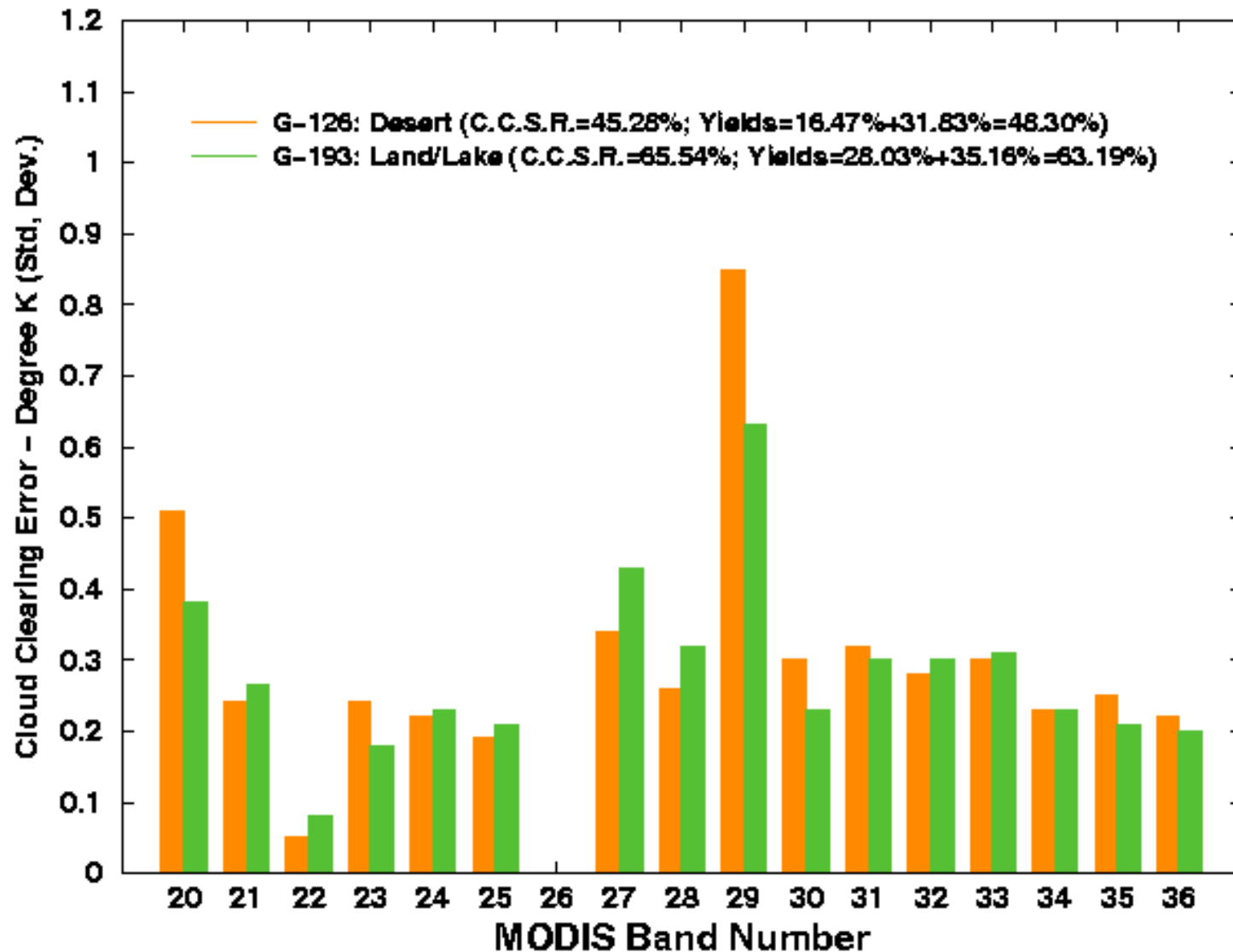
**Pseudo Single AIRS FOV**

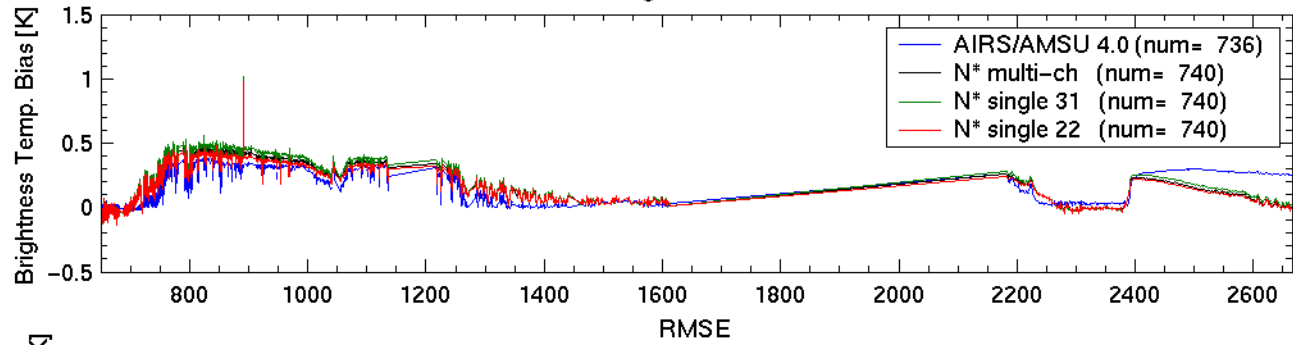




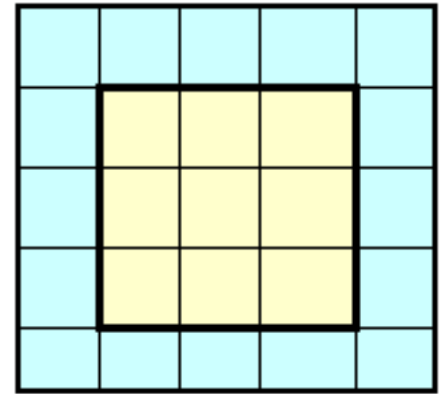
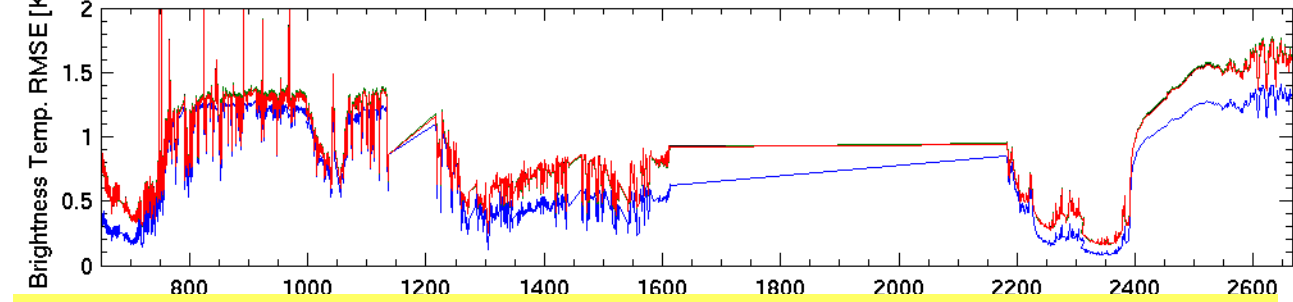
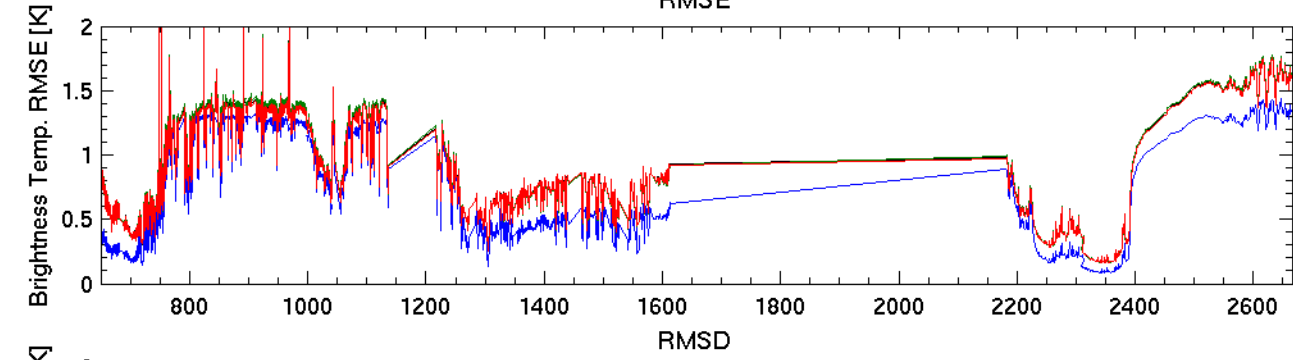
# Multi-Channel N\* Desert vs. Land C.C. Error Comparison

MODIS/AIRS Synergistic Cloud-Clearing (M-ch.; Q.C.=0.5K)  
AIRS G#126-Desert & G#193-Land/Lake; 09/02/2002

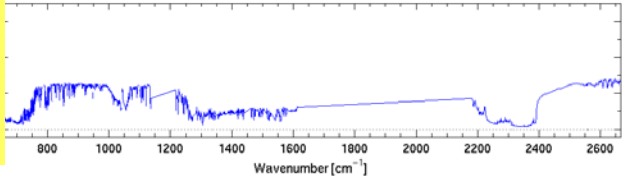
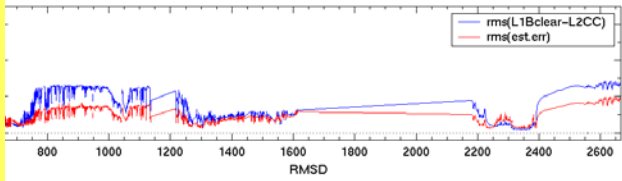
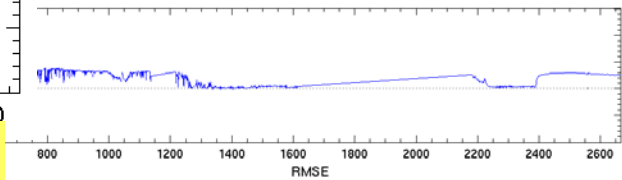




# Wisconsin Granule



Bias L2CC AIRS. 2002.09.06.193.L2.CC.v4.0.0.0.Focus.T0429025621.hdf

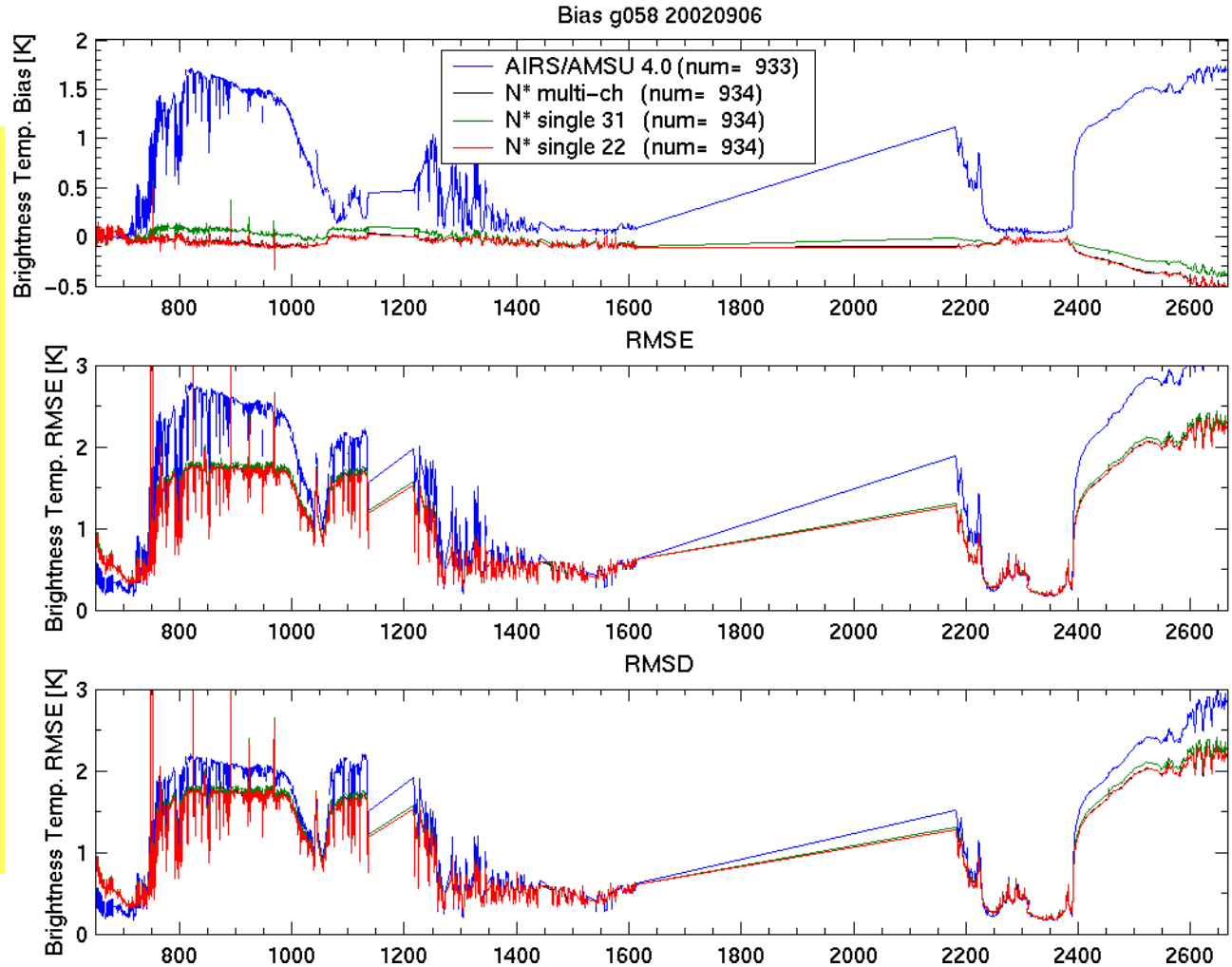


**AIRS/AMSU C.C. (3 by 3 AIRS FOV) V4.0 - Blue**  
**AIRS/MODIS C.C. (1 by 2 AIRS FOV) Multi-Ch. - Black**  
**Single-Ch.:Band 31 – Green; Band 22 - Red**

# AIRS/MODIS Synergistic C.C. can Supplement AIRS/AMSU C.C. Especially over Desert Region

**AIRS/AMSU C.C.  
(3 by 3 AIRS FOV)  
V4.0 - Blue**

**AIRS/MODIS C.C.  
(1 by 2 AIRS FOV)  
Multi-Ch. - Black  
Single-Ch.:  
Band 31 - Green  
Band 22 - Red**

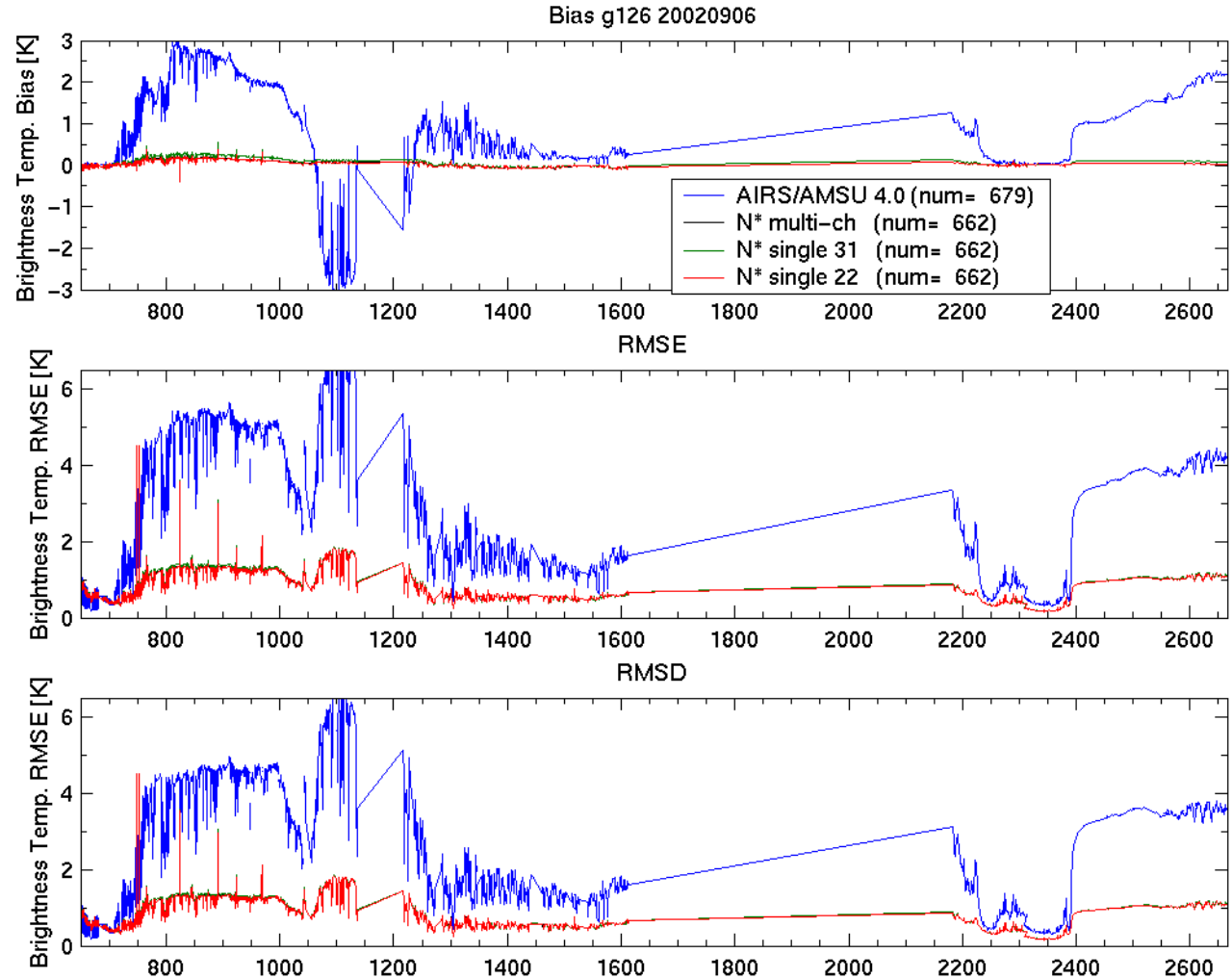


**Australia Granule**

# AIRS/MODIS Synergistic C.C. can Supplement AIRS/AMSU C.C. Especially over Desert Region

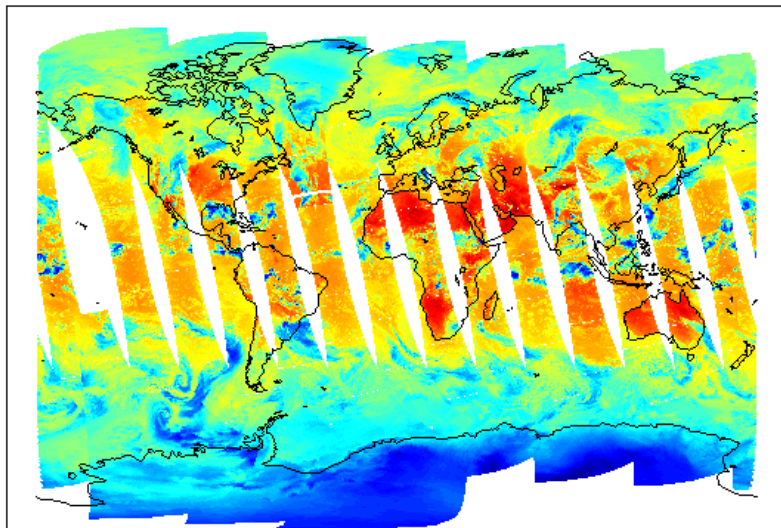
**AIRS/AMSU C.C.  
(3 by 3 AIRS FOV)  
V4.0 - Blue**

**AIRS/MODIS C.C.  
(1 by 2 AIRS FOV)  
Multi-Ch. - Black  
Single-Ch.:  
Band 31 - Green  
Band 22 - Red**



South Africa Granule

Global AIRS Level 1B Brightness Temperatures, Ascending Granules, September 6, 2002

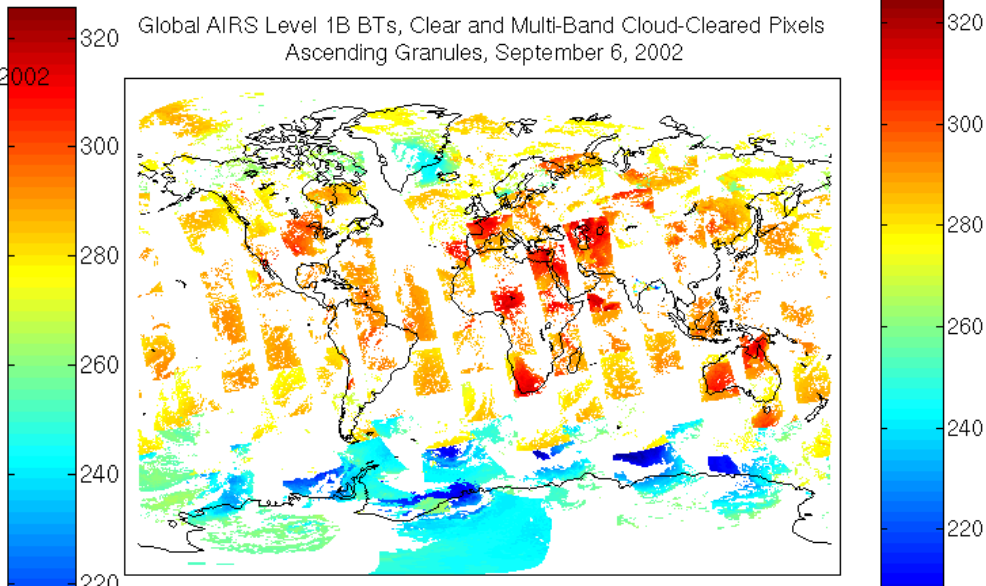


AIRS BT  
(All)

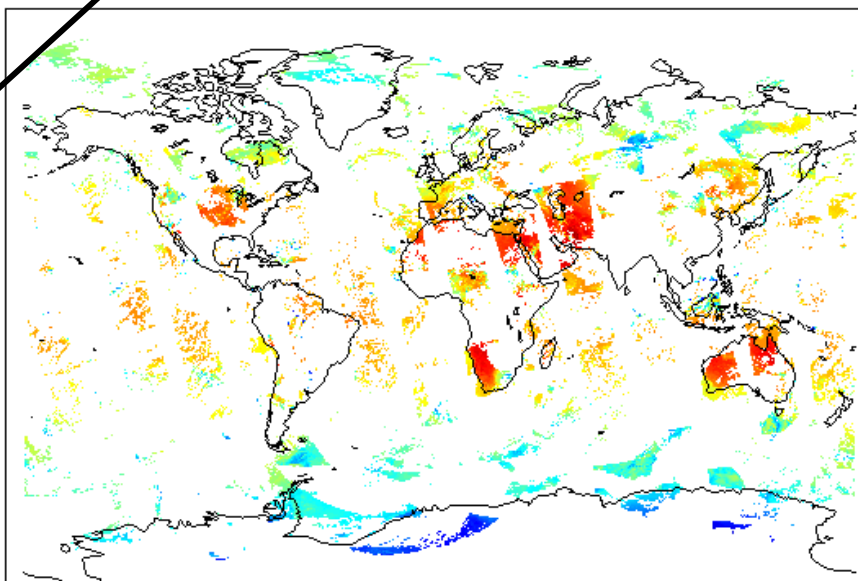
AIRS BT  
(Cloud-Cleared)

AIRS BT  
(Clear Only)

Global AIRS Level 1B BTs, Clear and Multi-Band Cloud-Cleared Pixels  
Ascending Granules, September 6, 2002



Global AIRS

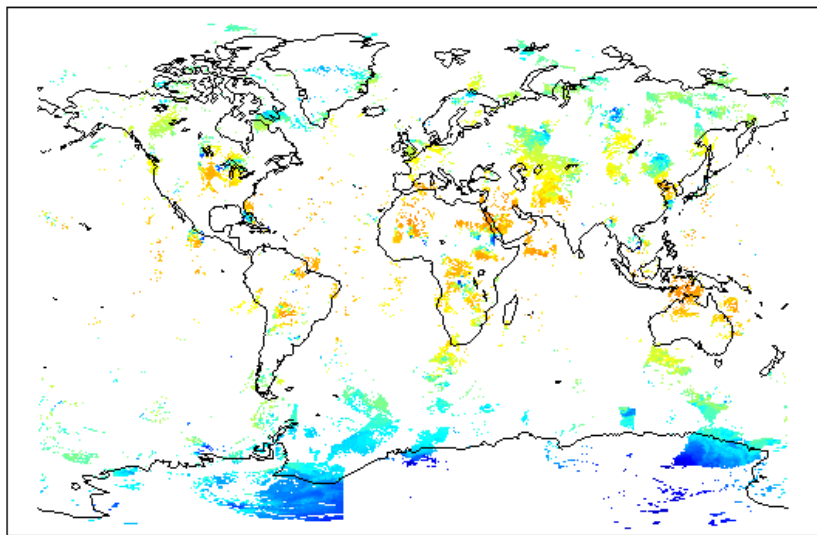


BT (K)

BT (K)

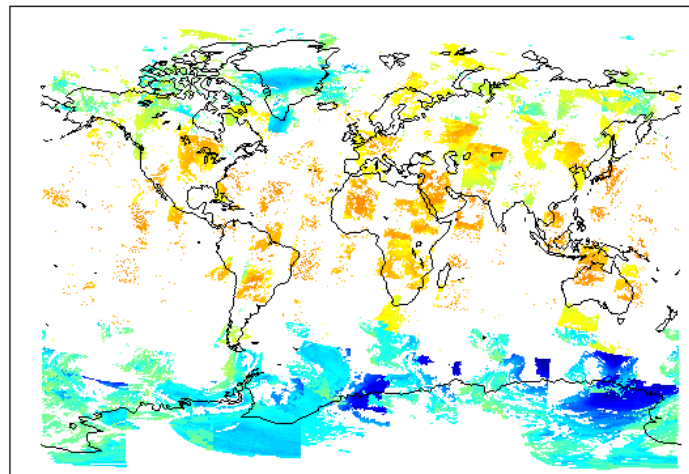
BT (K)

Global AIRS Level 1B BTs, Clear Pixels Only, Descending Granules, September 6, 2002



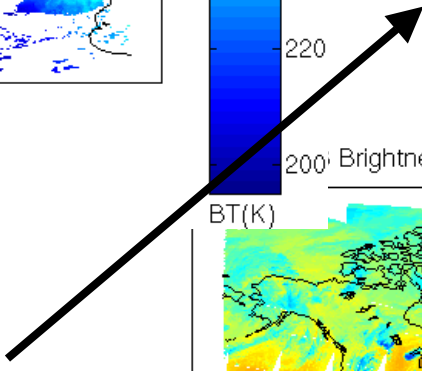
AIRS BT  
(Clear Only)

Global AIRS Level 1B BTs, Clear and Multi-Band Cloud-Cleared Pixels  
Descending Granules, September 6, 2002

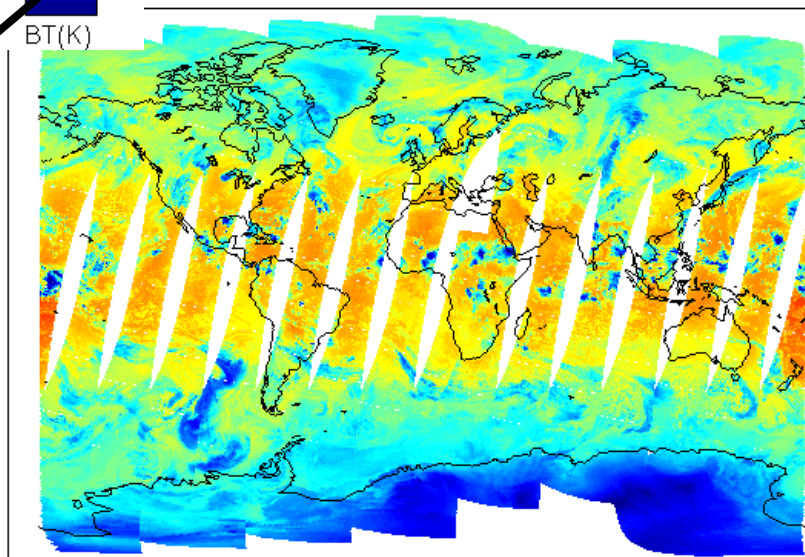


AIRS BT  
(Cloud-Cleared)

AIRS BT  
(All)



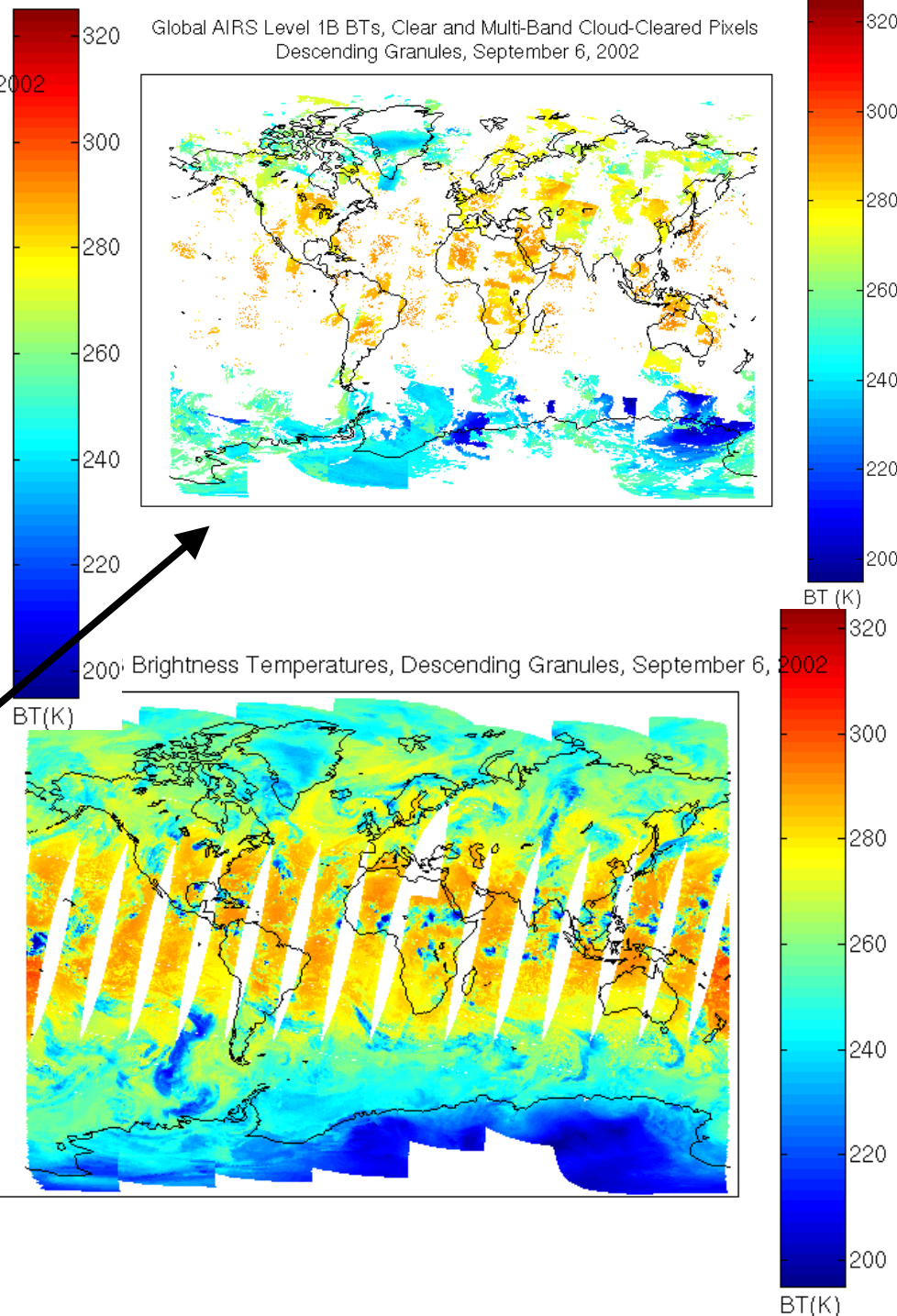
Brightness Temperatures, Descending Granules, September 6, 2002



BT(K)

BT (K)

BT(K)



# Synergistic AIRS/MODIS C.C.

## Summary

- **Synergistic AIRS/MODIS C.C. could provide cloud-cleared radiances over non-oceanic scenes with good yield and performance at high spatial resolution (pseudo single AIRS FOV)**
- **Synergistic AIRS/MODIS C.C. could also provide additional pseudo-clear AIRS single FOV radiances (without conducting actual C.C.) (not presented here)**
- **MODIS can provide additional Q.C. to refine/enhance AIRS/AMSU C.C. performance**

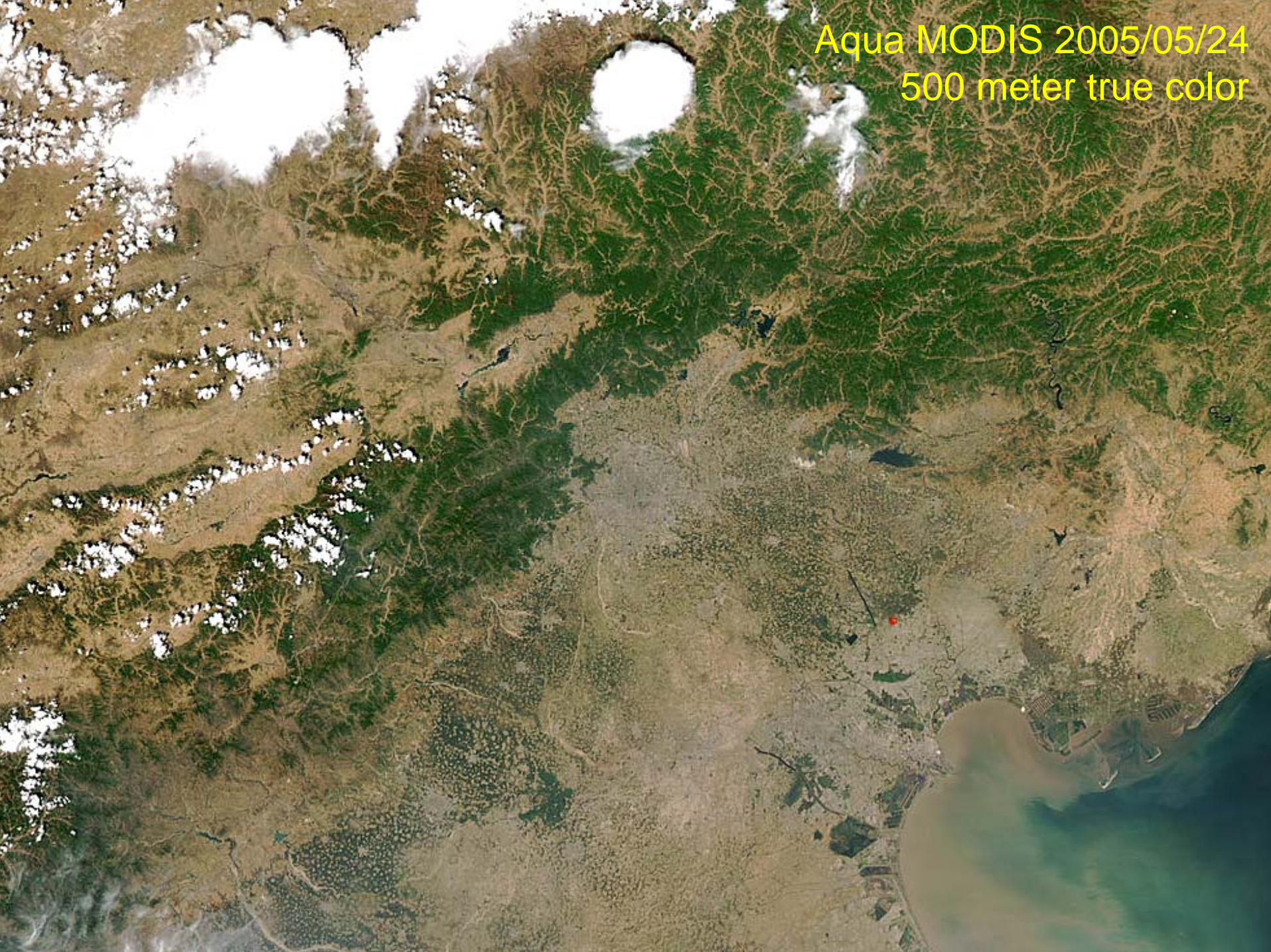
Aqua MODIS 2005/05/24  
1000 meter true color



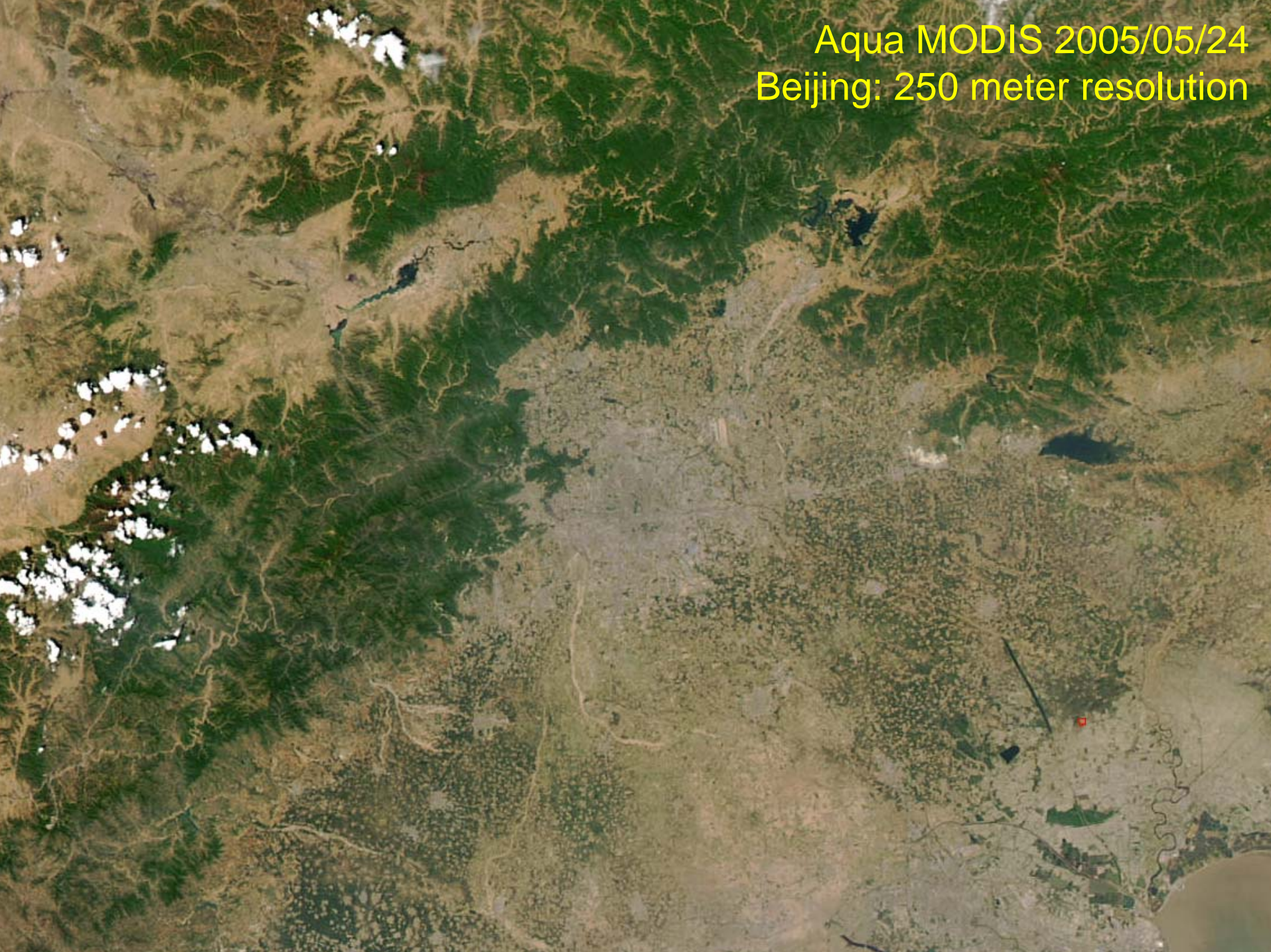
Here we are!!!!



Aqua MODIS 2005/05/24  
500 meter true color



Aqua MODIS 2005/05/24  
Beijing: 250 meter resolution



# **IMAPP Poster**

**B44**

International TOVS Study Conference, 14<sup>th</sup>, ITSC-14, Beijing, China, 25-31 May 2005.  
Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center,  
Cooperative Institute for Meteorological Satellite Studies, 2005.