Synergistic use of high spatial resolution imager and high spectral resolution sounder for atmospheric and cloud retrievals

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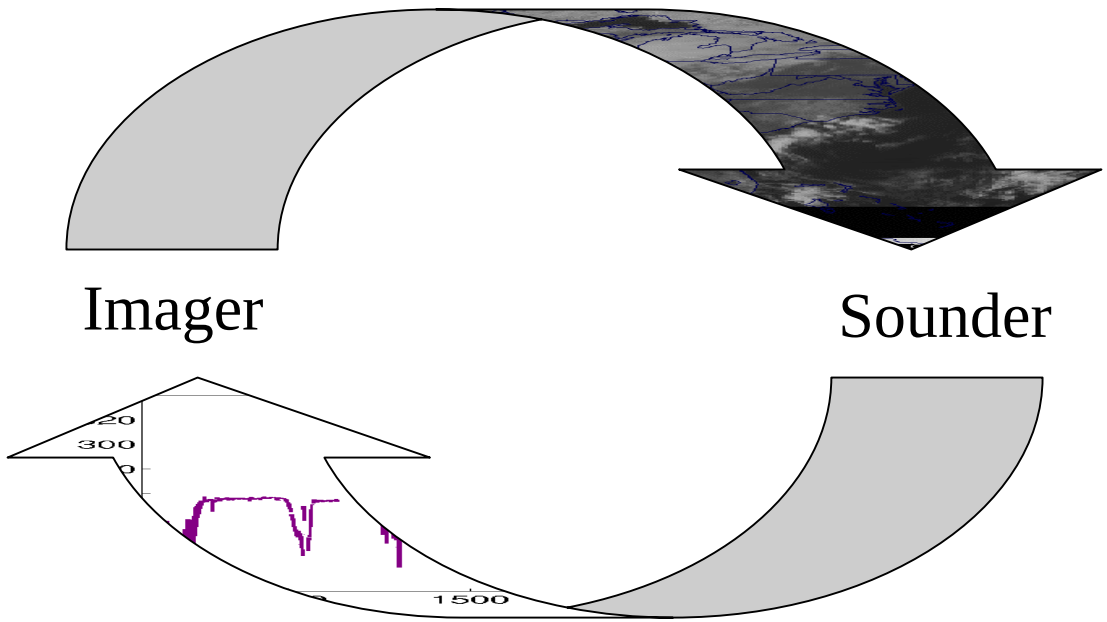
Best products will be realized from combinations of imager *and* sounder data!

Using MODIS/AIRS data to simulate ABI/HES system !

Better cloud detection and characterization, better spatial, etc

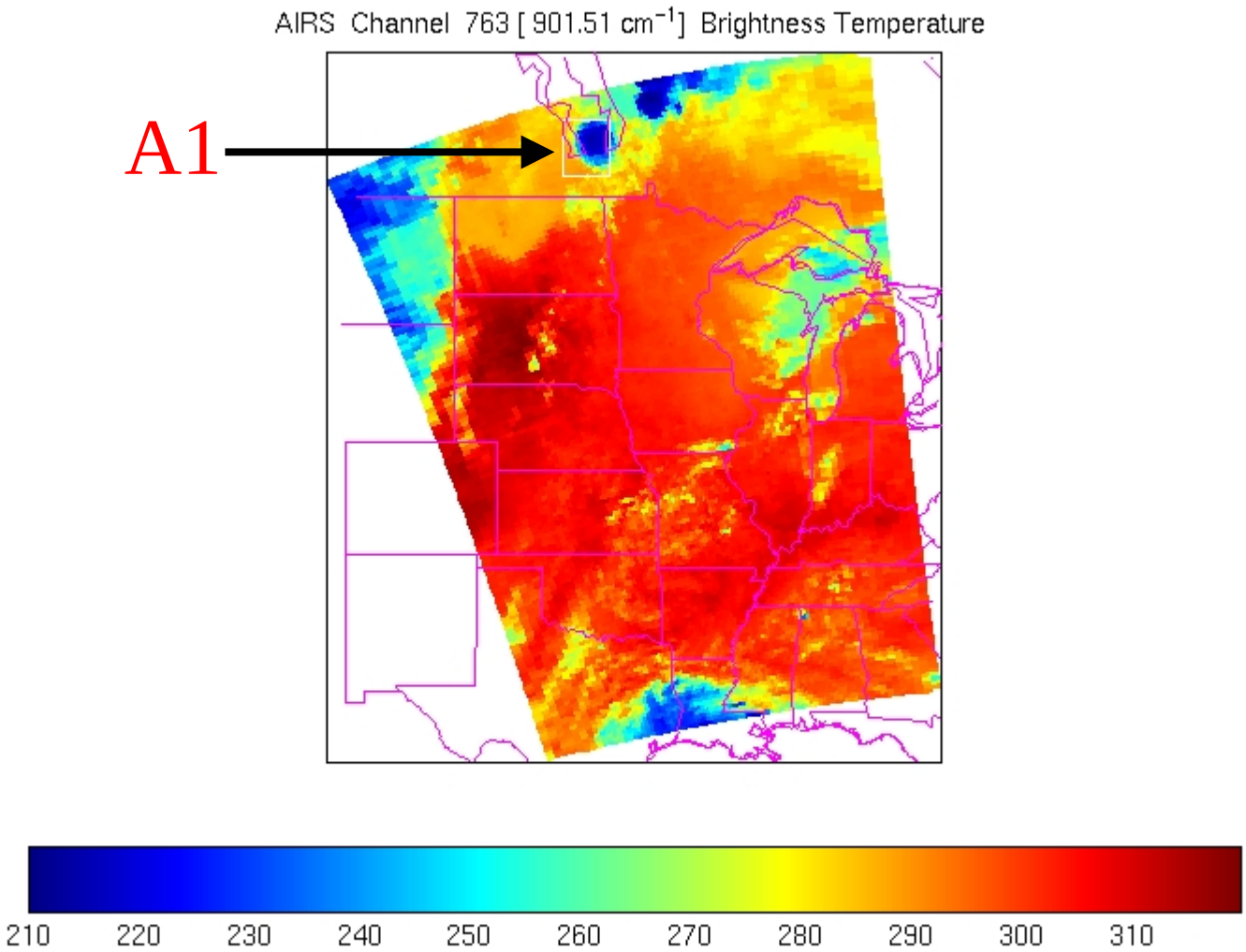


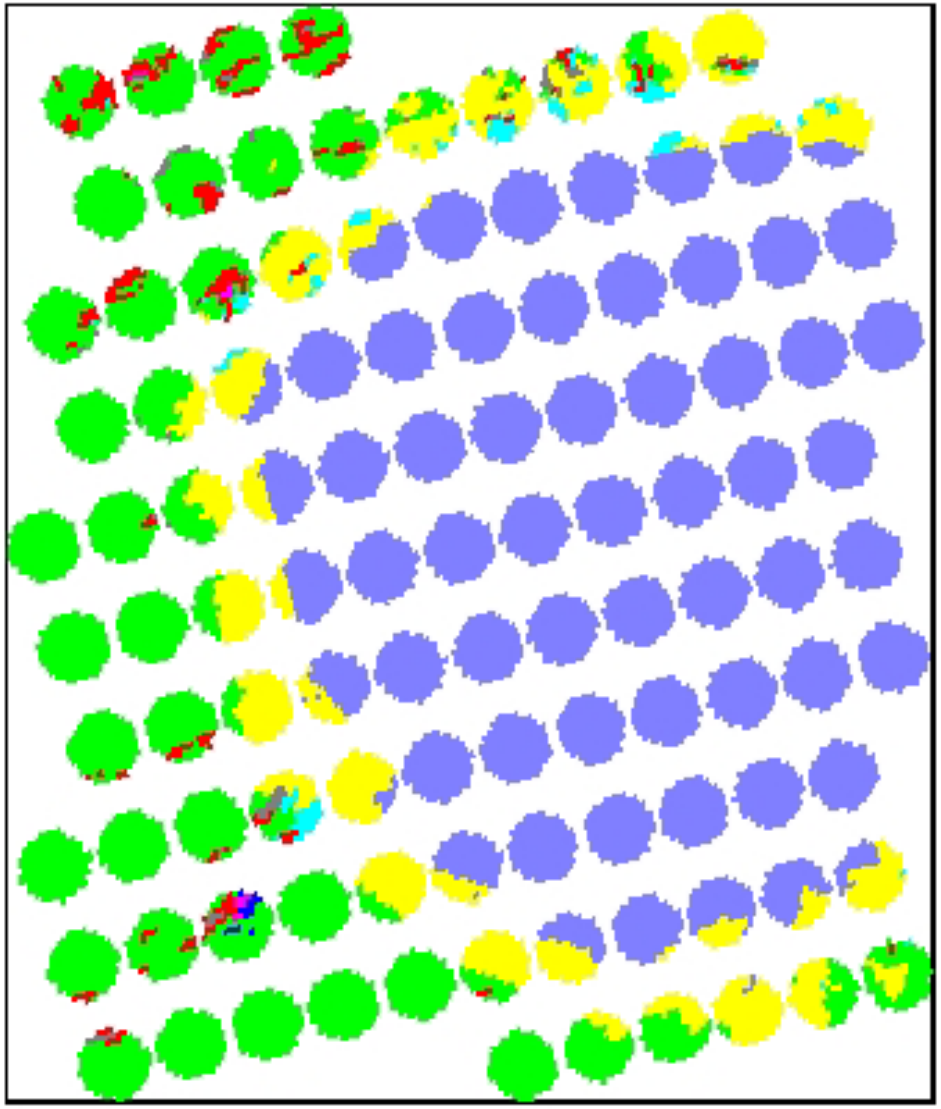
Better surface emissivity, better spectral, better accuracy, etc

What can we do for MODIS/AIRS synergistic retrieval?

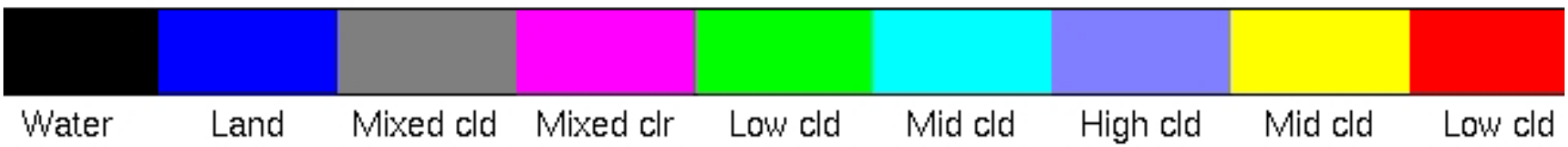
- AIRS sub-pixel cloud detection and characterization using MODIS data

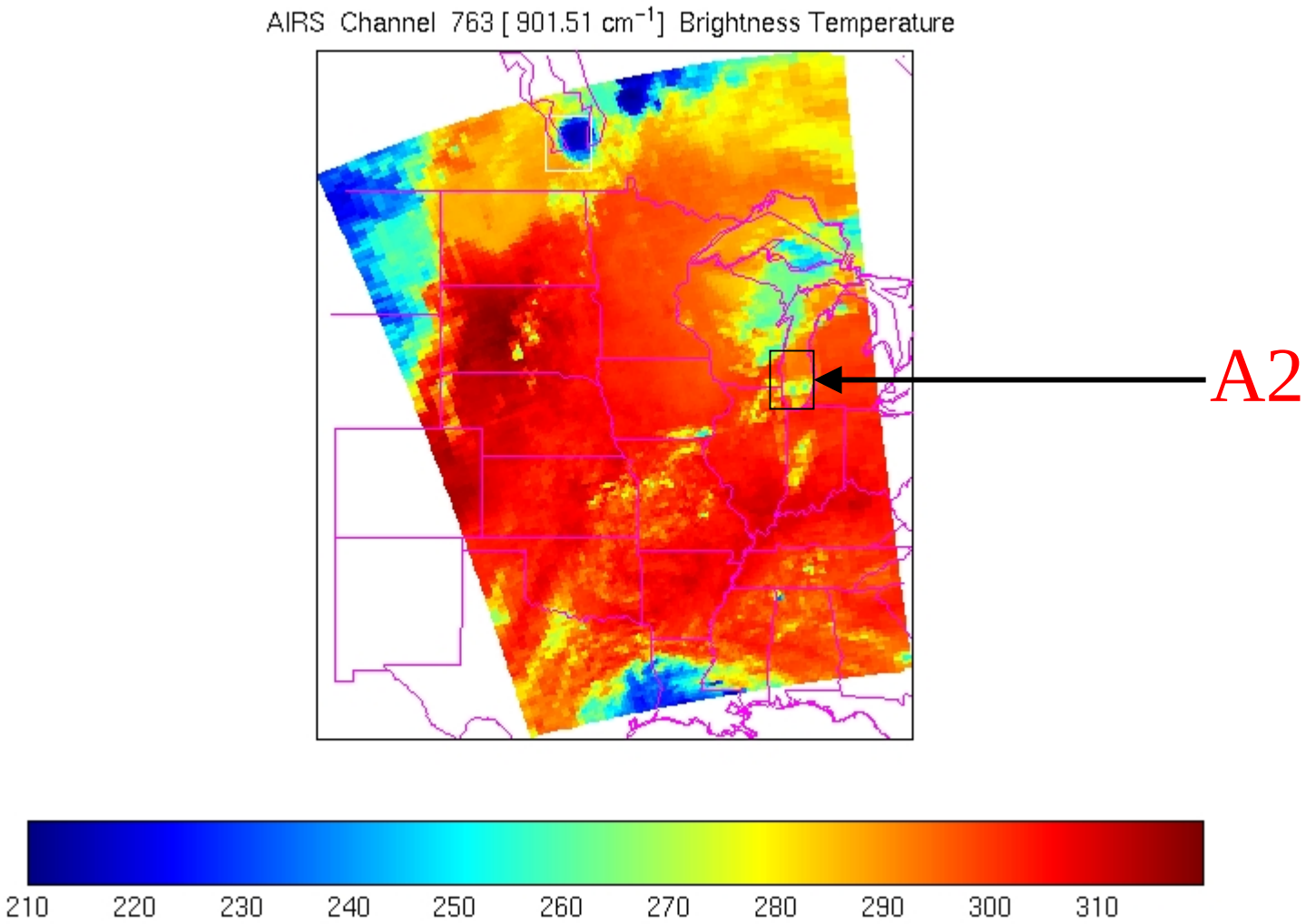
- MODIS products serve as the background information for sounder retrieval


AIRS Channel 763 [901.51 cm^{-1}] Brightness Temperature
A1
210
220
230
240
250
260
270
280
290
300
310



MODIS classification mask at 1km resolution



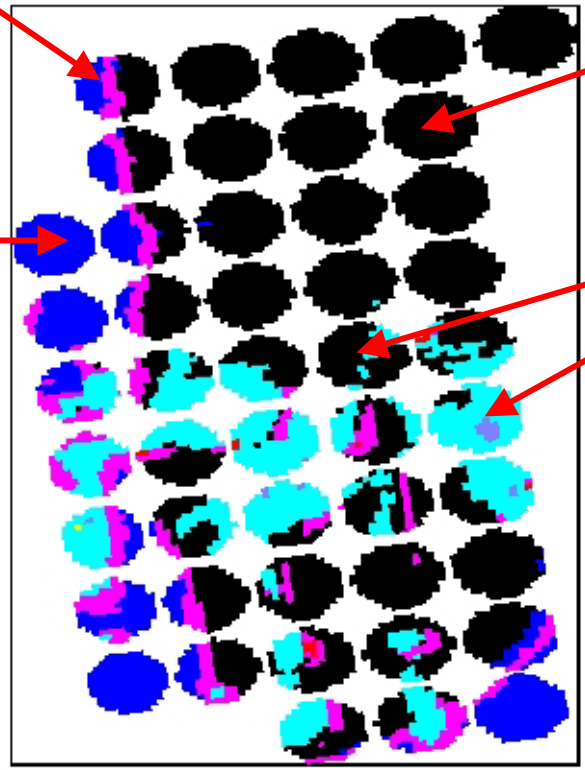

AIRS Channel 763 [901.51 cm^{-1}] Brightness Temperature
A2
210
220
230
240
250
260
270
280
290
300
310

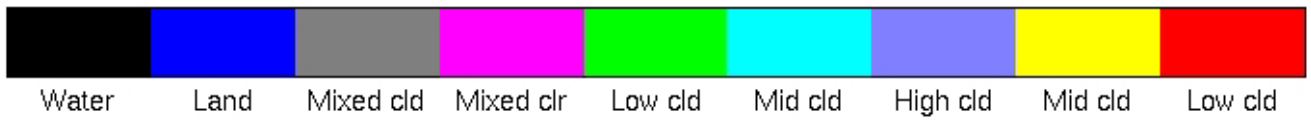
Clear mixed water/land (Milwaukee)

Clear Water

Clear Land

Cloudy FOV





What can we do for MODIS/AIRS synergistic retrieval?

- AIRS sub-pixel cloud detection and characterization using MODIS data

- MODIS products serve as the background information for sounder retrieval

1DVAR algorithm for cloud retrieval (Li, Menzel and Schreiner 2001)

Observed AIRS Radiance Measurements **Background Information from MODIS**

$$J(X) = [R^m - R(X)]^T E^{-1} [R^m - R(X)] + [X - X_B]^T B^{-1} [X - X_B]$$

Fast Cloudy Radiative Transfer Model: coupled

(1) Single - Scattering Cloud Model and

(2) AIRS Clear Sky Radiance Model – SARTA.

(3) Temperature/moisture profiles are from ECMWF.

$$X = (CTP, ECA_1, ECA_2, ECA_3, \ldots, ECA_{10}, CPS, COT)$$

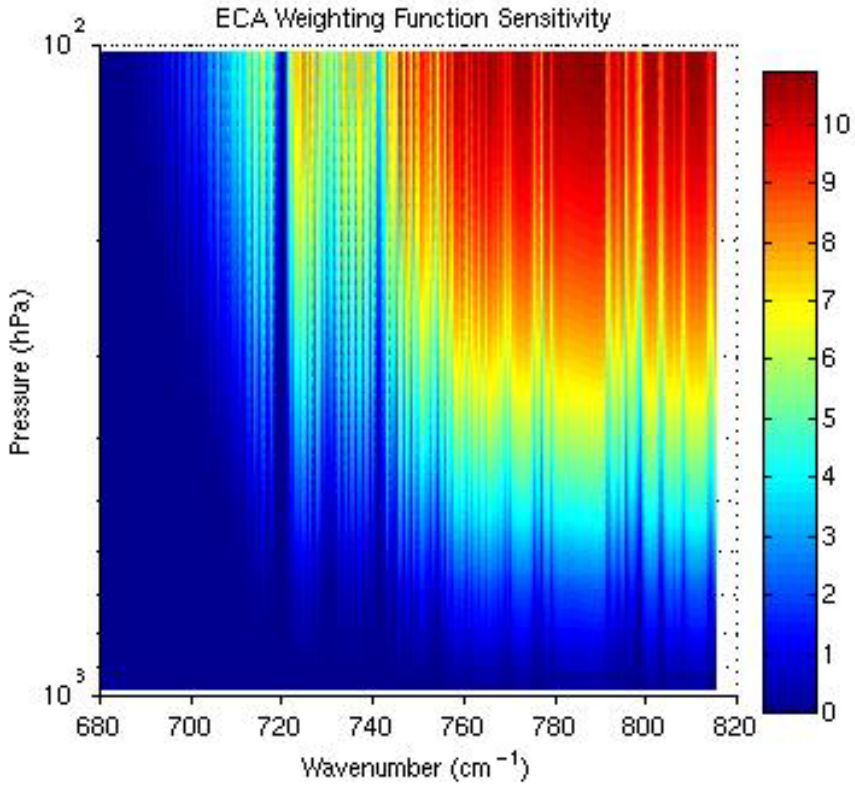
CTP: Cloud-Top Pressure

ECA: Effective Cloud Amount

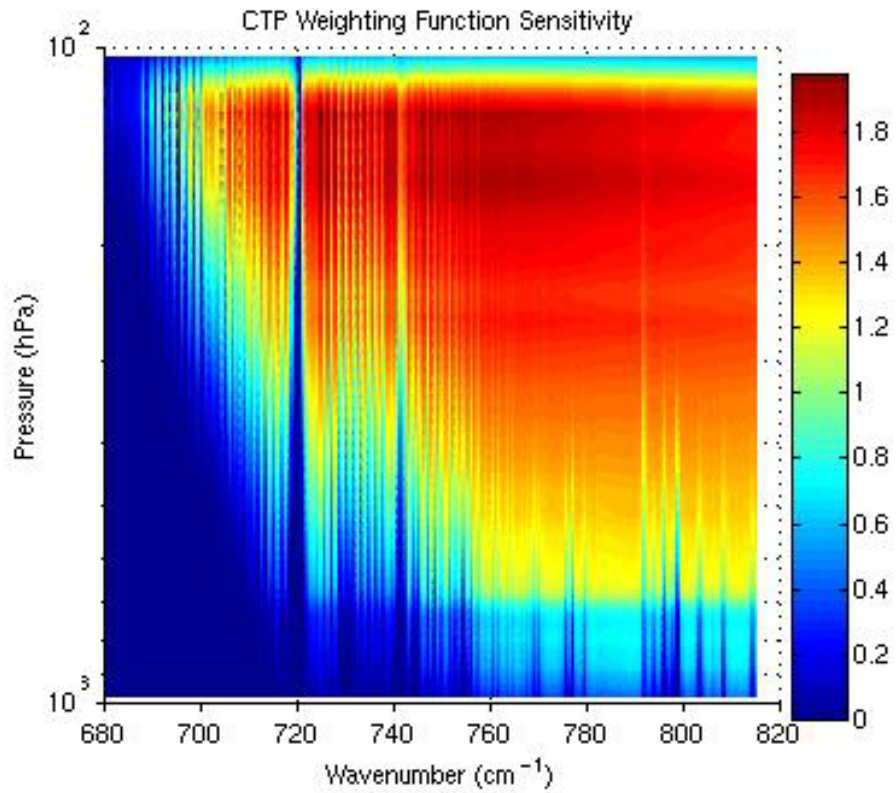
CPS: Cloud Particle Size

COT: Cloud Optical Thickness at 0.55μm

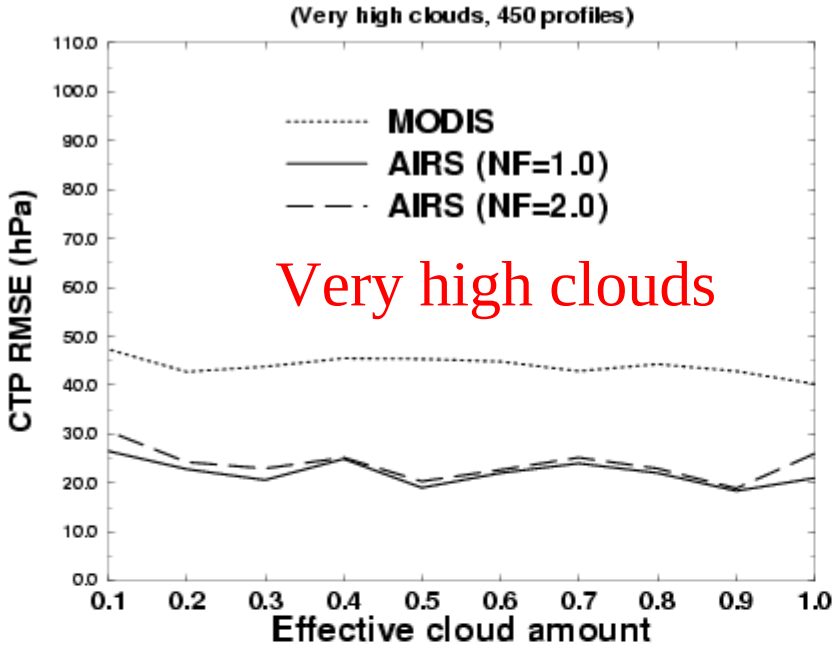
ECA Sensitivity

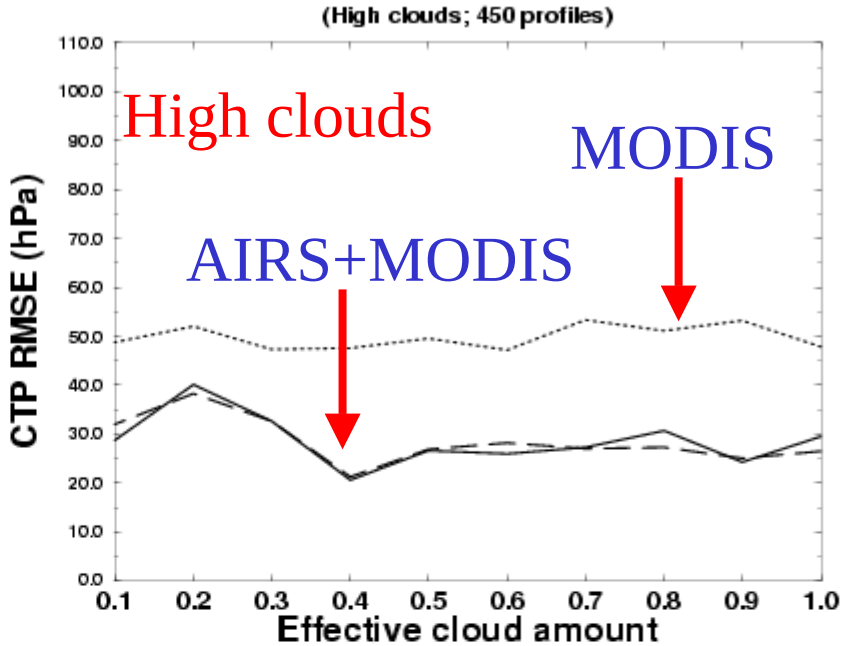


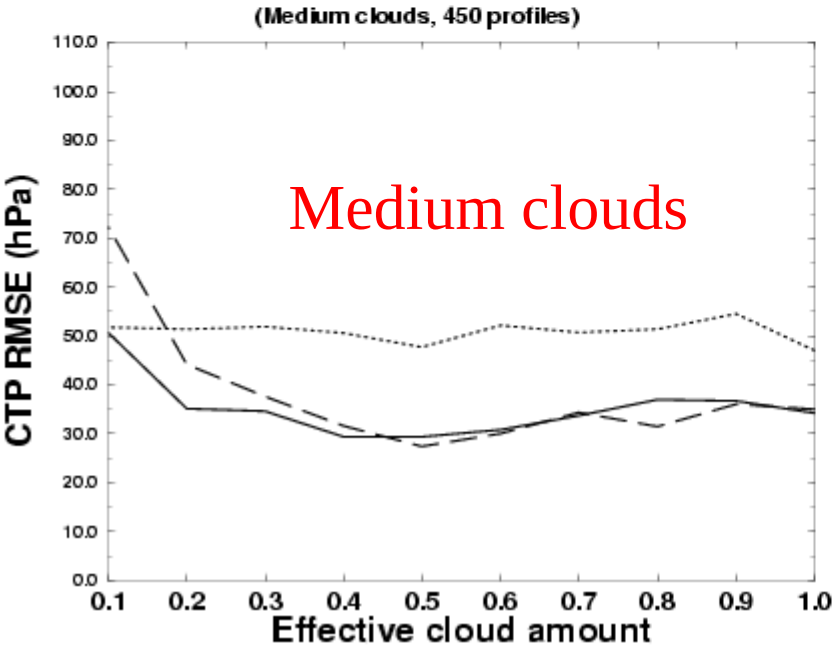
CTP Sensitivity

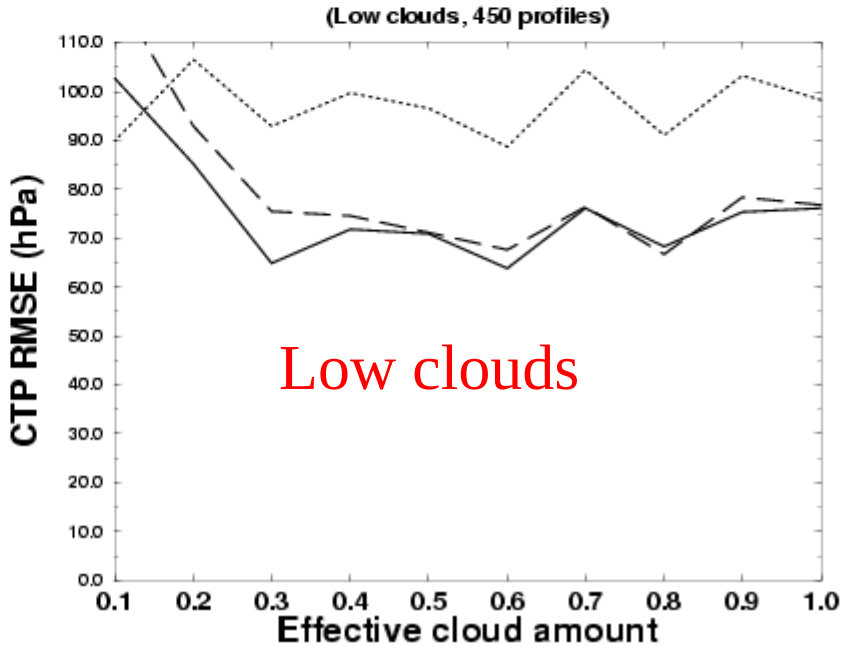


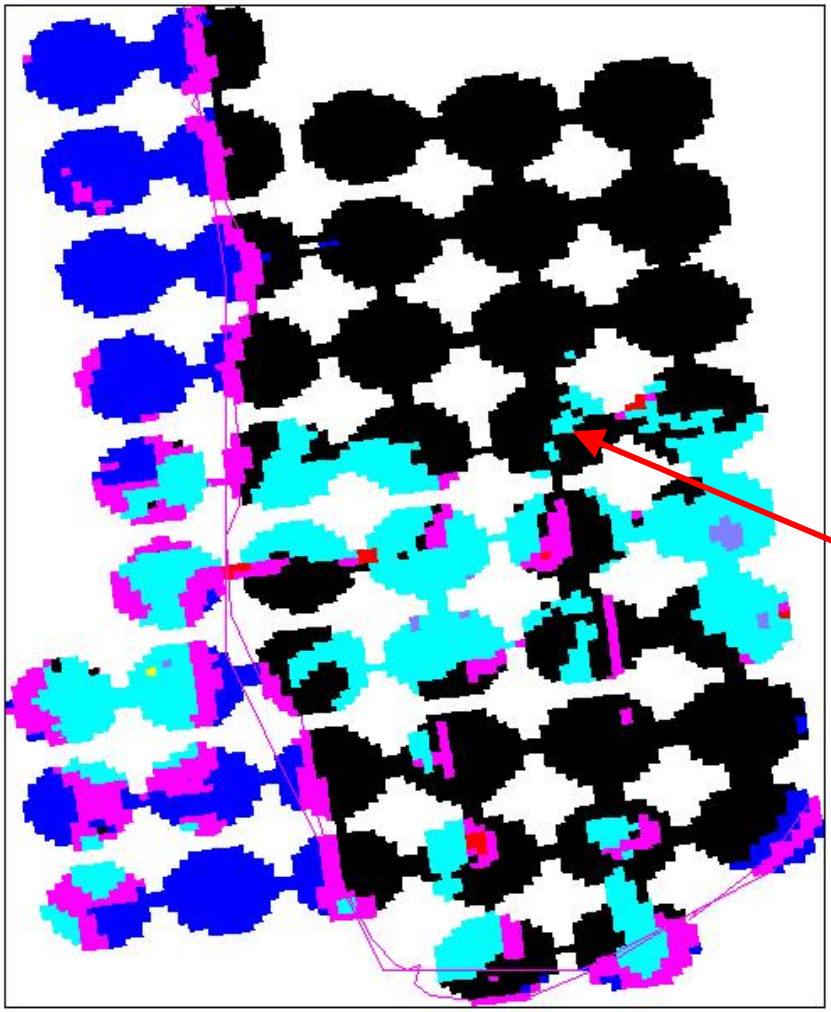
Tropical atmosphere


(Very high clouds, 450 profiles)
MODIS
AIRS (NF=1.0)
AIRS (NF=2.0)
Very high clouds
CTP RMSE (hPa)
Effective cloud amount


(High clouds; 450 profiles)
High clouds
MODIS
AIRS+MODIS
CTP RMSE (hPa)
Effective cloud amount

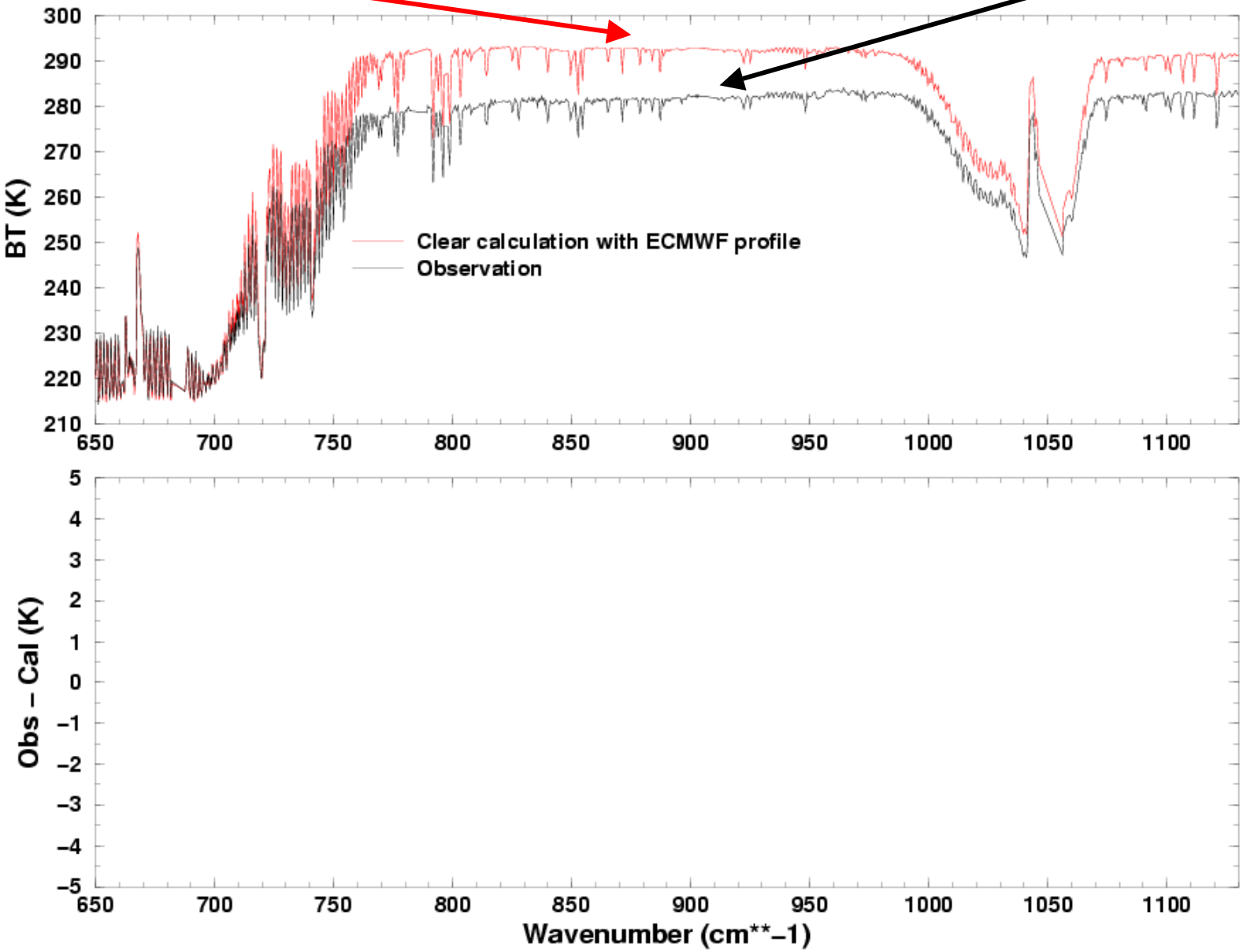

(Medium clouds, 450 profiles)
Medium clouds
CTP RMSE (hPa)
Effective cloud amount


(Low clouds, 450 profiles)
Low clouds
CTP RMSE (hPa)
Effective cloud amount

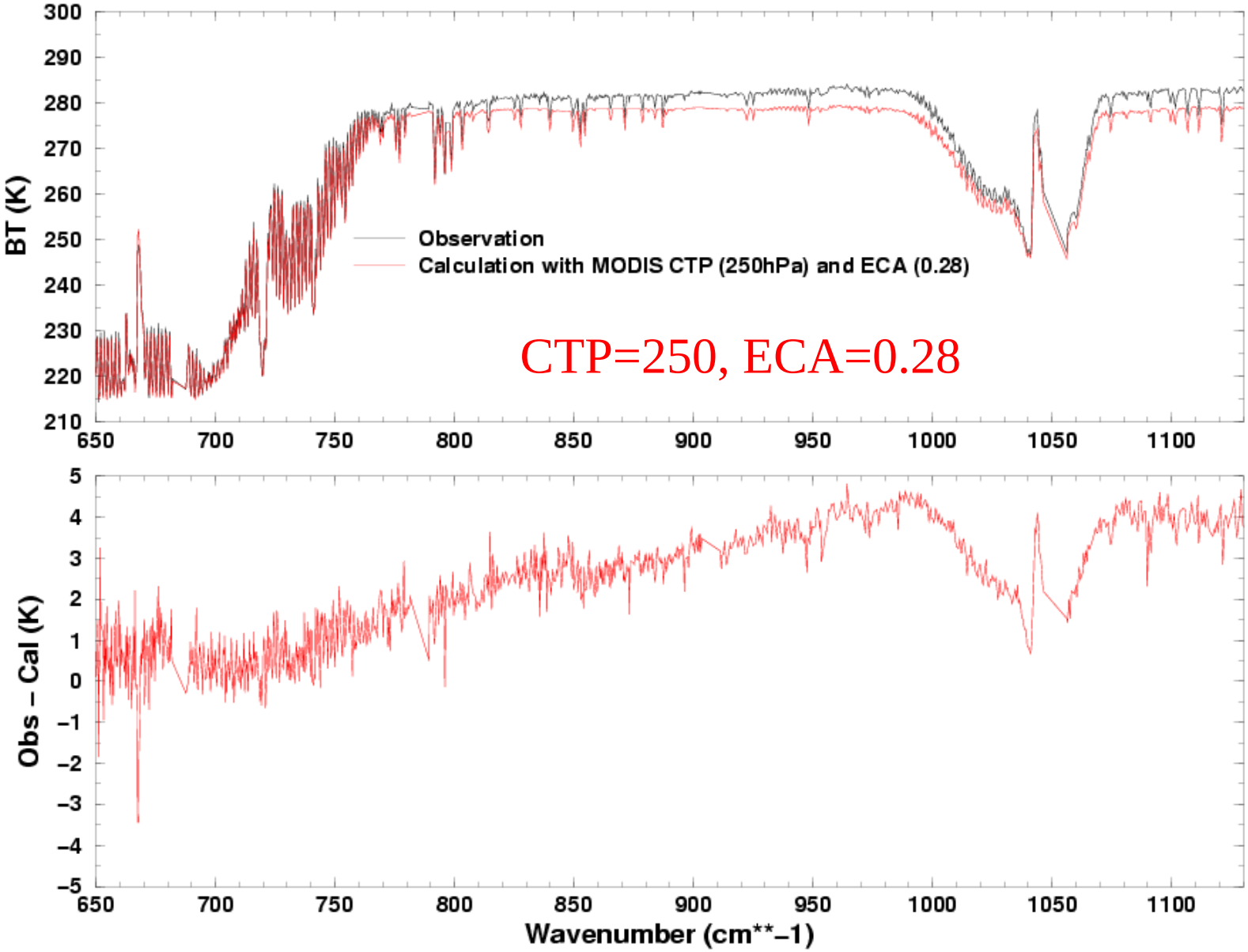

Thin ice clouds

Water
Land
Mixed Cld
Mixed Clr
Low Cld
Mid Cld
High Cld
M.L.Cld
Low Cld

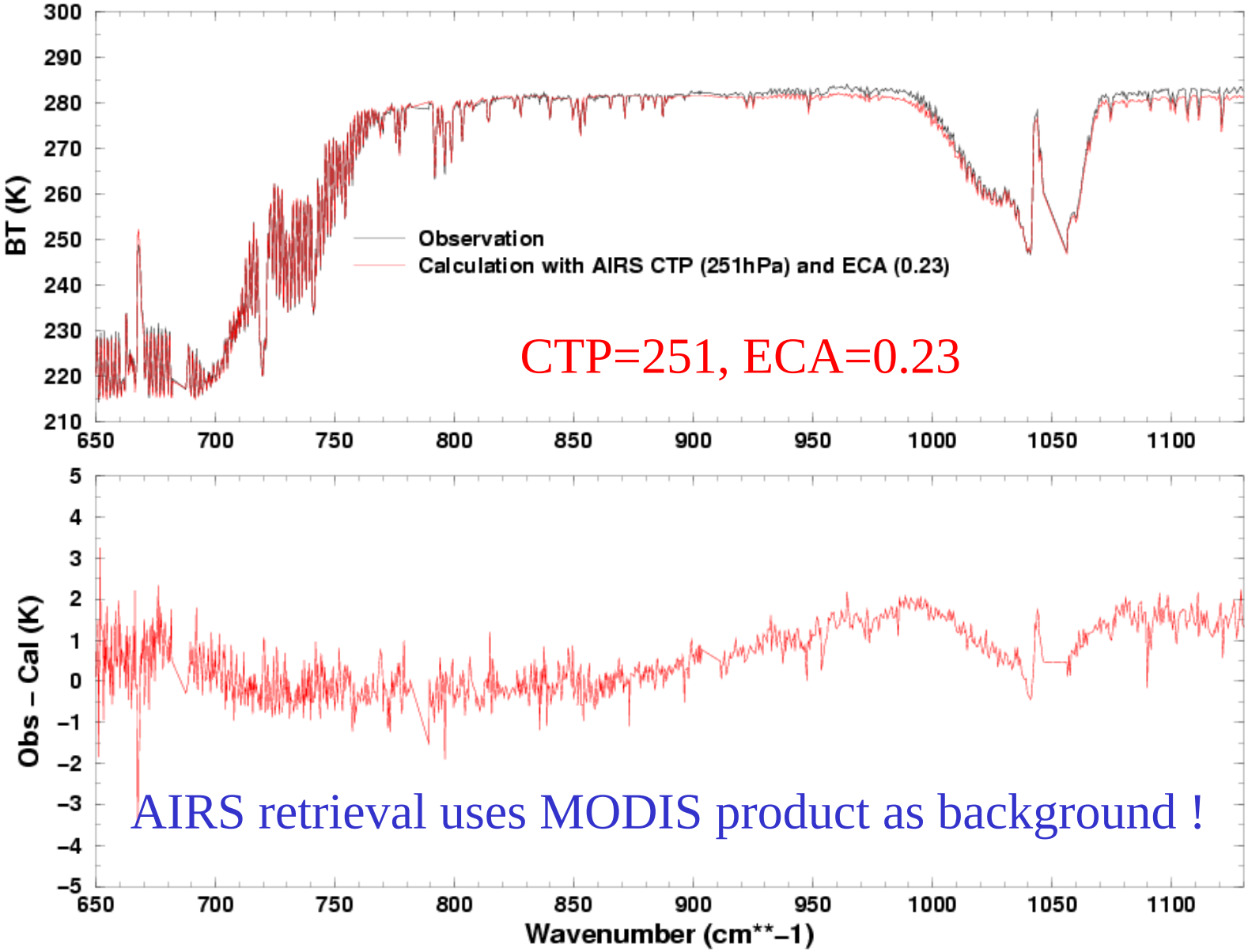
AIRS clear calculation with ***ECMWF profile*** versus cloudy observation



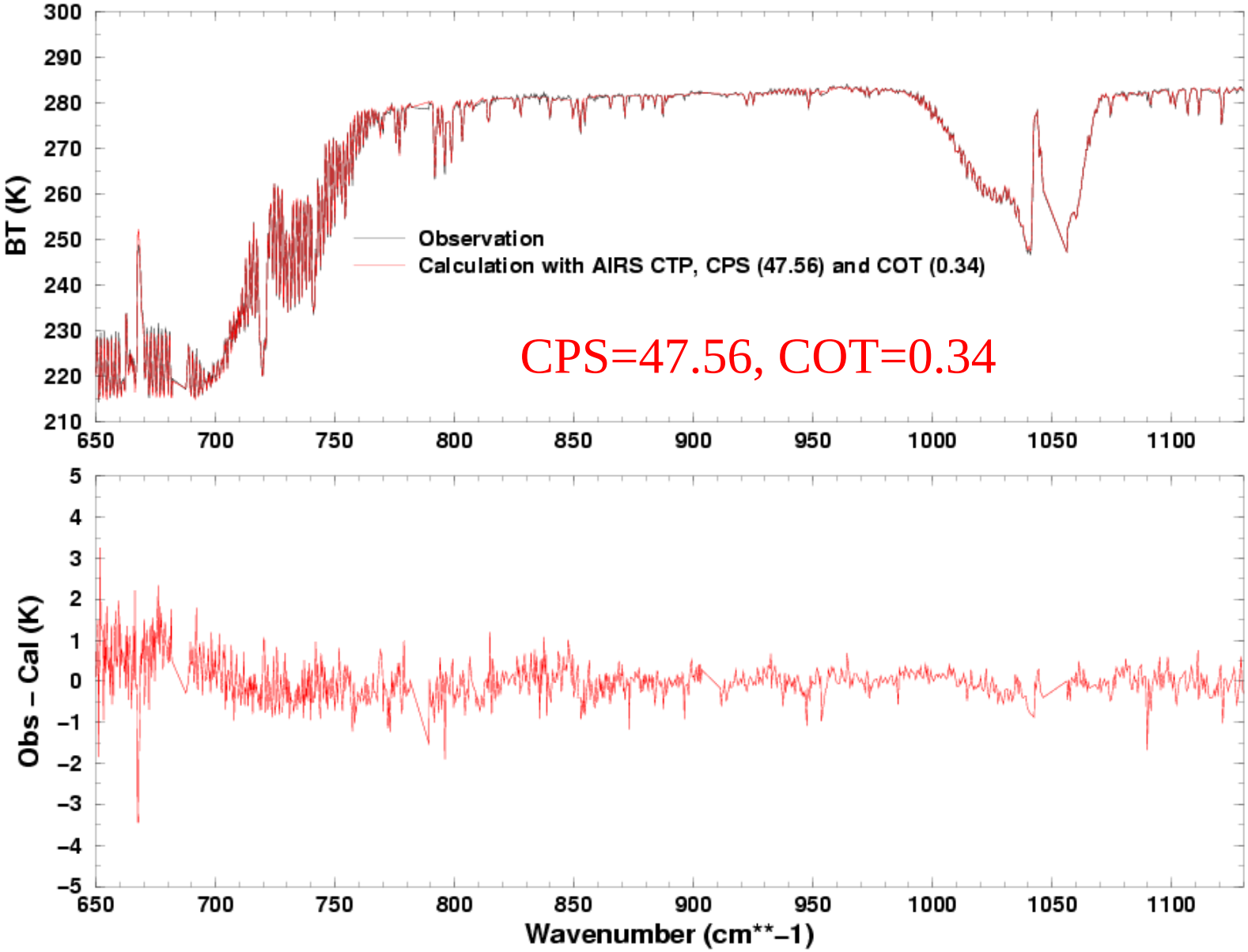
AIRS cloudy calculation with ***MODIS CTP and ECA*** versus cloudy observation

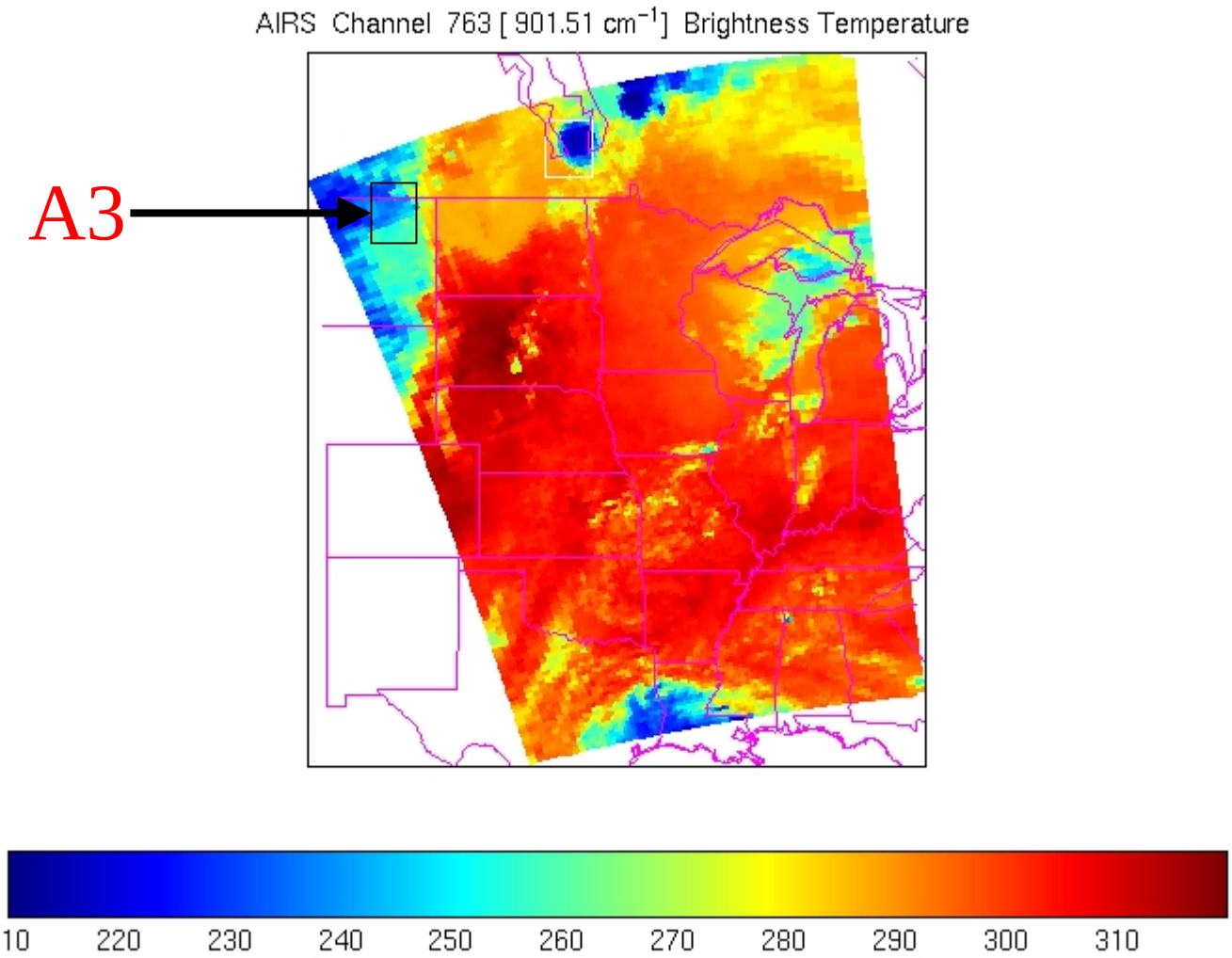


AIRS cloudy calculation with ***AIRS CTP and ECA*** versus cloudy observation

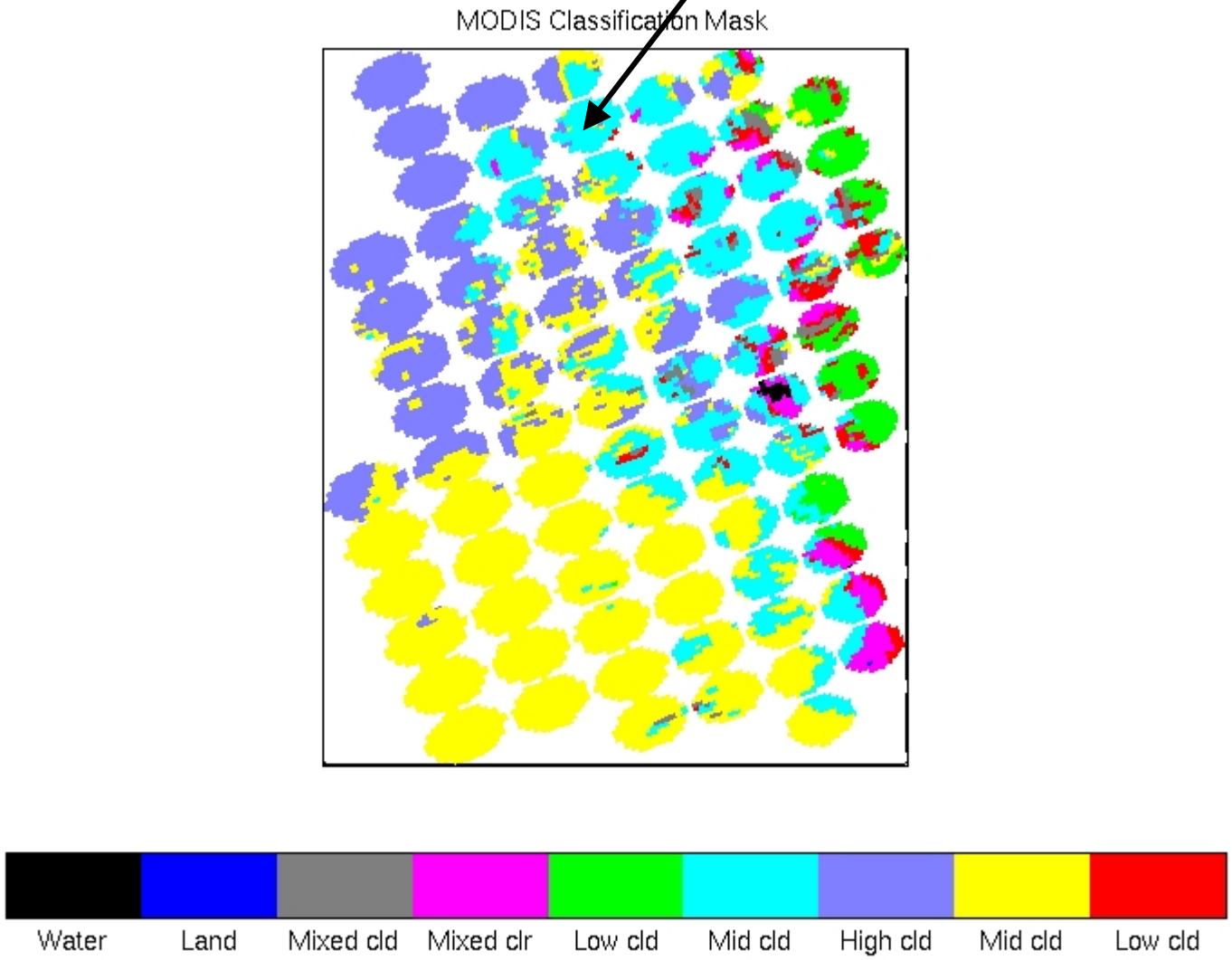


AIRS cloudy calculation with ***AIRS CTP, CPS, and COT*** versus cloudy observation

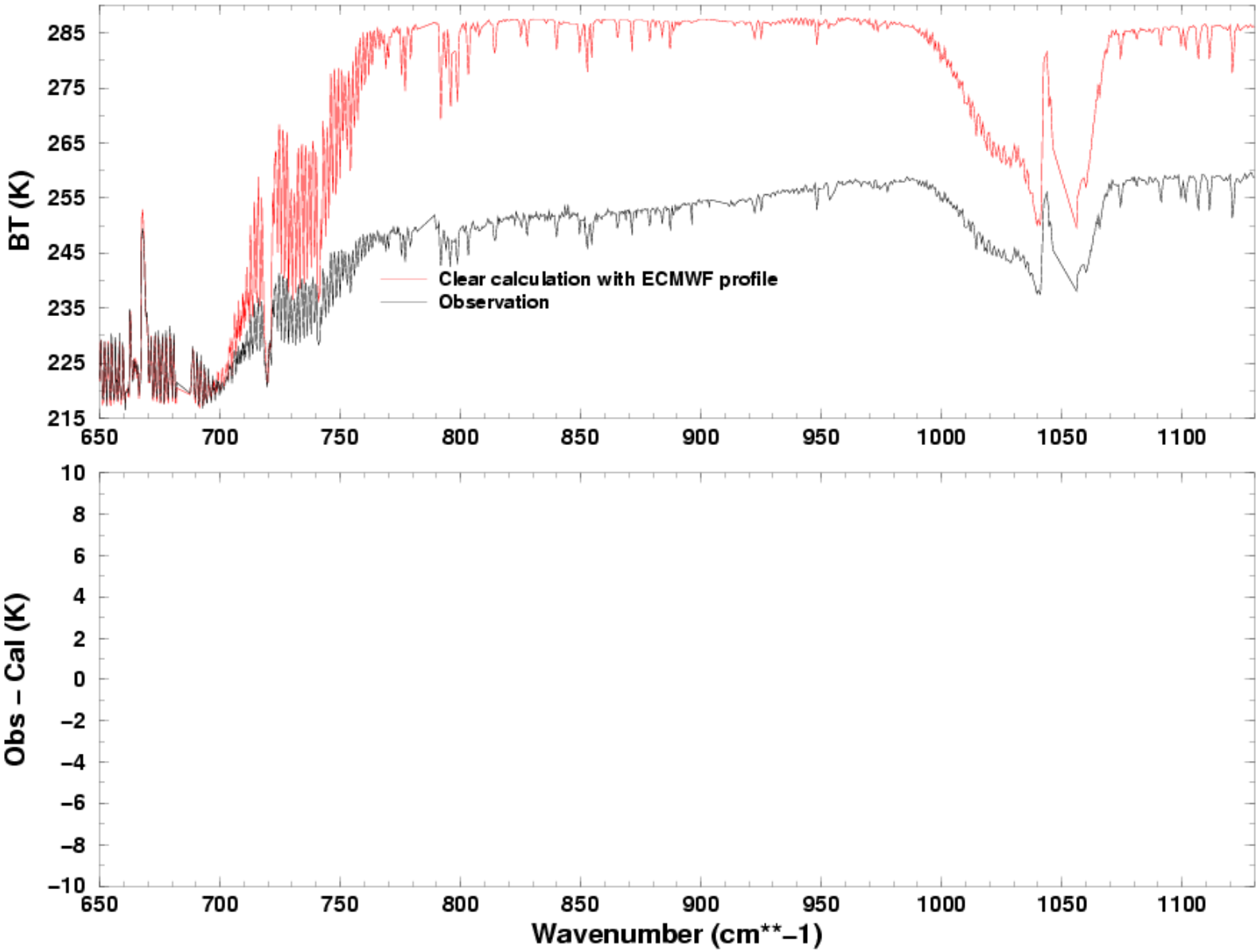



AIRS Channel 763 [901.51 cm^{-1}] Brightness Temperature
A3
210
220
230
240
250
260
270
280
290
300
310

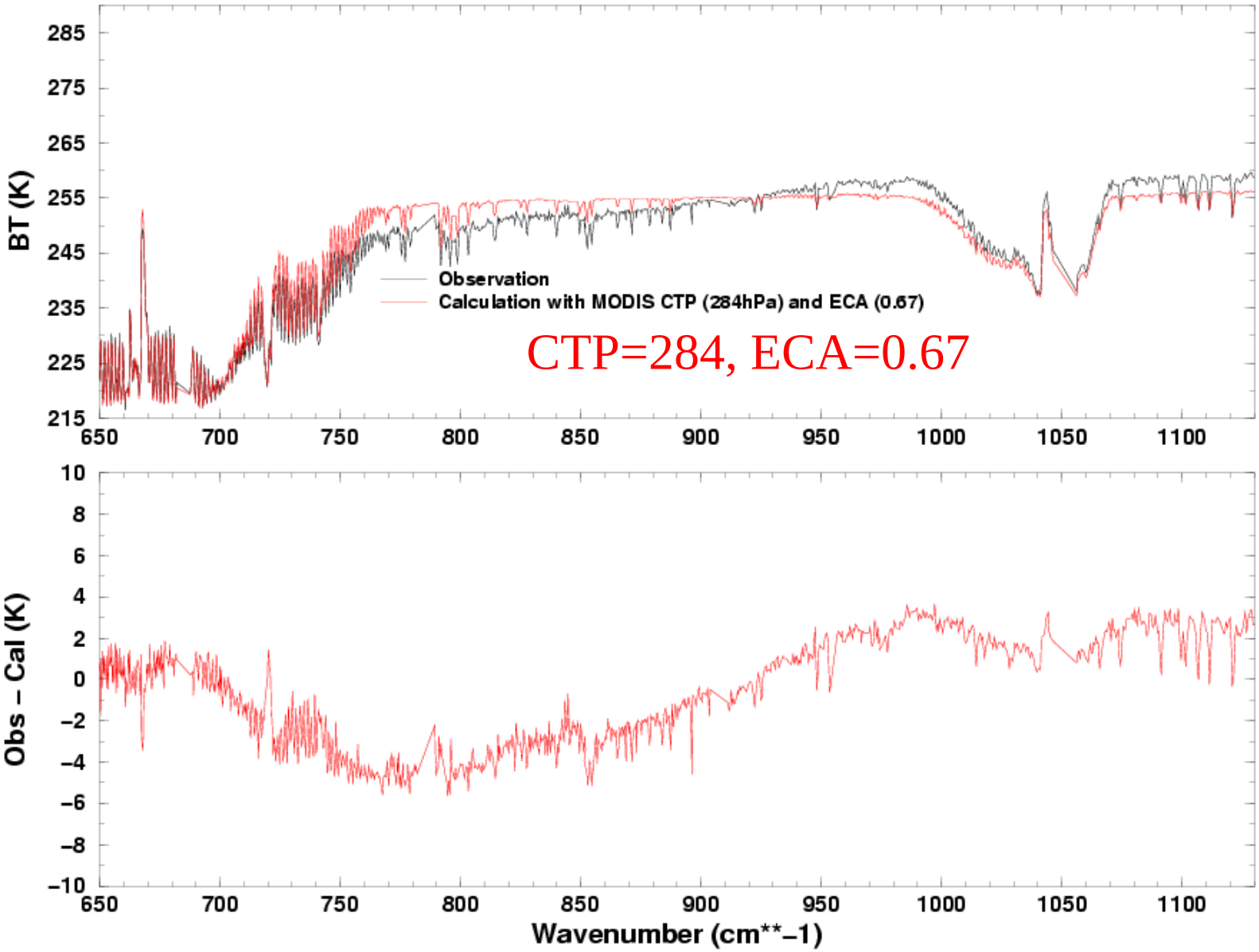
Thick ice clouds



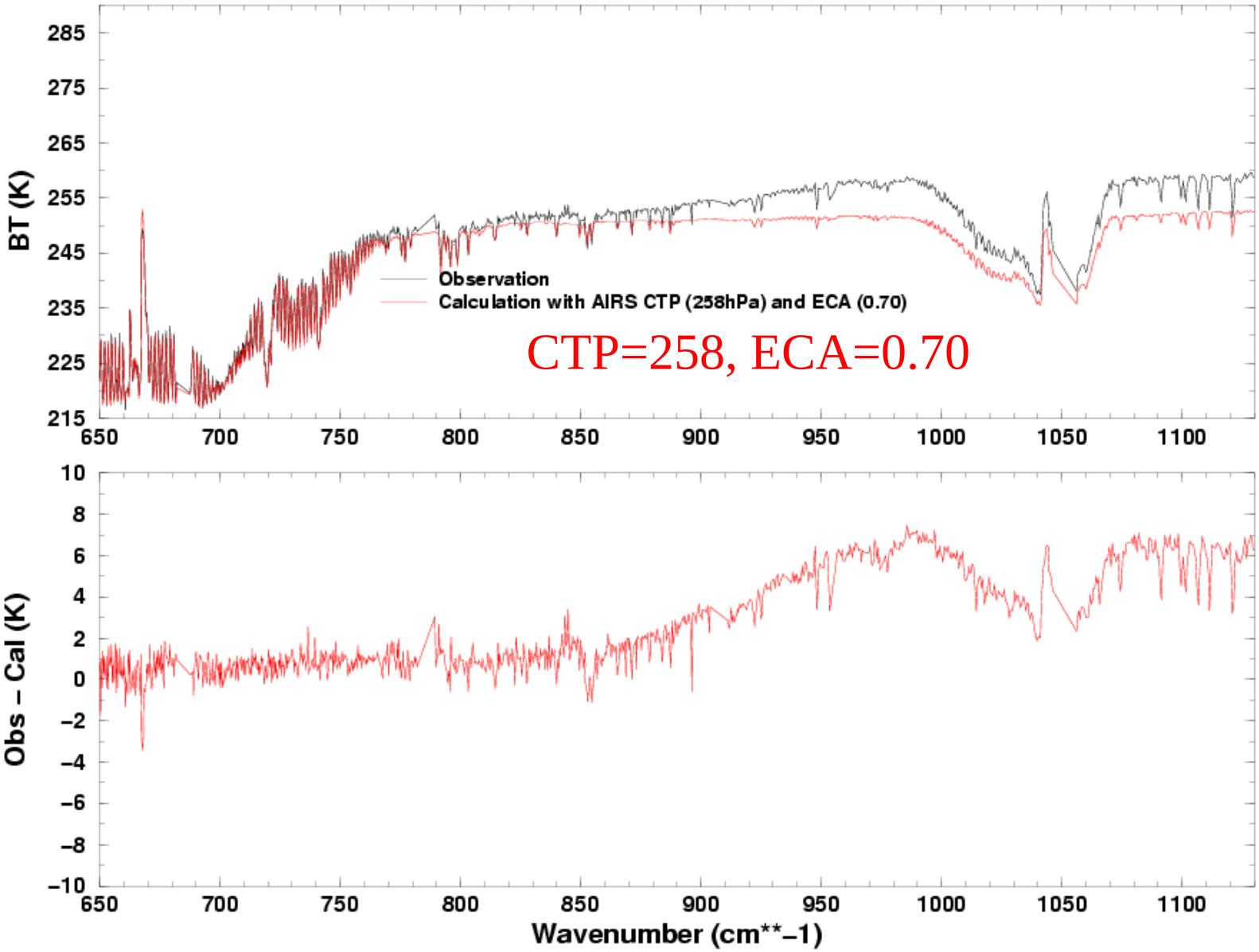
AIRS cloudy calculation with ***ECMWF profile*** versus cloudy observation



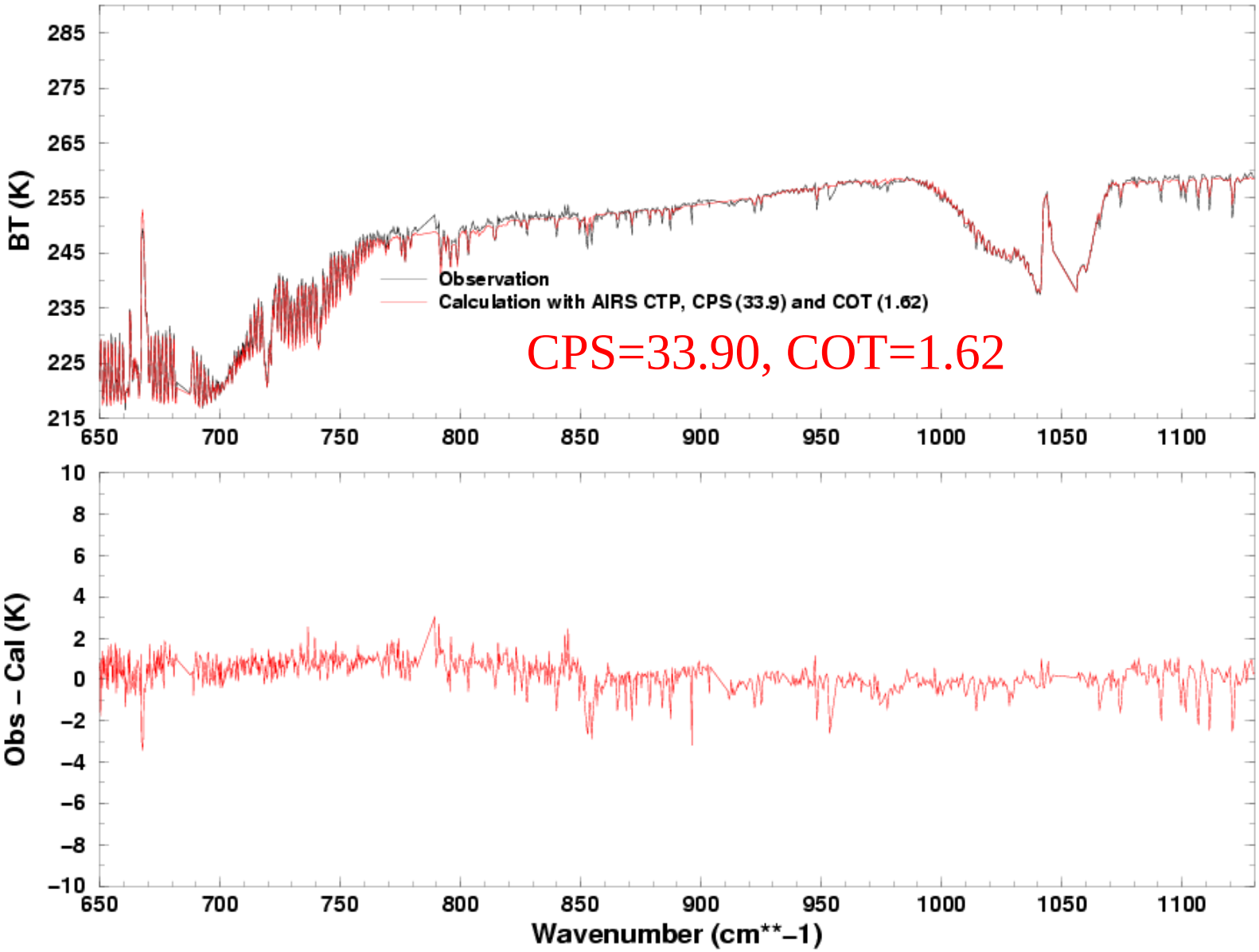
AIRS cloudy calculation with ***MODIS CTP and ECA*** versus cloudy observation

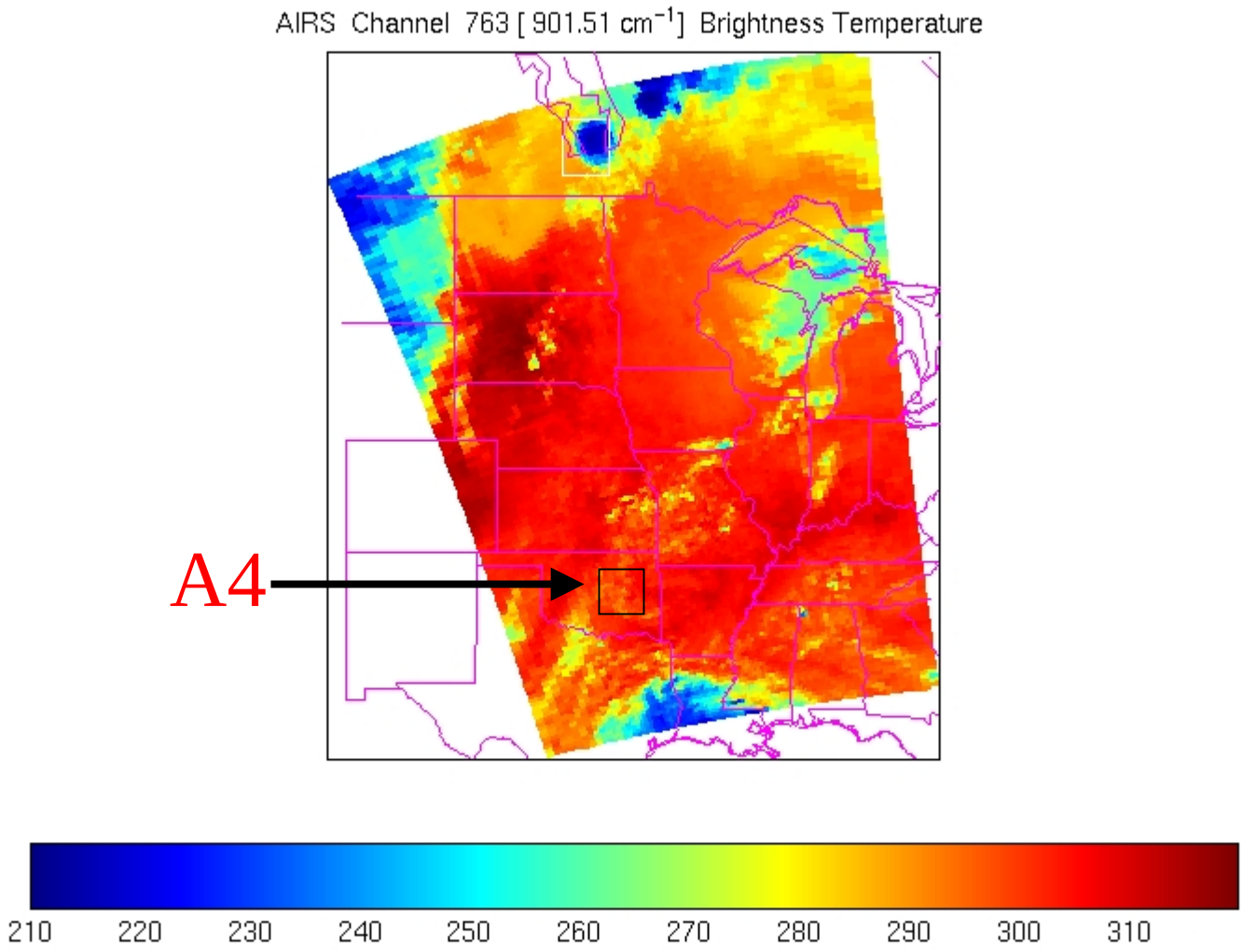


AIRS cloudy calculation with ***AIRS CTP and ECA*** versus cloudy observation

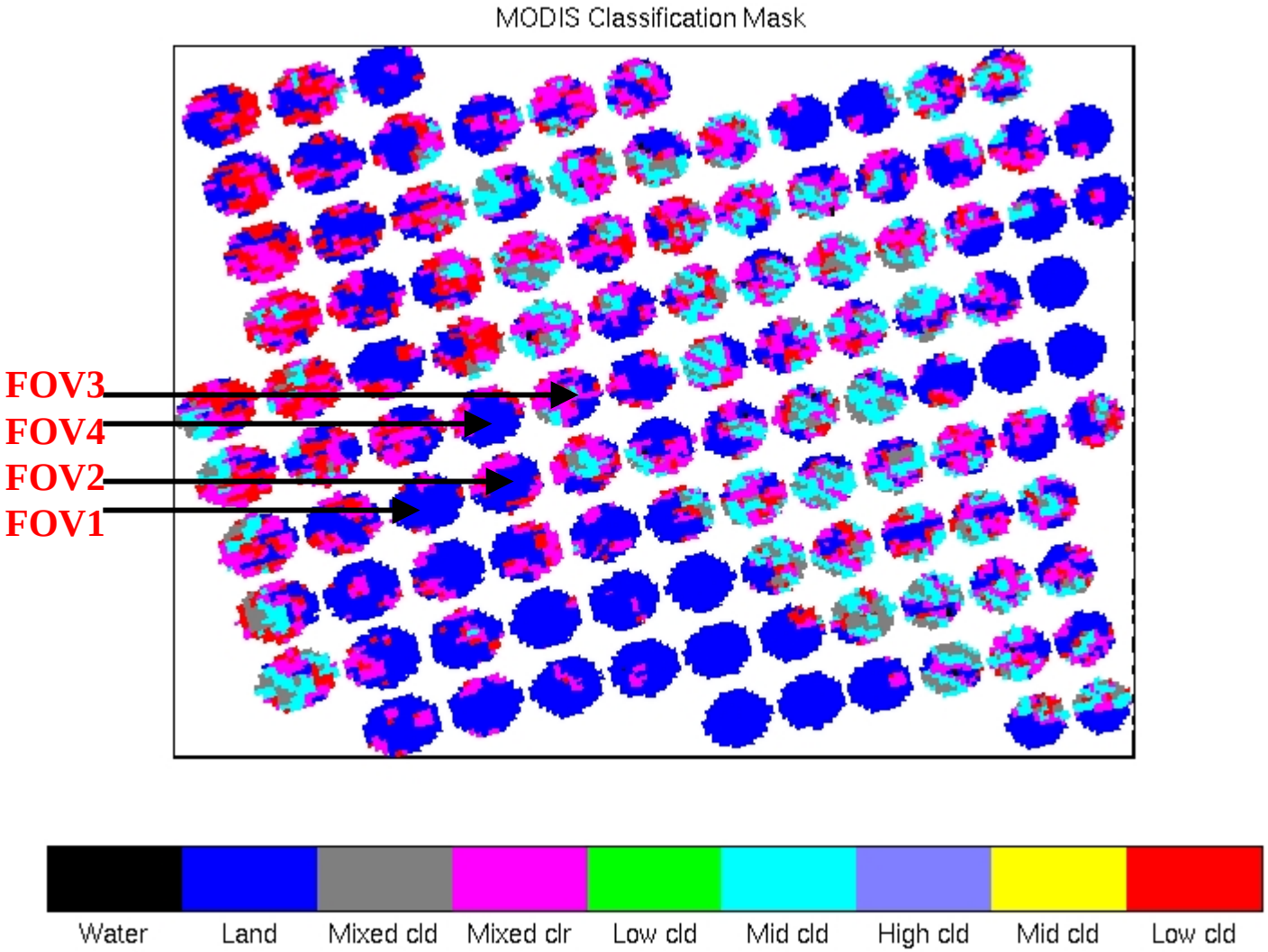


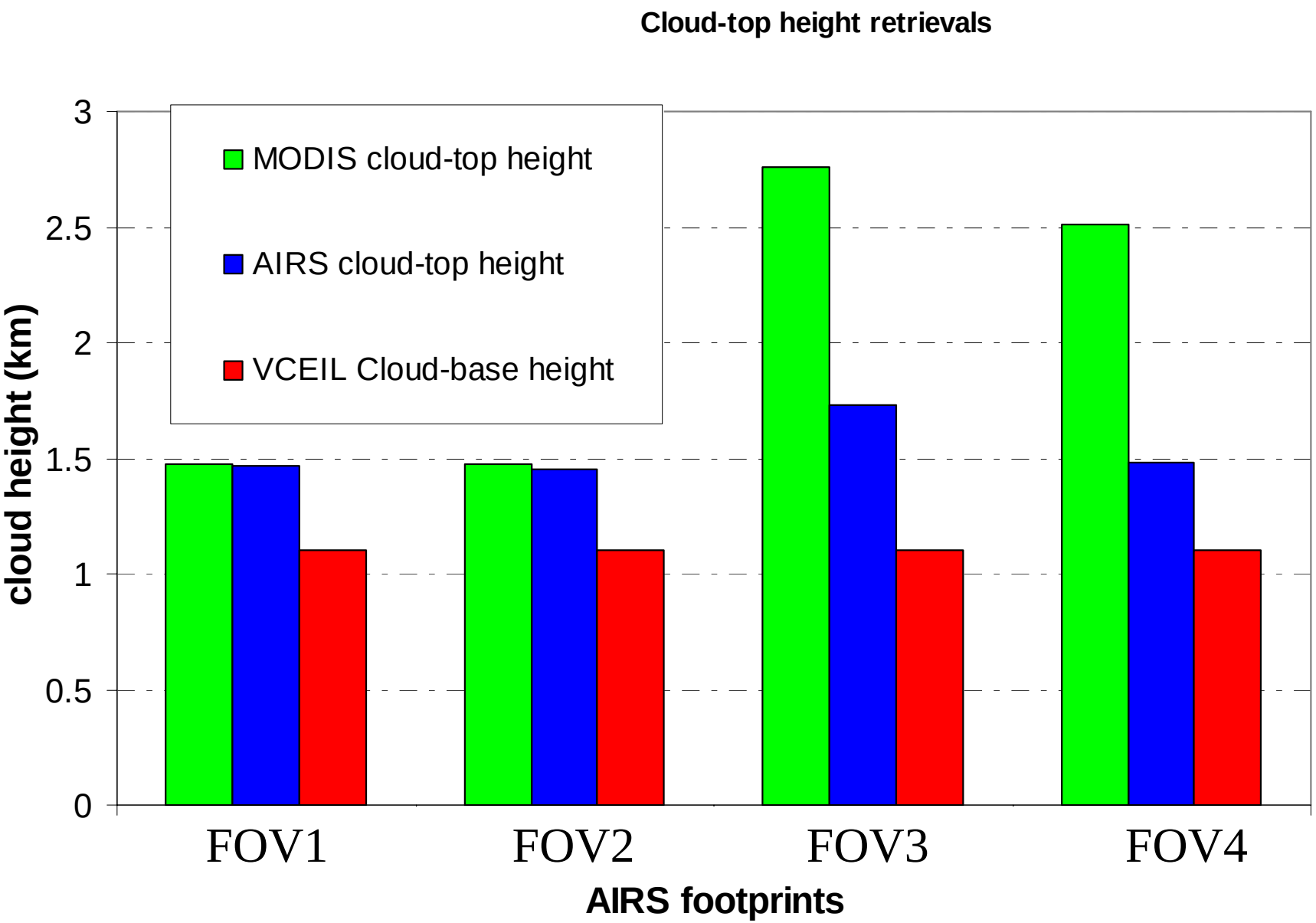
AIRS cloudy calculation with ***AIRS CTP, CPS, and COT*** versus cloudy observation

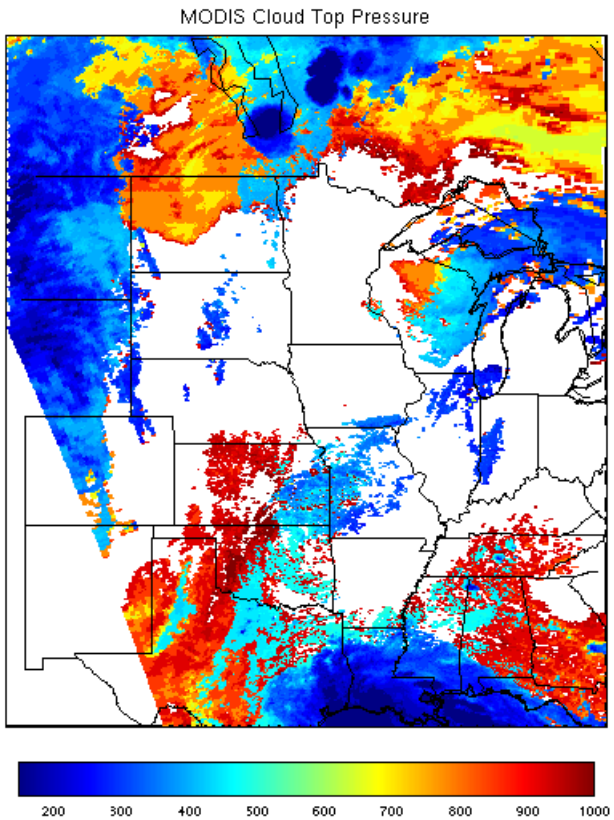



AIRS Channel 763 [901.51 cm^{-1}] Brightness Temperature
A4
210
220
230
240
250
260
270
280
290
300
310

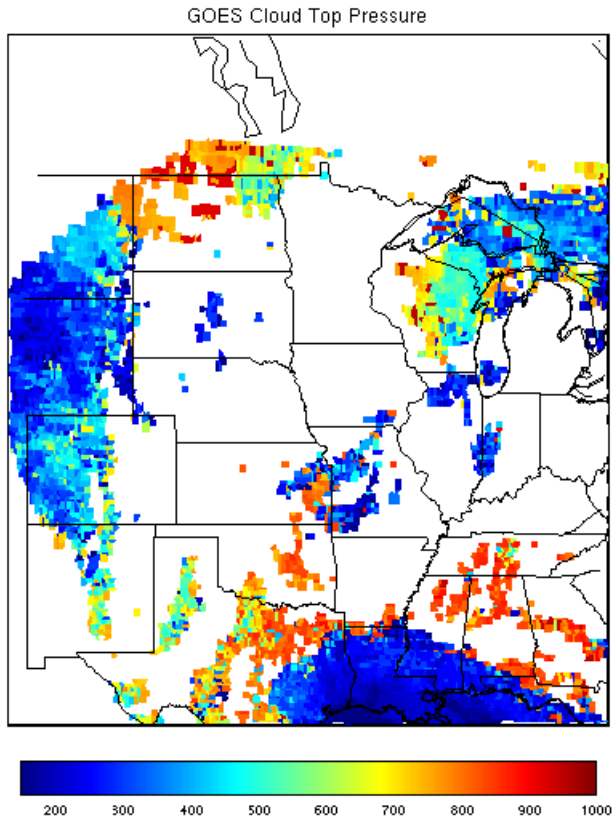
AIRS Four Footprints Near Purcell, OK



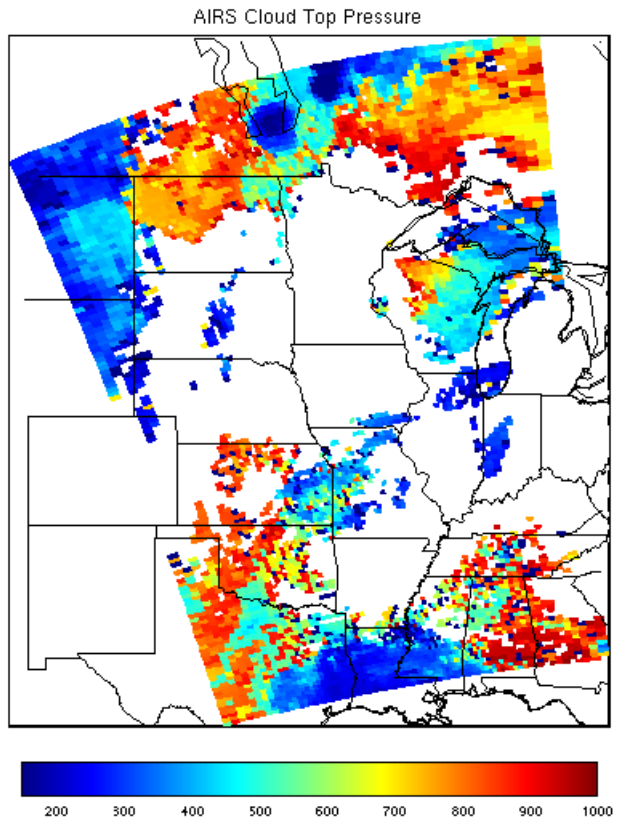

Cloud-top height retrievals
MODIS cloud-top height
AIRS cloud-top height
VCEIL Cloud-base height
cloud height (km)
3
2.5
2
1.5
1
0.5
0
FOV1
FOV2
FOV3
FOV4
AIRS footprints



MODIS at 5km



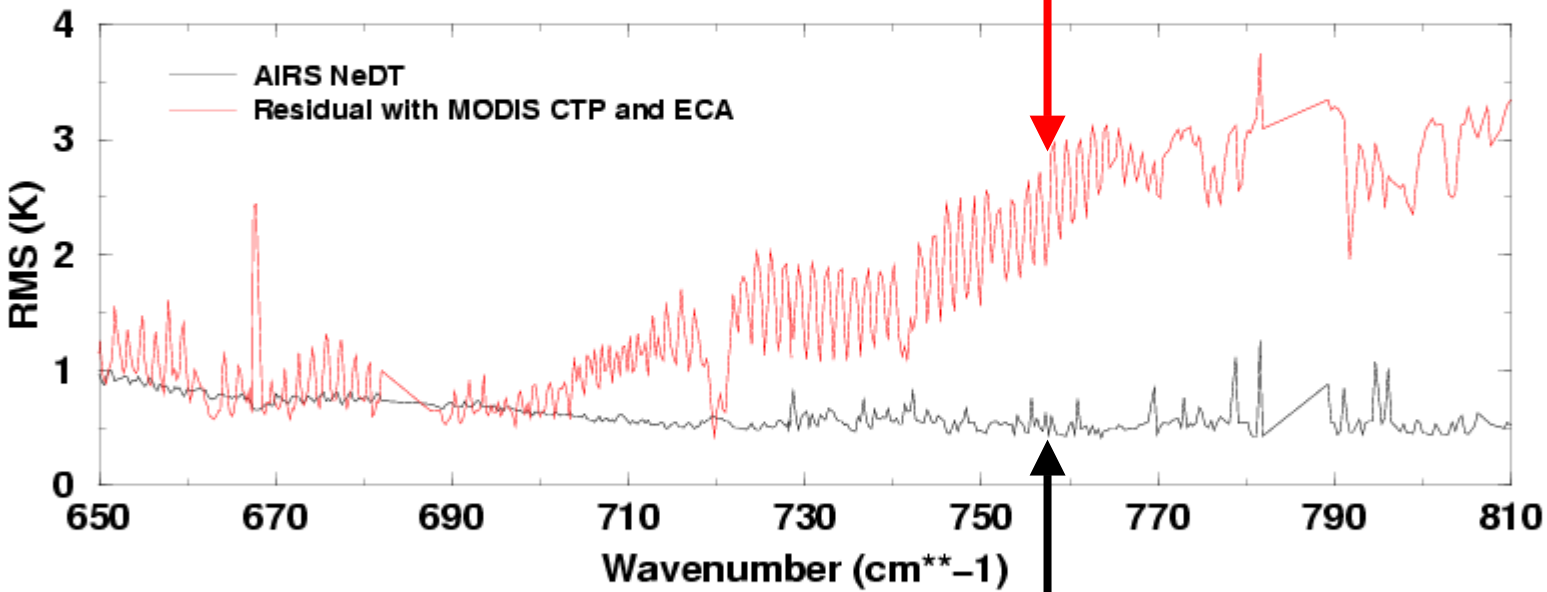
GOES at 10km



AIRS at 14km

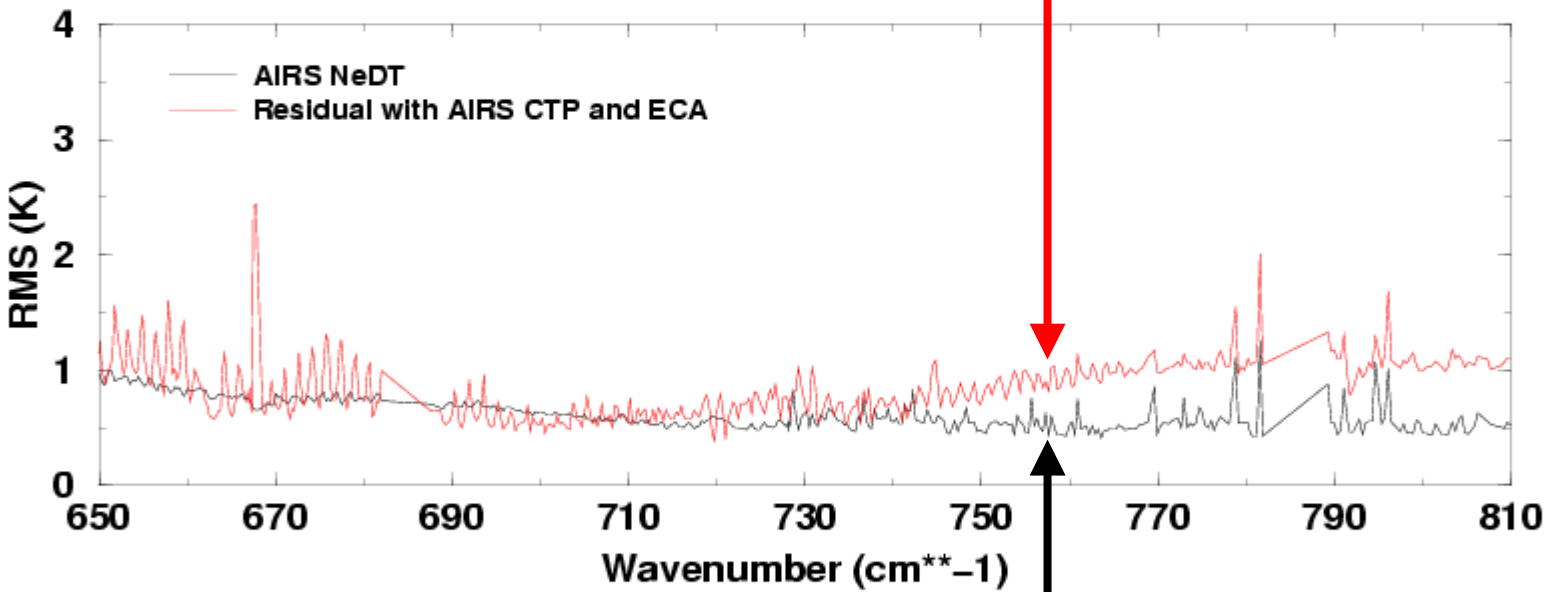
AIRS/MODIS/GOES CTP comparisons

RMS Residual with MODIS CTP and ECA



AIRS NeDT

RMS Residual with AIRS CTP and ECA



AIRS NeDT

Summary

- **MODIS data help AIRS sub-pixel cloud detection and characterization**
- **With MODIS products as the background, improved atmospheric and cloud parameters can be obtained from sounder radiance measurements**
- **Other**
  - **Improved imager SST products with sounder emissivity retrieval**
  - **Image product + sounder product => better imager product**

Future work

- Synergistic use of MODIS/AIRS for retrieving the atmospheric profiles and cloud properties simultaneously
- Prepare ABI/HES retrieval system, MODIS/AIRS data will be used