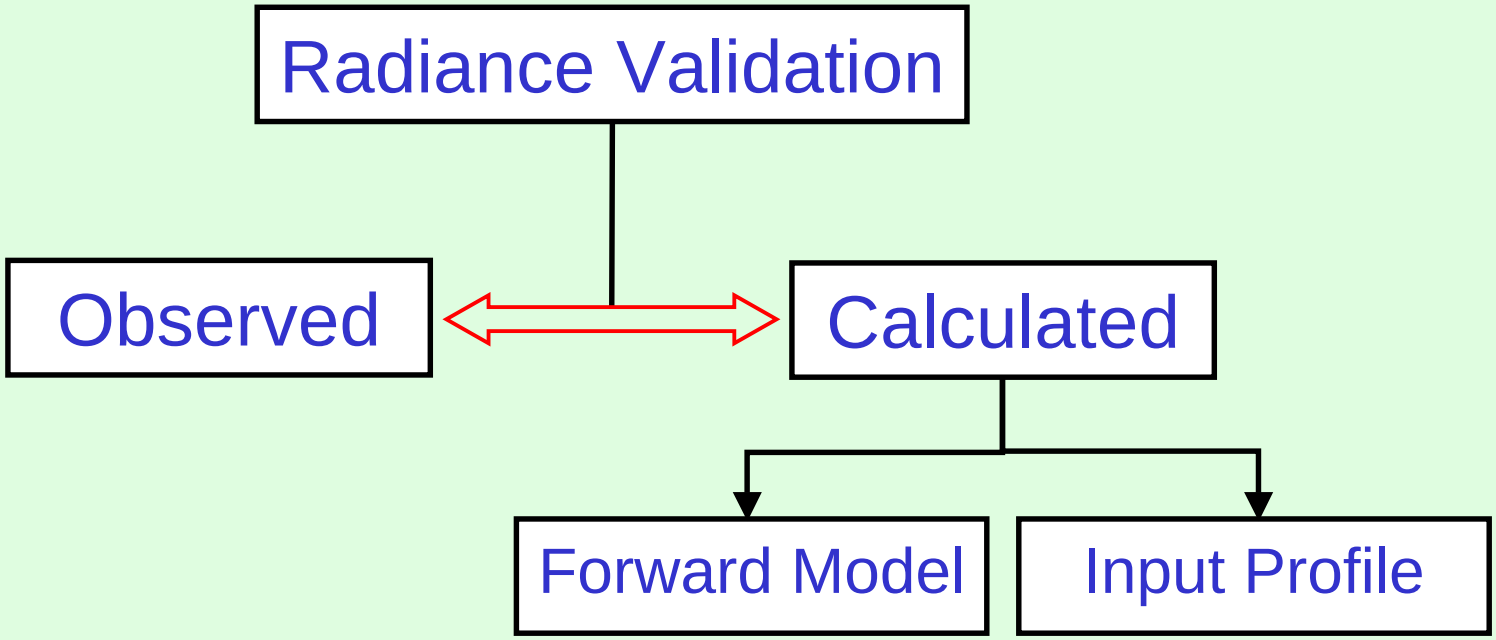
some recent

Radiance Validation

efforts at CIMSS/SSEC


Radiance Validation
Observed
Calculated
Forward Model
Input Profile

Outline

1. Forward model development and validation with ground-based uplooking high spectral resolution radiance observations

2. AIRS radiance validation with coincident aircraft based high spectral resolution radiance observations

3. Forward model development and validation with coincident AIRS and ARM site observations.

Contributors:

Larrabee Strow, Scott Hannon, Sergio DeSouza-Machado, Howard Motteler, Tony Clough, Pat Brown, Eli Mlawer, Mark Shephard, Bob Ellingson, Tim Shippert, Tom Pagano, George Aumann, Steve Gaiser, Chris Barnet, Walter Woolf, Steve Ackerman, Paolo Antonelli, Kevin Baggett, Fred Best, Nick Ciganovich, Ralph Dedecker, Daniel Deslover, Tim Dirkx, Steve Dutcher, Scott Ellington, Wayne Feltz, Rich Frey, Ray Garcia, Liam Gumley, Mat Gunshor, Ben Howell, Allen Huang, Bormin Huang, Jeff Key, Bob Knuteson, Dan Laporte, Chia Lee, Jun Li, John Mecikalski, Chris Moeller, Leslie Moy, Erik Olson, Brian Osborne, Hank Revercomb, Tim, Schmidt, Suzanne Seemann, John Short, Larry Sromovsky, Kathy Strabala, Joe Taylor, Yao Te, Dave Tobin, Dave Turner, Paul Van Delst, Ken Vinson, Elisabeth Weisz, Mark Werner, Hal Woolf, Bill Smith, ...

Outline

1. Forward model development and validation with ground-based uplooking high spectral resolution radiance observations

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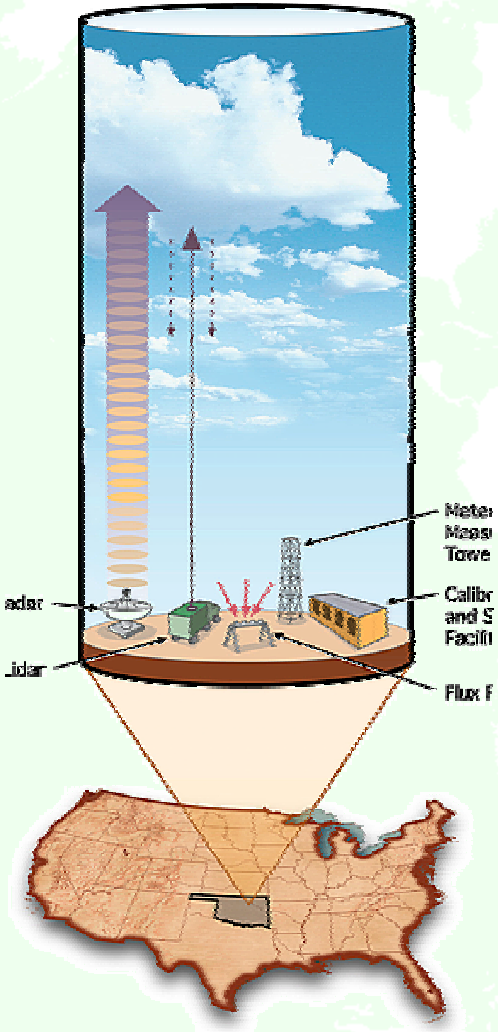
ARM

The Atmospheric Radiation Measurement Program

… the ultimate goal of improving the parameterizations of clouds and radiation used in climate models.



Vaisala radiosondes

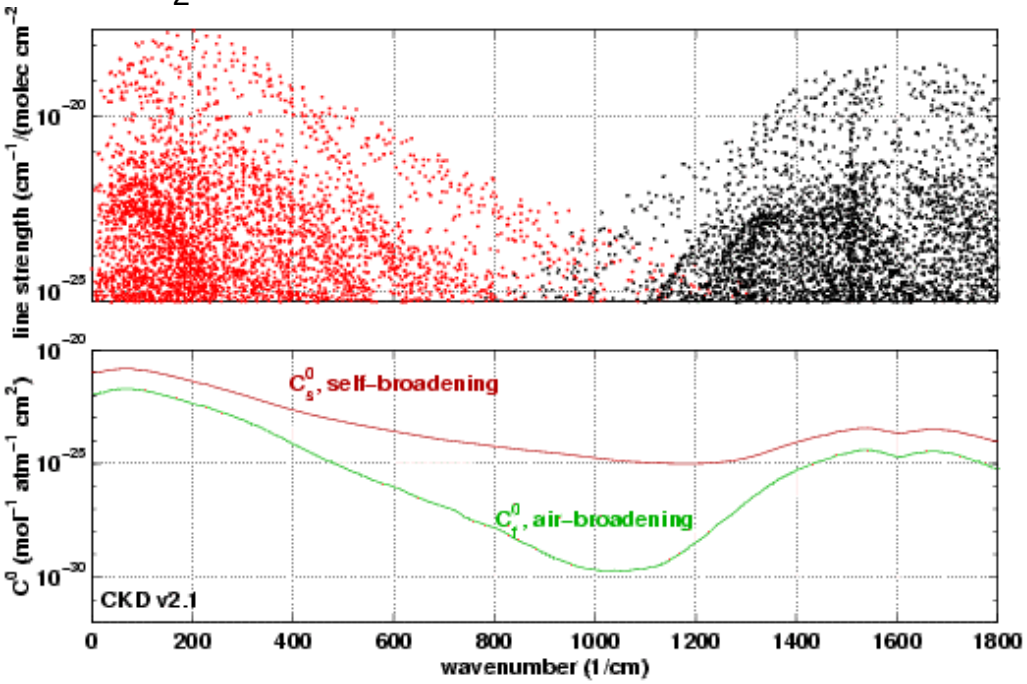
Raman Lidar

AERI

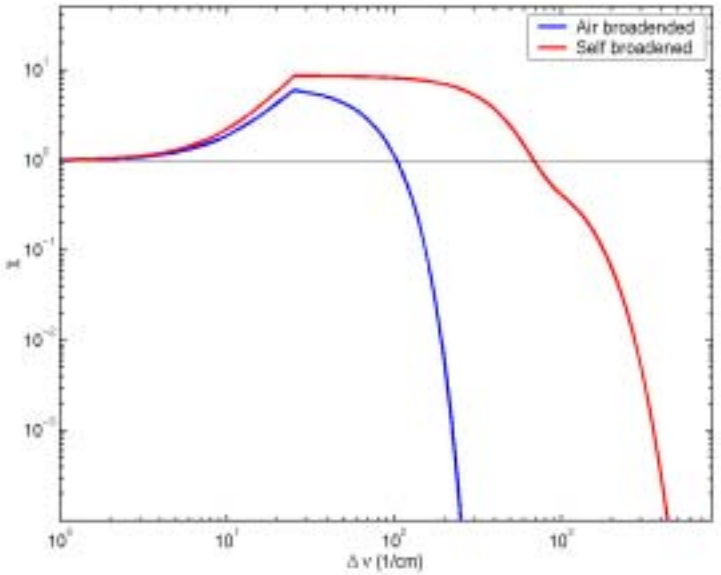
Microwave Radiometer (MWR)

Water vapor absorption modeling

H_2O lines and continuum coefficients



CKDv0 χ-functions



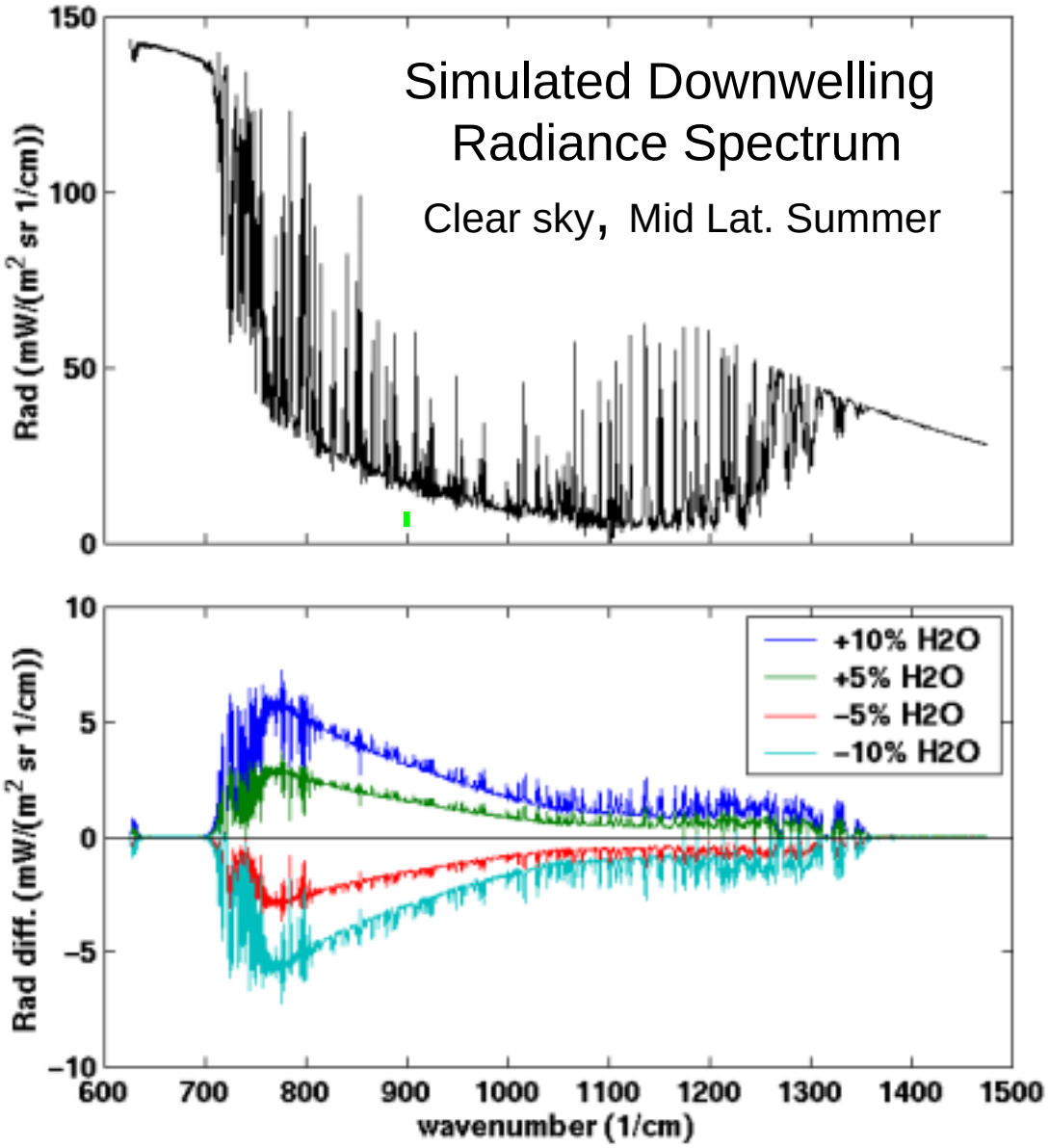
$$k(\nu) \propto \sum_{\text{all lines},i} k_{\text{local}}(\nu_i, \nu) + \underbrace{\rho_{H_2O}\{\rho_{H_2O} C_s^0(\nu, T) + \rho_{air} C_f^0(\nu)\}}_{\text{continuum}}$$

Lower Troposphere Water Vapor Measurement Goal: <2% in precipitable water vapor

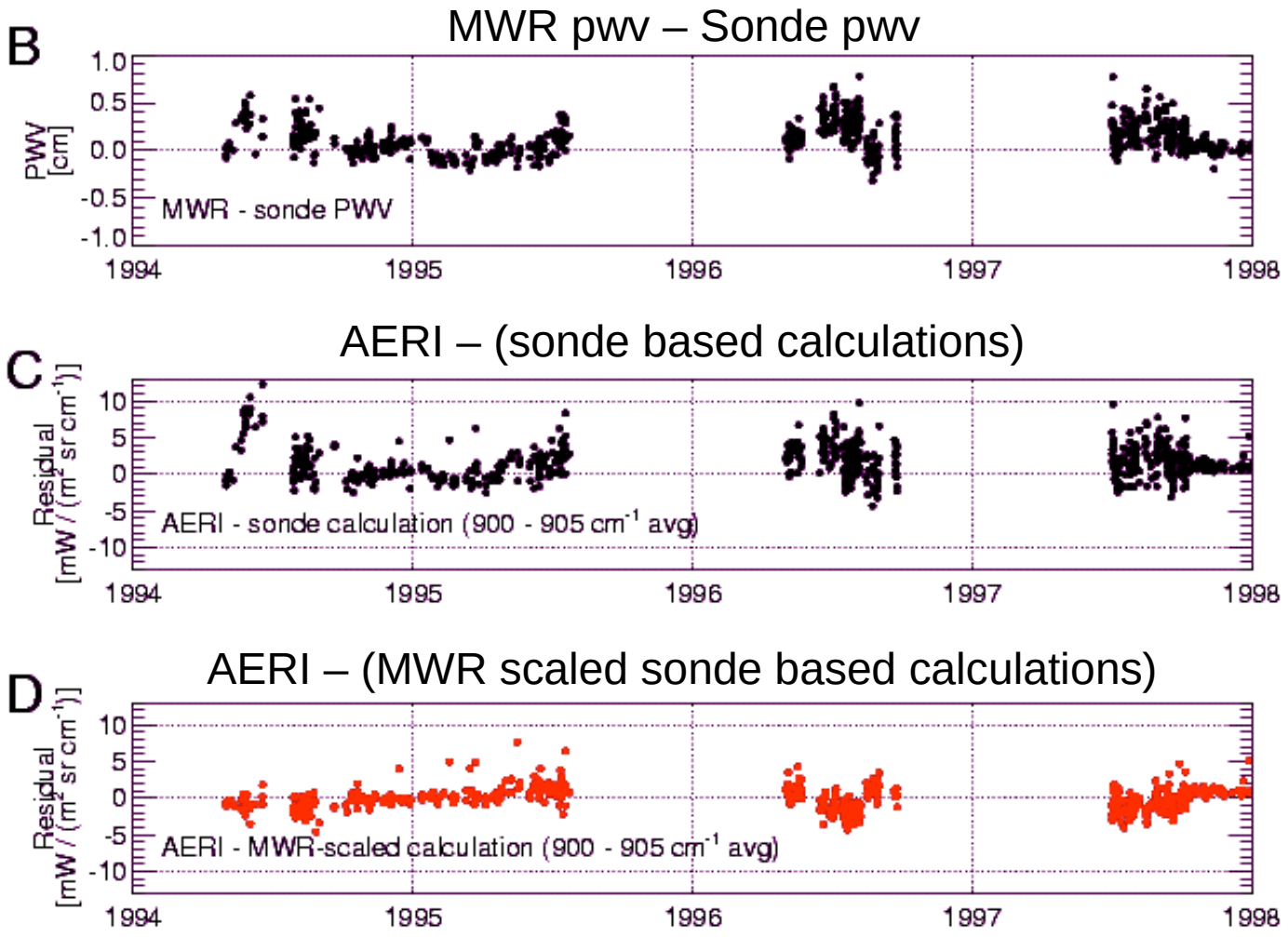
Based on desire to improve clear sky absorption models and to resolve significant climate changes, such as the effect of CO_2 doubling on surface radiation budget.

For midlatitude conditions, a 10% H_2O perturbation results in a ~7 W/m^2 change in downwelling Flux at the surface.

2% is order (1 W/m^2)



Line-by-line Radiative Transfer Model improvements initially limited by radiosonde water vapor uncertainties



Note strong correlation between the uncertainty in the sonde water vapor (**B**) and the longwave radiance residuals (**C**)

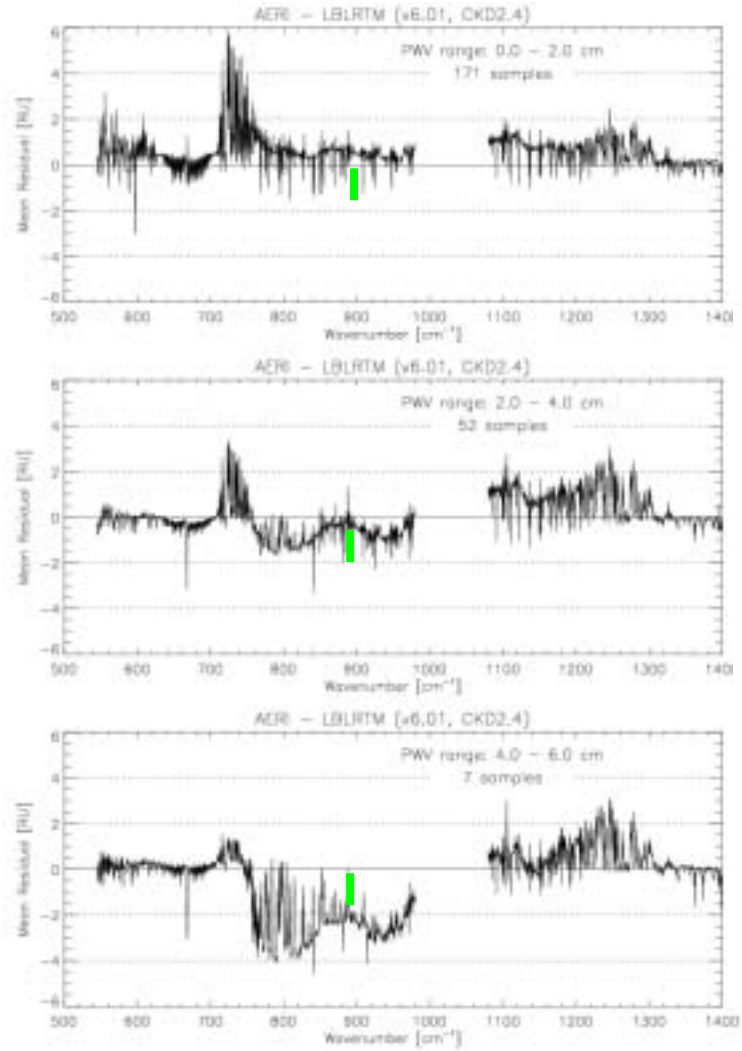
AERI Observed minus Calculated versus Total Column Water

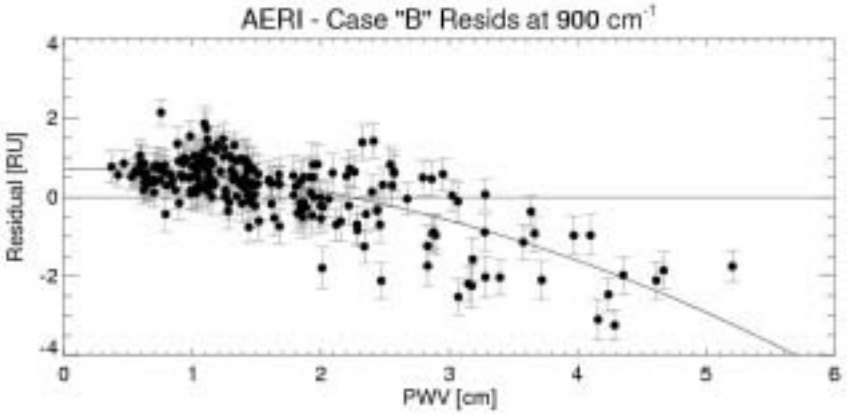
1998-2001 AERI/LBLRTM QME dataset

0 to 2 cm

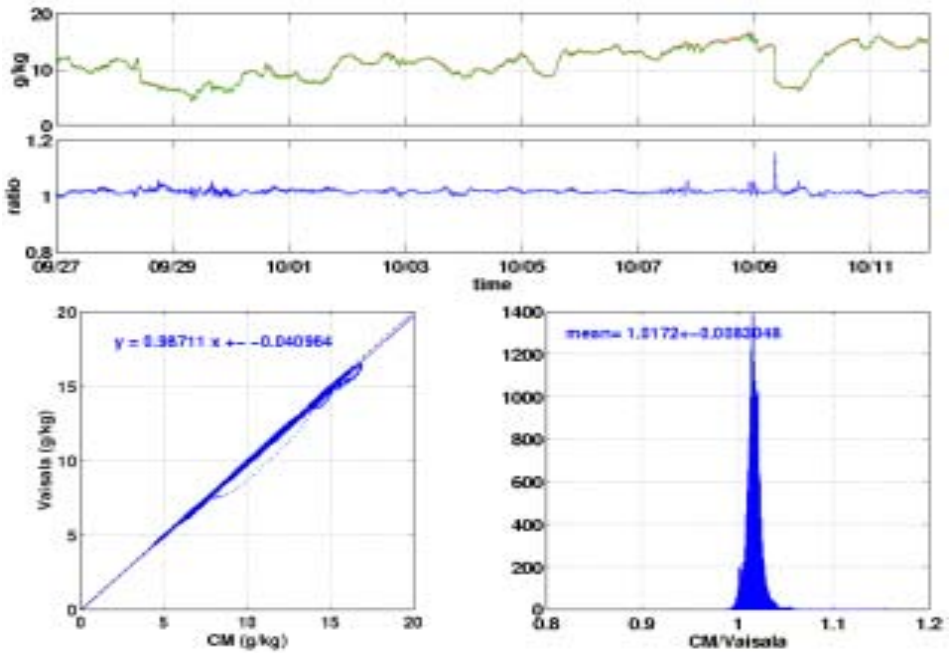
2 to 4 cm

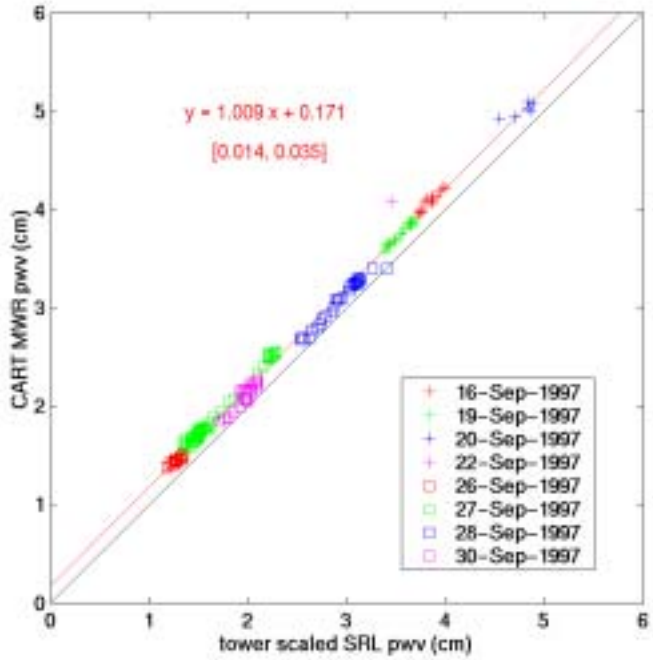
4 to 6 cm



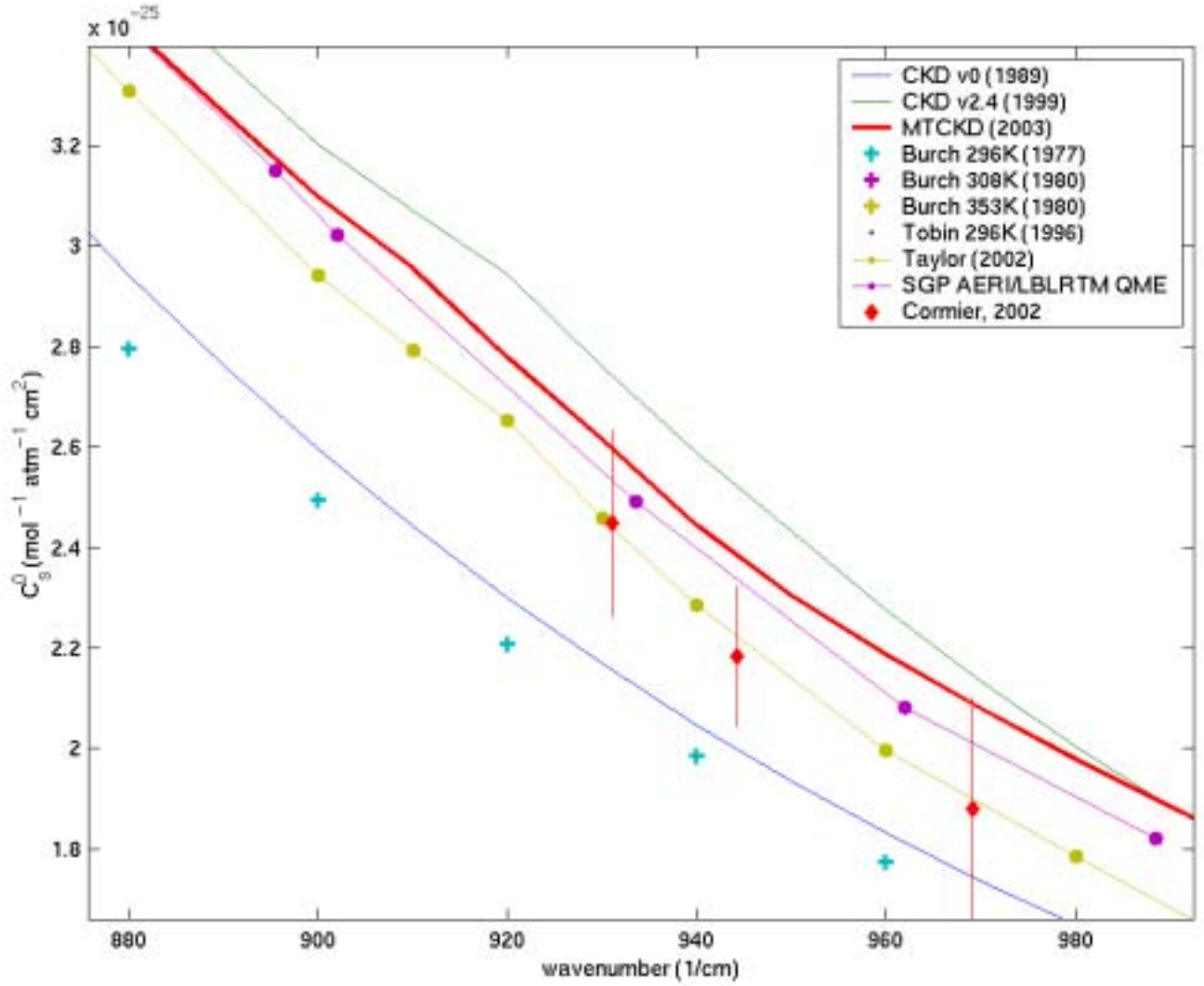


The Rosetta Stone, 1997 WVIOP



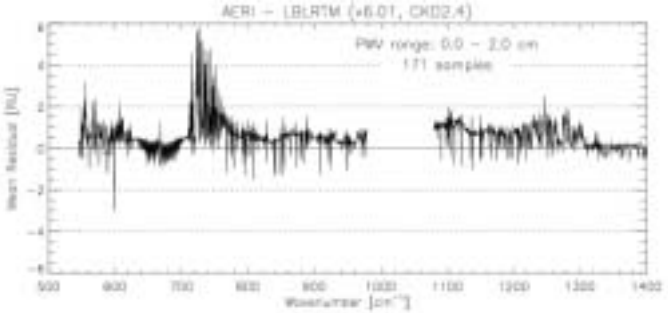
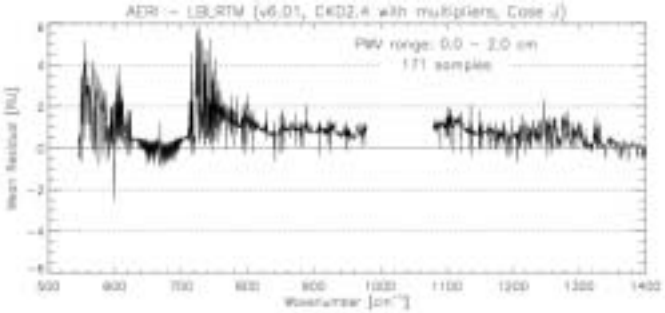
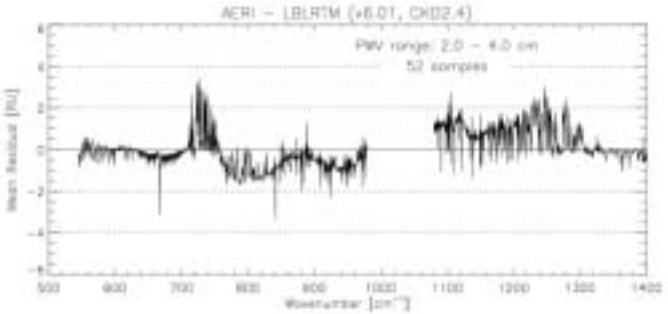
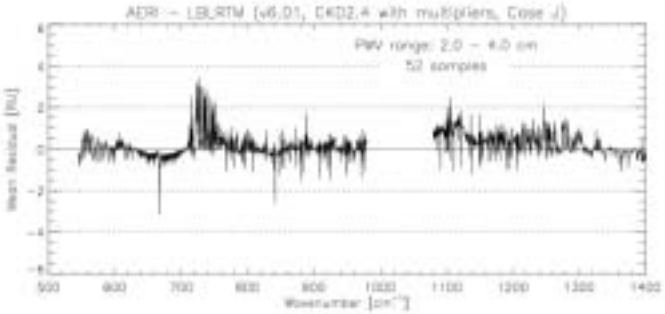
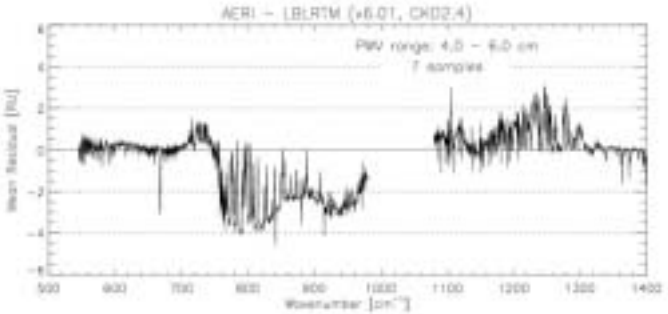
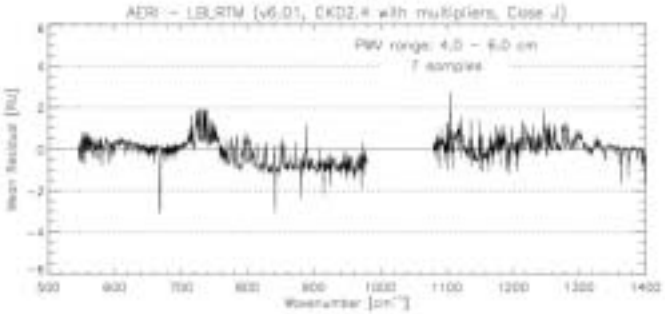


Self-broadened Water Vapor Continuum Coefficients



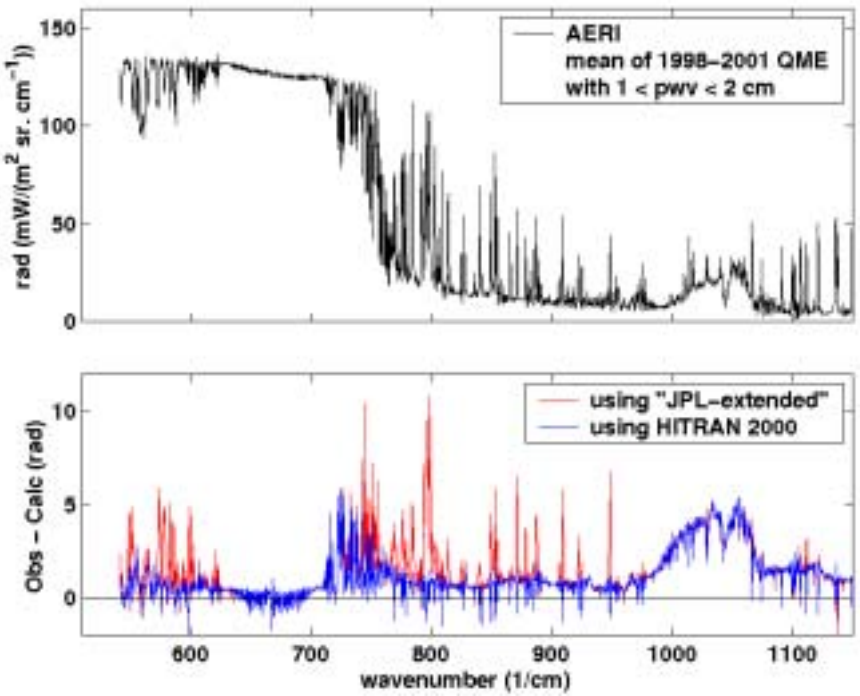
Effect of new Continuum on AERI obs-calcs

1998-2001 AERI/LBLRTM QME dataset

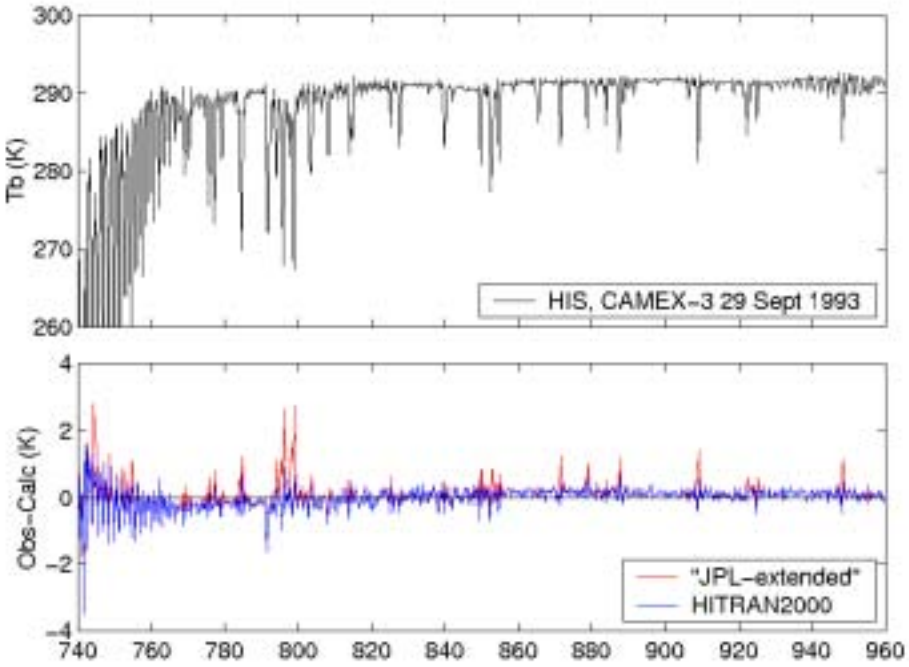
	LBLRTM v6.01, CKD2.4	with changes
0 to 2 cm		
2 to 4 cm		
4 to 6 cm		

Effect of HITRAN2000 H_2O line parameters

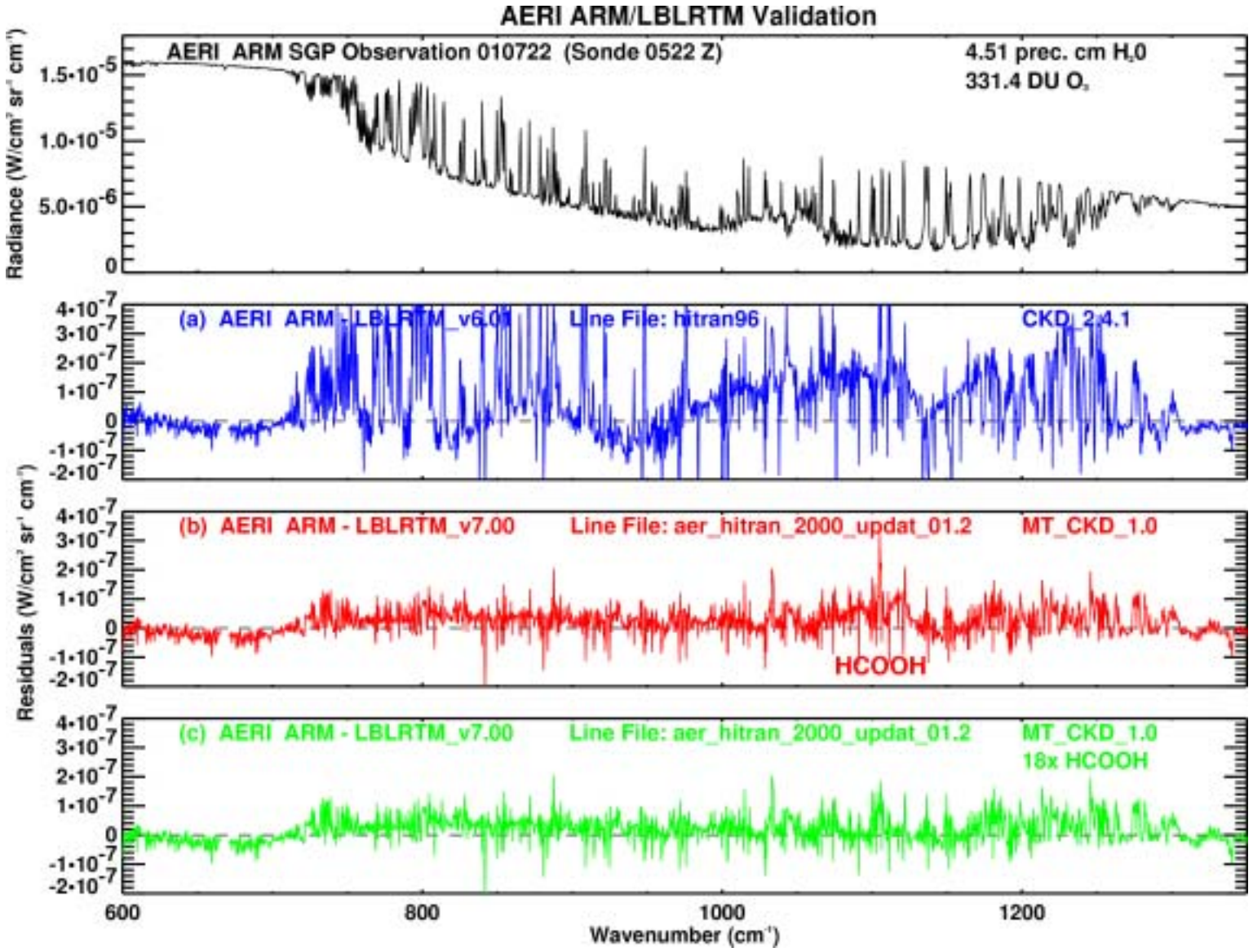
1998-2001 AERI/LBLRTM QME dataset



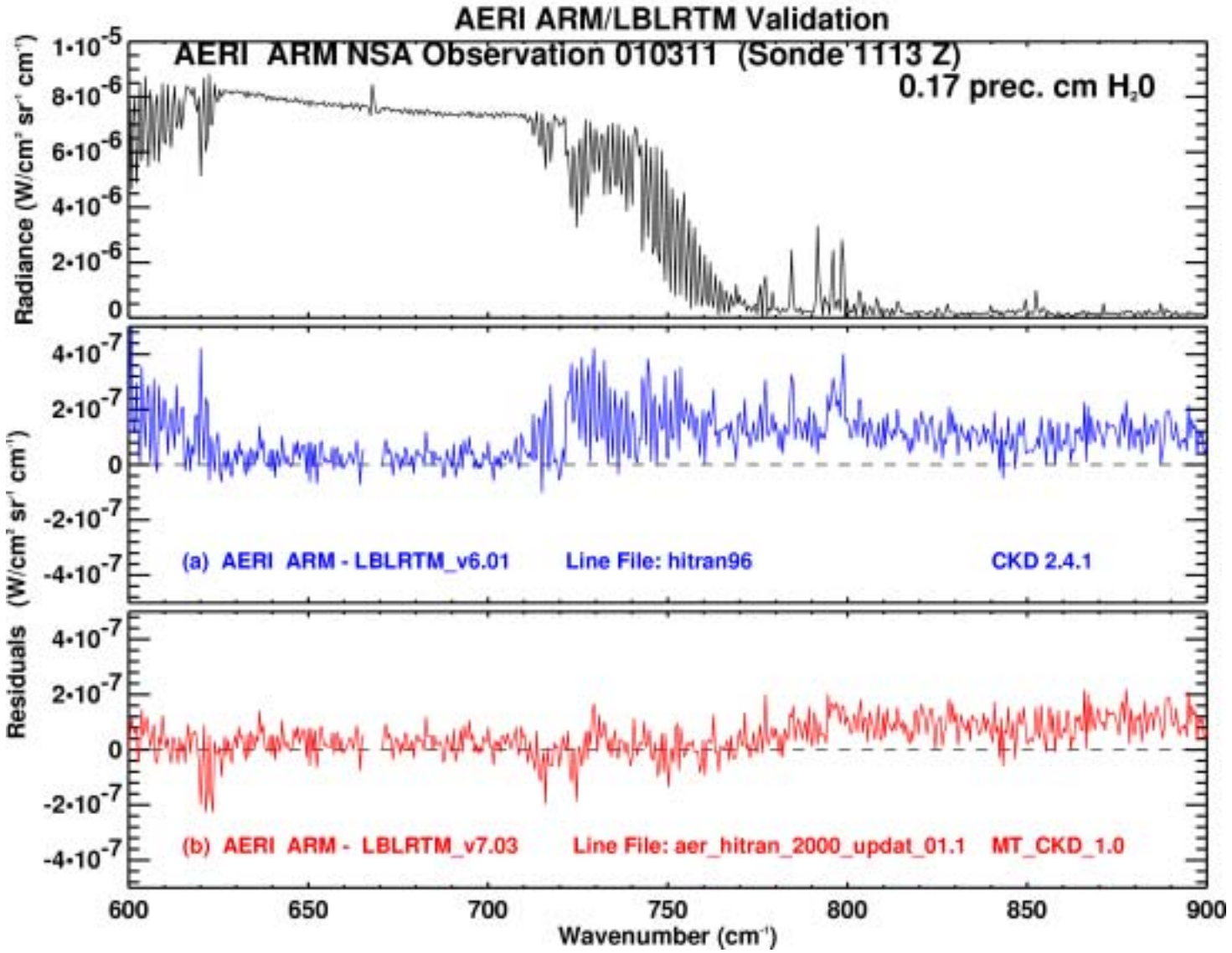
HIS CAMEX 3/29/93 Case



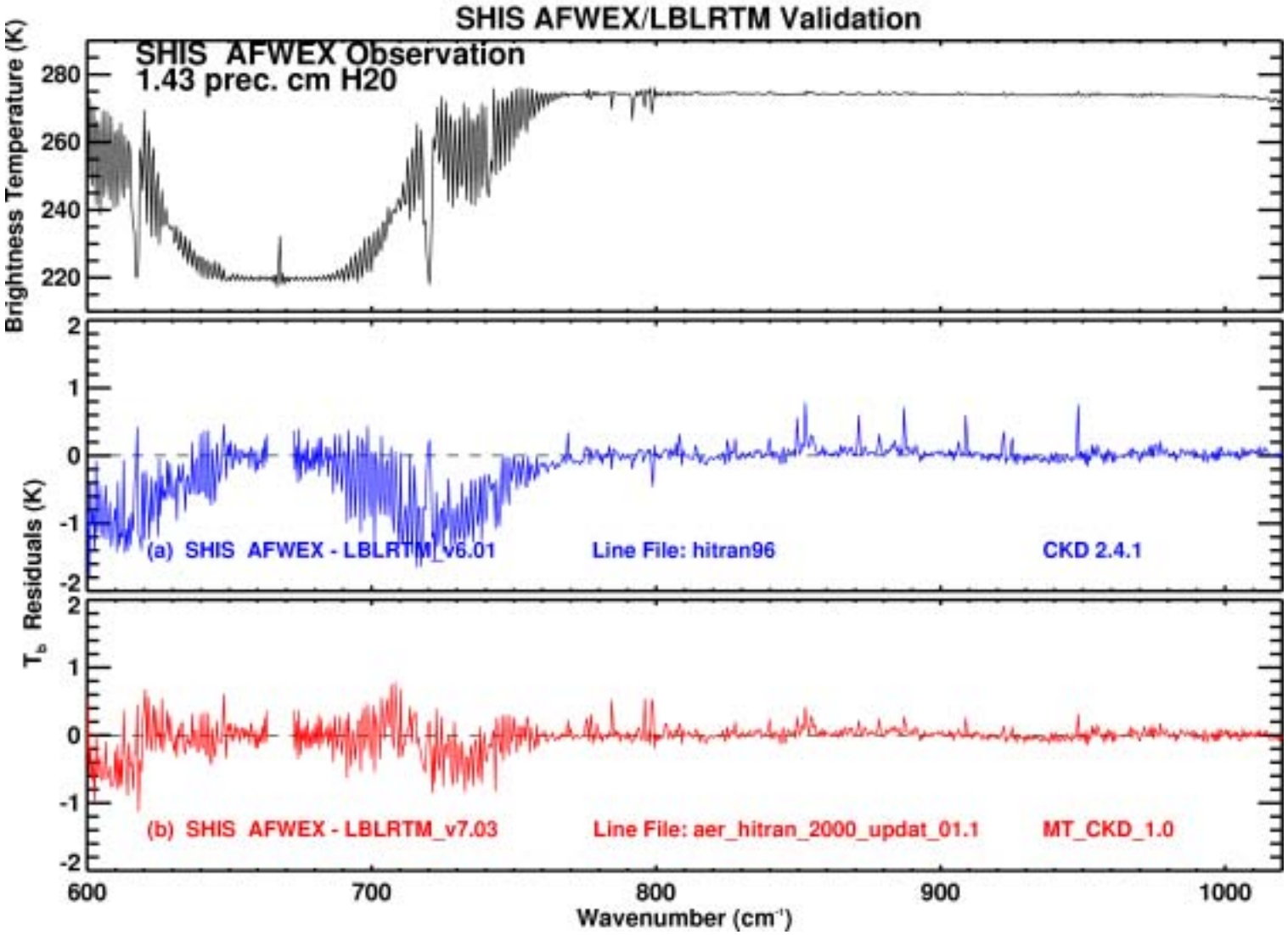
from Clough et al, 2003 ARM Science Team Meeting:



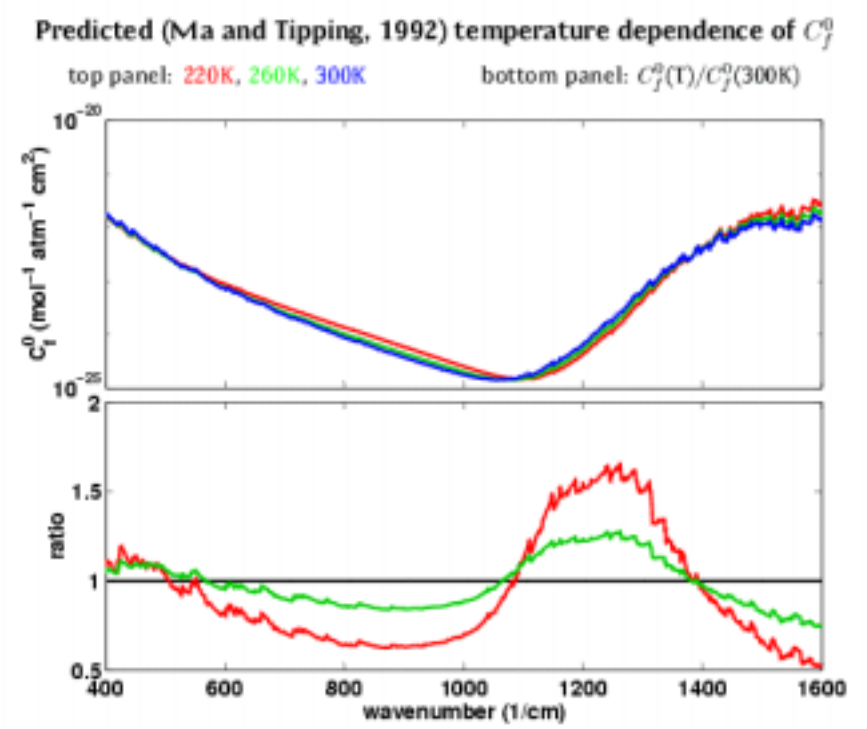
from Clough et al, 2003 ARM Science Team Meeting:

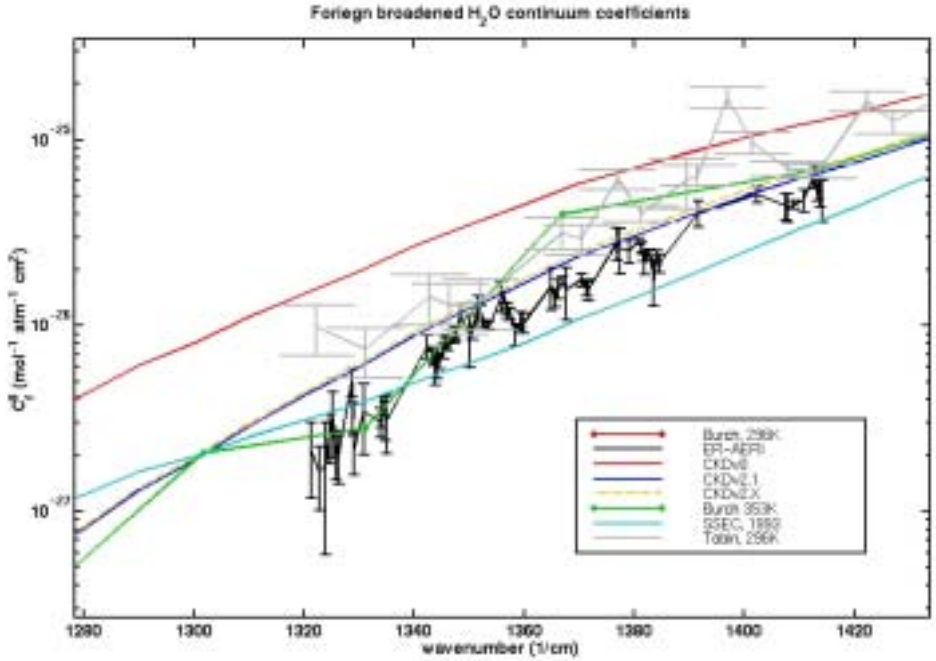


from Clough et al, 2003 ARM Science Team Meeting:



Temperature Dependence of C_f^0





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UW Scanning-HIS: 1998-Present

(HIS: High-resolution Interferometer Sounder, 1985-1998)

Characteristics

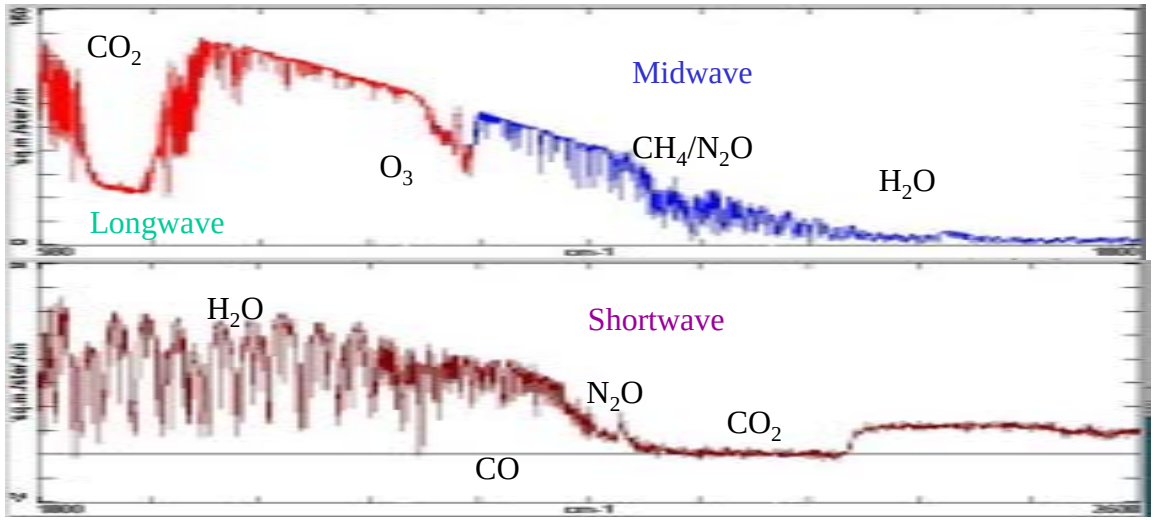
Spectral Coverage: 3-17 microns

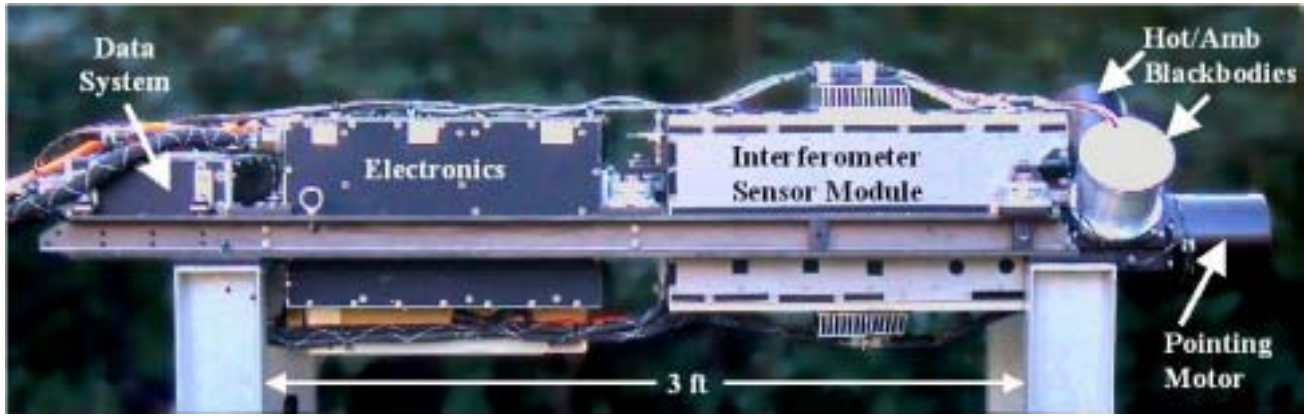
Spectral Resolution: 0.5 cm^{-1}

Resolving power: 1000-6000

Footprint Diam: 1.5 km @ 15 km

Cross-Track Scan: Programmable including uplooking zenith view



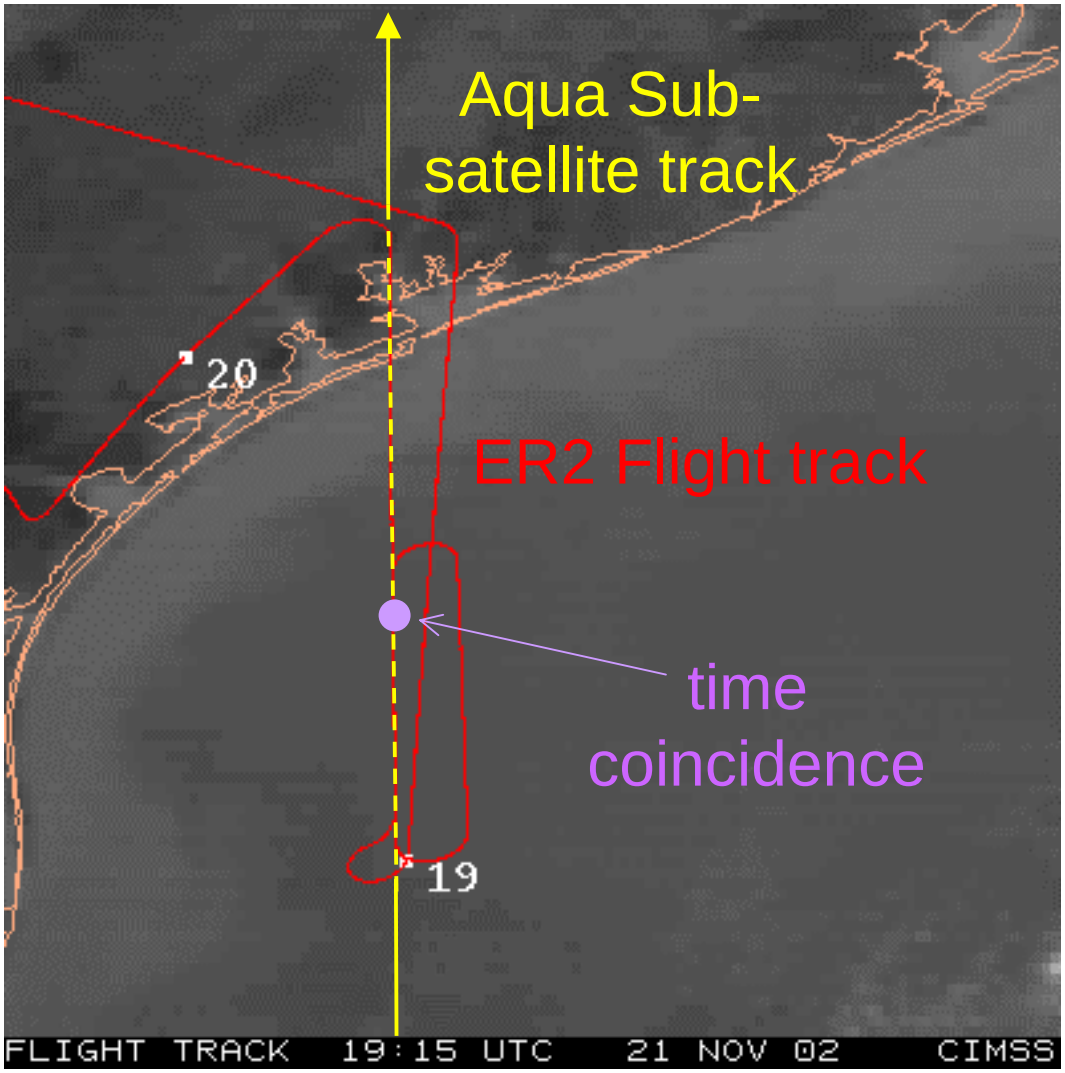


Applications:

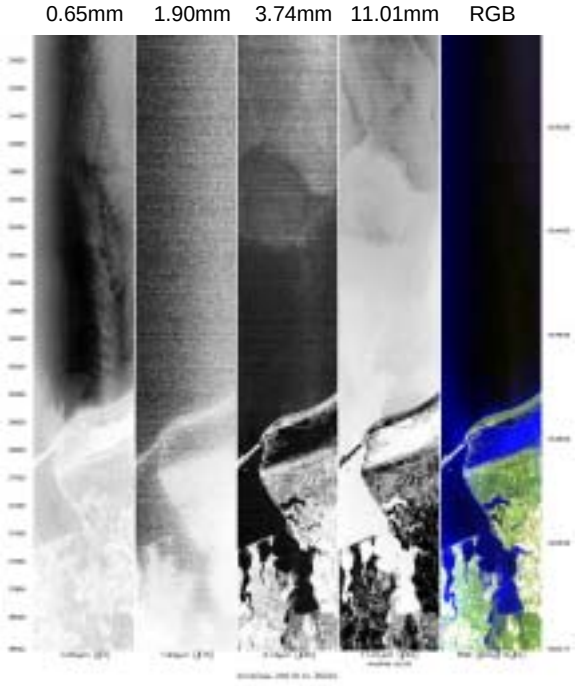
- Radiances for Radiative Transfer
- Satellite validation
- Temp & Water Vapor Retrievals
- Cloud Radiative Prop.
- Surface Emissivity & T
- Trace Gas Retrievals

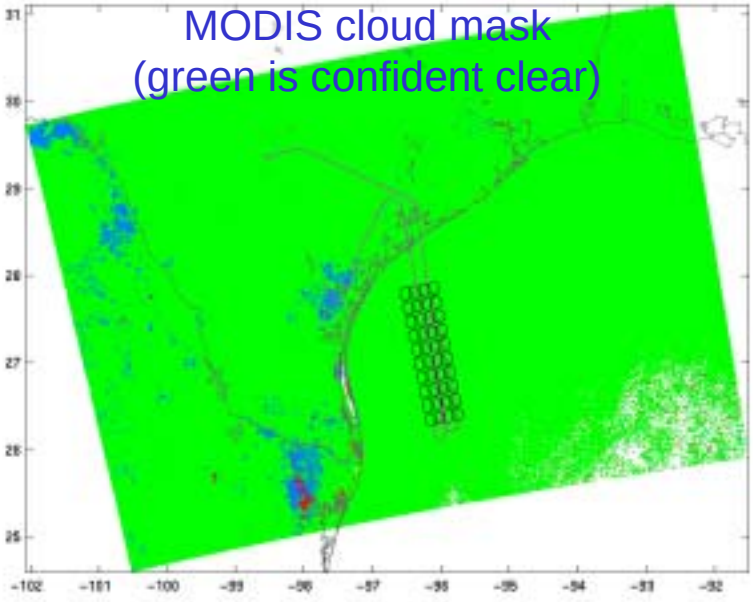
Terra/Aqua Experiment-2002

19:40 UTC (daytime), Gulf of Mexico
11/21/2002

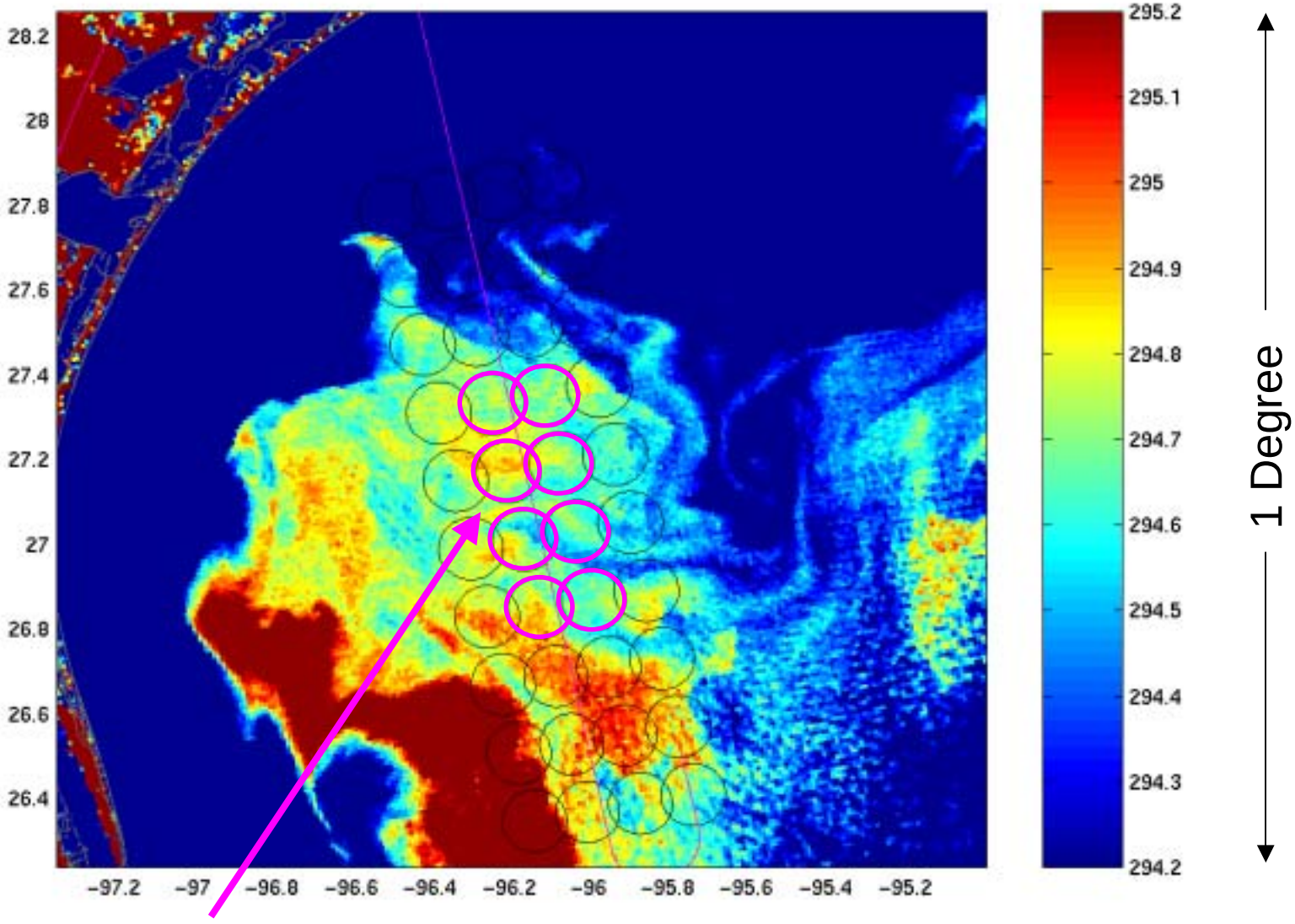


MAS Quicklooks flight leg 5





MODIS 12 micron Band & near-nadir AIRS FOVs

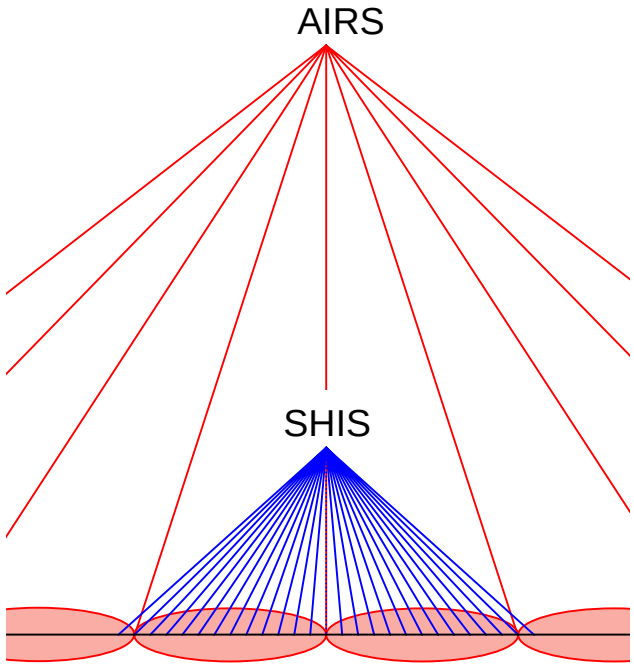


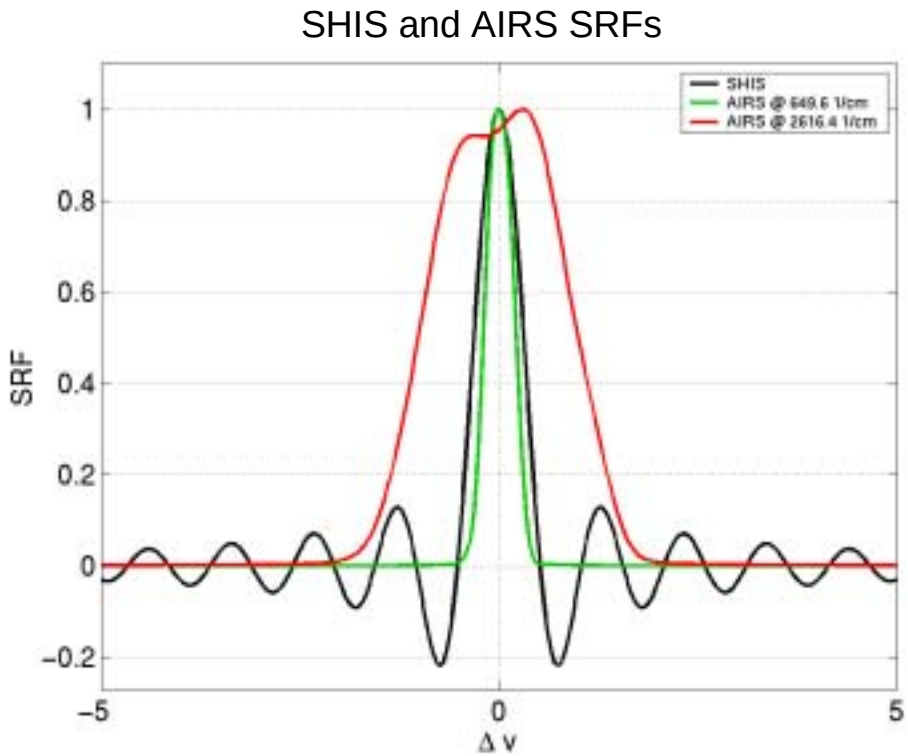
8 AIRS FOVs used in the following comparisons

AIRS / SHIS Comparisons

A detailed comparison should account for:

- instrumental noise and scene variations
- Different observation altitudes (AIRS is 705km, SHIS is ~20km on ER2, ~14km on Proteus)
- Different view angles (AIRS is near nadir, SHIS is ~±35deg from nadir)
- Different spatial footprints (AIRS is ~15km at nadir, SHIS is ~2km at nadir)
- Different spectral response (AIRS $\Delta\nu=\nu/1200$, SHIS $\Delta\nu=$~0.5 cm^{-1}) and sampling





AIRS / SHIS Comparison steps

0. Average SHIS data within AIRS FOV(s) & compare
   - No attempt to account for view angle, altitude, spectral differences.

1. Compare Residuals from calculations:

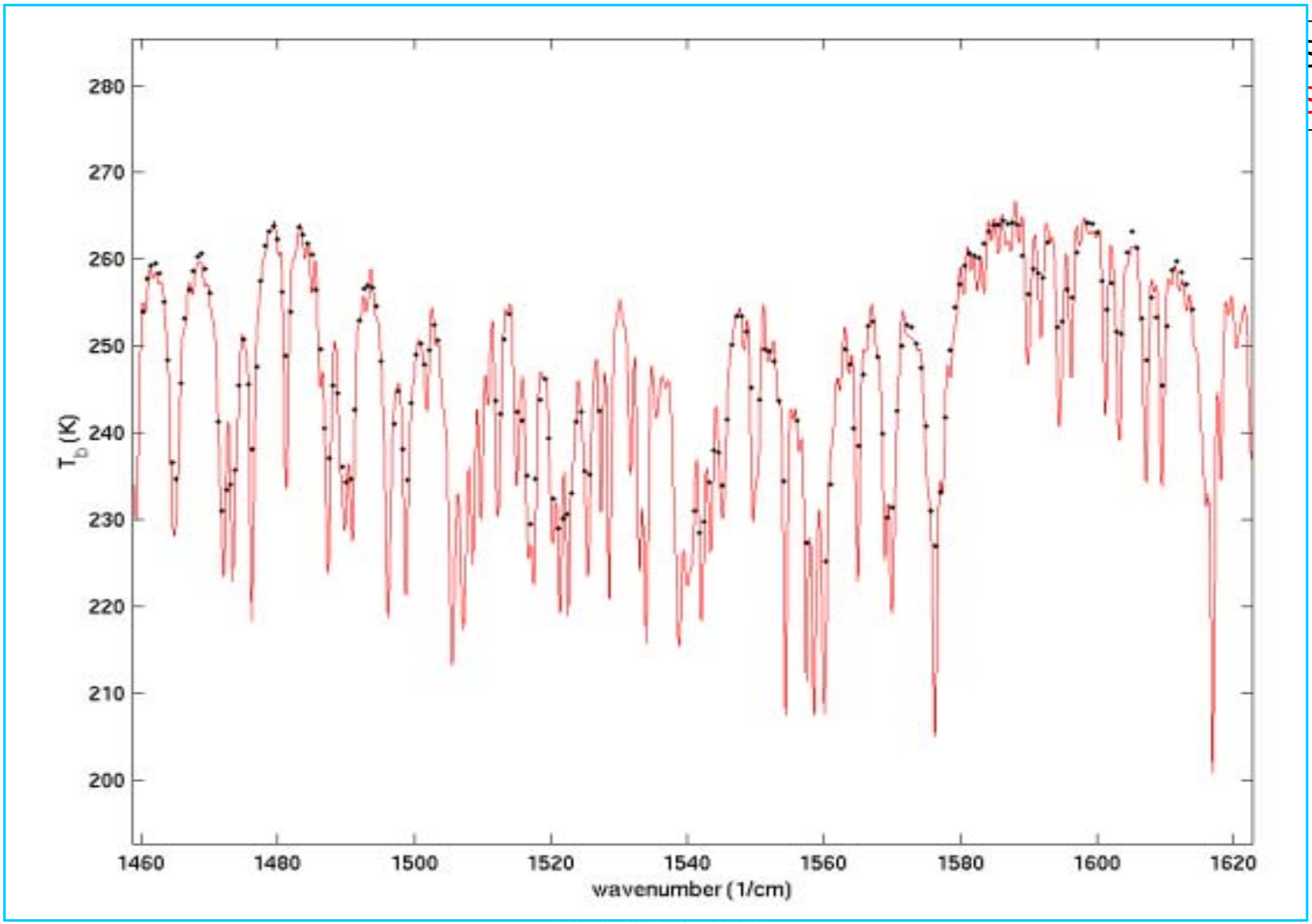
   $(\text{obs-calc})_{\text{SHIS}}$ to $(\text{obs-calc})_{\text{AIRS}}$

   - SHIS and AIRS calcs each done at correct altitudes, view angles, spectral resolution and sampling.
   - Monochromatic calcs done using same forward model, atmospheric state, and surface property inputs.

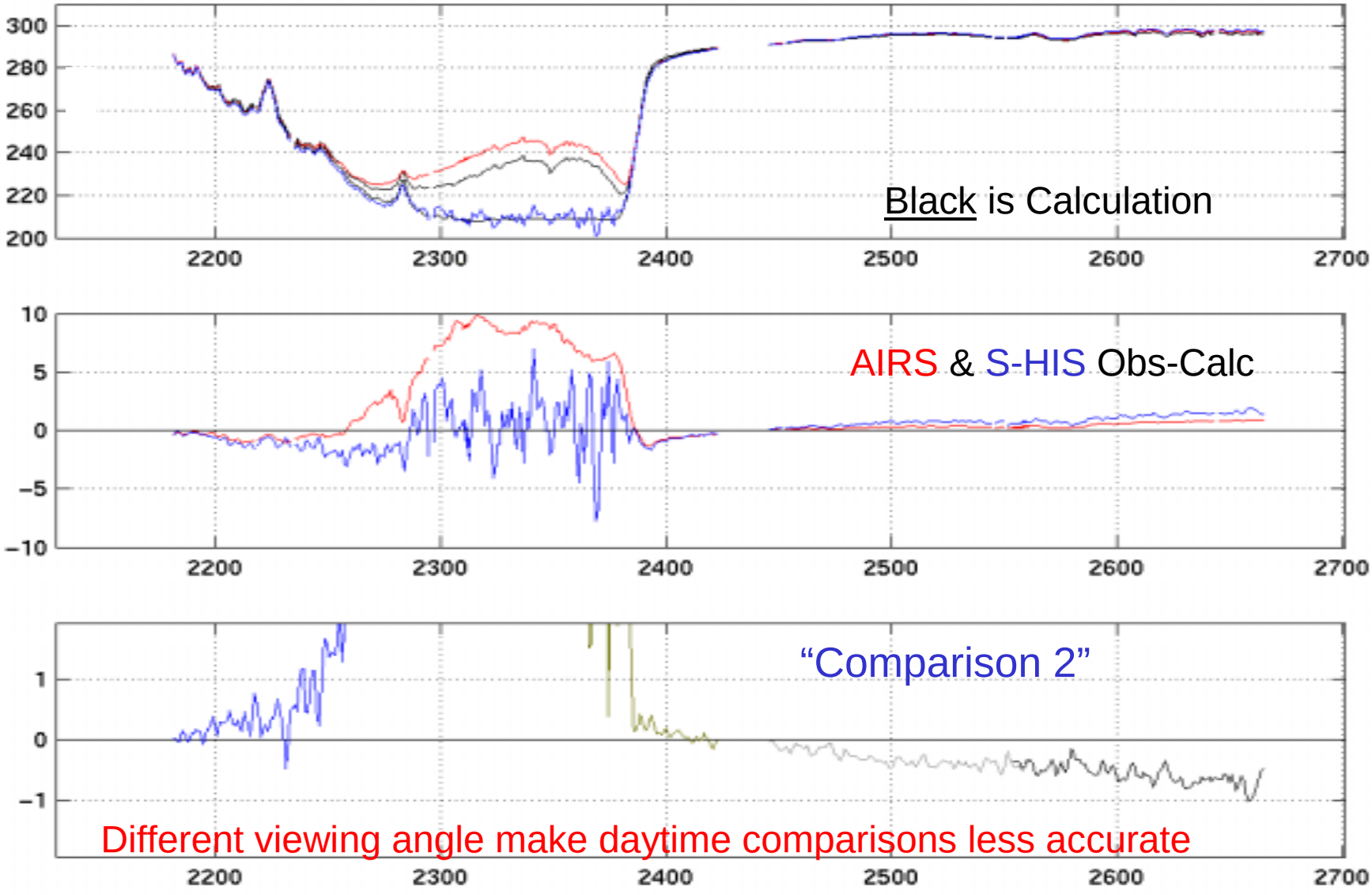
2. Difference Residuals: Spectral Resolutions made similar
   - valid comparison except for channels mainly sensitive to upper atmosphere, above aircraft altitude

“comparison 0”

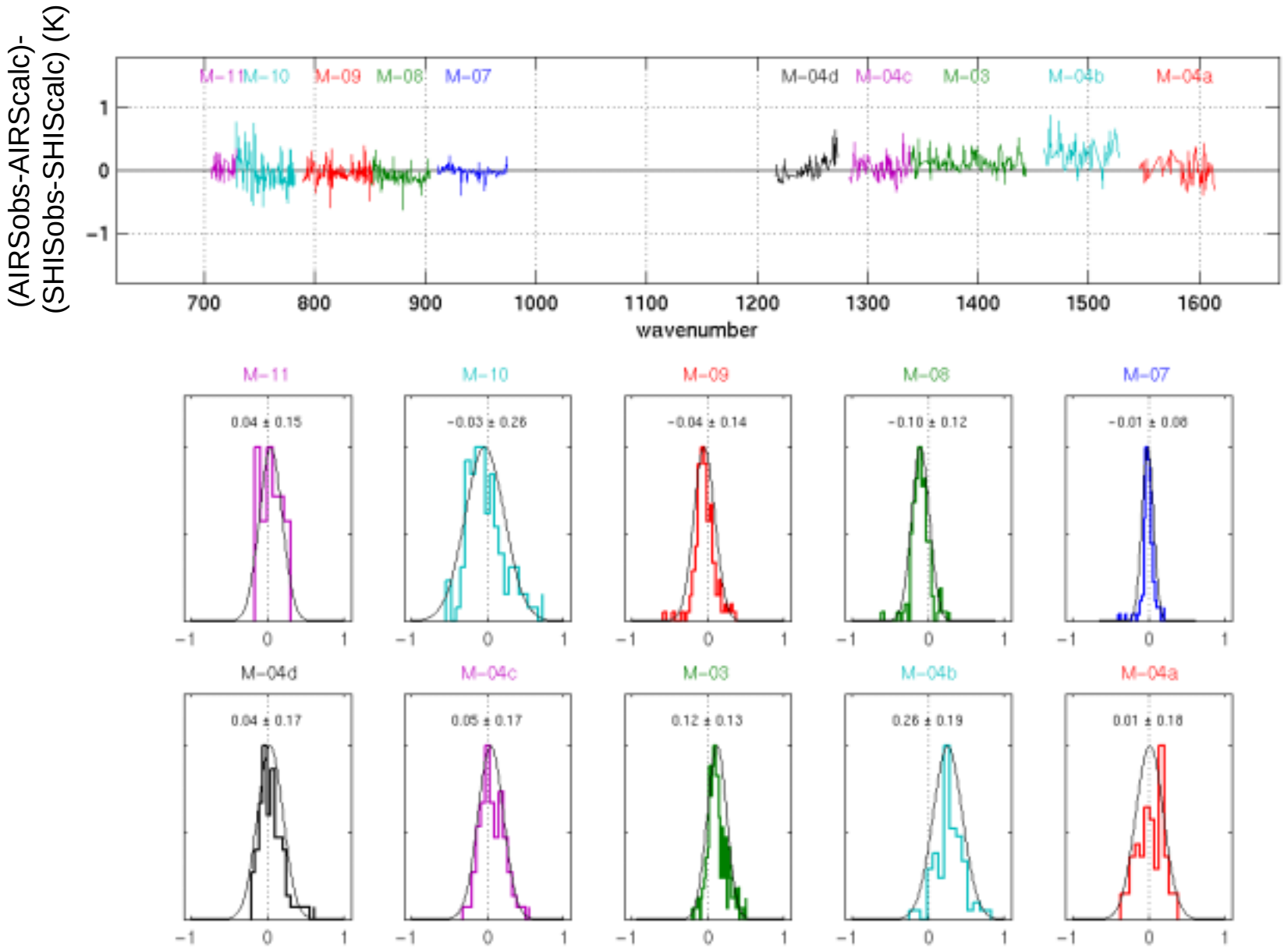
8 AIRS FOVs, 448 SHIS FOVs, PC filtering



AIRS Compared to S-HIS, 21 Nov 2002



“Comparison 2” (21 November 2002)
Excluding channels strongly affected by atmosphere above aircraft



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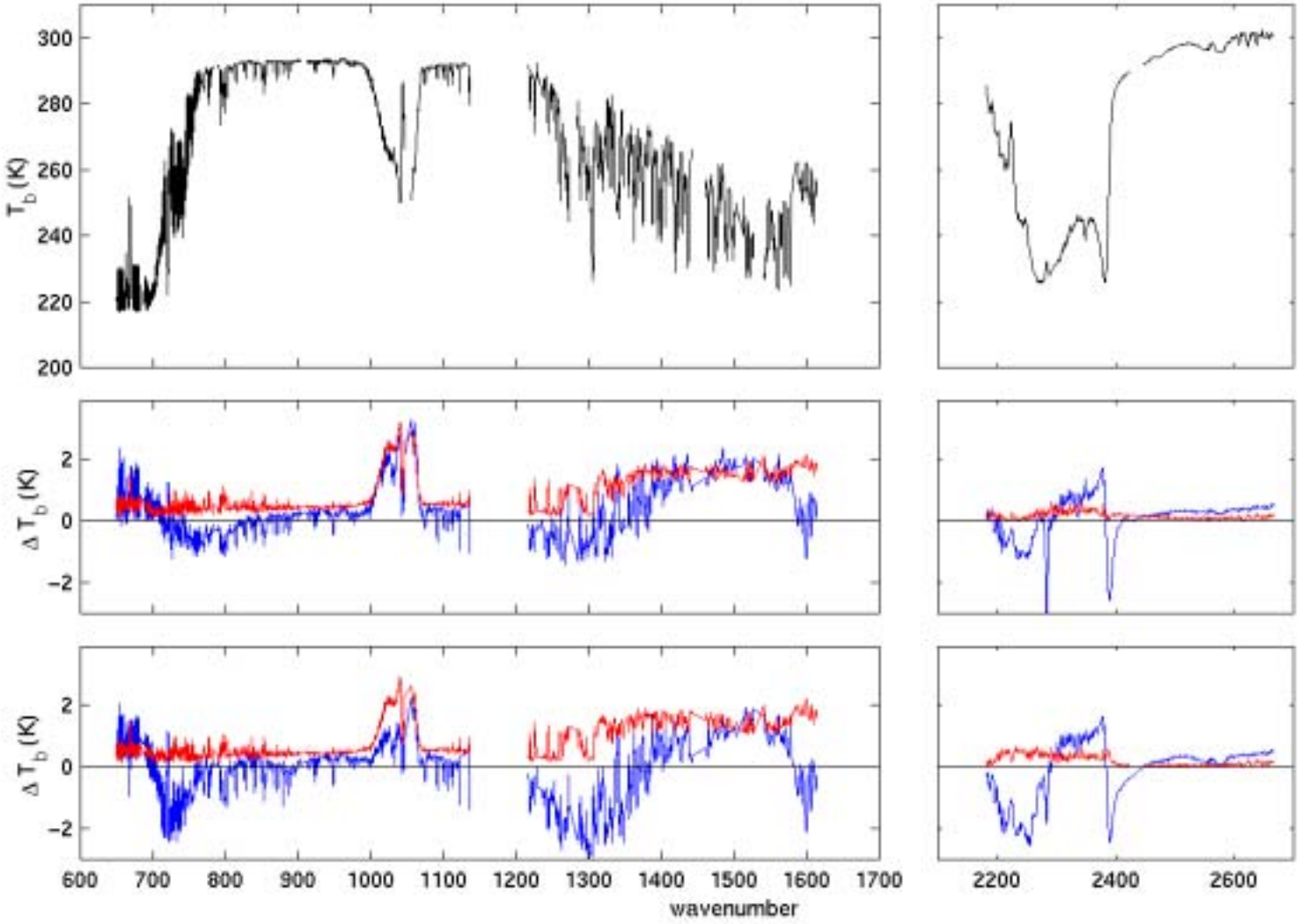
AIRS Obs-Calcs using Global Radiosondes

focus day number 1, 6/14/02, clear sky, nighttime ocean

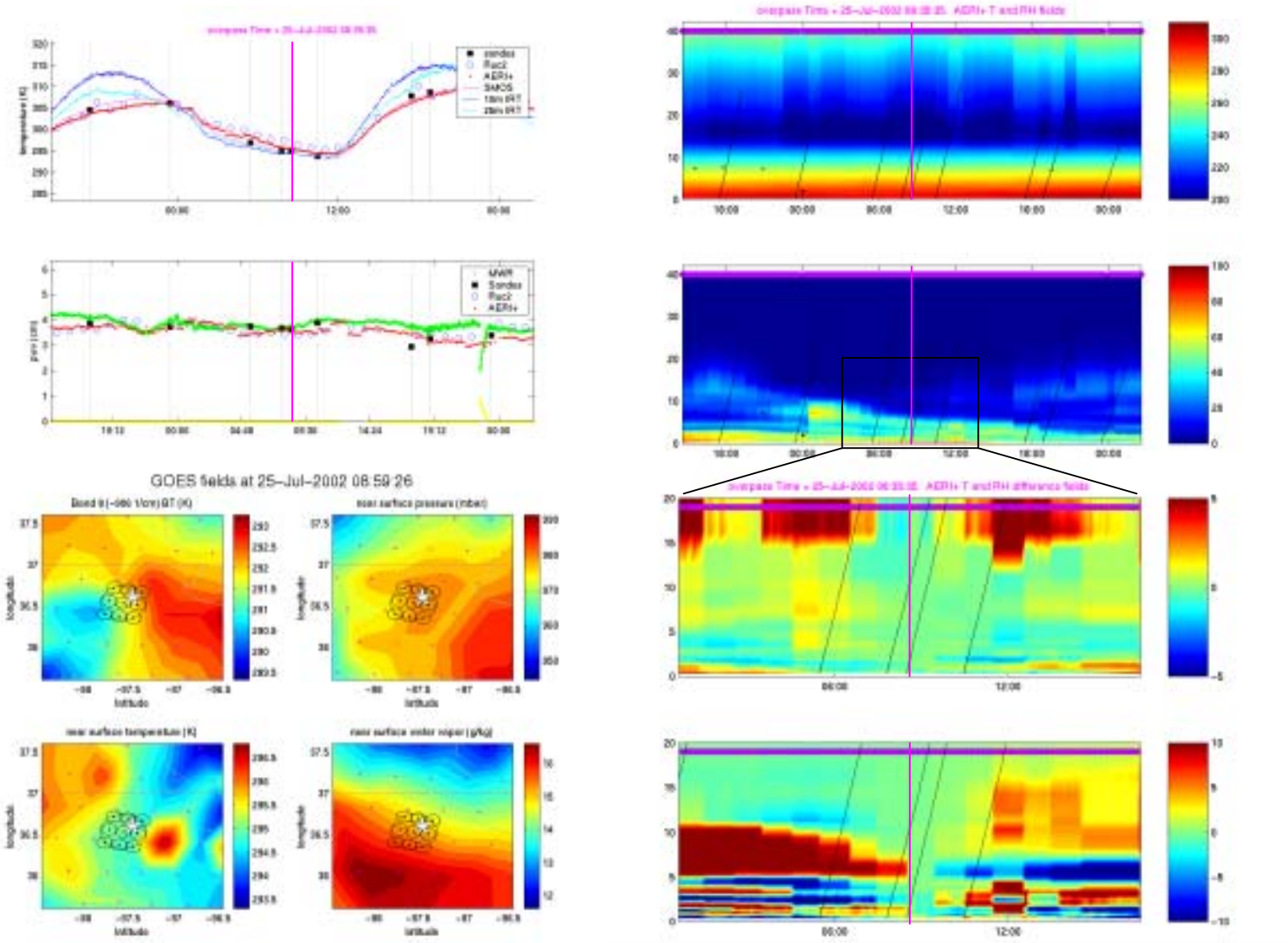
mean obs

kCARTA (at launch)
mean obs-calc
rms obs-calc

LBLRTM (v6.01)
mean obs-calc
rms obs-calc



25-Jul-2002 08:35 ARM SGP Overpass Best Estimate



• “Best estimate” atmospheric profiles for AIRS overpasses of the ARM sites are constructed from various ARM measurements, including RS-90 radiosondes launched near the overpass time.

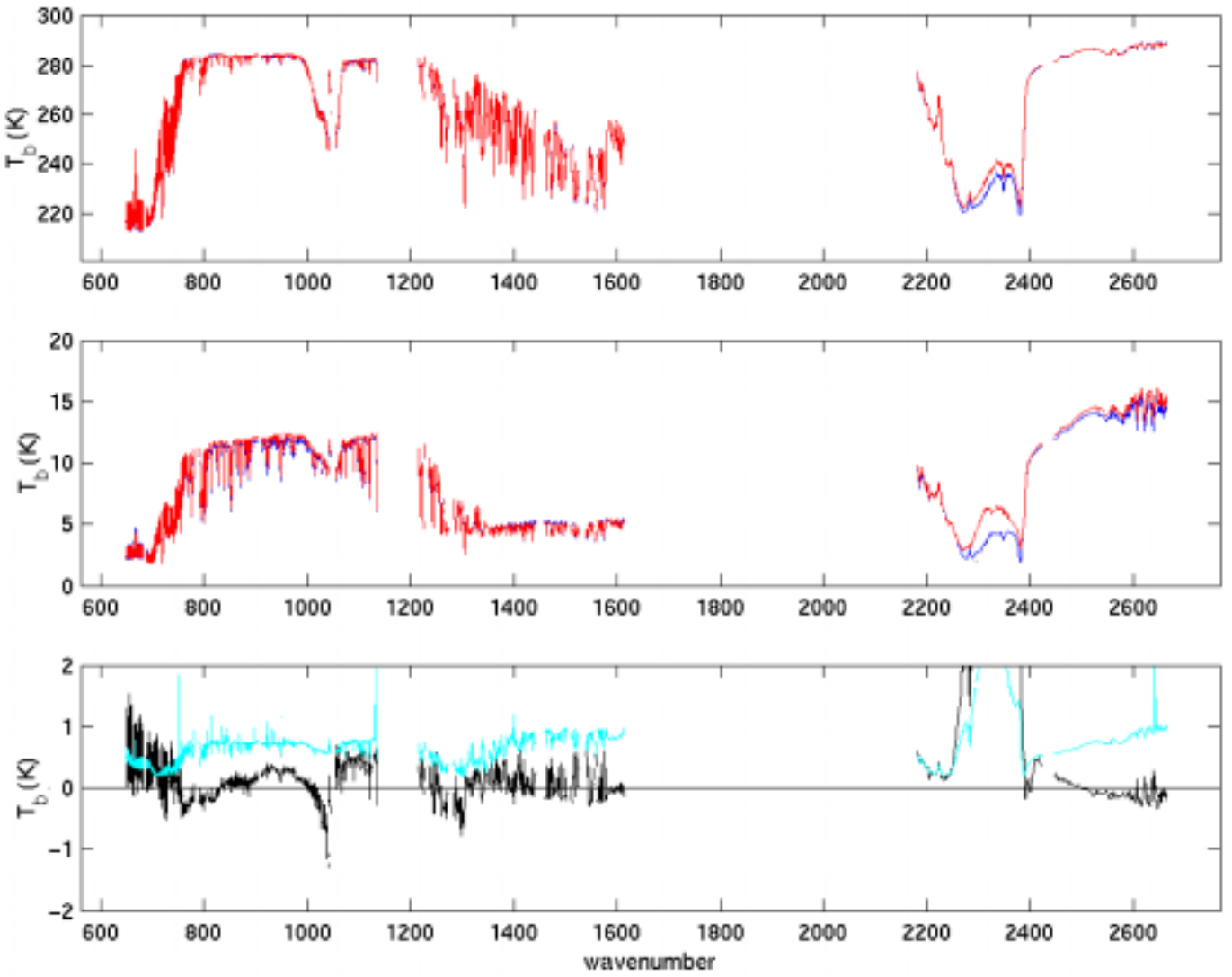
ARM site AIRS obs-calcs

SGP site, 9/02-02/03, “nearby, semi-clear”, day and night

mean obs
mean calc

rms obs
rms calc

mean obs-calc
rms obs-calc

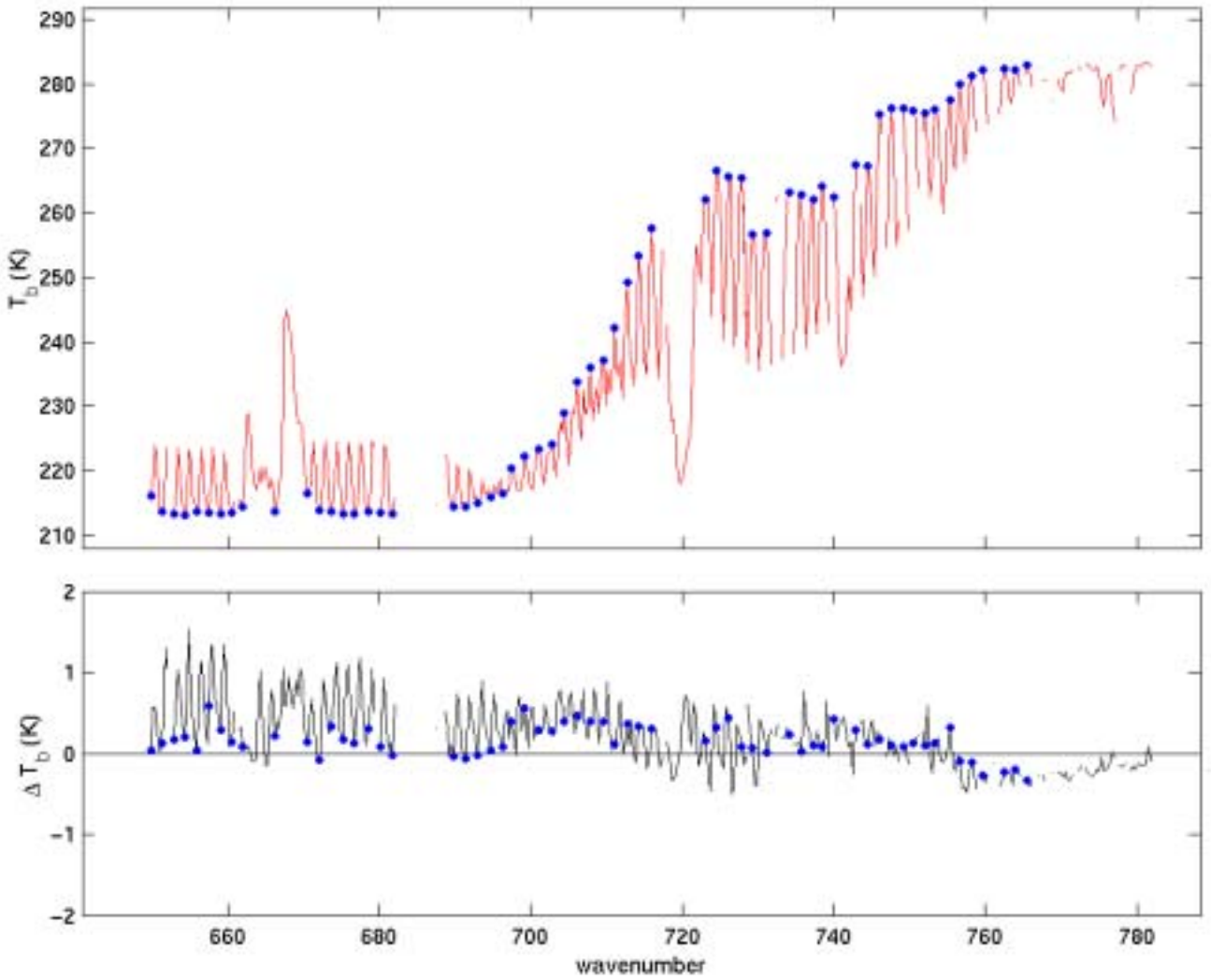


ARM site AIRS obs-calcs

SGP site, 9/02-02/03, “nearby, semi-clear”, day and night

mean obs

mean obs-calc

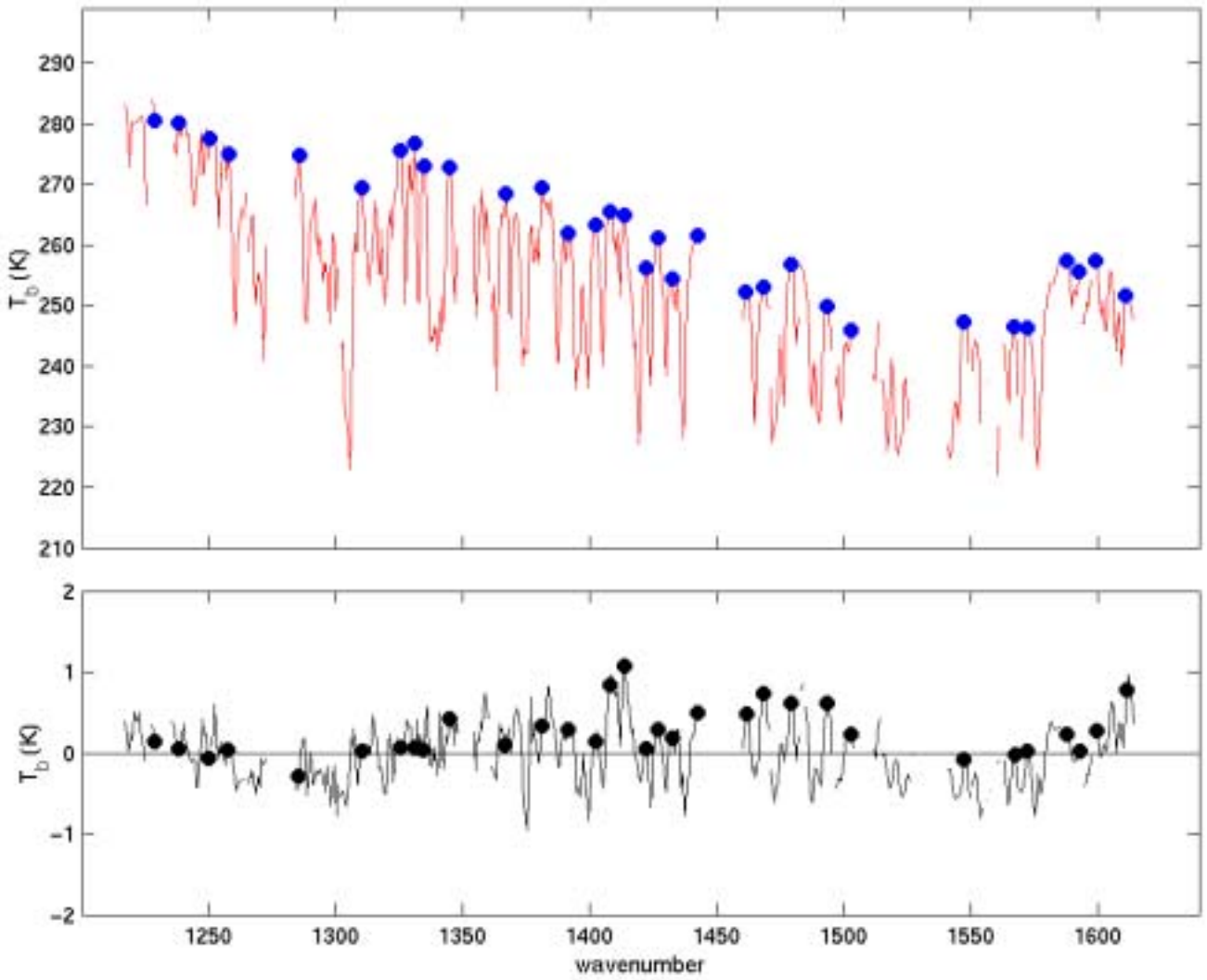


ARM site AIRS obs-calcs

SGP site, 9/02-02/03, “nearby, semi-clear”, day and night

mean obs

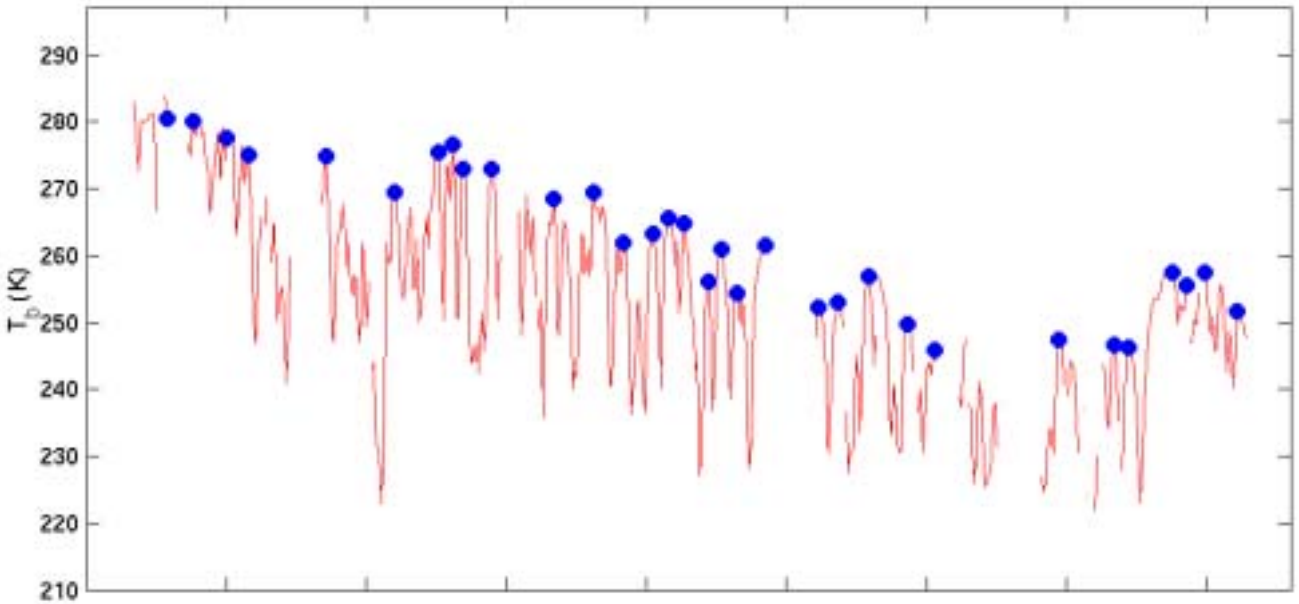
mean obs-calc



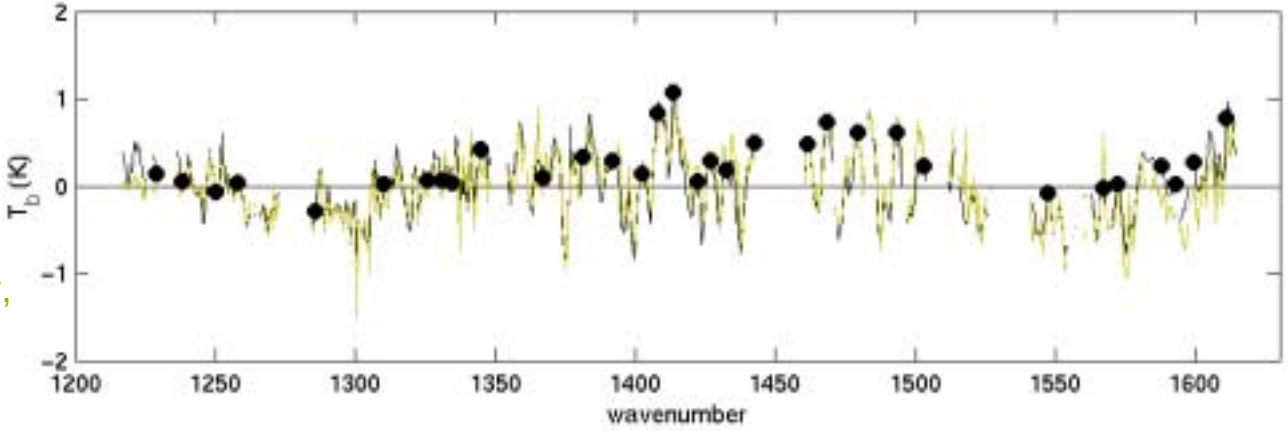
ARM site AIRS obs-calcs

SGP site, 9/02-02/03, “nearby, semi-clear”, day and night

mean obs



mean obs-calc



Mean obs-calc from frost point hygrometer, Galapagos Islands, Vömel et al

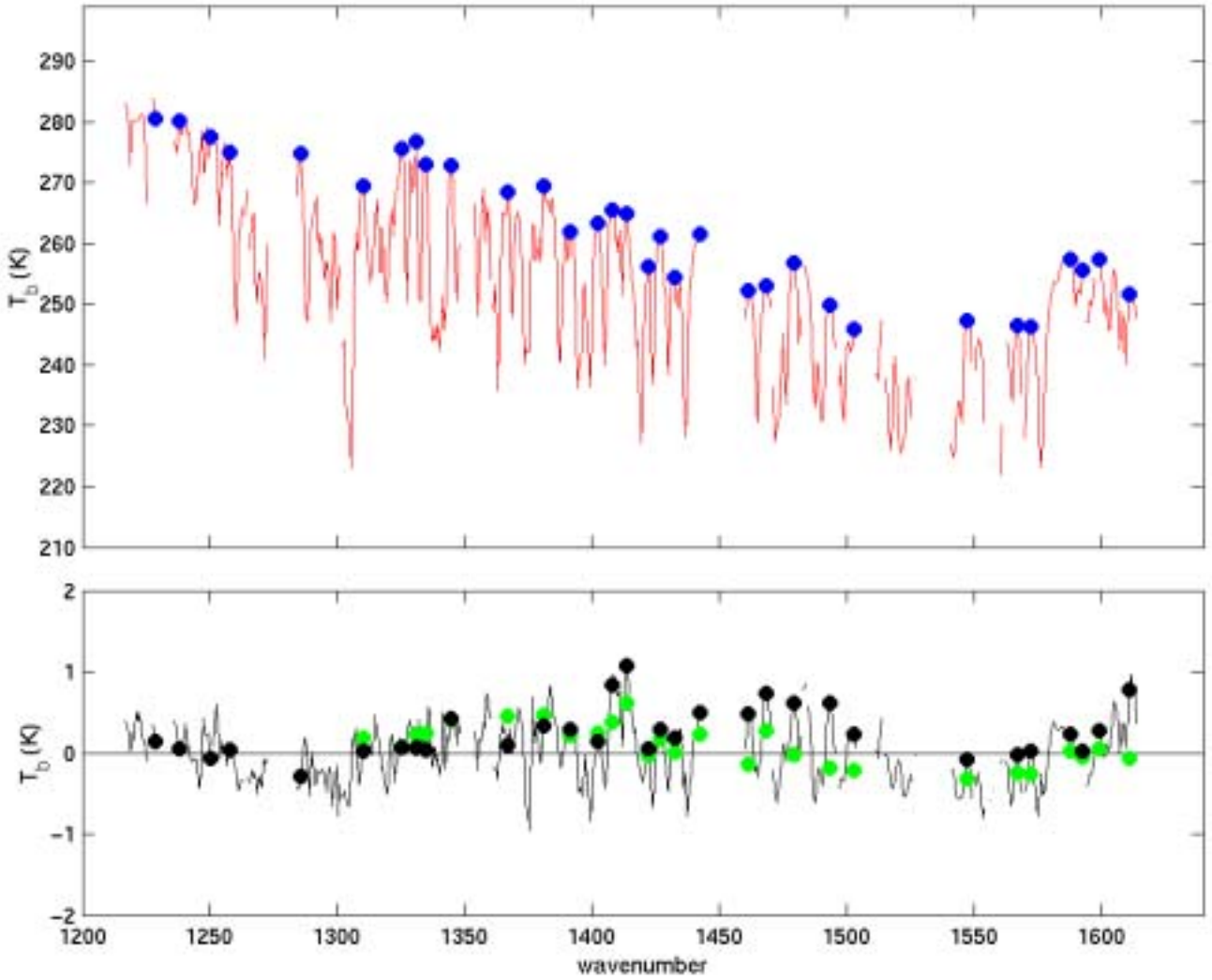
ARM site AIRS obs-calcs

SGP site, 9/02-02/03, “nearby, semi-clear”, day and night

mean obs

mean obs-calc

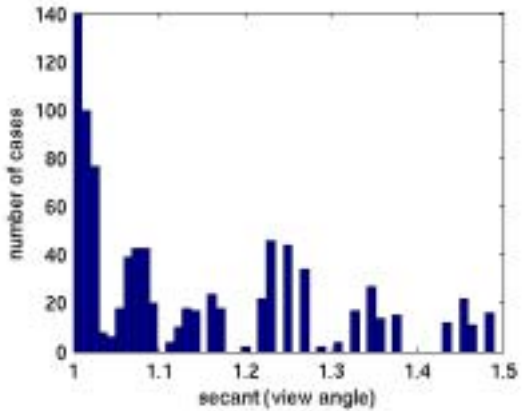
Mean obs-calc with preliminary channel transmittance “tuning” c/o UMBC

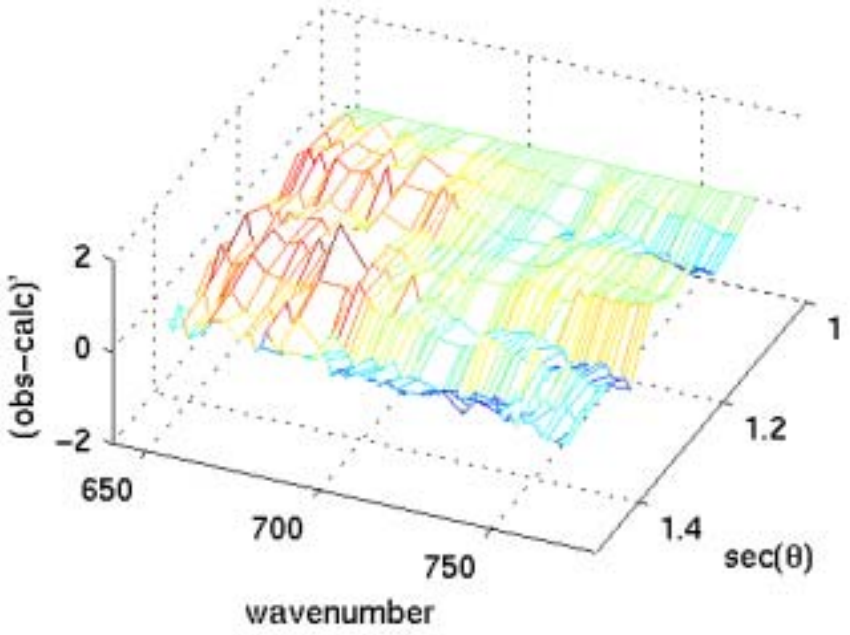


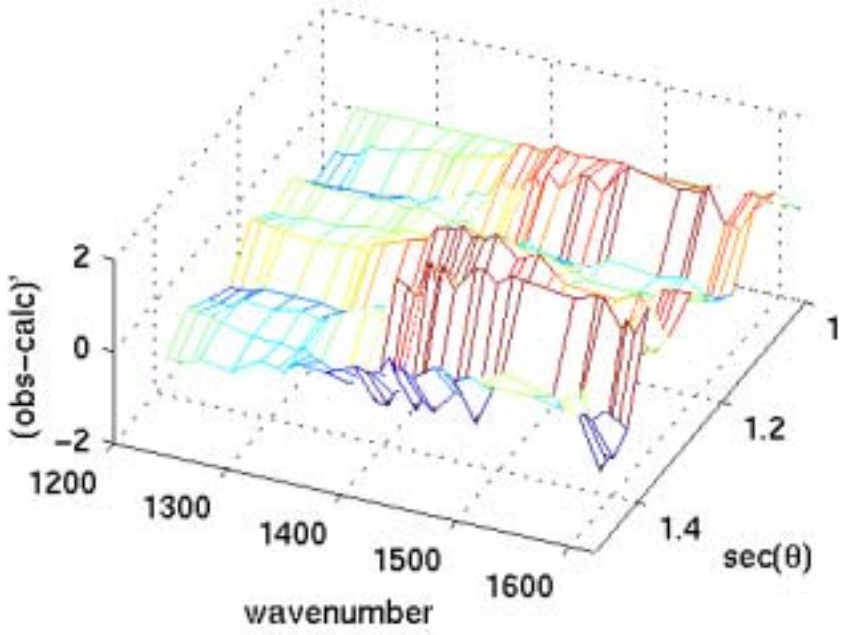
ARM site AIRS obs-calcs

SGP site, 9/02-02/03, “nearby, semi-clear”, day and night

view angle dependence of obs-calcs







Summary / Issues

• Uplooking, ground-based observations are well suited for forward model development and validation studies of transparent (surface) channels.
  • Window region C_s^0 measurements are converging
  • Need further investigation of T dependence of C_f^0

• AIRS radiance validation with Scanning-HIS shows very good agreement. Along with other studies, this suggests no significant instrument calibration contributions to AIRS obs-calcs.

• AIRS obs-calcs with ARM site best estimates are providing validation and further information for refinement of the AIRS forward model.
  • Should pursue further validation of LBLRTM with downlooking data, and
  • Should pursue further validation of kCARTA with uplooking data.
  • Upper level water vapor is still an issue on the ~10 percent level. Can physical retrieval with current forward model further reduce 1400-1600 cm^{-1} obs-calcs ?

• In general, retrievals should converge with spectral residuals similar to those shown here (or better), without the need for IR forward model spectral biases or tuning.