Errors in (Observed - Calculated) Radiances

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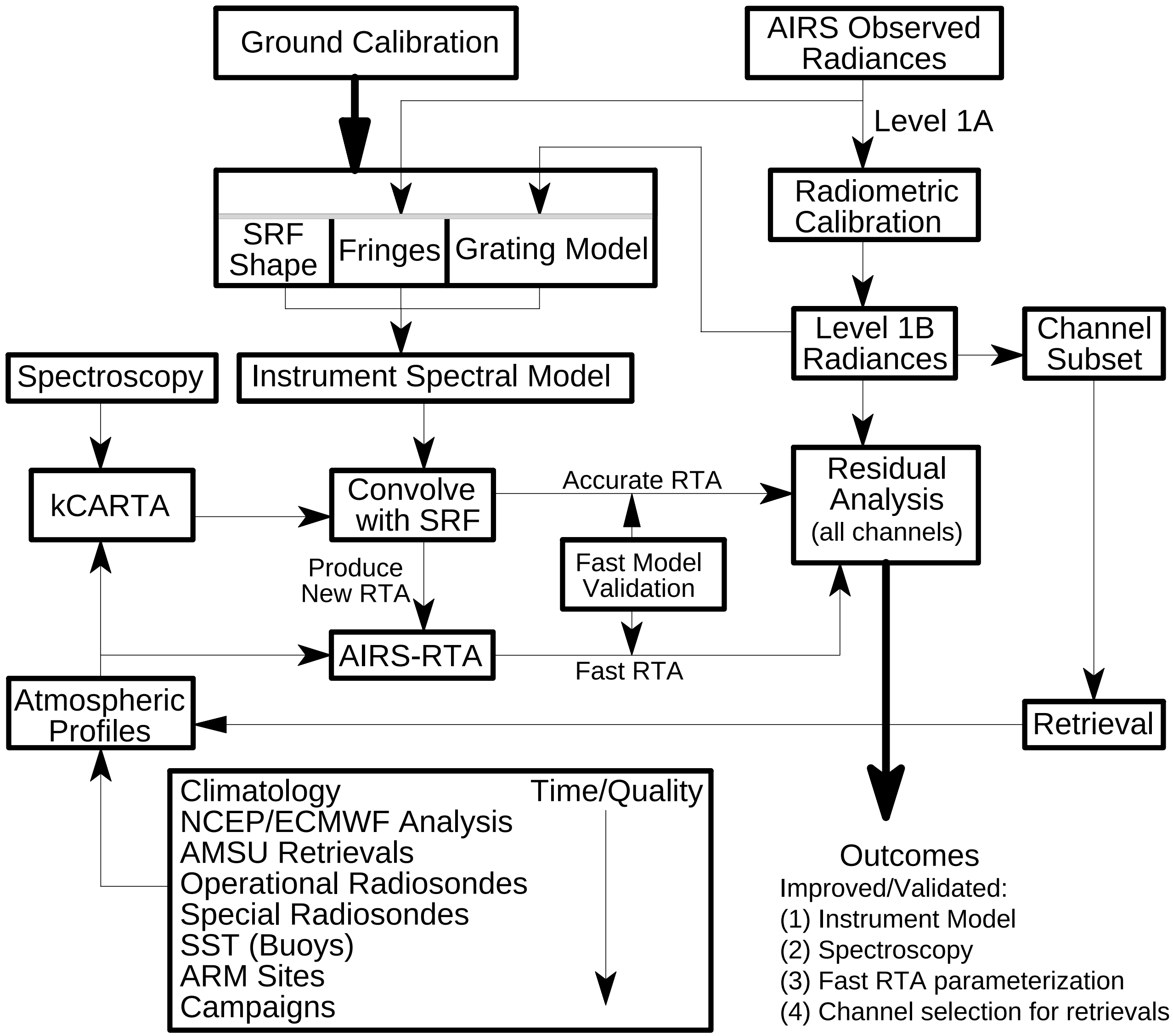
Overview

- Validation Overview
- Error sources and some estimates of their magnitude, mostly on the "Calc" side. Will not concentrate on solutions...
  - Instrumental uncertainties: SRF, via forward model. (Radiance uncertainties covered by T. Pagano's.)
  - Spectroscopy uncertainties
  - Fast model parameterization errors
  - Atmospheric state errors
- Coordination needed to eliminate error sources as quickly as possible. I hope that the NWP centers can target initial analysis of AIRS data towards helping to validate/improve the forward model spectroscopy and parameterization.

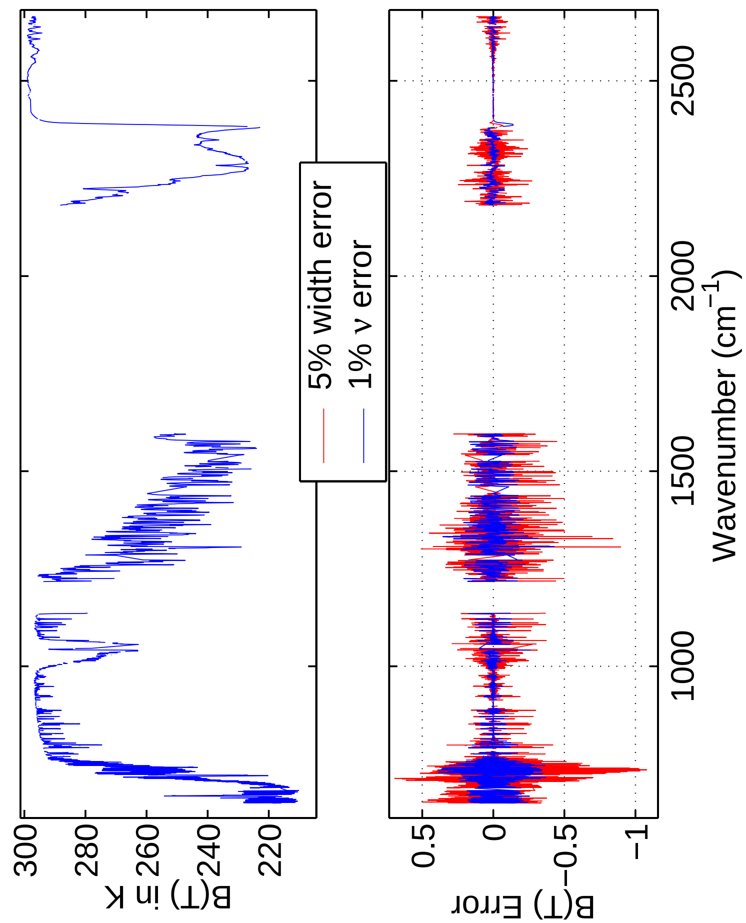
Overview of Validation

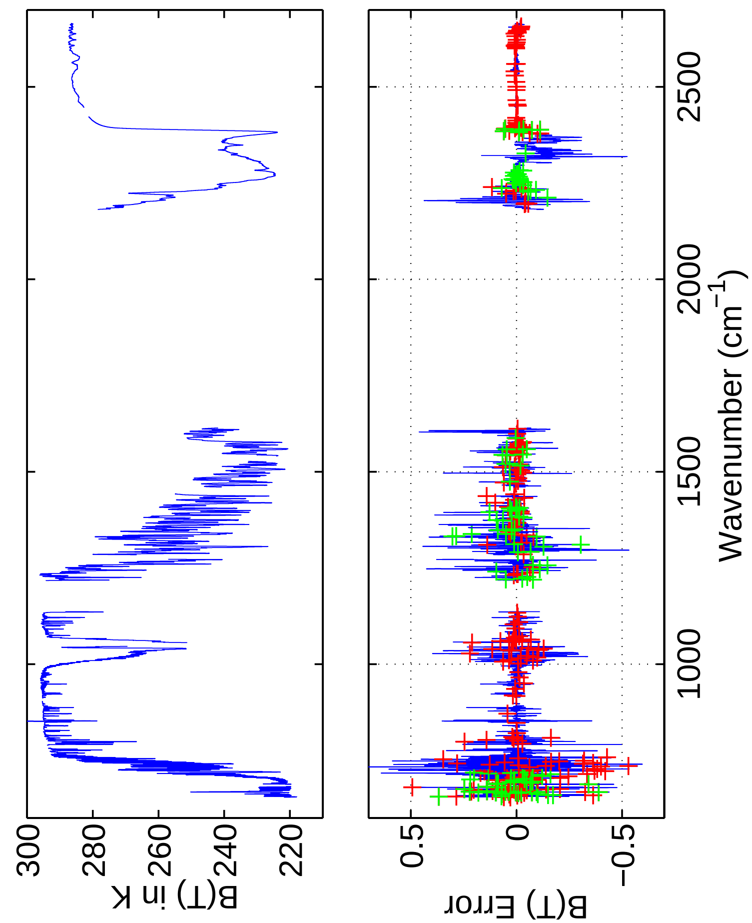


Instrument Uncertainties - SRFs

- SRF centroids: Upwelling radiance technique should work well, any concerns more to do with stability.
- SRF widths: Based on pre-launch calibration. Grating plate scale will change if focus ($\Rightarrow$ widths) changes. Can either adjust model (based on ground calibration) or adjust instrument to correct. Highly unlikely, never changed during vibration tests. Ground calibration width accuracy $\sim$ 1%.
- SRF shape: Based on pre-launch calibration. Error estimates on order of 0.1 - 0.2K.
- SRF fringing: Based on ground calibration and in-orbit temperature of entrance filters. Independent tests to determine fringe phase will be done as instrument stabilizes, and practiced during thermal vacuum tests. Any residual error should enter as a bias, hopefully below 0.1K range.

Sensitivity of B(T) to Channel Centers, Widths, and Fringing

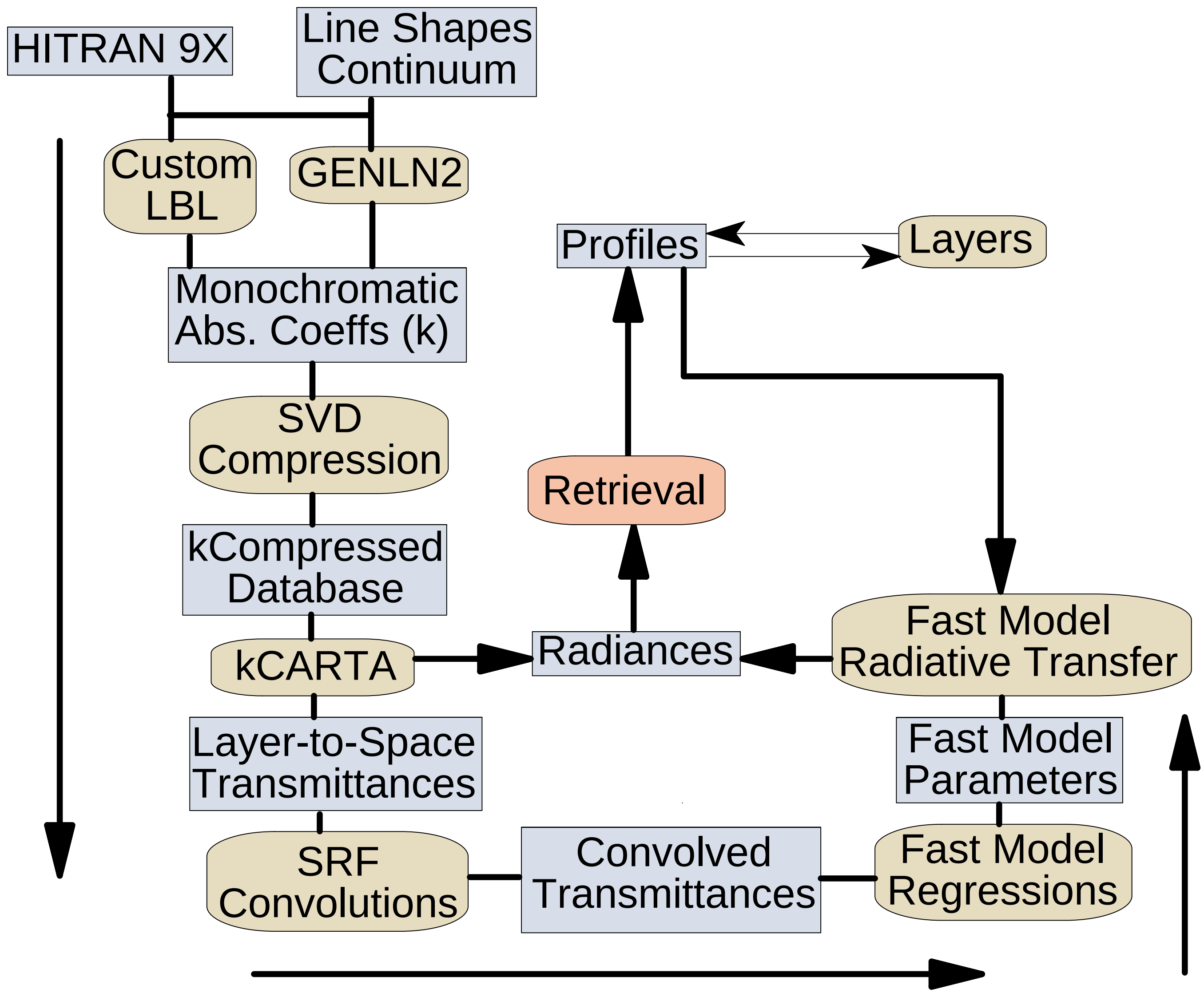




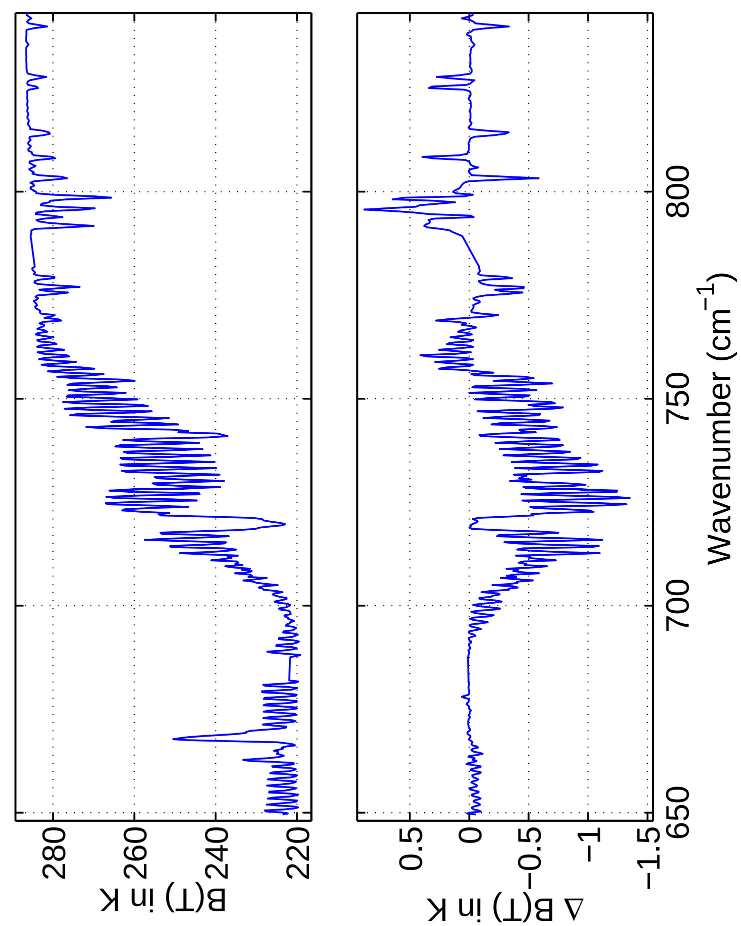
Spectroscopy Errors

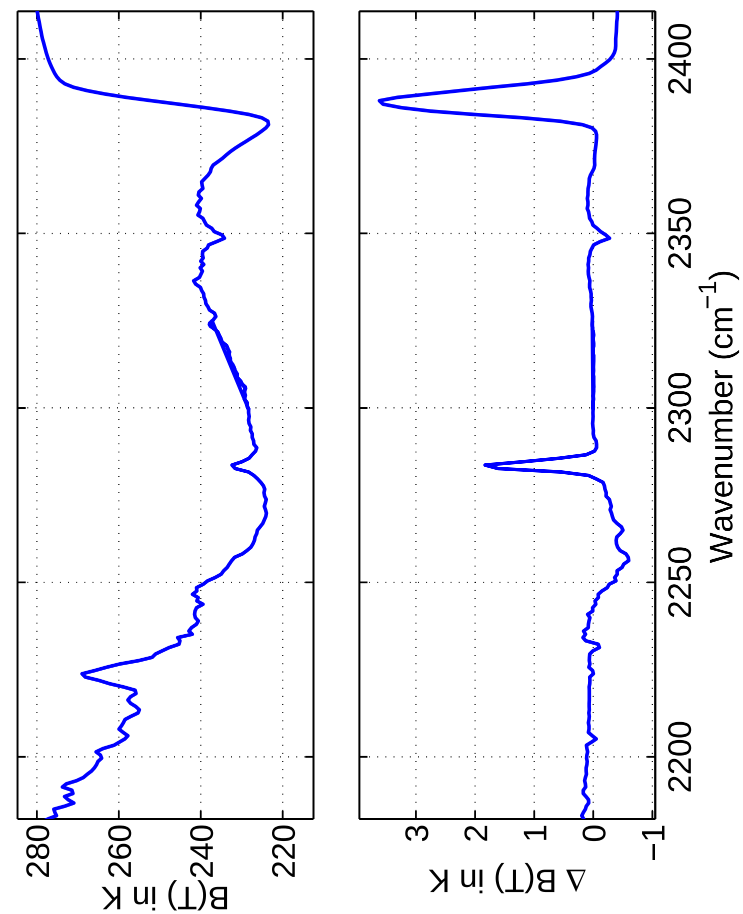
- AIRS most sensitive to CO_2 and H_2O spectroscopy, especially line shapes/continuum.
- Extensive comparisons of CO_2 and H_2O theoretical lineshape to laboratory data and aircraft measurements (HIS/NAST-I/etc.) indicate good agreement.
- However, UMBC CO_2 lineshapes quite different (1-5K) from those in GENLN2, (and maybe LBLRTM), so disagreements exist in the spectroscopy community.
- UMBC's kCARTA is only "LBL" at this time with these new CO_2 lineshapes.
- Expect uncertainties in the H_2O continuum to impact AIRS. Validating the H_2O continuum will be an important part of forward model validation after launch.
- New data from DOE-ARM AFWEX campaign should help to improve H_2O continuum. Hopefully the validation NRA will fund a promising H_2O continuum laboratory experiment.

Fast Model Generation

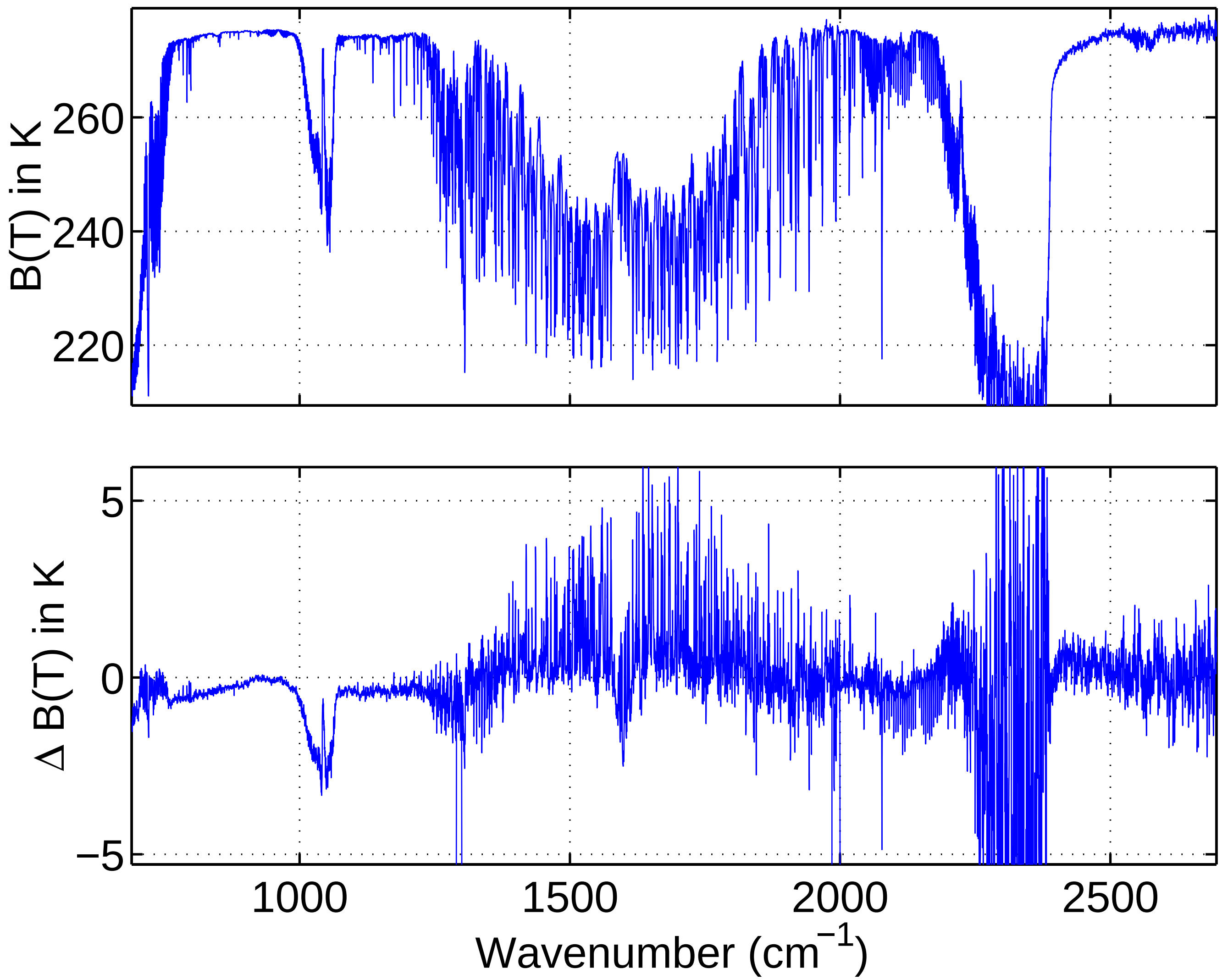


Differences Between kCARTA and GENLN2, LBLRTM?





NAST-I Obs-Calcs (WINTEX)



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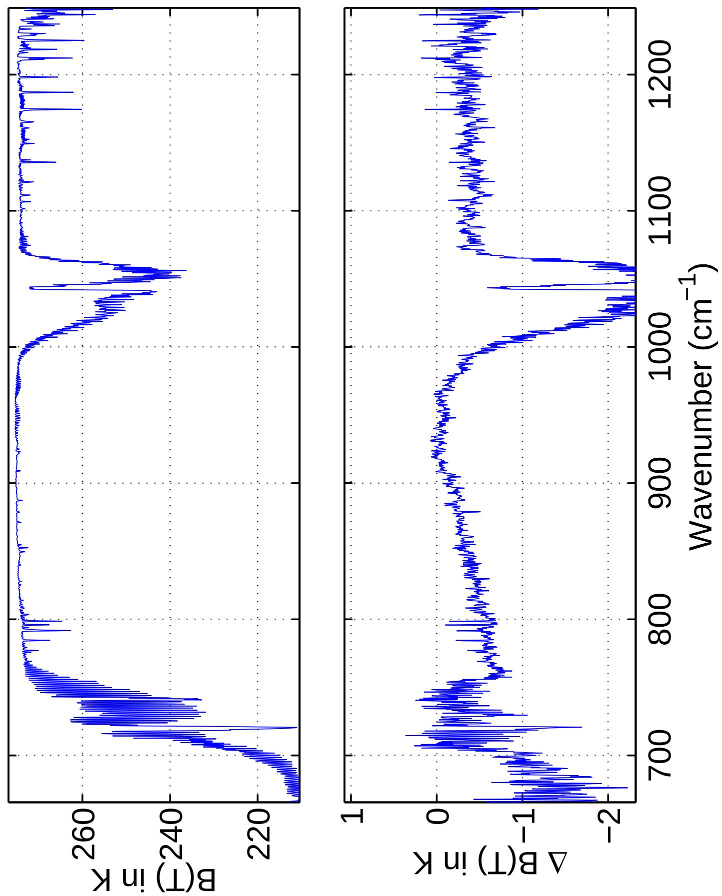
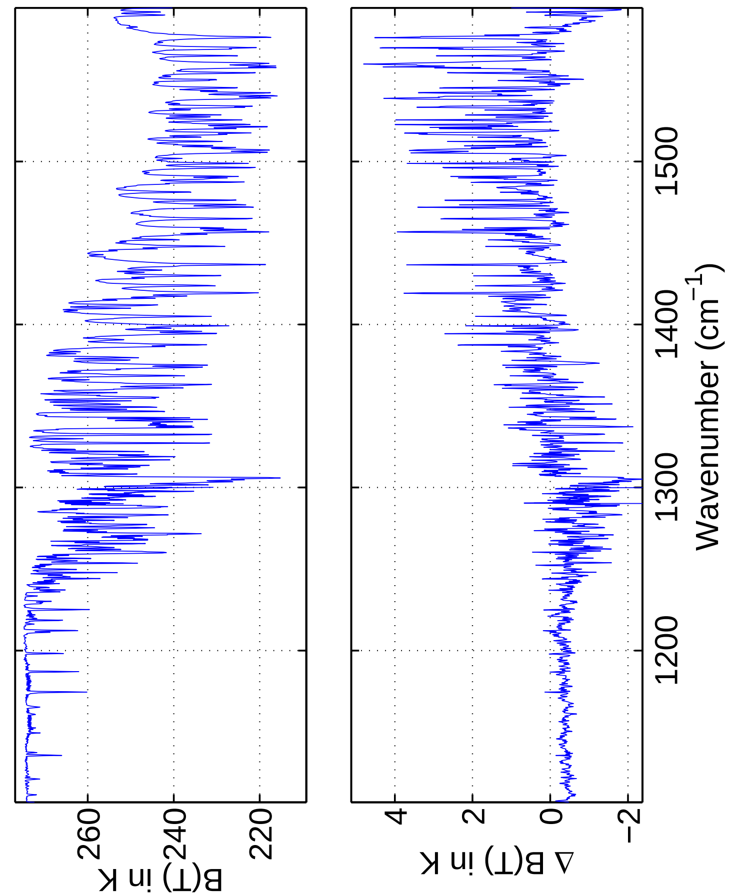
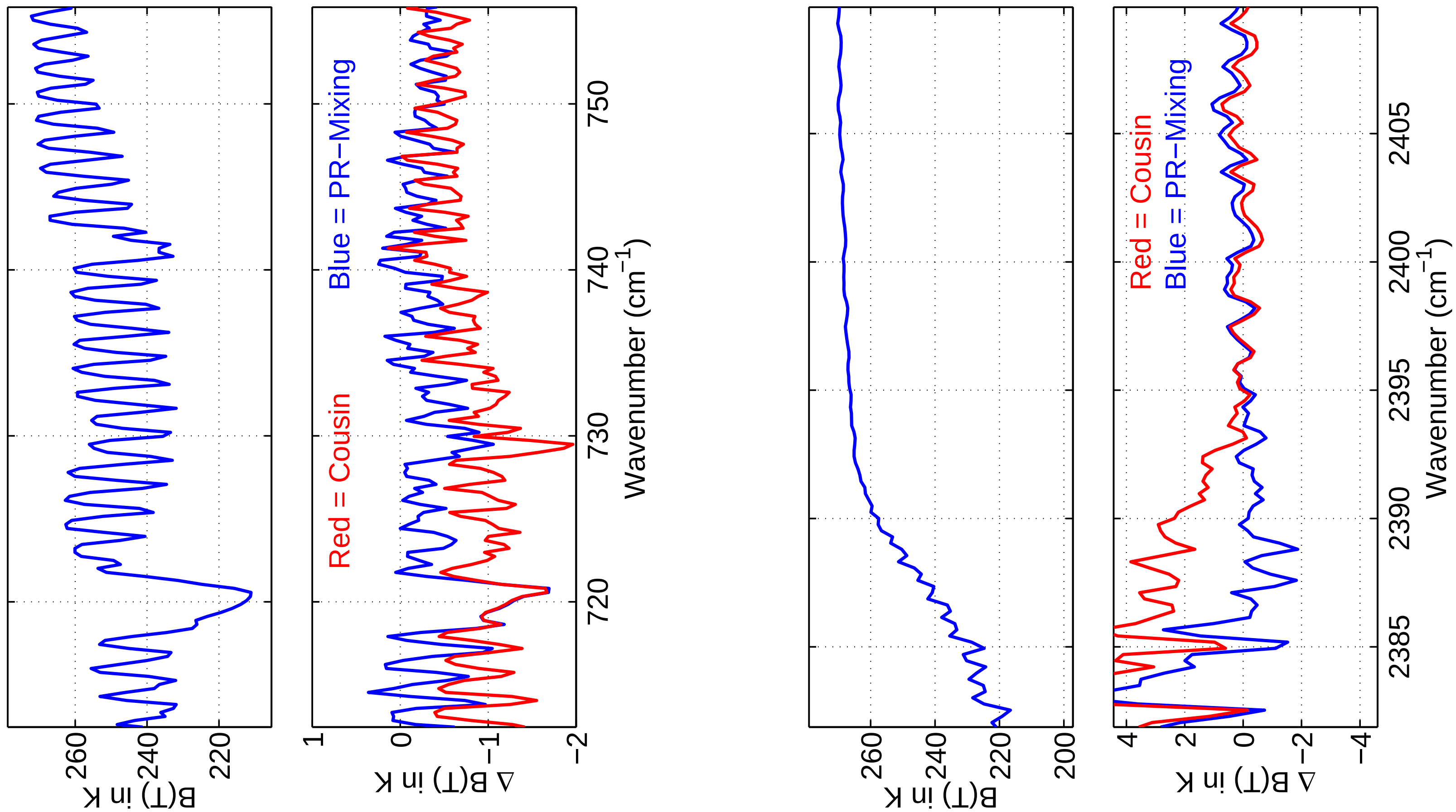
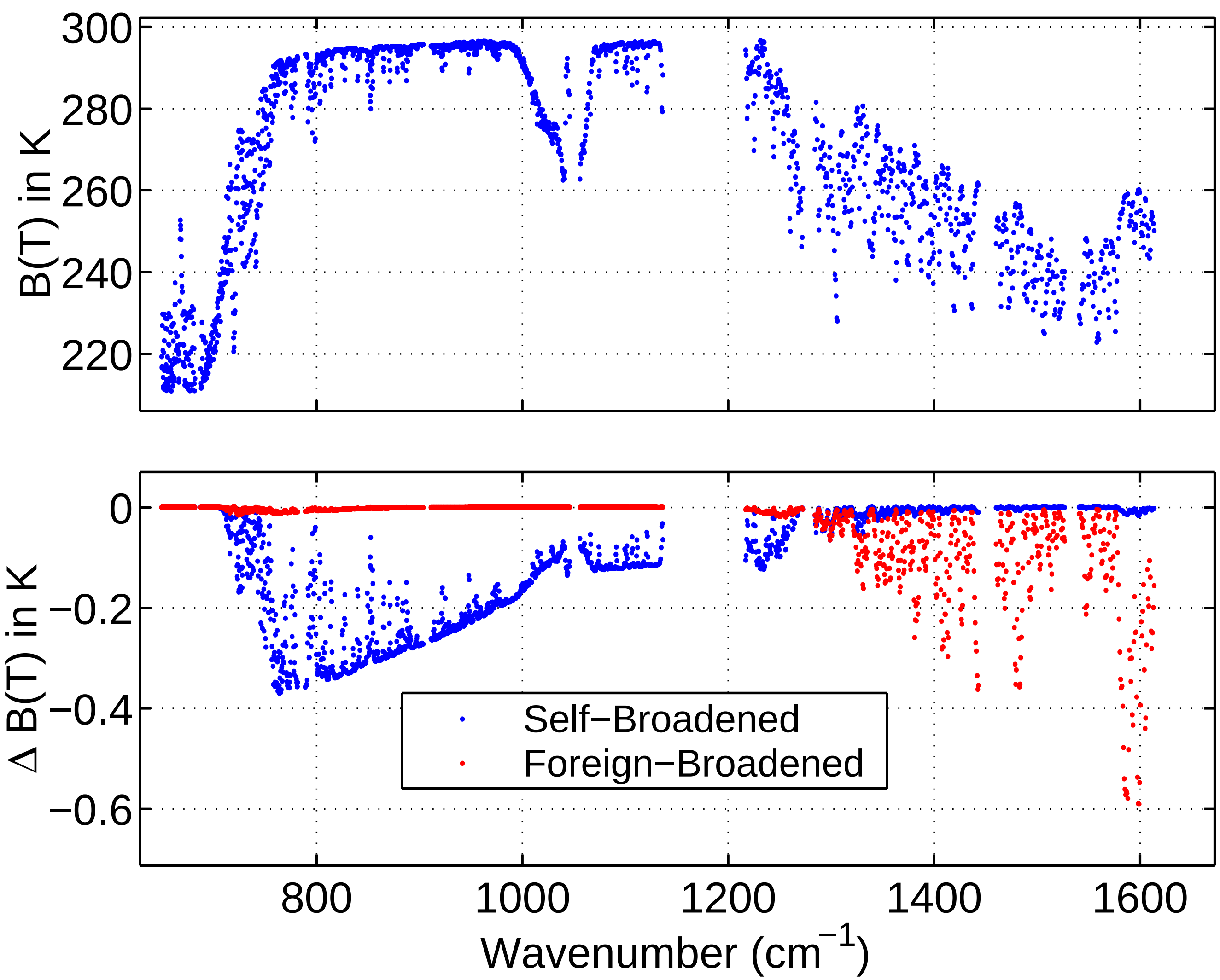




kCARTA vs "GENLN2" for NAST-I Spectra (WINTEX)



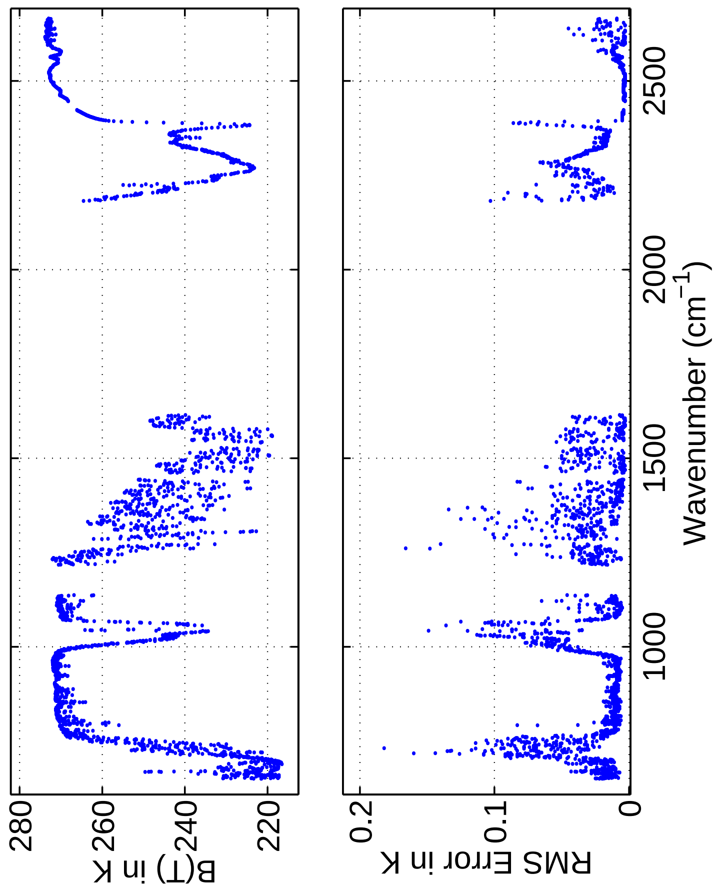
B(T) Error for a 10% Uncertainty in the Water Continuum

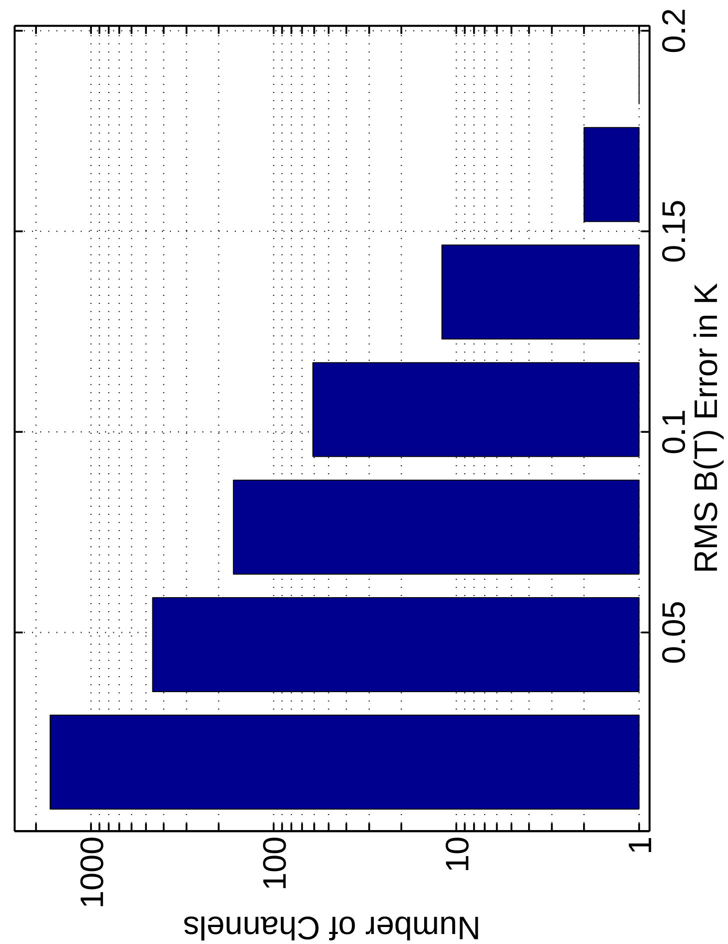


Fast Forward Model Parameterization Errors

- Fitting errors for the AIRS-RTA transmittance parameterization are quite low. Hybrid PFAAST/OPTRAN algorithm.
- More testing needed with independent profile sets.
- Need to monitor forward model accuracy for statistically unusual profiles?
- Reflected thermal radiation difficult to handle, errors may be significant for low emissivity scenes.
- High solar angles always difficult
- UMBC will endeavor to produce new forward model coefficients in a timely fashion when the instrument changes or new validated spectroscopy is available. This will include updates to kCARTA and the AIRS SRFs for use by NWP centers.

AIRS-RTA Fitting Errors

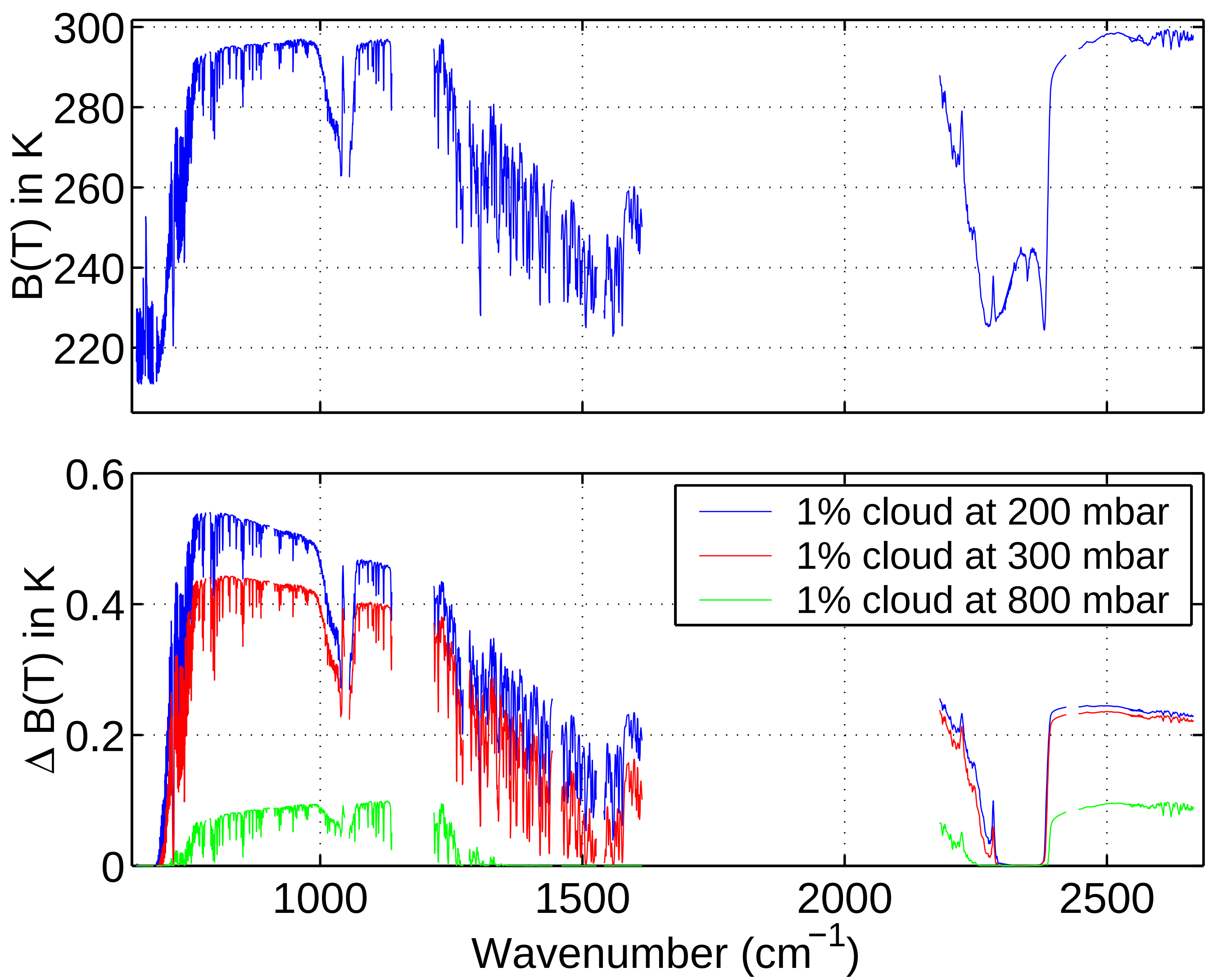




Atmospheric and Ground state Errors.

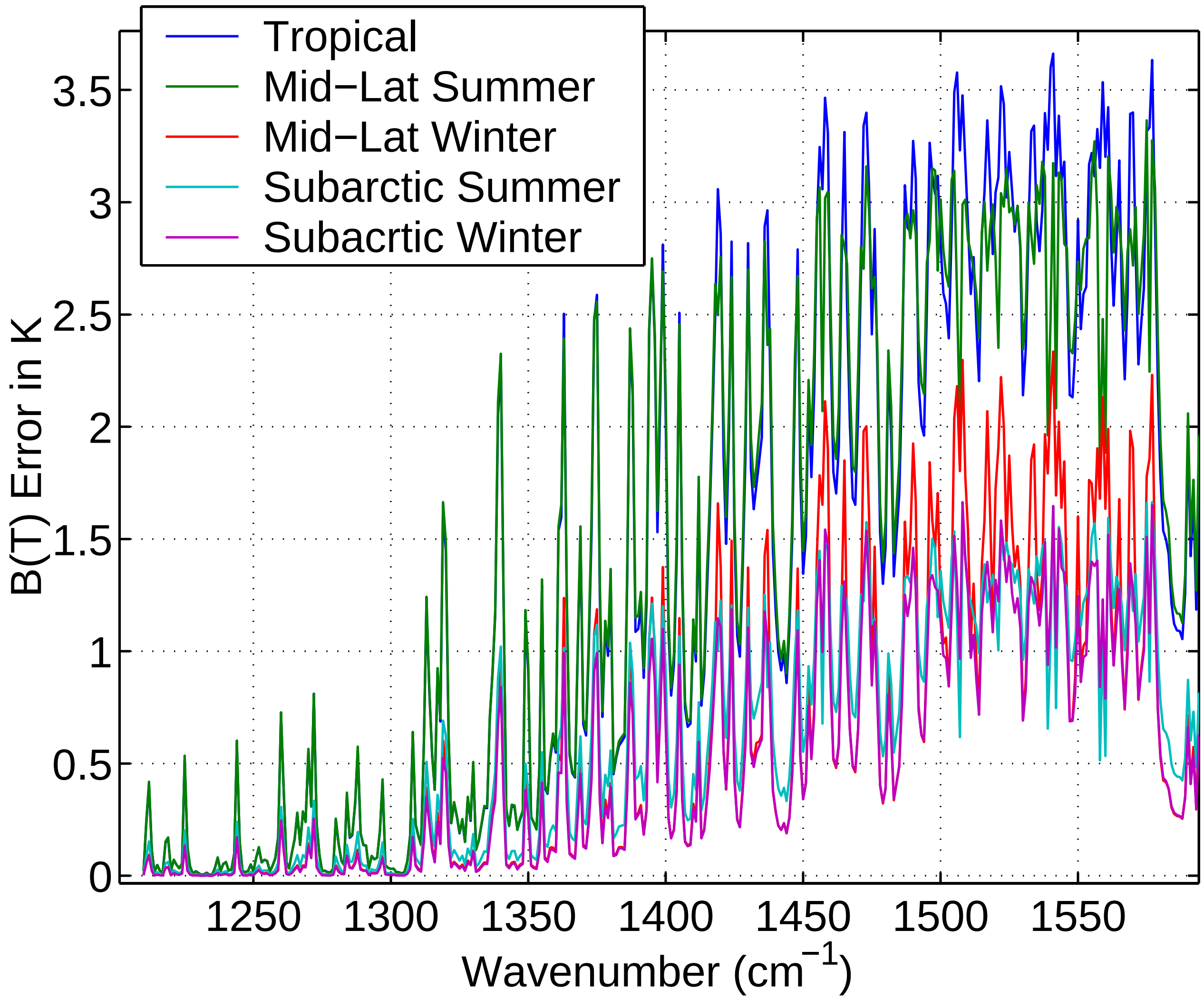
- Above all: clear field identification and optimal selection of FOVs for radiance monitoring. (Later discussion - can we make sure we are all working with the same data?)
- Emissivity uncertainties, especially over land.
- Land surface emissivity model. Looking into CERES approach, also implemented by T. Kleespies at NOAA/NESDIS. Possible input is the weekly NDVI product. Eventually use retrieved emissivities.
- Upper tropospheric water. Cross-validate with AMSU. Also special sonde/lidar sites. Model comparisons useful?
- Minor gas abundances, including CO_2. Although CO_2 can be varied in the AIRS-RTA, it will be fixed initially. Need to validate concentrations of a number of gases that are fixed in the AIRS-RTA (esp. N_2O).
- Cirrus contamination could be significant. LIDAR systems can detect optical depths of $\sim$0.03 min. That translates into about IR optical depths of $\sim$0.06, which can mean a 0.5K B(T) difference across the 10-13 μm window.

Effect a 1% Cloud Fraction

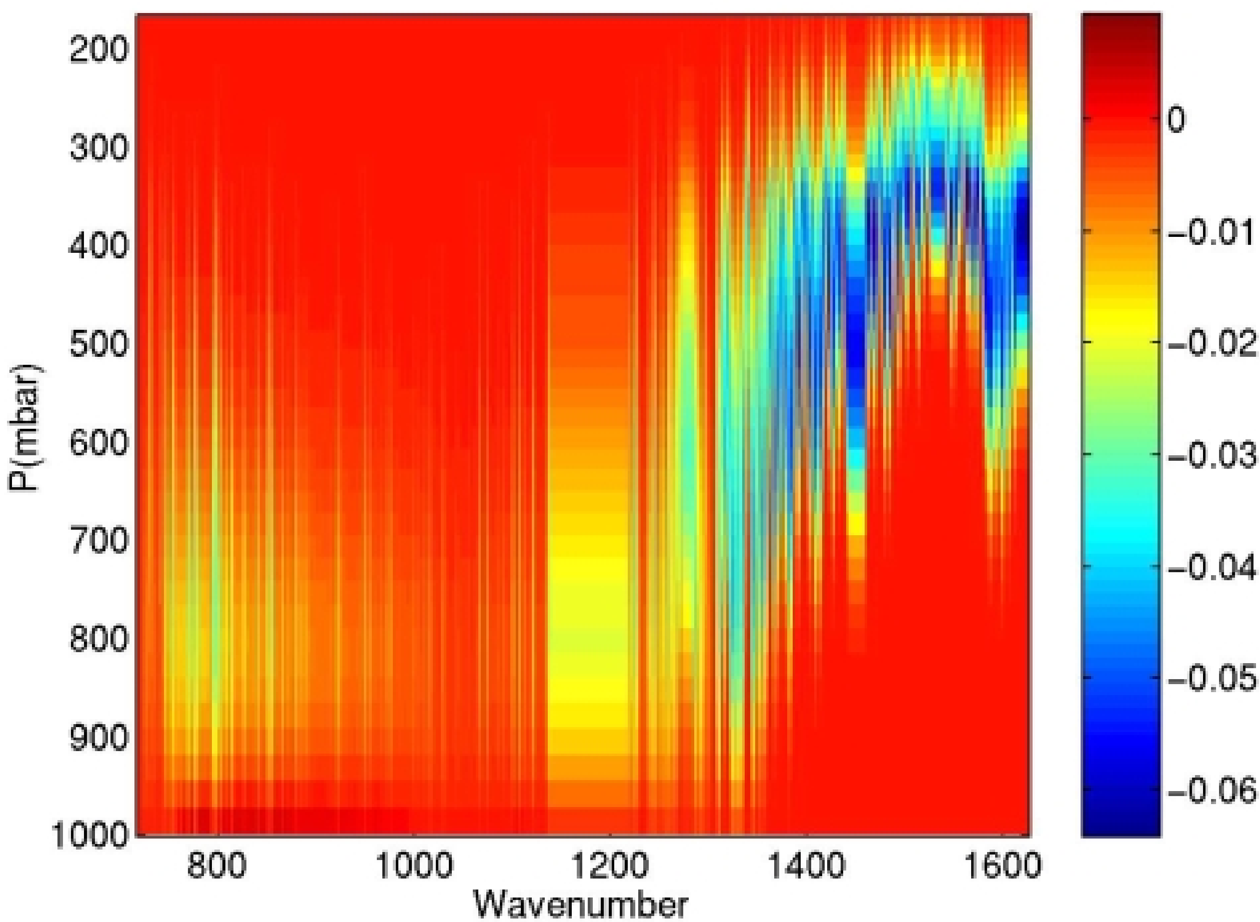


Nominal Errors in B(T) using Sonde H_2O Profiles

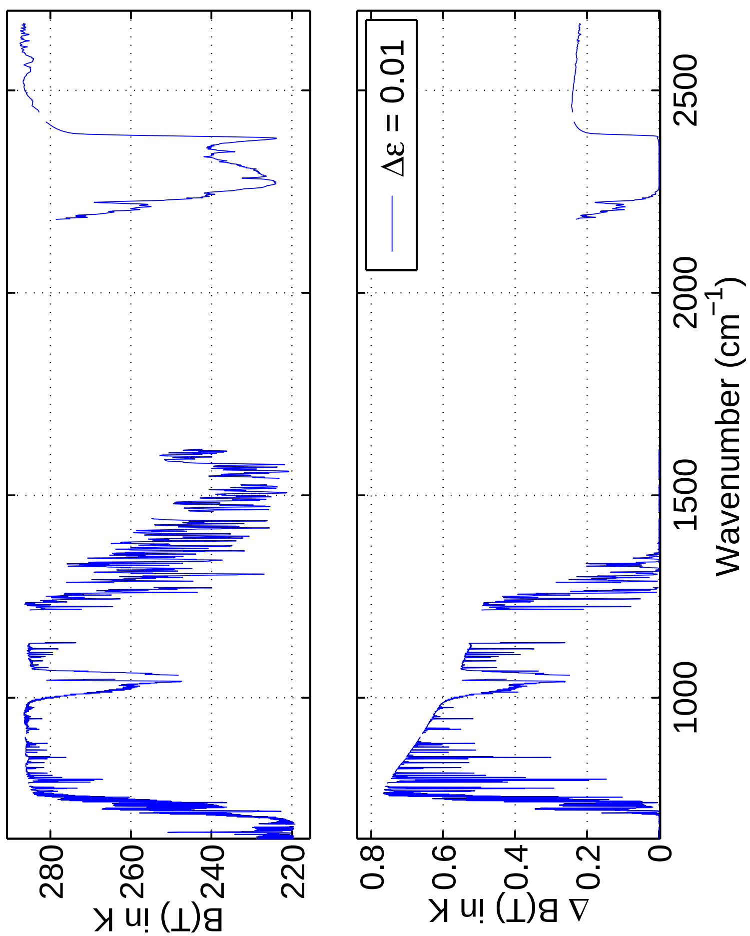
Used linear perturbation of H_2O; 0% at 400 mbar up to 50% at 300 mbar

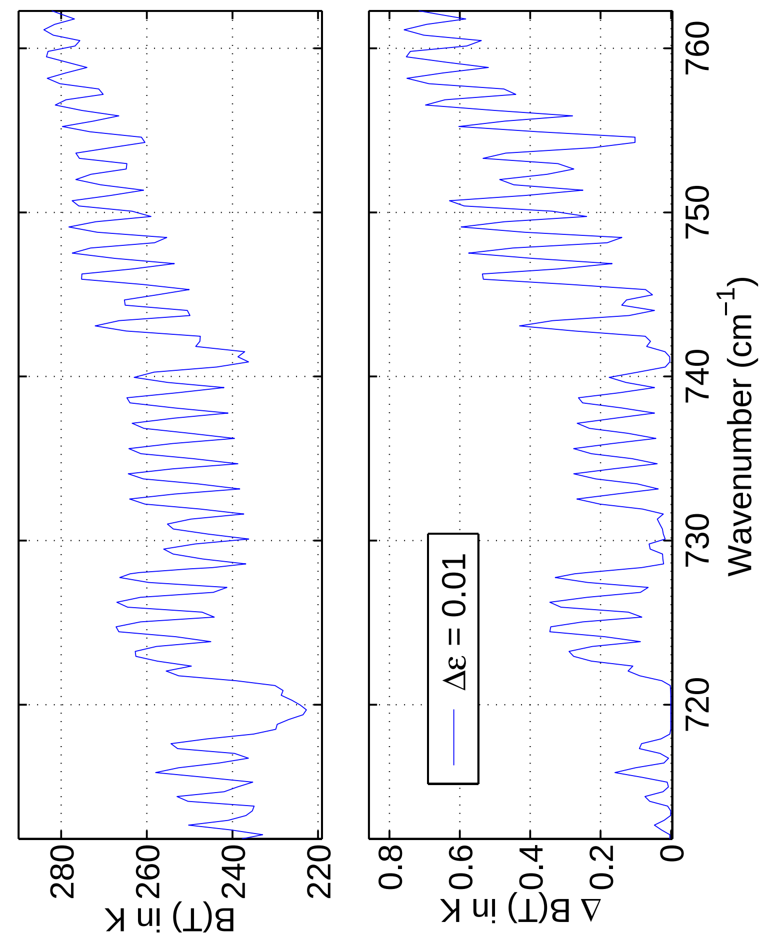


Water Jacobians - 10% Bump/AIRS Layer

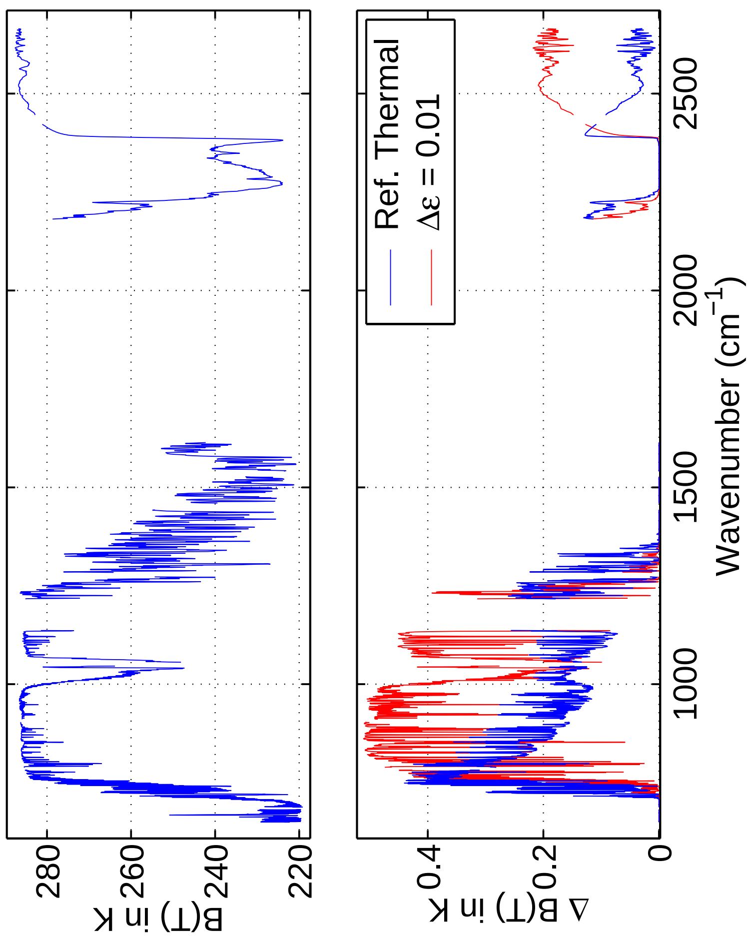


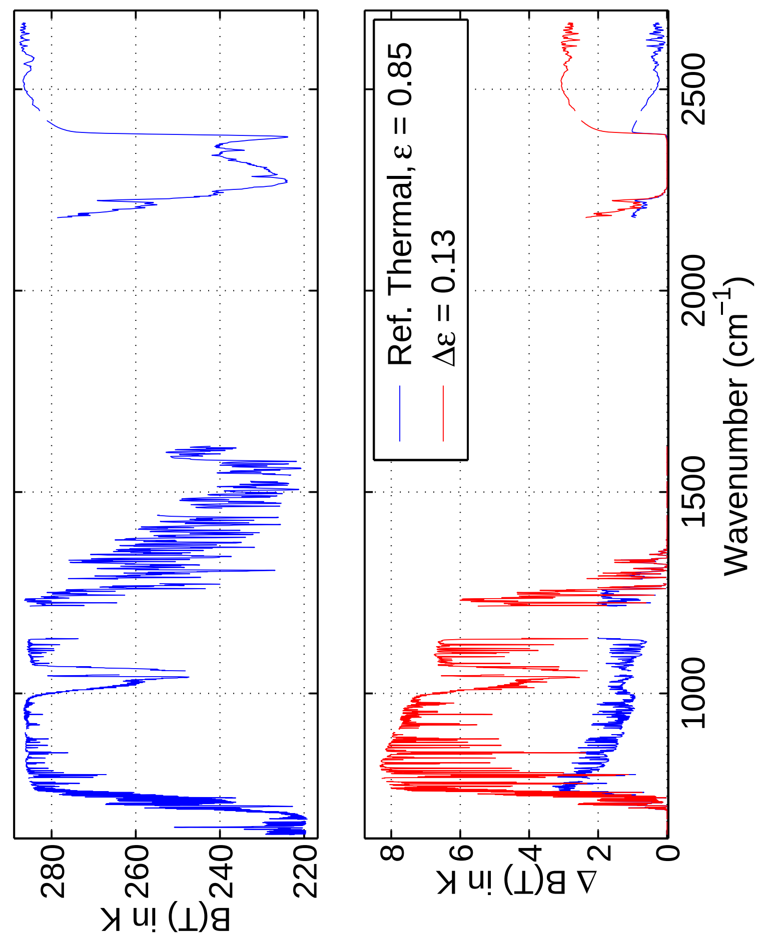
Emissivity Errors, High Emissivity



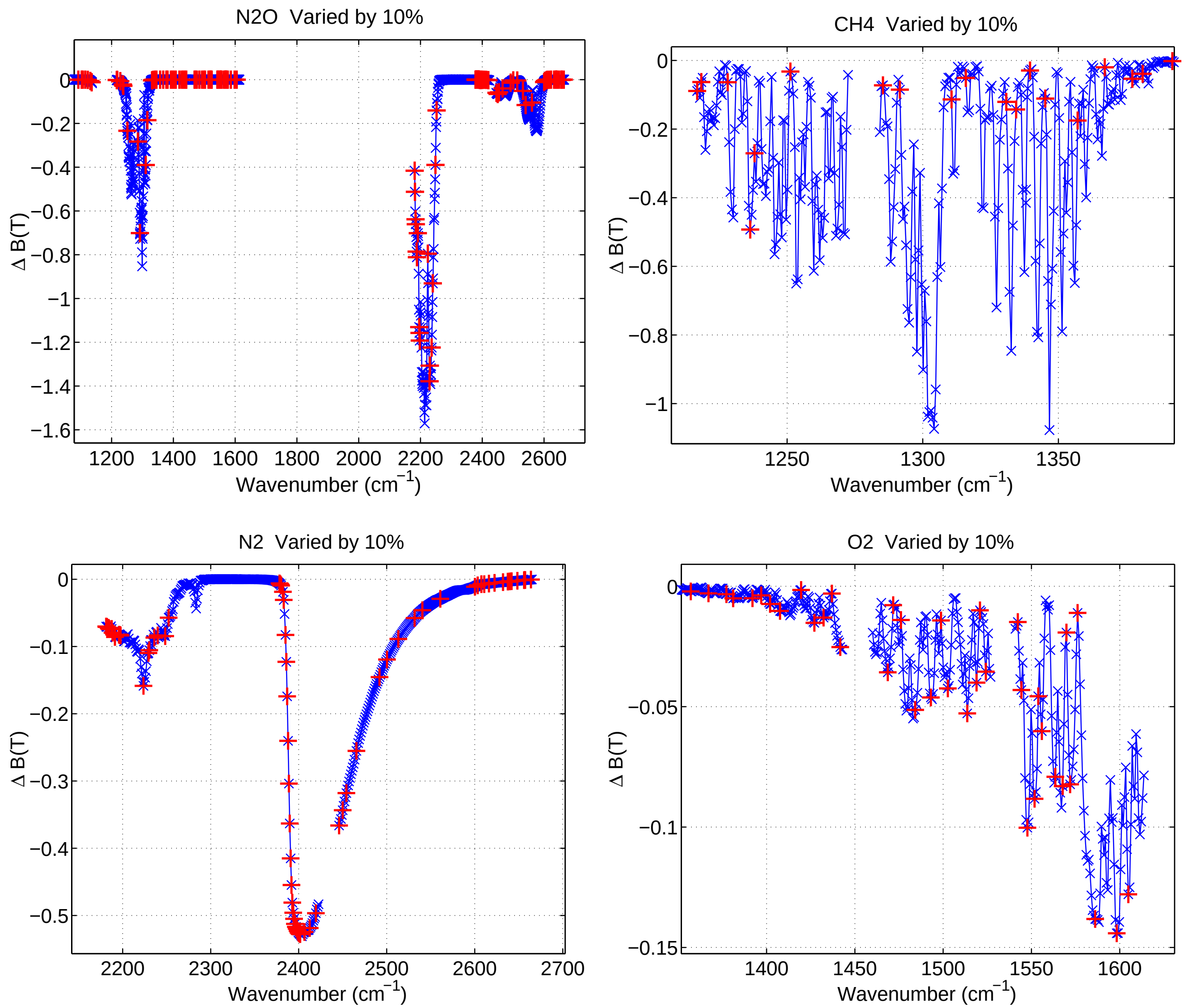


Emissivity Errors, Low Emissivity





Minor Gas Sensitivities



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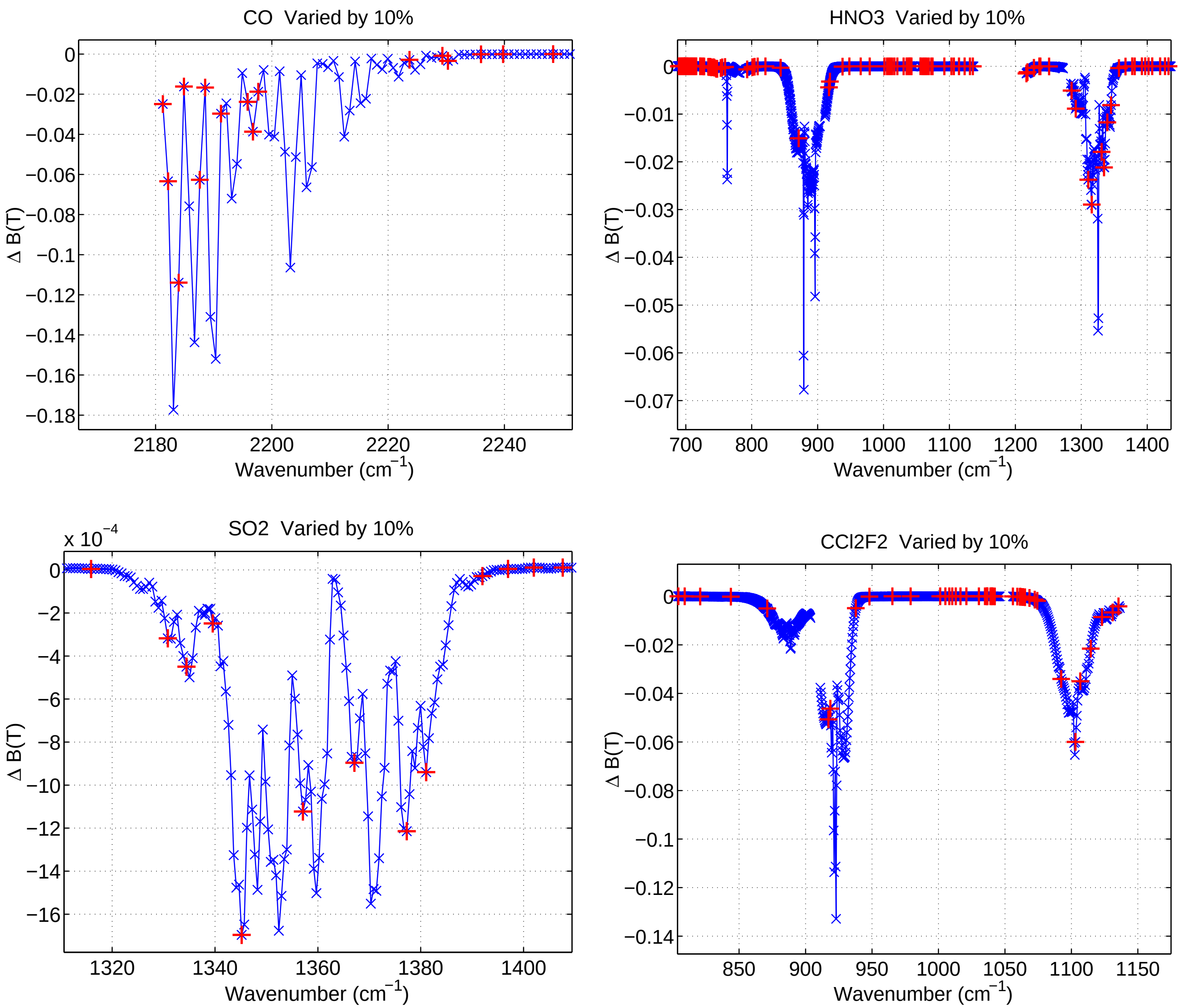

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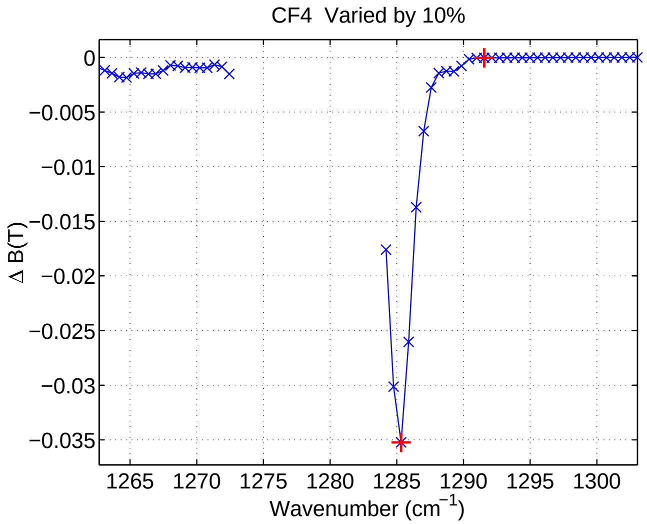
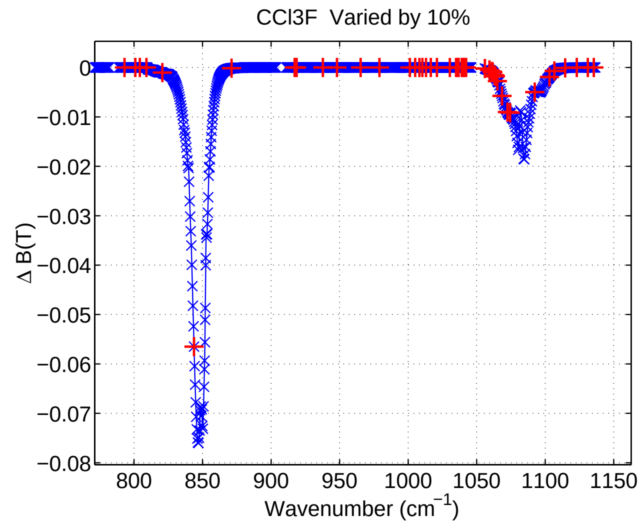
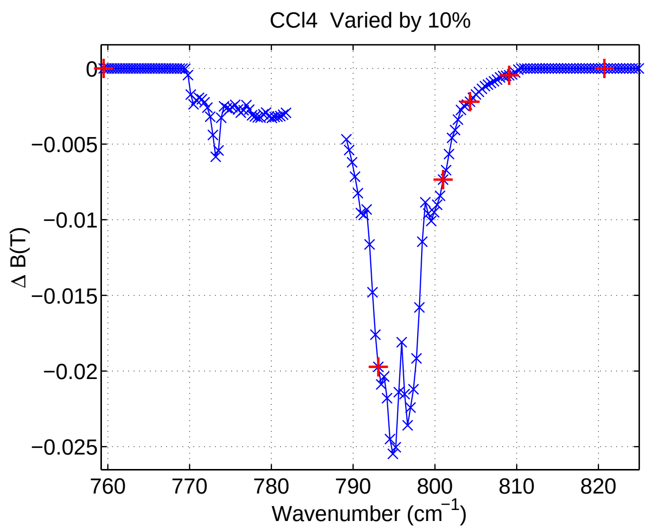
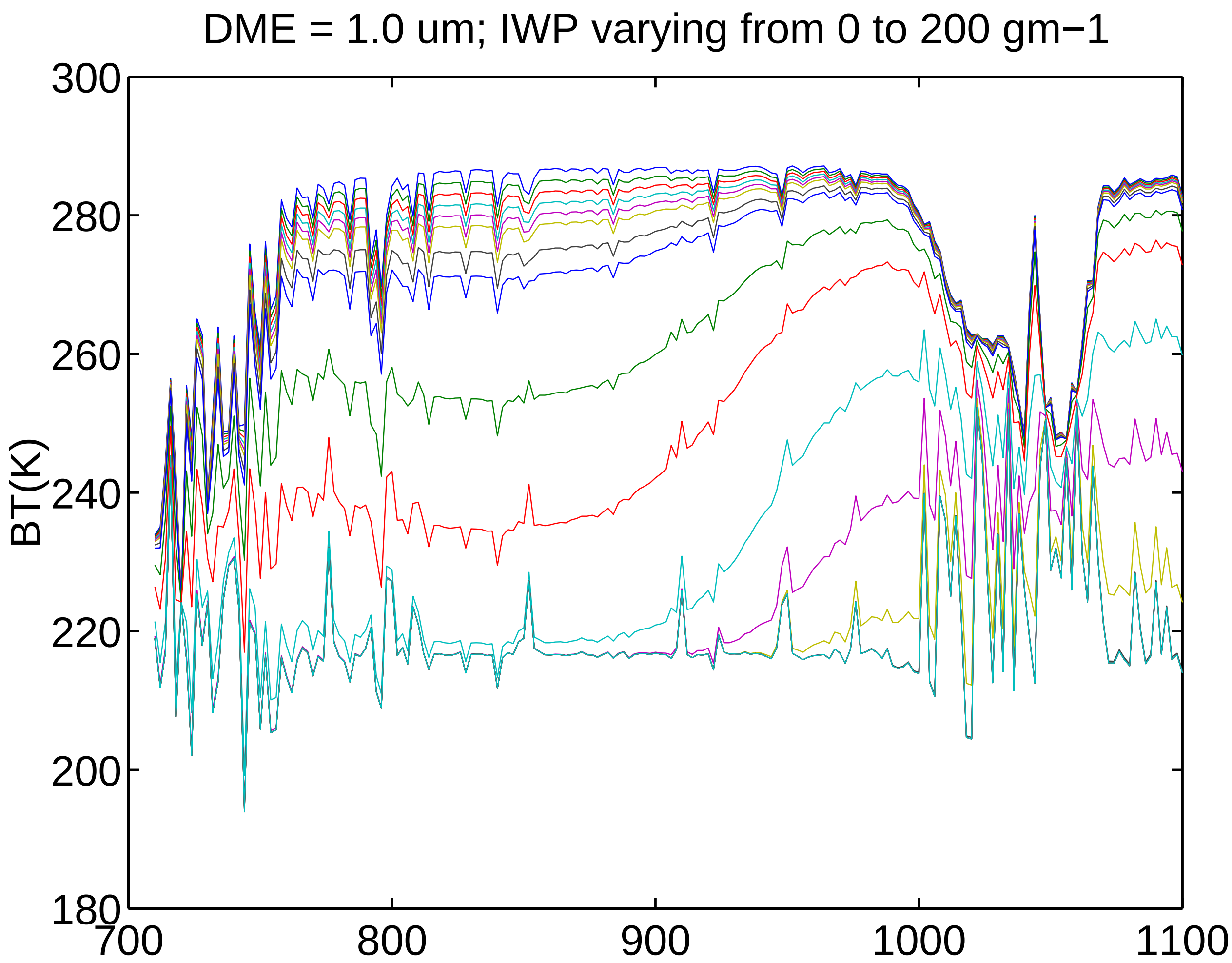






Cirrus Interference - AIRS Extremely Sensitive to Cirrus

AIRS can easily detect see sub-visible cirrus, and allow retrieval of mean particle size and ice water path. Should a search for thin cirrus be part of clear flag?



Forward Models Used for AIRS Research

Our interest: validation and improvement of AIRS-RTA

Organization	Spectroscopy	Parameterization
AIRS Project	kCARTA	AIRS-RTA
[1]DAO	kCARTA (via NCEP?)	"Optran" (via NCEP?)
NCEP	kCARTA	"Optran"
ECMWF	GENLN2	RT-TOVS/IASI-A?
UKMO	kCARTA?	Gastropod?
[2]CMC	GENLN2/kCARTA?	Gastropod?/RT-TOVS

[1] Only for radiance assimilation? AIRS-RTA for retrieval assimilation or whatever model Mitch Goldberg chooses to use?

[2] Plan to perform radiance monitoring with AIRS-RTA.

- Can Andrew C. clarify ECMWF vs UKMO forward models?
- Monitoring with different forward models may make it difficult to arrive at definitive conclusions about RTA biases.

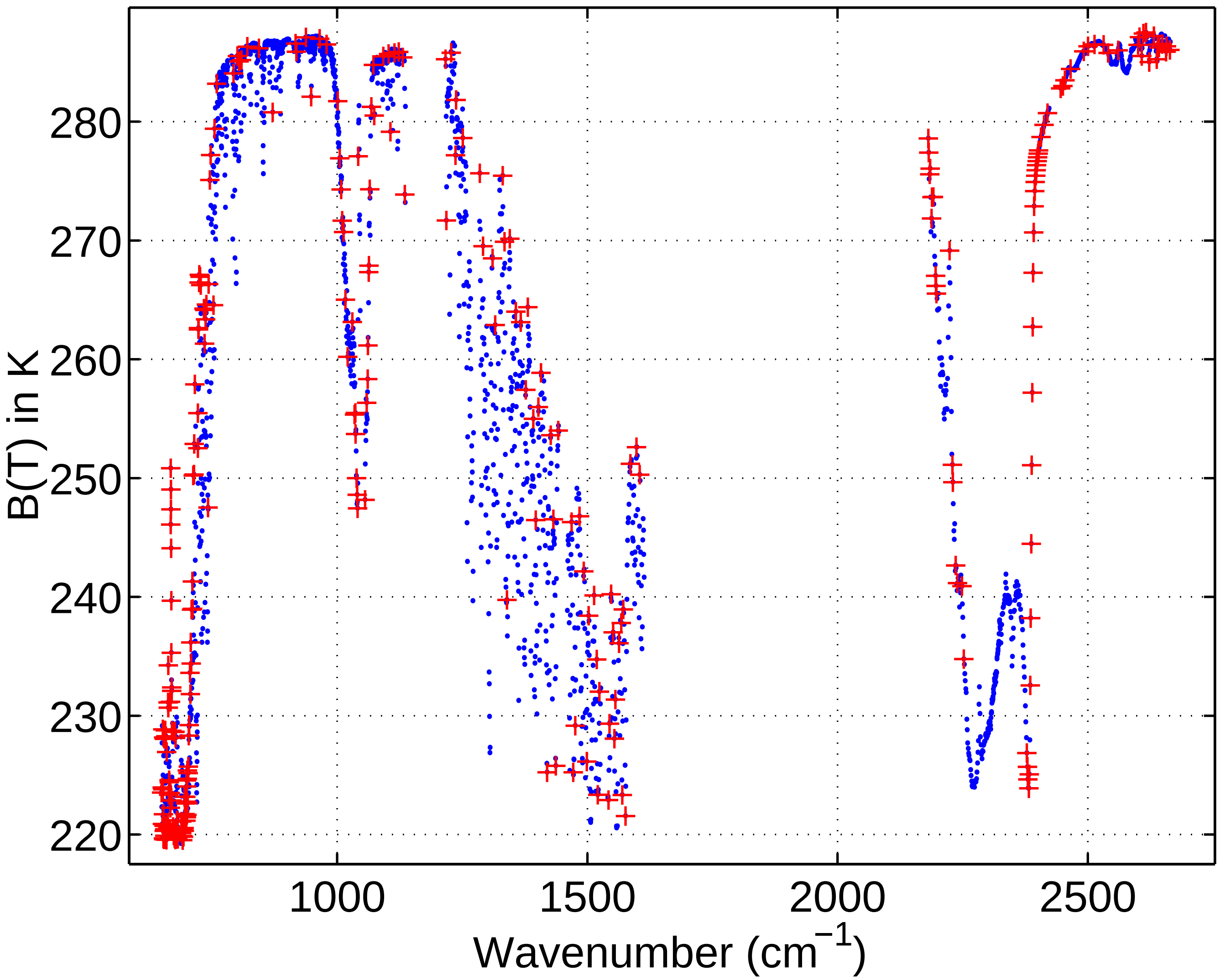
UMBC Plans

- Produce new forward model and convolved layer-to-space transmittances as soon as AIRS channel centers settle down. Also provide new SRF file.
- Initial validation of forward model will concentrate on standard sondes, NWP models, and DOE-ARM site until special validation sites are in operation. Will continue DOE-ARM site monitoring long-term.
- Plan to produce radiance residuals using both NCEP and ECMWF models for some unspecified time period, for all channels (although expect large biases for upper atmospheric H_2O). Need common, agreed upon set of clear FOV flags.
- UMBC will re-process these residuals when the fast model is updated.
- Analyze special validation site data as they become available (for nominally clear FOVs).

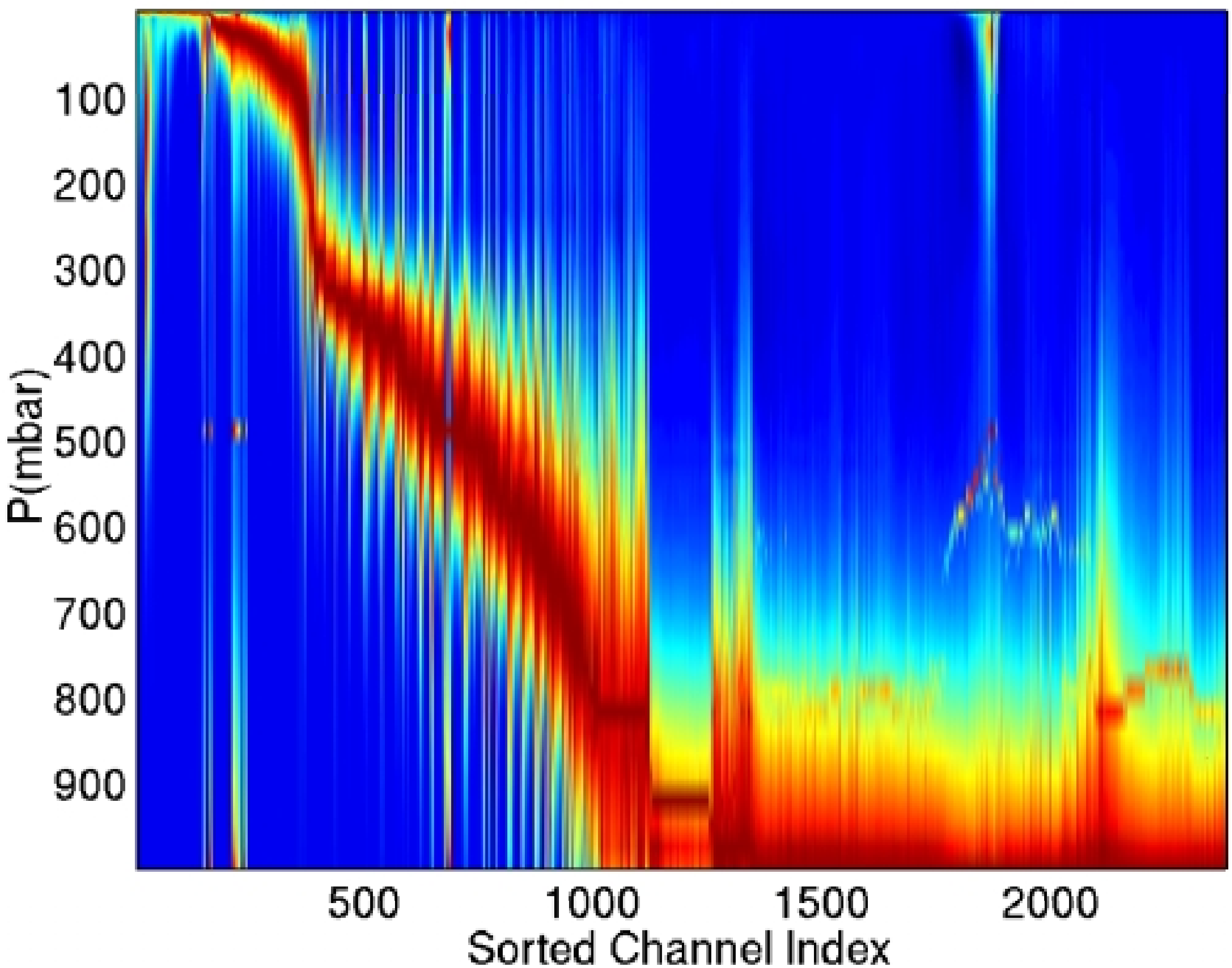
Recommendations/Requests/Questions

- AIRS Science Team and NWP centers should agree upon common test data sets for specific radiance monitoring exercises.
  - How will we intercompare radiance bias/variance statistics among organizations using different forward models?
  - Can we initially use a common, very conservative clear flag for these special test data sets?
  - How will we communicate these clear flags? Take the intersection of everyone's suggestions?
  - Do we, should we, have a universal FOV locater (UFL) for communication between groups? Lat/lon/time too difficult.
  - How communicate radiances residual results between groups?
- Can NWP centers use *all the channels* for initial, but limited radiance residual monitoring? This would be *very* helpful for radiance and forward model validation. Can M. Goldberg provide all channels for a limited time period?
- For medium-term validation is it better to use sondes or models?

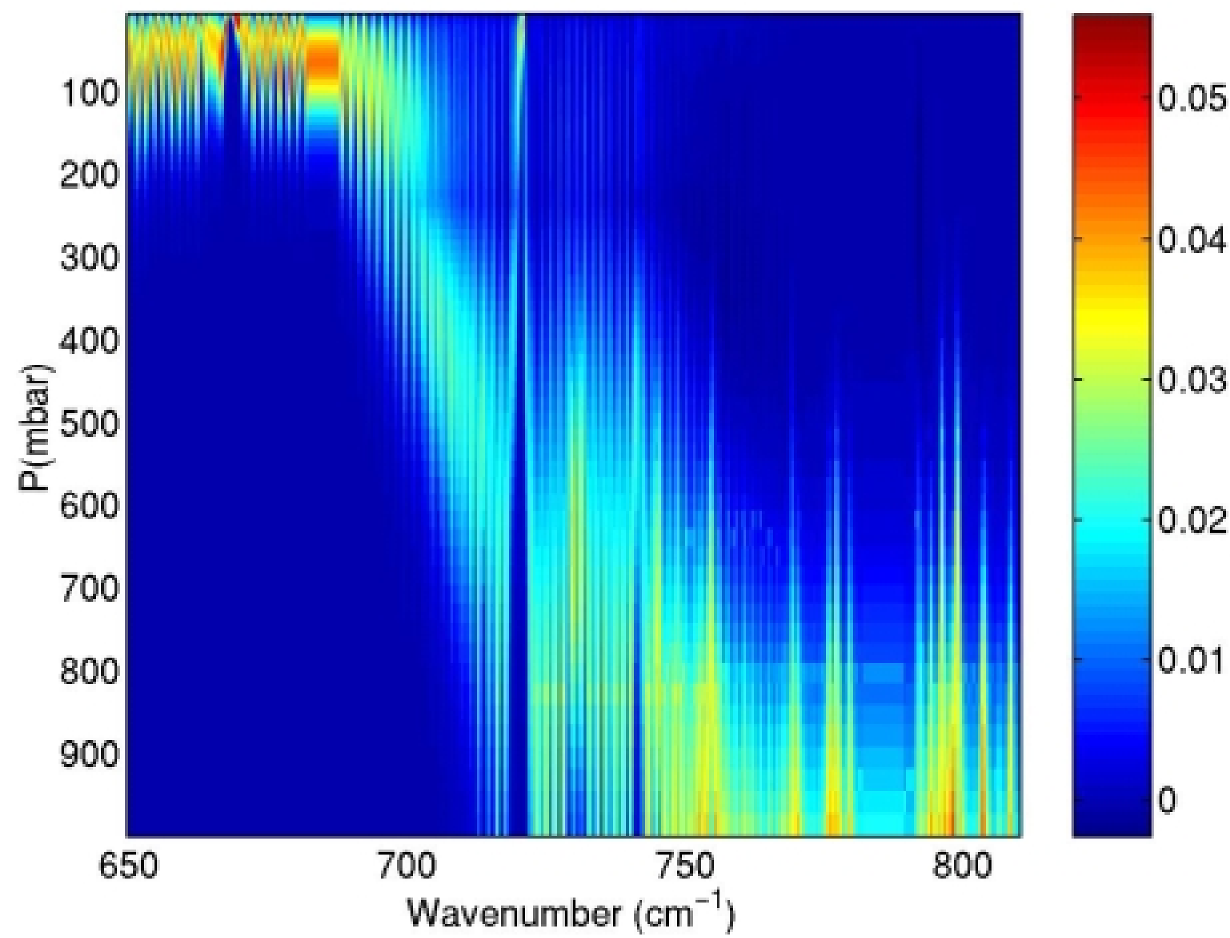
NWP Channel Selection



Temperature Jacobians Sorted by Maximum



Longwave Temperature Jacobians



Shortwave Temperature Jacobians