Atmospheric Spectroscopy with AIRS: Validation of the AIRS Forward Model

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- Status of AIRS-RTA and Radiance Validation (AIRS NASA/JPL)
  - Many advances since Jan. 2003 when existing AIRS-RTA finalized
  - New AIRS-RTA will be available in the Jan. 2004 time-frame
  - We are working with almost all 2378 channels…
- Validation Data Sets
  - ARM-SGP, very large dataset (RS-90's with microwave scaling)
  - ARM-TWP, high water vapor over ocean (RS-90's with microwave scaling)
  - Frost-point hygrometer (Voemel), small but high accuracy UTH dataset
  - ECMWF
- Approach
  1. Broad validation with ECMWF in 2002, biases < 0.5-1K in general
  2. Water vapor continuum using ARM-TWP, then ECMWF
  3. CO_2, other fixed gas bias evaluation with ARM-TWP, then ECMWF
  4. Mid-, Upper-atmosphere water vapor with a range of validation sensors

AIRS Validation Datasets

- ARM-Tropical Western Pacific; RS-90's with microwave scaling
- ARM-Southern Great Plains; RS-90's with microwave scaling
- Various frost-point sonde releases (Voemel)
- ECMWF
- ABOVE
- AERI in Antarctica (Von Walden)
- Raman lidar
- EUMETSAT validation data; sondes + lidar
- Many more ...

We are presently concentrating our efforts on ARM-TWP, ARM-SGP, Frost-points, and ECMWF.

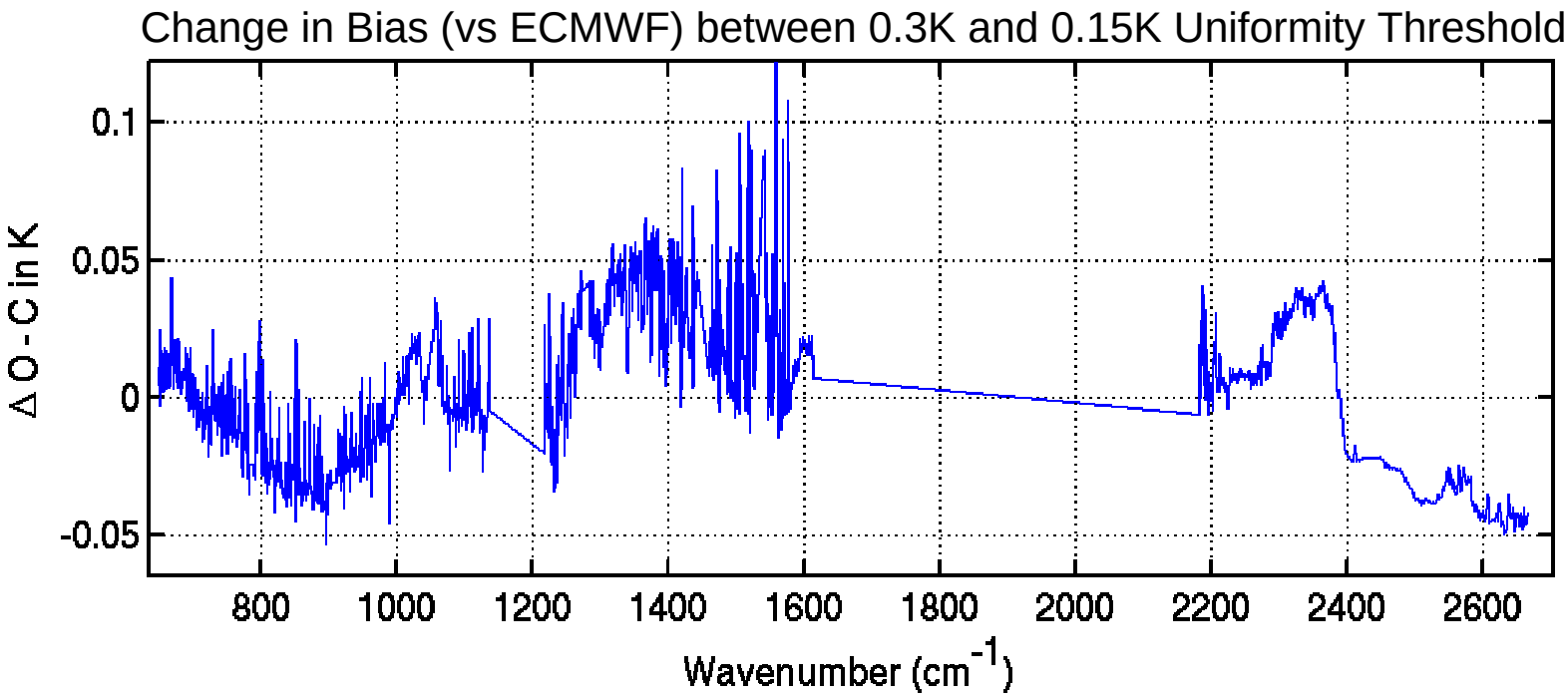
ARM Datasets Possible Candidates for ITWG RTA Inter-comparisons

General Approach

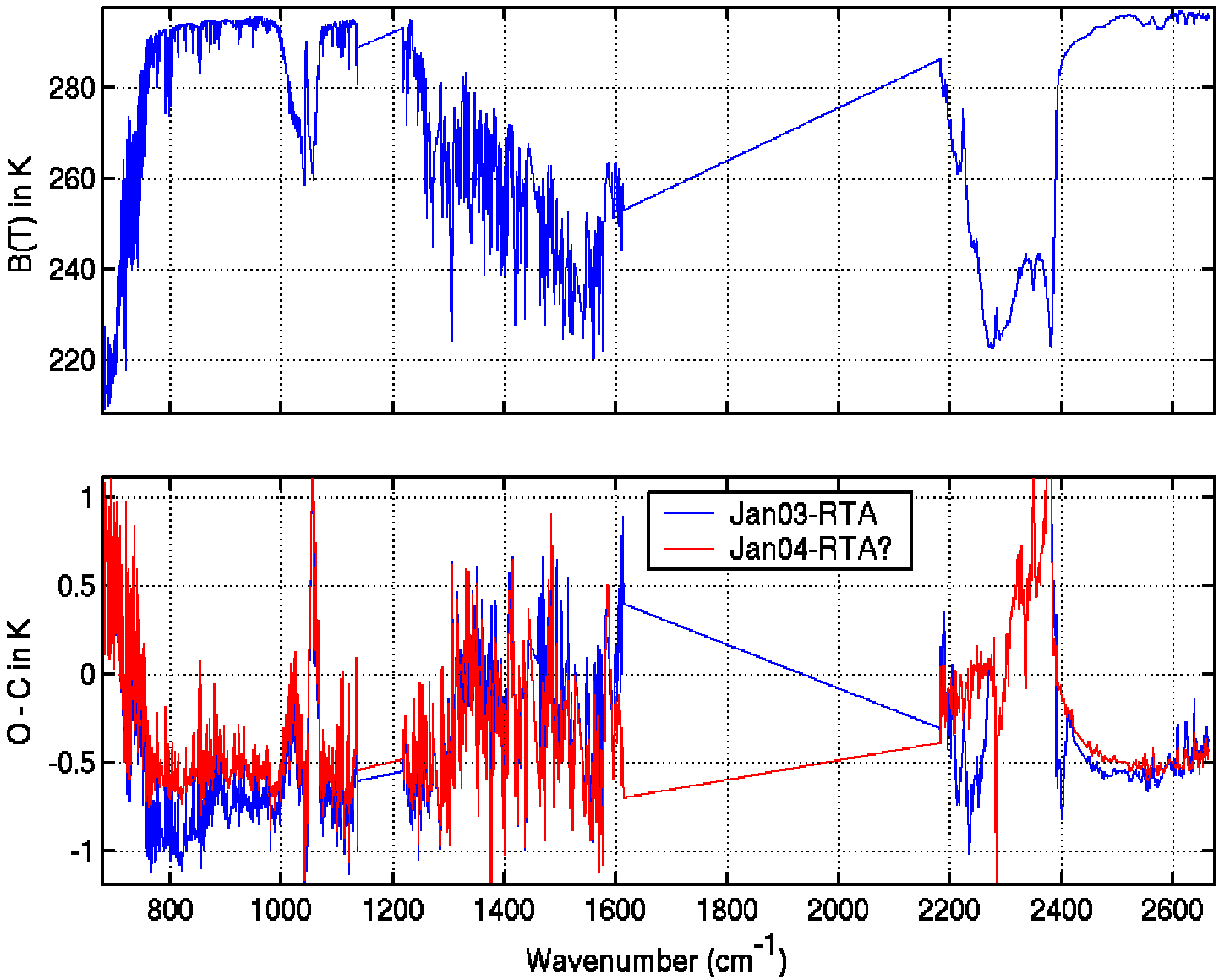
- Use the best physics possible in the RTA transmittances
  - Do our own spectroscopy whenever practical
  - Produce our own LBL, kCARTA, so we can get new spectroscopy into the RTA's as quickly as possible
  - Early work on Q-, and P/R-branch line-mixing has given relatively low biases in CO_2, so move to water vapor bias problems first
  - ARM-SGP AERI now providing best independent water continuum data in most spectral regions
  - Mid- to upper-tropospheric water channel transmittances may be tuned empirically, although we are working on a physical basis for these remaining biases using new laboratory results.
- Base RTA improvements on multiple data sources whenever possible
- Correct spectroscopic errors at the source; the transmittances
  - Not always possible to go back to LBL in a timely manner
  - So, we sometimes will directly modify channel-averaged transmittances in AIRS-RTA in advance of fixing the LBL

Cloud Filter

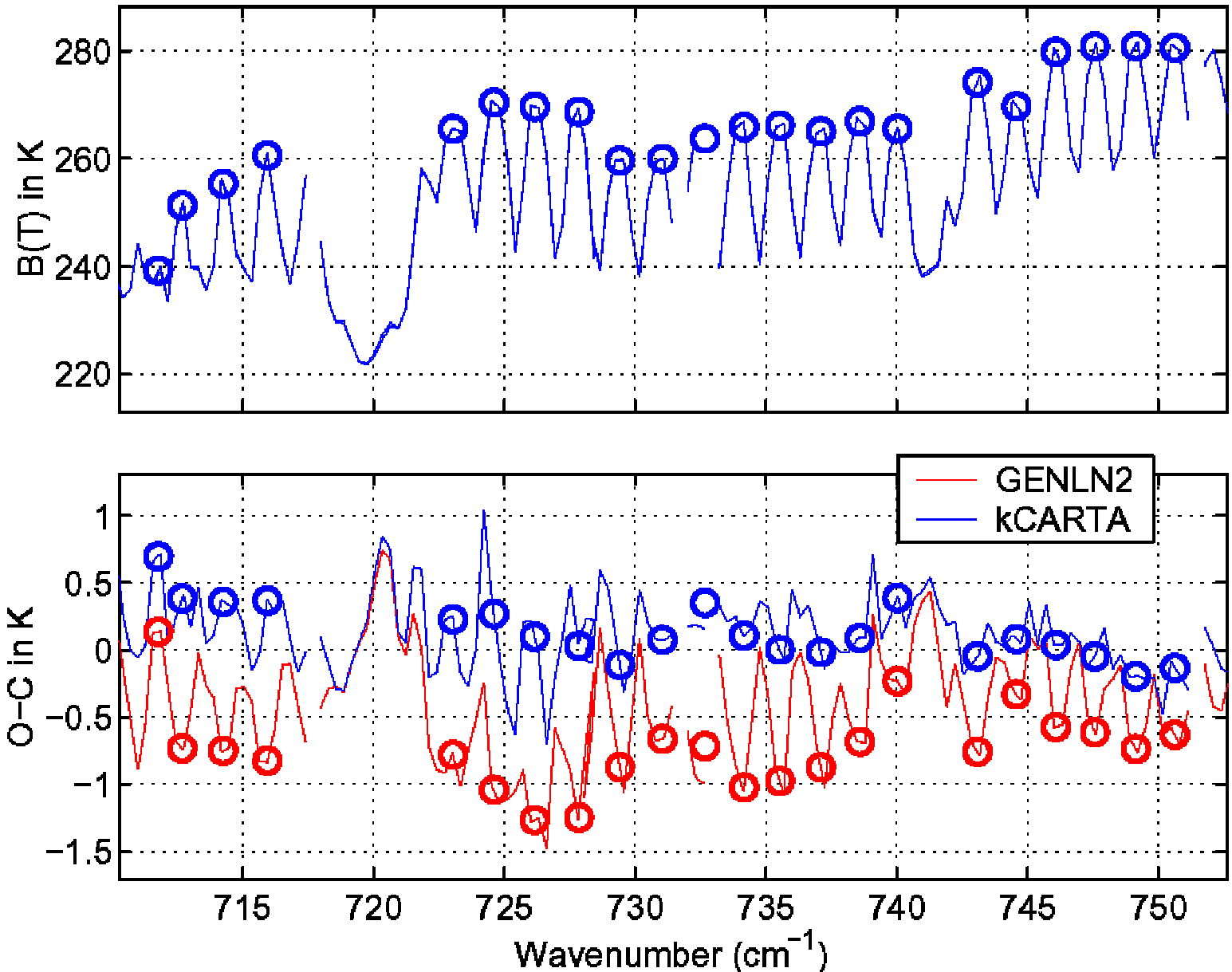
- We can afford to be very picky for RTA validation studies
- Ocean only: well known emissivity
- Night only: avoid near-IR solar contamination
- Uniformity filter: nearby FOV B(T)'s must be within 0.3K
- Additional 4K threshold for derived vs model SST to avoid low stratus
- ~800K hits/month, ECMWF bias results are monthly means (March 03)



Jan03-RTA vs Jan04-RTA??



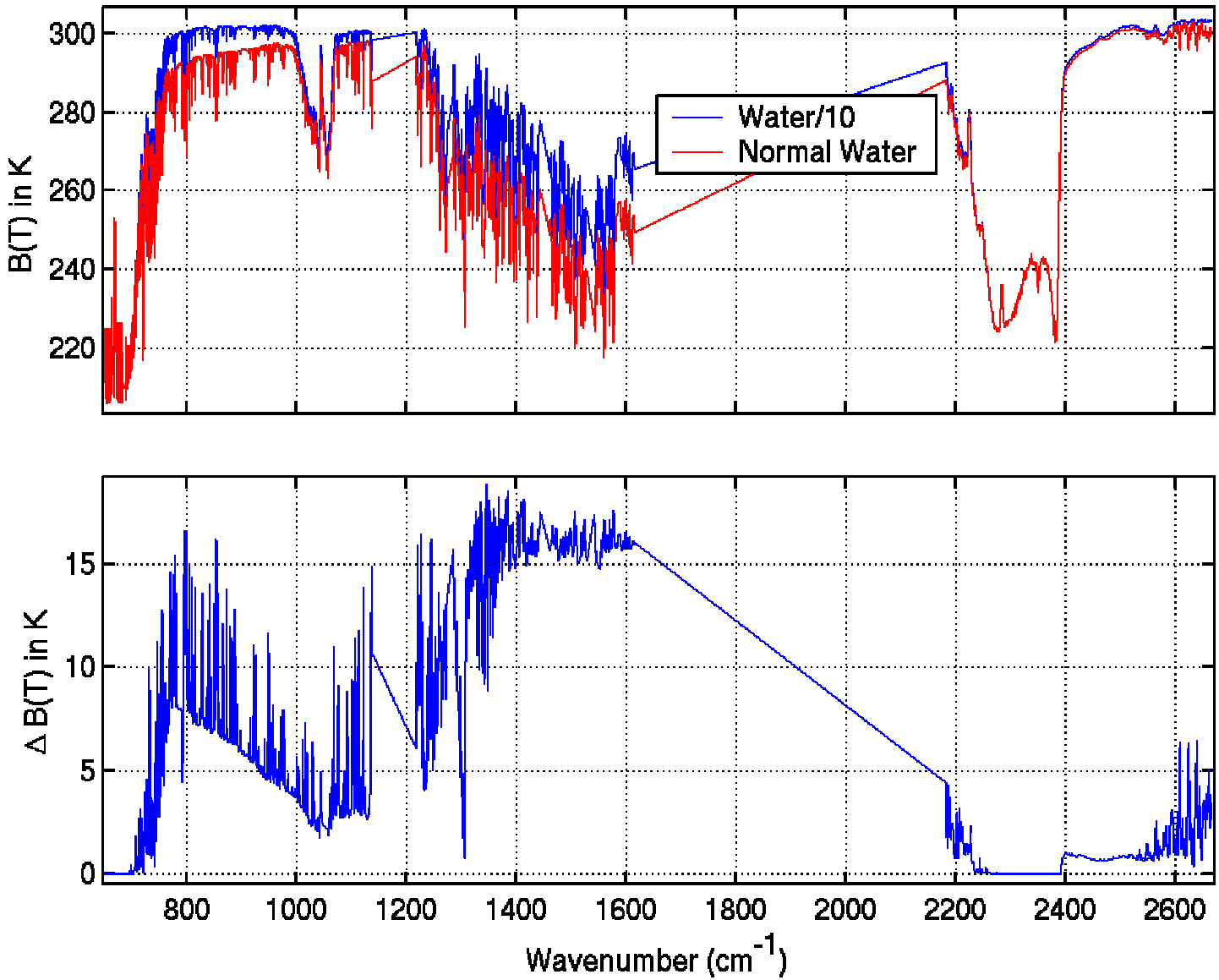
P/R-Branch Line Mixing in CO_2
Low Biases vs ECMWF for CO_2 in mid-trop



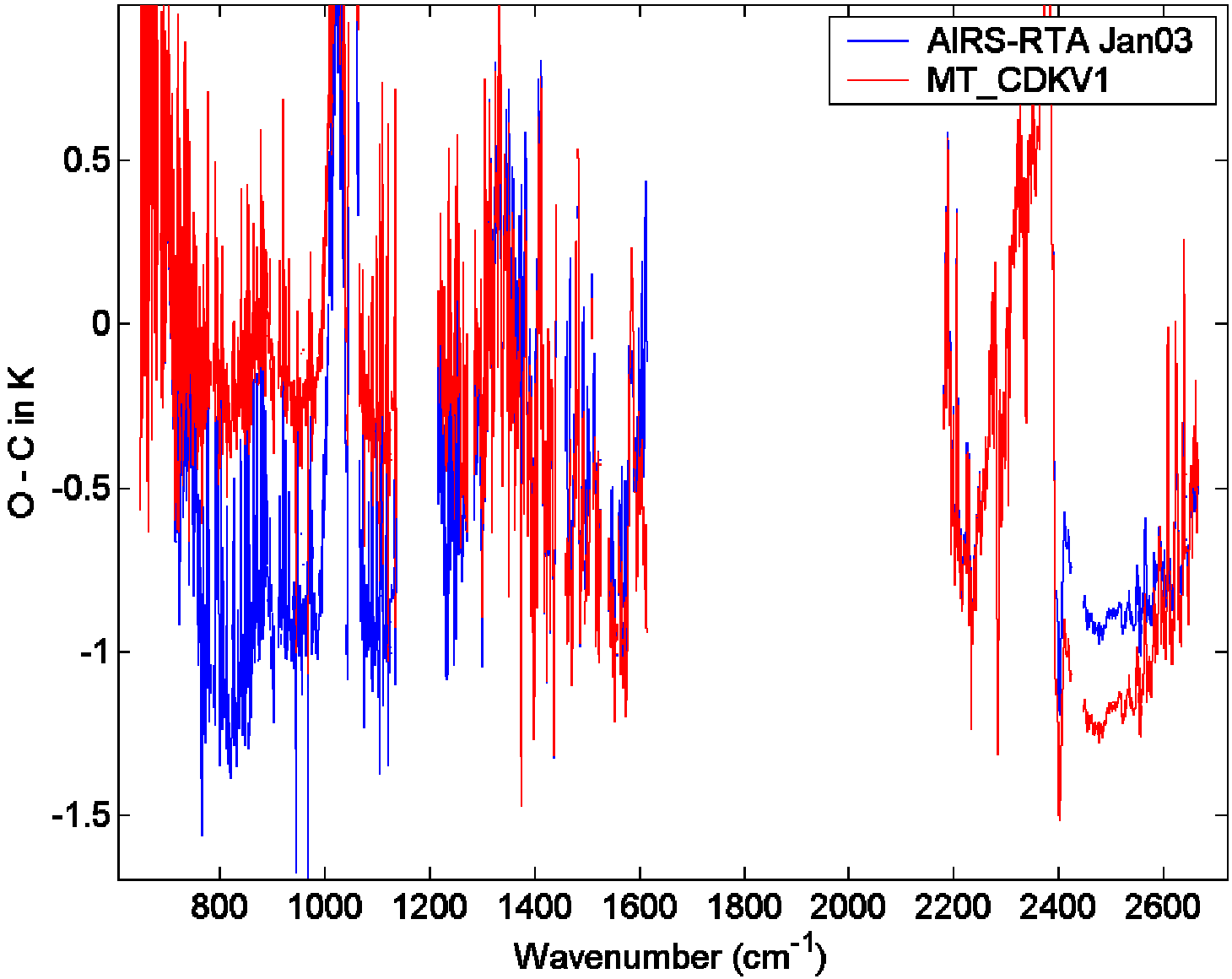
H_2O Continuum

- Work from bottom of atmosphere up, start with the H_2O continuum
- Used MT_CKD-V1 (released Spring 2003) as our baseline
- ARM-TWP validation site (1) has lots of water (~40 mm), (2) provides ocean scenes with known emissivities, and (3) had a reasonable number of "clear" overpasses.
- Examine ARM-TWP ARM biases and assess their origin
  - Fix problems with new independent data, new analyses of old data *or*
  - Fix problems directly with ARM-TWP bias observations
- Test new RTA against other validation data
  - ARM-SGP (not good for continuum…)
  - ECMWF
- Consistency between datasets gives us confidence
- Working down to the 0.1-0.2K level is tough

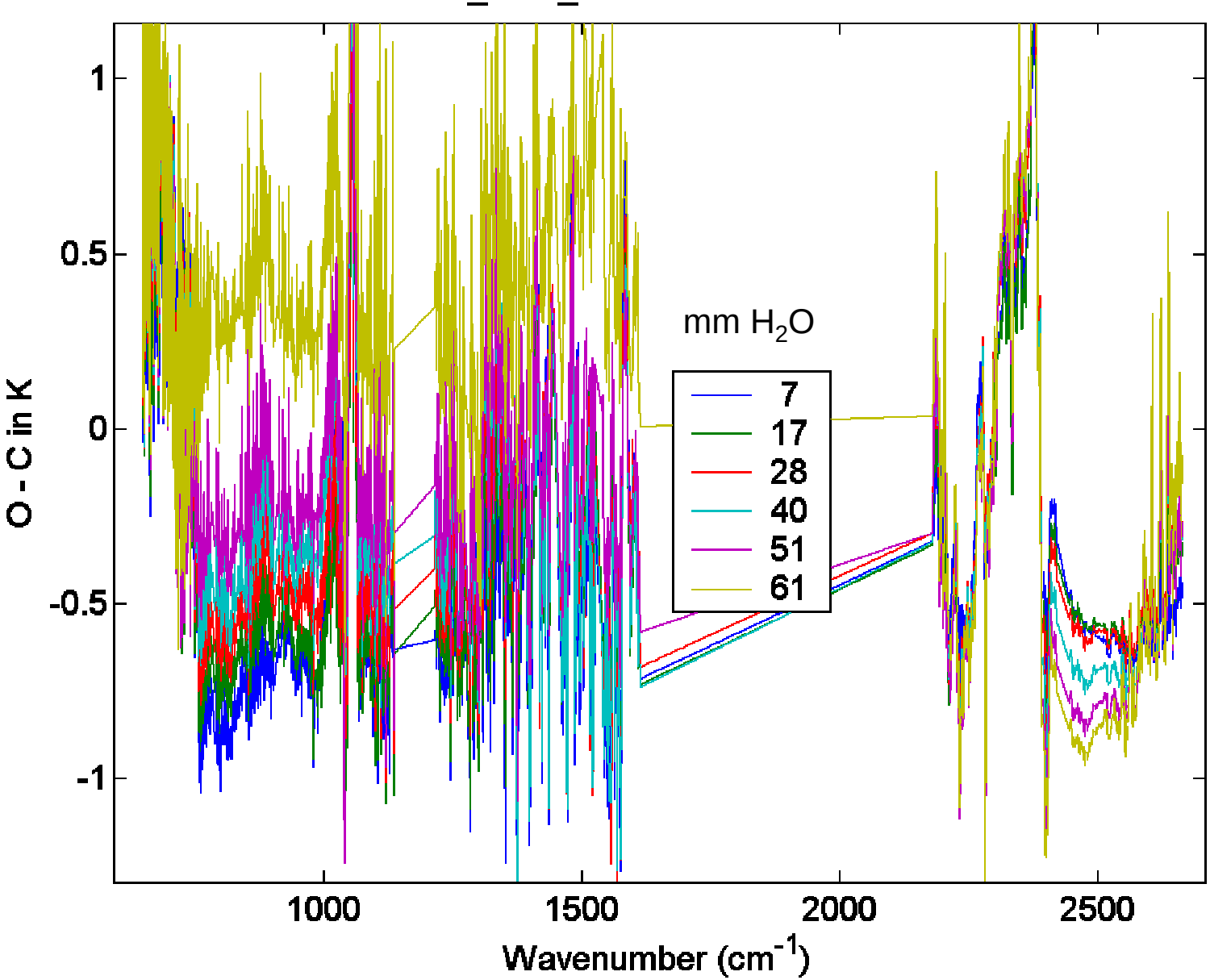
Strength of Water Continuum, ARM-TWP



ARM-TWP Biases



MT_CKD Biases Relative to ECMWF

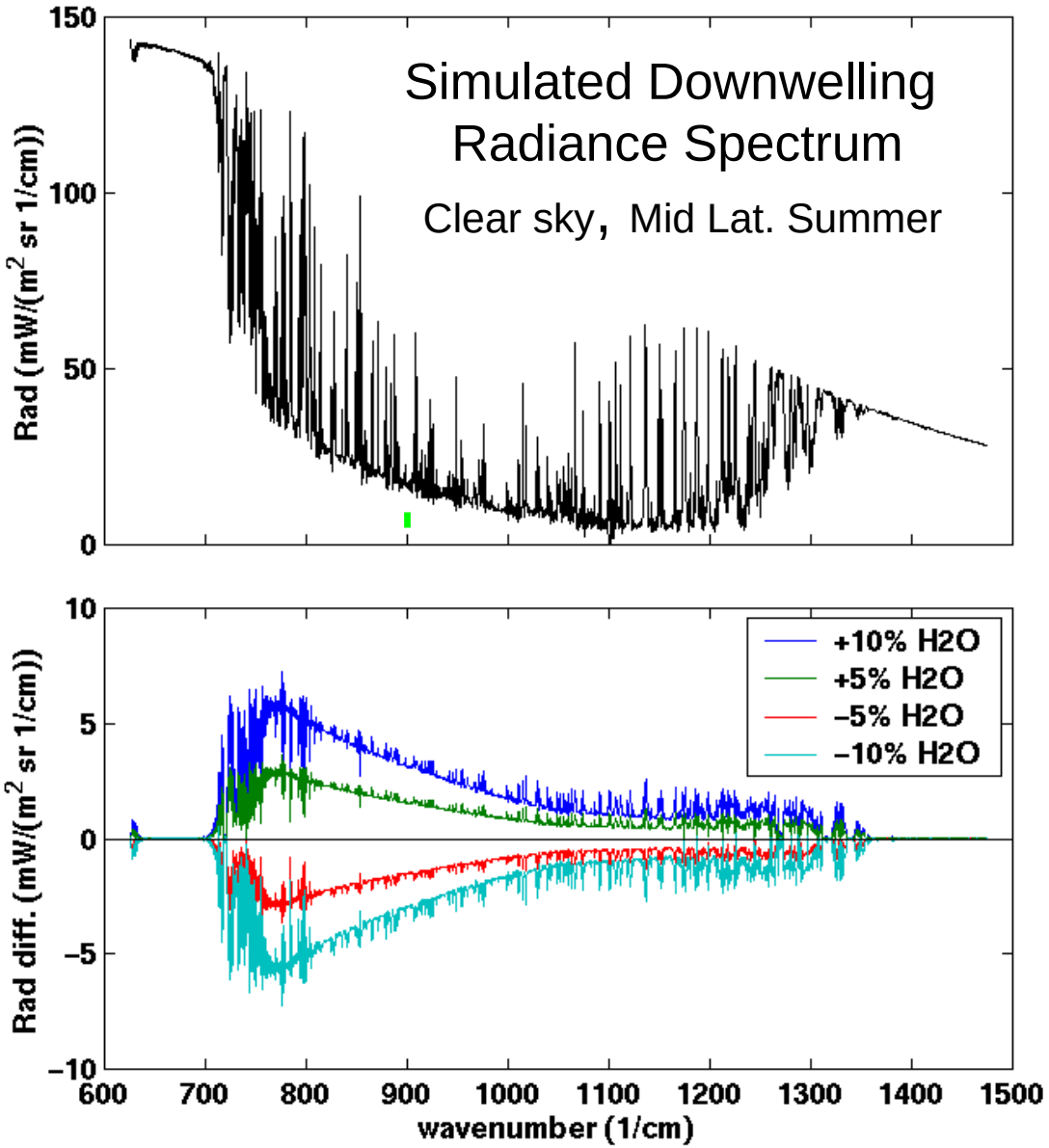


Lower Troposphere Water Vapor Measurement Goal: <2% in precipitable water vapor

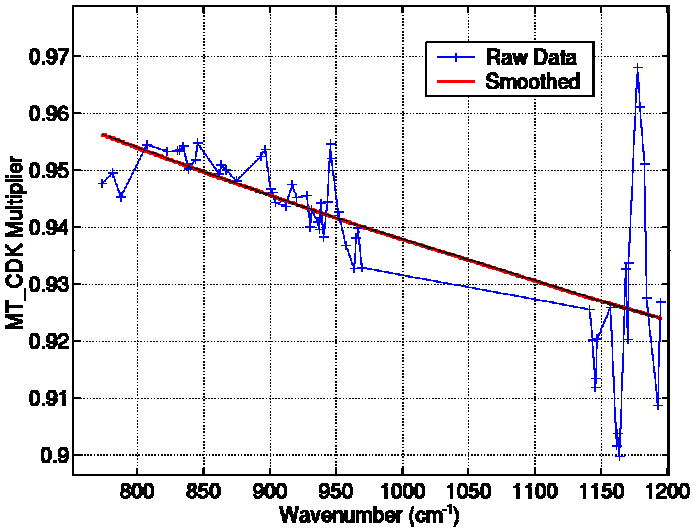
Based on desire to improve clear sky absorption models and to resolve significant climate changes, such as the effect of CO_2 doubling on surface radiation budget.

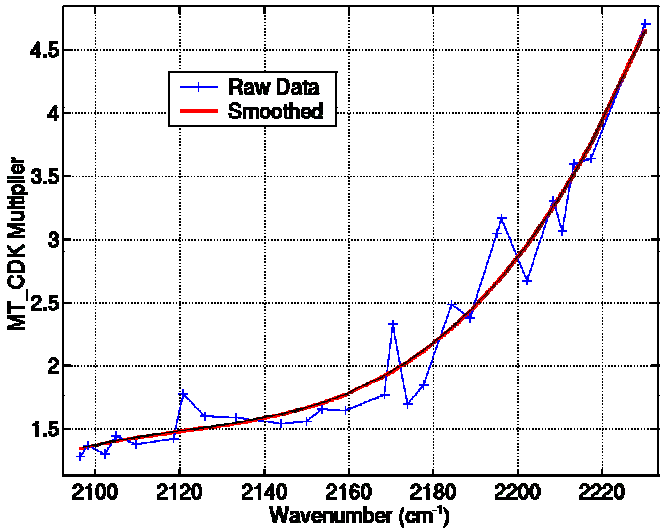
For midlatitude conditions, a 10% H_2O perturbation results in a ~7 W/m^2 change in downwelling Flux at the surface.

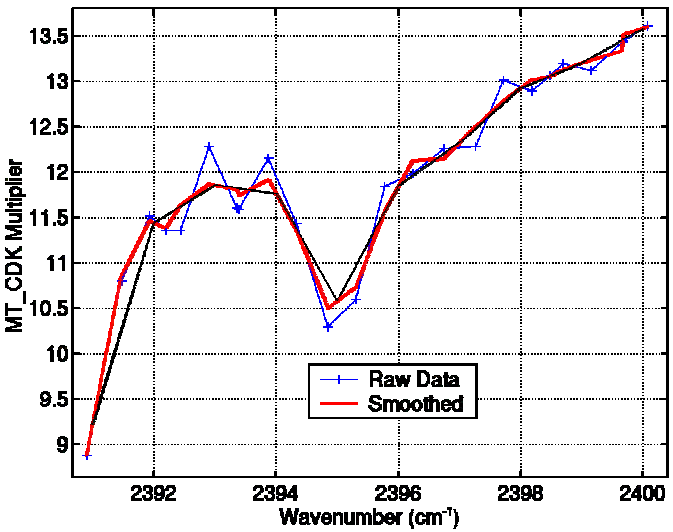
2% is order (1 W/m^2)

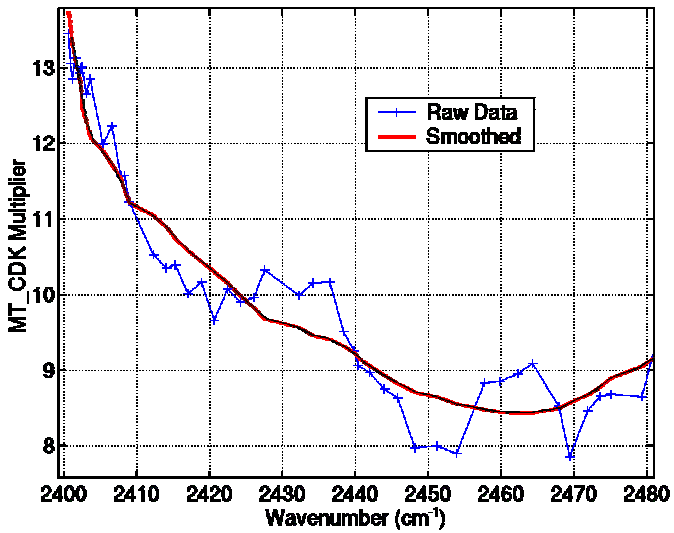


AERI-derived Changes to MT_CKD

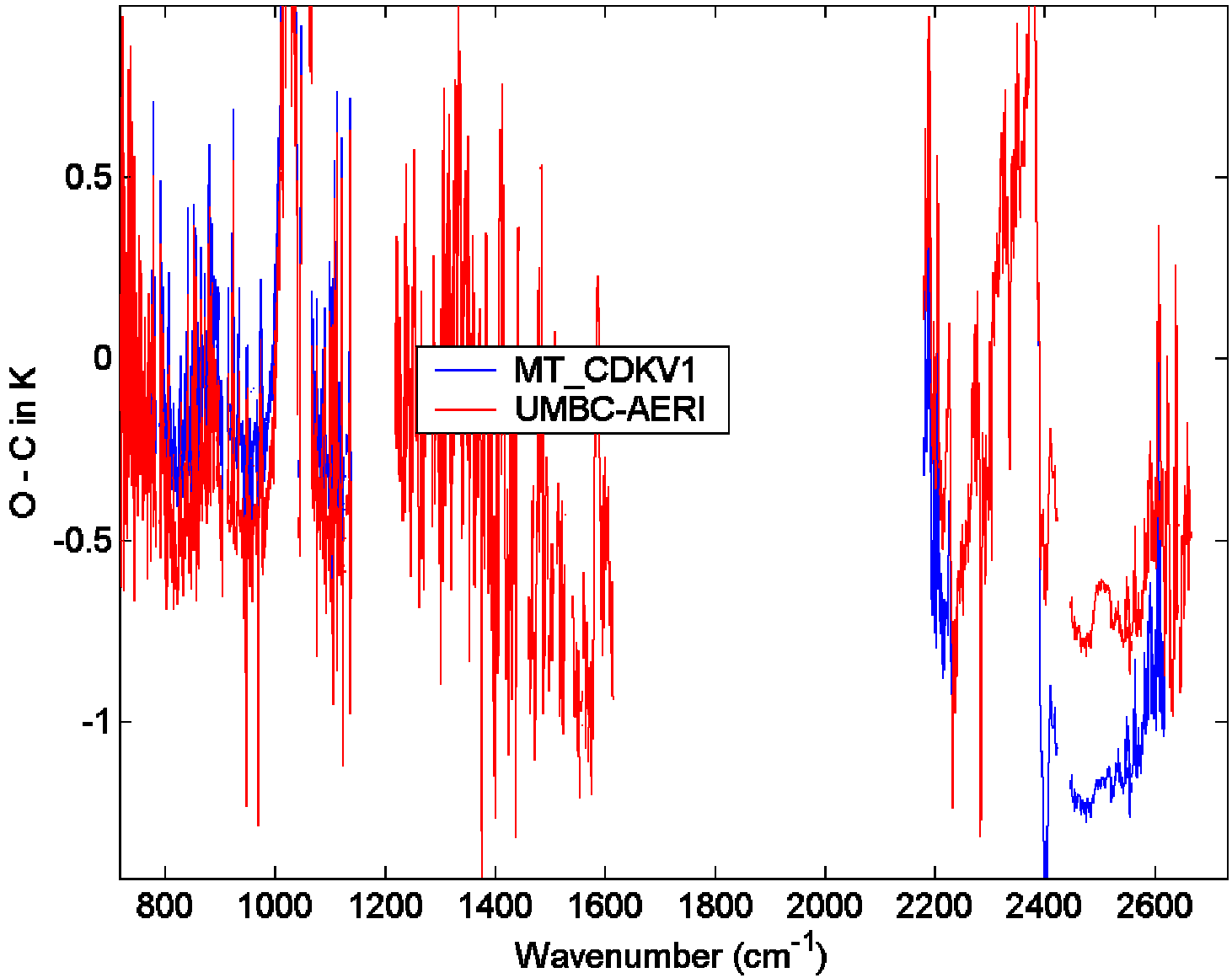




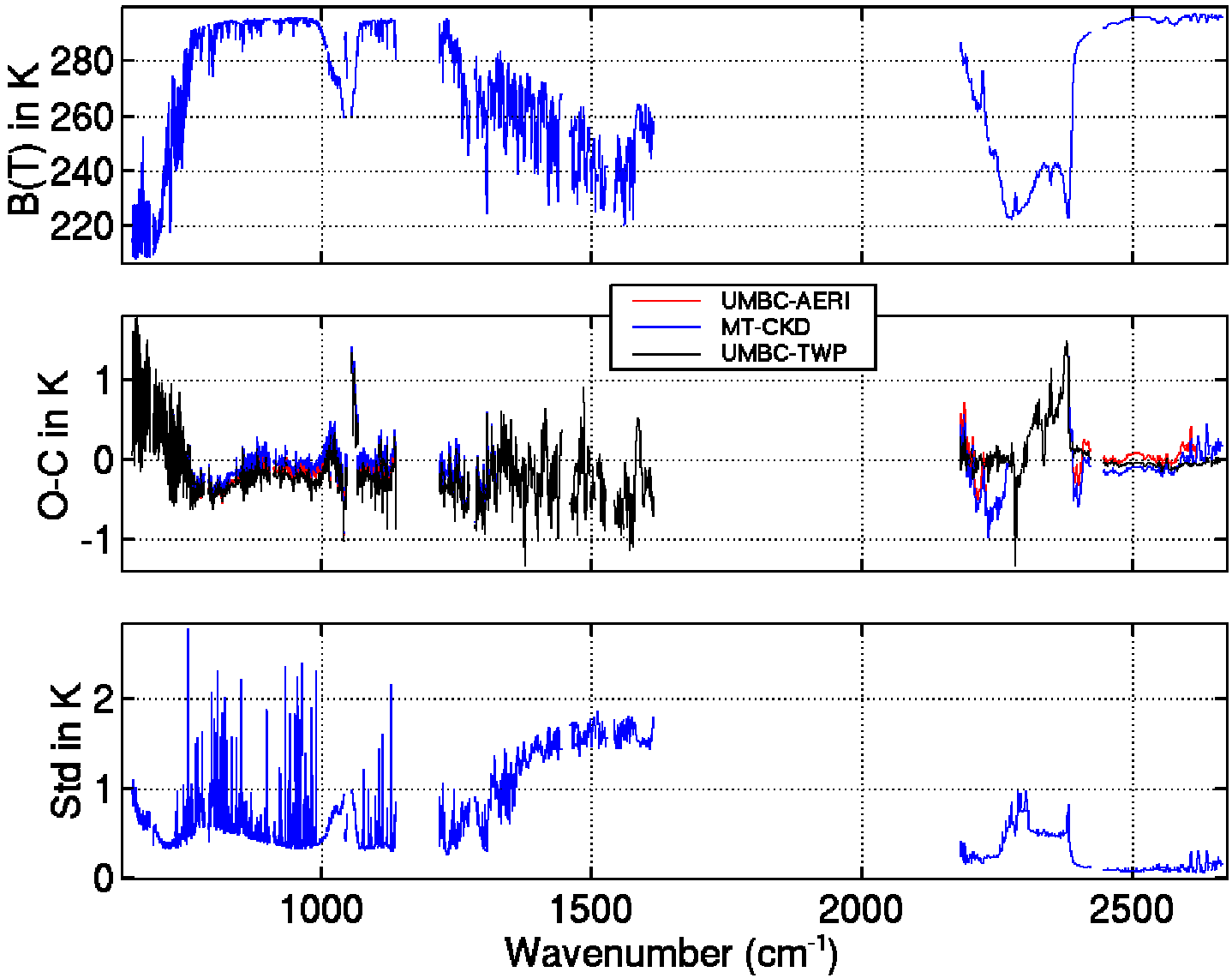




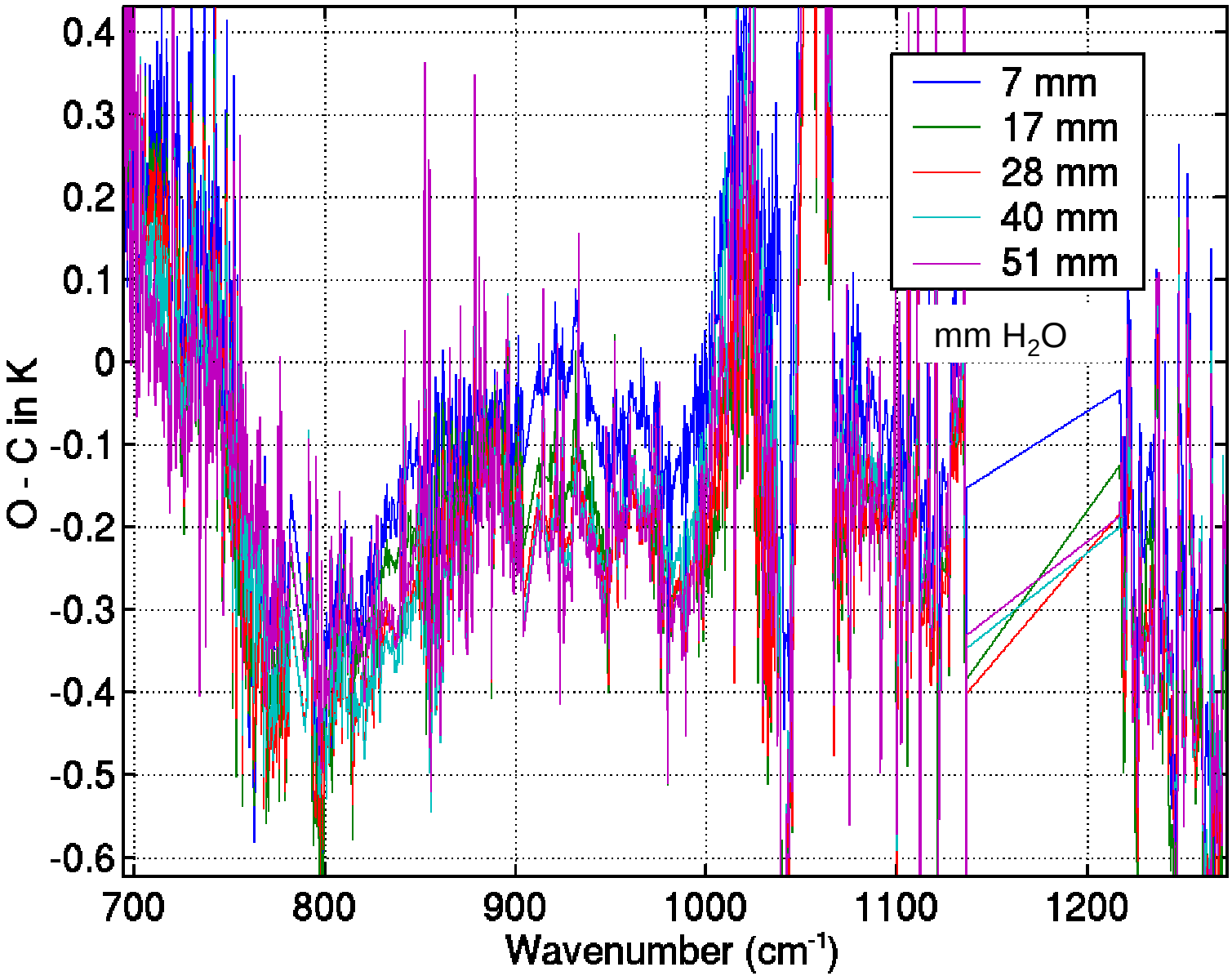
ARM-TWP Bias Improvements from New AERI-Derived Continuum



ECMWF Biases for 3 Continuum Models

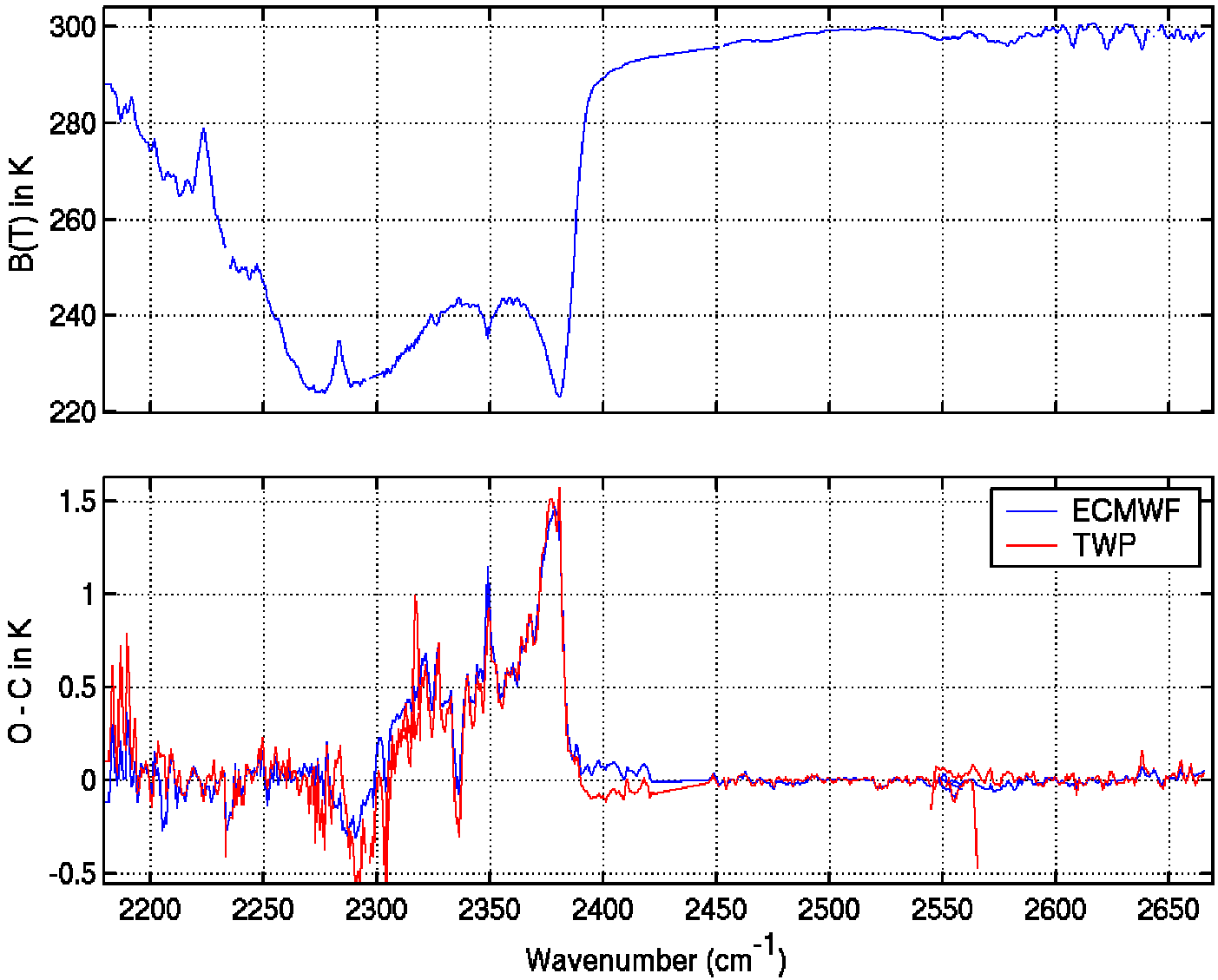


ECMWF Bias in Longwave - ~2% Accuracy in Total column Water?

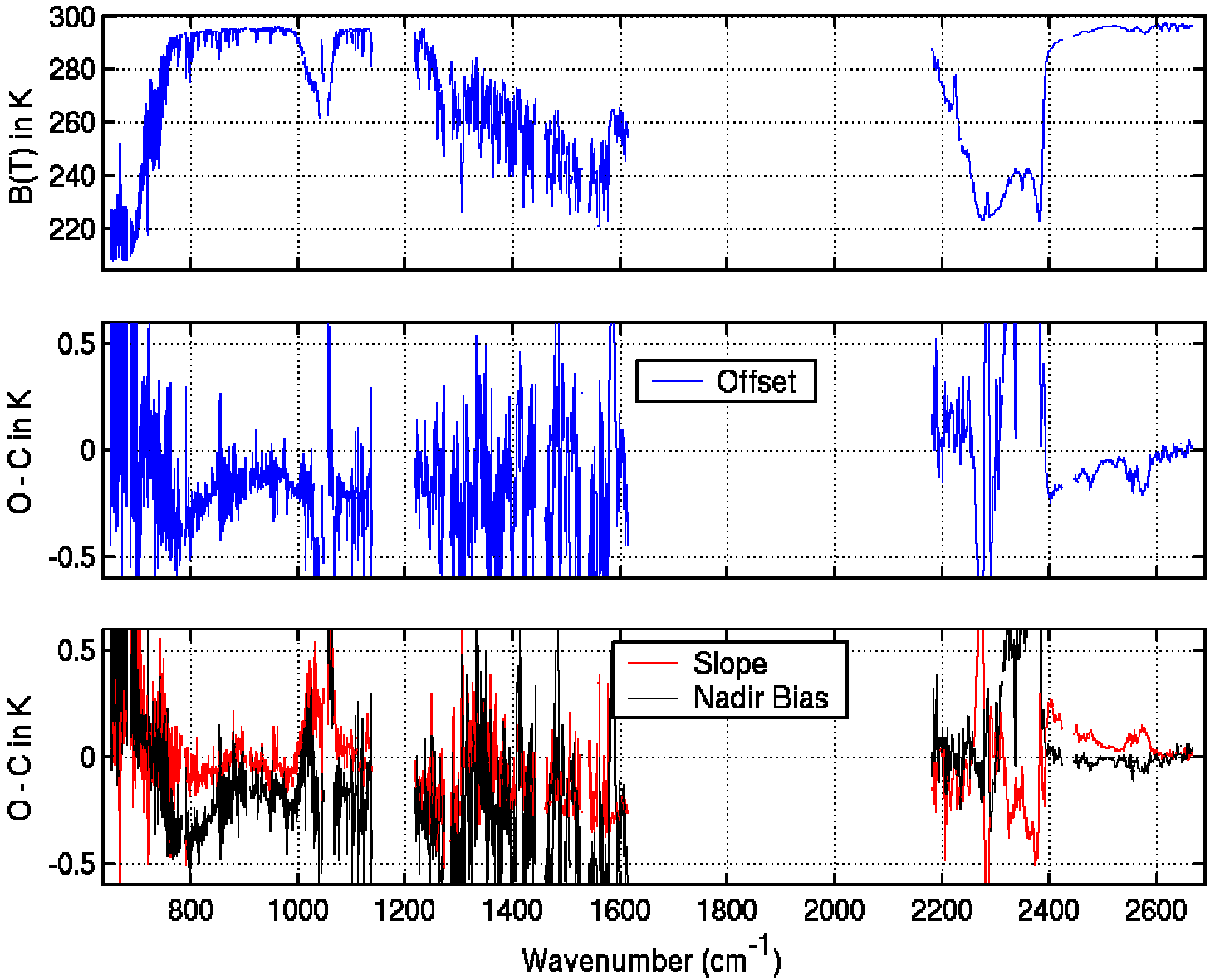


ECMWF vs TWP Biases, 4.3 Microns

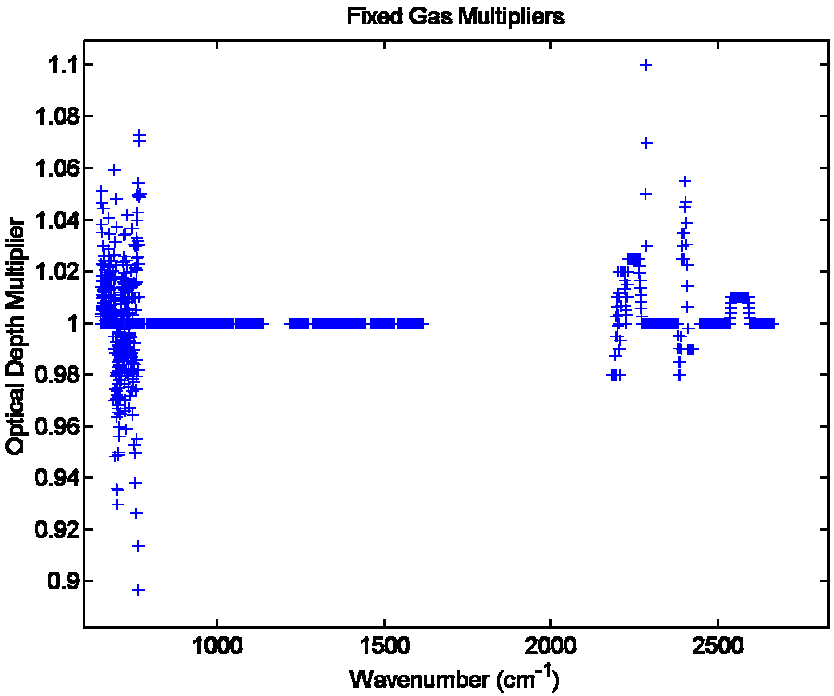
(using continuum derived from TWP)

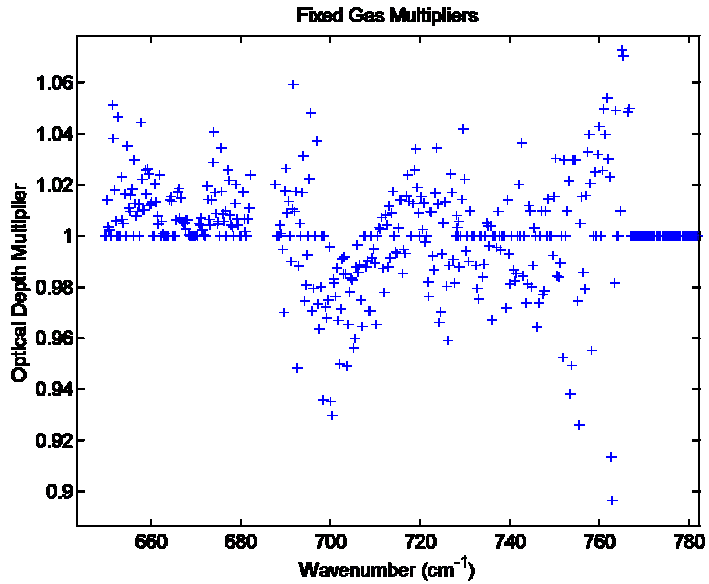


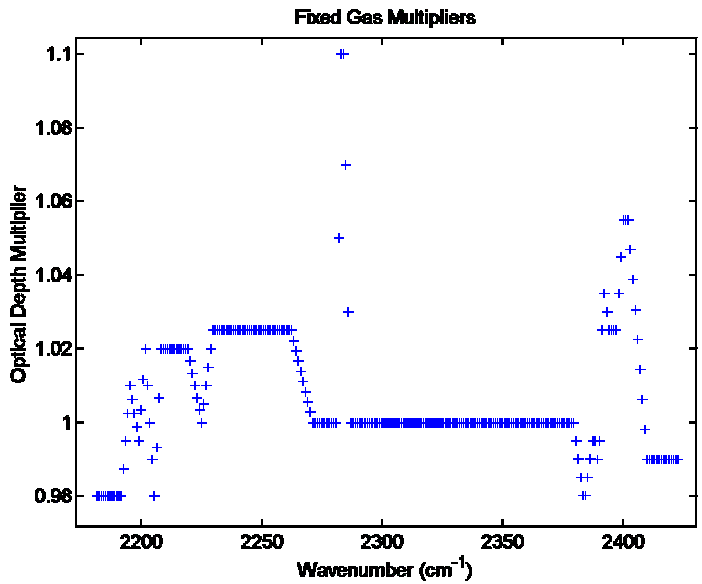
ECMWF Bias Fitting
Bias = Offset + Slope*secant(θ)



Fixed Gas Multipliers from TWP

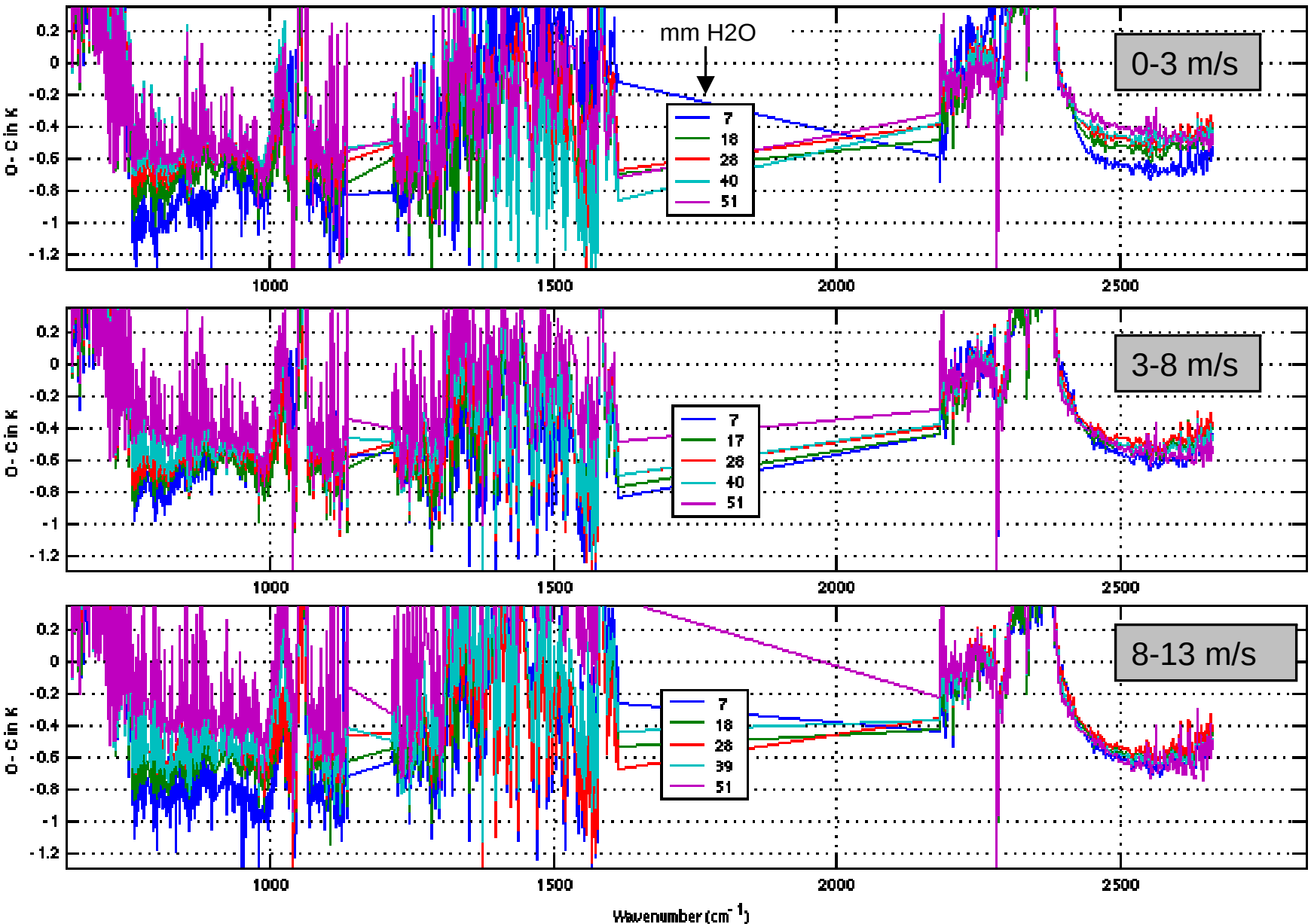






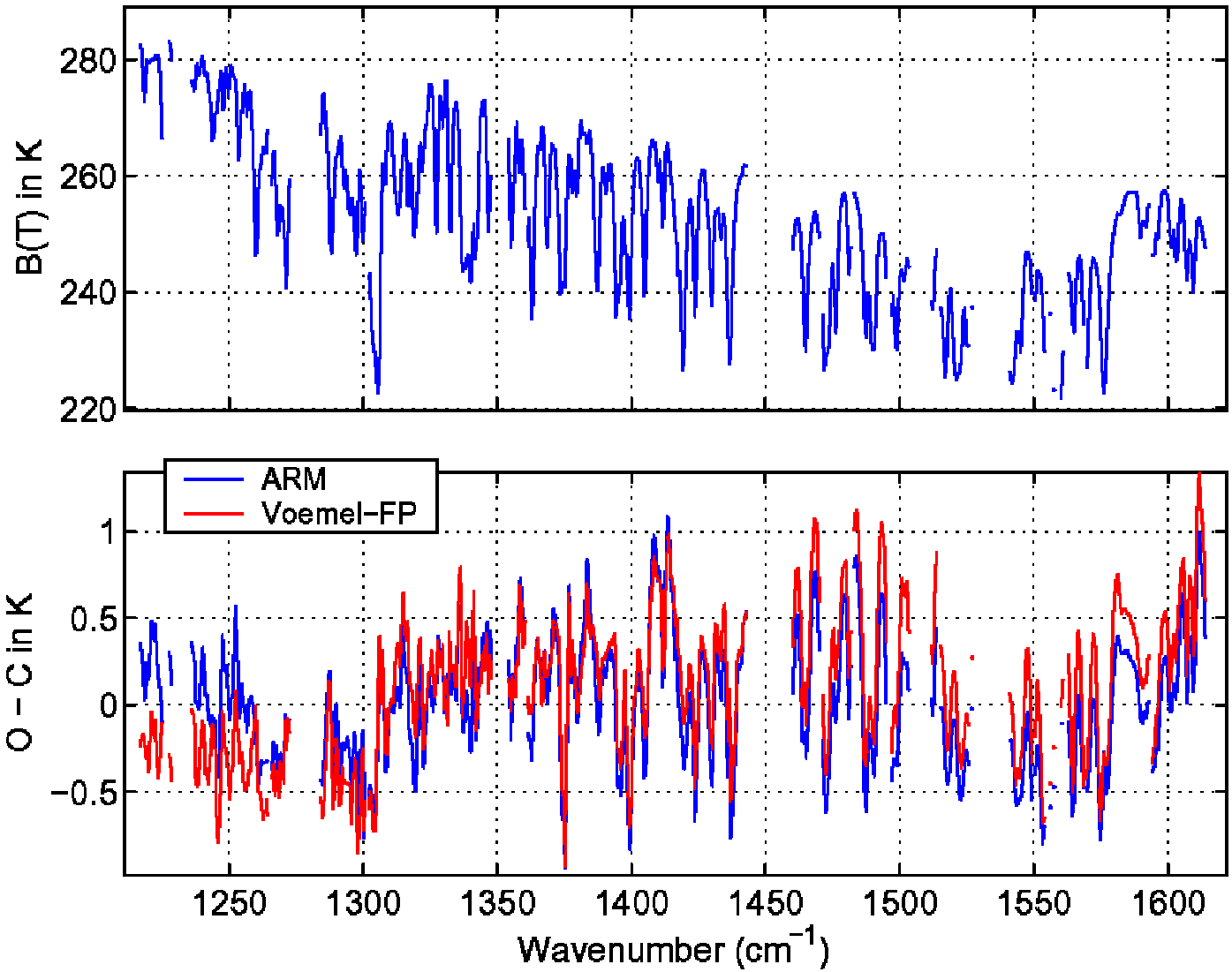
- Trial fixed gas optical depth multipliers were generated using the ARM-TWP AIRS validation data.
- Longwave multipliers are reasonable
- 2400 cm^{-1} multipliers seem a little large

Bias vs Wind Speed and Total Column Water

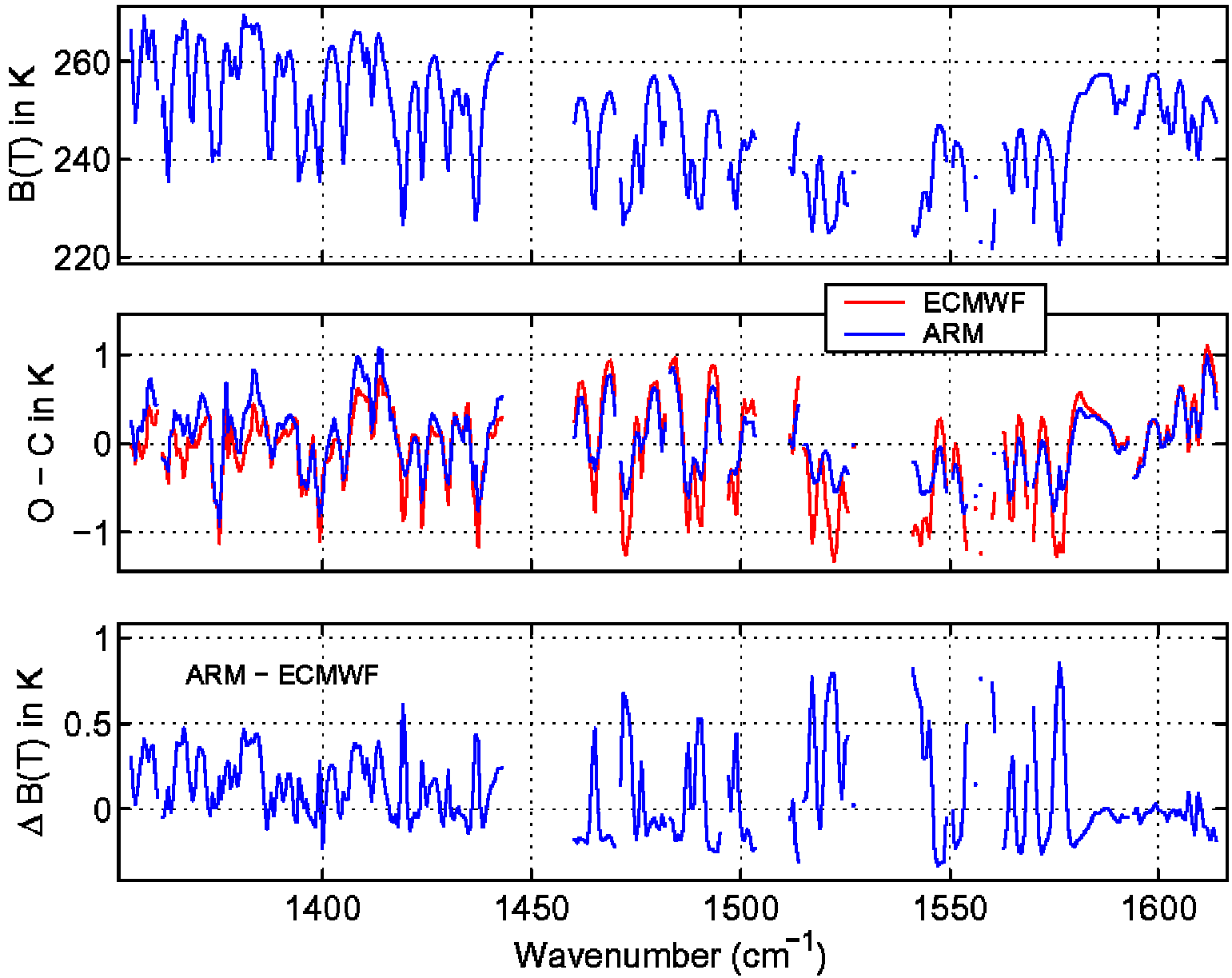


Upper Trop Water RTA Validation Remains

AWEX may help, already have good agreement between ARM-SGP, Voemel, and ECMWF (between lines)



ARM-SGP vs ECMWF Global Biases in H_2O-sounding Channels



Concluding Thoughts

- AIRS validation datasets of high quality, very useful for forward model improvements
- Many RTA errors have been fixed by modifying the transmittances, which is more physical
- Water continuum much improved, significant for SST in shortwave, and for 4.3 micron CO_2 sounding channels
- Revisit AIRS SRFs one more time but they look good
- AIRS-RTA available from our ftp site (asl.umbc.edu), new version in Jan. 2004
- kCARTA, our LBL, also available from our ftp site
- Future work: effect of aerosols on AIRS
  - See our poster on dust observations with AIRS
  - We have developed an AIRS-RTA with scattering for this work and for retrieving cirrus cloud properties

International TOVS Study Conference, 13th, TOVS-13, Sainte Adele, Quebec, Canada, 29 October-4 November 2003. Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2003.