

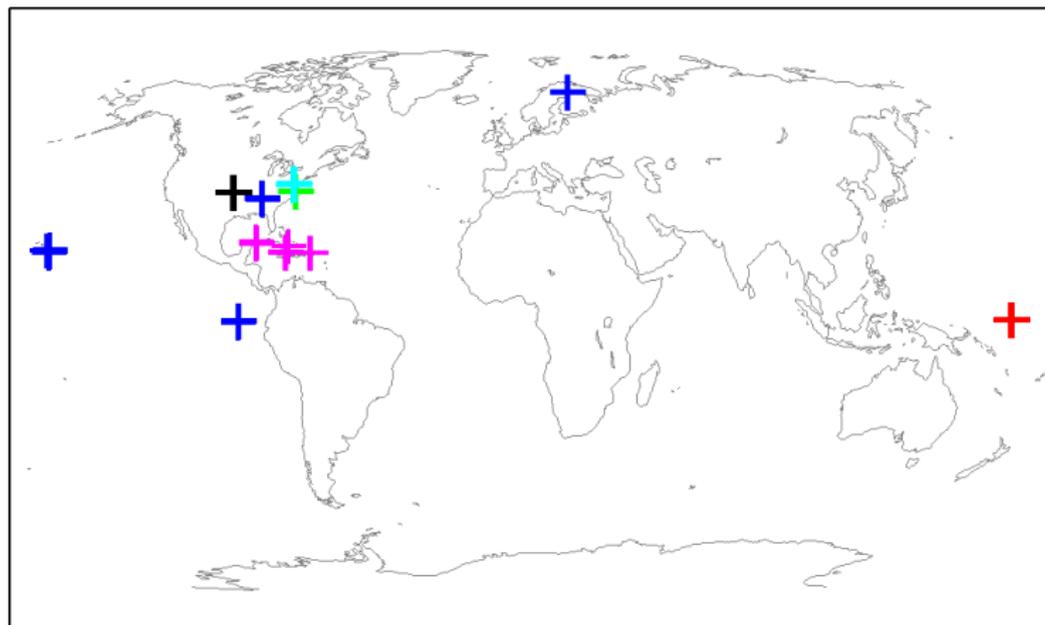
# RTA Validation

AIRS Science Team Meeting

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## Location of Validation Soundings



Map of the validation sites used in this work. Legend: black=ARM-SGP, red=ARM-TWP, blue=Vömel, magenta=Minnett, green=ABOVE, cyan=LIDAR. The Vömel sonde in northern Europe was not used in our analysis because of clouds.

# Data Summary

## All Sondes

Name	Technique	# of Coincident Sondes
ARM TWP Phase1	RS-90	154
ARM TWP Phase2	RS-90	178
ARM TWP Phase3	RS-90	163
ARM SGP Phase1	RS-90	125
ARM SGP Phase2	RS-90	171
ARM SGP Phase3	RS-90	160
Mcmillan/ABOVE	RS-90	195
Minnett	RS-90	<sup>a</sup> 146
Vömel	FP	29
Whiteman/LIDAR	SRL	23

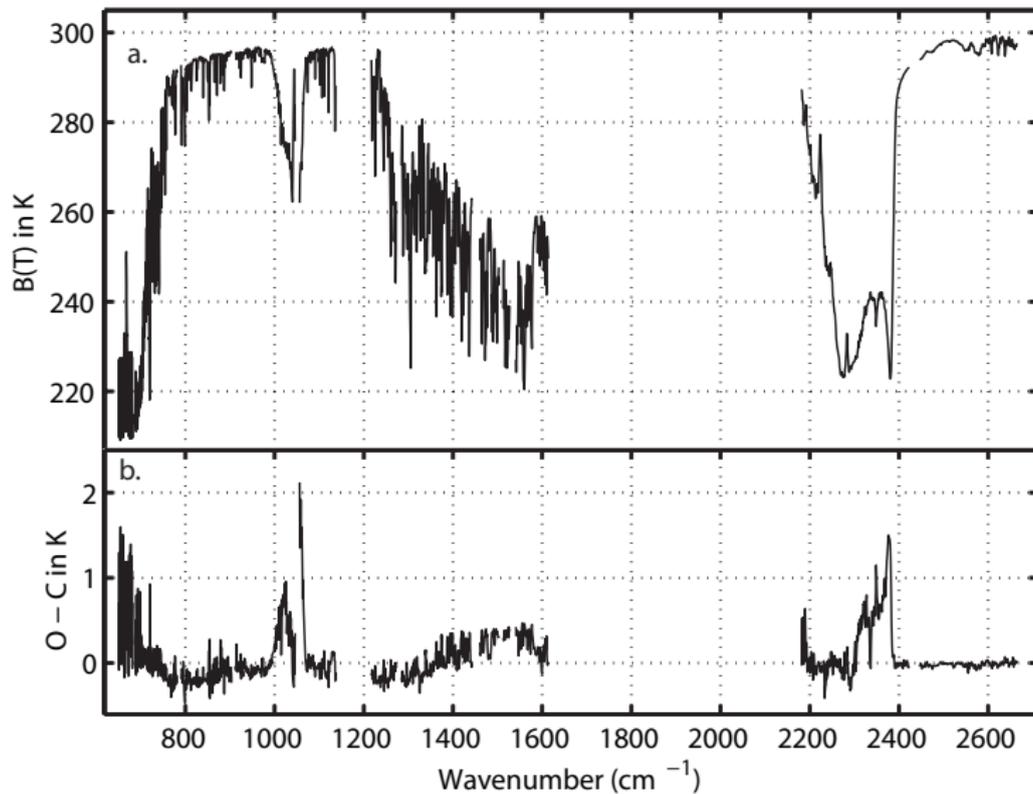
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<sup>a</sup>Includes RS-80 sondes not used here.

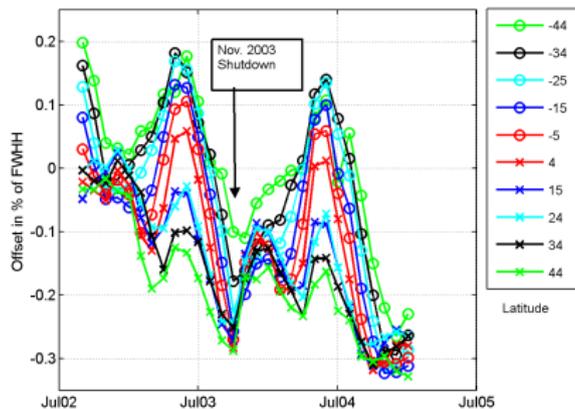
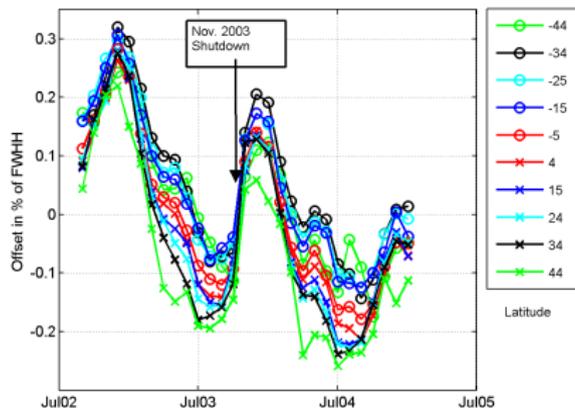
## Clear Ocean Cases

Name	% Clear	# Sonde/Lidar Profiles
ARM TWP	15	38
Mcmillan/ABOVE	7	7
Minnett	25	23

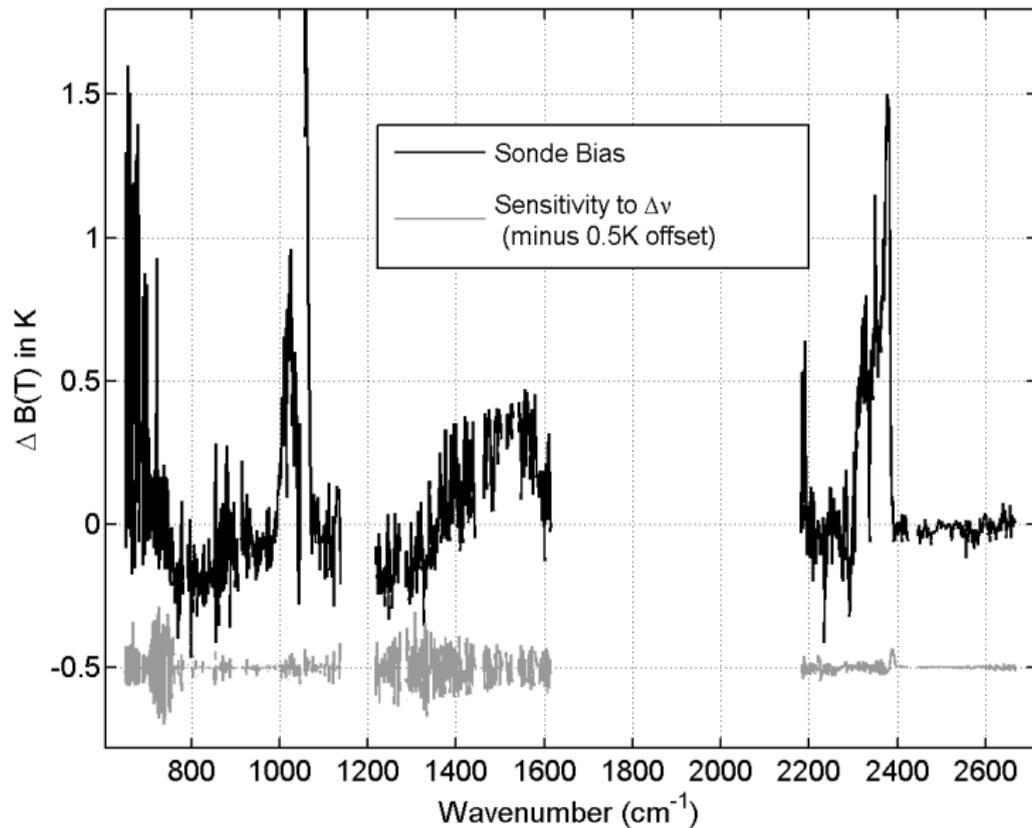
## Summary Graph: RS-90 Results over Ocean



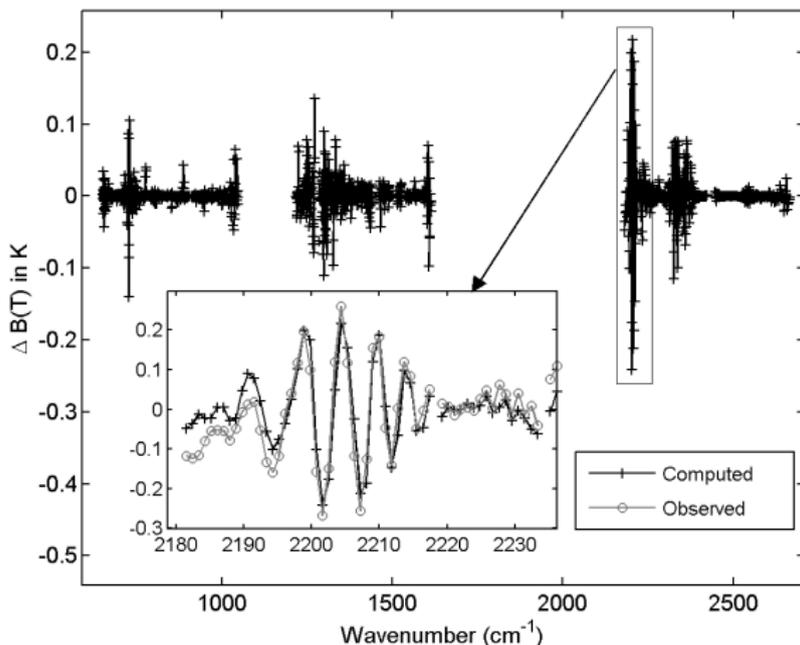
# AIRS Spectral Calibration: Night vs Day



## Radiometric Error for 0.6% of a FWHM of SRF

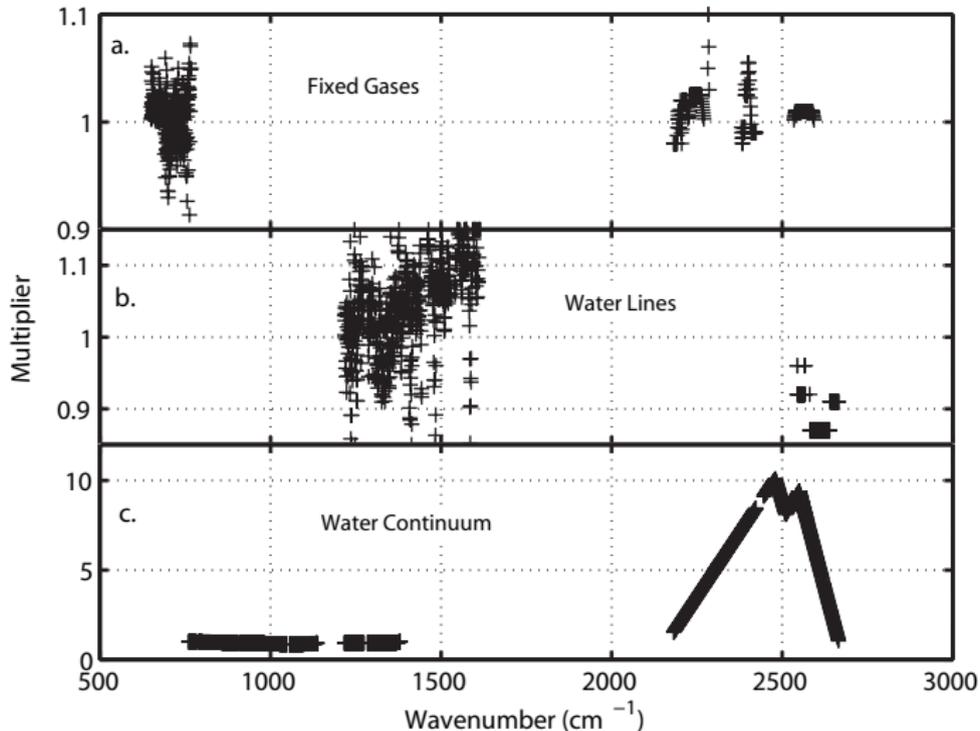


## RTA Treatment of Fringes



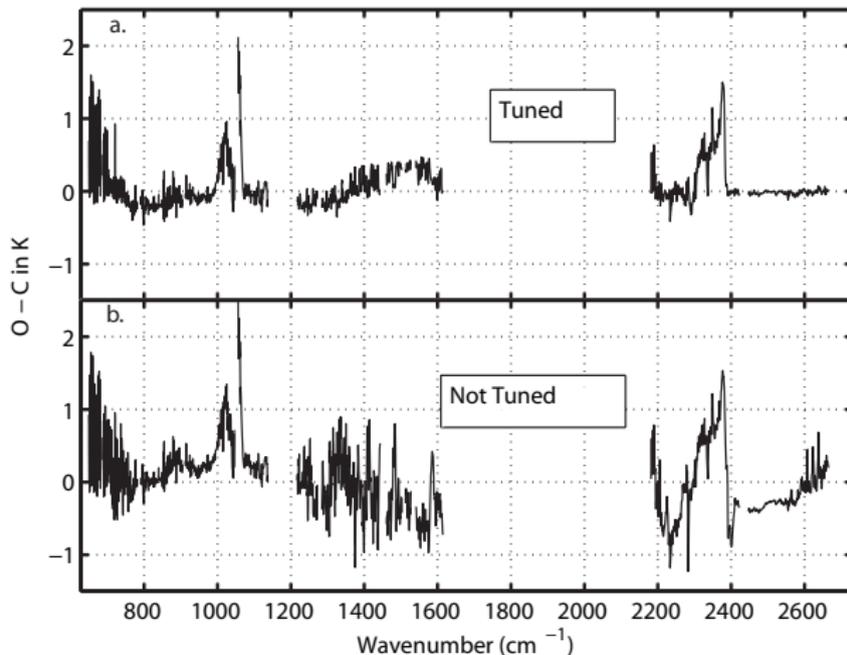
Computed change in brightness temperatures due to entrance filter temperature change after the Nov. 2003 AQUA shutdown. Inset shows observed change in brightness temperatures before versus after the shutdown, showing good agreement with the computed change.

## RTA Empirical Tuning



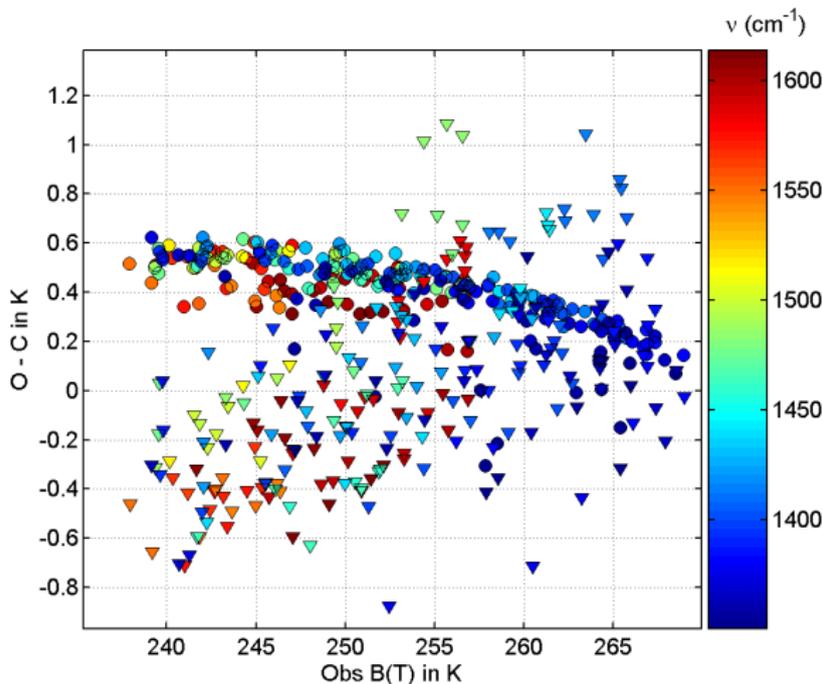
Multipliers to the channel-averaged absorption coefficients in the Ver. 4 RTA. Different multipliers were derived for the RTA fixed-gases, water lines, and water continuum using the ARM-TWP Phase 1 observations.

## Effect of Tuning on RS-90 Biases



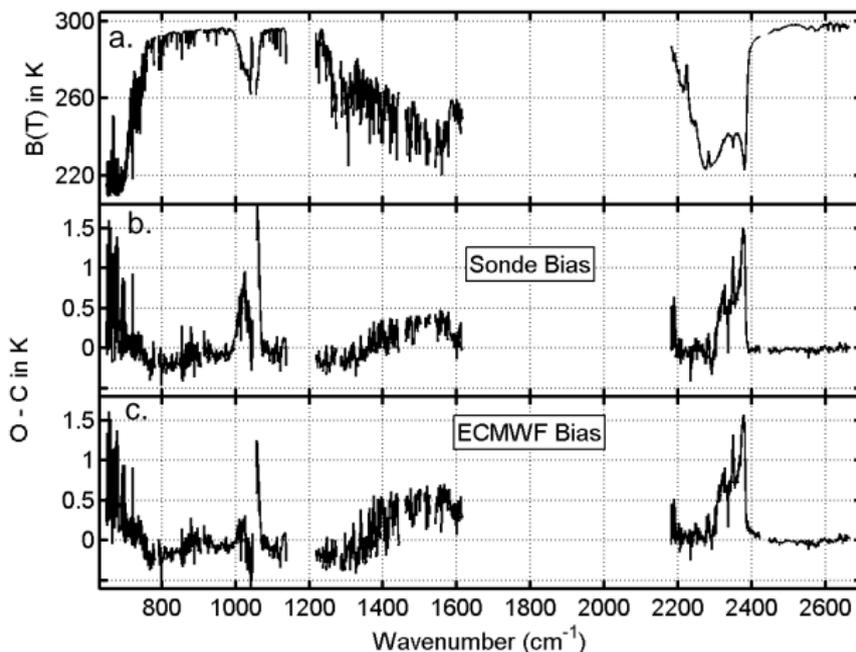
a. Biases relative to all clear-sky RS-90 sondes, using Ver. 4 RTA, which has been tuned using ARM-TWP Phase 1 observations. b. Biases relative to all RS-90 sondes, but with no empirical adjustments/tuning made. Note, little adjustment is made to channels below  $690\text{ cm}^{-1}$

## Tuning in the Water Band: Scatter Plot



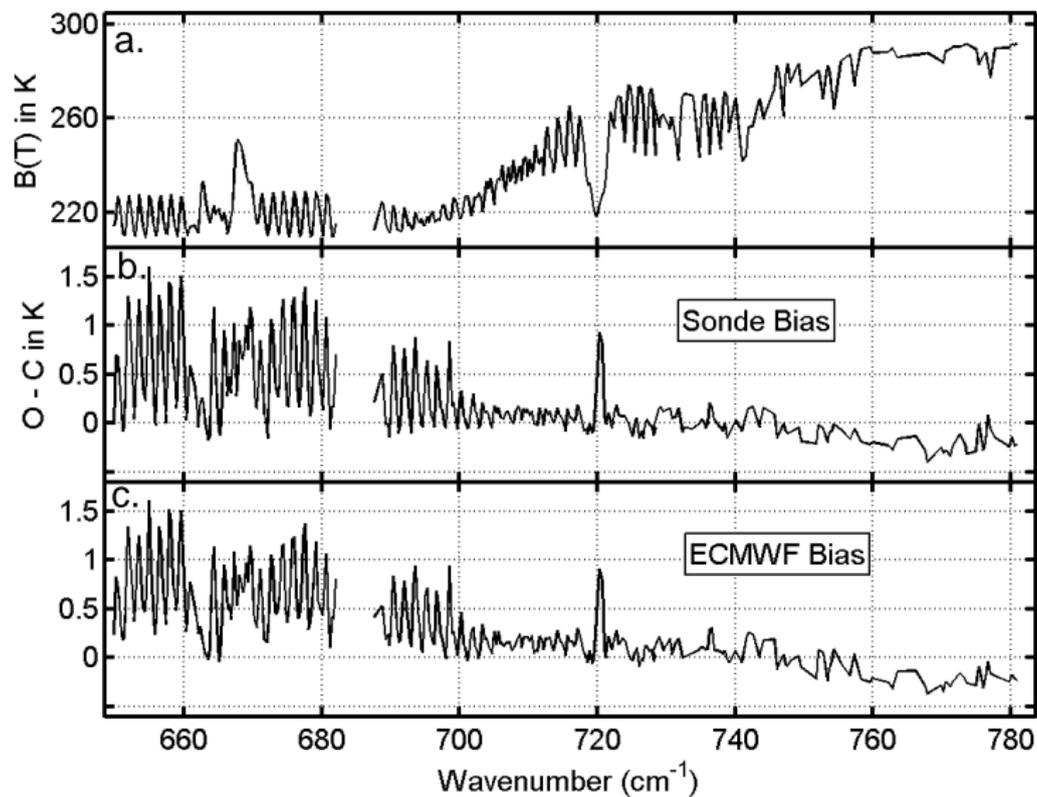
Scatter plot of ARM-SGP biases with and without ARM-TWP tuning. The circles are the Ver. 4 RTA biases, and the diamonds are biases without the tuning. The color codes the channel wavelength. The observed brightness temperatures are a proxy for altitude.

## RS-90 and ECMWF Biases

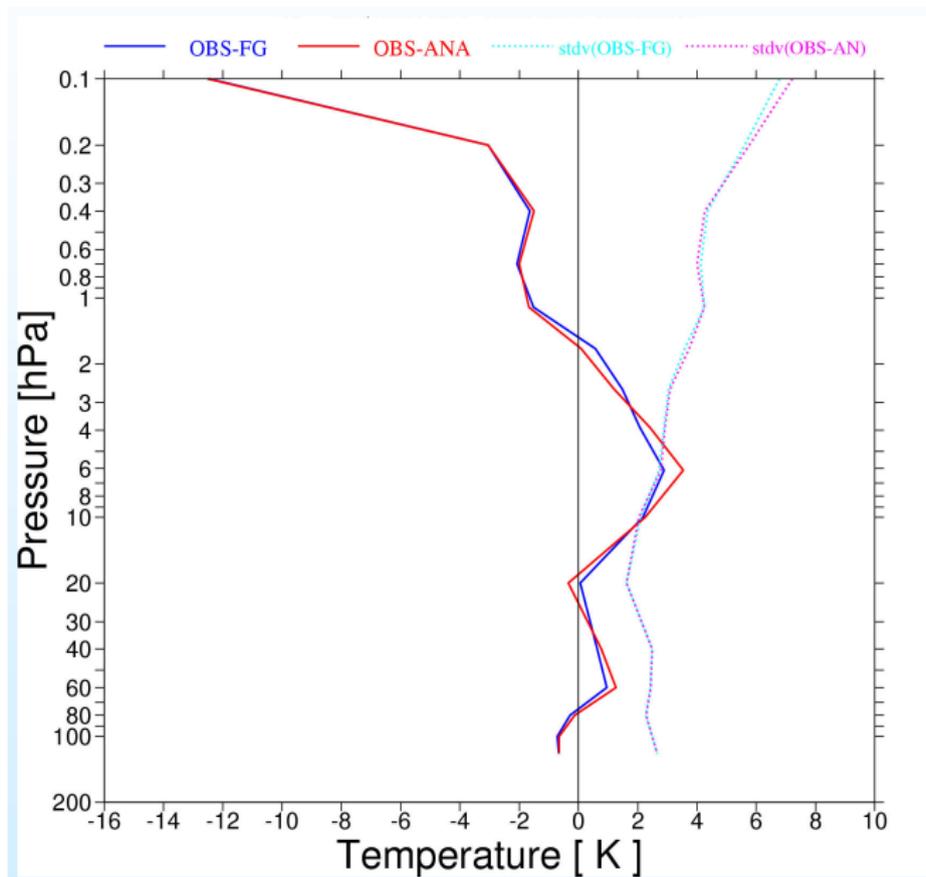


a. Mean brightness temperature spectrum for all RS-90 validation campaign sondes under clear conditions, night only. b. Mean nighttime sonde bias using the Ver. 4 RTA. c. Mean nighttime bias of the Ver. 4 RTA relative to ECMWF model fields, ocean only, between  $\pm 45$  degrees latitude. The ECMWF biases are averages over 24 months. Panels b. and c. used SST's derived from the shortwave AIRS channels.

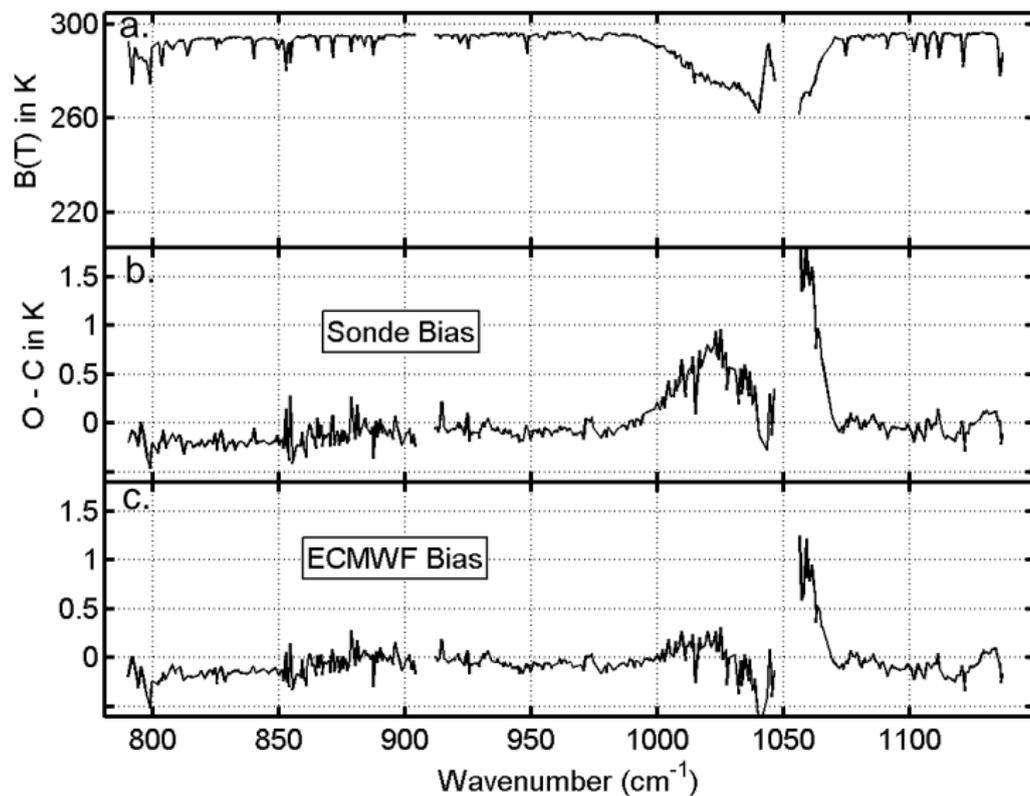
## RS-90 and ECMWF Biases: Zoom



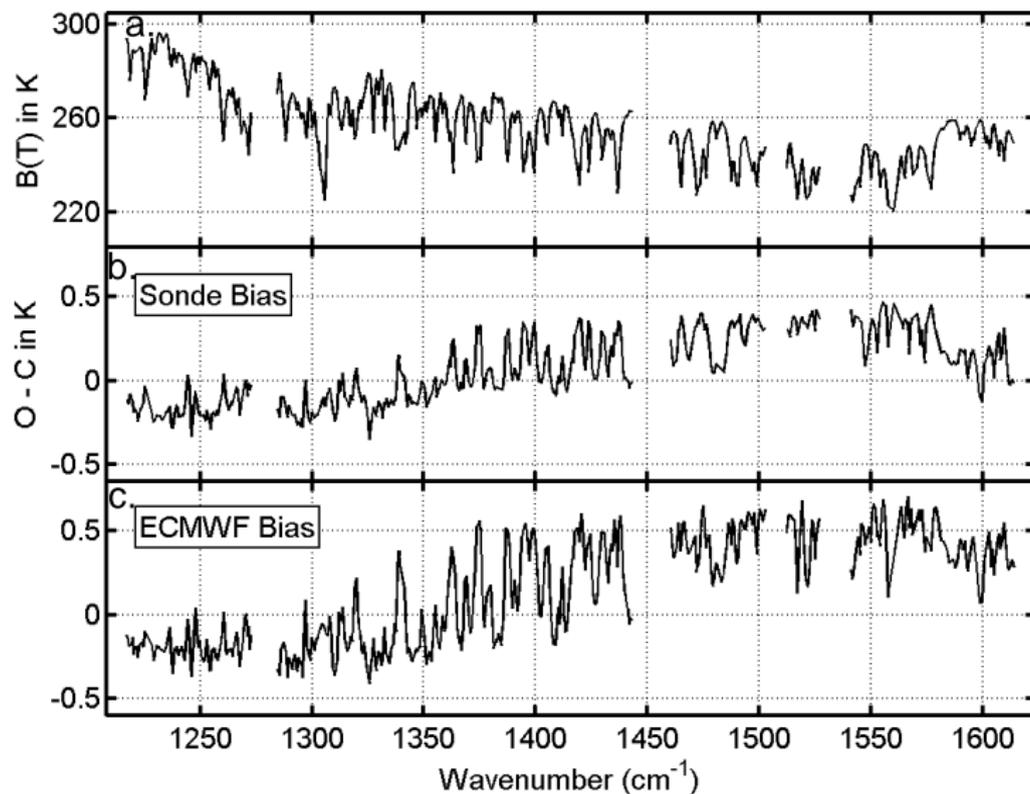
# ECMWF Cold Bias A/C MIPAS



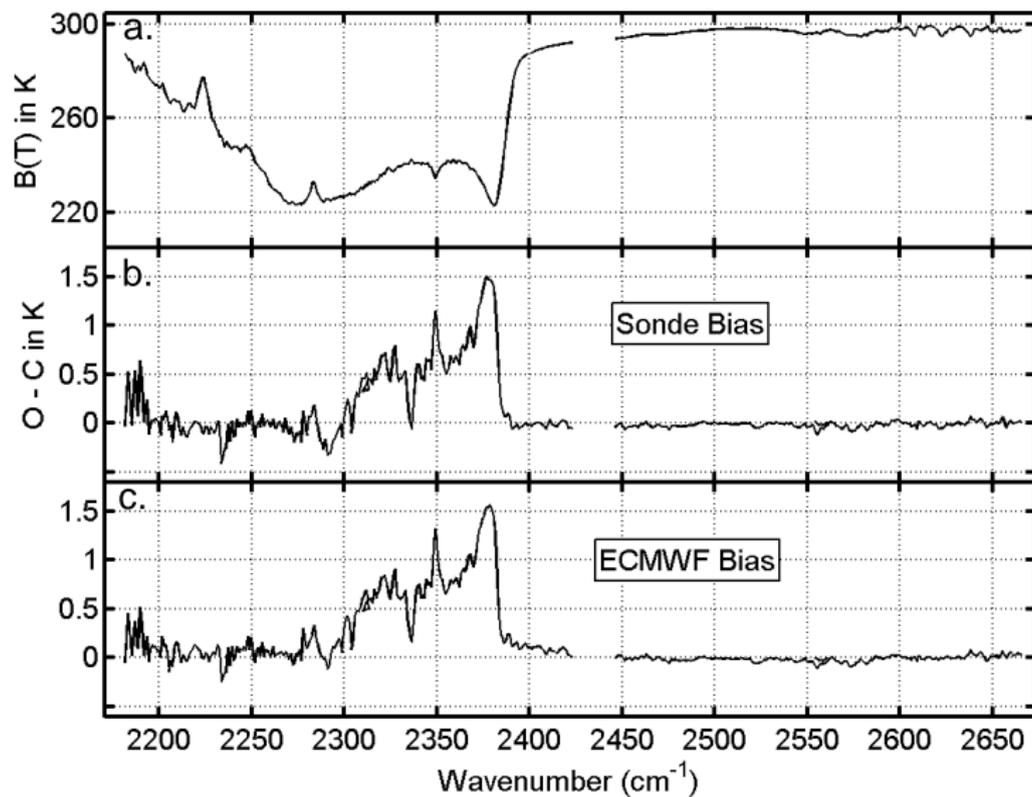
## RS-90 and ECMWF Biases: Zoom



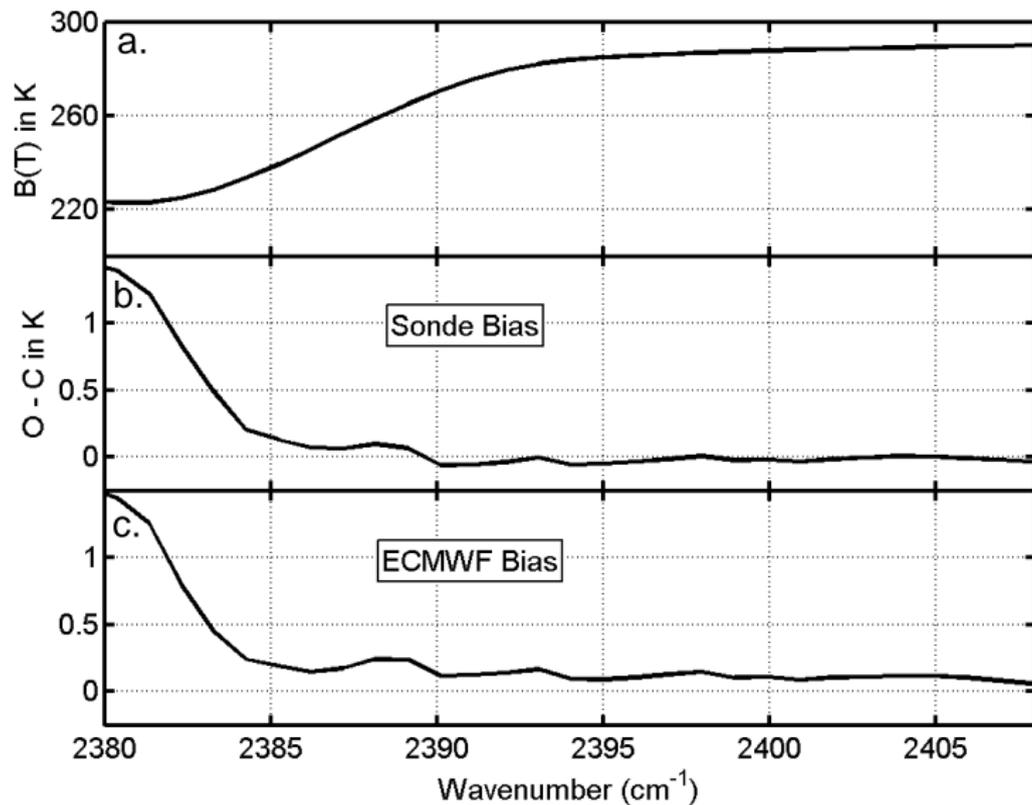
## RS-90 and ECMWF Biases: Zoom



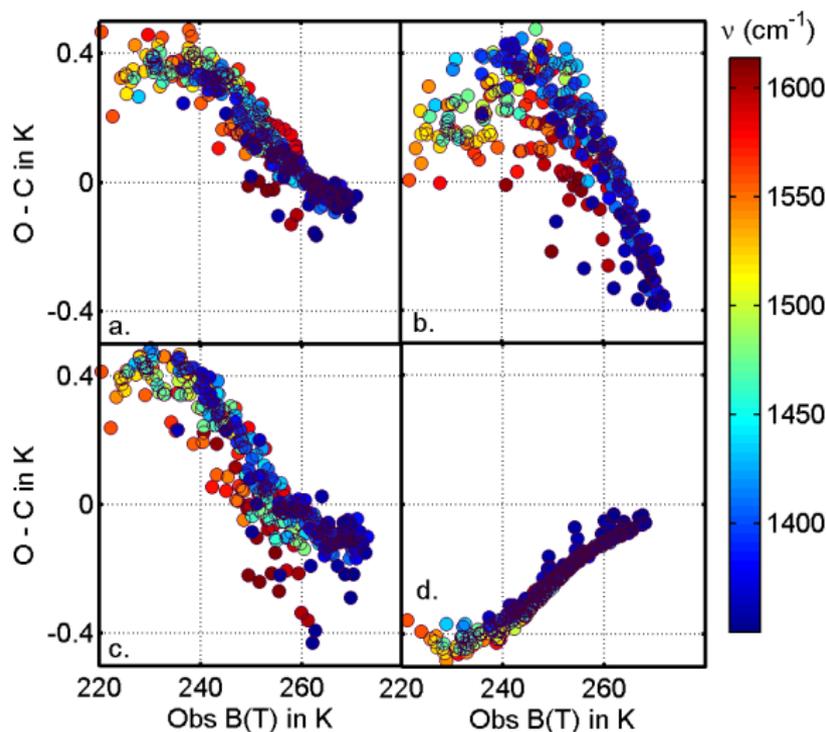
## RS-90 and ECMWF Biases: Zoom



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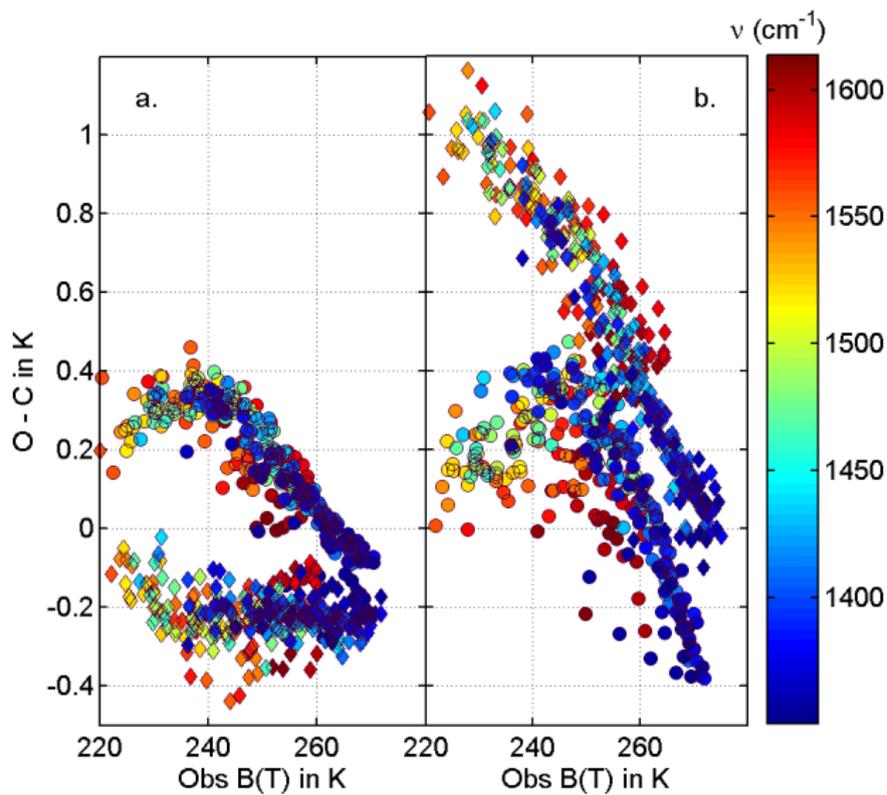


## Water Biases for RS-90, Vömel's FP, LIDAR



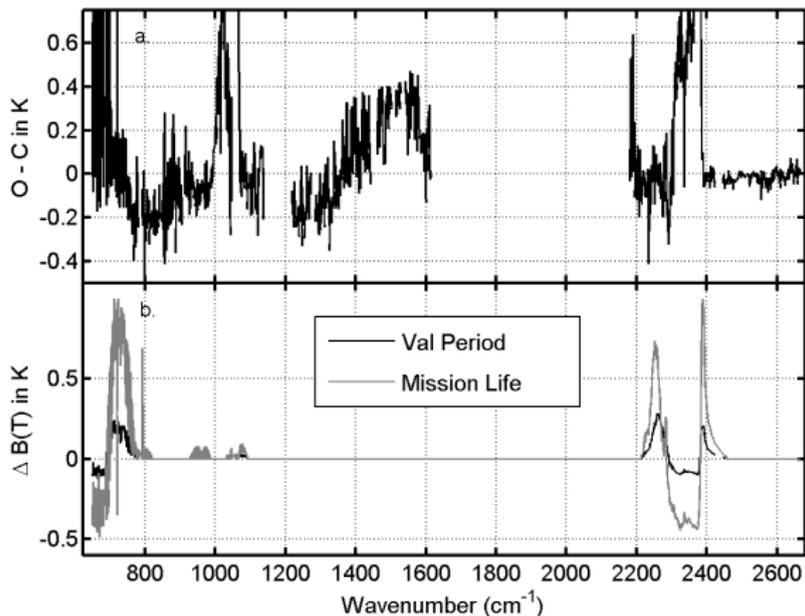
Nighttime biases for a. all RS-90 sondes, b. Vömel's (NOAA/CMDL) frost-point hygrometers, and c. Whiteman's (NASA/GSFC) scanning Raman lidar water profile measurements. d. Theory only calculation of AXEX-G correction; add to RS-90  $B(T)$ 's.

## Day vs Night: RS-90s, Vömel' FP



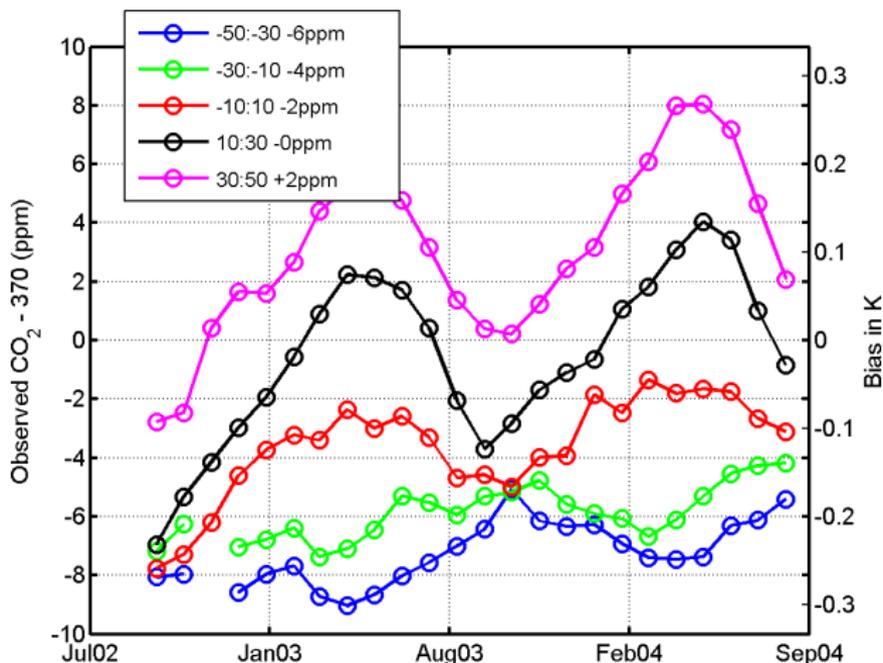
Circles: Nighttime, Diamonds: Daytime a. Mean of all RS-90 validation campaign biases. b. Mean of all of H. Vömel's (NOAA/CMDL) frost-point hygrometer measurements.

## Effect of Variable CO<sub>2</sub> on Validation



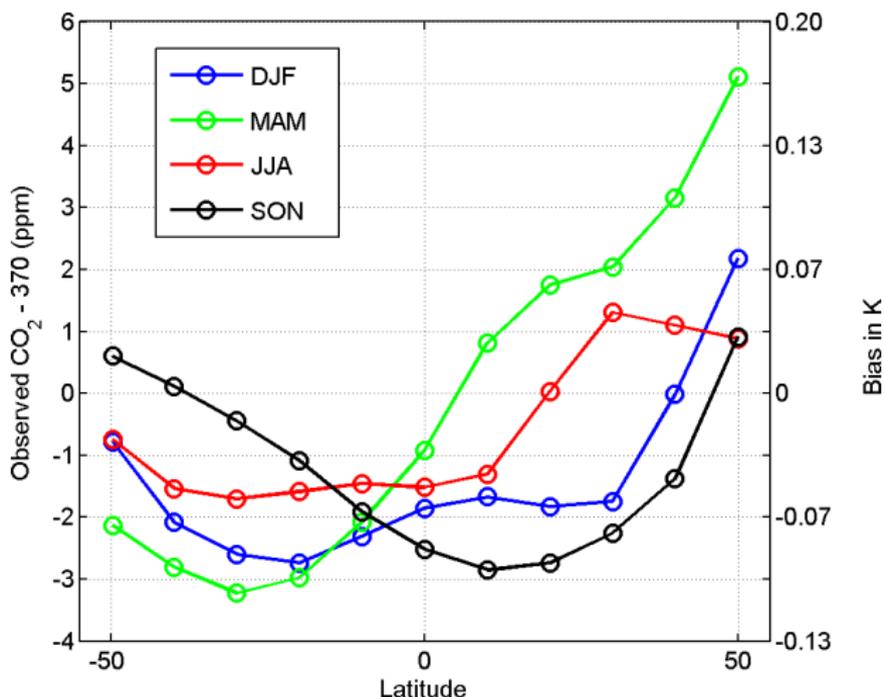
a. Nominal brightness temperature biases shown for Ver. 4 RTA b. Expected variation in AIRS brightness temperatures due to spatial and temporal variability in CO<sub>2</sub> using NOAA/CMDL CO<sub>2</sub> climatology. Black line: maximum variation expected during the validation time period of ~2-years; Gray line: estimate of the variability in brightness temperature over the mission lifetime of seven years.

## CO<sub>2</sub> Biases vs Time: 791.75 cm<sup>-1</sup>



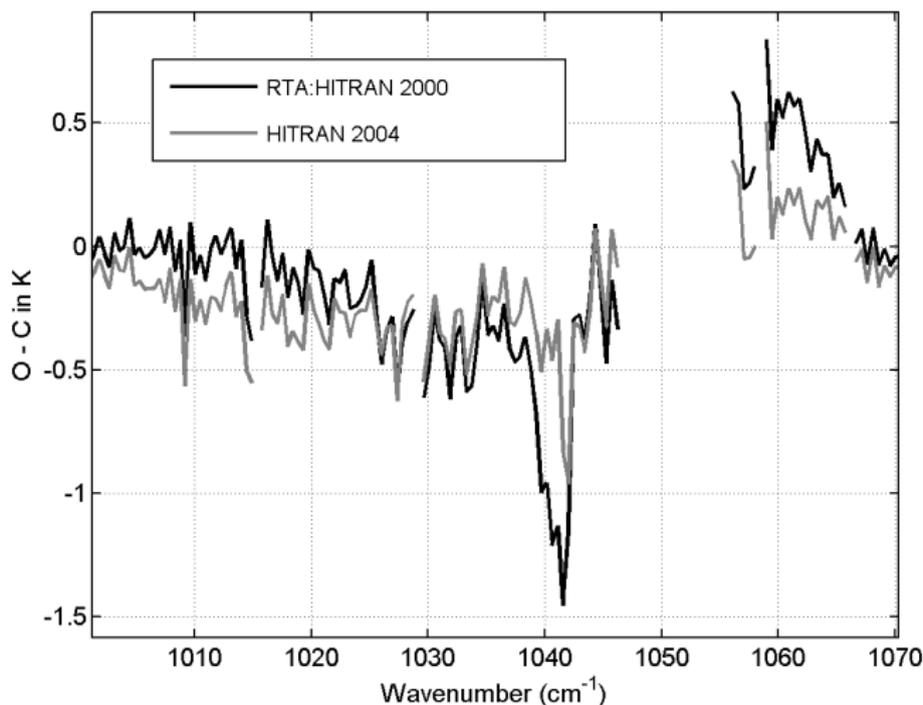
Zonal mean variability in the biases of the 791.75 cm<sup>-1</sup> CO<sub>2</sub> channel with respect to radiances computed from ECWMF model fields. The right-hand y-axis gives the scale in brightness temperature which is translated to relative units of CO<sub>2</sub> in ppm on the left-hand y-axis.

## CO<sub>2</sub> Biases vs Latitude: 791.75 cm<sup>-1</sup>



Variation in the 791.75 cm<sup>-1</sup> channel biases with latitude, relative to ECMWF computed radiances, for four sets of 3-month averages. The right-side y-axis is in brightness temperature units and the left-hand side y-axis is in relative units of CO<sub>2</sub> in ppm.

## Ozone Validation



Bias between AIRS and ECMWF computed brightness temperatures, averaged over a 24-month period from  $\pm 45$  degrees latitude, in the spectral region of strong O<sub>3</sub> features. Black line: bias for the Ver. 4 RTA; Gray line: for an RTA using the HITRAN 2004 O<sub>3</sub> line parameters rather than the HITRAN 2000 database.

# Conclusions

- ▶ Un-tuned biases (pre-Version 4)
  - ▶ Mid- to lower-trop CO<sub>2</sub> channels:  $\pm 0.3\text{K}$ ; CO<sub>2</sub>? Correlated with freq. cal. estimates?
  - ▶ H<sub>2</sub>O: 0 to  $\pm 0.8\text{K}$ ; spectroscopy?
  - ▶ N<sub>2</sub>O/CO<sub>2</sub> near 2250 cm<sup>-1</sup>: 0.8K; spectroscopy? N<sub>2</sub>O concentration?
  - ▶ Shortwave window: 0.3K; H<sub>2</sub>O continuum
  - ▶ Shortwave CO<sub>2</sub> near 2400 cm<sup>-1</sup>: 0.7K; spectroscopy
- ▶ Version 4 biases relative to ECMWF/RS-90's
  - ▶ Mid- to lower-trop CO<sub>2</sub> channels:  $\pm 0.1\text{K}$
  - ▶ H<sub>2</sub>O: -0.2K to 0.4K; scatter reduced, spectroscopy?
  - ▶ N<sub>2</sub>O/CO<sub>2</sub> near 2250 cm<sup>-1</sup>:  $\sim 0\text{K}$ ; spectroscopy? BUT, varies with latitude.
  - ▶ Shortwave window:  $\sim 0\text{K}$  relative, any offsets left?
  - ▶ Shortwave CO<sub>2</sub> near 2400 cm<sup>-1</sup>: 0.1K
  - ▶ O<sub>3</sub>: Needs more attention
- ▶ Differentiate static vs dynamic biases
  - ▶ Spectroscopy; static
  - ▶ Radiometry; static?
  - ▶ SRF shape and  $\nu$ 's: known variations including fringes; FIX, but not in RTA.
  - ▶ Val data itself; Day/night water sonde variability
  - ▶ Variable CO<sub>2</sub>; 0.2K during validation, 0.8K life of mission
  - ▶ Variable N<sub>2</sub>O, HNO<sub>3</sub>, SO<sub>2</sub>, CH<sub>4</sub>, CO
- ▶ Re-analyze validation data with better CO<sub>2</sub> amount estimates, corrected frequency calibration, better fringe model.