CLARREO: Development Guided by Existing Hyperspectral Satellite Knowledge Base

L. Larrabee Strow, Sergio DeSouza Machado, Scott Hannon, and Paul Schou

Physics Department and
Joint Center for Earth Systems Technology
University of Maryland Baltimore County (UMBC)

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Overview

The AIRS Radiance Record

- Radiometric stability estimates
- Radiance liens
- AIRS L1c product
- Combining AIRS with IASI/CrIS (for now?)

Radiance Time Series

- Approaches to improve information content (binning)
- Examples of 8-year AIRS time series

The Competition: Reanalysis

- How stable are reanalysis products?
- Can we use reanalysis to improve CLARREO?
- New science done with AIRS, etc. should help CLARREO

AIRS

The AIRS Radiance Record

Stability:	Versus SST 2.1 ± 2.2 mK/year (longwave, 2σ) 6.5 ± 2.2 mK/year (extreme shortwave, 2σ)
Accuracy:	0.1-0.2K?? 1σ??
Precision:	L1b: 0.6K (vs time, vs xtrack); L1c: *much* less
Duration:	Nearly 9 years, 15 years possible

Datasets Used Here

Clear Scenes:	About 1% yield, best over ocean
Fixed Sites:	Scenes w/in 30 nautical miles of 20 fixed sites
Random:	Random scene, about 1 every 6 minutes
DCCs:	Deep convective clouds observations

Approach

Remove offset, seasonal and shorter harmonics

Clear Scene and Fixed Site data are fit to:

$$BT = a + R * t + \sum_{n=1}^{4} c_n sin(2n\pi t/T + \phi_n)$$

to obtain the radiance rate R. T = 1 year.

Details:

Clear Scenes: Use zonal bins, daily average. Here show 0-25N ocean.

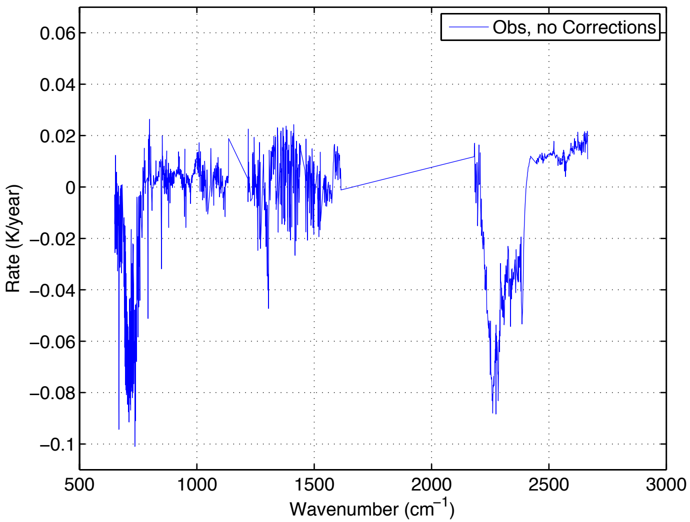
Fixed Sites: Fit individual spectra

Compare to models: ECMWF, ERA-Interim Reanalysis, matched on a per-FOV basis

RTA: SARTA with fast scattering (AIRS, IASI, CrIS)

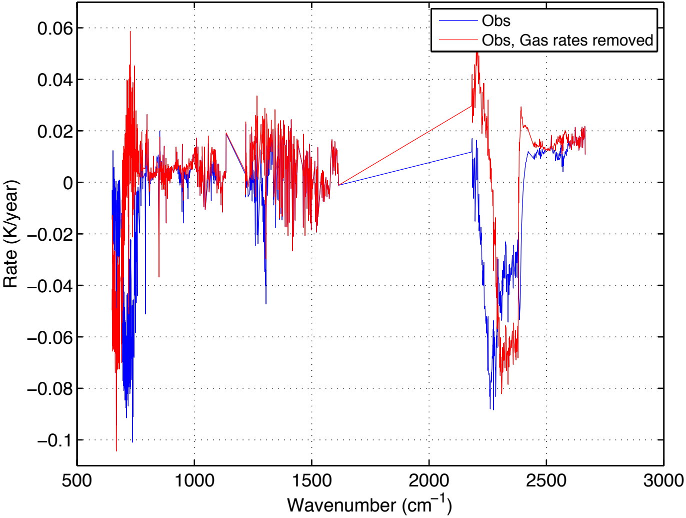
Clear Scene Zonal AIRS Rates

Observed raw BT rate.



Clear Scene Zonal AIRS Rates

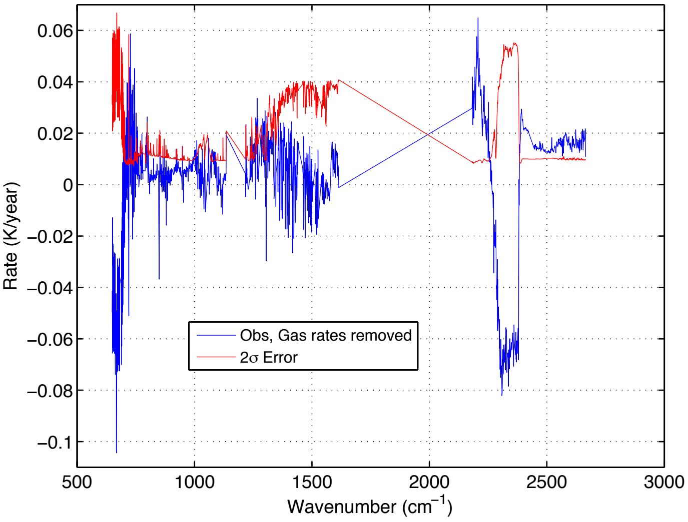
Correct obs rates for minor gas rates.



Clear Scene Zonal AIRS Rates

Now plot 2σ uncertainty. Corrected for serial correlation.

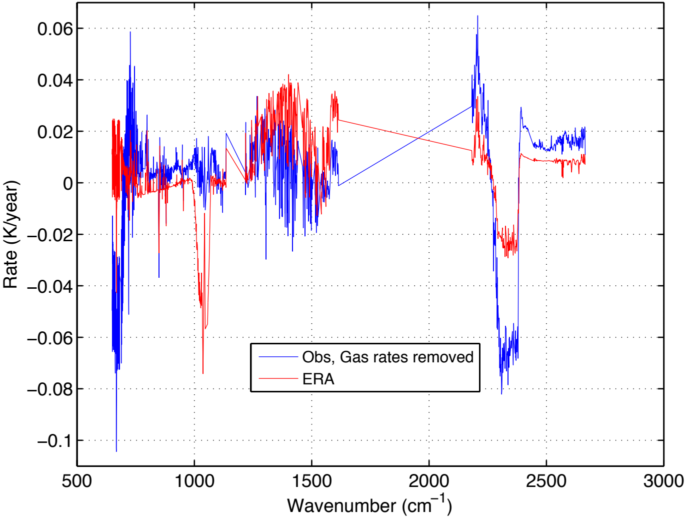
Errors are low because spectra are clear, tropical.



Clear Scene Zonal AIRS Rates

Compare Obs to ERA Rate (using RTA)

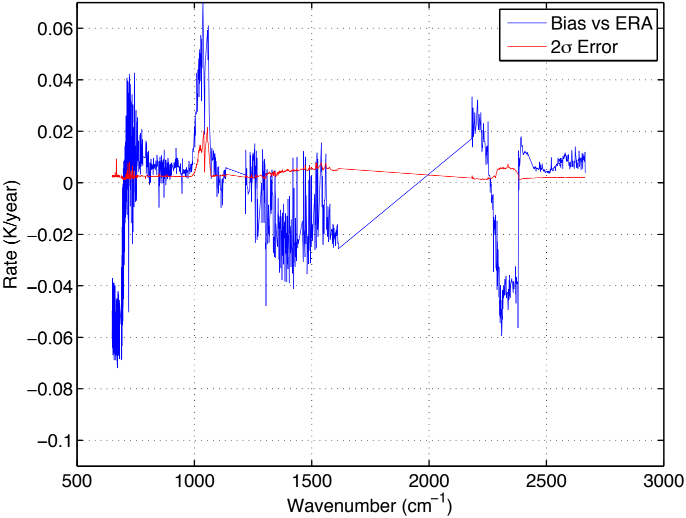
ERA Interim Rates are very good.



Clear Scene Zonal AIRS Rates

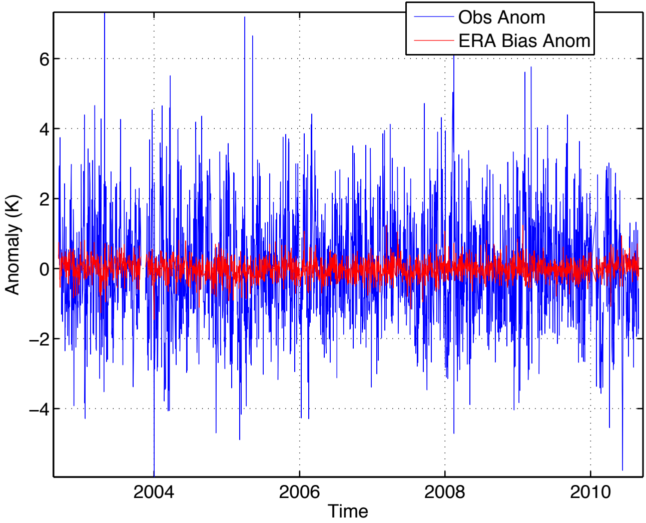
The bias rate (OBS-ERA)

Errors are very low, ERA and AIRS anomalies agree very well.



Strong H_2O Line Anomaly: 1564 cm^{-1}

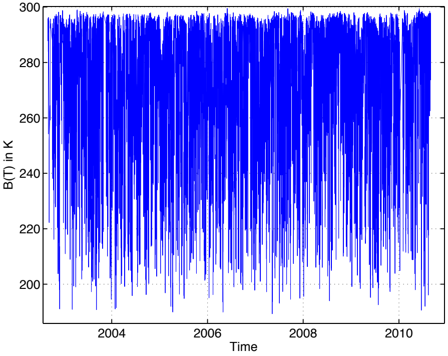
Bias statistics better because ERA is so good.

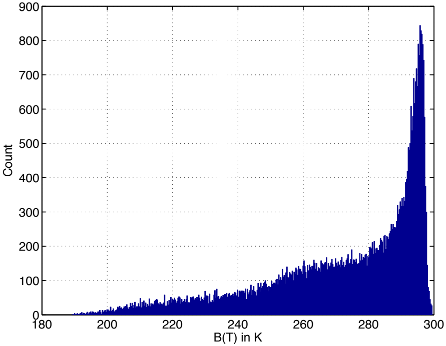


Site Radiance Time Series: Manus

Tropical Ocean Site, Now with clouds

Radiance (BT) time series for 1231 cm^{-1}. Very clear longwave channel.



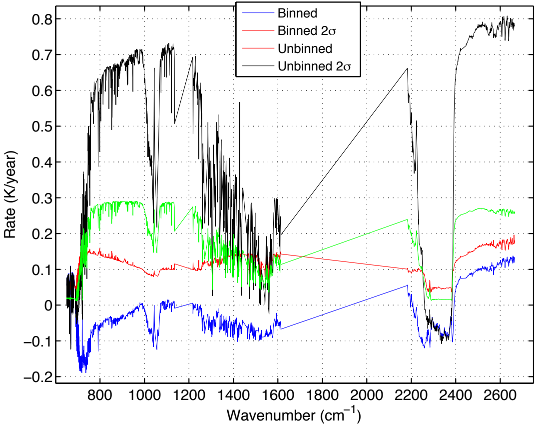


Site Radiance Time Series: Manus

Full BT Average versus Binned Average

Fitted timeseries for BT two ways.
(a) As is
(b) Binned data into 10K wide bins based on BT of 1231 cm^{-1} channel

This is essentially binning by cloudy type.



Reanalysis

Commonly used for climate process studies. Trends?

- Reanalysis better than 1Dvar retrievals.
- CLARREO spectral rates will be very complicated.
- Difficult to separate temperature and CO_2 trends
- Can reanalysis data improve CLARREO detection and identification of climate trends?

First, a quick look at AIRS observed radiances vs AIRS radiances simulated from ECMWF (combination 3-hour forecast and 6-hour analysis).

Examine (a) "Validation" of ECMWF computed radiances via CO_2 retrievals, (b) Simulated radiances for all-sky measurements, Test day: March 10, 2011

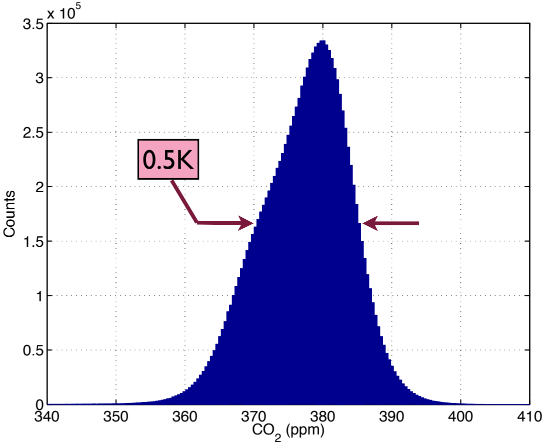
AIRS CO_2 Using ECMWF for Temperature

Essentially tests ECMWF for mean mid-trop tempeatures.

CO_2 is bias between observed and computed radiances (after fixing surface emission using nearby window.)

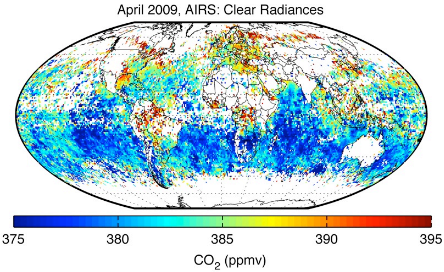
This global CO_2 PDF contains: (a) CO_2 variability, (b) AIRS noise (0.1K), (c) ECMWF variability

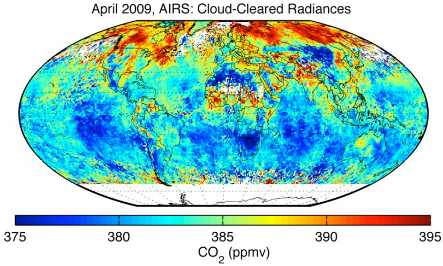
These data are for clear FOVS.

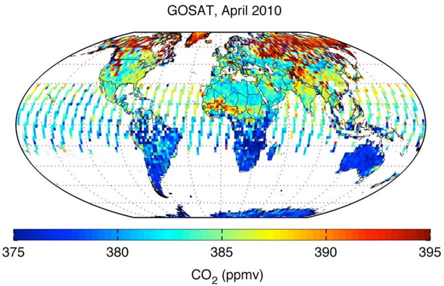


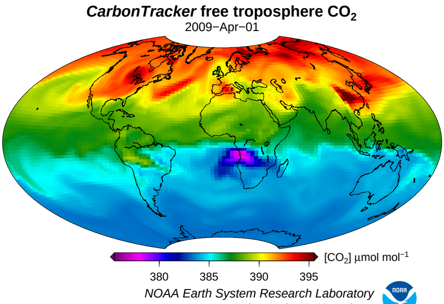
AIRS CO_2 vs GOAT, CarbonTracker

Validation against aircraft suggest 1-2 ppm accuracy, 0.05K

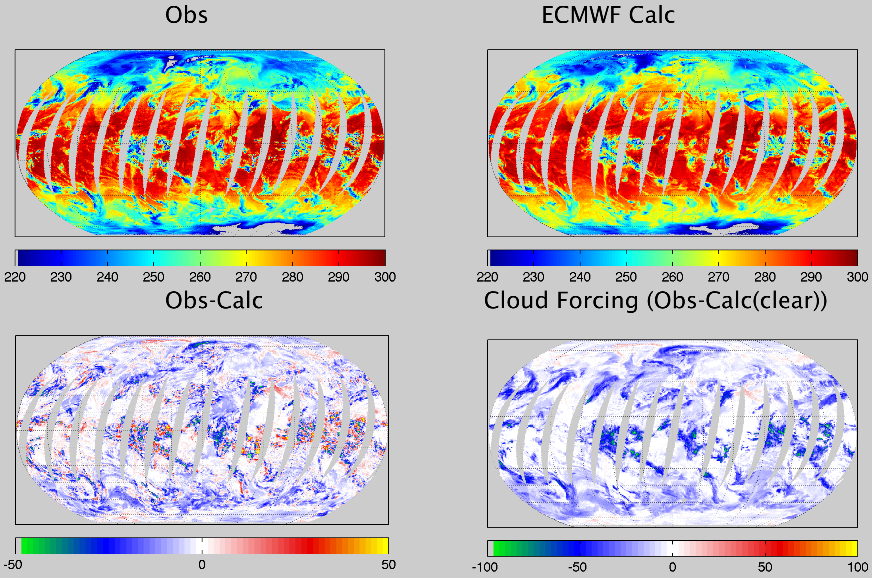






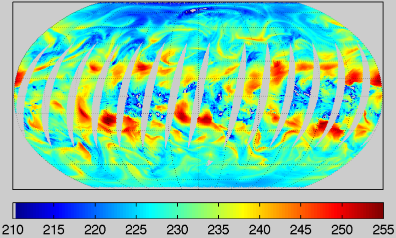


Single Day Comparisons: 1231 cm^{-1} Window

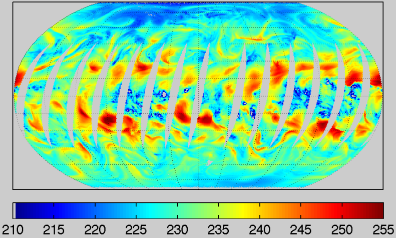


Single Day Comparisons: 1575 cm^{-1} H_2O

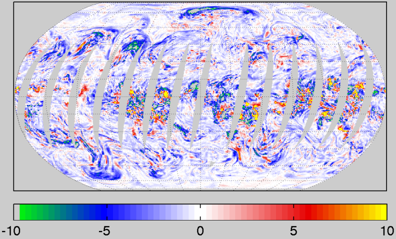
Obs



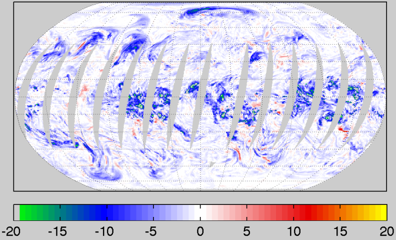
ECMWF Calc



Obs-Calc

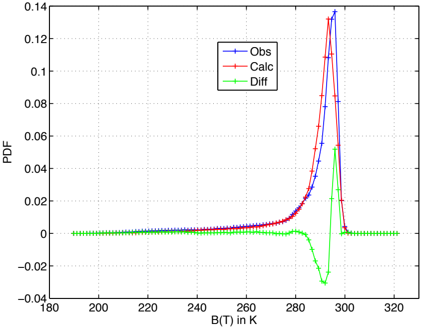


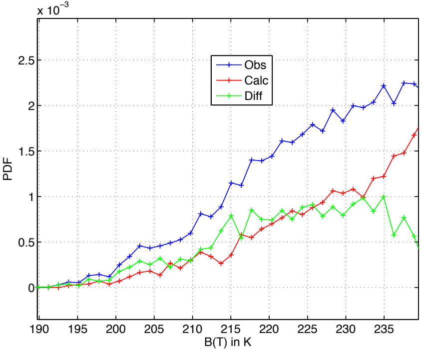
Cloud Forcing (Obs-Calc(clear))



Radiance PDFs (and their change with time)

Another Way to Examine Climate Models, esp clouds?





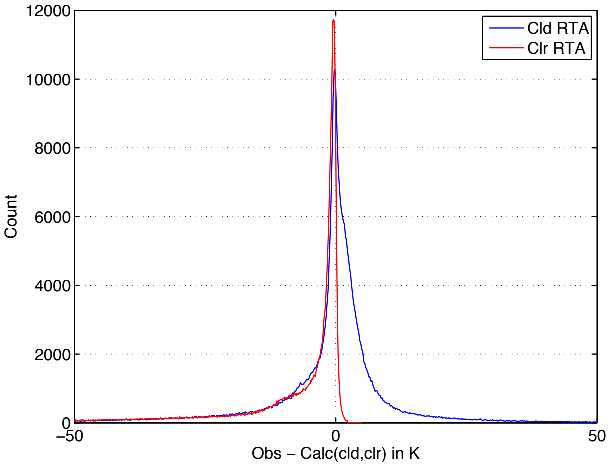
Radiance PDFs

Can Reanalysis be Used to get Spectral Cloud Forcing?

See Allan and Ringer, GRL 2003

CF = Obs - Calc(clear). For ocean Calc(clear) is *very* good (0.05K?).

Here is $\pm$30 deg ocean cloud forcing PDF (red) for March 10, 2011.



Conclusions

- Climate research using AIRS should help make the case for CLARREO
- AIRS is very stable, many liens removed in L1c product
- Better climate fingerprinting may be possible by binning observed time series before analysis
- Reanalysis products are very good, maybe they can be used to our advantage?
- Can similar work be done with a much simpler spectrometer? Maybe.