Progress Update on Optimal Estimation Retrievals of CO_2 from AIRS clear spectra

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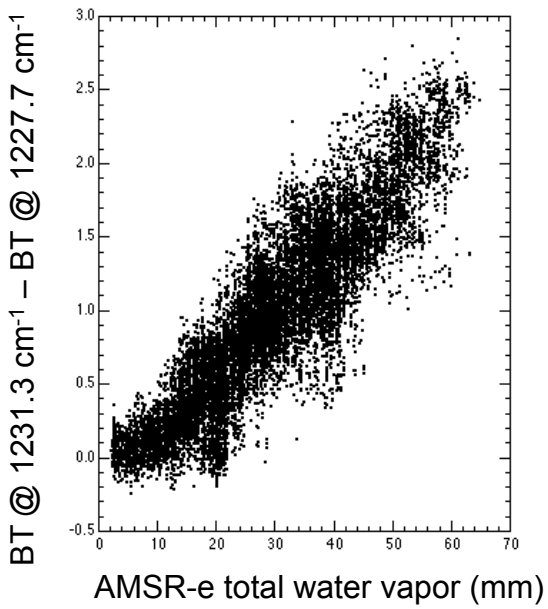
With thanks to Susan Kulawik, Sung-Yung Lee, John Worden, Kevin Bowman

Selection of clear footprints

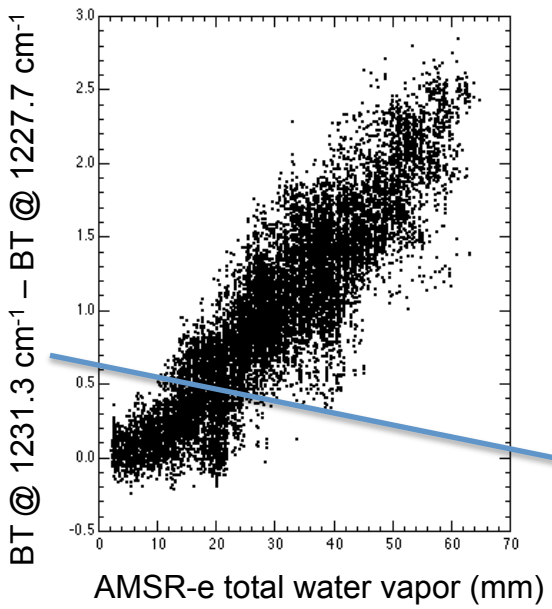
1. Look for zero cloud in AIRS L2 results (duh!)
2. Apply George Aumann's clear test
3. Apply Brian Kahn's test [Kahn et al., 2005] for cirrus clouds (limited to nighttime ocean observations)
4. (new?) Check ΔBT(857.0 – 2616.3 cm^{-1}) vs ΔBT(1231.3 – 1227.7 cm^{-1})

Selection of clear footprints (continued)



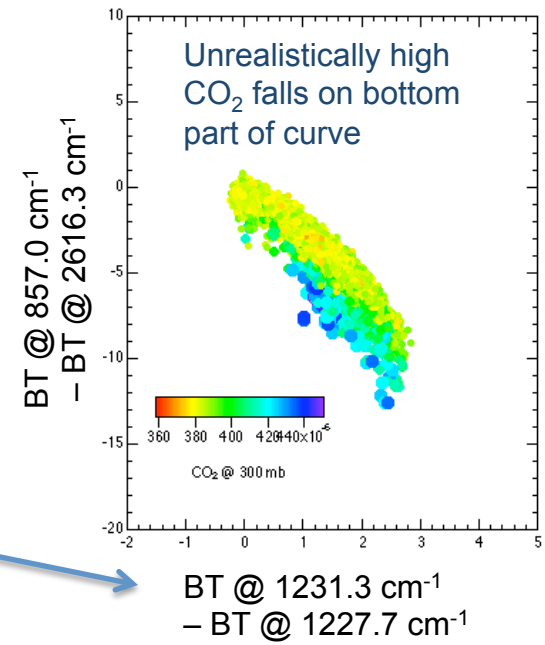
4/28/07 nighttime
ocean only
AIRS 15 km
“cloud-free”
footprints

Selection of clear footprints (continued)



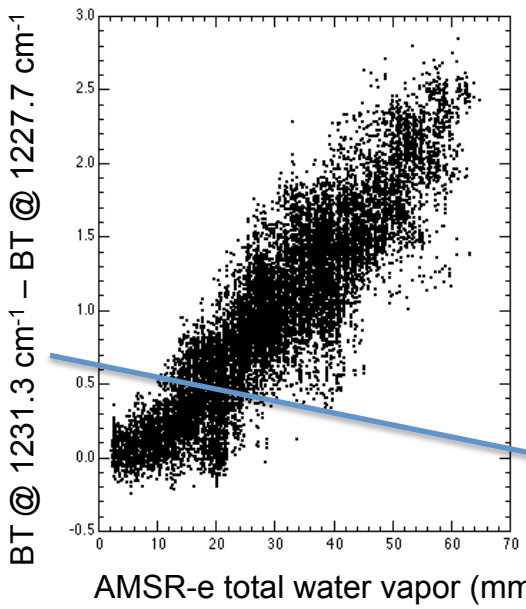
4/28/07 nighttime ocean only AIRS 15 km "cloud-free" footprints

ONLY CO_2 retrieved using OE from ECMWF prior

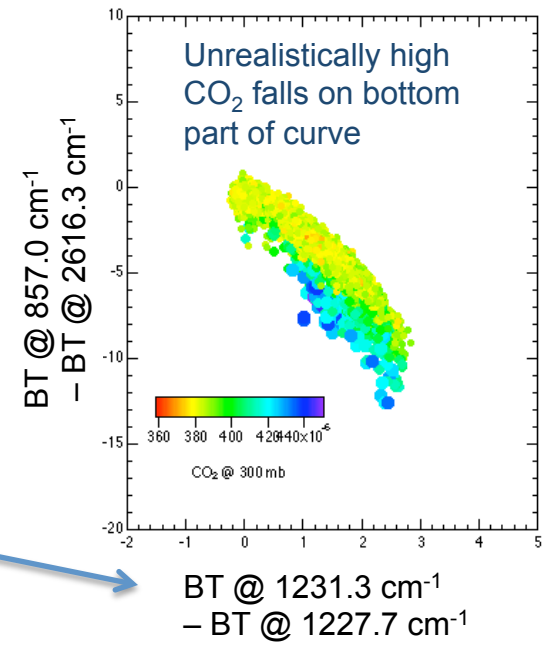


Selection of clear footprints (continued)

ONLY CO_2 retrieved using OE from ECMWF prior



4/28/07 nighttime ocean only AIRS 15 km "cloud-free" footprints



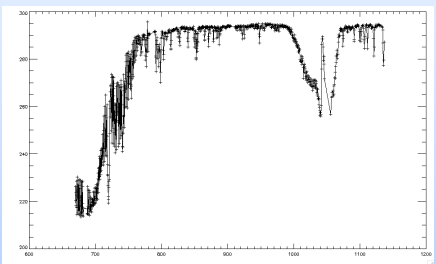
In clear scenes, $\Delta BT(857.0 - 2616.3\ cm^{-1})$ affected by H_2O, but not CO_2. Points below the curve in the upper right may indicate cloud contamination.

Reject scenes that where $|\Delta BT(857.0 - 2616.3\ cm^{-1})| > 0.5K$ than that predicted from a polynomial fit using $\Delta BT(1231.3 - 1227.7\ cm^{-1})$

Optimal Estimation Retrieval of CO_2 from AIRS clear spectra

SARTA
Fast forward model tuned for AIRS cloud-free radiances
Ref: Strow, L. L. et al., An overview of the AIRS radiative transfer model, *IEEE Trans. Geosci. Remote Sensing, 41,* 303-313, 2003.

AIRS radiances + noise vector



Optimal Estimation Code originally developed for TES, using "trust-region" Levenberg-Marquardt and Gauss-Newton minimization
Ref: Bowman, K. W. et al., Tropospheric Emission Spectrometer: Retrieval Method and Error Analysis, *IEEE Trans. Geosci. Remote Sensing, 44,* 1297-1307, 2006.

Results:
Profiles and averaging kernels for CO_2, T_{atm}, T_{sur}, H_2O and O_3

A priori profiles etc:

CO_2 with linear ramp with time
ECMWF for temperature profile, ozone, and water vapor
There is some "re-use" of spectral information as ECMWF assimilates some AIRS radiances.
AMSR-E for ocean skin temperature if available, otherwise ECMWF.
Fixed ocean emissivity.

Constraints:

A priori covariances are currently ad hoc:

- ~$(4\%)^2$ assumed on diagonal of CO_2 covariance matrix at sea-level decreasing to ~$(2.7\%)^2$ at 100 mb
- $(0.6\ K)^2$ assumed on diagonal of T_{atm} covariance
- $(50\%)^2$ assumed for tropospheric water
- $(25\%)^2$ assumed for tropospheric ozone, $(10\%)^2$ assumed for stratospheric O_3
- $(0.1K)^2$ assumed for ocean skin temperature

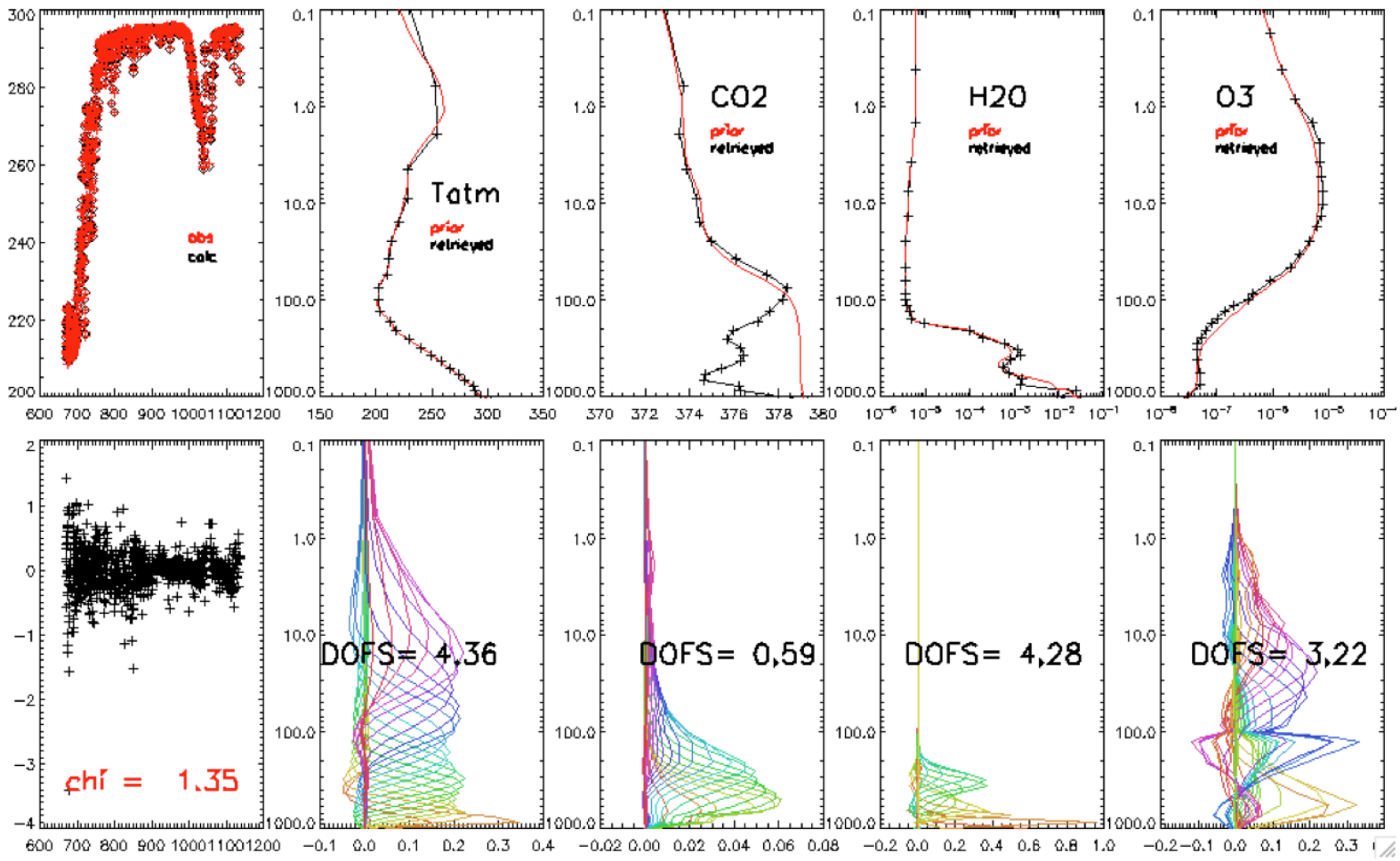
Off diagonal covariance for individual species calculated as:

$$\sigma_{i,j}^2 = \sigma_{i,i}^2 \exp\left(\frac{-|z_i - z_j|}{h}\right)$$

Where z_i is approximate altitude at level i, and h ~ 0.75 km for CO_2, H_2O and O_3, and ~4.5 km for T_{atm}.

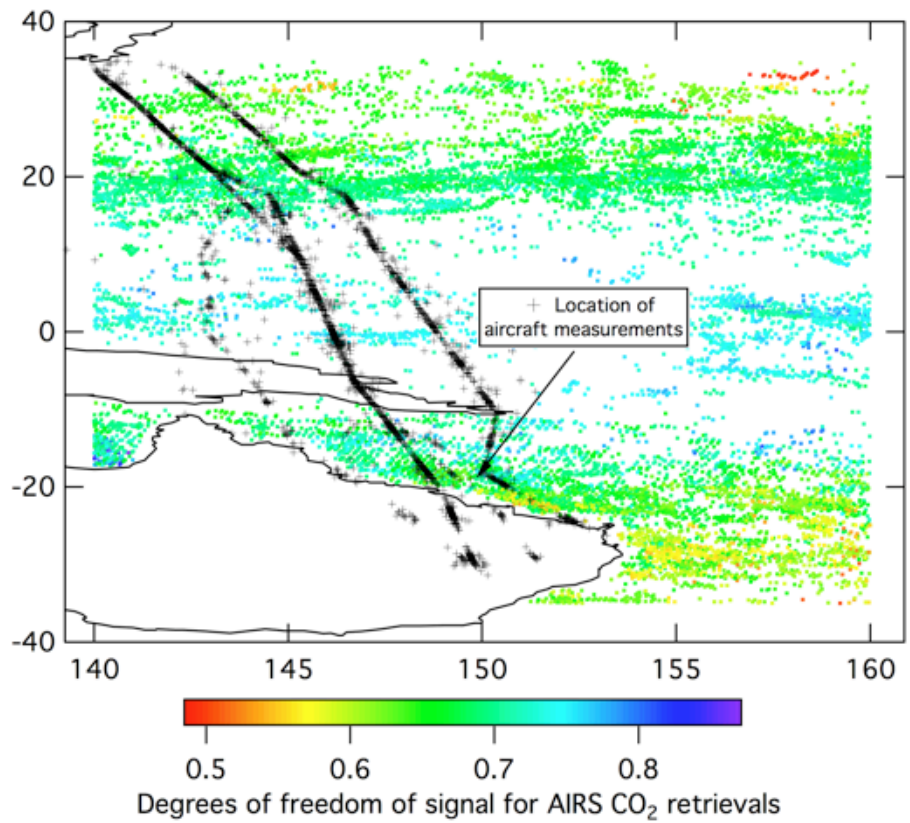
An ad-hoc covariance exists across ocean skin temperature and lowest altitude T_{atm}

Sample retrievals and AKs



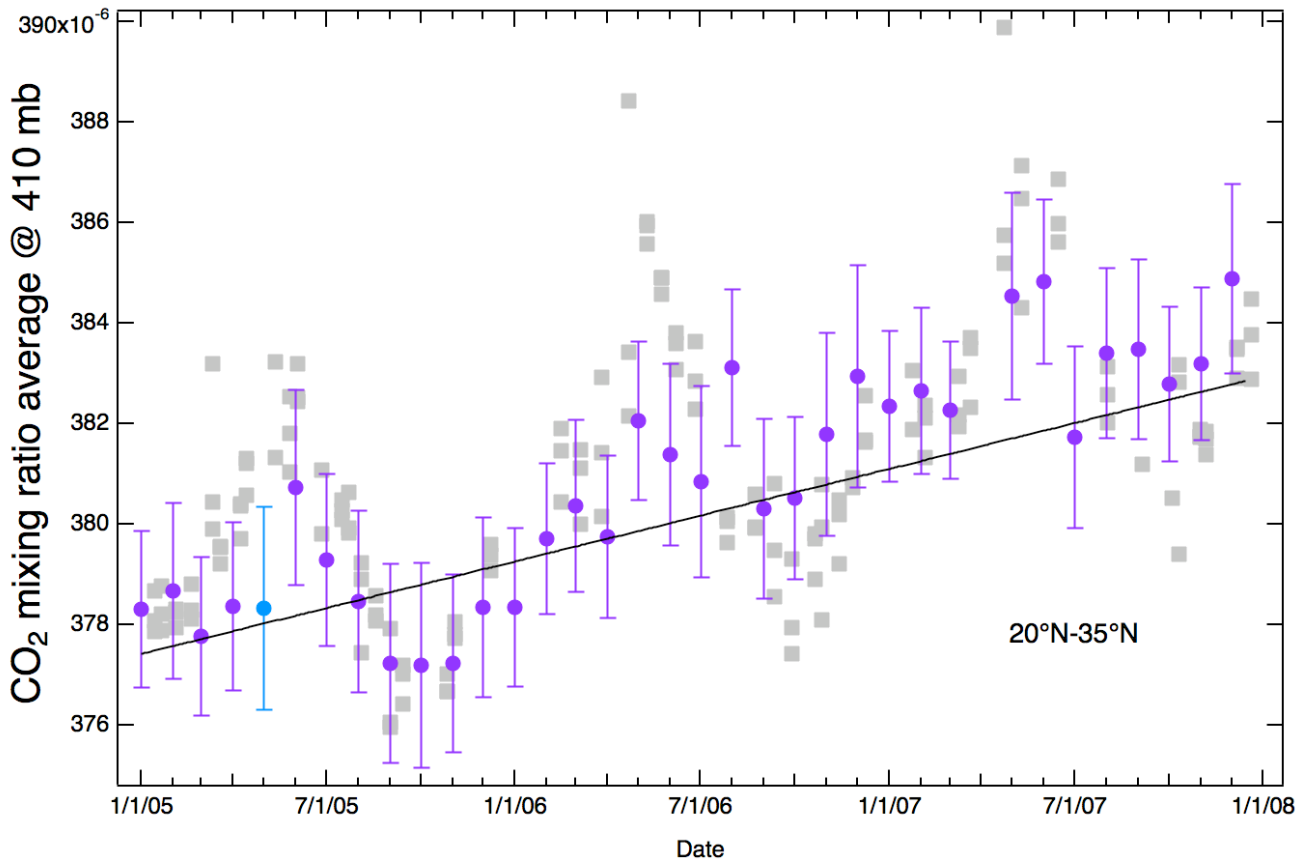
Retrieval locations 2005-7

Clear locations selected for coincidence to CONTRAIL measurements.
Some regions less well sampled due to cloud cover.



N. mid-lat results @ 410 mb

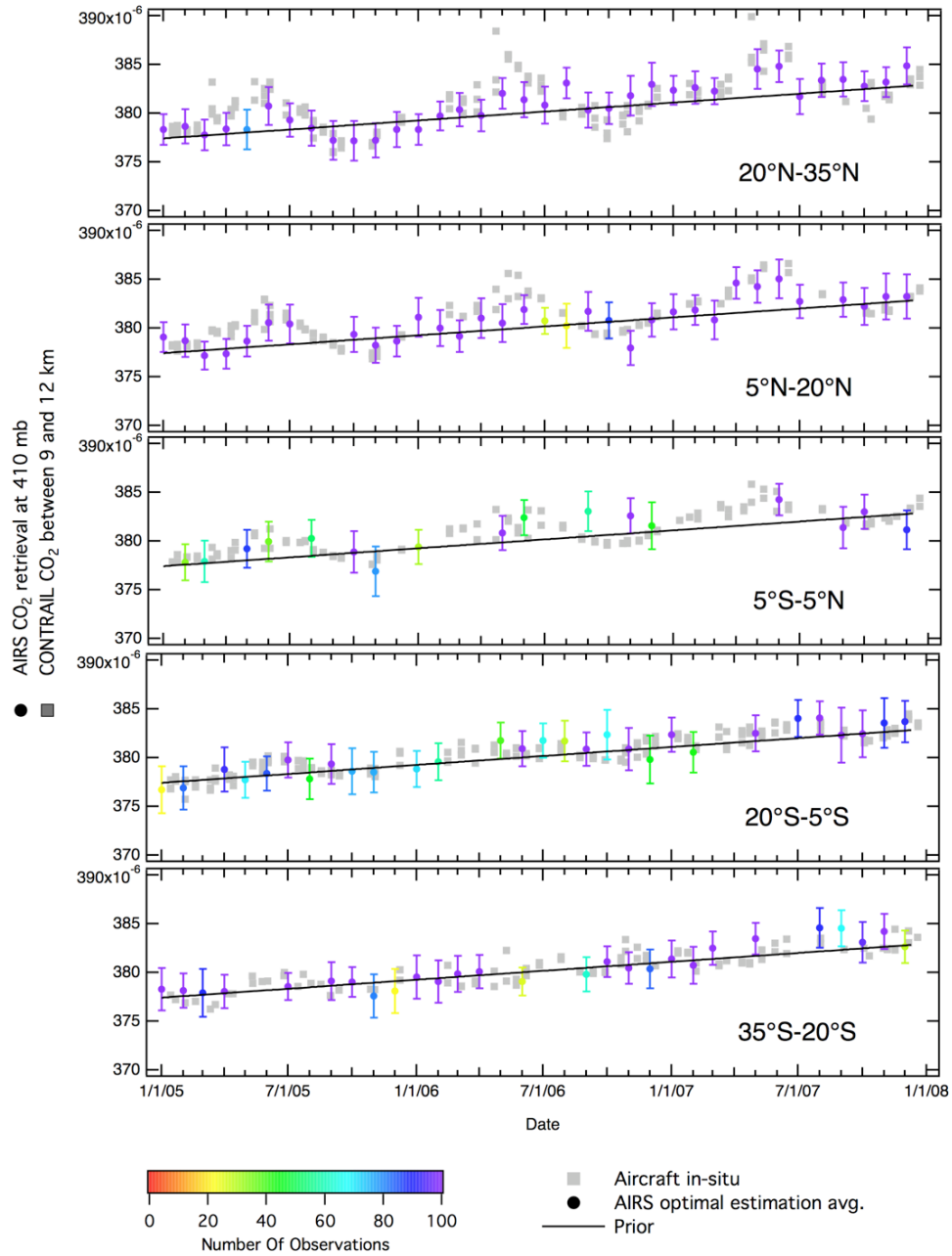
Maximum 100 retrievals attempted per month.



Have to be careful if averaging kernel peaks move around by season!

CO_2 results @410 mb binned by latitude

Only 100 observations per month per latitude bin attempted



AIRS results shifted by 5ppm

Thank you
No, these are not my dogs.