Status of AIRS V6 Upgrades at NOAA/NESDIS

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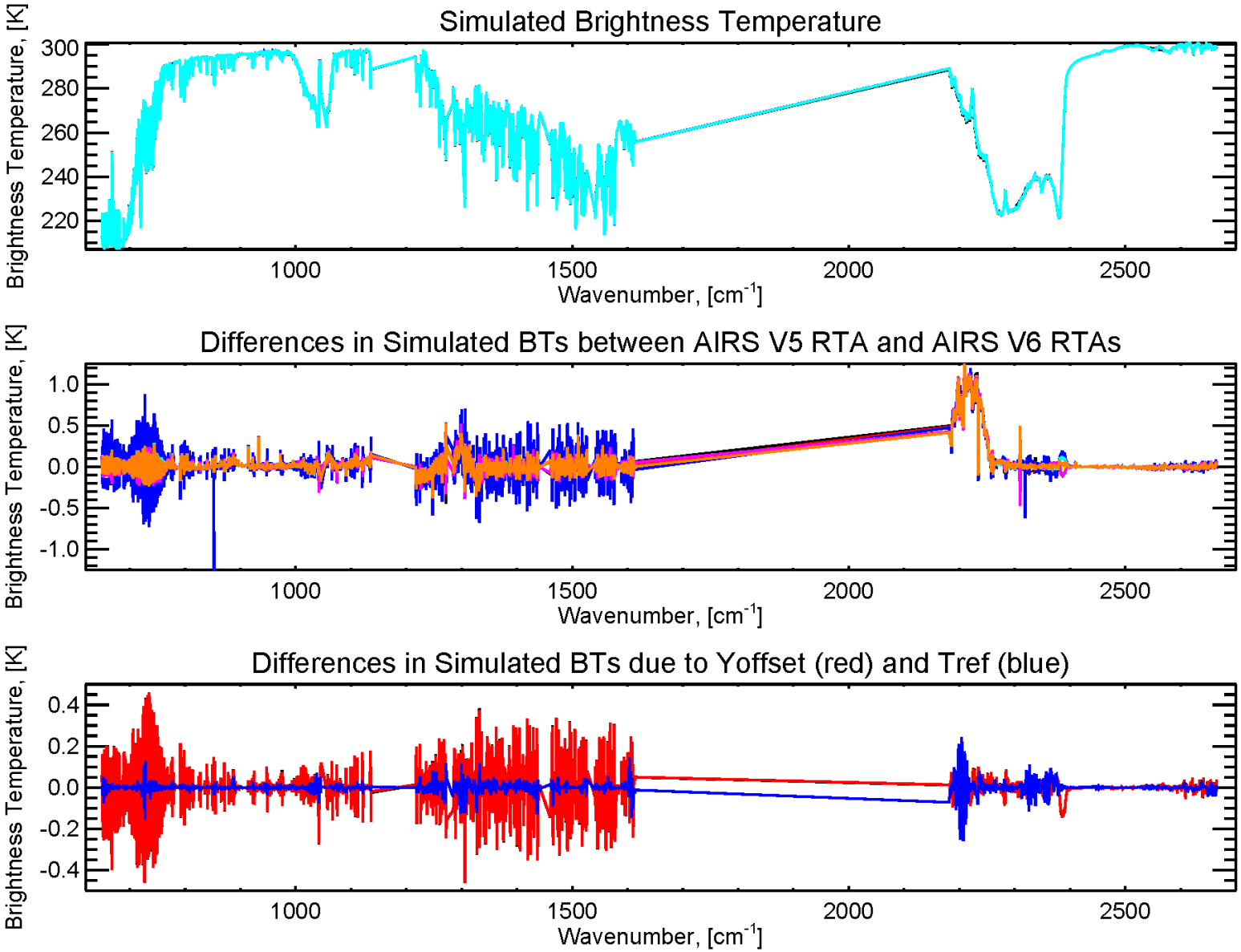
Overview of Activities

NOAA/NESDIS/STAR is currently supporting the following activities for AIRS V6 development:

1. Install the variable frequency RTA (and cloudy).
2. Understand and mitigate spurious time-dependent trends in AIRS L2 retrievals.
3. Upgrade the AIRS *cloudy* (minus AMSU 4, 5, 7) and *clear* regressions using extended time period training of eigenvectors and regression coefficients over AIRS' mission.
4. Install and test an optimal estimation CO retrieval algorithm.
5. Add convective parameters to AIRS L2 Standard Products.

In the following, I will describe the status of each of these projects.

V6 and V5 RTAs Behavior for a Clear-Sky Tropical Spectrum



V6 / Variable Frequency RTA

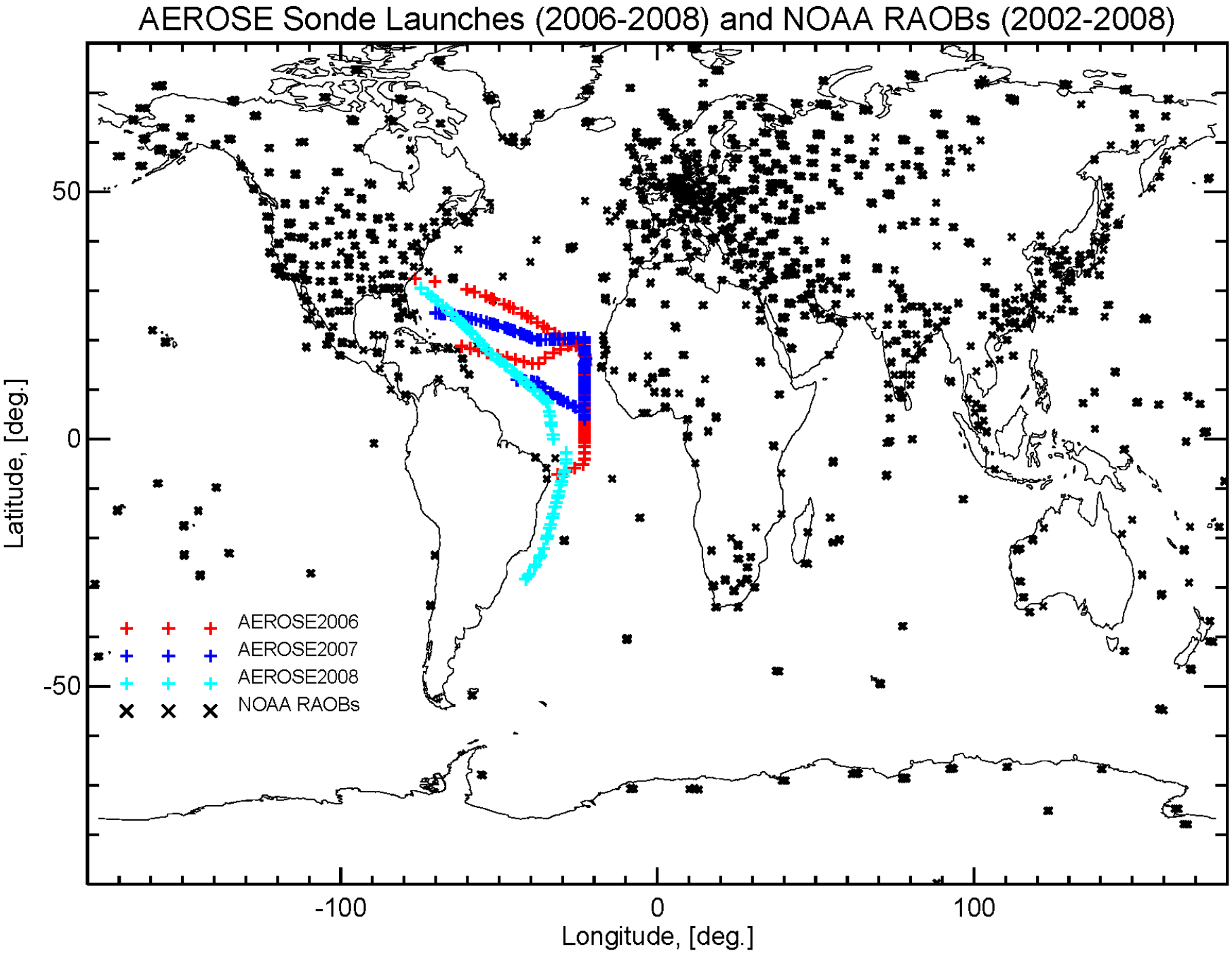
- V6 RTA includes new predictors for the ΔCO_2 and nonLTE models (fast CO_2 derivative routines requires 2 new subroutines).
- X. Xiong has converted updated SARTA coefficients and is creating reader(s) and frequency interpolation routines.
- Does JPL want to implement the variable frequency RTA in the retrieval?
  - Our implementation requires 3 solar files and 3 RTA coefficients to be loaded at the same time to facilitate the use of the model in non-granular datasets (op. RAOBs, gridded datasets, *etc.*).
  - We need to think about how we use these variable frequencies/RTAs in the retrieval as the channel behavior will now be a time-dependent/orbital phase dependent quantity. ($\delta\nu$ thresholds in many places: namelists, cloud-averaging file, etc.).
- We will require UMBC to finalize the "yoffset" model.
- Static radiance tuning will have to be revisted due to the large differences between the v5 and v6 AIRS RTAs in the CO_2 and N_2O sounding regions.
- These modificiations will be provided to J. Blaisdell for installation into the AIRS PGE.

Spurious Trends in AIRS L2

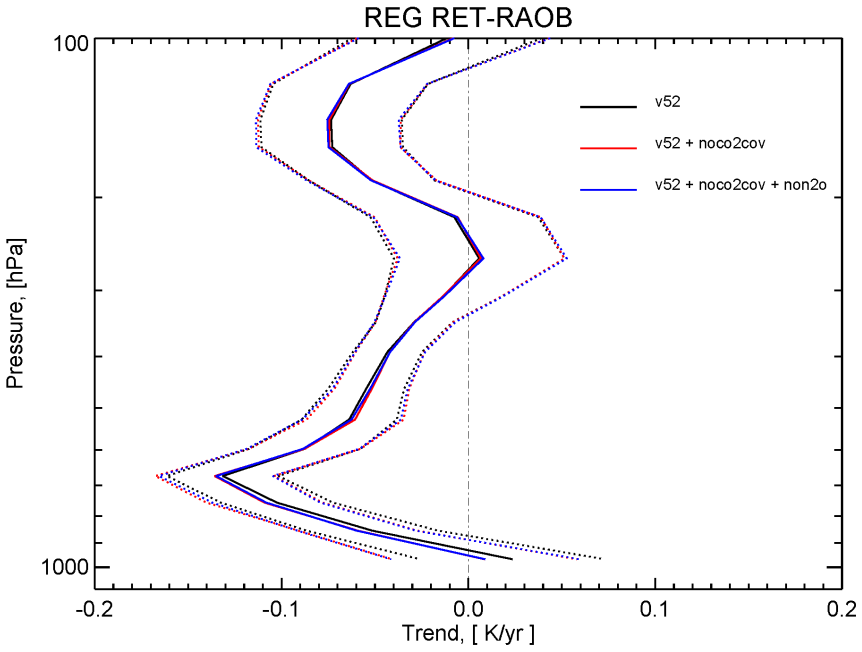
Summary of Findings

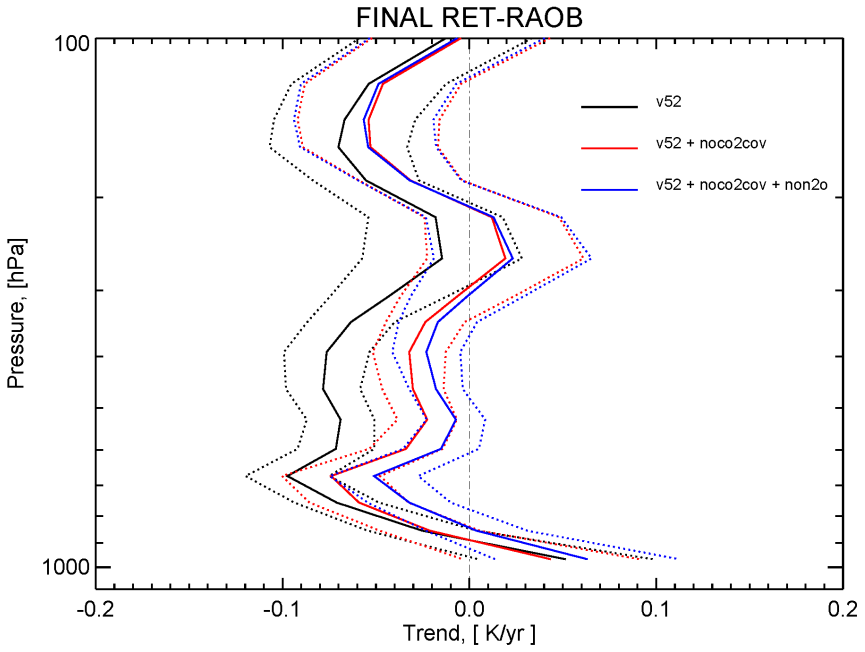
- AIRS V5 L2 T(p) retrievals have spurious trends at roughly 0.1K/yr.
- We have determined that the increase in atmospheric CO_2, a possible feedback on the CO_2 noise-covariance term, and the (in)separability between T(p)/CO_2 is responsible for $\approx$ 50-75% of the observed trend.
- N_2O is a small component $\approx$20-30mK/year.
- Portions of the profile trend are "inherited" from the NOAA first guess regression (clear/cloudy regressions) and possibly AMSU.

Biases in the clear estimate used for cloud-clearing will bias AIRS cloud-cleared radiances. Therefore trends in AIRS cloud-cleared radiances can be due to a combination of regression trends, AMSU trends, and physical retrieval trends due to incorrect prescription of CO_2.


AEROSE Sonde Launches (2006-2008) and NOAA RAOBs (2002-2008)
Latitude, [deg.]
50
0
-50
-100
0
100
Longitude, [deg.]
AEROSE2006
AEROSE2007
AEROSE2008
NOAA RAOBs

Comparison of Clear Regression (left) and Physical (right) Trends





NOAA V52, V52 + no CO2NCV, V52 + no CO2NCV + no N2O chls.

- Trends between 100hPa and 200hPa and below 700hPa are “inherited” from the the regression solution.
- Regression work should remove these trends.

Methodology to Analyze Regional Behavior of Trends

- Calculate the difference in various monthly averaged retrieval parameters where a candidate change is introduced in one system.

$$\Delta T(lat, lon) = \frac{1}{N_2}\sum_t T_2(lat, lon, t) - \frac{1}{N_1}\sum_t T_1(lat, lon, t);$$

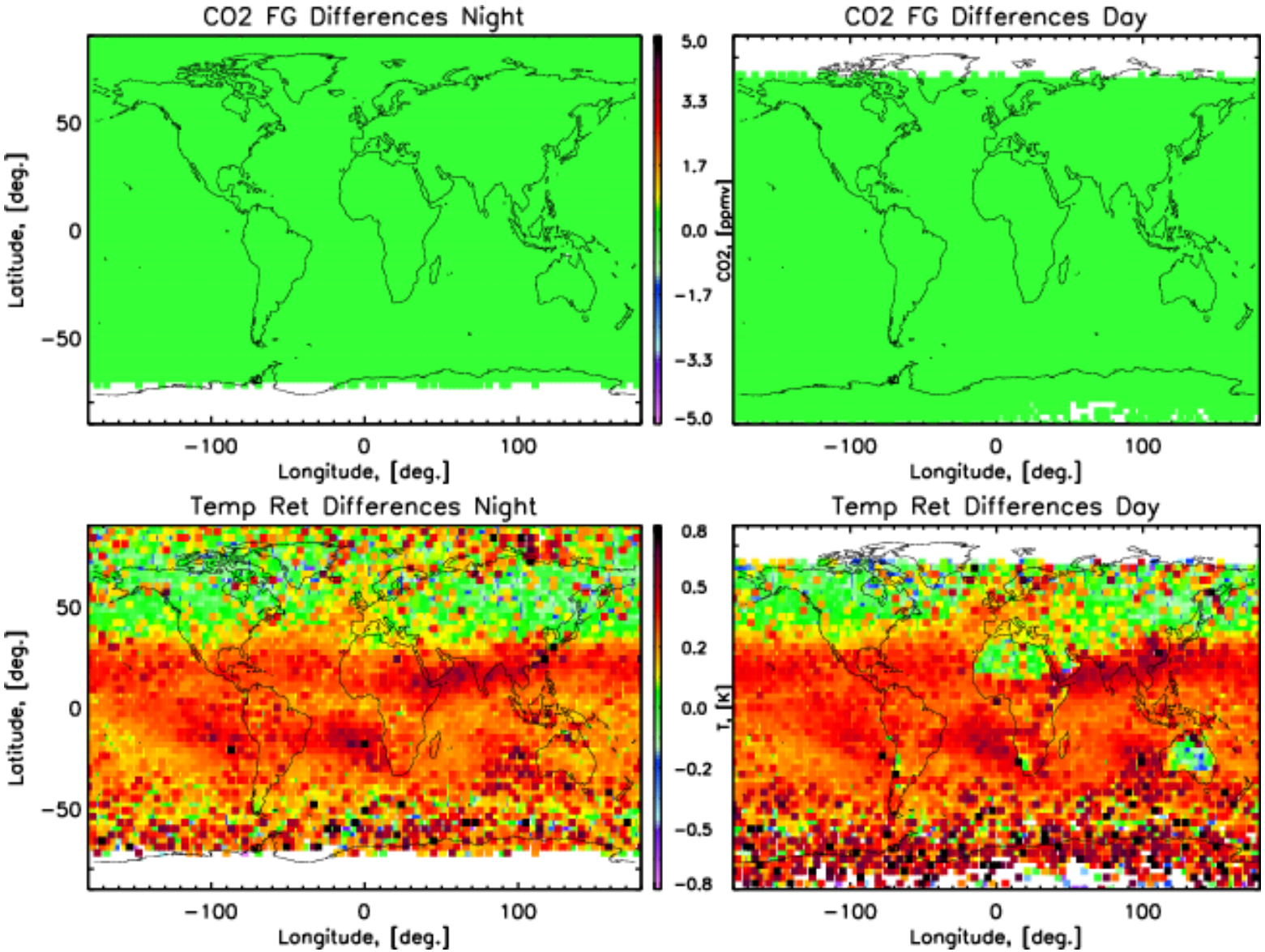
where t is the time index N_1 and N_2 are the number of accepted cases per each grid box.

- I will show differences for our CO_2 initialization field (top panels) and also mean temperatures in the layer spanning tropopause - 700hPa (bottom panel).
- Left panels show nighttime behavior, and right panels show daytime behavior.

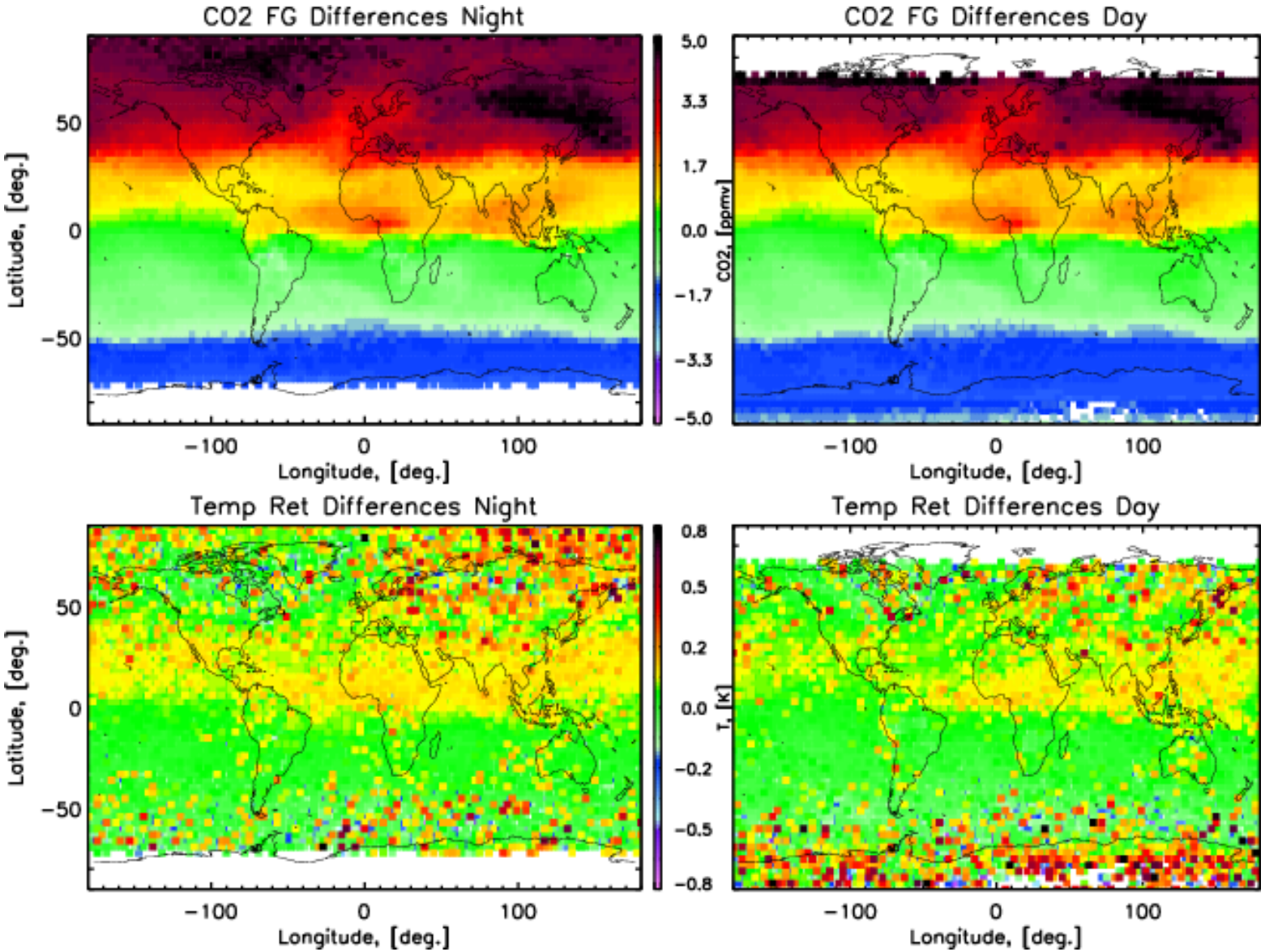
Systems differences are calculated for (2 - 1) and (3 - 2) :

1. CO_2 NCV On
2. CO_2 NCV Off
3. CO_2 NCV Off + CO_2 = NOAA/ESRL/GMD CarbonTracker

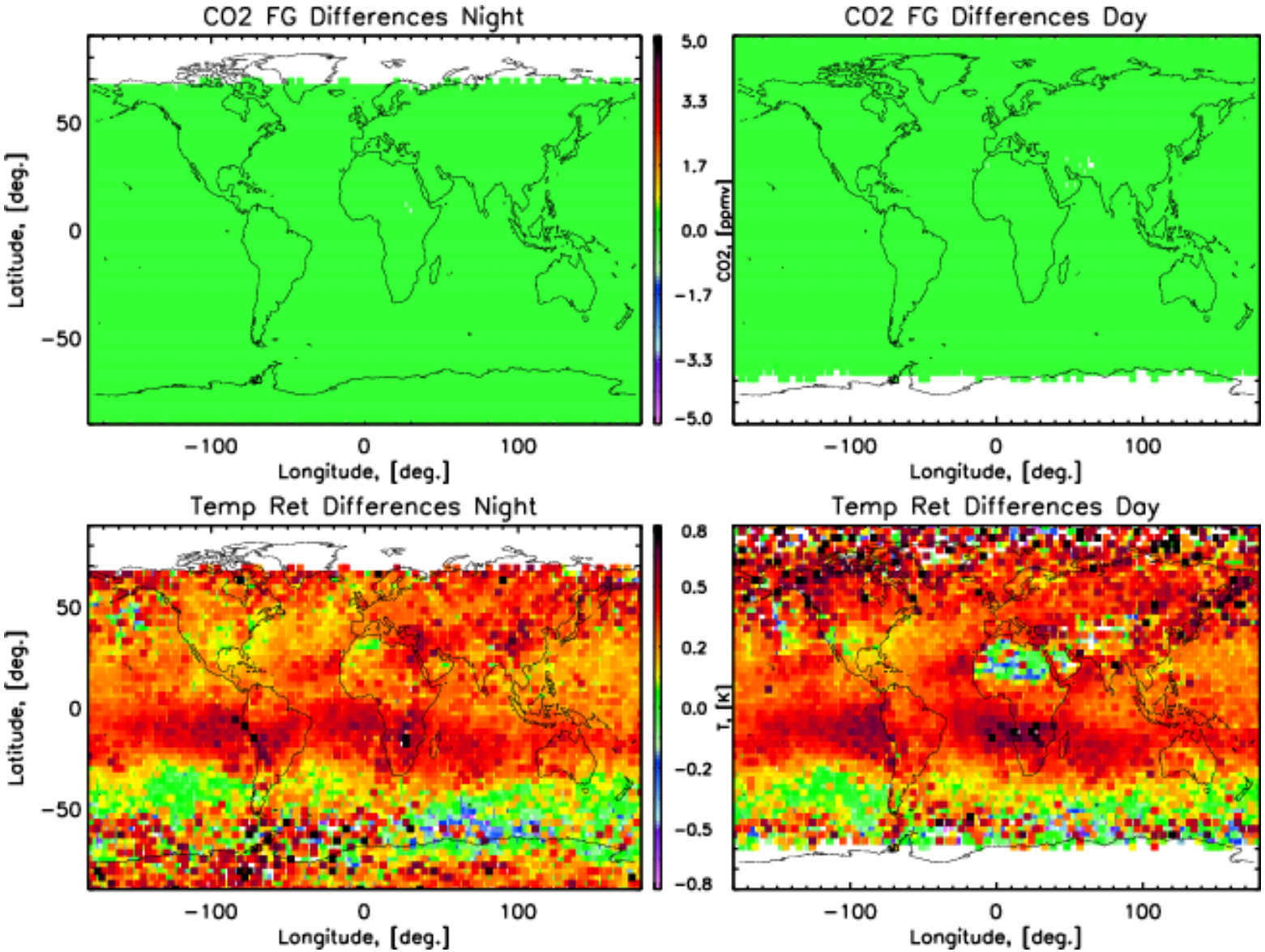
January 2006: Regional Behavior of the CO2 NCV term (Off - On)



January 2006: Regional Behavior of the Changing CO2 FG



July 2006: Regional Behavior of the CO2 NCV term (Off - On)



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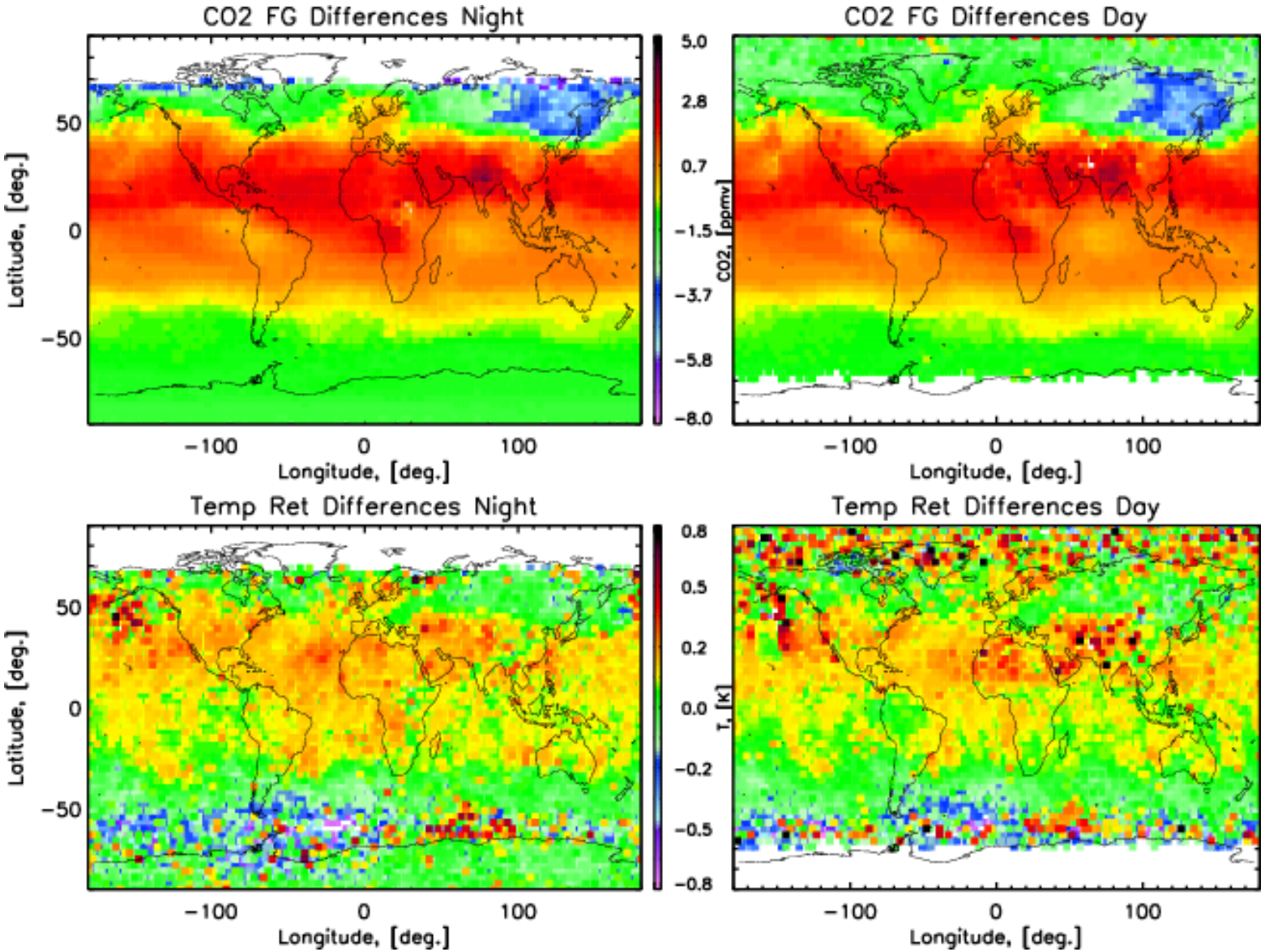
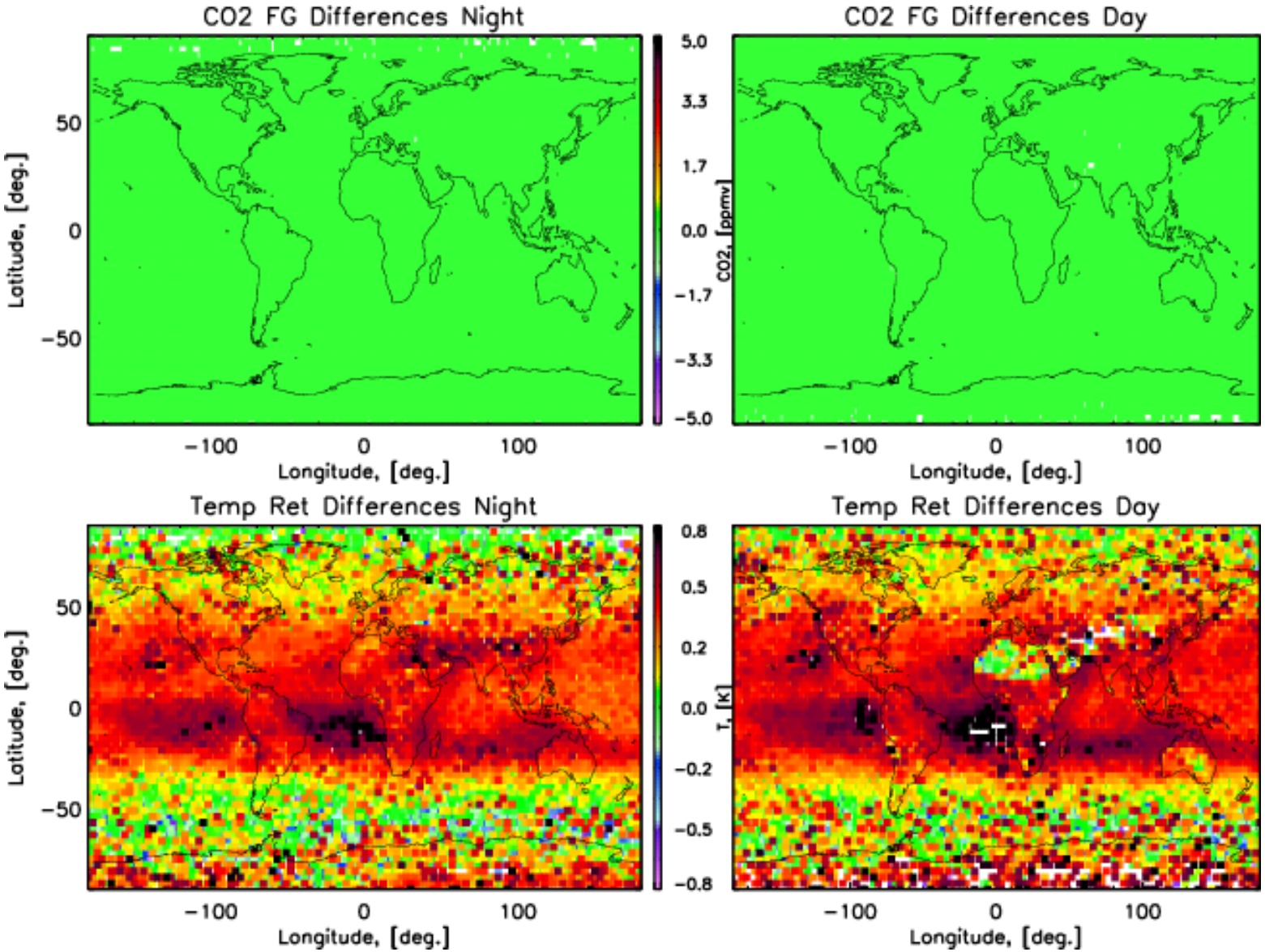


September 2006: Regional Behavior of the CO2 NCV term (Off - On)



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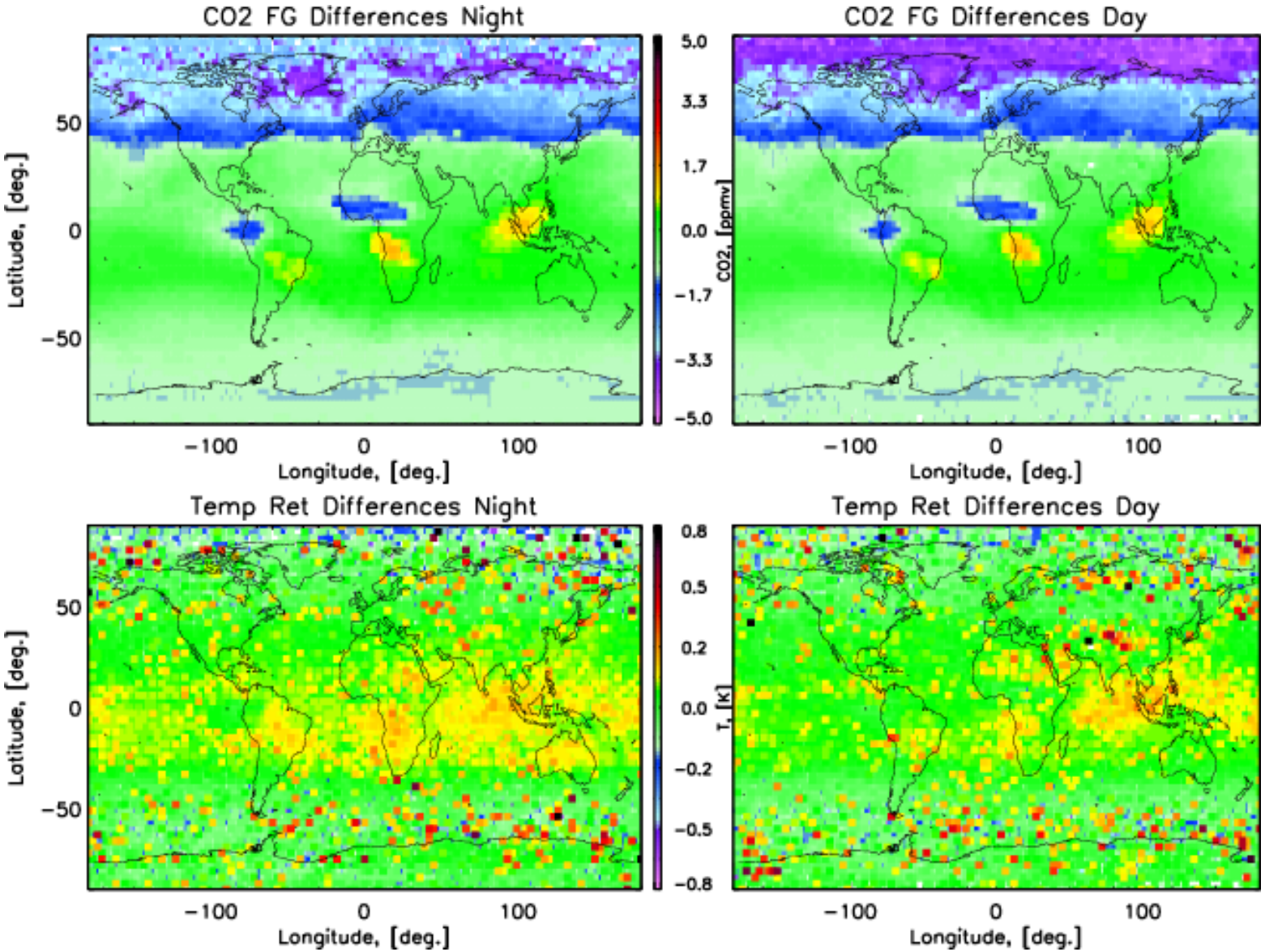
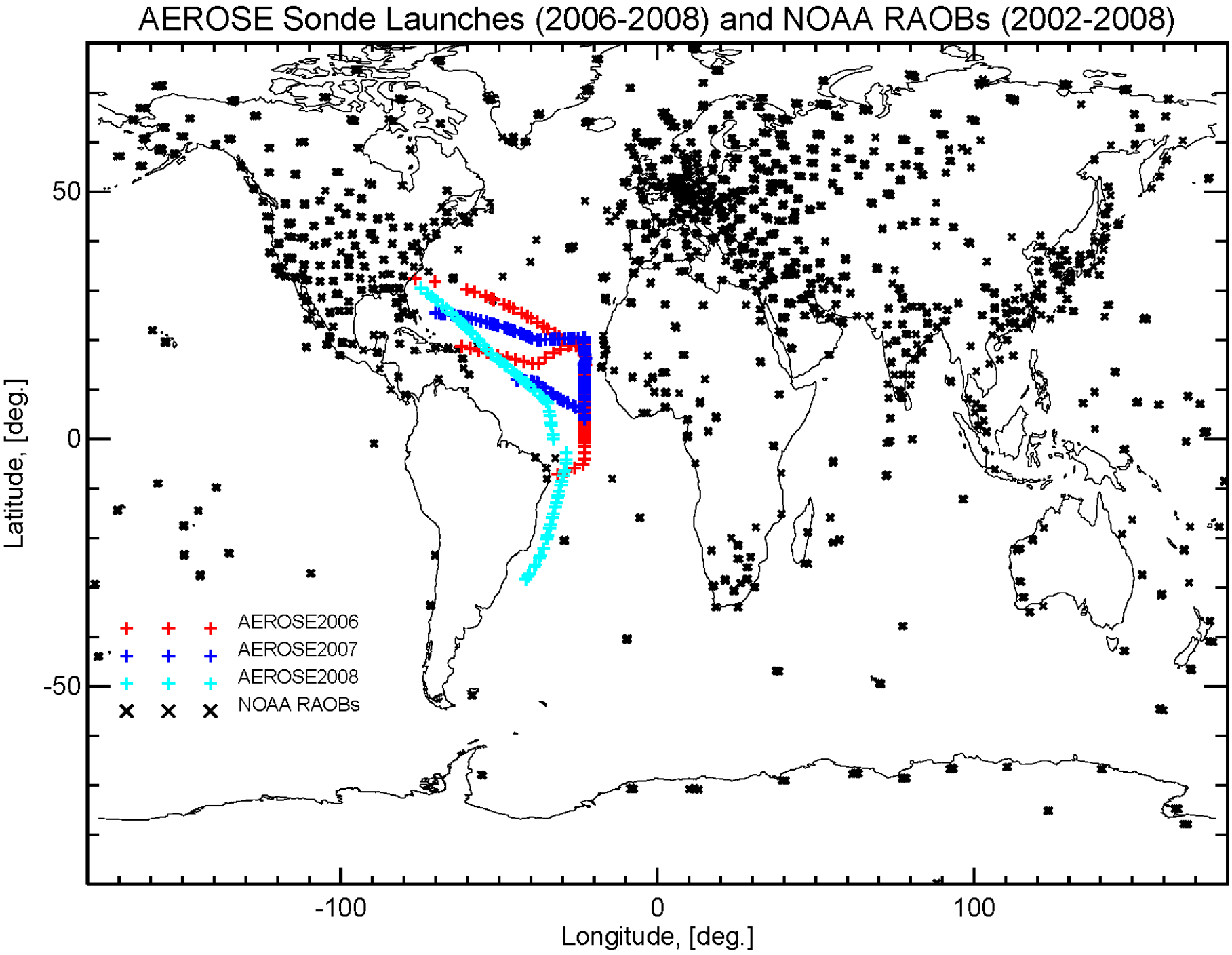


Summary of Regional Behavior of AIRS L2 T(p) Retrievals With Respect to CO_2 Initialization

- Mean tropospheric temperature changes due to CO_2 NCV off - on are $\leq$ 1K; however, differences are also noted (not shown) for T_{surf}, $H_2O(p)$, $O_3(p)$, etc.
- Differences between retrievals (CO_2 NCV off - on) are largest throughout the tropics and mid-latitudes in regions corresponding to the downwelling branches of the atmospheric circulation – possibly due to airmass dependent errors in the RTA and/or cloud-clearing.
- There are some day/night effects over desert surfaces for this version of the AIRS retrievals– do not include some of Joel's surface retrieval changes.
- There is also a seasonal dependence of the CO_2 NCV – the CO_2 NCV term does not have as large an effect in the winter hemisphere.
- The removal of the CO_2 NCV also causes the temperature retrieval to respond more to CO_2 initialization field.

Can we validate that the differences due to CO_2 NCV are in the correct direction?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NOAA RAOBs

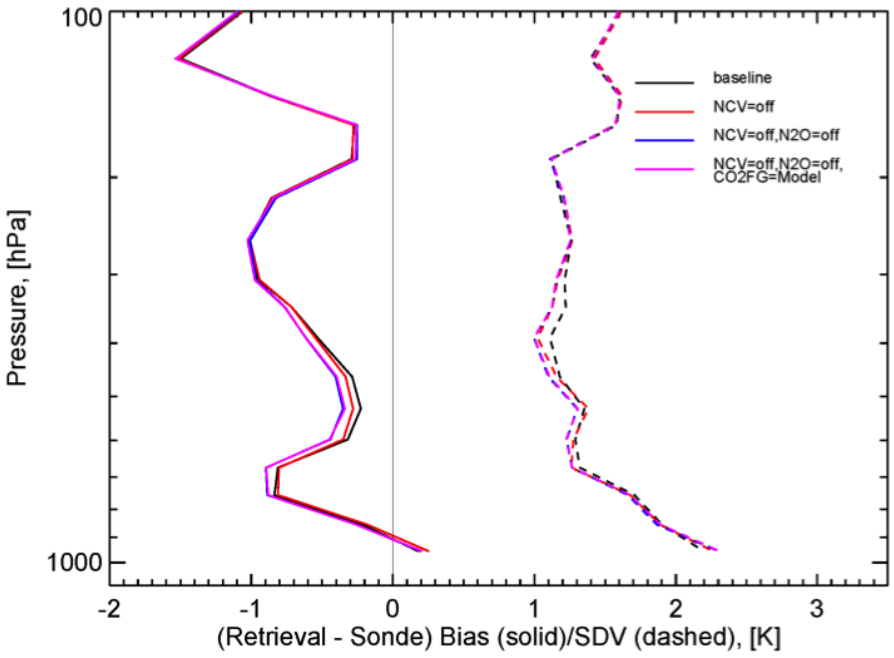
Validation of Upgrades to AIRS V5 Temperature Retrievals

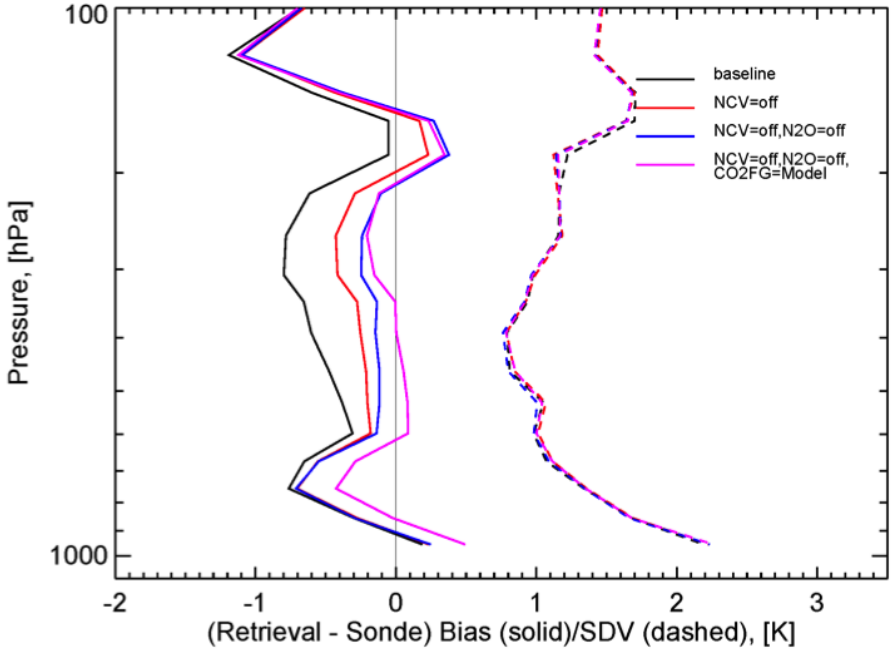
- We utilize the NOAA/NESDIS/STAR 3°x 3°dataset to match AIRS retrievals to AEROSE sondes (courtesy of N. Nalli) within 300km and +/- 3hr.
- We then calculate the bias and std. deviation between the sonde and AIRS temperature retrievals for all collocations for various retrieval setups.

Setup's considered are :

1. NOAA V52 (CO_2 NCV On)
2. NOAA V52 (CO_2 NCV Off)
3. NOAA V52 (CO_2 NCV Off + no N_2O)
4. NOAA V52 (CO_2 NCV Off + no N_2O + CO_2FG = NOAA/ESRL/GMD CarbonTracker)

Comparison of Clear Regression (left) and Physical (right) Statistics





NOAA V52, V52 + no CO2NCV, V52 + no CO2NCV + no N2O chls.
V52 + no CO2NCV + no N2O chls. + CarbonTracker CO2 FG

- Biases between 100hPa and 300hPa and below 700hPa are “inherited” from the the regression solution.
- Regression work should remove or reduce these biases.

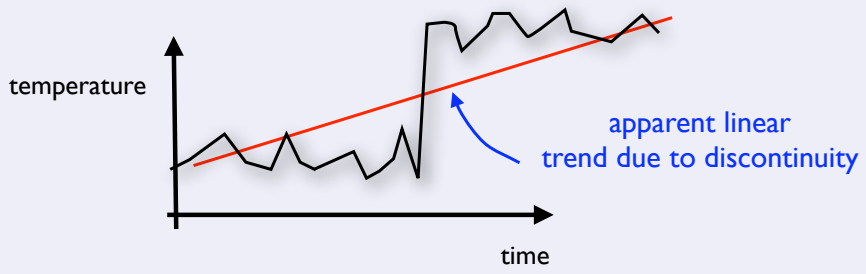
Regression Updates

- We have acquired AMSU L1B, AIRS L1B and AIRS L2 CCR from NASA/JPL and the GES/DISC for the period between September 2002 through December 2009.
- Data throughout the period (static days + volcano events) have been used to re-train eigenvectors with a pristine channel set consisting of 1567 channels.
- We are in the process of creating ECMWF for 80 days throughout the mission for regression coefficient training.

Regression Updates

AIRS Cloudy and Clear Regression Upgrade Liens

- NOAA diff-test uses AMSU 4, 5, and 6 to predict some shortwave temperature sounding channels. Due to the loss of AMSU 4 we cannot include this test post - Oct. 2007. We are testing the use of other possible tests for regression coefficient training.
- ECMWF model changes (e.g. model resolution Feb. 2006). This change introduced a kink in the ECMWF record that results in an apparent 0.05-0.07 K /yr warming in the upper troposphere.

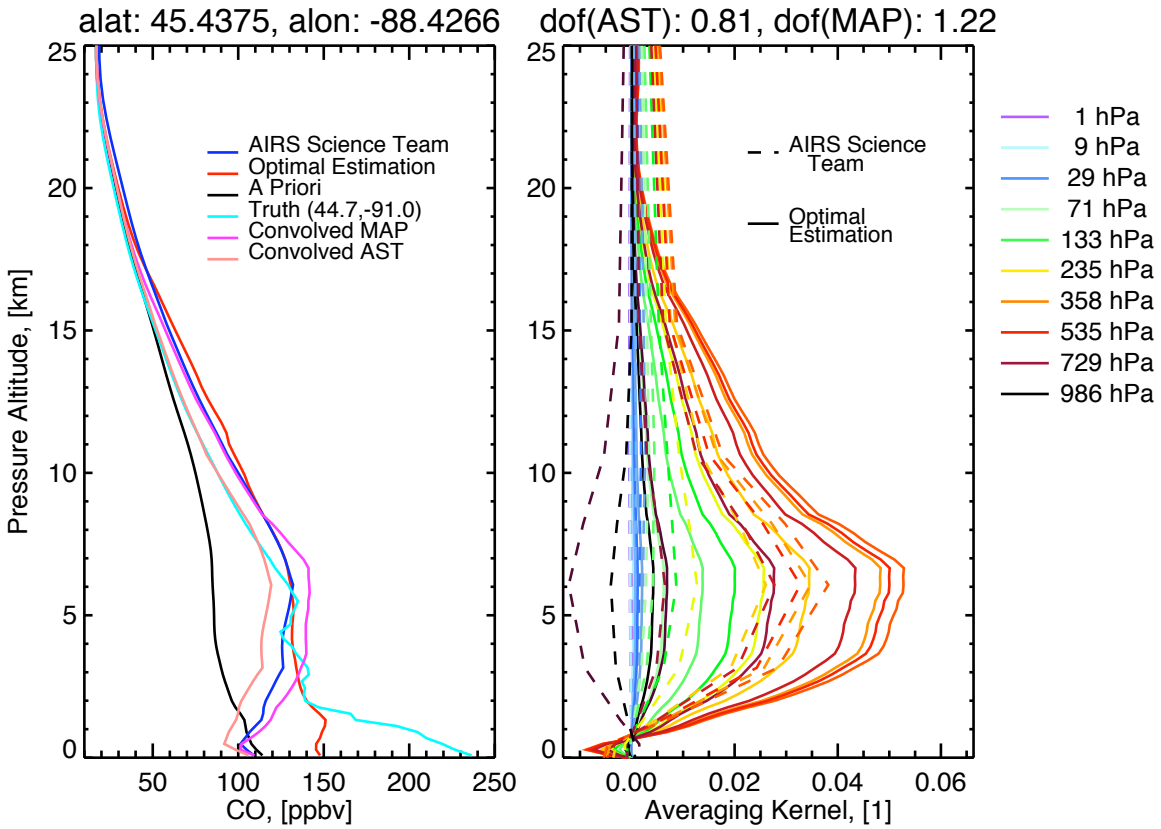


Regressions which use data before and after will be sensitive to this apparent trend. Temporal training of regressions (non-linear or linear) may require data more temporally stable than ECMWF forecast/analysis fields. We are testing the stability of the algorithm using the sonde database and optimizing the regression coefficient training sets with respect to minimization of spurious trends.

We expect that the new regression coefficients and eigenvectors will be ready in the June 2010 timeframe.

Optimal Estimation CO retrieval

- Optimal Estimation CO retrieval (methodology published in [Maddy *et al., IEEE GRSL*, 2009]) was delivered to UMBC on September 22, 2009.



- No testing has been performed since the passing of W. McMillan.

Stability Indices in AIRS L2 Standard Product

- NOAA has a subroutine in our offline system that calculates various convective/stability parameters (e.g., CAPE, CINH, EL, LFC, LCL, etc.) from AIRS 100 layer L2 - presented in previous meetings (work performed by F. Sun).
- Problem: AIRS L2 Standard Product does not have sufficient vertical resolution to accurately calculate these stability indices.
- We propose to provide this subroutine to J. Blaisdell for incorporation into the PGE and have the outputs included in the AIRS standard product.
- The code offers some flexibility in the choice of derived parameters and details will need to be discussed.

Summary

- NOAA is currently supporting the AIRS V6 development of the variable frequency RTA, regression upgrades, and spurious trend mitigation.
- We have determined the causes of the spurious L2 trends and have submitted upgrades/suggestions for improvement to GSFC for testing and incorporation into the official AIRS L2 software.
- We are currently upgrading the AIRS L2 Clear and Cloudy regressions using long-term training of eigenvectors and regression coefficients. This work will be complete in the June 2010 timeframe.
- The AIRS V6 variable frequency RTAs have been converted for single RTA use. In-retrieval usage is currently still in development. Once the work has been completed, we will work with J. Blaisdell to incorporate this RTA in the official AIRS L2 software.