OCO-2 Progress and Plans

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For the OCO-2 Science Team

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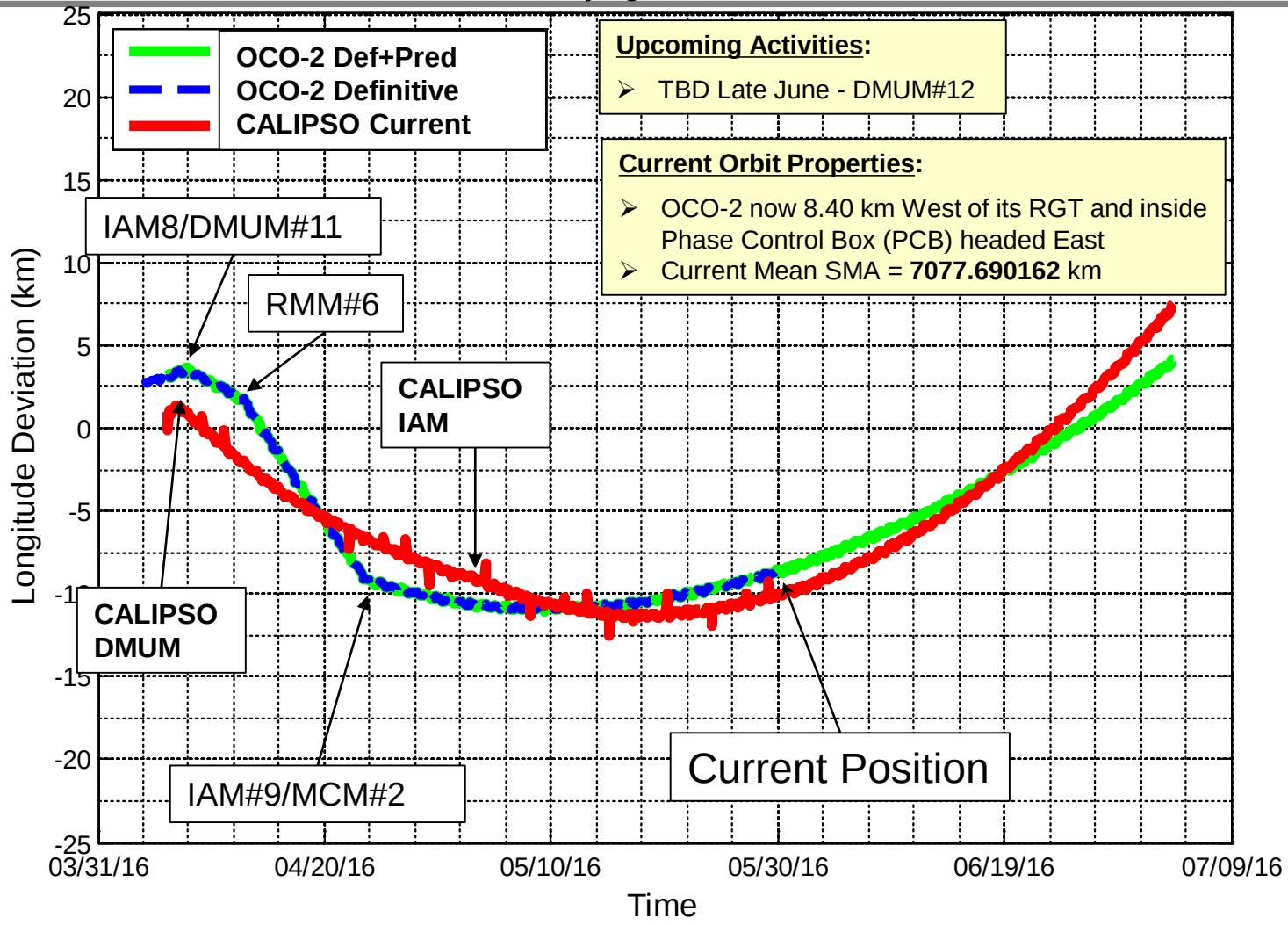
Government sponsorship acknowledged.

Overview

- Navigation Status
  - Next Drag Makeup maneuver anticipated for near the end of June
  - May have to be carefully coordinated with the RRV Campaign
- Absolute radiometric calibration status and plans
- ABO2 degradation
  - Fast degradation and zero level offset
  - Slow degradation
- ABSCO Progress and Plans
- Version 8 Processing Status and Plans

Navigation Status

Formation Flying Ground Track Error



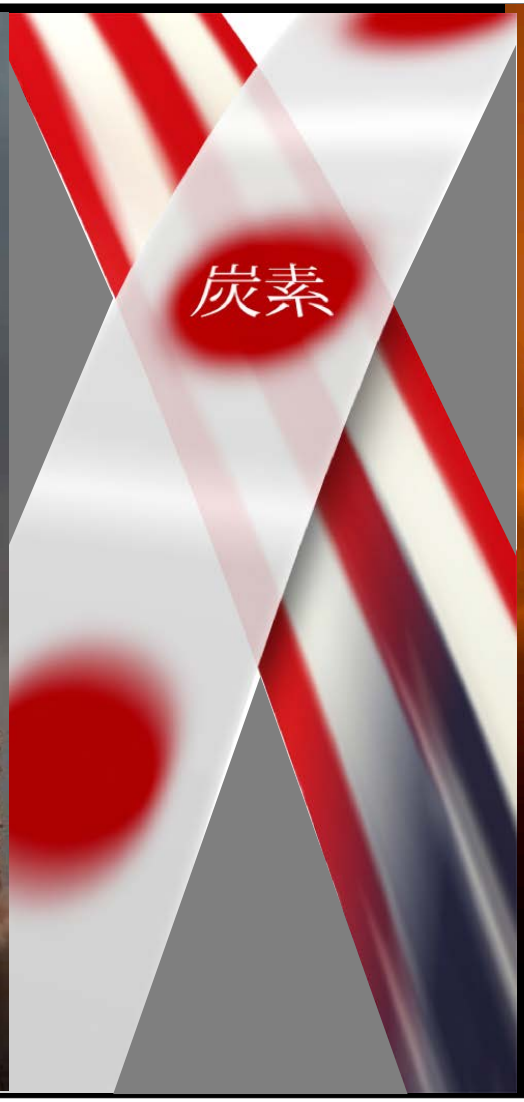
Upcoming Activities:

- TBD Late June - DMUM#12

Current Orbit Properties:

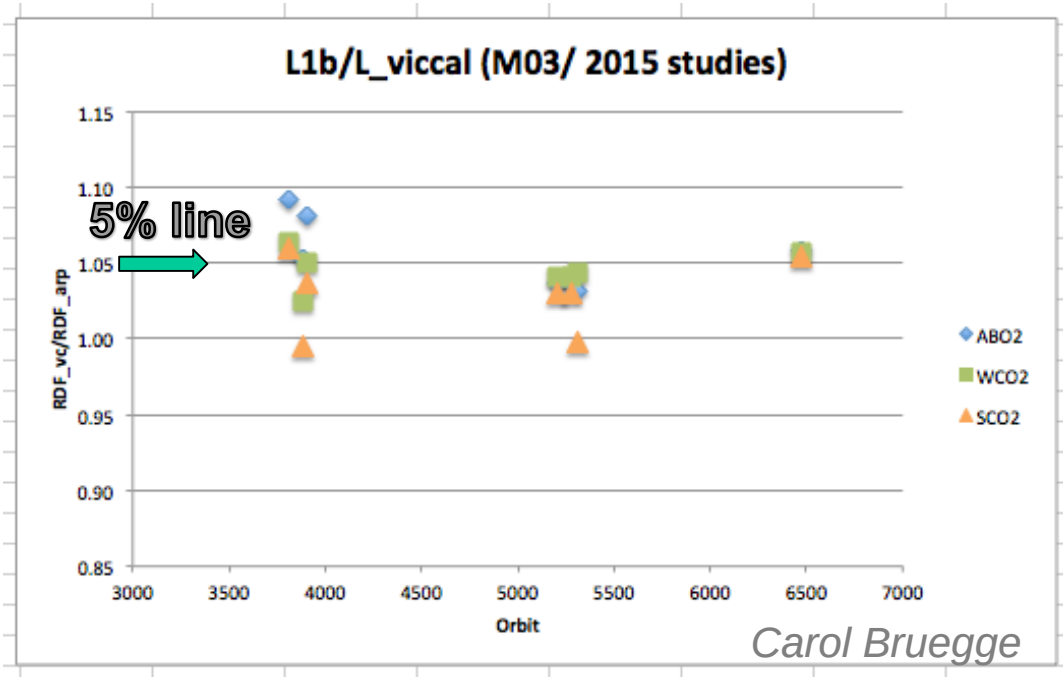
- OCO-2 now 8.40 km West of its RGT and inside Phase Control Box (PCB) headed East
- Current Mean SMA = **7077.690162** km

Calibration



Absolute Radiometric Calibration: Level 1B vs Vicarious Calibration

- Absolute calibration uncertainties > 5% can introduce XCO2 errors as large as 1 ppm under certain conditions
- Early analysis of measurements over Railroad Valley (RRV) suggested that the reported OCO-2 Level 1B radiances may be 5% high compared to Vicarious Calibration (VC) estimates



- More recent analyses of the data indicate that these estimates are still quite uncertain
- Additional vicarious calibration observations and comparisons with GOSAT are being used improve our understanding of the absolute radiometric calibration

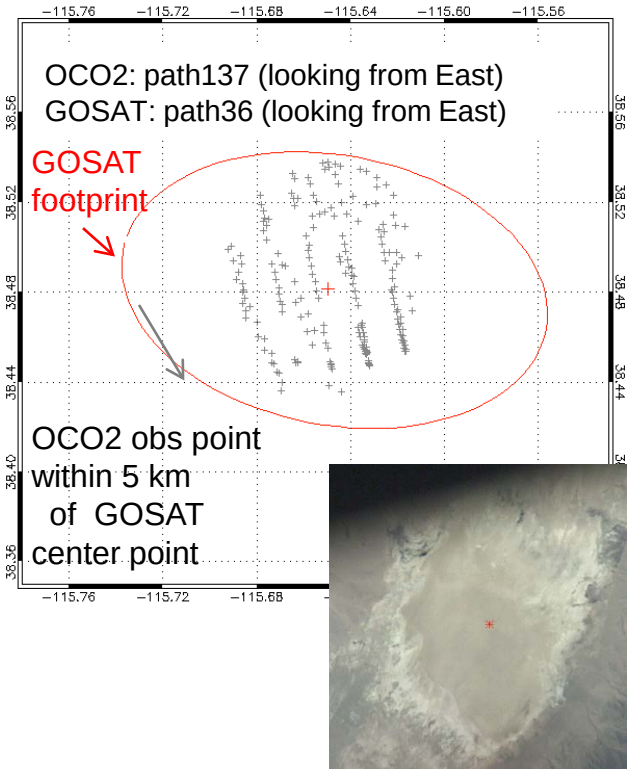
OCO2- GOSAT Spectra Comparison
Kataoka et al.

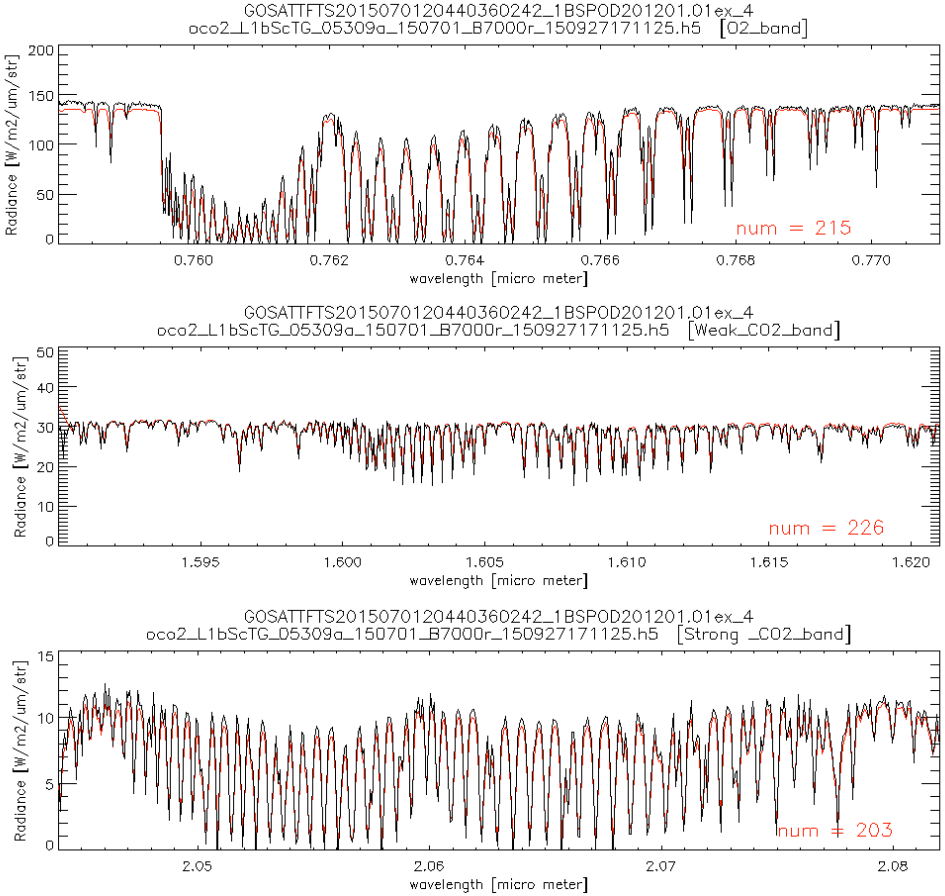
Comparisons between OCO-2 and GOSAT also indicate very good agreement

GOSAT Rad
OCO2 average Rad within 5km of GOSAT cnt point X 2
ratio1 = OCO2/GOSAT

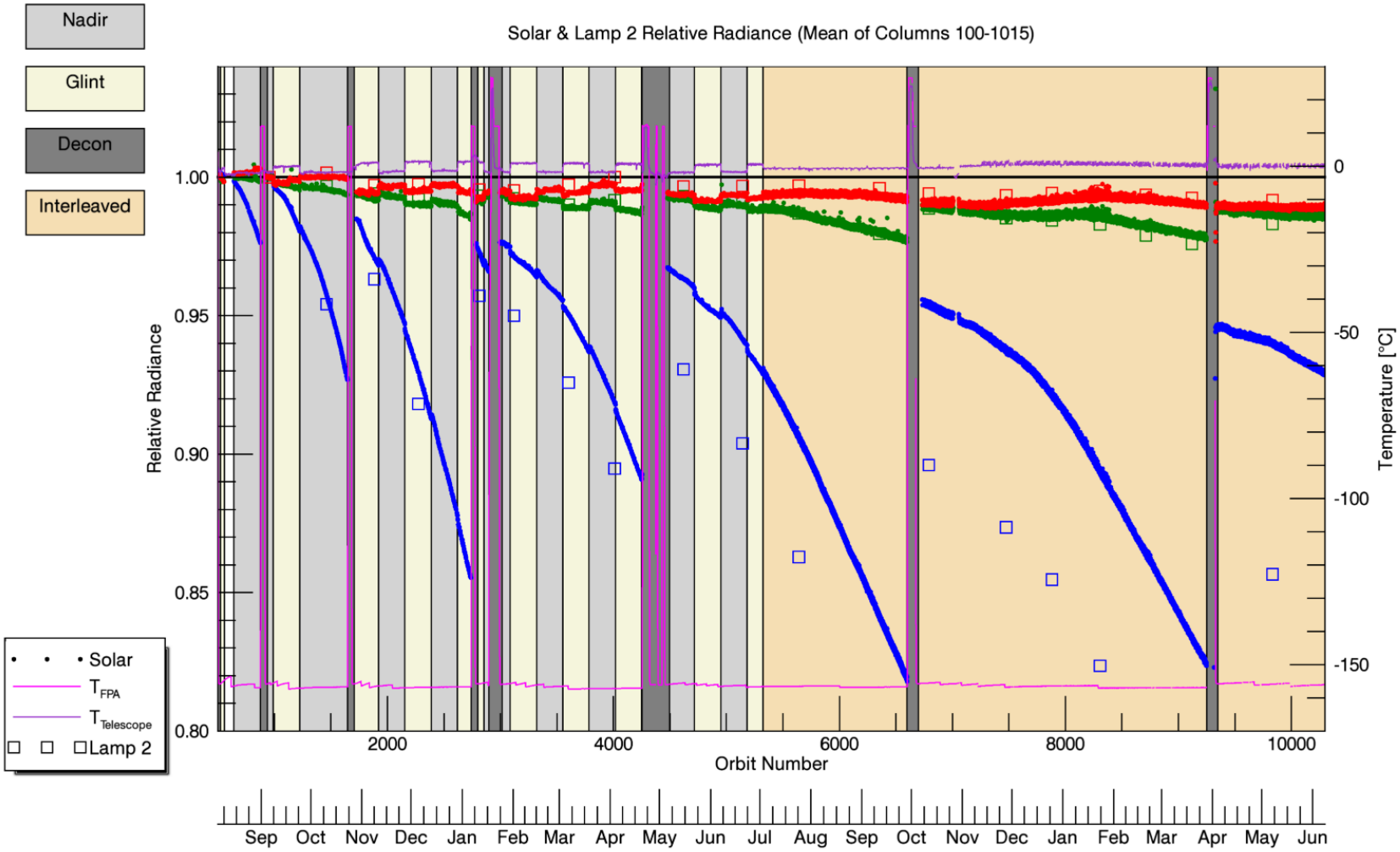
Jul01,2015 [1]

oco2_L1bScTG_05309a_150701_B7000r_150927171125.h5
GOSATTFTS2015070120440360242_1BSPOD201201.01





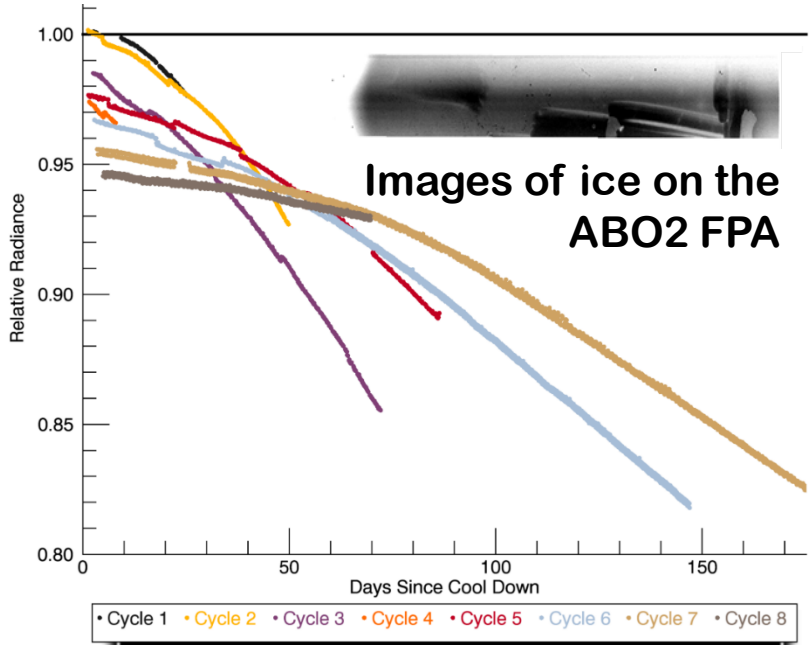
Sensitivity Variations Over Time



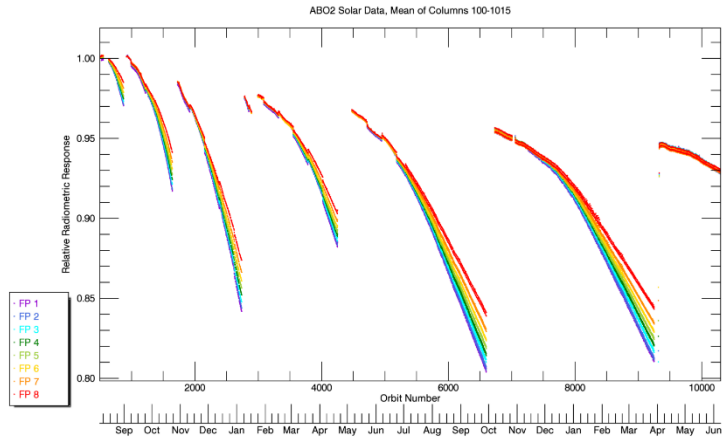
A-Band Sensitivity Variations

- The sensitivity of the OCO-2 ABO2 channel has varied over time, while the WCO2 and SCO2 show much less variability
- The ABO2 sensitivity degradation has two components
  - A "fast degradation" that is reversed by decontamination activities
    - This component has been attributed to temporary degradation of the anti-reflection coating on the A-band focal plane array detector (FPA) due to ice accumulation on the FPA
  - A monotonic "slow degradation"
    - Lunar and Vicarious Calibration measurements indicate that this is due to degradation of the solar diffuser rather than a throughput loss in the instrument

A Closer Look at the Fast Degradation

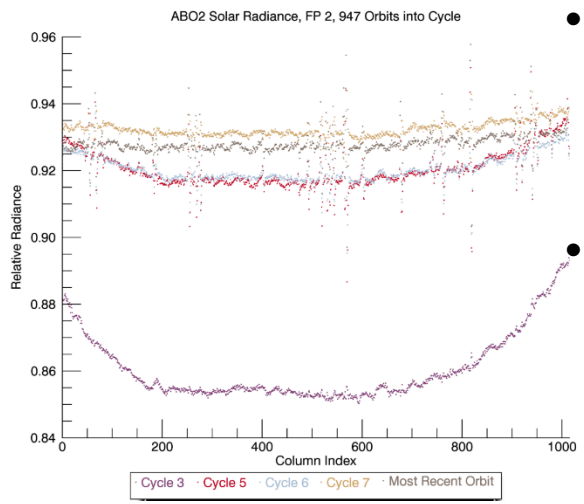


Images of ice on the ABO2 FPA



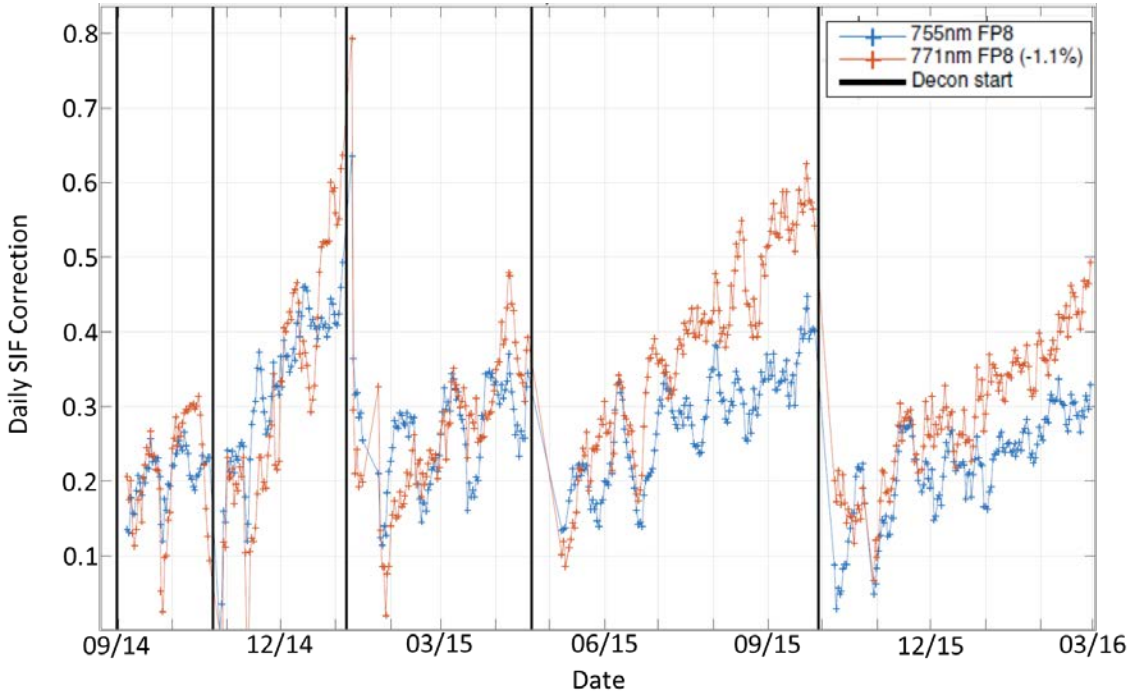
The signal loss varies with footprint

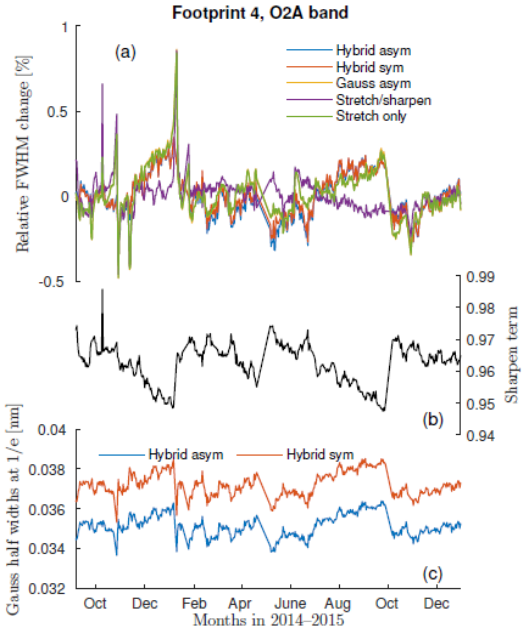
The rate of signal loss has decreased over time, as the contamination level has decreased → Losing ice



- The signal loss also varies with wavelength
- These variations are corrected in the V7 L1b product

A Zero Level Offset





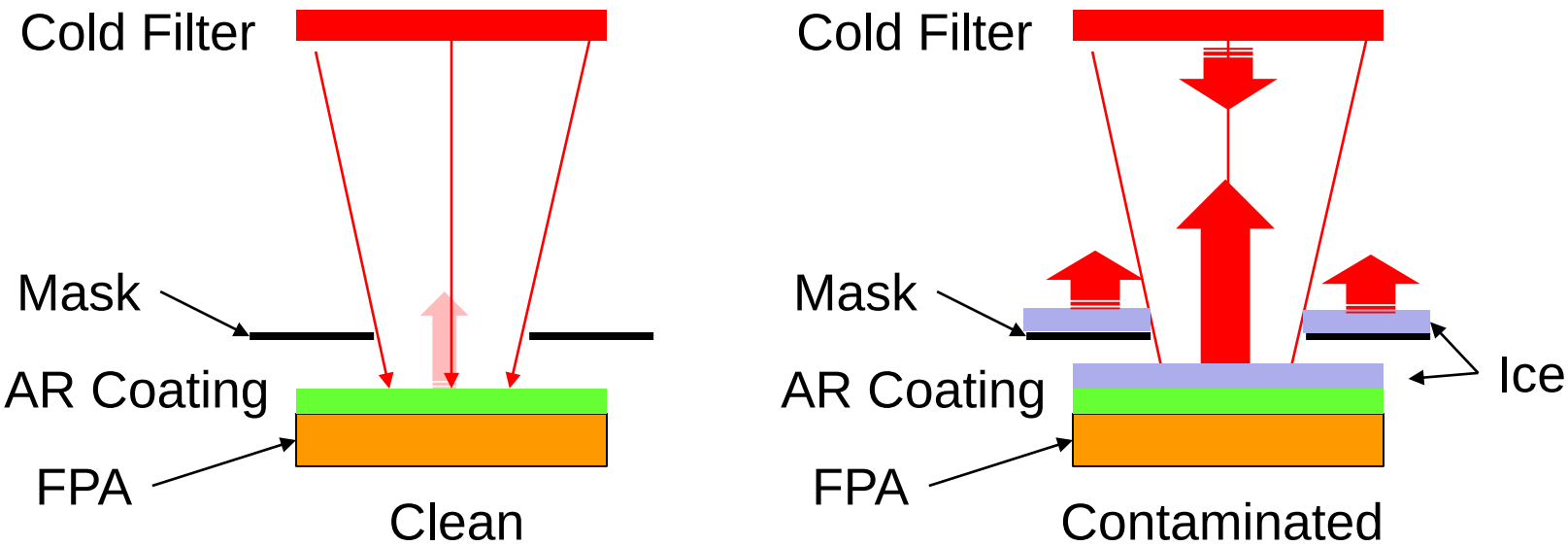
SIF observations show a zero level offset (or ILS change) that is correlated with the level of signal degradation [C. Frankenberg}

Changes also seen in ILS fits from solar Doppler experiments [Sun Kang]

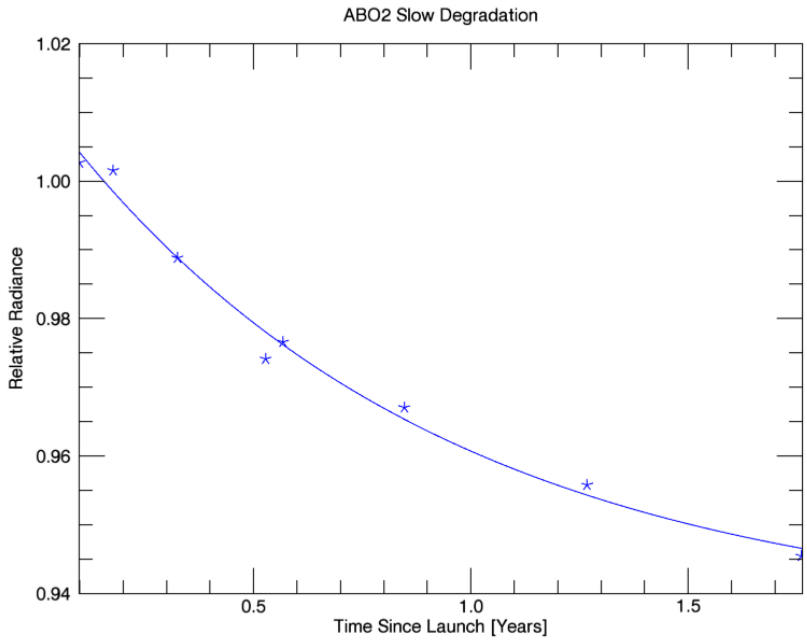
Possible Mechanism: Increased Scattered Light from FPA

Hypothesis

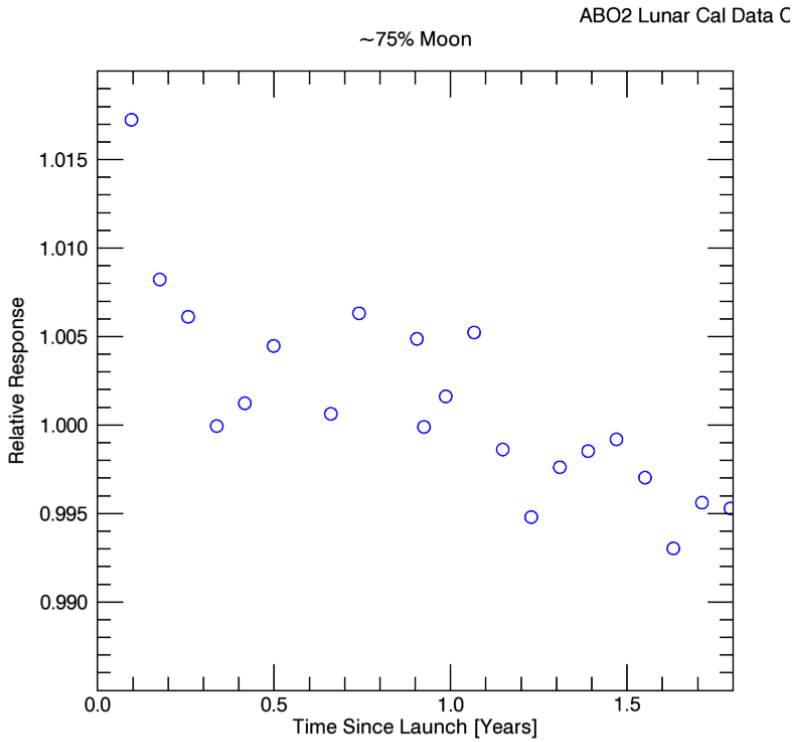
- As ice accumulates on the FPA surface (and perhaps the FPA mask), it increases the reflectivity of the FPA surface
- Some of the additional light reflected by the FPA is back-reflected by the cold filter (or other components) to the FPA as an out of focus scattered light source.



More Insight on the Slow Degradation

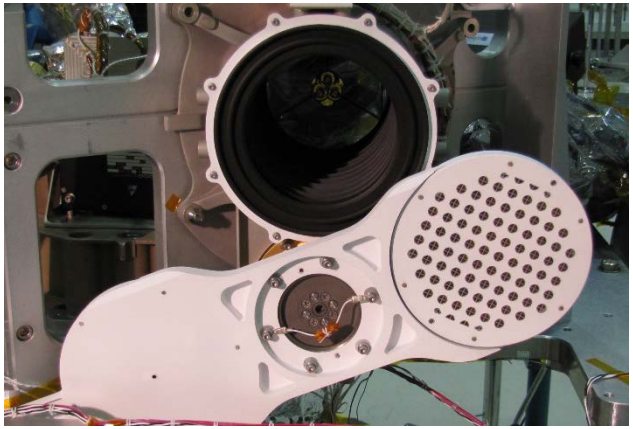


The "slow" component of the degradation is ***mostly*** due to the calibrator, not the instrument.

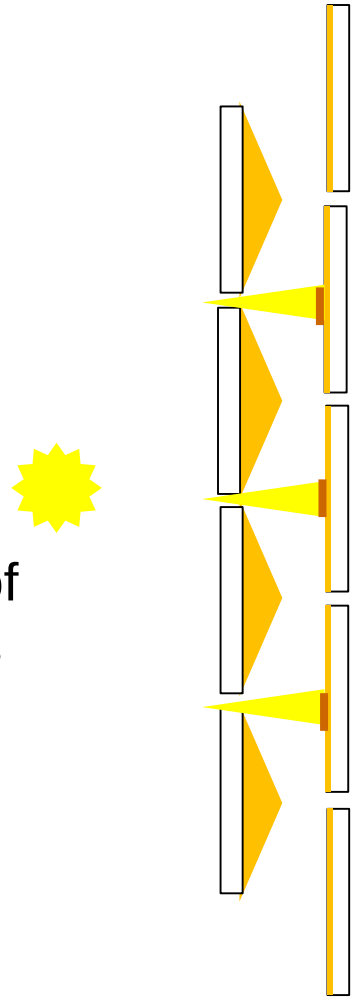


A reanalysis of the Lunar Calibration Data indicates that about 20% of the slow degradation is in the instrument optics

The Slow Degradation Mechanism



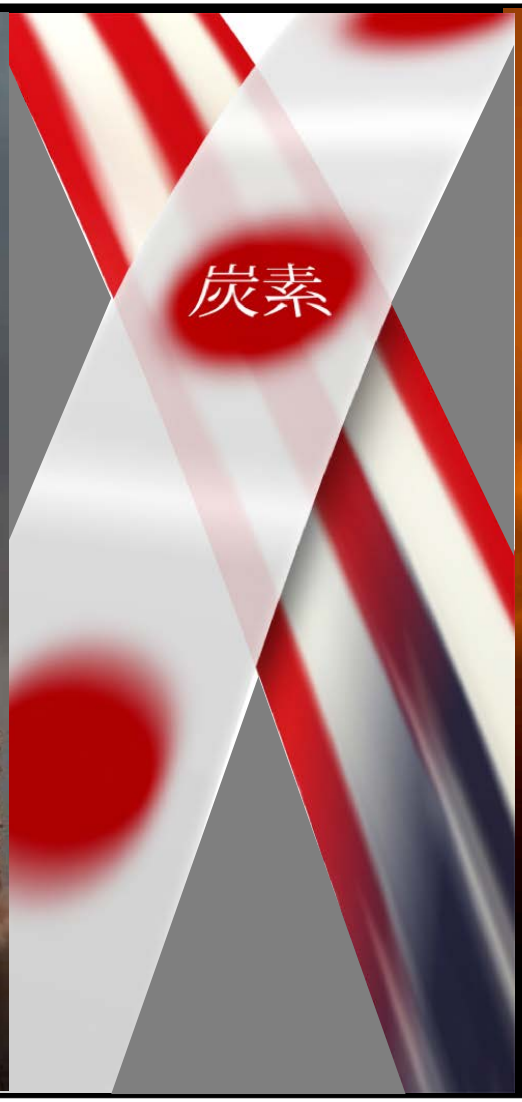
The solar diffuser consists of a pair of plates with a series of pin holes that are offset from each other, with a gold coated internal surfaace



Hypothesis;

- As solar UV interacts with contaminants on the gold coated inter surface, it causes darkening.
- The most severe darkening is expected in the ABO2 Channel
- The rate of the darkening is uniform, but cannot be predicted prior to launch.

ABSCO Updates



O_2 A band

ABSCO Tables		v4.2 (L2 v7)	v5.0
13200cm^{-1} O_2	**Line shape**	Voigt for main iso. Galatry for minor iso. Positions, intensities from Long [2010; 2011]	Speed-dependent Voigt from self-consistent set of multi-spectrum fits, utilizing FTS and CRDS measurements **(Drouin et al. 2016, JQSRT)**
	Line mixing	Tran & Hartmann [2008]	
	Collision Induced Absorption (CIA)	Tran & Hartmann [2008]	From ground-based atmospheric measurements at Lamont (E. Mlawer, AER) and CRDS
	H_2O-O_2 broadening	Drouin et al. [2014]	Drouin et al. [2014]

ABSCO v5.0: Self-consistent set of parameters!

Multispectrum fitting approach pioneered by Chris Benner and Malathy Devi

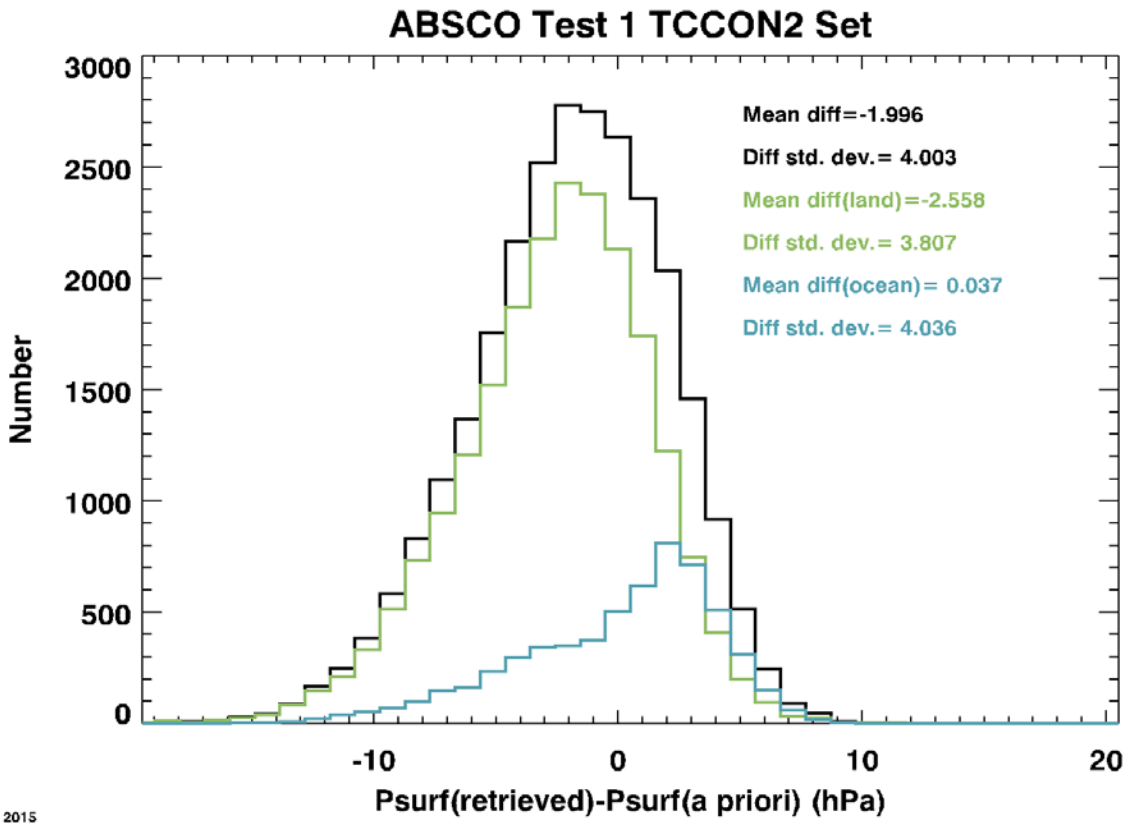
Speed Dependent Voigt (SDV): Accounts for the fact that collisions between molecules take place with velocities spanning some distribution

Line mixing: Accounts for collisional coupling (mixing) between spectral lines. Interactions described by a relaxation matrix.

Collision Induced Absorption: Accounts for inelastic collisions between molecules

Impact of O_2 A-band ABSCO update on surface pressure retrieval

A priori surface pressure values are from ECMWF.
We expect ECMWF values to be a good estimate of reality, on average.



2 Dec 2015

B7 No-EOF baseline (ABSCO v4.2)

Impact of O_2 A-band ABSCO update on surface pressure retrieval

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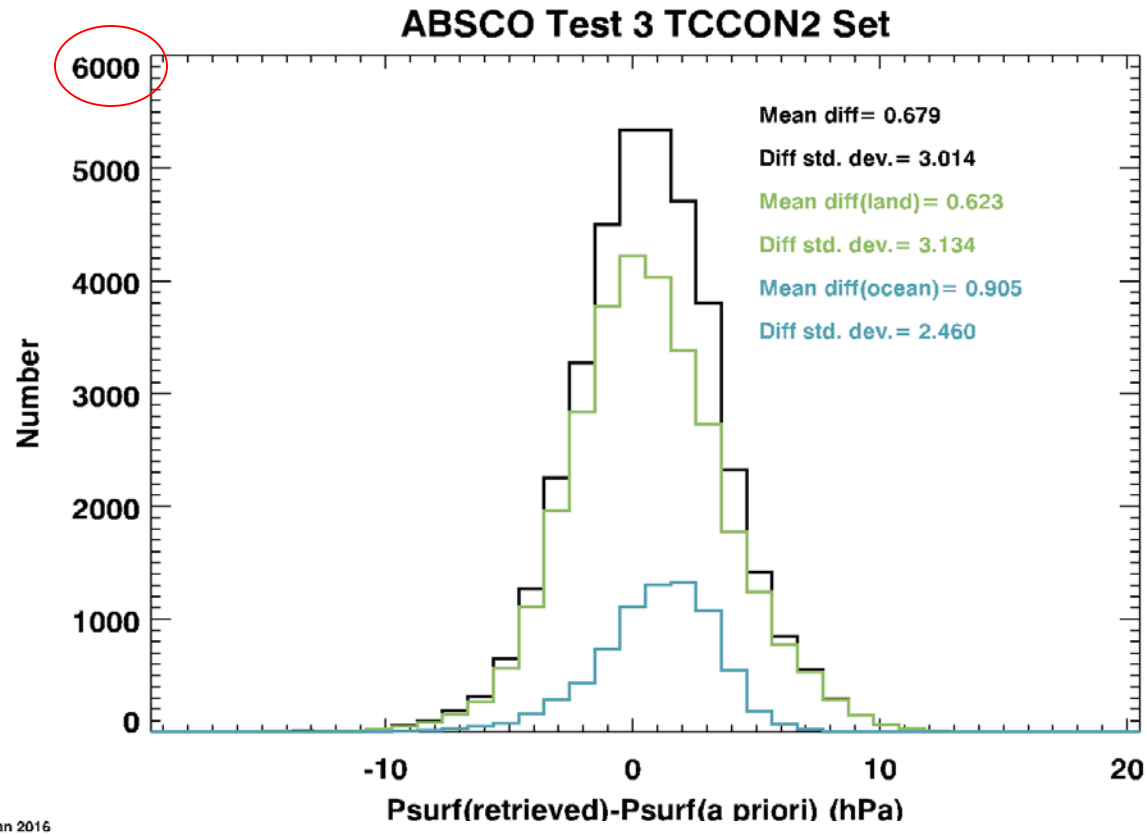


ABSCO v5.0

ABSCO v5.0

- Land and ocean closer
- Peak closer to zero
- Std. dev. reduced
- Distributions more symmetric

ABSCO updates also have a strong impact on the retrieval of aerosol parameters!

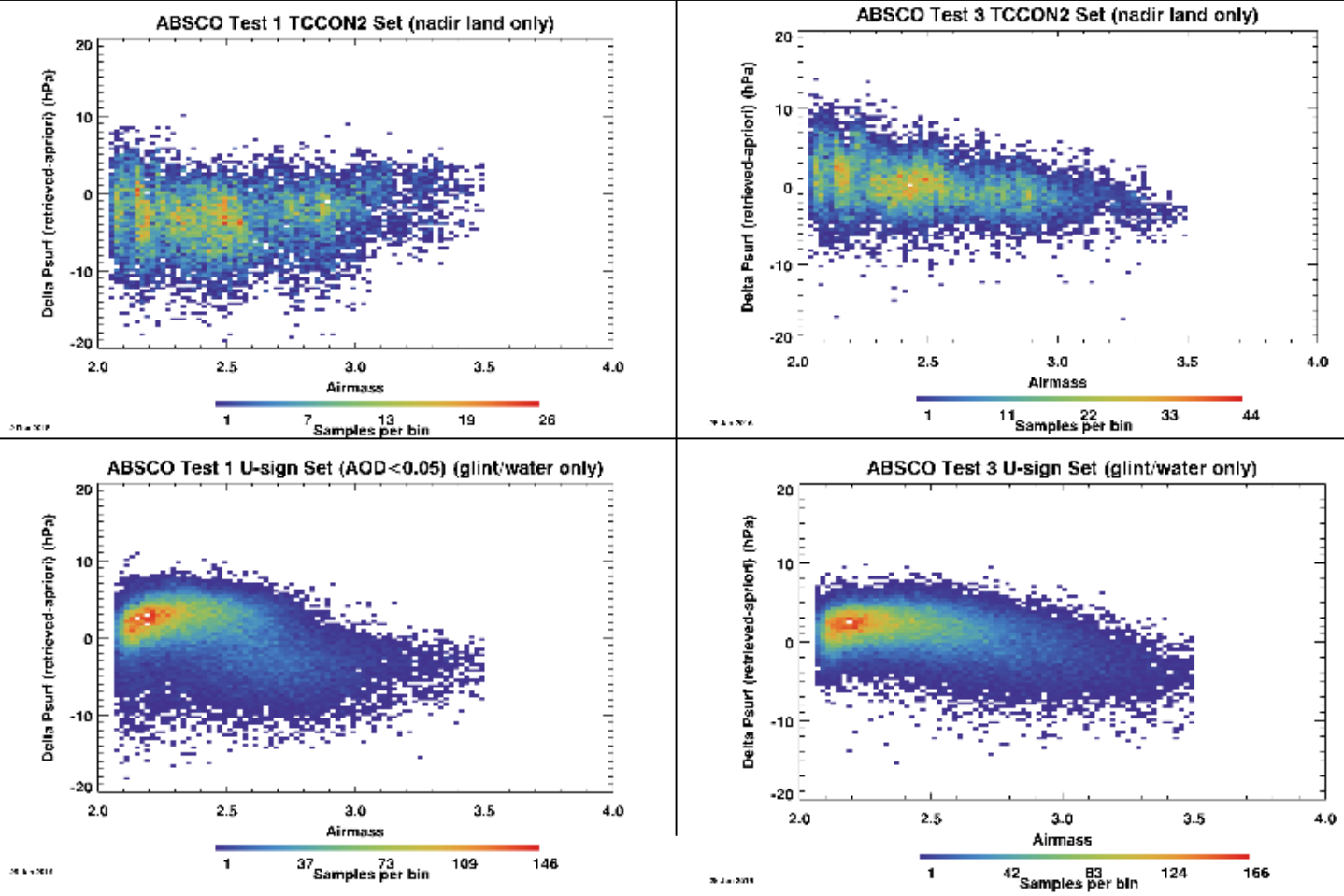
Impact of O_2 A-band ABSCO update on airmass dependence of PSUR retrieval

B7 No-EOF baseline (ABSCO v4.2)

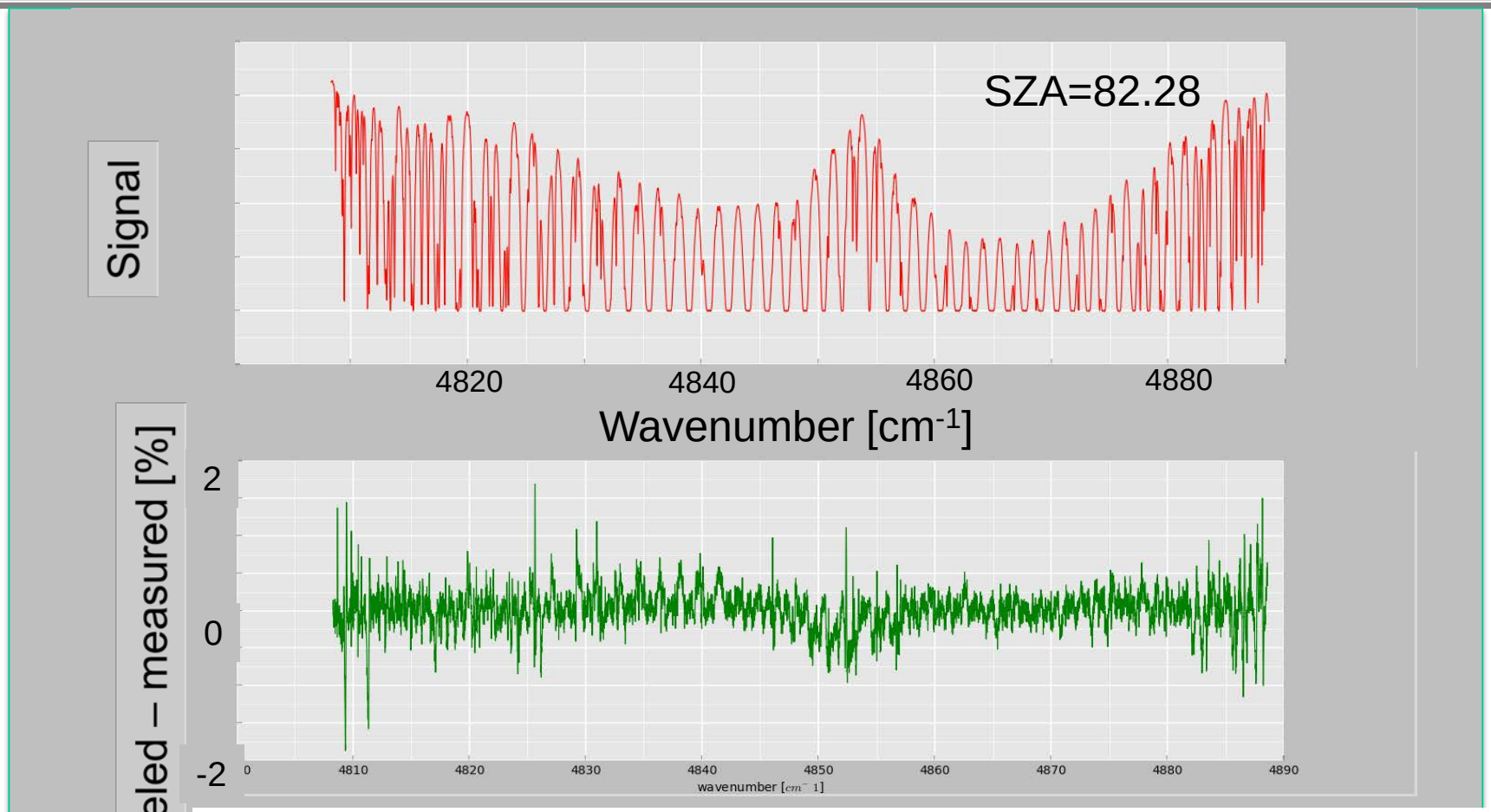
ABSCO v5.0

Land nadir ("TCCON2")

Ocean glint ("u-sign")



Update to 2.06 μm: TCCON FTS residuals



ABSCO v4.x, v5.0: Empirical absorption is added to center of SCO2 band to improve the residual fits.
(These residuals include this empirical absorption)

Line mixing: Relaxation matrix

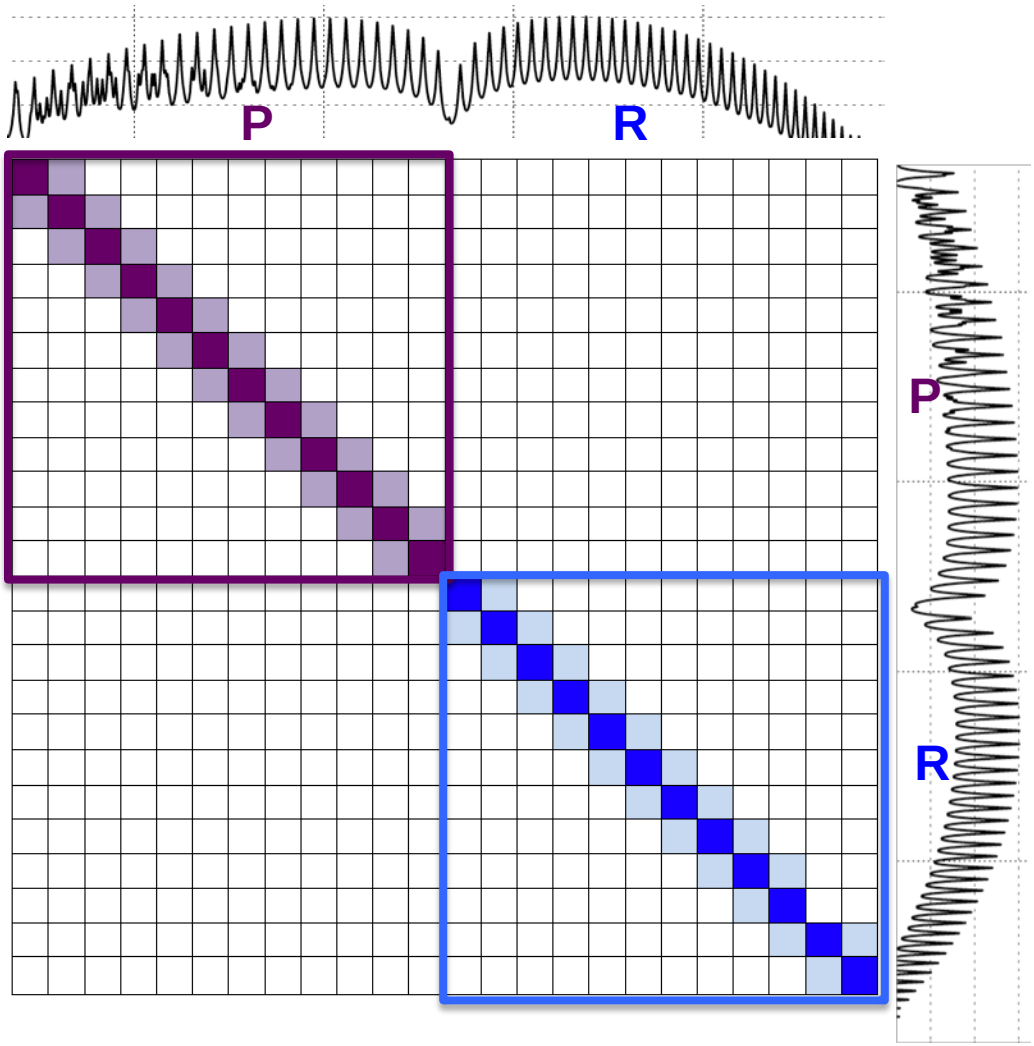
Absco v4.x, 5.0:

Multi-spectrum fits to laboratory spectra

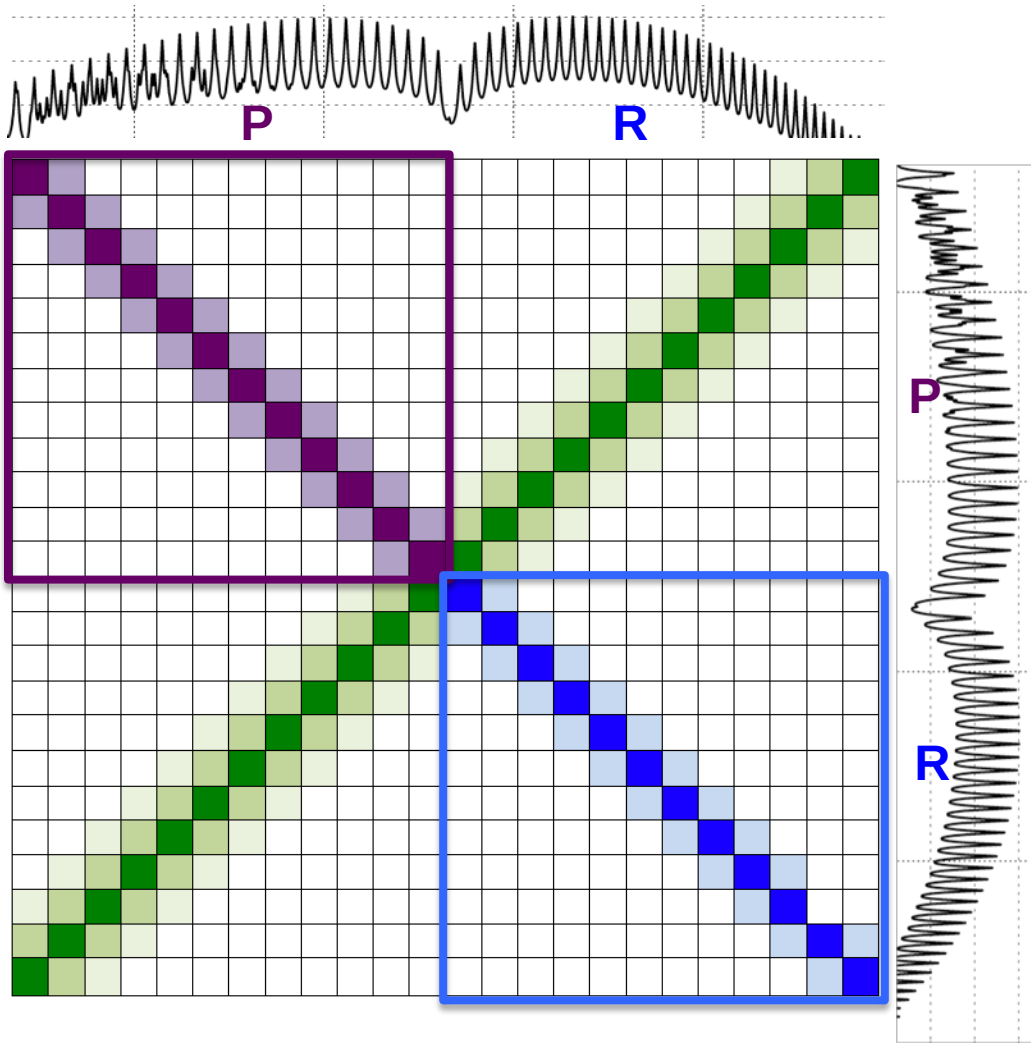
Nearest-neighbor line mixing

Fit relaxation matrix elements in the multi-spectrum fit

Self-consistent set of multi-spectrum fit parameters gave better results than matrices from theory combined with available spectroscopic databases.
(e.g. Thompson et al [2012])

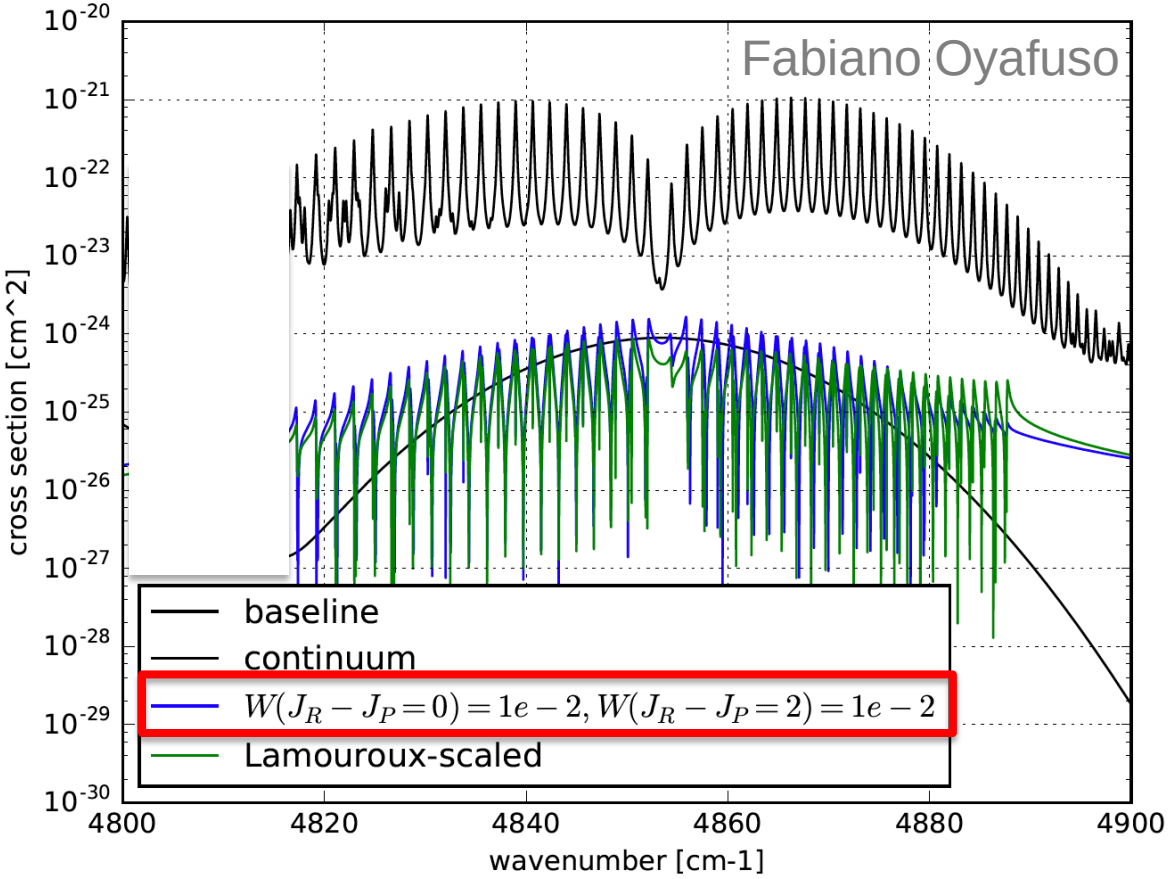


Line mixing: Relaxation matrix

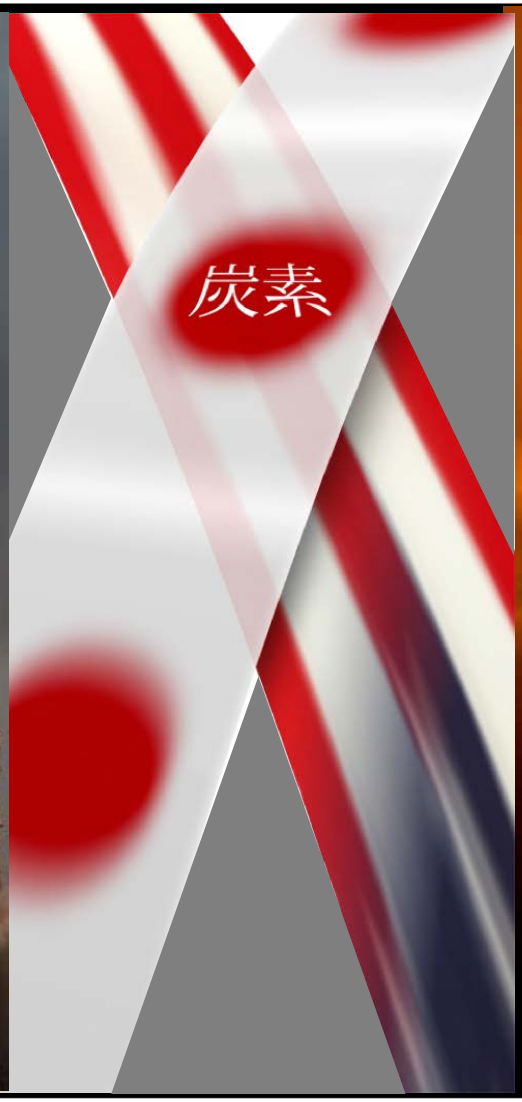


Mixing between P and R branch lines can account for the empirical SCO2 absorption

(No more need for "SCO2 CIA"!)



Version 7 Status and Version 8 Plans

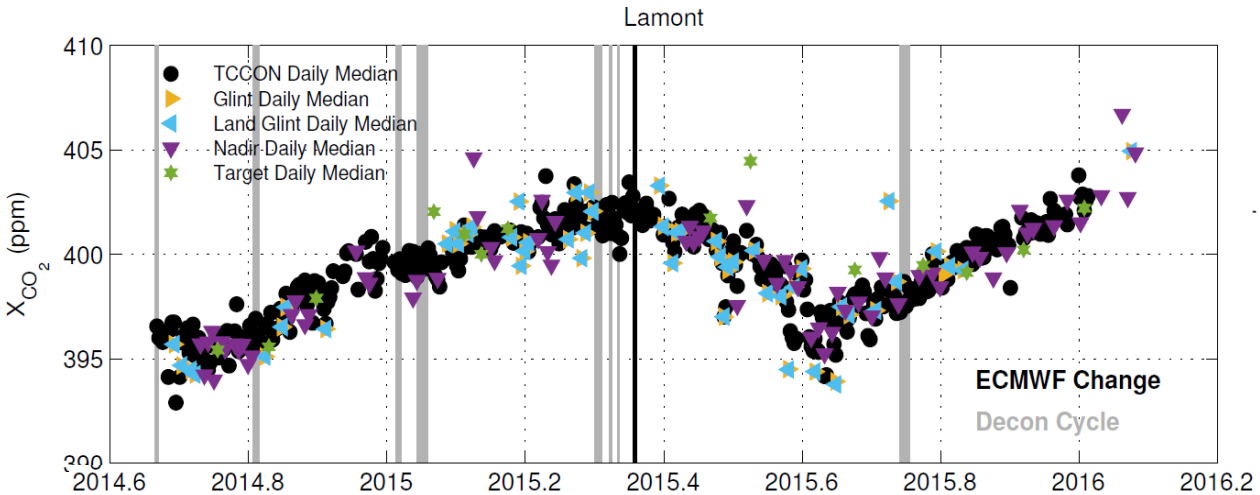


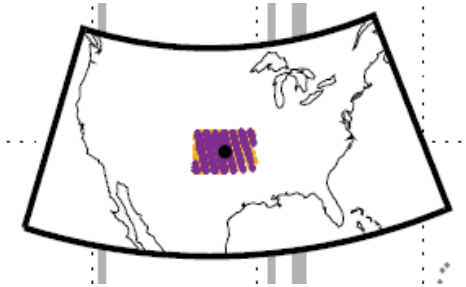
V7 Updates and V8 Testing

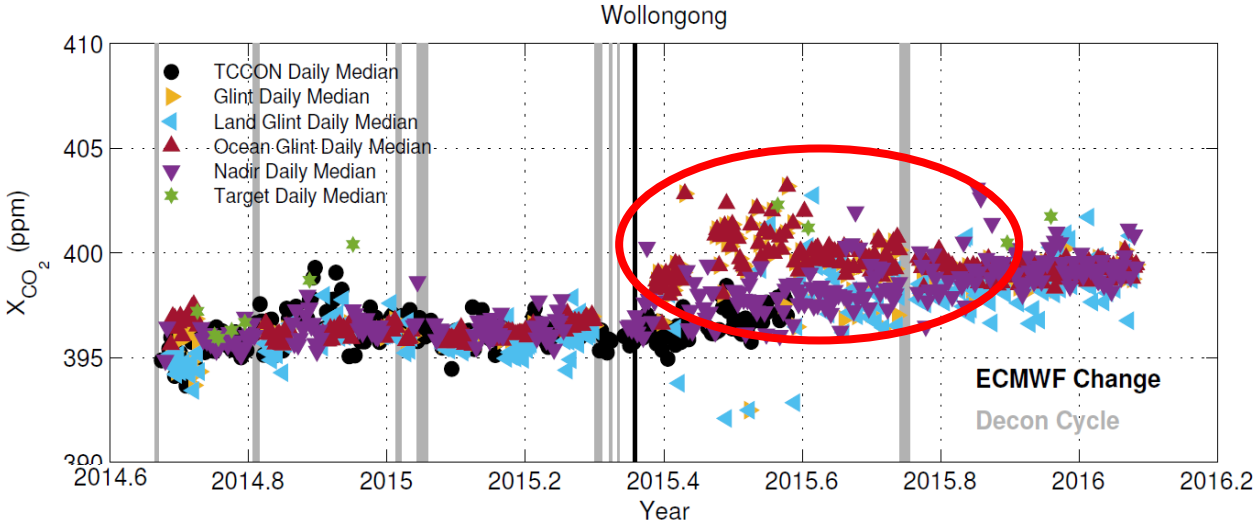
- V7 Updates – improved data screening
  - A revised bias correction is being developed to correct the ECMWF Geopotential error
  - Revised warn levels have been developed, using a much larger set of data
  - These changes will be incorporated into the Lite files for release in the near future

- V8 Testing
  - Recent testing indicates that the retrievals in the region where the southern hemisphere XCO2 glint anomaly is seen are very sensitive to the presence of a thin (AOD ~0.005), high altitude (stratospheric, 30 hPa) aerosol layer
  - Tests are ongoing to determine the extent which the addition of a thin stratospheric aerosol layer might mitigate the observed XCO2 bias

Temporal Changes in X_{CO2}: Comparisons with TCCON and other Standards



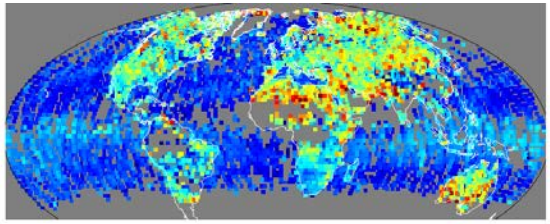




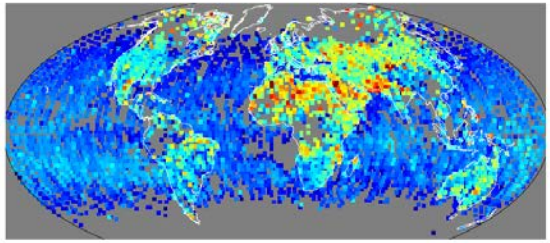
CSIRO Marine and Atmospheric Research and Australian Bureau of Meteorology (Cape Grim Baseline Air Pollution Station)

Bias Corrections in the V7 Lite Products

Amplitude of V7 Lite bias correction in 2°x2° bins



06/2015



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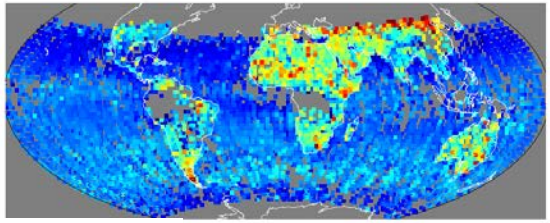
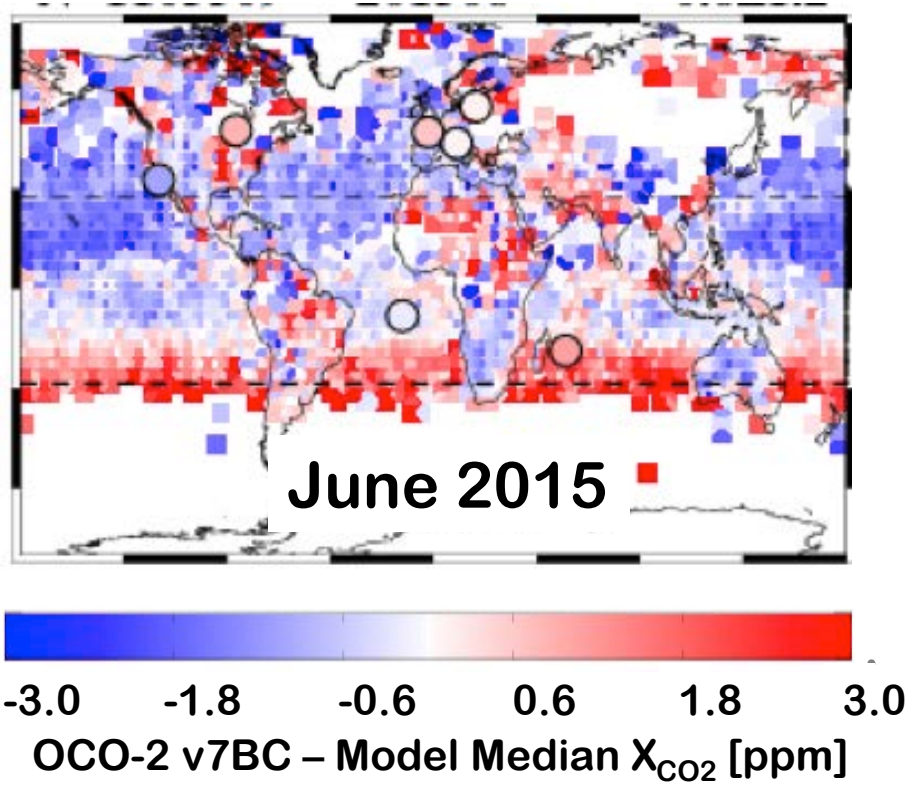
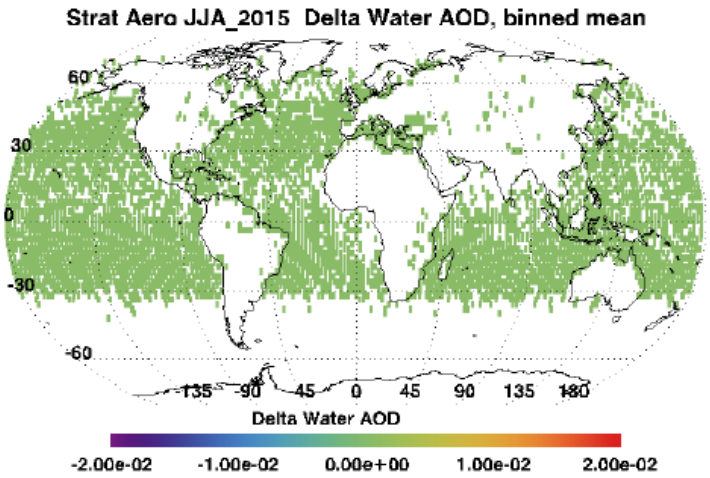


12/2015

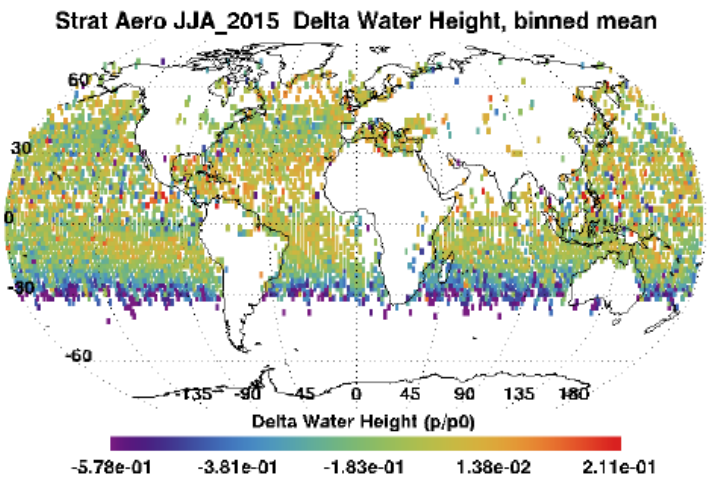
Residual bias vs Multi-Model Means

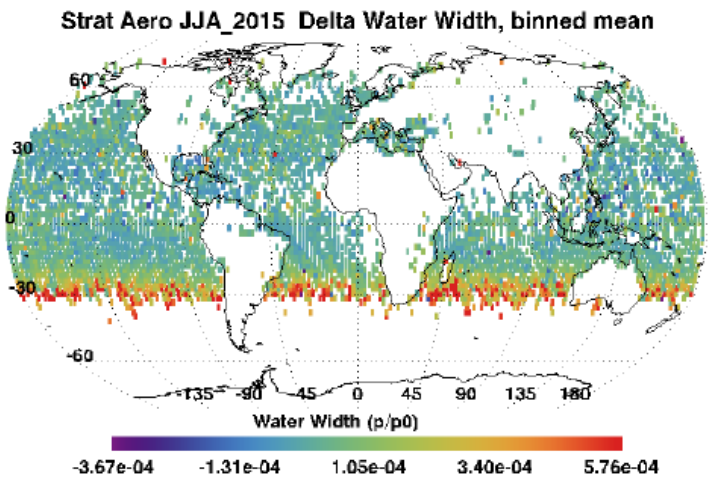


Impact of Stratospheric Aerosols on Retrieved Liquid Water Distribution

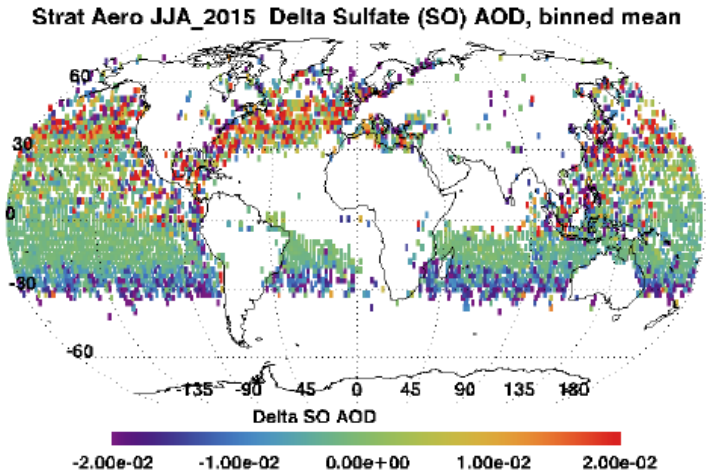


The addition of a thin stratospheric aerosol changes the liquid water vertical distribution.

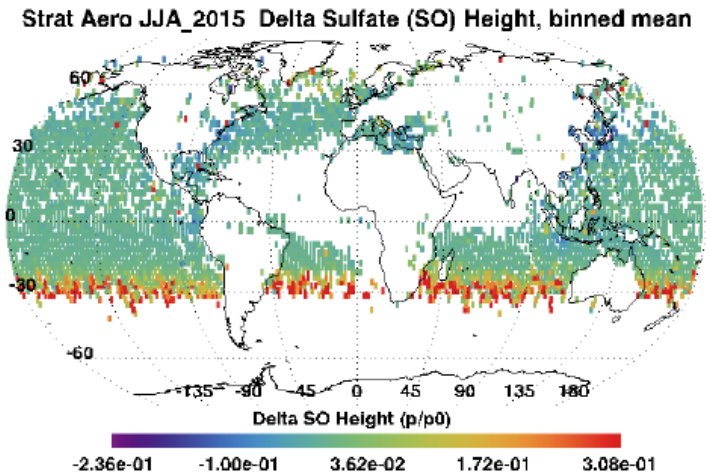


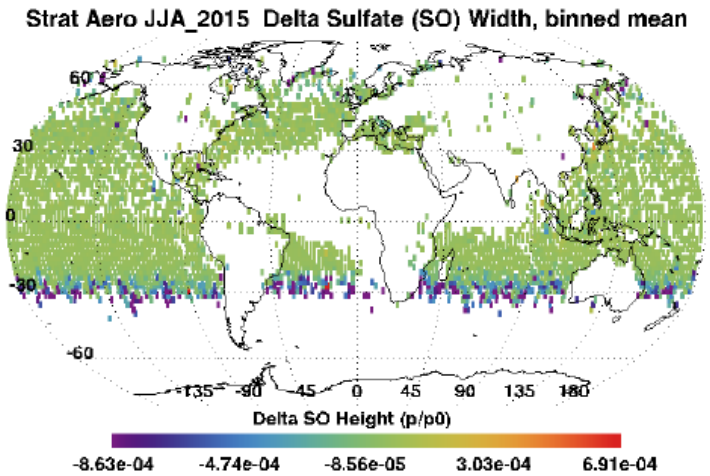


Impact of Stratospheric Aerosols on Retrieved Sulfate Aerosol Distribution

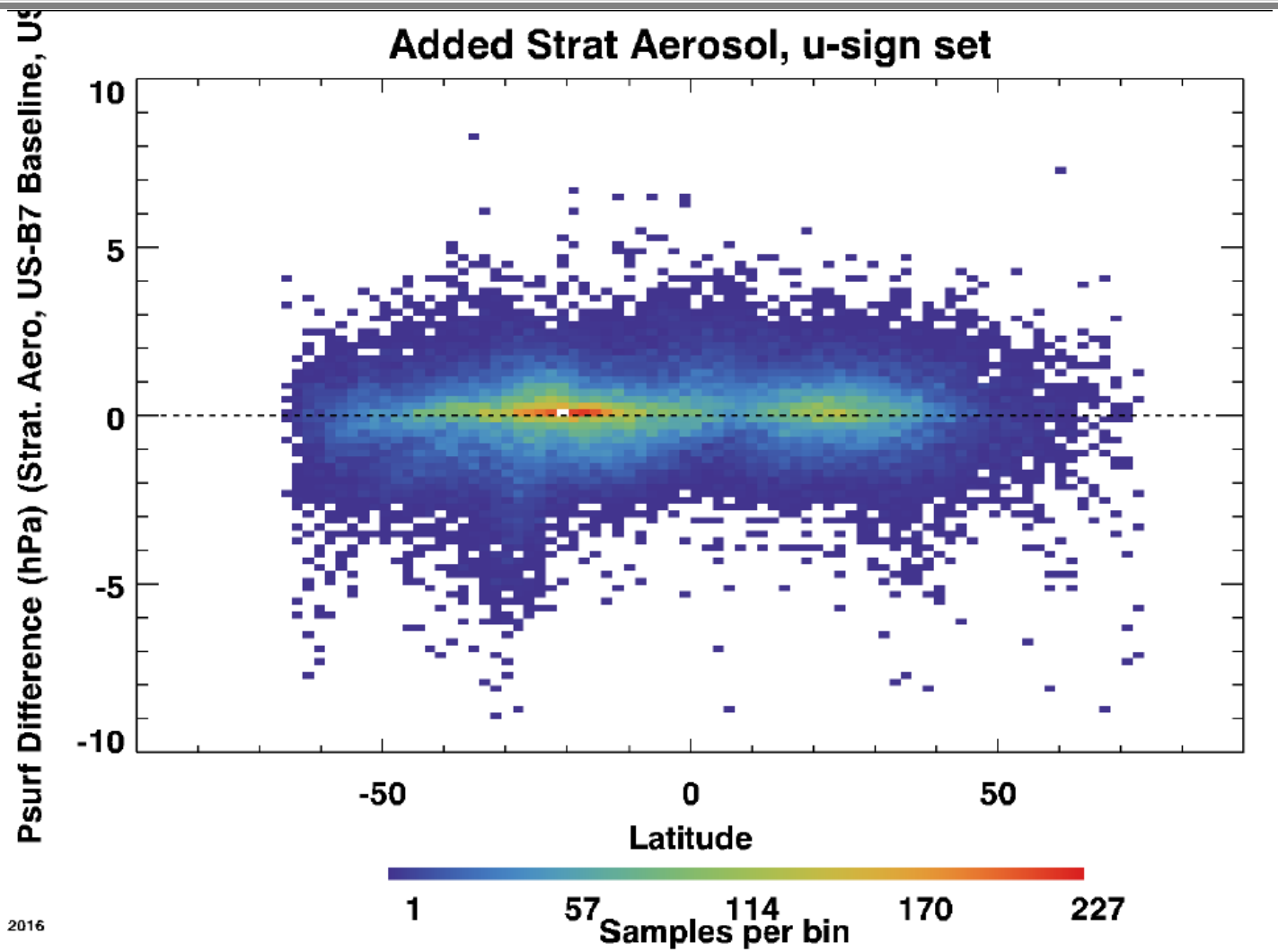


The addition of a thin stratospheric aerosol layer changes the retrieved sulfate aerosol optical depth and vertical distribution.

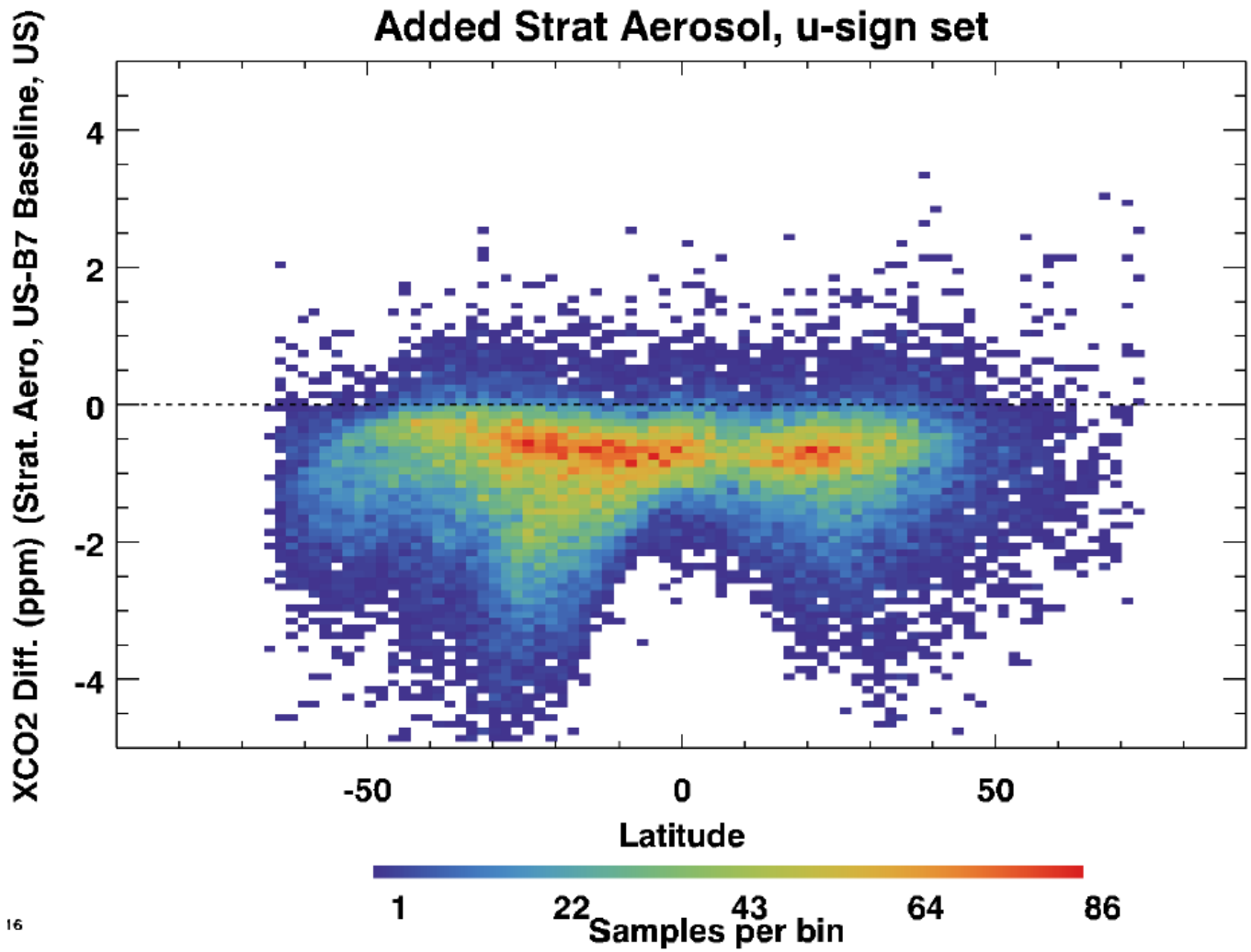




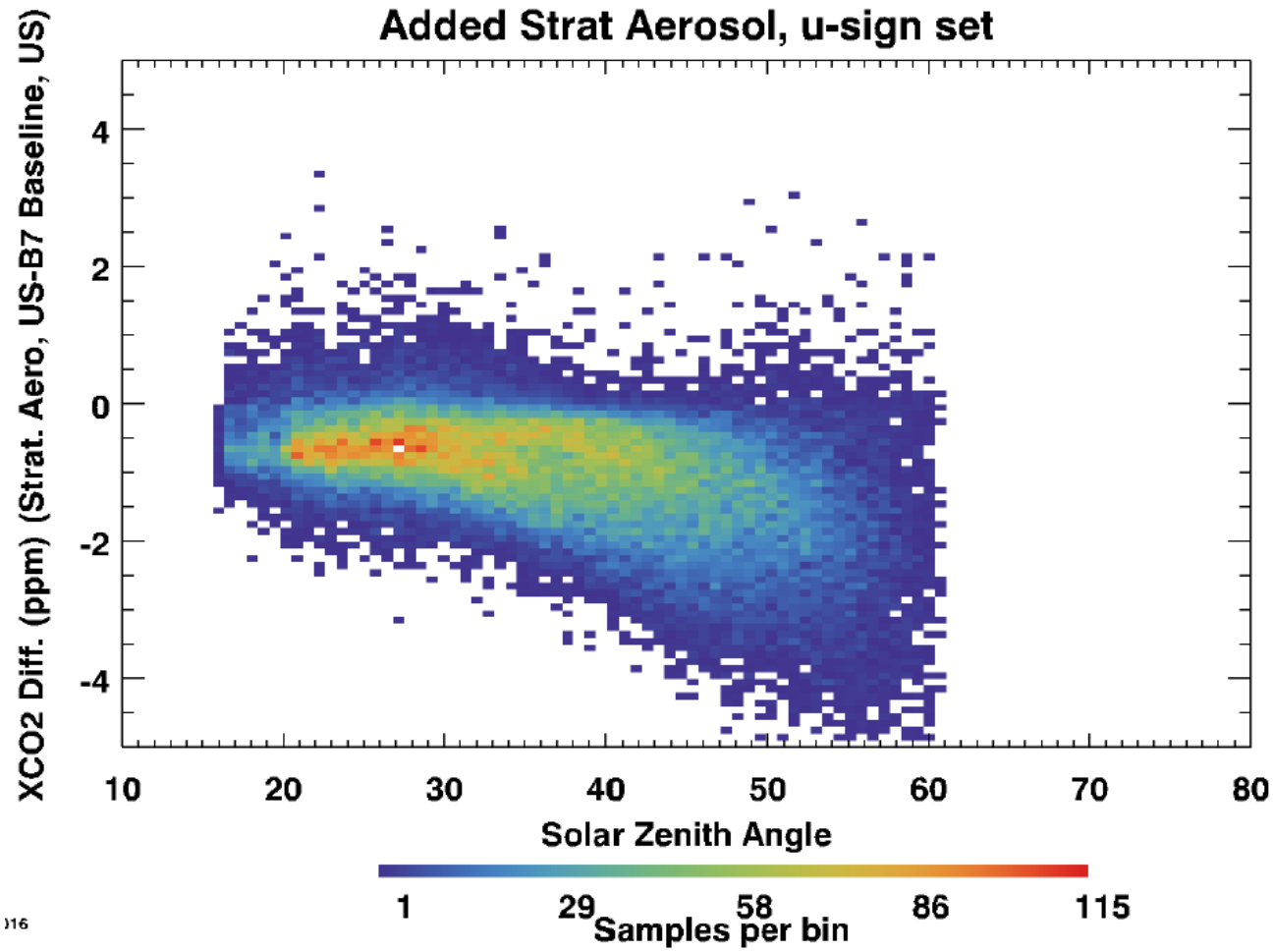
Impact of Stratospheric Aerosol on Surface Pressure



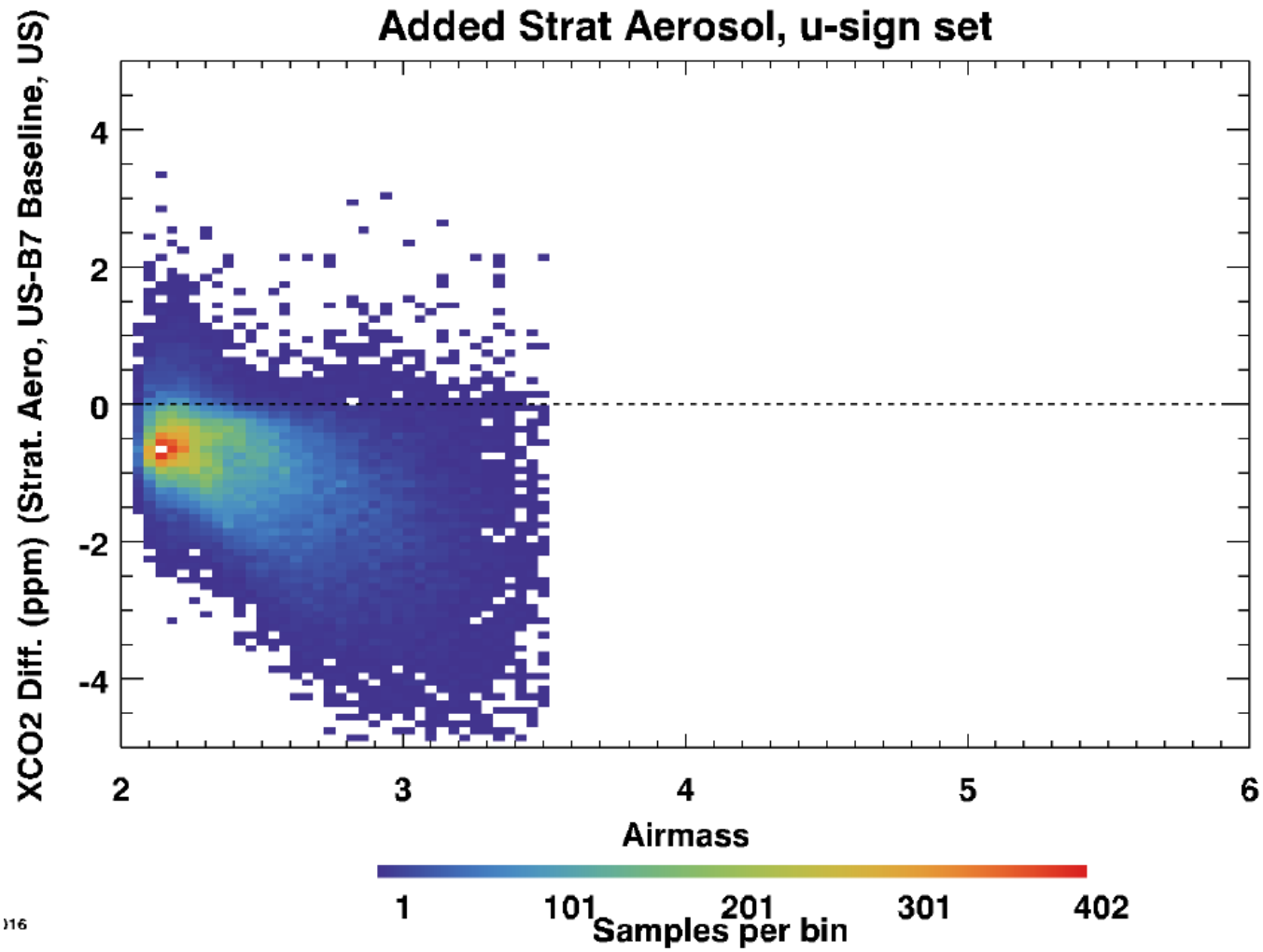
Effect of Stratospheric Aerosol: Latitude Dependence



Effect of Stratospheric Aerosol: Solar Zenith Angle Dependence

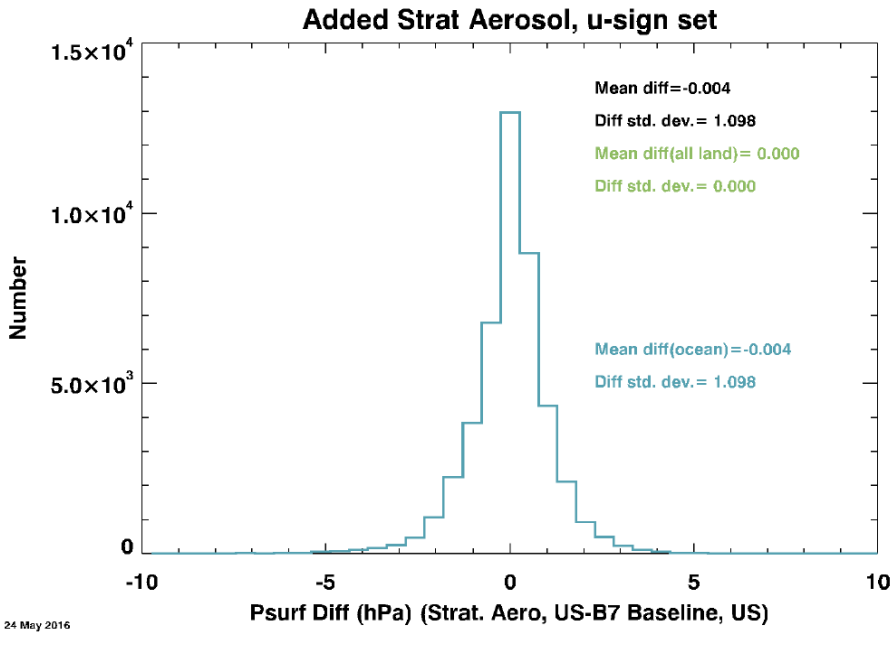


Effect of Stratospheric Aerosol: Solar Airmass Dependence

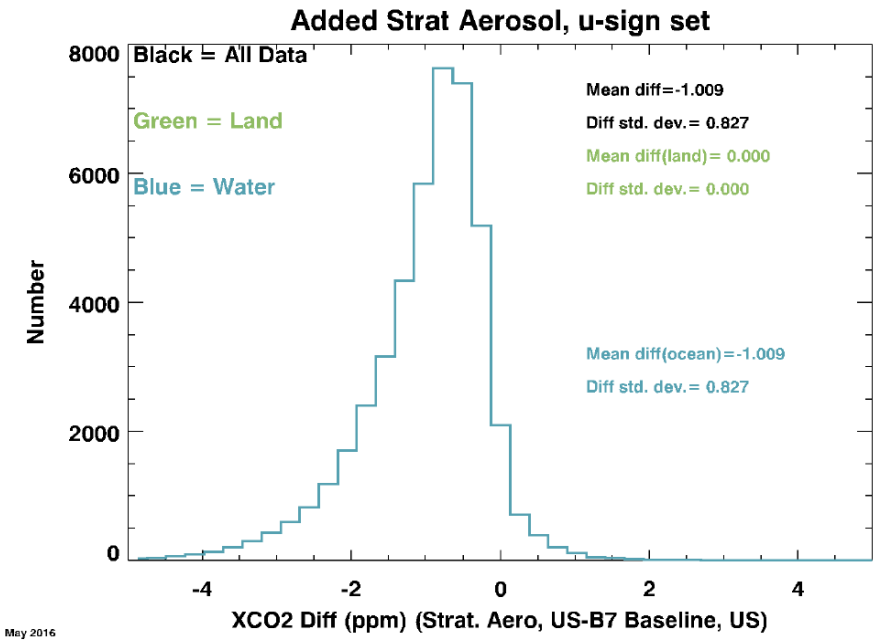


Summary: Effect of Stratospheric Aerosol on Surface Pressure and XCO2

Surface Pressure



XCO2



Negligible Impact on surface pressure

Large, systematic change in XCO2

V8 Testing Continues!