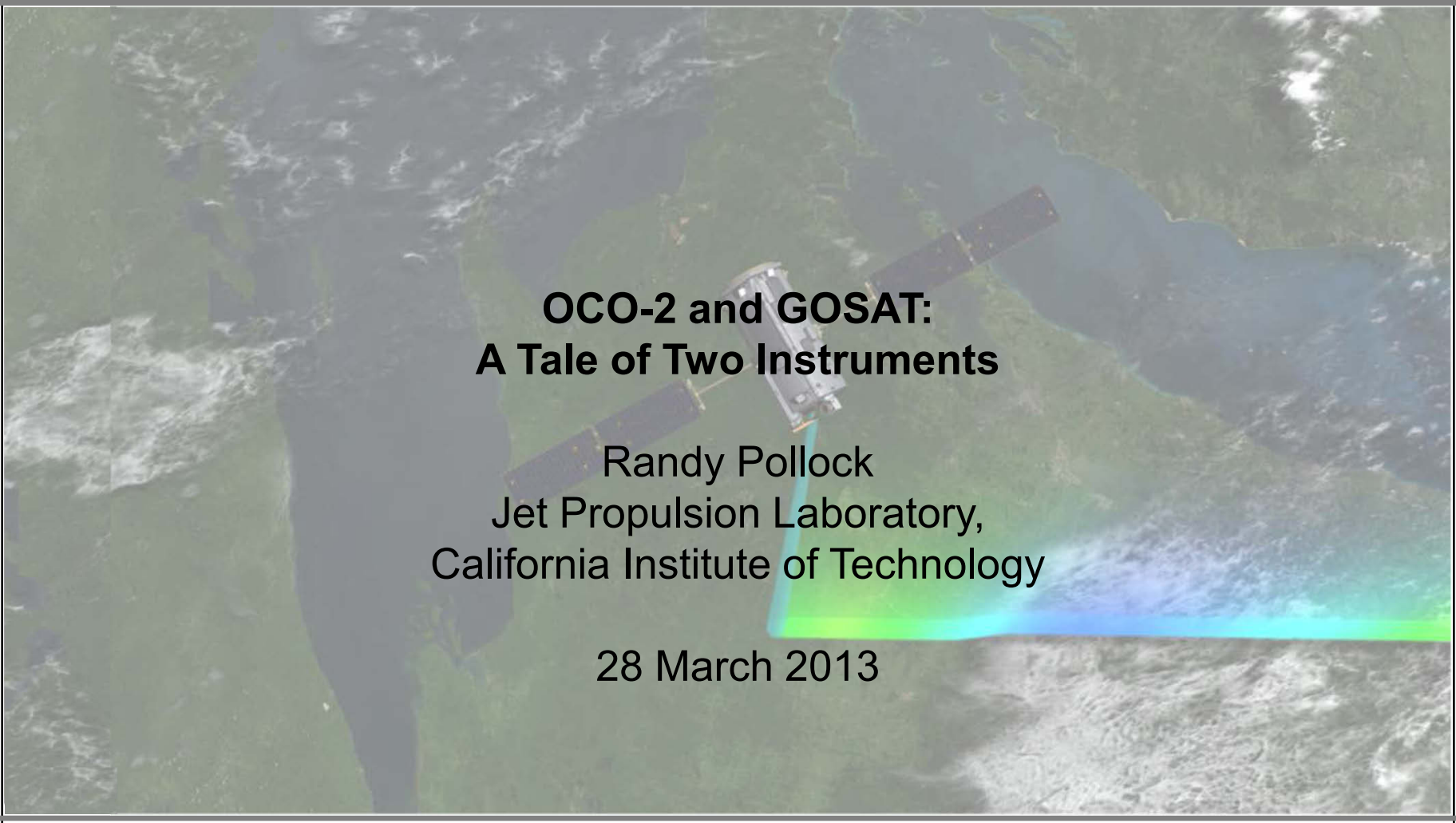

OCO-2 and GOSAT:
A Tale of Two Instruments

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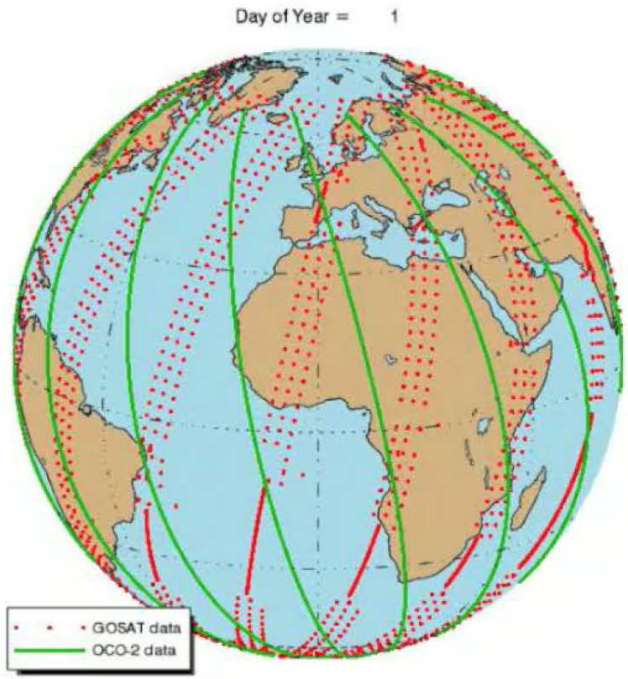
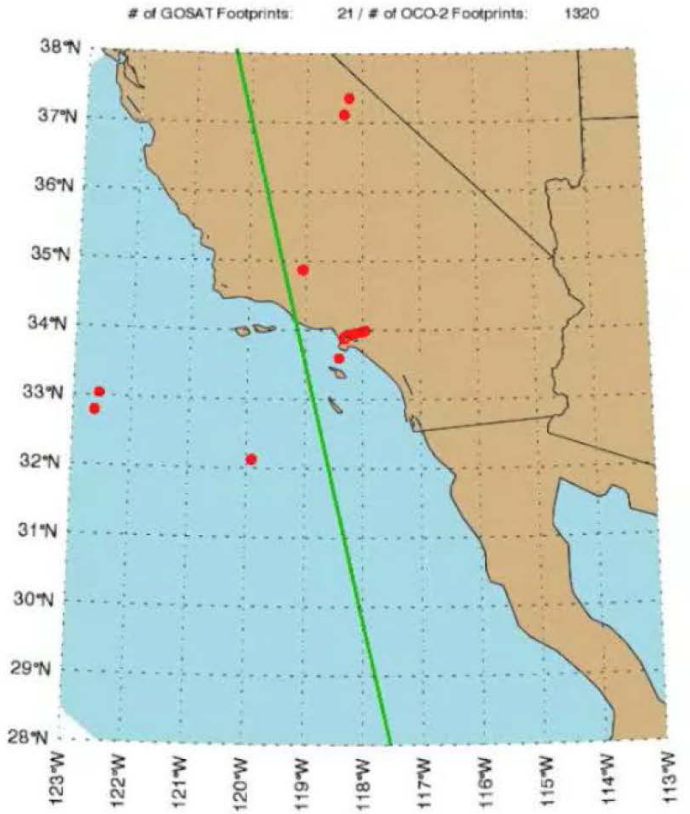
Summary of Differences in Approach to Sampling the Earth

Parameter	OCO-2	GOSAT
Spatial	○ ~3 km^2 ○ ~1,000,000 sounding/day ○ 16-day repeat cycle ○ Glint mode at all latitudes ○ Target mode with large variation in path lengths	○ ~75 km^2 ○ ~10,000 sounding/day ○ 3-day repeat cycle ○ Glint mode only in tropics ○ Target mode only at closest approach
Spectral	○ 24,000 ILS's ○ 1,016 samples per band ○ Resolution ~21,000:1	○ 6 ILS's ○ ~1,800 - 3,500 samples per band ○ Resolution varies by band
Radiometric	○ 24,000 Gain Curves ○ 487,885 pixels ○ Noise independent for each sample	○ 6 Gain Curves ○ 6 pixels ○ White noise
Polarization	○ 1 linear polarization	○ 2 linear polarizations

Footprint Sampling

- OCO-2 will take thousands of sample over a given region every couple of days
- GOSAT will take a few dozen sample over the same region most days



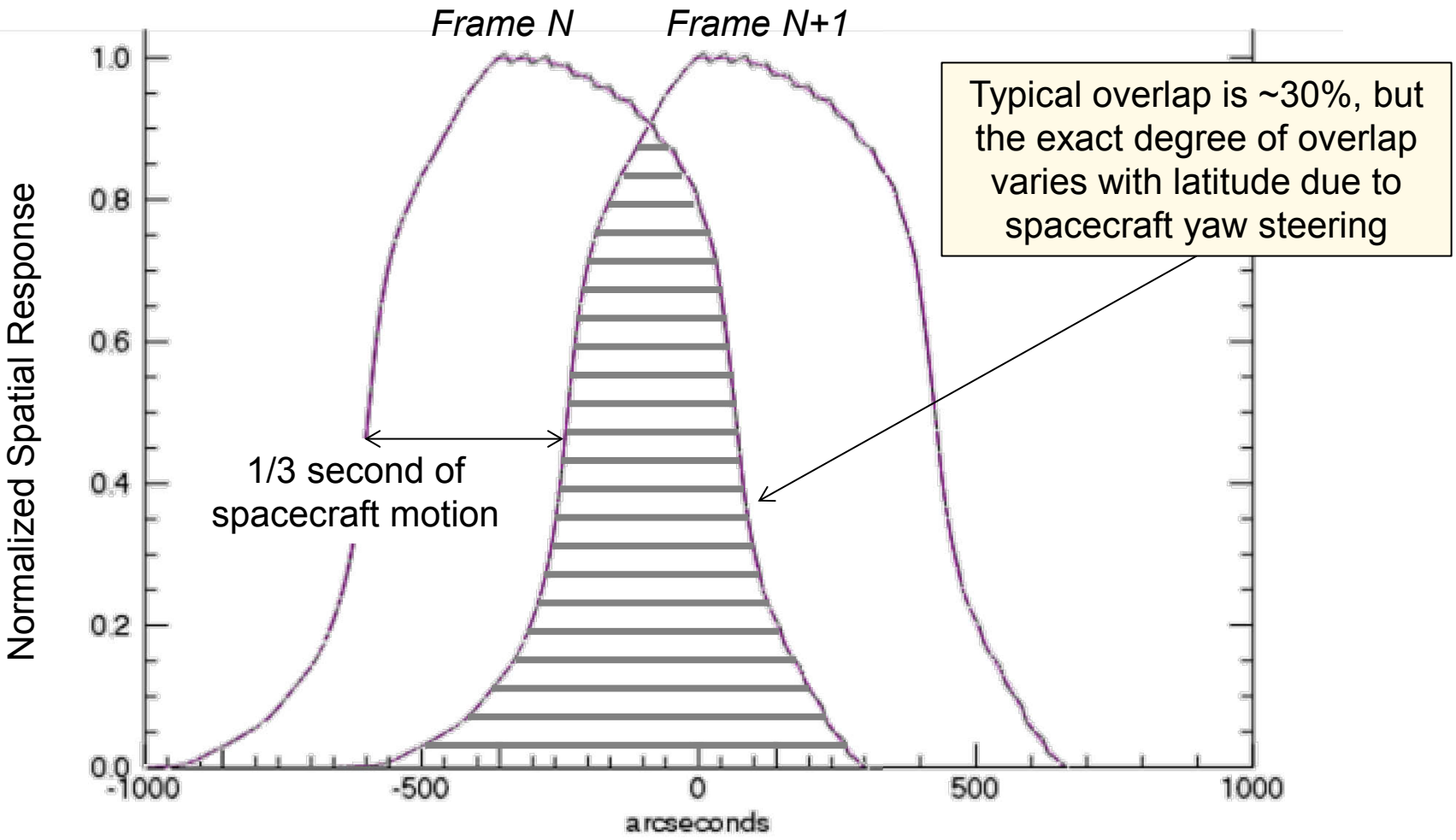


Other Sampling Notes

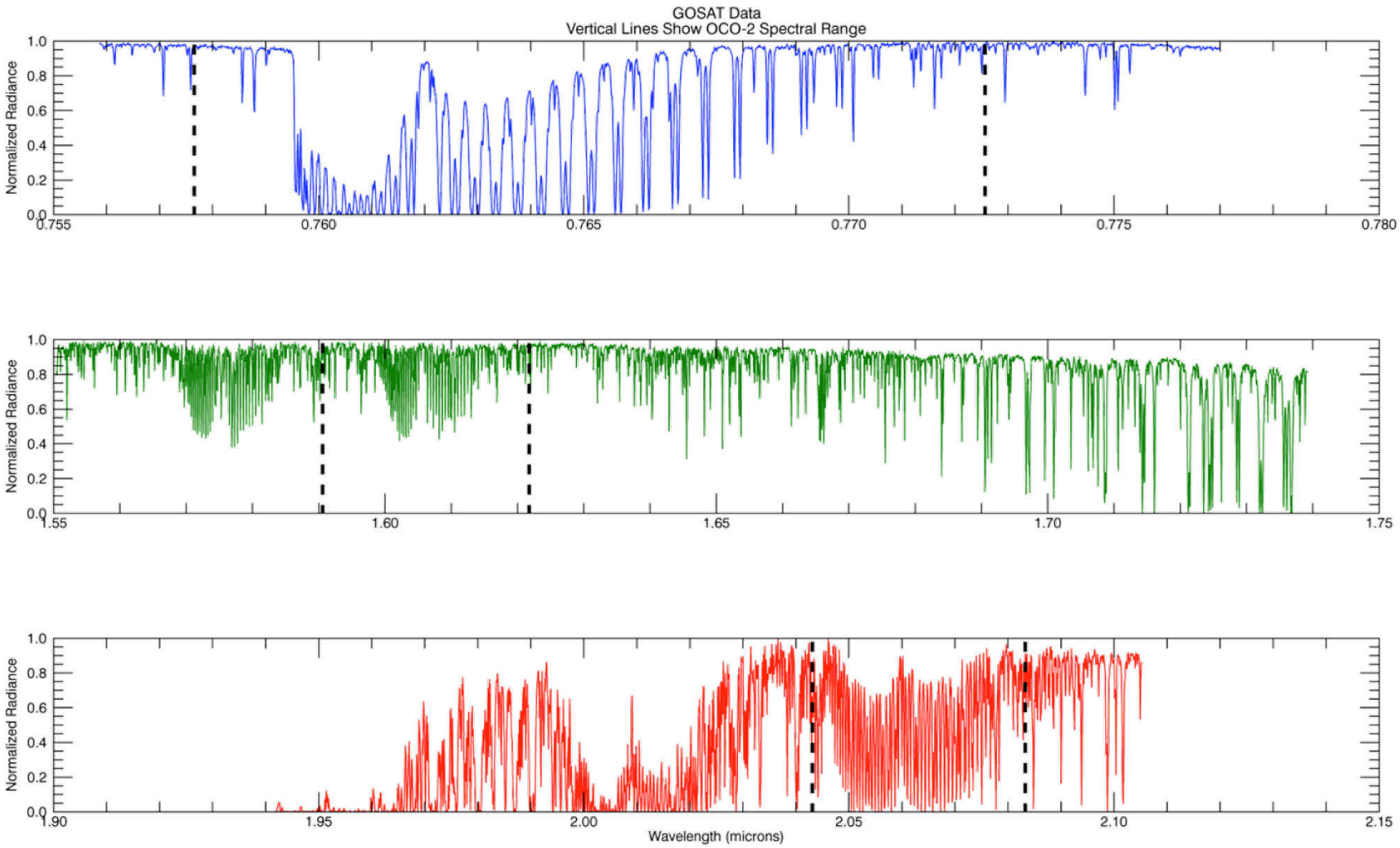
- Glint Mode
  - GOSAT can only track the glint in the tropics
  - OCO-2 will track the glint from pole to pole (even over land) 16 days out of every 32 days
    - OCO-2 will observe much, much longer path lengths at high latitudes
    - Especially at high latitudes, the Doppler shift is non-negligible

- Target Mode
  - GOSAT takes up to 6 spectra at a given location
    - All are at near directly overhead
  - OCO-2 takes > 10,000 spectra in the neighborhood of a given location
    - Path lengths vary from a couple of atmospheres to several atmospheres
    - Once again, the Doppler shift is non-negligible

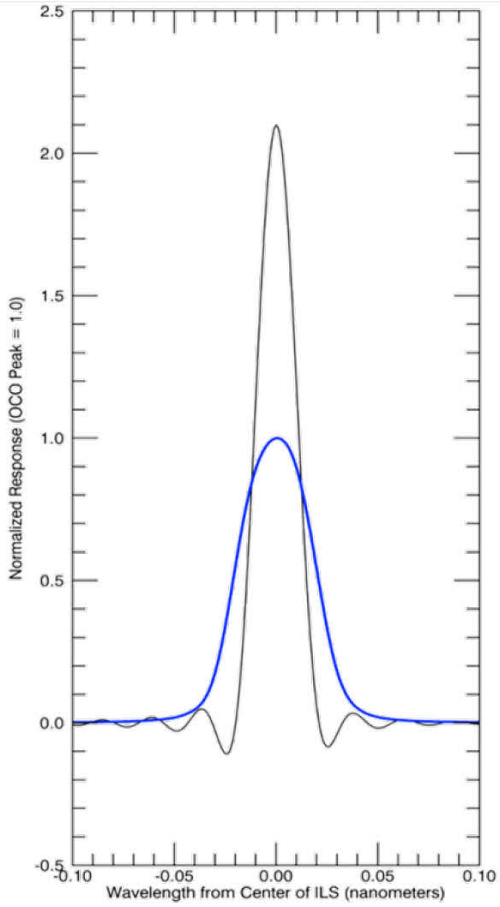
OCO-2 Spatial Sampling is Not Independent

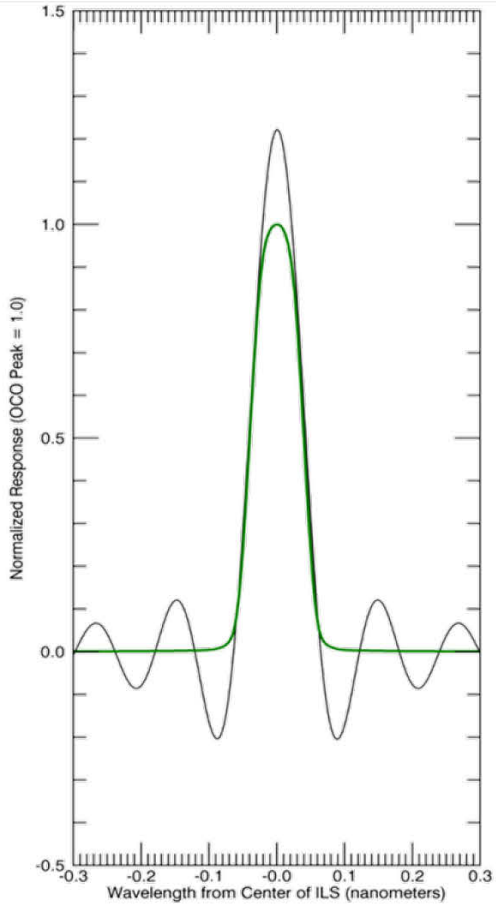


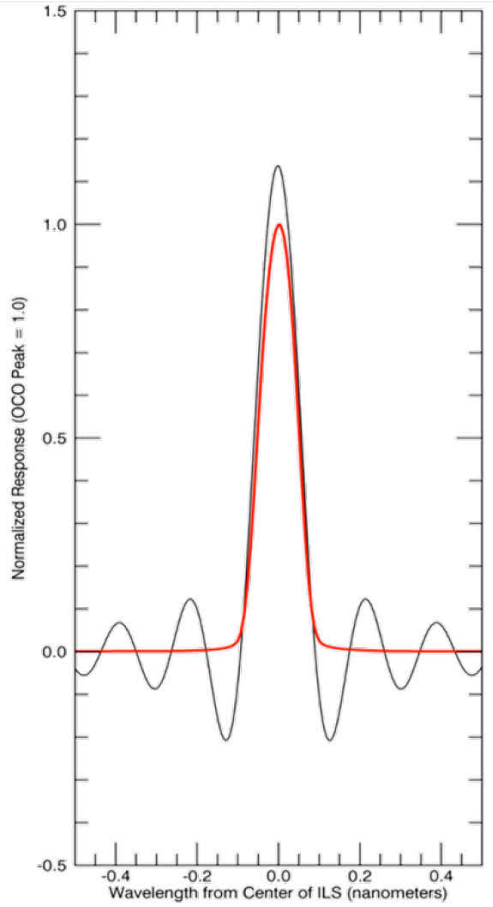
GOSAT Has Wider Spectral Ranges



Linear Instrument Line Shapes
GOSAT = Black / OCO-2 = Colors

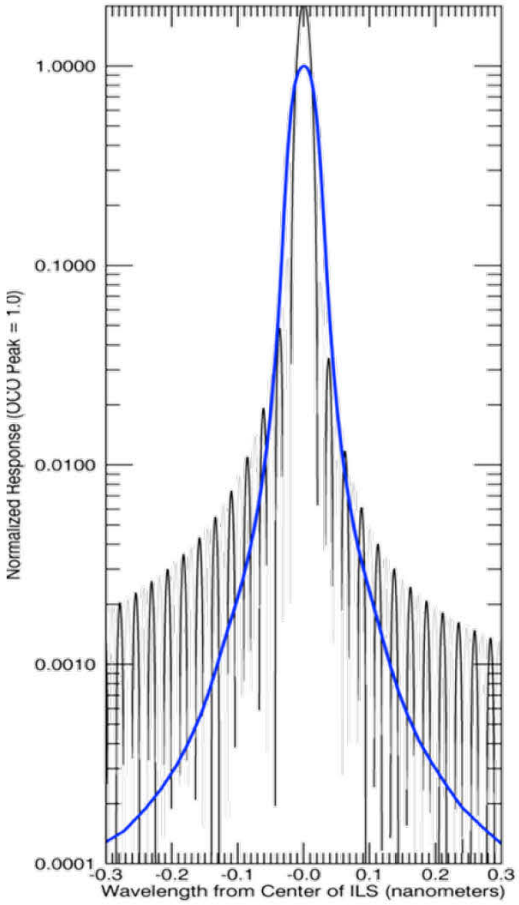


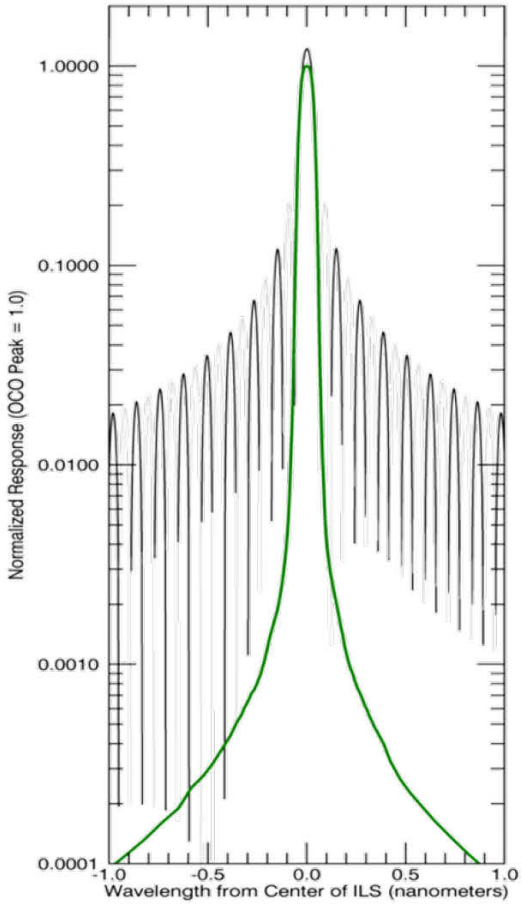


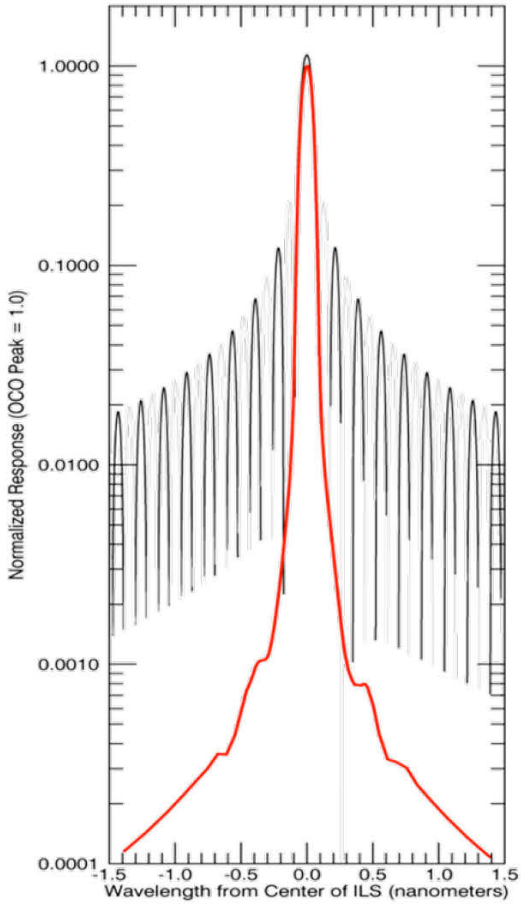


GOSAT has ~2x higher resolution in the A-band / comparable in the CO_2 bands

Logarithmic Instrument Line Shapes
GOSAT = Black & Grey / OCO-2 = Colors



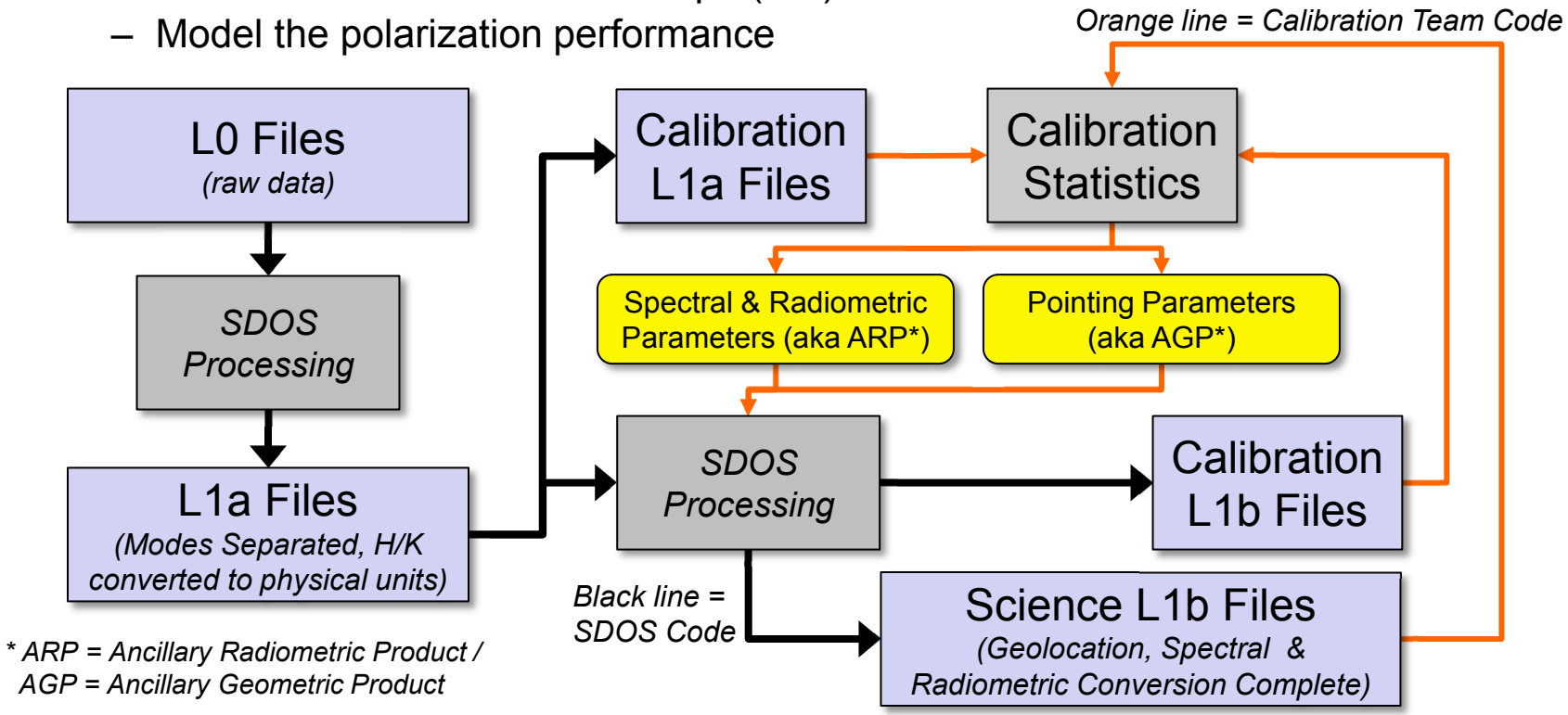




OCO-2's ILS falls off much faster than GOSAT's
Less light will be detected far from the peak wavelengths

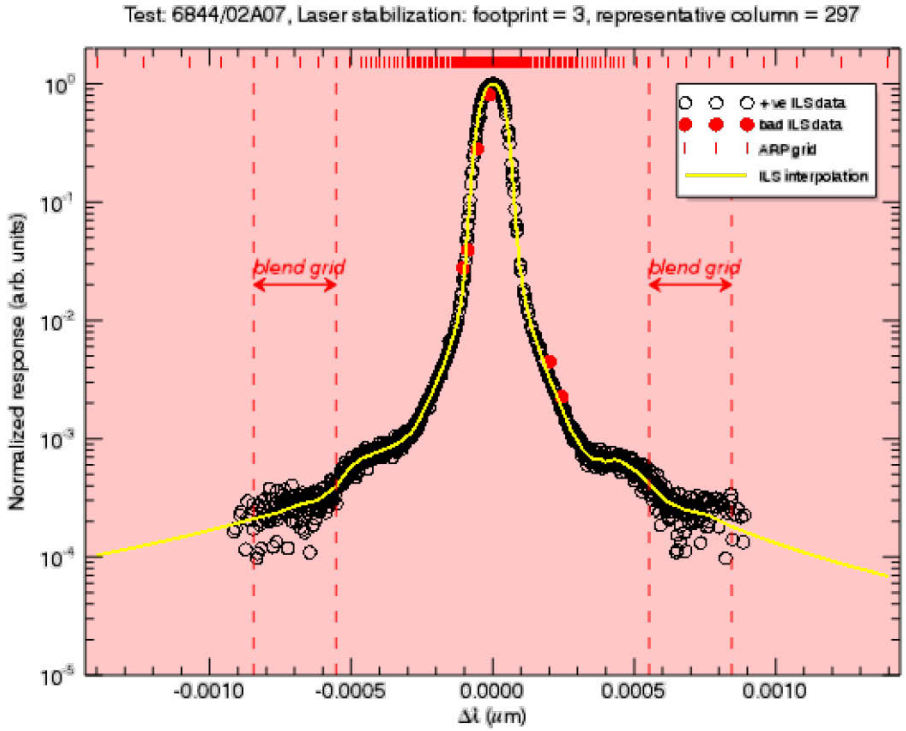
Calibration And It's Role In Data Processing

- Calibration Team provides instrument related parameters used to:
  - Convert spacecraft pointing/time data into geolocation information
  - Convert raw detector data into calibrated radiances including noise estimates
  - Convert FPA columns into wavelengths (non-Doppler corrected)
  - Model the Instrument Line Shape (ILS)
  - Model the polarization performance

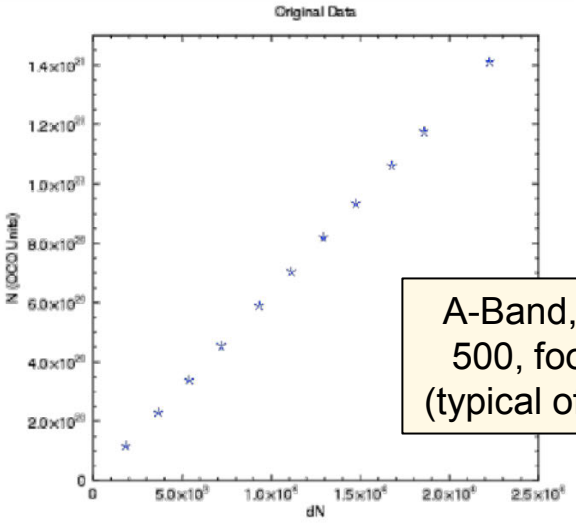


OCO-2 Instrument Line Shape (ILS) Expression

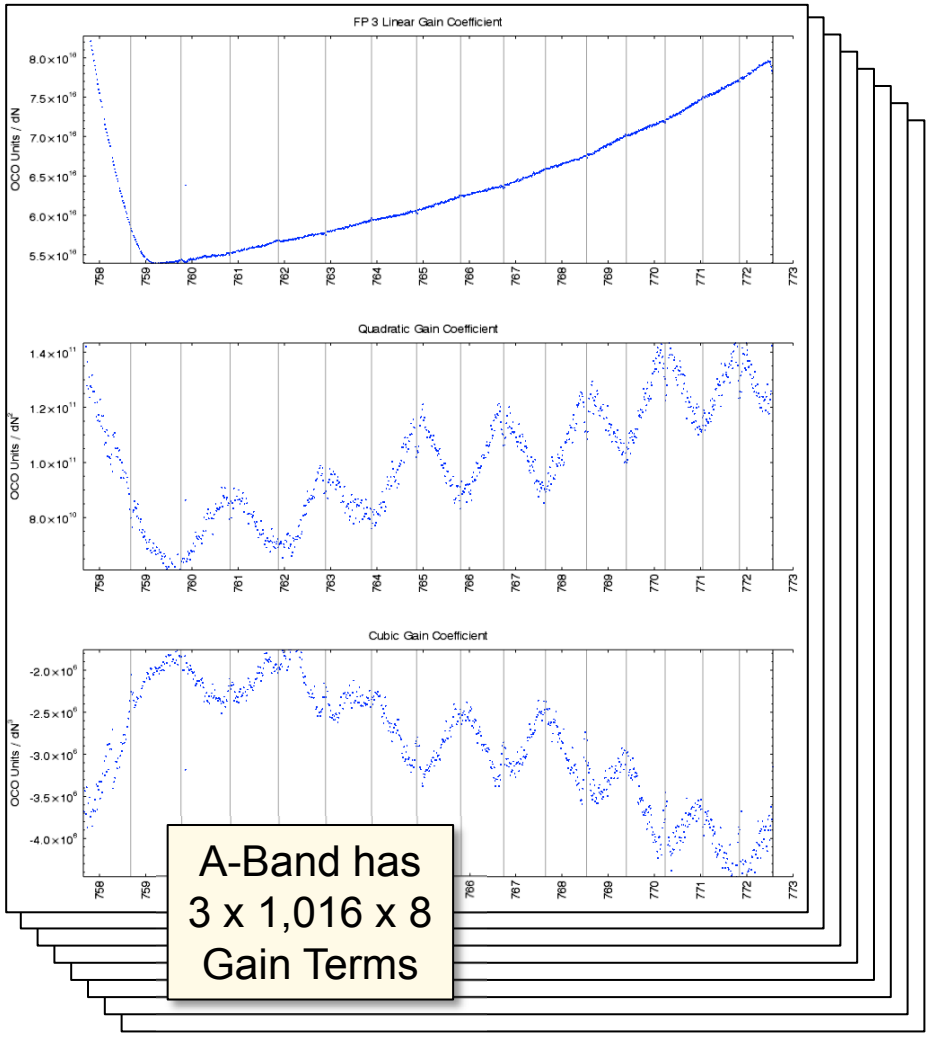
- Each OCO-2's ILS is based on many parameters, several of which vary with wavelength or field angle
  - Simulated line shapes match the measured values well, but not exactly as the model does not capture detailed optical aberrations, filter performance, etc.
  - The ILSs are therefore expressed as a series of look-up tables
- Each of the 3 bands, 8 footprints and 1,016 columns has its own look up table with 200 wavelength and 200 responses (**9,753,600** values)



OCO-2 Radiometric Gains



A-Band, column 500, footprint 4 (typical of all data)

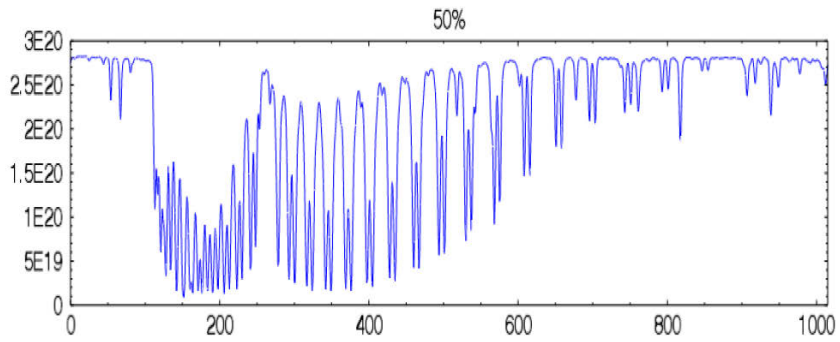


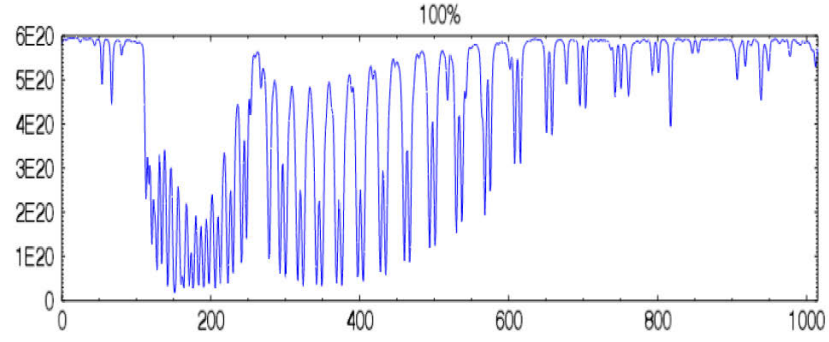
A-Band has 3 x 1,016 x 8 Gain Terms

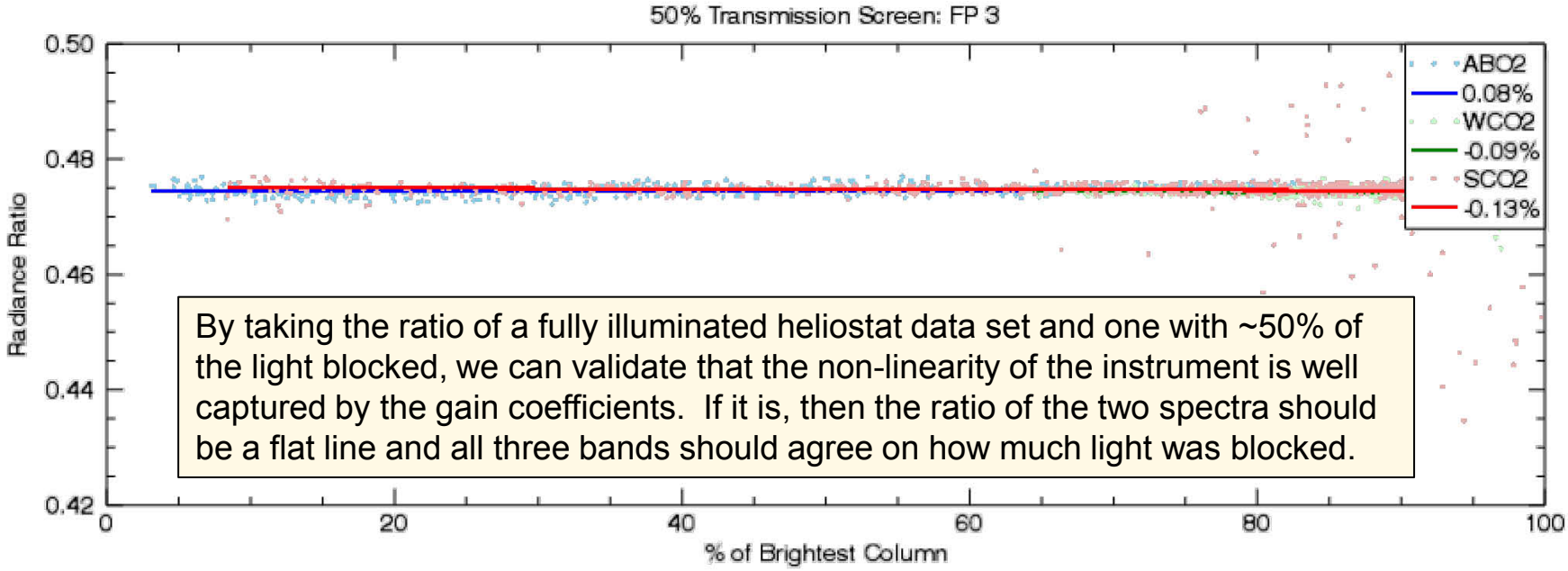
- OCO-2 gain coefficients assume a cubic response
  - Each (band x footprint x column) has three independent terms
  - Total of **73,152** values

- For single pixel data, the number of coefficients rises to **~1,700,000**!

Validating Radiometric Non-linearity



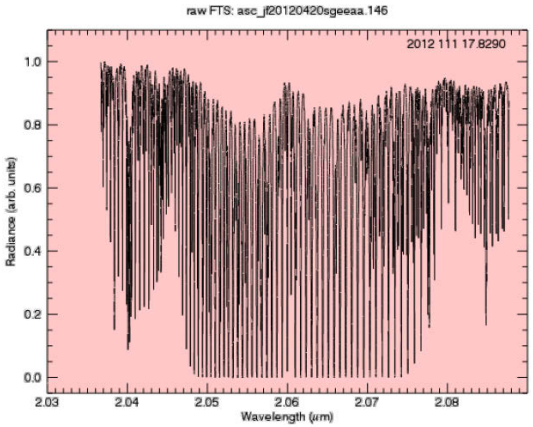




By taking the ratio of a fully illuminated heliostat data set and one with ~50% of the light blocked, we can validate that the non-linearity of the instrument is well captured by the gain coefficients. If it is, then the ratio of the two spectra should be a flat line and all three bands should agree on how much light was blocked.

Validating the Dispersion and Instrument Line Shapes

FTS spectrum



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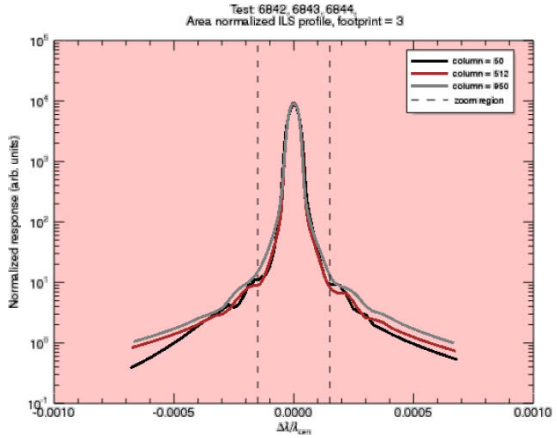
OCO-2 ILS



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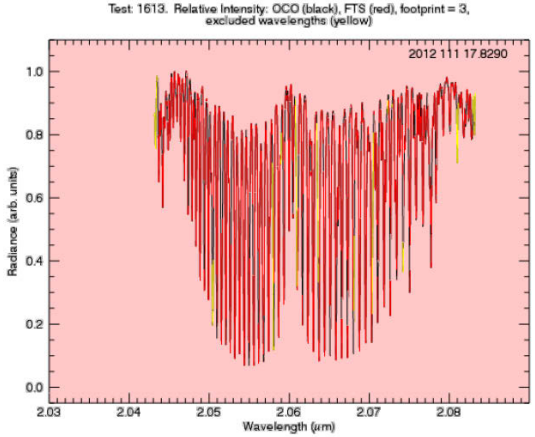
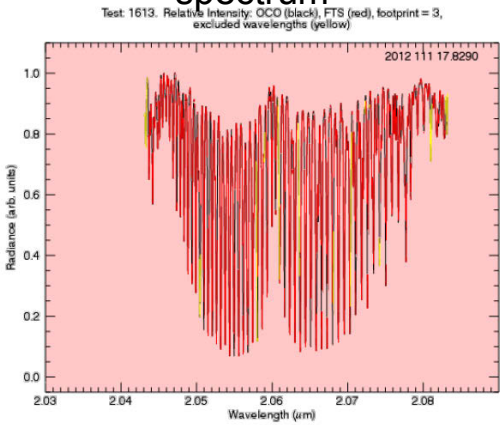
Simulated OCO-2 spectrum



Simulated OCO-2 spectrum



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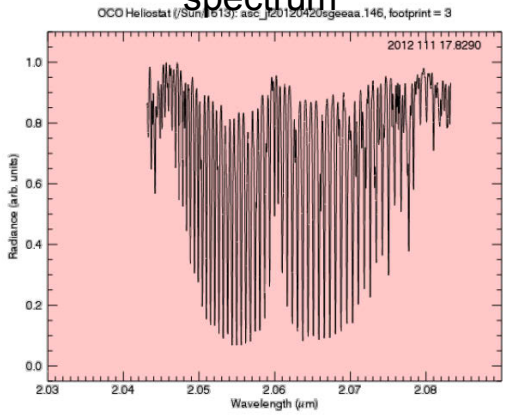
Measured OCO-2 spectrum



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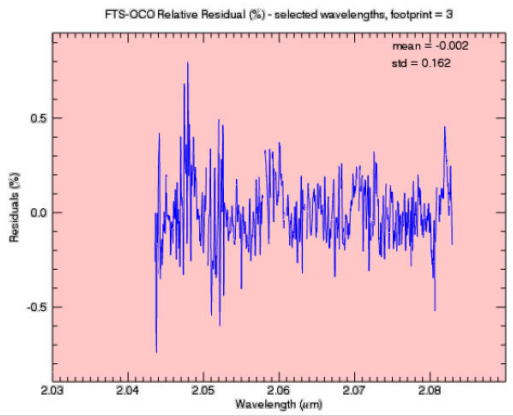
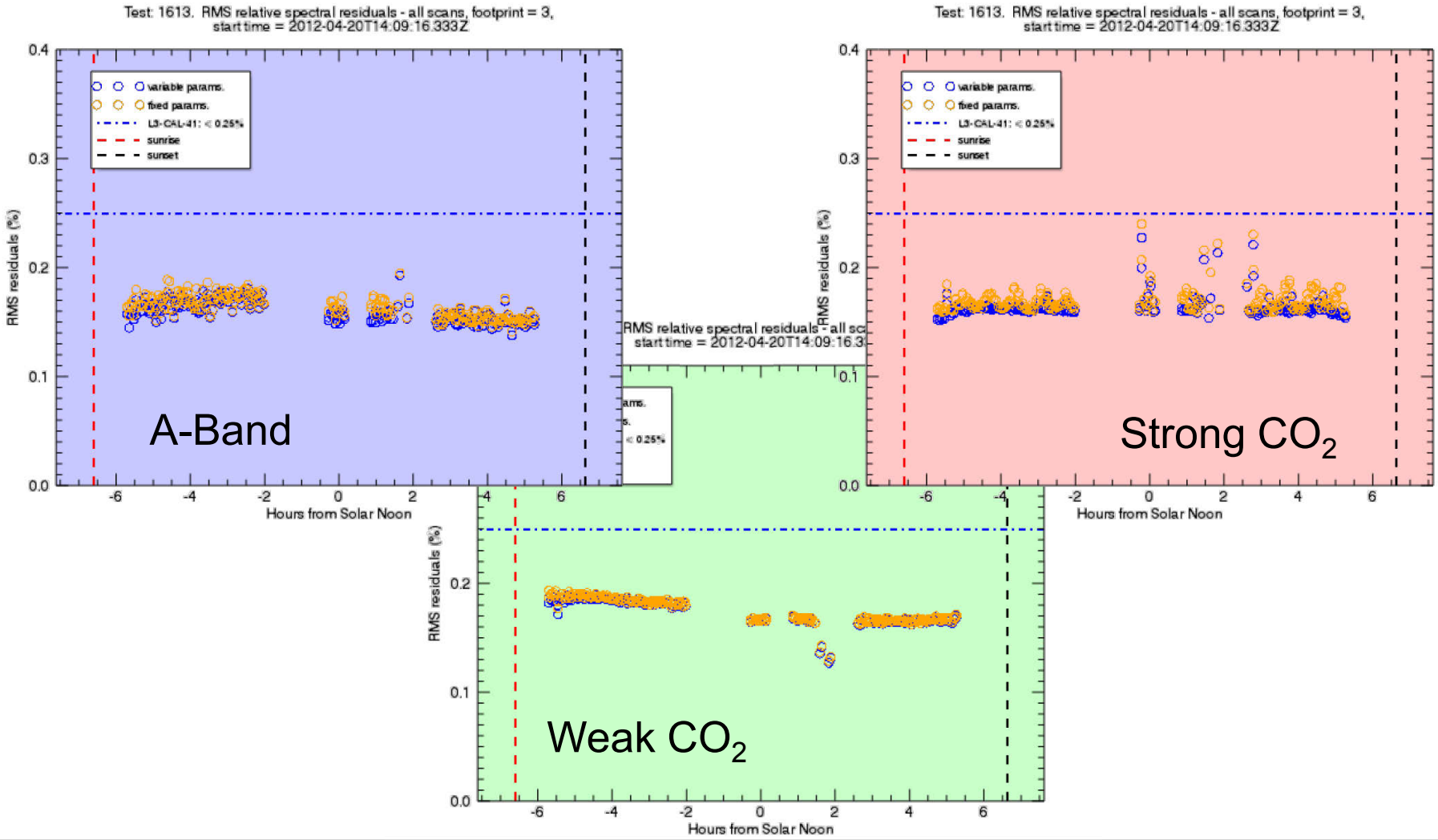
Spectral Residuals

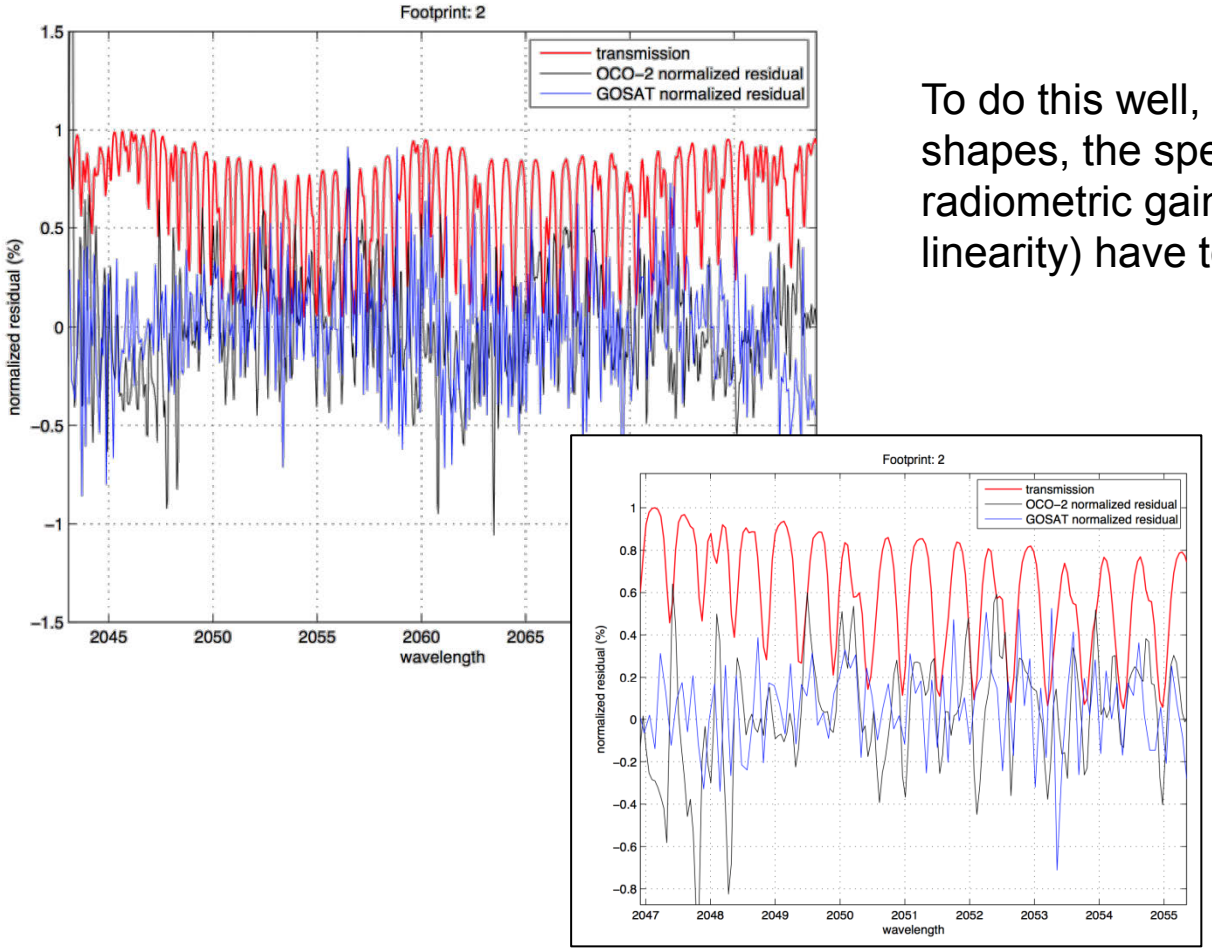


Validation Shows Good Performance at a Huge Range of Atmospheric Pathlengths



Putting all the Calibration Together…

The residuals from OCO-2 spectra are quite similar to the residuals from GOSAT data



To do this well, the instrument line shapes, the spectral dispersion and the radiometric gains (including non-linearity) have to be very good.

These charts use ***100,000's*** of parameters to calibrate the raw data and they all have to be quite good to get this performance

Summary

- OCO-2 is **NOT** GOSAT-2
  - The GOSAT FTS has different performance characteristics than the OCO-2 imaging spectrometer
  - Get ready for far more data but with significantly smaller wavelength ranges

- OCO-2 Preflight Calibration is in good shape
  - Level 2 retrievals residuals validate that the 24,000 “instruments” that make of OCO-2 are well described by the ARP