OCO ABSCO and Solar Flux

Minutes of the TIM

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ABSCO Updates

Spectroscopy for the OCO missions

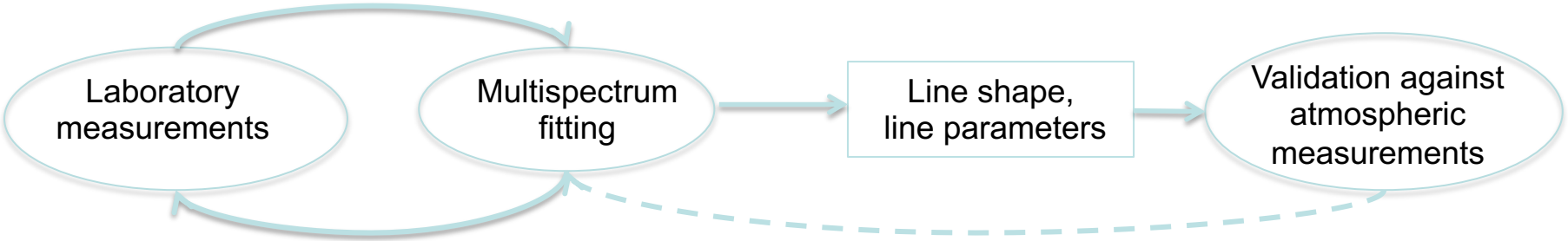
- 0.1 % accuracy goal challenges measurement accuracy AND our understanding of the physics
- Voigt line shape is not sufficient for OCO-2 accuracy goal
- Many subtle physical effects come into play at this level
  - E.g. Line Mixing, Speed Dependence, Collision Induced Absorption
- **Getting it wrong can introduce airmass/regional biases**

- **Goal:**

"Find fundamental errors in our representation of the physics and correct them."

Approach

- **Laboratory measurements:**
  - Cover range of conditions necessary to characterize Earth's atmosphere
- **Multispectrum fitting approach:**
  - Utilize **multiple spectra** in the fitting of **line shape** and **line parameters**
    - Capitalize on strengths of different measurement techniques
  - **Consistent** use of line parameters with the line shape used in their determination
- **Evaluation/validation** of results against atmospheric measurements



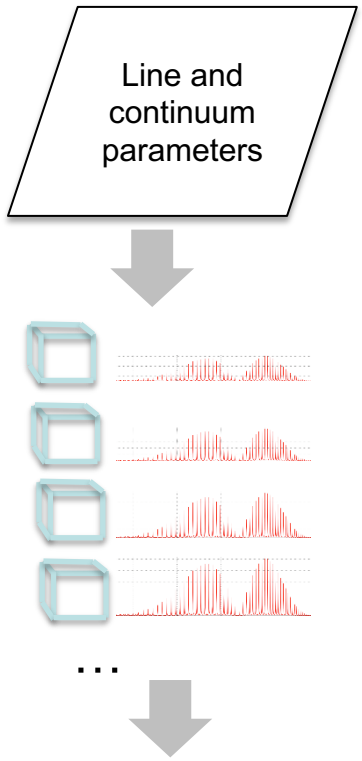
Methods

Laboratory measurements

- **Fourier Transform Spectroscopy** (JPL)
  - Measurements over wide spectral regions (consistency)
- **Cavity Ringdown Spectroscopy** (NIST)
  - High precision
- **Photoacoustic Spectroscopy** (California Institute of Technology)
  - Large dynamic range and high sensitivity

Absorption coefficient (ABSCO) tables

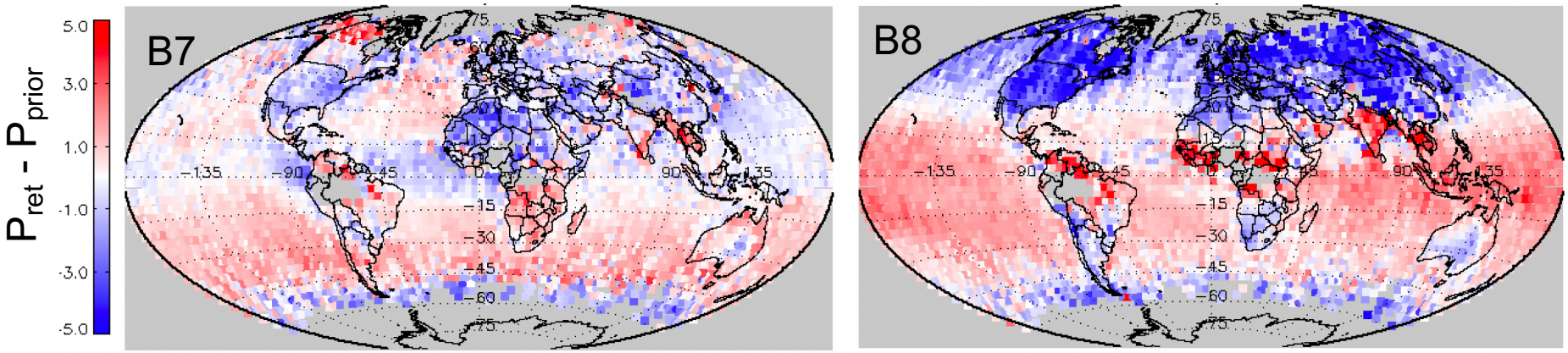
- **Problem:** Advanced spectroscopic models too slow for online use
- **Solution:** pre-computed lookup table for linear interpolation
- Compute cross sections at multiple temperatures, pressures, H_2O amounts



HDF File with **4 dimensions**:
- Molecule (CO_2, O_2, H_2O, CH_4)
- Pressure
- Temperature
- H_2O amount

Issue: Surface Pressure Biases associated with O_2 A-band Spectroscopy

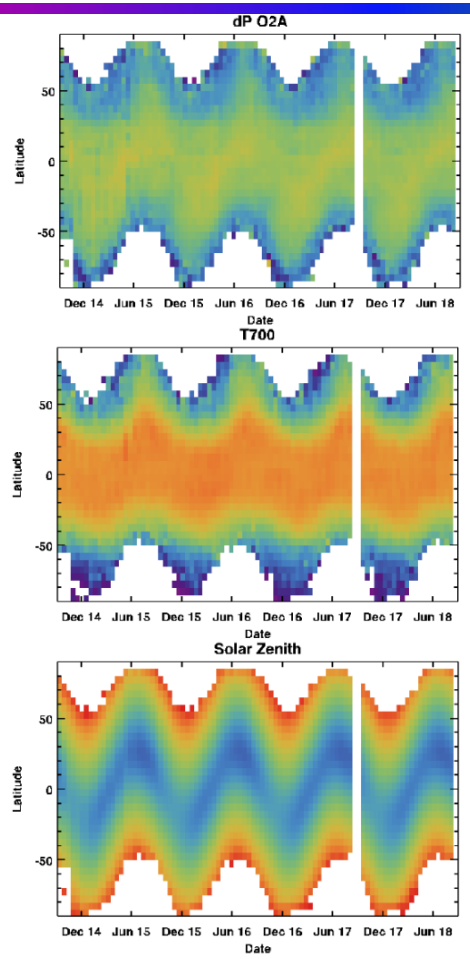
Differences between the retrieved and prior (ECMWF) surface pressures for ABSCO 4.2 (V7) and ABSCO 5.0 V8) (no EOFs)



March-April-May seasonal means for B7 (ABSCO 4.2) and B8 (ABSCO 5.0) (Chris O'Dell, 2018)

Improvements in the O2 A-Band spectroscopy reduced spectral residuals and scatter in surface pressure retrievals, but introduced a coherent, pole-to-equator surface pressure bias, and a corresponding inverse pole-to-equator XCO_2 bias.

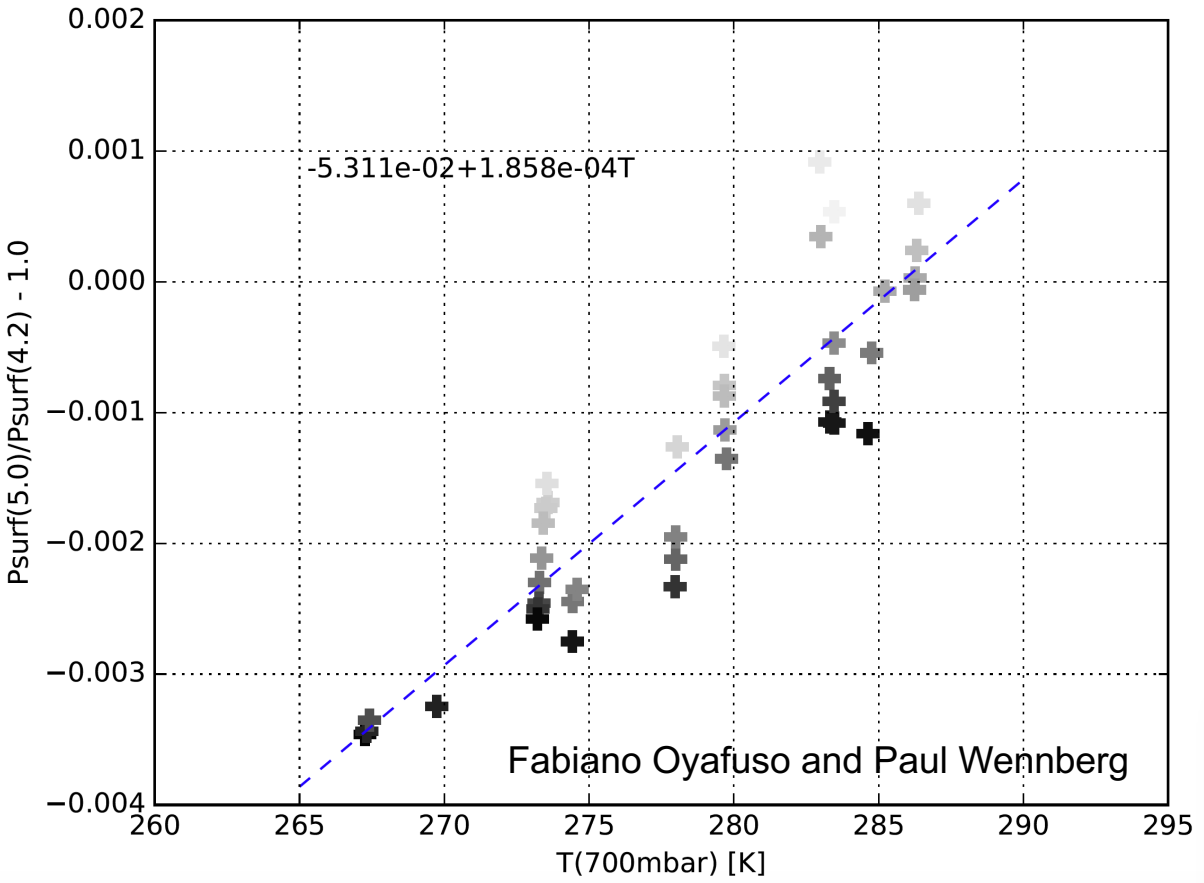
Origin of the Surface Pressure Bias



ΔP_{surf}

T(700 hpP)

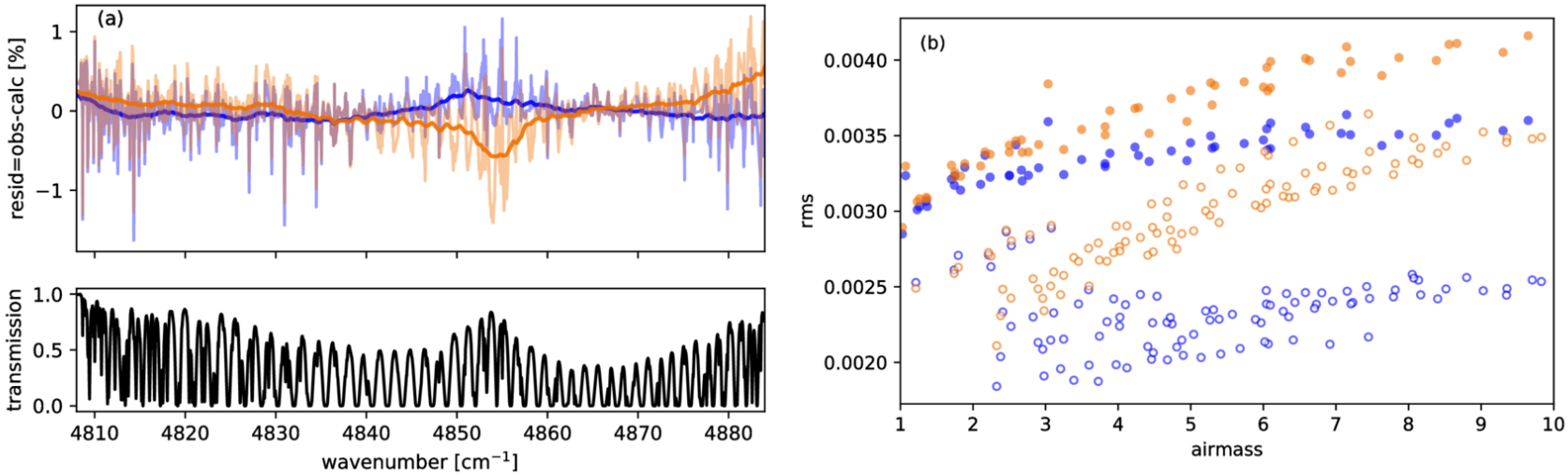
SZA



The time-dependent amplitude of the surface pressure bias is more strongly correlated with near-surface temperature and/or column water vapor than air mass (note ~1-month lag in ΔP_{surf} and T(700 hP) vs solar zenith angle (SZA)).

Outstanding issues for CO_2

- Line mixing/line shape for SCO2 band
  - Nearest neighbor line-mixing sufficient to fit existing set of lab FTS spectra
  - Atmospheric residuals suggest that additional absorption is needed near the band center – may be due to line mixing between P & R branches
    - See Oyafuso et al. [2017]



(a) Mean of high airmass (μ>4) residuals for ABSCO v5.0 with ad hoc continuum-like absorption (blue) and without (orange). (b) corresponding rms of residuals with and without ad hoc continuum. Closed/open symbols denote summer/winter data.

OCO-2 ABSCO Status

- ABSCO v5.1
  - Updates to O_2 A-band
    - New Cavity Ringdown laboratory measurements: New constraints on line mixing and CIA
  - Updates to H_2O continuum
    - MT_CKD v3.2
  - No updates to CO2 spectroscopy for this version

- Test sets
  - ABSCO v5.1 updates have been validated using Lamont TCCON spectra
  - Evaluation in L2 algorithm using large, global set of OCO-2 spectra is underway
    - Datasets for OCO-2 L2 testing of this ABSCO update: ~1.8 million soundings
    - More comprehensive than the test sets used for ABSCO v5.0 evaluation (~150,000 soundings)

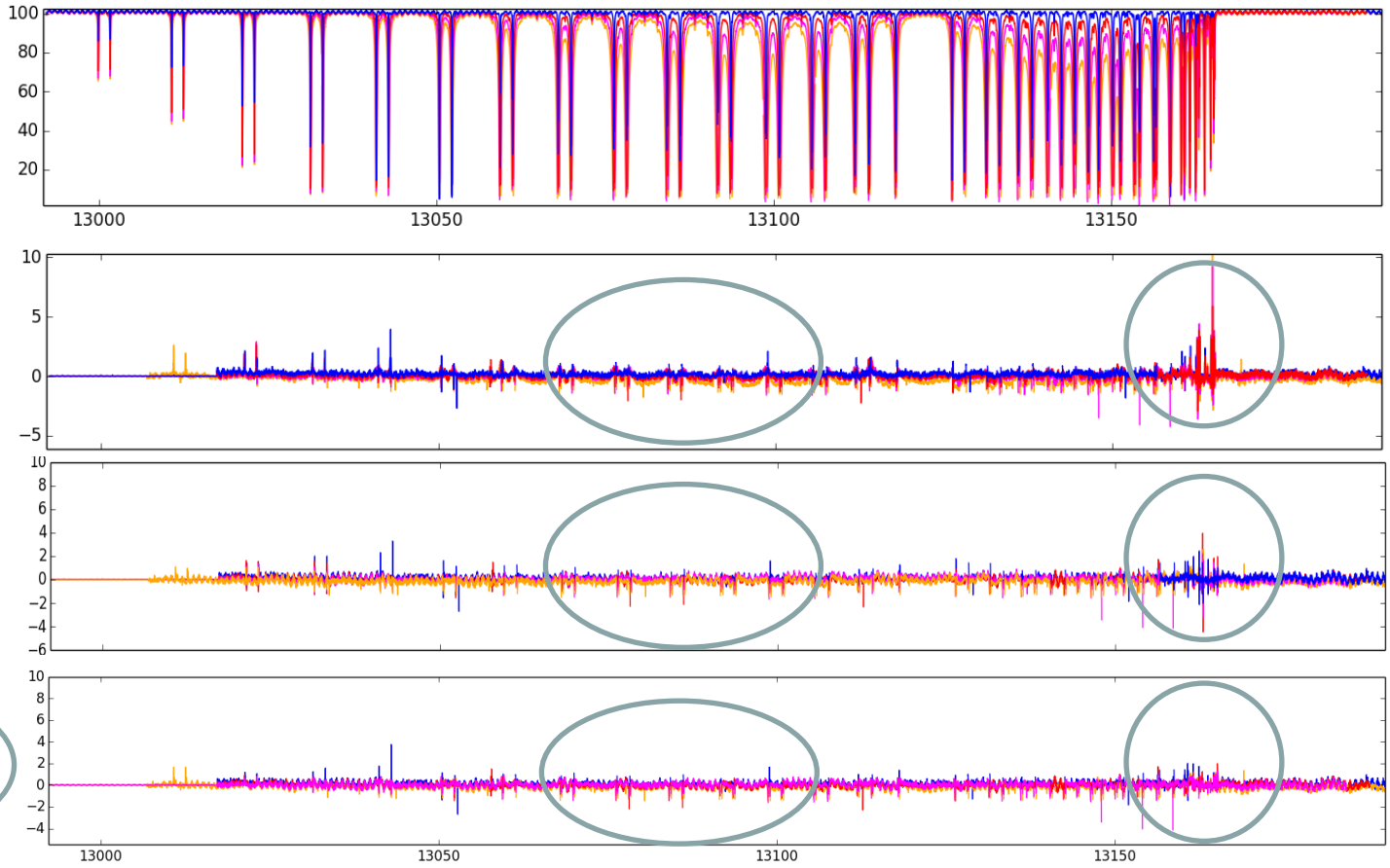
New multispectrum fits for O_2: Lab residuals, CRDS

290 K
2.0% O_2
100-1000 Torr

Residuals from Drouin 2017

Residuals in July

Residuals in Sept



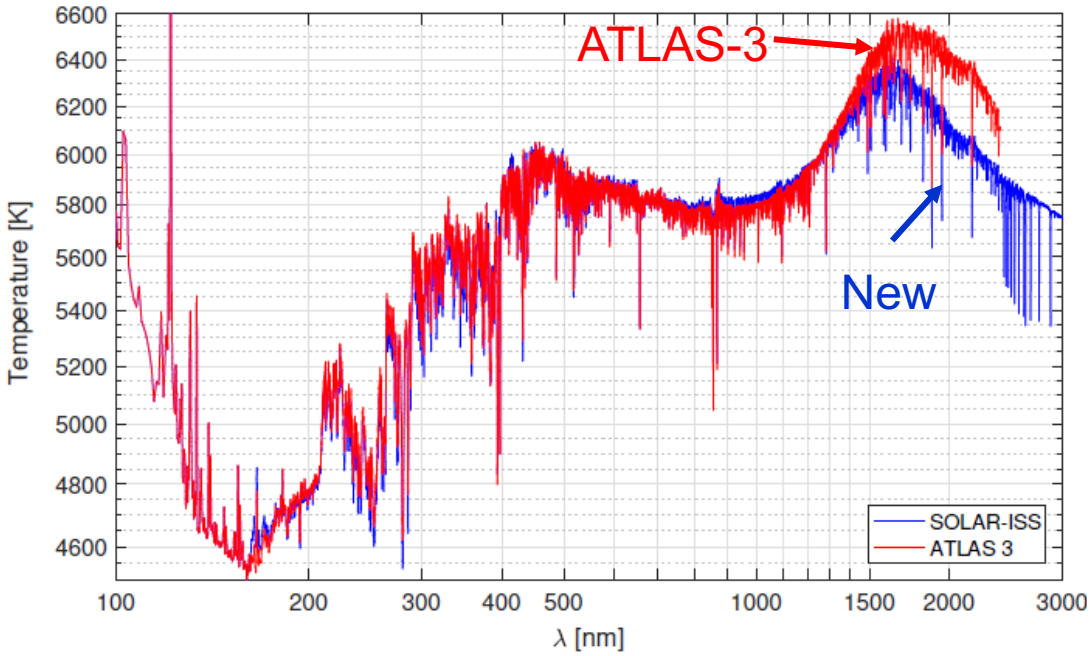
From Brian Drouin's slides at the ABSCO breakout, October OCO-2 STM

Solar Flux Updates

Updates to the Top of Atmosphere Solar Flux

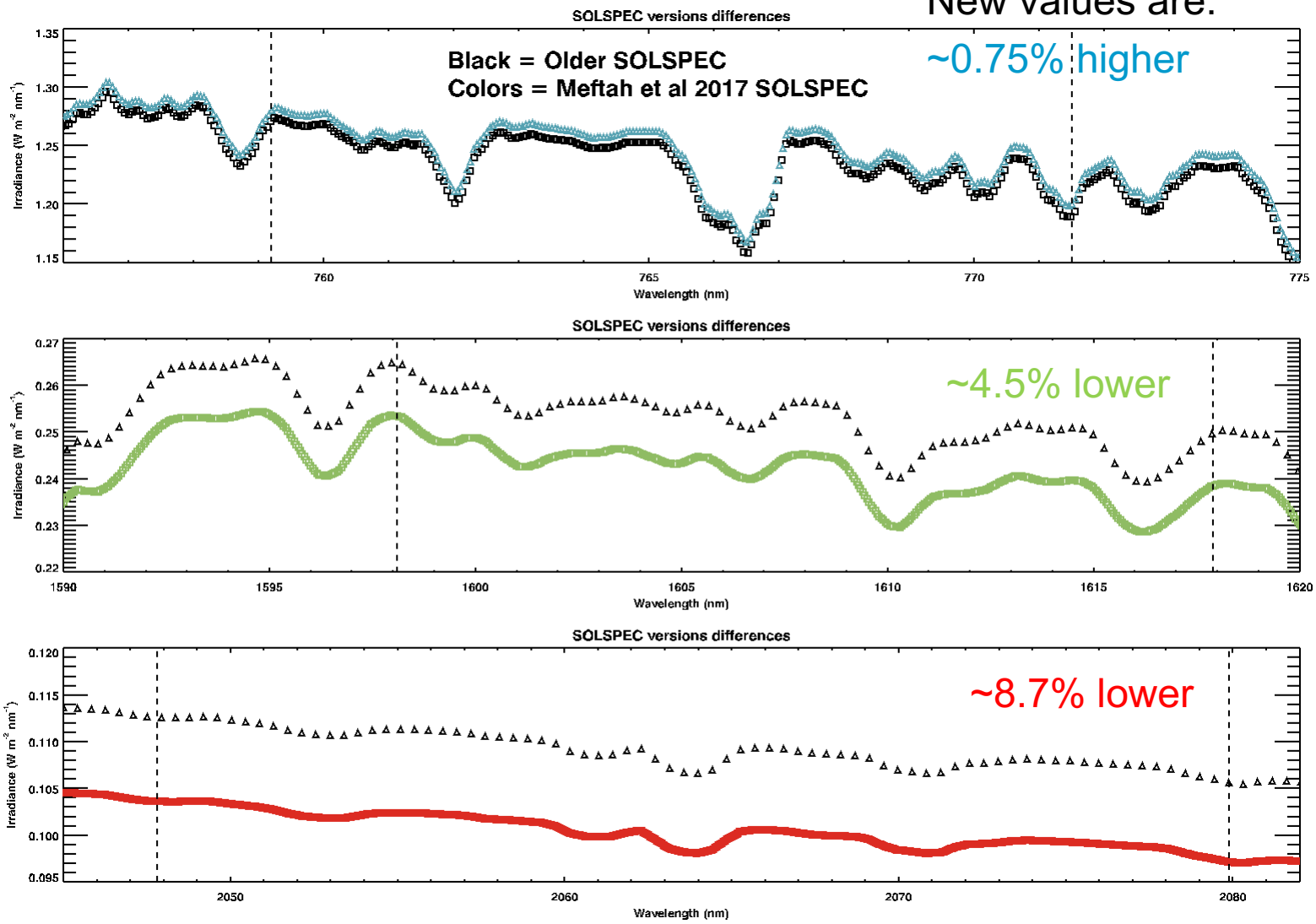
- Accurate estimates of the top-of-atmosphere solar flux are critical to XCO2 and SCH4 retrievals
- Two recent studies have identified substantial biases in the ATLAS 3 Solar fluxes in the 1.61 and 2.06 micron CO_2 channels
  - Reanalysis of the SOLSPEC observations (Meftah et al. 2018)
  - New data from the TSIS SSI instrument (Richard e al. 2018)

M. Meftah et al.: A new reference solar spectrum based on SOLar SPECtrometer (SOLSPEC) instrument of the SOLAR payload on the International Space Station (ISS)observations. (Bright temperatures shown to emphasize differences at SWIR wavelengths.

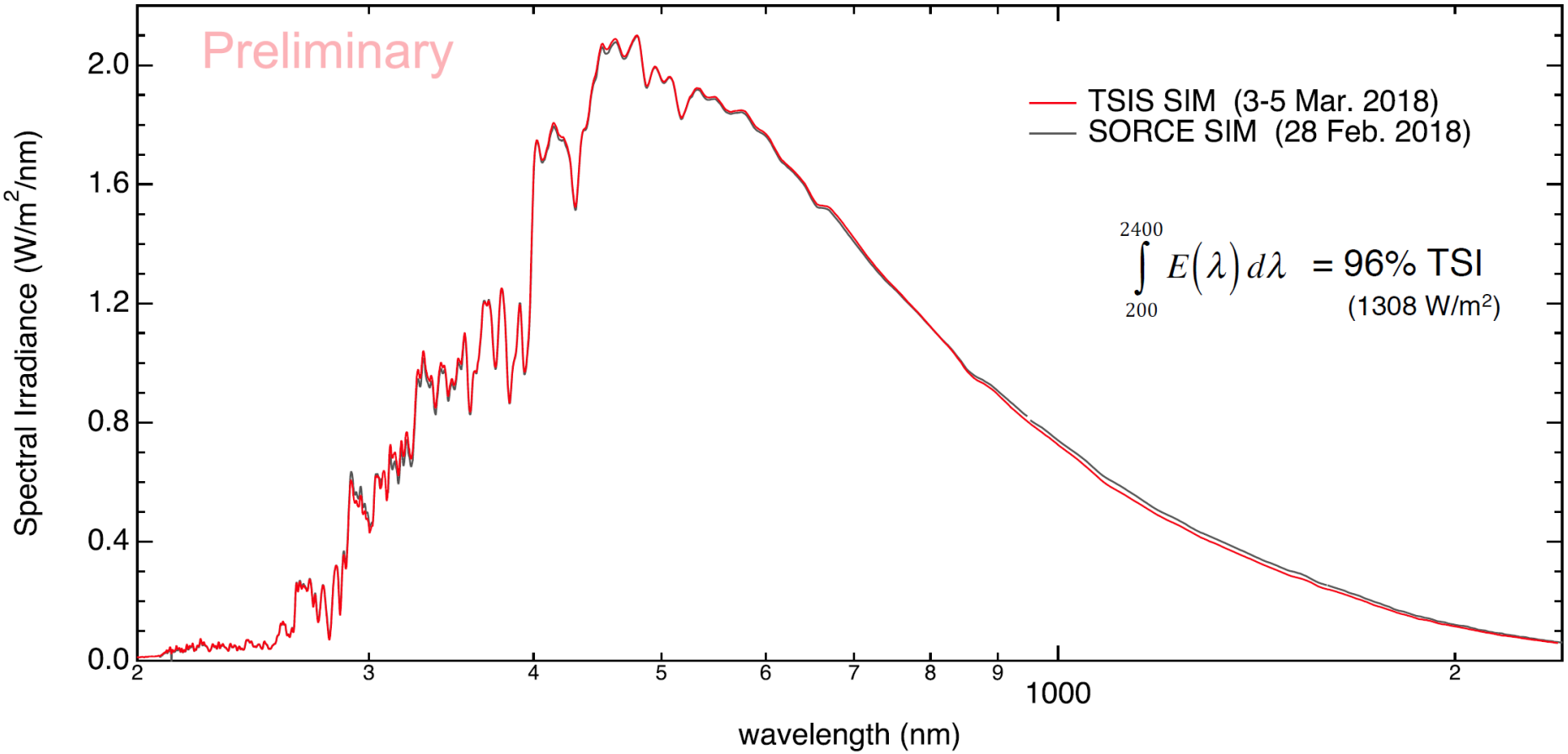


Differences in SOLSPEC

New values are:



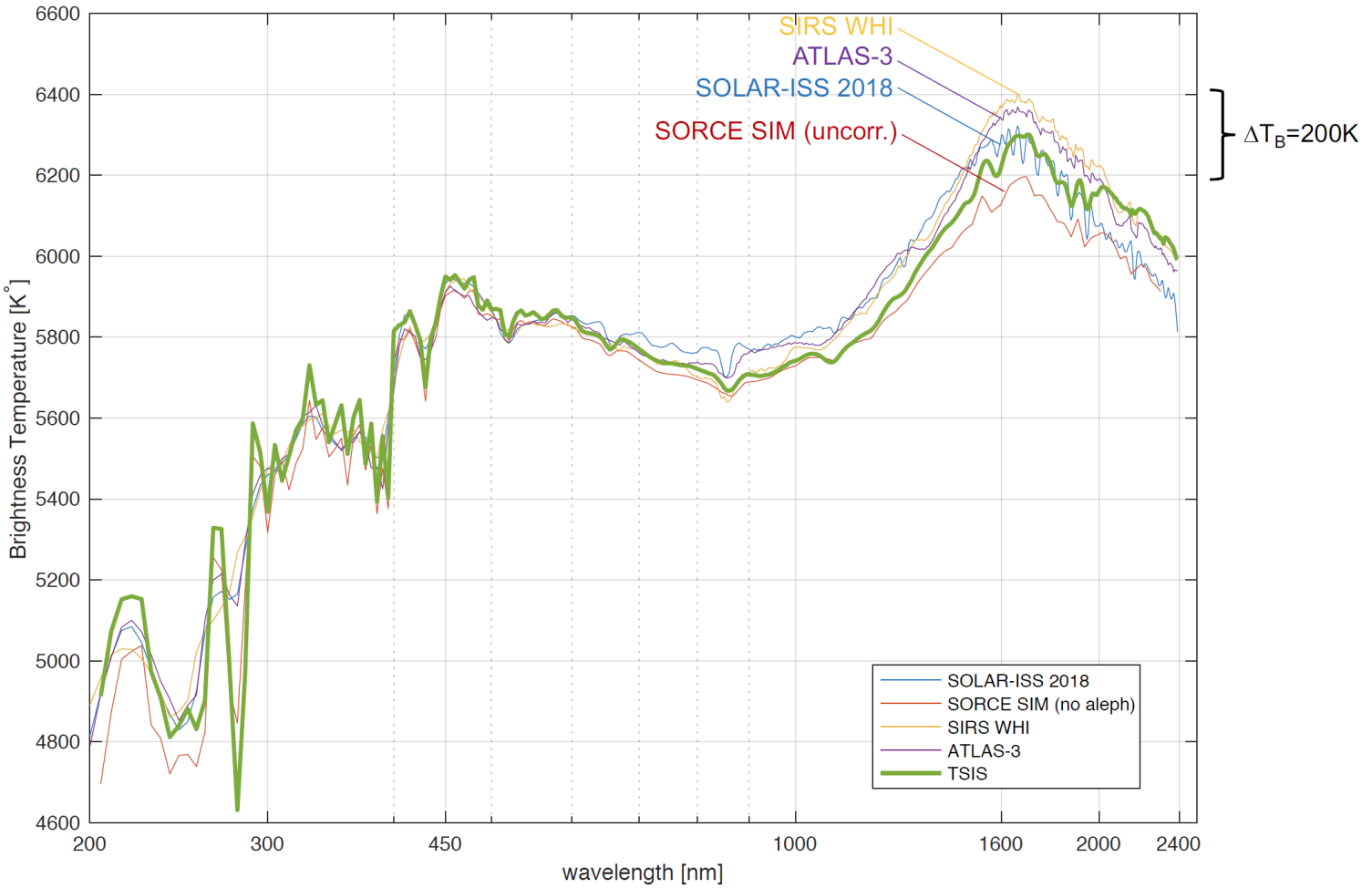
First Light SSI Spectrum Comparison
TSIS & Source SSI



TSIS SIM First light shows lower fluxes than Source SIM at wavelengths between 0.85 and 2 microns, supporting the work by Meftah et al.

Eric Richard (SSI Team)

Brightness Temperature Comparison



E. Richard et al.: Brightness Temperatures from the Total and Spectral Solar Irradiance Sensor (TSIS) Spectral Irradiance Monitor (SIM) on the ISS.