

# Impacts of updates to spectroscopy (ABSCO tables) in the OCO-2 full-physics retrieval algorithm

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The accuracy of spectroscopic input (absorption coefficients, or ABSCO) used in the OCO-2 forward model directly impacts the quality of the XCO<sub>2</sub> retrievals.

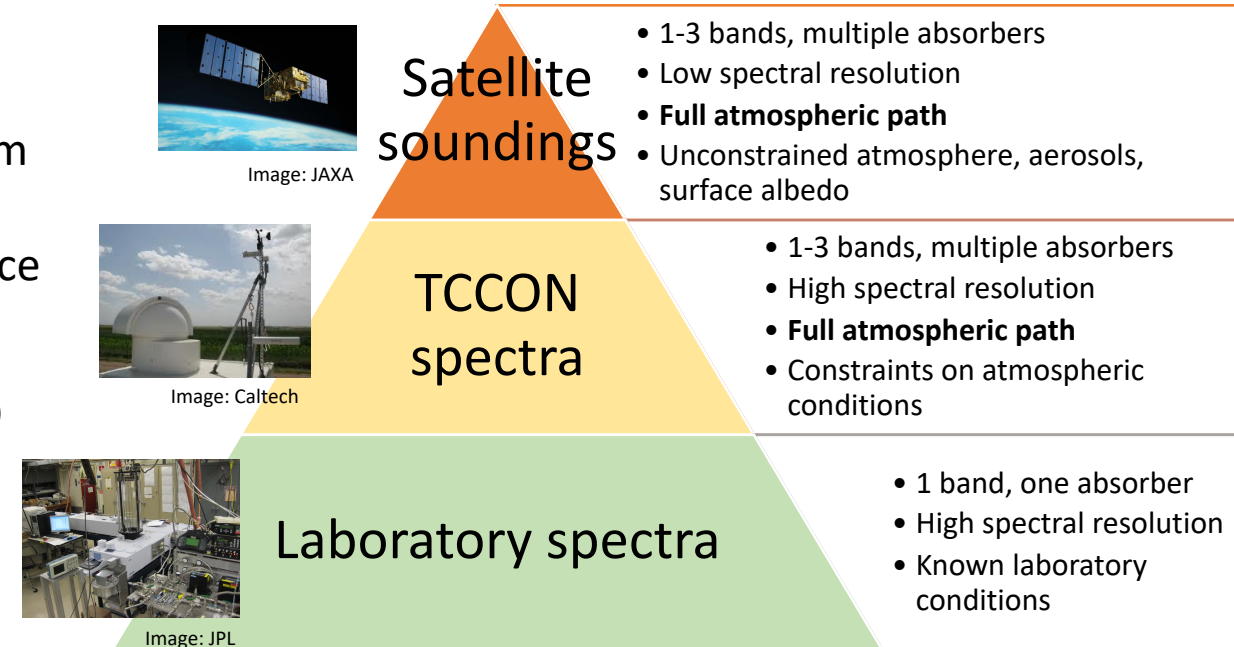
- ABSCO 5.1, used in OCO-2 Build 10, included updates to
  - 0.76  $\mu\text{m}$  oxygen (O<sub>2</sub>) A-band spectroscopy,
  - Water vapor (H<sub>2</sub>O) continuum model within the 1.6  $\mu\text{m}$  (weak CO<sub>2</sub>) and 2.06  $\mu\text{m}$  (strong CO<sub>2</sub>) bands
- These changes reduced fitting residuals and biases in surface pressure (Payne et al., 2020).

To address remaining issues with the spectroscopy in the OCO bands, ABSCO for OCO-2 B11 will include updates to:

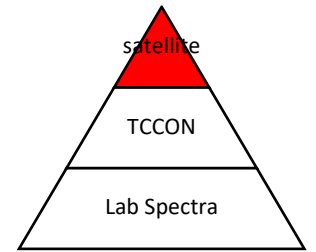
- The H<sub>2</sub>O line list
- Line mixing and line intensities in the strong CO<sub>2</sub> band

**These updates have been tested using a carefully selected subset of OCO-2 measurements that covers all latitudes and seasons over the time period of the mission.**

Further work on the representation of line mixing, line shape (O<sub>2</sub> A-band and CO<sub>2</sub> bands), collision-induced absorption (CIA) in the O<sub>2</sub> A-band and on modeling of H<sub>2</sub>O absorption is ongoing.

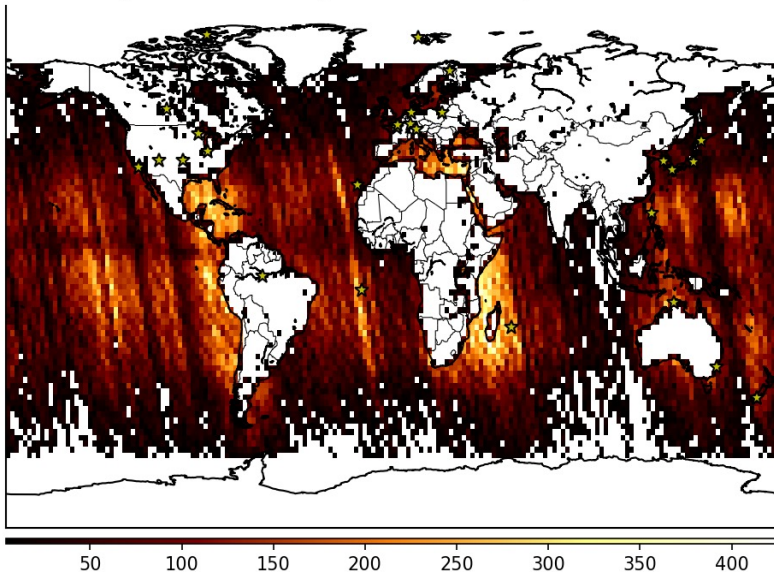


# V10 “Quick test sets” (Y. Marchetti et al.)

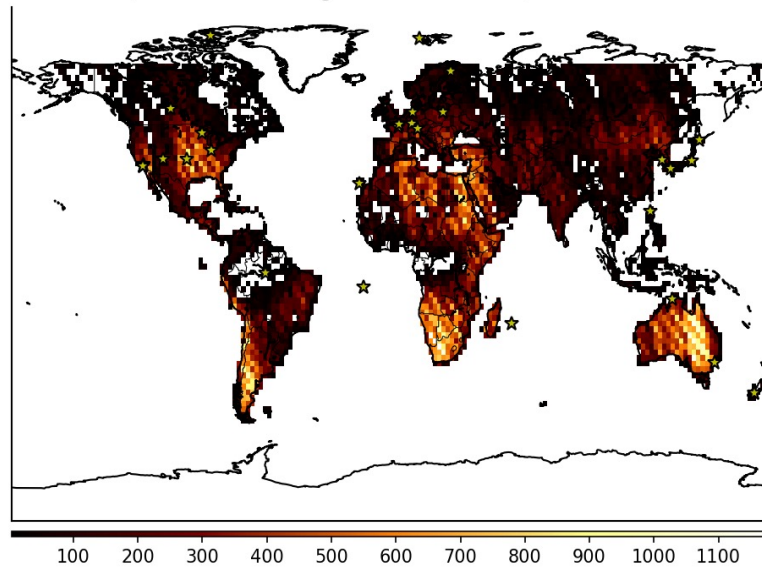


- Subset of OCO-2 soundings that span latitudes and seasons
- A variety of test sets have been constructed for purposes of algorithm testing
- ABSCO testing: Focus on low aerosol cases, “well-behaved” soundings
  - Main focus for ABSCO testing is ocean glint observations
- **1.8 million soundings** for “ocean glint”, “land nadir” and “land glint” sets combined
- Additional **8185 soundings** matched to IGRA radiosondes

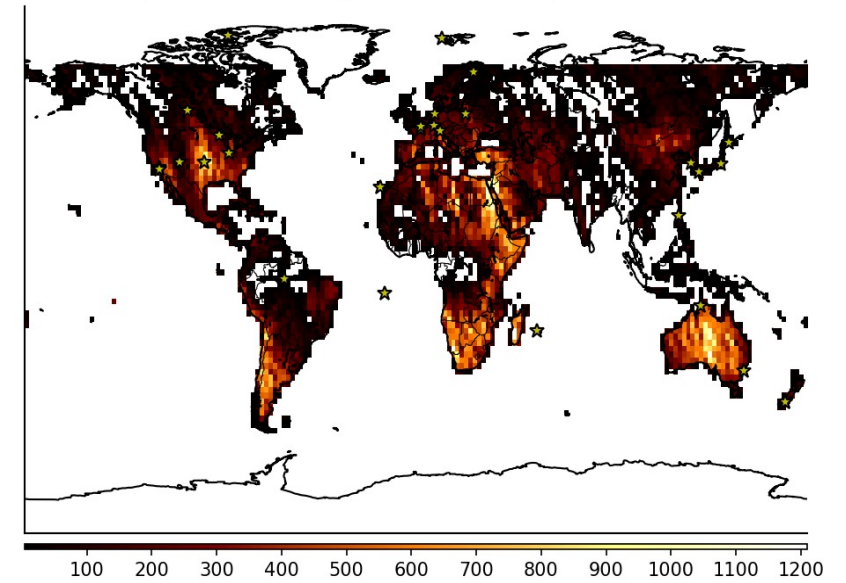
QTS Global Coverage: EOFSG83 600k / 23M = 2.6%



QTS Global Coverage: EOFLN83 600k / 13M = 4.5%



QTS Global Coverage: EOFLG83 600k / 13M = 4.5%

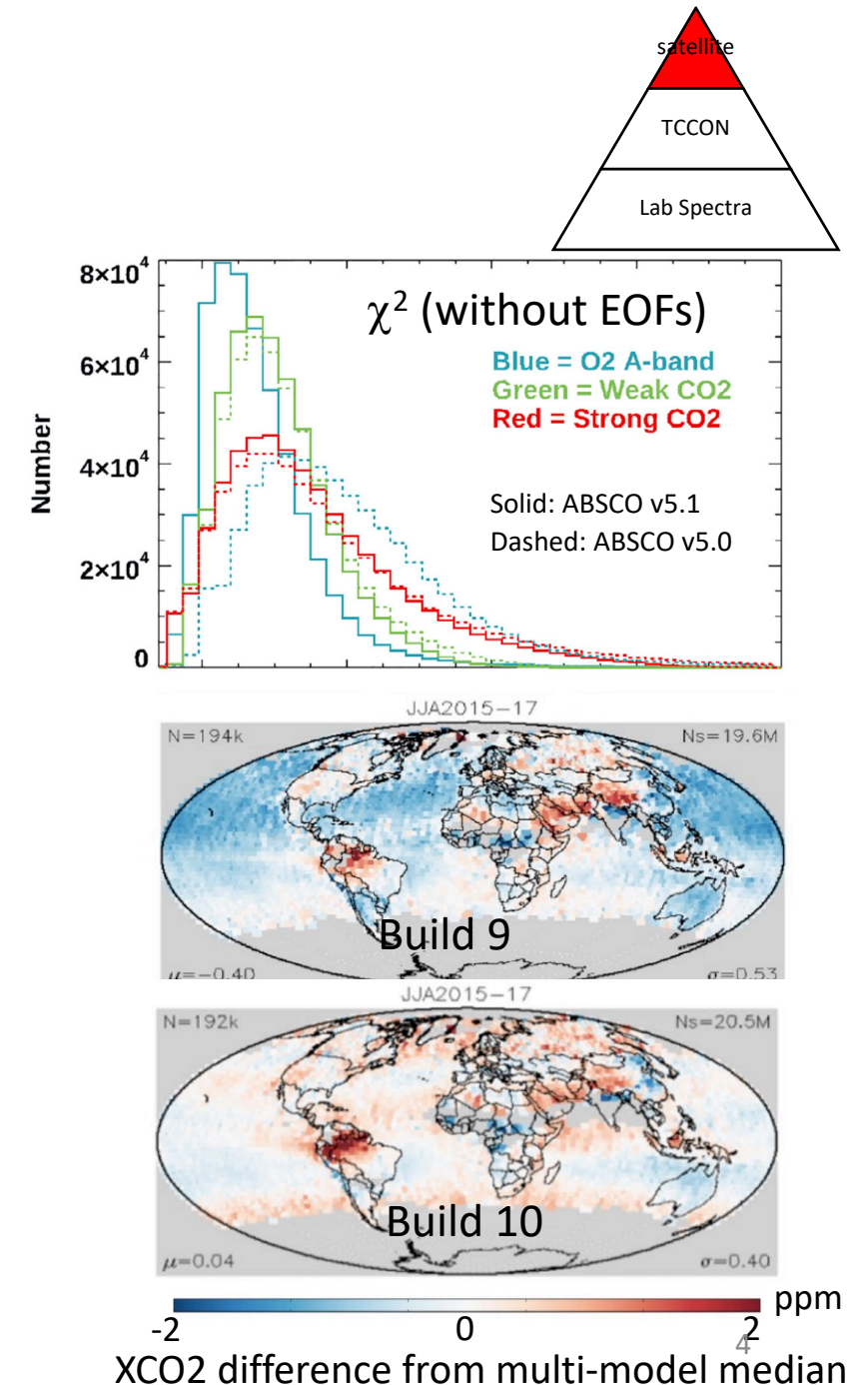


# OCO ABSCO updates: recent history

ABSCO version	L2 algorithm version	O <sub>2</sub> A	SCO <sub>2</sub>	WCO <sub>2</sub>	H <sub>2</sub> O lines	H <sub>2</sub> O continuum
ABSCO v5.0	B8/B9	Drouin et al., 2017	Benner et al. 2016 (scaled)	Devi et al. 2016 (scaled)	HITRAN 2012	Mlawer et al., 2014
ABSCO v5.1	B10	Payne et al., 2020	Benner et al., 2016 (scaled)	Devi et al., 2016 (scaled)	HITRAN 2012	MT_CKD v3.2
ABSCO v5.2	B11 (planned)	Payne et al., 2020	Drouin et al. new SCO <sub>2</sub> fit (scaled)	Devi et al., 2016 (scaled)	G. Toon, 2019	MT_CKD v3.2

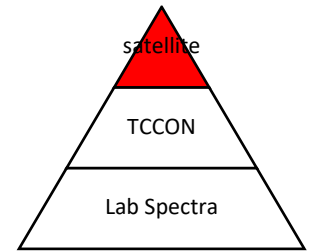
# ABSCO v5.1 (OCO-2 B10 L2)

- ABSCO 5.1, used in OCO-2 Build 10 [Payne et al., 2020]
- Included updates to
  - 0.76  $\mu\text{m}$  O<sub>2</sub> A-band spectroscopy,
  - H<sub>2</sub>O continuum model within 1.6  $\mu\text{m}$  (weak CO<sub>2</sub>) and 2.06  $\mu\text{m}$  (strong CO<sub>2</sub>) bands
- Beneficial impacts:
  - Reduced magnitude of fitting residuals
  - Reduced spatial variation in surface pressure bias
  - Reduced spatial variation in XCO<sub>2</sub> bias
  - Improved agreement with TCCON XCO<sub>2</sub>

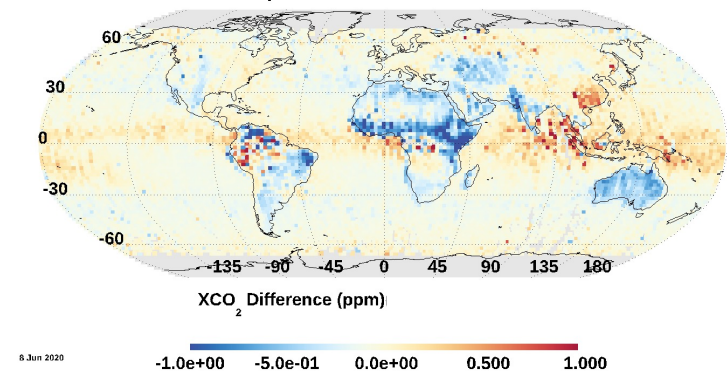
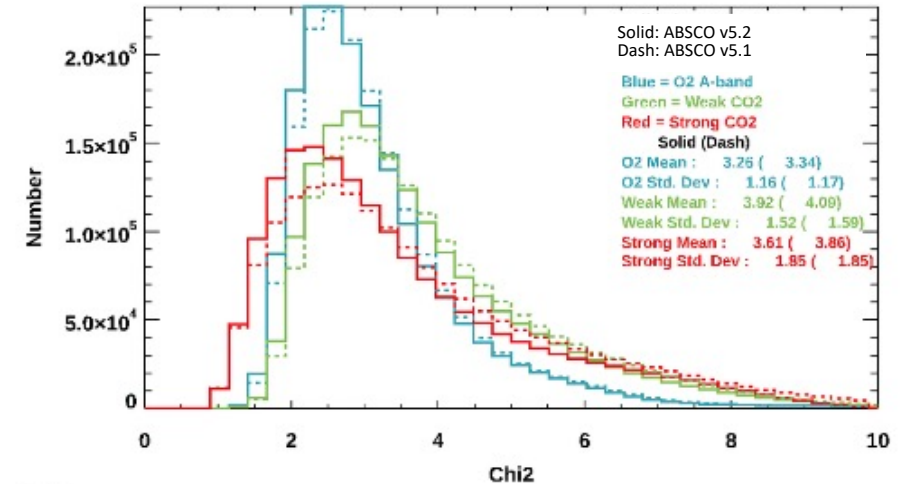




# ABSCO v5.2 (for OCO-2 B11 L2)

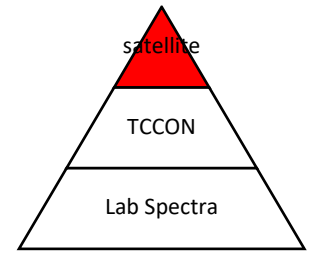


- Updated multispectrum fits to lab spectra for Strong CO<sub>2</sub> (2.06 μm) band
  - (See V. Payne IWGGMS talk)
  - Updated representation of line mixing (full relaxation matrix)
  - Constraints on intensities from new NIST measurements
- Earlier versions of ABSCO, including ABSCO 5.1, required an “ad-hoc” continuum to fit the CO<sub>2</sub> spectrum. With the updated line mixing in the SCO2 band, this artificial absorption is no longer needed.
- Updated H<sub>2</sub>O line list
  - Geoff Toon’s update to ATM18 water vapor line list with rescaled line strengths
  - Results in improved residual fits in all three OCO-2 bands



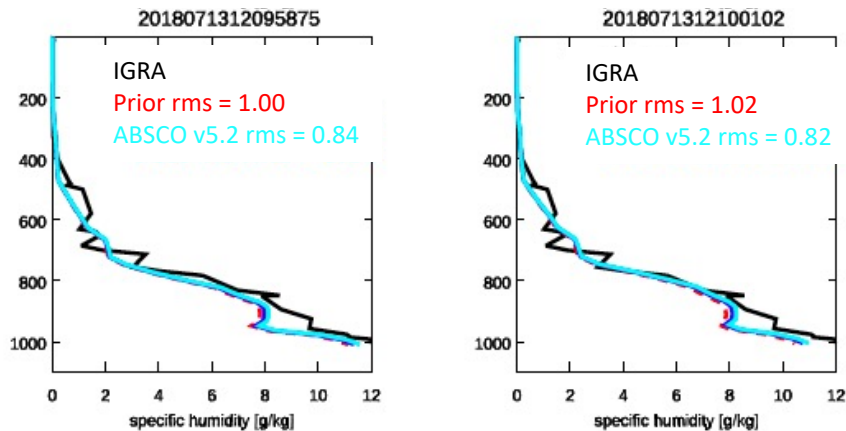
Impact of water vapor line parameter update on XCO<sub>2</sub> map. New EOFs have not yet been generated for ABSCO v5.2, so final evaluation of impact is still pending.

# ABSCO v5.2: Impacts on H<sub>2</sub>O column retrieval

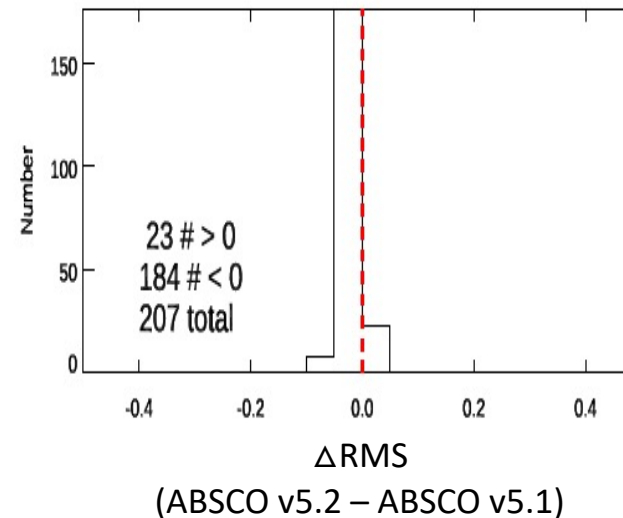


- OCO-2 L2 algorithm includes an H<sub>2</sub>O scale factor in the state vector
  - See Nelson et al. 2016
- Test results using ABSCO v5.2 (H<sub>2</sub>O line list from G. Toon, scaled) showed better agreement with radiosonde (IGRA) profiles than ABSCO v5.1 or the prior.

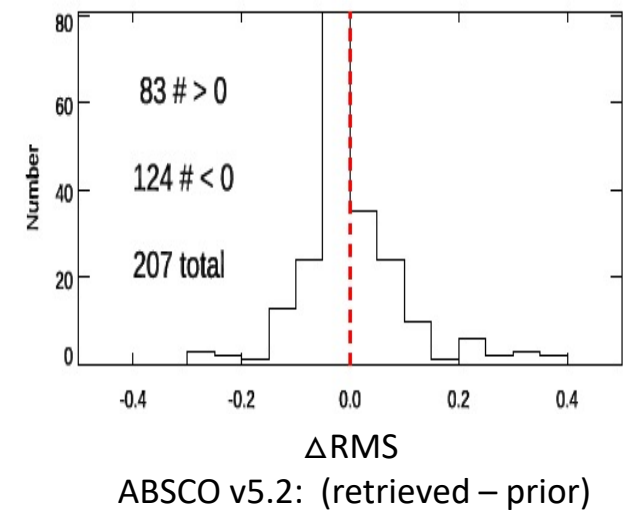
RMS (in unit of g/kg) is calculated from differences to IGRA for all levels in each individual profile.



Two examples of the improved retrieved RMS in ABSCO v5.2 comparing with its prior RMS.



90% QTS dataset of ABSCO v5.2 RMS are less than ABSCO v5.1 RMS.



More than 60% QTS dataset of ABSCO v5.2 retrieved RMS are less than the prior RMS.