An overview of the tests and evaluations of the OCO-2 version 11 retrieval algorithm

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July 12, 15:00-16:00 PDT

Abstract

The OCO-2 Atmospheric Carbon Observations from Space (ACOS) column-averaged dry-air mole-fraction of carbon dioxide (XCO_2) product has been widely used to improve our understanding of regional- and global-scale carbon fluxes. However, known outstanding issues remain with the existing v10 product. These include spectral residuals above the instrument noise and regionally-dependent biases in retrieved surface pressure, which propagate into errors in the bias corrected XCO_2.

Here, we show results of testing for the new version 11. The updates accepted for v11 include 1) updating the spectroscopy to ABSCO v5.2, 2) instrument line shape improvements, 3) South Atlantic Anomaly screening modifications, 4) an updated CO_2 prior and 5) new ABSCO scaling coefficients.

1) the spectroscopy update to ABSCO v5.2

- H2O line list updates:

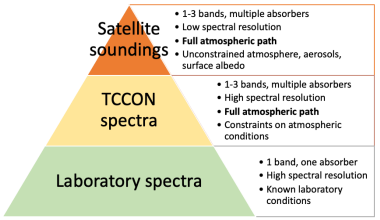
-New line list from Geoff Toon (updated from HITRAN 2012):
https://mark4sun.jpl.nasa.gov/toon/atm18/atm18.html
- Improved Chi2 (see Fig. 1) and H_2O column retrieval (Fig. 2)

- New SCO2 tables:

-Same data previously used to derive line mixing parameters used in updated line mixing model
-Ad hoc continuum used in previous versions of ABSCO no longer used
-Improved SCO2 fits (Fig. 3)

- New SCO2 scaling:

-Post hoc scaling of table applied in B11 modified from that used in B10
-New scaling help to fix XCO2 shift (Fig. 4)



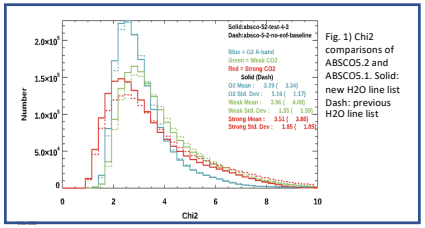


Fig. 1) Chi2 comparisons of ABSCO5.2 and ABSCO5.1. Solid: new H2O line list Dash: previous H2O line list

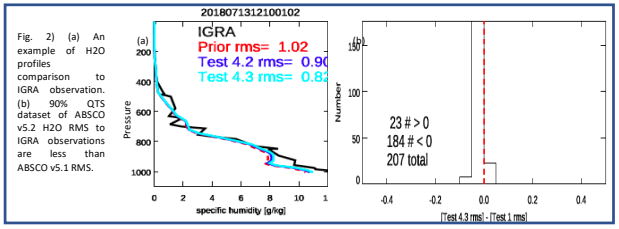


Fig. 2) (a) An example of H2O profiles comparison to IGRA observation. (b) 90% QTS dataset of ABSCO v5.2 H2O RMS to IGRA observations are less than ABSCO v5.1 RMS.

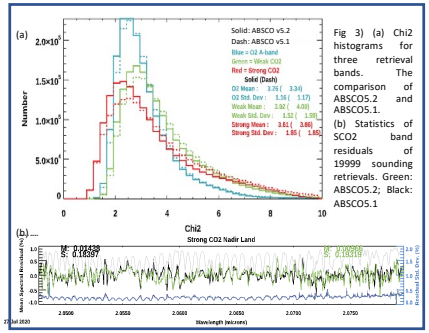


Fig 3) (a) Chi2 histograms for three retrieval bands. The comparison of ABSCO5.2 and ABSCO5.1. (b) Statistics of SCO2 band residuals of 19999 sounding retrievals. Green: ABSCO5.2; Black: ABSCO5.1

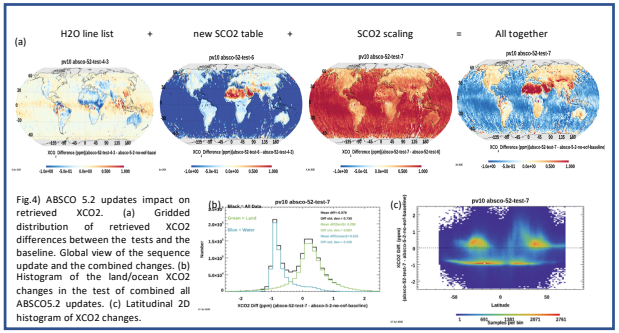


Fig.4) ABSCO 5.2 updates impact on retrieved XCO2. (a) Gridded distribution of retrieved XCO2 differences between the tests and the baseline. Global view of the sequence update and the combined changes. (b) Histogram of the land/ocean XCO2 changes in the test of combined all ABSCO5.2 updates. (c) Latitudinal 2D histogram of XCO2 changes.

2) instrument line shape (ILS) improvements

Between the two choices of ILS update, test 1) New ils-lua with narrower ILS and test 2) using updated ils_delta_lambda and ils_relative_response in the ABO2, our analysis suggest the comparable Chi2 improvements but preferred CO2 grad del of test 2. The second ILS updates are selected.

3) South Atlantic Anomaly screening modifications

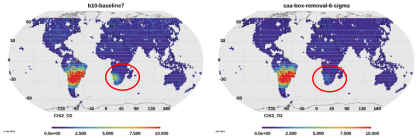


Fig. 5 Global map of Chi2 of O2-A band for baseline and test retrieval of SAA-box-removal-6-sigma.

Modify OCO-2 South Atlantic Anomaly (SAA) spike flagging by removing box (saa-box-removal-6-sigma). Improved Chi2_O2 are found S. Africa

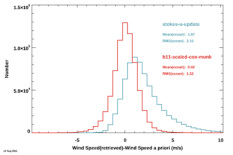


Fig. 6 Histogram of the difference of retrieved wind speed to a priori. Comparison of ocean data retrievals between the test of scaled-cox-munk and the baseline case: stokes-u-update.

4) An updated CO_2 prior

From B10 on, the CO2 priors use NOAA measurements at Mauna Loa and American Samoa to capture the overall growth rate. B10 priors use NOAA flask data that ends in Dec 2018; the trend is extrapolated past then. B11 priors use NOAA in situ data which is updated monthly.

JPL receives updated hourly data each month, and generates a monthly average file locally. This monthly average file is only appended to; existing monthly averages are not changed. This ensures that we can regenerate past L2Cpr files and get the same answer even if NOAA data is updated after we initially receive it. Before applying the new CO2 prior, we switch to customized land and ocean surface albedo model.

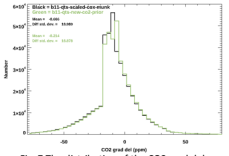


Fig. 7 The distribution of the CO2 grad del. New-co2-prior compared to the baseline case.

Ocean soundings use scaled-cox-munk

- Scaled Cox-Munk enabled via Lua.
- Wind speed a priori uncertainty set to 3 m/s via l2_special_run.py since we forgot to update it in the static input file.
- Wind speed get closer to a priori (Fig. 6).
- Retrievals are now more linear
- Bias correction terms now look much more like land retrievals

Land soundings use land-turn-off-polarized-brdf

- Lrad updated within the L2.
- Not much changes

New-co2-prior

- a new CO2 prior that reduces the need for extrapolation of CO2 trends and is now tied to the X2019 WMO scale instead of X2007.
- More CO2 grad del closer to zero (Fig. 7).

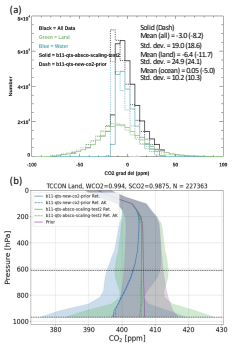


Fig. 8 CO2 grad del comparison between test retrievals of new WCO2, SCO2 scaling and the baseline of new-co2-prior (a) histogram of all data, land data, and ocean data. (b) the statistics of retrieved CO2 profiles at TCCON land sites.

5) New WCO2, SCO2 scaling to make XCO2 ~ unbiased

Attempting to mitigate a raw XCO2 bias of about -2.9 ppm vs. the model median validation dataset by scaling the CO2 ABSCO tables.

Also attempting to mitigate a negative co2_grad_del by changing the scaling slightly (Fig. 8).

- Current ABSCO scalings: [WCO2, SCO2]:[1.0, 0.9975]
- Test 1: [WCO2, SCO2]:[0.992, 0.9895]
- **Test 2: [WCO2, SCO2]:[0.994, 0.9875]** (Selected)

Conclusions:

We highlighted the updates of the ACOS new version 11 retrieval algorithm. The analysis showed the improvement of Chi2, residuals, retrieved H2O, XCO2 bias, and CO2 grad del by using new ABSCO v5.2, new ILS, new CO2 prior, and new WCO2 and SCO2 scaling.