CO_2 and O_2 spectroscopy improvements: impacts on XCO_2 retrieved from OCO-2 observations

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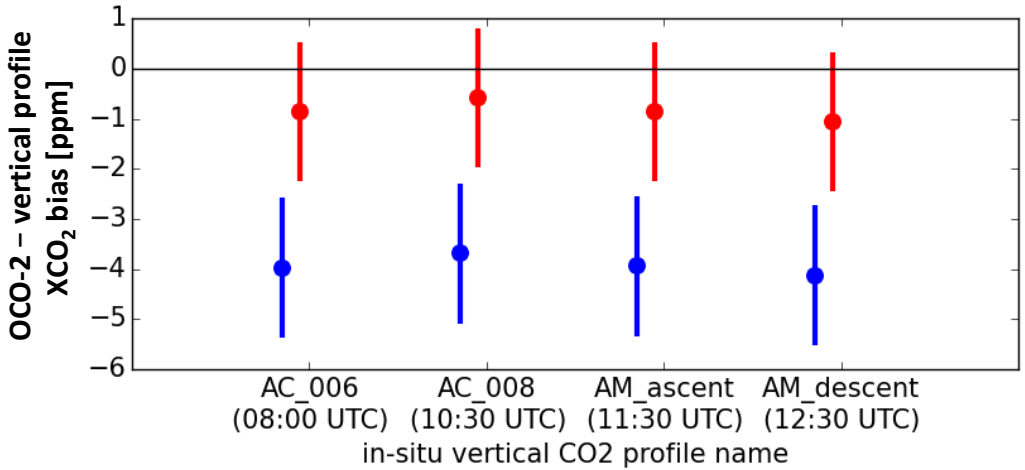
Context:

XCO_2 retrievals from shortwave infrared are critically dependent on atmospheric absorption parameters provided by molecular spectroscopy.

Data:

XCO_2 retrieved from **OCO-2 against four MAGIC 2019 in-situ vertical CO_2 profiles**, acquired on the 13th of June, 2019.

Here, we assess the impact of XCO_2 retrieved with Lamouroux 2015 model, adapted for Speed-Dependent Y (1st order) line mixing approach fueled with HITRAN 2012 line parameters (**new spectro**) against older CO_2 spectroscopy (**old spectro**)



Data

Monitoring of Atmospheric composition and Greenhouse gases through multi-Instrument Campaigns (MAGIC)

Funding: cnes, cnrs, EUMETSAT, esa

information: https://magic.aeris-data.fr/
contact: cyril.crevoisier@lmd.ipsl.fr

We use OCO-2 soundings collocated with four MAGIC 2019 in-situ vertical CO_2 profiles

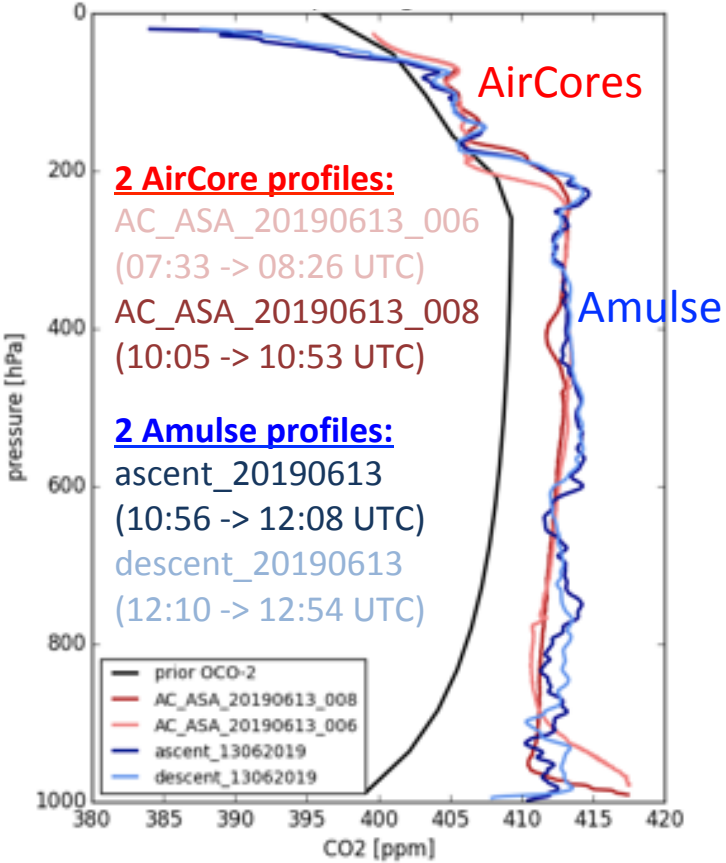
Orbiting Carbon Observatory – 2

(ACOS version 9r)

169 OCO-2 soundings with:

- All best quality flags
- |in-situ − a priori Surf. Pressure| < 15 hPa
- collocation ~ 100 km, overfly ~ 13:00 UTC

4 CO_2 in-situ vertical profiles



Method: 5AI retrieval scheme

We retrieve XCO_2 from OCO-2 nadir measurements using the **5AI inverse scheme**[1] based on **Optimal Estimation**. It relies on 4A/OP radiative transfer model and **we seek to compare two spectroscopic parameter sets** (**old spectro** and **new spectro**).

[1](Dogniaux et al., 2021, in press: https://amt.copernicus.org/preprints/amt-2020-403/)

State =

- T profile shift
- H_2O scaling factor
- CO_2 profile
- Surface pressure
- Bandwise albedo
- Bandwise albedo slope

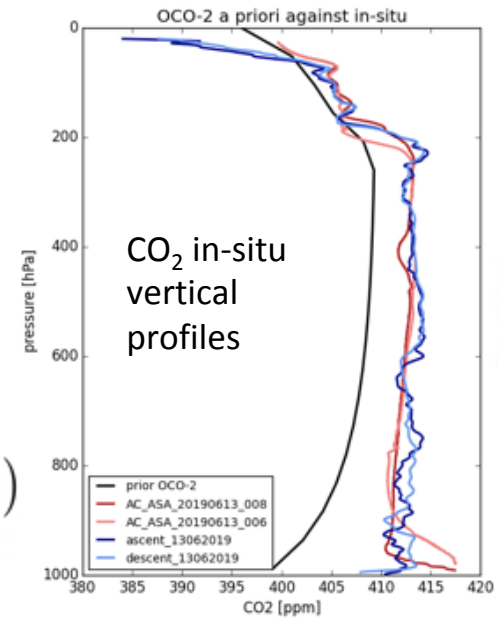
A priori state and covariance = **ACOS**

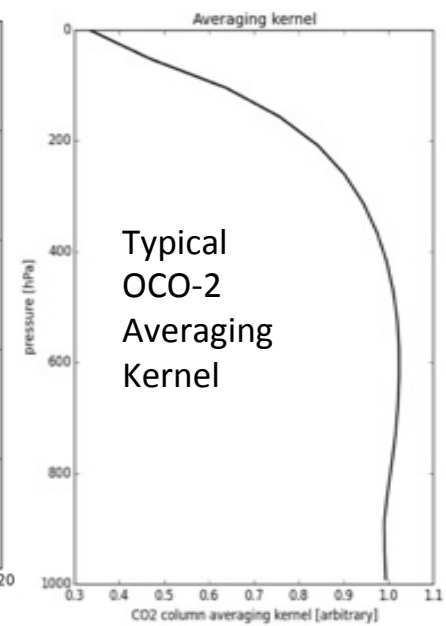
Method for comparison

XCO_2^{insitu} is computed for each OCO-2 point for the four in-situ vertical profiles by using AKs:

$$X_{CO_2}^{insitu} = X_{CO_2}^{ap} + h^T A \left(x_{CO_2}^{insitu} - x_{CO_2}^{ap}\right)$$

$$= X_{CO_2}^{ap} + \sum_j h_j \; a_{CO_2,j} \; \left(x_{CO_2}^{insitu} - x_{CO_2}^{ap}\right)$$





CO_2 and O_2 spectroscopy improvements

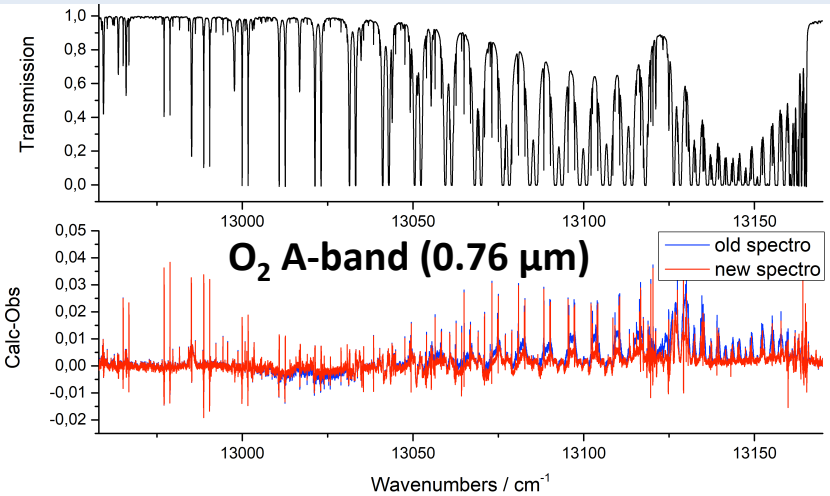
Two different spectroscopic parameter sets are tested:

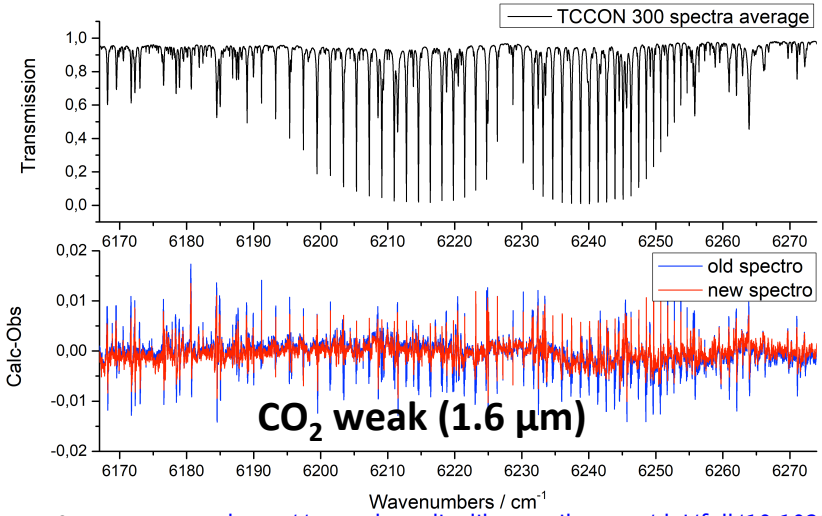
old spectro:

- O_2: Tran Hartmann 08 collision-induced absorption (CIA) model
- CO_2: HITRAN08 + Lamouroux 2010 line mixing

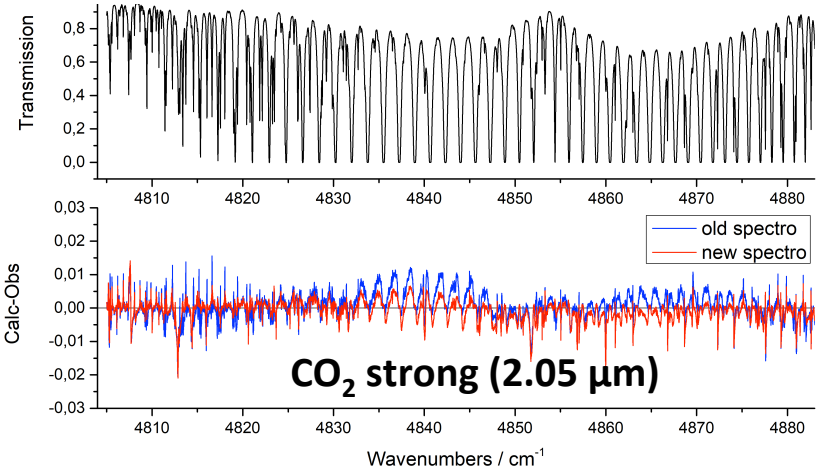
new spectro:

- O_2: **empirically correction** on Tran and Hartmann 2008 CIA model
- CO_2: Lamouroux 2015 model, adapted for **Speed-Dependent Y (1st order) line mixing approach** fueled with HITRAN 2012 line parameters
- Improved sampling strategy of spectrocopic parameters





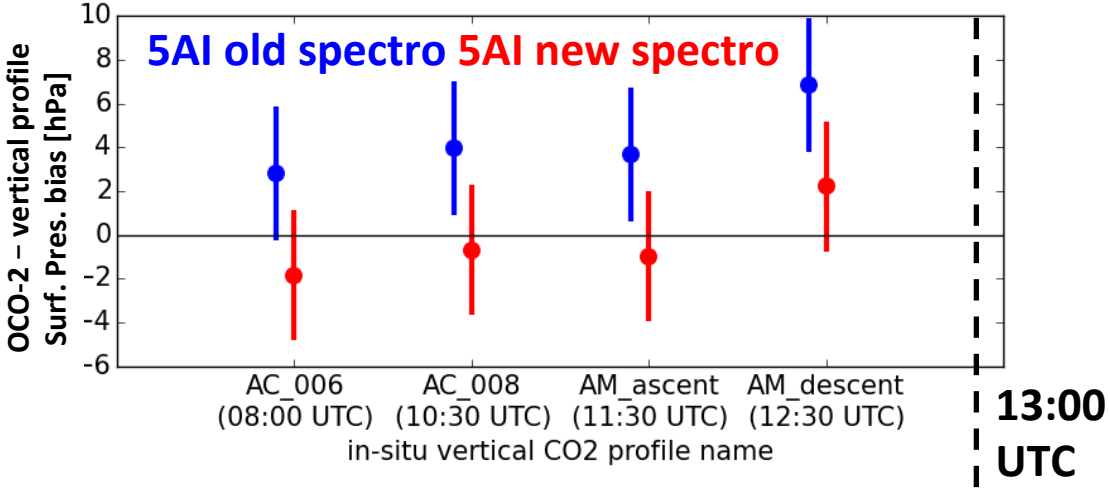
calculated-observed spectral residuals evalutated on 300 TCCON spectra

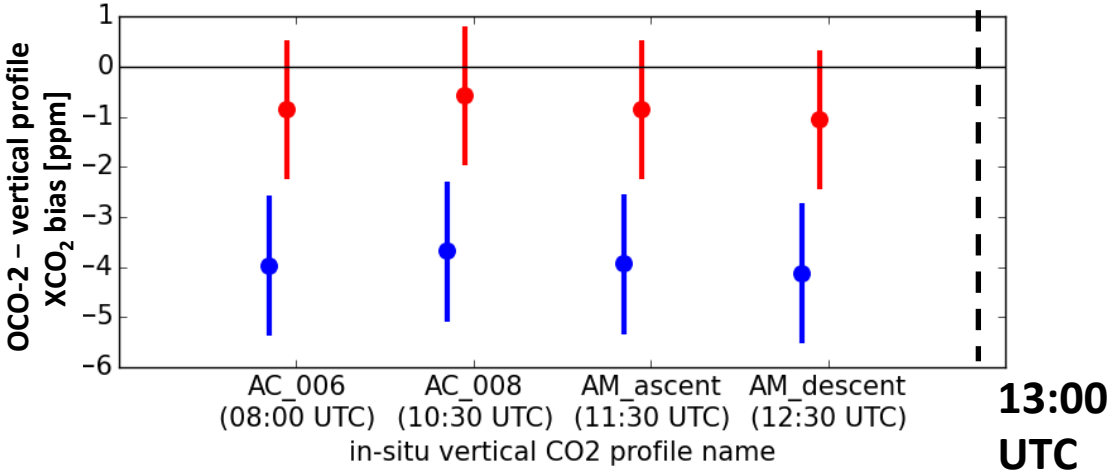


Tran & Hartmann, 2008: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2008JD010011
Lamouroux et al, 2010: https://www.sciencedirect.com/science/article/pii/S0022407310000920
Lamouroux et al, 2015: https://www.sciencedirect.com/science/article/pii/S0022407314003896

Retrieval results & Conclusions & Perspectives (1/2)

OCO-2 overfly time = **13:00 UTC**





The **empirical CIA correction** reduces the surface pressure bias.

It contributes to reducing XCO_2 bias along with **SDY line mixing + HITRAN 2012 model** for CO_2, compared to **previous spectroscopic parameters**.

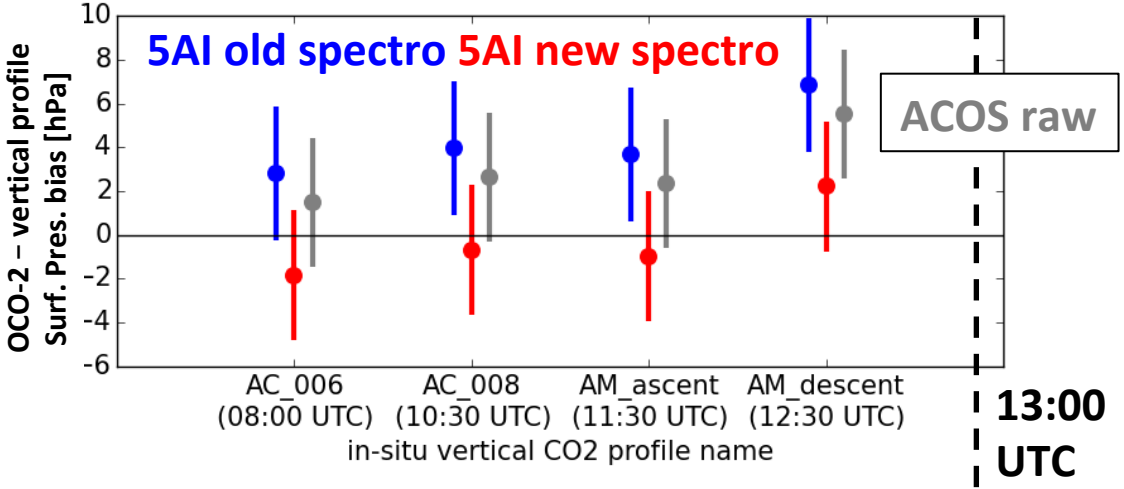
Next steps

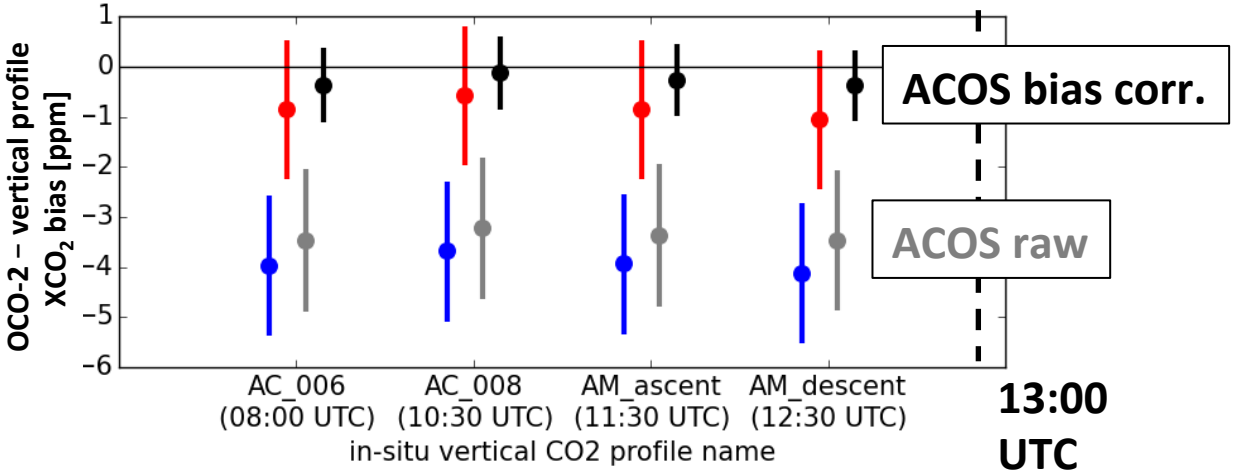
Latest spectroscopic updates are being similarly tested:

- GEISA 2020 version
- HITRAN 2016
- Different CO_2 Line Mixing models

Retrieval results & Conclusions & Perspectives (2/2)

OCO-2 overfly time = **13:00 UTC**





Main differences between ACOS and 5AI are related to scattering particle treatment and spectroscopy.

We argue that an extensive in-situ vertical profile dataset collocated with OCO-2/3 could help both spectroscopy validation and algorithm intercomparison studies for the preparation of upcoming concepts.