Universität Bremen

Institut für Umweltphysik

Fachbereich 01
Physik/Elektrotechnik

Applying the CO2M candidate algorithm FOCAL to OCO-2

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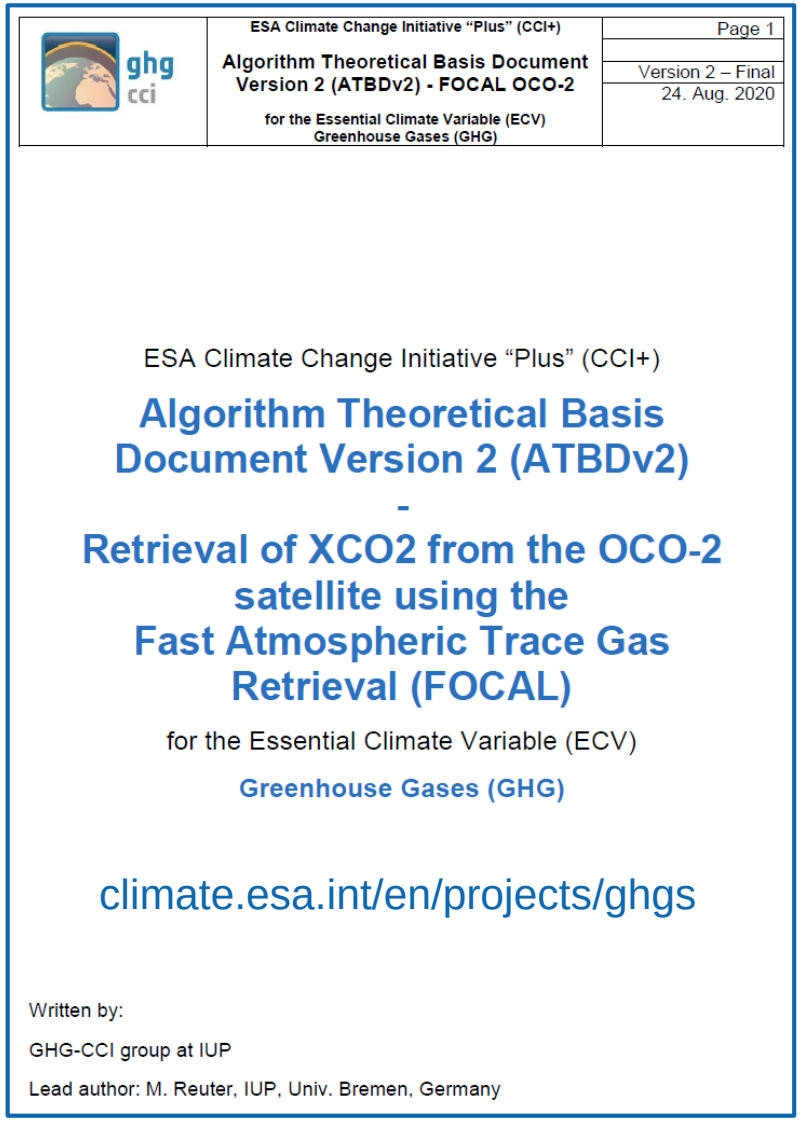
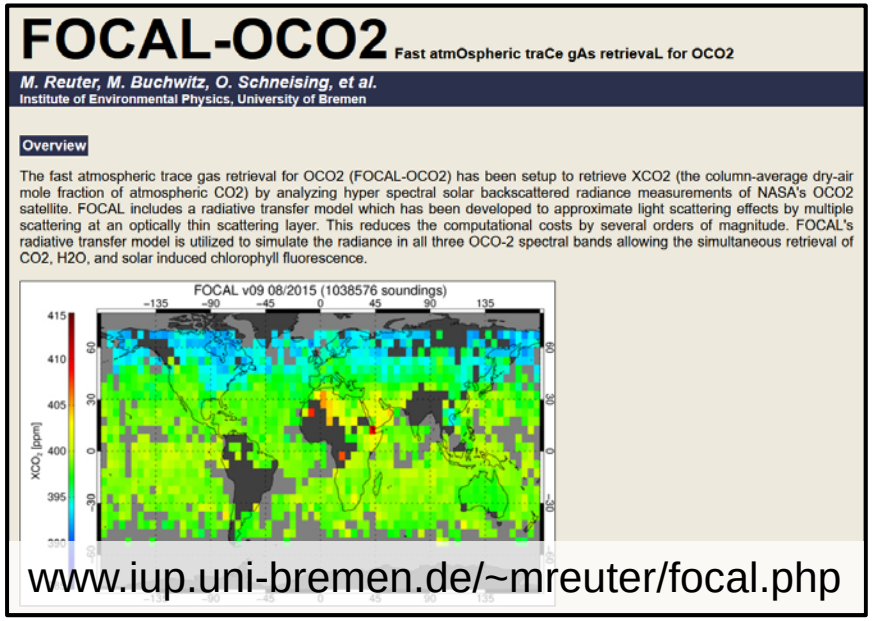
Introduction

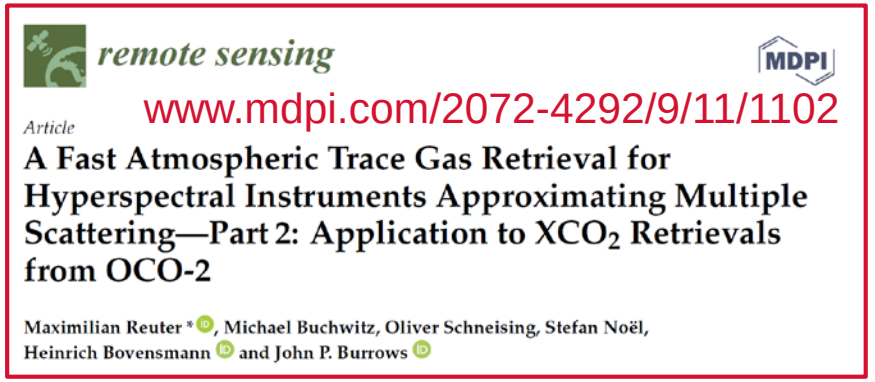
- The European Copernicus CO2M mission is envisaged to be launched in 2025.
- EUMETSAT is preparing to operate up to three retrieval algorithms in its ground segment.
- One of these algorithms is FOCAL (fast atmospheric trace gas retrieval).
- Retrieval studies with simulated data are essential. However, it turned out, that the retrieval algorithms usually require significant adaptations when applying them to the observations from instruments in orbit.
- This comprises, e.g., pre-processing steps, handling of systematic residuals, outlier detection, and bias correction.
- Thus, we are developing strategies to adapt FOCAL to satellite instruments already in orbit, from which hope to learn for a smooth transition to CO2M, eventually.
- The presentation of S. Noël et al. shows results for FOCAL GOSAT and GOSAT-II.

Introduction

- Here we present the most recent developments for the FOCAL OCO-2 algorithm.
- Starting point: FOCAL v09 as described by Reuter et al. 2017a, b, and 2020
- v10 is work in progress.







Cloud detection

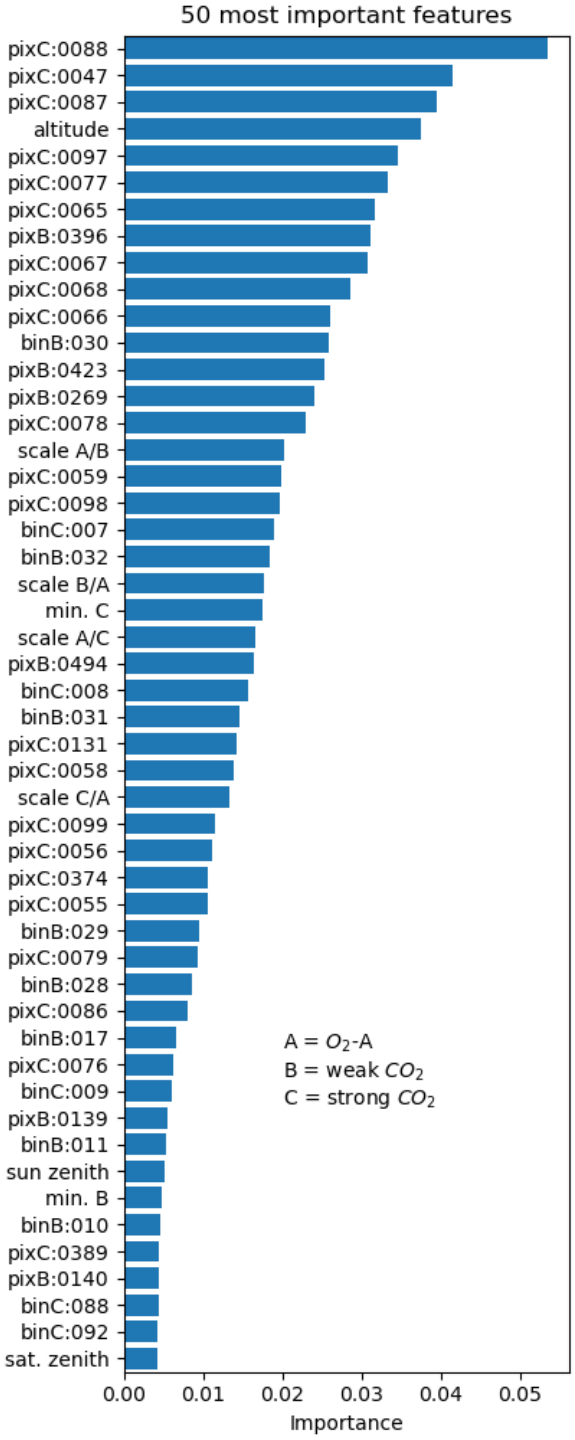
- v09: based on NASA MODIS AQUA cloud mask
  ⇒ poor throughput (<11%)
- v10: random forest classifier analyzing OCO-2 v10 L1b
  - Training / control truth: MODIS AQUA
  - Candidate features: OCO-2 v10 L1b all colors normalized by continuum radiance, colors binned by 8, observation geometry, etc.
  - Features selected for training: 50 most important
  - High performance in training and control

Training		Actual	
		cloudy	free
Predicted	cloudy	49575	449
	free	425	49551

Control		Actual	
		cloudy	free
Predicted	cloudy	80819	201
	free	897	18083

~1% of actually free

~5% of predicted free



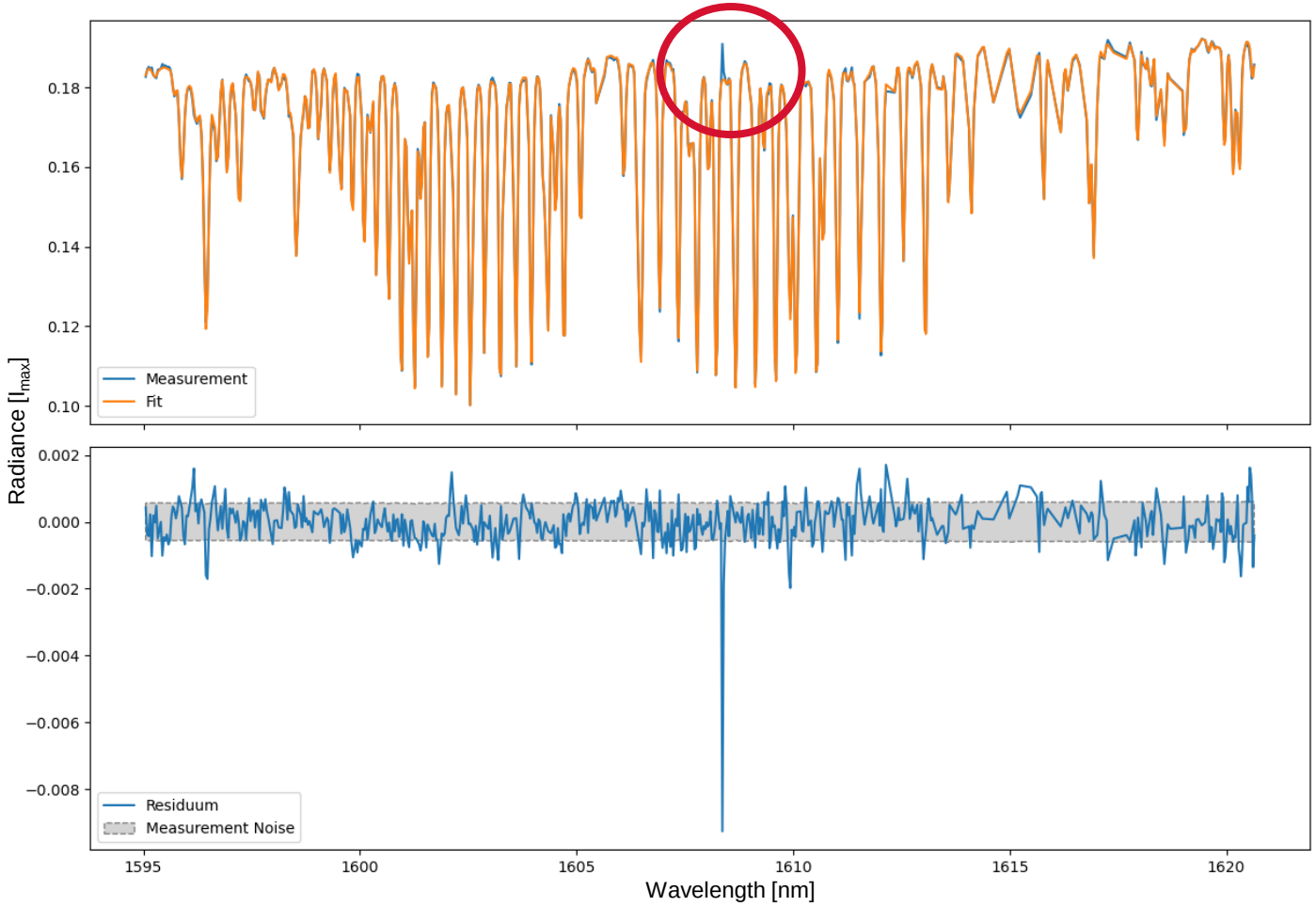
Handling of spectral spikes

v09

- Allows <60 “bad colors” in the O2 band, no “bad colors” in the SWIR bands.
- Throughput: ~90% but rejected basically all soundings in the SAA.
- Static bad pixel mask.

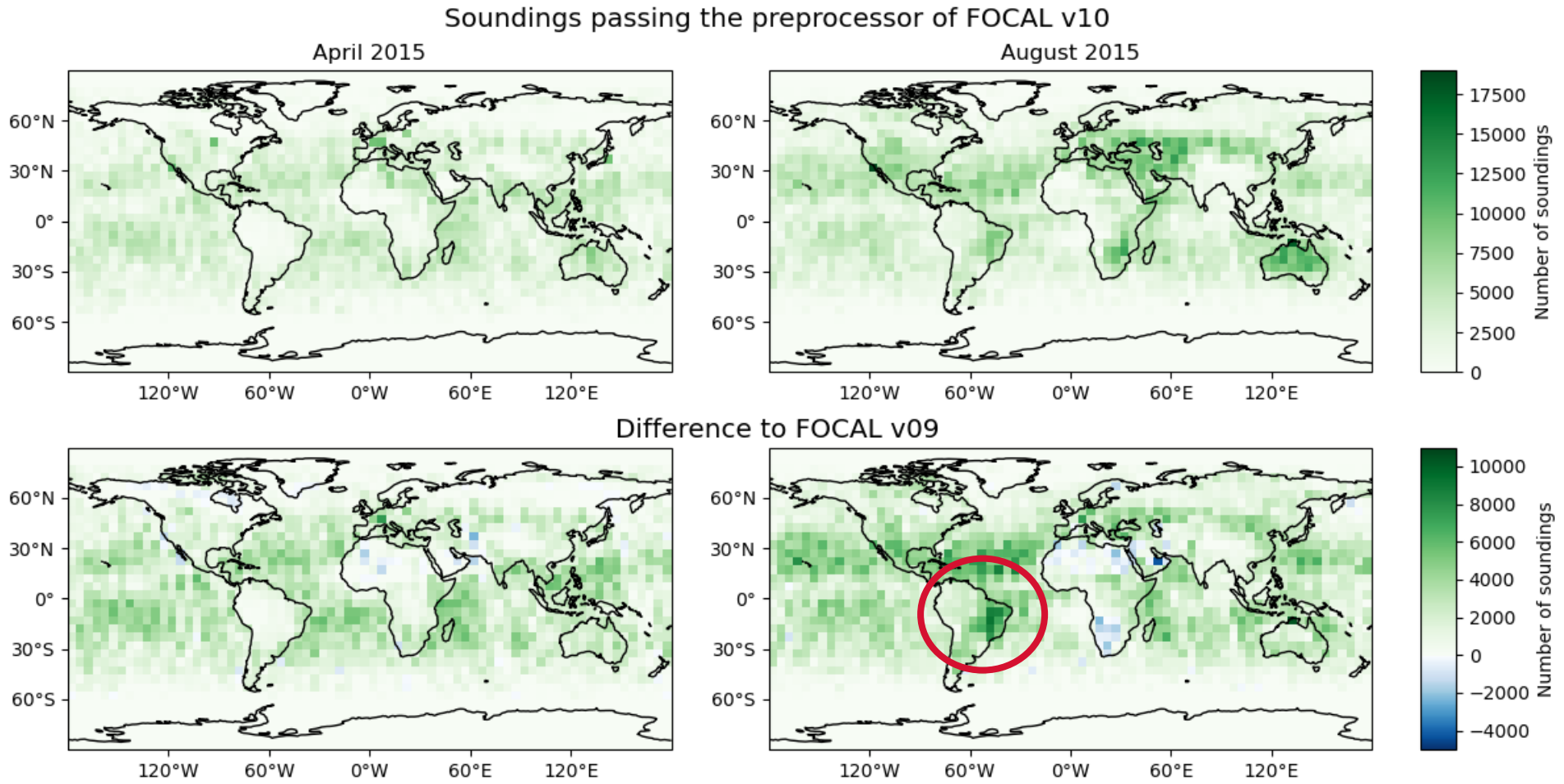
v10

- No pre filtering by bad colors.
- Dynamic bad pixel mask, i.e., only those parts of the spectra are used which are not affected by, e.g., cosmic rays.
- Improved throughput especially in the SAA.



Pre-processor throughput

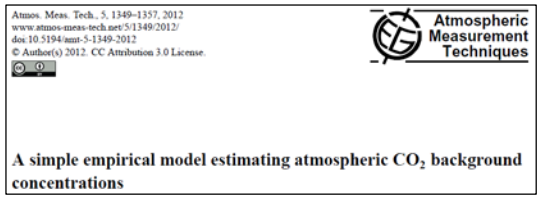
The overall pre-processor filtering throughput of v10 is ~3.7 times larger than for v09.

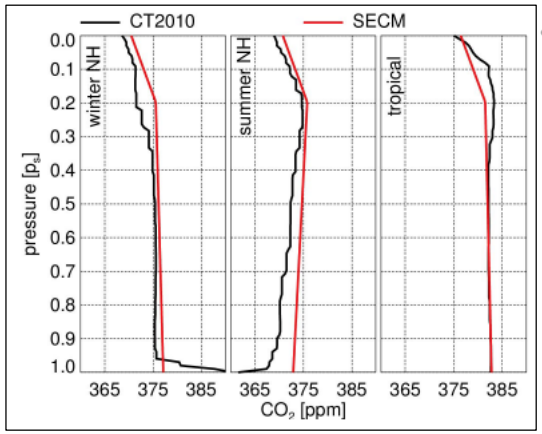


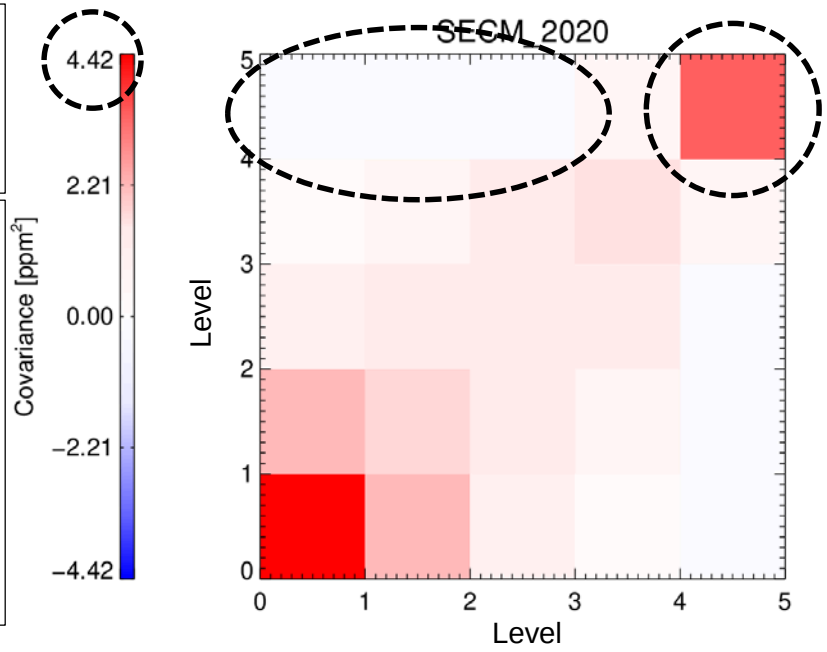
CO2 a priori

v09

- SECM 2020 has been used as a priori for CO2.
- SECM is an empirical function fitting NOAA's CarbonTracker (CT) model.
- SECM parameterizes profiles linearly in the troposphere and stratosphere.

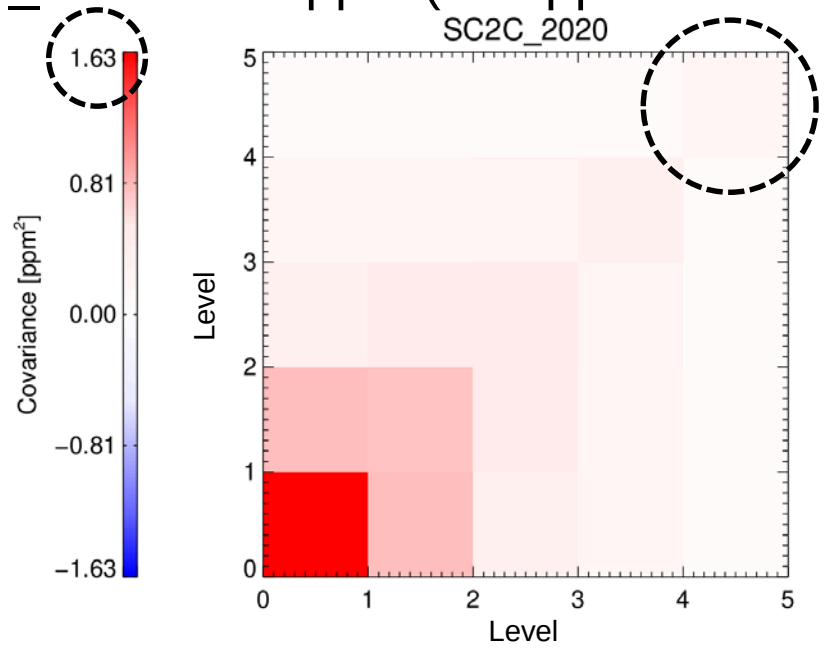






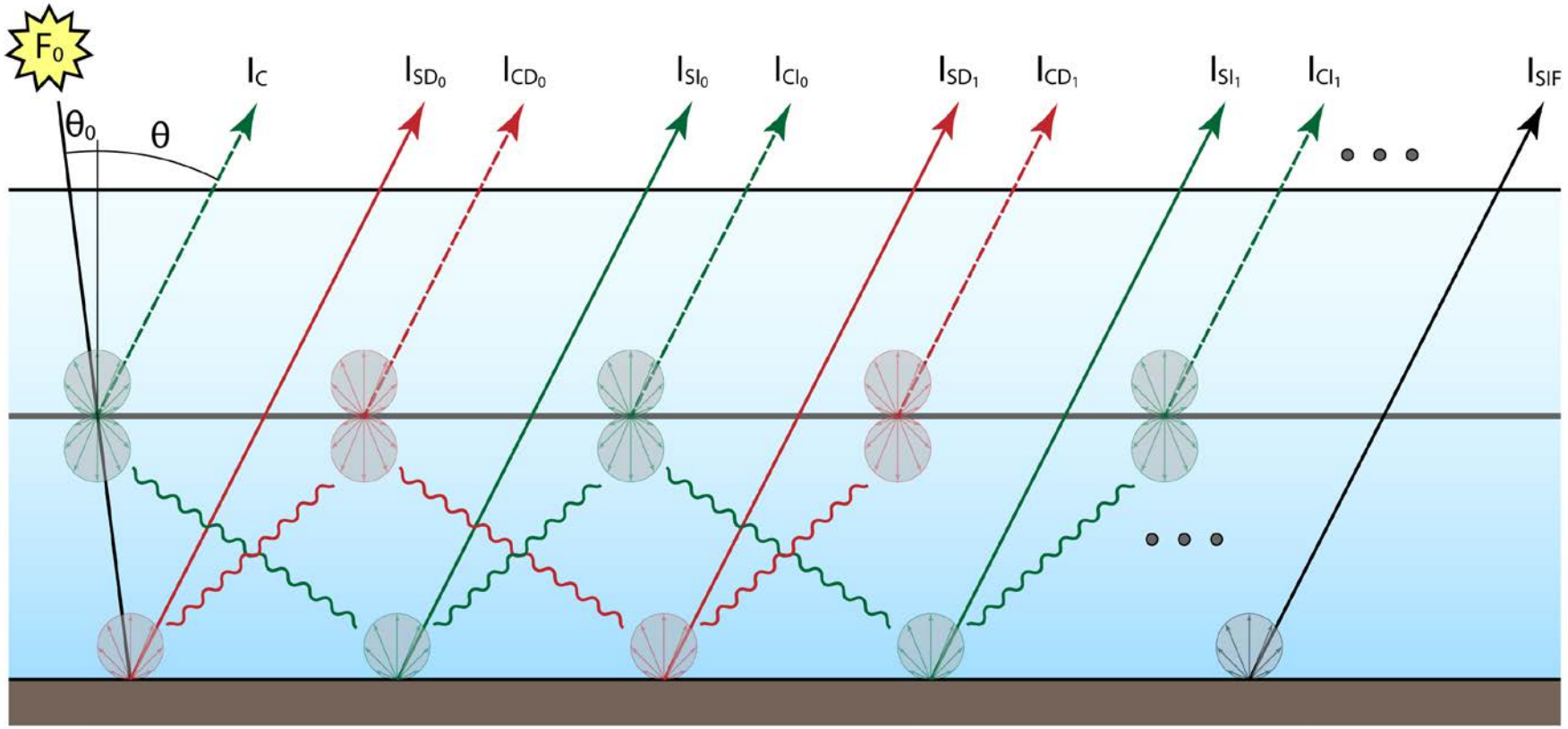
v10

- The v10 a priori bases on a 16-year CT climatology corrected for the annual growth.
- More realistic XCO2 and profile shape (especially in the stratosphere).
- No negative correlations.
- σΔXCO2 = 0.58ppm (1.00ppm for SECM)
- σΔCO2_strat = 0.49ppm (1.84ppm for SECM)



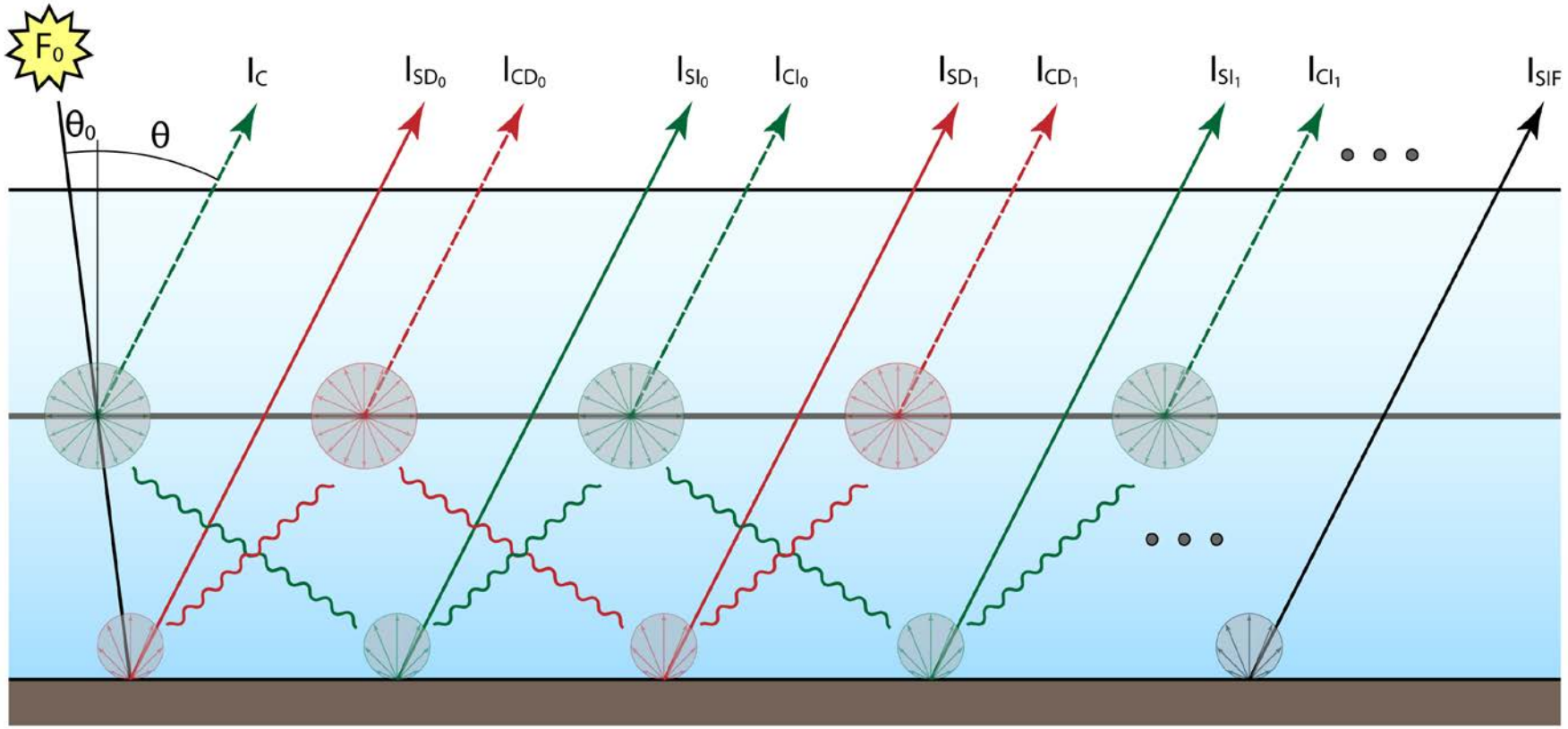
Radiative transfer **v09**

- FOCAL v09 approximates scattering to occur only at one optically thin scattering layer.
- Scattering at the surface and the scattering layer is assumed to be Lambertian.
- The observed radiance is split into direct and diffuse parts.
- The transmission of the diffuse flux can be computed by 2E3(τ).
- Multiple scattering of the diffuse flux can be expressed by a geometric series.



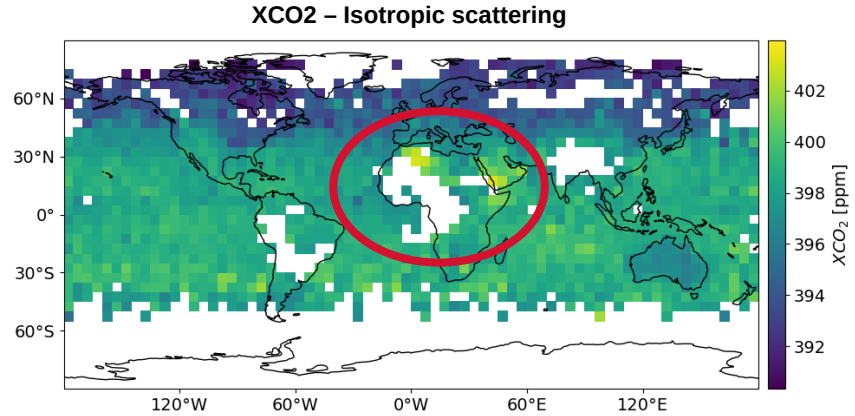
Radiative transfer **v10**

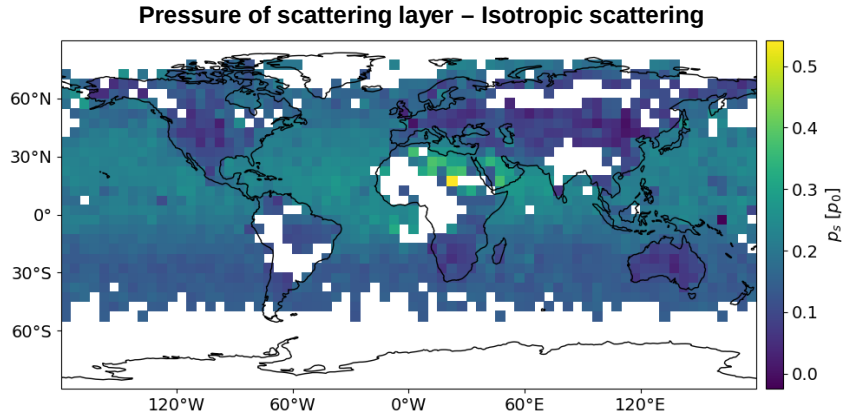
- FOCAL v10 assumes isotropic scattering at the scattering layer which is more realistic for an optically thin layer.
- The transmission of the downward flux becomes E2(τ) and the geometric series change accordingly.

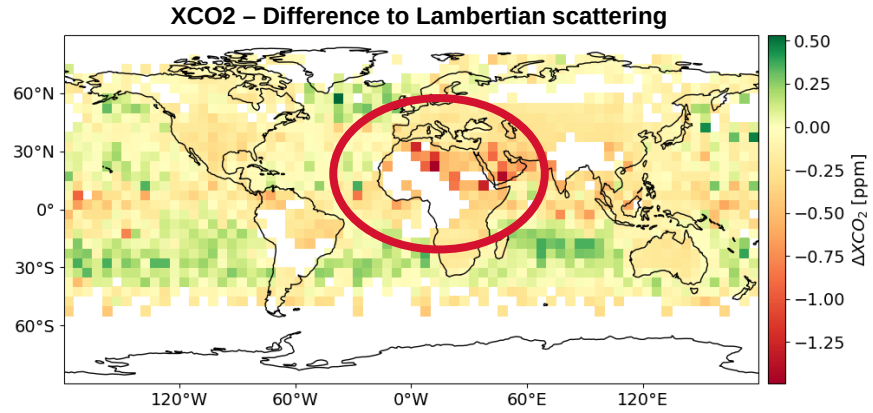


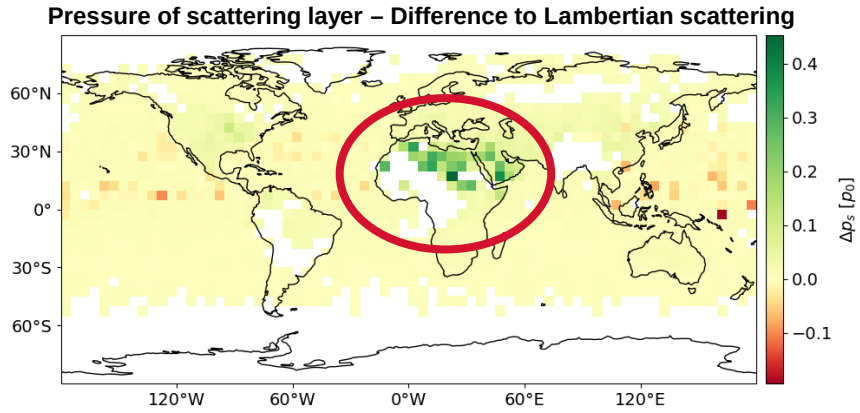
Radiative transfer **v10** vs. **v09**

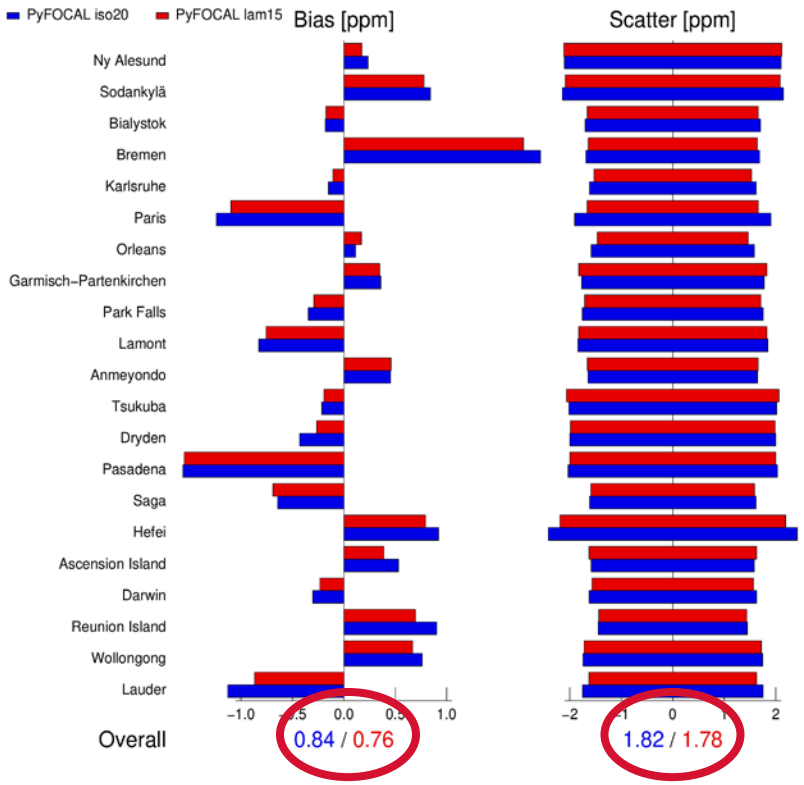
- Overall similar XCO2 results.
- More realistic XCO2 values above the Saharan desert in some months due to changes in the retrieved scattering properties (especially, pressure of the scattering layer).
- 5-10% more converging soundings; fewer iterations needed.
- Slightly degraded agreement of rudimentary bias corrected XCO2 with TCCON (likely not significant).











Summary

- New pre-processor has about 3.7 times larger filtering throughput.
- Improved handling of spectral spikes.
- More realistic CO2 a priori.
- Modified RT resulting in better convergence behavior and more realistic values above Sahara.
- Applying the filtering strategy of v09, v10 has about 2.7 time more soundings.

Next steps

- L2 Processing.
- Adaptation of filtering and bias correction according to Noël et al.
- Validation, documentation, and release of v10 data set.

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Acknowledgements

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