Retrieved of L2 Products from new V205 L1B spectra in the thermal infrared band of TANSO-FTS over the Arctic ocean and comparison with retrievals from previous versions.

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Context

- Among the instruments performing remote sensing from space, measurements using Fourier transform spectrometers operating in the thermal infrared (TIR) spectral domain are not hampered by the requirement of not too large solar zenith angles as in SWIR measurements.
- In this study we concentrate on the calibration/validation of the Thermal and Near Infrared Sensor for Carbon Observation (TANSO)–Fourier Transform Spectrometer (FTS) spectra in the TIR spectral region (B4 band) over the Arctic Ocean
- It appeared quickly that the changes in the various versions of L1b products in B4 were resulting in different retrieved products
- Our goal was to quantify the differences between versions and to contribute to the assessment of the quality of the successive new versions

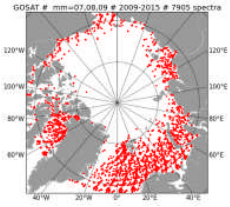
Summary

- We have previously performed inter-comparisons of the retrieved L2 products from five successive versions of L1B products (V150, V160, V201, V203) to check the differences and the improvement in the spectral and radiometric calibration of TANSO-FTS spectra in the narrow spectral domain of 940–980 cm^{-1} covering CO_2 lines of the so-called laser band in the rather clear 10.4 µm atmospheric window, allowing sounding down to the lowest atmospheric layers. To our knowledge, this was the first attempt to retrieve XCO_2 from this spectral region.
- A new L1B version (V205) is now available and we present new retrievals using this data. The period covered is the summer months (July, August, September) and the years from 2009 to 2015. Internal comparisons of L1B TANSO-FTS spectra, as well as comparisons of our previously retrieved L2 products, i.e., T_{surf} (sea surface temperature or SST) and the retrieved column-averaged dry air volume mixing ratio XCO_2 derived with the same algorithm are presented, as well as the overall trend in XCO_2.

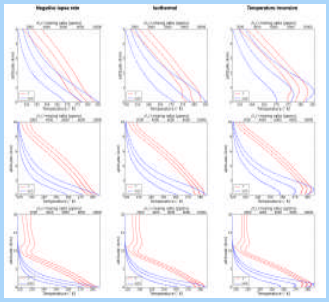
Retrieval of T_{surf} and XCO_2 from GOSAT SWIR TANSO-FTS data

Spectral synergy techniques for lowermost tropospheric retrievals

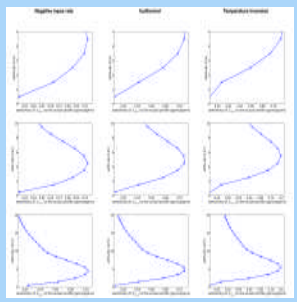
- Retrieved products using exactly the same « home made » inversion configuration (LARA algorithm
- Window: 940 - 980 cm^{-1}, "CO_2 laser band region"
- State vector: x=(T_{surf}, XCO_2, coeff_H_2O, coeff_O_3)
- Diagonal covariance matrix S_y (L1B unapodised spectra)
- No *a priori* for T_{surf} and XCO_2 constant mixing ratio profile
- T(z) extracted from ECMWF ERA-Interim analyses
- H_2O(z) profile scaled from ECMWF ERA-I
- SF_6 fixed (including trend between 2009 and 2017)
- We have checked the retrieval sensitivity to the shape of the actual T(z) profile
- Retrieval results have considered as reliable only for normal (negative) lapse rate profiles among the 3 classes of profiles: normal lapse rate, isothermal, temperature inversion → pre-filtering
- Version of L1b GOSAT spectra : v15x15x, v16x16x, v201202, v203203, and v205v205



Plot of the footprint position of selected TANSO-FTS "clear, sea, normal lapse rate, good line contrast" for year 2009 to 2015. A third filter is applied on the profiles. We first eliminated all saturated ECMWF ERA-I water vapor profiles. We selected then only IFOVs for which the ECMWF/ERA-I temperature profile (extracted and interpolated in time and space for any particular footprint) was appropriate. Over the Arctic Ocean, different geophysical situations can occur with respect to the temperature profile. We have distributed 29945 profiles ECMWF T(z) profiles into three classes: negative (normal) lapse rate profiles, temperature inversion below 2 km and quasi-isothermal profiles in the 0-1 km layer and others. We found 7905 negative lapse rate profiles, 3089 isothermal profiles and 18951 profiles with temperature inversion. The mean temperature profile for the different categories are shown in the left panel of the Figure on the right. The results of a sensitivity study (right panel of the Figure on the right) led us to retain only the negative lapse rate profiles.



Mean temperature (red) and humidity (blue) profiles used to check the performance of the retrievals



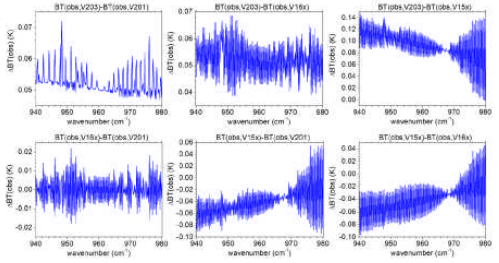
Sensitivity curves for GOSAT to check the performance of the retrievals.

In order to get the overall and more detailed views of the situation in the atmosphere, including the range covering the boundary layer (of about 1 km thickness for the conditions of our Arctic retrievals), the profiles are successively zoomed from 0-20 km, to 0-10 km and down to 0-5 km (from the upper to lower panels)

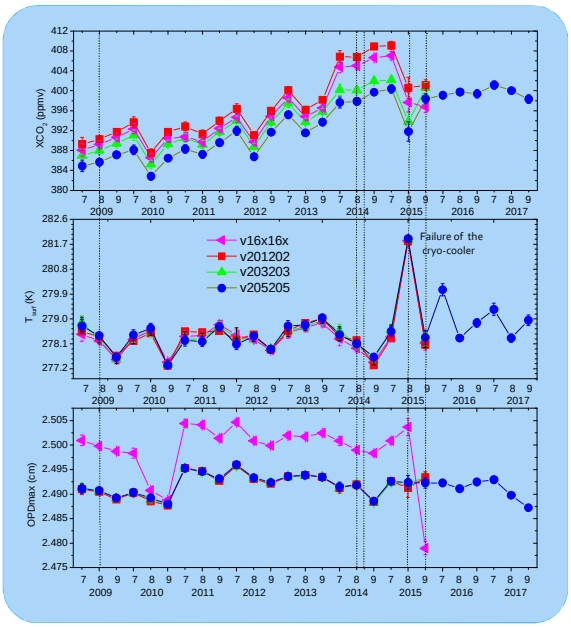
Comparison of L2 TIR products from five different versions of TANSO-FTS spectra

Overall results :

- This exercise was initially to compare the capabilities of retrievals of T_{surf} and CO_2 from GOSAT in one "surface window" i.e. 940-960 cm^{-1} (~10.4 µm) for obtaining "climate quality records" at a regional scale in the summer months of the Arctic Ocean for a period of 9 years for clear and ice-free IFOVs and to compare with IASI (2009 to 2017) in the latitude region [68N ; 80N]
- The individual T_{surf} precision (not accuracy!) of GOSAT is ~ 0.05 K 1σ for clear IFOVs, over sea and with a normal atmospheric lapse rate T(z) profile (from ECMWF)
- The individual XCO_2 precision (not accuracy!) of GOSAT in the TIR is ~ 6 ppmv 1σ for clear IFOVs, over sea and with a normal lapse rate
- There is no *a priori* constraint on the XCO_2 value except a constant mixing ratio profile x_{CO2}(z)
- The variation of T_{surf} with latitude and between July/Aug/Sept is significant
- The inter-annual variability does not show a trend in T_{surf} at the regional scale
- The overall trend in the CO_2 column averaged VMR is well captured over the 9 years period for GOSAT
- But radiometric calibration issues (related to non-linearity correction, blackbody emissivity and in orbit changes in the FTS temperature) was still hindering the use of TANSO-FTS TIR spectra for accurate and stable XCO_2 and T_{surf} products.
- New v205 L1 products show significant differences in our L2 retrieved parameters (see figure).



Mean brightness temperature difference spectra between versions. First row, from left to right: V203-V201, V203-V16x, V203-V15x. Second row: V16x-V201, V15x-V201, V15x-V16x. Note the quite expanded vertical scales in ΔBT.



Perspectives

- It is very important to confirm the absolute radiometric calibration of TANSO-FTS in the TIR for providing series of "climate quality variables" for T_{surf} and possibly CO_2 in the not so well documented Arctic Ocean region not covered by the SWIR/NIR bands
- IASI will be a good reference for checking the new version of TANSO-FTS spectra in the TIR region (B4)

Acknowledgments

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References

- Payan, Sébastien, Claude Camy-Peyret, and Jérôme Bureau. « Comparison of Retrieved L2 Products from Four Successive Versions of L1B Spectra in the Thermal Infrared Band of TANSO-FTS over the Arctic Ocean ». Remote Sensing 9, n° 11 (November 17th 2017): 1167
- See also the poster A1.1 of IWGGMS14 by Masiello et al. on the same topic, but using IASI spectra.