Potential of TIR+SWIR combination from space measurements for CH_4 retrievals: application to IASI and S5P

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Atmospheric CH_4 is measured continuously from space-borne passive optical instruments, providing valuable information at global and regional scales for atmospheric monitoring and for surface flux estimates. Spectra produced from instruments operating in the SWIR domain provide a vertically unresolved total atmospheric column with rather uniform sensitivity from the surface up to the tropopause. In contrast, instruments operating in the TIR provide spectra from which it is possible to partially resolve the vertical structure of the CH_4 profiles, as the middle and upper tropospheric spectral contributions of the gas can be distinguished. However, the CH_4 sensitivity of TIR instruments is lower near the surface, compared to SWIR instruments. These differences in vertical sensitivity can be exploited to provide profiles having significantly improved vertical resolution by a synergistic combination of measurements from these two spectral domains. Such profiles will be valuable for the understanding, quantification and monitoring of surface processes as well as sources and sinks of CH_4.

To demonstrate the improvement in vertical resolution we implemented and tested an original L1/L2 approach for the joint TIR+SWIR retrieval of CH_4 profiles from IASI L1C spectra and TROPOMI/S5P L2 vertical column density estimates. This combination was shown to be promising in previous work in the context of this ongoing study supported by CNES. A scheme for retrieving methane profiles from TIR IASI L1C spectra using the Optimal Estimation Method (OEM) with the 4AOP radiative transfer forward model has first been developed and evaluated. This method has then been extended by constraining the retrieved methane profiles using information from L2 CH_4 products, which are separately derived from the SWIR spectra of S5P.

Tools for finding near-simultaneous IASI and S5P observations within a given region of interest and with acceptable footprint overlaps and time differences have been implemented. Using those, a collection of coincident IASI and S5P data spanning an area over the boreal region extending from 55N to 78N and from 40E to 190E for a two-week period in September 2020 was obtained. The TIR-only and TIR+SWIR joint retrieval schemes were then carried out. Comparisons were made between the S5P SWIR, TIR-only and joint TIR+SWIR methane estimates, both for profiles and for total column values. In addition, the profiles were also compared against available correlative airborne *in situ* local concentration measurements.

The objectives of this work are 1) to analyse the consistency of these complementary but different datasets, 2) to evaluate the behaviour and added value of our scheme for the proper combination of TIR and SWIR information, and 3) to investigate the ability of this combination to provide further information on the vertical profiles, especially in the lower troposphere. This work is also expected to contribute to the joint exploitation of the co-located measurements that will be collected by the IASI-NG and Sentinel5/UVNS instruments onboard Metop-SG.