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Towards estimating atmospheric carbon dioxide and methane columns over boreal ecosystems from hyper-spectral infrared sounders

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Recent studies based on the existing space-borne hyper-spectral IR sounders (like AIRS/EOS-Aqua, IASI/MetOp) have demonstrated their capability to detect the space and time variations of atmospheric carbon dioxide and methane concentration. Their aptitude to reproduce seasonal and inter-annual trends of column-average CO_2 mixing ratio Q_{CO2} and to retrieve the similar average mixing ratio Q_{CH4} for CH_4 is of significant importance in the context of carbon cycle research, the problem of global warning, and other climatic and ecological applications.

This presentation first describes the approach developed for clear-sky spectral radiance inversion and retrieval of Q_{CO2}. Sensitivity studies (using FRTM simulations of synthetic spectra) enabled to select a set of CO_2-dedicated channels in both SW and LW regions with strong signal responses to CO_2 concentration changes and weak signal responses to variations of interfering factors i.e. surface temperature, water vapor and ozone profiles. To retrieve Q_{CO2}, an original procedure has been proposed based on a physical inversion algorithm (Gauss-Newton iterative scheme). The validation effort carried out with real AIRS data for two areas over boreal ecosystems in Western Siberia (Novosibirsk and Surgut regions) and for 10 months of year 2003 demonstrates that the retrieved monthly-averaged Q_{CO2} values reproduce seasonal variations of CO_2 column amounts (in a layer between ~3.5 km and about 7-8 km) with a precision of about 3.0 ppmv as compared to *in situ* airborne observations.

With respect to Q_{CH4} retrievals from AIRS and IASI data, two approaches have been investigated. The first and more traditional one is based upon a physical inversion algorithm and utilizes clear-sky AIRS or IASI data in 3 to 4 channels within the methane absorption band around 7.7 μm together with AIRS/IASI-based Level 2 products. The performance of this algorithm is of the order of 3-5% as evaluated using synthetic AIRS and IASI data. The second approach is also based on a physical inversion and utilizes clear-sky AIRS or IASI data in 3 super-channels, generated in order to reduce the effect of temperature profile uncertainties on the precision of Q_{CH4}retrievals. For IASI the CH_4-dedicated super-channels can be built as linear combinations of T- and CH_4-dedicated channels with wavenumbers 706.5 & 1332.5, 715.25 & 1341.75, and 714.0 & 1346.75 cm^{-1} respectively.

The performance of the described retrieval algorithms is currently being evaluated in a case study experiment involving datasets of IASI/MetOp and IASI-balloon together with ground based and radio-sonde observations for Esrange (Kiruna, Sweden) on 22 Feb 2007. This dataset was produced by the LPMAA team and was complemented with quasi-synchronous and collocated AIRS data as well as with AIRS-based L2 retrievals. The first experimental retrievals of Q_{CH4} andQ_{CO2} from AIRS and IASI data are consistent within their corresponding error bars and that seems promising.

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