Methane vertical profiles over the Indian subcontinent derived from the GOSAT/TANSO-FTS thermal infrared sensor

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We examine CH_4 variability over different parts of India and the surrounding oceanic regions using thermal infrared (TIR) band observations by the Thermal And Near-infrared Sensor for carbon Observation-Fourier Transform Spectrometer (TANSO-FTS) onboard the Greenhouse gases Observation SATellite (GOSAT). GOSAT/TANSO-FTS TIR (hereafter referred to as “GOSAT-TIR”) band provides data coverage and density that captures detailed features of CH_4 distributions even in the cloudy conditions, which is very common for the region with a monsoon climate.

The vertical profiles of CH_4 observed from GOSAT-TIR were compared to results of simulations by the Model for Interdisciplinary Research on Climate (MIROC, version 4.0) based atmospheric chemistry-transport models (ACTM) referred to as MIROC4-ACTM. The ACTM runs are conducted at a horizontal resolution of T42 spectral truncations (≈2.8°×2.8°) with 67 sigma-pressure vertical levels. The ACTM CH_4 was simulated with two combinations of inverted fluxes:
1) $ACTM_{Cao}$: EDGAR432 + GFED4s + Termite + ... + VISIT wetland (Cao scheme),
2) $ACTM_{WH}$: EDGAR432 + GFED4s + Termite + ... + VISIT wetland (WH (Walter&Heimann) scheme).
A comparison of modeled and observed CH_4 shows that the GOSAT-TIR retrievals at 22 vertical levels provide critical information about CH_4 transport from the top of the boundary layer to the upper troposphere and lower stratosphere in the region. Even if no averaging kernel incorporated, the mean ACTM-GOSAT misfit is within 50 ppb, except for the level of 150 hPa and upward, where the GOSAT-TIR sensitivity becomes very low. The GOSAT-ACTM misfit above the level of 150 hPa is likely to arise from a priori model for TIR retrievals. Convolution of the modeled profiles with retrieval a priori and averaging kernels reduces the misfit to below uncertainty. However, the weight of the a priori profiles becomes too large with such smoothing.

Overall, the ACTM simulations of CH_4 in the Indian regions compare favorably with the GOSAT-TIR samplings, in terms of seasonality and regional variability. However, the GOSAT-ACTM inconsistencies indicate opportunities for further flux optimization and emission uncertainty reduction by inverse modeling methods.

Fig. 1. **Center**: The map of the regional divisions for the analysis –the high mountain range on the northern sides and oceans in the southern boundaries form a unique monsoonal flow in the region. The Indian regions from Southwest to Northeast are following: the Arabian Sea (AS), Southern India (SI), the Bay of Bengal (BB), Western India (WI), Central India (CI), Eastern India (EI), Arid India (AI), Western IGP (WIGP), Eastern IGP (EIGP), and Northeast India (NEI). **(a-l)** Averaged CH_4 vertical profiles: **left panel**) pre-monsoon season (April-June), **right panel**) monsoon season (July-September) of 2011 over the considered Indian regions. The black line with error bars shows the GOSAT-TIR data with uncertainty (1-σ STD). Blue and red lines with shaded areas correspond to the $ACTM_{CAO}$ and $ACTM_{WH}$ data with uncertainty. Magenta and cyan lines represent the CH_4 from the $ACTM_{CAO}$ and $ACTM_{WH}$ after the averaging kernel implementation [Belikov et al., in preparation].

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