An analysis of the sensitivity of the GOSAT-TIR observations to the near-surface CH4

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Abstract

We examined methane (CH_4) variability derived from 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) in comparison with ground-based observations from the World Data Centre for Greenhouse Gases (WDCGG), and simulations of an atmospheric chemistry-transport model (ACTM) for the period 2009–2014. Objective is to understand the sensitivity of GOSAT TIR retrievals at the near-surface layers of the atmosphere based on the prior assumptions.

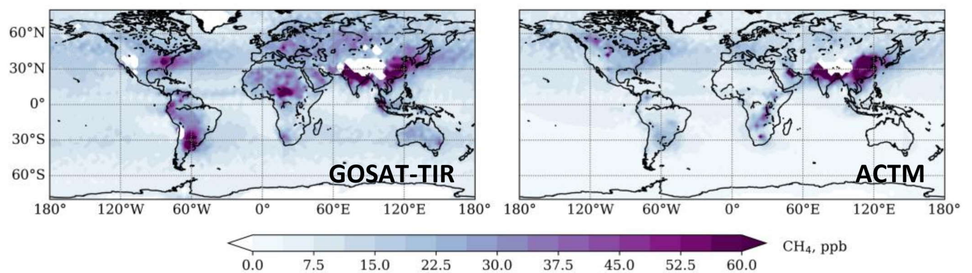
The near-surface GOSAT-TIR CH_4

Here, we defined the near-surface GOSAT-TIR CH_4 as the GOSAT-TIR CH_4 at the levels of 850 - 950 hPa. The original GOSAT-TIR CH_4 product (Saitoh et al., 2012) is produced on 22 fixed pressure levels (from the surface to 0.1 hPa) retrieved by the GOSAT-TIR Version 1 (Level 2 V1) algorithm (Saitoh et al., 2016) released for the period from April 23, 2009, through May 24, 2014.

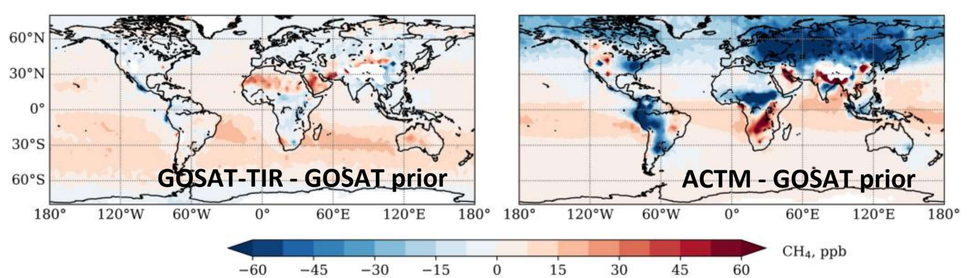
Datasets for comparison

1. The ACTM modeled CH_4 is at a horizontal resolution of T42 spectral truncations (≈2.8 ×2.8) with 67 sigma-pressure vertical levels. The model uses inverse modeling optimized CH_4 emission based on a priori emission scenario: EDGAR + GFED + wetland + rice (Chandra et al., JMSJ, 2021) and an OH field that leads to a favorable comparison to long-time measurement records (Patra et al., Nature, 2014). CH_4 from ACTM and GOSAT-TIR were collocated and resampled on the regular grid of 3°×3°.
2. The WDCGG CH_4 was obtained from monthly, daily, and hourly observations: 124, 55, and 51 sites, respectively.

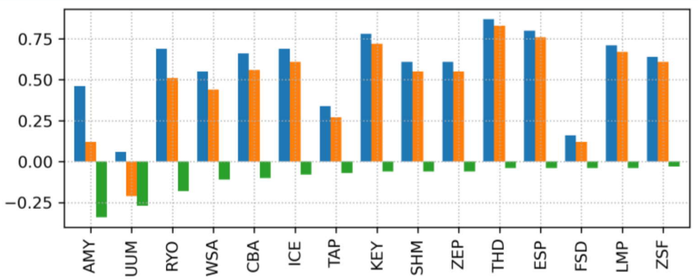
Results



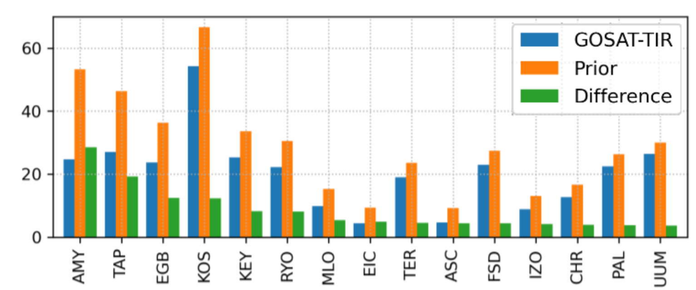
Latitude–longitude distributions of the CH_4 1-σ SD averaged over the levels of 850 - 950 hPa from GOSAT-TIR and ACTM for June-September 2010-2013



The CH_4 difference between GOSAT-TIR and the GOSAT prior, ACTM and the GOSAT prior averaged over the levels of 850-950 hPa for June-September 2010-2013



Sites with the improvements against WDCGG monthly observations using the correlation coefficient (top) and RMSE (bottom). Blue and orange bars represent values calculated using GOSAT-TIR and the GOSAT prior CH_4, respectively, green bars are for differences between them.



Conclusion

We studied the sensitivity of GOSAT-TIR CH_4 in the lower part of the troposphere at the level of 950-850 hPa. Comparisons with the WDCGG and ACTM CH_4 showed the GOSAT-TIR CH_4 observations have a sufficiently high density of observations to detect the variability of CH_4 with different time scales (monthly, daily, hourly). Based on the selected metrics (correlation coefficient, RMSE, SD) a good improvement has been achieved with respect to the GOSAT-TIR prior CH_4 for remote and coastal sites located in Asia (AMY, BKR, RYO, YON), America (EGB, FSD, KEY), and Europe (NGL, PAL, TER) sites. Good agreement with the WDCGG observations increases the reliability and confidence of the global distribution of the GOSAT-TIR CH_4 and the possibility of its application for the validation of three-dimensional methane products. However, these conclusions should be taken with caution, as they are based on a short period of time. The date availability extension for the period 2014-2020 is essential for a more detailed analysis of the global three-dimensional distribution of methane.