Geophysical Research Abstracts
Vol. 20, EGU2018-11908, 2018
EGU General Assembly 2018

Evaluation of the seasonal cycle and variability of the trend from GOSAT methane retrievals

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Methane (CH4) is a potent greenhouse gas with substantial spatial and temporal variability that is efficiently covered with space-based remote sensing. The variability in atmospheric CH4 concentrations is directly linked to the sources and sinks of methane: these fluxes induce region-dependent seasonal cycles and an observed, nonlinear global increase in CH4 concentration. Therefore, it is important to evaluate the accuracy of satellite CH4 retrievals from the perspective of these quantities.

In this study, we evaluate the seasonal cycle and variability of the trend of column-averaged dry air mole fraction of methane (XCH4) from the Greenhouse Gases Observing Satellite (GOSAT) by applying the dynamic linear model (DLM). We study XCH4 from three different GOSAT retrieval algorithms: National Institute for Environmental Studies v.02.21, SRON Netherlands Institute for Space Research (SRON) and the Karlsruhe Institute for Technology (KIT) jointly developed RemoTeC CH4 Proxy v.2.3.8 and SRON/KIT RemoTeC CH4 Full Physics v.2.3.8. Evaluations are made against the Total Carbon Column Observing Network (TCCON) retrievals at 15 TCCON sites, from which 11 are in the Northern Hemisphere and four in the Southern Hemisphere. To study the latitudinal dependence, we compare the variability of the trend from the GOSAT retrievals at 31 latitude bands to the NOAA's Marine Boundary Layer reference data.

We find that the GOSAT XCH4 retrievals can present the seasonal cycle and variability of the trend accurately if the number of co-located soundings is sufficiently large and the soundings cover most of the year, which is a challenge particularly at high latitudes during winter time. We show that in cases where these conditions are met, the peak-to-peak amplitude of the seasonal cycle can be captured with GOSAT to within 5 ppb and the growth rate of XCH4 to within the estimated uncertainty ranges. In addition, we show that there are clear regional features in the seasonal cycles and in the variability of the trend of XCH4. We also found that the peak-to-peak amplitude and phase of the seasonal cycle are very sensitive to the regional sources and sinks.