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

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Methane is a potent greenhouse gas with a lot of spatial and temporal variability that can not be fully explained with the current knowledge. Deeper knowledge of these variations is crucial for understanding the contribution of each source and sink of methane, and also when trying to predict future methane concentrations and their impact on climate. To fully understand the spatial distribution of methane, global observations are needed, and tool for this demand, is space-based methane observations. Space-based methane measurements, for example the Greenhouse Gases Observing Satellite (GOSAT) spectra measurements, provide near-global observations of column-averaged dry air mole fraction of methane (XCH4). XCH4 concentrations are used because they do not depend on the pressure, temperature or water content that are highly variable within the column as well as between the observation locations. Before the space-based methane observations in are used in studies, their accuracy have to be clarified.

In this study, we evaluate the seasonal cycle and variability of the trend of XCH4 from three GOSAT XCH4 retrievals: NIES v02.72, RemoTeC Proxy v2.3.8 and RemoTeC Full Physics v2.3.8 retrievals. To study the cycle and the trend, we apply the dynamical linear model (DLM), which models the cycle with harmonic components and is able to consider nonlinear trends. The evaluation is done at 15 Total Carbon Column Observing Network (TCCON) sites, from which eleven are at the Northern Hemisphere and four at the Southern Hemisphere. The evaluation at the TCCON sites is done for 2009 to 2015. In addition, we study the latitudinal dependence of the seasonal cycle and growth rate by comparing the three retrievals against each other at latitude bands between 45° S and 54° N. We also compare the growth rates at latitude bands against NOAA's Marine Boundary Layer (MBL) reference data.

Our results suggest that NIES, RemoTeC Proxy and RemoTeC Full Physics retrievals can present the seasonal cycle and variability of the trend accurately, if there are sufficiently co-located soundings available throughout the year. We show that if the number of co-located soundings is sufficient, GOSAT can capture the seasonal cycle amplitude to within 5 ppb. Generally, the day of maximum methane concentration is captured better than the day of minimum methane concentration. At most TCCON sites, both days are captured to within one month for the three retrievals. At the latitude bands, the three retrievals and the MBL reference are generally agreeing better in the growth rate of XCH4 in the Southern Hemisphere. The seasonal cycle of XCH4 is in agreement between the GOSAT retrievals at most of the latitude bands, except in the tropics. Reasons for the differences in the tropics might be explained by the lack of data but also by differences in the locations of soundings processed by the retrievals.