Comparison of GOSAT xCH₄ and airborne measurements over Siberia

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1. Introduction
The radiative forcing of methane (CH₄) is estimated as the second largest, after carbon dioxide (CO₂) [IPCC, AR4, 2007]. Despite the importance of atmospheric CH₄ in global warming, however, the strength of individual sources of CH₄ remains highly uncertain [Dlugokencky et al., 2011]. Western Siberia is known to be the largest wetland area in the world [Kremenetski et al., 2003]. The change in CH₄ emissions from the wetlands in this region under climate change may have a substantial impact on the interannual variations in atmospheric CH₄ on a global scale [Morimoto et al., 2006]. Airborne measurements have been carried out by NIES over Novosibirsk and Surgut in western Siberia since 1993 [Umezawa et al., 2012]. GOSAT was launched in January 2009 to measure the column amount of CH₄ globally. GOSAT products are expected to improve the estimates of the CH₄ budget by inverse analysis. To reduce the uncertainty in estimates of CH₄, the precision of the column-averaged volume-mixing ratios of CH₄ observed by satellite is required to be within ±1%, without systematic biases [Meirink et al., 2006]. For this purpose, GOSAT must be validated by higher-precision data obtained independently using ground-based or airborne measurements. The results of a validation of GOSAT xCH₄ (NIES ver02.xx) by comparison with TCCON xCH₄ is reported by validation with TCCON [Yoshida et al., 2013]. Therefore, the presented results demonstrate that the GOSAT xCH₄ dataset obtained from the SWIR band over Siberia (Novosibirsk, Surgut) is well validated and is reliable for inverse analysis of the CH₄ budget over Siberia. We cannot directly compare GOSAT SWIR xCH₄ with CH₄ profiles observed by the aircraft because GOSAT SWIR observes column-averaged dry-air mole fractions (xCH₄). Therefore, we have to convert CH₄ profiles observed by the aircraft into xCH₄ by setting the CH₄ profile at the altitudes where the aircraft flight observed. We will compare the TIR (vertical profile) measurement data with CH₄ profile from the aircraft at the altitudes where the aircraft flight occurred.

2. Dataset
Period of analysis: 2009-2011
<GOESAT>
• Products by NIES
• TANSO-FTS, SWIR ver.2
• Airborne measurements over Siberia
• Conducted by NIES
• Novosibirsk (55N, 83E), Surgut (61N, 73E)
• Altitude: 0.5-7.0 km

<GOESAT>

Δ Goodman
Goodman's xCH₄ = Total number density of CH₄ Total number density of air

Fig. 1: All profiles observed by the aircraft in 2009-2011 Methane concentration tends to be higher near the ground.

The observation method of GOSAT was changed from 5 pointing mode to 3 pointing mode in 2010. After that, GOSAT observed the same (or similar) point three times over a short interval. Therefore, we sometimes obtain three retrieval data at the same (or similar) points.

3. Method
We cannot directly compare GOSAT SWIR xCH₄ with CH₄ profiles observed by the aircraft because GOSAT SWIR observes column-averaged dry-air mole fractions (xCH₄). Therefore, we have to convert CH₄ profiles observed by the aircraft into xCH₄ by setting the CH₄ profile at the altitudes where the aircraft flight occurred.

• CH₄ profile setting
0.0~0.5 km (about 950 hPa)
• Methane concentrations below 0.5 km are set to be constant down to the surface.
0.5~7.0 km (about 400 hPa)
• Airborne measurement data
7.0 km~1.0 hPa (about 65 km)
• We use the climatology data of HALOE. This dataset is used by NIES as an a priori.
• Meteorological data
• We use the grid point value (GPV) data that are used by NIES for retrievals.

Table 1: The list of the matching data for airborne and GOSAT measurements. The colors and symbols indicated in Table 1 are the same as the data points in Fig. 5.

Table 2: Same as in Table1

Table 3: Relative difference

5. Summary
We compared GOSAT data with airborne measurement data over west Siberia to confirm the quality of the GOSAT xCH₄ dataset obtained from the SWIR band over Siberia (Novosibirsk, Surgut). To compare GOSAT xCH₄ with the CH₄ profiles observed by aircraft, we set the distribution of CH₄ concentrations at the altitudes where the aircraft did not observe. The xCH₄ values corresponding to the aircraft measurements were then calculated. We used climatology data from the HALOE satellite to set the distribution of CH₄ concentrations in the stratosphere. The GPV dataset was used to calculate the air density and the dry air column. The Diff. (%) values between the GOSAT and airborne measurements shown in Table 3 are smaller than the difference reported by validation with TCCON [Yoshida et al., 2013]. Therefore, the presented results demonstrate that the GOSAT SWIR dataset had enough reliability to be used for inverse analysis of the CH₄ budget over Siberia. When the gap between the dates of GOSAT and the airborne measurements is one day, Diff. (%) is larger than for the comparison on the same day. The Diff. (%) values seem to depend on the measurement time rather than the distance.

<Uncertainty factors>
• Climatology data of HALOE in the stratosphere
• Heterogeneity of land cover
• Suitability of the distance (300 km)
• Meteorological data to determine air and column density

<Future topics>
• We will compare the TIR (vertical profile) with airborne measurements and SWIR data.
• Meteorological Data
Temperature profile: GPV → GPS

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