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Preliminary study on possibility of application of GOSAT to fire research

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Introduction

Greenhouse gases Observing Satellite " IBUKI" (GOSAT) launched in January 2009 has been getting data steadily, and investigations on algorithm improvement and data application are just getting started. We aim to estimate methane emission ratio for wildfires based on the distribution of column-averaged volume mixing ratios (VMRs) of CO_2 and CH_4, hereinafter referred as XCO_2 and XCH_4, obtained by GOSAT/TANSO-FTS. So far, satellite observation has been difficult for the value, which represents the proportion of CH_4 to fire-induced gases, unlike for burned area or biomass. Successful observation is predictably effective to major improvement in the evaluation of wildfire contribution to global CH_4 emission. At the start of examining possibility of the application of GOSAT to fire research, we looked for enhanced VMRs due to fires.

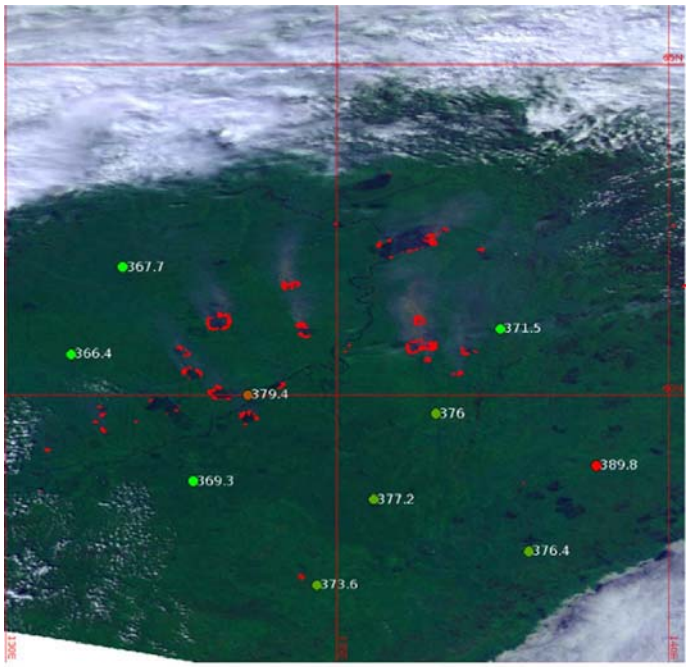

Figure 1. True color image of CAI obtained over the study area. Observation points of FTS are represented by circles filled with color proportional to the value of XCO_2, which is a number beside in the unit of ppm, and red points indicate hotspots.

Result

Besides latitudinal and seasonal variation, locally or temporally prominent changes were observed in VMRs. Visually examining simultaneously-obtained CAI image, it was often difficult to determine smoke from small-sized fire due to similarity to haze. We therefore used hotspot data detected by the MODIS rapid response system in the examination. The data showed that numerous fires occurred in 2009 as usual year, mainly in Africa and South America. However, fire size in these regions was relatively small and accordingly less smoke was observed. On the other hand, intense fires associated with dense smoke plume were recognized in the Eastern Siberia where an incidence of fires was relatively low. The fires occurred near the city of Ust-maya, Russia, continuing on and off for nearly two months in the summer of 2009. We selected approximately 1x1 degree region most seriously burned as a study area. Fortunately, GOSAT passed over the study area just on 30 July, when the maximal fire number was observed. Figure 1 shows observed XCO_2 distribution and the hotspots overlapping on a quasi true color image of CAI on that day. Starting from the hotspots, several smoke rivers are obviously swept in a west-northerly or a northerly direction. Looking at near-surface wind field from the NCEP Final Analysis (FNL) dataset, sea breeze was going inland in a west-northerly direction at a given time;

the result showed no contradiction with the smoke direction.

Except for 379.4 and 389.8 ppm, XCO_2 showed decrease as moving inland. It can be interpreted as a sign of CO_2 sink by vegetation photosynthetic activity. The relationship was linear and greatly improved by taking ratio of XCO_2/XCH_4; this suggests the possibility of presence of some common errors in the magnitude of VMRs. The previously-mentioned two outliers remained even in the ratios. The large value of 379.4 ppm would be obviously attributed to the smoke plume, because the observation point was at a distance of only 30 km downwind of the nearest fires. There are additional two points lying on the downwind area of fires, but the distance of 92 km and 143 km would have been enough to disenable GOSAT to detect fire-induced gas. The value of 389.8 ppm was, however, mysterious because fires were not found near by the point. One possible reason is that underground or surface fires, which are often seen in boreal forests, may have occurred actually, because land surface temperature was remarkably high in the neighborhood and upwind area of the point according to the data by MODIS (MOD11_L2).

Summary

The present study showed GOSAT was able to detect enhancement of VMRs in the downwind neighborhood of fires. A decrease in background XCO_2 was also observed as upwind distance increased. Future study will be done on confirmation of hypothesis that the decrease is attributed to vegetation photosynthesis activity and on estimation of methane emission ratio with the help of numerical models.

Keywords: global warming, wildfire, methane