# Summary of the Final Report of Research Results

## 1) Title of the proposed research

Wildfire detection and the estimation of methane emission ratio and gas emission rates

## 2) Principal Investigator (PI) and Co-Investigators (Co-Is)


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## 4) Summary of the Final Report of Research Results

Biomass fire is associated with gas emissions consisted of $CO_2$, CO, $CH_4$, $H_2$, hydrocarbons, and particulates. These gases injected into the atmosphere work to increase radiative forcing, which accelerates the global warming. Burned biomass is estimated from the area submitted to the fire, the above-ground biomass, and burning efficiency. Because of conspicuous dominance in the gases, it is relatively easy to estimate $CO_2$ emission. However, $CH_4$ emission is rich in variety depending on burning condition mainly determined by fuel composition and wetness. Our final aim was to derive $CH_4$ emission ratios from the GOSAT data for various vegetation types, and to improve an estimation accuracy of emission amount from the wildfires in the world with the use of the ratios. The emission ratio is represented as a ratio of concentration (or mass) excess in smoke plume from its ambient background level for $CH_4$ to that for $CO_2$, and typically provides an important measure of emission amount.

Although accuracy of FTS data are intensively examined by various researchers and assured to be 1-2% for values averaged in some extent of area and time, we need to know the intrinsic error in a single scan data. We used the FTS data (V01.XX) and examined its variance in central Australia (latitude between 18.8 and 25.3 north and longitude between 123.8 and 131.5) and in the Southern Hemisphere winter of 2009. The place and season were selected so that an effect of complex topography, vegetation cover, and artificial emission could be minimized. The average of the $XCH_4$ data (total number $n$=251) was 1.742 ppm and the standard deviation was 0.011 ppm, corresponding to ca. 0.7% of the average.

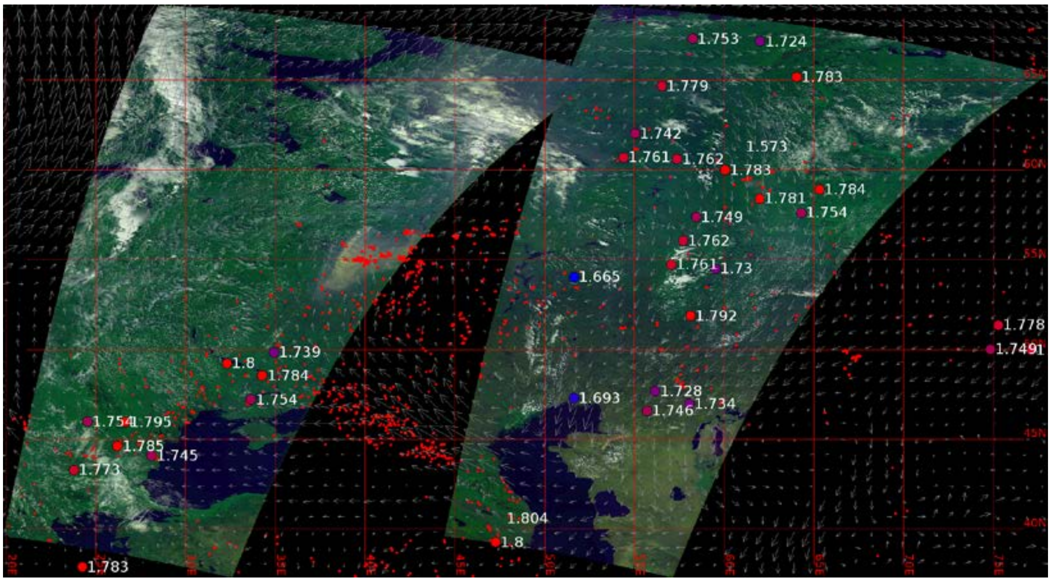


Figure 1. Distribution of $XCH_4$ over European Russia on 31 July 2010. Points indicate $XCH_4$ (ppm) and the color gradation (blue-red) is proportional to its magnitude. Background is true color image obtained from CAI, and tiny red plots indicate hot spots of wildfire. Gray arrows represent wind speed and direction at 850hPa.

In investigating the ability for detection of the concentration excess, we focused on the case of massive wildfire near Moscow which continued for more than two months in the summer of 2010. In the event, large emission amount of $CH_4$ was predicted because the most intensive fires occurred in disturbed wetland area. Fist FTS L2 data were plotted on CAI image with the help of GIS. In addition, fire hotspots information generated from MODIS data and wind fields obtained from NCEP/NCAR reanalysis were superimposed on the image to infer the location of fire plumes easily. Figure 1 shows an example of one day. Here we can see no systematic enhancement in downwind $XCH_4$ values and several outliers of unrealistically low level (1.57-1.69 ppm). The low values suggest the wrong estimates of total column amount (CLA) of dry air. Comparing retrieved atmospheric pressure to a priori value from GPV dataset, difference of several tens or more than 100 hPa was found frequently. Retrieved values are generally overestimated, which inevitably brings underestimation of VMRs. Dense aerosol concentration in fire plumes may have resulted in large error in the retrieval. For this reason, we applied a simple correction method applied to SCIAMACHY data following Frankenberg et al. (2005). This method uses $CLA_{CO2}$ as a proxy for $CLA_{dry\_air}$. The corrected $XCH_4$ is represented as follows:

$$XCH_4' = \frac{CLA_{CH_4}}{CLA_{CO_2}} XCO_2' \tag{1}$$

where $XCO_2$' is actual $XCO_2$, which is not affected by the error mentioned above. Here, we used the global annual mean $XCO_2$, which is assumed to be 370 ppm. Note that $XCH_4$' indicates relative

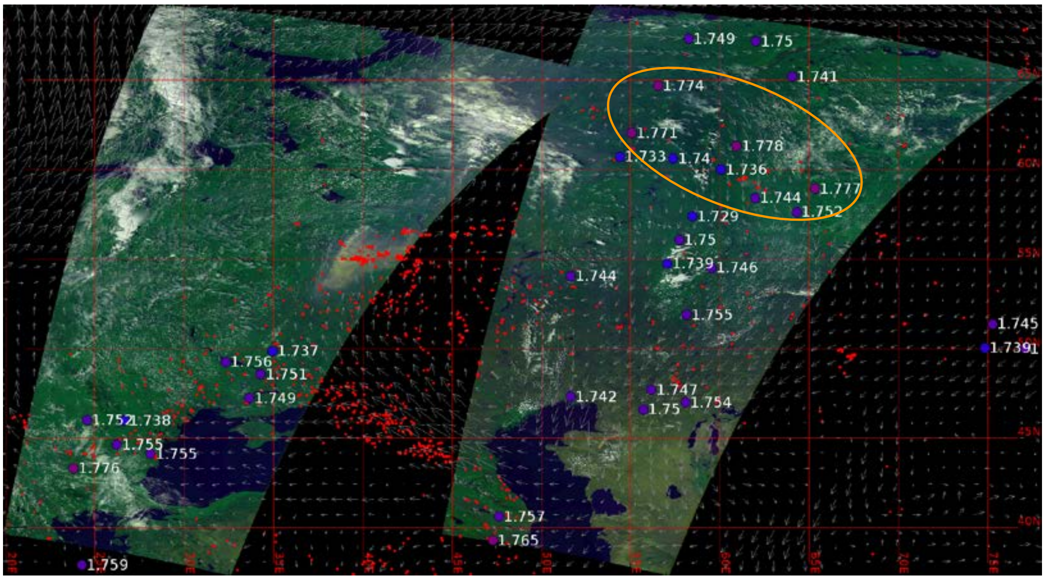


Figure 2. The same as Figure 1, but for $XCH_4$'. Relatively high values are highlighted by a yellow circle.

value to the $XCO_2$' value, and now the absolute value has little meaning. By replacing $XCH_4$ by $XCH_4$' in Figure 1, outlier disappeared and some were above average of neighborhood (more than 1.77 ppm) on the path of a smoke plume expected from wind vectors (Figure 2). The concentration excess was corresponding to 2-3 times of the single-scan standard deviation observed in Australia, and the credibility would be high in light of the consistency with visible smoke distribution. Furthermore, because $CO_2$ concentration is likely to have increased as well, the 370 ppm of $XCO_2$' would be smaller than in reality. Thus, $XCH_4$' would have been underestimated, not overestimated. To decrease such uncertainties, we will need to estimate more realistic value of $XCO_2$' with numerical simulation combining atmospheric circulation model with surface $CO_2$ emission and vegetation activity such as WRF-chem, VPRM, and STILT.

This study aimed to construct a dataset of methane emission rates in wildfire by use of GOSAT data, and to estimate methane emission amount more precisely than before using a mesoscale atmospheric model with the rates. But we went no further than investigation of data accuracy and of ability for plume detection as described above. This is mainly due to insufficient ability and time of PI, but also due to the data scarcity around fires after being selected according to strict criteria. We hope that our information can be any of help in further improvement of GOSAT product and for studies aimed at wildfire research.

**5) List of publications relating to the proposed research**

None.