# Summary of the Final Report of Research Results

**1) Title of the proposed research**

A study on the relationship between distributions of $CO_2$ and $CH_4$ near ground and land-use in Northeast Asian regions

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

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

Our research from 2008 to 2013 by using GOSAT data could be divided into 5 parts:

**Contents 1:**

Northeast Asia is a unique region of various land-use systems. It includes Forest areas of stock-raising in Mongolian grasslands, Xingan Mountains in Siberia and China, Changbai Mountains, etc; Densely populated zone of heavy industry area in China, etc; The area of paddy fields in southern China and Japan, etc. Human activity in these regions have different forms, the emissions of Methane from pasture and paddy fields area, The absorption and emission of carbon dioxide from forest area, The emission of carbon dioxide from heavy industry and densely populated area, however the balance of $CO_2$ and $CH_4$ are different. In order to analysis these causes. At first, depending on the availability of L2, L3 data, 1) Analysis the concentration of $CO_2$, $CH_4$ distribution in narrow range region ($100km^2$-$300km^2$) and seasonal changes. Land-use and vegetation analysis use AVHRR, SPOT and MODIS data. Moreover, 2) Depending on the L4 data reception, it will be used to analysis the concentration of $CO_2$, $CH_4$ distribution in wide-ranging region (2.5-degree Mesh), seasonal changes, time series change and high concentration distribution. Also use MODIS to analysis land-use. In addition, 3) Extract the special district of abnormal concentration, and examine the relationship between land-use and concentration of $CO_2$, $CH_4$ distribution.

**Contents 2:**

With the continuous development of human society and associated increase in industrialisation,

atmospheric concentrations of $CO_2$ and $CH_4$ have also increased. Asia has the third largest nominal GDP of all continents, after North America and Europe. Rapid growth in large regional economies such as China and India has elevated human prosperity. Thus, a study of this region's GHG emissions has great significance for understanding global climate change. The observations from the GOSAT are being processed to generate the initial results for $XCO_2$ and $XCH_4$, which are calculated from the GOSAT radiant spectrum data obtained under cloud-free conditions. Therefore, to integrate land classification and other environmental data with the regional GHG and environmental interaction research, this part combines GOSAT FTS Level 2 data with the Kriging method to analyze the spatial variations and distributions of GHG throughout the land surface in this region.

**Contents 3:**

In this part, we used the GHGs from GOSAT, meteorological data from ground stations in China (192) and Japan (133) and the NDVI from the MODerate resolution Imaging Spectroradiometer (MODIS) in 2010 to analyze the correlations among GHGs, climate parameters and NDVI. After analysis, we found that the $XCH_4$ concentration in the atmosphere had a strong correlation with climate parameters and NDVI (r=0.672**, 0.709**, 0.733 ** and 0.684** to temperature, precipitation, relative humidity and NDVI, respectively). Also, the concentration of water vapor in the atmosphere ($XH_2O$) has a slight correlation with climate parameters and NDVI, and it has the highest correlation with relative humidity (r=0.732**) followed by the correlation with NDVI (r=0.638**). Furthermore, the $XCO_2$ has a low correlation with climate parameters and NDVI and has the highest correlation coefficient with precipitation (r=0.625**) followed by the correlation with NDVI (r=0.450**). We also monitored the spatial distribution of the GHGs and found that the higher GHGs are distribute in the southeast coastal areas of China, Japan and South Korea, and the low GHGs are distributed in western China and Mongolia.

**Contents 4:**

Measurements of land cover changes have suggested that such shifts may alter the GHGs in the atmosphere. However, due to the lack of large-scale GHG data, a quantitative description of the relationships between land cover changes and GHG concentrations does not exist on a regional scale. The Greenhouse Gases Observing SATellite (GOSAT) launched by Japan on January 23, 2009 can be used to investigate this issue. In this part, we first calculated the monthly average GHG concentrations in East Asia from April 2009 to October 2011 and found that the $CO_2$ concentration displays a seasonal cycle, but the $CH_4$ seasonal trend is unclear. To understand the relationship between land cover and GHG concentrations, we used the GHG data from GOSAT, the Normalized Difference Vegetation Index (NDVI) from the MODerate resolution Imaging Spectroradiometer (MODIS) and the land cover data from EAS-GlobCover (2009) to analyze the correlation coefficients between land cover and GHG concentrations. We observed that vegetation may generally be considered as a source but not a sink of $CO_2$ and $CH_4$, either

on a yearly scale or during the growing season. With respect to the relationships between land cover types and GHG concentrations, we conclude that on a yearly scale, land cover types are not closely correlated with GHG concentrations. During the growing season, croplands and scrublands are negatively correlated with $XCO_2$, and forest, grasslands and bare areas are positively correlated with $XCO_2$. Forest and croplands can be viewed as $CH_4$ sources, while scrublands and grasslands can be thought of as $CH_4$ sinks.

**Contents 5:**

We used GHG data from the ENVIronment SATellite (ENVISAT) and the Greenhouse gases Observing Satellite (GOSAT), the Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST) data from the MODerate resolution Imaging Spectroradiometer (MODIS) and precipitation data from ground stations to analyze the way land degradation affects GHG concentrations in northern China and Mongolia, which exhibit the most serious land degradation process in East Asia. Due to the infrequency of sustained periods of carbon uptake, there is no research on the spatial distribution of GHG concentrations in arid and semi-arid regions based on remote sensing data for that time frame. To fill this gap, the aims of this study were as follows: first, to analyze changes in $XCO_2$ and $XCH_4$ from 2003 to 2011 using ENVISAT SCIAMACHY and GOSAT TANSO data; second, to analyze the spatial distributions of $XCO_2$ and $XCH_4$ in the study area in 2010 based on the TANSO data and using the Ordinal Kriging method; and finally, using NDVI data from MODIS combined with precipitation data and LST data to analyze the spatial distribution of GHG concentrations. We know that human activities are the most important source of GHG. However, here we will only discuss the relationships between NDVI and GHG concentrations.

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

Meng Guo, Xiufeng Wang, Jing Li, Hongmei Wang, And Hiroshi Tani: Examining the relationships between land cover and greenhouse gas concentrations using remote sensing data in East Asia. *International Journal of Remote Sensing*, 34, 4281-4303, 2013.

M. Guo, X. Wang, J. Li, K. Yi, G. Zhong, H.Wang, and H. Tani: Spatial distribution of greenhouse gas concentrations in arid and semi-arid regions: A case study in East Asia. *Journal of Arid Environments*, 91, 119-128, 2013.

Yang Liu, Xiufeng Wang, Meng Guo And Hiroshi Tani: Mapping the FTS SWIR L2 product of $XCO_2$ and $XCH_4$ data from the GOSAT by the Kriging method – a case study in East Asia. *International Journal of Remote Sensing*, 33(10), 3004–3025, 2012.

Meng Guo, Xiufeng Wang, Yang Liu, Jing Li, Hongmei Wang, Nobuhiro Matsuoka And Hiroshi Tani: The effects of sand dust storms on greenhouse gases. *International Journal of Remote Sensing*, 33(21), 6838–6853, 2012.

Meng Guo, Xiufeng Wang, Jing Li, Kunpeng Yi, Guosheng Zhong and Hiroshi Tani: Assessment of global carbon dioxide concentration using MODIS and GOSAT data. *Sensors*,

12(12), 16368-16389, 2012.

Meng Guo, Xiufeng Wang, Kunpeng Yi, Guosheng Zhong, and Hiroshi Tani: The distribution of greenhouse gas concentrations in arid and semi-arid areas. *International Conference on Agricultural Biodiversity and Sustainability 2012*, August 26-31, 2012, Sapporo, Japan.

Meng Guo, Xiufeng Wang, Guosheng Zhong and Hiroshi Tani: The distribution of greenhouse gas concentrations in China using GOSAT data. *International Symposium on Agricultural Meteorology 2012*, pp.160, March 13-17, 2012, Osaka, Japan.

Y. Liu, X. F. Wang, H. Tani, M. Guo: Analysis of relationship between NDVI and GHG in Daxing'an Mountain region, China. *Proceedings for ISPRS Workshop on Dynamic and Multi-dimensional GIS*, pp.40-43, October 17-19, 2011, Shanghai, China.

Yang LIU, Xiufeng WANG, Meng GUO and Hiroshi TANI: Comparison of GOSAT CAI and SPOT VGT NDVI data with different season and land cover in East Asia. *ISPRS Workshop on Geospatial Data Infrastructure: from data acquisition and updating to smarter services*, pp.94-97, October 20-21, 2011, Guilin, China.

Yang Liu, Xiufeng Wang, Meng Guo, Hiroshi Tani and Guosheng Zhong: Application of the Kriging method to $XCO_2$ and $XCH_4$ data from GOSAT - a case study in East Asia. *The 49th Autumn Conference of the Remote Sensing Society of Japan*, pp.77-78, November 13-14, 2010, Kagoshima, Japan.