

**RF-063 Global Greenhouse Gas Observation from Satellites in Post-GOSAT Era
(Abstract of the Final Report)**

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[Abstract]

The objective of this study is to contribute to the future satellite mission planning concerning global greenhouse gas monitoring from space. According to interviews and other meetings, it was inferred that there are two different requirements for future satellite observation. The first is similar to current GOSAT's requirements aiming estimation of global carbon dioxide flux distribution and the second is a new requirement targeting estimation of regional carbon dioxide emission from cities, forest fires, and so on. Activities of domestic and foreign research groups engaging in the development of Differential Absorption Lidar (DIAL) system for the measurement of atmospheric carbon dioxide concentration were investigated, and then, resources necessary for DIAL for a future satellite mission were studied. It became clear that DIAL system which is more capable than GOSAT Fourier transform spectrometer system can be realized using current and near-future technologies. Papers regarding inverse model analysis and remotely sensed global carbon dioxide data were searched and evaluated. Accuracy requirements for satellite sensors to be competitive with ground monitoring stations in terms of carbon dioxide flux uncertainty reduction using inverse model analysis were clarified. Also, the estimation of the amount of carbon dioxide emission from point sources, such as cities and forest fires, was investigated and how satellite data will contribute to this topic was discussed.

1. Introduction

GOSAT, Greenhouse gases Observation SATellite is a earth observing satellite whose objectives are to monitor atmospheric concentrations of two major greenhouse gases, carbon dioxide and methane, and to improve the accuracy of global carbon flux estimation, and slated to be launched in early 2009. GOSAT is a joint project among Ministry of Environment, Japan, Japan Aerospace Exploration Agency (JAXA), and National Institute for Environmental Studies (NIES), Japan. US National Aeronautics and Space Administration's OCO (Orbital Carbon Observatory)

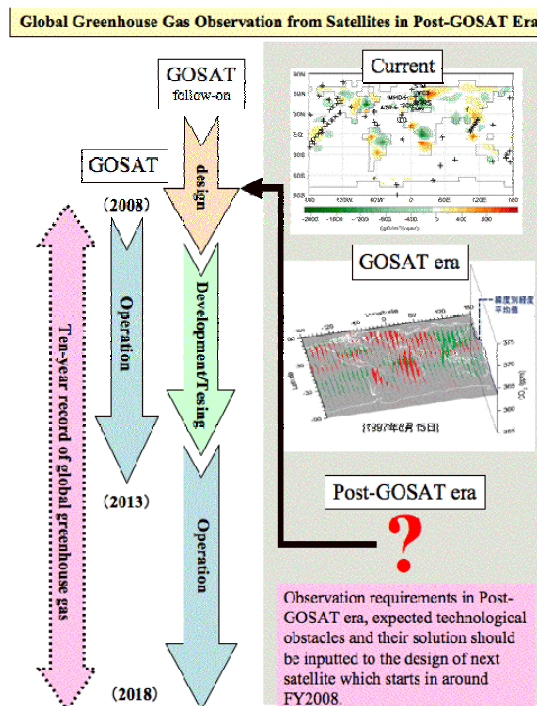
satellite has similar objectives to GOSAT, and will be launched almost in the same time frame. Although the operations of these satellites will be terminated around 2012, there are no approved satellite missions for atmospheric carbon dioxide measurement in any countries beyond this year. In Japan, "global observation of greenhouse gases" has a priority for these ten years given by CSTP(Council for Science and Technology Policy) and Japan should play an important role as one of leaders in the world in terms of global observation of greenhouse gases using satellites. However, in case that GOSAT is launched on schedule, there is not enough time for designing and development of a new spacecraft and instruments by the termination of GOSAT operation and launch of GOSAT-follow on satellite to avoid any data gaps.

2. Research Objective

The objective of this research is to develop scenarios for satellite observation of global greenhouse gases based on scientific and political requirements, and to contribute future mission planning activities towards GOSAT follow-on.

The four issues below are major components of this research:

- 1) To clarify the requirements to global greenhouse gases observation from a satellite in Post-GOSAT era,
- 2) to develop multiple observation scenarios which satisfy each requirement,
- 3) to extract problems from each observation scenario, and
- 4) to investigate solutions for extracted problems



The schematics to explain the objective of this research.

3. Research Methods and Results

1) Requirements for global greenhouse gas observation from a satellite in Post-GOSAT era

Requirements from NIES GOSAT Project include conservative instrument specifications to achieve current success criteria on the accuracy of retrieved carbon dioxide with smaller mesh size and shorter averaging time. Researchers in the field of inverse modeling and those who are engaged in emission inventory need quantitative source and sink information for each country, and if limitations such as spatial resolution allow, data which can be used for the estimation of carbon emitted from relatively large point sources such as cities and forest fires.

2) Requirements from the estimation of global carbon dioxide flux using inverse models

The recent advances in inverse model studies are reviewed using mainly works by S. Maksyutov¹⁾, NIES, and then, specifications for future missions are discussed.

Maksyutov discussed, using an inverse model in which the globe is divided into 22 or 66 regions, the contribution of GOSAT FTS SWIR data to the accuracy improvements on global carbon flux estimation. It was shown that in case of 5 ppm single-shot error and 0.5 ppm bias error, the addition of GOSAT data to ground observation data reduces the carbon flux uncertainty as much as 50% in average. And if the total error of 7.5x7.5 degree mesh GOSAT carbon dioxide data is below 0.8 ppm for 22-region case and 1.5 ppm for 66-region case, GOSAT data alone can be competitive with ground observation data.

In the inverse model studies in Post-GOSAT era, satellite data and ground data should be used separately and independently to compare and validate each other. From this point of view, the carbon dioxide data retrieved and averaged from GOSAT data of 0.8 ppm for 22-region case and 1.5 ppm for 66-region case are the requirements for the future mission.

3) Atmospheric carbon dioxide measurements conducted by Japanese local governments and the distribution of carbon dioxide in and around urban areas

To infer the amount of carbon emission from point sources such as cities and forest fires, the measurement of carbon dioxide columnar amount at upwind side and downwind side of the target area can be used. In this context, carbon dioxide measurements conducted by Japanese local governments in which both of downtown data and suburban data are included were searched and studied.

According to results from Kanagawa Prefecture, Nagoya City, Tokushima Prefecture, and Saitama Prefecture, the distance between the downtown site and the suburban site is a range of 10 - 40 km, and the difference of measured carbon dioxide between downtown and suburban sites is 10- 40 ppm. And the differences between downtown and suburban sites are variable for some cases and almost stable for other cases. In "variable" difference cases, the maximum differences often occur during daytime and the minimum ones occur during nighttime.

4) Investigation on Differential Absorption Lidar(DIAL)

Active sensors using laser light, "laser radar" or "lidar", are used to measure the amount of carbon dioxide in the atmosphere. In this case, two wavelengths, the one is close to the absorption center of carbon dioxide and the other is not, are used to calculate the ratio of intensity of transmitted energy which is a function of the amount of target molecules in the atmosphere. This type of sensors is called Differential Absorption Lidar, or DIAL. As DIAL does not rely on solar light, it can measure even in the nighttime and in the polar region where solar elevation is very low. In addition, the foot print of DIAL system is often smaller than that of Fourier transform spectrometer onboard GOSAT spacecraft and the number of "cloud-free" DIAL data is more than that of GOSAT FTS.

The status of domestic and foreign DIAL research groups is investigated, and then, the necessary resources for spaceborne system based on specific DIAL type was discussed. It became clear that spaceborne DIAL system which is more capable than GOSAT Fourier transform spectrometer can be realized using current and near-future technologies.

5) Scenarios for global carbon dioxide observation from a satellite in Post-GOSAT era

In this section, two observation scenarios for greenhouse gas monitoring from space in Post-GOSAT era were discussed. In the first case, which is for the estimation of global carbon dioxide flux using inverse model calculation, if the bias error of retrieved carbon dioxide concentration is smaller than 1ppm, GOSAT data alone can be competitive with ground observation data. In the second case, which is to estimate carbon emission from point sources such as cities, GOSAT may have difficulties to detect concentration difference of atmospheric carbon dioxide between the downtown site and the suburban site. Although DIAL systems may have enough accuracy to detect such a small change of carbon dioxide amount, it should be noted that concentration difference may disappear in nighttime when DIAL can achieve the requested accuracy of 1 ppm.

4. Discussions

There are two different requirements for greenhouse gas observation from space in Post-GOSAT era: The first is similar to current GOSAT's requirement aiming estimation of global carbon dioxide flux distribution and the second is a new requirement targeting estimation of regional carbon dioxide emission from cities, forest fires, and so on. Although it is not impossible to satisfy these two different requirements at the same time, aiming two different requirements often make the scope of a project, and sometime, cost-effectiveness unclear. Thus, careful decision making should be done after examining the results from GOSAT and OCO.

References

- 1) S. Maksyutov, N. Kadygrov, Y. Nakatsuka, P. K. Patra, T. Nakazawa, T. Yokota, G. Inoue, Projected impact of the GOSAT observations on regional CO₂ flux estimations as a function of total retrieval error, submitted to Journal of Remote Sensing Society of Japan, 28, 2, pp. 190-197,

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Major Publications

None.