Long-term analysis of greenhouse gases using tower observation network in the Siberian cryosphere
（Abstract of the Final Report）

Contact person: Dr. Sasakawa Motoki
Earth System Division
National Institute for Environmental Studies
16-2 Onogawa, Tsukuba, Ibaraki 305-8506, Japan
Tel: +81-29-850-2671 Fax: +81-29-850-2649
E-mail: sasakawa.motoki@nies.go.jp

Total Budget for FY2017-2021 129,389,000 JPY
（**FY2021**: 26,699,000 JPY）

Key Words: CO_2, CH_4, Tower Observation, Siberia, Gas flux, Taiga, Wetland

1. Introduction

Siberia includes various ground surfaces of source/sink for greenhouse gases. For example, the Siberian taiga is the largest in the world, and the most extensive wetlands exist in West Siberia. However, the spatial coverage of greenhouse gas observations was not enough there in particular. To overcome this problem and to capture spatial and temporal variations in greenhouse gases, NIES started to build a tower network, called JR–STATION (Japan-Russia Siberian Tall Tower Inland Observation Network)[1] to observe regional and short-term variations of greenhouse gases (carbon dioxide (CO_2) and methane (CH_4)) in 2001.

2. Research Objectives

We have conducted continuous measurements of CO_2 and CH_4 through the JR–STATION to reveal the spatial and long-term temporal variations of these greenhouse gases in the continental interior. We also plan to estimate the distribution of the fluxes of various types of soils (taiga, steppe, wetland, etc.) and reduce the uncertainty to clarify the behavior of the greenhouse gases.

3. Research Methods

The JR–STATION consists of six towers located in West Siberia (Fig. 1). The collected air was delivered via a Decabon tube by a diaphragm pump into the freight container with insulators to reduce temperature variation and dried with (1) adiabatic expansion in a glass water trap, (2) a semipermeable membrane dryer, and (3) magnesium perchlorate. The dehumidified air was then introduced into a non-dispersive infrared analyzer (model LI-820, LI-COR, USA) and a CH_4 semiconductor sensor at a constant flow rate of 35 cm^3 min^{-1} using a mass flow controller. Three standard gases were prepared from pure CO_2 and CH_4 diluted with purified air, and their concentrations were determined against the NIES 09 CO_2 scale[2] and NIES 94 CH_4 scale[3].

We used GELCA inversion system to estimate CO_2 flux globally. We calculated 3D distributions of atmospheric CO_2 mixing ratios using a combination of a global transport model NIES-TM and a Lagrangian Dispersion model FLEXPART. We used prior fluxes of fossil fuel, terrestrial biosphere, ocean, and biomass burning from inventories and system models. Fluxes are optimized to match observed atmospheric mixing ratios; taken from the global dataset provided by NOAA ObsPack GV+ v.4.2 and the JR-STATION.

4. Results and Discussions

Figure 2 shows the temporal variation in CO_2 concentrations and its daytime means observed from 2002 to 2021. Due to the COVID-19 pandemic, we stopped the observations from spring to early summer in 2020, but we could restart them before long. An increasing secular trend was observed at all sites.

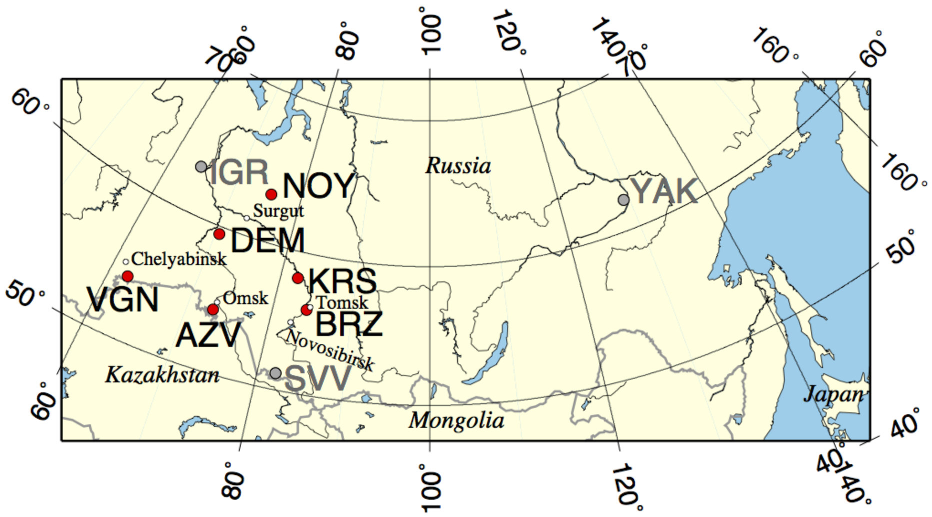

Figure 1. Location of towers making up the JR–STATION (red circles). Gray circles indicate closed sites.

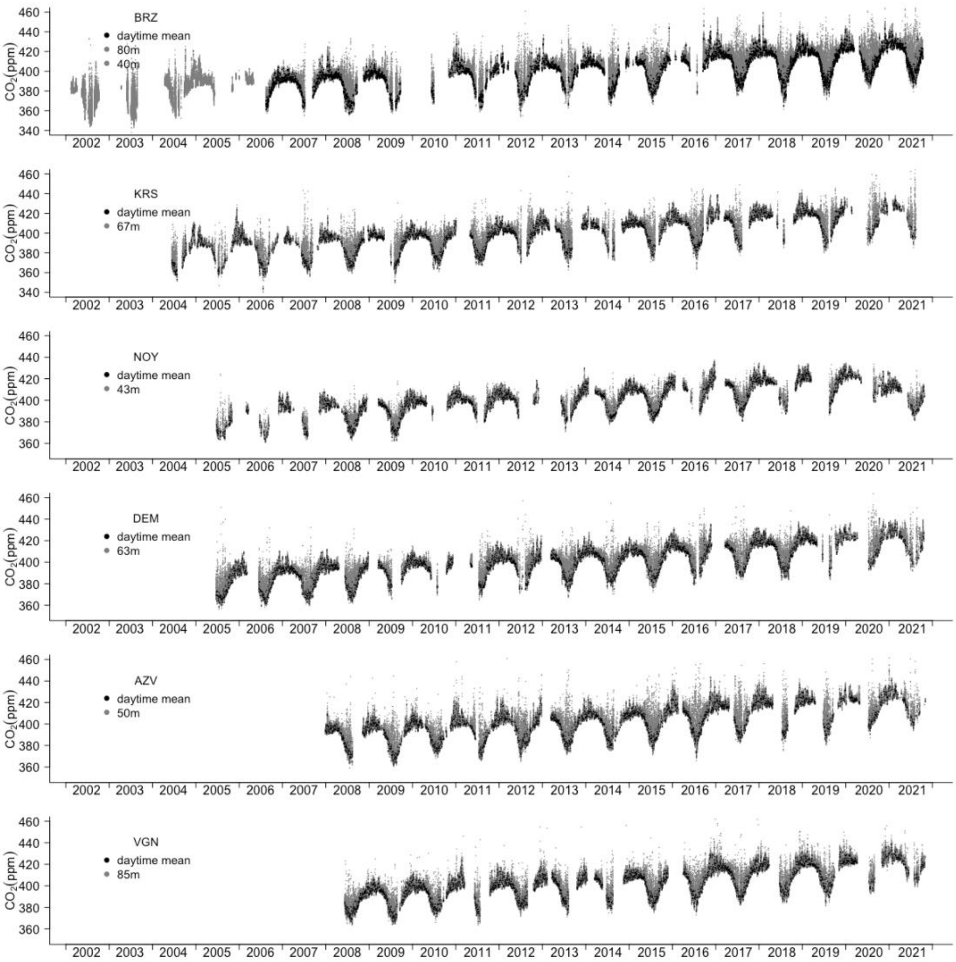

Figure 2. Temporal variation in CO_2 mixing ratio (ppmv) observed from high inlet at JR-

STATION (Gray circle). Black circle indicates its daytime mean (13:00-17:00 at LST). Figure 3 shows the multi-year trend of terrestrial CO_2 fluxes and NDVI during the summertime (June-September) in 2002-2017. Summertime CO_2 fluxes showed increasing sink with considerable variability interannually and among sub-regions. NDVI showed clear increasing trend as well. The location of the increase of summertime CO_2 uptake and NDVI greening matched well, suggesting the contribution from more active vegetation in Northern Siberia. This indicates that the increase of vegetation activity served as a driving force of the increase of summertime CO_2 uptake during the study period.

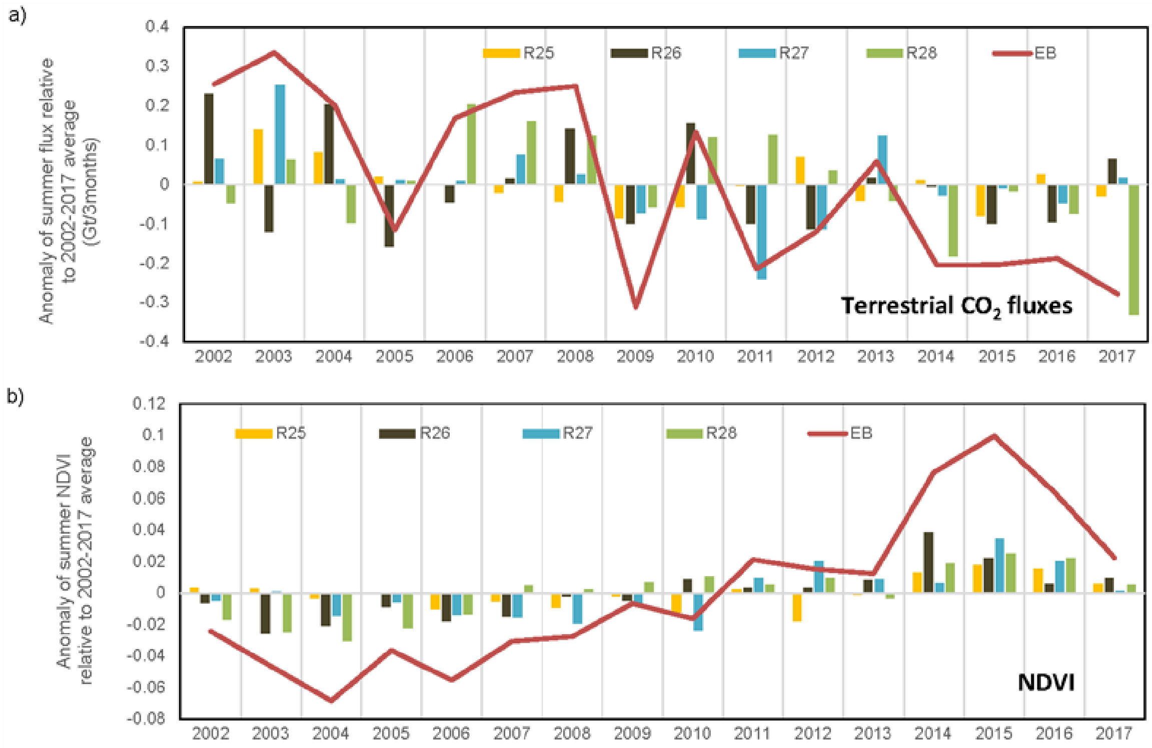

Figure 3. Anomaly of summertime terrestrial CO_2 flux (a) and NDVI (b) relative to 2002-2017 average (yellow bar: R25, dark green bar: R26, light blue bar: R27, light green: R28, Red line: Eastern Boreal total) .

References

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