Studies on variations of atmospheric greenhouse gases in the ArCS project 2015-2019

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To reveal the spatial and temporal variations of the atmospheric greenhouse gases in the Arctic region and to interpret their variations in terms of their sources and sinks, we have conducted systematic and extended observations of the greenhouse gases and modeling studies as a part of ArCS (Arctic Challenge for Sustainability) project from 2015 to 2019. At the ground-based stations in Ny-Ålesund, Svalbard, the mole fractions and isotope ratios of greenhouse gases have been observed regularly by the grab-sampling method since 1990s, and the O_2/N_2 ratio, CO_2, CH_4, CO mole fractions have been continuously observed by in-situ measurement systems since 2012/2013. The high precision data observed at Ny-Ålesund help in separating the oceanic and terrestrial uptake rates of CO_2 and revealed contribution of biogenic CH_4 emissions to the atmospheric CH_4 variations. Shipboard observations of atmospheric CO_2, CH_4, CO mole fractions and O_2/N_2 ratio were conducted on the Arctic observation cruises of R/V Mirai since 2012. The atmospheric CH_4 mole fractions in the Arctic Ocean showed several short-term variations associated with regional CH_4 sources on the surrounding continent. In addition, an underestimation of climatological O_2 flux from the ocean was suggested by the O_2/N_2 observations on board. Systematic observations of the greenhouse gases and related constituents at 8.5-12.5 km altitude over Eurasian continent have been conducted by regular air sampling on board commercial passenger flights between France and Japan operated by Japan Airlines since 2012. In the upper troposphere and the lower stratosphere, characteristic seasonal variations and long-term trends of each gases were observed. By analyzing trajectories of the observed air mass, it was revealed that the distributions of SF_6 and CO_2 were controlled by air mass transport between the troposphere and stratosphere, while those of CH_4, N_2O, and CO are largely controlled by chemical destruction along their transport paths in the stratosphere. Forward and inverse modeling and surface observation of CH_4 at Churchill, Canada, it was suggested that the prescribed CH_4 emission needs downward revision at Hudson Bay Lowland, Canada. The terrestrial ecosystem model study showed increasing trends in the CH_4 emission in inland North America, Alaska and northern part of West Siberian Lowland.