Distributions of methane, nitrous oxide, and their isotopomers in the Arctic Ocean

Sakae Toyoda[1], Kushi Kudo[1], Florian Breider[1], Keita Yamada[1], Naohiro Yoshida[1], Daisuke Sasano[2], Naohiro Kosugi[2], Masao Ishii[2], Hisayuki Yoshikawa-Inoue[3], Shigeto Nishino[4], Hiroshi Uchida[4], and Akihiko Murata[4]

[1]*Tokyo Institute of Technolpogy,* [2]*Meteorological Research Institute,* [3]*Hokkaido University,*
[4]*Japan Agency for Marine-Earth Science and Technology*

Methane (CH_4) and nitrous oxide (N_2O) are increasing greenhouse gases, and N_2O is also the most important ozone-depleting gas in the stratosphere [*IPCC*, 2013; *Ravishankara et al.*, 2009]. Although the increase of CH_4 and N_2O is mainly caused by anthropogenic emissions such as agriculture and fossil fuel combustion, they are biogenically produced or consumed, and emitted from various sources including oceans. Several studies have reported over-saturation of CH_4 and N_2O with respect to atmospheric equillibrium in the surface water of several regions in the Arctic Ocean [*Kitidis et al.*, 2010 and references therein]. In this study, we aimed to reveal the horizontal and vertical distriutions of CH_4 and N_2O in the Bering Strait and the Chukchi Sea and to analyze their production or consumption processes based on relative abundance of isotopomers, isotope-substituted molecules such as $^{13}CH_4$, CH_3D, ^{15}NNO, $N^{15}NO$, and $NN^{18}O$.

Seawater samples were collected at 22 and 14 stations in August-Septemeber 2012 and 2013, respectively, during the cruises of R/V Mirai (MR12-E03 and MR13-06) (Figure 1). Surface or 5-m depth water was sampled for CH_4 concentration analysis at all the stations, and samples at several depths and those for N_2O and isotopomer analyses were collected at selected stations. Dissolved CH_4 was determined with GC-FID and dissoved N_2O and its isotopomers were determined with GC-IRMS [*Yamagishi et al.*, 2007].

Concentrations of dissolved CH_4 and N_2O ranged from 0.5 to 48.5 nmol/kg and from 9.3 to 49.0 nmol/kg, respectively, and most of the samples showed oversaturation of these gases with respect to the atmosphere. The highest values were observed near the seafloor at a shallow station in continental shelf (72.7°N, 168.2°W) in 2013. They correspond to 1281% and 306% saturation, respectively, and are as high as ever reported in the Arctic Ocean. Maxima of CH_4 and N_2O were also observed in the surface or subsurface water at deeper stations and they did not always coincide. These results suggest that production of CH_4 and N_2O ocurr not only in the sediments but also in the water column. Isotopomer analysis of N_2O indicated that origin of N_2O is different between shallow and deep stations.

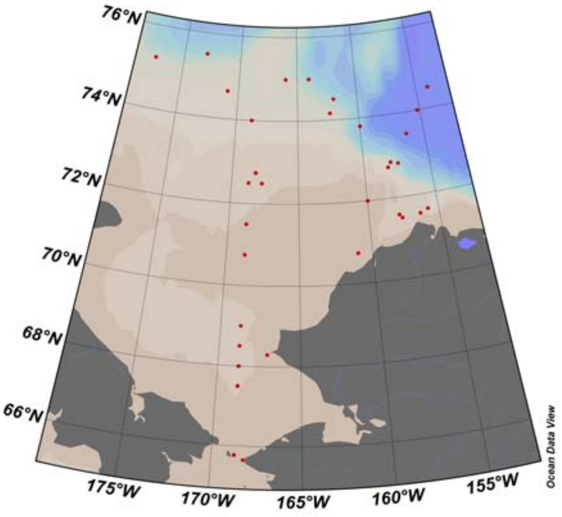

Figure 1. Map of seawater sampling stations in 2012 and 2013.

References

IPCC (2013), Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change 1535 pp., Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

Kitidis, V., R. C. Upstill-Goddard, and L. G. Anderson (2010), Methane and nitrous oxide in surface water along the North-West Passage, Arctic Ocean, Marine Chemistry, 121(1–4), 80-86, doi:10.1016/j.marchem.2010.03.006.

Ravishankara, A. R., J. S. Daniel, and R. W. Portmann (2009), Nitrous oxide (N2O): The dominant ozone-depleting substance emitted in the 21st century, Science, 326, 123, doi:10.1126/science.1176985.

Yamagishi, H., M. B. Westley, B. N. Popp, S. Toyoda, N. Yoshida, S. Watanabe, K. Koba, and Y. Yamanaka (2007), Role of nitrification and denitrification on the nitrous oxide cycle in the eastern tropical North Pacific and Gulf of California, J. Geophys. Res.: Biogeosci., 112(G2), G02015, doi:10.1029/2005JG000227.