Seasonal and interannual variations in the atmospheric Ar/N_2 ratio observed at five ground based stations in Japan

*Shigeyuki Ishidoya[1], Yasunori Tohjima[2], Kazuhiro Tsuboi[3], Shohei Murayama[1], Yosuke Niwa[3], Hidekazu Matsueda[3]

1. National Institute of Advanced Industrial Science and Technology (AIST), 2. National Institute for Environmental Studies, 3. Meteorological Research Institute

Atmospheric Ar/N2 ratio is a unique tracer to detect the spaciotemporally-integrated air-sea flux or ocean heat content (OHC), since the variations in surface Ar/N2 ratio are driven by air-sea Ar and N2 fluxes principally due to changes in solubility in seawater. The relative temperature dependence of the solubility of Ar is larger than that of N2, so that the atmospheric Ar/N2 ratio increases with increasing ocean temperature. We have started systematic measurements of the Ar/N2 ratio by using a mass spectrometer (Ishidoya and Murayama, 2014) at Tsukuba (36˚N, 140˚E) and Hateruma Island (24˚N, 124˚E), Japan since 2012 and at Cape Ochi-ishi (43˚N, 146˚E), Takayama (36˚N, 137˚E) and Minamitorishima Island (24˚N, 154˚E), Japan since 2013. Not only clear seasonal Ar/N2 cycles with summertime maxima were found at all stations, but also clear interannual variations were seen from the 5-years data at Tsukuba and Hateruma; gradually increased from 2012 to the begenning of 2015 and did not show a significant increase/decrease since then. The seasonal amplitudes and appearances of maxima and minima of the Ar/N2 cycles were larger and earlier, respectively, at coastal stations at Hateruma, Ochi-ishi and Minamitorishima than those at inland sites at Tsukuba and Takayama. The peak-to-peak seasonal amplitudes were in the range of 15-45 per meg, which were comparable to or larger than those reported by past studies (Keeling et al., 2004; Cassar et al., 2008). The interannual variations of Ar/N2 ratio at Tsukuba and Hateruma were generally in phase with those in the global OHC reported by NOAA/NODC (updated from Levitus et al., 2012), which suggests our observational results reflect wide-area averaged information of ocean temperature.

Acknowledgements
We thank staff of Global Environmental Forum (GEF) and Japan Meteorological Agency (JMA) for their work to collect the air samples at Hateruma and Ochi-ishi stations (GEF) and Minamitorishima station (JMA).

References

Cassar, N. et al. (2008) An improved comparison of atmospheric Ar/N2 time series and paired ocean-atmosphere model predictions. J. Geophys. Res., 113, D21122. DOI: 10.1029/2008 JD009817.
Ishidoya, S. & Murayama, S. (2014) Development of high precision continuous measuring system of the atmospheric O2/N2 and Ar/N2 ratios and its application to the observation in Tsukuba, Japan. Tellus B, 66, 22574, http://dx.doi.org/ 10.3402/tellusb.v66.22574.
Keeling, R. F. et al. (2004) Measurement of changes in atmospheric Ar/N2 ratio using a rapid-switching, single-capillary mass spectrometer system, Tellus B, 56, 322–338.
Levitus, S., J. I. Antonov, T. P. Boyer, O. K. Baranova, H. E. Garcia, R. A. Locarnini, A. V. Mishonov, J. R. Reagan, D. Seidov, E. S. Yarosh and M. M. Zweng, World ocean heat content and thermosteric sea level change (0-2000 m), 1955–2010, Geophys. Res. Lett., 39, doi:10.1029/2012GL051106, 2012.

Keywords: atmospheric Ar/N2 ratio, ocean heat content, seasonal variation, interannual variation

