Seasonal evolution of the N_2/Ar ratio in the upper ocean of the western subarctic Pacific: a modeling study

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The N_2/Ar saturation ratio (ΔN_2/Ar) in seawater provides a powerful constraint on water column and benthic denitrification. To use ΔN_2/Ar as a tracer of denitrification, accurate knowledge of the influence of abiotic processes, such as air-sea heat flux related to diffusive gas exchange, turbulent mixing, sea-level pressure variation, and bubble injection, on the distribution of these two gases in the upper ocean is required. To this end, we investigate the contribution of each of these abiotic processes to the seasonal evolution of N_2 and Ar saturation anomalies and ΔN_2/Ar in the western subarctic Pacific using a one-dimensional model. Variations in surface heat flux and sea-level pressure tend to create an undersaturation of N_2 and Ar in the mixed layer from winter to early spring, when the mixed layer depth reaches its maximum; this undersaturation is carried to depths below the mixed layer. Mixing induces a small supersaturation of both gases in and below the mixed layer. Because these processes affect both gases in a very similar manner, they lead to only very small ΔN_2/Ar anomalies in and below the mixed layer. In contrast, bubble-mediated gas exchange leads to higher supersaturation of N_2 than Ar, and it accounts for almost all the ΔN_2/Ar anomalies in and below the mixed layer. The contribution of bubble-mediated gas exchange thus needs to be well understood when using ΔN_2/Ar as a tracer for oceanic denitrification.

Keywords: N2/Ar ratio in the upper ocean, abiotic process, seasonal evolution

