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Insights into the production processes of N2O in the western north Pacific by using a marine ecosystem isotopomer model

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Nitrous Oxide (N_2O) is a significant anthropogenic greenhouse gas and a stratospheric ozone destroyer. Although the estimation of global N_2O flux from ocean to the atmosphere is 3.8 $TgNyr^{-1}$, the estimation varies greatly, from 1.8 to 5.8 $TgNyr^{-1}$. This is because previous models had estimated N_2O concentration from oxygen concentration indirectly. In fact, marine N_2O production processes are very complicated; hydroxylamine oxidation during nitrification, nitrite reduction during nitrifier denitrification and nitrite reduction during denitrification produce N_2O and N_2O deduction during denitrification consumes N_2O. Therefore marine N_2O production processes are poorly understood quantitatively. N_2O isotopomers (oxygen isotope ratio (delta-^{18}O), difference in abundance of $^{14}N^{15}N^{16}O$ and $^{15}N^{14}N^{16}O$ (SP), and average nitrogen isotope ratio (delta-^{15}N)) are useful tracers to distinguish these processes and had revealed N_2O production processes in various ocean environments.

In this study, a marine ecosystem model including the two N_2O production processes (hydroxylamine oxidation during nitrification and nitrite reduction during nitrifier denitrification) and isotopomers cycle is developed, in order to understand the N_2O production processes quantitatively and make the equations of N_2O production processes. We applied this model to the water above the 220m depth at the JAMSTEC time-series subarctic and subtropical sites (K2 and S1) in the western north Pacific. The observed N_2O in the waters above the depth of 1000m at K2 show high concentrations, nearly 33 permill of SP values, isotopically heavy delta-^{15}N values and isotopically heavy delta-^{18}O values compared to S1. These results suggest that the age of water mass above 1000m at K2 is high and the water accumulates N_2O with progression of nitrification compared to S1.

Our model is constrained by the observed nitrate, chlorophyll a and N_2O concentrations and delta-^{15}N values of nitrate, phytoplankton, zooplankton and N_2O and SP values of N_2O at K2 and S1. In the case applied to K2, the observed subsurface N_2O profile cannot be represented just by abiological N_2O processes (gas exchange and vertical water exchanges). This result suggests that biological N_2O processes occur in the subsurface water at K2. Moreover, from the results of sensitivity studies about SP values of N_2O, we estimate that N_2O is produced only by nitrification at K2 and the ratio of N_2O production to nitrate production during nitrification is 0.22%, which is within the range of previous studies, from 0.13 to 0.37%. Furthermore, the results of sensitivity studies about delta-^{15}N values of N_2O suggest a higher contribution of archaeal ammonia oxidation during nitrification than bacterial ammonia oxidation. In this presentation, we will also show the simulated results applied to S1, where the observed isotopomer ratios suggests both contributions of hydroxylamine oxidation during nitrification and nitrite reduction during nitrifier denitrification to the subsurface N_2O production.