Which Parameter Does Affect the N\textsubscript{2}O Exchange between the Air and the Sea?

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ABSTRACT

Water temperature decides solubility and the direction of N\textsubscript{2}O flux. When water temperature is low, solubility is high and N\textsubscript{2}O in seawater is under saturation. Water temperature also affects the volume of the flux in this situation. When water temperature is high, because solubility decreases, N\textsubscript{2}O is emitted from the sea to the air. The volume of flux is decided by N\textsubscript{2}O concentration in seawater. Water temperature is main factor for N\textsubscript{2}O exchange. Japanese coastal seas can have as both sink and source of N\textsubscript{2}O.

KEY WORDS: Nitrous Oxide; N\textsubscript{2}O; In-situ Data; Greenhouse Effect Gas; Coastal Sea; Flux; Solubility.

INTRODUCTION

Nitrous Oxide (N\textsubscript{2}O) is a greenhouse effect gas, as defined by the Kyoto Protocol. Total disappearance of N\textsubscript{2}O in the air is estimated as 38.6 Tg-N\textsubscript{2}O y\textsuperscript{-1}, and only disappearance in the stratosphere is counted (IPCC, 2001). On the other hand, the total emission of N\textsubscript{2}O into the air is estimated as 55.6 Tg-N\textsubscript{2}O y\textsuperscript{-1}. The difference is presumed to be increasing N\textsubscript{2}O concentration in the air. According to the IPCC report (2001), nature gives off 65 % of the N\textsubscript{2}O emissions in the world, and most common natural sources is soil. Ocean is the second most prominent nature source, and emits 17 % (= 10 % from open oceans + 7% from estuaries and coastal seas). N\textsubscript{2}O gas is generated by nitrification and de-nitrification processes in seawater and the sea bottom sediment. Ocean is source of N\textsubscript{2}O in general. Coastal sea area occupies only 3% of the whole ocean (Yanagi, 1999). But the amount of N\textsubscript{2}O emissions per area of coastal seas is 3 times that of the emissions from the whole ocean (Bange, 1996a) because of active biochemical processes.

On the other hand, it is possible that the ocean behave as a sink for N\textsubscript{2}O like for CO\textsubscript{2}. The N\textsubscript{2}O flux, \( F \) (\( \mu \)mol m\textsuperscript{-2} d\textsuperscript{-1}) between the air and seawater is estimated by Eq. 1.

\[
F = 0.24k_g \Delta N\textsubscript{2}O = 0.24k_g (C_{\text{sea}} - C_{\text{sol}})
\]  

\( \Delta N\textsubscript{2}O \) is the difference of \( C_{\text{sea}} \) (nmol l\textsuperscript{-1}) and \( C_{\text{sol}} \) (nmol l\textsuperscript{-1}). \( C_{\text{sea}} \) is the N\textsubscript{2}O concentration in seawater, and \( C_{\text{sol}} \) is the N\textsubscript{2}O solubility of seawater. The direction of N\textsubscript{2}O flux is decided by \( \Delta N\textsubscript{2}O \). \( k_g \) is the gas transfer velocity (cm h\textsuperscript{-1}), and is function of the wind speed. 0.24 is the coefficient for unit exchange (Bange et al., 1996a; Bange et al., 1996b; Wilde and Helder, 1997; Bange et al., 2001). \( k_g \) accelerates N\textsubscript{2}O flux, but don't related to the direction of the flux. Solubility is given by Eq. 2 (Weiss and Price, 1980).

\[
C_{\text{sol}} = k_s X_{\text{air}}
\]  

\( X_{\text{air}} \) (natm) is N\textsubscript{2}O partial pressure in the air. \( k_s \) (mol l\textsuperscript{-1} atm\textsuperscript{-1}) is the solubility coefficient which is a function of water temperature and salinity. Solubility means how much N\textsubscript{2}O can dissolve into the seawater in the condition of water temperature and salinity at the time.

Therefore not only N\textsubscript{2}O concentration in the air and sea but also water temperature and salinity are related to N\textsubscript{2}O flux. In considering the role of coastal sea to the greenhouse effect by N\textsubscript{2}O, explaining parameter that dominate the N\textsubscript{2}O exchange is important. We considered the parameter which the affects N\textsubscript{2}O exchange between the air and the sea based on the in-situ data measured in Japanese coastal seas and the theoretical equations.

METHODS

Data