## Review of Harms *et al.* (iteration #2)

**General comments:**

Overall, Harms *et al.* addressed most of my concerns. The dataset presented is interesting as it focuses on an under-sampled region of the ocean (the subtropical South Indian Ocean). While they now use their dual nitrate isotope data a bit more in their discussion, I was not entirely satisfied. In my opinion, this section of the manuscript remains insufficient. The study would be improved if they could use their dual nitrate isotope data in a simple model to validate their current estimate of newly fixed N derived using Redfield assumptions. I have provided the equations that I use for similar simple isotope box models in my 2009 and 2013 manuscripts below. The authors are welcome to contact me (abourbonnais@seoe.sc.edu) with any questions.

**Specific comments and technical corrections:**

**Abstract:**

Page 1, lines 14-15: Change to: "Our results are the first in this ocean region and provide new information on nitrogen sources and transformation processes."

Page 1, line 16: Change to "... IOSG with values of <3 μM for both $NO_3^-$ and $PO_4^{3-}$...."

page 1, lines 23-24: What do they mean by "partial-assimilated organic matter"? Do they mean organic matter with a low $\delta^{15}N$? Is there any evidence for low $\delta^{15}N$ of organic material in the SAMW?

Page 1, line: They did not use an isotope budget to derive this estimate (see my general comments above).

**Materials and Methods:**

page 5, lines 19-20: What was the $\delta^{15}N$ and $\delta^{18}O$ for the internal standard? What was the size of the blank (if any)?

**Results:**

Page 7, line 9: Change to ".... of <3 μM for both $NO_3^-$ and $PO_4^{3-}$"

**Discussion:**

Page 14, lines 2-3: Change to "and biologically $N_2$-fixation are major processes..."

Page 15, lines 9-11: Change to "... N*. The analytical error on N* estimate based on the relative error for nitrate and phosphate analysis was below 1.5% for duplicate sample measurements."
Is the error on N* calculated from propagating the errors for these analysis?

page 15, line 15: Change "characteri<u>z</u>ed" to "affected".

Page 16, lines 11-13: $^{18}\varepsilon$:$^{15}\varepsilon$ is associated with both assimilative (nitrate assimilation) and dissimilative (denitrification) nitrate reduction.

Page 16, lines 15-17: This sentence is not clear. The isotope effect associated with ammonium production and nitrification does not affect the $\delta^{15}N$-$NO_3^-$ because ammonium and nitrite generally does not accumulate in oxic waters.

Page 16 and 17, last and first sentences: This point needs to be discussed more. How the $\delta^{18}O$ of seawater is affected by ammonium and nitrite oxidation?  For instance, they could add the following sentence: "$\delta^{18}O$ depends on the ε during $NH_4^+$ and $NO_2^-$ oxidation, water incorporation (with $\delta^{18}O$- $H_2O$ of ~0‰), and the exchange of oxygen atoms with water that should generate a $\delta^{18}O$ of newly produced $NO_3^-$ between -8 and -1‰ (Buchwald and Casciotti, 2010; Casciotti *et al*., 2010).

Page 19, lines 13-14: Provide an estimate of N atmospheric depositions in this region to support this claim.

Page 19, line 22: Correct "$N_2$-fiaxtion"

Page 19, section 4.2.2. The manuscript would be improved if they could also derive an $N_2$ fixation estimate using a simple isotope model, as described below.

**Additional references:**

Bourbonnais, A., Lehmann, M. F., Hamme, R. C., Manning, C. C., & Juniper, S. K. (2013). Nitrate elimination and regeneration as evidenced by dissolved inorganic nitrogen isotopes in Saanich Inlet, a seasonally anoxic fjord. *Marine chemistry*, *157*, 194-207.

Casciotti, K. L., McIlvin, M., & Buchwald, C. (2010). Oxygen isotopic exchange and fractionation during bacterial ammonia oxidation. *Limnology and Oceanography*, *55*(2), 753-762.

**Example of simple isotope box model (Bourbonnais *et al.*, 2009 and 2013)**

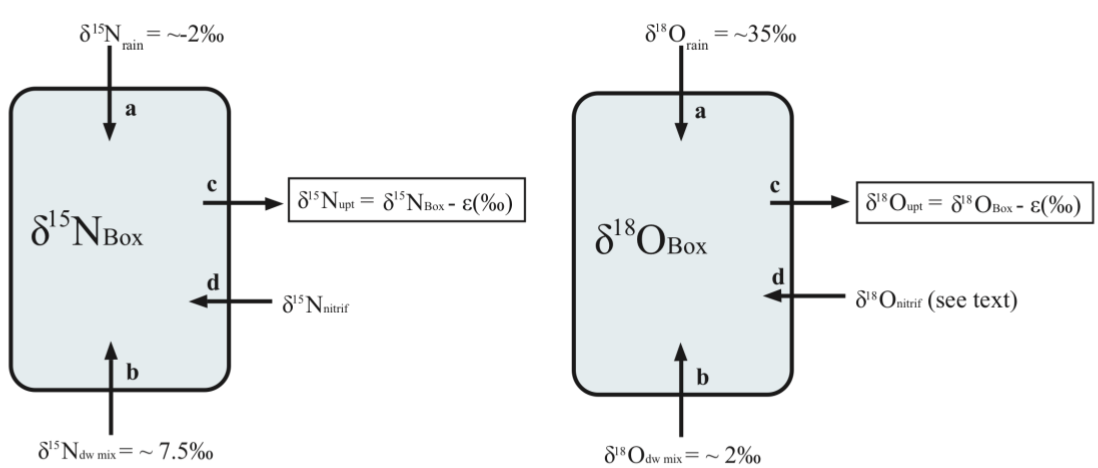


**Figure 1.** Nitrate isotope box-model for scenario 2a in Bourbonnais *et al.* (2013).

**Note: $\delta^{15}N_{rain}$ in this model represents the $\delta^{15}N$ in precipitations, but could be replaced by the $\delta^{15}N$ for $N_2$ fixation in the Harms *et al.* paper.**

N flux terms:

**a** = N from precipitation flux

**b** = seawater mixing

**c** = nitrate removal (by nitrate assimilation ($C_{upt}$)

**d** = organic matter remineralization and nitrification (recycled production)

$\delta^{15}N_{Box}$ = steady-state $\delta^{15}N\text{-}NO_3^-$ (under model assumptions)

$\delta^{18}O_{Box}$ = steady-state $\delta^{18}O\text{-}NO_3^-$ (under model assumptions)

$\delta^{15}N_{rain}$ = $\delta^{15}N\text{-}NO_3^-$ from precipitation (2‰)

$\delta^{18}O_{rain}$ = $\delta^{18}O\text{-}NO_3^-$ from precipitation (35‰)

$\delta^{15}N_{dw\ mix}$ = $\delta^{15}N\text{-}NO_3^-$ added from vertical mixing with deep-water (7.5‰)

$\delta^{18}O_{dw\ mix}$ = $\delta^{18}O\text{-}NO_3^-$ added from vertical mixing with deep-water (2‰)

$\delta^{15}N_{upt} = \delta^{15}N_{Box} - \varepsilon_{upt}$ (‰) = $\delta^{15}N\text{-}NO_3^-$ of nitrate assimilated

$\delta^{18}O_{upt} = \delta^{18}O_{Box} - \varepsilon_{upt}$ (‰) = $\delta^{18}O\text{-}NO_3^-$ of nitrate assimilated

where

$\varepsilon_{upt}$ (‰) = nitrate assimilation isotope effect (5 ‰)

$\delta^{15}N_{nitrif}$ = $\delta^{15}N$ of nitrate generated in the process of organic matter remineralization and nitrification.

$\delta^{18}O_{nitrif}$ = $\delta^{18}O$ of nitrate generated in the process of organic matter remineralization and nitrification (-3.8 ‰).

The equation for $\delta^{15}N_{Box}$ is derived from:

$$\delta^{15}N_{Box} = [\delta^{15}N_{rain} \times a] + [\delta^{15}N_{dw\ mix} \times b] - [(c_{upt} - d) \times (\delta^{15}N_{Box} - {}^{15}\varepsilon_{upt})]$$

$$\delta^{15}N_{Box} = [\delta^{15}N_{rain} \times a] + [\delta^{15}N_{dw\ mix} \times b] - [(c_{upt} - d) \times \delta^{15}N_{Box}] + [(c_{upt} - d) \times {}^{15}\varepsilon_{upt}]$$

$$\delta^{15}N_{Box} + [(c_{upt} - d) \times \delta^{15}N_{Box}] = [\delta^{15}N_{rain} \times a] + [\delta^{15}N_{dw\ mix} \times b] + [(c_{upt} - d) \times {}^{15}\varepsilon_{upt}]$$

$$\delta^{15}N_{Box} + [(c_{upt} - d) \times \delta^{15}N_{Box}] = [\delta^{15}N_{rain} \times a] + [\delta^{15}N_{dw\ mix} \times b] + [(c_{upt} - d) \times {}^{15}\varepsilon_{upt}]$$

$$\delta^{15}N_{Box} \times [1 + (c_{upt} - d)] = [\delta^{15}N_{rain} \times a] + [\delta^{15}N_{dw\ mix} \times b] + [(c_{upt} - d) \times {}^{15}\varepsilon_{upt}]$$

The final equation for $\delta^{15}N_{Box}$ is:

$$\delta^{15}N_{Box} = [(\delta^{15}N_{rain} \times a] + [\delta^{15}N_{dw\ mix} \times b] + [(c_{upt} - d) \times {}^{15}\varepsilon_{upt}] / [1 + (c_{upt} - d)]$$

The equation for $\delta^{18}O_{box}$ is derived from:

$$\delta^{18}O_{Box} = [\delta^{18}O_{rain} \times a] + [\delta^{18}O_{sw\ mix} \times b] - [c_{upt} \times (\delta^{18}O_{Box} - {}^{18}\varepsilon_{upt})] + [d \times \delta^{18}O_{nitrif}]$$

$$\delta^{18}O_{Box} = [\delta^{18}O_{rain} \times a] + [\delta^{18}O_{sw\ mix} \times b] - [c_{upt} \times \delta^{18}O_{Box}] + [c_{upt} \times {}^{18}\varepsilon_{upt})] + [d \times \delta^{18}O_{nitrif}]$$

$$\delta^{18}O_{Box} + [c_{upt} \times \delta^{18}O_{Box}] = [\delta^{18}O_{rain} \times a] + [\delta^{18}O_{sw\ mix} \times b] + [c_{upt} \times {}^{18}\varepsilon_{upt})] + [d \times \delta^{18}O_{nitrif}]$$

$$\delta^{18}O_{Box} \times [1 + c_{upt}] = [\delta^{18}O_{rain} \times a] + [\delta^{18}O_{sw\ mix} \times b] + [c_{upt} \times {}^{18}\varepsilon_{upt})] + [d \times \delta^{18}O_{nitrif}]$$

The final equation for $\delta^{18}O_{Box}$ is:

$$\delta^{18}O_{Box} = [\delta^{18}O_{rain} \times a] + [\delta^{18}O_{sw\ mix} \times b] + [c_{upt} \times {}^{18}\varepsilon_{upt})] + [d \times \delta^{18}O_{nitrif}] / [1 + c_{upt}]$$

The $\Delta(15,18)$ is calculated according to the following equation:

$$\Delta(15,18) = (\delta^{15}N - \delta^{15}N_{deep}) - [({}^{18}\delta/{}^{15}\delta)\ (\delta^{18}O - \delta^{18}O_{deep})]$$