Appendix

Appendix A: Equivalence of Eqs. (13) and (15)

Below, we prove that the Eq. (13) is equal to Eq. (15). First of all, Eq. (15) can be rewritten as the following equation which represents an individual datum point instead of a slope from pooled data (Trimmer and Nicholls, 2009).

$$ra = \frac{2 - 2 \cdot \frac{q\mathrm{N_2}}{q\mathrm{N_2O}}}{2 - \frac{q\mathrm{N_2}}{q\mathrm{N_2O}}}. \tag{A1}$$

On the other hand, Eq. (13) is

$$ra = \frac{A_{14}}{D'_{14\text{-}\mathrm{N_2}} + A_{14}}. \tag{A2}$$

By substituting D'_{14} and A_{14}, respectively, with Eq. (5) and Eq. (6), we can express *ra* as

$$ra = \frac{P_{29} - 2 \cdot r_{14\text{-}\mathrm{N_2O}} \cdot P_{30}}{P_{29} + P_{30} \cdot (1 - r_{14\text{-}\mathrm{N_2O}})}. \tag{A3}$$

Since $P_{29}/\ P_{30}$ is equal to $2{\cdot}r_{14\text{-}\mathrm{N_2O}}$, the *ra* can be expressed in terms of r_{14} after the numerator and the denominator are divided by P_{30}, which is

$$ra = \frac{2 \cdot r_{14\text{-}\mathrm{N_2}} - 2 \cdot r_{14\text{-}\mathrm{N_2O}}}{2 \cdot r_{14\text{-}\mathrm{N_2}} - r_{14\text{-}\mathrm{N_2O}} + 1}. \tag{A4}$$

Substituting r_{14} with q using Eq. (14) produces Eq. (A1).

Appendix B: Discussions of Assumptions 5 and 6

Assumption 5 assumes that NO_3^- reduction is the only source of NO_2^- in anoxic sediment layer. That is, supplies from other potential sources, such as NO_2^- from ammonia oxidation or downward diffusion from overlying water, are insignificant. Under this assumption, the fraction of ^{15}N in nitrite will be equal to that of nitrate. This assumption is indispensable for all versions of IPT; however, it is difficult to test specifically via IPT itself (see below). Several studies specifically focusing on NO_2^- production showed that NO_2^- in anoxic sediment mainly results from NO_3^- reduction (De Beer, 2000; Meyer et al., 2005; Stief et al., 2002), which supports this assumption. Although it is untestable via IPT itself, some phenomena caused by the violation of the assumption can be recognized through slurry incubation.

Conditions of high anammox activity and significant NO_2^- supply from non-labelled sources to anammox will result in inconsistent outcomes between incubations of intact core and slurry sediment. For example, significant anammox activity can be revealed in slurry incubation after adding $^{15}NH_4^+$; meanwhile, a positive correlation between values of $D_{14\text{-classic}}$ and $^{15}NO_3^-$ concentrations should be obtained from the intact core experiment if all NO_2^- comes from labelled sources (e.g. Fig. 7c). On the contrary, if NO_2^- is largely supplied from non-labelled sources a constant value of $D_{14\text{-classic}}$ will be obtained in the $^{15}NO_3^-$ concentration series experiment because N_2 produced from anammox will be supported by non-labelled NO_2^-. Note that the violation of Assumption 6 below might result in the same inconsistency.

In general, nitrification which uses NH_4^+ as the substrate will not be affected by the addition of $^{15}NO_3^-$ (Assumption 6). However, an indirect effect might occur in the NO_3^- addition experiment since high $^{15}NO_3^-$ concentrations may stimulate benthic microalgae (BMA) and/or anammox activity to deplete NH_4^+ thus limiting nitrification. Considering an environment without anammox, reduced nitrification might happen once BMA production is stimulated by the addition of $^{15}NO_3^-$. Such enhanced BMA may decrease coupled nitrification-denitrification ($P_{14}n$). Apparently, the underestimation of $P_{14}n$ causes an underestimate of $D_{14\text{-classic}}$ as the increase of $^{15}NO_3^-$ concentrations. However, if the growth of BMA doesn't result in reduction of nitrification, $D_{14\text{-classic}}$ is expected to be independent of $^{15}NO_3^-$ additions, thus, a negative correlation between values of $D_{14\text{-classic}}$ and $^{15}NO_3^-$ concentrations should be obtained from intact core incubated in the light condition, theoretically. By comparing $D_{14\text{-classic}}$ responses between the light and dark incubations, the violation of Assumption 6 due to BMA growth can be proved and distinguished with the violation of Assumption 5.

Besides BMA, anammox is another process that might cause nitrification underestimate. Similar to the effect of BMA, this, in turn, diminishes the NO_3^- supply resulting in an underestimation of $P_{14}n$ and subsequently $D_{14\text{-classic}}$. Possibly, higher $^{15}NO_3^-$ additions will cause larger degree of underestimation in $D_{14\text{-classic}}$. In contrast, if this is the case anammox must be traceable. In other words, the $^{29}N_2$ produced from anammox will cause the overestimation of $D_{14\text{-classic}}$. This overestimation of $D_{14\text{-classic}}$ is also grows with increased additions of $^{15}NO_3^-$. If both anammox and BMA co-exist, the underestimation of $D_{14\text{-classic}}$ caused by diminishing nitrification is compensated by stimulating anammox in different $^{15}NO_3^-$ treatments. Such compensation blocks a good positive correlation between $D_{14\text{-classic}}$ and the concentration spike of $^{15}NO_3^-$; more seriously, the positive correlation may even turn into negative correlation. Coupled with significant anammox activity observed in slurry incubation by adding NH_4^+, phenomena observed here thus resembles that caused by the violation of Assumptions 5. In addition, the degree of compensation might respond differently in light and dark incubation, the difference can be used to reveal the competition of BMA and nitrifier, and check the violation of Assumption 6.

Reference of Appendix

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