Isotopic evidence for alteration of nitrous oxide emissions and producing pathways contribution under nitrifying conditions

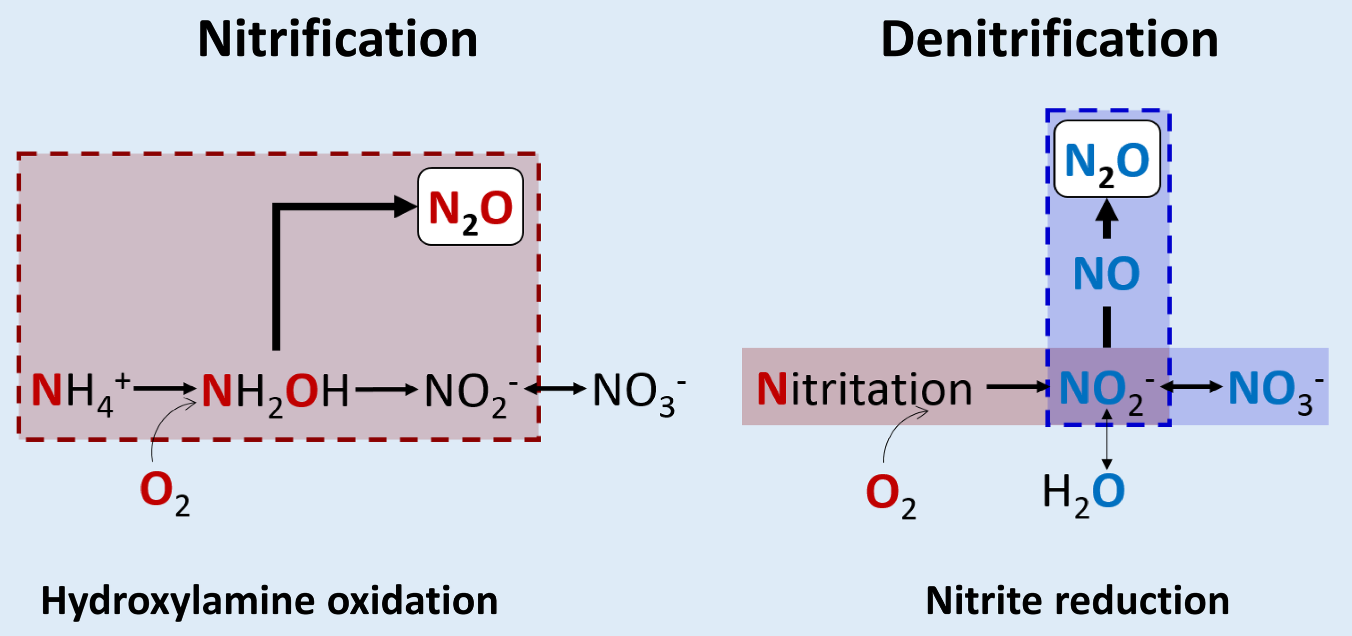
Guillaume Humbert, Mathieu Sebilo, Justine Fiat, Longqi Lang, Ahlem Filali, Véronique Vaury, M. Sperandio, Anniet M. Laverman

Isotopic evidence for alteration of nitrous oxide emissions and producing pathways contribution under nitrifying conditions

*Guillaume Humbert[1, 2, *], Mathieu Sébilo[1, 3], Justine Fiat[4], Longqi Lang[5], Ahlem Filali[4], Véronique Vaury[1], Mathieu Spérandio[5], Anniet M. Laverman[2]*

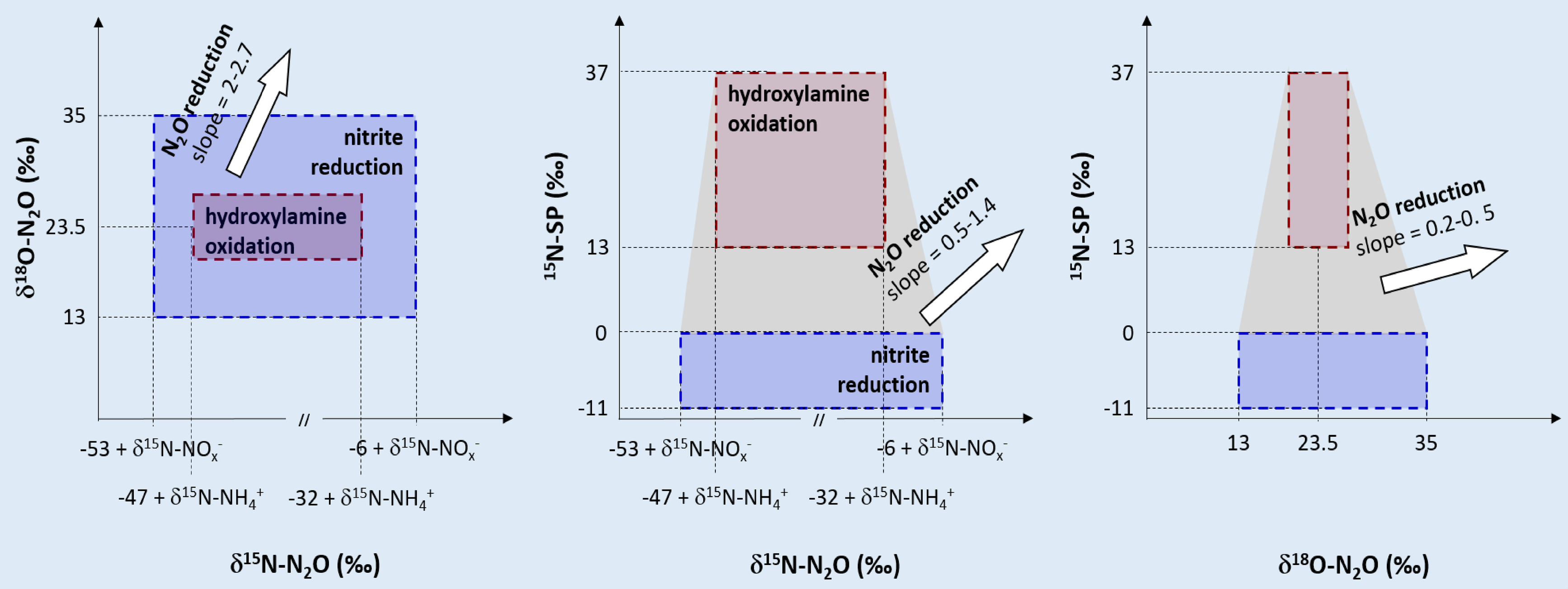
[1]Sorbonne Université, CNRS, INRA, IRD, UPD, UPEC, Institute of Ecology and Environmental Sciences – Paris, iEES, F 75005 Paris, France; [2]Centre National de la Recherche Scientifique (CNRS), ECOBIO – UMR 6553, Université de Rennes, 35042 Rennes, France; [3]CNRS/Univ. Pau & Pays Adour/E2S UPPA, Institut des Sciences Analytiques et de Physico-Chimie pour l'Environnement et les Matériaux, UMR 5254, 64000, Pau, France; [4]Irstea, UR PROSE, CS 10030, F-92761, Antony Cedex, France; [5]LISBP, Université de Toulouse, CNRS, INRA, INSA, Toulouse, France

N_2O producing pathways



Hypothesis on N_2O production *Koba et al. 2009, GCA* **:**

- ✓ Substrate isotope composition *Snider et al. 2013, GCA*
- ✓ Referenced isotope effects *Denk et al. 2017, SBB*
- ✓ Referenced ^{15}N-SP *Lewicka-Szczebak et al., 2014, GCA; Sutka et al., 2006, AEM; Yamazaki et al., 2014, BG*



Research questions

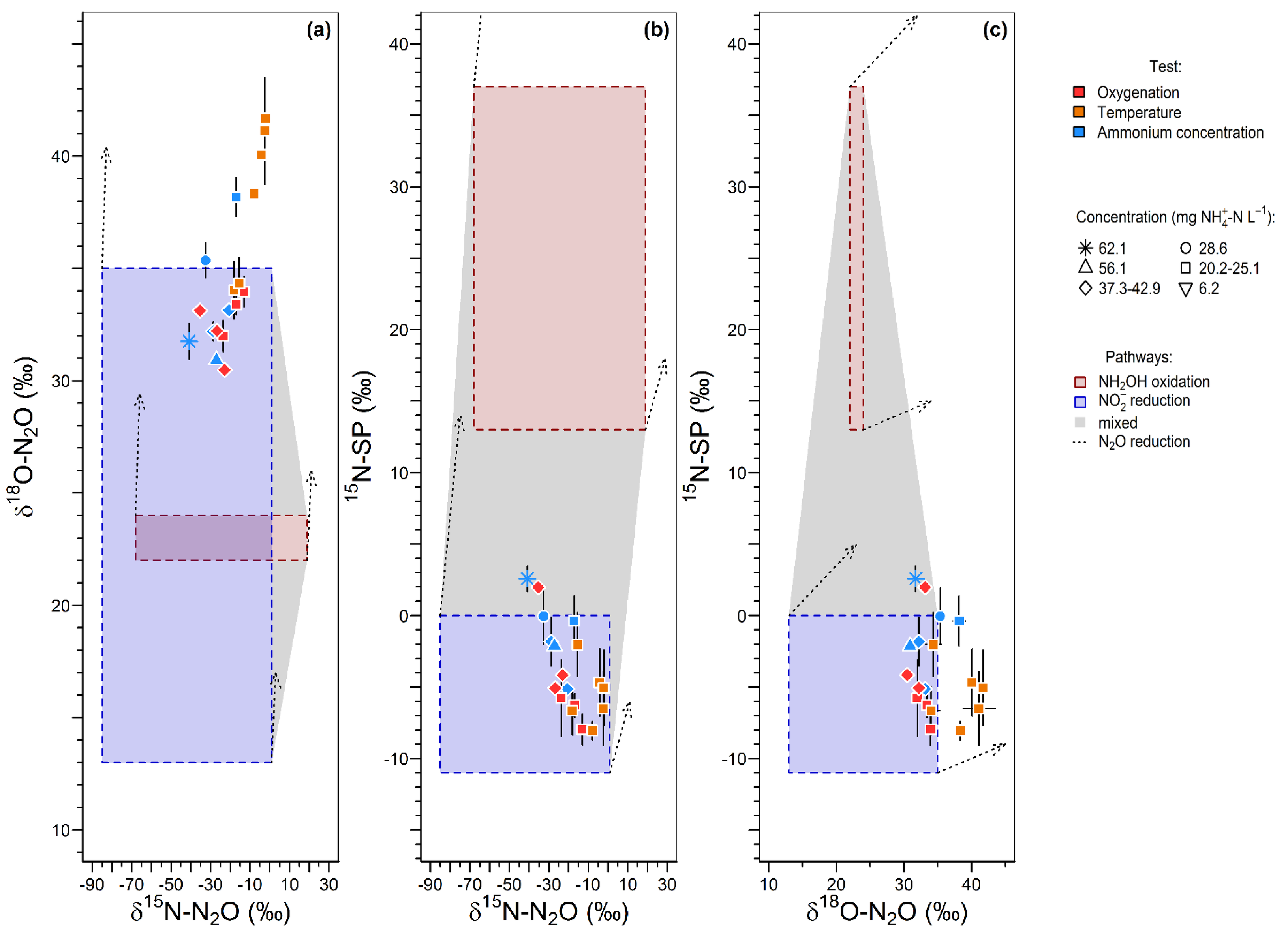
- Can we deduce N_2O producing pathways using isotope measurements under nitrifying conditions?
- Do oxygenation, temperature, and ammonium (NH_4^+) concentration alter N_2O emissions, and what are the involved processes?

Material & Methods

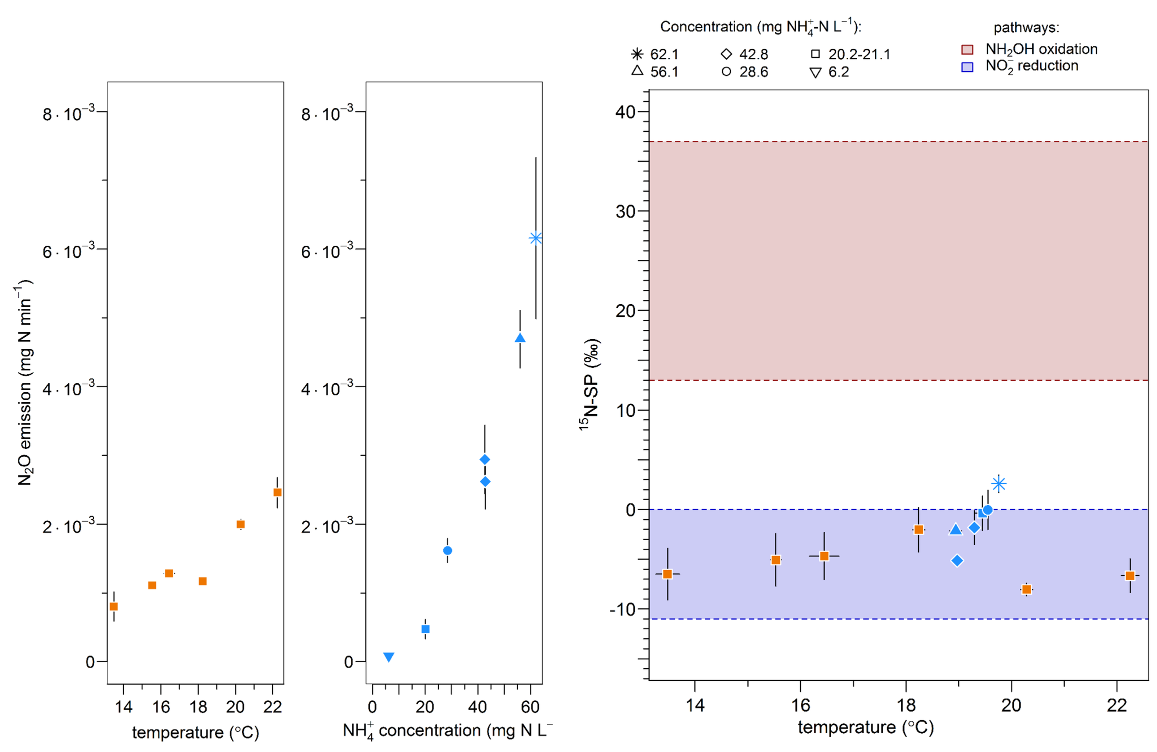
- **Lab-scale nitrifying biologically active filter**
  - ✓ Oxygenation: 0- 21 % O_2 in gas mix
  - ✓ Temperature: 13- 22 °C
  - ✓ NH_4^+ 6- 62 mg N L^{-1}
- **Monitoring :**
  - ✓ Nitrification yield: NH_4^+, NO_2^-, NO_3^-, N_2O
  - ✓ Operating conditions: O_2, pH
- **Isotope analysis:**
  - ✓ N and O isotope ratios (δ^{15}N and δ^{18}O)
  - ✓ N isotopomer site preference (^{15}N-SP)

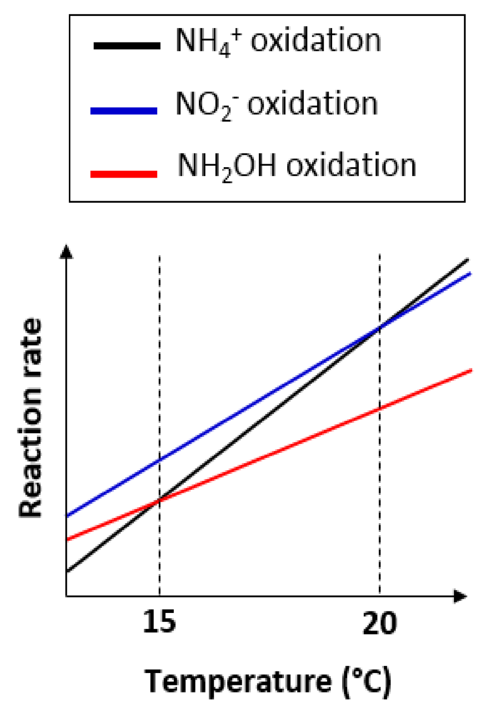
Results

- N_2O isotope composition data revealed that:
  - ✓ **Nitrite reduction** was the main N_2O producing pathway
  - ✓ **Heterotrophic denitrification** occured



- Difference in **temperature dependency** of hydroxylamine and ammonium oxidizers as driver of **hydroxylamine oxidation** contribution to N_2O emissions





- 15 < T < 20 °C: linear increase in the contribution of the hydroxylamine oxidation pathway to N_2O emission
- T > 20 °C: increase in the contribution of the nitrite reduction pathway to N_2O emission. Ammonium oxidation rates exceed nitrite oxidation rates?

Conclusions

➢ Difference in oxidation and reduction rates of nitrite as key driver of nitrite reduction contribution to N_2O emissions

➢ The combination of low N_2O emissions and high nitrification rates would occur close to 15 °C

SORBONNE UNIVERSITÉ CRÉATEURS DE FUTURS DEPUIS 1257 · UNIVERSITÉ DE RENNES 1 · CNRS · INSA TOULOUSE · irstea · SIAAP · ANR