Towards understanding the N_2O production in dust-rich Antarctic ice

DEEPICE MSCA ITN

Lison Soussaintjean[1], Jochen Schmitt[1], Joël Savarino[2], Andy Menking[3], Edward Brook[4], Barbara Seth[1], Thomas Röckmann[5], Hubertus Fischer[1]

[1]Climate and Environmental Physics, Physics Institute & Oeschger Centre for Climate Change Research, University of Bern, Switzerland
[2]Institut des Géosciences de l'Environnement, CNRS, Univ. Grenoble Alpes, France, [3]Australian Antarctic Program Partnership, Institute for Marine and Antarctic Studies, University of Tasmania, Hobart & Environmental Research Unit, Commonwealth Scientific and Industrial Research Organisation, Aspendale, Victoria, Australia
[4]College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, USA, [5]Institute for Marine and Atmospheric research Utrecht, Utrecht University, the Netherlands

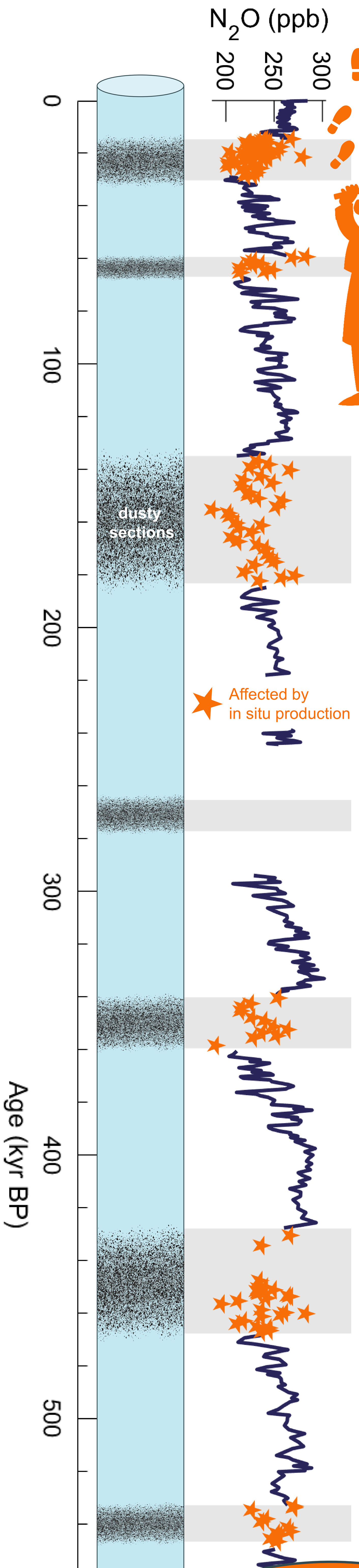
lison.soussaintjean@unibe.ch

Nitrous oxide (N_2O) is a potent greenhouse gas involved in ozone destruction

This presentation participates in OSPP

EGU

Outstanding Student & PhD candidate Presentation contest



INTRODUCTION – What happened to the N_2O record?

Air bubbles trapped in ice cores are unique archives of the past atmosphere. They have allowed the reconstruction of greenhouse gas concentrations over the past 800,000 years. But we still lack a continuous record for N_2O...

Why? Non-atmospheric N_2O is formed in dust-rich ice core sections [1]. This in situ produced N_2O gets added to the atmospheric N_2O and can lead to misinterpretation in terms of past atmospheric concentrations. To eventually correct the N_2O record, let's investigate the production process:

- What is the chemical precursor of in situ N_2O?
- What is the chemical reaction?

METHODS – The detective geochemist's tools

Isotopes give us information on the history of the molecule. In dusty samples from different Antarctic ice cores – Vostok, NGRIP, EDC, EDML, Taylor Glacier, TALDICE – we carried out:

- Bulk isotope analysis ($\delta^{15}N_{bulk}$) of N_2O in air bubbles
- Position-specific isotope analysis ($\delta^{15}N_\alpha$, $\delta^{15}N_\beta$) of N_2O
- Isotope analysis ($\delta^{15}N$) of NO_3^- in meltwater

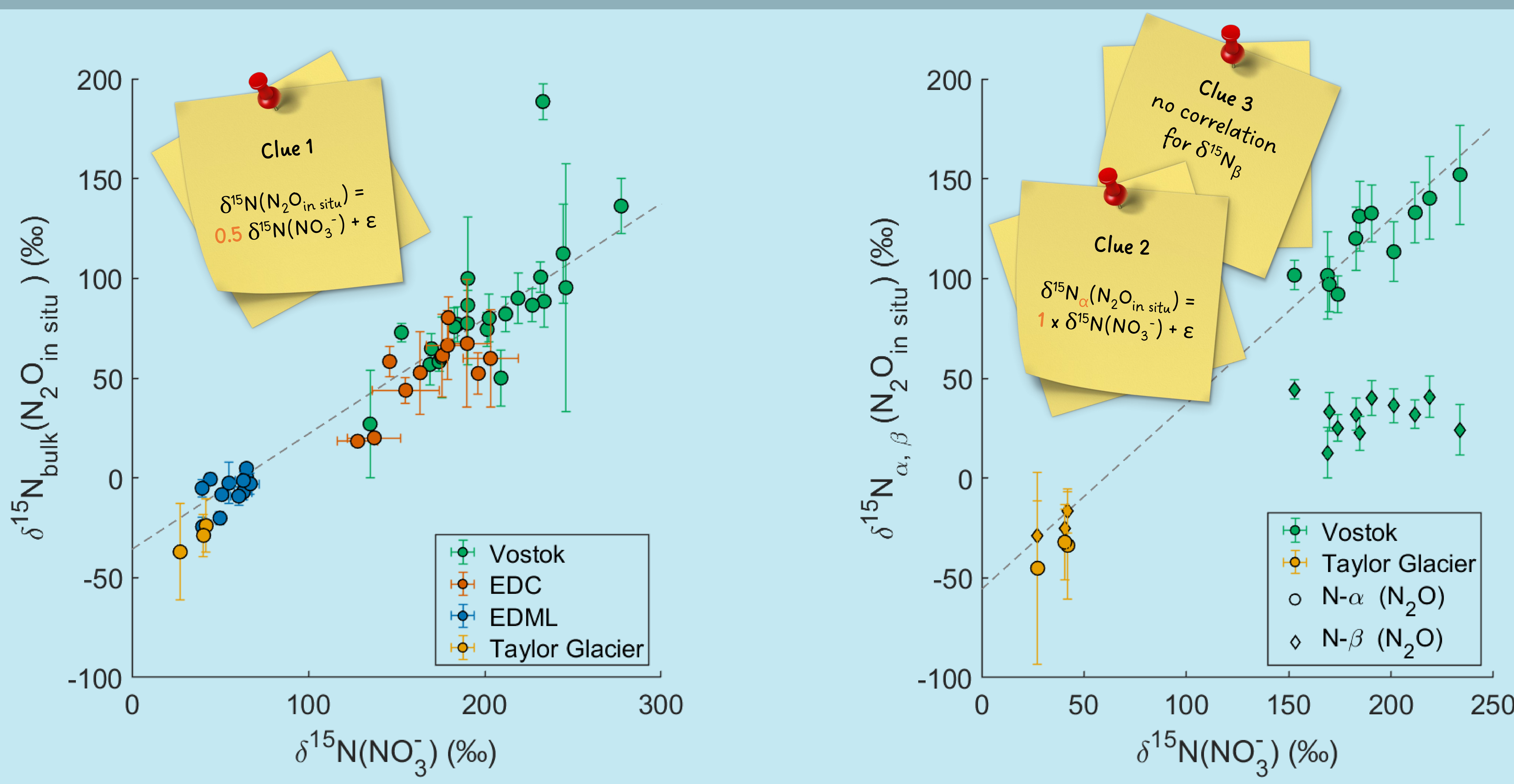
The isotopic composition of the in situ N_2O fraction was calculated using the N_2O record from the TALDICE ice core as atmospheric values:

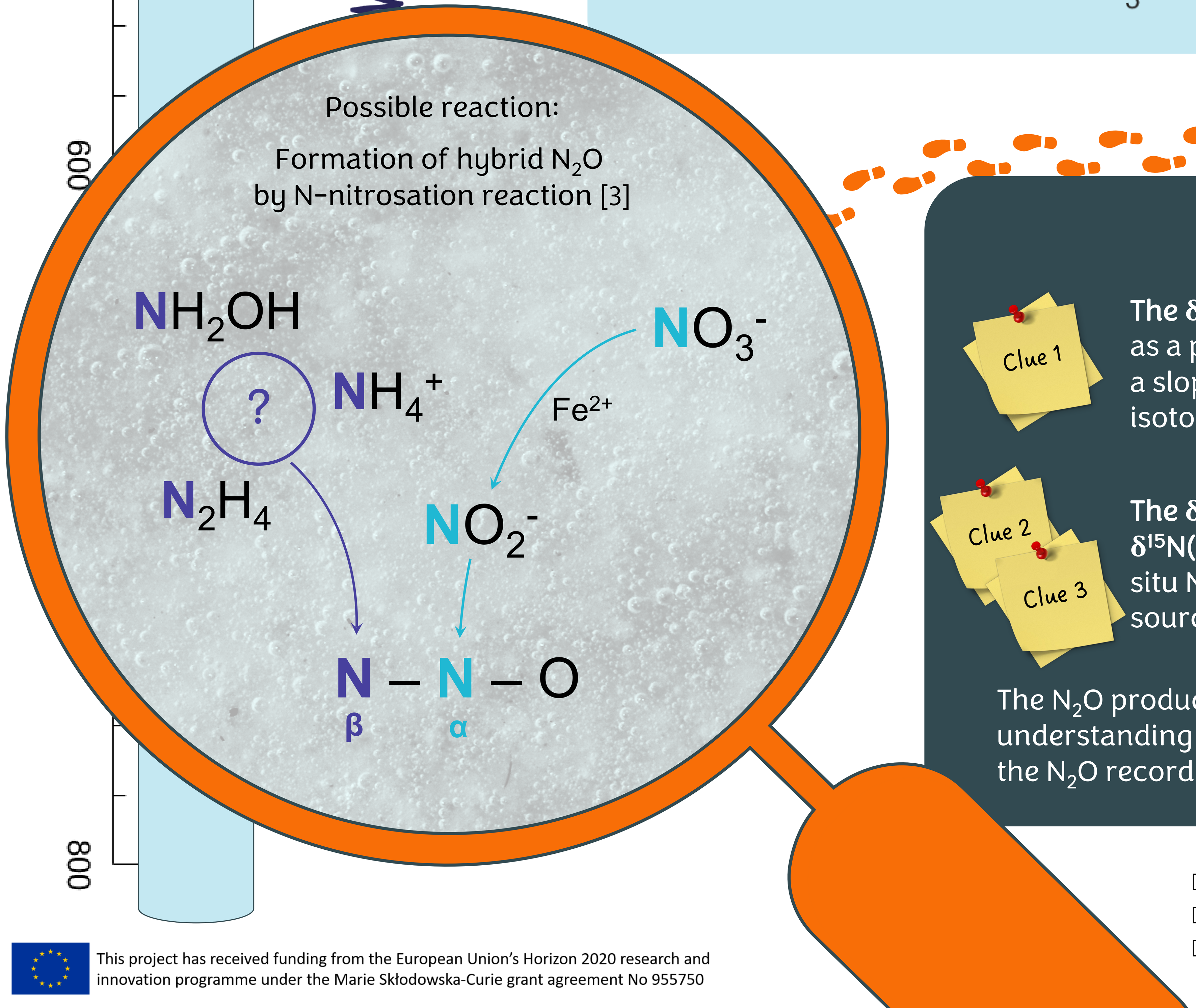
$$\delta_{in\ situ} = \frac{\delta_{measured} \times [N_2O]_{measured} - \delta_{TALDICE} \times [N_2O]_{TALDICE}}{[N_2O]_{measured} - [N_2O]_{TALDICE}}$$

BACKGROUND – Nitrate, our chemical precursor suspect

The $\delta^{15}N$ values of in situ N_2O vary significantly with the location of ice cores and the snow accumulation rate. Because the snow accumulation rate also controls the $\delta^{15}N$ values of nitrate (NO_3^-) archived in the ice [2], NO_3^- (attached to dust) is suspected to be the precursor of in situ N_2O. We therefore compare the isotopic compositions of NO_3^- and in situ N_2O to investigate a potential source–product relationship.

RESULTS – Collecting clues





INTERPRETATION & CONCLUSION

Clue 1

The $\delta^{15}N_{bulk}(N_2O_{in\ situ})$ and $\delta^{15}N(NO_3^-)$ values are correlated, which supports the hypothesis of NO_3^- as a precursor of in situ N_2O. However, the slope is 0.5. If all the nitrogen in N_2O came from NO_3^-, a slope of 1 would be expected. The $\delta^{15}N_{bulk}$ signature of in situ N_2O reflects a mixing between the isotopic composition of NO_3^- and that of another nitrogen source.

Clue 2 Clue 3

The $\delta^{15}N_\alpha(N_2O_{in\ situ})$ and $\delta^{15}N(NO_3^-)$ values are correlated with a slope of 1. The $\delta^{15}N_\beta(N_2O_{in\ situ})$ and $\delta^{15}N(NO_3^-)$ values are not correlated. This result indicates that the central-position N atom (α) of in situ N_2O comes from NO_3^- and the terminal-position N atom (β) comes from a different nitrogen source.

The N_2O produced in situ is **hybrid N_2O**, i.e. the two N atoms come from different sources. Using our understanding of the production process and isotopic analyses of N_2O and NO_3^-, we aim to correct the N_2O record for the in situ fraction and determine the past atmospheric concentrations of N_2O.

[1] Schilt A et al. (2010) Earth and Planetary Science Letters 300: 33-43 https://doi.org/10.1016/j.epsl.2010.09.027
[2] Frey MM et al. (2009) Atmos Chem Phys 9: 8681-8696 https://doi.org/10.5194/acp-9-8681-2009
[3] Spott O et al. (2011) Soil Biology and Biochemistry 43: 1995-2011 https://doi.org/10.1016/j.soilbio.2011.06.014

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 955750