Real-time measurement of site specific N_2O isotopic composition above intensively managed grassland reveals controls on N_2O source processes

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Motivation

- N_2O is a potent GHG mainly produced by nitrification, nitrifier denitrification or denitrification
- ≥60% of anthropogenic emissions attributed to food production (Syakila & Kroeze 2011) → atmospheric mole fraction increases
- development of mitigation strategies pertinent BUT: which source process needs to be controlled to tailor target-oriented strategies?
- relative contribution of N_2O source processes to bulk emission uncertain

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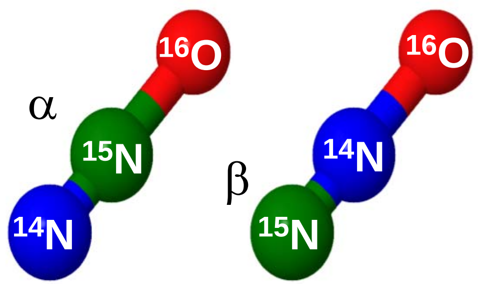
N_2O isotopomers



SP = $\delta^{15}N^{\alpha}$-$\delta^{15}N^{\beta}$

- N_2O isotopomers carry process infromation: processes with
  - preference for α-position (N_2O_N; SP~33 ‰*)
    - nitrification, abiotic N_2O production, fungal denitrification
  - low preference (N_2O_D; SP ~-2 ‰*)
    - (nitrifier) denitrification

→ SP can be used to seperate N_2O_N and N_2O_D

* SP values for N_2O_N and N_2O_D according to Decock and Six 2013

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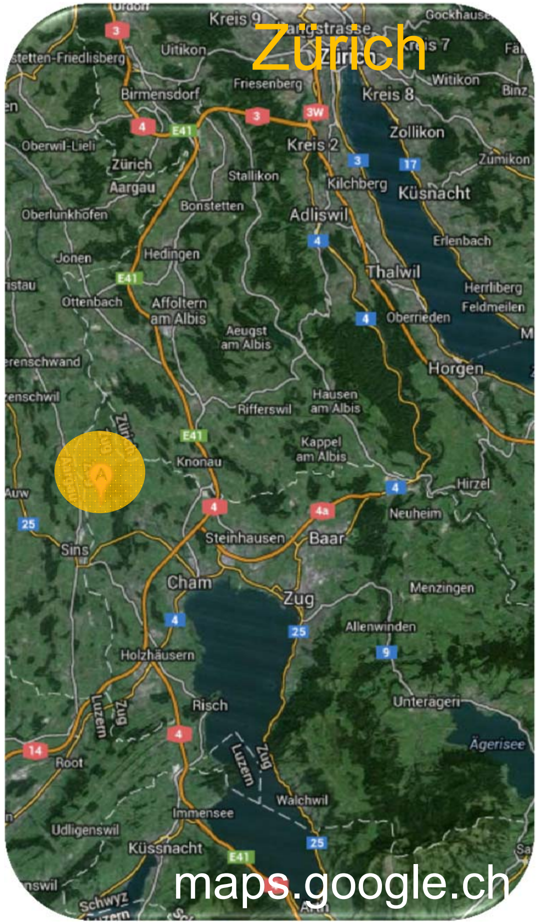
Sampling site & specific aims

- site specific measurements predominately lab based
- intensively managed grassland site (ETH site Chamau)
- eddy covariance & chamber measurements



- study
  - dynamics of N_2O site specific isotopic composition
  - effects of environmetal drivers and management

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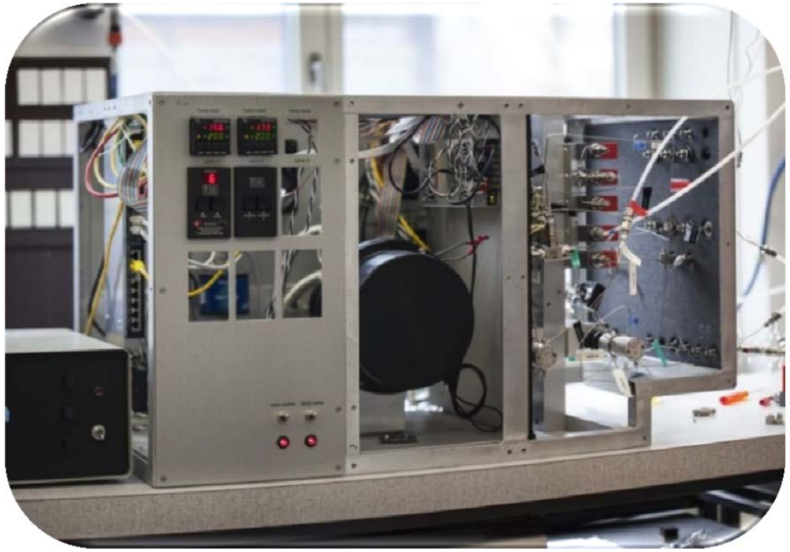
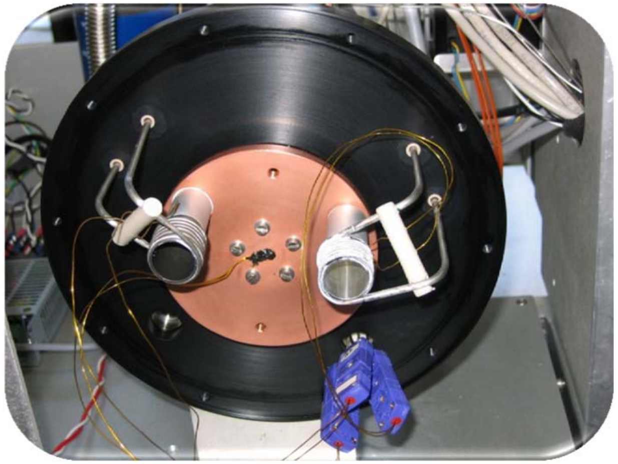
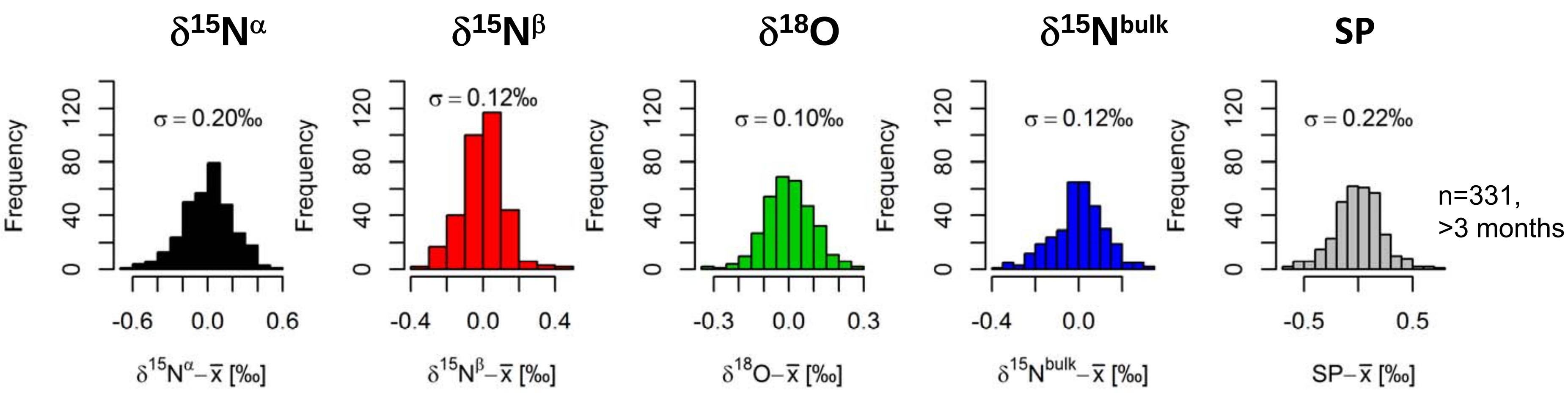
Isotopomer analysis

- until recently exclusively IRMS measurements (not field deployable)
- quantum cascade laser absorption spectroscopy (QCLAS) allows online analysis of N_2O isotopic composition in the field
- ambient air N_2O concentration too low for precise on-line measurement of isotope ratios
- N_2O of ~ 8 liters ambient air is adsorbed on a HayeSepD trap
- desorption in low synthetic air flow increases concentration to 50ppm





System performance



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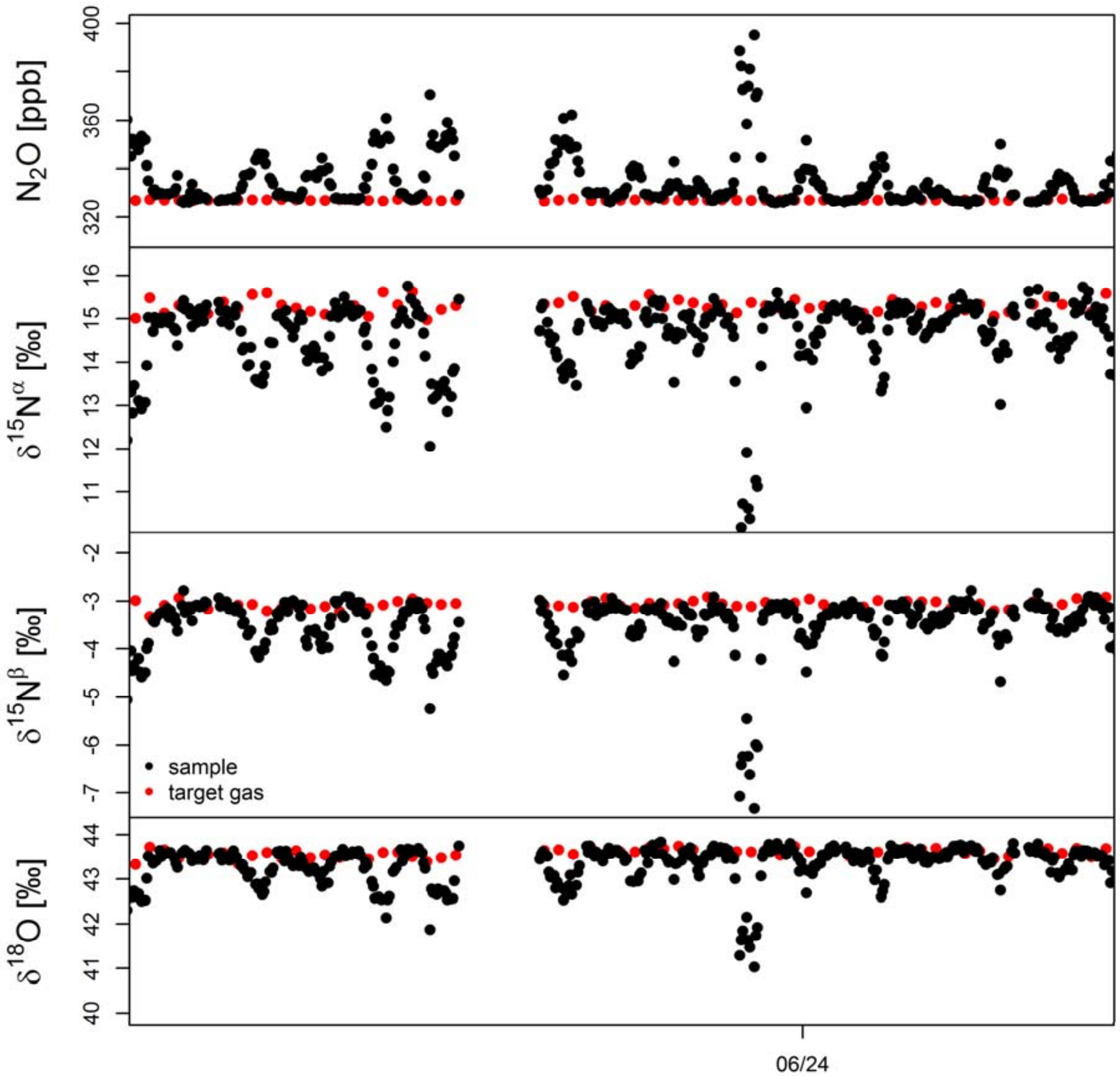
Surface layer measurements

- ambient air sample (inlet @ 2m height)
- compressed air sample

- C_{input}: diurnal cycle of atmospheric N_2O (source strength and stability)

- depletion of δ-values with increasing concentration



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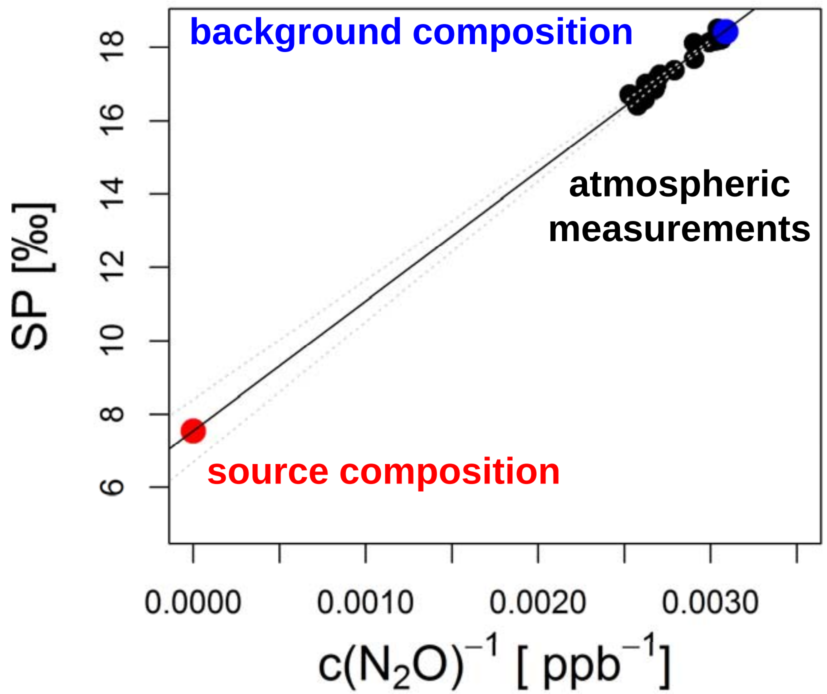
Keeling-plots for SP, $\delta^{15}N^{bulk}$ and $\delta^{18}O$

- **atmospheric isotopic composition** in surface layer reflects combination of source and atmospheric background composition

- source composition equals intercept when noon-to-noon **atmospheric isotopic composition** is plotted versus inverse concentration



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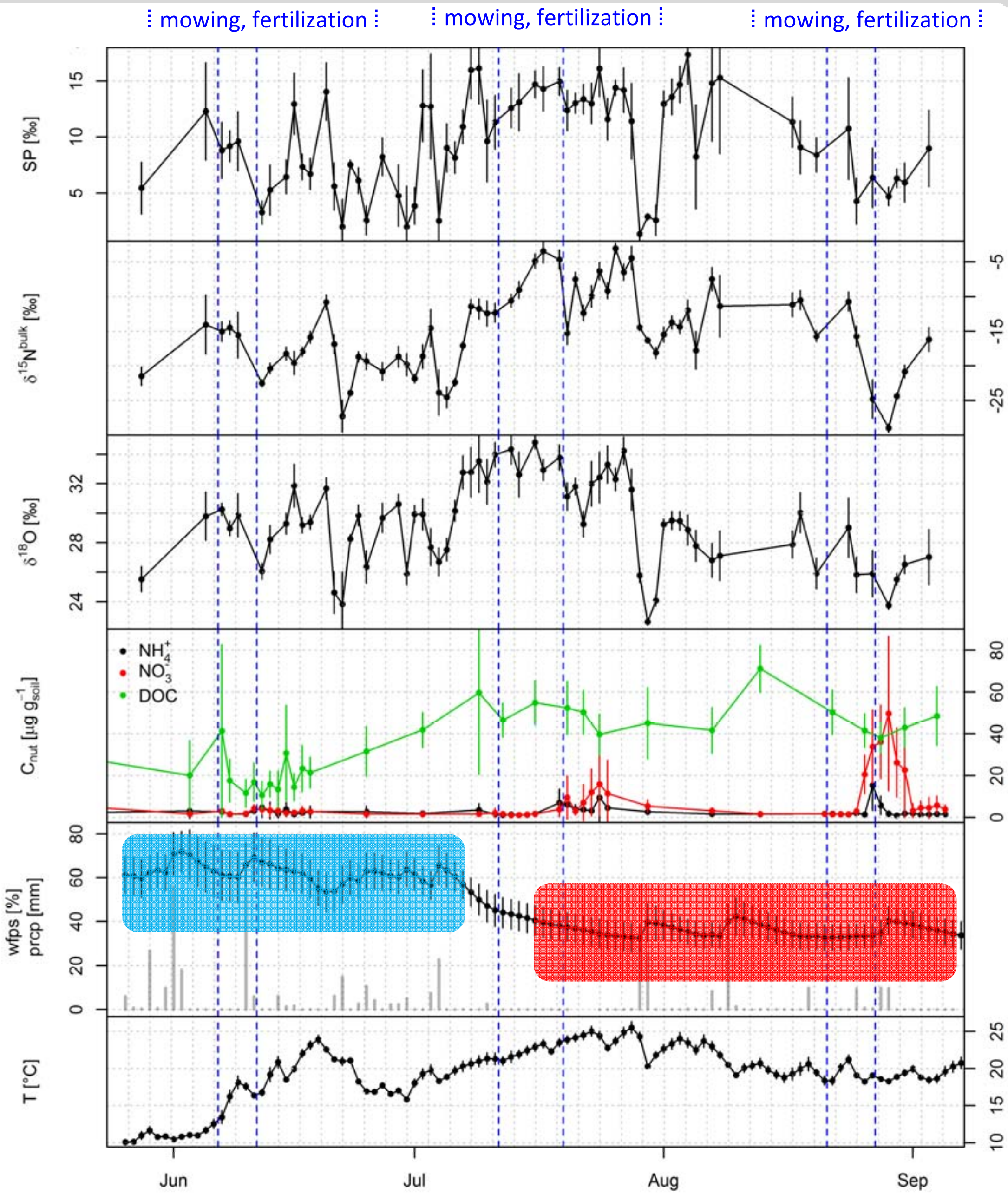
Isotopic composition: soil-emitted N_2O

- SP between 1 and 17‰
- large (short term) variation
- management actions & rewetting event decreased SP
- correlations of N_2O isotopic composition highest with
  - temperature
  - DOC (dissolved organic carbon)
  - r^2 below 30%
- «wet» and «dry» period



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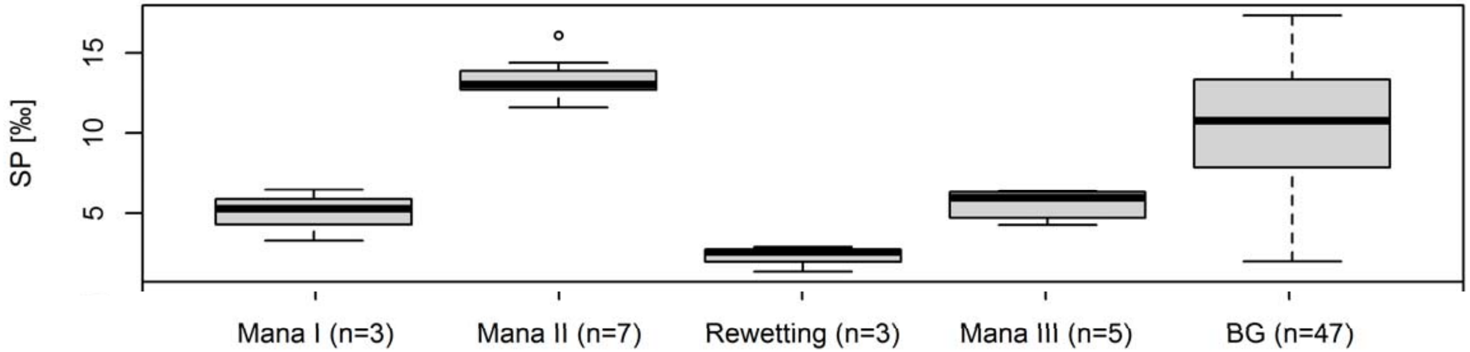
Event based data aggregation

- classes: ManaI – ManaIII, rewetting, all others (BG)
- variability during events like management or rewetting low
- isotopic composition very variable when no obvious drivers



- isotopic composition significantly different for dry/wet phases
  - SP lower during wet phase, higher during dry phase

→ larger contribution from nitrification?

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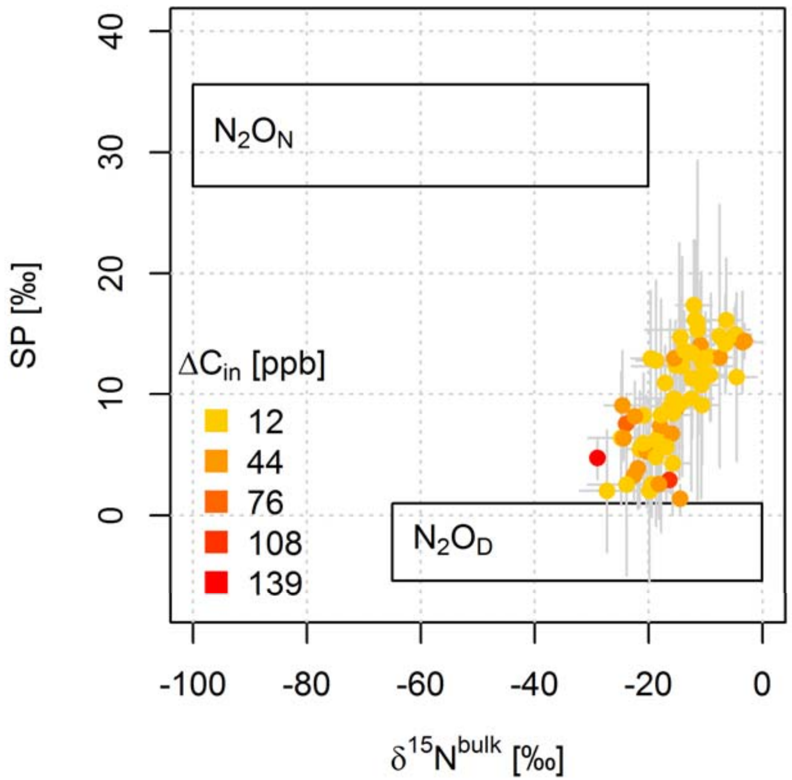
Isotopomer maps (according to Koba et al. 2009)



Process groups N_2O_N and N_2O_D based on:

Bedard-Haughn et al. (2003),Pörtl et al. (2007), Baggs (2008), Toyoda et al. (2011), Decock and Six (2013)

- high emission rates: denitrification
- enrichment of $\delta^{15}N^{bulk}$ and SP indicates N_2O reduction

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Conclusions

- simultaneous field measurement of $\delta^{15}N^{\alpha}$, $\delta^{15}N^{\beta}$ and $\delta^{18}O$ of N_2O with high reproducibility (0.2, 0.1 and 0.1 ‰)

- during management/rewetting low δ-values and well constrained (denitrification)

- significantly lower SP during wet phase, higher SP during dry phases

- isotopomer maps: process dynamics not due to transition of $N_2O_D \rightarrow N_2O_N$; rather due to variable extent of N_2O reduction to N_2

- large (short term) variability probably due to uncertainty, or mismatch between flux and concentration footprint

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Thank you for your attention

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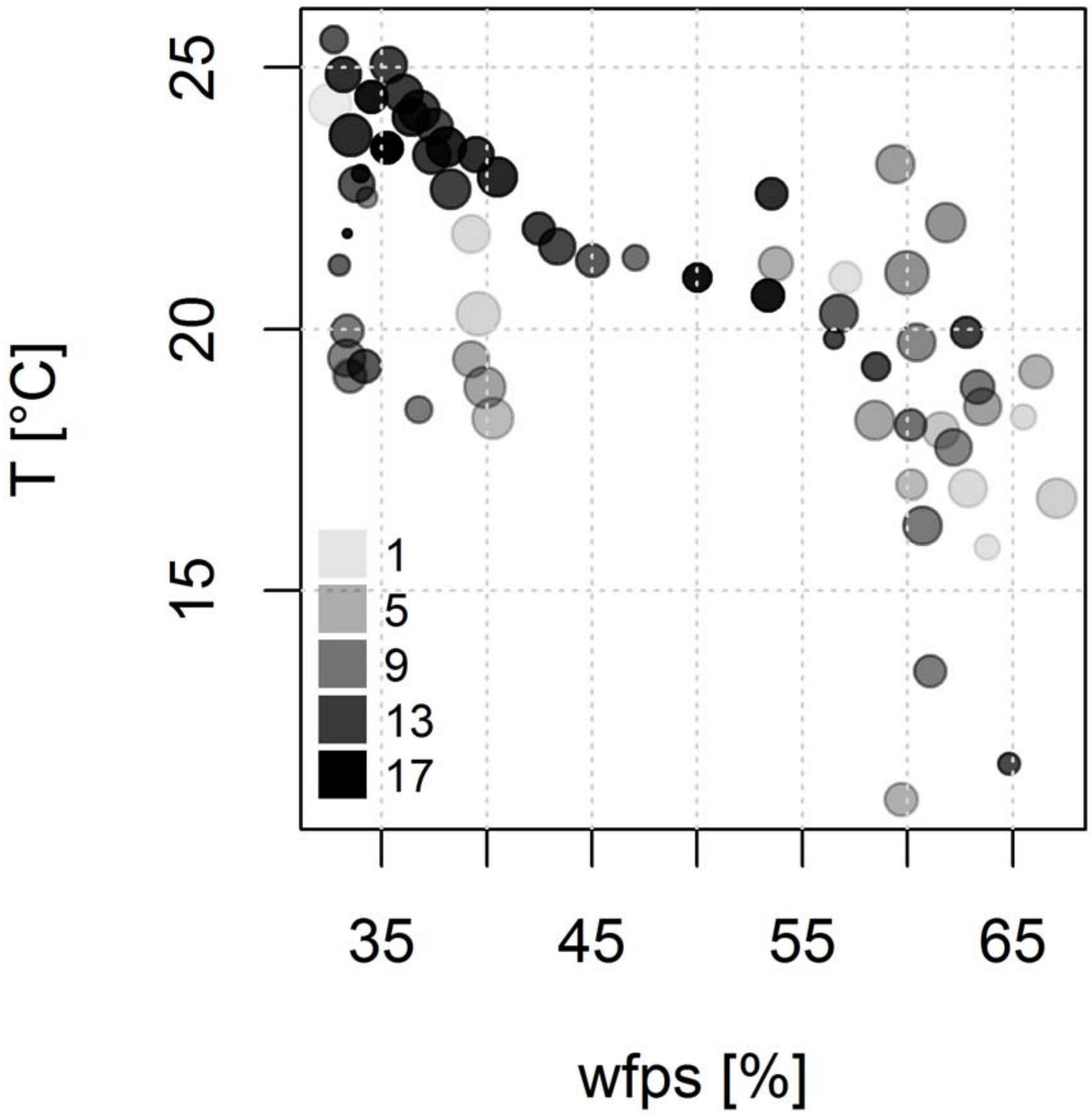
Controls: whole dataset

- correlations of N_2O isotopic composition highest with
  - temperature
  - DOC (dissolved organic carbon)
- r^2 below 30%
- additive models do not increase explanatory power significantly



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