Karlsruhe Institute of Technology

Simulating the isotopic composition of terrestrial N-cycle components with the stable isotope model of N-cycle evolution (SIMONE)

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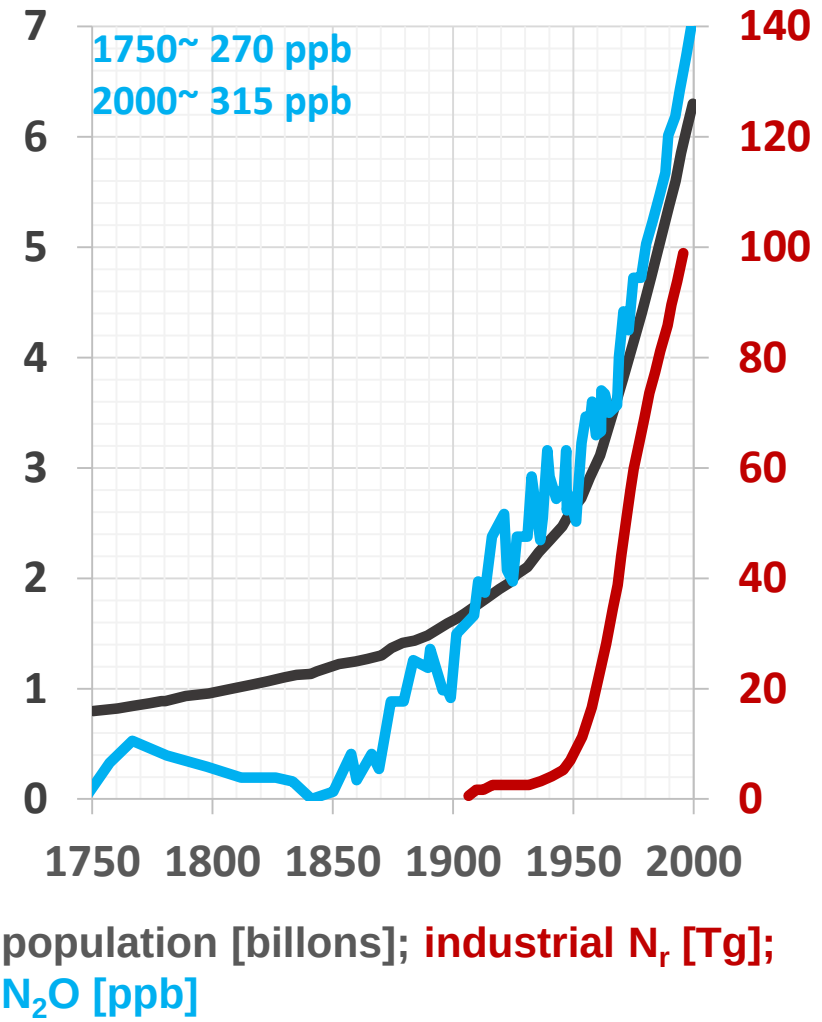
Background

- Nitrogen is the limiting element for biomass production
- Increased use of fertilizers boosts global population growth
- Detrimental effects:
  - Eutrophication of lakes
  - N_2O emission:
    Strong greenhouse gas
    Stratospheric ozone depletion
- Mitigation strategies needed



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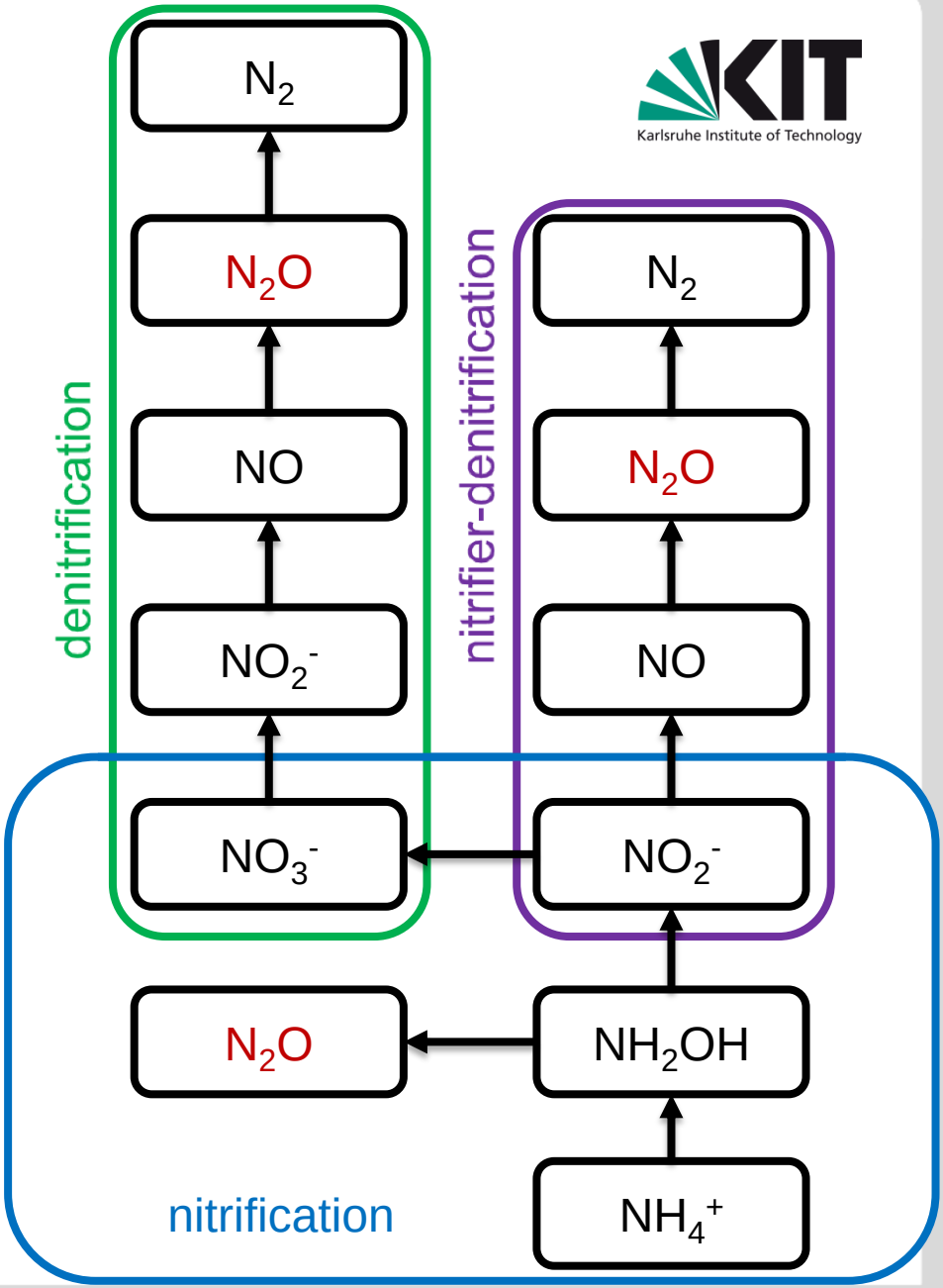
N_2O in the N-cycle

- Process based models are calibrated and validated using bulk N_2O emissions
- Which processes produce the N_2O?
- Measurement of stable nitrogen isotopes
- Use nitrogen isotope effect for source process identification



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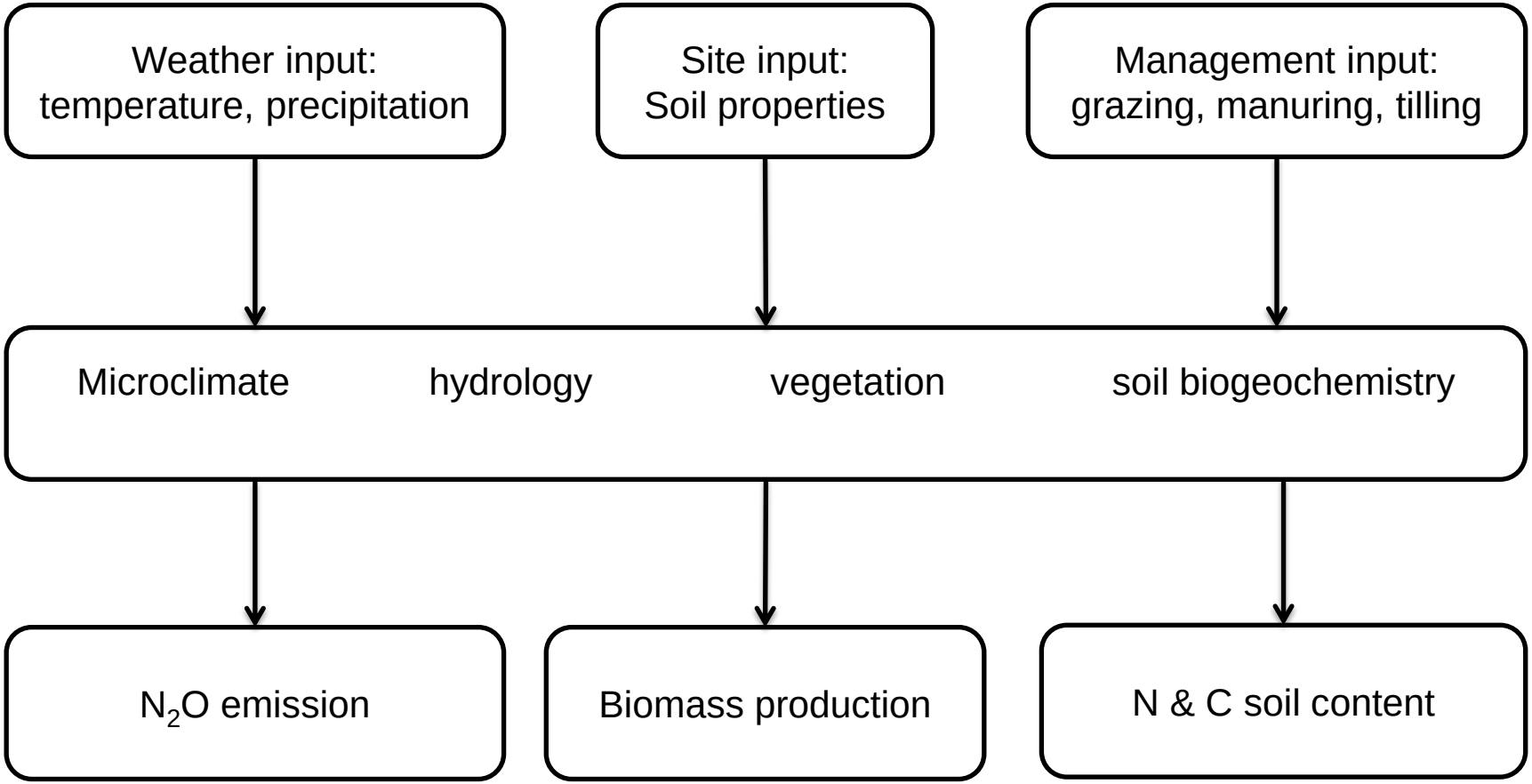
Model structure of Landscape DNDC



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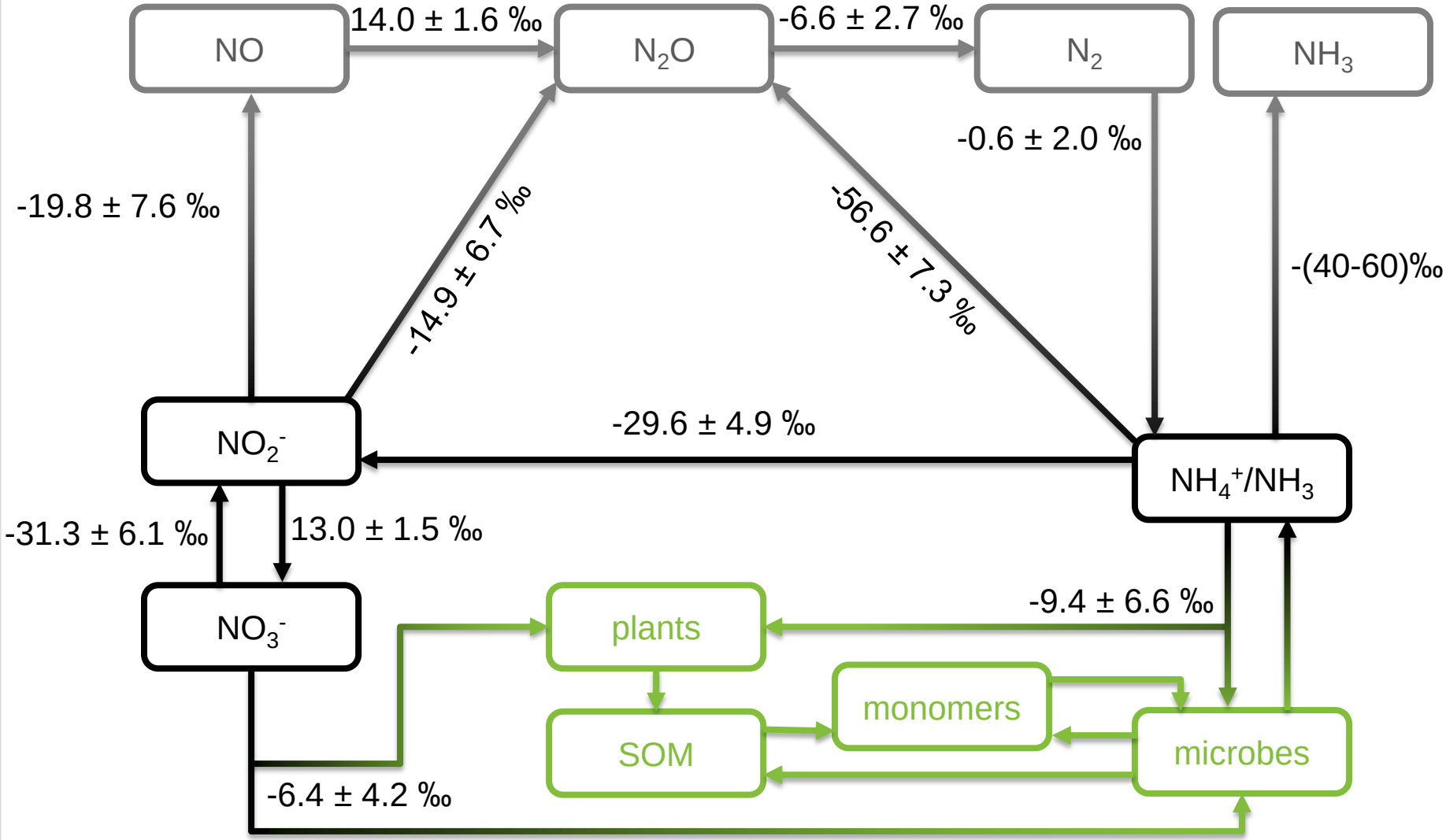
Process structure and isotope effects used by SIMONE



Review Denk et al., submitted

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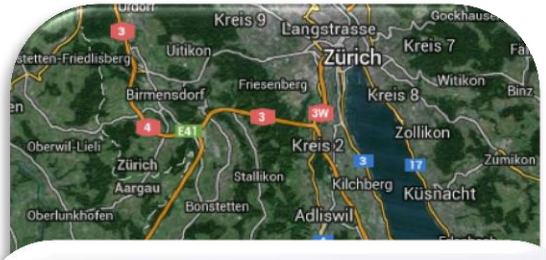
Validation data: the Chamau campaign (EMPA and ETH)

- intensively managed grassland site (ETH research farm Chamau, Switzerland)



- Eddy-covariance & chamber measurements (Lutz Merbold, Charlotte Decock - ETHZ)

- effects of environmetal drivers and management on isotopic composition of atmospheric N_2O

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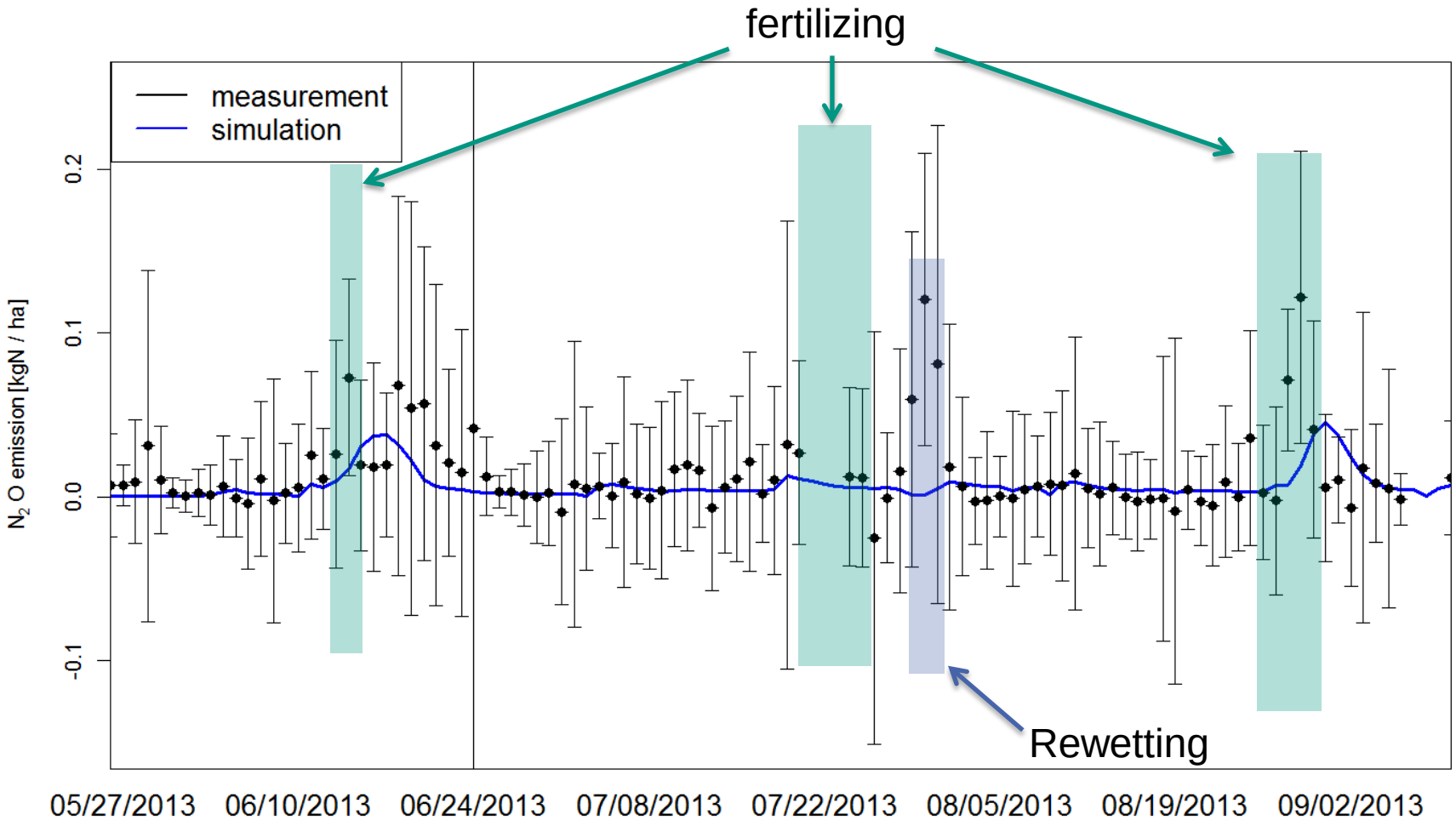
Simulation results at grassland site Chamau



Wolf et al. 2015, Biogeosciences

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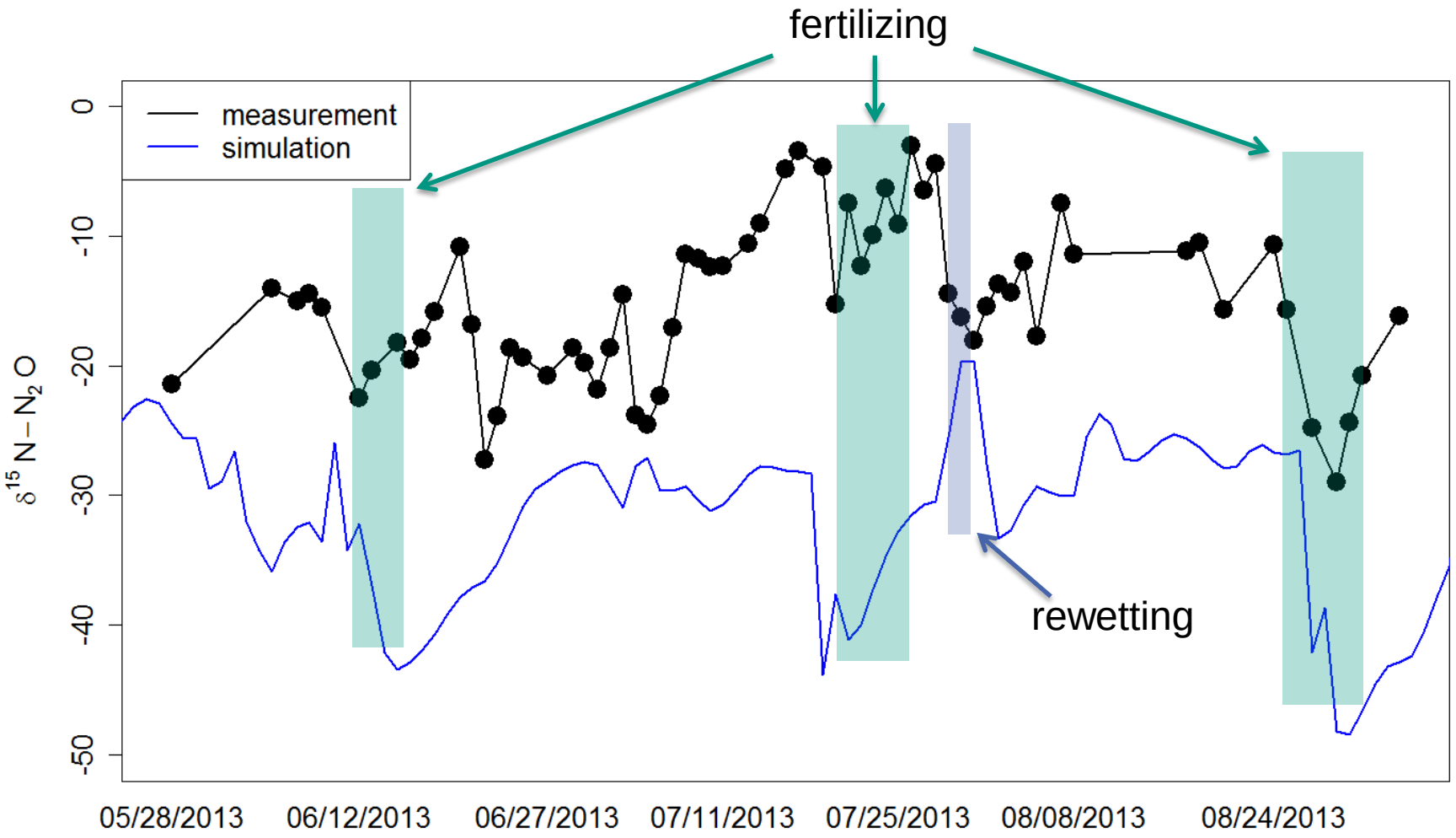
SIMONE simulation: $\delta^{15}N\text{-}N_2O$ (Chamau)



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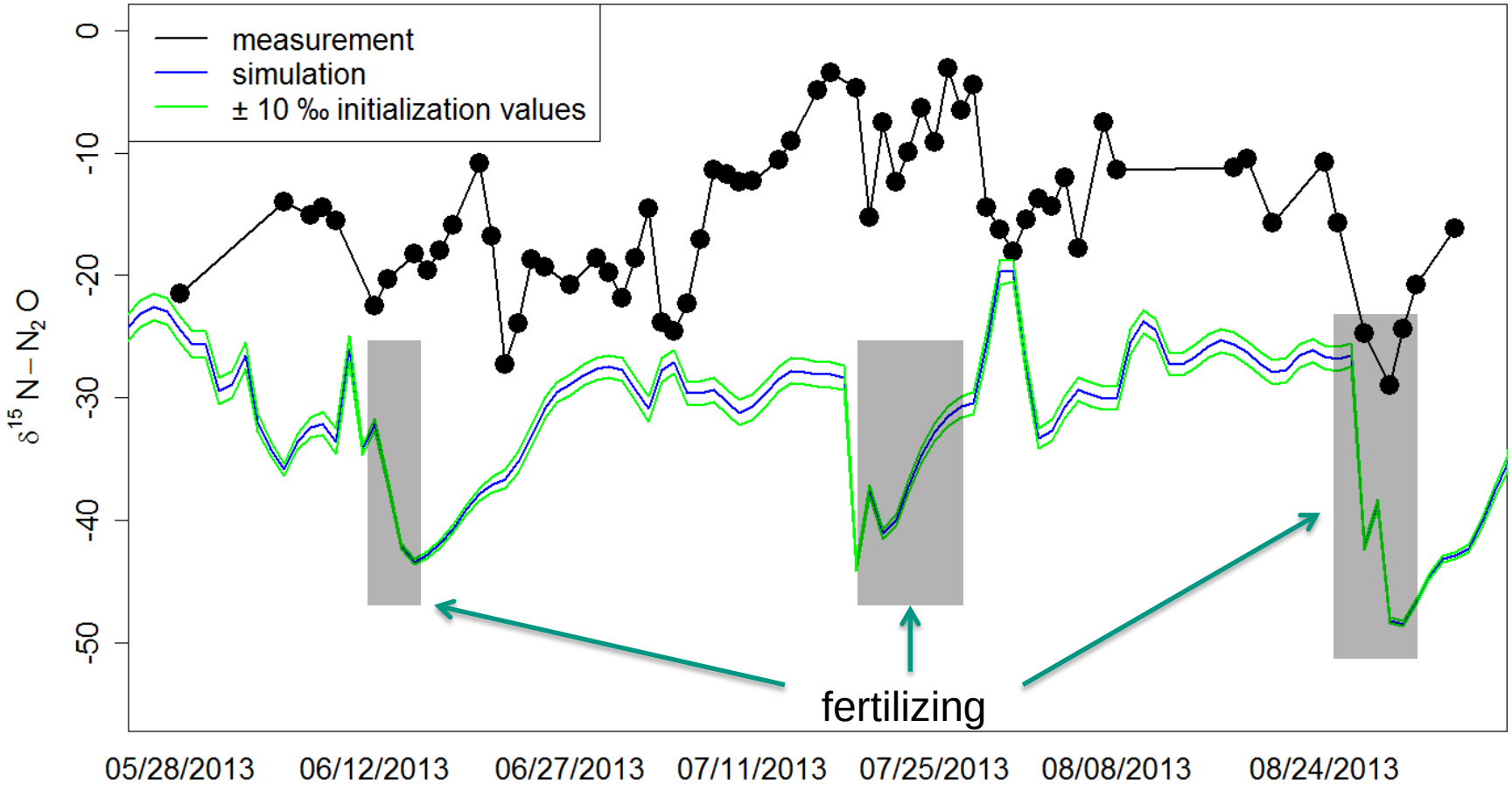
Sensitivity towards initial soil isotopic composition



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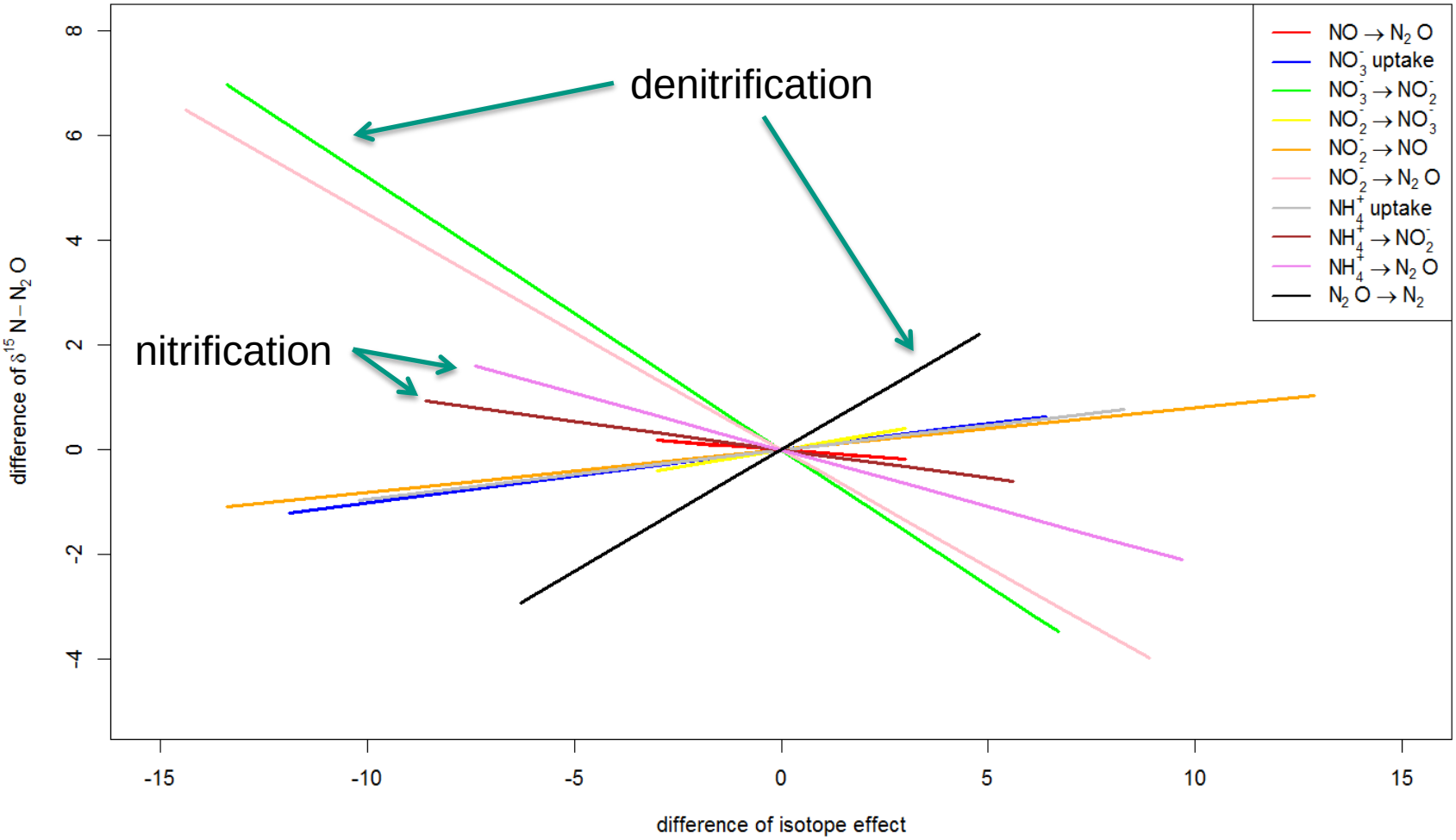
Sensitivity of isotope effects



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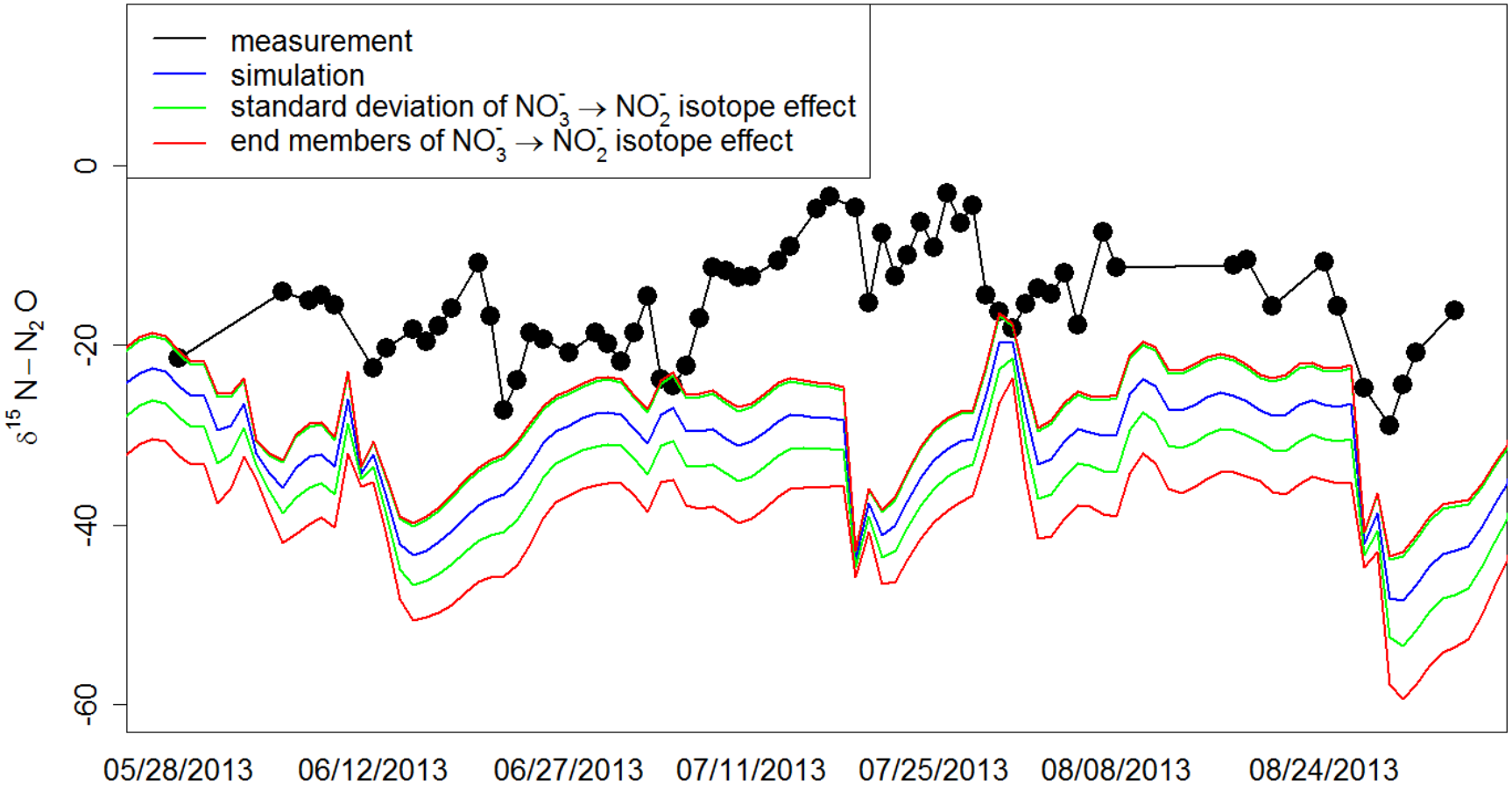
Sensitivity of isotope effects ($NO_3^- \rightarrow NO_2^-$)



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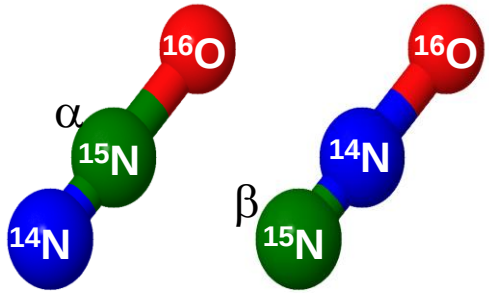
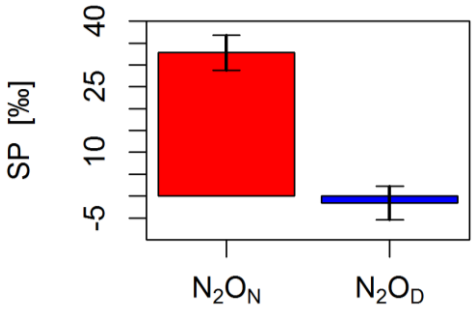
N_2O site preference

- linear three-atom molecule



- Toyoda and Yoshida, 1999: „site preference“ SP = $\delta^{15}N^{\alpha}$-$\delta^{15}N^{\beta}$
  - dominant processes prefer a site
  - Independent of precursors



N_2O_N: nitrification, abiotoic production and fungal denit.
N_2O_D: denitrification, nitrifier denitrification

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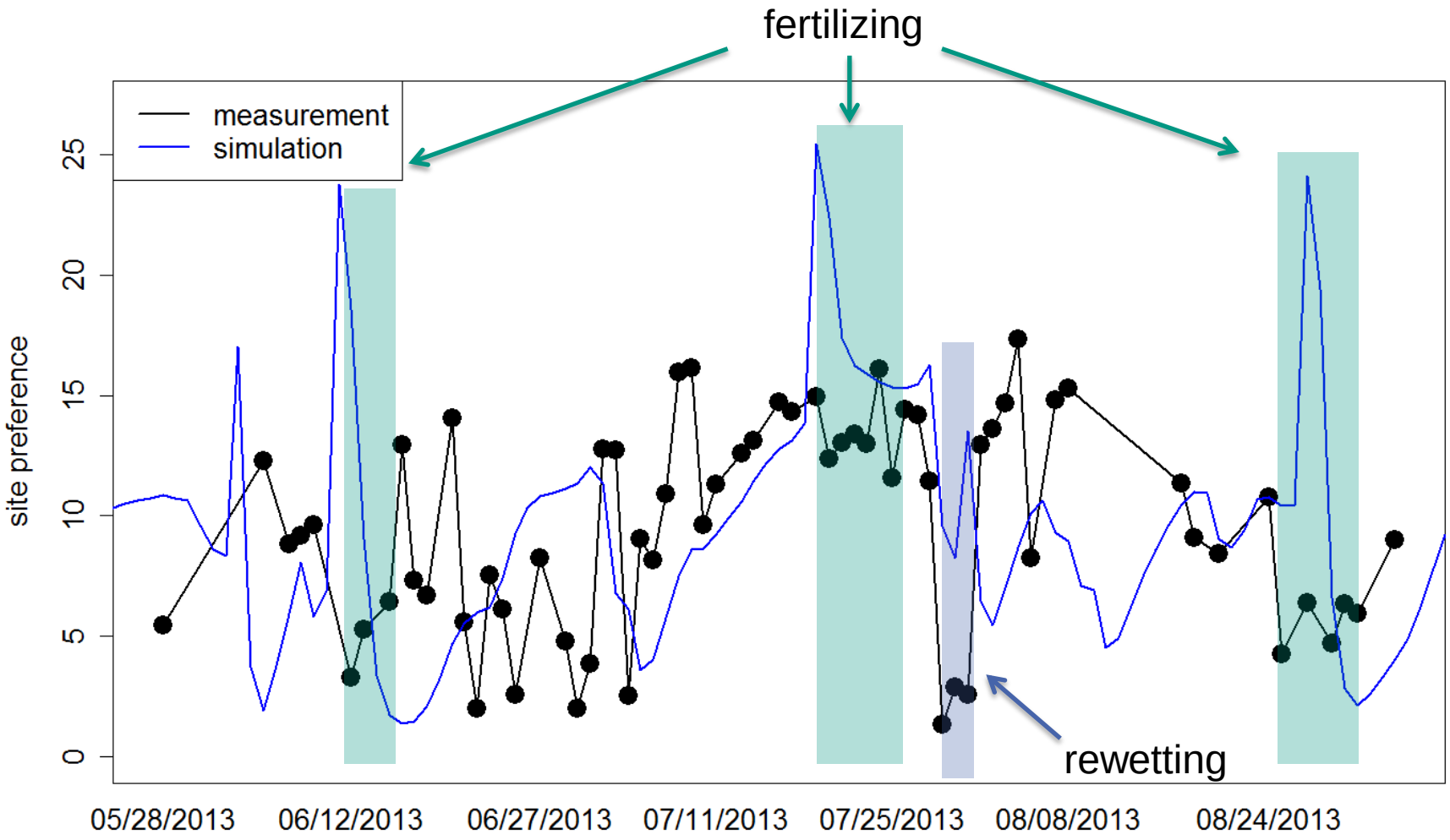
SIMONE simulation: site preference (Chamau)



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Summary and Outlook

- The simulation environment SIMONE is capable of reproducing the dynamics of the N_2O isotopic composition
- Using average literature isotope effects and standard Landscape DNDC process parameterization resulted in an offset in the range of 1.6 to 39.2 ‰
- Initial soil N isotopic composition and single isotope effects could not explain the general offset
- Comparison of measured and modelled Site Preference indicates an overestimation of nitrification directly after fertilization
- The relevance of specific process rates is subject to ongoing analysis

Thanks to EMPA and ETH Zürich

Thank you for your attention

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