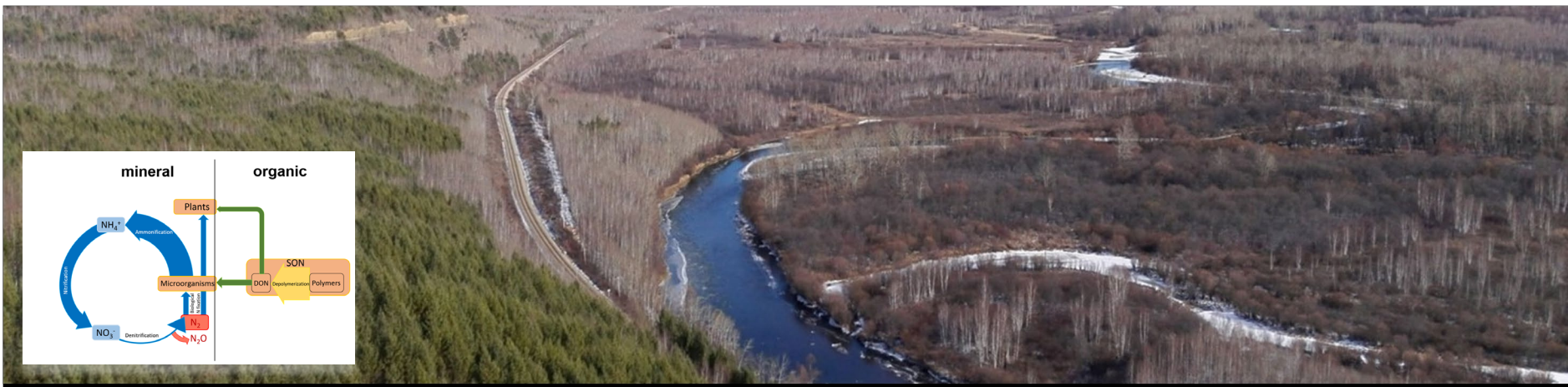
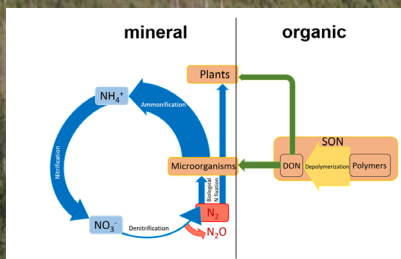


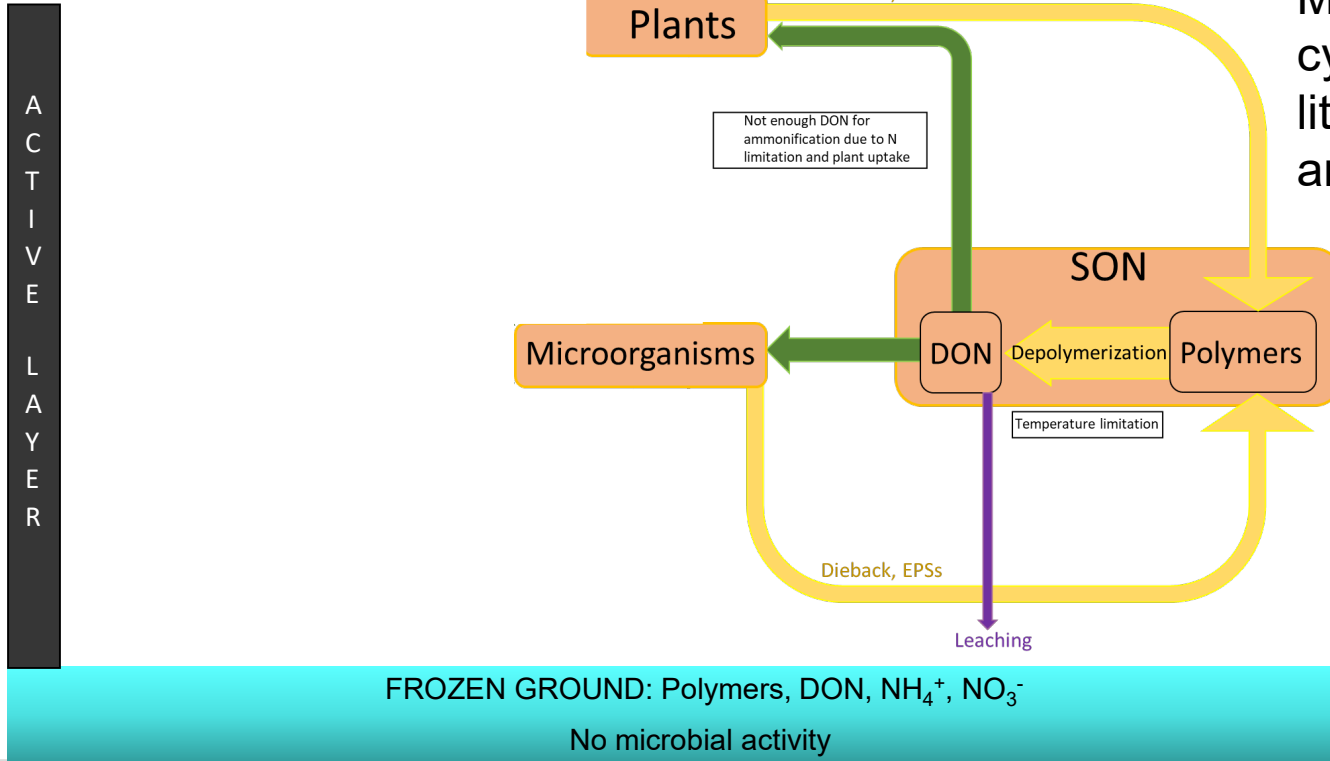
A review of the importance of mineral nitrogen cycling in the plant-soil-microbe system of permafrost-affected soils – changing the paradigm

Michael Dannenmann, Elisabeth Ramm, Chunyan Liu, Per Ambus, Klaus Butterbach-Bahl, Bin Hu, Pertti J. Martikainen, Maija E. Marushchak, Carsten W. Mueller, Heinz Rennenberg, Michael Schloter, Henri M. P. Siljanen, Carolina Voigt, Christian Werner, Christina Biasi



“Old” paradigm of the permafrost N cycle

(see e.g. Schimel & Bennett 2004, *Ecology* 85)



Mainly organic N cycling loops with very little mineral N cycling and soil N_2O emissions



Why questioning this paradigm?

1. Paradigm largely based on soil DON/DIN concentrations and net rates but not on gross rates of N turnover
2. Recently large N₂O emissions from permafrost-affected ecosystems reported
3. Increasing active layer depths and soil temperatures due to climate warming
4. Large SOC and TN concentrations in many permafrost-affected soils should allow for high N ammonification

→ Meta analysis on on permafrost N turnover

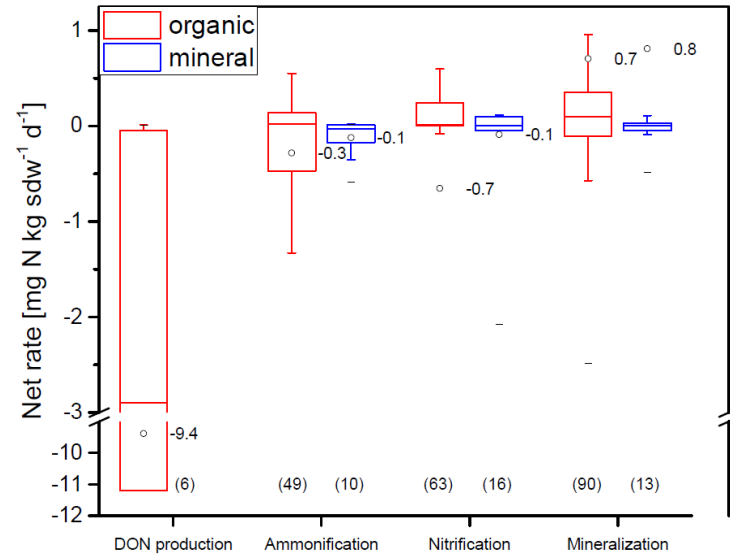
→ 33 studies on net rates 16 on gross rates

→ 163 datasets on net rates, 81 on gross rates

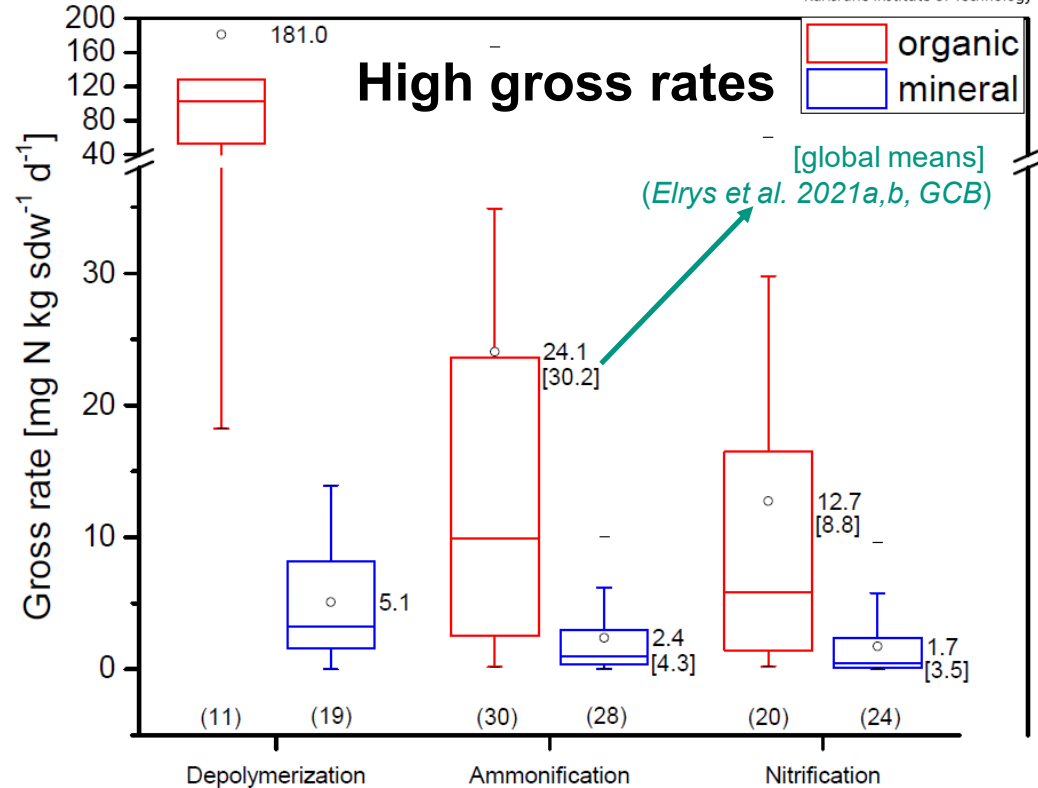


Synthesis of permafrost N turnover

Low net rates

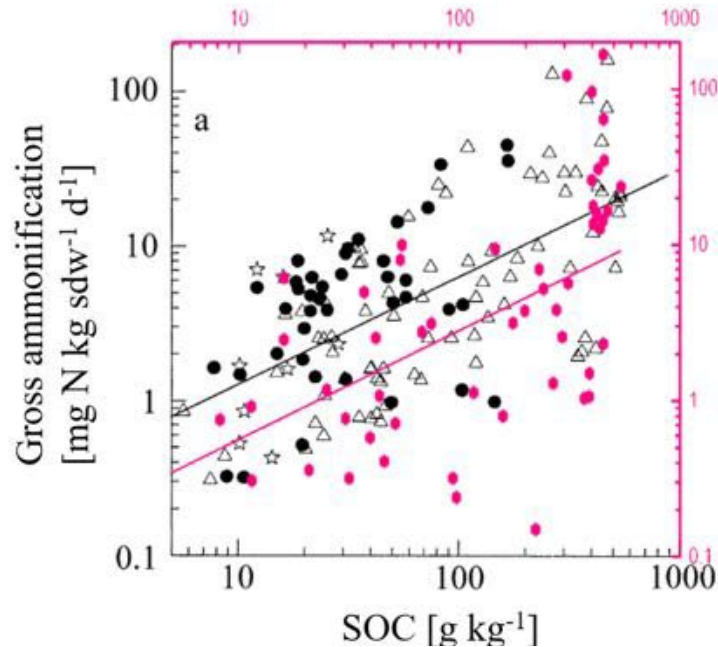


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Soil organic carbon (SOC) and total nitrogen (TN) as driver of gross N turnover: global vs permafrost

Global values by Booth et al. (2005, *Ecological Monographs* 75) vs. permafrost values by our study



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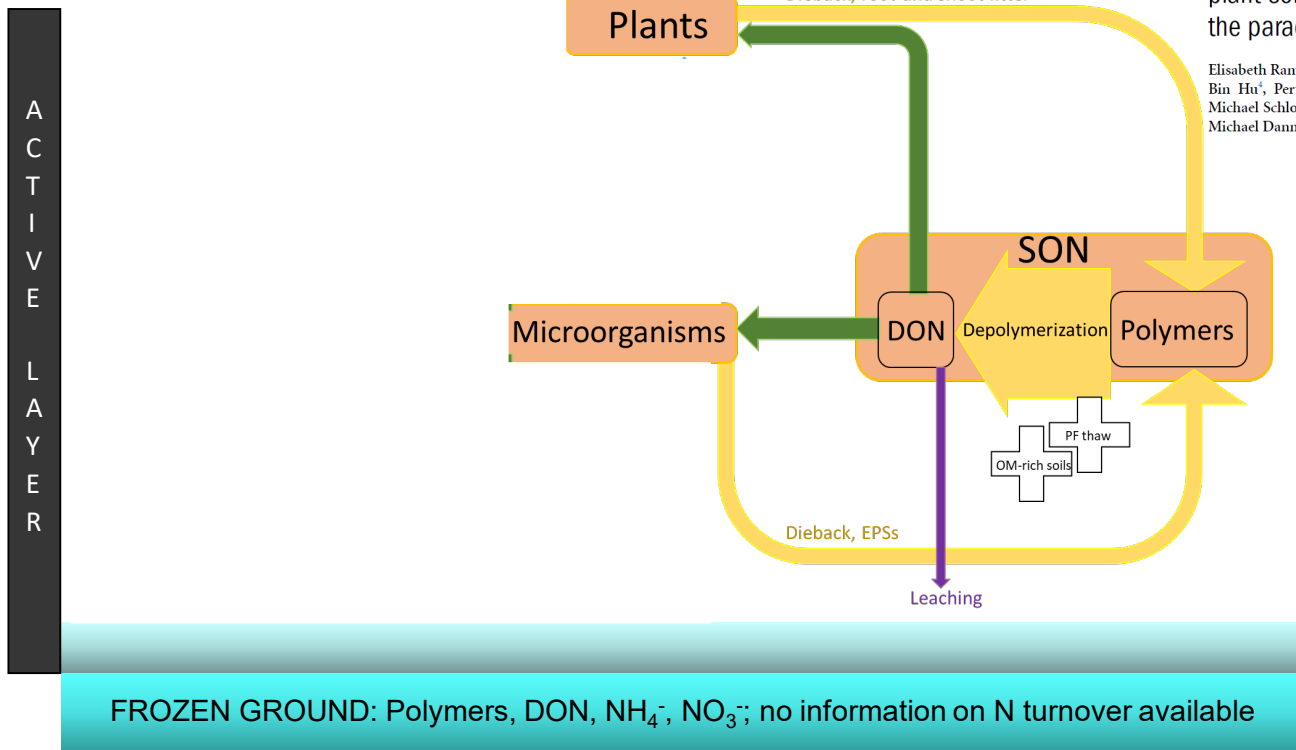
Revised paradigm

ENVIRONMENTAL RESEARCH LETTERS

TOPICAL REVIEW

A review of the importance of mineral nitrogen cycling in the plant-soil-microbe system of permafrost-affected soils—changing the paradigm

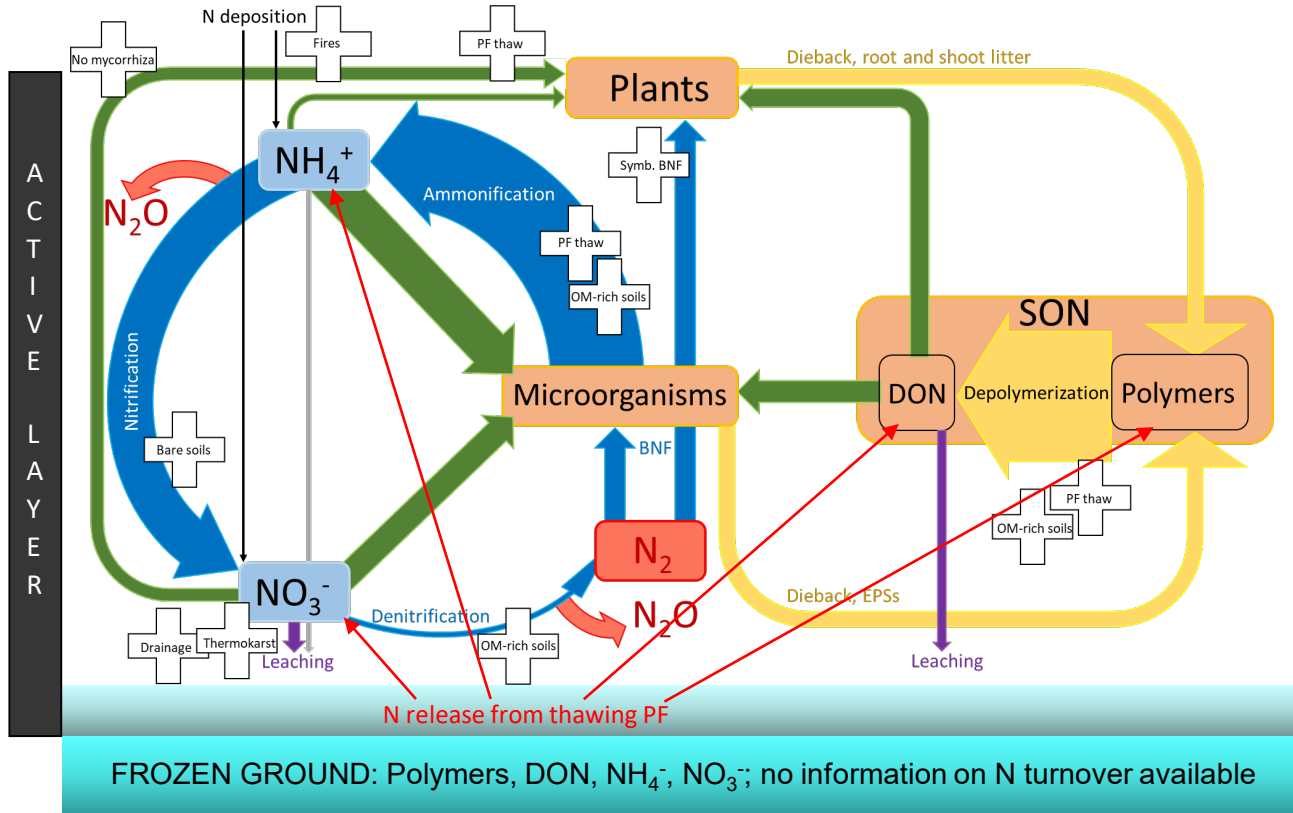
Elisabeth Ramm¹, Chunyan Liu^{2*}, Per Ambus³, Klaus Butterbach-Bahl¹, Bin Hu⁴, Pertti J Martikainen⁵, Maija E Marushchak⁶, Carsten W Mueller⁷, Heinz Rennenberg⁸, Michael Schlöter^{2,9}, Henri M P Siljanen¹⁰, Carolina Voigt^{5,9}, Christian Werner¹, Christina Biasi¹¹ and Michael Dannenmann^{1,2}



- Soil organic N composition/availability
- Soil microbiome
- Biological N fixation
- Atmospheric N deposition
- Plant N nutrition
- Gaseous/hydrological N losses

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Revised paradigm

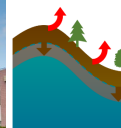
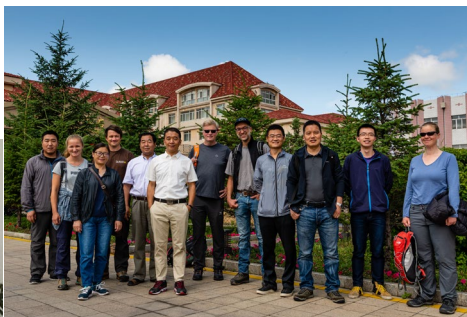


- Important role of mineral N cycling
- Mineral N cycle not generally different compared to temperate and tropical soils
- New paradigm suggests larger permafrost-climate-N-feedbacks via N_2O emissions



Karlsruhe Institute of Technology

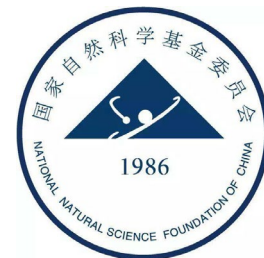
林木分子生态生理学研究中心
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