Karlsruhe Institute of Technology

Campus-Alpin

IMK-IFU: Atmospheric Environmental Research

Soil-atmosphere trace gas exchange - the importance of lateral water fluxes and groundwater as controlling variables

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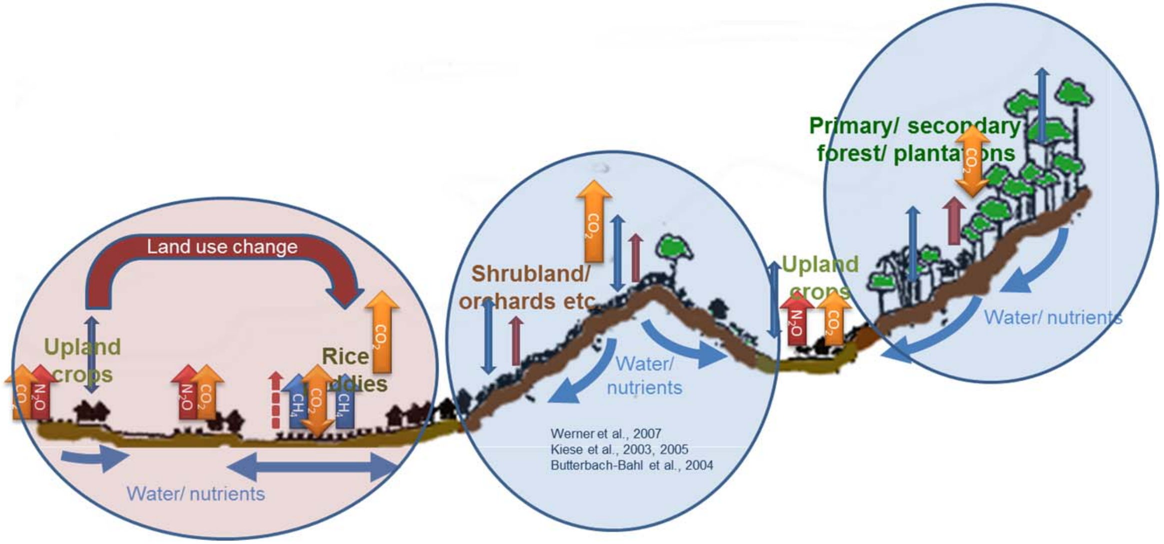


Soils as sources and sinks for N_2O and CH_4

Estimates of global N_2O and CH_4 budgets (Tg y^{-1}).

N_2O source[a]	Tg N_2O–N y^{-1}	CH_4 source[b]	Tg CH_4 y^{-1}
Natural sources			
Oceans	3.8 (1.8–5.8)	Oceans	4 (0.2–20)
Atmosphere	0.6 (0.3–1.2)	Termites	20 (2–22)
Soils	6.6 (3.3–9)	Wetlands	100 (92–232)
		Others[c]	21 (10.4–48.2)
Anthropogenic sources			
Agriculture	2.8 (1.7–4.8)	Rice cultivation	60 (25–90)
Biomass burning	[illegible] (0.2–1)	Biomass burning	50 (27–80)
Energy & industry	[illegible]	Energy[d]	106 (46–174)
Others[e]	2.5 (0.9–4.1)	Ruminants	81 (65–100)
		Waste disposal	61 (40–100)
Total sources	17.7 (8.5–27.7)		503 (410–660)
Sinks			
Stratosphere	12.5 (10–15)[f]	Stratosphere	40 (32–48)
Soils	1.5–3[g]	Soils	30 (15–45)
		Tropospheric OH	445 (360–530)
Total sinks	14 (11.5–18)		515 (430–600)

Approx. 50% of N_2O fluxes and 20% of CH_4 fluxes are directly linked to soil processes

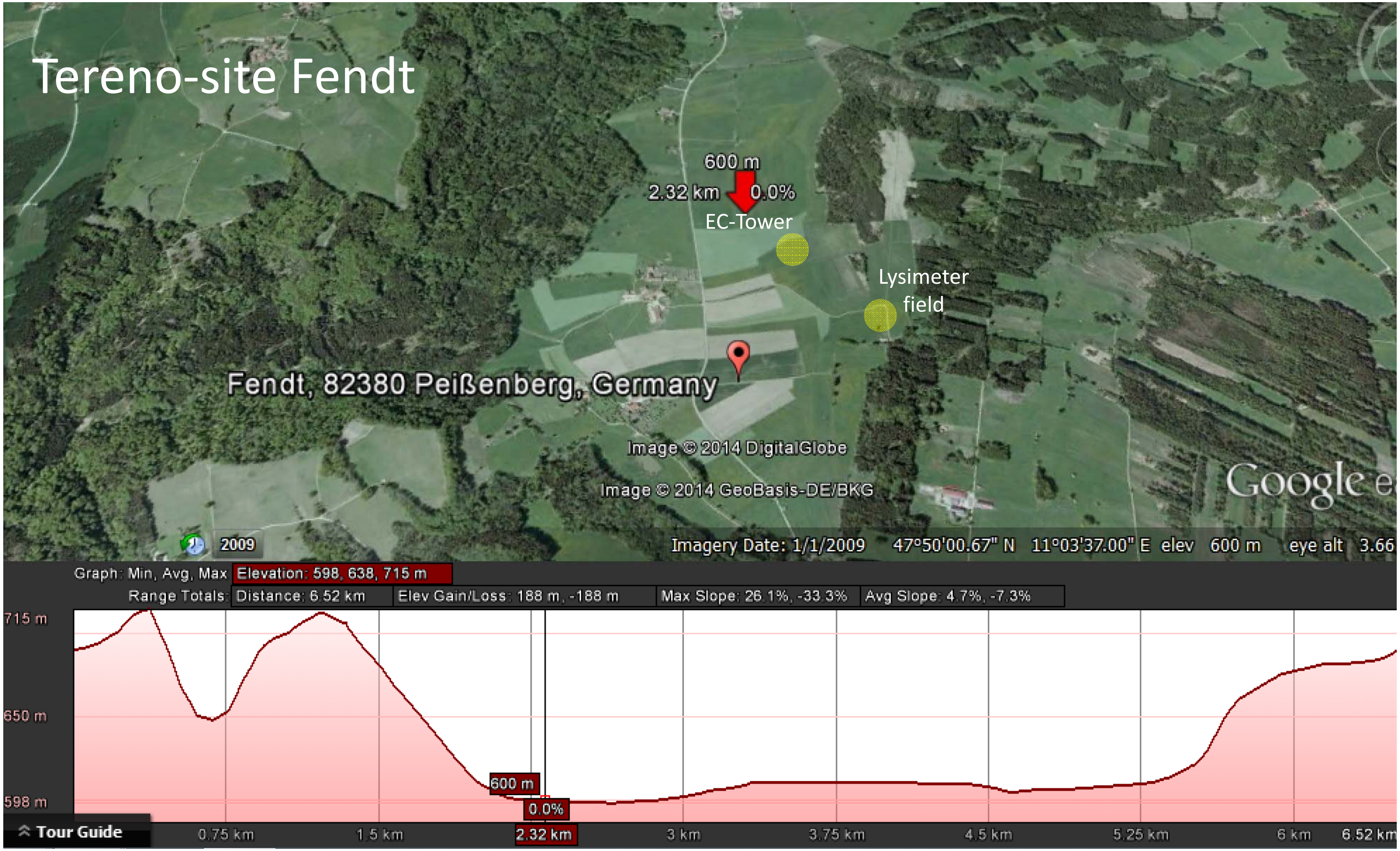
Fowler et al. 2009, Atm. Environm. 43, 5193-5267

Criteria for site selection

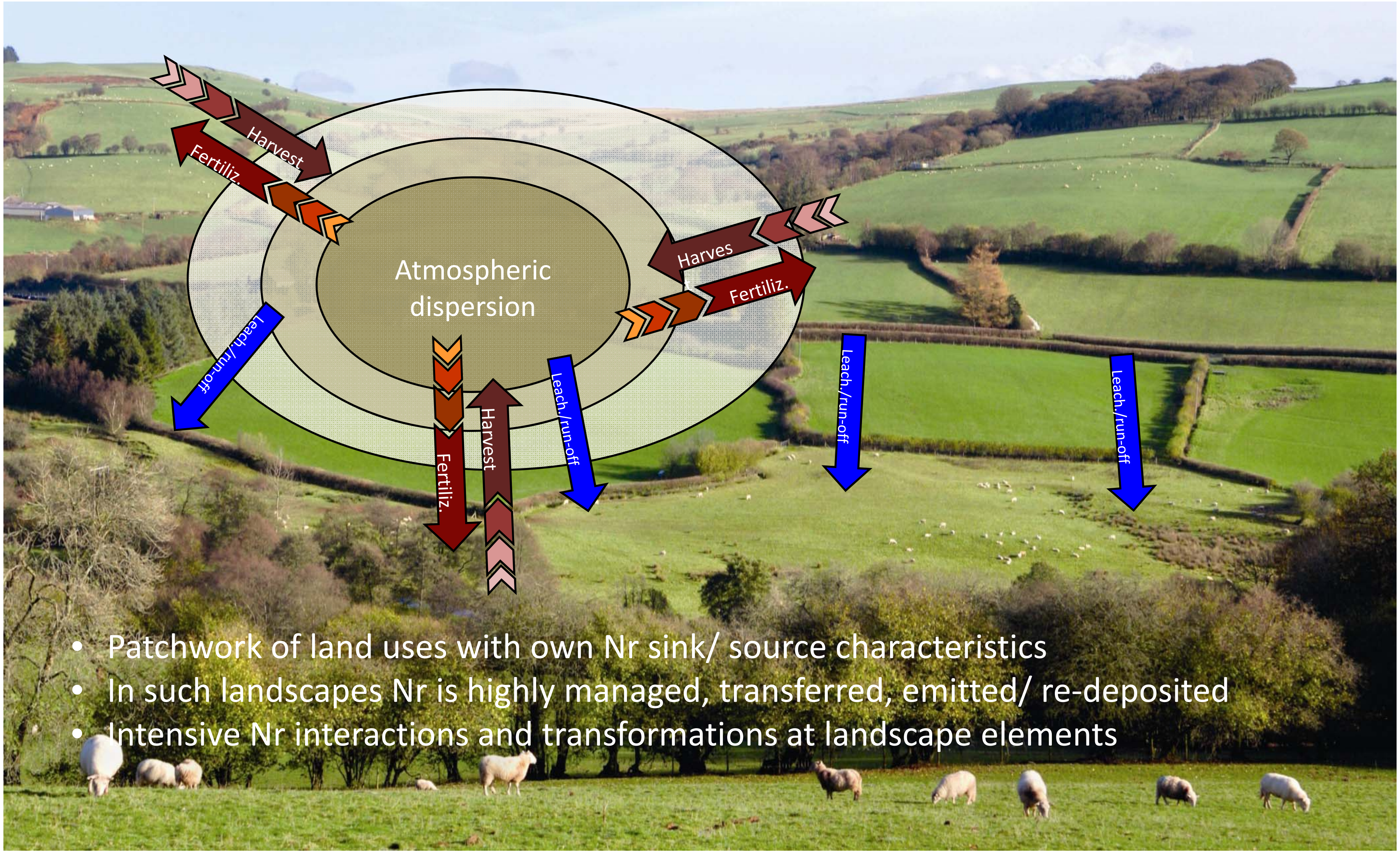
- Representativeness
  - Climate
  - Vegetation
  - Land use and land management

> - What do we know about the importance of „landscape inhomogenities“ and edge effects for C/N/water/energy fluxes?
> - How important is landscape water routing for biosphere-atmosphere N and C fluxes?
> - Does this potentialy affect our view on landscape fluxes?
> - Should we reconsider how we measure fluxes and how we scale fluxes?

- •
- •
      - Water routing
      - Vegetation
      - ..


Tereno-site Fendt
600 m
2.32 km
0.0%
EC-Tower
Lysimeter field
Fendt, 82380 Peißenberg, Germany
Image © 2014 DigitalGlobe
Image © 2014 GeoBasis-DE/BKG
2009
Imagery Date: 1/1/2009
47°50'00.67" N 11°03'37.00" E elev 600 m eye alt 3.66
Graph: Min, Avg, Max Elevation: 598, 638, 715 m
Range Totals: Distance: 6.52 km
Elev Gain/Loss: 188 m, -188 m
Max Slope: 26.1%, -33.3%
Avg Slope: 4.7%, -7.3%
715 m
650 m
598 m
600 m
0.0%
Tour Guide
0.75 km
1.5 km
2.32 km
3 km
3.75 km
4.5 km
5.25 km
6 km
6.52 km

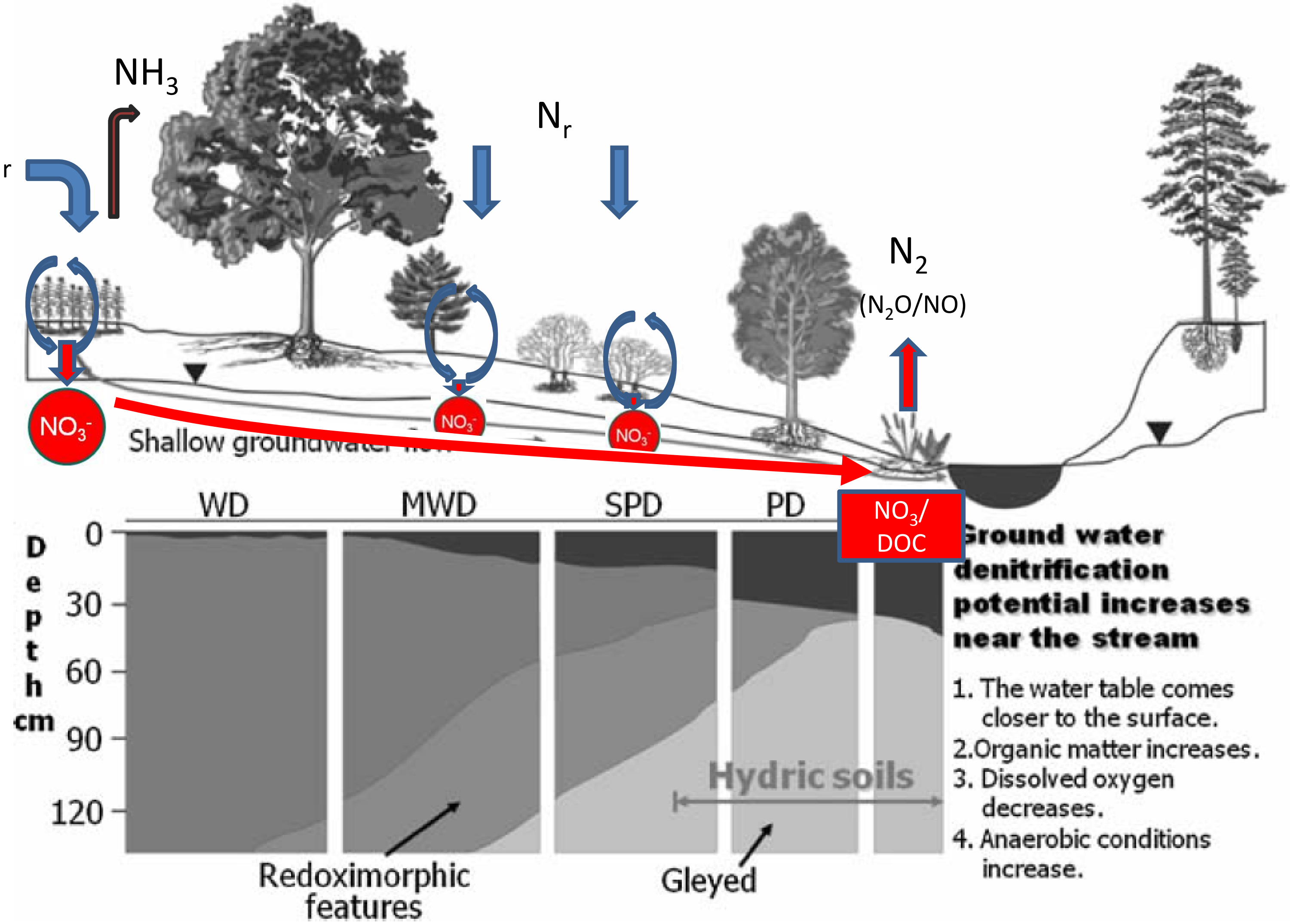
Fragmented landscape – N fluxes



- Patchwork of land uses with own Nr sink/ source characteristics
- In such landscapes Nr is highly managed, transferred, emitted/ re-deposited
- Intensive Nr interactions and transformations at landscape elements

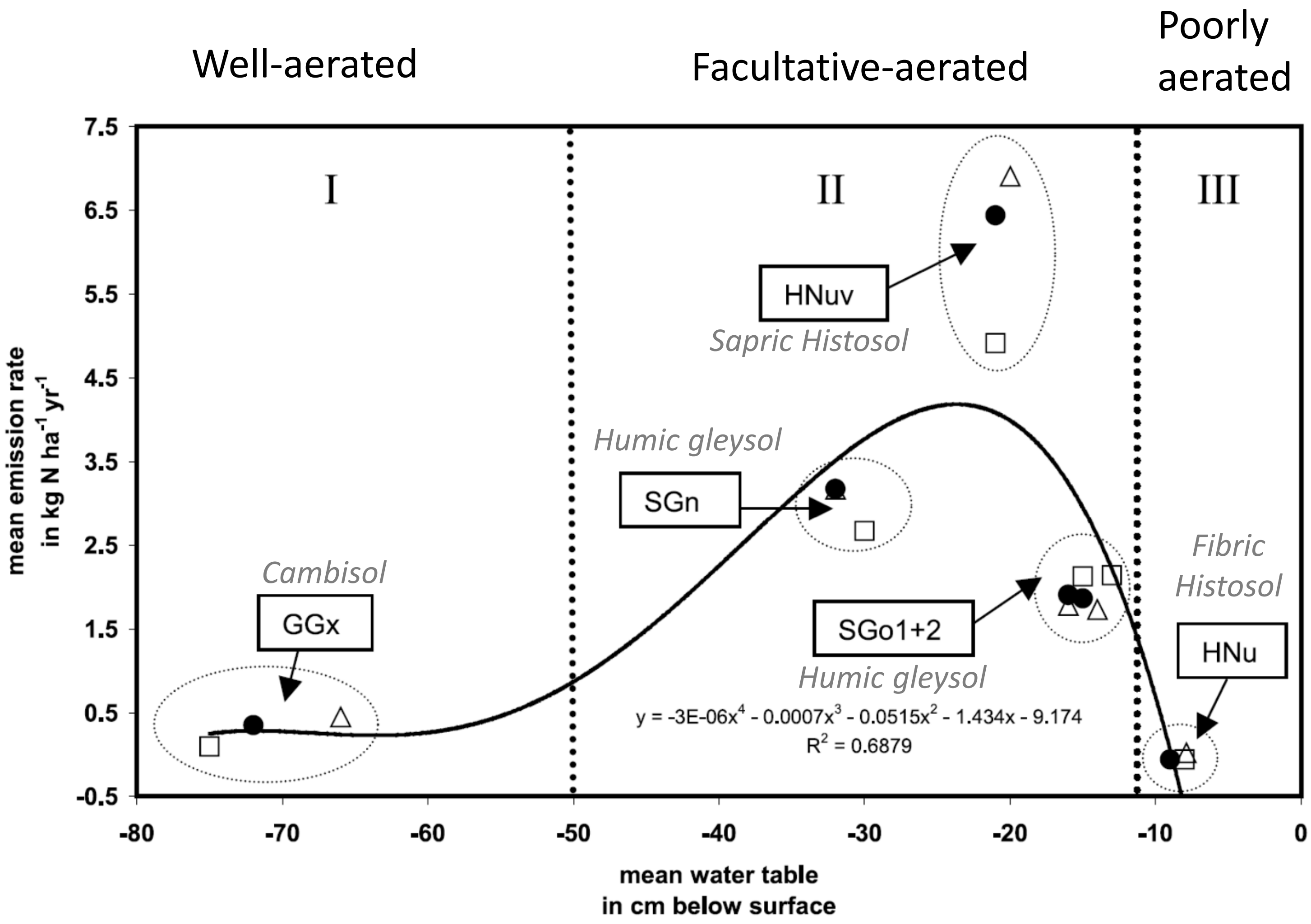
Fragmented landscape – N fluxes

Groffman et al., 2009 Biogeochemistry



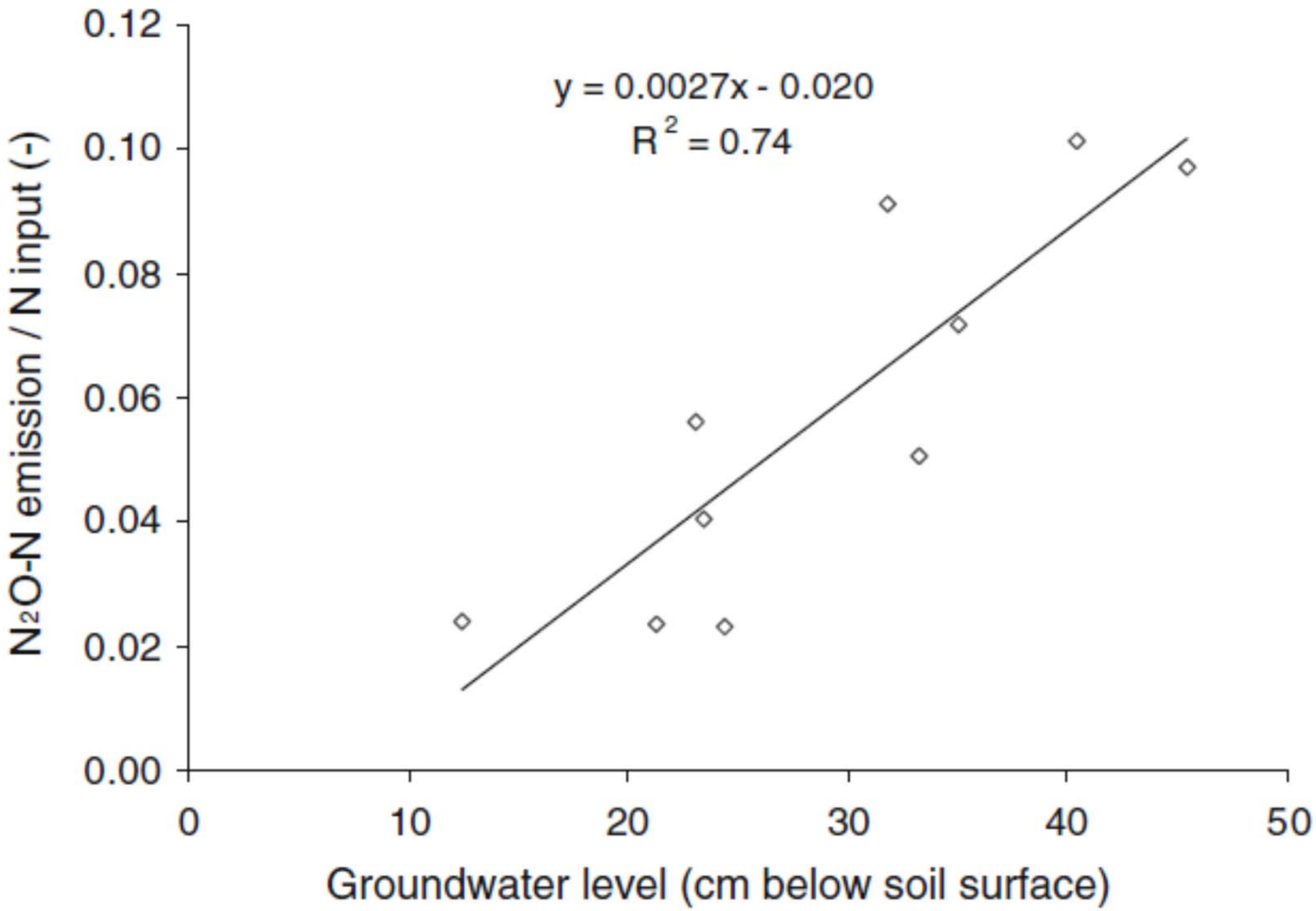
WD: well drained; MWD: moderately well drained, SPD: somewhat poorly drained, VPD: very poorly drained

Small scale variability of soil water status and effects on N_2O fluxes



Jungkunst et al. 2003, J. Geophys. Res. 109, D07302

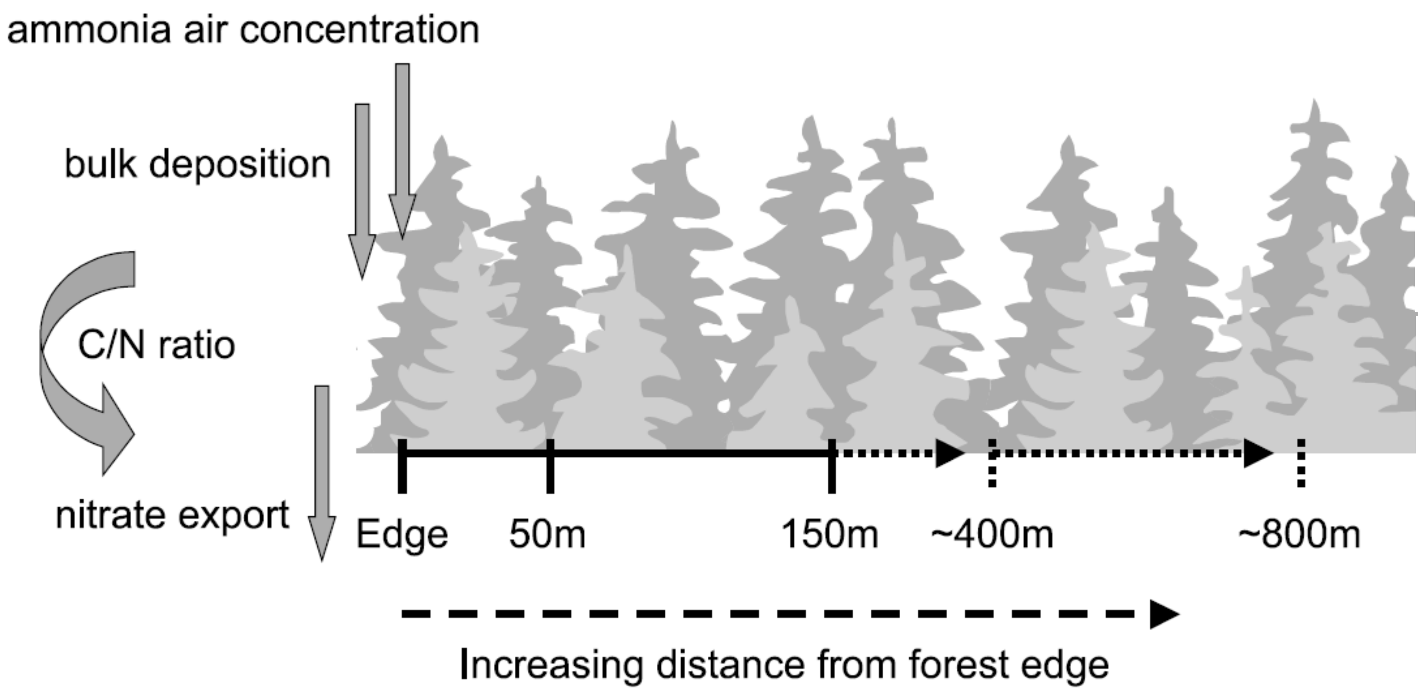
Groundwater level affects soil N_2O fluxes

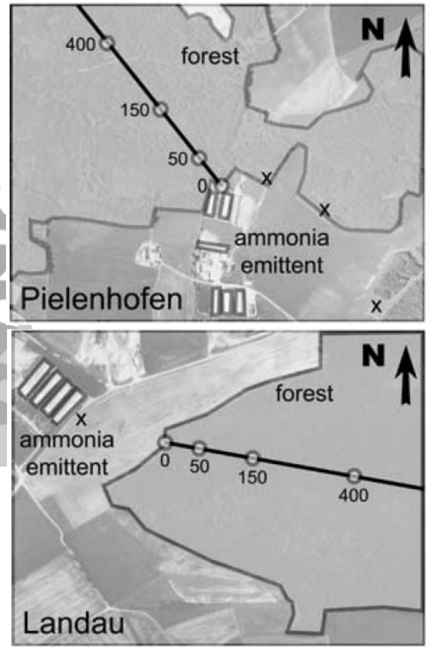


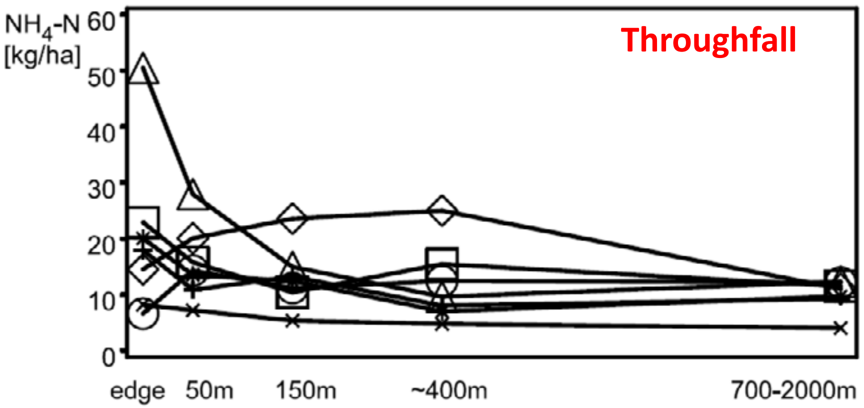
Van Beek et al. 2010, Nutr. Cycl Agroecosys. 86, 331-340

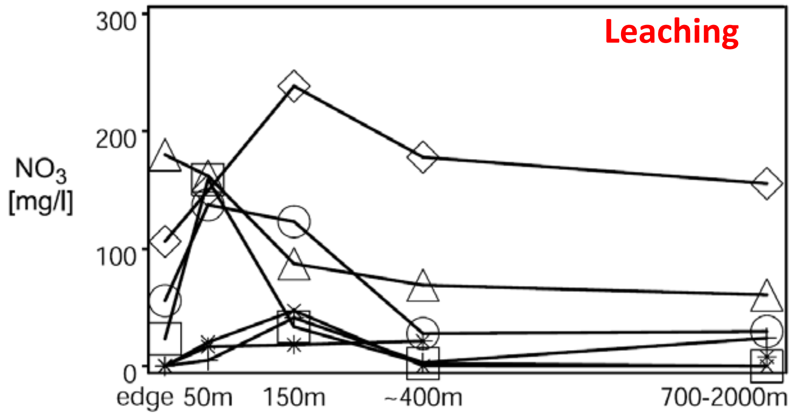
Fragmented landscape – N fluxes

Spangenberg and Kölling 2004 Water, Air, and Soil Pollut.

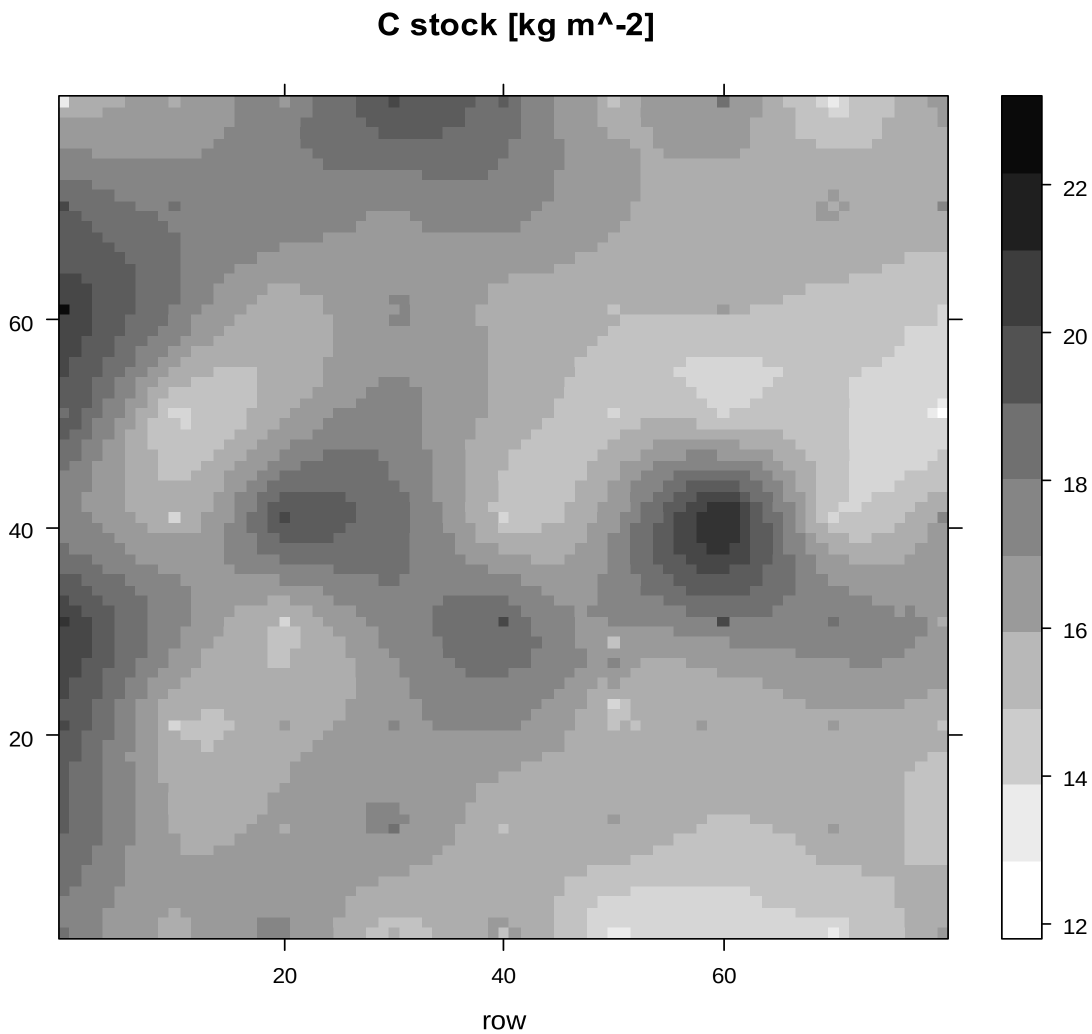






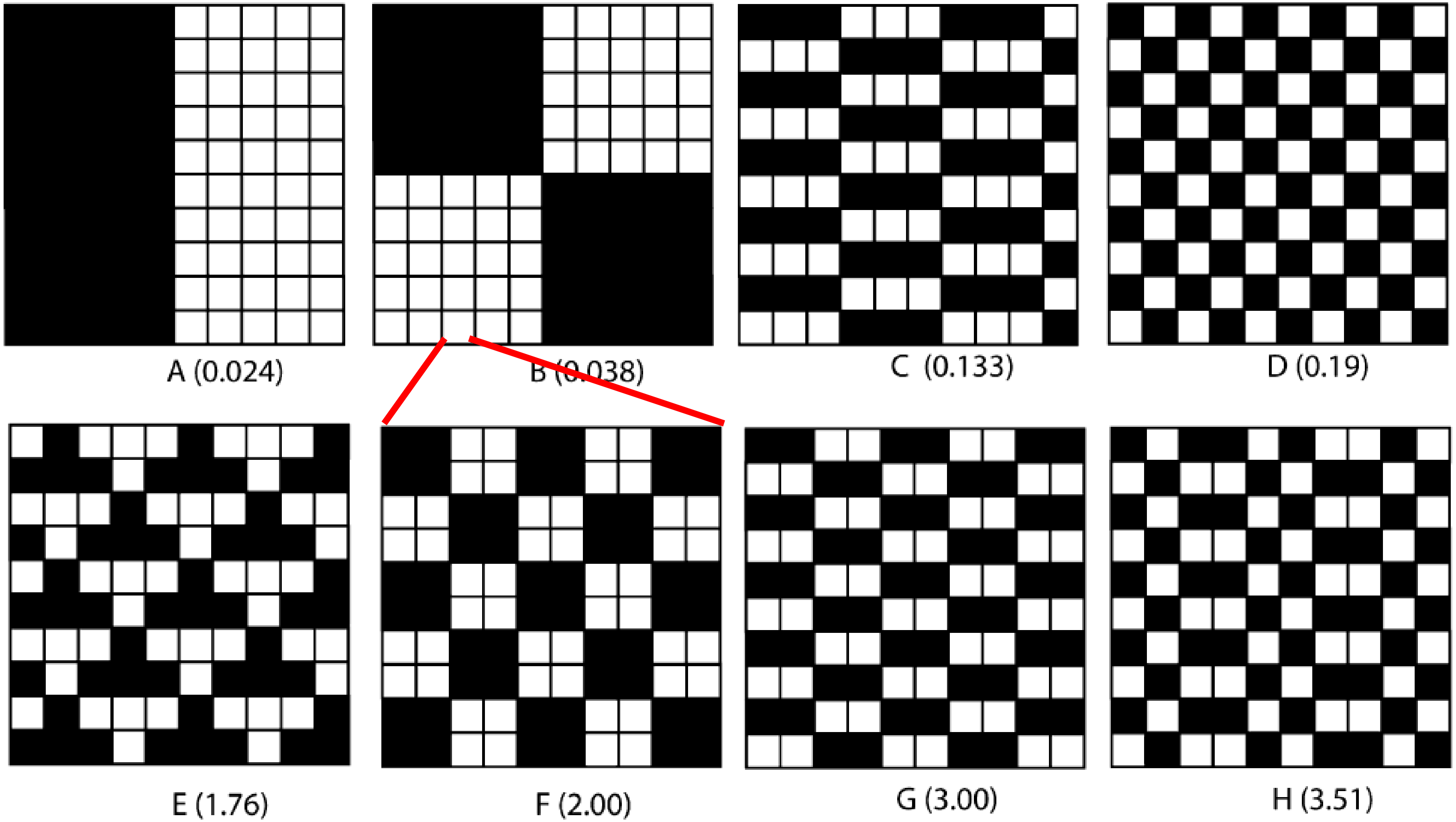


Fragmented landscapes – C fluxes



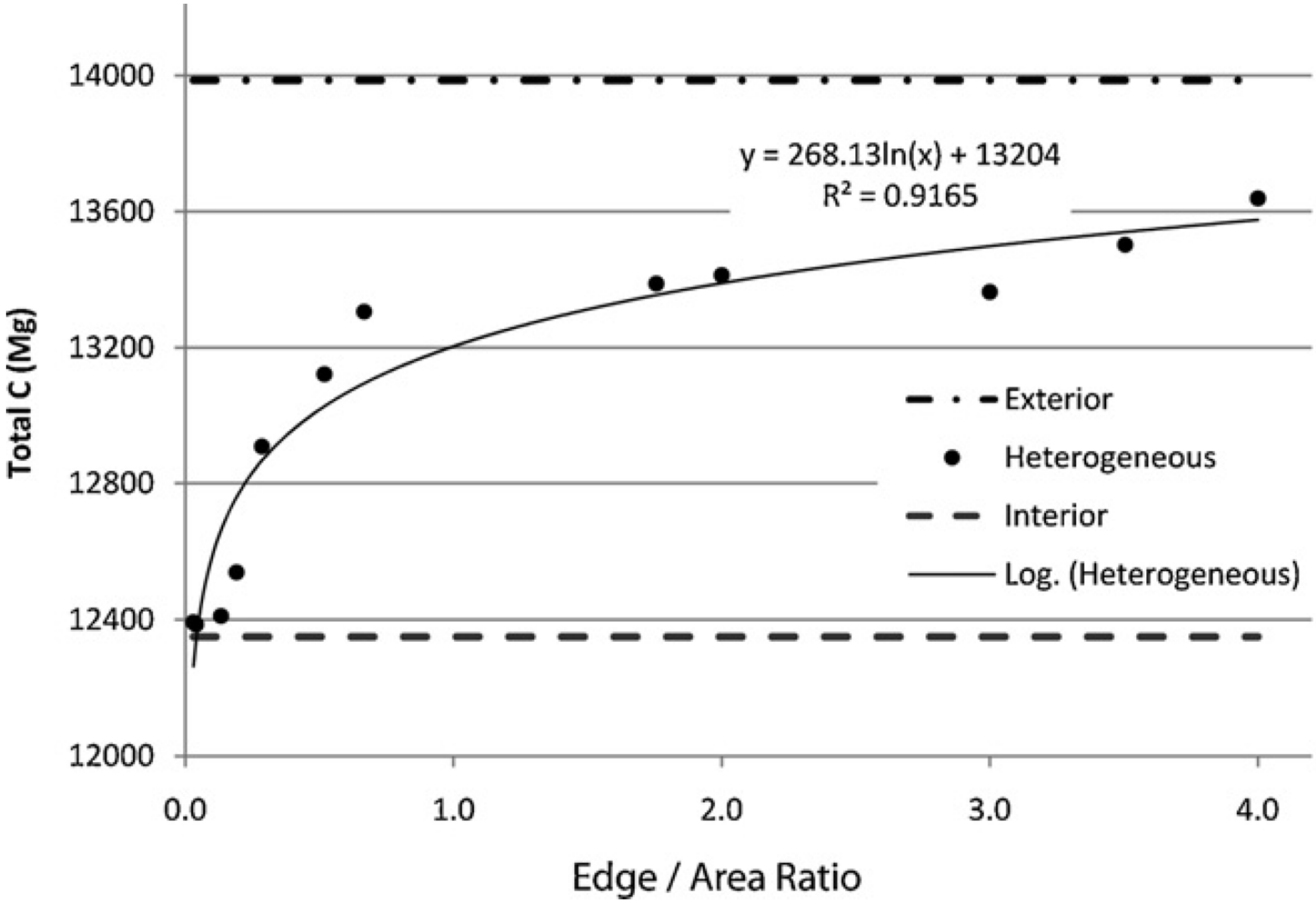
Fragmented landscape – C fluxes

Robinson et al., 2009 Ecol Modelling

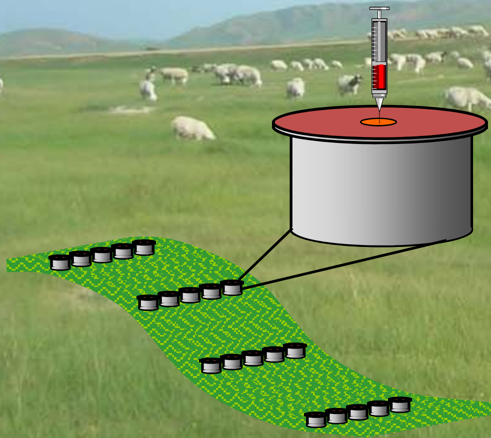


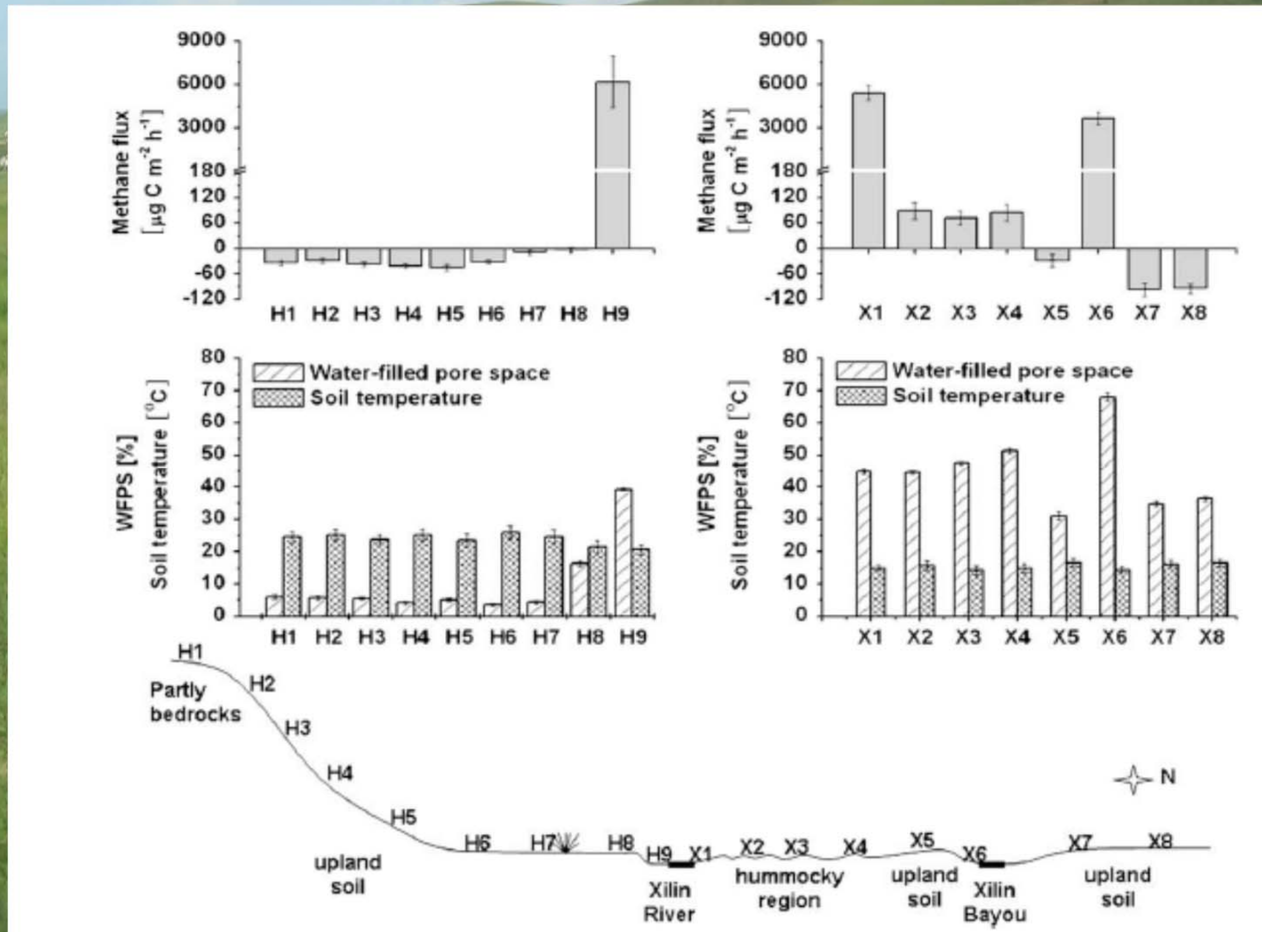
Fragmented landscape – C fluxes

Robinson et al., 2009 Ecol Modelling



Small scale variability of soil water status and effects on CH_4 fluxes



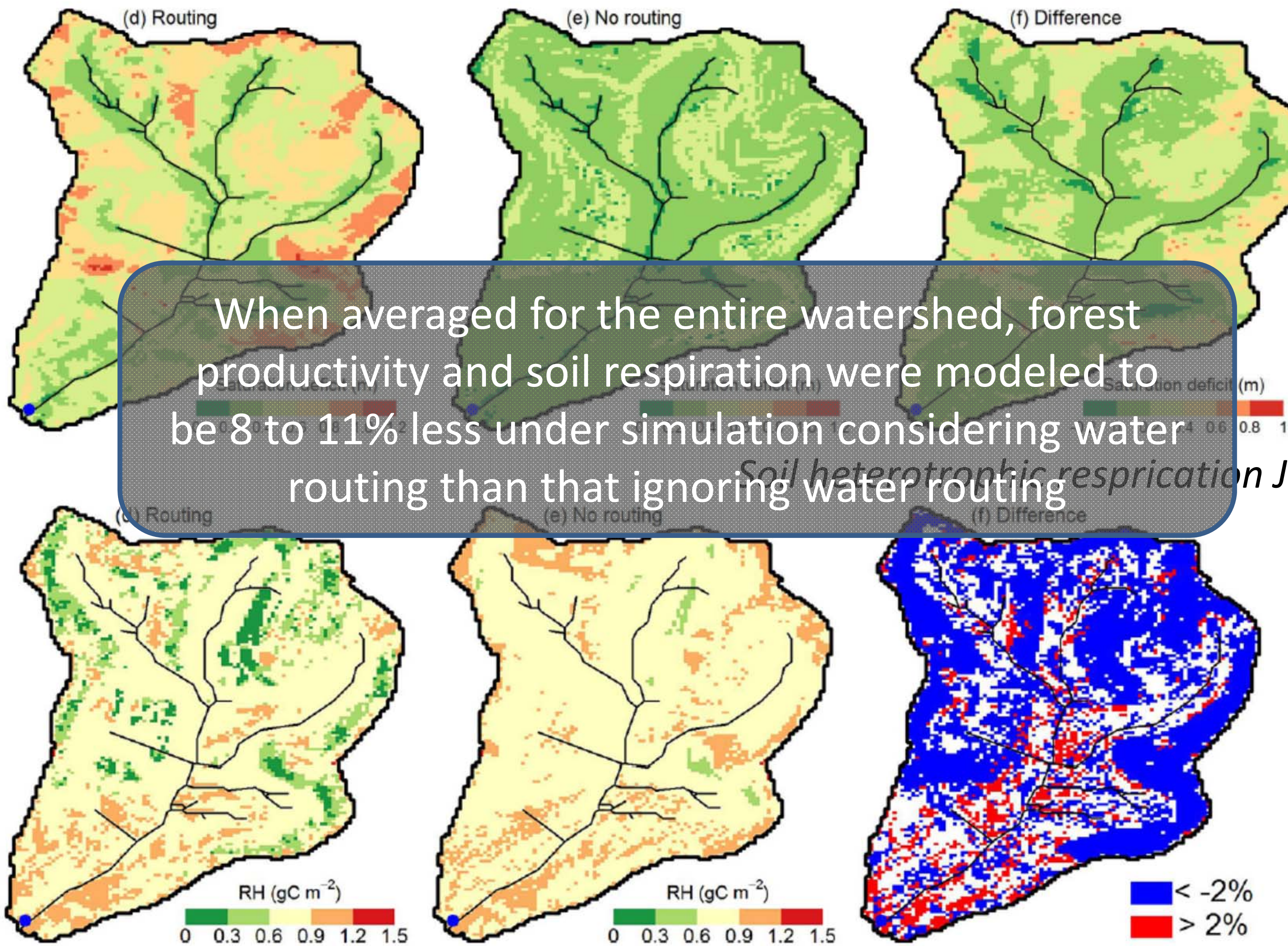


Does consideration of water routing affect simulated water and carbon dynamics in terrestrial ecosystems?

Hydrol. Earth Syst. Sci., 18, 1423–1437, 2014
www.hydrol-earth-syst-sci.net/18/1423/2014/
doi:10.5194/hess-18-1423-2014

G. Tang[1], T. Hwang[2], and S. M. Pradhanang[3]

Water saturation deficit July 1994



Soil heterotrophic resprication July 1994

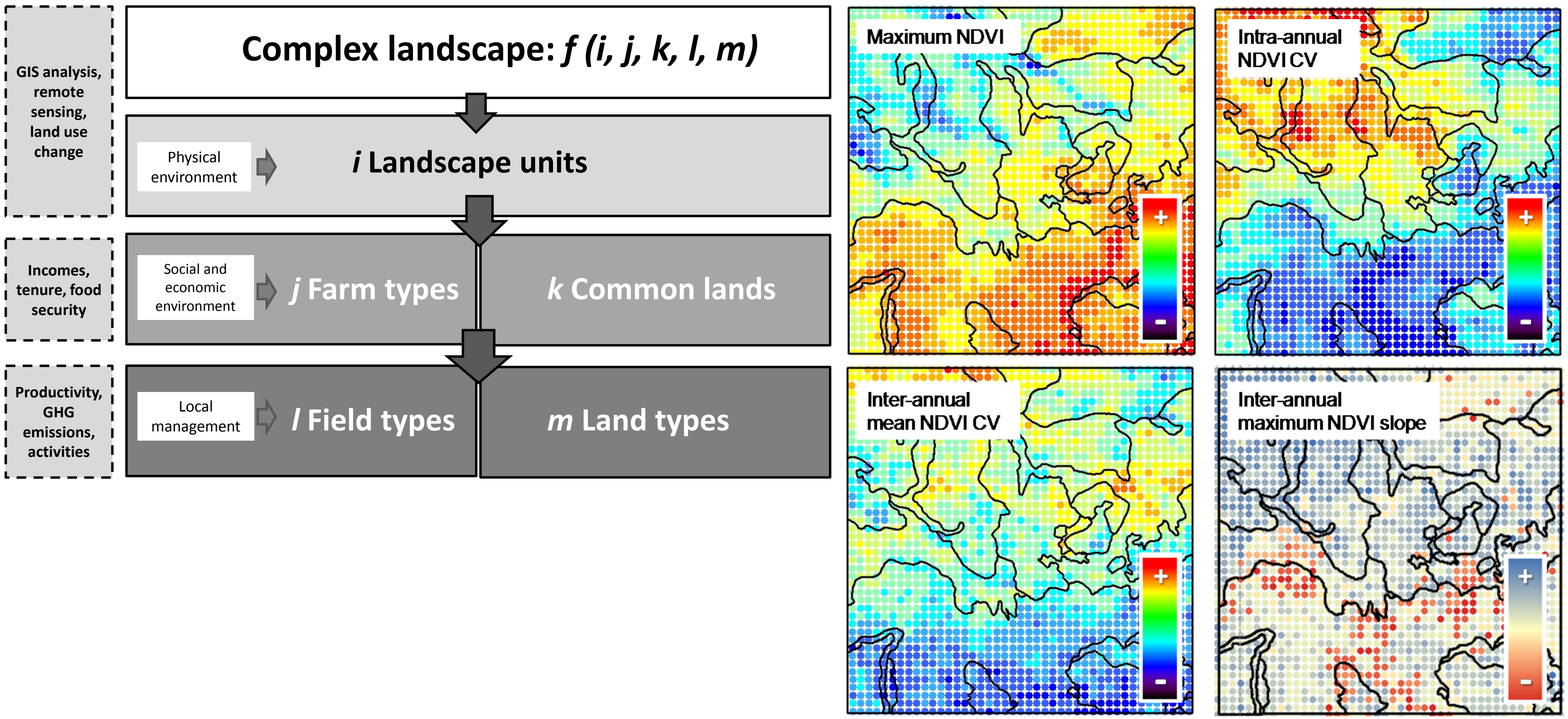
When averaged for the entire watershed, forest productivity and soil respiration were modeled to be 8 to 11% less under simulation considering water routing than that ignoring water routing

What is the problem?

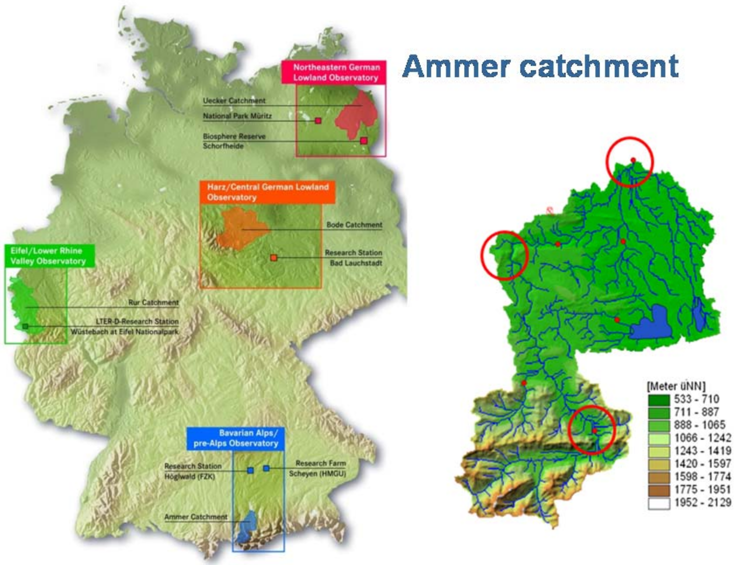
- Atmosphere-biosphere exchange of C and N is biased due to the selection of measuring sites
  - Avoiding complexity
  - Ignoring topography, water routing and deposition gradients
- Huge uncertainties with regard to fluxes and C/N stocks hampers to identify e.g. climate change feedbacks

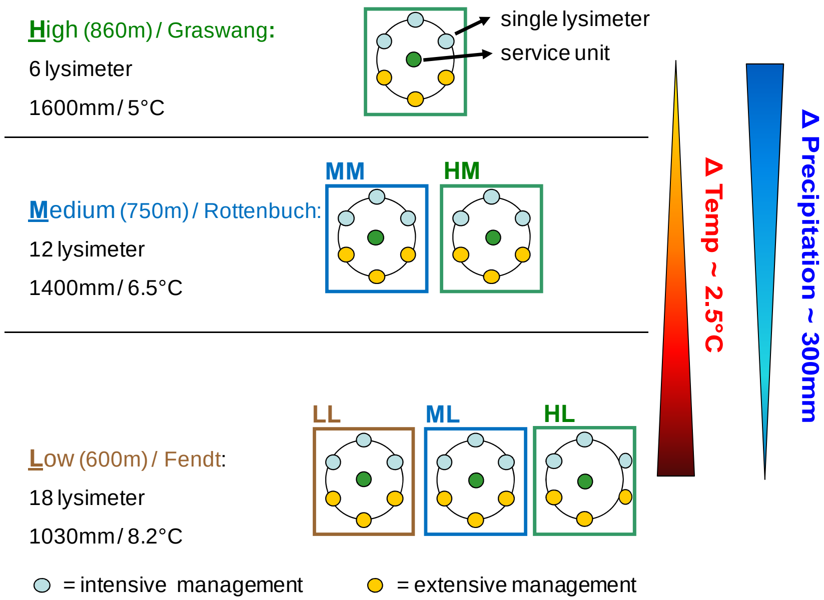
- *New criteria for site selection*
- *Additonal measurement approaches*
- *Advanced modeling tools*

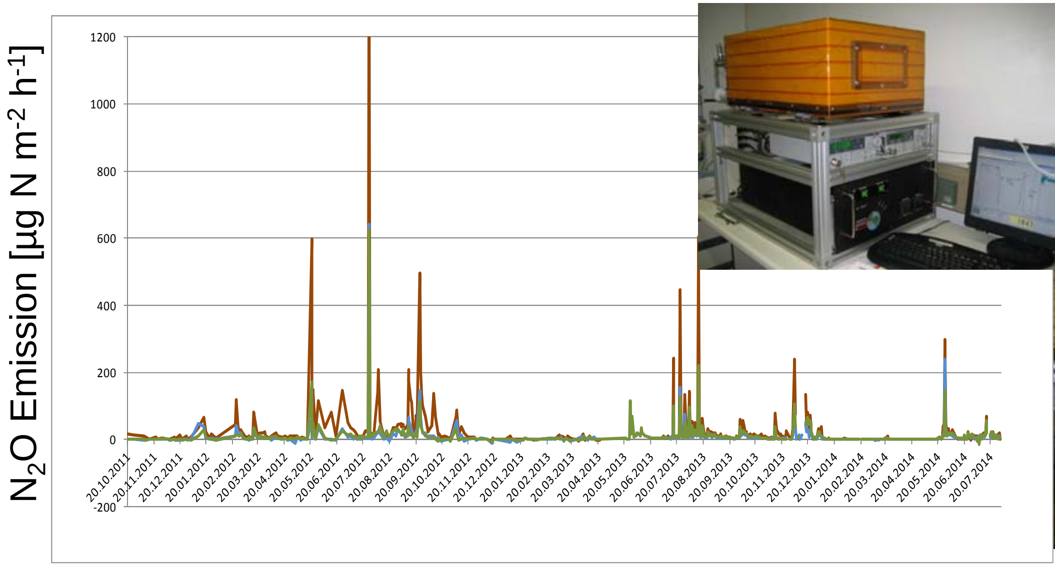
Targeting landscapes to allow and down- and upscaling



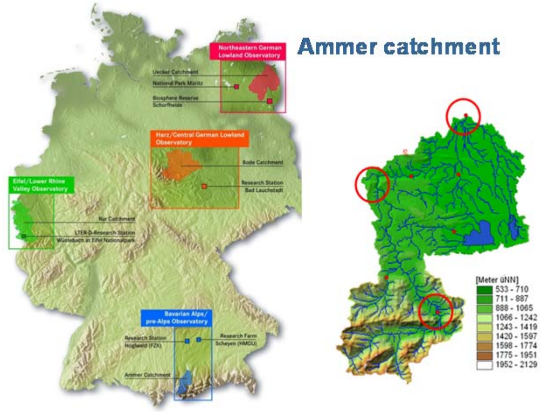
Additonal measurement approaches

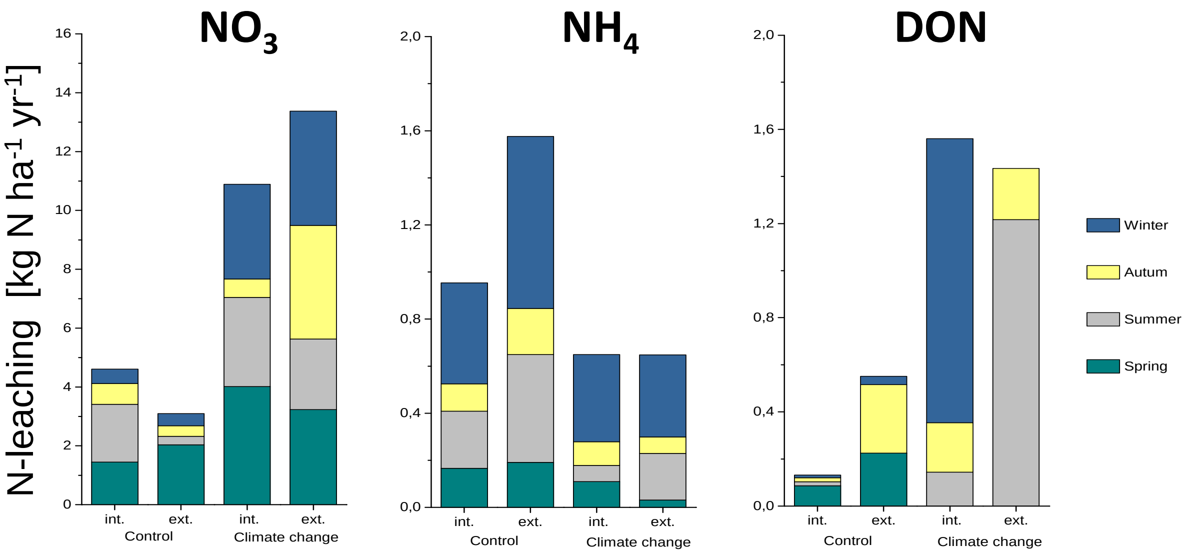






TERENO
Terrestrial Environmental Observatories





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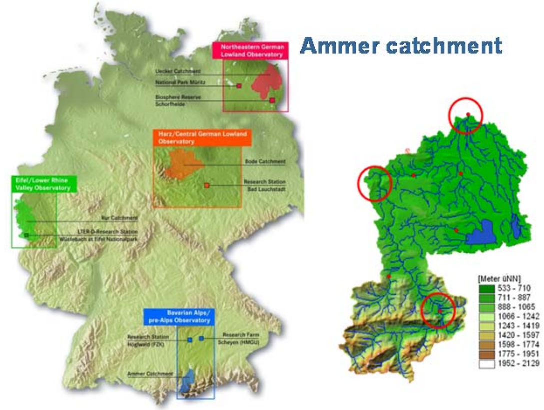
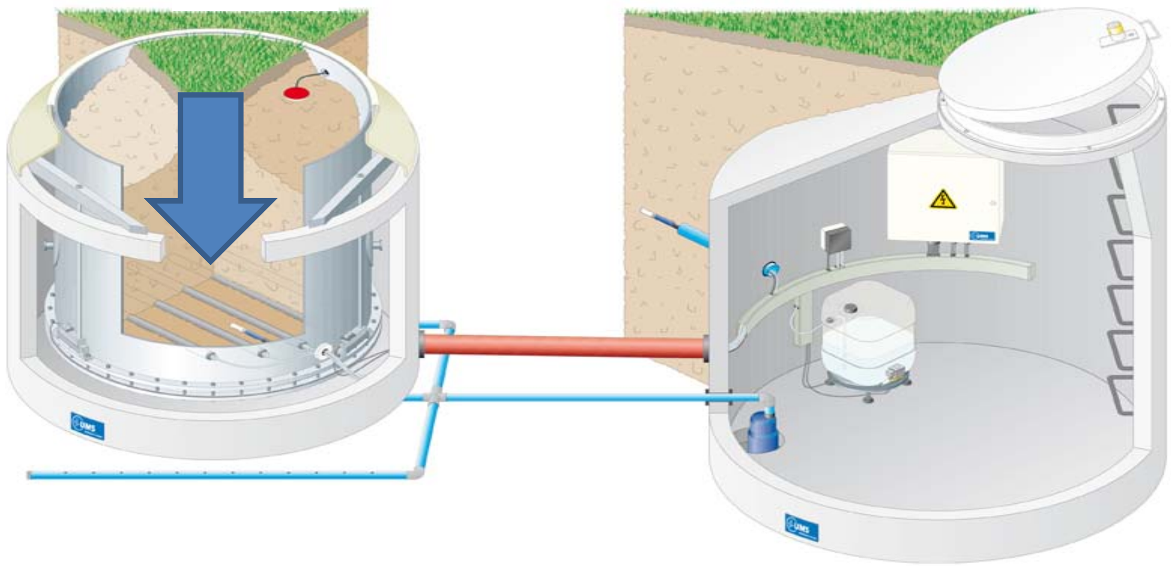
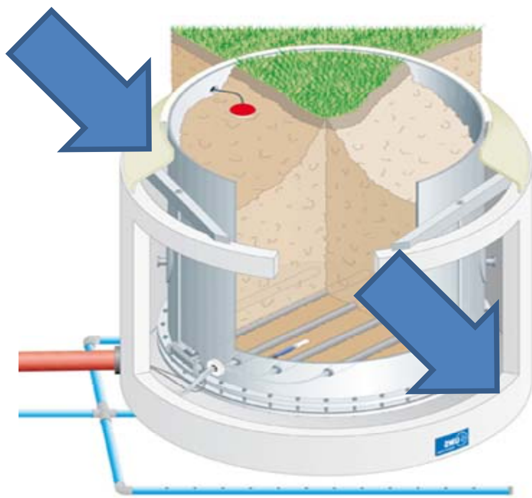


1d

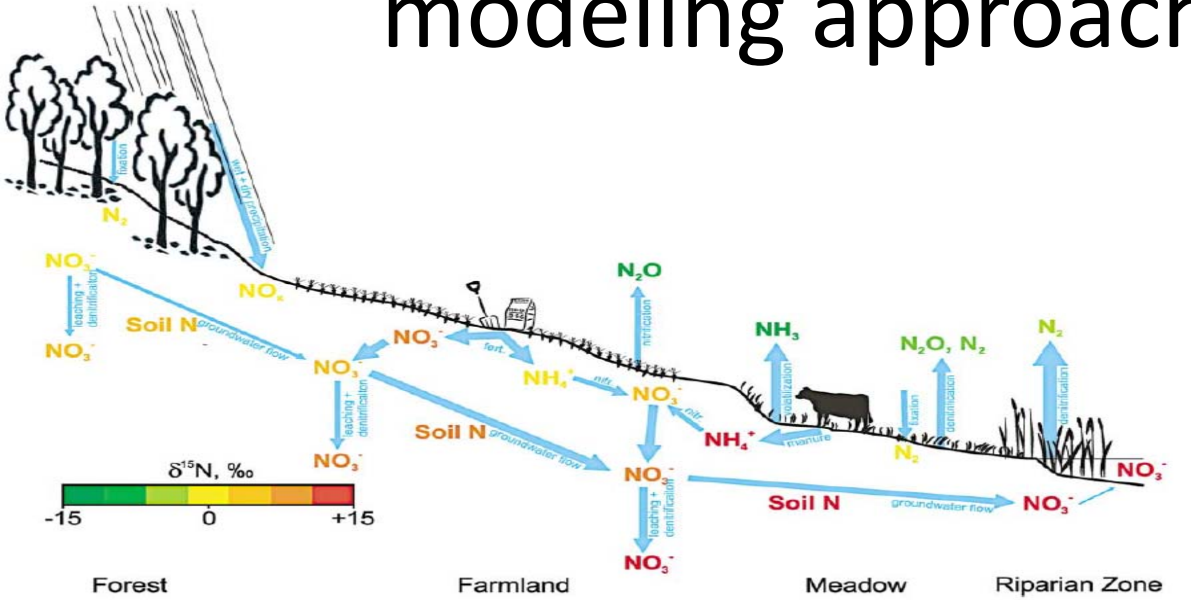


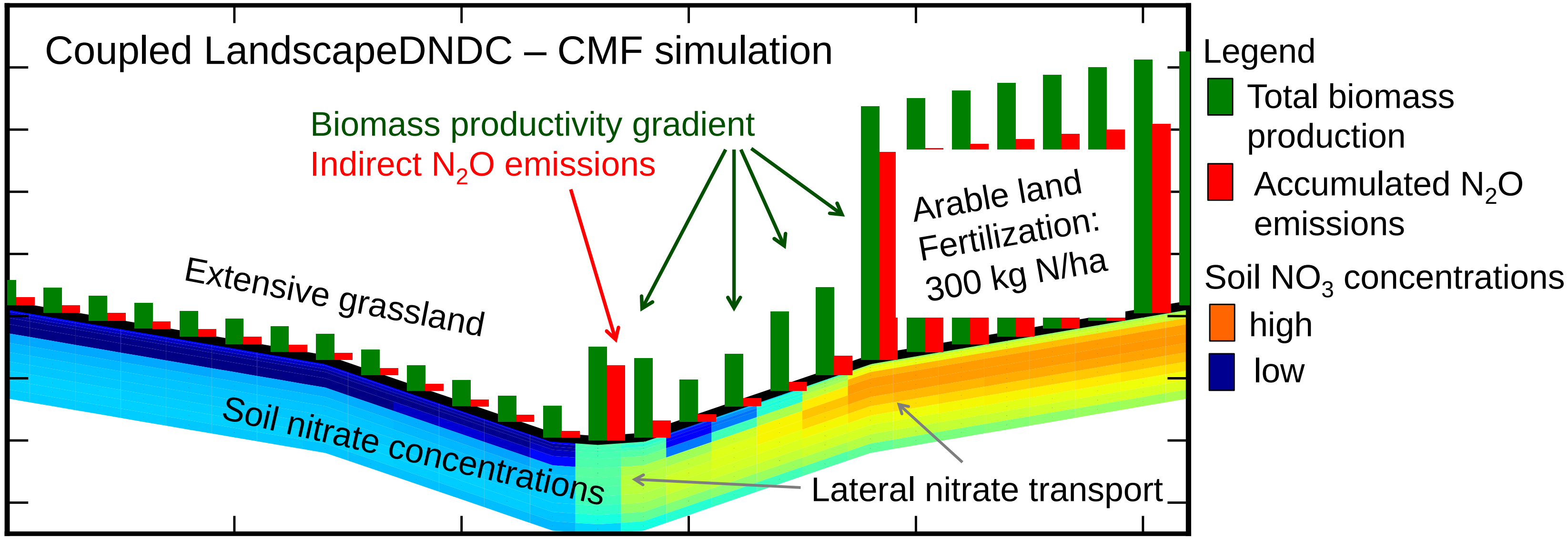
2d



Towards landscape measurement and modeling approaches

Bedard-Haughn et al., 2003, J. Hydrol.)



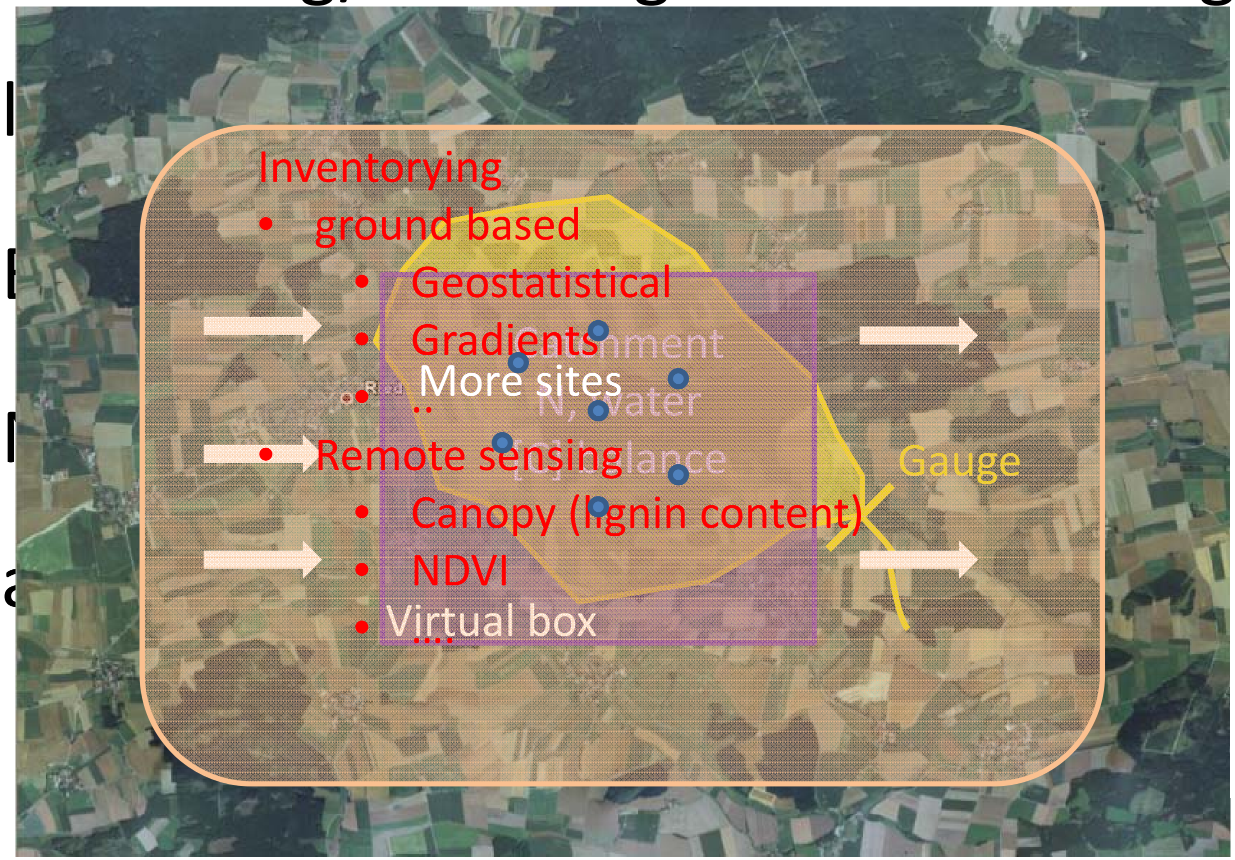


Conclusions

- Water routing, fragmentation and edge effects are enhancing/ reducing fluxes and storage of C/N at landscape scales
- Effects remain unquantified
- New measuring/modeling strategies to assess effects and to reduce uncertainties

Conclusions

- Water routing, fragmentation and edge effects are enhancing/ reducing fluxes and storage of C/N at



→*advanced measuring and modelling tools for studying the complex interactions of water, C, and N at landscape scales*