Karlsruhe Institute of Technology

LandscapeDNDC
A process based model for biogeochemical simulations from site to the regional scale

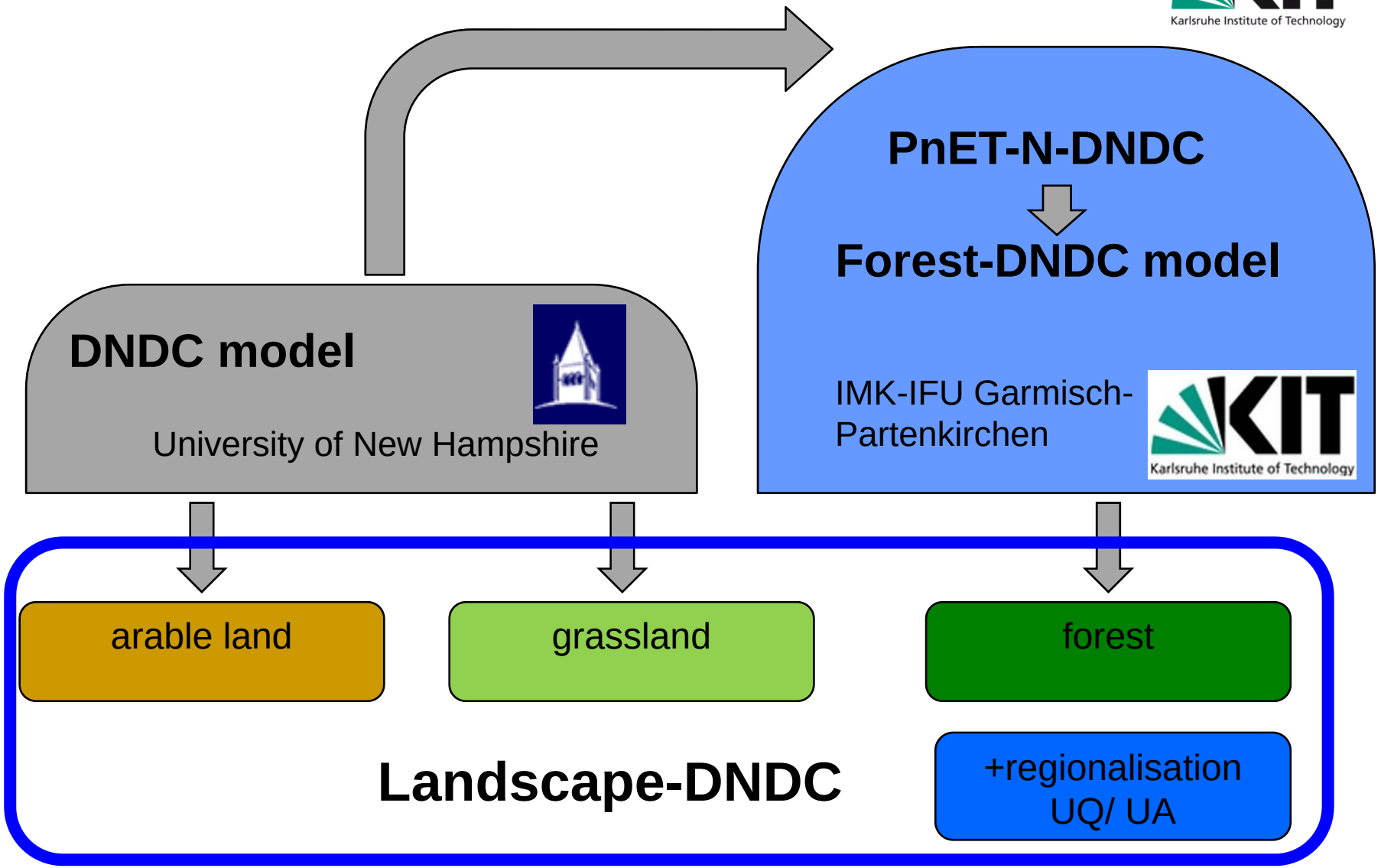
E. Haas, **R. Kiese**, S. Klatt, D. Kraus, S. Molina,
R. Grote, Y. Kim, Klaus Butterbach-Bahl

IMK-IFU Garmisch-Partenkirchen
Department of biogeochemical processes

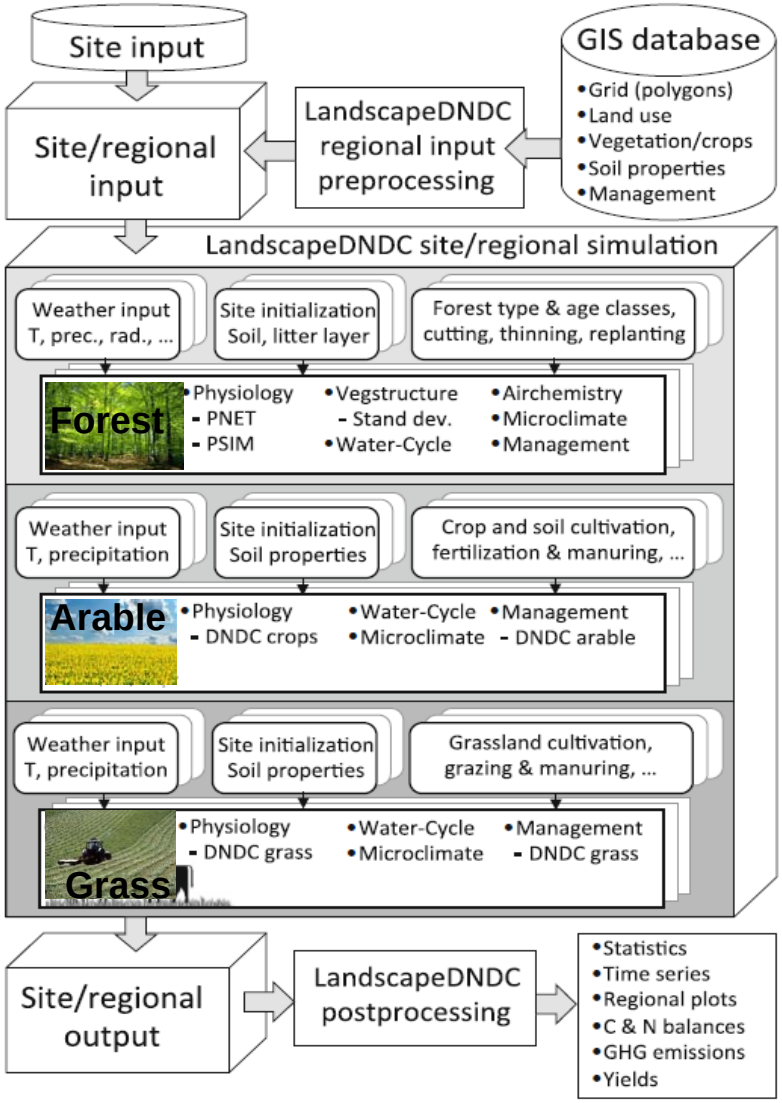
Overview

- LandscapeDNDC – History/ background
- Site validation
- Regional applications
- Uncertainty quantification (parameter vs. input uncertainty)
- Scenario applications
- Outlook – coupled biogeochemical/ hydrological simulations

LandscapeDNDC history/ background



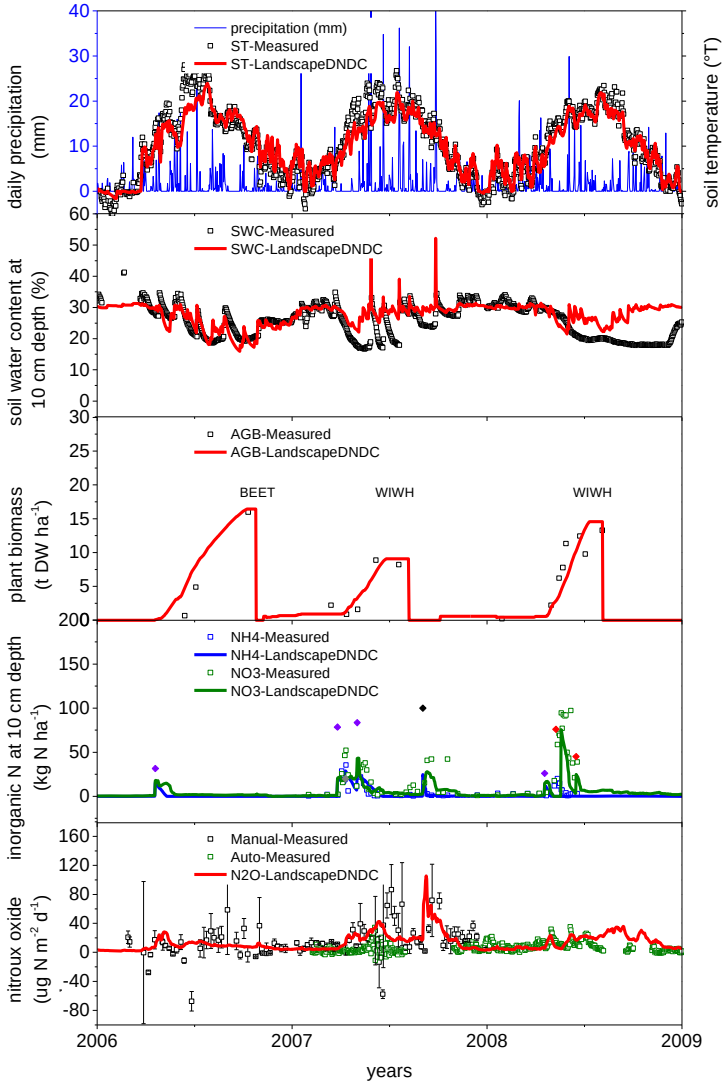
LandscapeDNDC – Model overview



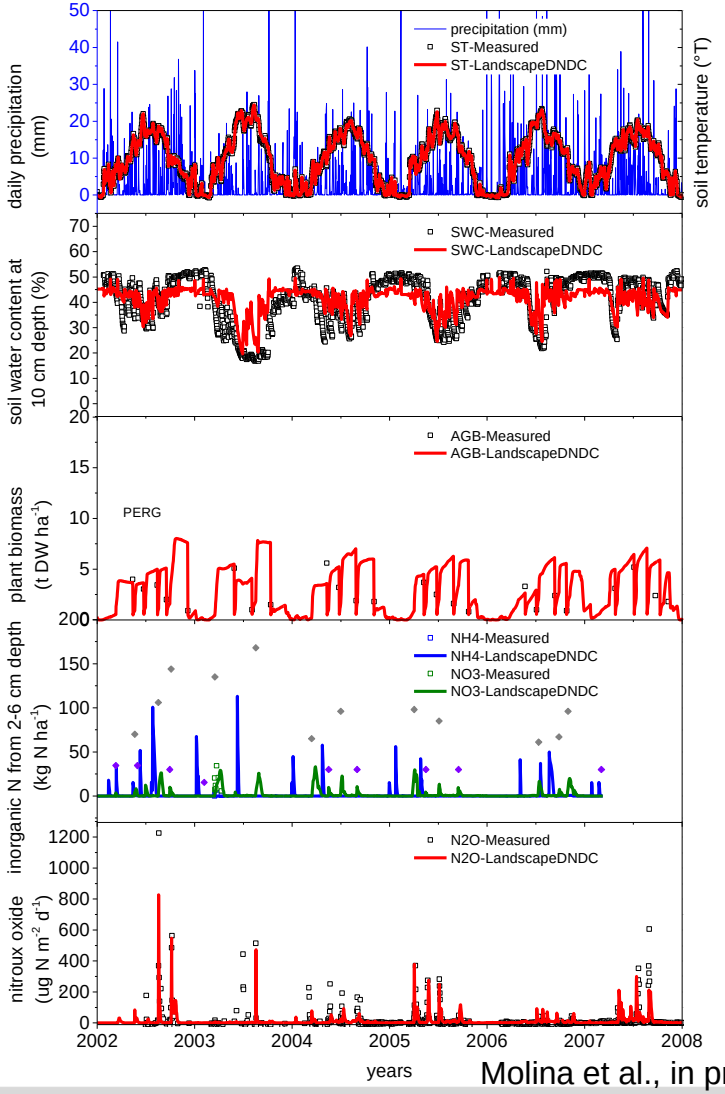
Haas et al.,2013

LandscapeDNDC site validation

Arable: Gebesee (D)

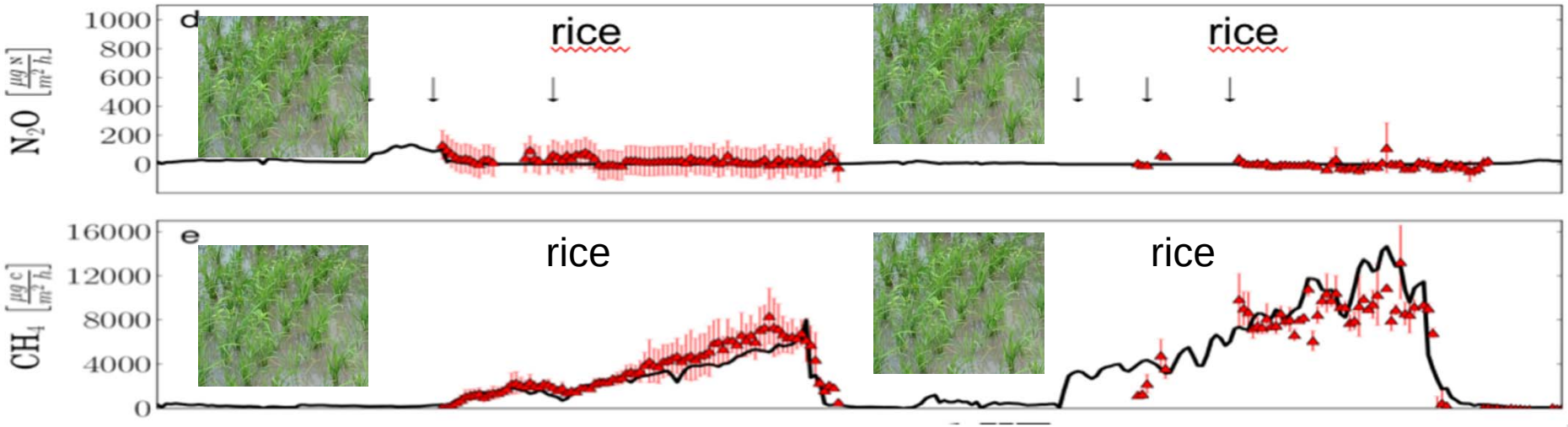


Grassland: Oensingen (CH)



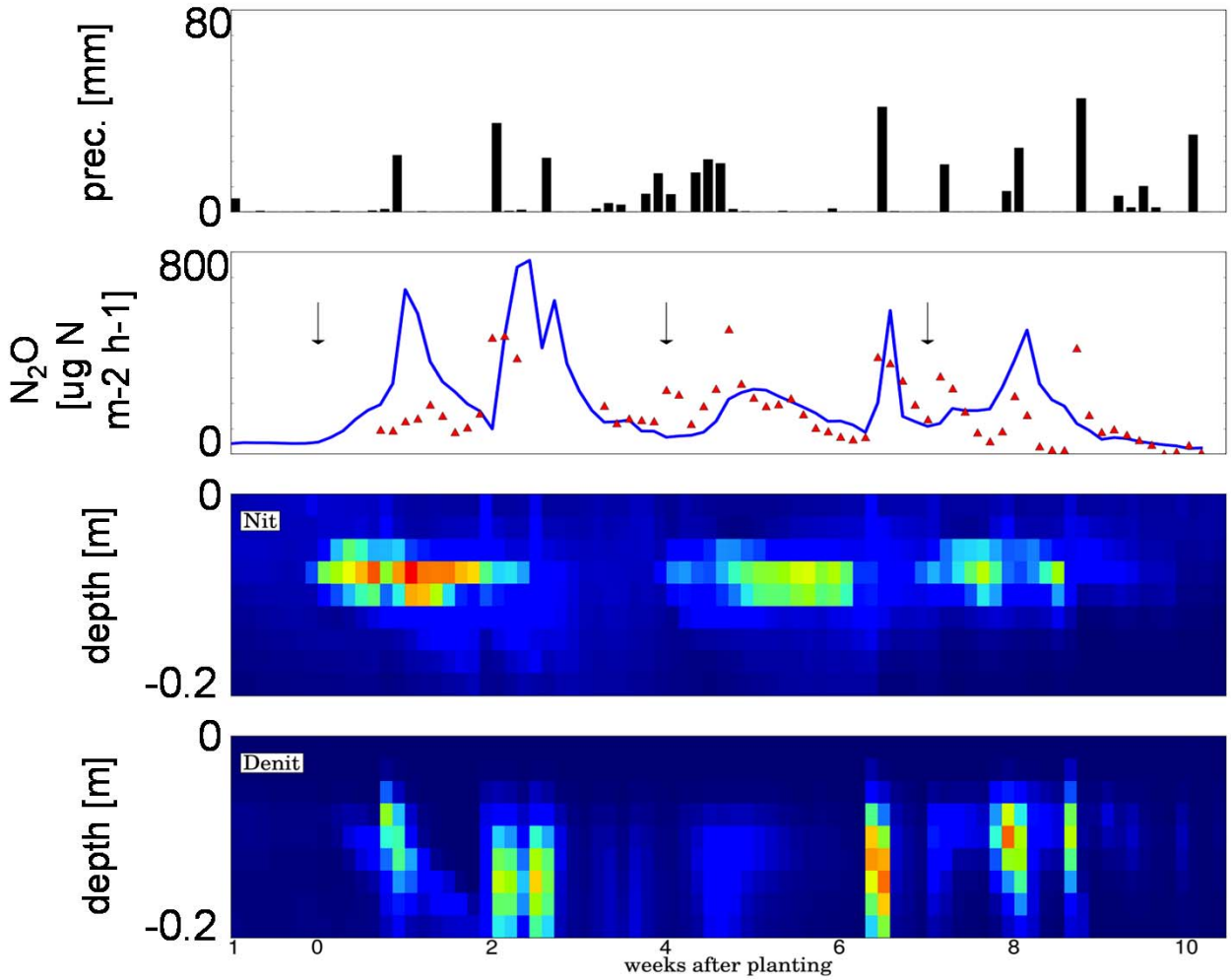
Molina et al., in preparation

LandscapeDNDC site validation



Kraus et al.,2014

LandscapeDNDC site validation

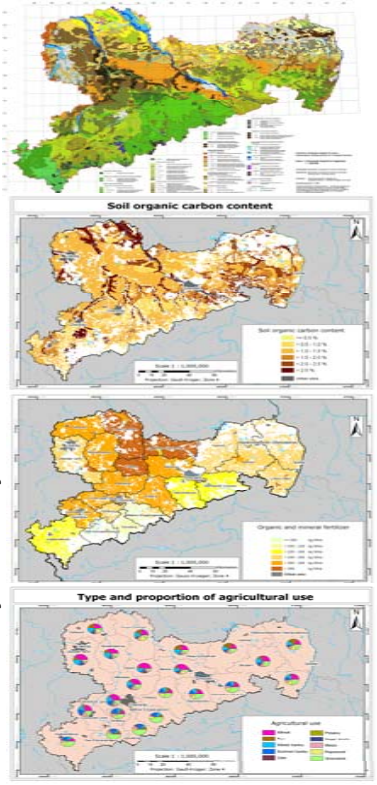


LandscapeDNDC – UNFCCC GHG reporting

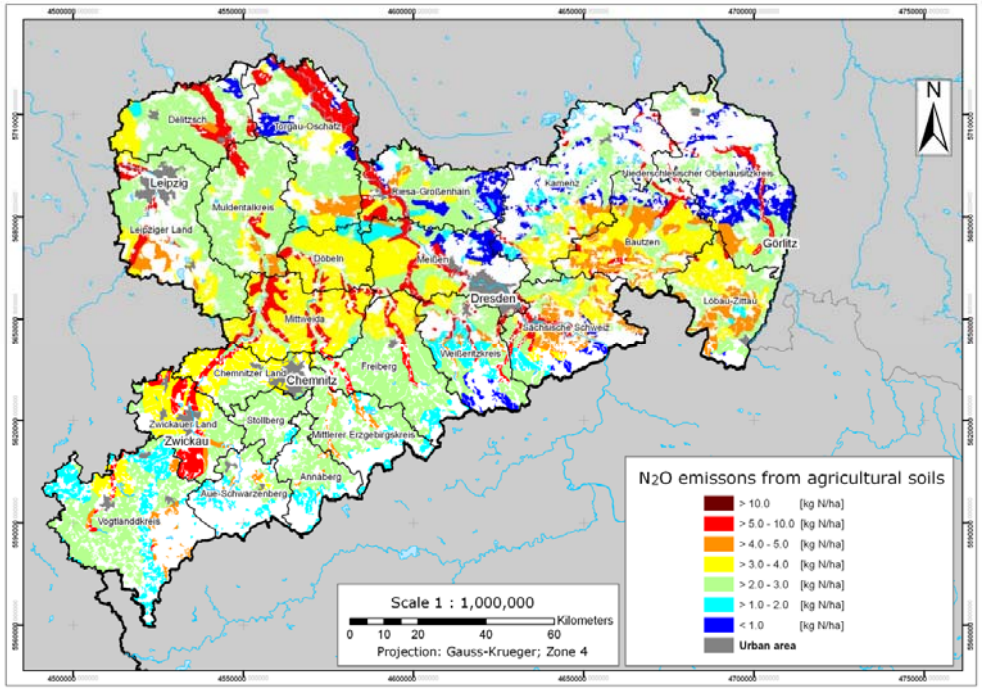
Regional N_2O emission inventory simulations

- 4400 polygons, BUEK200 soil database, Climate input on 1 x 1 km,
- 3 crop rotation: w-barley, w-wheat, maize; N-Fertilizer: 111 000 t / yr

GIS database



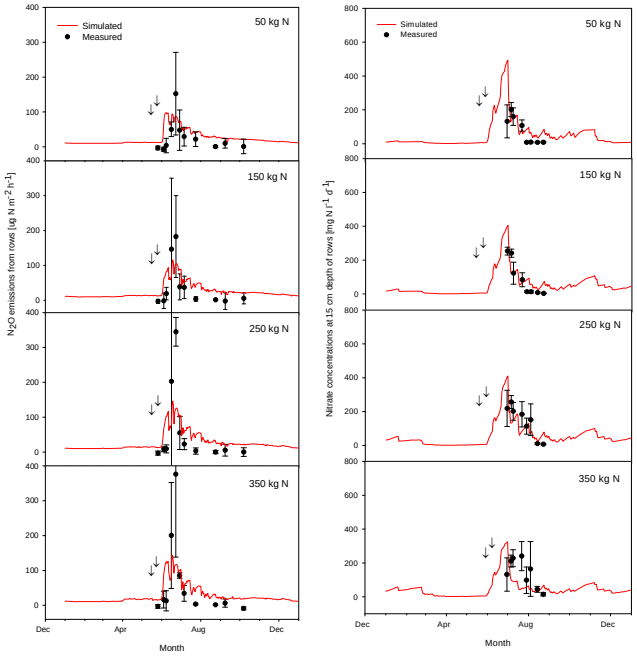
Data source: LfULG, Environmental Service, State of Saxony, Germany

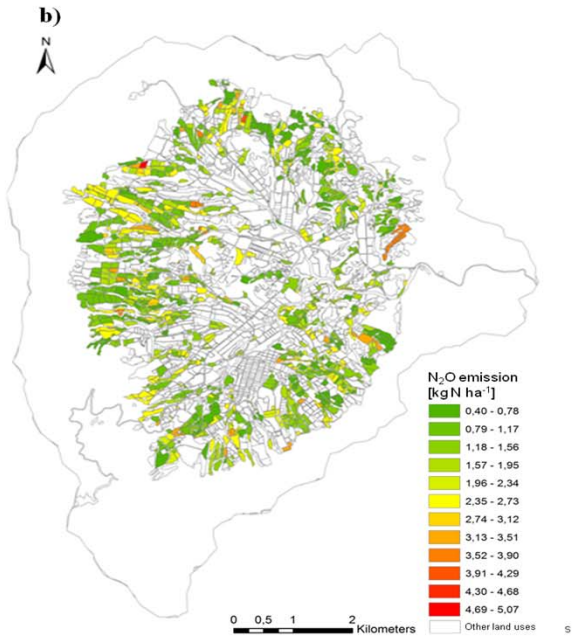


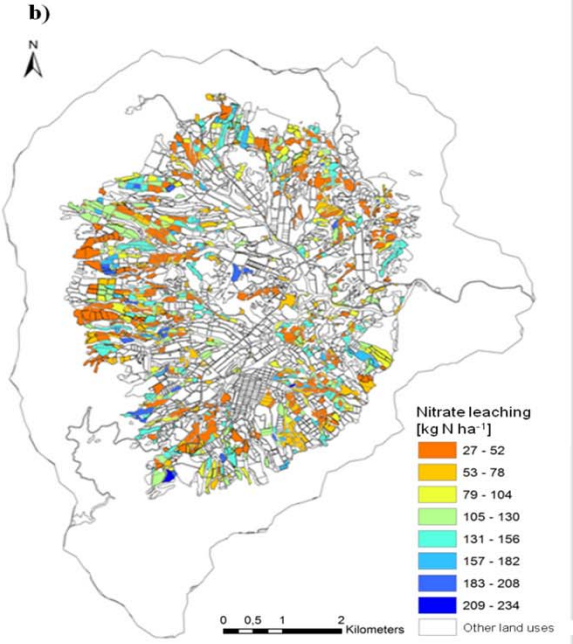
IPCC (Tier 1): 1 110 t N_2O-N / yr
NIR (Tier 2): 3 000 t N_2O-N / yr
LandscapeDNDC (Tier 3): 2 693 t N_2O-N / yr

LandscapeDNDC – Mitigating N losses

Kim et al., 2014

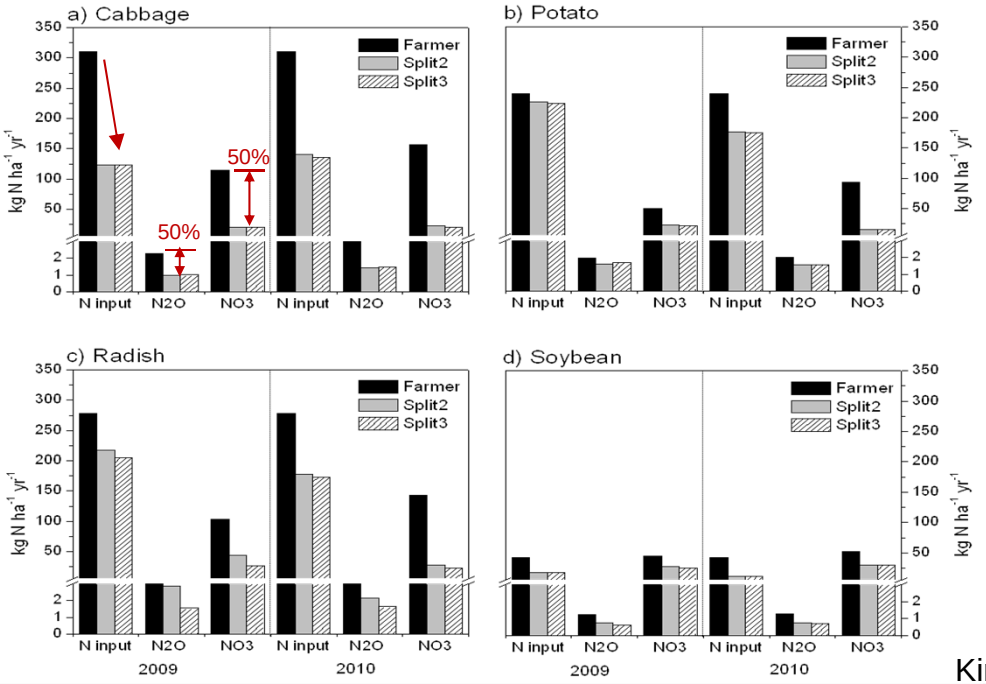






Kim et al., in preparation

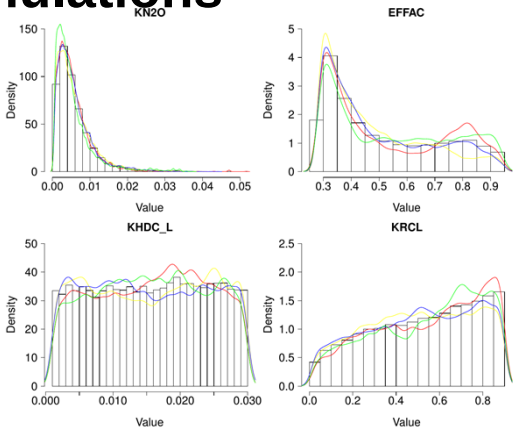
LandscapeDNDC – Mitigating N losses



Kim et al., in preparation

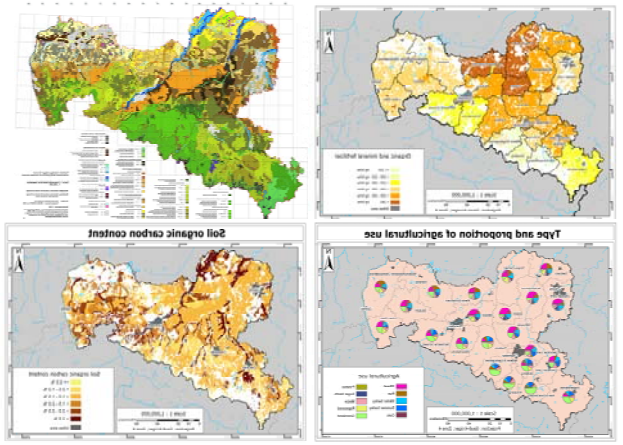
LandscapeDNDC – Uncertainties (regional scale)

Sources of Uncertainty in N_2O & NO_3 inventory simulations



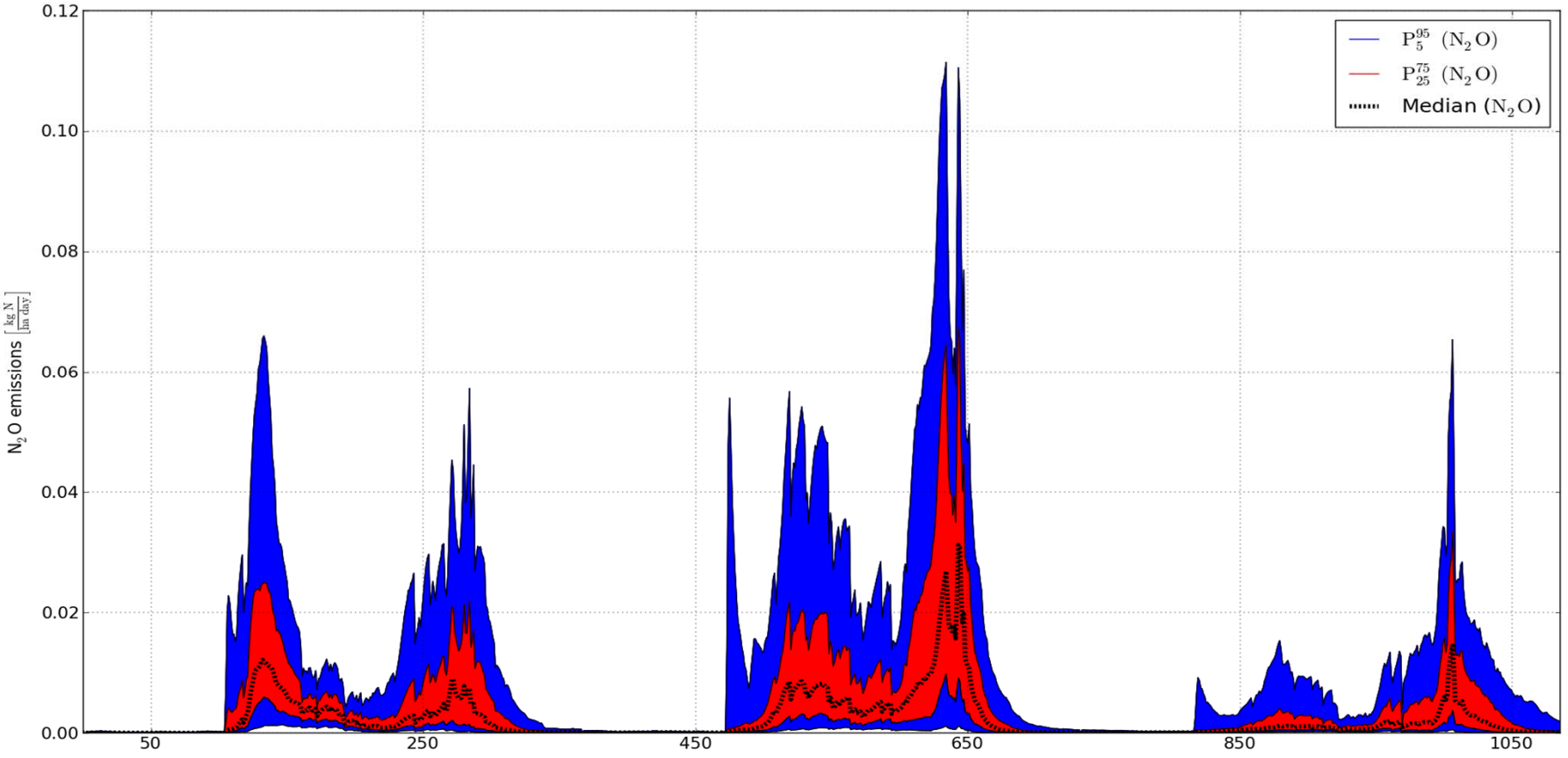
- *Parameter Uncertainty*
  - Bayesian Calibration technique used to obtain parameter probability distribution

- Input Uncertainty of soil properties (LH samp.)
  - bulk density (approx. 20%)
  - soil carbon content (approx. 100%)
  - pH values (approx. 0.25)
  - hydraulic properties (approx. 20%)



➔ Nearly 1000 regional inventory simulations

LandscapeDNDC – Parameter Uncertainty
(regional scale)



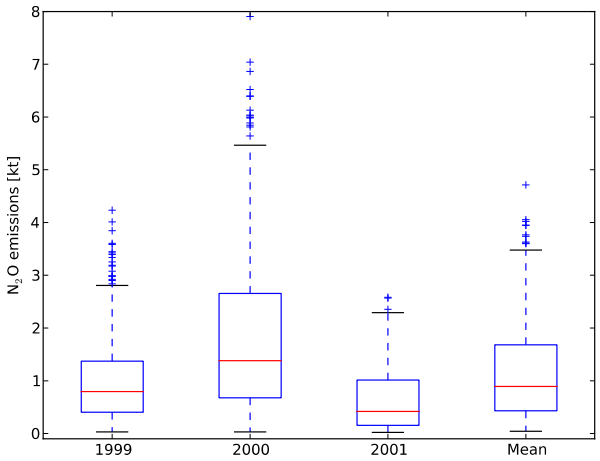
Klatt et al., accepted

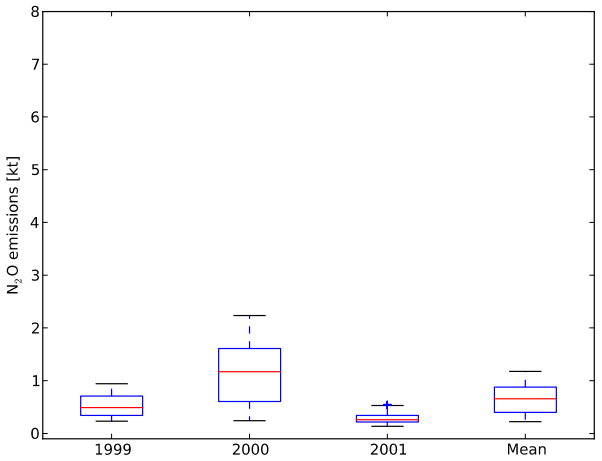
LandscapeDNDC – Parameter/ Input Uncertainty
(regional scale)

Parameter induced

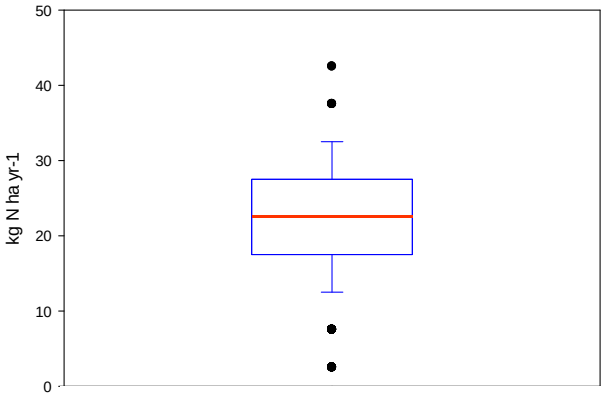
Input Data induced

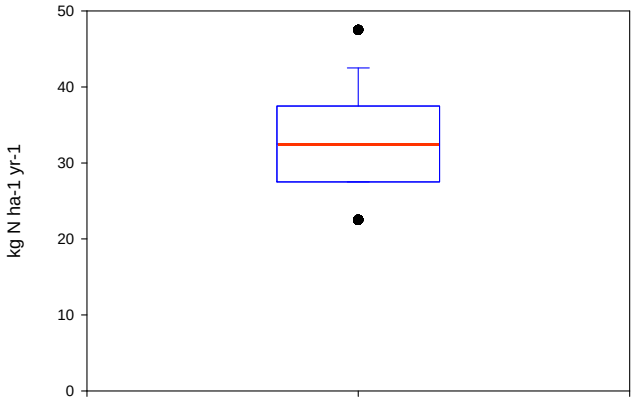
N_2O Emission





NO_3 Leaching

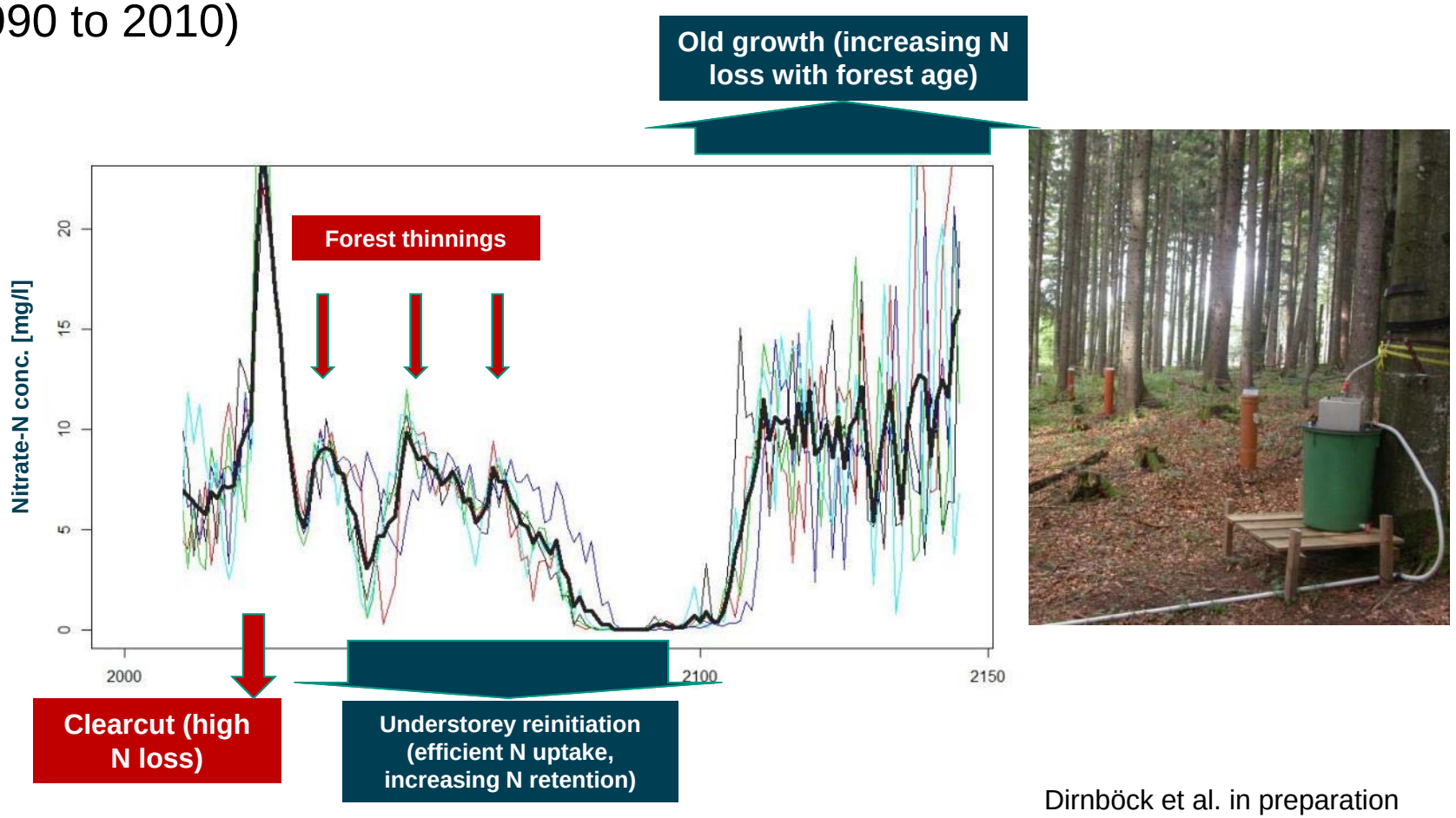




Klatt et al., accepted

LandscapeDNDC scenario application

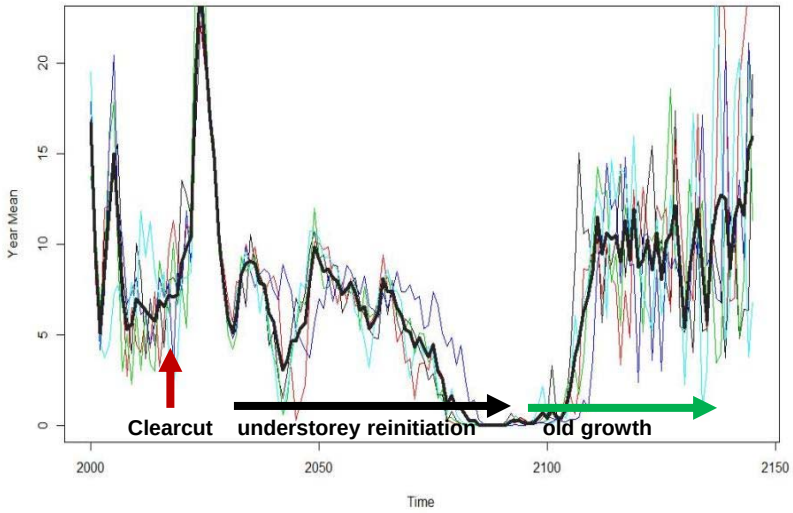
- Nitrate seepage flux during a ~120 yr rotation time (Climate baseline 1990 to 2010)



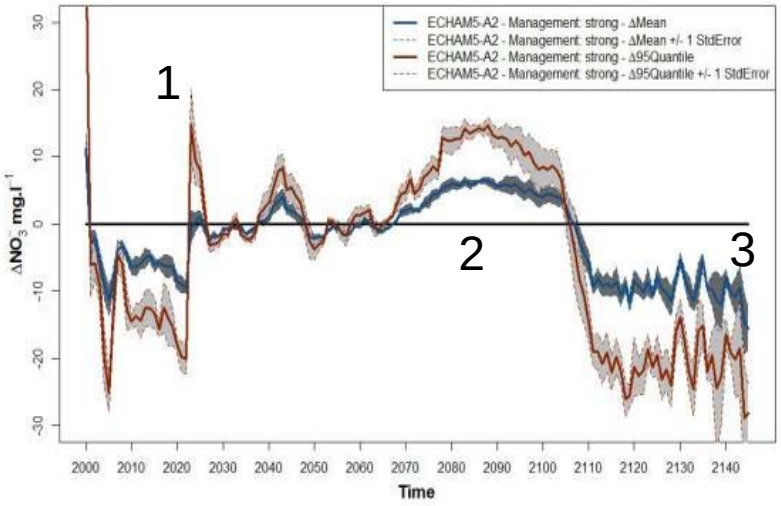
Dirnböck et al. in preparation

LandscapeDNDC scenario application

Baseline 1990 to 2010



ECHAM5-A2 **2090**

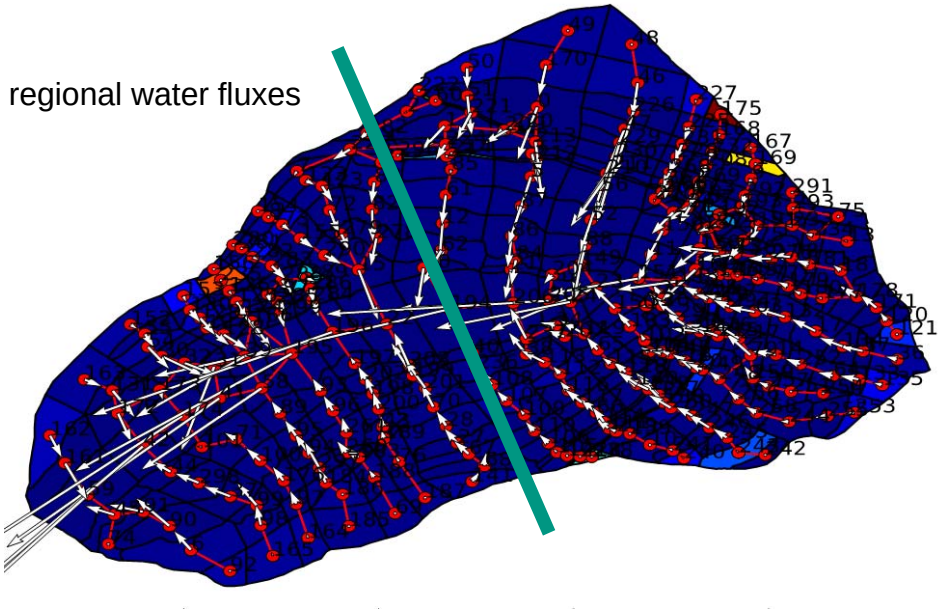


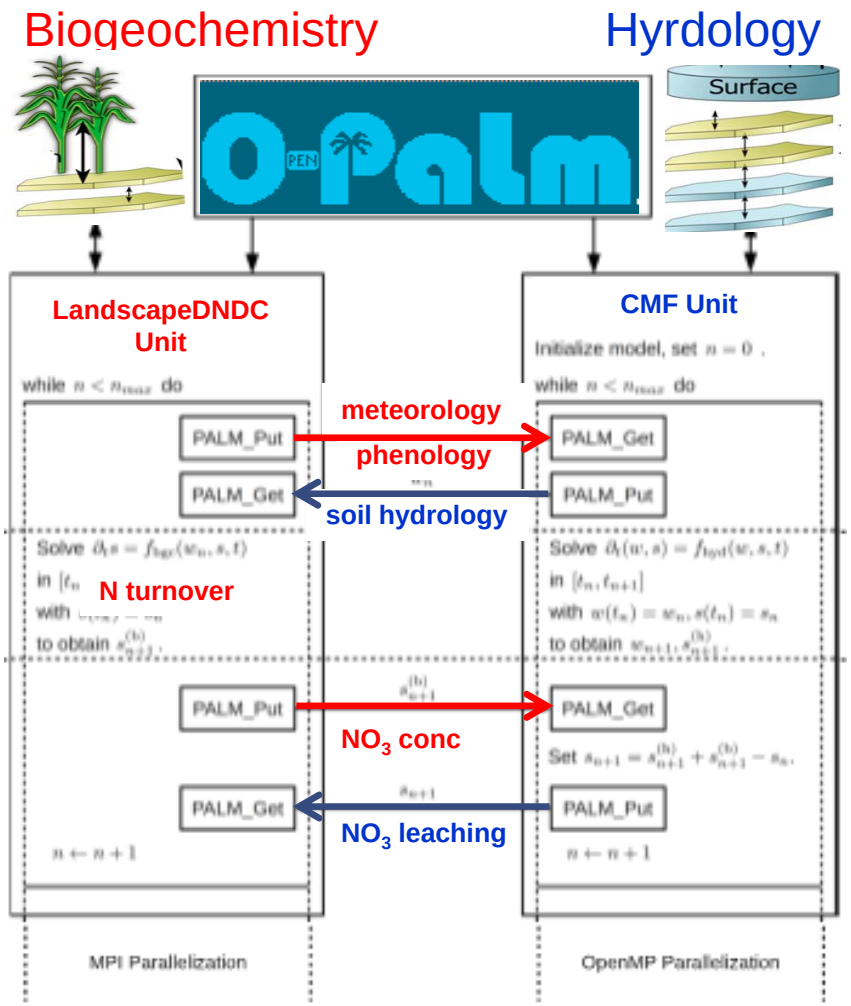
1. **Increased peak flows of nitrate**
2. **Summer drought** causes retarded tree regeneration
   Less N-uptake and **more water percolation in winter** causes **higher seepage nitrate concentrations during understorey reinitiation**
3. **Mature forests have a higher growth rate under climate change** and therefore **retain nitrate more efficiently**

Dirnböck et al. in preparation

Coupled biogeochemical-hydrological model

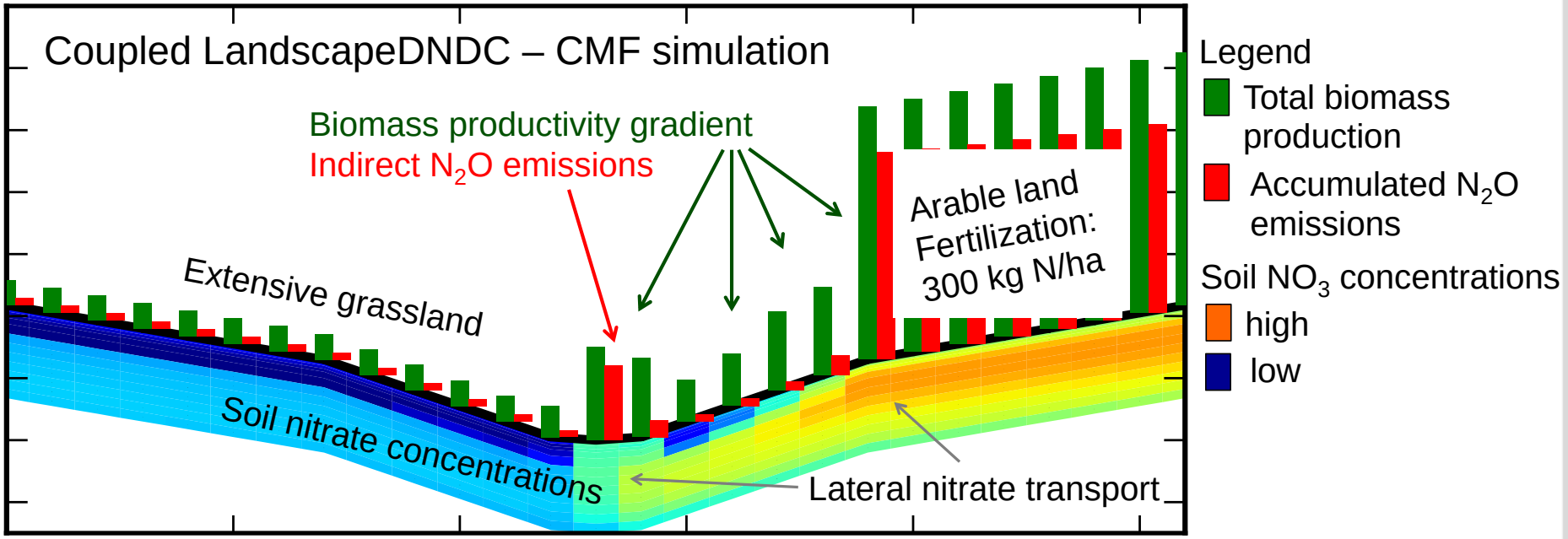
regional water fluxes





ralf.kiese@kit.edu

LandscapeDNDC coupled to reg. hydrological model



ralf.kiese@kit.edu

Thank you

for your attention!

Ralf.kiese@kit.edu

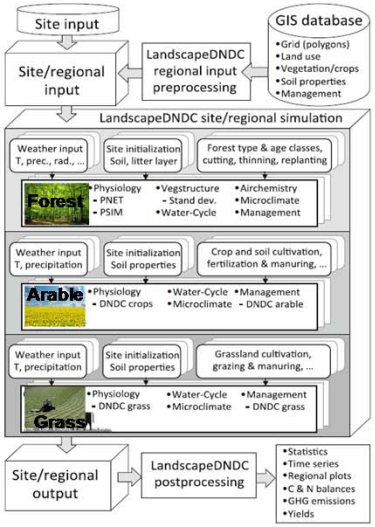
LandscapeDNDC – Uncertainties (regional scale)

- *Parameter Uncertainty*
  - Sampling of 400 joint parameter distributions out of 400 0000
  - ➔ 400 regional inventories

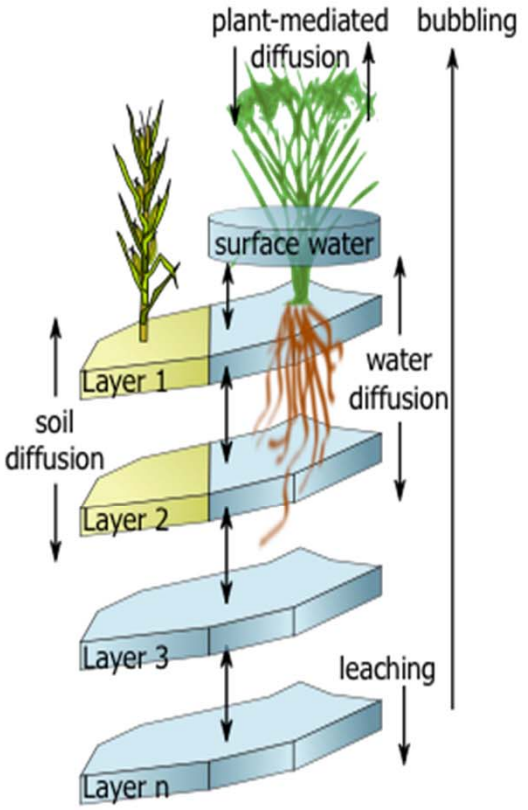
- *Input Uncertainty*
  - Latin hypercube sampling for bulk density, soil carbon content, pH values, hydraulic properties
  - ➔ 525 regional inventories

➔ Nearly 1000 regional inventory simulations

LandscapeDNDC – Model overview



Vertical layering

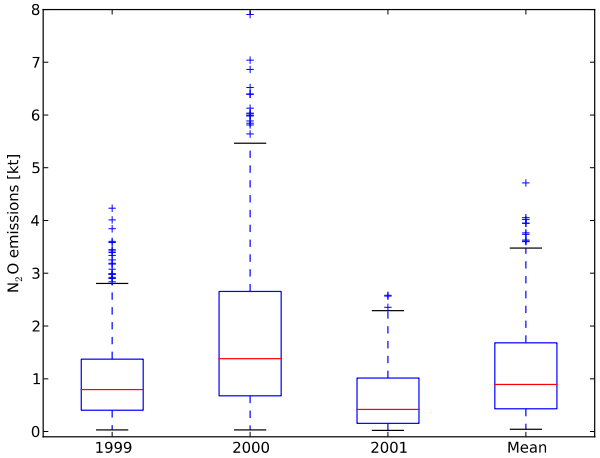


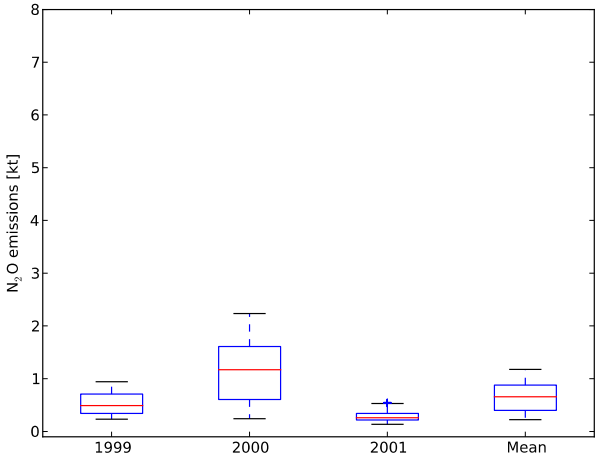
LandscapeDNDC – Parameter Uncertainty
(regional scale)

Parameter induced

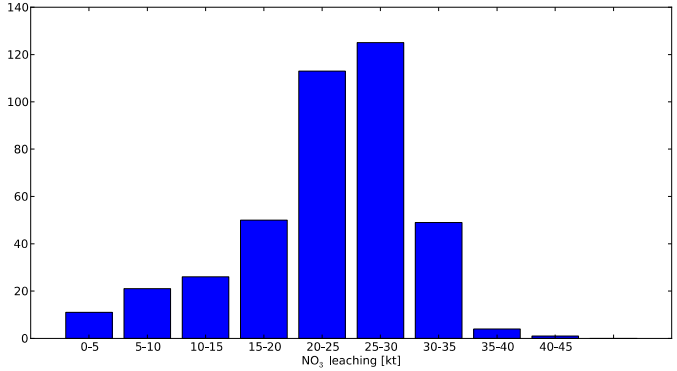
Input Data induced

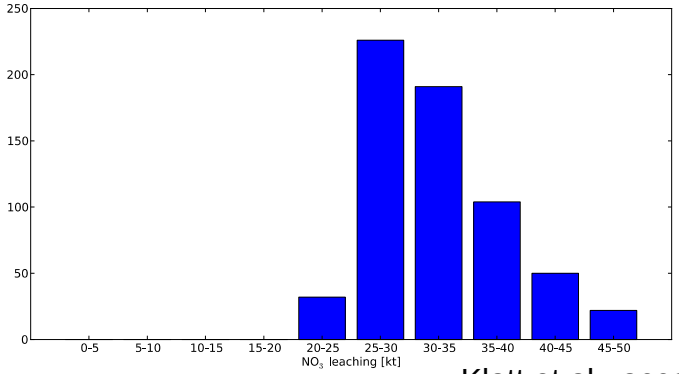
N_2O





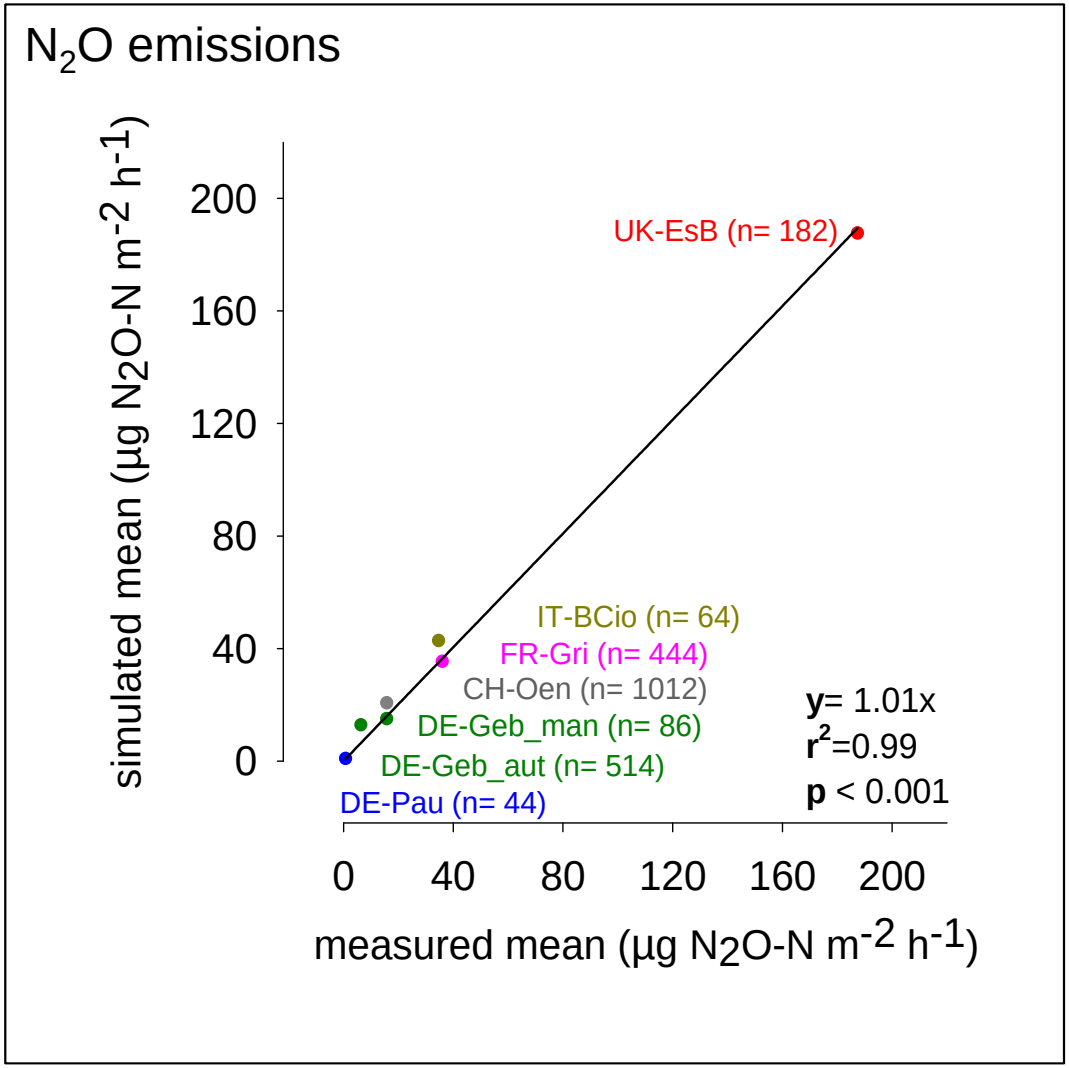
NO_3





Klatt et al., accepted

LandscapeDNDC site validation



Molina et al., in preparation

- Establishing regional modelling for UNFCC Tier III reporting
- Coupling LandscapeDNDC to Hydrology & Air Quality models
- "*Dynamic Farmer*" / agent based modelling to replace static agricultural management prescribed via input data
- …

Comparing Parameter vs Input Data Uncertainty in N2O & NO3 inventory simulations

N_2O emissions [t N/yr]	Parameter induced	Input Data induced
Mean	1 166	644
$Q_{0.25}$	379	400
Median ($Q_{0.5}$)	858	656
$Q_{0.75}$	1 686	878
NO_3 leaching [t N/yr]		
Mean	22 845	32 310
$Q_{0.25}$	19 174	27 990
Median ($Q_{0.5}$)	24 000	31 230
$Q_{0.75}$	28 060	35 990

State of Saxony: area 18 416 km^2, arable cropland: 7 190 km^2

Klatt et al., in preparation

Concept of anaerobic ballon - Nitrogen cycle