Effects of reactive nitrogen in Europe

Ralf Kiese, Klaus Butterbach-Bahl

Institute for Meteorology and
Climate Research (IMK-IFU)
Garmisch-Partenkirchen, Germany

http://imk-ifu.fzk.de/index.php

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Outline

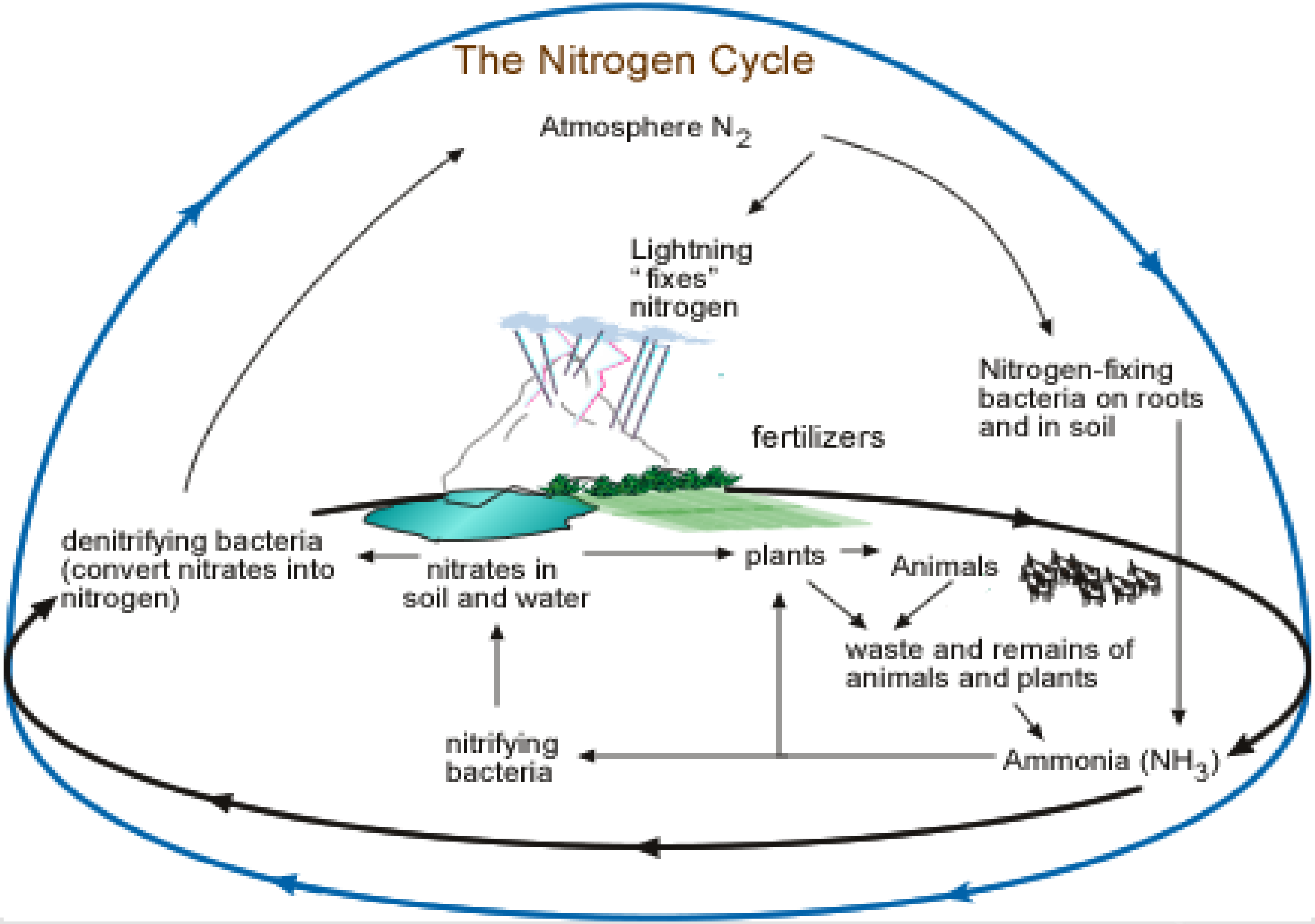
Background information on N cycling and human pertubation

Work of IMK-IFU combined with results of NitroEurope IP

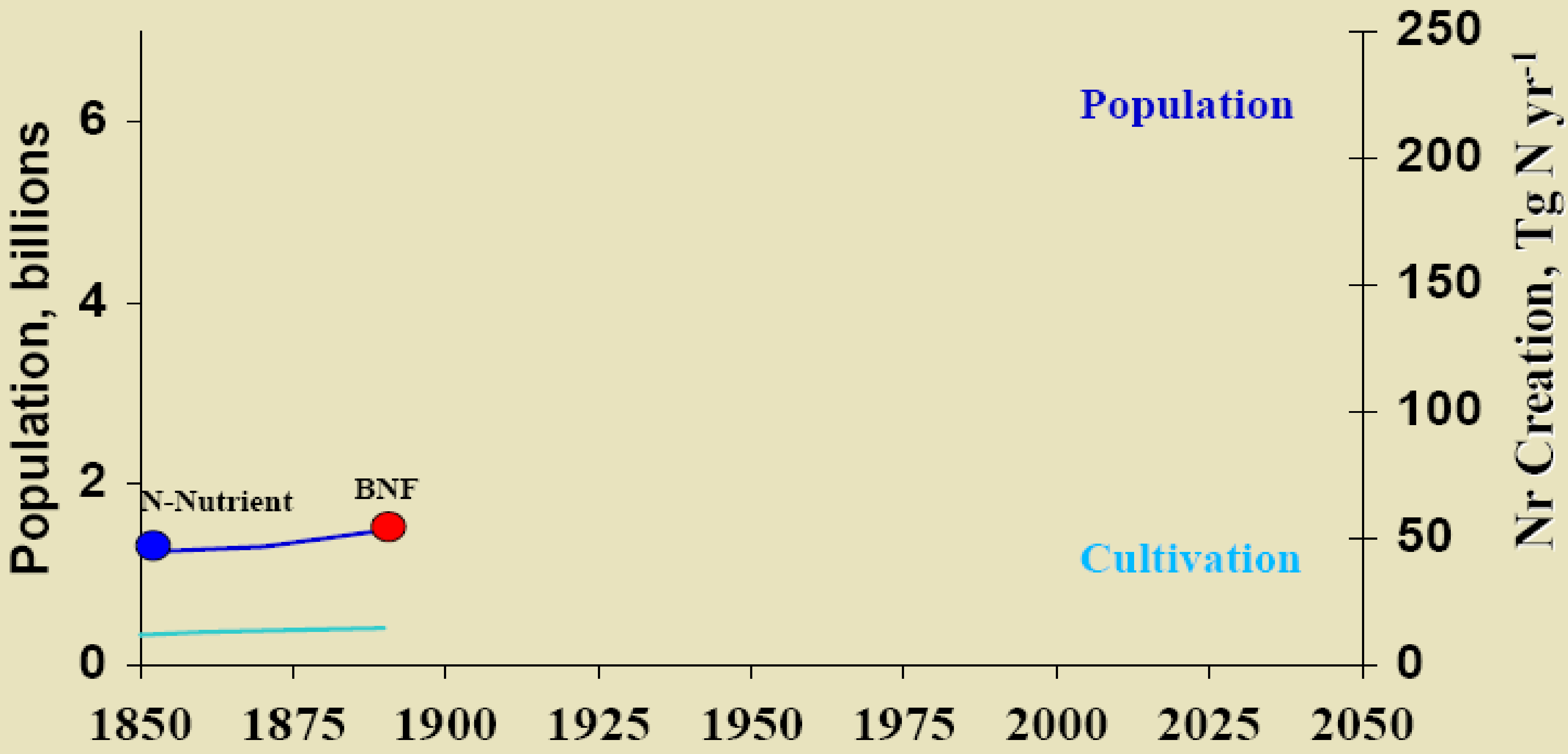
Summary

NitroEurope IP

Globale N-Cycle



Timeline of Global Reactive N Creation by Human Activity 1850 to 2000



Galloway et al., 2003

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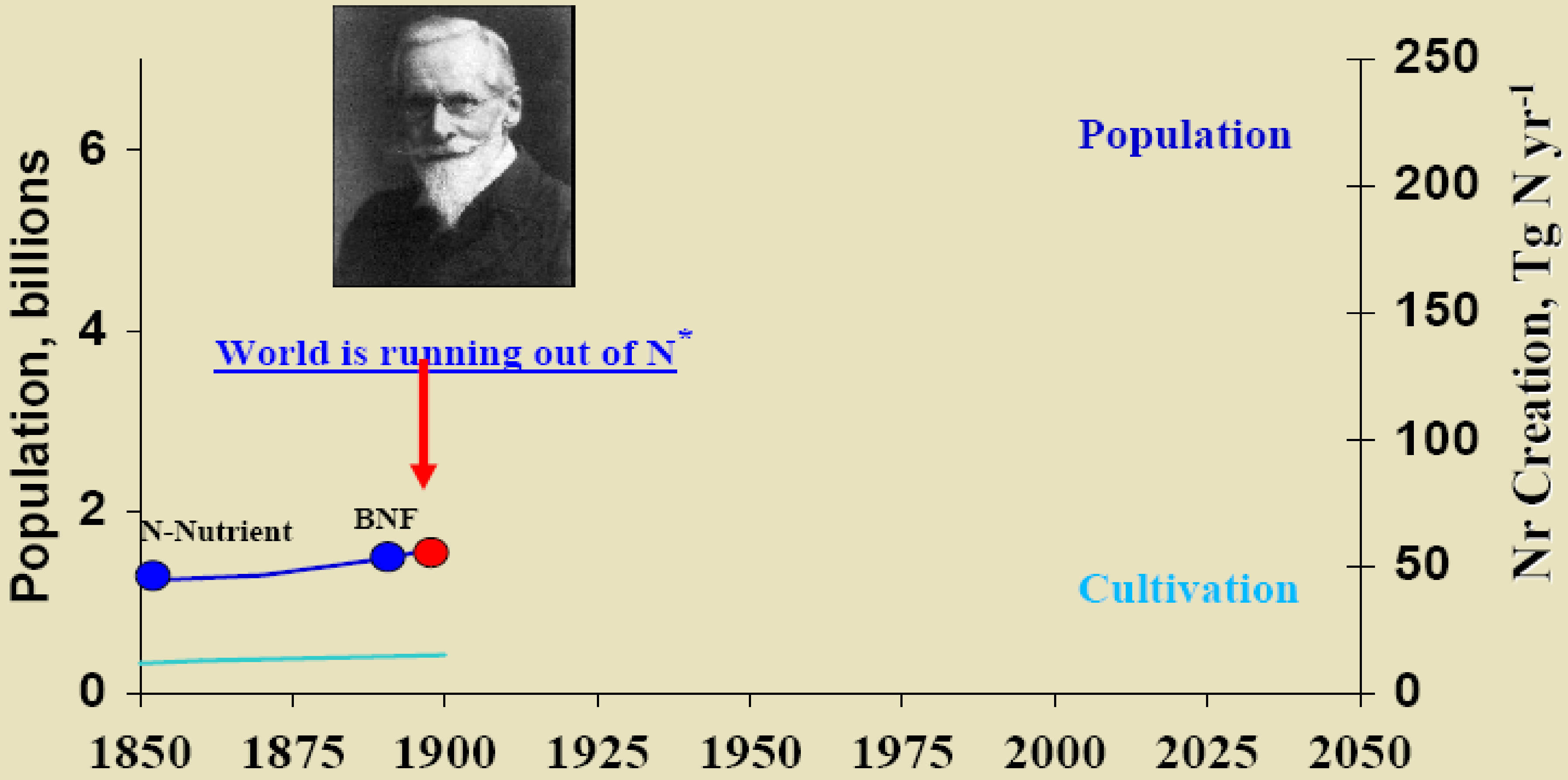
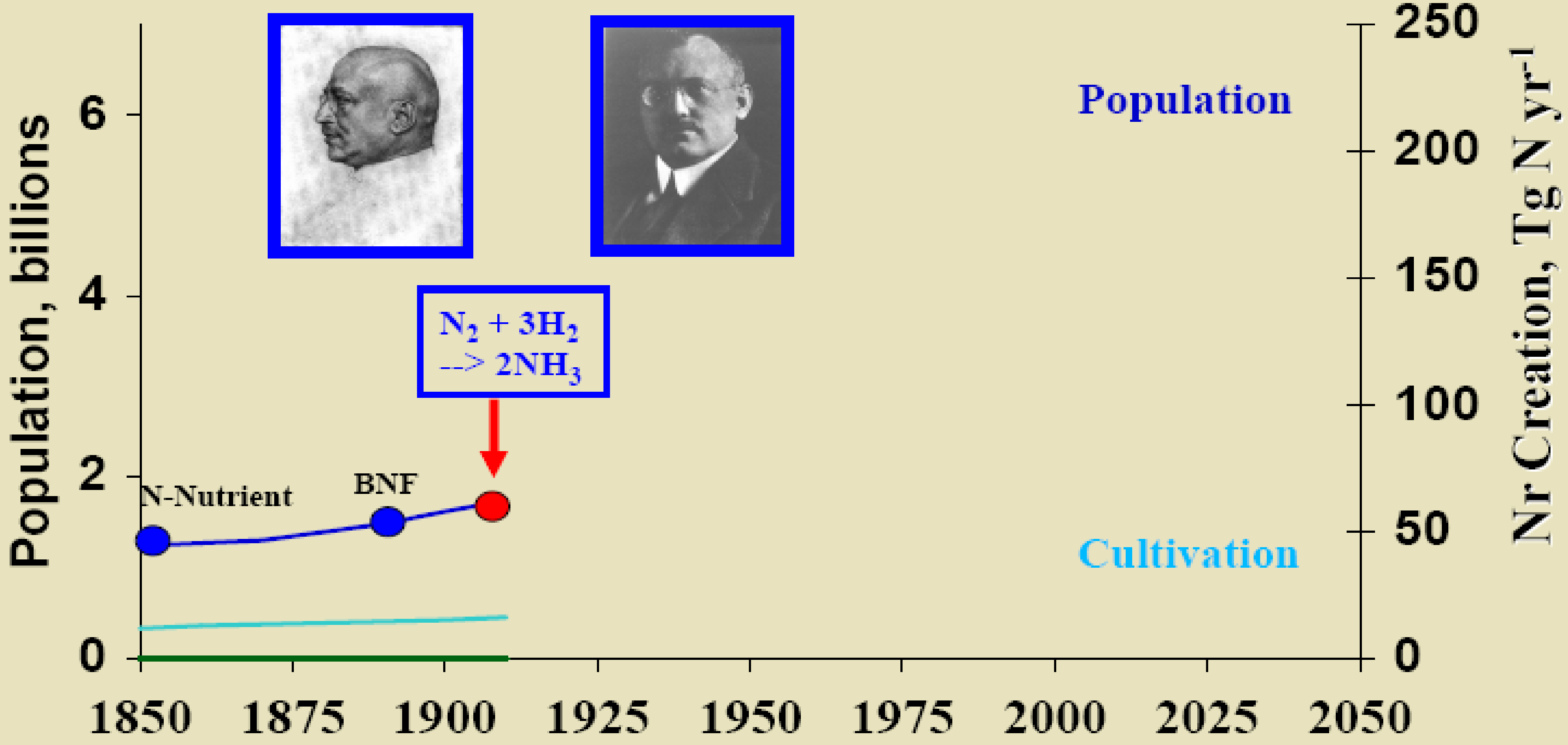


*1898, Sir William Crookes, president of the British Association for the Advancement of Science

Galloway et al., 2003

Timeline of Global Reactive N Creation by Human Activity 1850 to 2000



Galloway et al., 2003

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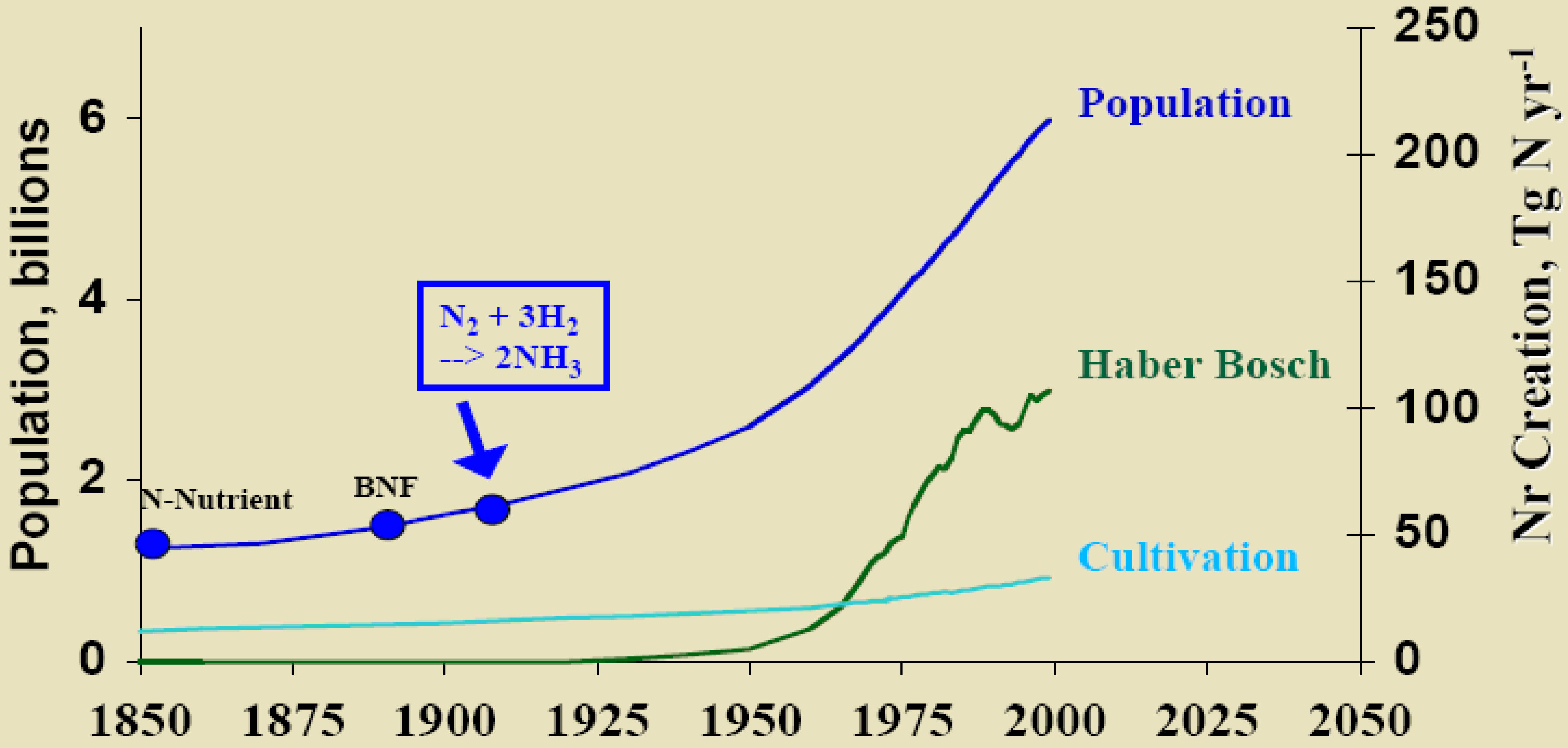
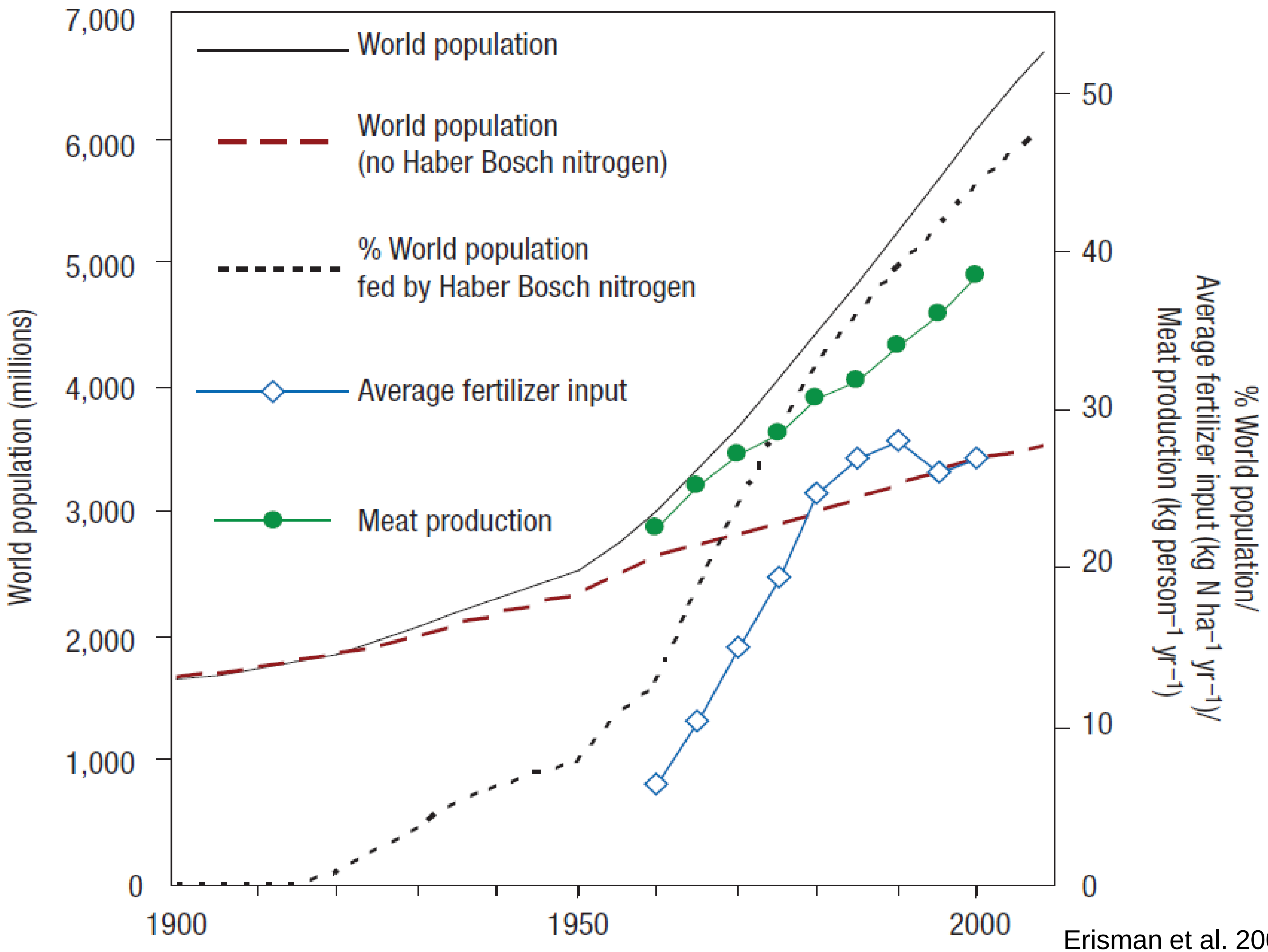


Galloway et al., 2003

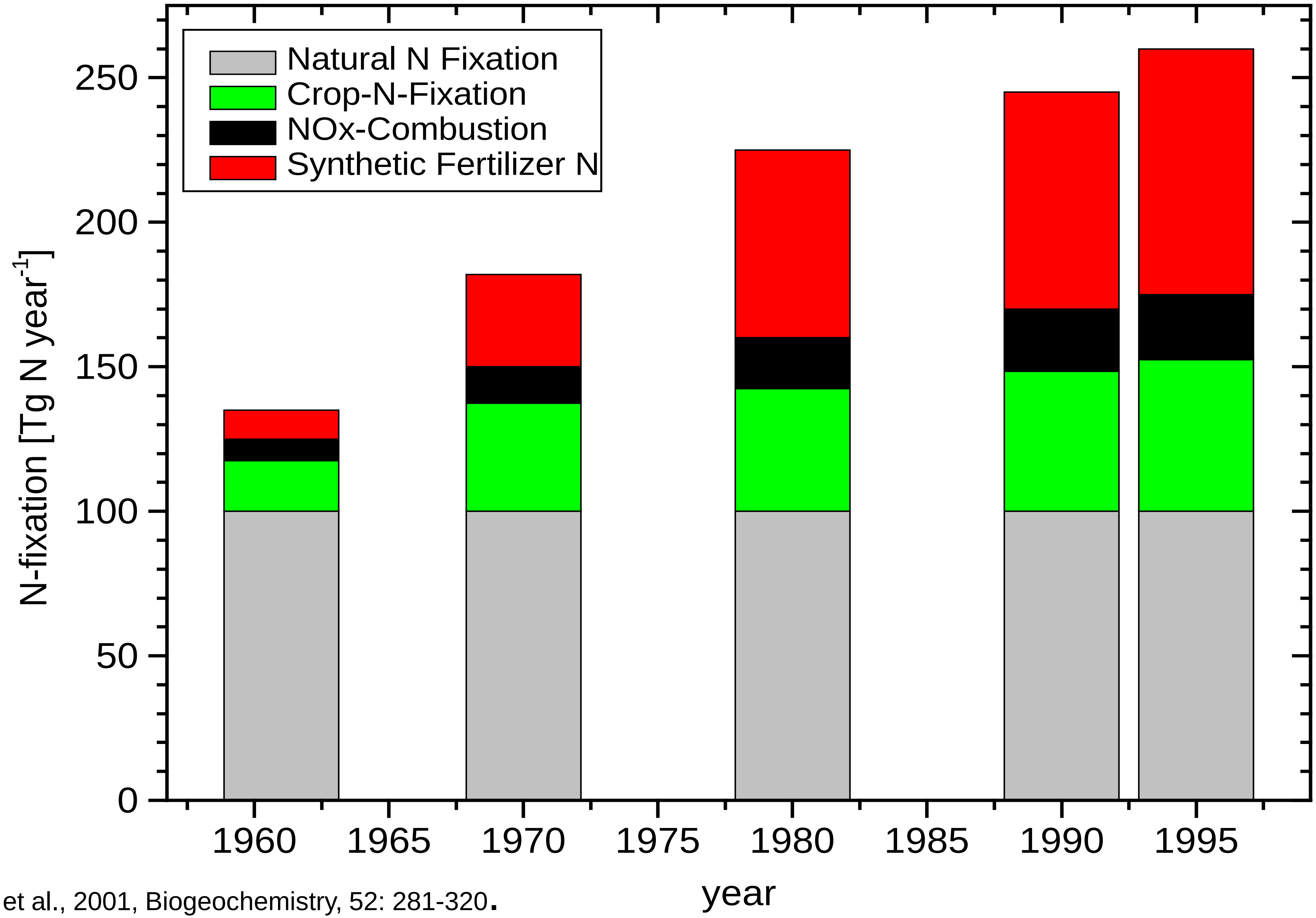
Nitrogen, food/feed production and population growth



Erisman et al. 2008, Nature Geosciences

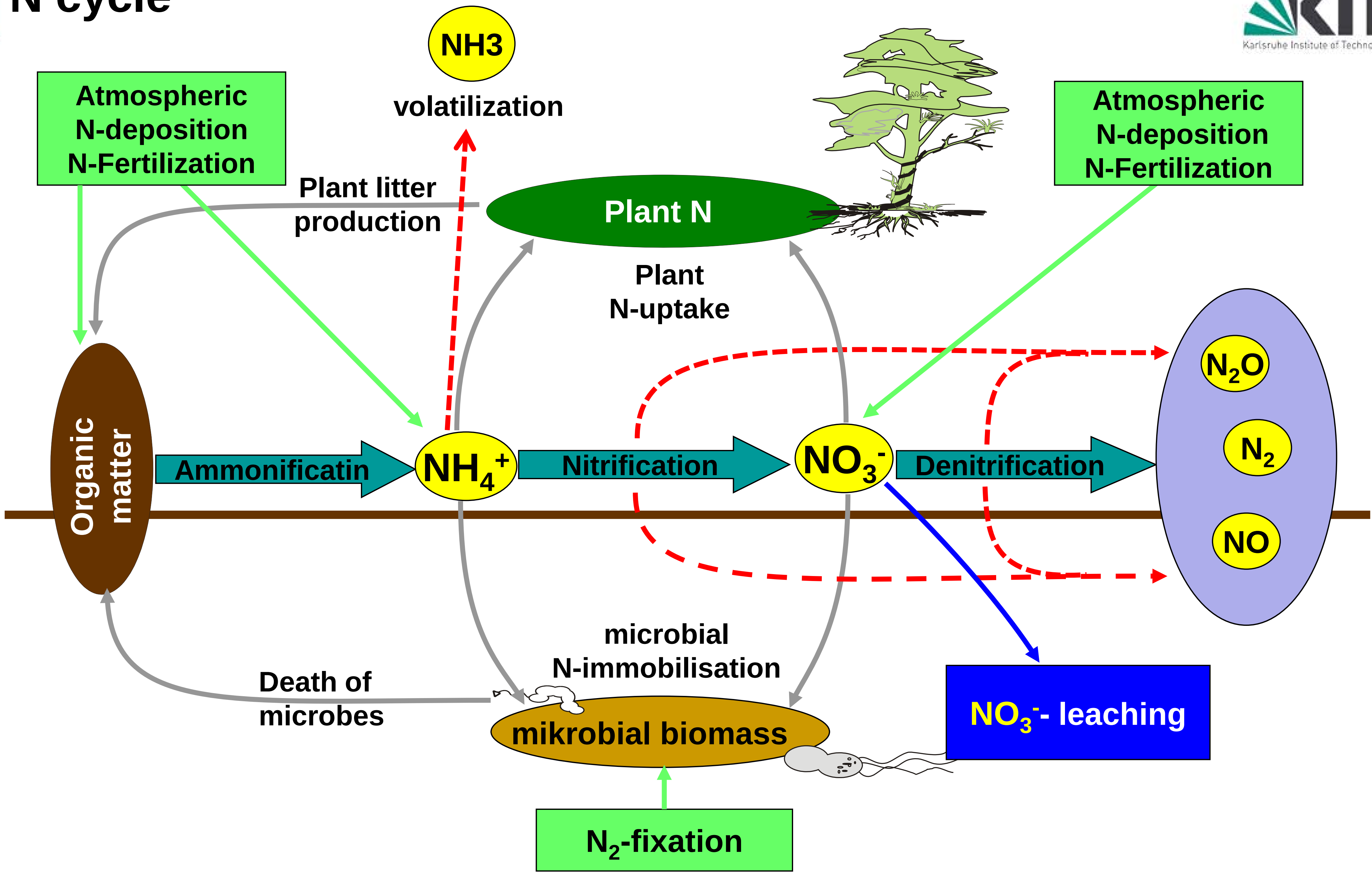
 Ralf.Kiese@kit.edu

Global Nitrogen-Fixation



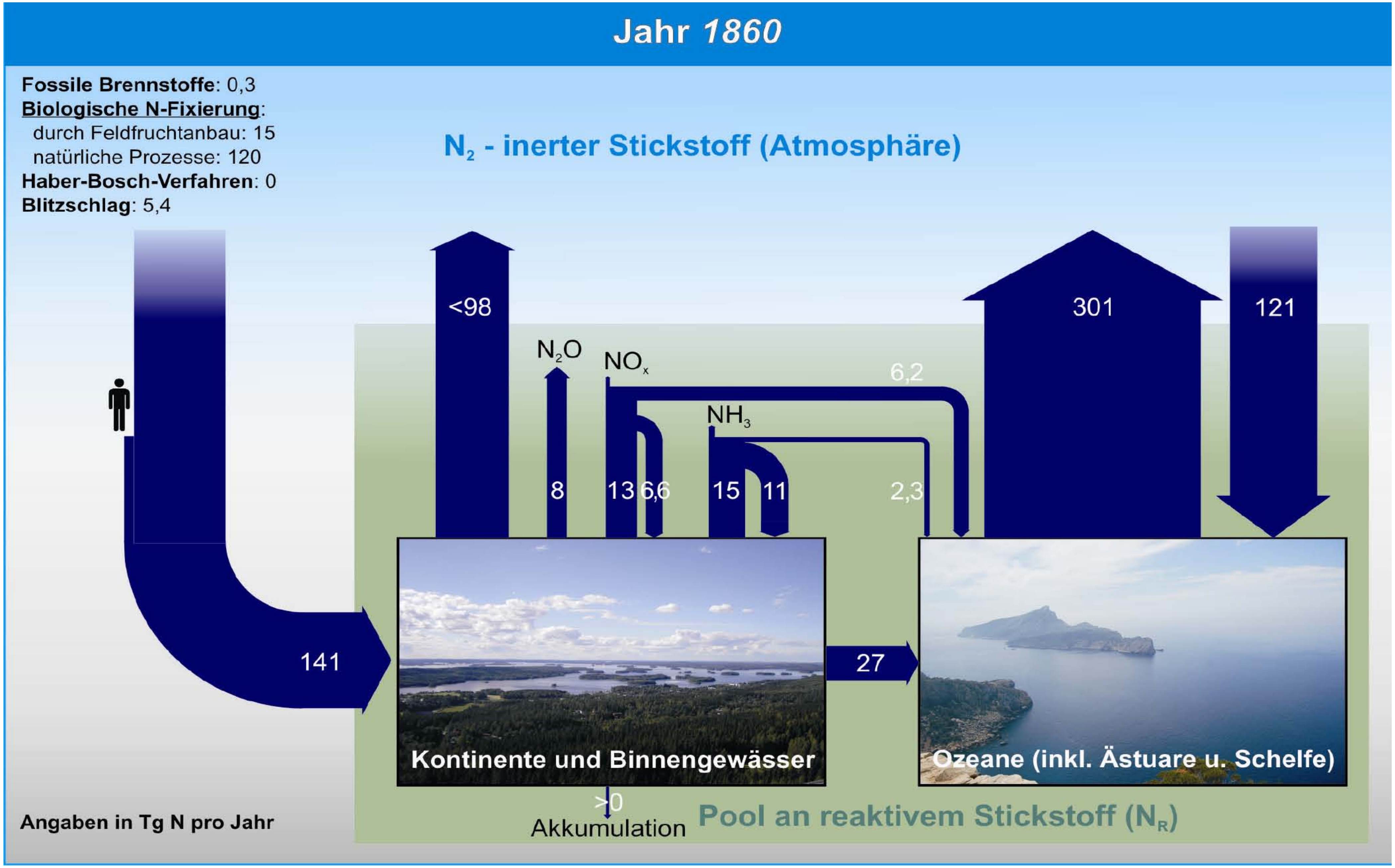
Mosier et al., 2001, Biogeochemistry, 52: 281-320.

N cycle



NH3
volatilization
Atmospheric N-deposition N-Fertilization
Plant litter production
Plant N
Atmospheric N-deposition N-Fertilization
Plant N-uptake
Organic matter
Ammonificatin
NH_4^+
Nitrification
NO_3^-
Denitrification
N_2O
N_2
NO
microbial N-immobilisation
Death of microbes
mikrobial biomass
NO_3^-- leaching
N_2-fixation

The Global Nitrogen Budget in 1860, TgN/yr



Butterbach-Bahl et al. 2010

The Global Nitrogen Budget in 1995, TgN/yr

Karlsruhe Institute of Technology

Jahr *1995*

Fossile Brennstoffe: 24,5
Biologische N-Fixierung:
durch Feldfruchtanbau: 31,5

[redacted]

Butterbach-Bahl et al. 2010

The European Nitrogen Budget in 1900 and 2000, TgN/yr

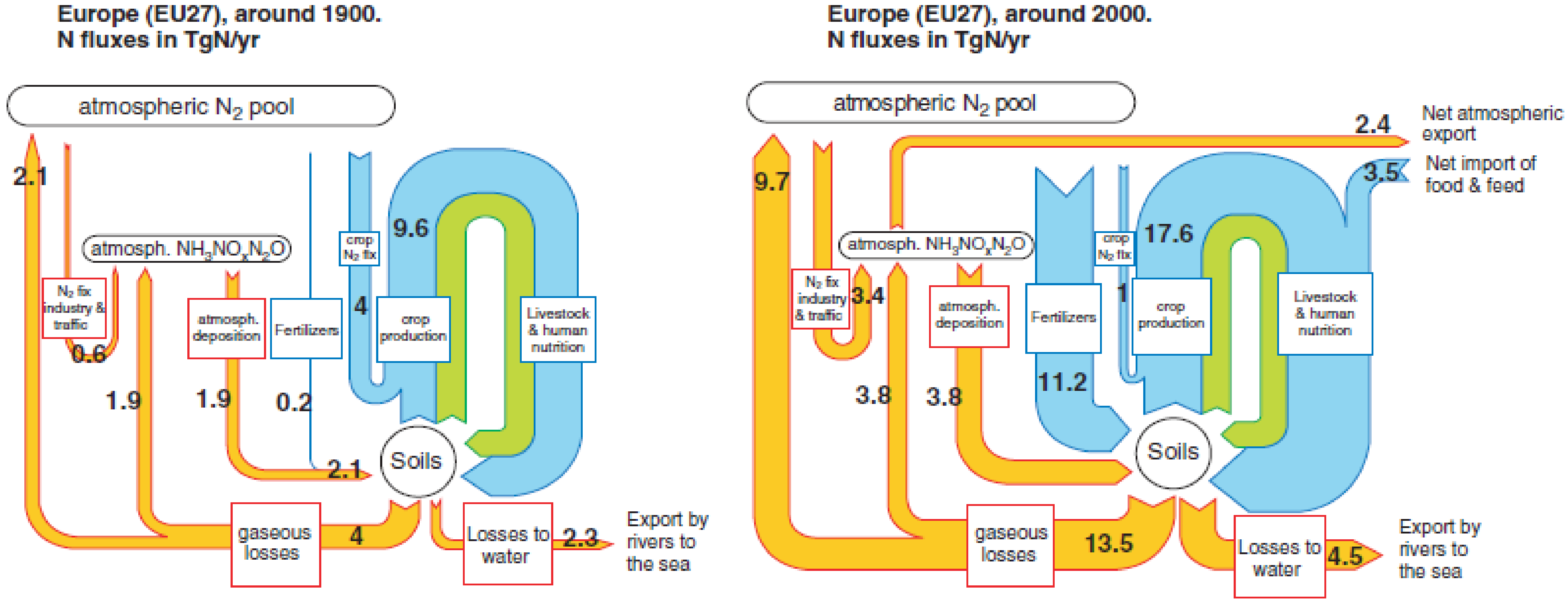
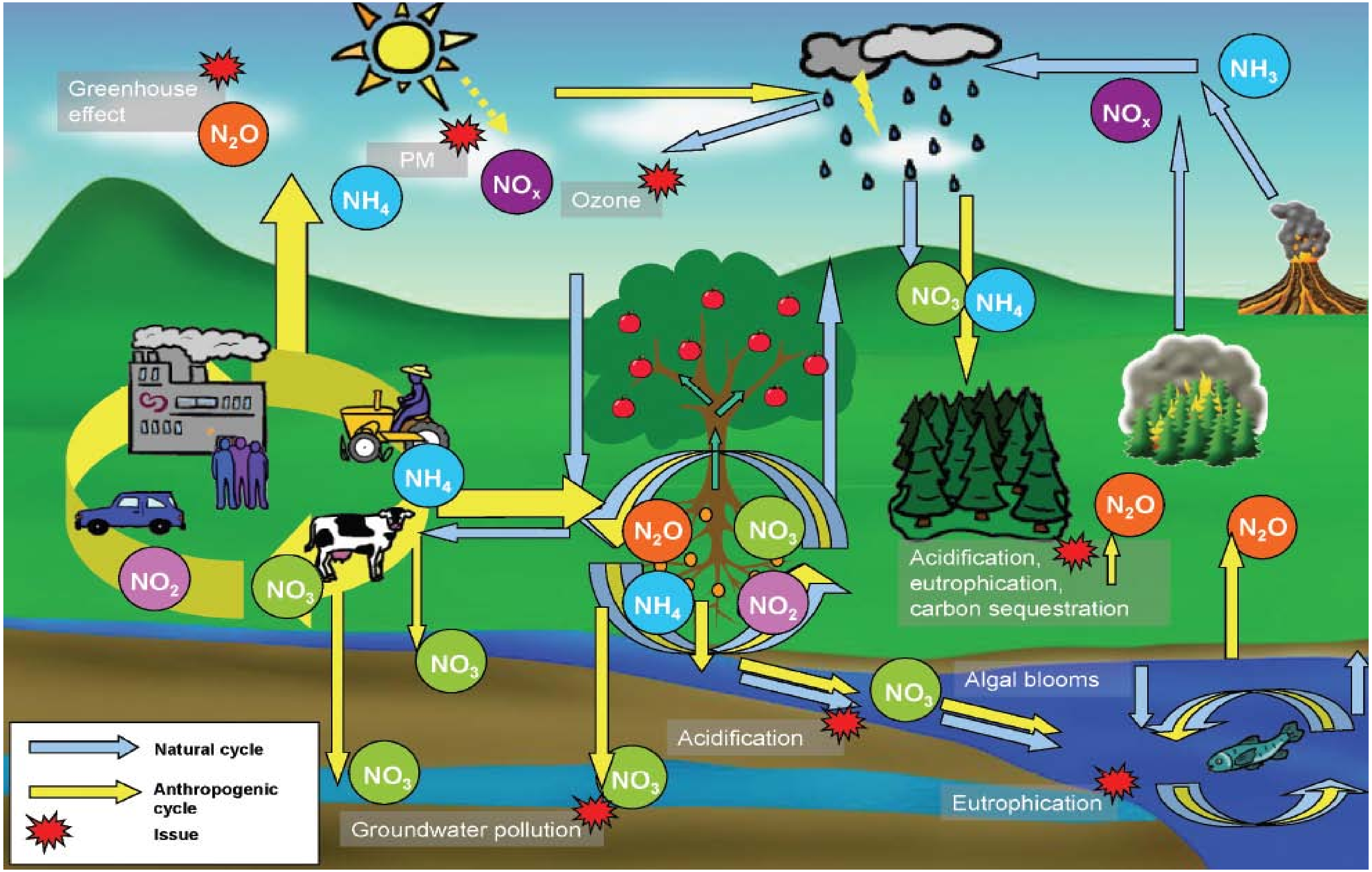


Figure SPM.3 Simplified comparison of the European nitrogen cycle (EU-27) between 1900 and 2000. Blue arrows show intended anthropogenic nitrogen flows; orange arrows show unintended nitrogen flows; green arrows represent the nearly closed nitrogen cycle of natural terrestrial systems [16.4 and 16 supplementary material].

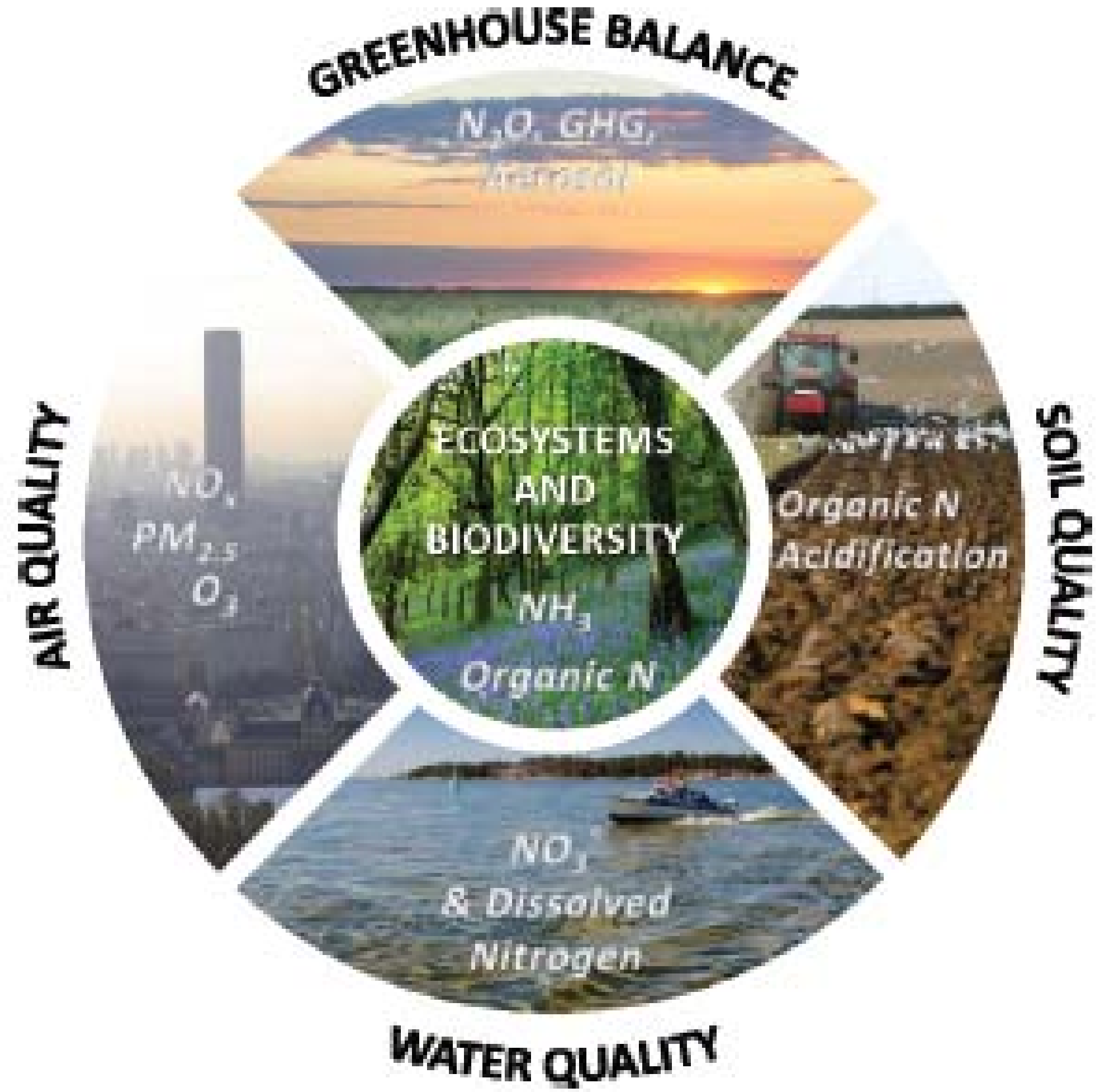
ENA, 2011

Nitrogen Cycle / Nitrogen cascade



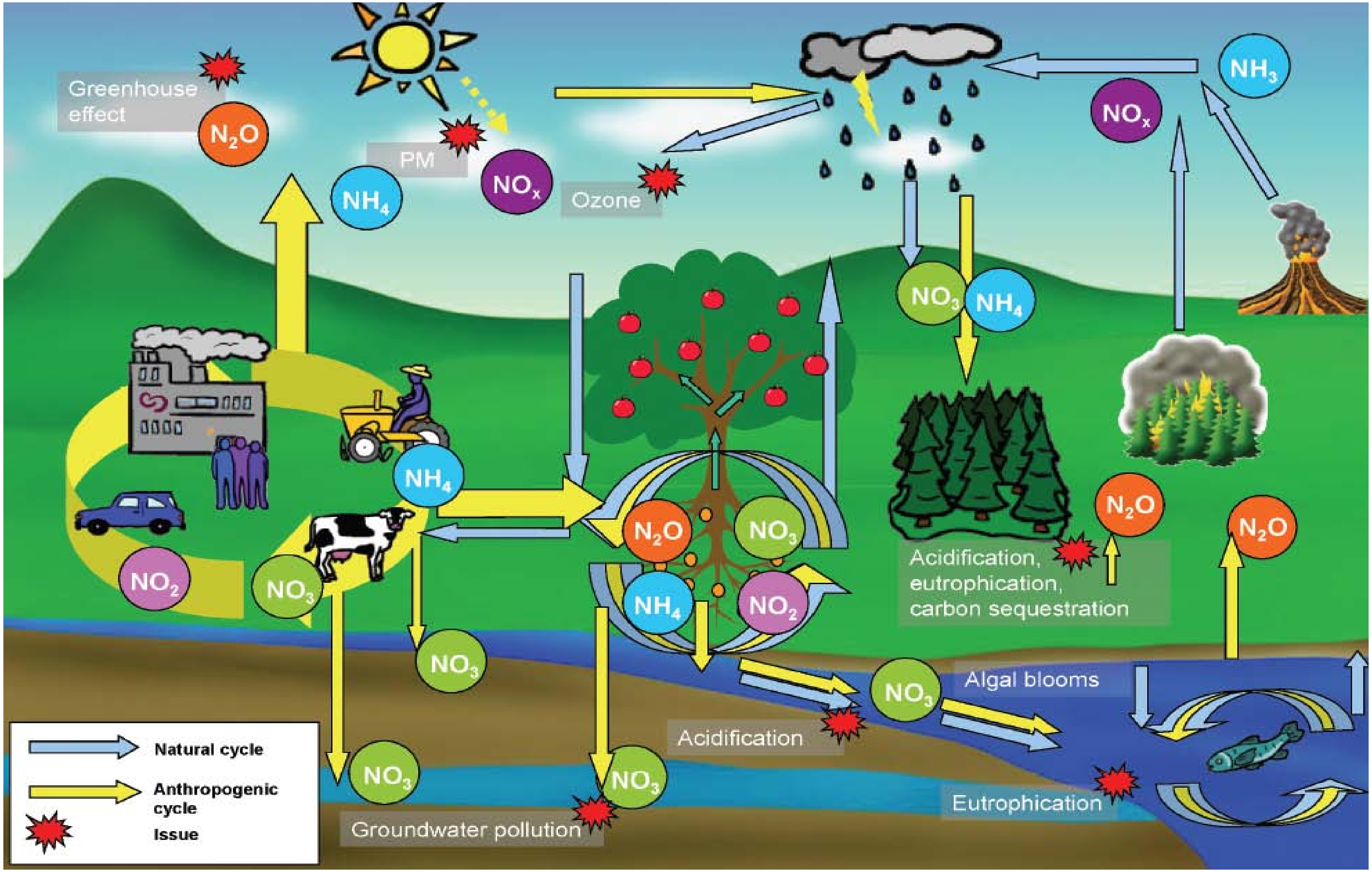
ENA, 2011

Five key social treats of excess reactive nitrogen



ENA, 2011

Nitrogen Cycle / Nitrogen cascade



ENA, 2011

Research Interests of IMK-IFU
Linking methods – bridging scales

Karlsruhe Institute of Technology

Exploration in space

Process studies

Parametrization

Field Measurements

Validation

Modelling Landscape-DNDC

Upscaling

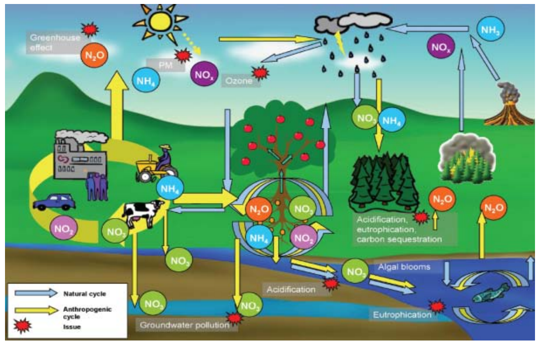
GIS

Regional Simulations

+ Coupled hydrological model

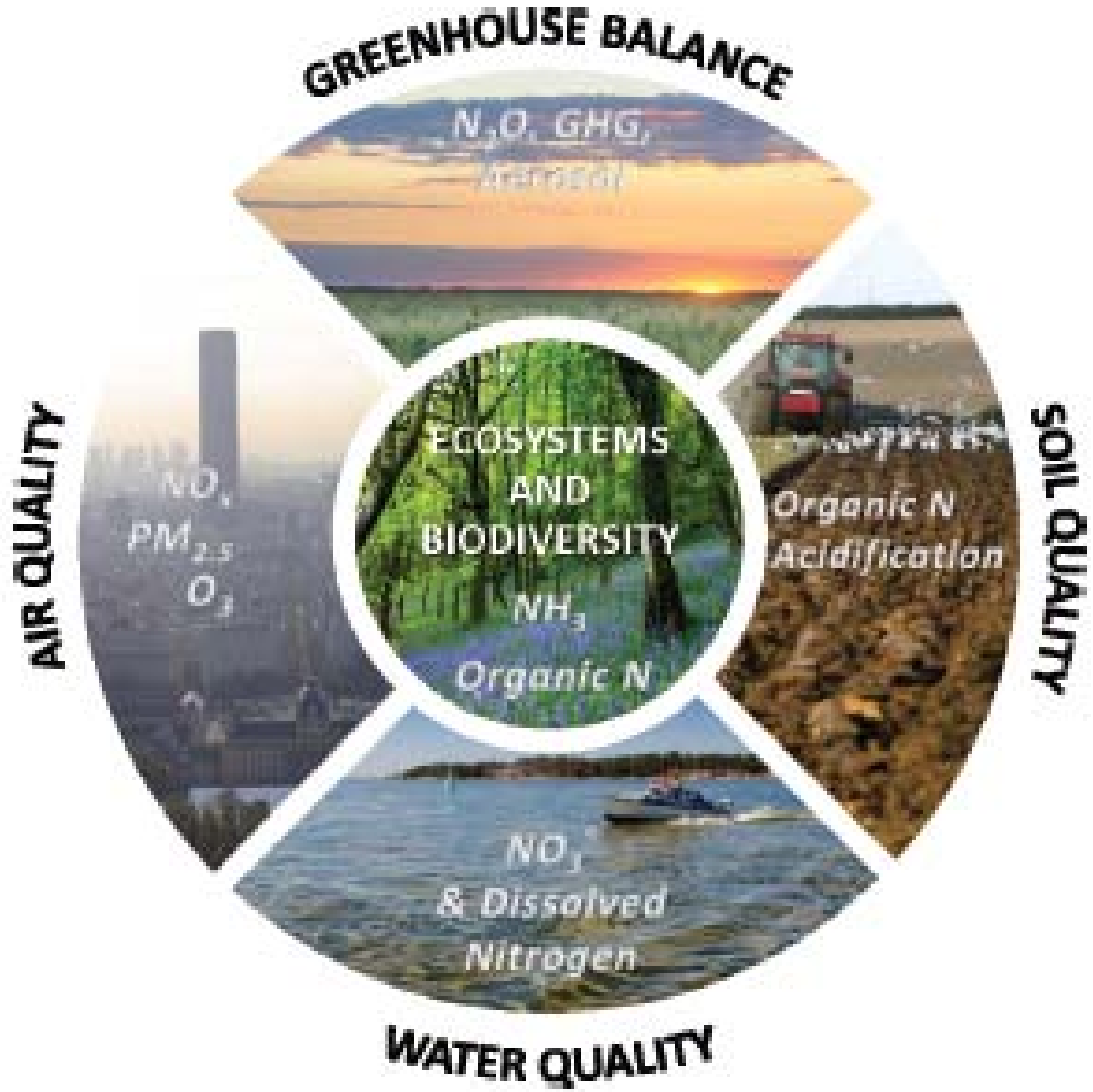
Uncertainty analysis

Site simulations



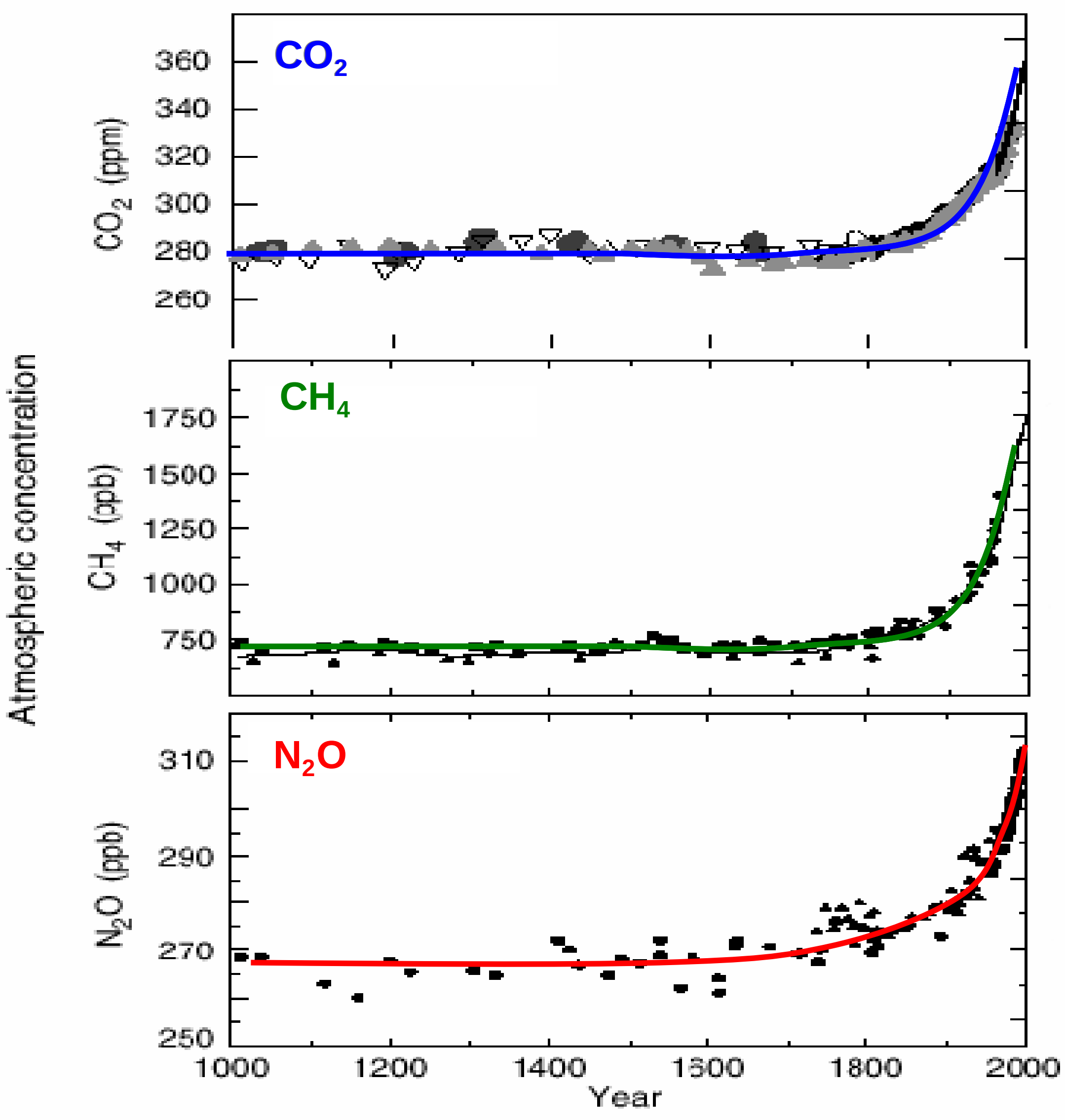
Exploration in time

Research Interests of IMK-IFU
Biosphere-Atmosphere Exchange of GHGs



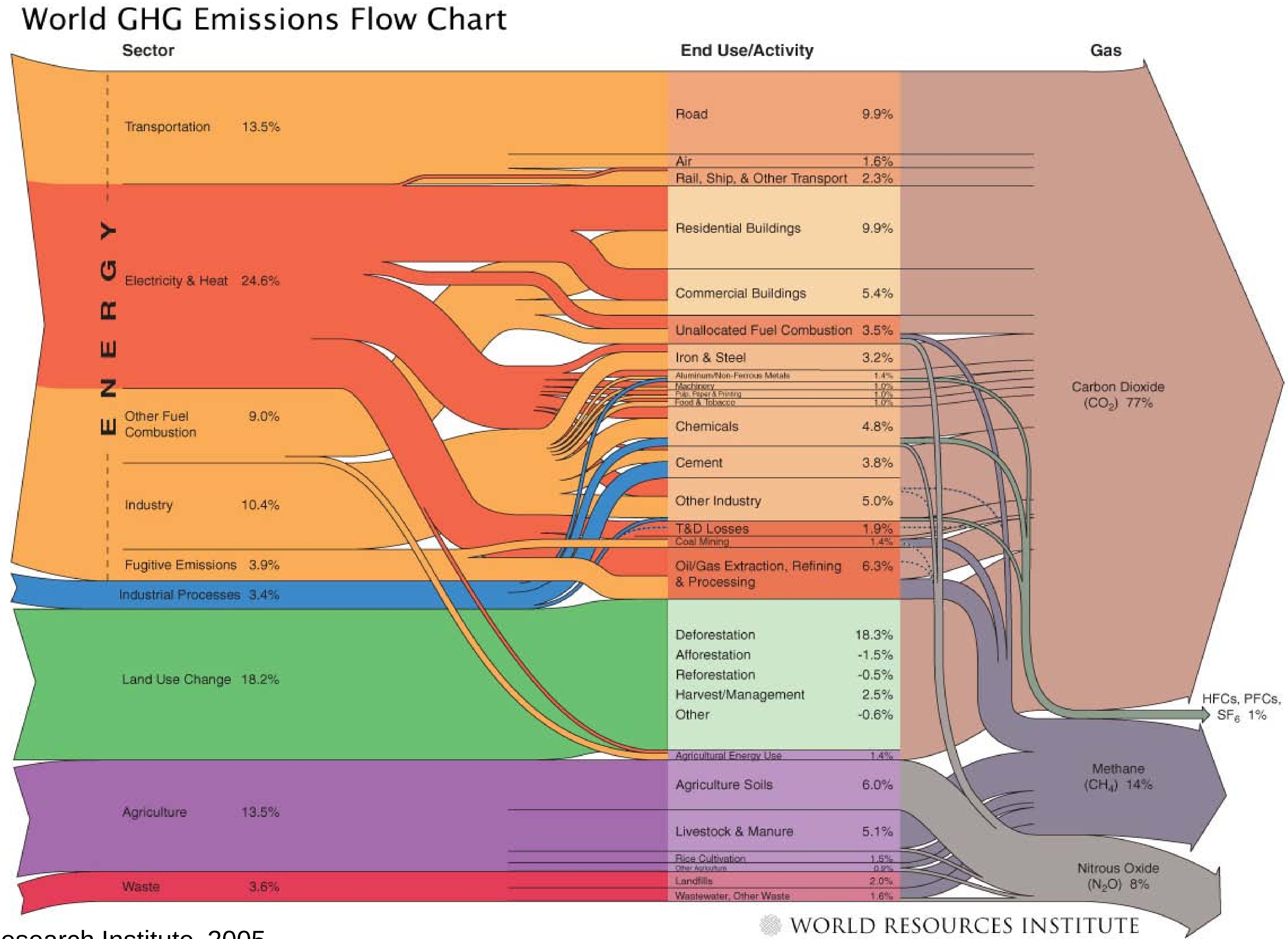
ENA, 2011

Motivation



 Ralf.Kiese@kit.edu

Motivation



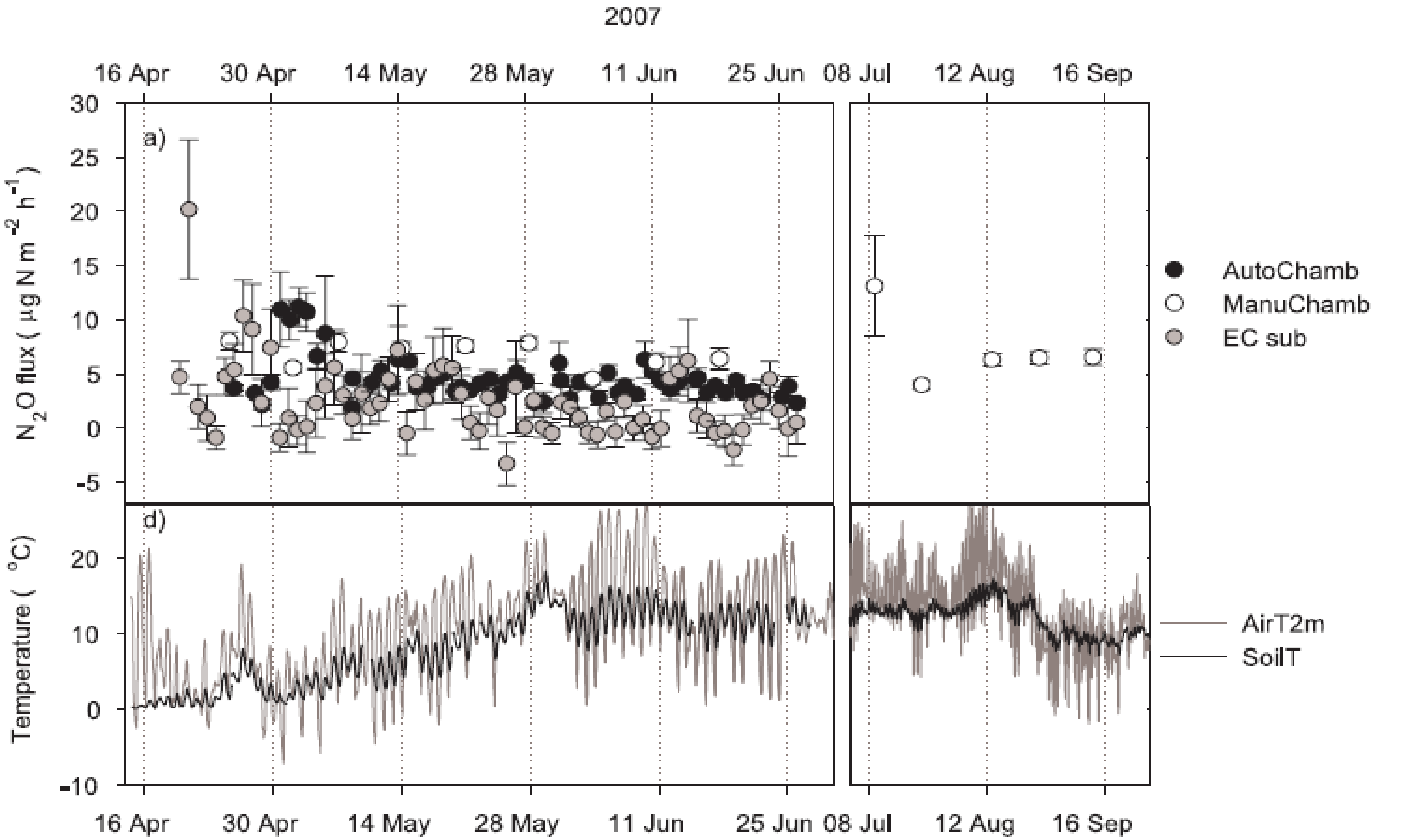
World Research Institute, 2005

Research Interests of IMK-IFU
Linking methods – bridging scales

Field
Measurements

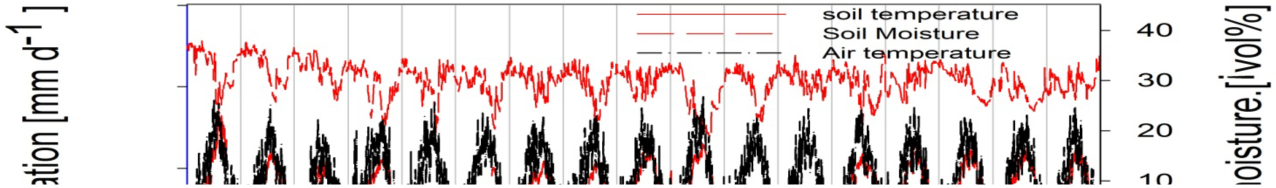
Measuring Principals of GHG fluxes:

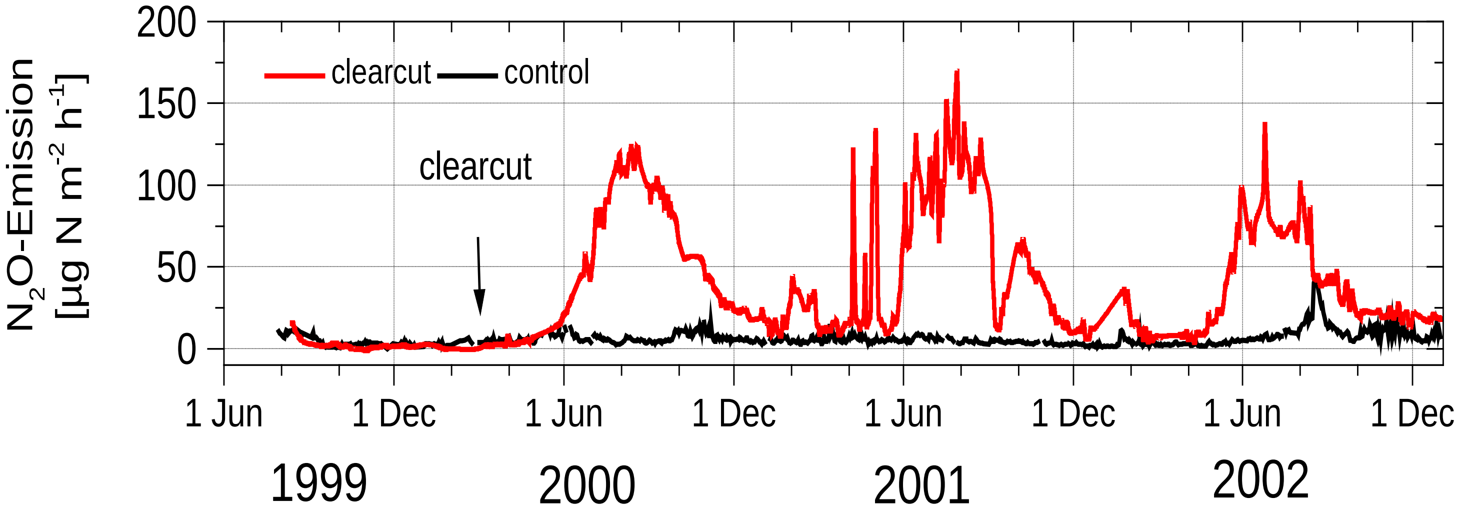
1.) chamber measurements

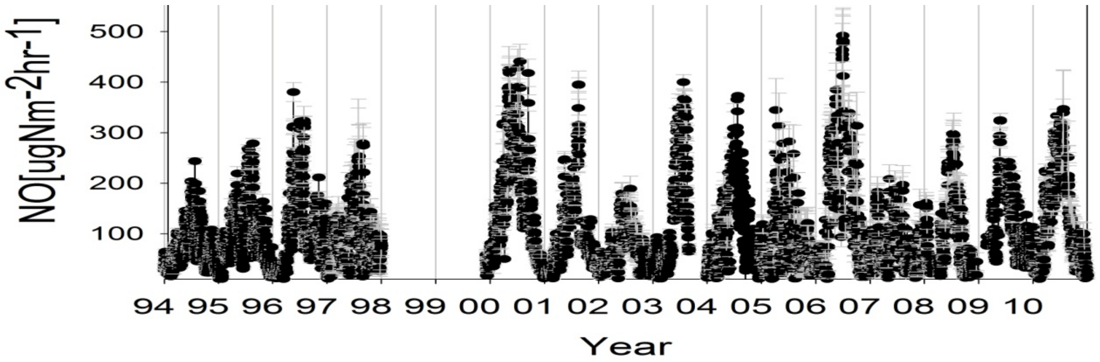


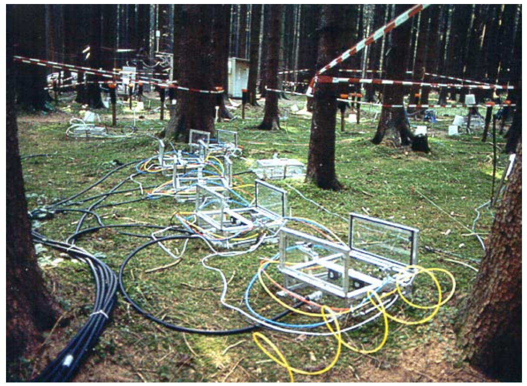
Höglwald , spruce forest, Germany

TODO
Bild Umland Hw









 Ralf.Kiese@kit.edu

Research Interests of IMK-IFU
Linking methods – bridging scales

Process studies

Field Measurements

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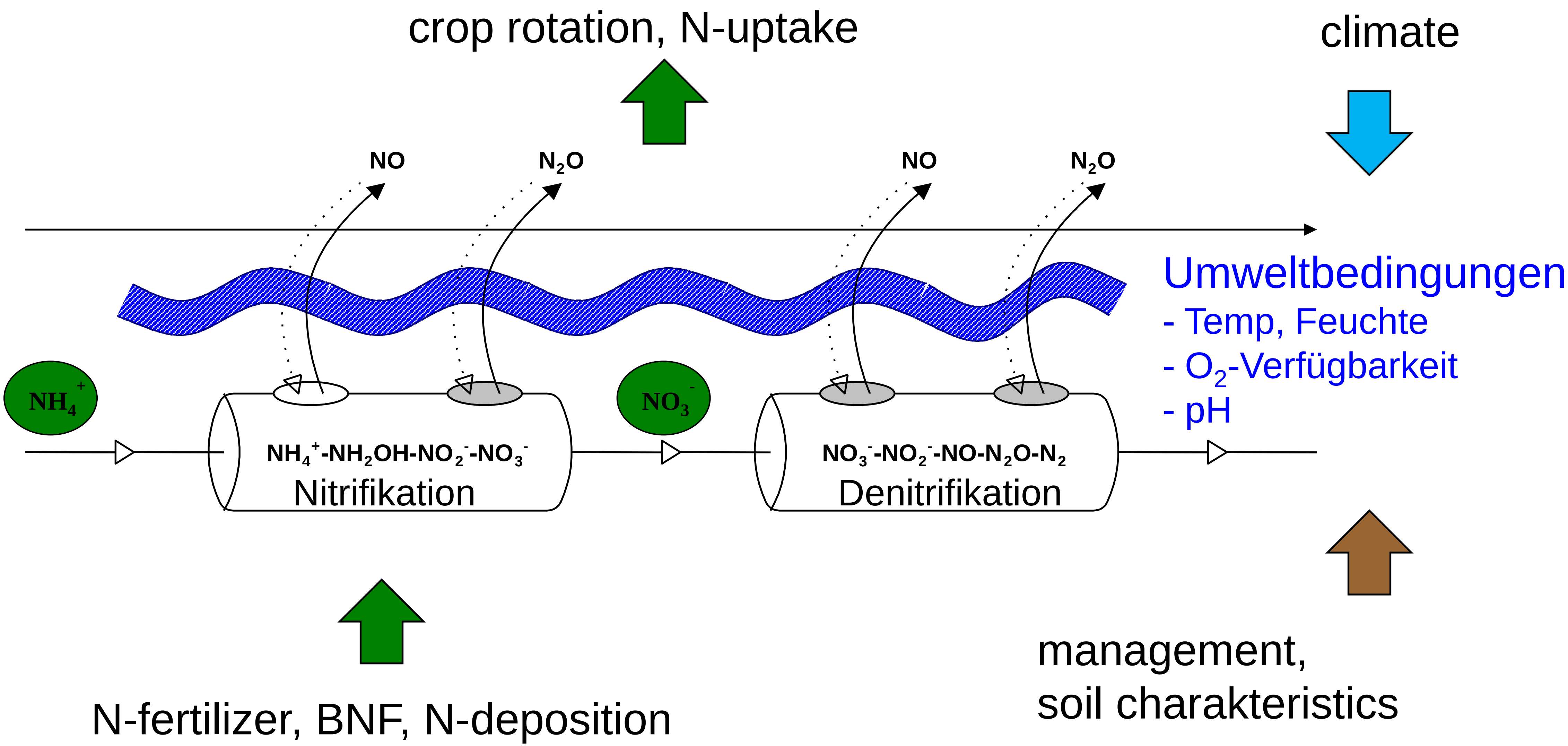
Research Interests of IMK-IFU
Linking methods – bridging scales



Modified after Davidson, 1991

Process studies by use of stable isotopes 15N/14N

KIT Karlsruhe Institute of Technology

15Nnatural abundance in soil-N-pools
= c. 0,363 Atom%

30% ^{15}N

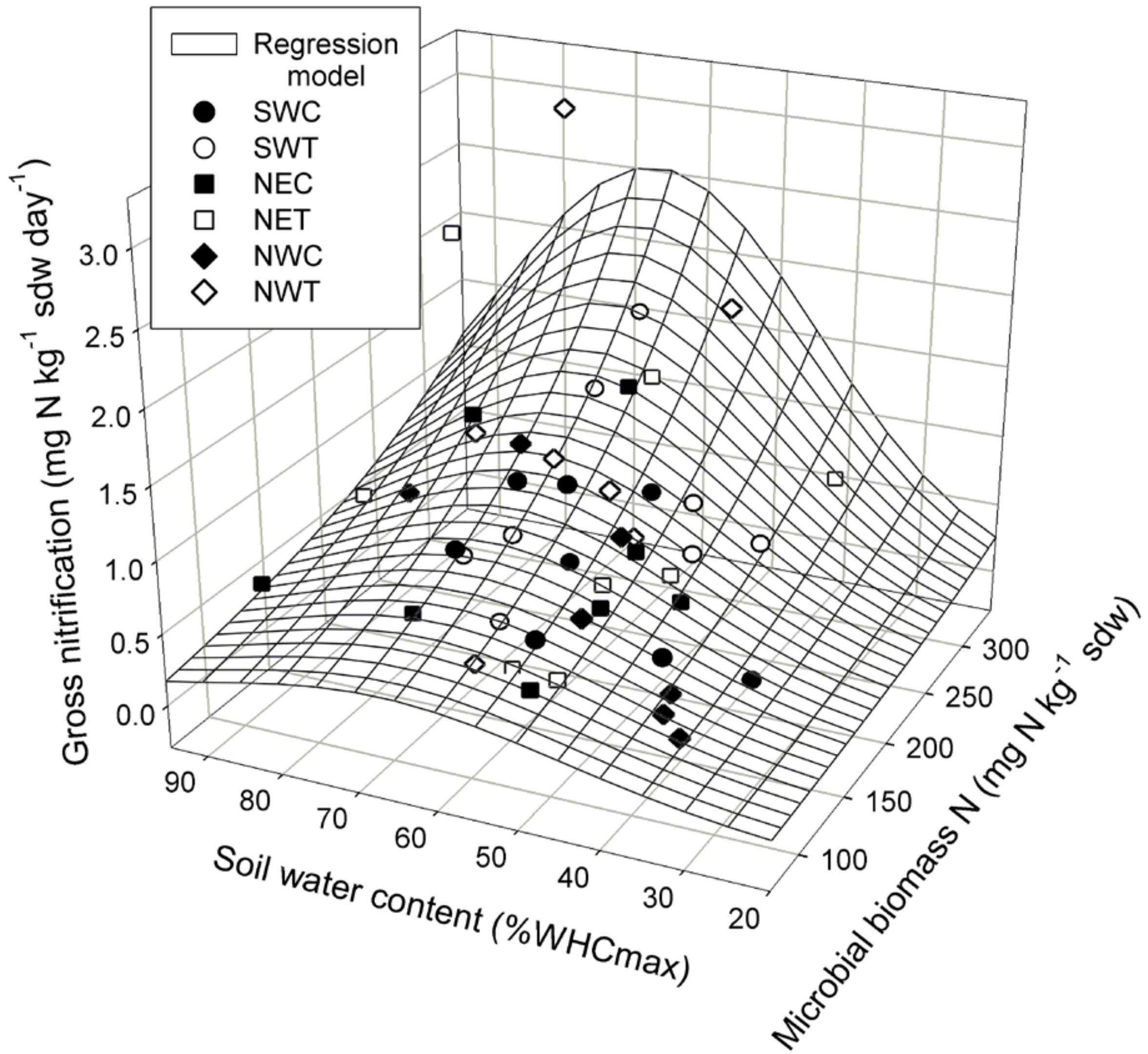
NH_4^+ → Nitrification → NO_3^-

$^{15}N/^{14}N$ decreases

$$\text{Nitr} = \frac{({}^{14+15}NO_{3\ t1}^{-} - {}^{14+15}NO_{3\ t2}^{-})}{(t_2 - t_1)} * \frac{\log({}^{15}NO_{3\ t1}^{-} * {}^{14+15}NO_{3\ t2}^{-} \ / \ {}^{15}NO_{3\ t2}^{-} * {}^{14+15}NO_{3\ t1}^{-})}{\log({}^{14+15}NO_{3\ t1}^{-} \ / \ {}^{14+15}NO_{3\ t2}^{-})}$$

(Kirkham+Bartholomew 1954)

Process studies by use of stable isotopes 15N/14N



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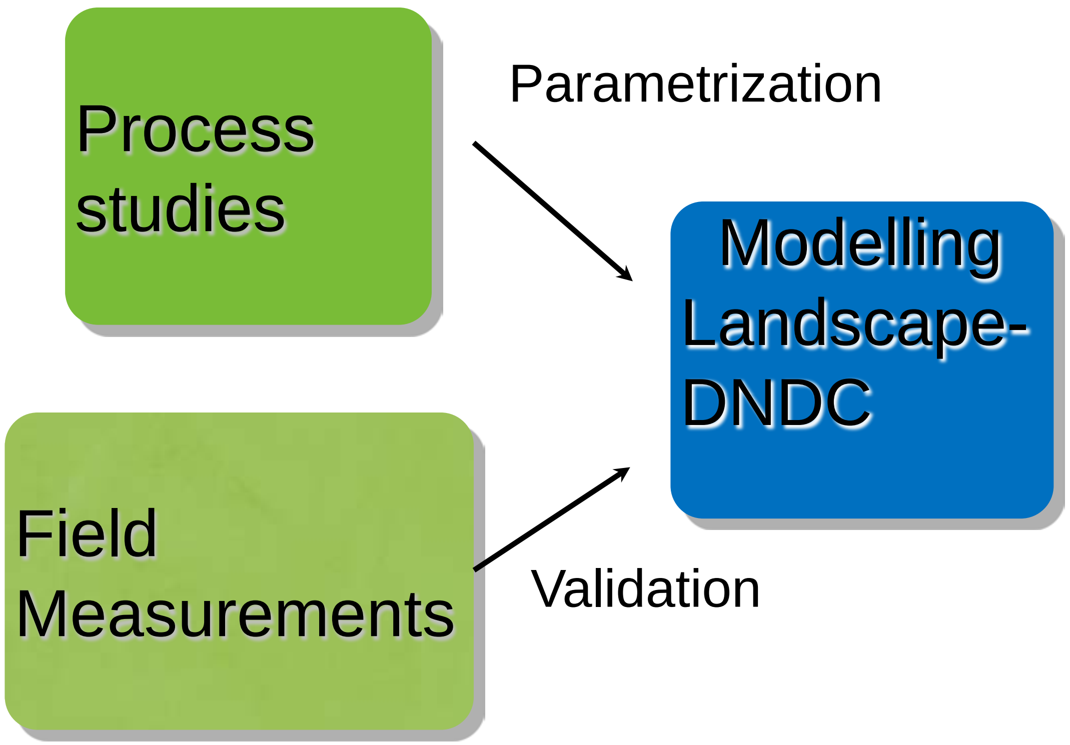
Research Interests of IMK-IFU
Linking methods – bridging scales



Modell approaches

EF Approach: IPCC n2o = Nfert * 0.01

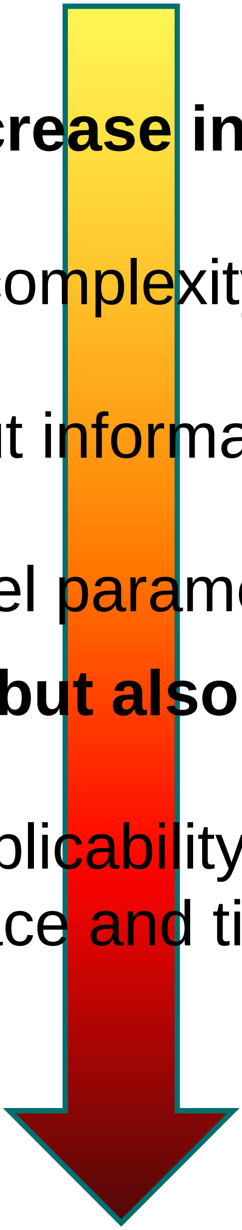
Stochastic model types:

regression models n2o = f (fert, temp, rainf)

neuralt networks n2o = f (fert, temp, rainf, xi…xz)

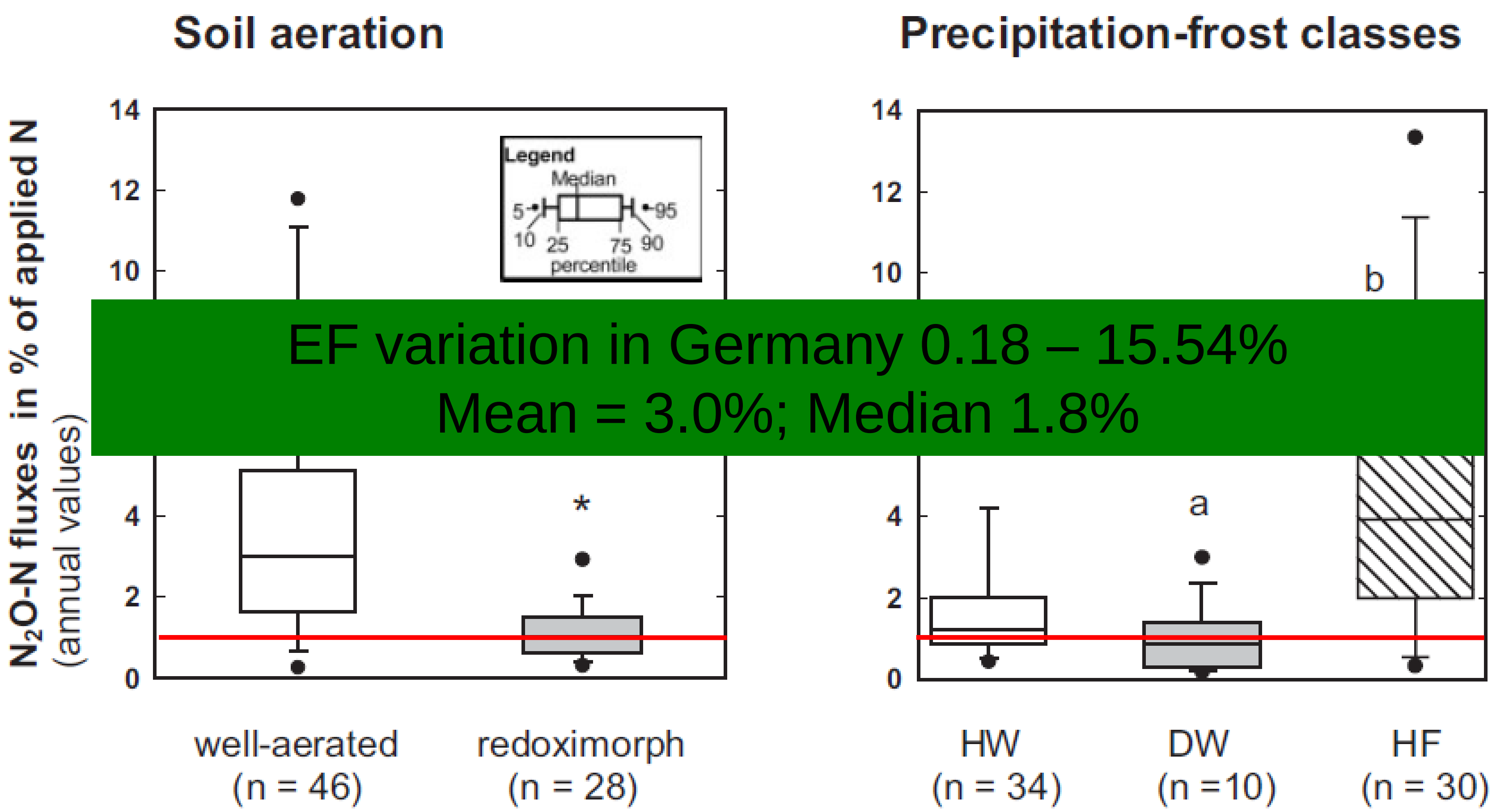
Numeric model types:

describing all relevant ecosystem processes
(e.g. nutrient uptake, mineralisation, nitrification, denitrification)



State of the art N_2O emissions

- Are fixed emission factors (1% IPCC, 2006) good enough?



Jungkunst et al., 2006, J. Plant Nutr. Soil Sci.

Mechanistic ecosystem models

Karlsruhe Institute of Technology

- Century, DayCent
- ExpertN
- CERES-BGC
- Coup-Model
- DNDC
- LandscapeDNDC
- Ecosys
- Orchidee
- LPJ-Model

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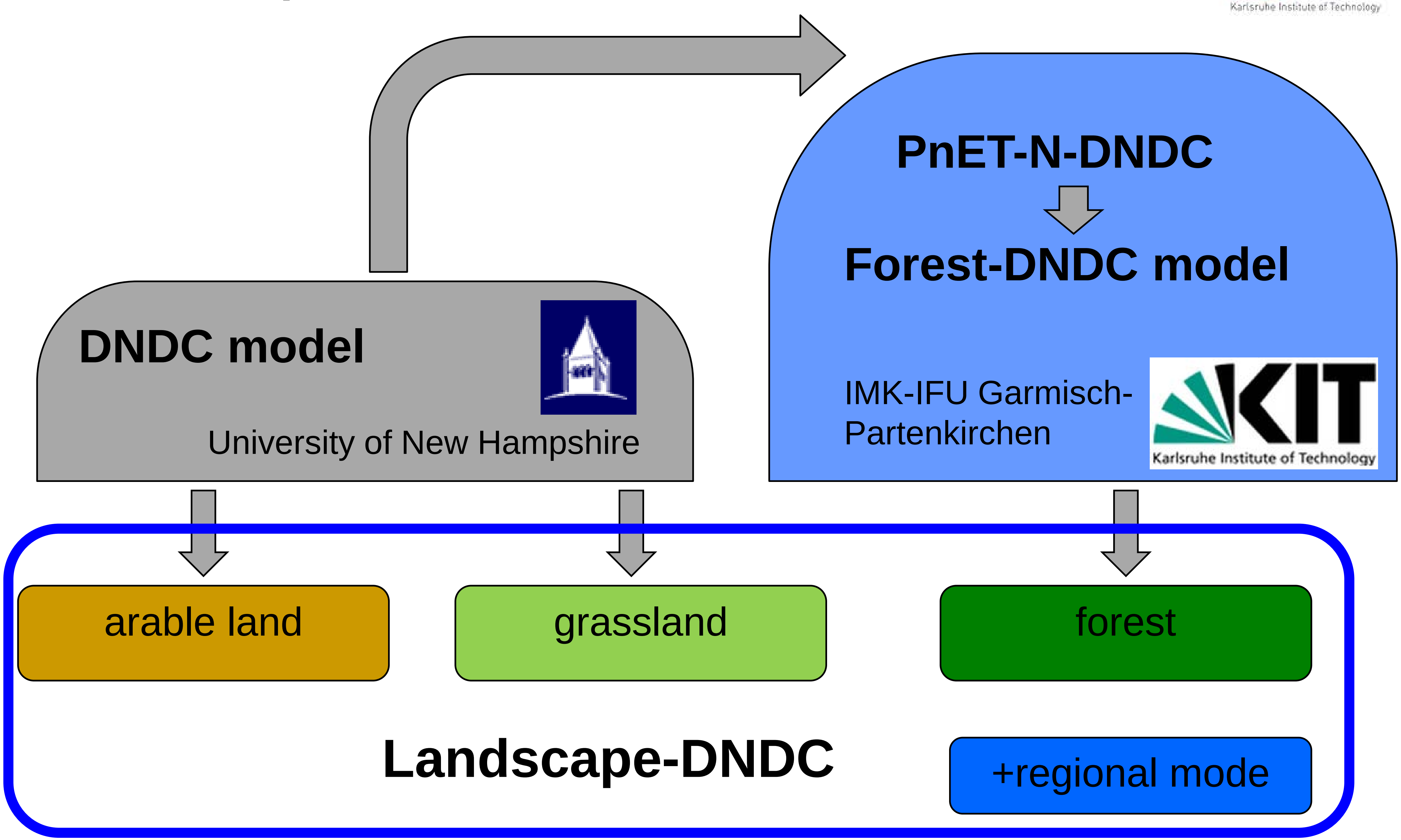
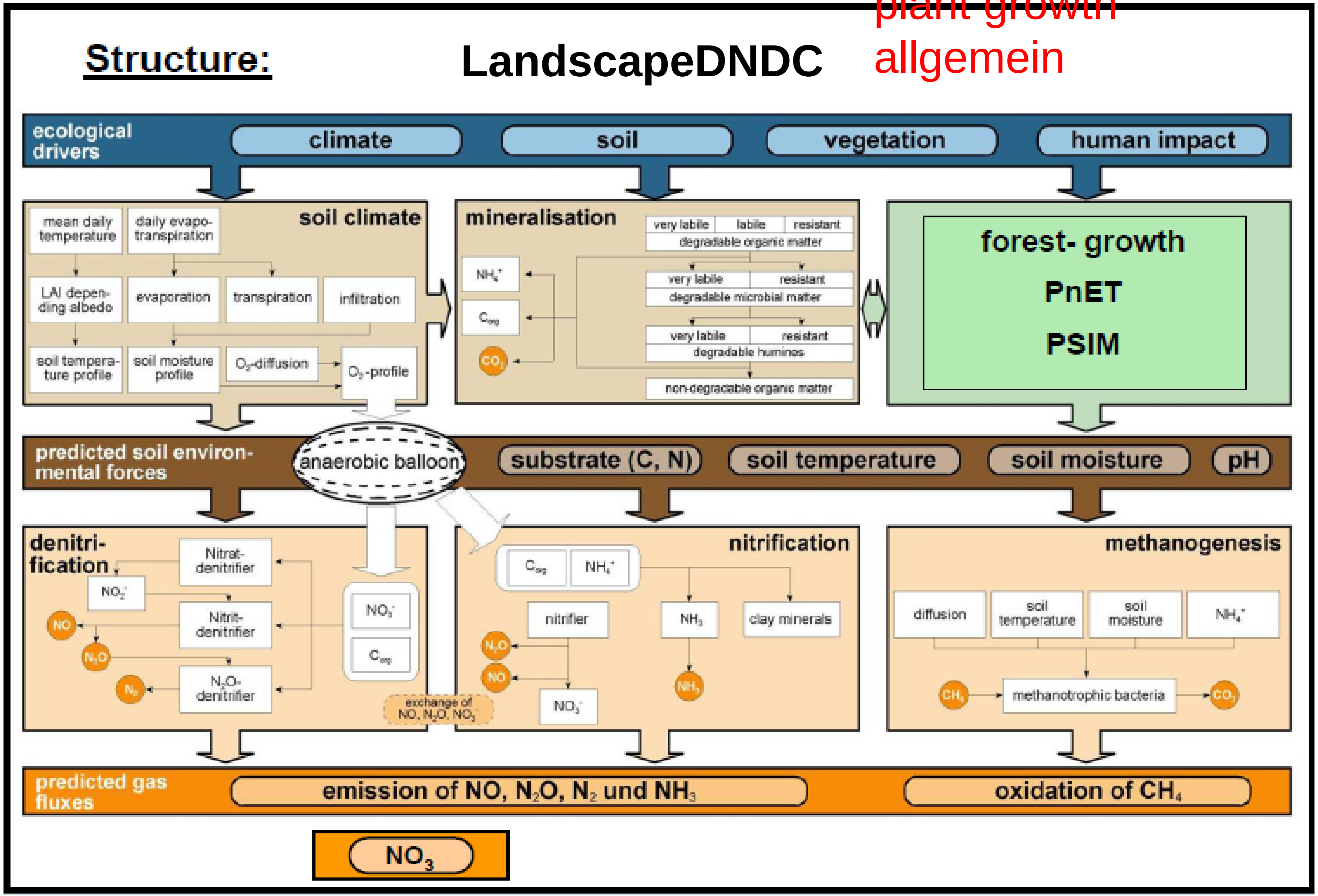
Model development at IMK-IFU



Structure of LandscapeDNDC

TODO
Animiert und
~~plant growth~~
allgemein



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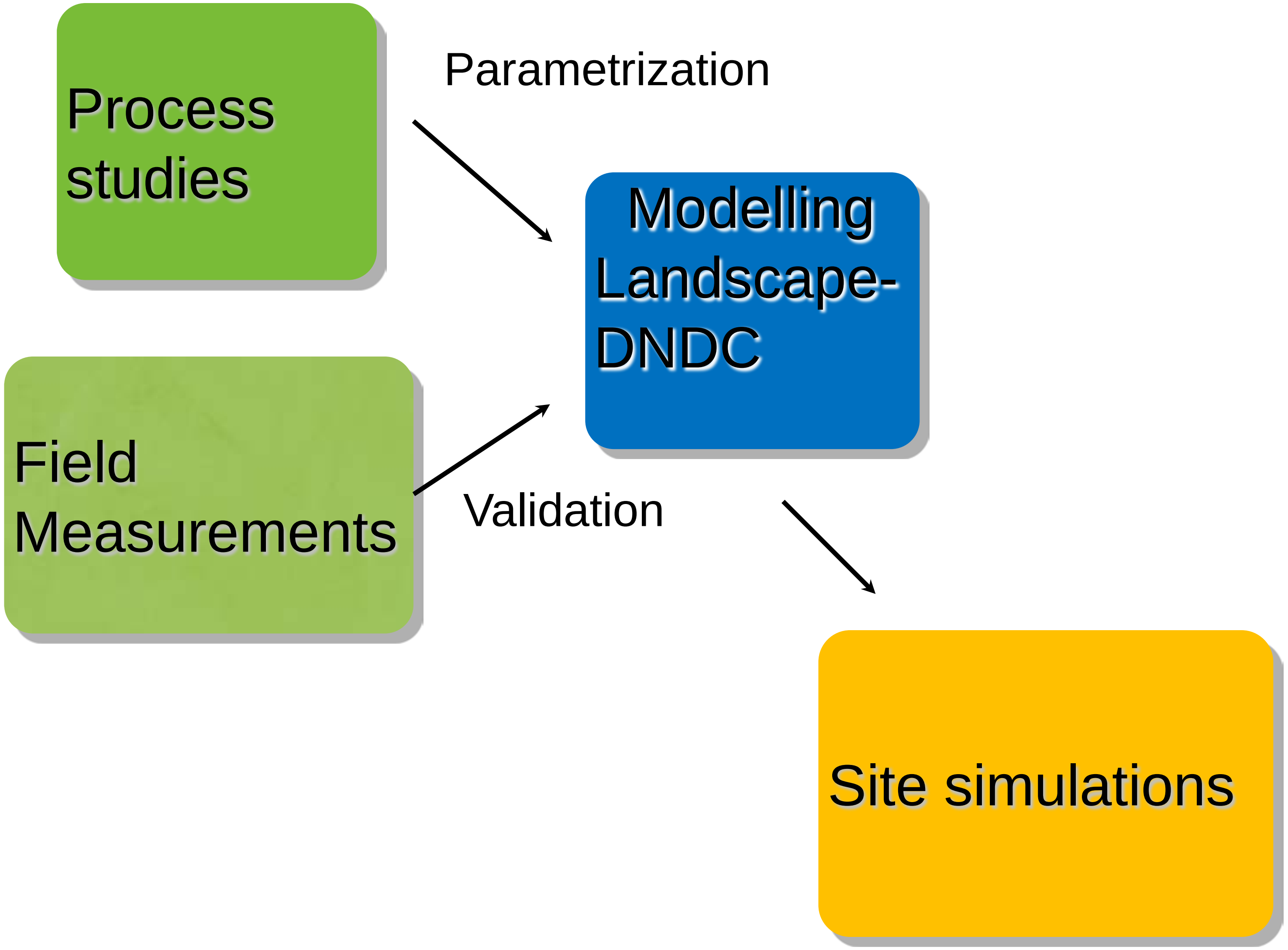

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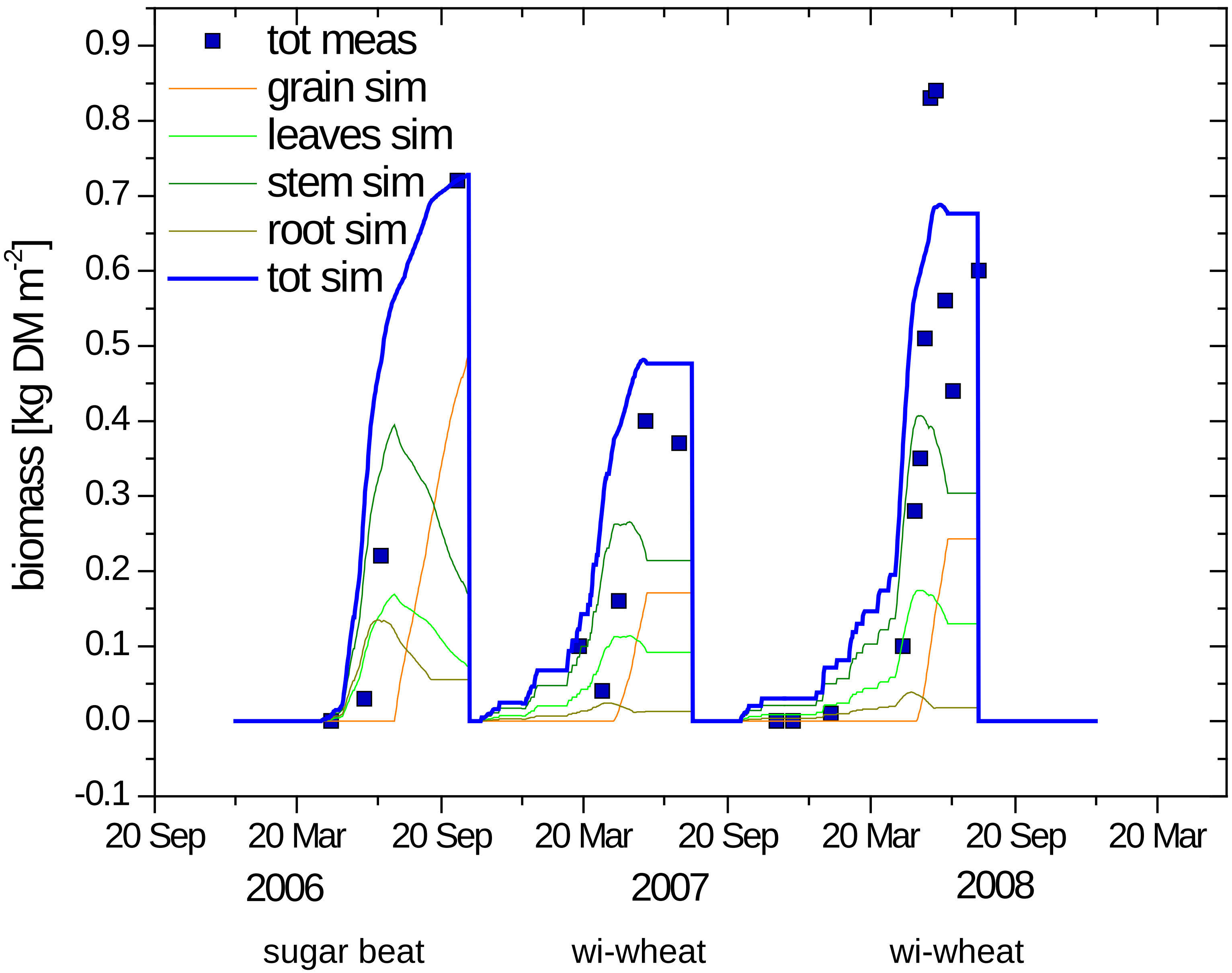
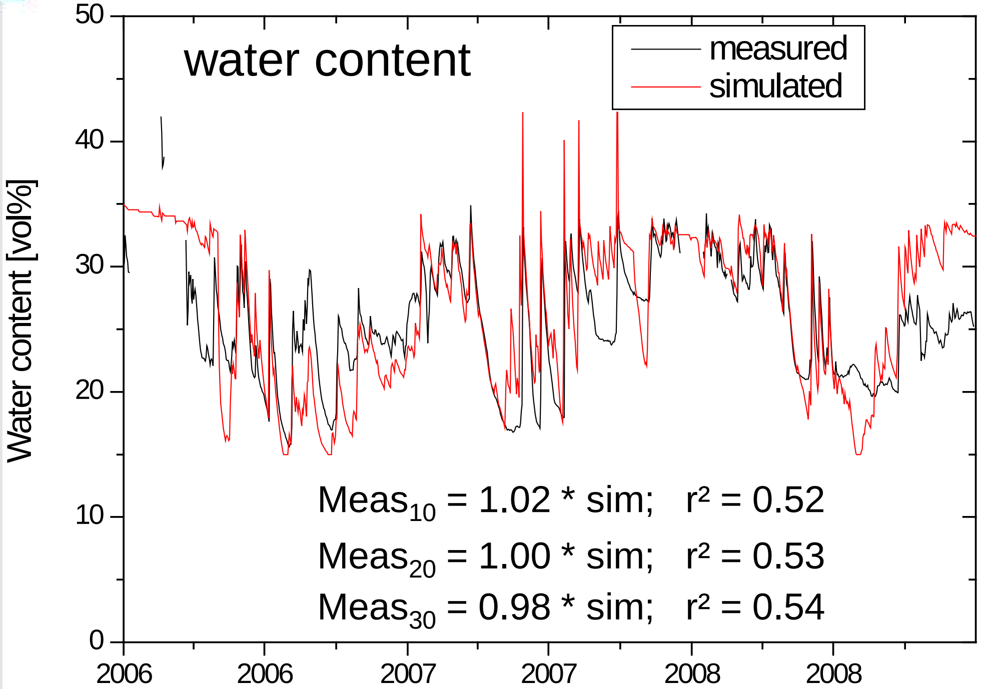
Gebesee arable field: biomass developement

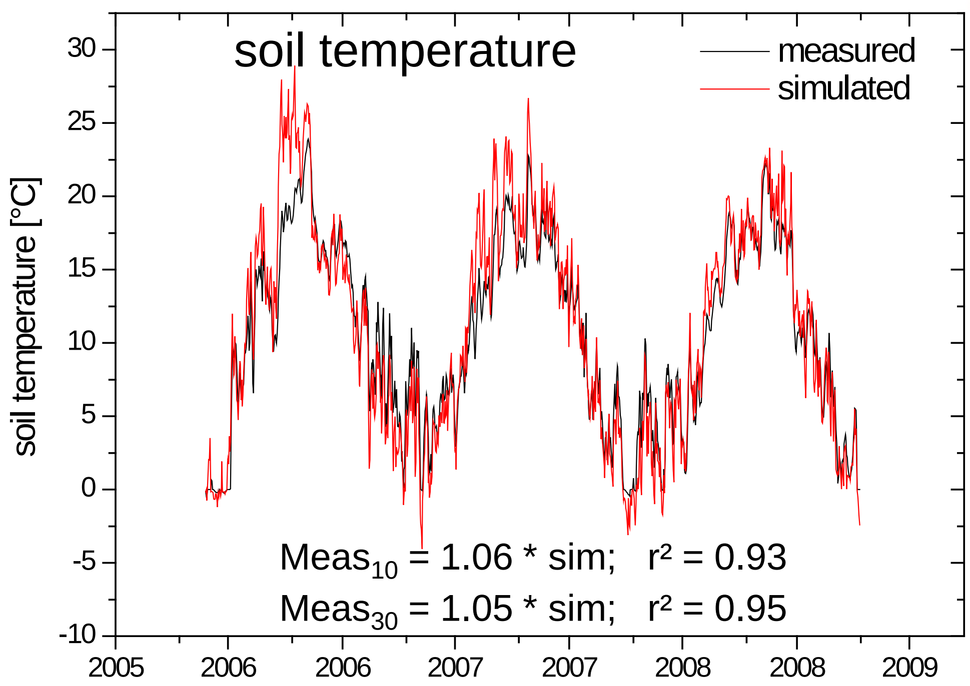


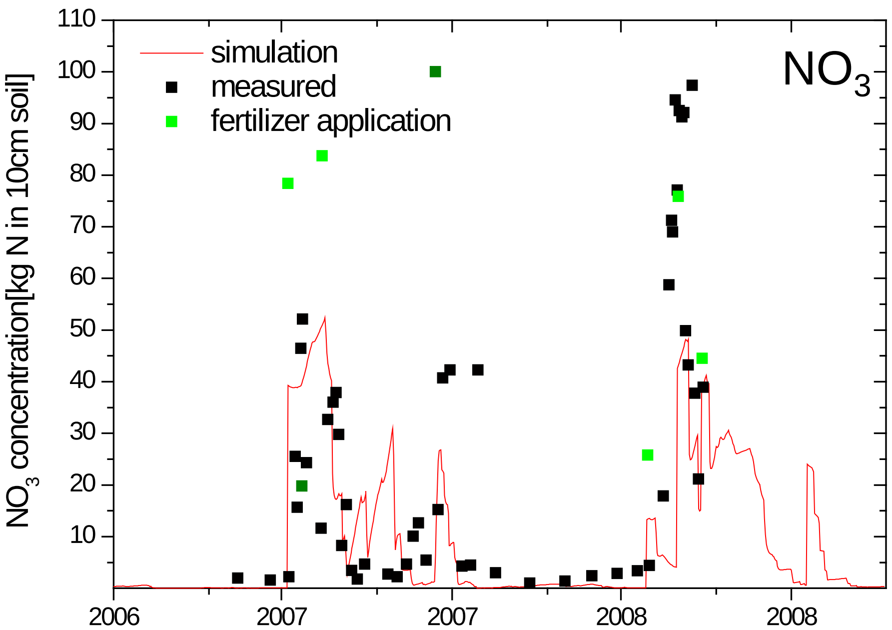
Meas = 0.92 * sim; r^2 = 0.8

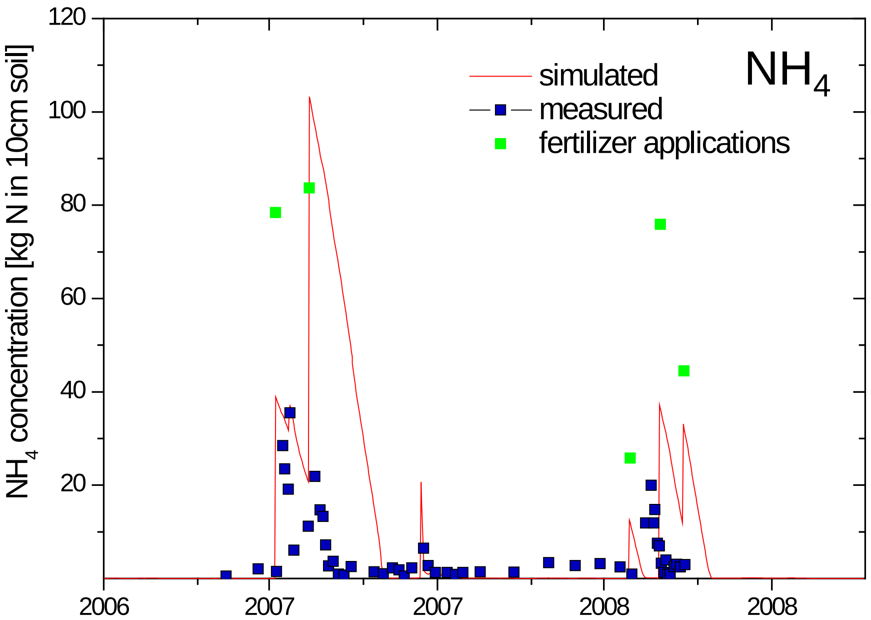
Messdaten Freibauer et al. vTI

Gebesee: soil environmental conditons









Measured data Freibauer et al. vTI

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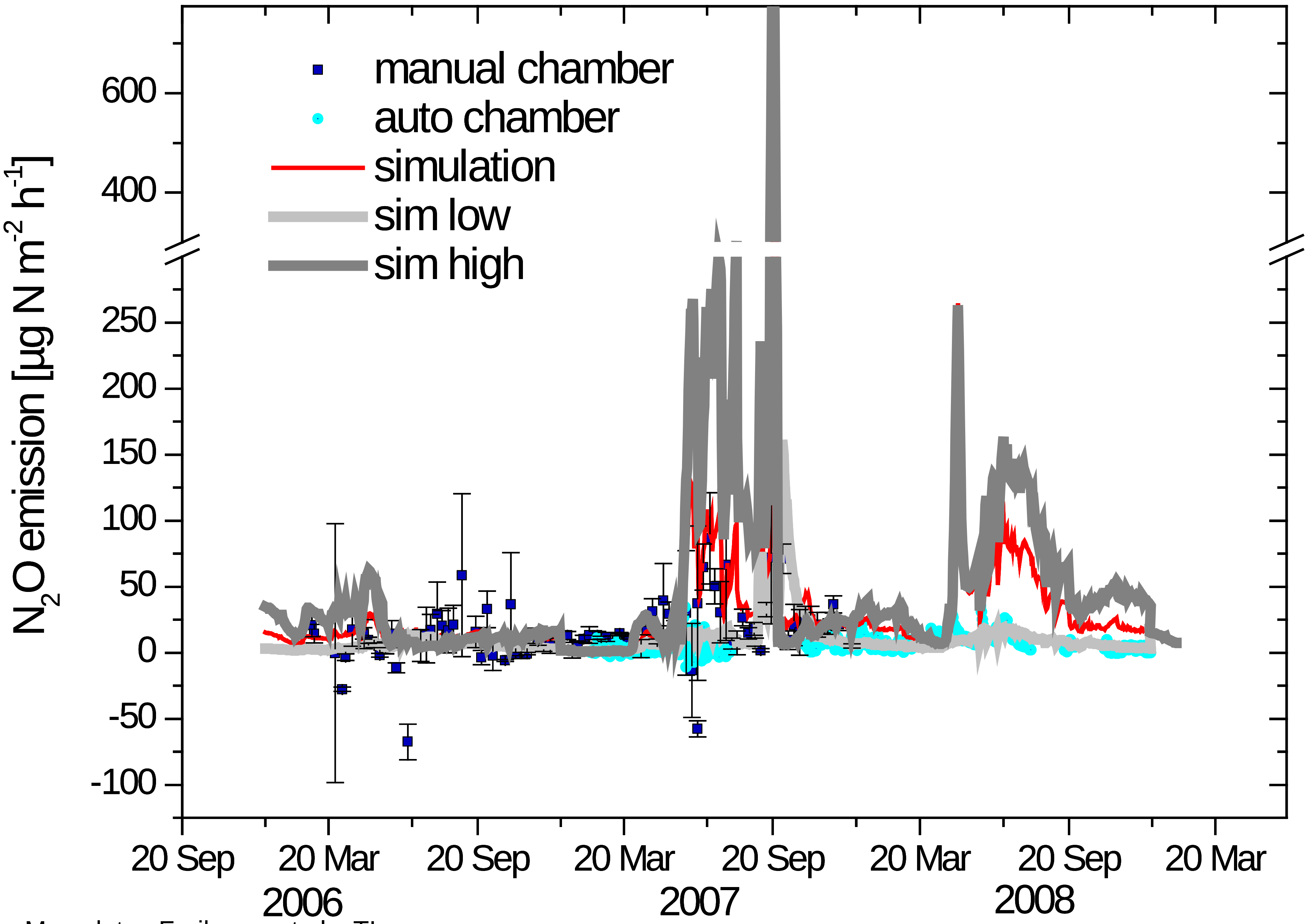
Gebesee: N_2O Emission



N_2O Range :

1-3 kg $Nha^{-1}yr^{-1}$

Messdaten Freibauer et al. vTI

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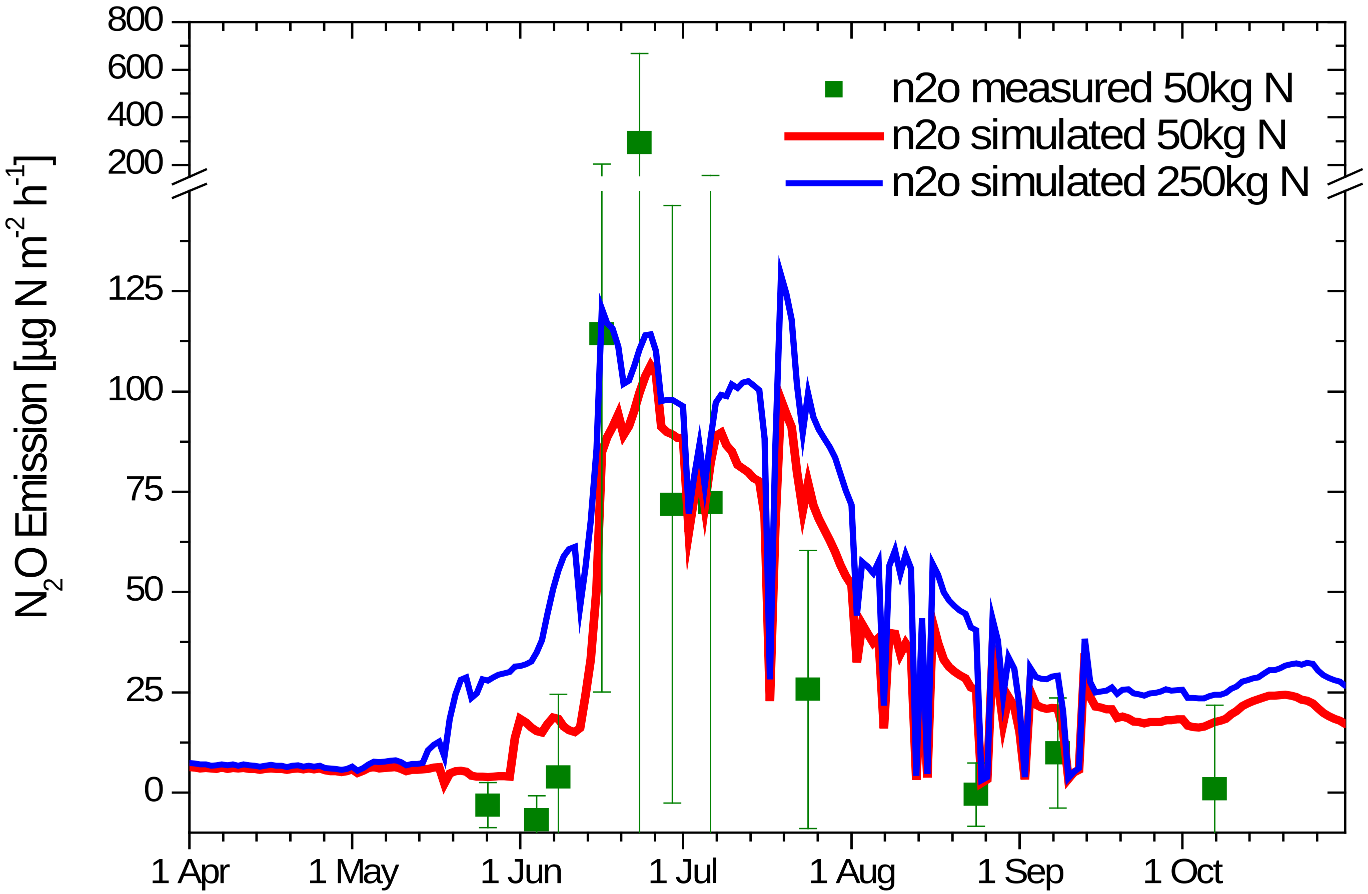
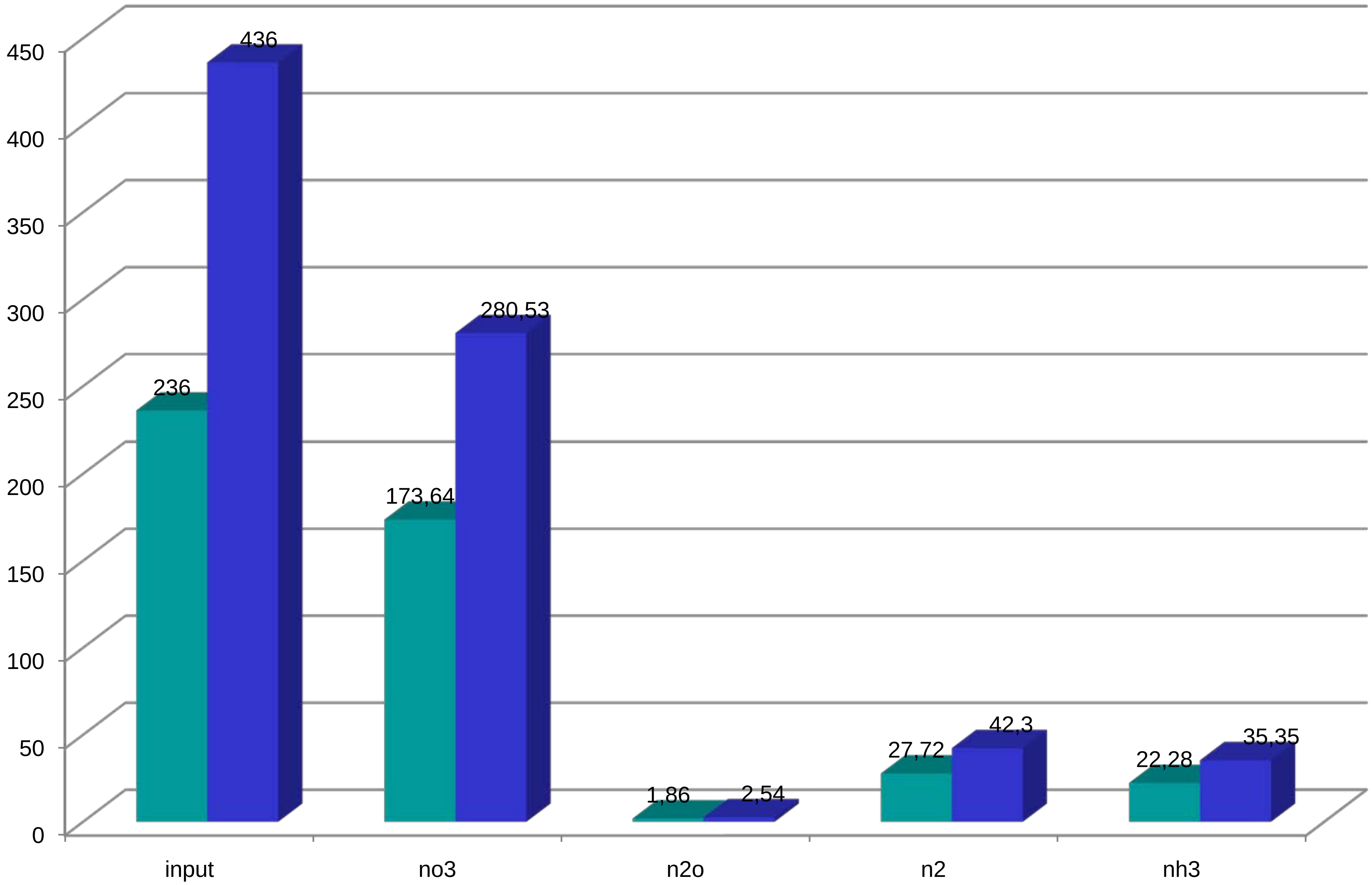
Haean, Korea: N_2O Emission



Hean, Korea: N fluxes with different N fertililzation



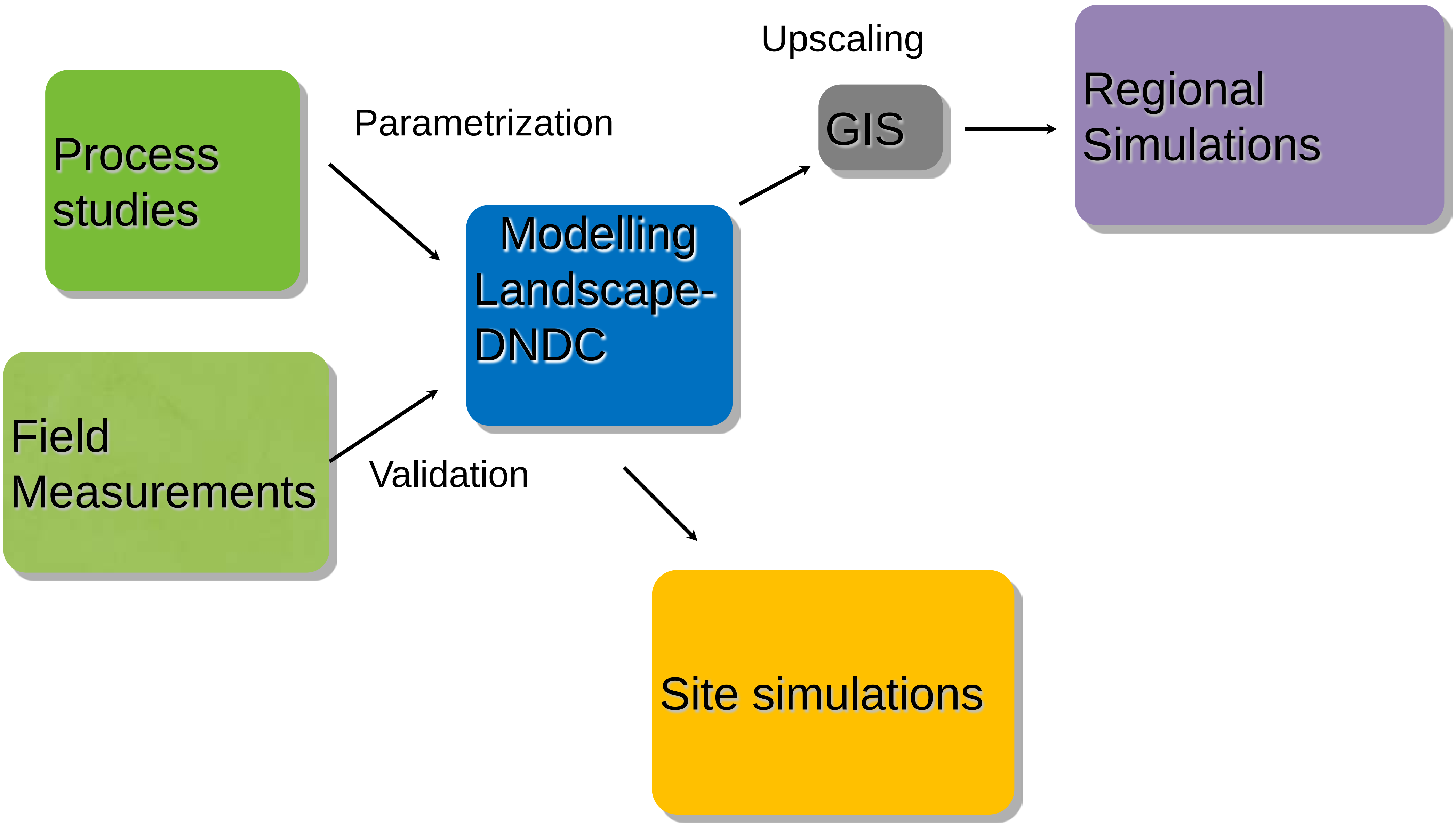
Mean seepage water concentration

30 mg l NO_3

57 mg l NO_3

Ralf.Kiese@kit.edu

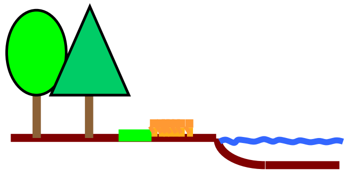
Research Interests of IMK-IFU
Linking methods – bridging scales



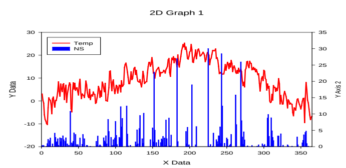
Regional Application Approach

TODO ev. auch andere

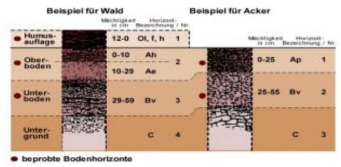
Vegetation



Climate

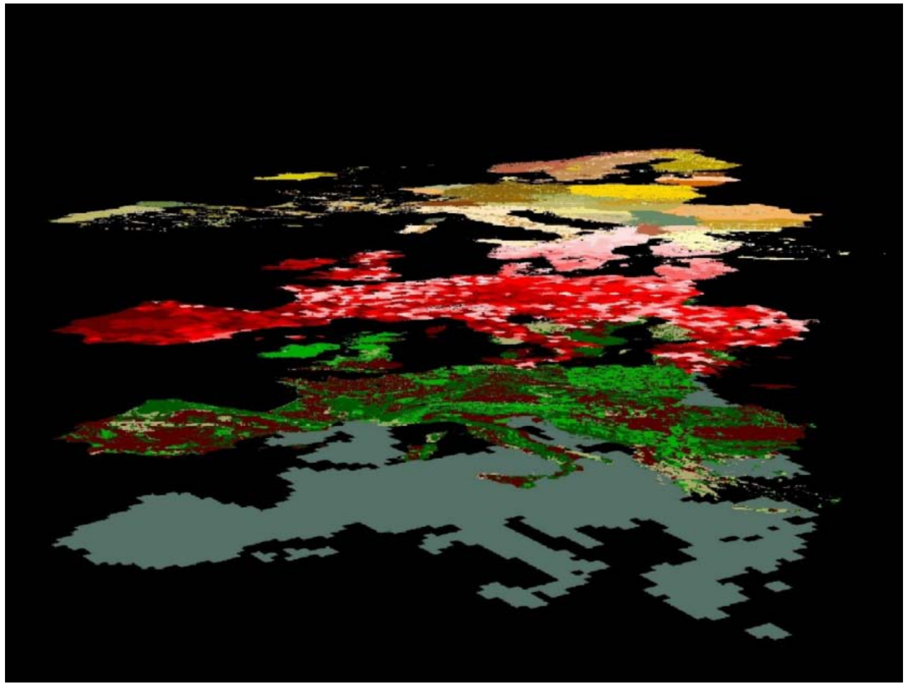


Soil



Administrative Units

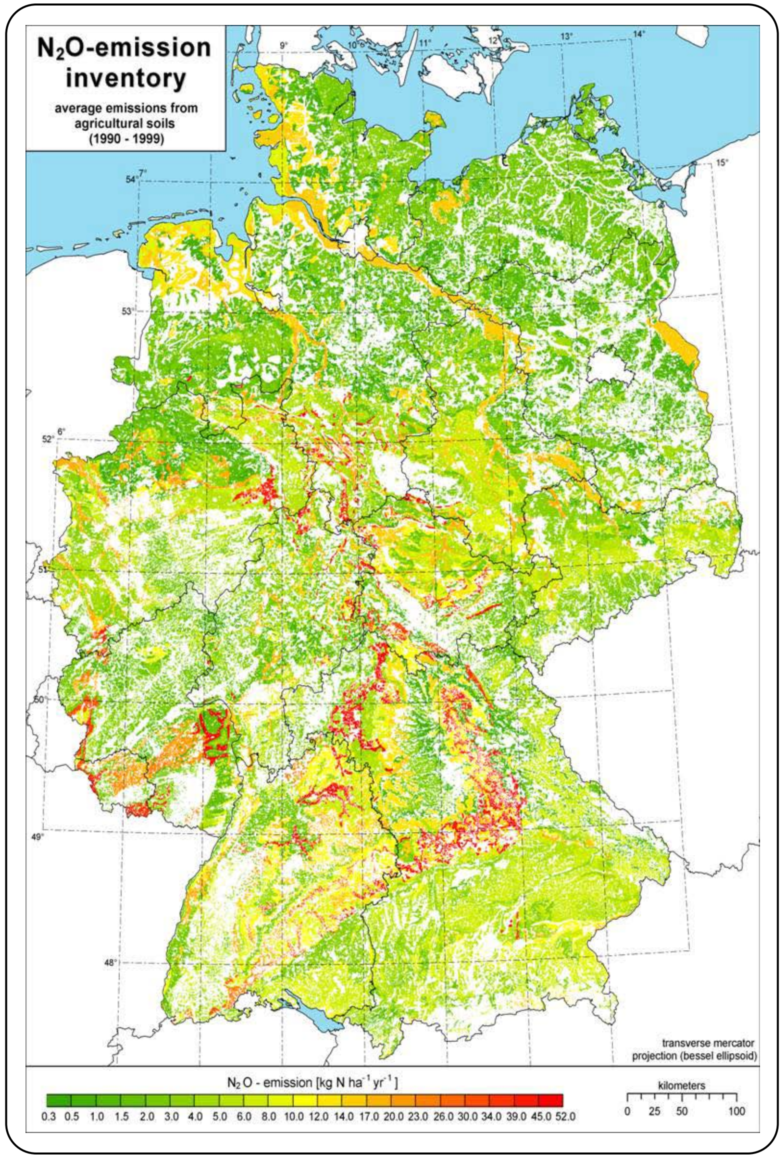
Nutzung	DNDC-Klassifikation	Feldfrucht	organische Wirtschaftsdünger [$m^3\ ha^{-1}$]	Anbaufläche [ha]	Summe [m^3]
Ackerland	winter wheat	Winterweizen	10,0	167.379,7	1.673.796,66
	rye	Roggen	15,0	72.631,5	1.089.472,08
	barley	Wintergerste	15,0	130.761,6	1.961.424,15
	rape	Winterraps	0,0	95.770,4	0,00
	barley	Sommergerste	10,0	58.157,2	581.571,76
	oats	Hafer	10,0	10.196,7	101.967,44
	corn	Körnermais, Corn-Cob-Mix, Silomais	15,0	90.682,1	1.360.231,01
	potatoes	Kartoffeln früh, mittelfrühe und späte	15,0	13.103,5	196.552,61
	beets	Zuckerrüben, Runkelrüben	0,0	25.579,3	0,00
	legume hay	Klee, Kleegras, Luzerne, Futtererbsen	15,0	46.735,2	701.027,74
	pasture	Ackerwiese, Ackerweide	10,0	23.269,3	232.693,33
	vegetables	Gemüse, Erdbeeren und andere Gartengewächse	0,0	5.533,6	0,00
Grünland	grasland	Grasland	10,0	73.120,1	731.200,61
	pasture	Weide	10,0	66.655,0	666.549,64
	non-legume hay	Wiese, Mähwiese	15,0	100.425,0	1.506.374,77
			Summe	980.000,0	10.802.861,80

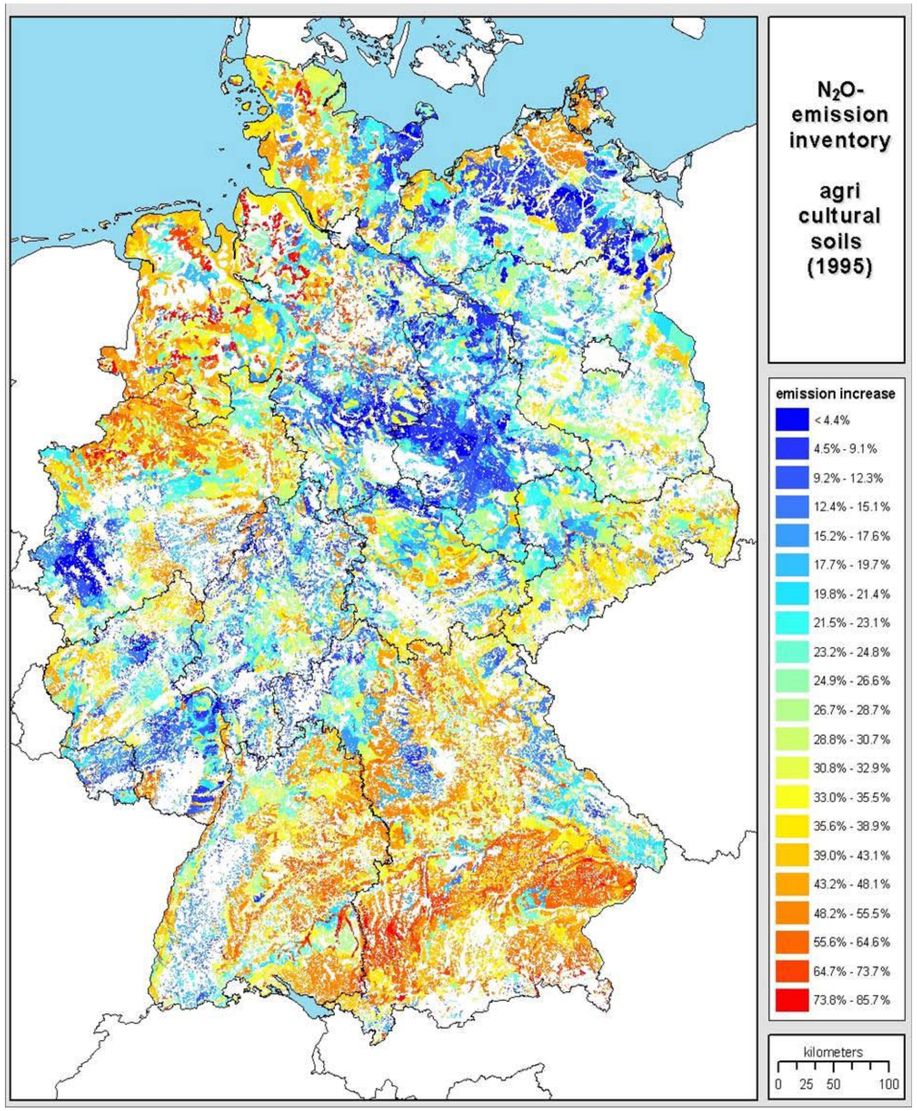


LandscapeDNDC

Regional NO and N_2O emission inventories

N_2O Emission Arable soils Germany

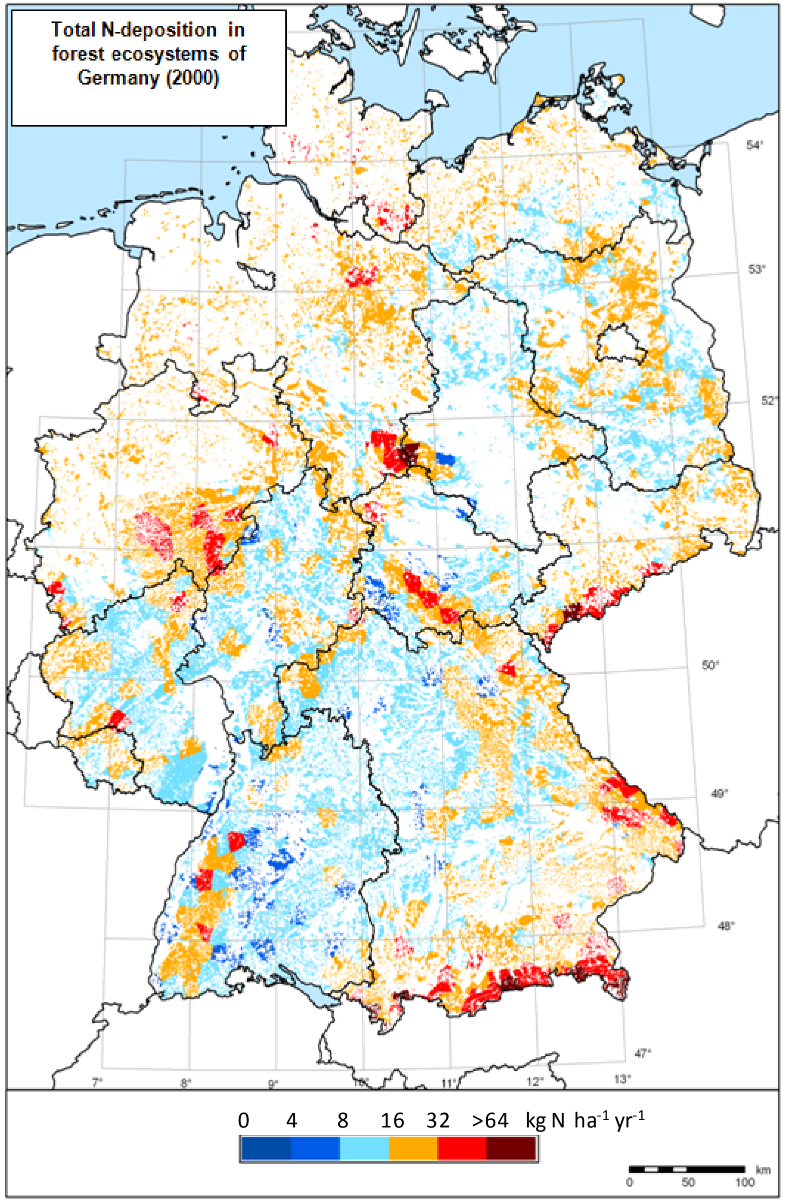


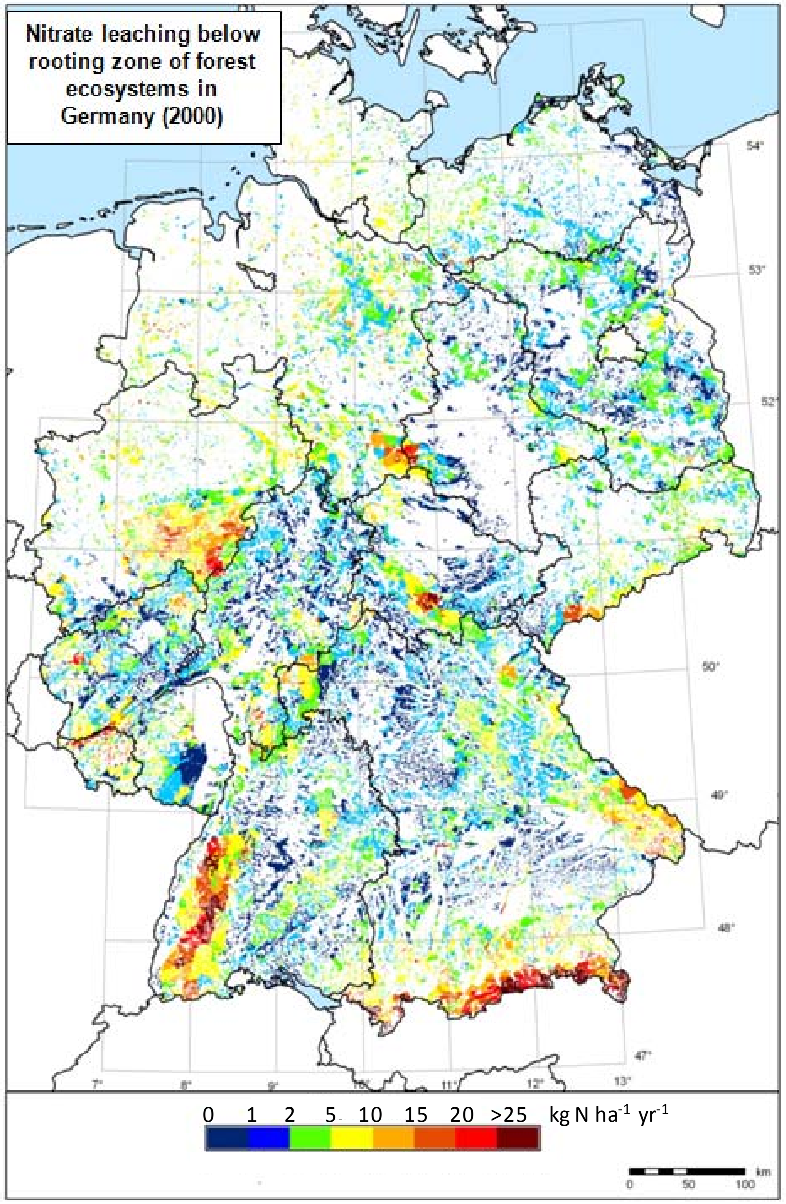


fertilizer induced N_2O emissions (%)

Nitrate leaching in German forest ecosystems

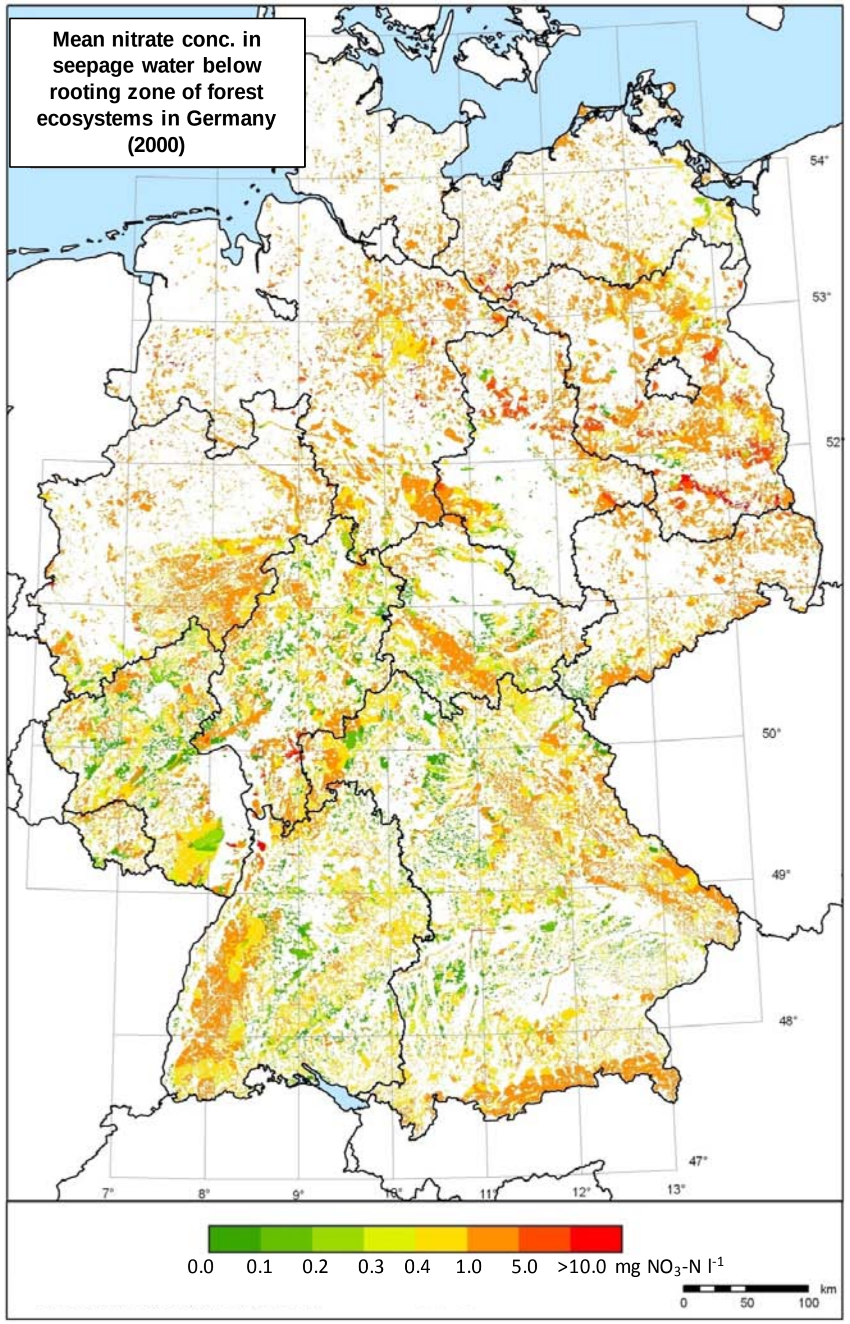
KIT
Karlsruhe Institute of Technology





Ralf.Kiese@kit.edu

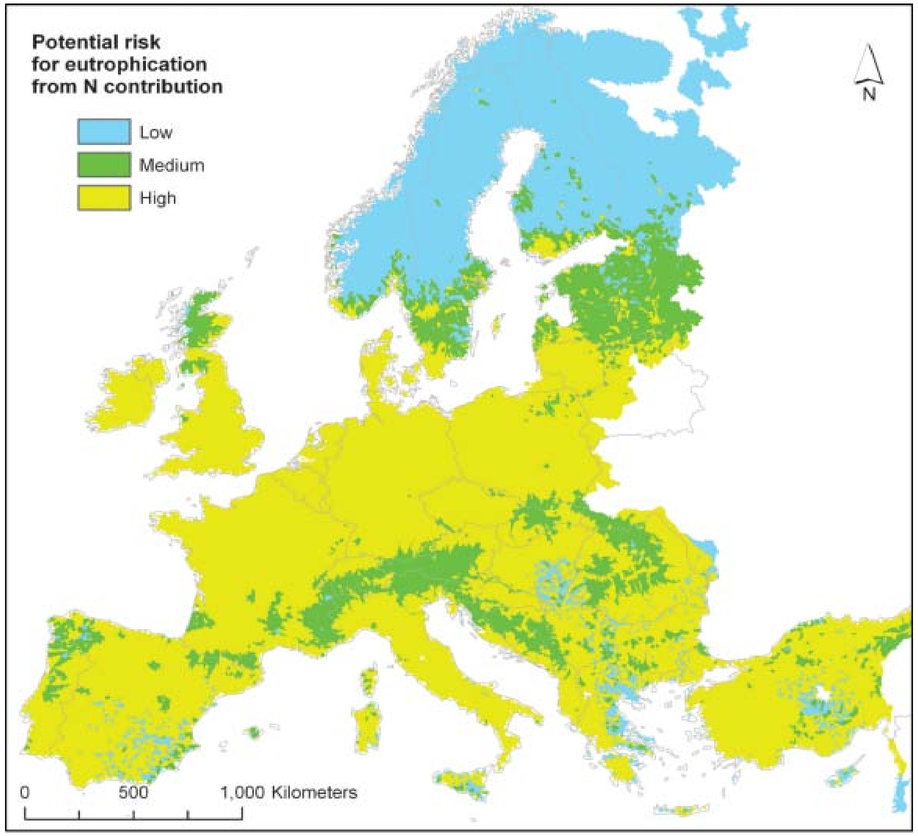
Mean nitrate concentrations in seepage water



3.5 mg/l NO3-N = 25 mg NO3/l (TVO CH)
7.0 mg/l NO3-N = 50 mg NO3/l (TVO D)

>0.5 mg/l NO3-N Nährstoffungleichgewichte

Situation in Europa



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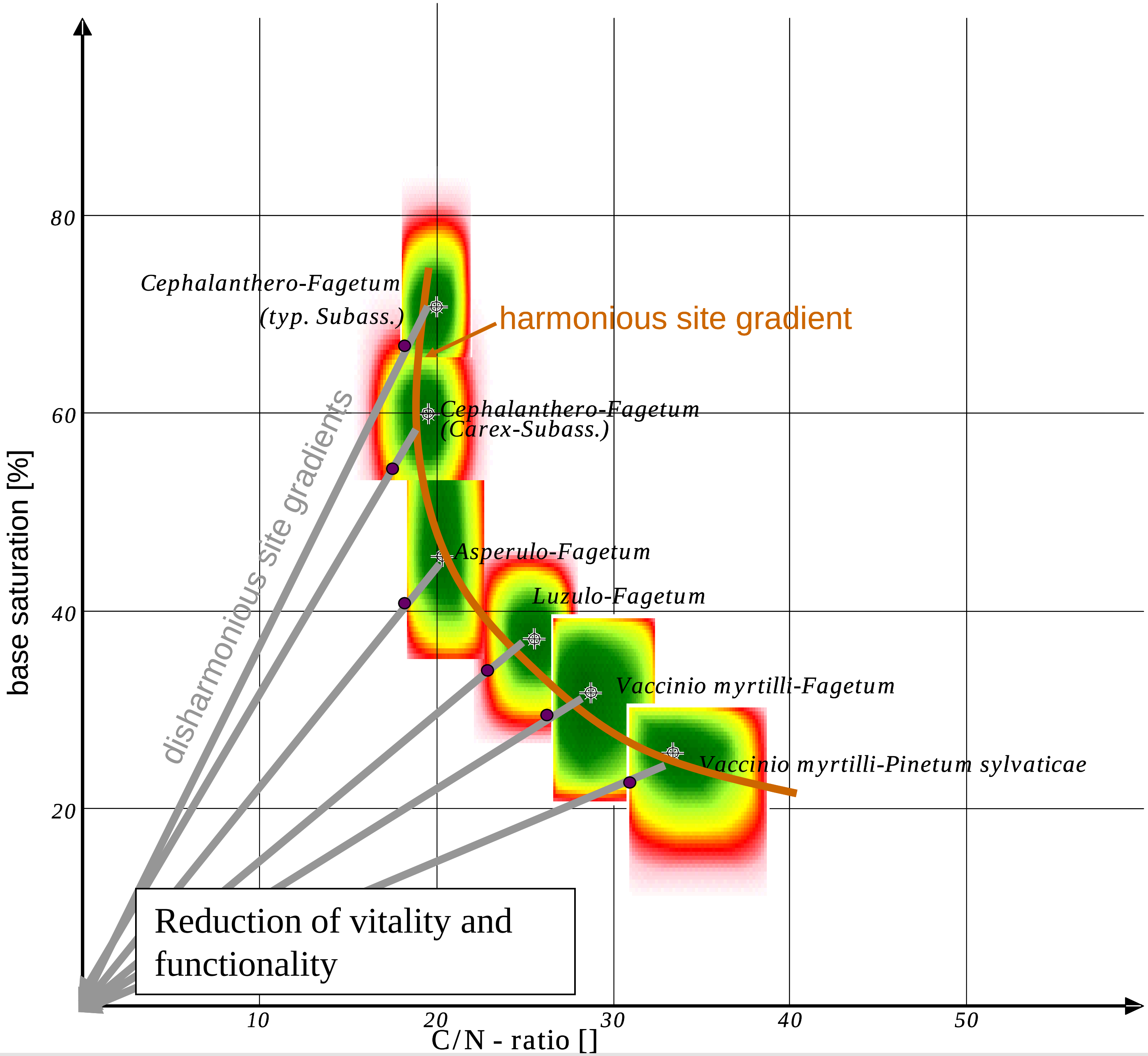
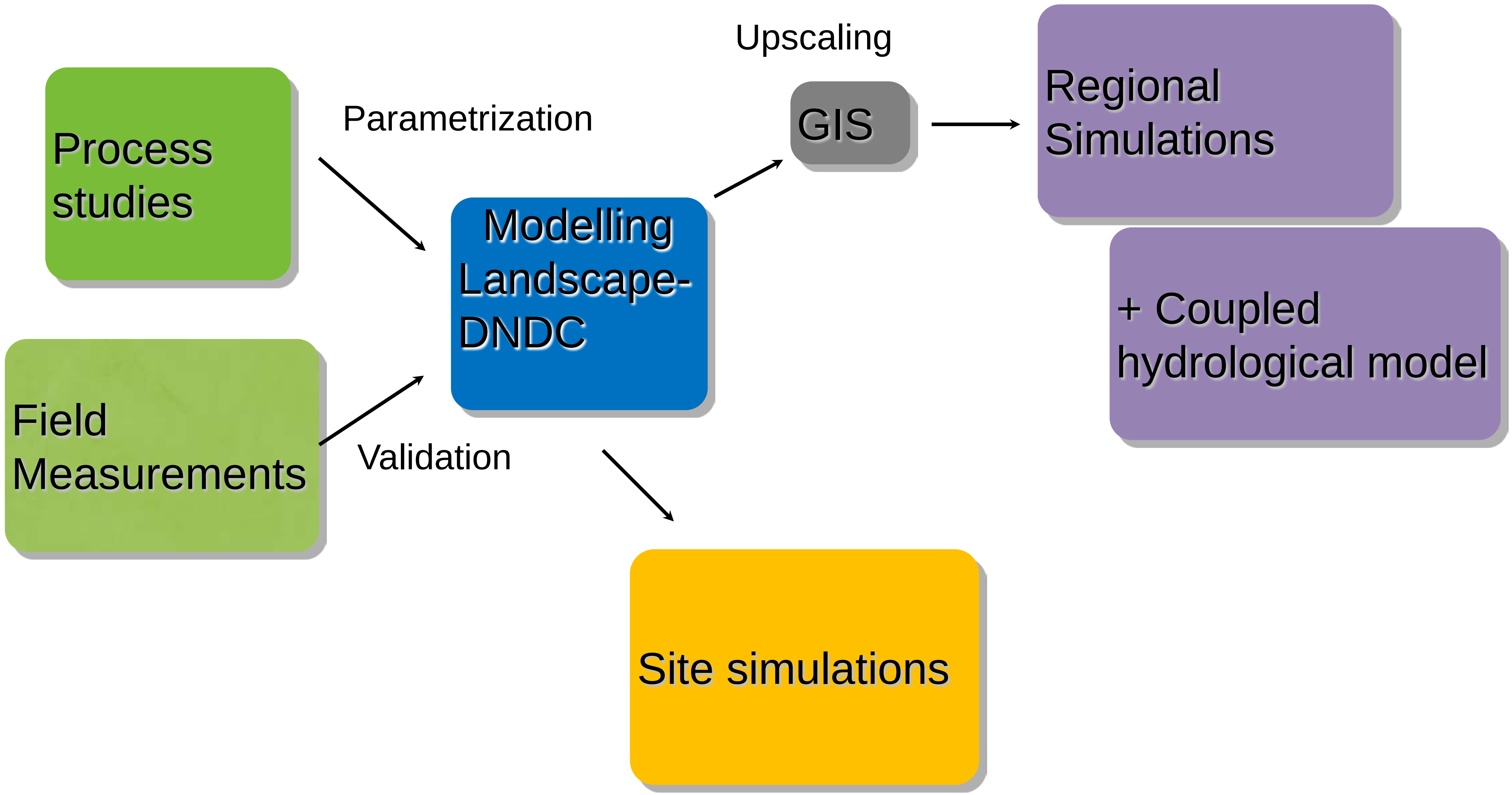
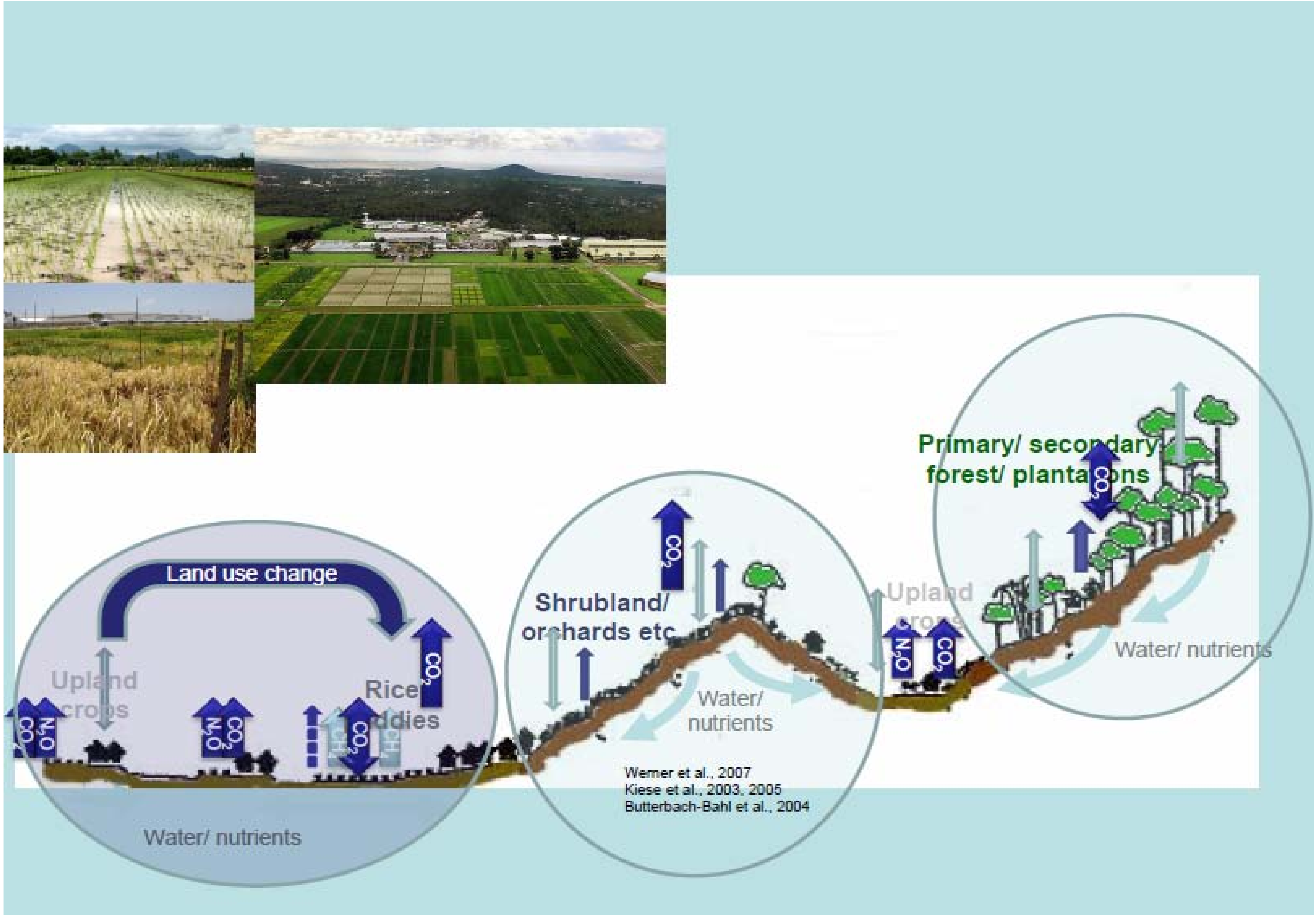
N-Deposition and Biodiversity – BERN model (ÖKODATA)



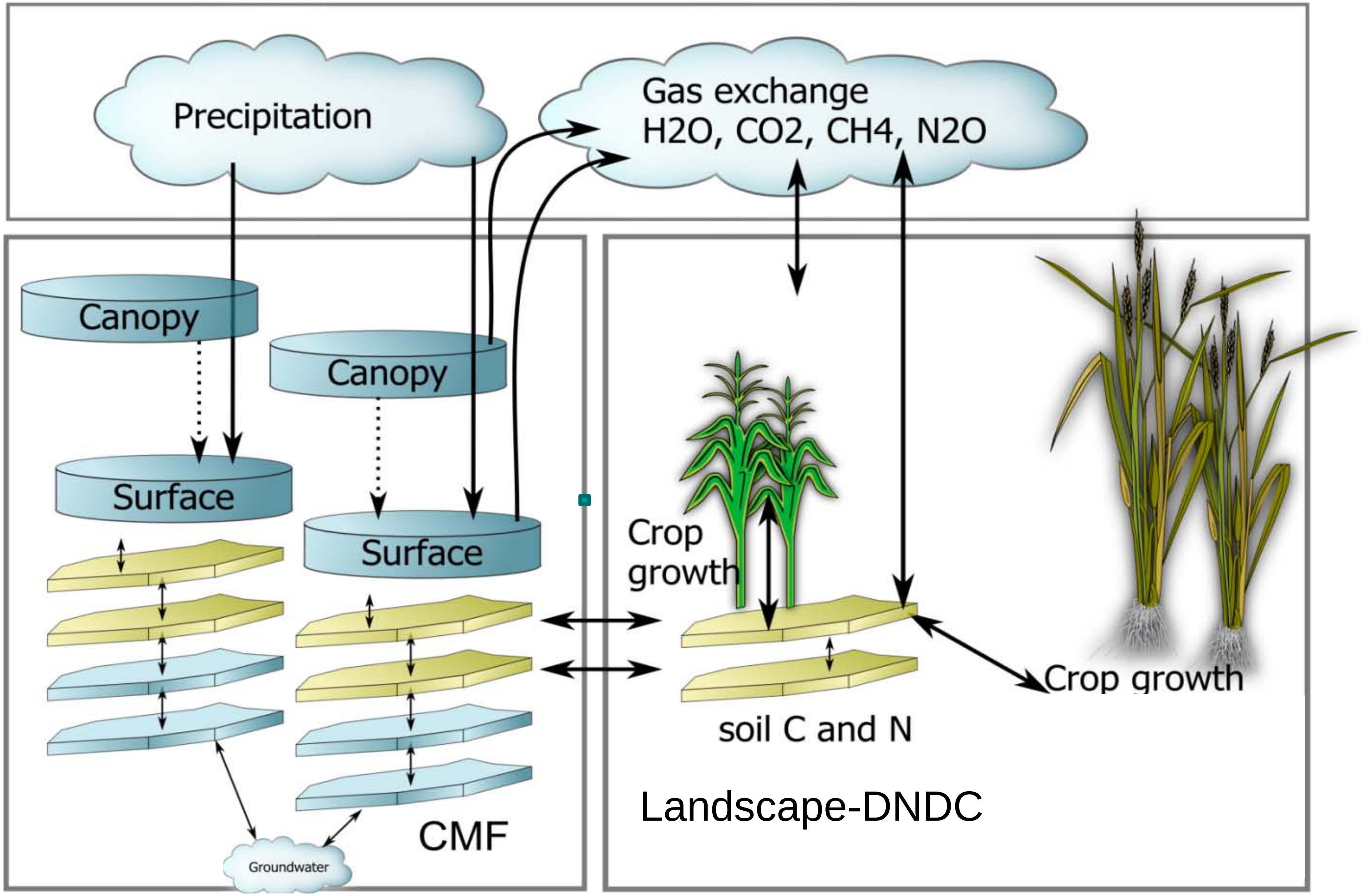
Research Interests of IMK-IFU
Linking methods – bridging scales



Work in progess regional scale ecosystem model



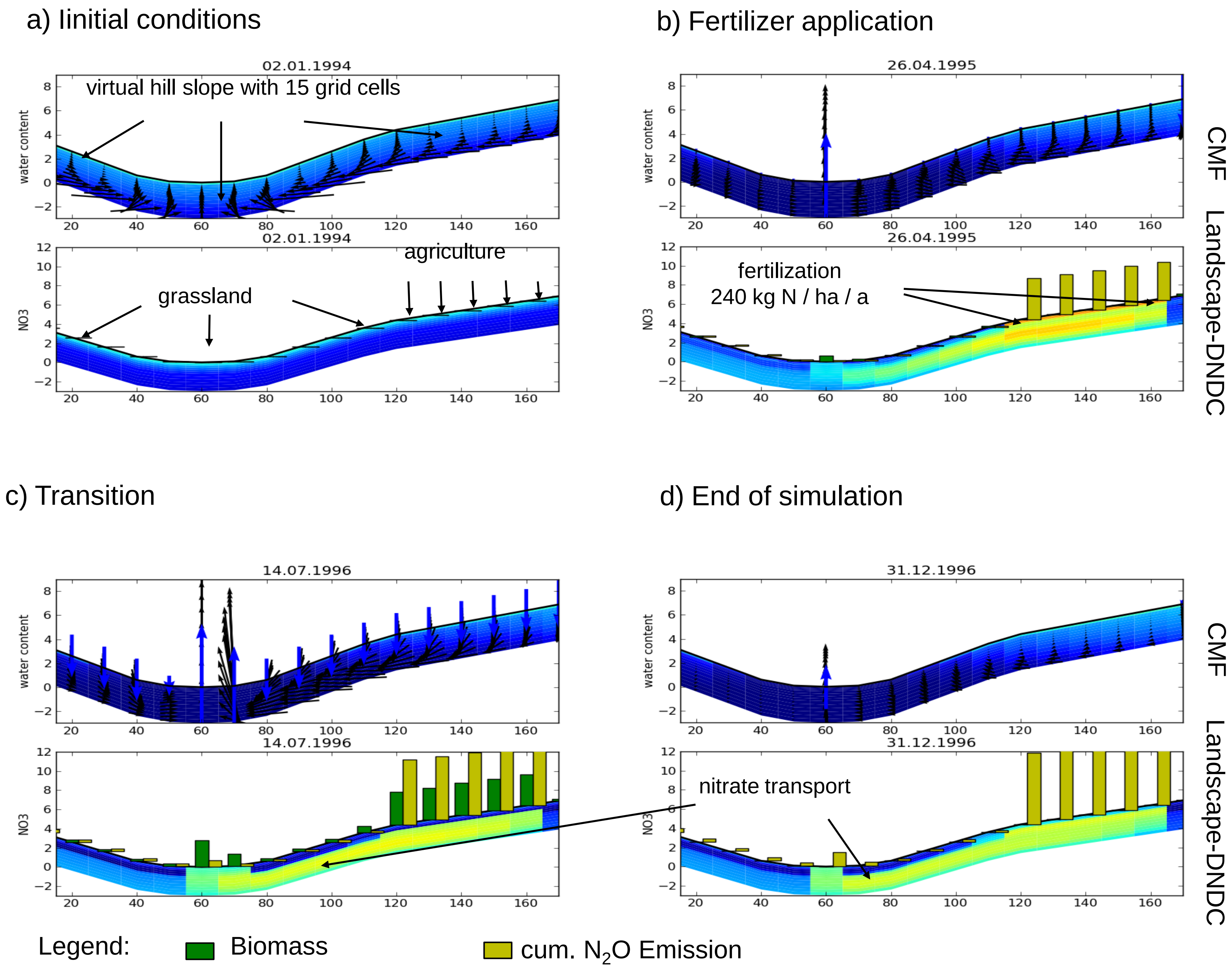
Work in progess regional scale ecosystem model



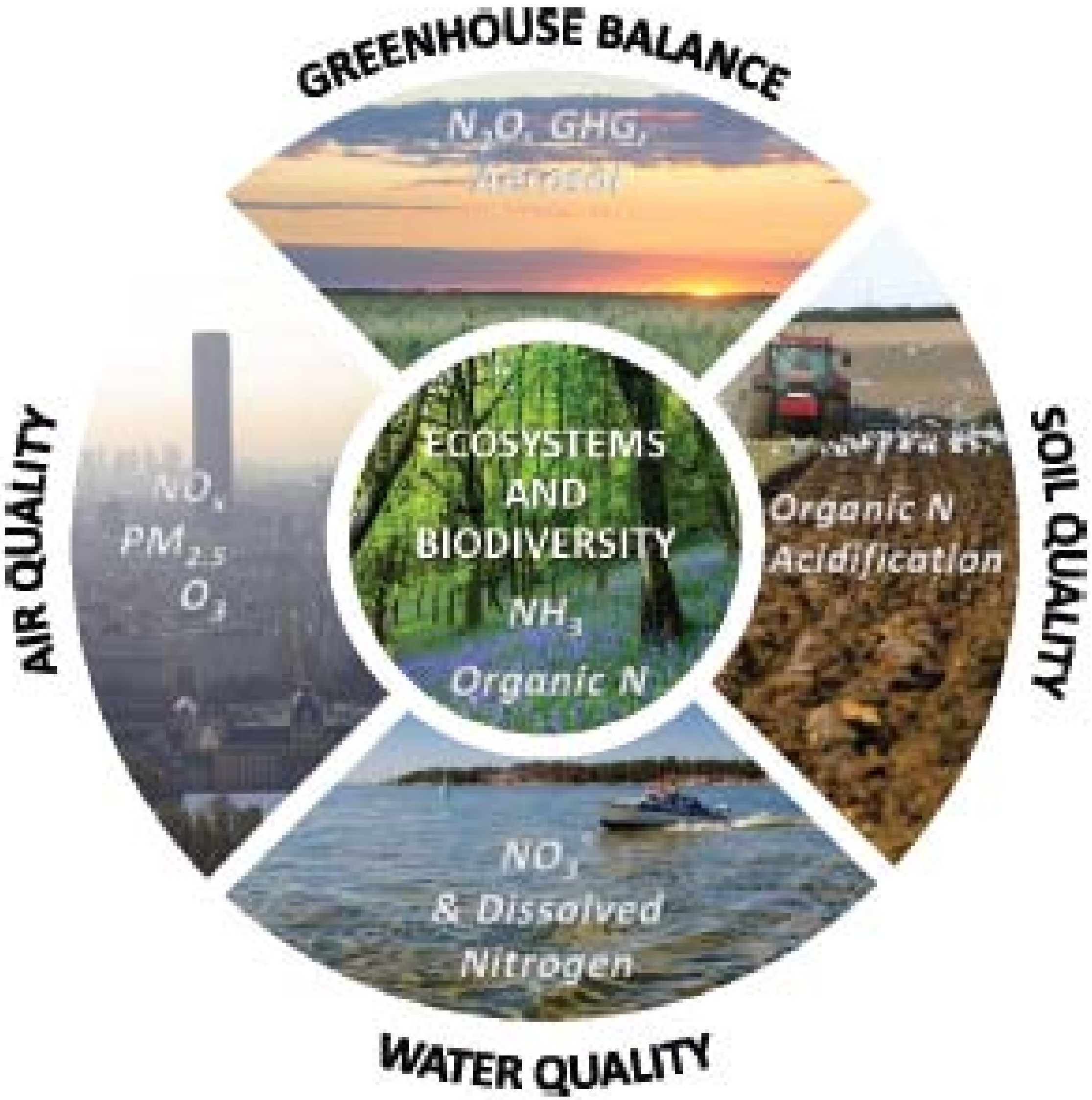
Hydrologie

Biogeochemie

Regional scale ecosystem model – first results



Five key social treats of excess reactive nitrogen



ENA, 2011

Gesellschaftliche Kosten verursacht von Umweltprobleme aus reaktiven Stickstoff- Emissionen EU-27

Table TS.2 Estimates of overall social damage costs in the European Union (EU-27) as a result of environmental N_r-emissions (billion € per year at 2000). Values are shown here rounded to the nearest 5 billion € to avoid over precision, explaining differences with the sums. The calculated value for N_2O effects on human health is 1–2 billion € per year [22.6]

	NO_x emission to air	NH_3 emission to air	N_r loss to water	N_2O emission to air	Total
Human health	35–100	5–70	0–20[a]	<5	40–190
Ecosystems	5–35	5–35	15–50[a]	—	25–115
Climate	—	—	—	5–10	5–10
Total	40–135	10–105	15–70	5–15	70–320

[a] The value for health effects is proportionately smaller than the value for ecosystems as not all leaching is associated with health effects (e.g., denitrified during the path from soil to sea).

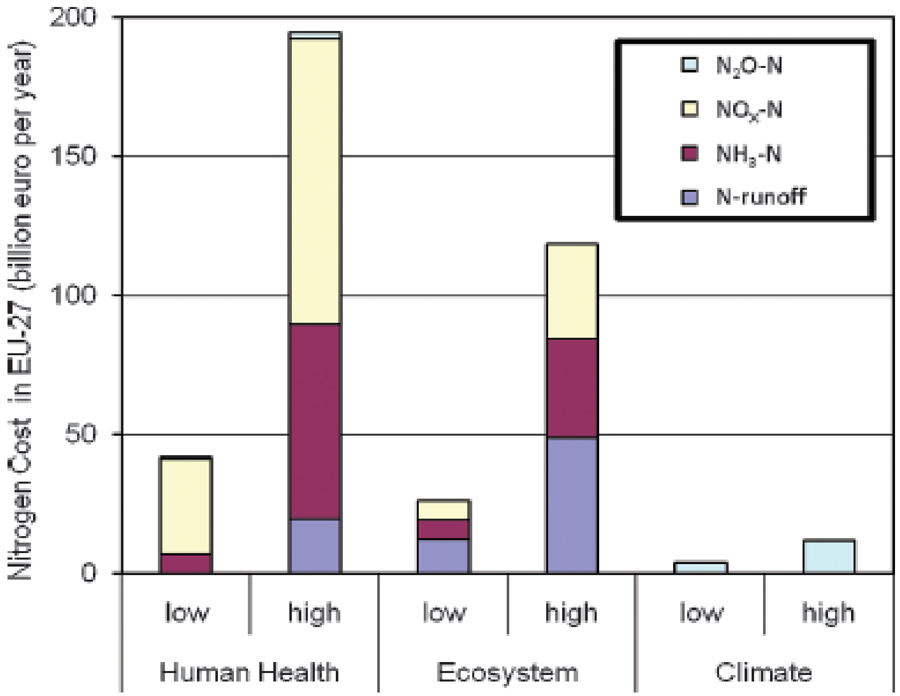


Figure SPM.8 Estimated environmental costs due to reactive nitrogen emissions to air and to water in the EU-27 [22.6].

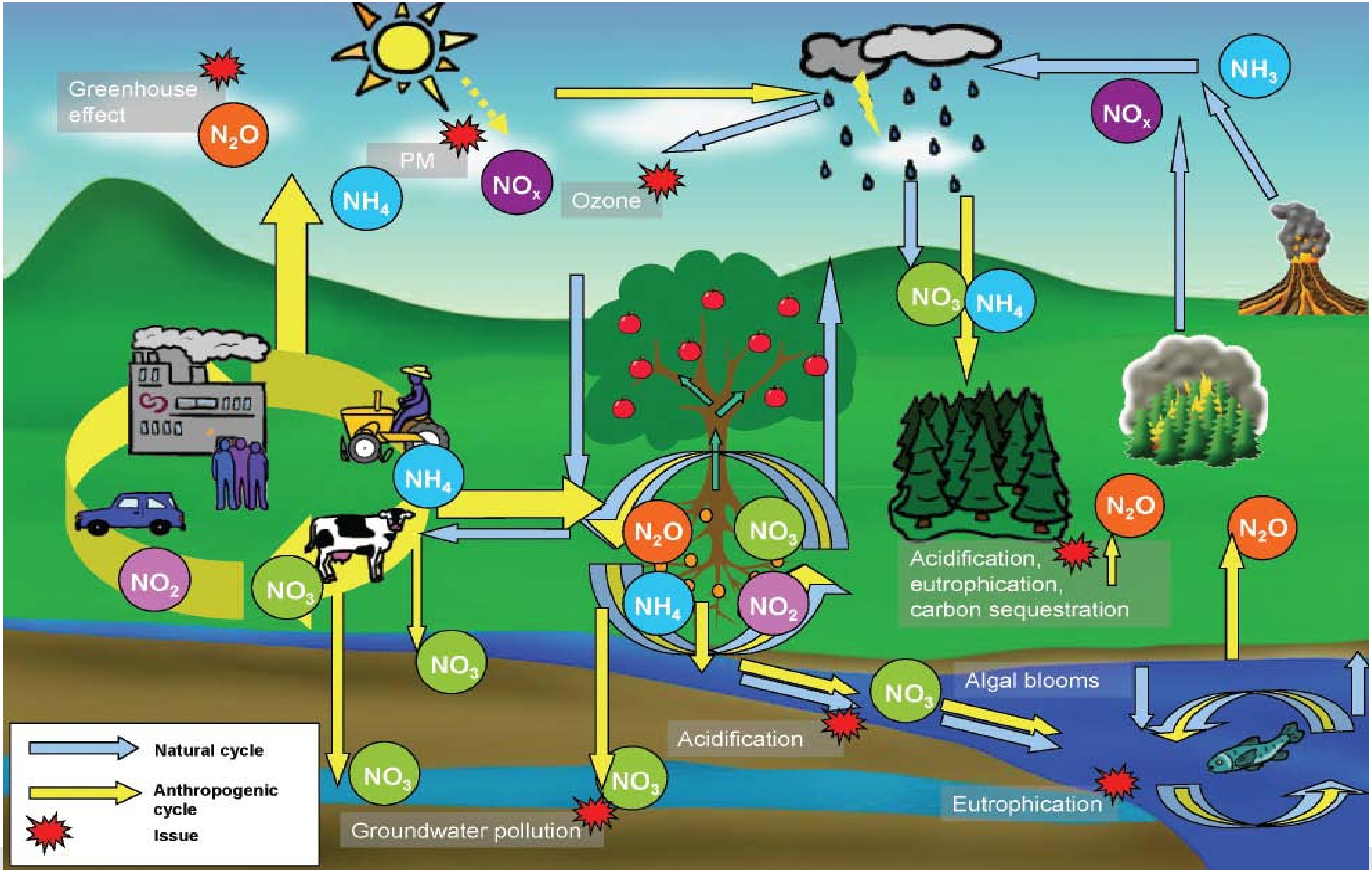
Gesellschaftliche Kosten verursacht von Umweltprobleme aus reaktiven Stickstoff- Emissionen EU-27

Table TS.3 Estimated cost of different N_r-threats in Europe per unit N_r emitted [22.6]

Effect	Emitted nitrogen form	Emission/ loss to	Estimated cost € per kg N_r emitted
Human health (particulate matter, NO_2 and O_3)	NO_x	Air	10–30
Ecosystems (eutrophication, biodiversity)	N_r (inc. nitrate)	Water	5–20
Human health (particulate matter)	NH_3	Air	2–20
Climate (greehouse gas)	N_2O	Air	5–15
Ecosystems (eutrophication, biodiversity)	NH_3 and NO_x	Air	2–10
Human health (drinking water)	N_r (inc. nitrate)	Water	0–4
Human health (increased ultraviolet radiation from ozone depletion)	N_2O	Air	1–3

Kosten Stickstoffdünger 1kg ca. 2 €

Zusammenfassung



Stickstoffbilanz globaler Landwirtschaft - Stickstoffeffizienz

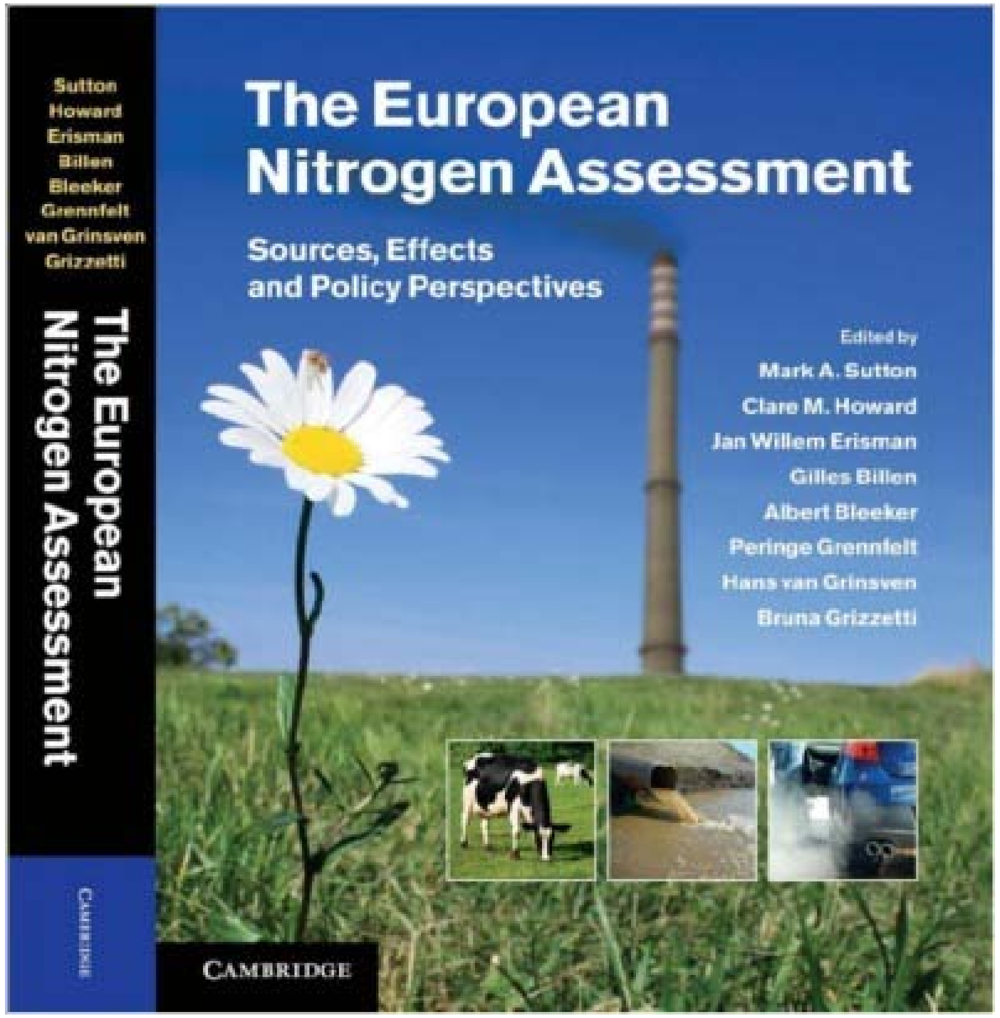
N-input	Tg N	Products	Tg N
Fertilizer	74	Animal	12
N-fixation	50	Crops	40
Feeds	10		
Unaccounted	10		
Total	140		52
		losses	88

Steigerung der N-Effizienz
Änderung der Nahrungsgewohnheiten

N Effizienz von ca. 40%

(Van der Hoek,, 1998, Environ. Pollut., 102: 127-132)

Zusammenfassung



Part A - Nitrogen in Europe: the present position

Part B - Nitrogen processing in the biosphere

Part C - Dispersion, budgets and impacts of nitrogen on different scales

Part D - Managing nitrogen in relation to key societal issues

Part E - European nitrogen policies and future challenges

http://www.nine-esf.org/ENA-Book

Thank you for your attention