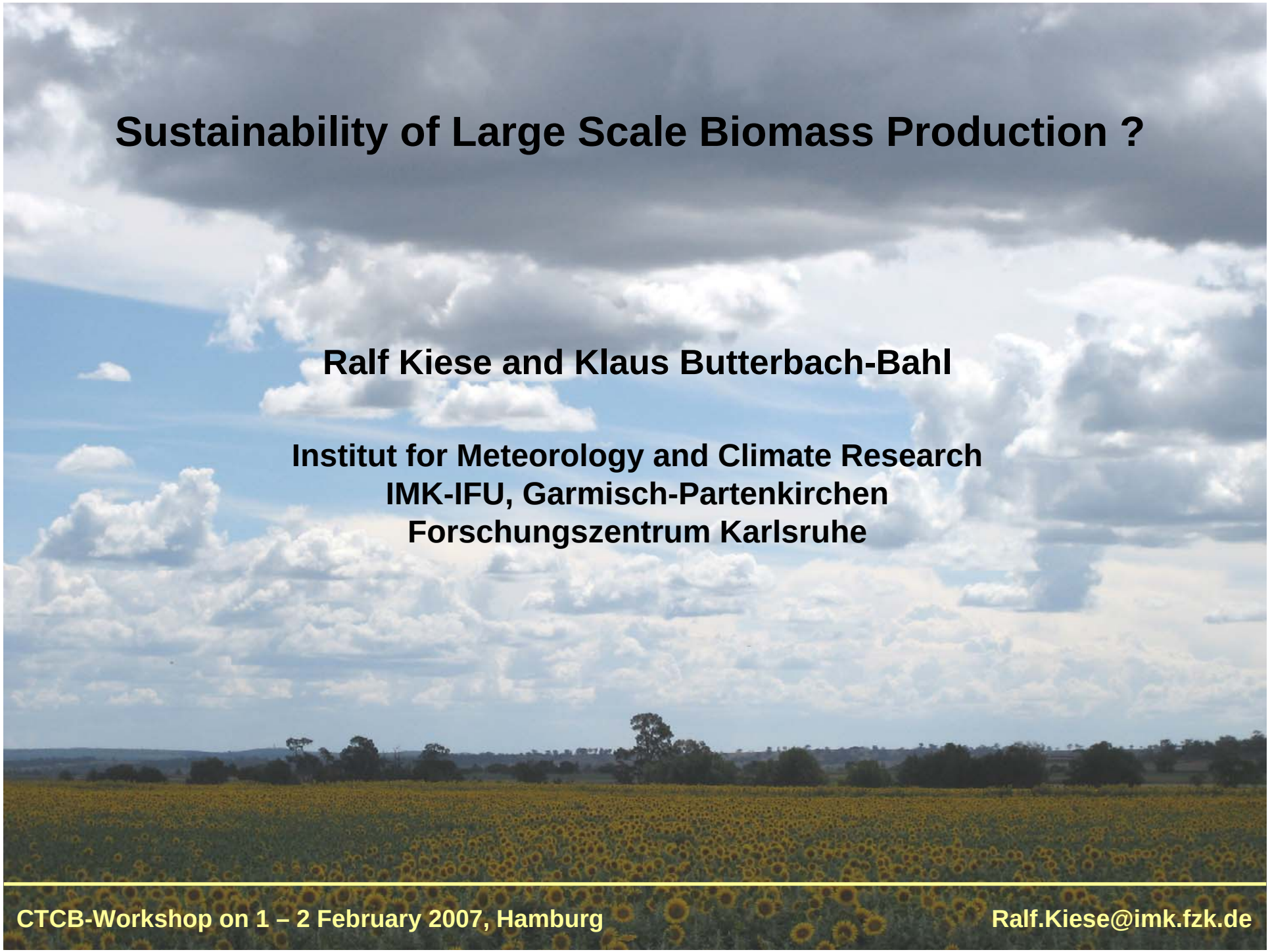

Sustainability of Large Scale Biomass Production ?

Ralf Kiese and Klaus Butterbach-Bahl

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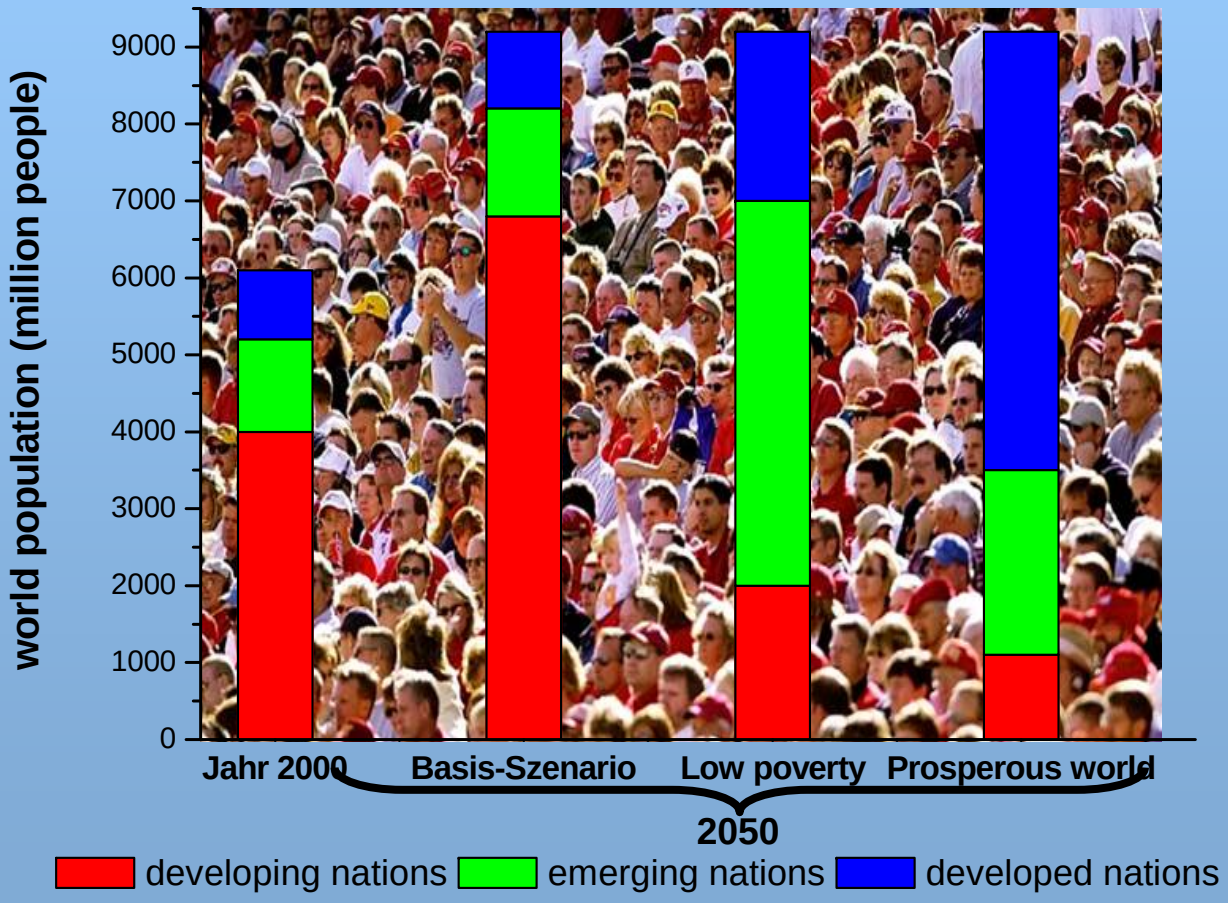
IMK-IFU, Garmisch-Partenkirchen
Forschungszentrum Karlsruhe

Ralf.Kiese@imk.fzk.de

Motivation (1):

Increase of world population and prosperity



Data from World Business Council Sustainable Development - 2004

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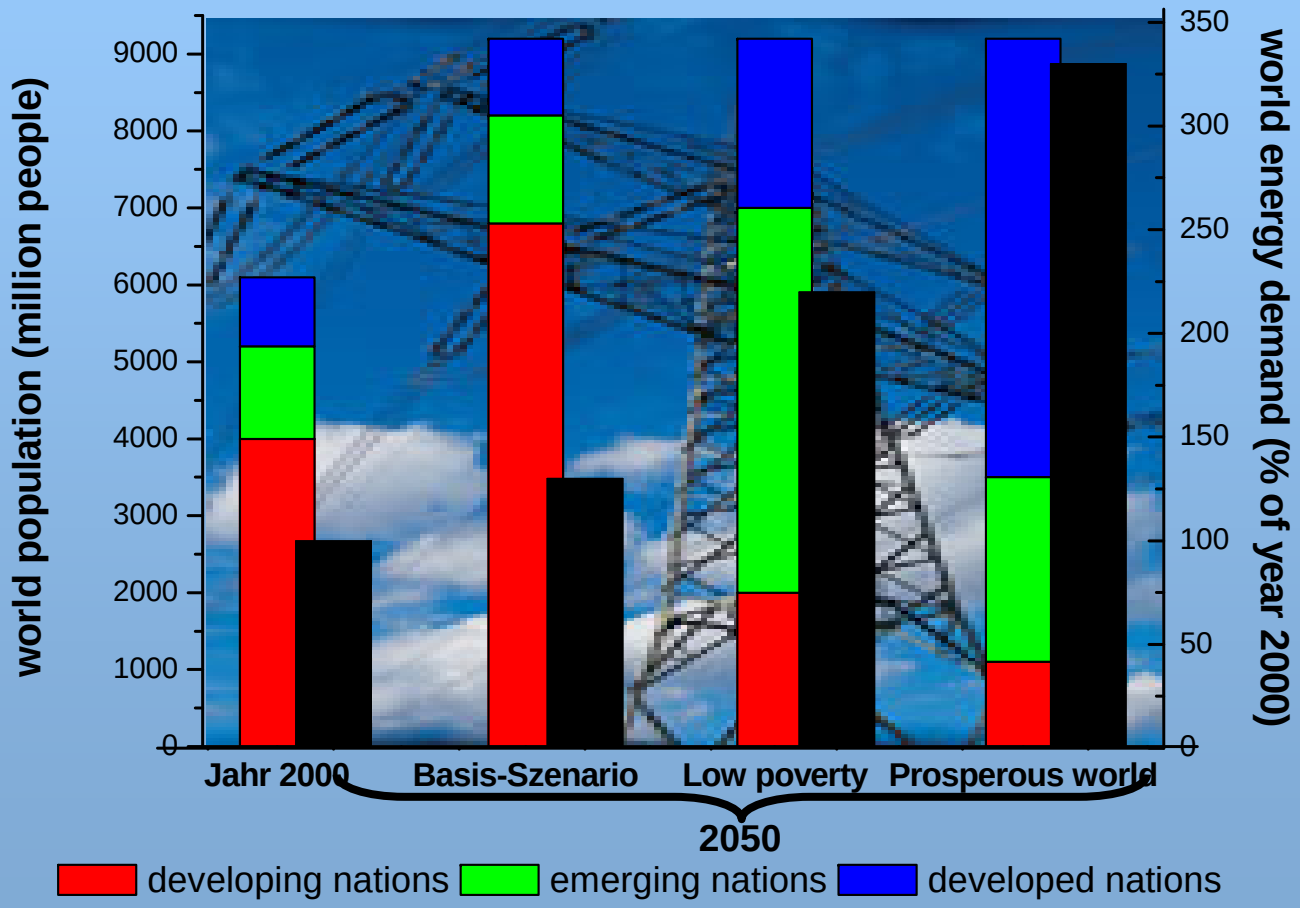
Motivation (1):

Increase of world population and prosperity cause increasing demand in energy



Data from World Business Council Sustainable Development - 2004

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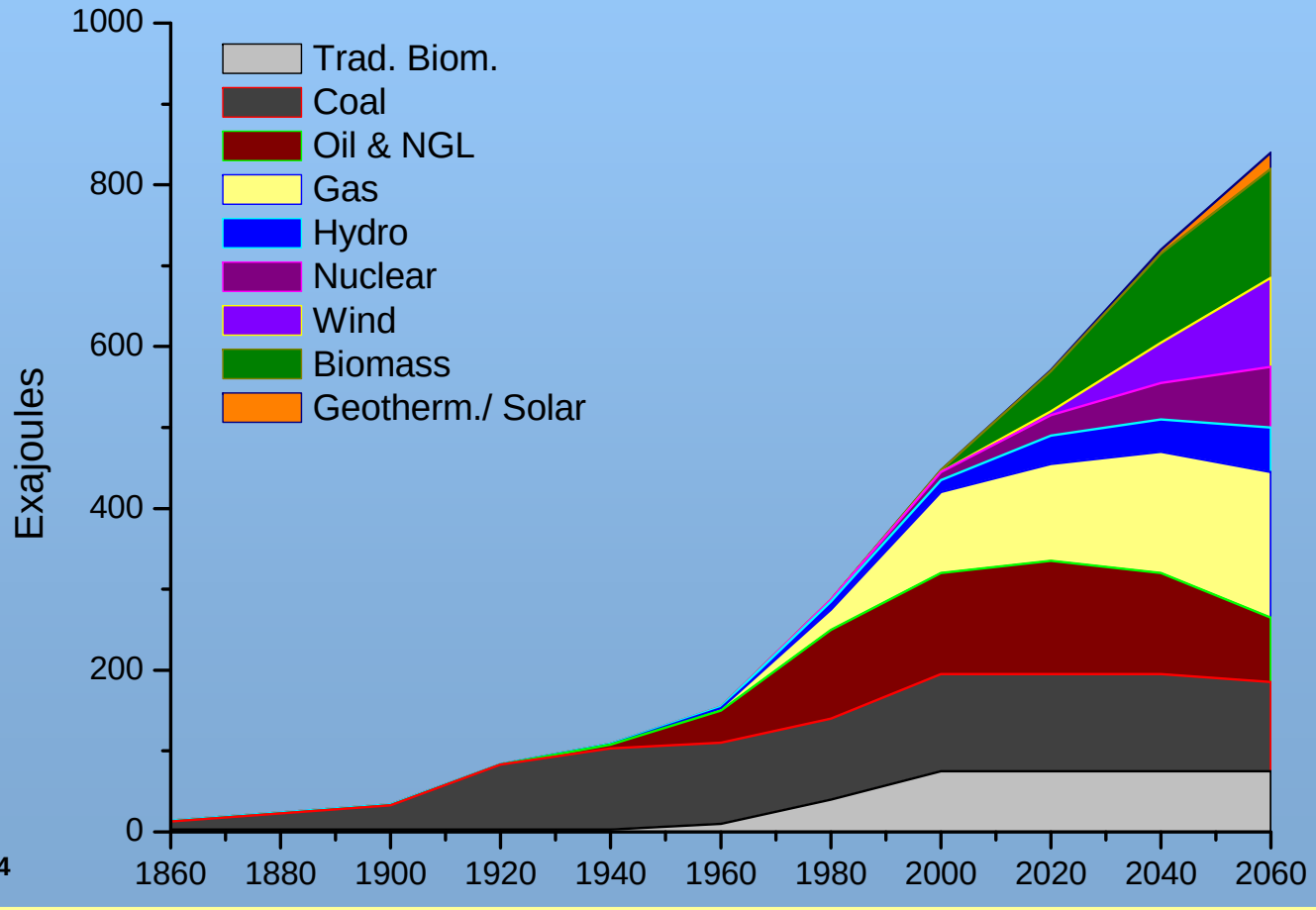
Motivation (2):

Increasing demand for energy requires alternative fuel sources such as “Bioenergy”



Data from World Business Council Sustainable Development - 2004

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Sustainability (of large scale biomass production ?)

... is an attempt to provide the best outcomes for the human and natural environments both now and into the indefinite future.

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Sustainability (of large scale biomass production ?)

... is an attempt to provide the best outcomes for the human and natural environments both now and into the indefinite future. It relates to the continuity of economic, social, institutional and environmental aspects of human society, as well as the non-human environment. It is intended to be a means of configuring civilization and human activity so that society, its members and its economies are able to meet their needs and express their greatest potential in the present, while preserving biodiversity and natural ecosystems, and planning and acting for the ability to maintain these ideals in a very long term.

Sustainability (of large scale biomass production ?)

... is an attempt to provide the best outcomes for the human and natural environments both now and into the indefinite future. It relates to the continuity of economic, social, institutional and environmental aspects of human society, as well as the non-human environment. It is intended to be a means of configuring civilization and human activity so that society, its members and its economies are able to meet their needs and express their greatest potential in the present, while preserving biodiversity and natural ecosystems, and planning and acting for the ability to maintain these ideals in a very long term. Sustainability affects every level of organization, from the local neighborhood to the entire planet.

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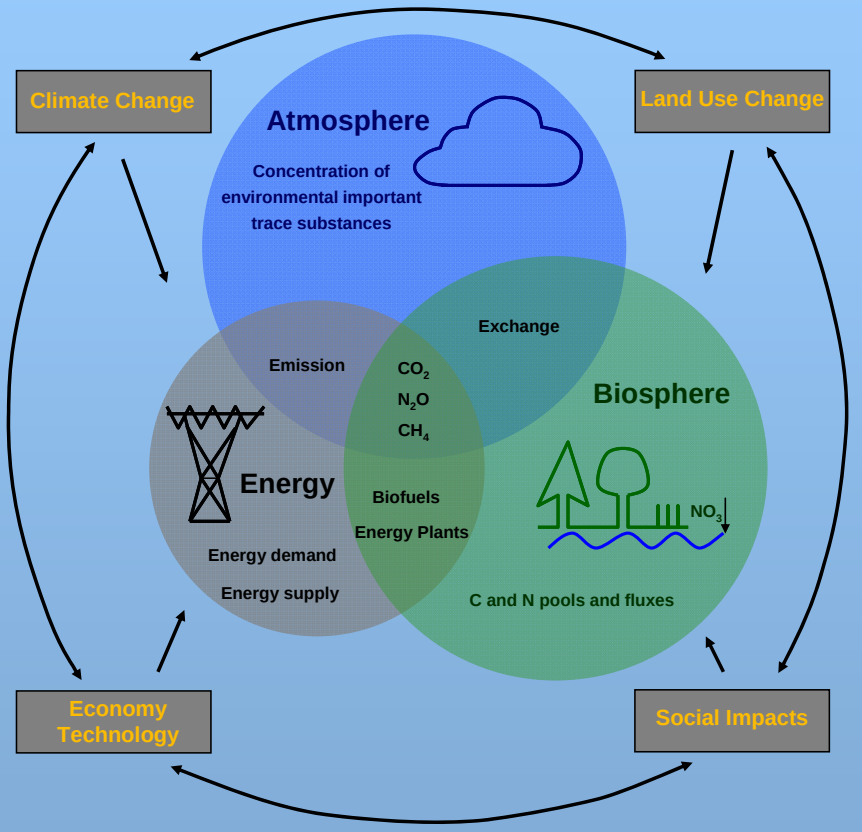
Sustainability of large scale biomass production

Is not only a question of carbon neutrality but …



Challange:

define and apply efficient and sustainable policies for biomass production and adequate adaptation strategies to changing environmental conditions caused by climate change

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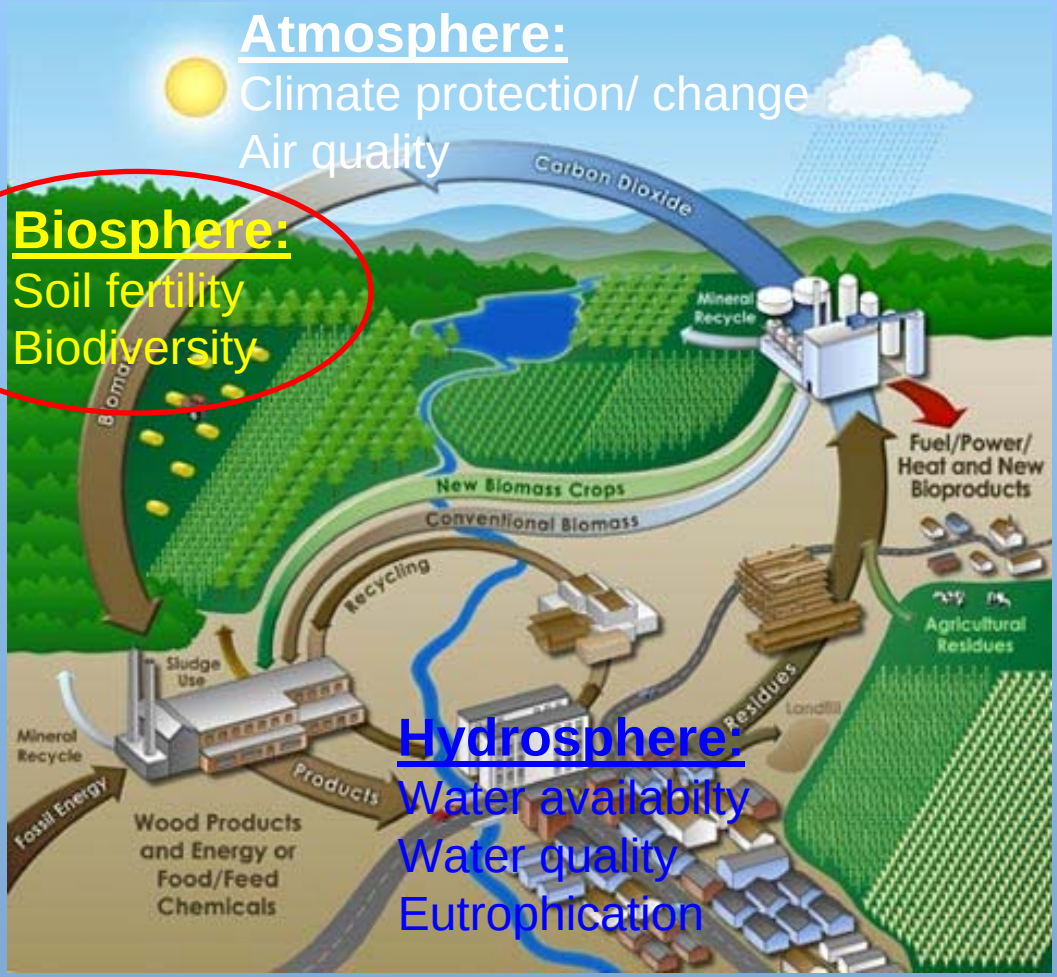
Problem:

Complex system …

Environmental impacts of large scale biomass production ?



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Biomass production and biosphere:

Soil fertility …

describes the productive part of the soil, containing nutrients, water and organic matter

Problem:

unbalanced farming management can lead to ….

- depletion of soil organic carbon
- reduced biological soil activity
- soil compaction and erosion, and thus to

reduced water and nutrient storage capacity

Furthermore, …

reapplication of residues from bioenergy production can lead to soil and ground/ surface water contamination (e.g. heavy metals, nitrate)

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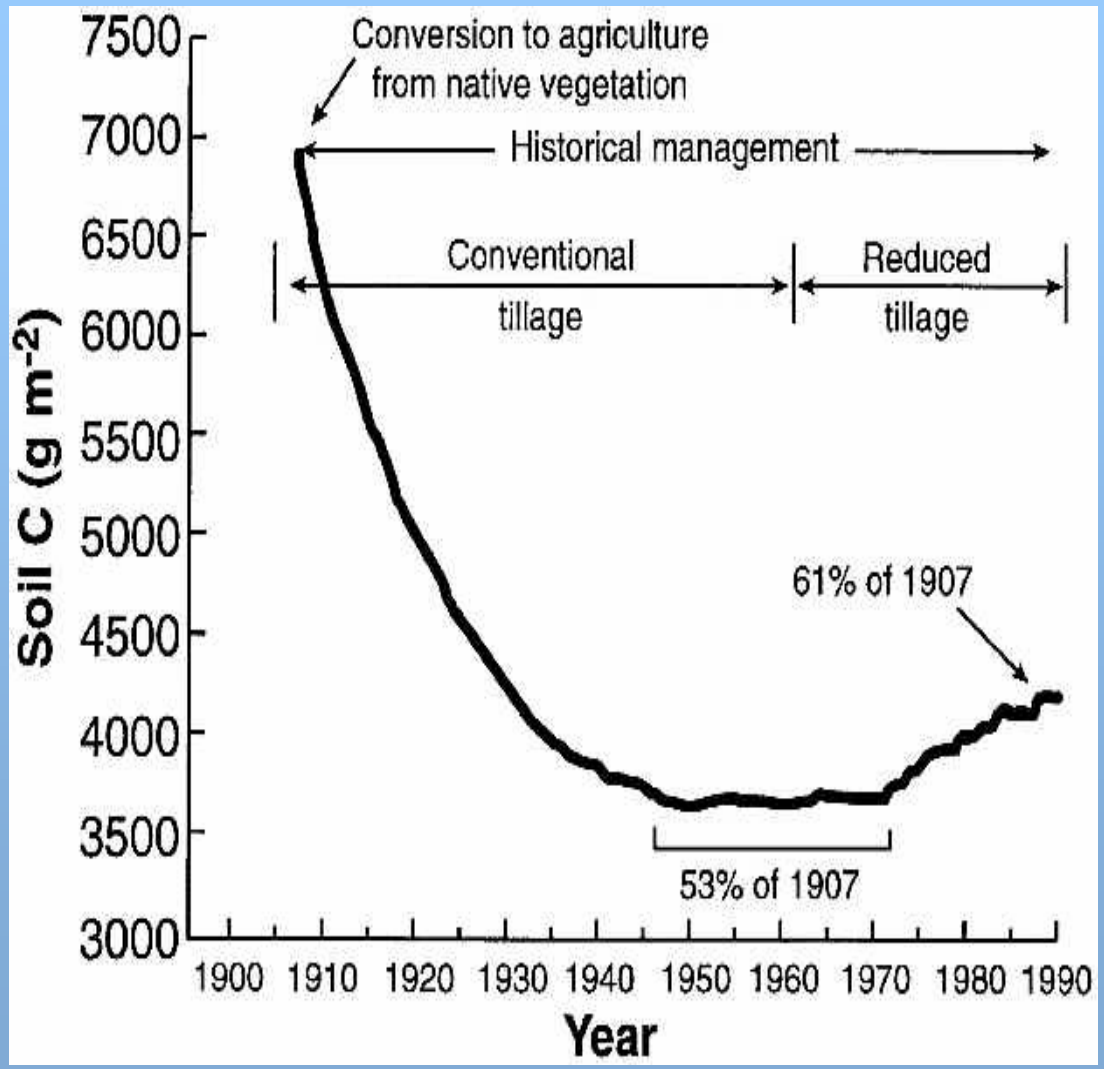
Changes in organic Carbon from forest conversion into maiz cultivation



Matson et al., 1998

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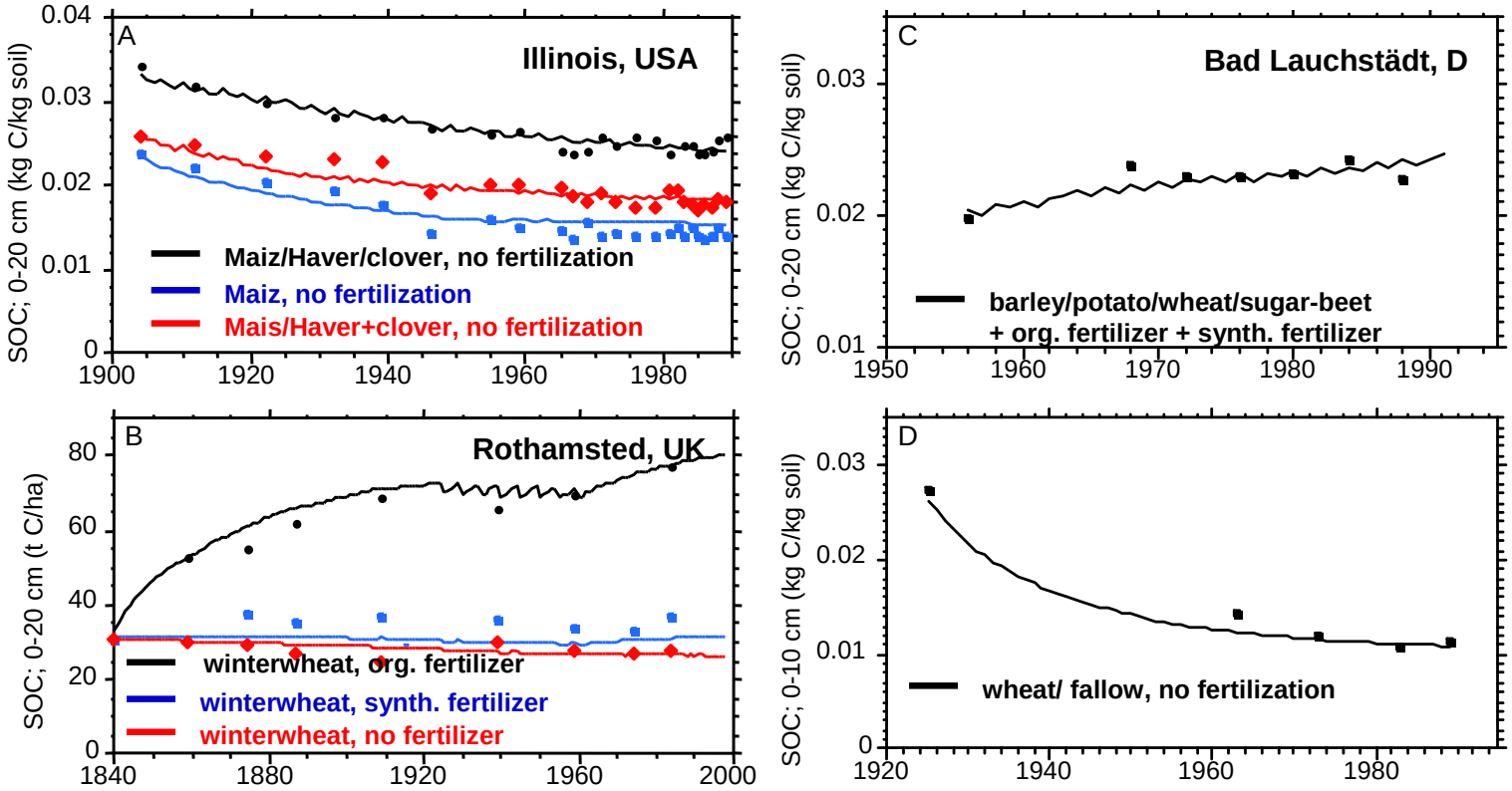
Change of SOC due to different farming management



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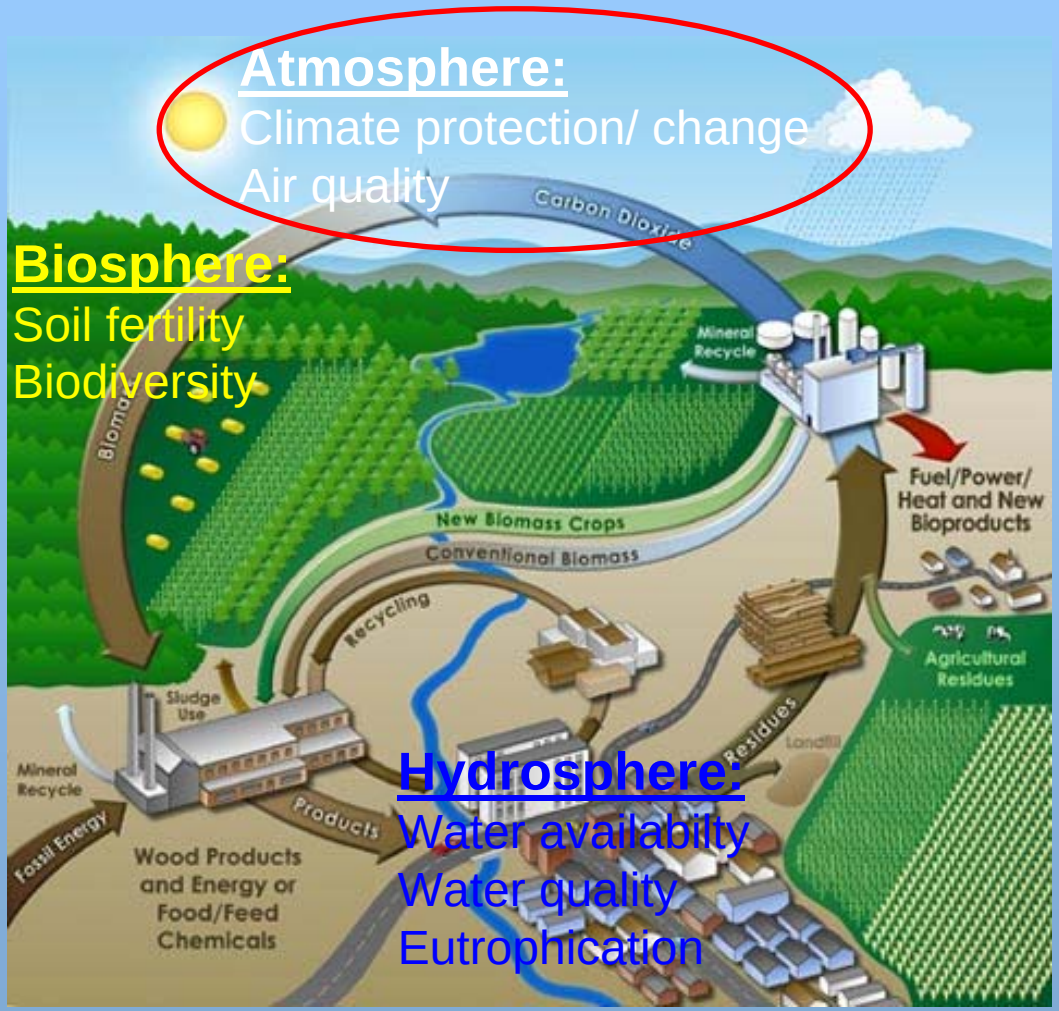
Environmental impacts of large scale biomass production ?



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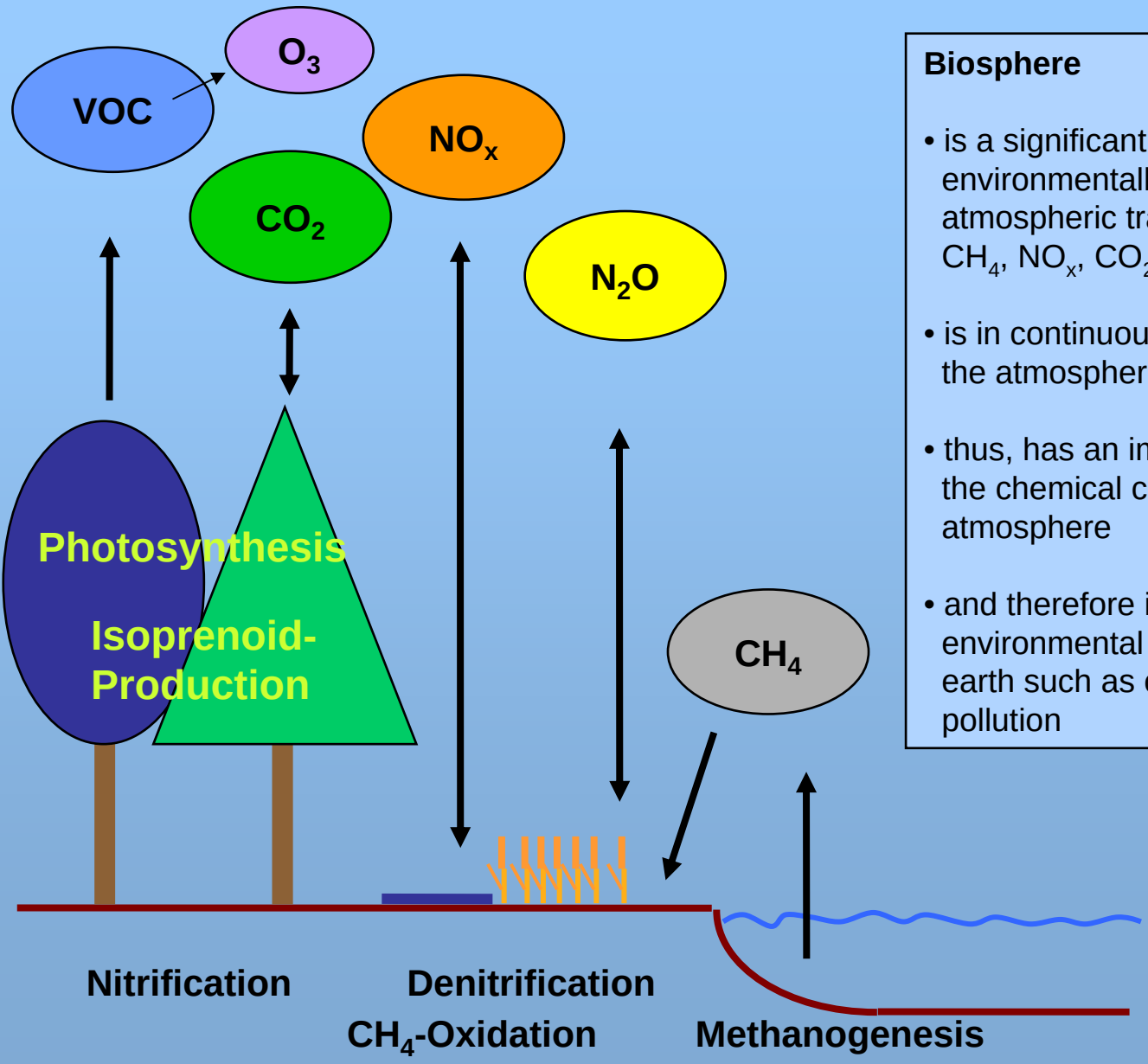
Biomass production and atmosphere:



Biosphere

- is a significant source and sink for environmentally important atmospheric trace gases (N_2O, CH_4, NO_x, CO_2, VOC)
- is in continuous exchange with the atmosphere
- thus, has an important effect on the chemical composition of the atmosphere
- and therefore influencing the environmental conditions on the earth such as climate and air pollution

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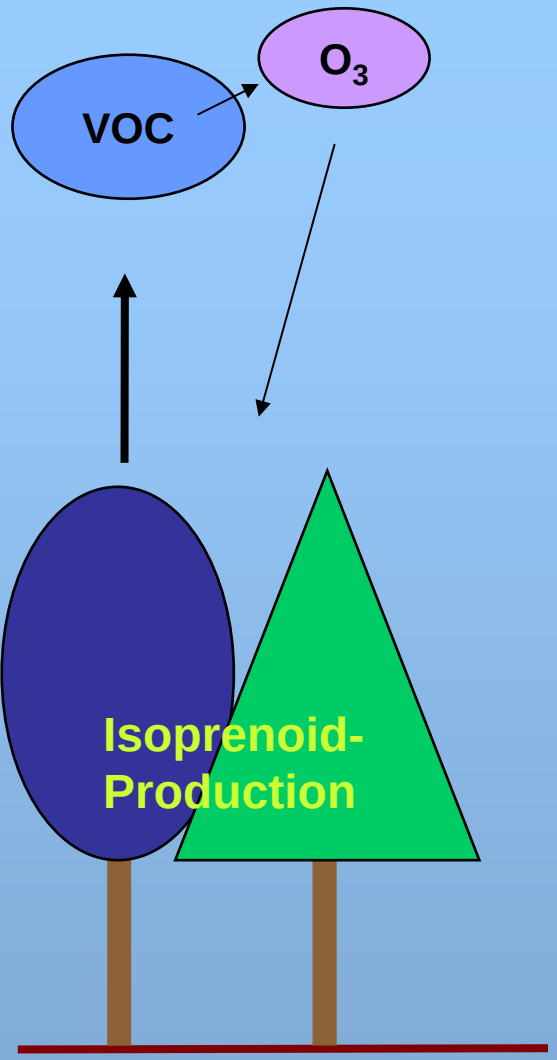
Air Quality



Fast growing trees like poplar and eucalypts are strong emitters of BVOC´s (e.g. Isoprene).

Isoprene significantly influences atmospheric chemistry.

In the presence of nitric oxides (NO_X), the oxidation of isoprene contributes significantly to the formation of ozone, a dominant tropospheric air pollutant

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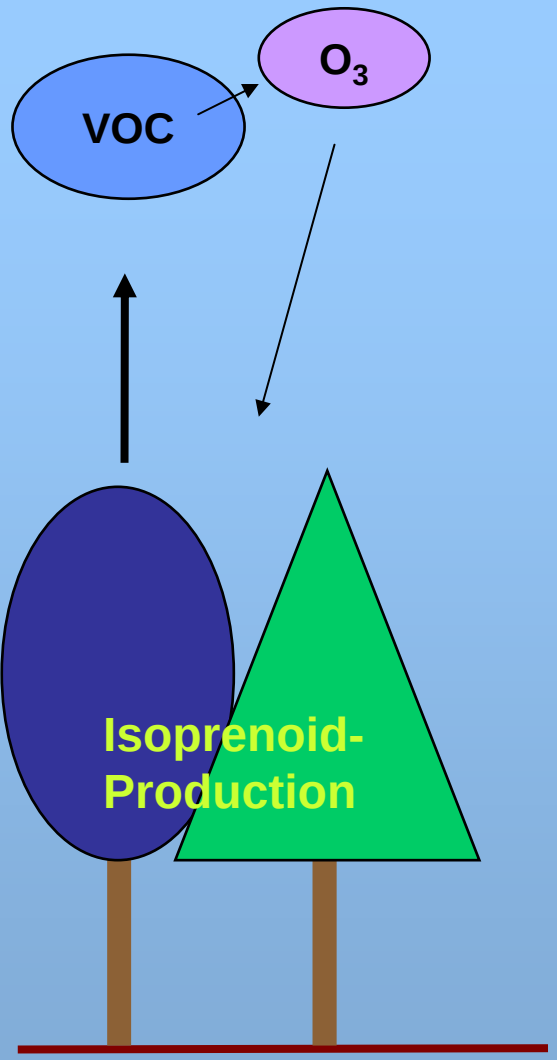
Air Quality



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Bioengeneering

Generation of low or non-emitting species

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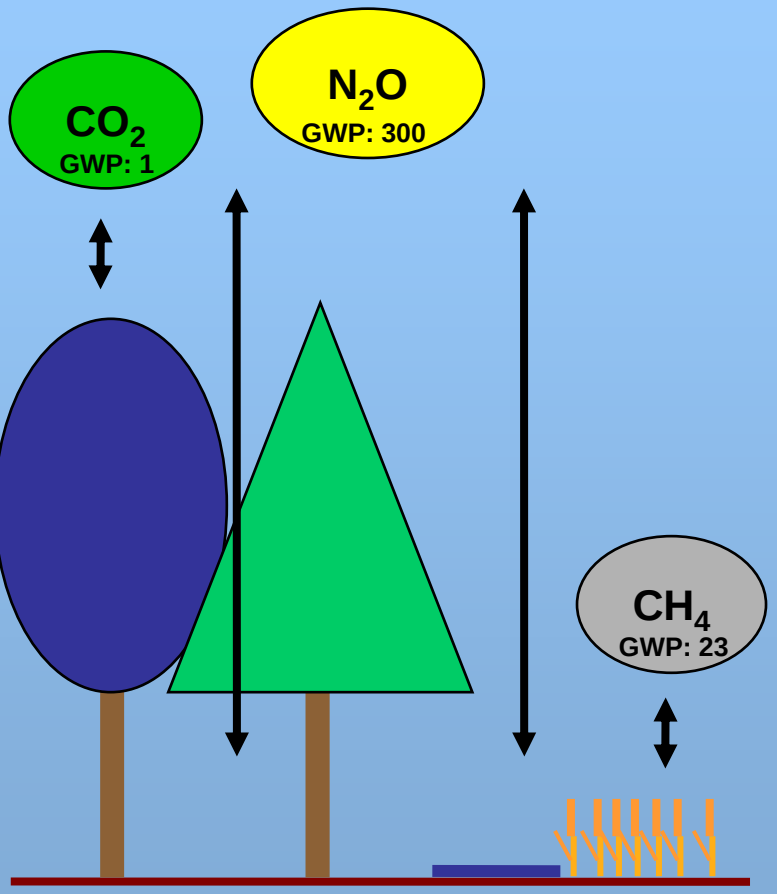
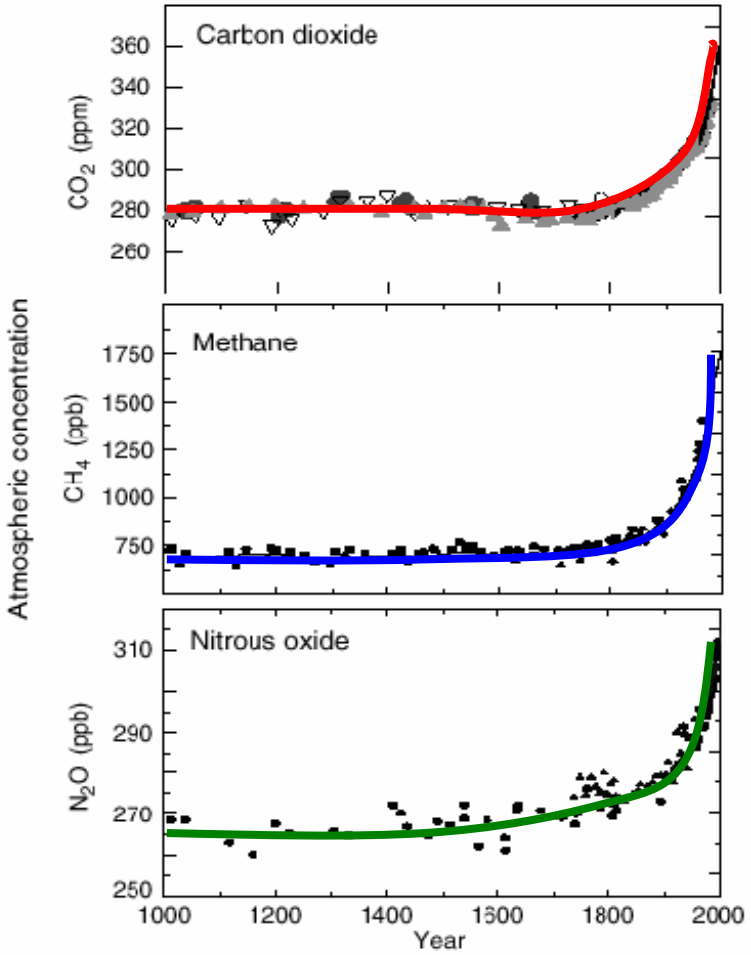
Climate protection/ change



Atmospheric increase of GHG



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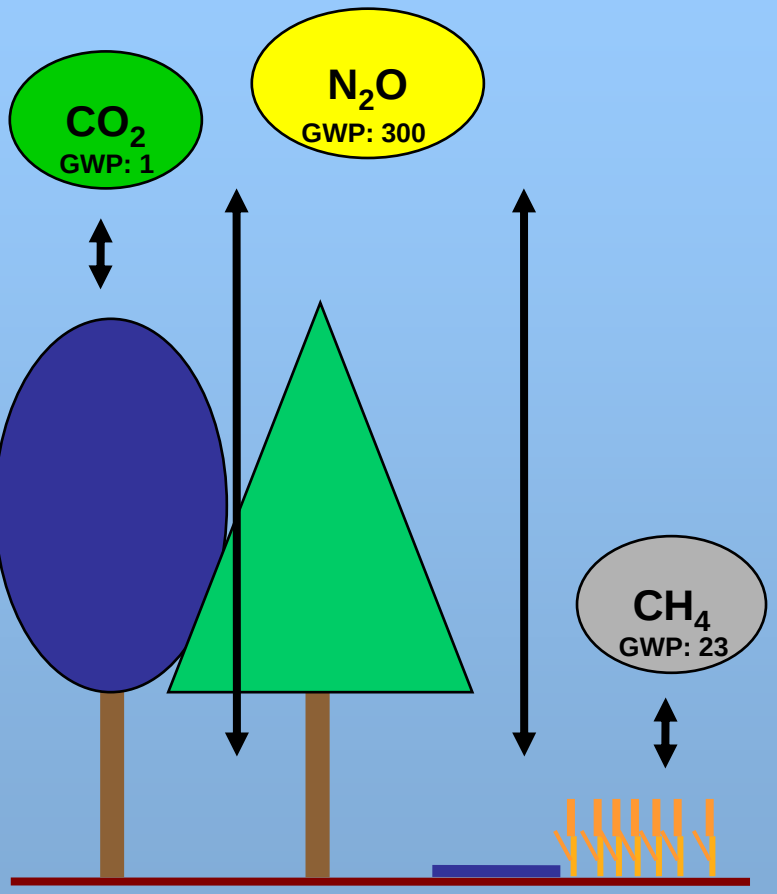
Climate protection/ change



Global N_2O budget

N_2O-sources	Relative contribution to all identified sources [%]	Tg (10^{12} g) N_2O-N a^{-1}	
Natural N_2O sources			
Ocean	18.5	3.0	(1.0-5.0)
Tropical soils			
Wet forests	18.5	3.0	(2.2-3.7)
Dry savannas	6.2	1.0	(0.5-2.0)
Temperate soils			
Forests	6.2	1.0	(0.1-2.0)
Grasslands	6.2	1.0	(0.5-2.0)
Anthropogenic N_2O sources			
Agricultural soils	**20.4**	**3.3**	**(0.6-14.8)**
Biomass burning	3.1	0.5	(0.2-1.0)
Industrial sources	8.0	1.3	(0.7-1.8)
Cattle and feedlots	13.0	2.1	(0.6-3.1)
Total N_2O sources		16.2	(6.4-34.4)
N_2O sinks and atmospheric increase			
Stratospheric destruction		12.3	(9.0-16.0)
Removal by soil microbes		?	(?)
Atmospheric increase		**3.9**	**(3.1-4.7)**

IPCC, 2001

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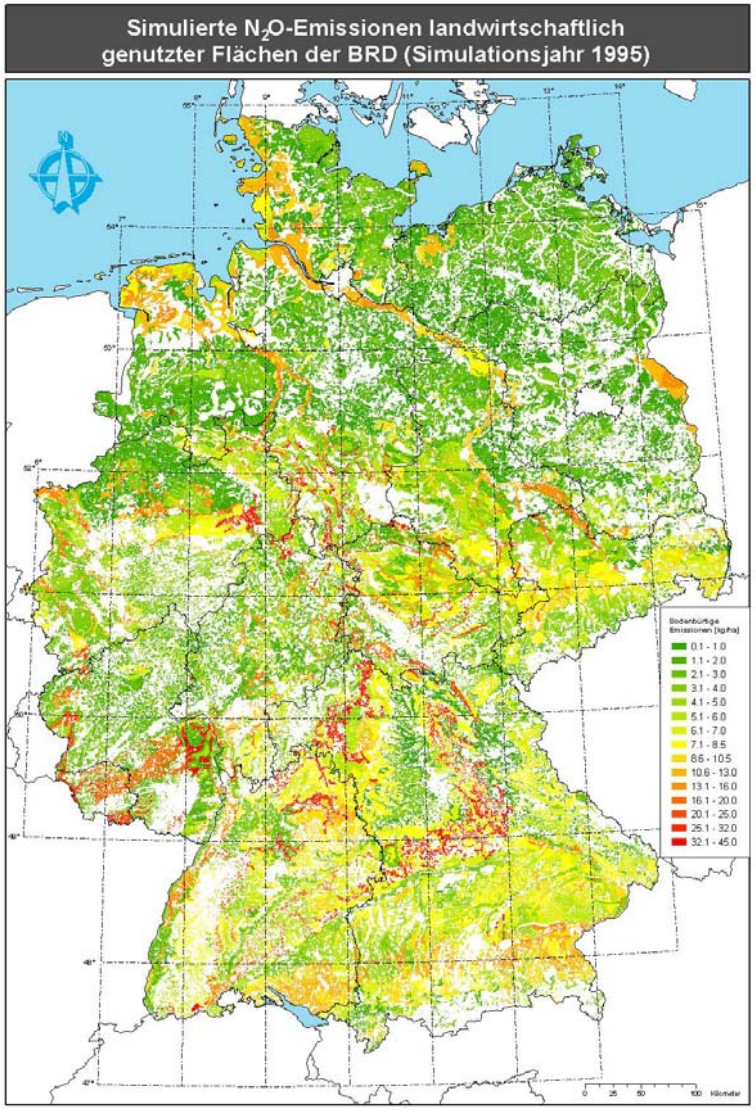
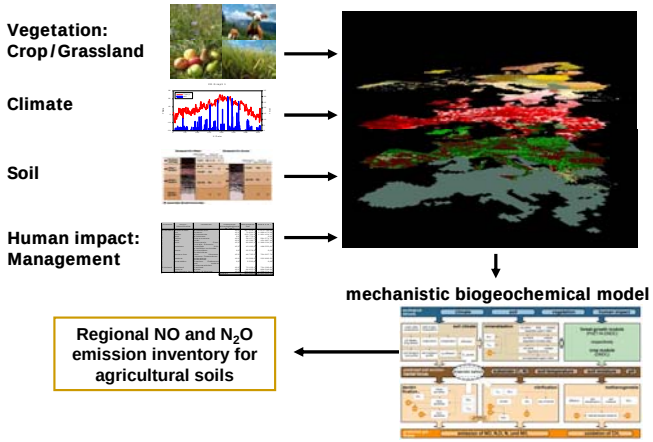
N_2O-Emission Inventory agricultural soils Germany



coupled model-GIS approach



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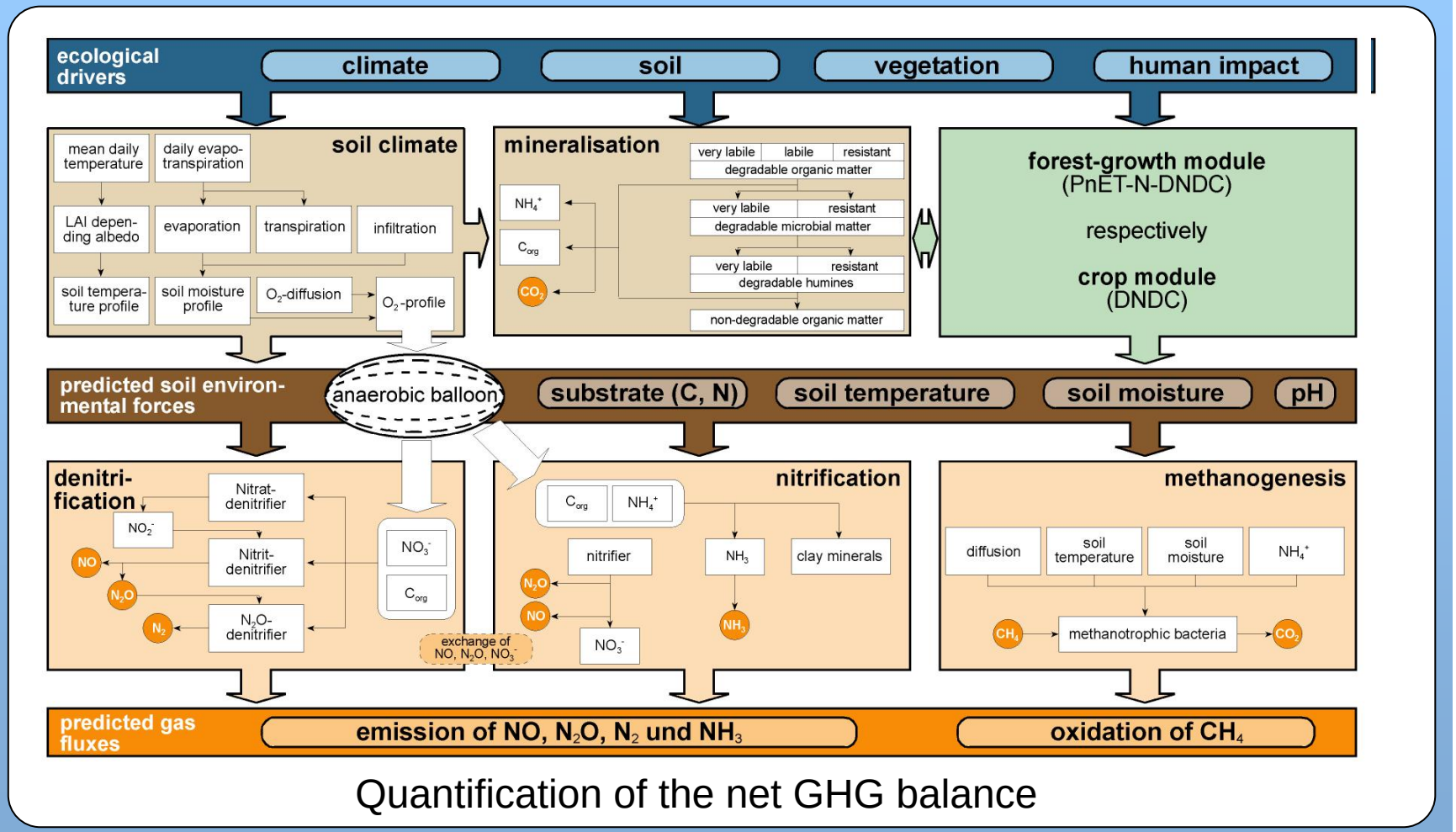
Biogeochemical Modelling of ecosystem processes



Quantification of the net GHG balance

model descriptions: e.g. Li et al. ,2000 / Li 2000

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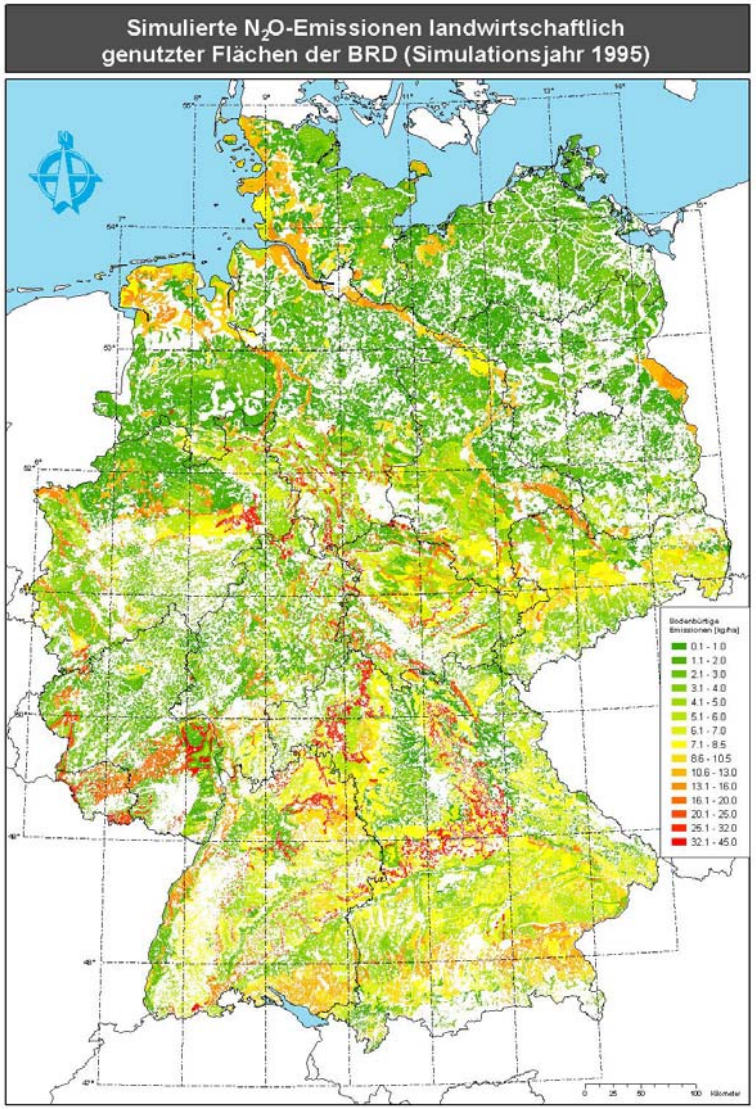
N_2O-Emission Inventory agricultural soils Germany



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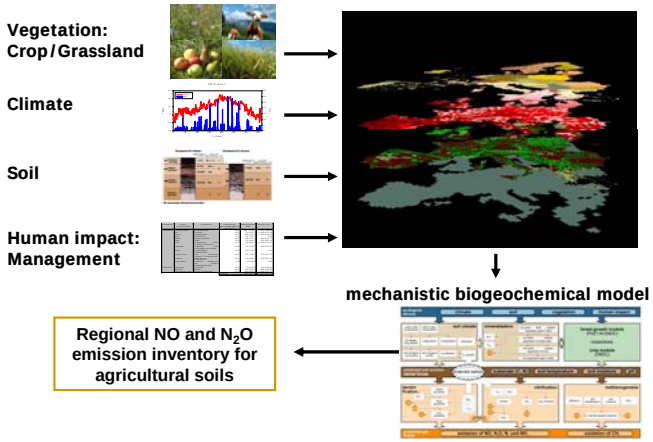
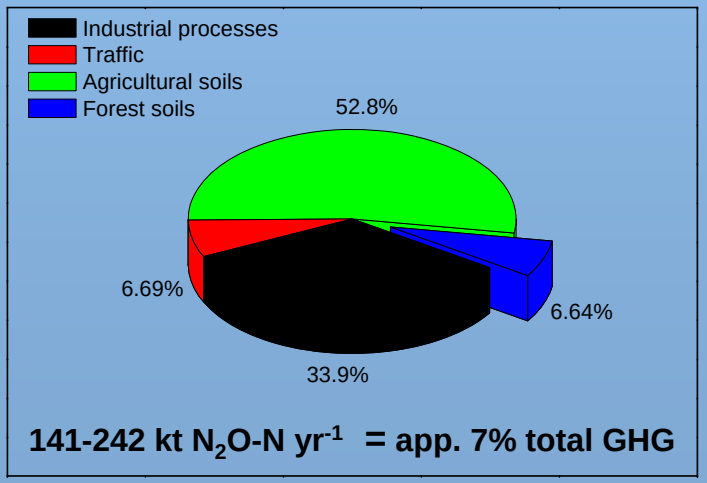


Sources of N_2O in Germany



141-242 kt N_2O-N yr^{-1} = app. 7% total GHG

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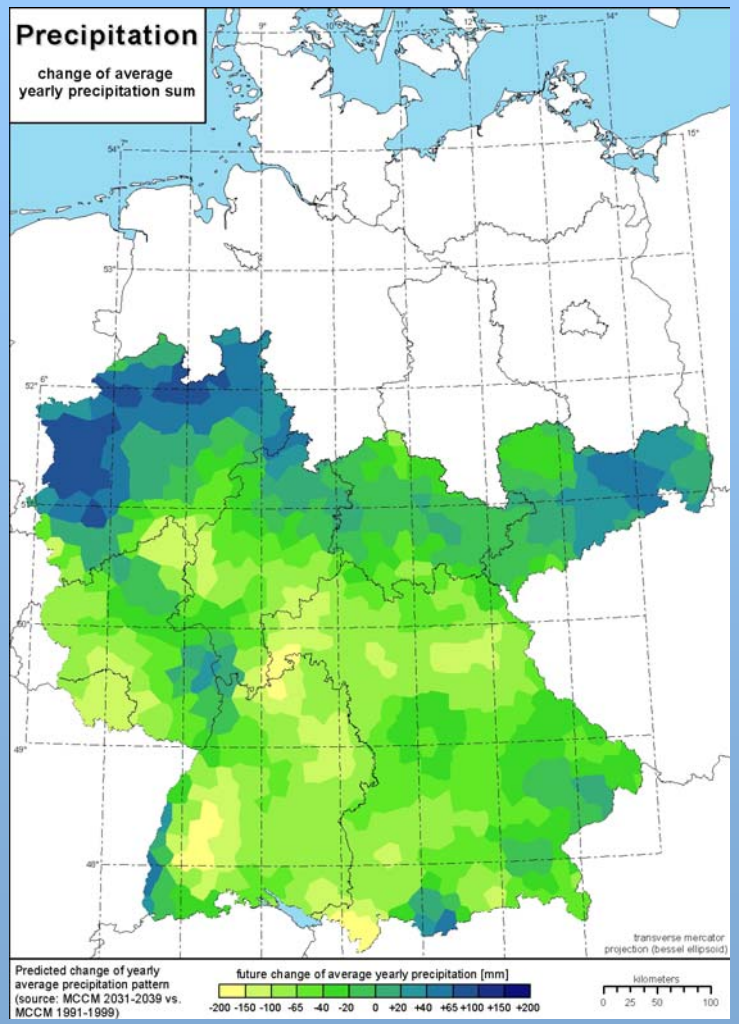
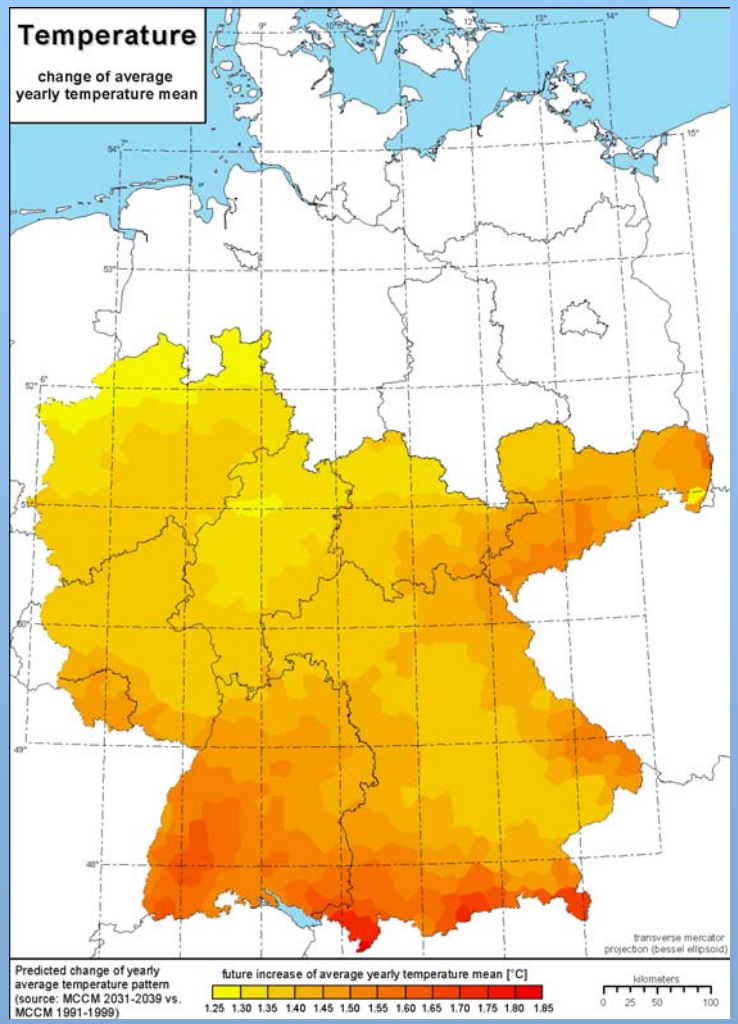
Climate change feedback on biogeochemical processes and suitability of bioenergy cropping systems





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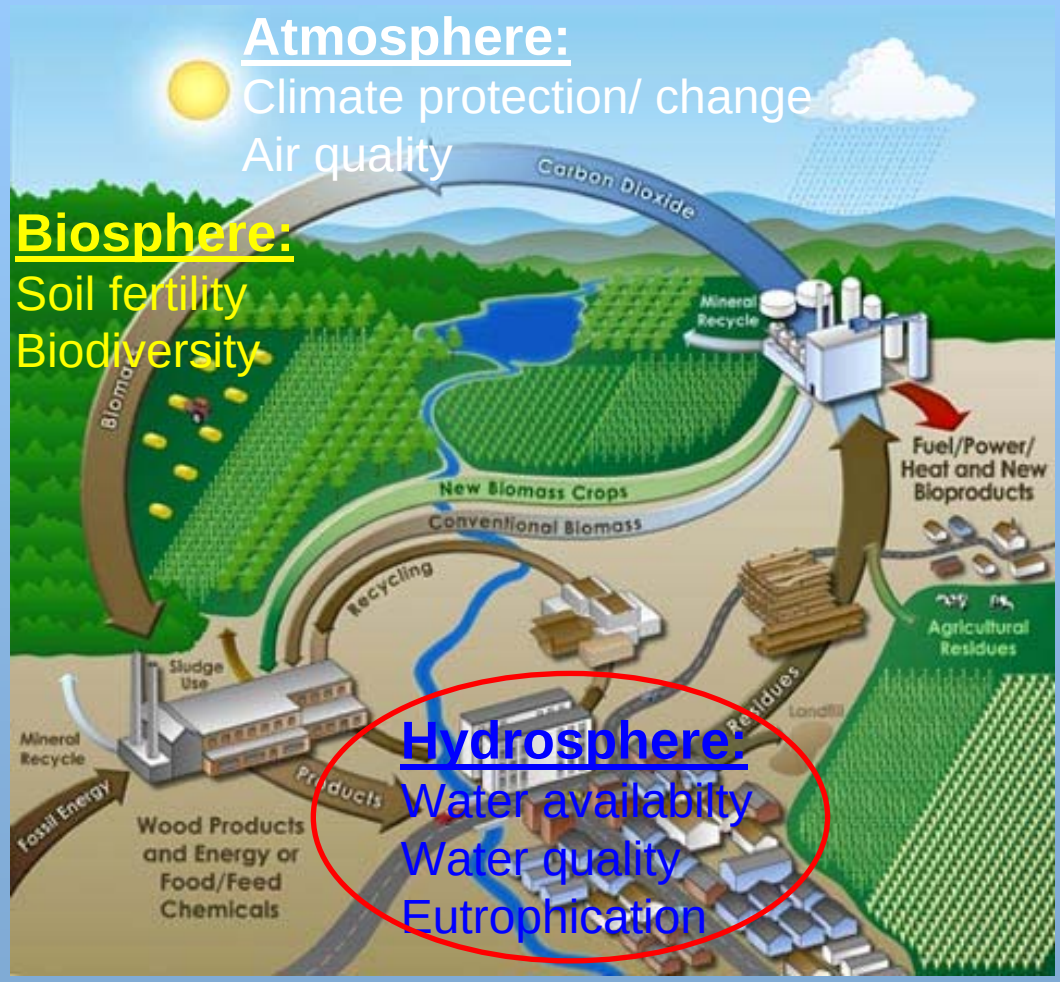
Environmental impacts of large scale biomass production ?



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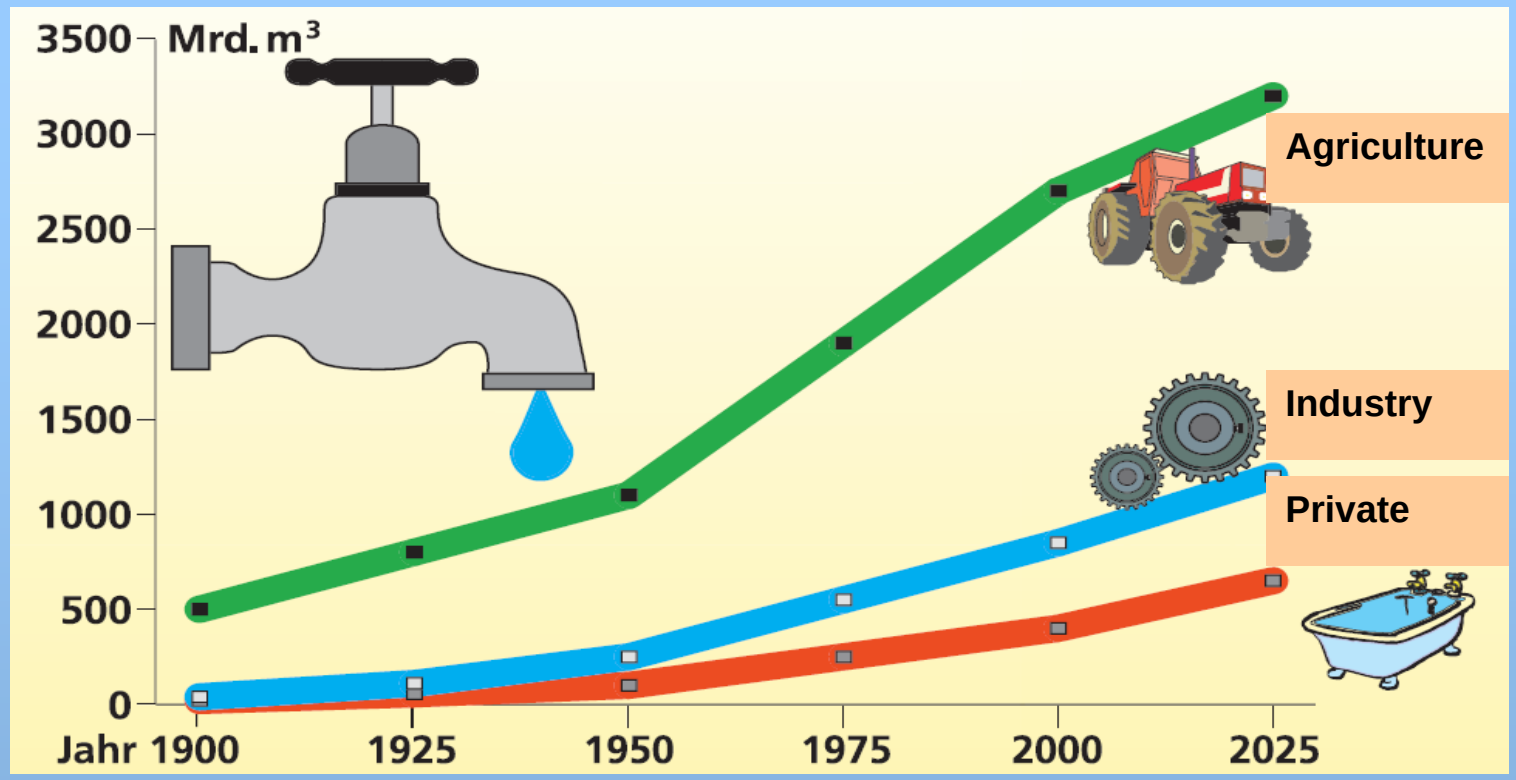
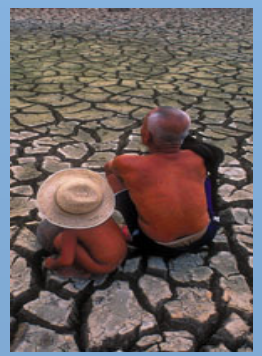
Global water demand



Water availabilty



in most regions limiting factor for biomass production

Soil salinity/ erosion

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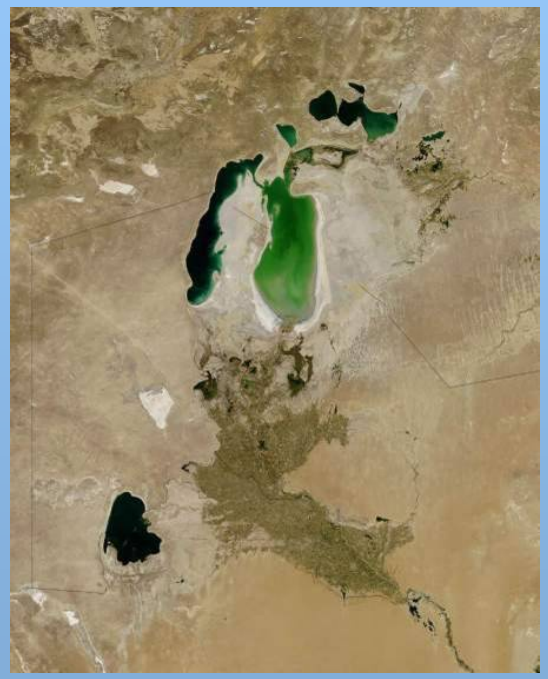
Decrease of Aral Sea Area

1976

1997

2004



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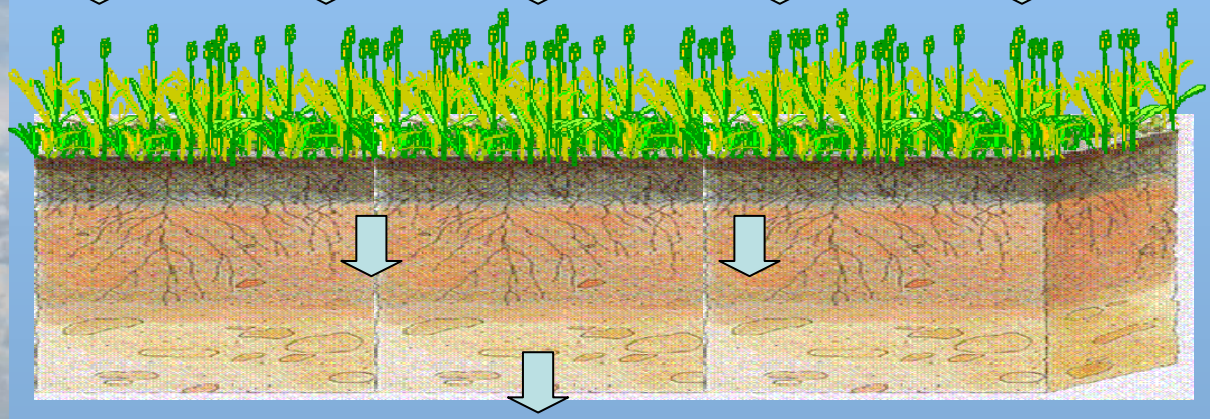
Eutrophication and contamination of surface and groundwater bodies

mineral./organ. N-fertilization

residue application

temporal, qualitativ, quantitativ unbalanced

erosion/ surface runoff



Surface waters

Perkolation into groundwater drinking water quality

groundwater recharge

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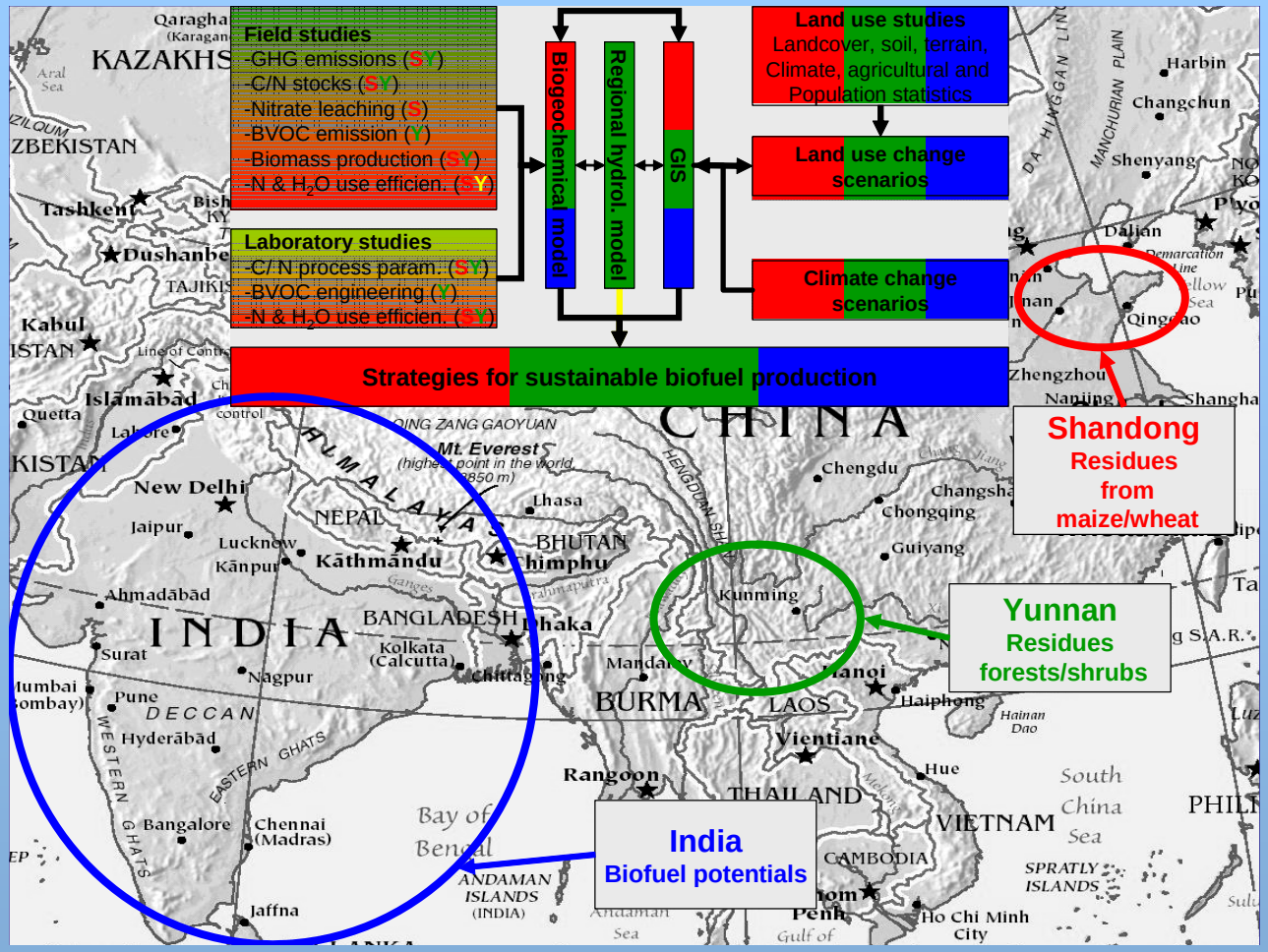
Proposed study design



Activities:

China:

1 Postdoc, 1 PhD

Helmholtz Allianz

„Sustainable Bioeconomy“

Thank you !!!

Partners:

University Freiburg

University Kassel

Local research groups

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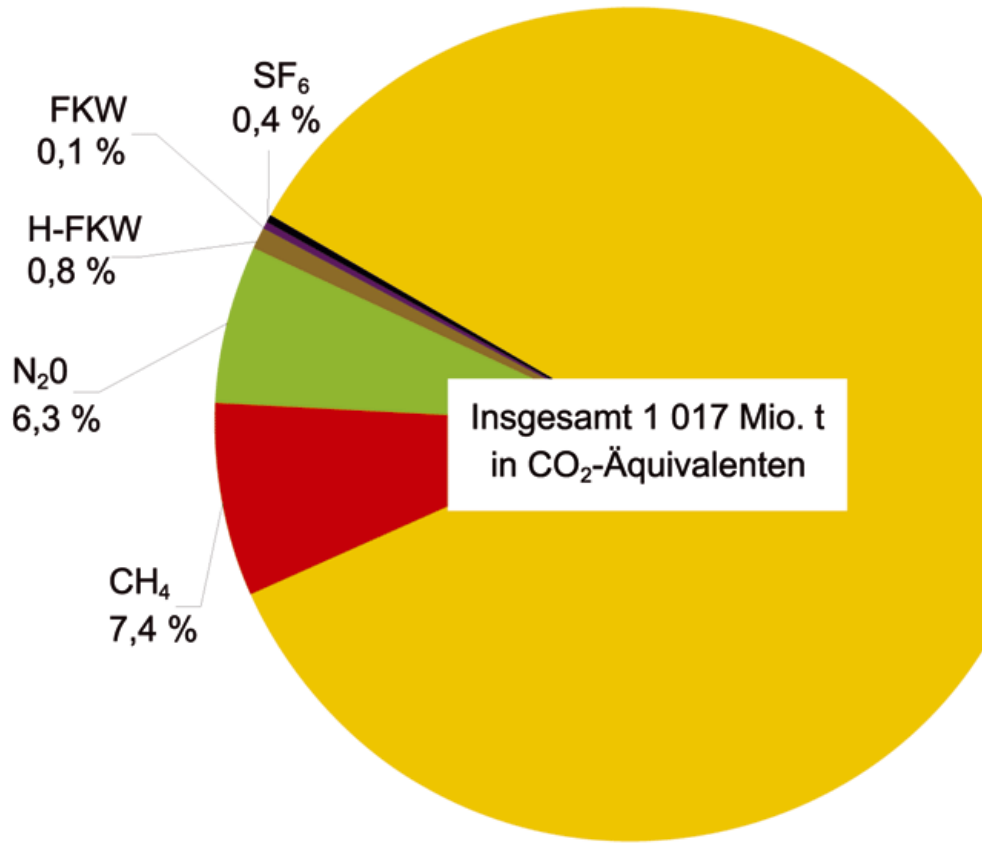
Summary and conclusion

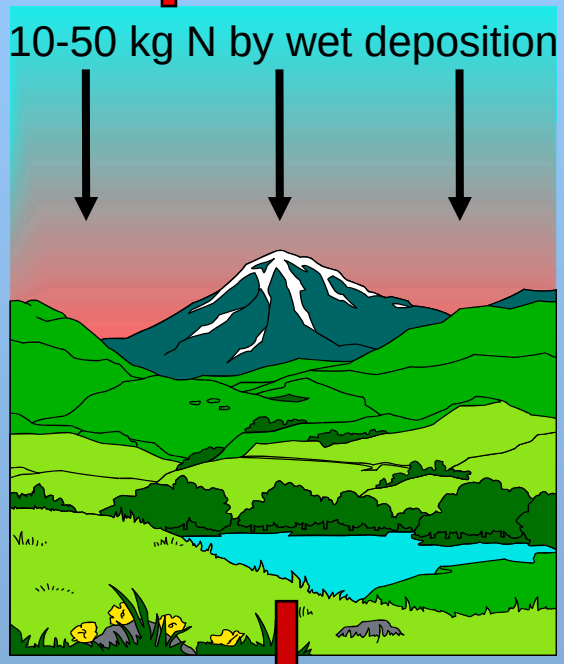
- „Energiepflanzenanbau“ ist eine interessante Option für die Energieversorgung,
- komplexen Wechselwirkungen von großflächiger Bioenergieproduktion mit ihren klimatischen, ökologischen, ökonomischen, politischen, sozialen und technologischen Aspekten sind nur wenig verstanden,
- Definition nachhaltiger Strategien zur Bioenergieerzeugung im Angesicht des Klimawandels erfordert umfassendes Systemverständnis inklusive der sozio-ökonomischen Implikationen,
- langfristig angelegte, interdisziplinäre und praxisorientierte Forschung ist erforderlich.

Anteile der Treibhausgase an den Emissionen (berechnet in CO_2-Äquivalenten) 2003



Quelle: Umweltbundesamt 2005 (Hrsg.) – Deutsches Treibhausgasinventar 1990–2003, Nationaler Inventarbericht 2005. Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen. Berlin, April 2005

The nitrogen cascade



Fossil fuel combustion

Agriculture

Natural ecosystems

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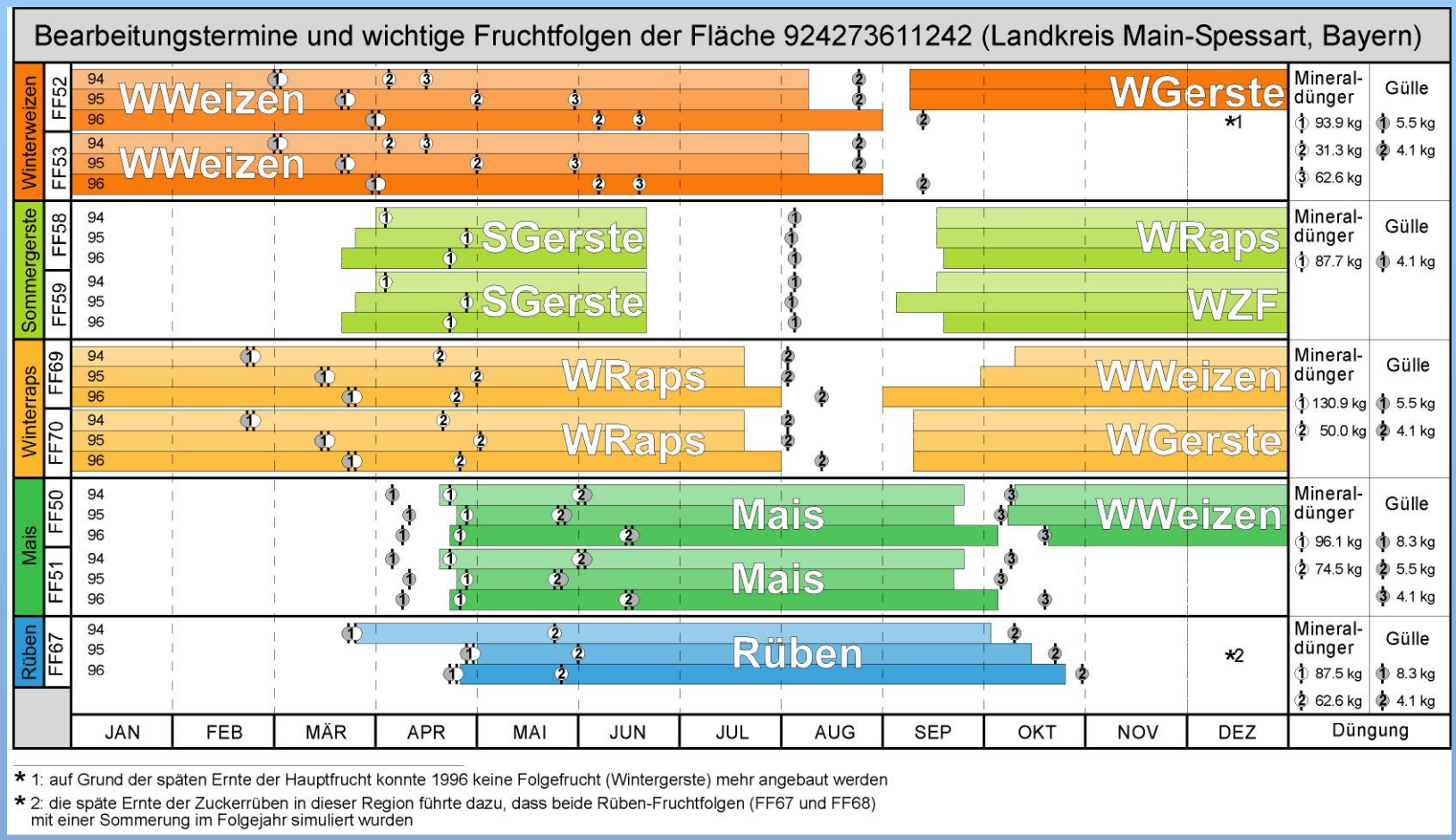
Crop rotation



* 1: auf Grund der späten Ernte der Hauptfrucht konnte 1996 keine Folgefrucht (Wintergerste) mehr angebaut werden

* 2: die späte Ernte der Zuckerrüben in dieser Region führte dazu, dass beide Rüben-Fruchtfolgen (FF67 und FF68) mit einer Sommerung im Folgejahr simuliert wurden

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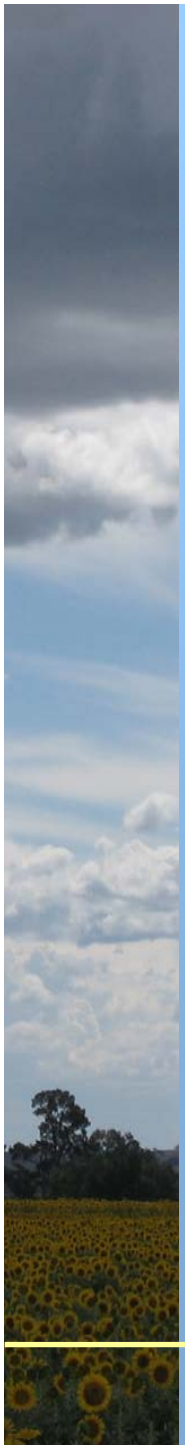

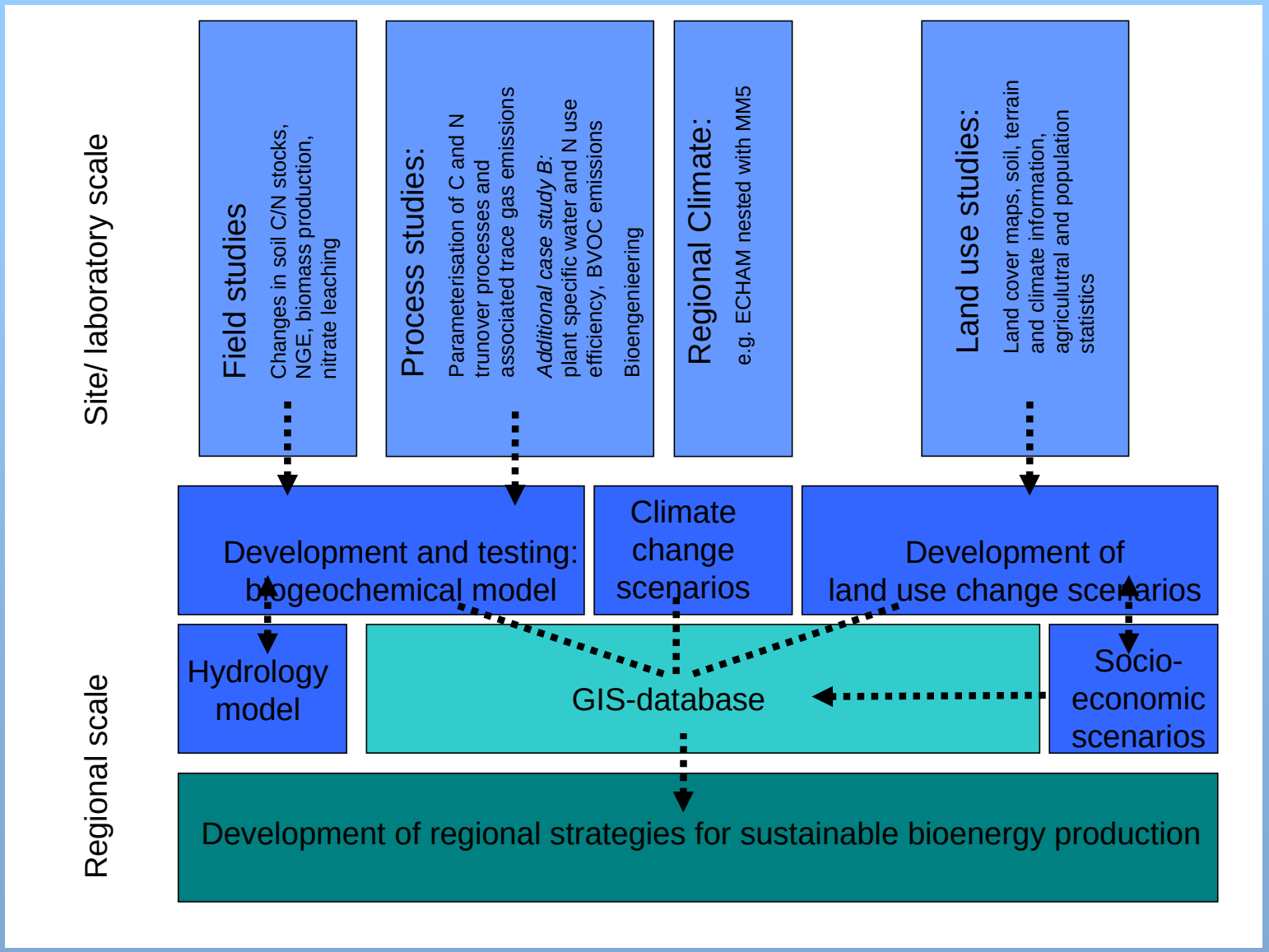

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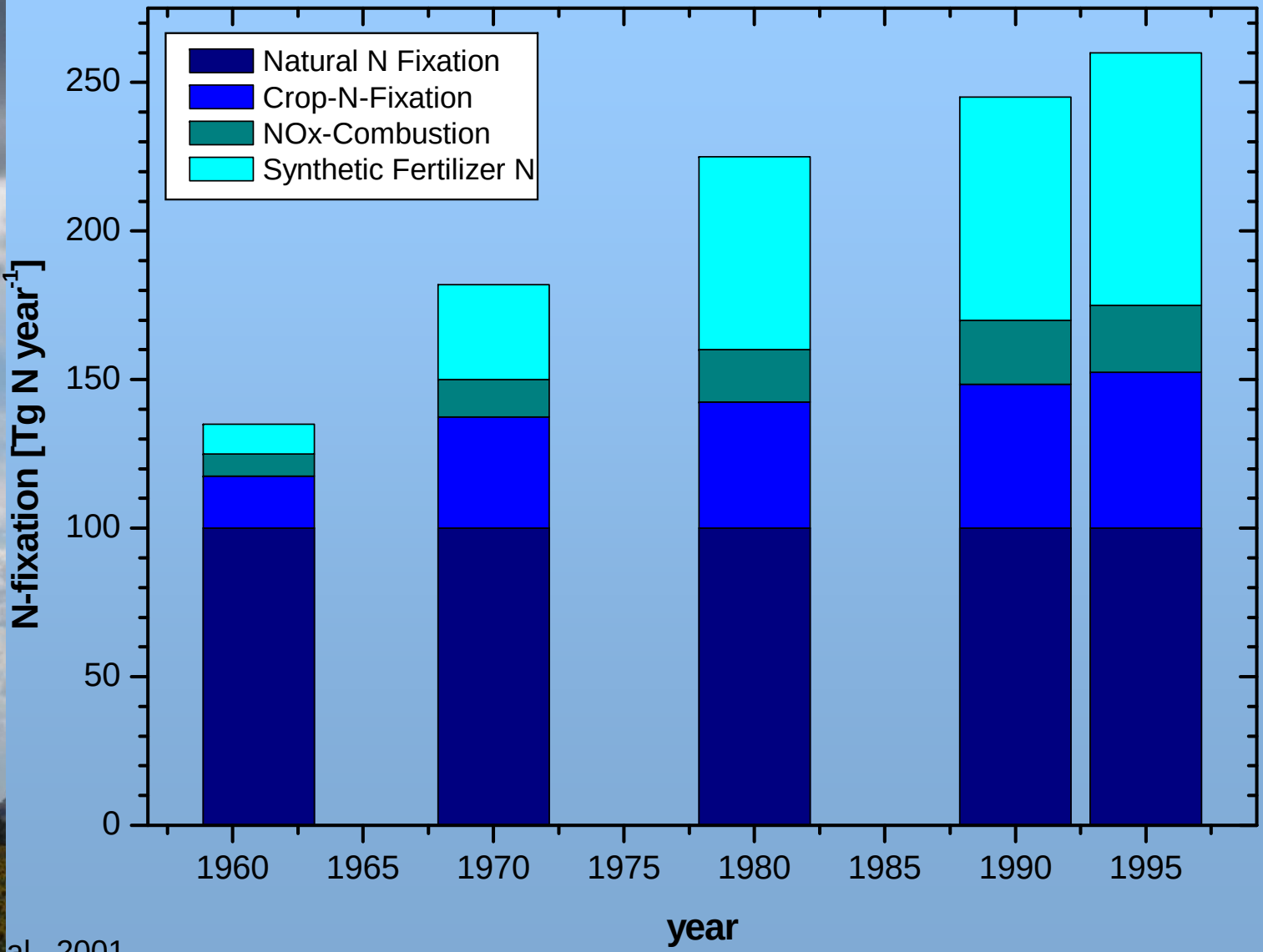
Global N-fixation (1961 – 1995)



Mosier et al., 2001

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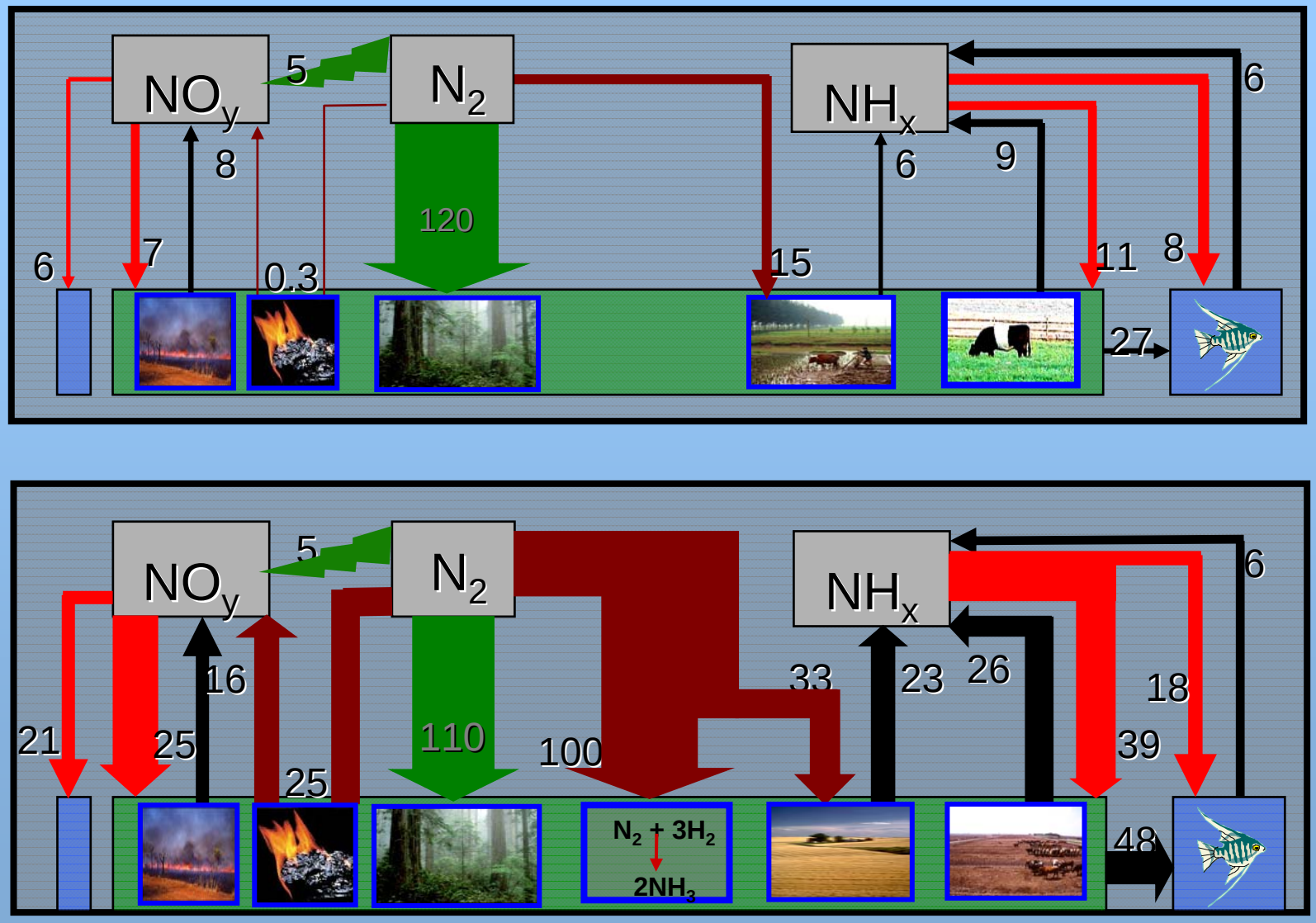
Globales N-Budget 1860 und heute



Galloway et al., 2003, Biogeochemistry

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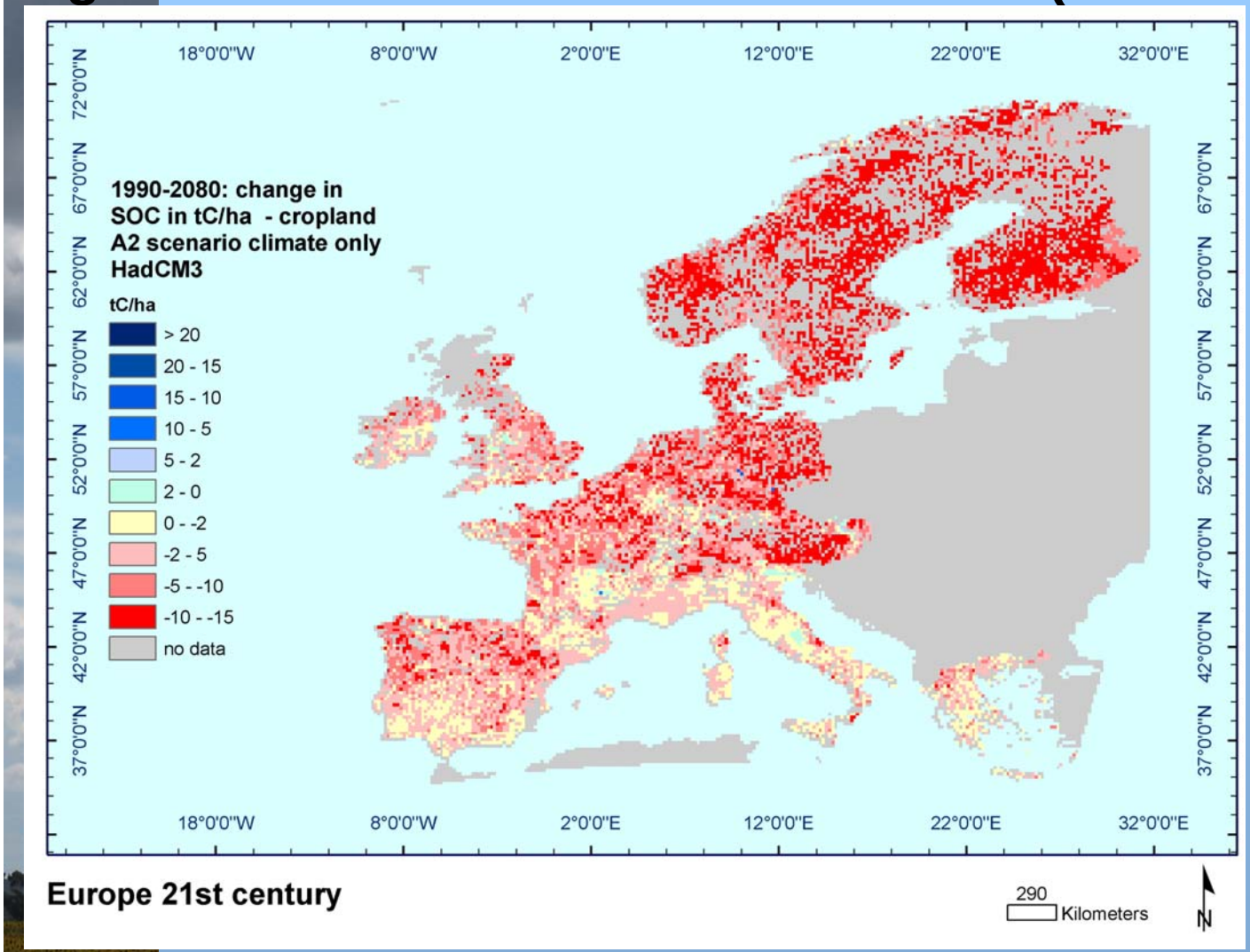
Änderungen der Bodenkohlenstoffvorräte in agrarisch genutzten Böden bis zum Jahr 2000 (business as usual)



Obwohl die NPP zunehmen wird (Klimaeffekt, CO_2-Düngung, N-Deposition), werden die C-Vorräte im Boden sinken (gesteigerte Mineralisation)

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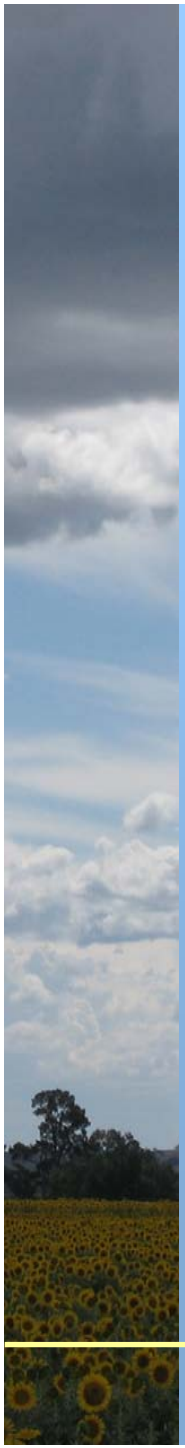
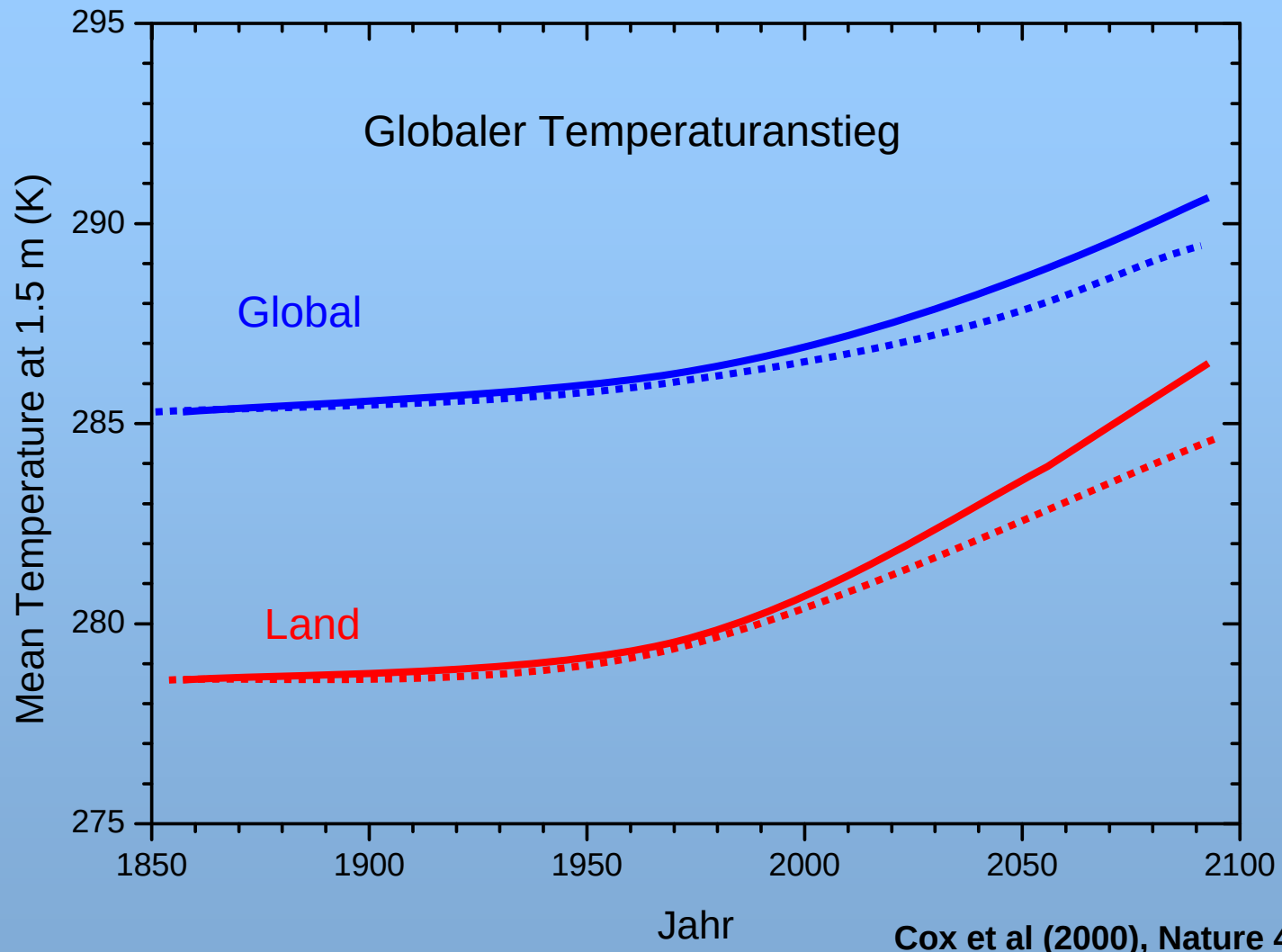


Rückkopplung Biosphäre-Atmosphäre



Cox et al (2000), Nature 408,184-187

Globales Klimamodell

Glob. Klimamodell+Biosphären-C-Modell

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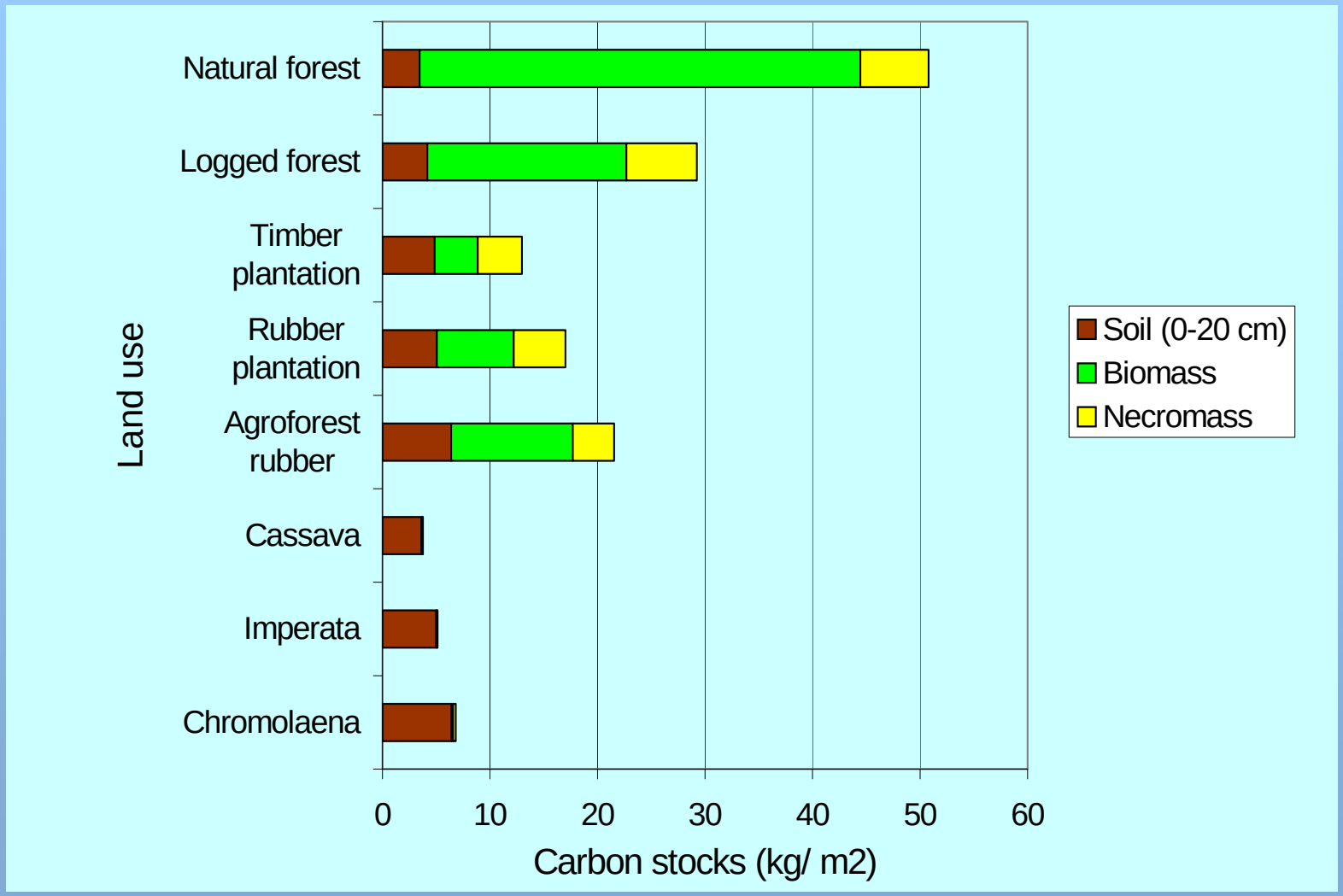
Carbon stocks in natural and agricultural ecosystems in the tropics



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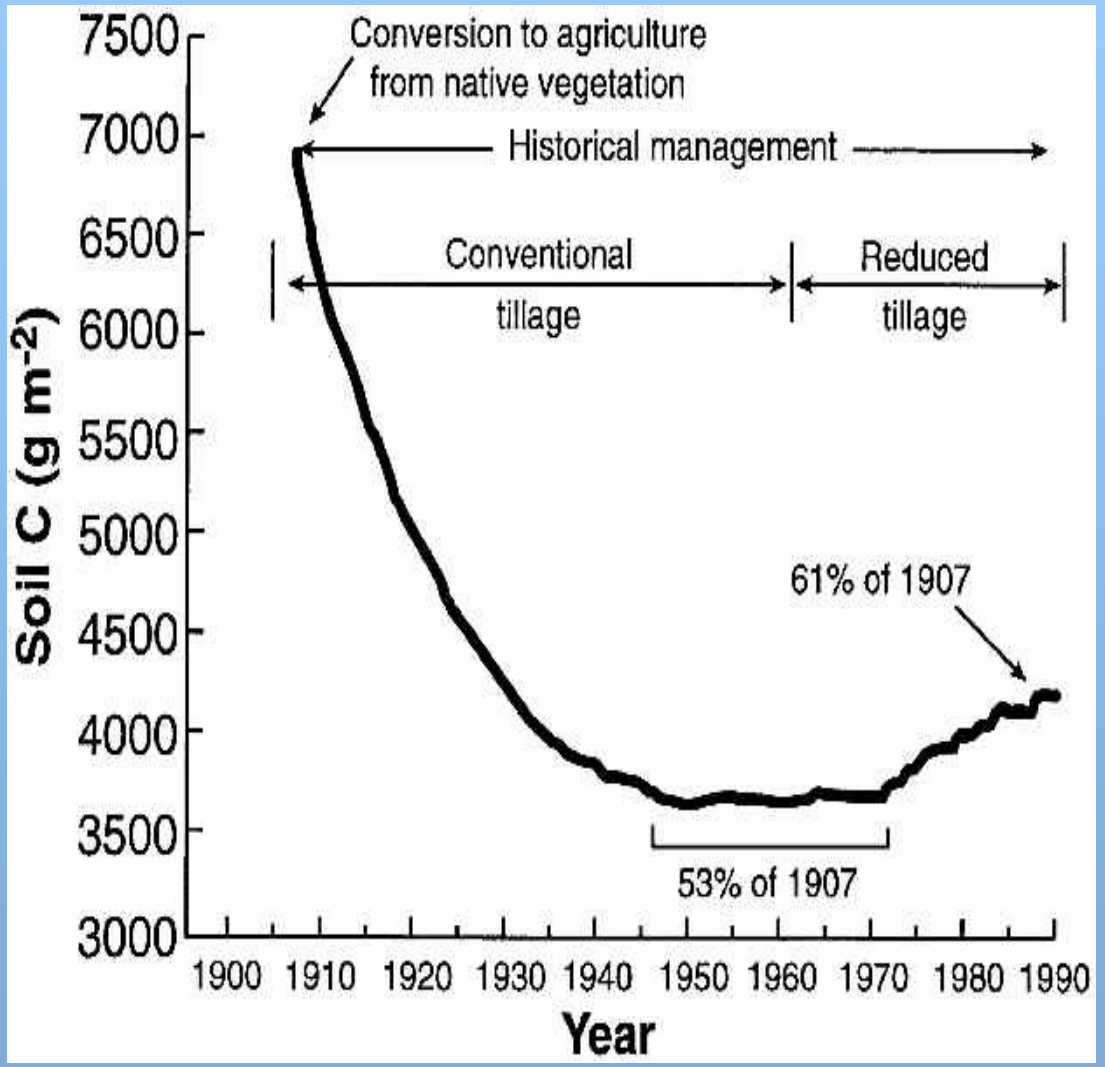
Changes in organic Carbon from forest conversion into maiz cultivation



Matson et al., 1998

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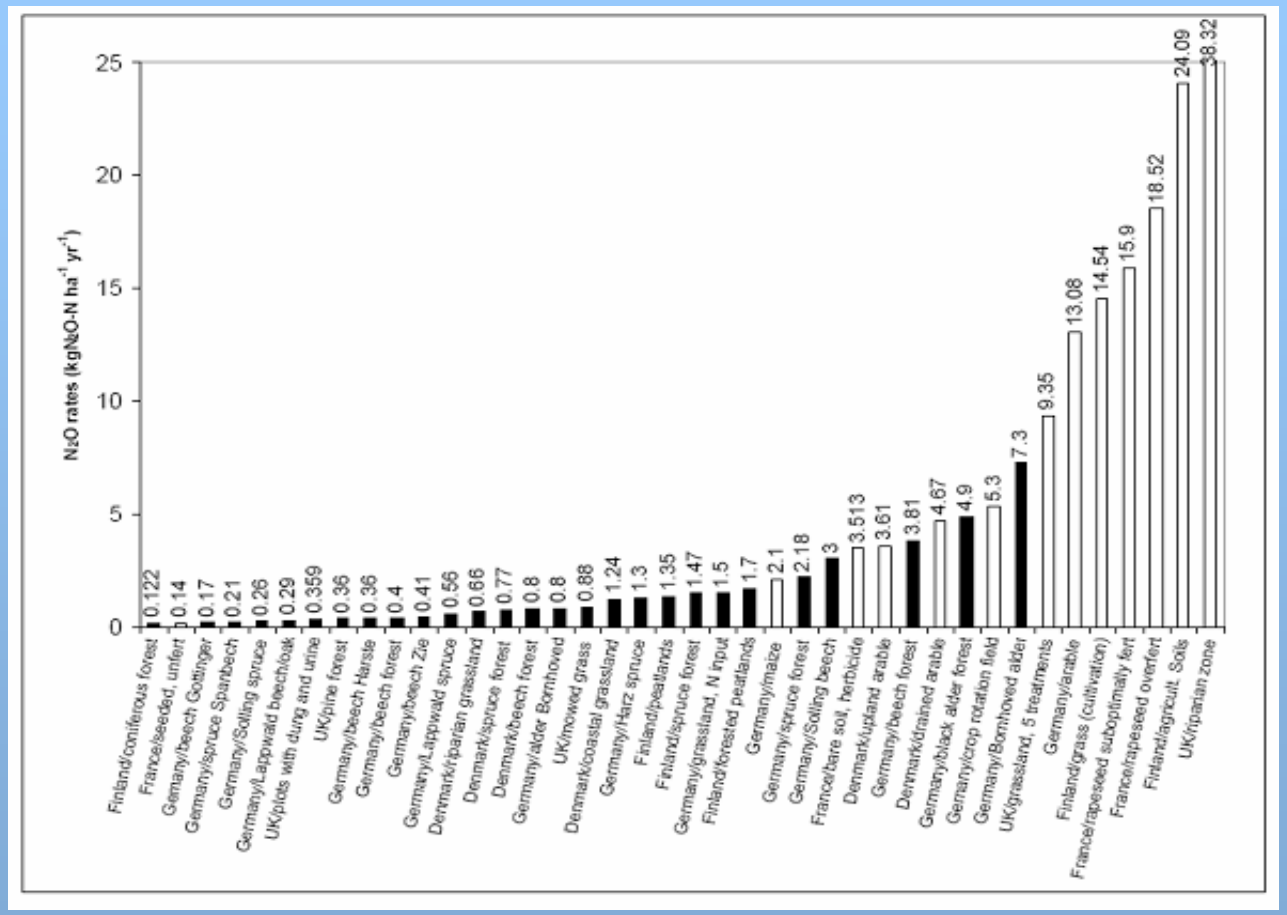
N_2O-emission from different ecosystems in Europe



Forests and grasslands agriculure

Machefert et al., 2002

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