Frage

- Waldnutzung in Thüringen: Welche Art der Nutzung bietet das größte Potential für die Speicherung von Kohlenstoff durch Holz- und Forstwirtschaft? Warum?
- Was ist bei der Durchführung von Aufforstungen zum Zweck der Kohlenstoffspeicherung zu beachten?

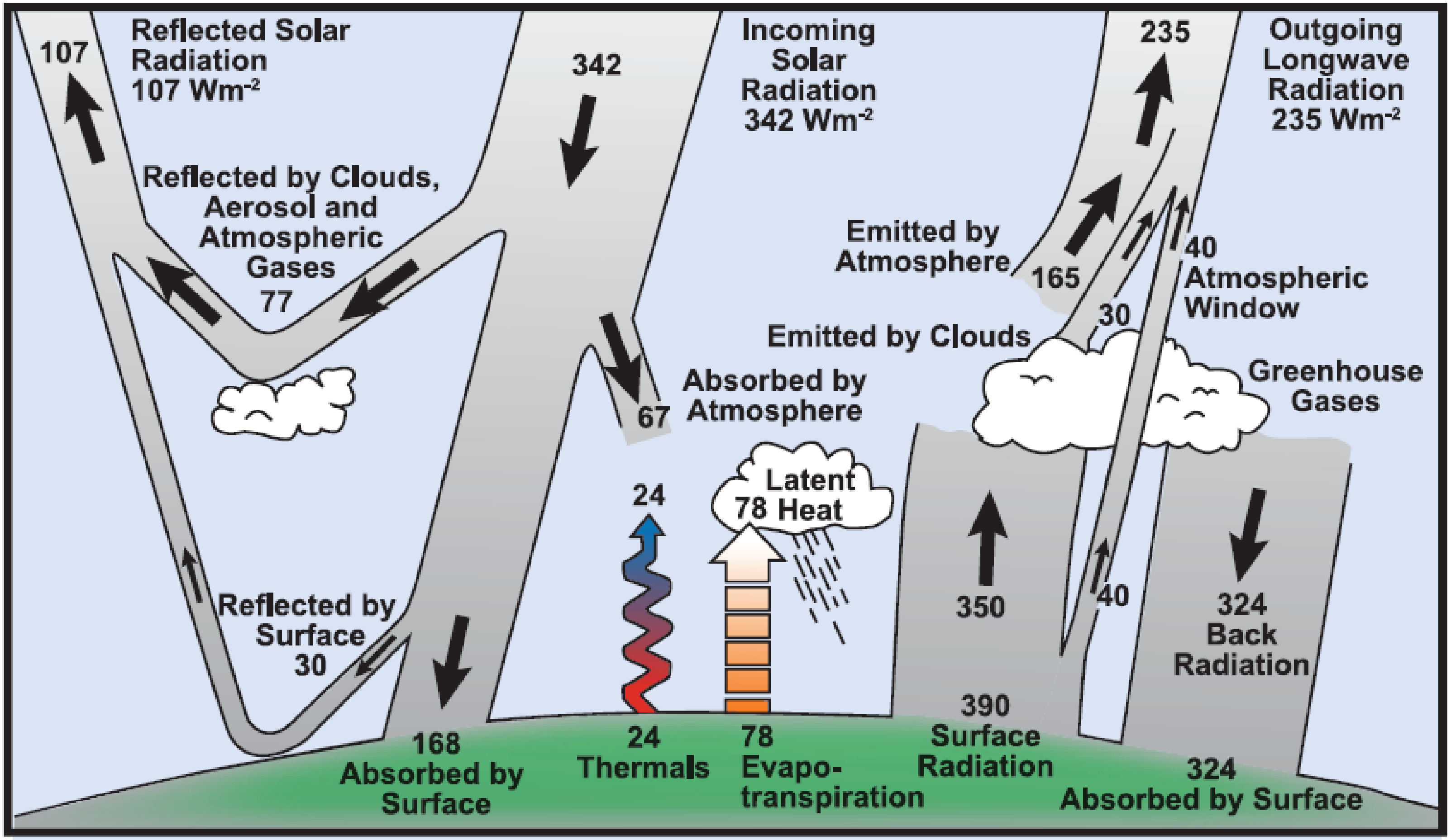

Greenhouse Gases
(CO_2, CH_4, N_2O, NO)

Contents

- Anthropogenic greenhouse effect
- N_2O
- CH_4 - GHG hotspot: peatlands
- GHGs in agriculture
  - sources
  - Mitigation

Greenhouse effect

IPCC FoAR 2007

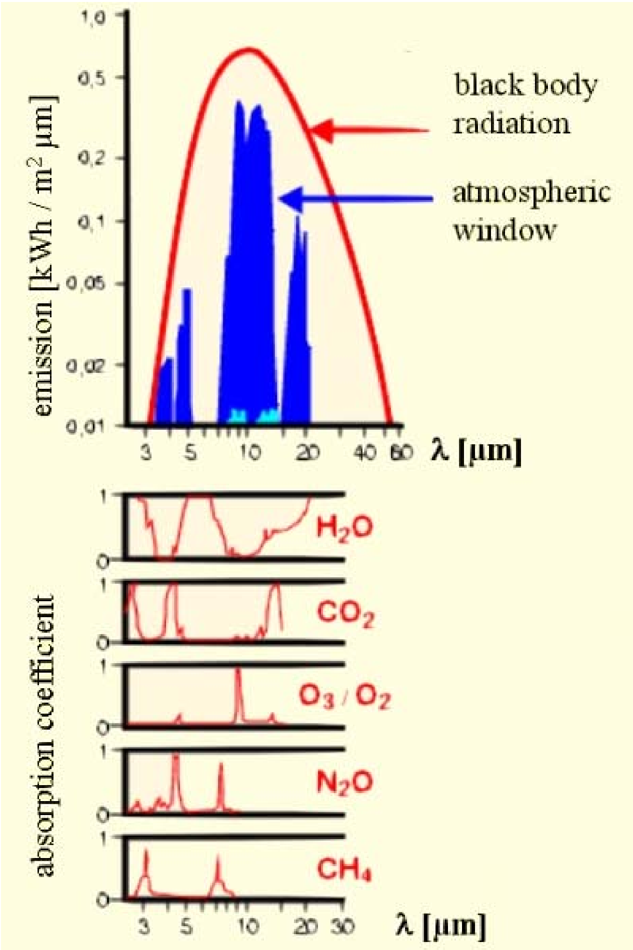


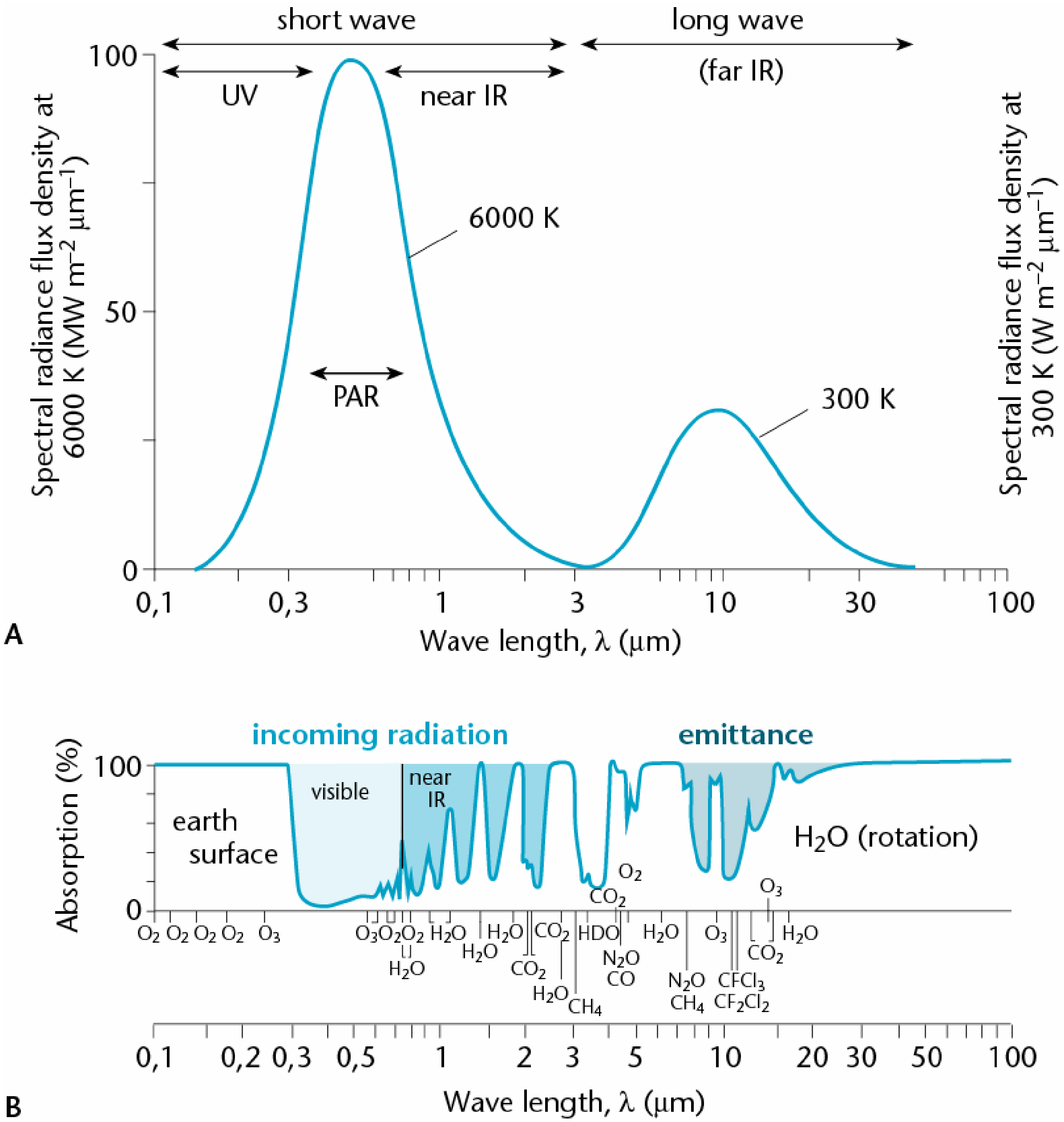
Physical processes first described & understood

1812: Fourrier – greenhouse effect & CO_2

1870: Arrhenius – doubling of CO_2 = 3-4°C higher global temperature

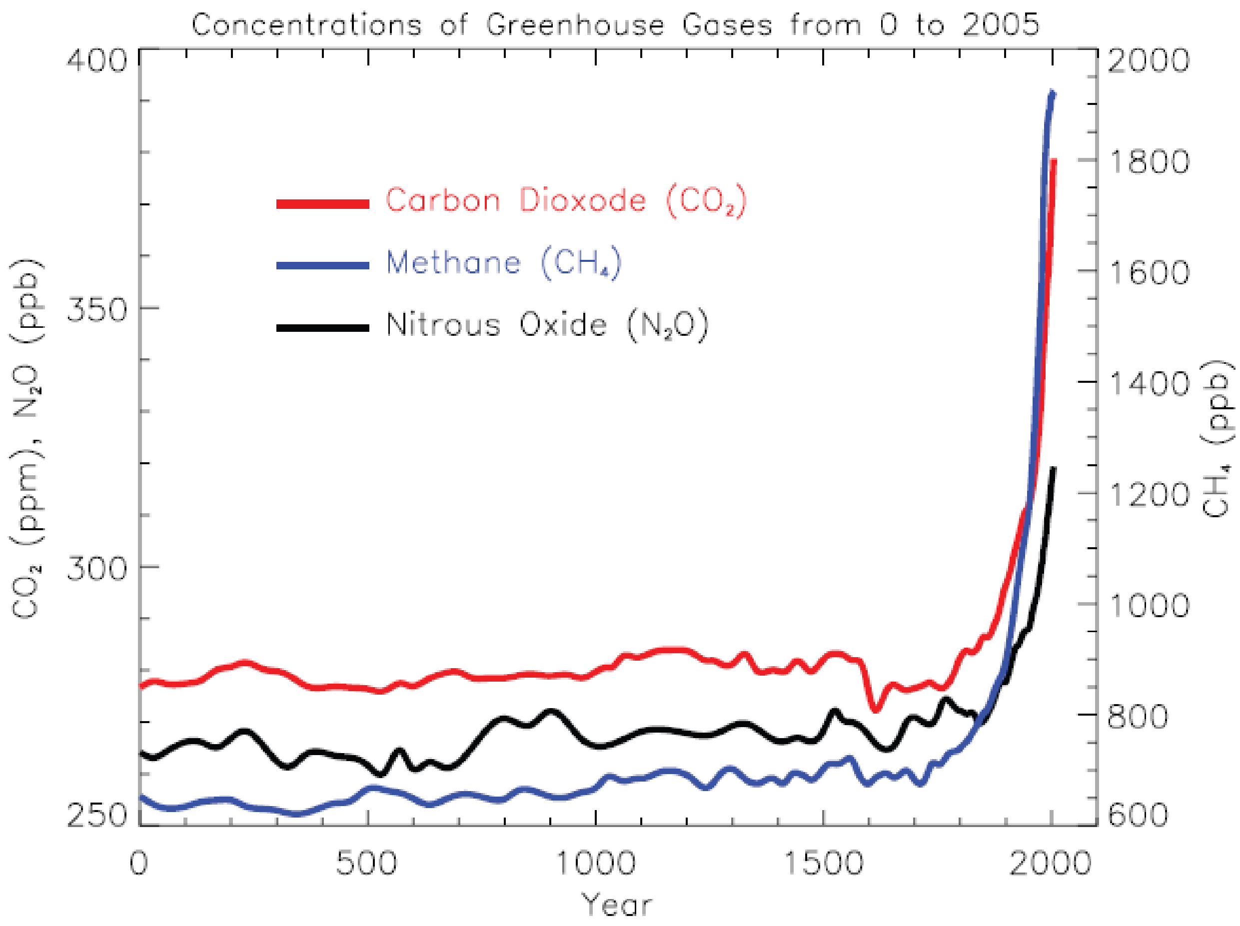
Energy distribution of the global radiation balance





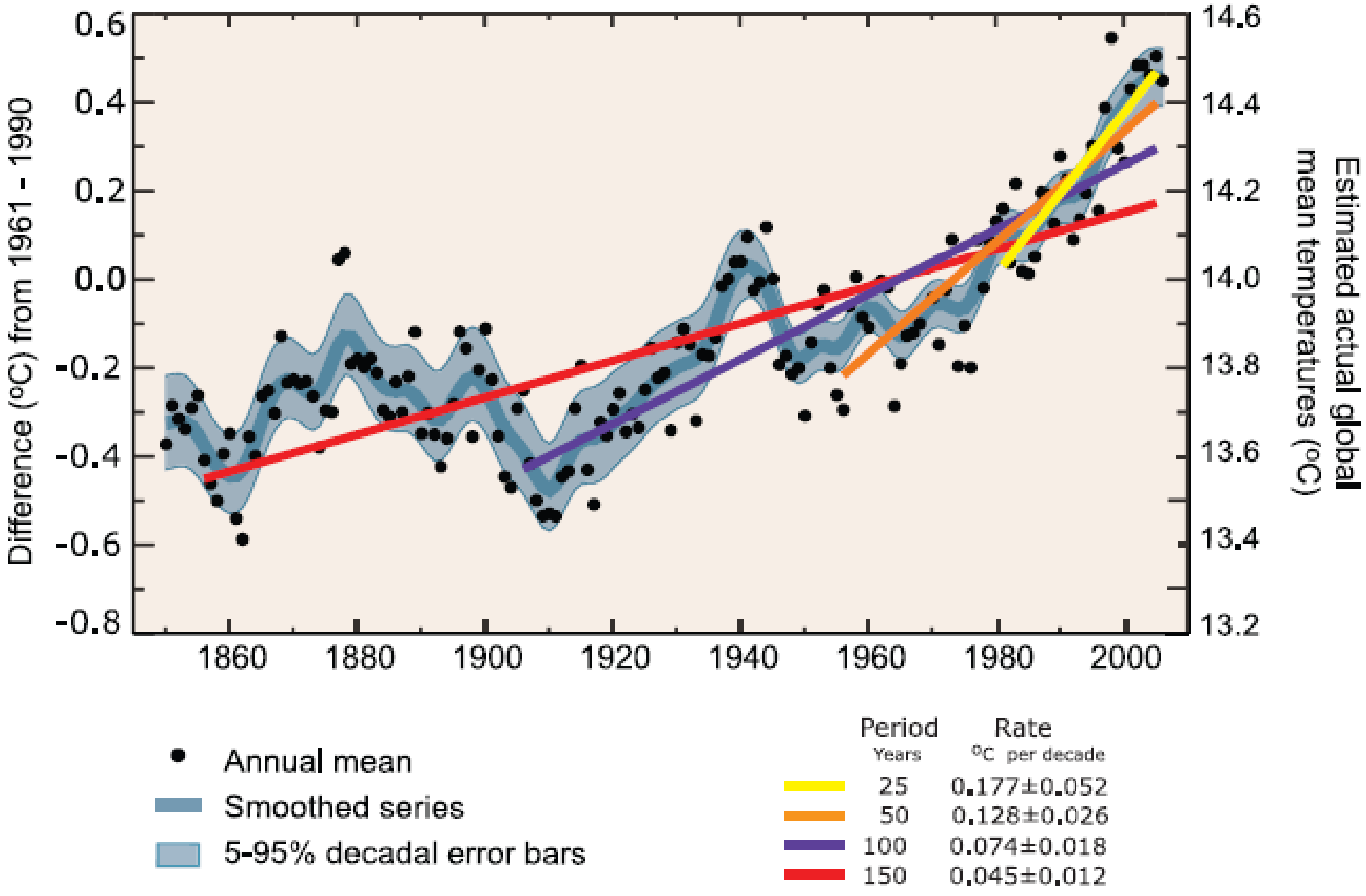
after Mitchell, 1989;
WBGU ,1997

Concentration Trends



IPCC, 2007

Temperature variations



IPCC, 2007

CHANGES IN GREENHOUSE GASES FROM ICE CORE AND MODERN DATA

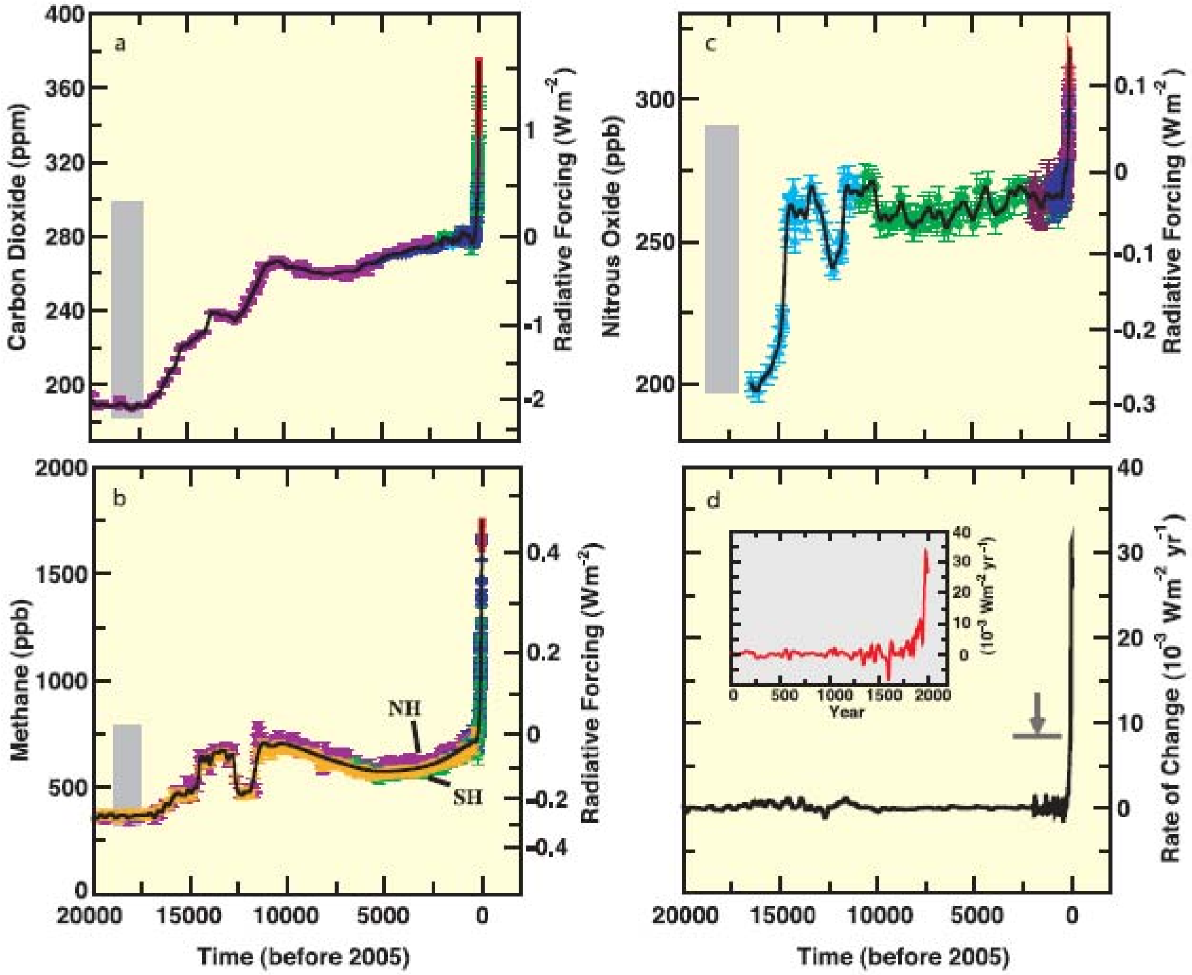


Figure TS.2. *The concentrations and radiative forcing by (a) carbon dioxide (CO_2), (b) methane (CH_4), (c) nitrous oxide (N_2O) and (d) the rate of change in their combined radiative forcing over the last 20,000 years reconstructed from antarctic and Greenland ice and firn data (symbols) and direct atmospheric measurements (panels a,b,c, red lines). The grey bars show the reconstructed ranges of natural variability for the past 650,000 years. The rate of change in radiative forcing (panel d, black line) has been computed from spline fits to the concentration data. The width of the age spread in the ice data varies from about 20 years for sites with a high accumulation of snow such as Law Dome, Antarctica, to about 200 years for low-accumulation sites such as Dome C, Antarctica. The arrow shows the peak in the rate of change in radiative forcing that would result if the anthropogenic signals of CO_2, CH_4, and N_2O had been smoothed corresponding to conditions at the low-accumulation Dome C site. The negative rate of change in forcing around 1600 shown in the higher-resolution inset in panel d results from a CO_2 decrease of about 10 ppm in the Law Dome record. {Figure 6.4}*

IPCC, 2007

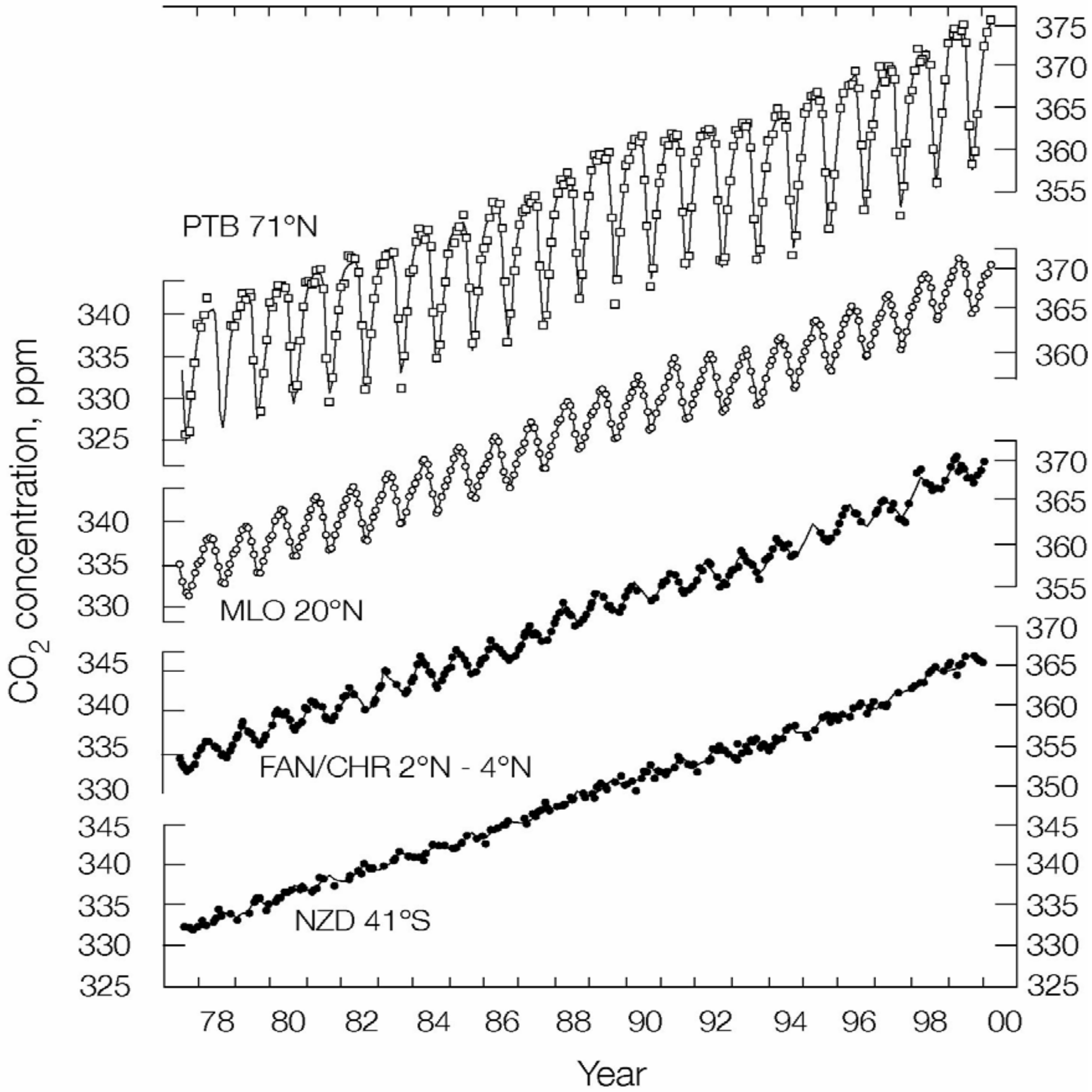
CO_2 Concentration Trends

PTB – Point Barrow, Alaska

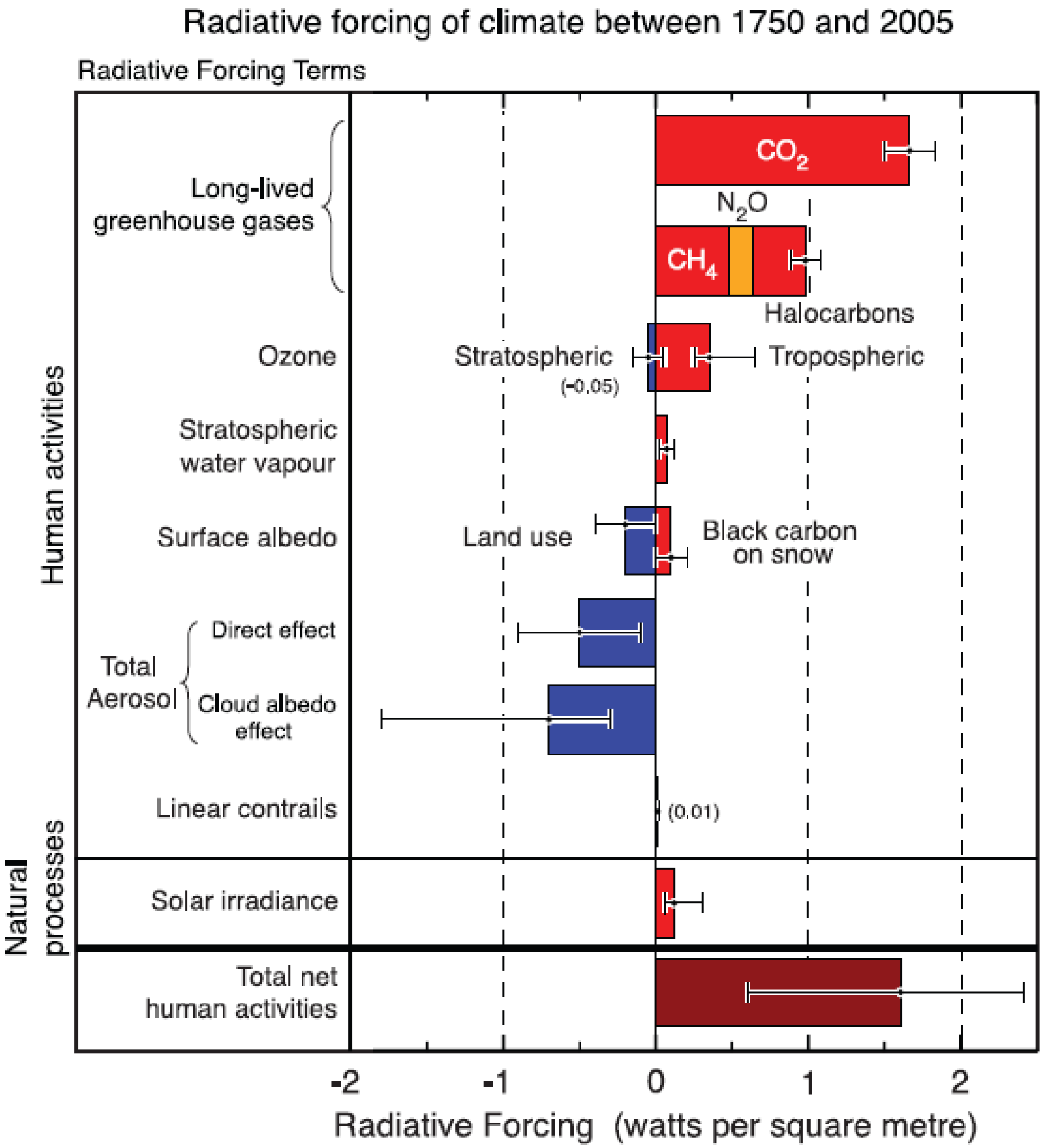
MLO – Mauna Loa, Hawai

FAN/CHR – Christmas Islands

NZD – New Zealand



Radiative Forcing



IPCC, 2007

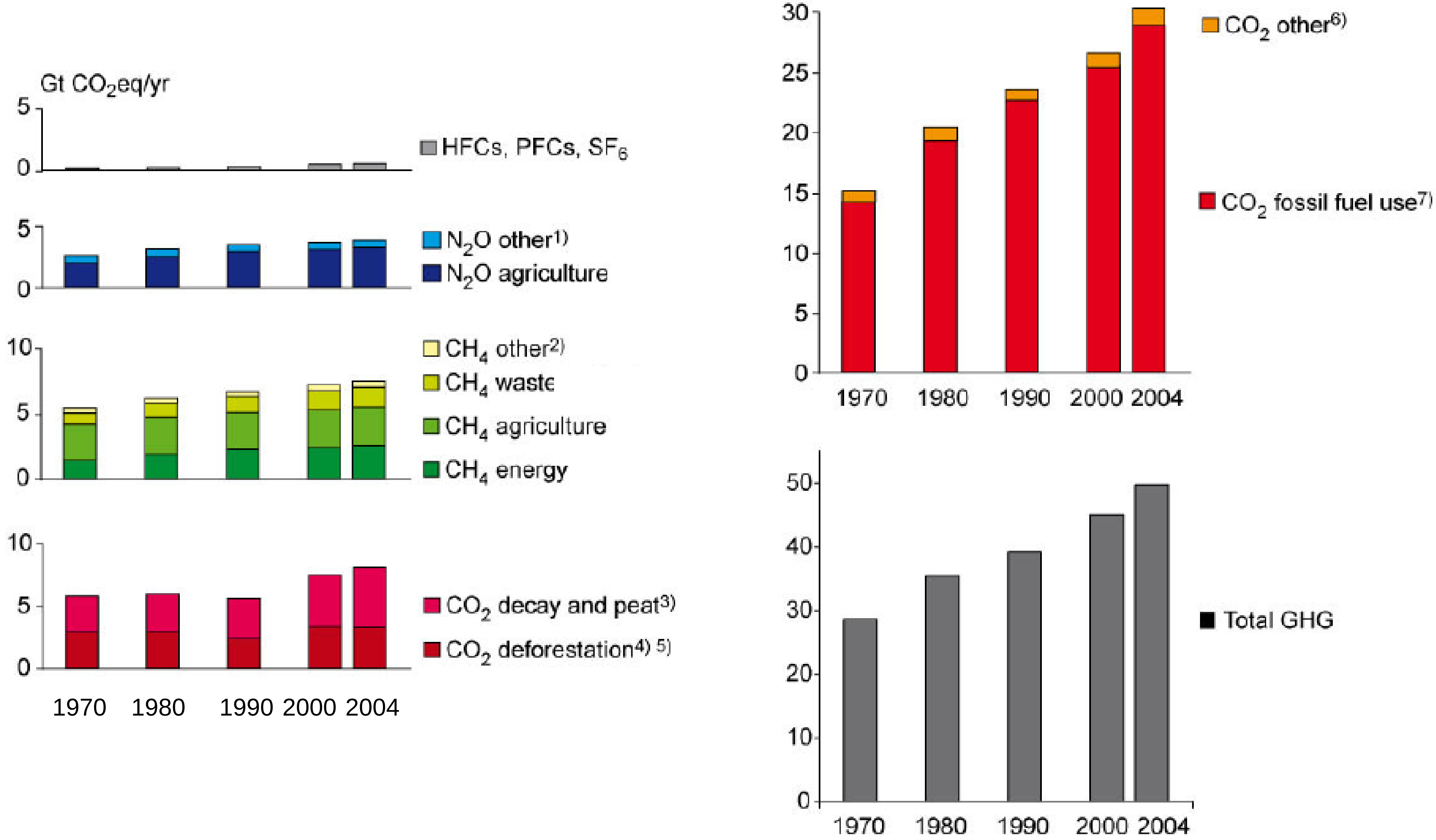
Anthropogenic GHGs

- „Global warming potential" –
  a politically used way to compare GHGs
- CO_2-equivalents depending on time horizon:
  global warming potential per molecule gas compared to CO_2

Gas	Life time	Horizon: 20 years	**Horizon: 100 years**
CO_2		1	1
CH_4	12	72	25
N_2O	114	289	298

IPCC 2007

Global anthropogenic emissions



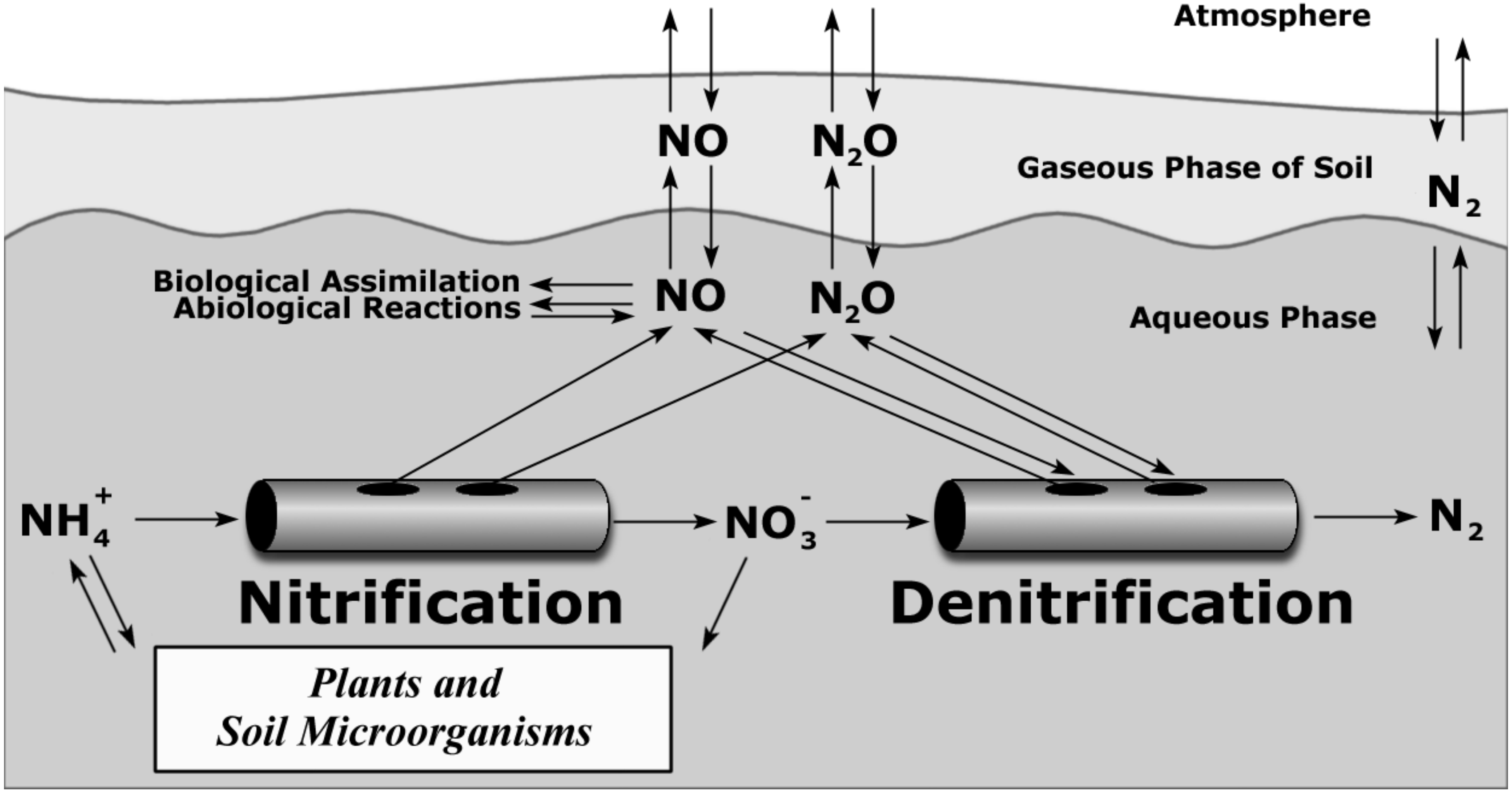
IPCC WG III, 2007

Frage

Bei welchen Aktivitäten werden die meisten Treibhausgase im Alltag produziert?

Nitrous oxide N_2O

Nitrifikation und Denitrifikation

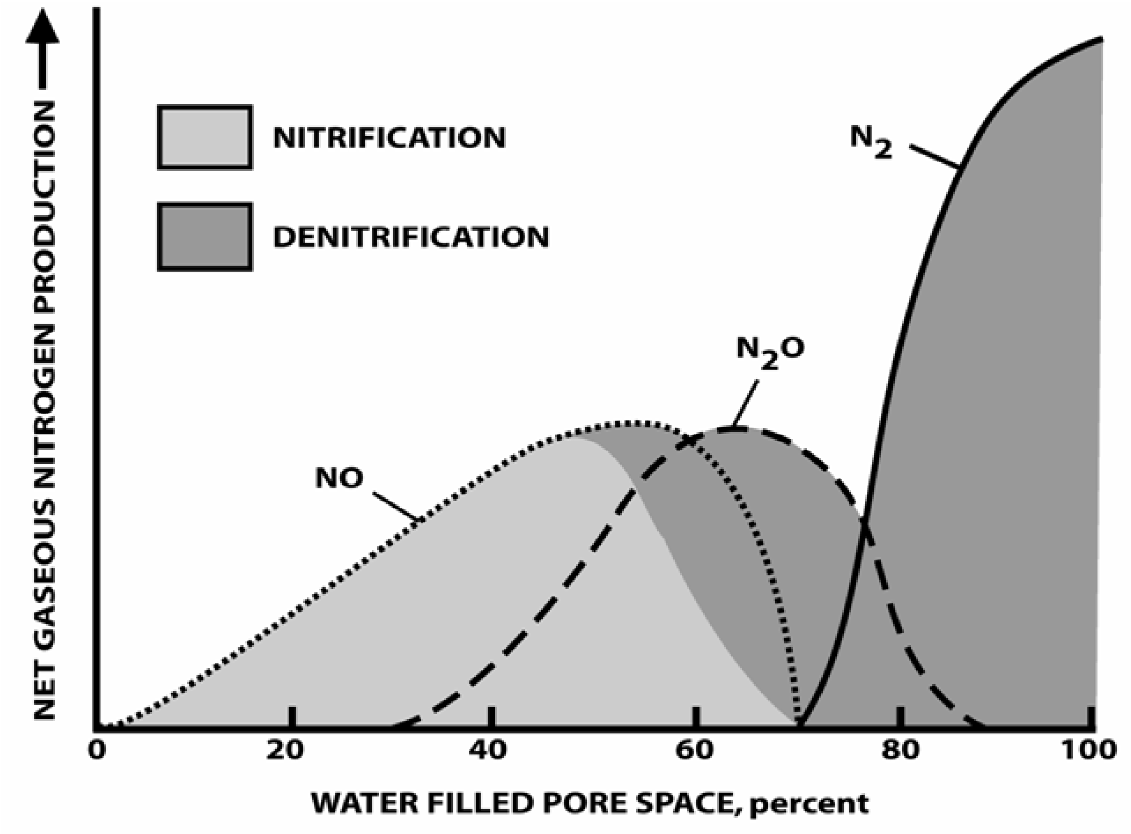


nach Firestone und Davidson 1989, Davidson 2000

Steuergrößen für N_2O-Freisetzung

- Mikroorganismen, Aktivität
- O_2-Verfügbarkeit (Bodenwassergehalt)
- Temperatur
- C-Verfügbarkeit (Humusgehalt, C-Dünger)
- N-Verfügbarkeit (N-Eintrag)

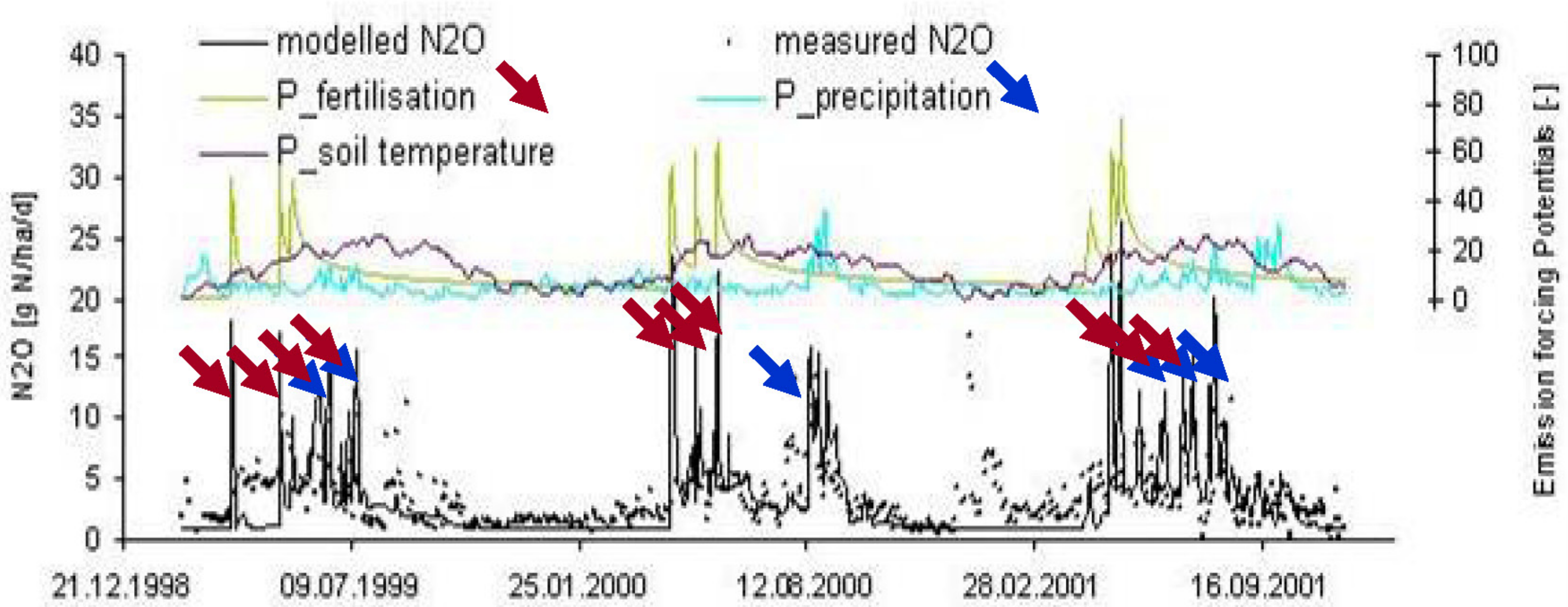
Einfluss der O_2-Verfügbarkeit



Davidson 1991

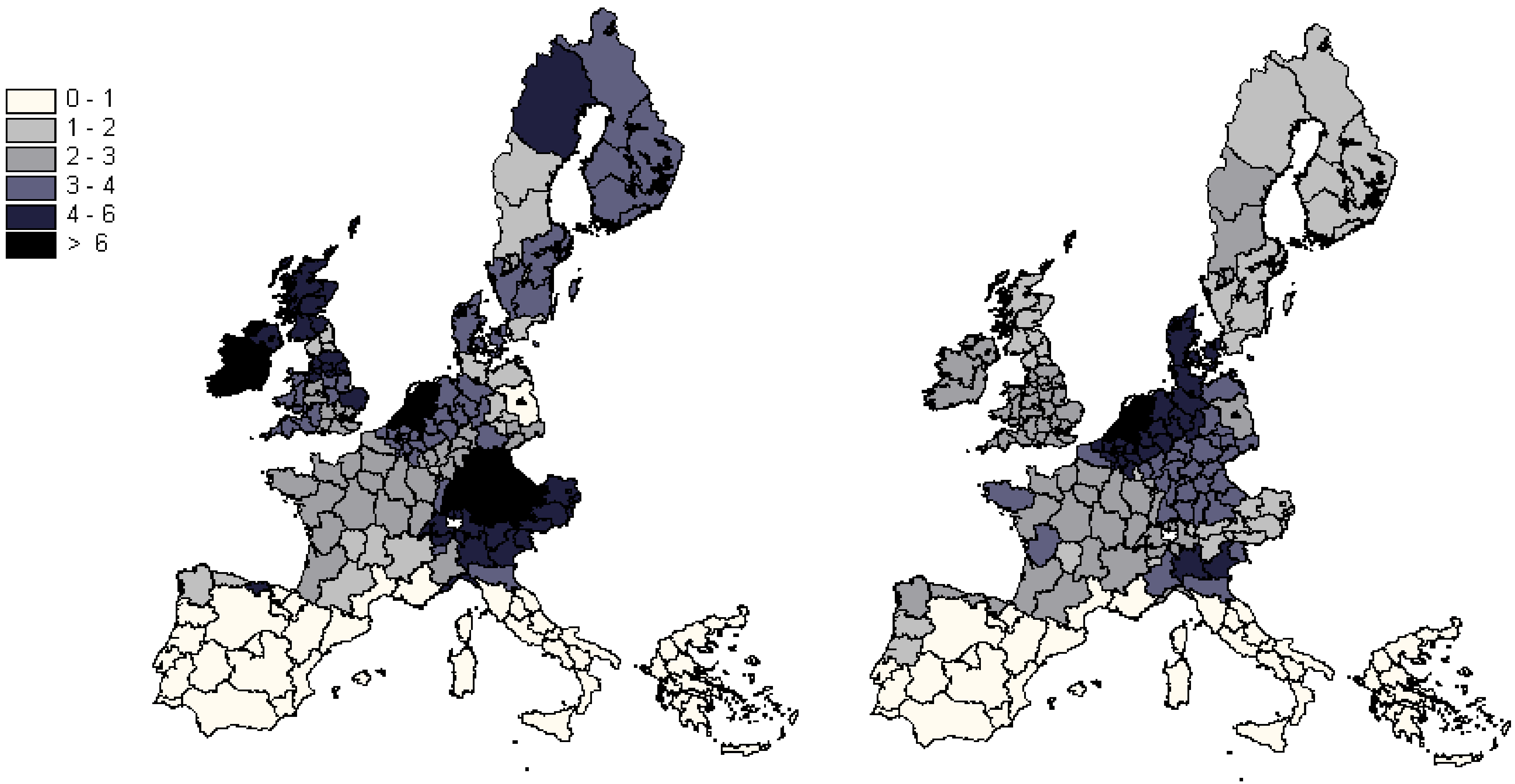
Drivers of N_2O emissions

- N fertilization
- Weather and seasonal climate
- Extreme events
- Soil texture: clay!



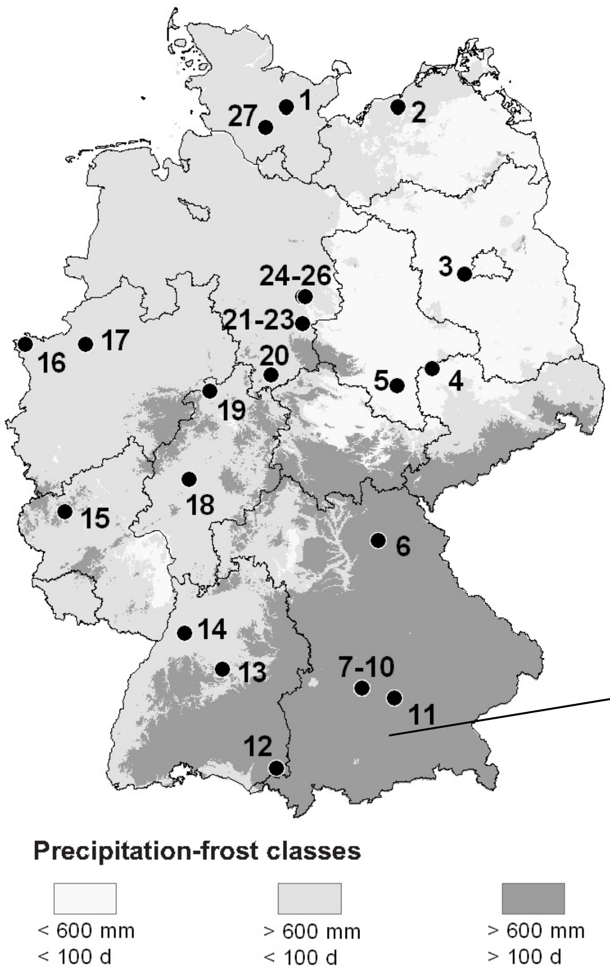
N_2O-Emissionen aus Böden

Arable land — kg N_2O-N ha^{-1} a^{-1} — Grassland

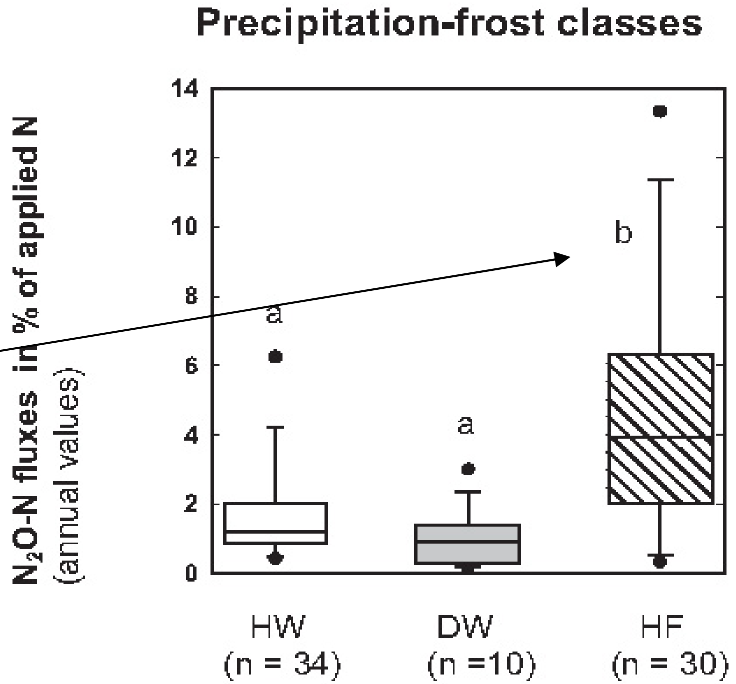


Freibauer 2003

N_2O: region-specific emission sensitivity to fertilizer



Freeze-thaw events increase sensitivity to fertilizer



N_2O: difficult to avoid

- Annual emissions driven by extreme events over few days
- Extreme events driven by
  - Fertilizer + weather + soil texture
  - Site and region specific „sensitivity“
- Useful:
  - Avoid large fertilizer doses
  - Closed N balance

- ➢ Concentrate on sensitive regions: MEASUREMENTS!
- ➢ Closed field-scale N balances, control the implementation of nitrate directive and water framework directive and good farming practice

Methane

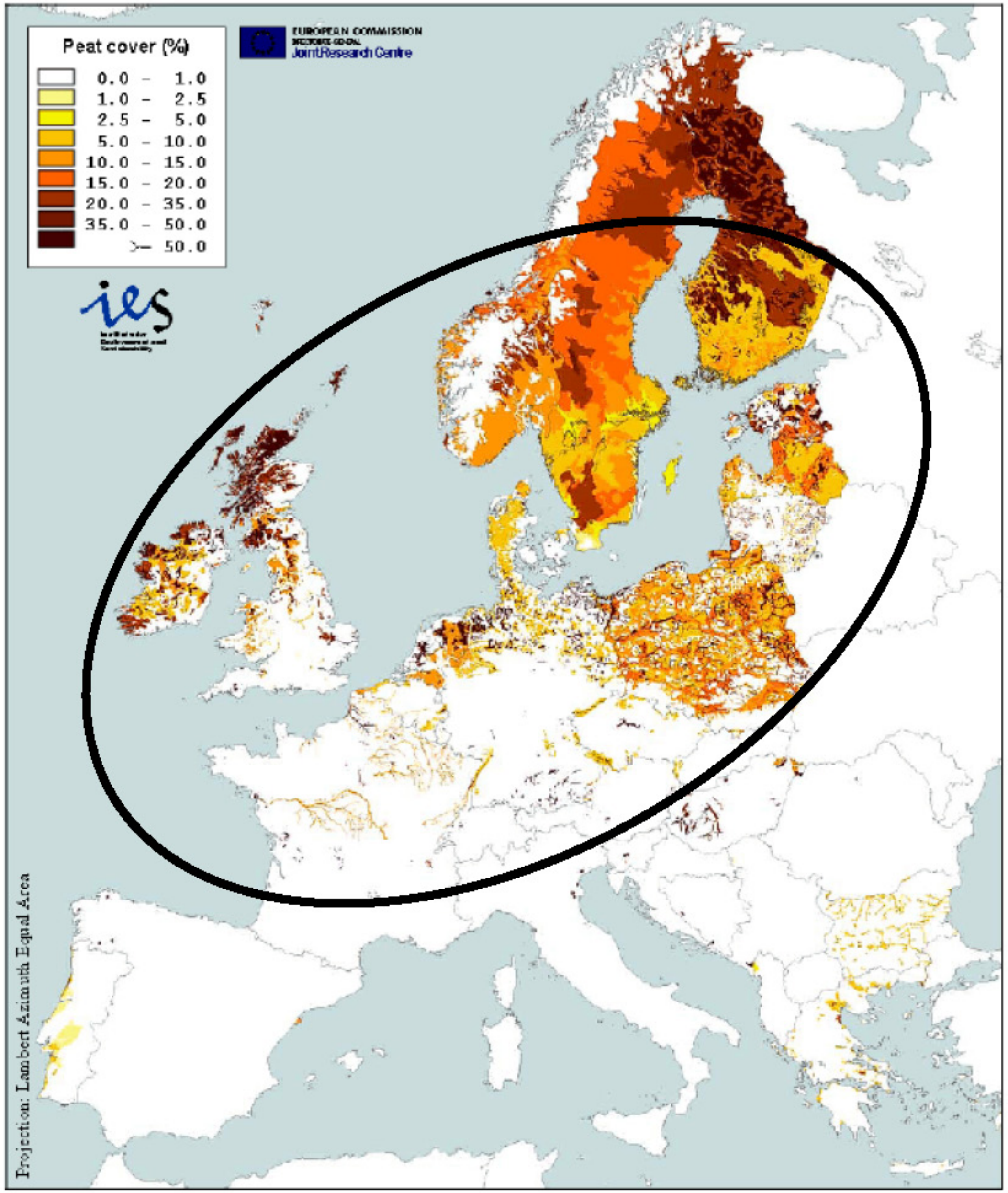
Hotspots of GHGs:

Managed peatlands: CO_2, N_2O

Natural peatlands: CH_4

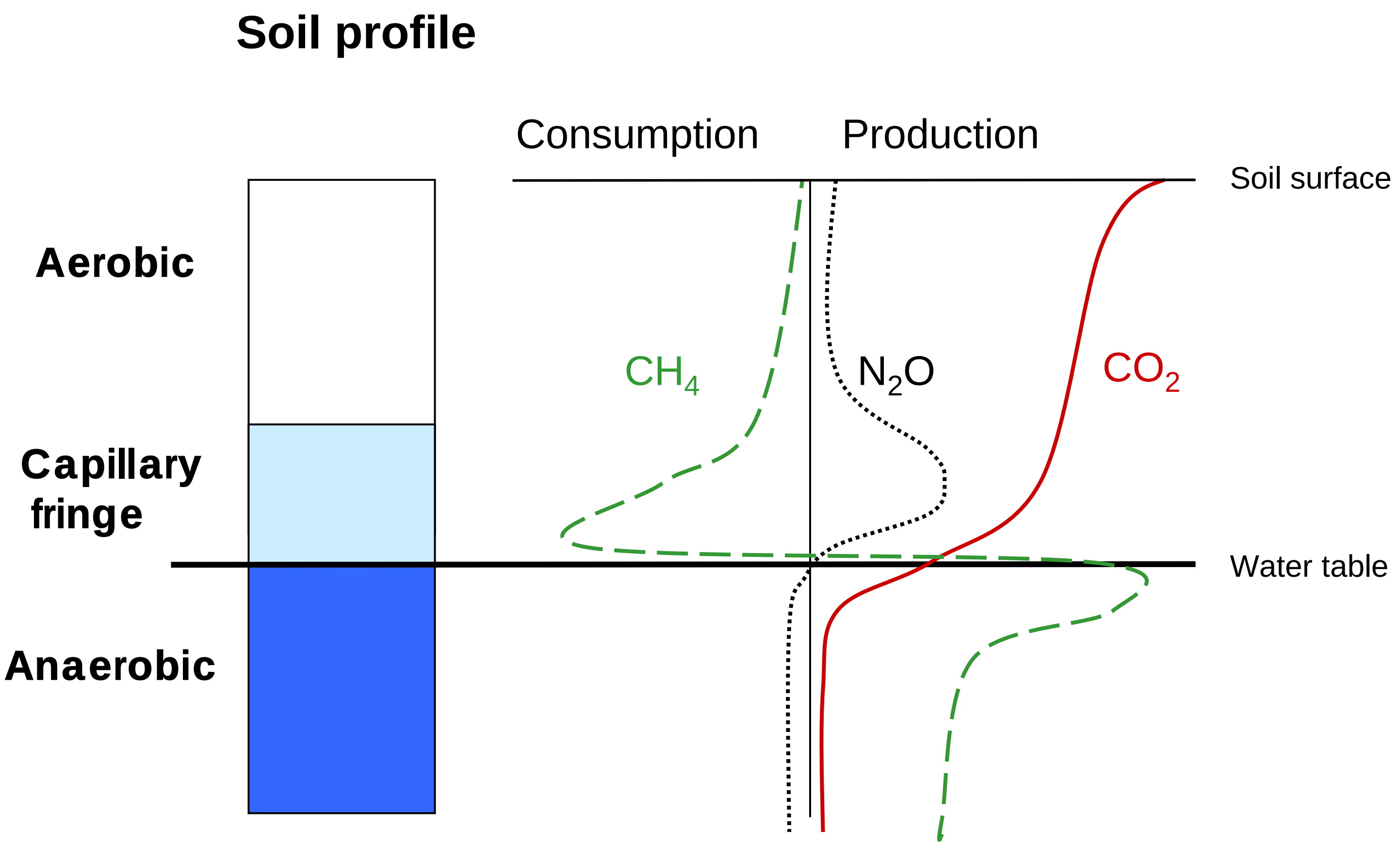
Peatland area in Europe

- Drained peatlands EU-25:
  - 7% peat area
  - ~4% drained peat area (>60% of peat area)



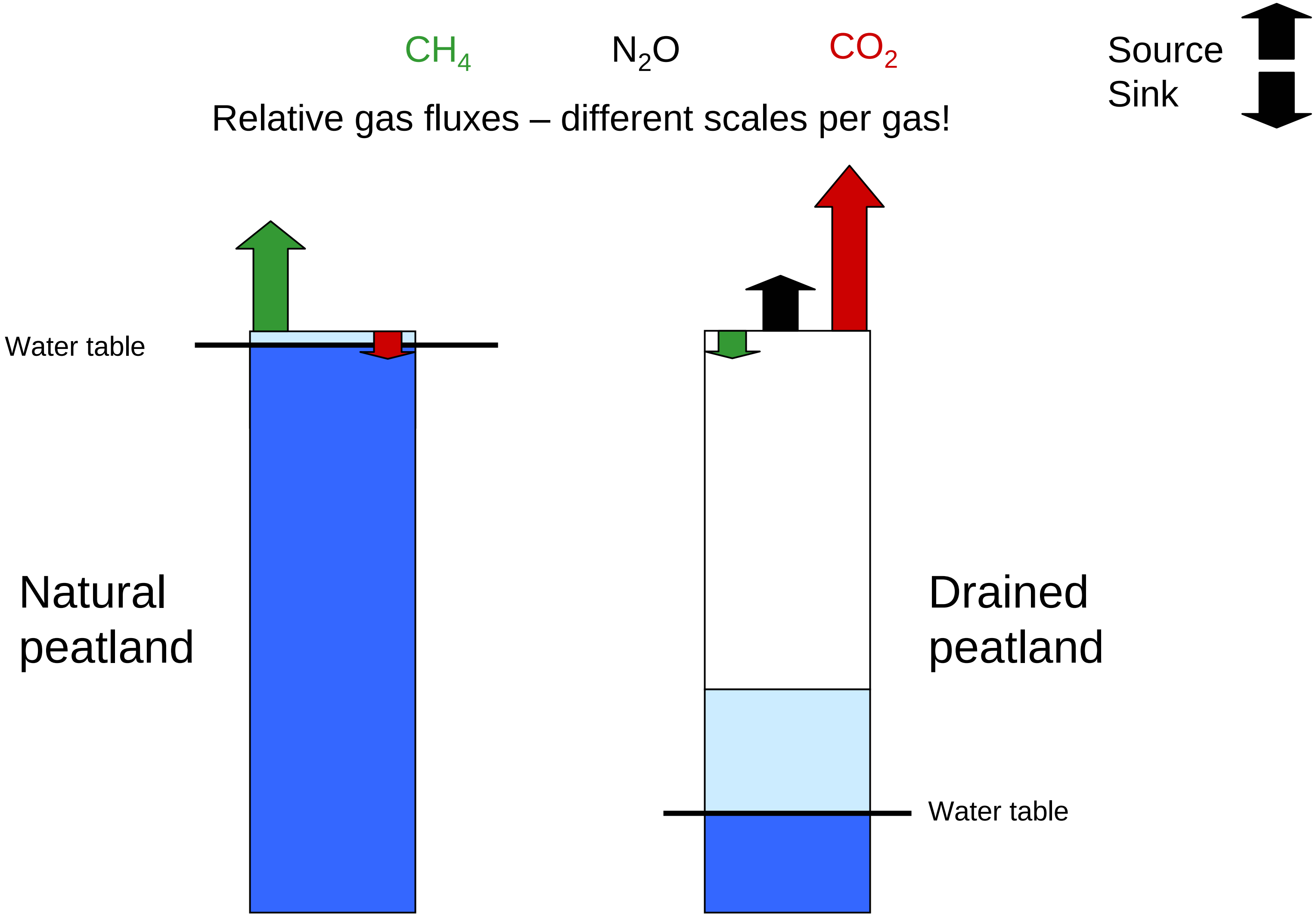
Montanarella et al.
Mires & Peat 2006

Greenhouse gases in peatlands

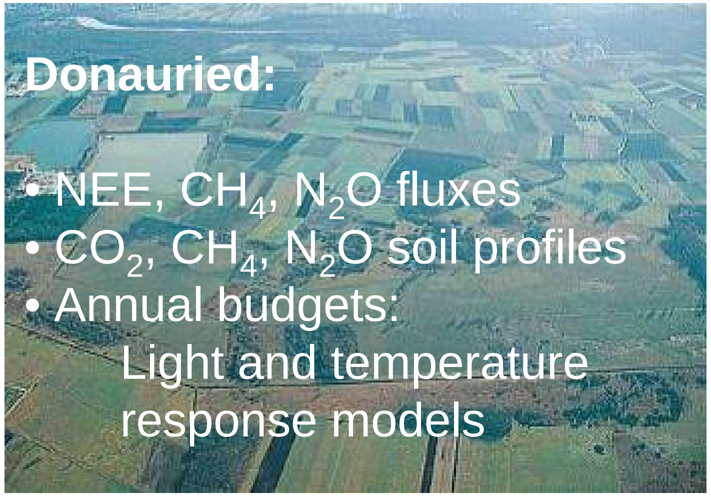


Relative gas fluxes – different scales per gas!

Greenhouse gases in peatlands



Donauried:
Drained and 25 years rewetted fen

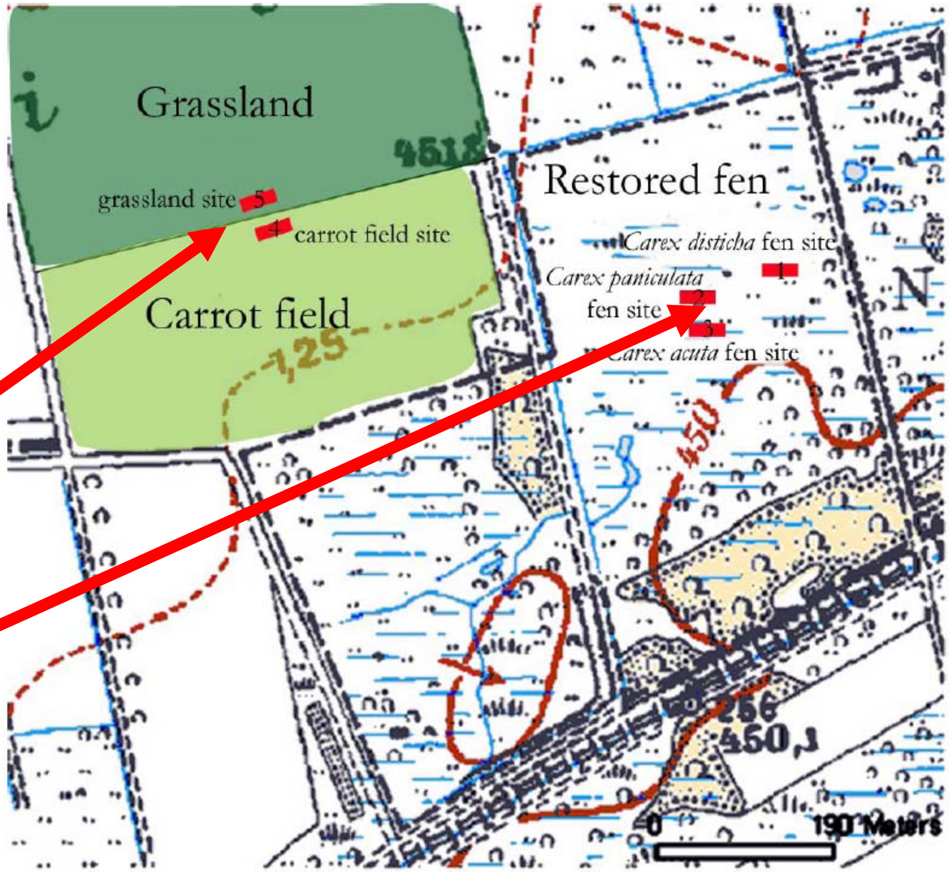


Example: fen restoration at Donauried/Ulm

Calcaric fen
heavily degraded
very productive

Drained for
100 years

Restored by weirs &
surface flooding
since 1980



Study sites

Restored

1.	Carex disticha / Typha	occasionally mowed
2.	Carex paniculata	dominant unmanaged
3.	Carex acuta	mowed every 2 years

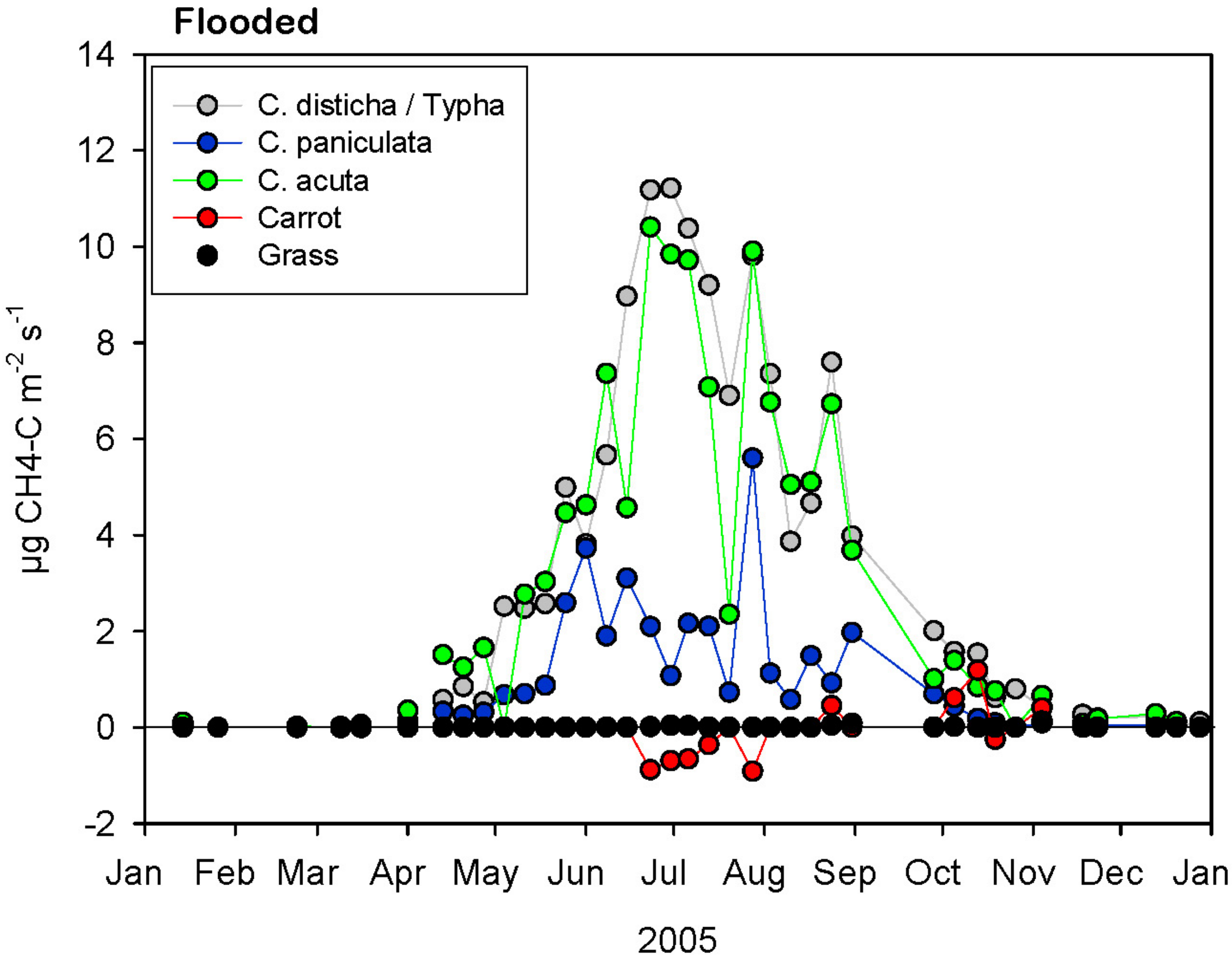
Drained

4.	Carrot	mounds
5.	Grass	mowed twice / year





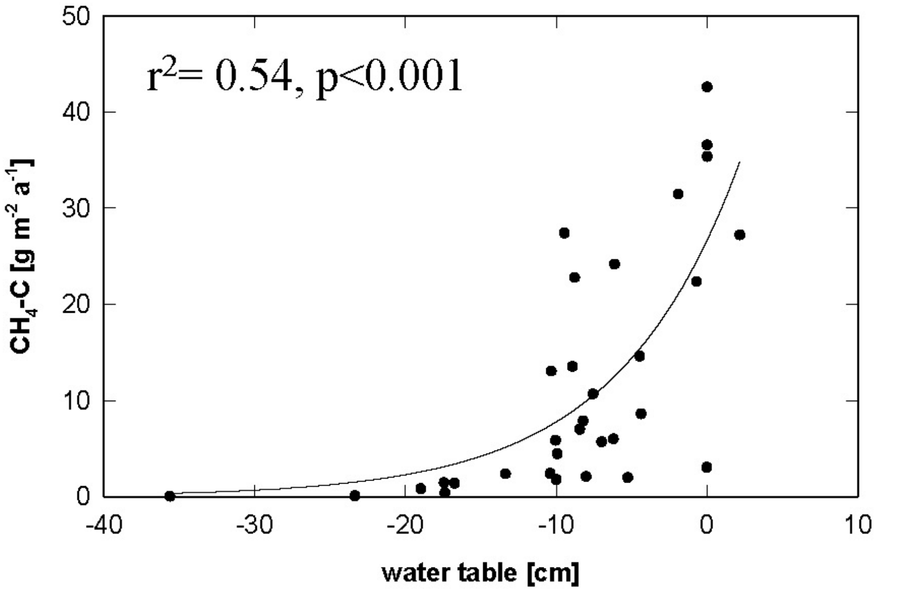
The CH_4 trade-off: Measurements

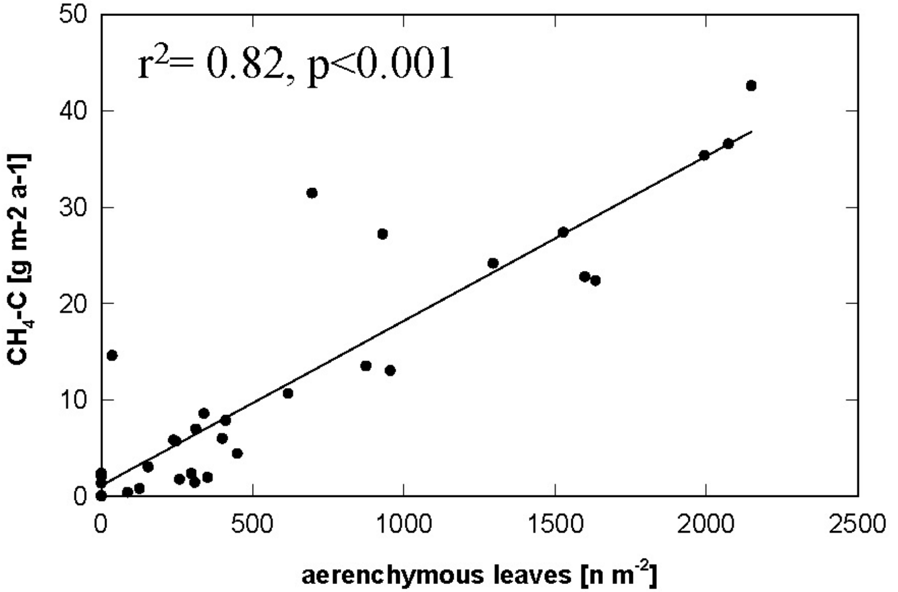


High CH_4 when flooded & warm

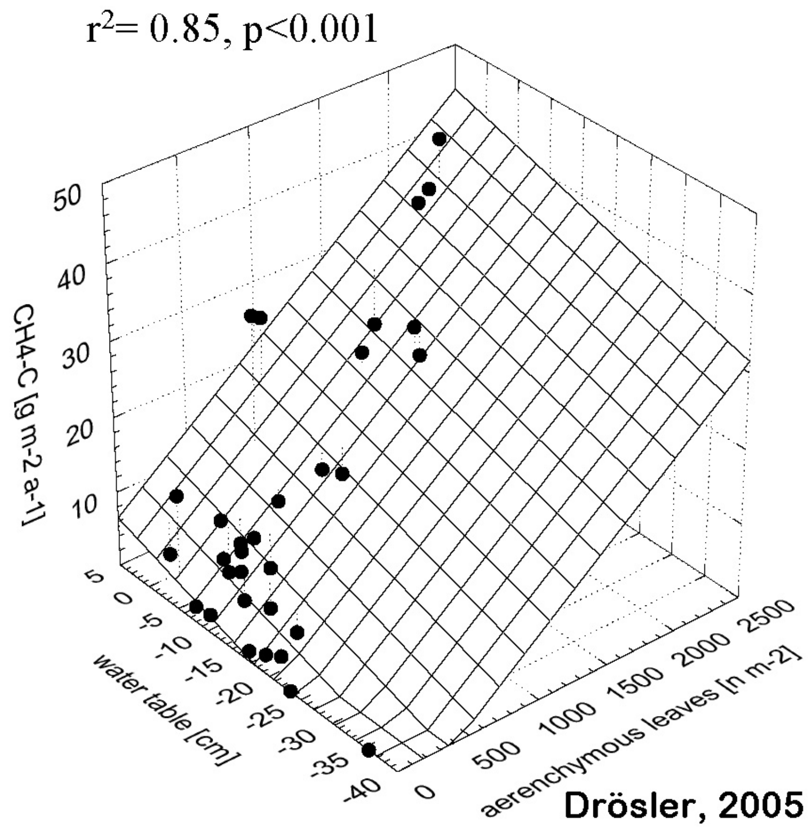
Immediate response to flooding

Controls of CH_4 emissions



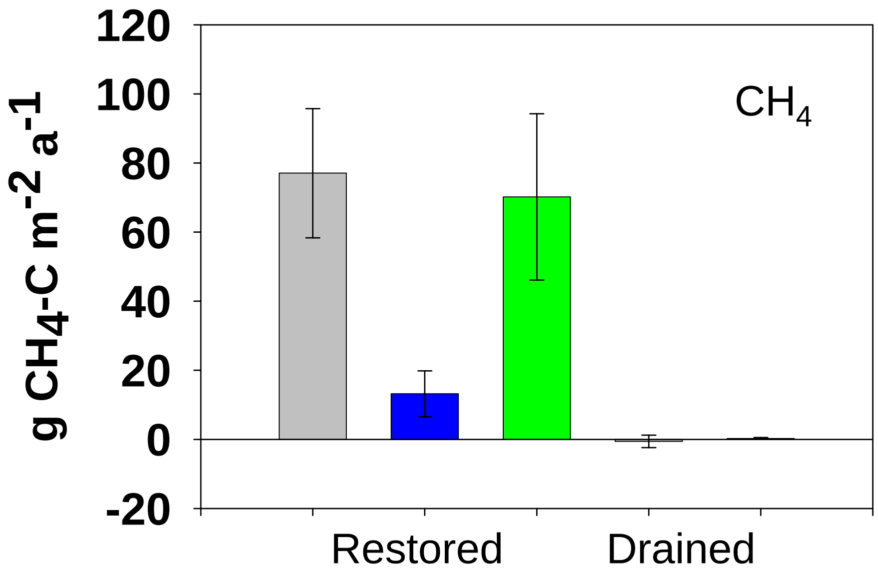


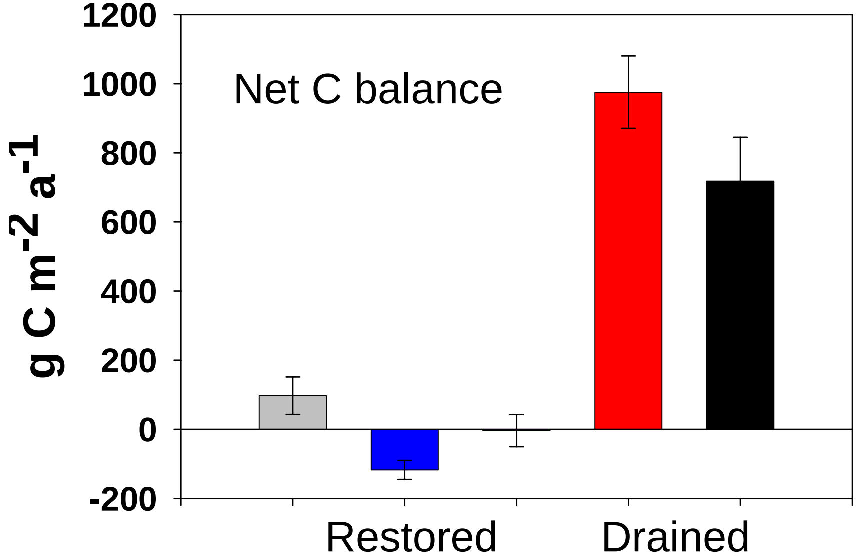
explanation of CH_4-C balances with water table and Aerenchyma

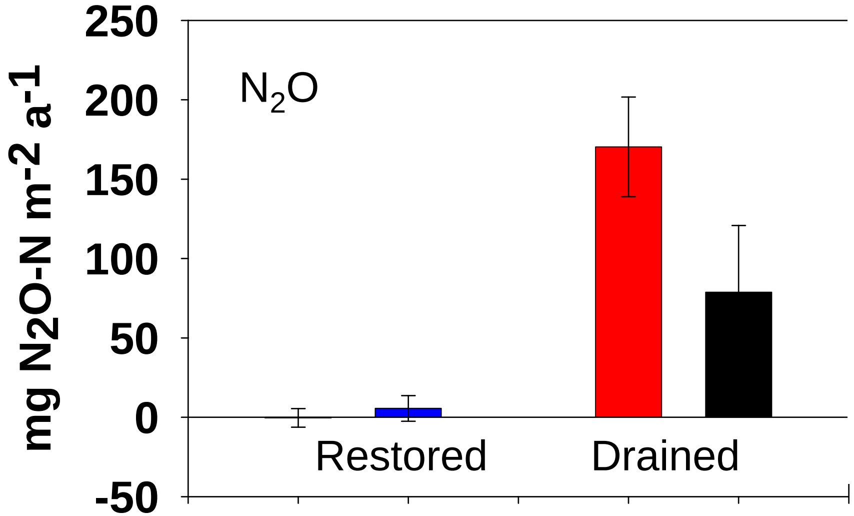


Drösler, 2005

Annual GHG budgets

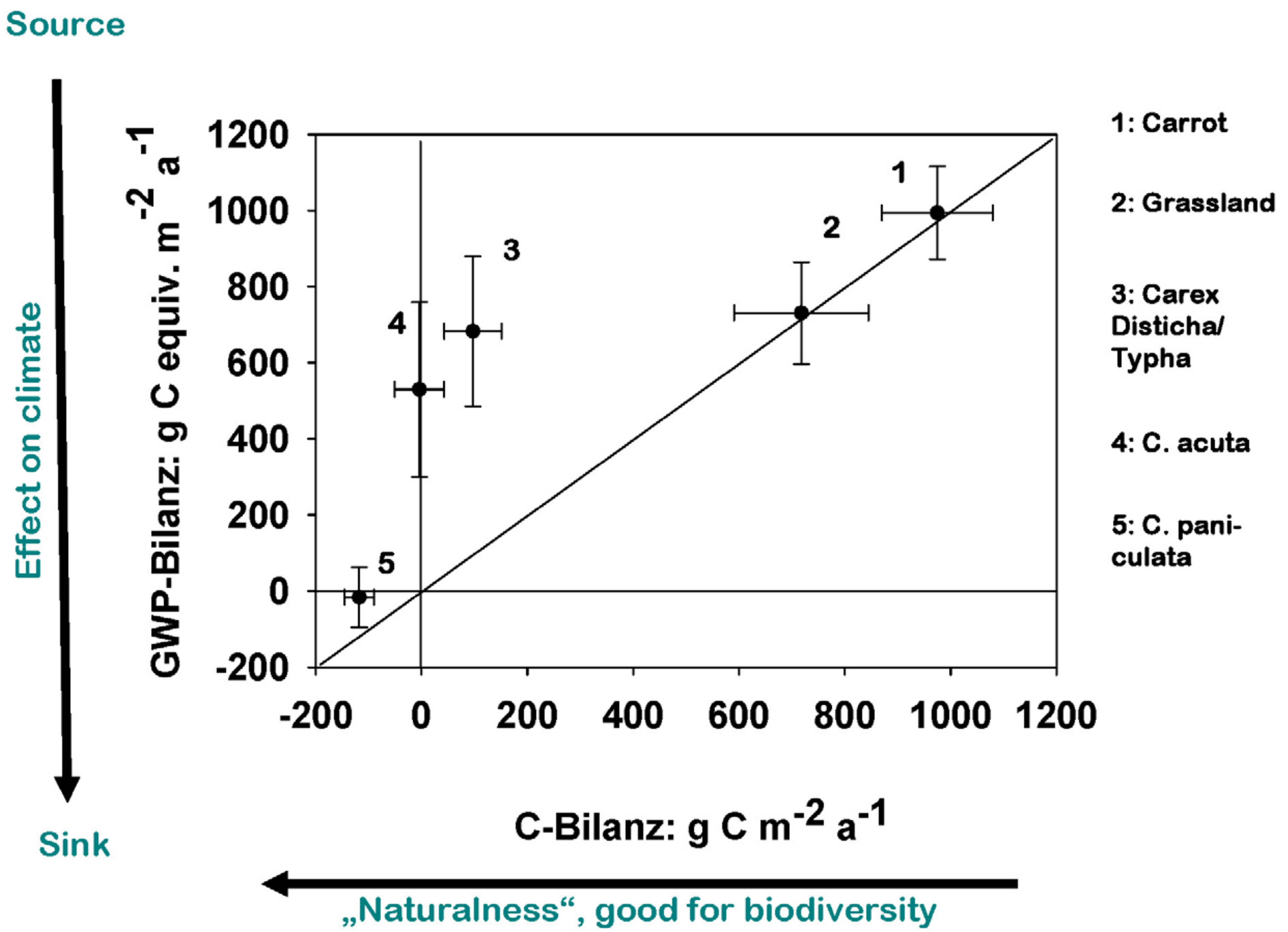




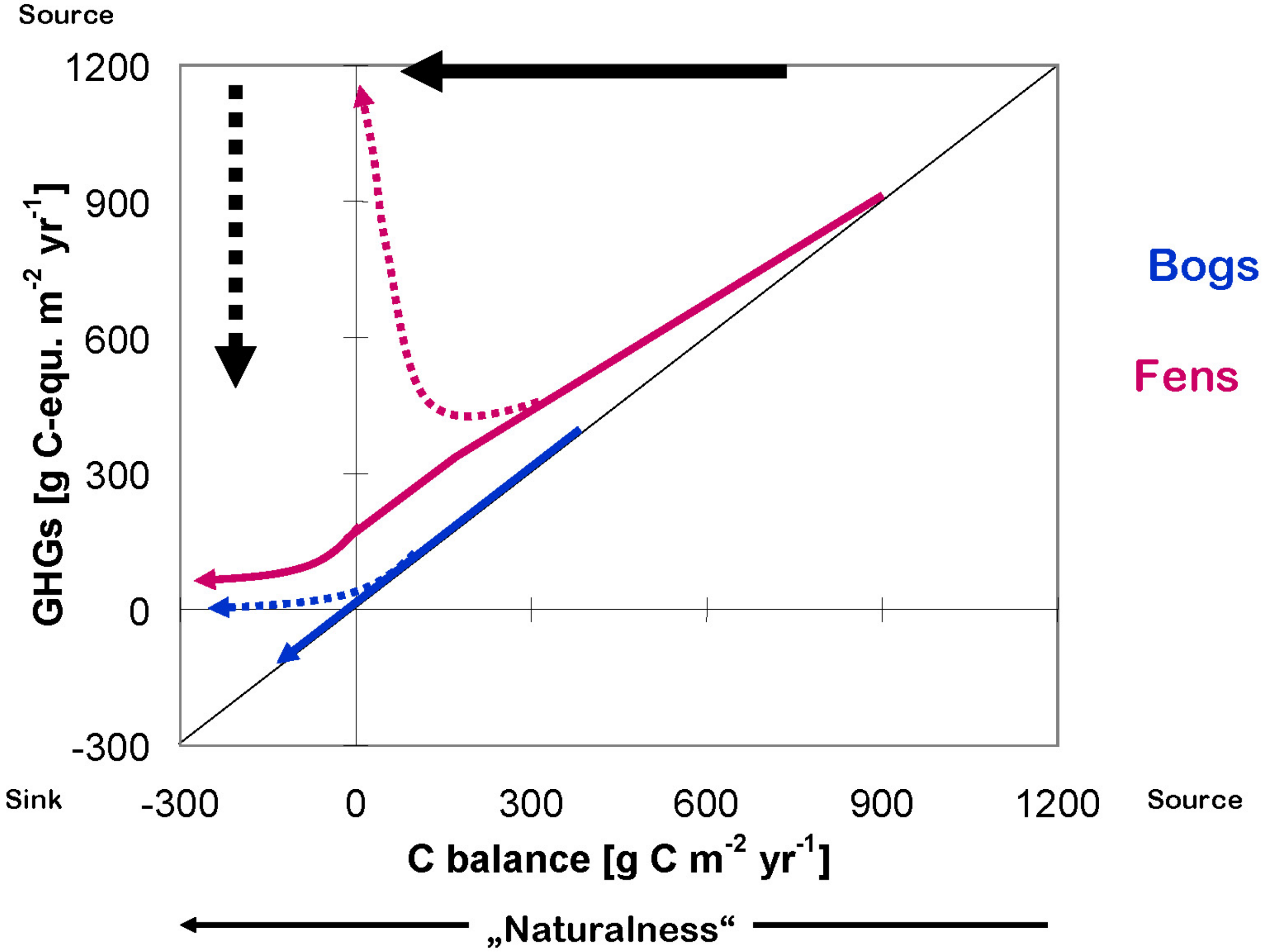


CO_2, N_2O: Climate benefits
But: High CH_4 can persist

Annual C and GHG budget



Restoration of drained peatlands: synergy biodiversity - climate?



Drösler 2005; Freibauer et al. in prep.; Drösler, Freibauer et al. in prep.

Restoration of drained peatlands: synergy biodiversity – climate!

- Drained bogs: safe synergies
- Drained fens: synergies in all cases where
  - flooding and full water saturation in summer is avoided (or only a small part of land surface is flooded or saturated)

- ➢ Current emissions: 80-130 Tg CO_2-equ / yr

  2-3% of emissions in EU-25
- ➢ Theoretical potential in Europe if all peatlands were restored (no water constraints!):

  50-100 Tg CO_2-equ / yr

  = 1-2% of emissions in EU-25

Recalculated from Byrne et al. 2005

Fragen

- Was sind global die wichtigsten anthropogenen Quellen für CO_2, CH_4 und N_2O?
- Wie beeinflusst der Wasserspiegel die Bildung und den Verbrauch von CO_2, CH_4 und N_2O?
- Wann können Peaks von N_2O aus dem Boden auftreten?

GHGs in agriculture: sources, mitigation




GHGs from agriculture

Landwirtschaftliche Emissionsquellen

Einsatz von Vorleistungs-produkten und Verbrennung von Energieträgern

- ✓ z.B. Mineraldünger, Zukauffuttermittel (CO_2, N_2O, CH_4)
- ✓ Diesel, Heizöl, Strom (überwiegend CO_2)

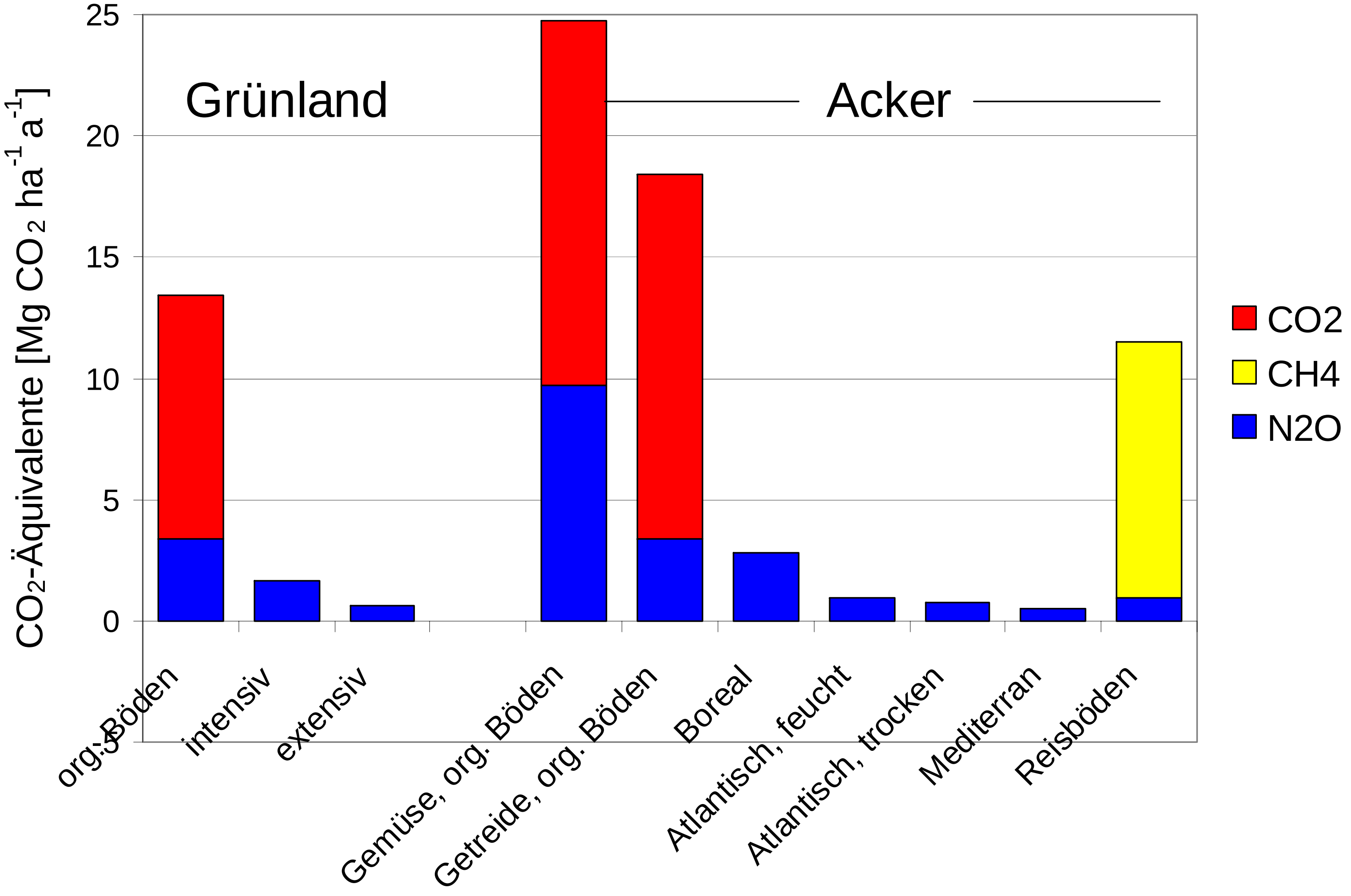
Tierhaltung

- ✓ Verdauungsbedingte Emissionen (CH_4)
- ✓ tierische Exkremente (CH_4, N_2O, NH_3)

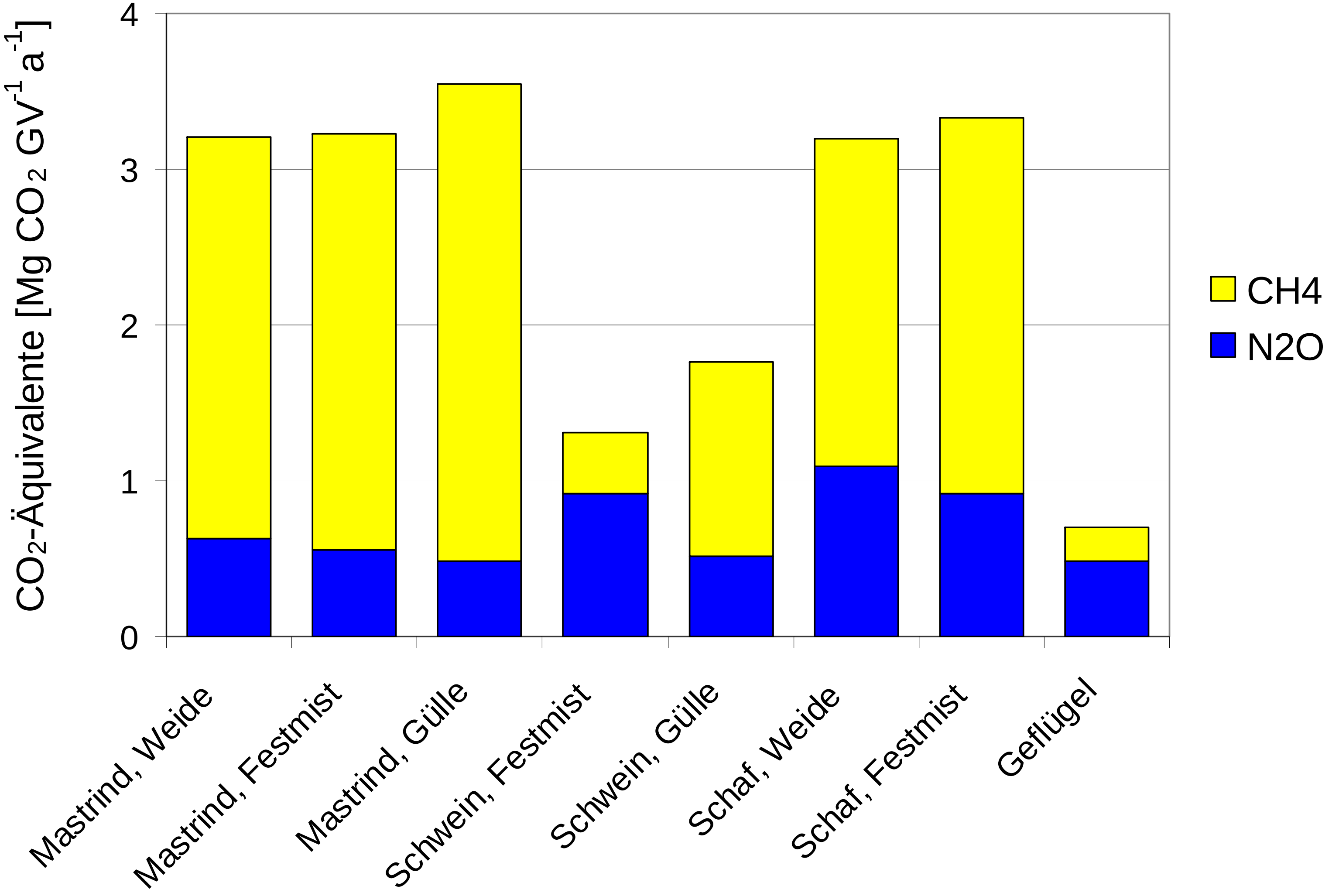
Düngung und Boden

- ✓ Einsatz von mineral. N-Dünger und Wirtschafts-dünger (N_2O, NH_3)
- ✓ Ernterückstände (N_2O)

GHGs from agricultural soils



GHGs from animals



What shall be optimized?

- Production
- Other environmental problems
- GHGs
  - GHGs/area
  - GHGs/farm
  - GHGs/unit product

Mitigation measures

- Reducing agricultural GHG emissions
  - reduced synthetic and overall nitrogen inputs
  - technological innovation in animal husbandry
  - further decline in animal numbers
- Abandonment of drained, farmed organic soils!?
- Many measures will also provide environmental benefits, especially if tightening nutrient cycles.
- Socio-economic changes!

How to consider energy substitution?

- Life cycle analysis
- Regional mix of energy carriers
- Regional mix of energy conversion technology

Bioenergy: Fossil C substitution

t fossil-C saved per t bioenergy-C

	Combined heat and power plant; natural gas	Heat plant; light heating oil	Power plant; lignite	**Regional substitution effectiveness in Thuringia**
Winter wheat, whole crop	0.36	0.54	0.75	**0.49**
Spruce, slash	0.45	0.65	0.89	**0.61**
Scaling fraction	0.27	0.11	0.17	

Conclusion: GHG mitigation

- Produce sustainably and RE-USE effectively
  - Maintain C stocks: do not shorten forest rotations
  - Take soils into account
  - Sequester C in low-risk, low-productive forests
  - Produce biomass on productive lands
  - Priority of product use before energy use
  - Use product waste for energy

- **A land-only view on GHG mitigation is not effective. It also matters what we do with the harvested products.**

Frage

- Soll Landnutzung einen Beitrag zum Klimaschutz leisten oder lieber Nahrungsmittel und sonstige Güter produzieren?

- Wie könnte klimafreundliche Landnutzung aussehen?

- Wie können Treibhausgasemissionen in der Landnutzung reduziert werden?