CC-LandStraD
Climate Change — Land Use Strategies

Modeling regionally differentiated N_2O emissions of agricultural soils in Germany by linking an agro economic and a data based model.

Rene Dechow, Martin Henseler, Sören Gebbert, Thomas Leppelt Peter Kreins

THÜNEN
zalf Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) e.V.
PIK Potsdam-Institut für Klimafolgenforschung
Bundesinstitut für Bau-, Stadt- und Raumforschung im Bundesamt für Bauwesen und Raumordnung
Gefördert durch Bundesministerium für Bildung und Forschung
iöw Institut für ökologische Wirtschaftsforschung
Westfälische Wilhelms-Universität Münster
Institut für Geographie AG Orts-, Regional- und Landesentwicklung/Raumplanung ifg

Motivation und Zielsetzung

- Motivation:
  - ca. 10% of German GHG emissions originate from the sectors agriculture and LULUCFLandnutzungsänderung
  - 3.7 % from N_2O emissions of mineral agricultural soils
  - recent IPCC approaches with emission factors on Tier 1 level used in the German GHG inventories neglect the local influence of key drivers like climate, soil properties, management

- Goals:

Improved spatial stratified GHG approaches
Simple interfaces to the agro -economic model RAUMIS

↓

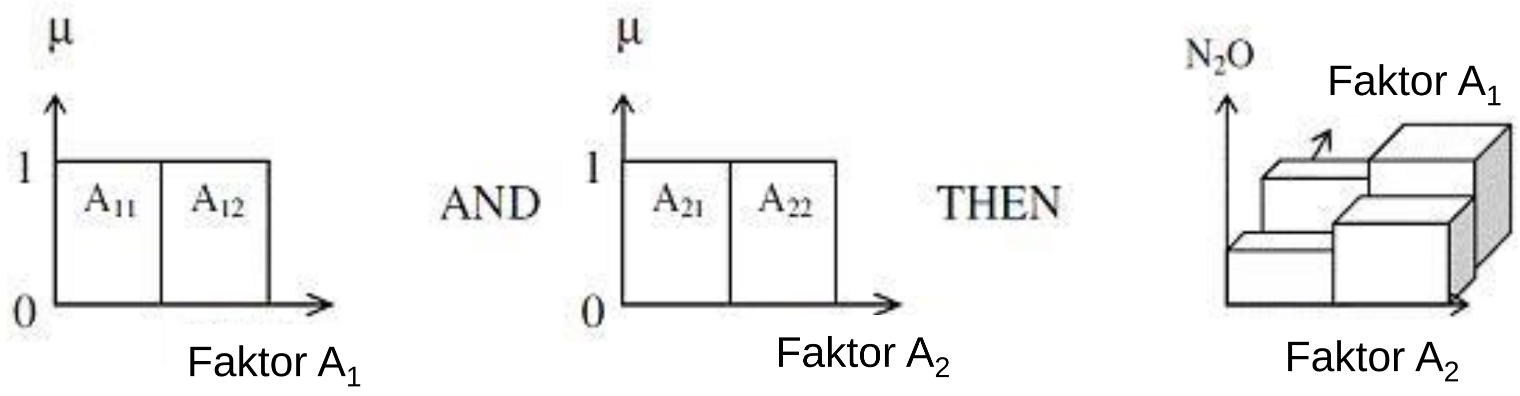
Assessment of mitigation strategies with respect to efficiency and economic welfare

Concept of MODE

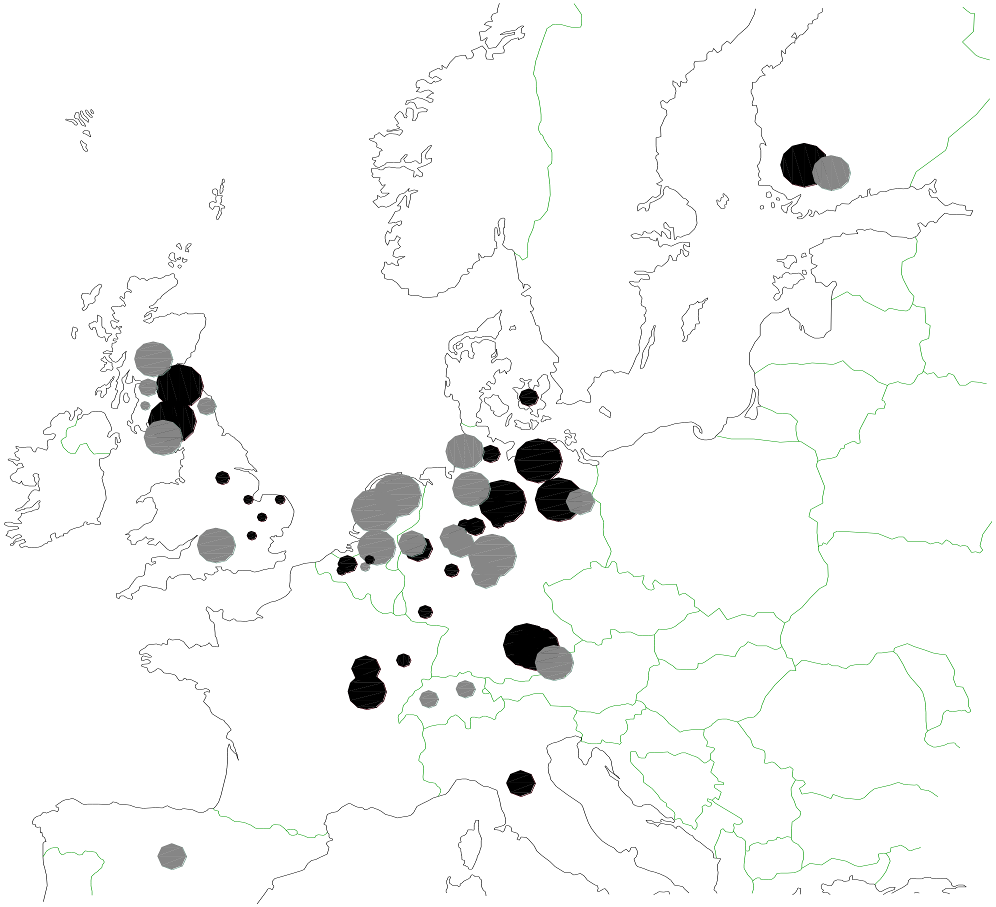
MODE (MODel Ensemble):

- Modellensemble of empirical approaches
- Fuzzy decison trees with a weighting scheme to consider categorical variables (croptype and type of fertilizer applied)
- model development includes factor search, validation and uncertainty analyses

Fig.: partition of a two dimensional domain of definition by„decision trees“



The training data



Plot scale measurements

annual values

(Stehfest and Bouwman, 2006)

grassland: 85 variants at 24 sites

cropland 164 variants at 30 sites

Meteorological data

REMO

seasonal water budget

Soil properties

texture

SOC, Ntot

ph

Management

croptypes grown

fertilized N

type of applied fertilizers

THÜNEN

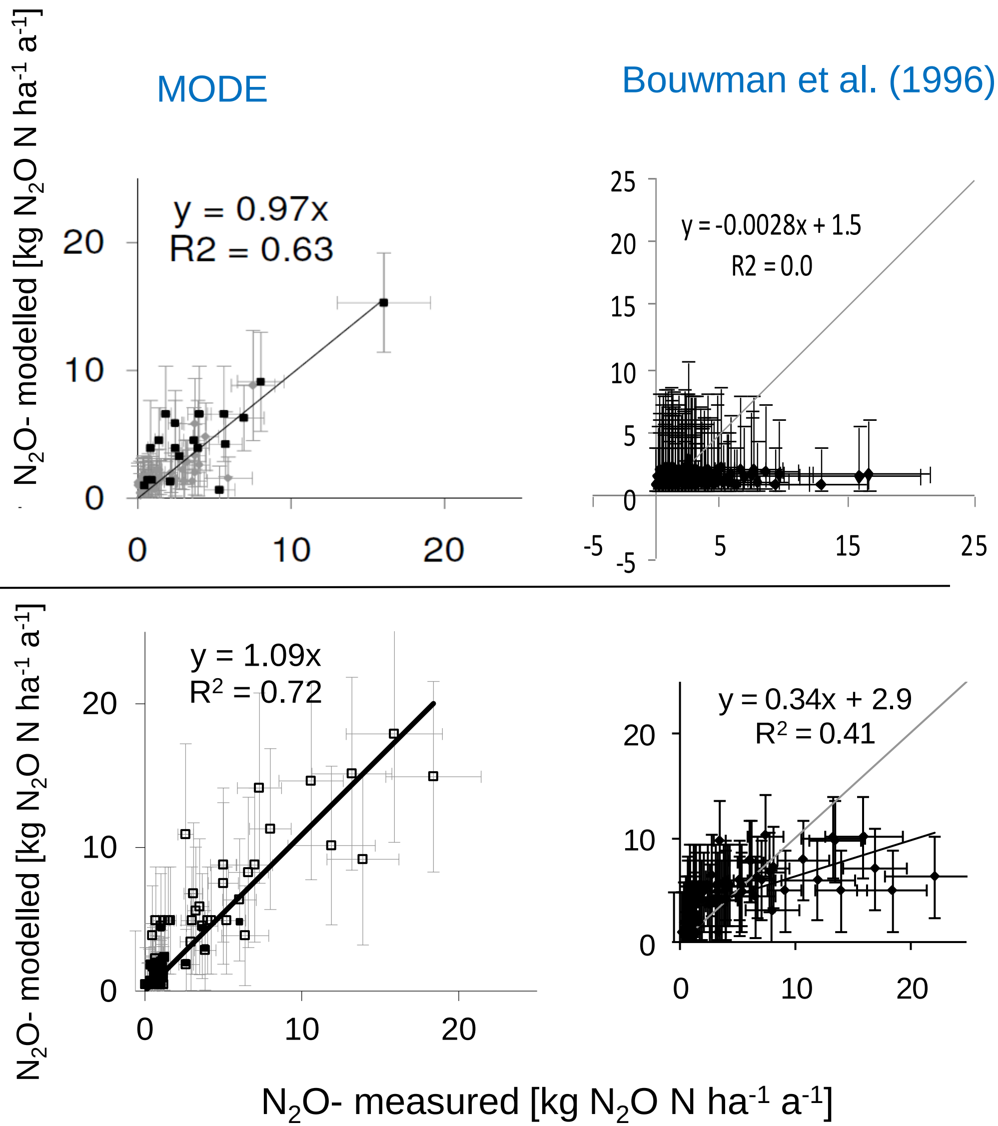
MODE on plotscale

Proxies – arable land

1. temperature in winter
2. precipitation in autumn
3. sand
4. amount of fertilisation
5. croptype

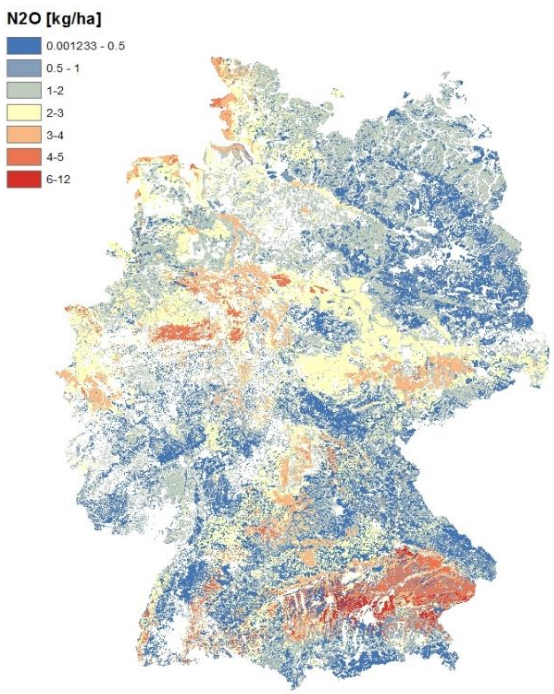
Proxies – grassland

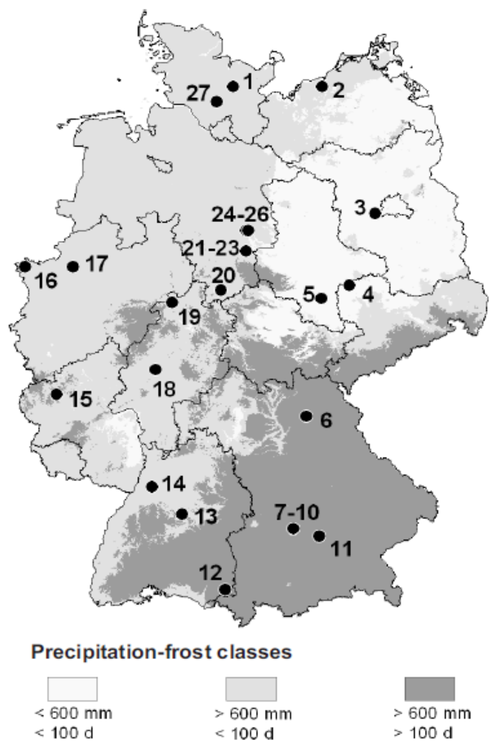
1. amount of N fertilisation
2. temperature in winter
3. ph

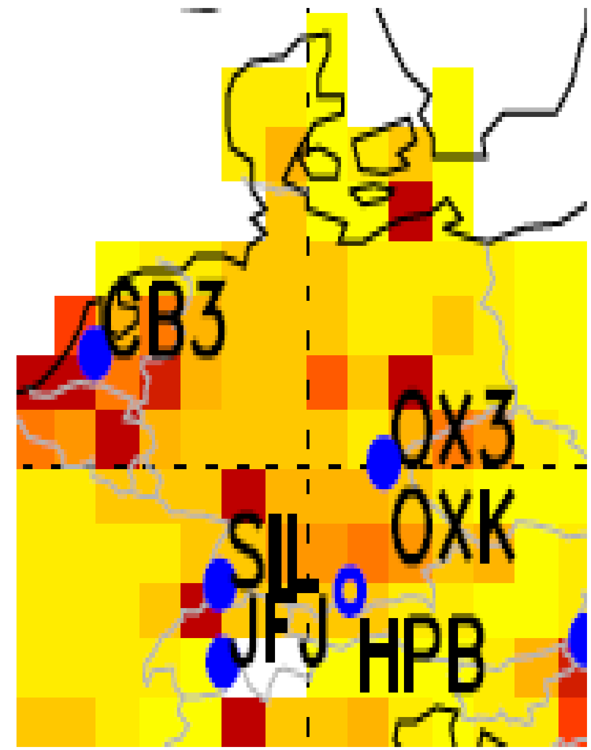


MODE on national scale

Direct N_2O emissions by MODE from agriculture (mean1990-2005) [kg N_2O-N ha^{-1}]	N_2O Emission potentials after Jungkunst et al. (2006)	N_2O sources after Corazza et al. (2011)





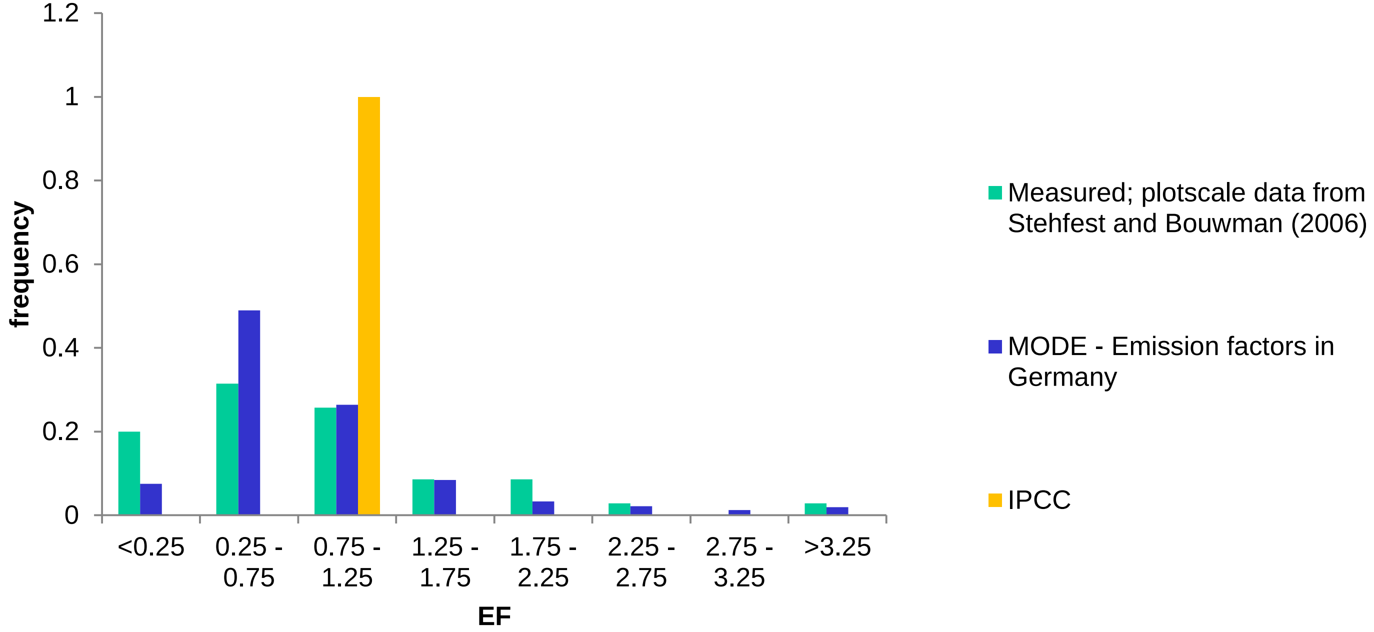


Regionalized emission factors

- Comparison of emission factors:

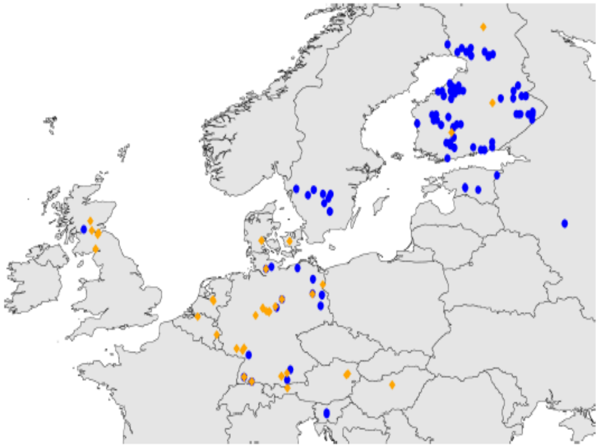
IPCC (1996)	IPCC (2006)	MODE	DNDC (Leip et al. 2011)
1.25	1.0	0.91	1.7 (2.6)

- Frequency distribution of emission factors:



N2O from forests

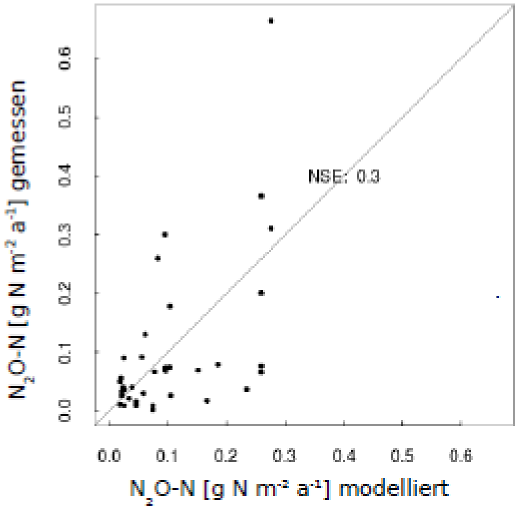
Training data



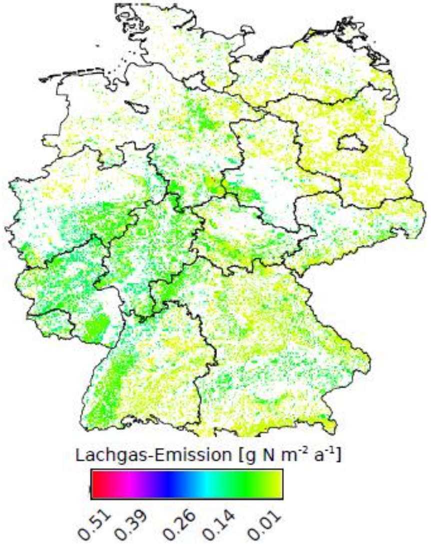
Proxies – forests

1. pH
2. silt
3. annual precipitation

MODE Validation

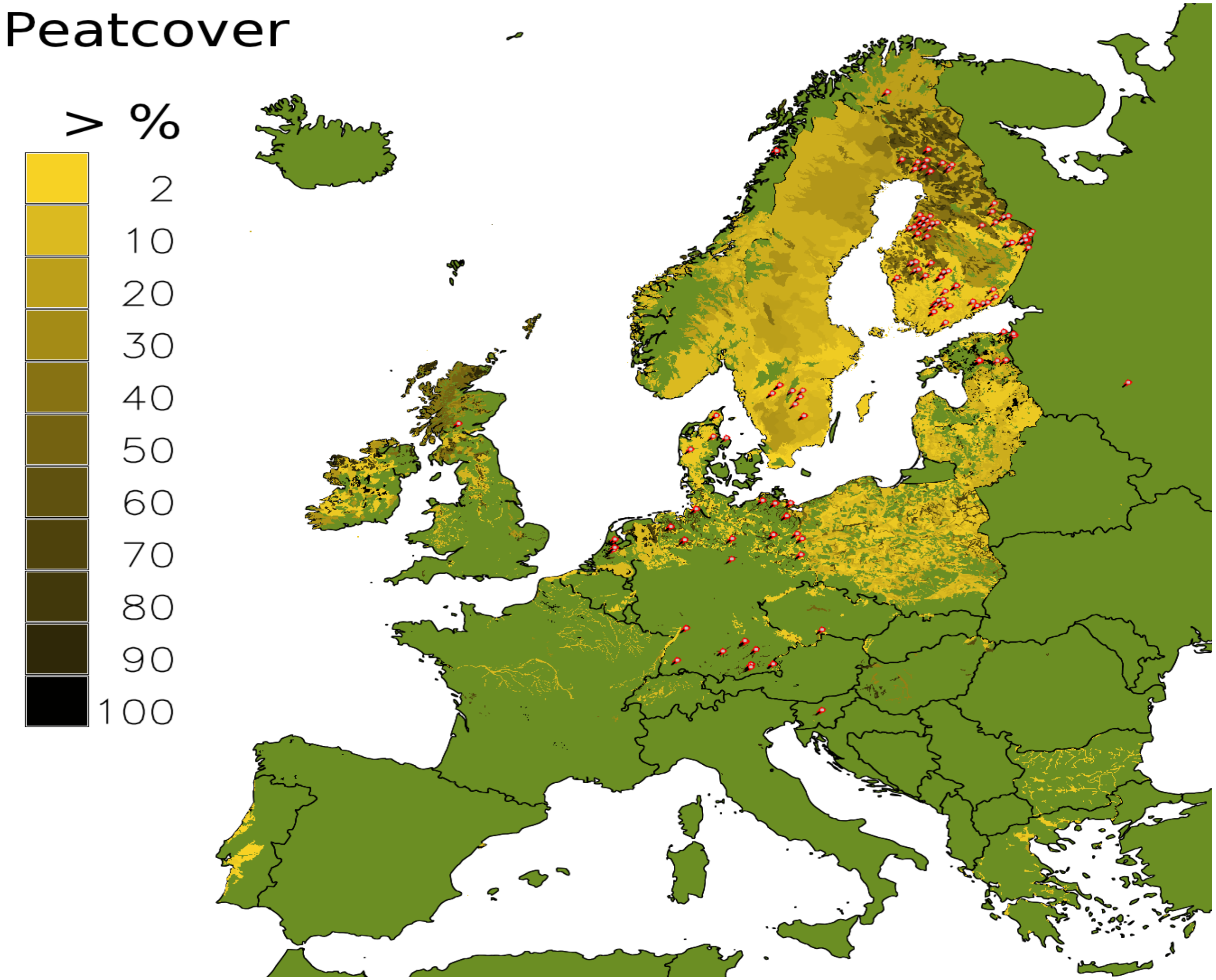


Regionalisation



N2O from organic soils

Spatial distribution of plot scale measurements

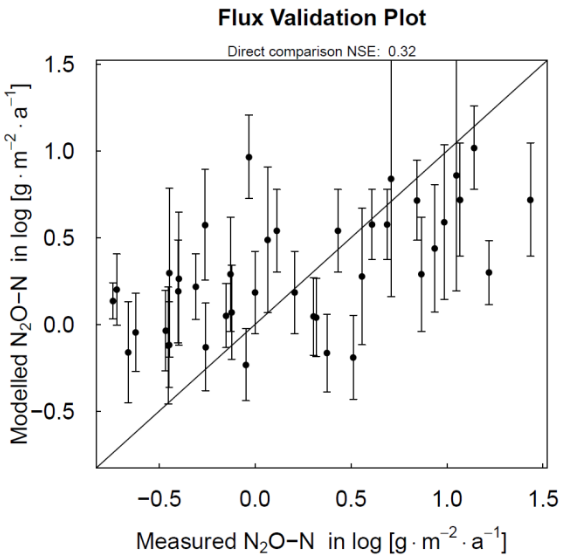


N2O from organic soils

CC-LandStraD
Climate Change – Land Use Strategies

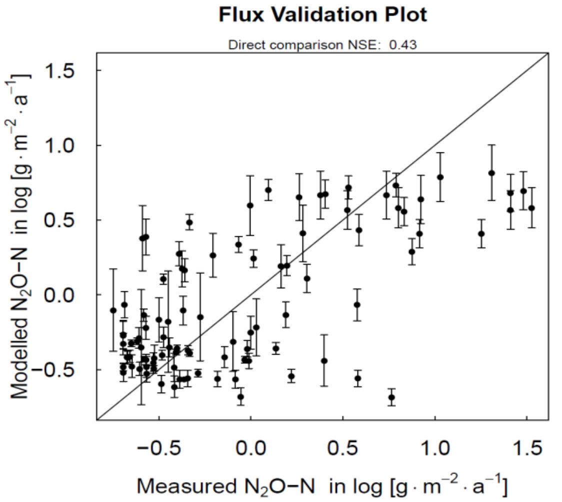
Proxies – cropland

1. mean annual water table
2. pH
3. annual precipitation



Proxies – grassland

1. N fertilisation
2. temperature in winter



The model RAUMIS

- RAUMIS is a regionalised agricultural and environmental information system
- 326 model regions (NUTS III / counties)
- simulates the impacts of agricultural and environmental policies on the

  - regional agricultural land use,

  - production,

  - income

  - environment
- drivers:

  - Product prices,

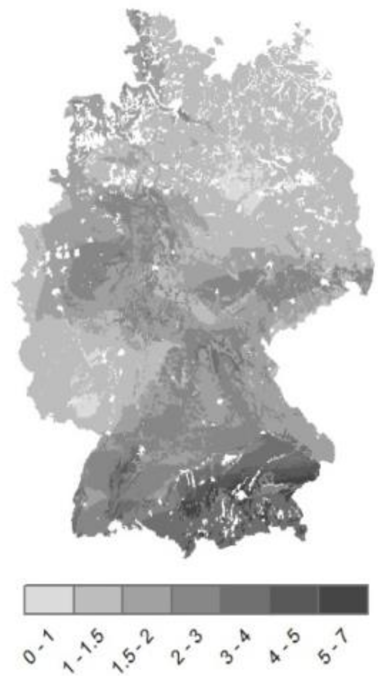
  - policy variables (e.g., area payments, quotas,..)

  - projection of technical coefficients

  - production costs and yields

$$N_2O = N_2O_{background} + EF \cdot N_{input}$$

$$EF = (N_2O_{100kg} - N_2O_{background})/\ 100\ kg\ N/ha$$

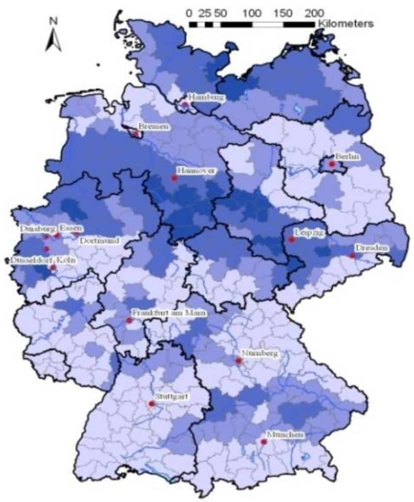


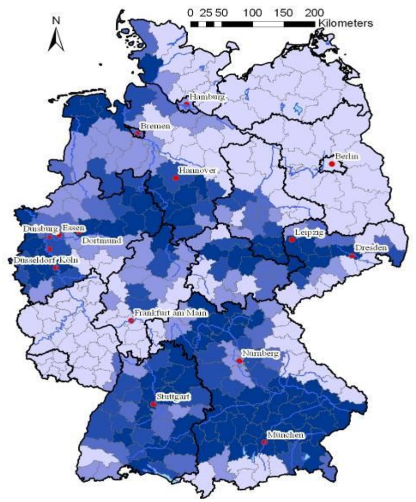
Results of the RAUMIS/ MODE linkage

CC-LandStraD
Climate Change — Land Use Strategies

IPCC/RAUMIS | **MODE/RAUMIS**

2007

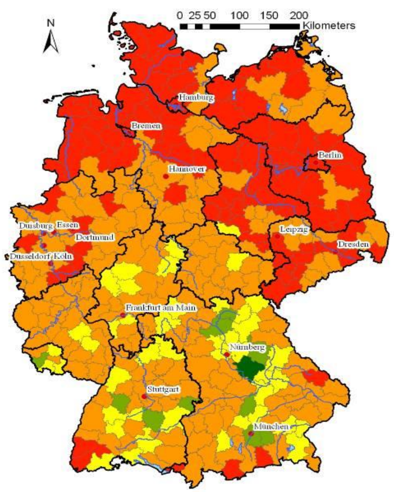


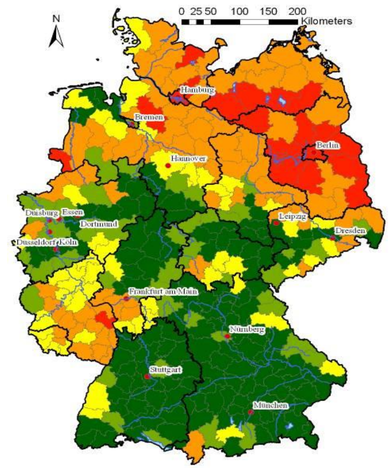


N_2O from soils
[kg CO_2 equiv/ha]

- smaller 900
- from 900 to 1000
- from 1000 to 1100
- from 1100 to 1200
- more then1200

Change till 2020





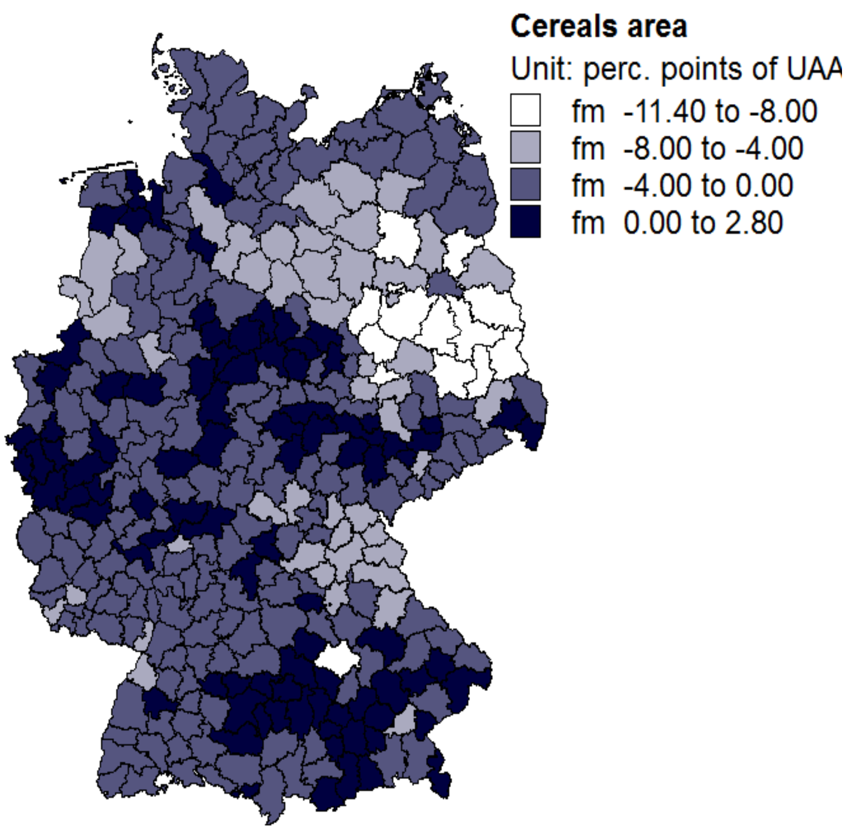
N_2O aus Böden
[kg CO_2 equiv/ha]

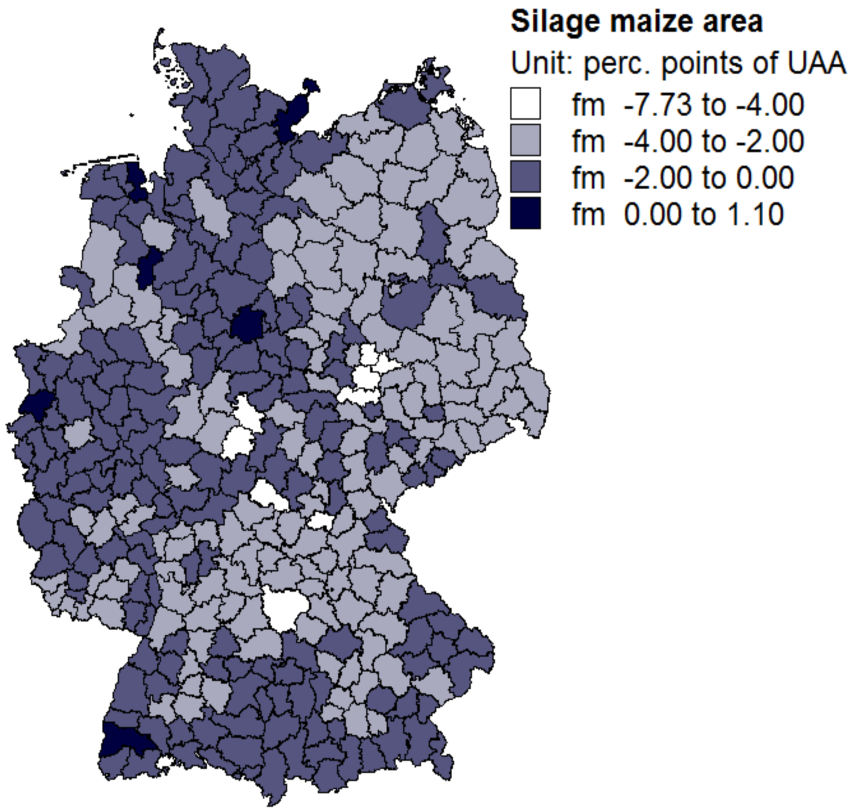
- Smaller 0
- from 0 to 50
- from 50 to 75
- from 75 to 100
- from to 100

THÜNEN

Scenario N tax

- production is less affected where organic amendment from livestock management can substitute the decrease in mineral N (North west and south east of Germany)
- production is less affected on fertile sites (corn belt)

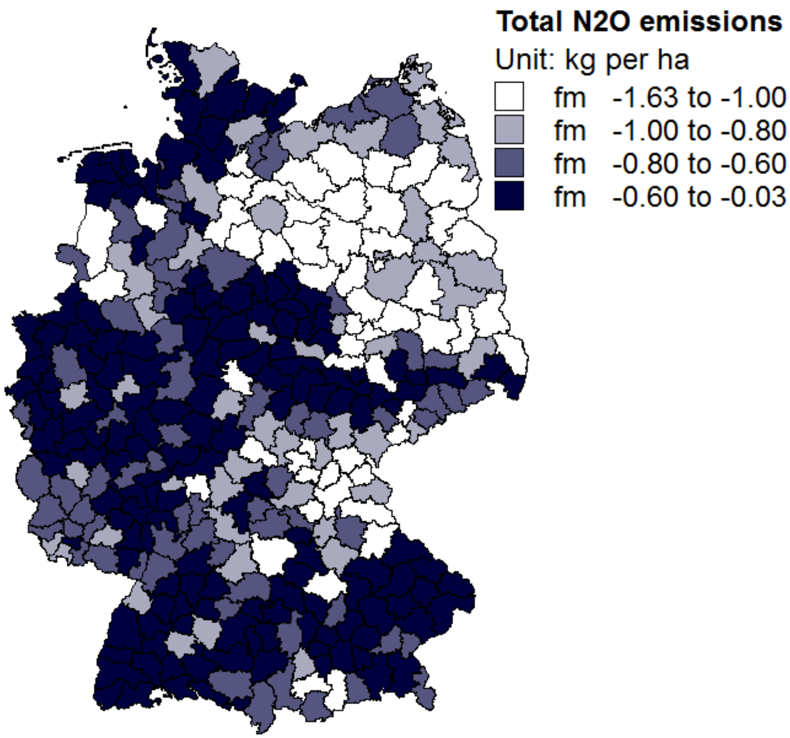




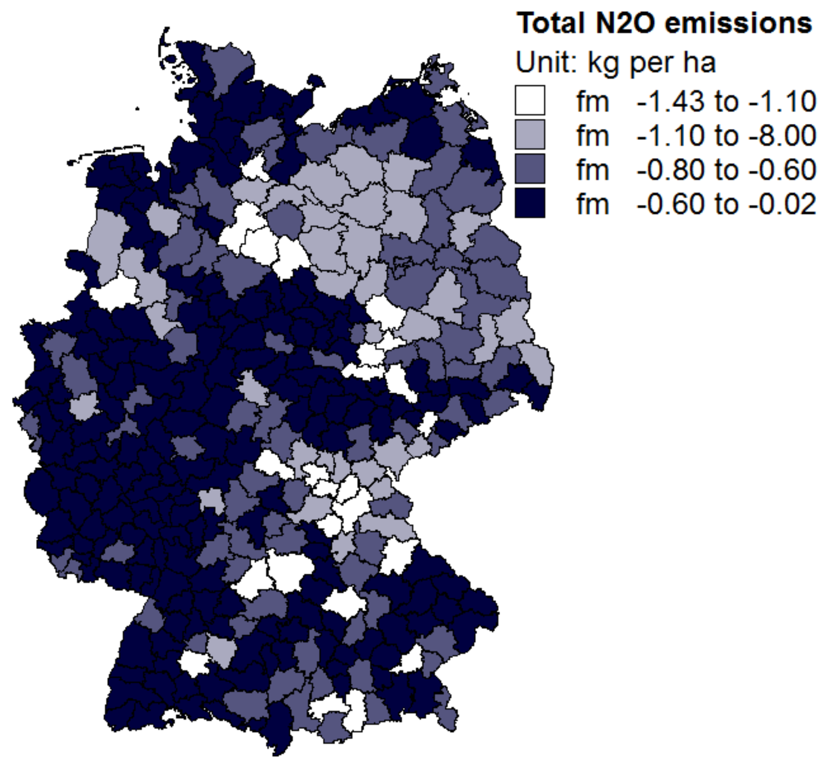
Scenario N tax N_2O mitigation

- The mitigation effect is slightly smaller for the stratified approach (MODE) than with the IPCC aproach
- IPCC calculates higher mitigation effects for regions of lower fertility (climate, soil properties) which are assigned by lower emission potentials by MODE

IPCC



MODE



Conclusion

- Development of empirical approaches to calculate regional stratified THG emissions (N_2O)
- advantages: less computation time; validated on comprehensive measurement data sets; less affected by driver uncerrtainty
- disadvantages: lower explanation depth than process based models
- Coupling of these approaches with the agro economic model RAUMIS results in significant different emission patterns and mitigation potentials
- 13 % of N_2O decrease by a 50 % increase of fertilizer price caused by N tax
- 21 % reduction from 1990 to 2020 (target EU : 25 % reduction of agicultural N_2O and CH_4 emissions in 2020)