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Research Institute of Organic Agriculture
Forschungsinstitut für biologischen Landbau
Institut de recherche de l’agriculture biologique

Mitigation and adaptation potential of organic farming to climate change

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Round Table on
Organic Agriculture and
Climate Change

Contents

- Background
- GHG emissions and its mitigation potential in crop production
- GHG emissions and its mitigation potential in livestock systems
- The potential of organic agriculture to adapt to climate change
- Outlook for future agriculture

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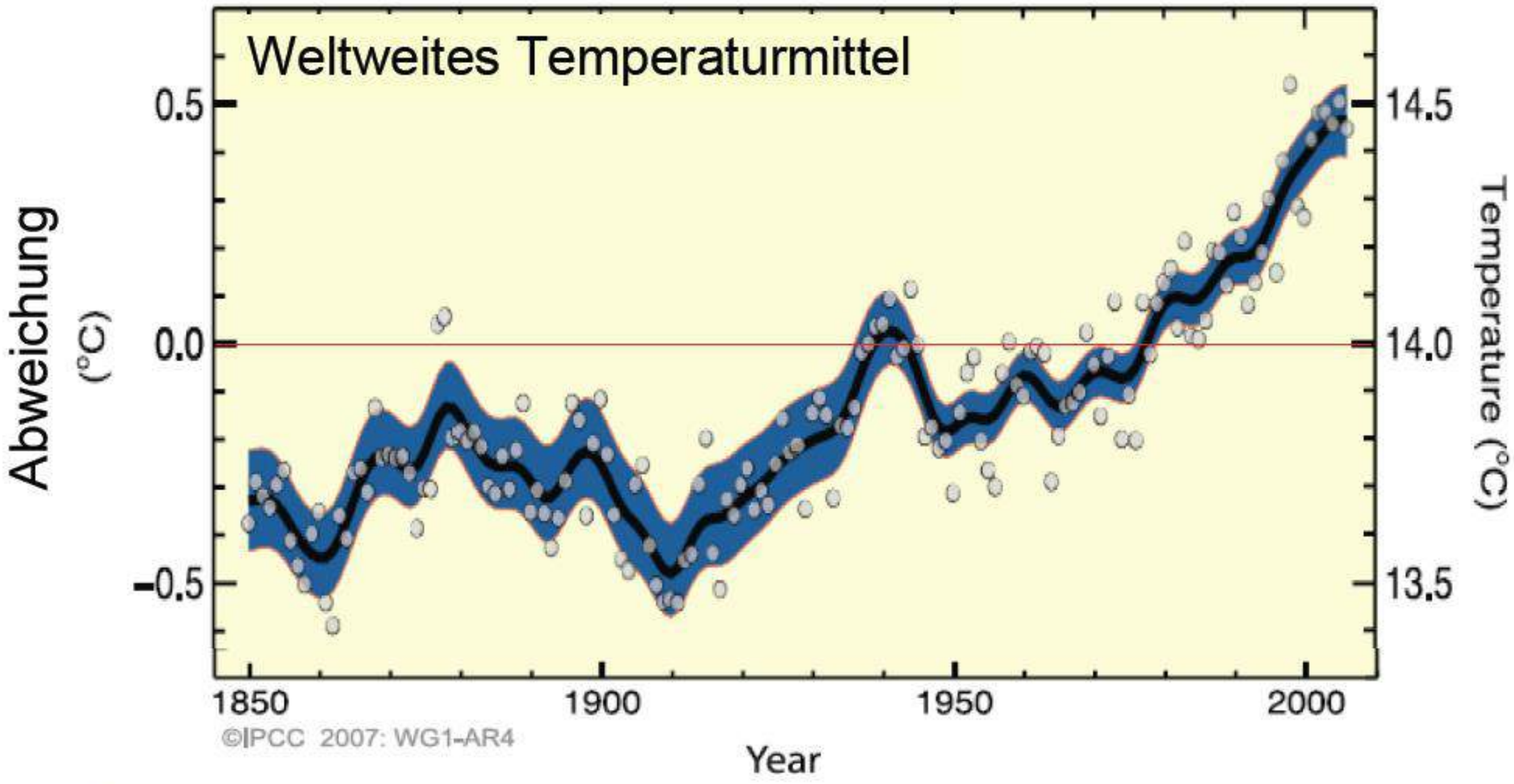
The earth becomes warmer…

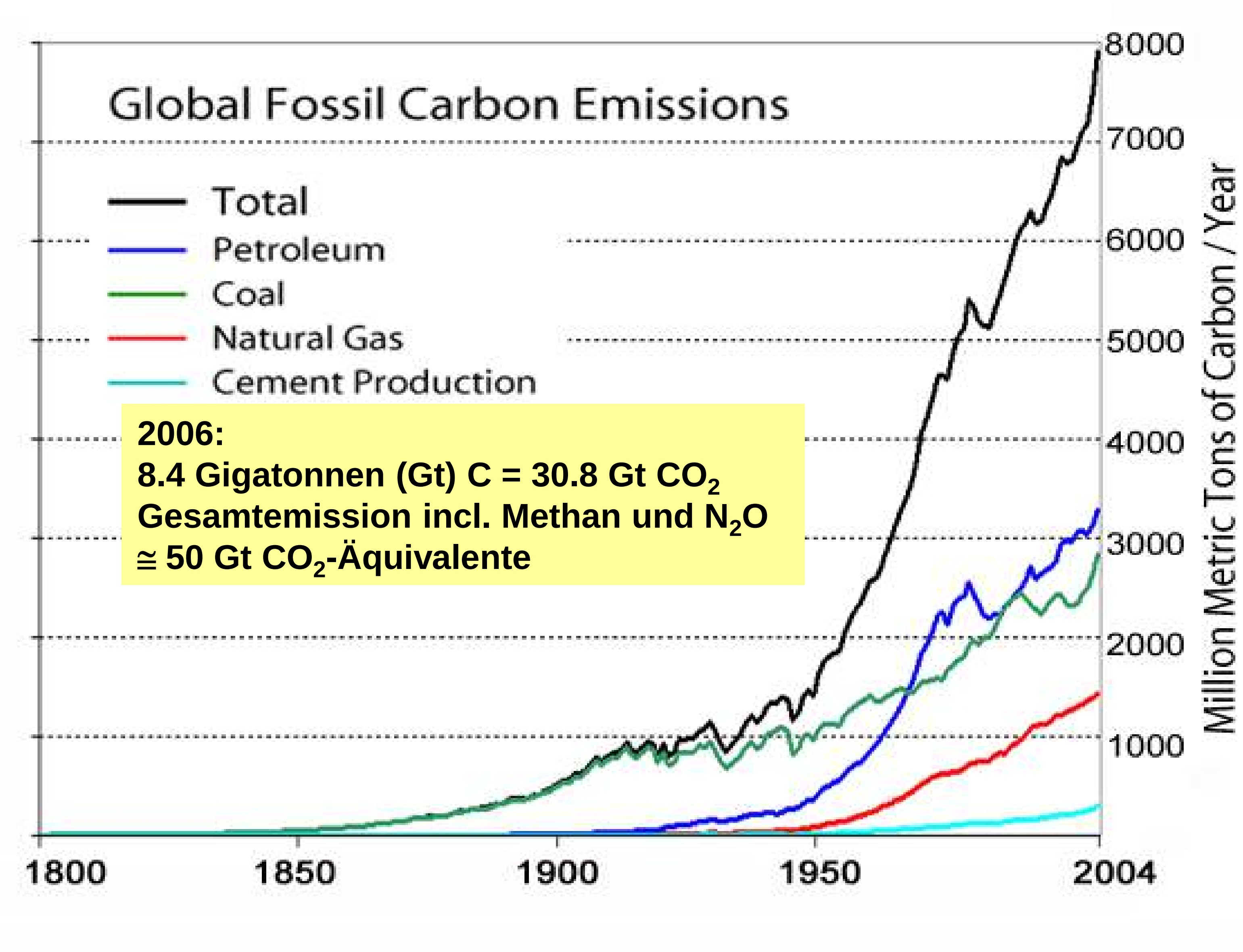


©IPCC 2007: WG1-AR4

100 Jahre linearer Trend (1906-2005): 0.74 [0.56 to 0.92] °C

Fuhrer, 2010

Increase in atmospheric CO_2 concentrations

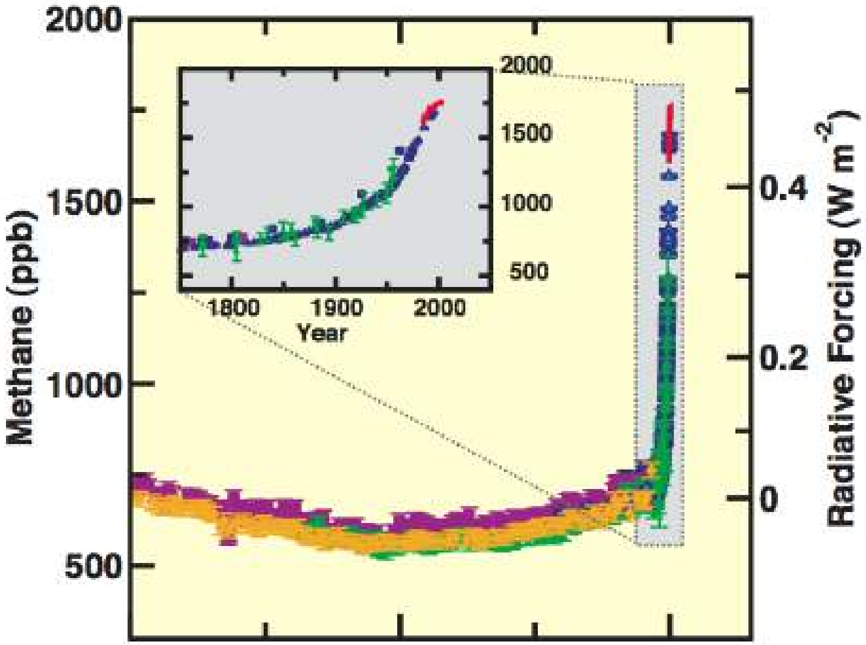


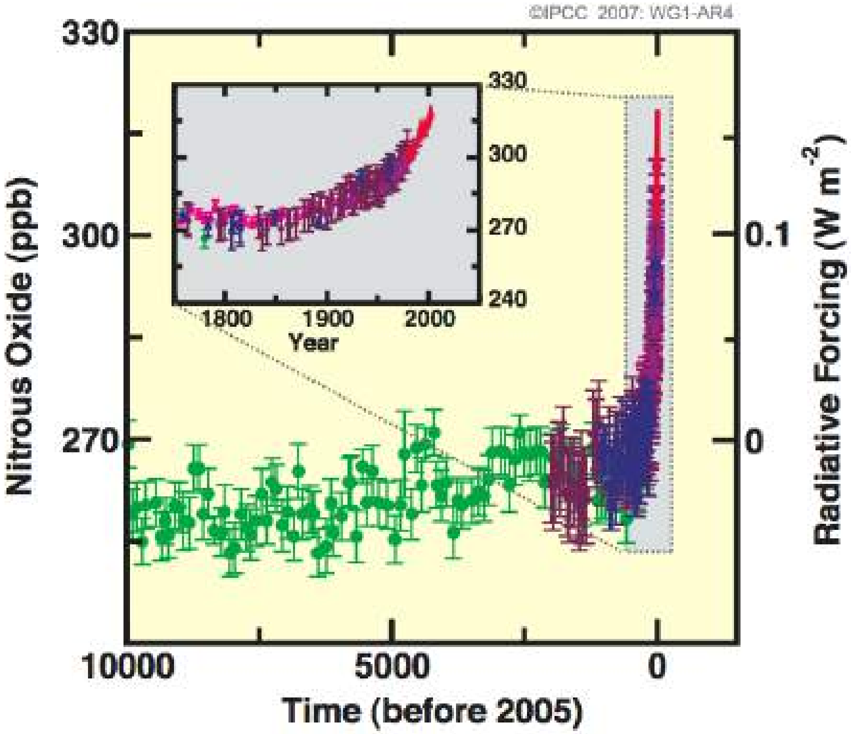
2006:
8.4 Gigatonnen (Gt) C = 30.8 Gt CO_2
Gesamtemission incl. Methan und N_2O
≅ 50 Gt CO_2-Äquivalente

Increase in atmospheric gas concentrations

Global warming potential:

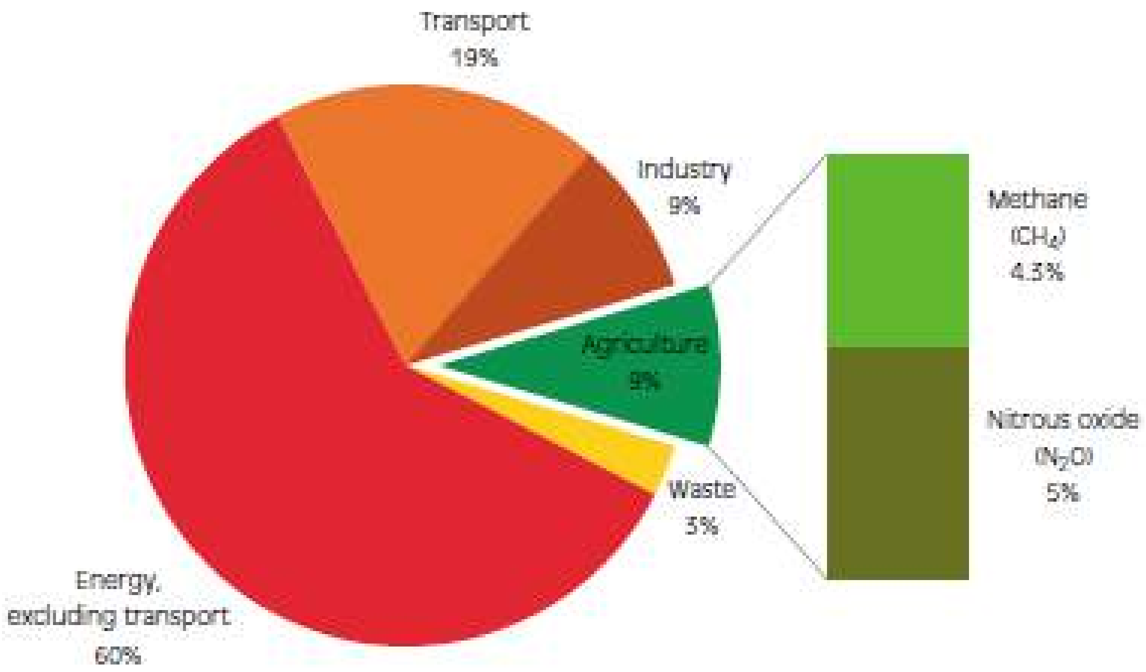
Methane (CH_4): 21 * CO_2 Nitrous oxide (N_2O): 300 * CO_2





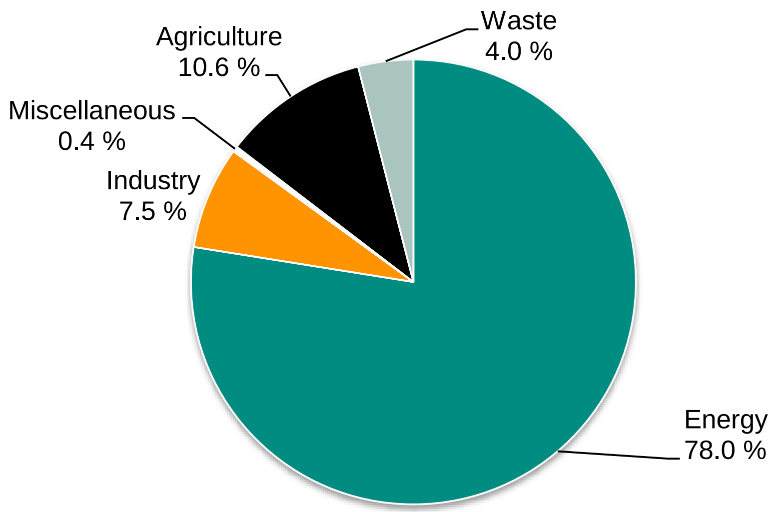
IPCC (2007) 4th assessment report

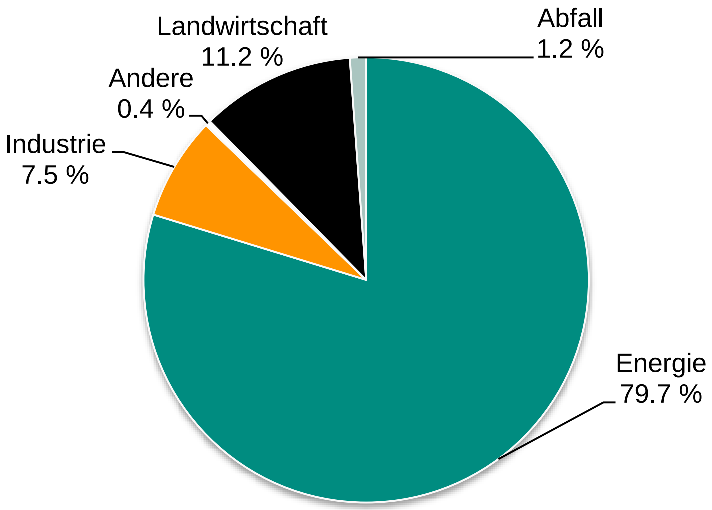
GHG inventories (EU-27 in 2007)



Based on EEA databases (on the basis of EU Member States greenhouse gas inventories and projections) (EC 2009a)

GHG inventories according to UNFCCC (04/2013)

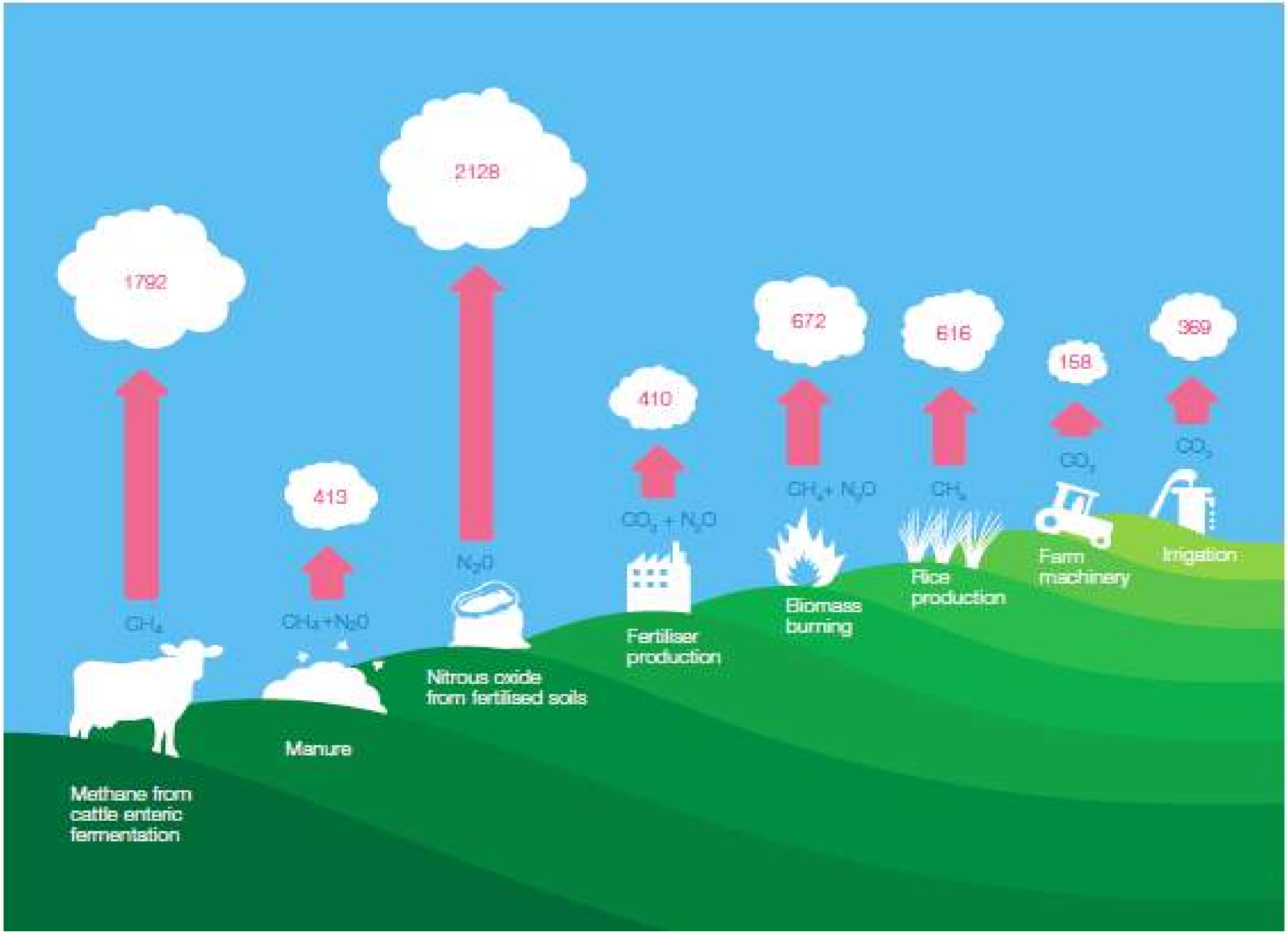




Spain (351 Mio t in total)

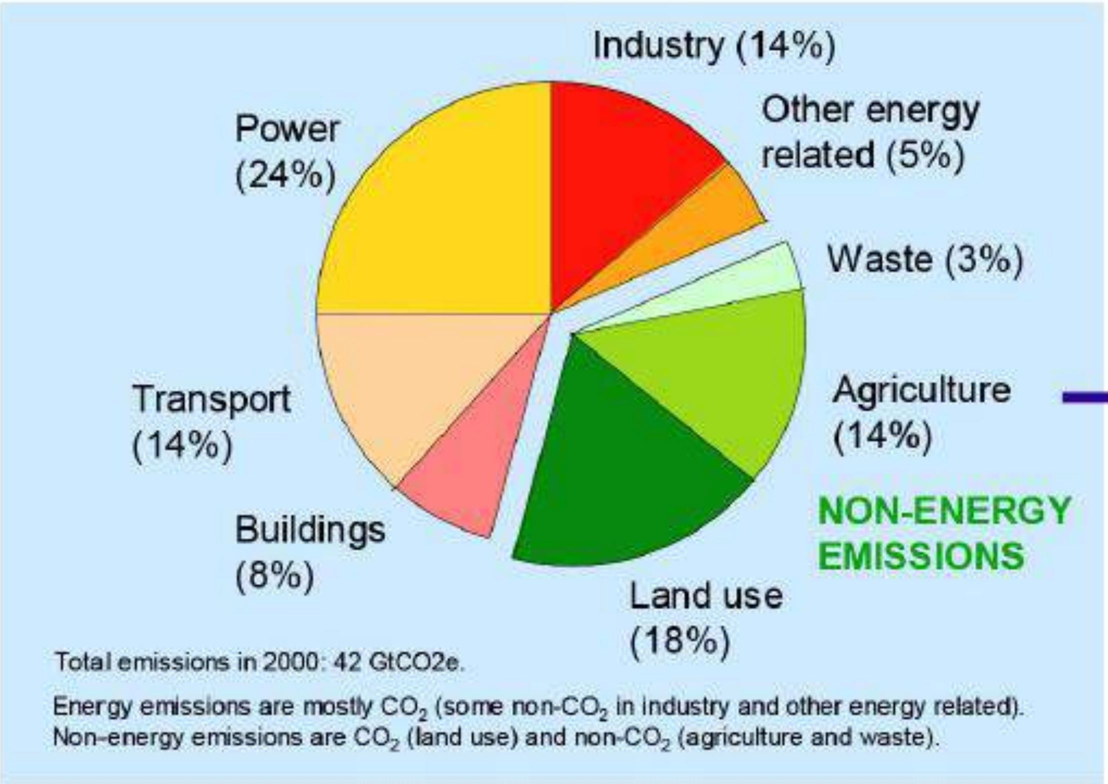
Switzerland (50 Mio t in total)

Agricultural greenhouse gases (without LULUCF)



Bellarby et al. 2008

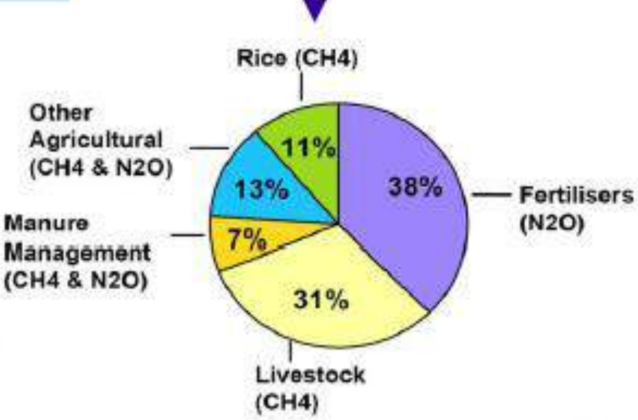
Agricultural emissions



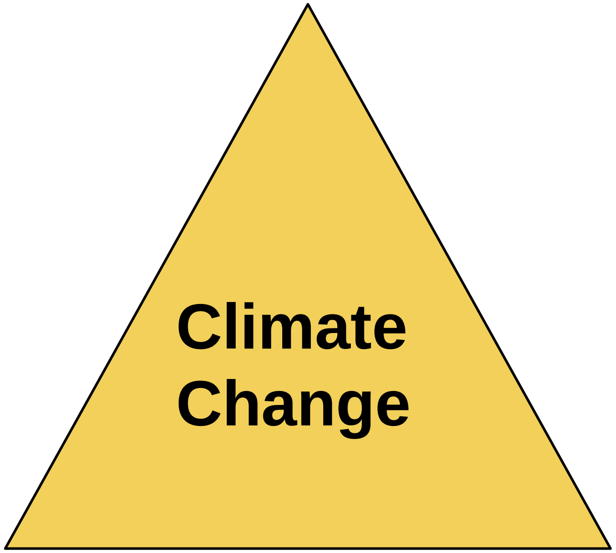
Total emissions in 2000: 42 GtCO2e.

Energy emissions are mostly CO_2 (some non-CO_2 in industry and other energy related).
Non-energy emissions are CO_2 (land use) and non-CO_2 (agriculture and waste).

Stern Review, 2006



The manifold role of agriculture regarding climate change



Climate polluter

Climate Change

Affected

Climate protector

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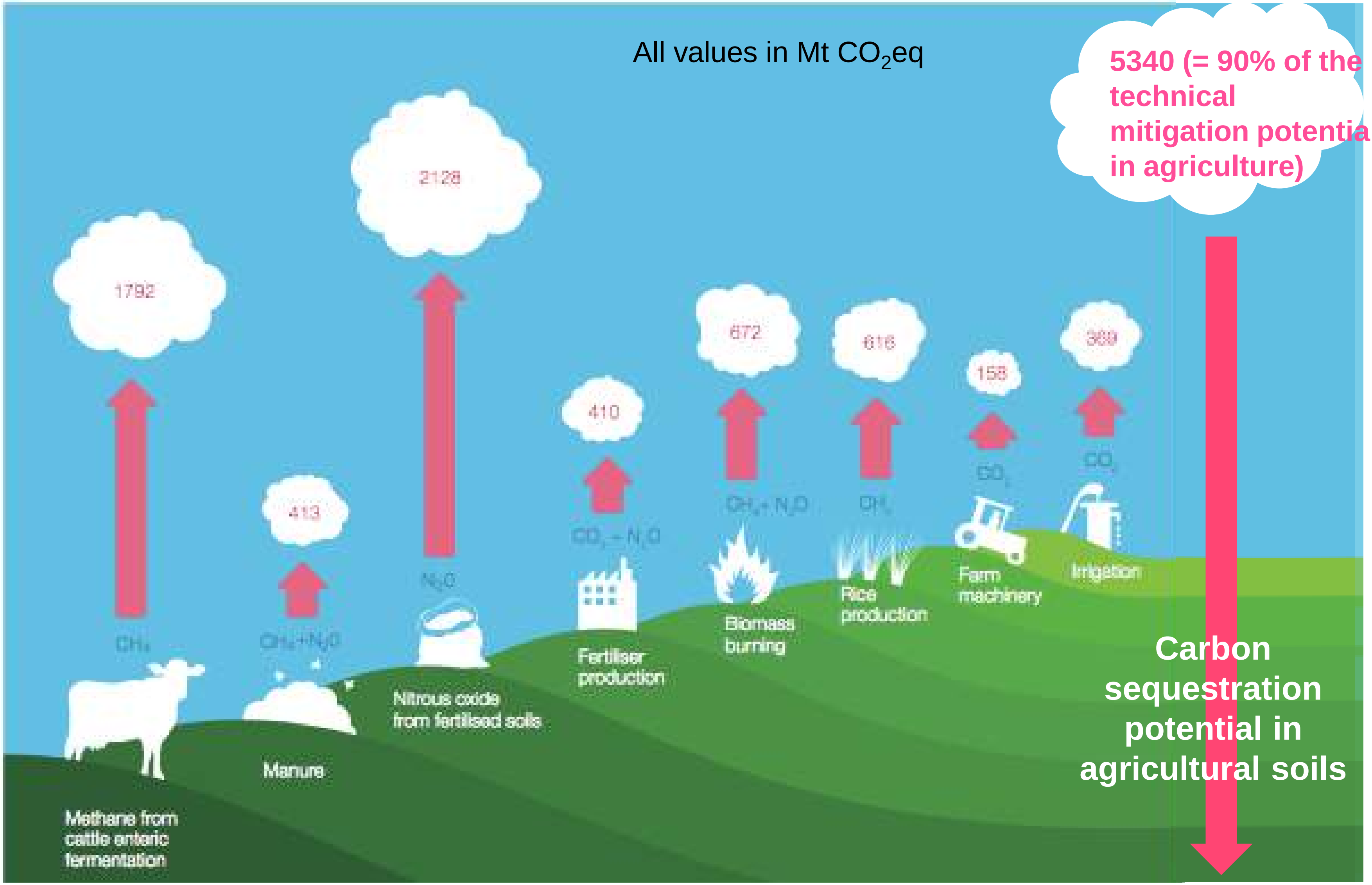
Agricultural greenhouse gases (without LULUCF)



All values in Mt CO_2eq

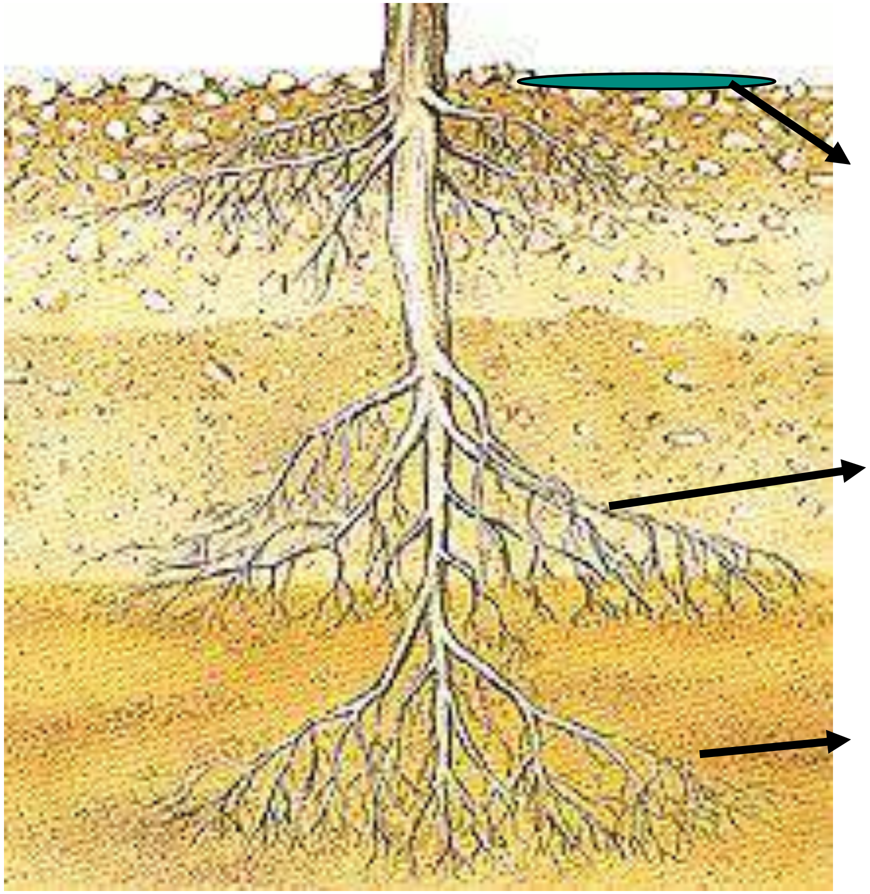
5340 (= 90% of the technical mitigation potential in agriculture)

Carbon sequestration potential in agricultural soils

Adapted from “Cool Farming”, Bellarby et al. 2008

The concept of C sequestration in soil

CO_2 –fixation via photosynthesis



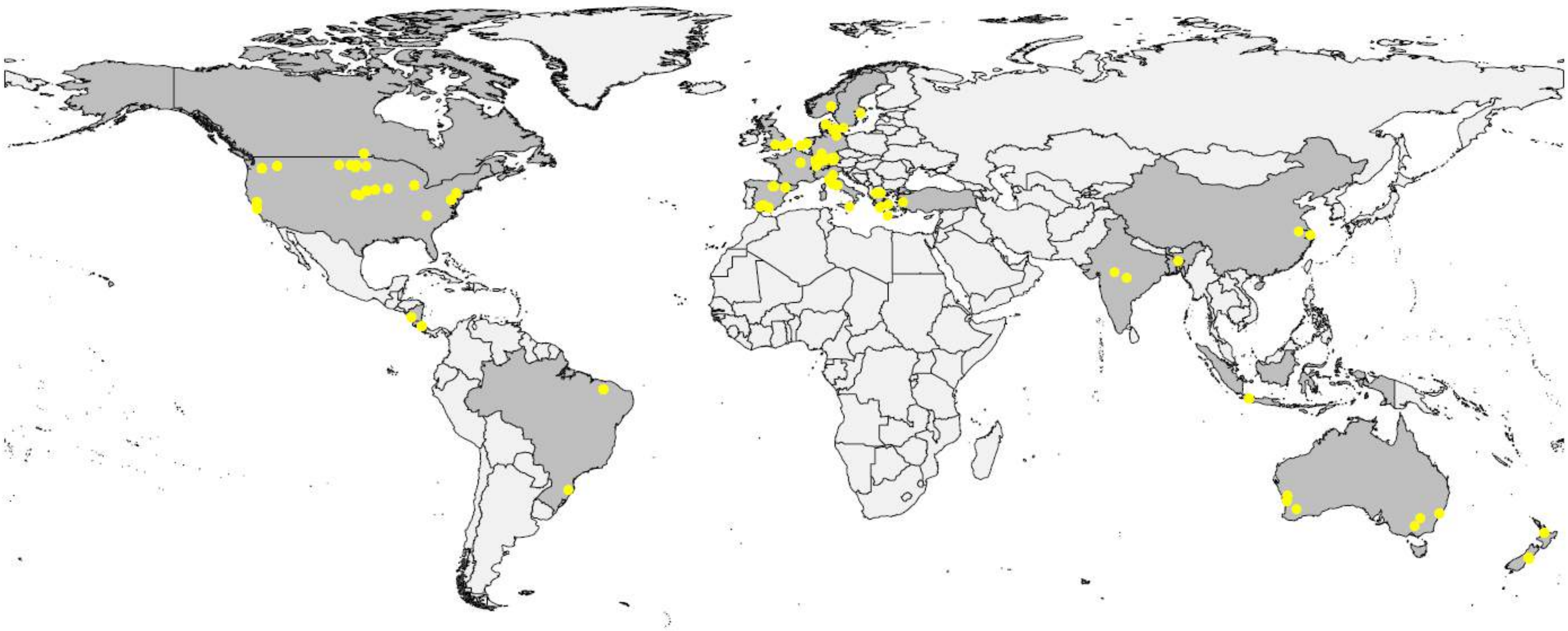
Transformation into soil organic matter (Humus formation)

Soil organic matter and organic farming

- Increasing and maintaining soil organic matter (SOM) is a core principle in organic farming
- It is essential for plant nutrition and soil fertility built-up in organic (= low external input) farming systems
- Diverse and legume containing crop rations and organic manuring are integral measures in OF
- Hence SOM (= soil carbon sequestration) levels are higher under OF practices?

GHG mitigation through carbon storage in soils: organic vs. non organic

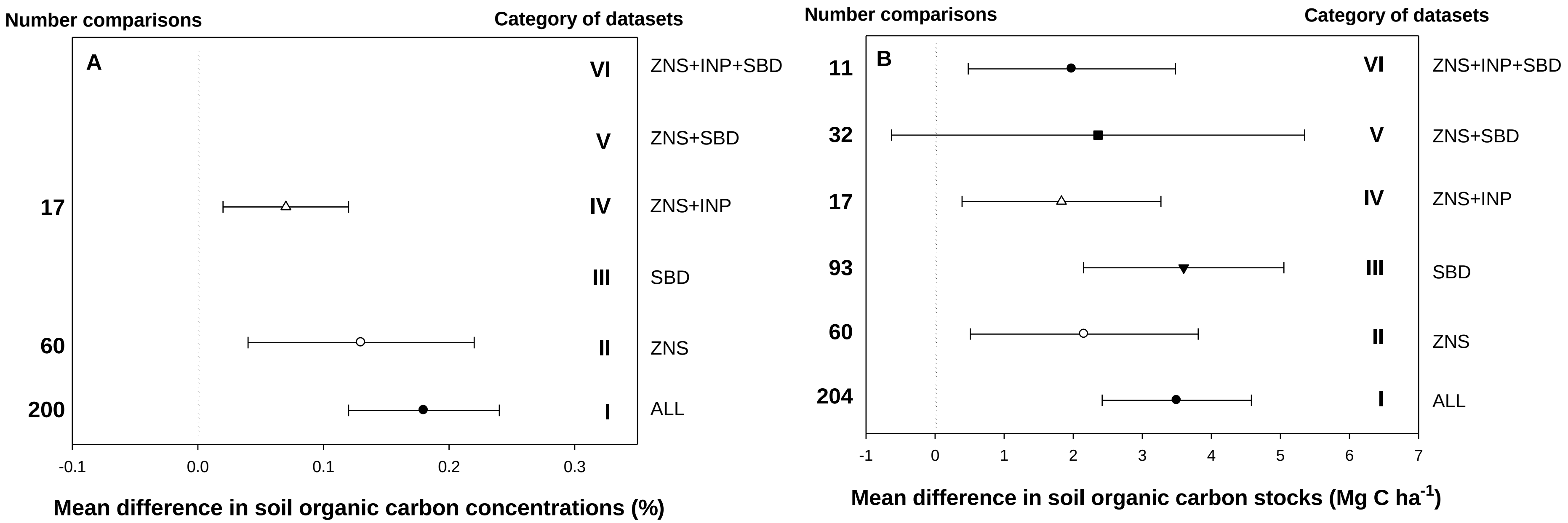
Geographic distribution of the system comparisons for meta-analysis



74 studies globally with up to 211 paired comparisons

Gattinger et al., PNAS, 2012

More carbon in organically managed soils?



Higher soil organic carbon concentrations (%) and stocks (t ha^{-1}) under organic farming management.

What influences differences in soil carbon?

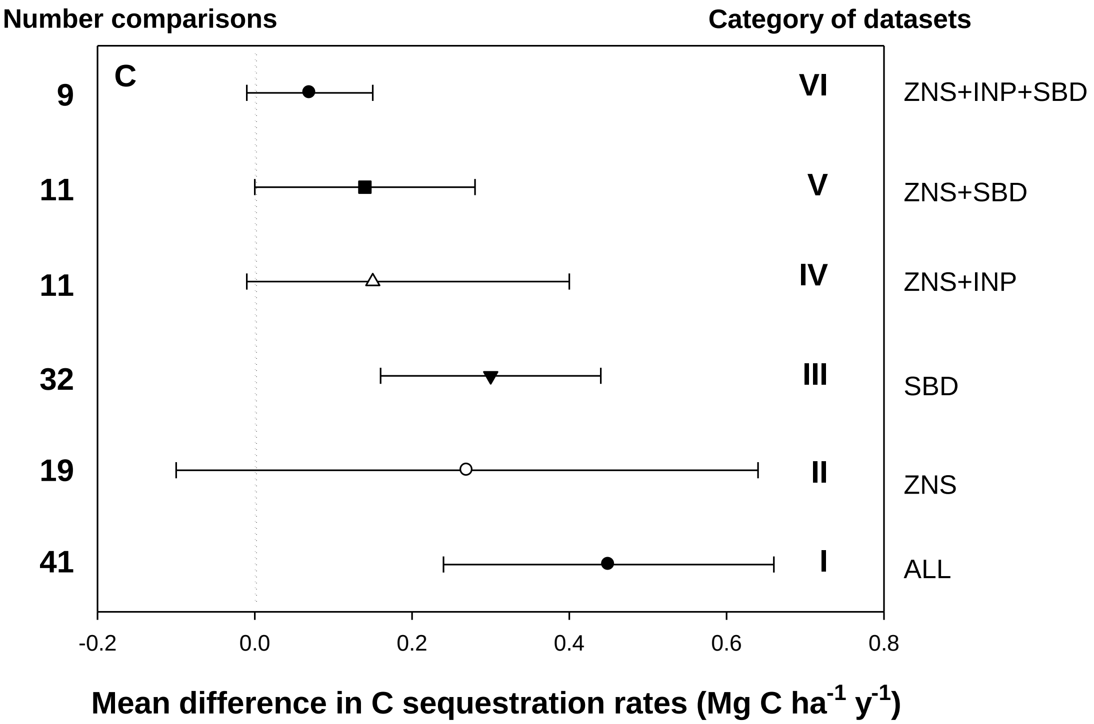
Based on meta-regression, no significant drivers could be identified, only tendencies:

- Management effects are stronger than site factors (temperature, precipitation, clay content in soil).
- Higher inputs of external C inputs (= organic fertiliser) in organic systems (1.20 vs. 0.29 Mg C ha^{-1} y^{-1})
- Higher frequency of cropping of deep rooting forage legume in organic systems.

↓

These are elements typical for mixed farming (integration of crop and livestock production) and in organic farming mixed farming systems are more frequent.

Is carbon sequestration possible within organic farming systems?



Yes, it is possible. Net sequestration of 450 kg C ha^{-1} y^{-1} (= 1.7 Mg CO$_2$ eq ha^{-1} y^{-1}) for all organic systems; the potential is lower for for zero net input systems (< 1.O ELU ha^{-1}): 70 – 270 kg C ha^{-1} y^{-1}.

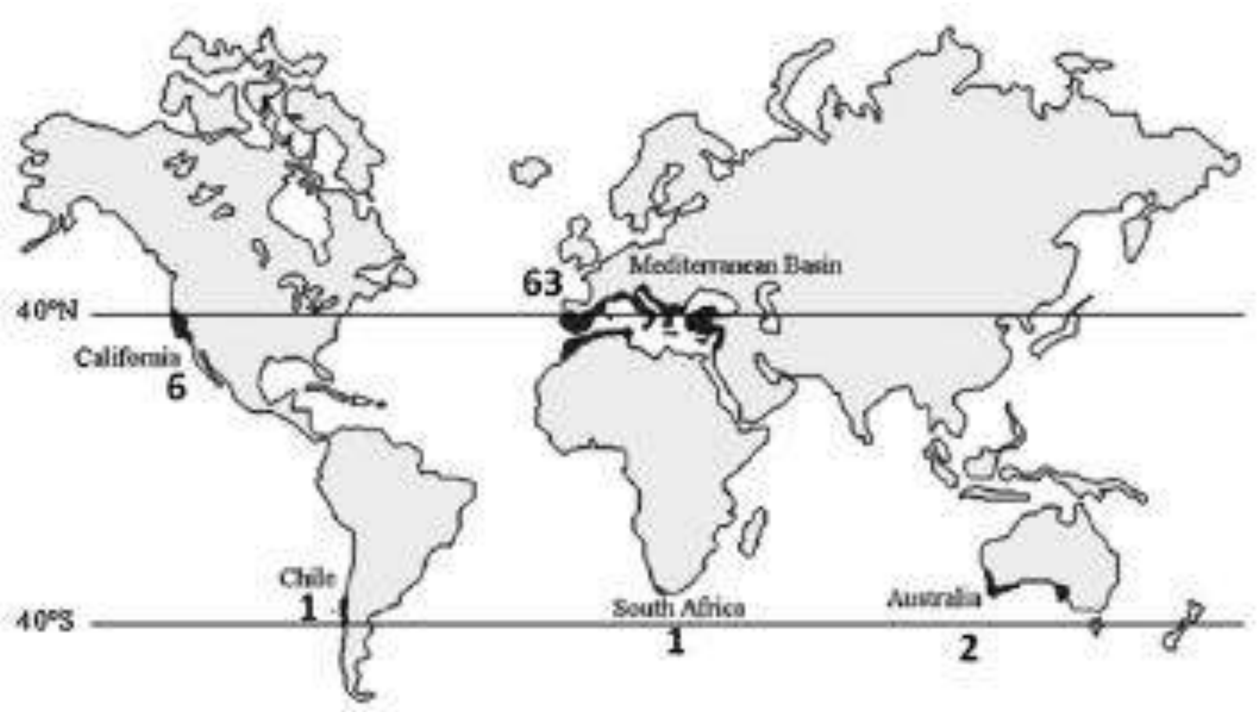
What does it mean in the wider context?

Switching to organic agriculture with a net C sequestration rate of 0.27 Mg C ha^{-1} y^{-}1 for net zero input systems…

- Would result in 0.37 Gt C sequestered per year globally (0.03 Gt C in Europe, 0.04 Gt C in the United States), thus offsetting 3% of current total GHG emissions (2.3% for Europe, 2.3% for the United States)
- Would offset 25% of total current agricultural emissions (23% for Europe, 36% for the United States), and equaling approximately 25% of the annual technical agricultural mitigation potential.
- The cumulative mitigation till 2030 would contribute 13% to the cumulative reductions that would be necessary until 2030 to stay on the path to reach the two degree goal by 2100 [56 Gt C globally from 2010 till 2030 according to the RCP2.6 scenario]

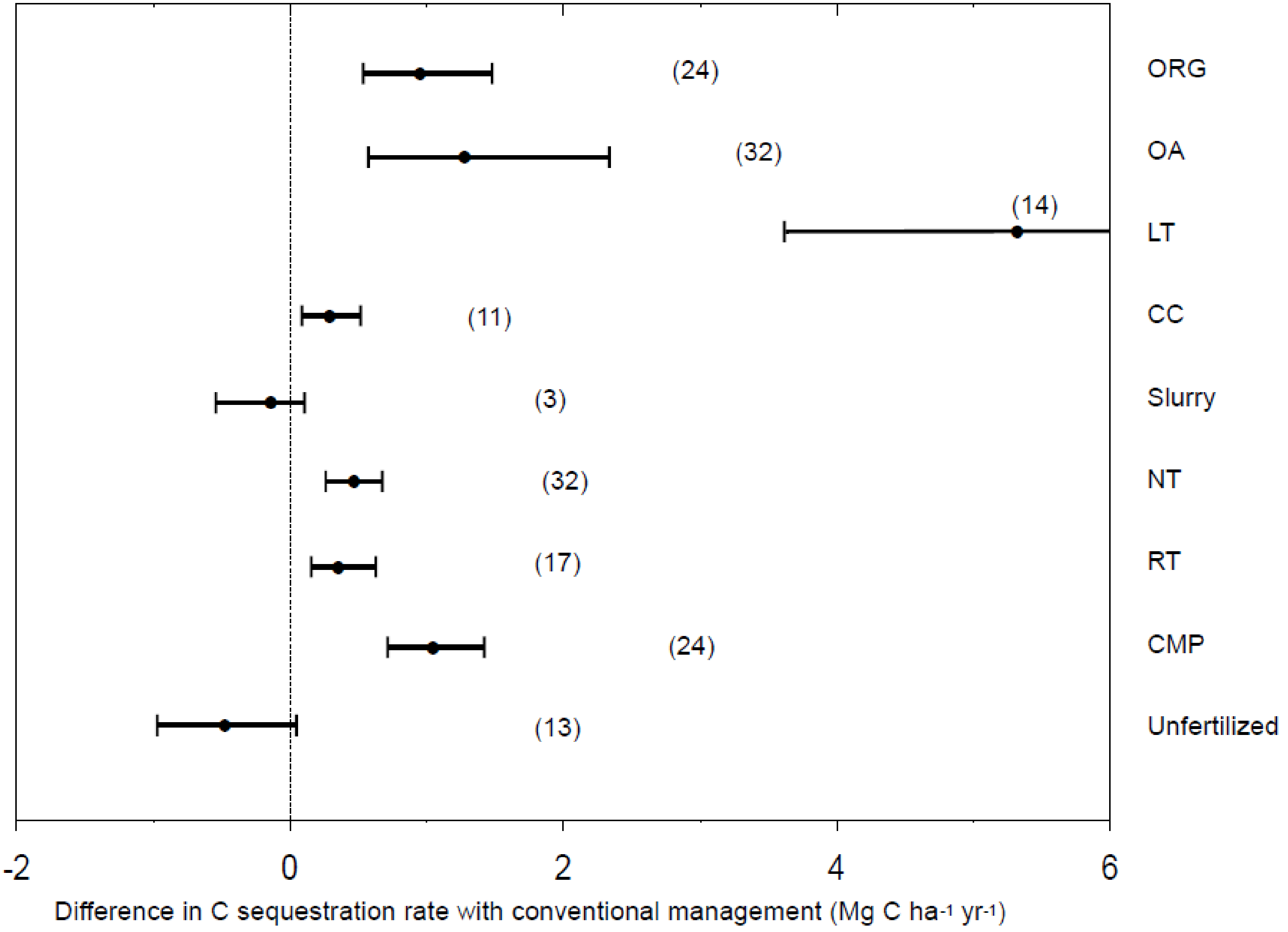
And under Mediterranean climate?

Areas with Mediterranean climate in the world and number of references selected for each area



Aguilera et al., AGEE, 2013

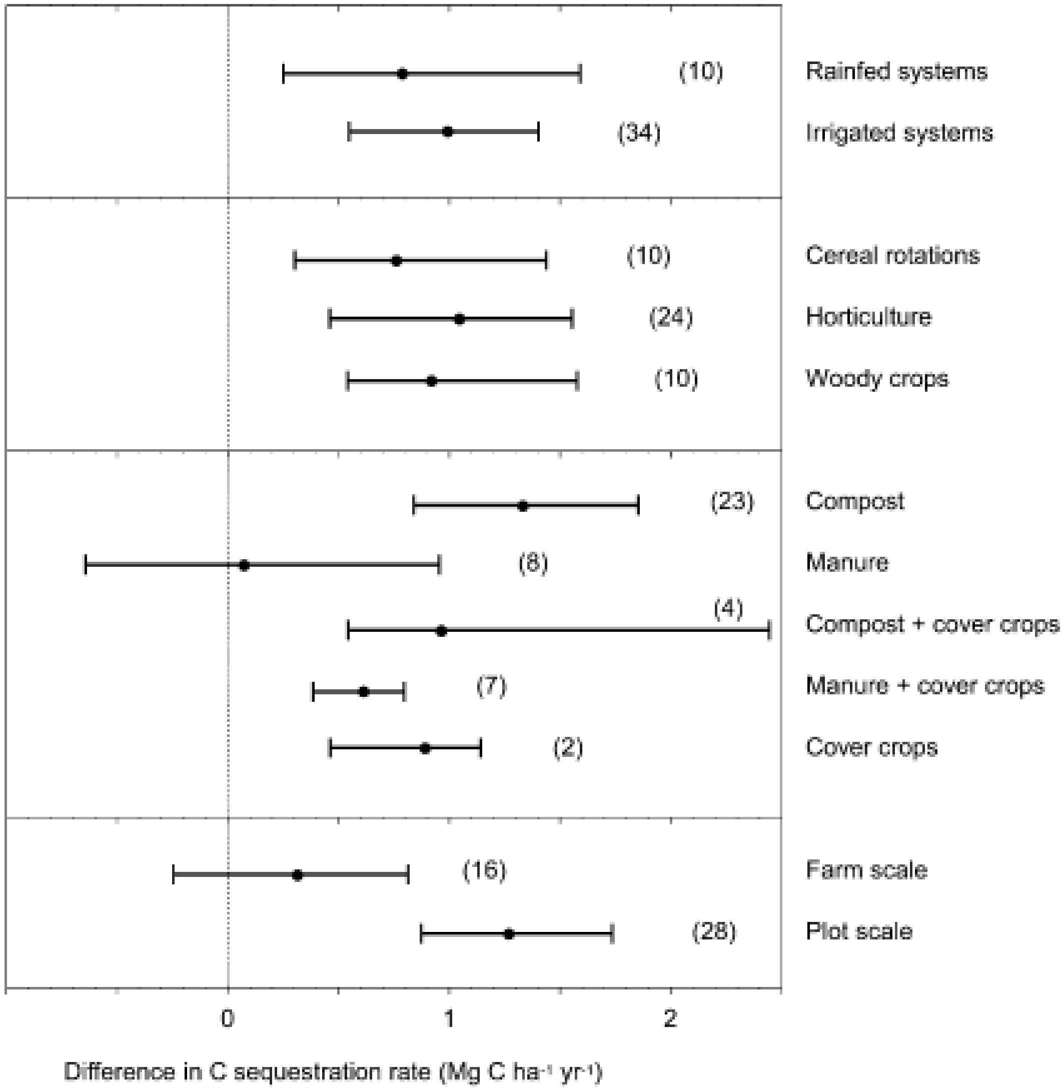
Pronounced C sequestration potential under ORG in Mediterranean soils



In ORG 0.97 Mg C ha^{-1} y^{-1} t (= 3.6 Mg CO_2 eq ha^{-1} y^{-1})

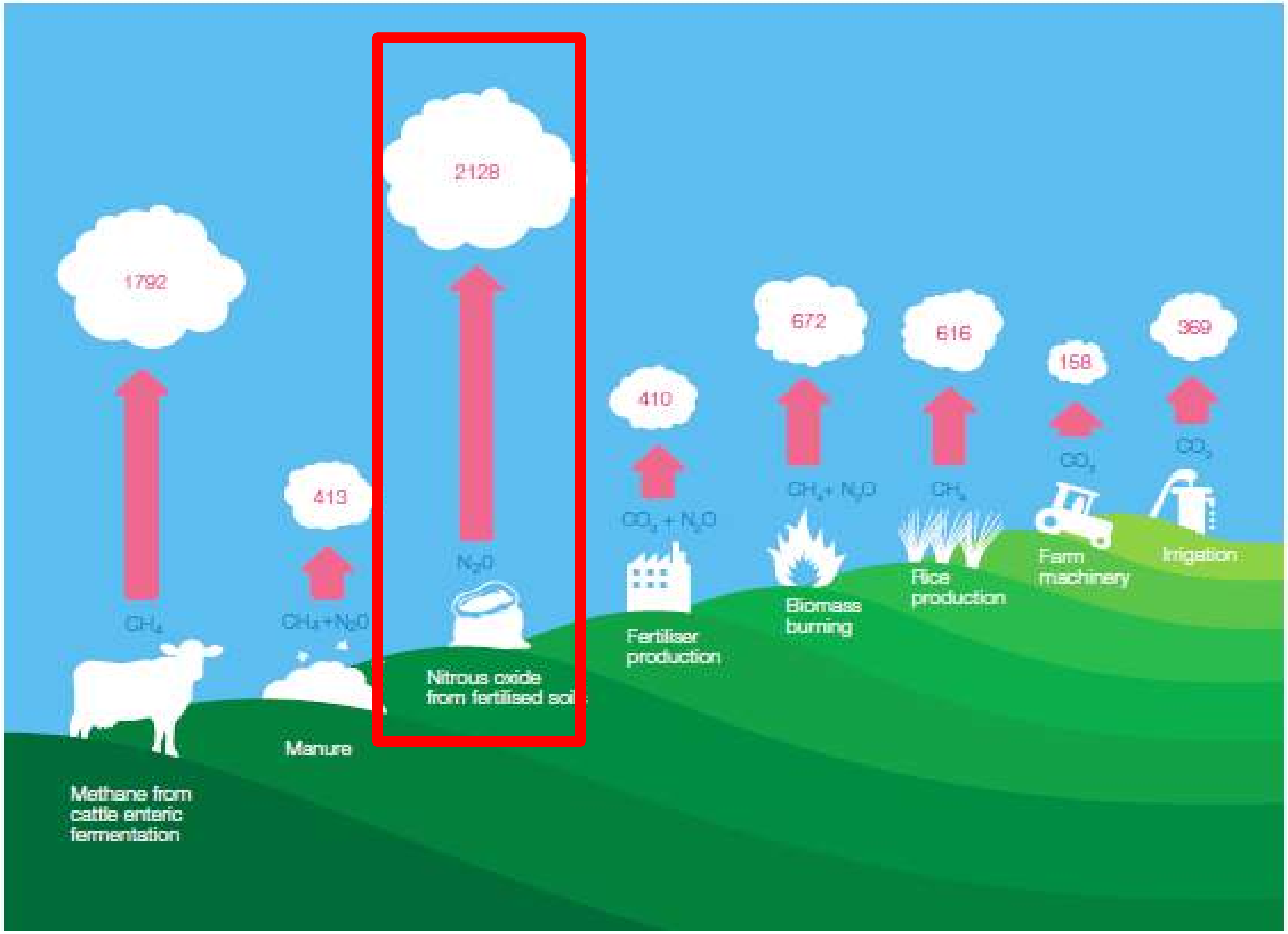
Aguilera et al., AGEE, 2013

Differences between ORG and CONV according to different treatments, crops, etc.



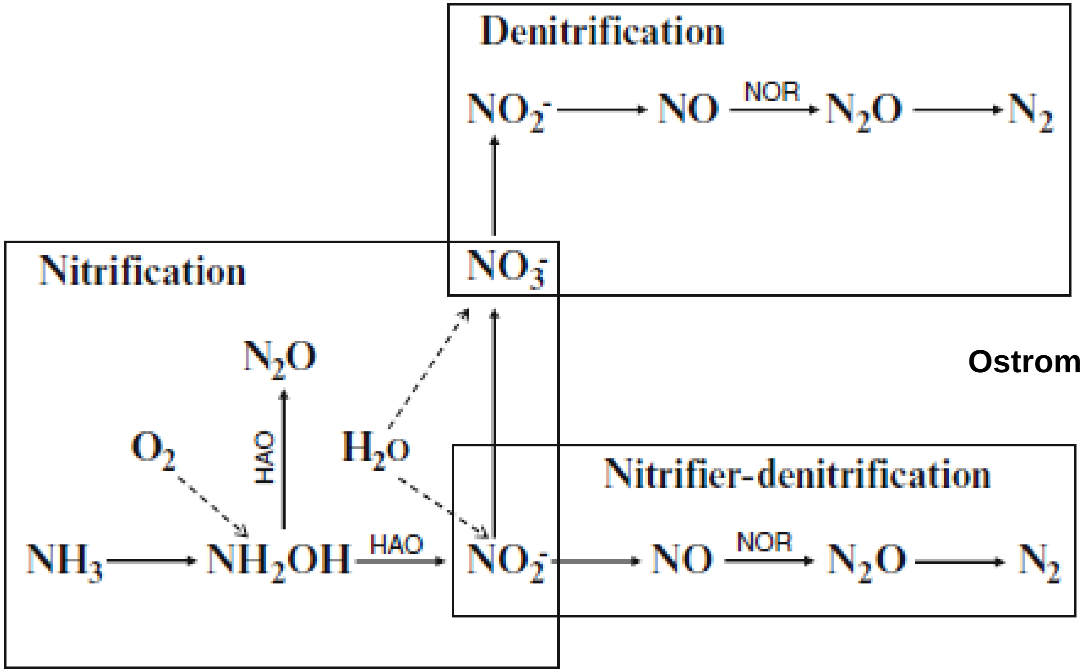
Aguilera et al., AGEE, 2013

N2O emissions from agricultural soils



Bellarby et al. 2008

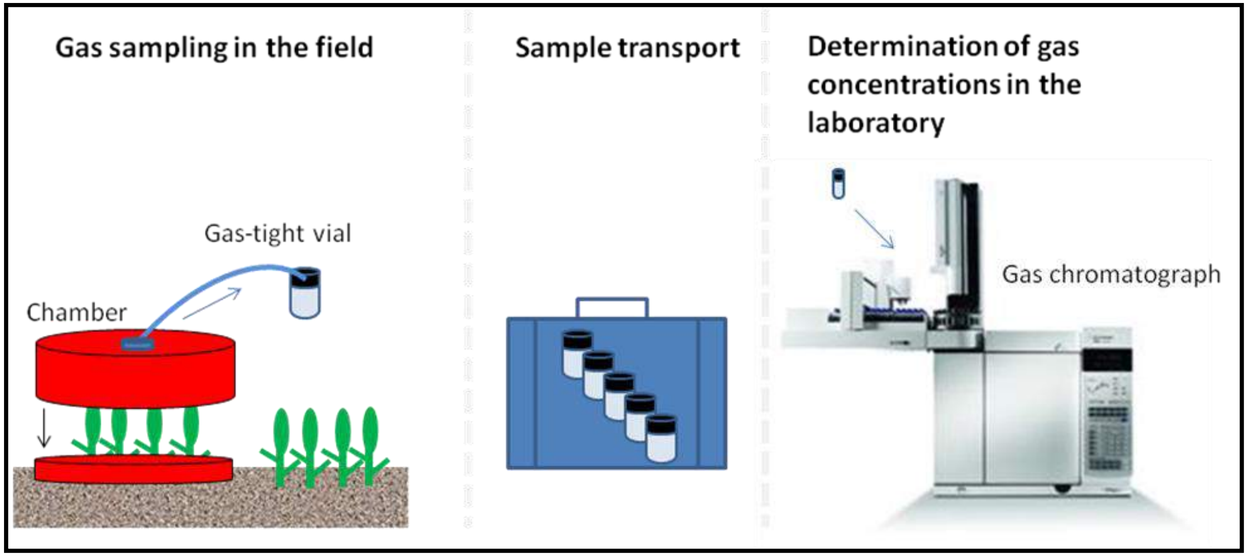
Microbial control of N_2O formation and reduction



Ostrom & Ostrom, 2011

Nitrification is the dominating source for N2O formation in
Well aerated soils water-filled pore space (WFPS) < 60%; denitrification is the dominating source for N2O formation in under anoxic conditions at 60-90% WFPS (Bateman and Baggs, 2005).

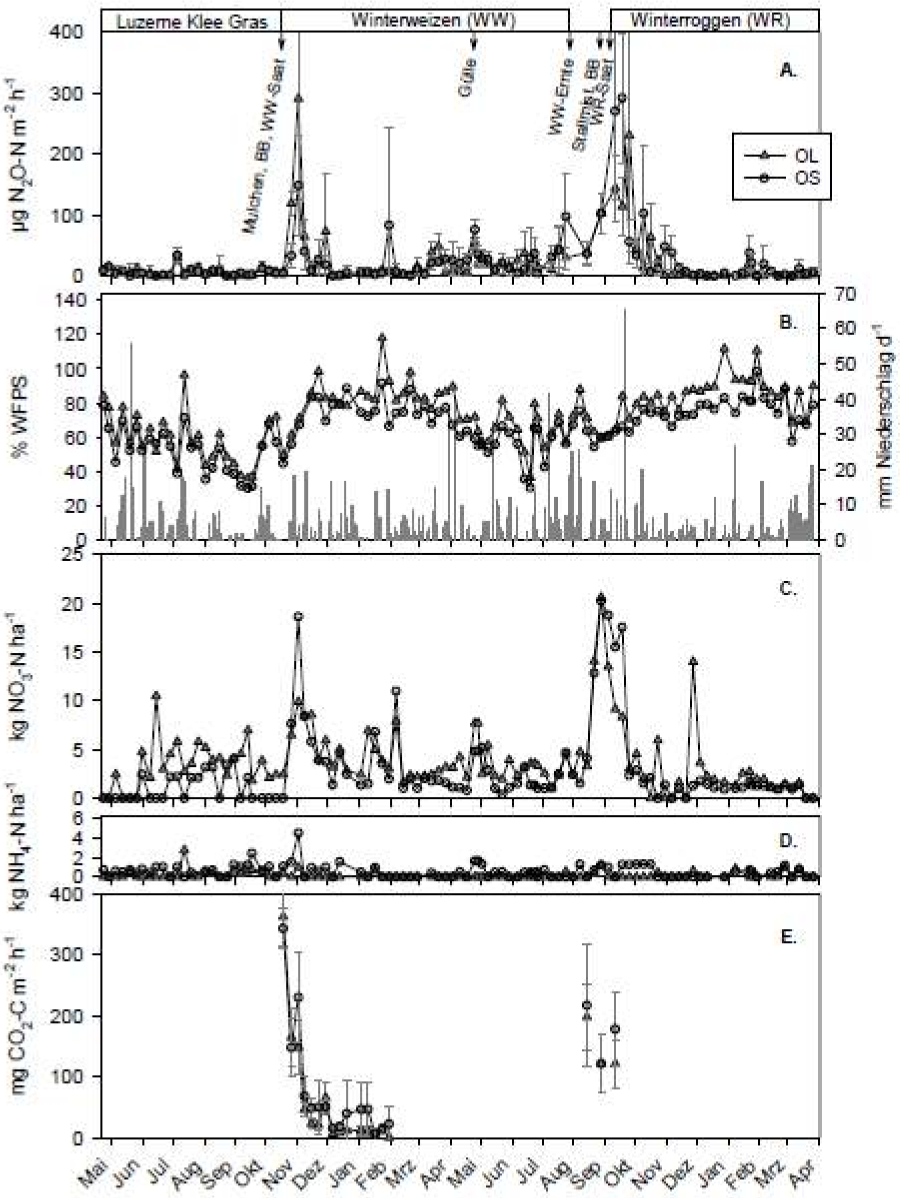
Determination of soil-derived N_2O fluxes


Gas sampling in the field

Sample transport

Determination of gas concentrations in the laboratory

Agricultural soils as source for N_2O (eg. Arable soil)



Sehy, 2003

N_2O emissions from soils

Proximal influencing factors (direct)

- Nitrate and ammonium availability
- Soil water <-> oxygen conten
- Carbon availability
- pH

N_2O emissions from soils

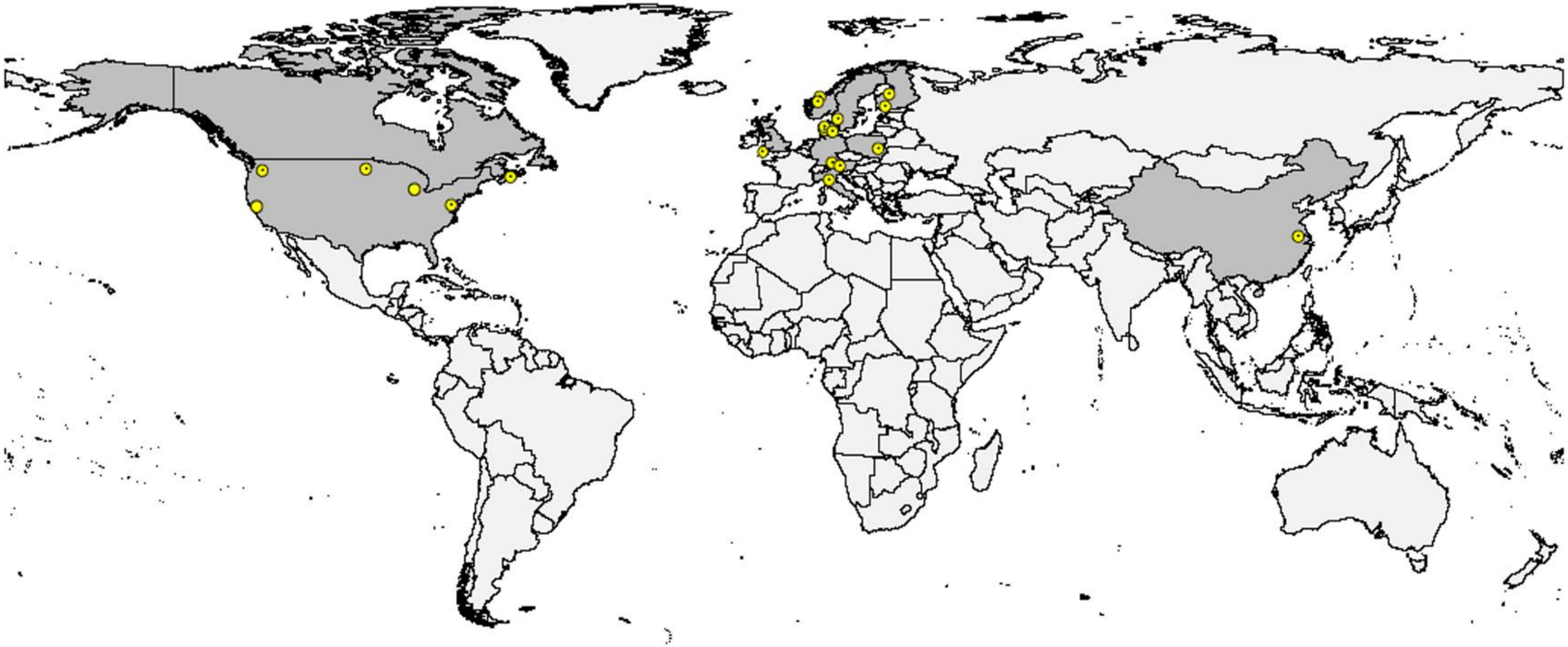
Distal controls (Indirect factors)

- **Climate:** Temperature and precipitation; freezing-thawing cycles
- **Soil:** Soil type; texture (e.g. clay content)
- **Bodenbewirtschaftung:** Fertilisation intensity and fertilisation type (1 kg N causes 0.3-3.0 kg N_2O-N/ha, IPCC); soil tillage; liming (inhibition of N_2O reduktion to N_2 at low pH)

GHG emissions and organic farming

- Nitrogen fixing legumes, green and organic manuring are key elements in organic crop rotation and bear the potential of N_2O losses when incorporated/applied to the soil.
- Easily available synthetic N fertiliser can be applied according to the plant nutrient status.
- But far more less (non easily availabe organic) N fertiliser are applied in organic farming.
- Hence GHG emission rates (esp. N_2O) are lower under OF practices?

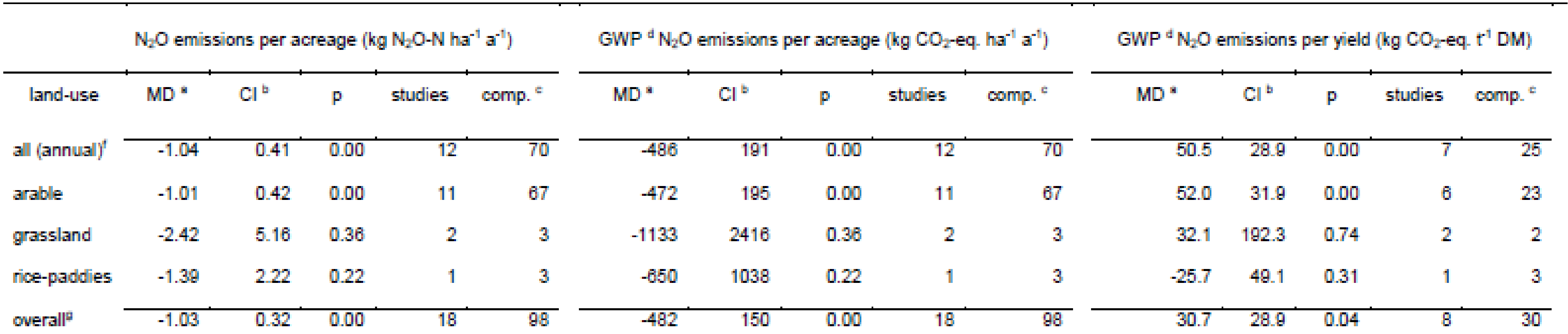
Meta study II: Soil-derived GHG fluxes (N_2O, CH_4) in soils under organic and non-organic management



18 studies globally with up to 98 paired comparisons

Skinner, Gattinger et al., STOTEN, submitted

Less N_2O from organically managed soils?



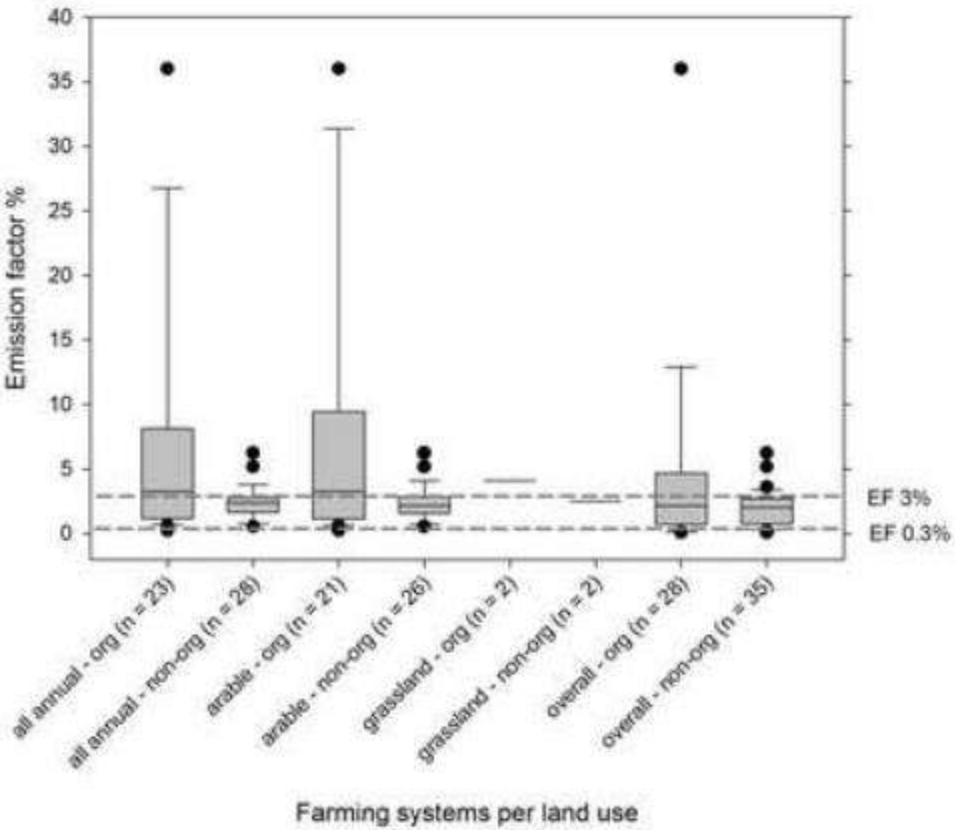
	N_2O emissions per acreage (kg N_2O-N ha^{-1} a^{-1})					GWP [d] N_2O emissions per acreage (kg CO_2-eq. ha^{-1} a^{-1})					GWP [d] N_2O emissions per yield (kg CO_2-eq. t^{-1} DM)				
land-use	MD [a]	CI [b]	p	studies	comp. [c]	MD [a]	CI [b]	p	studies	comp. [c]	MD [a]	CI [b]	p	studies	comp. [c]
all (annual)[f]	-1.04	0.41	0.00	12	70	-486	191	0.00	12	70	50.5	28.9	0.00	7	25
arable	-1.01	0.42	0.00	11	67	-472	195	0.00	11	67	52.0	31.9	0.00	6	23
grassland	-2.42	5.16	0.36	2	3	-1133	2416	0.36	2	3	32.1	192.3	0.74	2	2
rice-paddies	-1.39	2.22	0.22	1	3	-650	1038	0.22	1	3	-25.7	49.1	0.31	1	3
overall[g]	-1.03	0.32	0.00	18	98	-482	150	0.00	18	98	30.7	28.9	0.04	8	30

Related to area: ca. 0.5 t ha^{-1} yr^{-1} less CO_2 eq. in form of N_2O under organic management

Related to yield: ca. 0.05 t ha^{-1} yr^{-1} more CO_2 eq. in form of N_2O under organic management

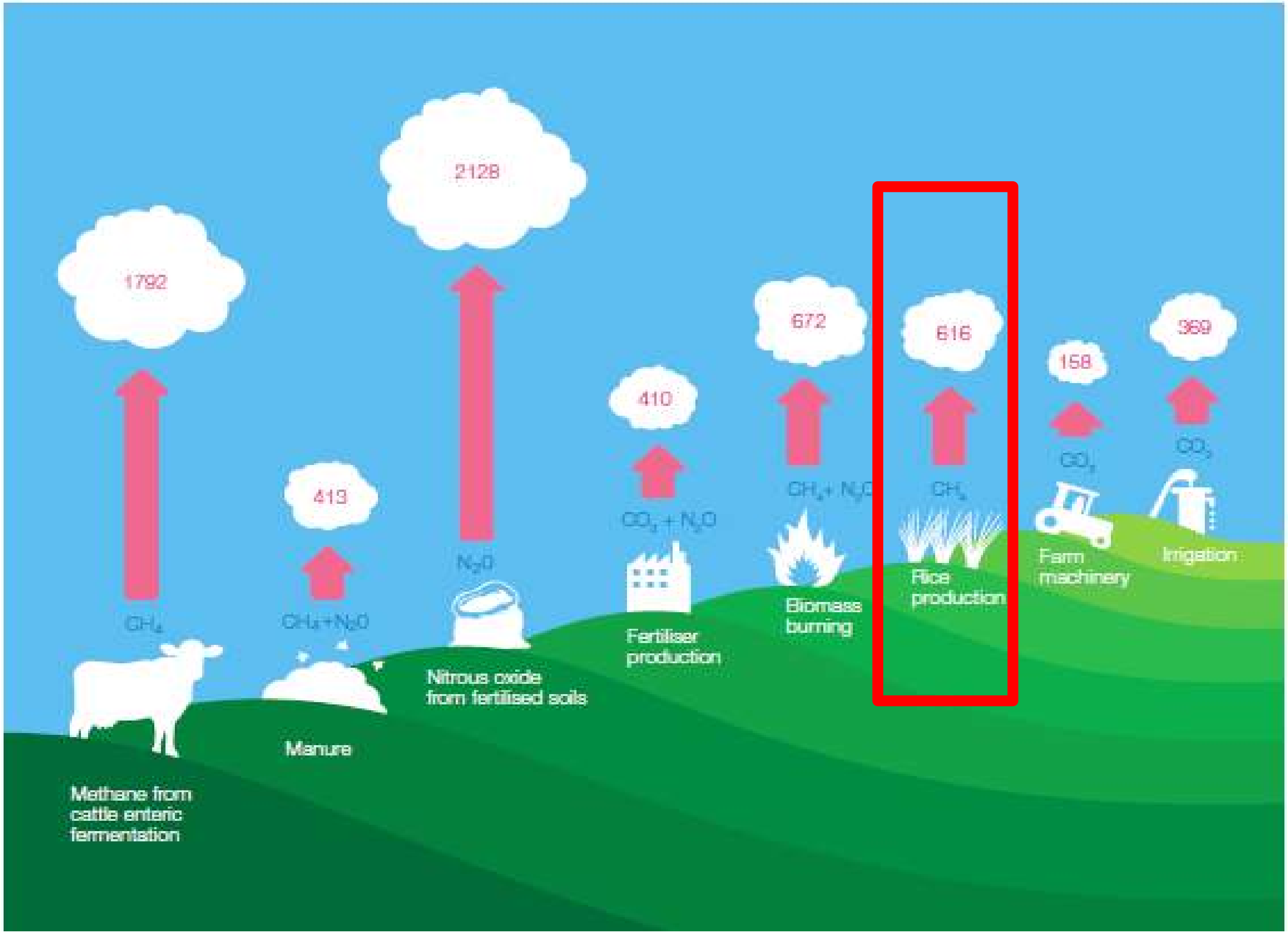
Skinner, Gattinger et al., STOTEN, submitted

N_2O (N-Input/N_2O-N) emission factors under organic and non-organic



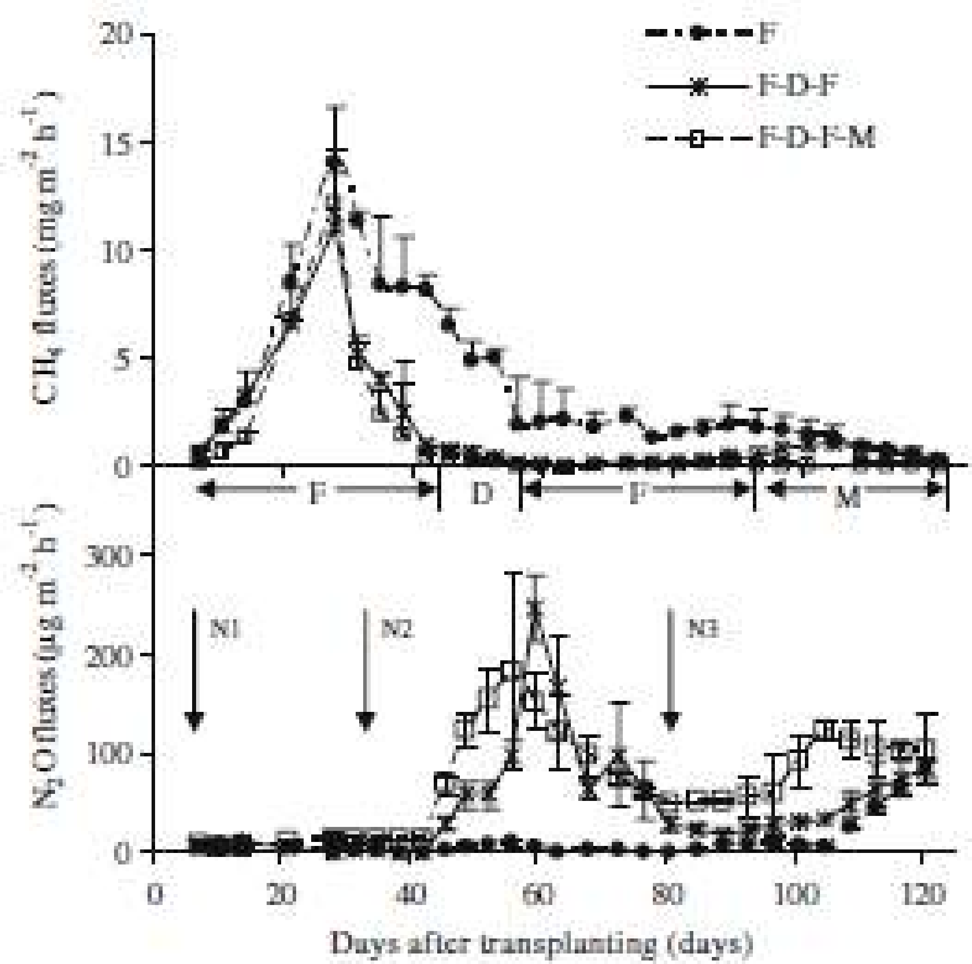
N_2O emission factors show large uncertaintities for organic systems; annual measurements or even throuhgout the entire crop rotation are required.

Agricultural greenhouse gases (without LULUCF)



Bellarby et al. 2008

Paddy rice (= wetland) soils as a source for methane



Qin et al., 2010