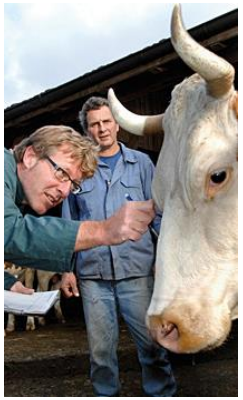
FiBL
EXCELLENCE FOR SUSTAINABILITY

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








# The climate relevance of organic farming systems – what do we know?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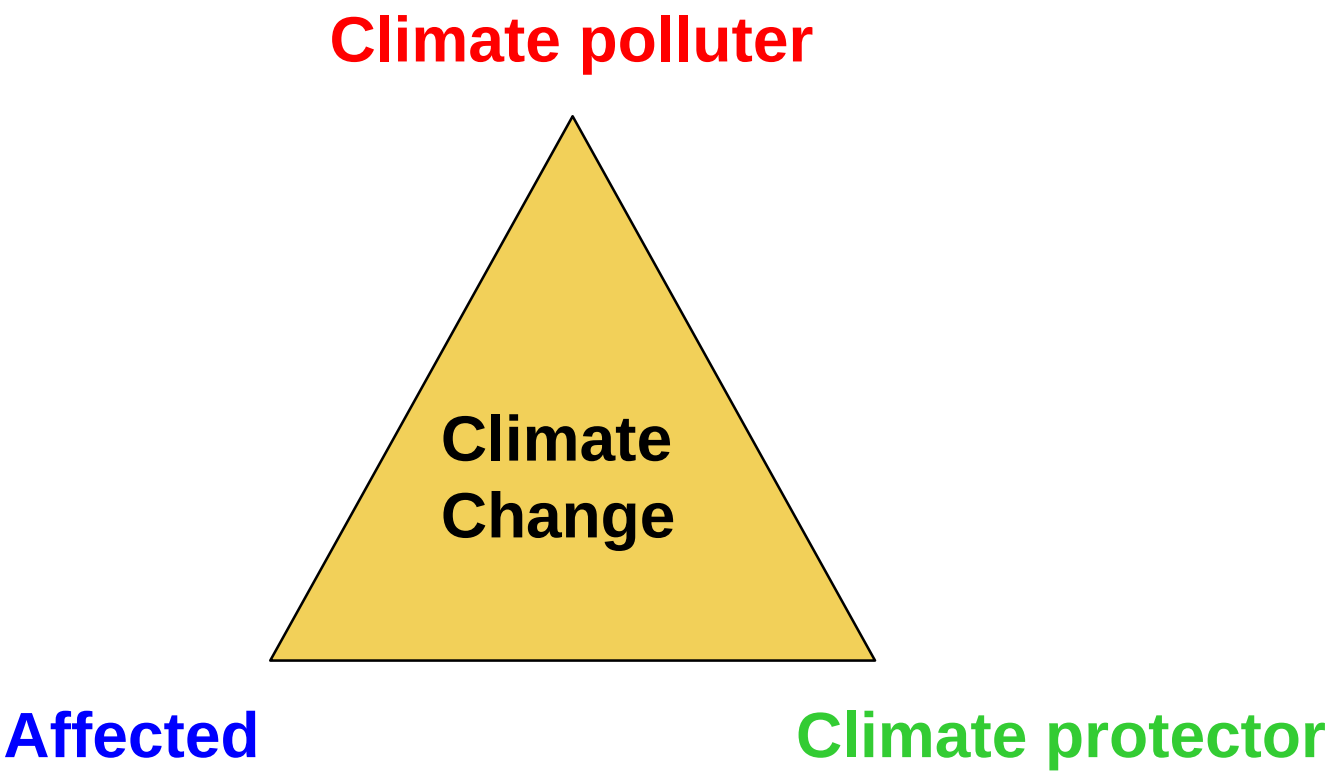
Round Table on Organic Agriculture and Climate Change

# The manifold role of agriculture regarding climate change



# **Organic Farming and Climate Change at FiBL** Focus: Emission reduction

**Information/Dissemination:**
**Bio-Sektor, Verbände, Betriebe**

**Scientific Basis:**
**- Feldmessungen**
**- Reviews/Meta-Analysen**
**- Prozessmodellierungen**
**- Betriebserhebungen**

→

**Process and system knowledge, Climate balance**

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**Implementation:**
**- Klima-Betriebsmodell**
**- SMART**
**- carbon-offset Methodologien**
**- politische Fördermassnahmen**

# Contents

- More soil carbon in soils under organic management?
- Less GHG emissions from soils under organic management?
- GHG mitigation of organic crop production at global scale?

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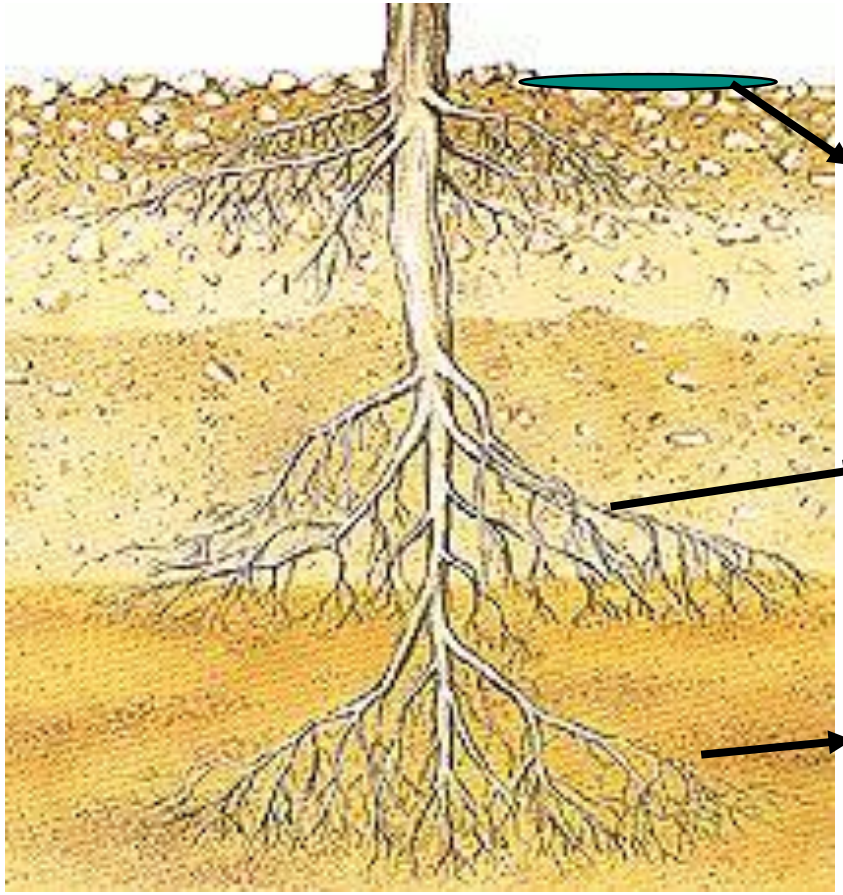
# The concept of C sequestration in soil

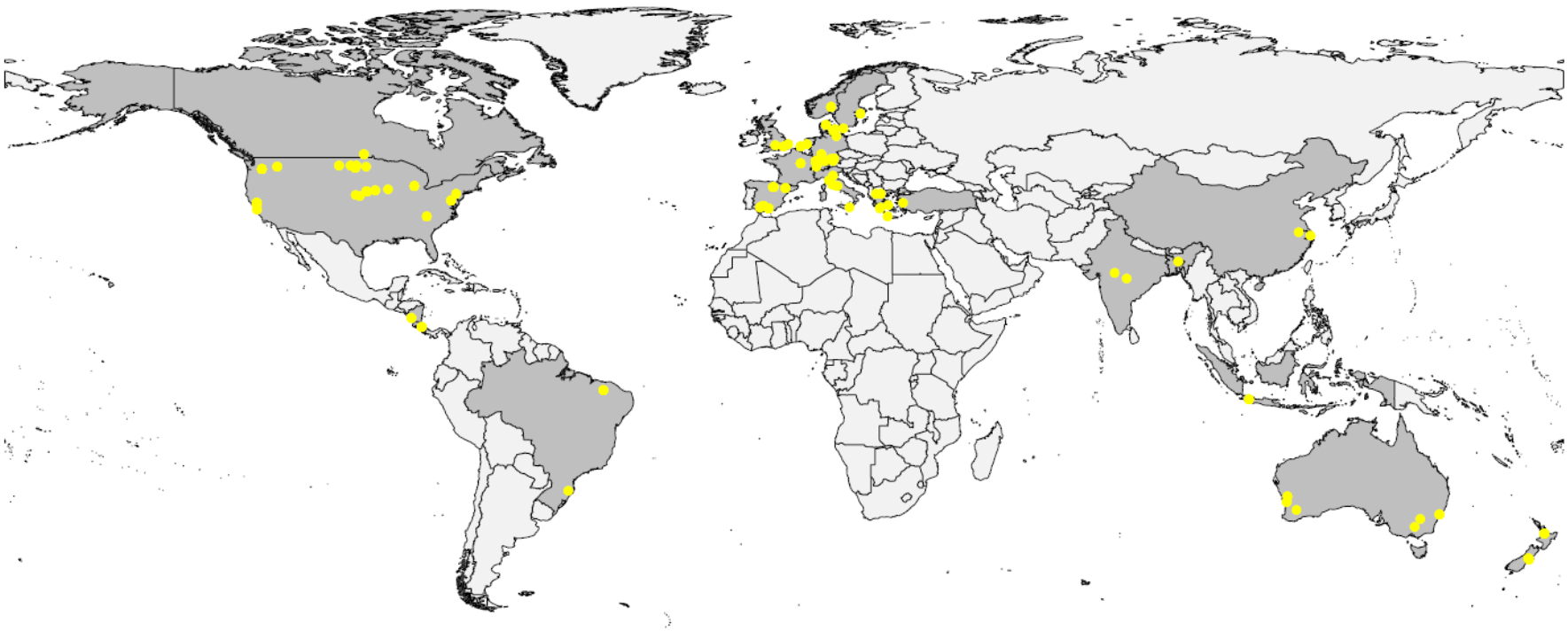
$CO_2$ –fixation via photosynthesis



Transformation into soil organic matter (Humus formation)

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

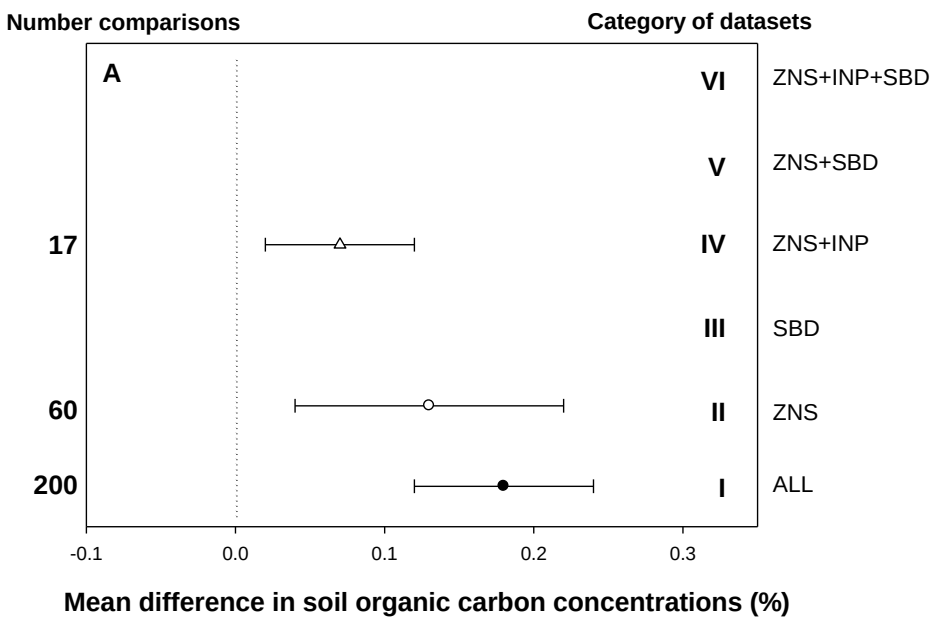
## Geographic distribution of the system comparisons for meta-analysis

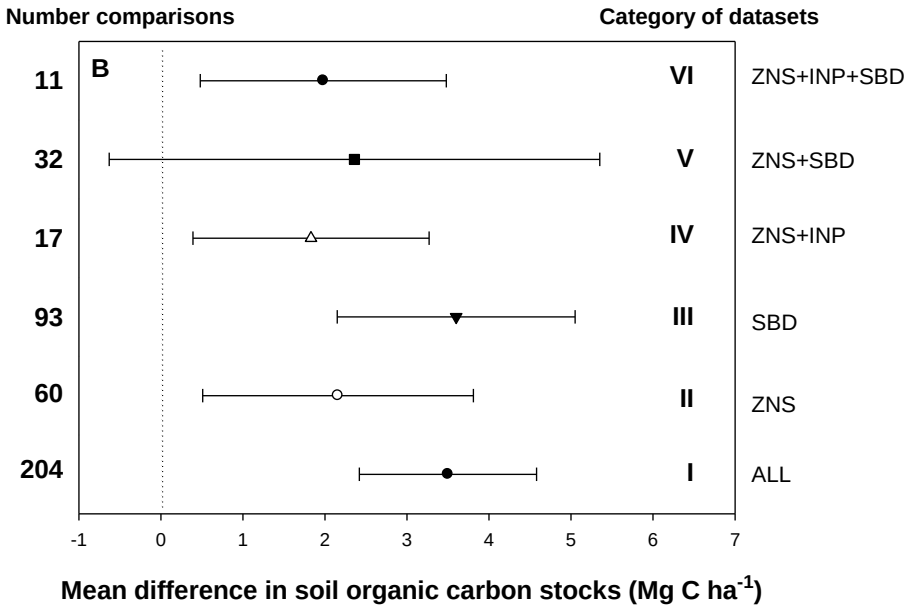


74 studies globally with up to 211 paired comparisons

Gattinger et al., PNAS, 2012

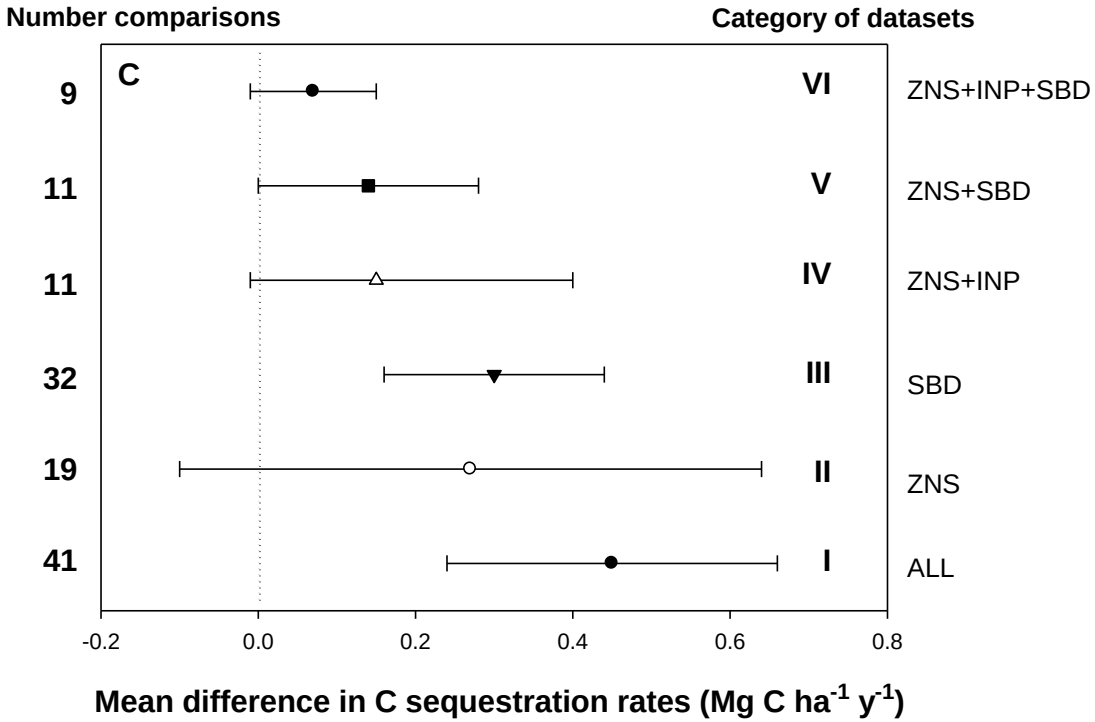
# More carbon in organically managed soils?




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

# 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 $ha^{-1}$ $y^{-1}$.**

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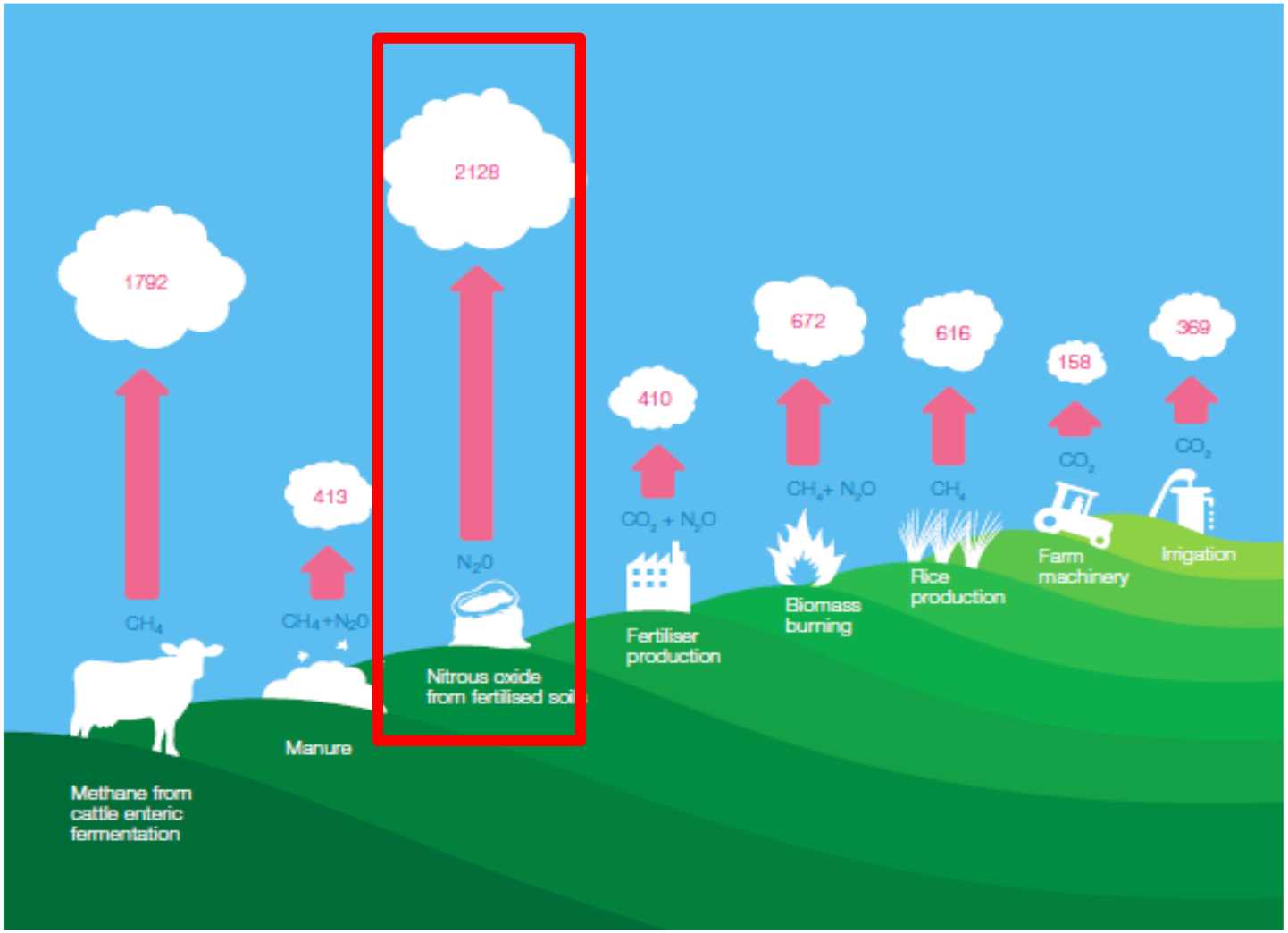
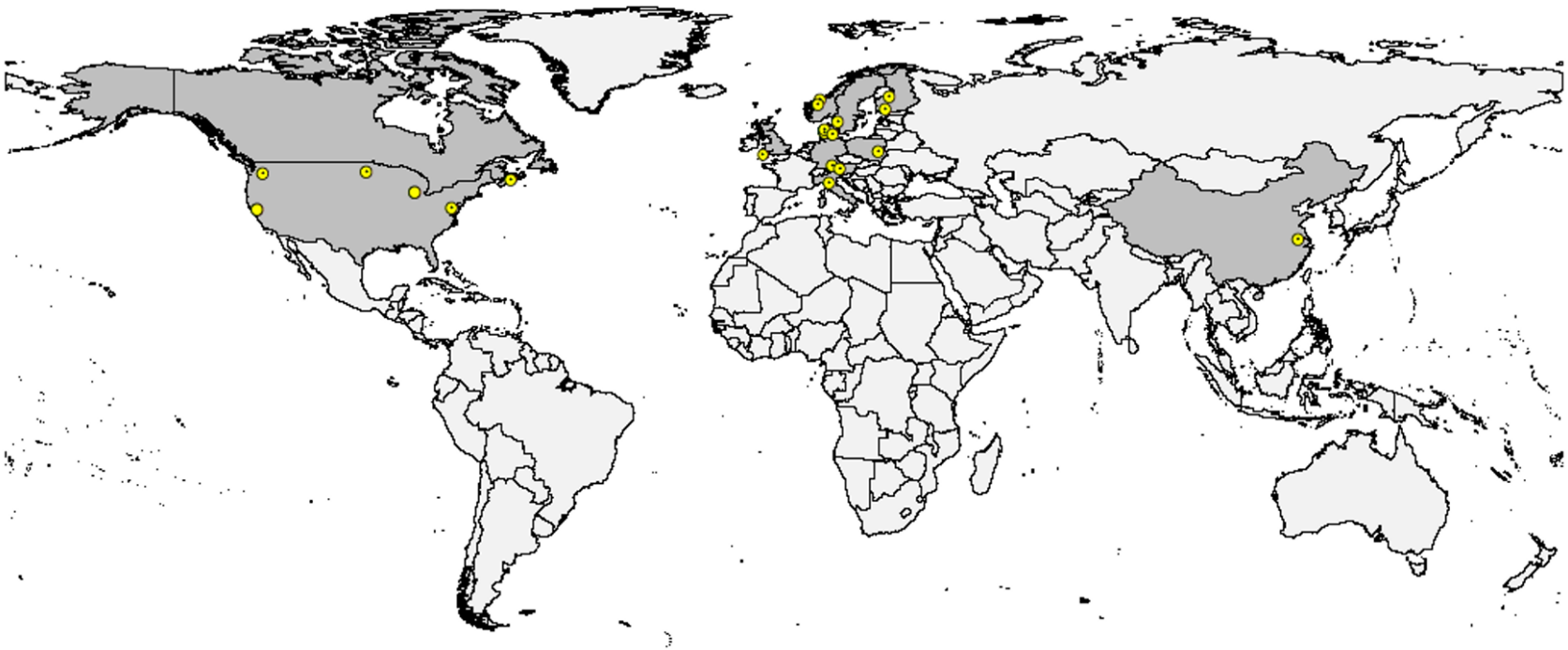
# N2O emissions from agricultural soils






Bellarby et al. 2008

# 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, 2014

# Less $N_2O$ from organically manaded soils?

| Land-use | Area-scaled $N_2O$ emissions ($kg\ N_2O\text{–}N\ ha^{-1}\ a^{-1}$) | | | | | Area-scaled GWP [d] $N_2O$ emissions ($kg\ CO_2\text{-eq.}\ ha^{-1}\ a^{-1}$) | | | | | Yield-scaled GWP [d] $N_2O$ emissions ($kg\ CO_2\text{-eq.}\ t^{-1}$ DM) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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] | −1.05 | 0.34 | 0.00 | 12 | 70 | −492 | 160 | 0.00 | 12 | 70 | 42.4 | 33.1 | 0.01 | 7 | 25 |
| Arable | −1.06 | 0.35 | 0.00 | 11 | 67 | −497 | 162 | 0.00 | 11 | 67 | 41.1 | 34.2 | 0.02 | 6 | 23 |
| Grassland | −2.33 | 5.40 | 0.40 | 2 | 3 | −1091 | 2531 | 0.40 | 2 | 3 | 45.6 | 190.3 | 0.64 | 2 | 2 |
| Rice-paddies | −1.38 | 2.22 | 0.22 | 1 | 3 | −646 | 1040 | 0.22 | 1 | 3 | −25.4 | 49.2 | 0.31 | 1 | 3 |
| Overall[g] | −0.93 | 0.25 | 0.00 | 18 | 98 | −434 | 118 | 0.00 | 18 | 98 | 30.7 | 28.9 | 0.08 | 8 | 30 |

[a] MD, Mean Difference under organic treatments; negative values mean less emissions compared to non-organic treatment.
[b] ±95%confidence interval (CI).
[c] Comparisons.
[d] Greenhouse Warming Potential (GWP).
[e] EF: Emission factor; total inputs: external inputs plus those from within the field e.g. N fixation and plant residues.
[f] All annual measurements excl. rice (arable & grassland).
[g] All landuse types excl. rice; annual and short time measurements.
[h] No data available for respective land-use type.

**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, 2014

# Less $CH_4$ from organically manaded soils?

| | Area-scaled $CH_4$ fluxes (kg $CH_4$–C $ha^{-1}$ $a^{-1}$) | | | | | Area-scaled $CH_4$ fluxes (kg $CO_2$–eq. $ha^{-1}$ $a^{-1}$) [f] | | | | | Yield-scaled $CH_4$ fluxes (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] |
| Arable | −0.10 | 0.15 | 0.01 | 3 | 8 | −3.2 | 2.5 | 0.01 | 3 | 8 | −2.10 | 2.33 | 0.08 | 2 | 5 |
| Rice-paddies | 9.37 | 8.19 | 0.00 | 1 | 3 | 950 | 415 | 0.00 | 1 | 3 | 128.3 | 26.1 | 0.00 | 1 | 3 |

[a] MD Mean Difference under organic treatments; negative values mean (higher) uptake, positive (higher) emissions compared to non-organic treatment.
[b] ±95%confidence interval (CI).
[c] Comparisons.

**Only a few studies: in arable soils increased CH4 uptake under organic, but in riced paddies highest CH4 emission under organic management**

Skinner, Gattinger et al., STOTEN, 2014

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# What is most effective in GHG mitigation in crop production?

## A few thoughts….

- **Conversion from wetland to upland rice production** (saving of 4.0 Mg $CO_2$ eq $ha^{-1}$ $y^{-1}$ ; Skinner et al. 2014)
- **Restoration of farmed organic soils (**saving of 10.0 Mg $CO_2$ eq $ha^{-1}$ $y^{-1}$; Freibauer et al., 2004), *restricted agricultural utilisation*
- **C sequestration by conversion to OF (**saving of 1.7 Mg $CO_2$ eq $ha^{-1}$ $y^{-1}$; Gattinger et al., 2012), *not permanent, less yield*
- **C sequestration by adoption of reduced tillage (**saving of up to 1.0 Mg $CO_2$ eq $ha^{-1}$ $y^{-1}$) *not permanent*
- **$N_2O$ mitigation by conversion to OF (**saving of 0.5 Mg $CO_2$ eq $ha^{-1}$ $y^{-1}$; Gattinger et al., 2012), *less yield*
- **$N_2O$ mitigation by site-specific fertilisation (**saving of up to 30%; Sehy et al., 2003)
- **C seq. + $N_2O$ + $CH_4$ mitigation by converting to OF: no rice-paddies + reduced tillage + site-specific fertilisation + biochar…?**

# Thank you very much for your attention!

**Further infos:**
**http://www.fibl.org/de/themen/klima.html**
**http://www.fibl.org/de/themen/nachhaltigkeit.html**
**http://www.organicandclimate.org**