Wetlands of glacial drift areas as hot spots for greenhouse gases with continental importance – the case study CH_4

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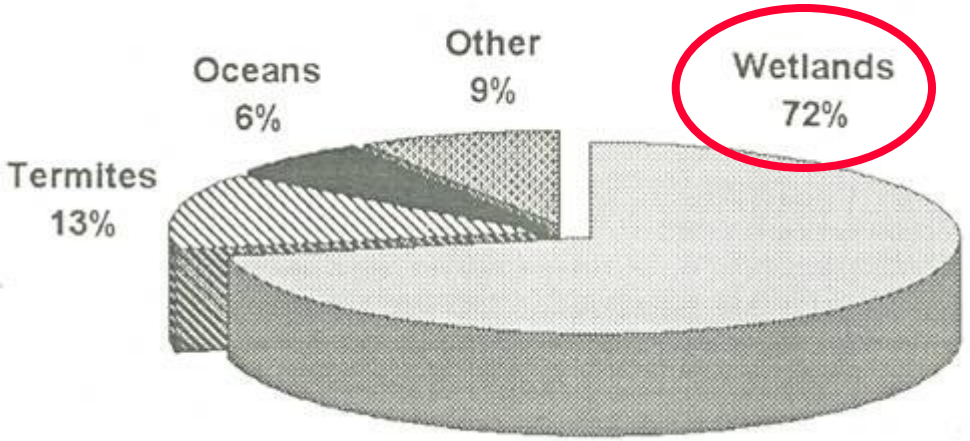
W3M, 24 September 2005

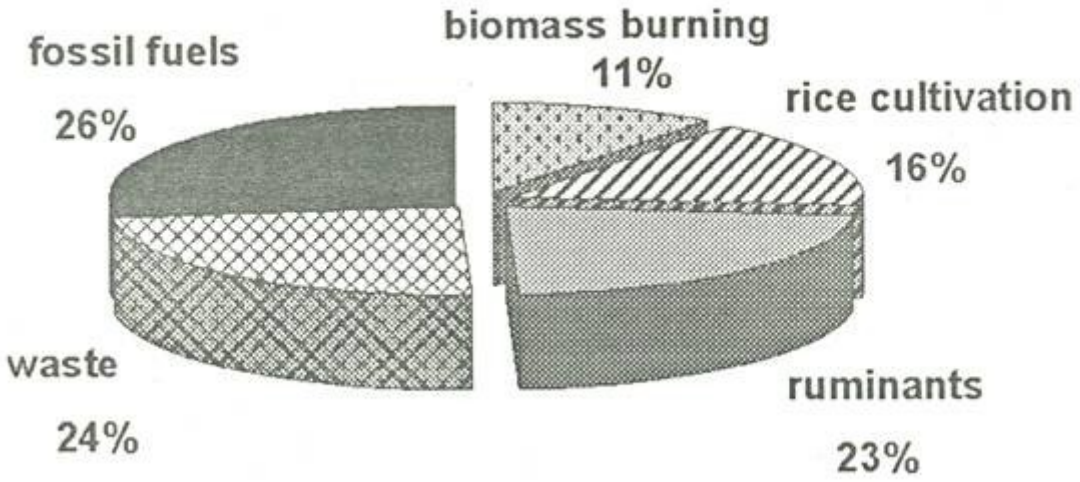
Global CH_4 Budget

sources

natural: 160 Tg yr^{-1}

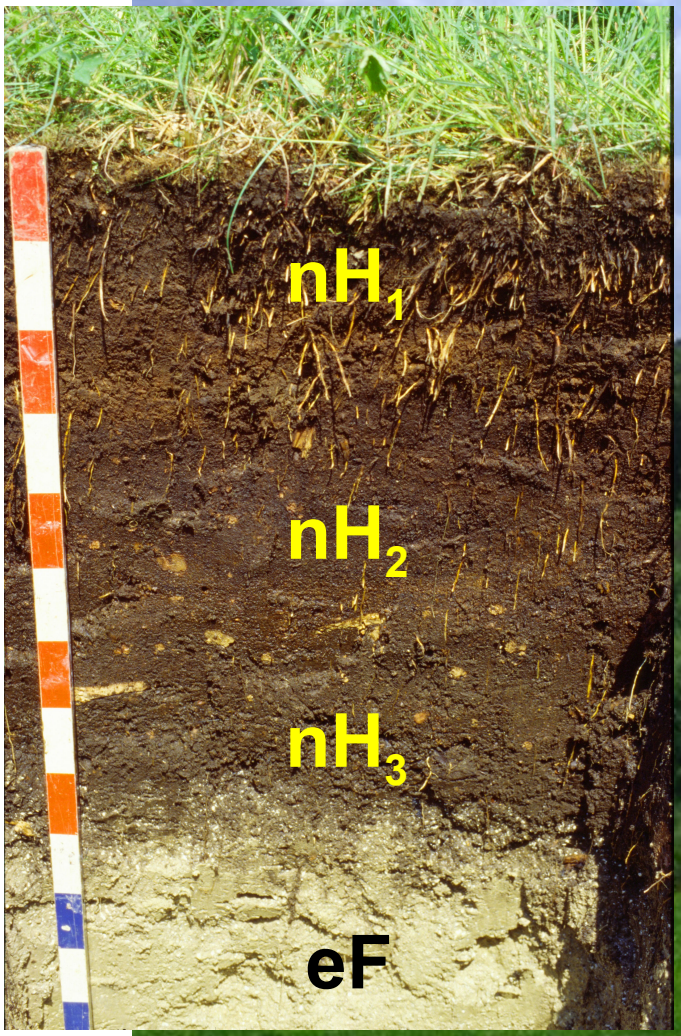


anthropogenic: 375 Tg yr^{-1}



IPCC, 2001

Natural Sources – organic wetlands



sources incomplete

- mineral wetlands
- anthropogenic influence (land use)

unit area emissions:

5 - 15 g CH_4 m^{-2} yr^{-1}

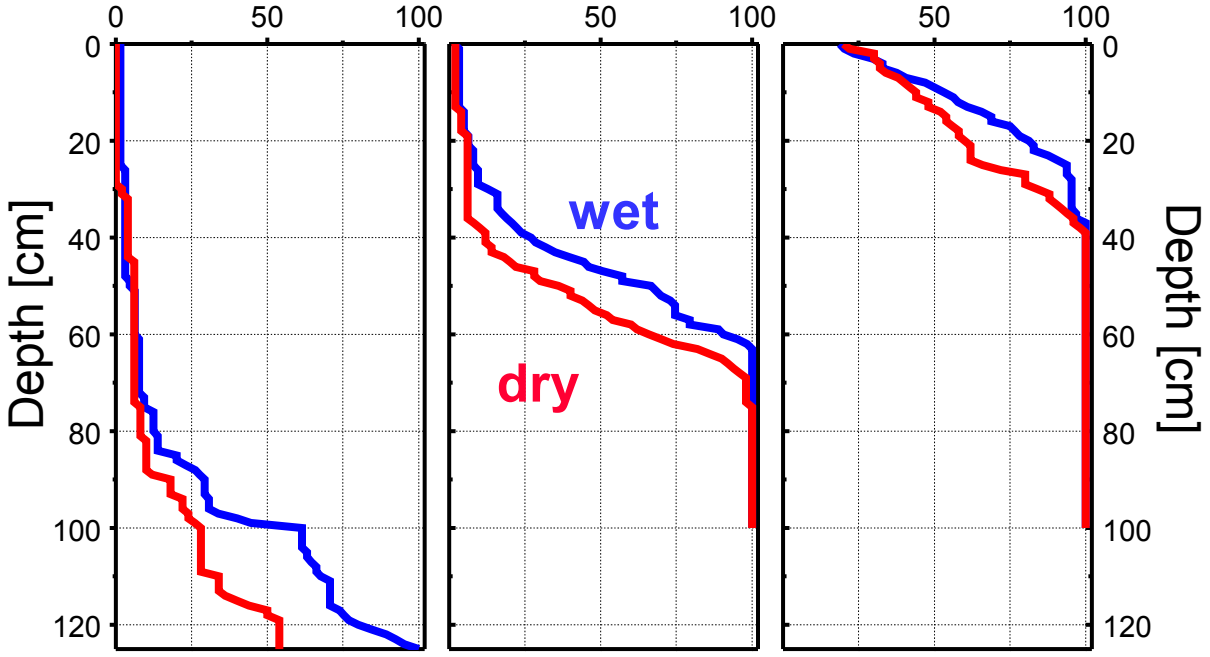
Generalized upscaling procedure

1. **Identifying source areas / source strength**
   (wetland identification, unit area emissions x acreages)
2. **Process analysis → drivers ?**
3. **Regionalisation of drivers**
   (GIS-based modelling, structural analysis)

Mineral wetland soils in hummocky moraines

wetness / redox gradient

% of time water saturation per year

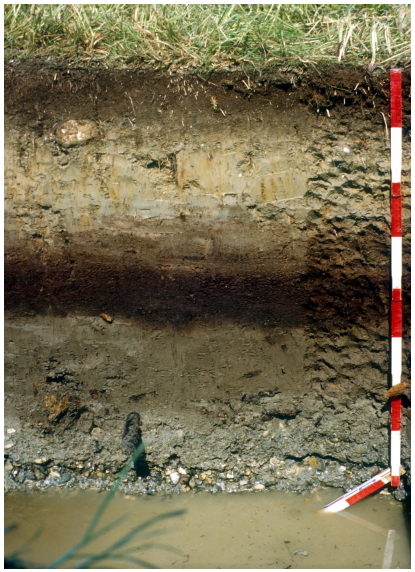


Fiedler & Sommer
Global Biogeochemical Cycles (2000)

Methane fluxes from wetlands

[g CH_4 m^{-2} yr^{-1}]

0.6 **1.1** **58.5 !** **12.4**

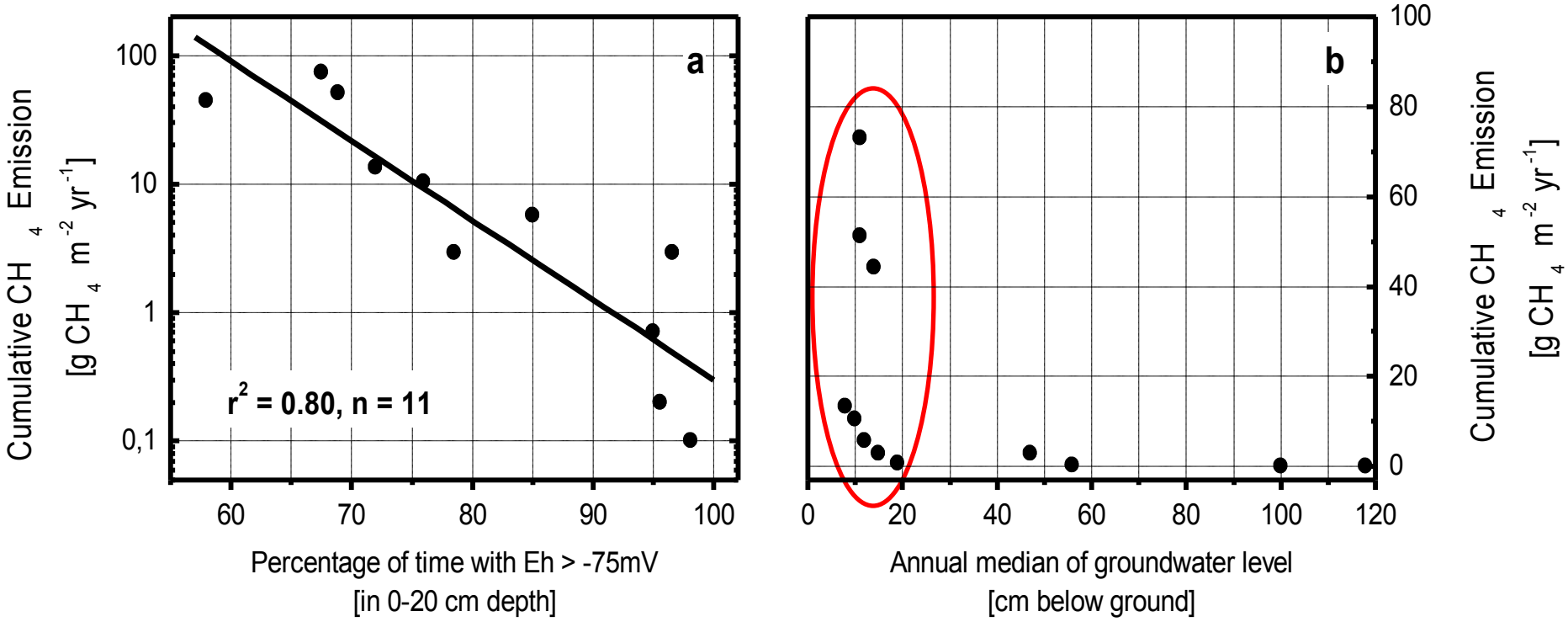



mineral wetland soils **organic**

Fiedler & Sommer, Global Biogeochemical Cycles (2000)

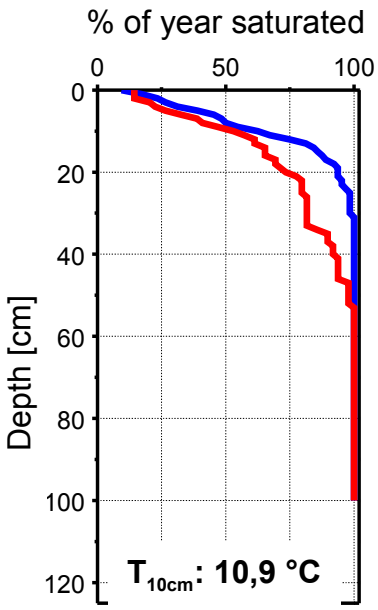
Drivers for methane emissions from wetland soils

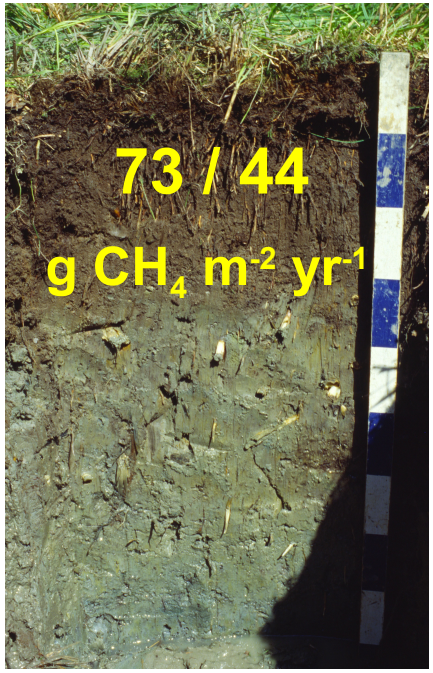
High groundwater level = necessary precondition

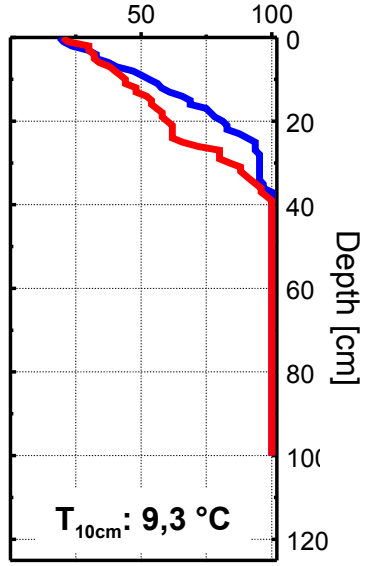


Fiedler & Sommer, Global Biogeochemical Cycles (2000)

Further drivers ?







Archaea [10^3 m^{-3}]	**17 - 18**	**9 - 14**
DM [g m^{-2}]	**750 ± 204, C/N = 25**	**269 ± 18, C/N = 27**
C/N [0-20 cm]	**17**	**11**
C_{min} [µg C cm^{-3} 42 d^{-1}]	**65**	**257**
DOC [µg C cm^{-3}]	**25**	**117**
C_{micro} [g m^{-2}]	**18 ± 6**	**30 ± 16**

soil humus quality !

Fiedler & Sommer, Global Biogeochemical Cycles 2000; Wachinger et al., Soil Biology & Biochemistry 2001

Drivers of soil humus quality ? → Landscape

soil pattern → strong link to geomorphic processes / units

soil humus quality not developed in-situ !

hot spots !

13 - 34 g C_{org} m^{-2} yr^{-1}

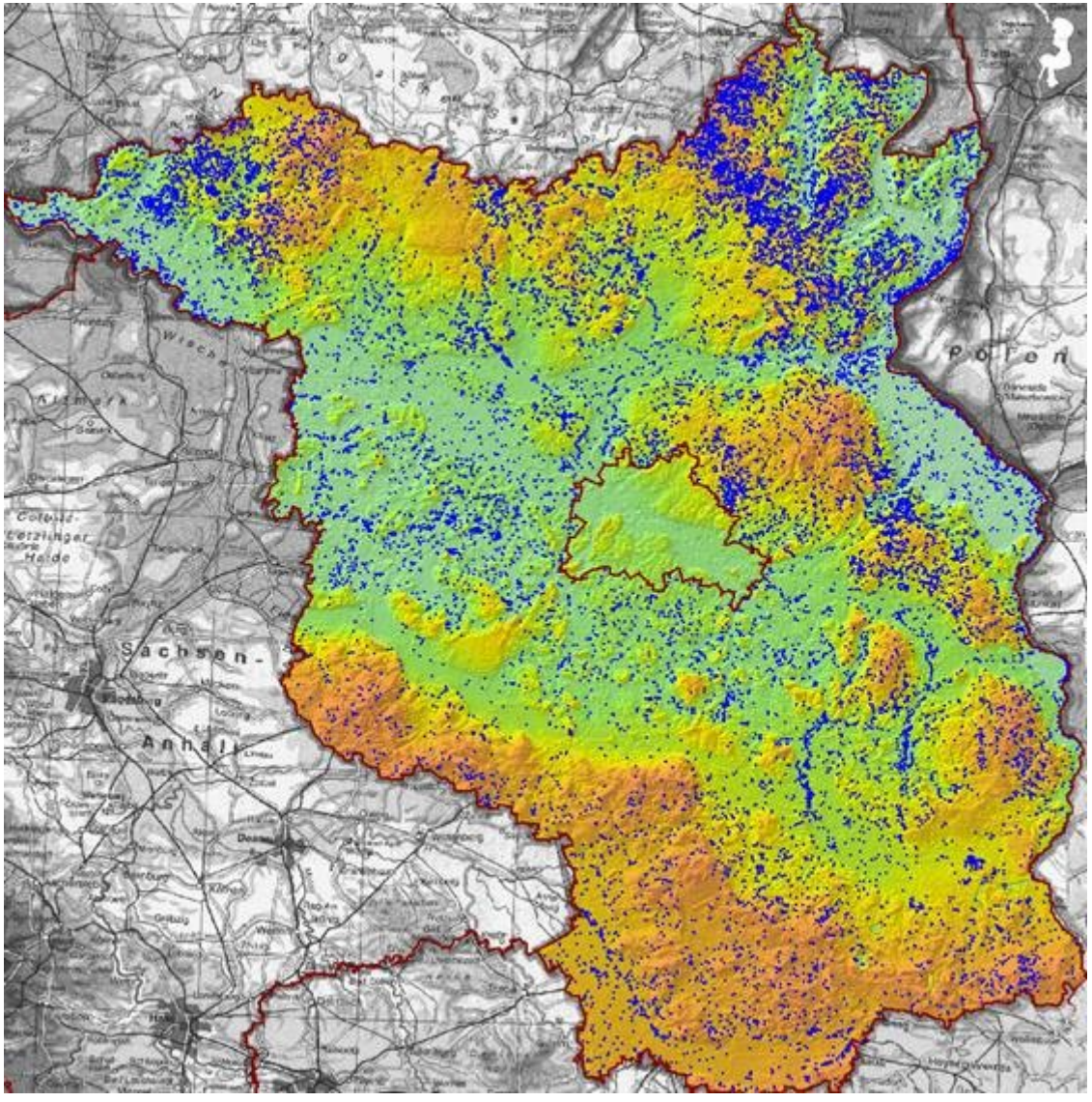
1 - 4 g N_t m^{-2} yr^{-1}

Photos: M. Sommer

Relevance ? → kettle hole density

Kettle holes in Brandenburg (Germany)

Modelled on basis
of DEM 25
(J. Kiesel, LSA)



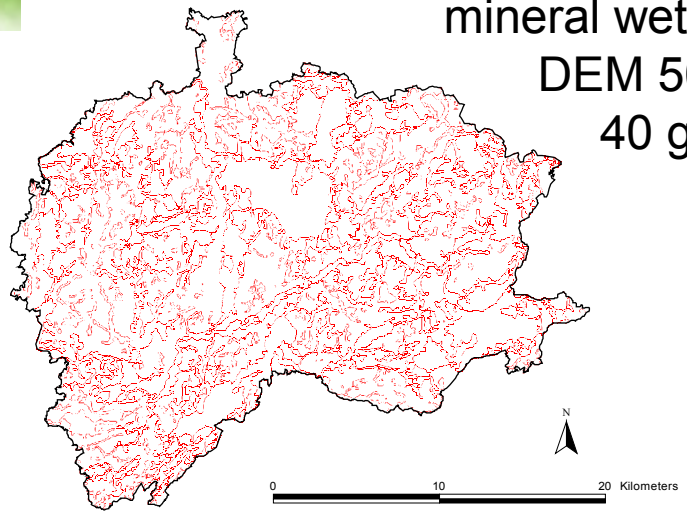
GIS-based regional upscaling

- **identification of closed depressions** (DEM, RS)

- **buffer – function (DEM)**
- **overlay of land use (e.g., remote sensing)**

Case study S-Germany (Allgaeu, 500 km²)

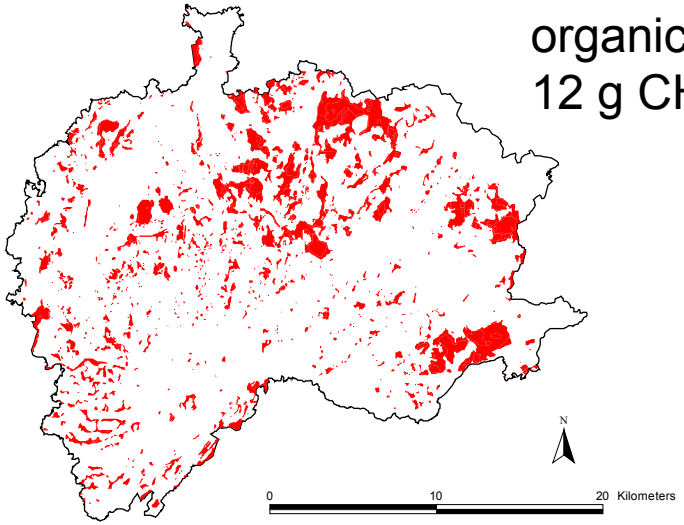
mineral wetlands (kettle holes):
DEM 50, buffer = 20m
40 g CH_4 m^{-2} yr^{-1}



1.5 Gg CH_4 yr^{-1}

(area = 7%)

organic wetlands
12 g CH_4 m^{-2} yr^{-1}



Relevance at regional scale ?

1 Gg CH_4 a^{-1}

(area = 17%)

Sommer et al., Agriculture, Ecosystems & Environment 2004

GIS-based continental upscaling

Data base request

FAO-Unesco „Soil map of the world"

1. Lithology: glacial till, glacial drift, or moraine ?

and 2. Climate: boreal, mesic, 7.2, 7.3, 7.6, 7.7 ?

and 3. Vegetation: field crops ?

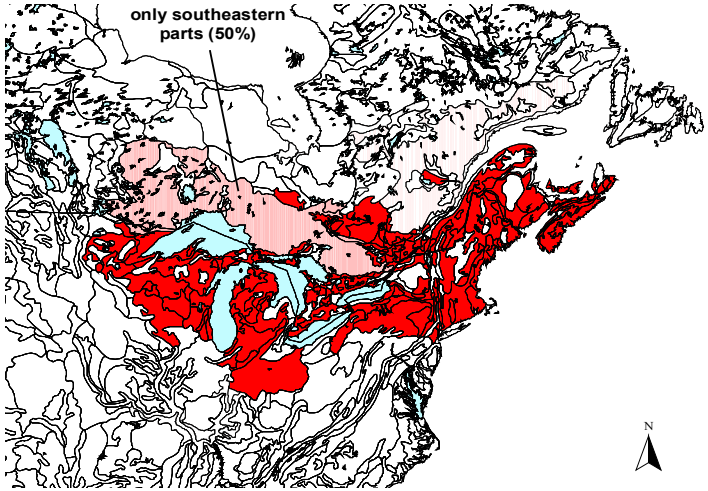
→ polygons of interest

assumptions: 65 % arable land

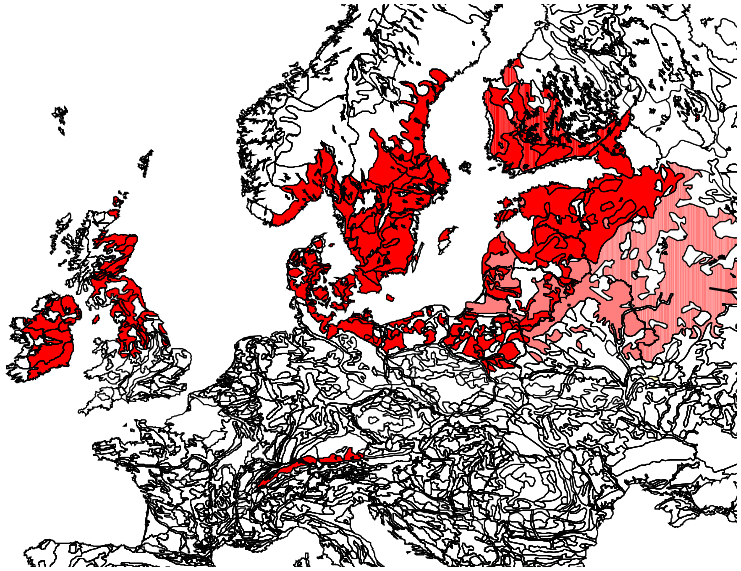
7 % colluvial margins

source strength: 40 g CH_4 m^{-2} yr^{-1}

Result of Continental Upscaling



2.5 Tg CH_4 yr^{-1}



≅ 1 – 7 % of paddy rice fields,

boreal or tropical wetlands

Sommer et al., Agriculture, Ecosystems & Environment 2004

Conclusions

1. **Mineral wetland soils around kettle holes are strong CH_4 sources with regional and, most probably, continental relevance. Source strength is induced by man (land use),**

2. **Key drivers are groundwater levels (threshold ≈ 15cm) and soil humus quality (C/N < 12),**

3. **Further improvments needed:**

   a) unit area emissions in different climates (n >),

   b) explicit delineation of wetland soils (RS, DEM5),

   c) areal dynamics ? (groundwater level).