SUMMARY

As a result of the climate conferences in Durban (2011) and Doha (2012), voluntary accounting for greenhouse gas emissions from organic soils is now possible in national climate reporting. The quality of the data describing the spatial extent of organic soils and their relevant soil properties thus becomes particularly important. For climate reporting issues, maps for organic soils at different scales and levels of detail are used. In Germany, for example, the soil map at scale 1:1,000,000 is the basis for the emission inventory (NIR 2013). In contrast, the national inventory report of The Netherlands is based on a soil map at scale 1:50,000 (Coenen et al. 2013). This leads to questions about the optimal level of detail or scale for climate reporting.

Datasets with scales ranging from 1:25,000 up to 1:1,000,000 were used to derive the spatial distribution of organic soils in two characteristic areas of the temperate zone, one in northern and one in southern Germany. Comparison of the results shows large differences in both areal and spatial accuracy, depending on the origin and quality of the data as well as on scale and landscape characteristics. In southern Germany, for example, only 50 % of the organic soils derived from smaller-scale maps can be verified by detailed data, in contrast to more than 70 % in northern Germany. In combination with the partially poor spatial accuracy, these differences have a strong impact on the calculation of greenhouse gas emissions from organic soils, leading to errors of more than 60 %.

As a result, for the temperate zone we recommend a minimum scale of 1:200,000 for maps of organic soils. However, in mountainous regions with higher geomorphic heterogeneity, more detailed data may be necessary.

KEY WORDS: GIS; greenhouse gas; scale; soil maps; temperate zone

INTRODUCTION

Even though the long-term effects of greenhouse gas emissions will be felt globally, the ongoing worldwide debate on this topic is strongly influenced by national interests and this affects prospects for achieving an objective and widely accepted knowledge base. This observation is especially pertinent for organic soils, as the processes in these are more complex and of higher uncertainty than, for example, the processes underlying emissions from industry or road traffic. It applies to both the spatial distribution of organic soils and land use specific emission factors.

According to the IPCC (2006) Guidelines, organic soils are characterised by an organic carbon content of more than 12 % in the uppermost horizon, up to a depth of 20 cm. This is not completely congruent with German classification schemes, which usually require a thickness of more than 30 cm and an organic carbon content of more than 15 %.

In their natural state, sites with organic soils are carbon sinks, mainly due to high water supply. Dead material from specialised plants like mosses, sedges and reed is incompletely decomposed and accumulates in situ, resulting in high soil carbon content. Worldwide estimates of organic carbon stored in soils range from 1,115 to 2,200 Pg (petagram = 10^15 grams) carbon (Batjes 1992, Eswaran et al. 1993). Referring to organic soils alone, estimates range from 330 to 550 Pg (Gorham 1995, Batjes 1996). These carbon deposits are in danger of being partly released primarily by changes in the water balance. When they are subjected to drainage, often accompanied by the application of fertilisers, the microbial degradation of organic material and the release of greenhouse gases like CO2 and N2O re-starts, and the former carbon sink changes into a carbon source (Kalbitz et al. 2001, Blodau & Moore 2003, Drösler 2005).

The carbon release rate depends strongly on the type and intensity of land use. The release of CO2 due to tillage of fens, for example, is 41.1 t ha^-1 and
more than double that from fens which are used as meadows, where CO₂ emissions are approximately 15–17 t ha⁻¹ (Oleszczuk et al. 2008). Therefore, a reliable estimate of greenhouse gas emissions from organic soils must take land use information into account. This implicitly requires similarly accurate information on the extent of organic soils, because the areas under different land uses may otherwise be miscalculated. In contrast to soils data, land use information is, in most cases, available at large scales.

One action of the 2011 Durban climate conference (United Nations Climate Change Conference COP17/CMP17) was to enable voluntary accounting for emissions from organic soils in national climate reporting. In Germany, data about the spatial distribution of these soils is spread over a multitude of surveys and data sources that differ greatly in scale and thematic content (Behrens & Scholten 2006). Some of them are geologically oriented while others are focused on pedological, agricultural or forestry interests.

In contrast to many mineral soils, the spatial extent of organic soils can be delineated rather sharply on the ground. Organic soils are composed of characteristic substrates such as peat, and they often follow geomorphic or hydromorphic features like depressions, slope toes or stream networks. This strong relationship with topographical elements suggests that organic soils could be delineated with sufficient accuracy for climate reporting, even in small-scale data.

Climate reporting for organic soils in Germany has been based hitherto on the soil map at scale 1:1,000,000 (NIR 2013). This dataset is also part of the European Soil Database, which was used to describe the distribution of peatland within Europe by Montanarella et al. (2006). More detailed data were used in, for example, Ireland and The Netherlands. A map of peatlands in Ireland was derived from soil and peatland maps with scales ranging from 1:127,560 to 1:575,000 (Connolly et al. 2007). In The Netherlands, a map of organic soils was compiled using, mainly, the soil map of The Netherlands at scale 1:50,000 and recent soil monitoring data (Kuikman et al. 2003).

Generally, the impact of scale in digital soil mapping is well known (McMaster & Shea 1992, Goodchild 2011). Depending on the initial purpose of the underlying survey, the information is subject to generalisation and aggregation during the map-making process. Geometry-based generalisation often leads to over-estimation of large units because small structures tend to be eliminated (Rapalee et al. 1998). Because organic soils in the temperate zone often occur in relatively small patches, they are highly vulnerable to the elimination process. This leads to possible under-estimation of the extent of organic soils, especially in smaller-scale maps. Aggregation is another relevant procedure in map making. In our case it involves the combination of similar soil types into higher soil classes. It is always accompanied by a loss of information. In the case of organic soils, aggregation may be of particular importance for non-peat soils with high carbon content. These soils are possibly in danger of being absorbed into map units with mineral soils, even if they cover large areas.

Few working groups have analysed scale-dependent effects in the process of delineating organic soils and their properties. The impact of generalisation on soil maps is confirmed by Zhao et al. (2006). The areal fraction of bog soils in their test area decreased from 0.55 % at scale 1:500,000 to 0.46 % at 1:1,000,000 and 0.44 % at 1:2,500,000. Davidson & Lefebvre (1993) calculated the soil organic carbon for a test area in Maine, in the north-eastern United States. Unlike Zhao et al. (2006), they found that the apparent extent of Histosols was 21 % higher when derived from soils data at scale 1:250,000 than when it was calculated from a more detailed dataset at scale 1: 20,000.

The aim of the work reported in this article was to compare the accuracy and completeness of different datasets that delineate organic soils in Germany, and thus to demonstrate how the choice of data source would impact on estimates of greenhouse gas emissions attributable to agricultural and forestry land use. To achieve this, parts of the datasets were compared using GIS techniques.

**METHODS**

Two large test areas were available, one in the north-east and the other in the south-west of Germany (Figure 1). To evaluate differences in the delineation of organic soils within these test areas, available national pedological and geological datasets were compared with detailed reference data from the Map of Organic Soils (MOS). The MOS is a synthesis of differently detailed geodata (Table 1) and a site-specific pedological characterisation based mainly on geomorphology and hydrology. It is being developed in the context of climate reporting issues as part of the Joint Research Project “Organic Soils” (funded by the Thünen-Institut), and will eventually cover the whole of Germany.

The national datasets used were the Soil Map of Germany SM1000 (BGR 2013) and the Geological...
Map of Germany GM1000 (BGR 1993), both at scale 1:1,000,000; and the Soil Map of Germany SM200 (BGR 2000–2011) and the Geological Map of Germany GM200 (BGR 1983–2003), both at scale 1:200,000. These were compared with the MOS as well as with highly precise land use information derived from ATKIS (Authoritative Topographic-Cartographic Information System) (AdV 2005). Because our focus was on the quality of data for soils, other sources of land use data were not considered, even though they might lead to different results (Trepel 2007).

Scale-dependent analyses were conducted in GIS for the two large test regions (Figure 1), within which a range of typical geomorphological conditions are represented.

The north-eastern test area covers the entire Federal State of Mecklenburg-Vorpommern and extends to 23,200 km². It is mainly composed of sediments from the late Weichselian glacial. The typical pattern of geomorphic structures such as ground moraines, terminal moraines, aprons and glacially initiated stream networks can be found. Large areas with organic soils appear mostly in valley situations or in coastal lowlands. A multitude of relatively small organic soil patches are bound to lakeshores or local depressions with relatively high groundwater levels. The climate is characterised by a transition from oceanic climate in the north and west to more continental climate in the south-east. The average annual precipitation ranges from 700 mm in coastal areas to 500 mm farther inland (Hurtig 1957).

The second test area covers the Federal State of Baden-Württemberg, with an area of 35,750 km². The landscape diversity is much higher than for the north-eastern test area. The western part of Baden-Württemberg is dominated by the sediment-filled initial rift valley of the Rhine. To the east of this rift valley lie the mountain ranges of the Black Forest (up to 1,500 m) and the Odenwald (up to 600 m),

![Figure 1. The test areas in Germany: Mecklenburg-Vorpommern (MV) in the north-east and Baden-Württemberg (BW) in the south-west.](image)

Table 1. Main input data for the Map of Organic Soils (MOS) for the two test areas. ATKIS: Authoritative Topographic-Cartographic Information System.

<table>
<thead>
<tr>
<th>north-eastern test area</th>
<th>south-western test area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geological Map of Prussia, 1:25,000</td>
<td>Soil Map, 1:25,000</td>
</tr>
<tr>
<td>Conceptual Soil Map of the local soil survey, 1:25,000</td>
<td>Soil Map, 1:50,000</td>
</tr>
<tr>
<td>Agricultural soil maps (Bodenschätzung) for quality assurance issues</td>
<td>Agricultural soil maps (Bodenschätzung), ~1:10,000</td>
</tr>
<tr>
<td>Digital Terrain Model, 25 m × 25 m grid</td>
<td>Digital Terrain Model, 25 m × 25 m grid</td>
</tr>
<tr>
<td>Hydrology (rivers and lakes) from ATKIS data</td>
<td>Hydrology (rivers and lakes) from ATKIS data</td>
</tr>
<tr>
<td></td>
<td>Forest soil maps (Forstliche Standortkartierung), ~1:10,000</td>
</tr>
<tr>
<td></td>
<td>Mire inventory (Moorkataster)</td>
</tr>
</tbody>
</table>
which are composed mainly of silicate rocks. Farther east there is the Swabian Alb with its limestones. The foothills of the Alps in the south are composed of glacial sediments. The majority of sites with organic soils are situated in the foothills of the Alps and in the valleys of large rivers like the Danube and the Rhine. Bogs can be found in the Black Forest region. Annual precipitation in the mountain regions is up to 1,000 mm, and much higher than in the lowlands (600–700 mm). The average annual temperature ranges from 4 °C to 10 °C, depending mainly on altitude. Temperatures in the lowlands, at least, are significantly higher than in the northern parts of Germany (Rosner 2008, Eberle et al. 2010).

From all available source data, those datasets with relatively sharp delineation of organic soils were selected. Simplified, organic soils have to meet the criterion of more than 12% organic carbon in a mixed sample taken from the uppermost 20 cm of the soil profile (IPCC 2006). With respect to the German soil classification (AG Boden 2005), non-peat organic soils with a carbon content of 9–15% in the upper layer were included as well.

In the case of the SM1000 we extracted all datasets describing fens and bogs. Soils with less organic carbon that are still considered to be organic soils according to the IPCC definitions are included in other soil classes and, therefore, are not spatially extractable. The SM200 is more detailed and supports the extraction of non-peat organic soils as well. The GM1000 distinguishes bogs, fens and non-peat organic soils. The GM200 follows the same taxonomy as the GM1000.

To verify the chosen soil classes, ground verification with respect to organic carbon content was carried out. Results from the north-eastern test area show that approximately 50% of the non-peat organic soils still have 9% or more organic carbon in the upper soil and fulfill the requirements of the adapted definitions for greenhouse gas reporting for organic soils in Germany, despite the partly old data (Table 2).

All data were pre-processed using GIS techniques, then intersected with the MOS and ATKIS land use data. Descriptive statistics were calculated, and spatial analyses were carried out in GIS.

RESULTS

According to the MOS, 328,696 ha of the north-eastern test area are covered by organic soils. This equates to 14% of the total area, of which 85% is peatland and 15% non-peat organic soils (Table 3).

<table>
<thead>
<tr>
<th>site characteristic</th>
<th>mean</th>
<th>avg.</th>
<th>min.</th>
<th>max.</th>
<th>CV</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>non-peat organic soil</td>
<td>9.0</td>
<td>11.7</td>
<td>1.2</td>
<td>40.2</td>
<td>79.7</td>
<td>29</td>
</tr>
<tr>
<td>shallow fen</td>
<td>22.0</td>
<td>21.4</td>
<td>1.3</td>
<td>43.2</td>
<td>58.1</td>
<td>44</td>
</tr>
</tbody>
</table>

Table 2. Ground verification results: carbon content (%) in a mixed sample taken from the uppermost 20 cm. CV = coefficient of variation (%); n is the number of sampled sites.

<table>
<thead>
<tr>
<th>site characteristic</th>
<th>MOS</th>
<th>SM1000</th>
<th>SM200</th>
<th>GM1000</th>
<th>GM200</th>
</tr>
</thead>
<tbody>
<tr>
<td>bog</td>
<td>5,389</td>
<td>-</td>
<td>4,811</td>
<td>3,631</td>
<td>3,851</td>
</tr>
<tr>
<td>fen</td>
<td>274,144</td>
<td>361,373</td>
<td>232,492</td>
<td>217,903</td>
<td>249,554</td>
</tr>
<tr>
<td>non-peat organic soil</td>
<td>49,163</td>
<td>-</td>
<td>400,0</td>
<td>-</td>
<td>34,729</td>
</tr>
<tr>
<td>total</td>
<td>328,696</td>
<td>361,373</td>
<td>237,703</td>
<td>221,534</td>
<td>288,134</td>
</tr>
</tbody>
</table>

Table 3. Areas of bog, fen and non-peat organic soil in the north-eastern test area, from different sources.

MOS: new Map of Organic Soils; SM1000: Soil Map at scale 1:1,000,000; SM200: Soil Map at scale 1:200,000; GM1000: Geological Map at scale 1:1,000,000; GM200: Geological Map at scale 1:200,000.
Comparing the total areas of organic soils in the north-eastern test area shows that the small-scale pedological map SM1000 over-estimates the area covered by organic soils by 10% whereas the geological map GM1000 under-estimates this statistic by 32.6%. In contrast, the medium-scale pedological map SM200 under-estimates the occurrence of organic soils by 27.7% and the GM200 by 12.3%. Even though this comparison shows huge differences in the total areas of organic soils, it is of limited value because it ignores the question of spatial accuracy (Figure 2).

Therefore, all data sources were intersected with the more detailed MOS. Only 40% of the SM1000 organic soils can be confirmed by the MOS, showing that 60% are not organic soils at all. A clearly higher spatial accuracy is achieved by the SM200 and the GM200, with more than 70% agreement. The GM200 is more complete, with an intersection of 207,155 ha (Table 4).

Taking detailed land use data derived from ATKIS into account, it is obvious that a decreasing spatial accuracy of soils data leads to an over-estimation of arable land use on organic soils. According to the MOS, the proportion of arable land on these soils is about 10%, and this is three times over-estimated using the SM1000 (Table 5).

According to the MOS, 52,077 ha (1.5%) of the south-western test area is covered by organic soils, of which 74% are peatland and 26% non-peat organic soils. The small-scale pedological map SM1000 under-estimates the extent of organic soils by approximately 70% whereas the GM1000 under-estimates it by just 14%. The medium-scale SM200 over-estimates the fraction of organic soils by 20%, whereas the area of organic soils in the geological map GM200 is almost identical to that in the MOS (Table 6).

Table 4. Intersection of organic soil inventories and the MOS in the north-eastern test area.

<table>
<thead>
<tr>
<th>site characteristic</th>
<th>SM1000</th>
<th>SM200</th>
<th>GM1000</th>
<th>GM200</th>
</tr>
</thead>
<tbody>
<tr>
<td>total area of organic soils</td>
<td>361,373 ha</td>
<td>237,703 ha</td>
<td>221,534 ha</td>
<td>288,134 ha</td>
</tr>
<tr>
<td>organic soils congruent with the MOS</td>
<td>145,956 ha</td>
<td>174,012 ha</td>
<td>130,289 ha</td>
<td>207,155 ha</td>
</tr>
<tr>
<td></td>
<td>40.4 %</td>
<td>73.2 %</td>
<td>58.8 %</td>
<td>71.9 %</td>
</tr>
<tr>
<td>organic soils not congruent with the MOS</td>
<td>215,417 ha</td>
<td>63,691 ha</td>
<td>91,245 ha</td>
<td>80,979 ha</td>
</tr>
<tr>
<td></td>
<td>59.6 %</td>
<td>26.8 %</td>
<td>41.2 %</td>
<td>28.1 %</td>
</tr>
</tbody>
</table>

MOS: new Map of Organic Soils; SM1000: Soil Map at scale 1:1,000,000; SM200: Soil Map at scale 1:200,000; GM1000: Geological Map at scale 1:1,000,000; GM200: Geological Map at scale 1:200,000.
Table 5. Land use (ATKIS data) on organic soils in the north-eastern test area.

<table>
<thead>
<tr>
<th>data</th>
<th>arable land</th>
<th>grassland</th>
<th>forest</th>
<th>unused</th>
<th>rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOS</td>
<td>9.8</td>
<td>58.6</td>
<td>18.5</td>
<td>9.8</td>
<td>3.1</td>
</tr>
<tr>
<td>SM1000</td>
<td>29.7</td>
<td>38.0</td>
<td>19.3</td>
<td>5.3</td>
<td>7.7</td>
</tr>
<tr>
<td>SM200</td>
<td>10.5</td>
<td>58.2</td>
<td>17.3</td>
<td>9.9</td>
<td>4.2</td>
</tr>
<tr>
<td>GM1000</td>
<td>18.4</td>
<td>49.7</td>
<td>16.1</td>
<td>7.4</td>
<td>8.5</td>
</tr>
<tr>
<td>GM200</td>
<td>13.0</td>
<td>55.9</td>
<td>18.0</td>
<td>8.4</td>
<td>4.7</td>
</tr>
</tbody>
</table>

MOS: new Map of Organic Soils; SM1000: Soil Map at scale 1:1,000,000; SM200: Soil Map at scale 1:200,000; GM1000: Geological Map at scale 1:1,000,000; GM200: Geological Map at scale 1:200,000; ATKIS: Authoritative Topographic-Cartographic Information System.

Table 6. Areas of bog, fen and non-peat organic soil in the south-western test area, from different sources.

<table>
<thead>
<tr>
<th>site characteristic</th>
<th>MOS ha</th>
<th>SM1000 ha</th>
<th>SM200 ha</th>
<th>GM1000 ha</th>
<th>GM200 ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>bog</td>
<td>4,145</td>
<td>4,176</td>
<td>2,551</td>
<td>2,356</td>
<td>3,237</td>
</tr>
<tr>
<td>fen</td>
<td>34,423</td>
<td>11,506</td>
<td>45,935</td>
<td>42,277</td>
<td>35,981</td>
</tr>
<tr>
<td>non-peat organic soil</td>
<td>13,509</td>
<td>-</td>
<td>14,688</td>
<td>-</td>
<td>12,825</td>
</tr>
<tr>
<td>total</td>
<td>52,077</td>
<td>15,682</td>
<td>63,174</td>
<td>44,633</td>
<td>52,043</td>
</tr>
</tbody>
</table>

MOS: new Map of Organic Soils; SM1000: Soil Map at scale 1:1,000,000; SM200: Soil Map at scale 1:200,000; GM1000: Geological Map at scale 1:1,000,000; GM200: Geological Map at scale 1:200,000.

Table 7. Intersection of organic soil inventories and the MOS in the south-western test area.

<table>
<thead>
<tr>
<th>site characteristic</th>
<th>SM1000</th>
<th>SM200</th>
<th>GM1000</th>
<th>GM200</th>
</tr>
</thead>
<tbody>
<tr>
<td>total area of organic soils</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>organic soils congruent with the MOS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>organic soils not congruent with the MOS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MOS: new Map of Organic Soils; SM1000: Soil Map at scale 1:1,000,000; SM200: Soil Map at scale 1:200,000; GM1000: Geological Map at scale 1:1,000,000; GM200: Geological Map at scale 1:200,000.
Table 8. Land use (ATKIS data) on organic soils in the south western test area.

<table>
<thead>
<tr>
<th>data</th>
<th>arable land</th>
<th>grassland</th>
<th>forest</th>
<th>unused</th>
<th>rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOS</td>
<td>9.7</td>
<td>40.1</td>
<td>26.5</td>
<td>20.9</td>
<td>2.6</td>
</tr>
<tr>
<td>SM1000</td>
<td>26.5</td>
<td>24.4</td>
<td>9.5</td>
<td>29.6</td>
<td>10.2</td>
</tr>
<tr>
<td>SM200</td>
<td>14.1</td>
<td>37.2</td>
<td>21.6</td>
<td>18.3</td>
<td>8.9</td>
</tr>
<tr>
<td>GM1000</td>
<td>21.2</td>
<td>34.2</td>
<td>17.8</td>
<td>16.3</td>
<td>10.6</td>
</tr>
<tr>
<td>GM200</td>
<td>16.9</td>
<td>35.7</td>
<td>19.7</td>
<td>17.9</td>
<td>9.6</td>
</tr>
</tbody>
</table>

MOS: new Map of Organic Soils; SM1000: Soil Map at scale 1:1,000,000; SM200: Soil Map at scale 1:200,000; GM1000: Geological Map at scale 1:1,000,000; GM200: Geological Map at scale 1:200,000; ATKIS: Authoritative Topographic-Cartographic Information System.

Table 9. Land use specific greenhouse gas emissions* for fen soils in the two test areas, derived using ATKIS land use data.

<table>
<thead>
<tr>
<th>site characteristic</th>
<th>north-eastern test area</th>
<th>south-western test area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg C-equ.a⁻¹ha⁻¹</td>
<td>kg C-equ.a⁻¹ha⁻¹</td>
</tr>
<tr>
<td>MOS</td>
<td>273,060</td>
<td>29,168</td>
</tr>
<tr>
<td>SM1000</td>
<td>1,267,755</td>
<td>43,800</td>
</tr>
<tr>
<td>GM200</td>
<td>345,401</td>
<td>57,179</td>
</tr>
<tr>
<td>arable land</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOS</td>
<td>933,127</td>
<td>39,529</td>
</tr>
<tr>
<td>SM1000</td>
<td>770,700</td>
<td>5,477</td>
</tr>
<tr>
<td>GM200</td>
<td>806,082</td>
<td>44,133</td>
</tr>
<tr>
<td>grassland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOS</td>
<td>228,131</td>
<td>3,992</td>
</tr>
<tr>
<td>SM1000</td>
<td>330,962</td>
<td>553</td>
</tr>
<tr>
<td>GM200</td>
<td>201,563</td>
<td>4,457</td>
</tr>
<tr>
<td>forest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOS</td>
<td>23,041</td>
<td></td>
</tr>
<tr>
<td>SM1000</td>
<td>33,427</td>
<td></td>
</tr>
<tr>
<td>GM200</td>
<td>20,358</td>
<td></td>
</tr>
<tr>
<td>unused</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOS</td>
<td>1,457,359</td>
<td></td>
</tr>
<tr>
<td>SM1000</td>
<td>2,402,844</td>
<td></td>
</tr>
<tr>
<td>GM200</td>
<td>1,373,404</td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>156,370</td>
<td>65,847</td>
</tr>
</tbody>
</table>

MOS: new Map of Organic Soils; SM1000: Soil Map at scale 1:1,000,000; SM200: Soil Map at scale 1:200,000; GM1000: Geological Map at scale 1:1,000,000; GM200: Geological Map at scale 1:200,000; ATKIS: Authoritative Topographic-Cartographic Information System.

*Emission factors for German peatlands according to Höper (2007): fen/arable land = 11,809 kg C-equ. a⁻¹ ha⁻¹; fen/grassland = 5,618 kg C-equ. a⁻¹ ha⁻¹; fen/forest = 4,746 kg C-equ. a⁻¹ ha⁻¹; fen/unused = 101 kg C-equ. a⁻¹ ha⁻¹.

According to the MOS, the total greenhouse gas emissions of the northern test area accumulate to an annual sum of 1,457,359 t CO₂ equivalents. Calculations based on the GM200 under-estimate the emissions by a mere 5.8 % whereas calculations based on the SM1000 over-estimate the emissions by 65 %.

Different results are achieved for the southern test area. Compared to the MOS, the SM200 over-estimates the emissions by 37 % whereas calculations based on the SM1000 under-estimate the emissions by 58 %.

DISCUSSION

The small-scale SM1000 and GM1000 seem to be of limited value for the objective of deducing a complete and spatially accurate database for the organic soils. The medium-scale SM200 and GM200 are clearly better. As geological data lacks information on pedological processes, the degree of aggregation is lower than in pedological data and maps. This partly explains the higher proportion of non-peat organic soils in the GM200, as well as its substantial intersection with the MOS. In
pedological data, soils with less than 15 % organic carbon are in danger of becoming part of mineral soils classes. Additionally, the MOS for the northern test area is mainly composed of large-scale geological data, and perhaps for this reason exhibits a greater intersection with geological data.

The ex ante hypothesis that, due to their specific type of genesis, organic soils can be delineated with sufficient accuracy even on the basis of medium- and small-scale maps is not generally confirmed by our analyses. Over- and under-estimations can be observed in both test areas, but the medium- and small-scale data for the north-eastern area deliver clearly better results than those for the south-western test area. Differences in landscape diversity may be a key factor here. The widespread organic soils of the north-eastern test area, with its relatively homogeneous glacial landscape, are in less danger of being merged with mineral soils in the course of map aggregation than the organic soils of the diverse landscape of south-west Germany. Thus, depending on the specific landscape, even medium-scale geodata may be suitable for deriving an inventory of organic soils.

The results obtained here demonstrate the need for detailed soils data to establish reliable inventories of organic soils. Small-scale data, regardless of whether they are pedological or geological, are inadequate for climate change reporting. Furthermore, it could be shown that, in addition to scale, aspects of landscape diversity have a great impact on the suitability of geodata. For homogeneous landscapes with widespread organic soils, medium-scale (1:200,000) geological or pedological data may be sufficiently accurate for climate reporting purposes. For diverse landscapes however, large-scale data are essential.

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