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HYDROLOGICAL MODELLING OF PEATLANDS – AN EVALUATION OF METEOROLOGICAL INPUT DATA

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SUMMARY:
The aim of this study is to evaluate high-resolution meteorological data from official weather stations on mineral soils for suitability as a proxy for *in situ* measurements at peatlands across Germany. Thus, *in situ* weather data from 18 peatlands was compared with data from nearby official weather station regarding temperature and humidity. Here, we focus on methods and first results of analysing differences of official data compared to *in situ* data of two different peatland sites. Strong effects of peatland microclimate were observed, e.g., stronger diurnal variation of temperature as well as a higher probability of fog.

KEYWORDS: peatland, microclimate, hydrological modelling, ecosystem services, scaling analysis

INTRODUCTION

This study is part of a joint research project “Organic Soils” (www.organische-boeden.de), which is working on improving the German national greenhouse gas inventory for peatlands and other organic soils (Histosols) according to the UN Framework Convention on Climate Change. The aim of the project is the definition of country-specific greenhouse gas emission factors depending on climate region, soil type and land use. In order to develop scaling methods and emission factors, hydrological models are designed on catchment and national scales. Using these models allows simulating the well known impact of groundwater level and soil moisture changes on greenhouse gas emissions from peatlands.
Within the research project hydrological models are developed, both on field scale and the national scale. These models require meteorological data sets, e.g. for estimation of evapotranspiration, which is based on temperature, solar radiation, vapour pressure deficit and wind speed as the most important driving parameters. For small scale modelling these parameters are taken from *in situ* measurements. In contrast, regionalisation and large scale modelling have to be based on large scale meteorological networks. In Germany, official meteorological data are available from the German National Meteorological Service (DWD). However, most of these raster or station based data sets are not created specifically for wetlands. Only 3.3 % of DWD high-resolution weather stations (“DWD-KL-Stations”) are situated on sites with organic soils, including raised peat bogs, fens and peaty Podzols (GÜK 200, BGR 2003).
We hypothesize that using DWD data for hydrological modelling of German peatlands creates a systematic bias. This bias follows from using the microclimate on mineral soils as

estimation for the specific microclimate of peatlands. Peatland microclimate is characterized by higher air humidity, higher amplitudes of diurnal air temperature cycles, and by a high fog probability per day (Eggelsmann, 1990).
The objective of this study was to evaluate the suitability of DWD data for hydrological modelling of peatlands. We studied differences of *in situ* meteorological datasets of 18 peatlands across Germany vs. climate data of adjacent DWD stations. This comparison was based on a characterization of peatland microclimate in dependence on peatland use, main water level and degradation level of the peat soil. Here, we present exemplary results of this comparison for a peatland in Northwest Germany (Ahlen-Falkenberger Moor) and one in the Southwest (Graben-Neudorf).

MATERIALS AND METHODS

This study is based on datasets, which were obtained from meteorological stations at 18 peatlands across Germany (Fig 1). Here we present results for two selected sites: the “Ahlen-Falkenberger Moor” peatland and a peatland close to the city of Graben-Neudorf. Each data set was compared with averaged climate data of the surrounding DWD stations. Therefore, data of at least three of the closest DWD stations was aggregated to get one DWD dataset for each peatland area. For each DWD station hourly values of air temperature at 2 meters height, air temperature close to ground, air humidity, vapour pressure deficit, dew point and percentage of fog time per day were composed to daily means. These daily mean values were aggregated by distance weighted averaging and compared to daily mean values of the corresponding peatland weather station.
Estimation of vapour pressure deficit was based on Magnus’ formula, its coefficients were taken from DVWK (1996) as were equations for calculation of dew point temperature. The difference between temperature in 2 m height and dew point temperature was used for estimation of fog probability. We assumed a high probability of fog if the difference of temperature in 2 m height and the dew point temperature was smaller than 0.1 °C.

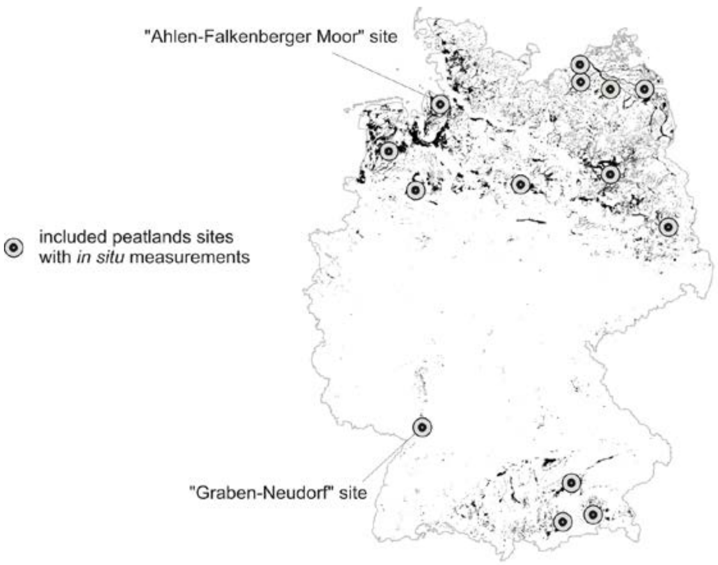

Fig. 1: Map of Germany showing peatland sites in the main study and the two example sites presented here (“Ahlen-Falkenberger Moor” and “Graben-Neudorf”). Map background: distribution of organic soils in Germany (including areas of raised peat bogs, fens and peaty podzols, based on GÜK 200, BGR 2003)

The “Graben-Neudorf” peatland site is situated within the “Oberrheinische Tiefebene”, 30 km south of the city of Heidelberg, at the altitude of 100 m. Mean annual precipitation at the site is 780 mm and mean temperature is 10.7 °C. Mean groundwater level below peat surface is 0.39 m (09/2010 until 08/2011). The site is a fen with a degraded peat layer of 1.1 m thickness. Main vegetation type is intensive grassland.

The “Ahlen-Falkenberger Moor” peatland site is situated close to the North Sea, approx. 16 km south of its coast, at an altitude of 2 m. The mean annual precipitation of the site is 850 mm, the mean temperature is 9.1 °C. Groundwater table is 0.56 m (09/2010 until 08/2011) below peat surface. The site is a raised peat bog with a peat layer of 3.3 m thickness. The upper peat layer is strongly degraded. Main vegetation type is intensive grassland.

RESULTS AND DISCUSSION

Fig. 2 depicts results of temperature comparison. Highly significant differences between peatland temperature data and corresponding DWD temperature data were observed. E.g., the mean difference in daily mean temperature between “Ahlen-Falkenberger Moor” data and DWD data was -0.256 °C (standard deviation: 0.298 °C, n=902). All plots show a characteristic seasonal dependence of the difference values.
On both sites the minimum temperatures are lower at the peatland compared to the DWD-Stations, with a maximum in absolute difference during summer of 4.9 °C (Fig. 2a). Most of the year, maximum temperature at “Ahlen-Falkenberger Moor” peatland is higher than at the surrounding DWD-stations by up to 3.7 °C (Fig. 2b). In contrast, the “Graben-Neudorf” peatland shows in late summer and autumn lower maximum air temperature and higher values during the rest of the year compared to DWD-stations. The daily mean temperature on both peatland sites is smaller than at the DWD stations for most of the year. This difference is more pronounced on the “Graben-Neudorf” peatland, up to 5.5 °C during summer (Fig. 2c).
Fig. 3 depicts differences in the daily means of vapour pressure and of probability of fog between peatlands and DWD-stations as well as water level below peat surface. On both sites the vapour pressure deficits are higher than the DWD data during the year. At the “Graben-Neudorf” site it was up to 11.5 hPa lower than at the DWD sites (Fig. 3a). The probability of fog is on both sites much higher than on the mineral sites of the DWD stations (Fig. 3b).
The observed effects of microclimate on peatland sites are consistent with the literature (Eggelsmann 1990, Dierssen and Dierssen 2001). Especially the strong diurnal variation of air temperature is characteristic, as well as the higher probability of fog. Besides the soil properties and land use, the water level below peat surface does have an influence on the observed effects. This is the main challenge in transforming the DWD Data for use in hydrological modelling of peatlands.

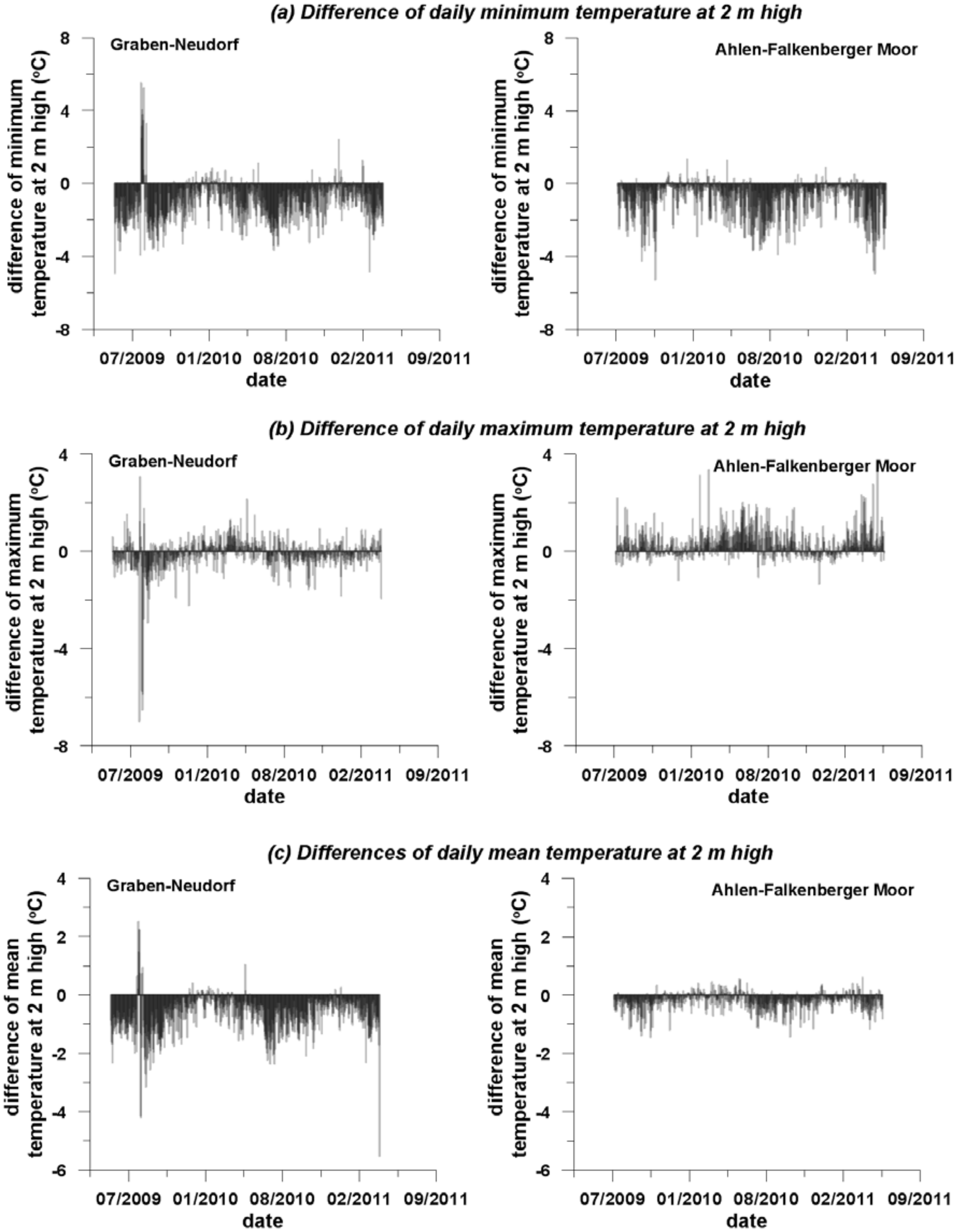

Fig. 2: (a) Difference of daily minimum temperature at 2 m height between peatland station and mean of the closest DWD stations. (b) Difference of daily maximum temperature at 2 m height between peatland station and mean of the closest DWD stations. (c) Difference of daily mean temperature at 2 m height between peatland station and mean of the closest DWD stations.

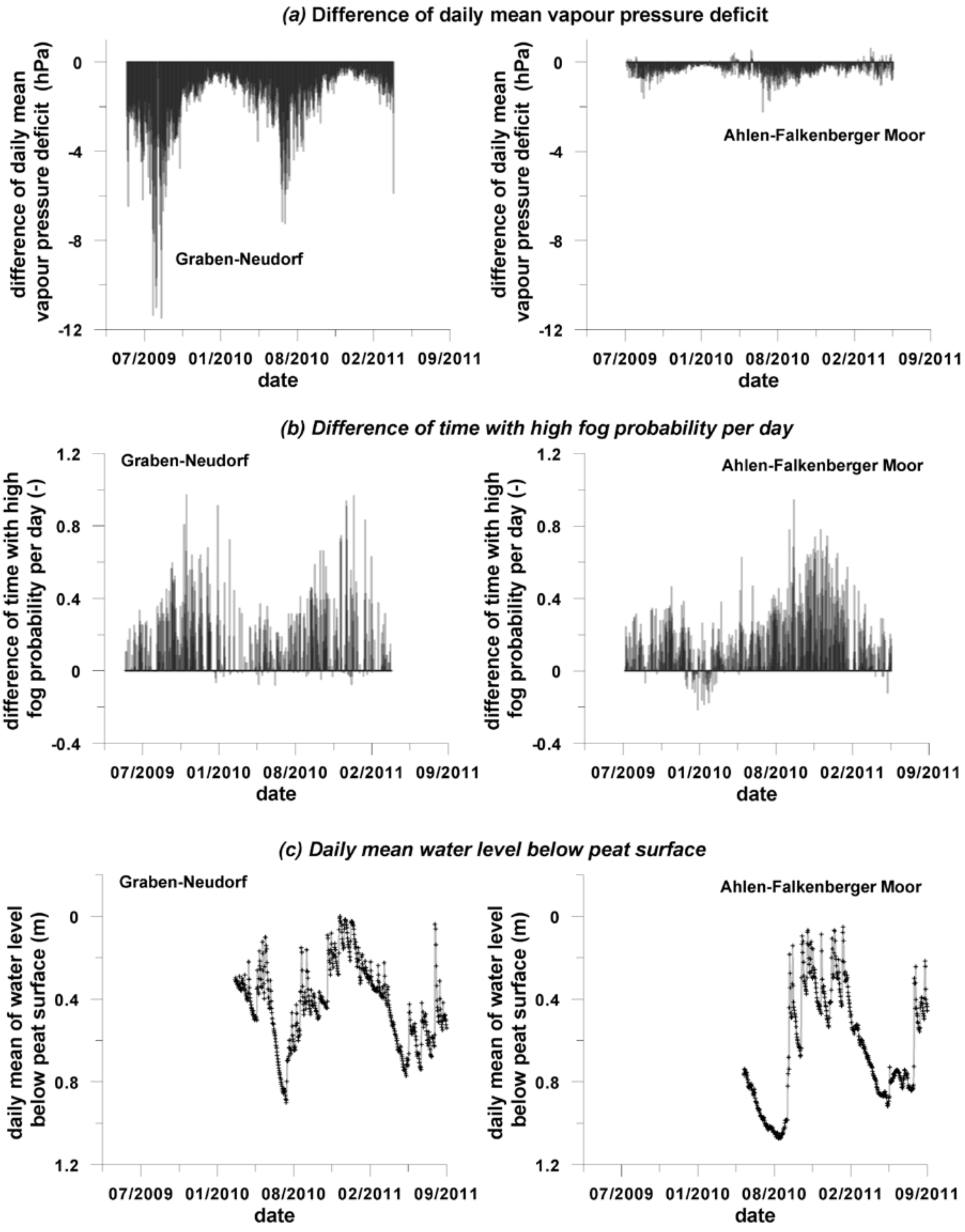

Fig. 3: (a) Difference of daily mean vapor pressure deficit between peatland station and mean of the closest DWD stations. Vapour pressure deficit was calculated from temperature at 2 m height and relative air humidity. (b) Difference of time with high fog probability per day between peatland station and mean of the closest DWD stations. Fog potential was inferred from temperature at 2 m height and dew point temperature. (c) Daily mean water level below peat surface at the peatland sites.

REFERENCES

BGR (2003): GÜK200 (Geologische Übersichtskarte der Bundesrepublik Deutschland 1:200 000). Hannover, Germany.
Dierssen, K. and Dierssen, B. (2001): Moore (Peatlands). Ulmer, Stuttgart, Stuttgart
DVWK (1996): Ermittlung der Verdunstung von Land- und Wasserflächen (Calculation of evapotranspiration of land and open water areas). Merkblätter zur Wasserwirtschaft. 238/1996, 135 pp., Bonn, Germany
Eggelsmann, E. (1990): Mikroklima der Moore (Microclimate of peatlands). In Göttlich, K. (eds.), Moor- und Torfkunde. Schweizerbartsche Verlagsbuchhandlung, Stuttgart, Germany, pp. 374 – 383.