WETLAND MAPPING IN THE WEST SIBERIAN LOWLANDS WITH ENVISAT ASAR GLOBAL MODE

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ABSTRACT

Boreal peatland covers large areas on the northern hemisphere and thus plays an important role especially as carbon storage. Results from a range of microwave sensors have already shown a large potential for hydrological applications. We tested the ScanSAR system ENVISAT ASAR Global Mode (1km) time series for wetland monitoring in boreal environments. With a simple threshold method homogeneous peatland can be identified where backscatter and thus soil moisture is high during summer. In regions with abundant open water surfaces (permafrost transition zone) a different method needs to be applied. The mean backscatter during spring snowmelt is lower than for other landcover in this area. The location specific beginning and end of the snowmelt period was thus derived from Ku-Band scatterometer data (25 km, Quikscat) and used for the extraction of spring data from the Global Mode time series. The resulting dataset allowed the identification of up to 70% of peatlands in the reference database.

Key words: ScanSAR; wetland; time series; spring snowmelt.

1. INTRODUCTION

Boreal peatland covers large areas on the northern hemisphere and thus plays an important role especially as carbon storage but also methane release. They feature thus an important source of radiative forcing [1]. Northern peatlands also exert strong control on the hydrological regime [2].

Radar signals are strongly dependent on hydrological conditions in addition to surface roughness and vegetation structure. Thus multi-temporal approaches allow the detection of environmental processes that are important for the functioning of terrestrial biota, in particular inundation dynamics [3], soil moisture [4] and freeze-thaw changes [5]. Results from a range of microwave sensors have already shown a large potential for hydrological applications.

We tested the ScanSAR system ENVISAT ASAR for wetland monitoring. Previous studies showed that peatlands can be identified with Global Mode (GM) using a simple threshold method in regions of sporadic permafrost but not successful in areas with many open water bodies below GM resolution in the permafrost transition zone [6]. The aim of this investigation was therefore to improve the classification method by analyses of the timeseries available for 2006. In order to capture spatial and temporal dynamics of snowmelt, Ku-Band scatterometer data (Quikscat) are employed.

The study is carried out within the West Siberian Lowland (WSL). Basic information on the distribution of peatland exist as a GIS database [7]. The entire West Siberian lowland covers about 1.5 Mio km^2.

2. METHODS

The selected study area is located within the WSL. It spans from 58^{o}N to 63^{o}N and from 72^{o}E to 75^{o}E (figure 1). The Ob River traverses the area from East to West at approximately 61^{o}N also passing the town Surgut. It covers the region south from the Ob River with sporadic permafrost as well as the discontinuous zone to the north [8].

All ENVISAT ASAR GM stripes have been preprocessed using the in-house software ESCAPE. It enables operational processing of Scansar data (Global and Wide Swath mode) with the use of modules of the commercial software Sarscape (Sarmap). This fully automatic processing chain includes georeferencing, radiometric correction and local incidence angle normalization. It allows operational mapping of large areas such as the West Siberian wetland complex with global mode data [9]. In a first step data are tested for errors and then radiometrically corrected and georeferenced using the GTOPO30 (USGS) dataset. Each image is normalized using a polynomial function. All results are made available in Geographic coordinates.

More than 200 images are available for July to September 2005. Coverage for the entire WSL during these three months ranges from 5 acquisitions in the north-western

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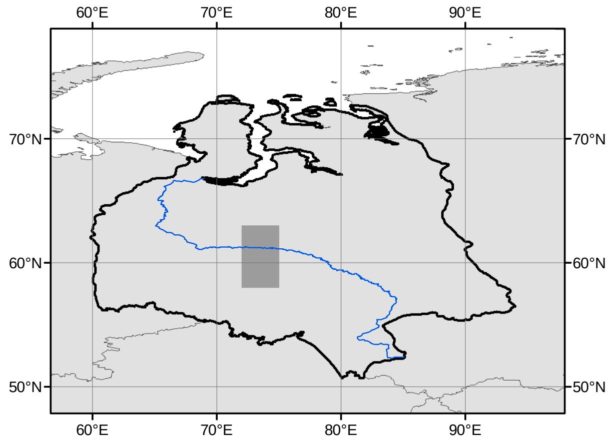

Figure 1. Location of study area and Ob River within the West Siberian Lowland (sources: WSL boundary [7], river and borders - arcdata,esri.com)

part to 48 in the middle and eastern lowlands. The total number of GM measurements for July to September 2006 varies between 25 and 45 in the study area.

A simple threshold based approach is applied for the classification of single scenes which have been subseted to a regular grid with cells of 0.5^ox0.5^o size. Pixels with normalized backscatter above -3dB are regarded as potential wet peatland area. With respect to the total number of available backscatter measurements at each point, a wetness-frequency class is assigned to each pixel. By the use of the WSL database [7] a minimum threshold of 20% was determined [6].

Many peatlands can be identified by the threshold method, but the occurrence of abundant open water surfaces below the spatial resolution impedes its application in some areas [6]. Backscatter values are lower than in homogeneous peatland during the summer period. A timeseries which also covers the spring period has been derived. It shows a distinctive backscatter behavior in peatland with open water. It remains relatively low compared to other peatland and also forest areas. This is demonstrated in Figure 2. Three locations have been selected. A) represents peatland with open water surfaces, B) is a forest site and C) a homogeneous peatland.

In order to distinguish the latter from other land cover the spring snowmelt period at each location needs to be determined and the backscatter solely for this period analysed. The required data can be provided by the investigation of diurnal freeze/thaw with Ku-Band scatterometer data (Seawinds Quikscat; [10, 5]). The beginning and end of spring freeze/thaw cycling can be extracted in 25 km sampling interval. The mapping approach is based on the analyses of diurnal backscatter changes. During the day surface thaws and backscatter drops. During the night re-freezing occurs and thus the backscatter is comparably high in the mornings. Significant changes are identified and longer periods of freeze/thaw cycling extracted. The

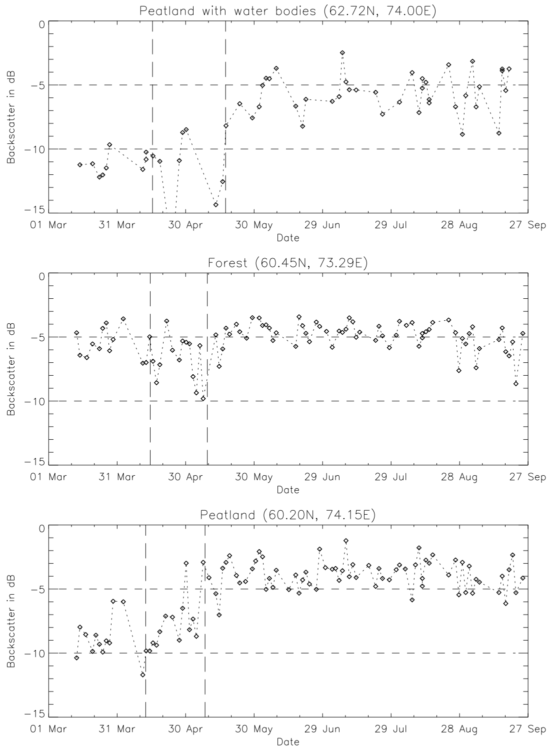

Figure 2. Comparison of ASAR GM time series (2006) for a) peatland with open water surfaces, b) forest, c) peatland without open water surfaces; dashed vertical lines indicate the spring freeze/thaw period; for location of sites see Figure 5

final period of intense thaw and re-freeze is regarded as the snowmelt period for the sample point. The end of thaw corresponds to the change in backscatter behavior that can be observed in the C-Band data (Figure 2).

The start and end dates for snowmelt from Quikscat have been used to extract relevant acquisitions separately for each location. A mean backscatter value was calculated from this new dataset. The minimum number of spring observations for 2006 was 5. Since the length of growing season increases to the south, the number of available measurements increases as well. Whilst on average seven values are available in the north, up to 15 observations are used for the calculation of mean backscatter in the South.

All areas with mean spring backscatter below -6 dB are located north of the Ob river. This is the zone of permafrost transition. Thresholds of minimum -10 dB and maximum -8 dB for the mean spring backscatter are determined for the heterogeneous peatlands. They are used for reclassification and creation of a peatland map.

Figure 5 shows the Quikscat results from 2006 for the test area, the extracted mean GM backscatter for the spring period, previous peatland classification results [6] and the reference database [7].

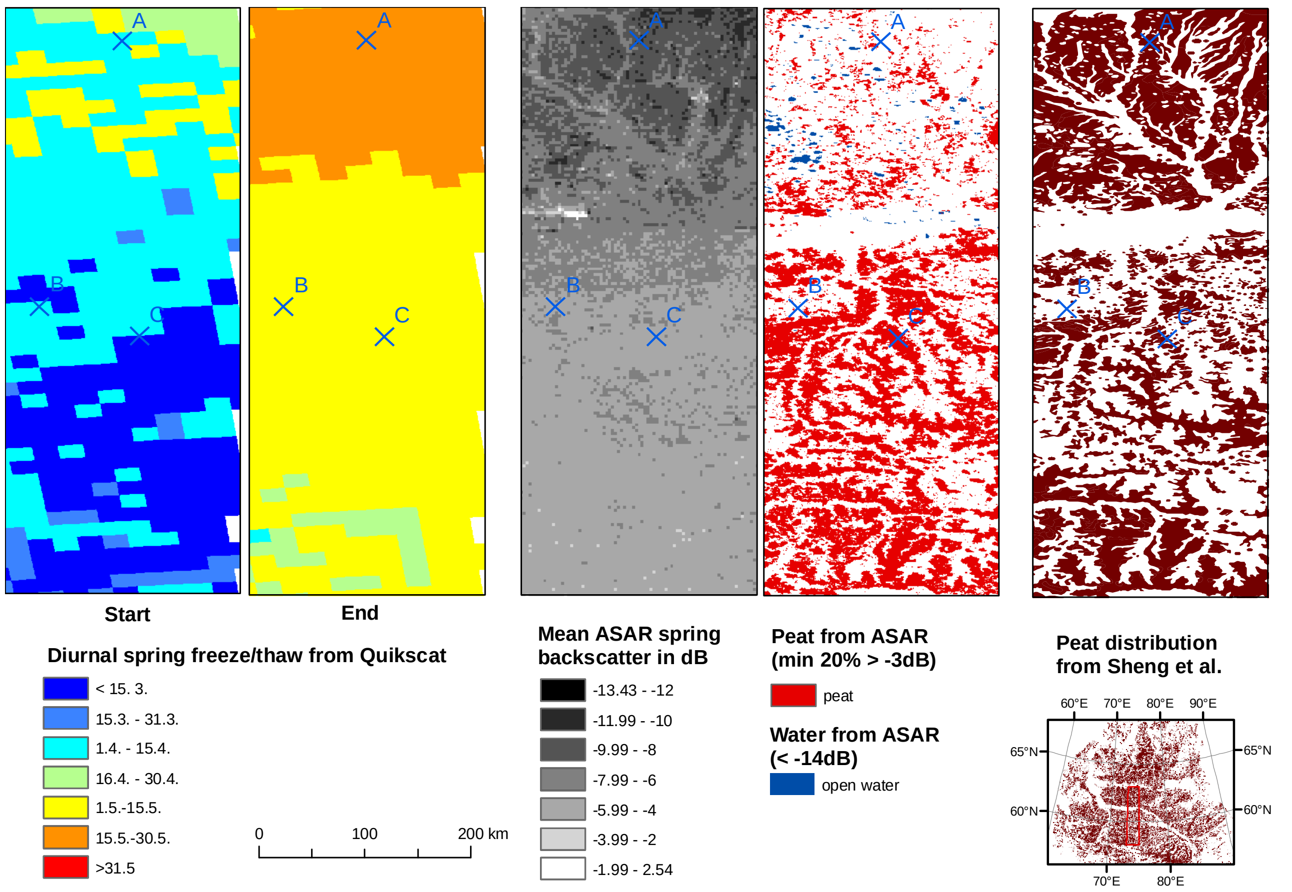

Figure 5. Comparison of Quikscat freeze/thaw dates (2006), ASAR GM mean spring backscatter (2006), ASAR GM derived peat (Jul-Sep 2006, threshold method) and WSL database [7]; for location see inset map

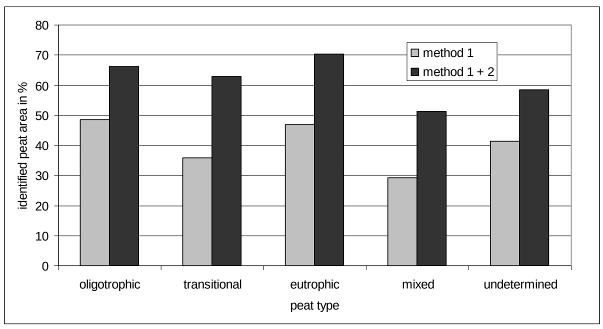

Figure 3. Comparison of ASAR GM derived peat maps (method 1: Jul-Sep 2006, threshold method; method 1 + 2: spring analyses added) with WSL database [7] for different peat types

3. RESULTS

As the area of interest stretches more the 500 km north - south the timing of spring period varies and also its length. In the southern part daily thaw and re-freeze occurs between beginning of March and beginning of May. To the middle and north it is shorter and later. Snowmelt starts in April to beginning of May and ends mostly in the end of May.

The threshold classification gives 20% wet peatland area for the whole study region. This is almost 10% lower than in the WSL database. The proportion of different peat types is shown in figure 3. The proportion of peat area which is can be identified does not vary considerably by type. Almost 50% of oligotrophic peat can be identified but only 29% of areas with mixed peat types.

The new peat map is a combination of the threshold based classification method and the re-classified time series analyses. 39% of entire landcover is mapped as peatland area. It should be noted that 10% in the final as well as first map have been identified additionally. This applies especially to the southern part (compare figure 5 and 4). Those are no additional peatland patches but the size of single patches is often larger but also shifted. This maybe due to generalization in the WSL data and/or geolocation errors (Figure 4) since the layer is derived from 1:1 Mio and 1:2.5 Mio maps [7]. Up to 70% of the major peatland types can be correctly identified with the new method which combines ENVISAT ASAR GM and Sea-

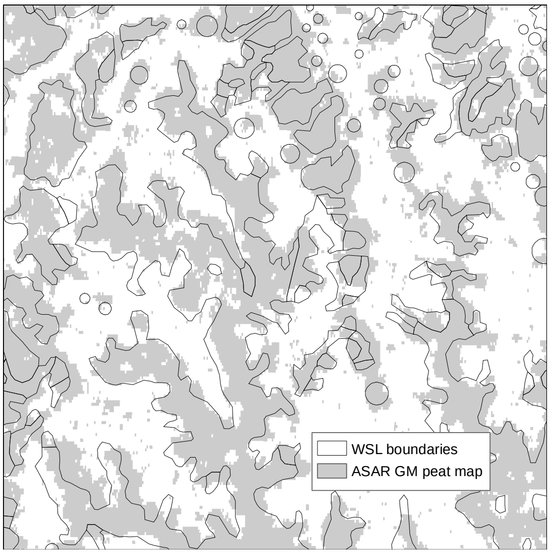

Figure 4. Comparison of ASAR GM derived peat map with WSL database [7]

winds Quikscat data.

4. CONCLUSIONS

Global mode time series analyses allows the identification of boreal peatlands even if they are heterogeneous due to open water surfaces. Although that ENVISAT ASAR Global Mode provides only data with 1km spatial resolution they can be used to map boreal peatlands due to their high temporal resolution. Large areas can be analysed on a frequent basis. In combination with other coarse resolution products from scatterometer, classification results can be considerably improved. Other studies showed that GM is also suitable for monitoring soil moisture dynamics [11]. A combination of monitoring extent and surface soil moisture may provide a valuable tool for climate change research.

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