DETECTION OF WETLAND DYNAMICS WITH ENVISAT ASAR IN SUPPORT OF METHANE MODELLING IN HIGH LATITUDES

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ABSTRACT

Wetland dynamics play an important role for methane release in high latitudes. Inundation as well as changes in surface wetness at local to regional scale can be detected using especially SAR (Synthetic Aperture Radar) data. Acquisitions available from ENVISAT ASAR are assessed for their potential for regular wetland monitoring at high latitudes within the ESA STSE project 'ALANIS - Methane'. Open water surfaces larger than approximately two ha can be identified using a simple threshold-based classification applied to the normalized ENVISAT ASAR wide swath (WS) data. Specular reflection from calm water surfaces which results in low backscatter enables a straight forward identification of inundation in areas with limited vegetation coverage. Open peatland can also be identified with SAR due to their higher moisture content and thus higher backscatter. Both backscatter mechanisms are exploited for intra-seasonal wetland monitoring in Northern Eurasia for ALANIS Methane. Inter-annual variations of inundation are also derived at selected sites in boreal/arctic environment as part of the ESA DUE Permafrost project. This paper especially discusses limitations due to sampling frequency and the potential for improvements of regional scale wetland detection approaches. [1]

Key words: high latitude, inundation, methane, SAR.

1. INTRODUCTION

ALANIS Methane[2] is a research project to produce and use a suite of relevant earth observation (EO) derived information to validate and improve one of the next generation land-surface models and thus reduce current uncertainties in wetland-related CH_4 emissions [1]. It is part of ESA's Support to Science Element Program.[3]

[1]Proceedings of the ESA Earth Observation for Land-Atmosphere Interaction Science conference, Frascati 2010

[2]www.alanis-methane.info

[3]www.esa.int/stse

Table 1. Number of ASAR WS acquisitions during May to September 2007 and 2008.

Region	2007	2008
Western Siberia North	364	340
Western Siberia South	274	295
Lena	146	142

The focus on the remote sensing side of the project is the development of new and/or improved wetland maps, and snowmelt and frozen ground information [2]. Wetland dynamics are investigated on regional to local scale over Northern Eurasia for the years 2007 and 2008. Algorithm development is carried out over three selected test regions in a first step. They cover the lower and middle Ob basin (West Siberian Lowlands) and parts of the Lena basin (see Figure 1).

Global wetland databases such as from [3] lack information on seasonal dynamics. Long term variations in inundation can be capture with coarse resolution passive microwave data (SSMI, [4, 5]). Such data can be used to improve methane modelling, but uncertainties are large in areas with lower water fraction [6]. Coarse to medium resolution satellite products which are used for landcover maps (such as from MODIS, 500m) show in general low accuracy in high latitude environments, since e.g. tundra ponds are mostly below the resolution of the satellite data [7, 8]. Synthetic aperture radars (SARs) operating in ScanSAR mode (e.g. ENVISAT ASAR Wide Swath, 150m) have shown to be applicable for efficient and accurate water bodies mapping at high latitudes. ScanSAR data are therefore used for the development of a local scale wetland dynamics product.

This paper presents results from the first studies with ENVISAR ASAR Wide Swath over the ALANIS-Methane test regions for 2007. Data availability is crucial and is therefore reviewed over all sites.

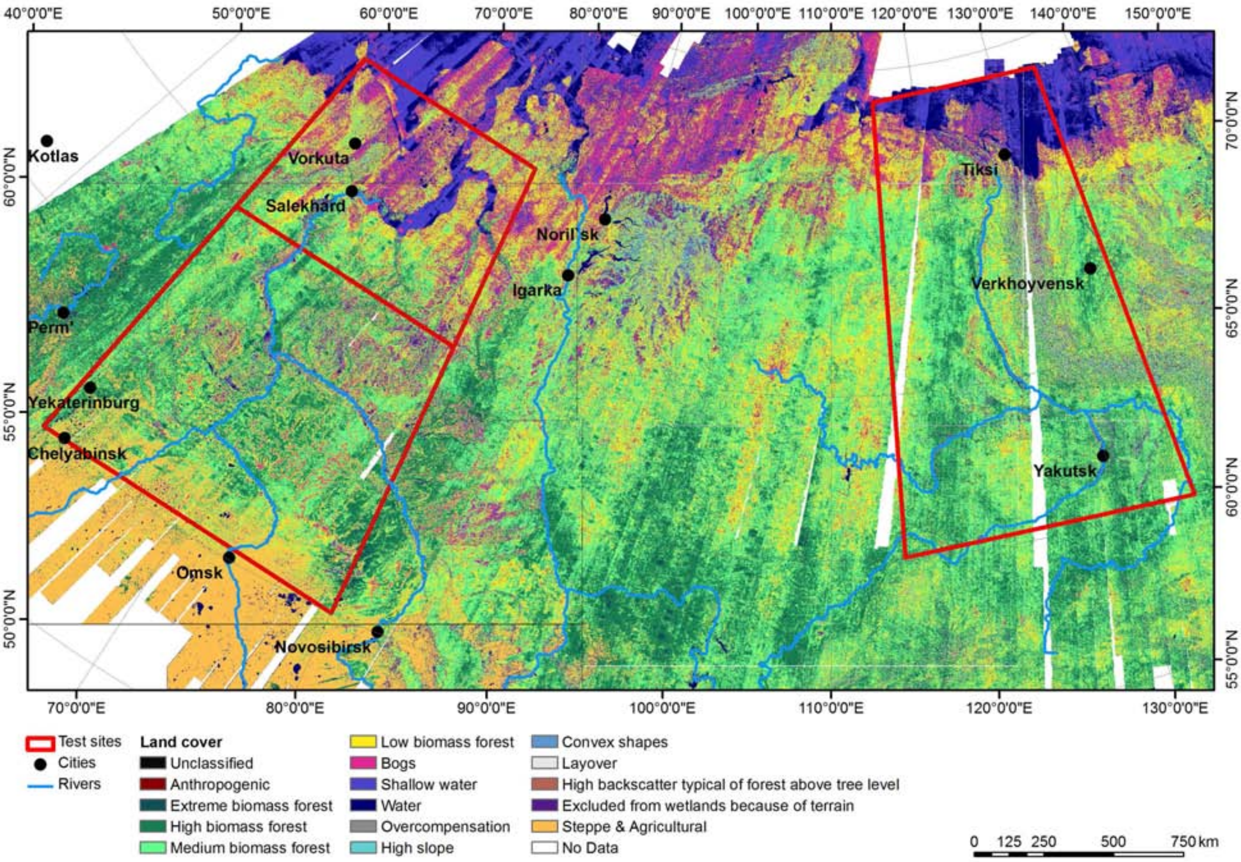

Figure 1. Overview of initial test sites of ALANIS-methane. Background: JERS derived land cover map from [9].

2. DATA AVAILABILITY

ENVISAT is orbiting the Earth in a sun synchronous orbit at about 800 km altitude. The Advanced Synthetic Aperture Radar (ASAR) is one of the instruments aboard. It operates in C-band (wavelength about 5.6 cm) and offers several acquisition modes. These modes differ in spatial resolution. Data in specific modes are acquired on request except for the coarse Global Monitoring Mode. This results in highly irregular sampling in space and time [10]. Data acquired in Wide Swath (WS) mode have a spatial resolution of about 150 m. In this study both images with HH and VV polarisation and with ascending and descending orbits were used in order to increase sampling frequency.

The number of acquisitions made by ASAR in wide swath (WS) mode during the summers of 2007 and 2008 was higher in Western Siberia than in the Lena region (Table 1). Data availability is low during May 2007 and August 2008, especially in the Lena region. The melting

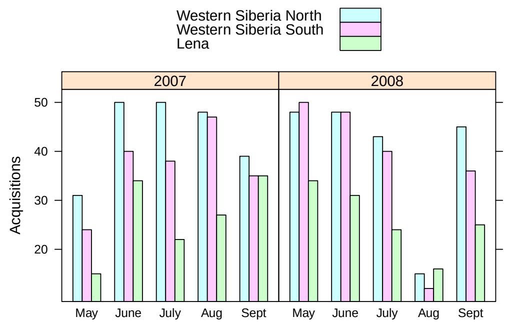

Figure 2. Number of ASAR WS acquisitions over the northern and southern West Siberia test sites and the Lena test site during the summers of 2007 and 2008.

period from May to June is otherwise covered (Fig. 2). The data density also increases from south to north (Fig. 3 - Fig. 6). This results in revisit times of about 8 to 13 days in the southern part and 2 to 3 days in the northern Ob basin. In the Lena region the revisit interval ranges from about 2.5 days in the north to 12 days in the south.

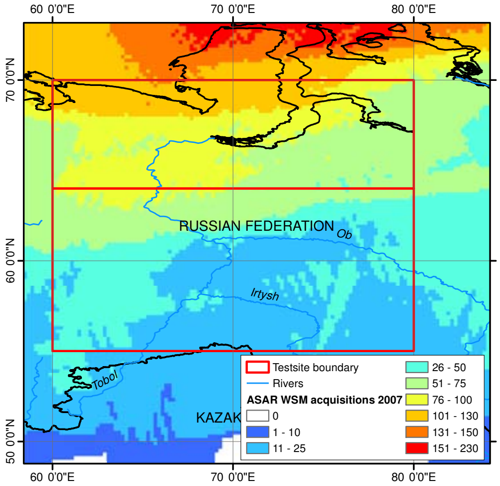

Figure 3. Density of ASAR WS acquisitions over Western Siberia during May - September 2007.

2007

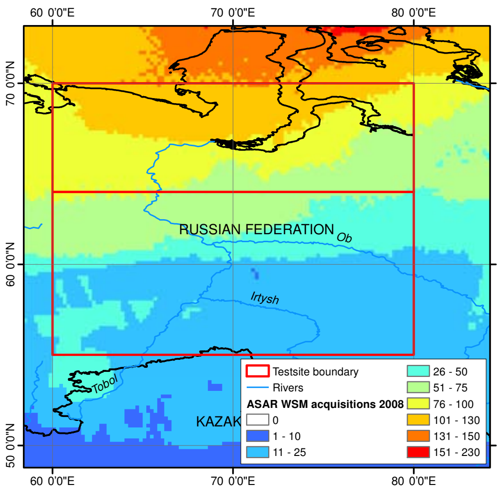

Figure 4. Density of ASAR WS acquisitions over Western Siberia during May - September 2008.

The regional inundation dataset which is used in ALANIS-Methane has 10-day sampling intervals. They ASAR WS intervals are on average below, but it can be also above for some cases (see Figure 2).

3. PROCESSING

Incoming microwave radiation is typically reflected away from the sensor at calm water surfaces which results in low backscatter in areas with limited vegetation cover. Several methods exist for deriving water extent from radar images some of which are described in [11]. Thresholding is one of the most straightforward and

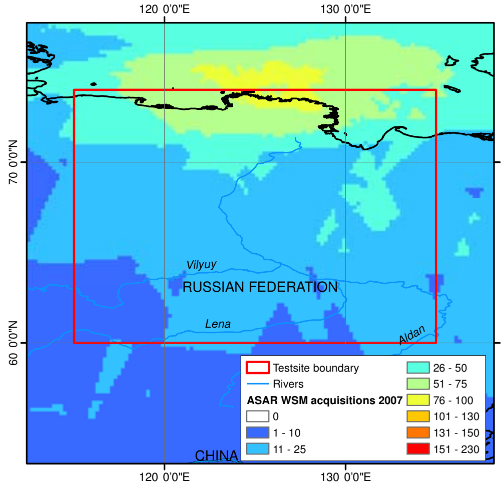

Figure 5. Density of ASAR WS acquisitions over the Lena test site during May - September 2007.

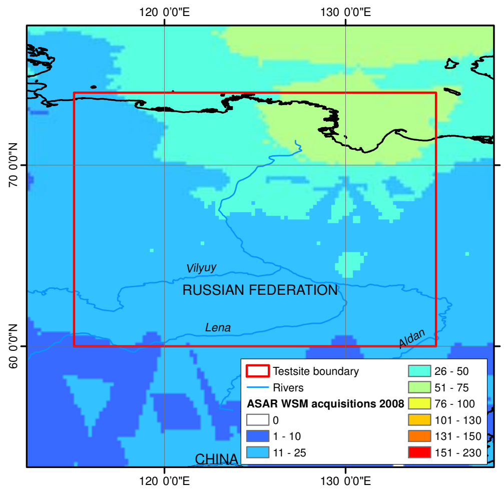

Figure 6. Density of ASAR WS acquisitions over the Lena test site during May - September 2008.

commonly used approaches.

In this study water bodies are classified using a simple threshold method as described in [7]. In a first step all pixels with backscatter $< -14dB$ are classified as water bodies. In this paper water bodies are reported on a monthly basis. A reclassification scheme is applied to determine whether areas are covered by water during the whole month or only part of the month. First pixels which were only sampled once during a month are set to 'no data. In order to cope with errors (edge effects, scalloping) which sometimes occurred within the raw data pixels and which are then subsequently misclassified as water bodies only once per month are therefore reclassified as no water. The remaining pixels are then reclassified according to the portion of observations during which they have been classified as water bodies.

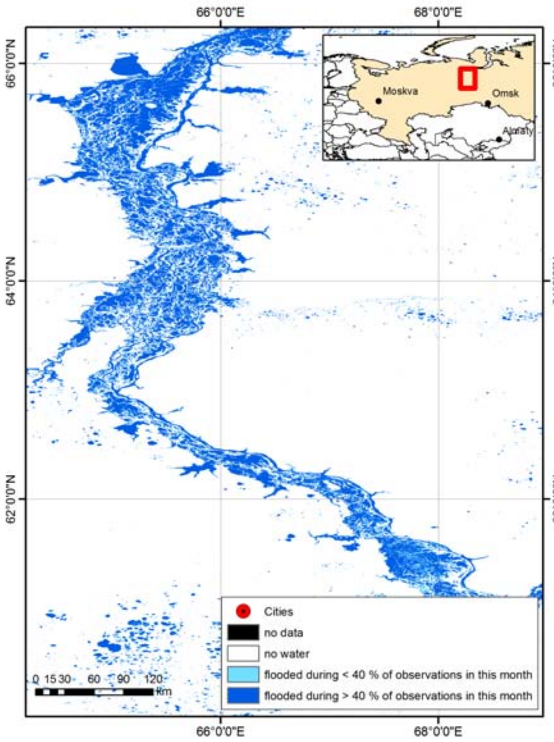

Figure 7. Water bodies in the lower Ob basin derived from ASAR WS for June 2007.

4. RESULTS AND DISCUSSION

Tests have been run for the middle Ob basin between approximately 60°N and 67°N and 64°E and 70°E for snowfree period of 2007. The derived maps show a considerable difference in flooded area between early and late summer due to the impact of snowmelt in spring. The variation is highest west of the Ob river (Fig. 7 and 8) what agrees with regional satellite derived wetland maps [5].

The differences in inundated are large between the seasons and change rapidly. The changes occur on the level of smaller lakes as well as the extent of the floodplain itself. Variations within single months do not only occur during spring but also towards autumn. ASAR WS can identify these changes but careful assessment is required regarding the actual sampling frequency, the limitations of the spatial resolution and the used wavelength. Parts of the flooding may occur below vegetation and is thus not identified with the simple threshold method. The dynamics detection algorithm also needs to consider the evaluation of snowmelt as wet snow area can be misclassified as inundated. This issue will be addressed

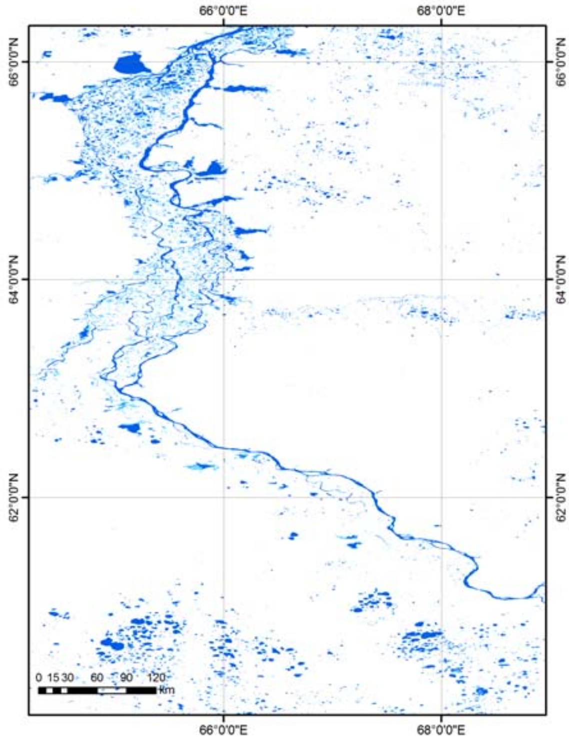

Figure 8. Water bodies in the lower Ob basin derived from ASAR WS for September 2007. For legend and inset map see Figure 7.

using the ALANIS Methane snowmelt product which is based on Metop ASCAT data [2].

5. SUMMARY AND OUTLOOK

The preliminary analyses of ENVISAT ASAR WS data over the test regions of ALANIS-Methane demonstrate the suitability to capture wetland dynamics in these environments. Sampling intervals are irregular what needs to be taken into account for the algorithm implementation. Verification will rely mostly on higher resolution satellite data with special emphasis on L-band SAR in order to identify the uncertainties when using C-band with respect to emerging vegetation. The algorithm will be implemented with the use of the SAR Geophysical Retrieval Toolbox (SGRT) developed by the Vienna University of Technology, and the Next ESA SAR Toolbox (NEST), which is developed by ESA. The NEST software features processing in the polar stereographic map projection, which is crucial for high latitude satellite data processing over large regions.

More information is available at www.alanis-methane.info

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