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# Spring snowmelt variability in polar Eurasia

### Introduction

Snowmelt dynamics play an essential role in the hydrological cycle of northern latitudes. Entire northern Eurasia is seasonally covered by snow. It instantaneously impacts not only surface hydrology and the energy budget but also terrestrial biota and thus the carbon cycle. An evolution towards earlier snowmelt in the northern hemisphere has been determined from different satellite date records starting in the 1980s ([58], [59]).

Diurnal differences are investigated in a range of studies since they indicate exactly when snowmelt is taking place. These single days of thaw and refreeze are usually summed up to obtain the number of melt days. Such a method has been specifically used with passive microwave systems over large ice caps like the Greenland ice sheet ([60], [61]) and for mass balance studies over smaller ice caps ([62]). The actual number of dates of snow thaw is of most interest for glacier mass balance studies but the final disappearance of snow together with the length of spring thaw is required in regions with seasonal snow cover. Clusters of consecutive days of diurnal cycling of freeze/thaw are characteristic for the final snowmelt period in boreal and tundra environments ([63]). The start, end and duration of such periods give inside into spring $CO_2$ emissions and river runoff behaviour ([64]). Results of the clustering of diurnal thaw and refreeze days as detected from active microwave satellite data over polar Eurasia is presented in this paper. The aim is the monitoring of spring snowmelt variability not only for assessment of impact of climate change on hydrology and energy budget, but also economy.

### Method

SeaWinds Quikscat (Ku-band) measurements are available since 1999. The first entire snowmelt period on the northern hemisphere is covered in 2000. Large changes in backscatter between morning and evening acquisitions are characteristic for the snowmelt period, when freezing takes place over night and thawing of the surface during the day. A change from volume to surface

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scattering occurs in case of melting. This may cause changes up to 6 dB ([65]). When significant changes due to freeze/thaw cycling cease, closed snow cover also disappears (63). For the identification of melt days over permanently snow or ice covered ground, only evening measurements are considered. Diurnal differences (63) on the other hand are calculated for the delimitation of the final spring snowmelt period. The exact day of year of beginning and end of freeze/thaw cycling can be clearly determined with consideration of long-term noise (63) in order to exclude unnatural effects and changes in soil moisture and snow pack characteristics. Therefore a location specific noise estimate $s_s$ is determined from analyses of long-term backscatter time series. Only then can significant diurnal differences be identified over a variety of environments.

Backscatter at each location in the northern latitudes is measured several times with spatially and temporarily varying footprints during a single day by QuikScat. As this occurs in irregular intervals, the exact number of measurements in the morning and in the late afternoon/evening needs to be taken into account. The diurnal difference $Ds^0$ is calculated by averaging all measurements acquired during morning and evening passes respectively and then calculating the difference . Since the estimated noise of $Ds^0$, $s_s$ is known, the standard deviation of $Ds^0$, $s_D$, can be directly estimated. To identify diurnal changes which are significant at the 99 % confidence interval, $Ds^0$ needs to exceed 3 times $s_D$. A simple three-step approach is pursued to determine the most significant period of freeze/thaw indicators within a time series:

[1] For calculations on the northern hemisphere only periods between 1st of January and 1st of July are considered.

[2] Indicators that are found within initially 10 days of each other are grouped into periods using temporal filtering.

[3] The onset of the major and, usually final, snowmelt period is determined as the indicator period containing the greatest number of indicators. The onset of snowmelt is determined as the first day of this period.

Thus the duration of the snowmelt as detected from QuikScat corresponds to periods of significant diurnal change of surface conditions due to thaw and refreeze.

**Results**

The end of snowmelt timing varied by less than a month in most regions during the eight years of data availability (2000-2007). There has been only a difference of up to two weeks in eastern Siberia. Central and western Siberia, especially the European part experienced more variability. This impedes an assessment whether there is a trend of earlier spring or not. However, monitoring of these regions is of importance for global change and thus also economic issues.

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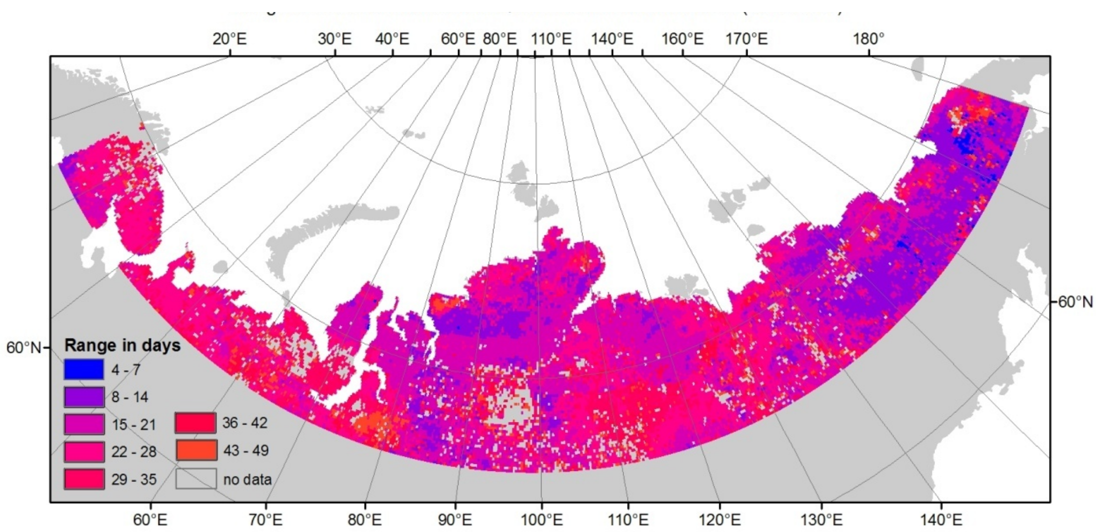


**Figure 1:** Range of end of snowmelt in days from QuikScat Diurnal Difference (2000-2007) over polar Eurasia (12.5km grid).

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