Application of remote sensing and terrestrial methods in distinguishing glacier zones - abstract

Glaciers are an important element of climate stabilization, and changes in the cryosphere may indicate a further, long-term warming trend in climate. For this reason, monitoring of Arctic glaciers and their components is crucial for assessing climate change and its impact on the global system. One of the components of glaciers are glacier zones (e.g. firn, superimposed ice, glacier ice). Glacier zones are areas with a distinct structure, density, percolation properties or albedo of the surface layer. Due to the close relationship between glacier zones and glacier mass balance, monitoring of glacier zones extents over time can provide information about the response of glaciers to climate change. Information on the extents of glacier zones can also support studies of e.g. mass balance, hydrology, thermal processes or microbiology of glaciers.

Satellite methods allow to obtain information both on a local and global scale. Synthetic aperture radar (SAR) satellite imagery is important for the polar regions. There are few studies on the possibility of distinguishing glacier zones using SAR data of different characteristics, typical for either free data or commercial data. This also applies to the methods of SAR image analysis that can be used depending on the type of the SAR data. At the same time, terrestrial data is extremely important for validation of the results of satellite data analysis. For distinguishing the extent of glacier zones, ground penetrating radar (GPR) data and shallow glacier cores are a good source of information. GPR data are usually interpreted visually and the results of such analysis are exposed to the subjectivity of the researcher. Therefore, this work is an attempt to compare the methods of analyzing free and commercial SAR data with different parameters, as well as to objectify the detection of glacier zones by classifying the internal reflection coefficients of the GPR signal.

There are a few high-quality studies on changes in the extent of gacier zones in response to climate change. This is due to the difficulty as well as logistical and technical requirements of the fieldwork, which is the source of the validation data. In this work, a unique set of terrestrial and satellite data was collected in order to study changes in the extents of glacier zones on Hornsund glaciers (Svalbard) between 2007 and 2017. The correlation of changes in the extent of the firn area with the superficial net mass balance of Hansbreen was also examined.

Results of distinguishing glacier zones using SAR data of different characteristics indicate that the analyzed commercial data and the methods dedicated to them have no advantage over free of charge SAR data. This confirms the possibility of using open and free of charge SAR data for distinguishing glacier zones. In addition, analyzes of the internal reflection coefficients of GPR data have shown their high potential as an alternative or additional method to the subjective method of visual interpretation of GPR data and can be used to verify the methodology of a monitoring of glacier zones.

As a result of the research, a decrease in the area of firn and superimposed ice zones for Hansbreen, Storbreen and Hornbreen was found. The largest loss of firn area was recorded between 2010 and 2017 and equaled 13.6 % of the contribution to the total glacier area (44.5 % of firn's area loss). In 2012-2017, a loss of 11.8 % of firn area contribution to the total glacier area was recorded for Hansbreen, 9.9 % for Storbreen and 8.8% for Hornbreen. The decrease in the area of firn of the analyzed glaciers seems to be significant on the scale of Svalbard. At the same time, a relatively strong relationship was found between changes in the extent of the firn zone and the superficial net mass balance of Hansbreen.