Perennial snow patch detection based on remote sensing data on Tröllaskagi Peninsula, northern Iceland

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The understanding of permafrost distribution in Iceland is still limited and current knowledge is mainly based on small scale observations and regional modelling using temperature data. In the Alps Perennial Snow Patches have been considered to protect permafrost from solar radiation and are used as an indicator for the occurrence of local permafrost. In this study perennial snow fields are detected and classified based on aerial and satellite images. Effects of climatic and topographic factors on the snow field occurrence are investigated aiming to provide insight into the distribution of local permafrost in northern Iceland. Multi-temporal optical satellite images (Landsat-5/-7/-8 and Sentinel-2, 1984–2017) have revealed a time-variable distribution of perennial snow patches as possible permafrost indicators on the Tröllaskagi Peninsula in northern Iceland. Calculated normalized difference snow index in combination with different threshold values at the end of summer season within six selected study areas show that several snow patches are present in a time period of over 30 years. Perennial snow patches in the study areas exhibit strong fluctuations in extent due to different local characteristics, e.g. elevation, aspect or topography (plateau/open slopes vs. valleys/cirques). In three of the six study areas snow patches have a high probability of occurrence and the pattern of the distribution is very similar in each time period. Comparison with climate data from nearby weather stations indicates that perennial snow patches can be used in combination with mean annual air temperatures as indicators for local permafrost distributions.

INTRODUCTION

While there are several studies on geomorphological features indicating extensive periglacial activity in Iceland in general (e.g. Thórarinsson, 1964; Friedman *et al.*, 1971; Schunke, 1974; Van Vliet-Lanoë *et al.*, 1998), the understanding of the regional distribution of permafrost is still limited. According to Lilleøren *et al.* (2013) knowledge of the local distribution of permafrost as well as of its thermal state is important for different issues, e.g. slope stability, natural hazard assessment and infrastructure development. In the mountain regions of Iceland, current knowledge on permafrost distribution is based on a limited number of small-scale observations (e.g. Sæmundsson *et al.*, 2012, Kneisel *et al.*, 2007; Sæmundsson *et al.*, 2018; Morino *et al.*, 2019). Among the first inventories of the permafrost distribution are those made by Þórarinsson (1951), Stingl and Hermann (1976), Priesnitz and Schunke (1978), Stötter (1991), Whalley and Martin (1994), Þórhallsdóttir (1994; 1996; 1997) and Sæmundsson *et al.* (2012). Based on point-measurements, Etzelmüller *et al.* (2007) and Farbrot *et al.* (2007a) developed the first ideas on Icelandic-wide patterns of permafrost distribution using the mean annual air temperature (MAAT) as an indicator. Etzelmüller *et al.* (2007) point out that permafrost exists at sites with limited snow cover below the MAAT -3°C isotherm, ranging from ca. 700 meter above sea level (m a.s.l.) in the north to ca. 1000 m a.s.l. in the