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Creating of topoclimatic map of High Arctic region (Forlandsundet region, NW Svalbard) by verifying the theoretical approach using thermal satellite images

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As is known the Arctic is more sensitive to climate change than others regions around the world. Resolution of both global and regional climatic models is so small that the variability of local climatic conditions is ignored. On Svalbard this variability is high, mainly because of terrain relief, lithology and land cover. Up to now, topoclimatic conditions is mainly evaluated by combining point, meteorological measurements data series with theoretical approach based on estimation of heat balance of active surface. High terrain variability and relatively short series of observations on small number of measurements sites does not give an opportunity to verify theoretical assumptions completely. In this study, we would like to present a new, comprehensive approach to creating of topoclimatic maps on Spitsbergen by combining theoretical approach with empirical data from point meteorological measurements and thermal satellite images.

Work has been carried out for two areas: Kaffiøyra located on the west coast of Oscar II Land, and the middle part of Prins Karls Forland island. In those two regions, a grid of air temperature and humidity measurement sites are located. Kaffiøyra region (129.7 km^2) covers extensive coastal plain and six alpine type glaciers filling mountain valleys. Glaciers and permanent snow patches covers 45% of total area and maximum altitude reaches 936 m a.s.l. In Prins Karls Forland region (135.4 km^2) ice cover encompasses only 13% of area and maximum altitude is 702 m a.s.l. In the axial part of the elongated island runs a mountain chain cut by a valley connecting its two banks.

Method presented in this study combines theoretical and empirical approaches. The source data for theoretical approach was Digital Elevation Model of Forlandsundet region with 5 m resolution, vector map of the coastline, glaciers range, frontal moraines, etc., digitalized geological map, land cover and vegetation raster maps and interpretation of modern Santinel-2A satellite images with 10/20 m resolution. Topoclimatic units have been distinguished by generalization of unique combination of terrain slope and aspect, windward/leeward location, substrate types and humidity, land cover and classes of direct and diffuse radiation sums.

On the other hand, an empirical approach was used. In this case remote sensing land surface temperature data (LST) has been main source of data. Landsat (5, 7 and 8) and Terra/ASTER satellites images with thermal infrared measurements (1985-2017) have been used. For the interval of 33 years, for each of the studied areas, more than 50 thermal images were acquired from the period of the whole polar day. Air temperature and humidity data from NCU sites net from 2010 – 2015 periods were also employed. The last source of data was calendar of circulation types to evaluate temporal representativeness of remote sensing data.

LST data have been converted into relative deviations from the average for individual areas and then standardized. In the next step, the PCA method was used to distinguish types of LST spatial distributions in the studied areas. Finally, a comparative analysis of LST spatial distributions with the "theoretical" topoclimatic units was carried out.