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Temporal and spatial dependencies of microwave scattering mechanisms in high latitudes across scales

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Permafrost and seasonal frost affect large parts of the Earth's surface, and are especially important features in high latitudes. Remote sensing has been utilized for Arctic research in numerous fields of study including Hydrology, Snow Science, Ecology and Geocryology. In permafrost research, microwave remote sensing has found many applications from deriving water bodies dynamics to surface state (freeze/thaw) distribution. Freeze/thaw determination requires the analysis of time series and is based on the assumption that backscatter changes uniformly over time for different landscape types when temperatures drop below zero degrees Celsius (autumn) or snow starts to melt (spring). In this study, we utilize C-band active microwave remote sensing datasets of different spatial and temporal resolutions (scatterometer and synthetic aperture radar (SAR)) together with ground temperature time series from the Global Terrestrial Network for Permafrost – Database (GTN-P) to characterize deviating patterns related to freeze/thaw. We explore issues of scale dependencies in freeze-thaw information derived from Advanced Scatterometer (ASCAT) and Advanced Synthetic Aperture Radar (ASAR) data. We also examine the implications of winter-time variability of backscatter time series for snow characteristics and freeze-thaw algorithms using Analysis of Covariance (ANCOVA) of near-surface temperature measurements and ASCAT backscatter time series. We found landscape type specific differences between datasets of differing spatial and temporal resolutions. Distinct differences were found for lake-rich landscapes during autumn, likely caused by lake-ice formation and forest dominated areas during spring. This lead us to further explore the influence of lake ice formation and break-up on backscatter signals using ASCAT and Sentinel-1 datasets. A further issue are winter-time backscatter variations which differ between continuous and non-continuous permafrost. The variations may relate to, for example, rain-on-snow events in warmer areas and a lower representativeness of coarse backscatter data in less homogeneous and warmer areas. Together, these results highlight spatial and temporal patterns in microwave backscatter time series which are essential for freeze/thaw determination.