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Elevation Change Detection for Quantification of Extensive Permafrost Thaw Subsidence in East Siberian Coastal Lowlands

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Permanently frozen ground in the Arctic is being destabilized by continuing permafrost degradation, an indicator of climate change in the northern high latitudes. Accelerated coastal erosion due to sea ice reduction and an increased intensity of ground settlement through ground ice melt caused by rising summer air temperatures result in widespread geomorphological activity. The objective of our study is to analyze time series of repeat terrestrial laser scanning (rLiDAR) for quantification of extensive land surface lowering through thaw subsidence, which is the main unknown in terms of recent landscape development in the vast but neglected coastal lowlands of the East Siberian Arctic. These in-situ data provide the basis for calibration and validation of large scale surface change assessments using very high resolution space-borne elevation data with high precision. Complementing our surveys, we conducted botanical mapping. This allows us to relate elevation differences to specific surface conditions and enhances our capabilities to extrapolate our local observations to larger areas through land-cover classifications of multispectral remote sensing data such as Sentinel-2. Additionally, highly detailed digital elevation models (DEMs) with sub-metre accuracy have been photogrammetrically derived from satellite stereo data. These DEMs contain valuable terrain height information for 3D change detection, in case of DEMs representing the state of a study area at different points in time. The results show that elevation differences are almost always negative. When calculated as rates over time, land surface lowering in the ground-ice-rich Siberian coastal lowlands permafrost amounts to 3-10 cm per year.