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Geoelectrical insights on the evolution of post-glacially uplifted permafrost on Svalbard

Michael Angelopoulos[1,2], Katharina Boie[1], Maximilian Rau[1], Ernst Hauber[3], Michael Zanetti[4], Cynthia Sassenroth[3,5], Andreas Johnsson[6], Harry Hiesinger[7], Nico Schemdemann[7], Pier Paul Overduin[2], Julia Boike[2], and Michael Krautblatter[1]

[1]Chair of Landslide Research, Technical University of Munich, Potsdam, Germany (michael.angelopoulos@tum.de)
[2]Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Potsdam, Germany
[3]German Aerospace Centre (DLR), Berlin, Germany
[4]NASA Marshall Space Flight Center, Alabama, United States
[5]Department of Earth Sciences, University of Pisa, Pisa, Italy
[6]Department of Earth Sciences, University of Gothenburg, Gothenburg, Sweden
[7]Institute of Planetology, University of Muenster, Muenster, Germany

Saline permafrost exists beneath shallow shelf seas, coastal plains shaped by past marine transgressions, and post-glacially uplifted landscapes that were once submerged. In Svalbard, the Kvadehuksletta region northwest of Ny-Ålesund features a diverse landscape comprising raised beach terraces, lagoons, paleo-lagoons (now lakes), and surface seeps. Our study aimed to decipher the evolution of uplifted permafrost over time through two extensive electrical resistivity tomography (ERT) surveys: a 2.3 km terrestrial profile and a 1.0 km amphibious profile that crossed a lagoon. Both profiles originated at the 2024 coastline, extending inland to higher elevations. The 2.3 km profile reached approximately 700 m beyond the Late Weichselian Marine Limit. Shallow sediment samples (0–200 cm deep) were collected to characterize near-surface porewater and sediment properties. Mobile LiDAR scanning was carried out to create a high-resolution topography map (3 cm/pixel, 100 m wide swath) along the 2.3 km transect for geologic context. The ERT data suggest that the state and salinity of permafrost are influenced by the surface geomorphology (e.g., frost-shattered shale/sandstone, coarse-grained beach deposits), uplift duration, storm surge flooding, and the mid-Holocene transgression. Groundwater flow, which freshens porewater, may have flushed salts from coarse-grained deposits during permafrost formation. Consequently, the behaviour of saline permafrost in the coarse-grained deposits of Svalbard may differ from that of finer-grained sediments in other Arctic regions, such as the Alaskan North Slope, where diffusive salt transport dominates in newly exposed marine sediments.