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Multitemporal UAV LiDAR detects seasonal heave and subsidence on palsas

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In the context of the accelerating impacts of climate change on permafrost landscapes, this study employs UAV (Unmanned Aerial Vehicle) LiDAR technology to investigate seasonal terrain changes in palsas – mounds of frozen peat – since traditional remote sensing methods have struggled to capture the full dynamics of these landforms. We investigated two tall (4–5 m tall) palsas in Sweden's largest palsa mire complex, where we performed five field campaigns between September 2022 and September 2023 to track intra-annual frost heave and thaw subsidence. Our approach allowed us to create digital terrain models (DTMs) from high density point clouds (>1,000 points/m²) and analyze elevation changes over time. We found that both palsas heaved 0.15 m from September to April and subsided back to their height from the previous year, or slightly below, over the course of the following summer. At one of the palsas, we observed notable lateral degradation over the study period in a 300 m^2 area, with 0.5–2.0 m height loss, likely initiated during the preceding warm and wet summer months. Part of this degradation occurred between September 2022 and April 2023, suggesting that the degradation of these palsas is not limited to the summer months. Our study shows the value of using UAV LiDAR for understanding how permafrost areas are changing. It helps in tracking the ongoing effects of climate change and highlights palsa dynamics that would not be captured by annual measurements only.