Estimating Snow Water Equivalent at the Watershed Scale using Drones in the Arctic Shrub-Tundra

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ABSTRACT

Spatial variations in snow depth and density translate to heterogenous snow water equivalent (SWE) in shrub-tundra environments. Spatial variability in snow depth is primarily due to winter blowing while density variability is due to snow metamorphism process. Recent advances in remotely piloted aircraft systems (RPAS) and structure-from-motion photogrammetry (SfM) have allowed for the measurement of high-resolution spatial and temporal changes in snow depth across snow covered landscapes. This is a major advance in high-resolution remote sensing that provides significant opportunities to advance hydrological process understanding and testing of predictive snow models. However, due to complexities relating to accurately estimating similar spatial or temporal variability in snowpack density, there has been little advance towards mapping SWE at comparable scales. In this paper we address these shortcomings by combining high-resolution snow depth maps created using RPAS SfM with spatially distributed snowpack bulk density observations to accurately map SWE for a small (1 km^2) watershed. These data allowed mapping of late winter snow depth, density and SWE across dominant vegetation and topographic land cover types. Spatially distributed snowpack density observations were collected using representative snow surveying and snow pits. An empirical relationship between snow depth and density was produced and applied to the SfM snow depth maps to estimate SWE. Final SWE maps were validated using *in situ* snow depth and SWE observations obtained within the study area, demonstrating highly accurate snow depth and SWE results. Furthermore, we were able to provide an in-depth analysis of late winter SWE variability across the dominant landcover types, revealing significant differences in water storage across the watershed.

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