Influence of vegetation and topography on snowmelt and spring freshet in nival tundra environments, NWT

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Tundra snowpack distribution

Arctic tundra environments are characterized by heterogeneous end-of-winter (EOW) snow cover resulting from wind transport and deposition over the winter months. Spatial variations in EOW snow depth and snow water equivalent (SWE) across tundra environments result in a sporadic spring snowmelt (Marsh et al., 2008, Pohl & Marsh, 2006). Documenting the effects of vegetation and topography on the timing and magnitude of the spring melt is important for understanding the hydrological systems, but is complicated by a lack of high resolution datasets that can accurately capture small scale changes in snowmelt runoff areas. Difficulties arise with rapid local climate warming as there are many poorly understood changes to the hydrological systems that make modelling future changes difficult (Shi et al., 2015).

Landscape controls on snowmelt patterns

The majority of water storage is located in short shrub and drift regions dominated by permafrost and is classified as a nival tundra system featuring large sporadic patches of tall shrubs.

Snow water equivalent

- SWE varies greatly across the basin
- Majority of water storage is located in tundra regions
- Tall shrub and drift regions on average contain 2-3 times basin average SWE. As the melt progresses tundra and short shrub SWE decline rapidly.
- Basin snow meltwater storage declines rapidly for tundra and short shrub whereas the tall shrubs and drifts still contain a relatively large portion of the basin water storage late into the melt.

Snow covered area

- Snowmelt patterns across the landscape arise from an uneven distribution of snow depths and variations in vegetation cover, slope and aspect.
- Regions dominated by short shrub vegetation melt at a much earlier date compared to the surrounding tundra.
- Tall shrub and drift sites last late into the spring period.
- Short shrub and tundra landscapes are responsible for contributing meltwater at the onset of the spring freshet.

Unmanned Aerial Systems (UAS) applications for hydrology

Remote sensing of snow with UAS

- UAS technology allows for the documentation of snow depth, snow water equivalent (SWE) and snow covered area (SCA) at high spatial and temporal resolutions.
- Snow water equivalent and snow covered area were calculated across the entire Siksik Creek catchment area using a GIS model.
- UAS methodology for documenting changes in snowcover across the melt proved to be highly accurate when compared to in-situ field data collected across the snowmelt.
- Landscape hydrological regions of interest were delineated using high resolution UAS orthomosaics and Digital Surface Models (DSM).

Spring snowmelt water balance

- Measurements of Precipitation, Evapotranspiration (ET) and Stream discharge were collected using various methods for the 2016 melt period (April 30-June 1).
- This data, along with inputs of SWE storage were used to create a spring water balance.

Spring Water Balance of Siksik Creek: April 30- May 31

- Lag period between snow ablation and streamflow initiation is likely a result of the transit time for meltwater to reach the stream channel.
- By the time we observe any substantial discharge the basin SCA is below 75%. Basin wide SCA dropped 50% between May 11th and May 12th.
- Significant lag periods between initial decline in basin snow water storage and the first measurable streamflow.
- Initial stream runoff is primarily sourced from tundra and short shrub meltwater output.
- Tall shrub and drift regions contribute meltwater on the downward curve of the hydrograph after the peak freshet. Less responsible for initiation of freshet.
- Future changes in snow distribution caused by changes in vegetation could result in changes to the timing and magnitude of the spring freshet.
- Timing and localized snowmelt strongly control soil temperatures, active layer development, lake recharge, and vegetation communities.

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References

- Marsh et al., 2015. Warming spring air temperatures, but delayed spring freshet.
- Pohl et al., 2008. Documenting the effects of vegetation and topography on the timing and magnitude of the spring melt is important for understanding the hydrological systems, but is complicated by a lack of high resolution datasets that can accurately capture small scale changes in snowmelt runoff areas. Difficulties arise with rapid local climate warming as there are many poorly understood changes to the hydrological systems that make modelling future changes difficult.