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

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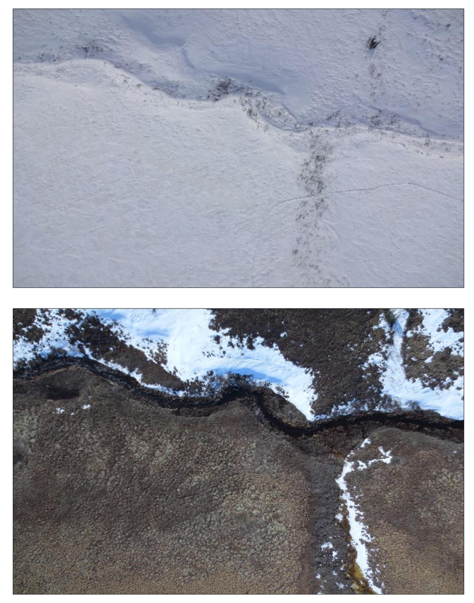
Tundra snowpack distribution

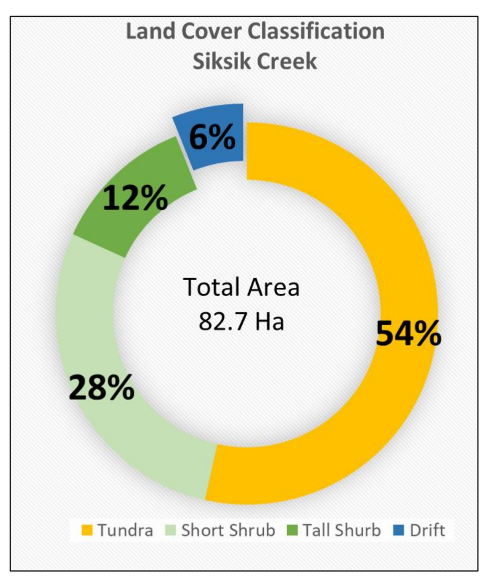
Arctic tundra environments are characterized by **heterogeneous** end-of-winter (EOW) snow cover resulting from wind transport and deposition over the winter months. Spatial variations in EOW **snow depth** and **snow water equivalent (SWE)** across tundra environments result in a **sporadic spring snowmelt** (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).

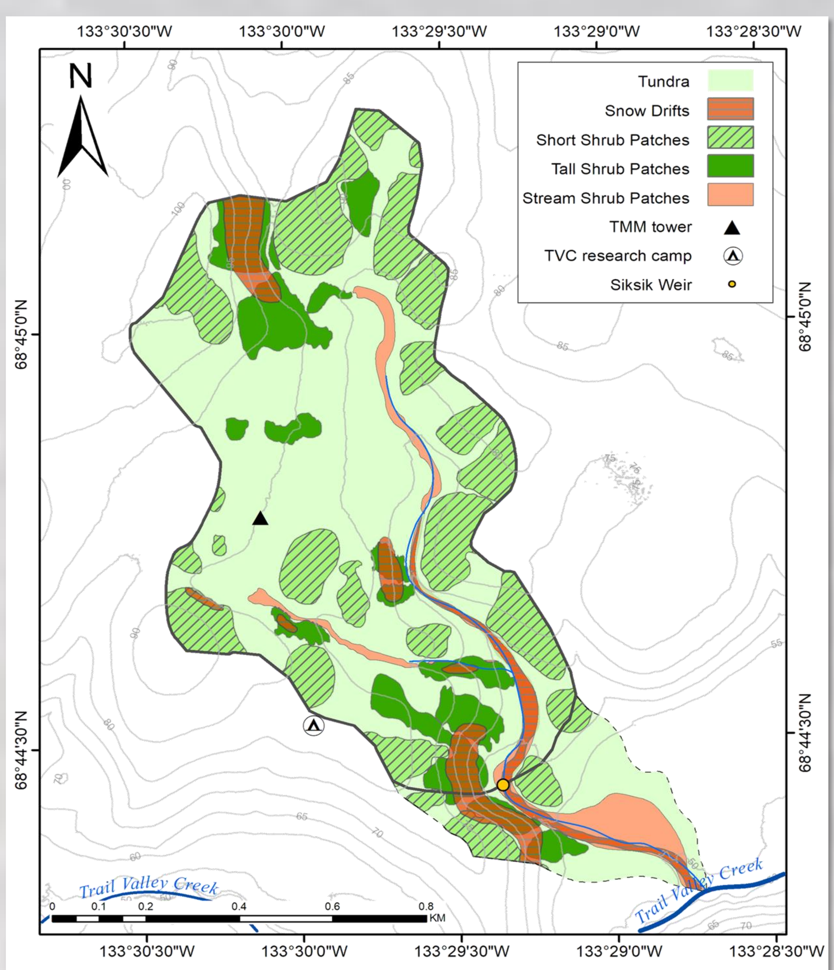


Top: Siksik Creek outlet on April 23, 2016.
Bottom: Siksik outlet on May 12

Siksik Creek, NWT

Siksik Creek (68.74N, -133.49W) lies in the southern Tuktoyaktuk Coastal Plains located east of the Mackenzie Delta. The 95-hectare headwater basin drains south into **Trail Valley Creek** and is situated 50 kilometres north-northeast of Inuvik. Siksik Creek is underlain with **continuous permafrost** and is classified as **a nival tundra** system featuring large sporadic patches of tall shrubs.





Siksik Creek catchment showing land classification units defined by vegetation type and presence of snow drifts. Note a significant amount of overlap between Tall shrub and drift regions.

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

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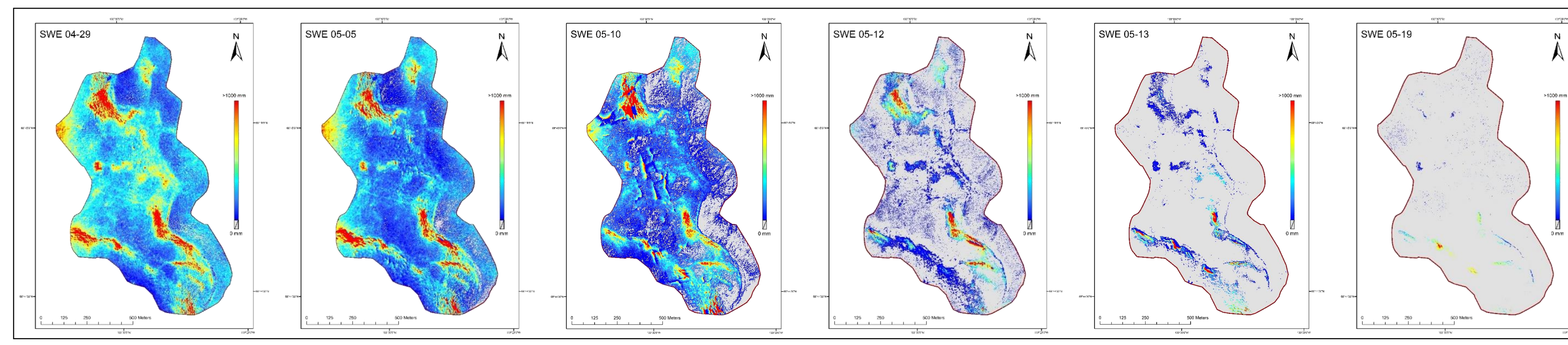
References

- Marsh P, J. Pomeroy, S. Pohl, W. Quinton, C. Onclin, M. Russell, N. Neumann, A. Pietroniro, B. Davison, S. McCartney. 2008. Snowmelt processes and runoff at the Arctic treeline: Ten years of MAGS Research.
- Pohl S, Marsh P. 2006. Modelling the spatial-temporary variability of spring snowmelt in an arctic catchment
- Shi X, Marsh P, Yang D. 2015. Warming spring air temperatures, but delayed spring streamflow in an Arctic headwater basin

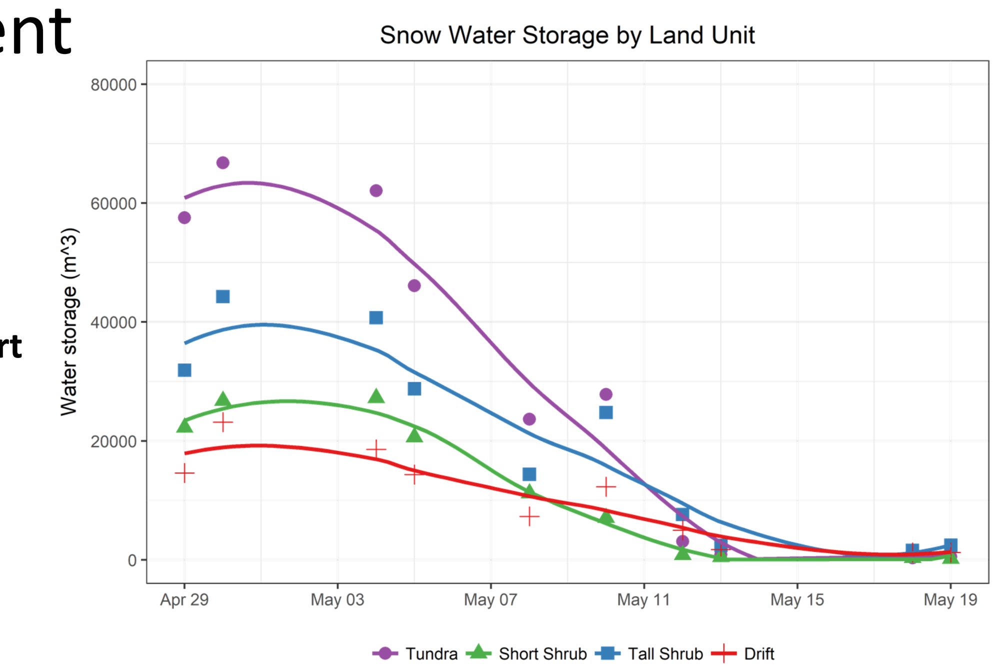
Landscape controls on snowmelt patterns

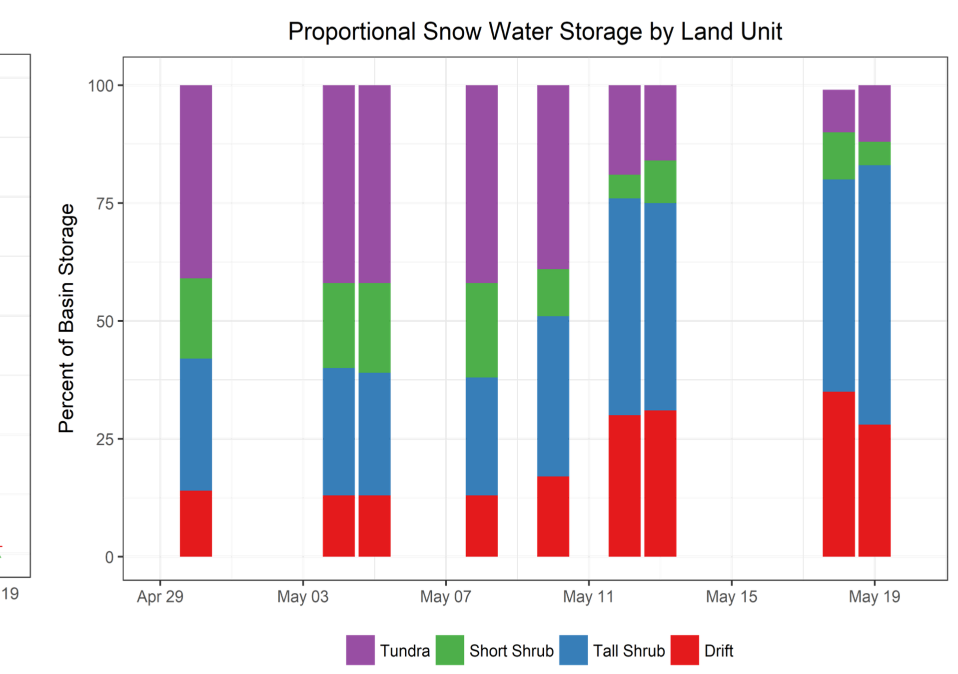


Check out an aerial time lapse video of the 2016 snowmelt!

Snow water equivalent

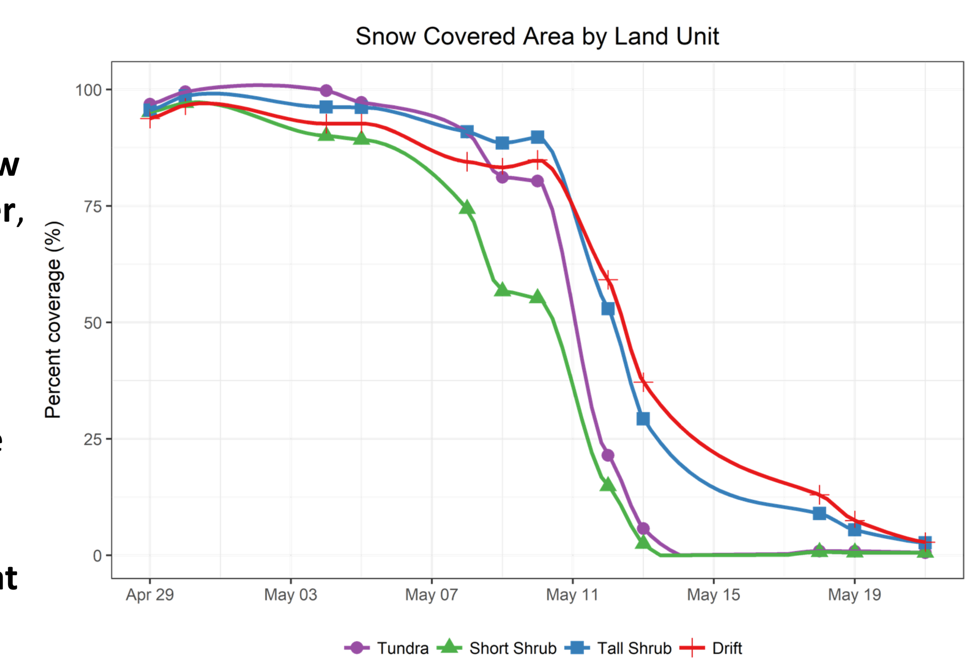
- SWE varies greatly across the basin
- Majority of water storage is located in tundra regions
- **Tall shrub** and **drift** regions on average contain **2-3 times basin average SWE**.
- As the melt progresses **tundra** and **short shrub** SWE decline rapidly
- Basin snow water storage declines rapidly 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

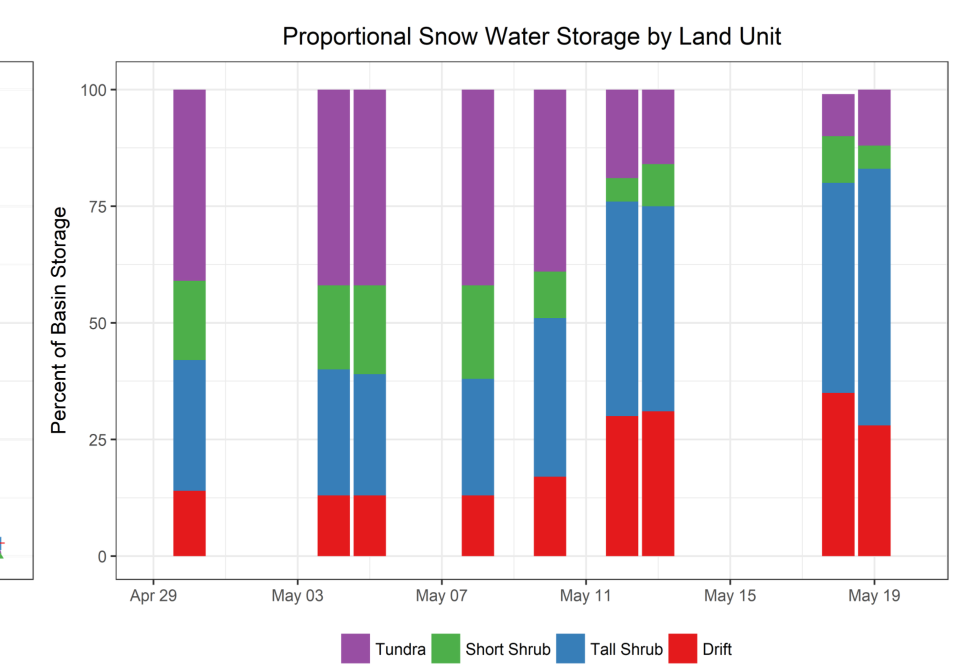




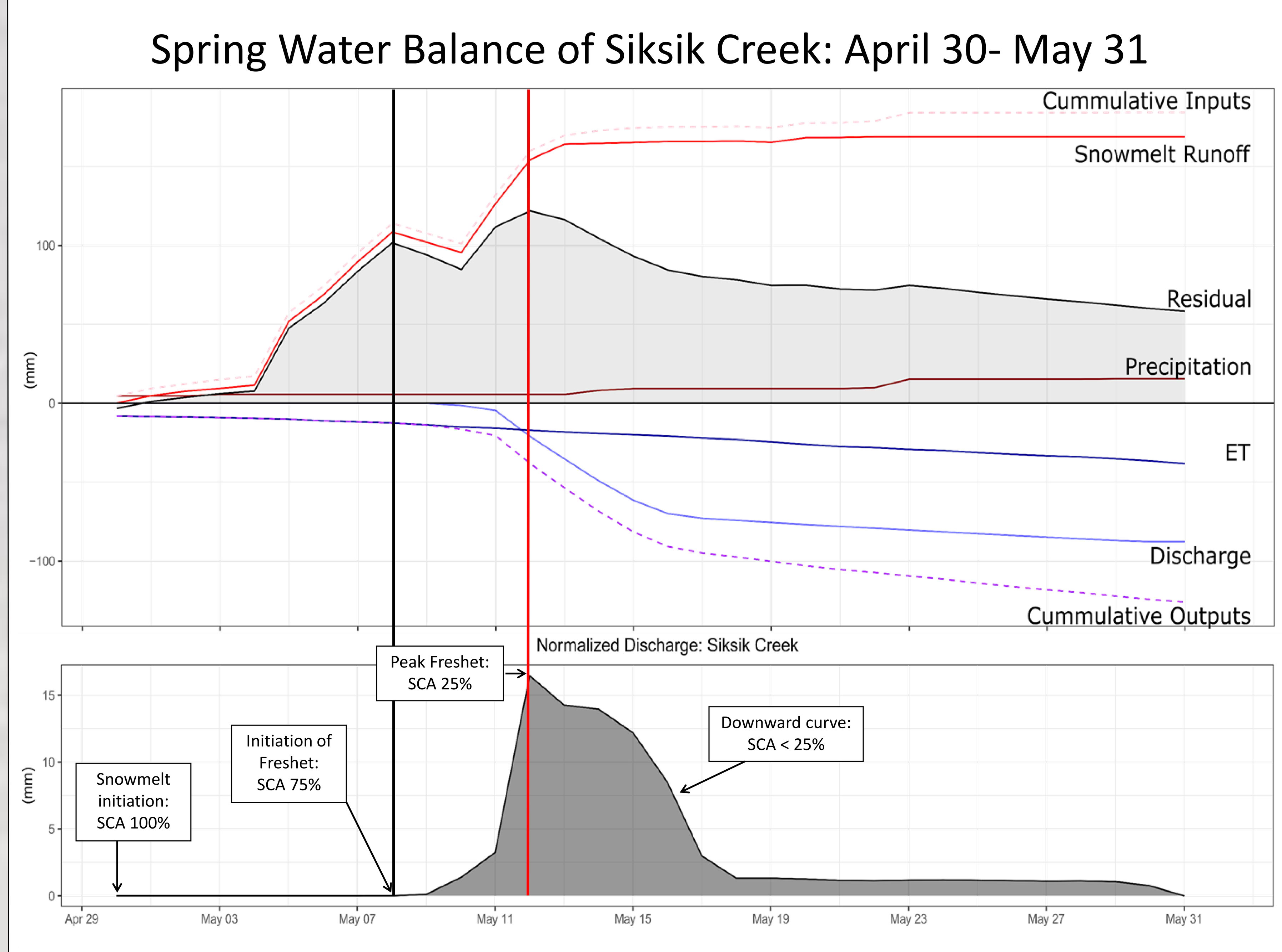
Snow covered area

- 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** followed by the surrounding tundra
- **Tall shrub** and **drift** sites last late into the spring period
- **Short shrub** and **tundra** landscapes responsible for **contributing meltwater at the onset of the spring freshet.**





Implications for snowmelt runoff and spring freshet



- Lag period between snow ablation and streamflow initiation that 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 period 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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