Snow Cover from Satellite Imagery — Summary of Key Messages

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1. Why Remote Sensing for Snow?

Ground-based snow monitoring in British Columbia relies on a network of Automated Snow Weather Stations (ASWS) that measure snow depth and snow water equivalent (SWE) at point locations. While these stations provide high-quality time series data they are sparsely distributed and biased toward treeline elevation. Remote sensing fills this spatial gap by providing wall-to-wall snow cover observations across entire watersheds and mountain ranges.

2. The Satellite Toolbox

A range of satellite platforms is available, each representing a trade-off between cost, spatial resolution and revisit frequency. Low-resolution sensors like MODIS and VIIRS (250 m–2 km) provide daily coverage ideal for tracking snow cover timing across broad regions. Medium-resolution sensors like Landsat and Sentinel-2 (10–30 m) offer more spatial detail but revisit every 5–16 days. High-resolution and commercial sensors (sub-metre to ~3 m) can resolve fine-scale snow patterns but are expensive and infrequent. The volume of freely available imagery has grown dramatically since about 2015 with the Sentinel missions, making operational snow monitoring increasingly feasible.

3. How Snow is Detected

Snow has a distinctive spectral signature: it is highly reflective in visible wavelengths (blue, green, red) but absorbs strongly in the shortwave infrared (SWIR). This contrast is the basis for the Normalized Difference Snow Index (NDSI), calculated from green and SWIR bands. A simple threshold (NDSI > 0.4) produces a reliable binary snow/no-snow classification. False-colour composites — particularly SWIR false-colour — make snow visually distinct from clouds and other bright surfaces, which is critical since clouds are also bright in visible bands but differ in the SWIR.

4. Snow Cover Timing and Duration

By applying NDSI to the full MODIS archive (2001–present), snow cover can be characterized as a seasonal phenomenon with measurable onset, offset, and duration at every pixel. LOWESS smoothing of daily NDSI time series at ASWS locations allows extraction of snow season dates that correlate well with in-situ SWE measurements. Across BC's 30+ ecoregions, snow duration varies by hundreds of days and fluctuates year-to-year by ±20–40 days relative to the mean — variability that is strongly modulated by large-scale climate drivers.

5. Tools for Interacting with Snow Data

Several web applications make satellite-derived snow data accessible for operational and research use.

- The **BC River Forecast Centre**'s interactive flood and drought map provides real-time ASWS data with percentile context https://bcrfc.env.gov.bc.ca/Real-time_Data/Interactive_Maps/Interactive_Q_maps/RFC_DailyQMap.html

- The **ENSO Snow BC** app allows filtering of SWE time series by ENSO phase https://ensosnow-0ce98d2f7c9e.herokuapp.com/
- The **watershedBC** Shiny application enables watershed-scale exploration of snow season duration and snow line elevation by day of year, integrating MODIS-derived snow metrics with other watershed characterization layers https://watershed-rs.shinyapps.io/watershedBC/
- A **Google Earth Engine** app provides near-real-time MODIS snow anomaly mapping across BC https://ee-bevingtona.projects.earthengine.app/view/modissnow

6. Limitations and Complementary Approaches

Optical remote sensing of snow cover is relatively straightforward, but retrieving snow depth, SWE, grain size, and ice lenses remains challenging. Cloud cover and darkness are fundamental limitations of optical sensors. Synthetic aperture radar (SAR) can see through clouds and is effective at detecting melt onset, as demonstrated in the La Joie Basin study. Airborne and spaceborne LiDAR offer direct snow depth measurement. Beyond snow, the same satellite archives enable monitoring of spring green-up phenology, growing season length, and treeline migration — processes closely coupled to snow cover dynamics in mountain environments.

Interested in more? See these references:

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