DSC2-OBS-004 - Getting the right answers for the right reasons: assessing the uncertainty in modelling snow and catchment processes for water resources management.

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Summary of key findings

New tools to assess how seasonal snow contributes to streamflow in Aotearoa New Zealand

The snow that falls in the mountain regions of New Zealand is a major source of freshwater. The seasonal snowpack that develops is unique as it acts as a natural reservoir of water in winter, which is later released over spring and summer. Mountain rivers feed our largest hydro-electric power schemes and provide critical water for irrigation, especially during drought. Given how vital water resources are to New Zealand's economic and social wellbeing, including their importance to Māori and their communities, it is imperative that we have the right tools to accurately assess the contribution of seasonal snow to the water cycle.

To meet this need, this research has taken advantage of state-of-the-art observations of snow obtained from satellites, as well as developing a new modelling framework to assess how much snow is redistributed once it has fallen, to improve how the New Zealand Water Model handles changes in streamflow in alpine catchments in New Zealand. The New Zealand Water Model is currently the primary hydrological modelling tool being used to resolve how weather and climate control streamflow at both the catchment and national scale.

1. State-of-the-art snow observations using high-resolution satellite imagery

It may be surprising to many that until recently we have not had an efficient way to determine how much snow has fallen in our mountain regions. The sheer volume of snow that falls on the highest parts of the Southern Alps has made it very difficult to measure the quantity of snow that is being stored. However, the emergence of high-resolution satellite imagery has been a game changer and opened new possibilities to monitor changes in seasonal snow.

By using very detailed overlapping satellite imagery of the mountains through time, three-dimensional information of the terrain can be extracted from the images using a method known as photogrammetry. This technique has been used to detect changes in snow depth in the central Southern Alps, which has enabled the evolution of the snowpack to be resolved in detail for the first time.

The exact location of where the snow resides in this complex mountain environment can be resolved at a very high spatial resolution. This is critical as our climate changes as we now have the ability to map exactly where the snow is stored and whether some areas will be more susceptible to future warming than others by virtue of the location of the snow (e.g. its elevation, aspect) in the alpine landscape. The detailed mapping has also revealed how much snow is redistributed through processes such as avalanching and blowing snow, which has hydrological significance if the snow is stored longer in spring and summer.

A scientific manuscript describing the key results of this research titled “Resolving and reconciling snow water resources in complex alpine terrain from stereo satellite imagery” has been submitted to the high-standing international journal Water Resources Research and will be publicly available once published.

2. A new modelling tool to assess the redistribution of snow

To better understand the complex spatial patterns of snow accumulation revealed from the satellite derived snow observations, a mass transport and deposition (MTD) model has been developed. The modelling of snow redistribution confirms that snowfall on its own cannot account for the patterns of snow accumulation observed in selected alpine catchments of the central Southern Alps. The new modelling tool has been used to reveal the quantity of snow being redistributed through avalanching and enabled improvements to be made in how the New Zealand Water Model represents the spatial variability of snow in its modelling framework.

A scientific manuscript describing the key results of this research titled “Simulating snow accumulation, redistribution, and mass transport in the Southern Alps of New Zealand” will be submitted to the flagship international journal for cryospheric research, Journal of Glaciology, and will be publicly available once published.

3. Enhancing the representation of snow accumulation in the New Zealand Water Model

The New Zealand Water Model provides a sophisticated modelling framework to predict how much freshwater is available, where it has come from, and how quickly it moves through catchments in New Zealand. The satellite derived observations and modelling of snow developed in this research, in conjunction with atmospheric and snow observations from high elevation weather stations in the Southern Alps, have ensured the New Zealand Water Model now does a “much better job” of capturing snow accumulation and melt than previously. While mapping of snow depth from satellite imagery reveals the elevational gradients of snow storage in the headwaters of selected alpine catchments remain oversimplified in the New Zealand Water Model, it still has the ability to replicate observed patterns of streamflow well.

To provide robust projections of how water resources will be affected by climate change using the New Zealand Water Model, we need to know whether we are getting the right answers for the right reasons. The advances made in this research to reduce and account for uncertainty in the New Zealand Water Model ensure it can now be used more confidently to resolve the climate processes governing the contribution of seasonal snow to the water cycle. Crucially for all New Zealanders, the Deep South Challenge has provided a gateway to ensure robust hydrologic “storylines” will be available for use in decision making by government, communities and industry.

It is anticipated the generation of new “storylines” will be particularly important to Māori and their communities due to their potential relevancy to agricultural and industrial activities, including hydropower, tourism and fisheries investments, and the revitalisation and sustainability of key mahinga kai sites.