Reconstructing the mass balance of Brewster Glacier, New Zealand, using MODIS-derived glacier-wide albedo

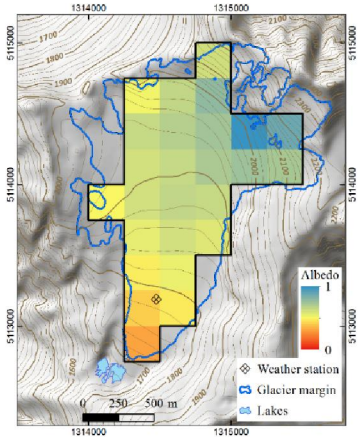
Dr. Pascal Sirguey and Holly Still, School of Surveying

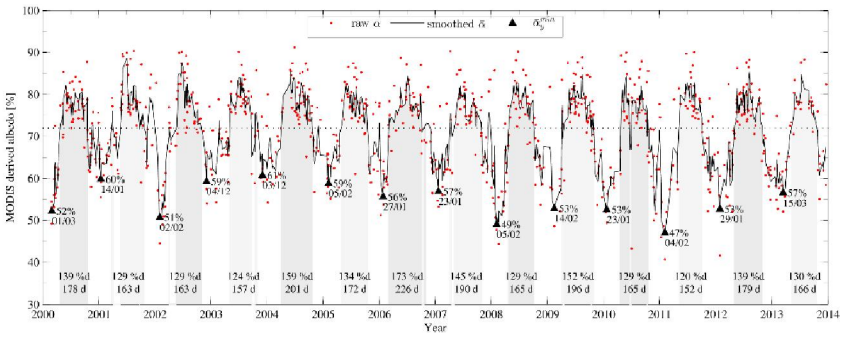
Dr. Nicolas J. Cullen, Department of Geography

Marie Dumont, Meteo France/CRNS, CNRM– UMR3589, CEN

Yves Arnaud, IRD/UGA/CNRS/INPG

Jonathan P. Conway, Bodeker Scientific





Abstract: In New Zealand, direct measurements of mass balance are sparse due to the inaccessibility of glaciers in the Southern Alps and the logistical difficulties associated with maintaining a mass balance record. In order to explore the benefit of remotely sensed imaging to monitor mass balance in the Southern Alps, this research assesses the relationship between measurements of glacier surface albedo derived from Moderate Resolution Imaging Spectroradiometer (MODIS) and mass balance observations using the glaciological method on Brewster Glacier over the 2005-2013 period. We confirm that minimum glacier-wide albedo is a reliable predictor for annual mass balance in this maritime environment (R2 = 0.93). Furthermore, we show that regular monitoring of glacier-wide albedo enables a new metric of winter accumulation to be derived, namely the cumulative winter albedo, that is found to correlate strongly with winter mass balance (R2 = 0.88), thus enabling the reconstruction of separate winter and summer mass balance records. This allows the mass balance record for Brewster Glacier to be extended back to the start of MODIS observations in 2000 and to confirm that the annual balance of Brewster Glacier is largely controlled by summer balance (R2 = 89 %). An application of the extended record is proposed whereby the relationship between mass balance and the photographic record of the end-of-summer snowline altitude is assessed. This allowed the annual balance record of Brewster Glacier to be reconstructed over the period 1977-2013, thus providing the longest record of mass balance for a glacier in New Zealand. Over the 37-year period, our results show that Brewster Glacier gained significant mass of up to 14.6±2.9 m w.e. by 2007. This gain was offset by a marked shift toward negative balances after 2008, yielding a loss of 5.1±1.2 m w.e., or 35 % of the gain accumulated over the previous 30 years. The good correspondence between mass balance of Brewster Glacier and the phase of the PDO/IPO associated with the fast terminus retreat observed between 1978 and 1998 strongly suggests that observed mass gain of Brewster Glacier since 1977 is only offsetting a longer sequence of dominantly negative balances

School of Surveying
Te Kura Kairūri

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L1 Lecture Theatre
School of Surveying
310 Castle Street

University of Otago
Te Whare Wānanga o Otāgo
New Zealand