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Weather pattern-based evaluation of the Intermediate Complexity Atmospheric Research Model (ICAR)

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To study the response of glaciers to a changing climate, process-based glacier mass-balance models (PBGMs) are employed. A wide variety of downscaling tools exists to bridge the scale gap between global circulation model (GCM) output and the input needed by PBGMs, ranging from statistics based methods to full dynamic downscaling. Both ends of the spectrum have their merits depending on the application. However, for the long term study of glacial response to a future climate, a method that is computationally inexpensive and not reliant on measurements is desirable.

The Intermediate Complexity Atmospheric Research Model (ICAR) addresses these requirements (Gutmann et al., 2016). Wind field physics are simplified by applying analytical equations based on linear theory. Scalar atmospheric quantities are then numerically advected within the generated wind field. This allows for computationally fast downscaling and yields a physically consistent set of atmospheric variables.

An important aspect of evaluating downscaling methods is testing their robustness in response to physical situations not explicitly implemented in the method, such as local climatic variations due to synoptic weather patterns. The results additionally may be seen as an indicator of model performance in a changing climate. This contribution therefore focuses on the ability of ICAR to model the climatic variability of precipitation on the local scale by analysing deviations from climatic means occurring during times at which a given synoptic weather pattern dominates. Weather patterns in New Zealand are defined by a classification scheme based on the 24 h mean elevation of the 1000 hPa level.

The analysis is carried out by comparing measured and modeled variations of 24 h precipitation means. Measurement data is obtained from 16 weather stations, six of which are located along the coast while the remaining ten are situated in the complex topography of the Southern Alps. The ability of ICAR to reproduce the observed temporal variations is quantified for the study period extending from January 2006 to December 2016.

At the majority of sites the results indicate a superior performance of ICAR in comparison to ERAI in modeling local scale climatic variations during synoptic weather patterns. ICAR performs best in complex topography, while still outperforming ERAI at most coastal sites. The analysis shows that, in some cases, the high correlation observed for ICAR is not realized in ERAI at all. While the high resolution digital elevation model accounts for the spatial complexity of the downscaled ICAR precipitation fields, the results suggest that the addition of simplified ICAR dynamics is sufficient to generate the temporal complexity found in the measured time series.

Gutmann, E.; Barstad, I.; Clark, M.; Arnold, J. and Rasmussen, R. The Intermediate Complexity Atmospheric Research Model (ICAR), *Journal of Hydrometeorology*, 2016, 17, 957-973