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A new, high-resolution climatological atmospheric dataset for southern New Zealand

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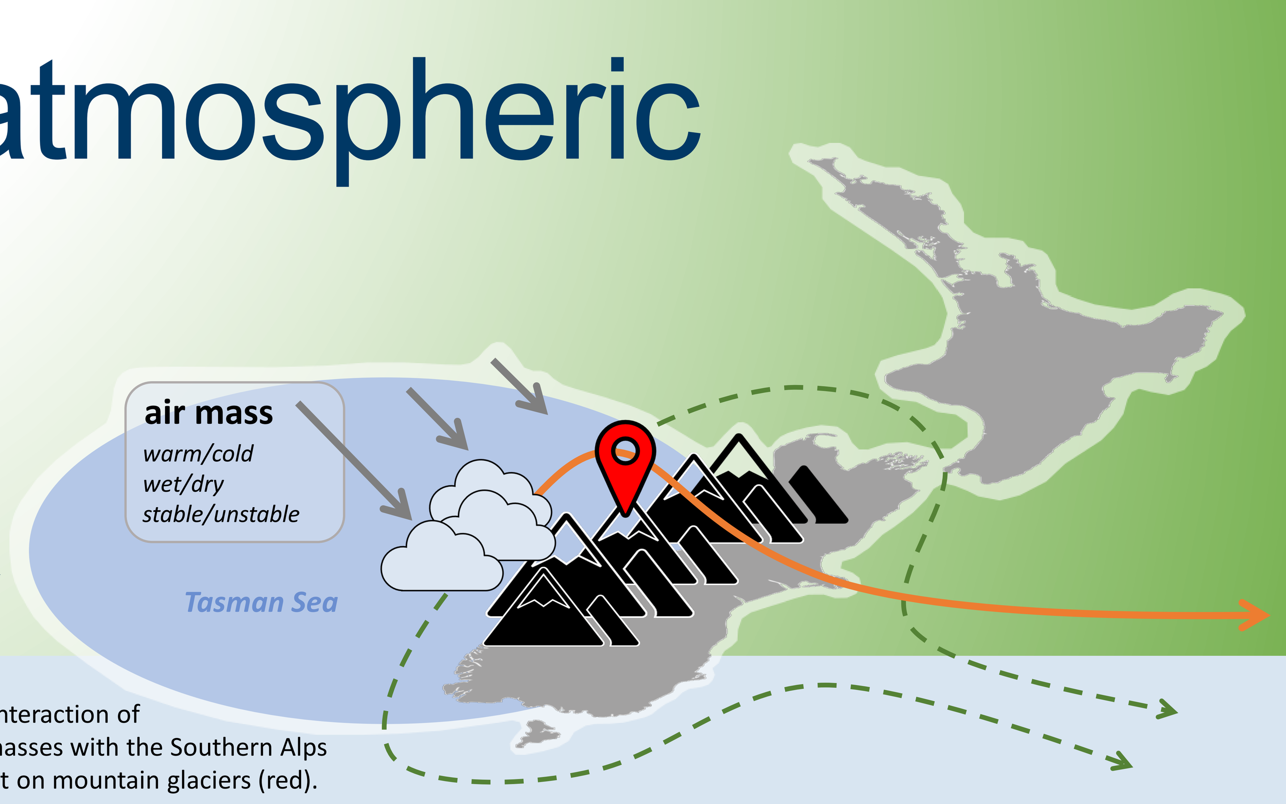


▲ **Figure 1 |** Interaction of maritime air masses with the Southern Alps and their effect on mountain glaciers (red).

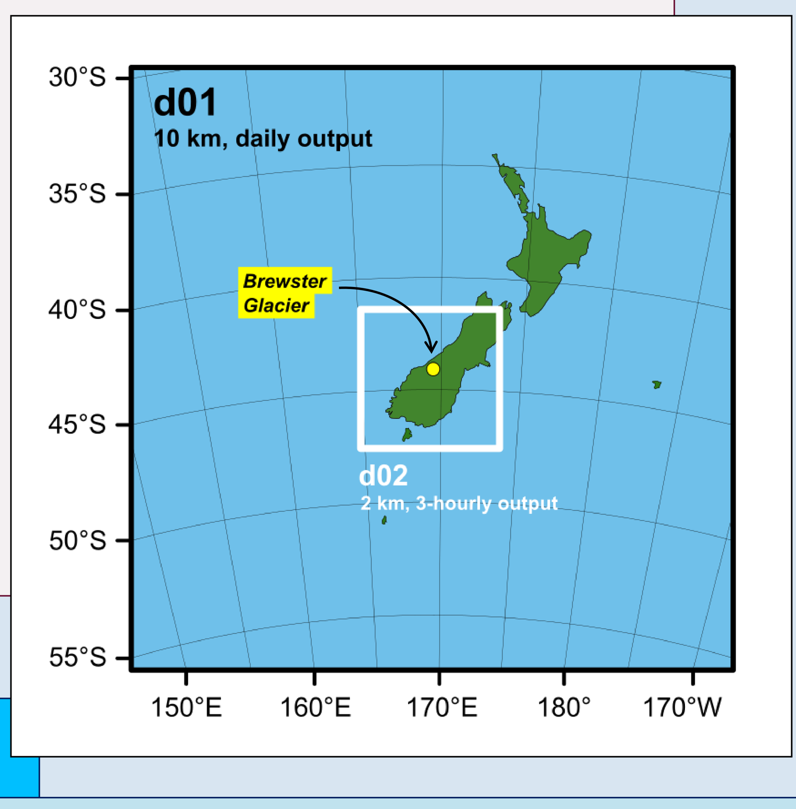
1. Motivation

The regional climate of New Zealand's South Island is shaped by the interaction of the Southern Hemisphere westerlies with the complex orography of the Southern Alps (Fig. 1). Due to the geographical setting of New Zealand in the south-west Pacific, the characteristics of the transported air masses and the regional circulation itself are strongly influenced by the surrounding oceans. Therefore, variations in sea surface temperature (SST) are reflected on a variety of spatial and temporal scales and are statistically detectable through to temperature anomalies and glacier mass balance changes in the high mountains of the Southern Alps. The relationship between SST and high-mountain climate has not yet been investigated from a process perspective, leaving the underlying physical mechanisms that transmit large-scale SST signals to local climate anomalies and glacier mass changes unknown. We have generated a new, high-resolution atmospheric data set to investigate the processes in question.

2. Data and methods

ATMOSPHERIC MODELING

- **Model:** Weather Research and Forecasting (WRF) model
- **Forcing data:** ERA5 reanalysis (31 km)
- **Modeling period:** 2005–2020
- **Domain setup:** Fig. 2
- **Horizontal grid spacing:** 10 km (d01) and 2 km (d02)
- **Output frequency:** Daily (d01) and 3-hourly (d02)
- **Computation time:** 33 days
- **Core hours used:** 1.74 mio.
- **Output size:** 8.2 TB



▲ **Figure 2 |** WRF domain setup

STATISTICAL EVALUATION

REGIONALLY

- **Monthly mean surface climate in d02** using meteorological measurements from a weather station network operated by NIWA and MetService New Zealand.

ⓘ Only stations with an absolute height difference of < 100 m between real station altitude and WRF height at the closest grid point were considered (Tab. 1).

- **Mean atmospheric water content in d02** using MODIS AQUA imagery (498 images) of Cloud Water Path (from MODIS cloud product MYD06_L2; 1 km resolution)

ⓘ Only images that fully cover D2 and are in a ± 30 min time window of a WRF output time were considered. MODIS TERRA did not provide images matching the requirements.

LOCALLY

- **Monthly and daily mean surface climate at Brewster Glacier** (44.08 °S, 169. 43 °E) using measurements (2010–2020) from an automatic weather station beneath the glacier (1650 m).

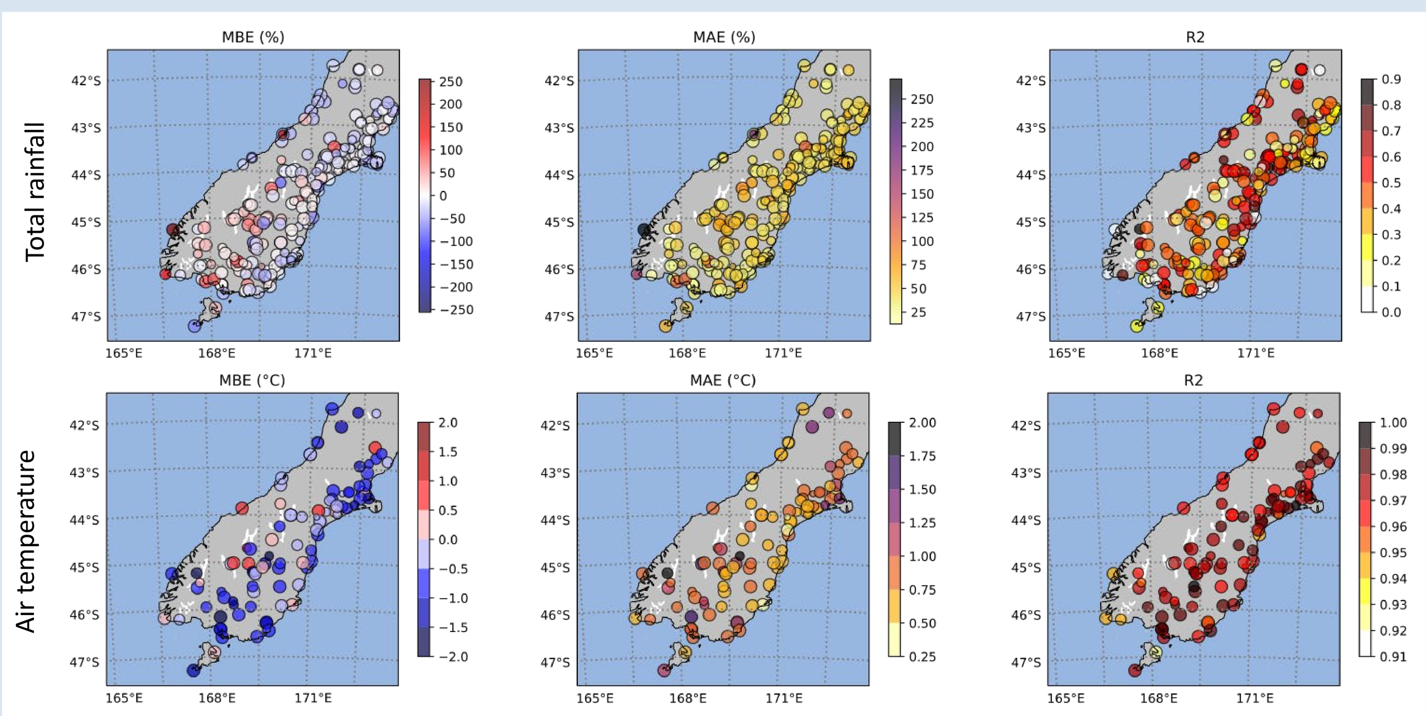
Table 1 | Number of weather stations per meteorological variable and altitude range used to evaluate the surface climate in d02

Variable	Total nr.	≤ 500 m	≤ 1000 m	≤ 1500 m
Monthly mean *air temperature*	102	93	8	1
Monthly total *rainfall*	235	212	22	1
Monthly mean *global radiation*	60	57	2	1
Monthly mean *vapor pressure*	87	80	6	1
Monthly mean *sea level pressure*	68	65	3	0

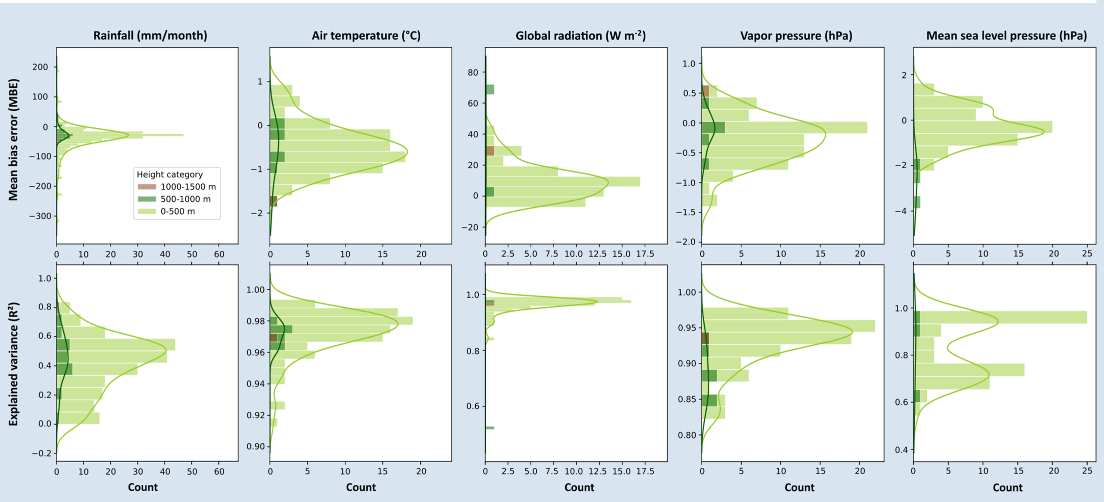
3. Results

The model represents variability in both near-surface meteorological conditions (Figs. 3 and 4) and atmospheric water content (Fig. 5) generally well, although there are both seasonal and spatial biases. High-mountain climate is well captured where the model output can be compared against observations. Despite of the simulation's high spatial resolution, real topography and model topography differ considerably in altitude in many locations so that several stations located in complex terrain could not be reasonably compared against modeled values. The local climate at Brewster Glacier (where landuse and topographic conditions have been optimized) is remarkably well represented on both seasonal and daily timescales (Fig. 6). Very local features like glacier winds, however, are not captured (not shown).

- **Monthly mean surface climate in d02**



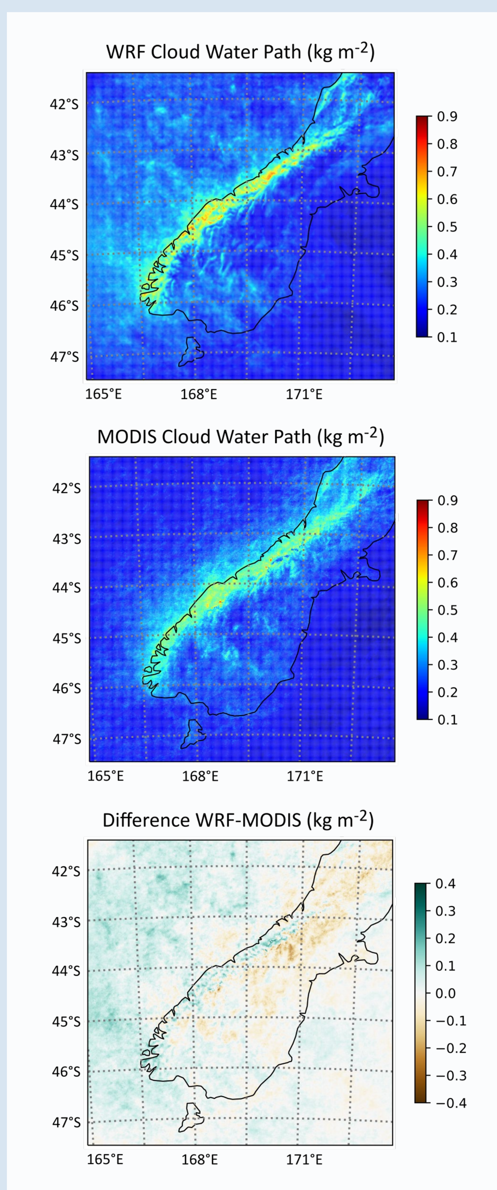
▲ **Figure 3 |** Comparison of monthly means/sums of selected meteorological variables to a network of weather stations for the full modeling period 2005–2020. The size of the circles indicates the percentage of months available for evaluation at each station (≤25%, ≤50%, ≤75%, ≤100%).



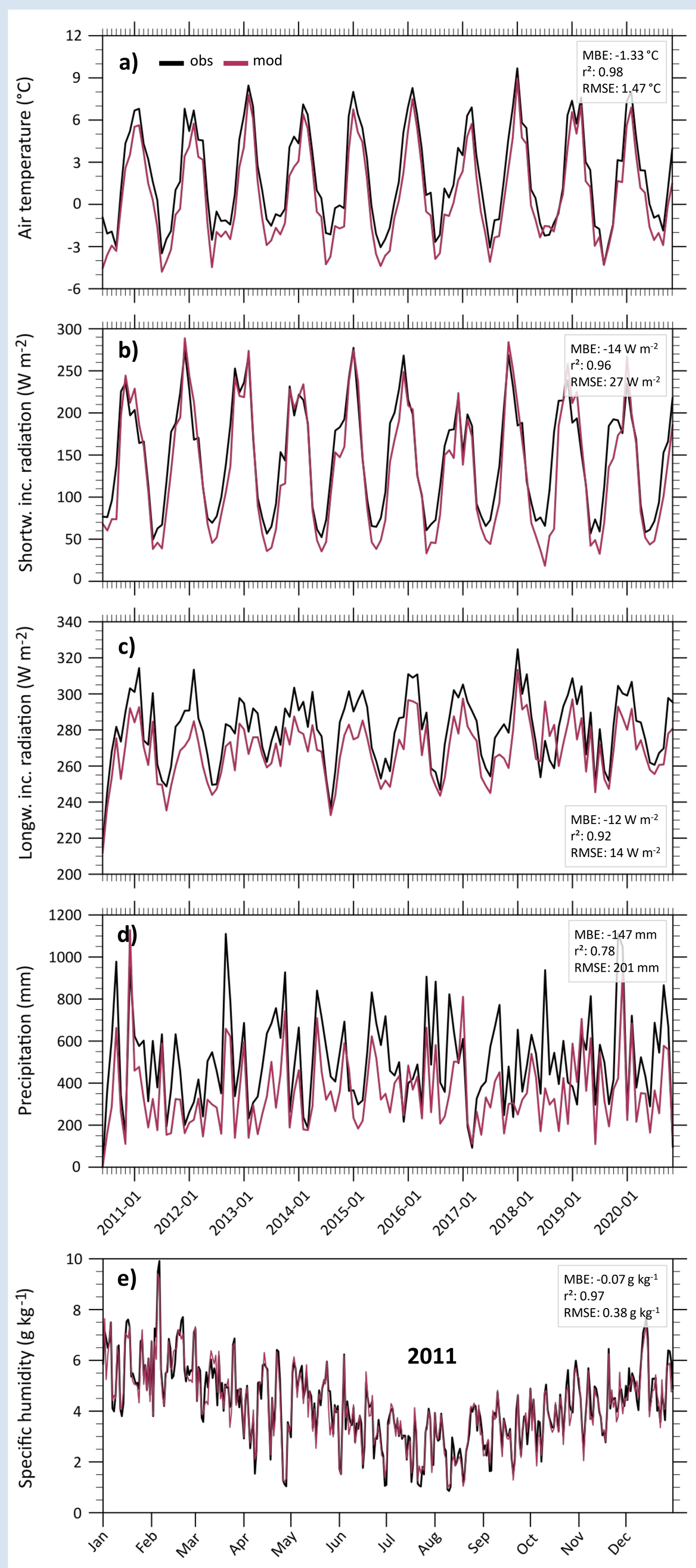
◀ **Figure 4 |** Frequency distribution of selected statistics describing the spatial statistical evaluation of WRF output vs. station measurements (Fig. 3) for monthly means/sums of all considered variables (see methods) in 2005–2020. Colors indicate different altitude ranges.

- **Mean atmospheric water content in d02**

▶ **Figure 5 |** Comparison of Cloud Water Path (CWP) between the WRF simulation (2 km) and MODIS AQUA imagery (1 km). CWP is calculated as the arithmetic mean over all suitable MODIS images (see methods) within the modeling period 2005–2020, as well as over the respective closest WRF output times (always 3 am). MODIS data are regridded to the WRF data.



- **Monthly and daily mean surface climate at Brewster Glacier**



◀ **Figure 6 |** Comparison of monthly (a–d) and daily (e) averages (sums in case of precipitation) of selected meteorological variables simulated by WRF (purple line) and measured at the automatic weather station beneath Brewster Glacier (black line) in 2010–2020.

Public access to data set

Photography encouraged

High Performance Computing
NHR FAU
Institut für Geographie
Funded by DFG Deutsche Forschungsgemeinschaft German Research Foundation
NZ-PROXY Linking Climate Models, Red Algae and Glaciers