Downscaling the Local Weather Above Glaciers in Complex Topography

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27.04.2017

Motivation

Image Credit: Alpenverein Österreich

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How do glaciers behave in a changing climate?

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- process-based glacier mass-balance models

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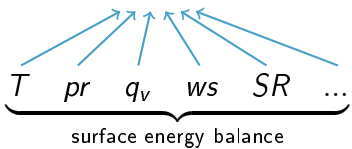

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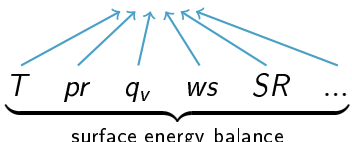

Atmospheric input

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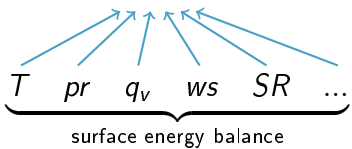

Atmospheric input

- high quality
- physically consistent
- at local scale

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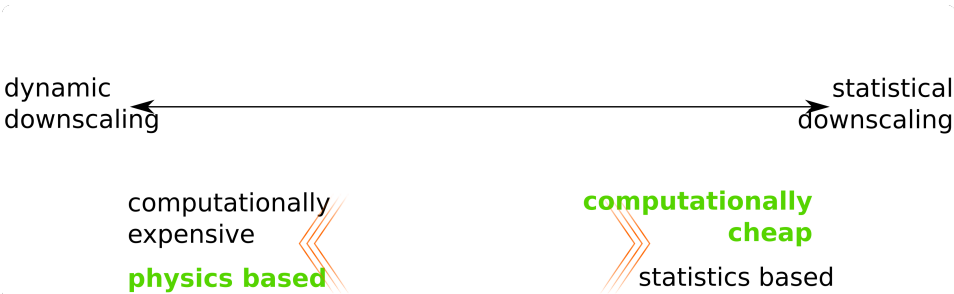
dynamic
downscaling
statistical
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computationally
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physics based
computationally
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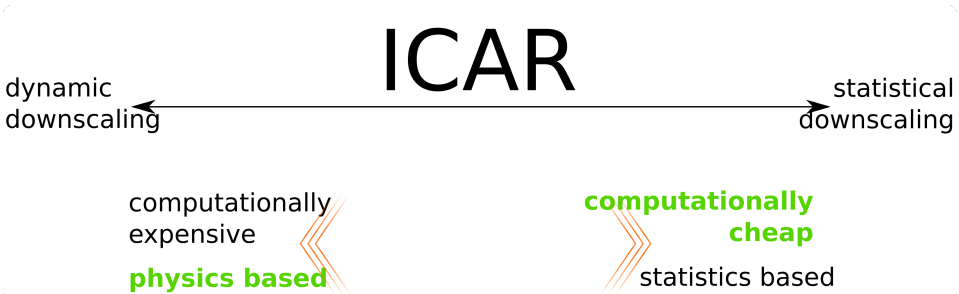

Intermediate Complexity Atmospheric Research model

Gutmann, Ethan, et al. "The intermediate complexity atmospheric research model (ICAR)." Journal of Hydrometeorology 17.3 (2016): 957-973.

ICAR

Atmospheric model

- allows **physics based downscaling**
- quantities stored in 3D grid
- advected within windfield

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Windfield

- calculated analytically
- based in linear theory
- calculated for every forcing time step
  $\Rightarrow$ Sequence of steady states

ICAR - Windfield

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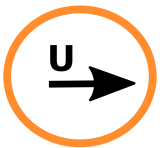


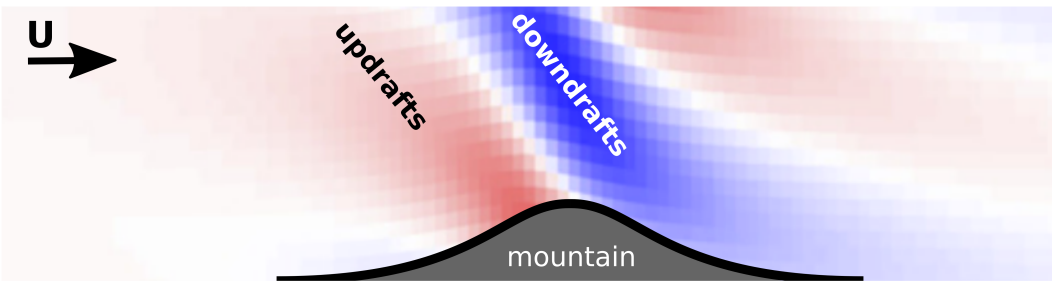
from coarse scale forcing

ICAR - Windfield

from coarse scale forcing

from high resolution DEM

ICAR - Windfield



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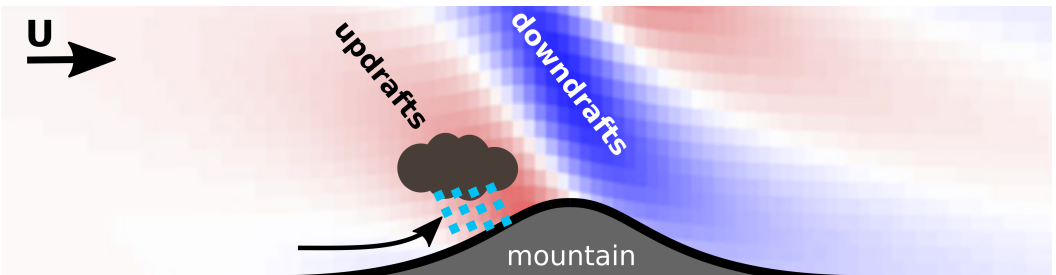


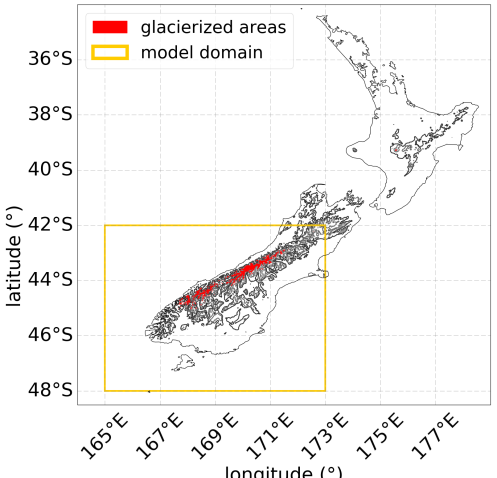
Setup

ERA-Interim forcing

- $\Delta t = 6\,\mathrm{h} \quad \Delta A \approx 60 \times 60\,\mathrm{km}^2$

downscale to

- $\Delta t = 1\,\mathrm{h} \quad \Delta A \approx 4 \times 4\,\mathrm{km}^2$
- model top at $\approx 5.7\,\mathrm{km}$



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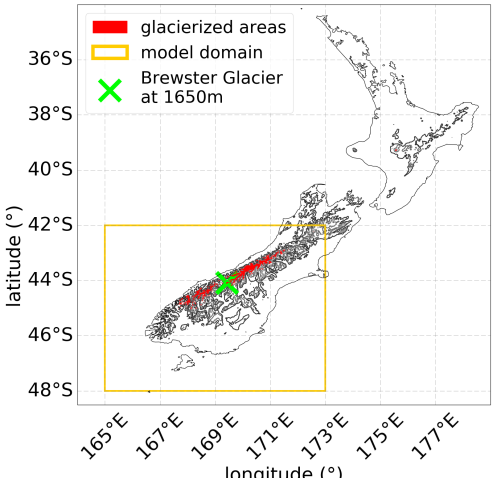

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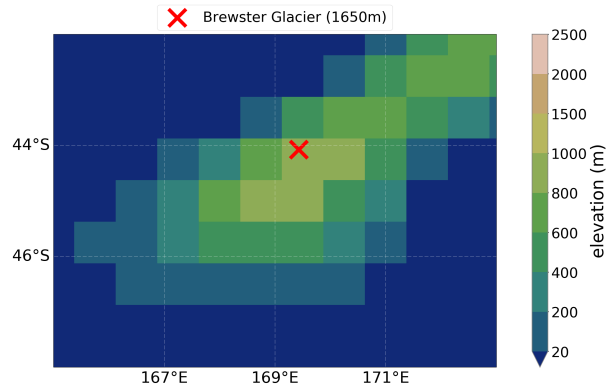

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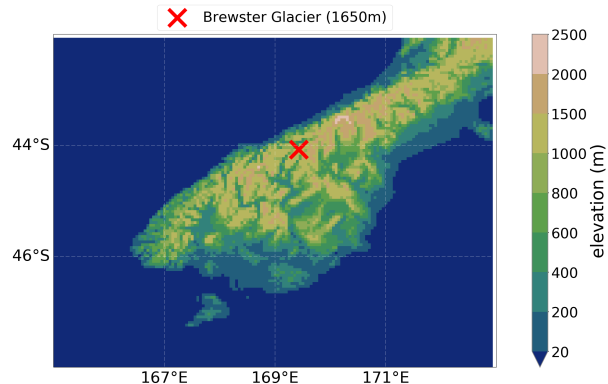

Evaluation

2010-2015

skill scores

- 24h accumulated precipitation
- 24h mean of T, q_v and ws
- added value wrt. nearest gridpoint
  ERAI

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skill scores

- 24h accumulated precipitation
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- added value wrt. nearest gridpoint ERAI

Also look at

- precipitation measurements from GPM mission
- compare to annual precipitation climatology

ICAR skill score with respect to ERAI

Quantity	ICAR Skill Score wrt.	
	ERAI at surface	ERAI at pressure level
precipitation	0.43	
10 m wind speed	0.34	
specific humidity	0.72	-1.22
temperature	0.82	-2.15

$$SS = 1 - \frac{\text{mse}_{\text{icar}}}{\text{mse}_{\text{erai}}}$$

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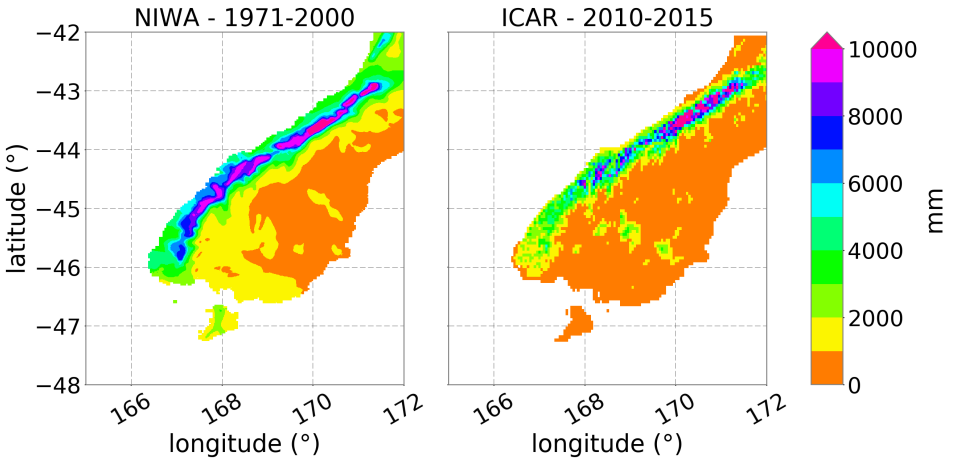
Median Annual Precipitation



NIWA
Taihoro Nukurangi

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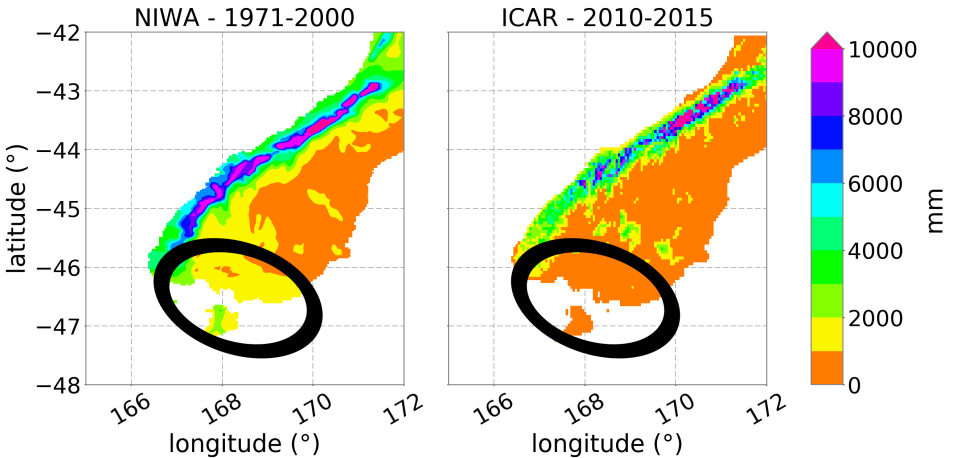

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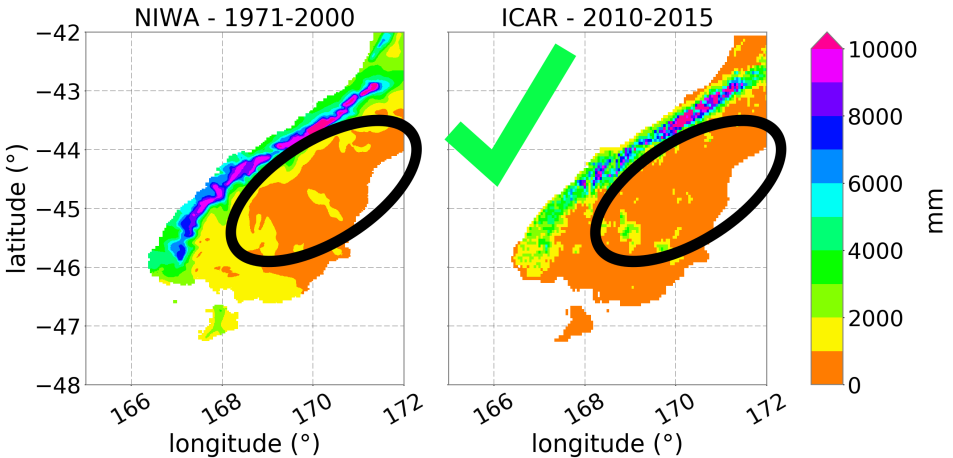

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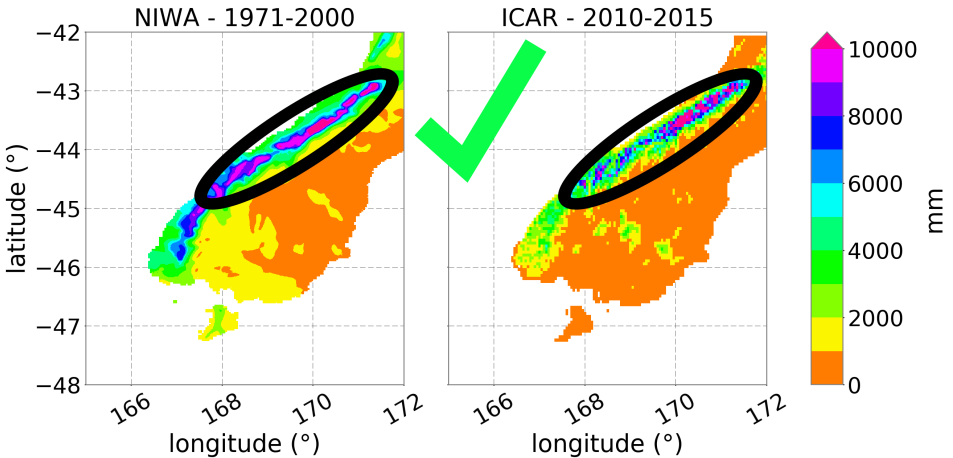

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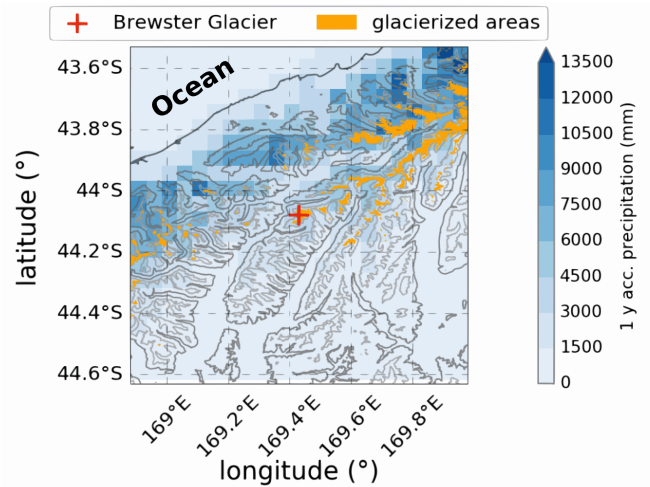
Precipitation - finer structure



pronounced topographic effect

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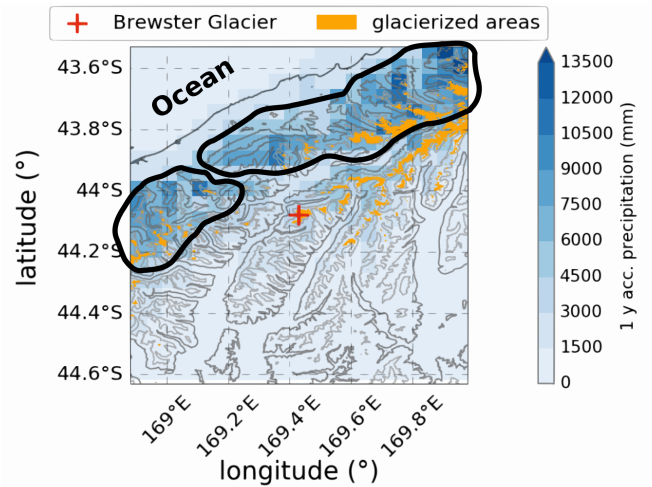

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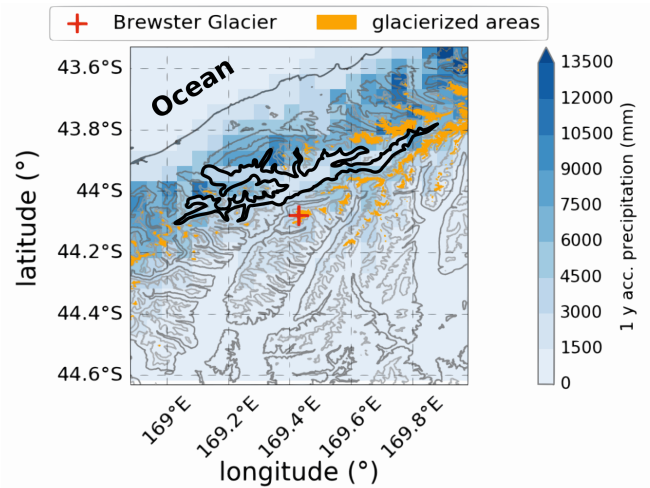

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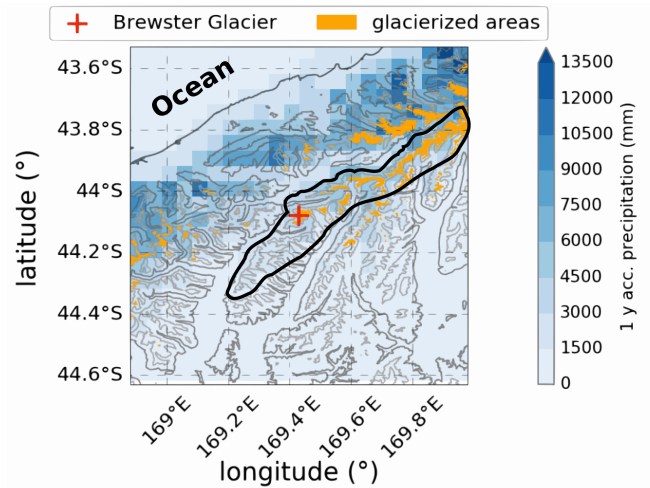

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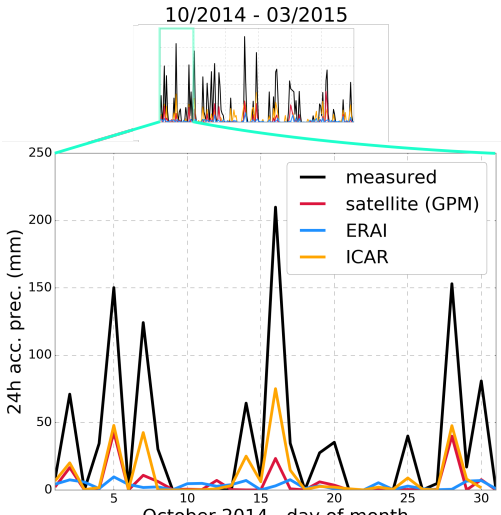

general observations:

- AWS measurements underestimated
- ICAR results closest
  $\text{rmse}_{\text{ICAR}} = 40\,\text{mm}$
  $\text{rmse}_{\text{GPM}} = 45\,\text{mm}$
  $\text{rmse}_{\text{ERAI}} = 53\,\text{mm}$
- ICAR correlation to measurements
  $\rho = 0.80$
- ICAR hit rate
  comparable to GPM
  superior at higher prec. thresholds

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Investigated ICAR at site in Alps of New Zealand

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of course - further investigations necessary

Outlook

- more stations for southern New Zealand
- increase resolution to $1 \times 1\,\mathrm{km}^2$
- turn on other physics packages

If you have a weatherstation near a glacier - please contact us!

- http://acinn.uibk.ac.at - DoG project
- johannes.horak@uibk.ac.at
- or at ResearchGate.net

Thank you!