

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

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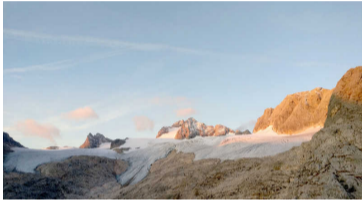
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Boulder, Colorado, USA



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Motivation

Local effects of a changing global climate



Glaciers



Hydrology



Agriculture



Cities

Reliability of the method

local variability of precipitation
well represented by the method?

Model

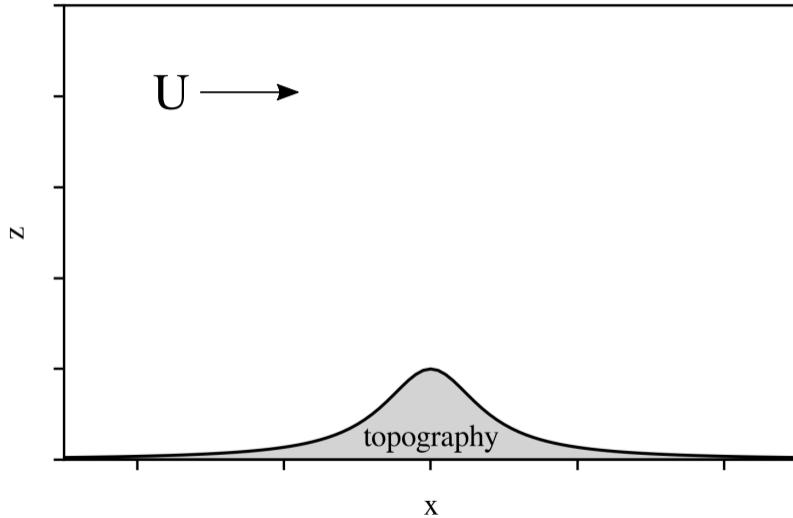
Intermediate **C**omplexity **A**tmospheric **R**esearch Model (ICAR)
(Gutmann et al., 2016)

- ▶ quantities stored on 3D grid
- ▶ advected within wind field
- ▶ microphysics
- ▶ physics based downscaling
- ▶ computationally frugal

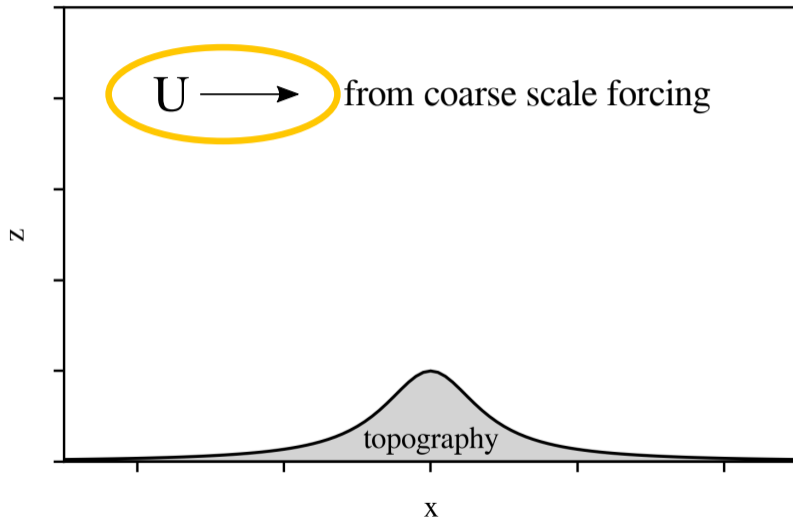
Wind field

- ▶ calculated analytically
- ▶ based in linear theory
- ▶ calculated for every forcing time step
⇒ Sequence of steady states

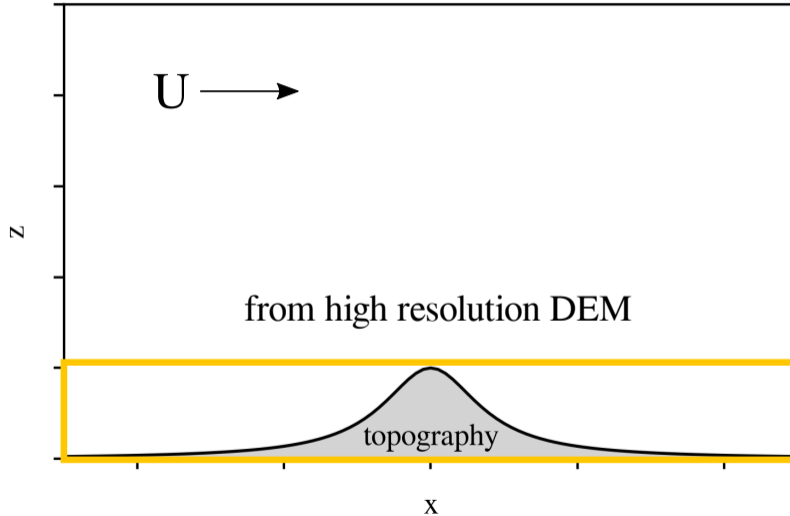
ICAR - Windfield



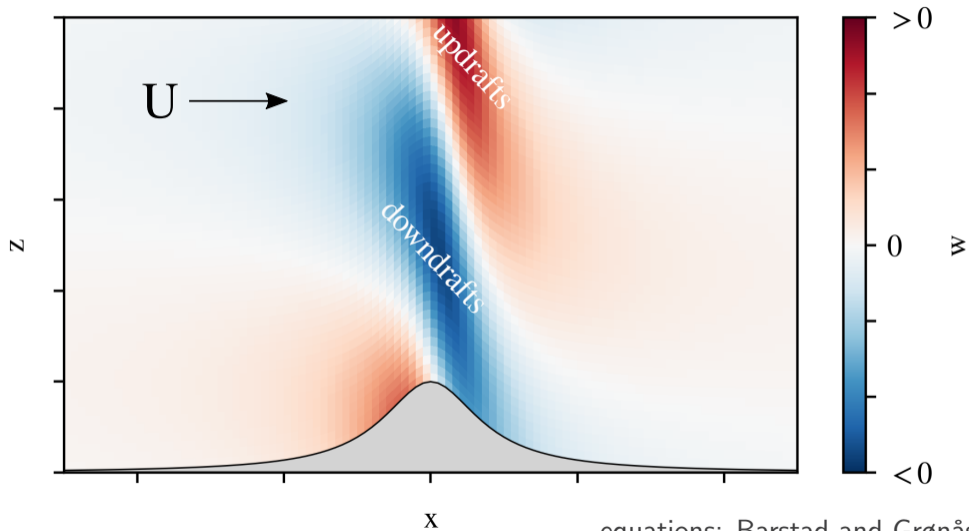
ICAR - Windfield



ICAR - Windfield

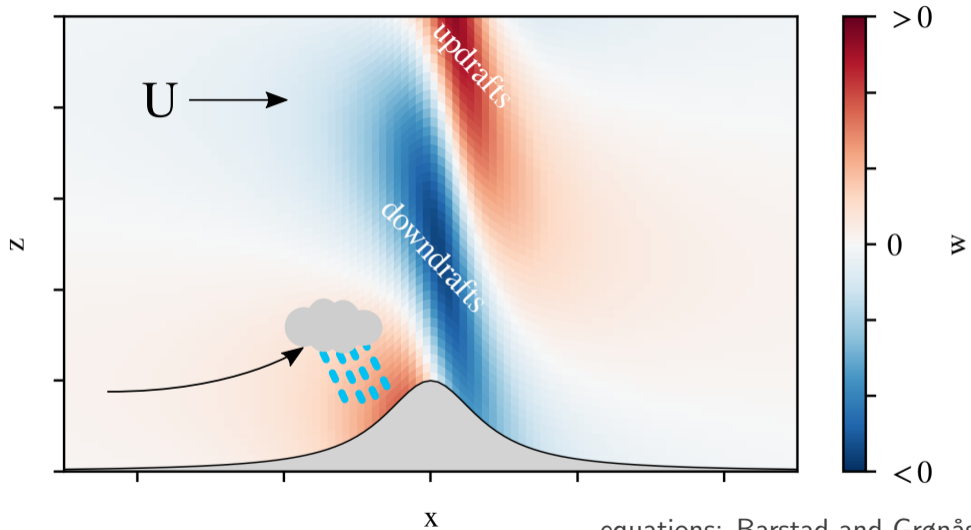


ICAR - Windfield



equations: Barstad and Grønås (2006)

ICAR - Windfield



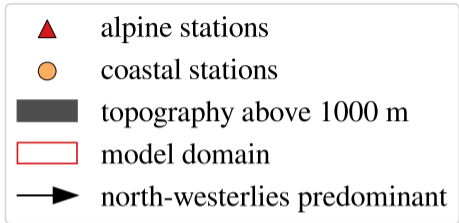
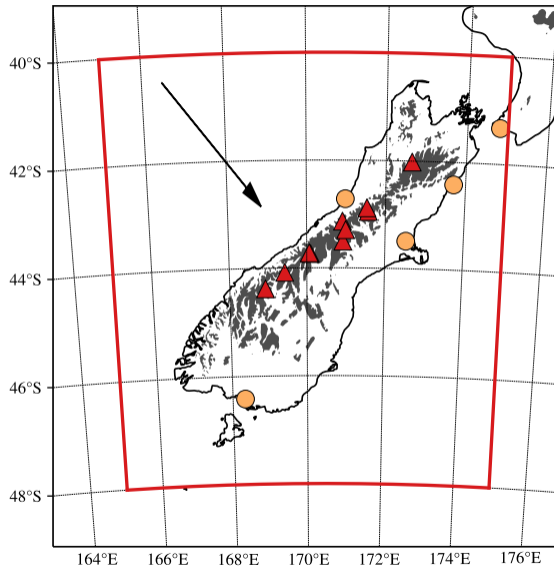
equations: Barstad and Grønås (2006)

Study Region

New Zealand



Domain - South Island of New Zealand



precipitation data provided by

NIWA, NZ

MetService, NZ

University of Otago, NZ

Setup

ERA-Interim forcing

- ▶ $\Delta t = 6 \text{ h}$ $\Delta A \approx 60 \times 83 \text{ km}^2$
also used as to determine added value

downscale to

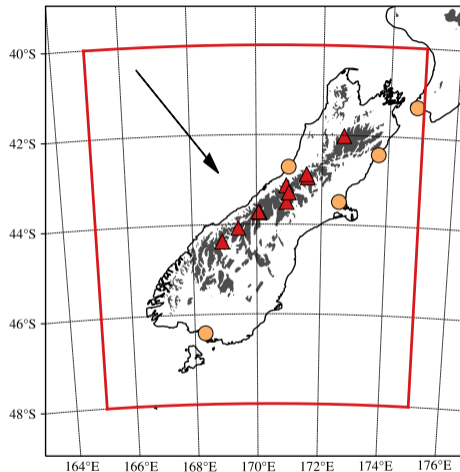
- ▶ $\Delta t = 1 \text{ h}$ $\Delta A \approx 4 \times 4 \text{ km}^2$
- ▶ model top at $\approx 5.7 \text{ km}$ above topography

10 year study period

- ▶ 01/2006 to 12/2016

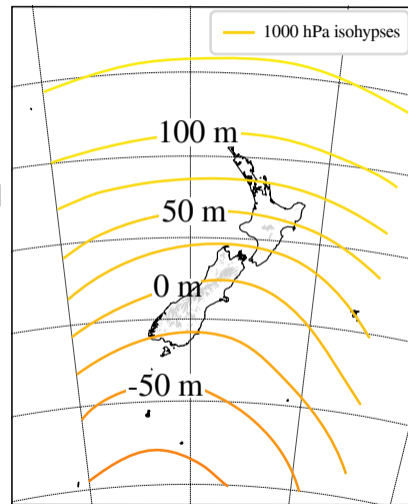
Settings

- ▶ **ICAR standard settings**
- ▶ **NO tuning to observations**



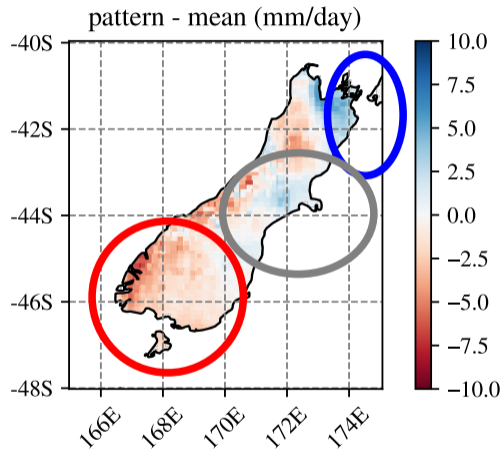
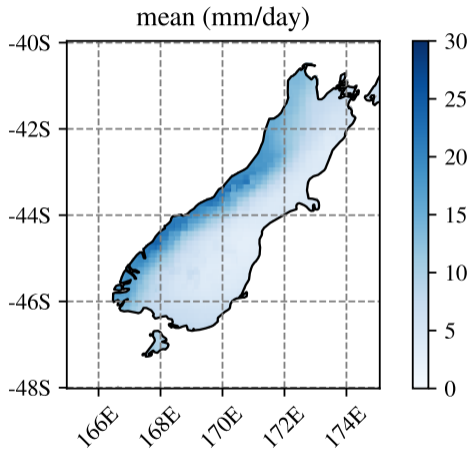
Weather Patterns

- ▶ 12 synoptic weather patterns (Kidson, 2000)
- ▶ daily classification since 1948 by NIWA, NZ
- ▶ defined by 24h mean elevation of 1000 hPa lvl
 - ▶ example: Trough - pattern
 - ▶ on $\approx 12\%$ of days
- ▶ linked to regional moistening / drying



Trough - pattern

Weather Patterns



Weather Patterns

Weather patterns - ideal for investigating ICAR

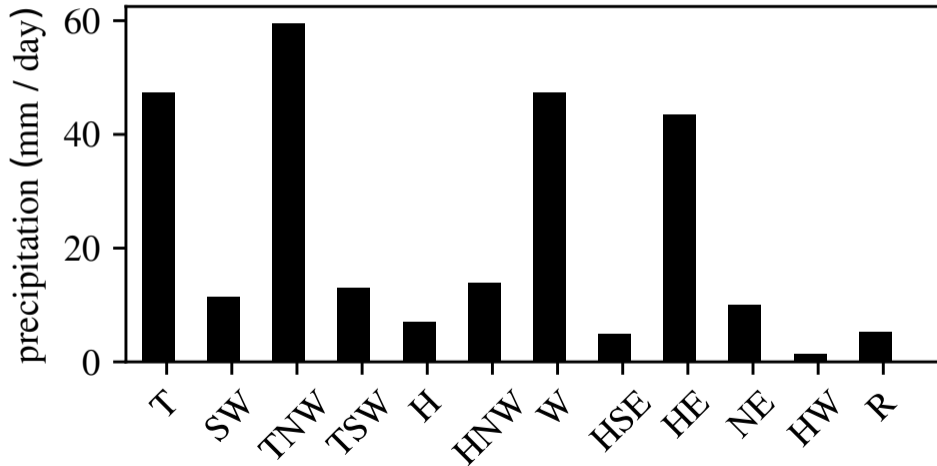
- ▶ not part of downscaling method
- ▶ indicator of physicality

Weather Pattern \Rightarrow local moistening and drying

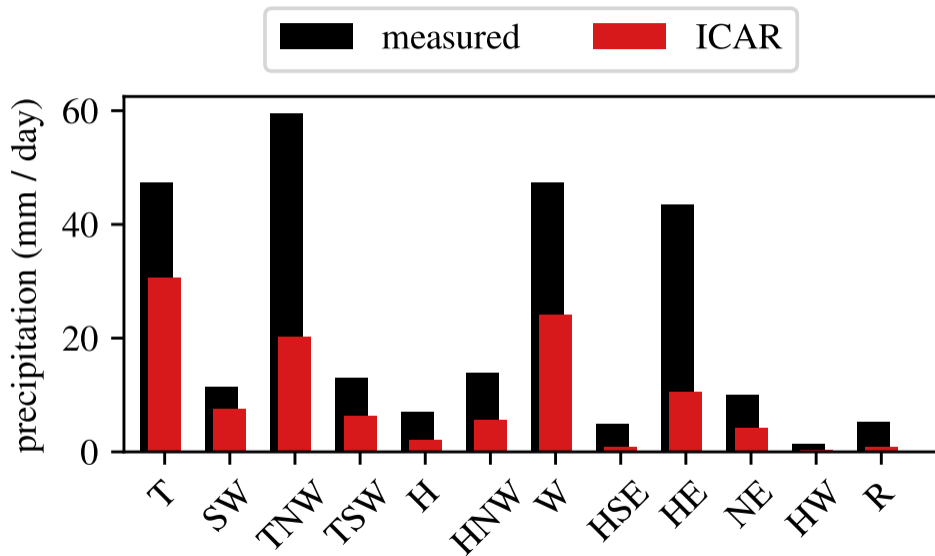
can ICAR model the measured variability?

Precipitation Variability at Alpine Station Ivory ($z = 1390$ m)

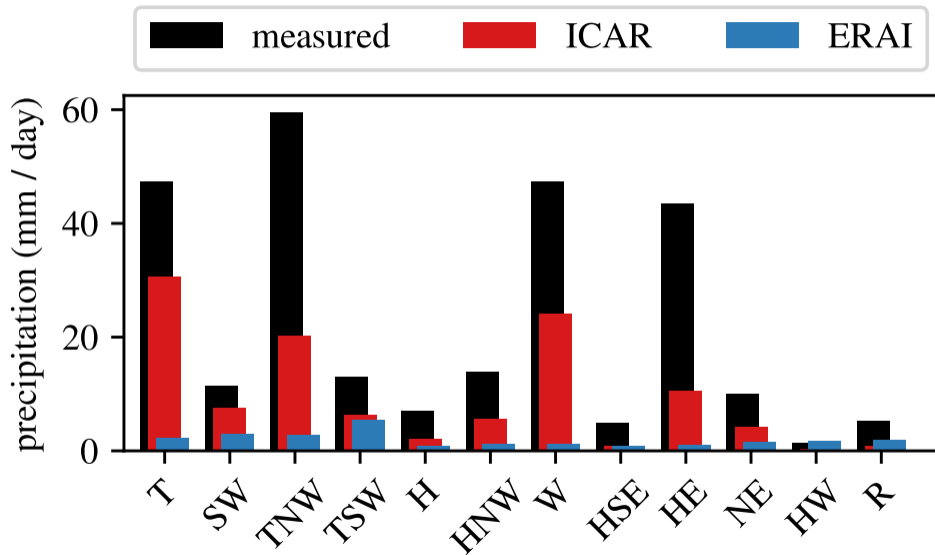
measured by  (niwa.co.nz)
Taihoro Nukurangi



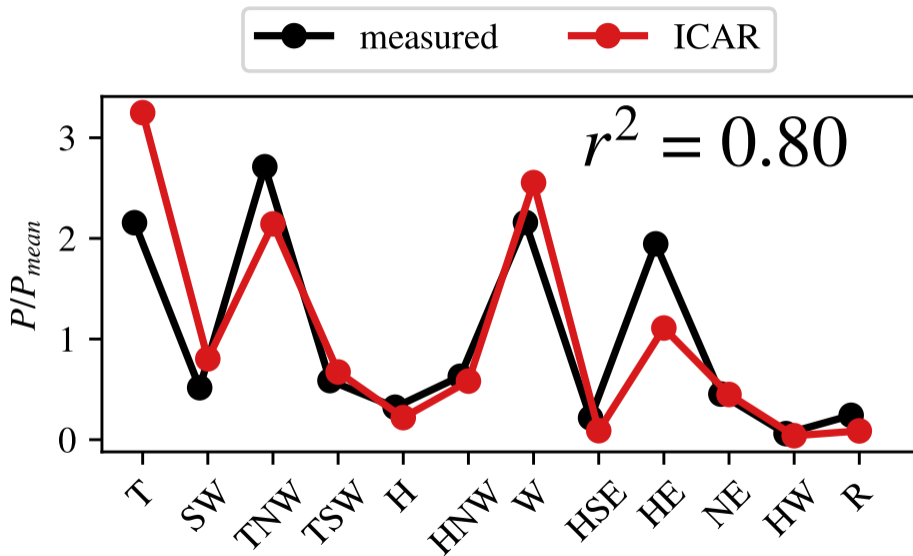
Precipitation Variability at Alpine Station Ivory ($z = 1390$ m)



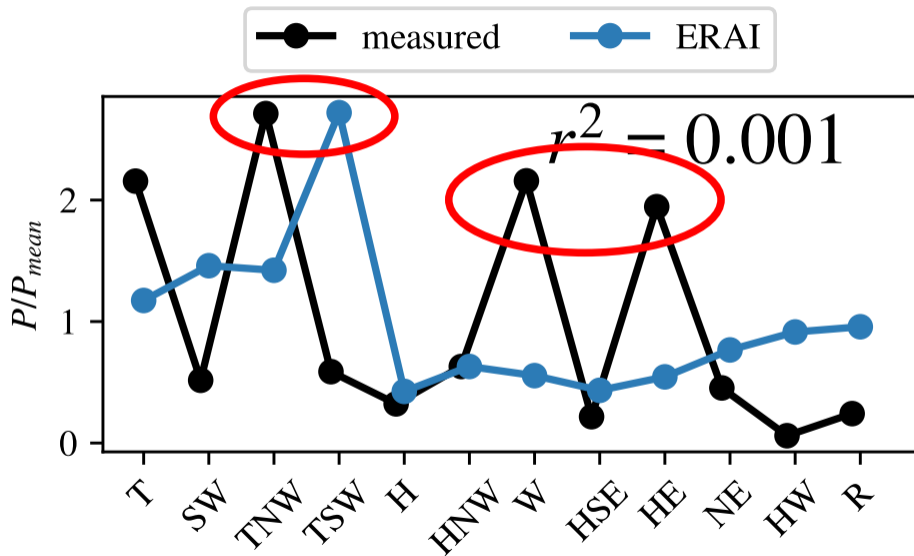
Precipitation Variability at Alpine Station Ivory ($z = 1390$ m)



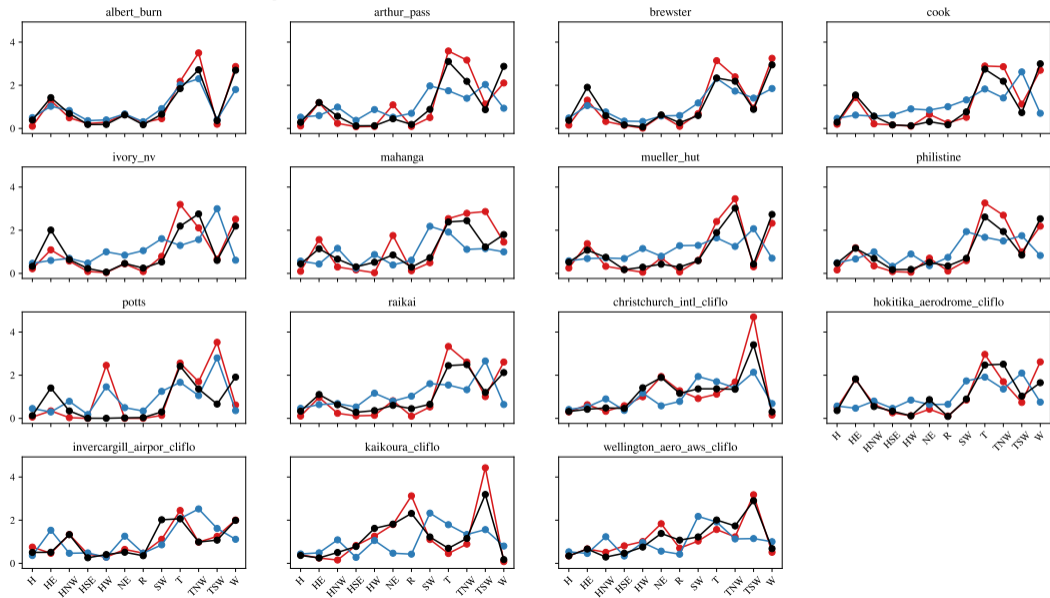
Precipitation Variability at Alpine Station Ivory ($z = 1390$ m)



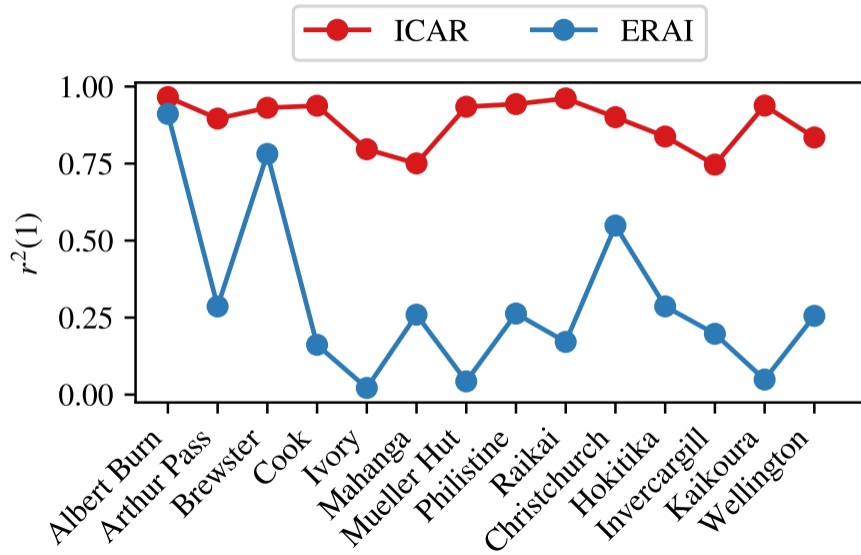
Precipitation Variability at Alpine Station Ivory ($z = 1390$ m)



Calculate for every station



Coefficients of Determination



Caveats

ICAR underestimates precipitation

- ▶ ERA-Interim too dry?
- ▶ strong influence of model top
⇒ further studies needed
- ▶ workaround: correction factor per site

Convection parametrizations not tested (yet)

Summary

Investigated variability of local precipitation due to synoptic weather patterns

- ▶ added value of ICAR compared to ERA-Interim
- ▶ local variability well explained by ICAR
- ▶ local variability linked to synoptic situation
- ▶ relevant processes well approximated

⇒ ICAR suited to investigate the local effects of a future climate

Outlook

- ▶ extend analysis to gridded precipitation data (e.g. GPM)
- ▶ variability of local temperature
- ▶ does ERA5 explain variability better?

More details in paper later this year

- ▶ skill scores (MSE and HSS based)
- ▶ performance indicators for ICAR

Updates / Contact:

- ▶ johannes.horak@uibk.ac.at
- ▶ or on ResearchGate.net

Thank you!

Literature I

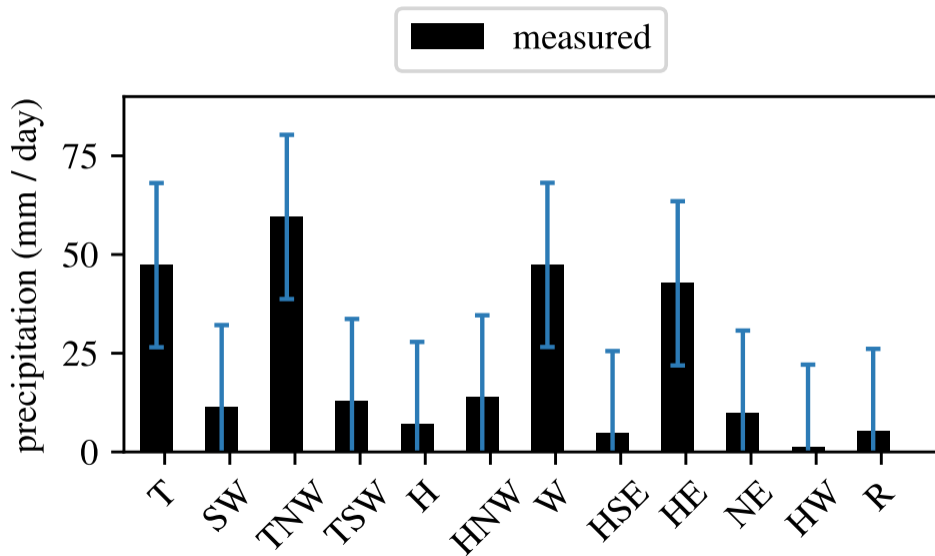
- Barstad, I. and Grønås, S. (2006). Dynamical structures for southwesterly airflow over southern norway: the role of dissipation. *Tellus A*, 58(1):2–18.
- Gutmann, E., Barstad, I., Clark, M., Arnold, J., and Rasmussen, R. (2016). The intermediate complexity atmospheric research model (icar). *Journal of Hydrometeorology*, 17(3):957–973.
- Kidson, J. W. (2000). An analysis of new zealand synoptic types and their use in defining weather regimes. *International journal of climatology*, 20(3):299–316.

The End

Appendix

Supplemental data and plots

Precipitation Variability w. Standard Deviation at Ivory



Correlation for permuted weather pattern data

