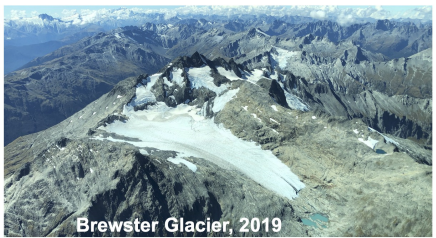
Attribution of extreme annual glacier mass loss to anthropogenic forcing

Lauren Vargo[1,*] Ruzica Dadić[1] Brian Anderson[1] Regine Hock[2,3] Huw Horgan[1] Andrew King[4] Andrew Mackintosh[5] Ben Marzeion[6]

[1]Victoria University of Wellington [2]University of Alaska Fairbanks [3]Oslo University [4]University of Melbourne [5]Monash University [6]University of Bremen

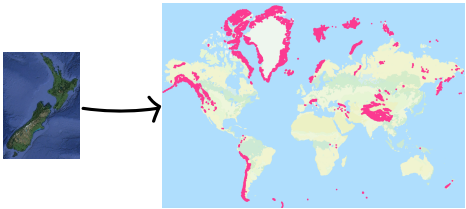
[*]**lauren.vargo@vuw.ac.nz**



Why attribution?

- How much are glaciers melting due to climate change?
- Impacts of glacier melt (water resources, hazards, tourism)
- Climate change communication tool

This talk:



Extreme event attribution

- Previous studies- attribution of extreme heat, rainfall, drought events

Western North American extreme heat virtually impossible without human-caused climate change

During the last days of June 2021, Pacific northwest areas of the U.S. and Canada experienced temperatures never previously observed, with records broken in many places by several degrees Celsius.

07 July, 2021 | HEATWAVE | NORTH AMERICA

https://www.worldweatherattribution.org/

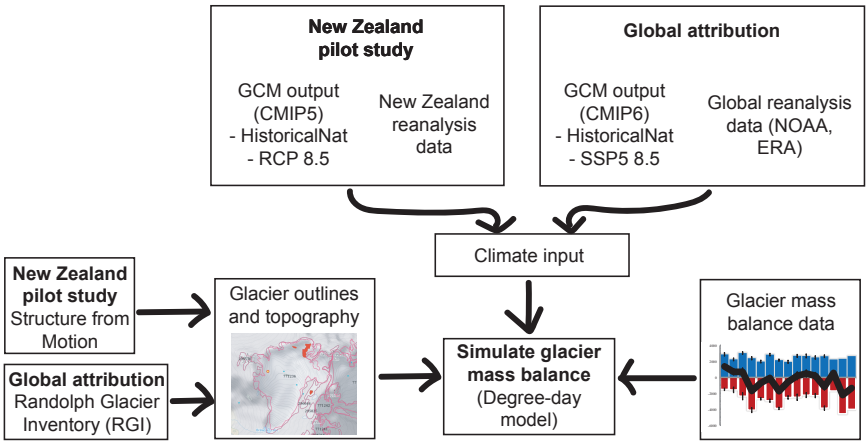
- Simulations of climate:

  1) Without climate change (greenhouse gases $\sim$50% lower than modern)

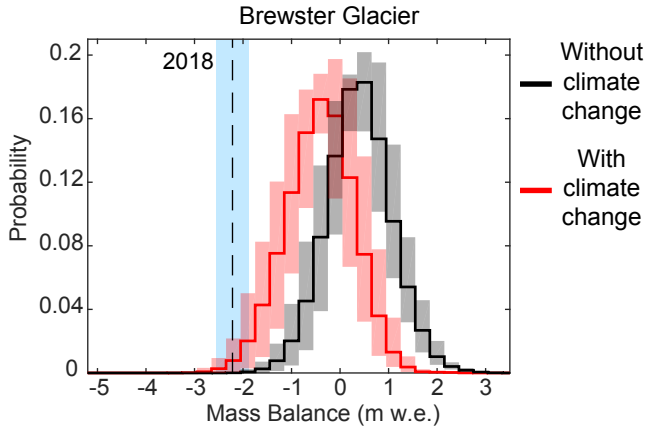
  2) With climate change (modern greenhouse gases)

Methods: glacier melt attribution

Added step of simulating glacier mass balance with GCM output



Attribution of New Zealand glacier melt (Vargo et al., 2020)

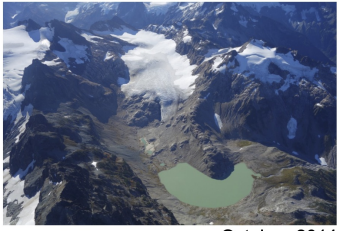


- Extreme melt $\geq$23x more likely with climate change
- Driven by $\sim$1°C warming

Attribution of extreme glacier melt: global

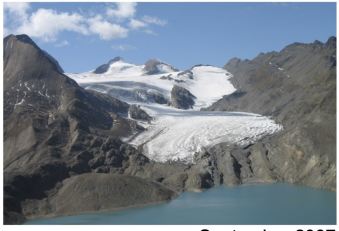
- 230 glaciers with $\geq$10 years of mass balance measurements (WGMS)
- Developing & testing workflow
- 3 glaciers selected to develop methods:

South Cascade Glacier, USA



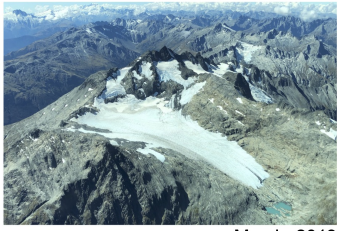
October, 2014
M. Bachmann
WGMS

Griesgletscher, Switzerland



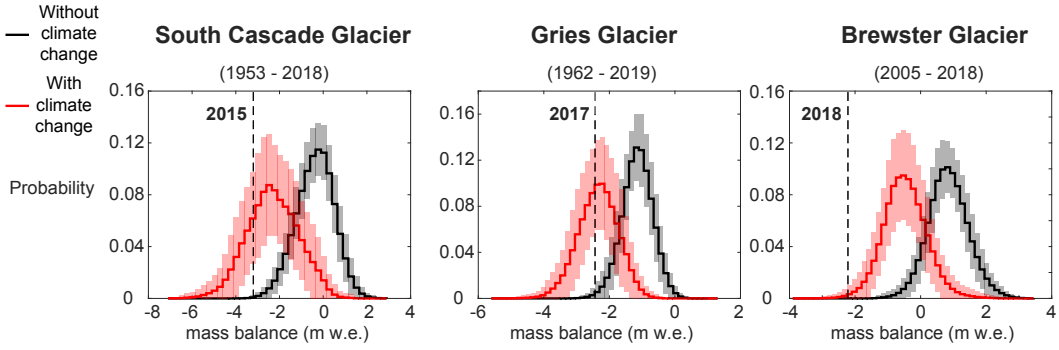
September 2007
M. Funk
WGMS

Brewster Glacier, New Zealand



March, 2019
L. Vargo

Attribution of extreme glacier melt: global



	South Cascade Glacier	Gries Glacier	Brewster Glacier
Minimum increase in likelihood:	**≥ 24x**	**≥ 12x**	**No increase in likelihood**

Going forward

Workflow development

- Is global climate data sufficient, or is regional climate data needed (or neither?)
- Is a degree day model appropriate for all/most 230 glaciers?
- Add geodetic mass balance to calibration and validation (Hugonnet et al. 2021)
- Can we attribute extreme melt from geodetic data? (higher annual uncertainties)

Attributions

- Increase in glacier melt due to climate change?
- Attributions for 1.5°, 2° or higher warming
- Communicating climate change & changes in water resources, hazards

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Thank you

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