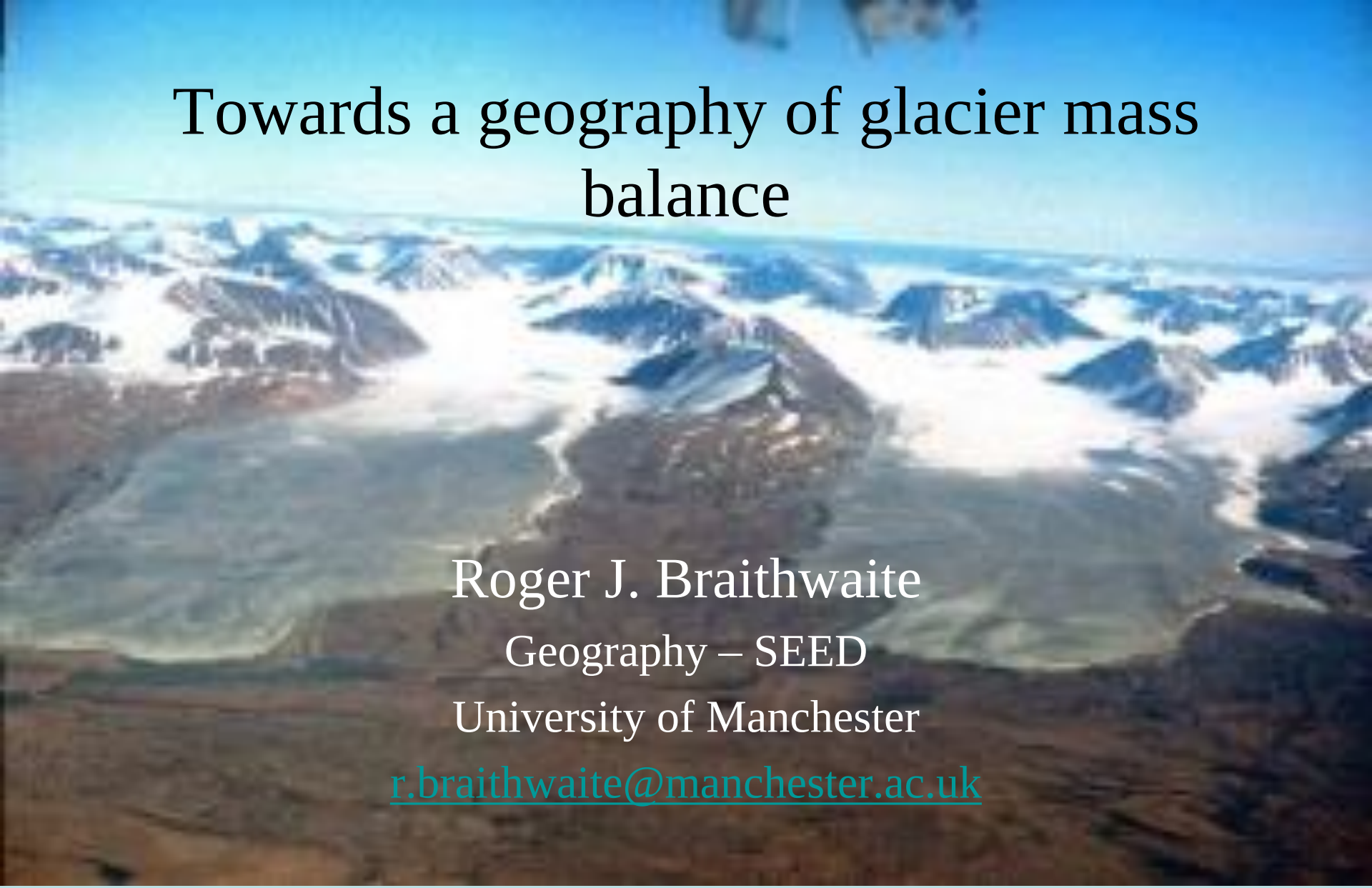
Towards a geography of glacier mass balance

Towards a geography of glacier mass balance



Roger J. Braithwaite

Geography – SEED

University of Manchester

r.braithwaite@manchester.ac.uk

What is “Geography of glacier mass balance” and why should we want it?

GLACIERS AND SEA LEVEL CHANGES

(Marzeion and others, 2016)

Table 1 Methods that can be used to determine elevation, volume and mass changes of glaciers from satellite data

Survey	Sensor	Change measured	Coverage	Time period	Temporal resolution	Issues	Accuracy
Field data	Stakes and pits, GPR	Elevation, mass	Selected glaciers globally	Since 1947	Annual	Point data, small sample, extrapolation	0.2 m
Repeat altimetry	ICESat, Cryosat2	Elevation	Globally but only along stripes	Since 2003 Since 2012	Sub-annual	Point data, extrapolation	0.5 m
DEM differencing	SRTM, GDEM SPOT/national High-resolution	Volume	Globally, w/o poles Mountain regions Selected glaciers	Around 2000 After 2000, 1960s After 2010	Decadal	Data voids, artifacts	1–2 m Better 1 m Better 0.5 m
Gravimetry	GRACE	Mass	Regional means and globally	Since 2002	Monthly	Coarse resolution	Variable

Field measurements added as reference

SELECTING GLACIERS GLOBALLY?

(Marzeion and others, 2016)

Table 2 Comparison of mass change estimates during common periods, in mm SLE year^{-1} and the 90% confidence interval, where given in the source

Source	2003–2009	1961–2010	1901–2010
WGMS (2015) direct	−1.12	−0.57	–
WGMS (2015) geodetic	−1.05	−0.85	–
Marzeion et al. (2015)	−0.78 ± 0.15	−0.49 ± 0.05	−0.62 ± 0.05
Updated from Cogley (2009)	−0.75 ± 0.07	−0.54 ± 0.05	–
Updated from Leclercq et al. (2011)	−0.84 ± 0.64	−0.58 ± 0.15	−0.78 ± 0.19
Gardner et al. (2013)	−0.70 ± 0.07	–	–
Average of GRACE-based studies, see Sect. 3.3 for sources	−0.61 ± 0.07[a]	–	–

[a] Averaged over different time periods (2002/2005–2013/2015) and adding the estimate for Greenland peripheral glaciers from Gardner et al. (2013)

BIASED ESTIMATE OF GLACIER MASS BALANCE

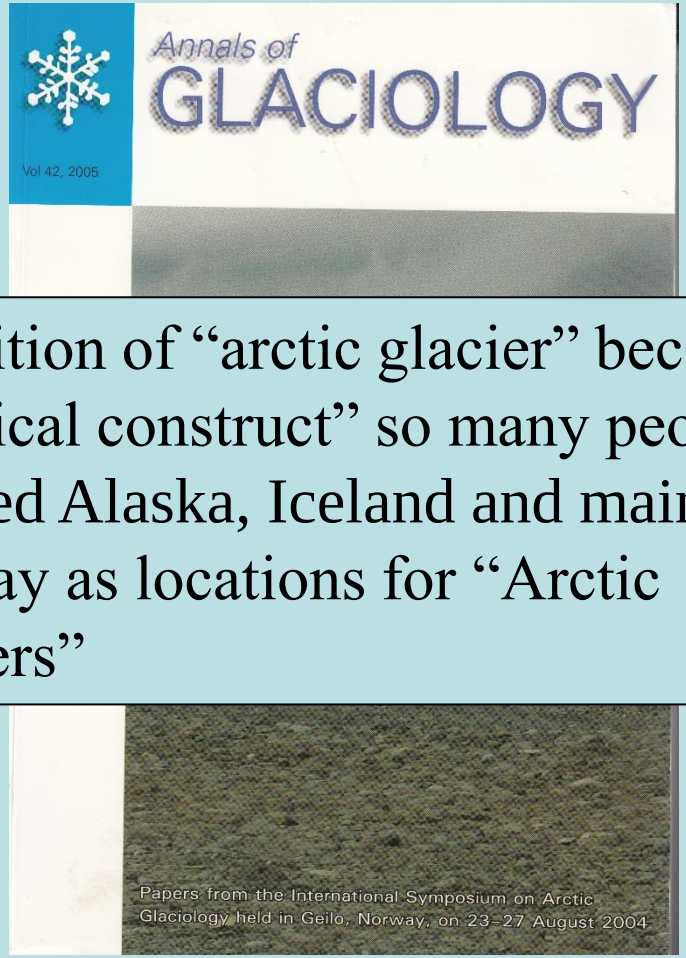
(Marzeion and others, 2016)

Specifically, glacier observations appear to be made on glaciers that tend to have more negative mass balances than the global, or even regional, mean (Gardner et al. 2013, also found indications of this).

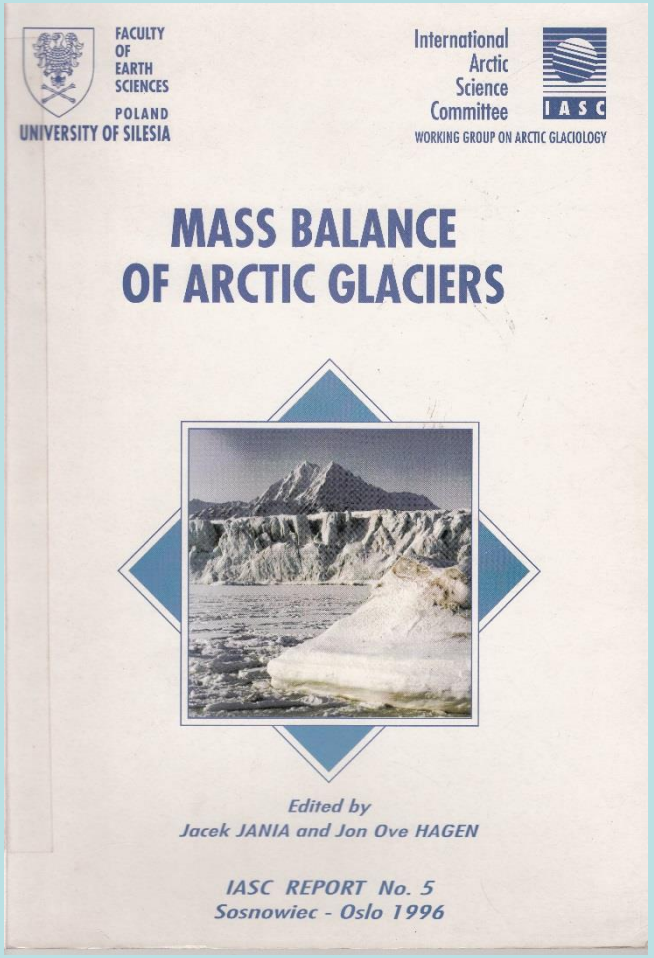
The reference within a bracket is very curious.

It looks like an after-thought. He could have suggested Braithwaite (2002, 2005 & 2009 for precipitation bias in locations of monitored glaciers.

Muddled geography of glacier mass balance

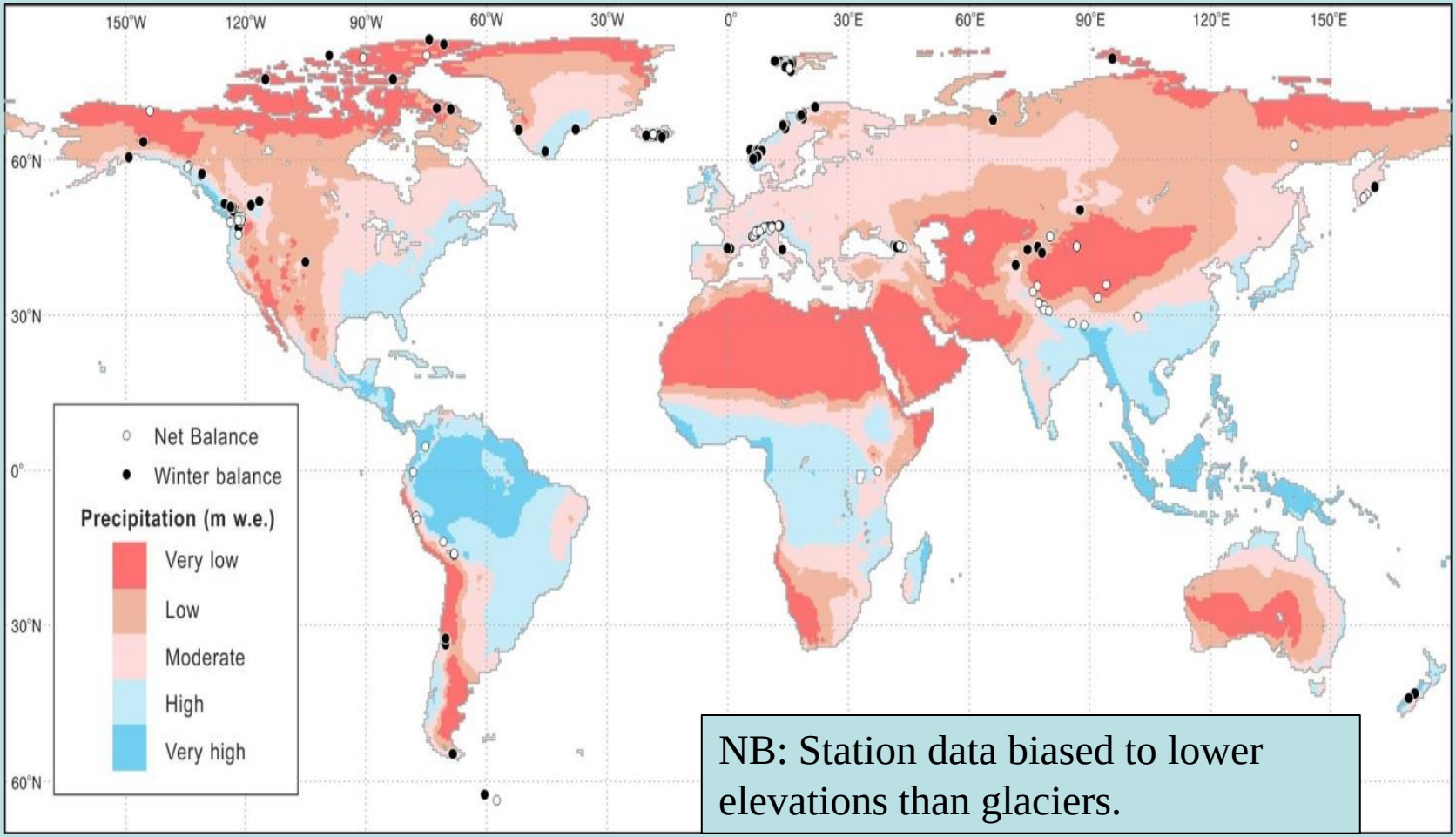


Definition of "arctic glacier" became a "political construct" so many people claimed Alaska, Iceland and mainland Norway as locations for "Arctic Glaciers"



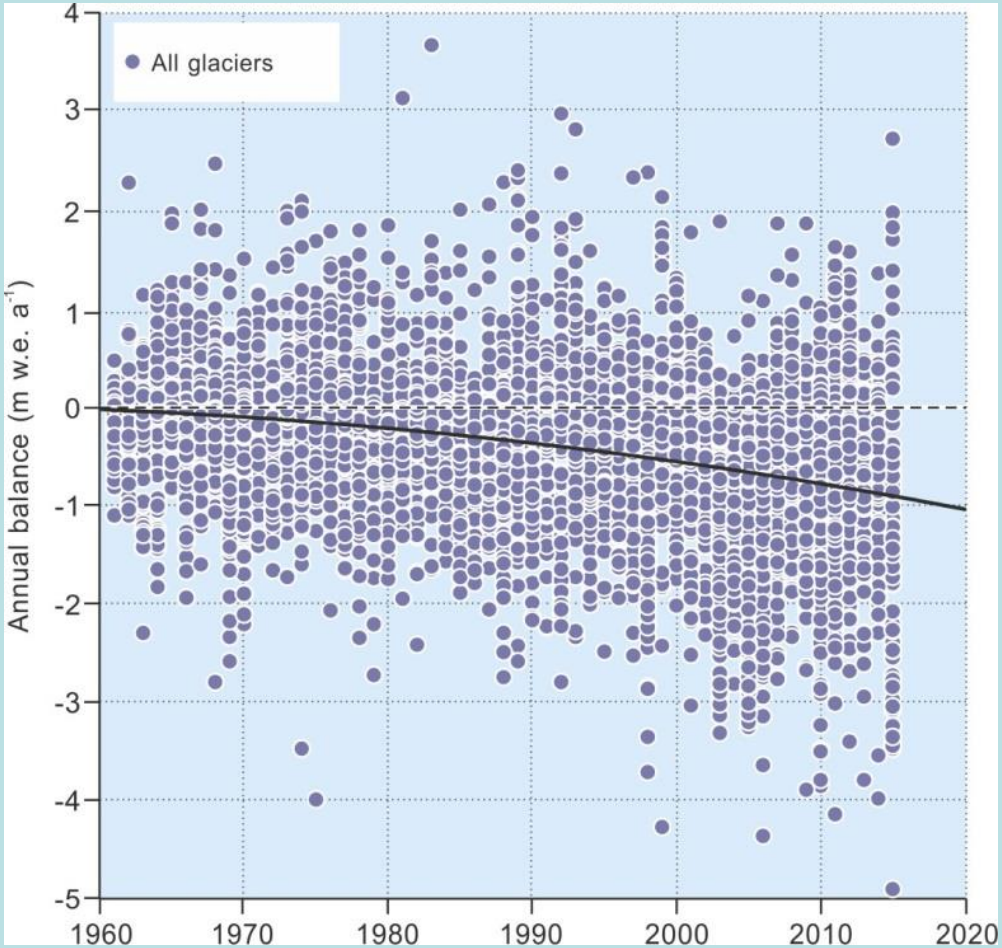
Glaciers and global precipitation

(Mass balance from WGMS and CRU/UEA gridded climatology)



Global average of observed mass balance

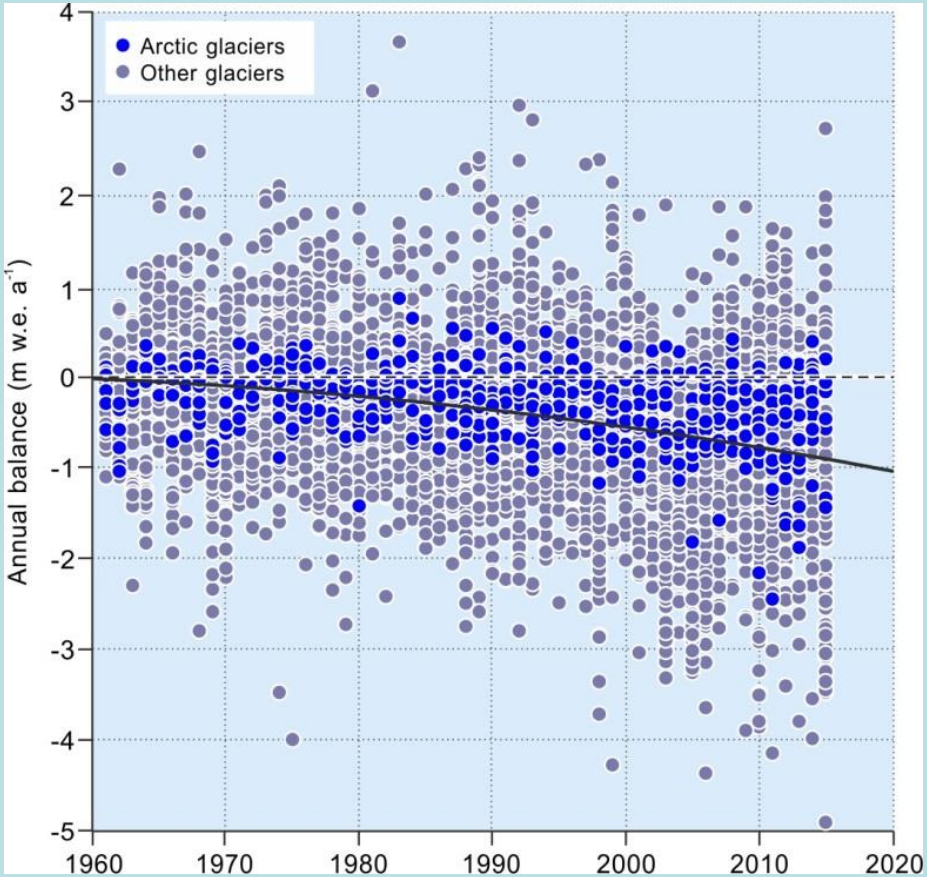
(WGMS database)



- Large inter-annual variations
- Small negative average balance in 1960s to 1980s
- Increasing trend to large negative balance today
- What is wrong?

Bias of observed mass balance

(Braithwaite, 2002, 2005 & 2009)



- Arctic glaciers have smaller than average variations
- Observed mass balance dataset is biased against arctic glaciers
- We must recognize characteristics of arctic glaciers

Muddle about arctic glaciers
(UNESCO/UNEP)

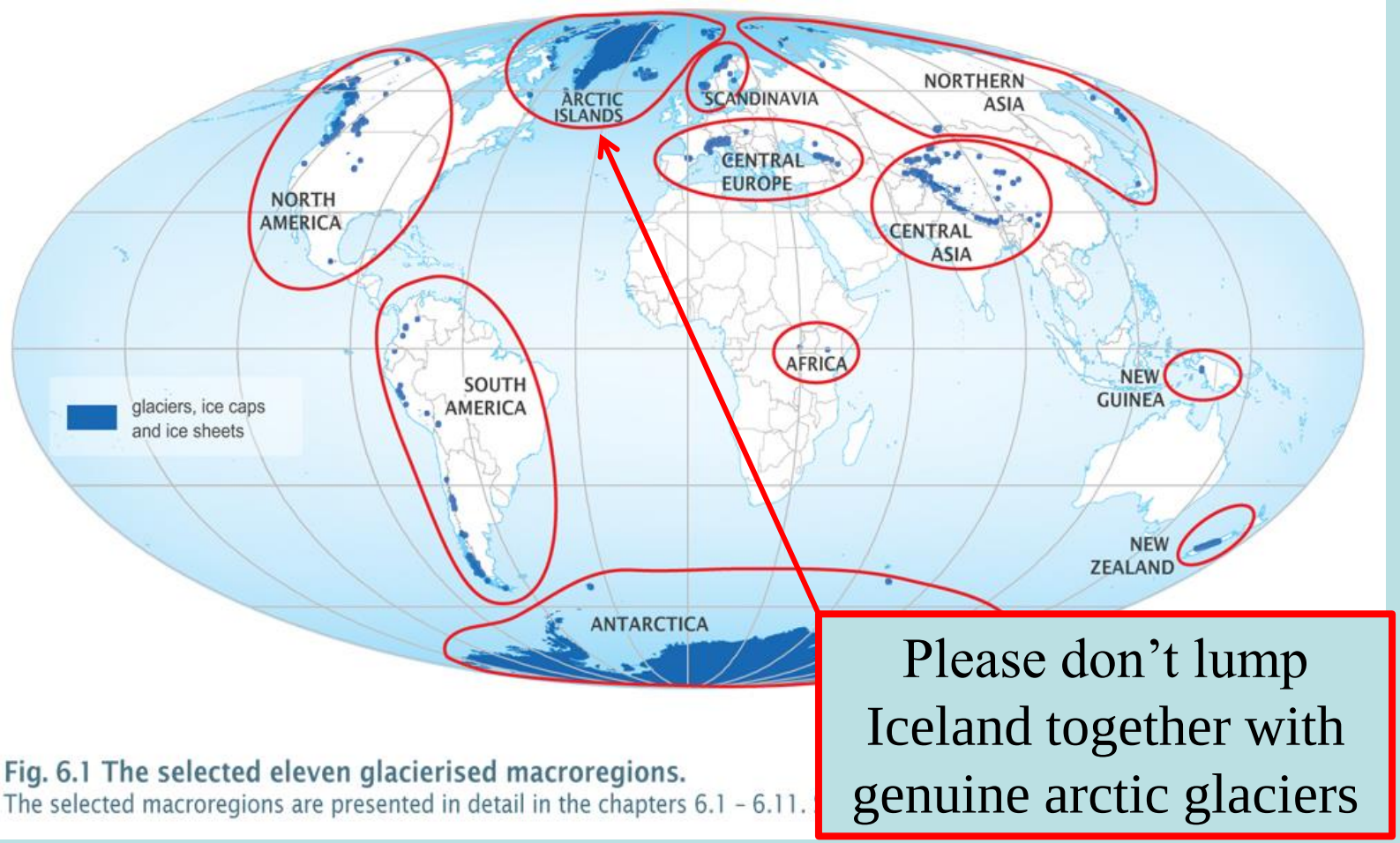
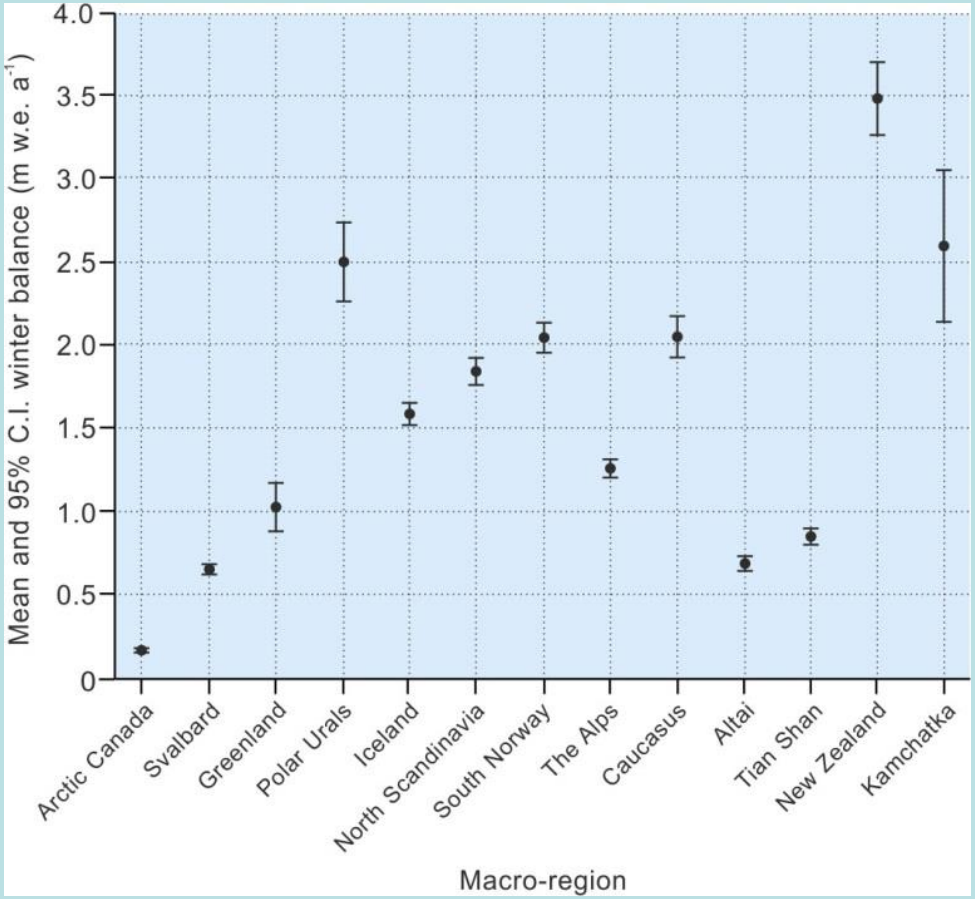


Fig. 6.1 The selected eleven glacierised macroregions.
The selected macroregions are presented in detail in the chapters 6.1 – 6.11.

Please don't lump Iceland together with genuine arctic glaciers

Winter balance and macro-regions

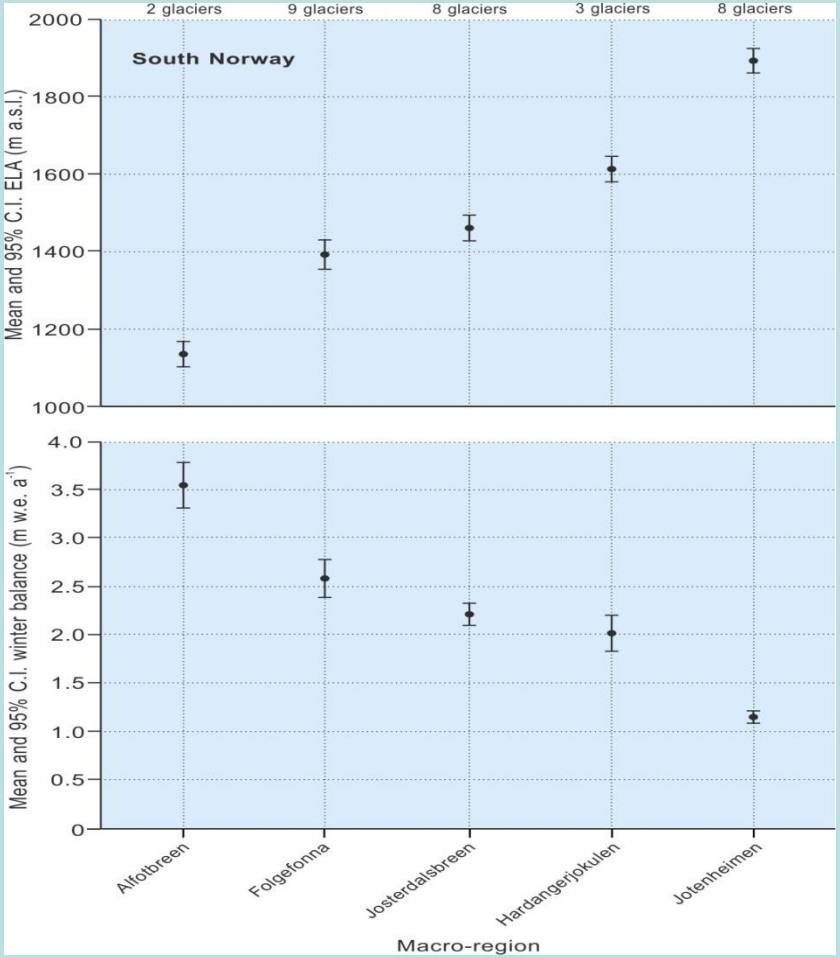
(New work)



- Glaciers on arctic islands have small winter balance
- Polar Urals and Iceland have high winter balance
- New Zealand might not be champion as Patagonia and Gulf of Alaska are not yet included in this analysis

Winter balance and micro-regions

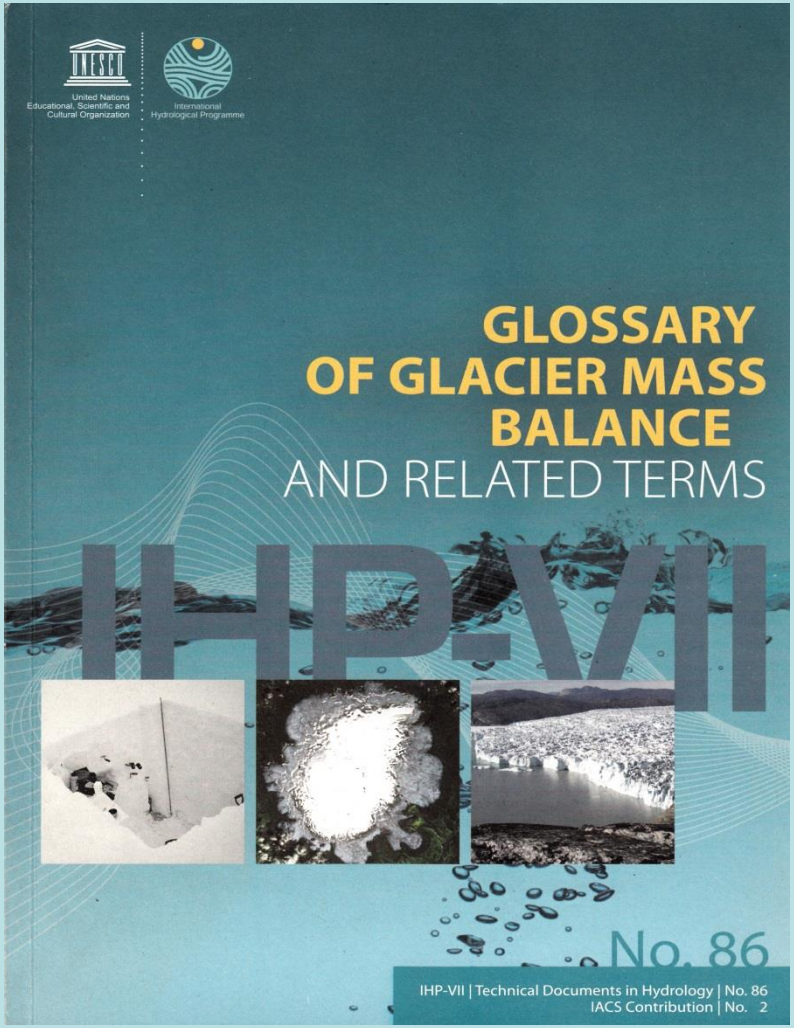
(New work)



Pattern of variation can be function of maritime or continental conditions. As winter balance falls, ELA rises to higher altitude with lower temperature to re-balance the budget.

Norwegians knew all this in the 1970s.

NEW WORKING GROUP?



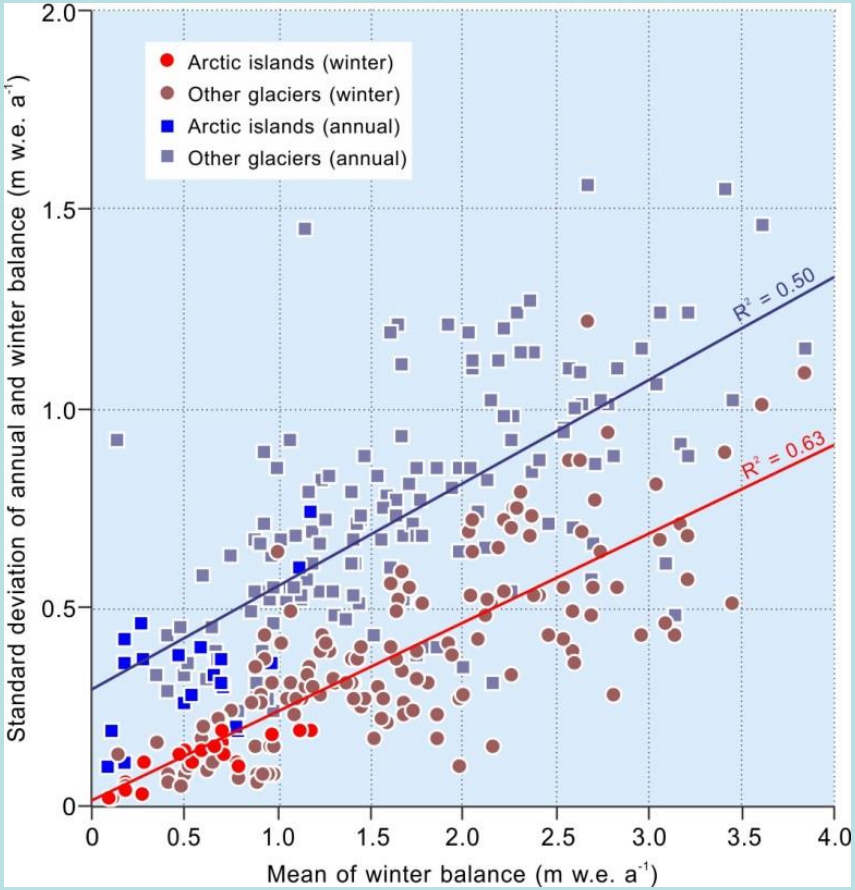
Advise WGMS on new developments in mass balance monitoring:

1. Geography of mass balance
2. Strategy for monitoring
3. Ice-berg calving
4. Melting under debris cover
5. Climate at ELA
6. Meltwater refreezing


Gee! Doctor Roger
that was a great talk!
Any
questions
?

Extra slides if time

Winter balance as mass balance driver



Standard deviation of winter balance is proportional to mean winter balance (ratio variable). This explains association between mass balance variability and winter balance.

How big is a glacier region?

(Braithwaite, 2015)

Similar annual balances for glaciers 100-200 km apart. Air temperature has strong spatial autocorrelation over many hundreds of km. Precipitation has poor spatial autocorrelation.