Towards a geography of glacier mass balance

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Towards a geography of glacier mass balance

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What is “Geography of glacier mass balance” and why should we want it?
# GLACIERS AND SEA LEVEL CHANGES

(Marzeion and others, 2016)

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

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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>WGMS (2015) direct</td>
<td>–1.12</td>
<td>–0.57</td>
<td>–</td>
</tr>
<tr>
<td>WGMS (2015) geodetic</td>
<td>–1.05</td>
<td>–0.85</td>
<td>–</td>
</tr>
<tr>
<td>Marzeion et al. (2015)</td>
<td>–0.78 ± 0.15</td>
<td>–0.49 ± 0.05</td>
<td>–0.62 ± 0.05</td>
</tr>
<tr>
<td>Updated from Cogley (2009)</td>
<td>–0.75 ± 0.07</td>
<td>–0.54 ± 0.05</td>
<td>–</td>
</tr>
<tr>
<td>Updated from Leclercq et al. (2011)</td>
<td>–0.84 ± 0.64</td>
<td>–0.58 ± 0.15</td>
<td>–0.78 ± 0.19</td>
</tr>
<tr>
<td>Gardner et al. (2013)</td>
<td>–0.70 ± 0.07</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Average of GRACE-based studies, see Sect. 3.3 for sources</td>
<td>–0.61 ± 0.07(^a)</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

\(^a\) 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.)

IGS Symposium, Victoria University, Wellington, New Zealand, February 2017
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)

NB: Station data biased to lower elevations than glaciers.
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?

IGS Symposium, Victoria University, Wellington, New Zealand, February 2017
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)

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
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.