IACS WG on Regional Assessments of Glacier Mass Change (RAGMAC)

26 June 2019, revised 12 December 2019

DURATION: 2019-2023 (4 years)

CO-CHAIRS: **Michael Zemp** (University of Zurich, CH) & **co-leads of WP1, WP2, and WP3**

1. MOTIVATION

Retreating and thinning glaciers are icons of climate change and impact the local hazard situation, regional runoff as well as global sea level. For past reports of the Intergovernmental Panel on Climate Change (IPCC), glacier mass-change estimates were based on the multiplication of averaged or interpolated results from available observations of a few hundred glaciers with regional glacier areas. For data-scarce regions, these results had to be complemented with estimates based on satellite altimetry and gravimetry. In addition, numerical modelling studies (calibrated with available observations) were used for process understanding, observational gap filling, attribution to climatic drivers, and for projecting future glacier changes and related secondary impacts. These past approaches - that were best practises at the time - were challenged by the small number and heterogeneous spatio-temporal distribution of *in situ* measurement series and uncertain representativeness for the respective mountain range as well as by spatial limitations of current satellite altimetry (only point data) and gravimetry (coarse resolution). Towards IPCC SROCC, there have been considerable improvements with respect to available geodetic datasets. Geodetic volume change assessments for entire mountain ranges have become possible thanks to recently available and comparably accurate DEMs. At the same time, new spaceborne altimetry (ICESat-2) and gravimetry (GRACE-FO) missions are in orbit and about to release data products to the science community. This opens new opportunities for regional evaluations of results from different methods as well as for truly global assessments of glacier mass changes and related contributions to sea-level rise (Wouters et al. 2019, Front. Earth Sci.; Zemp et al. 2019, Nature). At the same time, the glacier research and monitoring community is facing new challenges related to data size, formats, and availability as well as by new questions with regard to best practises for data processing chains and for related uncertainty assessments.

2. OBJECTIVES

The overall goal of this working group (WG) is bringing together the research community that is assessing regional glacier mass changes from various observation technologies and to come up with a new consensus estimate of global glacier mass changes and related uncertainties. The WG is organized in three work packages (WPs), two related to different remote sensing technologies and a third that aims at regional comparisons of corresponding results:

WP1: Glacier mass changes based on glaciological and geodetic (DEM differencing) methods

Co-leads: **Matthias H. Braun** (University of Erlangen-Nürnberg, DE) & **Fanny Brun** (Utrecht University, NL)

Members (in alphabetic order): Liss M. Andreassen (Norwegian Water Resources and Energy Directorate, NO), Anthony Arendt (University of Washington, US), Etienne Berthier (University of

Toulouse, Fr), Tobias Bolch (University of St Andrews, UK), Jacqueline Huber (University of Zurich, CH), Matthias Huss (ETH Zurich, Switzerland), Andreas Kääb (University of Oslo, NO), Robert McNabb (University of Oslo, NO), Brian Menounos (University of Northern British Columbia, CA), Laura Thomson (Queen's University, CA), Michael J. Willis (University of Colorado Boulder, US), Michael Zemp (University of Zurich, Switzerland) & […please sign up…]

WP1 Objectives

- **Best practises for geodetic estimates of glacier mass changes**. We aim at coming up with best practises for the estimation of glacier mass changes and related uncertainties based on geodetic methods from DEM differencing, combined with glaciological field observations. Thereto, we will organize the following activities:
    - **Expert Workshop.** In an initial workshop, we aim at bringing together the members of the WG to present and discuss good practices for geodetic data (pre and post) processing, combination of geodetic and glaciological observations making use of methodological advantages (e.g., temporal and spatial resolutions of glaciological and geodetic methods, respectively), and related uncertainty estimates at individual glacier and regional levels.
    - **Round robin experiment**. Based on the outcome of the above workshop, we aim at setting up an inter-comparison of geodetic glacier mass change estimates for defined glacier samples (e.g. selected glaciers or entire mountain range) and input data (i.e., glacier outlines, DEMs).
    - **Best practices white paper.** The results of the round robin experiment together with a consensus on best practises shall be published in a joint publication.
- **Global coverage of geodetic glacier change assessments**. Based on periodical gap analysis, we aim at identifying regional deficits in observational coverage and target the production of geodetic glacier mass change assessments from DEM differencing. By the end of the WG, we aim for an observational geodetic coverage of more than 75% of the glacier area in all glacier regions of the world (i.e., the 19 first-order GTN-G glacier regions; for current observational coverage see Zemp et al. 2019, Nature, Extended Data Fig. 1). In regular meetings, the WG will coordinate their activities with respect to data production, workshop and round robin experiment organization, and paper writing (cf. Gantt-chart in Section 3).

WP2: Glacier mass changes based on altimetry and gravimetry

Co-leads: **Alex Gardner** (NASA Jet Propulsion Laboratory, US) & **Bert Wouters** (Institute for Marine and Atmosphere Research, NL), and **Geir Moholdt** (Norwegian Polar Institute, NO)

Members (in alphabetic order): Martin Horwath (TU Dresden, Germany), Noel Gourmelen (University of Edinburgh, UK), Andreas Groh (TU Dresden, Germany), Andreas Richter (TU Dresden, Germany), Ingo Sasgen (AWI, Bremerhaven, DE) & […please sign up…]

WP2 Objectives

Develop best practices for the propagation of errors in glacier mass-change estimates derived from satellite altimetry and gravimetry. Sources of error in regional glacier mass change estimates derived from satellite altimetry and gravimetry data are many and often of complex origin.

Quantification of such errors requires measurement-specific knowledge. We aim to develop best practices for the propagation of errors when estimating regional changes in glacier mass through:

- **Expert Workshop**. In an initial workshop, we aim at bringing together the members of the WG to present and discuss good practices for regional glacier mass change estimation from satellite altimetry and gravimetry. The discussion will focus on identifying sources of error (e.g., interpolation, solid earth corrections, hydrology corrections, density corrections), their magnitudes and their spatial and temporal correlation.
- **Best practices white paper**. Building on the outcomes of this workshop, we will assemble a publication that outlines the best practices for the propagation of errors in glacier mass change estimates derived from satellite altimetry and gravimetry.

WP3: Regional comparisons of glacier mass changes from different methods

Co-leads: **Regine Hock** (University of Fairbanks, US) & **another WG member** (tbd)

Members: all of WP1, WP2, and WP3

WP3 Objectives

- **Consensus estimate of regional mass changes.** SROCC illustrates the divergence of regional-scale estimates between studies and methods. The purpose of this WP is to establish a 'best' estimate for each large-scale region based on the available assessments from glaciological, geodetic, altimetric, and gravimetric methods, while accounting for the strengths and weaknesses of these methods such as with respect to data coverage, methodology, and related error bars. In addition, the opportunities and limitations in the combination with numerical modelling will be discussed (e.g. gap filling versus observational independency). The ultimate goal is to develop a consensus estimate of global glacier mass changes based on regional selection and combination of available results. Existing and newly emerging regional estimates will be compared in direct collaboration with the other WPs, and differences will be analysed to inform method improvement. A joint publication is envisioned.
- **Common framework for regional mass change estimates.** With the onset of the WG, we will define a general framework to harmonize region-wide glacier change estimates and to facilitate comparisons between different methods. This will include definitions of common glacier regions, time periods, area changes over time, and separation of peripheral glaciers from the ice sheets in Greenland and Antarctica.
- **Open and free access to glacier data**. The WG urges the community to share their data after publication through the designated international data repositories (e.g. NSIDC, WGMS). For glacier-wide results from geodetic methods, the WGMS has resources (from the Copernicus Climate Change Service) to support data providers in bridging the last mile in data submission. In addition, the WGMS offers the possibility of scientific working stays for data producers to bridging the last mile of the integration of their data into the 'Fluctuations of Glaciers' database. In addition, the opportunities and challenges of new data formats (e.g. storage and handling of distributed glacier elevation change fields) will be discussed during WG meetings.
- **Regional assessments of glacier mass changes**. We opened a corresponding research topic in Frontiers in Earth Science (https://www.frontiersin.org/research-topics/9957). This thematic paper collection shall provide an attractive opportunity for the community publishing their assessments of glacier mass changes and, hence, contributes to an improved observational coverage. The research topic timeline is aligned with the publication requirements for IPCC AR6

WG1 (i.e., submission deadline: 31 Dec 2019, acceptance deadline: 30 Sep 2020). A call-for-papers was sent out to Cryolist. Together with the IPCC SROCC compilation of results from various studies, the research topic serves as starting point for a regional comparison of glacier mass changes from different methods.

3. MILESTONES AND DELIVERABLES

We aim for the following milestones and deliverables related to above objectives:

- WP 1-3: joint video conference (VC) to setup a common framework and coordinate activities.
- WP 1: Initial workshop (W), round robin experiment (RR), white paper (P), data production coordination (DC)
- WP 2: Initial workshop (W), white paper (P)
- WP 3: Research topic in Frontiers in Earth Sciences: proposal to journal (1), announcement (2), submission (3) and acceptance (4) deadlines in line with IPCC AR6, publication and outreach (5). This WP will bring together the results from WP1 and WP2 in a joint workshop (W) in the third year resulting in a consensus estimate publication (P) towards the end of the WG. Periodically conference sessions on regional mass balance assessments will be organized (X).

The following Gantt-chart provides an overview of corresponding milestones.

Obj.	2019		2020				2021				2022				2023	
WP1		DC	VC	W	RR	RR	RR	DC		P		DC				
WP2			VC	W						P						
WP3	1,2	3	VC	X	4	X	5	X		X	W	X		X	P	X

4. MEMBERSHIP

The present proposal was prepared by a core team of scientist currently active in regional glacier change assessments. After approval of the WG, we will send out an open call for participation through Cryolist, specifically encouraging the participation of female and early career scientists. In addition, we will send out invitations to the WGMS and GLIMS collaboration networks in the Andes, Asia, and New Zealand in order to solicit involvement from colleagues beyond Europe and North America. The participation is open to everybody who is willing to actively contribute to one or several of the objectives listed above.

5. WORKING PROCEDURES

The WG will coordinate its activities during WG meetings at established conferences (e.g., EGU, AGU) as well as during video conferences at monthly to quarterly frequency. The co-chairs will organize and announce these meetings. Co-leads are responsible to coordinate activities and report corresponding progress with respect to the WG main objectives. WG members will contribute to one or several of the WG main objectives. The WG co-chairs will report annually to the IACS Bureau.

Coordination with other bodies: The WG will coordinate its activities with the WGMS as well as with other IACS WGs of relevance (e.g. RGI/GLIMS WG).

Outreach to the scientific community: The WG considers the organization of public webinars to present the outcome of the planned workshops and publications. In addition, the WG will encourage the community to present and discuss their glacier mass change assessments and regional comparisons in well-established and newly proposed sessions such as at EGU, AGU, IUGG, or IGS conferences.

6. BUDGET

We ask for 6,000 Euro as a contribution to the organization of the proposed workshops and to the publication fee of the proposed paper. In view of the limited budget and to minimize our carbon footprint, the planned workshops will be organized as a combination of regional workshops and virtual sessions.

7. CONCLUSIONS

In view of the swiftly emerging possibilities and challenges of measuring glacier mass balances from space, the establishment of the proposed WG is a timely effort towards a better coordination of the research community. We will foster the regional assessment of glacier mass changes to improve the observational coverage and the corresponding data availability as well as to establish a consensus on best practises in data processing related uncertainty estimates. Towards the end of the WG, we aim for presenting a new consensus estimate of global glacier mass changes based on all available assessments from glaciological, geodetic, altimetric, and gravimetric methods. With these activities, the WG will stimulate a constructive discussion within and between different research communities and will improve both observational coverage and methodological understanding towards future IPCC reports.