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WGMS Report 2020 & Program 2021

1. Introduction

Internationally coordinated glacier observation was initiated in 1894 with the foundation of the *Commission Internationale des Glaciers* at the 6th *International Geological Congress* in Zurich, Switzerland. Since 1986, the *World Glacier Monitoring Service* (WGMS) has maintained and continued the collection of standardized information about distribution and ongoing changes of glaciers. Today, the WGMS is a service of the *International Association of Cryospheric Sciences* (IACS) within the *International Union of Geodesy and Geophysics* (IUGG) as well as a member of the *World Data System* (WDS) of the *International Science Council* (ISC, formerly ICSU), and works under the auspices of the *United Nations Environment Programme* (UNEP), the *United Nations Educational, Scientific and Cultural Organization* (UNESCO), and the *World Meteorological Organization* (WMO). The WGMS maintains a scientific collaboration network of *Principal Investigators* and *National Correspondents* in all the countries involved in glacier monitoring.

Based on a decision in 2009 relating to the participation of Switzerland in the *United Nations Framework Convention on Climate Change* and the *Global Climate Observing System* (GCOS), the *Swiss Federal Council* decided to provide long-term funding through GCOS Switzerland to the *Department of Geography* of the *University of Zurich* (UZH) for the operational lead and coordination of the WGMS. In 2021, the original contract between the UZH and MeteoSwiss was replaced by a long-term framework agreement and a four-year finance agreement, to be extended after successful evaluation.

In addition, WGMS products and projects have recently been supported by national and international organizations such as the *Cryospheric Commission* of the *Swiss Academy of Sciences*, the *Swiss Agency for Development and Cooperation* (SDC), the *University of Fribourg*, IACS, and UNESCO. As in the past years, the WGMS has strengthened its remote sensing capacities within ESA's *Climate Change Initiative* (CCI) and in the *Copernicus Climate Change Service* (C3S).

Detailed information about the WGMS, its partner organizations, monitoring strategy, and data products are available on the WGMS website: <https://www.wgms.ch>.

In addition, the GTN-G website gives an overview on the overarching structure of international glacier monitoring as well as on the available global datasets: <https://www.gtn-g.org>

2. Annual Report for 2020

2.1 Status report

In 2020, the WGMS successfully accomplished all its operational tasks, in spite of the pandemic. In addition, the WGMS published the third *Global Glacier Change Bulletin* (WGMS, 2020; <https://wgms.ch/ggcb/>), new datasets of the *Fluctuations of Glaciers* (FoG) and the *Glacier Thickness Database* (GlaThiDa), as well as several scientific publications and media reports. Throughout the year, the service supported the negotiations of the UZH and MeteoSwiss to finalize the long-term framework agreement and the four-year finance agreement for the period 2021-2024. WGMS staff members have been active in numerous international boards, including the *GCOS Steering Committee*, the *WDS Scientific Committee*, and several IACS working groups.

2.2 Activities

Core business and special tasks

The operational tasks of the WGMS include the management of its databases and website, the response to data and information requests, and the periodical contact with its scientific collaboration network of *National Correspondents*, *Principal Investigators*, and partner institutions. In addition, the WGMS is present at various national and international conferences, meetings and workshops and is actively involved in selected education and public outreach activities.

In 2020, the WGMS responded to more than 20 data and about 100 information requests. Due to the facilitated online access to glacier data, the number of data requests sent by email to the WGMS is decreasing. Nevertheless, these remaining requests often require more effort because of special demands. The WGMS website registered about 4,000 visits per month on average and the GTN-G website about 1000 visits per month. Besides the welcome page («home»), the pages «latest mb data», «mb_ref», «global glacier state», and «FoG browser» were visited most. For the *wgms Glacier App*, no more user statistics are available for 2020 due to decommission of *Google Analytics* for mobile apps.

Beside the operational tasks, the main effort in 2020 was related to the production, publication, and shipment of the third *Global Glacier Change Bulletin* (WGMS, 2020; <https://wgms.ch/ggcb/>), the update of the online products, and to the negotiation and formulation of the new agreements between UZH and MeteoSwiss on the long-term support of the WGMS.

In addition, the WGMS completed the following tasks in 2020:

- Control and quality check of data from the *Call-for-Data* 2017/18 (incl. *Near-time reporting* for 2018/19) and online publication of the latest database version with the respective *Digital Object Identifier*,
- Organization of glacier monitoring sessions at EGU, EC/ESA EO4Polar, and AGU conferences,
- Update of the WGMS and GTN-G websites,
- Update of the WGMS cooperation and address database (from SMD4GC project),
- Appointment of a new *National Correspondent* for Germany,
- Re-submission of the Agora proposal for the *wgms Glacier App 3.0* to the *Swiss National Science Foundation*,
- *Call-for-Data* for the observation period 2018/19 and *Near-time reporting* for 2019/20,
- Glacier safety training in Zermatt,
- Online publication of mass-balance values for 2018/19 and preliminary values for 2019/20,
- Videoconference with WGMS *National Correspondents* and *Principal Investigators*,
- Reporting for 2020 and planning for 2021.

On request, several support letters for research projects and trainings in the field of national and international glacier monitoring (e.g., Argentina, Bolivia, Greenland, and Russia) were written.

In 2020, the WGMS staff was active at several national and international meetings (mainly by virtual attendance, due to the COVID19 pandemic). The research stay of M. Zemp at the University of Bremen took place and resulted in an article by Zemp & Marzeion on the impact of large volcanic eruptions on global glacier mass changes, which is currently under revision with an academic journal.

International collaborations

In close collaboration with the *US National Snow and Ice Data Center* in Boulder (NSIDC) and the *Global Land Ice Measurements from Space* (GLIMS) initiative, the WGMS has been in charge of the *Global Terrestrial Network for Glaciers* (GTN-G) since its creation in 1998. In 2008, the three bodies proposed a generic structure and terms of reference for a GTN-G *Steering Committee* (including an *Executive Board* and an *Advisory Board*) to the IACS Bureau. This proposal was approved in 2009 and at the beginning of 2011,

the *Advisory Board* (under the lead of IACS) was finally staffed with representatives from data user and producer communities, as well as from international organizations (see <https://www.gtn-g.org>). Over the past years, periodical meetings of officers from NSIDC, GLIMS, and the WGMS were held to discuss and coordinate the current key tasks. In 2020, joint (virtual) conference sessions were set up at EGU in Vienna, AT, and at AGU in San Francisco, US, dedicated to the monitoring of glaciers from in-situ and remotely sensed observations. In combination with the conferences, (virtual) meetings of the *Executive Board* were held, with attendees from all GTN-G bodies.

The integration of glacier datasets into the multi-temporal GLIMS database was continued at NSIDC. At WGMS, a continued focus is on complementing the glaciological observation series with geodetic volume changes of glaciers by the analysis of remote sensing data within C3S. Within this framework and thanks to the support of several research groups, the dataset on geodetic thickness change was extended substantially: this dataset now comprises about 95,000 observations from more than 27,000 glaciers.

In July 2020, the WGMS signed a *Memorandum of Understanding* with the *Kilian Jornet Foundation* (<https://www.kilianjornetfoundation.org>). The main purpose is to establish a working relationship of mutual collaboration to contribute to monitoring of glaciers and to take different actions to show the importance that glaciers have in our ecosystem. In 2020, the activities of the University of Fribourg within the project *Cryospheric Climate Services for improved Adaptation* (CICADA Phase 1) was in its last project year. Due to COVID-19 pandemic, capacity building activities were reduced to online lectures and communication. However, the long-term training from the previous years showed to be very successful as all local researchers performed all measurements on the glaciers in the network by themselves. In addition, a very successful online workshop trying to improve the gender balance with title *Adventure of Science, Women and Glaciers in Central Asia* was organized by an experienced, women-only instructor team from Switzerland. The participants of the 10-day online course acquired important knowledge about glaciers and the mountain cryosphere environment, ecology, scientific observations, art and its relation to science, leadership, group collaboration and critical reflection. The monitoring and capacity building activities will be continued by a new four-year project with the title *Strengthening the resilience of Central Asian countries by enabling regional cooperation to assess cryospheric systems to develop integrated methods for sustainable development and adaptation to climate change*, financed by UNESCO. Activities will mainly focus on the two countries Kyrgyzstan and Tajikistan. In addition, a new SDC project related more to permafrost monitoring but establishing larger cryospheric monitoring sites will be prepared by end of June 2021.

The relations to the international umbrella organizations were fostered at several occasions, for example with the participation of the WGMS in the GCOS *Steering Committee* (M. Zemp) and in the WDS *Scientific Committee* (I. Gärtner-Roer) with several meetings. In addition, the WGMS was actively involved in the IACS working groups (*Randolph Glacier Inventory*, *Regional Assessment of Glacier Mass Change*; <https://cryosphericciences.org/activities/working-groups/>), in the writing team of the upcoming GCOS *Status Report*, as well as in reviewing IPCC SROCC und AR6.

2.3 Outreach

The WGMS team was actively involved in a large number of education and public outreach events. Some of them are available from an additional page giving a selection of articles, videos, and audio files from newspapers and other media with reference to the WGMS: <https://wgms.ch/media/>

2.4 Publication of data and results

In 2020, the WGMS staff was involved in the following selected publications related to glacier monitoring:

- Barandun, M., Fiddes, J., Scherler, M., Mathys, T., Saks, T., Petrakov, D., Hoelzle, M. (2020): **The state and future of the cryosphere in Central Asia**. Water Security.
- Carturan, L., Rastner, P. and Paul, F. (2020): **On the disequilibrium response and climate change vulnerability of the mass balance glaciers in the Alps**. Journal of Glaciology, 66 (260), 1034-1050.
- GlaThiDa Consortium (2020): **Glacier Thickness Database 3.1.0**. World Glacier Monitoring Service, Zurich, Switzerland. <https://doi.org/10.5904/wgms-glathida-2020-10>.
- Goerlich, F., Bolch, T. and Paul, F. (2020): **More dynamic than expected: An updated survey of surging glaciers in the Pamir**. Earth Syst. Sci. Data, 12, 3161-3176.
- Haeberli, W., Huggel, C., Paul, F. and Zemp, M. (2020): **The response of glaciers to climate change: Observations and impacts**. Treatise on Geomorphology, 2nd edition, Volume 13, Academic Press, p. 152-175. <https://doi.org/10.1016/B978-0-12-818234-5.00011-0>.
- Hoelzle, M., Kronenberg, M., Machguth, H., Mattea, E. (2020) Englacial Temperatures. Cryospheric Commission (EKK) of the Swiss Academy of Sciences (SCNAT), Zürich.
- Huber, J., McNabb, R. and Zemp, M. (2020): **Elevation changes of west-central Greenland glaciers from 1985 to 2012 from remote sensing**. Front. Earth Sci. 8(35). doi: <https://doi.org/10.3389/feart.2020.00035>.
- Paul, F., Rastner, P., Azzoni, R.S., Diolaiuti, G., Fugazza, D., Le Bris, R., Nemec, J., Rabatel, A., Ramusovic, M., Schwaizer, G., and Smiraglia, C. (2020): **Glacier shrinkage in the Alps continues unabated as revealed by a new glacier inventory from Sentinel-2**. Earth Systems Science Data, 12(3), 1805-1821.
- Popp, T., M.I. Hegglin, R. Hollmann, F. Arduin, A. Bartsch, A. Bastos, V. Bennett, J. Boutin, C. Brockmann, M. Buchwitz, E. Chuvieco, P. Ciais, W. Dorigo, D. Ghent, R. Jones, T. Lavergne, C.J. Merchant, B. Meyssignac, F. Paul, S. Quegan, S. Sathyendranath, T. Scanlon, M. Schröder, S.G.H. Simis and U. Willén (2020): **Consistency of satellite climate data records for Earth system monitoring**. Bulletin American Meteorological Society, 101 (11), E1948-E1971.
- Tielidze, L. G., Bolch, T., Wheate, R. D., Kutuzov, S. S., Lavrentiev, I. I., and Zemp, M. (2020): **Supra-glacial debris cover changes in the Greater Caucasus from 1986 to 2014**. The Cryosphere, 14, 585-598, <https://doi.org/10.5194/tc-14-585-2020>.
- Sommer, C., Malz, P., Seehaus, T.C., Lippl, S., Zemp, M., and Braun, M.H. (2020): **Rapid glacier retreat and downwasting throughout the European Alps in the early 21st century**. Nature Communications, 11, 3209. <https://doi.org/10.1038/s41467-020-16818-0>.
- Thomson, L., Brun, F., Braun, M. and Zemp, M. (2020): **Editorial: Observational assessments of glacier mass changes at regional and global level**. Front. Earth Sci., <https://doi.org/10.3389/feart.2020.641710>.
- Welty, E., Zemp, M., Navarro, F., Huss, M., Fürst, J.J., Gärtner-Roer, I., Landmann, J., Machguth, H., Naegeli, K., Andreassen, L.M., Farinotti, D., Li, H., and GlaThiDa Contributors (2020): **Worldwide version-controlled database of glacier thickness observations**. Earth Syst. Sci. Data, 12, 3039-3055, <https://doi.org/10.5194/essd-12-3039-2020>.
- WGMS (2020a): **125 years of internationally coordinated glacier monitoring: achievements and future challenges – Summary report on the IUGG General Assembly and the WGMS General Assembly of National Correspondents 2019**. World Glacier Monitoring Service, Zurich, Switzerland, 63 pp.
- WGMS (2020b): **Global Glacier Change Bulletin No. 3 (2016-2017)**. Zemp, M., Gärtner-Roer, I., Nussbaumer, S. U., Bannwart, J., Rastner, P., Paul, F., and Hoelzle, M. (eds.), ISC(WDS)/IUGG(IACS)/UNEP/UNESCO/WMO, World Glacier Monitoring Service, Zurich, Switzerland, 274 pp., publication based on database version: doi:10.5904/wgms-fog-2019-12.
- WGMS (2020c): **Fluctuations of Glaciers Database**. World Glacier Monitoring Service, Zurich, Switzerland. <https://doi.org/10.5904/wgms-fog-2020-08>
- Zemp, M., Huss, M., Eckert, N., Thibert, E., Paul, F., Nussbaumer, S.U., and Gärtner-Roer, I. (2020): **Brief communication: Ad hoc estimation of glacier contributions to sea-level rise from latest glaciological observations**. The Cryosphere, 14, 1043-1050, <https://doi.org/10.5194/tc-14-1043-2020>.

3. Annual work plan for 2021

3.1 Activities

As in previous years, the operational service of the WGMS consists of its annual core business, aligned with the hydrological year and special tasks.

In 2021, these special tasks are to (i) sign and implement the new WGMS agreements, (ii) recruit a database manager, (iii) produce the *Global Glacier Change Bulletin No. 4 (2018-2019)*, (iv) revise and update the WGMS and GTN-G websites, (v) contribute to publications related to the IACS WG on Regional Assessment of Glacier Mass Change, and (vi) start the migration of the FoG database to a server-based solution and the development of an internal user interface. In addition, the WGMS team supervises BSc, MSc and PhD theses, interns, and visiting scientists working in the field of glacier monitoring and research.

The following schedule lists the main activities for 2021.

1. Quarter (JFM)

- Signature and implementation of new WGMS agreements.
- Annual report and balance 2020, program and budget for 2021.
- Search for and employment of new WGMS database manager.
- Check and upload of data for 2018/19 and *Near-time reporting* for 2019/20.
- Decision about future of the wgms Glacier App based on feedback from SNF Agora.
- Prepare production of the GGCB No. 4.
- Response to invitation to tender for C3S follow-up.

2. Quarter (AMJ)

- Workshop on new WGMS database concept.
- Production of GGCB No. 4.
- Database release (FoG-2021-06).
- Final data and document deliverables to C3S 312b.

3. Quarter (JAS)

- Printing and shipment of GGCB No. 4.
- Actualisation of digital online products (FoG-2021-06).
- Safety training/crevasse rescue training.
- Contribution to IACS *Working Groups* RGI & RAGMAC (e.g., workshop, publication).

4. Quarter (OND)

- *Call-for-Data* for observation period 2019/20 & *Near-time reporting* for 2020/21.
- Annual telecons with WGMS NCs and PIs.
- Lecture series on *Glacier Mass Balance Measurements & Analysis* (GEO851).
- Reporting 2021 and program 2022.

3.2 Outreach

In 2021, several glacier monitoring activities of WGMS, NSIDC, GLIMS, and different IACS working groups are planned. Conference sessions on glacier monitoring are set up for the virtual EGU General Assembly and planned for the AGU *Fall Meeting* (USA). In combination with the EGU and AGU conferences, meetings of the GTN-G *Executive Board*, with representatives of the GTN-G bodies WGMS, NSIDC, and GLIMS are organized. Additional regional/national meetings (e.g., *Alpine Glaciology Meeting*, *Swiss Polar Day*, *Swiss Geoscience Meeting*) will be attended by the WGMS staff physically or virtually, depending on the COVID situation.