Summary Report on the WGMS General Assembly of the National Correspondents

1st – 4th September 2010, Zermatt, Switzerland

wgms
World Glacier Monitoring Service

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Summary Report on the WGMS General Assembly of the National Correspondents 2010

Edited by the WGMS staff members:

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Executive summary
The World Glacier Monitoring Service General Assembly was held from 1–4 September 2010 at Riffelberg, Zermatt, and brought together the staff members of the central service, National Correspondents or their deputies representing 28 countries of its worldwide scientific collaboration network, as well as special guests from the Global Land Ice Measurement from Space community, the Norwegian Water Resources and Energy Directorate, the European Space Agency, and from the Swiss Global Climate Observing System Office. Besides the strengthening of the personal contacts within this network, the main goals of the meeting were to present and discuss (i) the international organization, strategy, and datasets of the Global Terrestrial Network for Glaciers, (ii) its implementation in the participating countries, (iii) the current status and challenges of glacier monitoring, (iv) measures to improve our service to the community, and (v) the definition of key tasks for the glacier monitoring of the coming decade.

As a conclusion of the presentations and discussions during the meeting, the main contributions of the international glacier monitoring for an improved understanding of glacier processes, distribution and changes can be summarized as to:

- continue the long-term observation series of glacier fluctuations,
- re-activate interrupted (long-term) fluctuation series,
- strengthen the monitoring network in under-represented mountain ranges,
- improve the richness and quality of available datasets,
- homogenize, validate, and calibrate long-term fluctuation series,
- start the compilation of standardized glacier thickness and volume measurements,
- complete a detailed global glacier inventory, and to
- compute and analyse repeat inventories in key regions.

The corresponding monitoring strategy has to be regularly reflected with respect to climate-related monitoring of glaciers but also regarding impacts of glacier changes, such as on global sea-level rise, regional hydrologic regimes, and the local hazard situation. This process has to include considerations of the historical evolution of glacier research and related datasets but also needs to anticipate future developments in both changes of glaciers and monitoring techniques.
The panoramic and culinary setting of the venue greatly supported the spirit of intensive and constructive discussions during the workshop and provided a perfect stage for setting the key tasks of the WGMS collaboration network for the coming decade, and until the next WGMS General Assembly to be held around the year 2020.

Background

The history of internationally coordinated glacier monitoring goes back to the foundation of the „Commission Internationale des Glaciers“ in 1894. Since then, the World Glacier Monitoring Service (WGMS) and its predecessor organizations have been compiling and publishing standardized information on glacier distribution and changes. The WGMS is a scientific collaboration network which consists of the Principal Investigators that carry out the measurements at glaciers around the world and National Correspondents that regularly compile the observations in their country in standardized formats. The data is finally compiled by the central WGMS office, hosted at the University of Zurich, Switzerland, which tests the data for plausibility and makes them available in digital and analogue form for the scientific community, non- and governmental agencies, and the general public. Together with the U.S. National Snow and Ice Data Center (NSIDC) and the Global Land Ice Measurements from Space (GLIMS) initiative, the WGMS runs the Global Terrestrial Network for Glaciers (GTN-G) as a contribution to the Global Climate Observing System (GCOS) in support of the United Nations Framework Convention on Climate Change (UNFCCC). Scientific insights, technology, and many glaciers have changed since the last expert meeting of the WGMS which was held in Zurich, Switzerland, in 1995 (Haeberli *et al.* 1998). So it was high time for another meeting.

Venue, participants and main goals of the meeting

The WGMS General Assembly of the National Correspondents was held from 1–4 September 2010 at Hotel Riffelberg which is situated at 2,600 m a.s.l. above Zermatt, with a panoramic view to the Matterhorn – the mountainous icon of Switzerland (which geologically seen belongs to the African continent). The meeting was attended by the WGMS staff members and the WGMS National Correspondents or their deputies representing glacier monitoring in 28 countries (including Greenland and Antarctica), as well as by special guests from the GLIMS community, the Norwegian Water Resources and Energy Directorate, the European Space Agency (ESA), and the Swiss GCOS Office (see Appendix). The main goals of the meeting were to present and discuss (i) the international organization, strategy, and datasets of GTN-G, (ii) its implementation in the participating countries, (iii) the current status and challenges of glacier monitoring, (iv) measures to improve our service to the community, and (v) the definition of key tasks for the glacier monitoring of the coming decade. Last but definitely not least, the aim was to personally meet the colleagues and collaborators from all around the world. In order to support the intercommunication of the mainly in-situ community of the WGMS with the colleagues from remote sensing, the WGMS General Assembly was organized subsequent to the final meeting of the ESA-project GlobGlacier which was held in Zermatt. This three-year project was funded by the European Space Agency and made a major contribution towards the completion of a global inventory of glaciers and ice caps using satellite remote sensing. The opportunity of the coordinated meetings was used by numerous colleagues of both communities. The present report, however, focuses on the WGMS General Assembly of National Correspondents.

Minutes of the meeting

The meeting started with the **registration** and an ice breaker in front of Hotel Riffelberg in the late afternoon on Wednesday, 1st September 2010, allowing the participants enough time to reach the scenic venue by public transportation. For the majority, this included several hours of train rides from the international airports to Zermatt and another 23 minutes with the famous Gornergratbahn to Riffelberg. After dinner, the WGMS General Assembly was officially opened by Michael Zemp, the new Director of the WGMS, with a **welcome** speech introducing the historical background, the participants and the main goals of the meeting. He thereby emphasized the need for a critical reflection and discussion of how the internationally coordinated glacier monitoring can even better support the scientific community in answering the urging question related to the distribution and changes of glaciers.

Thursday, 2nd September 2010, started with an opening talk by Wilfried Haeberli, immediate-past Director of the WGMS, on the **historical background of international glacier monitoring and the integration of in-situ measurements within the Global Terrestrial Network for Glaciers**. It was emphasized that the international multi-level monitoring strategy aims at integrating in-situ and remote sensing measurements and puts the individual measurement programs in a wider international context. The rest of the day was dedicated to the report of the National Correspondents and their deputies on the **implementation of the international strategy and corresponding challenges within their countries.** These key talks were grouped in four session covering (i) North and South America (i.e., Argentina, Canada, Chile, Colombia, Ecuador, and Mexico; including activities in Antarctica), (ii & iii) Europe (Austria, France, Germany, Greenland, Iceland, Italy, Norway, Poland, Spain, and Switzerland), as well as (iv) Africa (Kenya, Tanzania, and Uganda), Asia (China, Iran, Japan, Kazakhstan, Nepal, Russia, and Uzbekistan), and New Zealand. Corresponding abstracts, including the one from Bolivia which was cancelled at the last minute, are found in the Appendix.

Friday, 3rd September 2010, was dedicated to five workshops with introductory remarks by WGMS staff members and a general discussion for each workshop topic. In the first workshop, the **current status and challenges of glacier monitoring at national and international level** was discussed again based on results from the talks on Thursday. It was agreed that glacier monitoring is well established at international level and that the compilation and free dissemination of glacier data for more than a century is a great success of this scientific collaboration network. The degree of implementation of the international monitoring strategy at national level, however, varies strongly from country to country. Only in about half of the participating countries, the glacier monitoring is coordinated at national level according to a national monitoring strategy which is linked to the international one. A key challenge thereby is the lack of structural and financial resources dedicated to (glacier) monitoring activities. In this regard, there was a general request for increasing the visibility of the value of long-term glacier monitoring both at the level of national and international agencies, but also within the scientific community. Positive examples on how to deal with these challenges are given by Switzerland and by Latin America. In Switzerland, the national funding for the long-term monitoring of climate-related observations has recently been secured through the national GCOS Office. In Latin America, the different groups that are active in cryospheric monitoring and research have created the „Grupo de Trabajo de Nieves y Hielos“ which has been fostering the scientific exchange with annual meetings and methodological workshops over the past years. Another key issue discussed was the challenges related to the monitoring of disintegrating glaciers and related issues with debris cover, dead ice, and lake formations. About half of the countries reported concerns about loosing long-term (>10 years) mass balance series due to the complete vanishing of the corresponding glaciers by 2050.

In a second workshop the **quality and richness of the available datasets** were discussed. In summary, it was noted that there is still no complete detailed inventory of the world's glaciers and that available fluctuation series have a strong bias towards the Northern Hemisphere and Europe (cf. WGMS 2008). An evaluation of the available mass balance dataset using a criteria catalogue in comparison with a literature review revealed that for most data series not the full information was submitted. As such, seasonal balances, mass balance vs. elevation, or ELA and AAR were measured but never made it to the international database. Also, pros and cons of point versus glacier mass balance measurement were discussed. It is noted that point measurements of mass balance (including exact information about location and elevation) are of great value for climatic interpretation and model validation, whereas for direct comparison between glaciers and questions related to the glacier contribution to hydrology and sea-level rise the glacier mass balance is still the most relevant information. It was suggested, that point mass balance measurements shall continue to be submitted as important meta-information with the glacier mass balance data. Another issue discussed was the heterogeneity of methods and terminology used in glacier monitoring and research. Reference was given to current efforts towards improved international guidelines and standards such as the works by Paul *et al.* (2009) and Cogley *et al.* (in press).

The general topic of the second workshop was extended in the third one with a more specific discussion on the **homogenization, validation, and calibration of glacier mass balance series**. One of the big open questions is the quality of available mass balance measurements. The comparison of (annual) direct glaciological with (decadal) geodetic mass balance measurement is considered to be a key task towards an improved understanding and quantification of related uncertainties. In this session, recent advances related to the homogenization of long-term mass balance series (e.g., Huss *et al.* 2009, Fischer 2010, Koblet *et al.* 2010, Nuth and Kääb 2010) as well as to the validation and calibration of glaciological and geodetic series (e.g., Thibert *et al.* 2008, Huss *et al.* 2009, Zemp *et al.* 2010) were discussed. It was agreed that the general concept of homogenization, validation and calibration of glaciological and geodetic mass balance series is a key issue related to the assessment of data quality. Methodological details shall soon be discussed in a separate workshop involving the key research groups.

The **current status and challenges of the remote sensing of glaciers** were presented and discussed in workshop number four. Currently, several glacier inventories exist in digital formats such as the World Glacier Inventory (point data), the GLIMS database (vector outlines), or the GGHydro data set from J. G. Cogley (raster). However, all suffer from either spatial incompleteness, missing topographic attributes, or a too coarse spatial resolution (Paul, 2010). Multispectral classification of glaciers from satellite data in combination with digital terrain information helps to effectively compile glacier inventory data and close the current gaps in a most efficient way. As demonstrated in the GlobGlacier project, satellite data can also be utilized for several further glaciological applications, for example mapping of snow covered areas, calculation of flow velocity and determination of changes in length, area and elevation. Thereby, the still required manual editing of debris-covered glacier parts and the digitization of drainage divides and central flowlines cause most of the workload. The recently started Glaciers_cci project of the ESA climate change initiative will further explore the possibilities and contribute to the completion of the global glacier inventory.

Workshop five was dedicated to summarize and discuss the feedback received on a questionnaire on „**how to improve our service to the (scientific) community?**“ that was sent out to all National Correspondents and Principal Investigators of the WGMS in summer 2010. Feedback was received from 37 colleagues in 29 countries. With respect to the WGMS services and products, the majority of these data contributors:

- evaluates the communication with the central office in Zurich as ok, good, or excellent (with 84% of the received feedbacks);

- evaluates the WGMS website (www.wgms.ch) as ok, good, or excellent (83%),
- does not comment on the new GTN-G website (53%) and the related meta-data browser (58%);
- evaluates the printed data reports as ok, good, or excellent, such as the Fluctuations of Glaciers (89%), the Glacier Mass Balance Bulletin (81%), and the report on Global Glacier Changes: facts and figures (76%);
- evaluates the digitally data products as ok, good, or excellent, such as the available fluctuation series (54%), the glacier photograph collection (52%), the WGI data (48%), the GLIMS data (46%), with 40–50% of the colleagues not commenting on these products.

With respect to specific suggestions to improve the WGMS service to the (scientific) communities, the majority of the data contributors evaluates the idea of:

- strengthening the cooperation between WGMS, NSDIC, and GLIMS under the framework of GTN-G as ok, good, or excellent (73%);
- digitizing and making available of all maps published in the Fluctuations of Glaciers and written data reports back to 1895 in PDF-format as good, ok, or excellent (FoG: 72%; maps: 78%);
- improve the visibility of and reference to WGMS datasets and products by citation as WGMS (YEAR) instead of Zemp *et al.* (YEAR) or ICSU(WDS)/IUGG(IACS)/UNEP/UNESCO/WMO (YEAR) as ok, good, or excellent (81%);
- improve the visibility of and reference to WGMS datasets and products by adding digital object identifier (DOI) number for mass balance, front variation, and inventory datasets as ok, good, or excellent (73%);
- improve our annual call-for-data by calling for (one) preliminary mass balance value of the running year and full details for the past year (compared to the present system calling only for the data of the past year) as ok, good, or excellent (47%); there is, however, a strong minority that evaluates this idea as bad (22%) or did not provide a feedback (31%);
- compiling and disseminating stake and pit mass balance values in addition to the specific glacier mass balance data as ok, good, or excellent (65%); there is, however, a strong minority that evaluates this idea as bad (16%) or did not provide a feedback (19%);
- compiling and disseminating glacier thickness measurements as ok, good, or excellent (78%).

The original questionnaire and full details on the received feedbacks are found in the Appendix.

In an additional session that was reserved to other topics arising during the workshop, issues related to data policy as well as to the tasks and succession plan of the National Correspondents were discussed and clarified as follows:

- A basic requirement for advancing research is **free and unrestricted international sharing of high-quality, long-term, and standardized data and information** products. The International Council for Science (ICSU) endorses as a general policy the fundamental principle of full and open exchange of data and information for scientific and educational purposes. Within GTN-G, a one-year retention period is granted to allow investigators time to properly analyse, document, and publish their data before submitting them in standardized format to the GTN-G operational bodies such as WGMS, NSIDC, and GLIMS. All data submitted to GTN-G are considered as public domain for non-commercial use and are made digitally available through the operational services at no cost. The data may be subject to errors and inaccuracies. GTN-G, therefore, strongly recommends performing data quality checks and, in cases of ambiguities, contacting the corresponding operational body as well as the Principal Investigators and sponsoring agencies of the data. The use of data and information from GTN-G requires acknowledgement to the GTN-G operational body (WGMS, NSIDC, GLIMS) and/or the original investigators and sponsoring agencies according to the available meta-information.

- **The main tasks of the WGMS National Correspondents** are to:
    - coordinate and represent the glacier monitoring of their country within our network,
    - be the central communication node for their country for the WGMS staff, and to
    - be responsible for the data collection within their country and the submission to WGMS for publication in the 'Fluctuations of Glaciers' and the 'Glacier Mass Balance Bulletin' series.

- **Succession plan for the position of the National Correspondent:**
    - the National Correspondents are asked to timely initiate the procedure for their succession,
    - the glaciological groups of a country have to nominate a candidate for the WGMS National Correspondent,
    - the Director WGMS finally accepts the nomination from within the countries and confirms the new National Correspondents.

In the late afternoon of Friday, 3rd September 2010, the WGMS General Assembly of the National Correspondents was officially closed. In his **concluding remarks**, the Director of the WGMS stressed out the strengths of the WGMS as a worldwide scientific collaboration network that follows a monitoring strategy integrating in-situ and remote sensing measurements in order to compile and disseminate standardized data and information on global glacier distribution and changes at highest quality to the (scientific) community. As a corresponding symbol and as gratitude for their long lasting contribution and support, all participants received a Swiss Army Knife in blue colour with the WGMS logo imprinted (and the hint not to put it in the carry-on luggage).

After the intensive work during the days, most had still some energy left for joining the evening talks after dinner on Thursday and Friday by our two guest speakers: Heinz J. Zumbühl, University of Bern, Switzerland, on the ‚Iconography of glaciers, ice and climate during the Little Ice Age' and Christoph Dehnert, University of Ulm, Germany, on ‚Acute high altitude associated illnesses – results from medical research at Capanna Regina Margherita (4,559 m a.s.l.)'. The scenic highlight of the meeting was probably the morning excursion on the 4th of September that was organized by Martin Hoelzle to Gornergrat (3,100 m a.s.l.) with perfect views to and explanations of ongoing research and monitoring activities at Gorner- and Findelengletscher, as well as on Stockhorn and Colle Gnifetti, Monte Rosa.

Conclusions and outlook

The WGMS General Assembly of National Correspondents was a great success in bringing together experts in glacier monitoring and science from all around the world. During this intensive meeting the organization, strategy and datasets of the internationally coordinated glacier monitoring as well as its implementation in the participating countries were presented and discussed. From the presentations of the National Correspondents and the workshop discussions, the main contributions of the international glacier monitoring for an improved understanding of glacier processes, distribution and changes can be summarized as follows:

- continue the long-term observation series of glacier fluctuations,
- re-activate interrupted (long-term) fluctuation series,
- strengthen the monitoring network in under-represented mountain ranges,
- improve the richness and quality of available datasets,
- homogenize, validate, and calibrate long-term fluctuation series,
- start the compilation of standardized glacier thickness and volume measurements,
- complete a detailed global glacier inventory, and
- compute and analyse repeat inventories in key regions.

Thereby, the monitoring strategy has to be regularly reflected with respect to climate-related monitoring of glaciers but also regarding impacts of glacier changes, such as on global sea-level rise, regional hydrologic regimes, and the local hazard situation. This process has to include considerations of the historical evolution of glacier research and related datasets but also needs to anticipate future developments in both changes of glaciers and monitoring techniques.

For the coming decade the following key tasks are to be tackled:

- improve the organizational structure and funding situation of glacier monitoring at national levels and make use of the scientific collaboration network of the WGMS and its contacts to international organizations (e.g., GCOS),
- use the WGMS collaboration network for capacity building (e.g., summer schools, scholarships, office and field training courses),
- develop and improve the monitoring strategy in order to deal with disintegrating and vanishing glaciers,
- enforce the homogenization, validation and calibration of long-term mass balance series (e.g., with small but well targeted scientific workshop),
- strengthen the integration of and the cooperation between the glacier in-situ and remote sensing communities,
- initiate (small) scientific workshops focused on specific aspects related to glacier monitoring (e.g., analysis of point mass balance data; the use of automatic weather stations and numerical modelling of glacier energy balance), and
- improve the visibility of the WGMS datasets (e.g., by joint review papers).

The panoramic and culinary setting of the venue greatly supported the spirit of intensive and constructive discussions during the workshop and provided a perfect stage for setting the key tasks of the WGMS collaboration network for the coming decade, and until the next WGMS General Assembly to be held around the year 2020.

As a first joint outcome of the GlobGlacier Final Project Meeting and the WGMS General Assembly of the National Correspondents, two articles were published: a first one just in the weeks after the meetings by Lukas Denzler in the Neue Zürcher Zeitung and another jointly by all participants in the first issue of the Climate and Cryosphere (CliC) Newsletter in 2011 (Zemp *et al.* 2011).

Acknowledgements
We are indebted to all National Correspondents and Principal Investigators of the WGMS collaboration network for their valuable input to the General Assembly and for their long-lasting support and collaboration. Special thanks go to the various guests attending our meeting and providing thorough input to the discussions and to Claudia Pinkwart and her team for great hospitality and culinary highlights during our stay at Hotel Riffelberg. The meeting was financed by the WGMS which receives substantial funds from the Swiss GCOS Office at the Swiss Federal Office of Meteorology and Climatology and the Department of Geography of the University of Zurich, Switzerland. The train tickets for the rides to Gornergrat and back to Zermatt on the excursion day were kindly sponsored by the Matterhorn Gornergrat Bahn AG.

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Appendix

Circular

PARTICIPANTS

National correspondents of the WGMS and members of the GTN-G advisory board.

REGISTRATION

Registration will open on the 20th of March 2010 and will close on the 1st of May 2010. Please register by email to: wgms@geo.uzh.ch with the subject "General Assembly" and your contact information (name, address, email). Please indicate in your email, whether you are willing to share a double room or not!

COSTS

Workshop fees and accomodation costs (1st - 4th September 2010, including breakfast and dinner) are covered by the WGMS. Travel costs and lunch have to be paid for by the participants.

ACCOMPANYING PERSONS

Due to the limited number of rooms at Hotel Riffelberg, we are unable to offer accomodation to accompanying persons.

MORE INFORMATION

- on the website: www.wgms.ch/general_assembly_2010
- or via email to wgms@geo.uzh.ch

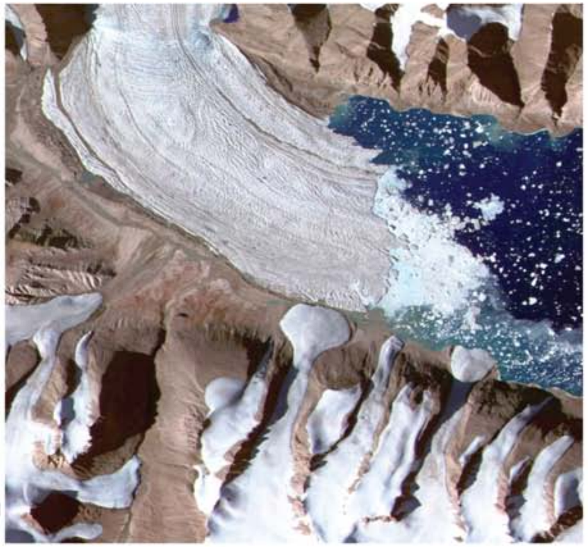


Photo front:
Oberaar glacier, CH
M. Zemp, 2003

Photo back:
Dobbin Bay, Ellesmere Island
ASTER image, July 2000

WGMS GENERAL ASSEMBLY

of the National Correspondents

including a workshop on

GLACIER MONITORING STRATEGY - CURRENT STATUS AND CHALLENGES

1st - 4th September 2010, Zermatt, Switzerland

WORKSHOP THEME

This meeting, organized by the World Glacier Monitoring Service about once a decade, aims at bringing all National Correspondents of the WGMS together. In addition, representatives of the newly established GTN-G advisory board will also be attending the meeting. The workshop gives the opportunity to discuss glacier monitoring strategies - current status and challenges.

ABSTRACTS & QUESTIONNAIRE

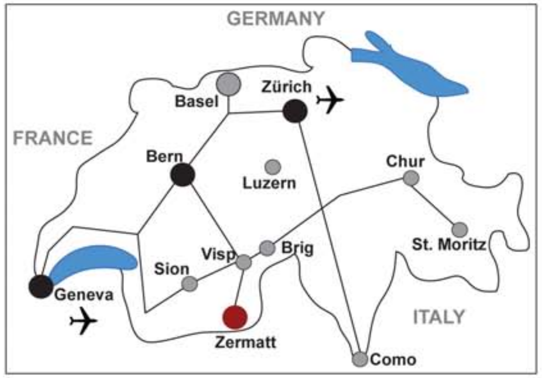
Each National Correspondent has the opportunity to give a short report (5-10 min) on the status and challenges of national glacier inventories, fluctuation series and recent developments in their country. This information should be summarized in an abstract and sent to the WGMS by May 1st, 2010. In addition, a questionnaire will be sent out by the WGMS in June 2010 in order to compile information on measurement techniques, mass balance calculations, as well as homogenizations.

SCHEDULE

On September 1st you will travel to Zermatt and Hotel Riffelberg. We will start the meeting with an icebreaker event in the early evening. On September 2nd and 3rd, an introduction to international monitoring strategies, presentations from the National Correspondents, and intensive discussion are scheduled. On the last day (September 4th) we will make a field trip starting from Gornergrat at 3135 m asl, where we will have a beautiful overview of the Zermatt valley with its breathtaking summits and large glacier systems. On one side we will have a view of the Gornergletscher, one of the most investigated glaciers in Switzerland. A short walk from Gornergrat will lead us to Hohtälli (3273 m asl) where we will have a nice view of the Findelengletscher. Front variations have been monitored at this glacier since 1885. Annual mass balance measurements were initiated in 2005 and are now validated in a new project with airborne laserscanning data. The excursion will end around noon and you can start your return trip.
Please bring hiking boots and warm clothes for the field trip!

TRAVELLING TO ZERMATT

Zermatt is situated in Southern Switzerland and is easily accessible from the west (airport at Geneva-Cointrin), the north (airports at Zurich-Kloten and Bern-Belp) and the south (airport at Milan-Malpensa). From there take the train to Visp, where you can change to the narrow-gauge railway to Zermatt. Please check your rail connections under www.sbb.ch. The rail-journey Visp-Zermatt takes 65 minutes and will take you through the romantic Vispertal and Mattertal valleys. If you travel by car you may go as far as Täsch, where there are parking facilities. Zermatt is easily accessible by rail: you can reach it in about 4 hours from Geneva-Cointrin, 3.5 hours from Zurich-Kloten and 3.5 hours from Milan-Malpensa. From Zermatt, you have to take the famous Gornergrat-train to Riffelberg (25 min). Please check the timetable on the website: www.ggb.ch/timetableprices/timetable.php. The last train to Riffelberg leaves Zermatt at 19:24!!



VENUE

Hotel Riffelberg is situated above Zermatt at an altitude of 2548 m asl in the middle of a hiking and skiing area. The hotel offers rooms with a beautiful view onto the glacier and mountain world of Zermatt, including the famous Matterhorn. You can enjoy an enticing combination of comfort and culture in unspoiled alpine surroundings.
Reservations are automatically made with your registration to the WGMS!

Detailed Programme

Wednesday 1st September

17.00–19.00	ice breaker & registration
19.00–20.30	dinner; welcome, introduction of representatives, programme (M. Zemp)

Thursday 2nd September

09.00–09.30	historical background of int. glacier monitoring and the integration of in-situ measurements within the Global Terrestrial Network for Glaciers (W. Haeberli)
09.30–11.15	glacier monitoring in North and South America (NCs)
11.15–11.45	break
11.45–12.30	glacier monitoring in Europe I (NCs)
12.30–14.30	lunch break
14.30–16.30	glacier monitoring in Europe II (NCs)
16.30–17.00	break
17.00–19.00	glacier monitoring in Asia, Afrika and New Zealand (NCs)
19.30–21.00	dinner
21.00–22.00	evening talk by H.J. Zumbühl on "Iconography of glaciers, ice and climate during the Little Ice Age"

Friday 3rd September

09.00–09.15	current status of the implementation of the GTN-G strategy (I. Gärtner-Roer)
09.15–10.00	discussion (All)
10.00–10.30	break
10.30–10.45	how to improve quality and richness of available glacier datasets? (M. Zemp)
10.45–11.30	discussion (All)
11.30–11.45	homogenization of glaciological and volumetric mass balance series (M. Zemp)
11.45–12.30	discussion (All)
12.30–14.30	lunch break
14.30–14.45	current status and challenges of remote sensing of glaciers (F. Paul)
14.45–15.30	discussion (All)
15.30–15.45	how to improve our service to the (scientific) community? (M. Zemp)
15.45–16.30	discussion (All)
16.30–17.00	break
17.00–17.30	varia (All)
17.30–18.00	conclusions and outlook (M. Zemp)
18.30–20.00	dinner
20.00–21.00	evening talk by C. Dehnert on "Acute high altitude associated illnesses – results from medical research at Capanna Regina Margherita (4,559 m a.s.l.)"

Saturday 4th September

09.00–12.00	excursion to Gornergrat (M. Hoelzle)

Abstracts NCs

Argentina/Antarctica

Monitoring glaciers in Argentina – Status report

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Glacier changes are key indicators of climate change and a major source of water for the development and sustainability of populations and ecosystems, especially in arid and semiarid regions of Argentina. The aim of this abstract is to present un update of glacier inventories, glacier fluctuations and mass balance data in some glaciers of the Argentina Andes between 17º and 55ºS over the past ~100 years. In selected glaciers the chronology of the glaciers extends to the Little Ice Age (LIA). The Andean mountain ranges in this transect, present general north-south orientation. The variation in size and occurrence of glaciers is a result of the interaction of topography and climate. The topographical system shows strong contrast in altitude and width and comprises a considerable climatic range creating different environments for the formation of glaciers. Following Lliboutry, the Andes are divided in the Desert Andes (17º30'S–31ºS), Central Andes (31ºS–36ºS), North Patagonian Andes (36º–45°S) and the South Patagonian Andes that contain all glaciers south of 45ºS. Early inventories are briefly presented and new inventories are also mentioned. The debris covered ice is clearly predominant north of 34º30'S, and to the south the ice free of debris is by far the most important glaciological component. Information of detailed glacier inventory and glacier fluctuations in the Desert Andes is very scarce and it is limited to the 20th century. At 29º20'S, an inventory covering 100 km² showed that the glacierized area lost about 12% in 1959–2005 and the overall mass balance in 2007/2009 was negative. Also, new glacier inventories at 28º–30ºS were recently published.

Studies about glacier fluctuations since the end of the 19th century or the beginning of the 20th century to 2007 are more abundant in the Central Andes (33º–35ºS). The Little Ice Age (LIA) maximum advance occurred between cal. yr 1550 and 1720 AD, and a readvance occurred around cal. yr 1830 AD. The frontal variations of selected glaciers of different sizes showed a negative trend from the end of the 19th century or the beginning of the 20th century to 2007. Some of these glaciers experienced minor advances in the 1980s and 1990s, which could be related with strong warm ENSO events during these decades. It is interesting to note that the glaciers in the Aconcagua area (33ºS) and in the Río del Plomo basin (32º57'S) lost about 30% of the glacierized area in the last hundred years. In the Glaciar Piloto Este (32º27'S) the mass balance series shows a very negative trend in the 1979–2003 period. Detailed knowledge about the distribution and characteristics of surging glaciers is fundamental for assessing risks from glacier hazards. Glaciar Horcones Inferior (32º40'S), and the Glaciar Grande del Nevado (32º57'S) are well documented cases of a surging glaciers. The Glaciar Laguna (34º30'S) advanced in 1970–1982 while the glaciers in the Atuel basin retreated, suggesting a surging event.

In Northern Patagonia, Monte Tronador (41º10'S) is covered by an icecap that feeds several glaciers flowing into Chile and Argentina. Glaciar Frías has been dated by dendro-geomorphological studies and at least nine events were identified during the past millennium. The maximum LIA extension was tree-ring dated to 1638. After this period, glacier shrinkage has prevailed throughout the 20th century. In Southern Patagonia, the number and extent of glaciers increases significantly. The SPI is ~370 km long from north to south. In 1944/45 the SPI covered 13,500 km^2 and diminished to 12,500 km^2 in 2009, due to the negative mass balance of the last decades. The most studied glacier is the Glaciar Perito Moreno, but also the nearby Ameghino and Mayo glaciers. The Perito Moreno is a calving glacier that advanced from the end of the 19th century to the beginning of the 20th century, and then remained stable. Also, five small glaciers have been studied near the northeast margin of the SPI (ca. 49ºS) and the LIA maximum position was dated to the late 1500s–early 1600s. Relatively synchronous

advances occurred at most glaciers in the early 1700s. All glaciers show advances mostly concentrated between the mid-19th and early 20th centuries. Besides, a new inventory of glaciers between 49º–49º30'S was recently compiled. In the Andes of Tierra del Fuego a preliminary inventory of glaciers, was based on satellite images of February 2002. In the study area all the glaciers retreated since the beginning of the 20th century. The best studied glaciers are Martial (0.1 km^2) and Vinciguerra. Four glaciers of Cordón Martial (1,319 m a.s.l.) have lost 75% of their total area since the Little Ice Age. The mass balance of Glacial Martial Este shows a negative trend since 1998. Finally mass balance observations have been made since 1999–2000 in Bahía del Diablo, Antarctic Peninsula. Results indicate a highly negative cumulative balance.

Most glacier inventories are incomplete and out of date; therefore it is very important to complete a new glacier inventory of the Andes of Argentina based mainly on satellite images. The review and the results provide important new information on the glacier distribution, behaviour and glacial history of the regions, but additional glaciological studies are needed as well as well-dated records of glacier fluctuations. The inventory provides information about the distribution and characteristic of the glaciers, allowing to assess the changes that have occurred since the maximum extends of the LIA. The inventories are also useful to study hydrological issues and natural hazards. This report shows significant recent contributions to the study of glaciers. Nevertheless, additional studies and well-dated records of glacier fluctuations are needed. In an attempt to compile an update glacier inventory in the Mendoza Province (32–36ºS) the IANIGLA-CONICET will start briefly with a new Inventory of glaciers based on Aster and Landsat satellite images, supported by the Government of Mendoza Province. The compiled data will be sent to the WGMS and GLIMS. Also researchers of the National University of San Juan are working on an update of the inventory of glaciers (28–32ºS), funded by the Government of San Juan Province.

Austria

Status and challenges of glacier inventories, fluctuation series and recent developments in Austria

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Glacier inventories

Additional to the two completed glacier inventories 1969 and 1998, a third one for 2006 is in progress. The glacier inventory of 1969 (Patzelt, 1980, Gross, 1987) was digitized during the compilation of the second glacier inventory 1998 (Lambrecht and Kuhn 2007, Kuhn *et al*. 2009). Both inventories are based on airborne photogrammetry and include DEMs and glacier margins for all Austrian glaciers. The third glacier inventory is based on airborne laser scan data. A test area in Ötztal was already mapped (Abermann, 2010), the rest of Austria will be completed in the next years.

The third glacier inventory is an update of the GI 1969 and the GI 1998, ice divides, names, number and ID of the glaciers are not changed, even when tributaries separate or disintegrate.

Small glaciers in high elevations or debris covered glacier are often difficult to map. The new glacier inventory allows the correction of the previous ones in case debris covered parts of the glacier were not included in the glacier areas. These areas are corrected by comparison of the glacier areas to the volume changes.

Snow patches connected with the glacier were originally not mapped in 1969, but included in the digitized GI 1969 and the GI 1998. Since the appearance and the disappearance of these snow patches is misleading in terms of area change of the glaciers, the inventory 2006 should correct the glacier margins also for the previous inventories. The compilation of the volume inventory is ongoing (Span *et al.* 2005, Fischer *et al.* 2007).

Fluctuation of glaciers

The length changes of about 100 glaciers are surveyed annually and published in the Journal of the Austrian Alpine Club (e.g. Patzelt 2005, Patzelt 2006). The recession of glaciers makes some changes in the observation program necessary. Some glacier tongues are now located on steep rock ridges, where rock falls occur. For this reason, the survey of 3 to 4 glaciers is intermitted. Some glacier tongues reached the end of the valley and split up in several tongues. In most cases, all the tongues are surveyed further.

An increasing problem causing discontinuities in time series is the disintegration of glaciers in a lower, dead ice part and a higher accumulation area. To avoid a bias in the data set, an international agreement how to cope with these problems would be beneficial.

On some glaciers the debris cover of the tongues makes the determination of the glacier end difficult, on others proglacial lakes develop. New technologies, Laser distometers, are used quite frequently.

Mass balance

Annual mass balances are measured on Goldbergkees, Hintereisferner, Hallstätter Gletscher, Jamtalferner, Kesselwandferner, Kleines Fleisskees, Mullwitzkees, Pasterzenkees, Schwarzmilzferner, Stubacher Sonnblickkees, Wurtenkees, and Vernagtferner. The time series of Übergossene Alm ended in 1996. On all glaciers apart from Kesselwandferner, winter mass balance is measured, in most cases with fixed date (30.04.). But the time of the maximum snow cover showed large variability and occurred between 01.04 and 01.06.

Within the last decade, in many cases the ELA was located above the summits. The determination of the ELA is more difficult, since for most glaciers, the vertical balance profile is zero at a number of altitudes. So far, the lowest altitude where b=0 is defined as ELA. On most glaciers, the ablation area is significantly larger than in the last decade, the glacier area reduced. Annual changes of glacier area are included in the calculation for some, but not all glaciers. The mass balance of Hintereisferner was homogenized (Fischer 2010).

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Bolivia

Resultados del monitoreo de los glaciares de La Cordillera Real de Bolivia

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En 1991 se inicia el monitoreo de glaciares en La Cordillera Real de Bolivia, por iniciativa de investigadores del IRD de Francia, en la actualidad este trabajo lo realizan junto a investigadores del Instituto de Hidráulica e Hidrología de la Universidad Mayor de San Andrés de La Paz.

Los glaciares monitoreados son: el Zongo, el Chacaltaya y el Charquini Sur; se ha hecho una clasificación de los glaciares, de la Cordillera Real, de acuerdo a la altura de cumbre y al área cubierta de hielo; los grandes glaciares tienen una altura de cumbre mayor a los 5,500 m a.s.l. y un área mayor a 1 km^2 y los pequeños tienen valores por debajo de estos. El Zongo representa a los grandes glaciares en tanto que Chacaltaya y Charquini Sur son representativos de los pequeños. Cada glaciar ha sido equipado con estaciones hidrometeorológicas, que permiten medir las principales variables climáticas y el escurrimiento, se tiene una red de balizas en la zona de ablación y pozos en la zona de acumulación que permiten calcular el balance de masa, se tiene puntos georeferenciados que conforman una poligonal que sirve para realizar levantamientos topográficos de las balizas y del borde del glaciar y se hace uso de fotografías aéreas e imágenes satelitales para determinar la evolución geométrica del glaciar en el tiempo.

En estos 18 años de monitoreo se ha verificado un retroceso sostenido de los tres glaciares estudiados, siendo esto mas crítico en los glaciares pequeños; Zongo ha experimentado una pérdida promedio anual de 0.4 (m w.e.) equivalentes de agua con un acumulado de 6.6 (m w.e.), la lengua ha retrocedido 239 m, la ELA se ha ubicado, en promedio, a una altura de 5,289 m a.s.l. Chacaltaya con una pérdida promedio anual de 1.4 (m w.e.) ha desaparecido completamente el año 2008 acumulando hasta ese año una pérdida de 23 (m w.e.) ubicándose la ELA, en promedio, a una altura de 5,423 m a.s.l. Charquini Sur ha experimentado una perdida promedio anual de 0.853 (m w.e.), con un acumulado de 5.12 (m w.e.) y la ubicación de la ELA a 5,210 m a.s.l., desde el año 2002 en el que se inicia el monitoreo de este glaciar.

Los resultados del monitoreo de estos 18 años han evidenciado que el fenómeno de El Niño afecta en forma drástica a los glaciares tropicales de la Cordillera Real, El Niño 1997–98 ha ocasionado las mayores pérdidas en Zongo y Chacaltaya de todo el periodo de estudio, con una pérdida de 2 (m w.e.) y 3.6 (m w.e.), respectivamente; y el hecho mas relevante sin duda es haber monitoreado la desaparición del glaciar Chacaltaya.

Canada

Glacier-climate observing in Canada – The state and evolution of Canada's glaciers

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Since the 1996 meeting of the National Correspondents and Consultants to the World Glacier Monitoring Service in Zurich, and a visit to the Plessur Range/Weissfluhjoch, there have been many developments in Canada related to glacier observing and research of value to the environmental and natural resource sectors. I will provide a brief overview of those developments, the partnerships, both domestic and international, that have enabled advances, and the numerous challenges along the way.

The underpinnings of a reference glacier observation program in Canada have seen a modest phase of expansion in the last decade. Other advances include the conduct of repeat altimetry surveys over regional scales, growing consideration of larger glacier systems/icefields using mass flux/geodetic techniques, better estimation of calving fluxes for Arctic ice caps whose outlet glaciers reach the sea, a new inventory for the Cordillera, a growing data basis for characterizing the regional Area-Volume relationship manifested by the carbonate terrain of the Canadian Rocky Mountains, and novel partnerships with other agencies such as the Canadian Parks Service and our colleagues in Chile.

Glacier observations are also destined to be part of an effort to expand hydro-climatological monitoring over Canada's higher elevations and frontier regions. At present, observations are significantly biased to lower elevations in the Cordillera and to coastal sites (versus inland) in the Arctic Islands, whereas water resources, food security and ecosystem functioning in the mountain-fed rivers of western Canada, for example, will demand improved observations for hydrological process/parameterization studies and prediction. In the Canadian Arctic, glacier and ice cap responses are significantly influenced by the presence of open water, with positive feedback phenomenon requiring additional attention.

Despite the iconic nature of freshwater and snow and ice in Canada, and its importance to the economy and ecology, resources for glacier science are still relatively scarce. The current global financial crisis, while being weathered relatively well in Canada, is never-the-less manifesting reduced program spending in many areas of science. The approach we have taken to ameliorate this is clear and obvious – but we have never-the-less given it a name! "FIRM" – *Framework for Integrated Research and Monitoring*. This has been critical in establishing growing support for long-term monitoring in a short-term, results-based driven world. Demonstrating value to the economic, environmental and social license-to-operate sensibilities is within in our collective reach. These efforts will be illustrated with several examples.

Chile/Antarctica

Current status of the glacier inventory in Chile

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The current status of the glacier inventory in Chile is presented, including recent results and challenges regarding glacier fluctuations and mass balance studies. Developments in Antarctica performed by Chilean teams are also presented. Much progress has been attained in recent years thanks to a renewed interest in glacier studies from the Chilean research community and from the Government, part of which has been triggered by environmental issues. The recent knowledge has also benefitted from enhanced foreign collaboration. New inventories have been completed in many regions of the Chilean

Andes, including for example the Copiapó River Basin in the north of Chile (Vivero *et al*. 2009) and the Cordillera Darwin Icefield (CDI) in Tierra del Fuego (Rivera *et al*. 2009). At the same time glacier inventories are in the process of being updated in a few regions, such as the Maipo River Basin (by Dirección General de Aguas). The total estimated glacier area in Chile is 22,131 km^2, which represents 76% of the total glacier area estimated for South America (Casassa 2010).

China

Study on recent glacier changes and their impact on water resource in Xinjiang, northwestern China

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Xinjiang, the Uyger Autonomous Region in northwestern China, possesses the biggest ice volume of the glaciers in China, which plays an extremely important role both on water resource and stabilization of river runoff in this vast arid and semi-arid region. During the past several decades, due to climate warming, the most glaciers in Xinjiang are in a state of rapid retreating. Therefore, the impact of the glacier recession on water resource has drawn a wide attention. Based on field observation and remote sensing technique, this study has revealed the variations of 1800 glaciers during the past four decades and analysed the potential influence of the glacier variations on the water resource in Xinjiang. As a result, the total area of the investigated glaciers has reduced 11.7 %. The average area of individual glaciers has reduced by 0.243 km^2, and the average retreat rate of that is 5.8 $m \cdot a^{-1}$. The area reductions in different regions range between 8.8%–34.2%. The potential impact of the glacier recession on water resource in future will be spatially different. For the Tarim River, the glacier runoff is estimated to maintain its current level or increase somewhat in next 30–50 years. Because the glacial runoff accounts for a large amount of the river's runoff, at the beginning, the increasing in glacier melt would enrich the river runoff. However, once the ice volume reduced to a certain value, a shortage of water resource in this region is inevitable. In the north slop of Tianshan, the glaciers with a size smaller than 1 km^2 are most likely to be melted away in next 20–40 years, and those larger than 5 km^2 are melting intensively. The impact of which on different river basin in this region would be different depending on the proportion of glacial runoff to the river runoff. In eastern Xinjiang, because the number of the glaciers is small and also because the climate is extremely dry, the glacier retreating are causing the water shortage problem. For Ili River and Irtysh River, because they are dominant by snow melt runoff, the impact of the glacier shrinkage and temperature rise would be limited on the quantity of the river runoff, but significant on the annual distribution of the river runoff. The snow melt is important for these two river systems and needed to be particularly study.

Colombia

Glaciers of Colombia

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The glacier area of Colombia currently covers a total of 46.8 km^2, consisting of six small glaciers: Ruiz (8.8 km^2), Santa Isabel (2.6 km^2), Huila (9.7 km^2), Tolima (0.93 km^2), which are volcano glaciers, and Sierra Nevada El Cocuy (17.4 km^2, 2009) and Sierra Nevada Santa Marta (7.4 km^2, 2009). The lower limits of the glaciers lie between 4,700 and 4,800 m. In the last 60 years the area has lost 57% of its original extent. If the loss tendency of 3% per year continues like this, it is estimated that, within the next three to four decades, the glaciers in Colombia will disappear completely.

In 2006 (April), Colombia initiated a new period of glacier monitoring with the aim of gaining a better understanding of glacier dynamics and the climate as well as reaching a high scientific level in Glaciology in order to be able to compare information with other countries of the region.

For the first time in Colombia, two glaciers in different conditions (local climate, topography and lithology) have been completely instrumented with ablation stakes, snow pits and automatic weather stations (Volcano Nevado Santa Isabel and Sierra Nevada de El Cocuy).

Throughout the period from April 2006 to April 2010 a monthly mass balance has been calculated for the glacier on the volcano Nevado Santa Isabel. In total resulted an accumulated loss of –6,955 mm eq. of water. Only during a heavy rain period in the year 2008 the mass balance was positive. This gain however, was lost quickly due to the influence of ENSO (May 2009 – April 2010). During this phenomenon called El Niño, the glacier Santa Isabel lost 5,805 mm eq. of water.

For specific case of the Sierra Nevada El Cocuy (Ritacuba Negro Glacier) the mass balance indicates a lost of 4,788 mm eq. water (January 2007 to January 2009) but in another highest glacier called Ritacuba Blanco where the AAR (Accumulation Area Ratio) was 100% during Nov. 2008 to April 2010, the mass balance was positive (914.3 mm eq. water).

For both glaciers Santa Isabel and El Cocuy the current ELA lies in average on 4,840 metres of altitude and a vertical gradient is 100 to 130 mm/m eq. of water (2006–2010).

Ecuador/Antarctica

Last update of the inventory for glaciers of Ecuador
Evidence of climate change over tropical glaciers and Antarctica

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The last inventory for the Glaciers of Ecuador was made and published in 1998 and it was carried out by the Professor Ekkehard Jordan and Dr. Stefan Hastenrath, by means of the use of air pictures in some cases and satellite images in other cases, this evaluation determined that for this year the total covering of the glaciers evaluated in the Ecuador was of 97.21 km^2.

The update inventory was carried out in the years 2006–2008 using field measurements inside the Ecuadorian Glacier Program during the years 2002, 2003, 2005 and 2006. This study took as reference the previous work mentioned above. The last existent air pictures available in that moment corresponded to the years of 1997 for five glaciers and 2006 for one glacier.

The present work uses digital aerophotogrammetric for the evaluation. A covering of 57.6 km^2 was measured for the year 1997, for seven glaciers. The other two glaciers were not studied due to the lack of actual images and probably their glacier coverage were lost.

Since 1997 (date of the last inventory) until the 2009 upgrade a reduction of 40.74% of the covered area has taken place for Ecuadorean glaciers, that correspond to a reduction of 39.61 km^2.

Also one Ecuadorian glacier (15Alpha of Antisana) has been studied since 1994, showing an extensive data that was published by World Glacier Monitoring Service in extensive format. We hope to continue with the study of this glacier in to the Ecuadorian Glacier Program at INAMHI.

During the last Austral Summer a Ecuadorian team in cooperation with the University of Fribourg, University of Zurich and WGMS installed a network of measurements in a little glacier in the Greenwich Island near a Ecuadorian Station Pedro Vicente Maldonado over the Quito Glacier, the objective is obtain data for calculate the mass balance in the next three years, also we hope to develop a study to determinate the temporal evolution of this segment using aerial photographs and satellite images, for this topic we obtain a preliminary data. In the future we try to relate the results with the investigations carry out over other glaciers in the Antarctic Peninsula by teams of other countries.

France

Abstract

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In France, mass balances have been observed over several decades on 5 glaciers. Two mass balance series exceed 50 years. Photogrammetric measurements have been carried out in order to check these mass balance series. In addition, winter and summer mass balance measurements have been performed since 1949 on Sarennes glacier and since 1995 on the other glaciers. Winter and summer mass balance data are required to analyse these data for climatic purposes.

In addition, ice flow velocities and thickness variations have been measured on these glaciers on different transverse cross sections. Some of these data are available on the tongue of these glaciers since the beginning of the 20th century.

These data have been analysed in order to give an overview of the glaciers fluctuations in France.

Germany

Abstract

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The National Correspondent of Germany (Commission for Glaciology of the Bavarian Academy of Sciences, Munich) reports the changes in the five still existing German glaciers (www.bayerische-gletscher.de) to WGMS based on geodetic surveys made in a decadal sequence after the late 1940s (older surveys go back to the early 1890s). An additional 10 glaciers in the eastern Alps have been monitored geodetically since the early 1920s (Vernagtferner as early as 1889, for details see Finsterwalder 1953) and are still being reported on by the Commission for Glaciology, Munich. More detailed direct glaciological monitoring of Vernagtferner has been carried out since the early 1960s, and hydrological and climatological data have been collected at the Vernagtbach gauging station since the fall of 1973. Numerous studies have been presented on the topic of ice core analysis (Zeitschrift für Gletscherkunde und Glazialgeologie 1982), hydrology (Moser *et al*. 1986, Braun *et al*. 2007), glacier mapping (Kuhn and Lambrecht 2007) and meteorological processes (Weber, 2008), among others. Glacier mass balance values of Vernagtferner are reported regularly to the WGMS. This stable continuity in monitoring and scientific analysis has been made possible by the long-term research concept of the Commission for Glaciology; however, this long-term project has become vulnerable due to a change in research policy by the Union of German Academies (www.akademienunion.de). After 2013 it is planned to stop all science-related projects, making it necessary to secure funding for glaciological monitoring and research by means of new initiatives.

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Greenland

News and updates from ongoing glacier monitoring and inventorying in Greenland

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We provide a brief overview of ongoing monitoring and inventorying activities in Greenland, together with more details for two specific projects: the GlacioBasis glacier monitoring programme at A.P Olsen Ice Cap in NE Greenland and the PROMICE project focusing both on the margin of the Greenland Ice Sheet (GrIS) and on mapping local ice masses surrounding the ice sheet.

Significant progress based on remote sensing datasets has been made recently to produce glacier inventories suitable as snapshots for change assessment. This notwithstanding, the current state of local glacier and ice cap inventorying, mapping and monitoring in Greenland remains strikingly deficient, especially when compared to the achievements in monitoring the GrIS both from the space and from the ground. It will suffice to point out that we still have no reliable figure for the aggregate glacierized area outside of the GrIS, let alone glacier thickness and size distribution, with reported values anywhere between 70×10^6 to 150×10^6 km^2.

As to field measurements, the recent start of glacier mass balance monitoring at Freya Glacier and A.P. Olsen Ice Cap in NE Greenland (respectively operated by the Central Institute for Meteorology and Geodynamics in Vienna and by the Geological Survey of Denmark and Greenland in Copenhagen) add on the east coast to the ongoing mass balance series being continued further south at Mittivakkat Glacier. Some of these sites are also been monitored with the use of automatic weather stations, with a significant knowledge transfer between projects focusing on the margin of the ice sheet and on local glaciers. The largest network of automatic weather stations is at A.P Olsen, and further details will be provided on the work going on at this site.

Overall, we still have a long way ahead before Greenland, and especially the local ice masses outside of the GrIS, will be monitored to the extent called for by the expected climate warming in the region. Existing estimates of the significance on global sea level rise of ice masses outside of the GrIS would certainly benefit from a more solid knowledge of mass balance sensitivity and glacier size distribution. This will require not only to fill the existing gaps in mapping and inventorying, but also to produce reliable figures for both ablation and accumulation, together with a better understanding of processes such as meltwater retention which is only feasible with in situ measurements of glacier surface weather.

Iceland

Eighty years of glacier front monitoring in Iceland

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Monitoring of glacier front-variations in Iceland was started in 1930 by meteorologist Jón Eyþórsson. In the database of the Iceland Glaciological Society of volunteers, there are about 4,000 individual measurements at more than 60 glacier snouts. The glaciers and outlet glaciers monitored are of great variety in size, type, gradient and aspect. About 15 of them are surge-type and a few are calving into lagoons. Several of the margins are covered by debris to a various degree. Volcanic activity does occasionally have huge effect on the mass of individual ice caps or outlet glaciers.

In general the non-surge-type glacier snout reacts to changes in mass balance within 1–3 years regardless of size. The optimal correlation between mean summer temperature of the region and the front variations of the glacier seems to be with one year lag. The period of surge-type glaciers varies from less than 10 years to 100 years or more.

The method that has been used to the present day (tape measurement from a bench mark to the glacier margin) with a report from the observer has proven to be very fortunate and will not be replaced by other methods (e.g. remote sensing) in the foreseeable future.

Outlines of all glaciers in Iceland were traced on geo-corrected images from around the year 2000. This brought the total number of individual glaciers and ice caps to 296 and the total area to 11,078 km^2. During the past decade glaciers in Iceland have decreased in area by about 30 km^2 per year which means that the total area has by 2010 decreased to less than 10,800 km^2.

Iran

Iran research plans for continues inventory on glaciers

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Available data corresponding to Iran’s glaciers is related to the late of thirties and early of seventies. This data are mainly the result of a handful foreign researchers and the studies of Vaziri conducted in years between 1985 and 2000. Although those research studies can give valuable information regarding glaciers activities in the past, but they were not conducted in a systematic and continuous manner. Therefore, only some preliminary conclusions can be made regarding to the detection of glacial regions along with the basic characteristics of them.

Considering the importance of glaciers and the staggering rate of their shrinkage, the Ministry of Energy in Iran has defined a national project regarding the assessment of glaciers and assigned its responsibility to the Water Research Institute (WRI). Given the novelty of this field of research and limited number of glacier experts in Iran, an attempt has been made to define a research framework, so as to the studies that are to be conducted on Iran’s glaciers be in line with other studies that are being done in the countries with natural glaciers. A few research projects have been defined in this regard and it is hoped that they will pave the way for future studies on glaciers.

1. Measurement of the glaciers fluctuations based on aerial photography and satellite Images in five glacier regions of the country.
2. Research, studies and monitoring the characteristics of the Alamchal and Takht-e-soleiman glacier region by using ALOS (or SPOT-5), GeoEye and ASTER satellite images.
3. Research & studies on the Zard-koh and Takht-esoleiman glaciers characteristics such as volume, annual fluctuation and etc with field operations by using GPR.
4. Introducing Iran glaciers by produce some special public TV programs to increase the knowledge of glaciers protection among the people and publishing the Glaciers Atlas.
5. Codify the special standard for application of remote sensing in glacial studies.
6. Research on ecological aspects of glaciers and future climate change impacts.

Italy

Ten years of monitoring of Italian glaciers

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The measurements carried out to monitor the front fluctuations of Italian glaciers are made by some dozens operators coordinated by several organizations and societies. The data are collected by the CGI (Comitato Glaciologico Italiano, Italian Glaciological Committee) and yearly published in its magazine “Geografia Fisica e Dinamica Quaternaria”. A selection of the data is also sent to the WGMS. Most of the glaciological operators are volunteers, some of the costs of the yearly glaciological surveys are covered by funds for research. A challenge is now the rising reduction of funds made by the Italian Government, whose consequence could be a gap in the long lasting series of measurements.

In the last ten years the front position of a hundred glaciers on average has been checked year by year. Far less are the glaciers where the mass balance is calculated. The resulting general trend is a withdrawal of the snouts: every year more than 75% of the glaciers was retiring, with a rate of about 10 m/year. Few glaciers show sporadic and reduced advancements, in a situation of general deglaciation. At the snout of several glaciers small lakes and pools appear. The mass balance of the measured glaciers confirm the downwasting of ice: a negative mass balance of more than 1,000 mm w.e. is common.

Japan

Self-regulated fluctuations in the ablation of a Japanese snow patch over the past four decades

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We report fluctuations in the ablation of the Hamaguri-yuki snow patch, northern Japan Alps, over the past four decades. Annual ablation depth through the melting season shows a significant correlation with the initial depth (at the beginning of the melting season), whereas a less significant correlation is found with a temperature index that is generally believed to correlate well with ablation. The scale effect of the snow patch, which modifies the wind speed over the patch, has a more significant effect on snow ablation than does the shadowing effect of surrounding mountains. In the case of a thinner initial springtime snow depth, wind speed over the snow surface is reduced by the concave topography, thereby suppressing ablation and vice versa. This self-regulating feedback means that over the past four decades, the snow patch has fluctuated in a manner that is largely independent of summertime temperature.

Nepal

Changes in three benchmark glaciers in the Nepal Himalaya for the first decade of the 21st century

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We recently conducted geodetic surveys on three benchmark glaciers (AX010, Yala and Rikha Samba) in the Nepal Himalaya. Accelerated wastage of glacier masses was found on the glaciers in rather humid climate.

Kazakhstan

The monitoring of mass balance of Tuyuksu glacier and change of glaciation in the mountains of Kazakhstan and the adjacent countries of Central Asia for the last decades

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Complex all-the-year-round glaciological observation on the basis of three research stations of the Kazakhstan's Institute of geography in Zailiyskiy Alatau range (Northern Tien Shan) with measurement of characteristics of mass balance of Tuyuksu glacier are spent since 1958.
On materials of aerial photography and satellite images the unified glaciers inventories of Zailiyskiy-Kungei glacial system (as of 1955, 1975, 1990, 1999 and 2008) and Dzhungarskiy glacial system (as of 1955, 1972, 1990 and 2000) are made.
According to results of researches, the glaciation of the region within last decades was in a stage of degradation. Rates of degradation of glaciation, having reached a maximum in the mid of 1970s, during the subsequent period were steadily reduced.
Considerable year-to-year fluctuations of glaciers mass balance characteristics are determined by not so much fluctuations of temperature in the ablation period, but rather by changes of the sums of precipitation for the cold period.
Snowiness fluctuations, first of all, variability of annual mass balance of glaciers predetermine. The rates of degradation of glaciers on the more-snow areas in western periphery of mountain countries are smaller inherent.
The revealed stability of parities of the glaciation area of individual basins and the area of complete glacial systems opens possibilities for the organization of operative monitoring of a condition of glacial systems and reconstruction of a mountains glaciation for the historical period.
Contrary to expectations, the glacial runoff owing to reduction of the area of glaciers in process of degradation of glaciation did not increase, but was reduced.
Despite the reduction of glaciers, annual runoff volumes and runoff distribution within a year remained unchanged during the last decades. During the same period, norms of atmospheric precipitation and maximum snow reserves in the zone of runoff formation remained stable as well. All these suggest the existence of a certain compensation mechanism. Such mechanism can be an increased (with climate warming) participation of melting waters of underground ice (buried glaciers,

rock glaciers, permafrost) in the river runoff. Taking also into the consideration the fact that reserves of underground ice in high mountains of Central Asia and Kazakhstan are equivalent to the present-day glacier resources and in the Chinese mountains they are two times greater, and also considering that the rates of melting underground ice are much lower than those of the open glaciers, we believe that even if the present-day trends in climate warming are preserved, the above mechanism may work for hundreds of years. Hence it can be predicted that the ongoing degradation of glaciers will not cause considerable reduction in the runoff and regional water resources at least up to next coming decades.

Kenya/Tanzania/Uganda

Abstract of state of glacier inventories, mass balances, front variations and recent developments

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All glacier inventories of the three glacierized African mountains could be updated (at least the aerial extent) referring to the class 'topo year' in the WGI data base. Only one distributed mass balance monitoring project is currently running in Africa – on Lewis Glacier, Mt Kenya since 2009. On Kilimanjaro point measurements of mass balance would be available. Campaigns of measuring front variation data are totally absent.
Several research projects have been started recently (see below), though only one of them measures 'classic' glaciological data (i.e. distributed mass balance and/or front variations).

1) Kenya (Mount Kenya)

glacier inventory: state WGI: topo year 1963/64 (update available: Rostom and Hastenrath, 2007 and FoG IX)

mass balances: no update since mass balance time series from Hastenrath 1979–1996 (reported to the WGMS: GMBB 1–5)

front variations: no update since FoG IX

recent developments: currently running research project of the University of Innsbruck (Georg Kaser) in cooperation with WGMS
- mass balance (glaciological method)
- area change
- ice thickness
- automatic weather station (installed 2009)
- Lewis Glacier only

2) Tanzania (Kilimanjaro)

glacier inventory: state WGI: topo year 1971 (update available: Cullen *et al*. 2006)

mass balances: no update/no data

front variations: no update/no data

recent developments: currently running research projects of the Universities of Innsbruck (Georg Kaser, Thomas Mölg) and Massachusetts (Douglas Hardy)
- point mass balances of plateau glacier (Northern Ice Field, since 2000) and slope glacier (Kersten Glacier, since 2009)

- front variation on a single point of the Northern Ice Field ice cliff (since 2006)
- 4 automatic weather stations (installed 2000–2009)

3) Uganda (Ruwenzori)

glacier inventory: state WGI: topo year 1963/68 (update available: FoG VIII annexed map)
mass balances: no update/no data
front variations: no update since 1958 (FoG III)
recent developments: SHARE (Comitato Ev-K2-Cnr, Bergamo, Italy)

- automatic weather station (installed 2006)

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Mexico

Recent glacier changes in Mexico

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Glaciers in Mexico have shown a retreat pattern along the last decades as a consequence of climate change. However, since these glaciers are capping active volcanoes with a wide variety in activity level, their changes are not only the result of climatic interactions but also the consequence of volcanic activity. Relations between the volcanic activity and the presence of glaciers have several aspects to study, among them: ice melting provoked by eruptive products and heat flux, glacier extinction, and debris flow generation.

Small-sized glaciers can be found at Iztaccíhuatl, Popocatépetl and Citlaltépetl whose volcanic activity is characterized by a different level of activity.

Popocatépetl volcano's glaciers have been influenced by the changing climatic conditions, the regional warming due to the presence of largely populated settlements in the surroundings, and the eruption of the volcano (Delgado-Granados 1996, Huggel and Delgado-Granados 2000, Julio-Miranda and Delgado-Granados 2003, Delgado-Granados *et al*. 2007). The glaciers of Popocatépetl volcano became extinct in the year 2000 (Delgado-Granados *et al*. 2007) because the ice masses lost the essential characteristics to consider them as a glacier when the ice became stagnant, attached to the steep slope, and the bedrock was exposed in between ice blocks. Crevasses were the sites where thinning took place in a way that bedrock became visible at their previous locations, leaving behind a series of "ice stripes".

Iztaccíhuatl volcano's glaciers have been influenced by the same factors except the eruption. The volcano was considered a dormant volcano but recent studies on degassing and seismic events on the volcano and its surroundings, shows that this is an active volcano (Delgado-Granados, 2001). The 12 reported glaciers by Lorenzo (1964) covered an area of 1.21 km^2. However, Delgado-Granados *et al*. (1985) found that three glaciers were extinct and the rest showed a strong retreat. Delgado-Granados *et al*. (2005) reported for 1982 a total glaciated area of 0.97 km^2, having lost an area of 20% in 24 years.

Schneider *et al*. (2008) indicated that only 4.3% of the ice cover existing in 1850 could be observed in 2007.

Citlaltépetl volcano's glaciers have been just affected by climatic changes. Available meteorological data suggests that a decrease in precipitation is the main climatic factor influencing glaciers' retreat. Studies on the surface of the volcano's Northern Glacier show the strong relationship between climatic conditions and the evolution of glaciers in Mexico. The net radiation is the factor that mostly influences the energy balance of Mexican glaciers, which is closely linked to the change in surface albedo (Ontiveros 2007). On the other hand, measurements of ice extent show a clear pattern of decline since the end of the Little Ice Age, showing fluctuations comparable with those reported for volcano Popocatepetl (Delgado-Granados *et al*. 2007).

Using the regional 0°C isotherm as a proxy for the observation of the equilibrium line during the last six decades in central Mexico, it can be observed the increase in altitude for this parameter, thus confirming the glacial retreat observed in the glacial measurements.

New Zealand

Glacier monitoring in New Zealand

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The last four decades have seen valuable glacier datasets collected in New Zealand. These records include the Ivory Glacier mass balance series[1] (1968–1974), and the Brewster Glacier mass balance series[2,3] (2004–present). Measurements of annual ELA at 50 glaciers have been collected by oblique aerial photography since 1977[4] and provide the best available long-term data on the influence of climatic variability on glaciers. These 'snowline flights' also provide terminus photographs and qualitative records of advance and retreat for many glaciers. In addition there are a few very good records of terminus position such as that at Franz Josef Glacier, one of the longest in the Southern Hemisphere, and the data exist to compile many more records over the last few decades.

The Brewster Glacier mass balance programme started in 2004 and is the first complete mass balance measurement programme since the Ivory Glacier monitoring finished in the 1970s (as the glacier disappeared). From the outset it has aimed to be a long-term programme of measurement and the first six years of study have yielded a high-quality dataset with few gaps.

While there are now a number of active glacier research groups within New Zealand, there is no national strategy for glacier monitoring, apart from continuation and refining of the NIWA end-of-summer annual snowline photography programme, and none of the monitoring that is going on has funding that is secure in the long-term. Glacier monitoring has largely been driven by a few individuals against the challenges of lack of funding, poor weather and few accessible and easy-to-measure glaciers.

Length fluctuations

Annual or sub-annual, on-the-ground, measurements are made at Franz Josef, Fox and Brewster Glaciers. The Franz Josef and Fox Glaciers were first mapped in 1893/94 (although there are earlier photographs) and the Franz Josef record is detailed for its full length, and is extremely detailed for some periods. The Brewster Glacier record has measurements in 1986, 1997 and annually from 2004, but there are sufficient data from the snowline flights for a quantitative reconstruction at annual resolution from 1977, with a few earlier photographs to 1955.

The annual snowline flights have recorded terminus position since 1977 on up to 100 glaciers in the Southern Alps. These terminus position changes have been reported qualitatively (advance/no change/retreat) and there is some potential to extract quantitative data from this dataset. There is a separate annual flight that photographs the glaciers on Mt Ruapehu (the only glaciers on the North Island).

The continuance of these records is reasonably secure as they are relatively easy to collect and attract a wide interest. The snowline flights are now well supported by the National Institute of Water and Atmospheric Research (NIWA) and the future of this programme is secure in the medium term.

Mass balance series

The Brewster Glacier mass balance programme is the only project which presently measures the complete mass balance of a New Zealand glacier. The mass balance measurement works on a mixed stratigraphic and fixed date system, where snow pits and high-density probing are used to measure winter balance and ablation stakes are used to measure summer balance. The mass balance programme is augmented with measurements of terminus position, climate near the terminus and water run-off.

The Franz Josef Glacier has continuous measurements of ablation at the terminus, and annual net accumulation, since 2000[5,6], but these measurements are not sufficient to calculate an overall mass balance.

The main priority for mass balance monitoring is to incorporate the Brewster Glacier project into a coherent, complete and funded national strategy for glacier monitoring.

Annual ELA measurements

This programme has now acquired more than 30 years of annual ELA data on 50 glaciers. This dataset initially indicated the relative mass balances throughout the Southern Alps[7], but it is becoming apparent that the data has many vital applications. Visual changes, length changes[8,9] and the development of proglacial lakes[10] were among the initial observations and analyses. The early data also provided the shape of the snowline trend surface through the Southern Alps[11], and demonstrated that for glaciers, the Southern Alps behaves as a single climatic unit[12]. By using mass balance gradients, the data permit estimates of annual ice mass changes[13], and now there is sufficient data to investigate the properties of glacial parameters, in particular those of the accumulation area ratio (AAR)[14].

In the course of the programme digital images connected to GPS systems have been introduced and the current challenges are rectifying the images to provide accurate ELA mapping and true areas. The ultimate challenge remains to predict the last day of flying weather before the first snowfall of winter.

Glacier inventory

The New Zealand glacier inventory was completed for the WGMS in 1989[15], published in 2001, and is yet to be updated. There have been many changes to glaciers since the original photography was taken, and New Zealand is notable for its absence from the GLIMS project, as one of very few glacierized areas of the world with no data in the database. Populating the database is a key challenge for the coming years, but there is no work being done at present. Unfortunately there was no New Zealand Representative at the International Glaciological Glacier Inventory conference in Tien Shan, 2009.

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Norway

Glacier monitoring and glacier inventories in Norway; Svalbard and mainland Norway

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In Svalbard the Norwegian long-term mass balance program is operated by the Norwegian Polar Institute and includes the two small glaciers Austre Bröggerbreen and Midre Lovénbreen (~5 km^2) since 1967 and on Kongsvegen (~100 km^2) since 1986, all in the Kongsfjorden area in North-West Spitsbergen. These series are reported to WGMS. In addition a shorter mass balance series is now available from the Austfonna ice cap (~8,100 km^2) in Nordaustlandet in North-East Svalbard since 2004. This has not been reported in WGMS.

Other mass balance series are carried out by Polish research groups.

The first glacier inventory of Svalbard was published as the Glacier Atlas of Svalbard in 1993 (Hagen *et al*. 1993). The Atlas was created following the World Glacier Inventory classification rules and guidelines. However, the Atlas has only been available in printed form. Recently, the Atlas has been digitized and updated. The new inventory follows the same identification scheme, but has been updated, mainly concerning some drainage basin borders and front positions. The most recent inventory is being compiled using SPOT5-HRS images and DEMs acquired between 2007 and 2008. The new digital Atlas will be publicly available in 2010 through the Norwegian Polar Institute's website. The Atlas is digitally interactive allowing for further development whereby information of individual glaciers can be uploaded and downloaded and published literature about the glacier can be linked up using the unique glacier ids. The design and basis of this new glacier inventory of Svalbard will be open source, such that people working on Svalbard will have access to download masks, and upload new masks if available, or if any errors have been detected. The updated inventory will also be submitted as input to the GLIMS global glacier inventory project (GLIMS.org).

In mainland Norway glacier monitoring and inventories is under the responsibility of the Norwegian Water Resources and Energy Directorate, Oslo (NVE). Mass balance investigations are currently (2009) performed on fourteen glaciers. Twelve of these glaciers are in southern Norway and two are in northern Norway. Both winter and summer balances are measured. There are results from ca. 600 years of measurements at Norwegian glaciers, the longest series are from Storbreen since 1949 and a number of others since the 1960s. Several glaciers have been measured for short periods of ~5 years. Data is available for 42 glaciers. The data is published in annual reports and reported to WGMS and in scientific journals (Andreassen *et al*. 2005).

Glacier length changes are currently measured at 36 glaciers, 28 in southern Norway and 8 glaciers in northern Norway.

Glacier inventories have been published in Glacier Atlas of South Norway in 1969 and in an updated version in 1988 (Østrem and Ziegler 1969, Østrem *et al*. 1988). For northern Norway the inventory was included in Glacier Atlas of Northern Scandinavia in 1973 (Østrem *et al*. 1973). A new digital inventory of glaciers in Norway is under preparation based on analysis of Landsat scenes TM/ETM+ imagery from the period 1999–2006. Results from the Jotunheimen and Svartisen regions have already been published (Andreassen *et al.* 2008, Paul and Andreassen, 2009). The complete inventory will be available online during 2010/2011 and delivered to the GLIMS database. NVE is regional GLIMS center for mainland Norway.

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Poland

Polish studies on fluctuations of glaciers: Status and perspectives

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Polish institutions started to participate in the works of the World Glacier Monitoring Service in the 1970s. At first they only gave the access to data on the changes of limits of glacier fronts located above the Hornsund fiord in the southern Spitsbergen where Polish Polar Station of Polish Academy of Sciences has been working since 1957. The data concerned two polythermal glaciers: Werenskioldbreen (which terminates in the land) and Hansbreen (tidewater). In the 1980s, the database included also the measurement results of fluctuations of front limits of nine other glaciers of this region (J. Jania). However these measurement series did not exceed five years.

In 1988 a systematic monitoring of changes of mass balance and fluctuations of medium size Hansbreen glacier (56 km^2) started (J. Jania, L. Kolondra, P. Glowacki, B. Gadek, D. Puczko). Now it belongs to reference glaciers of the WGMS, and the dynamics of processes and the observed rate of changes are representative for the glaciers of Southern Spitsbergen. Thanks to a unique chemical method which applies chlorites from sea spray admixture in snow it was possible to determine internal alimentation of the Hansbreen glacier (P. Glowacki). In the last decade, the database has included also data on mass balance changes and fluctuations of front limits of three glaciers in the Kaffiøyra region (NW Spitsbergen): Waldemarbreen, Irenebreen and Elisebreen (M. Grzes, I. Sobota). The research station of the University of Nicolaus Copernicus works nearby these glaciers. Additionally, since 2006 a small mountain glacier Ariebreen has been included in continuous observations. Recently it changes its thermal structure from polithermal into cold, despite a simultaneous increase of air temperature recorded in the nearby meteorological station in Hornsund.

Moreover since 1978 in the Polish Tatra Mountains, the measurements of front changes of three glacierets – Mieguszowiecki, Pod Bula and Pod Cubryna (A. Wislinski) – have been carried out. At the turn of the 1980s and 1990s, a photogrammetric monitoring of Miedziany glacieret (the largest in the Tatras) and Mieguszowiecki glacieret started (J. Jania, B. Gadek). Also all firn and snow patches in the Tatras were catalogued.

The obtained data indicate that there is mass decrease and diminution of limits of all the observed glaciers. On the other hand, the changes of glacierets in the Tatras which existence is influenced by topographic conditions do not show any clear trends. The Polish scientific teams are going to continue the hitherto monitoring of the glaciers. Apart from the applied so far methods of geodetic ground surveys, aerial and terrestrial photogrammetry, remote sensing (M. Blaszczyk, J. Jania, L. Kolondra), GPS and GPR surveys (M. Grabiec, D. Puczko), also terrestrial laser scanners and high resolution remote sensing (A. Adamek, P. Glowacki, J. Jania) are planned to be applied.

Russia

Glacier monitoring in Russia today

Victor V. Popovnin
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The contemporary state of glacier monitoring in Russia mainly inherits glaciological backgrounds created in Soviet times. It was just during the period between the late 1950s and the early 1980s when: a) all glaciers within the territory of the USSR were catalogued with the tables of their individual morphometry; and b) a complex of regular regime observations for selected glaciers, accompanied with periodical remapping of their geometry, was settled. As a matter of fact, the quite harmonic unity of terrestrial exploration and remote sensing constructed the ideal model of glacier monitoring for those times – one of the best (if not the optimum, indeed) on a world scale.

Successes of Russian glaciology should be recognized as much more modest. It can be partly explained that after the decay of the USSR most of the formerly observed alpine glaciers found themselves outside Russia – mainly they remained in new independent states. Of course, the glaciated area of Russia is still large enough. However, it is mostly represented either by ice sheets of the Arctic islands (where monitoring principles are not completely devised yet), or by numerous mountain ridges with sporadic glaciations in Siberia (which are almost non-explored due to severe accessibility problems). All this resulted in the existence of only 3 mountain systems with the developed alpine glaciations over the vast territory of Russia: namely, Caucasus, Altai and Kamchatka. Moreover, the first two of them share their glaciers with the neighbouring states. This circumstance, alas, vigorously influenced actions and decisions of policy-making governmental institutions, which do not definitely promote glacier monitoring in Russia today.

Nevertheless, after observation series (including some long-lasted series) on a number of Russian glaciers in the Arctic, Urals and Kamchatka have been irretrievably broken off, monitoring of the remained glaciers not only proceeded, but even revealed a certain theoretical and methodological progress. First of all, this concerns the Djankuat Glacier in the Caucasus, where Moscow Univ. continues its 43-year-long uninterrupted measurements of mass balance and glacier geometry. Accuracy and combination of independent approaches, applied there in the course of direct 5-month-long fieldwork every year, are unprecedented not only over Russia but even in wider scope. Creation of the local GIS made it possible to perform the output data as spatial patterns (fields) of various morphometrical and budget parameters as well as to introduce some methodic innovation such as estimation of snow avalanche nourishment, melting rate in crevasses and under the debris cover etc., while a set of AWSs, water level recorders, sonic rangers and different data loggers serves as a major requisite for reconstructions and forecasts. At present Djankuat remains the definite leader among all the monitored glaciers in Russia.

Another glacier under investigation in the Caucasus, Garabashi, is situated nearby, only 15 km afar from Djankuat. Being a part of star-shaped glacier complex of the Mt. Elbrus extinct volcano, it is much less representative for the whole mountain system, but covers the extreme altitudinal span that is very important even despite its relatively short time series and rather simplified monitoring scheme.
Siberian glaciation is represented by the Aktru basin in the Altai Mts. where Tomsk Univ. maintains the long-term monitoring programme. The evident merits of this work are: 1) independent mass balance calculation not for a single object but for 4 glaciers within the catchment area; 2) long observation period (since 1962 for the Maliy Aktru Glacier, with only few annual balance values reconstructed indirectly); 3) combination of mass balance measurements with meteorological observations and, periodically, geophysical surveys. However, it should be admitted that during the recent years the former minuteness diminished obviously.

There are 3 ways to prevent or decelerate the outlined decrease of glacier monitoring in Russia:

1. In case of impossibility to maintain regular annual observations further on somewhere, it should be replaced by periodical resurveys from time to time as far as possible. This would give the chance to remap the glacier and to calculate at least a number of cumulative mass balance values for the time spans between resurveys by means of overlaying the corresponding DEMs. The methodic aspect of this principle has been formerly tested for glaciers in the Caucasus, and afterwards it was successfully approbated recently for several glaciers in rarely visited areas (mainly, in the Siberian Region) such as Cherskiy and Suntar Khayata Ranges, Kodar Mts. and so on. The basic problems here are the grounded recalculation of glacier volume categories into water equivalent (that requires evaluation of mean glacier density) and precise estimation of glacier area changes.
2. In case of impossibility to carry out terrestrial surveys even from time to time, a series of discrete cumulative mass balance values may be deduced from analysis of irregular satellite imagery. Time spans for these procedures depend on image availability and frequency of reshooting glacier surface from the space. However, the key problems of this approach remain: a) necessity of high vertical resolution of satellite stereo-pairs; and b) difficulties when identifying glacier limits.
3. Finally, a good option for Russia to restore somewhat of the lost positions in glacier monitoring ranking could become incorporation of regime observation programmes into international (bilateral or multi-lateral) scientific projects. A perfect and recent example of this way is a fruitful collaboration of Russian glaciologists with the colleagues from the UK, Georgia and Germany. The established consortium under the leadership of Dr. M. Shahgedanova from Reading Univ., UK, made it possible to supply field parties working in the Caucasus, Altai and Kodar with the up-do-date scientific equipment and devices, to reanimate glacier monitoring in the Georgian part of the Caucasus, to restore field exploration of the Urals glaciers and to make a serious step forward in anticipated glacier evolution simulation. Another inspiring example is the intention of our Japanese colleagues to include the Aktru Basin in the Altai into the list of Asian complex monitoring polygons according to Dr. T. Ohata’s supersite conception as well as conduction of joint expeditions to the glaciers of Eastern Siberia and Kamchatka. It should be quite desirable if WGMS could play a more active role in arranging, promoting and coordinating similar collaborations in future.

The current reality does not allow to preserve hopes for renovation of the complete glacier inventory over the entire territory of Russia in order to compare results with the initial Glacier Catalogue of the USSR (status 1970s) which is completely digitized by now. However, attempts of covering some glaciated ridges by thorough examination of satellite imagery for detecting changes in glacier extent are ongoing. This work revealed once again the old but unsolved problem – accuracy and reliability of glacier boundary delineation (for debris-covered glaciers, in particular). Discrete field verification still shows rather low compatibility of terrestrial estimates with the conclusions based on remote sensing.

Anyway, despite a certain regress in glacier monitoring in Russia, the existing system continues functioning and proceeds providing the direct data on the glacier fluctuations and trends on the vast territory, occupying a good share of the globe. It can be concluded that the past decade was remarkable by accelerated degradation of alpine glaciers that replaced the period of relatively favourable conditions, having been registered in different Russian mountains in the late 1980s – early 1990s. An interesting peculiarity is the growth of contrasts in mass balance values (including components) between the adjacent balance years which is revealed while analysing series of the directly observed glaciers. One of the main goals in Russia at present is not to lose those observational series which are still maintained. Sometimes such threats are created even not by policy-makers but by nature itself. The most dramatic situation nearly arose at the Djankuat Glacier, the most investigated in Russia. Last year the 40-year-old research station below the snout was completely destroyed by a tremendous snow avalanche. A number of known and anonymous friends not only from Russia, but from Kazakhstan, Germany, USA and other countries should be acknowledged for their donations aimed at restoring the station, so that hopes for the final success of this affair are well-grounded.

Sweden

Changes in size, dynamics and temperature distribution of Swedish glaciers

Per Holmlund
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Swedish glaciers are thinning now and thermal changes within the glaciers causes irregular responses to climate warming. The Swedish national glacier field survey front programme covers about 20 glaciers and annual mass balance surveys is carried out on 5 glaciers, but much more data is available to day. Satellite surveys and airborne surveys of ice geometry and the ice thermal distribution has added significantly to our knowledge about the complicated link between climate change and glacier response. Since the mid 1990s thermal information received from high resolution radar soundings are available for 45–50 Swedish glaciers. Resurveys in 2008–2010 show how the temperature distribution within the glaciers matches the increased melt off during the last decade. All these glaciers have a polythermal temperature distribution with a perennial cold surface layer in the ablation area. In continental parts of the mountain range high ablation rates have caused a warming of the ice masses as a consequence of thinning cold surface layer. In wetter parts of the range the temperature distribution has remained more or less unchanged, while the ice thickness has declined. The net effect of such a change is a net cooling of the glacier tongue which influences the flow rates. In this paper an overview is given of the status of a number of Swedish glaciers, both in terms of size changes and in thermal changes.

Switzerland

Glacier Monitoring in Switzerland (GLAMOS): State of 2010

Martin Hoelzle[1], Andreas Bauder[2], Martin Funk[2], Matthias Huss[1] and Frank Paul[3]
Glacier Group of the Cryospheric Commission of the Swiss Academy of Sciences

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In Switzerland, systematic long-term glacier monitoring has importantly contributed to an enhanced process understanding of the glacier-climate interactions within the high mountain environment. Already in 1893, the Swiss Glacier Commission was established, initiating observations of the glaciers in Switzerland. Recently, the Glaciological Commission (formerly Swiss Glacier Commission) was extended by including other cryospheric monitoring networks, such as snow and permafrost, to the newly established Cryospheric Commission. In 2002, the Swiss glacier monitoring program was peer-reviewed by the Swiss Academy of Sciences (SCNAT) in order to ensure and to improve the well-established connection to the international integrated monitoring concepts and programmes. In 2007, the new monitoring programme was launched under the name GLAMOS (Glacier Monitoring in Switzerland).

GLAMOS contributes to efforts on an international level in order to keep records of glacier changes as part of the Global Terrestrial Network for Glaciers (GTN-G) within the Global Terrestrial Observing System (GTOS). The continuous measurements are therefore reported to the World Glacier Monitoring Service (WGMS). The main objectives of the GLAMOS observations are related to glacier-climate interactions. Ongoing monitoring activities are regularly evaluated and adapted to both ongoing glacier changes and new monitoring technologies. New methods are introduced in combination with the traditional measurement techniques to provide cross-calibration.

GLAMOS currently involves the determination of the following variables:
a) glacier surface mass balance and volume change, b) ice flow velocities, c) length change, d) inventory of glacier characteristics, and e) englacial temperature. In contrast to the international glacier monitoring programmes, GLAMOS also includes velocity and englacial temperature measurements. Currently, mean mass balance values for the entire glacier are calculated for the glaciers Basòdino, Giétro, Gries and Silvretta, which have the longest time series, and two new glaciers (Findelen and Pizol). Some very long series of individual stake measurements exist for Grosser Aletschgletscher (Jungfraufirn), Claridenfirn and in the Mattmark region, and are maintained as well. In addition to the direct measurements of annual or seasonal mass balance, ice volume changes are determined at intervals of about five years to a few decades for 34 glaciers by aerial photo surveys. Currently, new techniques are tested such as laser scanning and the new ADS80 digital camera of Swisstopo. Flow velocities are measured on six glaciers: Allalin, Corbassière, Giétro, Oberaar, Schwarzberg and Unteraar. Length changes have been measured at 161 glaciers of which 110 are observed regularly. Local people, mainly from forestry service are performing these measurements using tapes or tachymeters. However, remote sensing methods are increasingly used. Glacier inventories provide basic data for the glacier coverage of all mountain regions of Switzerland at a particular point in time. Currently, glacier inventories are available in a digital form for the years 1850 and 1973 (based on aerial photographs and reconstructions of moraines and old maps), 1998/99, and 2003 (based on satellite data). Englacial temperature is a new measurement variable within the Swiss glacier observation. It has been selected because there are only few existing observations of temperature above 4,000 m a.s.l. that are suitable to be used as representative climatic indicators. However, temperature measurements of firn and ice provide a valuable contribution to observe climatic changes at very high elevations in the Alps. As the main observation site Colle Gnifetti was selected, where investigations have been performed since the end of 1970s. The measurements will be repeated at 5- to 10-year intervals.

Uzbekistan

Estimation of current mountain glaciers of selected regions of Gissar–Alay and its changing during 45 years with use of ASTER images

Andrey Yakovlev
The Center of Hydrometeorological Service (UzHydromet), Tashkent

In 1999 the TERRA orbital platform was launched. Onboard the orbital platform the Japanese sensor ASTER was installed. Characteristics of the sensor give unique possibility for monitoring glaciers from the space. In the given work the cataloguing of glaciers of some river basins of Alay, Turkestan and Zeravshan ranges of Gissar–Alay mountain system, which in turn is a part of Pamir–Alay mountain system, was fulfilled. Thematic processing of the images was implemented for the range of the images on the date of the survey – second half of August 2001–2002 years. Previous data of glaciation of this region were obtained as per 1957 and 1980 with application of materials of aerial photography (1957) and analogue satellite images (1980). According to data for 2001 the aggregate area of the glaciers of Gissar–Alay study region amounted to 514.7 km^2. In 1957 and 1980 years the aggregate area of the glaciers of these basins was 624.8 and 553.6 km^2, accordingly. In spite of global climate warming which occurs from the middle of 20 century and till the present time, there is a fact that for period from 1980 to 2001 years the mean annual rates of degradation of the glaciation are, approximately, in one and half times lower than for the period from 1957 to 1980 years, 0.43% per a year and 0.61% per a year, accordingly. For last 45 years the glaciers of the study river basins lost about 17.6% of the initial area and 25.4% of volume.

Summary Questionnaire

Questionnaire WGMS General Assembly of NCs

Please fill out and return to wgms@geo.uzh.ch by August 6, 2010!!

Glacier Country [ ]

○ **NC (National Correspondent)** ○ **PI (Principal Investigator)**

1. Current status of glacier monitoring in your country

Does active glacier research groups exist in your country?	☐ YES	☐ NO	☐ Don't know	if YES, how many? [ ]
Is a national glacier report compiled?	☐ YES	☐ NO	☐ Don't know	if YES, how often? [ ]
Does a national glacier data base exist?	☐ YES	☐ NO	☐ Don't know	
Does a national glacier website exist?	☐ YES	☐ NO	☐ Don't know	url [ ]
Does a national monitoring strategy/concept exist?	☐ YES	☐ NO	☐ Don't know	
Does a national monitoring organization exist?	☐ YES	☐ NO	☐ Don't know	
Does a succession plan for the position of the NC exist?	☐ YES	☐ NO	☐ Don't know	
Does an early warning system/concept for endangered long-term monitoring series exist?	☐ YES	☐ NO	☐ Don't know	
How can the WGMS support the organization of the glacier monitoring in your country?				

Additional comments regarding glacier monitoring in your country:

2. Currently available glacier datasets in your country

Do you have a complete/incomplete national glacier inventory? For which year(s)?	
At how many glaciers are front variations currently measured?	
At how many glaciers are mass balances currently measured?	
How many of these mass balance programmes are regularly checked with geodetic methods?	
What is the number of ceased long-term (>10 years) mass balance series?	
How many of your glaciers with long-term (>10 years) mass balance series might be gone (under present melting rates) by 2050? How to deal with these vanishing glaciers?	

Additional comments regarding glacier data:

3. Feedback to WGMS services and products

How do you evaluate:

- the communication with the central service in Zürich?
- the WGMS website (www.wgms.ch)?
- the GTN-G website (www.gtn-g.org)?
- the GTN-G metadata browser (www.gtn-g.org/data_exploration.html)?
- the FoG publication (www.wgms.ch/fog.html)?
- the GMBB publication (www.wgms.ch/gmbb.html)?
- the Global Glacier Changes publication (www.grid.unep.ch/glaciers)?
- the digitally available fluctuation series (www.wgms.ch/dataexp.html)?
- the digitally available WGI data (nsidc.org/data/glacier_inventory/index.html)?
- the digitally available GLIMS data (www.glims.org)?
- the digitally available glacier photo collection (nsidc.org/data/glacier_photo)?

Additional comments regarding service and products:

4. Specific suggestions for improvements

How do you evaluate the following ideas for an improved service to the (scientific) community?

- strenghten cooperation between WGMS, NSIDC, and GLIMS under the framework of GTN-G (e.g., joint advisory board)
- digitising and making available of all FoG maps in pdf-format
- digitising and making available of all written reports (back to 1894) in pdf-format
- improve visibility of and reference to WGMS datasets and products by citation as WGMS (YEAR) instead of Haeberli et al. (YEAR) or ICSU(WDS)/IUGG (IACS)/UNEP/UNESCO/WMO (YEAR)
- improve visibility of and reference to WGMS datasets and products by adding digital object identifier (doi) number for mass balance, front variation, and inventory datasets
- improve our annual call-for-data by calling for (one) preliminary mass balance value of the **running year** and full details for the **past year** (compared to the present system calling only for the data of the past year)
- compile and disseminate stake and pit mass balance values in addition to the specific glacier mass balance data
- compile and disseminate glacier thickness measurements

Additional comments and suggestions to improve our service:

Question 1

Current status of glacier monitoring in your country

	Argentina	Australia	Austria	Bolivia	Canada	Chile	Colombia	Ecuador	France	Germany	Iceland	Iran	Italy	Japan
Does active glacier research groups exist in your country?	yes, 3-4	yes, 1	yes, 4-6	yes, 1	yes, 4-6	yes, 4	yes, 1	yes	yes	yes, 3	yes, 3	yes, 1	yes, ca. 10	yes
Is a national glacier report compiled?	no	no	yes, annually	yes, annually	yes, every 1-5 yrs	no	yes	yes	no	no	yes, annually	yes, twice a yr	yes, annually	no
Does a national glacier data base exist?	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	no	no
Does a national glacier website exist?	yes	no	no	no	yes	no	no	yes	yes	yes	no	no	yes	no
Does a national monitoring strategy/concept exist?	no	no	yes	no	yes	yes	yes	yes	yes	no	yes	yes	yes	no
Does a national monitoring organization exist?	no	yes	no	no	yes	yes	no	yes	yes	yes	yes	yes	yes	no
Does a succession plan for the position of the NC exist?	no	no	yes	no	yes	?	no	?	?	yes	no	yes	yes	no
Does an early warning system/concept for endangered long-term monitoring series exist?	no	no	no	no	yes	no	no	yes	?	no	no	no	yes	no

	Kenya Tanzania Uganda	Mexico	Nepal	New Zealand	Norway	Peru	Poland	Russia	Spain	Sweden	Switzerland	U.S.	Uzbekistan
Does active glacier research groups exist in your country?	no	yes, 2	?	yes, about 6	yes	yes, 1	yes, 5	yes, 10-15	yes, 1	yes, 2	yes, 6	yes	no
Is a national glacier report compiled?	no	no	no	no	yes	yes, twice a yr	no	yes, annually	yes, annually	no	yes, annually	no	no
Does a national glacier data base exist?	no	yes	no	yes	yes	yes	no	yes	yes	no	yes	no	yes
Does a national glacier website exist?	no	no	?	yes	yes	no	no	no	yes	no	yes	no	no
Does a national monitoring strategy/concept exist?	no	no	?	yes	yes	yes	no	yes	yes	no	yes	no	no
Does a national monitoring organization exist?	no	no	no	no	yes	yes	no	yes	yes	no	yes	yes	no
Does a succession plan for the position of the NC exist?	yes	no	no	yes	no	yes	no	no	yes	no	?	no	no
Does an early warning system/concept for endangered long-term monitoring series exist?	no	no	no	no	no	no	no	no	no	yes	yes	no	no

Additional comments:

- Problems of funding long-term series: it would be important to support the data and metadata distribution.
- Long-term perspective: ensure continuation of monitoring and glaciological research.
- Ensure financing of basic monitoring.
- Future of research institutes and structures is uncertain.
- There are no plans for securing the long-term future of research groups.
- National monitoring strategy exists on the paper; implementation?
- Nothing exists on a national level.
- There is need to create a national database (data compilation).
- Improve the coordination on national level and between academic and government researchers.
- Cooperation is needed for accessing required data (especially satellite data).
- Networking/contacts: A strong WGMS (or head or partner organisation) helps to convince local authorities to support our work.
- Support letters help showing the importance of the national glacier monitoring within the international framework of glacier monitoring.
- The WGMS can provide political support; support letters are an effective tool; the WGMS can be contacted for various questions.
- The personal contact is very important.
- Prioritiy of glacier monitoring within glaciology: popularity faded away.
- Show the importance of measurements; public perception.
- Consider both net mass balances and summer/winter balances; possibly also interim balances.
- Understanding and handling of measured data is very important.

National glacier websites:

Argentina	http://www.glaciares.org.ar
Canada	http://pathways.geosemantica.net
France	http://www-lgge.ujf-grenoble.fr/ServiceObs/SiteWebPOG/index.htm
Germany	http://www.bayerische-gletscher.de
Italy	http://www.glaciologia.it
New Zealand	http://www.sirg.org.nz/
Norway	http://www.nve.no/en/Water/Hydrology/Glaciers/
Spain	http://www.mma.es/portal/secciones/aguas_continent_zonas_asoc/saih/
Switzerland	http://glaciology.ethz.ch/swiss-glaciers/

Question 2

Currently available glacier datasets in your country

	Argentina	Australia	Austria	Bolivia	Canada	Chile	Colombia	Ecuador	France	Germany	Iceland	Iran	Italy
Do you have a complete/incomplete national glacier inventory?	incomplete	yes	yes	yes	incomplete	incomplete	yes	incomplete	(yes)	yes	yes	incomplete	yes
For which year(s)?	1960-70s,1990s,2005-10	2001	1969, 1998	1990			late 19th c.				~2000	1983-2000,2009-10	
At how many glaciers are front variations currently measured?	39	variable	91	2	variable	variable	6	3		0	~50	variable	150
At how many glaciers are mass balances currently measured?	7	0	11	2	16 (6)	4	3	2	6	5 (+ 10)	15	0	~12
How many of these mass balance programmes are regularly checked with geodetic methods?	4	0	11	1	8	3	3	0	5	0 (1)	0		3
What is the number of ceased long-term (>10 yrs) mass balance series?	0	0	8	1	numerous	1		0	0	0	1		5
*How many of your glaciers with long-term (>10 yrs) mass balance series might be gone (under present melting rates) by 2050? **	0-2	0	2	1	2	?	all	1	2	all	0		

	Kenya Tanzania Uganda	Mexico	Nepal	New Zealand	Norway	Peru	Poland	Russia	Spain	Sweden	Switzerland	U.S.	Uzbekistan
Do you have a complete/incomplete national glacier inventory?		yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	incomplete	yes
For which year(s)?			2000	1978/1988	1969,1988 / 1973, (1999-2006)	1989	1981-85 / 1994	1970s	1982-2009	(1910,1959),1973,2001,2008	1850,1973,1998/99		1957, 1980
At how many glaciers are front variations currently measured?	0	1	~10	~100	~30	8	4 (+ 7)	10-15	11	18	~100	few	0
At how many glaciers are mass balances currently measured?	1	0	1	1	21	5	7	5-7 / variable	2	5	~10	fewer	0
How many of these mass balance programmes are regularly checked with geodetic methods?	1	0	5	numerous	variable	0	2	5	2	4	~8	fewer yet	0
What is the number of ceased long-term (>10 yrs) mass balance series?	1			1	0		2	~8	1	0	2	?	1
How many of your glaciers with long-term (>10 yrs) mass balance series might be gone (under present melting rates) by 2050?	1	all	2		?	all except for 3		0	1	0	1-3	0	0

** How to deal with those vanishing glaciers?*

- Observe the disintegration.
- Continue the measurements until the glacier has disappeared.
- Consider new sites.
- Replace the measurement with another glacier close-by that is monitored.
- Find a glacier in the region with a higher elevation range (if there is one; representativeness?) and measure parallel as long as possible.
- Vanishing glaciers should be complemented by parallel measurements at new "longer existing" glaciers.
- Start with new mass balance series at glaciers with a high accumulation area (e.g. above 3500 m asl. in the Alps).
- Consider topographical factors when choosing new glaciers for monitoring.
- To be evaluated.
- Don't know.

Additional comments regarding glacier data:

- Importance of metadata: improve the description of data.
- Data without metadata and data description does not make sense: instead of adding new data I would prefer to see better described data.
- Most of the data is not financed by WGMS, but by national authorities. These want to see citations.
- Problems: discontinuities in the data; differences in the data quality.
- Glacier inventories are incomplete.
- Cooperation may facilitate access e.g. to satellite data.
- How to archive analog data?
- Start a database with mountain and glacier photographs.
- National bulletins and databases should be established.

Question 3

Feedback to WGMS services and products

How do you evaluate:	excellent	ok	bad	no comment
the communication with the central service in Zürich?	14	17	1	5
the WGMS website (www.wgms.ch)?	9	22	1	5
the GTN-G website (www.gtn-g.org)?	1	11	0	25
the GTN-G metadata browser (www.gtn-g.org/data_exploration.html)?	2	6	2	27
the FoG publication (www.wgms.ch/fog.html)?	13	20	0	4
the GMBB publication (www.wgms.ch/gmbb.html)?	15	15	1	6
the Global Glacier Changes publication (www.grid.unep.ch/glaciers)?	11	17	0	9
the digitally available fluctuation series (www.wgms.ch/dataexp.html)?	6	14	1	16
the digitally available WGI data (nsidc.org/data/glacier_inventory/index.html)?	4	14	1	18
the digitally available GLIMS data (www.glims.org)?	6	11	3	17
the digitally available glacier photo collection (nsidc.org/data/glacier_photo)?	9	10	0	18

Additional comments regarding service and products:

- Please add citations and a data description to the data.

- The WGMS model for publication of data needs to change, within funding constraints. The datasets should be more readily downloadable. More ambitiously, WGMS needs to address (perhaps in conjunction with NSIDC and GLIMS) the very low rate of reporting of geodetic data.

- WGMS website: The listed literature is confusing because it wasn't clear what manual to use for mass balance measurements. Some are hard to get (Forel) and the online available manual from Kaser seems to be mainly for low latitude glaciers (according to the title), which is not necessarily the case.

- I also had several questions about the data submission. There might be potential for improvement.

- Available data should include glacier outlines (shapefiles) and flowlines.

- Communication with WGMS: answers to the e-mails are too late.

- WGMS web page is not updated.

Question 4
Specific suggestions for improvements

How do you evaluate the following ideas for an improved service to the (scientific) community?	excellent	ok	bad	no comment
strenghten cooperation between WGMS, NSIDC, and GLIMS under the framework of GTN-G (e.g., joint advisory board)	10	17	0	10
digitising and making available of all FoG maps in pdf-format	17	10	1	9
digitising and making available of all written reports (back to 1894) in pdf-format	21	8	0	8
improve visibility of and reference to WGMS datasets and products by citation as WGMS (YEAR) instead of Haeberli et al. (YEAR) or ICSU(WDS)/IUGG (IACS)/UNEP/UNESCO/WMO (YEAR)	14	16	0	7
improve visibility of and reference to WGMS datasets and products by adding digital object identifier (doi) number for mass balance, front variation, and inventory datasets	12	15	0	10
improve our annual call-for-data by calling for (one) preliminary mass balance value of the running year and full details for the past year (compared to the present system calling only for the data of the past year)	5	12	8	12
compile and disseminate stake and pit mass balance values in addition to the specific glacier mass balance data	7	17	6	7
compile and disseminate glacier thickness measurements	16	13	0	8

Additional comments and suggestions to improve our service:

- I suggest to promote glaciological activities in countries without data. The experience in Latin America by promoting the Working Group on Snow and Ice, supported by IHP-UNESCO was very useful.

- Don't shorten the time for data compilation and control. For the interpretation of stake and pit data, much additional metadata is necessary. This data should be used in a cooperation to ensure the support.

- Current status of financial and human resources available needs significant improvement.

- Reference in WGMS documents should cite, as much as they possibly can, the source of the data as published papers where authors and institutions are identifiable.

- Pit mass and stake measurement are "raw" i.e. untreated data so their diffusion is precarious because it could lead to erroneous interpretation.

- Make available the existing methods for glacier monitoring through the web page.

- Generally I like the idea of making data accessible. However, I am sceptical about disseminating the mass balance data from the stakes and pits. I think this could cause some problems if data hasn't been published yet. Also, the data comes from various places with varying conditions/measuring methods/climate.

- We need information and access to articles referred to ice thickness measurements and qualification for this field because we do not apply any method to measure directly the glacier thickness.

- Ideally, the annual call would be supplemented by a facility for submitting data at any time, perhaps with the databases updated monthly.

- Support more than one agent in each country for conferences.

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