meeting/workshop summaries

Summary of International Glacier Monitoring Summit

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[1] WGMS Coordinating Office, [2] WGMS National Correspondents and Deputies, [3] GlobGlacier Consortium, [4] GlobGlacier User Group, [5] Swiss GCOS Office, [6] European Space Agency, [7] United Nations Environment Programme, [8] U.S. National Snow and Ice Data Center, [9] Global Land Ice Measurements from Space

*In the first week of September 2010, international experts on glacier monitoring convened in Zermatt, Switzerland, for two separate but related meetings. They discussed glacier data compiled over the past 150 years and how to improve this dataset to meet the challenges of the 21st century, presented latest results from **in situ** and remotely sensed observations, and came up with key tasks for the glacier monitoring community for the coming decade.*

About Worldwide Glacier Monitoring

Internationally coordinated observation of glaciers began in 1894 in Zurich, Switzerland, with regularly published standardized glacier data available from the very beginning. Today, the World Glacier Monitoring Service (WGMS), in close cooperation with the U.S. National Snow and Ice Data Center (NSIDC) and the Global Land Ice Measurements from Space (GLIMS) initiative, runs the Global Terrestrial Network for Glaciers (GTN-G) within the Global Climate Observing Systems (GCOS) as a contribution to the United Nations Framework Convention on Climate Change (UNFCCC). The international data compilation efforts over more than a century have resulted in unprecedented datasets that allow for a robust (but rough) estimate of the global distribution of glacier ice and its changes since the *Little Ice Age*, which lasted roughly from the 16th to the 19th centuries.

To answer questions about linkages between changes in glaciers and climate change—e.g., How much of the current global sea-level rise can be attributed to melting glaciers?—more precise and quantitative studies of glaciers are required. This includes systematically extending the available *in situ* and remote sensing data, putting together a more-detailed world glacier inventory (WGI), continuing and strategically enlarging the global mass balance monitoring network, and conducting a rigorous uncertainty assessment of the available data series.

Towards a Complete Global Glacier Inventory

The science community first considered the need for a global overview of glacier distribution during the International Hydrological Decade (1965-74); this resulted in the development of the first world glacier inventory based mainly on aerial photographs and maps. The original inventory included preliminary estimates of the *glacierized* area of Earth and detailed information on 70,000 glaciers. This inventory task continues through the present day, and is now based mainly on satellite images within GLIMS. The satellite inventory began in 1999 with the launch of NASA's Terra mission, and was originally under the auspices of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Science Team. It has since expanded into an international scientific initiative to map Earth's glaciers using spaceborne sensors.

In 2006 the European Space Agency (ESA) initiated the *GlobGlacier* project, under the lead of the Department of Geography of the University of Zurich in Switzerland, with the intention of making a major contribution towards global documentation of glaciers and ice caps. The project's goal is to provide detailed glacier inventories from well-established remote sensing methods in regions not yet covered in the GTN-G databases (i.e., WGI and GLIMS). A *GlobGlacier* user group, composed of institutions and individual sci-

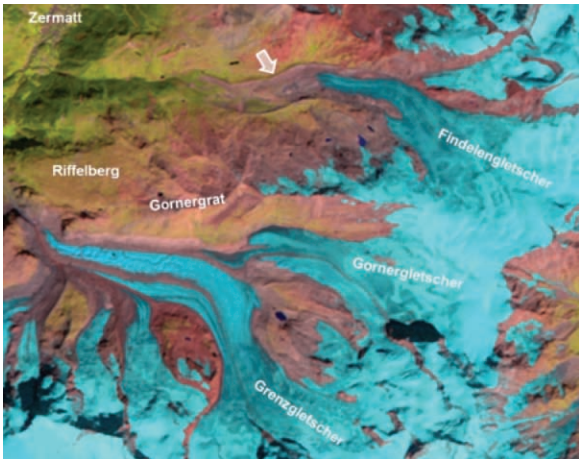

Figure 1. [*Left*] The participants of the *GlobGlacier* meeting got a chance to view ongoing glacier research up close at Findelengletscher. In this photo they are assembled at the location known as the Little Ice Age moraine. As the glacier advanced during the Little Ice Age, it "piled up" till and rock and left it behind, leaving a high lateral ridge as the glacier retreated. [*Right*] A Landsat scene taken at the same time as the photo on the left (September 1, 2010, at 11:07 a.m. local time) of the Monte Rosa region, Switzerland gives some perspective. It shows the three largest glaciers in the area: [*from top to bottom*] Findelen-, Gorner-, and Grenzgletscher. The white arrow in the top middle of the image indicates the location of the *GlobGlacier* group. Note how far Findelengletscher has retreated since the Little Ice Age.

entists involved in glacier monitoring, evaluates proposed data products and science. Once approved, data products are made available to the scientific community through GTN-G.

The final user group meeting of the three-year *GlobGlacier* project took place at Hotel Schweizerhof on August 31, 2010, in Zermatt, Switzerland, located at an elevation of ~5250 ft (1600 m) above sea level. Invited guests included representatives from the Swiss GCOS Office, ESA, GLIMS, NSIDC, United Nations Environmental Programme (UNEP), and several of the WGMS national correspondents.

Gabriela Seiz [GCOS Office[1]—*National GCOS Coordinator*] opened the first of four sessions held at the user group meeting. Two keynote addresses followed. **Wilfried Haeberli** [University of Zurich] gave a presentation on the combined glacier monitoring strategy within GTN-G, and **Olivier Arino** [ESA] discussed the efforts of ESA to use spaceborne sensors for coordinated monitoring of essential climate variables. After the keynotes, came discussion of an effort to produce a promotional DVD visualizing the GTN-G project.

To start the second session, consortium members gave an overview of the outcome from the different work packages. **Frank Paul** [University of Zurich—*GlobGlacier Project Leader*] then gave a general summary of project results.

In the third and fourth sessions, all members of the users group gave feedback on the generated documents and products, along with an overview of current remote sensing activities. **Stephen Plummer** [ESA—*GlobGlacier Project Officer*] closed the official part of the meeting with a short overall evaluation of the project. On September 1 **Martin Hoelzle** [University of Fribourg] organized a morning excursion to nearby Findelengletscher, where meeting participants had the opportunity to get an *in situ* perspective of ongoing glacier changes and challenges related to glacier mapping from space—see **Figure 1**.

The main achievements of the *GlobGlacier* project are the development and documentation of remote sensing methods for the semiautomated mapping of glacier outlines, late summer snow lines, topography, elevation change, and velocity. For all these products, glacier data are compiled for key regions around the globe. Altogether, additional outlines for 28,000 glaciers were produced, which brings the global glacier inventory to about two-thirds of the estimated total number of glaciers.

Strengthen and Improve the Quality of the *in situ* Monitoring Network

Subsequent to the *GlobGlacier* meeting, the WGMS General Assembly of the National Correspondents started in the afternoon on September 1 at Hotel Riffelberg[2] in Zermatt. The meeting began with an icebreaker and welcoming remarks from **Michael Zemp** [WGMS—*Director*]. WGMS national correspondents (or deputies) from 24 countries, staff members of the WGMS coordinating office, and special guests from the Swiss GCOS Office, ESA, GLIMS, and the Norwegian Water Resources and Energy Directorate all attended the meeting.

Wilfried Haeberl [WGMS—*Former Director*] opened the first full day of the general assembly with a keynote

[1] Located at the Federal Office of Meteorology and Climatology, MeteoSwiss.

[2] Located ~8530 ft (2600 m) above sea level.

Figure 2. Participants of the WGMS General Assembly of the National Correspondents at Riffelberg in Zermatt, Switzerland, on September 3, 2010.

address on the historical background of international glacier monitoring and the integration of *in situ* measurements within the GTN-G strategy. Subsequent to the talk, national correspondents (or their deputies) gave overviews on the status and challenges of glacier monitoring in their respective countries.

The second day started with a general discussion of the national summaries of the first day, followed by four workshops on:

1. improvement of the quality and richness of available glacier datasets;
2. homogenization, validation, and calibration of glacier mass balance series;
3. current status and challenges of remote sensing of glaciers; and
4. how to improve WGMS's service to the scientific community.

In his concluding remarks, **Michael Zemp** emphasized the strength of the WGMS as a global scientific collaboration network that follows an integrative monitoring strategy in order to actively measure, compile, and disseminate standardized data and information of the highest quality on global glacier distribution and changes to the scientific community, political authorities, and the wider public. Based on the global and national overviews presented and on the discussion during the different workshops, the following key tasks for glacier monitoring of the coming decade have been developed. They are to:

- Improve the organizational structure and funding situation of the national monitoring programs through WGMS network collaborations and contacts to international organizations (e.g., GCOS);
- use the WGMS network for capacity building (e.g., summer schools, scholarships, and mass balance measurement training);
- adjust monitoring strategies for disintegrating and vanishing glaciers;
- strongly facilitate homogenization, validation, and calibration of long-term mass balance series (e.g., scientific workshops);
- strengthen integration of and improve cooperation between *in situ* and remote sensing communities dealing with glaciers;
- initiate (small) scientific workshops focused on specific monitoring-related aspects (e.g., point mass balance analysis, automated weather station measurements, and energy balance modeling), and;
- improve the visibility of WGMS datasets (e.g., through joint review papers).

The panoramic and culinary setting of the Swiss venue greatly supported the spirit of intensive and constructive discussions during the workshop, and provided a perfect stage for the evening talks by two guest speakers:

- **Heinz J. Zumbühl** [University of Bern] discussed the iconography of glaciers, ice, and climate during the Little Ice Age.

- **Christoph Dehnert** [University of Ulm] presented information on acute high-altitude associated illnesses, and discussed results from medical research he has conducted at Capanna Regina Margherita, located "next door" at an altitude of 14,957 ft (4559 m) above sea level.

On September 4 **Martin Hoelzle** organized a morning excursion to Gornergrat, located ~10,170 ft (3100 m) above sea level. It was the perfect place to view (and receive explanations of) ongoing research efforts at Gorner- and Findelengletscher, as well as on Stockhorn and Colle Gnifetti, Monte Rosa.

Laying the Foundation for Future IPCC Assessment Reports

The two meetings in Zermatt clearly demonstrated that GTN-G is not just another acronym in the sea of international organizations. It is, rather, a framework for global glacier monitoring, with operational bodies (i.e., the WGMS, NSIDC, and GLIMS) that actively compile and disseminate glacier data as a unique service to the scientific community. Thanks to the successful *GlobGlacier* project and the continued close cooperation with the leading space agencies around the world, it is on its way to completing the world glacier inventory within the coming decade, and continues to provide repeat inventories of key regions. **NASA is a key player in this effort, as its release in 2008 of the complete Landsat image archive at no cost to users makes large-scale mapping efforts much easier.** ESA will continue its strong involvement in the operational glacier monitoring from space with its new Climate Change Initiative.

The WGMS will put all its efforts into continuing the long-term *in situ* observation series, reactivating interrupted data series of strategic importance, strengthening the monitoring network in underrepresented mountain ranges, and improving the richness and quality of available data series. Furthermore, in Zermatt the WGMS decided to start compiling standardized measurements of glacier thickness to improve estimates of the global distribution of the remaining glacier volume. While scientists are about to draft their scientific papers for on-time submission to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (papers should be submitted to journals before July 31, 2012), international glacier monitoring is laying the (data) foundation for the assessment reports beyond the fifth.

For more information, visit:

www.wgms.ch
www.nsidc.org
www.glims.org
www.gtn-g.org
www.globglacier.ch
www.esa-glaciers-cci.org
landsat.usgs.gov/documents/USGS_Landsat_Imagery_Release.pdf ■

Erratum

In our May–June 2011 issue we ran an article titled "NASA and the International Year of Chemistry 2011" [**Volume 23**, **Issue 3**, pp. 19-24, 31]. In the last paragraph on page 22 we mistakenly reported that carbon dioxide is the "*most abundant of all the so-called greenhouse gases*". It should have said, "*the second-most abundant of all the so-called greenhouse gases*"—water vapor being most abundant. *The Earth Observer* regrets this error; the online pdf version of the newsletter has been corrected.