NVE

WGMS achievements and future challenges– View from IACS & GTN-G advisory board

& NVE

Liss Marie Andreassen
Norwegian Water Resources and Energy Directorate (NVE)
Section for Glaciers, Ice and Snow

IACS
International Association of Cryospheric Sciences

Global Terrestrial Network for Glaciers
GTN-G

NVE measures the glaciers in Norway

NVE

- MB: **15** glaciers
- Front: **30+** glaciers
- Geodetic surveys
- Ice thickness data
- Photographical records
- Glacier inventories

GLIMS

RGI

wgms

NSIDC

+ + + +

Global Terrestrial Network for Glaciers
GTN-G

Three bodies:

- World Glacier Monitoring Service
- U.S. National Snow and Ice Data Center
- Global Land Ice Measurements from Space initiative

- **compiling** and **disseminating standardized observations** and **methods** on **glacier distribution and their changes**

- Steering comitee:
  Executive & **Advisory board**

WGMS & IACS

- WGMS a service of IACS
- IACS leads the Advisory Board of GTN-G

Members of the ADVISORY BOARD

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email: arendta@gi.alaska.edu

Dr. Stephen Briggs

email: Stephen.Briggs@esa.int

Prof. Graham Cogley

email: gcogley@trentu.ca

Prof. Alex Gardner

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Prof. Ben Marzeion

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http://www.gtn-g.ch/contact/

IACS The International Association of Cryospheric Sciences

- Established in 2007
  Association of International Union of Geodesy and Geophysics (IUGG)
- Promote cryosphere studies & public awareness –collaboration & international co-ordination
- Standardize collection of cryosphere data, analysis, archiving & publication
- IACS Bureau
  - Snow and Avalanches
  - **Glaciers and Ice Sheets**
  - Marine and Freshwater Ice
  - Cryosphere, Atmosphere and Climate
  - Planetary and other Ices of the Solar System

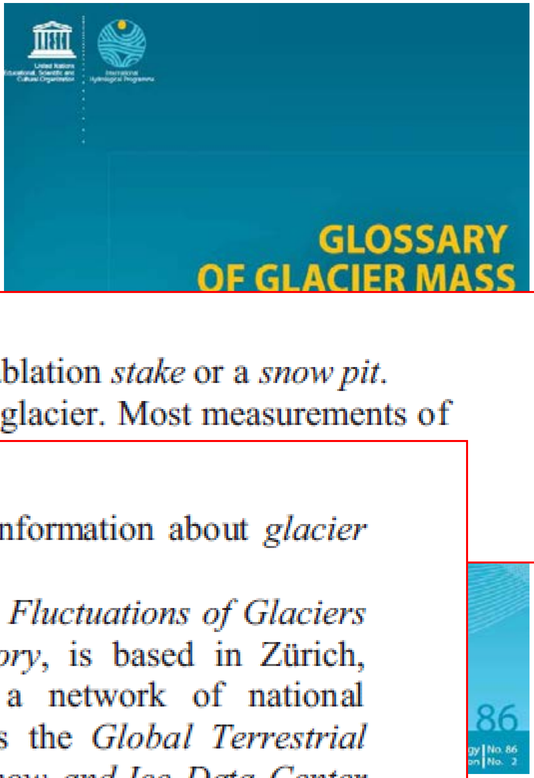
President:
Charles Fierz

http://www.cryosphericsciences.org

IACS Working Groups on glaciers

- **Mass balance terminology and methods** *(2008 – 2012)*

"early milestone in the work of the IACS"



Point mass balance
Mass balance at a particular location on the *glacier*, for example at an ablation *stake* or a *snow pit*.
The point referred to is at the top of a vertical column through the glacier. Most measurements of

World Glacier Monitoring Service (WGMS)
The leading organization for the collection, storage and dissemination of information about *glacier fluctuations*.

The WGMS, formed in 1986 by merging the *Permanent Service on the Fluctuations of Glaciers* and the *Temporary Technical Secretariat for the World Glacier Inventory*, is based in Zürich, Switzerland. It coordinates the work of local investigators through a network of national correspondents in countries involved in glacier monitoring. WGMS runs the *Global Terrestrial Network for Glaciers* (GTN–G) in close collaboration with the *National Snow and Ice Data Center* and the *Global Land Ice Measurements from Space* initiative.

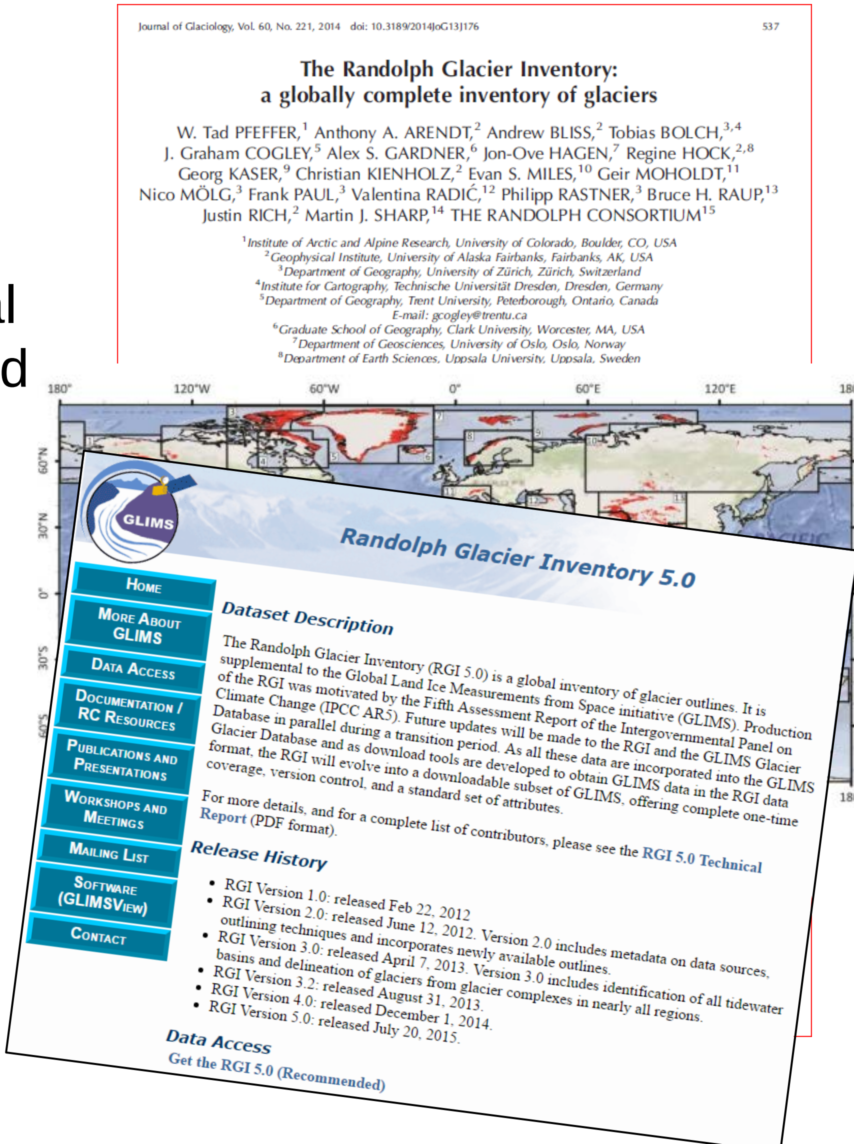
Cogley, J.G., R. Hock, L.A. Rasmussen, A.A. Arendt, A. Bauder, R.J. Braithwaite, P. Jansson, G. Kaser, M. Möller, L. Nicholson and M. Zemp, 2011, *Glossary of Glacier Mass Balance and Related Terms*, IHP-VII Technical Documents in Hydrology No. 86, IACS Contribution No. 2, UNESCO-IHP, Paris.

IACS WG: Randolph Glacier Inventory and infrastructure for glacier monitoring

Period: 2014 – 2018

Chairs: Cogley & Hock

- **Randolph Glacier Inventory** a global inventory of glacier outlines (motivated by the 5th IPCC A. Report).
- RGI a complete **one-time coverage**, version control, attributes.
- GLIMS – **multiple outlines**
- RGI merging into GLIMS -> **RGI will be a downloadable subset of GLIMS**.



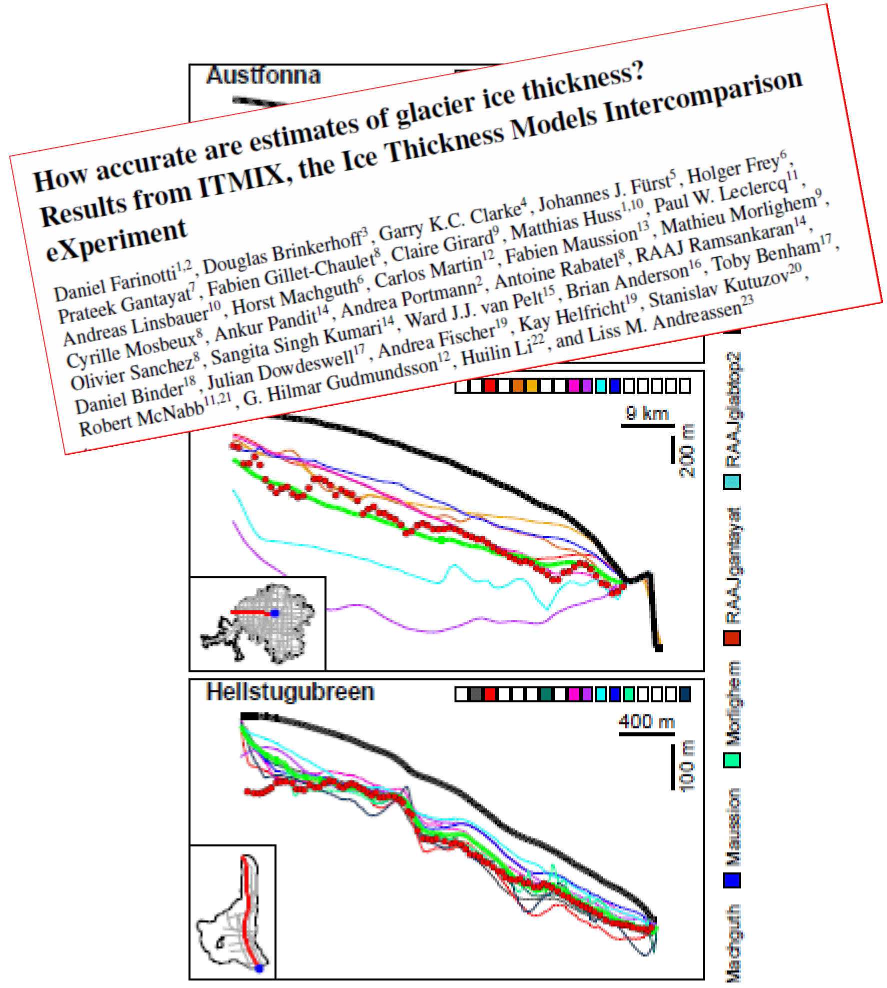
IACS WG: Glacier ice thickness estimation

Period: 2014 – 2018

Chairs: Farinotti, Li & Andreassen

- Perform a **model intercomparison** and validation experiment

- Continue the **WGMS** effort in the collection of **ice thickness measurements**



WGMS Achievements

Ice thickness – GlaThiDa

- **GlaThiDa 1.0** literature review & NASA's IceBridge *(WGMS, 2014; Gärtner-Roer, 2014)*

- **GlaThiDa 2.0**

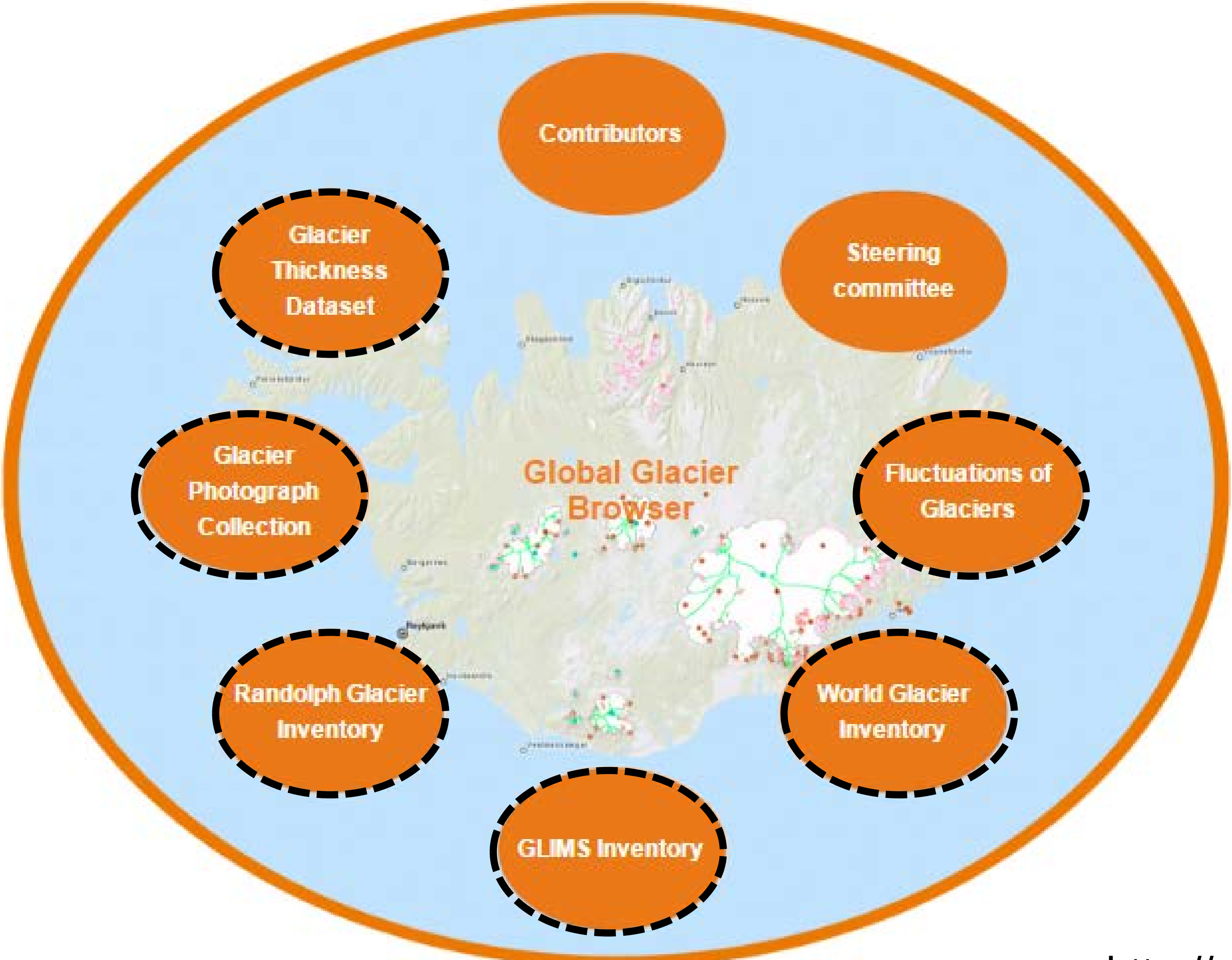
  Contribution to IACS WG on ice thickness estimation (WGMS, 2016)

- **GlaThiDa 3.0**

  ....next year......

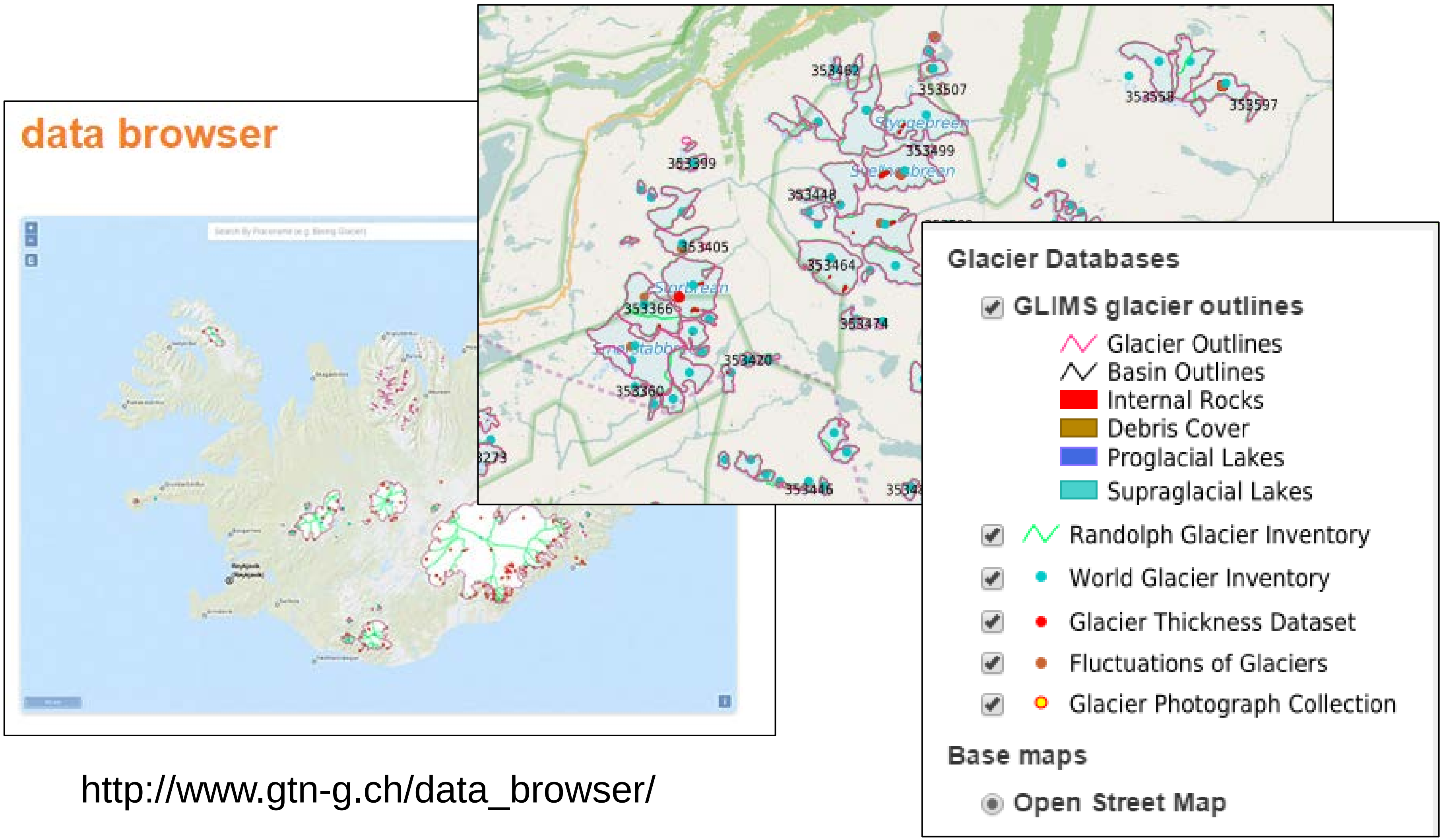
Citation: WGMS (2016): Glacier Thickness Database 2.0. Gärtner-Roer, I., Andreassen, L. M., Bjerre, E., Farinotti, D., Fischer, A., Fischer, M., Helfricht, K., Huss, M., Knecht, T., Kutuzov, S., Landmann, J., Lavrentiev, I., Li, H., Li, Z., Machguth, H., Naegeli, K., Navarro, F., Rabatel, A., Stentoft, P., Zemp, M. (eds.), World Glacier Monitoring Service, Zurich, Switzerland. DOI:10.5904/wgms-glathida-2016-07.

Global Glacier Browser



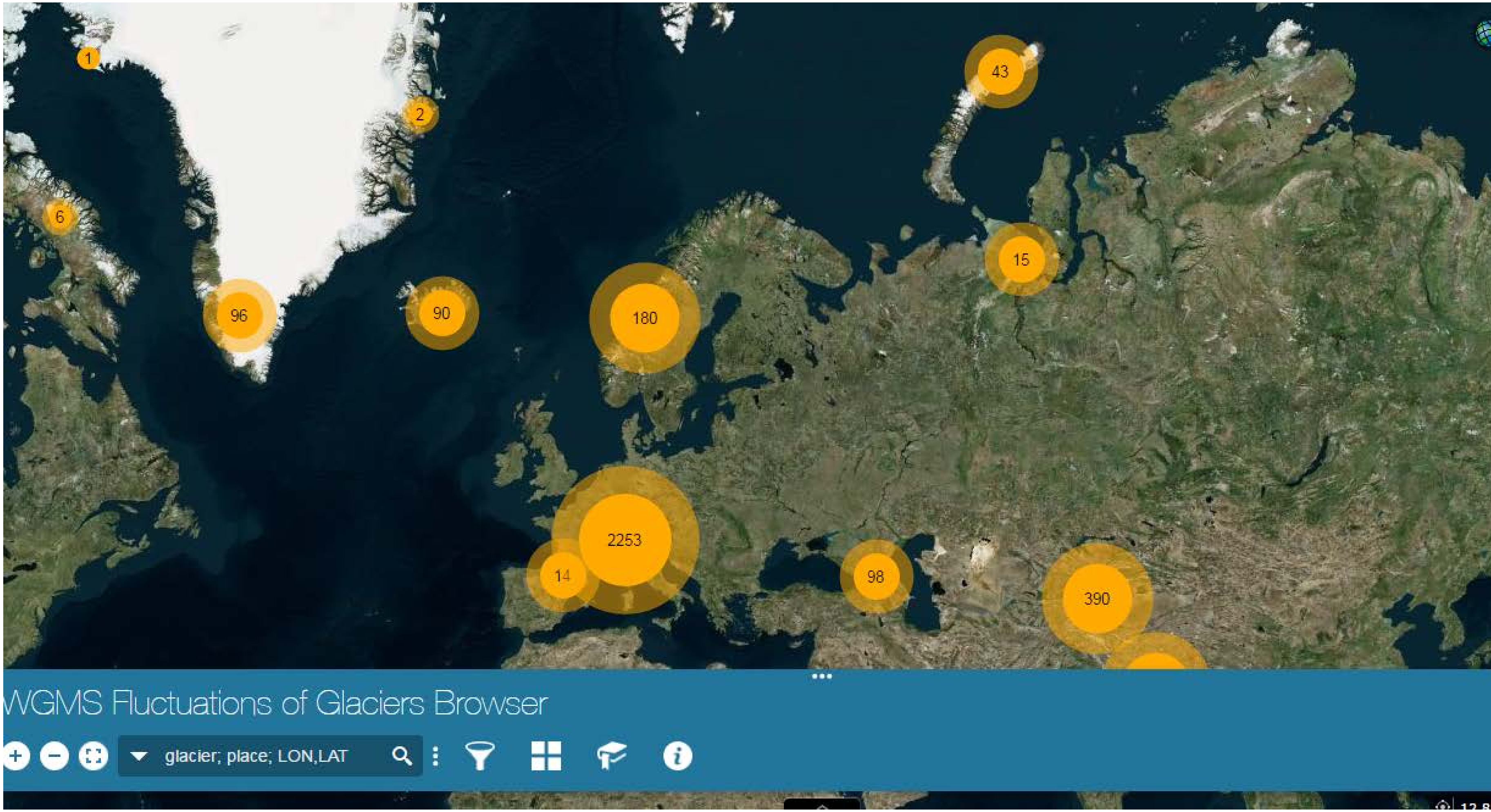
http://www.gtn-g.ch/

Viewing the GTN-G datasets



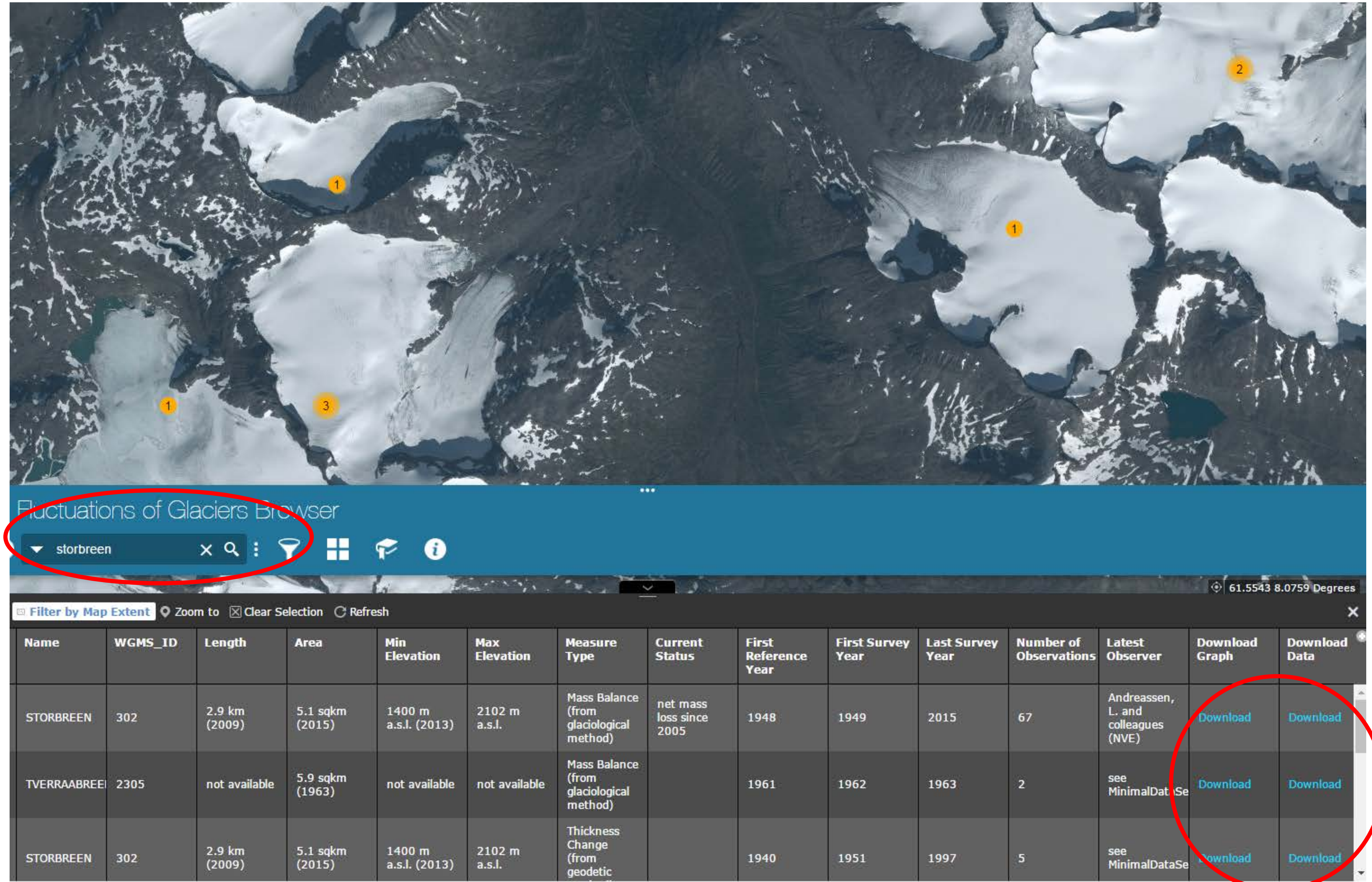
http://www.gtn-g.ch/data_browser/

WGMS Fluctuations of Glaciers Browser



http://www.wgms.ch/fogbrowser/

WGMS Fluctuations of Glaciers Browser



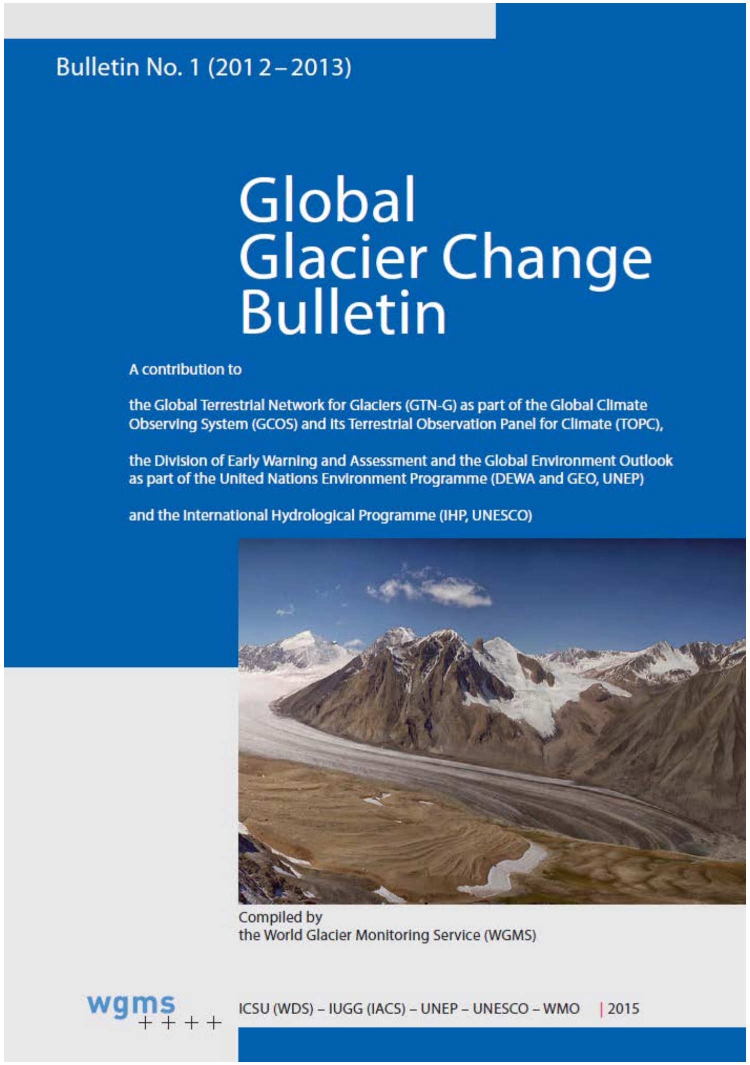
WGMS reporting

Merging of

- Glacier Mass Balance Bulletin (MBB)
- Fluctuations of Glaciers (FOG)

- Global Glacier Change Bulletin

"..free resources and offer the public a more timely product..."



Versioning

- Each database version gets a Digital Object Identifier (DOI)

Creator: World Glacier Monitoring Service (WGMS)

Title: Fluctuations of Glaciers Database

Publisher: World Glacier Monitoring Service (WGMS)

Publication Year: 2015

Release date: 2015-11-30

Citation:

WGMS (2015): Fluctuations of Glaciers Database.

World Glacier Monitoring Service, Zurich, Switzerland.

DOI:10.5904/wgms-fog-2015-11.

Online access: http://dx.doi.org/10.5904/wgms-fog-2015-11

VERSIONS	DOI	METADATA	DATA DOWNLOAD
2015 (current)	10.5904/wgms-fog-2015-11	website	zip file
2014	10.5904/wgms-fog-2014-09	info	zip file
2013	10.5904/wgms-fog-2013-11	info	zip file
2012	10.5904/wgms-fog-2012-11	info	zip file
2008	10.5904/wgms-fog-2008-12	info	zip file

New data sets

- Ice thickness
- Point mass balance
- Photos

More data

- Extension of geodetic
- Reconstruction length change

Photo: Hallgeir Elvehøy

Capacity building

Training courses

Traineeships

General Assembly of National Correspondents

Workshops

Training course for mass balance measurements and analysis, Bolivia

Photo: WGMS

Mass balance workshops

Publications

Bulletin No. 1 (2012–2013)

Global
Glacier Change
Bulletin

etwork for Glaciers (GTN-G) as part of the Global Climate
DS) and its Terrestrial Observation Panel for Climate (TOPC),

arning and Assessment and the Global Environment Outlook
ations Environment Programme (DEWA and GEO, UNEP)

ydrological Programme (IHP, UNESCO)

lled by
orld Glacier Monitoring Service (WGMS)

WDS) – IUGG (IACS) – UNEP – UNESCO – WMO | 2015

The Cryosphere, 7, 1227–1245, 2013
www.the-cryosphere.net/7/1227/2013/
doi:10.5194/tc-7-1227-2013

The Cryosphere
Open Access

Reanalysing glacier mass balance measurement series

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[11]Institute for Interdisciplinary Mountain Research, Austrian Academy of Sciences, Innsbruck, Austria
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Received: 1 February 2013 – Published in The Cryosphere Discuss.: 4 March 2013
Revised: 10 June 2013 – Accepted: 21 June 2013 – Published: 6 August 2013

Abstract. Glacier-wide mass balance has been measured for more than sixty years and is widely used as an indicator of climate change and to assess the glacier contribution to runoff and sea level rise. Until recently, comprehensive uncertainty assessments have rarely been carried out and mass balance data have often been applied using rough error estimation or without consideration of errors. In this study, we propose a framework for reanalysing glacier mass balance series that includes conceptual and statistical toolsets for assessment of random and systematic errors, as well as for validation and calibration (if necessary) of the glaciological with the geodetic balance results. We demonstrate the usefulness and limitations of the proposed scheme, drawing on an analysis that comprises over 50 recording periods for a dozen glaciers, and we make recommendations to investigators and users of glacier mass balance data. Reanalysing glacier mass balance series needs to become a standard procedure for every monitoring programme to improve data quality, including reliable uncertainty estimates.

1 Introduction

Changes in glacier mass are a key subject of glacier monitoring, providing important information for assessing climatic changes, water resources, and sea level rise. The most extensive dataset of glacier-wide in situ mass balance measurements covers the past six decades (WGMS, 2012; and earlier volumes) and is widely used to assess global glacier changes (e.g. Cogley, 2009) and related consequences of regional runoff (e.g. Weber et al., 2010) and global sea level rise (e.g. Kaser et al., 2006). However, most of these data series consist of just a few observation years, and most results are reported without uncertainties (Zemp et al., 2009).

There are a dozen mass balance programmes with continuous time series dating back to 1960 or earlier on relatively small mountain and valley glaciers (Zemp et al., 2009). Combined with multi-annual geodetic surveys, these long-term glaciological mass balance series provide a unique opportunity for quantitative assessment of the related uncertainties. Earlier works found both agreement (e.g. Funk et al., 1997) and disagreement (e.g. Østrem and Haakensen, 1999) between the mass balance results from the two methods. Recent

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Historically unprecedented global glacier decline in the early 21st century

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National Correspondents for [2]CH, [3]GL, [4]NZ, [5]NP, [6]IT, [7]DE, [8]EC, [9]CL, [10]ES, [11]PE, [12]MX, [13]CA, [14]AR, [15]AT, [16]JP, [17]PL, [18]PK, [19]NO, [20]SE, [21]IR, [22]CN, [23]US, [24]RU, [25]KE, [26]TZ, [27]UG, [28]IN, [29]KZ, [30]IS, [31]BO, [32]KG, [33]FR*
Correspondence: michael.zemp@geo.uzh.ch

ABSTRACT. Observations show that glaciers around the world are in retreat and losing mass. Internationally coordinated for over a century, glacier monitoring activities provide an unprecedented dataset of glacier observations from ground, air and space. Glacier studies generally select specific parts of these datasets to obtain optimal assessments of the mass-balance data relating to the impact that glaciers exercise on global sea-level fluctuations or on regional runoff. In this study we provide an overview and analysis of the main observational datasets compiled by the World Glacier Monitoring Service (WGMS). The dataset on glacier front variations (~42 000 since 1600) delivers clear evidence that centennial glacier retreat is a global phenomenon. Intermittent readvance periods at regional and decadal scale are normally restricted to a subsample of glaciers and have not come close to achieving the maximum positions of the Little Ice Age (or Holocene). Glaciological and geodetic observations (~5200 since 1850) show that the rates of early 21st-century mass loss are without precedent on a global scale, at least for the time period observed and probably also for recorded history, as indicated also in reconstructions from written and illustrated documents. This strong imbalance implies that glaciers in many regions will very likely suffer further ice loss, even if climate remains stable.

KEYWORDS: glacier fluctuations, glacier mass balance, mountain glaciers

1. INTRODUCTION

Glacier fluctuations, i.e. changes in length, area, volume and mass, represent an integration of changes in the energy balance and, as such, are well recognized as high-confidence indicators of climate change (Bojinski and others, 2014). Past, current and future glacier changes impact global sea level (e.g. Raper and Braithwaite, 2006; Meier and others, 2007; Gardner and others, 2013; Radić and others, 2014; Marzeion and others, 2014), the regional water cycle (e.g. Fountain, 1996; Kaser and others, 2010; Weber and others, 2010; Huss, 2011; Bliss and others, 2014) and local hazard situations (e.g. Kääb and others, 2003; Bajracharya and Mool, 2009; Haeberli and others, 2015). In the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Vaughan and others, 2013) glacier mass budgets for 2003–09 were reconciled in order to obtain an estimate of the glacier contribution to sea level. This was achieved by combining traditional observations with satellite altimetry and gravimetry as a way of filling regional gaps and obtaining global coverage (Gardner and others, 2013). However, the analysis was possible only during a short time period; additional datasets are needed to detect climatic trends and to compare current change rates with earlier ones.

In this study we present a joint analysis of data compiled by the World Glacier Monitoring Service (WGMS, 2008a, and references therein) and its National Correspondents in order to provide the scientific community with an in-depth summary of changes in glacier length, volume and mass. For this purpose we apply the observational dataset in its full richness for a comprehensive assessment of decadal glacier changes at global and regional levels. Results from different methods are not merged (as in Gardner and others, 2013), rather they are treated separately in order to demonstrate and discuss both the strengths and limitations of the respective

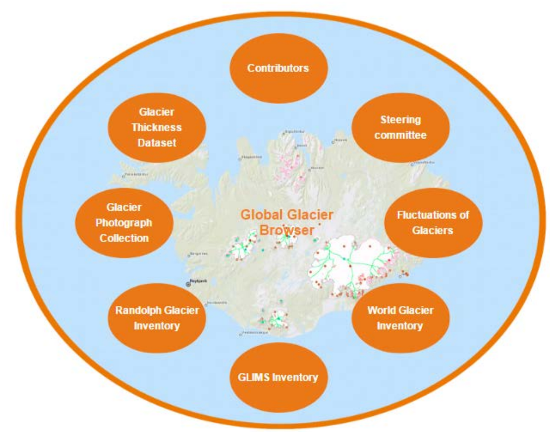
*Complete affiliations of the WGMS National Correspondents are given in the Appendix.

WGMS Challenges

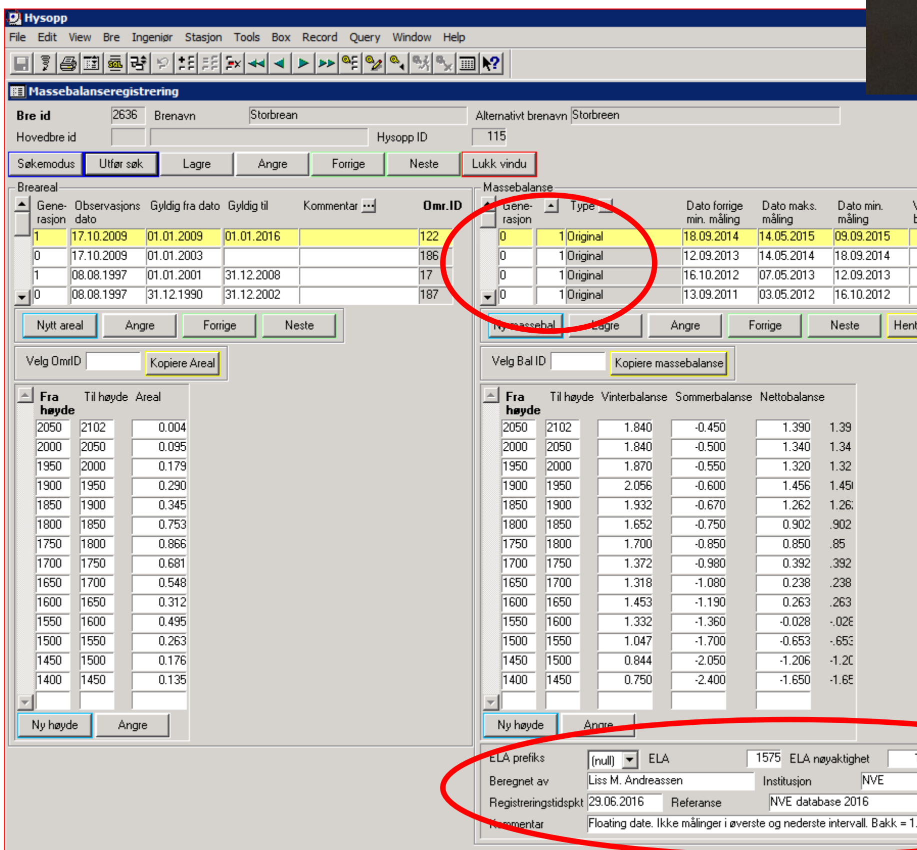
GTN-G vision

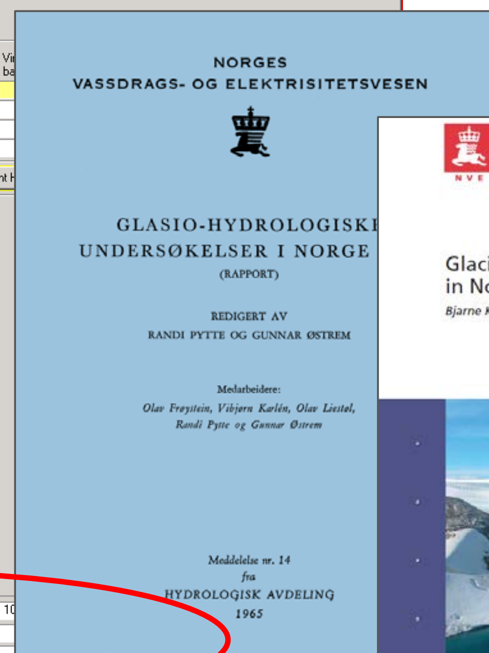
Recommended by the Advisory Board
in the evaluation report 2014

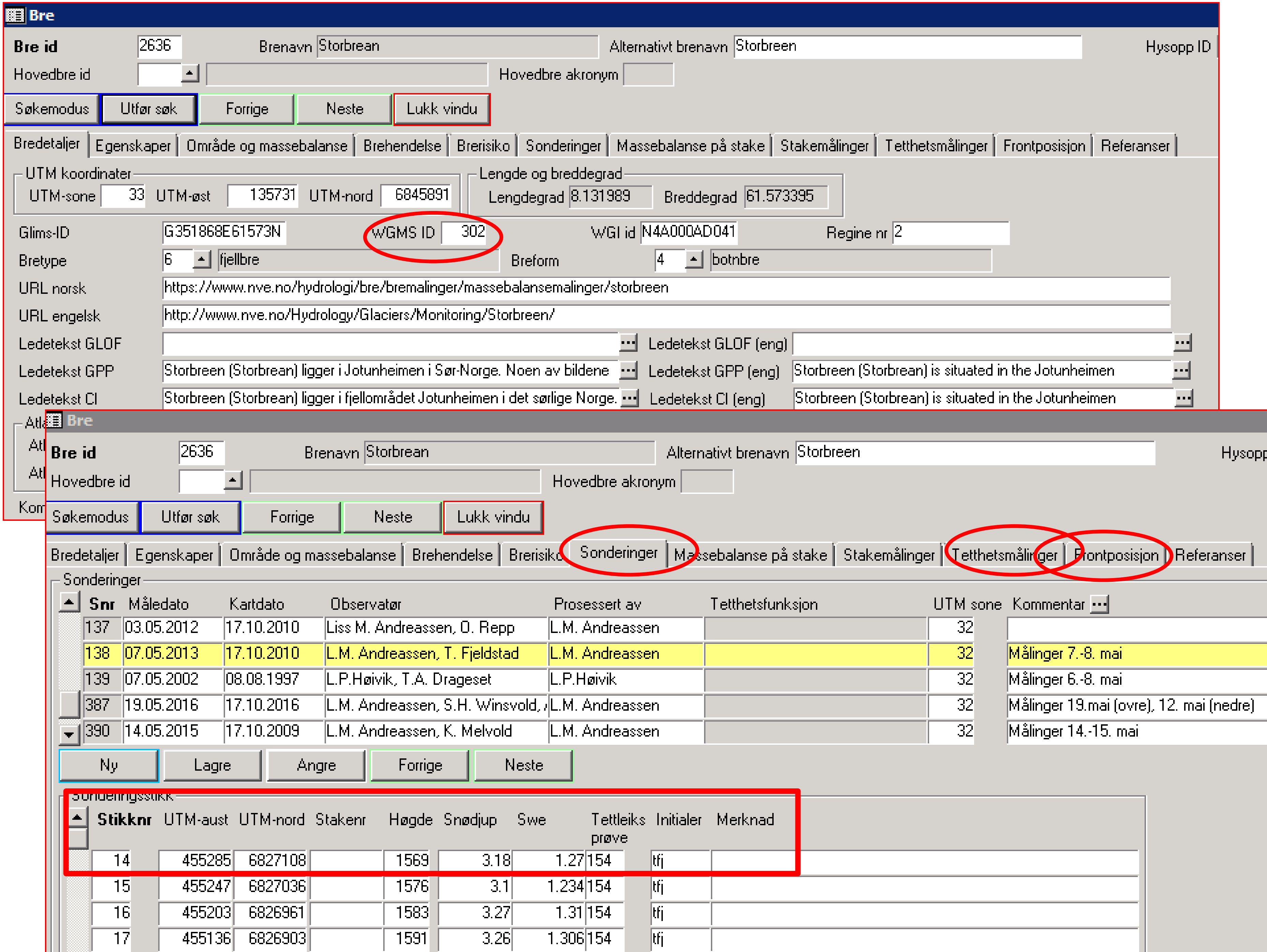
- **Products** of **value within** - and **beyond glaciology**
- A community that is **willing to contribute data**
- **Secured** long-term **funding** for stewardship, access, and accommodation of future needs
- A rich, highly visible and user-friendly **one-stop portal**



Data reporting & storage



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Lukk vindu
Bredetaljer
Egenskaper
Område og massebalanse
Brehendelse
Brerisiko
Sonderinger
Massebalanse på stake
Stakemålinger
Tetthetsmålinger
Frontposisjon
Referanser
UTM koordinater
UTM-sone 33
UTM-øst 135731
UTM-nord 6845891
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WGI id N4A000AD041
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Breform 4 botnbre
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URL engelsk http://www.nve.no/Hydrology/Glaciers/Monitoring/Storbreen/
Ledetekst GLOF
Ledetekst GLOF (eng)
Ledetekst GPP Storbreen (Storbrean) ligger i Jotunheimen i Sør-Norge. Noen av bildene
Ledetekst GPP (eng) Storbreen (Storbrean) is situated in the Jotunheimen
Ledetekst CI Storbreen (Storbrean) ligger i fjellområdet Jotunheimen i det sørlige Norge.
Ledetekst CI (eng) Storbreen (Storbrean) is situated in the Jotunheimen
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Alternativt brenavn Storbreen
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Lukk vindu
Bredetaljer
Egenskaper
Område og massebalanse
Brehendelse
Brerisiko
Sonderinger
Massebalanse på stake
Stakemålinger
Tetthetsmålinger
Frontposisjon
Referanser
Sonderinger
Snr Måledato Kartdato Observatør Prosessert av Tetthetsfunksjon UTM sone Kommentar
137 03.05.2012 17.10.2010 Liss M. Andreassen, O. Repp L.M. Andreassen 32
138 07.05.2013 17.10.2010 L.M. Andreassen, T. Fjeldstad L.M. Andreassen 32 Målinger 7.-8. mai
139 07.05.2002 08.08.1997 L.P.Høivik, T.A. Drageset L.P.Høivik 32 Målinger 6.-8. mai
387 19.05.2016 17.10.2016 L.M. Andreassen, S.H. Winsvold, L.M. Andreassen 32 Målinger 19.mai (ovre), 12. mai (nedre)
390 14.05.2015 17.10.2009 L.M. Andreassen, K. Melvold L.M. Andreassen 32 Målinger 14.-15. mai
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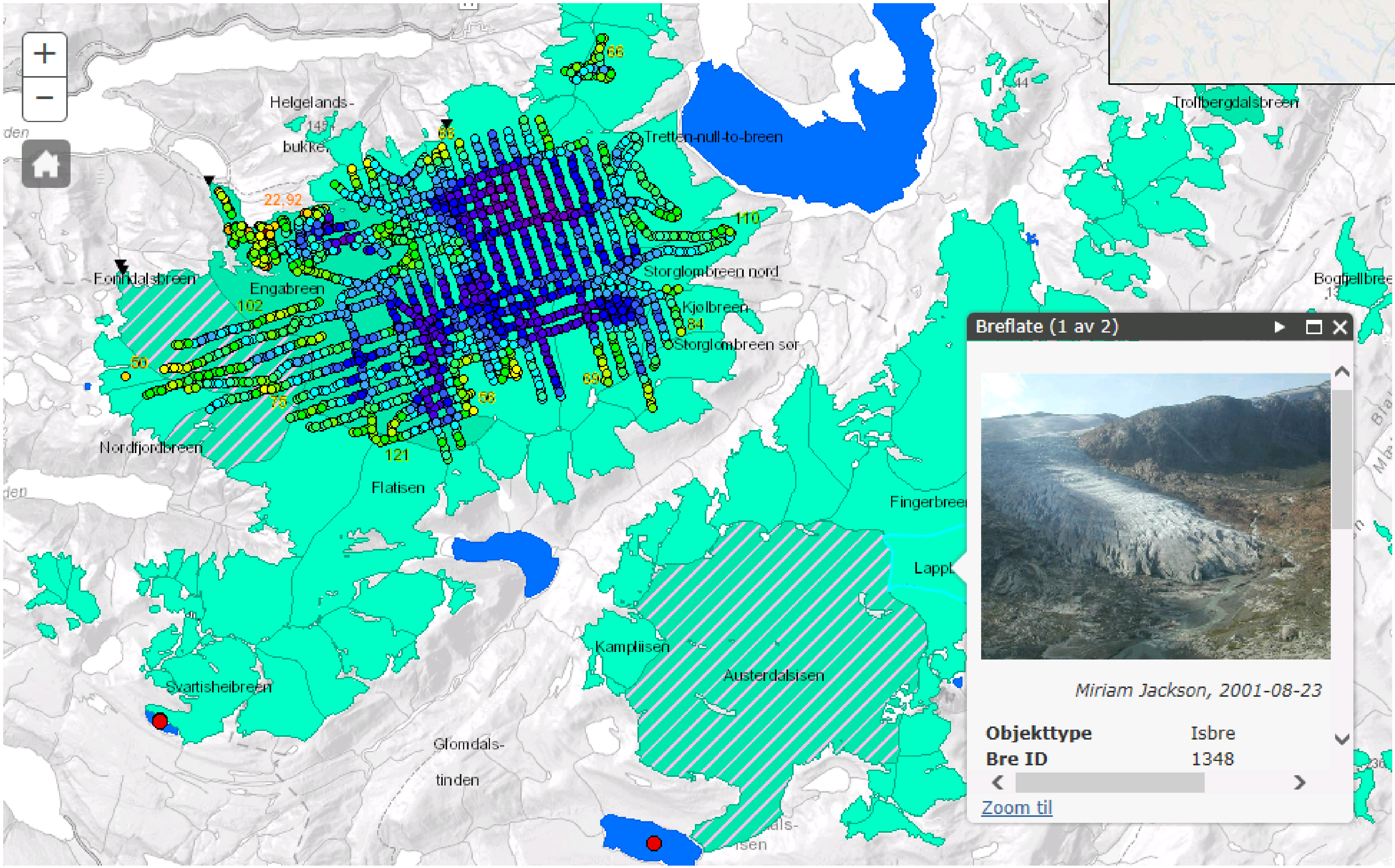
15 455247 6827036 1576 3.1 1.234 154 tfj
16 455203 6826961 1583 3.27 1.31 154 tfj
17 455136 6826903 1591 3.26 1.306 154 tfj

NVEs Breatlas

www.nve.no/glacier

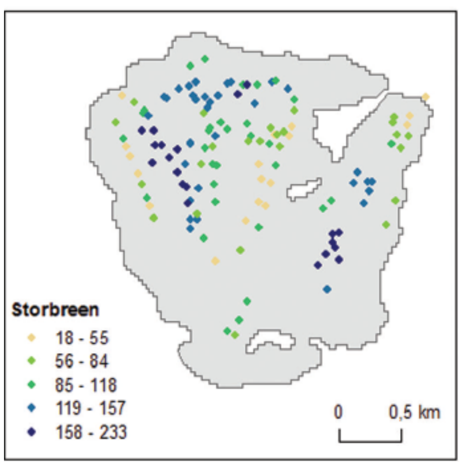


Citing the data

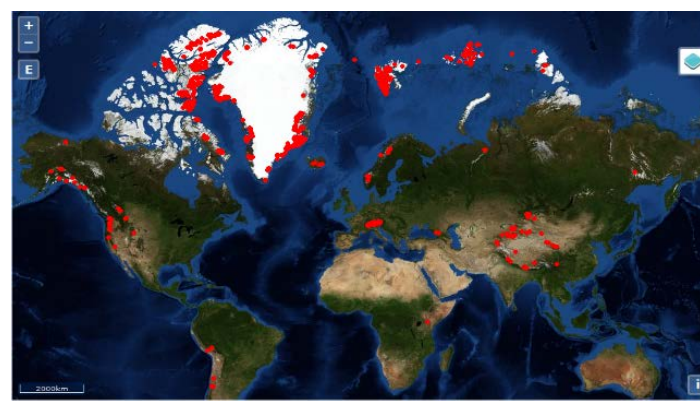
- Could we be better at citing?

WGMS: Fluctuation of glaciers
"When using the data, cite the World Glacier Monitoring Service (WGMS 2015, and earlier reports) **and/or** the original investigators and sponsoring agencies according to the available meta-information."

- Local → Regional → Global



Data: NVE. Andreassen et al., 2015



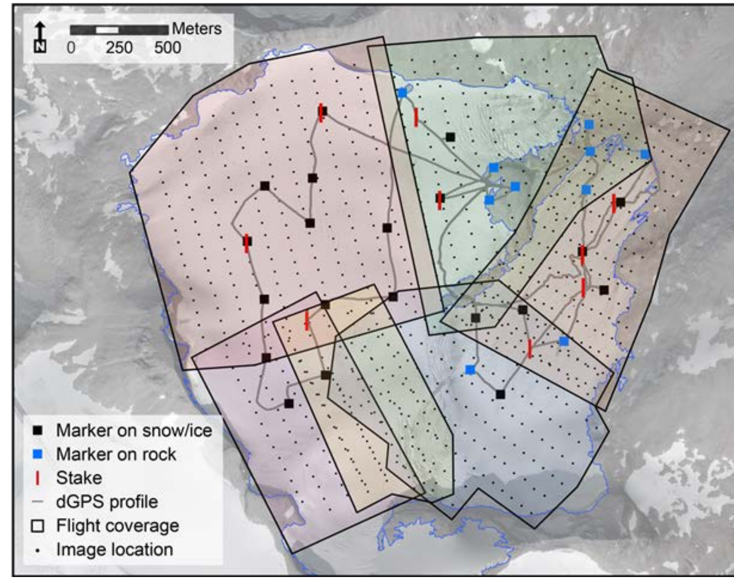
. GlaThiDa 2.0 (WGMS, 2016)

Geodetic data

- wealth of new data:
  - laser scanning
  - UAV
  - satellite sensors
  - gravimetric
- extend the geodetic database
- surveys cover regions & parts of glaciers

Challenges:

- density conversions
- tabular (excel) vs spatial (GIS)
  store DEM, glacier extents, area covered



UAV Storbreen 10 Sep 2015

Vestisen
PLEIADES© CNES, 2016, distribution Airbus DS

Summing up

well done

WGMS a commendable job

- data compilation & archiving
- products of high quality & increasing detail
- scientific analysis, outreach & training
- data more available (download, browsers & app)

Challenges

- secure long-term funding for the service
- make it easy & attractive to submit data
- incorporate storage of spatial data

Community: submit to data archives

Congratulations on the 30th Anniversary

Photo: Ragnar Ekker