Climate Assessment Report (CAR)

Prepared by:	Glaciers_cci consortium
Contract:	4000127593/19/I-NB
Name:	Glaciers_cci+D5.1_CAR
Version:	1.0
Date:	11.11. 2022

Contact:
Frank Paul
Department of Geography
University of Zurich
frank.paul@geo.uzh.ch

Technical Officer:
Anna Maria Trofaier
ESA Climate Office

Document status sheet

Version	Date	Changes	Approval
0.1	15.07. 2022	Initial draft	
0.2	18.09. 2022	Consortium Feedback integrated	
0.3	10.10. 2022	Feedback from TO integrated	FP
1.0	11.11. 2022	Accepted version	

The work described in this report was done under ESA contract 4000127593/19/I-NB. Responsibility for the contents resides with the authors who prepared it.

Author team:
Frank Paul, Philipp Rastner (GIUZ); Thomas Nagler, Jan Wuite (ENVEO); Tazio Strozzi, Andreas Wiesmann (Gamma); Andreas Kääb, Livia Piermattei, Désirée Treichler (GUIO); Lin Gilbert, Andrew Shepherd (SEEL)

Glaciers_cci Technical Officer at ESA:
Anna Maria Trofaier

Table of Contents

1. Purpose

This is the Climate Assessment Report (CAR) of the Glaciers_cci+ project. It describes the products generated, the feedback received and the outreach activities performed.

2. Introduction

The focus of Glaciers_cci+ (start 1.9.2019, end 31.8.2022) was on activities related to research and development, specifically on testing algorithms and performing research in two study regions (Eastern Arctic and High Mountain Asia) that serve as use cases. The datasets created in the framework of this set-up (Section 3) were thus prepared to support the contents of scientific publications rather than for evaluation by a larger user or climate research community. Hence, instead of a dedicated workshop with user feedback to the data products we provide here the reviewer feedback we received for two of the publications and a dataset (Section 4).

A summary of the contents of major publications (Section 5.1) is presented in Deliverable 6.4 (PSH) and thus not repeated here. Due to Covid19, most conferences, meetings and workshops were cancelled or replaced by online meetings. Compared to previous years presentations and outreach possibilities were thus reduced in 2020 and 2021. This includes opportunities for student lectures, summer schools, field courses and other outreach activities. However, a few opportunities emerged (Sections 5.2 and 5.3).

Basic data processing (e.g. creating new glacier inventories) has now been transferred to the Copernicus Climate Change Service (C3S) using the methods developed in Glaciers_cci. As a part of the work for version 7 of the Randolph Glacier inventory (RGI7) includes new methodological developments by Glaciers_cci, the related datasets (Baffin Island and New Zealand) have been included in Section 3 and a comment by an independent reviewer is added in Section 4.

Two members of our climate research group (L. Andreassen and B. Raup) provided feedback on the URD and PUG of the former Glaciers_cci project for integration in deliverable D2.3 (named CMUG_D2.3_Suitability_of_CCIECVs) by CMUG (see Section 4.4). CRG member E. Berthier provided valuable datasets (SPOT DEMs) for Use Case II in the Karakoram. Datasets for Use Case I (Historic flow velocities of Eastern Arctic glaciers) have already been used by a study published in Nature Communications (Kochtitzky et al. 2022). Further glacier outline datasets which are to be used by CRG members B. Marzeion and M. Zemp have been generated in the framework of C3S.

3. Datasets

In Table 1 and Fig. 1 we provide an overview of the datasets generated with financial support from CCI. Datasets Nr. 1 (Baffin Island) and 5 (New Zealand) were co-produced with C3S for integration in RGI7. The datasets are available from the CRDP server at Enveo (http://glaciers-cci.enveo.at), the glacier inventories are also available from http://glims.org. Results of a first survey of surging glaciers by Leclercq et al. (2021) are not listed.

Table 1: Overview of the generated datasets. Nr. 2, 4, 6, 7 and 12 have been produced for the eastern Arctic use case, nr. 8 to 11 are produced for the HMA use case. L5/7/8: Landsat 5/7/8, S-1/2/3: Sentinel-1/2/3, TSX: TerraSAR-X, AP: ALOS-1 PALSAR-1, CS-2: Cryosat-2, SRTM: Shuttle Radar Topography Mission DEM, HMA: High Mountain Asia DEM.

Nr.	RGI	Region	Product	Year/Period	Sensor	Remarks
1	4	Baffin Island	Inventory	2000	RGI6, L7	RGI6 outlines manually corrected
2	7	Svalbard	Inventory	2016/17	S-2, L8	used for #6
3	9	Franz-Josef-Land	Outlines	1962	Corona KH4	manually digitized
4	9	Franz-Josef-Land	Inventory	2016	S-2	used for #6
5	18	New Zealand	Inventory	2000-2002	L7	based on 2016 outlines from S-2
6	7+9	Eastern Arctic	Velocity	1992-2021	JERS-1, AP, ERS-1, S-1	dates & sensors are specific for each region
7	7+9	Eastern Arctic	Elevation change	1991-2020	ERS1/2, S-3, EnviSat, CS-2	continuous time series from the available sensors
8	14	Karakoram	Outlines	2000-2022	L5/7/8, S-2	front variations for 3 glaciers
9	14	Karakoram	Elevation changes	2000, 2010, 2015, 2020	SRTM, HMA SPOT	only SRTM/HMA difference DEMs (2000-2015) can be shared, SPOT 2010/2015 provided by E. Berthier
10	14	Karakoram	Elevation changes	2000-2021	SRTM, HMA, ICESat-2	elevation profiles crossing 6 glaciers
11	14	Karakoram	Velocity	2000-2020	L7/8, TSX, S-2, Planet	detailed time series & sensor inter-comparison, not possible with S-1
12	7	Svalbard	Velocity	2018-2019	S-1	High-res InSAR + merged offset tracking-InSar IV maps

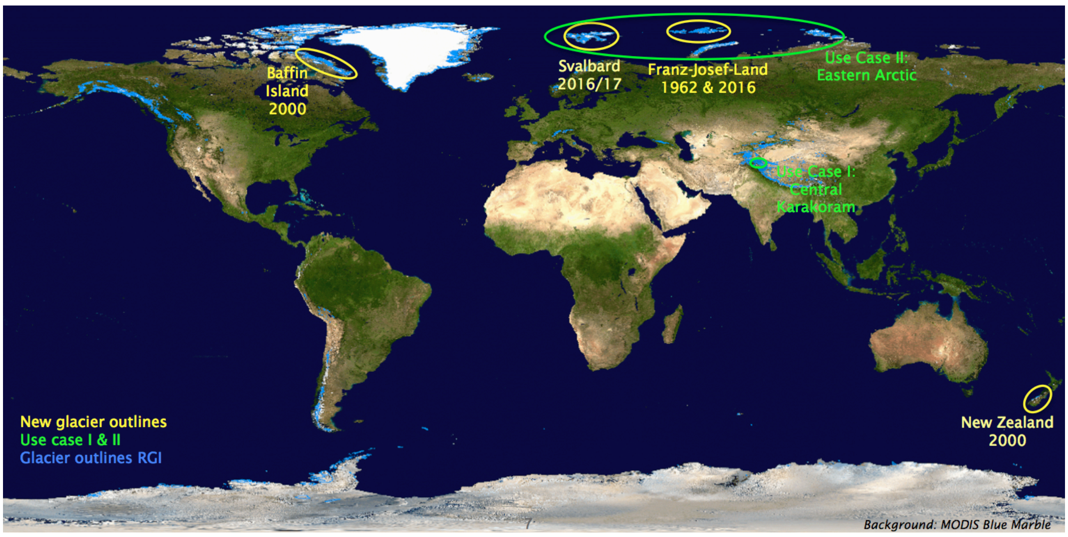

Figure 1: Location of the datasets listed in Table 1.

4. Feedback to publications, datasets and documents

We provide below the feedback of two reviewers to the Paul et al. (2022) and the Strozzi et al. (in revison) paper, to one of the datasets produced for RGI7, two documents from Glaciers_cci and citations of two publications summarising document deliverables.

4.1 Publication: Recent surges of the Chongtar glaciers

Reviewer 1: 'This paper provides an interesting review of the contrasting behaviour of adjacent surge-type glaciers in the Karakoram, and in particular how a very slowly surging glacier (likely controlled by changes in basal thermal conditions) can exist next to rapidly advancing ones (likely controlled by changes in basal hydrological conditions). These changes are well documented and illustrated through changes in terminus position, surface elevation and ice velocity, both in the main paper and the extensive supplemental material. I haven't seen many comparisons of surging glaciers which contrast in their behaviour over such a short distance before, so this provides the primary novel contribution of this study.'

Reviewer 2: 'Authors report on the surge behaviour of three glaciers in the same valley discussing differences in timing, extent and progression of the surges. For this purpose, they use a comprehensive dataset comprising different optical and radar satellites to map glacier advance, flow velocities and elevation changes.
The paper is well written with high quality figures and it also gives a good overview on the literature about glacier surges.'
The complete reviews are available here: https://tc.copernicus.org/articles/16/2505/2022/tc-16-2505-2022-discussion.html

4.2 Publication: Historic glacier flow velocities in Eastern Arctic

Reviewer 1: 'The study presents glacier flow velocity derived from SAR data for several subregions of the Eastern Arctic. The dataset primarily focuses on filling the gap in the 1990s, making it valuable for future investigations to monitor glacier changes in the highly sensitive Arctic under global warming.'

Reviewer 2: 'This paper demonstrates mosaics of winter ice surface velocities for the 1990's over the Eastern Arctic (Novaya Zemlya, Franz-Josef-Land, Severnaya Zemlya and Svalbard) through using the offset tracking approach on historical SAR data. Both the JERS-1 SAR data (primary) and the ERS-1/2 SAR/InSAR data (secondary) are used to generate the 1990's velocities. The authors also studied the long-term variability of winter ice surface velocity from the 1990's by comparing to mosaics derived from ALOS PALSAR in 2008-2011 and Sentinel-1 in 2020-2021. The paper generally reads well and compensate the existing ice velocity products on the knowledge of the ice surface velocity in 1990's.'
The complete reviews are available here: https://doi.org/10.5194/essd-2022-44-RC1

4.3 Dataset: Year 2000 glacier outlines for Baffin Island

The feedback from an independent review reads: 'Hi Frank, I had a look at your Baffin outlines today. Overall, still think they are really good. Congratulations on putting these together, I know it took a mountain of effort, so thank you for your work here.

4.4 CRG feedback on Glaciers_cci deliverables for a CMUG report

For the Glaciers ECV, members of the Glaciers_cci Climate Research Group (CRG) have evaluated two documents, the User Requirements Document (URD) for Year 3 of Phase 2 dated 1.10.2016 and the Product User Guide (PUG) version 1.5 dated 25.10.2016. These versions were selected as they provide the most complete overview of the consortium activities. Whereas the PUG still applies to the products created now, the former URD is now out-dated.

4.4.1. User Requirements Document (URD)

The document is still an adequate overview of user requirements, with a focus on satellite-based possibilities, but the document is also partly outdated as it is more than 5 years old and does not reflect some of the recent progress in the field. Depending on future use, the document could be updated to represent the situation today. As one example, the Sentinel-1 and 2 satellites launched from 2014 and 2015 with a higher spatial and temporal resolution that are very useful for glacier outline mapping and deriving velocity fields are not mentioned in this document.

The text in 3.1.3 on IPCC could be updated including latest assessments report. The text and title in 3.1.6 on the IACS RGI working group is now outdated. The text should be updated in a new version to reflect that, including names of leaderships (e.g. replace late Graham Cogley) and mention some of the current objectives and deliverables. The Section 4.2 elevation change-DEM differencing can be updated with the recent progress on dense ASTER time series on a much larger scale (Urq-15). In 4.4, much progress has been made using Sentinel-1 data to derive velocity fields. The summary list needs to be updated to reflect the current situation.

4.4.2. Product User Guide (PUG)

The Glaciers CCI Product User Guide (PUG) describes well the nature, format, and use of the different data products from the Glaciers CCI project. Products on glacier area, elevation change from altimetry and DEM differencing, and velocity are all described. Ample tables and illustrations provide examples and detailed documentation of the proper use of the products, as well as known issues.

The document also describes software tools, both proprietary and open-source, that can be used to work with the data.

Users of these data sets will naturally need to know what sources of error exist, the error magnitudes, and under what conditions the data sets should be used. The PUG discusses limitations in the different data sets and includes figures that illustrate potential problems for some applications. For example, Figure 2.3 shows the complications that arise when digitizing outlines for debris-covered glaciers. As another example, Figure 3.1 shows the potential effects of varying coverage and time ranges on altimetry measurements in Antarctica.

Finally, the PUG includes 25 references to relevant documentation in the literature. In this reviewer's opinion, the PUG adequately covers all the information and metadata users will likely need to make effective use of the Glaciers CCI data sets.

4.5 Citations of the former Glaciers_cci ATBD and PVIR documents

The essentials of the Algorithm Theoretical Basis Document (ATBD) and Product Validation and Intercomparison Report (PVIR) of Glaciers_cci have both been published in peer-reviewed journals. The ATBD content was published as Paul et al. (2015) and the PVIR as Paul et al. (2017). After 7 and 5 years it is possible to use the number of citations as indicators of their usefulness for the wider science community. As the content of both documents is still valid for the work in Glaciers_cci+ and C3S, we report related citations here. As of 10.10.2022, the ATBD paper has been cited 191 times and the PVIR paper 78 times. Considering that both papers are very technical and largely refer to the work in Glaciers_cci, it seems that both documents are well received.

Paul, F. and 24 others (2015): The Glaciers Climate Change Initiative: Algorithms for creating glacier area, elevation change and velocity products. Remote Sensing of Environment, 162, 408-426. (https://doi.org/10.1016/j.rse.2013.07.043)

Paul, F., T. Bolch, K. Briggs, A. Kääb, M. McMillan, R. McNabb, T. Nagler, C. Nuth, P. Rastner, T. Strozzi, J. Wuite (2017): Error sources and guidelines for quality assessment of glacier area, elevation change, and velocity products derived from satellite data in the Glaciers_cci project. Remote Sensing of Environment, 203, 256-275. (https://doi.org/10.1016/j.rse.2017.08.038).

5. Outreach

Over the duration of the Glaciers_cci+ project (2020-2022) consortium members have published 21 peer-review articles in 10 different journals including one in Nature and one in Science. Those marked in Section 5.1.1 in blue are summarized in more detail in Deliverable 6.4 (Project Scientific Highlights). We have also published 6 peer-reviewed articles in textbooks (Section 5.1.2). In total, 15 publications by the Glaciers_cci team or its CRG members were cited in the IPCC AR6 WG I report (several of them more than once) and 3 in the WG II report. The IPCC SROCC report cites 15 publications of the Glaciers_cci team in total 22 times. The Zemp et al. (2019) dataset served in SROCC as one of the baseline datasets for assessment of global glacier mass changes. Despite travel restrictions due to the Covid19 pandemic, the team presented or co-authored 29 talks or posters at national or international conferences (Section 5.2). Further outreach activities are listed in Section 5.3.

5.1 Peer-reviewed publications by the Glaciers_cci+ consortium

5.1.1. Journals

Kochtitzky, W., Copland, L., Van Wychen, W., Hugonnet., R., Hock, R., Dowdeswell, J., Benham, T., Strozzi, T., Glazovsky, A., Lavrentiev, I., Rounce, D., Millan, R., Cook, A., Dalton, A., Jiskoot, H., Cooley, J., Jania, J., and Navarro, F. (2022): The unquantified mass loss of Northern Hemisphere marine- terminating glaciers from 2000–2020. Nature Communications, 13, 5835, doi.org/10.1038/s41467-022-33231-x

Strozzi, T., A. Wiesmann, T. Schellenberger, A. Kääb and F. Paul (in revision): Long-term trends and seasonal variability of ice surface velocity in the Eastern Arctic from satellite SAR data. Earth Syst. Sci. Data Discuss. https://doi.org/10.5194/essd-2022-44 (pre-print).

Hegglin, M. and 37 others (2022): Space-based Earth observations in support of the UNFCCC Paris Agreement. Frontiers in Environmental Science, 10, 941490. doi.org/10.3389/fenvs.2022.941490

Windnagel, A., Hock, R., Maussion, F., Paul, F., Rastner, P., Raup, B.H., and Zemp, M. (2022): Which glaciers are the largest in the world? Journal of Glaciology, doi.org/10.1017/jog.2022.61

Gärtner-Roer, I., Nussbaumer, S., Raup, B., Paul, F., Welty, E., Windnagel, A.K., Fetterer, F., Zemp, M. (2022): Democratizing glacier data – maturity of worldwide datasets and future ambitions. Frontiers in Climate, 4, 841103, doi.org/10.3389/fclim.2022.841103.

Paul, F., Piermattei L., Treichler D., Gilbert, L., Girod, L., Kääb, A., Libert, L., Nagler, T., Strozzi, T., Wuite, J. (2022): Three different glacier surges at a spot: what satellites observe and what not. The Cryosphere, 16, 2505–2526.

Tielidze, L. G., Nosenko, G. A., Khromova, T. E., Paul, F. (2022): Strong acceleration of glacier area loss in the Greater Caucasus over the past two decades. The Cryosphere, 16, 489-504.

Leclercq, P.W., A. Kääb and B. Altena (2021): Brief Communication: Detection of glacier surge activity using cloud computing of Sentinel-1 radar data. The Cryosphere, 15, 4901–4907.

Shugar, D.H. and 52 others (2021): A massive rock and ice avalanche caused the 2021 disaster at Chamoli, Indian Himalaya. Science, 373 (6552), 300-306; doi.org/10.1126/science.abh4455.99.

Hugonnet R, McNabb R, Berthier E, Menounos B, Nuth C, Girod L, Farinotti D, Huss M, Dussaillant I, Brun F, Kääb A. (2021): Accelerated global glacier mass loss in the early twenty-first century. Nature, 592, 726-731; doi.org/10.1038/s41586-021-03436-z.

Kääb, A., Jacquemart, M., Gilbert, A., Leinss, S., Girod, L., Huggel, C., Falaschi, D., Ugalde, F., Petrakov, D., Chernomorets, S., Dokukin, M., Paul, F., Gascoin, S., Berthier, E. and Kargel, J. (2021): Sudden large-volume detachments of low-angle mountain glaciers - more frequent than thought. The Cryosphere, 15, 1751–1785; doi.org/10.5194/tc-15-1751-2021.

How, P., A. Messerli, E. Mätzler, M. Santoro, A. Wiesmann, R. Caduff, K. Langley, M.H. Bojesen, F. Paul, A. Kääb and J.L. Carrivick (2021): Greenland-wide inventory of ice marginal lakes using a multi-method approach. Scientific Reports, 11, 4481; doi.org/10.1038/s41598-021-83509-1.

Altena, B. and Kääb, A. (2020): Ensemble matching of repeat satellite images applied to measure fast-changing ice flow, verified with mountain climber trajectories on Khumbu icefall, Mount Everest. Journal of Glaciology, 66 (260), 905- 915.

Carturan, L., Rastner, P. and Paul, F. (2020): On the disequilibrium response and climate change vulnerability of the mass balance glaciers in the Alps. Journal of Glaciology. 66 (260), 1034-1050.

Goerlich, F., Bolch, T. and Paul, F. (2020): More dynamic than expected: An updated survey of surging glaciers in the Pamir. Earth Syst. Sci. Data, 12, 3161-3176.

Haga, O., McNabb, R., Nuth, C., Altena, B., Schellenberger, T. and Kääb, A. (2020). From high friction zone to frontal collapse: Dynamics of an ongoing tidewater glacier surge, Negribreen, Svalbard. Journal of Glaciology, 66 (259), 742- 754.

Paul, F. (2020): A 60-year chronology of glacier surges in the central Karakoram from the analysis of satellite image time-series. Geomorphology, 352, 106993.

Paul, F., Rastner, P., Azzoni, R.S., Diolaiuti, G., Fugazza, D., Le Bris, R., Nemec, J., Rabatel, A., Ramusovic, M., Schwaizer, G., and Smiraglia, C. (2020): Glacier shrinkage in the Alps continues unabated as revealed by a new glacier inventory from Sentinel-2. Earth Systems Science Data, 12(3), 1805-1821.

Popp, T., M.I. Hegglin, R. Hollmann, et al. (2020): Consistency of satellite climate data records for Earth system monitoring. Bulletin American Meteorological Society, 101 (11), E1948-E1971.

Werder, M. A., Huss, M., Paul, F., Dehecq, A. and Farinotti, D. (2020): A Bayesian ice thickness estimation model for large-scale applications. Journal of Glaciology, 66 (255), 137-152.

Zemp, M., Huss, M., Eckert, N., Thibert, E., Paul, F., Nussbaumer, S.U. and Gärtner-Roer, I. (2020): Brief communication: Ad hoc estimation of glacier contributions to sea-level rise from latest glaciological observations. The Cryosphere, 14, 1043-1050.

5.1.2. Articles in books

Allison, I., Paul, F., Colgan, W., King, M. (2021): Ice sheets, glaciers and sea level. In: Haeberli, W. and C. Whiteman, eds. Snow and Ice-Related Hazards, Risks, and Disasters, Amsterdam, Netherlands, Elsevier (Hazards and Disasters Series, J. Shroder, Ed. in Chief), pp.707-740.

Truffer M., Kääb A., Harrison W., Osipova G., Nosenko G., Espizua L., Gilbert A., Fischer L., Huggel C., Craw Burns P., Lai A. (2021): Glacier surges. In: Haeberli, W. and C. Whiteman, eds. Snow and Ice-Related Hazards, Risks, and Disasters. Elsevier, Amsterdam, pp. 417-466.

Haeberli, W., Huggel, C., Paul, F. and Zemp, M. (2020): The response of glaciers to climate change: Observations and impacts In: Shroder, J. (Editor in Chief), James, L.A., Harden, C.P., Clague, J.J. (Eds.): Treatise on Geomorphology. Academic Press, San Diego, CA, vol. 13, Geomorphology of Human Disturbances, Climate Change, and Natural Hazards, pp. 152-175.

Paul, F. and Hoelzle, M. (2020): Gletscherbeobachtung und globale Trends. In: Lozán J. L., S.-W. Breckle, H. Graßl, et al. (Hrsg.): Warnsignal Klima: Hochgebirge im Wandel. pp. 115-121 (doi: 10.2312/warnsignal-klima.hochgebirge-im-wandel.17).

Allen, S., Huggel, C. and Paul, F.(2020): Gefahren aus vergletscherten Vulkanen: Das Beispiel Nevado del Ruiz. In: Lozán J. L., S.-W. Breckle, H. Graßl, et al. (Hrsg.): Warnsignal Klima: Hochgebirge im Wandel. pp. 324-329 (doi: 10.2312/warnsignal-klima.hochgebirge-im-wandel.49).

Rott, H. and Paul, F. (2020): Satellite remote sensing of glaciers and ice sheets. In: A. Fowler and F. Ng (Eds.) 'Glaciers and ice sheets in the climate system', A. Fowler and F. Ng (eds.), Glaciers and Ice Sheets in the Climate System, Springer Textbooks in Earth Sciences, Geography and Environment, pp. 327-348.

5.2 Presentations at conferences, meetings and workshops

ESA Living Planet Symposium 2022, Bonn (23.-27.5.22)

L. Gilbert et al.: 'Long-term multi-mission integrated cryosphere surface elevation timeseries – a case study over Svalbard for Glaciers CCI+'

A. Kääb et al.: 'World-wide detection of glacier surge activity using multi-year stacks of Sentinel-1 radar backscatter data'

F. Paul et al.: 'Three different glacier surges at a spot: What satellites observe and what not'.

L. Piermattei et al.: 'Sensor inter-comparison for quantifying surface velocity and elevation change of surging glaciers in the Karakoram'

T. Strozzi et al.: 'Characteristic patterns of glacier surface velocity time series over dynamic instabilities in the Eastern Arctic from satellite observations'
F. Paul et al.: 'Gorner – reflections on glaciers in a changing climate' Agora Climate Day
T. Nagler et al.: 'Advancements in Monitoring of Ice Velocities and Discharge for Polar Ice Sheets and Ice Caps by Sentinel-1'

EGU General Assembly 2022, Vienna (23.-27.5.22)
J. Wuite et al.: 'Monitoring of key climate variables on glaciers and ice sheets using Sentinel-1 SAR'
F. Paul et al.: 'Three different glacier surges at a spot: What satellites observe and what not'
J. Reinthaler, F. Paul: 'On the use of high resolution web map services for mapping Little Ice Age glacier extents'
B. Raup et al. 'More data and increased automation leads to better quality for GLIMS and RGI glacier data sets'
F. Maussion et al.: 'The Randolph Glacier Inventory (RGI) version 7'
M. Zemp et al.: 'Which are the largest glaciers in the world outside the ice sheets?'
I. Gärtner-Roer et al.: 'Maturity of worldwide glacier data sets – history and future ambitions'

Arbeitskreis Hochgebirge, Südostasien Institut, Heidelberg (21.5.22)
F. Paul et al.: 'Three different glacier surges at a spot: What satellites observe and what not'.

Alpine Glaciology Meeting, 24.-25.3. 2021 (Munich)
F. Paul et al.: 'Three different glacier surges at a spot: What satellites observe and what not'.
J. Reinthaler, F. Paul: 'On the use of high resolution web map services for mapping Little Ice Age glacier extents' Alpine Glaciology Meeting, Munich, 24./25.3.2022.

IGS Nordic Branch Meeting, Oslo (6.11.2021)
D. Treichler et al.: 'Observing small surging glaciers from space',

ESA Polar Science Cluster Meeting (17.9.21), online
F. Paul et al.: 'Alpine Glaciers'

High Summit COP26 in Minoprio (24.9.21)
F. Paul: 'Rapid glacier decline and the challenges for updating glacier inventories',

European Geosciences Union General Assembly vEGU2021, 25.-26.3. 2021 (online)
F. Paul, P. Rastner, F. Goerlich: A new glacier inventory for Svalbard from Sentinel-2 and Landsat 8 for improved calculation of climate change impacts (vPICO presenation)

Alpine Glaciology Meeting, 25.-26.3. 2021 (online)
F. Paul: Convener for the session 'Glaciers in High Asia'

European Polar Science Week, 26.-30.10. 2020 (online)
Maussion, F. and the IACS Working Group on the RGI: 'Towards a multi-temporal global glacier inventory: challenges and applications'
Paul, F. and the Glaciers_cci team: 'Global monitoring of glacier distribution and changes: Where we are and where we (would like to) go'
Paul, F., Y. Schaub, P. Rastner: 'Strongly increased glacier retreat in Franz-Josef-Land: A shape of things to come?'

Swiss Geoscience Meeting 2020, Zurich, 17. Nov. 2020 (online)
Bannwart, J., Zemp, M., Rastner ,P., Paul, F., McNabb, R.: 'Towards a global assessment of glacier change – A focus on satellite based geodetic mass changes in polar regions'

EGU GA, 4.-8.5. 2020 (virtual online chat)
F. Paul: Convener Session CR2.7 'Glacier monitoring from in-situ and remotely sensed observations'. The session attracted more than 260 participants.

AGU Fall Meeting (IMC) 2019, 9.-13.12.2019, San Francisco, USA
R.W. McNabb, C. Nuth et al.: 'A multi-decadal time series of Arctic glacier elevations from automated DEM processing'

Internal CCI Meetings
CCI Co-location Meeting (online), 4.-8.10.2021.
F. Paul et al.: 'Scientific highlights of the Glaciers_cci project: Year 2'

CMUG Integration Meeting, 5.-7.11.2019, Barcelona, Spain
F. Paul et al.: Glaciers_cci+: Investigating new algorithms to reveal the dynamics of instable glaciers in the Arctic and HMA

5.3 Further outreach activities and services

5.3.1. Outreach

Climate week, elementary school in Oslo (three classes)
- A. Kääb: "The Ocean and Cryosphere in a Changing Climate", teaching and experiments.
- P. Rastner: "Glacier_cci remote sensing schoolab" (Technische Fachhochschule Bruneck, Italy)

5.3.2. ESA Webstories and news items

ESA video about melting glaciers for COP26 (4.11.21) and LPS (2022):
https://www.esa.int/ESA_Multimedia/Videos/2021/11/Melt#
ESA interviews at Gorner Glacier (Switzerland) with F. Paul for COP26 (17.8.21)

ESA web-stories related to Glaciers_cci publications
https://climate.esa.int/en/news-events/low-angle-mountain-glacier-detachments-more-frequent-than-thought
https://www.esa.int/Applications/Observing_the_Earth/Glacier_avalanches_more_common_than_thought
https://climate.esa.int/en/news-events/recent-acceleration-in-global-glacier-melt-study-warns
https://www.esa.int/Applications/Observing_the_Earth/Satellites_reveal_cause_of_Chamoli_disaster

Newspaper article about the rapidly shrinking glaciers in the world
https://www.theguardian.com/environment/ng-interactive/2021/apr/29/visualised-glaciers-now-and-then

Süddeutsche Zeitung, 17.2.2021
F. Paul cited in article 'Ein Berg stürzt ab' which presents a first analysis of the rock-ice avalanche disaster in India.

RTL Nieuws, 4.7.2022
J. Wuite in Dutch News on Marmolada Glacier (Italy) collapse

CBC, 07.07.2022
P. Rastner cited in article 'As Europe experiences extreme heat and drought, EU votes for power plan critics call 'greenwashing''.

5.3.3. Services

Review of the GCOS Implementation Plan 2022
IPCC Report, WGI, Second Order Draft:
F. Paul, J. Wuite: Expert review; A. Kääb: Contributing author