

Svalbard Integrated Arctic Earth Observing System

– the current state

16 May 2023

The vision of SIOS

We will be the leading long-term observing system in the Arctic to serve Earth system science and society

The mission of SIOS

SIOS – an international partnership of research institutions studying the environment and climate in and around Svalbard to

- *Develop an efficient observing system*
- *Share technology, experience and data*
- *Close knowledge gaps*
- *Decrease the environmental footprint of science*

The Svalbard Integrated Arctic Earth Observing System (SIOS) is a collaborative effort to develop and maintain a regional observational system for long-term measurements in and around Svalbard, addressing Earth System Science (ESS) questions related to Global Change. The observing system and research facilities offered by SIOS build on the extensive observation capacity and diverse world-class research infrastructure provided by many institutions already established in Svalbard. This includes a substantial capability for utilising remote sensing resources to complement ground-based observations. From this solid foundation, SIOS envisions a significant contribution to the systematic development of new methods and observational design in Svalbard. This knowledge can advance other observational networks in the Arctic and elsewhere.

SIOS is aiming at more efficient use and better integration of the observing system based on a distributed data management system, an open access programme, as well as training and education activities. Working groups, task forces and other SIOS components pursue these

aims in direct and structured dialogue with scientists, user groups, policy-makers and other indicators of societal and scientific needs.

SIOS brings observations together into a sustained, coherent and integrated observational programme. Thus, SIOS offers unique opportunities for research and the acquisition of fundamental knowledge about global environmental change.

SIOS focuses on processes and their interactions between the different spheres, i.e., biosphere, geosphere, atmosphere, cryosphere, and hydrosphere. The core observational programme of SIOS provides the research community with systematic observations that are sustained over time, yet dynamic enough to be adapted as new methods appear or society poses new questions.

SIOS entered the operational phase in January 2018, after a three-year long interim phase (November 2014 – January 2018) and a four year long preparatory phase (October 2010 – November 2014). Currently, the consortium consists of 29 institutions from 10 countries (Appendix 1). The goals, benefits, and duties of SIOS are summarised in appendix 2 and the main achievements to date are compiled in appendix 3. The following text gives a detailed description of the elements within SIOS.

Development and integration of the observation system

SIOS aims to set an example for how to systematically construct observational networks in the Arctic and how joint efforts provide added value to the user community. SIOS uses several means to achieve this goal. The working groups secure user commitment and impact on the process of improving the existing observing system; the data portal, with its access to standardised data, facilitates the integration between different research fields and nations; and the State of Environmental Science in Svalbard (SESS) report is an efficient tool for research-based guidance towards optimisation of the Svalbard Observing System for Earth System Science. Strategic decisions are made by the General Assembly, after recommendations from the Board of Directors, who in turn are guided by the Science Optimisation Advisory Group and other working groups.

State of Environmental Science in Svalbard (SESS) report

The main tangible product of SIOS is the annual State of Environmental Science in Svalbard (SESS) report.

The SESS report:

- is established as an authoritative source of information about the state of the environment in and around Svalbard;
- is an important tool to convey knowledge to stakeholders and the public;
- addresses the scientific community, as well as stakeholders and the public. This format ensures that there is synergy between the scientific investigations and the knowledge needed by society to sustainably develop and safeguard the Arctic environment;
- is the main driving force for the science-based development of the observing system and represents an opportunity for research groups to actively influence the prioritisation within SIOS (Figure 1).

The report summarises the state of current knowledge of key Earth System Science parameters and analyses how these parameters influence one another. It combines the long-term monitoring data that form the core of the observing system with innovative monitoring and research. In addition to evaluating the state of current knowledge, the SESS report highlights questions that remain unanswered and recommends solutions in terms of research infrastructure improvements and research priorities.

The report is an arena for open sharing of ideas and discussions on measures that should be taken to enable scientists to provide observations needed to gain a holistic view of the Earth System of Svalbard and the Arctic in general.

Contributions to the SESS report are written by international and, preferably, multidisciplinary teams under the lead of researchers from SIOS member institutions. All chapters are peer-reviewed and subject to final approval by an editorial board. The editorial board consists of two senior researchers, one early career researcher and two representatives of the SIOS Knowledge Centre.

The fifth SESS report was published 23 January 2023.

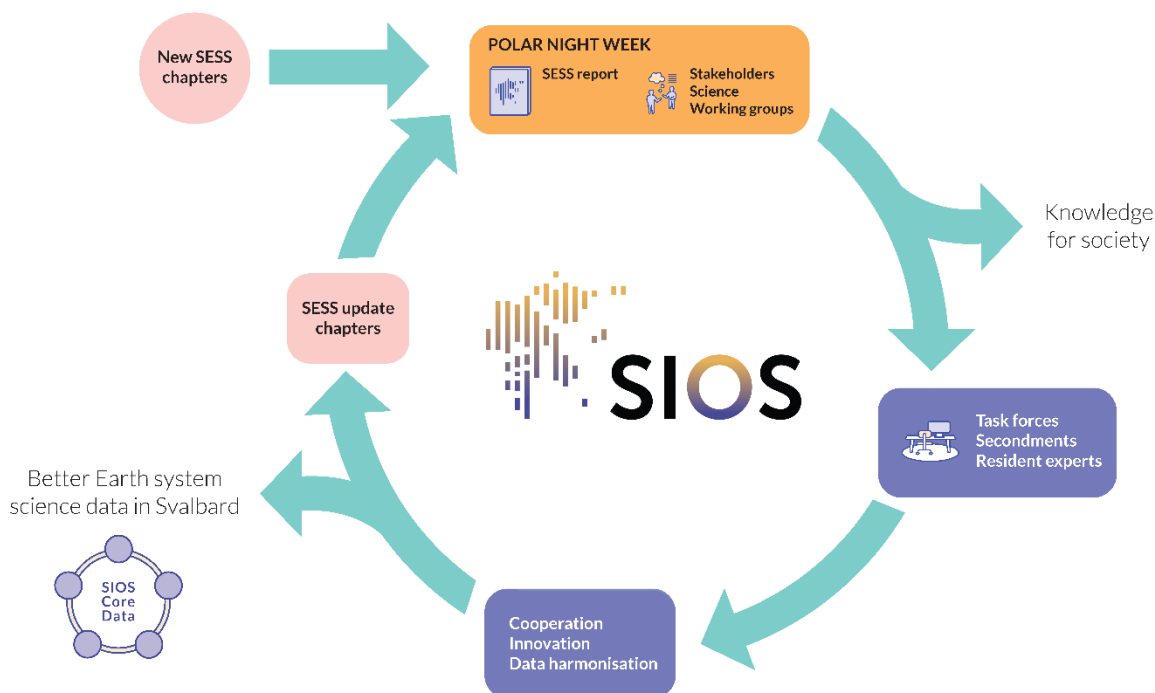


Figure 1: Concept of the SIOS science wheel to develop an observing system for many. SIOS, i.e. the SIOS member institutions, the working groups, and the SIOS Knowledge Centre are the internal drivers that move the SIOS wheel forward with the aim to provide better Earth system science data in Svalbard and thus, serve the societal needs caused by climate change, pollution and diversity loss. The different aspects of the Earth System and the means to improve the observing system are subject of many work units, incl. task forces, secondments, and expert residents. With the principles of cooperation, innovation and data harmonisation this work ensures that the SIOS community produces relevant long-term data series, the SIOS core data, and improved research infrastructure as basis for new research projects and capacity building. The State of Environmental Science in Svalbard (SESS) report allows international research groups to identify observational gaps and provide recommendations on how to close those (bottom-up process). The SIOS collaboration culminates in annual gatherings, the Polar Night Weeks. There, the SESS report is released and stakeholders, researchers, and SIOS working groups meet to discuss and plan next years' activities. The plans are aligned with strategical aspects by the General Assembly (top-down process), before the wheel starts its next round.

The SIOS Knowledge Centre

The SIOS Knowledge Centre (SIOS-KC) is the central hub of SIOS. It is located in the Svalbard Science Centre in Longyearbyen and coordinates the services provided by the SIOS consortium for the international research community. The SIOS-KC is presently mainly funded by the Research Council of Norway. It has a staff of six, one associated staff from the Meteorological Institute of Norway (data manager) and is occasionally complemented by additional personnel (e.g., secondments and interns).

SIOS-KC established five working groups and committees to support the services offered to the SIOS community: The Science Optimisation Advisory Group (SOAG), the SIOS Data Management System Working group (SDMS WG), the Remote Sensing Working group (RSWG), the Research Infrastructure Coordination Committee (RICC), and the Information Advisory Group (IAG). These working groups and committees consist of representatives of the member institutions and carry out tasks given by the General Assembly or the Board of Directors. They also suggest the work programme for the different services. In addition to the working groups, ad-hoc task forces are formed for shorter periods to tackle specific tasks delegated from the working groups and the Board of Directors.

SIOS Science Optimisation Service

The science optimisation activities are central to SIOS. They develop the science case for SIOS and strive to advance the SIOS research infrastructure towards a solid base for comprehensive knowledge of the Earth System in Svalbard.

Key research questions are formulated by the working groups, considering feedback from users and stakeholders, and the recommendations from the SESS report (Figure 1). This broad basis ensures relevance for modelling, remote sensing calibration and validation, and ultimately society.

A common resource to answer these research questions are the SIOS core data. The SIOS core data are based on the Essential Climate Variables¹ relevant to the Arctic and follow the criteria of scientific relevance, data availability and collecting commitment in the SIOS community.

Based on these core data, recommendations from the SESS report, and input from the SIOS community as well as other stakeholders, workshops and training courses are developed to further scientific collaboration and competence in ESS related issues.

In addition, in 2022 an optimisation call has given opportunities to develop the observing system through e.g., campaigns, workshops, and access. The SIOS call programmes are currently under development to better coordinate the calls and support the SIOS mission more efficiently.

¹ <https://gcos.wmo.int/en/essential-climate-variables>

The annual meeting, SIOS Polar Night Week, brings the SIOS community together for science seminars, meetings and the SESS report release. Monthly webinars, including panel discussions, on specific themes related to SIOS and ESS keep the community informed and offer a platform for interdisciplinary discussions.

A task force organised by SOAG is currently developing a strategy for optimisation of SIOS that is expected to be published in summer 2023. This document proposes SIOS owners a process that can lead to fulfilment of the joint vision of optimised SIOS infrastructure based on the “one system – many users & uses” -principle.

The joint prioritisations of the consortium enhance the ability to compete for external funding. Successful examples of externally funded projects are:

- ‘SIOS – Infrastructure development of the Norwegian node (SIOS InfraNor)’ - funded through the National Financing Initiative for Research Infrastructure by the Norwegian Research Council of Norway (owned by SIOS)
- ‘ENVironmental Research Infrastructures building Fair services Accessible for society, Innovation and Research (ENVRI-FAIR)’ and ‘Pan-Arctic observing System of Systems: Implementing Observations for societal Needs (Arctic PASSION)’ - funded by European Union’s Horizon 2020 (both: SIOS participation)
- ‘A federated European FAIR and Open Research Ecosystem for oceans, seas, coastal and inland waters (Blue-Cloud 2026)’ - funded by European Union’s Horizon Europe (SIOS participation).

Although SIOS focuses on the Svalbard region, it works on the integration with other regional, pan-Arctic and European initiatives. SIOS plays an active role in several international networks and projects (e.g., SAON/IASC, EU Polar Cluster, Arctic PASSION, CRIOS, ENRIITC, AASCO, ENVRI community, WMO/WIGOS) and has recently established cooperation with the Greenland Integrated Observing System (GIOS).

SIOS Data Management Service

The SIOS Data Management Service integrates information from SIOS partner data repositories into a unified virtual data centre, the SIOS Data Access Portal, allowing users to search for and access data regardless of where these data are archived. Providers and users must commit to the SIOS data policy. The current focus is on discovery through standardised metadata, and retrieval, as well as visualisation and transformation of data.

Ultimately, the Data Management Service works towards integration of datasets which requires a high level of interoperability at the data level.

The SIOS Data Management System is also used by other initiatives, like the Norwegian project Nansen Legacy² and the international GCI-Cusp initiative³.

SIOS Remote Sensing Service

The SIOS Remote Sensing Service is designed to offer researchers a single point of contact for satellite information for Svalbard while drawing on the combined knowledge of the network of SIOS partner institutions. The Remote Sensing Service coordinates commissioned data processing, communicates with space agencies for promoting Svalbard as a potential cal/val site, advises researchers on their respective satellite needs, and provides tailored training on remote sensing. It facilitates and promotes the use of remote sensing products in the diverse SIOS science community, and organises annual online conferences on remote sensing and Earth observation, as well as the webinar series 'An anchor point to a drifting world'.

SIOS contributes to the EU Copernicus programme by acting as the northernmost Copernicus Relay of the planet.

SIOS Research Infrastructure Access and Logistics Service

SIOS runs an Access Programme that aims to facilitate access to the distributed research infrastructure owned and operated by SIOS members and made available to SIOS. The SIOS Research Infrastructure Access and Logistics service provides support to the Access Programme, as well as the Optimisation Call by reviewing proposals for feasibility and helping owners of successful projects coordinate their access to field facilities. The services are coordinated by SIOS-KC in collaboration with the working groups RICC and SOAG.

The logistics component facilitates the access to logistical services and supports the work for more standardised solutions. SIOS hosts a platform for offers and requests related to field work and associated logistics, the Logistics Sharing Notice Board, and actively works on

² <https://arvenetternansen.com>

³ <https://www.grandchallenge.no>

finding solutions for requests filed at the board. Other services currently offered include storage, transport, guest office and links with commercial service providers.

SIOS Training Service

The SIOS Training Service aims to provide researchers with necessary skills to make the best use of the SIOS research infrastructure and observing system. Based on requests by the SIOS community and training needs identified by the working groups, SIOS currently offers two types of training courses:

- Training courses in data management to encourage and facilitate good data management right from the planning of a project. These courses are either held as webinars, separate courses for targeted audiences, or can be applied for through an add-on module in the frame of the Svalbard Strategic Grant by Svalbard Science Forum.
- Training courses in remote sensing tailored towards specific fields. Previous courses focussed on cryosphere, marine, and terrestrial remote sensing, airborne hyperspectral remote sensing sensors, and artificial intelligence. The 2023 course will encompass the effective use of unmanned aerial vehicles in Svalbard research.

SIOS Communication Service

The Communication Service is closely interconnected with the other SIOS services to promote their activities. It provides information about SIOS-KC activities, the Observing System developments, and SIOS-related activities within the member institutions. It maintains the SIOS web portal www.sios-svalbard.org, communication on social media (Twitter, Instagram, Facebook, LinkedIn), and through newsletters. It supports scientific presentations by the SIOS-KC staff and produces information and outreach material for conferences, networking and other opportunities. In addition, the Communication Service engages with the general public through local public events as well as presenting ESS in a popular way through social media.

Governance and organisational structure

SIOS is a distributed research infrastructure organised as a consortium. The cooperation within the consortium is based upon non-legally binding statutes and an MoU. Institutions that own or operate research facilities in the Svalbard region or who provide research data

relevant for the consortium may become members. The SIOS Knowledge Centre, the central hub of SIOS, facilitates the coordination, development and optimisation of research infrastructure owned by the member institutions.

The General Assembly is the ultimate authority of SIOS and consists of representatives of the consortium members. It is responsible for the overall direction and supervision of SIOS. The General Assembly appoints the Board of Directors and may establish advisory boards and committees.

The Chair of the Board of Directors is, by statute, an employee of a Norwegian member institution. The Board of Directors is responsible for the operation of SIOS in accordance with the directions and decisions given by the General Assembly.

The SIOS Director is appointed by the General Assembly on the proposal from the Board of Directors and carries out the day-to-day management of SIOS. The SIOS director is head of the SIOS Knowledge Centre and the SIOS administration. The SIOS director is also the director of the public limited company 'SIOS Svalbard AS', which was established 20 December 2016 to serve as the legal body of SIOS in its operational phase. The company is owned by the University Centre in Svalbard and is the vehicle for SIOS to enter contracts necessary for running the consortium, e.g., employing staff for the Knowledge Centre.

On 26 January 2018, the start of the operational phase of SIOS was marked by 10 members of the interim phase signing the MoU accepting the SIOS statutes. These are the founding members. At the same time the General Assembly also accepted 13 new members. In addition, two institutions became observers. The consortium has been growing ever since. The budget is based on contributions from the Norwegian host and the consortium members as well as external projects. The member contribution consists of two parts; an obligatory annual indexed in-cash contribution of currently €10 000, and a contribution that may consist of in-kind or in-cash. The host contribution is dedicated to the SIOS Knowledge Centre and is guaranteed until the end of 2026. The member contributions go in full towards activities decided by the General Assembly.

Further information

Consortium - <https://sios-svalbard.org/Consortium>

Management - <https://sios-svalbard.org/Management>

Observing System - <https://sios-svalbard.org/ObservingSystem>

Knowledge Centre - <https://sios-svalbard.org/KnowledgeCentre>

Working Groups - <https://sios-svalbard.org/WorkingGroups>

SESS report - <https://sios-svalbard.org/SESSreport>

Optimisation call programme - <https://sios-svalbard.org/OptimisationCall>

RI Access Programme - <https://sios-svalbard.org/RIAccess>

Logistics Sharing Notice Board - <https://sios-svalbard.org/logistic-notice-board>

SIOS data access portal - https://sios-svalbard.org/metadata_search

Core data - <https://sios-svalbard.org/CoreData>

Polar Night Week - <https://www.sios-svalbard.org/PolarNightWeek>

Documents (e.g., statutes, data policy and access policy) - <https://sios-svalbard.org/Documents>

APPENDIX 1

Current SIOS member institutions

1. Akvaplan-NIVA, Norway
2. Alfred Wegener Institute, Germany, Founding Member
3. Andøya Space Center, Norway
4. Geological Survey of Norway, Norway
5. Institute for Atmospheric and Earth System Research of the University of Helsinki, Finland, Founding Member
6. Institute of Geophysics, Polish Academy of Sciences, Poland, Founding Member
7. Institute of Marine Research, Norway
8. Korea Polar Research Institute, Korea
9. Nansen Environmental and Remote Sensing Center, Norway, Founding Member
10. National Centre for Polar and Ocean Research, India
11. National Institute for Polar Research, Japan, Founding Member
12. National Research Council of Italy, Italy, Founding Member
13. NORCE - The Norwegian Research Centre, Norway
14. NORSAR, Norway
15. NILU - Norwegian Institute for Air Research, Norway
16. Norwegian Institute for Nature Research, Norway
17. Norwegian Institute for Water Research, Norway
18. Norwegian Meteorological Institute, Norway, Founding Member
19. Norwegian Polar Institute, Norway, Founding Member
20. Norwegian Water Resources and Energy Directorate, Norway
21. NTNU – Norwegian University of Science and Technology
22. Swedish Polar Research Secretariat, Sweden, Founding Member
23. The Norwegian Geotechnical Institute, Norway
24. The University Centre in Svalbard, Norway, Founding Member
25. UiT The Arctic University of Norway, Norway
26. University of Bergen, Norway
27. University of Groningen, The Netherlands
28. University of Oslo, Norway
29. University of Silesia in Katowice, Poland

APPENDIX 2

Goals of SIOS

- Enhance Svalbard as an Earth system science research platform
- Coordinate long-term monitoring
 - To enhance data availability
 - To increase the impact of the Svalbard monitoring in international processes
 - To enhance stakeholder influence on monitoring
 - To address grand challenges of Arctic environmental research
- Stimulate new research endeavours in Svalbard by providing a “core data” and infrastructure backdrop that is unprecedented in polar regions.
- Stimulate innovation in instruments, methods and measurement strategies to enhance monitoring in the Arctic (and as a spin-off probably elsewhere too).
- Work towards creating an environment where interactive experiment adjustment in the field will be made possible through real-time data services.
- Efficient use of infrastructure
- Stimulate inter-station cooperation and exchange in Svalbard
- Ensure transparency of research activities at all stations
- Enable an open access data policy in Svalbard with a database system

Benefits for SIOS members

- Prioritised access to SIOS infrastructure
- Prioritised services from SIOS
- Improved data visibility through data management support and training
- Increased cost efficiency and quality for monitoring and science
- Better overall usage of own research infrastructure
- Influence on the long-term development of monitoring and research infrastructure in Svalbard
- Influence what constitutes core data
- Influence the development of SIOS services
- Better coordination of funding applications improving chances of success
- Promotion of own institution and data through SESS report and SIOS outreach activities
- Logistics optimisation support through use of Logistics Sharing Notice Board

- Right to use SIOS brand

Duties of members

- Commit to long-term monitoring efforts
- Participate in working groups, task forces, and SIOS governing bodies
- Support SIOS with cash and in-kind contributions as decided by the General Assembly
- Adhere to SIOS data and access policies
- Compulsory reporting to RiS⁴

Duties, rights, and opportunities for non-members

- Adhere to Svalbard research data policies
- Compulsory reporting to RiS
- Open access to data
- SIOS services are offered when there is available capacity at full cost recovery
- Access to infrastructure is open but at owners' discretion and at full cost recovery
- Provide input to SESS reports to empower own future membership/participation

⁴ Research in Svalbard (RiS) database (<https://www.researchinsvalbard.no>) containing information about research and monitoring projects in Svalbard and surrounding waters.

APPENDIX 3

Main achievements during the operational phase

- Five issues of the [State of Environmental Science in Svalbard \(SESS\) report](#) have been published since 2018 resulting in 36 new chapters and 9 updates with contributions from 18 nations covering a wide range of Earth system science topics.
- The [SESS recommendation synthesis report](#) is the result of a series of workshops, in which the 169 recommendations presented in the first 4 SESS reports were condensed into sets of disciplinary recommendations. These allowed for identifying foci for future developments of the SESS as well as major cross-cutting interdisciplinary steps forward for SIOS.
- In October 2022, the first call of the [optimisation call programme](#) was published.
- A first set of core data has been identified. It is based on the [Essential Climate Variables](#) relevant to the Arctic and contains currently almost 60 parameters.
- The [Research Infrastructure Access Programme](#) was established in 2018 and 29 projects have been successfully completed since then. In 2023, SIOS will support nine projects.
- The [Observation Facility Catalogue](#) provides an overview of facilities collecting SIOS data and the [Logistics Sharing Notice Board](#) enables SIOS members to cooperate and share field logistics.
- [Logistical services](#) offered to the SIOS community include services from SIOS-KC, member institutions and commercial providers.
- An [E-learning platform](#) has been established to provide an overview of the key information necessary for those intending to visit Svalbard for research purposes.
- The research infrastructure investment project "SIOS – Infrastructure development of the Norwegian node ([SIOS-InfraNor](#))" funded by the Research Council of Norway (94.27 million NOK) and the Norwegian Space Agency (13 million NOK) started in 2018 and includes 41 items ranging from new instruments to remote sensing products.
- SIOS is a partner in three EU funded projects: 'ENVironmental Research Infrastructures building Fair services Accessible for society, Innovation and Research ([ENVRI-FAIR](#))', 'Pan-Arctic observing System of Systems: Implementing Observations for societal Needs ([Arctic PASSION](#))', and 'A federated European FAIR

and Open Research Ecosystem for oceans, seas, coastal and inland waters (Blue-Cloud 2026)’.

- SIOS is partner in the EEA funded project “Cryosphere Integrated Observatory Network on Svalbard ([CRIOS](#))”.
- SIOS contributes to and collaborates with several networks and initiatives, e.g., SAON/IASC, EU Polar Cluster, ENRIITC, AASCO, ENVRI community, WMO/WIGOS.
- Five [SIOS Polar Night Weeks](#), the annual meeting of the SIOS community, have been held with between 70 and 100 participants every year.
- SIOS engages with the local community to public outreach events, e.g. talks during the popular Svalbard Seminar in Longyearbyen, and ‘[expert nights](#)’ in a local pub.
- A [marine infrastructure network](#) was established in 2020 to discuss science, harmonise data, optimise research infrastructure and share logistics related to marine biology and oceanography – as a response to recommendations from the SESS report. Its third workshop will take place in October 2023.
- SIOS is a full member of [Svalbard Science Forum](#) and an observer in the [Ny-Ålesund Science Managers Committee](#).
- SIOS actively mentors early career researchers (ECR) to promote SIOS activities in the younger generation. For each issue of the SESS report, SIOS has engaged an ECR in the editorial board. Since 2020, an ECR observer member has been recruited annually into RSWG. In 2023, this offer was extended to IAG for the first time.
- A multidisciplinary [workshop on snow research](#) was held online in February 2021 with more than 100 participants. The aim was to draft an [agenda paper for snow research in Svalbard](#), initiate discussions on snow technology between researchers and SMEs, and explore the potential of community-based snow observations in Svalbard. The final agenda paper is currently under revision for publication in the scientific journal Polar Research.
- SIOS hosted the [special issue](#) “Earth Observation (EO), Remote Sensing (RS), and Geoinformation (GI) Applications in Svalbard” in the Remote Sensing (MDPI) journal, resulting in [18 publications](#).
- A [perspective paper](#) on the impacts of travel restrictions during the pandemic and SIOS’s operational activities to respond to these was published in February 2021 in the peer-reviewed international MDPI Remote Sensing journal. The paper was written by 32 authors from 18 SIOS member institutions across 6 countries.

- SIOS-KC and RSWG launched the [SIOS webinar series 'An anchor point to a drifting world'](#) in March 2020 as response to cancelled field campaigns and conferences due to the COVID-19 pandemic. In 2020, a total of 16 talks and 3 panel discussions were conducted during 4 webinars which were attended by around 200 international participants. Due to its success, the series has continued since then with 4-5 webinars each year.
- Since 2020, SIOS-KC in cooperation with RSWG has organised an [online conference](#) on Earth Observation (EO), Remote Sensing (RS), and Geoinformation (GI) applications in Svalbard. Between 200 - 370 participants registered to the conferences attending up to 50 talks by presenters from more than 25 institutions from more than 10 countries each year.
- The service '[patch up your field data with remote sensing observations](#)' was launched in March 2020 to fill gaps in field data occurred due to cancelled fieldwork. Up to now, 5 requests were received.
- Annual training courses on remote sensing applications (e.g., cryosphere, marine, terrestrial, hyperspectral images, AI and machine learning) have been conducted since 2018. Training courses and webinars on data management are offered for different knowledge levels.
- Two calls for project proposals for acquiring aerial imagery and hyperspectral data using SIOS airborne remote sensing platforms resulted in 25 h of flight time for 10 scientific research projects in 2020, and 13 projects with 23 flying hours using the Dornier aircraft and UAVs in 2021.
- In November 2021, SIOS granted an [innovation award](#) to promote innovative technologies or methods in support of Earth system science in the Svalbard region. Results were presented during Polar Night Week 2023. The innovation award 2023 will be announced during the Svalbard Science Conference in autumn 2023.
- The [SIOS Data Access Portal](#) provides access to a large collection of Svalbard Earth System Science data sets. The data management service is continuously adding new datasets from the SIOS partner data depositories. The portal is currently being integrated as service provider to the [European Open Science Cloud marketplace](#).