SESS REPORT 2021
SUMMARY FOR STAKEHOLDERS

The State of Environmental Science in Svalbard – an annual report

SIOS
SVALBARD INTEGRATED ARCTIC EARTH OBSERVING SYSTEM

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in Svalbard – an annual report

Josefine Feldner, Christiane Hübner,
Heikki Lihavainen, Roland Neuber,
Agata Zaborska (Editors)

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The State of Environmental Science in Svalbard
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Foreword

Another year under the shadow of the COVID-19 pandemic has passed. With vaccinations, the world started to open up. Scientific field work was possible to some extent, and it was a pleasure to meet scientists visiting the SIOS office again. We have learned to use virtual tools but also miss meeting people in real life. The Arctic Circle Assembly and the Svalbard Science Conference were the first events I attended in person after the start of the pandemic. Indeed, meeting people face-to-face is an all-embracing experience all in all and virtual tools cannot fully replace it. Even as I write this, restrictions are being reintroduced due to increasing numbers of COVID-19 cases. It is not over yet, but we are also learning a new way of life.

The first funding phase of the host contribution from Norway to support SIOS Knowledge Centre ended last year and new funding has been secured until the end of 2026. I would like to acknowledge the Research Council of Norway for their continuous support for our endeavour. The renewed funding is also a sign that we as a SIOS community have succeeded and are seen as an important actor, not only in Svalbard, but also in the Pan-Arctic and in the landscape of European Environmental Research Infrastructures. Nevertheless, there is still lot to accomplish and for the new funding period we have also renewed the strategy of SIOS.

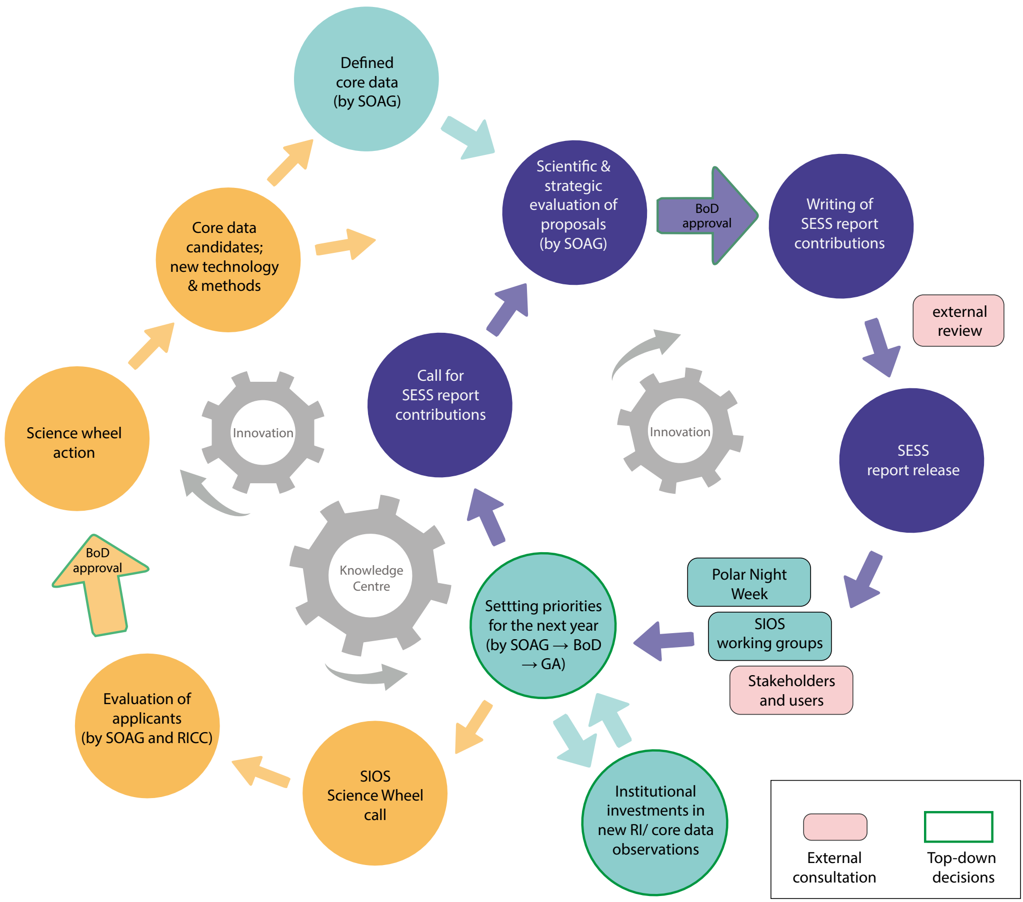
One of the key strategic objectives is the construction of a roadmap for optimisation of the observing system. The roadmap is built on the renewal of the research infrastructure optimisation report, the SIOS core data process and a synthesis of the recommendations provided by the SESS reports. The SESS report thus plays an important role in the development of the observing system. The SIOS science wheel is a concept showing the development of the SESS report and the associated call for activities. The teeth of the cogwheels that drive SIOS forwards are the working groups and task forces deployed by the governing bodies of SIOS. The science wheel is driven mainly through bottom-up processes such as the SESS report, but is regularly aligned through top-down decisions.

After three published SESS reports containing a total of 147 recommendations for developing the observing system, we felt a need to shift gears in the SIOS science wheel to better synchronise the machinery's cogwheels. Slowing down the SIOS science wheel means that new SESS report chapters are accepted only every other year while update chapters are accepted every year. This issue will be the first containing solely update chapters. The strengthened focus on updating previous chapters will help fine-tune the existing parts of the machinery with new insights and updated recommendations. Thus the science wheel can advance SIOS, guided by the roadmap and fuelled by new concrete recommendations, and we can adapt our work by adding new horizons as the need arises.

My sincere thanks go to Agata Zaborska, Josefine Feldner and Roland Neuber for their engagement as the editorial board. I would also like to acknowledge the person who keeps the SESS threads together, our information officer Christiane Hübner; her task is hard but at the same time delicate. I thank the anonymous reviewers for their efforts. I am grateful to the rest of the SIOS-KC crew for their energy and for being an endless source of fresh ideas. And, of course, thanks to the authors of the SESS report 2021.

Longyearbyen, December 2021

Heikki Lihavainen
Director, SIOS



The SIOS science wheel

The SIOS science wheel concept to optimise the observing system, showing the development of the State of Environmental Science in Svalbard report (blue) and the SIOS science wheel call (yellow). Other elements within SIOS that influence the processes are shown in turquoise. SESS = State of Environmental Science in Svalbard report; GA = General Assembly; BoD = Board of Directors; SOAG = Science Optimisation Advisory Group; RICC = Research Infrastructure Coordination Committee; RI = Research Infrastructure.

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Executive Summary

Josefine Feldner[1], Christiane Hübner[2], Heikki Lihavainen[2], Roland Neuber[3], Agata Zaborska[4]

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The State of Environmental Science in Svalbard (SESS) report 2021 together with its predecessors contributes to the documentation of the state of the Arctic environment in and around Svalbard, and highlights research conducted within the Svalbard Integrated Arctic Earth Observing System (SIOS). Climate change is a global problem, but many of its impacts are being felt most strongly in the Arctic. Given its remote but accessible location, Svalbard constitutes an ideal place to study the Arctic environment in general, including, more specifically, the causes and consequences of climate change.

The Arctic Climate Change Update (2021)[1] emphasised the severity of global climate change for ecosystems across the Arctic. They are undergoing radical changes regarding their structure and functioning, affecting flora, fauna and livelihoods of Arctic communities. Oceanic ecosystems and food webs are directly and indirectly altered by the warming and freshening of the Arctic Ocean. A prolonged open water period and the expansion of open water areas caused by declining sea ice affect under-ice productivity and diversity. These changes have cascading effects through ecosystems and impact the distribution, abundance and seasonality of a variety of marine species.

Svalbard is located at one of the key oceanic gateways to the Arctic. This land–ice–ocean transition zone is a system particularly vulnerable to environmental changes. Svalbard's environment is influenced by maritime processes; thus extensive observation of the ocean system is nowadays necessary. The chapter on the iMOP project reports seawater temperature and salinity variability over the last decades and indicates changes of Svalbard fjord seawater properties. The chapter highlights the role of a collaborative and supportive network of observatory operators and encourages joint planning and maintenance of future marine observatories.

Arctic vegetation plays a key role in land–atmosphere interactions. Alterations can lead to ecosystem–climate feedbacks and exacerbate climate change. Extreme precipitation events are already becoming more frequent. Together with an increasing rain-to-snow ratio they impact the structure and functioning of terrestrial ecosystems.

Dynamics in Arctic tundra ecosystems are expected to undergo fundamental changes with increasing temperatures as predicted by climate models. To detect, document, understand and predict those changes, COAT Svalbard provides a long-term and real-time operational observation system through ecosystem-based terrestrial monitoring. The observation system consists of six modules comprising food web pathways as well as one climate-monitoring module and focuses on two contrasting regions in Svalbard to allow for intercomparison. To date, the project has done an initial assessment of tundra ecosystems in Norway and will now begin with the long-term ecosystem-based monitoring.

1 AMAP, 2021. Arctic Climate Change Update 2021: Key Trends and Impacts. Summary for Policymakers. Arctic Monitoring and Assessment Programme (AMAP), Tromsø, Norway. 16 pp

For remote regions such as the Svalbard archipelago, terrestrial photography is a crucial addition to satellite imagery, because land-based cameras offer high temporal resolution and insensitivity towards varying weather conditions. PASSES provides an overview of cameras operating in Svalbard managed by research institutions and private companies. The survey revealed difficulties and knowledge gaps preventing the full potential of the terrestrial photography network in Svalbard from being used. Therefore, PASSES recommends the creation of a Svalbard camera system network.

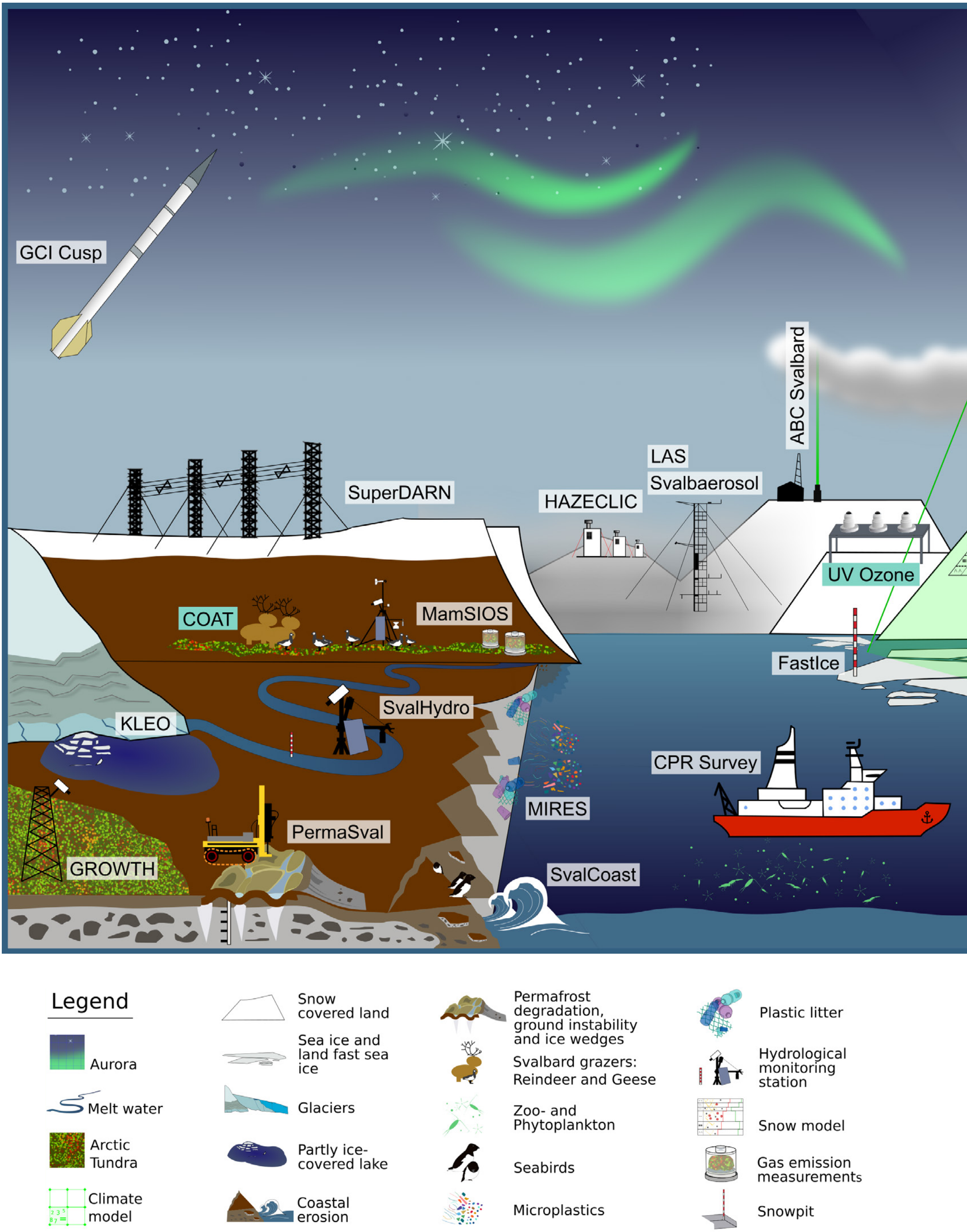
The effects of climate change contributed to a specific anomaly of the springtime Arctic atmosphere, namely a pronounced depletion of stratospheric ozone during March and April 2020, which can be called an Arctic ozone hole. In Svalbard, the amount of ozone loss was recorded by ground-based dedicated spectroscopic instruments measuring the total ozone column as well as the UV irradiance (EXAODEP-2020, an update of UV Ozone). The latter is important for effects on the biota. Corresponding erythemal daily doses for spring 2020 show a doubling compared to previous years with less or no ozone depletion. While the correspondence between ozone loss and increase in UV doses follows a well-known relationship, the possible later consequences of the observed springtime increase of UV doses on Svalbard's environment need to be further studied.

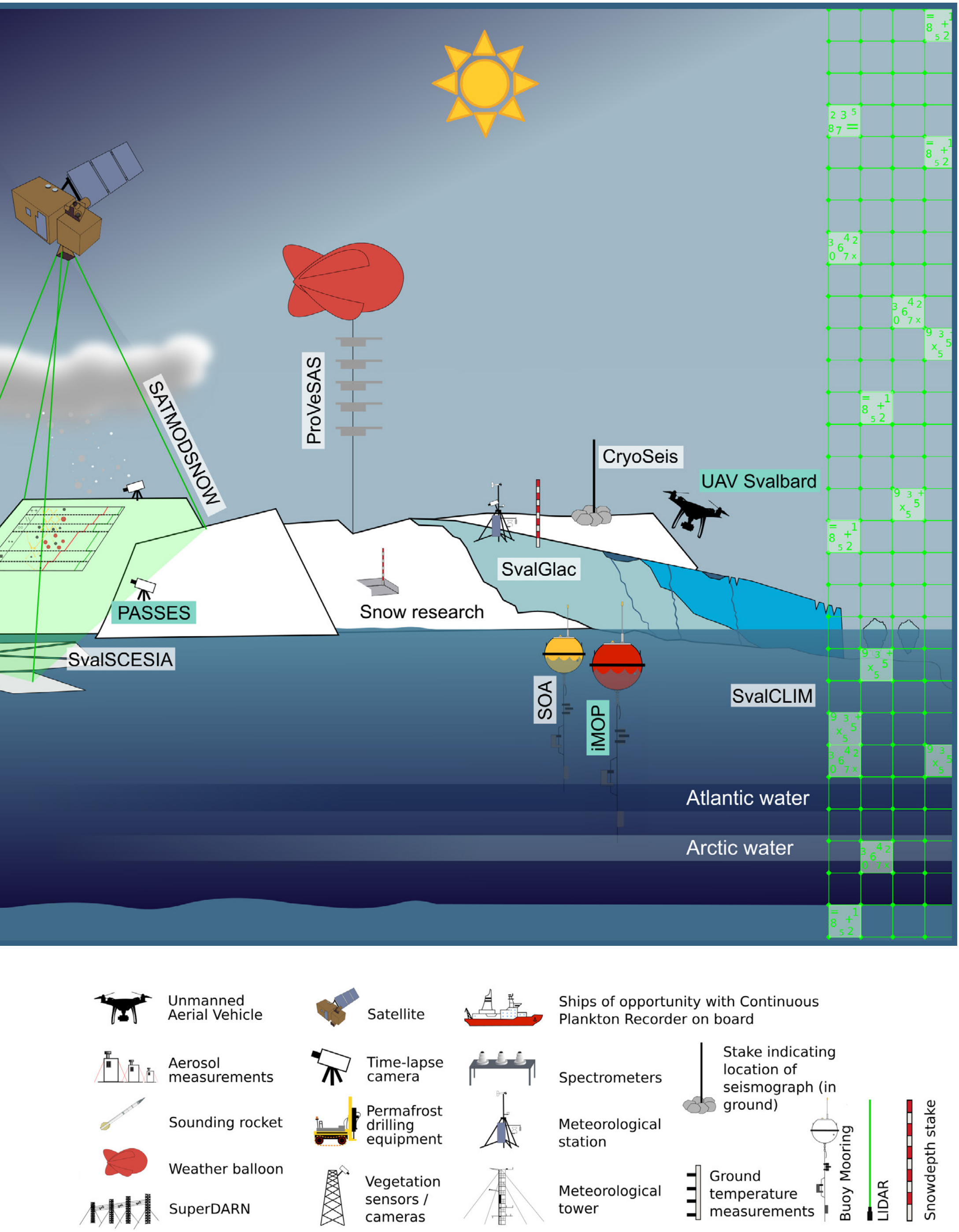
A particular method to observe the Svalbard environment, which has seen a very strong increase in usage during recent years, is the application of unmanned airborne or marine vehicles. The update on recent publications using these devices (UAV Svalbard) reveals that especially conventional remotely operated aerial vehicles (drones) with camera equipment are now widely used. It is recommended to SIOS to foster interdisciplinary communication among the multitude of drone users to establish exchange of information and data. New EU regulations for drone operations are being put in place from 2022 onwards also in Svalbard.

Climate services are receiving more and more attention from Arctic countries, because they translate data into relevant and timely information, thereby supporting governments, societies and industries in planning and decision-making processes.

SIOS contributes to climate services by providing research infrastructure with an overarching goal to develop and maintain a regional observational system for long-term measurements in and around Svalbard. The SIOS Core Data (SCD) consists of a list of essential Earth System Science variables relevant to determine environmental change in the Arctic. SCD is developed to improve the relevance and availability of scientific information addressing ESS topics for decision-making. SIOS Core Data providers have committed to maintain the observations for at least five years, to make the data publicly available, and to follow advanced principles of scientific data management and stewardship.

Arctic climate change is posing risks to the safety, health and well-being of Arctic communities and ecosystems. Still, there remain gaps in our understanding of physical processes and societal implications. The authors of the SESS chapters have highlighted some unanswered questions and suggested concrete actions that should be taken to address them. The editors would like to thank the authors for their valuable contributions to the SESS Report 2021. These chapters illustrate how SIOS projects contribute to ensure the future vitality and resilience of Arctic peoples, communities and ecosystems.


GCI Cusp
ABC Svalbard
LAS
Svalbaerosol
HAZECLIC
SuperDARN
UV Ozone
COAT
MamSIOS
FastIce
SvalHydro
KLEO
CPR Survey
MIRES
PermaSval
GROWTH
SvalCoast
Legend
Aurora
Melt water
Arctic Tundra
Climate model
Snow covered land
Sea ice and land fast sea ice
Glaciers
Partly ice-covered lake
Coastal erosion
Permafrost degradation, ground instability and ice wedges
Svalbard grazers: Reindeer and Geese
Zoo- and Phytoplankton
Seabirds
Microplastics
Plastic litter
Hydrological monitoring station
Snow model
Gas emission measurements
Snowpit



The Earth System in Svalbard as described in the first three SESS reports. Acronyms of all original chapters are shown, the chapters updated in this issue have a green background (Figure: Floor van den Heuvel).

CHAPTER 1

RV *Helmer Hanssen* operating in the Svalbard fjords (Photo: Finlo Cottier)

Temperature and salinity time series in Svalbard fjords – 'Integrated Marine Observatory Partnership (iMOP II)'

Click here for full chapter

HIGHLIGHTS

- Svalbard's west-facing fjords show increasing temperatures in the warmest and coldest periods of the year
- The inner part of Kongsfjorden has a slight cooling trend in the last decade
- Rijpfjorden shows no trend in temperature
- Outer Kongsfjorden has increased salinity at a rate of 0.1 per decade

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We show temperature records from five marine observatories located around the fjords of Svalbard – Kongsfjorden (3 observatories), Isfjorden and Rijpfjorden. We have analysed the records from these observatories (the shortest is 5 years, the longest is 18 years) to determine trends in the water temperature. We investigated trends in the warmest part of the year (September to November) and the coldest part (March to May).

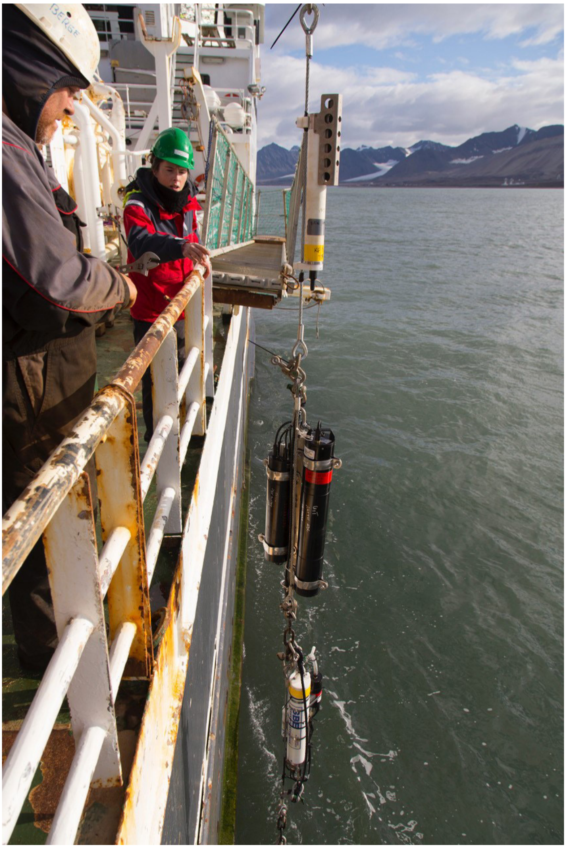
In those fjords facing west towards the Fram Strait we typically see increasing temperatures, the maximum rate being 1.5°C per decade for the coldest period of the year in Kongsfjorden. This has resulted in much less sea ice in these western fjords. In the far northeast, Rijpfjorden shows no signs of warming at any point in the year.

We also investigated the salinity of the bottom water in the outer part of Kongsfjorden and show that the salinity peaks in October and that there is a gradual increase in salinity since 2003 at a rate of 0.1 per decade.

Finally, the proportion of Atlantic-type water in Kongsfjorden has been very high since 2014.

RECOMMENDATIONS

- Continue to develop a collaborative and supportive network of observatory operators to encourage joint planning and maintenance of future marine observatories. This can be done through the SIOS Marine Infrastructure workshops and Kongsfjorden Flagship meetings.
- Undertake a community analysis of temperature records from all long-term inshore moorings and, where possible, include an analysis of water salinity to capture the rates and locations of change around Svalbard.
- Metrics to quantify the changes in Atlantic-type water should be developed and applied to all moorings with salinity and temperature data. Such a widespread analysis could be undertaken to find evidence for the greater occurrence of Atlantic-type water in Svalbard fjord systems. This could be done in conjunction with analysis of offshore moorings.
- Efforts should be made to identify similar long-term marine records (e.g. zooplankton or fish populations) and for other Earth System processes (e.g. meteorology and glaciology) and undertake coupled analyses.



Mooring recovery
(Photo: Unknown)

CHAPTER 2

COAT Svalbard (2016-2021) has established a variety of research infrastructure related to data collection, field logistics and data management solutions. Implementation of new technology and techniques, such as drones, herbivore exclosures, camera traps, sound stations and GPS-collars on reindeer and foxes complements and enhances traditional monitoring techniques (Photos from upper left to lower right: I. Eischeid, S. Thomson, V. Ravolainen, E. Fuglei, image captured by the Reconyx camera trap, V. Ravolainen, F. Samuelsson, N. Lecomte and E. Fuglei)

Climate-Ecological Observatory for Arctic Tundra (COAT) — Adaptive system for long-term terrestrial monitoring

Click here for full chapter

HIGHLIGHTS

COAT:

- provides scientifically robust systems for ecosystem-based long-term real-time observation of climate impacts on Arctic tundra ecosystems;
- provides new infrastructure to collect and manage data;
- assessed ecological condition of low and high Arctic tundra ecosystems in 2021;
- is entering the operational phase of the long-term ecosystem-based monitoring.

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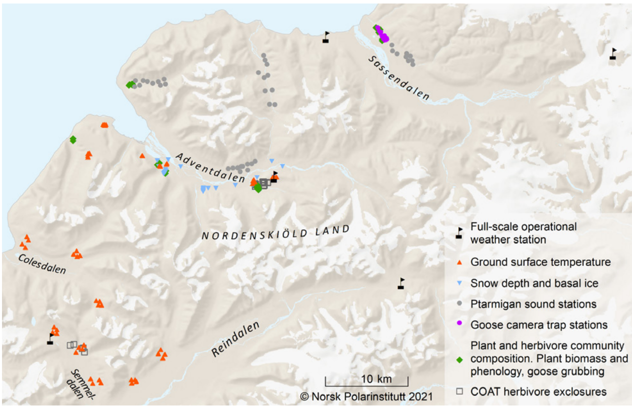
Predicted temperature increases in the Arctic are expected to fundamentally alter tundra ecosystem dynamics. The Arctic's extreme year-to-year and place-to-place variability make long-term monitoring challenging, yet essential for environmental conservation, management and policy making. COAT has developed a framework that addresses these complex issues using a holistic, ecosystem-based adaptive approach. This is achieved by integrating data on the state of various characteristics of the ecosystem measured at relevant sites and relevant times to reach clearly defined goals and targets for monitoring the terrestrial food web. For this reason, COAT Svalbard is an essential component of the Svalbard Integrated Arctic Earth Observing System (SIOS).

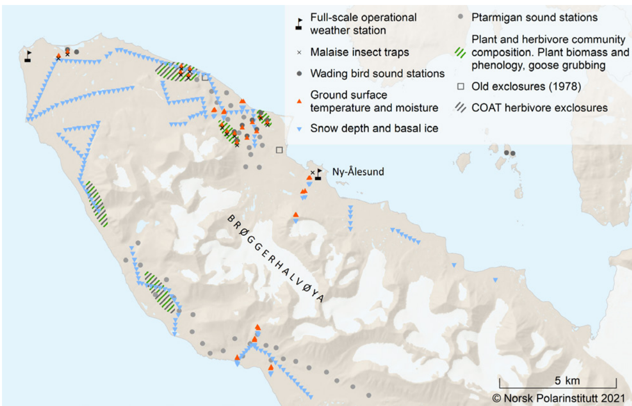
COAT Svalbard contains six monitoring modules, with study sites in two contrasting regions in Svalbard, Nordenskiöld Land (inland) and Brøggerhalvøya (coastal). Five of the modules focus on the Svalbard food web – vegetation, Arctic fox, geese, ptarmigan and reindeer. The sixth module, a climate-monitoring network with full-scale operational weather stations and associated infrastructure, has now been fully implemented.

Svalbard's tundra ecosystems have undergone rapid and substantial changes in climatic conditions – manifested particularly as rising surface temperatures, longer and warmer growing seasons, shortening of the snow-covered season and rising permafrost temperatures. Currently, monitored vertebrate populations appear to be stable or increasing in these regions. Long-term monitoring of vegetation communities is being implemented and will enhance understanding of bottom-up processes in the terrestrial food web.

RECOMMENDATIONS

The COAT Svalbard observation system is an integral part of the SIOS land module. This offers opportunities for multidisciplinary studies, integration of ecologically relevant state variables at comparable spatial and temporal scales, and opportunities to develop products and modelling approaches that are based on a variety of data sources. We recommend further focus on: 1) climatic drivers of ecosystem change and multi-model development, 2) new methods and technologies to improve the spatial and temporal coverage of monitoring efforts and 3) cooperation with end-users.





CHAPTER 3


The time-lapse camera at the snow monitoring site close to the Gruvebadet Laboratory, Ny-Ålesund (Photo: Federico Scoto)

Improving terrestrial photography applications on snow cover in Svalbard with satellite remote sensing imagery (PASSES 2)

Click here for full chapter

HIGHLIGHTS

- Time-lapse cameras are an efficient and economically advantageous way to observe changes in Svalbard's environment.
- Snow cover monitoring with time-lapse cameras is an inherently multidisciplinary approach.
- Terrestrial photography is a vital ground truth for satellite remote sensing.

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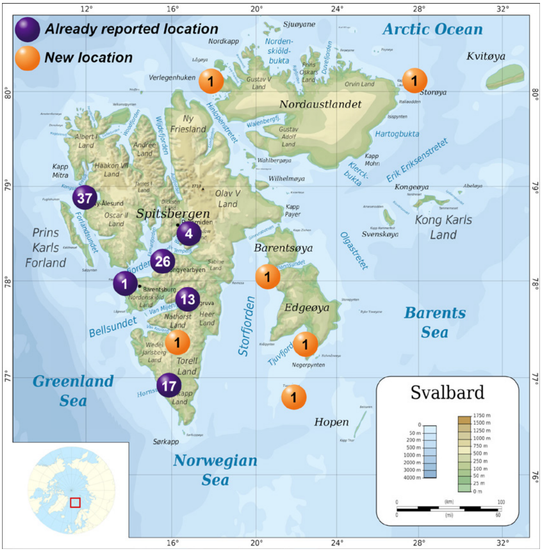
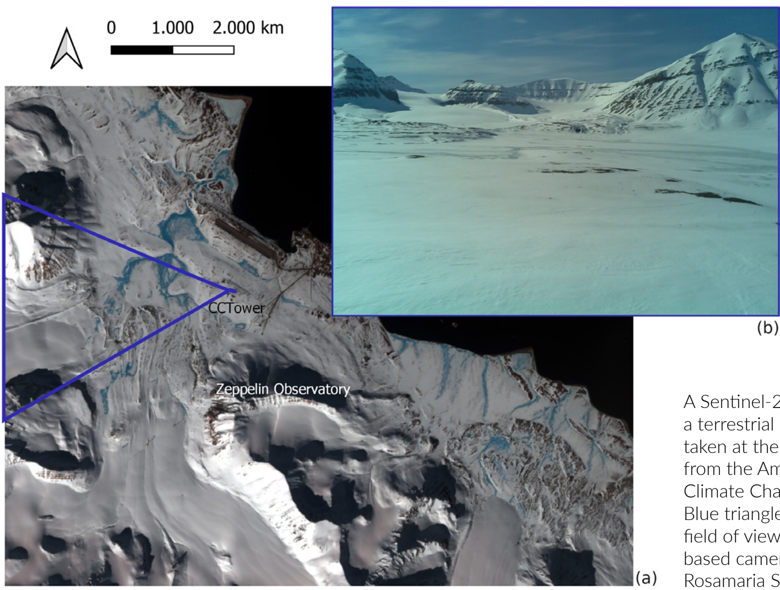
Three actions are required to improve terrestrial photography applications in Svalbard, according to the SESS report recommendations. The first one is focused on maintaining the dataset on terrestrial photography applications in Svalbard, widening the range of involved disciplines. The second one is aimed at defining a harmonised protocol based on established experience and describing guidelines for developing novel applications with a network perspective. Finally, exploring integration with remotely sensed data, it is possible to highlight potential ways of solving multi-scale gaps by combining ground based and remotely sensed data. This novel knowledge highlights even more the need for a strategic network of terrestrial cameras located in key locations where different disciplines could benefit from the description of snow cover evolution during the melting seasons.



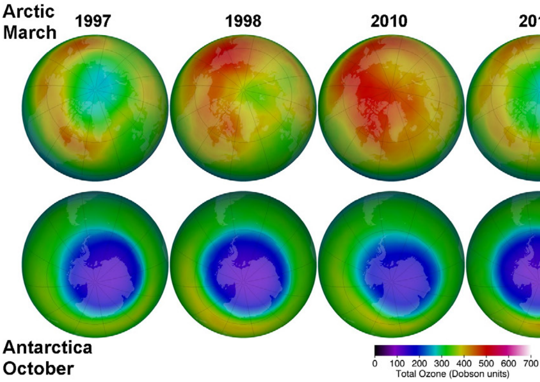
Locations of terrestrial photography applications identified in the Svalbard archipelago. The numbers denote how many camera(s) are available at each location (Photo: Riccardo Cerrato)

RECOMMENDATIONS

- Promote actions and projects that use time-lapse cameras, especially in the more remote areas of Svalbard. Cameras with a field of view covering higher-elevation terrain should be particularly encouraged.
- Stimulate the creation of a Svalbard-wide camera system network. There is a need to create a common and easy to apply algorithm for processing large quantities of images from different devices for snow cover applications.
- Further integrate terrestrial photography and satellite remote sensing since this is a promising strategy for extending in situ observations to improve regional monitoring.
- Encourage the use of time-lapse cameras by different disciplines where high time-resolved information can be retrieved for different purposes (glaciology, hydrology, plant and animal ecology, coastal processes, sea ice tracking, satellite cal/val).



A Sentinel-2 image and a terrestrial photograph taken at the same time from the Amundsen-Nobile Climate Change Tower. Blue triangle represents the field of view of the ground-based camera (Photo: Rosamaria Salvatori)



Comparison between Arctic and Antarctic ozone reductions in spring. The upper row shows the ozone distribution over the Northern Hemisphere in March of the years indicated. The lower row shows ozone distributions in the Southern Hemisphere in the austral spring (October) of the same years. The colours represent total ozone (in Dobson Units): blue indicates low values while red indicates high values. Images downloaded from the NASA website https://ozonewatch.gsfc.nasa.gov/NH.html and https://ozonewatch.gsfc.nasa.gov/SH.html.

The extreme Arctic ozone depletion in 2020 as was observed from Svalbard (EXAODEP-2020)

Click here for full chapter

HIGHLIGHTS

Strong springtime decreases in ozone have been seen in the Arctic in the past decades. The strongest episode took place in 2020. It was studied by using data from instruments based in Svalbard. The ozone reduction episode caused a twofold increase of solar ultraviolet irradiance vs normal conditions.

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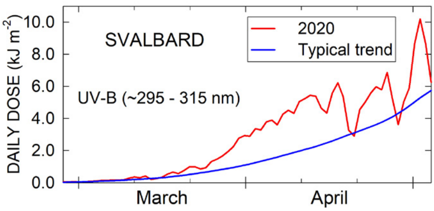
Strong stratospheric ozone reductions during the spring months were first observed in Antarctica in the early 1980s. Follow-up ozone monitoring showed that such reductions occurred annually to a varying extent, mainly in the Southern Hemisphere. However, similar events were occasionally observed also in the Northern Hemisphere; these Arctic ozone reductions were especially pronounced in 1996, 1997, 2011 and 2020. Ozone distribution maps for March (Arctic spring) clearly show the strength of these episodes and how they contrast with the usual Arctic ozone behaviour. Comparison with the ozone distribution during the Antarctic spring (October) in the same years reveals that the extremely strong 2020 Arctic episode was comparable to the ozone depletion events in the Antarctic. According to current knowledge, these phenomena are triggered by the specific dynamics in the atmosphere over the polar regions in late winter and early spring when an extremely large vortex forms in the stratosphere and closes off a certain volume of the air from external impacts. That leads to a deep cooling and the formation of clouds in the low stratosphere. Heterogeneous chemical reactions taking place on the particles within these clouds form active chlorine species which destroy ozone. Usually, the Arctic polar vortex is much less intensive than the Antarctic one and is unable to create the conditions for a strong ozone reduction, which explains the differences between hemispheres.

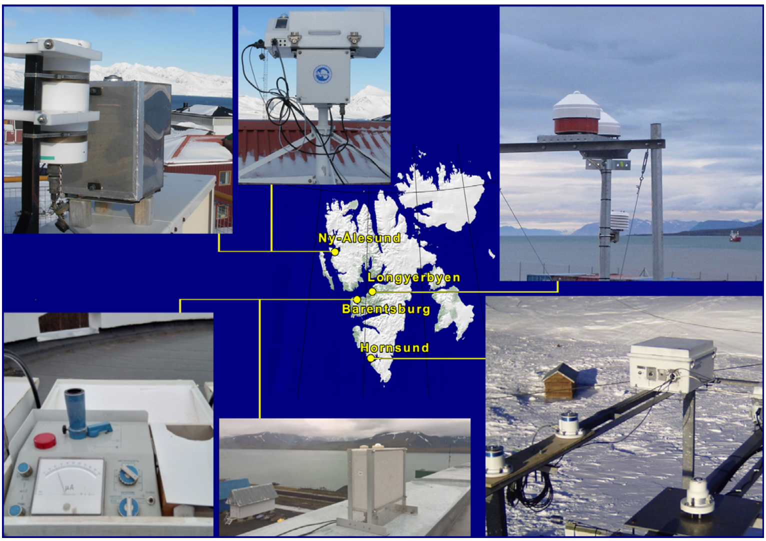
This report presents total ozone levels and solar ultraviolet (UV) radiation during the 2020 episode as measured from Svalbard. The stratospheric ozone reduction in spring 2020 nearly doubled the amount of UV-B radiation that reached the ground. This could significantly stress organisms adapted to a certain level of UV-B irradiance.

RECOMMENDATIONS

- All instruments operating in Svalbard should ultimately be coordinated in a regional network to ensure reliable and coherent data over most of the archipelago. In particular, the coverage of UV spectral observations should be improved.
- The solar UV observation network should be extended across the Fram Strait to Eastern Greenland.
- The effects of climate change on the frequency of ozone reductions must be taken into account in future studies.



The development of the daily amounts of solar UV-B radiation (doses) in the early spring of 2020 compared with the typical annual course determined from nearly 20 years of observations.



Instruments based at four Svalbard stations provided data for the present study (see main text). Ny-Ålesund has filter radiometers (left) and a Brewer spectroradiometer. Longyearbyen station is equipped with a Kipp & Zonen UVS broadband radiometer. A filter ozonometer M 124 operates at Barentsburg (on the left), where a UFOS spectroradiometer (on the right) was also recently established. The Kipp & Zonen UVS broadband radiometer at Hornsund can be seen at the lower right.

CHAPTER 5

An off-the-shelf drone (DJI Phantom 4) being used to monitor changes in the coastline of Recherchefjorden, Bellsund (Photo: Piotr Zagórski)

Update to Scientific Applications of Unmanned Vehicles in Svalbard (UAV Svalbard Update)

Click here for full chapter

HIGHLIGHTS

- This year, 15 articles using unmanned systems in Svalbard were published, vs 51 publications in 2007-2020.
- Basic operations with off-the-shelf multirotor drones are most common.
- New EU drone regulations apply from 1 January 2022.
- We show what this means for Norwegian and non-Norwegian drone operators.

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Unmanned systems are an emerging technology adding value to an increasing number of research fields. The previous SESS report presented the first inventory of all the research work in Svalbard that utilised marine or aerial unmanned vehicles. In this update, we found that since last year's report, 15 new articles that used unmanned systems for research in Svalbard have been published. Compared to the 49 publications that were identified in the previous review period of 2007-2020, this is a clear indication that unmanned systems have a growing importance for scientific applications in Svalbard. We identified that most research is performed using unmanned aerial vehicles (commonly called drones) with quite basic operational missions. Mostly, commercial off-the-shelf multirotor drones are used.

In this report, we also examine the new EU drone regulations that will be applicable in Svalbard from 1 January 2022. We give an overview of the most relevant operational categories for scientific drone operations in Svalbard and their requirements. Furthermore, we discuss the most significant differences from the old Norwegian drone regulations and give instructions on how pilots can be certified within the new rules. The information is aimed at Norwegian and non-Norwegian drone pilots.

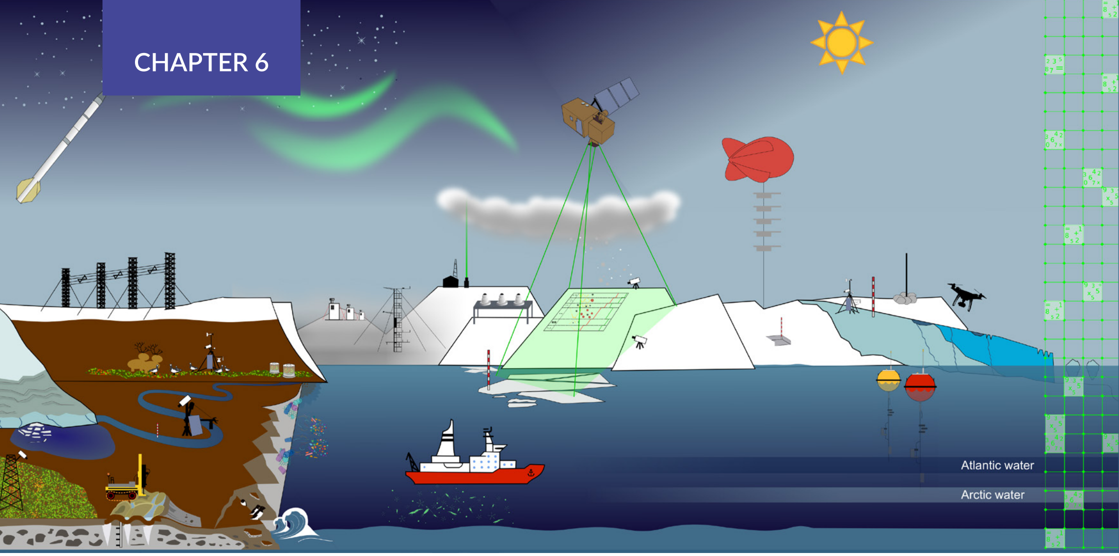
RECOMMENDATIONS

In addition to the four recommendations from the previous SESS report we suggest the following additional three:

- Develop national standard operational scenarios (NSTS) for drone operations in Svalbard. Such scenarios should include operations with extended visual line of sight and altitudes higher than 120m, as long as they are performed with small drones in remote and uninhabited areas.
- Disseminate information about the new EU drone regulations. This will help new drone users get started and support users in adapting their operations to the new rules.
- Establish an interdisciplinary communication platform. The scientific drone community in Svalbard would greatly benefit from a platform to share experiences and develop common best practice guidelines for safe and sustainable drone operations.

A commercial off-the-shelf drone is used for counting reindeer in Svalbard (Photo: Richard Hann)

CHAPTER 6



The Svalbard Observing System as described in the SESS reports 2018-2021.

SIOS Core Data (SCD)

Click here for full chapter

HIGHLIGHTS

- A process to identify SIOS core data is in place
- For the first set of SIOS core data, 51 variables have been identified
- The SIOS Data Access Portal provides access to datasets covering 29 of the identified SCD, with the number increasing
- Members are committed to providing SIOS core data

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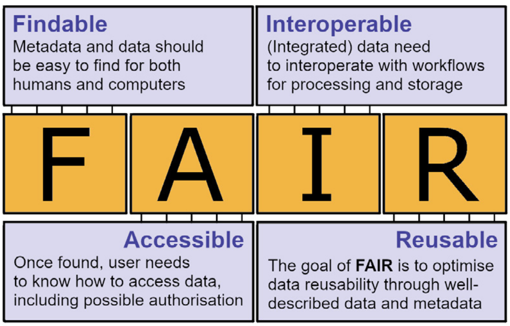
Svalbard Integrated Arctic Earth Observing System (SIOS) is an international consortium of currently 26 member institutions which develops and maintains a regional observing system in Svalbard and surrounding waters. SIOS brings together the infrastructure and data of its members into a multidisciplinary network dedicated to answering Earth System Science (ESS) questions related to global change. The 'SIOS Core Data' (SCD) are composed of long-term data series collected by SIOS partners, fulfilling defined criteria: (1) relevant to answer key ESS questions, (2) available to interested parties according to advanced ('FAIR') data management principles and (3) data collection to be guaranteed by members for a minimum of 5 years.

The first set of SCD variables has been identified by the Science Optimisation Advisory Group in cooperation with the Research Infrastructure Coordination Committee and scientific experts. Many SCD variables are derived from the list of Essential Climate Variables defined by the Global Climate Observing System and are described using WMO standards and the Global Change Master Directory keywords, thus following earlier standardisation efforts. SCD variables are critical for characterising the climate system and its changes in the Arctic, and answering key ESS research questions prioritised by the SIOS community. SIOS activities related to SCD are in line with Sustaining Arctic Observing Networks' (SAON) Roadmap for Arctic Observing and Data Systems process.

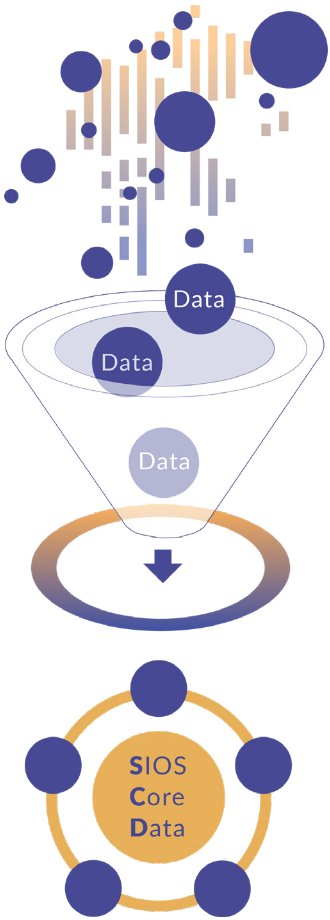
SIOS core data are made freely available through the SIOS Data Access Portal. The datasets cover mainly physical entities like geophysical, meteorological, or oceanographic data. They allow for example the determination of mass and energy flows across Svalbard, which enables better understanding of the archipelago's role within the Earth System.



The 'FAIR guiding principles for scientific data management and stewardship' were published in 2016 by Wilkinson et al. in Scientific Data (https://doi.org/10.1038/sdata.2016.18). The principles emphasise machine-actionability, meaning that there should be minimal human intervention required in finding and accessing data.

RECOMMENDATIONS

- Facilitate transformation of SCD-candidates to SCD and verification of previously reported SCD-candidate variables
- Prioritise defining and harmonising measurement protocols and data protocols for SCDs
- Do an annual evaluation of variables on the SCD list to ensure their significance and reusability
- Activate hidden data from multi-year monitoring efforts that are currently not available in any database that meets the FAIR data principles
- Share knowledge, expertise, and experience of the SCD definition process in international projects



A diagram illustrating the processes of selection and harmonisation of SIOS core data state variables from among all the SIOS Earth System Science data. The datasets collected in Svalbard are selected as core data candidates based on their importance for assessing the state of the environment in Svalbard (shown as funnel). To become full SIOS core data, they must additionally fulfil certain criteria and be in a FAIR format (shown as circle).

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You can find this and previous SESS reports on our webpage:
https://sios-svalbard.org/SESSreport

Visit the SIOS data access portal to find metadata and datasets described in this report: https://sios-svalbard.org/metsis/search

SIOS
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