The Svalbard Integrated Earth Observing System

A regional initiative to build observing capacity for an

Arctic Observing System

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The SIOS Preparatory Phase Project

Executive summary

The Svalbard Integrated Earth Observing System (SIOS) is conceived as a regional response to the Earth System Science (ESS) challenges posed by the Amsterdam Declaration[1] on Global Change. SIOS is intended to develop and implement methods for how observational networks in the Arctic are to be designed and implemented in order to address these issues in realms approaching the continental scale. Earth System Science is in itself a colossal task that has led to the inception of the Earth System Science Partnership (ESSP; www.essp.org). The ESSP community has recently published a strategy document[2], SIOS seeks to be consistent with and contribute to this endeavor. SIOS will provide upgraded and relevant ***Observing Systems and Research Facilities*** of world class in and around Svalbard. The initiative builds on the extensive observation capacity and research installations already in place by many nations. It is a distributed research infrastructure set up to provide a regional observational system for long term measurements under a joint framework. As one of the large scale research infrastructure initiatives on the ESFRI roadmap (European Strategy Forum on Research Infrastructures), SIOS is currently developing its scientific case as well as working out sustainable legal, organizational and financial plans. This is done under its preparatory phase project (2010-2014) with 26 partner institutions based in 14 countries, which have existing research and research infrastructure in Svalbard. The new research infrastructure organization, the SIOS Operational and Knowledge Center (SIOS-KC), will be crucially involved in developing methods and solutions for setting up its regional contribution to a systematically constructed Arctic observational network useful for global change studies.

Svalbard is a region that is influenced by the surrounding areas but also influences its surroundings. Earth system science observations must be able to separate the regional influences from those influences from afar. To do this we need knowledge about the most important processes that influence the observations. By bringing many types of observations together and asking questions about how these are influenced by each other we can gain new insights about the Svalbard regions role in the Earth system. Globally relevant Earth system science questions are complex and require collective efforts to be solved. A systematic approach is essential in this collective effort to yield insights in a cost effective way. SIOS will supply added value to all participants well beyond what their separate investments would provide by themselves. SIOS will, importantly, enhance the scientific environment in Svalbard by providing the core measurement program and the special expertise of the SIOS-KC.

The main assets of SIOS are the coordinated observation capacity guided by a joint strategy and development plan and the joint services set up to provide better and open access to the research facilities and observations, data, logistics, as well as providing better knowledge management, training and meeting places for scientists and students.

The SIOS Core Activities – are based on the observation that most changes occur at the interfaces between different spheres (e.g. ocean-atmosphere, ocean-biology, atmosphere-biology). SIOS will prioritize measurements of variables whose interactions are believed to be significant in Svalbard. In

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[1] Moore B, Underdal A, Lemke P, Loreau M: The Amsterdam declaration on global change. In: In Challenges of a Changing Earth: Proceedings of the Global Change Open Science Conference. Amsterdam, The Netherlands, 10–13 July 2001. Edited by Steffen W, Jäger J, Carson D, Bradshaw C. Challenges of a Changing Earth: Proceedings of the Global Change Open Science Conference. Amsterdam, The Netherlands, 10–13 July 2001 Springer-Verlag; 2001:207-208. GBP Global Change Series.

[2] Leemans, R., Asrar, G., Canadell, J.G., Ingram, J., Larigauderie, A., Mooney, H., Nobre, C., Patwardhan, A., Rice, M., Schmidt, F., Seitzinger, S., Virji, H., Vörösmarthy, C. and Young, O.: 2009, 'Developing a common strategy for integrative global change research and outreach: the Earth System Science Partnership (ESSP)', Current Opinion in Environmental Sustainability 1, 4-13.

particular measurements that are assumed to be able to elucidate important processes acting on annual to decadal time-scales will be prioritized. This core observational program of SIOS will provide the research community with systematic observations that are guaranteed to be available over time. The SIOS Research Infrastructure Optimization Report presents the first suggested observation priorities which will be the basis for the future SIOS research infrastructure development strategy.

The SIOS Knowledge Center (KC) – will use the observations and knowledge to continuously develop the core program. The core observational program of SIOS will be stable over time, yet dynamic as new methods and questions from society appear. An important capacity building activity at the SIOS-KC will be to stimulate the development of new observational techniques for environmental monitoring that are: clean, energy efficient and robust in the Arctic environment. The SIOS-KC will provide an intellectual environment where sampling strategies and observational practices are developed with an Earth system science perspective, and will thus become a unique international meeting place for developing the science of long term environmental monitoring in Polar Regions. The center will continuously inform users and society about the accrued knowledge within its field of expertise.

The SIOS open access data policy and an ambitious meta-database service will be managed and maintained under the SIOS-KC. This will also enable SIOS to establish itself as a major regional building block of SAON, as well as contributing effectively with an Arctic component to global datasets and GEOSS.

A case for Earth System Science in Svalbard

Implicit in the ESS concept is that we are studying a closed system. The Earth is not a closed system but is influenced by external variability (both with respect to energy, mass exchange and influence of gravitational fields from coincidental heavenly bodies). Furthermore, the internal characteristics of Earth are also changing (e.g. number of radioactive nuclei remaining in Earth declines with time altering the amount of energy available for volcanism and continental drift). These influences shape the Earth System on all time scales. Of particular note is that energy exchange has externally forced variability (e.g. solar radiation) that influences the Earth system on decadal and shorter time-scales.

ESS is by definition a global study so applying system analysis studies on the regional scale has some severe deficiencies. These need to be acknowledged and considered when prioritizing efforts. For example, many entities can pass through a region without modifying or being modified within the region yet they may still play important roles for the Earth system and/or for the region. Some of the entities observed changing in a region can have drivers outside that region causing this change. Changes in an entity at some location can also be due to redistribution within the region or between regions without it necessarily being important for the Earth system. Sometimes natural barriers define a region making it meaningful to study the realm thus delineated as a closed system for certain entities. In regional work there will always be complications for the system analysis because there are more often than not other relevant entities that can pass the same barrier unobstructed.

Some Svalbard specific examples to illustrate the above: ocean currents transport large amounts of heat past Svalbard yet the ocean-atmosphere exchange in the Svalbard area is probably small when discussing the overall Arctic heat balance though it certainly influences the local climate. There is anecdotal evidence that polar bears are increasing in numbers around Svalbard, despite increases in concentrations of toxic chemicals entering the food chain and (presumably) adverse effects through changes in climate, but the fact that hunting was banned in 1973 is probably still the dominating factor influencing the regional polar bear population. Anecdotes regarding increased numbers of bear sightings on the west coast can be related to redistribution of bears as their fear of human contact have waned. For the reindeer Svalbard can be considered as essentially a natural enclosure. The grazing is modified by goose droppings that are both direct food for reindeer and fertilizer for the grass but the goose population is, nevertheless, mainly increasing because of changes in management and habitat in their wintering grounds.

Despite these challenges to the ESS approach in general and the Svalbard-specific examples provided it is, nevertheless, considered appropriate to develop an ESS observational platform on the archipelago.

For example it is frequently suggested that the polar systems have lower complexity than other regions; from this follows that deconvolving the Arctic system may be a more tractable problem than tackling other regions. Simultaneously the Arctic is a region of special interest for GEC both for its climate sensitivity and its fragile ecosystems.

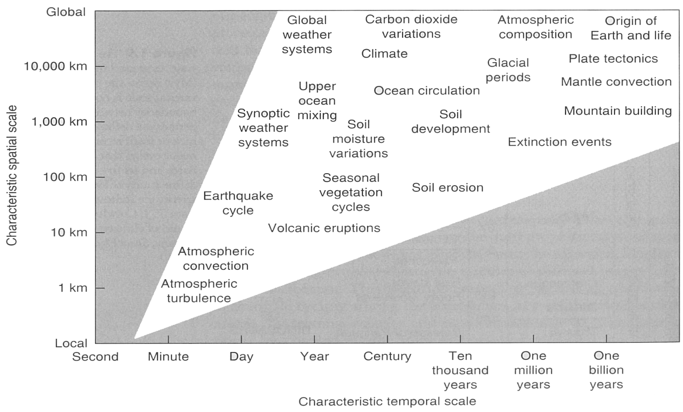
In a general sense it is tempting to conjecture that the larger the region or the stronger the boundaries (physical or otherwise) the more of the variations observed will originate from processes and phenomena within the region and the less will the boundary transfers be dominating the variations. Presently studies are to a large extent limited to point measurements or single fjords or glaciers in Svalbard; SIOS will aim to address more effective regional coverage with the goal of providing a better foundation for a regional system understanding.

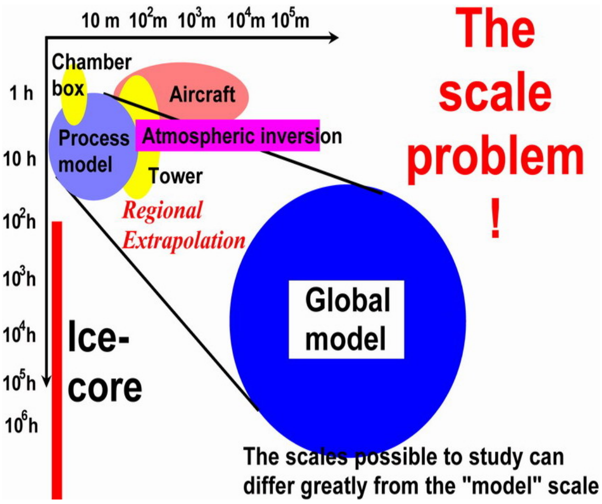
Svalbard is a region within the Arctic that provides physical barriers for at least some of the entities and processes that are particularly relevant for a system understanding. This makes it possible to formulate studies where one utilizes the boundaries to separate internal transformations within the region and external factors. Svalbard is also a region with relatively substantial data coverage already as well as infrastructure and access capacity. It, thus, singles itself out as a region of choice to develop the ESS approach. Such an endeavor will provide increased understanding of the region and will significantly advance ESS methods.

The core measurement program of SIOS will provide a high level of interlinked systematic observations that are guaranteed to be available over time. This will further enhance Svalbard as an experimental environment where it will be attractive to perform basic and applied research.

Overall design considerations

The challenge for SIOS is to establish an infrastructure and measurement program in and around Svalbard that provides an environment that energizes ESS science. How can we design an observational network that is sensitive enough and dense enough to pinpoint the cause of change? We need to consider scales in our regional network design.





The left panel is an assessment of processes in the real world; the right is a simple analysis of some of the measurement techniques we are utilizing to study these processes. A current gap in SIOS is that of scrutinizing the gaps of knowledge in this type of context. Within the SIOS gap analysis there are only brief discussions and considerations regarding the number of measurements required to quantify the entities for Svalbard as a whole. The figures also clearly support the conclusion that a regional study like SIOS has limitations in an ESS endeavor.

What further complicates the situation is that the Earth System and in particular the regional Arctic System are in a process of rapid (and possibly accelerating) change beyond the boundaries of the realms investigated with current Earth System Models, e.g., changes between ice ages and interglacials. The Arctic System may enter a phase where processes considered up to then as irrelevant for the time horizons included in a system study may accelerate so much that they become relevant; one cannot then any longer simply extrapolate the system description applied in the model. This would severely hamper the ambition to identify an adequate set of parameters to cover the important aspects of Arctic change. A strategy[3, 4] to meet this challenge would seem to be a moderate oversampling in terms of the number of parameters, combined with regular reviews of the continuing relevance of these parameters for the system.

It is clear that for most parameters of interest in the ESS regime there is a clear under-sampling in both the temporal and spatial domains. This is true globally as well as in the Svalbard (and polar generally) environment. Philosophically, any basic research can be relevant for our pursuit of elucidating GEC but an argument is made here for a prioritization strategy to make most efficient headway on the issues society needs addressed at the present time. All measurements are potentially useful for the unknown questions of the future; for example, a mundane observational record that is not displaying any “exciting” change (or publications) can become incredibly important if some unpredicted change occurs in the system. The ozone hole story is a case in point. We don’t know what questions society will be asking in the future because we simply don’t know what the long term effects of something that we do or release may be. We don’t know what the future society may be sensitive to other than (possibly) entities that influence our bodies or basic resources (e.g. food).

If we had exact data for everything everywhere we would not need models. If we had perfect models we would not need data. Neither of the two will happen anytime soon. An important issue for SIOS is to consciously meld model development and sampling/monitoring strategies such that we acquire the most rapid and cost effective development of both to maximize the amount of understanding from the available information. Inevitably, data will be limited in time and space and the gaps between can only be “filled” through models. Conceptually, data should be acquired in time and space realms where model data entail our only knowledge (e.g. testing/verifying models) and models should be utilized to point to areas where our present knowledge (as depicted in the model) suggest that there is large (poorly predictable) variability and also to point to areas where further measurements are superfluous.

When exploring entities with unknown variability and for which we have little understanding of the mechanisms controlling their variability we must begin with acquiring data. The temporal and spatial resolution that is useful to pursue in a monitoring effort can be (partially) explored with high resolution studies in a period and/or area of choice. Such studies can lead to conclusions regarding meaningful sampling strategies (to the extent that the high resolution study has captured the scales of variability).

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[3] Lindenmayer, D. B. and G. E. Likens, 2009, Adaptive monitoring: a new paradigm for long-term research and monitoring, Trends in Ecology and Evolution Vol.24, No.9.

[4] Nichols, J. D. and B. K. Williams, 2006, Monitoring for conservation, Trends in Ecology and Evolution Vol.21, No.12.

There are many limitations but this can provide a better strategy than starting with single stations at whatever temporal scale happen to be possible. There is a strong case for performing high resolution studies to determine representativity of the anticipated data before investing in long time series and monitoring.

A strategy for the SIOS observing system

SIOS must be designed around topics related to GEC in such a manner that we can:

1) Detect change
2) Attribute change
3) Describe the effects of the change
4) Understand and communicate what will be required to mitigate, adapt to and/or reverse change

Some overarching (pragmatic) considerations:

i. "Environmental" in GEC involves the entire system but building a complete ESS observational program should focus towards the interface between atmosphere and Earths' surface and the processes there where many existing programs are already active. There remain fundamental (energy- and mass- exchange) weaknesses (and uncertainties) for the interface descriptions in ESS models.
ii. "Change" in GEC is for all practical purposes (management and mitigation) considered on century or shorter time-scales.
iii. ESFRI (and thus SIOS) commitments have a decadal perspective.

These considerations consequently points out themes of observation and the spatial and temporal scales involved. The points influence what should be considered as part of the monitoring/observation activity and what are considered add-on experiments. It also has bearing on where the core of activity should be and what phenomena and processes the observational system regard as "external" forcing to the regional ESS effort. This still leaves outstanding the issue as to what strategy SIOS should adopt to handle/quantify these boundary conditions in space and time.

Activities to be prioritized are measurements that other data series need for their interpretation and measurements that will plausibly see change on decadal time-scales. Priority should also be given to conducting systematic representativity analysis of the measurements programs through an intimate interaction with the modeling communities. Solitary measurements that need no one else and are not used by anyone else should not be considered as core SIOS activities. Obviously such measurements have profound value as basic research and can suddenly become immensely important when a "surprise" occurs but in the infancy of SIOS the issues relevant to the questions posed at the present time must be prioritized.

The SIOS-KC will compile knowledge in a way that ensures that the correct choices are made at each crossroad where future prioritization and directions need to be crafted. The SIOS-KC will also enable research, inform society and build capacity according to the ideas suggested by Leemans et al. (footnote 2). An important capacity building activity should be that of encouraging development of new observational techniques for environmental monitoring in frigid and sensitive areas. The comprehensive knowledge of the Svalbard system and observations harbored within the KC combined with the general accessibility of Svalbard should facilitate rapid development of new high technology observation schemes. The KC should provide an intellectual environment where sampling strategies and observational practices are developed at the intersections between stringent scientific evaluations, pure statistical considerations, what is technically possible, what is economically possible, and the specific issues of doing long term measurements in Svalbard.

Svalbard is to be one of the best managed wilderness areas of the world; 65% of the land areas and 87% of the marine areas within the 12 nm line are protected as nature reserves or national parks. There are provisions allowing science to be performed in the protected areas but under compliance to a number of regulations. There is at the same time compelling need for data from these regions. There is a grand challenge in developing techniques that produce the data necessary for ESS work with minimal environmental footprints. SIOS must stimulate innovation in techniques and accelerate their use in the Arctic.

Based on these considerations it is tempting to define specific criteria to apply to the prioritization of SIOS infrastructure investments. This note highlights that there are many considerations to take into account. The most important being the fundability of a specific infrastructure as this may in practice be defined from national priorities essentially independent of any SIOS project considerations. It is also clear that SIOS will evolve during the course of its existence and so care is necessary to not overly "hard wire" the infrastructure at the outset. Rather SIOS should evolve and grow in a responsive manner over time, that reflects developing opportunities and priorities, whilst holding to the core ESS values; SIOS must be innovative, dynamic and, counter intuitively, conservative at the same time.

Guidelines for prioritization

Using the approach outlined above the SIOS Research Infrastructure Optimization Report took the view that the study of Earth System parameters be grouped under **vertical coupling** and **horizontal transport** coupled with **Svalbard landmass and biota interactions with changing climate**. The vertical coupling includes the entire atmosphere and the vertical profile of the ocean whilst horizontal transport includes atmospheric and ocean circulation, long range transport of pollutants and migration of wildlife.

Scientific guiding principles:

- Identify and monitor state variables of importance for GEC diagnostics.
- Identify and monitor exchanges of energy and mass.
- Identify the monitor combined effects of human perturbations on the Earth System.
- Monitor the effects of GEC on organisms, populations, and ecosystems.
- Focus on measurements that will plausibly detect change on annual to decadal time-scales.
- Systematically apply representativeness analysis of the measurements programs through an intimate interaction with the modeling communities.
- Solitary measurements should not be considered as core SIOS activities.
- Innovations in monitoring techniques, methods and sampling strategies are to be encouraged.

Other guiding themes:

- SIOS infrastructure must contribute to the filling of gaps, spatial or temporal, as well as providing added value information in achieving increased insight to governing processes.
- The infrastructure investments shall contribute to the overarching ESS approach of SIOS.
- SIOS infrastructure providers should envisage decadal scale operational commitment to ensure the benefits of a unique reliable core data set for SIOS partners.
- There must be a clear added value from each contribution to other parts of the SIOS project.
- Investments should be consistent with national prioritizations so there needs to be an ongoing dialogue between SIOS and national bodies.

- Investments in singular infrastructure and research projects not providing essential parts of the above shall not be included in SIOS.
- New measurements of unconfirmed value can be associated with SIOS activities as they may have future importance, but should not be included in the core set of SIOS measurements.

Earth System Science questions that provide a basis for the prioritization of SIOS observations include:

Vertical Coupling

- *EQ1: "What are the primary coupling processes that connect the troposphere, stratosphere, mesosphere and lower thermosphere and how is this coupling changing over seasonal and multi-year timescales?"*
- *EQ2: "What controls changes in the vertical structure of the Arctic atmosphere and the ocean?"*
- *EQ3: "How are changes in the extent of sea-ice cover in the Arctic impacting biogenic emissions from open water, notably in shelf seas, and what are the implications?"*
- *EQ4: "Is there evidence of change in Arctic marine ecosystem structure through warming, break down in vertical mixing and reducing sea-ice extent and age structure?"*

Horizontal Transport

- *EQ5: "What roles do oceanic exchanges of heat between the Arctic and lower latitudes play in Arctic-global climate linkages?"*
- *EQ6: "To what extent are emissions of short lived greenhouse gases and aerosols (e.g. methane and 'black carbon') outside the Arctic affecting Arctic change?"*
- *EQ7: "How are the horizontal influxes of sensible heat, nutrients and particulate matter to the Greenland and Barents Seas altering over time and what are the regional consequences?"*
- *EQ8: "How are the patterns and sources of long-range transported pollutants changing over time and how are these patterns manifested in Arctic ecosystems?"*

Svalbard land mass and biota interactions with changing climate

- *EQ9: "What are the impacts of climate change on Arctic landscape and terrestrial ecosystems?"*
- *EQ10: "What ecological changes are accelerating?"*

General ESS questions that the SIOS infrastructure could help address include:

- *EQ11: "What is the significance for Arctic climate of the substantial natural variability and feedbacks associated with high latitude winds and ocean currents?"*
- *EQ12: "What is the relative importance of anthropogenic forcing for Arctic change, especially on the regional and local scales?"*
- *EQ13: "What is the status of the Arctic water cycle and how are the different components (transport from low latitudes, atmosphere/ocean/sea ice exchange, ice sheets, glaciers, ecosystem exchange) contributing to the budget changing?"*
- *EQ14: "Why are many aspects of Arctic change amplified with respect to global conditions"*
- *EQ15: "What are the most important feedback mechanisms for amplification and are they specific to the Arctic System?"*
- *EQ16: "Will natural variability, particularly the interannual to multi-decadal modes of variability, be affected by anthropogenic forcing in the future?"*

A first version of the SIOS Research Infrastructure Optimization Report, suggesting a possible categorization and prioritization of existing and new observation, can be downloaded at the following link:
https://www.dropbox.com/s/rlzw96u69wys88d/SIOS%20infrastructure%20opimisation%20report_1%208.pdf?m

The SIOS Data policy

SIOS aims to provide an effective, easily accessible data management system which is fully compatible with and makes use of existing data handling systems in the thematic fields covered by SIOS. As a final result, the SIOS Data Management System (SDMS) will be a functionality enabling component of the Knowledge Centre, supporting data submission, discovery, access, use and preservation of SIOS relevant data sets. As the SDMS will be designed as a distributed system which intends to make extensive use of already existing data centres holding data relevant for SIOS, a common data policy is defined which clarifies the relations between contributing partners as well as the necessary conditions for public access to SIOS data. The largest challenge hereby arises from the wide spectrum of scientific fields, which, to a large degree, have developed individual solutions of data handling, partially through international agreements. SIOS will, therefore, implement a data policy which matches the ambitions that are set for the new European research infrastructures, but at the same time be flexible enough to consider these 'historical' legacies.
The first draft data policy acknowledges the framework given in the data policy of the International Polar Year (IPY). However, as a European Research Infrastructure, SIOS gives special considerations for the legal as well as the political and strategic frameworks for the European Research Area.
The first draft data policy of SIOS can be downloaded at the following address:
http://www.sios-svalbard.org/prognett-sios/Project_Documents/1234130481050

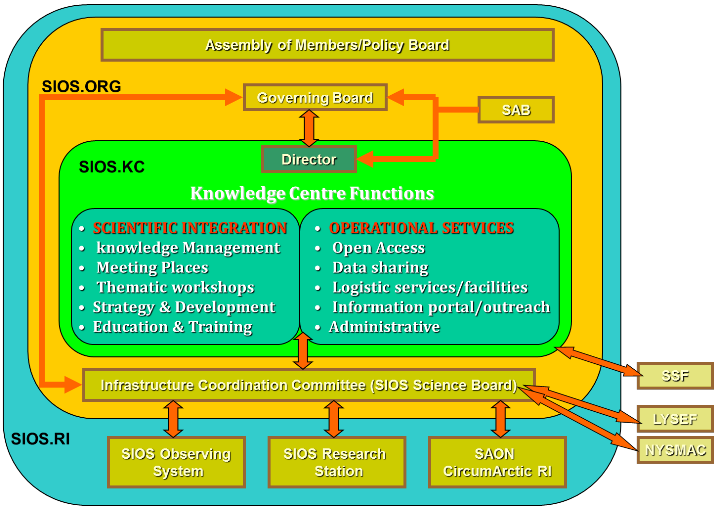
The SIOS Knowledge Center

The SIOS KC is the coordinating unit of the distributed SIOS research infrastructure, managing its daily operation and services offered to the polar research community. It manages the interests of the owners and stakeholders of the SIOS consortium and is the first point of contact for all enquiries concerning SIOS. It is the main connector between the users of SIOS and the capabilities it provides, implementing the joint policies agreed by the SIOS community. By building on existing networks, infrastructures and services the scope and scale of the SIOS KC will be unique providing coordination and integration between scientific fields ,access and use of research infrastructure and data/datasets to the observational platforms in Svalbard and the surroundings. SIOS supporting facilities such as national research stations, vessels, existing databases and instruments are not part of the SIOS legal entity – e.g. not owned by SIOS, but made available to SIOS and accessible through the KC. Operational relations between SIOS and these facilities will be established through bilateral agreements and organisational meeting structures with regular meetings of the Infrastructure Coordination Committee.
The main services provided by the SIOS-KC will be the provision of

- One access point for users with a joint information and evaluation system
- An open access data policy with a state-of-the-art meta database system
- Integrated logistical services for coordinated operations
- Scientific integration, meeting places and training programs for the research community
- A dynamic knowledge management system for infrastructure utilization and development

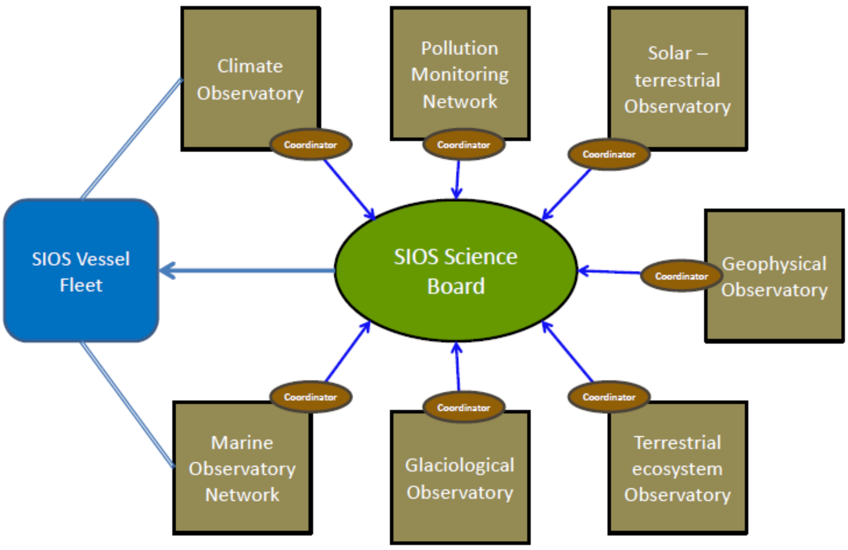
SIOS will be a new research infrastructure organization in Svalbard, with a legal personality and with the main task to establish, operate and provide a state-of-the-art research infrastructure and observing system for the polar research community. The new organization, hosted by Norway, will require international membership and co-funding, while the physical research infrastructure and observing system will still be nationally owned by those nations that have already built observing capacity on the Svalbard shores. The national ownership and legacy invoke constraints on how it is possible to organize the inception and development of the observational system in Svalbard. There are also a number of previous initiatives at stations or within villages to seek coordination measures. To build a new structure with whole region ESS responsibilities is a delicate process that simultaneously should offer enhanced efficiency for all. SIOS is presently in a process of defining these aspects of its organization.

The SIOS-KC draft organization and functions:



SIOS.ORG: The new joint SIOS coordinating organisation with governing bodies and the KC.
SAB: The Science Advisory Board
Infrastructure Coordination Committee: The link between the KC and the distributed research infrastructure
SIOS.RI: The overall SIOS research infrastructure including the distributed observational research infrastructure and facilities owned by the participating member countries
SSF: Svalbard Science Forum
LYSEF: Longyearbyen Science and Education Forum
NYSMAC: Ny-Ålesund Science Managers Committee
SAON: Link to Sustaining Arctic Observing Networks

A possible organization of scientific integration and observational networks under SIOS:



SIOS coordination of thematic multinational observation networks:

- The multidisciplinary SIOS research infrastructure in Svalbard to be reorganized in **thematic observatories and networks**
- Thematic observatories/networks having multinational contributions, electing a **scientific network coordinator** being one.
- Thematic network coordinators sitting together in a **Science Board**, giving advice on practical matters and identifying needs.
- Thematic monitoring observatories/networks are related to the research infrastructure development strategy and are not fixed.

Conclusions: The SIOS contribution to SAON

With climate and environmental change accelerating since the start of the millennium, especially in the Polar Regions, the Arctic has emerged as a particular focus area for research within Europe (as well as in North America and the Asian continent. The coordination and integration of an Earth System science infrastructure on Svalbard is in itself a formidable challenge but given the substantial international presence in the Svalbard archipelago and the pan-Arctic nature of the issue, there is an opportunity to build SIOS further into a wider regional network and pan-Arctic context, ideally under the umbrella of the Sustaining Arctic Observing Networks (SAON) initiative. With its strategic position in High Arctic Europe, it's already substantial and long established research covering all relevant disciplines, and many multi-platform infrastructures maintained by several of the countries involved in Arctic research, SIOS already constitutes a concrete and natural node for SAON. However, it is necessary to anchor SIOS strongly in a European context and connect it to extra-EU initiatives, in order to establish a pan-Arctic perspective. SIOS must develop and secure a robust communication with other bodies carrying out and funding research activities in the Arctic (observational as well as modelling) and actively promote a sustained Arctic observing network. This involves interaction with the EC European Arctic Strategy and the European Polar Board, close collaboration with other Arctic ESFRI projects such as INTERACT or ESFRI projects that include Arctic segments (e.g. EuroArgo, ICOS) as well as with existing EU and Nordic infrastructure projects. It further requires the establishment of regular communication and cooperation with non-European nations, not involved in SIOS, notably USA and Canada, and with the various international bodies charged with developing a pan-Arctic observational network under SAON.