

***The in situ component of Arctic observing systems – opportunities and challenges in implementation of platforms and sensors***

Authors: Stein Sandven<sup>1</sup>, Hanne Sagen<sup>1</sup>, E. Buch<sup>2</sup>, R. Pirazzini<sup>3</sup>, D. Gustavson<sup>4</sup>, A. Beszczynska-Möller<sup>5</sup>, P. Voss<sup>6</sup>, F. Danielsen<sup>7</sup>, L. Iversen<sup>1</sup>, P. Gonçalves<sup>8</sup>, T. Hamre<sup>1</sup>, G. Ottersen<sup>9</sup>, M. Sejr<sup>10</sup>, D. Zona<sup>11</sup>, N. Dwyer<sup>12</sup>

Contact: stein.sandven@nersc.no

<sup>1</sup> Nansen Environmental and Remote Sensing Center, Thormøhlensgate 47, N-5006 Bergen, Norway

<sup>2</sup> EuroGOOS, Avenue Louise 231, 1050 Brussels, Belgium

<sup>3</sup> Finnish Meteorological Institute, PO BOX 503 FI-00101 HELSINKI, FINLAND

<sup>4</sup> Swedish Meteorological and Hydrological Institute (SMHI), 601 76 Norrköping, Sweden

<sup>5</sup> Institute of Oceanology PAS, Physical Oceanography Dept. Powst. Warszawy 55 81-712 Sopot, Poland

<sup>6</sup> Geological Survey of Denmark and Greenland (GEUS), Øster Voldgade 10, DK-1350 København K, Denmark

<sup>7</sup> NORDECO, Skindergade 23, 1159 Copenhagen K, Denmark

<sup>8</sup> Terradue Srl, Via Giovanni Amendola, 46, 00185 Rome, Italy

<sup>9</sup> Institute of Marine Research, P.O. Box 1870 Nordnes, 5817 Bergen, Norway

<sup>10</sup> Aarhus University, Ny Munkegade, bldg. 1540, DK-8000 Aarhus C Denmark

<sup>11</sup> The University of Sheffield, Western Bank Sheffield, S10 2TN UK

<sup>12</sup> EurOcean, Avenida Dom Carlos I, 126-2º, 1249-074 Lisboa, PORTUGAL

*Abstract*

The INTAROS project funded by H2020 for the period 2016-2021 has been established to advance the development of an integrated Arctic Observation System. INTAROS has focus on the in situ component of the observing system, where collaboration across the Pan-Arctic regions is necessary in order to make progress on the four main challenges: (1) Organisation, (2) Technology, (3) Data collection and dissemination, and (4) Funding mechanisms. In Europe, the collaboration is built on established initiatives such as the EU Arctic Cluster projects, infrastructure projects and the Copernicus services. In the Pan-Arctic region, collaboration is developed under SAON (Sustaining Arctic Observing Networks) including the Arctic Data Committee, Committee on Observations and Networks, Global Cryosphere Watch, Year of Polar Prediction and other ongoing polar programmes.

*Introduction*

The possibilities to build up in situ observing systems in the Arctic are foreseen to increase in the coming years as a result of more human activities in the region. Many countries, in particular the Arctic countries, EU and several Asian countries, plan to increase their research efforts, participate in exploitation of resources, development of transport systems, and thus play a role in the economic development in the region (Arctic Research Commission, 2016). On this background, the opportunities to collect more environment and climate data in the Arctic are expected to increase. The main challenge is therefore to organise and enhance the data collection as a collaborative effort between researchers and stakeholders and to establish funding mechanisms to secure sustainability of the observing systems.

## *Requirements to a Pan-Arctic Observing System*

In order to better observe, understand and predict the changes, it is important to build up a network of observing systems covering atmosphere, ocean and terrestrial sites across the pan-Arctic region. Observing systems are normally set up to serve specific applications, such as climate monitoring, natural hazard monitoring (storm surges, earthquakes), pollution monitoring or fisheries management. Common for all observing systems is the definition of requirements on what variables should be observed, where and how the data should be collected and be used in the specific applications. Observing systems for climate should operate over decades and secure global observations that are required for climate research and climate change impact assessment. The Global Climate Observing System (GCOS) has defined a number of Essential Climate Variables that are key for sustainable climate observations (GCOS, 2016). Weather and sea ice services have requirements for climate data as well as near real-time data for use in forecasting models. Other dedicated observing systems are under development for pollution monitoring and traffic control.

## *Ongoing efforts*

Significant efforts have been initiated to build components of Arctic observing systems, addressing specific thematic areas or regions in order to serve relevant stakeholders. Most efforts to build and operate observing systems are based on time-limited research funding, which is usually not sustainable. The IPY (2007-2009) and the upcoming MOSAIC programme (2019-2020) are examples of intensified observing campaigns. These campaigns provide enhanced data collection, but they do not necessarily contribute to long-term observing system. A number of countries have invested in infrastructure and logistical services (research stations, ships and aircraft) supporting the observing systems, but they are very scattered in the Pan-Arctic areas. Svalbard, as an example, has many research stations and a large number of scientist involved in developing and maintaining various observing systems. However, most of the Arctic is not covered by any ground-based observing system.

Satellite Earth Observation is the major contributor to data collection in the Arctic. The Sentinel satellites under EU's Copernicus programme is the single largest data producer, providing vast amounts of data that are openly available to users. However, many essential variables cannot be observed from satellites and require in situ observations. For some basic variables (e.g. meteorological observations) national weather services operate in situ observing systems in the Arctic as part of their monitoring and forecasting services. However, these are usually limited to national areas, which means that there are few observations in the large Arctic Ocean.

## *Building sustainable observing systems*

How can research-generated observations be transferred to long-term monitoring programmes for selected key variables? In order to succeed in building sustainable observing systems, the following four challenges need to be advanced: organisation, technology, data collection and dissemination, and the funding mechanisms.

(1) Organisation. It is necessary to develop better collaboration between the providers of data, including both researchers, operational agencies, industry and local communities. The goal is to optimize usage of the available resources and to find new resources to fill major gaps in the observing systems. There is collaboration for example among institutions working on research vessels and icebreakers as well as operators of research stations and other infrastructures. But in many cases, the collaboration regarding data collection can be improved among the scientific groups working in the Arctic as well as with local communities and industry. The organisation of

the in situ data collection is hampered by lack of an overarching body working on Pan-Arctic scale. The Satellite Earth Observation community is well organised through space agencies (e.g. ESA, Eumetsat, NASA, etc.), implying that the observing systems are well-functioning and evolves in a coordinated manner. The in situ component of the observing systems does not have this level of organisation, and is therefore mainly dependent on national, regional or discipline-oriented programmes. Some global programmes (e.g. through WMO, CGOS) support internationally coordinated observing systems, but these are mostly funded nationally and have poor data coverage in the Arctic.

(2) Technology. There is significant development of observing technologies that can contribute to the in situ component of the observing systems in the Arctic, such as ice buoys, underwater platforms, drones and other atmospheric-terrestrial systems. The main challenge is to install and operate robust and automated systems that can function throughout the year. Industry plays an important role to develop such systems, but this requires technology development programmes which are scarce in most countries. Industry investments in Arctic technology is dependent on expected future market development in shipping, oil and gas exploration, tourism, communication and other commercial activities. There are expectations for increased commercial activities in the coming years, which can play an important role in developing and operating observing systems in the Arctic.

(3) Data collection and dissemination. Thanks to the Copernicus programme and other satellite programmes, data collection and dissemination services develop rapidly for Earth Observation data. For the in situ component the data collection evolves much slower because deployment of observing platforms is hampered by technology, logistics, data communication and relative high cost of operating the platforms. Also data policy and accessibility to data are limiting factors.

(4) Funding mechanisms. For space data, the space agencies are funded by the governments/countries, usually with long-term budgeting that is necessary for planning and implementing space infrastructure, ground segments and data dissemination. The main funding for the in situ observations (from stations on land and ship observations at sea) comes from the nations who have responsibilities in national territories and coastal ocean areas. Observations in the central Arctic is usually funded by research programmes and is therefore challenging to sustain. EU is the largest contributor to Arctic research projects and it would be important for the sustainability if some of this funding can be allocated towards building and operating long-term observing systems.

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