



# Integrated Arctic Observation System

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### iAOS portal with user manual V2

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## EXECUTIVE SUMMARY

The INTAROS project develops an integrated Arctic Observation System (iAOS) by extending, improving and unifying existing systems in the different regions of the Arctic. Within INTAROS, WP5 (Data integration and management) develops the iAOS Portal, which provides access to selected datasets and services offered by INTAROS partners and by other Arctic data providers and service providers. This document describes the major functionality and features of this portal and how it has been implemented.

Required functionality has been identified through dialogue with users and stakeholders. The approach has been to use agile development techniques to quickly refine user needs and implement new features iteratively. Two main categories of users of the portal were identified: (1) data/service providers and (2) data/services consumers. Providers make their data or services available through the portal, and update the descriptions of these if changes are made. Consumers search for and access data or services, with sufficient descriptions (metadata) for both data and services to whether to use them in their work. The population and promotion of the iAOS Portal equally depends on data providers and consumers including service providers.

The iAOS Portal has been implemented using a leading data management system framework named CKAN (Comprehensive Knowledge Archive Network). CKAN offers a broad range of the needed features out of the box and has an active community that develops additional features (plugins) that can be added to the iAOS Portal as needed. Using the CKAN core components and mature plugins, we have implemented the following main components of the iAOS Portal:

- **INTAROS Data Catalogue**, holding descriptions (metadata) of datasets collected or generated with support from INTAROS.
- **iAOS Portal Data Catalogue**, holding metadata harvested from other catalogues offering relevant dataset for the applications under development in WP 6 of INTAROS.
- **Services and Applications**, describing services and applications developed in INTAROS and by other service providers offering products or functionality that can be exploited in WP 6.
- **Tools and Resources**, providing links to software libraries and tools, computer platforms, data systems, infrastructures and projects that offer data, information and/or software tools that can be useful for scientists and stakeholders in Arctic sciences and for local communities in the region.

The **ARCMAP** web application for mapping and assessing Arctic in situ observing systems is available through the portal. ARCMAP that was developed in a spin-off project is also part of the iAOS Portal.

The iAOS Portal will be extended with more features, data and services during the course of the INTAROS project as well as in future projects following up INTAROS and the recommendations from the INTAROS Roadmap. These projects will use the iAOS Portal as a mechanism to make their data and services known to the large network of Arctic scientists and local communities established within INTAROS. In this way, the iAOS Portal will become an important element in a Sustained integrated Arctic Observing System.

The IAOS Portal is available at <https://portal-intaros.nersc.no/>.

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## Acronyms and abbreviations

<b>ACTRIS</b>	Aerosol, Clouds and Trace Gases Research Infrastructure
<b>AMAP</b>	Arctic Monitoring and Assessment Programme
<b>API</b>	Application Programming Interface
<b>Cal/Val</b>	Calibration/Validation
<b>CBM</b>	Community-Based Monitoring
<b>CKAN</b>	Comprehensive Knowledge Archive Network
<b>CMEMS</b>	Copernicus Marine Environment Monitoring Service
<b>CS</b>	Citizen Science
<b>CTD</b>	Conductivity Temperature Depth (sensor)
<b>EMEP</b>	European Monitoring and Evaluation Programme
<b>ESA</b>	European Space Agency
<b>GAW</b>	Global Atmosphere Watch
<b>HTTP</b>	HyperText Transfer Protocol
<b>HTTPS</b>	Hypertext Transfer Protocol Secure
<b>IAOS</b>	integrated Arctic Observation System
<b>IASOA</b>	International Arctic Systems for Observing the Atmosphere
<b>ICOS</b>	Integrated Carbon Observation System
<b>ICT</b>	Information and Communication Technologies
<b>IMR</b>	Institute of Marine Research
<b>IPCC</b>	Intergovernmental Panel on Climate Change
<b>LRM</b>	low-resolution mode
<b>NASA</b>	National Aeronautics and Space Administration, U.S.A.
<b>NGO</b>	Non-Governmental Organization
<b>OGC</b>	Open Geospatial Consortium
<b>OPeNDAP</b>	Open Data Access Protocol
<b>OSSE</b>	Observing System Simulation Experiment
<b>PALAOA</b>	PerenniAL Acoustic Observatory in the Antarctic Ocean

<b>PROMICE</b>	Programme for Monitoring of the Greenland Ice Sheet
<b>SAR</b>	Synthetic Aperture Radar
<b>SAR-in</b>	SAR Interferometric
<b>SMAP</b>	Soil Moisture Active Passive
<b>SMOS</b>	Soil Moisture and Ocean Salinity
<b>SPL</b>	Sound Pressure Levels
<b>THREDDS</b>	Thematic Real-time Environmental Distributed Data Services
<b>WMS</b>	Web Map Service
<b>WPS</b>	Web Processing Service
<b>WYSIWYG</b>	What You See Is What You Get
<b>YOPP</b>	Year of Polar Prediction

## Definitions

### Application

A program or group of programs designed for end users. An application, application program or application software is a computer program designed to help people perform an activity.

### Application Programming Interface

An interface that defines how software applications can interact with each other, e.g. to exchange data or metadata, or to request services from one another. The interface can also describe interaction between software applications and hardware entities, e.g. to control how a sensor collects data.

### Cloud service

When an application software has been integrated and tested for cloud computing operations, it is deployed on production servers and made available as a “cloud service”: the application functionality can be delivered via a simple invocation interface, making the full application functionality available to others as a service of the iAOS Cloud Platform.

### Data catalogue

An inventory of metadata describing datasets and offering links to data repositories where the data themselves can be accessed. The catalogue provides search mechanisms for user defined discovery of data through e.g. free text search and selection of keywords, parameters and/or spatio-temporal coverage. In addition, a data catalogue often offers machine interfaces enabling software clients to query its metadata holdings.

### Portal

A website that is designed to bring together information from different sources and present the gathered information in a uniform manner. Information from different sources may be shown in separate areas of the portal, or combined if the information is similar e.g. georeferenced data that can be overlaid on a map.

**Service**

An application that has been implemented and thoroughly tested before being deployed in a computer network where it can be accessed by humans as well as computer programs to perform a specific functionality. The service must offer an interface that provides access to all functionality for other applications whether running on INTAROS or external computer infrastructures.

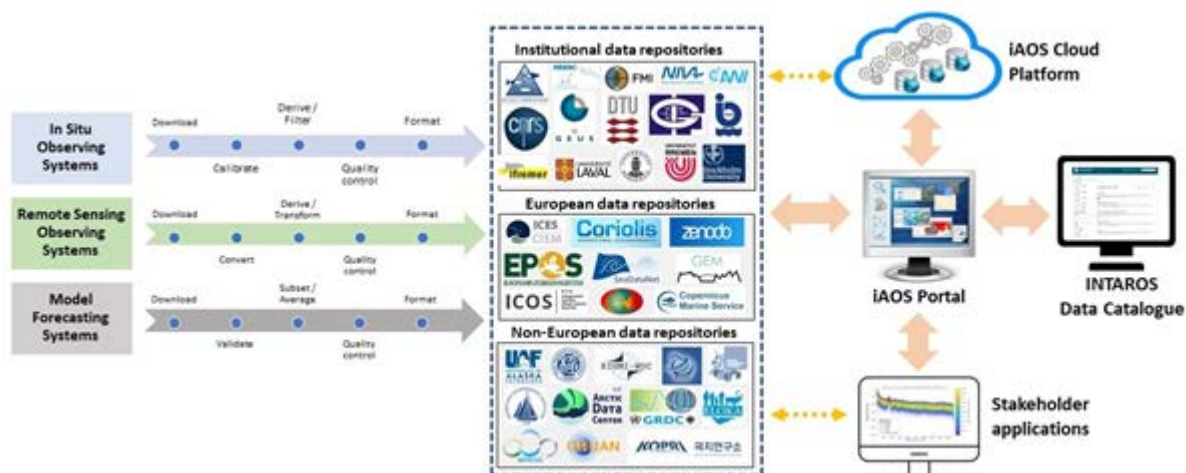
**Web service**

An application that can be accessed over a computer network using a standard protocol, such as HTTP or HTTPS for accessing services over the Internet. The web service must have an interface allowing cloud or other web services, within INTAROS or externally, to access all of its functionality through a standard interface (e.g. OPeNDAP, WPS, WMS).

# 1. Introduction

The INTAROS project develops an integrated Arctic Observation System (iAOS) by extending, improving and unifying existing systems in the different regions of the Arctic. The project has a strong multidisciplinary focus, aggregating tools for data integration from different domains like atmosphere, ocean, cryosphere and terrestrial sciences, provided by institutions in Europe, North America and Asia.

This document describes one of the components of the iAOS – the iAOS Portal. This portal provides access to selected datasets and services offered by INTAROS partners and by other Arctic data providers and service providers. The INTAROS project addresses the full data value chain from observation or simulation to delivery to users through the iAOS Portal or custom applications. All INTAROS data are stored in open data repositories with long-term funding to ensure data remain available for future use in science, public and private sectors. Figure 1.1 illustrates the data delivery chains for the major categories of data used in INTAROS: (1) in situ observations, (2) remote sensing data and (3) model simulations. Each data delivery chain is set up using established practices to process and quality control the data before preparing datasets for publication using standard formats. Datasets are stored in open data repositories enabling the iAOS Portal, iAOS Cloud Platform and applications to integrate data using standard protocols. The iAOS does not include a data repository so the applications and cloud based services must establish the link directly to the data center holding the required datasets (indicated by dotted arrows in Figure 1.1).



**Figure 1.1** Data delivery chains for integrating INTAROS data into the various iAOS subsystems.

## 1.1 Purpose and scope of the document

This document focuses on the major functionality and components of the iAOS Portal. In addition, the overall design and implementation decisions, selected datasets, applications and tools, as well as a plan for sustaining the portal, are presented. The datasets are chosen to illustrate the different categories of data made available by WP2 (extending time series of in situ data and remote sensing products), WP3 (collecting new in situ observations), WP4 (e.g. citizen science programmes) and WP6 (e.g. decadal model reanalysis), with support of the portal administrators (Task 5.6). The selected applications and tools are developed in WP5, WP6, or in some cases jointly. Their overall aim is to support scientific studies, environmental assessments, and decision-making in public or private sector, integrating data and functionality from INTAROS services into established or new workflows.

## 1.2 Users and stakeholder requirements

The key stakeholder groups in the Arctic are Science community (science teams from various disciplines); regional stakeholder groups (Europe, USA, Canada, Russia); exploitation users (service



providers, private sector users, shipping, oil and gas industry, fishing, aquaculture, recreation), assessment users like governmental agencies (AMAP, IPCC, civil society organisations, NGOs); nations (funders of observing systems) and observation providers (in situ and satellite, public and private, scientists and community members). INTAROS has an open dialogue with representatives from these key stakeholder groups, to clarify their needs for data and further development of existing observing systems, data value chains to deliver customized and well documented products, including model forecasts (Buch et al., 2017, 2019, 2021). This continued dialogue with a broad range of users and stakeholders has been carried out in WP1 (Requirements and strategy for Pan-Arctic Observing Systems). The resulting high-level requirements for data and functionality needed, included, among other improved access to observed, derived and predicted parameters, with documented uncertainties, and delivery of customised data products such as time series and indicators.

To get from these overarching requirements to specific features that could be implemented within the frames of INTAROS, the portal developers engaged with project scientists to elaborate their needs using a widely adopted technique from software engineering to capture user needs - User stories. A user story is short statement that can be used as a starting point for discussing with users to clarify their needs such as:

- As a polar scientist I want to analyse sea ice observations to support risk assessment for offshore operators
- As a climate modeller I want to access all relevant observations to validate my model
- As a policy maker I want to review all relevant observations and model projection to obtain a sound basis for making recommendation for new policies
- As a data provider I want to make my dataset visible to the Arctic scientific community
- As a data provider I want to give credit to all projects that have contributed to my data

With the user stories as basis, developers and scientists can work together to develop a joint understanding of requirements for the portal. Then, the requirements can be implemented and integrated in the iAOS portal in an iterative manner. This is a low-cost technique for capturing user requirements stepwise development of a software system.

### 1.3 Intended audience of this document

The main target audience of this document are Arctic data providers and consumers, the INTAROS Consortium Partners (especially the WP5 partners integrating processing services and the WP6 partners developing applications), projects in the EU Polar Cluster and European Commission officials working with Arctic topics.

### 1.4 Document Structure

This document is structured as follows:

**Section 1** is this introduction section. It describes the context in which the iAOS Portal has been developed, and outlines the content of the remaining sections.

**Section 2** provides an overview of the major functionality in the iAOS Portal, for the identified categories of users (data/service providers and data/service consumers).

**Section 3** describes how the iAOS Portal has been designed and implemented using the CKAN framework and a set of community plugins to provide the desired functionality for users.

**Section 4** presents the major components of the iAOS Portal. These include, among others, the INTAROS Data Catalogue and the ARCMAP application for assessment of in situ observing systems.

**Section 5** and **Section 6** present a selection of datasets and services that have been produced in the INTAROS project, respectively.

**Section 7** summarises the current capabilities of the iAOS Portal and outlines plans for further developing and maintaining the portal as an important component of a Sustained integrated Arctic Observation System.

**Appendix A** contains the user manual for the iAOS Portal.

## 2. User requirements

This section summarizes the major user requirements identified and elaborated through interaction with scientists and developers in the INTAROS consortium. Two main categories of users of the iAOS Portal were identified: (1) data/service providers and (2) data/services consumers. The user category represents all users with common requirements, e.g. all scientists that want to make their data available through the INTAROS Data Catalogue, or a developer that wants to build a new service using a geostatistics toolbox that another provider offers as a service through the portal. A particular user, on the other hand, can be a provider for some data or services, and a consumer of additional data and services.

Data providers need to make their datasets available through the iAOS Portal. This can be done either by registering their data in the INTAROS Data Catalogue or by letting the iAOS Portal harvest metadata from an interoperable data repository where they have stored their datasets together with ample metadata. In both cases, the iAOS Portal must hold sufficient metadata to allow data consumers to easily find relevant data. The metadata structure should be the same whether the dataset is registered or harvested.

Service providers must be able to promote a link to each service through the iAOS Portal, to give a short description of the service functionality, what input data it uses and what results (output data) it produces. In addition, a service provider may allow access to the software used to implement the service, enabling other providers to develop new services based on it.

Data consumers need an easy way to search for data. The search functionality should be the same whether the data are generated within INTAROS or harvested from an external data system. Typical search criteria should be supported, such as free text search (in title or summary fields), keywords and parameter names, data license and data formats offered, and organization providing the data. Service consumers need access to all service descriptions, their implementations, and software available (if any) for their own development. Since there are currently few services promoted through the iAOS Portal, there is no need for search functionality. A simple listing of the services will help consumers get an overview of available services and to assess if a given service can be useful for their purposes.

The remainder of this section highlights some of the major user requirements and the detailed needs that were identified during dialogues between users and portal developers.

## 2.1 Registration of datasets in the INTAROS Data Catalogue

All datasets generated with support from INTAROS must be registered in the INTAROS Data Catalogue. The standard metadata structure provided by CKAN fulfilled most of the needs for providing a good description of a dataset, but discussions with scientists revealed that three new fields had to be added to capture:

- Parameters contained in the dataset.
- Project(s)/Programme(s) that have contributed to data collection, processing, analysis and/or publication.
- Observing system that the dataset belongs to.

Registration of parameters contained in the dataset will facilitate richer search and thereby support reuse. Giving credit to all projects and programmes (including historical ones) is of utmost importance when INTAROS makes data available. WP2 (“Exploitation of existing observing systems”) carried out dedicated actions to “exploit” existing datasets, e.g., by extending long time series or deriving new parameters, standardizing metadata and/or data formats, before publishing the data in open data repositories. Then it is vital that all relevant contributors in the data delivery chain from observation to publication are acknowledged. Linking the datasets to the originating observing system is another way to give credit to the many initiatives, organizations, individual scientists and members of Arctic local communities that have spent significant time and resources over many years to collect key environmental parameters.

INTAROS focused on keeping the metadata schema simple to reduce the effort needed to register a dataset. A schema based on e.g., ISO 19115 would have given more information to support service development, but dataset registration would have become far more complex and time consuming. The chosen schema offered sufficient metadata for easy discovery of datasets.

## 2.2 Harvesting metadata for datasets held in external data catalogues

To make datasets registered in external data catalogues findable and accessible through the iAOS Portal, there is a need for harvesting metadata. This should result in metadata structured in the manner as for the datasets registered in the INTAROS Data Catalogue. A prerequisite for harvesting is that the data catalogue holding the datasets offer a standard metadata search and access protocol to enable a portal component (a CKAN plugin) to automatically gather the relevant metadata. In this case, the data provider need only provide the data catalogue’s harvesting endpoint and the criteria for datasets to be harvested. Based on this information, the portal administrator will set up and run the harvesting procedure. Harvesting of metadata from external data catalogues will enable users to get access to additional relevant data for e.g. the applications being developed in WP6 (“Applications of iAOS towards Stakeholders”).

## 2.3 Searching for datasets in the iAOS Portal

Data consumers need to find relevant data for their work in the INTAROS project. Thus, flexible search mechanisms are needed, including free text search (of dataset title and summary fields), combined with search for keywords, parameter names, data licenses, formats, as well as organisation owning the data. Support for multi-criteria (multi facet) search will allow users to quickly refine their search to find relevant data. The same search functionality must be available for both the iAOS Portal as well as the INTAROS Data Catalogue.

## 2.4 Promoting services and applications

Service providers can promote their services and applications in the iAOS Portal. This means providing information about the capabilities, interfaces, access point and optionally a link to source code for their services and applications. One of more examples of output produced by the service/application can also be incorporated in the description. The portal administrator will publish the provided information in the portal and include the name of the organization offering the service or application. External providers can also be allowed to promote their services/applications if these are relevant for the scientific topics and stakeholder interests addressed in INTAROS.

## 2.5 Listing tools and resources of relevance for INTAROS

There are a number of online tools, and other resources such as data systems, projects and initiatives that can potentially bring relevant data, services, tools or competences that can contribute to the development of an integrated Arctic Observation System. Thus, it is useful to compile a list of links to such tools and resources that can benefit scientists and stakeholders in Arctic sciences and for local communities in the region. The description for each tool or resource will include a name or title, what data or functionality is offered and a link to access it.

# 3. Design and implementation

The iAOS Portal provides access to datasets from INTAROS partners as well as from other data providers offering relevant data from the Arctic region. Datasets collected or exploited within the project can be searched through the INTAROS Data Catalogue, their metadata inspected, and their observations or derived values plotted or downloaded in a standard data format (when data providers support standard interfaces for data access). Datasets collected or generated by other projects, monitoring programmes and operational services can be searched through the iAOS Portal, displayed on a map and downloaded (if supported by the providers' data formats and access protocols).

Several INTAROS partners implement cloud or other web services to process and analyze data from open Arctic data systems. As these services are fully implemented with standard interfaces, the iAOS Portal will provide an access point enabling potential users to get in contact with the service providers and learn how the service can be utilized. Services offered by other providers may be integrated if they implement standard interfaces that can be used to generate data products that can be utilized in one or more of the applications of WP6.

## 3.1 High-level design of the portal and major components

Based on the identified user needs we designed five major components of the iAOS Portal:

- (1) INTAROS Data Catalogue, holding descriptions of the datasets generated and published with support from the project.
- (2) Portal Data Catalogue, harvesting dataset descriptions (metadata) from several catalogues holding data of relevance for INTAROS, including the catalogue in (1).
- (3) Services and Applications, a module to present services and applications of relevance to the INTAROS community and other Arctic scientists and stakeholders.
- (4) Tools and Resources, a module to present software libraries, training material, cloud platforms, data systems, projects, initiatives and other online resources of relevance to the INTAROS community and other Arctic scientists and stakeholders.
- (5) ARCMAP, a web application to maintain information about the Arctic in situ observing systems, and to analyze changes in observing capacity over time.

Through these components the iAOS Portal provides a gateway to a selection of relevant data, services and applications, as illustrated in Figure 3.1. In addition, the portal provides access to a set of tools and other resources that can be used in scientific studies or in development of new services and applications.

Data providers in INTAROS can use the INTAROS Data Catalogue to register the datasets they have created with support from the project. To help scientists with registering their datasets in the INTAROS Data Catalogue, detailed instructions were prepared. These instructions are included at the end of user manual for the iAOS Portal (Appendix A). This will make the datasets visible through the iAOS Portal as the metadata in the INTAROS Data Catalogue is harvested in the Portal Data Catalogue. External data providers can make their datasets visible by exposing a metadata endpoint that follows a standard protocol enabling the Portal Data Catalogue to harvest event dataset descriptions. INTAROS partners which hosts large institutional or national data centres can also make visible selected datasets from other projects and initiatives by exposing a metadata endpoint that the Portal Data Catalogue can harvest from. By means of the data access links in the dataset descriptions, users can get to the data repositories holding the data and download the whole or part of the dataset. The data access links can also be used by the different services and applications developed in the project to retrieve needed input, validation or auxiliary data.

The Services and Applications module provides information and links to software systems for data integration, processing, analysis or visualization of Arctic data. First and foremost, this module presents systems developed or enhanced with support from INTAROS. In addition, external providers may promote systems of interest of the wider Arctic scientific and stakeholder community. The systems promoted in this module, are aiming at providing needed functionality for data and service consumers.

The Tools and Resources module provides information that can be used by providers to develop new services or applications, or to build competence or find partners to do so. For a tool, this includes, among others, a short description of its purpose, current functionality, libraries or computer platforms it relies on, and a link to a website or contact email. For a general resource, this information includes, among other, a short description of its purpose, objective and/or results, as well as a link to a website or contact email.

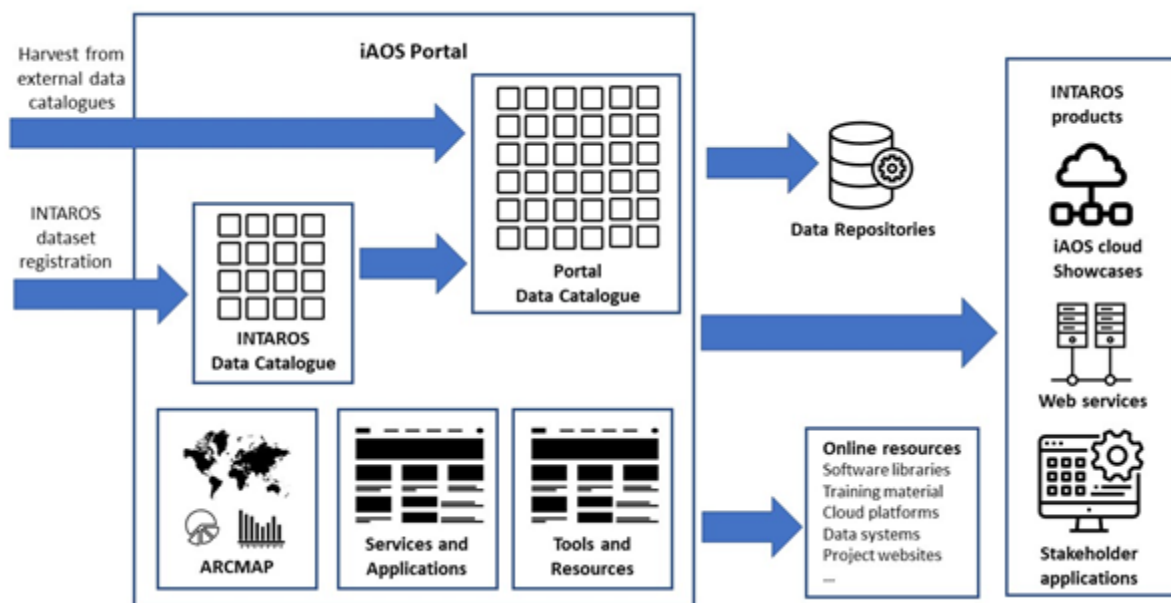


Figure 3.1 Major components of the iAOS Portal and their interconnections.

## 3.2 Overview of implementation

We have selected CKAN - the Comprehensive Knowledge Archive Network - an open-source data management platform as the basis for the iAOS Portal. CKAN is a widely used platform for management and dissemination of open geographic data. CKAN provides a number of features out-of-the-box, such as registration and update of information about datasets, organisations and themes (groups), multi-faceted search for datasets, ready-made templates for presentation of catalogue content, and a role-based user management system. In addition, CKAN provides a flexible extension mechanism that enables developers to implement new features that can draw upon the core functionality to provide customised user interfaces for entry, editing and display of geographic datasets.

Figure 3.2 illustrates the modular design of CKAN. The CKAN core has a layered architecture, where each layer provides a well-defined functionality. The Routes layer maps the incoming requests (URLs) to the correct view component that processes these requests and sends the generated response back to the connecting client (typically a web browser). The Views layer is responsible for processing incoming requests, using available functions (called actions) to read and update resources in the CKAN instance. The Views layer then provides a rendering of the result using the Jinja2 templating language for easy generation of HTML that can be shown in a web browser. This layer also contains template helper functions with simple code to modify parts of the rendering; such functions can be called by all Jinja2 templates in a CKAN instance.

The Logic layer contains so-called action functions to e.g. perform queries on, updating and validation of the resources managed by the CKAN instance, authentication, routine tasks to be run in the background, and components for business logic. The Models layer is responsible for storing all data about datasets, organisations and groups, as well as the registered users of the CKAN instance, using the SQLAlchemy Object Relational Mapper to map objects in the system to the underlying relational database (PostgreSQL). This layer also builds indexes of the registered data to facilitate and speed up queries for the registered entities. Finally, the API layer provides access to all CKAN core features through an RPC-style API, enabling external clients to call CKAN components to utilize their functionality. In this way clients can e.g. upload a series of datasets instead of registering them manually one by one through the CKAN web interface.

We have used several established and mature extensions (plugins) in the implementation of the iAOS Portal. These extensions include:

- **ckanext-spatial**: Provides support for management of geographic coordinates and spatial objects in the CKAN databases.
- **ckanext-harvest**: Enables harvesting of metadata from external repositories.
- **ckanext-nextgeossharvest**: Enables harvesting of (among others) selected CMEMS products.
- **ckanext-geoview**: Provides a visualisation component for registered datasets.
- **ckanext-pages**: Offers an easy way to generate new pages linked from the main menu, and populate them with a WYSIWYG editor.

We have also used the **FileStore** plugin, that allows for easy upload of files to the data catalogue. This allowed partners to add e.g. logos for their organisations, and plots of selected parameters or maps showing the location of observation systems for their datasets.

To cater for partner requirements to capture additional metadata for a dataset, we have implemented a small plugin that modifies the default CKAN schema. This plugin adds three new fields that enables capture of

- Parameters (names) that are contained in the dataset

- Project/Program (names) that supported data collection, processing and/or preparation for integration in iAOS.
- Observing system (name) that the dataset was collected as part of.

Additional plugins will be installed as needed to provide new functionality required by users.

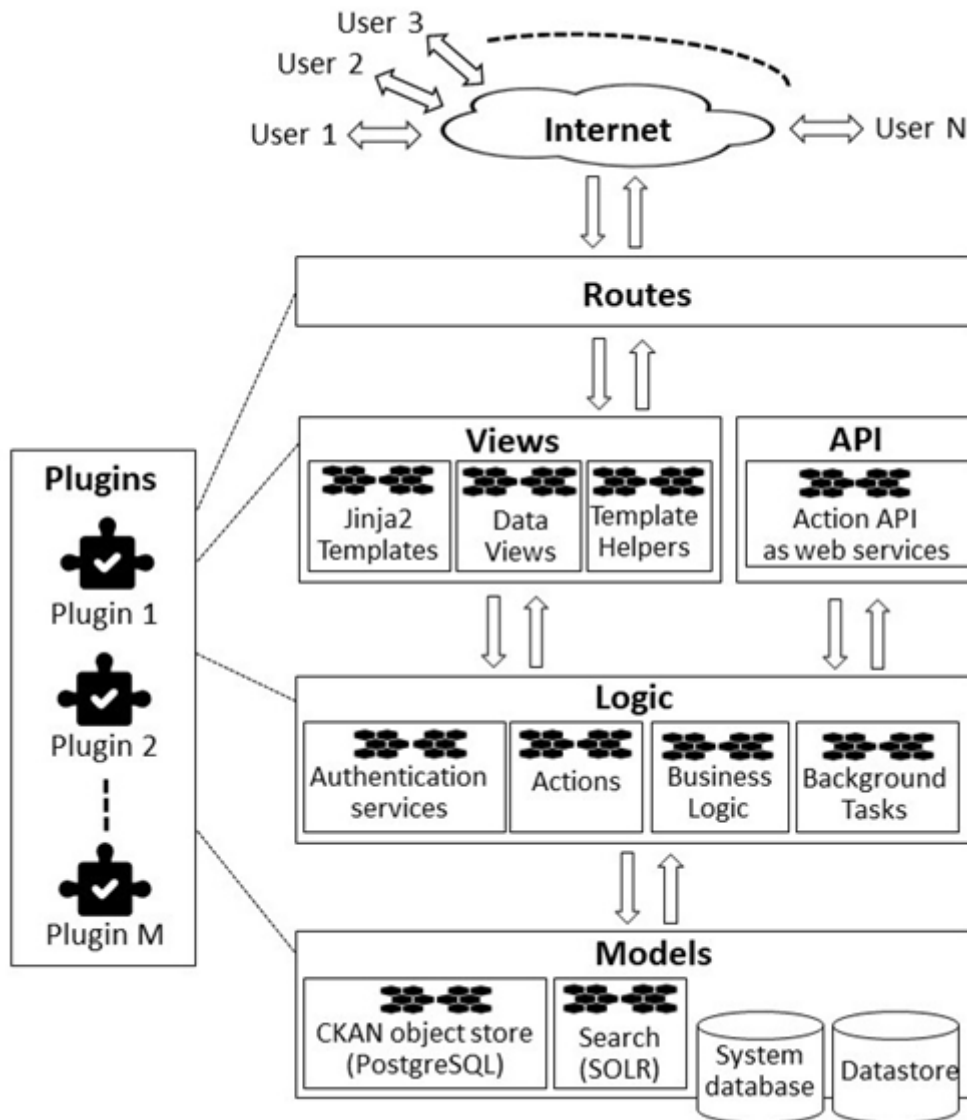


Figure 3.2. Architecture of CKAN (adapted from CKAN online documentation).

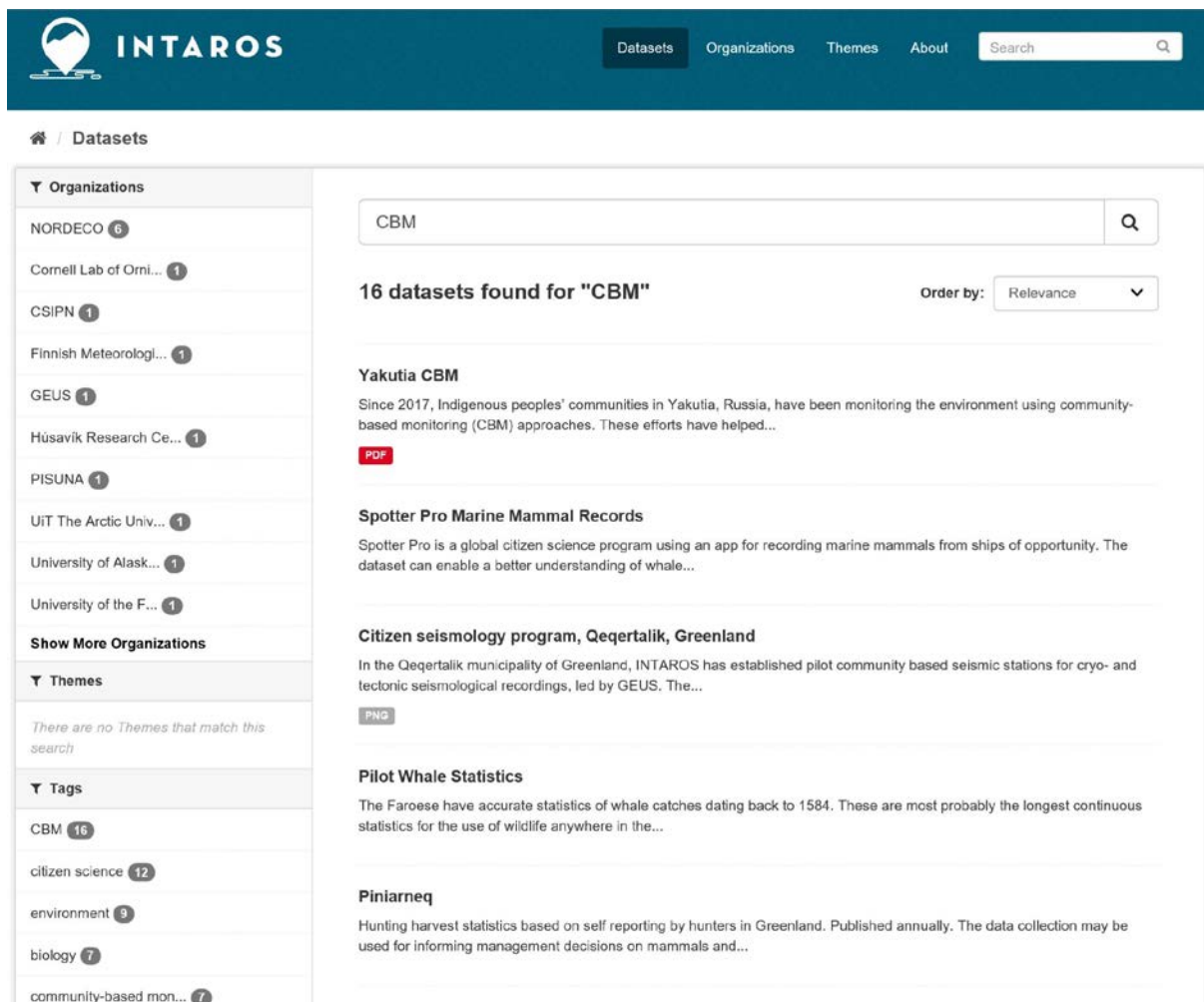
## 4. Major components of the iAOS Portal

The iAOS Portal provides a joint entry point to the datasets generated by the project and selected datasets from other Arctic data systems. In addition, the portal provides access to some of the services and applications being developed within INTAROS or in other projects. Among these are the ARCMAP application which was implemented in a spin-off project to support and sustain the INTAROS assessment of Arctic in situ observing systems and datasets.

## 4.1 INTAROS Data Catalogue

The INTAROS Data Catalogue (<https://catalog-intaros.nersc.no/>) contains descriptions of datasets that have been collected or generated by computer algorithms or models, with support from INTAROS project funding. These descriptions (metadata) provide information such as title and summary of dataset contents, names of scientists and organizations providing the data, which parameters it holds, a data license regulating how data can be reused, and a data access link. Additional resources, e.g. maps of data coverage or plots of certain parameters, can also be registered for a dataset. INTAROS partners in WP 2, 3, 4, 5 and 6 have registered the datasets they have produced or contributed to making available through collaboration with external parties (e.g. projects, local communities).

Once registered in the INTAROS Data Catalogue, the datasets can be searched through the graphical user interface of the catalogue. The search functionality is publicly available and allows for multi-faceted search on any of the following criteria: free text (e.g. in title and summary fields), keyword, data provider, license, format. Figure 4.1 shows a search for Community-Based Monitoring (CBM) data in the INTAROS Data Catalogue.



The screenshot shows the INTAROS Data Catalogue search interface. The search bar at the top contains the text "CBM". Below the search bar, the results are displayed as follows:

- 16 datasets found for "CBM"** (Order by: Relevance)
- Yakutia CBM**: Since 2017, Indigenous peoples' communities in Yakutia, Russia, have been monitoring the environment using community-based monitoring (CBM) approaches. These efforts have helped... (PDF icon)
- Spotter Pro Marine Mammal Records**: Spotter Pro is a global citizen science program using an app for recording marine mammals from ships of opportunity. The dataset can enable a better understanding of whale...
- Citizen seismology program, Qeqertalik, Greenland**: In the Qeqertalik municipality of Greenland, INTAROS has established pilot community based seismic stations for cryo- and tectonic seismological recordings, led by GEUS. The... (PNG icon)
- Pilot Whale Statistics**: The Faroese have accurate statistics of whale catches dating back to 1584. These are most probably the longest continuous statistics for the use of wildlife anywhere in the...
- Piniarneq**: Hunting harvest statistics based on self reporting by hunters in Greenland. Published annually. The data collection may be used for informing management decisions on mammals and...

On the left side of the interface, there are filters for Organizations, Themes, and Tags. The Tags filter shows "CBM" with 16 results, "citizen science" with 12, "environment" with 9, "biology" with 7, and "community-based mon..." with 7.

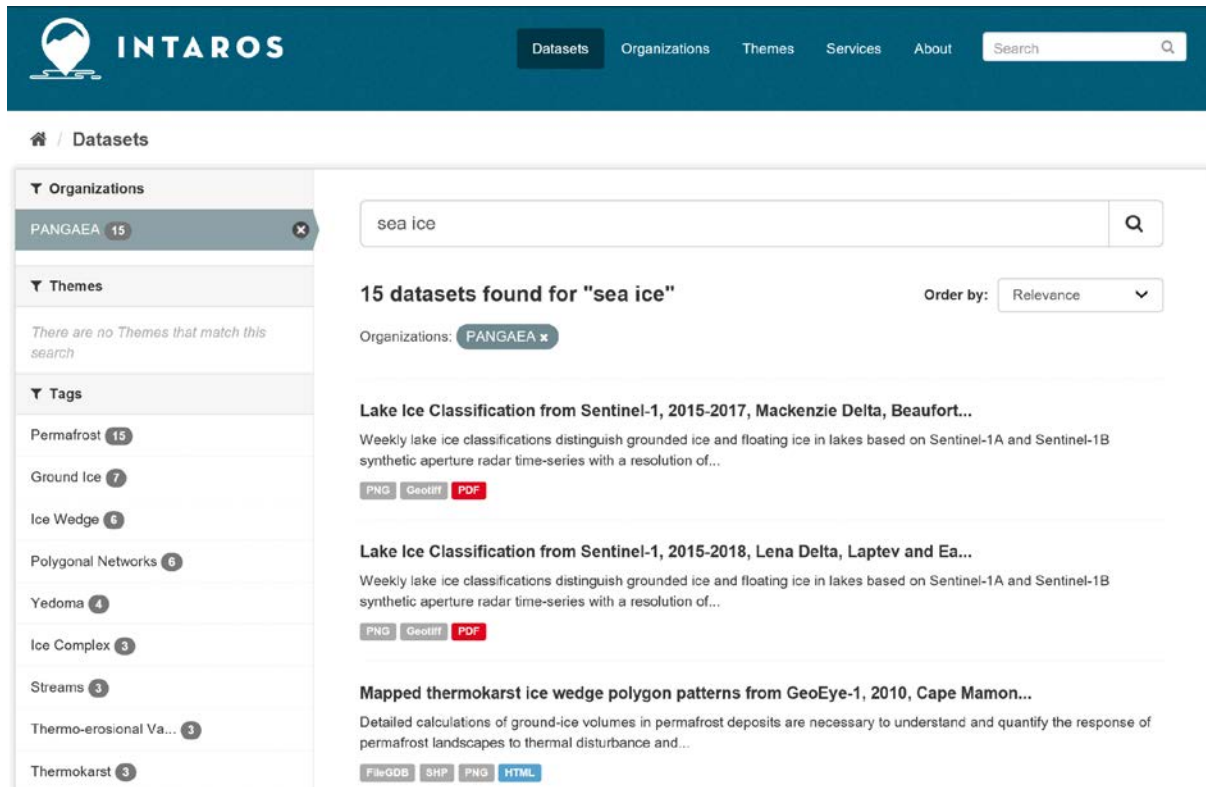
Figure 4.1 Searching for Community-Based Monitoring (CBM) data in the INTAROS Data Catalogue.

## 4.2 Portal Data Catalogue

The Portal Data Catalogue (<https://portal-intaros.nersc.no/dataset/>) harvests descriptions of datasets



from several catalogues holding Arctic data, including the INTAROS Data Catalogue. These descriptions are structured in a similar manner; hence the same search functionality is available for the iAOS portal catalogue. Since the portal catalogue holds a significantly larger number of datasets (i.e. dataset descriptions), it is often useful to combine several search facets. Figure 4.2 shows a search in the portal catalogue, first for datasets containing the words “sea ice” and then drilling down to datasets from a particular data provider or data system. This enables the user to quickly identify datasets of interest by reducing the number of entries fulfilling the search criteria to a manageable count. (Note: Only a tiny fraction of metadata entries from PANGAEA has been harvested into the iAOS Portal. For a full search of PANGAEA visit <https://www.pangaea.de/>.)



The screenshot shows the INTAROS Data Catalogue search interface. The top navigation bar includes 'Datasets', 'Organizations', 'Themes', 'Services', and 'About', along with a search input field. The main content area displays search results for 'sea ice'. On the left, there are filters for Organizations (PANGAEA 15), Themes (none), and Tags (Permafrost 15, Ground Ice 7, Ice Wedge 6, Polygonal Networks 6, Yedoma 4, Ice Complex 3, Streams 3, Thermo-erosional Va... 3, Thermokarst 3). The search results list 15 datasets found for 'sea ice', ordered by Relevance. The first two results are 'Lake Ice Classification from Sentinel-1, 2015-2017, Mackenzie Delta, Beaufort...' and 'Lake Ice Classification from Sentinel-1, 2015-2018, Lena Delta, Laptev and Ea...'. The third result is 'Mapped thermokarst ice wedge polygon patterns from GeoEye-1, 2010, Cape Mamon...'. Each result includes a brief description and available file formats (PNG, Geotiff, PDF, File-GOB, SHP, PNG, HTML).

Figure 4.2 Searching for sea ice datasets harvested from the PANGAEA repository.

### 4.3 Services and Applications

The Services and Applications module is a page-based component of the iAOS Portal. This module allows partners as well as external organizations to present services and tools that can be useful for the scientific topics or stakeholder interests addressed by INTAROS. The description of a service and tool includes a short description of its functionality, what input data it uses, what results it produces, how to access the service (e.g. service endpoint or a contact e-mail) and optionally a link to the underlying software (e.g. a GitHub repository for open source code). At the time of writing, only services and tools developed within the INTAROS project are listed, but the aim is to let external providers promote services and applications provided these have relevance for INTAROS themes. Figure 4.3 illustrates one such service for analysis of passive acoustic data developed in INTAROS. This service has been implemented using the R version of the open source PAMGuide software package (Merchant et al., 2015), and NERSC has extended support for new data formats (NetCDF) and data access through the OPeNDAP protocol. The service produces spectrograms and noise statistics plots that can be used for analysis in combination with time series of satellite remote sensing products, and has been tested with

passive acoustic data from several sources (NERSC, CNRS, PANGAEA). The service is implemented as a Jupyter Notebook which can be downloaded from <https://github.com/ec-intaros/PAMGuide-R-Tutorial>.

### Analysis of passive acoustic data

This service processes and characterizes passive acoustic data, and produces spectrograms and noise statistics plots that can be used for analysis in combination with time series of satellite remote sensing derived parameters. It is implemented using the R version of the open source PAMGuide software package, and has extended support for new data formats (NetCDF) and data access through the OPeNDAP protocol.

The service has been tested with datasets from several sources (NERSC, CNRS, PANGAEA). Figure 2 shows an example of passive acoustic collected by CNRS in Kongsfjorden, Svalbard, as part of the INTAROS field campaigns. The spectrum is dominated by low-frequency noise below 10 Hz. Local peaks around 10 Hz and 80 Hz are also seen, which could be mammal vocalization. Intermittent broad-band signals are also seen in the spectrogram. Read more about the passive acoustic service in INTAROS Deliverable D5.7.

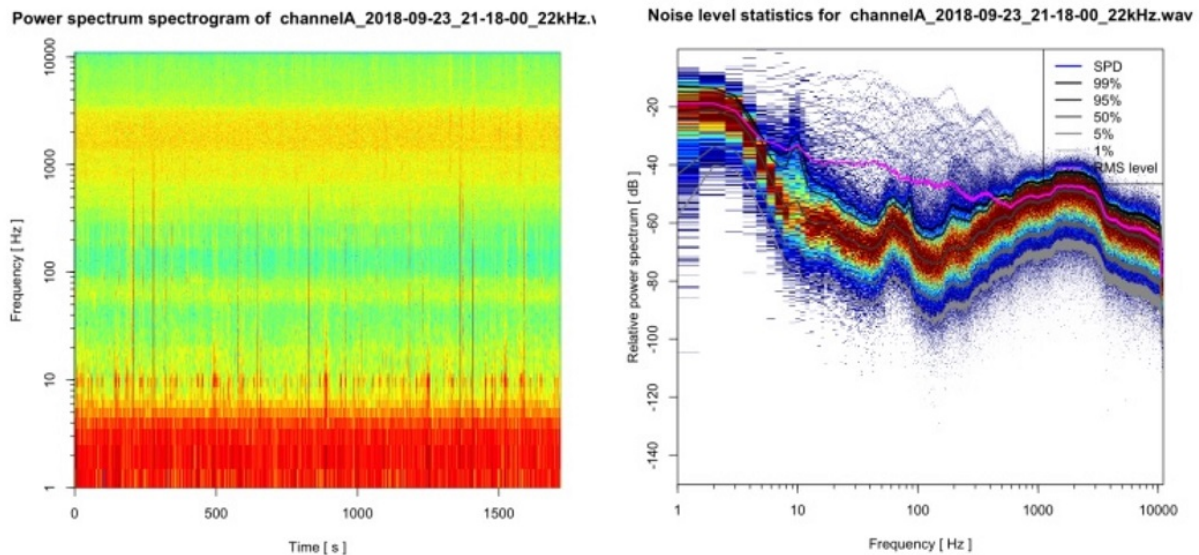


Figure 2. Examples of power spectrum spectrogram (left) and noise statistics plot (right) generated by the passive acoustic service when analysing acoustic data collected in Kongsfjorden, Svalbard, during the INTAROS project.

Jupyter Notebook files: PAMGuide-R-Tutorial

Software packages needed:


- R
- PAMGuide
- Jupyter notebook

Developer: NERSC

### Figure 4.3 Extract of service description in the iAOS Portal.

## 4.4 Tools and Resources

The Tools and Resources module is a page-based component of the iAOS Portal. This component provides a set of links to tools and other online resources such as systems, infrastructures and projects that offers data, information and/or software tools that can be useful for scientists and stakeholders in Arctic sciences and for local communities in the region. Name and (optionally) short description can be provided for each link to a tool or resource (Figure 4.4).


INTAROS

[Datasets](#) [Organizations](#) [Themes](#) [Services](#) [About](#) [Tools](#)

## Tools Edit

Geostatistical Library (RIntaros)

The RIntaros package is a library developed to facilitate easy access to a set of geostatistical methods that partners needed in several services and applications in the INTAROS project. RIntaros relies on the extensive RGeostats package (<http://cg.enscm.fr/rgeostats>), which includes a comprehensive collection of geostatistical procedures for R platform users.

RIntaros is used in several INTAROS services to interpolate in situ observations, which typically is scattered in space and time due to the high cost and/or limitations caused by harsh weather conditions in the Arctic. Figure 1 shows an example from a service where RIntaros was used to generate gridded fields of ocean temperature based on more than 20 years of CTD data.

### Temperature at 20m depth

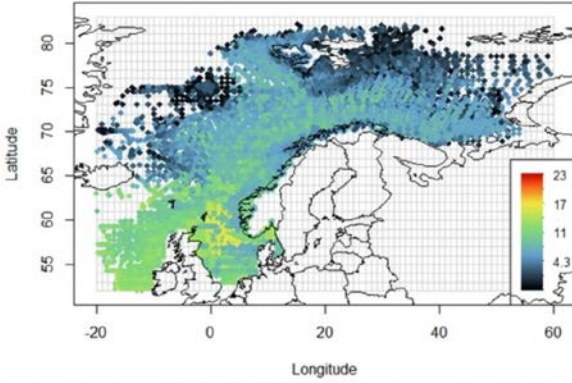


Figure 1. Temperature (°C) at 20m depth interpolated from more than 20 years of CTD data collected by research vessels operated by IMR (Renard et al., 2020).

References:  
 Renard, D., Ors, F., Caumont, H. (2020). INTAROS Deliverable D5.6 Geostatistical Library v1.

Figure 4.4 Extract of Tools and Resources page in the iAOS Portal.

## 4.5 ARCMAP application

In the first three years of INTAROS, partners conducted a survey of in situ observing systems, in situ datasets and some satellite-based products for the Arctic region to assess current observation capabilities and identify gaps (Tjernström et al., 2020). To continue and update this survey, NERSC and FMI submitted a proposal to the Norwegian Arktis 2030 research programme. After successful evaluation, the project “Marine data in the Arctic: From mapping to knowledge” was funded by the Norwegian Ministry of Climate and Environment. In this spin-off project, NERSC developed a web application called ARCMAP that enables INTAROS partners to update the information they provided in the INTAROS survey and scientists from other Arctic projects and initiatives to register and assess additional observing systems. ARCMAP stores all registered information in a database making it easy to extract summaries and generate statistics across the survey results. ARCMAP organizes a questionnaire as a set of web forms that are presented to the user in separate web pages, which can be edited and stored individually. Figure 4.5 shows the structure of Questionnaire A from the INTAROS survey. After a user has logged in, (s)he can open earlier submissions and update these or register new observation systems by creating new forms. ARCMAP links each observing system to the specific user that registered it. This ensures that a user can easily update the registered information later, e.g. when additional ocean moorings are deployed in an observing system or when a dataset has been published.



**Figure 4.5 Extract of ARCMAP survey application home page showing structure of Questionnaire A.**

ARCMAP (<https://arcmmap.nersc.no/>) offers a number of different plots and maps that can be used to assess current capacities and bottlenecks of Arctic in situ observing systems. Figure 4.6 shows two examples of plots generated automatically daily to illustrate the kind of information that can be extracted from the ARCMAP database. The upper plot of Figure 4.6 shows an overview of the geophysical domains that the observations system covers. A strong focus of ARCMAP are observations of ocean and sea ice, as many as 66 of the 115 observation systems cover the ocean and sea ice domain. The atmosphere and the terrestrial domain are covered by 32 systems each. In the INTAROS survey, the responders have been asked to list which essential parameters they observe in their system. The lower plot of Figure 4.6 presents the results as a histogram for each sphere, showing the number of observing systems addressing the different variables.

Figure 4.7 shows an overview map with the locations of some of the in situ observing systems that were assessed in the INTAROS survey. Due to the heterogeneous nature and location of observing systems, an interactive overview map in polar stereographic projection has been developed. Each observing system is plotted, and a short information “bubble” is revealed when an observing system marker is clicked. The information for the observing systems is updated once per day from the ARCMAP survey database.

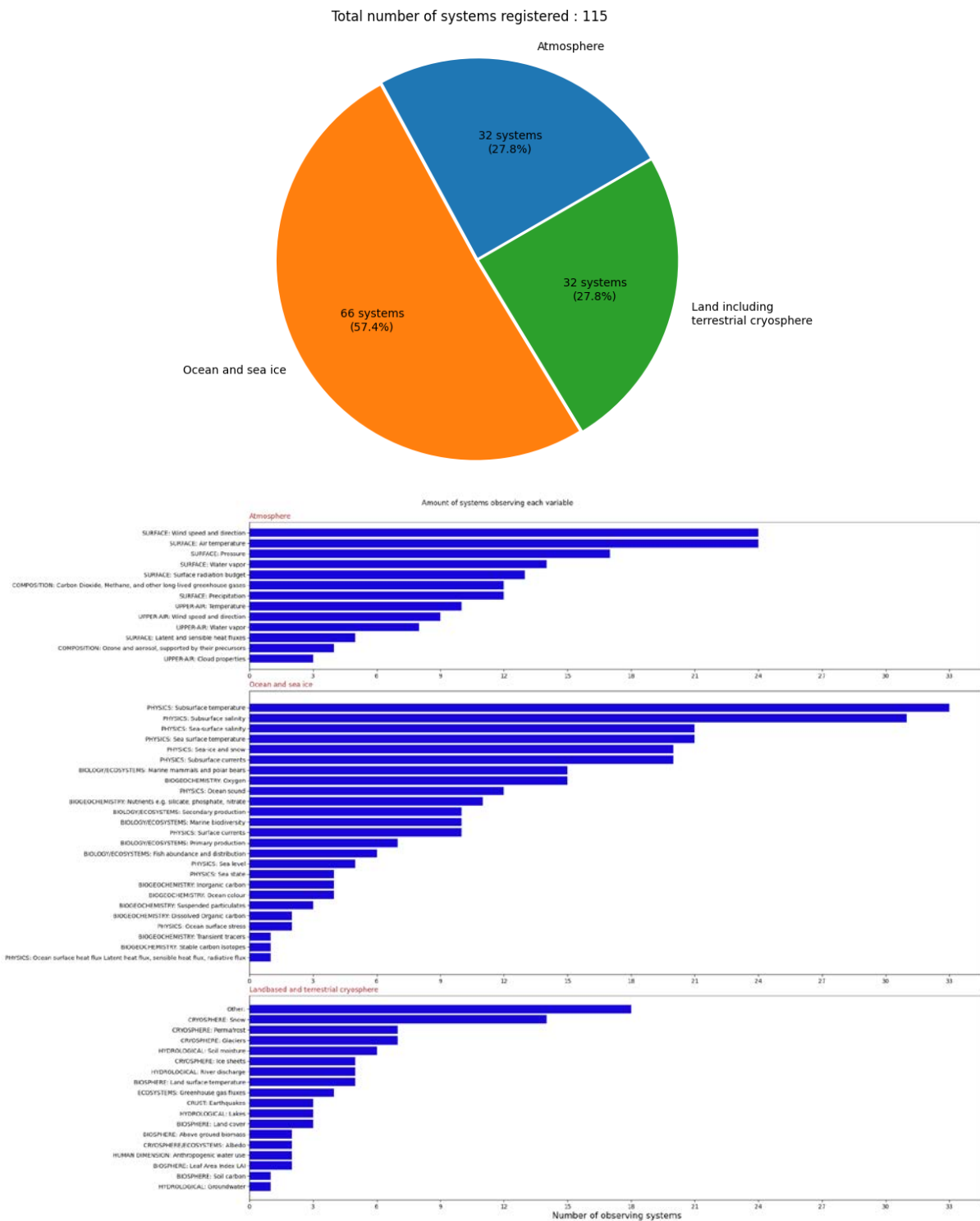
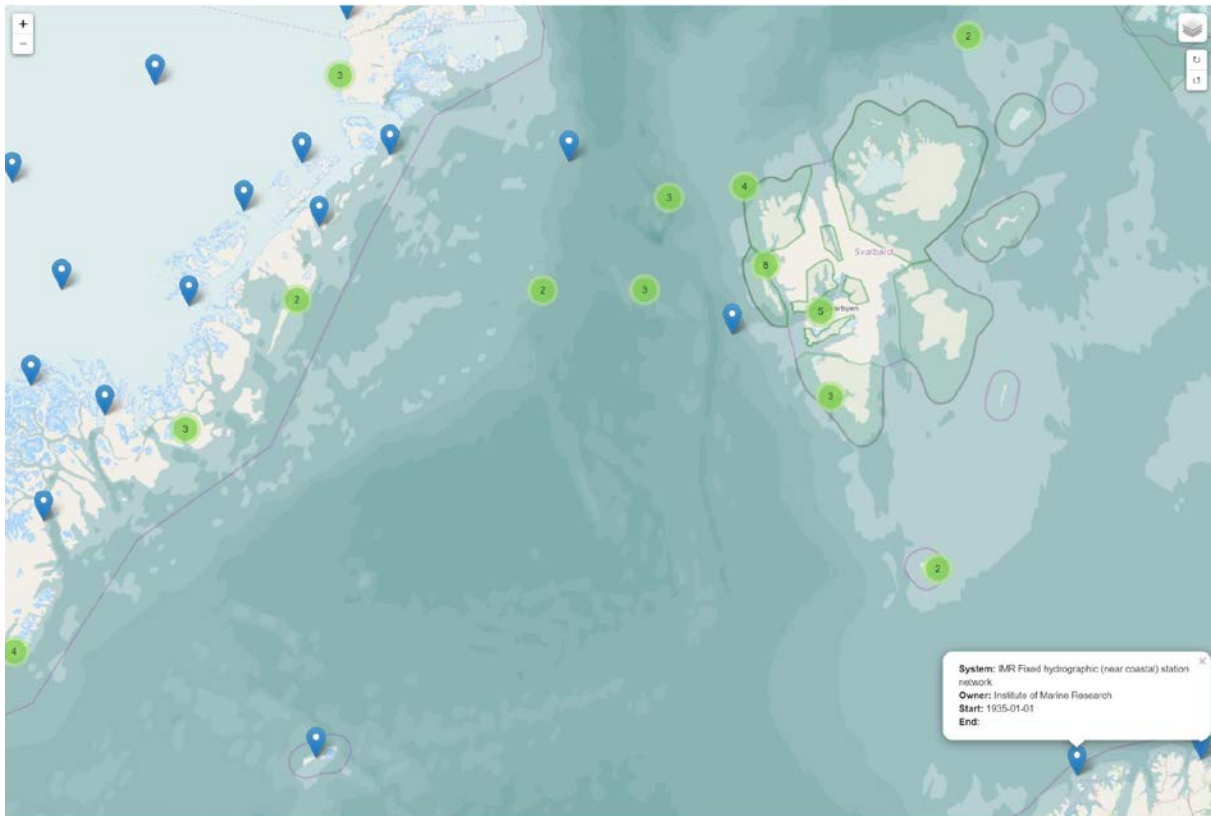


Figure 4.6 Example plots from ARCMAP: geophysical domains observed in Arctic Observing Systems (top), frequency of parameters measured by the in situ observing systems (bottom).



**Figure 4.7** Location of some of the individual stations, ocean moorings and other point-based in situ observing systems in ARCMAP.

## 5. Examples of datasets registered in the INTAROS Data Catalogue

The INTAROS Data Catalogue holds descriptions of new and exploited data sets. New observations are collected, and processed with support from the project. The term “exploited” data is used for existing data that have been collected in earlier projects. The new and existing data has been prepared for publication in an open data repository with support from INTAROS. Processing and enhancing existing data was performed in WP2 (Sagen et al., 2018; Asmi et al., 2018; Ahlstrøm et al., 2018). New observations were collected, processed and formatted in WP3 (Ahlstrøm et al., 2019; Johannessen et al., 2019; Solwedel et al., 2019; Zenone et al., 2019; Beszczynska-Möller et al., 2019) and in WP4 (Danielsen et al., 2018; Danielsen et al., 2020b). Model data were produced in WP6 (Lyu et al., 2020).

The INTAROS Data Catalogue includes in situ data, remote sensing products, model output as well as CBM and CS data. To prepare each dataset, the INTAROS partners have worked within their respective organizations or in collaboration with other partners, projects or initiatives. This work typically included activities such as data processing, quality control, documentation and formatting. The resulting datasets are ingested into an open data repository for long term storage and then registered in the INTAROS Data Catalogue.

The datasets registered in the INTAROS Data Catalogue are heterogeneous with large variations in, among others, sampling frequency, spatial resolution and coverage, duration and parameters contained. Furthermore, INTAROS partners work within many themes, which can be grouped into the different spheres of Earth System Sciences: atmosphere, ocean and sea ice, land and terrestrial

cryosphere. Table 5.1 shows the distribution of datasets across the spheres, and what the data generation mechanism has been. The majority of datasets contain ocean or sea ice parameters, in most cases collected by different kinds of in situ sensors. This is due to the strong focus of INTAROS to improve and extend existing in situ observing systems to contribute to filling gaps in in situ measurements of important environmental parameters. In situ observations are also dominant in the other two spheres.

While most datasets fall within a single sphere there are also some the contain parameters from multiple spheres. For instance, the CBM dataset entitled «[Piniarneq](#)» contains Greenlandic hunting statistics for both marine and terrestrial species (e.g. fish, seals, reindeers). Thus, this dataset falls within two spheres “ocean and sea ice” and “landbased and terrestrial cryosphere”, even if all data on harvested species are provided through the same CBM program. Other datasets combine multiple data categories (i.e. generator mechanisms) in the same dataset. As an example the dataset entitled «[Integrated AARI map of the state of the Kara Sea ice cover...](#)» combines remote sensing imagery and in situ observations of sea ice to produce a best quality map of sea ice conditions in a regions. Consequently the mapping from data category to sphere as shown in Table 5.1 is not 1:1, and the total number of registered datasets in the INTAROS Data Catalogue by 31 May 2021, is 137.

**Table 5.1 Number of data categories for each sphere in the INTAROS Data Catalogue (31 May 2021).**

Data category	Atmosphere	Ocean and sea ice	Landbased and terrestrial cryosphere	Total
In situ	18	65	18	101
Remote sensing	1	14	5	20
CBM and CS	1	9	7	17
Models	0	6	2	8
Total	20	94	32	146

Making INTAROS datasets available through the INTAROS Data Catalogue has been a focus in the project. The remainder of this section will present a few datasets to illustrate the broad range of themes addressed in the project, and the different data categories. For an updated view of the current datasets the reader should visit <https://catalog-intaros.nersc.no>. The catalogue will continue to be updated with descriptions of new datasets as these become available.

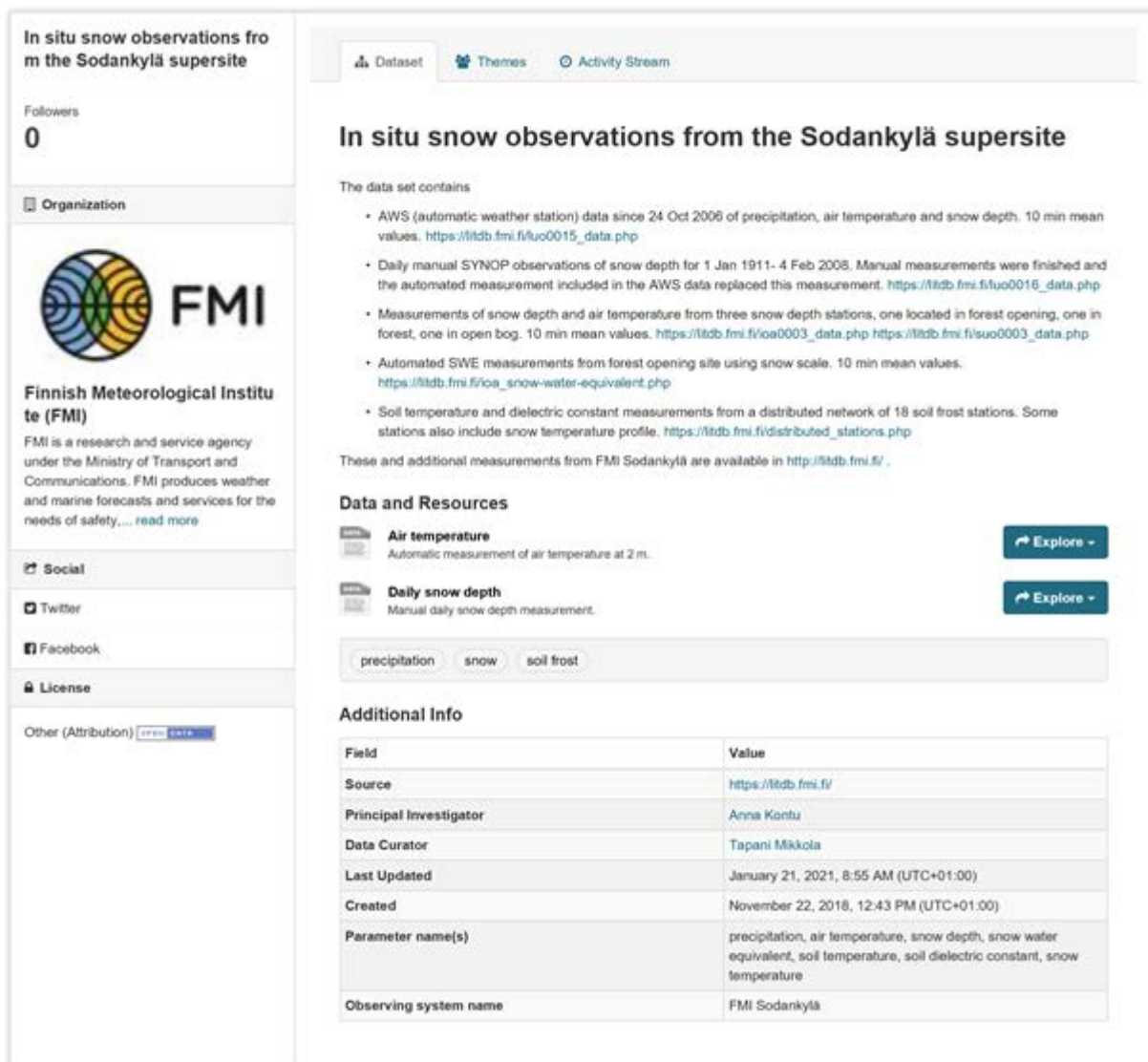
### 5.1 In situ datasets (historical and INTAROS field campaign)

One of the datasets made available as part WP2 is the in situ snow observations from the Sodankylä supersite in northern Finland (Figure 5.1). This is an extensive dataset from a national observing station hosting numerous sensors collecting a broad range of in situ snow, soil, ecosystem and atmospheric parameters. FMI has operated Sodankylä for a long period of time, and the longest available time series (snow depth) runs for more than 97 years. The site is part of integrated atmospheric networks such as

GAW, ACTRIS, ICOS, IASOA and EMEP. Data from the various sensors operated at this supersite are available from the Arctic Space Centre at FMI and through the portals of the thematic networks. Data access links to specific time series are provided in the registered metadata, and plots for a few of the measured parameters are provided in the INTAROS Data Catalogue (Figure 5.2).

Because of its unique, multidisciplinary and collocated measurements, the Sodankylä supersite is a Cal/Val site for the NASA SMAP and ESA SMOS missions representing the boreal forest zone. Moreover, Sodankylä datasets from the Intensive Observing Periods of the Year of Polar Prediction (YOPP) have been formatted into netCDF files called Merged Observatory Data Files to enable a direct intercomparison with process-based evaluation and verification of numerical weather prediction and climate models (INTAROS Task 5.3). These datasets have been used by members of the EU H2020 project APPLICATE to improve the snow representation and the forecast of near surface temperature over the Arctic (Arduini et al., 2019).

Catalogue entry: <https://catalog-intaros.nersc.no/dataset/in-situ-sodankyla>

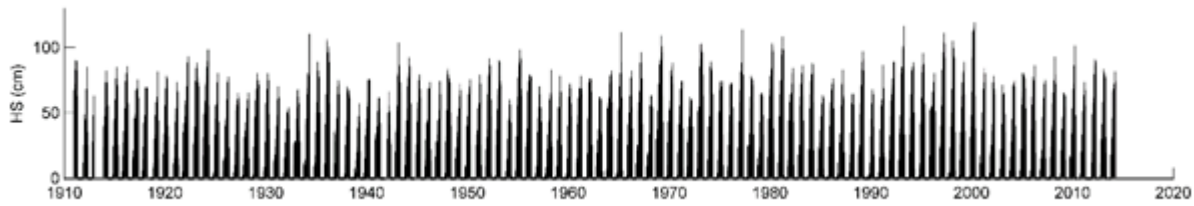


The screenshot shows a web interface for a dataset. On the left is a sidebar with the title 'In situ snow observations from the Sodankylä supersite', 0 followers, and the organization 'Finnish Meteorological Institute (FMI)'. The main content area has the same title and a description of the data set containing AWS data, manual snow depth observations, and soil temperature measurements. It lists 'Data and Resources' like 'Air temperature' and 'Daily snow depth'. At the bottom, there is an 'Additional Info' table.

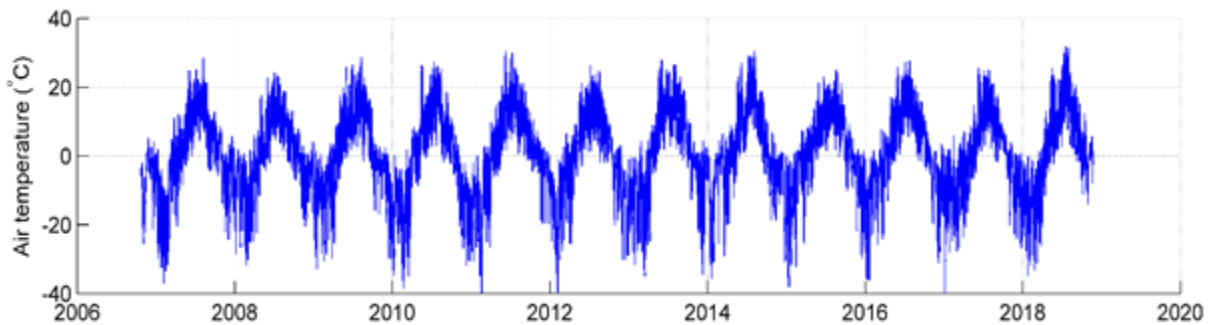
Field	Value
Source	<a href="https://itdb.fmi.fi/">https://itdb.fmi.fi/</a>
Principal Investigator	Anna Kontu
Data Curator	Tapani Mikkola
Last Updated	January 21, 2021, 8:55 AM (UTC+01:00)
Created	November 22, 2018, 12:43 PM (UTC+01:00)
Parameter name(s)	precipitation, air temperature, snow depth, snow water equivalent, soil temperature, soil dielectric constant, snow temperature
Observing system name	FMI Sodankylä

Figure 5.1 Metadata for in situ snow observations from the Sodankylä supersite provided by FMI.





Manual daily snow depth measurement.



Automatic measurement of air temperature at 2 m.

**Figure 5.2** Plots of selected data from the Sodankylä supersite.

Partners in WP3 have collected a number of datasets from the targeted regions in the Arctic. Among these, a dataset containing passive acoustic data from Kongsfjorden, Svalbard, in September 2018, has been registered in the INTAROS Data Catalogue (Figure 5.3). This dataset is one of several passive acoustics datasets collected by CNRS at the entry of Kongsfjorden, where a system of autonomous recorders were deployed at several times during the INTAROS project (Figure 5.4). These deployments extend the time series from the Kongsfjorden passive acoustics observing system which was initiated in 2013. The 2018 dataset is available from the DATARMOR data server operated by IFREMER-France.

Passive acoustic monitoring allows to assess sound pressure levels (SPL) through different sampling periods and within different frequencies bandwidths to assess noise level evolution through time. The SPL can be explained by the number of boats within a 30 km range area (based upon the maximum distance in the fjord from the hydrophone) and by the distance of the nearest boat from the hydrophone. A regression per number of vessels within a 30 km range (from 1 to 8) explains the SPL according to the distance of the nearest boat from the hydrophone (Fig.5.5). This preliminary analysis seems to reveal an additive effect of the number of boats in the area and the distance to the nearest boats (Fig.5.5). Additionally, marine mammals are also recorded on hydrophone, and more frequently bearded seals sound, since a colony is present in the Kongsfjorden. These sounds could last from a few seconds to 1 minute and are produced between 0.1-6 kHz. A tonal sound detector was implemented based upon an energy detection and upon a contouring detection of the energetic event previously found. This method should allow detecting seal occurrence on the recordings.

Catalogue entry: <https://catalog-intaros.nersc.no/dataset/passive-acoustic-data-from-kongsfjorden-svalbard-september-2018>

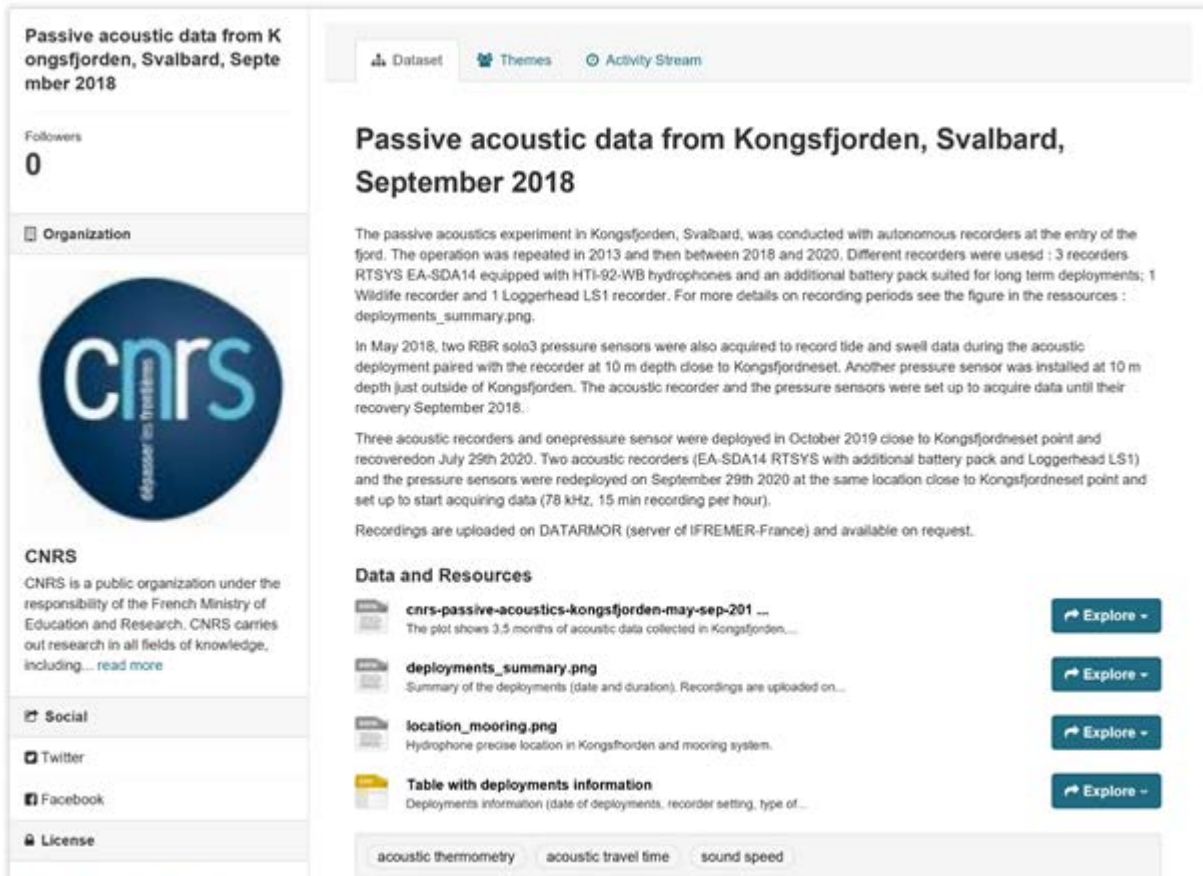


Figure 5.3 Metadata for passive acoustic data collected in Kongsfjorden, Svalbard, by CNRS.

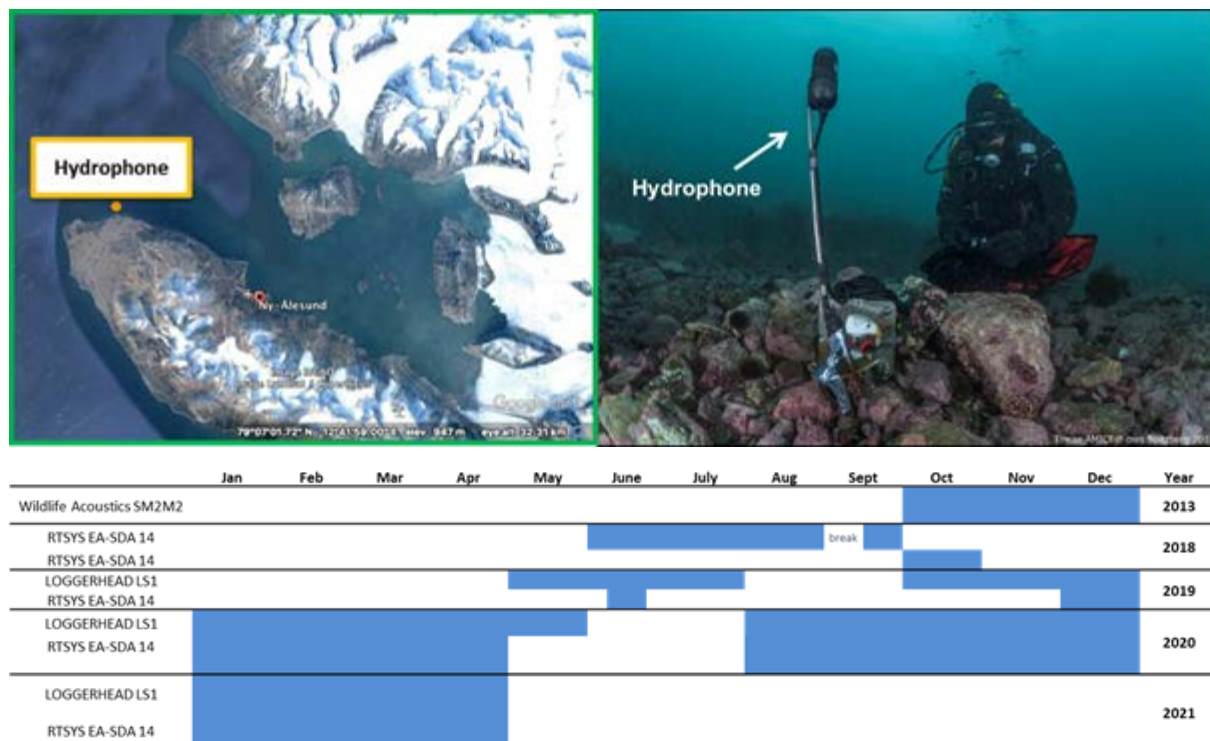
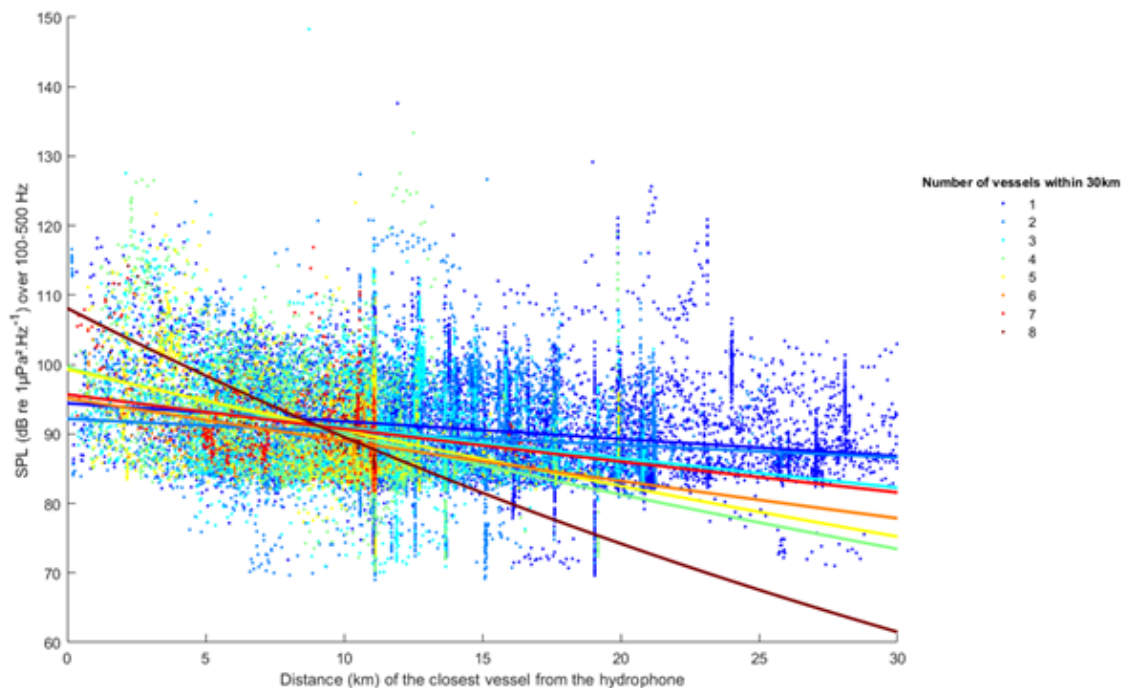


Figure 5.4 CNRS passive acoustic observing system at the entry of Kongsfjorden, Svalbard. Upper: Location of the observing system at the entry of the fjord; photo of hydrophone with batteries and data storage unit mounted on the seafloor. Lower: duration of the passive acoustics datasets from different deployments prior to and during the iNTAROS project.



**Figure 5.5** Linear regressions of the SPL according to the distance of the closest vessel from the hydrophone. One regression was assessed for each number of vessels within the area (from 1 to 8).

## 5.2 CBM and CS datasets (seismic activity monitoring)

INTAROS is working closely with several local communities and citizen science programs across the Arctic. In one of these programs, INTAROS partners NORDECO and GEUS are collaborating with communities in Disko Bay, Greenland, to collect information on seismic activity. A pilot program with seismic stations operated by fishermen and hunters has been established, where they have installed seismographs on rocks below their houses (Figure 5.6). The data collected feeds into the Raspberry Shake Community<sup>1</sup> and the GEUS' earthquake bulletin<sup>2</sup>. A community data portal (Figure 5.7) gives access to the seismic data from this community.

To establish citizen science programs such as the seismology program in Disko Bay, Greenland, trusted relationships exist between government agencies, scientists and the local residents (Danielsen et al., 2020a). Citizen seismology programs may be useful in Arctic communities where buildings are constructed on bedrock enabling installation of low-cost instruments under the houses with easy access to electricity. Such programs may help build community awareness of natural hazards and contribute to improved decisions on safety, if seismic events detected by the installed geophones are discussed within the communities as well as within the authorities. The knowledge and data gained from the operation of the seismic stations, are used for the policy brief on natural disasters (WP4) and to monitor and map earthquakes, cryo-generated events and potential landslides, in the Disko Bay area (WP6).

Catalogue entry: <https://catalog-intaros.nersc.no/dataset/citizen-seismology-program>

<sup>1</sup> <https://raspberrysshake.org/about/>

<sup>2</sup> <https://www.geus.dk/natur-og-klima/jordskaelv-og-seismologi/registrerede-jordskaelv-i-groenland/>



Gerth Olsen, Akunnaaq, with a seismograph before connecting it to electricity and a router and placing it on the rock below his house. Photo: F. Danielsen.

Figure 5.6 A seismology sensor installed in the Qeqertalik municipality, Greenland.

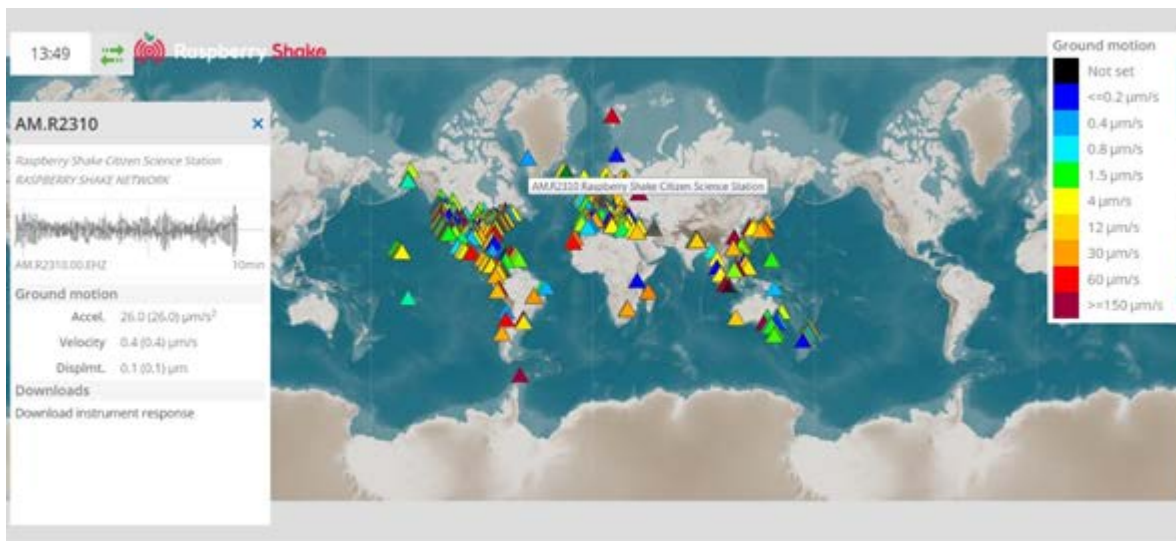


Figure 5.7 Raspberry Shake Community data portal showing seismic stations operated as part of the CBM program (source: <https://raspberrysshake.net/stationview>).

### 5.3 Remote sensing based products (ice velocity maps of Greenland ice sheet)

Within INTAROS, GEUS has extended and improved the generation of ice velocity maps for the Greenland ice sheet based on Synthetic Aperture Radar (SAR) data from the two Sentinel-1 satellites of the Copernicus programme. These maps cover the Greenland Ice Sheet margin (and the interior when data is available) with a grid resolution of 500 m (Figure 5.8). Each product is a mosaic produced of all 6 and 12-day image-pairs available. A new product is produced every 12 days. The work on preparing this dataset started in WP2 (Ahlstrøm et al., 2018) and has continued in WP6. Dataset is available from GEUS Dataverse system and is part of the PROMICE network.

The high temporal resolution ice velocity product is used as input to an operational product estimating solid ice discharge from all marine terminating glaciers in Greenland in INTAROS task 6.4 (“Natural hazards in the Arctic”). Solid ice discharge is one of the necessary components when calculating the total mass balance of the ice sheet using the input-output method. Solid ice discharge from marine terminating glaciers is also of interest for users working with marine eco systems, because the icebergs are a source of freshwater to the fjords and oceans. The time series of ice velocity mosaics are also used by researchers interested in the dynamics of glaciers.

Catalogue entry:

<https://catalog-intaros.nersc.no/dataset/ice-velocity-maps-of-the-greenland-ice-sheet-margin-based-on-sentinel-1-data>.

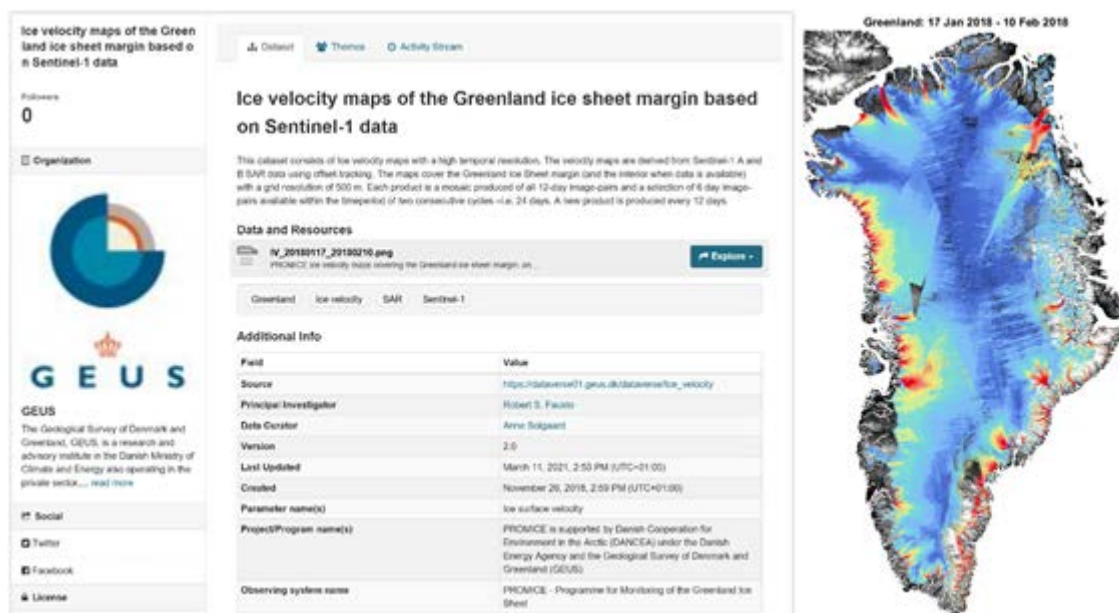


Figure 5.8 A Sentinel-1 derived sea ice velocity dataset of the Greenland ice sheet from GEUS.

## 5.4 Model products (sea ice reanalysis)

In WP6, UHAM conducted a series of Observing System Simulation Experiments (OSSEs) to form the basis for an evaluation of the capacity of the existing Arctic Ocean observing systems (Lyu et al., 2021a,b; Lyu et al., 2020) and how to further complement the Arctic Ocean observing system in the future. Subsequently, a 10-year ocean-sea ice synthesis was produced by assimilating all available observations into a coupled ocean-sea ice model using the adjoint method. This dataset contains a 10 year (2007-2016) long reanalysis of important ice-ocean parameters, including, among others, ocean potential temperature, salinity, sea surface height, sea ice thickness, sea ice concentration and sea ice drift (Figure 5.9). The data are available from the NERSC THREDDS data server. Figure 5.10 shows the locations of the assimilated in situ data, illustrating the sparseness of in situ data in the Central Arctic Basin.


Compared with filter-based Arctic ocean-sea ice synthesis, the new dataset is dynamically consistent without introducing mass and energy discontinuities. It could be used for understanding causes of the rapid sea ice changes, and contributions from ocean and atmosphere. Moreover, the dataset provides daily ocean temperature and salinity for the acoustic model in Task 6.3 (“Ice-ocean statistics for decisions support and risk assessment”).

Catalogue entry: <https://catalog-intaros.nersc.no/dataset/ocean-sea-ice-synthesis-from-2007-2016>.

**Ocean-Sea Ice Synthesis from 2007-2016**

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## Ocean-Sea Ice Synthesis from 2007-2016

Using MITgcm and its adjoint model, we assimilate all available observations to produce this synthesis. The model covers the entire Arctic Ocean, north of Bering Strait and ~44N in the Atlantic Ocean. The data assimilation are performed with 3 chunks: 2007-2010, 2010-2013, 2013-2016, with a one year overlap. Daily mean state of the model parameters are provided. The data could be used for exploring the 3-D Arctic Ocean variability and mechanisms. It could also be used to explain the observed variability since all state variables are supplied. Details are in <http://doi.org/10.1002/qj.4002>

**Data and Resources**

Model domain and available profiles in the ... Explore -

ocean salinity
ocean temperature
sea ice

**Additional Info**

Field	Value
Source	<a href="http://thredds.nersc.no/thredds/gecco/catalog.html">http://thredds.nersc.no/thredds/gecco/catalog.html</a>
Principal Investigator	Detlef Stammer
Data Curator	Guokun Lyu
Last Updated	March 15, 2021, 6:12 AM (UTC+01:00)
Created	April 3, 2020, 11:55 AM (UTC+02:00)
Parameter name(s)	Ocean potential temperature, salinity, zonal and meridional velocity, Sea surface height, Sea ice thickness, Sea ice concentration, Sea ice drift, Momentum, freshwater, and heat fluxes at the sea surface
Project/Program name(s)	INTAROS
Observing system name	MITgcm model assimilate all available observations (see <a href="http://doi.org/10.1002/qj.4002">http://doi.org/10.1002/qj.4002</a> )

Figure 5.9 Ice-ocean reanalysis dataset from UHAM assimilating all available in situ observations to produce this synthesis.

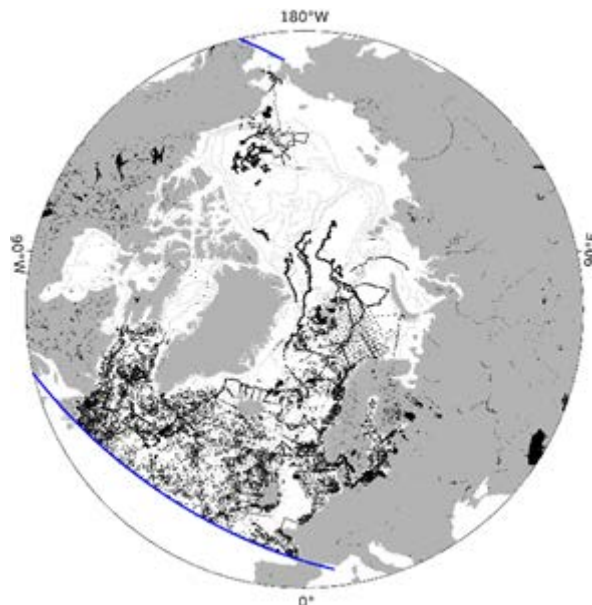


Figure 5.10 Map of location of in situ data assimilated into the GECCO model when generating the 10-year ice ocean synthesis.

## 6. Examples of developed services, applications and tools

This section presents some of the services, applications and tools developed or enhanced with support from INTAROS. The aim is to give a short overview of the purpose and functionality of each of these, what libraries they depend on (if any), and links to accessing them and optionally their source code. New services, applications and tools will be added to the modules “Services and Applications” and “Tools and Resources” as the project moves forward. Hence, the reader is referred to:

- <https://portal-intaros.nersc.no/services>
- <https://portal-intaros.nersc.no/pages/tools>

for an updated overview.

### 6.1 iAOS Service: Acoustic data analysis (C-PAD)

The iAOS Service Characterization of Passive Acoustic Data (C-PAD) enables users to analyze and present passive acoustic data. The service can be used to generate spectrograms and noise level statistics to support detection and classification of different sources of noise pollution in the ocean. The C-PAD service is developed using the R version of PAMGUIDE (Merchant et al., 2015), a widely used software package for analysis of passive acoustics data. PAMGUIDE supports the WAV format for acoustic data, and in the Matlab version also the proprietary Matlab (.mat) format. In INTAROS, NERSC has implemented support for reading acoustic data from NetCDF files in the R version of PAMGUIDE.

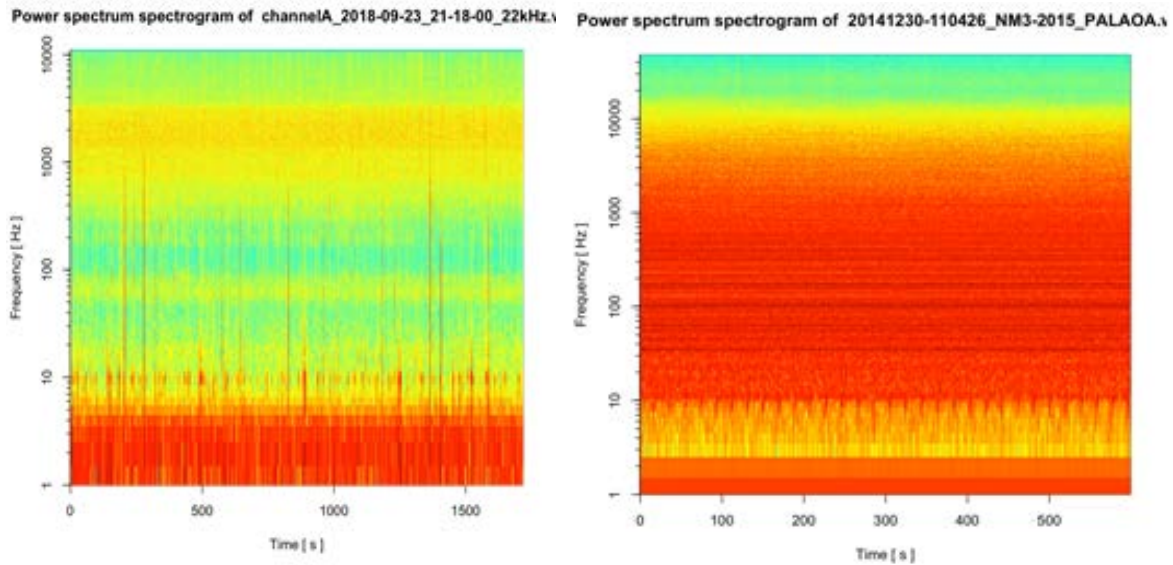
Within INTAROS, the service is used in Task 6.3 (“Ice-ocean statistics for decisions support and risk assessment”) to process and analyze passive acoustic data collected within the project and obtained from other projects. Figure 6.1 (left) shows the spectrogram for an acoustic recording collected during the INTAROS project in September 2018 (Chauvaud et al., 2020). The spectrum is dominated by low-frequency noise below 10 Hz. Local peaks around 10 Hz and 80 Hz are also seen, which could be mammal vocalization. Intermittent broad-band signals are also seen in the spectrogram. Figure 6.1 (right) shows the spectrogram and noise statistics for an acoustic recording collected at PALAOA (Kindermann, 2013). This recording is very stable throughout the 10 minute recording period. Peaks are seen from 40 Hz to 400 Hz, but are difficult to identify without further analysis.

The C-PAD service is implemented in a Jupyter notebook (Caumont et al., 2019) as part of Task 5.5 (“Integration of new processing services”). This notebook can be used by other scientists, either as is or as basis for new services. The notebook can also be suitable for students that want to learn about acoustic data analysis and the widely used PAMGuide library.

Source code and documentation on how to use the service is available from:

- <https://github.com/ec-intaros/PAMGuide-R-Tutorial>

Service developer: NERSC (<https://www.nersc.no/>)



**Figure 6.1 Spectrograms generated by the C-PAD Service. Left: Passive acoustic data collected in Kongsfjorden, Svalbard (see section 5.1). Right: Passive acoustic data from the PALAOA observatory in Antarctica (<https://doi.pangaea.de/10.1594/PANGAEA.773610>).**

## 6.2 iAOS Service: Time Series of Conductivity-Temperature-Depth (TS-CTD)

This service demonstrates access and analysis of time series of CTD data using the OPeNDAP standard, which is widely used by data centres and infrastructures world-wide. Based on the data retrieved, the service can generate different kinds of plots to visualize the location of the observations (Figure 6.2) or the different parameters contained (Figure 6.3). In Figure 6.2, the two letter platform code indicates the research vessel from which the CTD data were collected (e.g. 'AA' represents the Norwegian research vessel Håkon Mosby owned by IMR). Clicking on one of the markers will provide information about the location of collected data. Before plotting the data, a set of filters can be applied to extract a subset, e.g. data within a user defined bounding box and selected parameter(s), optionally combined with time filters. Figure 6.3 shows an example of a plot generated after applying data filtering and extracting a subset of CTD data from a single research vessel. Data can also be aggregated across *all* observing platforms to fill gaps in space or time before being plotted.

The TS-CTD service is implemented in a Jupyter notebook (Caumont, 2021) as part of Task 5.5, and relies on the xarray Python package for data analysis and plotting. The notebook can be used by scientists or service developers to familiarize with data access through the OPeNDAP standard. It demonstrates data access through two of the most commonly used OPeNDAP implementations: the THREDDS data server and the Hyrax data server.

Source code and documentation on how to use the service is available from:

- <https://github.com/ec-intaros/opensdap-xarray-use-cases>

Service developer: TDUE ([www.terradyne.com](http://www.terradyne.com))



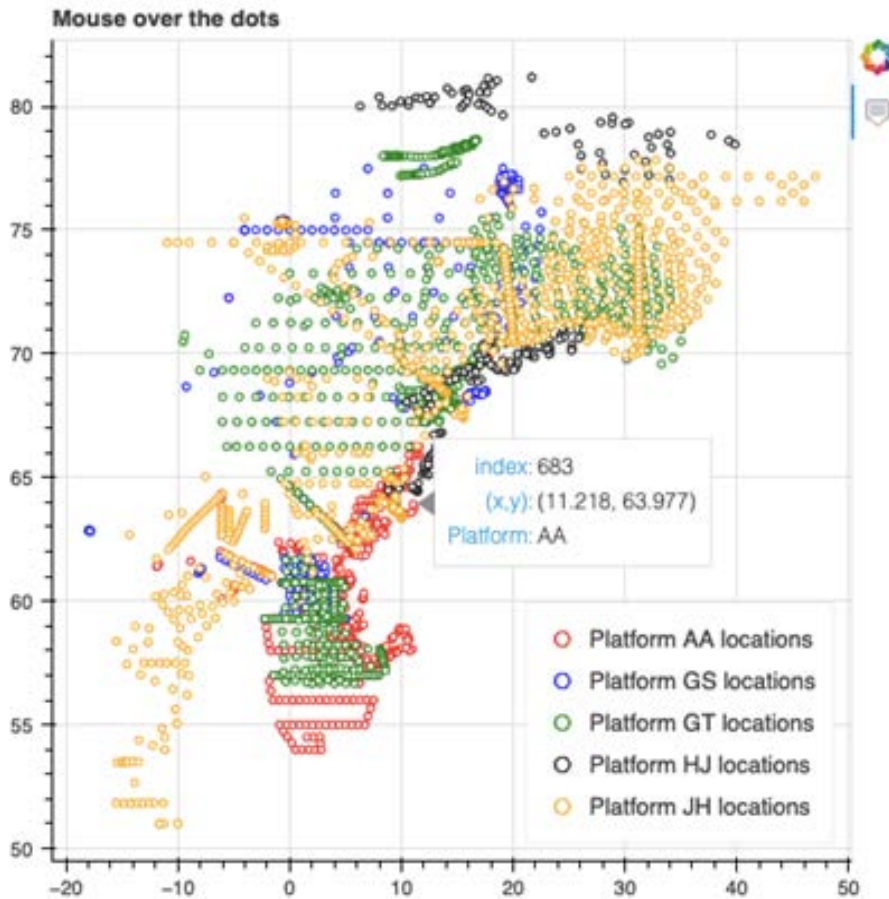


Figure 6.2 Interactive plot of data retrieved from OPeNDAP servers (source: <https://github.com/ec-intaros/opendap-xarray-use-cases>).

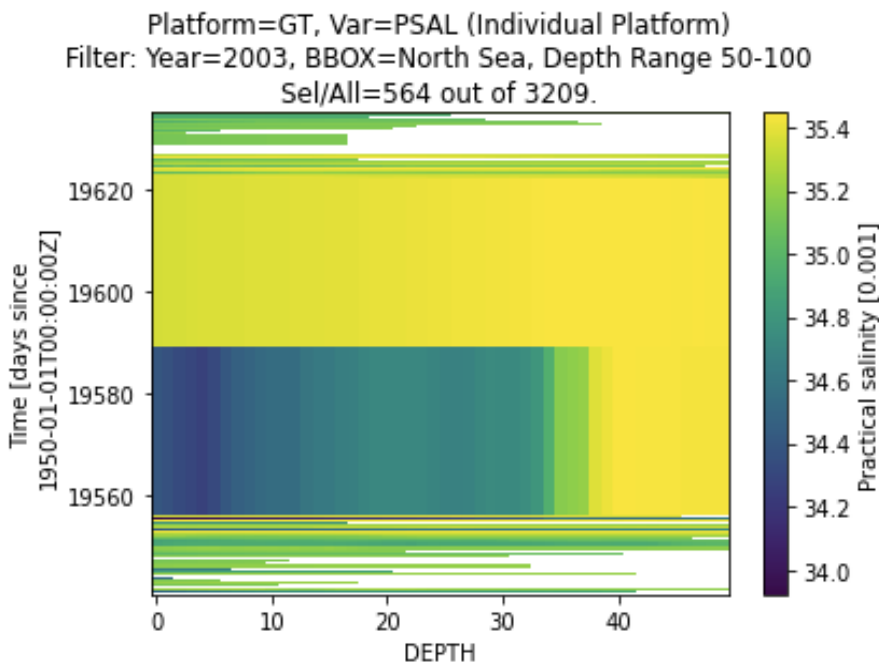


Figure 6.3 Plot of individual salinity observations from one research vessel in the North Sea in 2003 (source: <https://github.com/ec-intaros/opendap-xarray-use-cases>).

## 6.3 INTAROS Partner Applications: Risk Assessment System and Ice Mapper

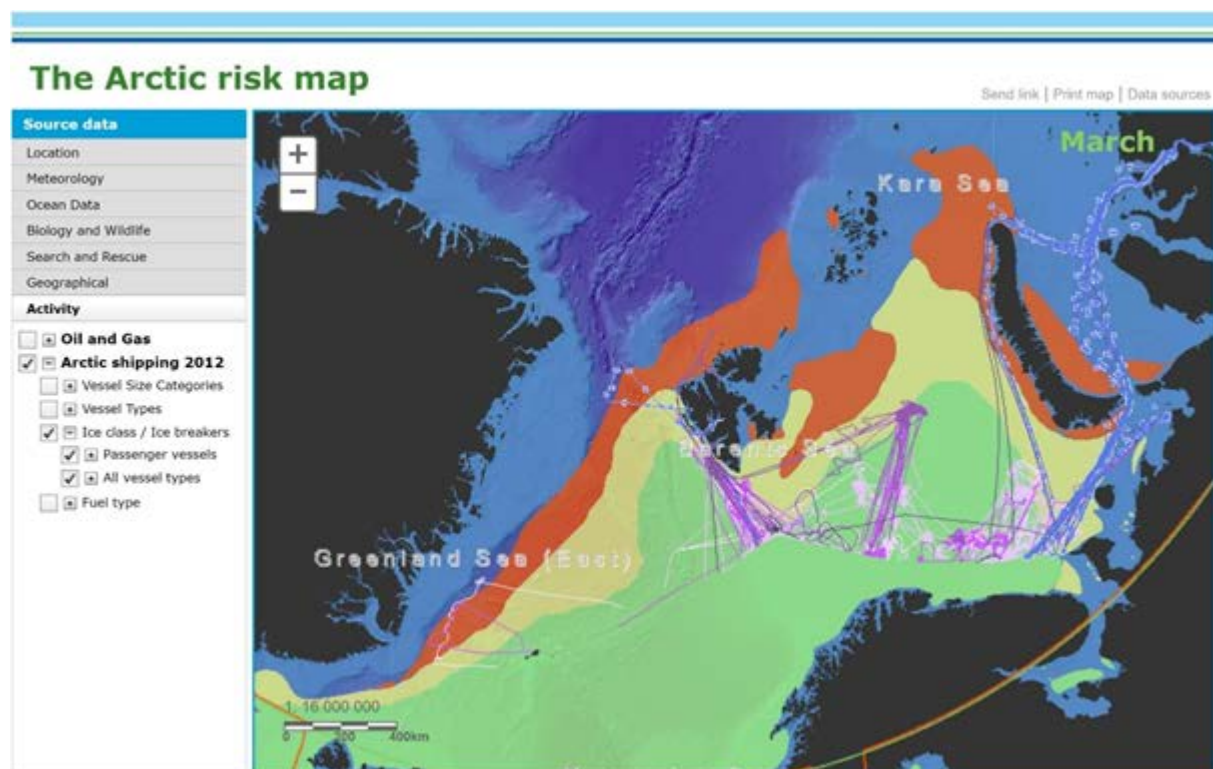
### Risk Assessment System

Reliable and updated information about sea ice conditions is crucial to conduct safe operations in Arctic waters. The Risk Assessment System integrates data from multiple sources and offers integrated analysis and visualization (Aarnes et al., 2020). The objective is to give the user insights into current and historical sea ice conditions in a given area, and how changes in these conditions can affect the risk of offshore operations.

Development in INTAROS has leveraged the “The Arctic Risk Map” system, which has been in operation for more than seven years. Focus in INTAROS has been on enhancing the system and integrating new datasets, such as the 10-year ocean – sea ice synthesis (see section 5.4). The Risk Assessment System is being further developed in Task 6.3 (“Ice-ocean statistics for decisions support and risk assessment”) and will be demonstrated to key stakeholders in Arctic business and societal development (Aarnes et al., forthcoming). This includes, among others, actors from shipping, offshore operators, fisheries, local and national authorities.

Application access: <https://maps.dnvgl.com/arcticriskmap/>

Application developer: DNV AS (<https://www.dnv.com/>)

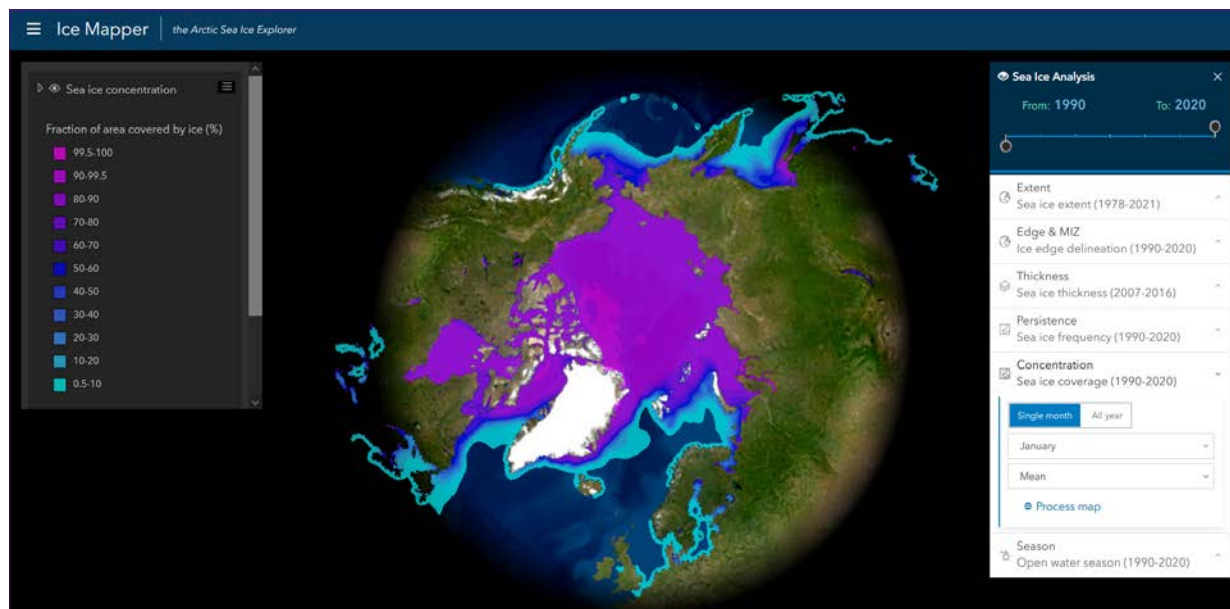


**Figure 6.4** Map of marine icing predictions (red – high, yellow – medium, green – low risk) overlaid with annual ship traffic patterns for ice strengthened vessels from the Risk Assessment System.

### Ice Mapper

The purpose of the Ice Mapper is to provide a novel and intuitive framing of the Arctic ocean environment and to deliver analytic capabilities to be used in Arctic risk assessments (Figure 6.5). The

application is complementary to the Arctic Risk Map, but targets sea ice as a key risk influencing factor. The ice mapper is based on state of the art data and knowledge and provides better detail and more analytic capability. It collates several sources, adopts a perspective of climatology, and covers both surface and subsurface conditions. The Ice Mapper application enables a consistent and reliable view of arctic sea ice conditions. It seeks to deliver insight towards trends and dynamics of the cryosphere, and sheds light to risk by applying criteria used in risk assessments.



**Figure 6.5** Ice Mapper tool providing coherent analysis of Arctic sea ice.

## 6.4 iAOS Tool: Geostatistical Library (RIntaros)

The RIntaros package is a library developed to facilitate easy access to a set of geostatistical methods that partners needed in several services and applications in the INTAROS project (Renard et al., 2021). RIntaros relies on the extensive RGeostats package, which includes a comprehensive collection of geostatistical procedures for R platform users. RGeostats is developed over a period of 20 years by the Geostatistical Team at the Geosciences Research Center at MINES ParisTech – ARMINES (Renard et al., 2017). The same team has developed RIntaros to provide an interface to RGeostats for the iAOS Cloud Platform, as part of Task 5.4 (“Development of geo-statistical methods for data integration”).

RIntaros is used in several INTAROS services to interpolate in situ observations, which typically is scattered in space and time due to the high cost and/or limitations caused by harsh weather conditions in the Arctic. One of the iAOS Showcase applications uses geostatistics to interpolate CTD data collected in the Barents Sea to gridded fields of temperature and salinity (Renard et al., 2020). Another showcase application developed for WP6 uses geostatistics to interpolate and analyse in situ data from weather stations and model output for terrestrial parameters (e.g. snow depth) in order to better assess the avalanche risk. More examples of how RIntaros and RGeostats can be used within the INTAROS community and wider scientific community can be found in INTAROS Deliverable D5.10 (Renard et al., 2021).

Geostatistical Library pre-built Linux-packages (for building processing services in the iAOS Cloud platform) are available from:

- <https://anaconda.org/Terradue/r-rintaros>
- <https://anaconda.org/Terradue/r-rgeostats>

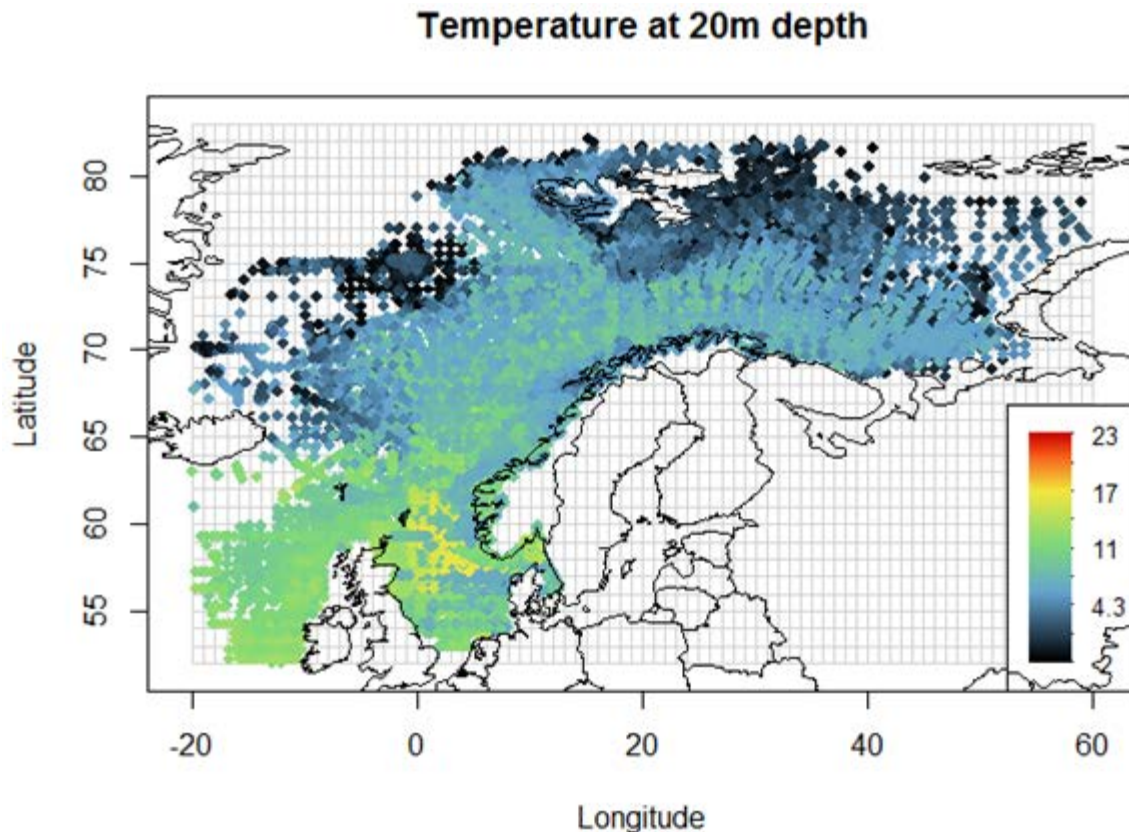
Official RGeostats website (for a standalone and local use):

- <http://cg.ensmp.fr/rgeostats>

RIntaros and RGeostats packaging procedures are available under GitHub:

- <https://github.com/ec-intaros/r-rintaros> (RIntaros)
- <https://github.com/ec-intaros/r-rgeostats> (RGeostats)

With these packages, scientists and service developers can deploy and use the RGeostats and RIntaros libraries in cloud computing infrastructures such as the iAOS Cloud Platform.



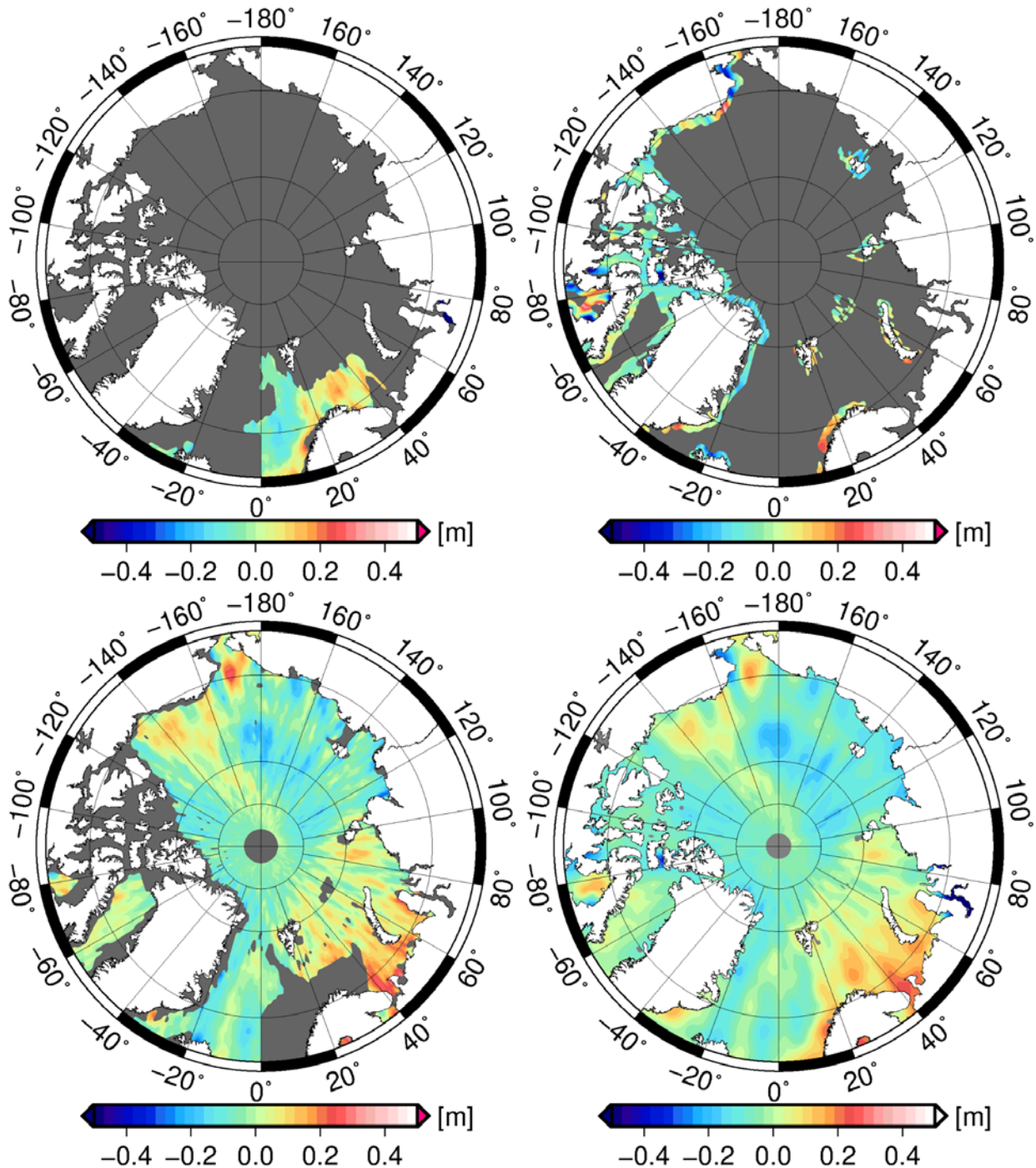
**Figure 6.6** Temperature measurements (°C) at 20m depth based over 20 years of CTD data collected by research vessels operated by IMR (Renard et al., 2020).

## 6.5 iAOS Tool: Geostatistics package for satellite point data

As part of Task 5.4 (“Development of geostatistical methods for data integration”) DTU has contributed to development of an add-on R package for interpolation of satellite or ship observations where it interpolate using Gaussian Markov random fields. Satellite observations will be scattered in space and time due to the way the satellite orbits the Earth and limitations caused by the presence of sea-ice in the Arctic. This tool bears some resemblance to the Geostatistical Library (see section 6.5). Due to the multiple satellite observations as the crosses a given cell, the tool performs an initial averaging of the multiple satellite observations before performing the interpolation. The geostatistics package is used in Task 6.3 to generate sea level products based on satellite altimetry data (Figure 6.7). This work has resulted in the generation of gridded monthly halosteric and thermosteric sea level in the Arctic region from 1990-2018 (Ludwigsen and Andersen, 2021) as shown in Figure 6.8.

Software access links: Software is available from DTU Space (contact O. Andersen (oa@space .dtu.dk)

The package is under further development being adapted to handle data in WP6 and is planned to be used in future projects.



**Figure 6.7 Gridded Sea surface height derived from Cryosat-2 (lower right picture). Data are merged from Cryosat-2 LRM observations (Upper Left) with Cryosat-2 SAR-in (Upper Right) and Cryosat-2 SAR (lower left) for July 2011.**

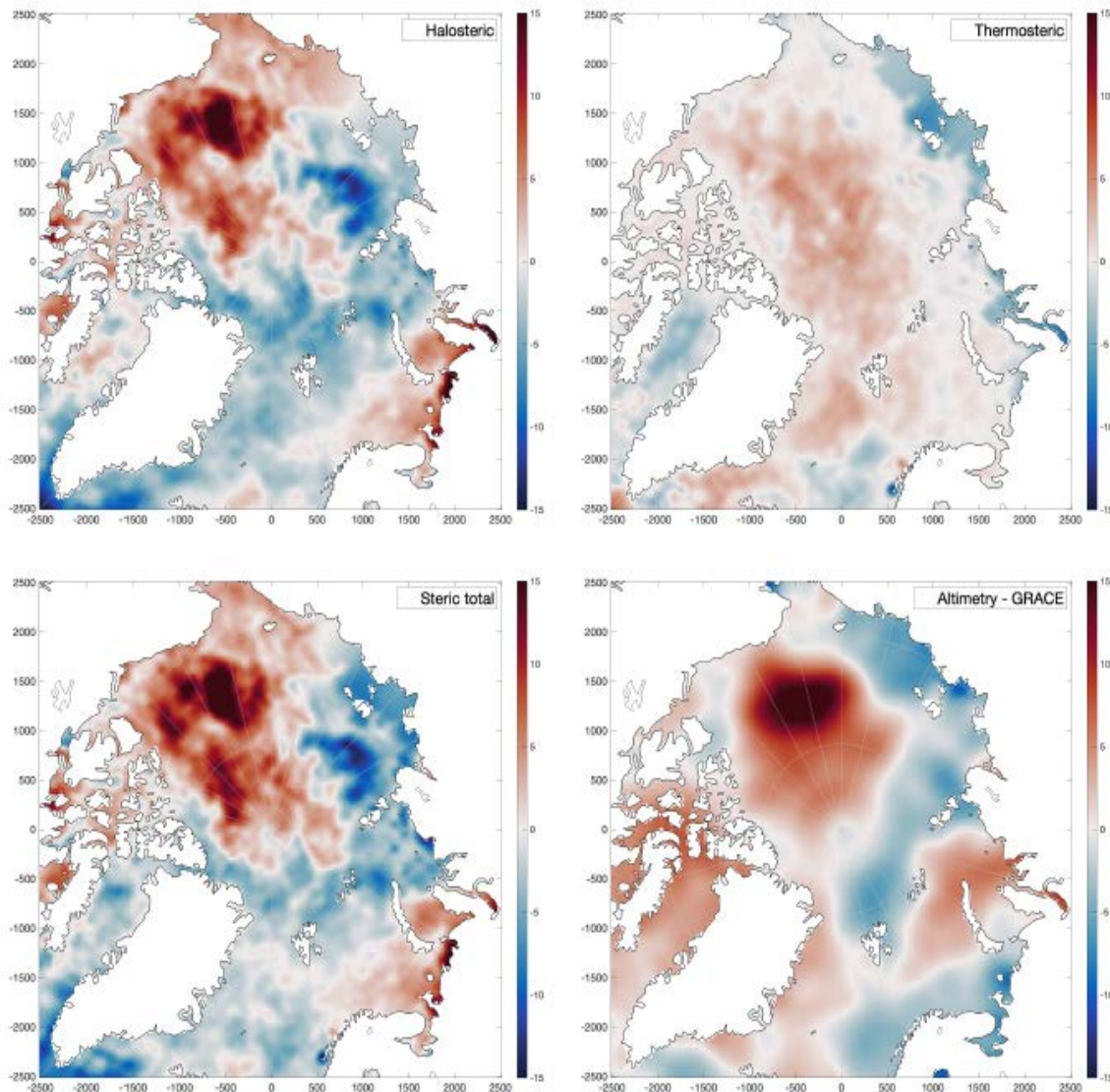


Figure 6.8. Interpolated grids of ship and satellite data. Halosteric (upper left), Thermosteric (upper right) and Total Steric (lower left) from ship observations and Total steric from satellite (lower right).

## 7. Conclusions and plans for sustainability

### 7.1 The functionality of the iAOS Portal

This report describes the current functionality of the iAOS Portal. The main components of the iAOS Portal include:

- INTAROS Data Catalogue, holding descriptions (metadata) of datasets collected or generated with support from INTAROS.
- iAOS Portal Data Catalogue, holding metadata harvested from other catalogues offering relevant dataset for the applications under development in WP 6 of INTAROS.
- Services and Applications, describing services and applications developed in INTAROS and by other service providers offering products or functionality that can be exploited in WP 6.
- Tools and Resources, providing links to software libraries and tools, computer platforms, data systems, infrastructures and projects that offer data, information and/or software tools that can be

useful for scientists and stakeholders in Arctic sciences and for local communities in the region.

- The ARCMAP web application for mapping and assessing Arctic in situ observing systems

With these components as a foundation, the iAOS Portal will be further extended with more features, data and services in future projects following up INTAROS and the recommendations from the INTAROS Roadmap (Sandven et al., 2022). These projects will use the iAOS Portal as a mechanism to make their data and services known to the large network of Arctic scientists and local communities established within INTAROS. In this way, the iAOS Portal will become an important element in a Sustained integrated Arctic Observing System.

## 7.2 Technical implementation

To implement the iAOS Portal, we have selected CKAN (Comprehensive Knowledge Archive Network), a widely used open-source data management system. CKAN is a widely used platform for management and dissemination of open geographic data. CKAN provides a number of features out-of-the-box, such as registration and update of information about datasets, organisations and themes (groups), multi-faceted search for datasets, ready-made templates for presentation of catalogue content, and a role-based user management system. In addition, CKAN has a modular design, which allows for easy extension of functionality through integration of plugins provided by the developer community of CKAN or by development within the INTAROS project itself. Two of these plugins are `ckanext-harvest` which enables harvesting of metadata from external repositories, and `ckanext-nextgeossharvest` which enables harvesting of (among others) selected CMEMS products from the CMEMS data catalogue. The choice of CKAN as the framework for the iAOS Portal significantly reduced the implementation time. Furthermore, it resulted in a stable portal system that can be maintained and extended at a reasonable cost. Future development of the iAOS Portal can benefit from the active CKAN developer community e.g., by involving members as expert software engineers or advisors. This will allow the iAOS Portal to be further enhanced using a mature data management system framework, with new web and GIS technologies included to improve functionality and add novel features.

## 7.3 The future of the iAOS Portal

The iAOS Portal has been extended with new features, more data and services during the course of the INTAROS project. The iAOS Portal will be brought forward as part of new projects in line with the recommendations from the INTAROS Roadmap (Sandven et al., 2022). The portal will facilitate the promotion of data, observing systems, services, tools and other results from new projects contributing to the implementation of the INTAROS Roadmap. The new projects can promote themselves by for example registering their observing systems into ARCMAP and datasets into the INTAROS Data Catalogue. Furthermore, by providing a standard interface to an external data catalogue, metadata for datasets can be harvested and made visible in the iAOS Portal. The iAOS Portal will further provide a mechanism for promoting services, applications and tools developed in collaborating projects through the iAOS Portal. This will make results from new projects known to a wide audience following Arctic observing and research, including the large network of Arctic scientists and local communities established during the INTAROS project.

Reusing and further developing the iAOS Portal in new projects will support the implementation of the FAIR data principles as well as making data management in the new projects more cost efficient by avoiding duplication of work. Sustaining the iAOS Portal should be supported by each new project with a share proportional to how many datasets, services, tools, etc., that the project will generate. This is especially important in projects that work towards operationalization of the data delivery chain for Arctic in situ observing systems. In addition, new projects that focus on service and tool development exploiting data or other resources from the iAOS Portal should also contribute to sustaining the portal. In this way, the iAOS Portal will become an important element in a Sustained integrated Arctic Observing System.

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<[https://intaros.nersc.no/sites/intaros.nersc.no/files/D3.9\\_INTAROS\\_Atmosphere\\_v1.5.pdf](https://intaros.nersc.no/sites/intaros.nersc.no/files/D3.9_INTAROS_Atmosphere_v1.5.pdf)>

## Appendix A. User Manual

### iAOS Portal User Manual

<https://portal-intaros.nerisc.no/>

From the home page (Figure A.1) of the iAOS Portal you can navigate by following links to

- Datasets that are described in the Portal Catalogue
- Organisations providing datasets for iAOS Portal
- Topics that collect datasets connected to a certain topic or theme
- Services with description and links to selected Services and Applications
- Tools with description and links to selected Tools and Resources
- About the catalogue, explaining what kind of datasets can be found in the catalogue

or using buttons below the main display area of the home page:

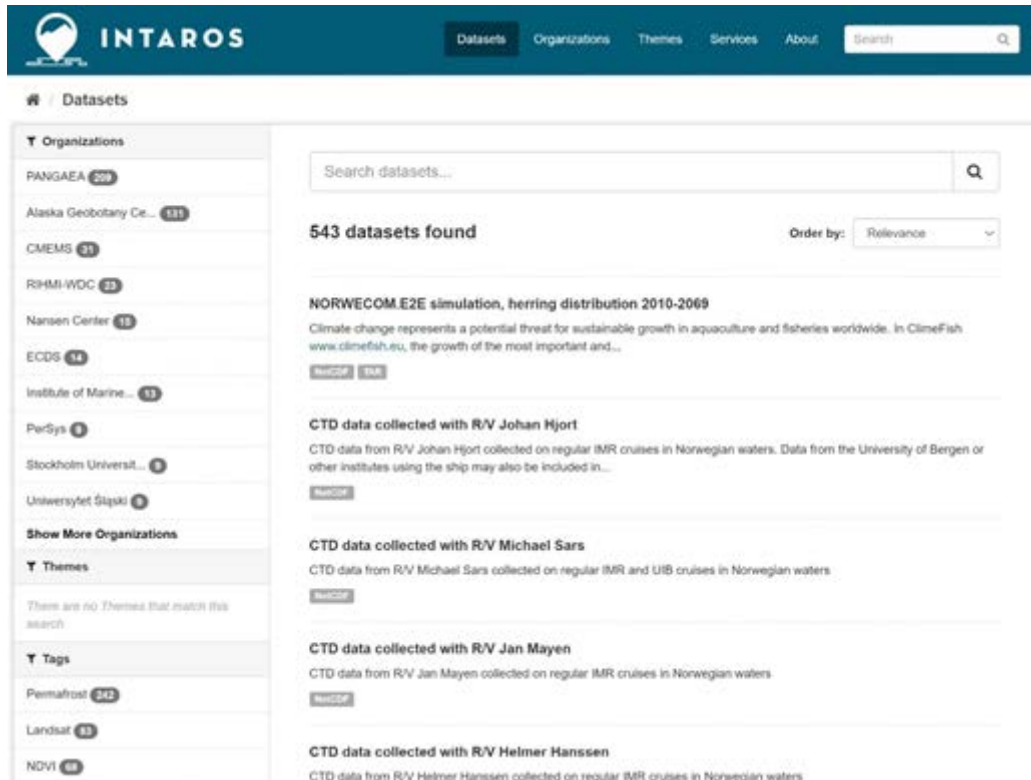
- INTAROS Data Catalogue: <https://catalog-intaros.nerisc.no/>
- ARCMAP application: <https://arcmmap.nerisc.no/>



Figure A.1 Home page of the iAOS Portal.

#### A.1 Searching for data in Portal Data Catalogue and INTAROS Data Catalogue

If you follow the Datasets link on the home, a page with short summaries of datasets in the Portal Data Catalogue is presented (Figure A.2). From this you can scroll down to find datasets of interest or use the different search facets to the left, such as organization names and tags associated with the datasets. You can select one or more such search facets to identify datasets of interest (Figure A.3 and Figure A.4). Behind each search facet, there is a number indicating how many datasets are associated with each facet. When you have selected a dataset of interest, you can view its metadata (Figure A.5) and navigate to access and download in the repository holding the dataset (Figure A.6).



**INTAROS** Datasets Organizations Themes Services About Search

# / Datasets

**Organizations**

- PANGAEA 209
- Alaska Geobotany Ce... 131
- CMEMS 31
- RHMI-WDC 23
- Nansen Center 13
- ECDS 14
- Institute of Marine... 13
- PerSys 8
- Stockholm Universit... 8
- Universytet Štýski 8

Show More Organizations

**Themes**

There are no Themes that match this search

**Tags**

- Permafrost 242
- Landsat 83
- NDVI 68

Search datasets... Q

**543 datasets found** Order by: Relevance

**NORWECOM.E2E simulation, herring distribution 2010-2069**  
Climate change represents a potential threat for sustainable growth in aquaculture and fisheries worldwide. In ClimeFish www.climefish.eu, the growth of the most important and...

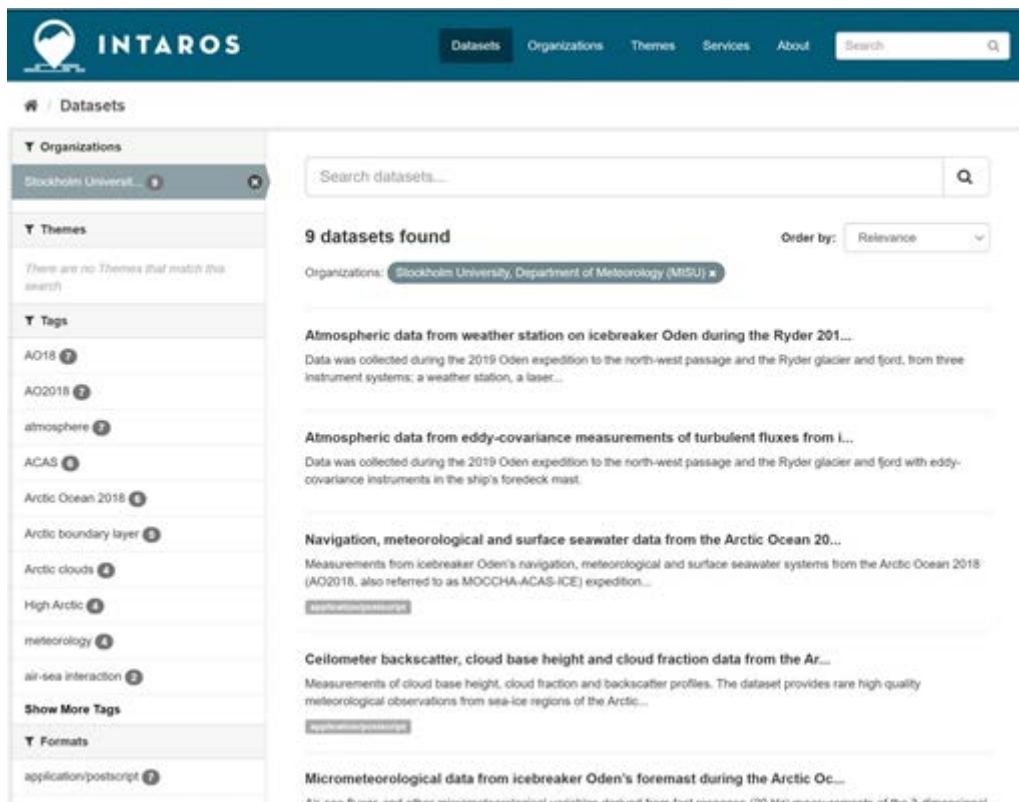
**CTD data collected with R/V Johan Hjort**  
CTD data from R/V Johan Hjort collected on regular IMR cruises in Norwegian waters. Data from the University of Bergen or other institutes using the ship may also be included in...

**CTD data collected with R/V Michael Sars**  
CTD data from R/V Michael Sars collected on regular IMR and UIB cruises in Norwegian waters

**CTD data collected with R/V Jan Mayen**  
CTD data from R/V Jan Mayen collected on regular IMR cruises in Norwegian waters

**CTD data collected with R/V Helmer Hanssen**  
CTD data from R/V Helmer Hanssen collected on regular IMR cruises in Norwegian waters

Figure A.2 Dataset overview page of the Portal Data Catalogue.



**INTAROS** Datasets Organizations Themes Services About Search

# / Datasets

**Organizations**

- Stockholm Universit... 8

**Themes**

There are no Themes that match this search

**Tags**

- AQ18 7
- AQ2018 7
- atmosphere 7
- ACAS 4
- Arctic Ocean 2018 4
- Arctic boundary layer 3
- Arctic clouds 4
- High Arctic 4
- meteorology 4
- air-sea interaction 2

Show More Tags

**Formats**

- application/postscript 7

Search datasets... Q

**9 datasets found** Order by: Relevance

Organizations: Stockholm University, Department of Meteorology (MISU)

**Atmospheric data from weather station on icebreaker Oden during the Ryder 201...**  
Data was collected during the 2019 Oden expedition to the north-west passage and the Ryder glacier and fjord, from three instrument systems; a weather station, a laser...

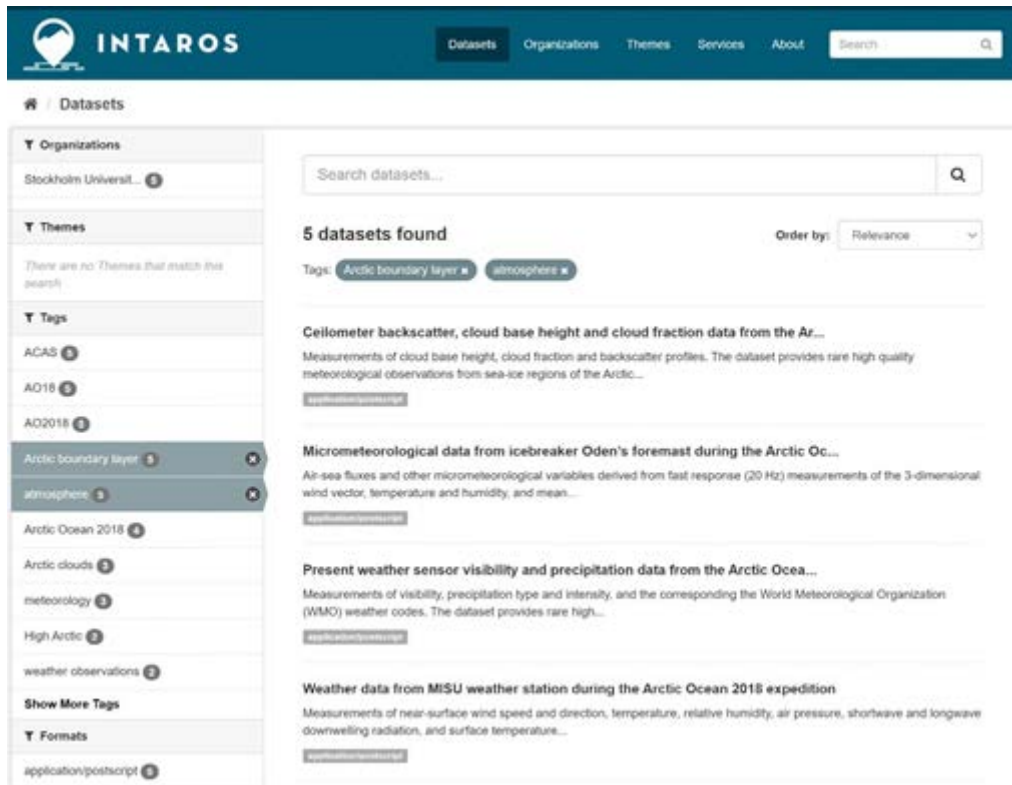
**Atmospheric data from eddy-covariance measurements of turbulent fluxes from l...**  
Data was collected during the 2019 Oden expedition to the north-west passage and the Ryder glacier and fjord with eddy-covariance instruments in the ship's foredeck mast.

**Navigation, meteorological and surface seawater data from the Arctic Ocean 20...**  
Measurements from icebreaker Oden's navigation, meteorological and surface seawater systems from the Arctic Ocean 2018 (AQ2018, also referred to as MOCCHA-ACAS-ICE) expedition...

**Ceiliometer backscatter, cloud base height and cloud fraction data from the Ar...**  
Measurements of cloud base height, cloud fraction and backscatter profiles. The dataset provides rare high quality meteorological observations from sea-ice regions of the Arctic...

**Micrometeorological data from icebreaker Oden's foremast during the Arctic Oc...**  
Air-sea fluxes and other micrometeorological variables derived from fast response (20 Hz) measurements of the 3-dimensional

Figure A.3 Searching for all datasets from an organization in the Portal Data Catalogue.



**INTAROS** | Datasets | Organizations | Themes | Services | About | Search

**Datasets**

Search datasets...

**5 datasets found** | Order by: Relevance

Tags: **Arctic boundary layer** | **atmosphere**

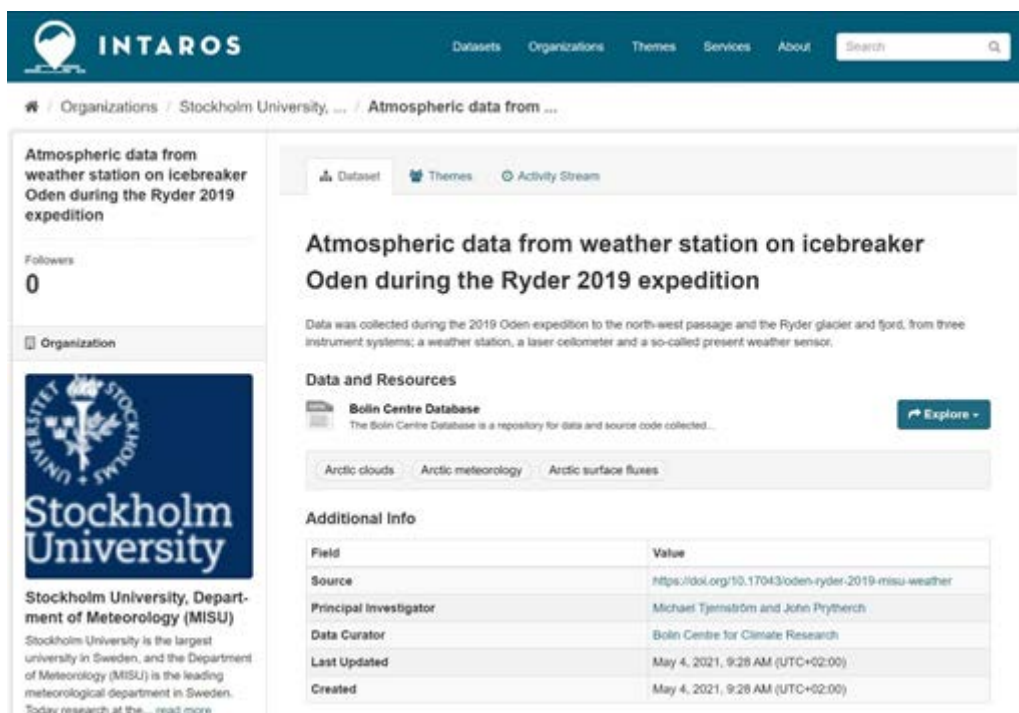
**Celometer backscatter, cloud base height and cloud fraction data from the Arctic Ocean 2018**  
 Measurements of cloud base height, cloud fraction and backscatter profiles. The dataset provides rare high quality meteorological observations from sea-ice regions of the Arctic...

**Micrometeorological data from icebreaker Oden's foremast during the Arctic Ocean 2018 expedition**  
 Air-sea fluxes and other micrometeorological variables derived from fast response (20 Hz) measurements of the 3-dimensional wind vector, temperature and humidity, and mean...

**Present weather sensor visibility and precipitation data from the Arctic Ocean 2018 expedition**  
 Measurements of visibility, precipitation type and intensity, and the corresponding the World Meteorological Organization (WMO) weather codes. The dataset provides rare high...

**Weather data from MISU weather station during the Arctic Ocean 2018 expedition**  
 Measurements of near-surface wind speed and direction, temperature, relative humidity, air pressure, shortwave and longwave downwelling radiation, and surface temperature...

Figure A.4 Searching for all datasets associated with two chosen keywords “atmosphere” and “Arctic boundary layer”.




**INTAROS** | Datasets | Organizations | Themes | Services | About | Search

Organizations / Stockholm University, ... / Atmospheric data from ...

**Atmospheric data from weather station on icebreaker Oden during the Ryder 2019 expedition**

Followers: 0

**Organization**  
  
**Stockholm University, Department of Meteorology (MISU)**  
 Stockholm University is the largest university in Sweden, and the Department of Meteorology (MISU) is the leading meteorological department in Sweden. Today research at the... read more

**Atmospheric data from weather station on icebreaker Oden during the Ryder 2019 expedition**

Data was collected during the 2019 Oden expedition to the north-west passage and the Ryder glacier and fjord, from three instrument systems; a weather station, a laser celometer and a so-called present weather sensor.

**Data and Resources**

**Bolin Centre Database**  
 The Bolin Centre Database is a repository for data and source code collected... [Explore](#)

Arctic clouds | Arctic meteorology | Arctic surface fluxes

**Additional Info**

Field	Value
Source	<a href="https://doi.org/10.17043/oden-ryder-2019-misu-weather">https://doi.org/10.17043/oden-ryder-2019-misu-weather</a>
Principal Investigator	Michael Tjernström and John Prytherch
Data Curator	Bolin Centre for Climate Research
Last Updated	May 4, 2021, 9:28 AM (UTC+02:00)
Created	May 4, 2021, 9:28 AM (UTC+02:00)

Figure A.5 Viewing metadata for a chosen dataset, including link to data source (repository).

The screenshot shows the Bolin Centre Database website. At the top, there is a navigation bar with 'Bolin Centre Database', 'About', and a 'Contribute' button. The header features the Stockholm University logo and the text 'Stockholm University | Bolin Centre for Climate Research'. The main content area has a breadcrumb trail: 'Home > Data > Oden data repository > Data from expedition Ryder, off North Greenland, 2019'. The title of the page is 'Weather data from MISU weather station during Ryder 2019 and Northwest passage 2019 expeditions'. Below the title, the authors 'John Prytherch, Michael Tjernström' are listed. The abstract describes measurements of near-surface wind speed and direction, temperature, relative humidity, air pressure, shortwave and longwave downwelling radiation, surface temperature, cloud base height, cloud fraction, backscatter profiles, visibility, precipitation type and intensity, and WMO weather codes from the eastern Canadian Arctic archipelago and Northern Greenland in July, August, and September 2019. A 'Download data' button is visible. Below the text is a map of the Arctic region with a yellow line indicating the expedition route. A 'Citation' section at the bottom provides the full reference: 'John Prytherch, Michael Tjernström (2021). Weather data from MISU weather station during Ryder 2019 and Northwest passage 2019 expeditions. Dataset version 1.0. Bolin Centre Database. <https://doi.org/10.17043/oden>'.

Figure A.6. Following a dataset link to the repository holding the data.

The INTAROS Data Catalogue is available at <https://catalog-intaros.nersc.no/>. This data catalogue can be searched in the same manner as the Portal Data Catalogue.

## A.2 Viewing Services and Applications

Clicking on the “Services” link in the main menu of the iAOS Portal homepage leads to a page describing selected services and applications developed with support from INTAROS. Each description outlines the purpose and capabilities of the service/application, provides an example of generated results, links to software libraries and tools needed to run it, and a link to accessing the service/application and/or its source code (Figure A.7)

### Analysis of passive acoustic data

This service processes and characterizes passive acoustic data, and produces spectrograms and noise statistics plots that can be used for analysis in combination with time series of satellite remote sensing derived parameters. It is implemented using the R version of the open source PAMGuide software package, and has extended support for new data formats (NetCDF) and data access through the OPeNDAP protocol.

The service has been tested with datasets from several sources (NERSC, CNRS, PANGAEA). Figure 2 shows an example of passive acoustic collected by CNRS in Kongsfjorden, Svalbard, as part of the INTAROS field campaigns. The spectrum is dominated by low-frequency noise below 10 Hz. Local peaks around 10 Hz and 80 Hz are also seen, which could be mammal vocalization. Intermittent broad-band signals are also seen in the spectrogram. Read more about the passive acoustic service in INTAROS Deliverable D5.7.

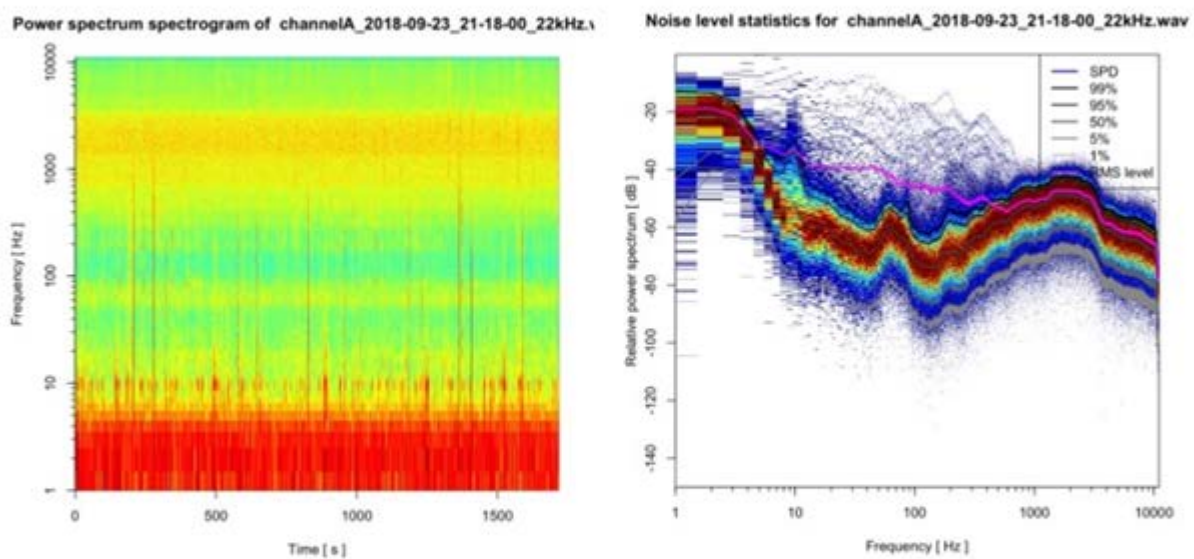


Figure 2. Examples of power spectrum spectrogram (left) and noise statistics plot (right) generated by the passive acoustic service when analysing acoustic data collected in Kongsfjorden, Svalbard, during the INTAROS project.

Jupyter Notebook files: PAMGuide-R-Tutorial

Software packages needed:


- R
- PAMGuide
- Jupyter notebook

Developer: NERSC

Figure A.7 Example of a service description in the IAOS Portal.

## A.3 Viewing Tools and Resources

Clicking on the “Tools” link in the main menu of the iAOS Portal homepage leads to a page describing a selection of tools and other resources that are relevant for the INTAROS community. Each tool is presented with an example of use and links to software (Figure A.8)


INTAROS

[Datasets](#)
[Organizations](#)
[Themes](#)
[Services](#)
[About](#)
[Tools](#)

## Tools Edit

Geostatistical Library (Rintaros)

The Rintaros package is a library developed to facilitate easy access to a set of geostatistical methods that partners needed in several services and applications in the INTAROS project. Rintaros relies on the extensive RGeostats package (<http://cg.enscm.fr/rgeostats>), which includes a comprehensive collection of geostatistical procedures for R platform users.

Rintaros is used in several INTAROS services to interpolate in situ observations, which typically is scattered in space and time due to the high cost and/or limitations caused by harsh weather conditions in the Arctic. Figure 1 shows an example from a service where Rintaros was used to generate gridded fields of ocean temperature based on more than 20 years of CTD data.

### Temperature at 20m depth

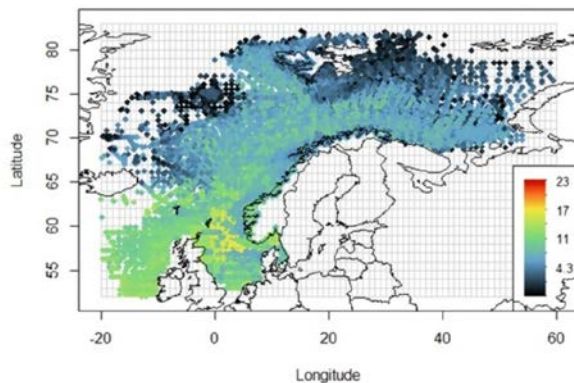


Figure 1. Temperature (°C) at 20m depth interpolated from more than 20 years of CTD data collected by research vessels operated by IMR (Renard et al., 2020).

Links to software:

- Rintaros packaging procedure: <https://github.com/ec-intaros/r-rintaros>
- RGeostats packaging procedures: <https://github.com/ec-intaros/r-rgeostats>

**Figure A.8** Example of tools and resources listed in the IAOS Portal.

## A.4 ARCMAP application

The ARCMAP application (<https://arcmmap.nersc.no/>) provides access to the survey component to register and maintain information about Arctic in situ observing systems, a wide range of plots of statistics for all registered observing systems. The ARCMAP home page (Figure A.8) also provides an overview map showing the location of the registered systems and in addition a set of observing systems imported from other catalogues. The various components can be accessed using the main menu at the top of the screen or by following links above the overview map.

ARCMAP [Home](#) [Daily Updated Plots](#) [More Plots](#)

## ARCMAP: Mapping Arctic in situ observing systems

The Arcmap survey application is one of the services offered by INTAROS. Selected stations and moorings from this survey is shown below.

**The Arcmap system consists of the following three main components:**

1. To ingest information about your Observing System Please go to [Arcmap survey site](#)
2. To view all your information about your own observing systems [Arcmap client site](#)
3. Obtain information and statistics about all the Observing Systems in the ARCMAP database (no password) [Arcmap daily updated plots](#)

[Download the Arcmap User Manual here.](#)



**The map shows in situ observing systems**

Explanations of icons, markers, and functions:

- Zoom in and out**  
To zoom in click the "+"-icon, to zoom out click the "-"-icon.
- Display layers**  
To turn on and off layers, click on the layers-icon to show the Layers-menu

Figure A.8 ARCMAP home page with overview map and links to plot and survey components.

A full user manual for ARCMAP, can be found [here](#).

## A.5 Registration of datasets in the INTAROS Data Catalogue

### 1. Login to the Data Catalogue

Open <https://catalog-intaros.nerisc.no/> in your browser.

Press the “Log in” link at the top right (Figure A.9) and log in with your provided user account and password (Figure A.10).





**Search data**

E.g. environment

Popular tags: ocean temperature, CBM, ocean salinity

**INTAROS Data Catalogue statistics**

155 datasets, 38 organizations, 0 topics

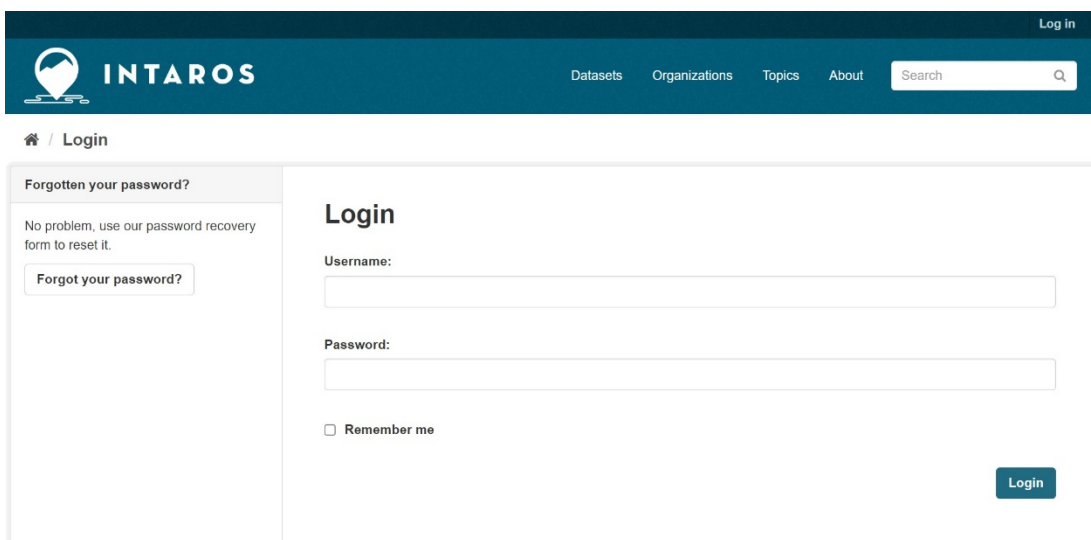
**Community Based Monitoring datasets and programs**

INTAROS is working closely with several local communities and citizen science programs across the Arctic. In one of these programs, INTAROS partner GEUS is collaborating with the municipality in Qeqertalik, Greenland, to collect information on seismic activity. A pilot program with seismic stations operated by local community members have been established, and the data collected feeds into the Raspberry Shake Community and the GEUS' earthquake bulletin. A data portal shown in image below gives access to the seismic data from this community. This and other CBM datasets can be found here.

**About INTAROS Data Catalogue**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No [727890]

Figure A.9 INTAROS Data Catalogue home page.



**INTAROS**

Home / Login

**Forgotten your password?**

No problem, use our password recovery form to reset it.

[Forgot your password?](#)

**Login**

Username:

Password:

Remember me

[Login](#)

Figure A.10 INTAROS Data Catalogue login page.

## 2. Enter the Datasets page and start registration of a new dataset

Press the “Datasets” link in the top banner (Figure A.9) to open the dataset view and registration area. Then, press the “Add Dataset” button to start registration (Figure A.11).

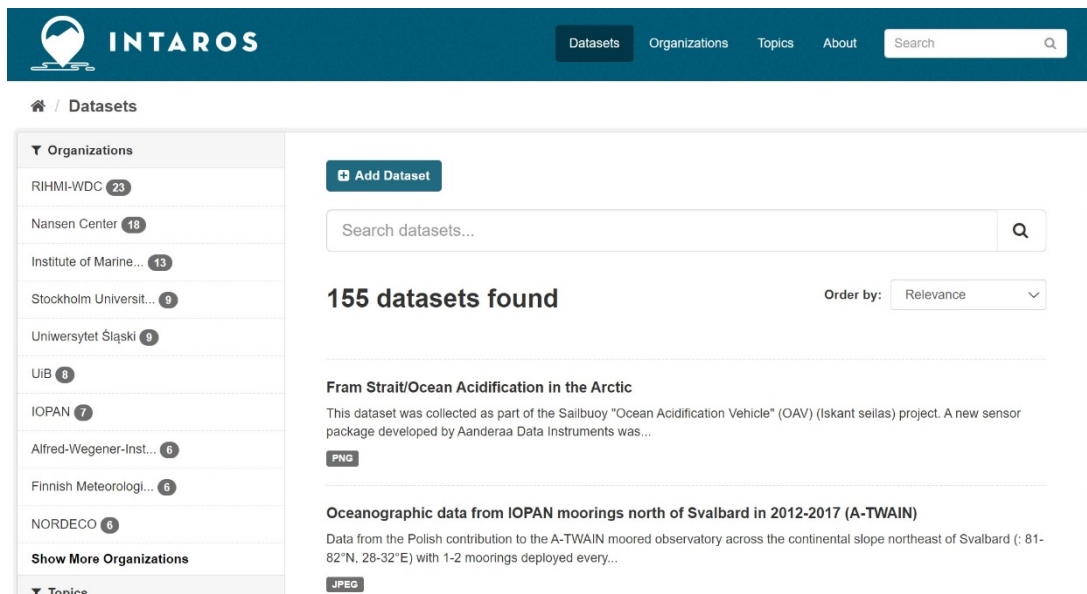


Figure A.11 INTAROS Datasets page.

### 3. Enter general description of the dataset

After pressing the “Add Dataset” button to start registration (Figure A.11), you will be guided through two input forms where you describe the dataset and upload one or more figures to illustrate its coverage and/or content.

The first fields of the dataset description include:

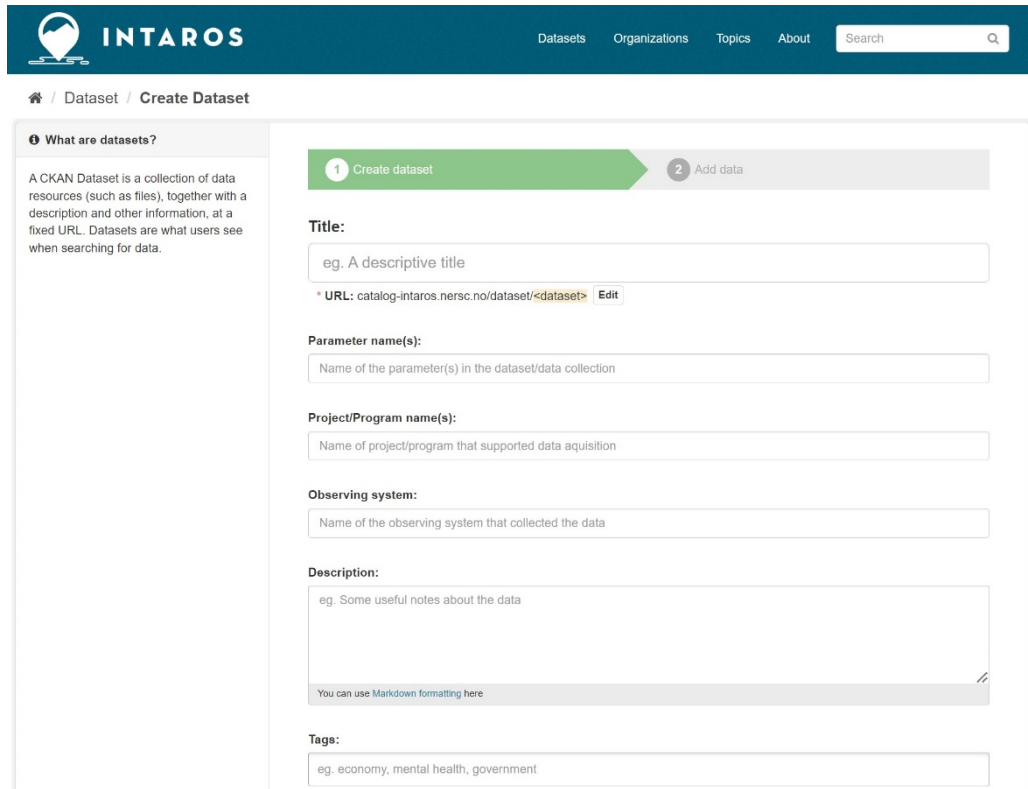
- Title (mandatory): descriptive title of the dataset
- URL (mandatory): link (URL) to the dataset within the data catalogue
- Parameter name(s): lists the parameters contained in the dataset
- Project/program name(s): lists the project(s)/program(s) that supported data collection/preparation. Remember the funding agency (e.g. EC) and the contract number.
- Observing system name: the name of the observing systems (if any) that collected the measurements on which the dataset is based
- Description: write a short text that describes the content of the dataset. The following elements could be included
  - What kind of parameters are included in the dataset
  - Geographic area (by name) and time period covered by the dataset
  - Summary of processing to generate the dataset (e.g. with reference to paper or report)
  - Indication of possible use of the dataset (e.g. model validation)
- Tags: keywords that you want to associate with the dataset, e.g. “ocean temperatur”, “sea ice”. Note that these will be used a way to quickly search for data (Figure A.14). To enter a tag, type the word(s) and press the enter key inside the field. Then, you can another tag, as/if needed.

The last part of the dataset description includes:

- License: what license the data are/will be provided under
- Organisation: which organisation the dataset belongs to
- Visibility: a flag controlling if the datasets description is not completed yet (select “private”) or if the description has been completed and can be made visible to all (select “public”)
- Source: a link (URL) to the dataset file(s), e.g. on a Thredds Data Server Note: Leave this field empty If the dataset has not yet been made available online
- Version: a number denoting the version of the dataset
- Principal Investigator: name of the PI for dataset

- • PI Email: e-mail address of the PI
- • Data Curator: name of the person in charge of maintaining the dataset and its metadata
- • Data Curator Email: e-mail address of the data curator

Once you have completed all the above fields (that are relevant at this stage), press the “Next: Add Data” button to advance to uploading of graphics illustrating the dataset.



**INTAROS** Datasets Organizations Topics About Search

Dataset / Create Dataset

**What are datasets?**  
A CKAN Dataset is a collection of data resources (such as files), together with a description and other information, at a fixed URL. Datasets are what users see when searching for data.

**1 Create dataset** **2 Add data**

**Title:**  
eg. A descriptive title  
\* URL: catalog-intaros.nersc.no/dataset/<dataset> **Edit**

**Parameter name(s):**  
Name of the parameter(s) in the dataset/data collection

**Project/Program name(s):**  
Name of project/program that supported data acquisition

**Observing system:**  
Name of the observing system that collected the data

**Description:**  
eg. Some useful notes about the data  
You can use Markdown formatting here

**Tags:**  
eg. economy, mental health, government

Figure A.12 INTAROS registration of dataset description (upper part of page).

**License:**  
 Please select the license License definitions and additional information can be found at [opendefinition.org](#)

**Organization:**  
 Nansen Center

**Visibility:**  
 Private

**Source:**  
 http://example.com/dataset.json

**Version:**  
 1.0

**Principal Investigator:**  
 Joe Bloggs

**Principal Investigator Email:**  
 joe@example.com


**Data Curator:**  
 Joe Bloggs

**Data Curator Email:**  
 joe@example.com

The data license you select above only applies to the contents of any resource files that you add to this dataset. By submitting this form, you agree to release the metadata values that you enter into the form under the Open Database License. \* Required field

**Next: Add Data**

Figure A.13 INTAROS registration of dataset description (lower part of page).



Datasets
Organizations
Topics
About

[Home](#) / **Datasets**

**Organizations**

- Nansen Center 9
- IOPAN 7
- CNRS 1
- Universität Hamburg 1

**Topics**

There are no Topics that match this search

**Tags**

- ocean temperature 18
- ocean salinity 13
- sound speed 9
- pressure 6
- XBT 5
- ocean currents 4
- conductivity 3
- CTD 3
- Arctic Ocean 2
- Arctic Ocean bounda... 2

**Show More Tags**

**Formats**

- PNG 13
- JPEG 6
- nc 2

**Add Dataset**

Search datasets... Q

**18 datasets found** Order by: Relevance

Tags: ocean temperature

---

**Oceanographic data from IOPAN moorings north of Svalbard in 2012-2017 (A-TWAIN)**  
 Data from the Polish contribution to the A-TWAIN moored observatory across the continental slope northeast of Svalbard (c. 81° 82'N, 28-32°E) with 1-2 moorings deployed every...  
JPEG

---

**Oceanographic data from the INTAROS deep mooring NERSC-4**  
 The deep ocean mooring NERSC-4 was deployed in 2019-2020 in the southern Nansen Basin at 81°47'N and 22°E at the water depth of 3458 m. The multidisciplinary mooring carried...  
PNG PDF

---

**Oceanographic data from IOPAN moorings north of Svalbard in 2017-2021 (INTAROS)**  
 Oceanographic data from two IOPAN moorings north of Svalbard deployed in 2017-2022 along the INTAROS (along 22°E) and A-TWAIN (along 31°E) mooring lines. Mooring IOPAS1x (x...  
JPEG

---

**Oceanographic data from profiling Argo floats in the Nordic Seas**  
 Polish national contribution to the Euro-Argo ERIC under the Argo Poland program. Polish Argo floats are deployed in the subpolar North Atlantic and Nordic Seas to trace...  
PNG

---

**Oceanographic data from the IOPAN long-term monitoring in Svalbard fjords (Ho...**  
 Repeated oceanographic measurements in two Svalbard fjords: Hornsund (76°50' - 77°10' N, 15-17°E) and Kongsfjorden (78°50'-79°05'N, 11-13°E) and adjacent shelf areas. Data...  
JPEG

Figure A.14 INTAROS search for datasets using tags.

#### 4. Upload graphics that illustrate the content and/or coverage of the dataset

After entering the general description of the new dataset, you must upload one or more graphics files showing e.g. geographical location or coverage, one or more parameters in the dataset. This is done in the “Add data” page of the new dataset registration (Figure A.15). Press the “Upload” button to select a file from you local computer of the “Link” button if you want to link to an online figure.

Each graphics resource is described by the following fields:

- Name: a title of the graphics
- Description: a short description of what the graphics resource is illustrating. Here you can also add one or more references to data capture, processing and analysis.
- Format: what format the graphic resource is stored. (This is found automatically by the data catalogue software and can be left open.)

Note: You **must** upload a graphics file or another resource to illustrate the dataset. E.g., a map showing location or coverage. (It is possible to upload more than one file, see point 6 below.)

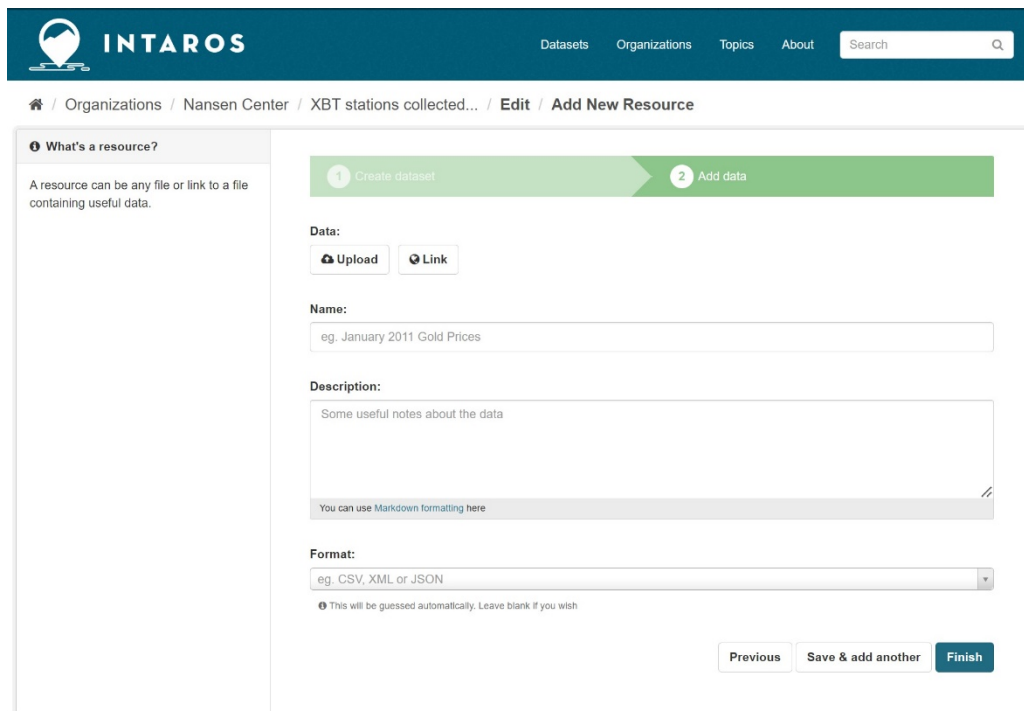


Figure A.15 INTAROS registration of graphics to illustrate a dataset.

#### 5. Save the description and graphics for the new dataset

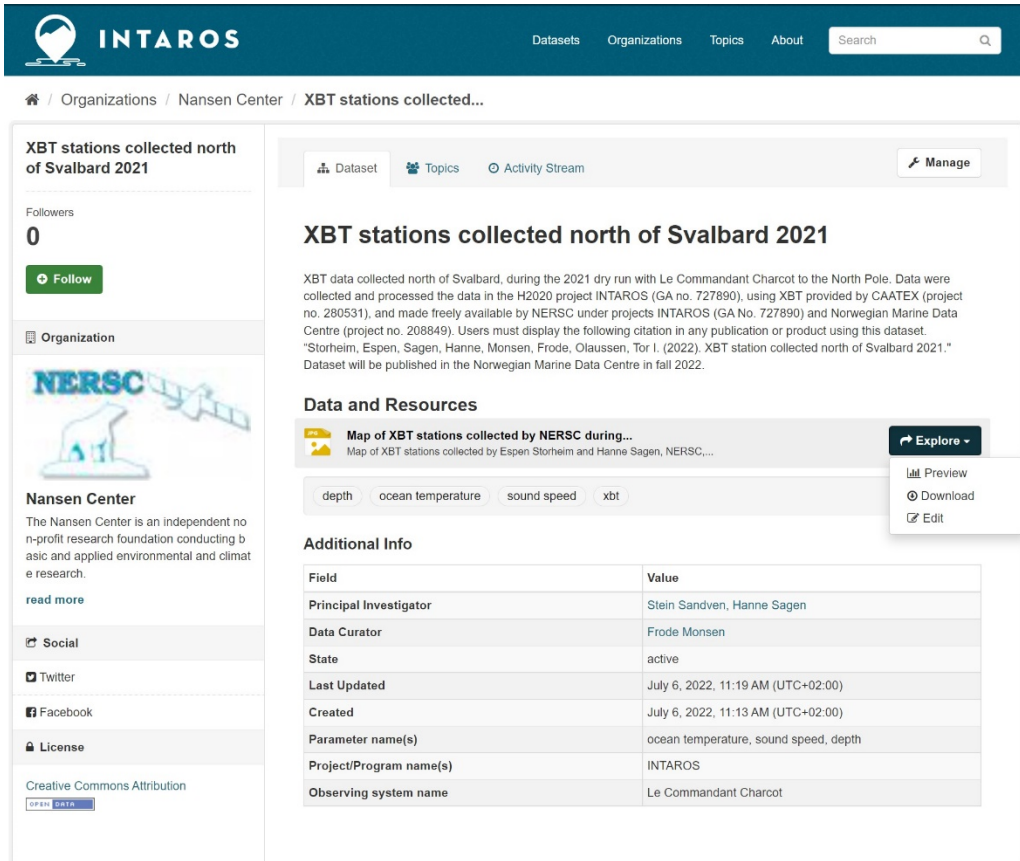
Press the “Finish” button to save the information you just provided. Press “Save & add another” if you have more than one dataset to register.

If you have chosen “public” for visibility, the dataset will be visible to all visitors of the data catalogue. If “private” is chosen, the description and graphics are stored but will not be made publicly available.

#### 6. Adding more than one graphic resource for a dataset

To add additional graphic resources, open the dataset again after saving it.

Press the “Explore” button and select “Edit” from the dropdown list (Figure A.16). This brings you to a new form where you can add another graphics by selecting “All resources” (Figure A.17) and then “Add new resource” (figure A.18). If you want to add a third resource, just repeat this procedure.



**XBT stations collected north of Svalbard 2021**

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**Organization**

**Nansen Center**  
The Nansen Center is an independent non-profit research foundation conducting basic and applied environmental and climate research.  
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### XBT stations collected north of Svalbard 2021

XBT data collected north of Svalbard, during the 2021 dry run with Le Commandant Charcot to the North Pole. Data were collected and processed in the H2020 project INTAROS (GA no. 727890), using XBT provided by CAAATEX (project no. 280531), and made freely available by NERSC under projects INTAROS (GA No. 727890) and Norwegian Marine Data Centre (project no. 208849). Users must display the following citation in any publication or product using this dataset. "Storheim, Espen, Sagen, Hanne, Monsen, Frode, Olaussen, Tor I. (2022). XBT station collected north of Svalbard 2021." Dataset will be published in the Norwegian Marine Data Centre in fall 2022.

**Data and Resources**

[Map of XBT stations collected by NERSC during...](#)  
Map of XBT stations collected by Espen Storheim and Hanne Sagen, NERSC,...

[Explore](#)

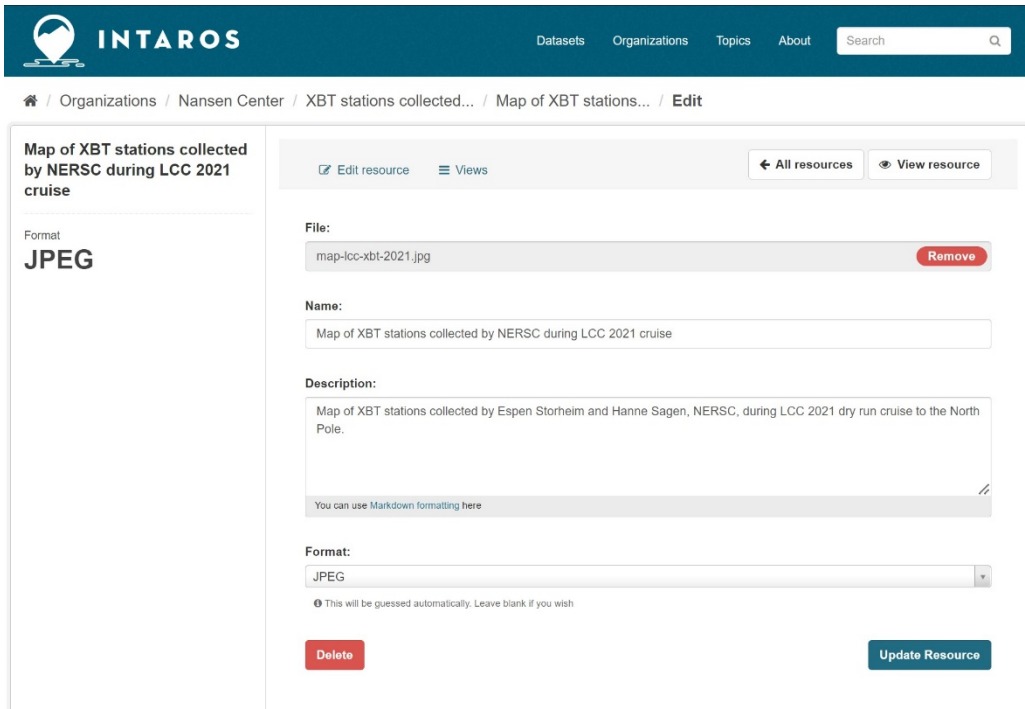
- [Preview](#)
- [Download](#)
- [Edit](#)

depth | ocean temperature | sound speed | xbt

**Additional Info**

Field	Value
Principal Investigator	Stein Sandven, Hanne Sagen
Data Curator	Frode Monsen
State	active
Last Updated	July 6, 2022, 11:19 AM (UTC+02:00)
Created	July 6, 2022, 11:13 AM (UTC+02:00)
Parameter name(s)	ocean temperature, sound speed, depth
Project/Program name(s)	INTAROS
Observing system name	Le Commandant Charcot

Figure A.16 Exploring graphics resources for a dataset.



Map of XBT stations collected by NERSC during LCG 2021 cruise

Format  
**JPEG**

[Edit resource](#) [Views](#) [← All resources](#) [View resource](#)

**File:**  
map-lcc-xbt-2021.jpg [Remove](#)

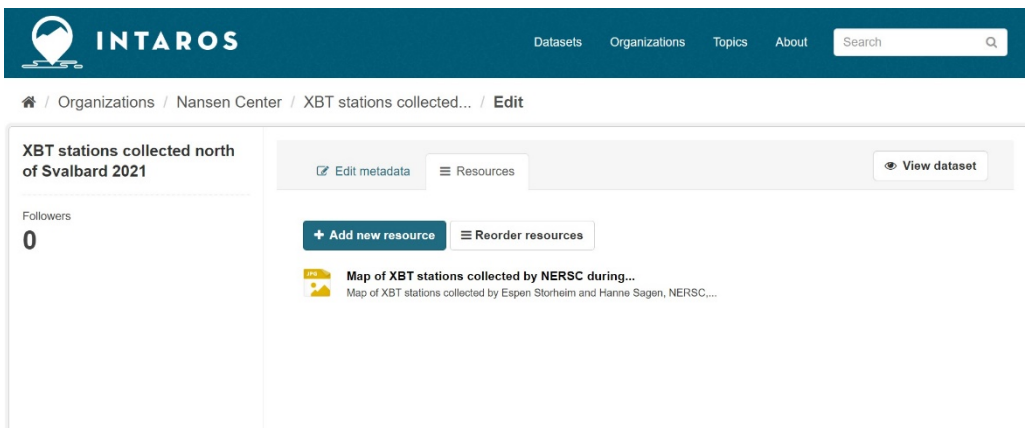
**Name:**  
Map of XBT stations collected by NERSC during LCC 2021 cruise

**Description:**  
Map of XBT stations collected by Espen Storheim and Hanne Sagen, NERSC, during LCC 2021 dry run cruise to the North Pole.  
You can use Markdown formatting here

**Format:**  
JPEG  
This will be guessed automatically. Leave blank if you wish

[Delete](#) [Update Resource](#)

Figure A.17 Inspecting all graphics resources for a dataset.



XBT stations collected north of Svalbard 2021

Followers  
**0**

[Edit metadata](#) [Resources](#) [View dataset](#)

[+ Add new resource](#) [Reorder resources](#)


 **Map of XBT stations collected by NERSC during...**  
Map of XBT stations collected by Espen Storheim and Hanne Sagen, NERSC,...

Figure A.18 Adding another graphics resource for a dataset.

----- END of DOCUMENT-----



# INTAROS

This report is made under the project  
**Integrated Arctic Observation System (INTAROS)**  
funded by the European Commission Horizon 2020 program  
Grant Agreement no. 727890.



## Project partners:

