Integrated Arctic Observation System

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Deliverable 5.4

iAOS Portal with User Manual V1

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20	UPM		**43**	NMEFC	
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DISSEMINATION LEVEL		
PU	Public, fully open	**X**
CO	Confidential, restricted under conditions set out in Model Grant Agreement	
CI	Classified, information as referred to in Commission Decision 2001/844/EC	

EXECUTIVE SUMMARY

The Integrated Arctic Observation System (INTAROS) is a research and innovation action funded under Horizon 2020 call H2020-BG-09 call in 2016 and will run from 2016 to 2021. INTAROS develops an integrated Arctic Observation System (iAOS) by extending, improving and unifying existing systems in the different regions of the Arctic. INTAROS has a strong multidisciplinary focus, with tools for integration of data from atmosphere, ocean, cryosphere and terrestrial sciences, provided by institutions in Europe, North America and Asia. To support a wide variety of users and stakeholders, the iAOS thus integrates different types of data from distributed sources, made available through established Arctic data repositories and e-infrastructures.

This document describes the ***iAOS portal***, which provides a joint access point to the data integrated by iAOS. The ***iAOS portal*** has been developed in cooperation with users, based on their requirements for search and access, processing and visualization of data. These requirements have been captured in a set of user stories, which is a systematic approach in agile software development for involving users in the process of building an information system. A selection of these user stories is included in this document. Further user stories are and will be developed in the course of the INTAROS project, to ensure the developed ***iAOS portal*** serves the needs of the targeted users and stakeholders. Only user stories currently under development are included in this report.

The design and implementation of the ***iAOS portal*** are also outlined in this document. We have selected the 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 dataset, organisation and group management, 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.

The first version of the ***iAOS portal*** is focused on INTAROS Data Catalogue, which is found at: https://catalog-intaros.nersc.no/.

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1. Introduction

1.1 Background

The INTAROS project will develop 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.

INTAROS will develop a common platform, iAOS, to search for and access data from distributed databases providing a common entry point to data originating from a wide range of observation networks, scientific campaigns and satellite missions, as well as new data generated within the project. The platform uses state-of-the-art cloud computing technologies to facilitate seamless access to multidisciplinary data, scalable allocation of data storage and computing power for big data processing, integration and analysis including geo-statistical methods. The usefulness and functionality of the platform for services development is demonstrated in selected applications, targeted at users and stakeholders in Arctic regions.

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 special report, 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 access and usage.

We use a widely adopted technique from software engineering to capture user needs: User stories. This technique allows us to quickly initiate the identification of user needs through simple statements, in the form of user stories 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

These short statements are the starting point for discussions with users and stakeholders to refine and understand their requirements, in order to develop a solution meeting their needs. In the refinement process, each user story is elaborated into more detail, identifying, among others, what data are required, which operations to perform, and how the result should be presented. As the user requirements are spelled out and a joint understanding between users/stakeholders and developers is established, the requirements are

progressively implemented and integrated in the iAOS.

Selected user stories identified by different users and stakeholders are included and described in this report. These user stories illustrate some of the capabilities of the ***iAOS portal*** that we expect many users will benefit from, such as data search and retrieval, running a processing workflow on retrieved data and visualisation of the result.

1.3 Organisation of document

The remaining part of this report is organised as follows: Section 2 describes user requirements for the iAOS Portal in the form of user stories with additional information about processing steps and/or visualisation of results. Section 3 outlines the high-level design of the iAOS portal and major implementation decisions made when realising the user requirements stated in the previous section. Section 4 shows selected examples of usage of the ***iAOS portal***, including screenshots, while Section 5 summarises the functionalities of the ***iAOS portal*** (version 1) and indicates planned work to enhance the portal.

2. User requirements

This chapter describes a selection of user stories defined to meet the needs of the targeted users and stakeholders of the iAOS portal. These stories illustrate important capabilities offered by iAOS for data search and access, processing, analysis and visualization.

2.1 Processing and analysis of satellite and in situ data

More efficient exploitation of long time series of sea ice observations from multiple sources is needed to provide a better foundation for making sound decisions on safely conducting offshore operations in the Arctic. Taking advantage of new cloud computing technologies for integrative analysis of such time series will also improve the understanding of the complex ice and ocean dynamic processes in this region, which will benefit the scientific community as well as public and private sector.

Processing Service #1: Sea ice classification maps based on Sentinel-1 SAR imagery

Aim: This service will enable users to generate a time series of sea ice classification maps for a selected time period in the Fram Strait and North of Svalbard. The generated time series can be: (1) used as basis for computing monthly sea ice statistics (e.g. 10% ice, 50% ice, etc.), (2) visualized in the iAOS Portal, and (3) downloaded in a standard data format.

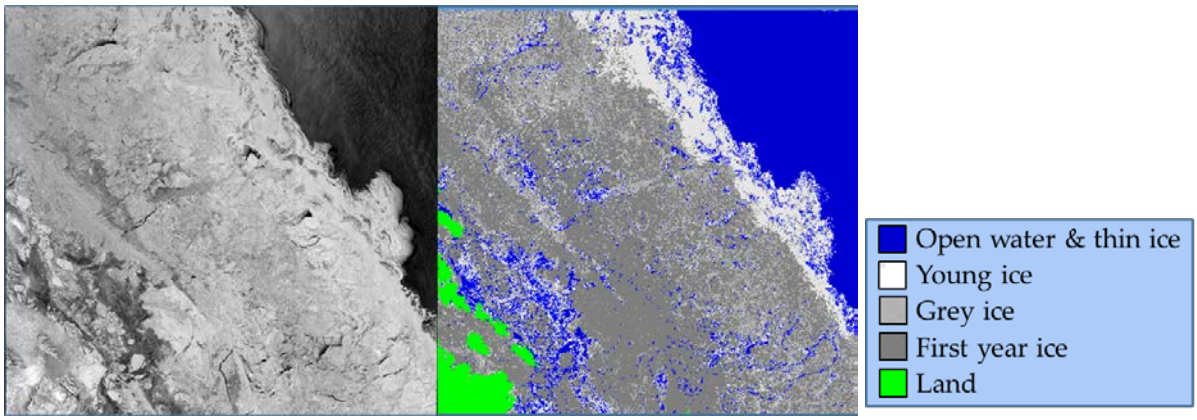
Story: As a scientist, I would like to generate a set of sea ice classification maps, to support risk assessment for offshore operators in Arctic waters.

Story exemplified for scientist John:

1. John selects the service for sea ice maps
2. John defines the area of interest, and the desired start and end date
3. iAOS searches for Sentinel-1 SAR images within the given area and time range
4. iAOS presents list of the images that satisfy the search criteria

5. John selects which of the available images to classify
6. iAOS runs the sea ice classification service for the selected SAR images
7. iAOS presents the resulting sea ice maps
8. John selects to download the results (optional)

NERSC and NIERSC has developed an automatic sea ice type classification algorithm (Zakhvatkina et al., 2017; Korosov et al., 2016) for classification of satellite SAR images from Radarsat and Sentinel-1 satellites. Figure 1 shows an example of the algorithm applied to a Sentinel-1A SAR image. By averaging a time series of such sea ice type maps, we can generate monthly sea ice statistics (or for another user defined time period).



(Source: M. Babiker, NERSC)

Figure 1. Sentinel SAR image and corresponding classification. Left: S1-SAR image. Right: Sea ice type classification.

The ***iAOS portal*** will reuse the sea ice classification service developed in the H2020 NextGEOSS project, to classify Sentinel-1 SAR imagery and create daily ice edge maps (Figure 2). Based on these maps, INTAROS will develop a sea ice statistics service will compute monthly statistics of sea ice concentration for user defined time periods and areas in the Fram Strait and North of Svalbard. The sea statistics service will be developed and integrated in the next version of the ***iAOS portal***.

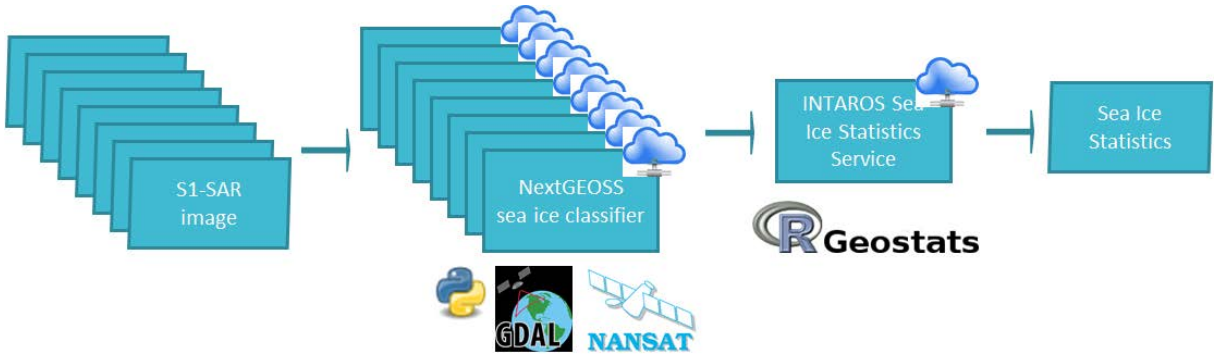


Figure 2. Illustration of workflow for the INTAROS sea ice statistics cloud service.

A first version of the sea ice classification service was implemented in the NextGEOSS project in July 2018. Figure 3 shows a Sentinel-1 SAR image from the Fram Strait and the classification of sea ice (all types merged) and open water.

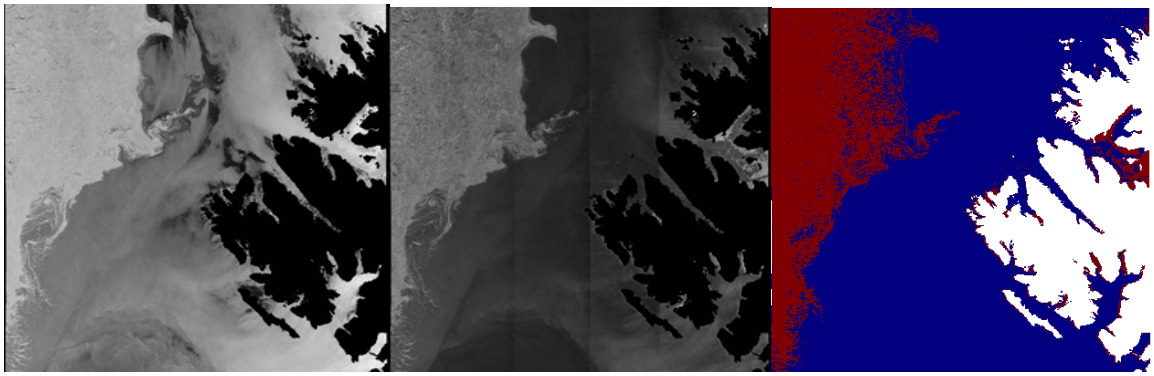


Figure 3. Sentinel-1 SAR image from 4 March 2016. Left: HH channel. Middle: HV channel. Right: Sea ice classification (red is ice; blue is open water).

Processing Service #2: Tools to process and characterize passive acoustic data

Aim: This service will enable scientists process passive acoustic data from ocean moorings. The processed data can be: (1) used as basis for studying the ocean soundscape, (2) visualized in the ***iAOS portal***, and (3) downloaded in a standard data format.

Story: As a scientist, I would like to process passive acoustic data to study the ocean soundscape.

Story exemplified for scientist Bob:

1. Bob selects the service for processing acoustic data
2. Bob defines an area and time range of interest
3. iAOS searches for passive acoustic datasets fulfilling these criteria
4. iAOS presents a list of these datasets
5. Bob selects one of the datasets for processing
6. iAOS runs the passive acoustic data processing service for the selected dataset
7. iAOS presents the estimated ocean soundscape parameters
8. Bob selects to download the results (optional)

From this general description we have started to elaborate user needs and define possible solutions through dialogue between software developers and ocean acousticians at NERSC. A survey of software for processing and analysis of passive acoustic data has been performed in (Røsvik et al., 2018). Here, the emphasis of the evaluation has been put on how user-friendly the software is, the processing capability, and on the possibility for customizing processing and visualization.

From the 8 tools evaluated, PAMGuide (Merchant et al., 2015), seems to be the most user-friendly option and the most versatile. It supports WAV and AIFF audio files as input, but can easily be modified to accept other input, e.g. NetCDF files. In addition, it has been used in several publications and is well established as a standard tool for passive acoustic analysis (P. Blondel, oral communication).

PAMGuide is available for both MATLAB and R, supports processing of both single files and large quantities of files, and is well documented (see e.g. the supplementary material of Merchant et al., 2015). Both frequency characteristics and statistical metrics are available, such as Power Spectral Density (PSD), 1/3 octave band levels, and percentiles. Predefined plot types are available for the different representations. Figure 4 shows the spectrogram and statistical metrics for a recording obtained from the WIFAR project (Geyer et al., 2016).

Figure 5 shows a screenshot of the Graphical User Interface (GUI) of PAMGuide upon start up. The GUI has a clear and logical layout and provides access to all functionality in the system. Note that a GUI is only available for MATLAB. The R version of PAMGuide can be run in a development environment like RStudio or from the command line.

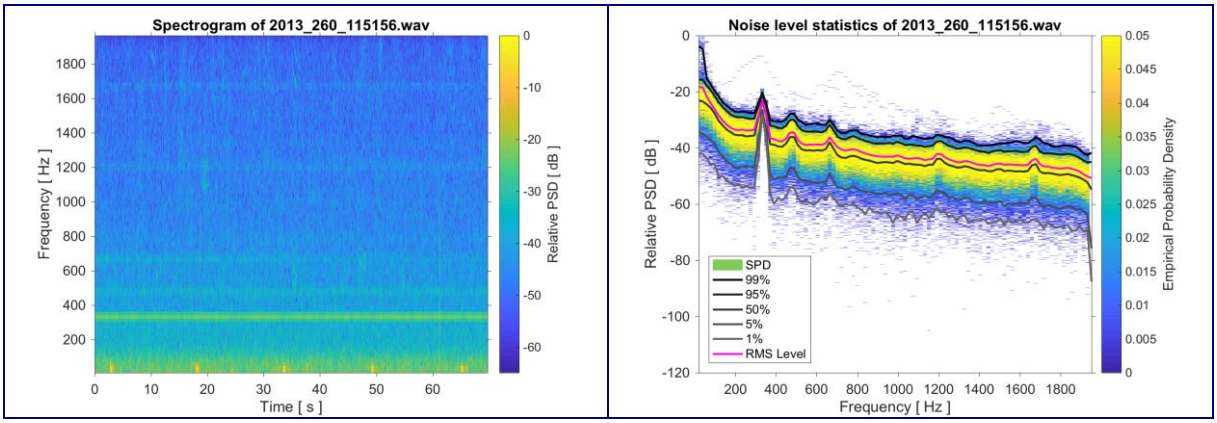


Figure 4. Analysis of a 70 s long recording made during the 2013 WIFAR field experiment using PAMGuide. Spectrogram (a) shown in normalized units, and (b) statistical metrics shown as a function of frequency. The black curves represent different percentiles, the magenta curve shows the RMS level, and the colour plot shows the spectral probability density (SPD) (Merchant et al. 2013).

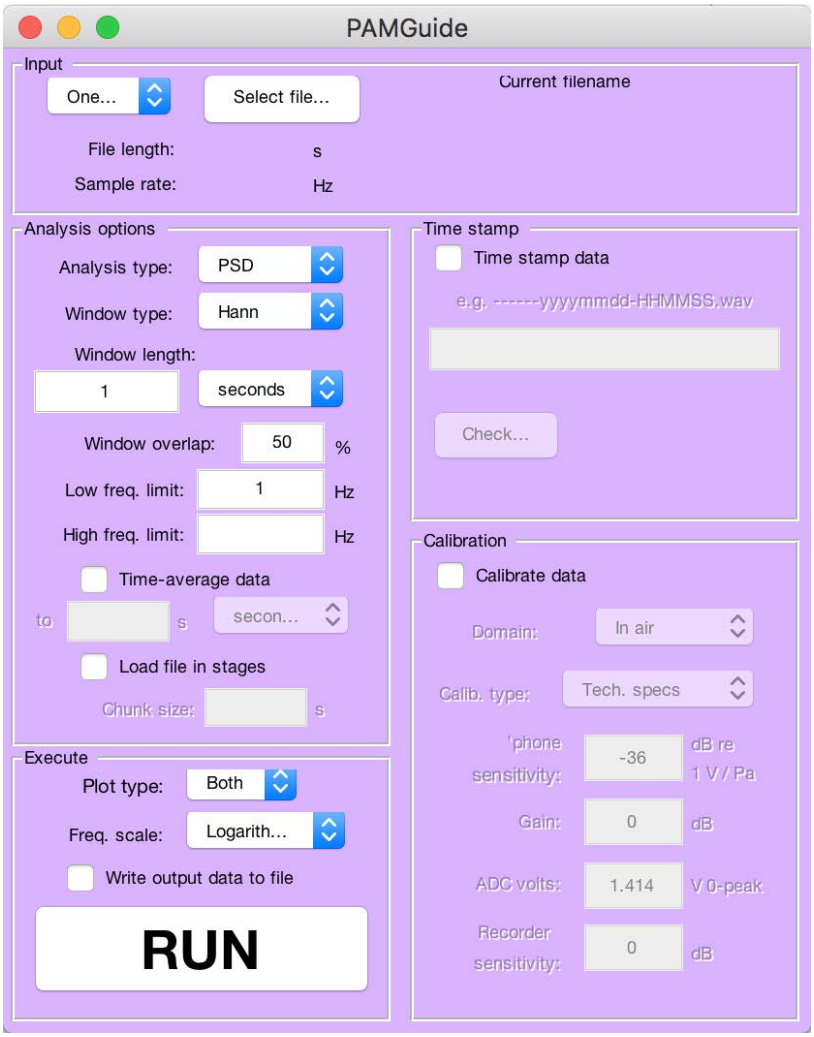


Figure 5. Startup screeen of PAMGuide (MATLAB version).

2.2 Geo-statistical analysis of oceanographic in situ data

Oceanographic in situ data provide detailed observations of the ocean, usually with high temporal and/or vertical resolution. Using geostatistical analysis, compilations of high temporal/vertical resolution in situ data can be transformed into gridded fields, that can be assimilated into numerical models for predicting future states of the ocean environment. This service makes use of the RGeostats package developed by ARMINES, a freeware R package containing a wide range of geostatistical techniques.

Processing Service #3: Generation of ocean temperature and salinity fields for validation of climate model projections

Aim: This service will enable users to apply geo-statistical methods to interpolate scattered in situ observations of ocean temperature to a gridded field that can be used to validate projections from a climate model.

Story: As a climate modeller, I would like to interpolate in situ observations of ocean temperatures to my model grid, to intercompare observational data with model projections.

Story exemplified for scientist Alice:

1. Alice selects the service for interpolating in situ data to a model grid
2. Alice selects the parameter to interpolate and the time range + area of interest
3. iAOS searches for in situ datasets that contains the chosen parameter for the specified area and time range
4. Alice selects which datasets to include in the interpolation
5. iAOS retrieves the chosen parameter(s) within given area+time range from these datasets
6. Alice selects which interpolation method to apply
7. iAOS runs the geostatistical toolbox to perform the chosen interpolation on the retrieved data
8. iAOS displays the result of the interpolation for visual inspection by Alice
9. Alice downloads the file containing the interpolated field

A typical scenario is that a series of scattered in situ data has been collected in a geographic area, where some parts are well covered and in other part of the area the measurements are sparse (Figure 6). For an ocean or climate modeller, a gridded field is required as forcing field or to validate the model. Figure 4 illustrates the planned workflow for this processing service generating an SST field using a set of scattered in situ measurements of sea surface temperature.

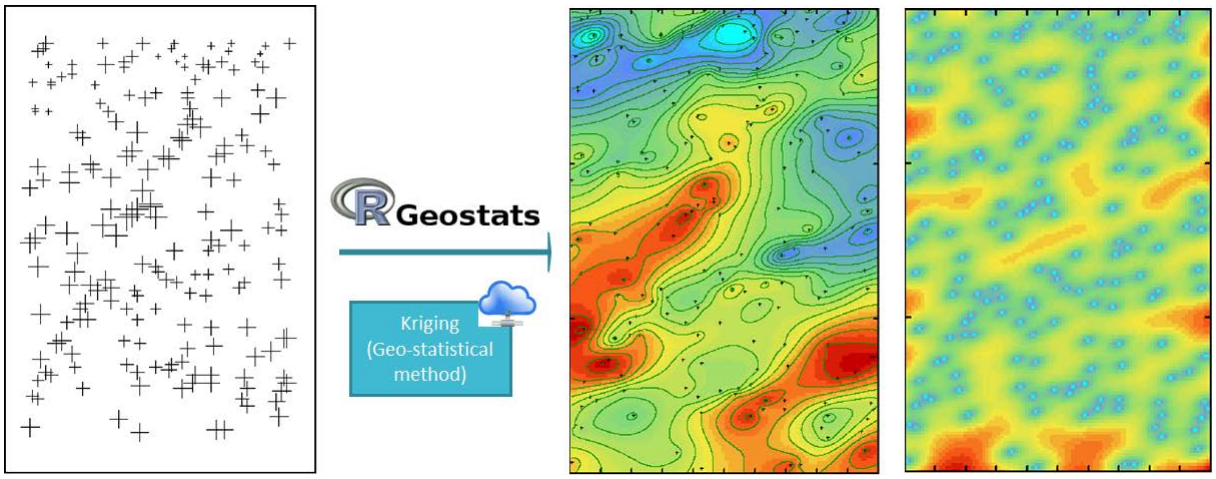


Figure 6. Scattered in situ measurements and the resulting interpolated field after Kriging with associated error estimate.

The first version of this service uses the Kriging method from RGeostats to generate an interpolated field of temperature, conductivity or salinity. An example of running the service is shown in Section 4.

2.3 Searching the INTAROS data catalogue

During the two first years of the project, INTAROS has collected, compiled and prepared data sets from the targeted geographical areas and spheres (land and cryosphere, atmosphere, sea ice, ocean). These datasets are described in the INTAROS data catalogue, which can be accessed and searched from https://catalog-intaros.nersc.no/. As INTAROS partners

generate new datasets in the course of the project, these will be registered in the data catalogue.

The data catalogue can be searched by, among others, (1) free text, (2) organisation, (3) tags (such as keywords, parameter names), (4) data license, and (5) format(s) offered. This will allow a user to quickly identify datasets of interest in the catalogue, and then move on to viewing dataset descriptions and accessing the data themselves. The content and organisation of the data catalogue is described in Deliverables D2.3 (Schewe et al., 2018) , D2.6 (O'Connor et al., 2018) and D2.9 (Kohnert et al., 2018). Figure 7 illustrates the Dataset page listing all datasets in the catalogue, while Figure 8 illustrates a filtered list of datasets after selecting one of the organisations that have registered datasets in the catalogue.

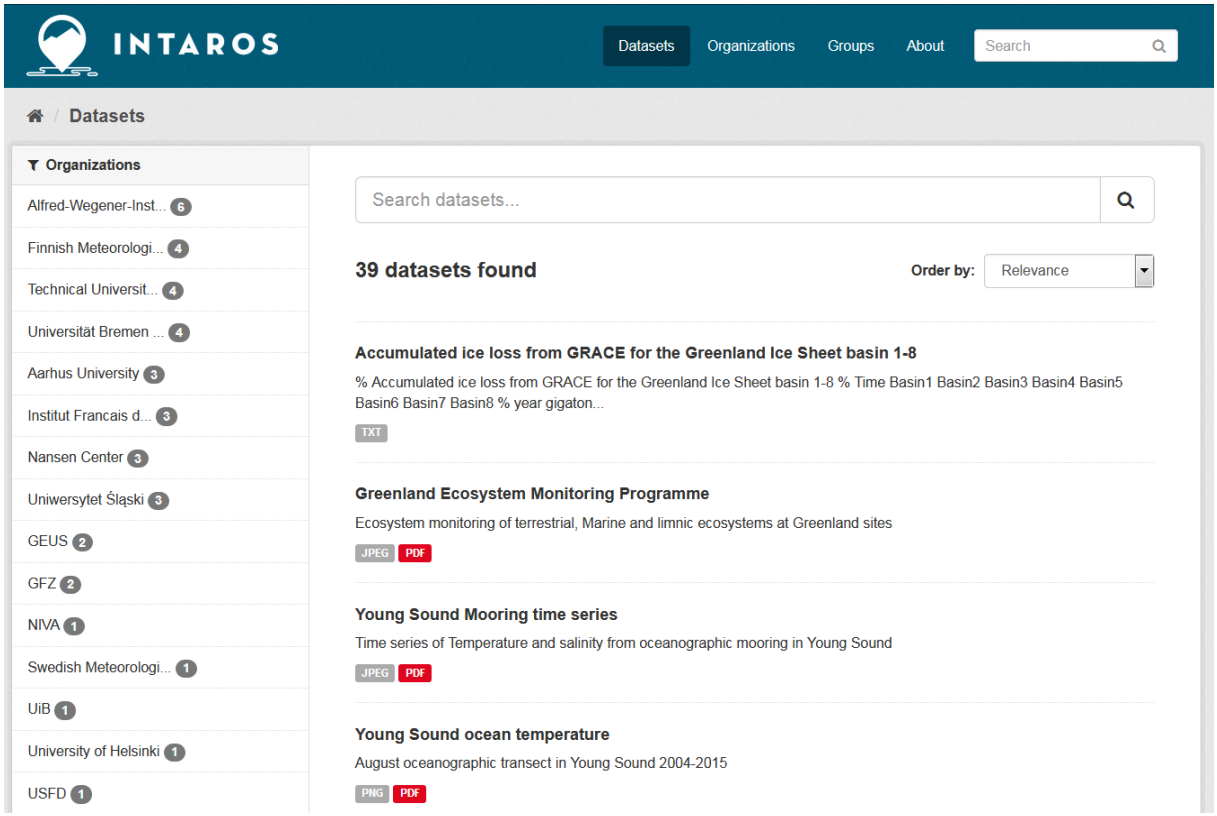


Figure 7. Dataset page of the INTAROS Data Catalogue.

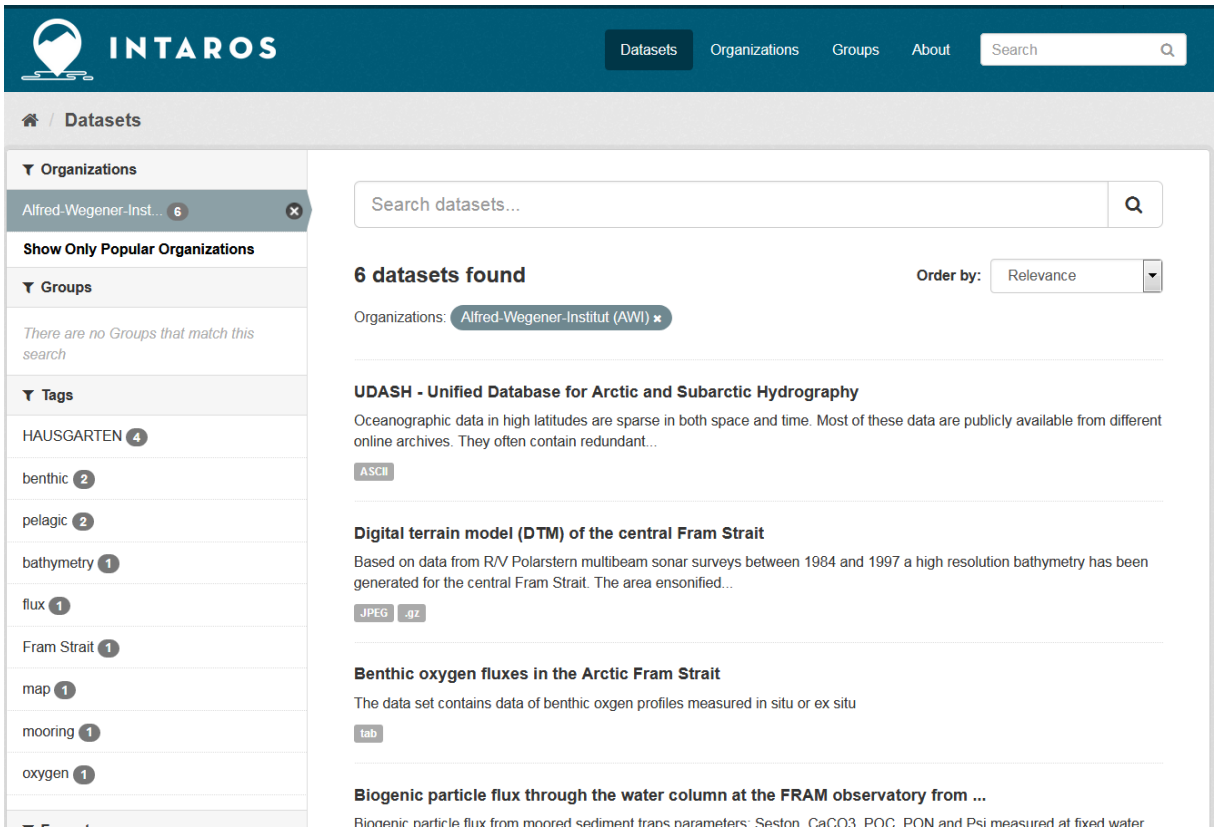


Figure 8. Searching for all datasets from a given organisation in the INTAROS Data Catalogue.

3. Design and implementation

The ***iAOS portal*** will provide 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 formats (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 (as supported by the providers' access protocols).

As the INTAROS partners implement cloud based or other web-based services to process and analyse data provided by means of integrated data providers, the ***iAOS portal*** will also provide access to these services and display the results on a map together with datasets from INTAROS or other sources. Registered users will be able to start these processing and analysis services from the ***iAOS portal***, selecting input data from one of the integrated repositories and receiving the results through the iAOS cloud platform.

We have selected the 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 dataset, organisation and group management,

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 9 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 process these requests and send 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 layers 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 three established and mature extensions (plugins) in the implementation of the INTAROS Data Catalogue. 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-geoview**: Provides a visualisation component for data.

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.

The extension mechanism of CKAN will be used to develop new plugins to provide access to the cloud services developed in the iAOS Cloud Platform (Caumont, 2018). These plugins will enable a user to define the needed input parameters to the cloud service, connect to the cloud platform to run the service, retrieve the result and to visualise it in the ***iAOS portal***. Planned services in the iAOS Cloud Platform include geo-statistics, computation of sea ice statistics and processing of passive acoustics data (see Section 2). Additional services is expected to be developed during the project, as stakeholder dialog in WP 6 ("Applications of iAOS towards Stakeholders") identifies new requirement for data processing, analysis and visualisation.

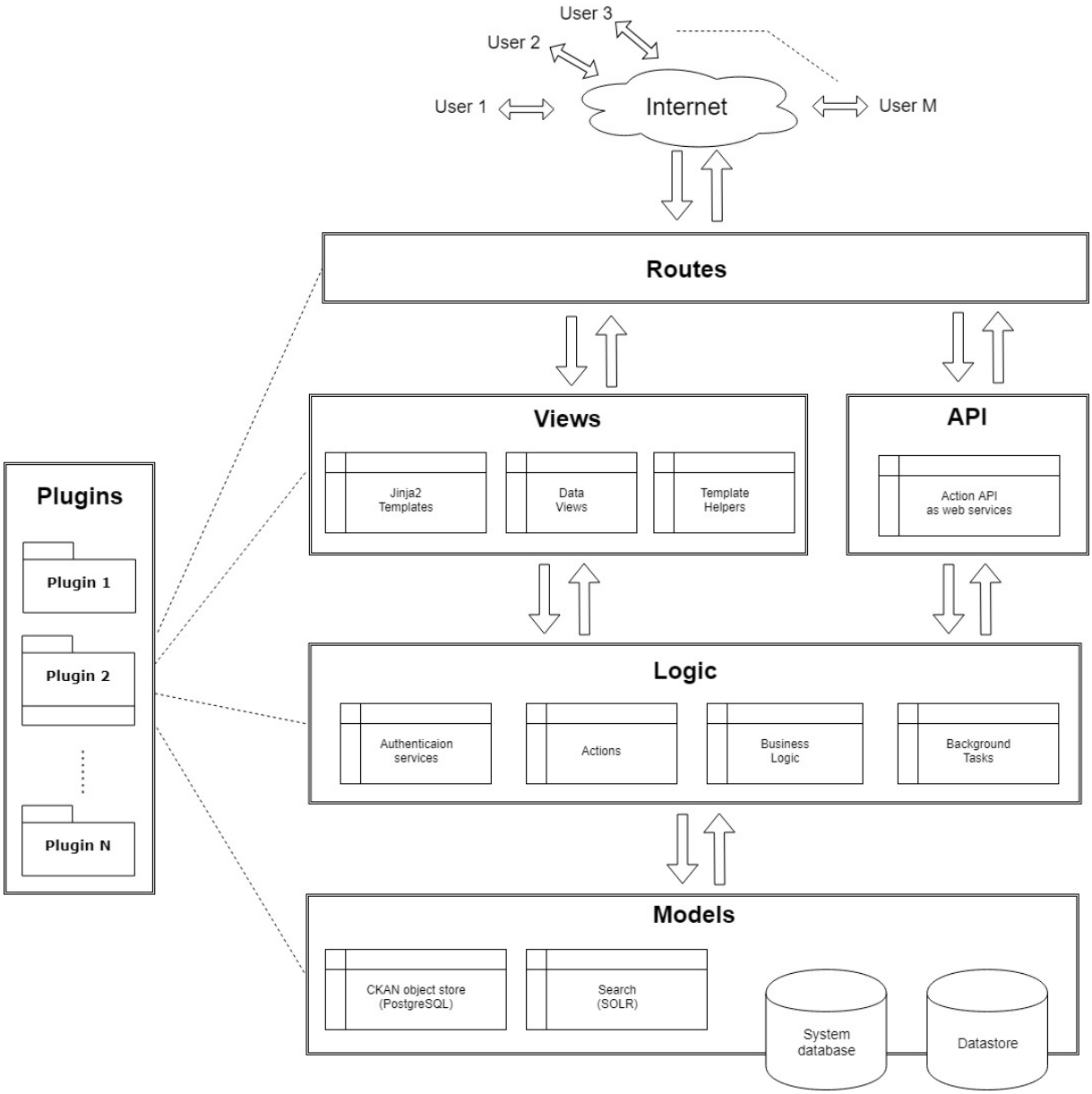


Figure 9. Architecture of CKAN (adapted from CKAN online documentation).

4. Examples of use

The INTAROS Data Catalogue provides access to datasets collected or made available by projects partners through WP 2 ("Exploitation of existing observing systems") during the two first years of the project. Users can view dataset descriptions (metadata), display figures and maps illustrating each dataset, and access data that have been published online. Figures 10 and 11 show examples of datasets published by INTAROS partners. Further examples from the INTAROS Data Catalogue are included in Appendix A.

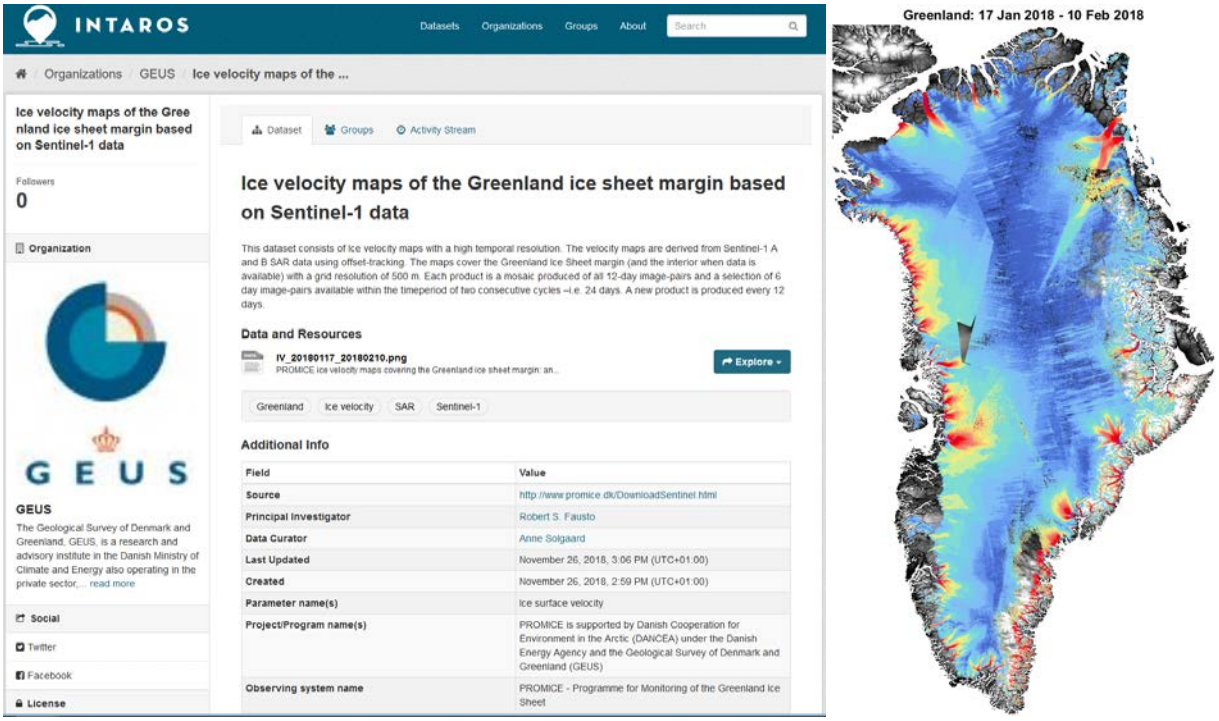
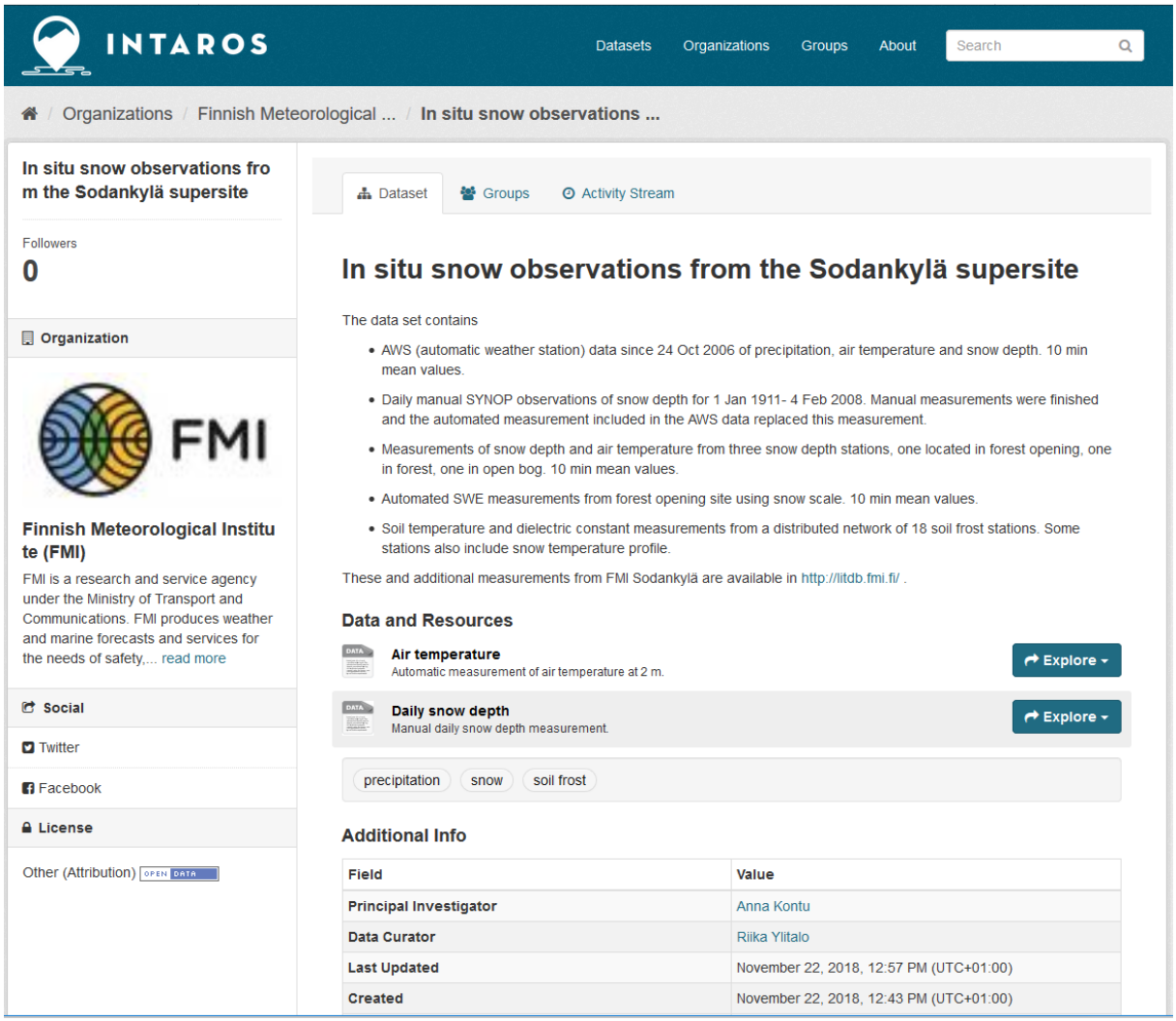


Figure 10. A Sentinel-1 derived sea ice velocity dataset of the Greenland ice sheet from GEUS.



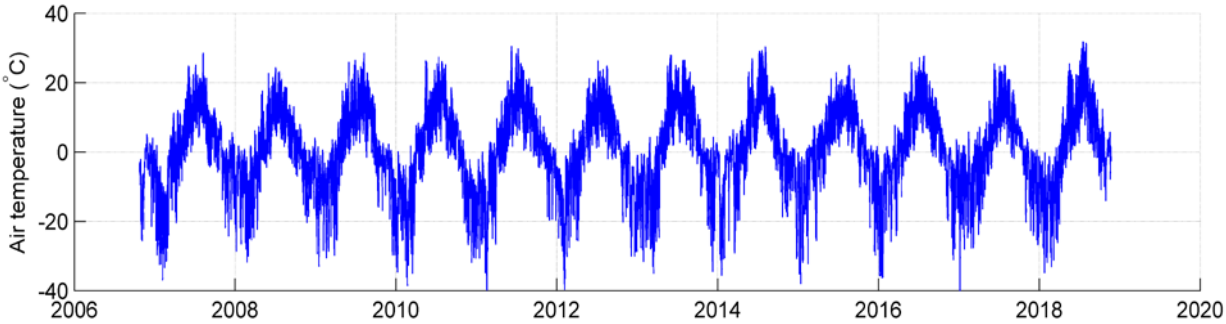


Figure 11. In situ snow observations from the Sodankylä supersite provided by FMI.

A first test dataset of Sentinel-1 SAR based sea ice classification maps were generated in the Terradue Cloud Platform in July 2018. Figure 12 shows two of these maps, with the corresponding dual polarization SAR images used by the classification algorithm.

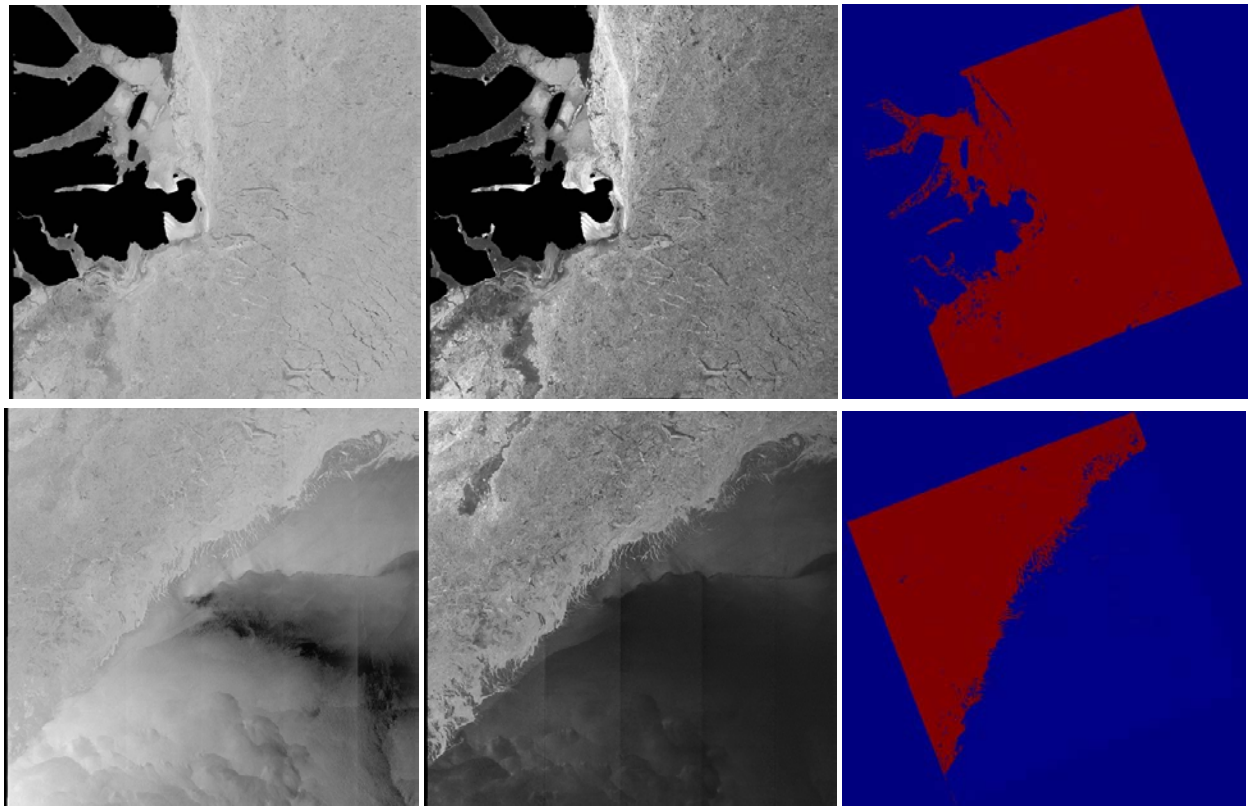


Figure 12. Sentinel-1 SAR images from 4 March 2016, northern Greenland/Fram Strait. Left: HH channel. Middle: HV channel. Right: Sea ice classification (red / blue (water/land/no data)).

The first version of the geo-statistics service for interpolation of in situ point measurements to a model grid, uses the Kriging method from RGeostats. This service can generate an interpolated field of temperature, conductivity or salinity, and has been tested on CTD data from one research vessel from IMR for the period 2002-2016. Figure 13 shows an example of the initial mapping of in situ temperature and salinity on a regular latitude-longitude grid.

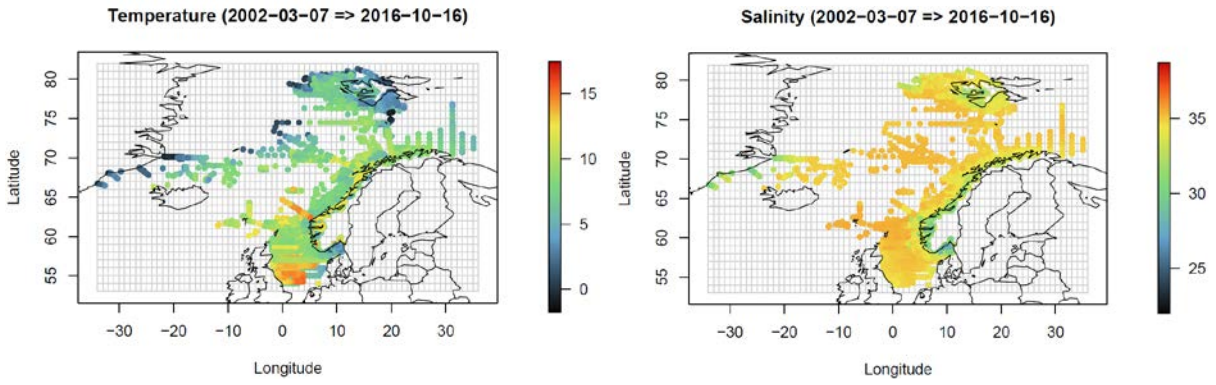


Figure 13. Map of temperature and salinity measurements from research vessel RV Håkon Mosby.

5. Summary and future work

This report describes the first version of the ***iAOS portal***, where focus has been on designing and implementing the INTAROS Data Catalogue (https://catalog-intaros.nersc.no/). We have selected CKAN (Comprehensive Knowledge Archive Network), a widely used open source data management system, to implement the data catalogue and portal for INTAROS. 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. Three mature plugins have been installed already for management of geographic data: **ckanext-spatial**, **ckanext-harvest**, and **ckanext-geoview**. In addition, a small plugin has been developed to extend the schema for datasets with new metadata elements that is needed by the INTAROS Data Catalogue.

The ***iAOS portal*** will be further developed throughout the INTAROS project. Among currently planned enhancements are: (1) improving the functionality of the INTAROS Data Catalogue, (2) integrating datasets from external data infrastructures and repositories according to the recommendations from WP2 ("Exploitation of existing observing systems") and stakeholder requirements from WP6 ("Applications of iAOS towards Stakeholders"), (3) ability to run selected iAOS Cloud Platform services from the portal, and (4) adding new functionality such as model – in situ or model – satellite data intercomparison and visualisation to the portal.

We will develop new functionality in close cooperation with INTAROS partners and the stakeholders of iAOS. This will ensure that important Arctic datasets for all spheres (ocean and sea ice, land and cryosphere, atmosphere) for the targeted application areas of WP6 are easily accessible through the ***iAOS portal***. We will also develop ample tools to process, analyse, display and download these datasets, leveraging existing software components from INTAROS partners and Open Source communities in GIS and geosciences. Special emphasis will be on demonstrating access to the iAOS Cloud Platform services developed in the project.

6. References

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Appendix A. User Manual

Enter the INTAROS Data Catalogue by opening https://catalog-intaros.nersc.no/ in your web browser. From the home page (Figure 14) of the data catalogue you can navigate to different parts of it by following links to

- Datasets that are described in the catalogue
- Organisations providing datasets for iAOS
- Groups that collects datasets connected to a certain topic of theme (not currently used)
- About the catalogue, explaining what kind of datasets can be found in the catalogue

The home page also allows you to search for datasets, either through free text search or by selecting one or more of a set of keywords (tags) that data providers have associated with their datasets. From the statistics summary, you have direct access to the datasets area, organisation and group descriptions. Further the home page contains a short welcome statement and the organisation that most recently added datasets, and a link to these.

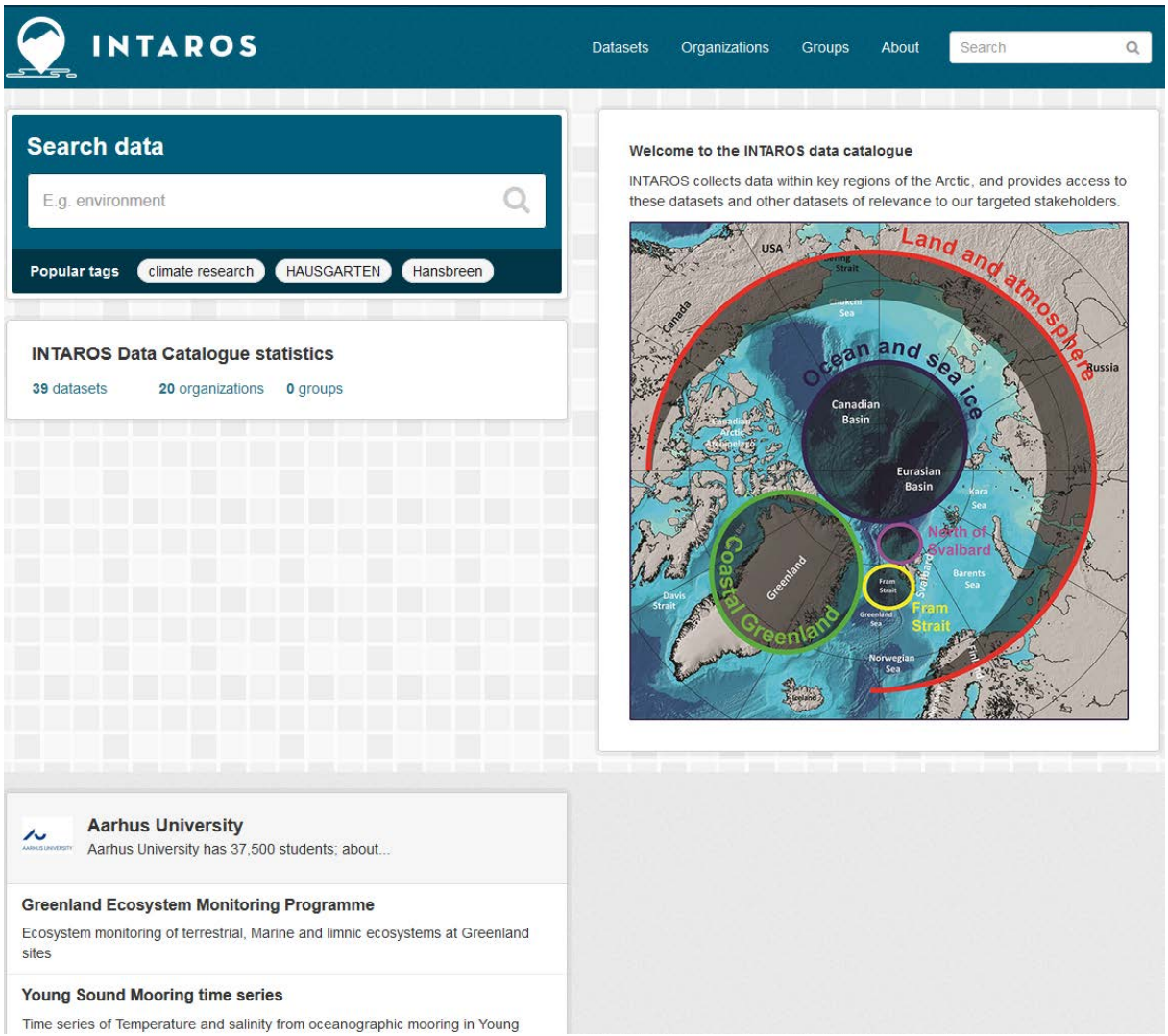

Figure 14. Home page of the INTAROS Data Catalogue.

If you follow the Datasets link, a page with short summaries of datasets in the catalogue is presented (Figure 15). From this you can scroll down to find datasets of interest or use the different search facets to the left, such as organisation names and tags associated with the datasets. You can select one or more such search facets to identify datasets of interest (Figure 16 and Figure 17). 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 18) and navigate to access and download in the repository holding the dataset (Figure 19).

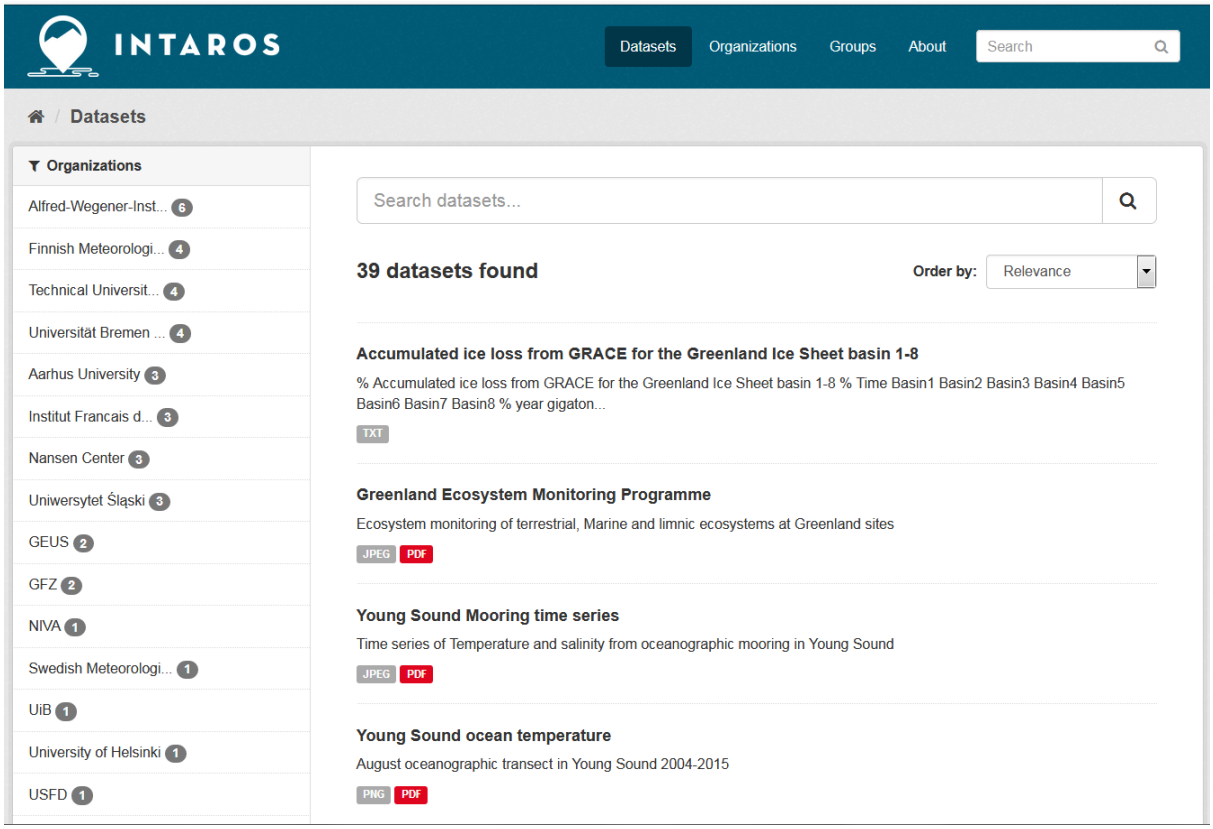

Figure 15. Dataset overview page of the INTAROS Data Catalogue.

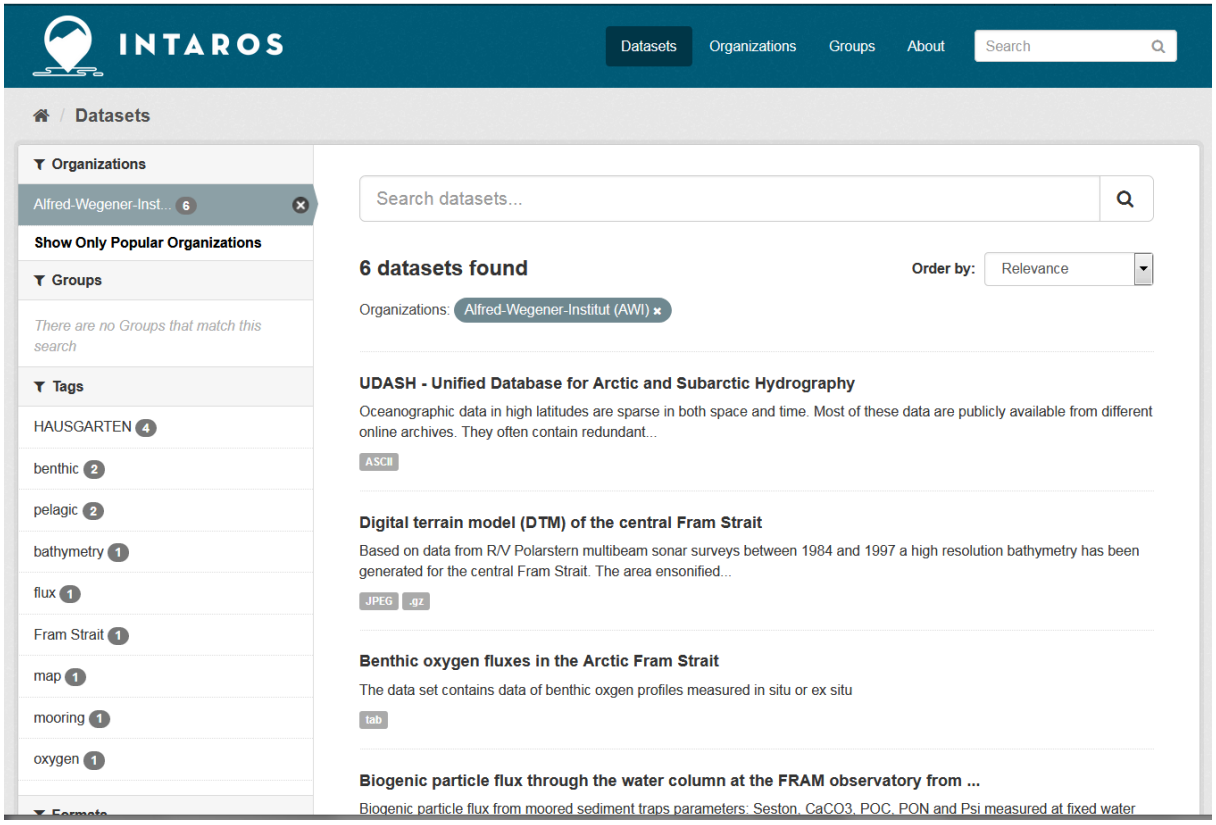

Figure 16. Searching for all datasets from an organisation in the INTAROS Data Catalogue.

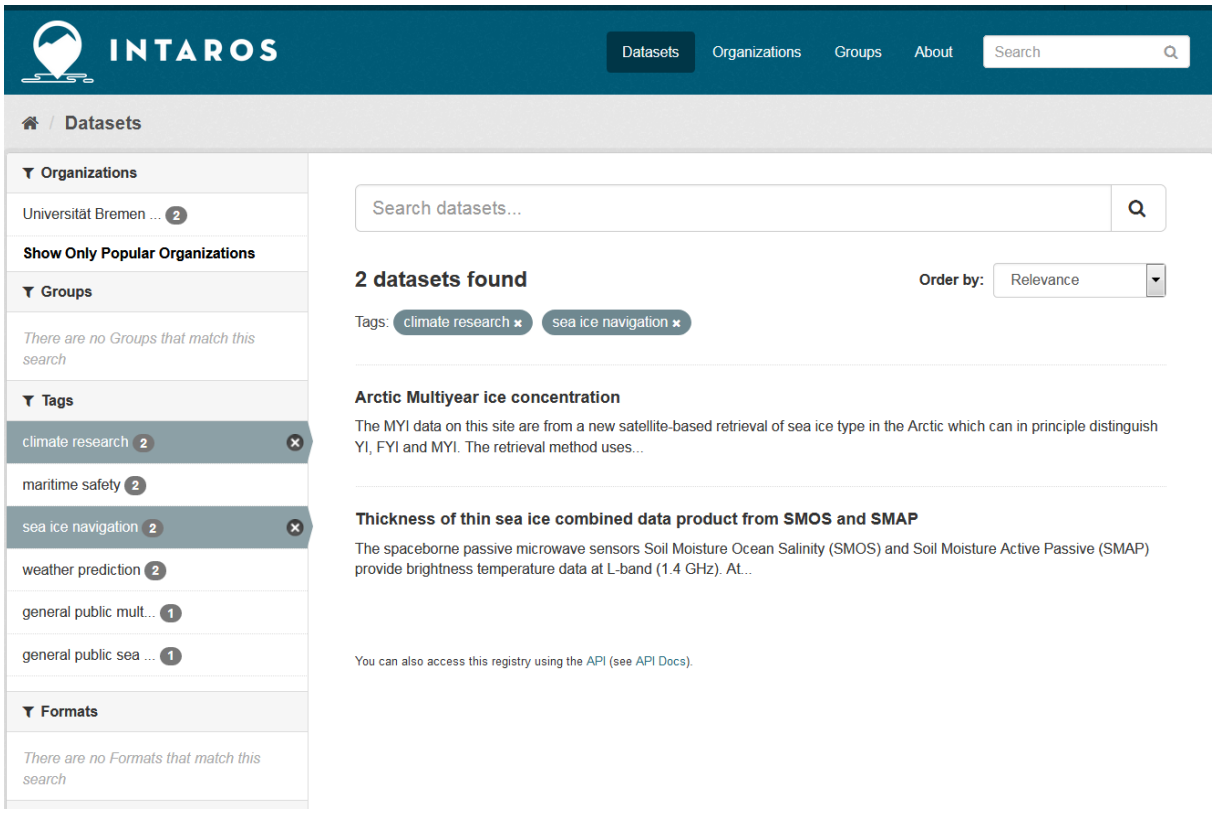

Figure 17. Searching for all datasets associated with two chosen keywords "climate research" and "sea ice navigation".

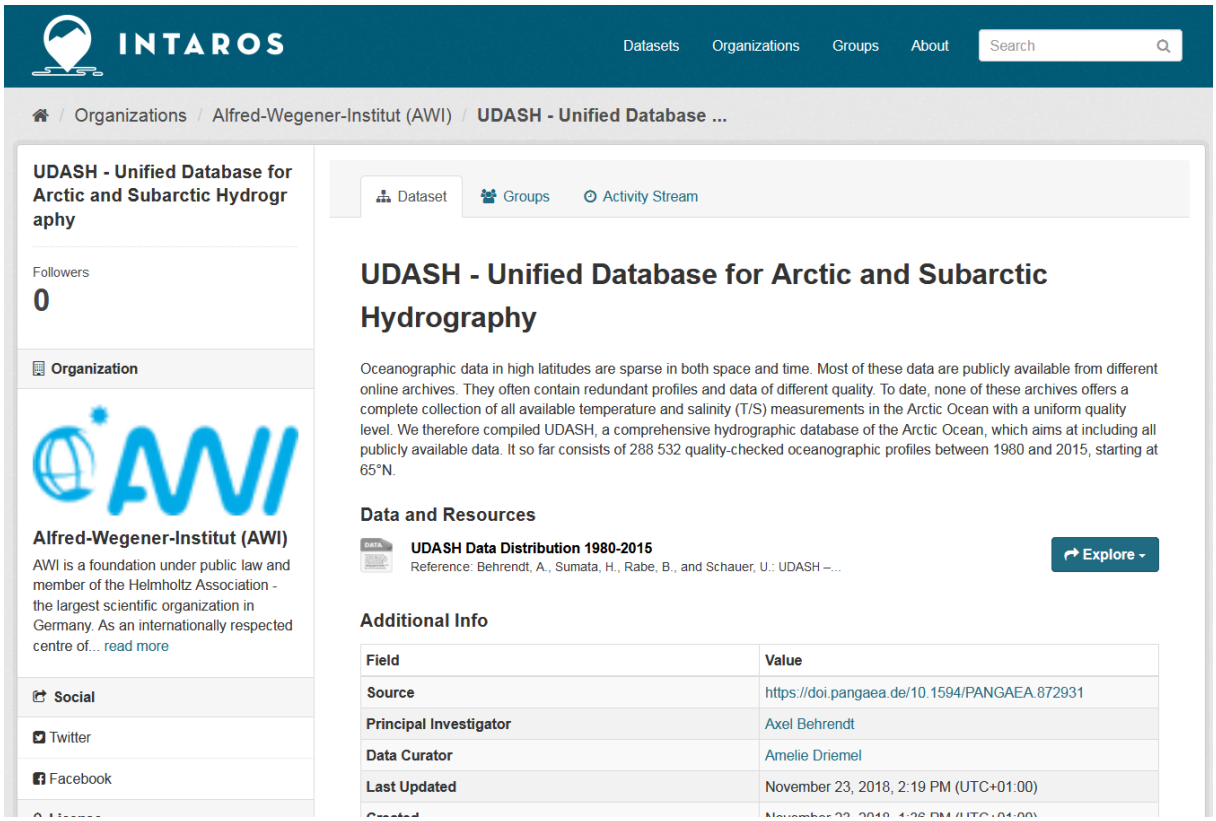

Figure 18. Viewing metadata for a chosen dataset, including links to data source (repository).

Figure 19. Following a dataset link to the repository holding the data.

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INTAROS

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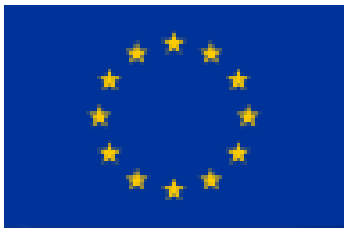

Project partners: