Integrated Arctic Observation System

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Deliverable 7.12

Educational Packages for Scientists

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Authors:

Ruth Higgins (EurOcean), Stein Sandven (NERSC), Donatella Zona (U.Sheffield), Mathilde Sørensen (UiB), Peter Voss (GEUS), Agnieszka Beszczynska-Möller (IOPAN), Roberta Pirazinni (FMI).

Version	DATE	CHANGE RECORDS	LEAD AUTHOR
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9	GEUS		**32**	IGPAN	
10	FMI	*1*	**33**	U SLASKI	
11	UNIS		**34**	BSC	
12	NORDECO		**35**	DNV GL	
13	SMHI		**36**	RIHMI-WDC	
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15	NUIM		**38**	WHOI	
16	IFREMER		**39**	SIO	
17	MPG		**40**	UAF	
18	EUROGOOS		**41**	U Laval	
19	**EUROCEAN**	***1***	**42**	ONC	
20	UPM		**43**	NMEFC	
21	UB		**44**	RADI	
22	UHAM		**45**	KOPRI	
23	NORCE		**46**	NIPR	
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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

Deliverable 7.12 derived from INTAROS Task 7.5, which is dedicated to building capacity among early-career researchers. This deliverable builds on D7.11, which described the training that was provided to higher level and post-graduate students during the project. D7.12 makes available independent learning resources, online, for those who could not participate in the training activities, but also to provide a legacy for the scientific expertise contributing to and emerging from INTAROS.

INTAROS Educational Packages for Scientists comprise four themed packages, designed for postgraduate level students and scientists. These packages cover the themes: terrestrial chemistry, seismology, ocean observation, and snow.

Each educational package includes one or more lectures on a specific topic, provided by an INTAROS expert in that area, a list of supporting reading materials, links to additional online resources, and an online self-evaluation module.

The formal educational packages are supported by other online learning materials including lectures and short movies on a broad range of topics within the scope of INTAROS.

INTAROS will continue to support early career researchers throughout the remainder of the project by featuring their research in an online poster gallery, in a series of inspirational films about their work, and by encouraging their contribution to online learning materials for their peers.

Table of Contents

1. Introduction

INTAROS brings together expertise from a broad range of scientific disciplines to better understand the Arctic through a fully integrated Arctic Observing System. As part of this remit, INTAROS has always focused on the longer-term perspective and the future of Arctic observing. Every opportunity was taken to build capacity among young and early-career researchers, among high school students and the general public. Many classes, lectures and courses were offered throughout the project, as described in Deliverable 7.11 - Scientific Capacity Building. Educational materials were provided for use with school groups and the general public, as described in Deliverable 7.7 – Educational Materials, V1, and new learning modules were created for these groups, as described in Deliverable 7.8 – Educational Materials V2.

The current report, Deliverable 7.12 – Educational Packages for Scientists, completes the capacity building process by providing the scientific educational materials used throughout the project in a format that facilitates independent learning and self-evaluation.

The set comprises four educational packages on the themes: Terrestrial chemistry, Seismology, Ocean observations, and Snow. The packages are designed to be followed independently by users with an existing level of scientific knowledge, the requirement of which is specified for each package. Nevertheless, these packages are also likely to be of interest and benefit to members of the broader public, particularly those with an interest in life-long learning and further education.

The core of the package is typically 1-2 introductory tutorials of about 1 hour in length, with accompanying reference materials, such as published scientific articles, publicly available scientific reports, and short films and clips from field expeditions. Having absorbed the information in the educational materials, learners have the opportunity to take an online self-evaluation, that provides a score and can be repeated as many times as necessary.

In addition to the four core packages, a selection of supplementary educational resources is provided through the INTAROS website, including further tutorials, posters and short clips and films from Arctic expeditions. The learning packages and supplementary materials will continue to be improved and augmented after the delivery of this report.

2. Packages for Scientists

Package 1: Terrestrial biogeochemical cycles.

Contributor: Donatella Zona, U. Sheffield.

Learning Objectives: To introduce the response of carbon fluxes from arctic tundra ecosystems to global climate change. Students are expected to gain an understanding of the fate of the extensive soil carbon storage in the Arctic following climate change, to understand the cost of Arctic carbon emissions on society, to learn about the impact of emissions on local communities.

Target Audience: Upper division undergraduate students, graduate students (masters and PhD). A background in basic ecosystem ecology is recommended, but not required.

Content of the Package:

1. Tutorial: Global Change in Northern High Latitudes.
2. Supporting reading material.
3. Self-evaluation module.

Tutorial: Global Change in Northern High Latitudes

Temperatures in Northern latitudes have increased by 0.6 °C in the last 30 years, which is twice the global average with the largest increase in the non-summer seasons. Organic carbon in northern soils is more than double the current atmospheric pool. An increasing fraction of this organic carbon is vulnerable to be released to the atmosphere. This lecture summarizes the main impacts of climate change on arctic ecosystems, discussing the feedbacks occurring in the Arctic, and the implication for the global carbon balance. It also includes a discussion of the estimated cost of the increase in Arctic carbon emissions to our society and the consequences of recent changes for native communities.

Package 2: Seismology

Contributor: Mathilde Sørensen, UiB, and Peter Voss, GEUS.

Learning objectives: This package aims to introduce scientists to the use of ocean bottom seismometers (OBS) to understand natural hazards in the Arctic. Learners will gain an understanding of the OBS data available and will learn how to find and extract the data from the INTAROS database. They will also gain an understanding of the application of the INTAROS OBS data to analyse seismic events in the Arctic.

Content of the Package:

1. Tutorial: Access, download and pre-processing of the INTAROS OBS data.
2. Tutorial: Examples on analysing seismic events recorded by the INTAROS OBS data.
3. Supporting reading material.
4. Self-evaluation module.

Target Audience: The audience for this video is mainly university students at bachelor or master level, but also researchers new to the field of seismological data.

Tutorial 1: Access, download and pre-processing of the INTAROS OBS data

In this video, we present how to access, download and pre-process the INTAROS OBS data. The INTAROS OBS dataset consists of broadband seismic recordings from three ocean bottom seismometers (OBS) deployed west of Svalbard, along the spreading ridge, for about one year during 2018-2019. The handling of the instruments is presented in another video (see INTAROS, 2019). A separate video is available on how to analyse the data after pre-processing. The data are exploited in the INTAROS data catalogue under Natural Hazards (see https://catalog-intaros.nersc.no/) and made available through the European Integrated Data Archive (EIDA) node at University of Bergen (https://eida.geo.uib.no/webdc3/). EIDA provides seismological data from multiple deployments of seismic instruments both on land and offshore, we present how to explore the many deployments and find the INTAROS OBS data. Access to data is provided as access to the ground movement data (waveform data) and to the metadata. The waveform data may be downloaded in different time intervals, we give examples of how to download and pre-process the data for different purposes. This includes a fast and simple way of screening the data for seismic events and extracting these for further analysis. Metadata are required to convert the acquired waveform data into ground

displacement or ground velocity for further analysis. We show how to access the metadata and how to combine the metadata with the waveform data for data analysis.
Free and open software is used throughout this demonstration. For the pre-processing we mainly use the SEISAN software package, for more examples on how to use SEISAN see the training document at http://seisan.info/ (Havskov et al. 2020).

Tutorial 2: Examples on analysing seismic events recorded by the INTAROS OBS data

In this video, we demonstrate how to analyse seismic events recorded by the INTAROS OBS data. The INTAROS OBS dataset consists of broadband seismic recordings from three ocean bottom seismometers (OBS) deployed west of Svalbard, along the spreading ridge, for about one year during 2018-2019. The handling of the instruments is presented in another video (see INTAROS, 2019). A separate video is available on how to access, download and pre-process the data.
Building on the video "Access, download and pre-processing of the INTAROS OBS data" (video 1), we select a few of the downloaded events and demonstrate how to enter the events into a SEISAN database, pick seismic phase arrival times and locate the events. SEISAN is freely available at http://seisan.info/ (Havskov et al. 2020). We also demonstrate how to read wave amplitudes for magnitude determination. Finally, we show how to combine the OBS data with data from permanent land-based seismic stations and how values describing the parametrisation of the seismic velocities in the earth affect the analysis of the data.
This demonstration will enable users of the INTAROS OBS data, not familiar with seismological data analysis, to preform simple analysis of earthquakes and other seismic events. The users will also be introduced to the complexity of generating seismological parametric data and some of the uncertainties in this field of natural hazards. As an inspiration on how such an OBS data set can be used to acquire new knowledge on active seismic zones we recommend looking at the work of Jeddi et al. (2020).

Package 3: Ocean observations

Contributor: Agnieszka Beszczynska-Möller, IOPAN.
Learning objectives: This module introduces the topic of long-term ocean observation via moorings. Learners will gain an understanding on how to plan and execute mooring deployment in challenging Arctic conditions.

Content of the Package:

1. Tutorial: Mooring operations in polar waters.
2. Supporting reading material.
3. Self-evaluation module.

Target Audience: Master and PhD students with background in oceanography or marine engineering, technicians working with oceanographic equipment in the field.

Tutorial: Mooring operations in polar waters

Fixed ocean moorings are the main platforms to provide long-term observations of marine environment, covering different time scales from shorter than hourly to monthly, seasonal, and multiannual measurements. Moored instruments can nearly continuously measure different ocean variables, including physical, biogeochemical, and biological parameters (and also collect samples and visual images) and are widely used in ocean research all over the world. However, mooring operations in the demanding, ice-covered polar areas are linked to unique

challenges, related to both the platform design (instrumentation and mooring hardware) and to how to deploy and recover a mooring from an icebreaker in the partial or even full sea ice cover. During this short course, we will introduce the main issues about how to plan, design, equip and operate a mooring for measurements in the polar region. We will present different types of oceanographic instruments and discuss their fitness for measurements in polar waters. We will also address the specific ship operations for deployment and recovery of moorings in ice-covered waters and discuss how to ensure safe and efficient work with under-ice moored equipment.

Package 4: Snow and sea ice

Contributor: Roberta Pirazzini, Anna Kontu, Henna-Reetta Hannula, FMI.
Learning objectives: This package introduces the Lapland field station, Sodankylä, and its role in monitoring the terrestrial Arctic snow, as well as looking at the role of drones in the study of sea ice. Learners will gain an appreciation of the cutting edge technologies applied in the field, and learn new approaches to Arctic data analysis.

Content of the Package:

1. Tutorial: Sodankylä supersite: Interdisciplinary, multisensory and multispectral observations of Arctic atmosphere, snow, and land.
2. Tutorial: Drone-based albedo measurements at the North Pole.
3. Supporting reading material.
4. Self-evaluation module.

Target Audience: Undergraduate and graduate students in the field of polar atmospheric and terrestrial science, as well as for research infrastructure managers and data users (above all modellers).

Tutorial 1: Sodankylä supersite: Interdisciplinary, multisensory, and multispectral observations of Arctic atmosphere, snow, and land.

The presentation describes the observational supersite of Sodankylä, in northern Finland, comprising a network of distributed observational towers and sensors in forest wetland, open fields, covering an area of few square kilometres. The major instruments will be illustrated, together with the obtained physical parameters and their application areas.

Tutorial 2: Drone-based albedo measurements at the North Pole.

Drone-based albedo and photo-mosaic observations over Arctic sea ice were carried out during the last leg of the MOSAiC experiment (August-September 2020). These albedo observations were the northernmost ever made from drone and complemented the surface-based albedo observations carried out over the drifting ice floe from fixed and portable instruments. The combination of drone based-albedo and photo-mosaic observations will enable the evaluation of albedo variability over different spatial scales (from m to 100m) in an environment characterized by high albedo heterogeneity and strong albedo contrasts between the different surface types (first-year ice, multi-year ice, melt ponds, open leads). The presentation will illustrate the measurement platforms, the performed flights, the encountered sea ice conditions and will introduce the scientific objectives of the planned data analysis.

Supplementary Educational Resources

Simple Tutorials and Lectures

A selection of simple tutorials and lectures on a range of themes is available to support and augment the education offer to scientists. These tutorials and lectures are not currently part of a complete educational package but may eventually be developed into a new themed package for greater learning potential. These materials are available on the INTAROS website in the area dedicated to learning materials for scientists.

Tutorials and Lectures:

Collaborative Resource Management - New UArctic Thematic Network. Finn Danielsen, Nordeco, 2021.

North of Svalbard - A vital region at the entrance to the Arctic. Hydrography and biogeochemistry. Angelika Renner et al., 2021.

Stable water isotope observations during INTAROS cruises North of Svalbard: links to atmospheric circulation and sea ice processes. Alexandra Touzeau, University of Bergen, 2020.

Engaging fishermen in documenting resources: Lessons from PISUNA in Greenland, PâviâraK Jakobsen, Qeqertalik Municipality, Greenland, 2021.

Informative Films:

Ice discharge from Greenland Ice Sheet. Francisco Navarro, UPM.

Field Missions:

KV Svalbard 2018 expedition: The INTAROS field experiment North of Svalbard in 2018 is documented in a film prepared for the INTAROS and UAK projects - Useful Arctic Knowledge. The INTAROS field experiment was planned and led by Nansen Environmental and Remote Sensing Center. Seventeen scientists from several countries and different generations participated in this cruise deploying instruments to measure oceanic, atmospheric and geophysical parameters.

INTAROS Cruise 2018 – Isotope installation. Impressions from the installation of stable water isotope measurement instrumentation on icebreaker KV Svalbard.

INTAROS – Journey to the Ice: In 2019 a group of Danish scientist responsible for the surveillance of the melt from the Greenland Ice Sheet discovered that a crucial weather station was broken. Here is their journey to the Greenland Ice sheet, and to recover the data for the INTAROS project.

Experiencing climate change first hand. An informative film about scientific field studies in Greenland, developed and produced by Deep Sea Reporter with the collaboration of INTAROS's Mikael Sejr, Aarhus University.

INTAROS Poster Gallery

To give scientists an insight into the scientific work carried out during the project, an INTAROS poster gallery has been set up, displaying the poster presentations made at international scientific meetings and conferences, during the course of the INTAROS project.

Alliouane, S., J. Fin, N. Metzl, U. Posner, P. Fischer, J.P. Gattuso. (2019) Carbonate system time-series in the coastal Arctic.

De Andrés E., F. Straneo, D. A. Slater, F. (2018) Why were buoyant plumes suppressed at a west Greenland tidewater glacier during the record 2012 melt season?

King, A.L., S. Marty, M. Norli, P. Jaccard, R. Bellerby, K. Sørensen (2019). Monitoring ocean acidification and carbon cycling on FerryBox Ships of Opportunity with underway carbonate system sensors.

Kohnert, K., B. Juhls, S. Muster, S. Antonova, A. Serafimovich, S. Metzger, J. Hartmann, T. Sachs (2017) Towards Understanding the Contribution of Waterbodies to the Methane Emissions of a Permafrost Landscape on a Regional Scale – A Case Study from the Mackenzie Delta, Canada.

Patilea, C., M. Huntemann, G. Heygster, G. Spreen. (2021) Thin Sea Ice Thickness From Combined SMOS and SMAP L-band Satellite Microwave Radiometer Observations.

Poulsen, M.K., L. Iversen, T. Cheeseman, B. Damsgård, V. Meraldi, N.E. Mikkelsen, Z. Sokolíčková, K. Sørensen, A. Tatarek, P. Wagner, S. Sandven, F. Danielsen. (2021) Monitoring Svalbard's environment and cultural heritage through citizen science by expedition cruises.

Serafimovich, A., S. Metzger, Jörg Hartmann, Sebastianwieneke, Torsten Sachs (2016) Variability of surface energy fluxes over high latitude permafrost wetlands.

3. References

Havskov, J., Voss, P.H. and Ottemöller, L. (2020): Seismological Observatory Software: 30 Yr of SEISAN. Seismological Research Letters, 91 (3): 1846-1852. DOI: https://doi.org/10.1785/0220190313 (preprint: http://seisan.info/reports/seisan_srl_preprint_2020.pdf).

Jeddi, Zeinab, Lars Ottemöller, Mathilde B. Sørensen, Sara Rezaei, Steven J. Gibbons, Marte L. Strømme, Peter H. Voss, Trine Dahl-Jensen; Improved Seismic Monitoring with OBS Deployment in the Arctic: A Pilot Study from Offshore Western Svalbard. *Seismological Research Letters* 2021; 92 (5): 2705–2717. doi: https://doi.org/10.1785/0220200471 (preprint: https://eartharxiv.org/repository/view/2731/).

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INTAROS

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Project partners: