H2020-EO-1-2014
New ideas for Earth-relevant space applications

SPICES
Space-borne observations for detecting and forecasting sea ice cover extremes

Deliverable: D1.1
Plan for buoy deployments
(including in-kind buoys from other projects)

SPICES project has received funding from the European Union's Horizon 2020 Programme under Grant Agreement No. 640161
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1 Document details

1.1 Overview of the document

The development and validation of algorithms that derive physical properties of sea ice from satellite observations require different kinds of ground truth data sets. Autonomous platforms (buoys) allow time series measurements of essential sea ice parameters from regions and times where and when manual measurements are not available otherwise. SPICES makes use of existing (archive) and new sea ice measurements from buoys. Main quantities for SPICES are sea ice thickness, snow depth on sea ice, sea ice drift velocity and direction, air, snow, and sea ice temperatures, as well as surface albedo of snow and sea ice. The main aim of this buoy deployment plan is to sketch data sets that may be expected for Arctic and Antarctic sea ice regions in the main data acquisition phase of SPICES (2015-2017). This refers to the spatial distribution as well as the timing and frequency of observations. The plan is meant to support the planning of validation efforts, together with the ordering and acquisition of dedicated satellite data (e.g. high resolution SAR scenes). Furthermore, it contains technical information about the different buoy types and data access.

1.2 Document Information

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1.3 Document history

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H2020 SPICES 3 Grant agreement: 640161
1.4 Reference Documents

*H2020 and SPICES documents (e.g. earlier deliverables); no literature references here*

- Grant Agreement no: 640161, Annex 1 - Description Of Action (part A)
- Grant Agreement no: 640161, Annex 1 - Description Of Action (part B)

1.5 Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<tr>
<td>IABP</td>
<td>International Arctic Buoy Program</td>
</tr>
<tr>
<td>IMB</td>
<td>Ice Mass-balance Buoy</td>
</tr>
<tr>
<td>IPAB</td>
<td>International Program of Antarctic Buoys</td>
</tr>
<tr>
<td>SRB</td>
<td>Spectral Radiation Buoy</td>
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<tr>
<td>SVP</td>
<td>Surface Velocity Profiler</td>
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2 Introduction

The development and validation of algorithms that derive physical properties of sea ice from satellite observations require different kinds of ground truth data sets. Autonomous platforms (buoys) allow time series measurements of essential sea ice parameters from regions and times where and when manual measurements are not available otherwise. From these time series, different kinds of data products may be derived, which then can be co-located with synchronous satellite observations. First of all, direct comparisons of physical quantities are possible, e.g. sea ice thickness, snow depth, and surface temperatures. Combing measurements from multiple buoys allows deriving seasonal and regional patterns, which can be compared to according results from satellites on larger temporal and spatial scales. But also an improved understanding of interactions between atmosphere, snow, sea ice, and ocean contributes to satellite algorithm development and validation.

SPICES makes use of existing (archive) and new sea ice measurements from buoys. Main quantities for SPICES are:

- Sea ice thickness
- Snow depth on sea ice
- Sea ice drift velocity and direction
- Air, snow, and sea ice temperatures
- Surface albedo of snow and sea ice

All these parameters are available from different types of autonomous instrumentation (buoys). Measurements are performed in different frequencies, ranging from minutes to days, depending on the predominant time scales of the governing processes. The exact measurement and transmission intervals of each buoy is planned in connection with other projects and autonomous devices, in particular with project partners that provide the funding for the buoys. Finally, these settings result from optimizing energy consumption, data volume, and buoy lifetime.

The main aim of this buoy deployment plan is to sketch data sets that may be expected for Arctic and Antarctic sea ice regions in the coming years. This refers to the spatial distribution as well as the timing and frequency of observations. The plan is meant to support the planning of validation efforts, the order and acquisition of dedicated satellite data retrievals (e.g. high resolution SAR scenes). Furthermore, it contains technical information about the different buoy types and data access.

It has to be noted that this plan depends on various external constraints, which may only partly be influenced by the SPICES community: All units depend on third party funding, all deployments depend on the logistics of the respective expedition, and none of the instruments may be maintained after deployment.

3 Buoy types and measured parameters

The following chapters provide an overview over the different buoy types and their measured parameters. More specific technical details (e.g. sensor types and accuracies) as well as information to individual units are available from the technical descriptions and deployment information from www.meereisportal.de, from the given references, or directly from the manufacturers fact sheets of the units, which are listed below.
3.1 Thermistor string buoys (IMB)

Thermistor string buoys (Figure 1) are designed to measure sea ice and snow mass balance through temperature and thermal conductivity measurements. They are often referred to as SAMS IMB, because they were originally build by the Scottish Association for Marine Science as Ice Mass-balance Buoys. The heart of the buoy is a 5m-long thermistor string reaching from the air through snow and sea ice into the ocean. Through its heating mode of the thermistor elements thermal conductivity is derived. Contrasts in temperatures, temperature gradients, and heat conductivities are used to determine the interface positions between air, snow, sea ice, and seawater. From this, snow depth and sea ice thickness are derived. [Hoppmann et al., 2015; Jackson et al., 2013]

**Buoy description**

Manufacturer: SRSL, Oban, UK  
Manufacturer's name: Thermistor Chain IMB  
Weight: approx. 20 kg (depends on battery amount)  
Deployment type: Installation on sea ice, chain through 5cm auger hole  
Measurement interval: Mostly 3-hourly temperature and daily heating data  
Data transmission interval: Mostly hourly  
Power supply: Alkaline batteries  
Life time: >1 year

**Measured parameters**

- Temperatures of air, snow, sea ice, water with 2cm vertical resolution along a 5m-long chain  
- Barometric pressure  
- GPS position

![Figure 1: Thermistor string buoy (IMB) deployed on Arctic sea ice (Photo: M. Nicolaus, AWI)](image)
3.2 Snow Depth Buoy

Snow Depth Buoys (Figure 2) are designed to measure snow depth in the vicinity of the buoy. The main sensors are 4 ultra-sonic range finders that measure the distance to the surface (snow cover). These distances are converted to snow depth, relative to absolute measurements, taken during deployment. The four sensors may be used to derive small-scale variability and/or to obtain a mean value with a footprint of a few square meters.

**Buoy description**

- **Manufacturer:** MetOcean, Halifax, Canada
- **Manufacturer's name:** Snow Beacon
- **Height of mast:** 1.75 m, total height: 2.55m, height of sensors: 1.5m
- **Weight:** approx. 30 kg
- **Deployment type:** Installation on sea ice (into 25cm diameter hole)
- **Measurement interval:** Depends on sensor (3 to 60 min), transmits hourly mean values
- **Data transmission:** Hourly
- **Power supply:** Lithium or Alkaline batteries
- **Life time:** >1 year

**Measured parameters**

- 4x Snow depth
- Air temperature (approx. 1.5 m above sea level)
- Body temperature
- Barometric pressure
- GPS position

*Figure 2: Snow Depth Buoy deployed on Antarctic sea ice (Photo: S. Schwegmann, AWI)*
3.3 Surface Velocity Profilers (SVP)

Surface Velocity Profilers (Figure 3) are designed to observe sea ice drift through GPS position measurements. It has to be noted that the term 'SVP' is used in various ways for many similar types of sensors that are mostly used for ocean drifters, including a drogue to make the surface unit drift with the ocean currents and less with the wind. Here we place the SVPs on sea ice, but they may continue drifting also after all sea ice has melted. This has to be considered when interpreting displacements as sea ice drift.

Buoy description
Manufacturer: MetOcean, Halifax, Canada
Manufacturer's name: iSVP
Weight: approx. 10 kg
Deployment type: Placement or drop on sea ice
Measurement interval: Mostly hourly
Data transmission: Same as measurement interval
Power supply: Alkaline batteries
Life time: >1 year

Measured parameters
- Body temperature
- Barometric pressure
- GPS position

Figure 3: Surface Velocity Profiler deployed on Antarctic sea ice (Photo: M. Nicolaus, AWI)
3.4 Spectral Radiation Buoy (SRB)

Spectral Radiation Buoys are designed to measure spectral radiation fluxes over and under sea ice. The key component is a set of three spectral radiometers (320-950 nm), measuring incident, reflected, and transmitted irradiance to obtain surface albedo and transmittance. [Nicolaus et al., 2010; Wang et al., 2014]

**Buoy description**

Manufacturer: No commercial product. Build by Alfred-Wegener-Institut, main optical components by Trios GmbH, Rastede, Germany

Manufacturer’s name: Spectral Radiation Buoy

Weight: Modular, approx. 20 kg

Deployment type: Placement on and beneath sea ice

Measurement interval: Mostly hourly

Data transmission: Daily

Power supply: Alkaline batteries and solar panel

Life time: No principal limitation

**Measured parameters**

- 3x Spectral irradiance
- GPS position

Figure 4: Spectral Radiation Buoy deployed on Arctic sea ice (Photo: M. Nicolaus, AWI). The cables lead to the under-ice sensors. In addition, a Thermistor String Buoy (yellow Pelicase) is shown.
4 Planned deployments

4.1 Quantities and funding

All buoys, as well as all logistics, which is required for deployments on Arctic and Antarctic sea ice are financed through external funds. In total, it is expected that SPICES has real-time access to data from 135 buoys, 89 on Arctic and 46 on Antarctic sea ice (Table 1). This number comprises 46 IMBs, 34 Snow Depth Buoys, 6 SRBs, and 51 SVPs. The Arctic units will mostly be funded through the FRAM infrastructure program (AWI, HGF) with additional SVP funding through FMI. The Antarctic units will be funded through the ACROSS infrastructure program (AWI, HGF). All data transmission is funded through AWI and FMI internal funds. These numbers refer to the years 2015 to 2017, which can be considered as the data acquisition phase of SPICES.

Table 1: Number of units per buoy type for deployment on Arctic and Antarctic sea ice. The years (top row) indicate years of deployment, while data retrieval may be expected in the following months. Regions of deployment are illustrated in Figure 6.

<table>
<thead>
<tr>
<th>Type</th>
<th>2015</th>
<th>2015/16</th>
<th>2016</th>
<th>2016/17</th>
<th>2017</th>
<th>2017/18</th>
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<td>8</td>
<td>10</td>
<td>10</td>
<td>1</td>
<td>10</td>
<td>7</td>
<td>46</td>
</tr>
<tr>
<td>Snow</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>34</td>
</tr>
<tr>
<td>SRB</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>SVP</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>1</td>
<td>11</td>
<td>7</td>
<td>45</td>
</tr>
</tbody>
</table>

4.2 Data from Non-SPICES platforms

The SPICES consortium will also make use of relevant data from autonomous devices, which are funded and deployed by other international projects and partners. Most of these deployments are coordinated through the International Arctic Buoy Program (IABP), where SPICES members are partners. Deployment plans are communicated and discussed from year to year at annual IABP meetings. In a similar way, the International Program for Antarctic Buoys (IABP) coordinates buoy deployments in the Antarctic. Their deployment plans are also discussed among partners. The SPICES consortium is involved in both networks and has access to all relevant information and data sets.

Furthermore the EU Horizon 2020 project IceArc has a buoy program. These data will be available through partners, which are members of IceArc and SPICES (e.g. FMI, AWI, met.no).

4.3 Deployment concept

Figure 5 illustrates the general concept of buoy deployments within one expedition. Buoys will be deployed as individual units, but also in “super stations”. Super stations describe collections of different buoy types as individual units on the same ice floe, placed on a common site with
rather homogeneous snow and ice conditions. These super stations contain various additional buoy types, which are not described here (e.g. oceanographic profilers, atmospheric measurements, biological sampling), but are central elements of the original programs that fund the instruments.

![Diagram](image)

**Figure 5:** Deployment concept for single units and two super stations during a ship expedition.

### 4.4 Deployment, schedule and regions of interest

All deployments require logistical support through research ice breakers or airborne campaigns with on-ice landings. Figure 6 summarizes the planned regions of deployments for the years 2015 to 2017. Colored regions sketch the approximate research areas of planned expeditions, while exact deployment locations will depend on weather and ice conditions, as well as the overall scientific plan of each expedition. Since all buoys are also parts of other networks and projects (see above), the SPICES consortium will coordinate and decide the deployments with other international partners.
5 Data access

All data are transmitted by satellite communication (mostly Iridium System) from the buoys to external data providers. The data provider compiles the original raw data and buoy messages into physical quantities. These data sets are retrieved and archived daily through the online data portal www.meereisportal.de. The buoy data pages of the data portal are updated daily (around 8 UTC), containing all data of the units from deployment to the actual date. Hence, live data are available through this portal on a daily base. Positions of all Arctic units are shared with the IABP and are also available through their web page: http://iabp.apl.washington.edu/. Most units also transmit their data (date, time, position, barometric pressure) into the Global Telecommunication System (GTS). This adds additional value to the autonomous measurements, because this makes the data available for weather forecasts and re-analysis in near real time.

After the end of transmission, all data from each buoy are manually post-processed and quality controlled. These final data sets are published in the www.pangaea.de data publishing and archiving system. From here, data are available also beyond the SPICES project. Each data set (buoy time series) is assigned a Digital Object Identifier (DOI).

6 References
