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SUMMARY

The overall objective of SIDARUS is to develop and implement a set of sea ice downstream services in the area of Marine Safety, Marine and costal environment, and Climate and seasonal forecasting. The products to be developed are high-resolution sea ice and iceberg products from SAR, sea ice albedo, sea ice thickness, sea ice habitat conservation and ice forecasting.

The aim of this document is to show how the data and products developed by SIDARUS can be integrated with MyOcean and other sea ice data. For this first deliverable D8.1, the following two integrations are outlined.

First of all, the Icebergs Monitoring Service, as developed by CLS, is based on satellite technologies for iceberg detection, on numerical modeling for icebergs drifting, and GIS/web server for the visualization of the ice reports. In the proposed approach, the altimeter-based detections can be used as a first guess to identify possible icebergs infested areas which are then imaged by high resolution SAR images. This document shows how the altimeter-based and SAR-based detections can be combined altogether.

Conventional monitoring techniques have been used for several years to conduct researches in marine and coastal habitat related to wildlife monitoring. The ARGOS satellite system has been used for three decades to help understanding of displacements and migrations of species dependent of specific environmental parameters, bearing in mind that animals are great indicators of threats. SIDARUS is going to add a spatial component to help environmental monitoring through the provision in near real time of key physical ice parameters. The project will improve the understanding of the impact of climate change on sensitive species and the results will bring an additional brick to build Conservation Action Plans and consolidate Global Biological and Scientific issues.

SIDARUS CONSORTIUM

Participant no.	Participant organisation name	Short name	Country
1 (Coordinator)	Nansen Environmental and Remote Sensing Center	NERSC	NO
2	Alfred Wegener Institute for Polar and Marine Research	AWI	DE
3	Collecte Localisation Satellites SA	CLS	FR
4	University of Bremen, Institute of Environmental Physics	UB	DE
5	University of Cambridge, Department of Applied Mathematics and Theoretical Physics	UCAM	UK
6	Norwegian Meteorological Institute, Norwegian Ice Service	Met.no	NO
7	Scientific foundation Nansen International Environmental and Remote Sensing Centre	NIERSC	RU
8	B.I. Stepanov Institute of Physics of the National Academy of Sciences of Belarus	IPNASB	BR

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D8.3 “Final report on integration and validation”, WP8, SIDARUS project

D9.11 “Report on demonstration no. 1 and service utility”, WP9, SIDARUS project

LIST OF ABBREVIATIONS

ASAR	Advanced Synthetic Aperture Radar
AVISO	Archiving, Validation and Interpretation of Satellite Oceanographic data
CNES	French Space Agency
DUACS	Developing Use of Altimetry for Climate Studies
GIS	Geographic information system
GMES	Global Monitoring for Environment and Security
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NRT	Near Real Time
SAR	Synthetic Aperture Radar
SARAL	Satellite with ARgos and ALtiKa
SSALTO	Segment Sol multimissions d'ALTimétrie, d'Orbitographie et de localisation précise
SSH	Sea Surface Height
SWH	Sea Wave Height

1 Introduction

The overall objective of SIDARUS is to develop and implement a set of sea ice downstream services that will extend the present GMES services with new satellite-derived sea ice products. All the SIDARUS products are to be validated with in situ or with data from other satellites. Some validation activities will be documented in the appropriate deliverables of WP4, WP5, WP6 and WP7. The objective of this document is to provide a status on the activities carried out in the frame of WP8 “Data integration and validation”.

Especially, SIDARUS should demonstrate new services and products in response to needs of users with responsibility to monitor and study changes in sea ice habitats (polar bears, walruses, seals...) in different regions of Arctic and Antarctic.

In addition, the Icebergs Monitoring Service, as developed by CLS, is based on satellite technologies for iceberg detection, on numerical modeling for icebergs drifting, and GIS/web server for the visualization of the ice reports. The idea is to provide on a regular basis an Icebergs Situation Map giving the icebergs conditions in real time and in a few days forecast. The chain is described in the SIDARUS deliverable D9.11. Three levels of surveillance are defined in the developed icebergs' services depending on the user‘s requirements for ice management:

- Surveillance mode: monitor the whole area and provide a seasonal surveillance of the ice and icebergs conditions by using altimetry and medium-resolution SAR imagery every 2-3 days: production of weekly bulletin
- second level if icebergs are entering a Warning area closed to the area of interest by using daily medium-resolution SAR imagery: production of daily report
- Icebergs are entering the Critical area (e.g. 7-day interval between the icebergs and the platform): late SAR images programming enabled.

In the proposed approach, the altimeter-based detections can be used as a first guess to identify possible icebergs infested areas which are then imaged by high resolution SAR images. This approach is particularly relevant in the Antarctica with relatively larger icebergs in much larger areas. Even though the current context with expensive SAR images is likely to change in the coming years with the new Sentinel-1 mission, altimeter-based iceberg detections are of interest and were compared with SAR detection in the frame of this WP8.

This document is organized in two sections:

- Section 2 outlines the comparison between altimeter and SAR-based iceberg detection
- Section 3 presents a first status regarding the integration of ARGOS data with the products from SIDARUS for sea ice habitats.

2 Comparison between Altimeter and SAR-based iceberg detection

Satellite Radar altimetry is a leading-edge technology used in space oceanography and a growing number of scientific and commercial applications and products are using altimeter data. Altimeter data are currently assimilated in most ocean forecast models and coupled ocean-atmosphere models used for predicting climate evolution. Altimeter satellites measure the peaks and troughs of the ocean surface with accuracy below the centimeter level.

CLS Space Oceanography Division has developed over nearly 2 decades a unique expertise in the field of altimeter data processing and analysis. The SSALTO/DUACS system, developed and maintained at CLS, collects altimetry data from numerous radar altimeter satellites: GeoSat, ERS-1, ERS-2, Geosat Follow-On, Topex/Poseïdon (past missions), Envisat, Jason-1 and now Jason-2. These measurements are processed in Near Real Time (NRT) to provide maps of Sea Level Anomaly (SLA) in NRT on a daily basis. These maps SLA are combined with maps of mean sea level to provide maps of Sea Surface Heights (SSH) which are the basis of altimeter products and will be used in this study. SSH is also reprocessed on a weekly basis using better geophysical corrections to produce more accurate data in Delayed Time (DT).

Based on its unique expertise and database, CLS also developed MetOcean products and services dedicated to the offshore industry.

It has been recently evidenced that the altimetric measurement can also contain a tiny signal caused by the presence of floating reflectors on the sea surface. Further analysis revealed the possibility to monitor the iceberg population and motion on the austral ocean. An experimental service, combining altimetry and SAR images has been developed for yacht races (such as the Vendée Globe) that sail across the southern ocean. Based on that experience, the present study is the opportunity to try to enlarge and consolidate this service on areas where the measurement conditions appear however different mainly due to the smaller size of icebergs and the denser presence of ships compared to the austral oceans.

2.1 Satellite radar altimetry missions

Since the first experiment on Skylab in the 1970’s, about 10 satellite radar altimeters have been launched, with 2 major families since the early 1990’s *(past missions in italic)*:

- The NASA/CNES missions: *Topex/Poseidon (1992)*; Jason-1 (2001), Jason-2 (2008), Jason-3 (2013)
- The ESA missions: *ERS-1 (1991), ERS-2 (1995)*, EnviSat (2002), CryoSat (2008), Sentinel-3 (2013)

Due to the high-latitude location of the study area, Envisat altimeter will be one of the instruments used at the beginning of the study.

In fact, Topex-Poseidon, Jason-1 and Jason-2 orbit ground track is limited between 66°S and 66°N and thus cannot be used for the Barents Sea. Older missions like ERS-1 and ERS-2 sampled the same track as Envisat a few years before, but the required data products (radar echo signal) are not accessible.

In February 11th, 2013, the Indo-French SARAL/AltiKa altimeter will be placed on the same ground-track as Envisat.

Another satellite could be used: Cryosat, which has enhanced observation capabilities over the cryosphere. However, the instrument is based on a new technology that is not still completely controlled and therefore no official product has been released yet by the European Space Agency. Cryosat will be used in this study depending on the availability of the data.

More information on the various altimetry missions can be found on the AVISO web site (portal to space altimetry developed and maintained by CLS on behalf of CNES and ESA).

Figure 1: Illustration of the various altimetry missions, taken the the AVISO website (Credit CNS/CLS)

2.2 Principle of the altimetric measurement

Altimetry satellites basically determine the distance from the satellite to a target surface by measuring the satellite-to-surface round-trip time of a radar pulse. The magnitude and shape of the echoes (or waveforms), that is a histogram of the power received by the instrument, also contain information about the characteristics of the surface which caused the reflection.

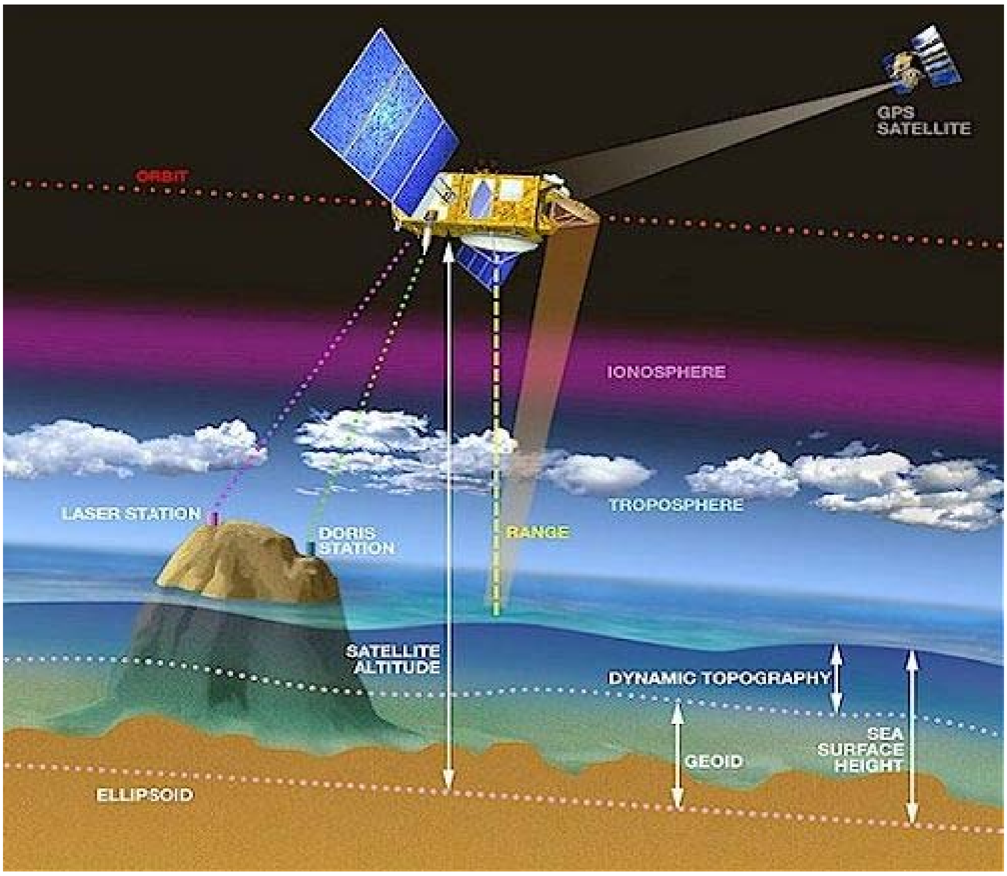


Figure 2: Principle of satellite altimetry

As illustrated on the figure below, the shape of the radar echo is highly dependent of the nature of the reflecting surface, i.e. is the ocean surface is calm or agitated.

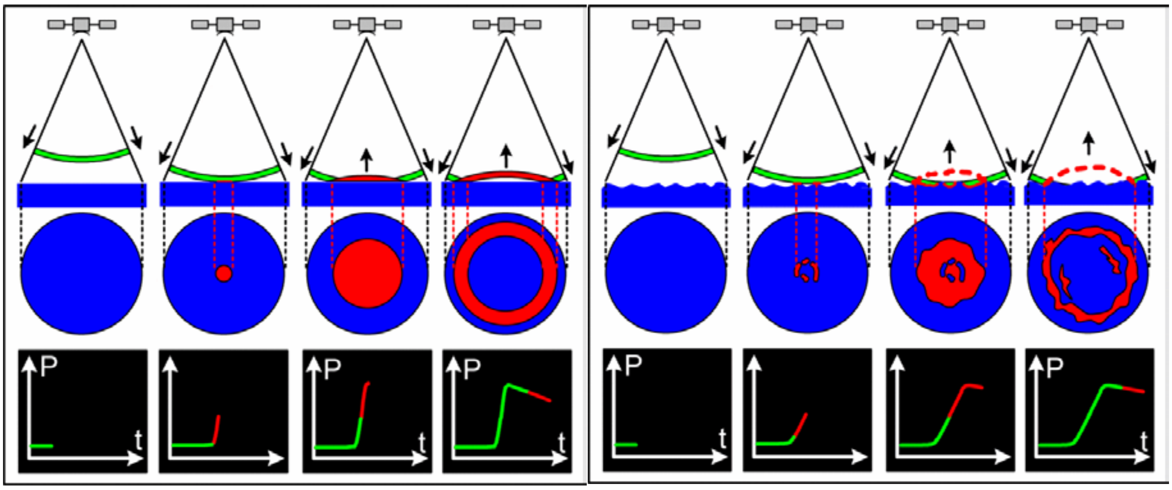


Figure 3: Generation of the radar echo on a flat ocean (left) and on a rugged ocean (right)

However, the ocean echoes are well modeled and very precise information can be extracted from their analysis:

- epoch at mid-height : this gives the time delay of the expected return of the radar pulse (estimated by the tracker algorithm) and thus the time the radar pulse took to travel the satellite-surface distance (or 'range') and back again.

- P: the amplitude of the useful signal. This amplitude with respect to the emission amplitude gives the backscatter coefficient, sigma0.
- Po: thermal noise
- leading edge slope: this can be related to the significant wave height (SWH)

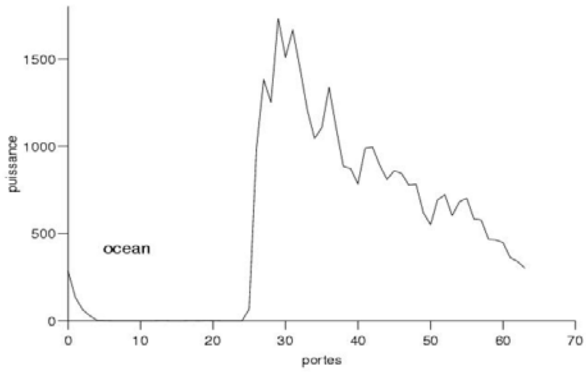


Figure 4: example of an ocean waveform

2.3 Coverage of the altimetric measurement

The ground track coverage of the altimetry missions are directly link to their orbital characteristics since the measurement is limited to the nadir direction.

Envisat has a repeat orbital cycle of 35 days (retrograde orbit) up to ~82° of latitude. Each orbital is composed of 1002 tracks (pathway from pole to pole). The full orbital cycle coverage is shown on the figure below, together with the coverage for 10, 5 and 1 days. For the altimetry part, the study area will be from 0° to 70°E in longitude and from 66°N to 82°N in latitude. Almost 400 Envisat ground tracks go through that area. For example, the ground track spacing at 75°N is around 18km.

Envisat has orbited on these tracks from March 2002 to October 2010 (i.e. almost 100 times over each and every track). Since October 2002, because of lack of hydrazine for orbit control, Envisat is now on a slightly drifting orbit.

AltiKa will orbit on the initial orbit of Envisat.

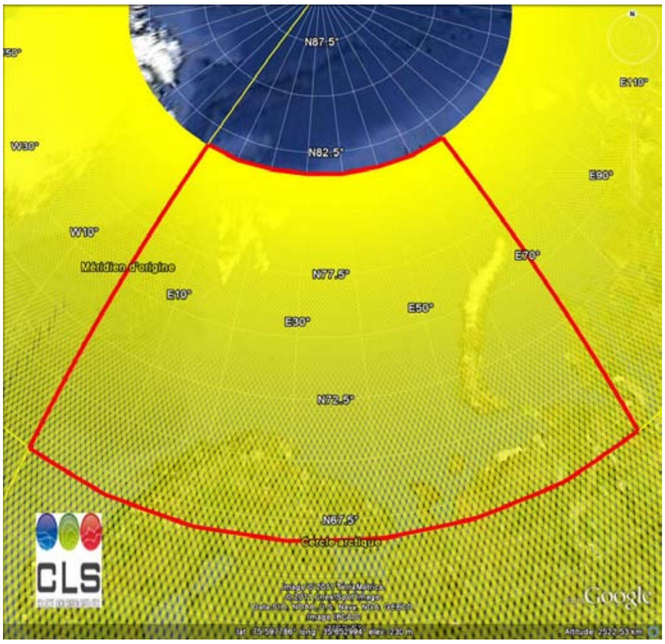


Figure 5: Ground track coverage of Envisat altimer over 35 days (and AltiKa). Study area in red. The satellite flies over each elementary track around every 35 days.

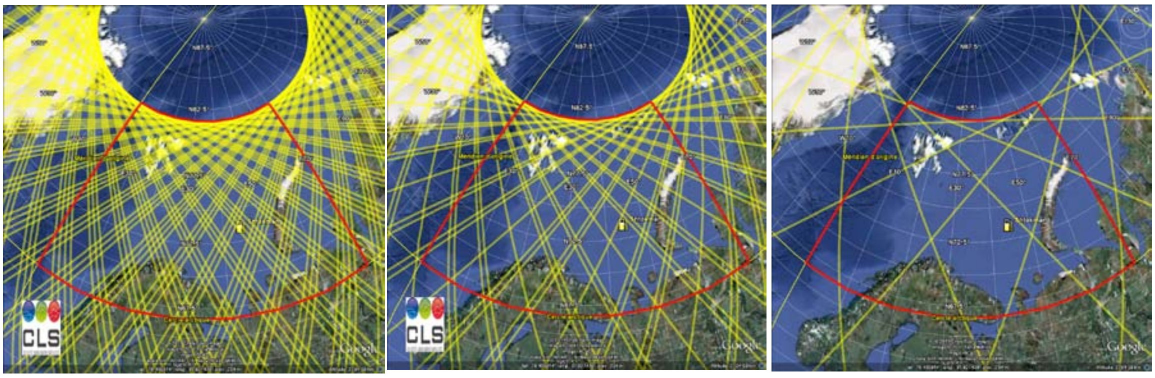


Figure 6: Ground track coverage of Envisat (and AltiKa) altimeter over 10, 5 and 1 days from left to right and top to bottom. Study area in red.

At the along-track portion scale, the coverage is limited to the nadir direction. However, when arriving to the reflecting surface, the radar pulse is wide enough to sample a significant portion of the earth surface.

2.4 Detection of icebergs in the radar altimeter echoes

When a floating object is reflective enough (combination of size and reflectivity) to significantly contribute to the radar echo, its contribution can appear as a bump that arrives before the leading edge is the floating reflector is close to the nadir, as shown on the figure below. If the floating reflector is in the far side of the “beam limited footprint”, its contribution will generally be important enough to emerge from the important noise level of the trailing edge of the waveform. However, in the case of large iceberg (several tens of km), their contribution may completely modify the waveform.

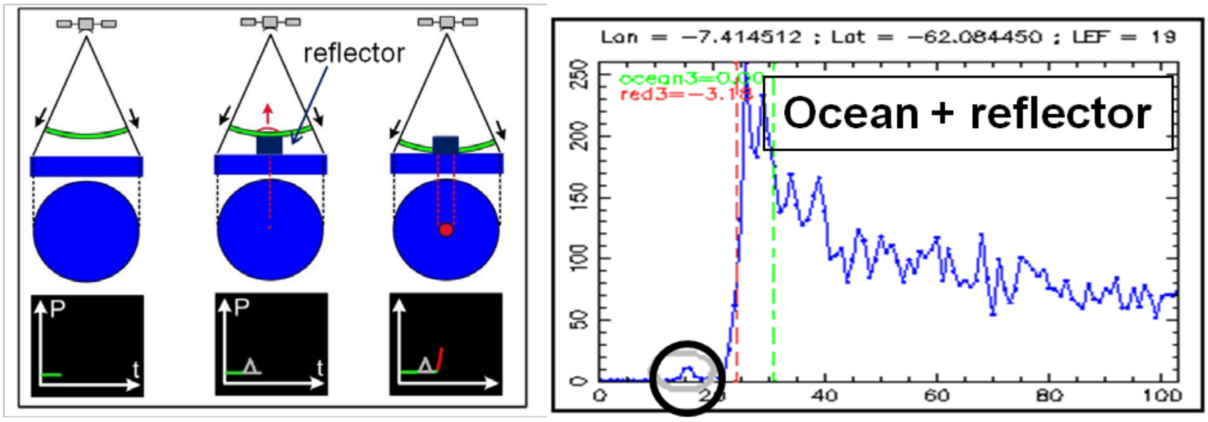


Figure 7: Signature of a floating reflector within the waveform (theory - left, real case - right)

The mapping of these "polluted" measurements give coherent structures as one can see on the figure below corresponding to the detection cumulated for November 2010 (Jason-1, Jason-2 and Envisat altogether, detections below 66°S not shown). Note the presence of a high density iceberg area near 47°S and 10°W.

Icebergs are not the only one floating reflector: the mapping of such echoes revealed that ships can also be detected.

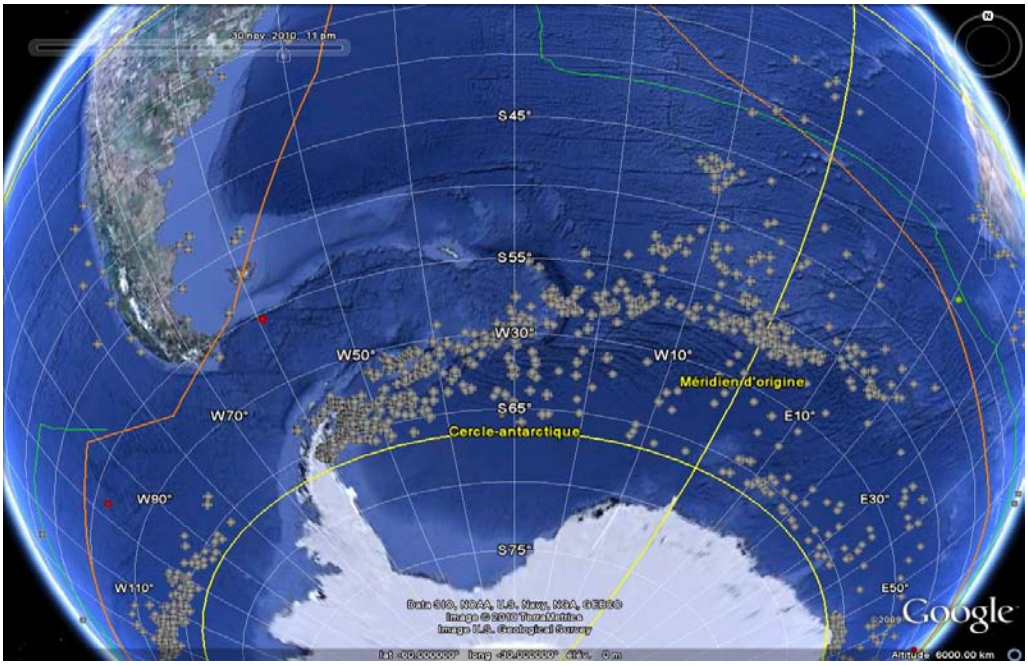


Figure 8: Iceberg detection in the Atlantic South Ocean for November 2010 (Jason-1, Jason-2 and Envisat, detections below 66°S not shown). Orange and green lines correspond to the trajectories of Orange2 and Groupama3 yachts (Jules Verne Trophy).

2.5 Validation of ENVISAT altimeter detection with Jason-2 and Jason-1 (altimetry) and Radarsat2 SAR images

We decided to validate the Envisat detections with an a posteriori integration in the analysis of the iceberg populations identified with Jason-2 and Jason-1 (altimetry) and Radarsat2 SAR images on the route of the Groupama3 trimaran skippered by Franck Cammas and his team during their successful attempt on the Jules Verne Trophy during the winter 2009-2010.

We tested several different parameterization of the algorithm until we obtained a set of detections comparable to the one obtained with Jason-1 and Jason2 in terms of iceberg distribution.

The thermal noise level is the most sensitive parameter. If set to too low values, some entire segments of erroneous detections may appear: this is observed in case of very high wind/wave conditions that diminish the signal to noise ratio (higher noise, lower signal). But if set to too high values, the icebergs that have a very little impact on the waveform geometry may not be detected. This is generally the case of isolated icebergs of limited size, which turn to be the most dangerous ones because hardly detectable.

On the figure below, we have plotted for the entire month of November 2009 the results of the detections for Jason-1 only (a), Jason-2 only (b), Envisat only (c) and J1+J2+Envisat (d), between 35°S and 66°S.

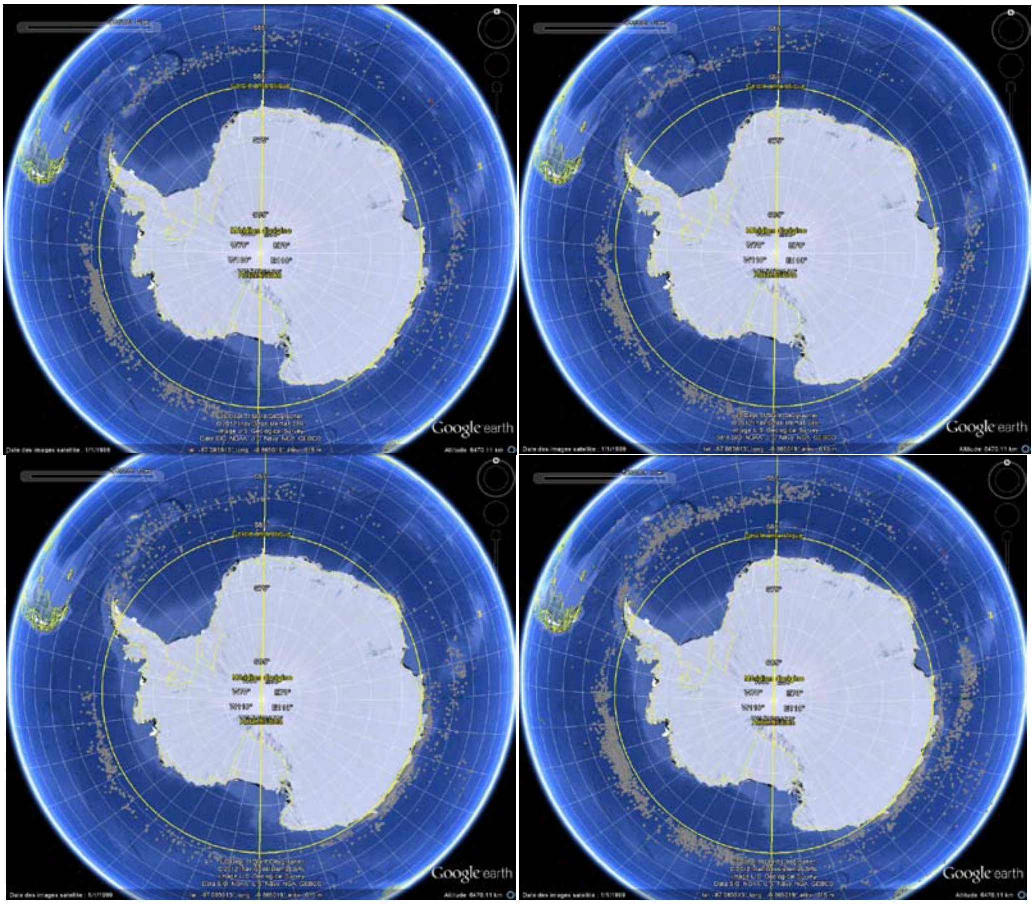


Figure 9: Comparison of iceberg detections for November 2009. Top Left(a): Jason-1 only, Bottom Left(b): Jason-2 only, Top Right (c): EnviSat only, Bottom Right(d): Jason-1+Jason2+EnviSat

Obviously, the same global populations are observed by each satellite individually. Given that Jason-1 and Jason-2 have an inclination of 66°, their ground tracks are tangent to the polar circle, whereas

Envisat tracks go up to 82°S. Therefore, the area between 60°S and 66°D is better sampled by J1 and J2 than by Envisat, leading to denser "clouds" of detections at these latitudes for J1 and J2.

During November 2009, isolated detections, corresponding to isolated icebergs or sparse iceberg populations (Flaklands plateau, Australia South) were also observed individually by each satellite with almost similar performances. The number of Envisat detection is however inferior to the corresponding numbers for J1 and J2 because of the Envisat smaller footprint. When combining the 3 satellites, the detections over these areas form much more coherent clouds, removing part the ambiguity for those detections.

Generally, a given iceberg is detected within several consecutive radar echoes. Since each waveform is treated separately, a single iceberg generates several consecutive detections along the track. Once again because of the smaller footprint of Envisat altimeter, the number of consecutive detection for a single iceberg is smaller for Envisat.

Some of the validation activities have been also documented in the deliverable D5.3 as seen by Figure 9 where ENVISAT altimeter detections are compared with fully-unsupervised RS2 images over the Barents Sea.

From this study, and waiting for a more precise comprehension of Cryosat-2 SAR mode detections, it appears that the potential of altimetry for the monitoring of icebergs in a "restricted" area such as the Barents Sea is rather low if only one satellite is used. The spatial and temporal coverage of only one satellite, such as Envisat of AltiKa is clearly insufficient. This point has of course to be added to the fact that Arctic icebergs are generally much smaller that Antarctic icebergs for which the combination of 3 satellites give valuable information. Given their accessible production cost, altimetry detections can however find their role in a long-term monitoring system since the presence of isolated detections nearby the target area should trigger acquisition of SAR image to better evaluate the risk for offshore infrastructures or sailboat during sail race.

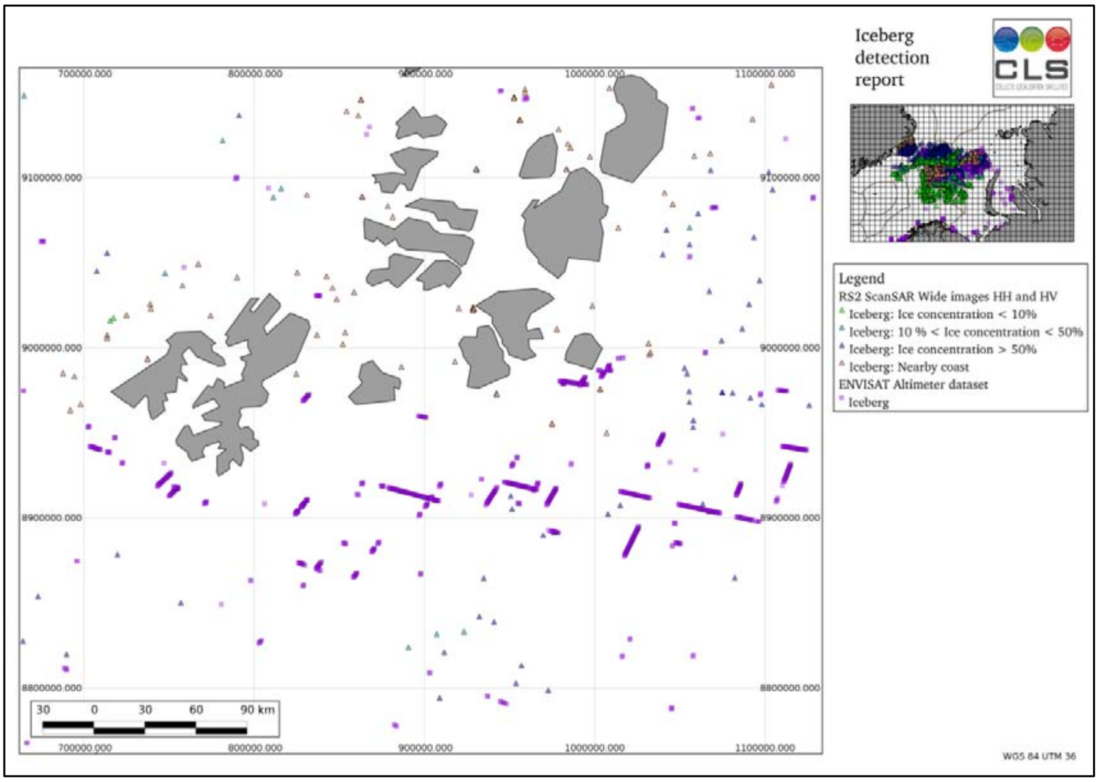


Figure 10: Detected icebergs in February and March 2012 from RS2 ScanSAR Wide imagery with HH- HV polarisation coupled with altimeter-based detection nearby Franz Joseph archipelagos

3 Integration of ARGOS data with sea ice products for wildlife habitat

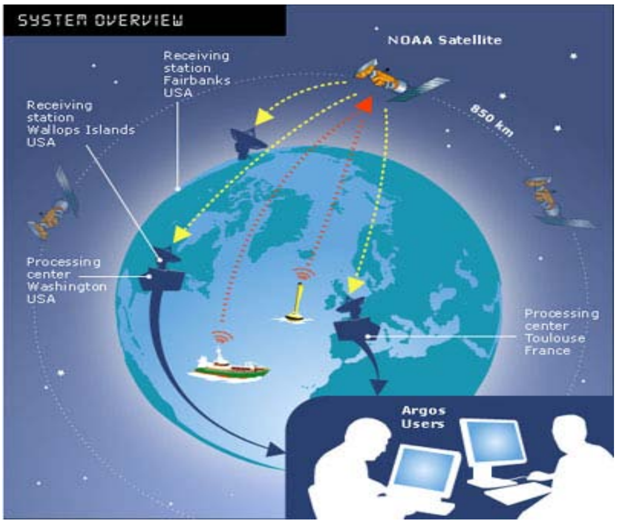
3.1 Introduction to ARGOS system for wildlife

Argos is a unique worldwide location and data collection system dedicated to studying and protecting the environment. Argos is a global location and data collection system.

Argos helps the scientific community to better monitor and understand our environment, governments. Biologists and scientists use Argos to locate and remotely study animals anywhere on earth.

The Argos system was created in 1978 by the French Space Agency (CNES), the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA), originally as a scientific tool for collecting and relaying meteorological and oceanographic data around the world. In 1986, CNES created a subsidiary, CLS, to operate, maintain and commercialize the system. Currently, several other international space agencies also actively participate in the Argos system including Eumetsat (European Organization of the Exploitation of Meteorological Satellites), the Indian Space Research Organization (ISRO) and others.

Currently, 5 NOAA satellites, 1 METOP satellite, (Eumetsat), 53 regional antennas, 3 global antennas and 2 processing centers are available for the best quality of data collection and processing. The Orbital Polar Satellites need about 100 minutes to complete 1 total orbit as they fly at 850 kilometer above the Earth. The ground visibility of each satellite is about 5000 km diameter.



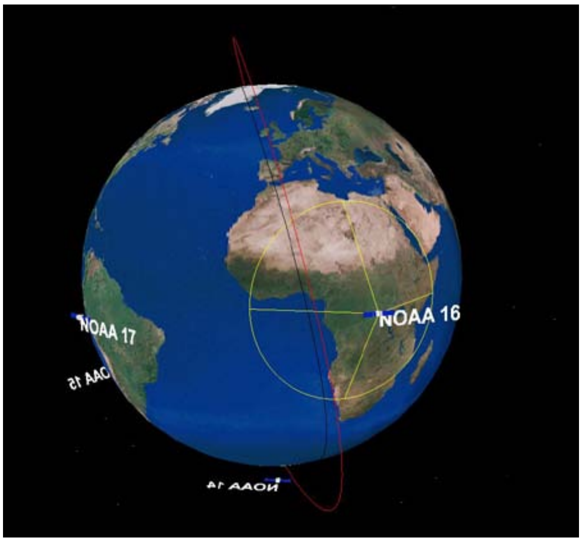


Figure 11 ARGOS system overview (Left) and ARGOS satellite orbits (Right)

The ARGOS system allows geo–positioning, time location and data collection for the monitoring of birds, marine and land animals. Scientists and biologists use Argos system for the observation and the trajectory study of animals and also for modeling purposes.

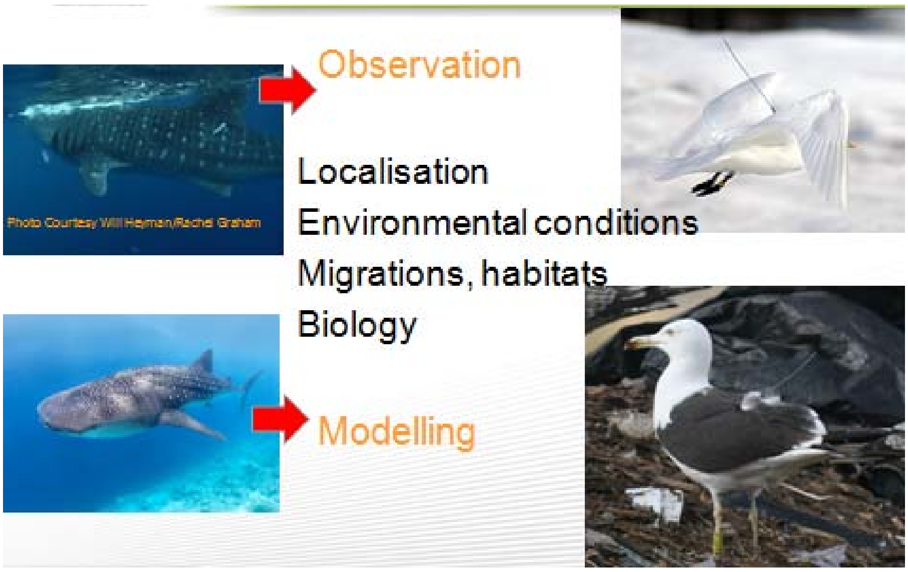


Figure 12 From ARGOS observation to wildlife habitat modeling

Thousands of animals, including birds, marine and land animals, are fitted with miniaturized Argos transmitters and tracked worldwide. The position information combined with data collected by sensors allow biologists to better understand animal's behavior, feeding strategies, breeding and adaptation to their environment. Such observations provide the basis for conservation measures aimed at helping many endangered species. In addition to its ecological value, this work allows the international community to learn more about our environment's natural resources and interactions between humanity and wildlife.

On the map below, each logo represents a beacon installed on an animal. The diagram shows from January 2004 the monthly number of beacons installed on animals and received in the month. The miniaturization of transmitters is a great progress for the monitoring of much smaller species, both for birds and mammals.

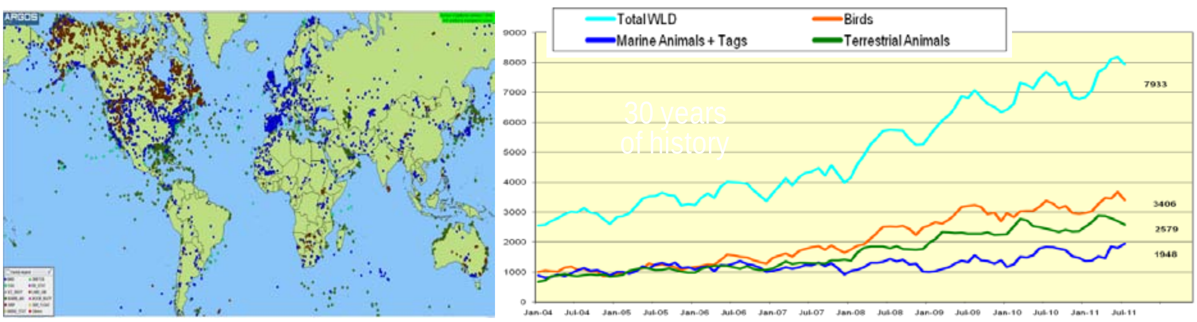


Figure 13 Coverage of the animals equipped with ARGOS beacon (Left) Number of species tracked with ARGOS beacons (Right)

When scientists are monitoring species of scientific specific interest, they focus their investigations on researching the environmental causes of a specific event (behavior, habitat, foraging and breeding habits). Additional environmental information is required to be able to answer questions related to habitat characteristics linked with ecological impacts.

In the frame of the SIDARUS project, sea ice information will be developed and validated. In the following subsections, some examples of integration of ARGOS data with the products from SIDARUS are outlined.

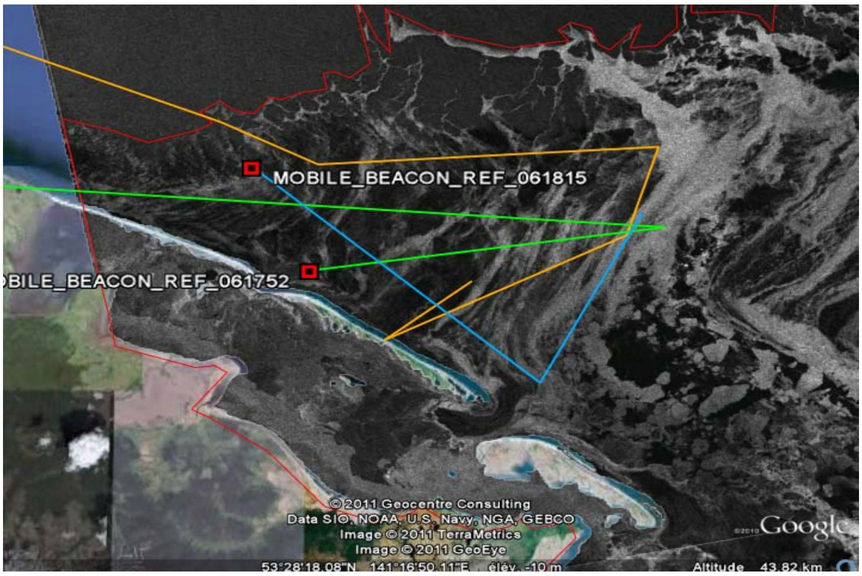


Figure 14 polar bear Argos trajectory data is correlated with ice information

3.2 Spatio-temporal changes in the habitat use of the sea-ice specialist: the ivory gull

Sea ice is the main habitat of the ivory gull (*Pagophila eburnea*). Two record sea ice extent minima within the past 5 years (2007 - 2012) and the overall trend of sea ice decrease within the past decades point out the major threat for the species. The limiting factors which affect the ivory gull population are closely connected to certain sea ice features, the most important of which are: sea ice concentration, distance to ice edge and daily duration of solar illumination.

The limitation on sea ice concentration and distance to the ice edge originates from the fact that ivory gull feeds on fish and arthropods and therefore needs open water or polynyas.

At the University of Bremen, data on 13 ivory gulls from North Greenland, Russian Arctic and Norwegian Arctic with total of more than 20 000 locations were analyzed. Within the time period from 3 July 2007 to 7 April 2008 only less than 6% of locations were over open water. 2/3 of all locations are within 50km from the ice edge. Combination of sea ice concentration data from AMSR-E produced at the University of Bremen with the bird positions showed that ivory gull mainly prefers moderate sea ice concentrations of 40-80%.

Another limiting factor for the population is the duration of sun light exposition of the sea ice. Polar night drastically worsens living conditions of the gulls, i.e. temperature and visibility. Therefore ivory gull avoids polar night and migrates southwards in winter (see Figure 15).

The reduction of sea ice extent will reduce the size of ivory gull feeding areas and is likely to induce local extinctions and affect migration schedule and reproduction.

With the reduction of ice covered area in summer, the ice edge will be located closer to the North pole, where Arctic summer is perhaps too short for successful reproduction. Further retreat of ice edge to the north will affect Arctic ecosystem via forcing a major change in the ivory gull habitat and possibly inducing its relocation to e.g. coastal areas of Greenland (Fig. 2).

According to the current knowledge on sea ice extent trend, the species might face a serious risk of extinction within the next decades.

Future work within SIDARUS consists of extended analysis of the whole dataset of more than 100000 Argos-taken positions of several dozens of ivory gulls breeding in N Greenland, Svalbard, Franz Joseph Land and Severnaya Zemlya in order to document population-specific preferences in the above described ice features for a longer temporal period.

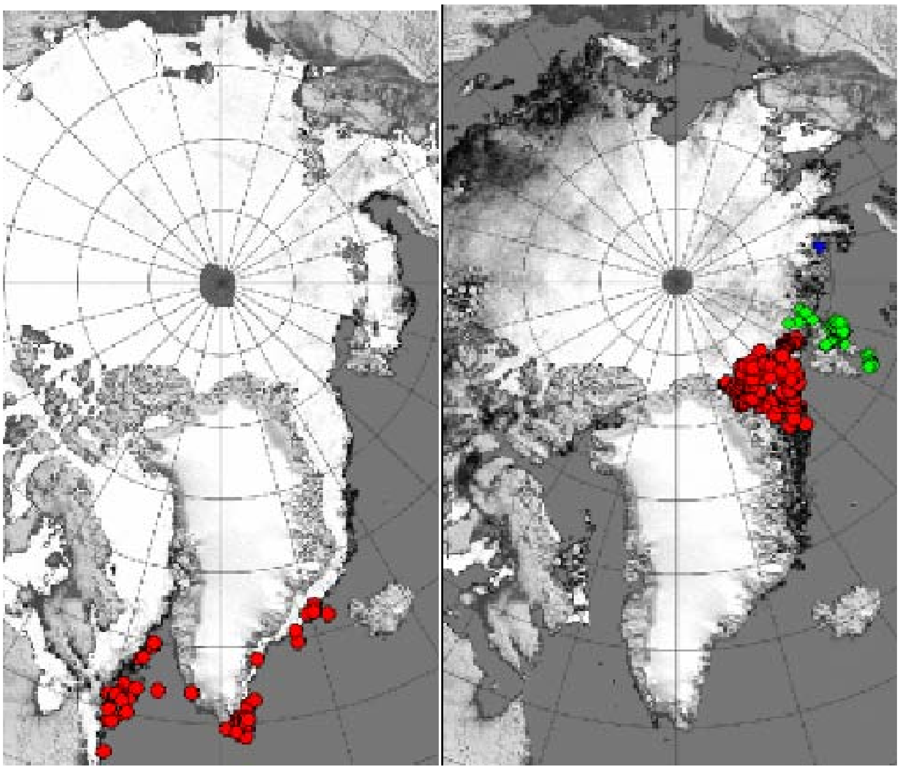


Figure 15 Locations of the studied ivory gulls for July 2007 (left) and January 2008 (right). Ivory gull prefers ice edge areas with ice concentrations of abour 40-80% as it needs open water and polynyas for feeding. Figure courtesy H. Wiebe, PHAROS Uni

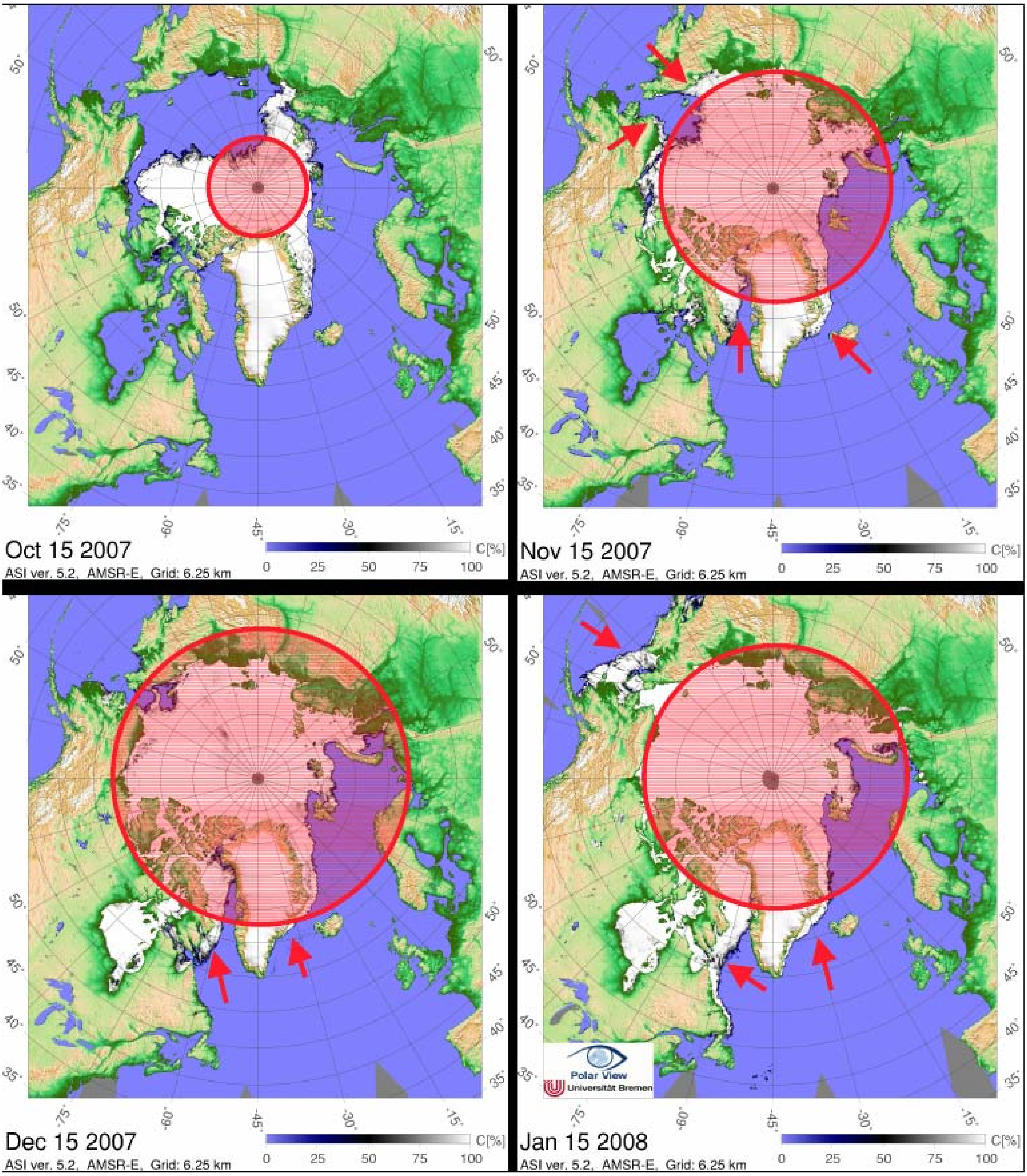


Figure 16 Maps of sea ice concentration produced at Uni Bremen. Red circles mark areas without solar illumination for the given dates. In some cases it is possible that no ice edge areas are located within the sufficient solar illumination, which is a critical situation for the ivory gull population. Red arrows mark locations which satisfy both illumination and ice edge criteria. Figure courtesy H. Wiebe, PHAROS Uni Bremen.

3.3 Analysis of the behaviors of polar bears

Polar bears demographic and habitat studies has focused on the effect of season's changing sea ice break up patterns. The type of habitat of the polar bears (high latitude areas or low latitude areas) may have more negative effects on polar bears populations depending on the region of habitat.

It has been observed that climate change projections show disproportional impacts on the sea ice habitat of polar bears so, increasing habitat fragmentation and declining habitat quality can severely impact the life cycle of polar bears. The first impact is a change in the food availability because the animals are facing a disruption in their food availability. A reduced mating habit has been observed as greater habitat fragmentation has altered the annual populations mating. Females polar bears choose their birth giving place according to the intra-habitat movements themselves and their cubs will have to make. In a case where less ice is available, the young populations will have to fast longer and there is uncertainly as per the frequency and the swimming distance to be able to find food. Polar bears are great swimmers and are able to swim long distances but swimming requires high energetic costs and cubs are particularly vulnerable to long distances movements. They also are quite exposed to hypothermia as they face variable sea ice condition when they are ready to follow their mothers.

Sea ice habitat conditions are deteriorating throughout the years and the polar bear is one of the species the most severely impacted by habitat loss. Ongoing monitoring will provide significant information related to changes of patterns within the same species and will provide an additional brick for an Early Warning System.

An example of integration of ARGOS data with the products from SIDARUS for sea ice habitat is described below. In October-November 2010, 3 female polar bears have been tagged with Russian collars at the Franz-Joseph Archipelago.

Figure 17 Deployment of ARGOS collar on adult female polar bears in October-November at Franz-Joseph Archipelagoes.

In the following figures, the ARGOS tracks for two polar bears have been correlated with sea ice concentration maps provided by MetNo via the MyOcean portal. There is a strong correlation between sea ice pattern and bears' location:

- When the sea starts freezing in the beginning of November around Franz Joseph Archipelagoes, the bears drift southward.
- Then they continuously stay nearby the marginal zone until they start to come back on Mid-February.

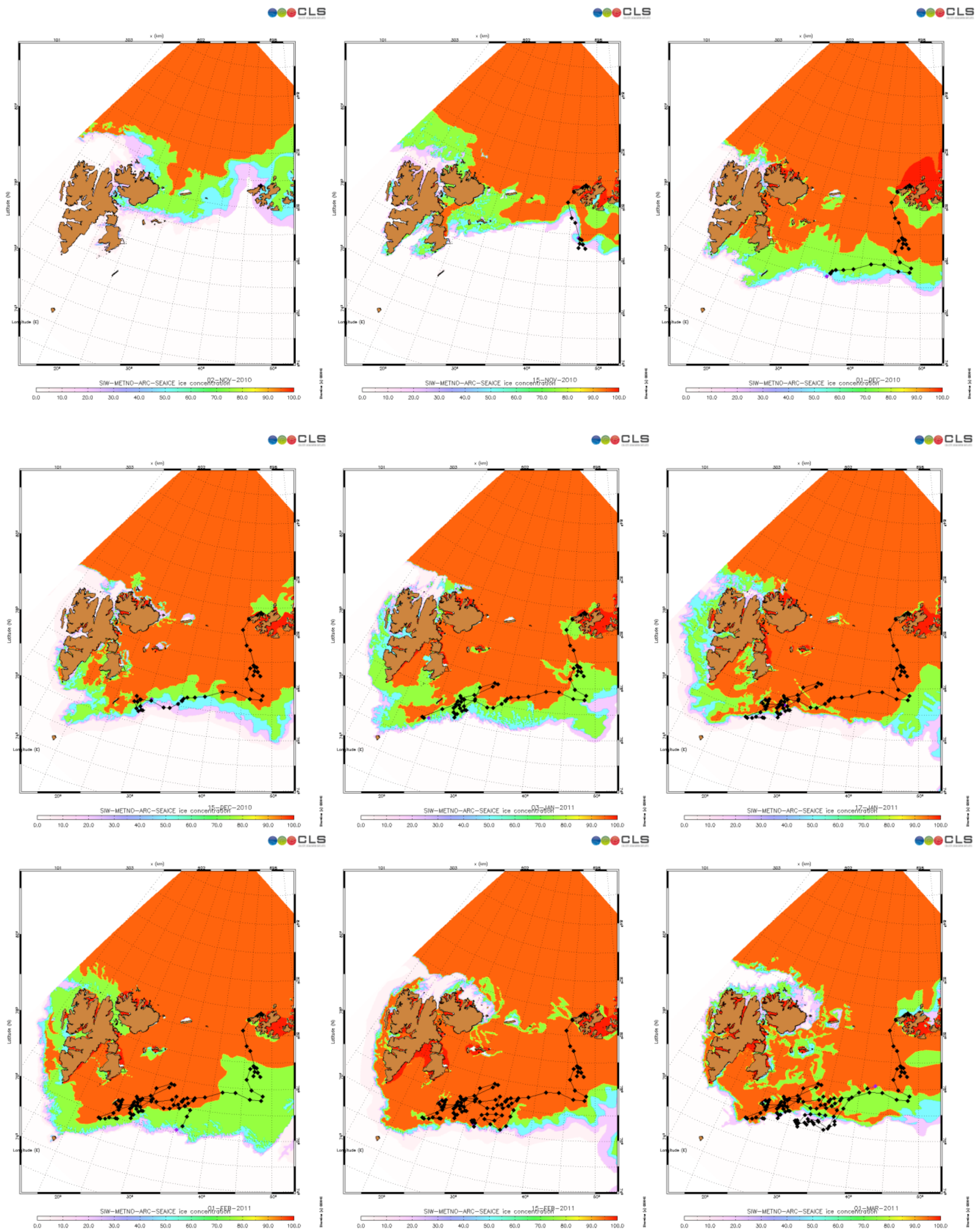


Figure 18 ARGOS ID 103383 tracks with sea ice concentration given by MyOcean MetNo: from November 2010 to March 2011 with one image every 15 days

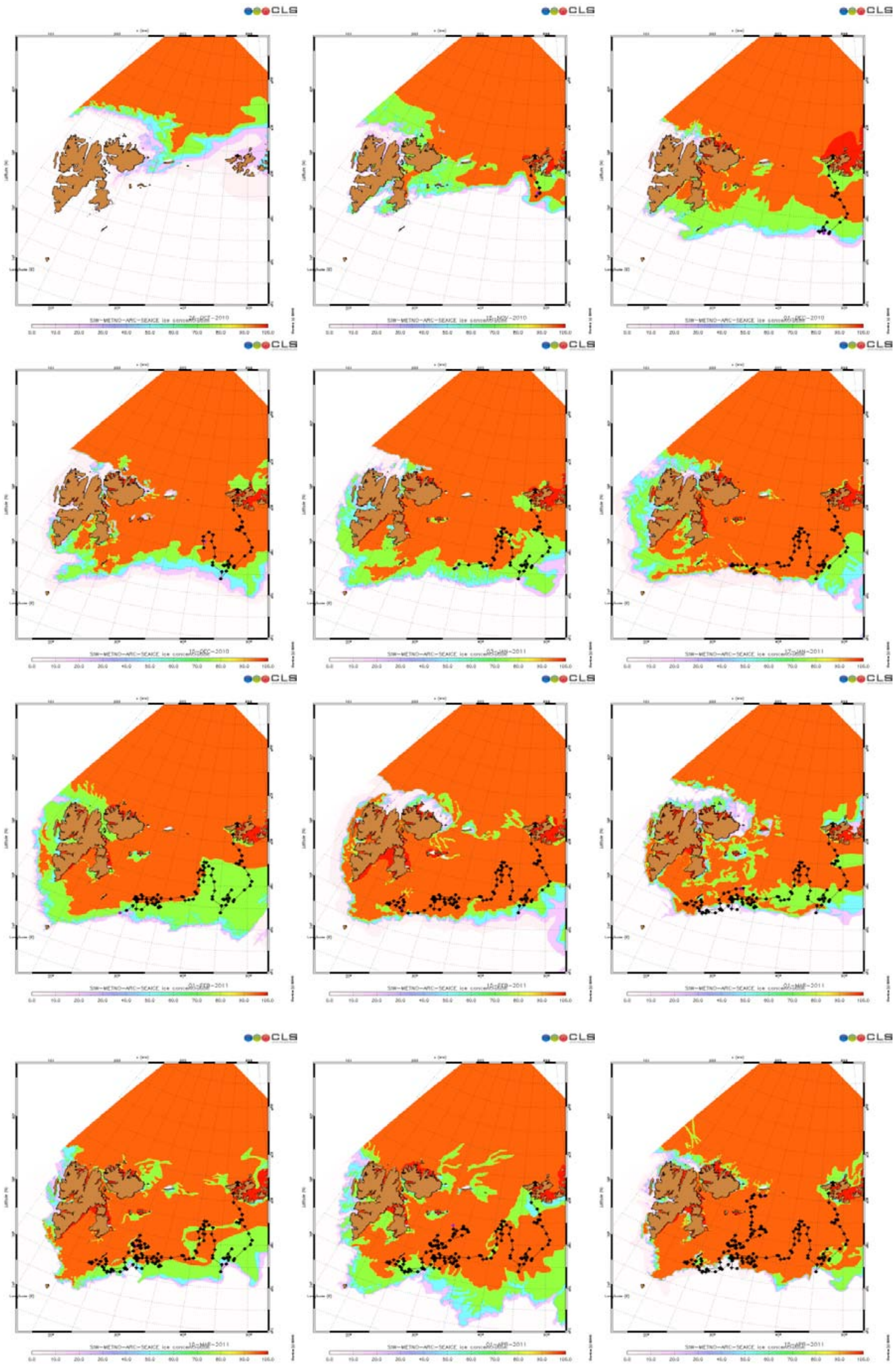


Figure 19 ARGOS ID 103385 tracks with sea ice concentration given by MyOcean MetNo: from November 2010 to April 2011 with one image every 15 days.

In this study, these patterns have been analyzed numerically by:

- computing the shortest distance between the animals and open water (using the sea ice concentration equal to 0 as a proxy for open water)
- saving the ice concentration contents all along the itinerary of the animals
- computing the cumulative distance performed by the animals

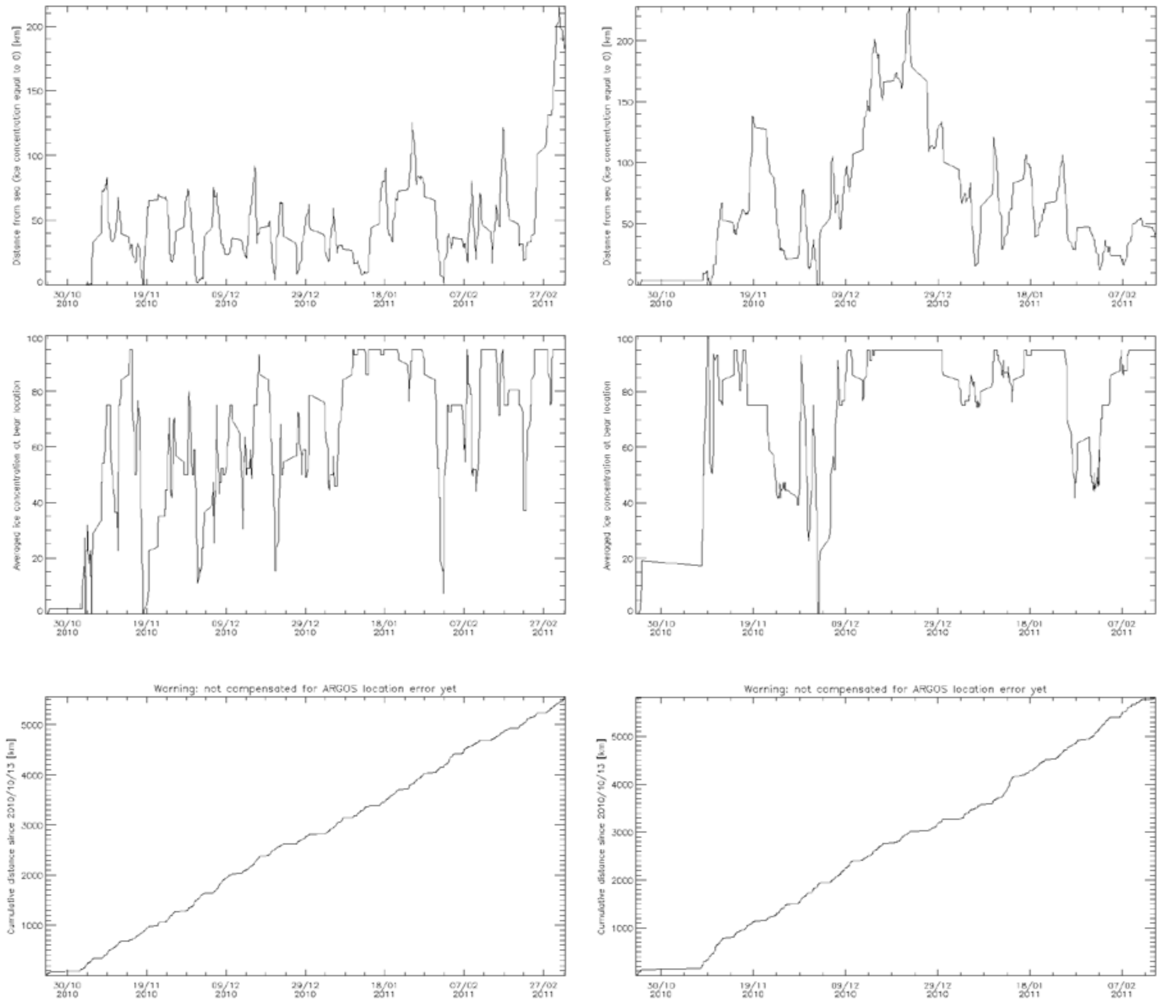


Figure 20 Bear ID 103383 (Left) and ID 103385 (Right): Shortest distance from open water based on sea ice concentration equal 0 (Top) sea ice concentrations at bear location (Middle) and cumulative distance from end October 2010 (Bottom)

The pattern for the bear ID103385 shows cyclical variations with about monthly period. This bear alternates in between high and low ice concentration (more or less equivalent to long and short distance from open water, respectively). Some additional studies with a statistical analysis of these figures will be carried out during Year 3.

3.4 On the benefit of SAR imagery for wildlife tracking and habitat understanding

SAR data combined with ARGOS can improve current usage of EO data and help for habitat determination and accurate animal route monitoring:

Up to now, mostly low resolution EO data are available for cryospheric studies:

- Ocean & Sea Ice Satellite Application Facility (OSI-SAF) produces sea ice products jointly by Norwegian and Danish Meteorological Institutes. 3 daily products are provided such as sea ice edge, sea ice concentration and sea ice type (multi or first year). They are based on SSM/I and ASCAT scatterometer data with a 10 km resolution grid
- AMSR-E sea ice concentrations are produced by University of Bremen, part of the GMES project Polar View and of the Arctic Regional Ocean Observing System (Arctic ROOS). They are available every day with a 6.25 km resolution grid using originally AMSR-E (stopped operations Oct 4, 2011). Since then SSMIS-based maps are used while waiting for the availability AMSR-2 onboard GCOM-W.

AMSR or equivalent low resolution data are still useful for a background wide view. However, medium resolution SAR data are programmed on a systematic basis at high latitude with more than daily revisit capability. The general context is likely to be very good in the coming years with the new Sentinel-1 mission. ESA Member States have adopted a free and open data policy. Anybody will be able to access Sentinel data; no difference is made between public, commercial and scientific use. This data policy still needs confirmation on the European Union side, as part of overall GMES data and information policy.

In the following, few examples are outlined regarding the benefit of SAR images for the understanding of wildlife habitat.

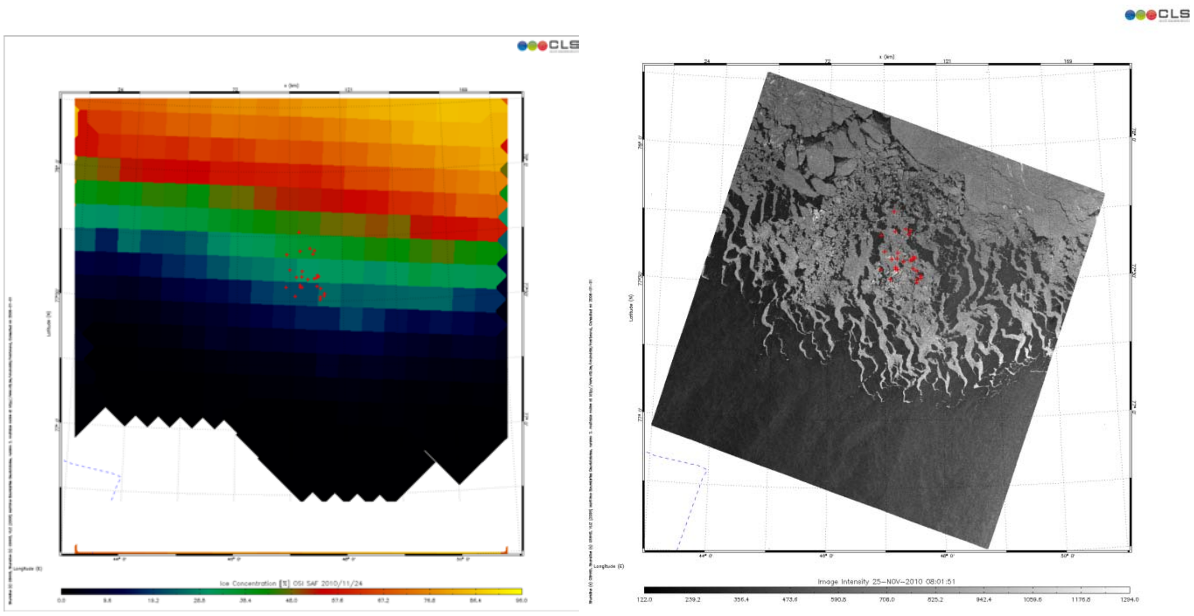


Figure 21 Polar bear positions (in red) with sea ice concentration provided by Uni Bremen (Left) and ENVISAT image

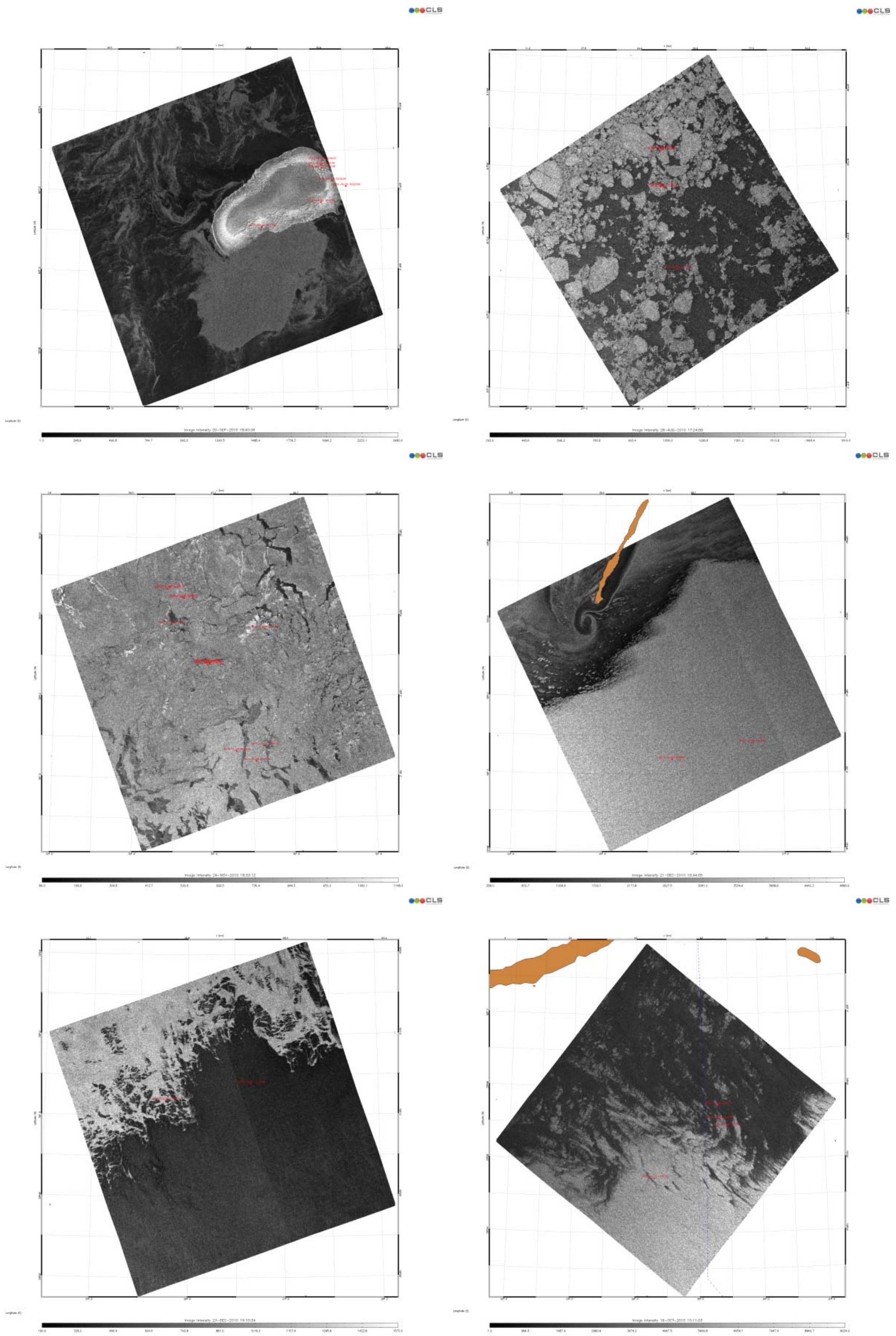


Figure 22 Location of Seal no. 97603 in various environments (island, marginal zone, multiyear ice, first year ice, water) from Aug. to Dec 2010 as imaged by SAR sensors

3.5 Towards future actions with Movebank initiative

Movebank is a free online database for managing, analyzing, sharing, and archiving animal movement data. The project is coordinated by the Max Planck Institute for Ornithology, the New York State Museum, and the University of Konstanz.

3.5.1 A data Management tool

The Movebank database supports the import of tracking data based on almost any tracking method: GPS, radio transmitters, Argos Doppler Shift, bird rings, and natural markers (support for solar geolocators will be available soon). Once imported, you can view your tracks online, add metadata, manage deployment information, and use all the other Movebank features described below. Having your data in Movebank also serves as a free backup of data you have stored on your personal computer.

3.5.2 A data Sharing tool

Researchers keep full ownership and control over the level of access to their data in Movebank. Movebank has flexible permissions settings for data owners, allowing you to easily share different levels of access with collaborators and the public. No shared software is required.

Movebank allows the compilation of multiple datasets for collaborative projects: All location data, once imported to Movebank, are in the same format. This feature, together with the ability to share your data privately with other collaborators, overcomes one of the major hurdles to combining datasets.

3.5.3 A data Analyzing tool

Movebank provides tools for making basic edits to tracking data, and includes a growing number of features to help users work with additional bio-logging data and link their data to external environmental datasets. In addition, you can easily export your dataset for use in ArcGIS, Google Earth, and other programs.

Movebank can be used to easily annotate weather parameters to wildlife tracking dataset using the NCEP-DOE Reanalysis 2 dataset, provided by the NOAA. Movebank uses this dataset to provide an estimate of wind speed and direction, temperature, and other variables for each time-location point in your tracking dataset.

Movebank Acceleration Viewer: Movebank has developed a Java program for analyzing data from accelerometers manufactured by e-obs. View the acceleration data in a flexible chart, link the acceleration to GPS locations on a map, and annotate your dataset with behavioral categories.

3.5.4 An archiving tool

Fifty years from now, how will wildlife study populations have changed? After scientific papers are published, what will happen to scientists raw data? Will their tracking data be available to help answer new questions about ecology, evolution, and global change? Collecting animal tracking data takes enormous time, effort, and funding, and also impacts the animals carrying tracking tags. Movebank believes that these data provide invaluable records about nature and should be preserved for future generations. To support this, Movebank is developing an infrastructure for archiving tracking datasets that will be stored at the University of Konstanz and the New York State Museum. After going through a review process, accepted tracking datasets will be granted a permanent digital object identifier (DOI) and added to the archive.

A combination of space technology will be initiated in the SIDARUS project for better detection and discrimination of categories of ice. Habitat mapping for wildlife interaction with sea ice regions will be one of the project’s outputs. It is foreseen that the establishment of international cooperation in science innovation will contribute to the worldwide knowledge base of animal tracking. MOVEBANK will be a depository for the new studies of polar bears movement data. It would be a key research area to further study at international level the correlation between animal movement data in time and space and high resolution satellite Earth Observation data.

4 Conclusion

The aim of SIDARUS is to demonstrate new services and products in response to needs of users with responsibility to monitor and study changes in sea ice habitats (polar bears, walruses, seals...) in different regions of Arctic and Antarctic. The ARGOS satellite system has been used for three decades to help understanding of displacements and migrations of species dependent of specific environmental parameters. In this document, we attempted to add a spatial component to help environmental monitoring through the provision of sea ice concentration/edge for polar bears and ivory gulls. These activities will be continued in year 3 with SAR-based ice products. Future actions will be also carried out for seals in collaboration with the Maritime Biology Institute of Murmansk (see Figure 23). The benefit of SAR imagery for wildlife tracking and habitat understanding has been outlined and should be further demonstrated.

It is foreseen that the establishment of international cooperation in science innovation will contribute to the worldwide knowledge base of animal tracking. MOVEBANK will be a depository for the new studies of polar bears movement data. It is recommended for SIDARUS partners to get closer to this Initiative by providing high-resolution sea ice products in combination with ARGOS tracks.

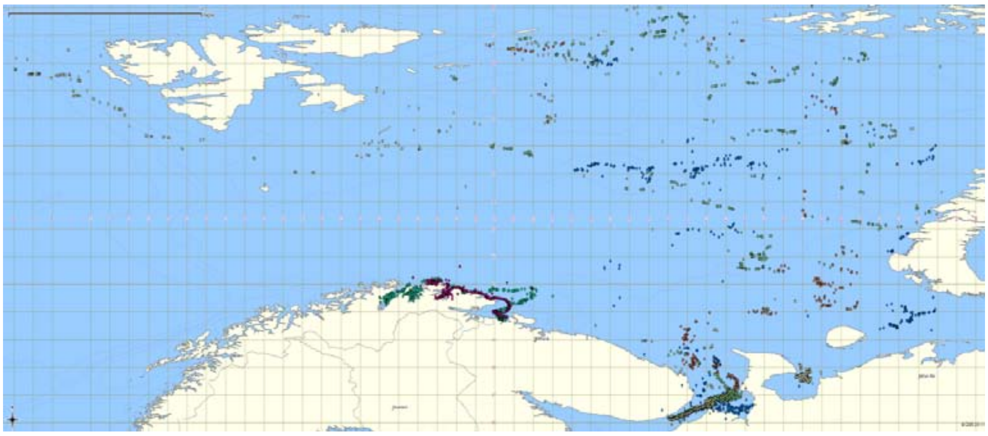


Figure 23 Locations of 6 seals (April 2010 to May 2011) – data provided by Maritime Biology Institute of Murmansk

In frame of WP8, other types of data combination have been also carried out. In particular, iceberg monitoring with both SAR sensor and altimeter has been outlined. This combination is a key aspect of the Icebergs Monitoring Service, as developed by CLS. In the proposed approach, the altimeter-based detections can be used as a first guess to identify possible icebergs infested areas which are then imaged by high resolution SAR images. This approach is particularly relevant in the Antarctica with relatively large icebergs in wide areas.

This deliverable D8.1 will be further documented in Year 3 with other data integration and validation.

END OF DOCUMENT