Documentation of SEAEIS seal census survey at Atka Bay with AWI research aircraft Polar 6 during campaign NEU2018

Contents

Camera and survey settings

Survey

Survey installation	2018-01-04

Camera

Type	Canon Mark III 1Ds photo (sensor-ID 724)
Sensor	24 x 36 mm full frame sensor with 3888 x 2592 pixel
Mount	Portrait

Lens

Type	Canon EF14mm f/2.8L II USM
Focal length	14 mm
Aperture	f 2.8
Angle of aperture	81° vertical, 104° horizontal

Camera and lens settings

Exposure program	manual
Exposure time	1/2000
ISO	125
Focus mode	manual
Focus	infinity
Aperture (f)	6.3
Image interval	00:00:06

Calculations

Image width (strip width) [m]	((TAN(40.5*PI()/180))*Altitude)*2
Image length (along strip) [m]	((TAN(54.0*PI()/180))*Altitude)*2
Pixel size (@image width) [cm]	Image width (strip width) / 2592
Pixel size (@image length) [cm]	Image length (along strip) / 3888

Flight data & survey settings

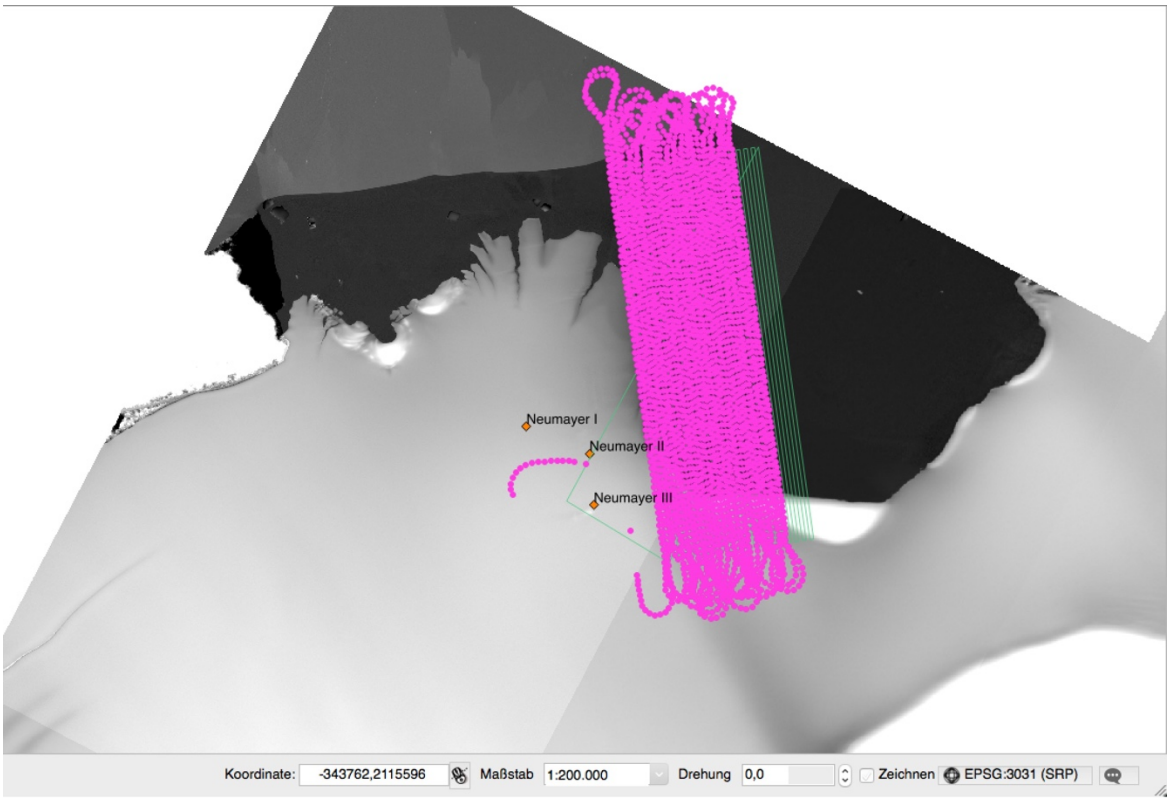
Altitude	183 m (600 ft)
Speed	130 kts
Survey box	8.250 x 26.250 km
Spacing	250 m
Start	2018-01-04T13:51:10
End	2018-01-04T18:52:50
Total time	05:02:40
No of tracks	34
Total distance	1,232 km

Image data

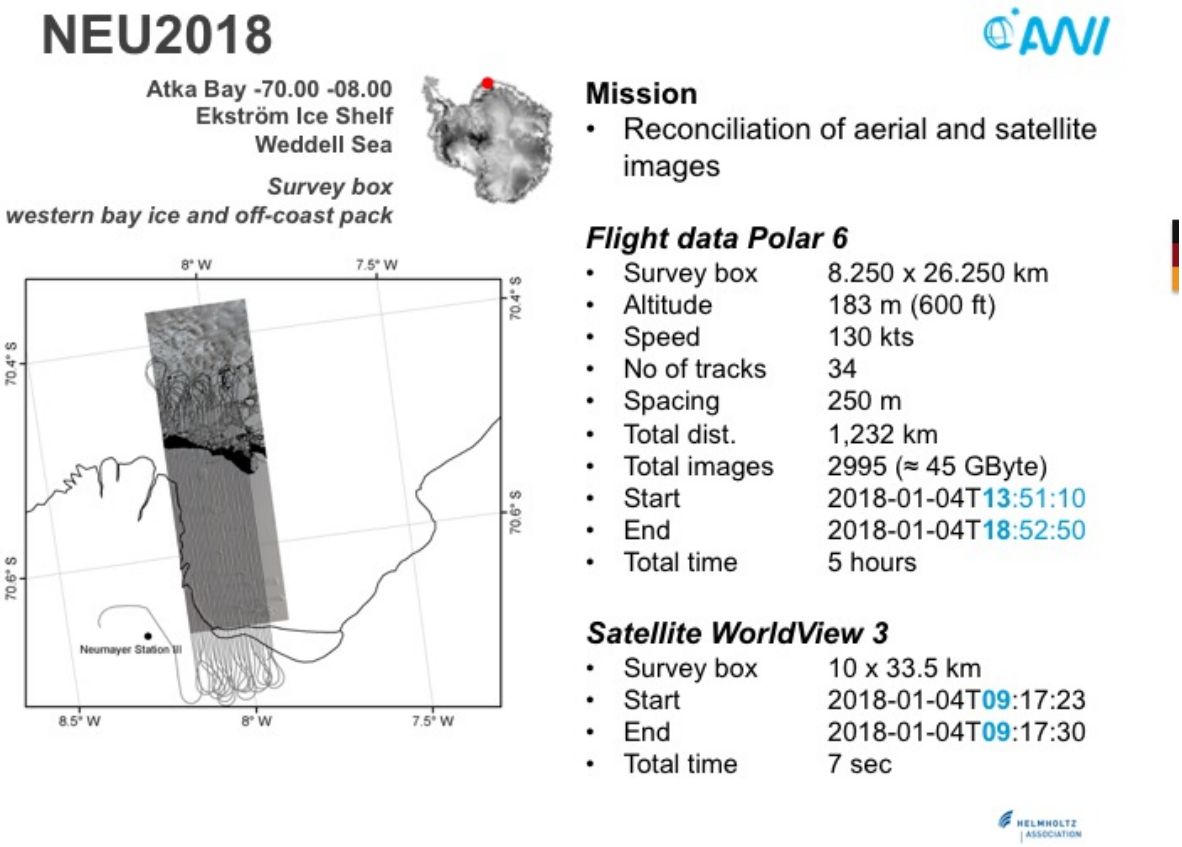
Total images (data storage)	2995 (≈ 45 GByte)
Image width (strip width)	312.59 m
Image length (along strip)	468.46 m
Image overlap (along strip)	67.28 m
Image overlap (between tracks)	61.55 m
Pixel size (ground resolution)	12 cm (@600 ft / 183 m)

Bornemann, H.; Hindell, M.; Steinhage, D.; Wesche, C. (2019). Documentation of SEAEIS seal census survey at Atka Bay with AWI research aircraft Polar 6 during campaign NEU2018

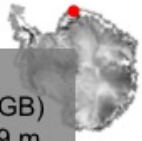
Survey box



Survey results



NEU2018 aerial satellite image



Polar 6

• Total	2995 (45 GB)
• Image / strip width	312.59 m
• Image / strip length	468.46 m
• Overlap (along track)	67.28 m
• Overlap (parallel)	61.55 m
• Pix. size (ground res.)	**0.12 m**

Polar 6 20180104_180020.144_IMG_2612.cr2

- 08:43:57

World View 3

• Total	1 (50 GB)
• Image / strip width	10,000.00 m
• Image / strip length	33,500.00 m
• Pix. size (ground res.)	**0.30 m**

WorldView3 20180104_091723

NEU2018

Atka Bay -70.00 -08.00
Ekström Ice Shelf
Weddell Sea

Survey box
western bay ice and off-coast pack

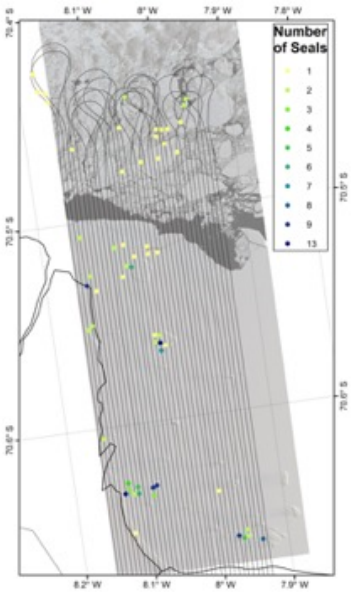


Image data

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Seal counts

• No of seals on images	166
• Double counts along track	15
• Double counts parallel tracks	11
• No of seals *clear*	**140**

Project summary

SEAEIS seal census survey at Atka Bay with AWI research aircraft Polar 6 during campaign NEU2018 is a preparatory campaign in view of the multinational project Censusing Animal Populations from Space (CAPS). CAPS focuses on the development of a cost-effective, remote sensing-based method for monitoring animal populations from space. As a bipolar initiative CAPS initially resumes the Antarctic Pack Ice Seals (APIS) Project of the former Group of Specialists on Seals (GSS) within the Scientific Committee on Antarctic Research (SCAR). APIS (1996 - 2001) aimed for a comprehensive circum-Antarctic investigation of the Antarctic pack ice seal stocks (crabeater, leopard, Weddell, and Ross seals), and considered in reconciliation with the Commission on the Conservation of Antarctic Marine Living Resources (CCAMLR) also investigations in feeding and distribution ecology. Under the working title APIS II, the Expert Group on Birds and Marine Mammals (EG-BAMM) within SCAR's Standing Scientific Group Life Science (SSG LS) seeks to resume the former seal survey in 2020. APIS II is part of CAPS and hence an integrated part of the Southern Ocean Observing Systems (SOOS), which in turn is an international initiative of the Scientific Committee on Oceanic Research (SCOR). APIS I integrated census from aircrafts, helicopters und ships over several years, APIS II, however, will be performed solely through analyses of satellite taken by WorldView-Satellites in one season. In doing so, APIS II will reveal for the first time trends in the status and stocks relative to APIS I. The interpretation of satellite images requires a preparatory ground truthing, in order to reconcile image data taken by aircrafts and satellites on spatially and temporally synchronous tracks. This reconciliation allows determining the detection probability for seals, and to develop algorithms for automated image analysis.

Outline

CAPS is integrated in the Southern Ocean Observing System (SOOS) initiative, and with its APIS II element intended to facilitate and develop the use of high-resolution satellite imagery to provide population status data for Antarctic animals. The on-going development of analytical techniques and the launch of new, higher resolution satellites ensure that the potential of the approach to make important contributions to our understanding of Southern Ocean ecosystems will only increase. CAPS has a broad remit, but has agreed that its initial focus will be the design and implementation of a circumpolar census of Antarctic Pack-Ice seals. The last attempt to do this was in 1990, and was a major international program coordinated by SCAR using ship-based survey techniques. This resulted in baseline estimates of abundance for large sections of the Southern Ocean, but left some regions without an estimate. This and the integration of different platforms let to relatively high uncertainties and low precision of the abundance estimates. CAPS aims to re-initiate the earlier work in order to provide the first indication of trends in this key component of the Southern Ocean ecosystem, as well as proved the first fully global census. The interpretation of satellite images requires a preparatory ground truthing, in order to reconcile image data taken by aircrafts and satellites on spatially and temporally synchronous tracks. This reconciliation allows to determine the detection probability for seals, and to develop algorithms for the identification of seal specific differences in brightness and contrasts for automated image analysis. CAPS consists of a multi-disciplinary multi-national team of seal ecologists, remote sensing experts and southern Ocean ecosystem specialists. As a result of its latest meeting during the SCAR biennial conference in Kuala Lumpur (2016) Prof. Dr. Mark Hindell (CAPS Co-Chair; IMAS, AUS) suggested that Germany due to its research presence in the Weddell Sea may take over initiative to facilitate the ground truthing for the aforementioned region. In this context three possible (alternative) areas of investigation were highlighted: Atka Bay, Drescher Inlet, and Filchner Trough (Weddell Sea, Antarctica) The timeline is set to facilitate the Antarctic Pack-Ice Seal survey soon as an integrative element of the international SOOS initiative "Towards a global pack-ice seal census in 2019-2020". Thus, ground truthing should be finalized preferably during the forthcoming austral summer

seasons 2017/2018 (as a secondary user request for already scheduled flight missions) or 2018/2019 (as a potential main or secondary user request in due course).

State of the art

Despite being the greatest consumers of krill in the Southern Ocean, our understanding of the status and trends in pack-ice seal populations and their relationship with key habitat characteristics, such as sea-ice, currently represents a major knowledge gap. Until now, it has been too logistically challenging and expensive to conduct regular pack-ice seal surveys at a spatial scale sufficient for assessing their regional-scale abundance and distribution; as a result, pack-ice seals have been largely neglected, with the notable exception of the large international Antarctic Pack Ice Seals (APIS) I survey conducted between 1996-2001 (Southwell et al. 2012). Remote sensing-based methods provide a cost-effective approach to monitoring seals that will enable these otherwise elusive data be made available. The APIS II working group will develop standardized methods that are easily understood by different Antarctic stakeholders, including policy stakeholders e.g. in the context of the German initiative for a Weddell Sea Marine Protected Area (*cf*. Teschke et al. 2016), which are repeatable, and easily transferred to other research teams looking to contribute to these surveys; determine the optimal division of labor to achieve regular continental-scale surveys. One option might be to perform regional assessments that could be combined post-facto into a global assessment. The advantage of this approach is that it naturally accommodates regionally specific approaches that account for differences in satellite coverage, regional climate differences e.g. cloud cover, sea ice conditions, the spatial distribution and composition of the seal assemblages, and the capacity to perform ground truth surveys; develop analytical/statistical procedures for estimating seal abundance and associated estimates of error, with particular consideration of estimator bias and precision; establish how population estimates and other products would be delivered to end users such as CCAMLR, SOOS, and SCAR.

Preliminary work

The international Antarctic Pack Ice Seal (APIS) Program of SCAR was initiated in 1994 to estimate the abundance of the four species of Antarctic pack ice seals: the crabeater seal (*Lobodon carcinophaga*), Weddell seal (*Leptonychotes weddellii*), Ross seal (*Ommatophoca rossii*) and leopard seal (*Hydrurga leptonyx*) and to identify ecological relationships and habitat use pattern (Southwell et al. 2012). It hence disregarded the southern elephant seal (*Mirounga leonina*), and the Antarctic fur seal (*Arctocephalus gazella*), both of which breeding almost exclusively on Antarctic and Subantarctic islands and migrate seasonally to the sea ice to forage (*cf*. Ropert-Coudert et al. 2013; Tosh et al. 2009; Bailleul et al. 2007 Bradshaw et al. 2003 Bornemann et al. 2000).

The Atlantic sector of the Southern Ocean (the eastern sector of the Weddell Sea) was surveyed for APIS by research teams from Germany, Norway, and South Africa using a range of aerial methods over five consecutive austral summers between 1996/1997 and 2000/2001. The German contribution was an integrative part of the German East Antarctic Margin Aeromagnetic and Gravity Experiment (EMAGE), and revealed aerial footage taken by research aircraft POLAR 2 between 1997 and 2001 (Plötz et al. 2011a, b, c, d, e), while the South African (Bester and Odendaal 1999, 2000) and Norwegian contributions were helicopter based seal surveys and the counts performed by dedicated observers. We used these observations to model densities of seals in the area, taking into account haul-out probabilities, survey-specific sighting probabilities and covariates derived from satellite-based ice concentrations and bathymetry. These models predicted the total abundance over the area bounded by the surveys (30°W and 10°E). In this sector of the coast, we estimated seal abundances of: 514 (95 % CI 337–886) x 10^3 crabeater seals, 60.0 (43.2–94.4) x 10^3 Weddell seals and 13.2 (5.50–39.7) x 10^3 leopard seals. The crabeater seal densities, approximately 14,000 seals per degree longitude, are similar to estimates obtained by

surveys in the Pacific and Indian sectors of the Southern Ocean by other APIS researchers. Very few Ross seals were observed (24 total), leading to a conservative estimate of 830 (119–2894) individuals over the study area. These results provide for the first time an important baseline over the whole Weddell Sea area against which to compare future changes in seal distribution and abundance (Gurarie et al. 2016).

APIS I needed a timeline of 20 years to be completed. As a result, the chance for an analysis or even an estimate of trends against earlier seal counts conducted in only small longitudinal sectors of the Southern Ocean between 1960s and '90s are nil. It is hence self-explanatory that only a concerted action can provide an opportunity to serve for the aforementioned urgent needs of a Southern Ocean wide assessment via the international initiative Censusing Animal Population from Space (CAPS).

As one of the first initiatives the British Antarctic Survey (BAS) conducted ground truthing studies on the Western Antarctic Peninsula in 2015/16, by conducting simultaneous aerial surveys and tasking near-simultaneous high-resolution images of the same region from DigitalGlobe. The analysis of the results is on-going, but preliminary results showed that the same seals could be detected in both types of images. The biggest challenge was that it was impossible to obtain the satellite images at precisely the same time as the aerial surveys, and these were typically several hours apart. This means the seals have time to move in out of the water between the two sets of images so there is no longer an expectation of a 1:1 concordance between the two types of images. The solution is to compare estimates of seal density between the two types of images, which is simply done by dividing the images into a number of sub-units of known area. It is likely that a correction factor for time of day will need to be applied as there is diurnal pattern in the number of seals hauled out throughout the day. This question of time-of-day corrections is another important parameter that will need to be quantified with independent studies, most likely from dive recorders.

Project topic and goals

This proposal concentrates on a ground truthing survey based on photographic transects and parallel video footage over ice covered sea in order to reconcile the air-borne image data with concordant satellite-borne images within the marine area around and respectively off the Filchner Trough or the Drescher Inlet or the Atka Bay, Weddell Sea, Antarctica during the austral summer season 2017/18 or 2018/19. By mapping occurrences of seals on sea ice, the survey will contribute to the interpretation of seal aggregations within the aforementioned areas, and in doing so contributing with ground truthed data to the international SOOS initiative "Towards a global pack-ice seal census in 2019-2020". Flight altitude has to be adopted upon reconciliation between image resolution of satellites and nadir camera.

Deliverables

1) Flight paths mandatorily need to be flown in synchrony with and along satellite flight path.

2) Geocoded images and footage over ice covered sea.

3) Gridded seal detections and derived densities along the flight paths.

Special request for the realization of the project

Region of operation and base (airport) for project (please provide map): Ice covered sea, centered at the outflow of the Filchner Trough, Southern Weddell Sea (74.5°S; 30-40°W), e.g. through a minimum aerial coverage during an anticipated two day stop over at Halley Research Station. Given that other applications for the region of the Filchner Trough may exist, this proposal also motivates for an enlargement of transect distance in particular further to the South (within the Trough), but also to the North if feasible. Airports: Halley Research Station, Halley Bay (75°35′S 26°34′W). Alternative operations may be considered in the

marine area off the Drescher Inlet (72°50'S; 19°9'W) or the Atka Bay (70° 40'S; 7°45'W), both via Neumayer Station III (70°40´S, 008°16´W).

Time and duration of operation

The project relies on sea ice! Thus, flights over open water cannot contribute to the data inventory. As a consequence, the flights may be scheduled preferably during the initial approach of the aircrafts to the Antarctic in November. According to routine ice observation, there is a polynia south-easterly of the Filchner Trough outflow developing in early austral spring. A subsequent flight operation at the end of the summer season is thus less promising but can be additionally considered to enlarge the data pool. The overall ice situation might furthermore require an adjustment of the flight tracks either being shifted more westerly or along their North-South direction. Transects should be continued as long as there are (fields of) ice flows, and the overall ice situation reported. Given that flight boxes exceed the ice field into open water due to unusual low ice coverage or a clearly defined ice edge, then the boxes need to be adjusted according to the ice, by reducing spacing between transects. Flights over pure open/ice-free water are useless.

Flight paths mandatorily need to be flown in synchrony with and along the satellite flight path of one of the WorldView-Satellites. AWI colleague and collaborator Dr. Christine Wesche (Logistics) will be responsible to forecast the satellite tracks in order to allow adjusting the flight tracks for the aircraft. The mission furthermore maximizes its potential output by adapting potential flights with behavioral parameters of the seals. It is suggested that the flights should correspond with the seals haul out maxima on the ice peaking between 12:00 - 13:00 local time. Thus, transects need to be scheduled for between 11:00 and 16:00 approximate (LT). Since the Filchner Trough is located ca. -3h relative to UTC, the flights should be scheduled between 14:00 and 19:00 UTC.

The flight level should be adjusted not higher than at 600 feet depending on the future photo-optical set-up. Based on a focal distance of 14 mm and an angle of field of 81° respectively in the current set-up, the census strip with of still pictures would then be ~520 m. Since the camera has (at present) 3000 pix horizontal resolution, ground resolution would be ~8 cm. However, discrimination on species level is still not possible at this pixel size, and hence lower altitudes would be only improve the quality of images and discernibility of objects. Since discrimination of seals on species level can empirically done on patterns of movements, parallel video footage may allowing to document potential movements of individual seals when the aircraft will pass.

Requested flight hours (without ferry to base of project)

Ca. 13 hours in total: 7 hours (1st flight) plus 6.0 hours (2nd flight).

Ground-based support

Forecasts of satellite tracks (see above).

Request for operation support during campaign

The flight log should wherever possible document aggregations of seals or penguins or other birds, and also the overall ice situations as observed by the pilots. This has been done as well for the APIS flights and provides a helpful meta-documentation along the flight transects. The recorded photo and video data should be stored on a portable/external hard drive, and shall be handed over to the PI in Bremerhaven.

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Reference to PACES II

The project contributes to Topic 1 WP 6 "*Large scale variability and change in polar benthic biota and ecosystem functions*". By doing so it comprises challenges towards "*The functional role of the benthic compartments of both polar biospheres (i.e. the sediment-water transition zone, benthic organisms, their demersal and endotherm predators and pelagic prey) in providing ecosystem functions and services, particularly biodiversity, nutrient recycling, and flow of energy and matter. Assimilation of ecological and environmental data relevant for developing an understanding of key polar characteristics and processes into a reference collection*" (see page 55), and, furthermore, particularly contributes to the milestones "*Integrated ecological database for Arctic and Antarctic ecosystems from shelf to deep sea.*", and "*Operative procedures to identify and manage data, analytical methods and models.*" (see page 58 of the PACES II Program).

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