High resolution airborne melt pond data for pond characteristics retrieval

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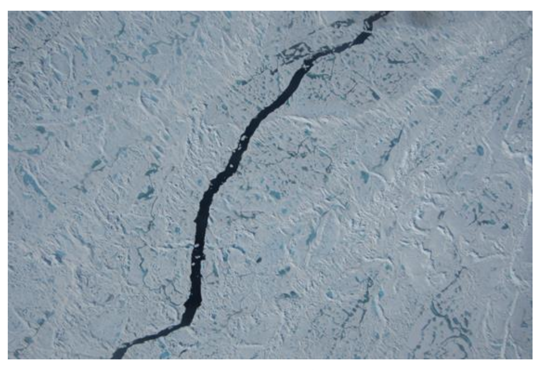
This poster is about AWI airborne measurements and developed processing steps to retrieve geometric melt pond characteristics. After a brief motivation about the importance of ongoing melt pond measurements in a changing Arctic (1.), we continue with presenting the different campaigns in which the data was recorded (2.). After that, we bring into focus airborne RGB image data used to retrieve melt pond characteristics. We explain pre-processing steps which we developed based on helicopter measurements and which should also apply for aircraft data later (3.). We explain the geolocation of airborne image data on ice floe coordinates which will be also useful for MOSAiC. Finally, we give an outlook on our next steps in which we are going to analyze all data from the different measurement campaigns. This part should give rise to a discussion (4.).

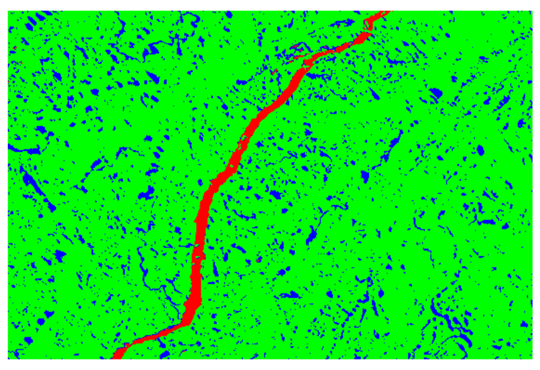
1. Changing ice regime – changing pond characteristics

Many efforts have been made to parameterize the impact of melt ponds on the surface energy balance of Arctic sea ice sufficiently in climate models (Curry et al., 2001). However, most of the currently existing and more advanced parameterizations are based on very few different measurement campaigns as for example SHEBA (1997-98). These campaigns were conducted mostly on multi-year ice (MYI) or land-fast ice (LFI). Both of them have an evidently different surface structure as well as different inner-ice physical properties and snow cover in comparison to first-year ice (FYI). This causes also different melt pond characteristics as shown in the example on the right side. Since FYI is becoming the dominating sea-ice type in the changing Arctic, new high-resolution image data and retrieved pond characteristics are necessary to improve simulations and evaluate large-scale satellite data.

MYI - RGB



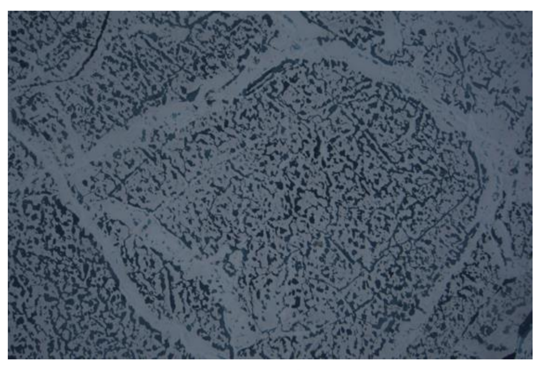
MYI – classified



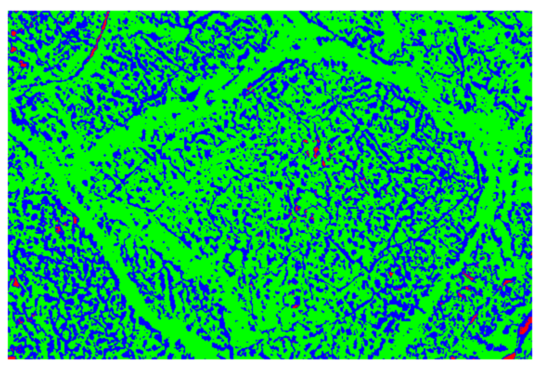
Airborne images of MYI and FYI at approximately the same state of melt. Calculated fraction:

	MYI vs. FYI fraction [%]	
ponds	10	31
snow / bare ice	90	69
ice cover	98	99.5
open water	2	0.5

FYI - RGB



FYI – classified



2. AWI airborne melt pond data

AWI has recorded an optical data set during the last years from flight measurement campaigns over ponded sea ice in different ice regimes and at different times in the melt season. The latest measurements took place this year during the Polarstern expedition PS106. In contrast to earlier measurements which used the aircrafts POLAR 5/6 as platform, the instrument setup was in PS106 flown from a helicopter. This enables the evaluation with ground truth data obtained during ice stations, as for example in-situ measured pond depth, which is planned to be derived from airborne hyperspectral measurements by project partners.

In the following, we present the different measurement campaigns including their timing in the melt season and a brief description of the encountered ice types.

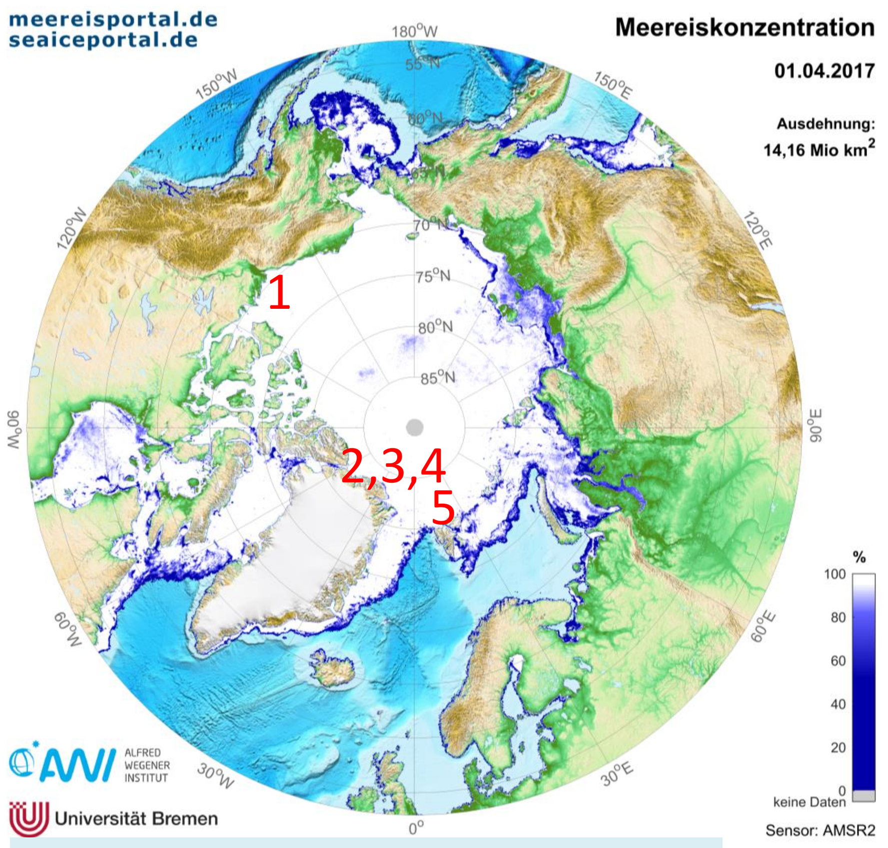


Figure 1: Locations of flight campaigns. (Map: meereisportal.de)

RGB images and partially hyperspectral data, radiation data as well as laser scanner data of melt ponds exists from the following AWI flight campaigns:

Location	Campaign	Date	State of melt	Dominating sea-ice type
1	MELTEX I	May/June 2008	Pond formation	FYI
2	MELTEX II	July/August 2015	Peak of melting	FYI + SYI (MYI)
3	NOGRAM-2	July 2011	Peak of melting	FYI + SYI
4	TIFAX	July/August since 2010	Melting and refreezing	FYI + SYI (MYI)
5	TEMPO	June/July 2017	Pond formation	FYI + SYI

FIY: first-year ice, SYI: second-year ice, MYI: multi-year ice

3. Airborne RGB imaging – geometric pre-processing

RGB camera system:

Camera: CANON EOS 1D Mark III
Lens: CANON 14mm/f2.8
Raw-Resolution: 3888 x 2592 Pixel
Ground resolution at 1000ft flight altitude:
17cm x 17cm.

Figure 2: revealed CANON camera in helicopter setup

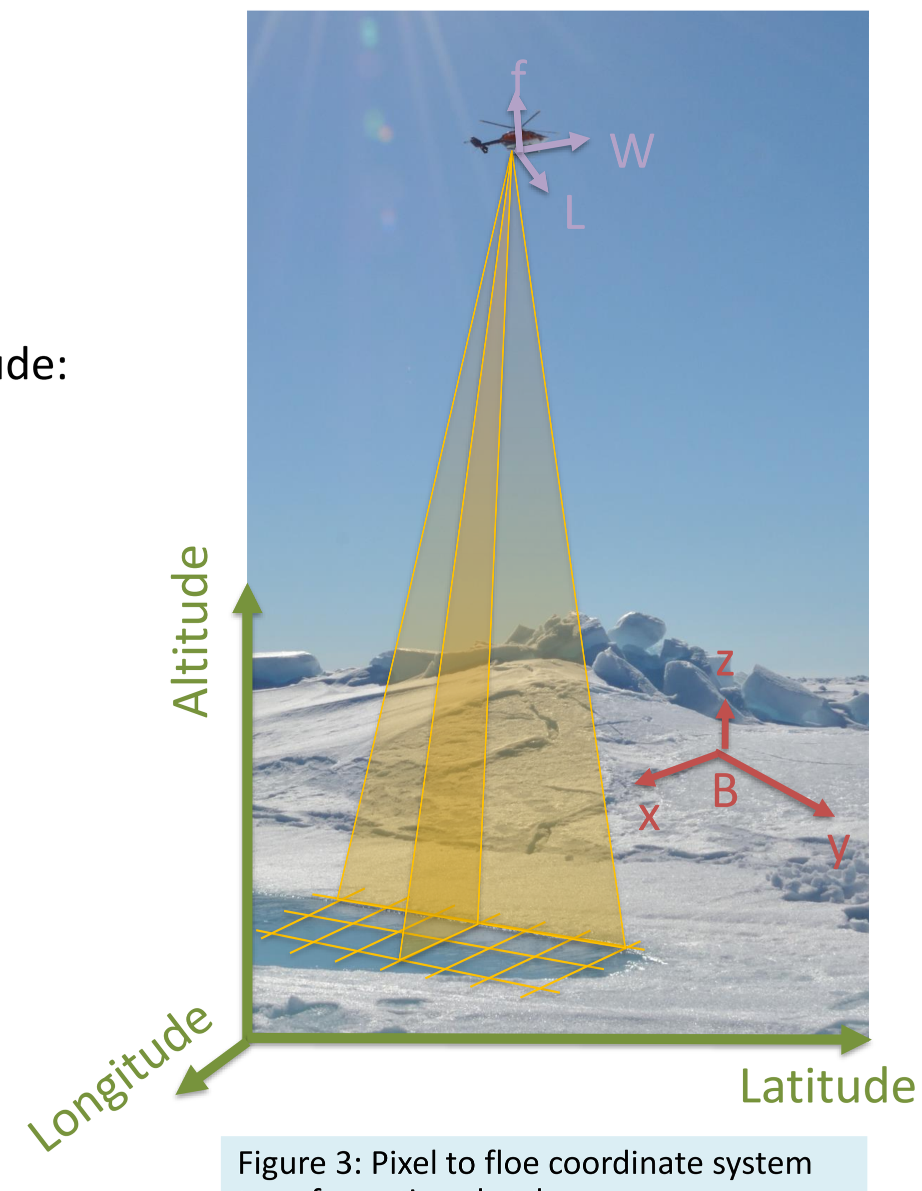


Figure 3: Pixel to floe coordinate system transformation sketch

Pixel geolocation for floe based observations:

To the best of our knowledge, no precise orthorectification is done so far for airborne melt pond imaging. Schwarz (2013) found errors of 20% ±10% in pond sizes in his evaluation. In the following we present a operative orthorectification algorithm

1. Camera coordinate system:
Camera calibration corrects lens and protection-window distortions. Each sensor pixel has a distinct position vector from the focal point.

2. Transformation: Earth to **Cartesian floe coordinate system**
Floe coordinate system basis point B(0,0,0) is calculated by averaging GPS drifter data in earth coordinate system. **Floe coordinates in meters.**

3. Transformation: Sensor pixel to **floe coordinates**:
Coordinate system rotation based on Tait-Bryan aircraft angles: pitch, roll and heading.

4. Projection: Sensor pixel to floe surface plane

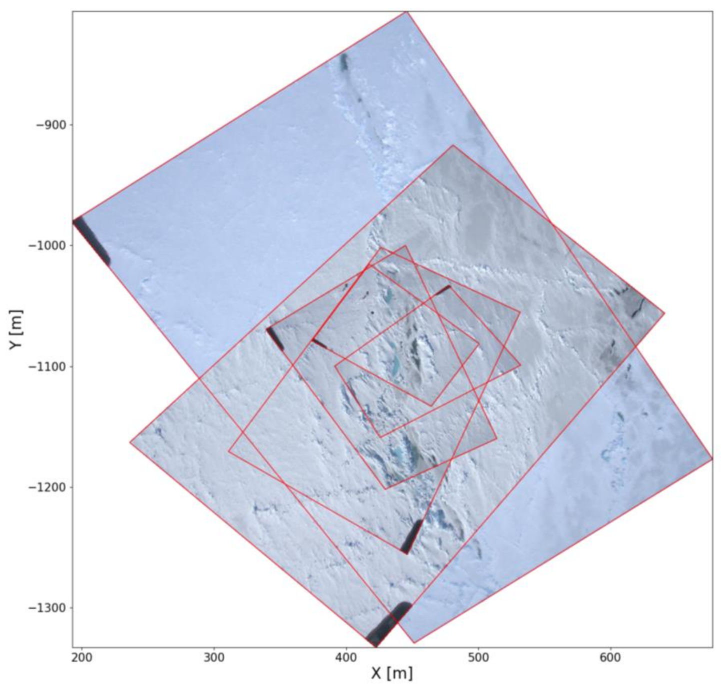


Figure 4: Orthorectified airborne RGB images from TEMPO 2017 in floe coordinate system

Accuracy: ±5% in distance and ±7.5% in area over the whole projection surface
Error caused by:
low resolution of CANON timestamp, camera optics, vibrations in the helicopter and GPS drifters on the ice. The position error is probably larger.

4. Future objectives – please discuss

Parameters that we plan to achieve:

Parameters: Pond fraction, pond depth, pond shape, pond connectivity, pond size distribution, pond distances

Dependent on: approx. ice age, location, time of the year, surface structure, pond brightness, ice thickness

Are you working with models? Please supplement the list:

Final image classification algorithm:

Normalize pictures and classify by RGB brightness:
Normalization with temporal running maximum value of each camera pixel: Each camera pixel captures at least one time a snow surface within a certain timespan. This gives a clean snow picture - during PS106 within 1 minute - which is directly comparable with the reflected shortwave radiation.
or
Feature detection algorithm:
Computer vision algorithm that detects ponds as known features.

References:
Curry, J. A., Schramm, J. L., Perovich, D. K., & Pinto, J. O. (2001). Applications of SHEBA/FIRE data to evaluation of snow/ice albedo parameterizations. *Journal of Geophysical Research: Atmospheres*, *106*(D14), 15345-15355.
Schwarz, P. (2013). *Quantitative characterisation of sea ice melt stages in the Arctic by means of airborne photographs* (Diplom thesis, University of Trier).
Grosfeld, K.; Treffeisen, R.; Asseng, J.; Bartsch, A.; Bräuer, B.; Fritzsch, B.; Gerdes, R.; Hendricks, S.; Hiller, W.; Heygster, G.; Krumpen, T.; Lemke, P.; Melsheimer, C.; Nicolaus, M.; Ricker, R. and Weigelt, M. (2016), Online sea-ice knowledge and data platform <www.meereisportal.de>, Polarforschung, Bremerhaven, Alfred Wegener Institute for Polar and Marine Research & German Society of Polar Research, 85 (2), 143-155, doi:10.2312/polfor.2016.011.

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