The MOSAiC ROV Program: One Year of Comprehensive Under-Ice Observations

Christian Katlein*, Philipp Anhaus, Ilkka Matero, Daniela Krampe, Stefanie Arndt, Julia Regnery, Marcel Nicolaus

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Bremerhaven, Germany

MOSAiC

PRESENTED AT:

AGU FALL MEETING
Online Everywhere | 1–17 December 2020

LEG 1: A DYNAMIC START

The ROV site of Leg 1 covered a sheet of residual ice that had survived the summer, but was affected by many small scale deformation events. It had to be abandoned in mid-December

Fig.1: Recovery of the ROV Tent after a crack appeared right underneath.

LEG 2&3: WINTER AND SPRING

During Leg 2 this site provided good coverage of the ridge observatory 'Fort Ridge' and the general Central Observatory including Ocean City. After deformations during Leg 3 it also included an actively regrowing lead that was surveyed intensely until the site was crushed in the final days of Leg 3.

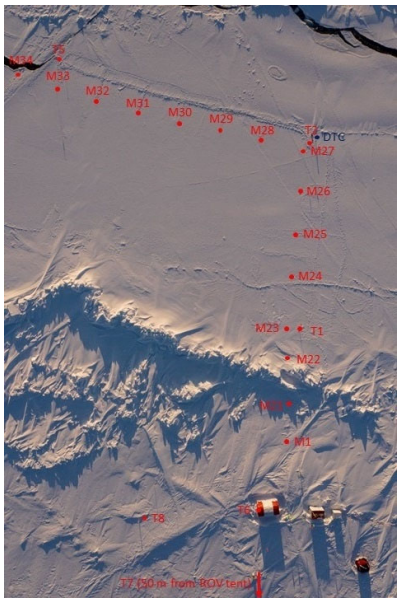


Fig.2: Aerial image of the survey area during Leg 3

ROV SYSTEM

Fig.3: ROV site consisting of power hub, control cabin and deployment tent in March 2020.

Main achievements:

- Year-round under-ice ROV operations
- Over 80 dive days
- No technical failures / downtime
- A unique unprecedented dataset

ROV used for:

- Environmental sensing (light, oceanography,...)
- Floe mapping (multibeam sonar)
- Zooplankton net tows
- Sediment trap deployments
- Ice and water suction sampling
- Deployment of fishing lines
- Hyperspectral imaging
- Documentation and maintenance of deployed sensor systems

Challenges:

- ice deformation (particularly on legs 1 and 3)
- changing ROV sites with different characteristics

Data available on MCS (preliminary data) and PANGAEA (processed data, expected spring 2021)

DATA EXAMPLES

Discovery of Platelet ice

Fig.4: Platelet ice growth was discovered during wintertime in the Central Arctic

See respective poster here (/default.aspx?s=B5-E9-35-38-54-E1-AF-4C-A0-F4-97-E4-84-D8-51-37&guestview=true) and GRL paper (https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020GL088898).

3D mapping of the ice floe

[VIDEO] https://www.youtube.com/embed/niUrbSLlbds?rel=0&fs=1&modestbranding=1&rel=0&showinfo=0

Fig.5: Animation of co-located airborne laser scanner surface topography and multibeam bathymetry in a survey radius of 300m around the ROV hole.

Light transmission through the ice

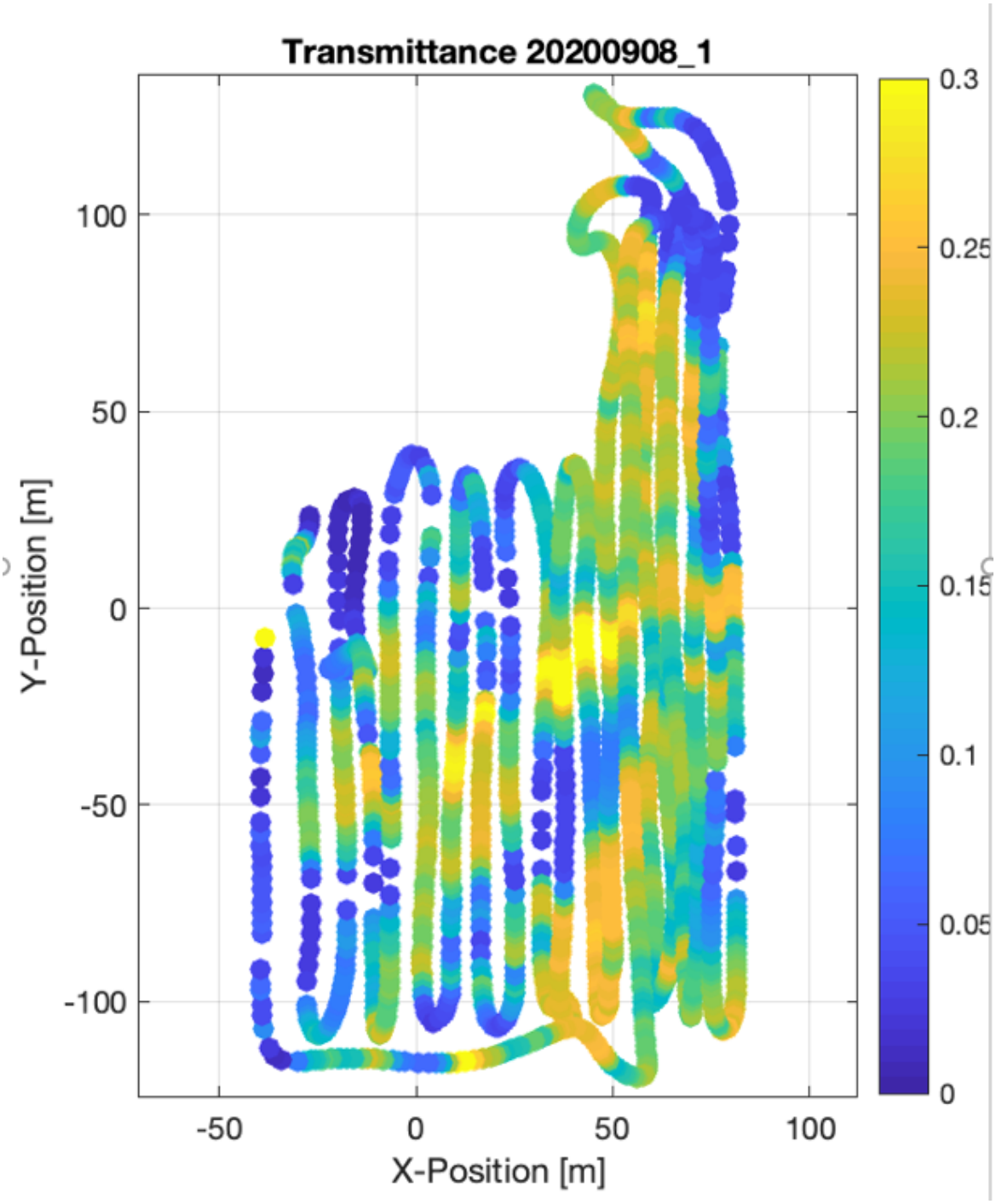
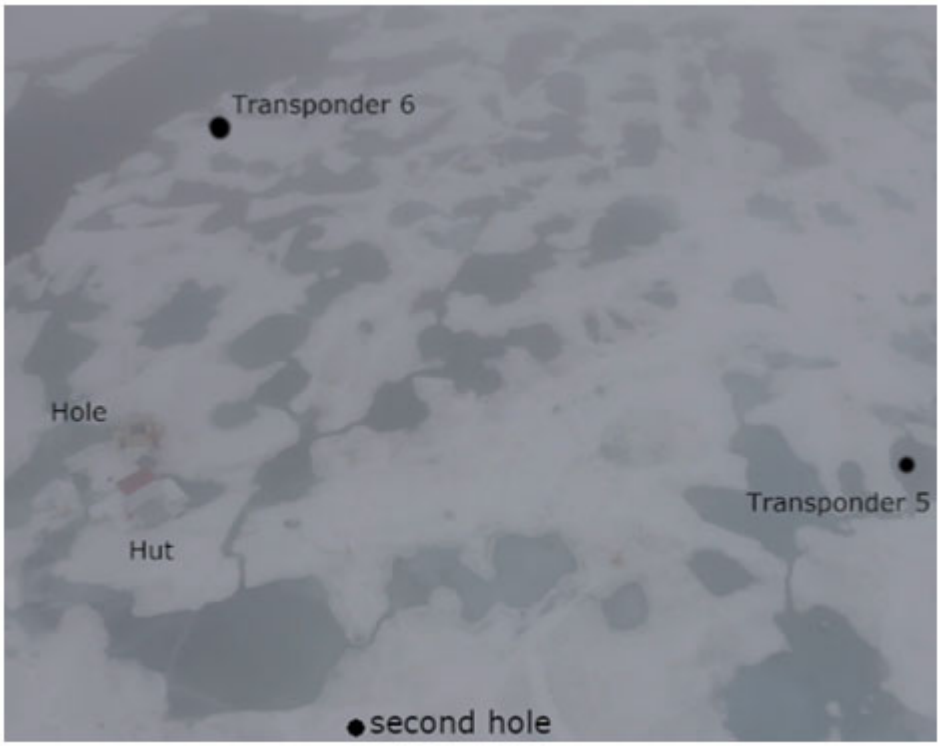


Fig.6: Spatial variability of light transmittance through sea ice on 8 Sep 2020 during refreezing.

LEG 4: THE MELT SEASON

After the ship came back to the ice floe, and the previous site could not be re-established, an ROV site was chosen comprising a combination of first year and older ice. The surveyed piece was located in the vicinity of the previous FYI coring and lead sampling sites. We observed the formation of melt ponds and a typical bi-modal transmittance distribution



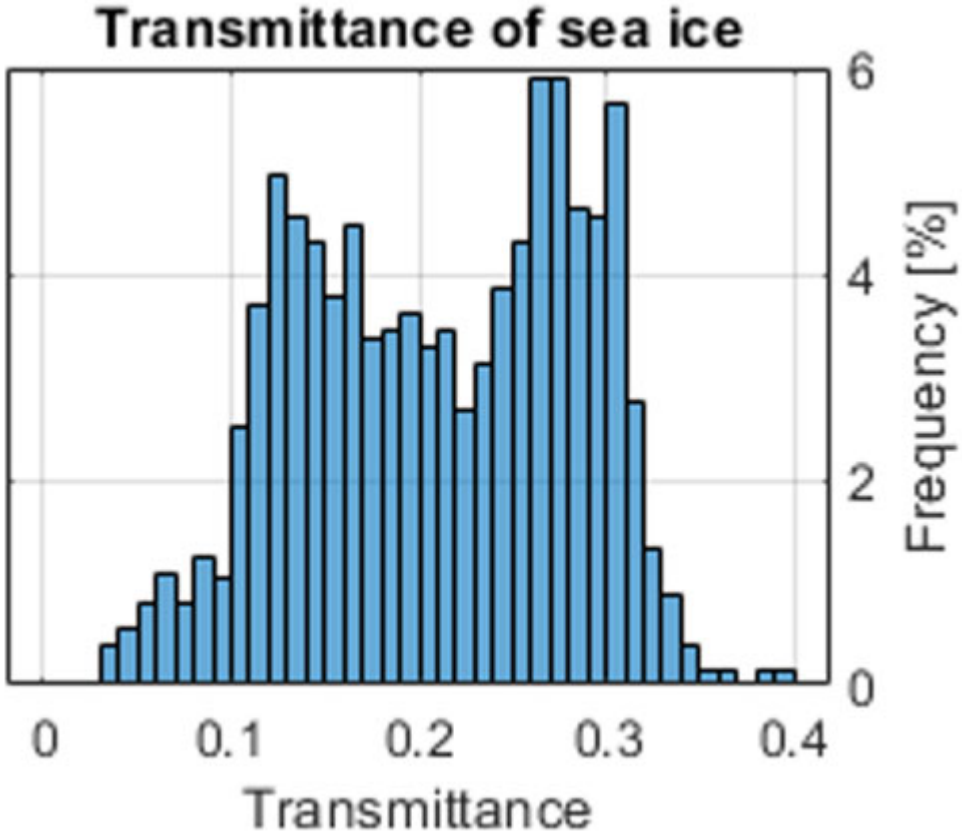


Fig.7: Top: Aerial image of ROV area during Leg 4
Bottom: Light transmittance histogram on 28 July 2020

LEG 5: FREEZE-UP

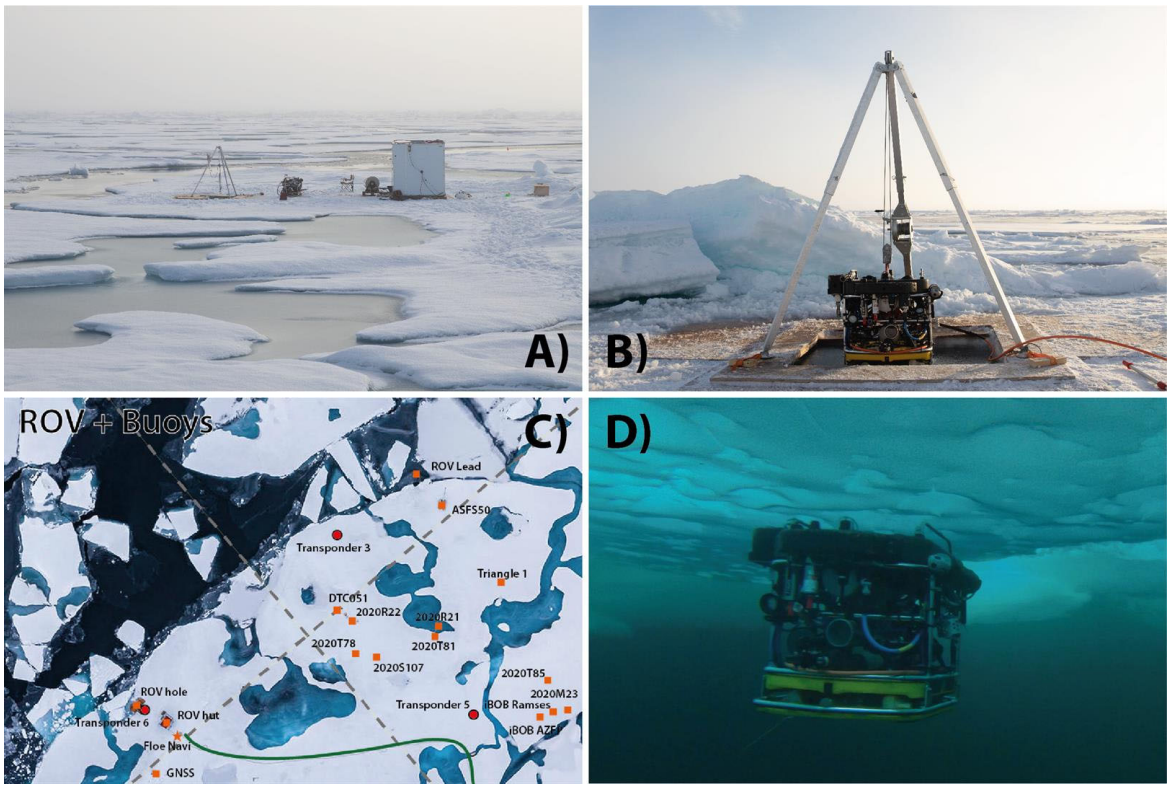


Fig.8: Overview on the ROV deployment site on the second MOSAiC floe during the refreezing conditions of Leg 5: A) Deployment site after ponds started refreezing. B) ROV awaiting deployment. C) Aerial picture of the ROV site. D) ROV operating under sea ice.

AUTHOR INFORMATION

Christian Katlein1*, Philipp Anhaus1, Ilkka Matero1, Daniela Krampe1, Stefanie Arndt1, Julia Regnery1, Marcel Nicolaus1

1Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Bremerhaven, Germany

*presenting author

for information on the MOSAiC ROV data please contact Christian.Katlein@awi.de

ABSTRACT

The overarching goal of the remotely operated vehicle (ROV) operations during MOSAiC was to provide access to the underside of sea ice for a variety of interdisciplinary science objectives throughout an entire year. The M500 ROV was equipped with a large variety of sensors and operated at several sites within the MOSAiC central observatory. Despite logistical and technological challenges, over the full year we accomplished a total of ~60 days of operations with over 300 hours of scientific dive time. 3D ice bottom geometry was mapped in high resolution using an acoustic multibeam sonar covering a 300 m circle around the access hole complementing other ice mass balance measurements on transects, by autonomous systems, airborne laser scanning and from classical ablation stakes. Various camera systems enabled us to document features of sea ice growth and decay. From early March onwards, with the sun rising again, a main focus was the investigation of the spatial variability in ice optical properties. Light transmittance was measured with several hyperspectral radiometers under marked survey areas, including various ice types such as first-year ice, second-year ice, pressure ridges, and leads. Optical surveys were coordinated with surface albedo measurements, vertical snow profiles and aerial photography. The ROV also supported ecosystem research by deploying sediment traps underneath pressure ridges, sampling algal communities at the ice bottom and in ridge cavities with a suction sampler as well as the regular towed under-ice zooplankton and phytoplankton nets. Ice algal coverage was further investigated using an underwater hyperspectral imaging system, while the ROV video cameras enabled the observation of fish and seals living in ridge cavities. The ROV also carried further oceanographic sensors providing vertical and horizontal transect measurements of small-scale bio-physical water column properties such as chlorophyll content, nutrients, optical properties, temperature, salinity and dissolved oxygen. Here we present first highlights from the year-long operations: the discovery of platelet ice under Arctic winter sea ice during polar night and the extensive time series of multibeam derived ice draft maps, which allow together with airborne laser scanner data a full 3D documentation of ice geometry.

REFERENCES

Katlein, C., Mohrholz, V., Sheikin, I., Itkin, P., Divine, D. V., Stroeve, J., et al. (2020). Platelet ice under Arctic pack ice in winter. Geophysical Research Letters, 47, e2020GL088898. https://doi.org/10.1029/2020GL088898 (https://doi.org/10.1029/2020GL088898)

Katlein, C., Arndt, S., Belter, H. J., Castellani, G., & Nicolaus, M. (2019). Seasonal evolution of light transmission distributions through Arctic sea ice. Journal of Geophysical Research: Oceans, 124, 5418– 5435. https://doi.org/10.1029/2018JC014833 (https://doi.org/10.1029/2018JC014833)

Katlein C, Schiller M, Belter HJ, Coppolaro V, Wenslandt D and Nicolaus M (2017) A New Remotely Operated Sensor Platform for Interdisciplinary Observations under Sea Ice. Front. Mar. Sci. 4:281. doi: 10.3389/fmars.2017.00281 (https://www.frontiersin.org/articles/10.3389/fmars.2017.00281/full)