Thermal Infrared Imaging of Sea Ice During the MOSAiC Expedition

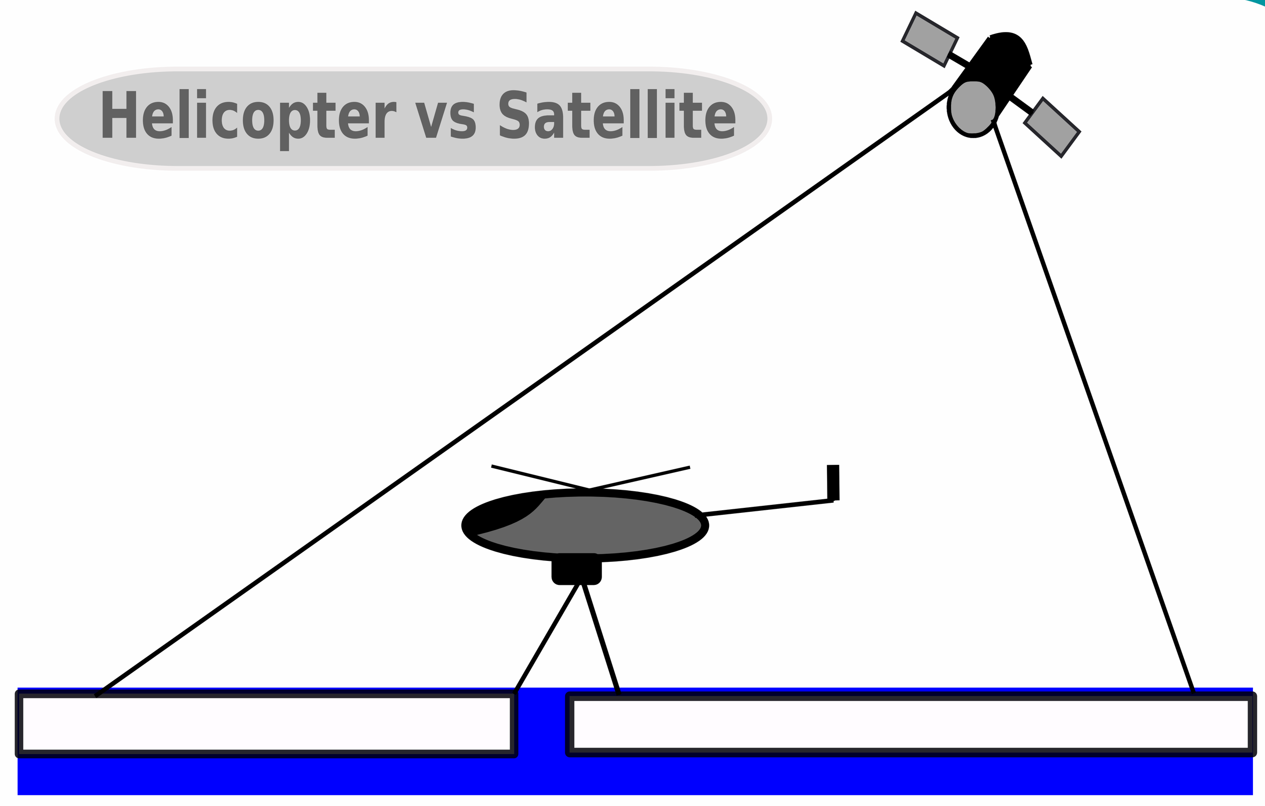
Linda Thielke[1], Gunnar Spreen[1], Marcus Huntemann[1,2]
(1) Institute of Environmental Physics, University of Bremen, Germany; (2) Alfred Wegener Institute, Bremerhaven, Germany

Motivation

Thermal infrared (TIR) imaging in the high Arctic winter is used, because:

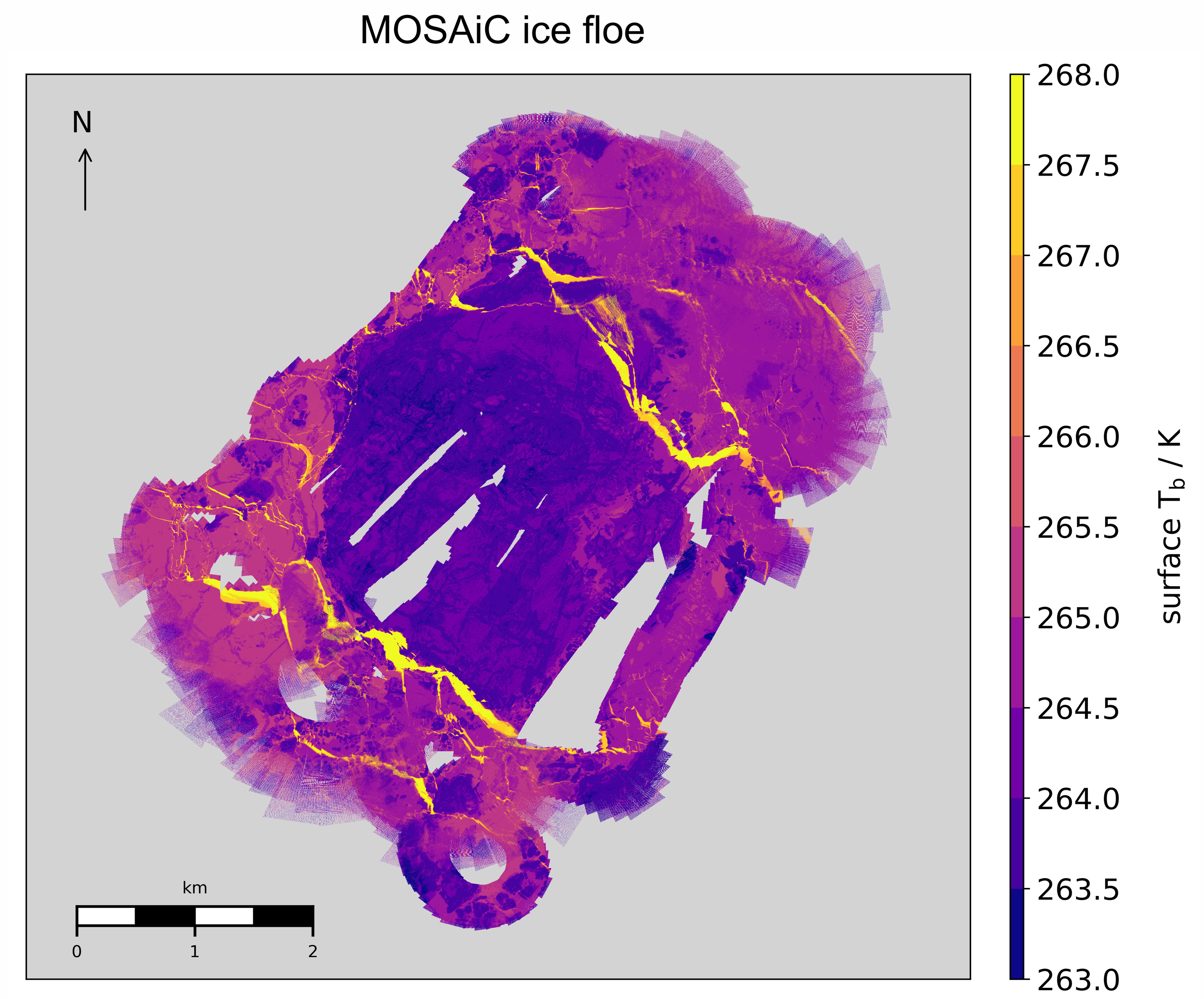
- **different ice types** and thicknesses can be distinguished from water in TIR images
- changing Arctic climate causes **thinner** and faster sea ice which **breaks up earlier** (e.g. Stroeve et al, 2012)
- **spatial resolution** of TIR channels on satellites is **too coarse** to identify smaller leads structures (e.g. Yu and Lindsay, 2003)
- **increased heat exchange** in the thin ice areas (Maykut, 1978)
- changes in the **surface type composition** have impact on the Arctic Climate System

Therefore, the aim is to improve the **thin ice detection in satellite retrievals** to better understand the physical processes in the changing Arctic Climate.



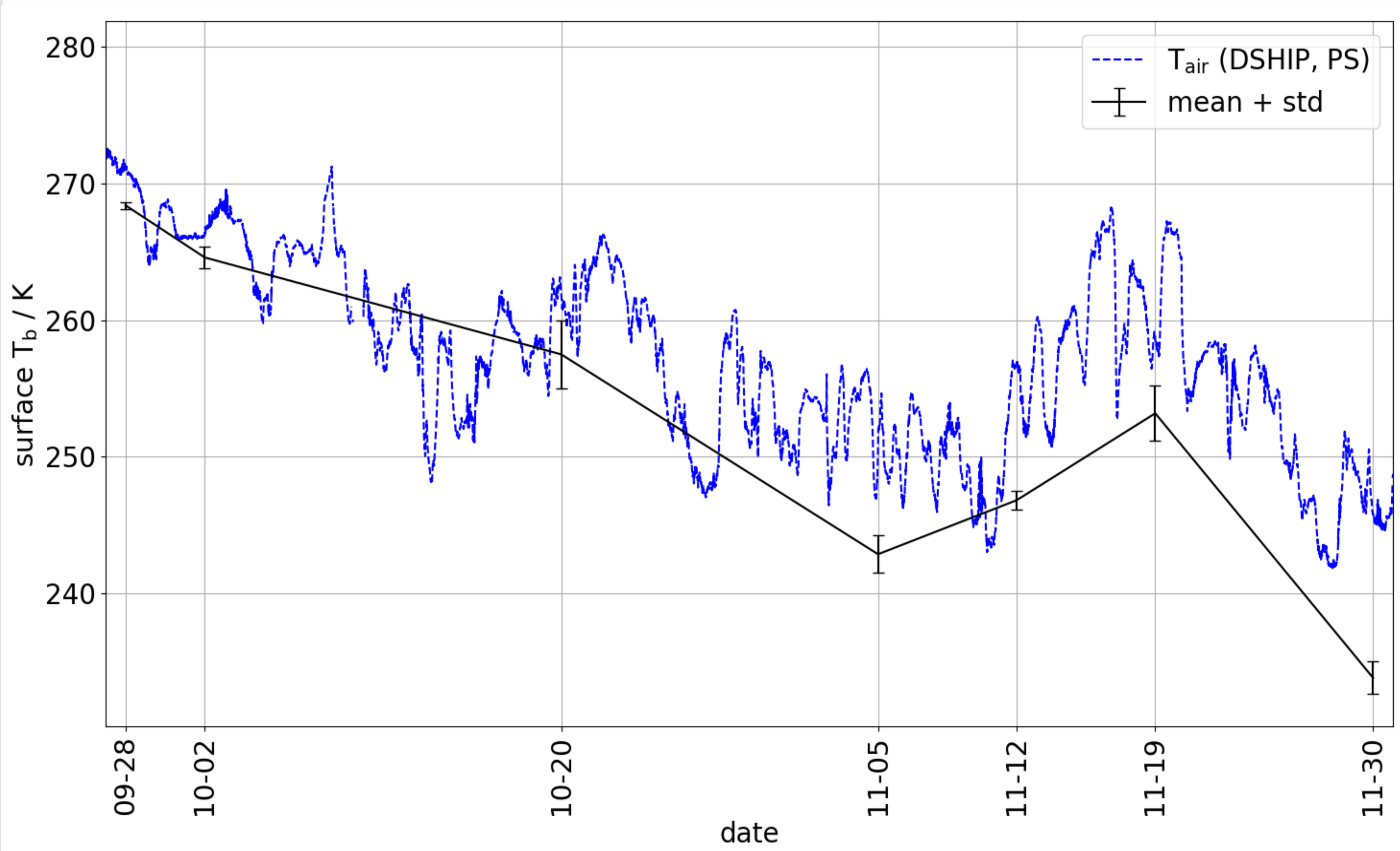
Infrared map example from 2nd Oct 2019

- Colder/warmer temperatures indicate thicker/thinner ice
- Linear warm strcutures can be identified as leads covered with thin ice
- Data resolution: 1 m
- Map is based on processed images which result in this gridded and georeferenced temperature map (for further information go to the box 'Data processing' below)



Temporal evolution Leg 1 (2019)

- Average surface brightness temperature T_b gets generally colder
- Surface T_b follows trend of atmospheric temperature T_{air} (temporarily increase from Nov 11 to Nov 18)
- challenge: strong temperature variation in short time change the surface T_b over the course of a single flight (high standard deviation)

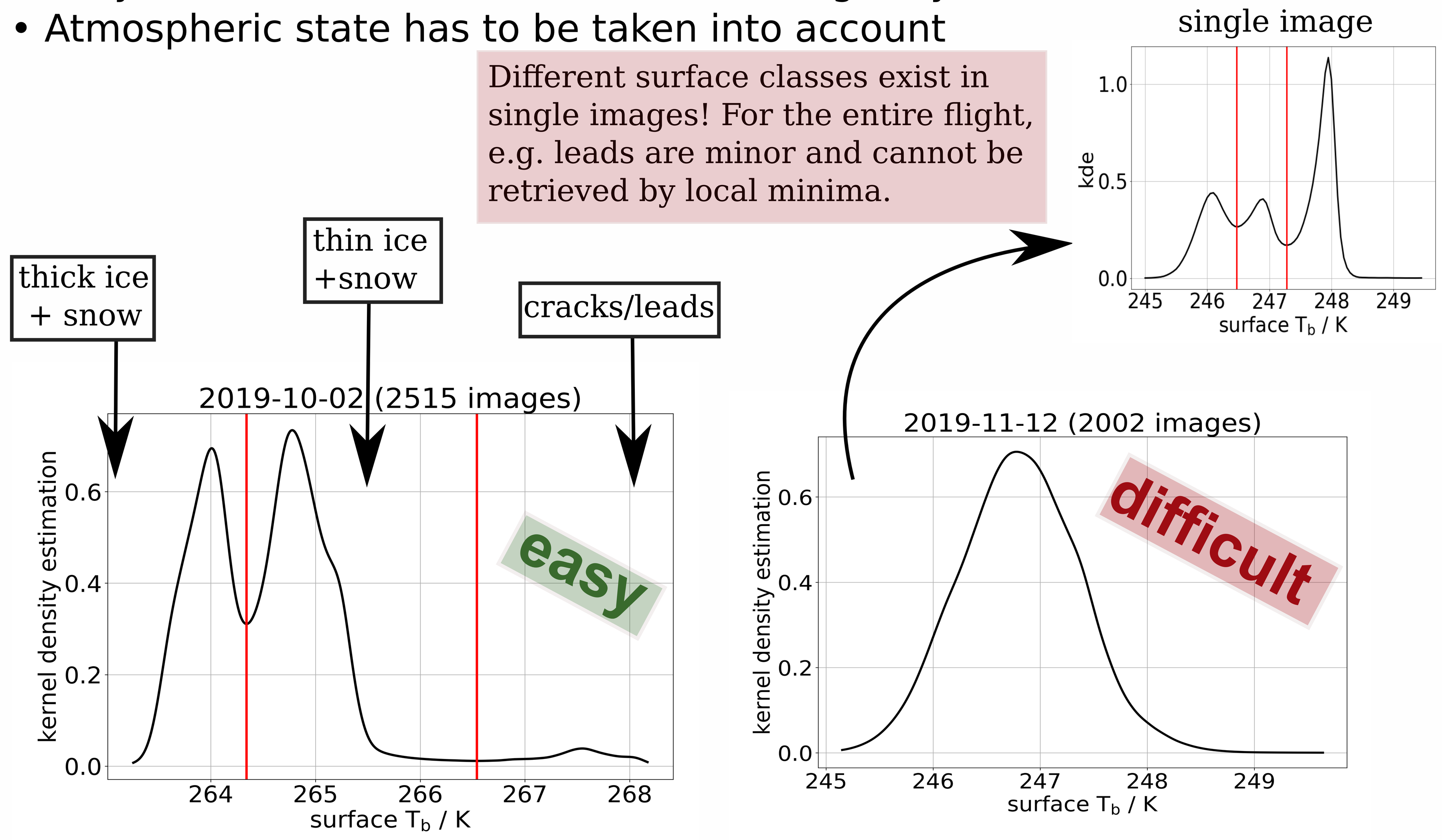


Data processing

- **Drift correction**: calculated from ground GPS data
- **Empirical correction**: of a radial gradient due to change of emissivity with exitance angle (results in homogenous temperature per image)
- **Georeferencing**: based on helicopter position, rotation and heading
- **Resampling**: merge pixel to an equidistant grid

Dynamic ice classfication

- Surface type classification of cracks/leads covered by thin ice as well as thicker ice with snow on top
- Constant threshold arcoss flights is not working for ice classification → dynamic thresholds needed for each flight by local minima
- Atmospheric state has to be taken into account



Conclusion & *Next steps*

- Different sea ice features represented in the **detailed ice flow map**
- Camera measures TIR **brighness temperature** of the surface
- **Atmospheric state** is essential for the measures temperatures
- **Dynamic surface classification** is necessary for thin ice detection

→ *evolution of the ice conditions in the following Legs with diffrent events in ice and atmsophere (additional data)*

→ *correction of brightness temperature to retrieve a physical surface temperature for heat flux estimation (emissivity, downw. lw. radiation)*

Camera setup

- Installed under a helicopter
- Nadir configuaration towards the surface
- Spectral range: 7.5-14 µm (TIR)
- 640 x 480 pixel; 56.1° x 43.6° (width x height)
- ~300 m flight altiudue -> image: 320 m x 240 m -> pixel: 0.5 m x 0.5 m

Future project goals

1) Scale comparison of ice thickness products from satellites (MODIS, SMOS) to high resolution thermal infrared surface classification.
2) Arctic-wide heat exchange analysis including the findings of lead and thin ice fraction and satellite data
3) Model sensitivity study on atmospheric effects of the investigated current Arctic thermodynamic state (regional or single column)

References

1. Stroeve, J. C. et al (2012). The Arctic's rapidly shrinking sea ice cover: a research synthesis. Climatic change, 110(3-4), 1005-1027.
2. Maykut, G. A. (1978). Energy exchange over young sea ice in the central Arctic. Journal of Geophysical Research: Oceans, 83(C7), 3646-3658
3. Yu, Y., & Lindsay, R. W. (2003). Comparison of thin ice thickness distributions derived from RADARSAT Geophysical Processor System and advanced very high resolution radiometer data sets. Journal of Geophysical Research: Oceans, 108(C12).

Acknowledgements

This project was supported by the Deutsche Forschungsgemeinschaft (DFG) through the International Research Training Group IRTG 1904 ArcTrain. Data used in this manuscript was produced as part of the international Multidisciplinary drifting Observatory for the Study of the Arctic Climate (MOSAiC) with the tag MOSAiC20192020 and Project ID AWI_PS122_00.

Universität Bremen

GLOMAR Bremen International Graduate School for Marine Sciences

MOSAiC International Arctic Drift Expedition

ArcTrain