High resolution helicopter-borne surface temperatures for satellite validation

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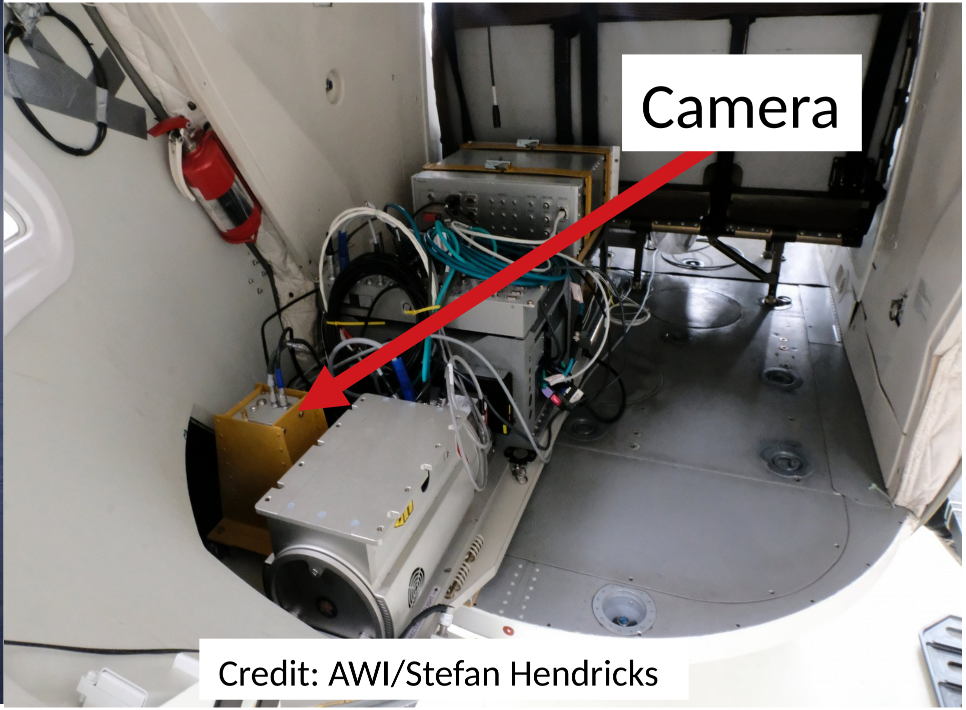
Thermal infrared imaging during MOSAiC

- Helicopter-borne imaging with thermal infrared camera @ 300 m altitude
- High spatial resolution of 1 m from October 2019 to April 2020


Credit: AWI/Michael Gutsche, CC-BY 4.0

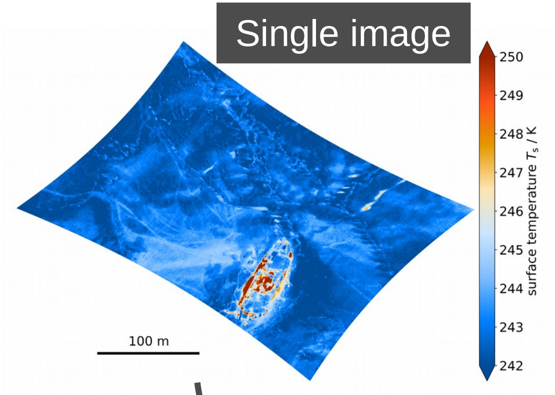


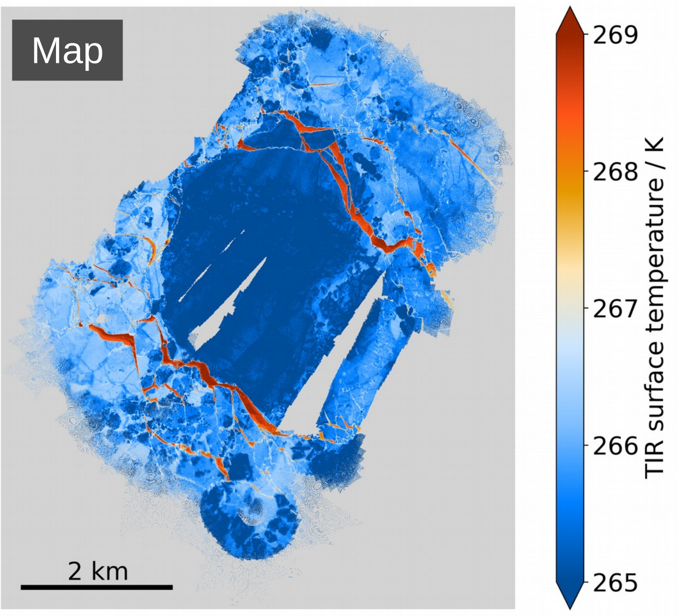
Credit: AWI/Stefan Hendricks

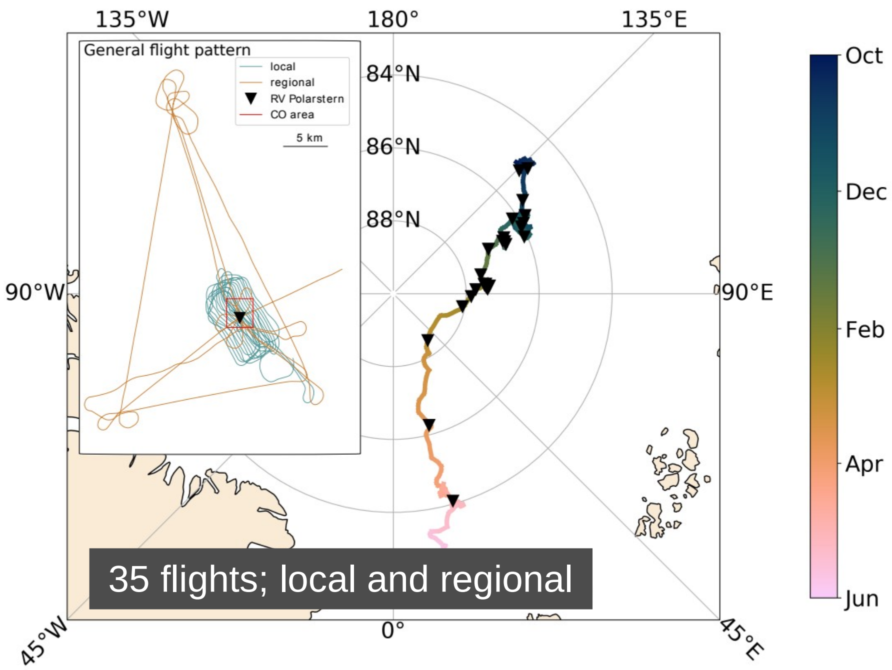
Motivation

- We can capture small-scale leads (1 m resolution) which are not captured by satellites (1 km resolution)
- We perform a regional study on lead properties
- Heat exchange significant larger for leads
- Reference for satellite-based and model-based studies
- Satellites are crucial for Arctic-wide observations

Data set: From images to maps

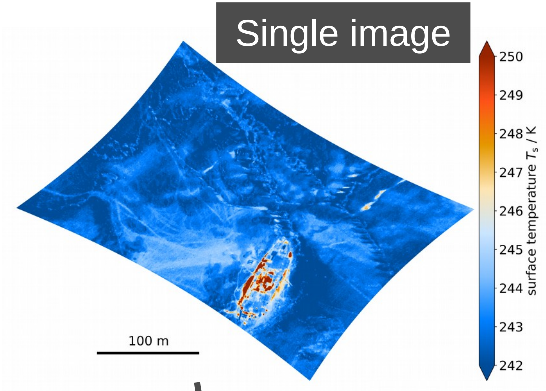


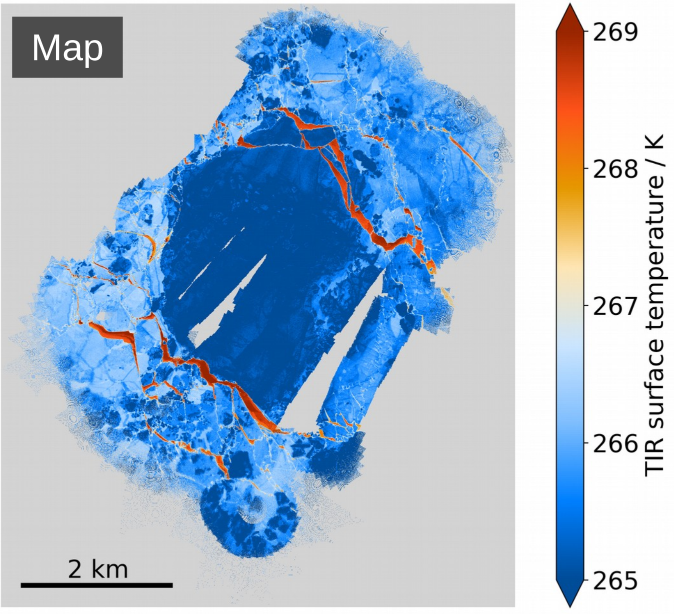


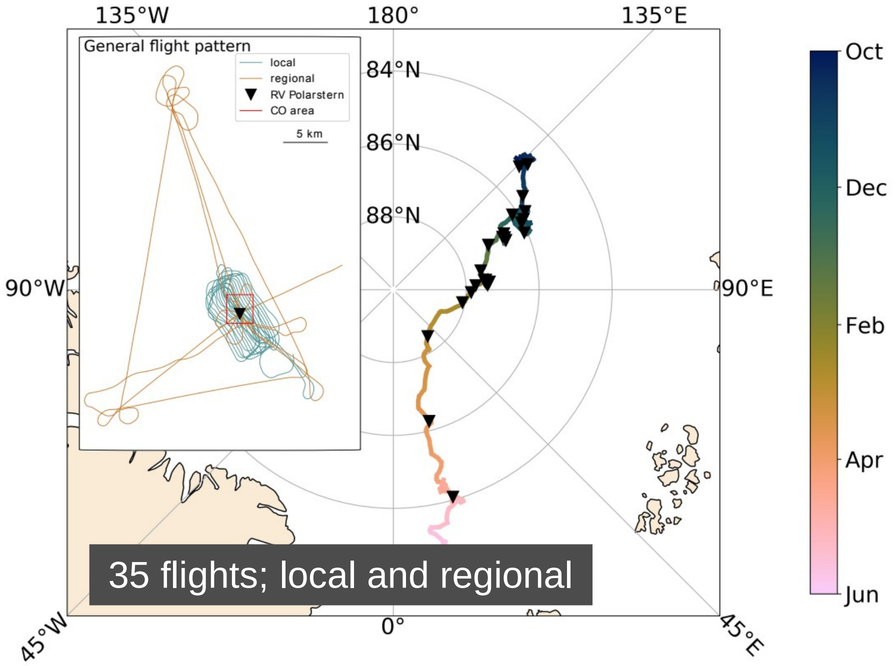


Data set: From images to maps

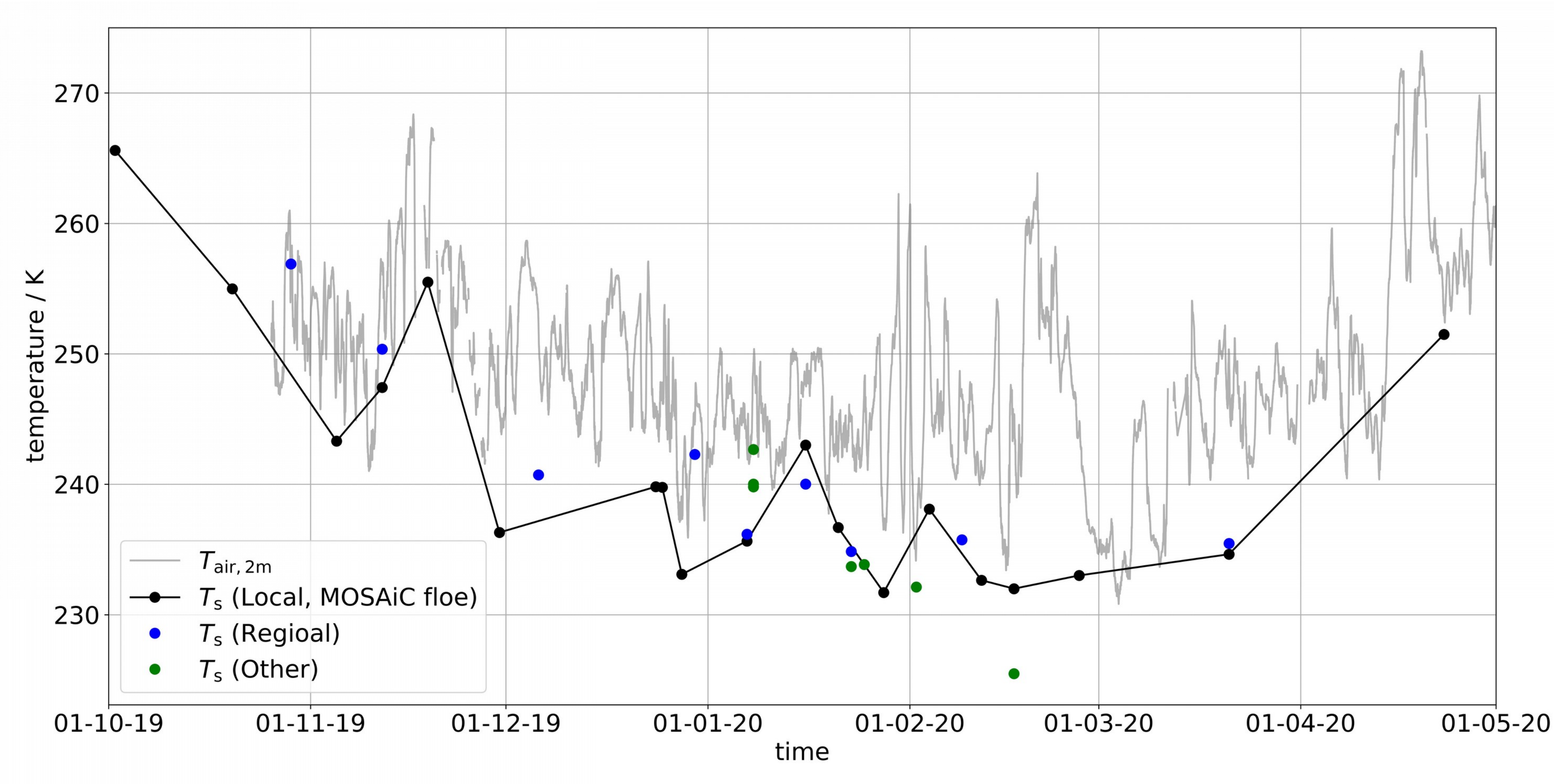
- Surface temperature images and maps published in PANGAEA
- Methods and first results published soon in Scientific Data





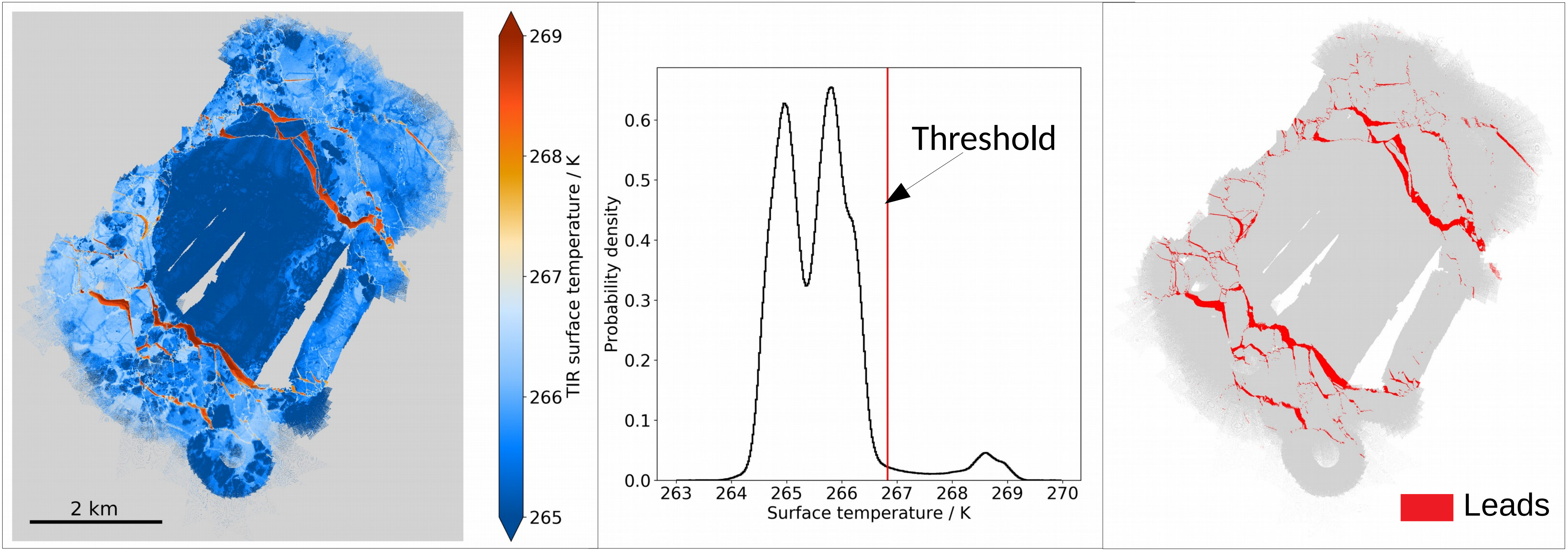


Seasonal evolution of surface temperature



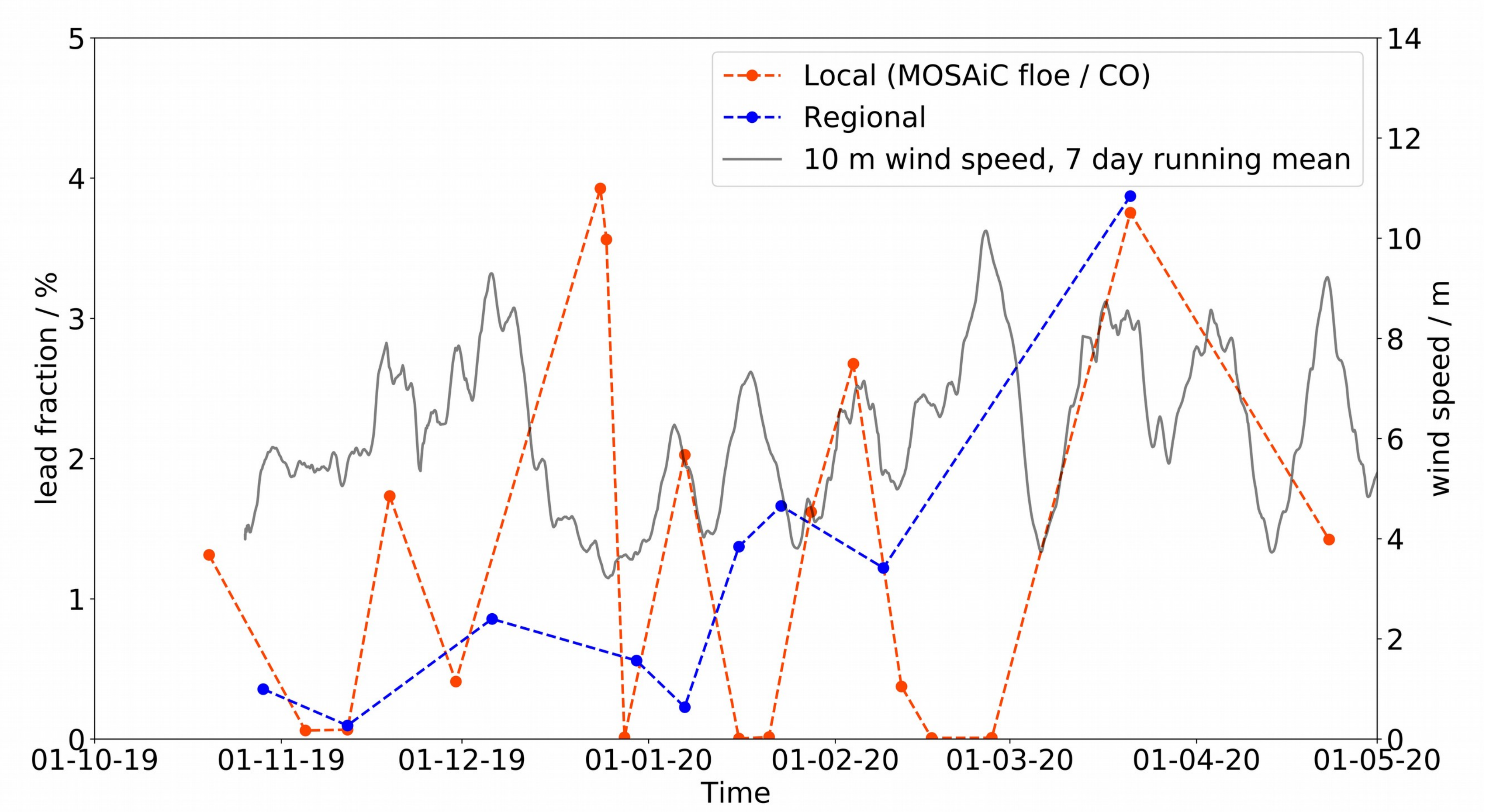
Lead classification

a) Temperature map b) Temperature histogram c) Lead map



Iterative method towards a converging threshold

Lead fraction evolution on different scales

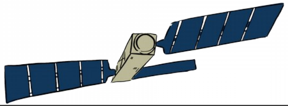


Reference for satellite products

A) Comparison to other lead fraction product
(Luisa von Albedyll et al)
← previous talk

B) Comparison to coinciding flights with ICESat-2
(Renée Mie Fredensborg Hansen et al)
→ Poster session

Satellite sub-footprint scale variability

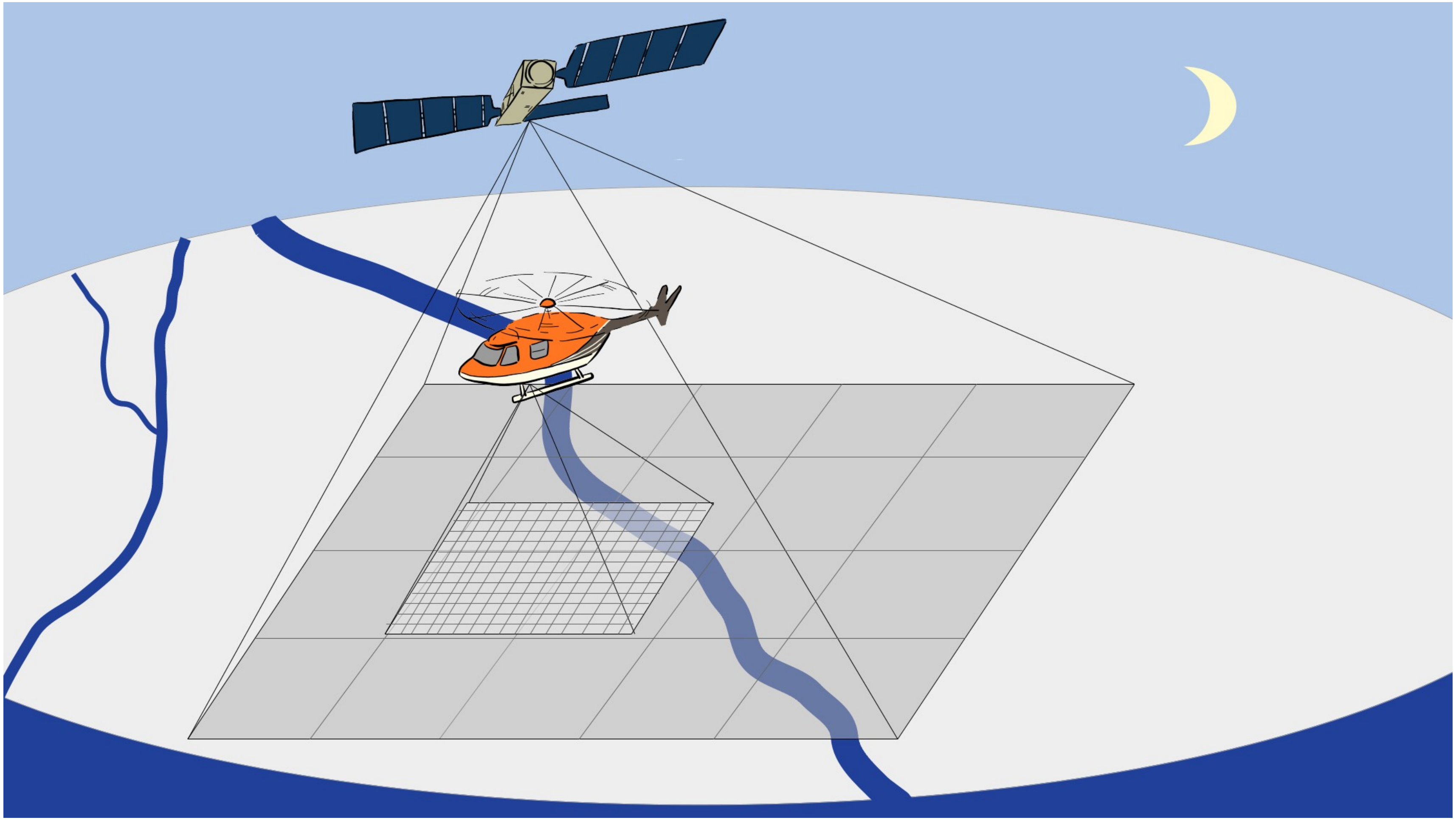


For direct comparison of surface temperatures:
Thermal infrared satellite MODIS (1 km resolution).

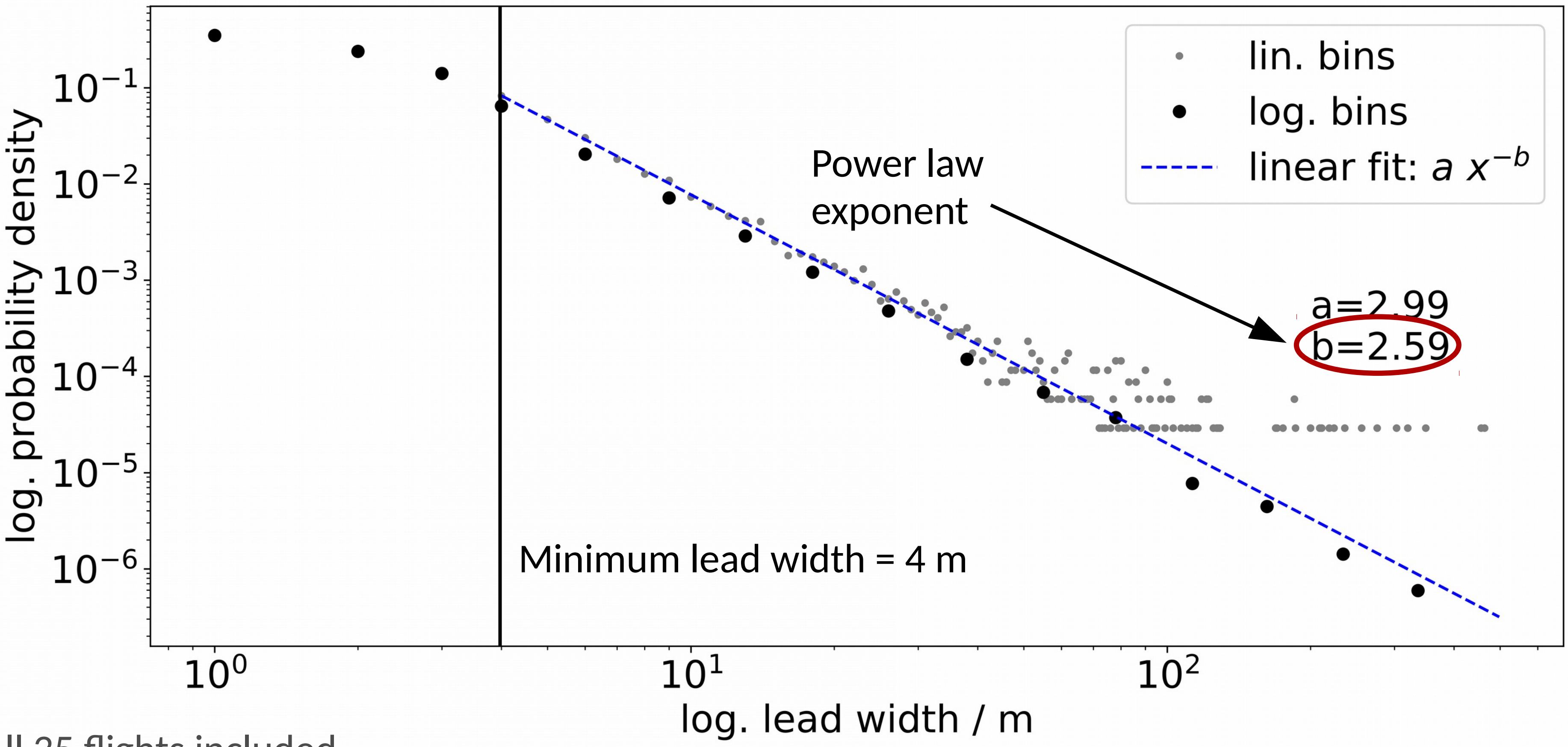
What do we miss in the 1 km x 1 km satellite footprint?

- ➔ How are small features (e.g., cracks in the sea ice) represented in the MODIS surface temperature retrieval?
- ➔ How strong is the contribution of the small features for the heat budget during the Arctic winter?

Satellite vs Helicopter? Different resolutions!



Helicopter lead width distribution



All 35 flights included

Comparison of power law exponent

Table 3. Different results from the literature and this study for the Weddell Sea sorted by publishing date. The threshold definition for lead identification differs between the studies. Marcq and Weiss (2012) use two different luminance thresholds. The last two entries are the results of this study for the Weddell Sea for which two thresholds (OW, open-water-covered leads; OWN, open-water-covered and nilas-covered leads) are also applied. The LF method stands for a linear fit, and the ML method stays for the method after Clauset et al. (2009). A detailed explanation of the methods is in Sect. 3.2.

Source	Fitting method	Platform/ instrument	Time and region	Resolution of the power law	Range of the power law	Power-law exponent α
Wadhams (1981)	LF	submarine mission	October 1976, European Arctic Ocean	about 5 m	50–1000 m	2.00
Wadhams et al. (1985)	LF	submarine mission	February 1967, Davis Strait	about 5 m	50–1000 m	2.29
Lindsay and Rothrock (1995)	LF	AVHRR	1989, central Arctic Ocean	1 km	1–50 km	1.60 ± 0.18
Marcq and Weiss (2012)	ML	SPOT	April 1996, central Arctic Ocean	10 m	0.02–2 km	2.1–2.3 2.5–2.6
Wernecke and Kaleschke (2015)	ML	CryoSat-2	winter 2011–2014, Arctic Ocean	300 m	≥ 600 m	2.47 ± 0.04
Qu et al. (2019)	LF	MODIS, Landsat 8	April 2015, Beaufort Sea	30 m–1 km	≥ 30 m	2.241–2.346
This study	LF	Sentinel-2	2016–2018 (November–April), Weddell Sea	10 m	0.01–6.5 km	OW: 1.110 ± 0.020 OWN: 1.280 ± 0.020
This study	ML	Sentinel-2	2016–2018 (November–April), Weddell Sea	10 m	0.01–6.5 km	OW: 1.399 ± 0.002 OWN: 1.413 ± 0.002

Table from: Muchow et al (2021). The Cryosphere. https://doi.org/10.5194/tc-15-4527-2021

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+ our study:
Range: 4-400 m
Exponent: 2.59

→ **Exponent similar for different methods and resolutions**

→ **With our study we add for very high resolutions**

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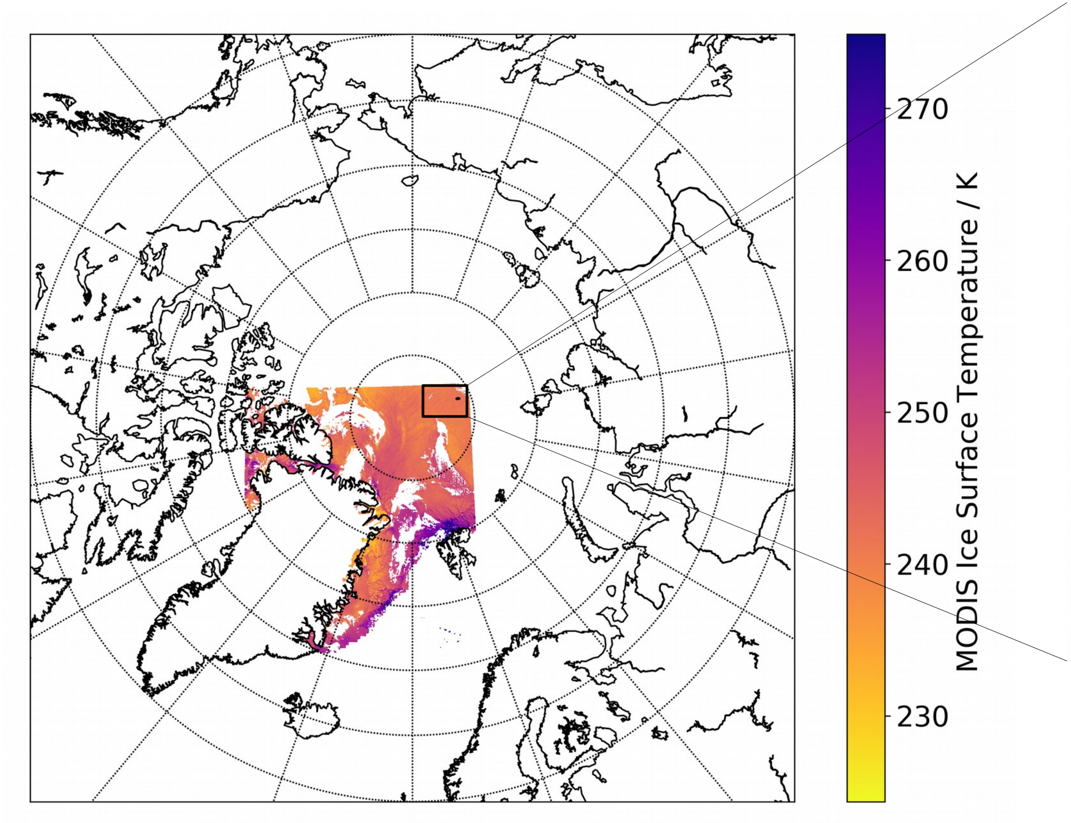
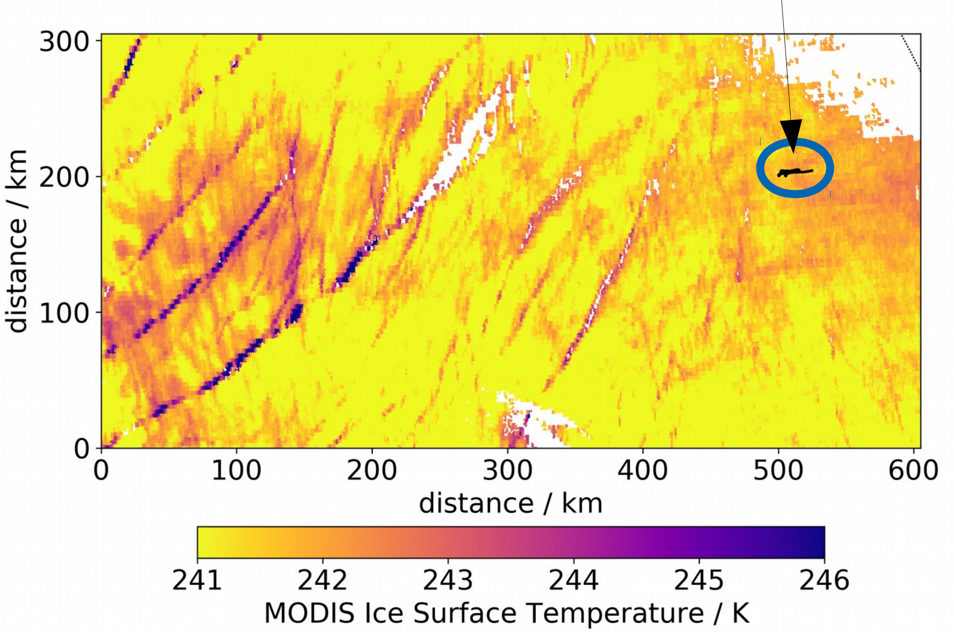
Satellite surface temperature by MODIS

MODIS Swath – 30 November 2019



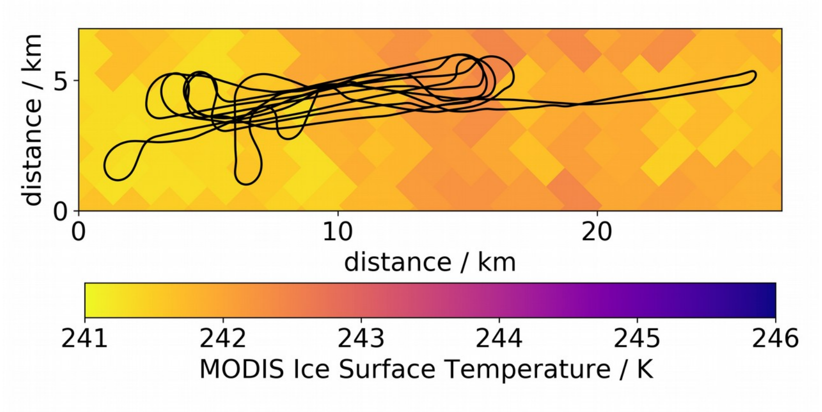
Helicopter flight track



Outlook: Satellite vs Helicopter

30 November 2019

Satellite (1000 m): 07:25 UTC



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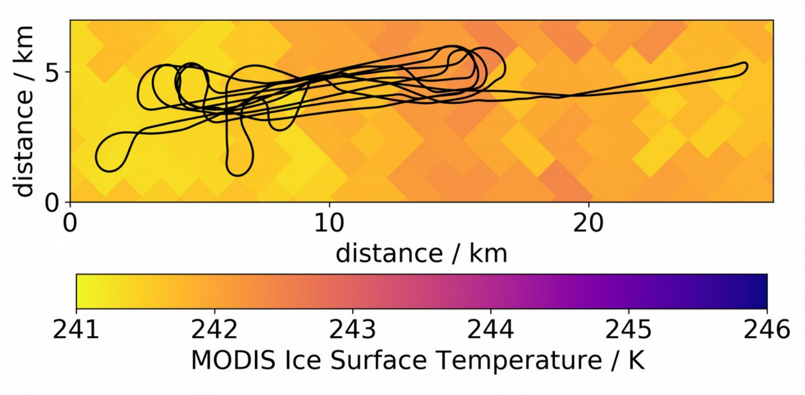
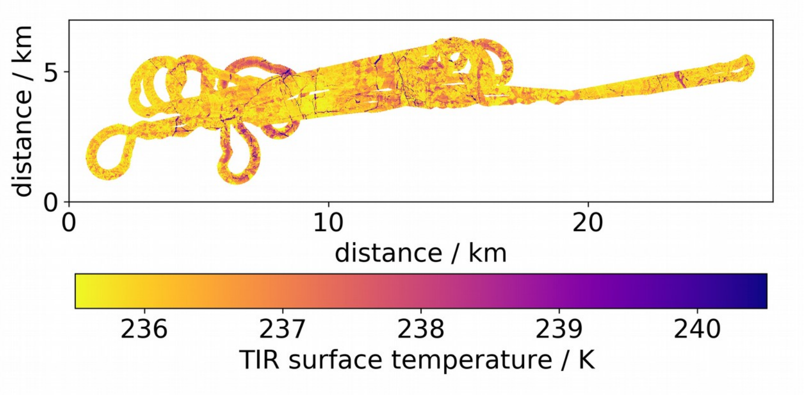


Helicopter (1 m): 05:19 UTC



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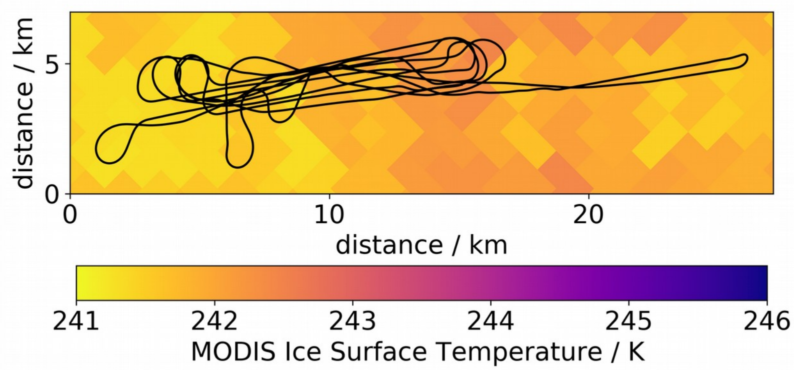

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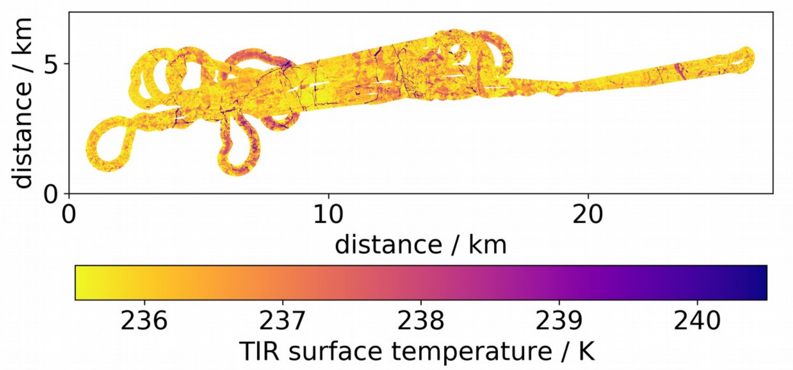
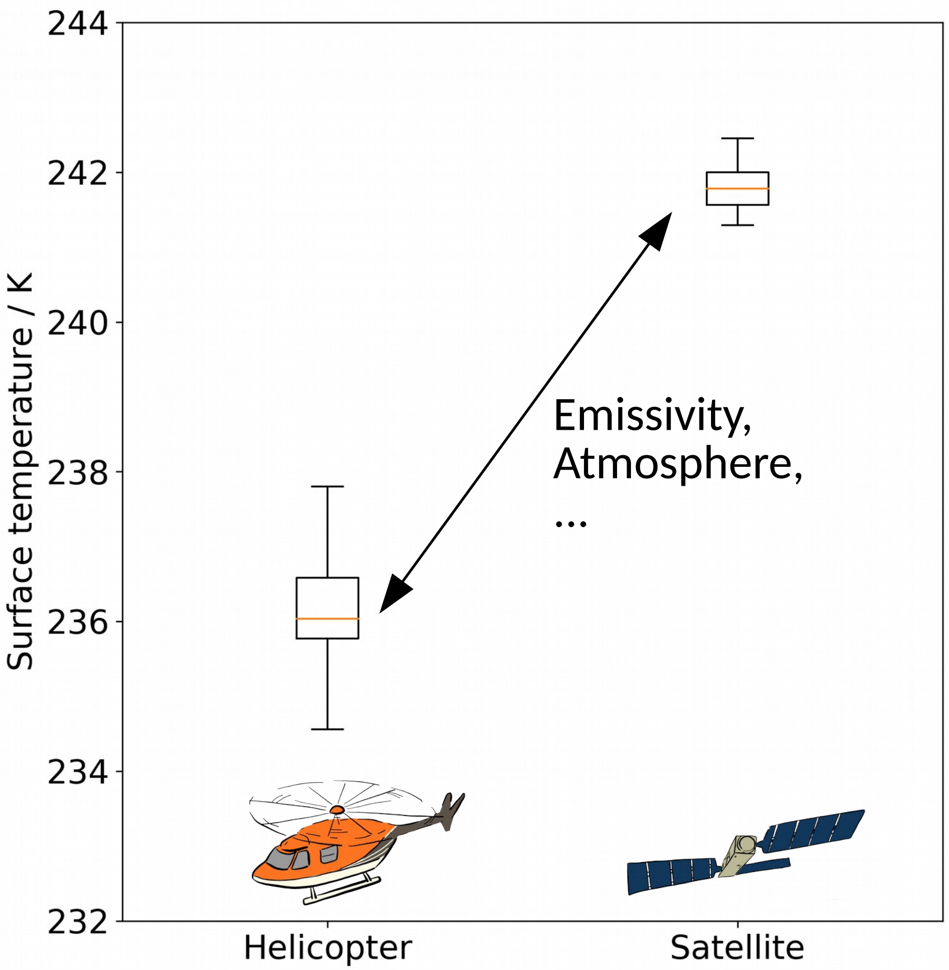
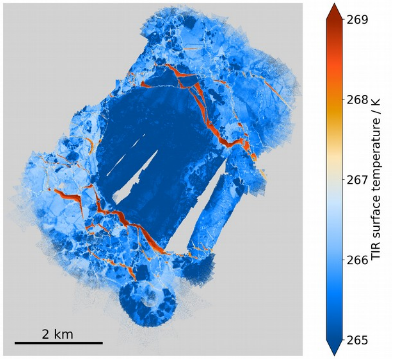




Conclusion

- Helicopter-borne data for an increased understanding of small scale process of Arctic sea ice in winter
  Thielke, L. et al (2022): Sea ice surface temperatures from helicopter-borne thermal infrared imaging during the MOSAiC expedition. Scientific Data, accepted.



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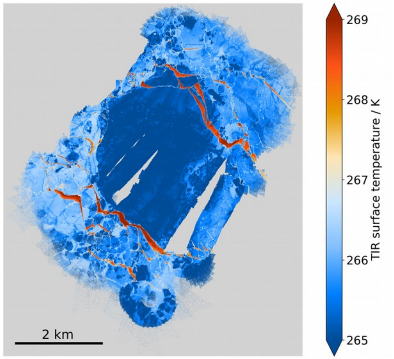

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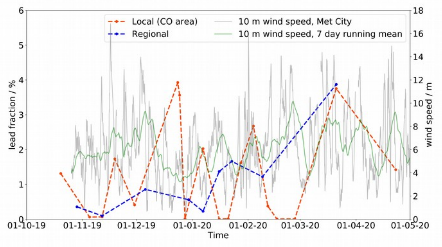

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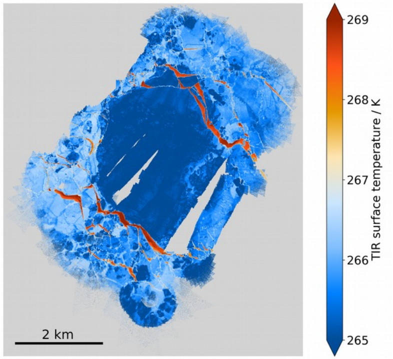

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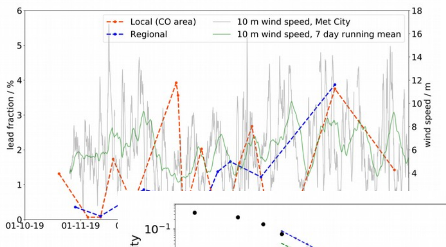
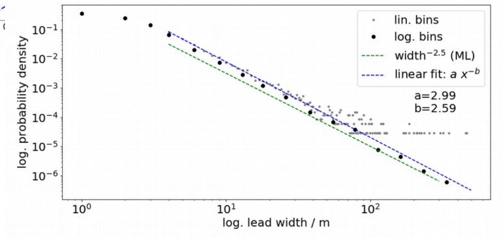


- Narrow leads dominate over wider leads



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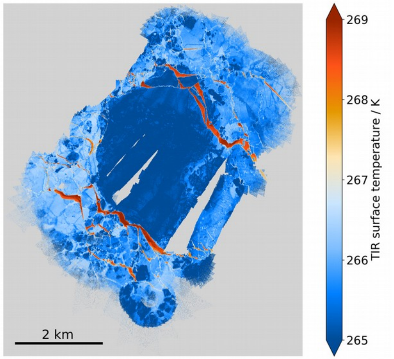

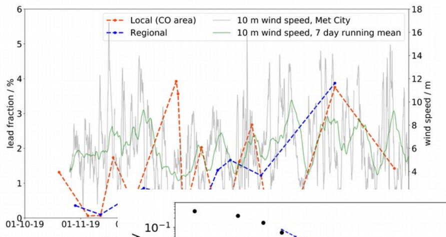

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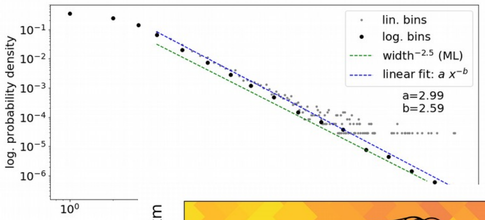

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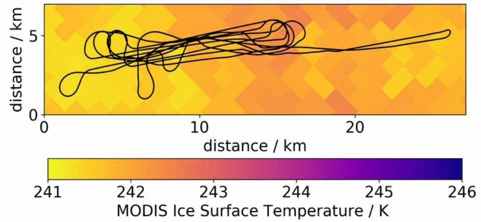

- Outlook: Satellite sub-footprint scale variability

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