Sea ice studies using drifting SIMBA buoys – collaborations with the CHINARE and other international Arctic expeditions

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[4] Nansen Environmental and Remote Sensing Centre
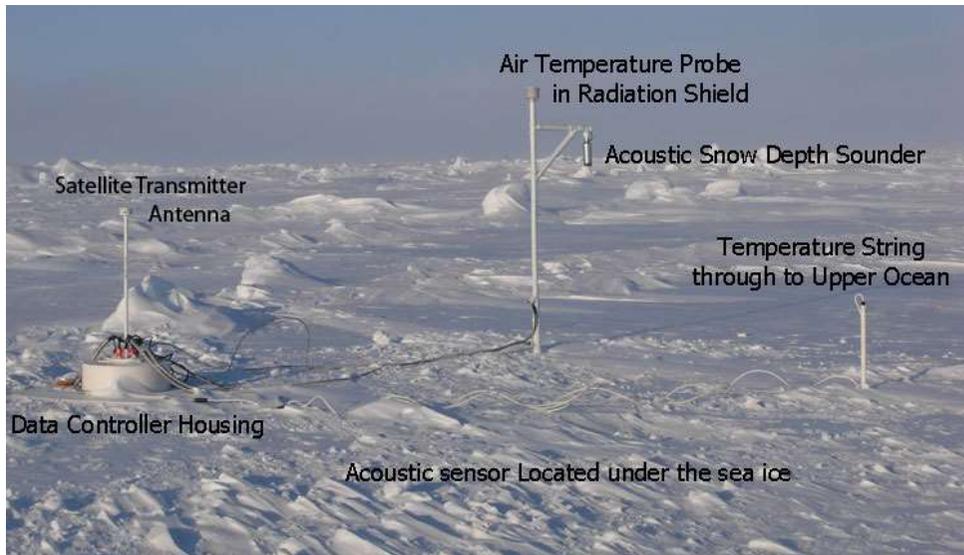[5] National Marine Environment forecasting Center
[6] Arctic Research Centre, Aarhus University, Denmark

R/V Xuelong I

SIMBA

SIMBA: This is thermistor string based ice mass balance buoy (IMB)

Air   < 0.4 m
Snow   < 0.8 m
Ice   < 3.0 m
Water   < 1.0 m

INTAROS

t0   t1   t2

Air

$\triangle T1 = T1 - T0$
$\triangle T2 = T2 - T0$

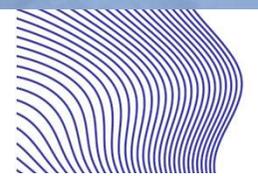Snow

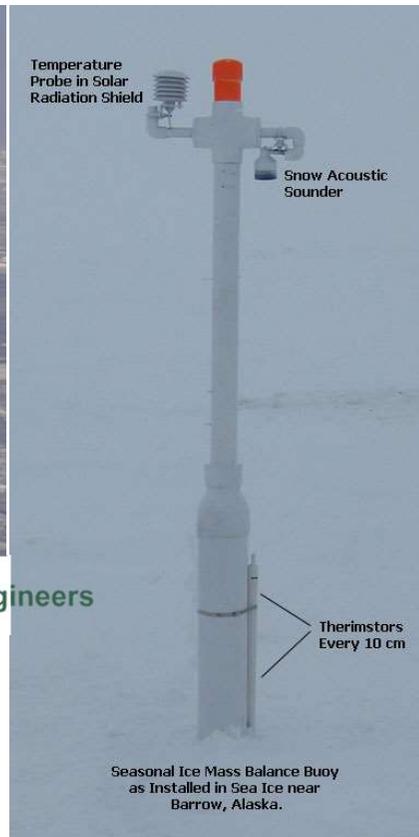Sea ice   T0   T1   T2

Ocean

Time(t)

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Temperature profile on Jday 266.3
Heating Temp
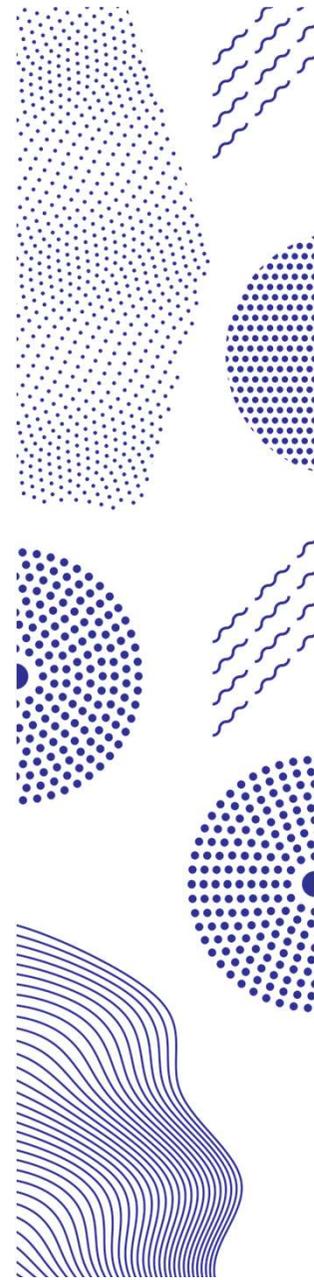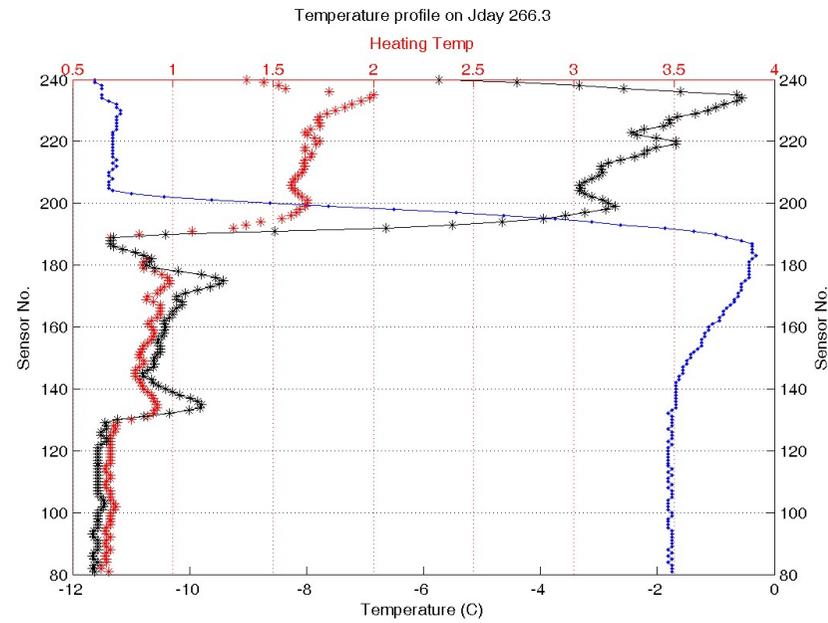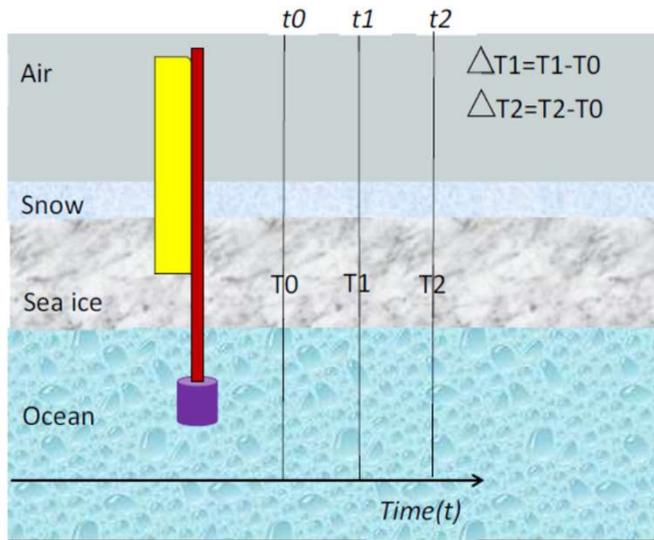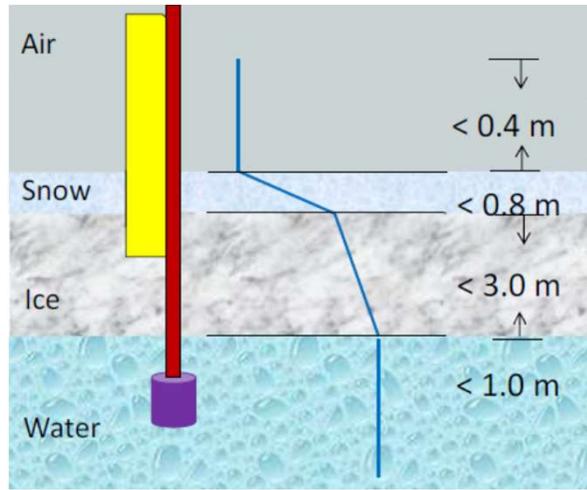
High-resolution Snow and Ice Mass Balance Array(SIMBA)

YoungSound, East Greenland

©CHINARE
Chinese National Arctic Research Expedition

©CAATEX2019
The Coordinated Arctic Acoustic Thermometry Experiment
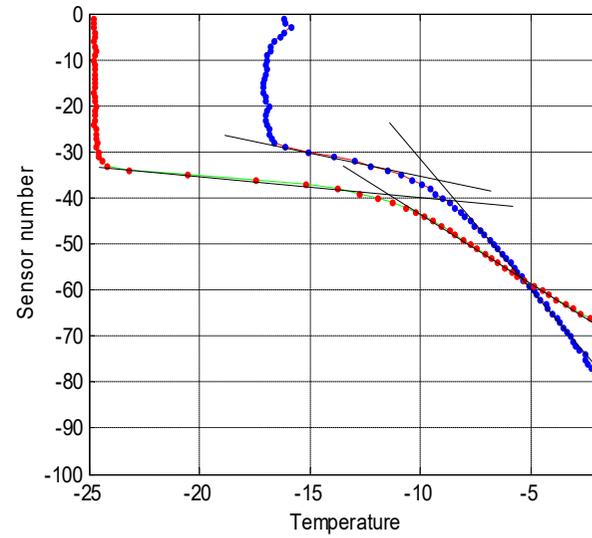
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©NABOS2018
Nansen and Amundsen Basins Observational System

© MOSAiC

Esther Horvath

SIMBA (33) deployed in the Arctic Ocean by the end of 2019

Table was checked on 22, April, 2020 when 17 SIMBA buoys in the table were still working

Another at least 8 SIMBAs have been deployed by partners between 2020 – 2022

- MOSAiC leg 5
- CHINARE2020/2021
- YoungSound

The data are available at
https://simba.srsl.com/fmi/
https://simba.srsl.com/pric/
https://simba.srsl.com/nmefc/
and will be released for open access after quality control

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| SIMBA name	IMEI	Starting position/date			Thickness (m)			Sensor Interface Position (SIP)				
		Lat	Lon	DD/MM/YY	Hi	Hs	Hf	Air/snow	Snow/ice	Sea level	Ice bottom	
NABOS2018												
FMI0404	300234064817090	80.44	161.93	16092018	1.82	0.004	0.25	20	20	32	111	■
FMI0502	300234065762510	80.76	163.18	14092018	2.39	0.0	0.29	32	32	47	152	∨
FMI0503	300234065765720	80.49	168.40	11092018	2.53	0.0	0.3	31	31	46	158	■
FMI0504R	300234065174770	79.63	167.97	11092018	2.62	0.0	0.8	23	23	63	154	■
FMI0505	300234065171770	80.72	159.83	15092018	2.11	0.003	0.47	21	21	44	126	■
CHINARE2018												
NMEFC0801	300234065179520	84.79	166.02	21082018	2.40	0.04	0.41	30	32	52	152	■
NMEFC0701	300234064876710	84.72	167.68	21082018	2.73	0.04	0.23	31	33	44	169	∨
PRIC0602	300234064979710	82.63	167.36	15082018	3.65	0.05	0.36	22	24	42	207	∨
PRIC0603	300234064593980	84.79	166.02	20082018	3.85	0.09	0.50	16	20	45	212	■
PRIC0604	300234064590990	84.58	162.17	23082018	1.45	0.05	0.14	25	27	34	100	■
PRIC0801	300234065173740	81.16	169.61	13082018	3.30	0.07	0.30	30	33	48	198	■
PRIC0802	300234065174780	84.08	166.99	18082018	1.34	0.04	0.09	24	26	30	93	∨
PRIC0803	300234065175770	82.03	168.19	14082018	2.15	0.11	0.30	31	36	51	144	∨
PRIC0804	300234065171760	84.73	167.68	21082018	1.85	0.08	0.2	20	24	34	116	■
PRIC0805	300234065179750	79.93	169.1	12082018	2.23	0.07	0.22	31	34	45	146	■
FMI0403	300234064918140	84.16	167.25	18082018	1.26	0.05	0.11	43	45	51	108	■
CAATEX cruise (KV-Svalbard-North Pole)												
FMI0507	300234065172770	87.99	55.63	2482019	1.81	0.07	0.25	44	47	59	138	∨
FMI17R	300234060795690	89.99	95.76	2182019	1.55	0.06	0.25	42	45	58	123	∨
MOSAiC2019												
FMI0406	300234064817930	84.89	133.22	07102019	0.35	0.05	0.03	37	41	42	59	■
FMI0508	300234065177750	84.87	135.80	07102019	0.81	0.14	0.01	29	36	36	76	■
FMI0509	300234065171790	85.05	137.84	07102019	1.57	0.1	0.09	18	23	27	101	∨
FMI0510	300234065170760	85.11	136.20	08102019	0.8	0.1	0.02	28	33	34	73	■
FMI0601	300234068708330	84.92	131.26	05102019	1.8	0.15	0.12	34	41	47	131	∨
FMI0602	300234068700320	84.99	134.48	11102019	0.75	0.05	0.03	31	33	34	80	∨
FMI0603	300234068705280	85.12	136.15	09102019	0.45	0.06	0.02	32	35	36	77	∨
FMI0604	300234068706760	84.74	135.84	11102019	0.7	0.1	0.03	31	36	37	71	■
FMI0605	300234068700290	85.05	139.03	09102019	0.97	0.13	0.05	26	32	34	80	∨
PRIC0901	300234068706290	85.65	125.47	29102019	0.82	0.16	0.04	40	48	50	99	∨
PRIC0902	300234068709320	84.99	134.99	07102019	1.06	0.1	0.06	23	28	31	81	∨
PRIC0903	300234068701300	85.13	133.22	10102019	1.74	0.14	0.24	28	35	47	122	∨
PRIC0904	300234068705730	84.99	135.03	07102019	1.31	0.15	0.07	26	33	36	101	∨
PRIC0905	300234068706330	85.65	125.51	29102019	0.4	0.1	0.02	41	46	47	66	∨
PRIC0906	300234068704730	85.01	132.78	05102019	1.44	0.13	0.08	22	28	32	100	∨

x: terminated ∨: still working
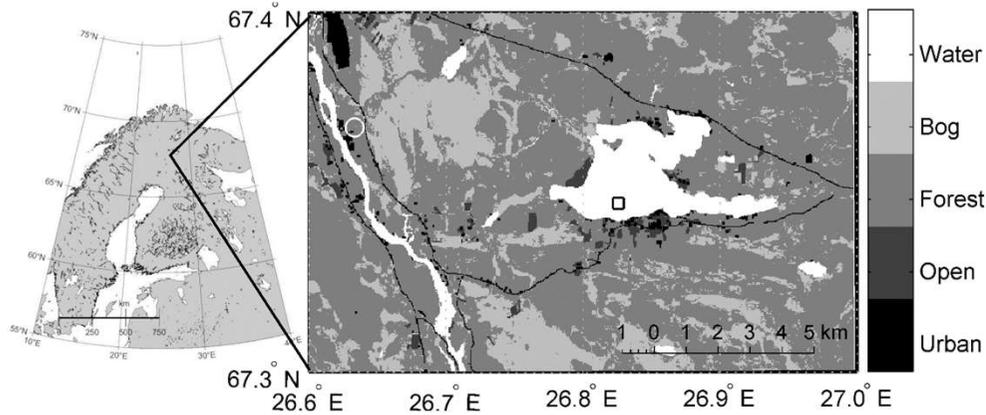
Liao, Z., Cheng, B., Zhao, J., Vihma, T., Jackson, K., Yang, Q., Yang, Y., Zhang, L., Li, Z. Qiu, Y. and Cheng, X. 2019 "Snow depth and ice thickness derived from SIMBA ice mass balance buoy data using an automated algorithm" International Journal of Digital Earth, 12:8, 962-979, DOI: 10.1080/17538947.2018.1545877

Cheng, Y., Cheng, B., Zheng, F., Vihma, T., Kontu, A., Yang, Q. and Liao, Z. 2020. Air/snow, snow/ice and ice/water interfaces detection from high-resolution vertical temperature profiles measured by ice mass-balance buoys on an Arctic lake. Annals of Glaciology 1–11. https://doi.org/10.1017/ aog.2020.51
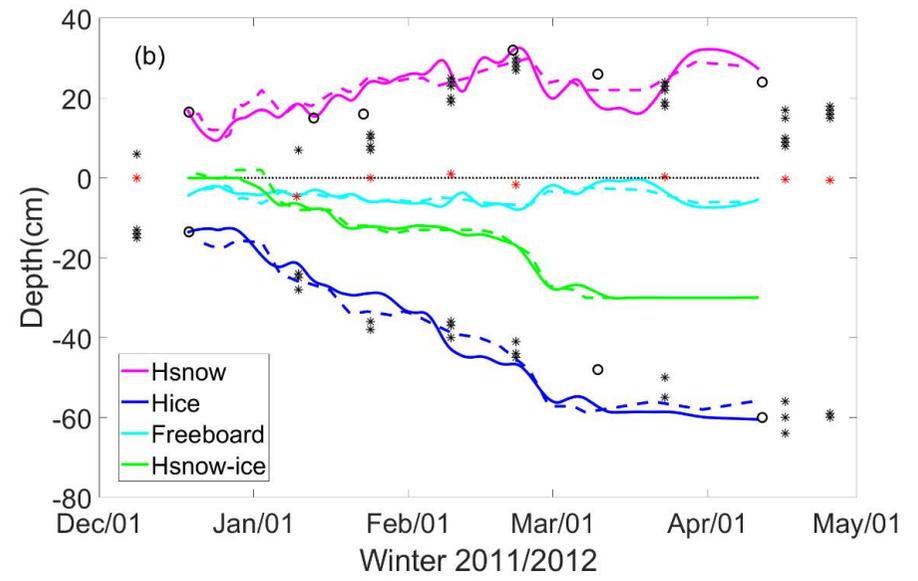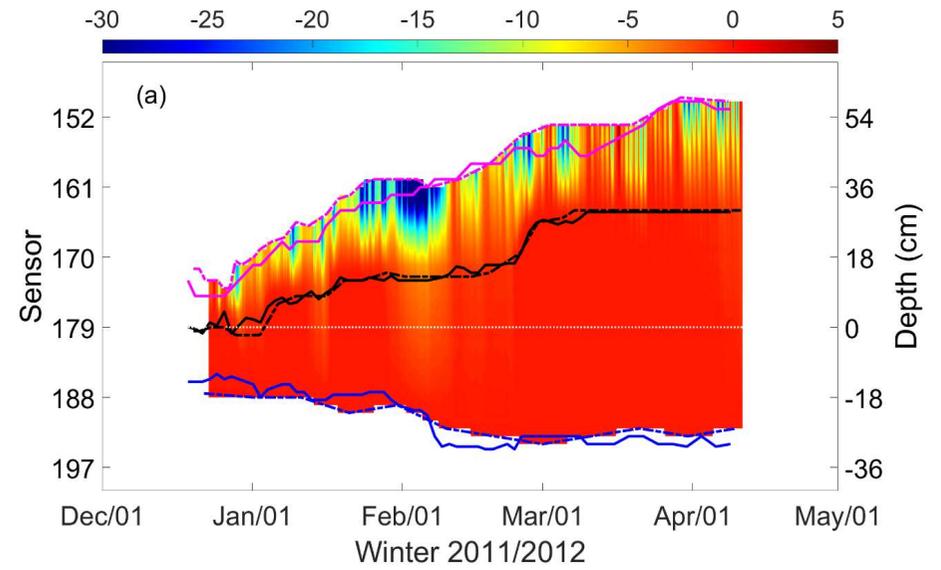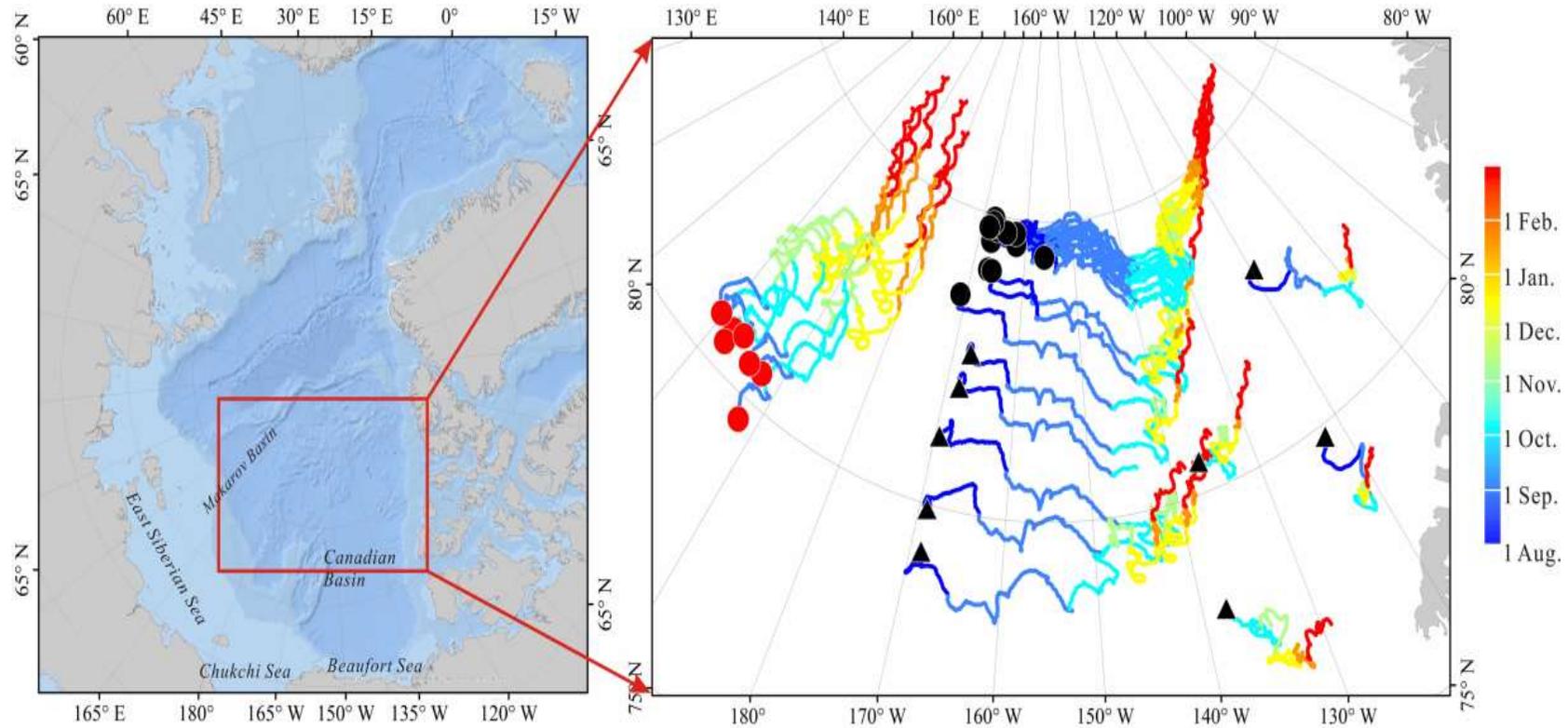
Lei, R., Hoppmann, M., Cheng, B., Zuo, G., Gui, D., Cai, Q., Belter, H. J., and Yang, W. 2021 Seasonal changes in sea ice kinematics and deformation in the Pacific Sector of the Arctic Ocean in 2018/19, The Cryosphere, 15, 1321–1341, https://doi.org/10.5194/tc-15-1321-2021
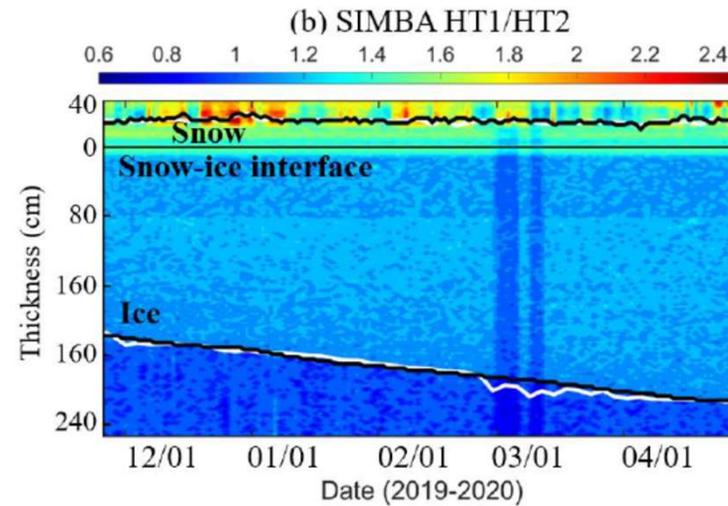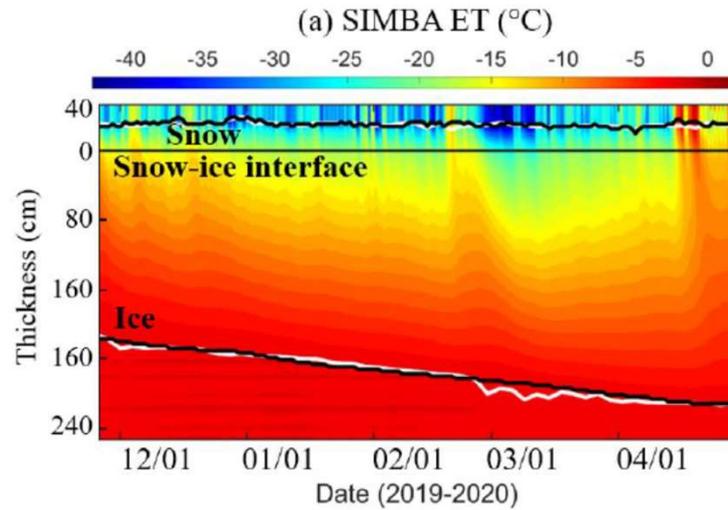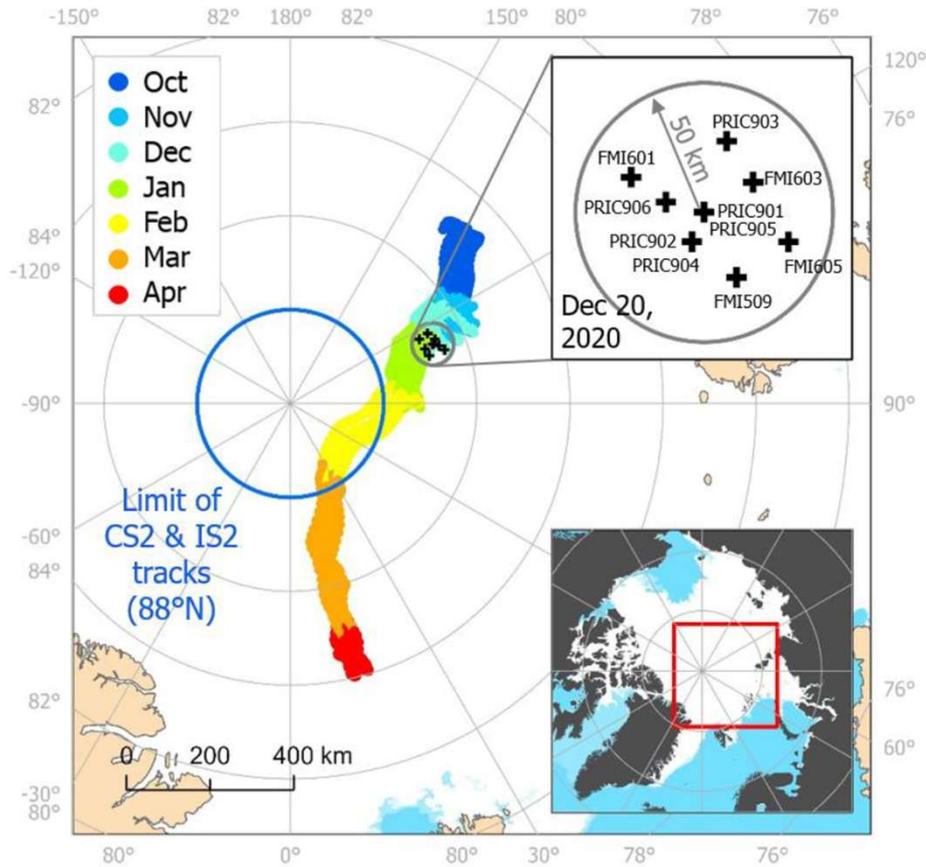
Koo, Y., Lei, R., Cheng, Y., Cheng, B., Xie, H., Hoppmann, M., Kurtz, N.T., Ackley, S. F and Mestas-Nuñez, A.M 2021. Estimation of Thermodynamic and Dynamic Contributions to Sea Ice Growth in the Central Arctic Using ICESat-2 and MOSAiC SIMBA Buoy Data. Remote Sensing of Environment, Vol. 267, https://doi.org/10.1016/j.rse.2021.112730.
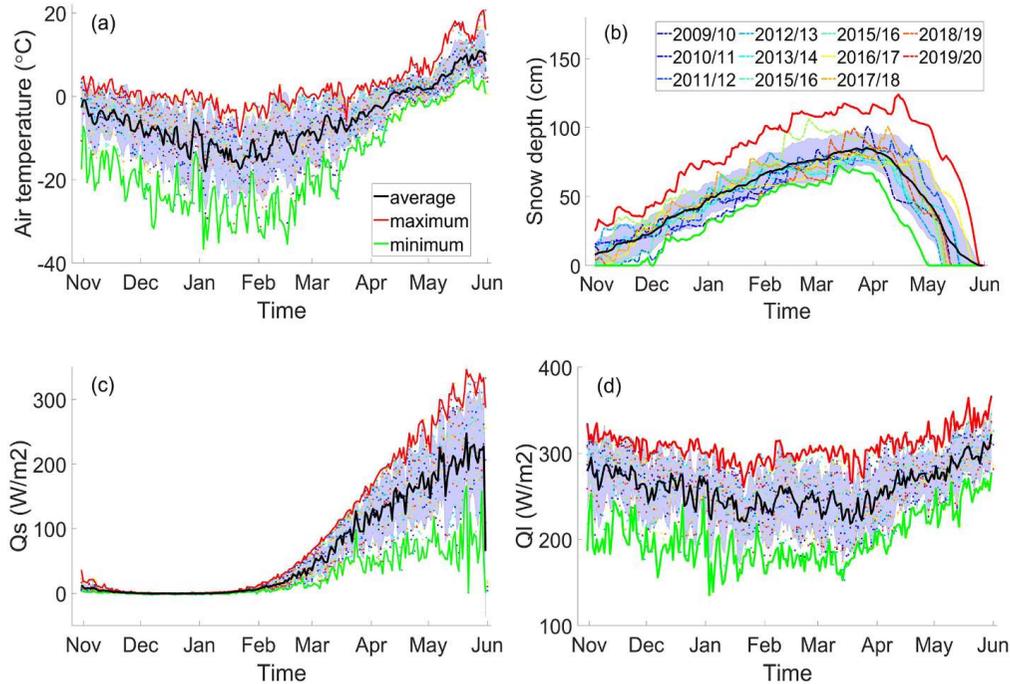
Seasonal daily mean: air temperature, snow depth, downward shortwave (c), and longwave (d) radiative fluxes for each ice season between 1 November and 31 May. The solid lines represent decadal daily maximum (red), minimum(green) and average (black) values. The shadow raea represents the standard deviation (STD). For snow depth, daily mean values rae given as thin color lines.

Cheng, et a., 2021. Inter-annual variation in lake ice composition in the European Arctic: observations based on high-resolution thermistor strings, Earth Syst. Sci. Data, 13, 3967–3978, https://doi.org/10.5194/essd-13-3967-2021
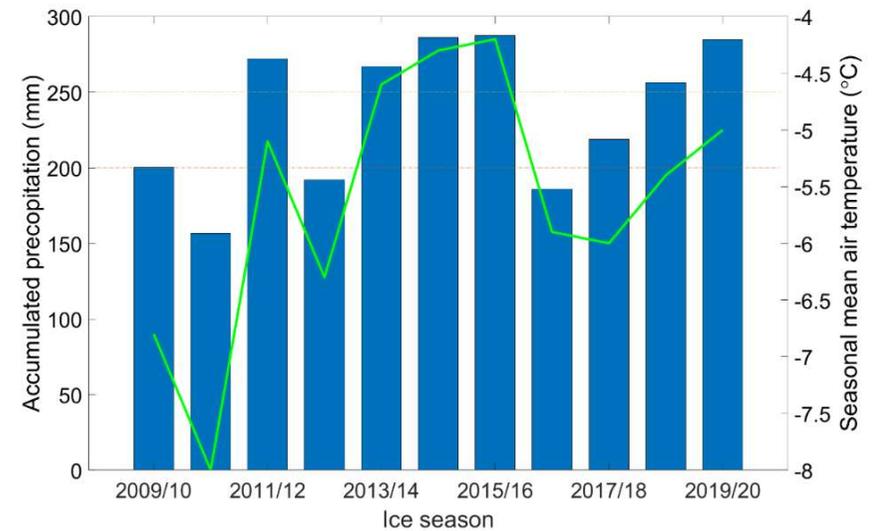
The accumulated total precipitation and mean air temperature between 1 November and 31 May.

Temperature rise -> thinner ice thickness;
shortened ice season;
Is this really the case?

Temperature rise

?   ?

More snowfall   ?   Thinner ice

?   ?

Shotter ice season

9
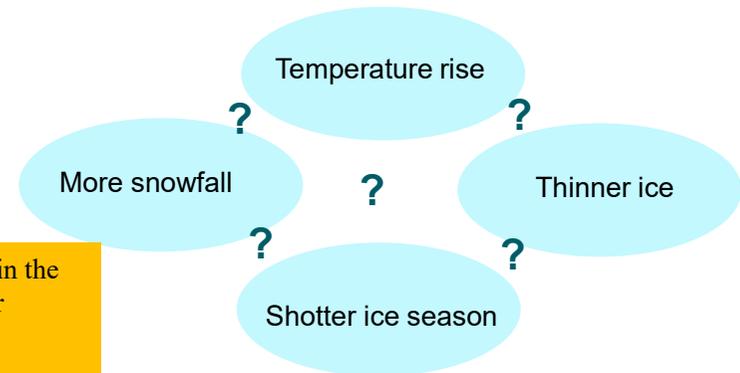
Lei et al., 2022, Seasonality and timing of sea ice mass balance and heat fluxes in the Arctic Transpolar Drift during 2019/20, *submitted to Elementa*
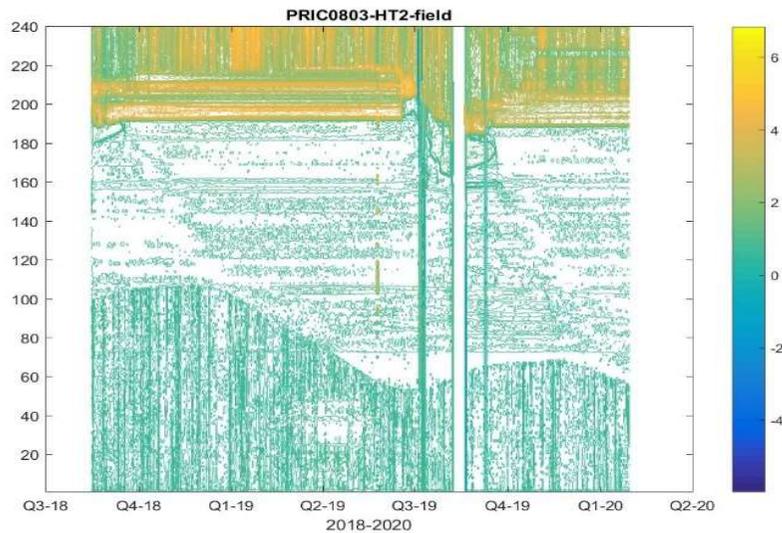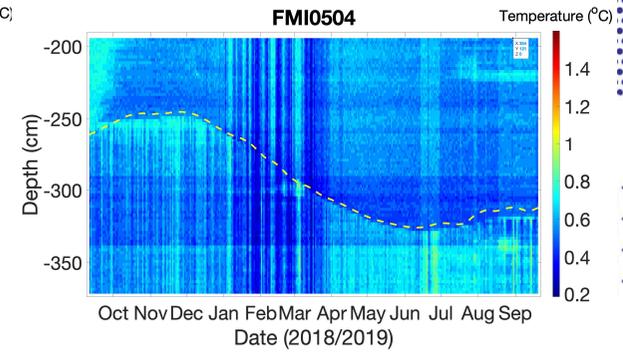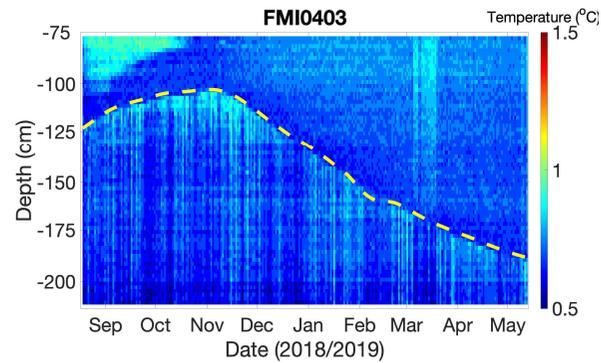
Freshing and warming of upper ocean

Supercooling: Convection due to desalination

Amundsen Basin

Nansen Basin

Yermak Plateau

Fram strait
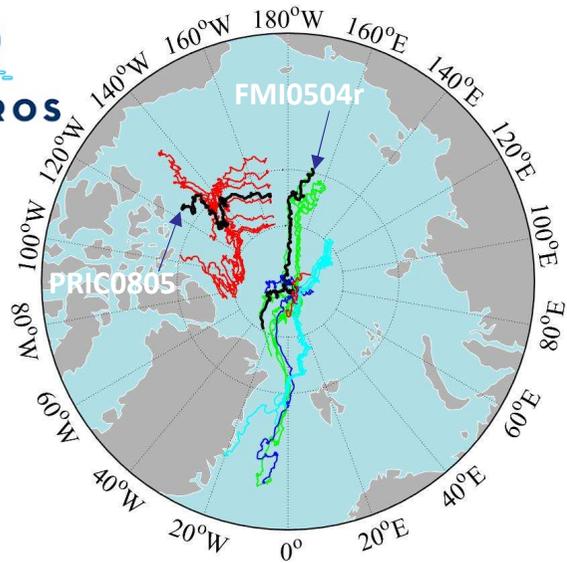
Gakkel Ridge

INTAROS

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Liao et al., 2022. Ice-ocean interface detection from SIMBA HT data applying neural networks (NEN), wavelet analyses (WAA) and Kalman filter (KAF); under preparation.
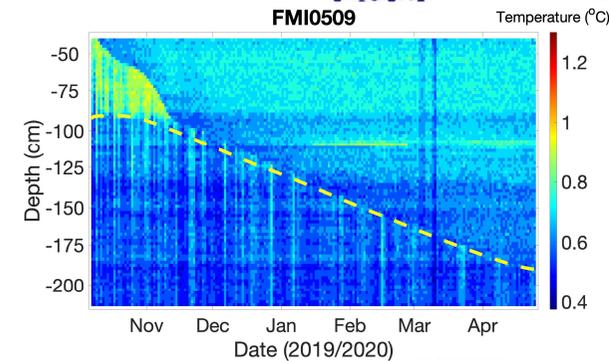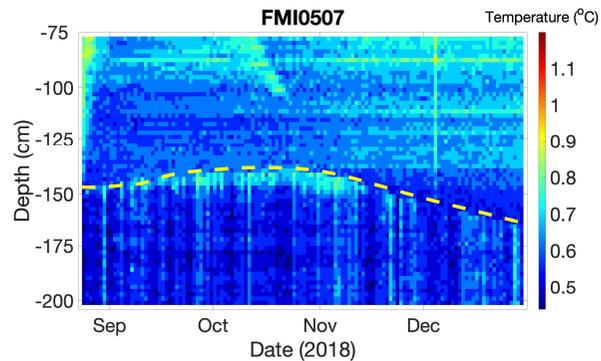
Ongoing modelling work:
SIMBA drift pattern in the Arctic Ocean. Initial ice thickness were different resulting faster ice growth for PRIC0805. The bottom ice growth patterns for both SIMBAs are similar in winter. More melting was seen along PRIC0805 drift trajectory in the south. HIGHTSI model simulations along two SIMBA drift trajectories(black) were simulated. Weather forcing were ECWMF reanalyses.

Modelled snow death and ice thickness for FMI0504r

Modelled snow death and ice thickness for PRIC0805
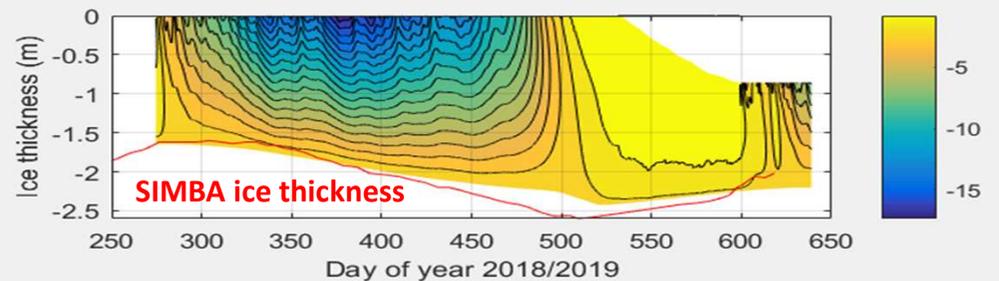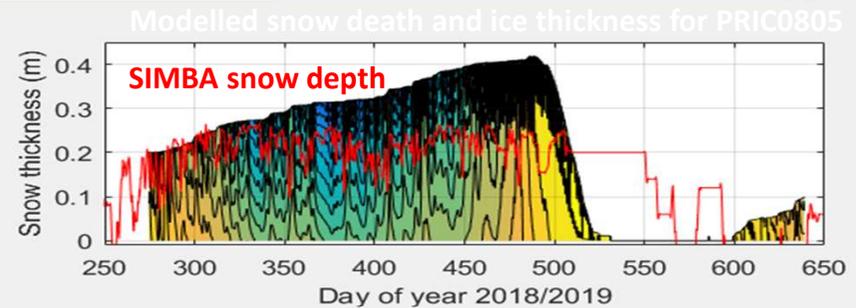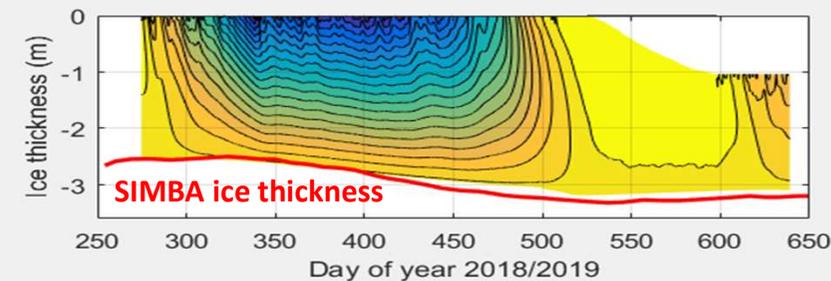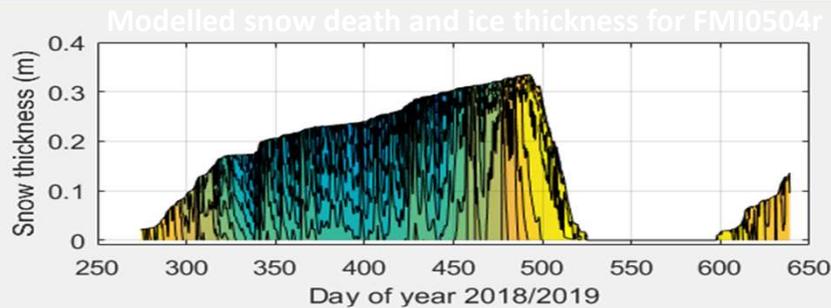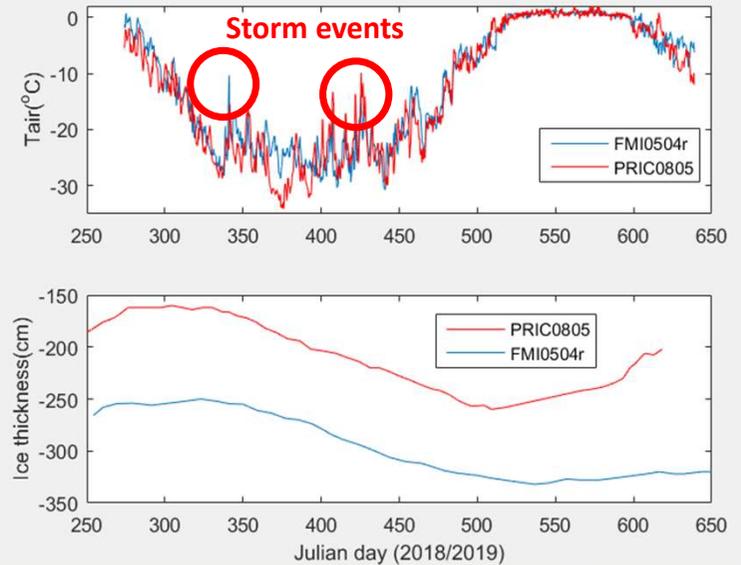
FMI SIMBA snow and ice mass balance buoy deployment in 2021 in collaborations with NERSC, PRIC and Aarhus University

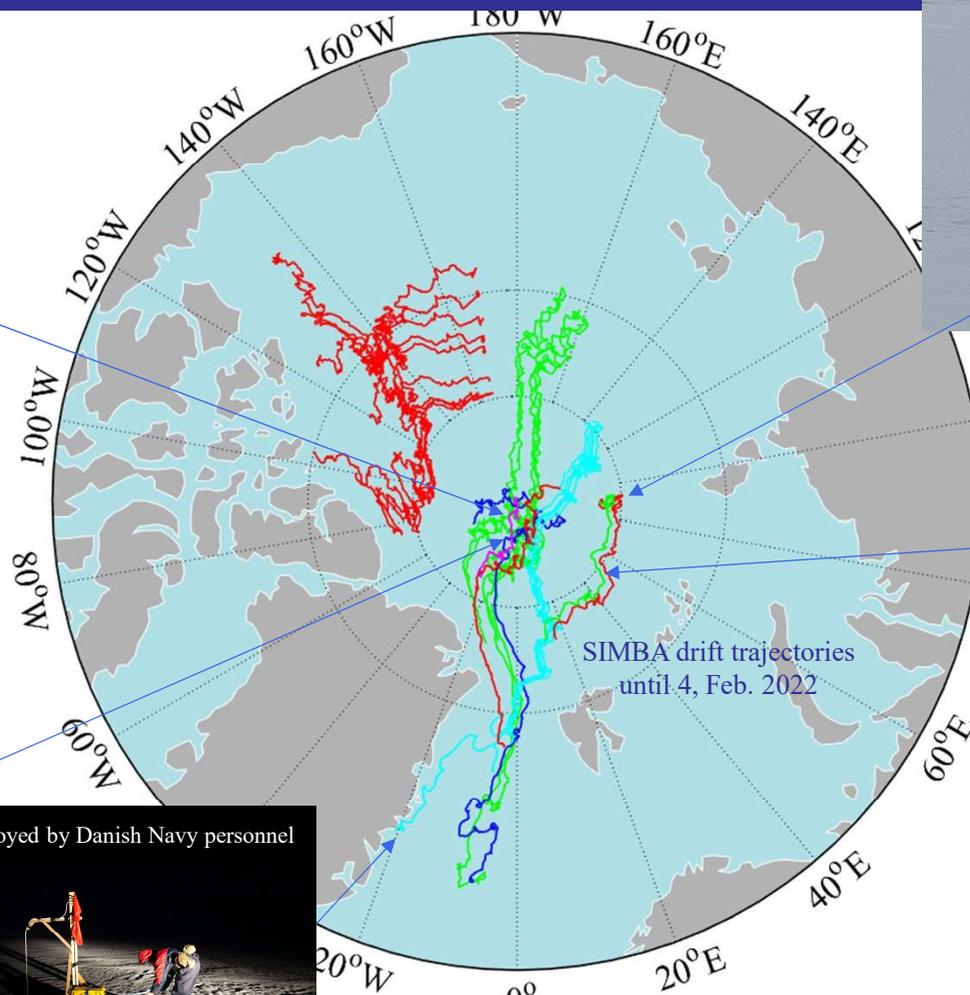**Chinese National Arctic Research Expedition (CHINARE2021) Ruibo Lei, PRIC**

SIMBA deployment during – Le Commandant Charcot test cruise Espen Storheim, NERSC
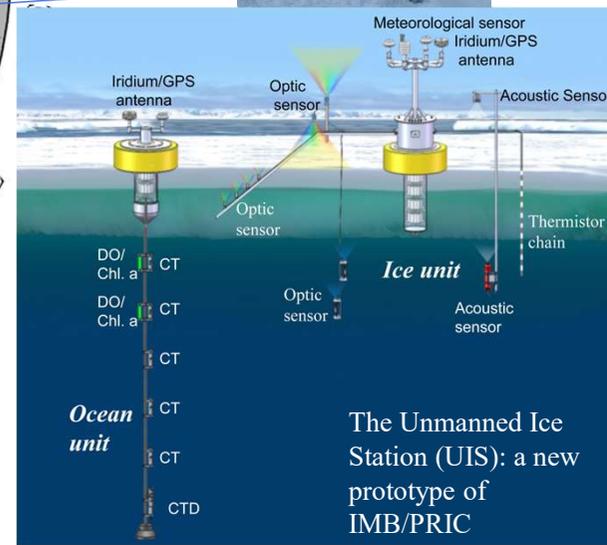
SIMBA drift trajectories until 4, Feb. 2022

SIMBA deployed by Danish Navy personnel

Young Sound deployment, in collaboration with Aarhus University

The Unmanned Ice Station (UIS): a new prototype of IMB/PRIC

Summary

SIMBA: Thermistor string based IMB, a good a feasible component of the INTAROS.
Parameters: Temperature regimes of near surface air, snow, sea ice and ocean; Snow depth and ice thickness; ice drift trajectories (GPS).

SIMBA data processing: algorithm development, mathematics.
SIMBA data analyses: sea ice physics, air-snow-sea ice-ocean interactions; modelling.

Data:
https://simba.srsl.com/fmi/   (raw data)
https://simba.srsl.com/pric/   (raw data)
https://simba.srsl.com/nmefc/ (raw data)
https://catalog-intaros.nersc.no (ongoing)
PANGAEA for MOSAiC SIMBA data (Lei et al., 2022) (done)

Scientific papers: data analyses; modelling studies

SIMBA deployment in the future: in close collaboration with CHINARE, NABOS and other international field programs.

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