Snow and ice observations/modeling in the Arctic Ocean and the Arctic lake

Bin Cheng[1], Yubing Cheng[2], Tuomas Naakka[1], Timo Vihma[1] and Mikael Kristian Sejr[3]

[1]Finnish Meteorological Institute, Finland

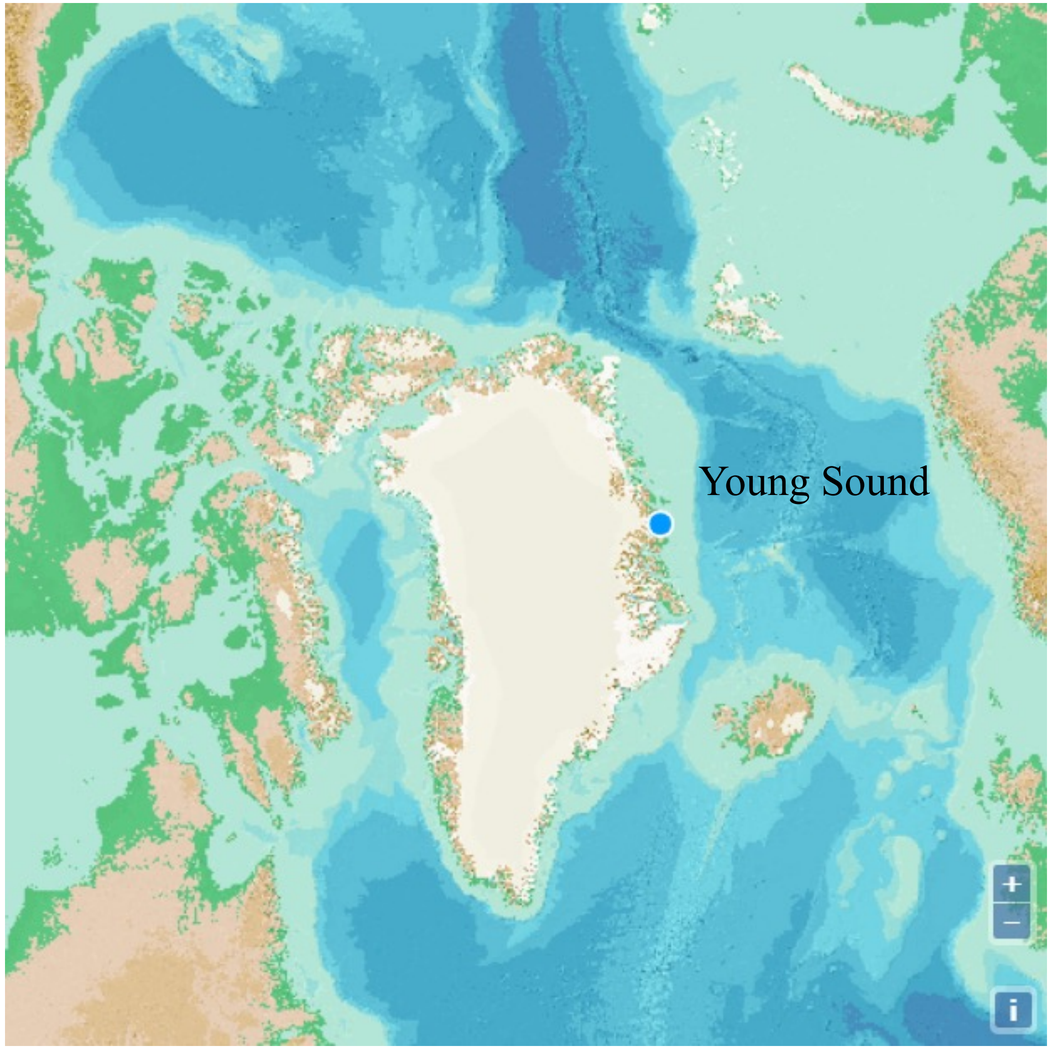
[2]Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China

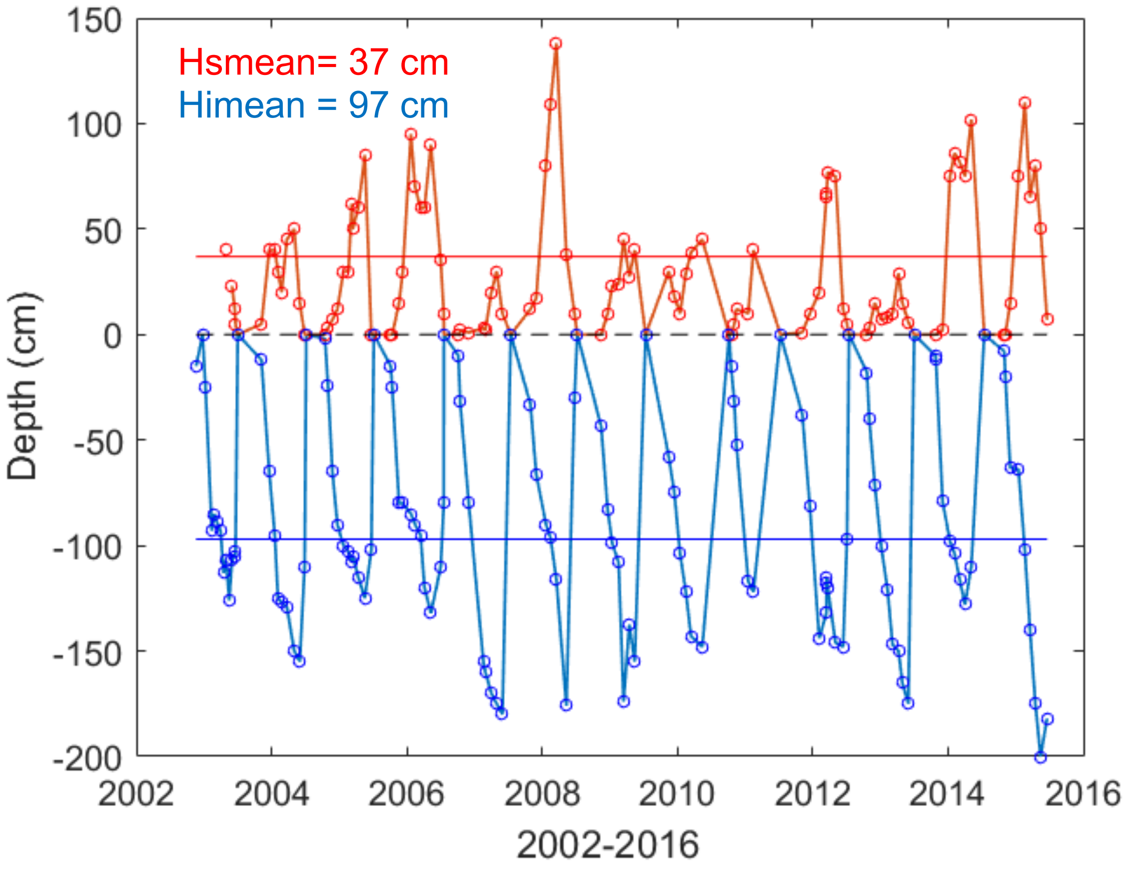
[3]Arctic Research Centre, Aarhus University, Denmark

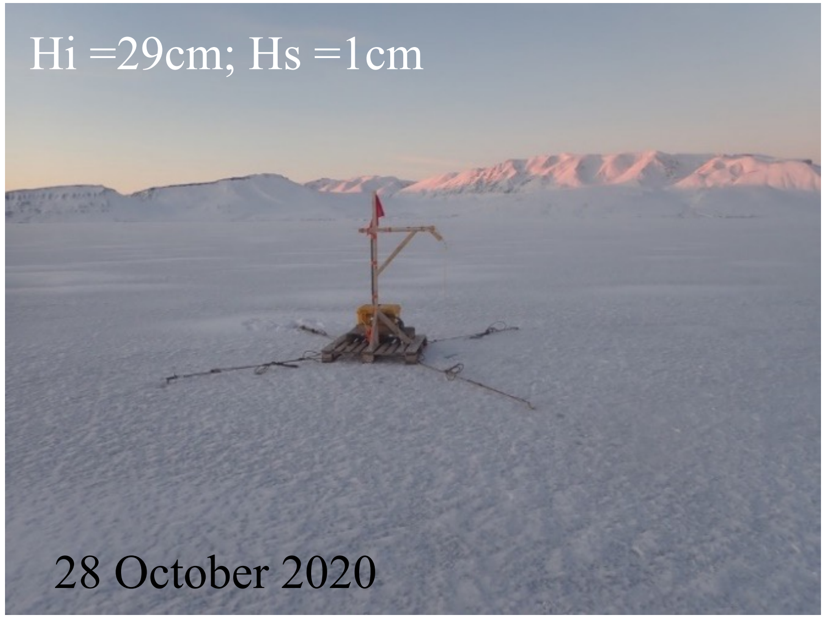
Objectives

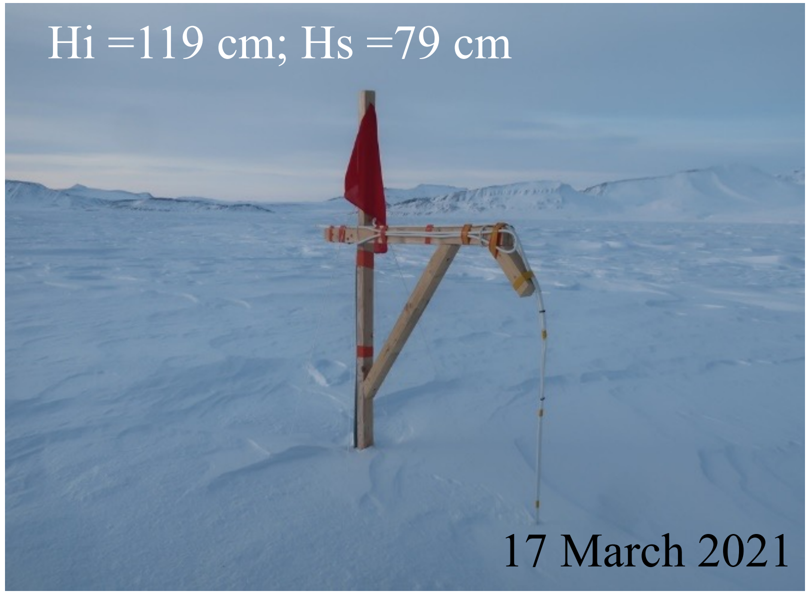
- To better understand snow and ice interactions
- Factors responsible for the extremes of snow and ice interactions
- Snow and ice mass balance

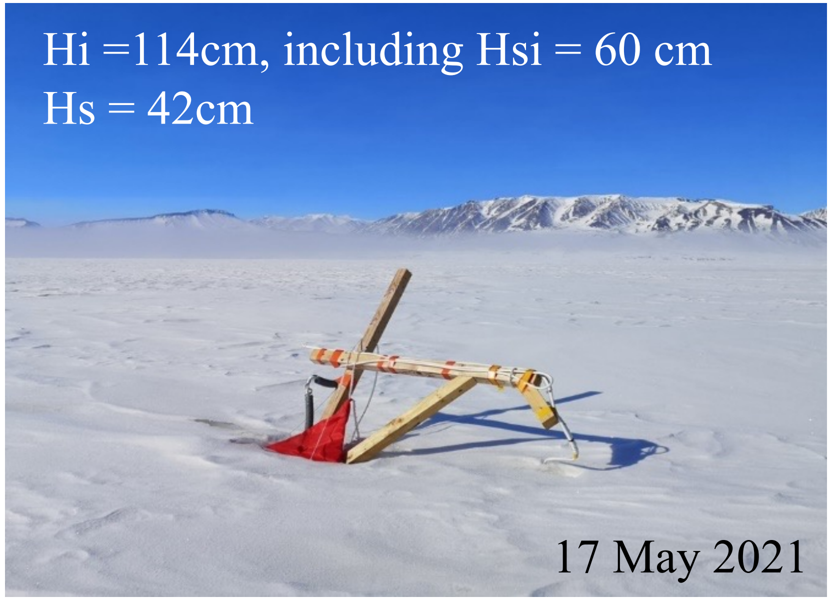
We use sustainable monitoring programs to understand snow and ice interactions.
We use a numerical model to simulate the snow and ice interaction processes.



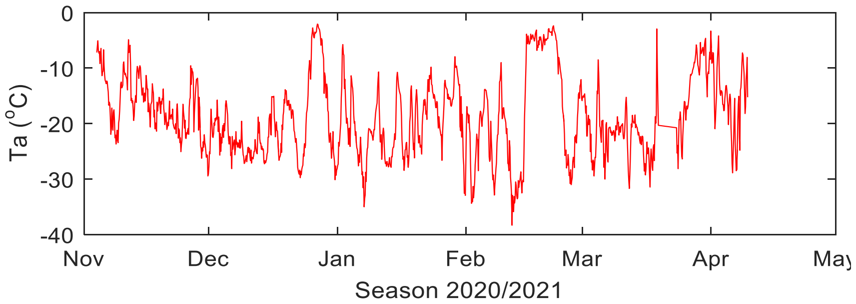


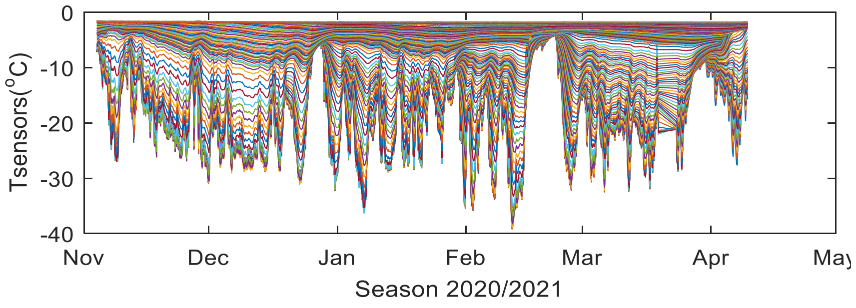


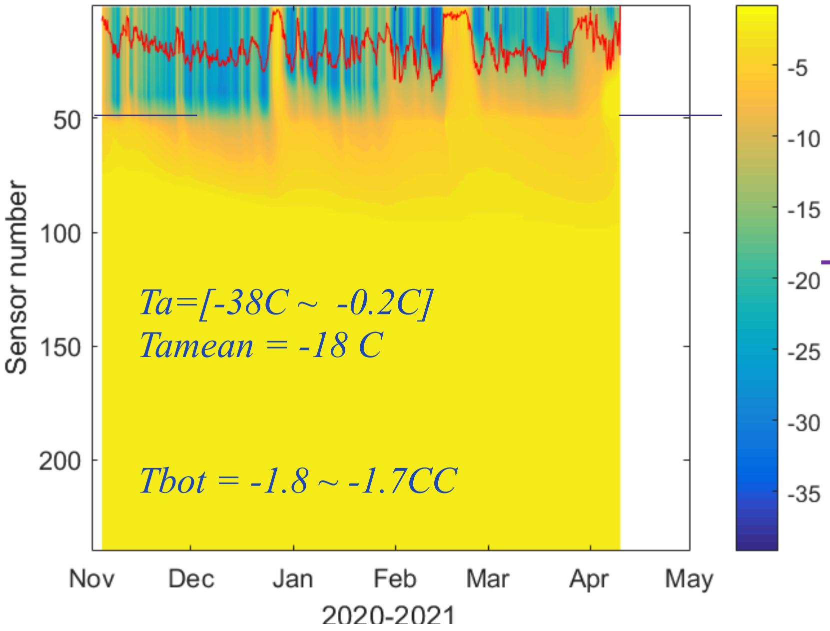


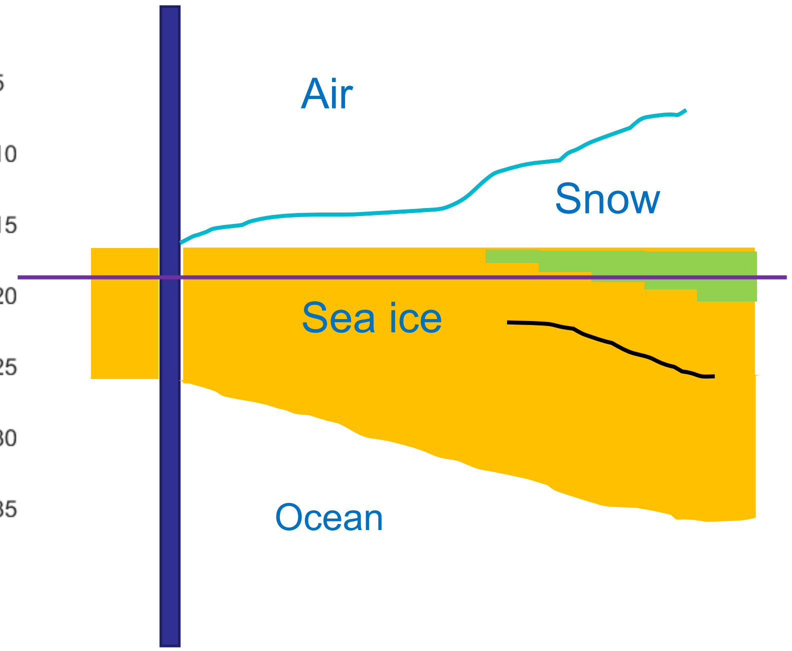


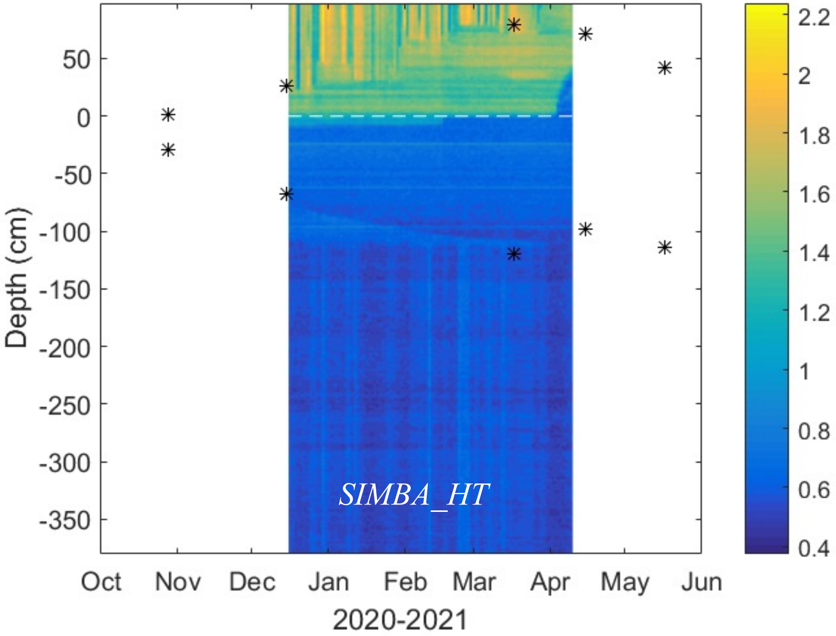
Extraordinary snow accumulation during winter 2020/2021

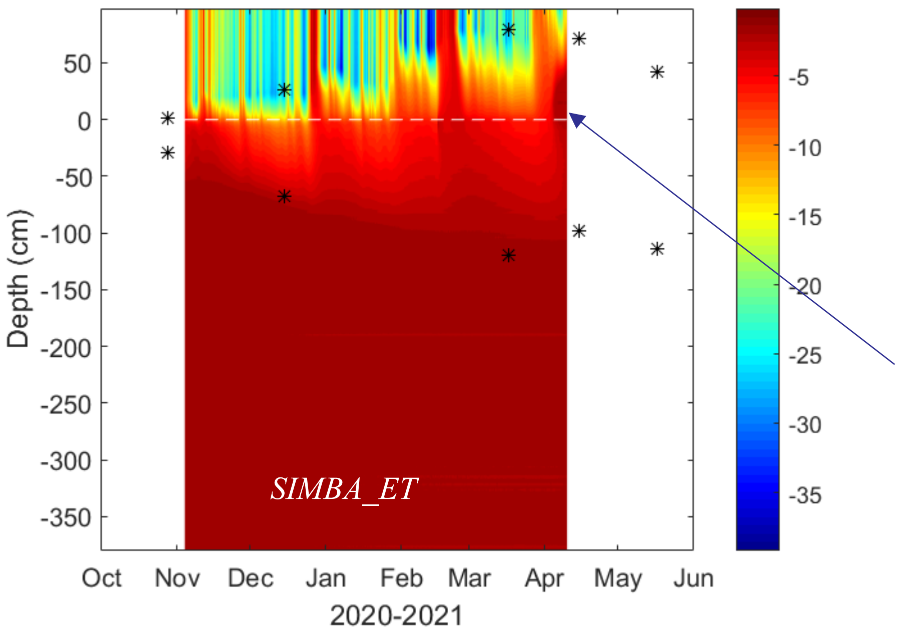












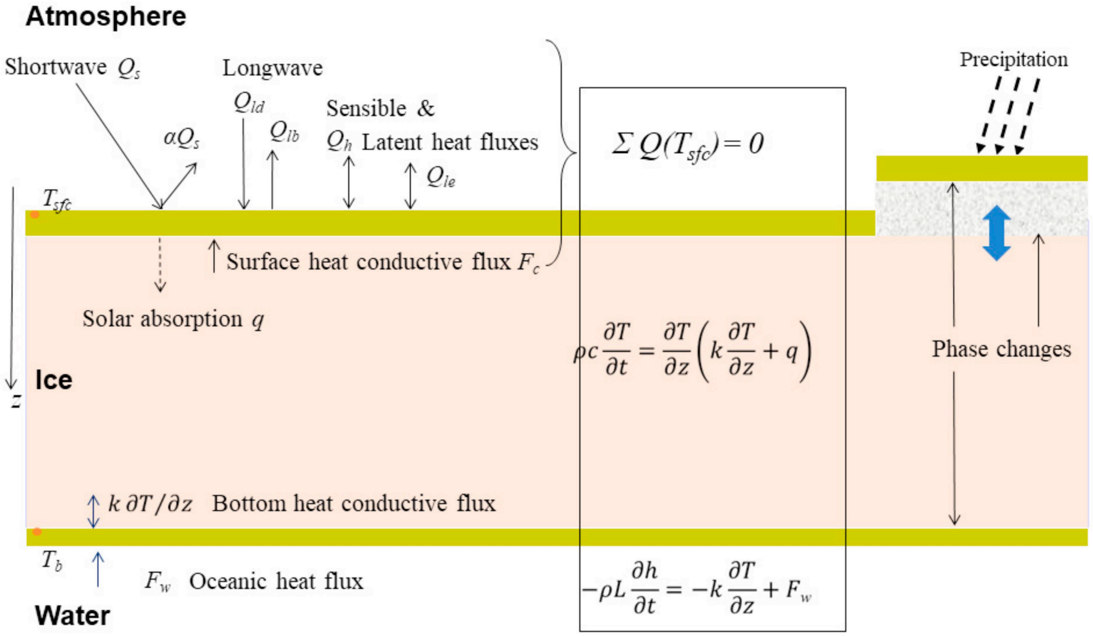
2020/2021 season

Seasonal snow depth = 79 cm

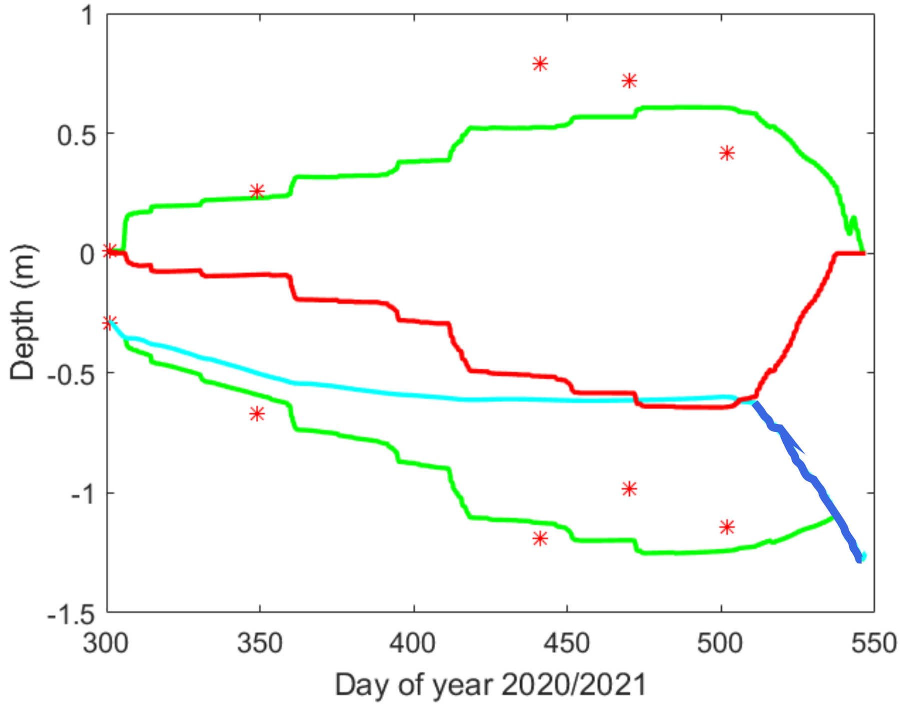
Seasonal ice thickness = 120 cm

Cold ice can resist the pressure of the overload snow before massive flooding when holes or ice cracks appear

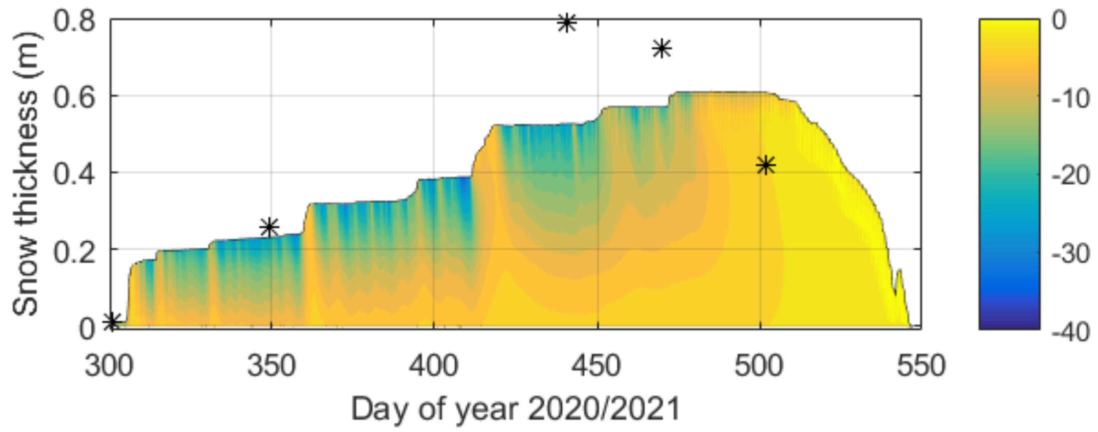
High resolution thermodynamic snow and ice model (HIGHTSI)

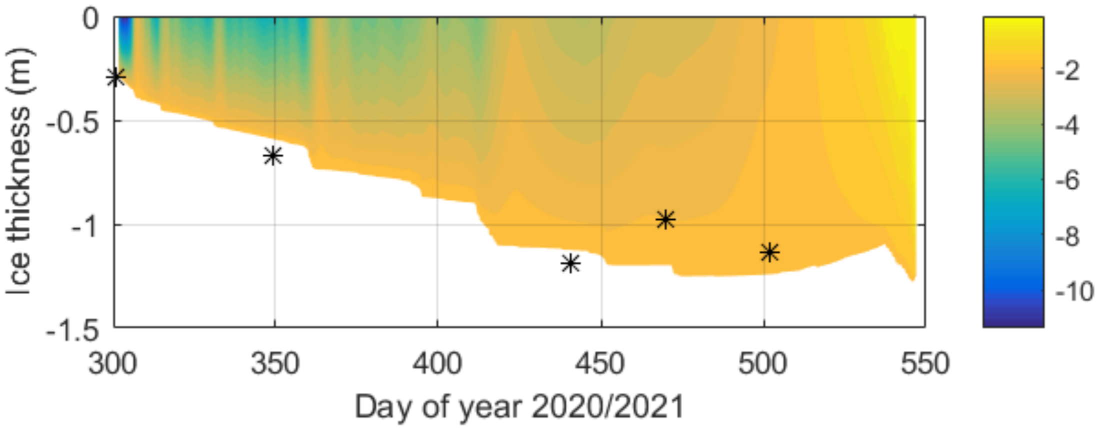


[Copernicus Arctic Regional Reanalysis (CARRA)]() forcing
Va, Ta, Rh, Cn, Total Precipitation, Qs, Ql

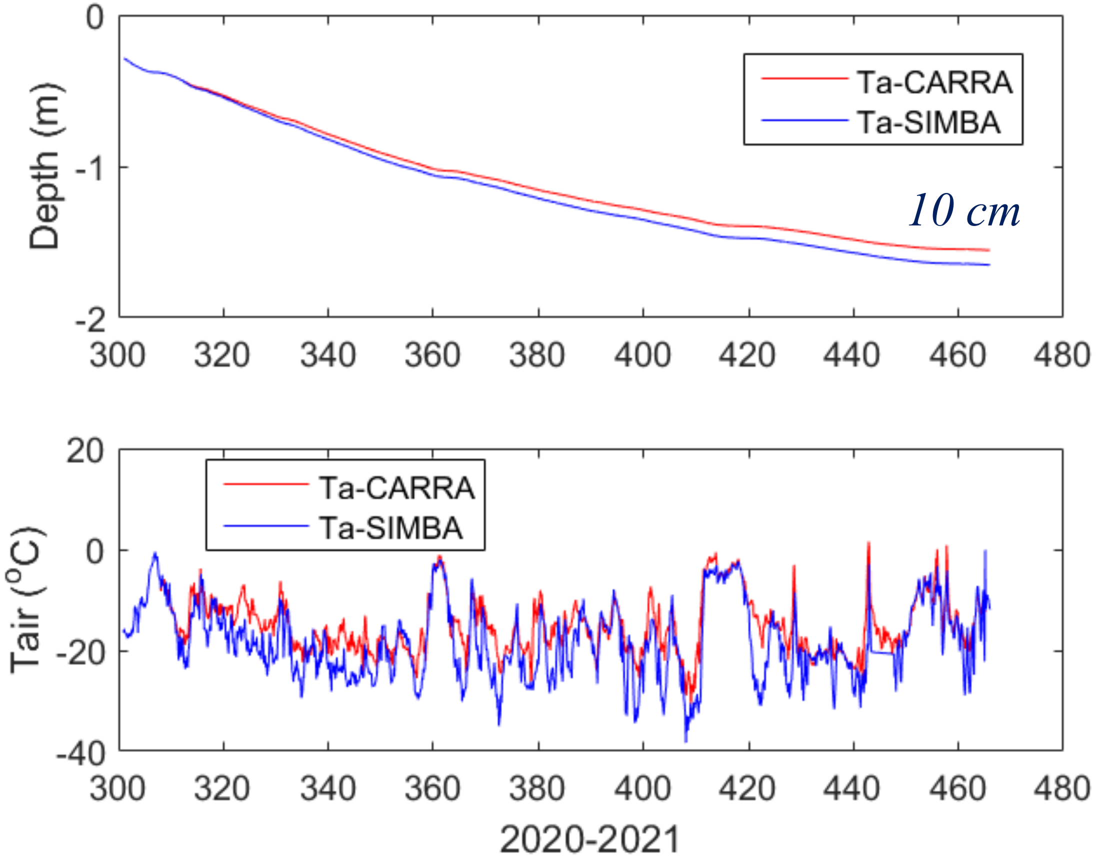


Snow
Snow-ice
Superimposed ice
Freezing/melting at ice bottom
Surface melting
Total integrated ice thickness

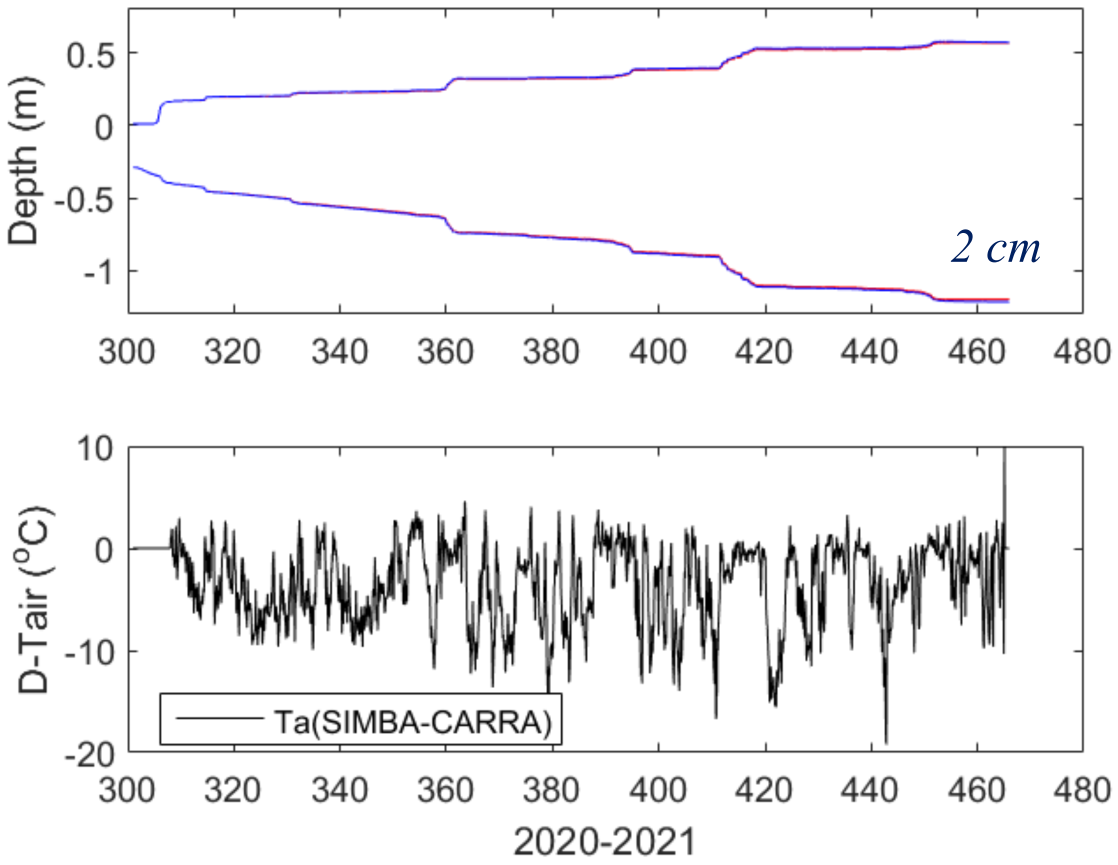




Without snow

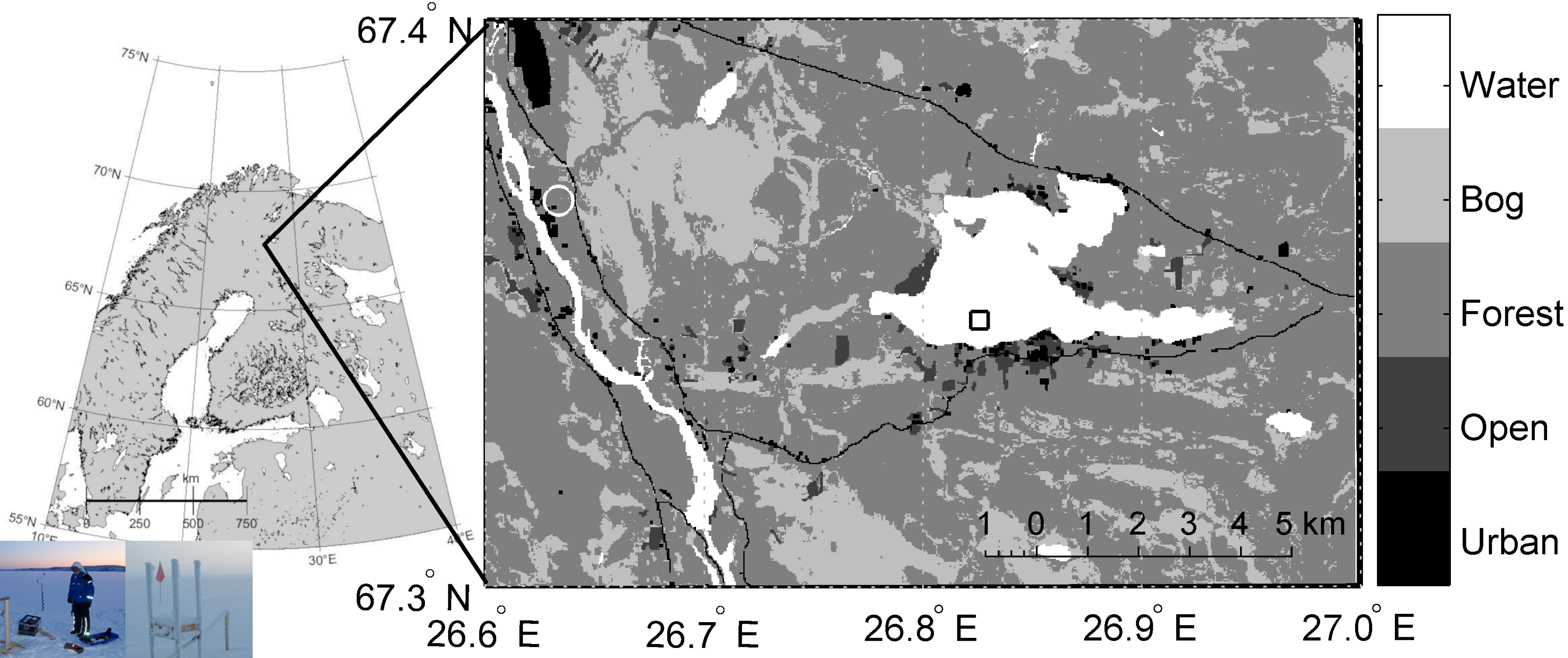


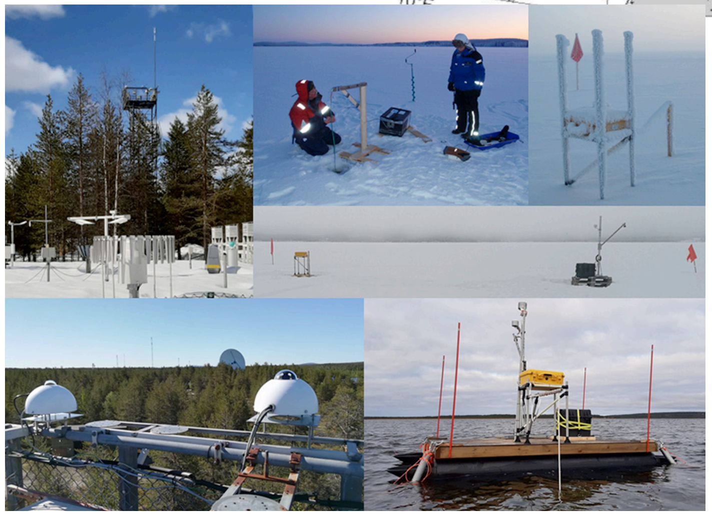
With snow



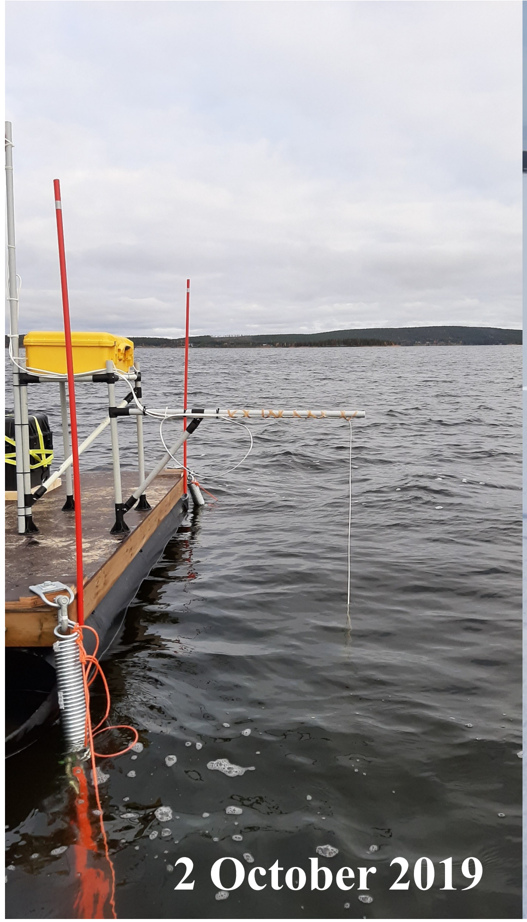
Impact of the atmosphere: Ta, Precipitation

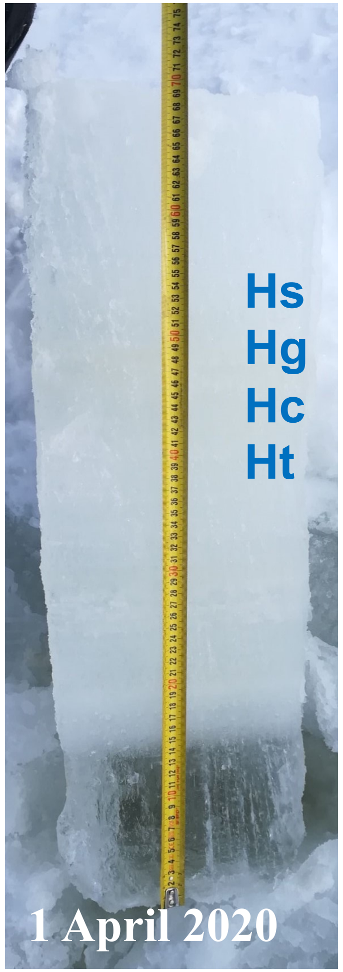
Impact of the ocean: Fw (Δ2W/m2) → 6 -7cm ice thickness

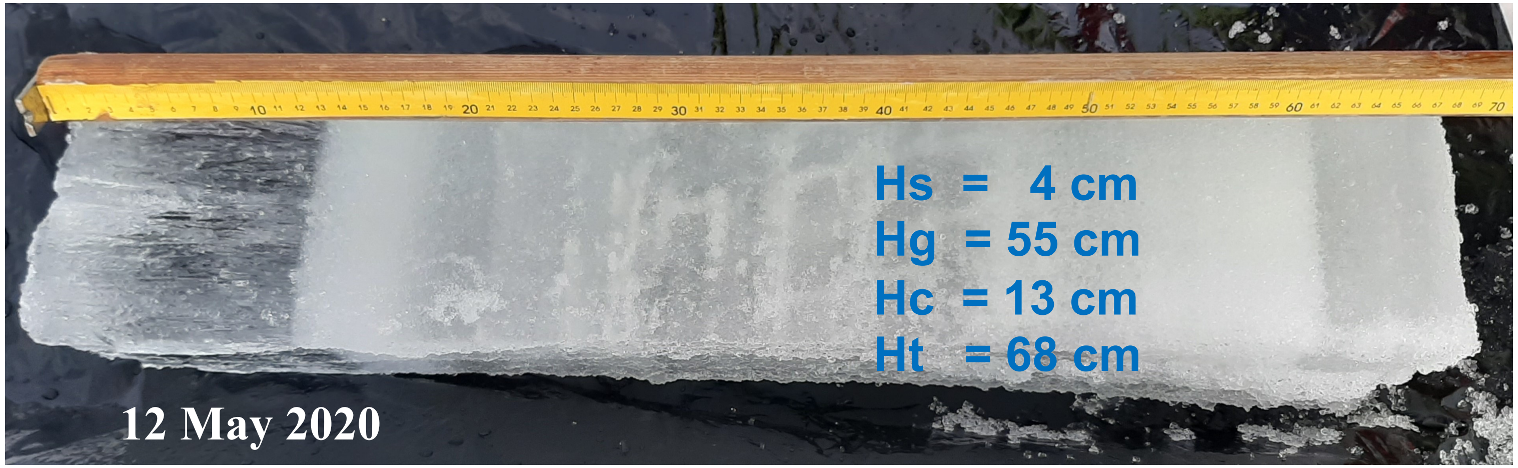




Sodankylä, lake Oräjarvi



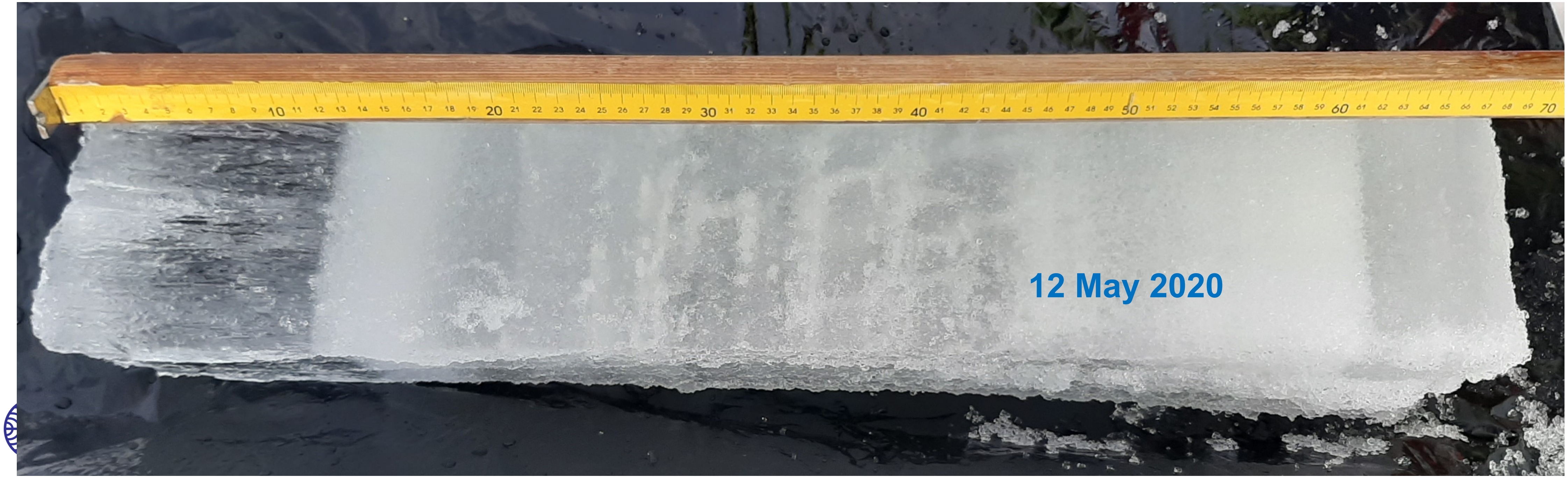


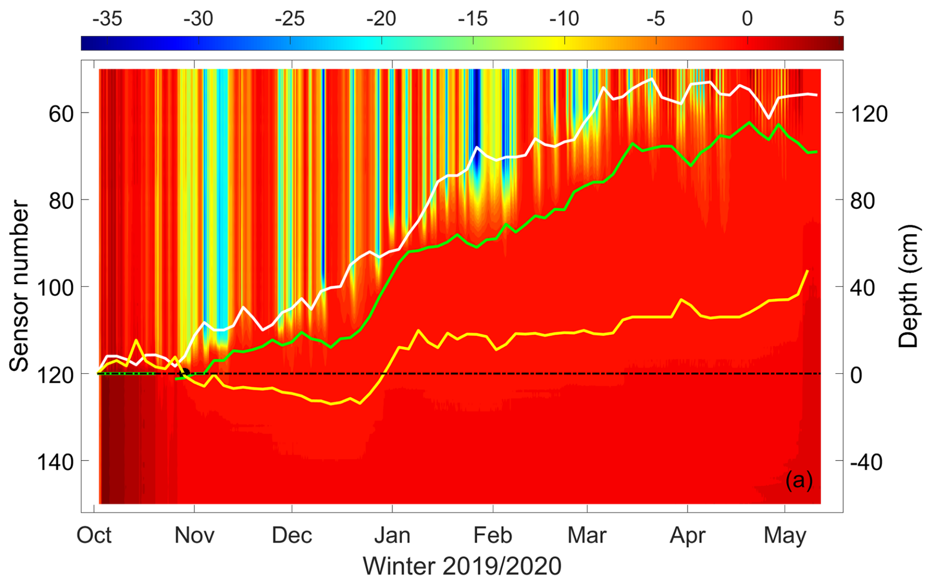


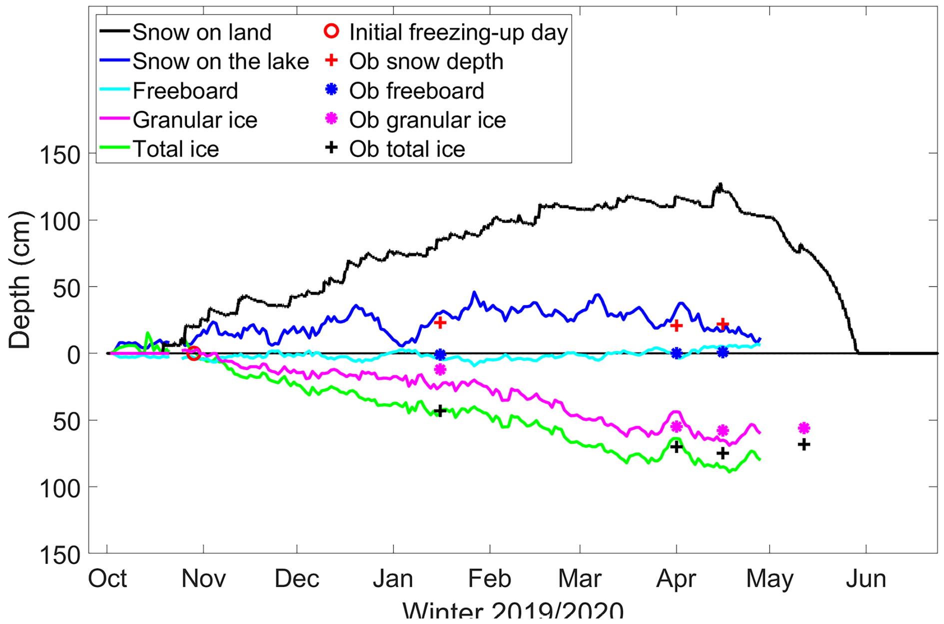
SIMBA measurement ice season 2019/2020 in lake Orajärvi

We see extraordinary granular ice formation.

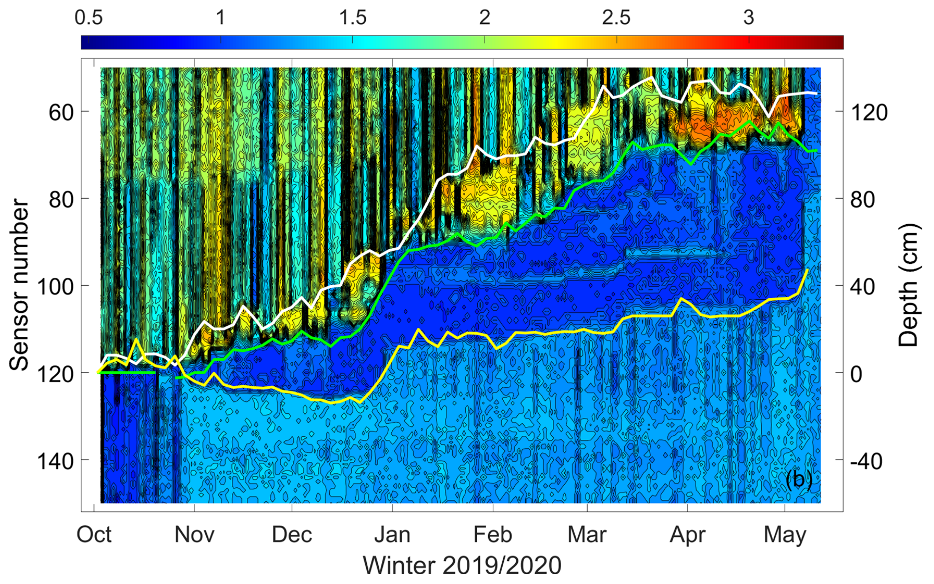

1 April 2020

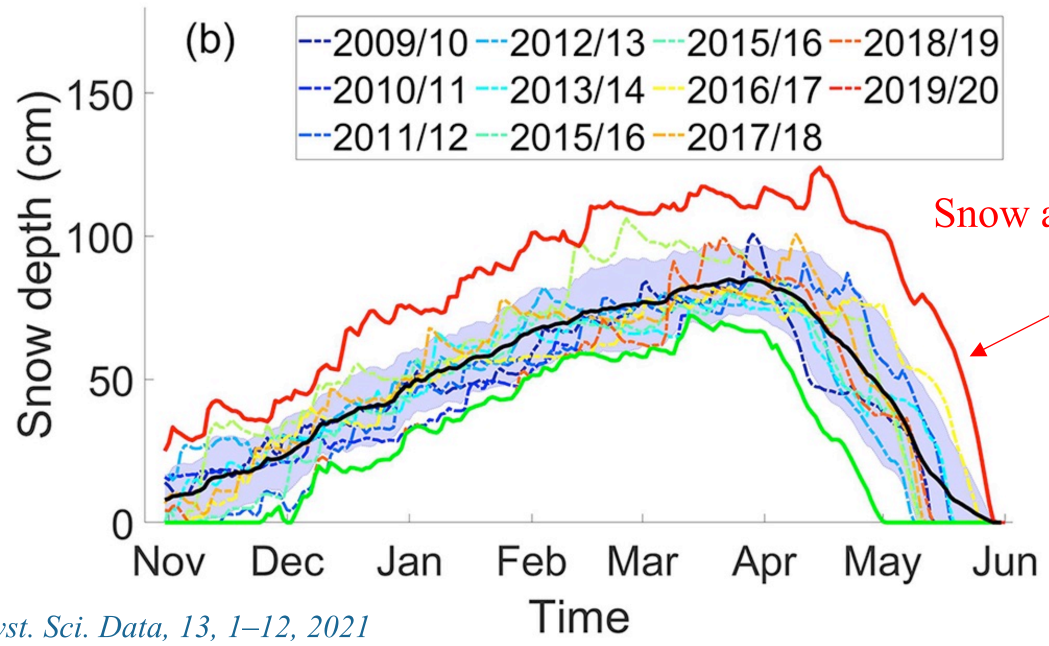

12 May 2020





Extreme seasonal snow accumulation is the primary driving factor to create extreme seasonal granular ice formation





Snow accumulation for 2019/2020

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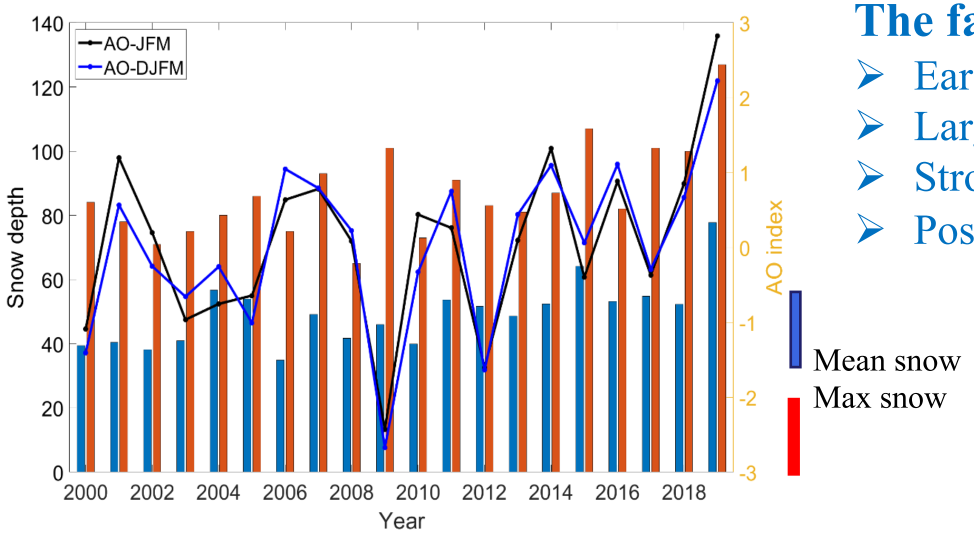
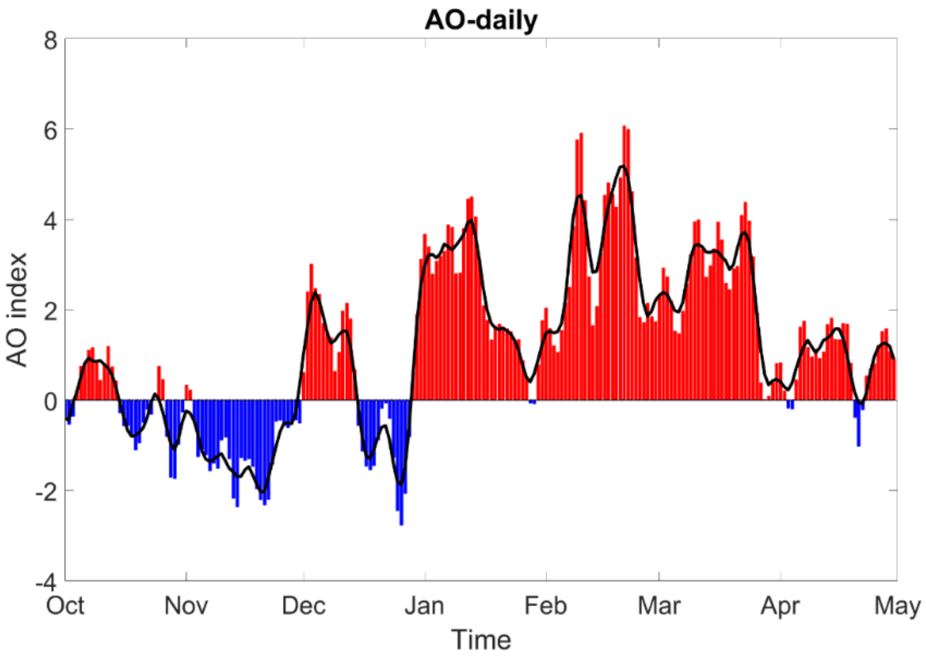
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Cheng et al., Earth Syst. Sci. Data, 13, 1–12, 2021
https://doi.org/10.5194/essd-13-1-2021

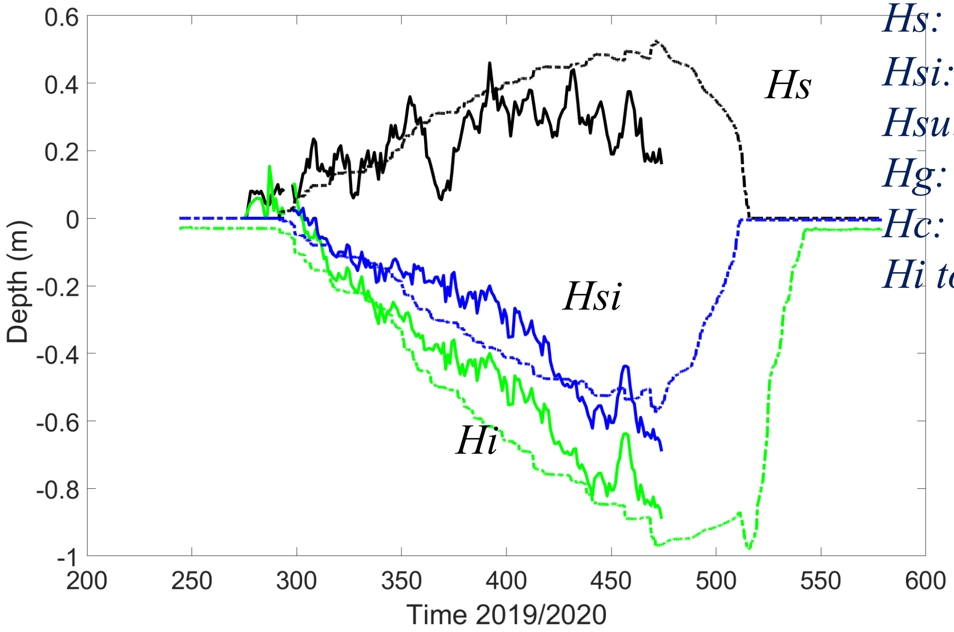




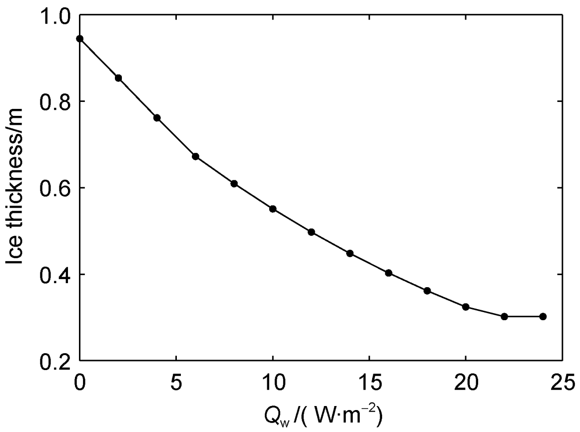
The factors responsible for extreme seasonal snow accumulation:

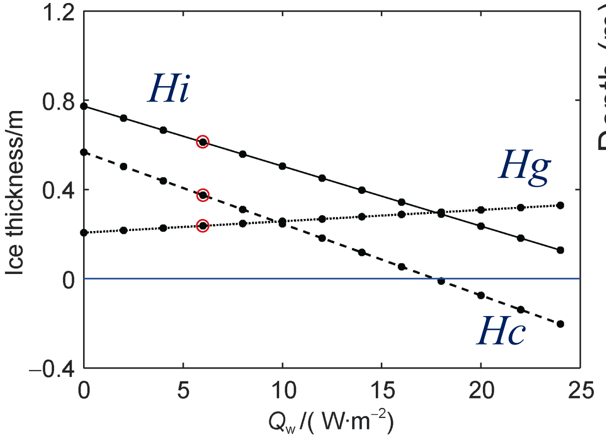
- Early ice formation
- Largest number of snowfall episodes, longest snow season
- Strongest seasonal AO (JFM) in the decades
- Positive AO (Jan. – Apr.): Keep cold air in the north, prompt refreezing of slush

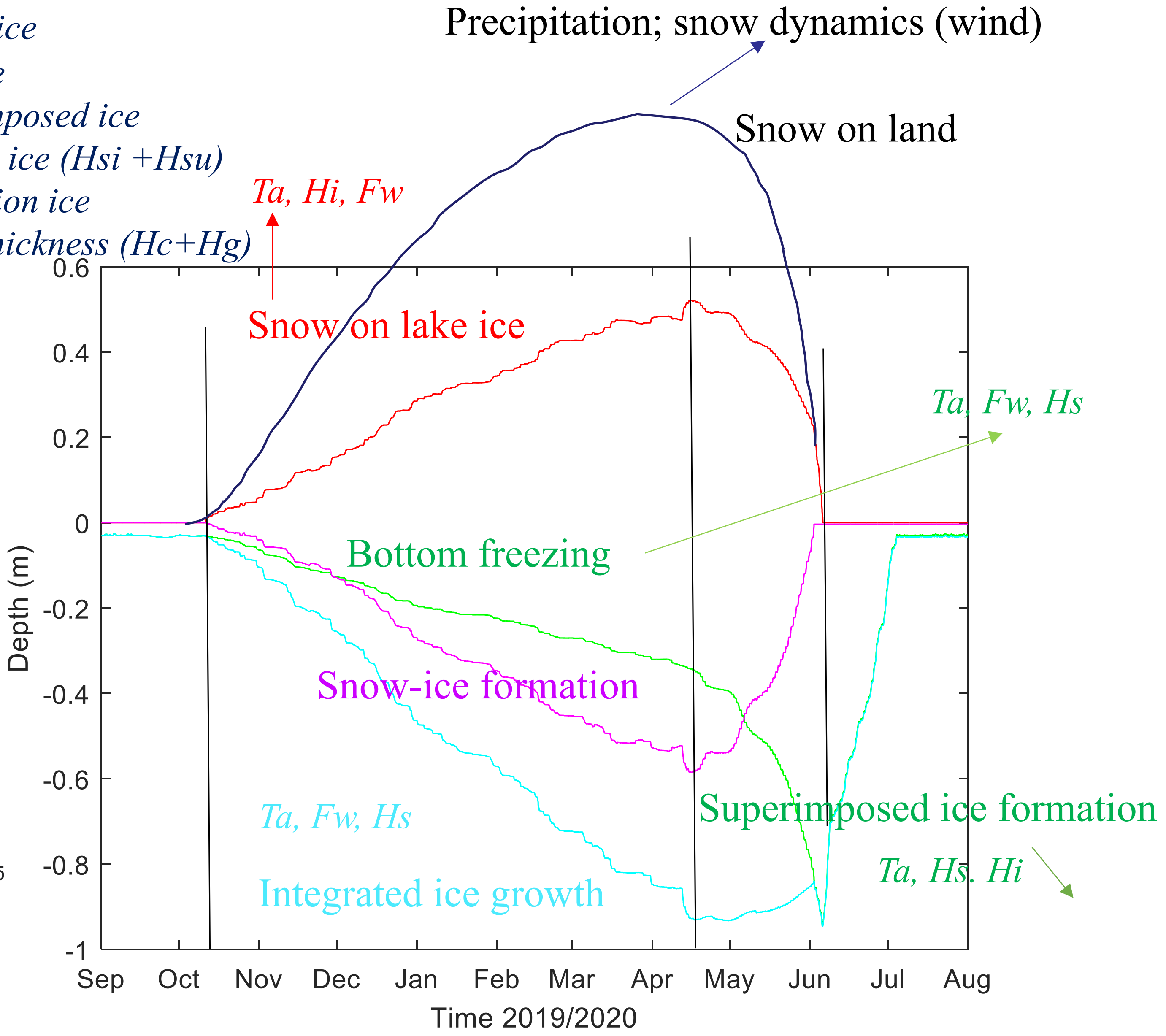
winter	Starting J-Day	Ending J-Day	Period Day	Mean Depth (cm)	Hsmax (cm) Occur date (J-Day)	No. of snowfall (>5cm)
2000	(298)322	495	173	40	84 (475)	11
2001	(291)301	486	185	41	78 (445)	9
2002	288	498	210	38	71 (389)	8
2003	290	493	203	41	75 (453)	11
2004	(295)319	510	191	57	80 (397)	10
2005	(292)318	491	173	54	86 (460)	9
2006	291	501	210	35	75 (467)	11
2007	304	499	195	49	93 (471)	15
2008	301	491	190	42	65 (407)	8
2009	280	500	220	46	101 (454)	12
2010	296	487	191	40	73 (437)	6
2011	320	505	185	54	91 (467)	16
2012	297	495	198	52	83 (401)	8
2013	295	505	210	49	81 (448)	13
2014	(297)318	497	179	52	87 (456)	9
2015	310	497	187	64	107 (422)	13
2016	310	512	202	53	82 (444)	8
2017	301	498	197	55	101 (465)	11
2018	(278)337	500	163	52	100 (446)	11
2019	291	515	224	78	128 (472)	18



Hs: snow on ice
Hsi: snow-ice
Hsu: Superimposed ice
Hg: granular ice (Hsi +Hsu)
Hc: congelation ice
Hi total ice thickness (Hc+Hg)







Cheng et al., 2021,doi: 10.13679/j.advps.2021.0051, Advances in Polar Science

Summary

- Snow and ice interaction may be intensified under global warming and Polar Amplification.
- Impact of precipitation and oceanic heat flux are critical factors for snow-ice interaction; the effect of Tair may not be very critical on total ice mass balance in cold conditions, especially with heavy snow on ice?
- CARRA reanalyses overestimate Tair in the YoungSound coastal Greenland.
- 2019/2020 extreme seasonal formation of granular ice resulted from a chain of events of:
  - Early freezing up;
  - Frequent and intensive snowfall episodes
  - and strong AO
- The composition of granular ice may have effects on the seasonality and timing of sea ice events with respect to *Hmax*, *Hs*, breakup, and sea ice dynamics