Self-Introduction

- My name is Ariana
- Pursuing my MSc in Geography at the University of Waterloo

Research Area

Limnology | Remote Sensing

- My research is focused on lake ice phenology (timing of lake ice formation and decay)
  - Utilizing passive microwave remote sensing

(NickolayV, 2014)

SnowTinel

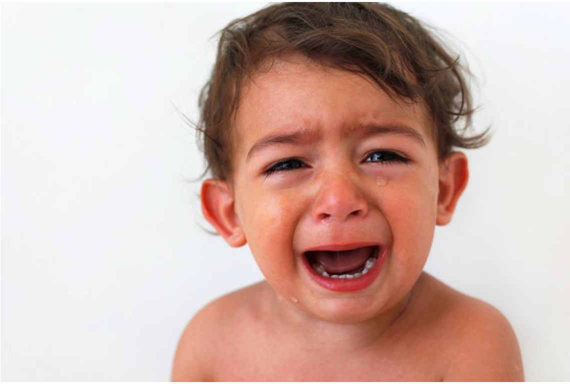
Mathias Bavay, Francesca Carletti, Chiara Ghielmini, Walter Benjamin, Loïc Brouet;
SLF

Giacomo Bertoldi, Carlo Marin, Valentina Premier, Christian Tonelli, Michele Bozzoli;
Eurac

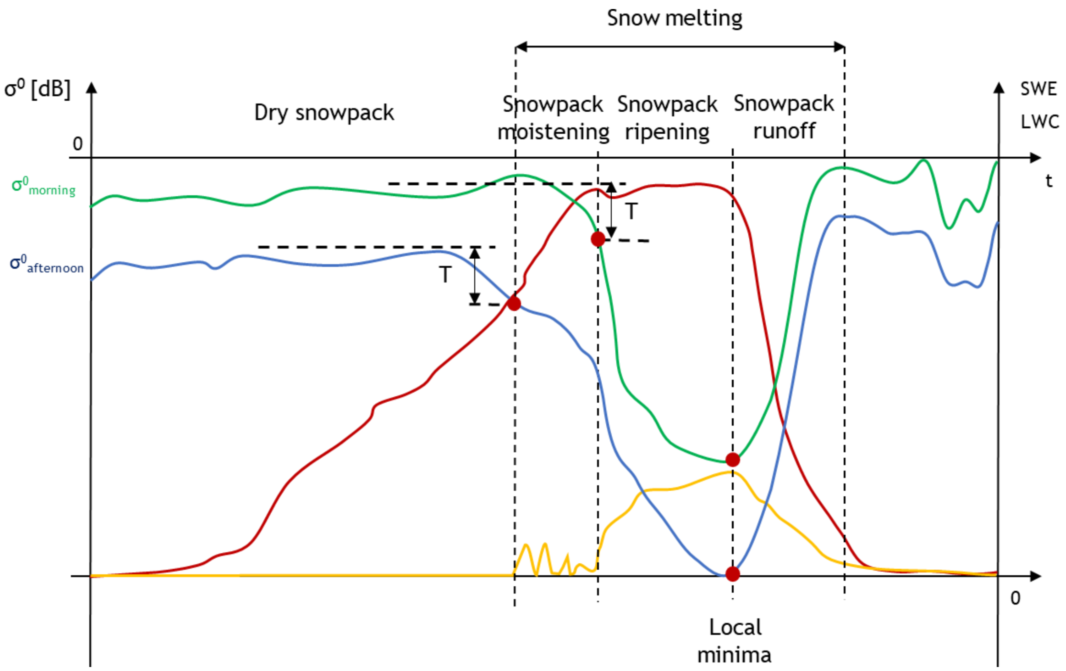
SnowTinel goals

Sentinel 1 satellites with SAR (5.405 GHz):

- Very interesting for Snow Water Equivalent retrieval
- Worldwide, all weather, 20 m resolution
- Almost daily revisit by combining all orbits
- Because of radar absorption, works for dry snow, not for wet snow…
- Really not solution for SWE during melt periods?



SnowTinel concept



Marin, C., Bertoldi, G., Premier, V., Callegari, M., Brida, C., Hürkamp, K., Tschiersch, J., Zebisch, M., and Notarnicola, C.: *Use of Sentinel-1 radar observations to evaluate snowmelt dynamics in alpine regions*, The Cryosphere, 14, 935–956, https://doi.org/10.5194/tc-14-935-2020, **2020**.

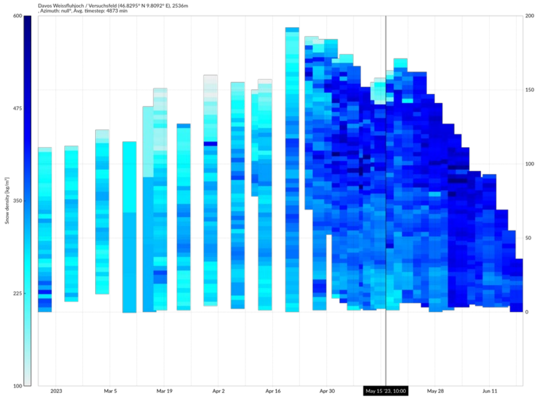
Comparing SAR backscattering with snow cover simulation:

- Well synchronized phases
- First Liquid Water Content → SAR signal starts dropping
- Increase in LWC → more SAR attenuation
- Drop in Snow Water Equivalent (start of runoff)→ SAR signal recovers
- Model this and assimilate SAR data to improve distributed SWE modeling *during* melt?

SnowTinel methods, 2023

Putting together a ground truth dataset:

- 3 times a week snow profiles: SWE, NIR, temperature, SSA, density, LWC (Denoth), LWC (melting calorimeter)
- Surface roughness (Lidar & Forex plate)
- Forcings → numerical snow cover simulations
- Snow scale, Lysimeter
- Stratigraphy profiles every 2 weeks
- Snow MicroPen daily profiles



More information

- Hopefully soon a data paper with all ground truth
- Upcoming paper on roughness measurements comparison (lidar / forex plate)
- Upcoming paper on sun cups formation

SCAN ME

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MSc - Geography & Environmental Management

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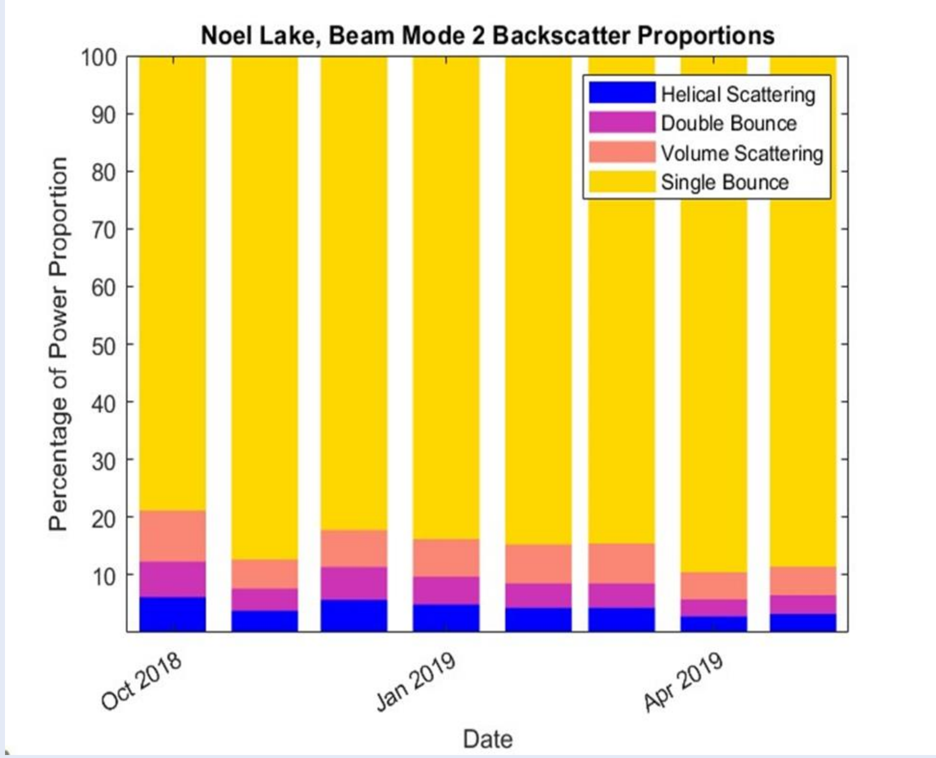
UNIVERSITY OF WATERLOO | FACULTY OF ENVIRONMENT

Research Focus

- Active spaceborne radar (RADARSAT 2)
- Ground penetrating radar (PulseEKKO)
- Freshwater lake ice features
- Backscatter analysis

Current projects

- Polarimetric decomposition of freshwater lake ice backscatter
- Ice-Water interface roughness analysis using GPR



Developing new tools
measure arctic snow density

Érika Boisvert-Vigneault

UNIVERSITÉ DE SHERBROOKE

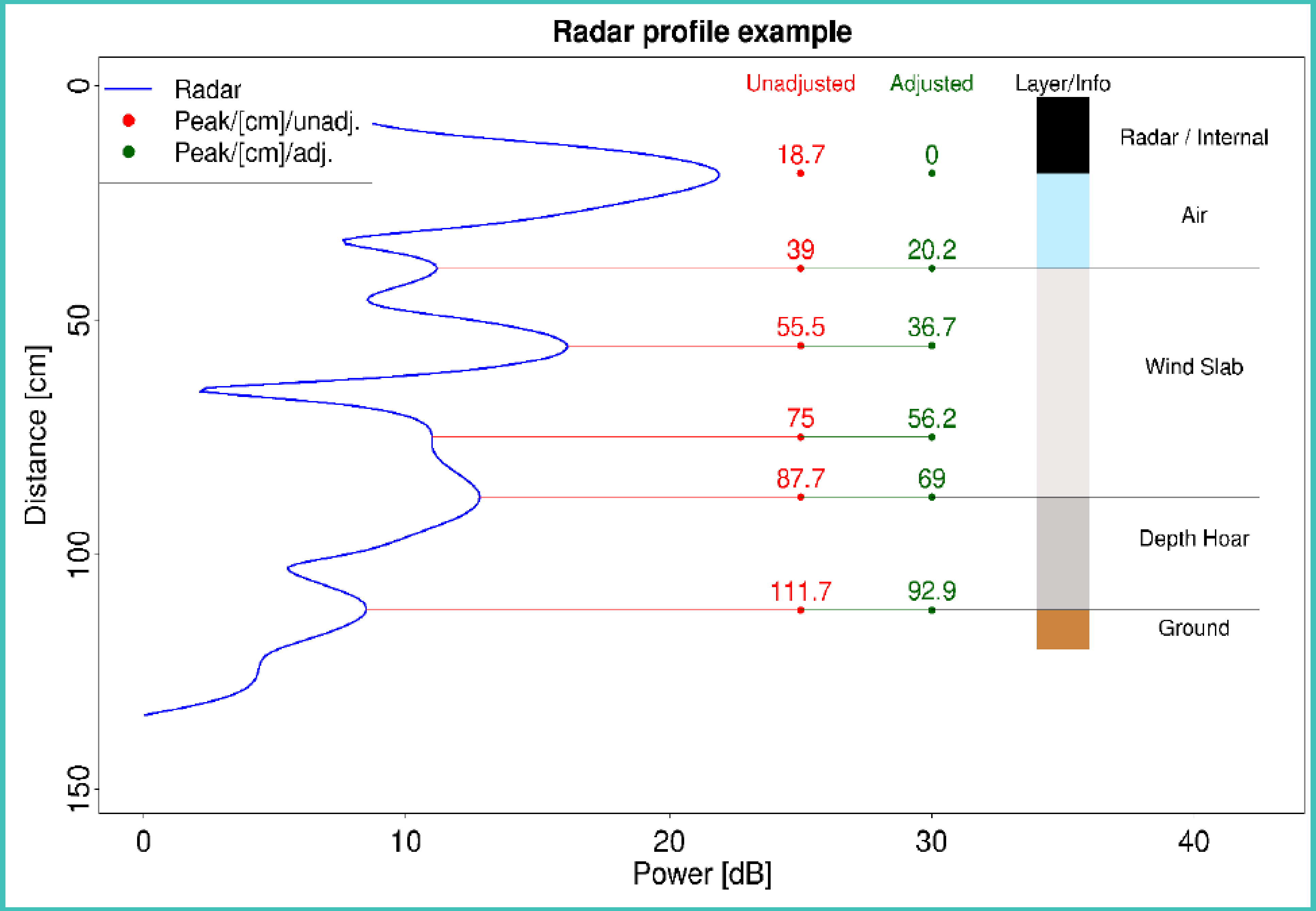
cartel

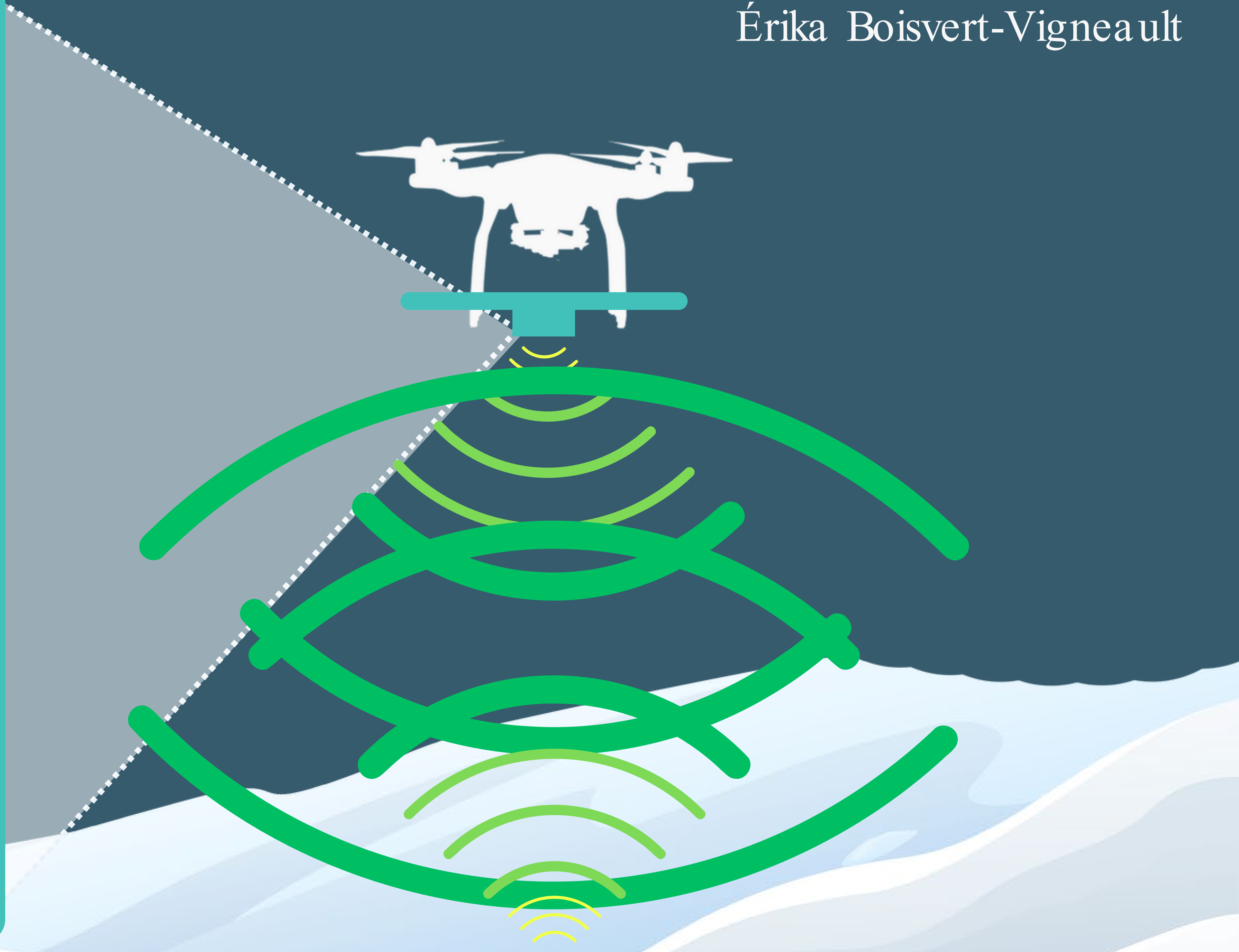
CENTRE D'ÉTUDES NORDIQUES
CEN Centre for Northern Studies

Developing new tools measure arctic snow density

Érika Boisvert-Vigneault

Figure from Kramer et al., 2022





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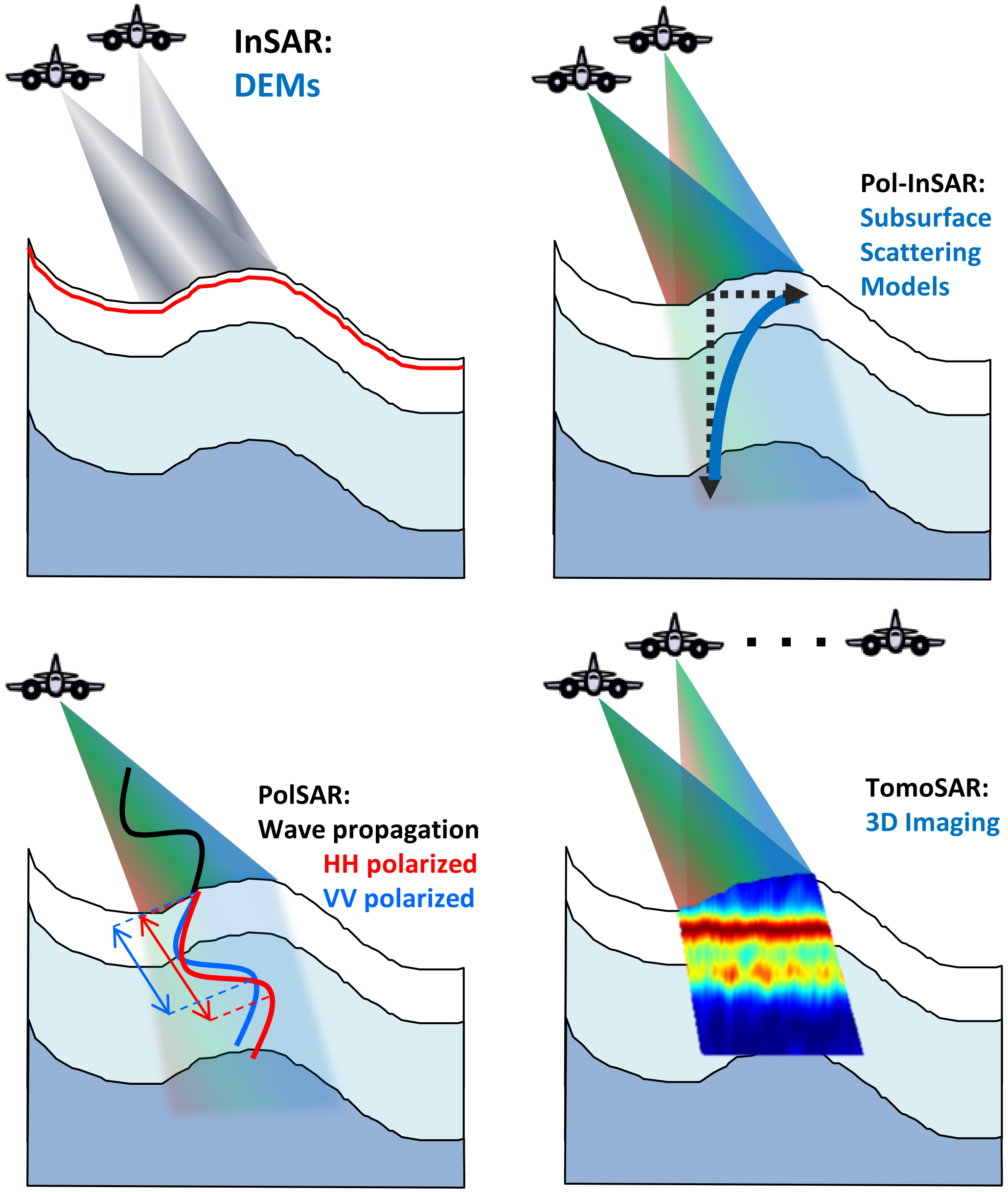
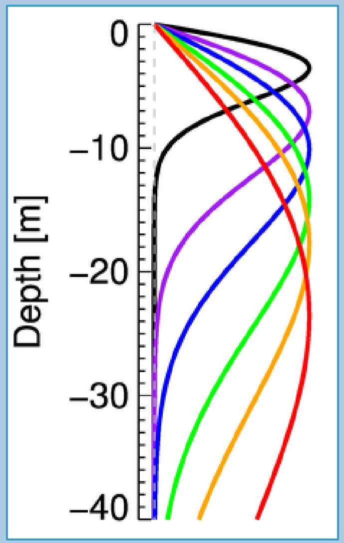
Looking Below The Surface With Synthetic Aperture Radar

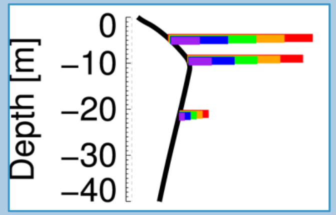


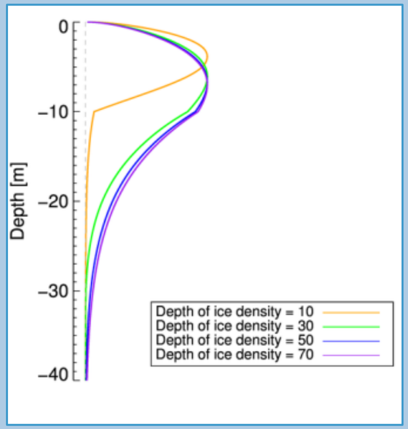
$$\begin{aligned}&\textit{Polarimetric, Interferometric SAR}\\ &= f(\textit{vertical backscattering distribution})\\ &= f(\textit{density, grain size, shape, refrozen ice lenses}, \ldots)\end{aligned}$$

Modelling Approaches



→ SMRT!





Ice Edge Verification

Measuring the skill in our Forecasts and disagreement in our Observations

Bimochan Niraula

FB-01, Universität Bremen

Alfred Wegener Institute – Helmholtz Center for Polar and Marine research

BsideScience

Young Investigator Group
Seamless Sea Ice Prediction

Bundesministerium für Bildung und Forschung

HELMHOLTZ
SPITZENFORSCHUNG FÜR GROSSE HERAUSFORDERUNGEN

YOPP YEAR OF POLAR PREDICTION

POLMAR
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ArcTrain

Universität Bremen

Advances in X/Ku radar SWE Algorithms

- Goal: a *global* SWE satellite mission ← snow RS community from Europe/N. America has been pursuing one for 20+ years
- many advances since ESA CoReH2O mission concept ~10 years ago
- validation using 8 airborne & tower field campaigns (e.g. SnowEx); more in progress
  - Dense medium RT theory, bi-continuous media, numerical solution of Maxwell's Eqs
- Recent review paper on radar snow sensing in the online journal Cryosphere.
  - Extensive improved measurements and characterization of snow microstructure effects
  - Extensive improved snow layering structure measurements and snow micro-physics models
  - Rough surface scattering: improved understanding, extended high-freq limit
  - Significantly improved understanding of forest effects & algorithms to retrieve SWE in forested areas
  - Advances in combined active/passive as well as passive-only microwave snow retrievals
- Latest algorithm advances:
  - Parametrized bi-continous DMRT → 2 equations, 2 unknowns → don't need detailed microstructure
  - New insights regarding 'priors' and cost function approaches; detailed prior not needed; no prior needed
  - Makes global snow retrieval far more practical
  - High-frequency (≥ 10 GHz) surface scattering, separation of surface & volume scattering
- Basis of a NASA snow mission proposal being submitted by August 2, 2023!

Sea Ice elevation retrieval using SAR Imagery

Lanqing Huang

06/07/2023

ETH zürich

Study area: Weddell Sea, Antarctica

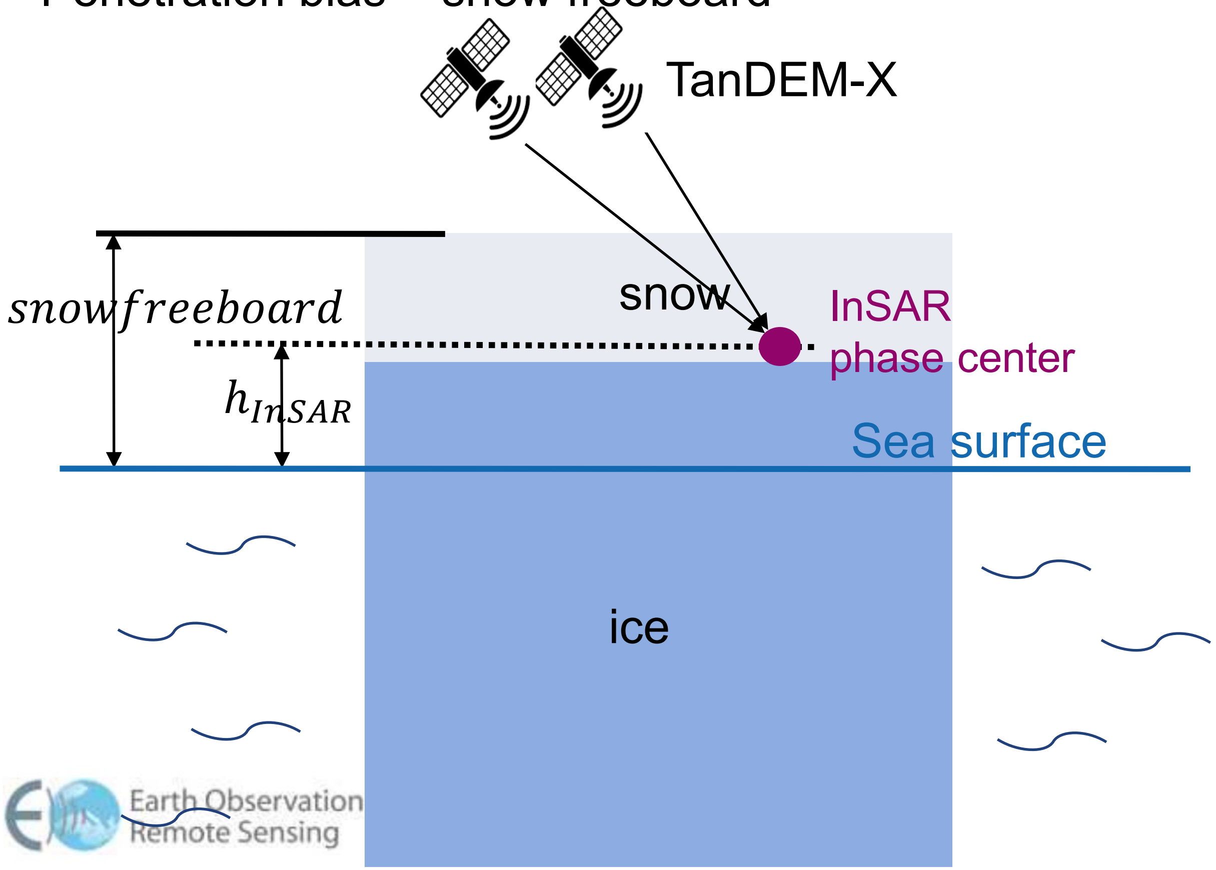
Sea Ice elevation retrieval using SAR Imagery

Personal

- Postdoc: Lanqing Huang from ETH Zurich

Key words

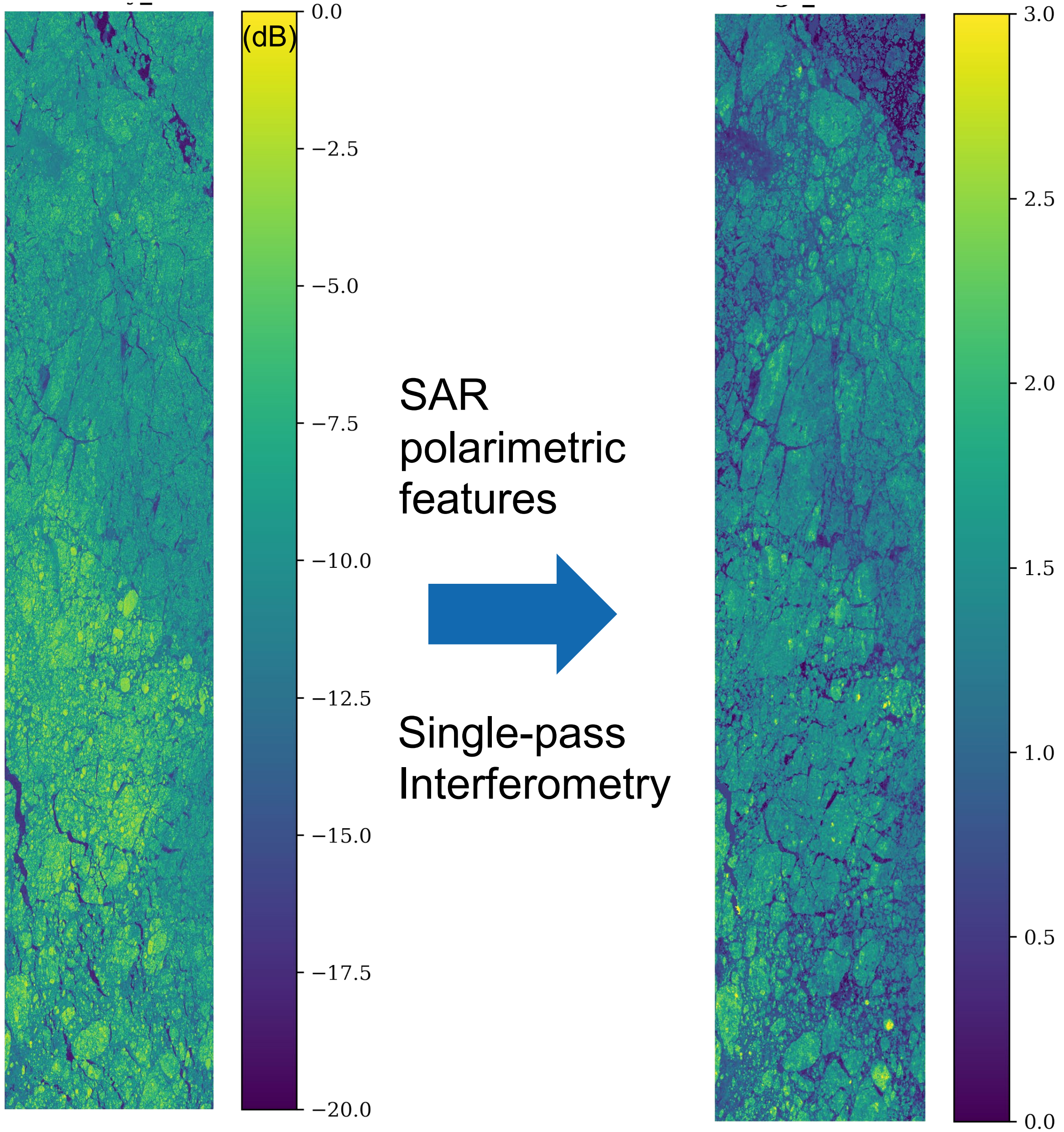
- SAR: synthetic aperture radar
- Penetration bias = snow freeboard -



Earth Observation Remote Sensing

SAR backscattering intensity

Sea ice elevation

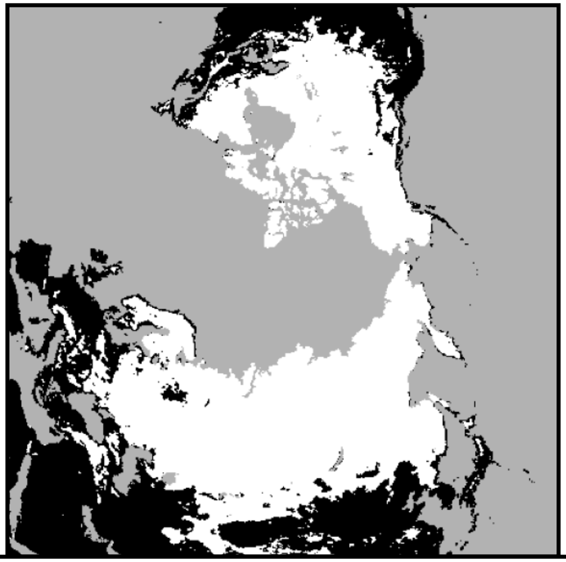


Passive Microwave Remote Sensing of Terrestrial Snow

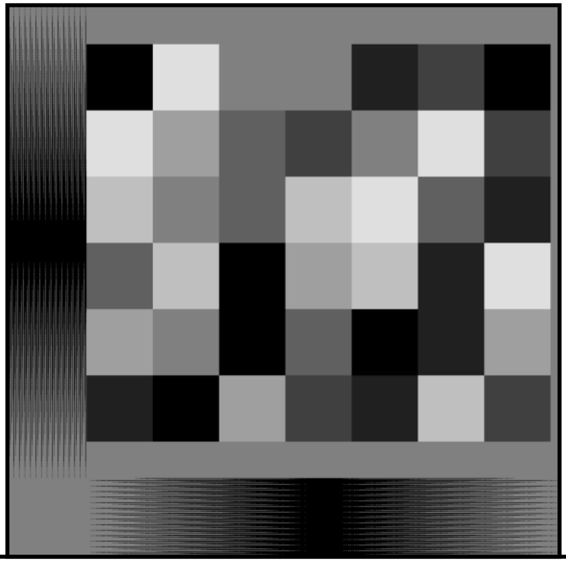
Dry Snow Detection

- TB difference(s) → scattering
- Binary snow maps
- Processing step of SWE retrieval

Snow Mapping



Radiometric Test Scene



Variability in Detection Success

- Minimum detectability (shallow snow)
- Changes with soil/vegetation
- Parameter space: H-pol (layering)
- Credibility for empirical algorithms

Copernicus Imaging Microwave Radiometer

- ESA CIMR L2 Algorithm Development
- SMRT = input TBs for test scenes
- High-resolution: incidence angle (terrain)

Lina.Zschenderlein@fmi.fi

Radar Remote Sensing of Terrestrial Snow

CryoSAR

- Ku/L-band SAR → snow properties
- Focus on soil-snow interactions
- In preparation for the Terrestrial Snow Mass Mission (TSMM)

SMRT Applications

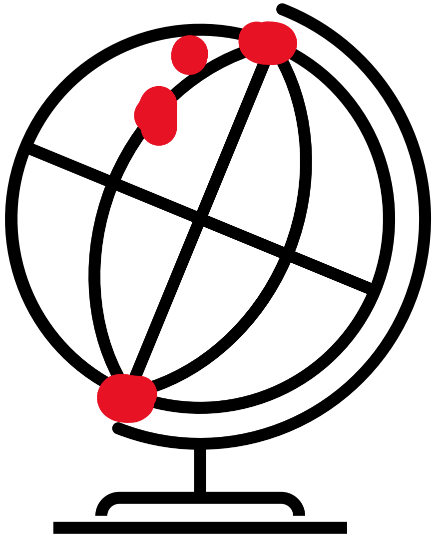
- Changes in backscatter due to soil properties
  - Roughness, moisture
  - Soil type
  - Freeze/thaw state
- Impact of layering
  - Increase of melt/freeze events: ice lenses
  - High seasonal variability of crystal types
- Something else???

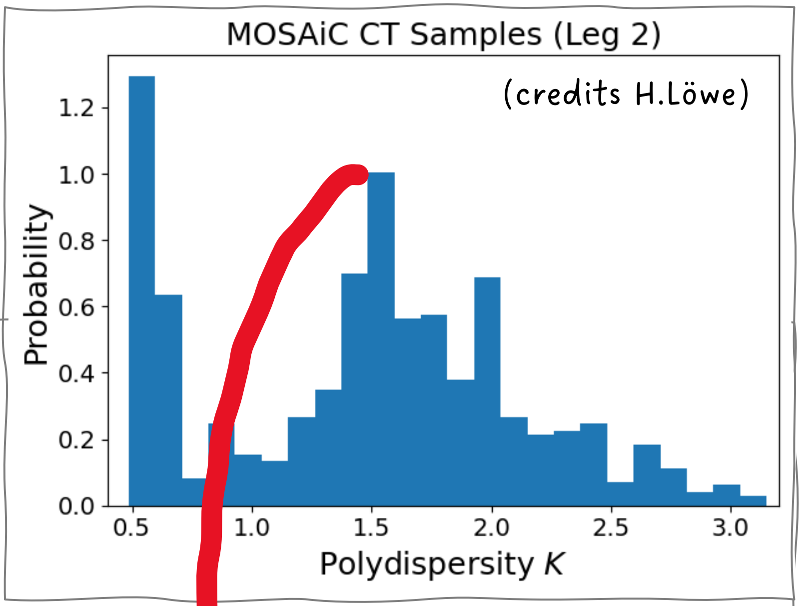
Amy Macfarlane
SMRT workshop
6th-8th July 2023

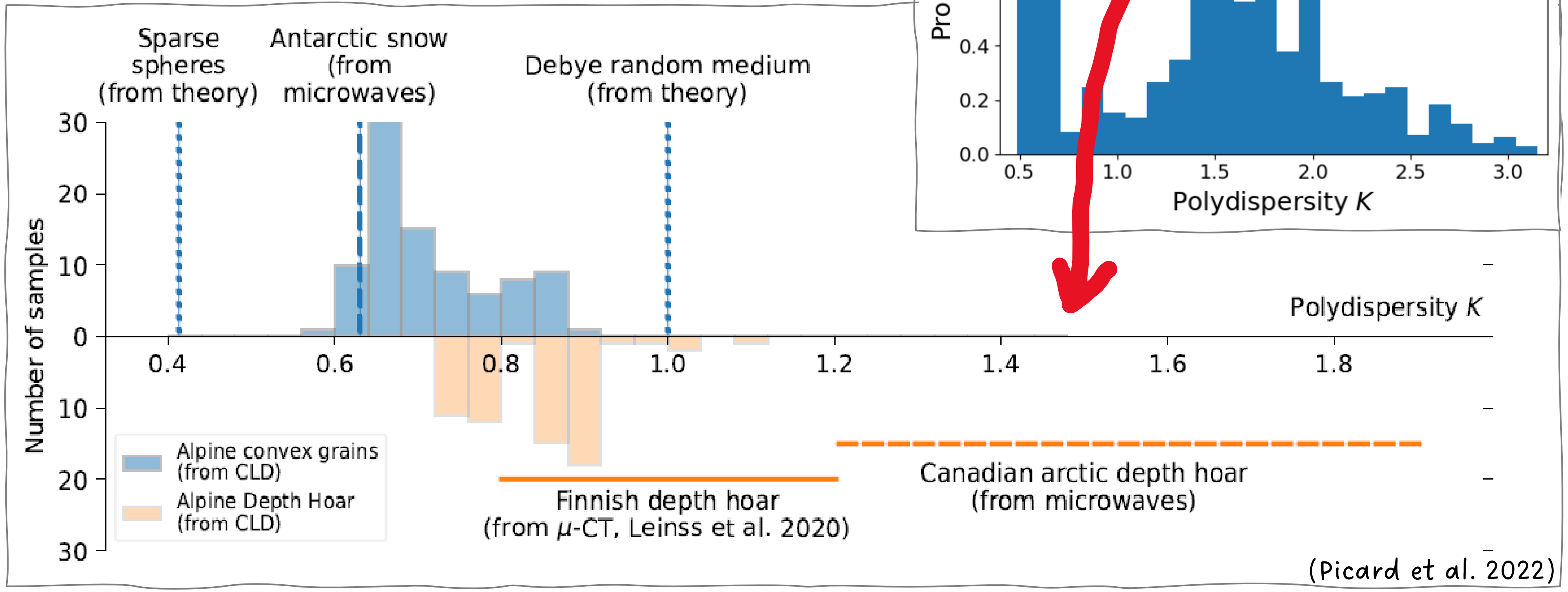
Microwave signatures of snow on sea ice

Datasets:
- ESA-SCANSAS
- CIRFA cruise
- MOSAiC
- Antartica-Davis

Work Packages:
- WP1: Derive polydispersity from existing datasets.
- WP2: Parameterise SMP to up-scale
- WP3: Model and satellite simulations







Swiss National Science Foundation
University of Tromsø
Northumbria University NEWCASTLE
SLF

Connor Nelson

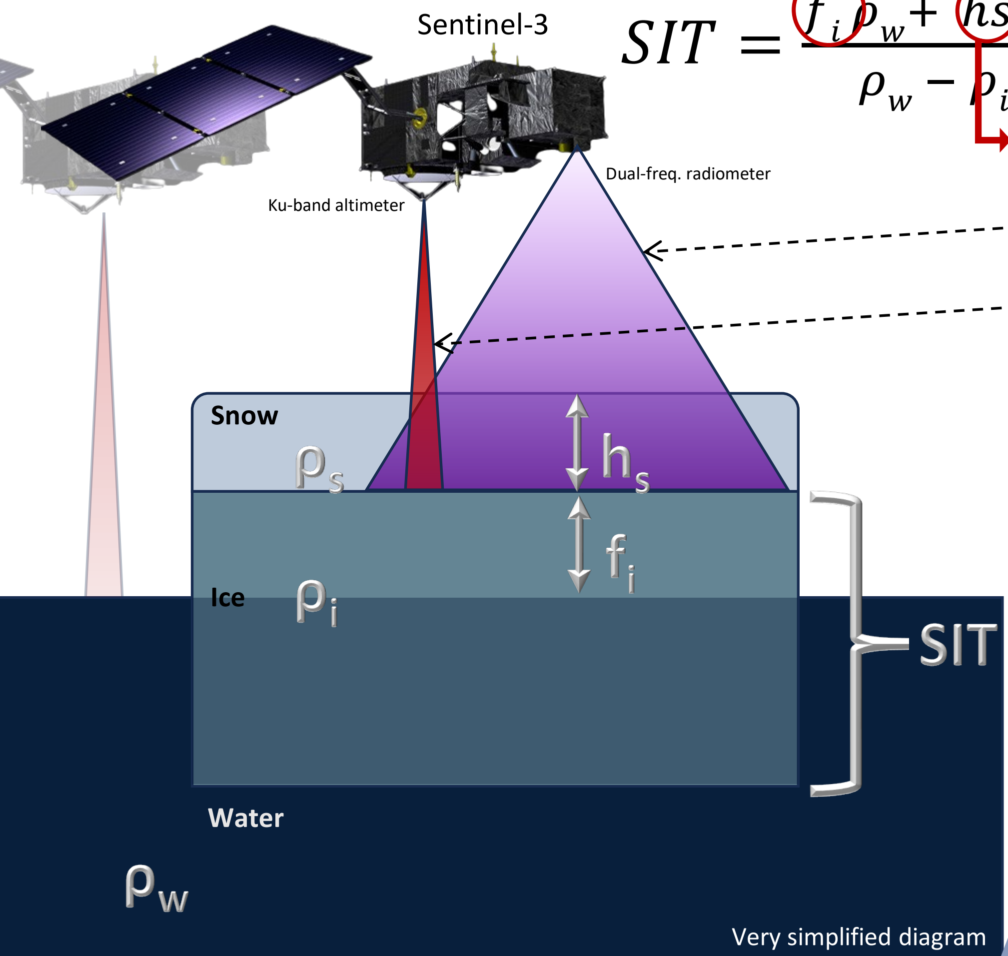
Snow depth for sea ice thickness

- Snow depth (h_s) is a leading source of error in the conventional conversion from altimeter-derived ice freeboard to sea ice thickness (SIT).

$$SIT = \frac{f_i \rho_w + hs\, \rho_s}{\rho_w - \rho_i}$$

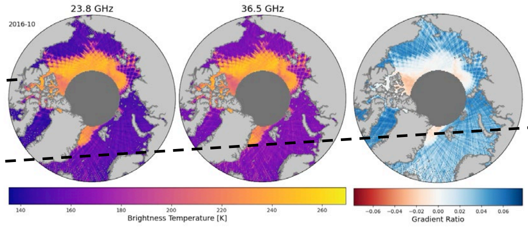
→ f_i: Derived using altimeter

→ hs: Taken from an external source (e.g., climatology or difference satellite product)

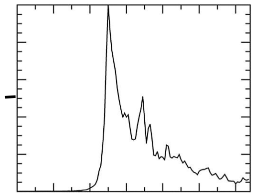


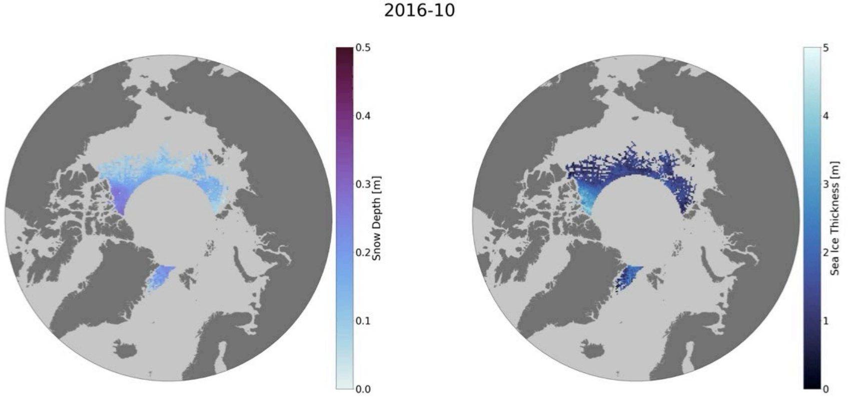
- Along-track snow depth product for Sentinel-3.
- Combination of coincident passive and active microwave measurements in a regression model.
- In theory, more accurate locally than external h_s values → more accurate thickness?

Passive microwave



Active microwave





- How does snow microstructure etc. impact this method? That's what I'm here to begin finding out.

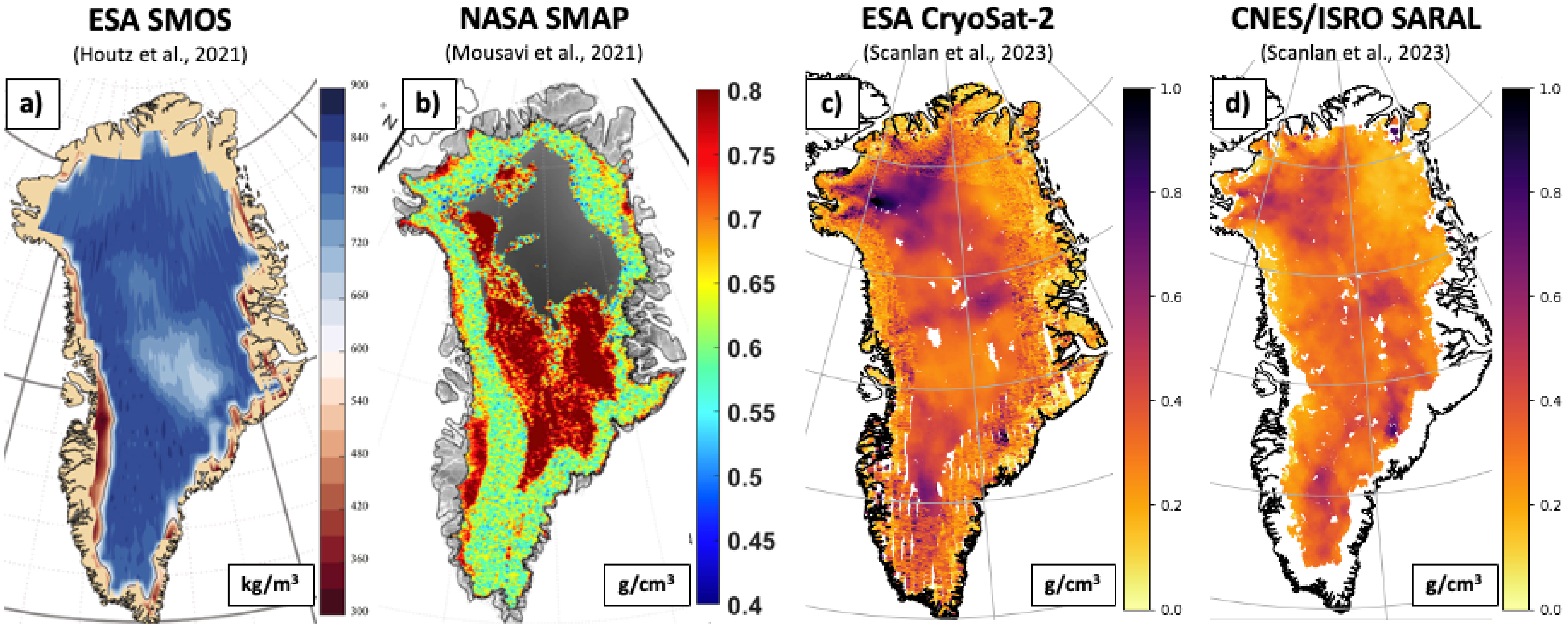
EO4GRHO

A Multi-Sensor Synthesis for Near-Surface Densities across Greenland

kimis@space.dtu.dk

OBJECTIVE: Timeseries of pan-Greenland near-surface density profiles

APPROACH: Inversion of SMOS brightness temperatures pre-constrained with permittivities derived from CryoSat-2 (Ku) and SARAL (Ka) radar altimetry surface echo powers



Institut de Ciències del Mar

BEC Barcelona Expert Center

MOSAiC L-band radiometry – Ferran Hernández-Macià

isardSAT

Gabarró et al., 2022

ARIEL

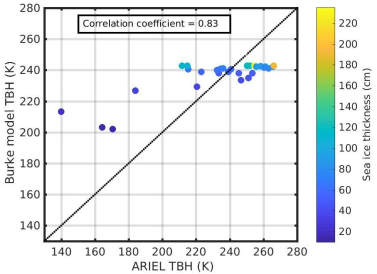
ELEMENTA Science of the Anthropocene

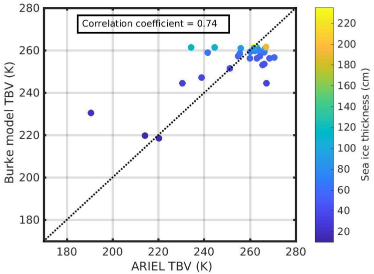
Gabarró, C, et al. 2022. First results of the ARIEL L-band radiometer on the MOSAiC Arctic Expedition during the late summer and autumn period. *Elem Sci Anth*, 10: 1. DOI: https://doi.org/10.1525/elementa.2022.00031

RESEARCH ARTICLE

First results of the ARIEL L-band radiometer on the MOSAiC Arctic Expedition during the late summer and autumn period

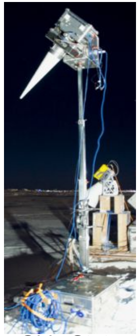
Carolina Gabarró[1]*, Pau Fabregat[2], Ferran Hernández-Macià[1], Roger Jove[2], Joaquin Salvador[1], Gunnar Spreen[3], Linda Thielke[3], Ruzica Dadic[4], Marcus Huntemann[3], Nikolai Kolabutin[5], Daiki Nomura[6], Henna-Reetta Hannula[7], and Martin Schneebeli[8]



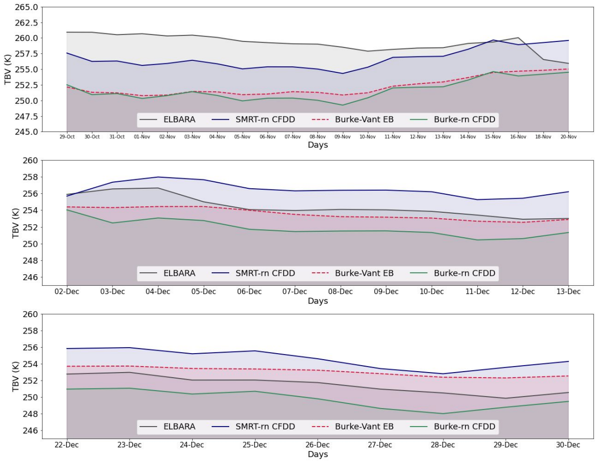


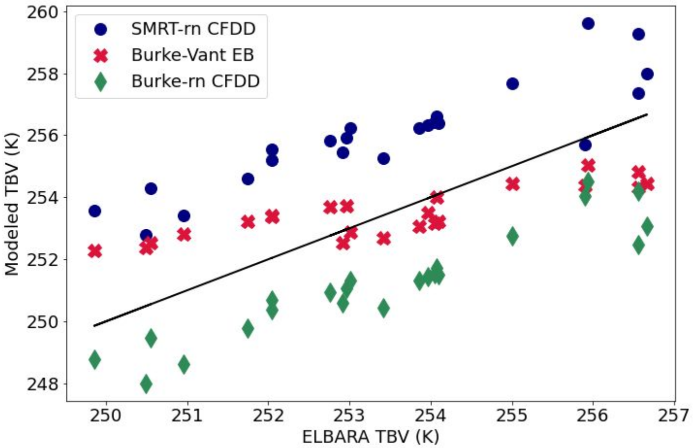
ELBARA & UWBRAD

Swiss Federal Institute for Forest, Landscape, and Snow Research



Ohio State University

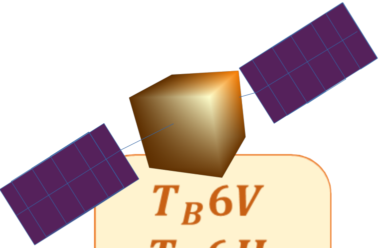




(Similar analysis for UWBRAD)

CHARS campaign
November 2023

- Canadian High Arctic Research Station Campus (CHARS), Cambridge Bay
- In collaboration with R. Scharien (U. Victoria) and G. Spreen (U. Bremen)



$T_B 6V$
$T_B 6H$
$T_B 10V$
.
.
.
$T_B 89V$
$T_B 89H$

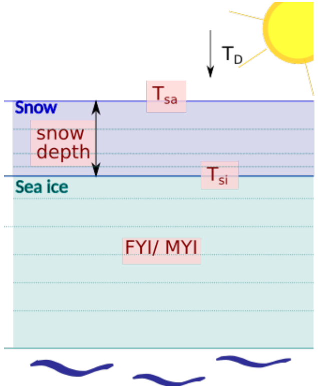
A priori background
Climatologies

$$\left(\text{Forward model} \right)^{-1}$$

Windspeed
Total Water Vapor
Liquid Water Path
Sea-Surface Temperature
Ice/Snow Temperature
Sea-Ice Concentration
Multi-Year Ice Fraction
Snow Depth

$$T_B = F(p) + e$$

Surface part of forward model:
Microwave emission model of **sea ice** and **snow**



JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 98, NO. C12, PAGES 22,569–22,577, DECEMBER 15, 1993

Low-Frequency Passive-Microwave Observations of Sea Ice in the Weddell Sea

JAMES D. MENASHI,[1] KAREN M. ST. GERMAIN,[2] CALVIN T. SWIFT,[1]
JOSEFINO C. COMISO,[3] AND ALAN W. LOHANICK[4]

The microwave emission properties of first-year sea ice were investigated from the R/V *Polarstern* during the Antarctic Winter Weddell Gyre Project in 1989. Radiometer measurements were made at 611 MHz and 10 GHz and were accompanied by video and visual observations. Using the theory of radiometric emission from a layered medium, a method for deriving sea ice thickness from radiometer data is developed and tested. The model is based on an incoherent reflection process and predicts that the emissivity of saline ice increases monotonically with increasing ice thickness until saturation occurs.

APPENDIX: DERIVATION OF A SEMICOHERENT EXPRESSION FOR THE EMISSIVITY OF AN IRREGULAR SURFACE

$$\langle e \rangle = \frac{(1 - r_i)(1 - Ar_w)}{(1 - Ar_i r_w)} \left[\frac{1 - (Ar_i r_w)^{1/2} e^{-\beta \sigma_l}}{1 + (Ar_i r_w)^{1/2} e^{-\beta \sigma_l}} \right]$$

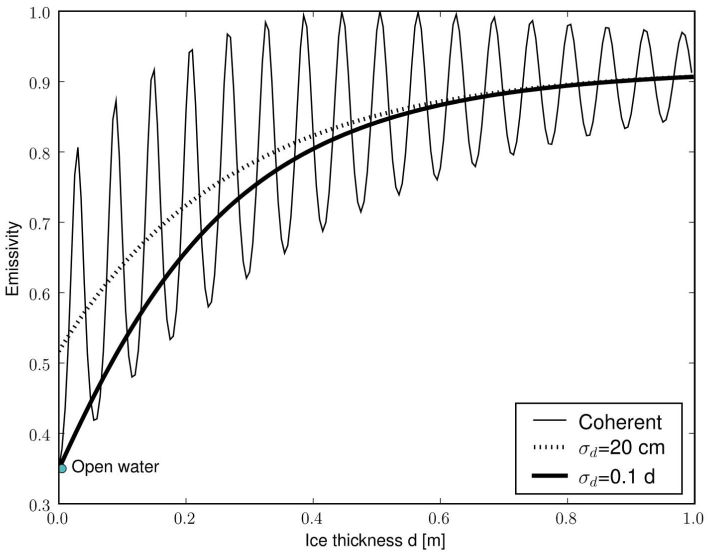


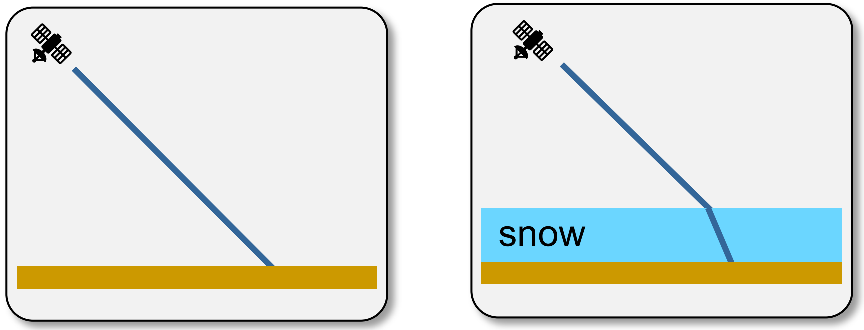
Fig. 1. Nadir 1.4 GHz emissivity of a slab of Baltic sea-ice ($S = 0.65$, $T = -2°C$). The coherent and two incoherent solutions are shown for two different parameterizations of the thickness roughness σ_d. The open water emissivity is indicated with the filled circle.

Kaleschke, L., Maaß, N., Haas, C., Hendricks, S., Heygster, G., and Tonboe, R. T.: A sea-ice thickness retrieval model for 1.4 GHz radiometry and application to airborne measurements over low salinity sea-ice, The Cryosphere, 4, 583–592, https://doi.org/10.5194/tc-4-583-2010, 2010.

SWE Retrieval Using Interferometric & Polarimetric SAR Data

1. Model for repeat pass InSAR acquisitions

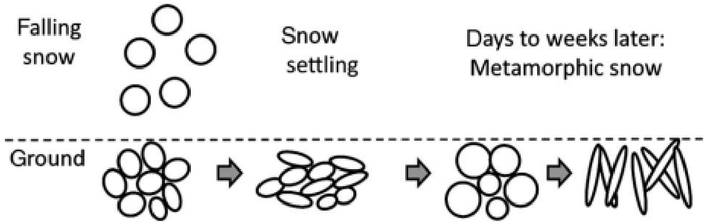
- Different dielectric properties in snow compared to air → refraction of radar waves



- Optical path length difference due to a SWE change can be measured with **interferometric phase**

2. Model for polarimetric SAR acquisitions

- Different polarizations show different propagation speeds in anisotropic snow

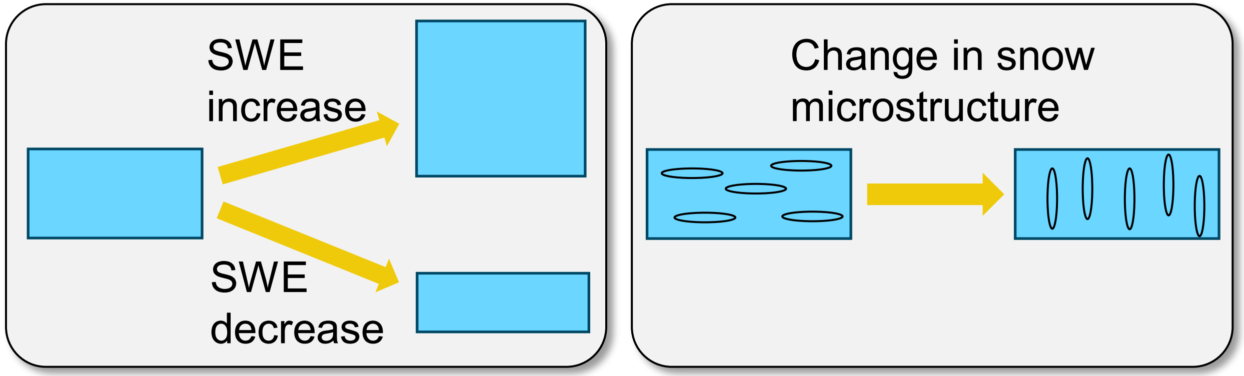


- Information on snow accumulation contained in **co-polar-phase** difference between VV and HH

3. Idea

- Combination of interferometry and polarimetry

4. Limitations for InSAR and PolSAR



- Phase change obtained for SWE change and for anisotropy change → possible to separate these effects?

5. Next step

- Model snow pack to investigate effects of snow depth and anisotropy changes

HafenCity Universität Hamburg

- B.Sc. Geography (GIS & Remote Sensing)
- M.Sc. Hydrography @ HCU Hamburg

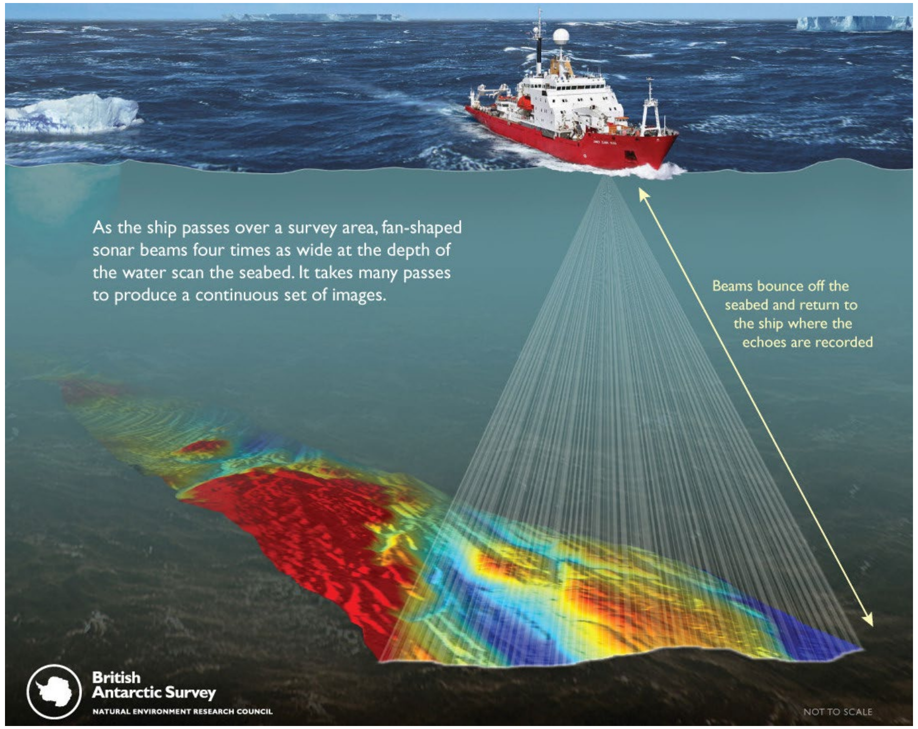
- Seabed (Bathymetry), Sub-Seabed and Water Column studies with echosounders (active sonars)

- Topic of my thesis: echosounder data improvement with water properties information (temp, salinity, etc. from CTD casts)

- Sea ice thickness determination with echosounders (master thesis by Ellen Werner)

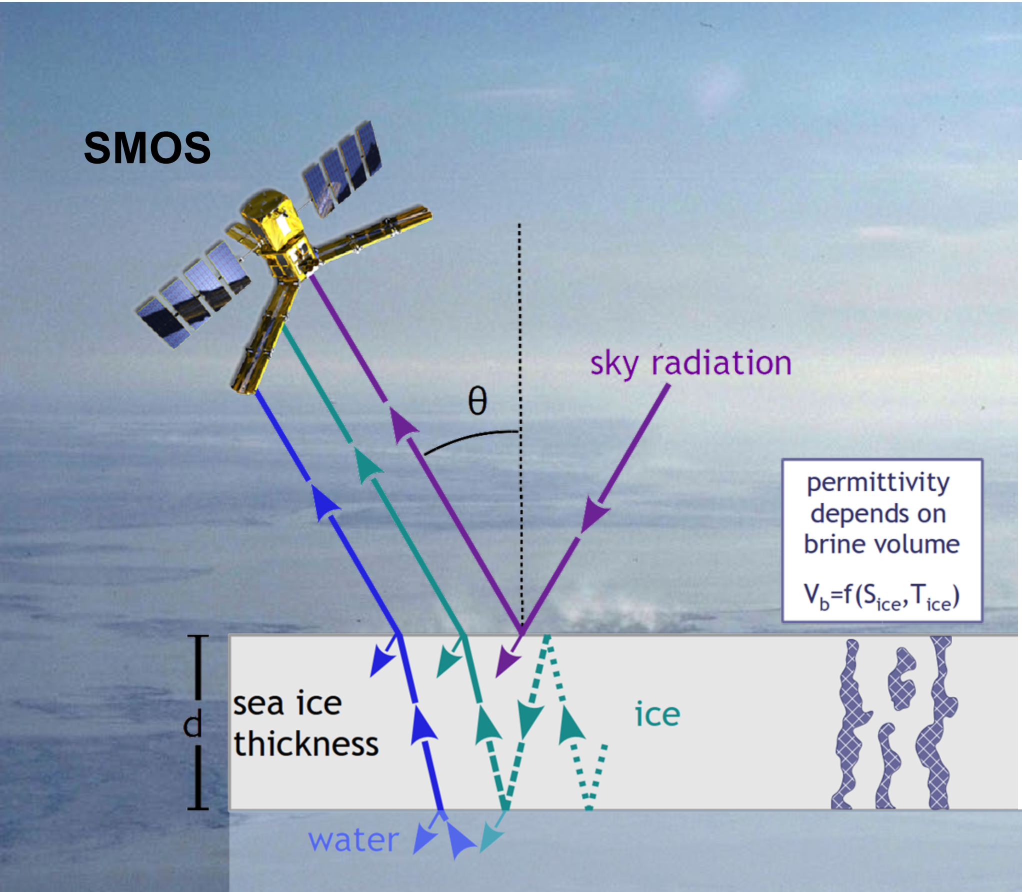
CTD, ©Helmholtz Institute

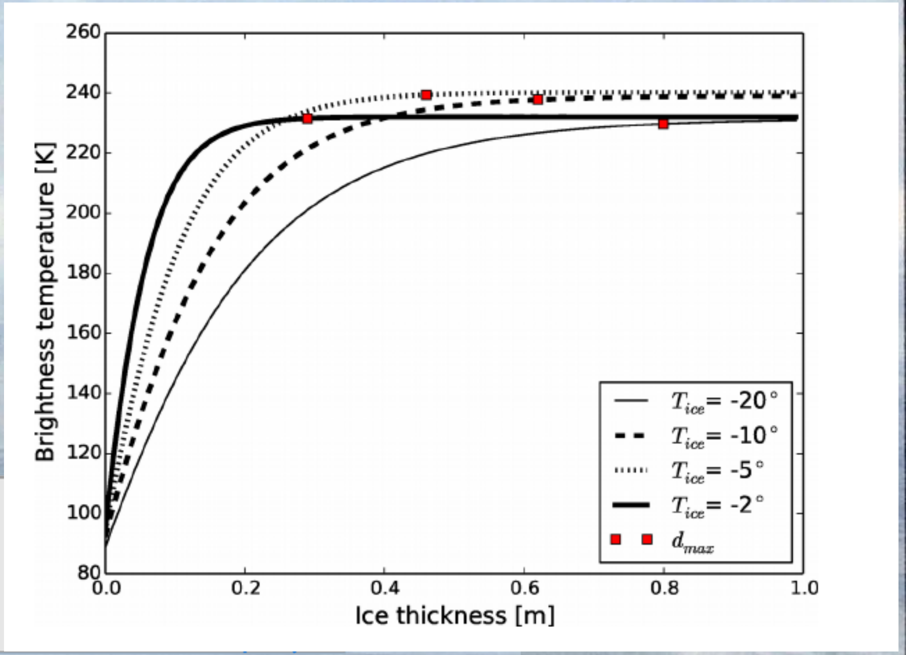
IMPROVES



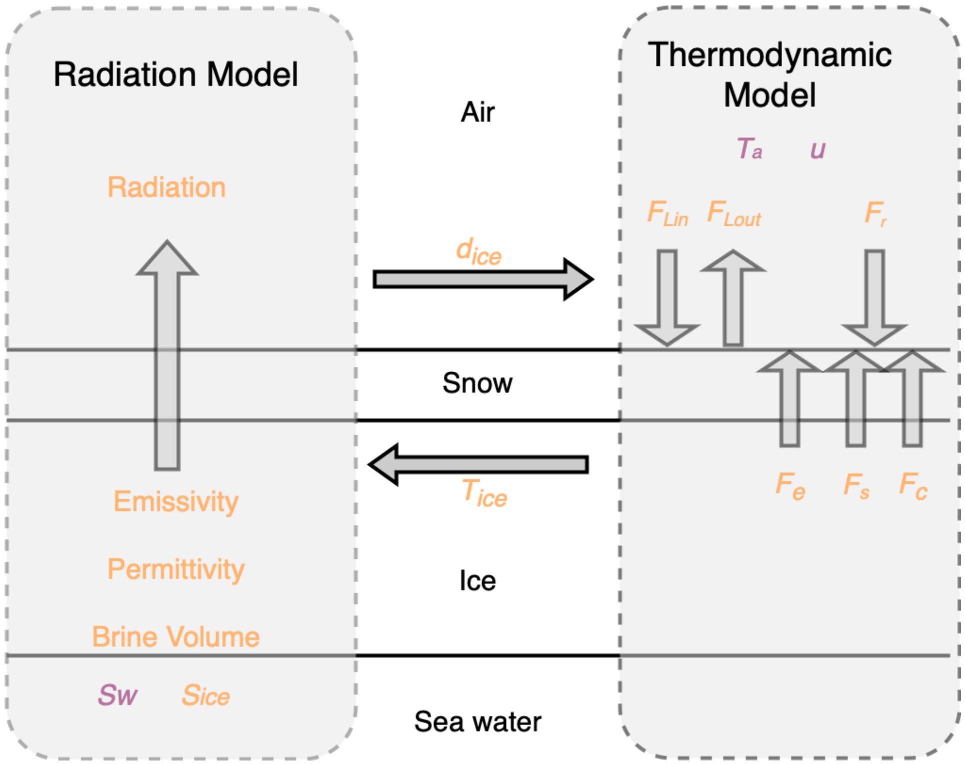
Multibeam Echosounder ©British Antarctic Survey

Sea ice thickness from SMOS



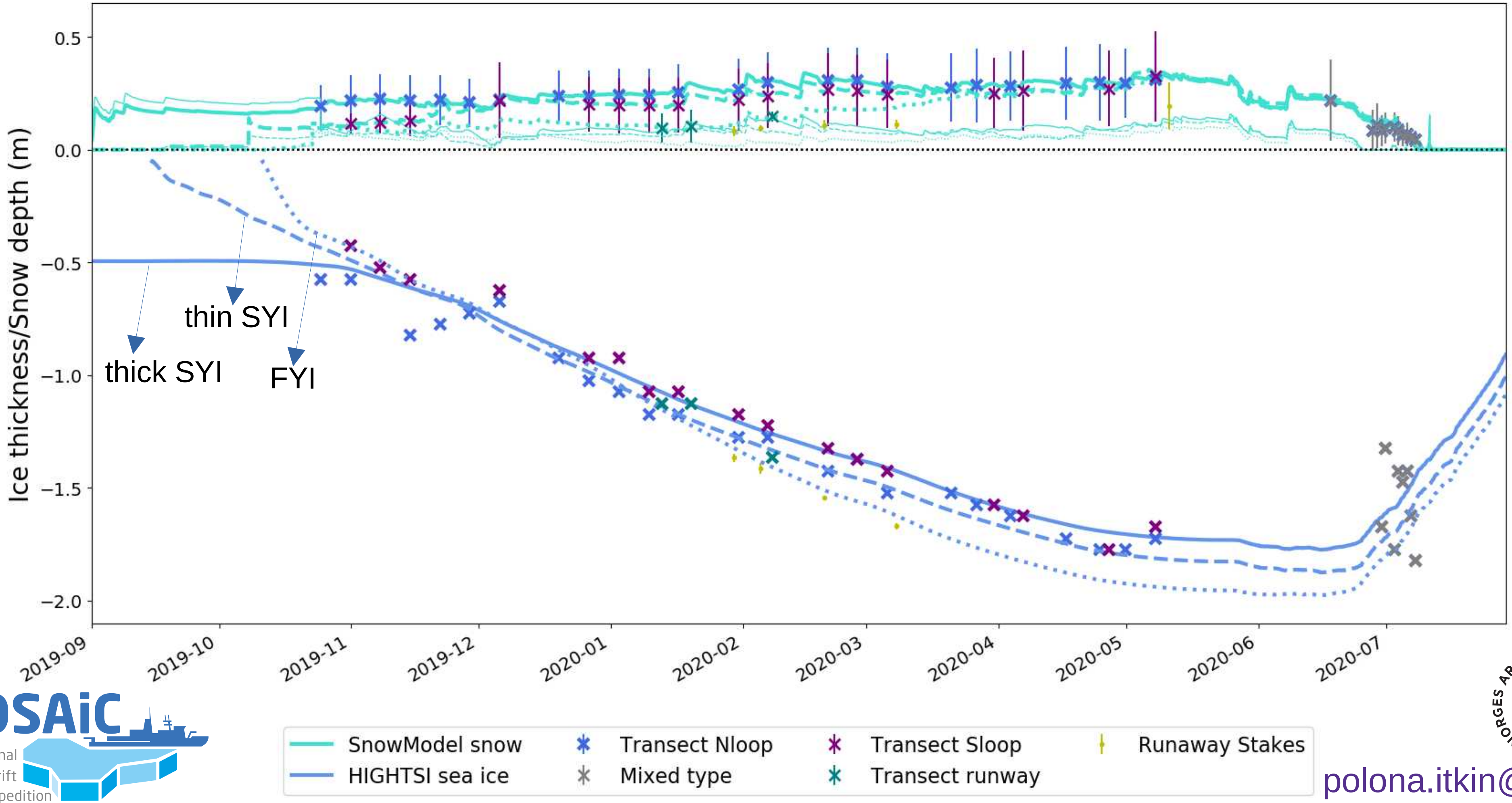


Retrieval algorithm



- Radiation model consists of snow, ice and sea water layers
- Linear temperature profile is assumed in the snow and ice layers
- Snow layer is considered to be transparent in L-band
- Bulk ice temperature and bulk ice salinity calculated with iteration method
- Auxiliary data needed: surface ice temperature and wind speed from JRA55 reanalysis; Sea surface salinity from model output
- Radiation model can be used for assimilation in ocean-ice models as a "forward operator"

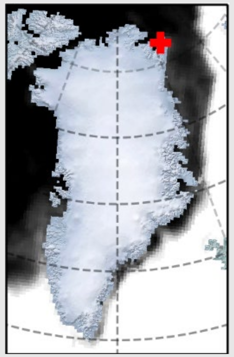
Combining observational data with numerical models to obtain a seamless high temporal resolution seasonal cycle of snow and ice



polona.itkin@uit.no

1) Objective: investigate the current state of Fürkeleferner as a basis for understanding the glacier response to the climate during the last glacier advance of the little ice age and in the 21st century

- COupled Snowpack and Ice surface energy and mass balance model in PYthon (COSIPY)
- measured atmospheric data, field data of glacier mass balance, albedo and glacier extent
- adaptation of DEM



2) Objective: improving snow modelling in the Arctic to study the impact of light absorbing impurities on snow properties and snow surface albedo

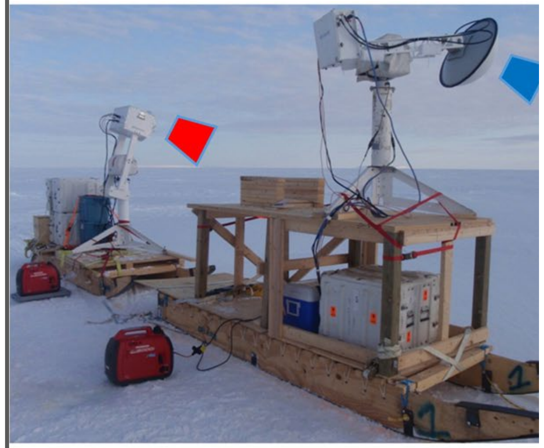
- snow model Crocus
- atmospheric measurements vs reanalyses
- measured snow properties and impurity content

daniela.krampe@awi.de

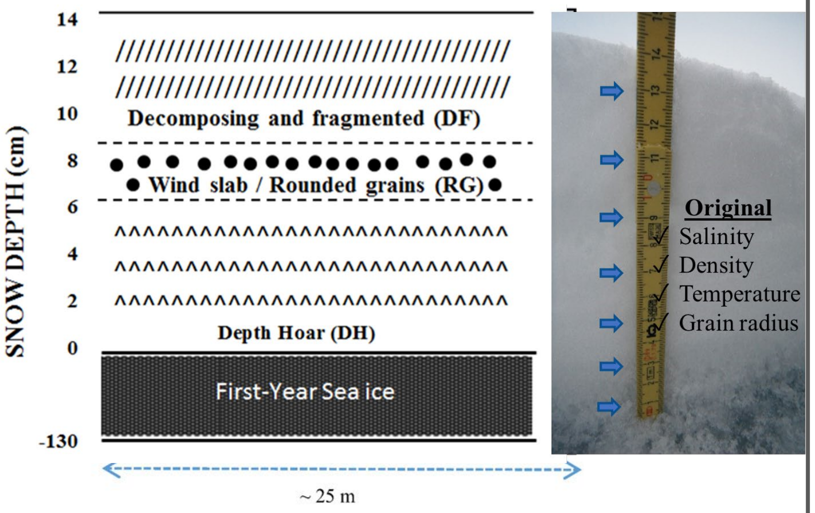
Microwave Remote Sensing of snow-covered Arctic Sea Ice using Multi-frequency Radar

Determine the salient snow thermophysical properties that influence Ku-, X-, and C-band microwave signatures from relatively smooth snow-covered FYI

Scatterometer Data



Snow Property Data



Resolute Bay Campaign 2012 (Nandan et al. 2016)

Snow-covered Sea Ice Modelling

Sensitivity Analysis

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