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ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

Digital twins: fast flyby X-ray CT of polar firn

EGU 2024
Session CL 1.2.4:
State of the art in ice core science
Poster X5.183
18th April 8:30-12:30

A freshly drilled firn core…

and its three dimensional reconstruction by X-CT

Background:

- Firn is a highly stratified porous medium
- There is layer specific densification

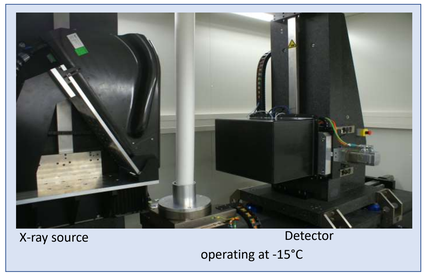
Research question:
What is the role of firn's microstructure in densification, gas transport and gas enclosure?

Problem:

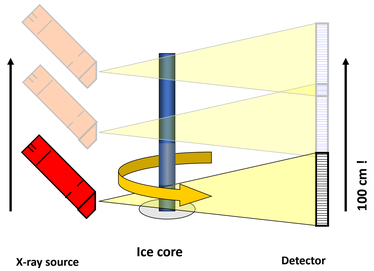
- Lack of microstructure data

Aim of this study:
Development of a method to retrieve **contiunuous records of three-dimensional firn structure** from surface down to firn-ice transitions applicable to archive pieces of firn cores

Method:

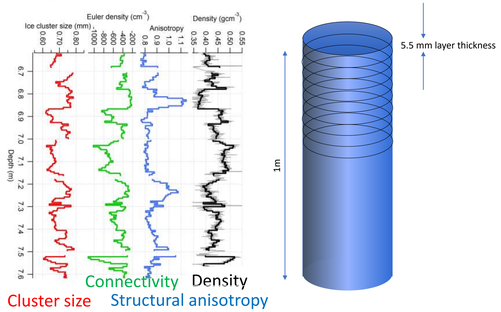


AWI-iceCT especially designed for ice core applications

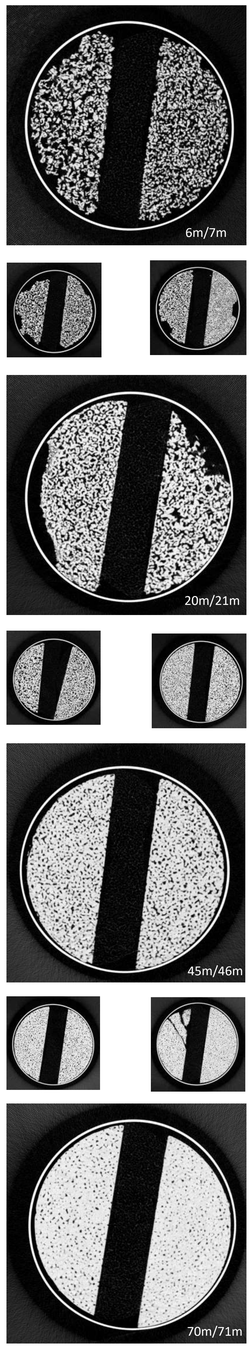


Flyby recording in helical mode under a time optimized measurement protocol:
Scan time: 100ms exposure time **25min/1m ice**
Resolution (x,y,z): 120µm in x,y,z dimensions
-> 10^6 horizontal slides/100m
Scan parameters: 140 kV, 84 W beam energy,
~ 800 proj/rotation -> 13000 projections
Preprocessing: denoising, image segmentation, outlier identification

Calculation of structure parameters
for each volume layer of 5.5mm thickness, resulting in 180 data points per firn meter



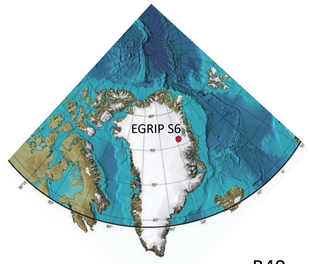
Example: 1m core segment EGRIPS6 NE-Greenland



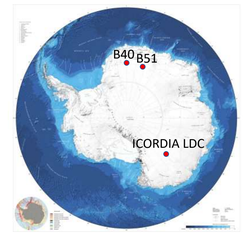
EGRIP S6: horizontal cross sections of half-core archive pieces

Firn core locations:

Ice repository, AWI, Bremerhaven



EGRIP-S6
(75.6°N, 36°W)
T_{annual} ≈ -30°C
A = 138 mm weq/a



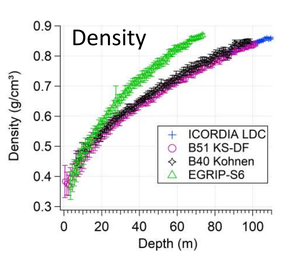
B40
(75°S, 0°E)
Kohnen station
T_{annual} ≈ -42°C
A ≈ 70 mm weq/a

B51
(75.1°S, 15.4°E)
T_{annual} ≈ -50°C
A ≈ 40 mm weq/a

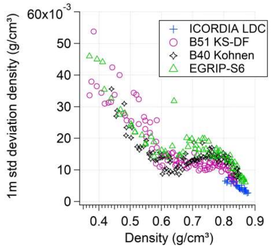
ICORDIA
(75°S, 123°E)
LDC - BOI
T_{annual} ≈ -55°C
A ≈ 25 mm weq/a

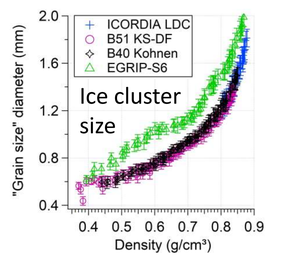
First results and conclusions:

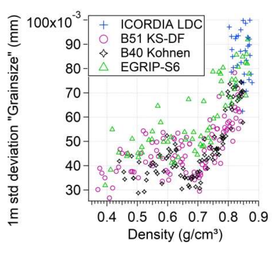
1m averaged profiles

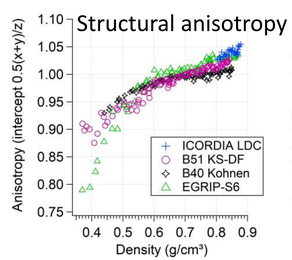


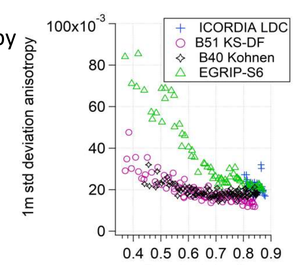
Layering (1m std dev)



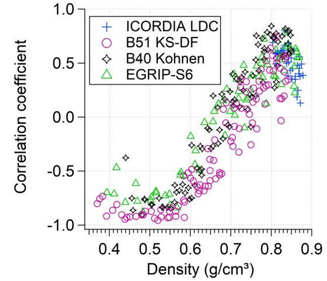








Grain size-density correlation



Stage I (density<0.6g/cm³)
- „Grain size" inverse correlated to density
- Decreasing density layering
- Low „grain size" layering
- Decreasing structural anisotropy (vertically aligned)

Stage II (0.6g/cm³ < density < 0.83g/cm³)
- Evolving of positive correlation between „Grain size" and density
- Second maximum in density layering
- Increasing „grain size" layering (density>0.7g/cm³)
- Increasing structural anisotropy (horizontally aligned)

More results can be shown in laptop presentation
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