

Mesurer les textures cristallographiques dans la neige

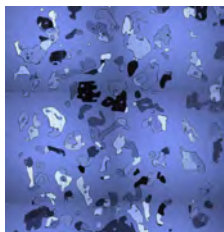
M. Montagnat, Neige Calonne, Martin Schneebeli, Matthias Jaggi,
Henning Löwe, Margret Matzl

IGE, CNRS, Univ. Grenoble Alpes, France
SLF-WSL Davos, Suisse

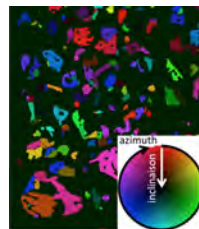
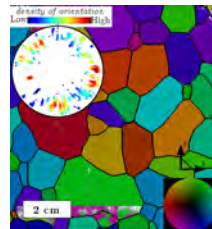
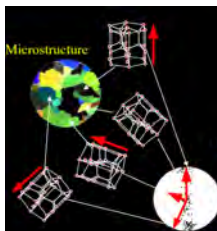
Vendredi 8 mars 2019



Texture and microstructure in ice and snow



Microstructure → grains
(crystals) size and shape

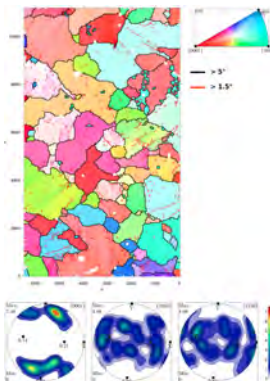
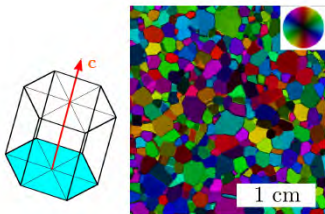


Texture → grains (crystals)
orientations

How do we measure textures

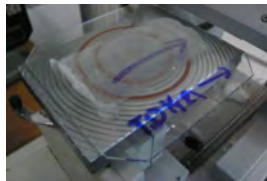
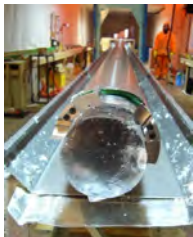


Optical measurements
of c-axis orientations



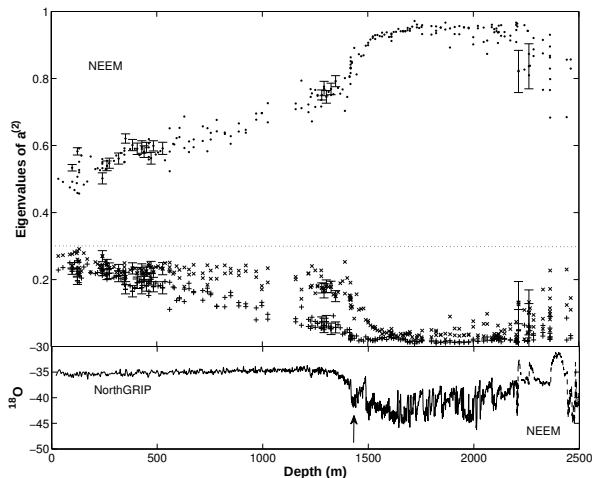
Electron BackScattering Diffraction
EBSD

Observations along deep ice cores



Observations along deep ice cores

Evolution of texture $\rightarrow$ eigenvalues a_1 , a_2 and a_3 of $\mathbf{a}^{(2)} = \sum \vec{c} \times \vec{c}$



$$a_1 + a_2 + a_3 = 1$$



$$a_1 \sim a_2 \sim a_3 \sim 0.3$$

$$a_1 \gg a_2 \sim a_3$$

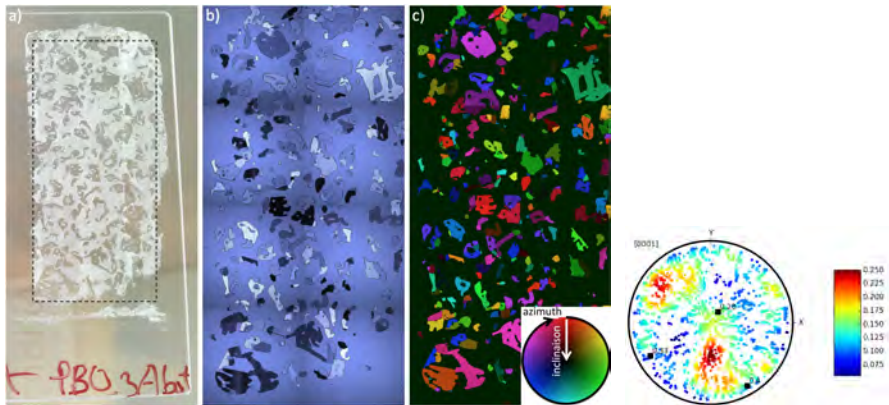
$$a_1 \sim a_2 \gg a_3$$

Impact of climate conditions
Impact of stress state (shear)

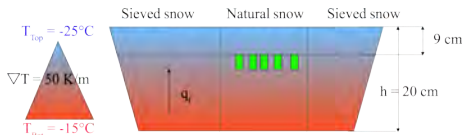
What about snow ?

General thinking $\rightarrow$ $\sim$ isotropy at snow fall, no texture evolution in the snowpack

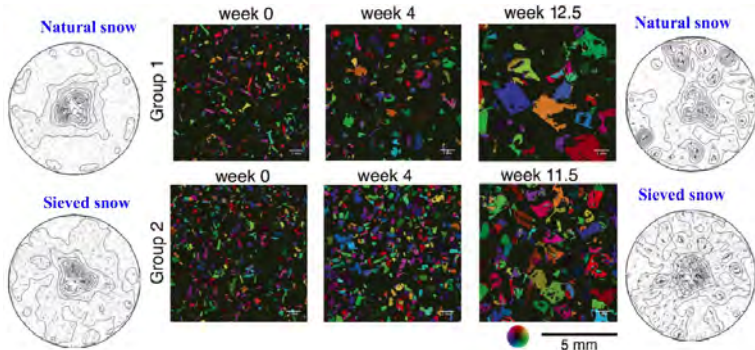
How to measure texture in snow (SLF)



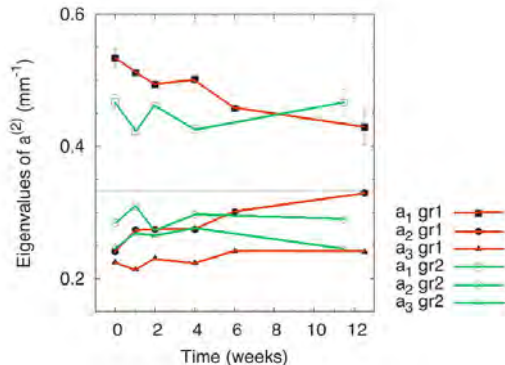
Snow texture and metamorphism



Natural snow $\rightarrow$ low density
 Sieved snow $\rightarrow$ high density



Snow texture and metamorphism



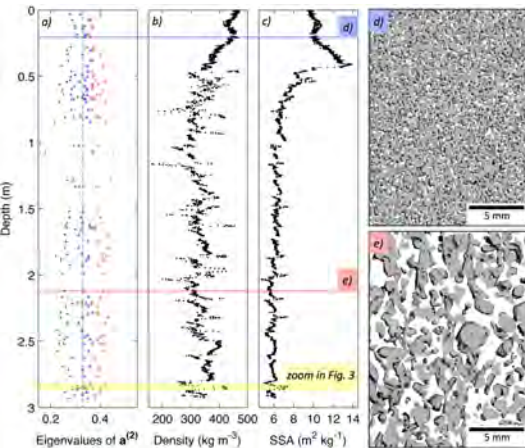
In **low density** snow :
evolution from
"single-max" texture
($a_1 > a_2 \sim a_3$)
to "girdle" texture
($a_1 \sim a_2 > a_3$)

- **Snow can be anisotropic at falling**
- **Texture can evolve with metamorphism**

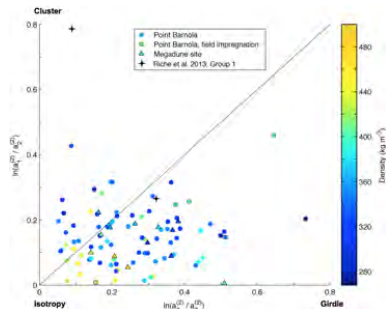
Riche et al. 2013, J. of Glaciol.

Antarctic snow texture

Point Barnola (near Dome C) :
very low T (-80°C / -25°C), very low accumulation ($25 \text{ kg m}^{-2}\text{yr}^{-1}$)



Calonne et al. 2017, EPSL

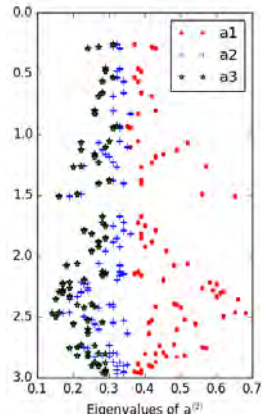
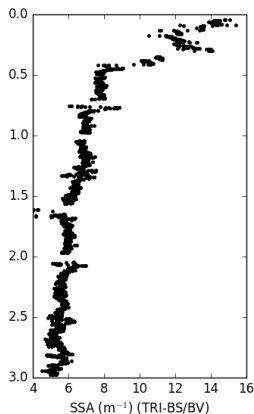
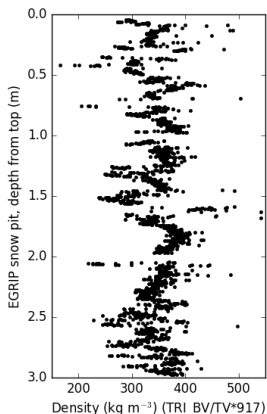


Low density snow :
girdle-type texture

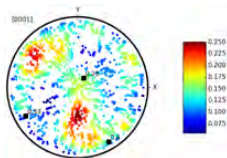
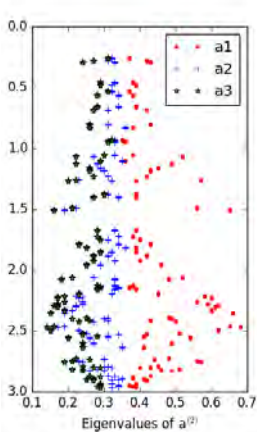
Greenland, EastGRIP, snow texture

EastGRIP (East of Summit) :

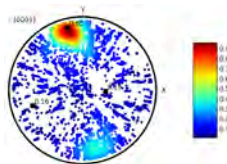
high T (-35°C / -5°C), high accumulation ($101 \text{ kg m}^{-2}\text{yr}^{-1}$)



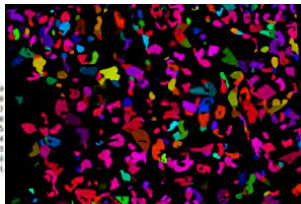
Greenland, EastGRIP, snow texture



$$a_1 \sim a_2 \sim a_3 \sim 0.3$$



$$a_1 \gg a_2 \sim a_3$$

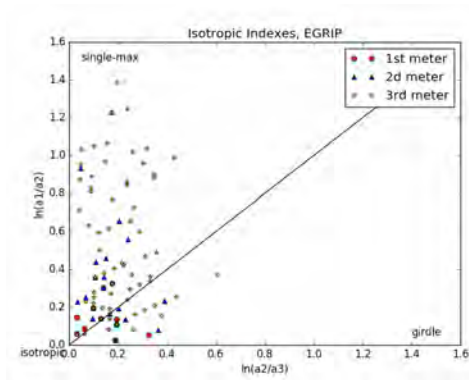


Evolution with depth toward a clustered texture !

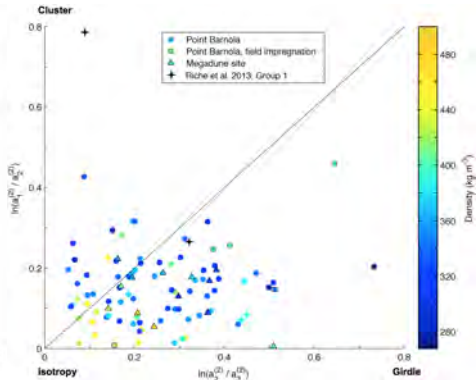
Strong "chain-like" microstructure

Greenland, EastGRIP, snow texture

EastGRIP isotropy indexes

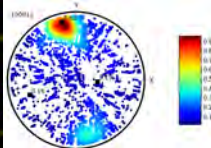
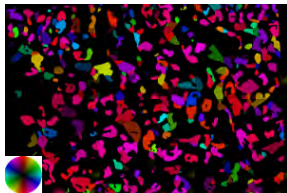


Point Barnola isotropy indexes

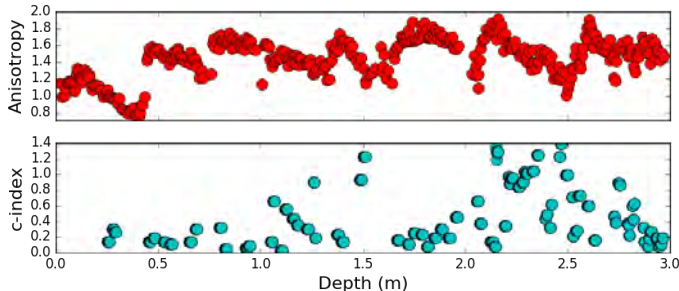


Textures et microstructures - Origine de l'anisotropie ?

EastGRIP, Groenland, 0 - 3 m



Echantillon à 2,46 m
Texture en "cluster"
fortement concentrée
(cluster-index $\sim 1,4$)



Anisotropie
(microstructure)
et cluster index
(cristallo)

A few concluding points

- Distribution of crystallographic orientation - texture - is a key parameter for mechanical behaviour of ice
- Texture in snow has been recently explored
- Texture in snow seems to be influenced by metamorphism + stress conditions
- What is the effect on mechanical behaviour of snow ?
- What could be the influence on snow - firn densification mechanisms ?