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Microstructure in EastGRIP

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The behaviour of Earth's ice sheets is intensely monitored via surface and remote sensing techniques to improve predictions of sea level evolution. In the 3rd dimension however, in particular concerning the ice material properties, this behaviour can only be studied via ice core drilling. Material properties control the deformation in general, and specifically the strain localization such as observed in ice streams, which supply the major discharges into the oceans.

Currently, the first ice core on an active ice stream, the North-East Greenland Ice Stream (NEGIS) is being drilled. EastGRIP (East Greenland Ice-Core Project) drilling started in 2016 and will likely be ongoing until 2019. This is the first chance to study ice fabrics from a dynamically active region, with a deformation regime differing from the usual locations of previous long ice cores, which are usually situated on domes or on ice divides.
We will present the results from the CPO (c-axes fabric) and the grain size measurements of the uppermost 350 m, which is the depth to which the ice core has been processed for analysis so far.
54 core pieces (bags) were selected for measurements, with a minimum depth resolution of 10 m. From these 275 thin sections were prepared in total, and measured and processed on site by means of an Automated Fabric Analyzer and a Large-Area-Scanning Macroscope (LASM). Mostly entire bags have been measured, to ensure constrains on small-scale variability with depth.

The CPO patterns found in the upper 350 m at EastGRIP show (1) a more rapid evolution of c-axes anisotropy with depth compared to other ice cores and (2) partly novel characteristics in the c-axes distributions.

(1) The microstructural measurements begin at a depth below the firn ice transition at 118 m. Starting with a very broad single maximum distribution, the alignment of the c-axes happens much more rapidly with depth than seen in ice cores from divides or domes. In our deepest samples available (350 m) we observe an anisotropy of a strength comparable to samples from $\sim$1000 m depth at for example GRIP, NEEM and EDML.

(2) Between 118 m and 160 m depth the almost random to very broad single maximum is similar to shallowest samples in other ice cores. Classically, we interpret this distribution as a result of vertical compression caused by the weight of overlying layers. An alternative interpretation may be a snow metamorphosis influenced by the temperature gradient. This weak pattern is, however, quickly overprinted in 160 m to 200 m, where a progressive evolution to girdle distribution is observed. Such a vertical great girdle can evolve with extension along flow, and, thus, the observed distribution indicates that the ice at this depth is deforming under conditions close to pure shear, rather than being translated by rigid block movement. This early-onset of deformation seems further supported by the observation of a broad "hourglass shaped" girdle, developing into a "butterfly shaped" cross girdle, which is observed for the first time in ice.