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Modelling of Radio Echo Isochrone Response by Highly Stratified Ice-Sheets

C.-C. Lin (1) and M. Tschudi (2)

(1) European Space Agency (ESTEC), 2200 Noordwijk, The Netherlands (chung-chi.lin@esa.int), (2) Swiss Federal Institute of Technology, 1015 Lausanne, Switzerland (matthias.tschudi@epfl.ch)

Radio echo sounding is a powerful technique for visualising internal structure of thick ice-sheets over Antarctica and Greenland. Several airborne and sled-carried sounding radars at various frequencies have been deployed since 1960s. Initially, the efforts concentrated on detecting the bedrock for estimating the ice thickness and bottom topography. More recently, attentions have been expanded to visualising internal layering for ice-flow studies. Layering information, derived from the radar observations, is now used for the study of three-dimensional ice flow and its past evolution through ice-sheet modelings. The information is also used to relate the ice-core profiles extracted from one drilling site to the others. The goal of this investigation was to advance the understanding of the relationship between the ice-sheet internal structure and the radar response, in particular for the interpretation of the isochrone response.

The study included:
- an electromagnetic modelling work on radar wave interaction with stratified ice-sheet in order to establish a relationship between its internal structure and the radar response. Computer simulations in one dimension (in depth) were performed which were sufficient for understanding the basic physics of the interaction. The simplified model is able to cope with a very large number of stratification layers exceeding 10,000 on a normal PC. Different radar system bandwidths were considered for assessing the dependence of the response.
- an analysis of the effects of bi-refringence of aligned crystals on the radar response using the tools developed above.
- processing of the P-band sounding data acquired over Greenland by ESA's POLARIS (POLarimetric Airborne Radar Ice Sounder) using the existing SAR processing tools for comparison with the results of the simulations.

The simulation results showed that the typically observed isochrone responses are the result of multiple interferences among the reflections created by the thin stratification as a result of annual snow accumulations. The thickness of the individual layers has a strong influence on the amplitude of the echoes. Those interference patterns appear only when the stratification is irregular, i.e. when the layer thickness and dielectric constant have a random distribution around some mean values which can evolve along the depth. Both constant and exponential density profiles in depth have been considered.

The presentation will summarise the key results of the investigation.