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Implication of ice flux on the geometry of basal freeze-on plumes

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In recent radio echo sounding (RES) surveys in Greenland and Antarctica large plume-like features in internal ice layer structures are seen. These large-scale anomalous structures rise from the bed to up to half of the ice thickness and commonly extend horizontally over several ice thicknesses. Numerical ice sheet flow models applying ice accretion at the base are able to reproduce such layer structures.
Here I explore the geometry of these plume-like features in relation to ice dynamics. From theoretical considerations, based on mass continuity, a simple quantification of plume height is derived that depends on balance ice flux and on its vertical deformation profile. The dominant factor controlling plume height is thereby given by the ratio between the ice flux originating from basal freeze-on and the surface balance flux. It further implies that for relatively high plumes the vertical shape function profile in flux is of secondary importance, but of increasing importance for smaller plumes.
Based on this concept, the ice flux originating from freeze-on at the bed can therefore be estimated from the observed relative plume heights. This provides direct constraints on rates of basal freeze-on, which is otherwise very difficult to quantify. This concept is explored on the example of observed plumes in North Greenland.