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The distribution of basal melting and freezing underneath the West Antarctic Ice Sheet. Implication for the Holocene decay of the ice sheet.

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Moderate flowing ice stream tributary connect the stagnant interior of the West-Antarctic Ice Sheet (WAIS) with the fast flowing Siple Coast ice streams. Basal water underneath these ice streams reduces basal resistance and enables the fast motion of the ice. Basal melting of ice is the only source for this basal water. Therefore it is important to include the distribution of basal melting and freezing into numerical models assessing the stability of the WAIS. However it is very difficult to constrain the distribution of basal freezing and melting from field observations.

Borehole observations confirmed the presence of basal water at Byrd Station in the WAIS interior and at different locations in the Siple Coast ice streams. The recent discovery of a 12 to 25 m thick basal ice layer however indicates that either basal freezing is currently occurring or had occurred up stream of its current location. As these direct observations in the vicinity of the WAIS are limited, we are currently using finite different models to assess and quantify the spatial and temporal distribution of basal melting and freezing in West Antarctica.

Taking into account the uncertainty in the geothermal heat flux and the basal resistance first results of the modeling indicate that the observed basal ice layer has important implication for the stability of the WAIS. The main results of the model are that it is likely that the basal ice layer has formed in the northern Tributary of Ice Stream C and that basal ice is currently forming in parts of the tributaries of Ice Stream C and D. The presence of the12-25-m-thick basal ice layer request that either a) flow in the ice stream tributaries had stopped in the past and the temperature at the bed was below the pressure melting point or b) that basal resistance in the tributaries is with 1 to 10 kPa similar small to the basal resistance in the ice streams. The results further suggest that basal melting was highest in the early Holocene possibly initiating the rapid decay of the ice sheet.

From the calculation it is sofar unclear if this decay of the WAIS is currently at the end or if the retreat of the ice sheet will continue into the future. The results of the model are sensitive to small perturbation in the basal energy balance, which could either lead to further collapse through increased lubrication or to a stoppage of the Holocene ice sheet decay through an increase in basal resistance. We therefore postulate the testable hypothesis that the basal energy balance is negative over large areas in the Siple Coast ice stream tributaries and the formation of basal ice increases basal resistance. To test this hypothesis further research and the acquisition of field data is necessary to decrease the uncertainties in the basal energy balance calculations and so to increase the chance to successfully predict the future behavior of the WAIS.