Comparison of thermodynamics solvers in the polythermal ice sheet model SICOPOLIS

*Ralf Greve[1], Heinz Blatter[1,2]

1.Institute of Low Temperature Science, Hokkaido University, 2.Institute for Atmospheric and Climate Science, ETH Zurich, Switzerland

In order to model the thermal structure of polythermal ice sheets accurately, energy-conserving schemes and correct tracking of the cold-temperate transition surface (CTS) are necessary. We compare four different thermodynamics solvers in the ice sheet model SICOPOLIS (www.sicopolis.net). Two exist already, namely a two-layer polythermal scheme (POLY) and a single-phase cold-ice scheme (COLD), while the other two are newly-implemented, one-layer enthalpy schemes, namely a conventional scheme (ENTC) and a melting-CTS scheme (ENTM) (Blatter and Greve, 2015, Polar Sci. 9, 196-207). The comparison uses two scenarios of the EISMINT Phase 2 Simplified Geometry Experiments (Payne and others, 2000, J. Glaciol. 46, 227-238), one with no-slip conditions at the base and one with basal sliding. In terms of temperate ice layer thickness, CTS positioning and smoothness of temperature profiles across the CTS (a requirement for the assumed case of melting conditions), the POLY scheme performs best, and thus its results are used as a reference against which the performance of the other schemes is tested. Both the COLD scheme and the ENTC scheme fail to produce a continuous temperature gradient across the CTS, and both overpredict temperate ice layer thicknesses to some extent (the COLD scheme more). In the ENTM scheme, a continuous temperature gradient is explicitly enforced. This scheme is more precise than ENTC for determining the position of the CTS, while the performance of both schemes is good for the temperature/water-content profiles in the entire ice column. Therefore, the one-layer enthalpy schemes ENTC and ENTM are viable, easier implementable alternatives to the POLY scheme with its need to handle two different numerical domains for cold and temperate ice.

Keywords: Ice sheet, Thermodynamics, Polythermal ice, Enthalpy method, Modeling