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A correction factor for positive degree-day modeling of ice sheet surface melt under changing orbital configurations

Alexander Robinson (1,2,3), Heiko Goelzer (4), and Philippe Huybrechts (4)

(1) Universidad Complutense de Madrid, Madrid, Spain (robinson@fis.ucm.es), (2) Instituto de Geociencias (IGEO), CSIC-UCM, Madrid, Spain, (3) Potsdam Institute for Climate Impact Research, Potsdam, Germany, (4) Earth System Sciences & Departement Geografie, Vrije Universiteit Brussel, Brussels, Belgium

Positive degree-day (PDD) models have commonly been used to approximate continental ice sheet surface melt for the last two decades. The approach is advantageous in that it approximates present-day surface melt reasonably well and it is computationally very efficient. However, the empirical coefficients used to translate PDDs into melt are tuned to present-day conditions and thus may not be appropriate for use under other orbital configurations.

Here we explore to what extent the current formulation of a PDD melt equation affects melt estimates for different levels of orbital-scale insolation changes. We find that insolation anomalies can cause large discrepancies between melt calculated using PDDs and using a simple energy-balance equation. However, higher temperatures reduce the effect of the insolation anomaly since its relative importance decreases in the energy balance. We introduce a correction factor for the PDD model that accounts for changes in insolation and improves the agreement of melt estimated by the two different methods. A particular feature of this factor is that it is fully consistent with current PDD models for present-day insolation. The new insolation-corrected PDD formulation is further tested with transient simulations of the Greenland ice sheet for the Eemian.