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Inland Ice-Sheet Bed Topography Estimations from Satellite Surface Measurements and a Reduced Uncertainty Flows Model

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Bed topographies beneath inland ice-sheets, Antarctica in particular, are estimated by Kriging between (very) sparse measurements (airborne campaings) or from gravity field inversions; the resulting uncertainties may be large. The present study proposes a new hybrid inverse method, combining physical-based model and data-driven model, to estimate bed topographies beneath glaciers in slow and moderatly fast flows areas. This inverse problem is challenging since the measured surface signatures integrate a mix of the bottom features signature (bed elevation and friction-slip amount) and the internal deformation signature (including uncertain vertical temperature profiles). The first key step of the method is the derivation of a "Reduced Uncertainty" (RU) version of the Shallow Ice Approximation (SIA) model taking into account non constant temperature fields (ahnce non constant creep parameters) and slipping at the base. The resulting RU-SIA model natively contains a single uncertain (dimensionless, multi-physics) parameter γ; moreover it natively integrates the surface measurements (acquired by altimetry and InSAR) in its coefficients. The next key steps of the method are advanced Variational Data Assimilation (VDA) formulations combined with estimations of this (single) dimensionless parameter γ by neural networks. (This last data-driven model is based on the depth measurements datasets).
Numerous numerical experiments demonstrate the robustness of the method and its relatively good accuracy. The estimations obtained in a few East Antarctica Ice-Sheet areas are analysed in detail and compared to BedMap2.

References
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