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Evaluating the hydrostatic equilibrium of the subglacial Lake Vostok, Antarctica, using a precise regional geoid model

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We present a study on the determination and application of a precise geoid model for the region of the subglacial Lake Vostok, Antarctica.
The geoid model is derived by combining a global satellite-only geopotential model mainly based on GOCE data with dense airborne gravity data and topographic information. Ice-thickness data and lake water depths are used for a residual terrain modelling (RTM) in a remove-restore approach. In that context, special focus is given to the correct treatment of the ice sheet when computing the residual terrain effects.
The use of the refined regional geoid model for glaciological and geophysical applications is exemplarily demonstrated by means of the hydrostatic equilibrium surface (HE) of the lake. It was found that the mean quadratic residual geoid signal is about two times larger than the estimated deviations of the HE surface. Thus, the significance of the refined geoid solution is proven.
In this context, a comparison with the strictly computed geopotential shows that the estimated apparent lake level may be expressed as a constant metric bias w.r.t. to the quasigeoid. Furthermore, the HE condition is used to derive an adjusted estimate of the lake water density. However, in this case the theoretical latitudinal trend of the equilibrium surface needs to be taken into account. Finally, the (hypothetical) deviations from the HE state at and around the shoreline of the lake indicate candidate outflow locations in case of a possible depletion event.