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Full Stokes dynamics at the Shirase Drainage Basin, Antarctica and comparison to the shallow ice approximation
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Covering an area of 2 x 105 km^2, the Shirase Drainage Basin is located in East Antarctica (37-50^o E, 70-78^o S). The basin is characterized by the convergence of the ice flow towards the Shirase glacier, one of the fastest flowing glacier in Antarctica. The Shirase glacier flows at a speed of 2.3 km a^{-1} at the grounding line (Rignot, 2002; Pattyn and Derauw, 2002; Nakamura and others, 2008) and drains about 10 Gt a^{-1} of ice through a narrow outlet into the Lutzow-Holm Bay (Fujii, 1981). With nearly 90% of total ice discharge from the basin being calved by the glacier, the fast flowing nature of the Shirase glacier is important for the investigation of the ice sheet mass budget in this region.

The dynamics of the Shirase glacier is investigated by means of the full Stokes equations and the shallow ice approximation. The model Elmer/Ice (http://elmerice.elmerfem.org) is applied to the Shirase Drainage Basin and employs the finite element method to solve the full Stokes equations, the temperature evolution equation and the evolution equation of the free surface. The shallow ice approximation is also implemented into Elmer/Ice so that both the full Stokes and the shallow ice approximation are computed on the same mesh. Data for the present geometry (surface and basal topographies with no shelf) are obtained from the BEDMAP2 data set (Fretwell and others, 2012) and a mesh of the computational domain is created using an initial footprint which contains elements from 15 km to 500 m horizontal resolution. The footprint is vertically extruded to form a 3D mesh of 240720 elements with 21 equidistant, terrain-following layers.

The approach taken in this study is to compare the response of the glacier to dynamical and climate forcings when separately the full Stokes and the shallow ice approximation are employed. The sensitivity experiments are modeled after the SeaRISE 2011 experiments (http://tinyurl.com/srise-lanl, http://tinyurl.com/srise-umt). Set C (three experiments) applies a change to the surface precipitation and temperature, Set S (three experiments) applies an amplification factor to change the basal sliding velocity and Set T (one experiment) combines the forcings. The experiments are compared to a constant climate control run beginning at present (epoch 2004-1-1 0:0:0) and running up to 100 years holding the climate constant to its present state. The present state of the glacier velocities and temperature field is obtained by computing a steady-state configuration for both the full Stokes as well as the shallow ice model.

キーワード: Shirase drainage basin, Antarctica, full Stokes, ice sheet modeling
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