Manufactured solutions and the verification of three-dimensional Stokes ice-sheet models

Objective

Develop analytic solutions for verification of isothermal, nonlinear Stokes ice sheet models

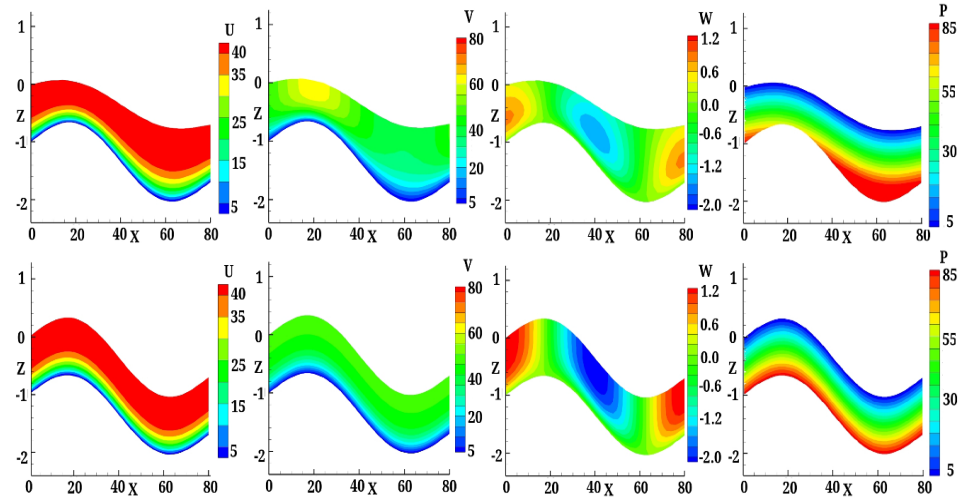
Approach

- Apply manufactured solution technique to develop analytical solutions for nonlinear Stokes flow
- Use standard glaciological benchmark tests for initial conditions
- Verify Stokes-flow model using the new manufactured solutions

Convergence of Stokes model solution errors for velocity and pressure (for a linear model, factors of 2 and 3, respectively, are expected).

Mesh	DOF	Velo. error	Conv. rate	Pres. error	Conv. rate
20×20×5	56 184	2.67×10^{1}	–	1.91×10^{1}	–
40×40×10	424 364	4.00×10^{0}	2.74	6.70×10^{0}	1.51
80×80×20	3 296 724	3.16×10^{-1}	3.66	1.82×10^{-1}	1.88
160×160×40	25 985 444	6.30×10^{-2}	2.33	5.66×10^{-2}	1.68

Cross sections (x,z) of 3d, manufactured, analytic velocity (u, v, w) and pressure (P) solutions at time = 100 years (top row) and time = 1000 years (bottom row).



Impact

- Analytic solutions for use in verification and validation (V&V) of time-dependent, three-dimensional, isothermal, nonlinear Stokes ice sheet models
- Verification of existing Stokes model and confirmation of model error convergence

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