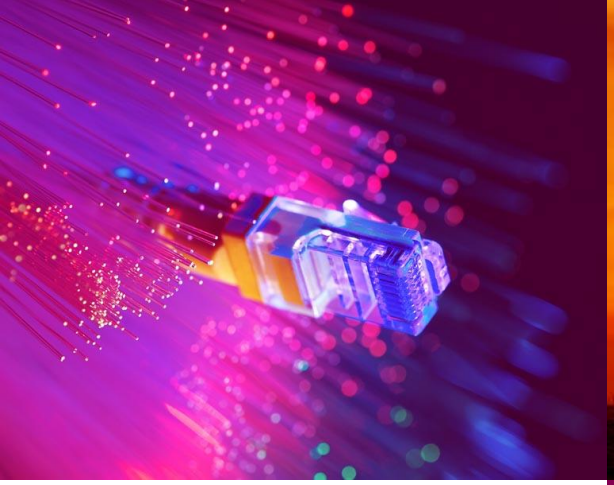

Work in progress

Thomas Zwinger

CSC – Suomalainen tutkimuksen, koulutuksen, kulttuurin ja julkishallinnon ICT-osaamiskeskus

Current developments

A simple permafrost model

Journal of Glaciology, Vol. 46, No. 153, 2000

A numerical investigation of ice-lobe–permafrost interaction around the southern Laurentide ice sheet

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A simple permafrost model

- Single heat transfer equation for mixtures: $$\frac{\partial}{\partial z}\left(K\frac{\partial T}{\partial z}\right) = C\frac{\partial T}{\partial t}$$
- Apparent volumetric heat capacity: $$C = C_{\mathrm{v}} + L\frac{\partial \theta_{\mathrm{u}}}{\partial T}$$
- Volumetric water content: $$\theta_{\mathrm{u}} = \begin{cases} (\rho_{\mathrm{b}}/\rho_{\mathrm{u}})aT_*^b & (T < T_{\mathrm{pmp}} - \Delta T) \\ \theta_{\mathrm{t}} & (T \geq T_{\mathrm{pmp}} - \Delta T) \end{cases}$$
- Effective conductivity by weighted geometric mean: $$K = K_{\mathrm{b}}^{\theta_{\mathrm{b}}} K_{\mathrm{u}}^{\theta_{\mathrm{u}}} K_{\mathrm{i}}^{\theta_{\mathrm{i}}}$$

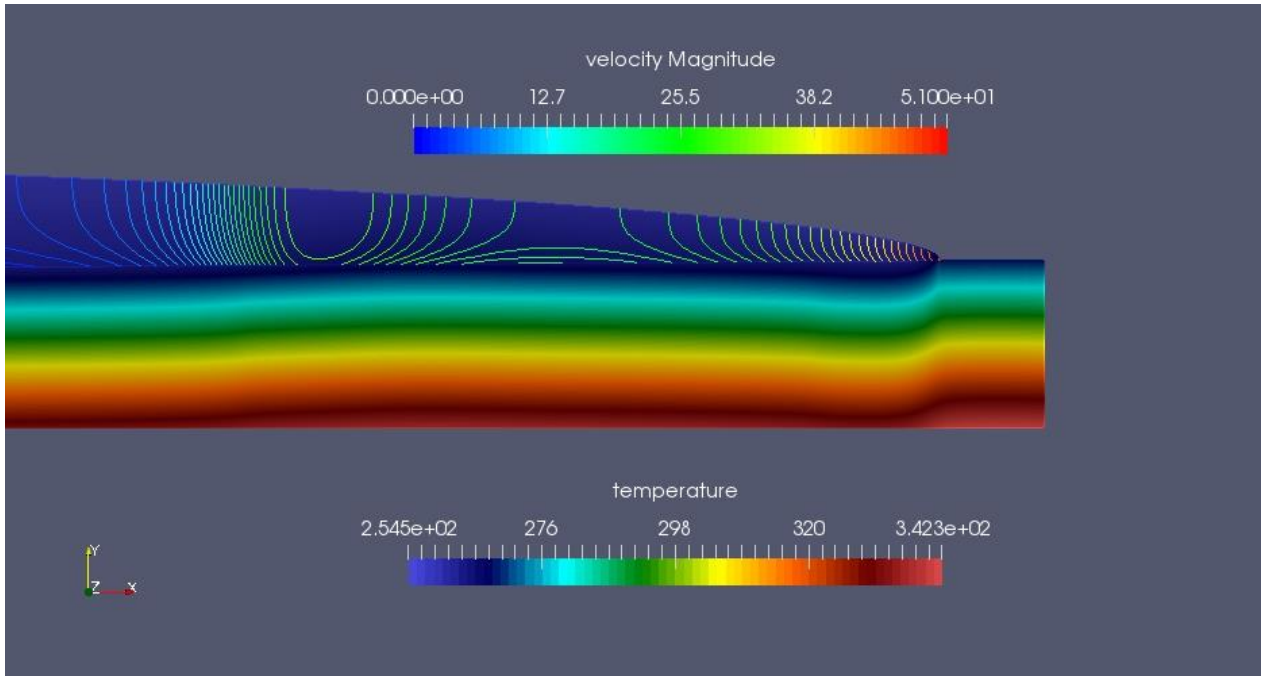
bedrock water ice

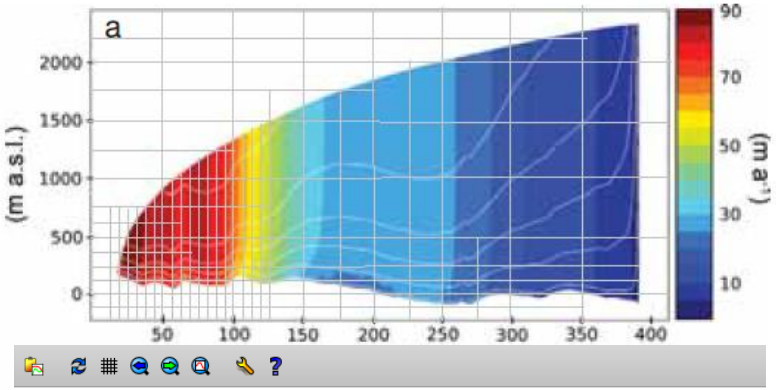
- Effective volumetric heat capacity:

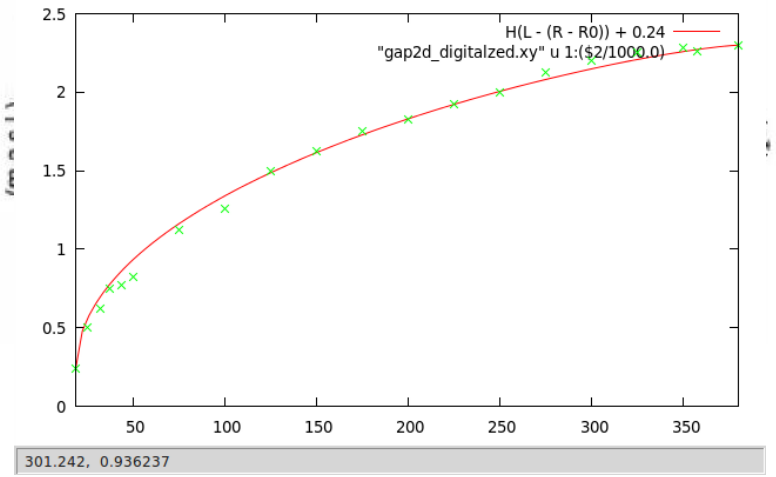
$$C_{\mathrm{v}} = \theta_{\mathrm{i}}C_{\mathrm{i}} + \theta_{\mathrm{u}}C_{\mathrm{u}} + \theta_{\mathrm{b}}C_{\mathrm{b}} \qquad \theta_{\mathrm{b}} = 1 - \theta_{\mathrm{t}}, \qquad \theta_{\mathrm{t}} = \theta_{\mathrm{u}} + \theta_{\mathrm{i}}$$

A simple permafrost model

- GAP test-site: Brinkerhoff et al., 2015
- Looks almost like a Bueler profile
- Based on steady state assumption



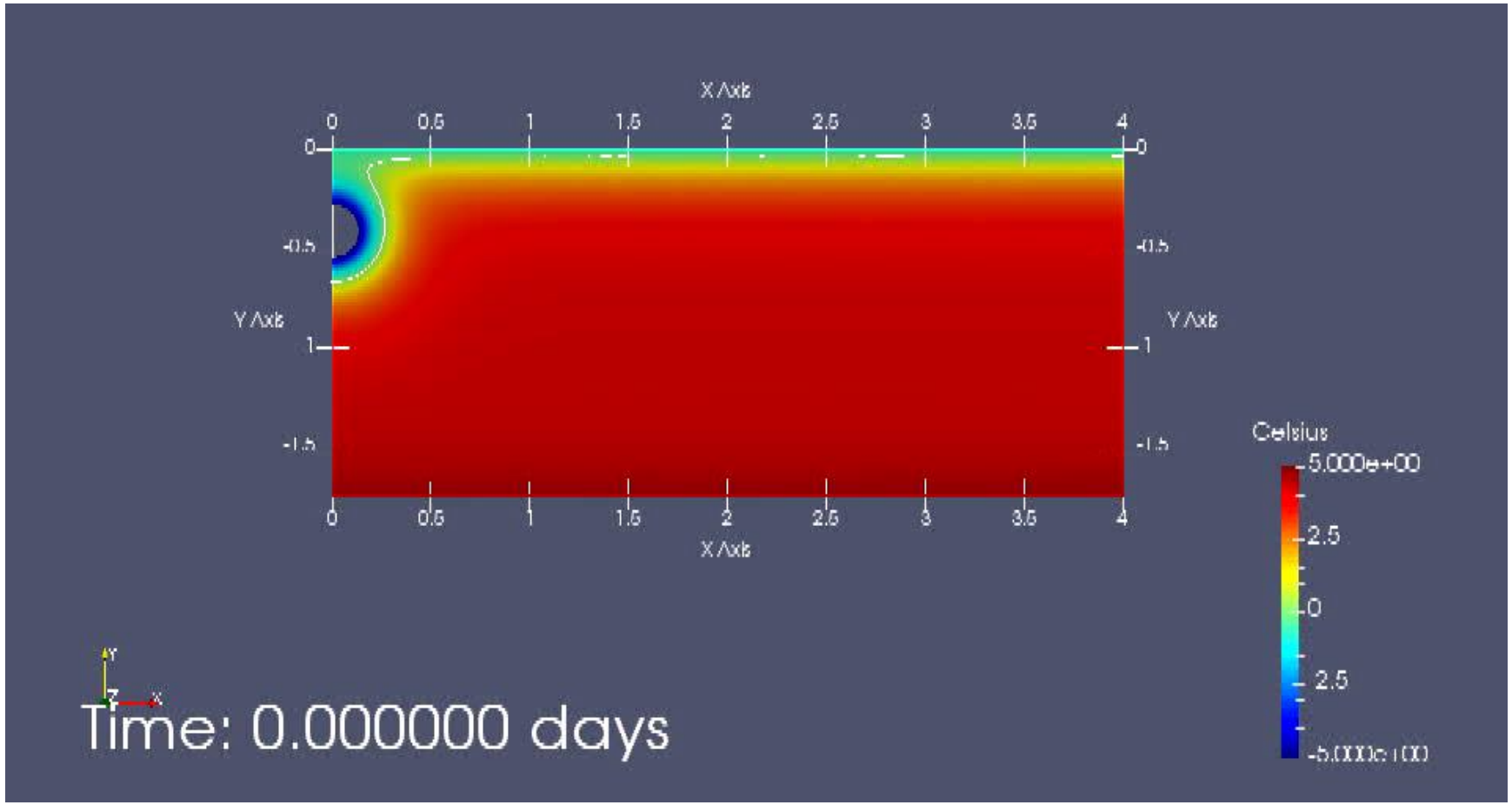




A simpler permafrost model

- Separate branch on GitHub: ElmerCSC/elmerfem/permafrost
- Cooperation between CSC, Denis Cohen and Juha Hartikainen
- Currently following new aspects available there:
  - Multi-level internal extrusion
  - Structured Mesh functionality for two layers (in elmerice and devel branch)
  - Simple model from Cutler et al. 2000 implemented using single HeatSolver with special switches for material parameters
- Development of coupled permafrost model:
  - Heat conduction and convection (done)
  - Water transport (Darcy)
  - Salinity transport
  - Porosity evolution

Heat transfer in soil around sub-zero gas-pipe



Glacial Isostatic Adjustment

- Working on coupled elastic/viscous model (L. Jong, UTAS)
  - Based on P. Wu, 2004 paper
  - Using PREM data
- Currently LLRA model (too embarrassingly simple to push to repository)

New rheology model

- Cooperation with UTAS (Jong,LeGallais,Treverrow,Warner)
  - Testing new rheology against laboratory experiments
- Scalar rheology using enhancement factor (Budd et al. 2013)
  - Co-linear model
  - Referred to as "ESTAR" rheology
- Finding the non-rotating shear plane
  - In principle this is a tensor-algebraic exercise
  - Plan to implement in near future into Elmer/Ice