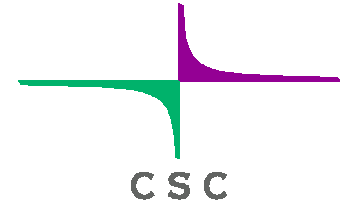




Laboratoire de Glaciologie et Géophysique de l'Environnement



First Elmer/Ice course

14-15 February 2008

Thomas ZWINGER ⁽¹⁾ and Olivier GAGLIARDINI ⁽²⁾

Introduction

- (1) CSC-Scientific Computing Ltd., Espoo - Finland
- (2) LGGE - Grenoble - France

Program - Thursday 14

9h00-10h00	Introduction. Brief overview of known glaciological applications using Elmer/Ice. Existing solvers implemented in Elmer/Ice [TZ, OG]
10h00-10h30 Break	
10h30-11h00	Installing and compiling Elmer (SourceForge, libraries) [TZ]
11h00-12h00	How to get a mesh (ElmerGrid and other input format, including DEM) [OG]
12h00-13h30 Lunch	
13h30-14h30	Description of the solver input file. How to prescribe variable dependent functions (MATC, tables and user functions) [TZ]
14h30-15h30	A simple hands-on example [TZ]
15h30-16h00 Break	
16h00-17h00	Post processing (ElmerPost, alternative formats, solver based output) [TZ]
17h00-17h30	Basic programming in Elmer (user functions and solver subroutines) [TZ]
17h30-18h00	Brief introduction to parallel Elmer version (MPI, compilation, mesh partitioning, post processing) [TZ]

Program - Friday 15

- 9h00-12h00** Tests ISMIP-HOM B and D [OG].
- 12h00-13h30 Lunch
- 13h30-17h00** Moving to the corresponding prognostic tests [OG]
- 17h00-17h30** Conclusion. How should we collaborate for our future modelling using Elmer/Ice? [TZ, OG]

Lunch at « No Name » around 12h00

Rendez-vous at 20h30 at the restaurant « **La Table Ronde** »
7 place Saint André

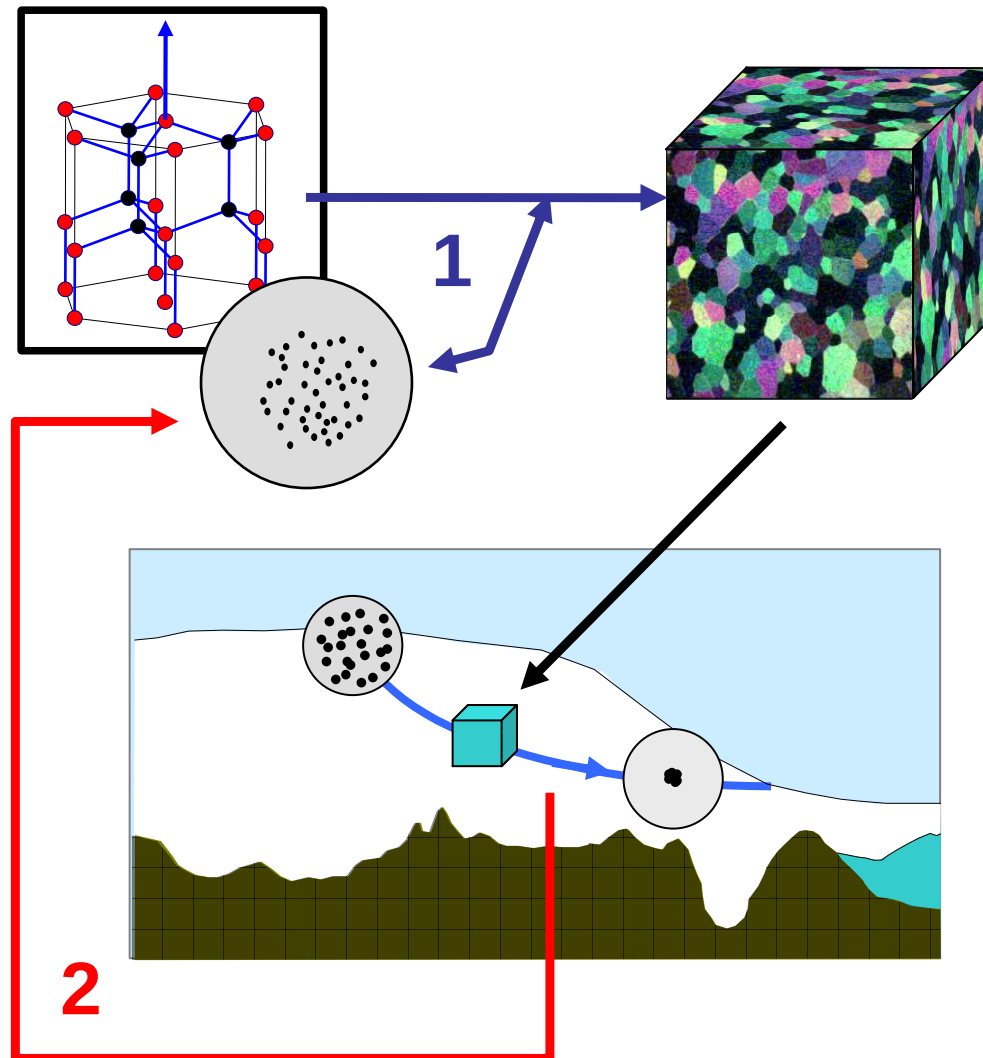


Short history of Elmer/Ice (from OG side)

- EGU2002: OG was looking for a 3D FE code to model the flow of strain-induced anisotropic polar ice – meet TZ
- March 2003: OG visited CSC for few days: AIFlowSolver and FabricSolver partly implemented
- August 2005 – One year visit of OG at CSC (Anisotropy, cavity, glaciers, ISMIP tests, ...)
- February 2008 – First Elmer/Ice Course

Brief overview of known glaciological applications using Elmer/Ice

Anisotropic polar ice



1 /Anisotropic Stokes

2/ Fabric evolution

+ Free surface
+ Transient

(2D and 3D)

Fabien Gillet-Chaulet PhD (LGGE)

[Gillet-Chaulet et al., 2006]

[Durand et al., 2006]

Hakime Seddik PhD (ILTS)

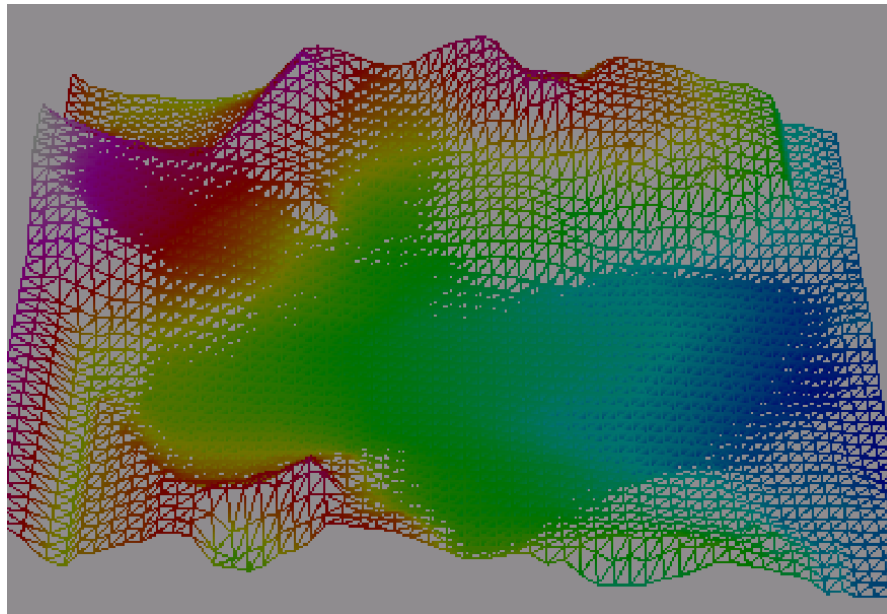
[Seddik et al., submitted]

Temperate Glacier

Isotropic, temperate ice
+ Free surface

Diagnostic and prognostic

2D and 3D



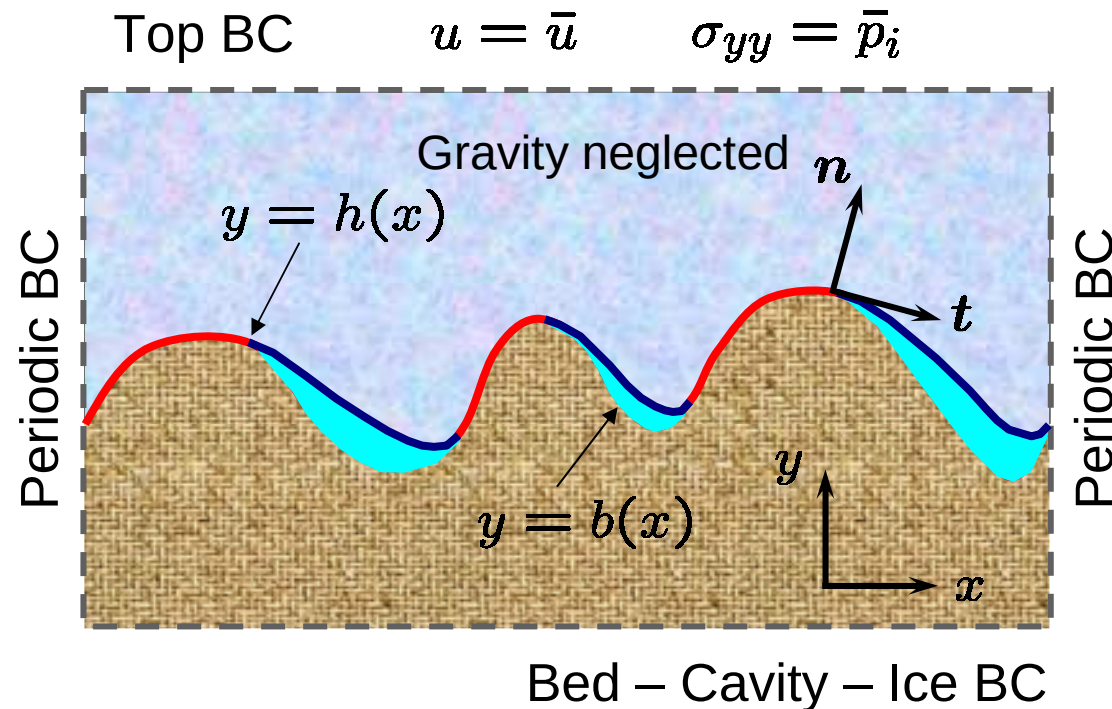
Martina Schaefer PhD

[Le Meur. et al., 2004]

Subglacial cavity and friction law

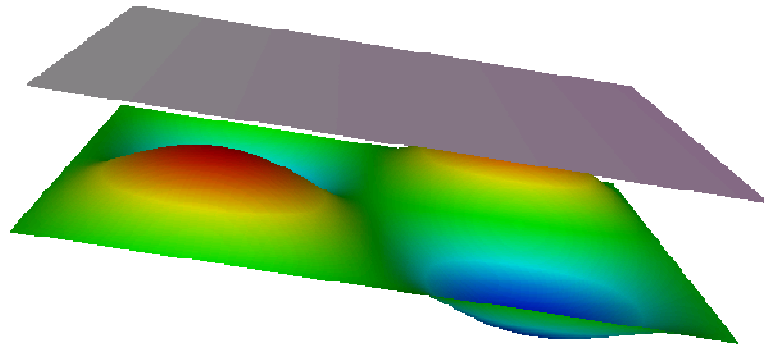
Isotropic, isothermal ice
Coupled with Free Surface

2D modeling



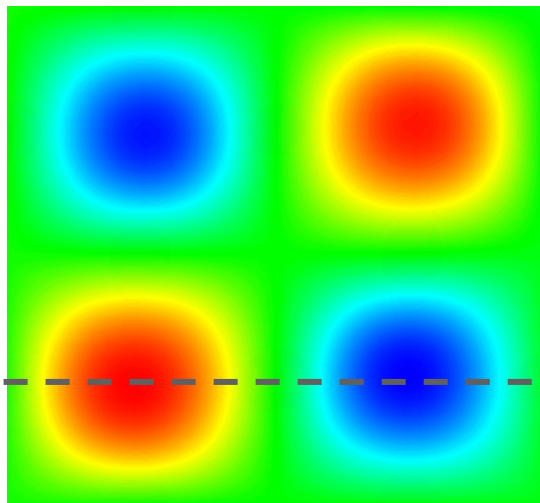
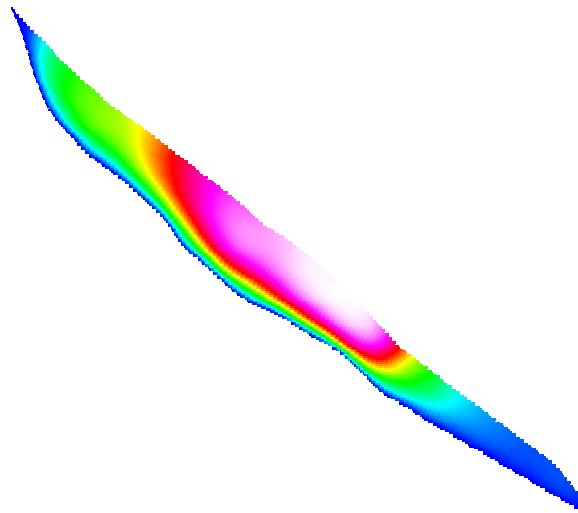
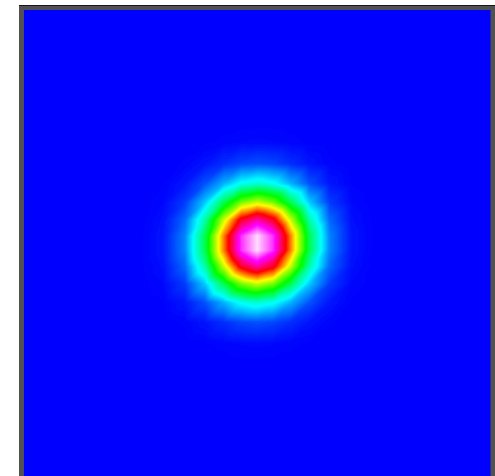
[Gagliardini et al., 2007]

ISMIP benchmark tests



Isotropic, isothermal ice
Coupled with Free Surface

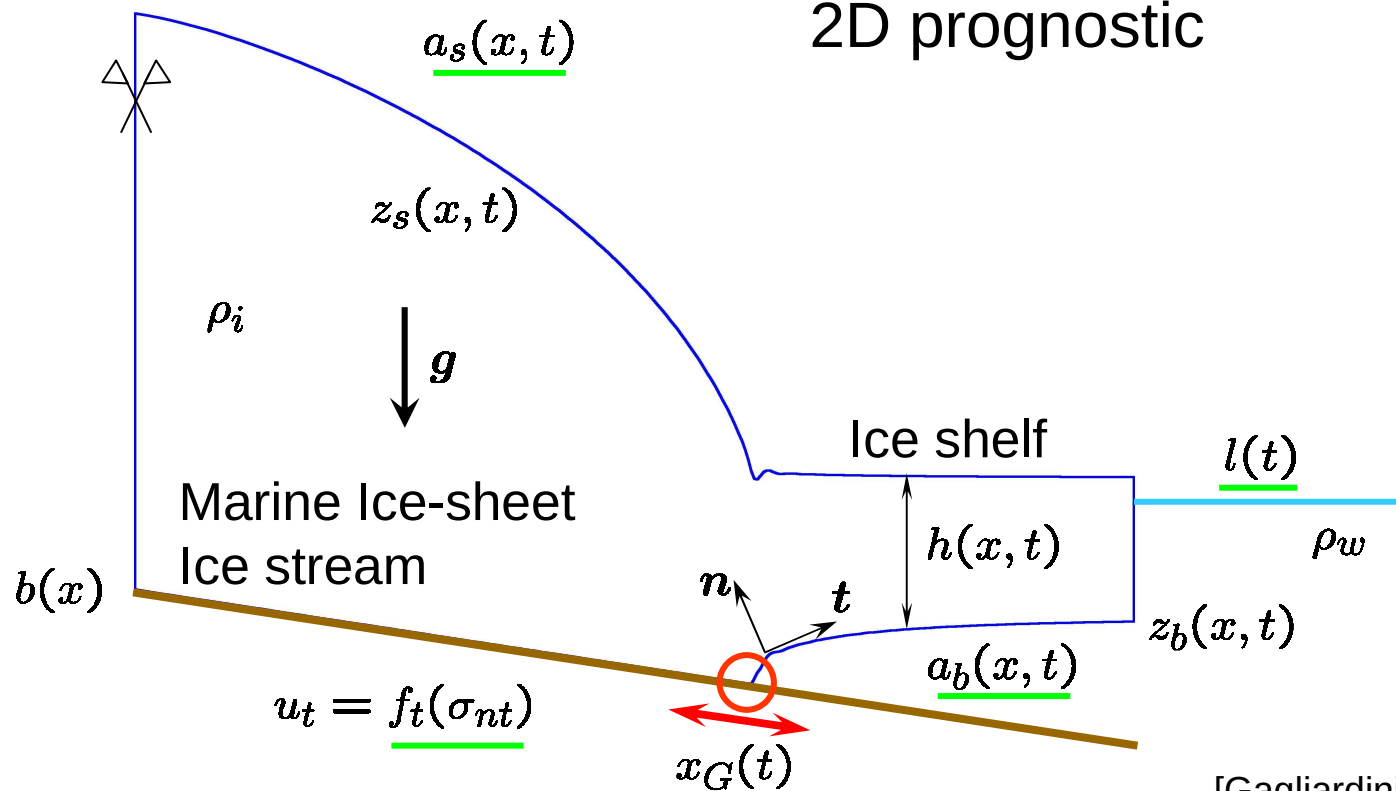
2D and 3D
diagnostic and prognostic



[Gagliardini and Zwinger, submitted]
[Pattyn et al., submitted]

Grounding Line migration

Isotropic, isothermal ice
Coupled with two Free Surfaces
'Contact problem'
2D prognostic



[Gagliardini EGU2007]
[Durand and Gagliardini, AGU2007]

Crater glacier with firn compaction

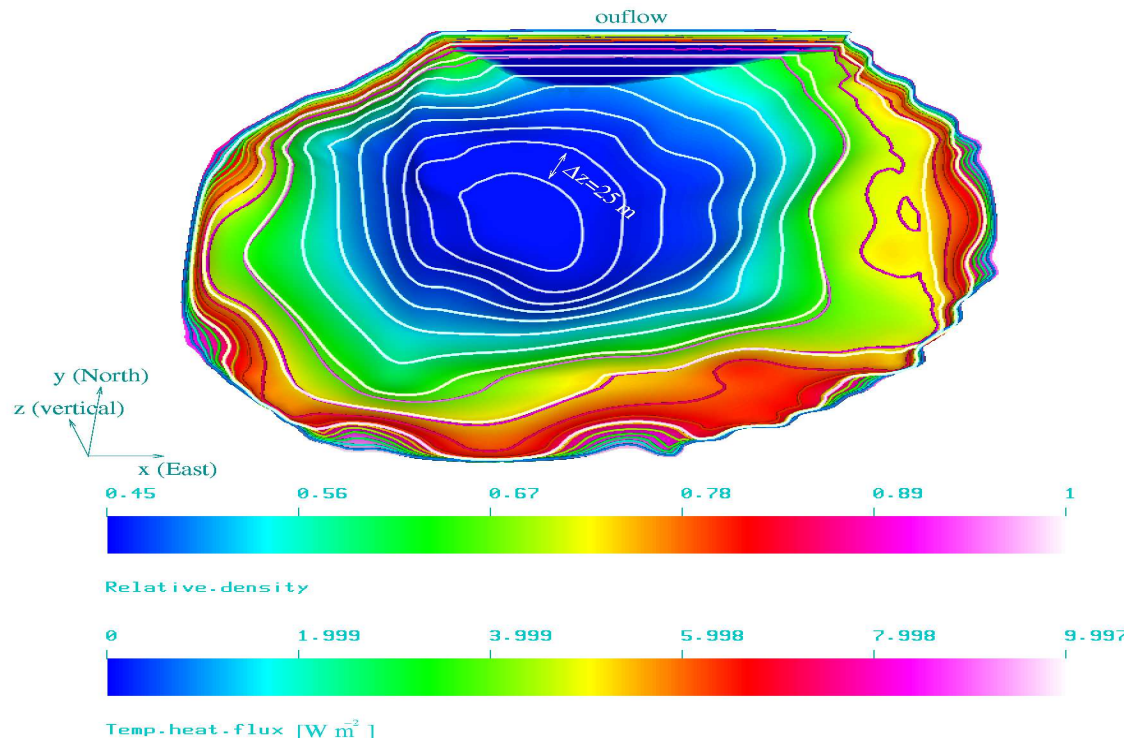
Gorshkov crater, Uskovsky volcano,
Kamchatka, RU

Isotropic, strong
thermo-mechanically
coupled flow.

Variational inequality
introduced into HTEq.
by pressure melting
point.

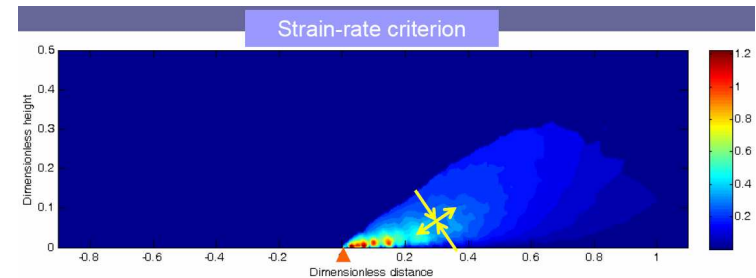
Compressible flow of
firn (Gagliardini &
Meyssonier)

[Greve et al. AGU2007]
[Zwinger et al., EGU2006]
[Zwinger et al., Annals Glac. 45]



Other applications

- Influence of a frozen glacier margin on sediment transport: measurements and modeling [Moore et al., AGU2007]



- Shiraze Glacier (N-E AAIS) (S. Sugiyama, R. Greve, TZ; ILTS + CSC)
- Lovenbreen (Svalbard) (V. Gandioka, A. Grinsted, TZ, J. Moore; Arctic Centre Rovaniemi + CSC)
- Dome F (N-E AAIS) (H. Seddik, R. Greve, TZ; ILTS + CSC)
- full Stokes on GIS (TZ, H. Seddik, R. Greve; ILTS + CSC)
concept of large parallel runs

Existing solvers implemented in Elmer/Ice

Distributed solvers

Distributed Solvers usefull for glaciological problems

- Navier-Stokes solver -> (In)compressible, isotropic ice !
Switch off the convection term (slow flow = Stokes)
- MeshUpdate solver -> Prognostic runs with free surface
(fictitious linear elastic deformation of the mesh)
- SaveData solver -> Output on a BC, a drilling, ... of all the variables
(*SaveLine*), save some scalars like volume, flux on a BC, cpu
(*SaveScalars*) and plot of parameter fields in ElmerPost (*SaveMaterials*).

Elmer/Ice solvers

Important notice:

All the following solvers are not maintained for new release: they might be some change to be done before making them work with the latest release of Elmer.

All solvers are based on previously implemented solvers, which were programmed by CSC staff (mainly by Juha Ruokolainen)

To obtain them from Sourceforge: (the latest version ?)
Elmer/fem/examples/ElmerIce/
Or e-mail the maintainers (noticed in brackets)!

Anisotropic Stokes

AIFlowSolver

(Gillet/Gagliardini, LGGE)

(based on the GOLF law from LGGE, needs second order orientation tensor to give the fabric)

FabricSolver

(Gillet/Gagliardini, LGGE)

(Compute the second order orientation tensor evolution using the AIFlowSolver velocity field)

CaffeSolver (user function)

(Seddik/Greve, ILTS)

(compute the anisotropic enhanced viscosity using the CAFFE law, to be use with the NS solver)

Porous Stokes

PorousSolver

(Gagliardini, LGGE)

(based on the Gagliardini and Meyssonier (1997) snow/firn law, need the relative density as an input)

DensitySolver

(Gagliardini, LGGE)

(Compute the relative density evolution using the PorousSolver velocity field)

LumiSolver

(Gagliardini, LGGE)

(compute both the flow and the density field from the same fonctionnal)

Free Surface solvers

AdvectionReaction

(Elmer team, CSC)

(General advection-reaction DG solver; for species transport, age-depth, simple chemistry; in main Elmer distro soon)

FSurfSolverLimited

(Zwinger, CSC)

(Impose the upper and lower limit using the contact method for variational inequality)

FSurfSolverPenalty

(Gagliardini, LGGE)

(Impose the upper and lower limits using a penalty condition)

Other solvers

TemperateIce

(Zwinger, CSC)

(compute the temperature field, include limited temperature, using the contact method for variational inequality method)

IceFlowProperties (user functions)

(Zwinger, CSC)

(library of usefull user functions; e.g. Glen)

DatingSolver

(Gagliardini, LGGE)

(Compute the age of the ice)

FlowDepthSolver

(Zwinger, CSC)

(compute depth or elevation – non-trivial problem in FEM)

Other solvers

DevStressSolver

(Gagliardini, LGGE)

(compute deviatoric or Cauchy stress)

StrainRateSolver

(Gagliardini, LGGE)

(Compute strain-rate)

GradTransFSolver

(Gillet/Gagliardini, LGGE)

(compute the gradient of transformation)

Buoyancy (user functions)

(Gagliardini, LGGE)

(Return the sea pressure and 'spring')