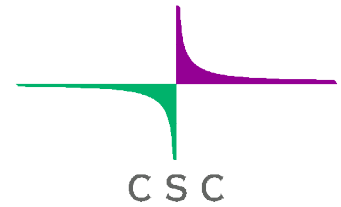




Laboratoire de Glaciologie et Géophysique de l'Environnement



Elmer/Ice course

October 2013, LGGE, Grenoble

Olivier GAGLIARDINI ⁽¹⁾, Fabien GILLET-CHAULET⁽¹⁾, Thomas ZWINGER⁽²⁾

Introduction

- (1) LGGE - Grenoble – France
- (2) CSC – IT Center for Science Ltd. – Espoo - Finland

Program

3rd October

- 9:00-10:30 General Introduction (T.Z.)
- 10:30-11:00 coffee break
- 11:00-12:00 Simple Setup square (F.GC.)
- 12:00-13:00 lunch
- 13:00 – 15:00 ISMIP suite (F.GC. + T.Z.)
- 15:00 – 15:30 coffee break
- 15:30-17:00 ISMIP suite cntd.

4th October

- 9:00-10:00 Tête Rouse Introduction (F.GC.)
- 10:00-10:30 coffee break
- 10:30-12:00 Tête Rouse Setup (Step 1) + general information on UDF's (T.Z.)
- 12:00-13:00 lunch
- 13:00 – 14:00 Tête Rouse diagnostic (Step 2) (F.GC. + T.Z.)
- 14:00 – 14:30 coffee break
- 14:30-15:30 Tête Rouse prognostic (Step 3) (F.GC. + T.Z.)
- 15:30-16:00 General discussion (you)

Short history of Elmer/Ice

- ✓ 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 - Grenoble
- ✓ June 2011 – SVALI summer school – Finland
- ✓ 2012 – Elmer/Ice has now a website, a logo and a mailing list
- ✓ 2012 – Elmer/Ice comes as a Elmer Package – New wiki
- ✓ 2012 – Elmer/Ice course at UBC/SFU
- ✓ 2013 – Elmer/Ice courses at Univ. Washington and Univ. Alberta
- ✓ 9 April 2013 – First Elmer/Ice users meeting
- ✓ May 2013 – Second SVALI summer school) - Finland

elmer/ice NEWS PUBLICATIONS CAPABILITIES USERS COMMUNITY COURSES TUTORIALS MATERIALS DOCUMENTATIONS LOG IN

search...

Welcome

Elmer is an open-source, parallel, Finite Element code, mainly developed by the **CSC-IT Center for Science Ltd.** in Finland. Elmer/Ice builds on Elmer and includes developments related to glaciological problems.

Elmer/Ice includes a variety of dedicated solvers and user functions which are described in these pages.

The aim of this website is to present in detail the Elmer/Ice capabilities and to distribute course materials and tutorials.

Elmer/Ice is mainly developed by CSC (Espoo, Finland), the Laboratory of Glaciology and Environmental Geophysics LGGE (Grenoble, France) and the Institute of Low Temperature Science ILTS (Sapporo, Japan), but others contributors are welcome!

Elmer/Ice at EGU 2013

Written by **Olivier Gagliardini**.

Don't miss the first **Elmer/Ice users meeting** to be held during the EGU 2013, Tuesday 9th April 12:15-15:00, Room Y3. More information regarding this meeting can be found [here](#).

Here is a list of the known Elmer/Ice talks and posters that will be presented at the forthcoming EGU in Vienna, 8-12 April 2013. Please, if your talk/poster is not listed, contact me (OG) and I will add your presentation.

Tuesday, April 09, 2013

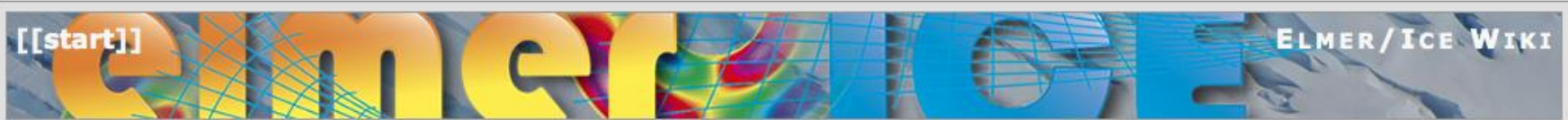
12:15-15:00 **Elmer/Ice users meeting, Room Y3.**

15:30-17:00 / Room G3 - CR1.3 - **Subglacial Environments of Ice Sheets and Glaciers**

- 16:45-17:00: **EGU2013-12218** Importance of basal processes in simulations of a surging Svalbard outlet glacier. **Rupert Gladstone**, Martina Schäfer, Thomas Zwinger, Tazio Strazzi, Yongmei Gong, John Moore, and Thorben Dunse.

The screenshot shows the Elmer/Ice website interface. At the top, there is a navigation menu with buttons for NEWS, PUBLICATIONS, CAPABILITIES, USERS COMMUNITY, COURSES TUTORIALS (circled in red), MATERIALS DOCUMENTATIONS, and LOG IN. Below the menu is a search bar. The main content area is titled "Elmer/Ice || courses - tutorials" and is written by Olivier Gagliardini. It contains a list of courses, with the first one circled in red: "- SVALI Elmer/Ice course 23 May to 3 June, 2011, Espoo, Finland [Material]".

Much more material available than what I will present today



Trace: • start

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- [Home](#)
- [Problems](#)
- [Solvers](#)
- [User Functions](#)
- [Meshing Tools](#)
- [Tips and Tricks](#)
- [Meetings and Courses](#)
- [Compilation of Elmer/Ice](#)
- [Links](#)

Welcome to the Elmer/Ice wiki

Elmer is an open-source, parallel, Finite Element code, mainly developed by the CSC-IT Center for Science Ltd. in Finland. Elmer/Ice builds on Elmer and includes developments related to glaciological problems. On this page you will find documentation and examples of the various solvers and user functions developed for **glaciological** applications using Elmer/Ice. Building Elmer/Ice on top of an existing Elmer installation is explained in the [Compilation Section](#).

The [Problems Section](#) presents the various categories of glaciological problems that can be solved using Elmer/Ice.

The [Solvers Section](#) and the [User Functions Section](#) describe the glaciology related solvers and user functions, respectively, that can be used to solve these problems.

Tools that can be used to mesh glacier and ice-sheet geometry are presented in the [Meshing Section](#).

The [Tips and Tricks Section](#) gives some useful demo of MATC, Post-treatments of results and more.

The [Courses Material Section](#) contains presentation as well as material proposed in the framework of the Elmer/Ice courses dispensed since 2008.

Some useful links are given in the [Links Section](#).

Scientific publications presenting glaciological applications with Elmer/Ice are listed in the [Elmer/Ice website](#).

start.txt · Last modified: 2012/12/03 17:45 by tzwinger

Elmer/Ice mailing list

To subscribe to the Elmer/Ice list *elmerice@elmerfem.org*, just sent an email to *majordomo@elmerfem.org*, with in the body the text:

subscribe elmerice

If you do not know how to use mailing lists run by majordomo you may sent a mail with "help" in the message body.

Elmer/Ice Forum

Under

<http://www.elmerfem.org> :

- Go to **Elmer Forum**: find answers on all aspects of Elmer
- Click on **Elmer/Ice** link: find answers specific to Elmer/Ice
- To get access: **Register** in upper right corner

Elmer Discussion Forum • Index page - Mozilla Firefox

Elmer Discussion Forum • Index...

www.elmerfem.org/forum/index.php

Most Visited Linux Mint Elmer/Ice elmerfem.org

phpBB Elmer Discussion Forum
Bulletin Board for Elmer FEM Users

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Board index

Register [] Login []
It is currently 02 Sep 2013, 10:54

View unanswered posts • View active topics

FORUMS	TOPICS	POSTS	LAST POST
General General discussion about Elmer	346	1289	by Gastón García [] 29 Aug 2013, 22:01
Installation & compilation Discussion about building and installing Elmer	166	680	by Jyh-Shyong [] 30 Aug 2013, 13:02
ElmerSolver Numerical methods and mathematical models of Elmer	944	4108	by druefer [] 30 Aug 2013, 15:54
ElmerGUI The graphical user interface of Elmer	226	908	by oster [] 26 Aug 2013, 00:00
ElmerPost Post processing utility for Elmer	90	346	by Edmund [] 30 Jul 2013, 11:01
Elmer/Ice Extension of Elmer in computational geophysics	8	27	by tzwingar [] 22 Aug 2010, 13:50
External tools Mesh generators, CAD programs, and other tools	113	558	by NickR7 [] 30 Aug 2013, 18:04
Software development Discussion about coding and new developments	37	120	by Takae [] 22 Aug 2013, 09:02
Bug reports Clearly defined bug reports and their fixes	80	230	by mlm [] 29 Aug 2013, 12:55
Contributed Cases Elmer cases by the users for the users	15	30	by sebastien ROUQUETTE [] 29 Apr 2013, 14:49
HPC High Performance Computing with Elmer	3	5	by muel1989 [] 21 Oct 2012, 15:34
Commercial services A forum for commercial service requests and offerings	3	3	by asher [] 12 Dec 2012, 11:30

ANNOUNCEMENTS	TOPICS	POSTS	LAST POST
Updates Updates in software, documentation, sites etc.	20	80	by mzenker [] 08 Jul 2013, 15:20
Events Courses, user meetings, seminars etc.	14	17	by ralsack [] 12 Apr 2013, 13:54

MISCELLANEOUS	TOPICS	POSTS	LAST POST
Testing Here you can test posting, attachments, ...	4	6	by Takae [] 03 Apr 2013, 10:16

Elmer/Ice Forum

Elmer Discussion Forum • View forum - Elmer/Ice - Mozilla Firefox

Elmer Discussion Forum • View...
www.elmerfem.org/forum/viewforum.php?f=21&sid=a236cdc8c59442ceeb58af716399763

Most Visited Linux Mint Elmer/Ice elmerfem.org

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Elmer/Ice

NEW TOPIC Search this forum... Search 8 topics • Page 1 of 1

TOPICS	REPLIES	VIEWS	LAST POST
Restarting Advection Reaction Solver for Age Equation by Hamhard - 14 Aug 2013, 17:35	1	56	by tzwinger - 22 Aug 2013, 13:56
Problem with calling DiffuseConvectiveBoundary subroutine by ygong - 19 Jul 2013, 12:40	4	172	by ygong - 22 Jul 2013, 14:18
How to use AIFlow Solver ? by Dangbing Wang - 11 Jul 2013, 20:09	1	103	by fgillet - 17 Jul 2013, 16:58
Problem with solving temperature after Inverse method by vaono - 23 May 2013, 12:28	7	1272	by Marina - 11 Jun 2013, 10:04
strange behaviour of SaveMaterials in Restart runs by Martha - 22 May 2013, 12:22	1	264	by jocalodd - 22 May 2013, 13:02
Linking subglacial hydrology to Heat Equation by josediaz1 - 20 May 2013, 14:28	1	235	by rabsack - 20 May 2013, 14:43
FreeSurface nonlinear iteration/MeshUpdate problem - SOLVED by Martine - 24 Apr 2013, 10:30	0	271	by Marina - 24 Apr 2013, 10:30
New forum for Elmer/Ice by tzwinger - 11 Apr 2013, 12:25	4	552	by tzwinger - 16 Apr 2013, 11:32

Display topics from previous: All topics | Sort by Post time | Descending | Go

NEW TOPIC 8 topics • Page 1 of 1

Return to Board Index Jump to: Elmer/Ice | Go

WHO IS ONLINE

Users browsing this forum: No registered users and 1 guest

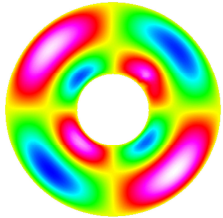
FORUM PERMISSIONS

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You cannot edit your posts in this forum
You cannot delete your posts in this forum
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Board index The team • Delete all board cookies • All times are UTC + 2 hours [DST]

Powered by phpBB © 2000, 2002, 2005, 2007 phpBB Group

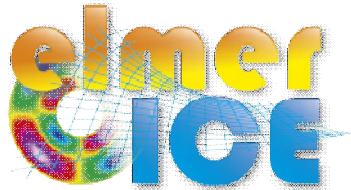
Elmer/Ice in relation to Elmer



Elmer is an open-source, parallel, Finite Element code, mainly developed by the CSC-IT

Center for Science Ltd. in Finland.

Elmer is constantly developed towards improved performance, utilizing international projects such as FP7 PRACE and HPC Europa2.



Elmer/Ice builds on Elmer and includes developments related to glaciological problems.

Elmer/Ice includes a variety of dedicated solvers and user functions for glaciological applications and its development is supported by EU FP7 Ice2Sea and NCoE SVALI



norden

Top-level Research Initiative



Elmer/Ice Package

All the Solvers, User Functions and Meshers presented on the Elmer/Ice wiki comes as an Elmer/Ice package on the Elmer distribution (in `elmerice/`)

To compile the package, go in `elmerice/` directory

```
$ make compile
```

```
$ make install
```

To use it (in the SIF file):

```
Procedure = File "ElmerIceSolvers" "NameSolver"
```

or

```
Procedure = File "ElmerIceUSF" "NameUSF"
```

Important links

Elmer at CSC (documentation, how to install, ...)

<http://www.elmerfem.org/>

<http://www.csc.fi/english/pages/elmer>

Elmer Forum

<http://elmerfem.org/forum/>

Elmer/Ice webpage

<http://elmerice.elmerfem.org/>

Elmer/Ice wiki

<http://elmerice.elmerfem.org/wiki/doku.php?id=start>

Important notices

In this course

- We will not teach finite element method (can give references)
- We will focus on some technical aspects of using Elmer for glaciological applications

What we expect from this course ?

- giving you a kick-start in Elmer/Ice
- some fruitful collaborations to begin

Elmer/Ice capabilities

- **Full-Stokes** equation but also SIA, SSA, diagnostic or transient
- Various **rheologies** (Glen's law, firn/snow and two anisotropic flow laws)
- **Temperature** solver accounting for the upper limit at melting point
- **Transport equations** for density, fabric, age ...
- **Post-processing solver** for strain-rate and stress fields
- Various **friction laws** (Weertman, effective-pressure dependent friction law)
- **Free surface evolution** as a contact problem (Grounding line dynamics)
- **Inverse methods** (linear adjoint and Arthern and Gudmundsson 2010 methods)
- Tools or plug-ins for **meshing** (YAMS, external and internal extrusion of footprint)
- **Highly parallel** Stokes solver

Elmer/Ice applications

More than 30 publications using Elmer/Ice since 2004

- ISMIP, MISMIP, MISMIP-3d
- 2D and 3D Grounding line dynamics
- Ice2sea and SeaRISE contributions (Greenland)
- Inverse methods (Variegated, Vestfonna ice-cap, GIS)
- Flow of anisotropic ice
- Glaciers

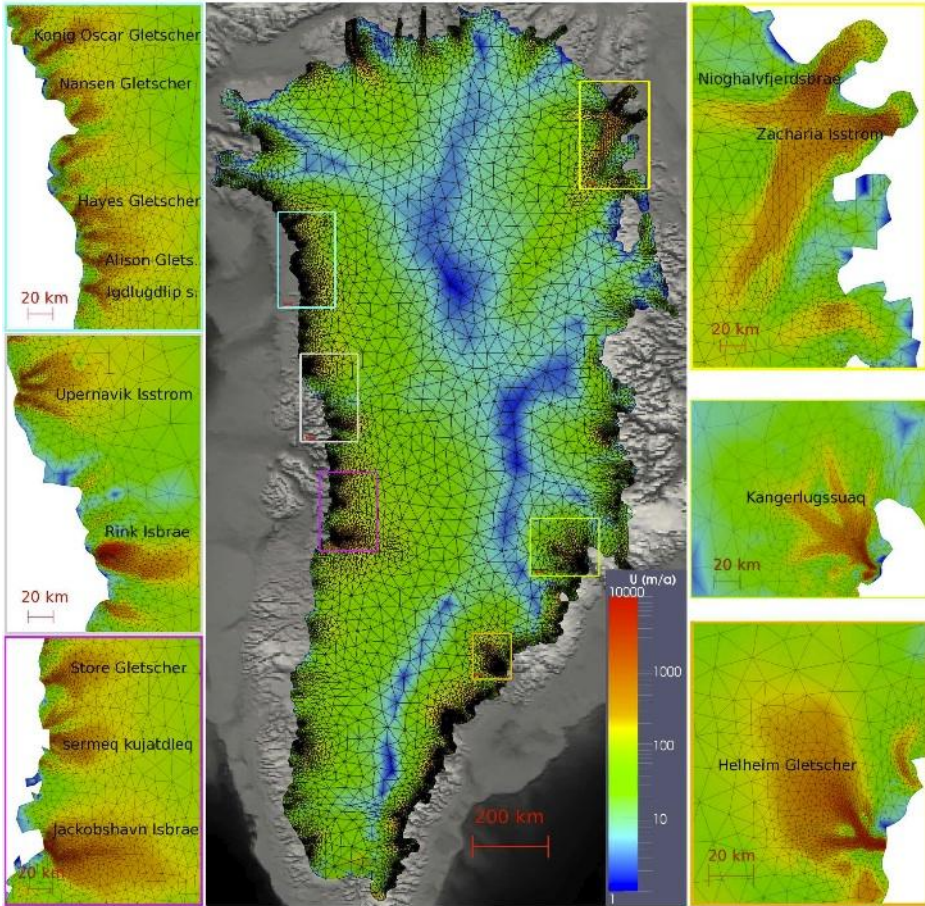
see <http://elmerice.elmerfem.org/publications>

Capabilities and performance of Elmer/Ice, a new generation ice-sheet model

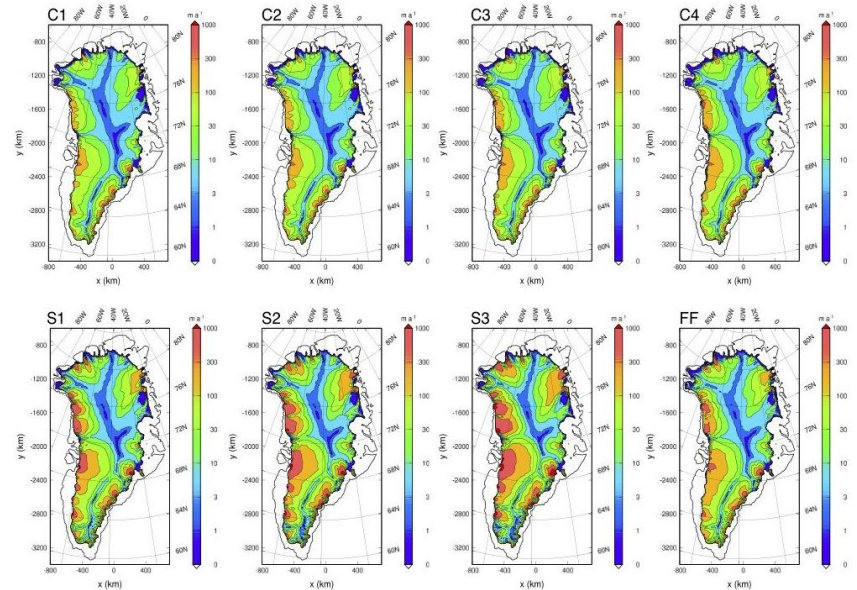
O. Gagliardini^{1,2}, T. Zwinger³, F. Gillet-Chaulet¹, G. Durand¹, L. Favier¹, B. de Fleurian¹, R. Greve⁴, M. Malinen³, C. Martín⁵, P. Råback³, J. Ruokolainen³, M. Sacchetti¹, M. Schäfer⁶, H. Seddik⁴, and J. Thies⁷

Few recent examples

Grenland within ice2sea
 @Fabien Gillet-Chaulet, LGGE



Grenland within SeaRise
 @Hakime Seddik, ILTS

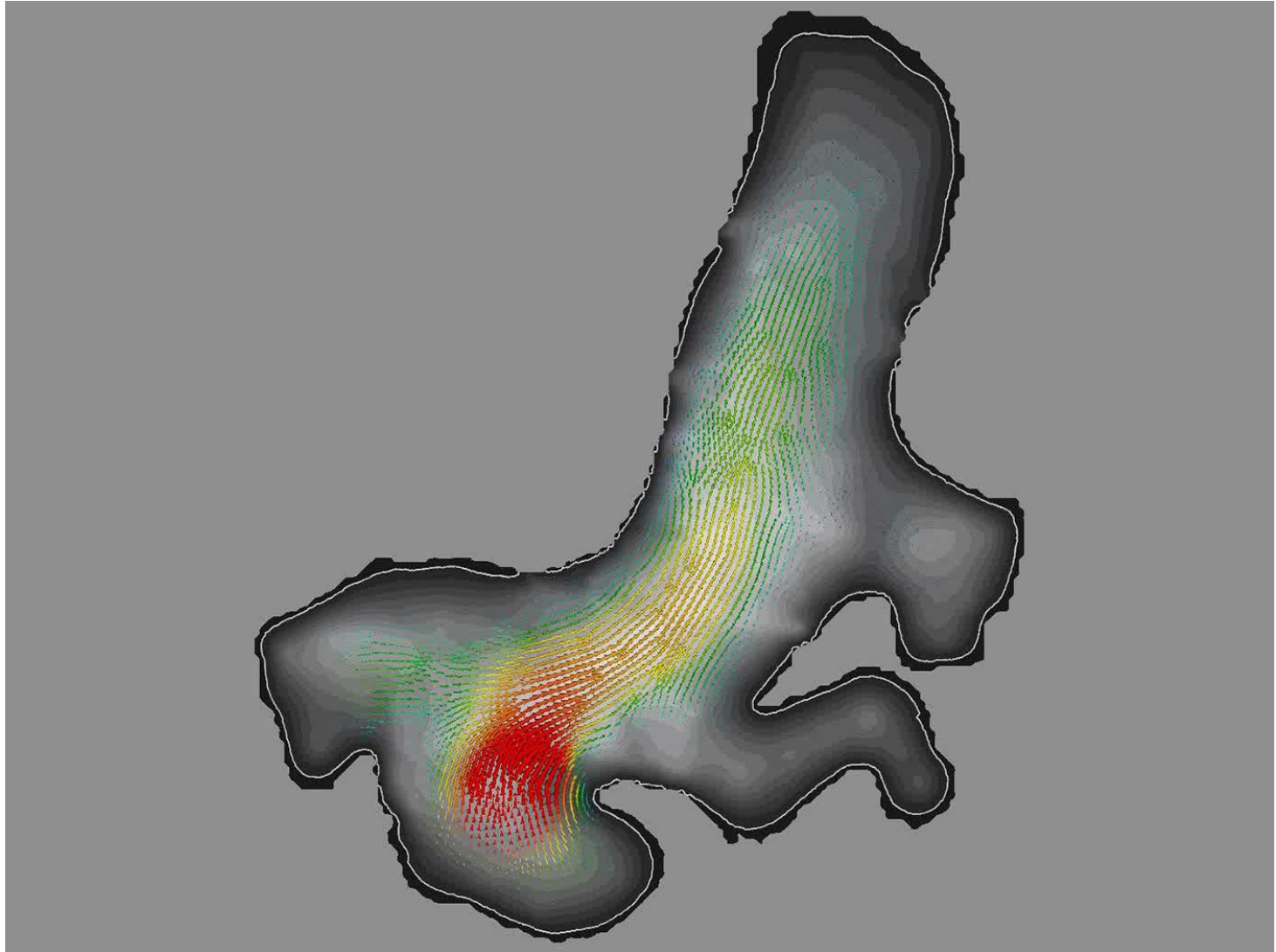


Few recent examples

Glacier simulations:

Midtre Lovénbreen, Svalbard, prognostic run 1977-2030

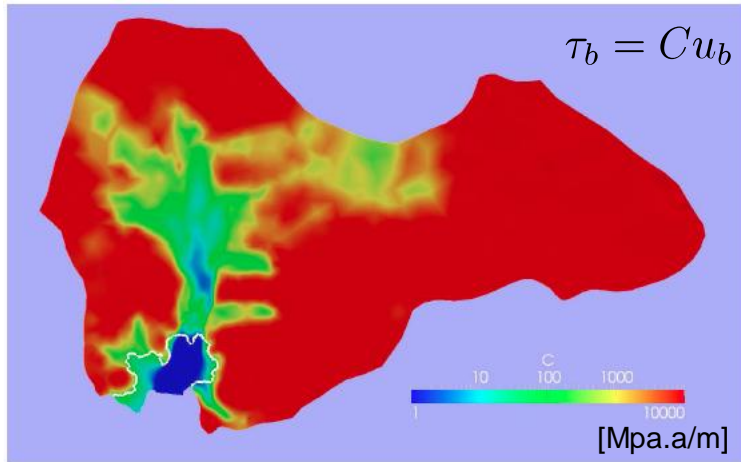
(Zwinger & Moore)



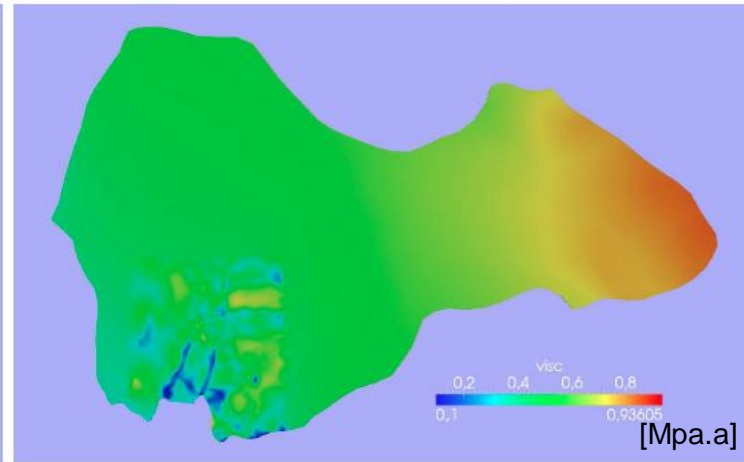
Few recent examples

Grounding line 3D @Lionel Favier, LGGE

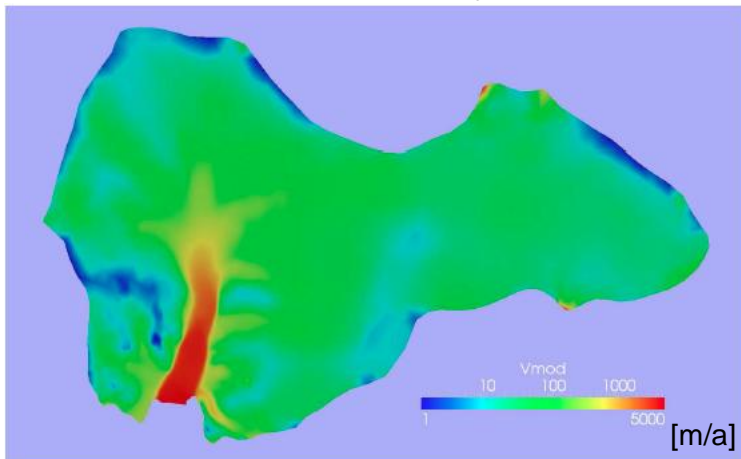
Inverted **basal friction** parameter



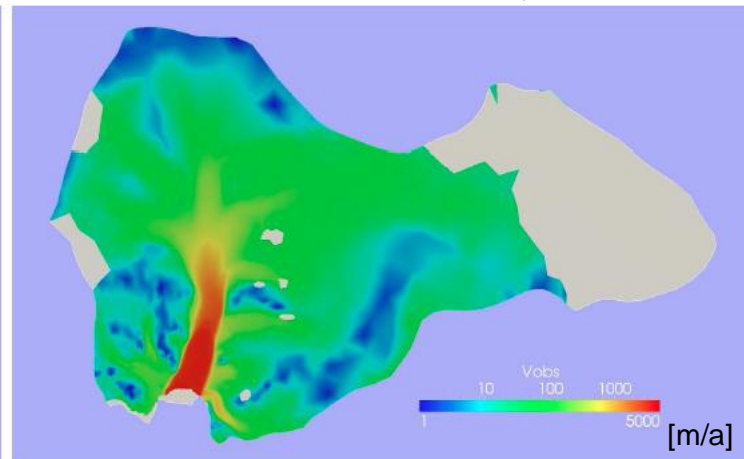
Inverted surface **effective viscosity**



Inverted surface velocity

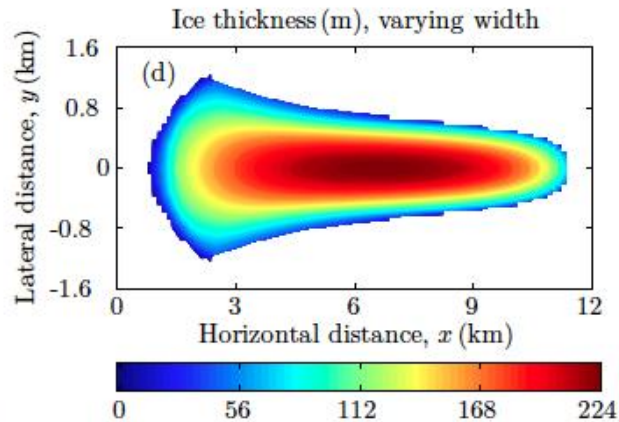
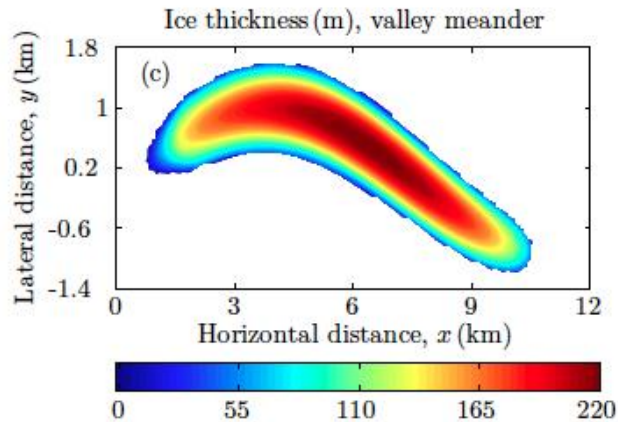
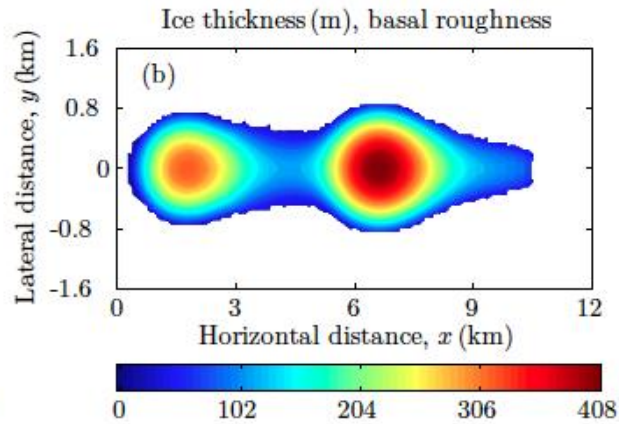
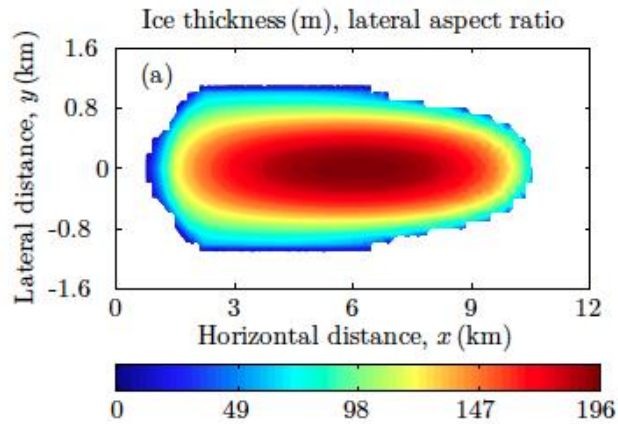


Observed surface velocity (Rignot et al., 2011)



Few recent examples

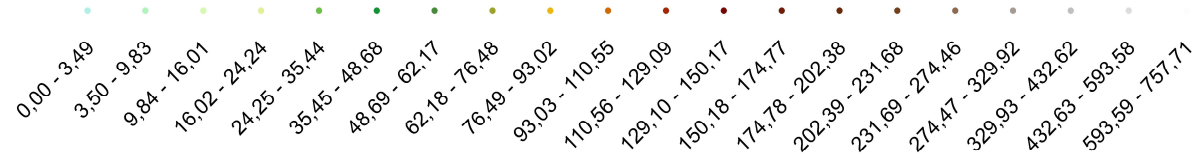
Volume/Area relation @ Surendra Adhikari, Univ. Calgary



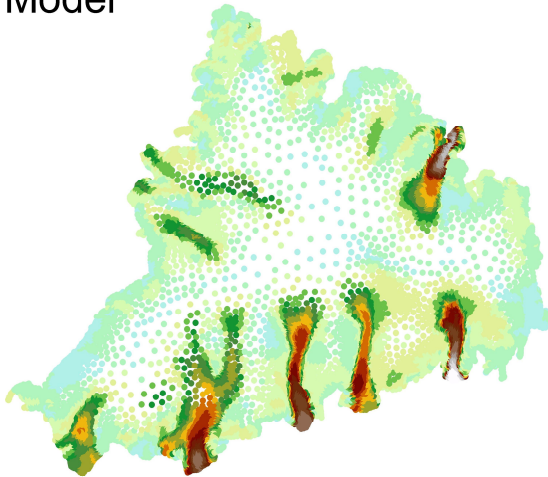
Few recent examples

Vestfonna ice cap basal friction @Martina Schäfer, Univ. Lapland

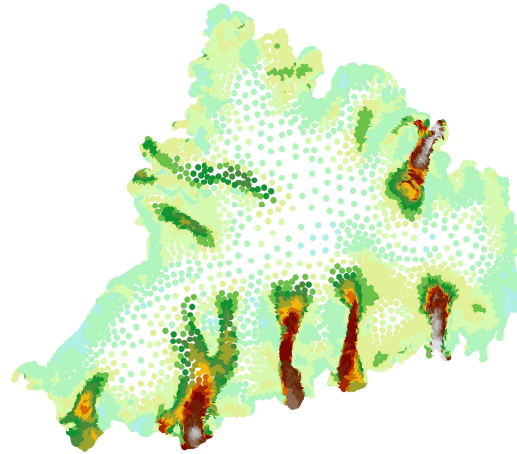
velocities m/yr



Model



Data

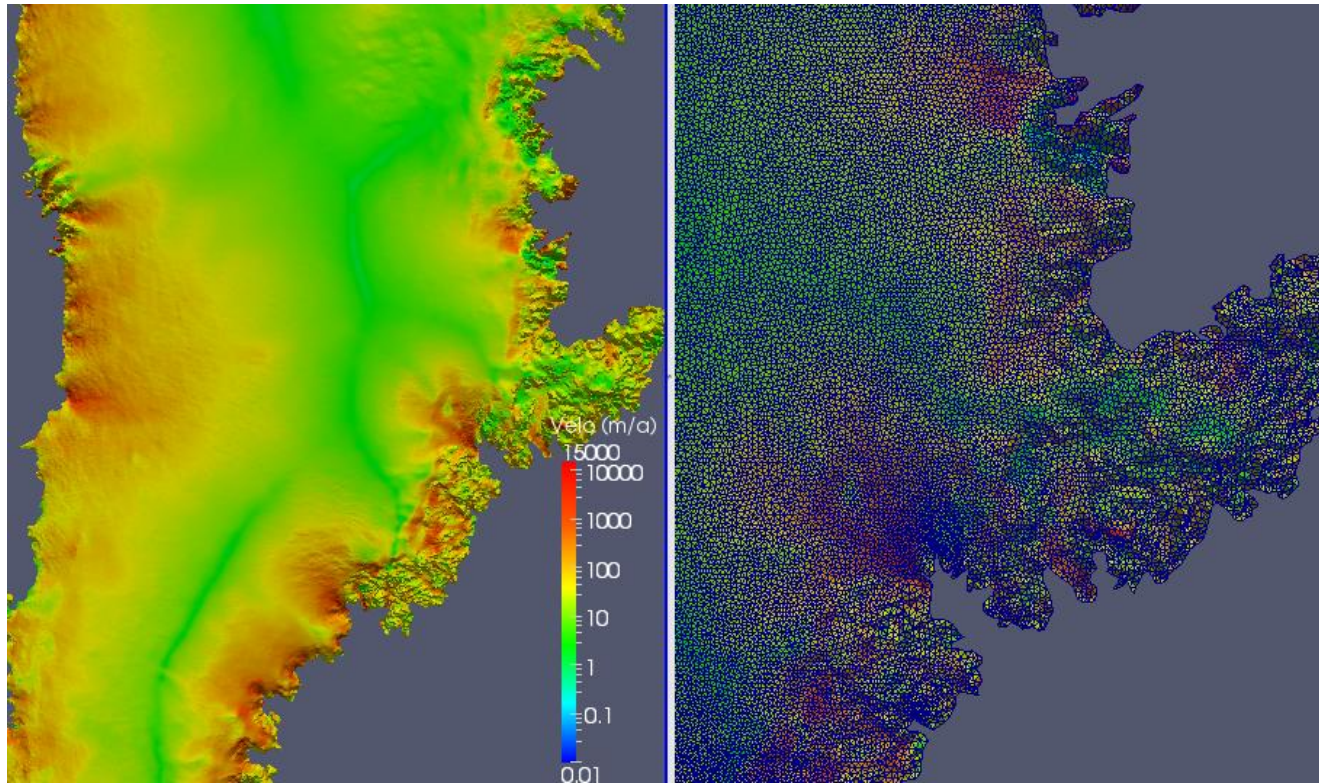


Few recent examples

High parallel computing @Fabien Gillet-Chaulet, LGGE

1 900 000 nodes on 400 partitions

~7 000 000 dofs

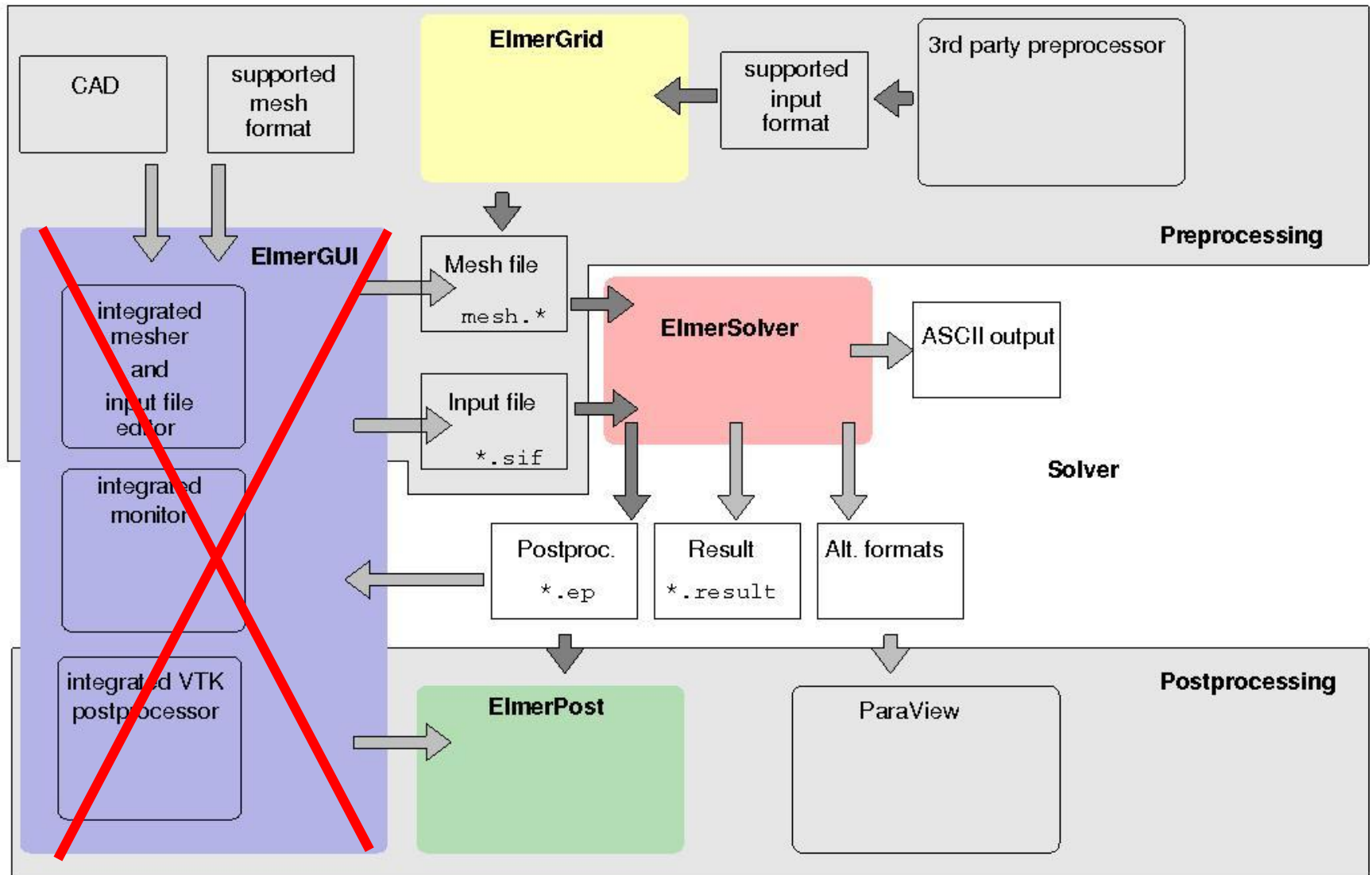


Current or planned developments

- Calving law (damage mechanics)
- Hydrology model to infer basal water pressure
- Moving margins / remeshing / adaptive mesh
- Coupling with an ocean model / Implementation of a plume model
- Accounting for refreezing in the temperature equations
- Inversion of bedrock topography
- Lower order Stokes models

How does it work ?

Elmer structure



Sequence of a serial simulation

- build a mesh in Elmer format, i.e. a directory containing `mesh.header`, `mesh.nodes`, `mesh.element`, `mesh.boundary`
- file in a solver input file (`mysif.sif`)
- compile object files linked with Elmer of your user functions and solvers (if needed)
- Execute :
\$ **ElmerSolver** `mysif.sif`
- Should create a `*.ep` file (ElmerPost format) or `*.vtu` file
- Visualise :
\$ **ElmerPost** or \$ **paraview**

We will see

- how to construct a simple mesh
- what is the content of a sif file
- how to execute
- how to visualise the results

How to get a mesh ?

Different possibilities to get a mesh

- use **ElmerGrid** alone
- use **another mesher** (gmsht, gambit) and then transform it in Elmer format - ElmerGrid can do this for many other mesh formats (just launch ElmerGrid without any argument to get list)
- Glacier particularities :
 - Small aspect ratio (horizontally elongated elements)
 - In 3D, mesh a footprint with an unstructured mesh, and then vertically extrude it (same number of layer everywhere)

will see this later during the course...

ElmerGrid

- command line tool for mesh generation
- native mesh format: `.grd`
- help : just execute : `$ ElmerGrid`
- possible to import meshes produced by other free or commercial mesh generators (Ansys, Abaqus, Fluent/Neutral, Comsol, gmsh, ...)
- Examples :

```
$ ElmerGrid 1 2 my_mesh.grd
```

```
$ ElmerGrid 14 2 my_gmsh_mesh.msh
```

```
$ ElmerGrid 14 3 my_gmsh_mesh.msh
```

Solver Input File (sif)

Example of sif file

- Comments start with !
- Not case sensitive
- Avoid non-printable characters (e.g., tabulators for indents)
- A section always ends with the keyword `End` or use `::`
- Parameters not in the Keyword DB need to be casted by types:
Integer, Real, Logical, String and File
- `Parametername(n,m)` indicates a $n \times m$ array

- Sections are

- Header
- Constants
- Simulation
- Solver *i*
- Body *i*
- Equation *i*
- Body Force *i*
- Material *i*
- Initial Condition *i*
- Boundary Condition *i*

```
Body Force 1
Heat Source = 1.0
End
```

OR

```
Body Force 1 :: Heat Source = 1.0
```

Example of sif file

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!! Elmer/Ice Course - Application Step0 !!
!! Updated May 2011
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

check keywords warn
echo on

Header
 Mesh DB "." "square"
End

Constants
! No constant needed
End

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
Simulation
Coordinate System = Cartesian 2D
Simulation Type = Steady State

Steady State Min Iterations = 1
Steady State Max Iterations = 1

Output File = "ismip_step0.result"
Post File = "ismip_step0.ep"
max output level = 100
End

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
Body 1
Equation = 1
Body Force = 1
Material = 1
Initial Condition = 1
End

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
Initial Condition 1
Pressure = Real 0.0
Velocity 1 = Real 0.0
Velocity 2 = Real 0.0
End

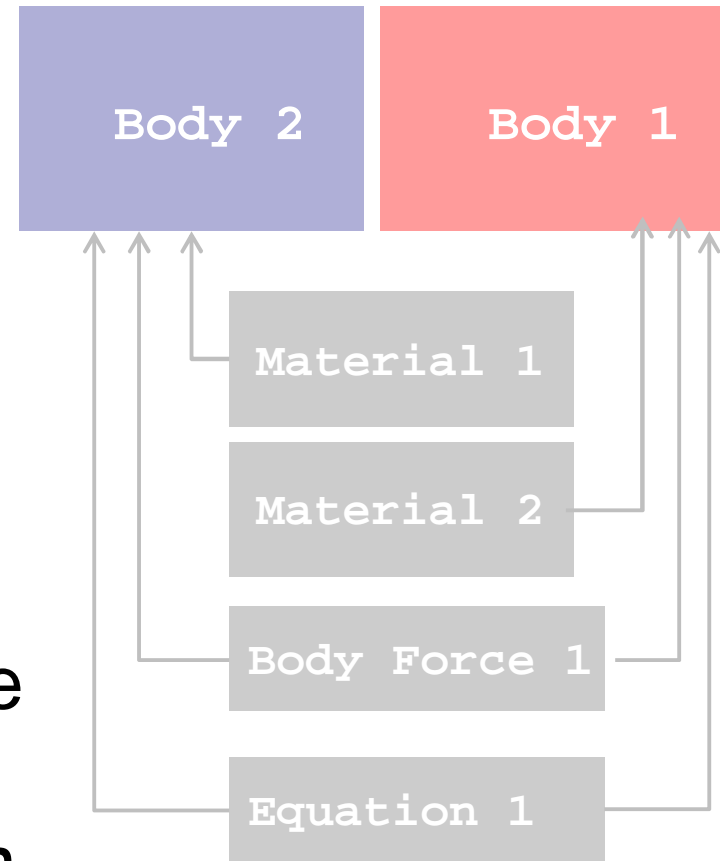
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
Body Force 1
Flow BodyForce 1 = Real 0.0
Flow BodyForce 2 = Real -1.0
End

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

- **Header** declares where to search for the mesh
- If any **constants** needed (i.e. Gas constant)
- **Simulation**
 - Type of coordinate system
 - Steady or Transient
 - If transient: time stepping parameters
 - Output files (to restart a run) and ElmerPost/VTU file
 - Output level : how verbose is the code?
 - Restart information (optional)
- In **Body** are assigned the Equation, Body Force, Material and Initial Condition
- In **Initial Condition** sets initial variable values
- In **Body Force** specify the body force entering the right side of the solved equation

On Bodies

- A Body is a distinct area of the FEM model (physics, material)
- Each **Body** has to have an **Equation** and **Material** assigned
 - **Body Force**, **Initial Condition** optional
- Two bodies can have the same **Material/Equation/Body Force/Initial Condition** section assigned



Variable defined as a function

1) Tables can be use to define a piecewise linear (cubic) dependency of a variable

```
Density = Variable Temperature
```

```
Real cubic
```

```
0 900
```

```
273 1000
```

```
300 1020
```

```
400 1000
```

```
End
```

Outside range: Extrapolation!

2) MATC: a library for inline (in SIF) numerical evaluation of mathematical functions

```
Density = Variable Temperature
```

```
MATC "1000*(1 - 1.0e-4*(tx-273.0))"
```

Evaluated every time

or as constant expressions

```
Viscosity Exponent = Real $1.0/3.0
```

Evaluated once

3) Build your own user function

```
Density = Variable Temperature
```

```
Procedure "filename" "proc"
```

filename should contain a shareable (.so on Unix) code for the user function whose name is `proc`

Example of User Function

```
FUNCTION proc( Model, n, T ) RESULT(dens)
USE DefUtils
IMPLICIT None
TYPE(Model_t) :: Model
INTEGER :: n
REAL(KIND=dp) :: T, dens

    dens = 1000*(1-1.0d-4 *(T-273.0_dp))

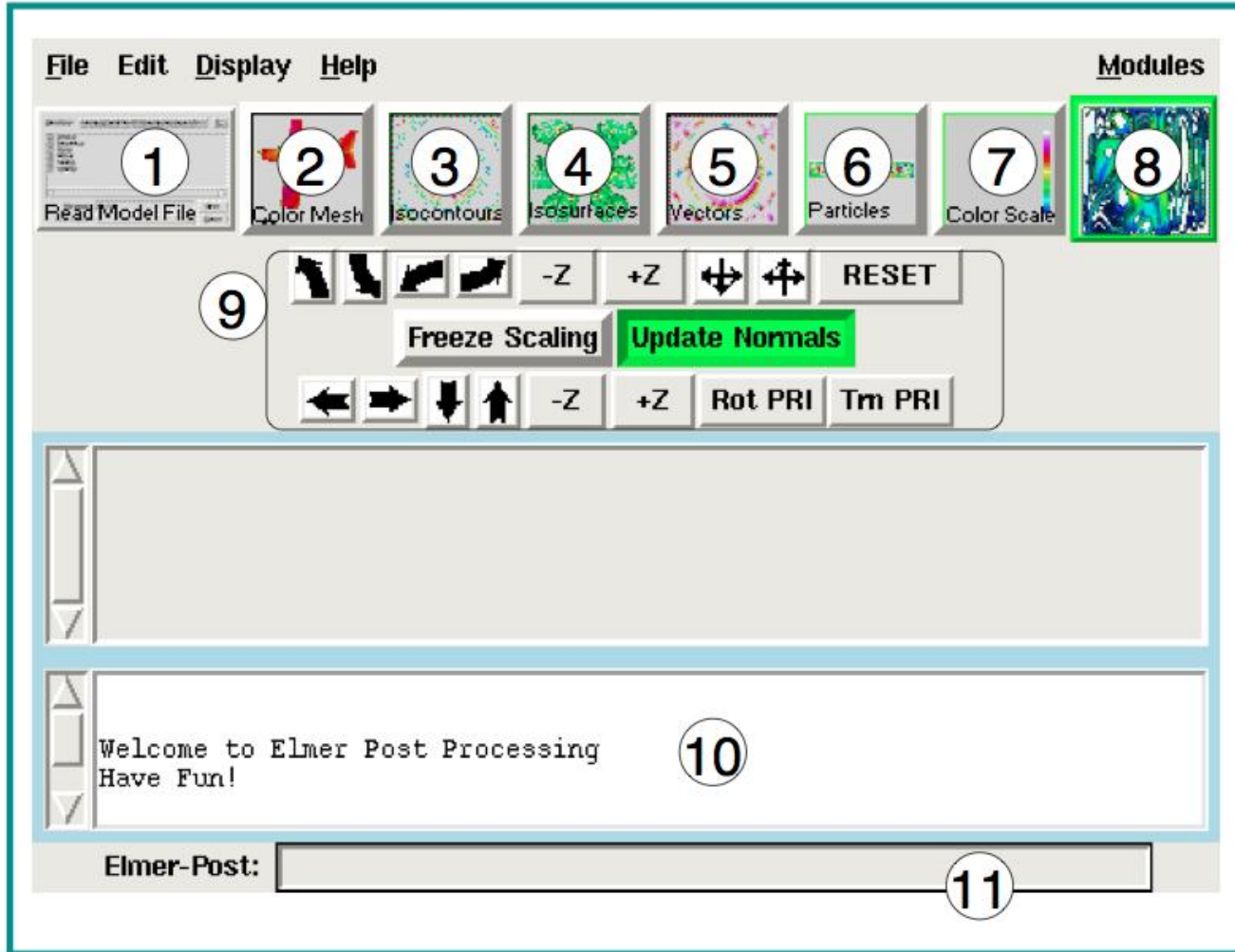
END FUNCTION proc
```

Compilation tools: `elmerf90`

```
$ elmerf90 filename.f90 -o filename.so
```

How to visualise results

ElmerPost (legacy format)



1. Read result
2. Mesh display
3. Iso-contours
4. Iso-surfaces
5. Vector-field
6. Particles
7. Color-bar
8. Refresh
9. View settings
10. Output
11. Command

Output for other post-processors

	GID	GID
	Gmsh	Gmsh
Output Format =	Vtk	VTK legacy
	Dx Format	Open DX
	vtu	ParaView

```
Solver 1
```

```
Equation = "ResultOutput"
```

```
Procedure = "ResultOutputSolve" "ResultOutputSolver"
```

```
Output File Name = "test"
```

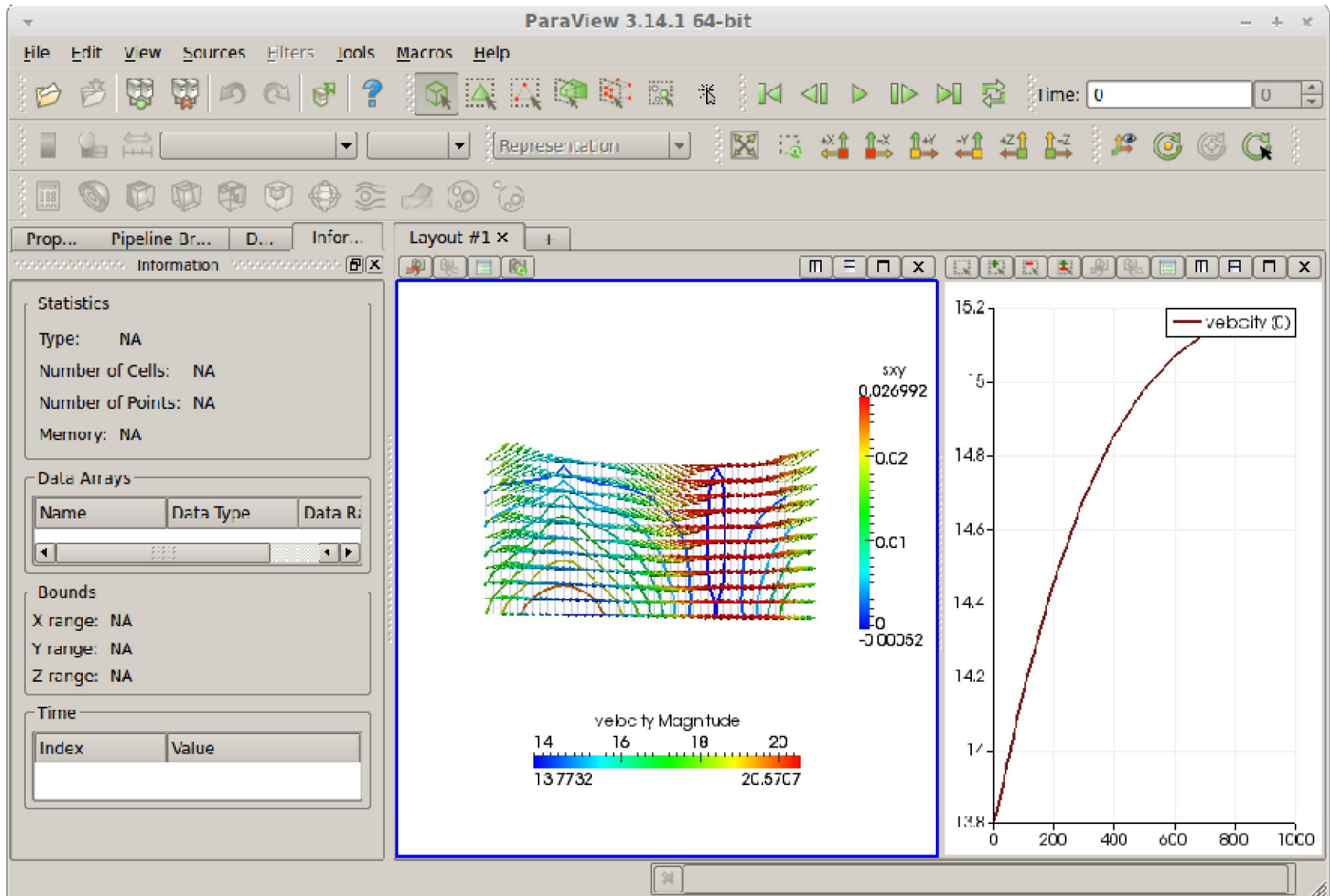
```
Output Format = string "vtu"
```

```
Scalar Field 1 = String "Temperature"
```

```
Vector Field 1 = String "Velocity"
```

```
End
```

Paraview



ASCII Based Output

- SaveScalars e.g. CPU time, mean, max, min of a variable, Flux
- SaveLine save a variable along a line (boundary or a given line)
- SaveMaterials save a material parameter like a variable

Example:

```
Solver 3
Exec Solver = After All
Procedure = File "SaveData" "SaveLine"
Filename = "ismip_surface.dat"
File Append = Logical False
End

Solver 4
Exec Solver = After TimeStep ! For transient simulation
Procedure = File "./MySaveData" "SaveScalars"
Filename = "ismip_scalars.dat"
File Append = Logical True ! For transient simulation

Variable 1 = String "Flow Solution"
Operator 1 = String "Volume"

Variable 2 = String "Velocity 1"
Operator 2 = String "Max Abs"

Variable 3 = String "Flow Solution"
Operator 3 = String "Convective flux"

Variable 4 = String "cpu time"

Variable 5 = String "cpu memory"
End
```

```
! Upper Surface
Boundary Condition 3
Target Boundaries = 3
Save Line = Logical True
Flux integrate = Logical True
End
```