First Elmer/Ice users meeting
9 April 2013 – Vienna (EGU 2013)

Program

- ✓ General presentation of Elmer/Ice – Olivier Gagliardini (LGGE)
- ✓ Recent important developments – Thomas Zwinger (CSC)
- ✓ Calving in Elmer/Ice
  - Joe Todd (Scott Polar Research Institute)
  - Jean Krug (LGGE)
- ✓ Work in Rovaniemi and sediment model - Rupert Gladstone (Arctic Centre)
- ✓ Dorothée Vallot (Upssala) – PhD program…
- ✓ Cavity and erosion - Flavien Beaud (SFU)
- ✓ Other know developments from people not at EGU
  - Hydrology: Basile de Fleurian (LGGE) and Mauro Werder (SFU) models
  - Temperature: Enthalpy solver, Adrien Gilbert (LGGE)
  - Inverse methods: Fabien Gillet-Chaulet (LGGE)
- ✓ Discussion / Prospective / Strategy for the future developments

Elmer/Ice versus Elmer

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 for glaciological applications.

The main core of the code is Elmer which needs to be installed before compiling the Elmer/Ice package.

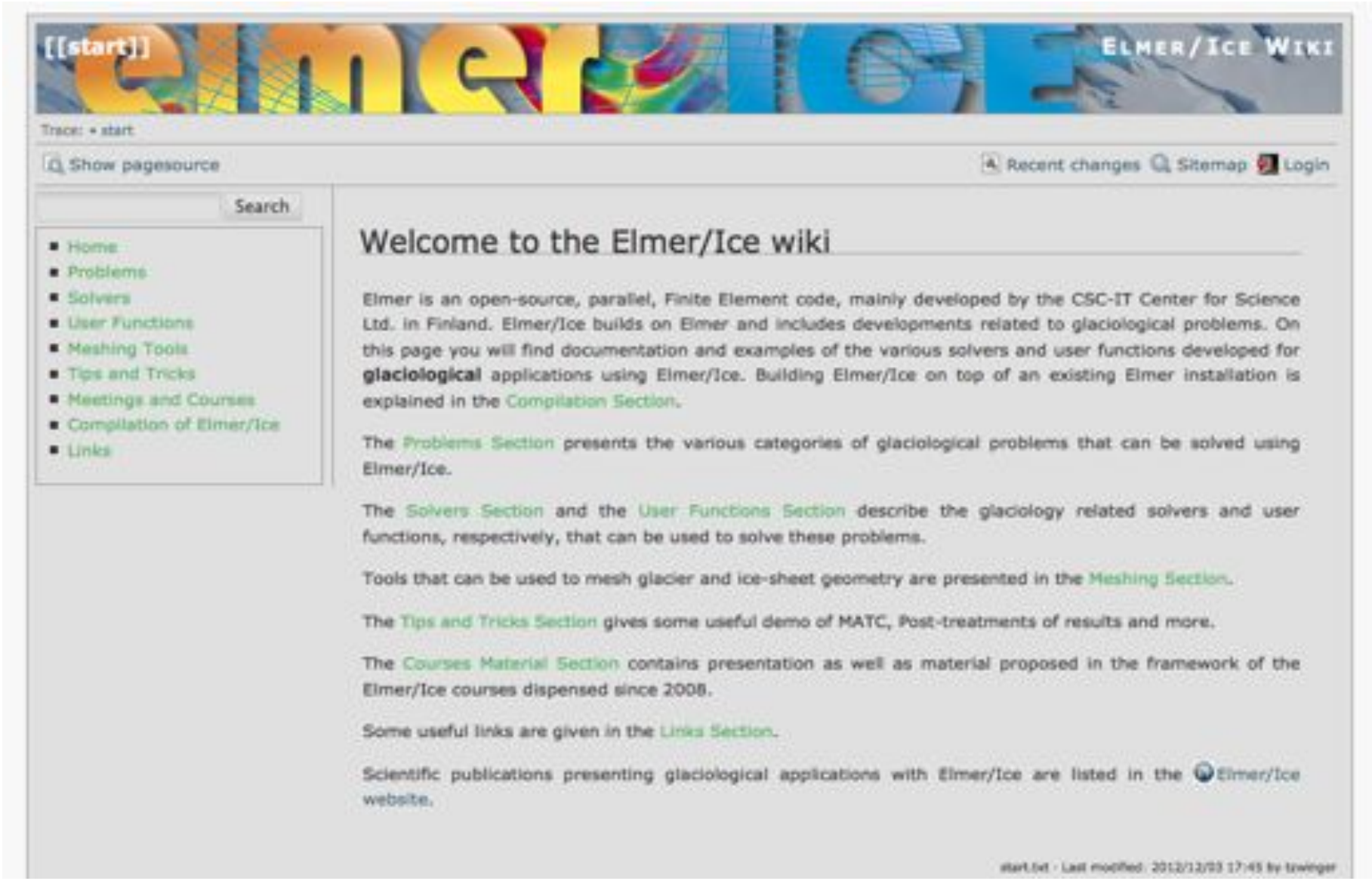
Short history of Elmer/Ice

- ✓ 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 – Second Elmer/Ice Course – 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 – Here we are…

Elmer/Ice website

http://elmerice.elmerfem.org/

Elmer/Ice wiki http://elmerice.elmerfem.org/wiki/doku.php



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?

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 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 `elmerfem/elmerice`)

List of the material available (05/04/2013)

- 20 Solvers
- 7 User Functions
- 4 Mesh Tools

Elmer/Ice Package - Solvers

Solvers

AIFlowSolve_nID2.f90
AIFlowSolve_nIS2.f90
CaffeSolver.f90
ComputeDevStressNS.f90
ComputeEigenValues.f90
ComputeNormal.f90
ComputeStrainRate.f90
DeformationalHeat.f90
ExportVertically.f90
FabricSolve.f90
Flowdepth.f90
ForceToStress.f90
GetHydrostaticLoads.f90
GolfLaw.f90
GroundedSolver.f90
IntegrateVertically.f90
IntegratedVelocity.f90
PorousSolve.f90
SIASolver.f90
SSASolver.f90
TemperateIce.f90
fAandfB_in.f90

Elmer/Ice Package

User Functions

Buoyancy.f90
CaffeFlow.f90
USF_Contact.f90
USF_LateralFriction.f90
USF_ShapeFactor.f90
USF_Sliding.f90
USF_Zs.f90

Mesh tools

ExtrudeMesh.c
MshGlacier.f90
MshGlacierDEM.f90
MshGlacierSynthetic.f90

Elmer/Ice capabilities

- Full-Stokes equation but also SIA, SSA, diagnostic or transient
- Various rheology (Glen's law, firn/snow and two anisotropic flow laws)
- Temperature solver accounting for the upper limit at melting point
- Evolution equations for density, fabric, …
- Dating, evaluation of strain-rate and stress fields
- Various friction laws (Weertman, effective-pressure dependent friction law)
- Grounding line dynamics as a contact problem
- Inverse methods (linear adjoint and Arthern and Gudmundsson 2010 methods)
- Tools to mesh glaciers (YAMS, 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

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

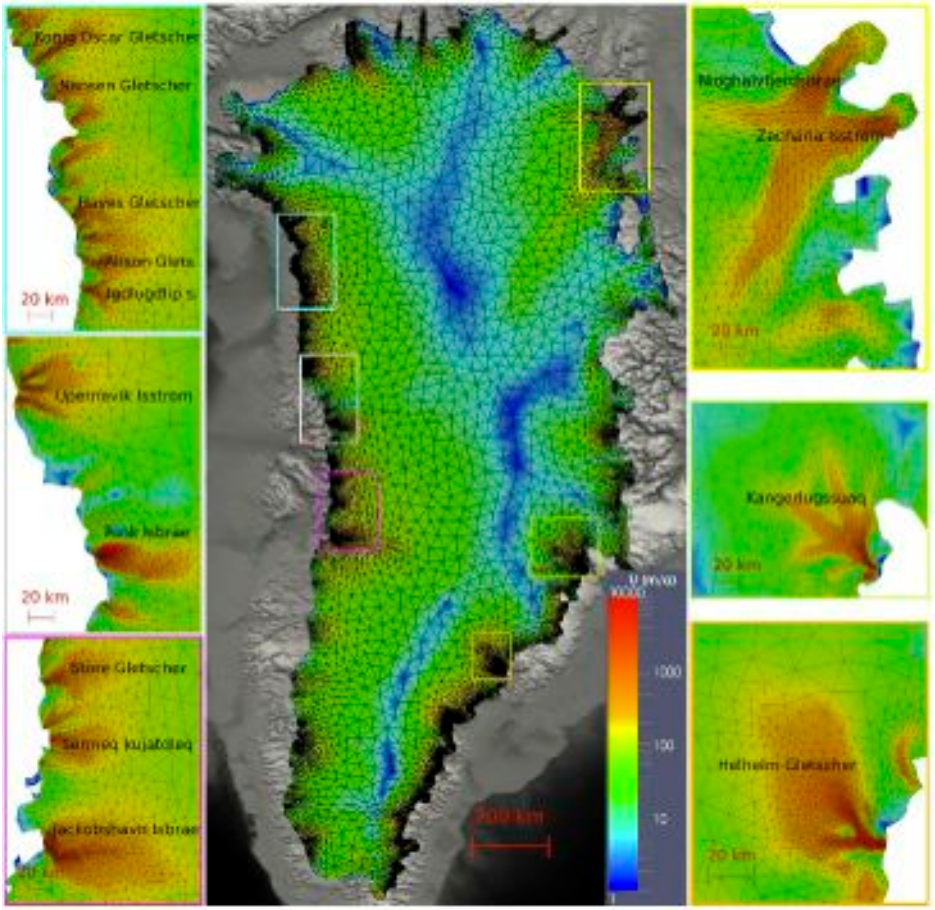
GMD paper

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

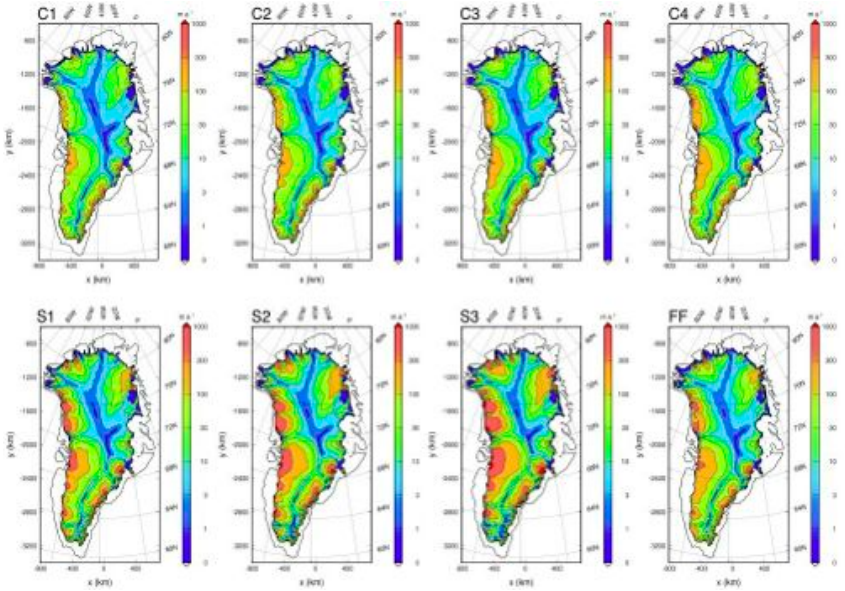
O. Gagliardini[1,2], T. Zwinger[3], F. Gillet-Chaulet[1], G. Durand[1], L. Favier[1], B. de Fleurian[1], R. Greve[4], M. Malinen[3], C. Martín[5], P. Råback[3], J. Ruokolainen[3], M. Sacchettini[1], M. Schäfer[6], H. Seddik[4], and J. Thies[7]

Few recent examples

Grenland within ice2sea
@Fabien Gillet-Chaulet, LGGE



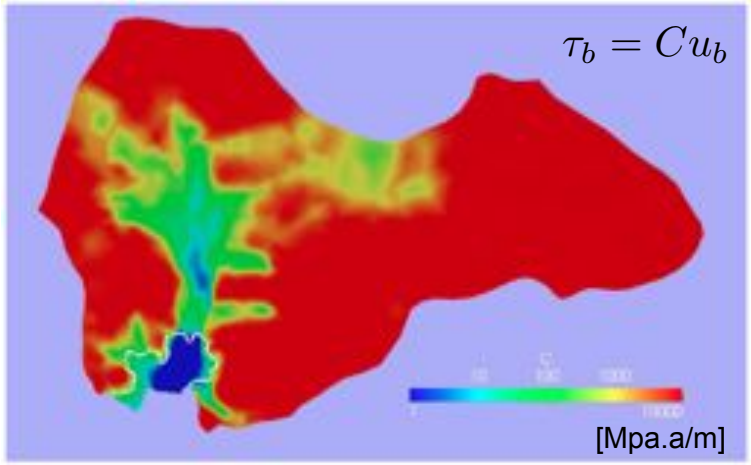
Grenland within SeaRise
@Hakime Seddik, ILTS



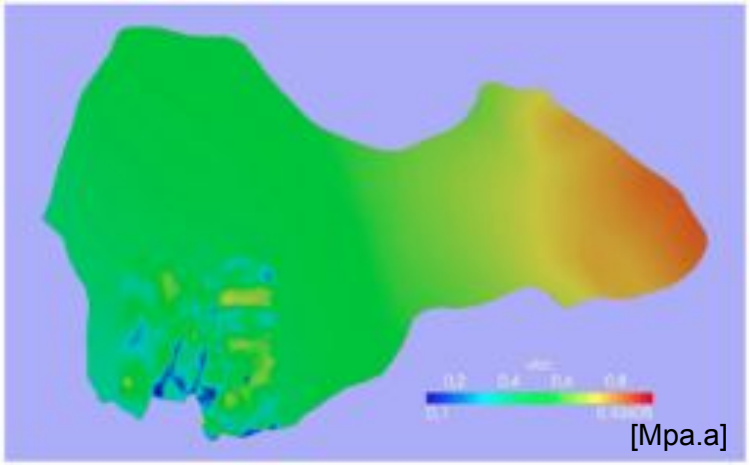
Few recent examples

Grounding line 3D @Lionel Favier, LGGE

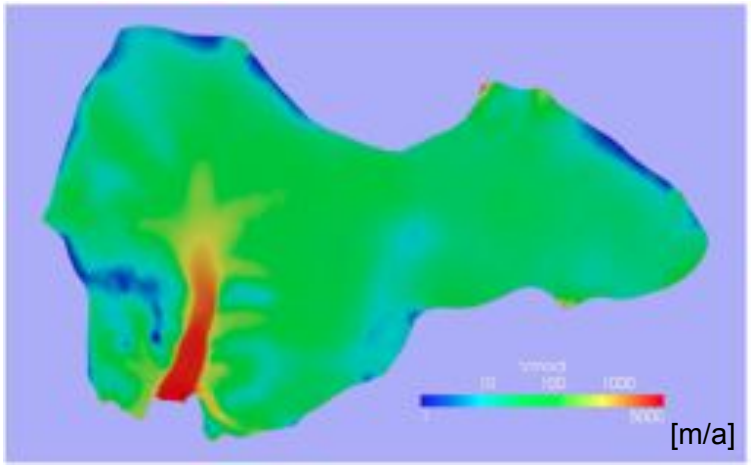
Inverted **basal friction** parameter



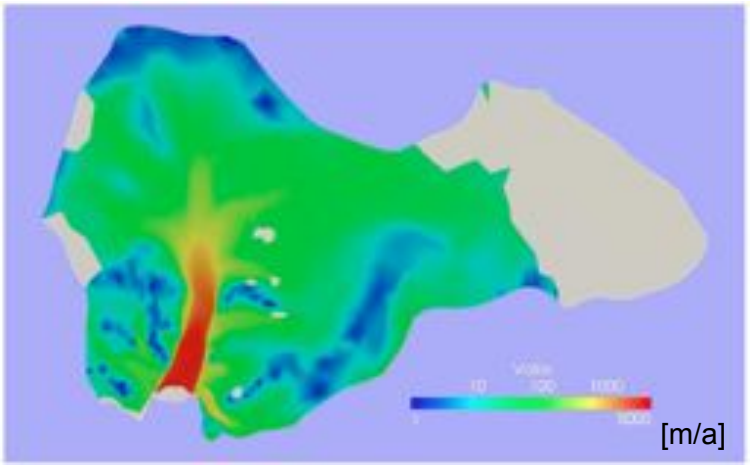
Inverted surface **effective viscosity**



Inverted surface velocity

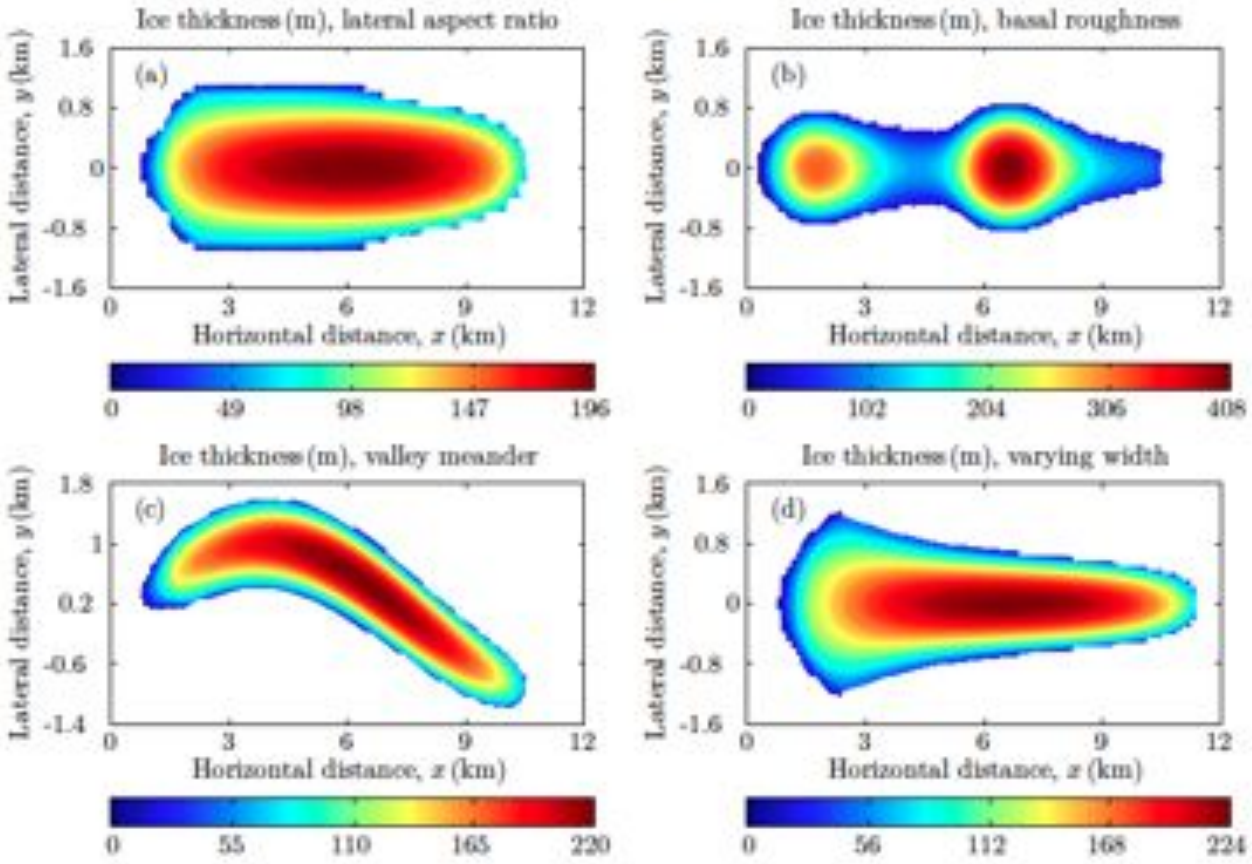


Observed surface velocity (Rignot et al., 2011)



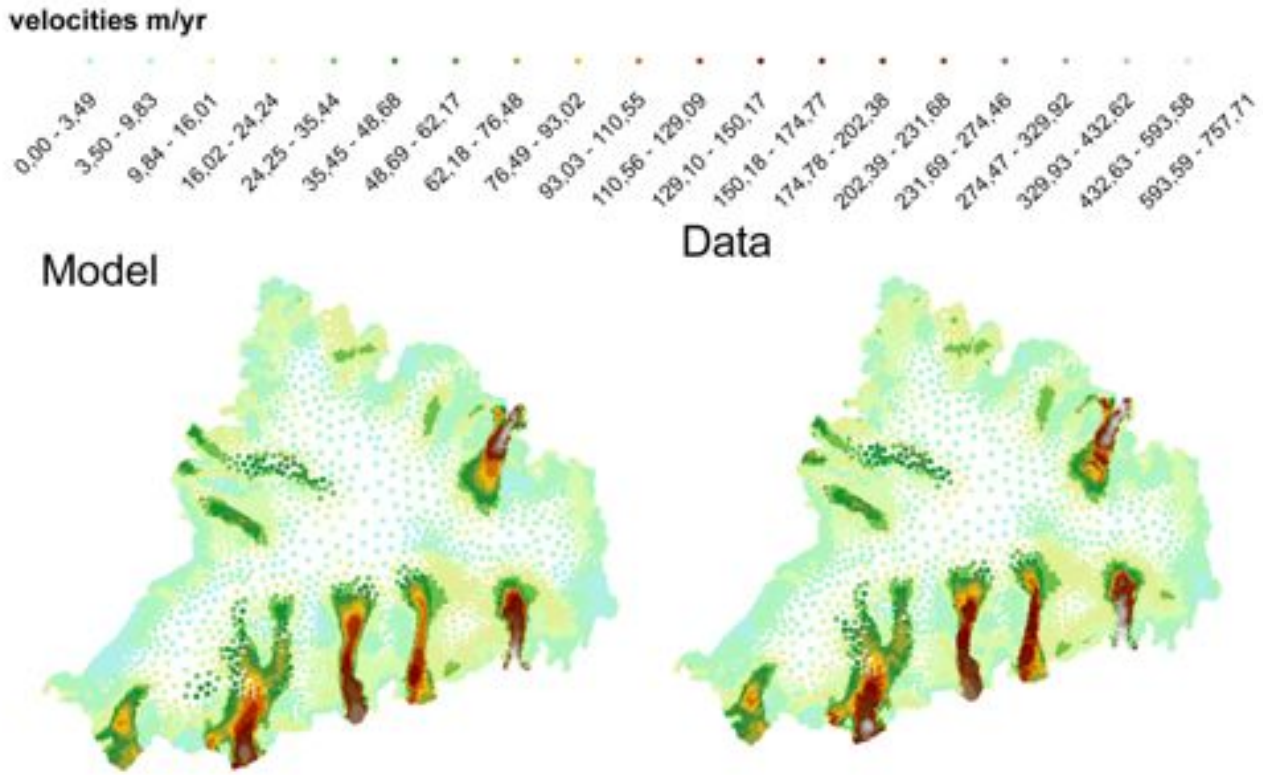
Few recent examples

Volume/Area relation @Surendra Adhikari, Univ. Calgary



Few recent examples

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



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