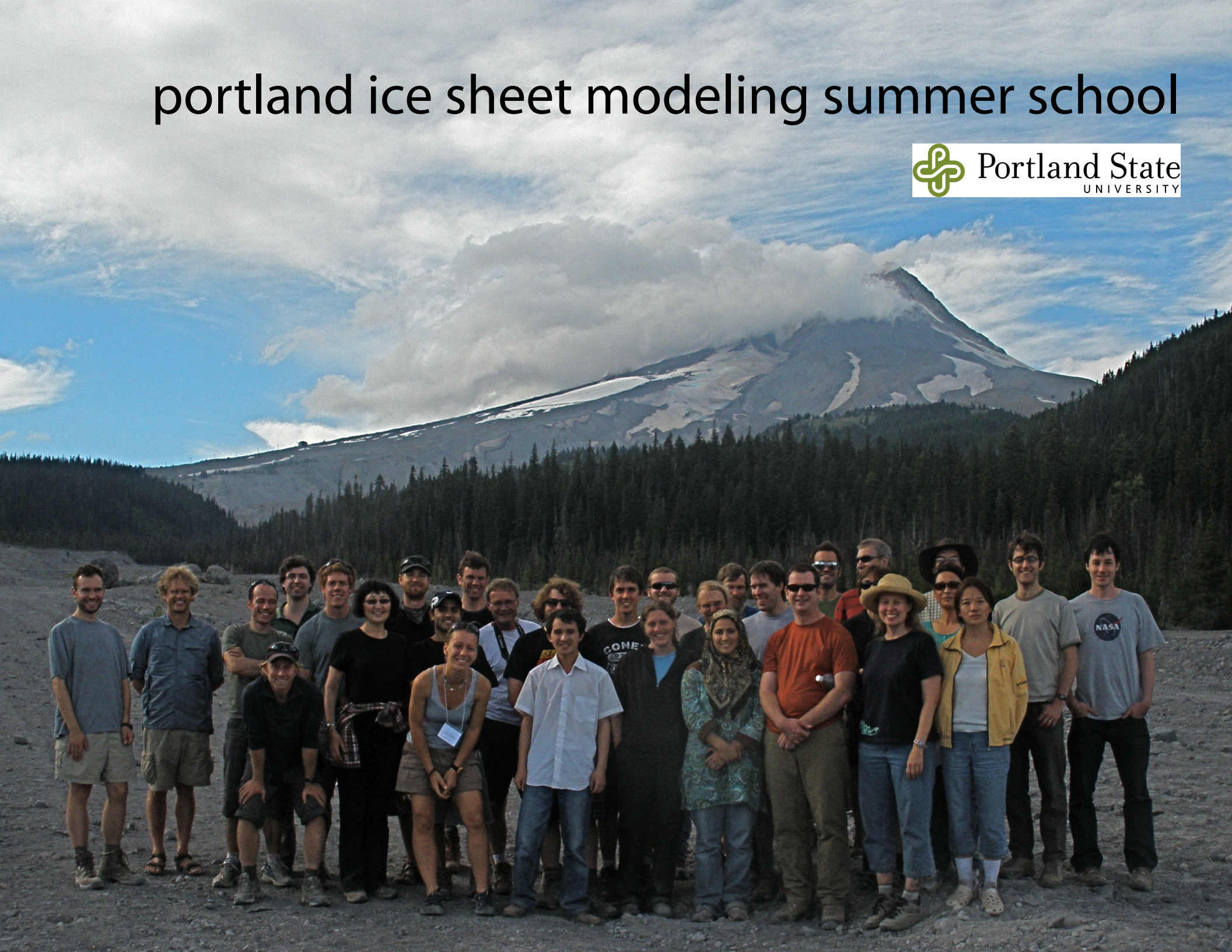
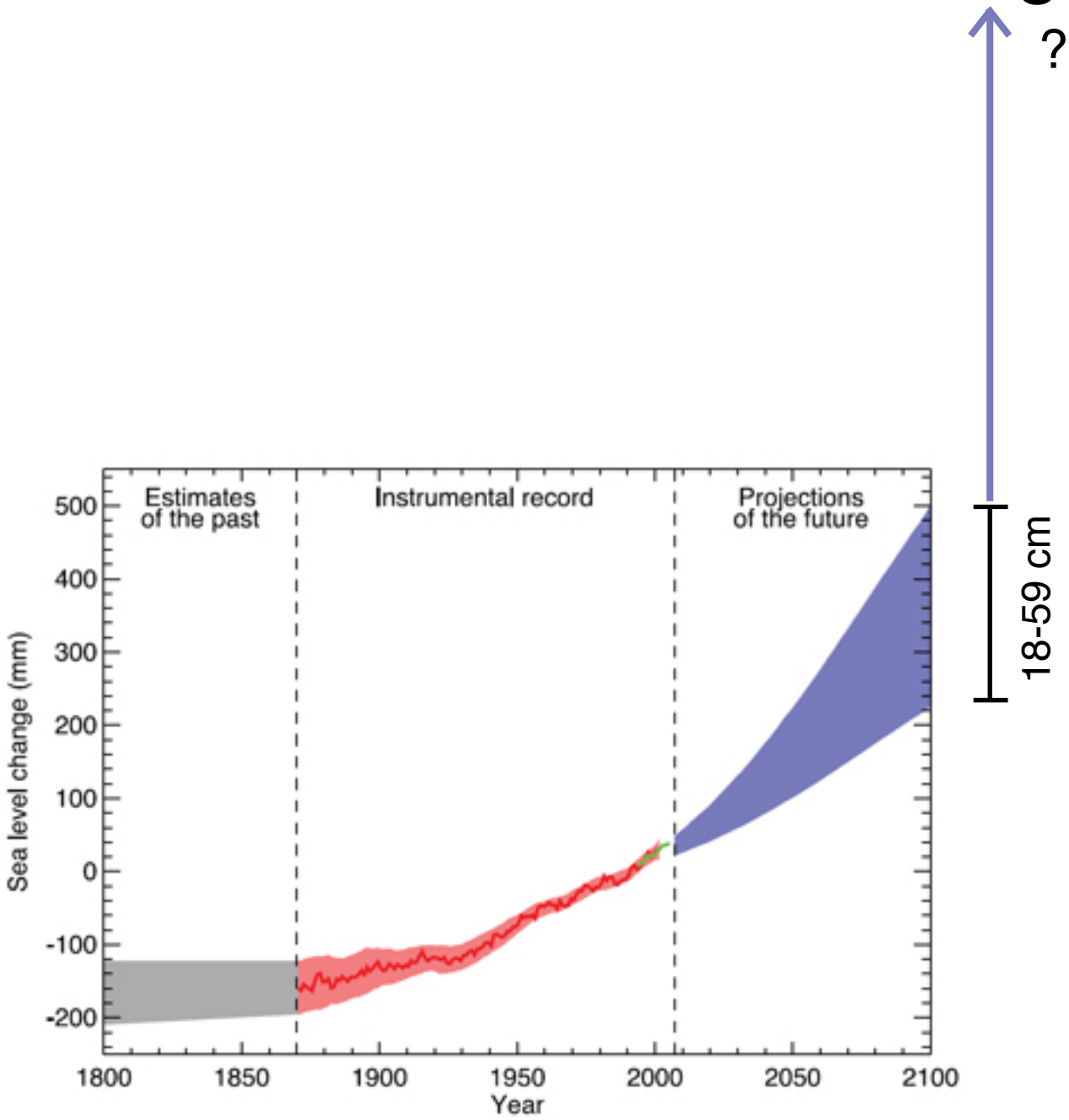
portland ice sheet modeling summer school



Goal for Summer Modeling School

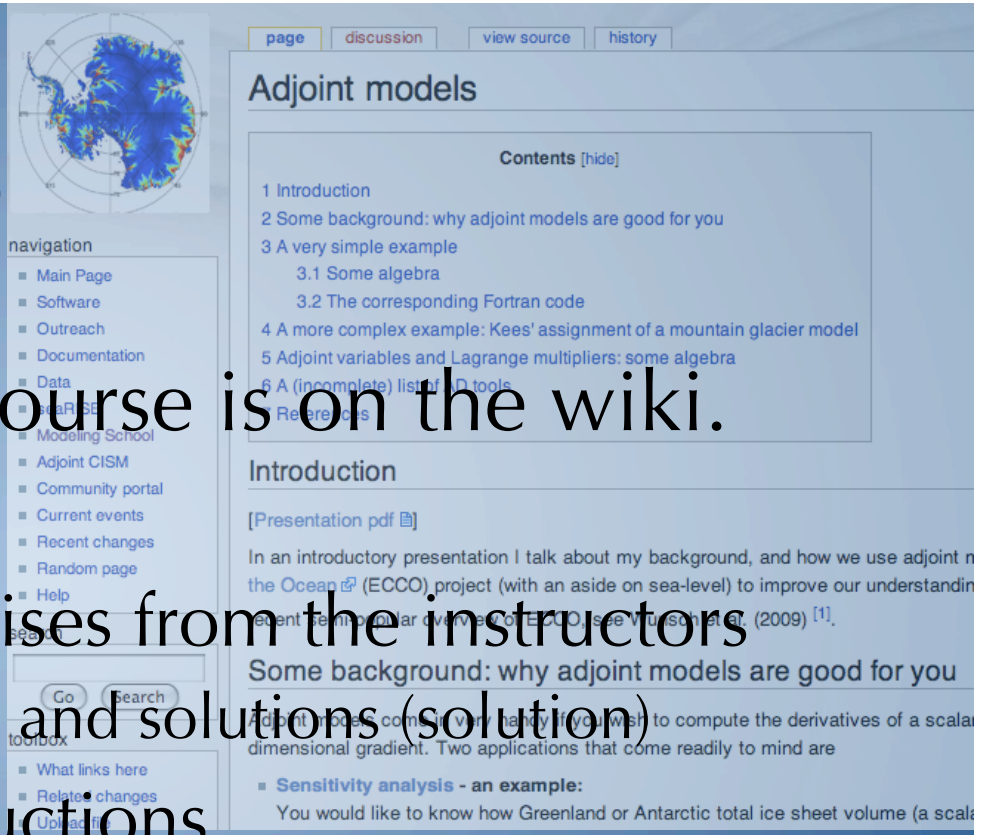


Course Design

- Goal: Foster a lot of interaction, because it takes a lot of collaboration to build a community ice sheet model
- Modelling school setup
  - Wiki page
  - Small groups (3 students, 2 instructor-students)
  - Lectures and model-running

Wiki Page

- EVERYTHING for the course is on the wiki.
  - Planned agenda
  - Presentations and exercises from the instructors
    - Students' (Kristin's) notes and solutions (solution)
  - Model installation instructions
  - Students' backgrounds and interests
  - PDX Afterhours



Groups

- 2 instructors (young profs or Todd DuPont) and 3 students
- Two computers, 4 monitors
- Work together or in subgroups on exercises
  - write easy explicit finite differences Fortran script
  - problem sets (force balance)
  - install & run Glimmer / other models

Participants (in groups)

Students
Instructors

Lipscomb, Bill
Price, Steve
Hagdorn, Magnus
Tulaczyk, Slawek
Johnson, Jesse
Hulbe, Christina
Jezek, Ken
Van der Veen, Kees

Fyke, Jeremy
Wang, YuanXiang
Xueyuan, Tang
Seifert, Fiona
Dupont, Todd
Wang, Weili

Mankoff, Ken
Campbell, Adam
Meierbachtol, Toby
Sargent, Aitbala
Rempel, Alan

Brinkerhoff, Douglas
Werder, Mauro
Hossainzadeh, Saffia
Heimback, Patrick
Rutt, Ian

Colleoni, Florence
McGovern, Jonathan
Poinar, Kristin

Kirchner, Nina
Jackson, Charles

Normani, Stefano
Lindsey, Daniel Seneca
Applegate, Patrick
Anderson, Brian
Sergienko, Olga

Adhikari, Surendra
Hoffman, Matt
Burke, Erin
Williams, Gethin
Nowicki, Sophie

Student Presentation

Our instructions:

"On Saturday morning, you'll have 1-2 hours to make a presentation to us. Introduce yourselves and your research. Other than that, it's completely up to you."

Student Presentation

- Our product: Roundtable Discussions
  - First
    - Organize by field site: Greenland, Antarctica, alpine, global
    - Discuss research
  - Second
    - Organize by academic background: Geology, math, physics, computer science / engineering
    - Discuss career path (past & future)

Roundtable 1: Study Regions

Greenland

- We need better communication between modellers & data-collectors, with feedback.

Antarctica

- Basal processes are the hot ticket.

Mountain glaciers

- We Heart Valley Glaciers
- Simple models are all you need..... for a valley glacier

Other/Global

- Is it just sea level change that's of interest to glaciologists?
- Are rapid changes large changes?
- Surprise: surges

Summary of four separate 20-30 minute discussions (students/instructors mixed)

Possible discussion questions:

- What questions are the climate change community pressuring us to answer?
- What do we know now that would have been a big surprise 10 years ago?
- How important is field data to your research? If you could collect any field data/observations to progress your work, what would it/they be?
- What is the holy grail of our subfield?
- What areas should we avoid trying to answer at this time due to complexity?

Roundtable 2: Background

Geology

- There exist opportunities to work in the private sector
- Taking classes, reading papers outside the discipline (e.g. math(s), physics)
- Flexibility!

Engineering/CS/Other

- Interesting research is at the boundary of disciplines, but the hiring is at the core... one's career is a balance game (NICE)
- Building personal relationships
- Predisposed to become pigeonholed as Endnote teachers / website writers

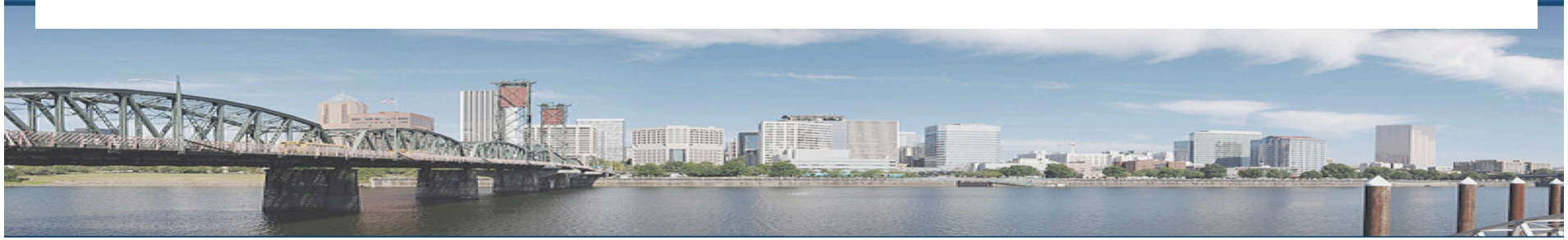
Physics

- Best background to have for glaciology, we have no regrets.
- Glaciology is presently a tiny field compared to its importance / focus on by IPCC
- Planetary ice is a new frontier that might blow up
- Building personal relationships with which to muddle through funding
- Career moves: at each transition, choose a new problem, institution, and even country.

Math(s)

- Math is great, but often weak in converting glacial processes into equations.
- We may have a disconnect between equations & physical space
- Dealing with the naysayers: fearmongering vs. reassurance

Summary of four separate 20-30 minute discussions (students/instructors mixed)



Lectures and Intro to the school

- What are we supposed to do here at the Summer Modeling School?
  - Student-teacher line should be blurred /nonexistent
  - Make Dave Holland happy: come up with a number to limit SLR from dynamical processes
  - Ian Rutt suggests thinking about *how* to test your code every time you are writing code
  - Ken Jezek wants us to better incorporate a measure of confidence we have in a model, but Charles Jackson says this is very hard to know.

Lectures

History of ice sheet modelling

Mahaffy model, 1976
Depth-averaged (2D)

The Model A

Jenssen model, 1977
Included temperature – 3D in a sense

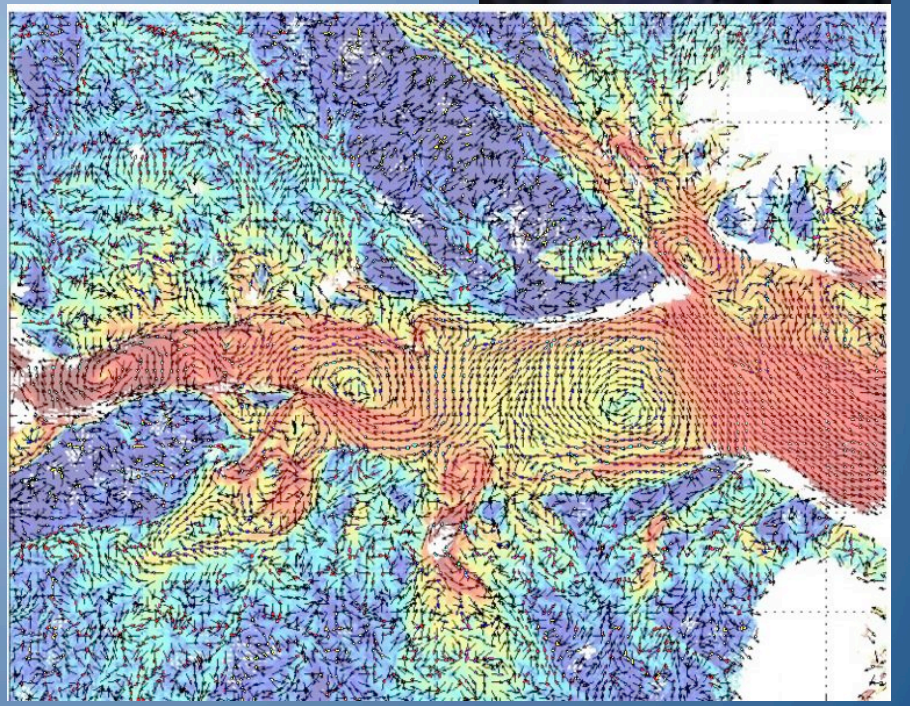
The Model T

GLIMMER, 2009

Mustang: a sleeker body & more loaded, but the same fundamental engine

Lectures

- Acceleration “whirlpools” on Lambert Glacier, feeding AmeryIS
  - an effect of ice being steered in the bedrock channel
  - not an indication of the motion of the ice sheet (velocity vortices cannot exist) but rather small imbalances that control speedup / slowdown of the ice.
  - models assume zero acceleration. nonzero curl of acceleration means nonconservative motion.



Lectures


Alan Rempel

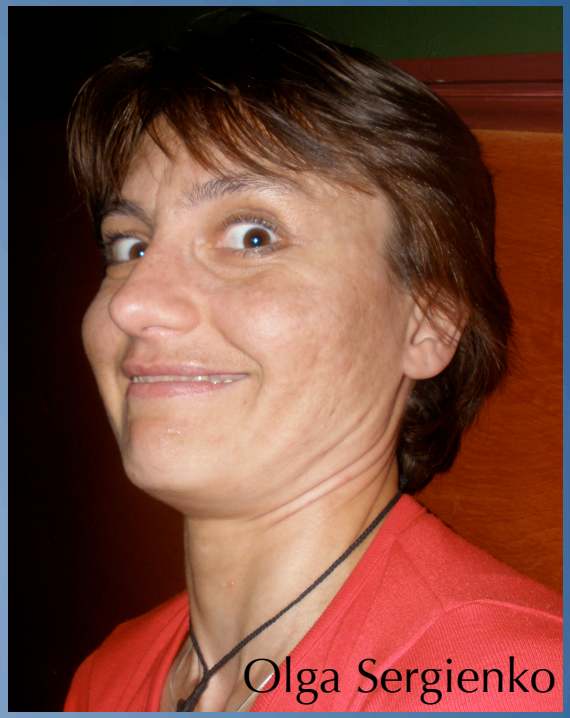
- How melted can a basal layer really be?
  - we can't maintain an ice-liquid interface at pressures greater than ~0.06 bar... but hydrostatic subglacial pressure is ~1bar.
  - Therefore
    - high N corresponds to large pressure difference (ice pressure minus water pressure)
    - water freezes in to the sediment layer (entrainment)
    - theory of melted beds is appropriate for film thickness only **much** greater than molecular distances
    - Evaluate film thickness using water flow requirements and force balance

Lectures

- We know the surface of Mars at almost 100x better resolution (~5m) than bedrock under Greenland Ice Sheet (dozens of meters)

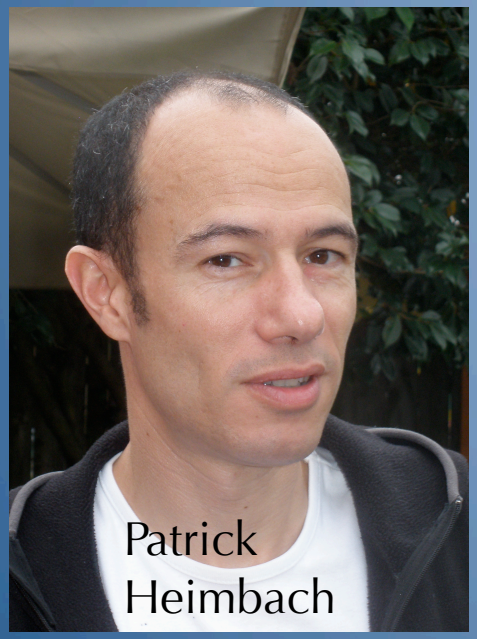
Lectures

- Olga derived the full force balance on an ice shelf
  - on the white board
  - over a two-hour period that straddled lunch
  - with no sign errors
  - with no confused pauses
  - with no erasing


Olga Sergienko

Lectures

- Adjoint Models



- Quantifying Uncertainty

RELIABLE **Models** CERTAIN

Simple physics	Complex physics
Few links	Many links
Strong constaints	Weak constraints
Testable	Poor understanding

Where are ice sheet models on this continuum?
IPCC says….

Lectures

- Adjoint Models

- Quantifying Uncertainty

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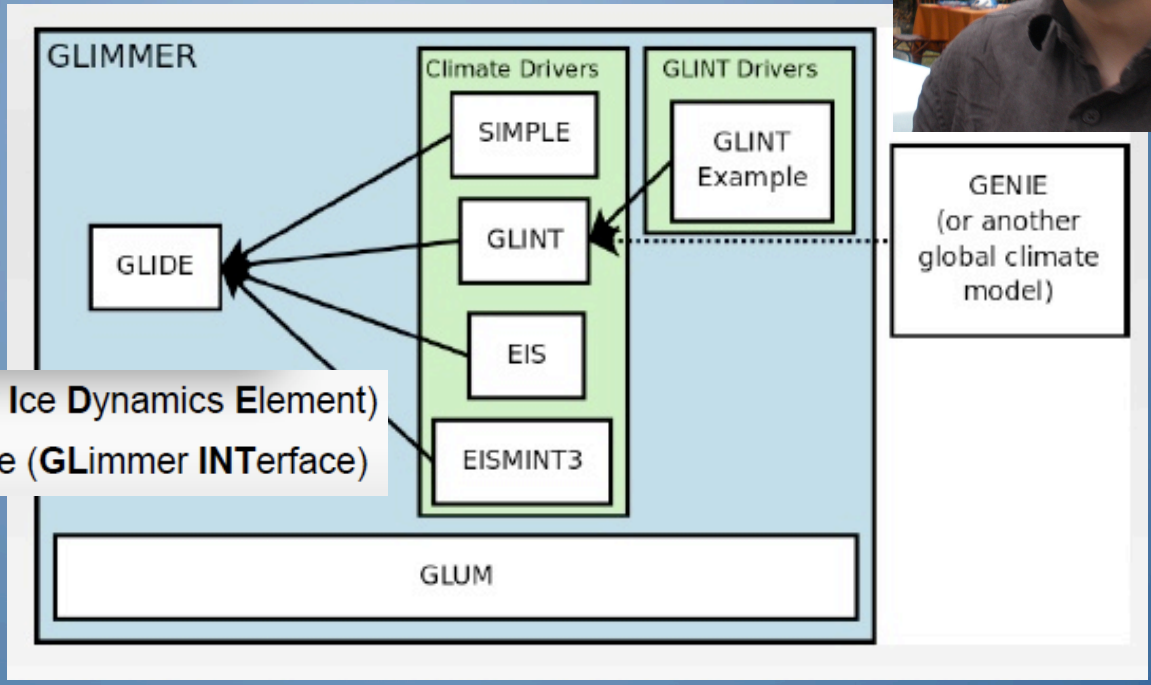
Lectures – intro to GLIMMER

"This diagram illustrates our obsessive approach to acronyms."



GLIDE: the core model (**GL**immer **I**ce **D**ynamics **E**lement)

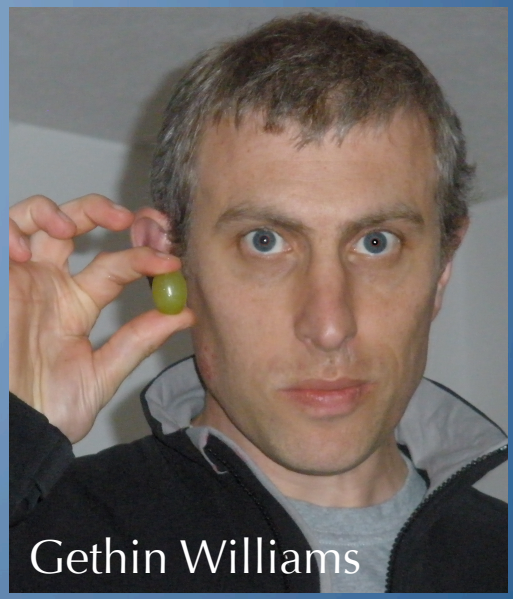
GLINT: the climate model interface (**GL**immer **INT**erface)

Lectures

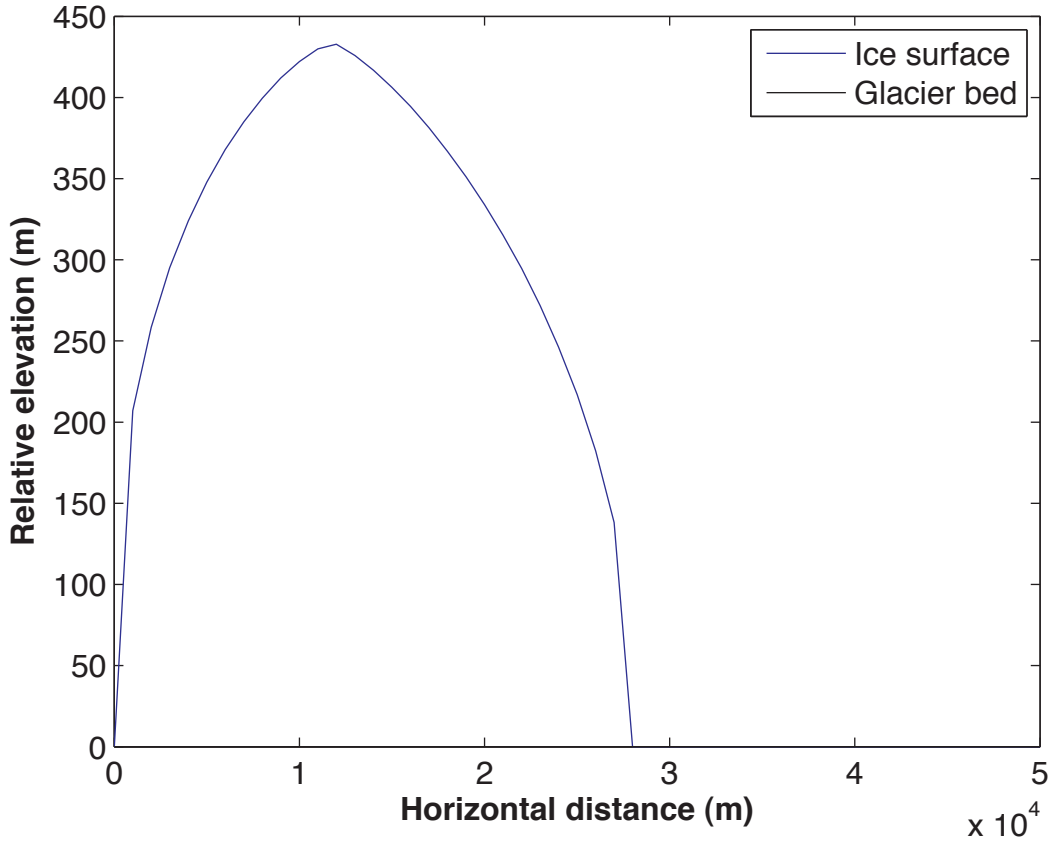
- Grounding lines

- GCM coupling

- Fortran / Linux



practicals
finite differencing



$$\frac{\partial H}{\partial t} = -\frac{\partial}{\partial x}\left(-D(x)\frac{\partial h}{\partial x}\right) + M$$

where

$$D(x) = CH^{n+2}\left|\frac{\partial h}{\partial x}\right|^{n-1},$$

and

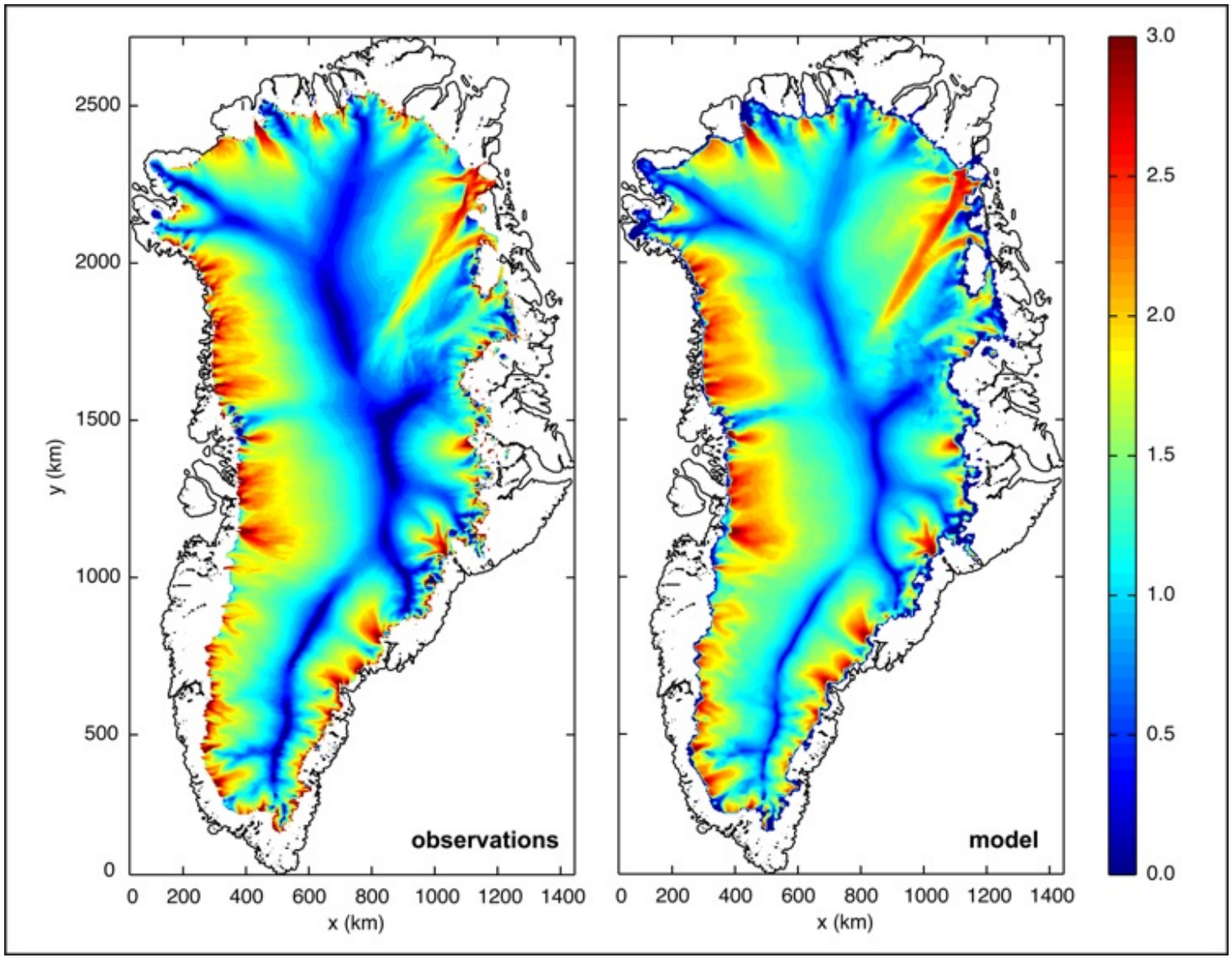
$$C = \frac{2A}{n+2}(\rho g)^n$$

practicals
GLIMMER

SIA - not perfect, but hey you can run Greenland for a thousand years in an afternoon

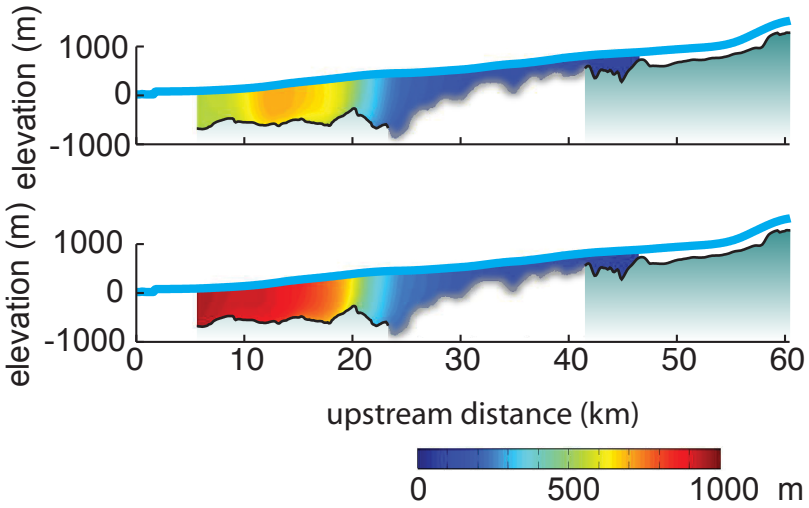
develop your own modules... please

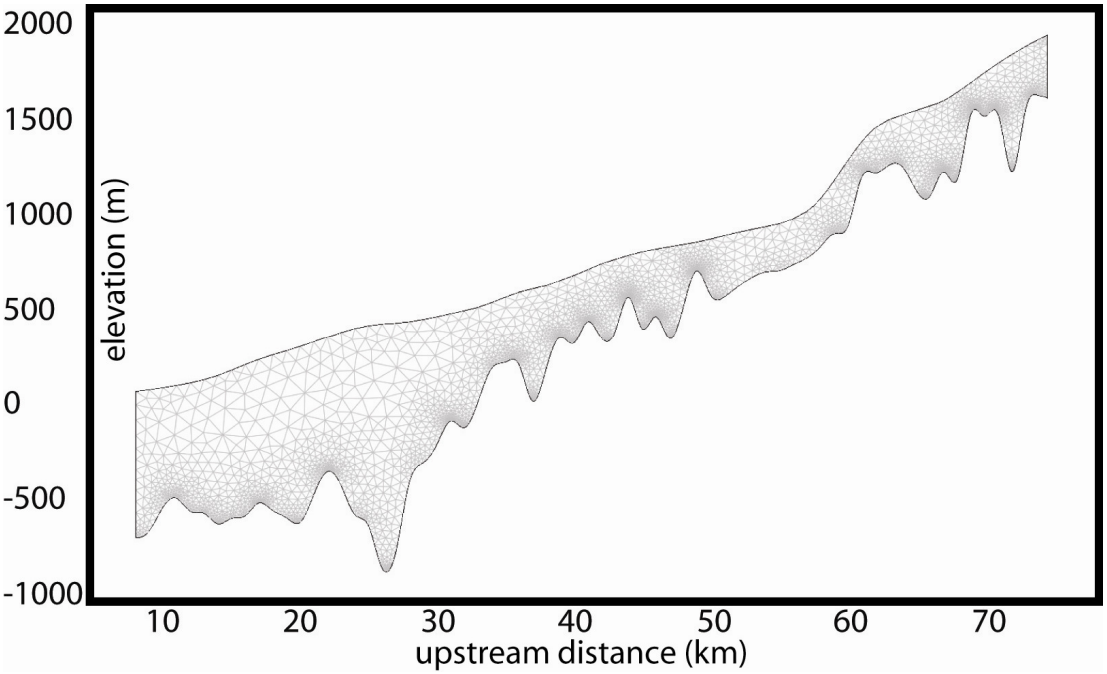
it's free!
(and some might say well documented)



practicals

COMSOL multiphysics



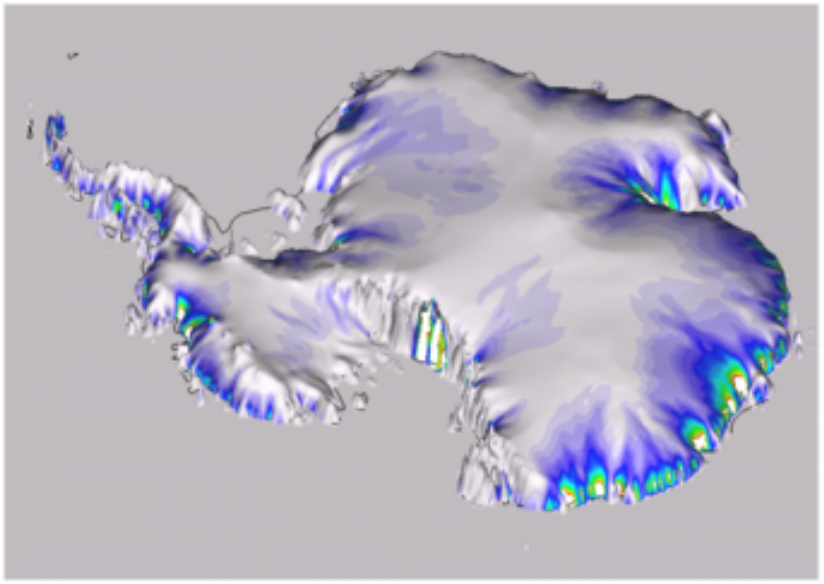


solve full momentum and mass balance equations easily

quickly make your mesh

easy to use for simple problems but steep learning curve - not designed with glaciers explicitly in mind

what i took away from the course



-we have to figure this out together

-full Stokes is great but...

-it’s all about the physics