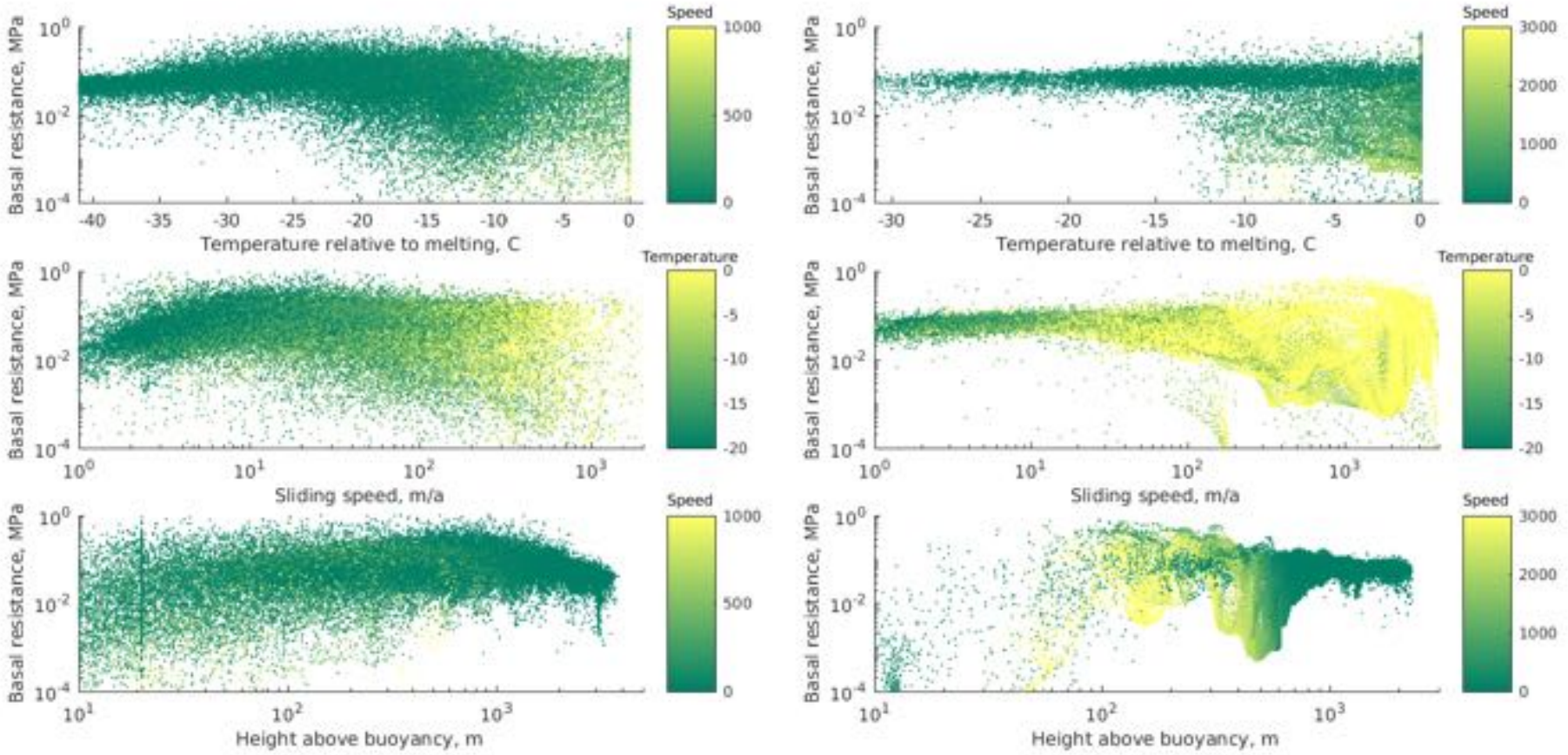
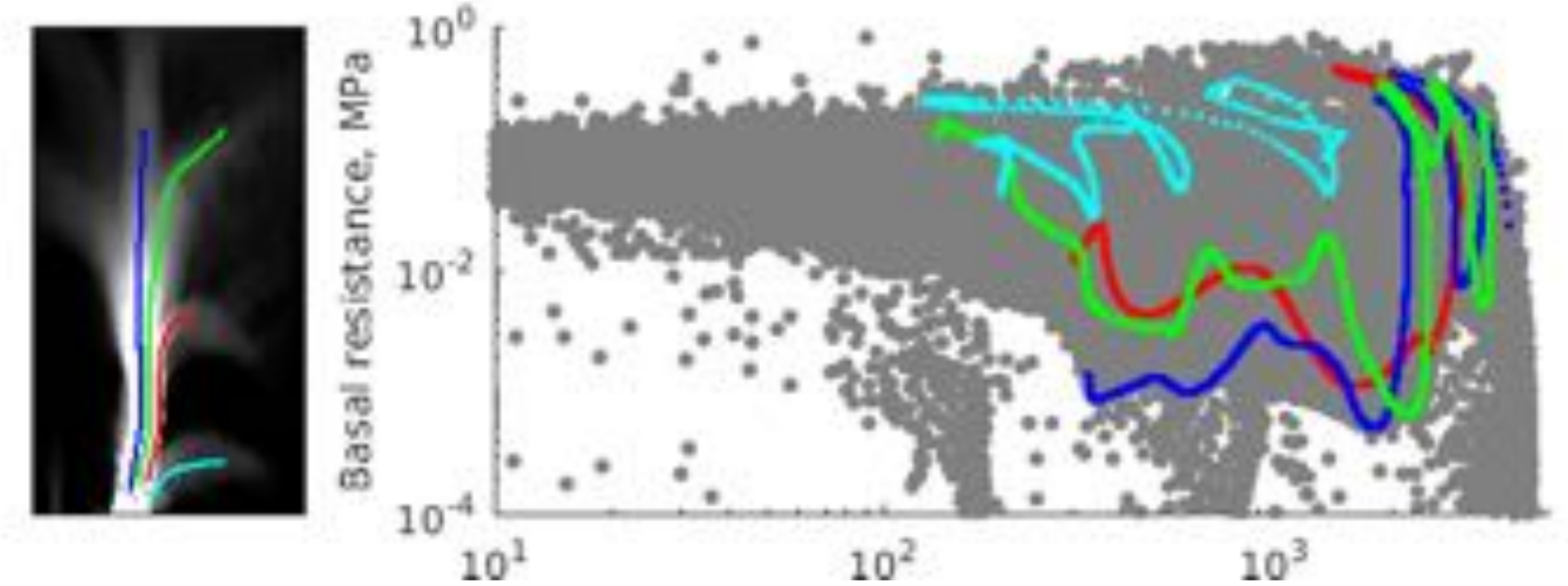
Implications for sliding

Relating basal resistance to key properties



Spatial patterns

Resistance and sliding speed along PIG flowlines



Rupert Gladstone, 29th October 2018

Modelling Antarctic Ice Sheet – Southern Ocean interactions with the Framework for Ice Sheet – Ocean Coupling (FISOC)

Rupert Gladstone, Ben Galton-Fenzi, David Gwyther, Chen Zhao, Thomas Zwinger, John Moore, and perhaps some others…

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FISOC: Framework for Ice Sheet – Ocean Coupling

Rupert Gladstone, Ben Galton-Fenzi, David Gwyther, Lenneke Jong

FISOC: Framework for Ice Sheet – Ocean Coupling

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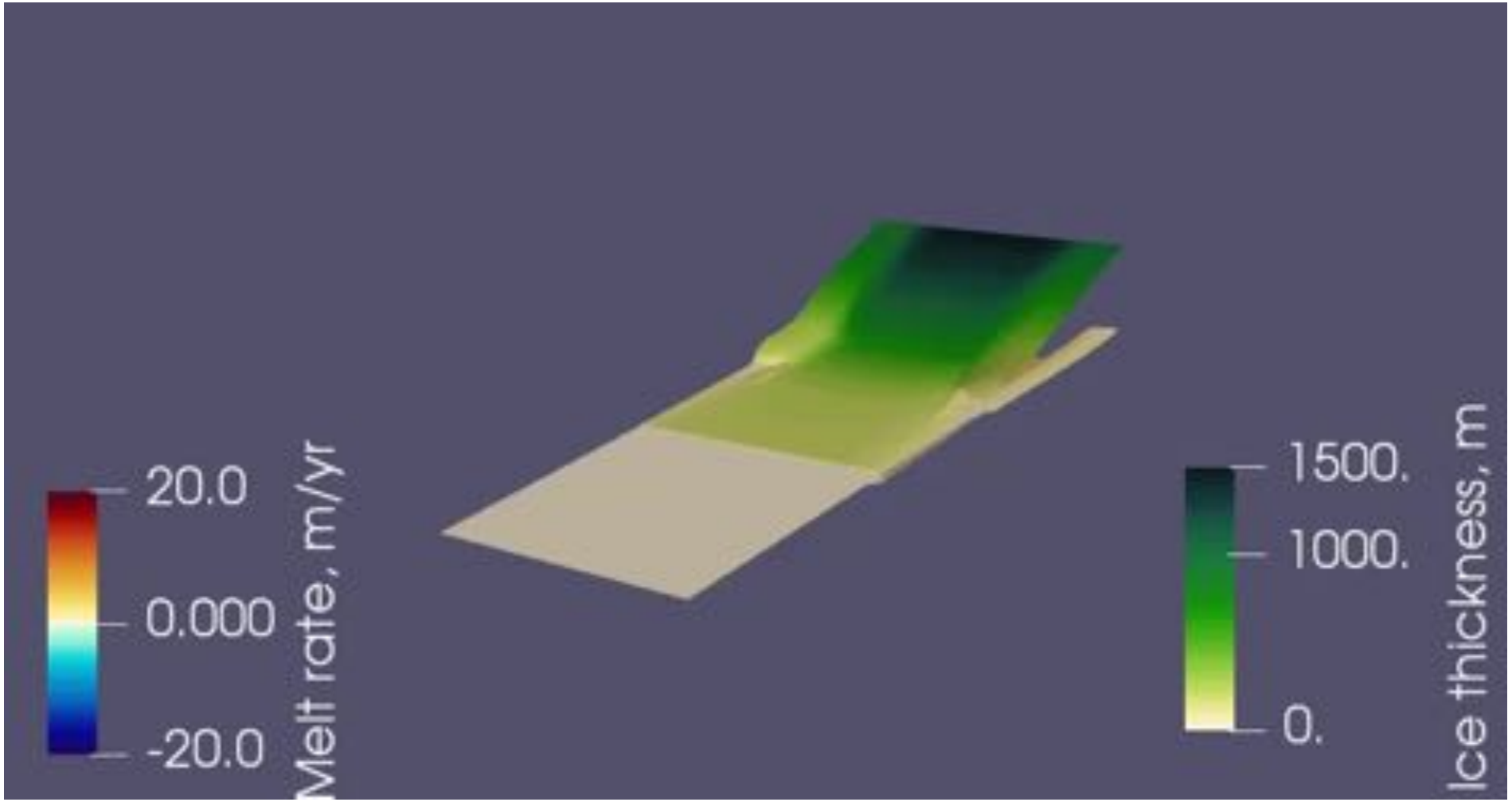
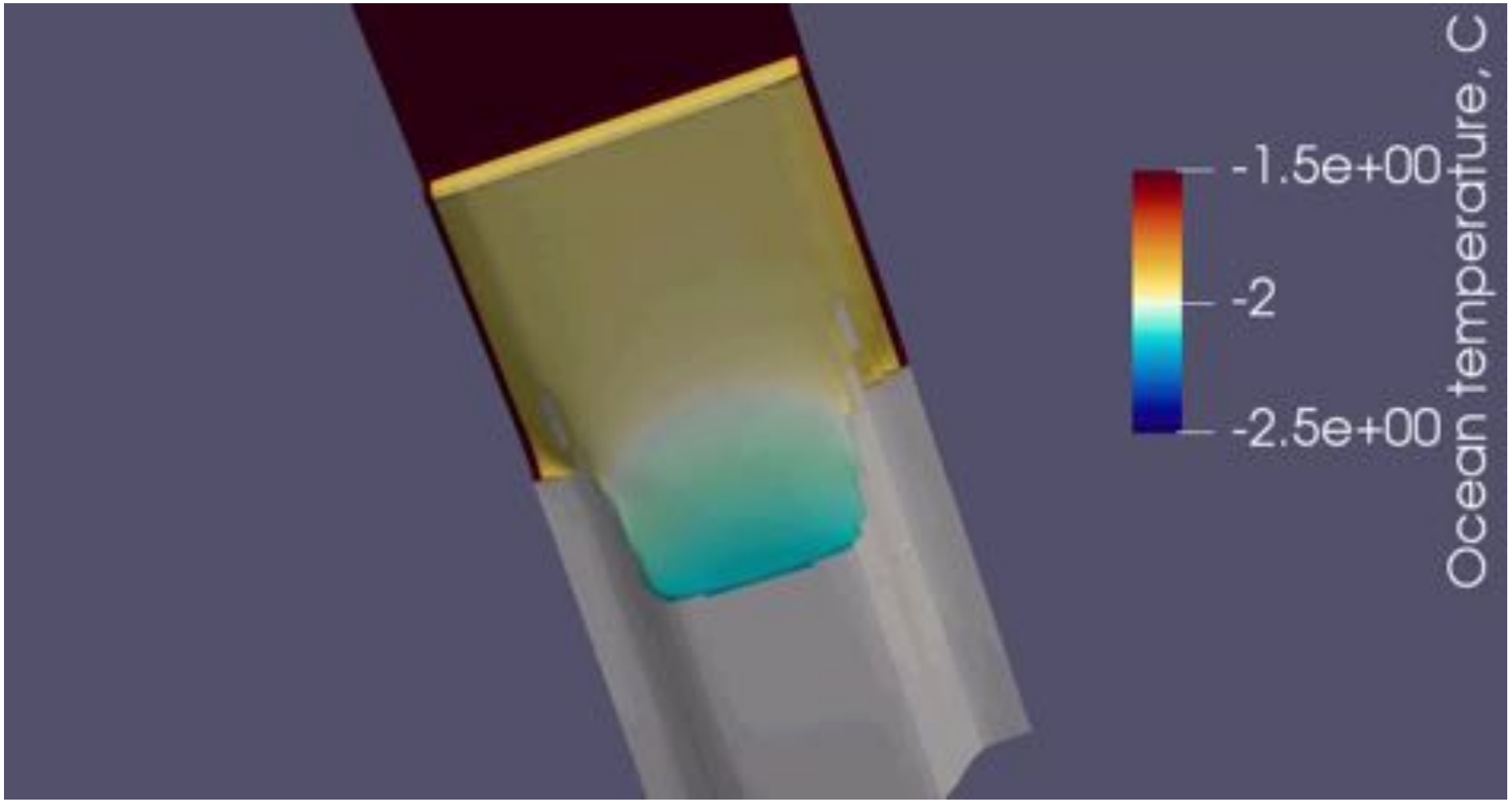
Toward coupled ice-ocean modelling

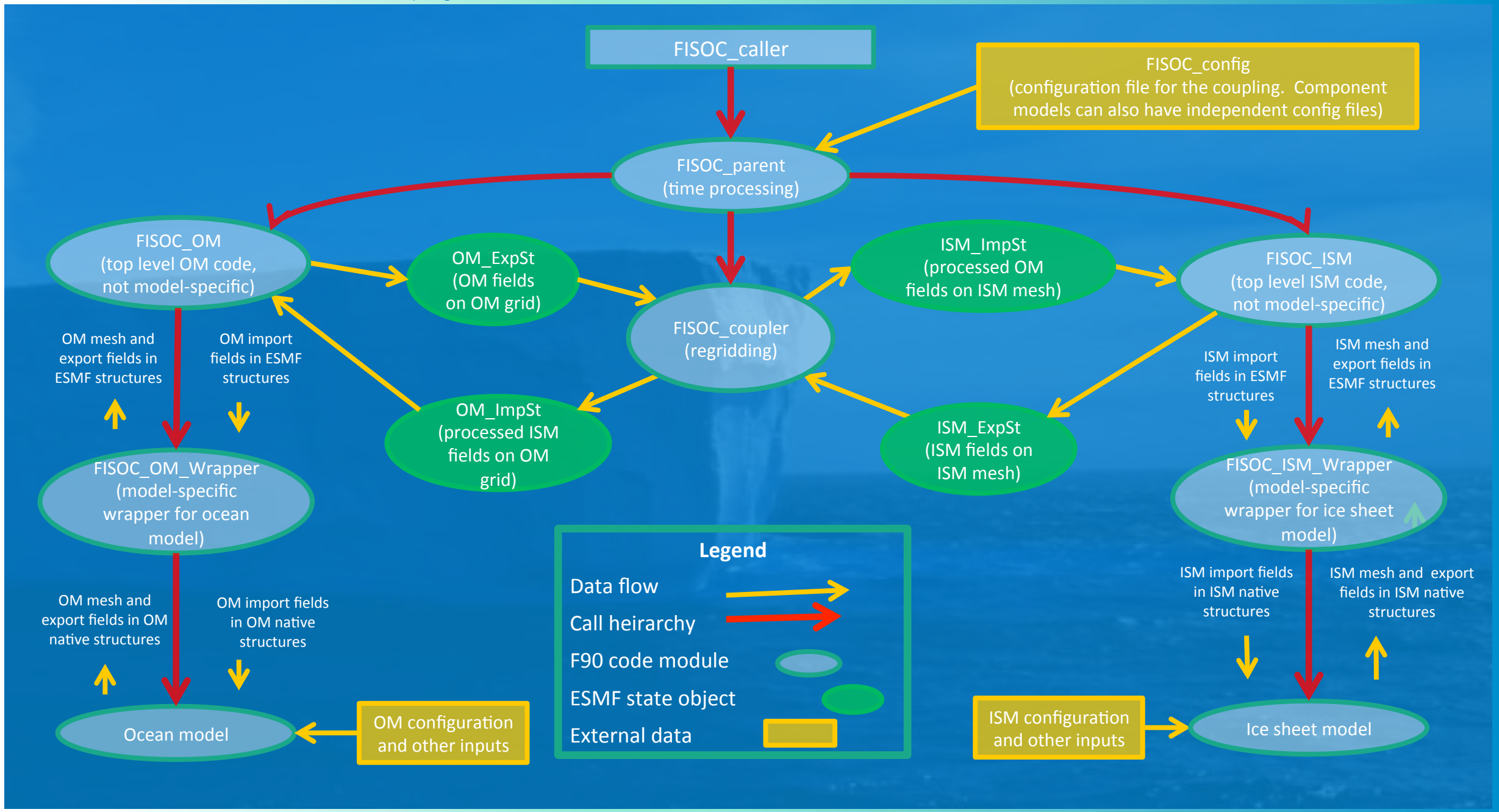
Idealised simulation of ice – ocean interactions



Simulating glaciers and ice sheets with computers

A closer look at the grounding line movement and the ocean grid




FISOC_caller
FISOC_config
(configuration file for the coupling. Component models can also have independent config files)
FISOC_parent
(time processing)
FISOC_OM
(top level OM code, not model-specific)
OM_ExpSt
(OM fields on OM grid)
FISOC_coupler
(regridding)
ISM_ImpSt
(processed OM fields on ISM mesh)
FISOC_ISM
(top level ISM code, not model-specific)
OM mesh and export fields in ESMF structures
OM import fields in ESMF structures
OM_ImpSt
(processed ISM fields on OM grid)
ISM_ExpSt
(ISM fields on ISM mesh)
ISM import fields in ESMF structures
ISM mesh and export fields in ESMF structures
FISOC_OM_Wrapper
(model-specific wrapper for ocean model)
FISOC_ISM_Wrapper
(model-specific wrapper for ice sheet model)
OM mesh and export fields in OM native structures
OM import fields in OM native structures
ISM import fields in ISM native structures
ISM mesh and export fields in ISM native structures
Legend
Data flow
Call heirarchy
F90 code module
ESMF state object
External data
Ocean model
OM configuration and other inputs
ISM configuration and other inputs
Ice sheet model

```
SUBROUTINE ElmerSolver(init)

  INTEGER :: Init

  Initialize = init

  CALL ElmerSolver_init()
  IF ( Initialize /= 1 ) THEN
     CALL ElmerSolver_runAll()
     CALL ElmerSolver_finalize()
  END IF

END SUBROUTINE ElmerSolver
```

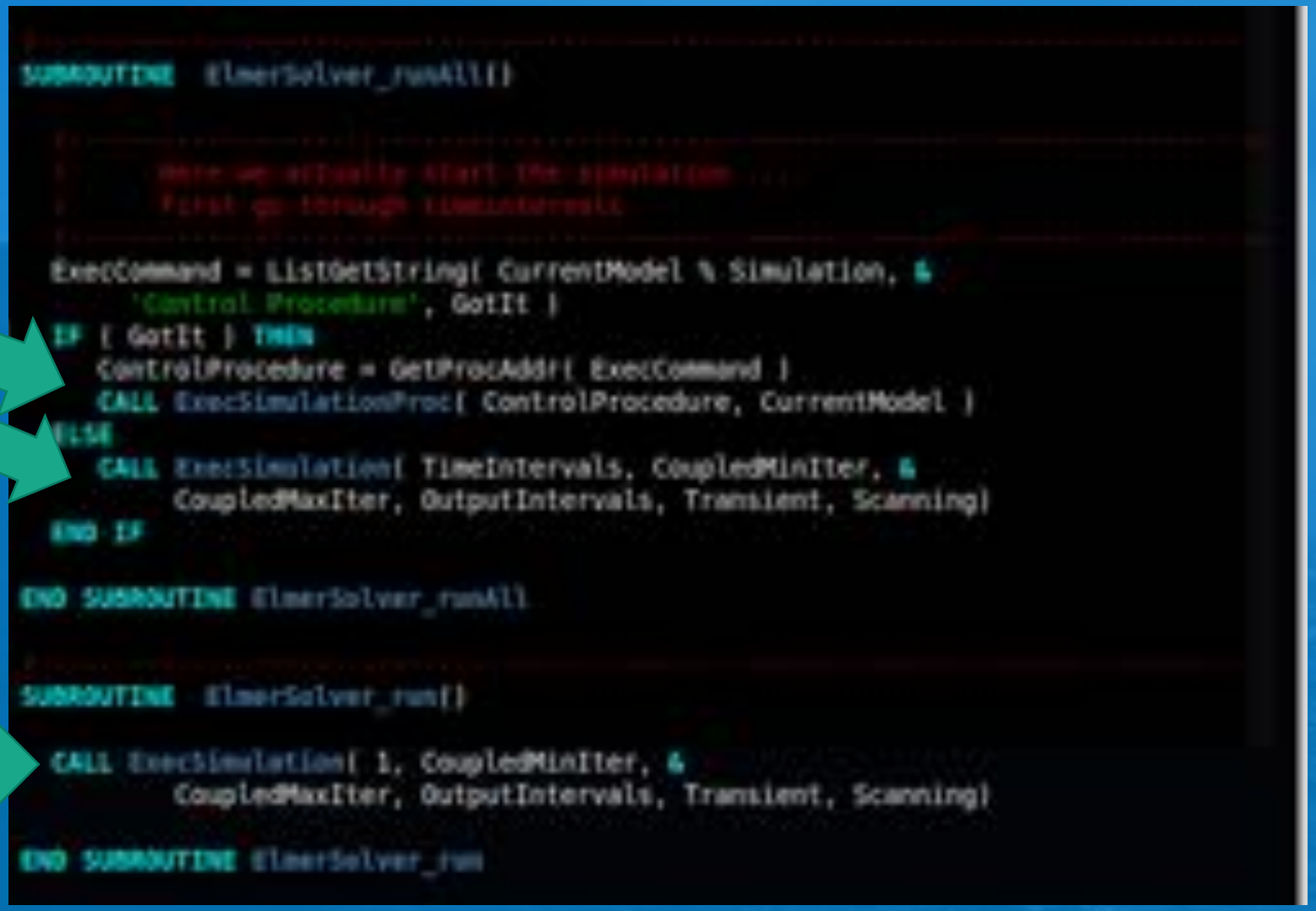
The new ElmerSolver subroutine is now simply a wrapper for the init, run and finalize methods implemented by restructuring. The original ElmerSolver code has been split between these methods.

ElmerSolver_init now contains the logic that handles the modes of initialisation.

Full code in the elmerice_FISOC branch in the main github repository. Needs tidying and merging! On my list of things to do…

RunAll wraps the existing method for running the full simulation

The Run method for FISOC is more restrictive and allows calling one timestep at a time



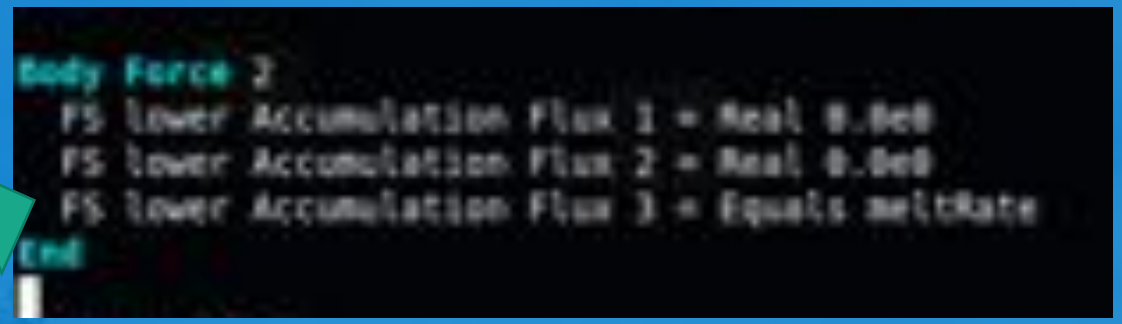
```
SUBROUTINE ElmerSolver_runAll()

  ExecCommand = ListGetString( CurrentModel % Simulation, &
       'Control Procedure', GotIt )
  IF ( GotIt ) THEN
    ControlProcedure = GetProcAddr( ExecCommand )
    CALL ExecSimulationProc( ControlProcedure, CurrentModel )
  ELSE
    CALL ExecSimulation( TimeIntervals, CoupledMinIter, &
         CoupledMaxIter, OutputIntervals, Transient, Scanning)
  END IF

END SUBROUTINE ElmerSolver_runAll

SUBROUTINE ElmerSolver_run()

  CALL ExecSimulation( 1, CoupledMinIter, &
         CoupledMaxIter, OutputIntervals, Transient, Scanning)

END SUBROUTINE ElmerSolver_run
```

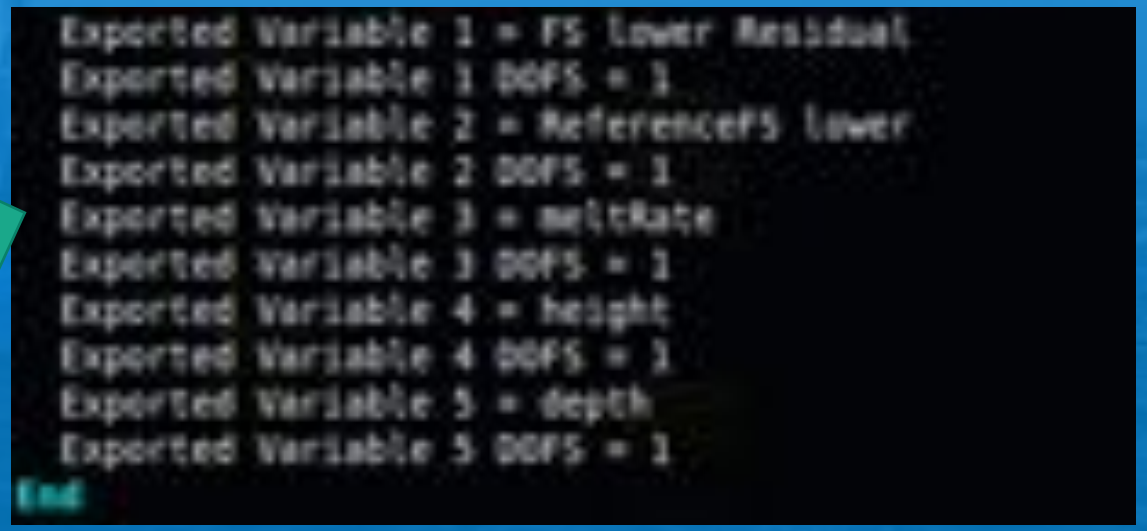
Run time intervention with FISOC is minimal.

The MeltRate variable name is hard coded in FISOC (though I could easily make this an input file option). Here the lower surface variable is called FS lower (this is used in the free surface solver, so the lower surface must have a body id).

The hard coded melt rate variable must match the name of an existing variable in Elmer, such as defined using the “Exported variable” statement in the .sif.

It is straightfoward to exchange additional variables through FISOC, e.g. temperature.





Grounding line movement

The "thin film" approach or "wetting and drying"

Pressure at the ice/ocean interface is determined by the floatation assumption, based on ice draft.

$$P_{interface} = g(\rho_{o1} - 0.5\frac{d\rho_o}{dz}d_i)d_i$$

mean water column density

ice draft

ice thickness in metres of water equivalent

wet-dry activation thickness

$$\eta + h - \frac{\rho_i}{\rho_{sw}}H_i < D_{crit}$$

ROMS implements a "wet/dry" scheme, similar to the "thin film" approach.

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Southern Ocean & Antarctic ice-ocean modelling

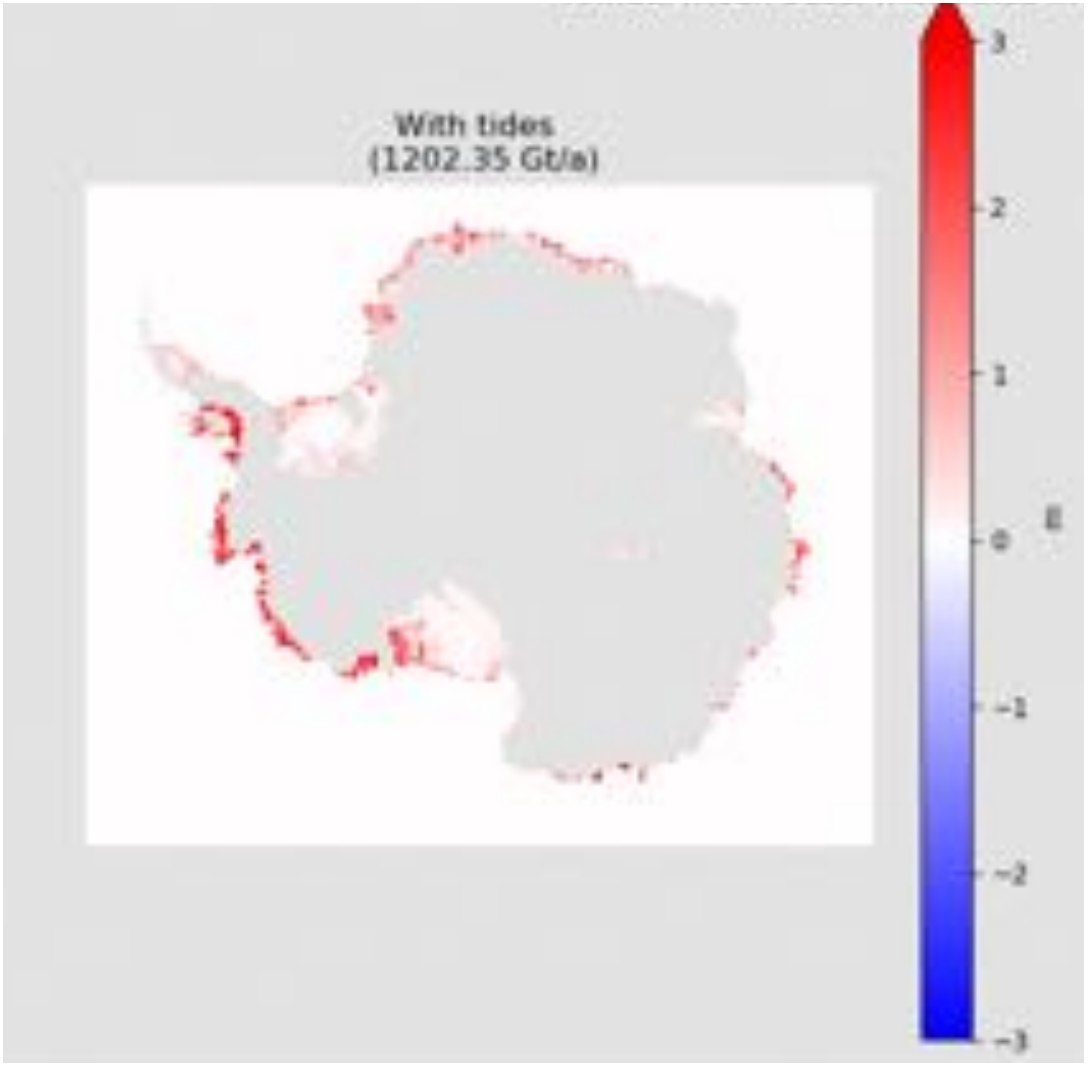
Southern Ocean model

We've set up a regional ocean simulation including all Antarctica's major ice shelf cavities.

Credit: Ole Richter, University of Tasmania

This will be coupled to an ice sheet simulation of the whole Antarctic Ice Sheet.

A fully coupled whole-Antarctic ice-ocean simulation would be a world first, enabling improved estimates of sea level rise.



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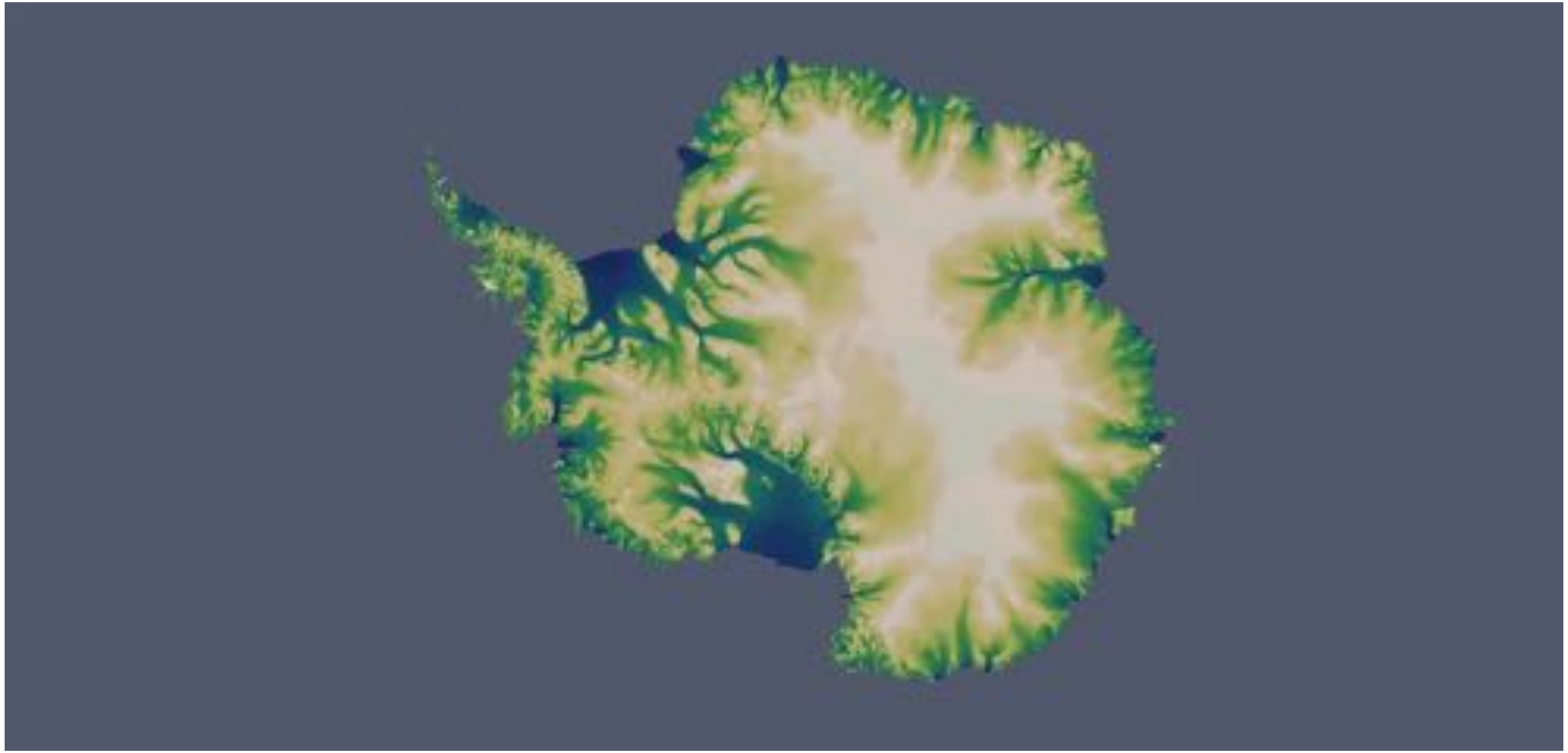
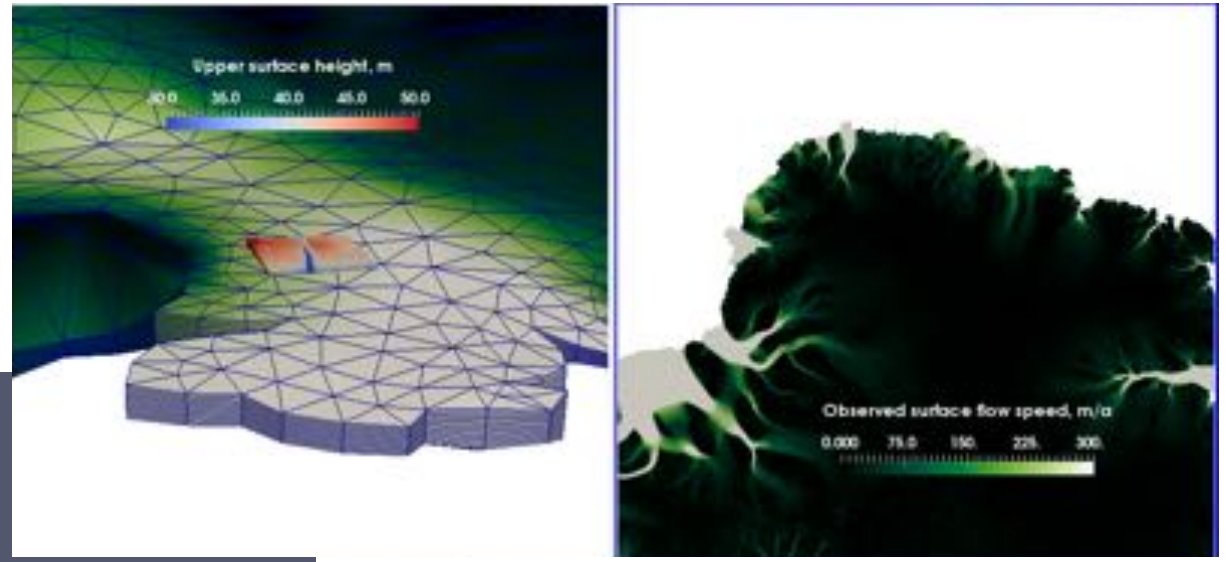
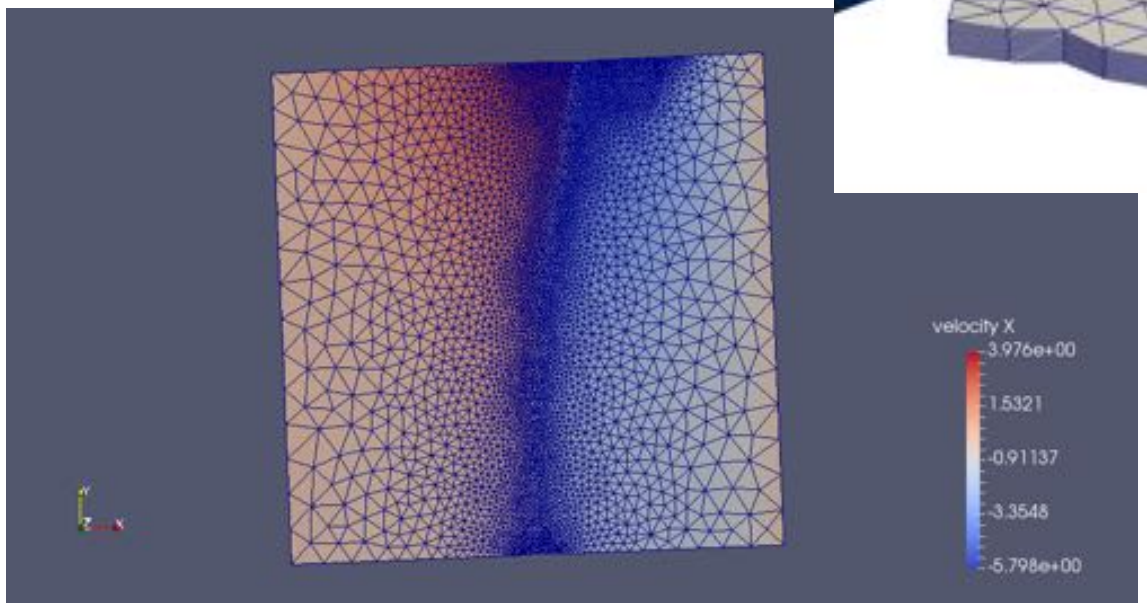
Southern Ocean & Antarctic ice-ocean modelling



Coupled ice – ocean modelling (FISOC)

The Roi Baudoin Ice Shelf and its melt channels





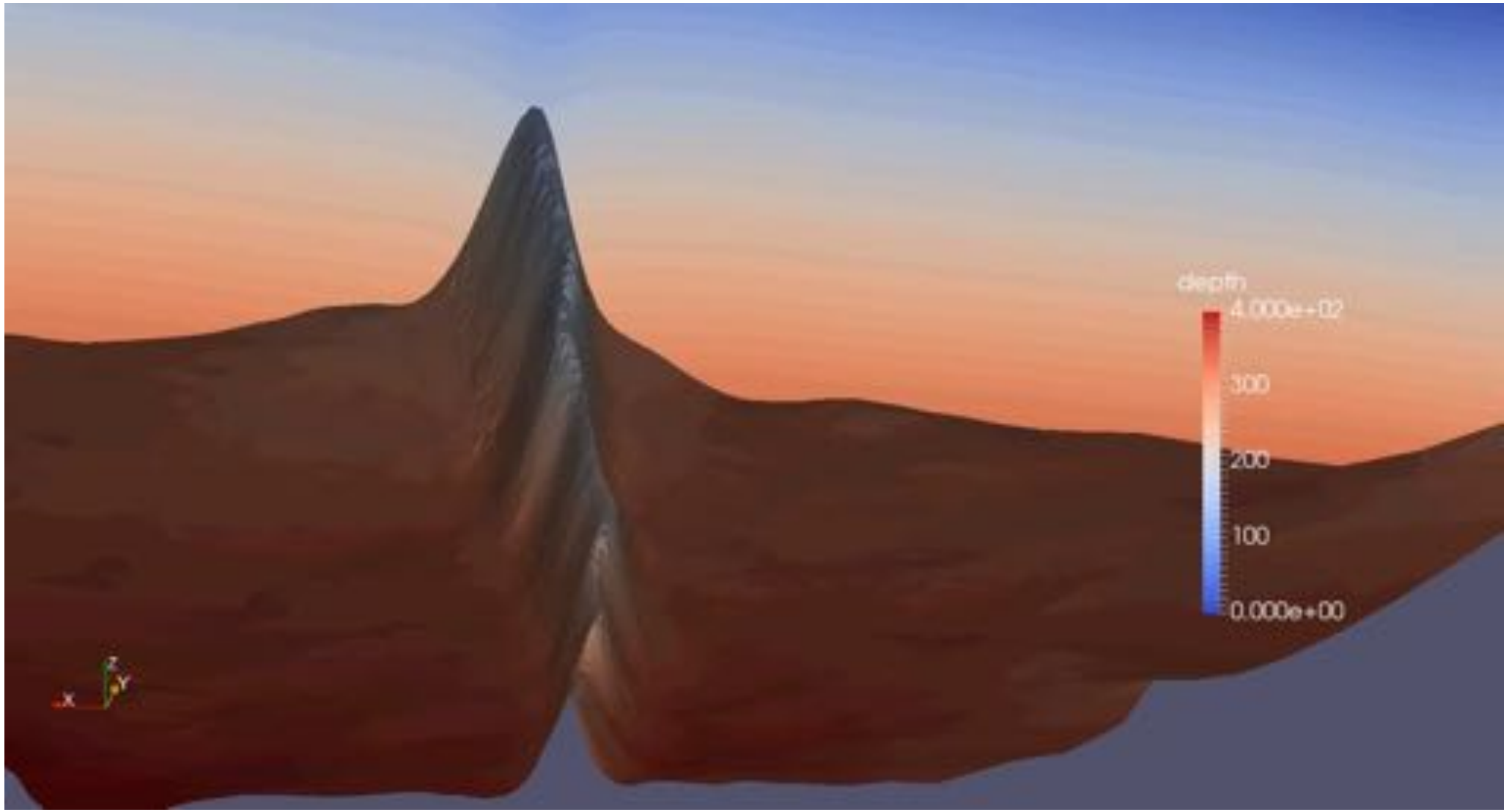
Applying Elmer/Ice at different scales

Above: Relatively coarse Antarctic mesh

Left: Fine resolution mesh for a detailed study of ice shelf melt channels

Ice sheet modelling: sub-shelf channels

A Roi Baudoin Ice Shelf channel with no melting...



One or two more comments…

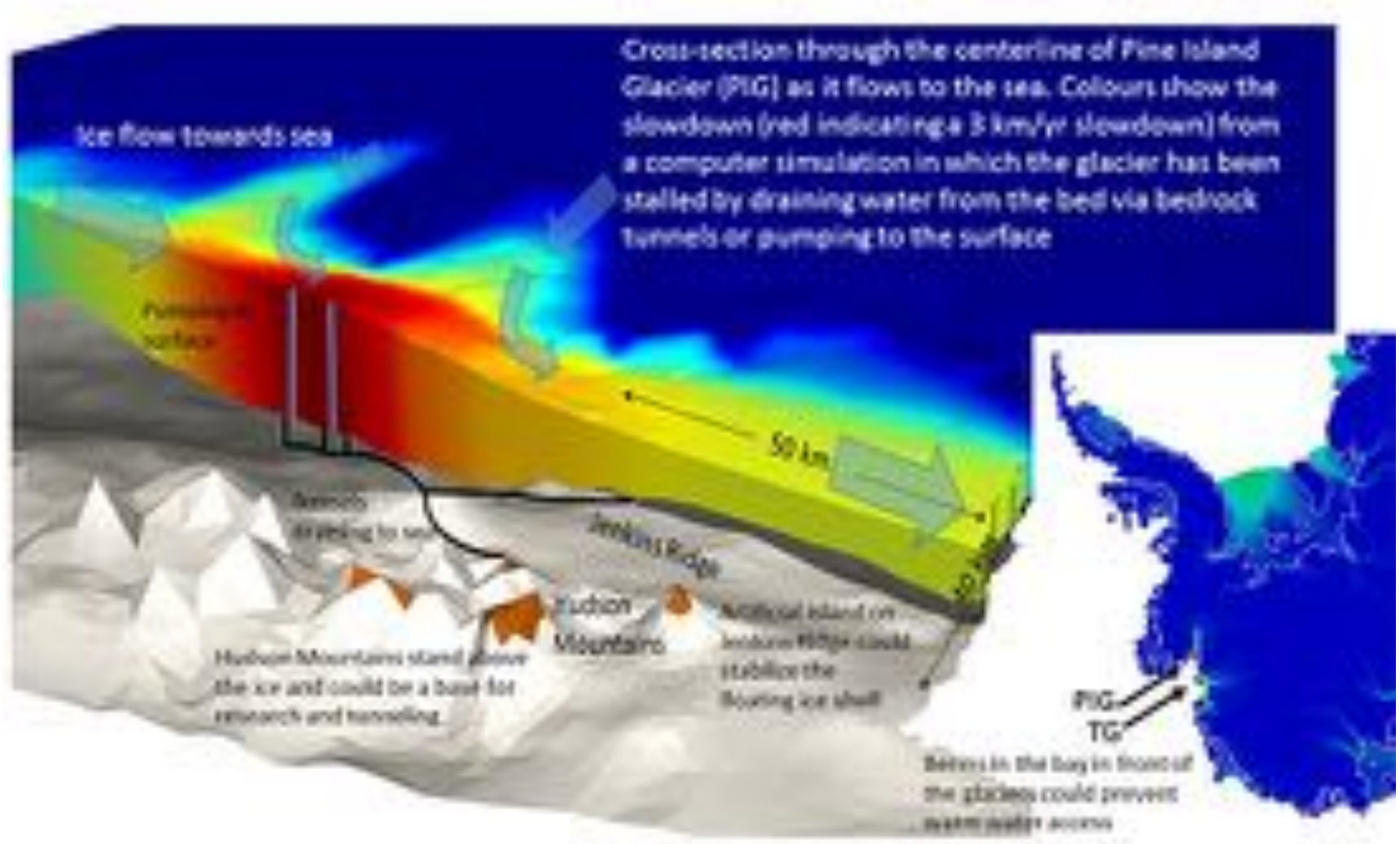
- Coupled ice ocean modelling is always at least as demanding as ocean modelling plus ice sheet modelling. This is why I don't recommend new people to go straight for coupled modelling with FISOC: you need ice and ocean competence and functioning domains first.
- FISOC: plan to couple FVCOM into FISOC in Jan 2019. Tore and I have allocated a week for this.
- Accelerated forcing for ocean in coupled simulations for long timescales: if timescales for ocean adjustment to forcing are sufficiently fast compared to the forcing trends, maybe we can condense, for example, a century of forcing into a decade of simulation.

The future of Antarctica

Assessing polar geoengineering

Xiaoran says he isn't going to present anything…. so…

We're now starting to carry out computer simulations of the Pine Island Glacier to assess the impact of "subglacial drying" (not yet published).

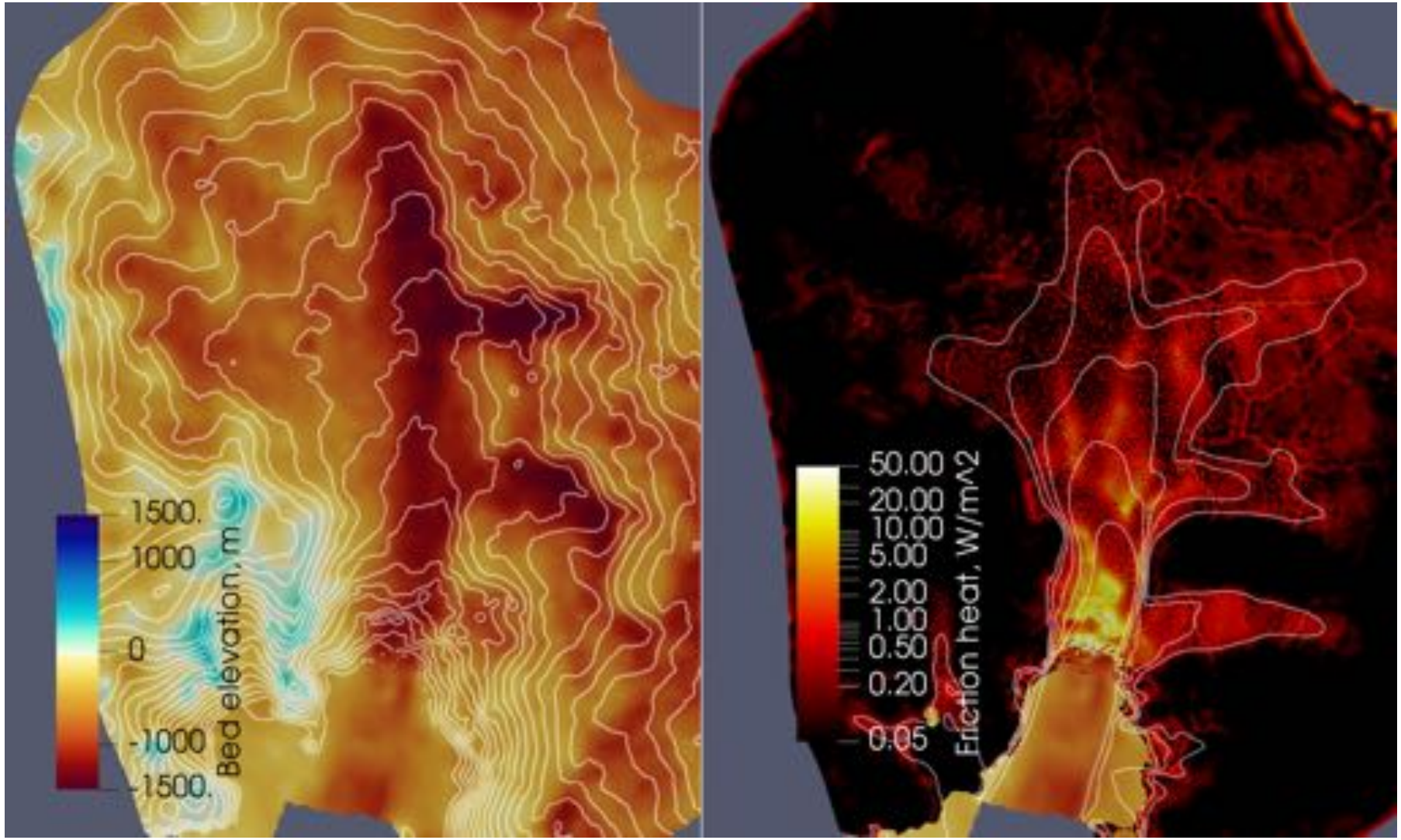


Ice Sheet Modelling: Pine Island Glacier

Heat and hydrology

And just in case Yufang doesn‘t present either....

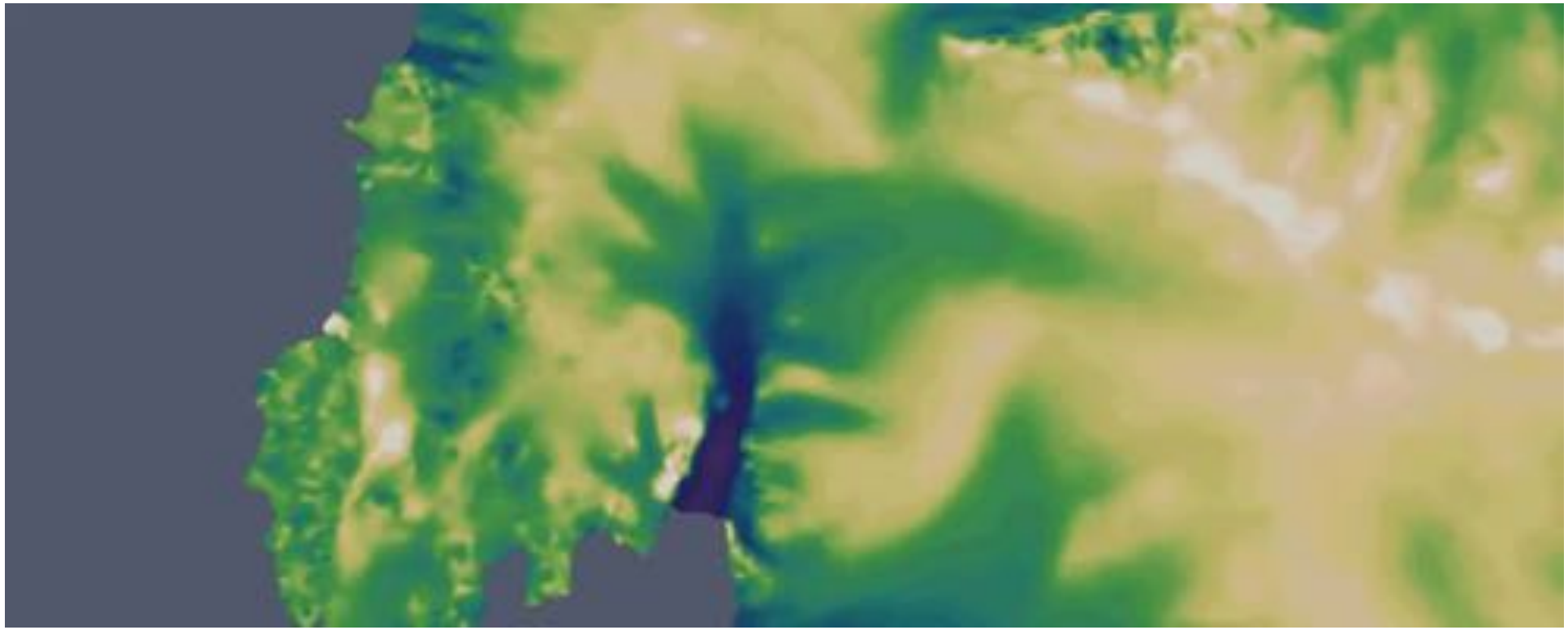
She might try applying Glads to look at basal hydrology – dynamic feedbacks under PIG.




Please clap now

Antarctic inversion

Pine Island Glacier and its ice shelf cavity

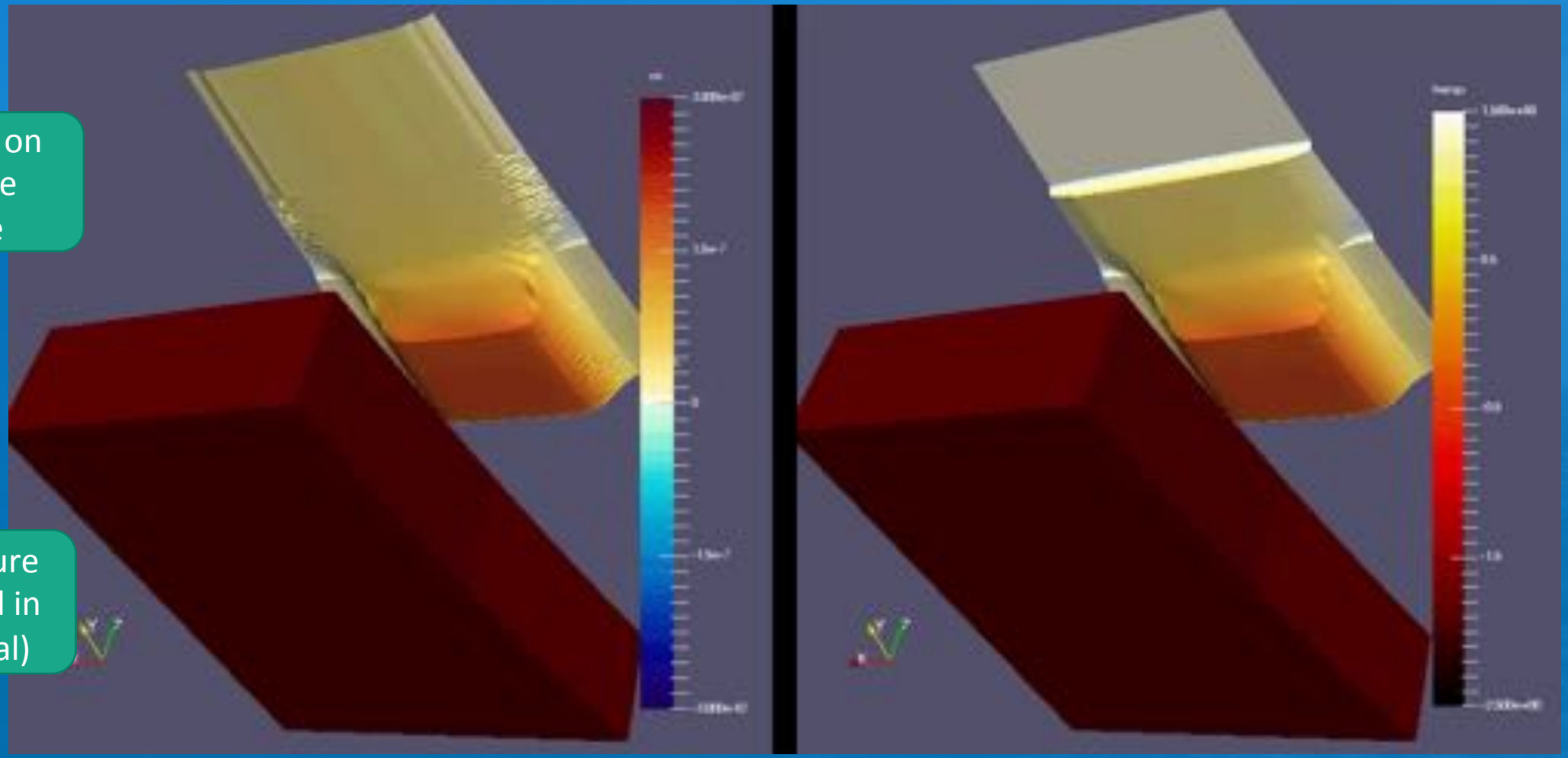


Coupled simulation (using Nacho's MISMIP+ Elmer/Ice setup)

ISOMIP+ setup using FISOC as a wrapper for time-evolving forcing)

Melt rate on lower ice surface

Temperature (not scaled in the vertical)



Ice Sheet Modelling: Pine Island Glacier

Basal shear stress obtained through inversion