Coupling FS, SIA and SSA for modeling paleotimescales

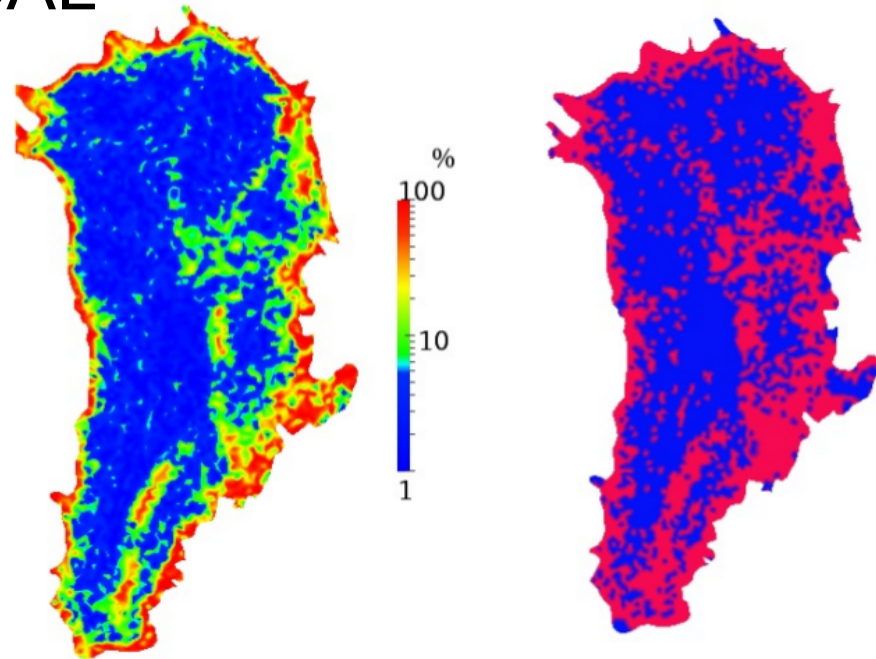MSc project Eef van Dongen
Together with
Josefin Ahlkrona, Nina Kirchner
Lina von Sydow, Per Lötstedt, Cheng Gong
Roderik van de Wal, Martin van Gijzen, Thomas Zwinger

Ice Sheet Coupled Approximation Levels (ISCAL)

- Dynamic FS-SIA coupling by Josefin Ahlkrona

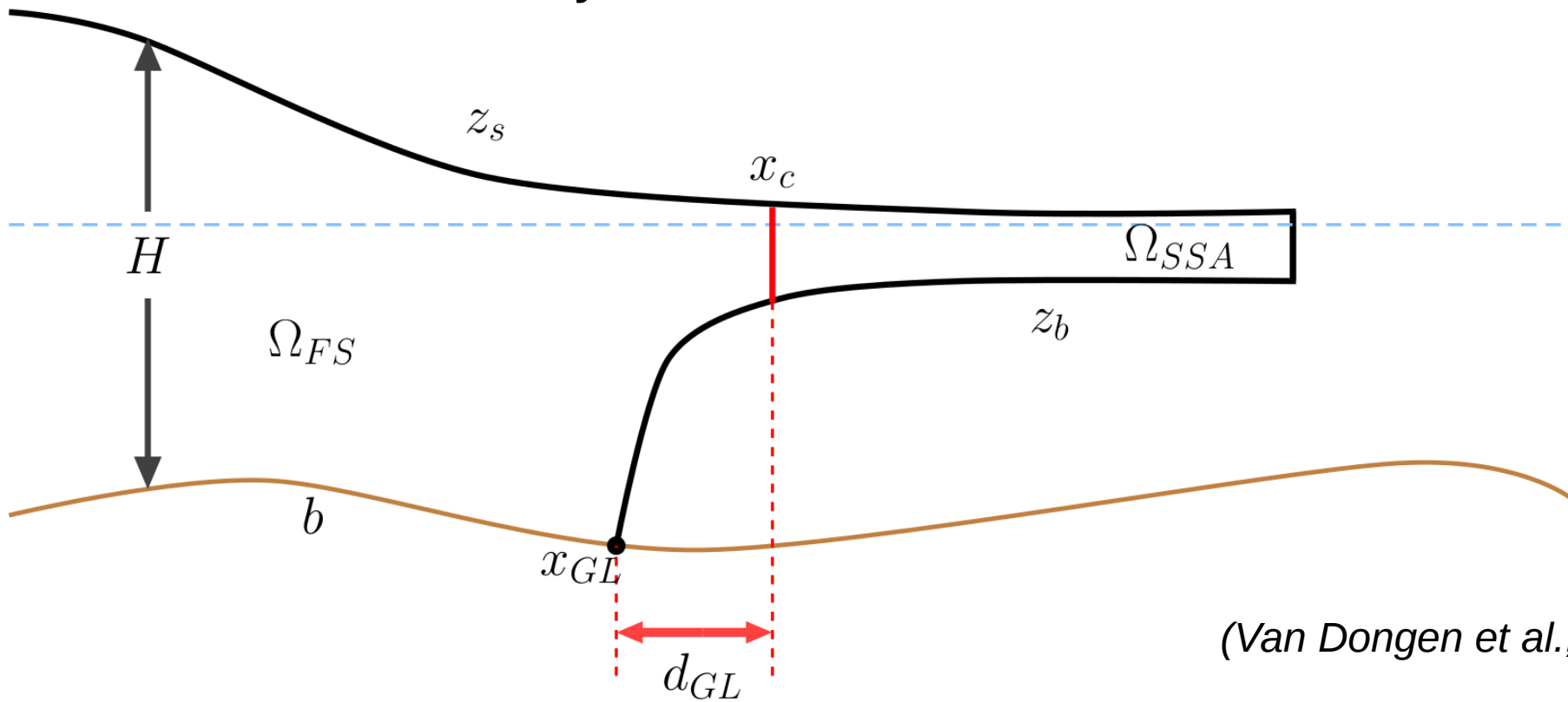   → see branch elmerice-iscal;

    elmerice/Solvers/ISCAL

(a) Relative Error in SIA, $\Delta\mathbf{u}_{SIA}$

(b) Ω_{FS} (red) and Ω_{SIA} (blue)
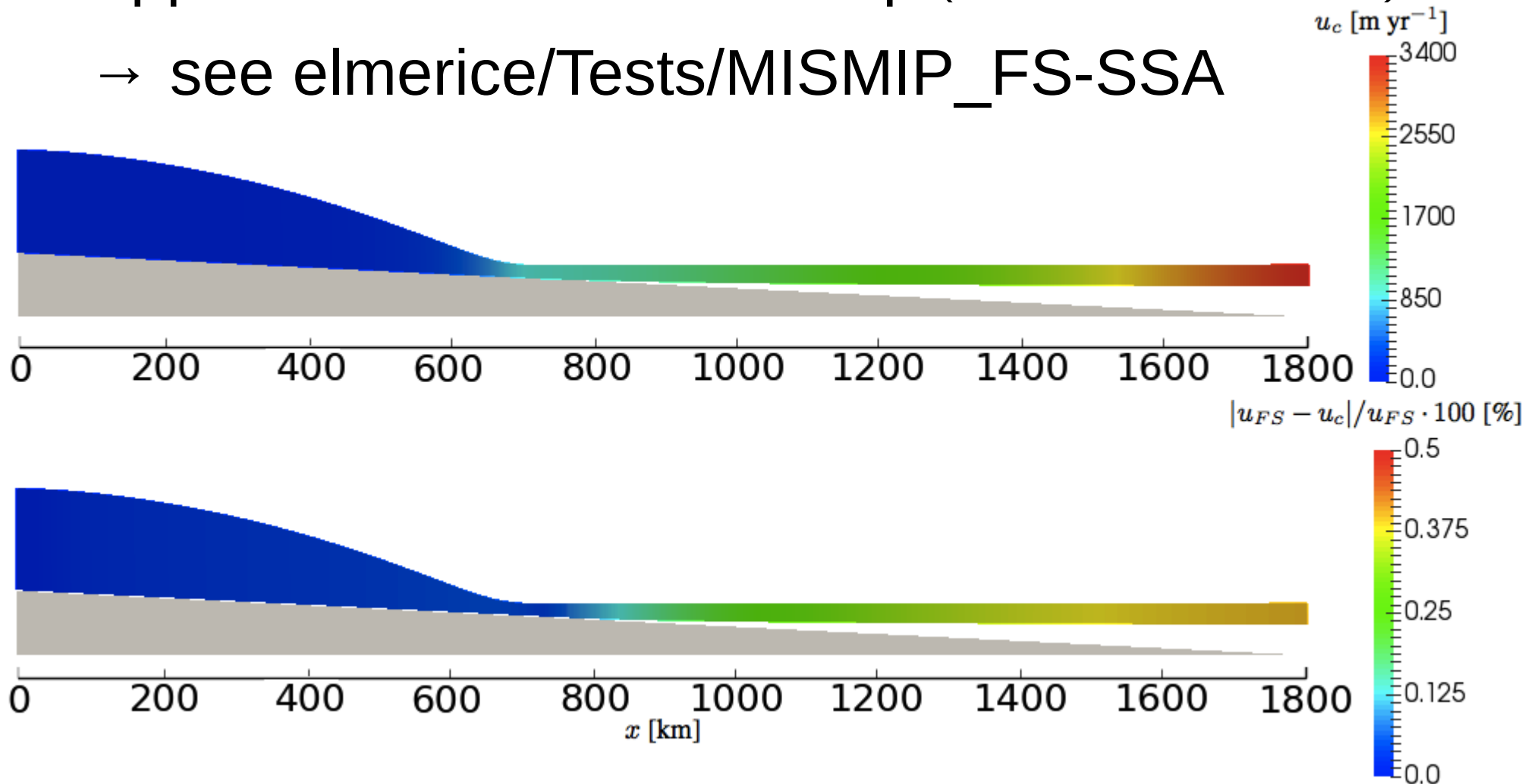
(Ahlkrona et al, 2016)

FS-SSA coupling

- Domain decomposition
- Coupling interface x_c based on distance to grounding line
- Implemented in SSASolver, independent of solver for Ω_{FS}
    - → ISCAL's FS-SIA coupling can be applied in Ω_{FS}
- Not robust in 3D yet

(Van Dongen et al., 2018)

FS-SSA coupling

- Applied to MISMIP-like setup *(Gladstone et al., 2017)*

  → see elmerice/Tests/MISMIP_FS-SSA

Difference below 0.5%

(Van Dongen et al., 2018)

Modeling of individual large-scale calving events at Bowdoin Glacier

PhD project Eef van Dongen
Supervisors
Guillaume Jouvet
Daniel Farinotti
ETH Zurich

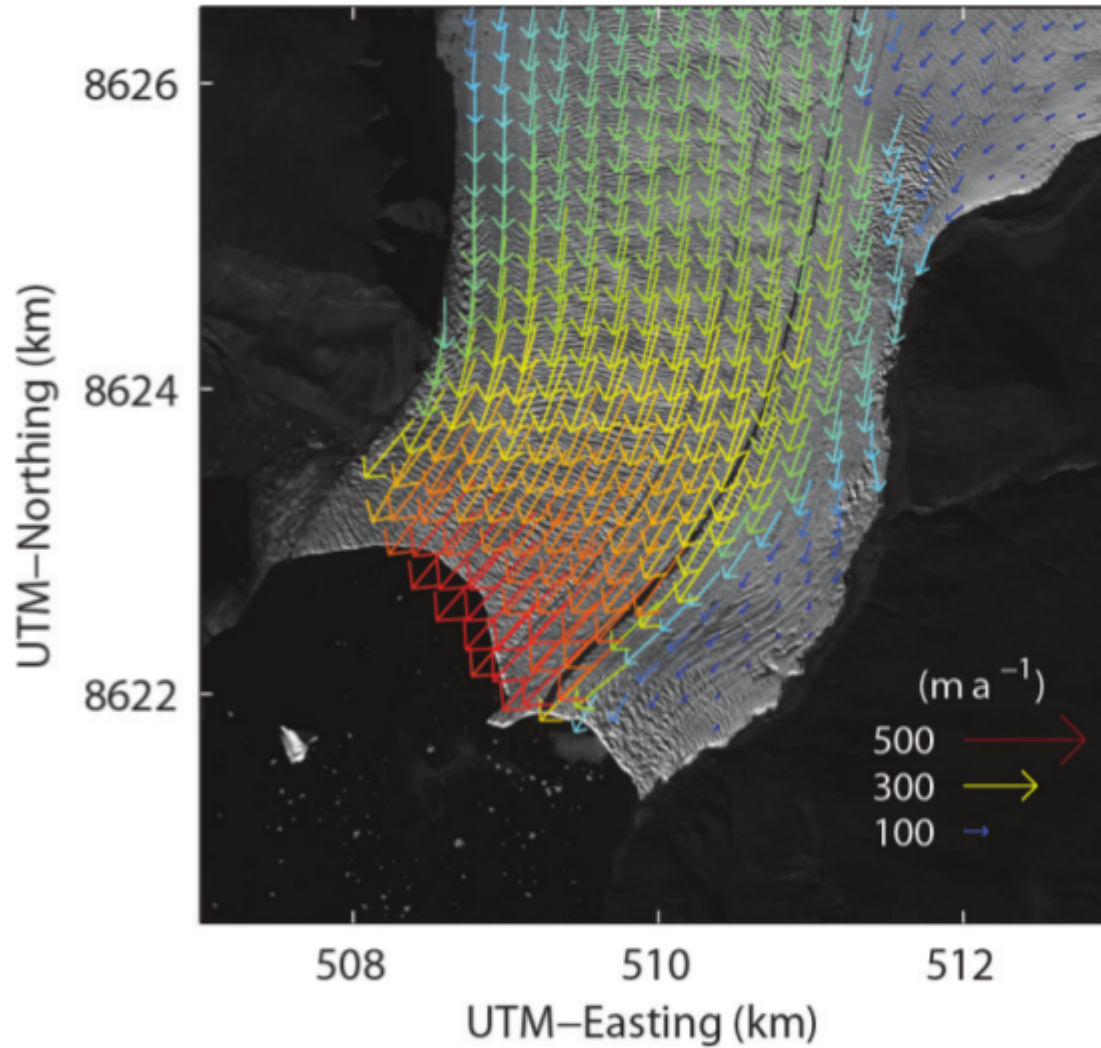*Photo Credit: Julien Seguinot*

Bowdoin Glacier

Sentinel2A, 2017-07-25, downloaded by J. Seguinot

Bowdoin Glacier

Averaged velocity 2013
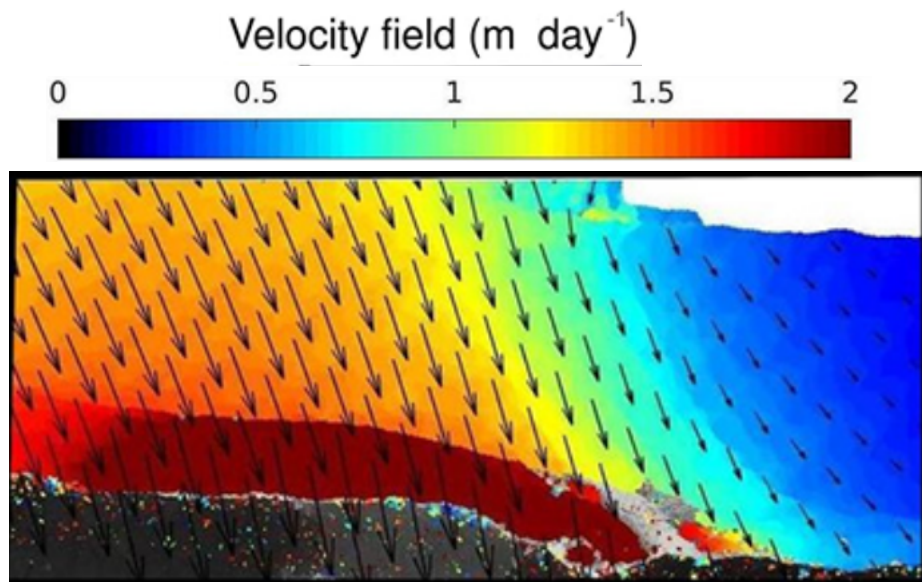
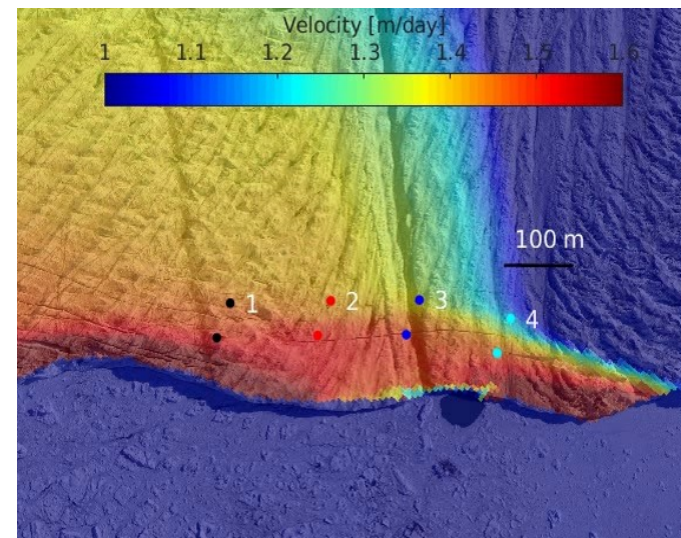Sugiyama et al. (2015)

Observed major calving events

2015   2017

Surface ice velocity data

UAV photogrammetry

2015

Velocity field (m day^{-1})
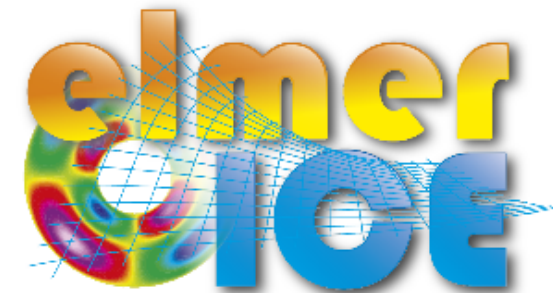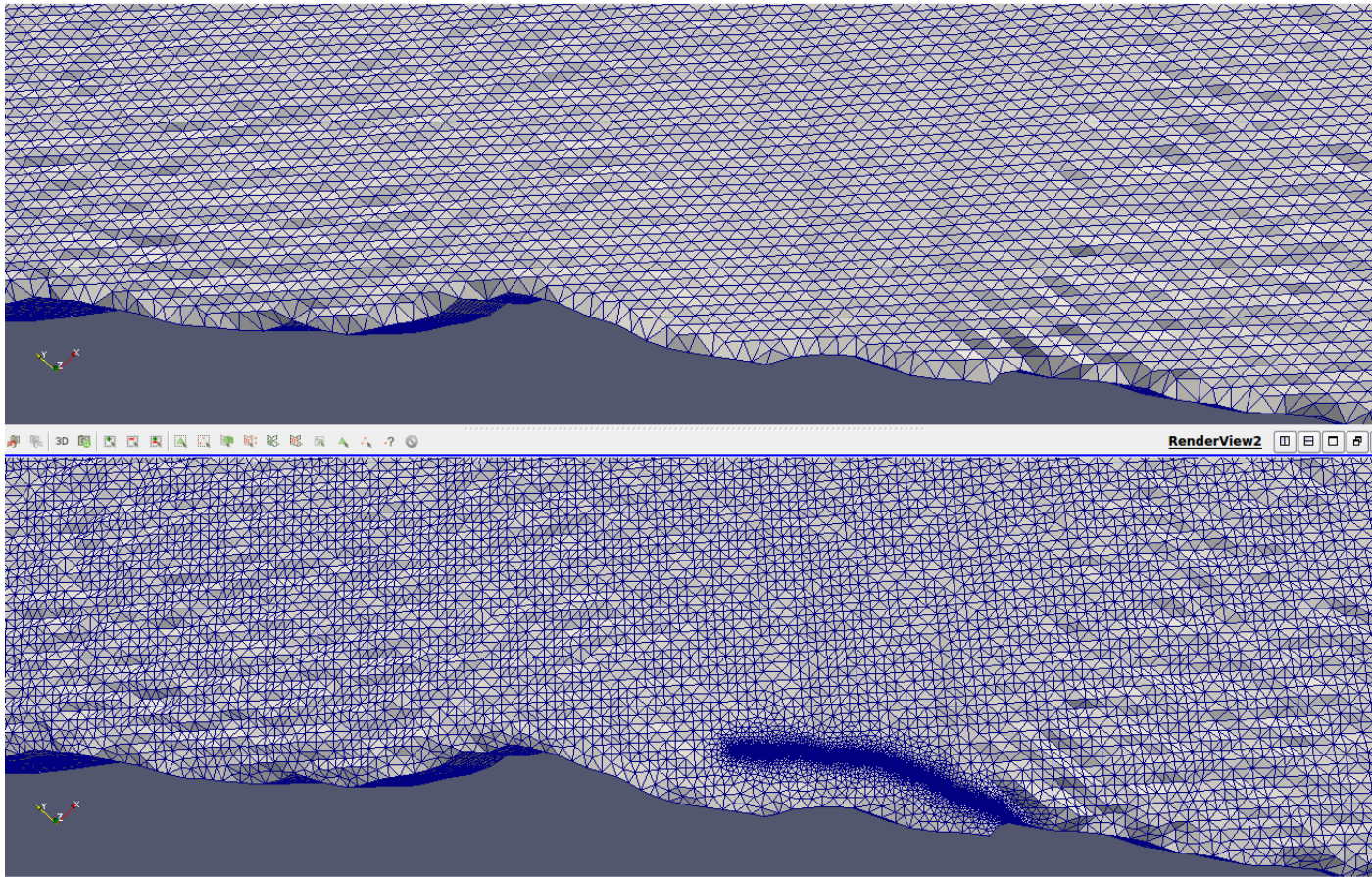
Jouvet et al., (2017)

Terrestrial radar interferometry

2017

Data processed by Andrea Walter,
PhD at UZH & VAW

Automatic 3D remeshing

Using MMG tools, support by Joe Todd
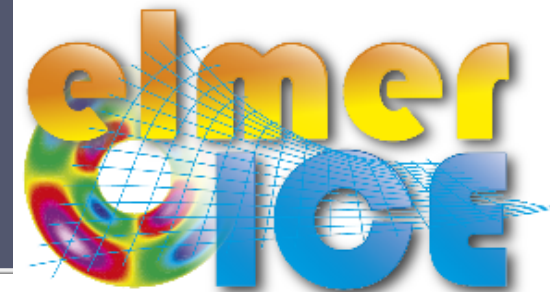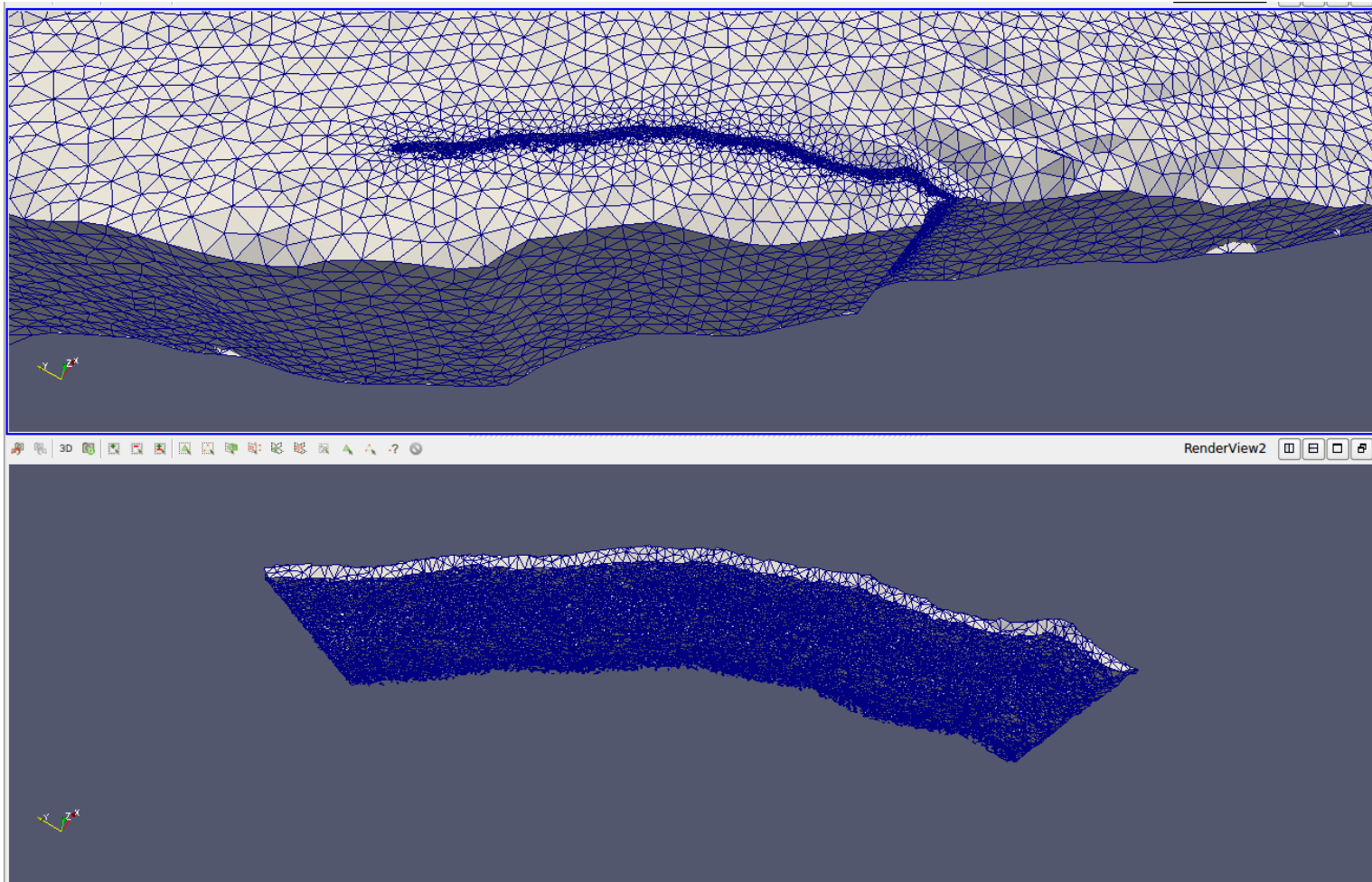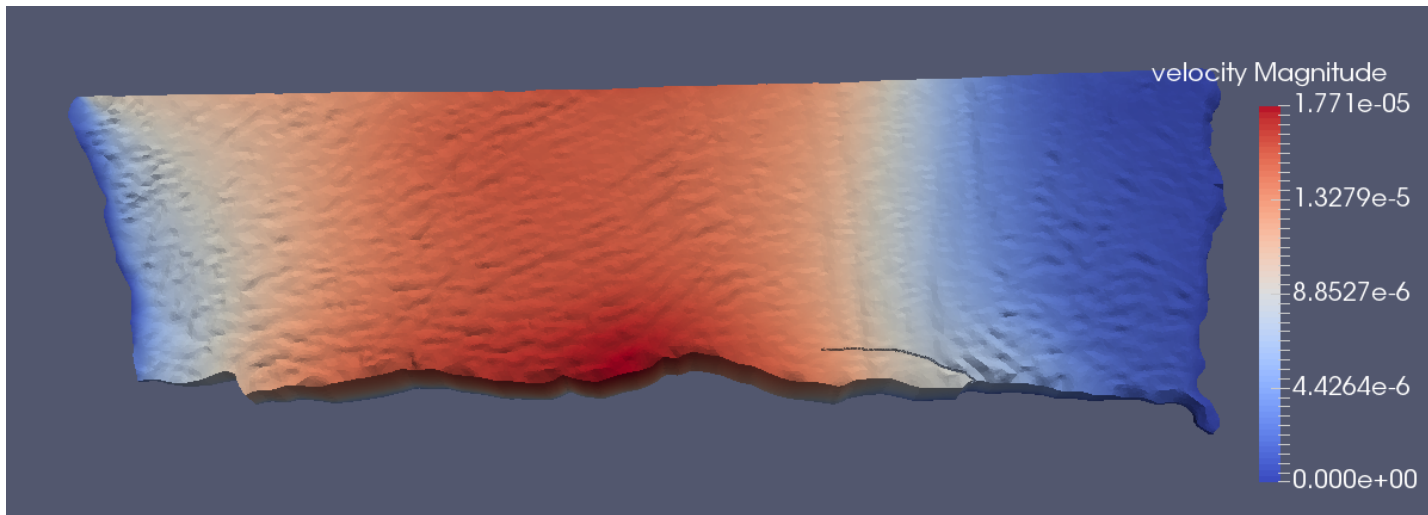Step 1: Refining input mesh

Automatic 3D remeshing

Using MMG tools, support by Joe Todd
Step 2: Remesh based on level set (<0 for deleted elements)

Crevasse modeling

- FS on new mesh:

Problems:

- Crack surface too rough (problematic with BC)
- Need to specify 'hausdorff' locally
- FlowDepth solver returns NaN for new mesh

Crevasse modeling

Future work:

- Update in runtime

- Let crack evolve based on stress criterion

- Combine with work by Joe for parallel

Thank you!

Photo Credit: Julien Seguinot

References

Ahlkrona, J., et al. (2016).
Dynamically coupling the non-linear Stokes equations with the shallow ice approximation in glaciology: Description and first applications of the ISCAL method. *Journal of Computational Physics.*

Jouvet, G. et al. (2017). Initiation of a major calving event on the Bowdoin Glacier captured by UAV photogrammetry. *The Cryosphere*.

Gladstone, R., et al. (2017). Marine ice sheet model performance depends on basal sliding physics and sub-shelf melting, *The Cryosphere.*

Van Dongen, E., et al. (2018). Dynamically coupling Full Stokes and Shallow Shelf Approximation for marine ice sheet flow using Elmer/Ice (v8.3). Accepted for publication in *Geoscientific Model Development.*