The Fast Full Stokes Method (FFS) - Applied to the Greenland Ice Sheet

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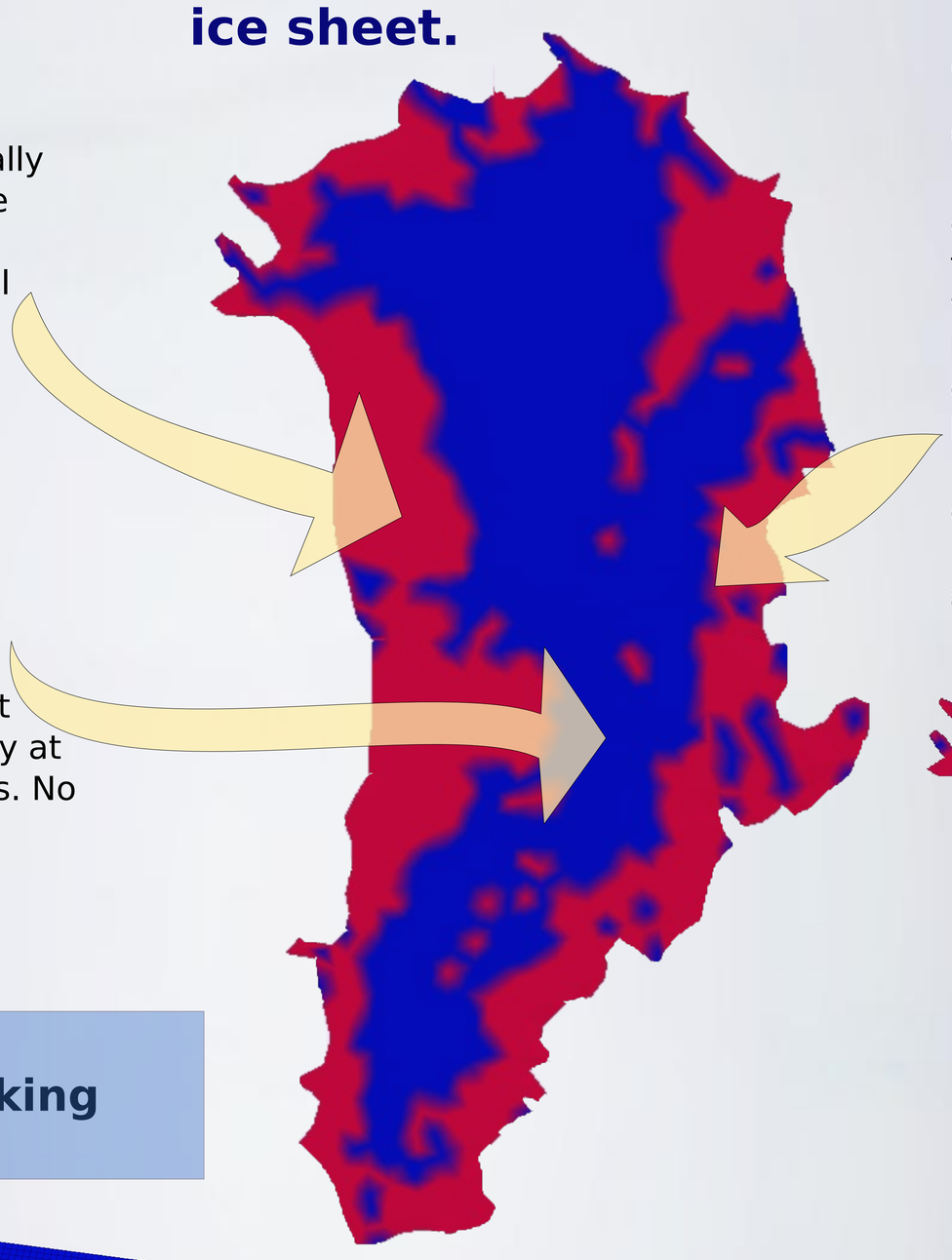
The FFS is a method to couple together the full Stokes equations and the SIA within an ice sheet.

Full Stokes Equations, FS (red) -

Accurate but computationally demanding. Computing the solution involves solving a linear system Ax=b several times per timestep.

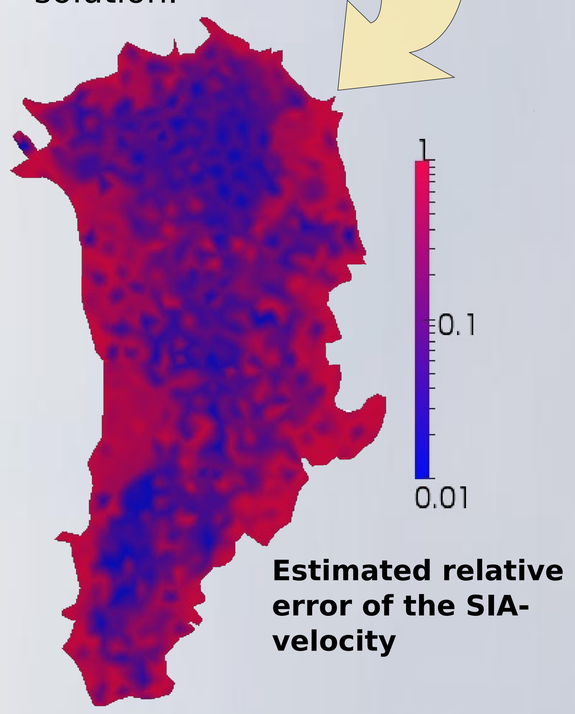
The Shallow Ice Approximation, SIA (blue) -

Computationally cheap but often inaccurate, especially at margins and in ice streams. No linear system is solved.



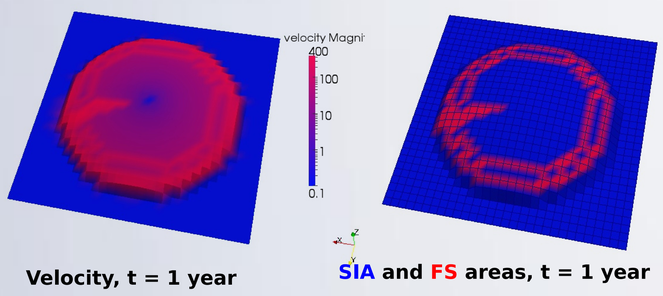
Coupling and error estimation

In the FFS, the full Stokes equations and the SIA is coupled together. The SIA is used only where it is accurate enough. Based on an **error estimation** of the SIA-velocity, the **boundary** between the models is moved when the dynamics changes. The switch between the models is not visible in the final solution.



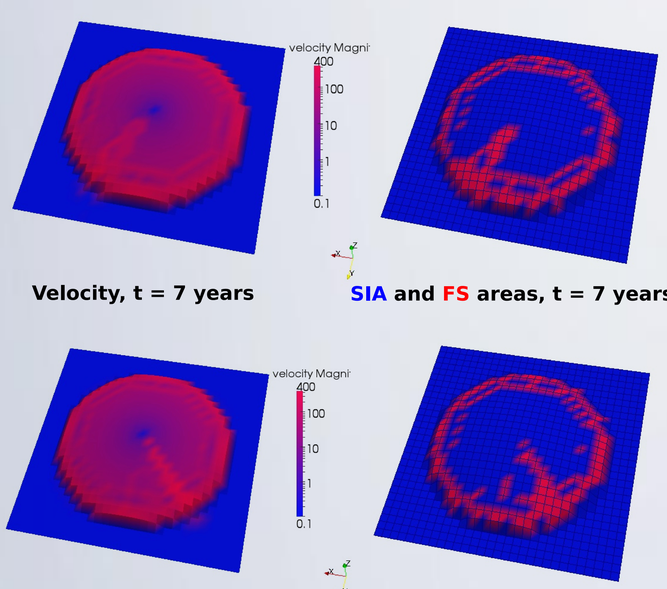
Estimated relative error of the SIA-velocity

Ice Stream tracking



Velocity, t = 1 year

SIA and FS areas, t = 1 year



Velocity, t = 7 years

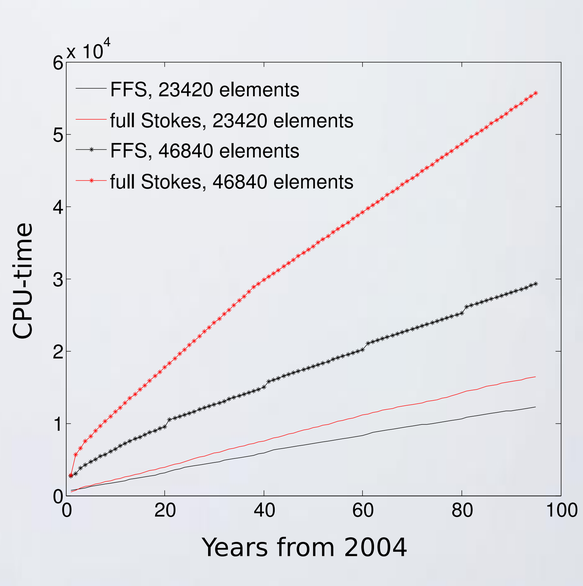
SIA and FS areas, t = 7 years

Velocity, t = 14 years

SIA and FS areas, t = 14 years

At the base of a circular ice sheet we introduce time-dependent sliding such that an ice stream forms and moves counter clockwise (left panels). The FFS **automatically** applies the full Stokes equations in the ice stream and at the margins, and SIA elsewhere.

Speed-up compared with full Stokes



For a **SeaRISE**-setup on two different coarse meshes, we apply both the FFS (black) and the full Stokes equations (red), and **compare the simulation time**. We start at year 2004 and run the models until year 2094. **The speed-up of the FFS compared to the full Stokes equations increases with problem size**

Conclusions

The method is a **trade off** between accuracy and efficiency

We are i**n control of the error**

The **speed-up** of FFS compared to the full Stokes equations **increases with problem size**

The FFS sucessfully **tracks ice streams** and margins **automatically**

The **SIA error** is **very high** at margins and at ridges.