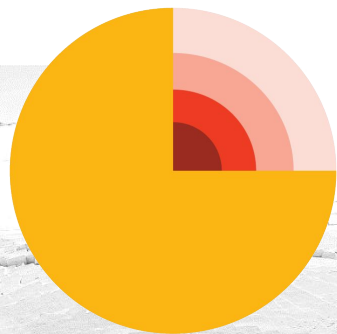




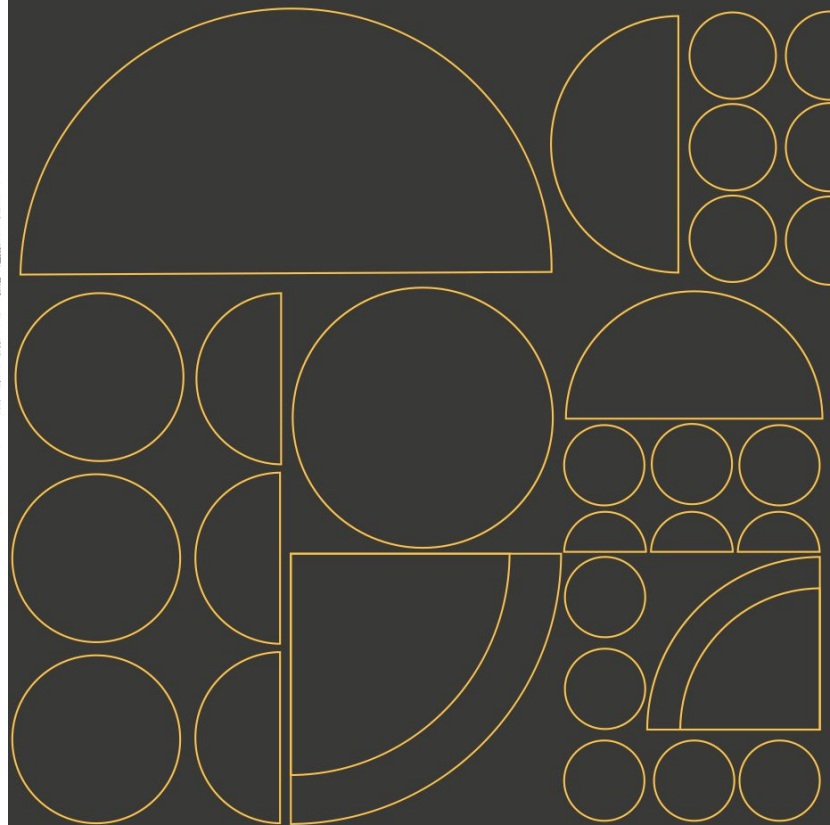
ChEESE



Thomas Zwinger (CSC) and Tómas Jóhannesson (IMO)



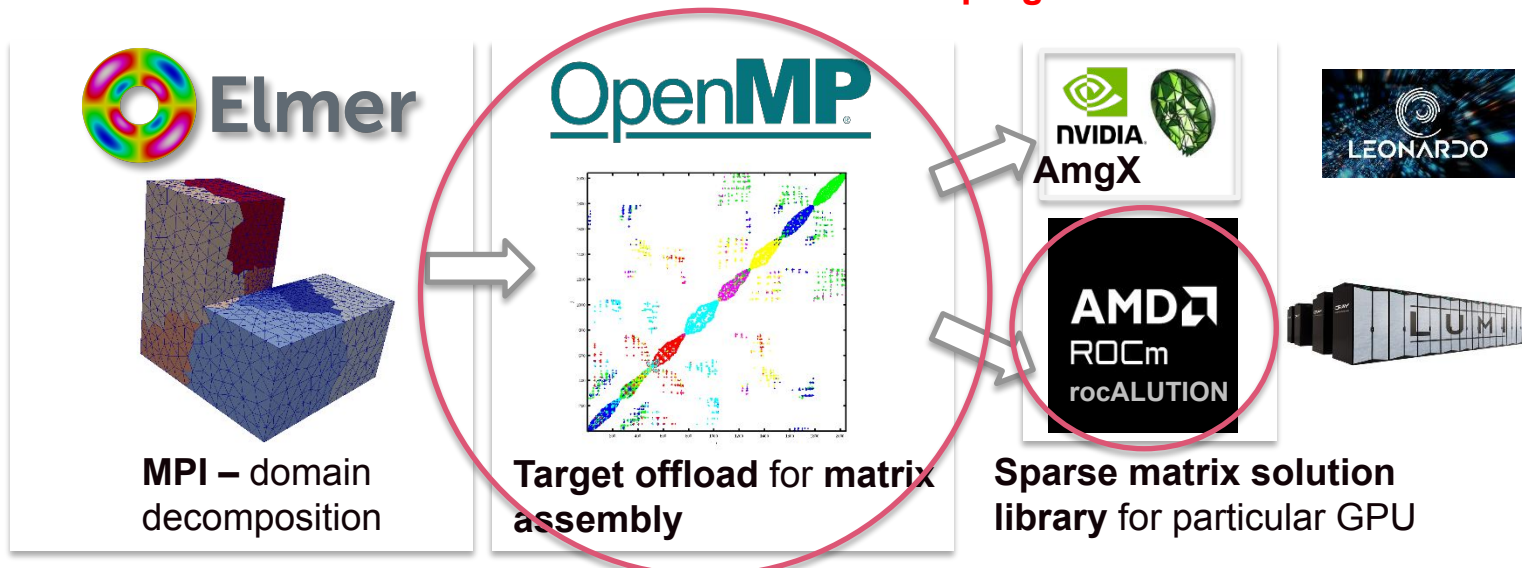
Project funded by EuroHPC under the grant agreement No 101093038.



Contributions to WP2

- **POP3 audit** with MPI + OMP SIMD CPU version (baseline for next audit using GPU offload)
- Working through **code-base** to reach **compatibility** with several involved compiler suites (gcc, clang, CrayCE) – LUMI needs Cray-Fortran to **enable OMP target** offloading!
- Working on different **interfaces for offloading linear system** solution step to GPUs (M250 and A100)

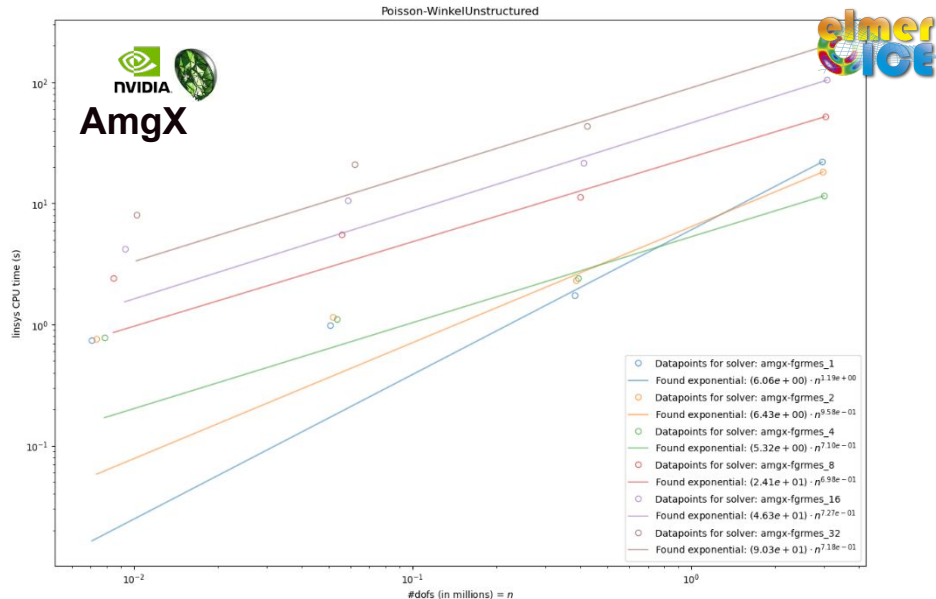
Work in progress within ChEESE



Contributions to WP2

- AmgX (NVIDIA) tests revealed super-linear scaling on CSC's platform mahti.csc.fi (AMD Epyc + A100)
- Interface for rocALUTION in Elmer code base
- First tests with single node (4 GPU) on simple Poisson problem on LUMI revealed 2 order of magnitude faster solution step
- Algorithmic improvements for PD and SC's:
Block-Pre-Conditioner (PBC)
for saddle point incompressible visco-elastic problem

$$\begin{bmatrix} \mathbf{A} & \mathbf{B}^T \\ \mathbf{B} & \mathbf{C} \end{bmatrix} \begin{bmatrix} \mathbf{V} \\ \mathbf{P} \end{bmatrix} = \begin{bmatrix} \mathbf{F} \\ \mathbf{G} \end{bmatrix} \quad \mathbf{P} = \begin{bmatrix} \mathbf{A} & \mathbf{B}^T \\ \mathbf{0} & \mathbf{Q} \end{bmatrix}$$



4 GPUS (AMD Trento + M250):

IterationControl RELATIVE criteria has been reached:
res norm=9.52537e-07; rel val=9.52537e-07; iter=195
PCG ends

Solver execution: **0.283371 sec**

on 2 CPUs (64 cores - AMD Trento):

IterationControl RELATIVE criteria has been reached:
res norm=9.52537e-07; rel val=9.52537e-07; iter=195
PCG ends

Solver execution: **30.4779 sec**

AMD
ROCm
rocALUTION

Other relevant technical contributions

CI/CD:

- Improved cmake build procedure (easier build on different platforms)
- Introduced workflows in GitHub repository
- Automatic parallel MPI functionality testing using Cpouta (CSC HPC cloud) instance
- Matrix test of gcc-clang w/o OpenMP 

Access to machines:

- National access to LUMI
- National access to mahti (NVIDIA A100's)
- CINECA is currently testing Elmer compilation on Leonardo
- Tests of Elmer on RIKEN Fugaku (ARM64)



HPE/AMD CoE:

- Elmer team got assigned 3 pm of support by HPE/AMD
- We will work on OpenMP target offload and rocALUTION implementation during LUMI-hackathon in Brussels (October 2024)



Jökulhlaups – Glacier Lake Outburst Floods

- The name **jökulhlaup** refers to outburst floods from glaciers having a wide range of magnitudes.
- **Discharge ranges** from a ten or few tens of m^3/s for the smallest floods to $\sim(1-10) \cdot 10^6 \text{ m}^3/\text{s}$ in floods that occurred at the end of the last Ice Age (Lake Missula, Altai mountains, English channel), more than the combined flow of all rivers on Earth!
- **Flow speeds** of $\sim 35 \text{ m/s}$ are inferred in the largest floods, **water depths** reached $\sim 200-400 \text{ m}$ and total volume of the largest floods may have been $> 2000 \text{ km}^3$!

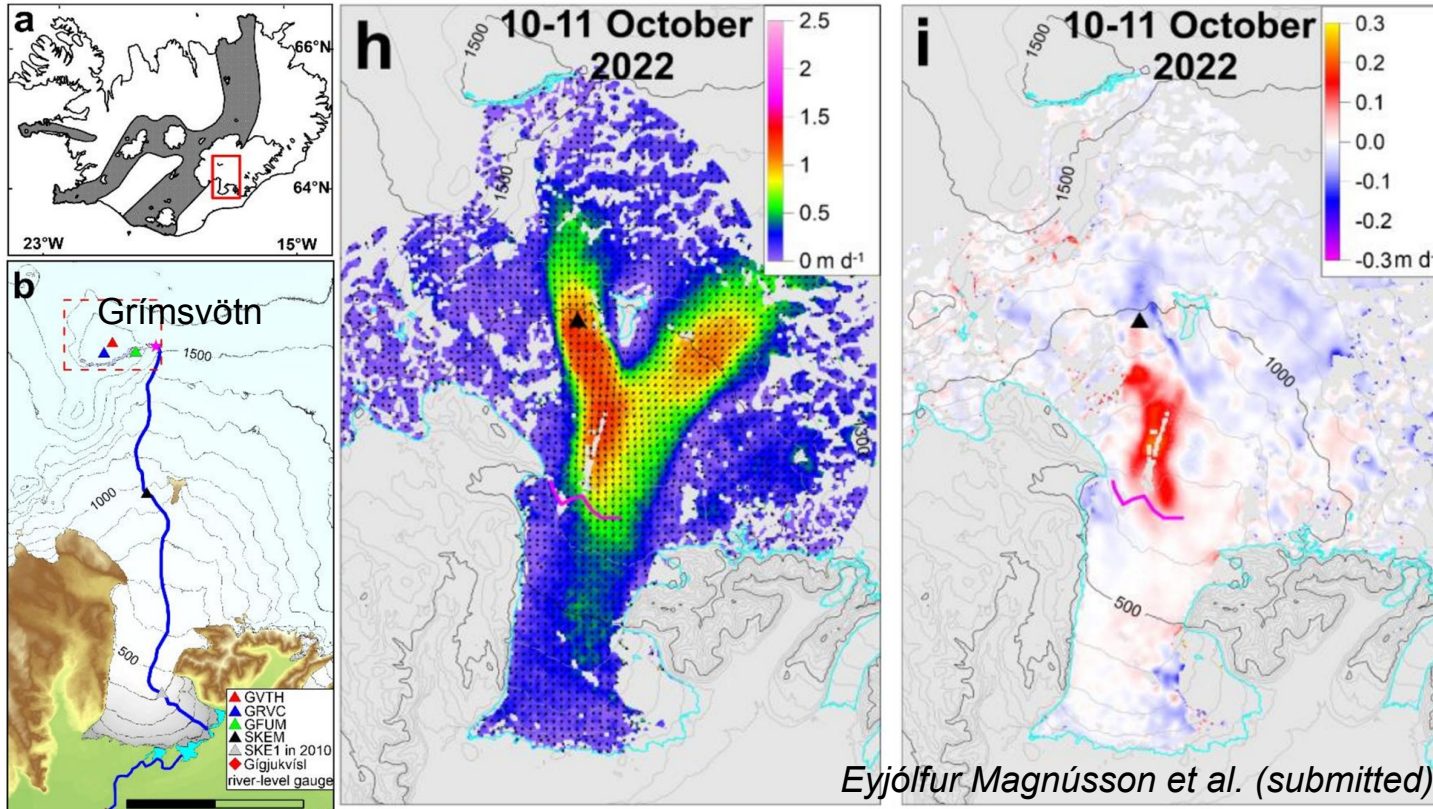
Ásbyrgi, N-Iceland



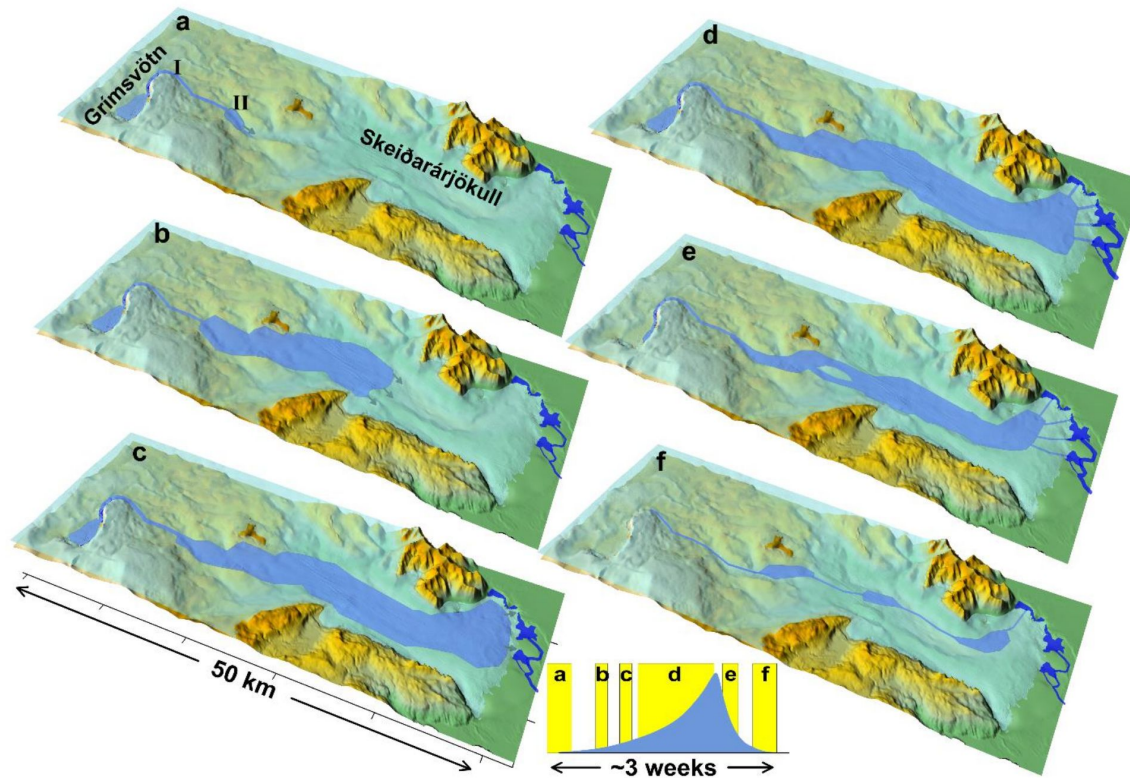
Vatnajökull National Park

Jökulhlaups are among the most important geomorphological processes in watersheds downstream from glaciers.

Recent observations of jökulhlaups in Iceland show that they are characterized by complex interactions between ice and water dynamics



These observations indicate widespread lifting of the glacier sole from the bed, ponding of flood waters and acceleration of the overlying glacier



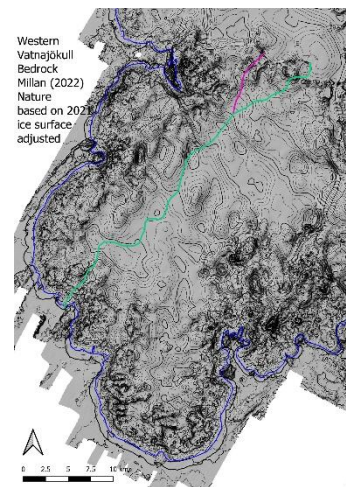
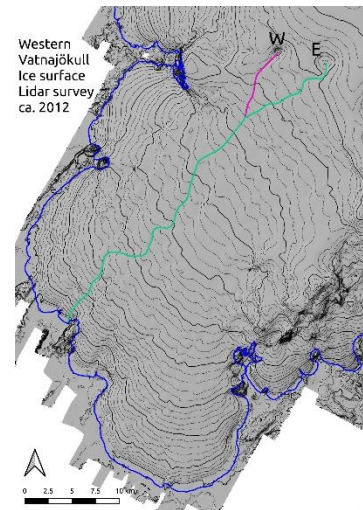
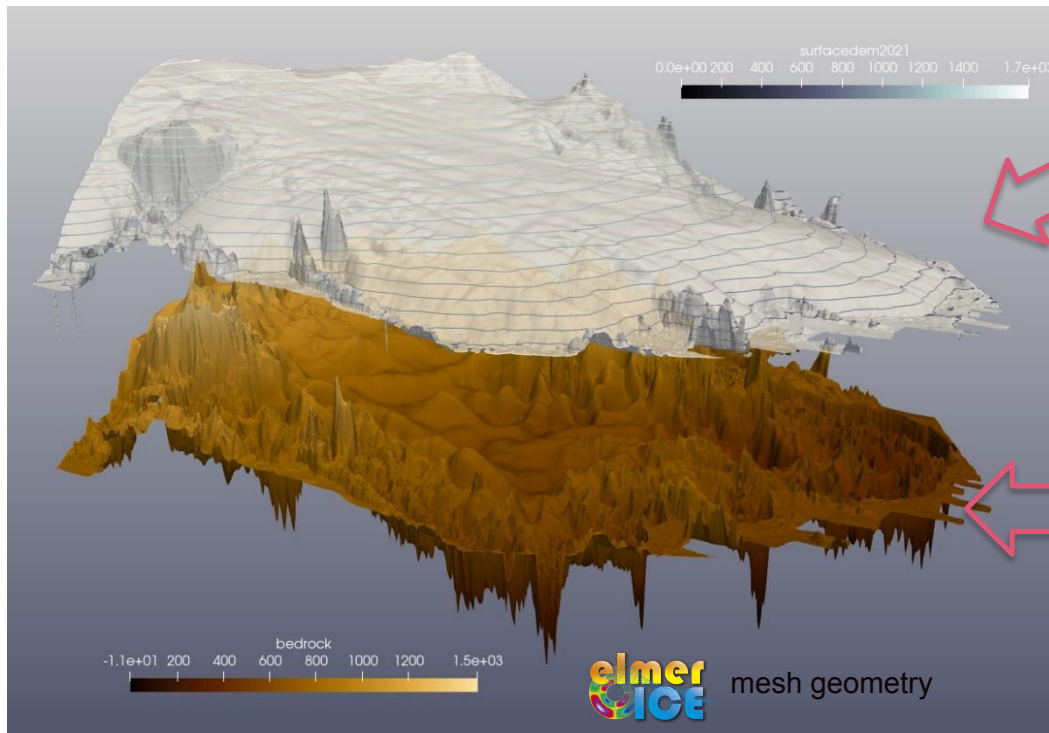
*Eyjólfur
Magnússon
et al.
(submitted)*

On-going Elmer/Ice model development for PD9 and SC9.1

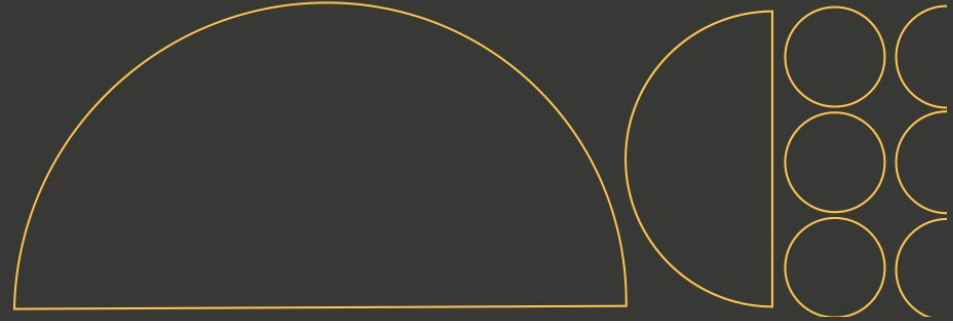
The observations show that a fundamentally new model is required to satisfactorily explain the dynamics of glacier floods

- **Visco-elastic glacier dynamics** (linear elasticity, non-linear Glen's flow law viscosity) – **Implemented**
- Thin **subglacial water flow** dynamics based on Manning's equation for the friction in turbulent water flow – **Implemented**
- **Fluid-structure interaction** at the subglacial ice-water interface based on **artificial compressibility** – **Implemented**
- **Contact problem** for tracing the propagation of a subglacial flood wave and the time-varying extent of the flooded area at the base – **Implemented** in principle, **incorporation** in jökulhlaup model **under development**
- **Coupling of water flow** in a thin sheet at the base with an overlying glacier – **Implemented** in principle, **incorporation** in jökulhlaup model **under development**
- **Setup of SC 9.1** (Skaftá) **under development**

Ice-surface and bedrock DEMs for planned jökulhlaup model validation



Thank you!



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<http://cheese2.eu>



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