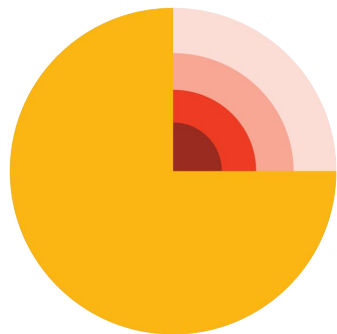




ChEESE

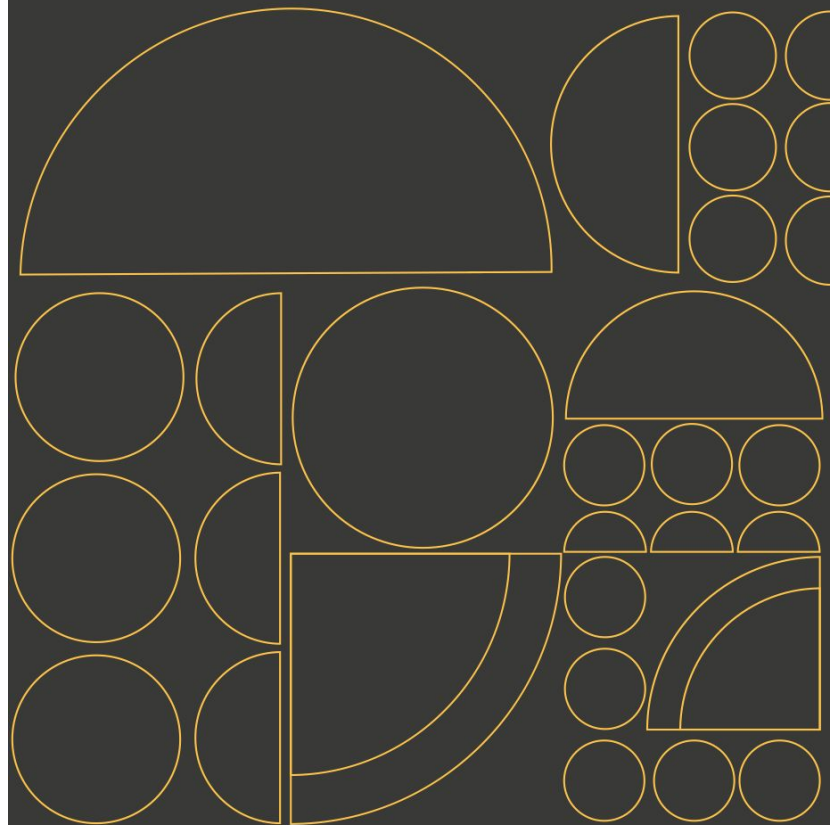
LaMEM

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Johannes-Gutenberg University Mainz (UM)



Project funded by EuroHPC under the grant agreement No 101093038.



LaMEM

- 3D thermo-mechanical code for geomechanics and geodynamics
- Finite-difference (staggered)
- C/C++, MPI
- Uses PETSc infrastructure
- Wide variety of solvers: Direct, AMG, (custom)GMG, coupled/decoupled
- Features:

**Marker-and-cell
method**

Julia interface

Phase transitions

**Visco-elasto-plastic
rheology**

Free surface

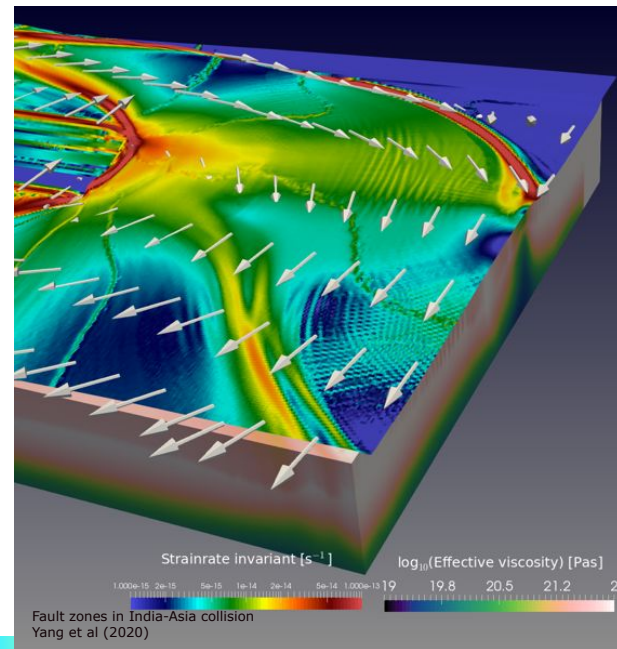
**Coupled to simple
erosion model**

**Inversion with
adjoint**

**Flexible input
options**

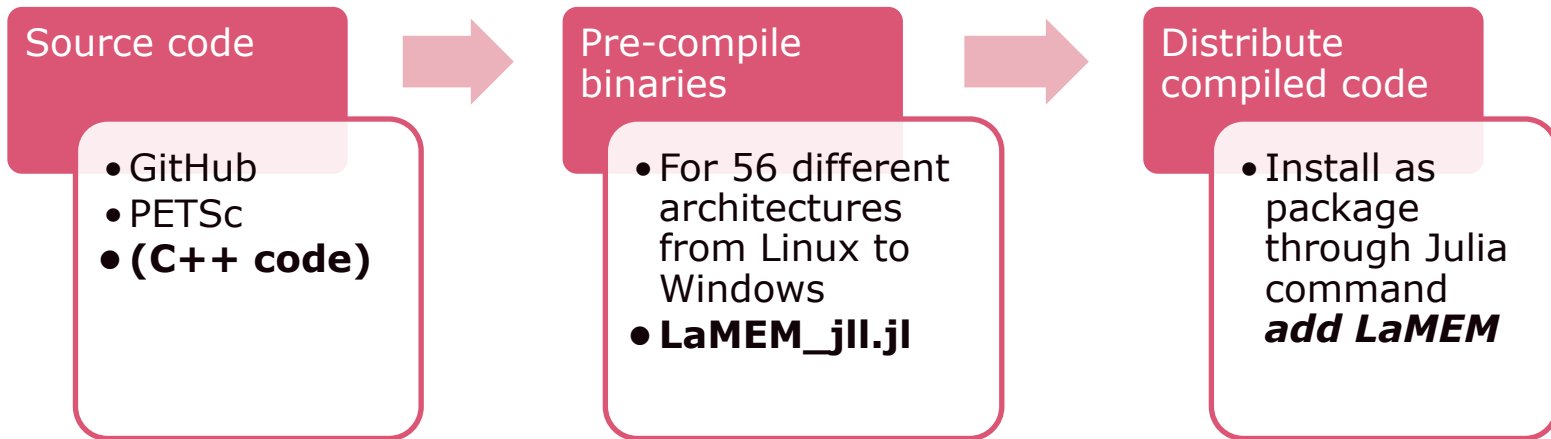
Compressible

- Since 2007



WP2

Code Portability



- Using **Julia**¹ package manager and **BinaryBuilder**² to **distribute** precompiled native binaries of LaMEM to different systems (Windows, Mac, Linux)
- We developed **precompiled binaries of PETSc**
- Link to MPITrampoline to allow deployment on different HPC systems (In progress)

¹ <https://julialang.org>

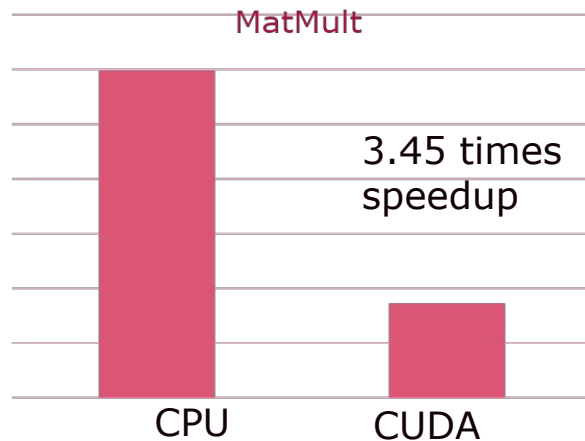
² <https://docs.binarybuilder.org>

WP2 / Porting to GPU

- Ongoing work with GPU runs
- Ran benchmark model (diffusion) with GPU (AMD EPYC 7543 32-Core with 2x NVIDIA A100 80GB)

PETSc options to run with GPUs

GPU type	Vec type	Mat type
NVIDIA	cuda	aijcusparse
AMD	hip	aijhipsparse
NVIDIA/AMD	kokkos	aijkokkos



MatMult takes 74,7 % of total runtime in simulation

Increasing PP level

Performance Portability Campaign

Weak and strong scaling was performed on

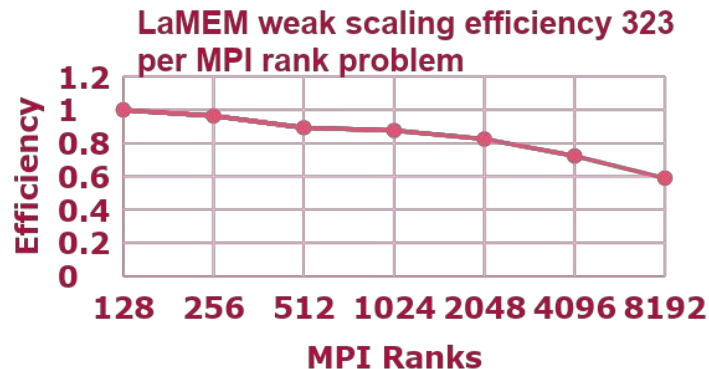
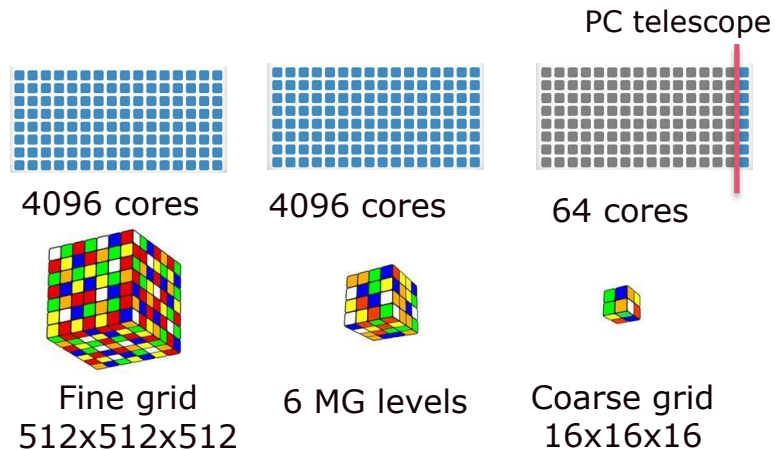
- LUMI-C
- UM HPC cluster MOGON NHR

Bottlenecks

- Solving **coarse grid** in high resolution with many MPI ranks

Potential solution

- **Repartitioning the coarse grid** to smaller number of MPI ranks
- Efficient runtime options not found yet



How to do this in practice ...

```
-jp_type mg
-gmg_pc_type mg
-gmg_pc_mg_levels 5
-gmg_pc_mg_galerkin
-gmg_pc_mg_type multiplicative
-gmg_pc_mg_cycle_type v
-gmg_mg_levels_ksp_type richardson
-gmg_mg_levels_ksp_richardson_scale 0.5
-gmg_mg_levels_ksp_max_it 10
-gmg_mg_levels_pc_type jacobi
-crs_pc_type telescope
-crs_pc_telescope_reduction_factor 2
-crs_telescope_ksp_type fgmres
-crs_telescope_pc_type hypre
-crs_telescope_pc_use_amat
-dm_mat_type hypre
-crs_telescope_pc_mg_galerkin_mat_product_algorithm hypre
-crs_telescope_pc_hypre_type boomeramg
-crs_telescope_pc_hypre_boomeramg_agg_nl 5
-crs_telescope_pc_hypre_boomeramg_max_iter 5
-crs_telescope_pc_hypre_boomeramg_relax_weight_all 0.8
-crs_telescope_pc_hypre_boomeramg_strong_threshold 0.999999
-crs_telescope_pc_hypre_boomeramg_smooth_type Euclid
-crs_telescope_pc_hypre_boomeramg_eu_bj
-crs_telescope_pc_hypre_boomeramg_coarsen_type HMIS
```

Galerkin multigrid to
solve from fine grid and
get to coarse grid



Using **PC telescope** to
reduce the amount of
MPI ranks involved in
solving coarse grid



Algebraic multigrid
(HYPRE) to **solve**
coarse grid

Other relevant technical contributions

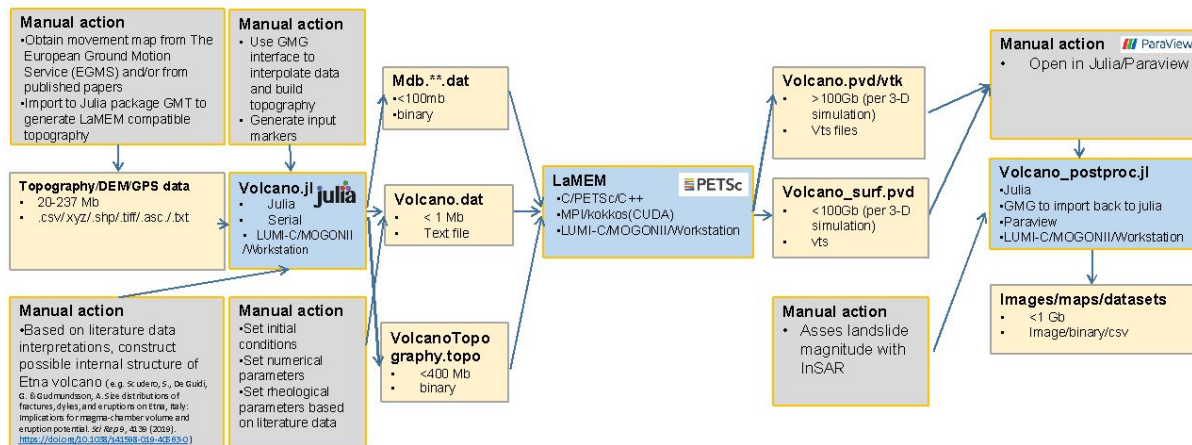
WP4 and WP5

- Workflow: has developed workflow for simulation any part of Earth for PD 8
- Workflow in WP4 employs WP5 implementation of Julia interface
- Development: BFBt preconditioner and matrix-free solvers

LaMEM workflow for SC 8.1

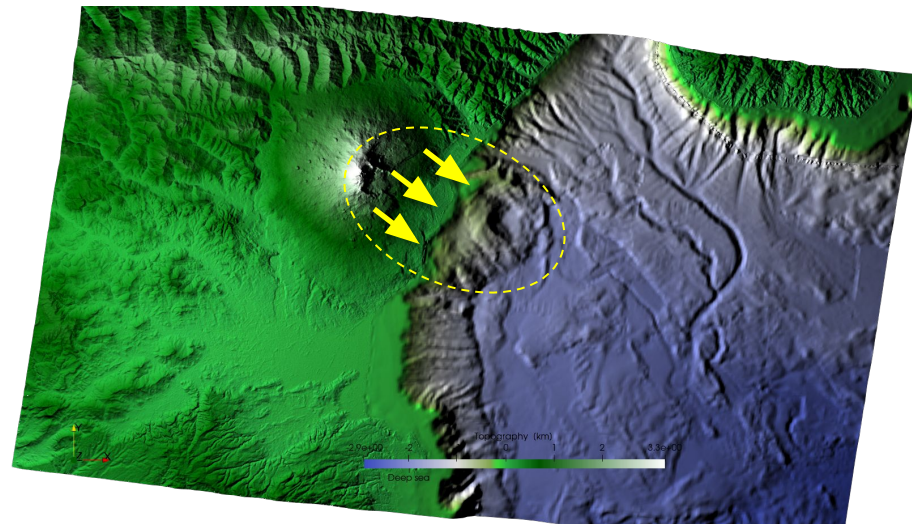
Description: Magmatic systems and induced landslides: the Etna case with a spatial resolution of around 50 meters to resolve the major faults

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Other relevant technical contributions

- ❑ Computational resources
 - LUMI-C and LUMI-G developer access
 - ❑ Scientific Grand Challenge
 - Etna Volcano South-East flank instability
 - ❑ CI/CD strategy
 - CI/CD added to LaMEM
 - Implemented in github
 - Julia interface also offers CI/CD including BinaryBuilder
- Bronze badge on SQAaaS



WP 7 Dissemination activities

Geodynamic modeling workshop with ChESEE codes

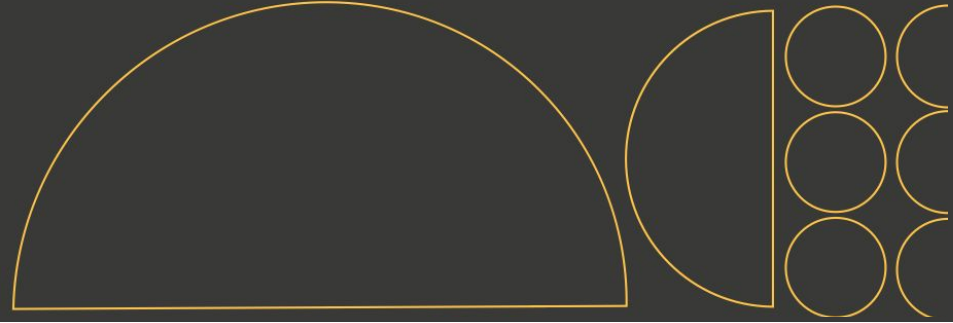


- 25-28 March 2024
- Organised by **University of Mainz** (UM) and **University of Sorbonne** (SU)
- LaMEM and pTatin3D
- Booked out in 5 hours



<https://cheese2.eu/2024/02/event-computational-geodynamics/>

Thank you!



@cheese-coe



<http://cheese2.eu>



@cheese-coe