

# Global Simulation and Parameter Inversion for Earth's Mantle Flow

## Scientific Achievement:

- ▶ Implicit solvers for complex, nonlinear PDEs and inversion of parameters in PDE
- ▶ Adaptivity to heterogeneous coefficients and wide range of spatial scales
- ▶ Algorithmic scalability to billions of DOFs & parallel scalability to millions of cores

## Significance and Impact:

- ▶ **Methods and Algorithms:** Innovations in robust nonlinear solvers, efficient linear multi-level solvers and preconditioners; scaling to  $\sim 100\text{B}$  DOF and 1.6M cores
- ▶ **Geophysics:** Understanding of fundamental mechanisms in the mantle; drivers of plate motion; mechanical plate coupling at subduction zones (govern large earthquakes)

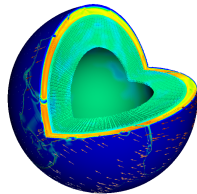
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## Realistic High-Resolution Physics Model:

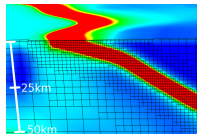
- ▶ Global mantle convection & associated plate tectonics
- ▶ Nonlinear viscous fluid flow (one time instant)

## Bayesian Inverse Problem:

- ▶ **What we know:** Observations of plate velocities at the surface, topography, etc.
- ▶ **What we want:** Parameters in constitutive laws and plate coupling strength that are consistent with data and model; uncertainties w.r.t. available observations



Colors represent viscosity, arrows show plate velocities.



Fault zone (red) between stationary and subducting plate.

## References I

Rudi, Johann, Michael Gurnis, and Georg Stadler (June 2022). “Simultaneous inference of plate boundary stresses and mantle rheology using adjoints: Large-scale 2-D models.” In: *Geophysical Journal International* 231.1, pp. 597–614.