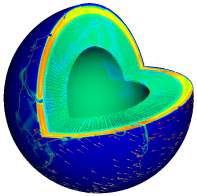
Global Simulation and Parameter Inversion for Earth's Mantle Flow

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$100B 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)



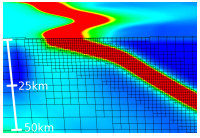
Colors represent viscosity, arrows show plate velocities.

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



Fault zone (red) between stationary and subducting plate.