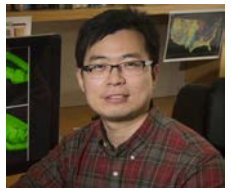
BLUE WATERS
SUSTAINED PETASCALE COMPUTING



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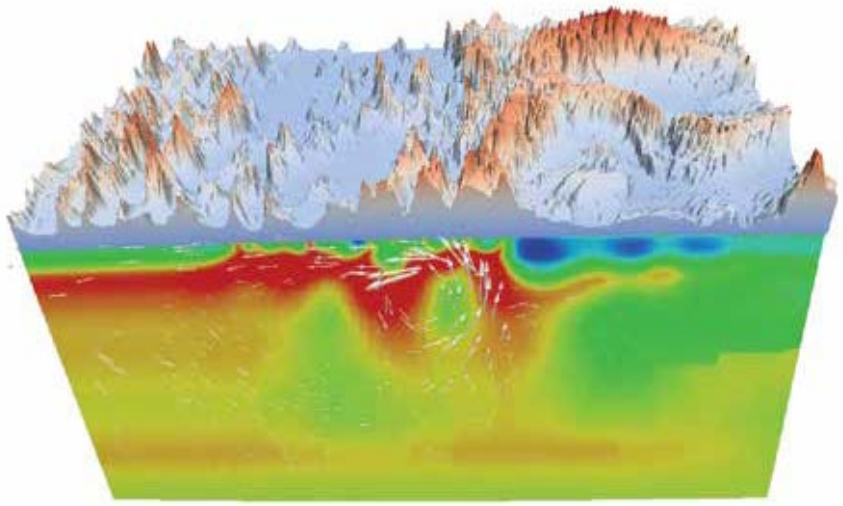
Geoscience

UNDERSTANDING THE 4-D EVOLUTION OF THE SOLID EARTH USING GEODYNAMIC MODELS WITH DATA ASSIMILATION



Lithosphere viscosity (color) and mantle flow (arrow) beneath the western United States. The viscosity is converted from electrical resistivity, and the flow is calculated from a geodynamic model.

Research Challenge

The goal of this project is to quantitatively understand current and past dynamic processes within the deep Earth, which are vital for explaining geological, geophysical, and geohazard observations. Such processes include:

- Heat source fueling of volcanoes far away from a subduction zone
- The influence of subduction on the mantle and the surface
- Earthquake- and volcano-generating deformation of continents

Methods & Codes

The team uses CitcomS, a community-based finite element code, to simulate a physics-based numerical model of the deep earth. This code, which can be run either forward or backward in time, uses various geodynamic modeling techniques that combine a variety of things such as mantle temperature and viscosity profiles, as well as tectonic plate motion.

Why Blue Waters

The enormous amount of data processing and computation makes Blue Waters the best platform. The CitcomS code has been designed and tested mostly on traditional supercomputers.

Results & Impacts

- Demonstrated that the electrical conductivity of rocks is an excellent proxy for the effective viscosity of the lithosphere, providing a practical way to “measure” the strength of the Earth’s rigid outer shell. (Liu & Hasterok, *Science*, 2016)
- Showed that the east-west topography difference of the Tibetan Plateau is due to the different crustal strength underneath. (Chen et al., *Nature Comm.*, 2017)
- Challenged the traditional view of intra-plate volcanism formation by demonstrating that Yellowstone-related volcanism was not caused by a deep-rooted mantle plume. (Leonard & Liu, *GRL.*, 2016)
- Found that the seismically fast upper-mantle structures beneath the southern Atlantic are mostly compositional anomalies, likely representing delaminated continental lithosphere. (Hu et al., *EPSL*, 2017)