Geophysical Research Abstracts
Vol. 21, EGU2019-9345, 2019
EGU General Assembly 2019

Full 3D numerical modelling of stress magnitudes due to variations of gravitational potential energy around the Tibetan Plateau

Emilie Macherel, Yuri Podladchikov, György Hetényi, and Stefan Schmalholz
University of Lausanne, ISTE, Switzerland (emilie.macherel@unil.ch)

The unusually large thickness of the Tibetan Plateau generates lateral variations of gravitational potential energy per unit area (GPE), which causes the thickened crust to flow apart by gravitational collapse and therefore to thin. The gravitational collapse is thought to have started approximately 10 to 15 Ma ago. If current deformation rates are assumed constant since 10 to 15 Ma ago, then the crust would have thinned by approximately 5.5 to 8.5 km until today (Ge et al., 2015). Due to mass conservation, thinning of the crust implies horizontal spreading of the plateau towards the lower altitude surroundings. This spreading is documented by GPS velocities on the order of 2 cm/yr around the Tibetan plateau. The crustal flow of the Tibetan Plateau also generates differential stresses in and around the plateau.

To quantify the three-dimensional (3D) stress and deformation field in and around the Tibetan Plateau, we develop a new thermo-mechanical algorithm based on an Eulerian pseudo-transient finite difference method. The pseudo-transient approach allows an explicit solution of the Stokes equations without the need of inverting a large stiffness matrix. When the pseudo-transient time derivatives approach zero a steady-state solution is obtained. We also use a pseudo free-surface method in which the topography represents vertical stresses, which are implemented as normal-stress boundary condition on the flat top boundary of the Eulerian grid. The shear stresses on the top boundary are zero. Surface processes are modelled with a non-linear diffusion equation based on a thin-film equation. The lateral sides and the bottom of the model are free slip boundaries. The initial model geometry and density field is defined by the CRUST1.0 dataset.

The calculated surface velocities are compared with the observed GPS velocity field. The stress magnitudes are quantified, and regions of compression, extension and strike-slip deformation are identified. We particularly focus on stress magnitudes around the two syntaxes region and discuss the potential evolution of uplift and exhumation in these regions. The stress magnitudes calculated by our 3D model are also compared with stress magnitudes calculated by 2D models applied to cross sections from India into Tibet.

Reference

Ge, W. P., Molnar, P., Shen, Z. K., & Li, Q. (2015). Present-day crustal thinning in the southern and northern Tibetan plateau revealed by GPS measurements. Geophysical Research Letters, 42(13), 5227-5235.