Modelling dynamic topography as a contributor to sea level change

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Abstract

Sea level changes over time and predictions of sea level rise or fall are vital to lives of millions of people who live near the seashore. Present-day sea level changes may be attributed to climate change and global warming, however, changes in ocean basin volume can also affect sea level; if ocean basin volume decreases, sea level increases and vice versa. Ocean basin volume, in turn, depends on dynamic topography; mantle convection causes uplift and subsidence of the ground. Dynamic topography has been studied by scientists since the 1980s, but both its pattern and amplitude, and how they change with time are yet poorly known.

One of the factors that affects modeling changes in topography is lithosphere thickness. Density anomalies within the lithosphere move with the tectonic plates and hence do not cause vertical motions in the reference frame of the plate. But those anomalies below the lithosphere move with mantle flow and hence may cause uplift or subsidence. Various lithosphere thickness models disagree with each other, hence it is not straightforward to separate those parts. Large scale dynamic topography may be due to density anomalies in lower mantle, whereas density anomalies in the upper mantle can create topography at smaller scales. By using appropriate seismic tomography models, we can estimate density anomalies in the mantle. Therefore, modeling topography due to mantle flow can help to explain observed topography. Besides lithosphere thickness, there are also large uncertainties regarding mantle rheology, which also affects rates of vertical motion.

Here we use numerical modeling to compute present-day rates of uplift and subsidence of the Earth’s lithosphere caused by mantle convection which can be extrapolated into the geological past back to a few million years ago. In a second step we are going to sum up the ocean basin volume and thus estimate the mantle contribution to sea level changes over those few million years. In this study, we use ASPECT to model convection flow. For

comparison, we will use a spherical harmonics methods as well, which is computationally simpler, and appropriate as long as lateral viscosity variations don’t affect results in a major way.