Recent glacial isostasy and new constitutive approaches to the spectrum of low frequency geodynamics

Erik R. Ivins, Lambert Caron, Andrew Lloyd, Eric Larour, Surendra Adhikari, Helene Seroussi, Mirko Scheinert, Martin Horwath and Douglas Wiens

Tidal band Q_{mantle} reveals a somewhat larger frequency-dependence than does seismic attenuation above about 5 mHz (1/200 sec) (Liu and Faul 2019). To explain this anelastic behavior in microphysical terms, a broad range of complex diffusion related grain boundary and intra-grain processes in upper mantle rocks are thought to be operative in the transition between the seismic and tidal frequency regime. For the long period tides, these may be modeled as a background band of continuously distributed Burgers and Maxwell viscoelastic elements, collectively having a shear modulus with a weak-dependence on frequency described by an α–power law, high and low cut-off periods and a single relaxation strength, Δ. Lateral heterogeneity associated with a strongly convective mantle is reflected in percent variations in seismic velocity and attenuation, and above 900°C there will be a strong temperature-dependence to these quantities and the time scales governing transient rheology.

Here we focus on testing an experimental parameterization of the most successful among competing anelastic constitutive laws to periods in which we have an increasingly accurate and comprehensive geodetic record. The latter now include rapid uplift responses to cryospheric unloading during 20^{th} and 21^{st} century climate warming. A level of complexity in the required linear viscoelastic law also realizes a continuum of relaxation parameters. We explore the parameterizations that have emerged from the torsional experiments of Jackson and Faul (2010) by developing analogues for tidal and post-seismic observations and models. The resultant parameterizations within extended Burgers model are entirely compatible with rapid uplift measured at bedrock geodetic stations in the coastal Amundsen Sea Sector, with ice mass loss initiated as late as 1979.