Constraining the thermal contribution to seismic velocity anomalies using GIA observations

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Lateral variations in seismic velocity can have a thermal or chemical origin, or can be caused by non-isotopic pre-stress. It is important to quantify each of these causes because of the consequences they have for mantle dynamics. This presentation constrains the contribution of thermal changes to seismic velocity anomalies using GIA observations.

GIA modeling is done with a Finite Element model coupled with the Laplace equation on a spherical visco-elastic compressible earth with self-gravitating oceans. The ice loading histories used are ICE-4G and ICE-5Gv1.2. Lateral viscosity perturbations are derived from the high resolution seismic tomography model of Grand (2002) using a conversion relation that takes into account both anelastic and anharmonic effects (Karato 2008). To perform a trade-off between chemical and thermal contribution to the seismic velocity anomalies, a scaling factor b is introduced in the conversion. b = 0 means that all observed velocity anomalies are caused by chemical changes and there are no lateral variations in viscosity. b = 1 is the other extreme, where all seismic velocity anomalies are caused by thermal variations and there is maximum lateral variation in viscosity. b is varied systematically between 0 and 1 in both the upper and lower mantle. The combination of upper and lower mantle values of b is searched that best fits the GIA data in North America, in Fennoscandia or globally. The GIA data that is used consists of 30 RSL sites, uplift rates derived from GPS, uplift rates derived from altimetry and tide gauges, and gravity rates derived from GRACE. For b uniform in the mantle, a value of b = 0.2 best explains all the data.