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The Effect of lateral density contrast variation on computation of the crustal thickness from Vening Meinesz-Moritz isostatic model

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Determination the Mohorovičič discontinuity (Moho), which is the surface separating the crust from the mantle, is a classical problem in geophysics. Some geophysical parameters varies at this surface, such as density contrast, gravity field, velocity of seismic waves, etc.

The Moho depth can be determined by the seismic or the gravimetric methods. The gravimetric methods are based on assumptions on isostatic equilibrium theories, like varying compensation depth or density contrast or both in the ideal case. For example, Vening Meinesz modified the Airy-Heiskanen hypothesis by considering regional/global compensation. In the Vening Meinesz isostatic hypothesis, the density contrast is constant, while the Moho depth is variable. In the Vening Meinesz model the Bouguer gravity anomaly on the Earth's surface is totally compensated by the mass attraction. Moritz (1990) generalized istotatic model to a spherically shaped sea level. The problem of determination of the Moho depth can be formulated mathematically by solving a non-linear Fredholm integral equation of the first kind. This method was recently presented by Sjöberg (2009) and called Vening Meinesz-Moritz (VMM).

Using a constant density contrast (e.g., 0.6 g/cm^3) is not realistic in gravimetric Moho depth models such as the VMM and Parker-Oldenburg models. Hence, determining the Moho depth by using the density contrast model or at least utilizing different density contrast value in continents or ocean seems becomes realistic. We know that the density of the topographic mass is varying about 10-20 % from its mean value, but the lateral variation of the density contrast is more than the topographic mass density variations.

The main purpose of this investigation is to study the lateral variation effect of the density contrast in the Moho depth estimation. Five density contrast models are used to estimate the global Moho depth by the VMM method. The first model uses a constant density contrast of 0.6 g/cm^3, the second one utilizes different values for continent and ocean areas. The third one is the seismic density model. Finally the two last models are based on VMM hypothesis, but they are obtained based on a constant or a variable density in the Bouguer reduction.

We compare the results of the Moho depth based on the VMM model with the seismic Moho model (CRUST2.0), which is regarded as the known crustal thickness. The numerical results show that the density contrast estimated from the VMM model, with variable density in the Bouguer correction, is close to CRUST2.0, and the mean value of both models are closer than the other models. The biases of the aforementioned five Moho models are 1.3±0.06, 0.63±0.07, 1.8±0.07, -0.2±0.06, 0.3±0.07 km, respectively. The global root mean squares of the fourth and fifth models are 5.0 and 7.7 km, respectively. Therefore, the error of the VMM model will decrease by using the realistic density contrast. It can be seen that Model IV is more correlated with CRUST2.0 as opposed to Model V. The VMM model can combines with CRUST2.0 in order to estimate a combined crustal thickness model, and it can be used in geophysical and geodynamical applications.