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Improved determination of rigid plate motion by incorporating intraplate deformation models

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For many scientific and non-scientific applications, positions determined at different epochs need to be intercompared or positions need to be referred to a common epoch. For that, a plate motion model is required that has a high accuracy; better than 1 mm/yr for the most demanding applications. Over the last 15 years, various plate motion models have been derived. Most of these models describe the global horizontal motions by a set of rigid plates distributed over the Earth's spherical surface. For each plate, the motion is fully determined by a 3-d rotation vector which fixes the corresponding Euler pole. These vectors are determined in a least squares fit of the predicted angular velocity field of the plates to observed geodetic velocities. For most plates, the uncertainty in the rotation vector is still large and is mainly the result of the lack of having a set of well-distributed velocity measurements on the plate. Moreover, these vectors turn out to be dependent on the pre-selection of observed velocities used in the data fit. For some plates, site selection for the data fit is dominated by the presence of well known, but possibly not well modelled, intraplate deformation. Proper modelling of this deformation could yield much better spatial data coverage and would thus enhance the stability and accuracy of the rotation vectors.

Any observed velocity field over a tectonic plate can be represented as a sum of a rigid body rotation and a velocity field due to intraplate deformation. Consequently, the inclusion of modeled intraplate deformations in the least-squares fit of the rotation pole can be expected to improve the separation of the rigid plate motion from the observations. Here, we extend the plate motion model definition by including geophysical models that describe intraplate deformation. One of these processes acting on a regional to global scale, for which sufficiently accurate models are available, is post-glacial rebound. We study the effect of post-glacial rebound on the resulting rotation vectors by including the present-day velocities predicted by various rebound models in the least squares fit. The newly obtained Euler poles are found to be more stable with respect to the selection of the observed velocity data. In particular for the Eurasian and North-America plates, the resulting poles differ significantly from those determined without modelling the intraplate deformation. Our approach can be expanded to include any intraplate deformation process that can be modeled. One example are models of post- and co-seismic deformation.