Estimation of crustal deformation in Miyakejima by finite element model including structure and topography

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Mogi model is a popular tool for analysis of a crustal deformation in a volcano. In the model, crustal deformation is calculated assuming that a small spherical pressure source buried in a uniform semi-infinite elastic body. The surface displacement can be expressed in a simple formula and easily applied to various problems. Usually there is a steep topography around a volcano as well as the underground structure beneath the volcanic body. There should be a systematic difference between the crustal deformation observed in volcano and the one calculated by Mogi model. In order to make the difference clear, we calculated the surface displacement caused by a spherical pressure source numerically with the finite element model including the structure and the topography of volcano, and compared the displacement to that of Mogi model. For the finite element model, we adopted the five-layers structure proposed Kikuchi et al.(2001). The first and the second layer to 3km depth have small elastic constants and easily deformed. The third and the forth layer of the depth between 3km and 22.5km have almost the same elastic constants to the usual value for Mogi model. The topography of Miyakejima such as the volcanic body and the central crater was modeled in the same way of Sakai et al.(2003). The horizontal and vertical displacements on the surface were calculated by the finite element model, and compared to that of Mogi model. We checked in detail for the case of the depth of pressure source is 5km and the radius is 1km. The underground structure made the surface displacements much larger, especially for horizontal component. The topography of the volcanic body made the displacements smaller. By the topography of the central crater, the horizontal displacement just around the crater was made a little large as shown in Sakai el al.(2003). GPS observation points in Miyakejima are mainly located at the distance of 4 to 5 km from the crater. In this range, the calculated horizontal displacement is as about 1.5 times large as that of Mogi model. If the calculated displacements of this finite element model are analyzed by Mogi model, the estimated depth of the pressure source should be shallower than 5km, the depth that the source is really located at. The volume change of the source is an important quantity estimated by analysis. The estimation of the volume change depends on both the depth of source and the amount of the surface displacement. The systematic difference of it should be examined considering the positions of GPS observation points.