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Local deformation and internal pressure changes due to annual recharge of ground water at Merapi Volcano

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A prerequisite for a successful assessment of volcanic risk is a proper discrimination between volcanic and non-volcanic signals for each data series entering a multidisciplinary evaluation scheme. This holds especially for volcanoes like Merapi, Java, which are continuously active on a certain pressure level with only small fluctuation. In that case, environmental disturbances gain importance and require a thorough investigation.

In the frame of the Indonesian-German joint research project MERAPI, four deformation stations have been installed along the hillsides of Merapi Volcano. Each station includes a bore-hole tiltmeter array, a semi-permanent DGPS receiver as well as various sensors recording environmental parameters. The continuous tilt records are dominated by rain- and ground water signals which mask any deformational signal related to volcanic activity phases. Two kinds of disturbances are observed:

(1) short period variations with amplitudes of several μrad which are related to individual rain falls. These signals are successfully removed from the tilt records by a convolution approach. Local rain data are convolved (i) with an exponential term, and (ii) with the complementary error function. A best fit between the resulting "rain-induced tilt" and the original curve is obtained by parameter variation. The impulse response functions used in the convolution approach reflect two different physical processes: loading of the ground by the water mass and deformations of the soil matrix due to percolating ground water. Thus, we interpret these disturbances as due to local poroelastic deformations of the ground. At two occasions, small possibly volcano related tilt anomalies become visible in the corrected tilt data.

(2) rapid, step-like drift changes with amplitudes of 15 to 80 μrad which are gen-

erally related to the alternation of wet and dry seasons, but not to individual rain events. These signals, highly correlated between the four deformation stations, occur within 14 days from the beginning of the rainy seasons. They cannot be removed using individual local rain records. Finite-Element-Modelling shows that sign and relative amplitudes of these signals are compatible with a pressure source within the central part of the volcano edifice. The dimensions of the central pressure source in the FE-model (radius: 1,8 km; depth below summit: 1,2 km) are adjusted to internal structures that have been obtained from seismic sounding and geoelectric conductivity measurements. The conclusion from FE-modeling is that the annual input of meteoric water may induce pressure variations within deeper parts of the hydrothermal system surrounding the central vent of Merapi.