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Post-eruptive microgravity changes from 1999 to 2004 at Unzen volcano, SW Japan: a window into hydrothermal dynamics

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We report on results from post-eruptive time-lapse gravity investigations performed between 199 9 and 2004 at Unzen volcanic complex, Shimabara Peninsula, Kyushu Island, southwest Japan. Unzen, one of the most active volcanoes in Japan, showed its most recent eruption between 1990 and 1995. Here we demonstrate that annual residual gravity variations reflect subsurface mass changes most likely coupled to changes in shallow aquifer levels on the order of several meters. We find a positive correlation between rainfall and gravity data with a 3 to 4 month lag time. We interpret this link as a delayed aquifer response to local rainfall and show that high permeability rocks of the Unzen complex are indicative for low aquifer storativity, which in turn results in substantial water table fluctuations upon deviation from average rainfall budgets. While aquifer dynamics may represent a first order explanation to the observed gravity data, hydrothermal fluid circulation in the feeder system of the recent eruptive episode is also likely to contribute to the gravity signals by deteriorating the signal-to-noise ratio compared to hydrothermally quieter volcanoes. This study shows that shallow hydrological processes may dominate temporal changes in the gravity field after dome-building eruptions identifying a clear need for a better understanding of the interaction between magmatic and hydrological systems at arc volcanoes. This study shows the need to record gravity variations over broader temporal spectra than achievable during generic annual surveys to also capture the short-times scales of dominant volcanic/hydrothermal phenomena at active volcanoes (Battaglia et al., 2008; Williams-Jones et al., 2008).

References:
Battaglia, M., Gottsmann, J., Carbone, D., Fernandez, J., 2008. 4D volcano gravimetry. Geophysics, Vol. 73, No. 6, p. WA3-WA18.
Williams-Jones, G., Rymer, H., Mauri, G., Gottsmann, J., Poland, M., Carbone, D., 2008. Toward continuous 4D microgravity monitoring of volcanoes. Geophysics, 73, No. 6, p. WA19-WA28.

Keywords: Unzen volcano, gravity changes, aquifer, hydrothermal system, magma, Japan