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A two-magma-chamber model as a source of ground deformation at Grímsvötn volcano, Iceland

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On the three last decades, Grímsvötn volcano showed a regular volcanic activity, with eruption every 6.5 years in 1998, 2004 and 2011. We analyse the displacements recorded around Grímsvötn volcano during the two last eruptive cycles and the current one, using ten stations from the Icelandic GPS network. Displacement signals show a long-term trend, of tectonic and glacio-isostatic origin, whose amplitude are coherent with the values of plate motions and vertical rebound previously estimated. Residual displacements after correction for the glacio-isostasic and tectonic components are small except at GFUM station, located at less than 3 km from Grímsvötn volcano, where a significant volcanic component is thus identified. At this station, the direction of volcanic displacement is consistent for all three eruptive cycles, favouring a common source of deformation for the three eruptions. The temporal evolution of the three post-eruptive inflations presents a striking similarity, characterized by an exponential trend followed by a linear trend. This temporal behaviour is well explained by an analytical model of two magma chambers, a deeper and a shallower, connected by an open conduit and fed at the bottom by a constant magma inflow. The eruption tends to rapidly depressurize the shallow reservoir. During the early post-eruptive phase, a pressure re-adjustment occurs between the two reservoirs with an exponential replenishment of the shallow one from the deeper one. Afterwards, a phase of linear uplift is observed corresponding to the pressurisation of the system as a consequence of the constant inflow of magma at the base of the system. We consider both oblate (sill) and spherical shapes for the reservoirs. For each case, the ratio of the erupted magma over injected magma at the bottom is mainly dependent on the size ratio between the two reservoirs. A larger deeper reservoir favors magma storage rather than surface emission. Based on displacements measured at GFUM station, we can estimate an upper limit for the lateral extension of the reservoir around 6 km.