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Fifty years of levelling measurements at Askja volcano, Iceland: New Bayesian interpretations of a unique dataset

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The year 2016 marks the 50th anniversary of the start of geodetic levelling surveys at Askja volcano in the Northern Volcanic Zone of Iceland. Askja has produced frequent basaltic fissural eruptions and rarer silicic caldera forming eruptions during the Holocene, the most recent of each type in 1961 and 1875 respectively. The potential for widespread disruption from larger eruptions and the popularity of the site with tourists makes Askja an important target for observation. Geodetic monitoring started in 1966 with the installation of a 12 station survey line on the 1961 lava flow, which provided a stable, extensive surface close to the putative source of magma. This was infilled and extended over the following two decades to give a finished levelling line of 35 stations spaced approximately 50 m apart (Tryggvason, Nordic Volcanological Institute, 1989). With the exception of the period 1972 to 1983, this line has been surveyed every year, providing a unique record of post eruptive deformation at a spreading rift segment capable of capturing magma motions at depth and any potential recharging in anticipation of future activity. The levelling has so far revealed that after an initial period of complicated inflations and deflations the volcano settled into a pattern of slowly decaying deflation from 1983 onwards (Sturkell and Sigmundsson, JGR, 105, 2000), a pattern that has been confirmed by newer geodetic techniques as they have become available (e.g. Pagli et al., JVGR, 152, 2005). The strength of the levelling data at Askja is its long time span, high accuracy and same measurement type over a period of 50 years. However, the small extent of the levelling line limits the power of the network to resolve changes in the magma plumbing system and requires the addition of constraints from other sources. This lends itself to Bayesian modelling techniques where assumptions are made explicit as priors and uncertainties in retrieved parameters can be comprehensibly modelled. Here we present a Bayesian inversion of the full dataset using the Stan probabilistic programming language that allows us to test a range of models of subsurface pressure changes and magma motions at depth.