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Oscillatory nature of the Okmok volcano's deformation

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The time-dependent deformation of volcanic edifices can help one understand the dynamics of pre-eruptive overpressure build-up in magma chambers. Thus, geodetic time series recorded at the Okmok volcano, in Alaska, show a pattern of fast and short inflations — referred to as "pulses" — followed by either slower and longer deflations, or time intervals with no deformation. This pattern is superimposed onto a longer-period inflation. A rapid inflation occurred just before the 2008 eruption, which suggests that the underlying process may lead to eruptions. It is crucial to understand whether such a behavior is driven by external forcing, such as melt supply variations, or whether it can develop spontaneously within the volcano's plumbing system. Here we model the observed oscillations (2004–2008) as resulting from the hydraulic interaction between two shallow magma chambers fed by a deeper source region, a geometry that is consistent with geochemical, petrological, and geophysical data. The model shows that episodes of periodic fast inflations occur (i) when a viscosity gradient is present in the vertical pipe, for instance as the result of a temperature gradient; and (ii) when the flux supplying the shallower chamber lies between two bounds that we derive analytically. The deformation pulses observed at Okmok can, therewith, be fully explained by the internal variability of the magmatic system and do not require time-variable external forcing. The proposed model can also be seen as an improvement upon the classic hydraulic models regularly used to explain a commonly observed pattern of volcanic deformations, i.e. newline exponential inflation.