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Response of the Nevados de Chillan and Peteroa volcanoes, Chile, to the 2010 M8.8 Maule earthquake.

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One of the fundamental uncertainties in Earth science is the link between large magnitude earthquakes and volcanism. The 2010 M8.8 Maule earthquake, Chile, provides an extraordinary opportunity to address this issue because of the on-going intense seismic and volcanic activity of this region.

Tectonic scale strike-slip faulting in Southern and Central Chile, upon which the arc resides, suggests that subduction zone earthquakes, faulting and volcanism are strongly coupled. As confirmed by post-seismic GPS velocities, the co- and post-seismic slip of the Maule earthquake induced a volumetric expansion of the upper plate. This facilitates the vertical migration of deep (subduction) fluids trapped at depth below the brittle-ductile interface. These upwelling fluids will ultimately reduce the effective normal stress acting on the faults promoting slipping and will affect the equilibrium of the volcanic plumbing systems by altering the fluid pressure inside magma chambers.

To test our hypothesis we deployed five broadband stations around the Nevados de Chillan and Peteroa volcanoes to record the occurrence of fluid-driven seismic activity. In addition, we performed GPU numerical simulations of a post-seismic toggle switch mechanism triggered by the Maule earthquake in the upper crust of this region. The numerical studies simulate the whole inter-, co-, and post-seismic cycle and account for measured GPS velocities. The seismic records underpin that fluid-driven seismic activity is on-going in the arc and it is particularly intense around the monitored volcanic centres. The numerical simulations highlight how fault and fracture networks evolve in a poro-elasto-plastic medium with pressure-dependent permeability and highlight how pressure fronts diffuse at depth after megathrust earthquakes. This study shows how relaxation of the upper plate initiates faulting, which we propose to be the primary mechanism for large-scale vertical migration of subduction fluids. We attribute the time-delay sometimes observed between megathrust earthquakes and subsequent arc-volcanism to the time needed for fluids to migrate upwards and affect the equilibrium of the entire geological system.