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Volcano-earthquake interaction at Mauna Loa Volcano, Hawaii

T. R. Walter and F. Amelung
Marine Geology and Geophysics, RSMAS - University of Miami, FL 33149, USA

The activity at Mauna Loa volcano, Hawaii, is characterized by eruptive fissures at the Southwest Rift Zone (SWRZ) and at the Northeast Rift Zone (NERZ) and by large earthquakes along a subhorizontal décollement at the base of the volcanic edifice. The catalogues of historic eruptions and earthquakes contain evidence for volcano-earthquake interaction, where about 90% of all historic earthquakes with magnitude M>6 were associated with eruptions. The historic record suggests a correlation in time and space, where earthquakes in the Kaoiki area are associated with eruptions at the NERZ, and earthquakes in the Kona and Hilea areas are associated with eruptions at the SWRZ. Furthermore, the volume of eruptions, the lava composition and the fumarole activity appear to be biased by preceding earthquakes.

We use numerical models, which demonstrate that elastic static stress changes can explain most of the observed volcano-earthquake interactions. The models show that (i) intrusions along the rift zones cause a significant increase in the Coulomb failure stress at the décollement type faults in the Kona, Hilea and Kaoiki areas, and thus promoting further earthquakes there, and (ii) earthquakes at the decollement faults cause a decompression of the magma chamber and a positive normal stress change at the rift zones, which are the main mechanisms for magma vesiculation, dike propagation and eruption triggering. By comparing the models to historical data we find that the locations of greatest stress changes well correlate with the locations of historic events, which implies that also the direction of flank slip and the propagation direction of dike intrusions is influenced - or even controlled - by the preceding activity. Our study hence suggests that the timing of eruptions, as well as the evolution of the magmas, the magma propagation pathways and the magma composition are influenced by near surface fault processes and the resulting static stress changes.