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The effect of lake drainage on active faults: two examples from central Italy

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Stress changes resulted from both elastic response and pore pressure changes due to large variations of water level in lakes and reservoirs may affect the seismicity on nearby faults. Several studies have confirmed this relationship, but the vast majority of them only focus on the effects of lake impoundments rather than lake drainage. A largely unanswered question is how lake drainage changes the stress conditions on nearby faults, possibly priming them for failure.

The Fucino lake and the Campotosto reservoir in central Italy, are two examples of lakes located near active normal faults. The Fucino lake, once the third largest lake in Italy, was completely drained between 1861 A.D. and 1875 A.D. to reclaim fertile land. Forty years after the completion of the drainage, a normal fault bounding the northeastern side of the flood plain ruptured during the 1915 Mw 6.9 Avezzano earthquake. The Campotosto lake, located on the hanging wall of the southern section of the Monte Gorzano fault, where the aftershock sequence of the 2016 Central Italy earthquake sequence is still ongoing, has not yet been drained. However, local officials have proposed draining the reservoir as hazard mitigation strategy to avoid possible future catastrophes, due to the proximity of one of the lake's three dams to the Monte Gorzano fault, and general concerns with respect to dam stability in case of a major earthquake.

In order to understand if lake drainage can effectively mitigate earthquake hazard, we use finite element modeling to calculate the stress changes on the faults in close proximity to both lakes during drainage. We calculate the evolution of stress and pore pressure in terms of Coulomb stress changes on the surrounding active faults induced by the 14 year-long drainage period of the Fucino lake, and investigate the stress state during the time of the occurrence of the 1915 Mw 6.9 earthquake. Using the same approach, we calculate the stress changes on the Monte Gorzano fault due to various drainage scenarios of the Campotosto lake. Preliminary results obtained by modeling the elastic response due to unloading show in both cases positive Coulomb stress changes (promoting failure) on the shallower part of the faults (0 to 4 km on the Fucino fault, and 0 to 2 km on the Monte Gorzano fault), and negative stress changes (inhibiting failure) at greater depths, where earthquakes tend to nucleate. The time-dependent pore pressure change will eventually decrease the Coulomb stress with a rate proportional to the diffusivity values used in the model.