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Evolution of potential energy during stick-slip dynamics in a dry and fluid saturated granular fault gouge investigated by 3D coupled CFD-DEM

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We study slip instabilities in a dry and saturated granular fault gouge using coupled discrete element method (DEM) and computational fluid dynamics (CFD). During shearing of the granular layer, potential energy is stored at the contacts, in soft sphere DEM simulated through overlaps between particles. We show that the potential energy builds up during the stick phase and drops during slip instability. We observe that some portion of this released energy goes into the kinetic energy of particles and the rest dissipates. Our observations show that around 8% of the drop in potential energy transforms into particle kinetic energy. Our simulations show that drop in potential energy is a good measure for the slip size since there is strong correlation between the drop in macroscopic friction coefficient and drop in potential energy. Our observations show that the drop in stored potential energy in the fluid saturated granular fault gouge is higher leading to a higher release in kinetic energy. We observe a higher mobilization of particles during slip due to dynamic fluid pressure compared to dry conditions. In other words, our results show a fluid-assisted type of particle mobilization in the fluid saturated fault gouge. This study emphasizes the important role of fluid-particle interactions at play in tectonic fault zones showing in particular how numerical models can help understand the hydro-mechanical processes that dictate fault slip.