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A common model to explain similarities between injection-induced and natural earthquake swarms

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Fluid injections at depth can trigger seismic swarms and aseismic deformations. Similarly, some natural sequences of seismicity occur clustered in time and space, without a distinguishable mainshock. They are usually interpreted as driven by fluid and/or aseismic processes. Those seismic swarms, natural or injection-induced, present similarities in their behavior, such as a seismic front migration. The effective stress drop, defined as a ratio between seismic moment and cluster size, is also weak for all swarms, when compared to usual earthquakes values. However, the physical processes that drive both types of swarms, and that can explain such similarities are still poorly understood. Here, we propose a mechanical model in which the fluid primarily induces an aseismic slip, which then triggers and drives seismicity within and on the edges of the active zone. This model is validated using a global and precise dataset of 16 swarms, from natural or induced origins, in different geological contexts. Consequently, our measurements of the migration velocity of the seismicity front, and of the effective stress drop for our swarms can be related to the seismic-to-aseismic moment. Using our model, we are then able to compute an estimate of the volume of fluids circulating during natural earthquake swarms, assuming the total moment is related to the volume of fluids. Our study highlights common characteristics and novel insights into the physical processes at play during seismic swarms.