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Scaling laws, aseismic slip and spatial complementarity of tectonic earthquake swarms

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Slow slip events (SSEs) are often accompanied by tectonic earthquake swarms (TESs). Swarms occurring on the SSE rupture plane are brittle failures of small velocity weakening patches repeatedly stressed by the SSE rupture front and/or by the stressing rate changes. When good quality deformation data are available, they can help assessing the aseismic release in an SSE and used to constrain its source parameters. On the contrary, if only seismic data of TESs are available, it is not straightforward to assess unequivocally whether the swarm activity was associated with a SSE or not. However, statistical and physical analysis of the source parameters and the spatio-temporal distribution of TES events can potentially provide information about the triggering mechanisms behind TESs. Here we investigate persistent and intense TES activity recorded in the last 20 years on the Húsavík-Flatey Fault (HFF), a ridge-transform plate boundary fault system offshore Northern Iceland. In the earthquake catalogue we identified six energetic TESs, some of which are composed by distinct sub-swarm sequences, leading to a total of 16 swarms that occurred along a $\sim$30 km segment of the HFF. In spite of the overall low seismic moment released seismically, the TESs have exhibited spatial complementary arrangement with subsequent swarms filling gaps left by earlier swarms, a pattern that suggests aseismic slip and moment release. In addition, each swarm usually started locally and then migrated outwards, showing faster migration in the rake direction and acceleration (or constant-speed), which is inconsistent with what would be expected from diffusive processes. The static stress drop associated with the TESs on the HFF is similar to the low values seen for global compilations of SSEs, showing that the fault area illuminated by earthquakes during the swarms may be more representative of the total and hidden moment release than the cumulative seismic moment of the swarm earthquakes. We estimate that the proportion of aseismic moment associated with the TESs is between 2 and 700 times larger than the respective cumulative seismic moment. The scaling properties of these and other TESs observed worldwide indicate that the importance of TESs in releasing tectonic strain at plate boundaries may have been underestimated.