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What drives the growth of earthquake clusters?

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Migration of hypocenters is a common attribute of induced injection seismicity and of earthquake swarms, which distinguishes them from aftershock sequences. Spreading of the triggering front is often examined by fitting the time dependence of hypocenter distances from the origin by the pore pressure diffusion model. The earthquake migration patterns however often exhibit not only spreading envelopes, but also fast-growing streaks embedded in the overall migration trends. We review the observed migration patterns and show that in the case of self-driven seismicity, where the new ruptures are triggered at the edge of previous ruptures, it is more suitable to examine the cluster growth as a function of the event index instead of time, which often discloses a continuous linear growth during time periods which appeared strongly discontinuous in the coordinate-time plots.

We propose a model that relates the speed of seismicity spreading to the average rupture area and the effective magnitude of the hypocenter cluster. Application of the model to selected linearly growing clusters of the 2008 West Bohemia swarm gives almost linear increase of the measured total rupture area with the event index, which fits the proposed model. This is confirmed by a self-similar scaling of the average rupture area with the effective magnitude for stress drops ranging from 0.1 to 1 MPa. The relatively small stress drop level indicates the presence of voids along the fault plane and a possible role of aseismic deformation. Further application of the model to seismic swarms from different areas confirms its validity and potential for distinguishing fluid-triggered seismicity.