Lateral migration patterns toward or away from injection wells for earthquake clusters in Oklahoma

José Ángel López-Comino\textsuperscript{1,2,3}, Martin Galis\textsuperscript{4,5}, P. Martin Mai\textsuperscript{3}, Xiaowei Chen\textsuperscript{6}, and Daniel Stich\textsuperscript{2}

\textsuperscript{1}University of Potsdam, Institute of Geosciences, Germany (lopezcomino@uni-potsdam.de)

\textsuperscript{2}Instituto Andaluz de Geofísica, Departamento de Física Teórica y del Cosmos, Universidad de Granada, Spain

\textsuperscript{3}KAUST, King Abdullah University of Science and Technology, Thuwal (Saudi Arabia)

\textsuperscript{4}Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava, Slovakia

\textsuperscript{5}Earth Science Institute, Slovak Academy of Sciences, Bratislava, Slovakia

\textsuperscript{6}School of Geosciences, The University of Oklahoma, Norman, OK, USA

Exploring the connections between injection wells and seismic migration patterns is key to understanding processes controlling growth of fluid-injection induced seismicity. Numerous seismic clusters in Oklahoma have been associated with wastewater disposal operations, providing a unique opportunity to investigate migration directions of each cluster with respect to the injection-well locations. We introduce new directivity migration parameters to identify and quantify lateral migration toward or away from the injection wells. We take into account cumulative volume and injection rate from multiple injection wells. Our results suggest a weak relationship between migration direction and the cluster-well distances. Migration away from injection wells is found for distances shorter than 5-13 km, while an opposite migration towards the wells is observed for larger distances, suggesting an increasing influence of poroelastic stress changes. This finding is more stable when considering cumulative injected volume instead of injection rate. We do not observe any relationship between migration direction and injected volume or equivalent magnitudes.