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Induced seismicity in the Cooper Basin (Australia): aftershocks, seismic efficiency, and fluid diffusion

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Long-term fluid-injection experiments that have been conducted in geothermal fields in the Cooper Basin (Australia) have created large numbers of induced earthquakes. We have analyzed catalogs of the seismicity that has occurred within a time interval between 2003 and 2012. We investigate Relative Locations of Consecutive Earthquakes (RLCE) to establish links between location and magnitude. The RLCE show a peculiar physical effect, here called "Christmas-tree" effect, namely smaller event separations towards higher magnitudes. An attempt is provided to explain the effect by inspecting the clustering ("aftershocks") that has occurred for events with magnitudes between 1 to below 4.

Seismic moment release has varied strongly during the injection history, also in function of the treatment parameters of the fluid injection, changing the "seismic efficiency". That could serve as a way to distinguish "triggered" from "induced" earthquakes.

Finally, we focus on the relation between seismicity and the injected fluid volume, e.g., fluid diffusion along a planar ("2D") feature in the subsurface, a localized single fault or fracture plane as an alternative to the 3D diffusion that is often considered. The 2D front is then compared to the classical volumetric (3D) fluid diffusion, in relation also to the injection history.

For the Cooper Basin, seismicity seems to be controlled by processes occurring on individual faults that become hydraulically conductive. Such a model seems to explain the observed seismicity, fracture, and aftershock extension.