

Supplemental Information for

Geospatial analysis of Oklahoma earthquakes (2011 - 2016):

Quantifying the limits of regional-scale earthquake mitigation
measures

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DATA SOURCES

The complete Oklahoma earthquake database was acquired by Internet download from OGS on 15 June 2017 (OGS, 2017), and annual datasets were compiled between 1 January 2011 and 31 December 2016 for complete annual earthquakes (M_{comp}), as well as magnitude 3.0+ ($M3.0+$), $M3.5+$, and $M4.0+$ earthquakes. To assess catalog completeness for the M_{comp} datasets, cumulative frequency-magnitude plots were created for each year of the study (Fig. S1). In doing so, the annual completeness threshold is identified on the basis of the Gutenberg-Richter Law (Gutenberg and Richter, 1944) by (1) fitting a line through the decreasing portion of the distribution, and (2) determining the lowest earthquake magnitude without substantial deviation from the linear fit. Figure S1 shows annual cumulative frequency-magnitude distribution plots, along with each linear fit and lower catalog completeness threshold.

Data for Class II injection well location and SWD volume in Oklahoma were acquired by Internet download for the calendar years 2011 - 2015 from the OCC website on 8 May 2017 (OCC, 2017a-e). Each data set was manually inspected to remove incomplete or duplicate records, as well as records without geo-location. The data were then filtered to include (1) wells within the study area, (2) wells completed within the combined Arbuckle-Simpson Group, and (3) wells with non-zero injection volume for a given year. For calendar year 2016, well locations and injection volume for Class II wells were acquired by Internet download from the OCC website on 7 June 2017 (OCC, 2017f). This 2016 data set includes weekly reports of daily injection volume for all Arbuckle disposal wells in the OCC Area of Interest, and, as a result, no filtering was required. In the context of geostatistical analysis, qualitative analysis of the annual datasets indicates that monthly SWD volume is generally consistent for individual wells, and, as a result, the assumption of stationarity is accepted for annual cross semivariogram analysis. For 2011 – 2016, the annual distributions of total Class II SWD injection volume are presented in Figure S3, and the spatial distribution of Class II injection wells is illustrated in Figure S4.

FIGURES

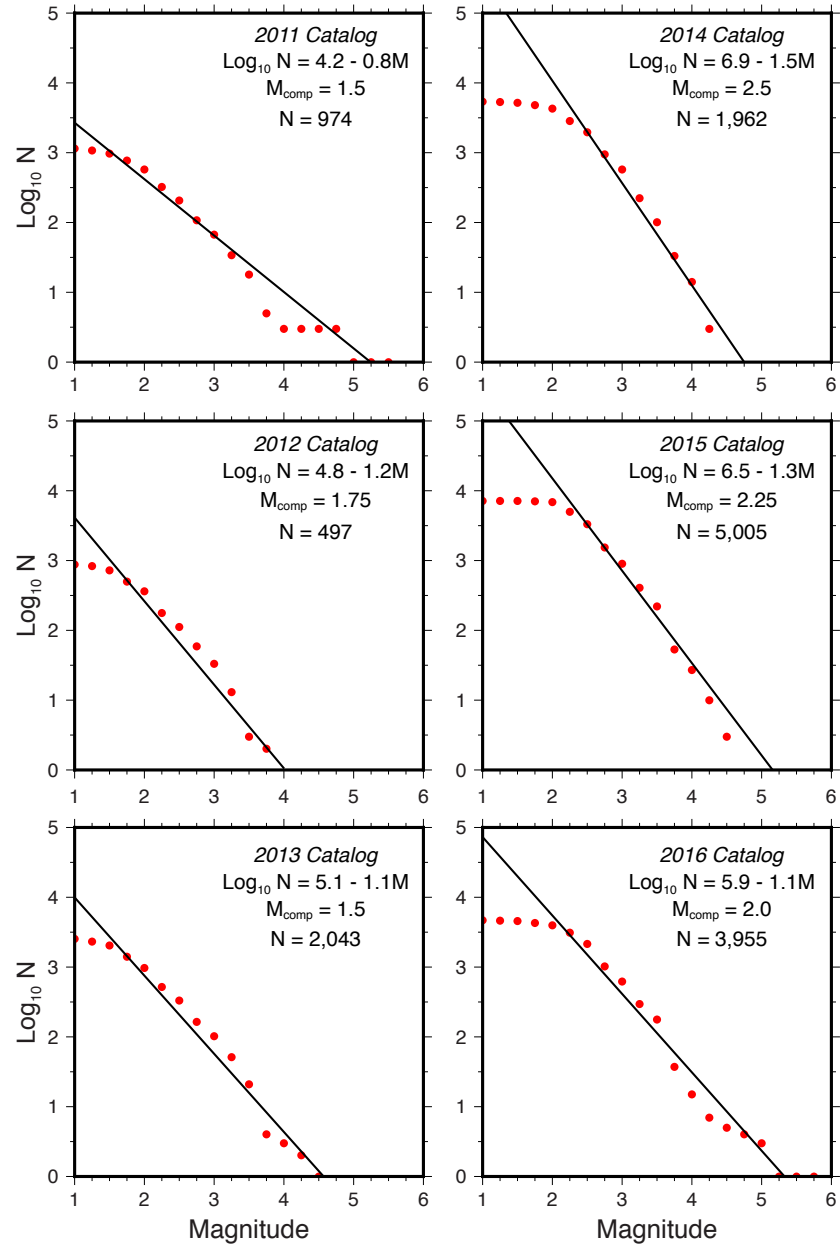


Figure S1. Cumulative frequency-magnitude distribution plots for each annual earthquake catalog compiled for this study. M_{comp} is the lower threshold for catalog completeness determined on the basis of the Gutenberg-Richter Law.

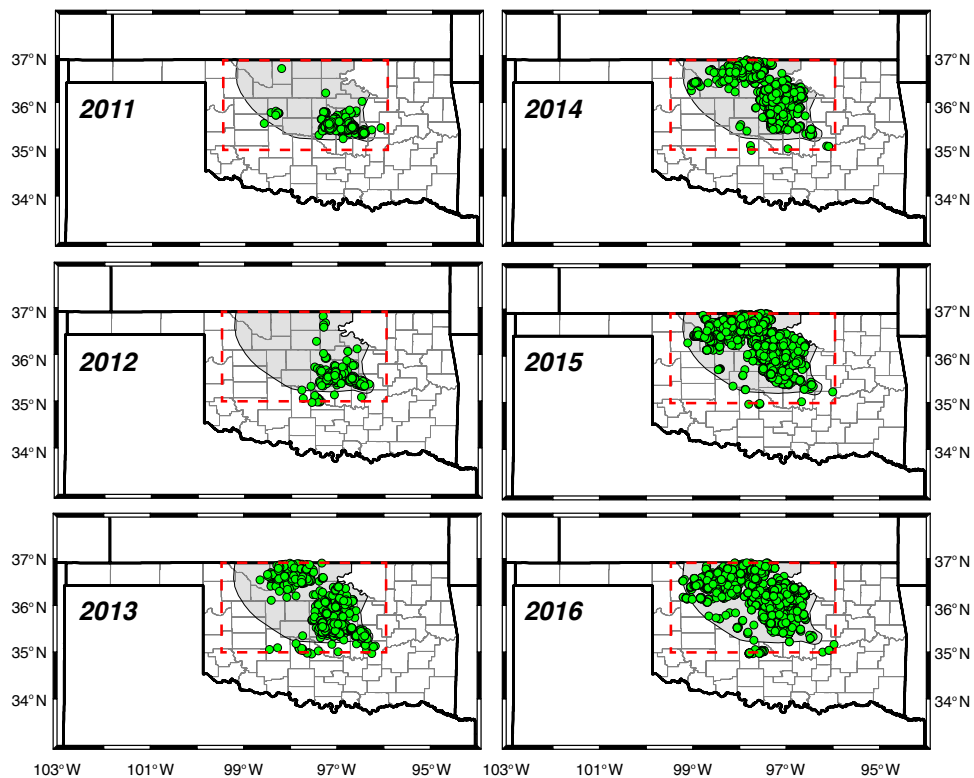


Figure S2. Spatial distribution of annual earthquake catalogs (green circles) used for geospatial earthquake analysis.

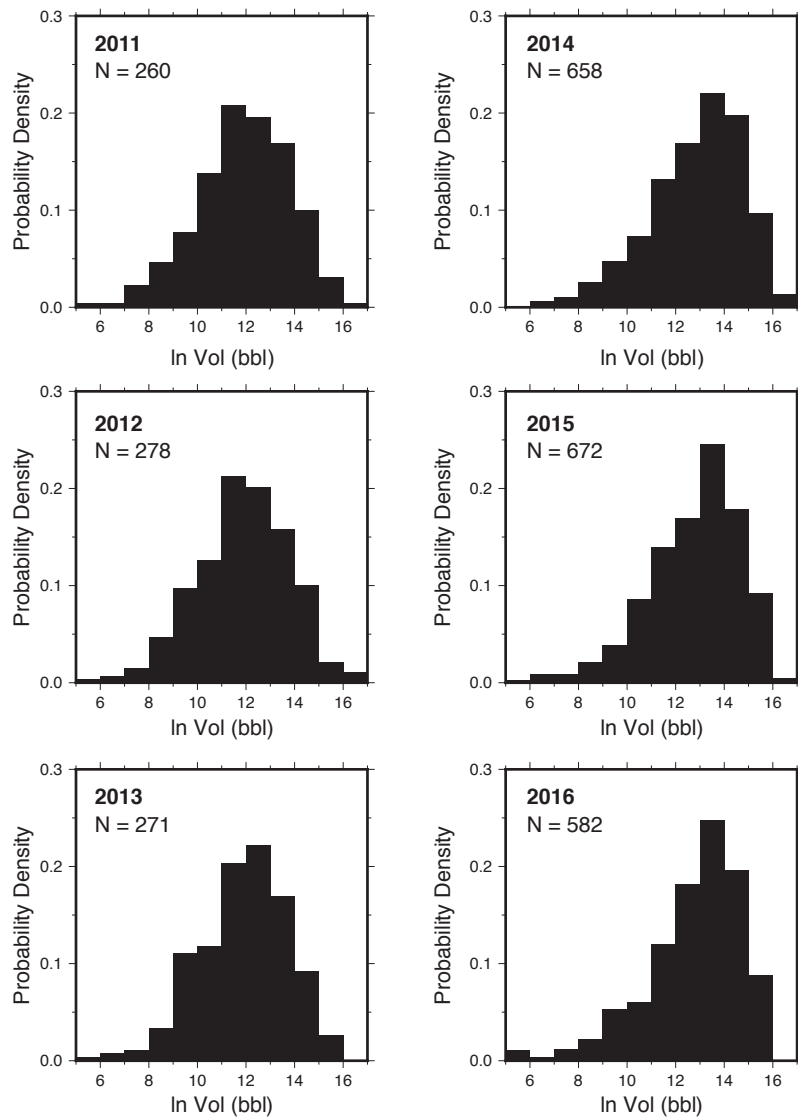


Figure S3. Annual distribution of class II injection volume for wells within the project study area (OCC, 2017a-f).

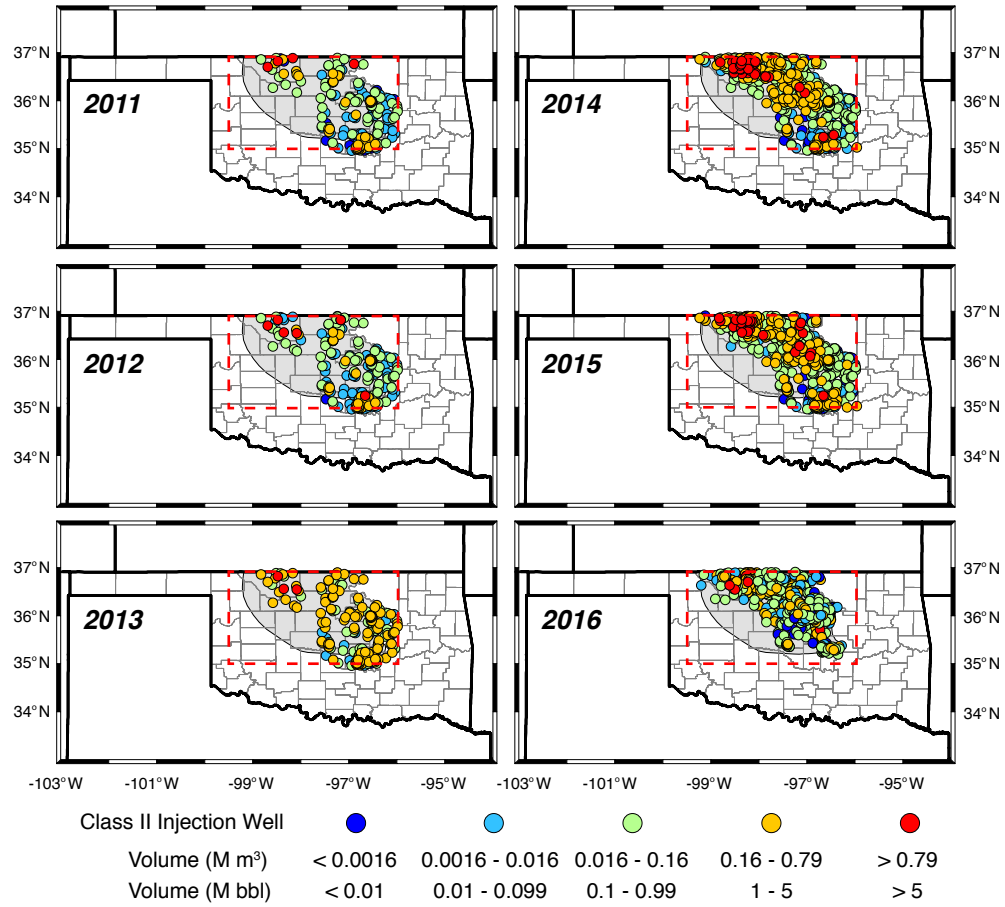


Figure S4. Class II injection well location and SWD volume (OCC, 2017a-f) within the study area. Gray shading denotes OCC Expanded Area of Interest for Triggered Earthquakes (OCC, 2016) and dashed red box denotes study area.

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