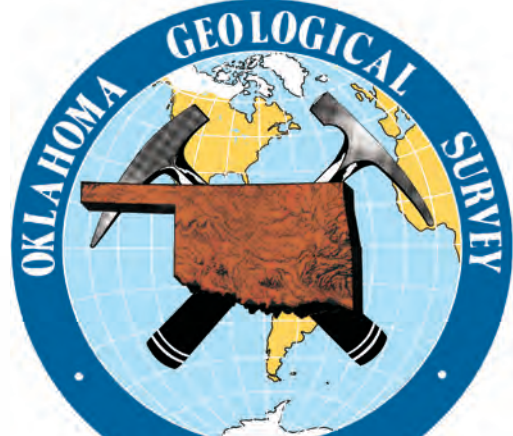


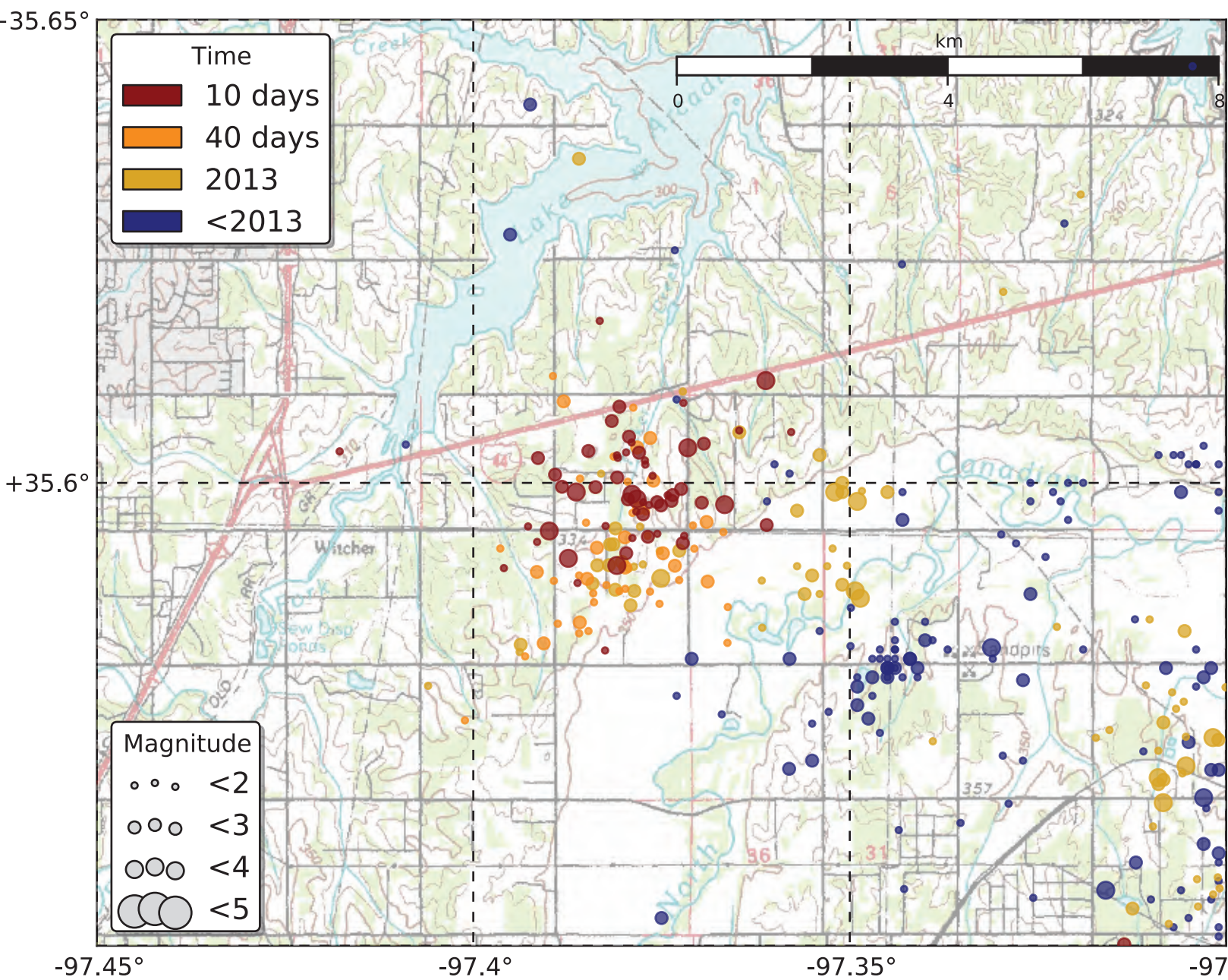
Southern Arcadia Lake, November 2013 Earthquake Swarm

Oklahoma Geological Survey Informational Series 16 (IS16), November 12, 2013

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Southern Arcadia Lake Swarm

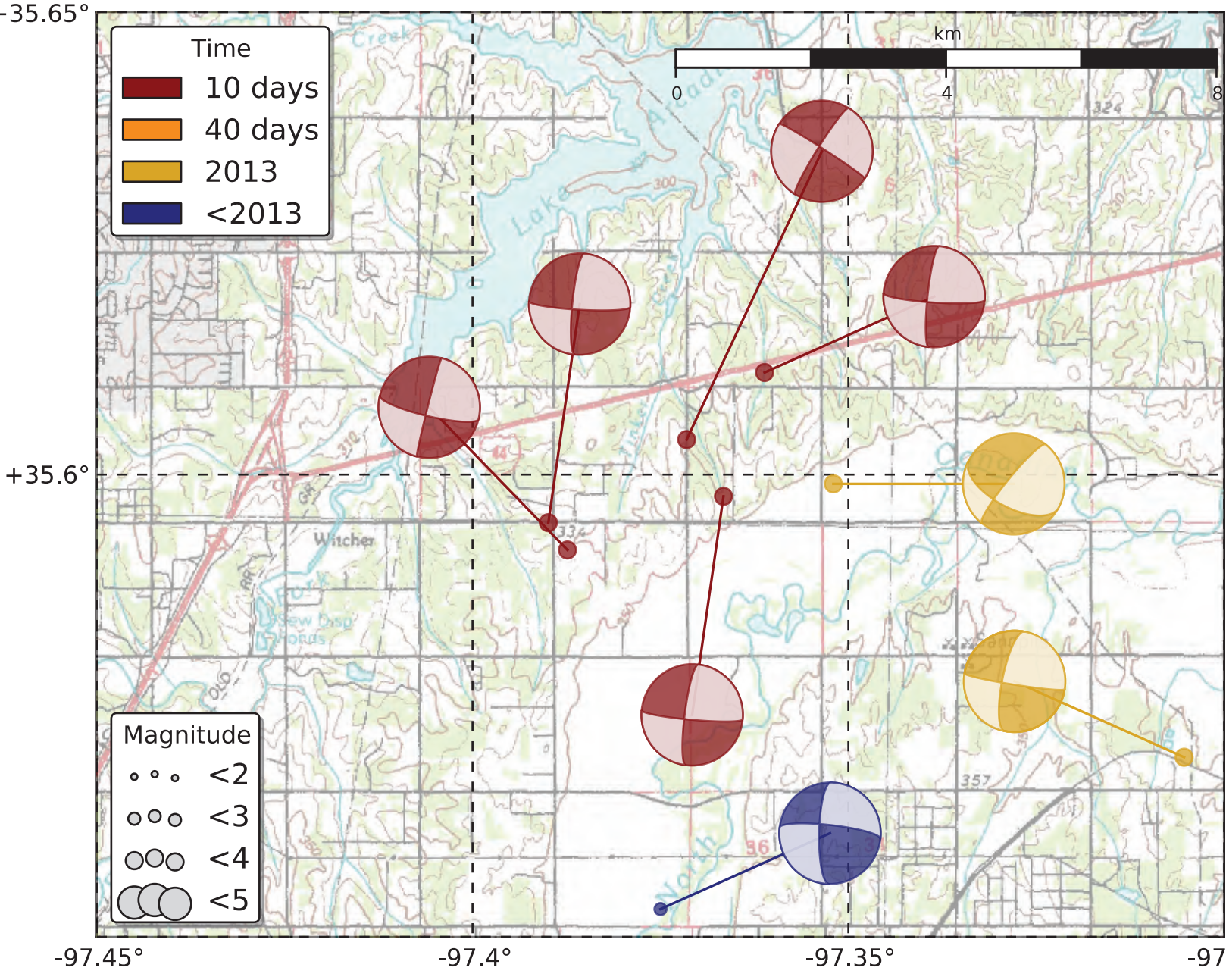
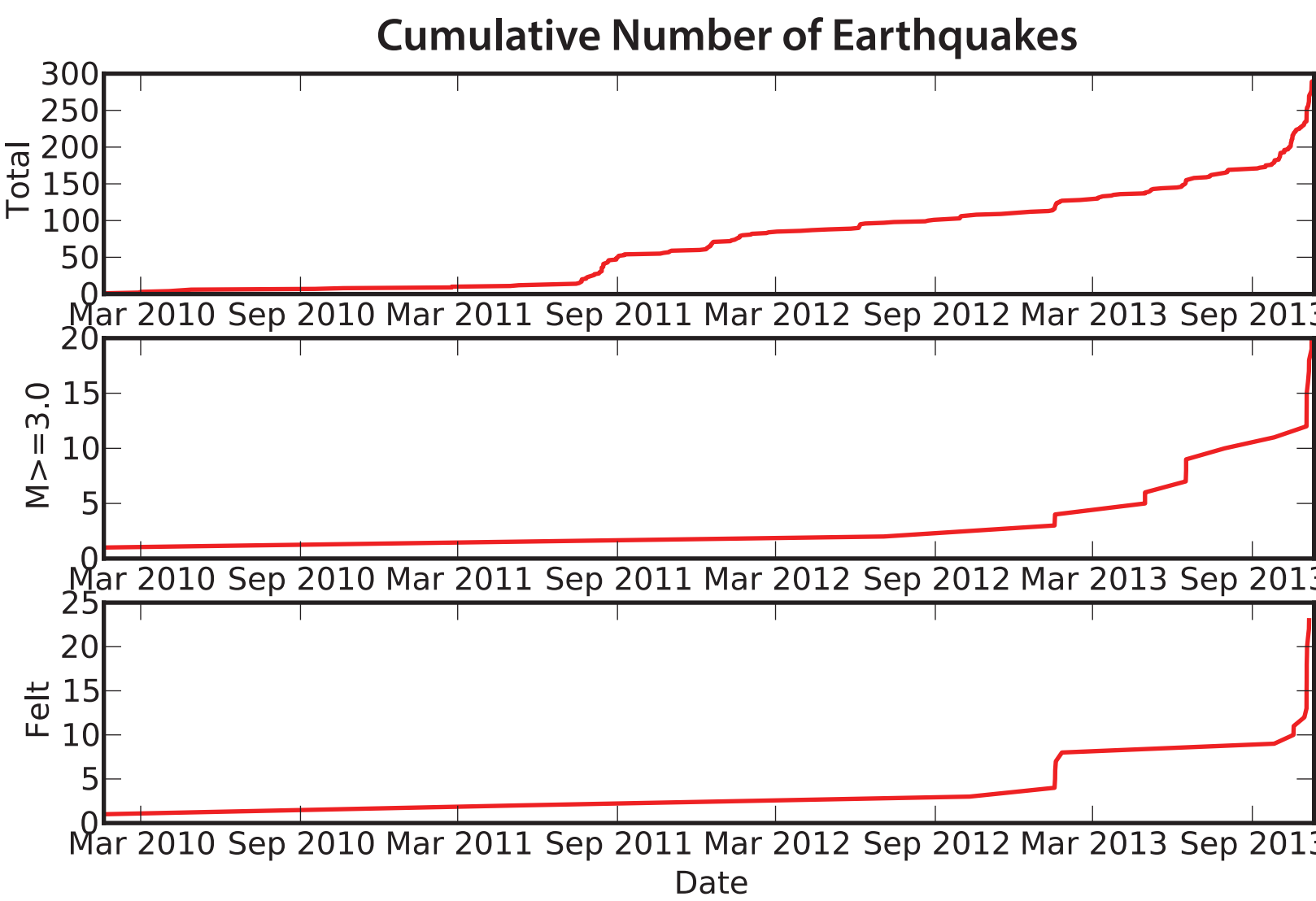


Increased earthquake activity south of Arcadia Lake began in late 2011 and remained fairly constant through time until October 2013. In November 2013, a significant number of magnitude 3 and greater earthquakes began occurring. These earthquakes were felt through significant portions of the northwest Oklahoma City metropolitan area, Edmond, and surrounding areas. The OGS has several seismic stations within the region as well as temporary seismic stations provided by the USGS, these seismic stations provide for good locations and analyses of this earthquake sequence.

It is possible that these earthquakes are a northwest extension of the Jones earthquake swarm. This sequence is quite comparable to previous periods of activity within the Jones earthquake swarm. One such similar period of increased activity was in August and September 2010 which occurred between Jones and Luther, with several magnitude three and greater earthquakes.

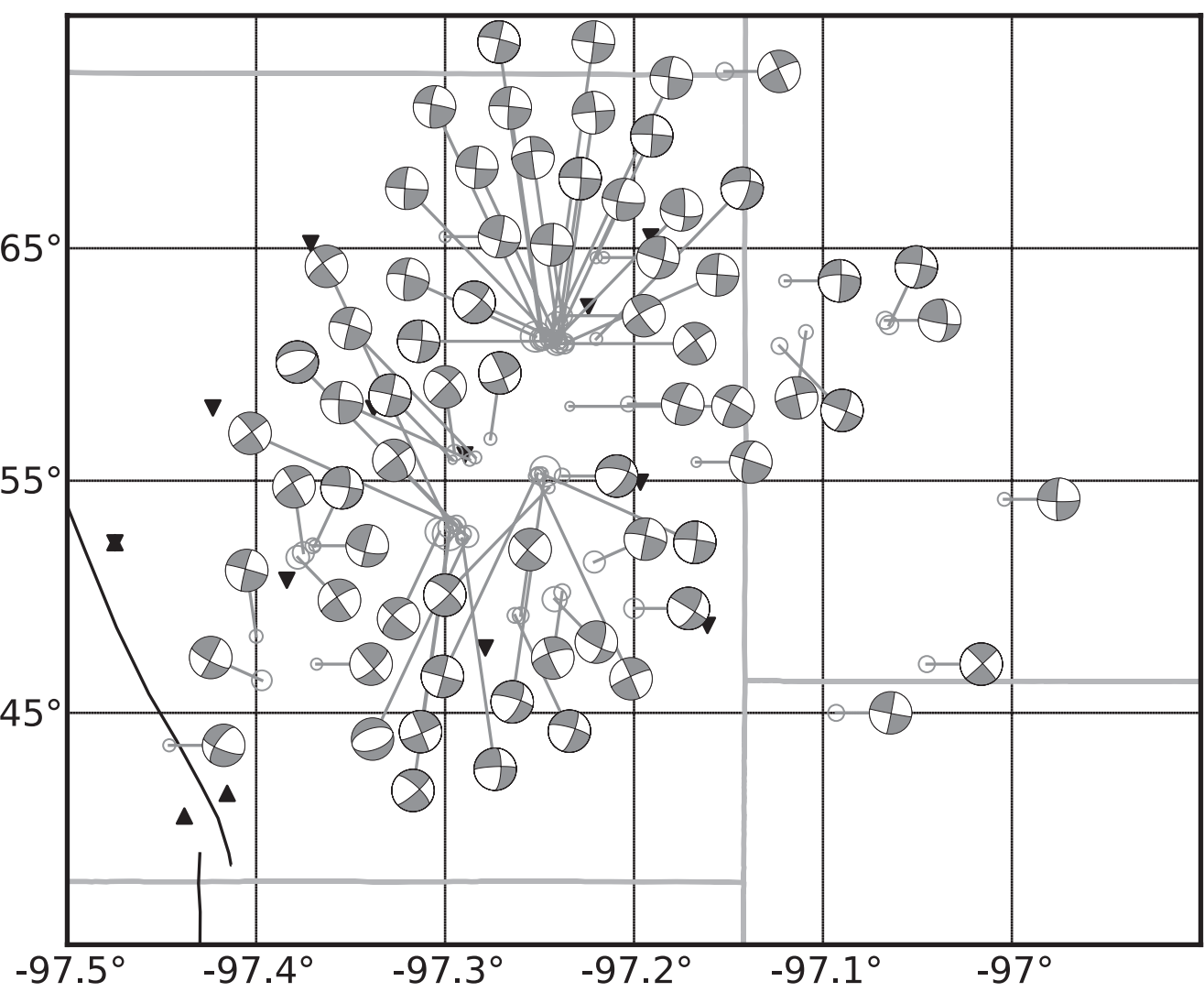
Left) Earthquake locations for the Arcadia Lake earthquake swarm. The time of occurrence is indicated by the color of the circle and the magnitude is indicated by the size of the circle.
Right) Earthquake locations for the Jones earthquake swarm and the Wellston April 2013 earthquake swarm. Faults are shown as solid black lines from OGS Special Publication SP85-2. The Jones earthquake swarm has seen punctuated periods of activity and quiescence with earthquakes slowly occurring at greater distances from Jones over time.

Left) Cumulative number of earthquakes within the area shown in the map above. The slope of these curves represents the rate of earthquakes within the shown map area.
Right) The April 2013 Wellston earthquake swarm stands out as a large jump in the number of magnitude 3 earthquakes that have occurred within eastern Oklahoma County and surrounding areas.

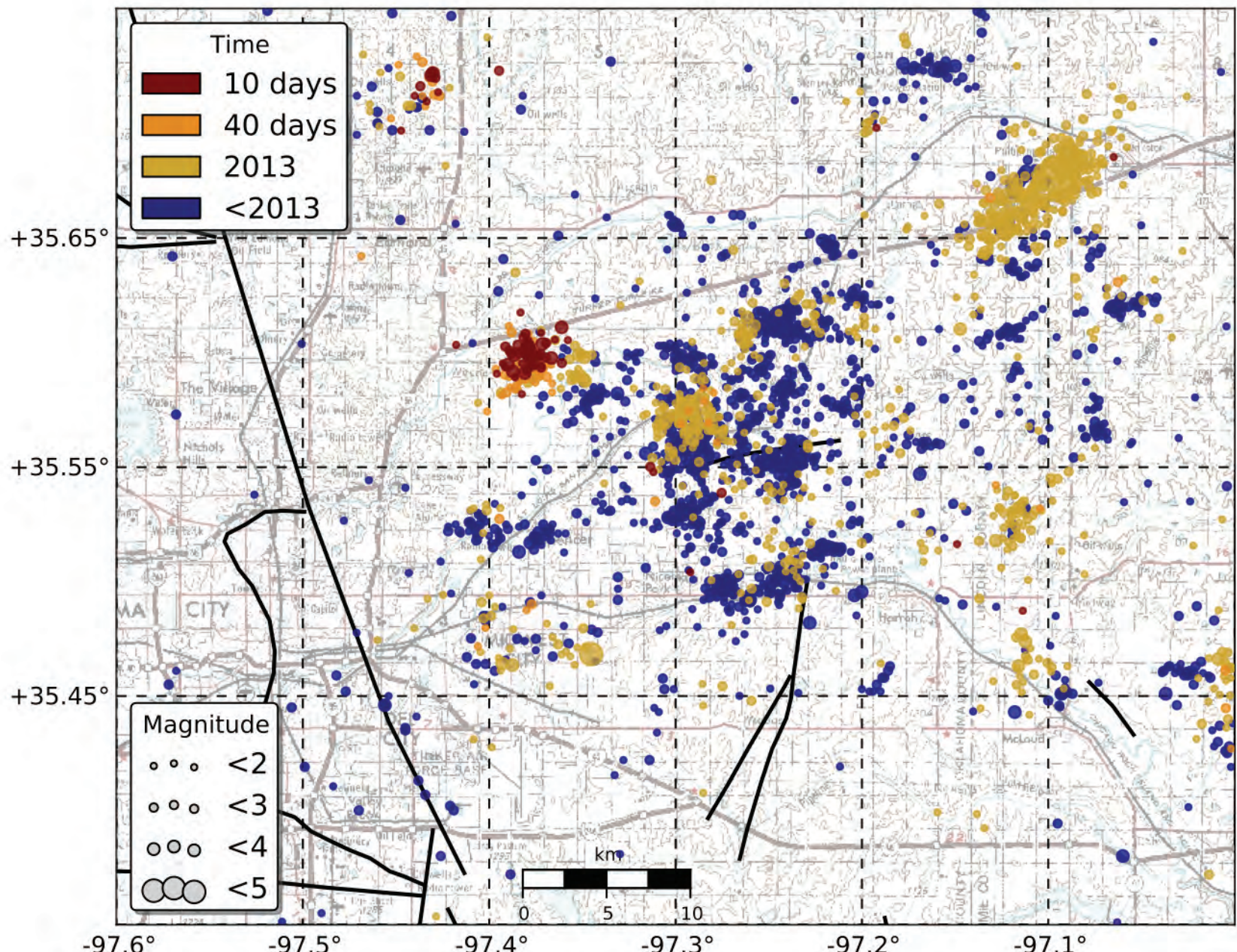


Focal Mechanisms

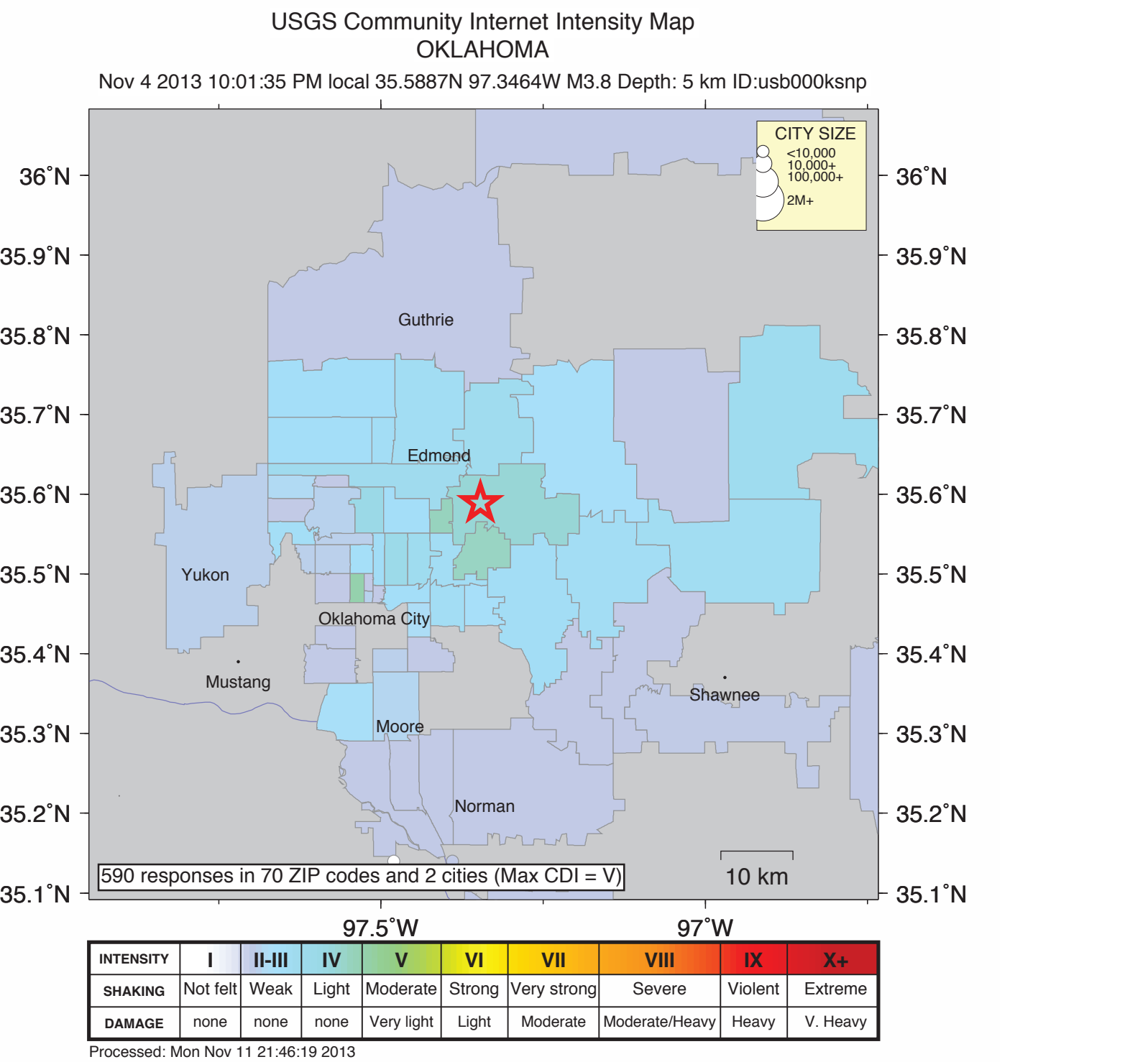
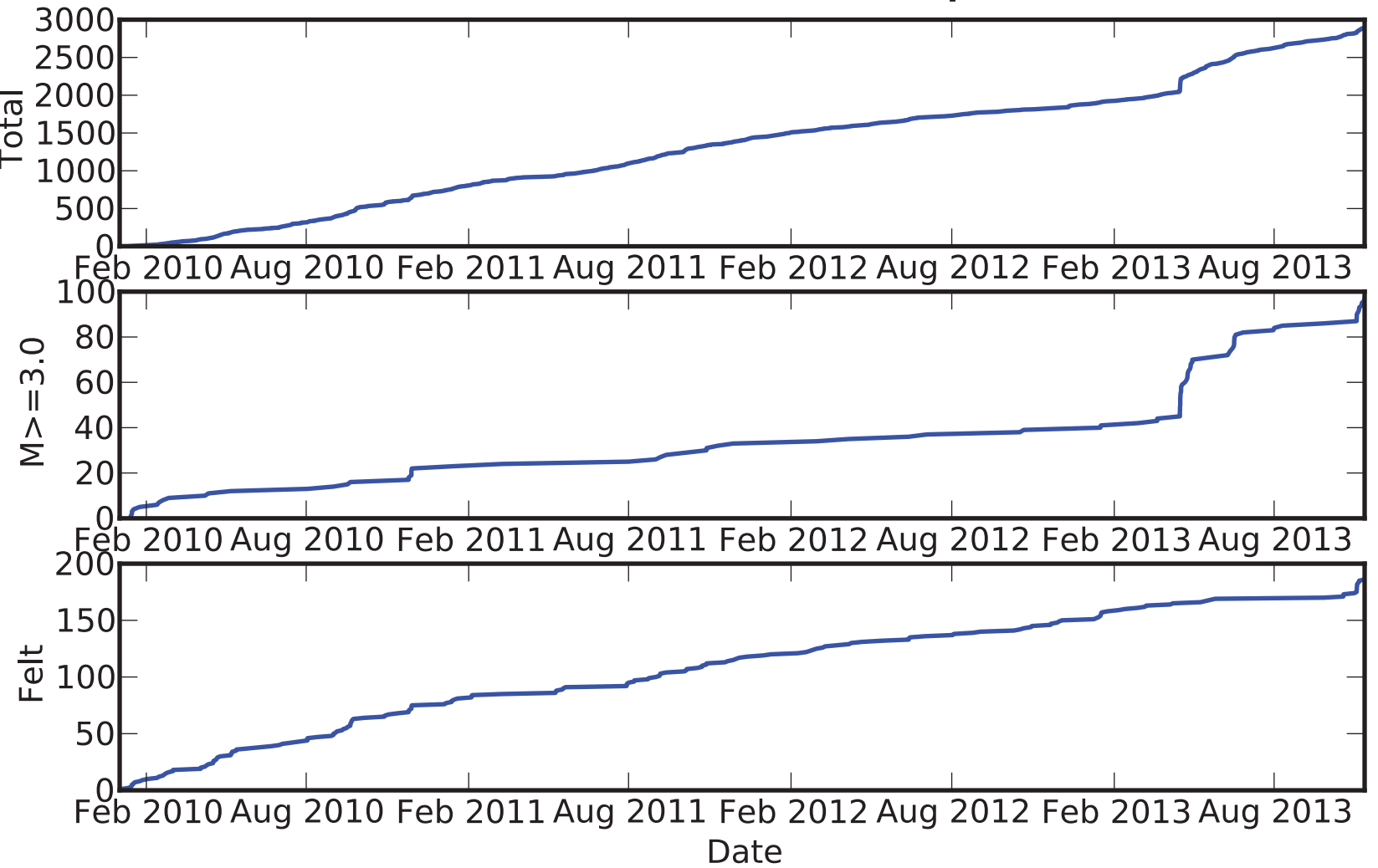
Focal mechanisms represent the possible orientations of faults that may be active for a specific earthquake. The arcs or lines that separate quadrants of the focal sphere represent the two possible orientations of a fault for the earthquake. The fault orientations within the Arcadia Lake swarm (**Left**) are quite similar to orientations observed in the northern parts of the Jones earthquake swarm (**Right**).



Jones/Eastern Oklahoma County Earthquake Swarm

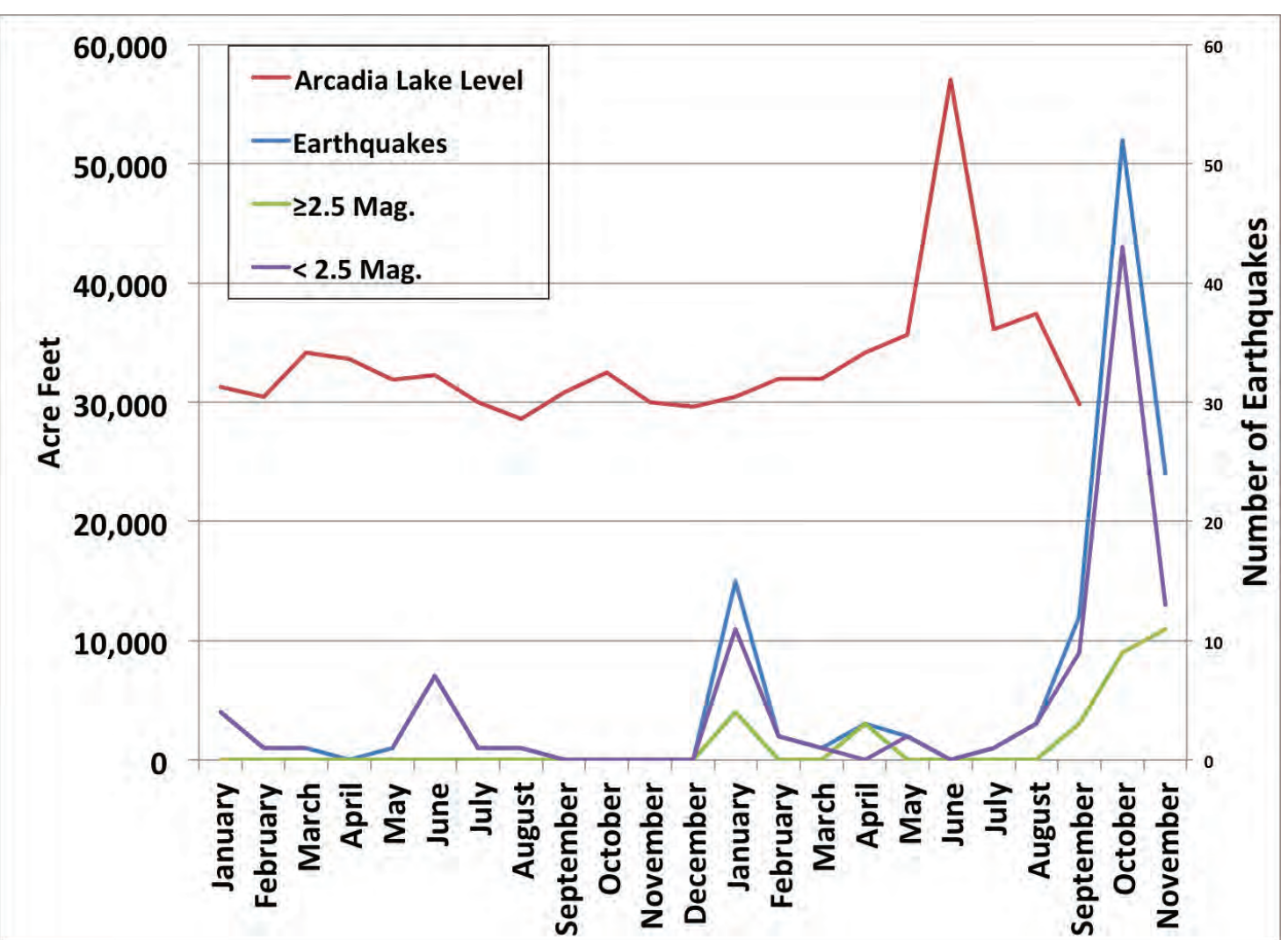


Cumulative Number of Earthquakes



The largest earthquake to occur within the southern Arcadia Lake earthquake swarm was a MW 3.8 or ML 4.0 with a maximum Modified Mercalli Intensity (MMI) of V, which occurred at 10:01 PM (CST), Nov. 4, 2013. The above map is from the USGS “Did you feel it?” community response for the largest earthquake in the sequence. Below is a table of the largest earthquakes to occur in the southern Arcadia Lake earthquake swarm. Origin times are listed in UTC, Central Standard Time (CST) is UTC - 6 hours.

Origin Time (UTC)	Magnitude	Latitude	Longitude	Maximum MMI
2013-11-02 09:36:45.152999	3.7 MW US	35.5977	-97.3666	V
2013-11-02 14:19:01.715000	3.6 MW US	35.6110	-97.3611	IV
2013-11-04 01:52:01.861000	3.3 MW US	35.5990	-97.3863	V
2013-11-05 04:01:34.691000	3.8 MW US	35.6038	-97.3715	V
2013-11-08 05:50:05.468000	3.3 ML OGS	35.5911	-97.3809	V
2013-11-08 05:52:59.439999	3.3 ML OGS	35.5919	-97.3874	IV



Data for Arcadia Lake levels provided to the OGS by the Oklahoma Corporation Commission.

When earthquake swarms occur in new areas there is always a question as to what caused the earthquakes. It is well accepted that ultimately the earthquakes are due to the natural accumulation of stress or pressure on faults. Sometimes external factors such as human activities or hydrologic loads can slightly alter pressures or stresses deep within the Earth and trigger earthquakes. There are no salt-water disposal wells within several miles of these earthquakes suggesting triggered earthquakes from disposal wells to be unlikely. There were no hydraulic fracturing operations in the area indicating that hydraulic fracturing is not a possible cause for these earthquakes as well. The correlation between lake levels at Arcadia Lake and this earthquake swarm is interesting and requires further investigation. Earthquakes can be caused by high lake levels or rapidly changing lake levels, and there often time-delays between these surface observations and earthquakes occurring at depth.