

Regional Trends and Local Seismicity Near CSTS Member Wells



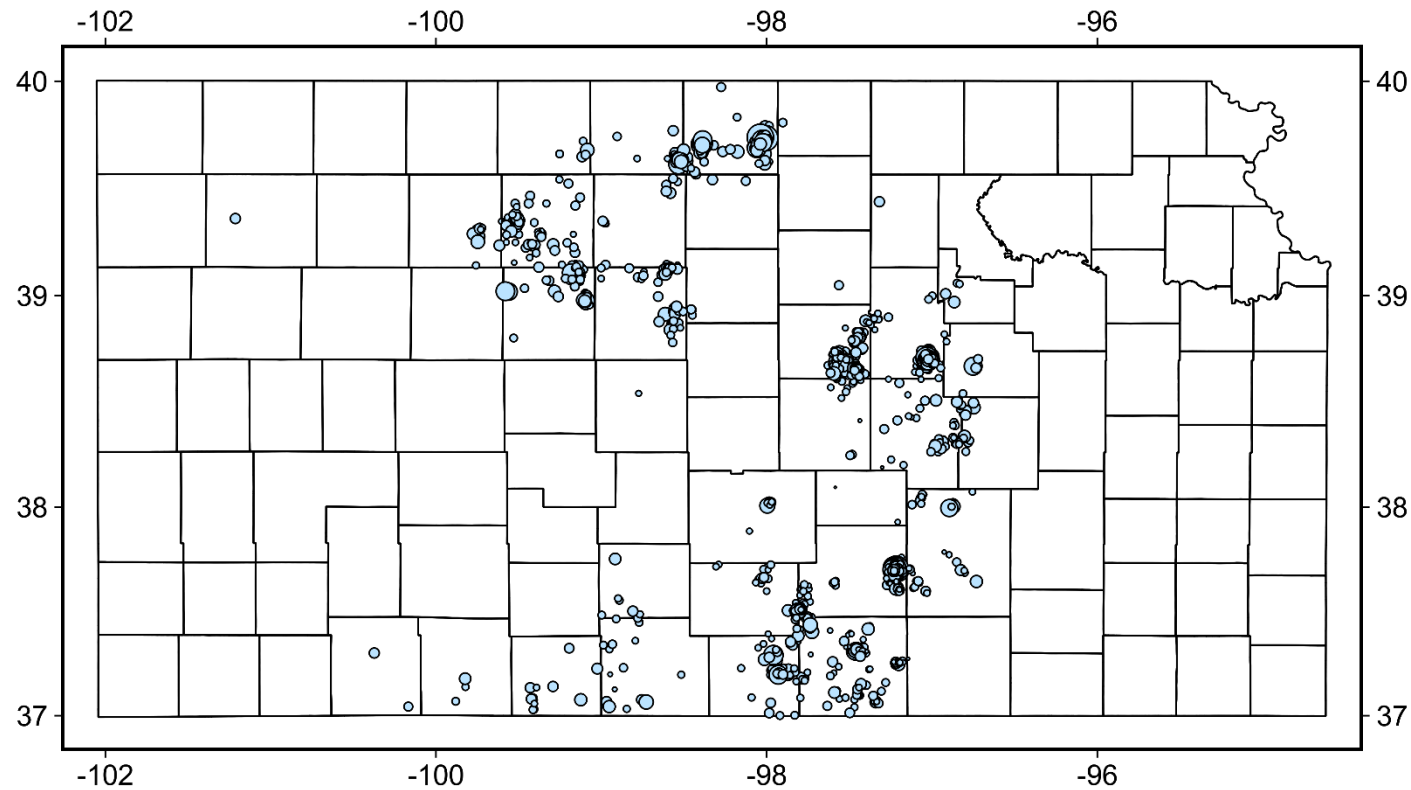
Shelby Peterie, Rick Miller, Juliana Gonzales, Carl Gonzales, Erik Knippel
Kansas Geological Survey

Fourth Annual CSTS Meeting
August 5, 2021
McPherson, KS



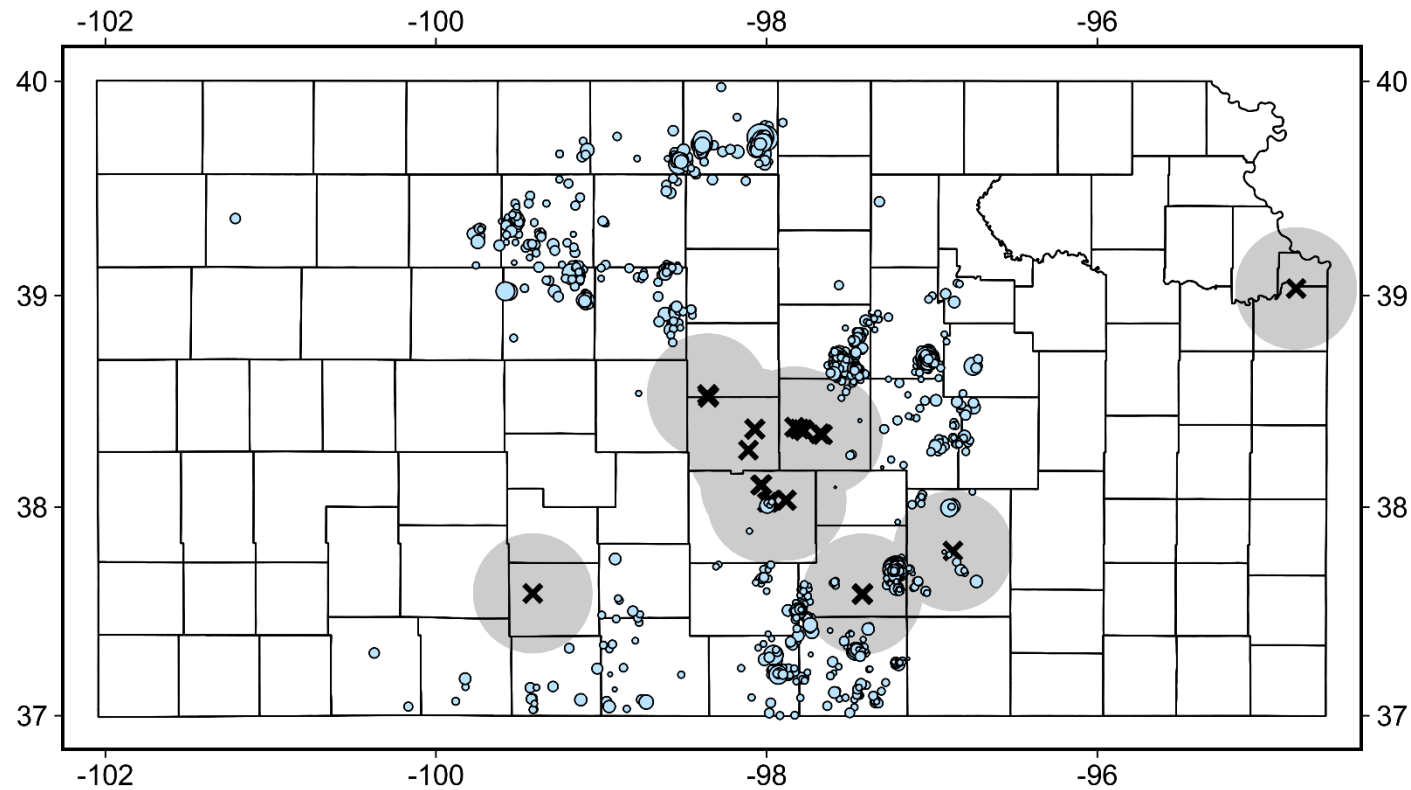
Statewide Overview

2020-2021 earthquakes

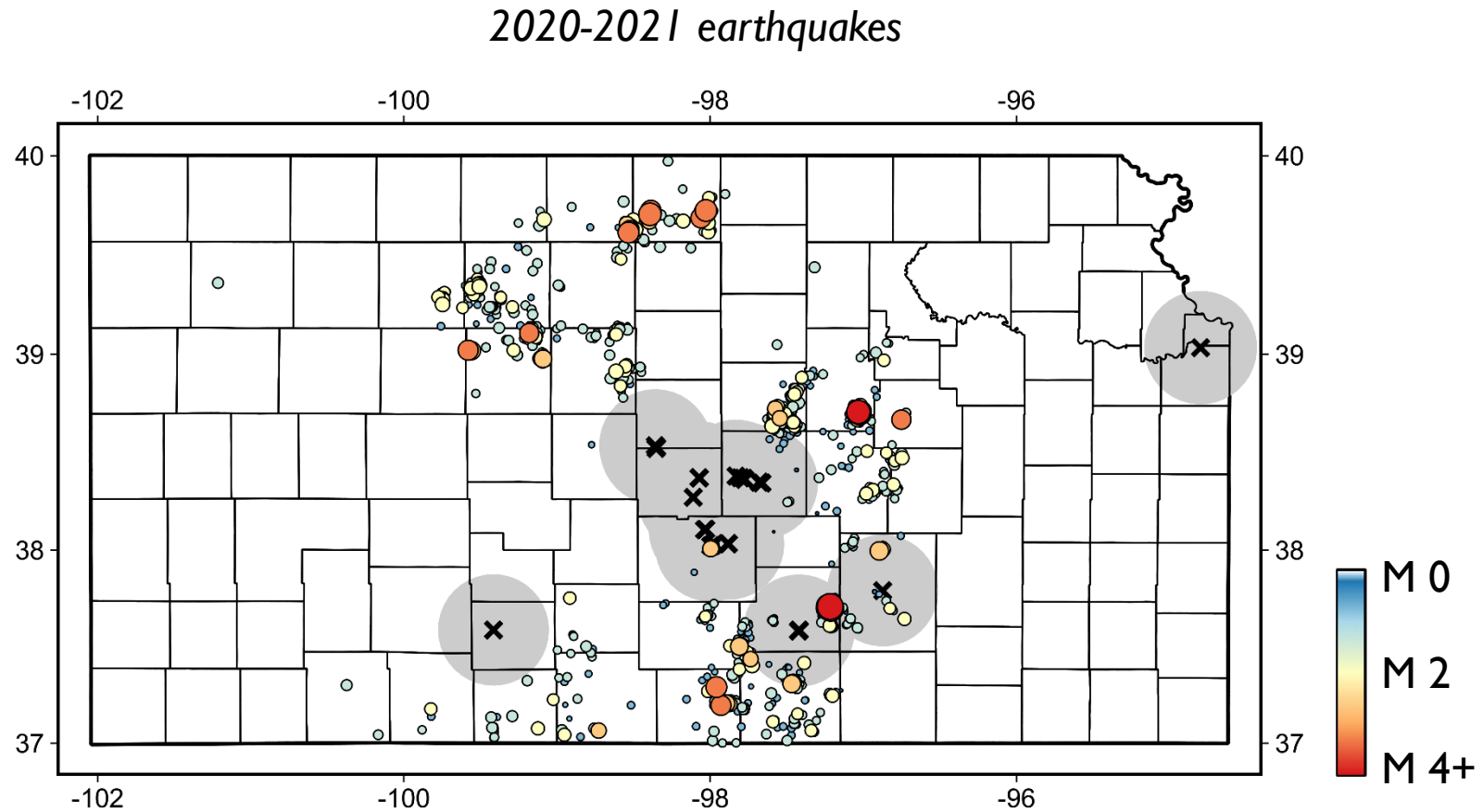


Statewide Overview

2020-2021 earthquakes

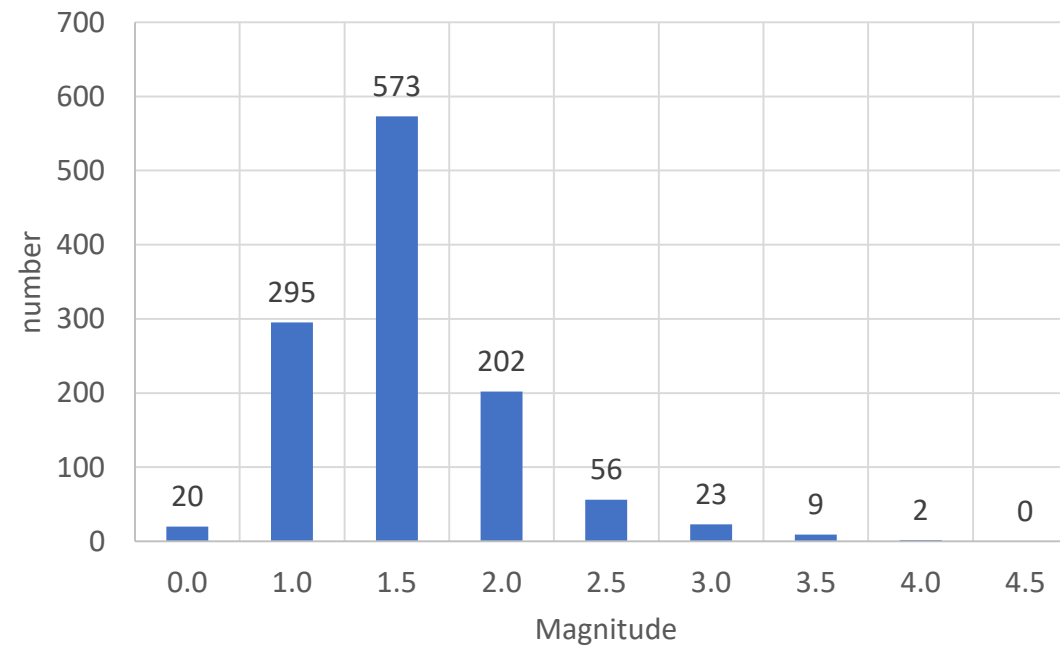


Statewide Overview



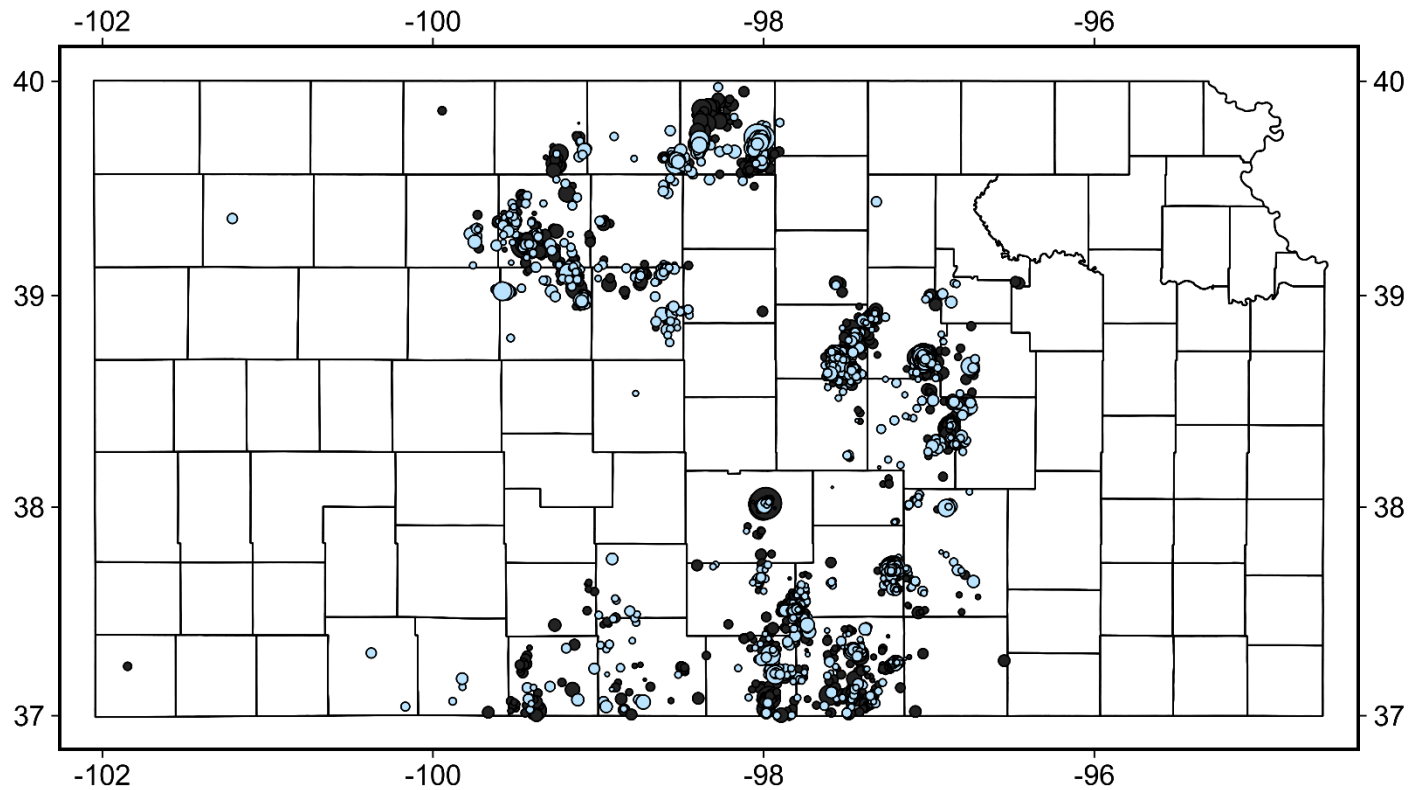
Magnitude Distribution

1180 total



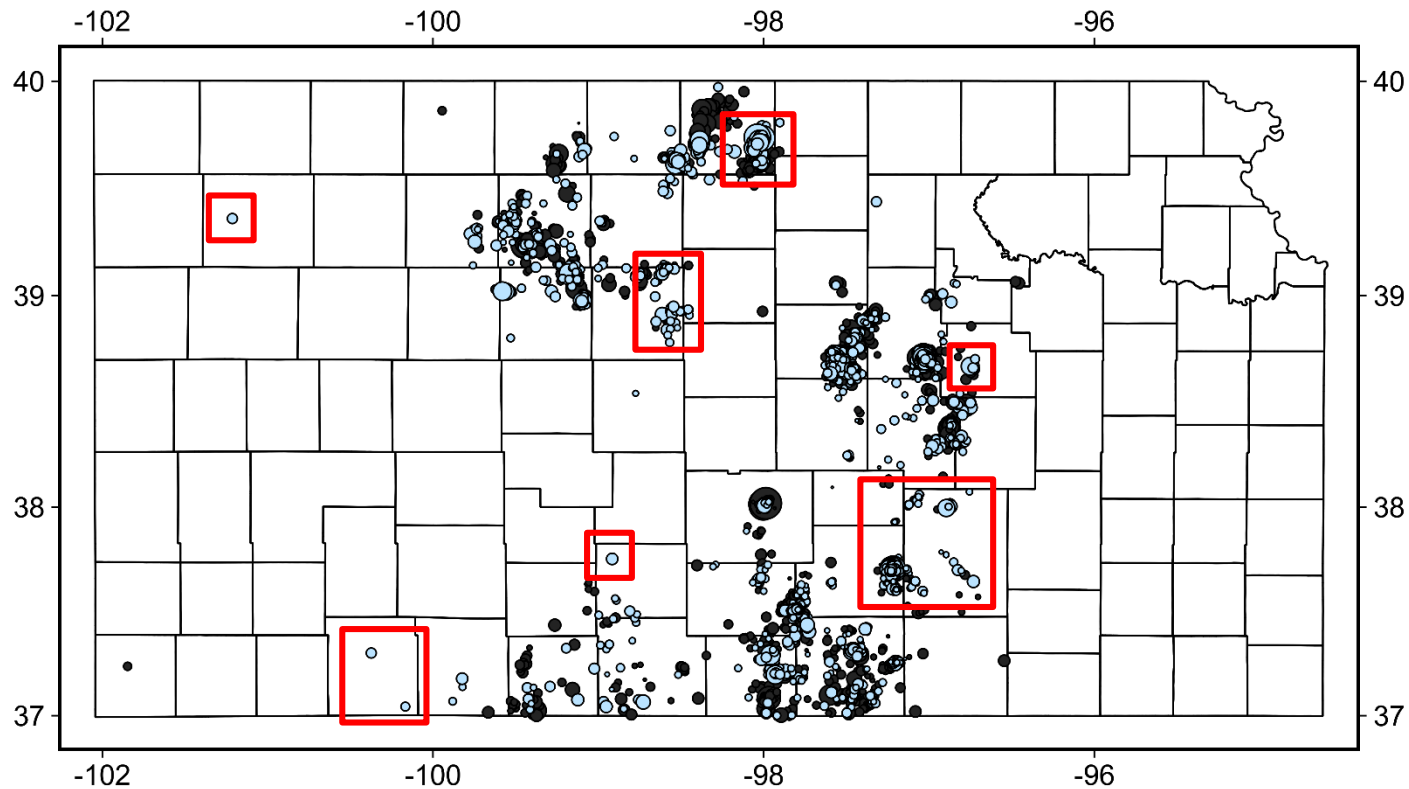
Comparison with 2019

● 2019-2020 earthquakes (1566) ○ 2020-2021 earthquakes (1180)



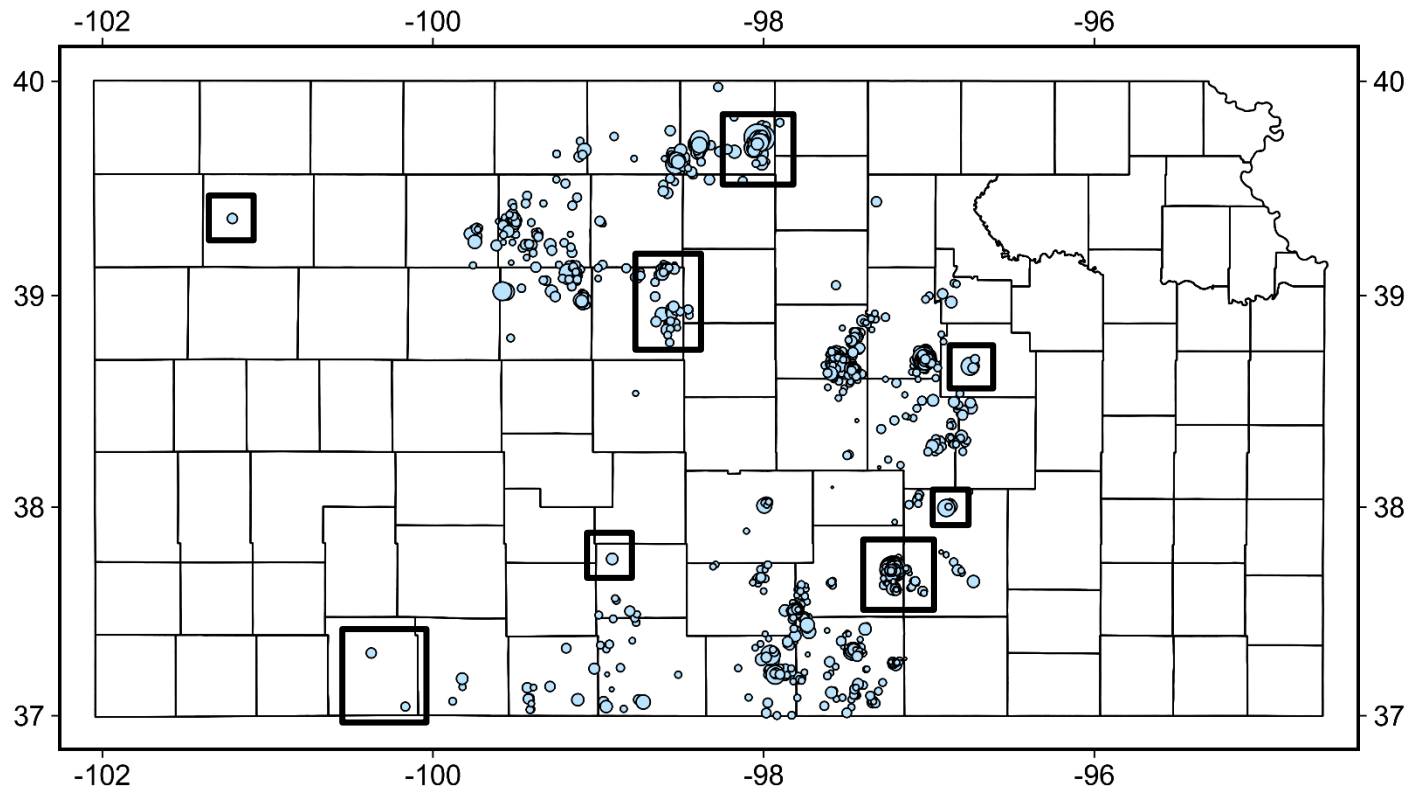
Notable Observations

● 2019-2020 earthquakes (1566) ○ 2020-2021 earthquakes (1180)



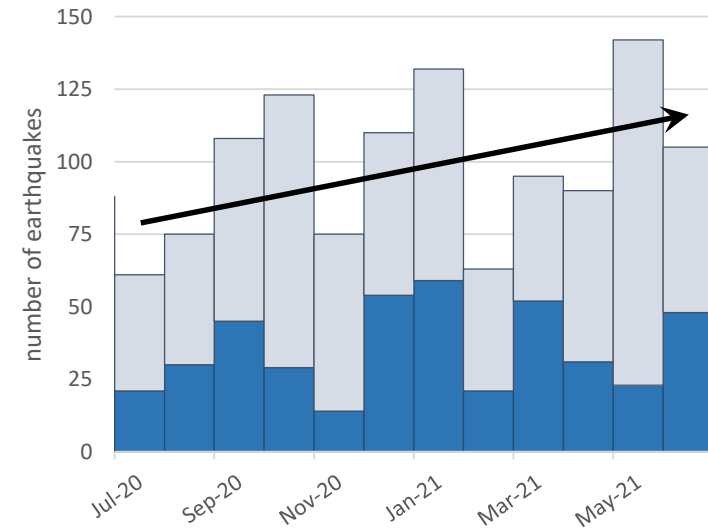
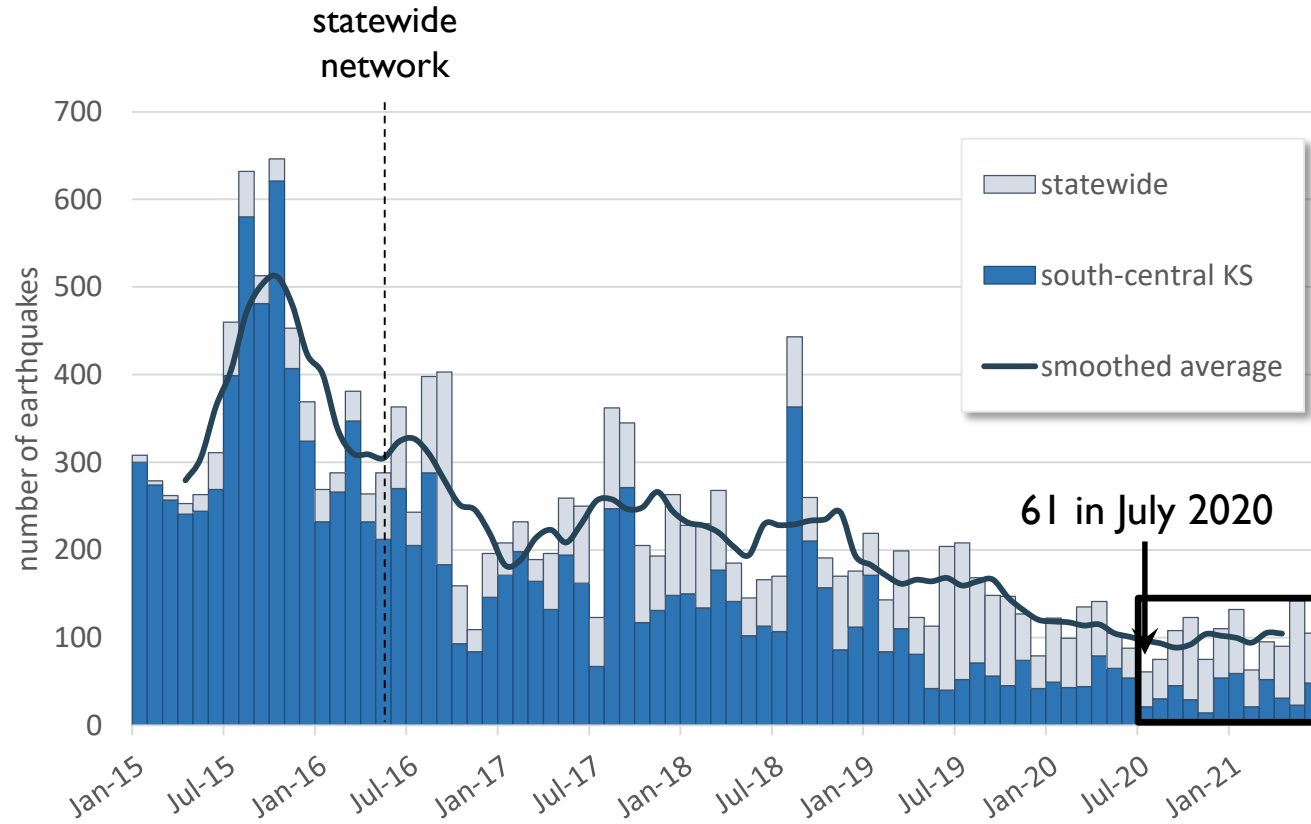
- First earthquake in TH
 - M 2.0 on Nov 28, 2020
- Increase in RS seismicity
- Largest events recorded in...
 - JW: M 4.2 and 4.1
 - MR: M 3.1
 - BU: M 3.0
 - PR: M 2.2
 - ME: 2.0
- 12 M 3+ in Wichita

Notable Observations

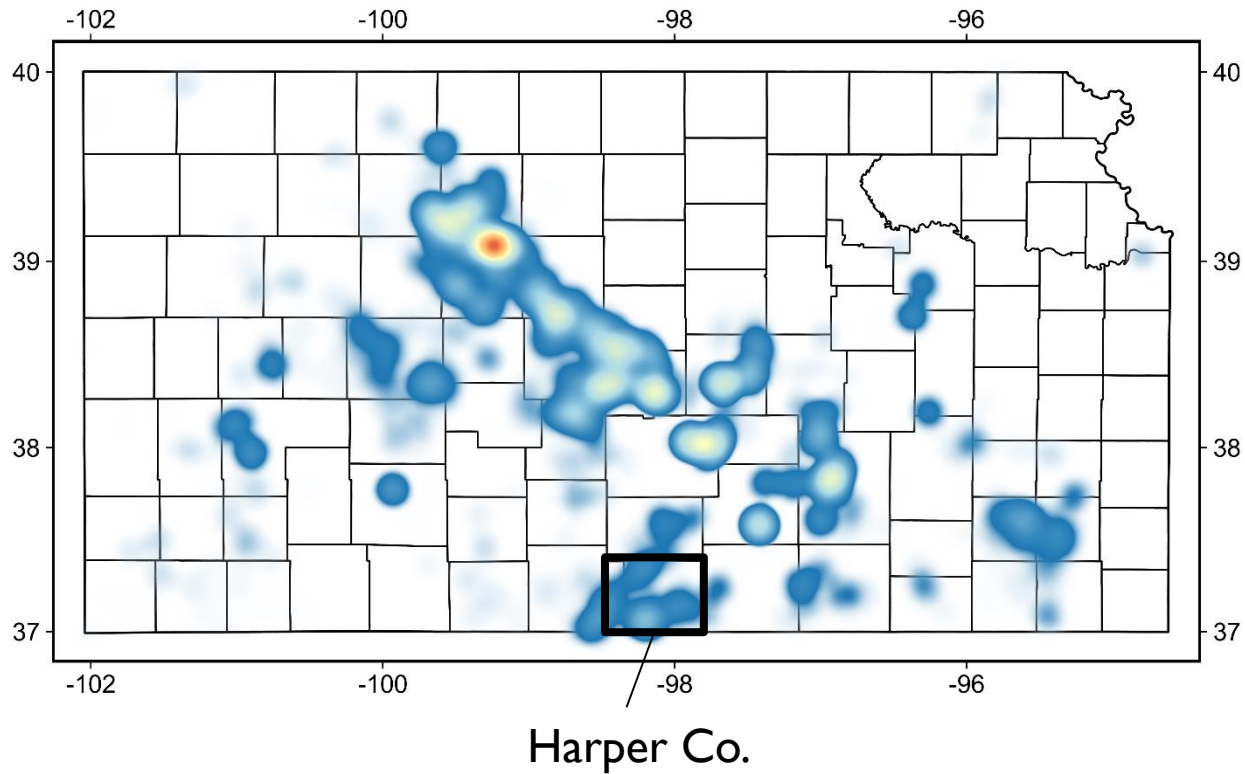


- First earthquake in TH
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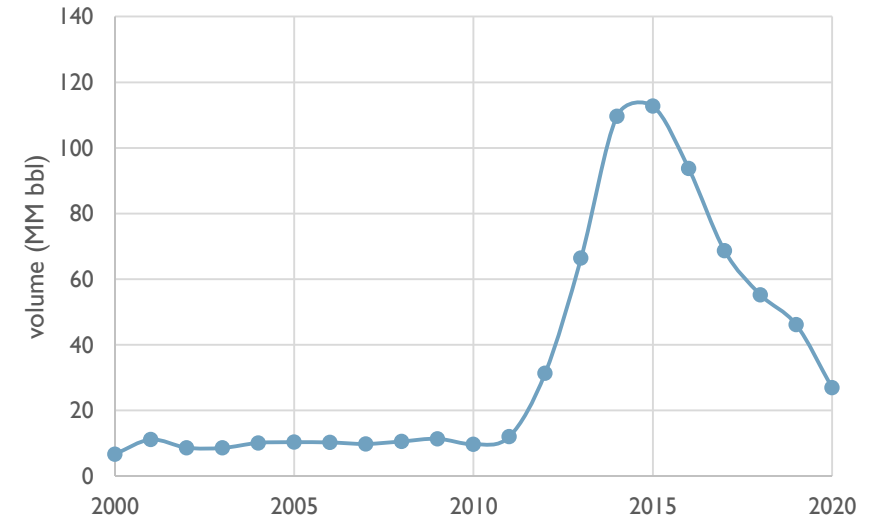
Monthly Earthquakes



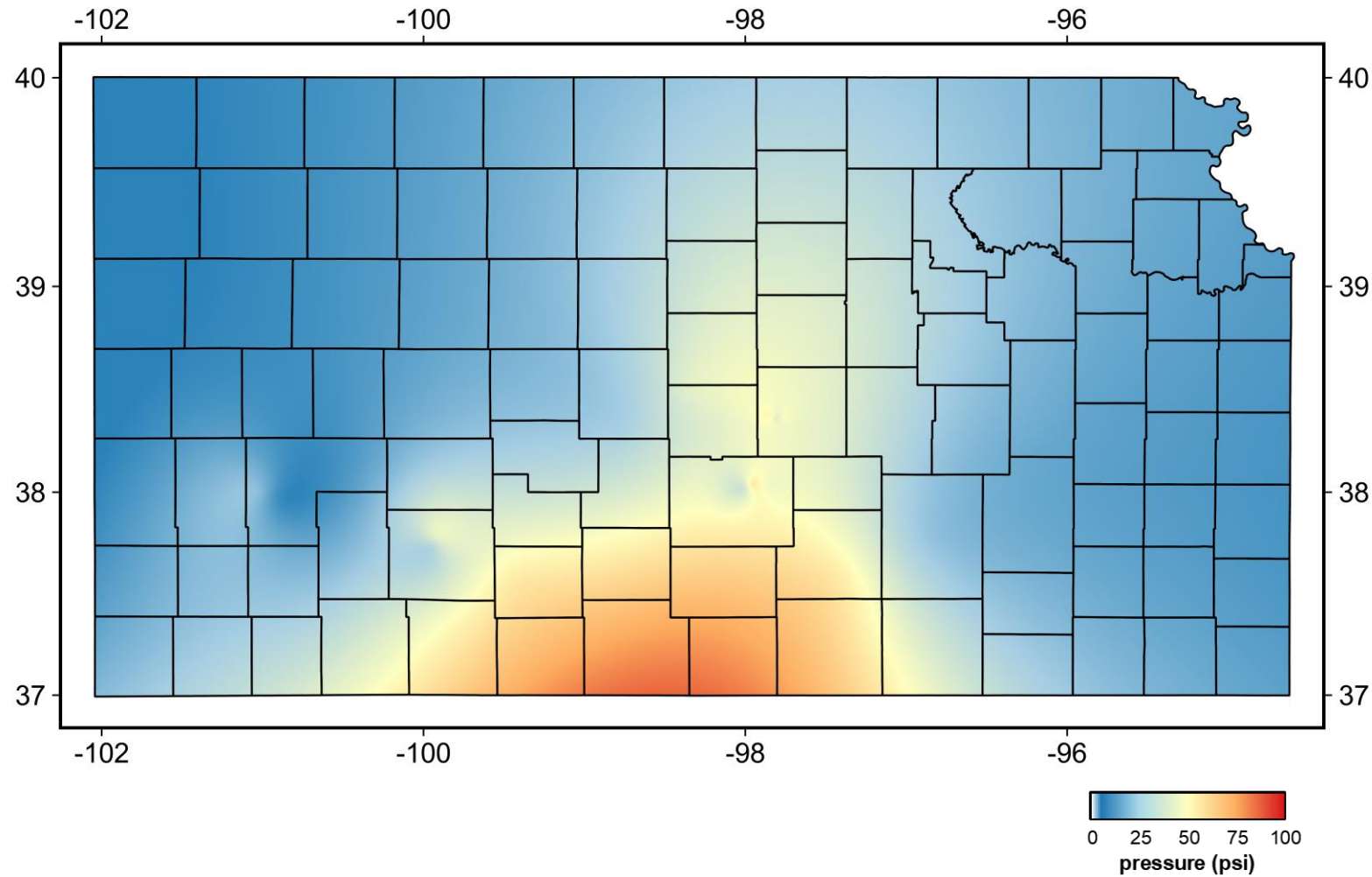
2020 Disposal Volumes



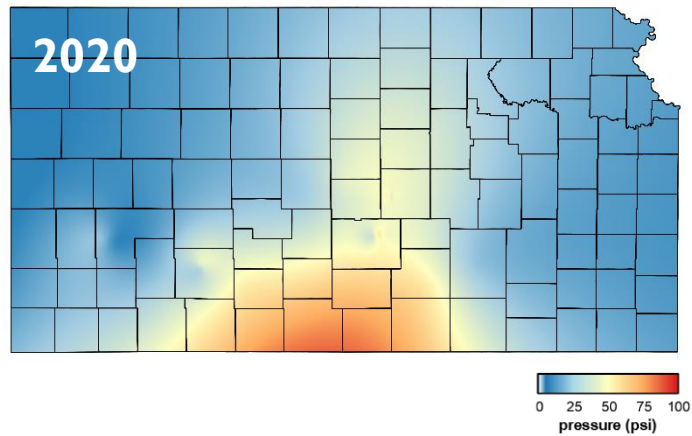
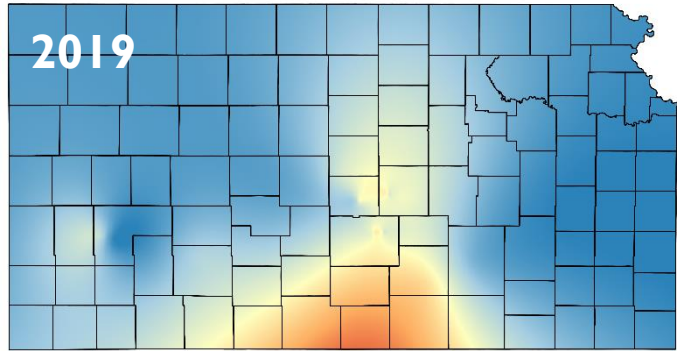
HP Annual Disposal



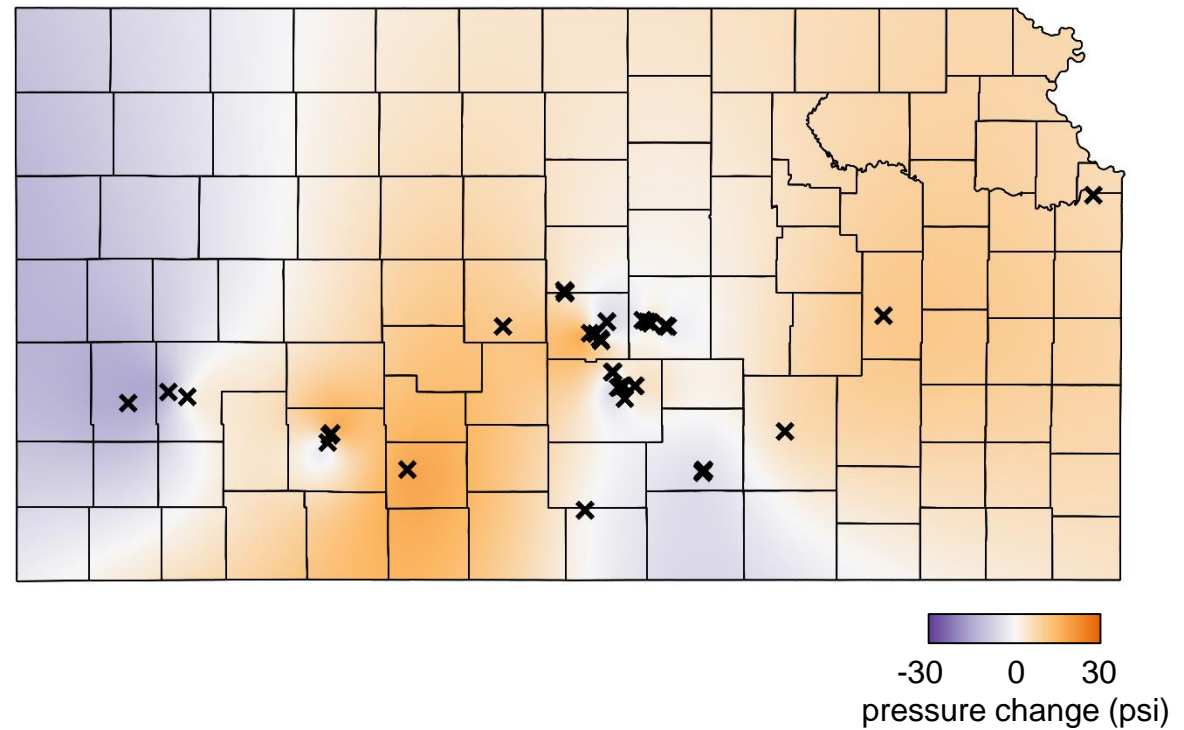
2020 Formation Pressure



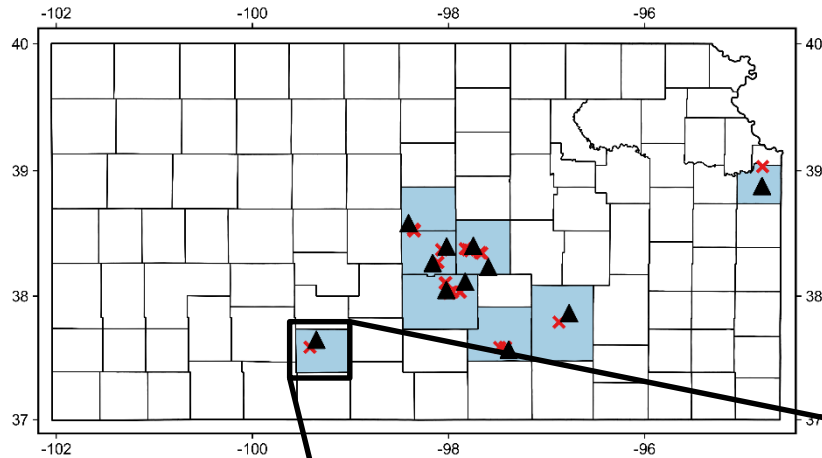
Formation Pressure Change



pressure change 2019 to 2020



Kiowa County

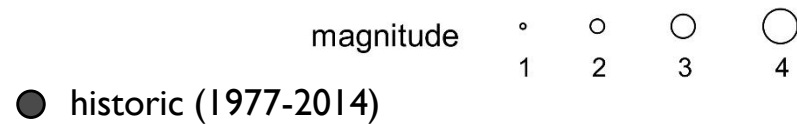
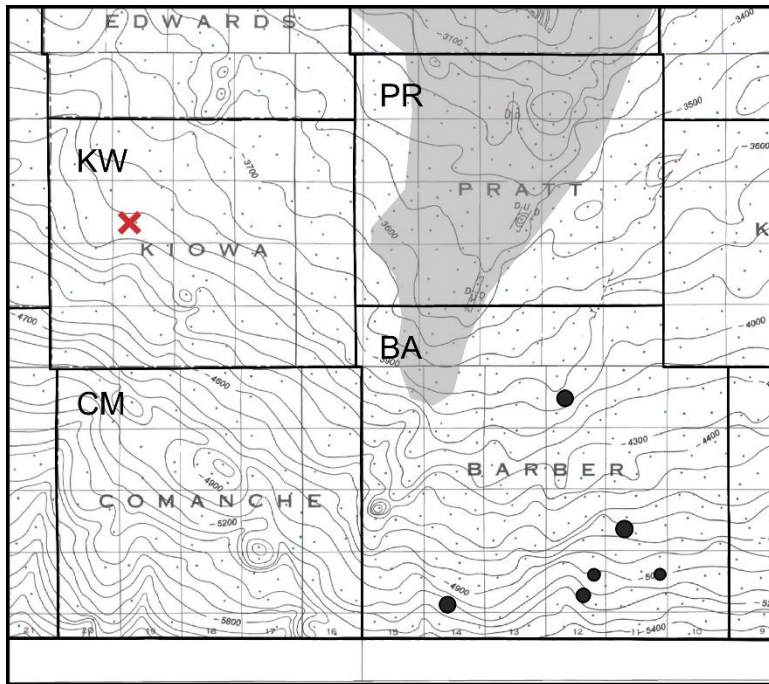


- KW02
 - north central KW
 - pasture
 - Greensburg



Kiowa County

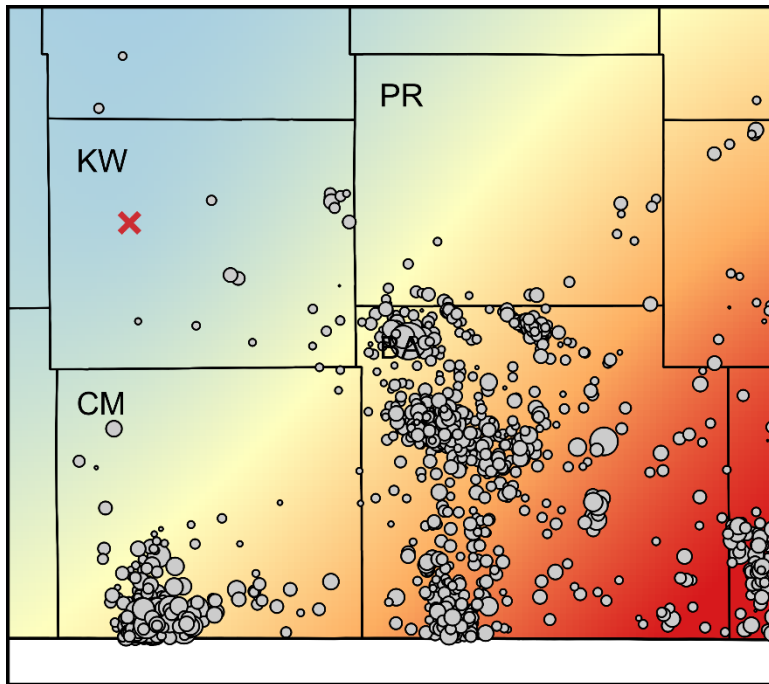
Arbuckle Group pressure



- Central Kansas Uplift
 - southwest margin
 - west of Pratt Anticline
- Mapped faults
 - None
- Historic earthquakes
 - None
 - Sparse recent seismicity
 - influenced by pore pressure

Kiowa County

Arbuckle Group pressure

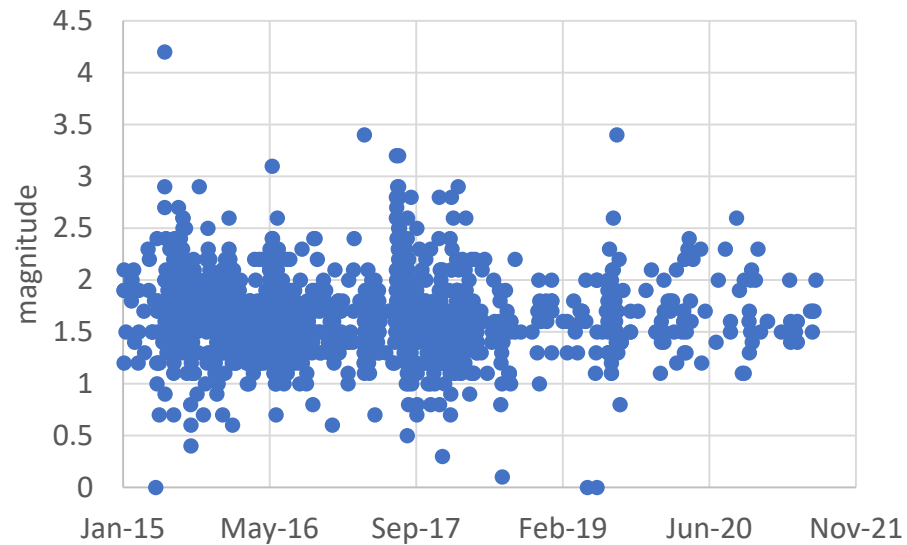


magnitude • ○ ○ ○
 1 2 3 4

- historic (1977-2014)
- KGS network (2015-2018)

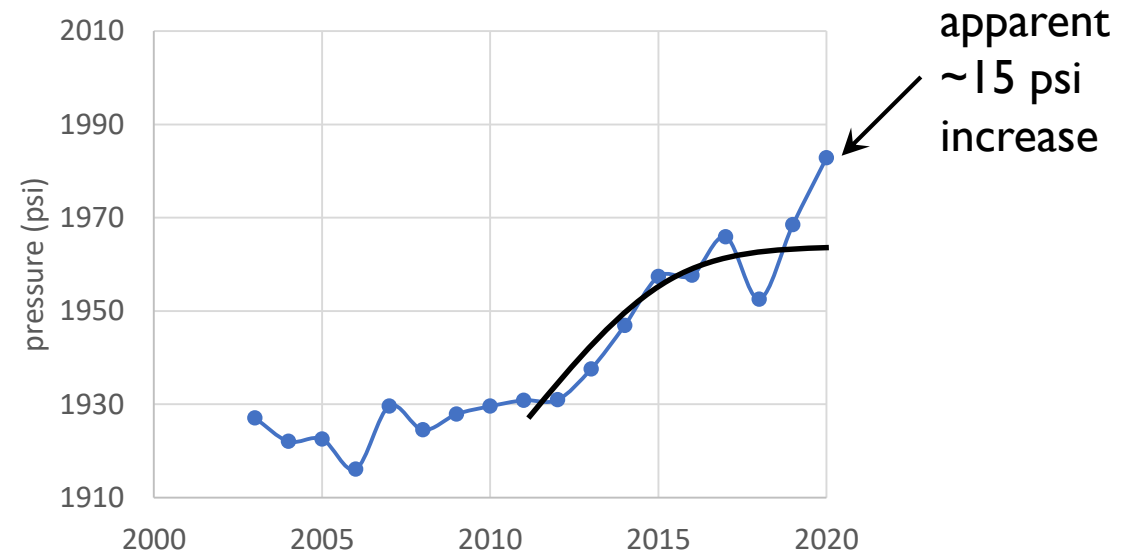
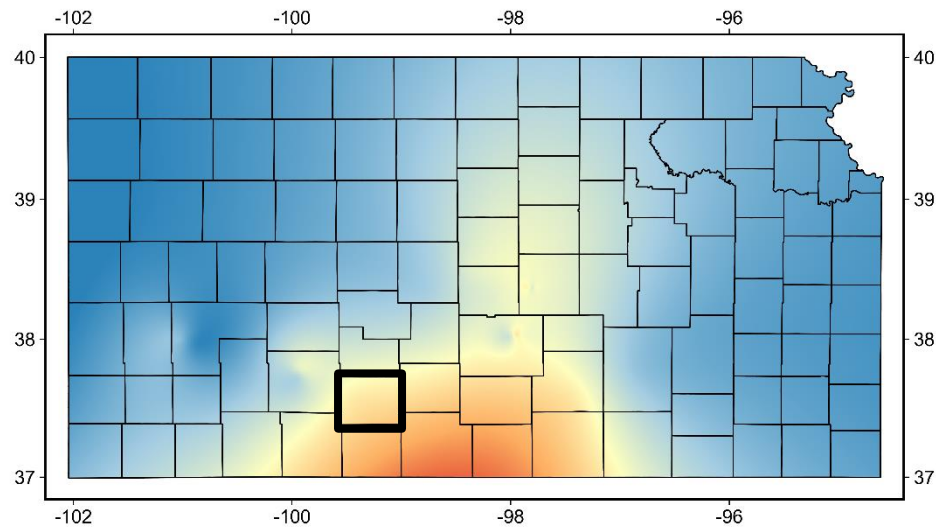
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Kiowa County

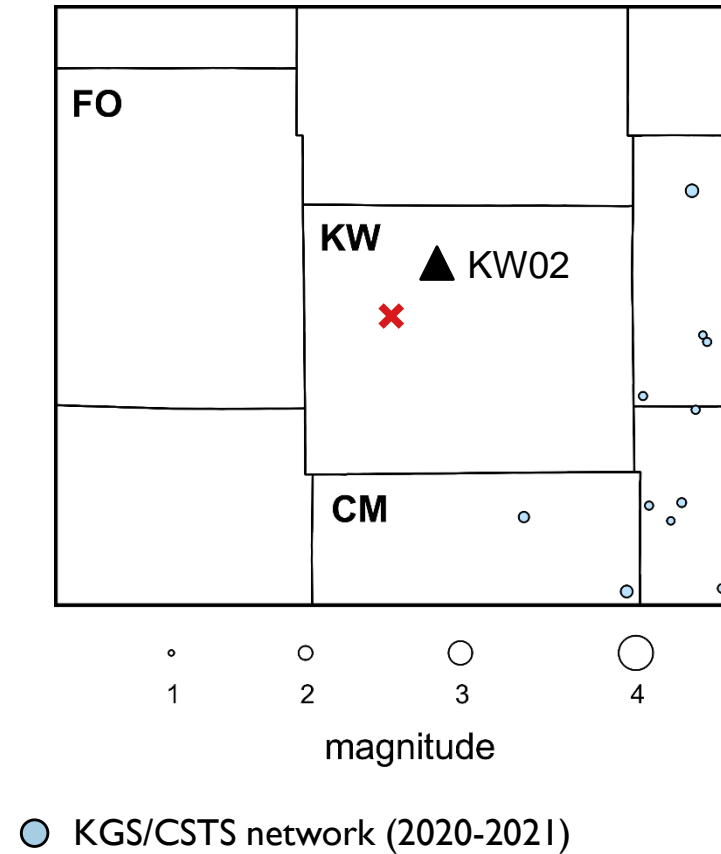


- Central Kansas Uplift
 - southwest margin
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Kiowa County

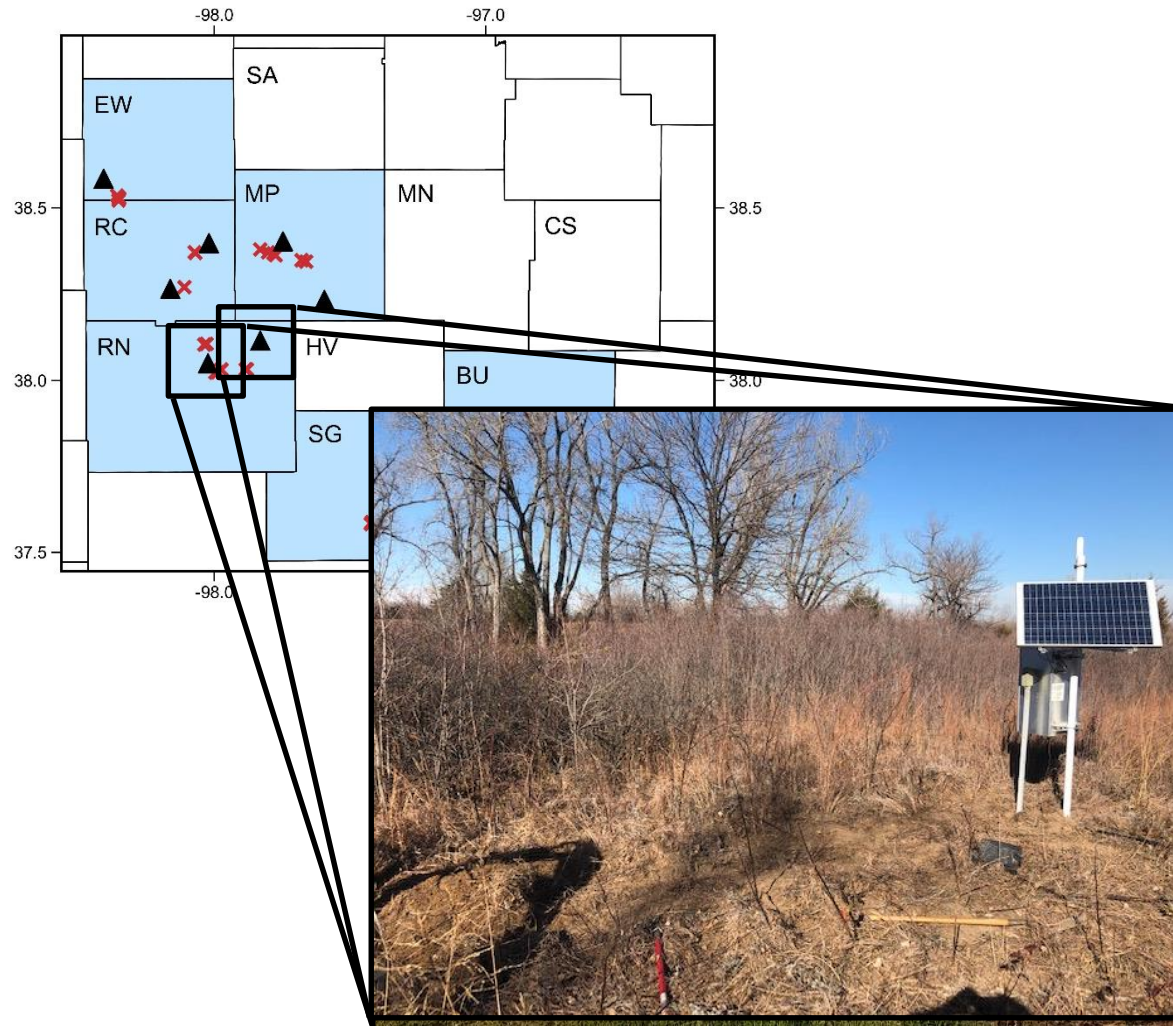


Kiowa County



- Local Earthquakes (<20 mi)
 - None
 - Pratt M 2.0 ~30 miles
- Subnetwork events
 - None
- Consistent with previous year

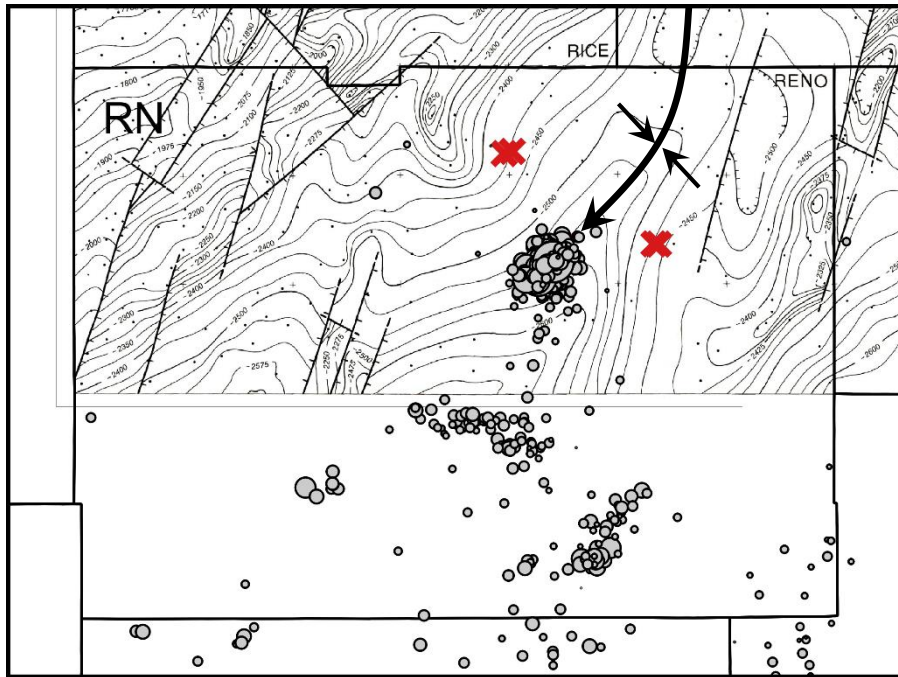
Reno County



- RN01
 - west of Hutchinson
 - cemetery
- RN03
 - pasture
 - Sand Hills State Park

Reno County

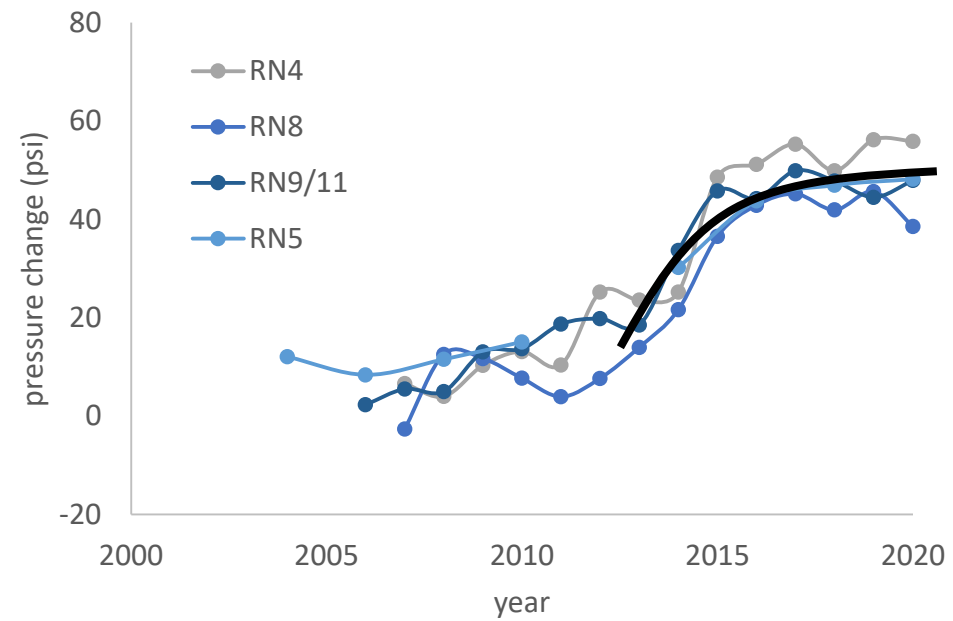
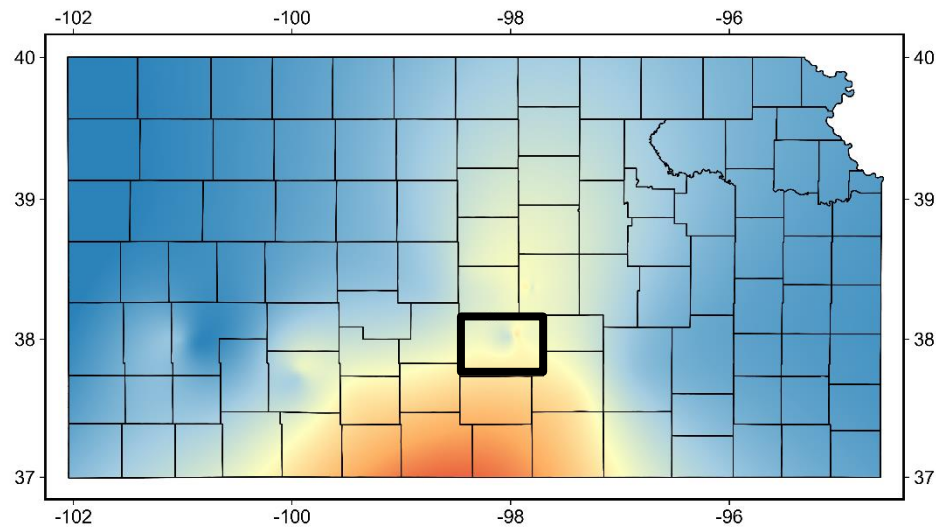
Conway Syncline



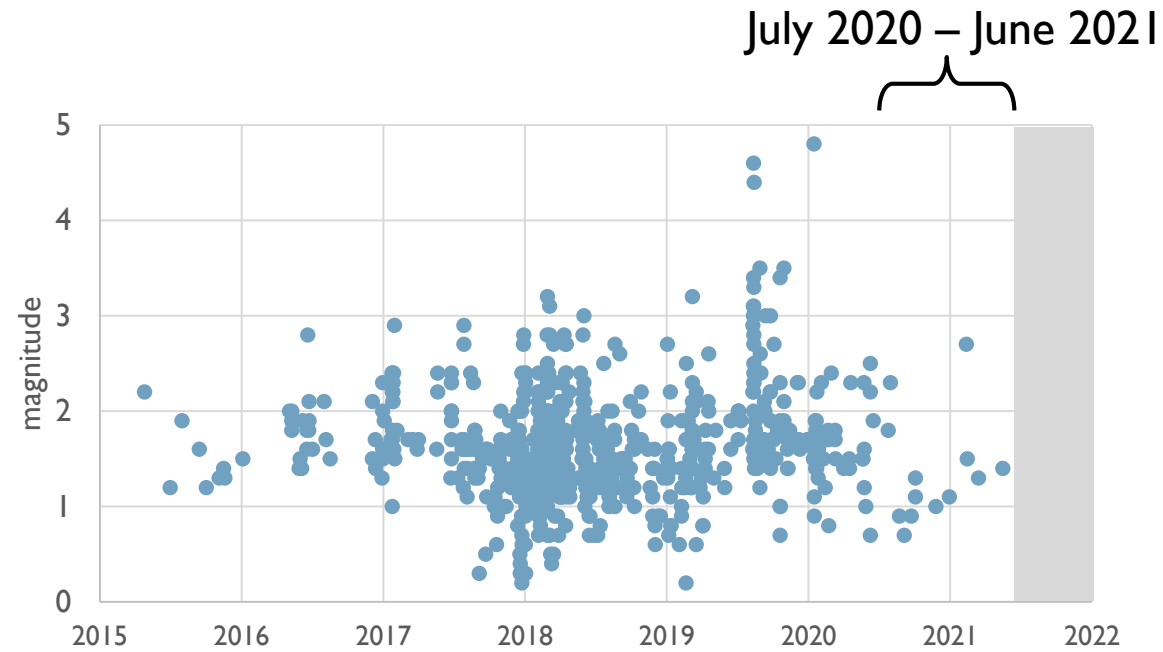
○ KGS network (2015-2020)

- Geologic Setting
 - CKU and MRS
 - structural low
 - Conway Syncline
 - faults bounding uplifted areas
- Historic earthquakes
 - None (M 3+)
 - Recent seismicity (2015-present)
 - progressed north
 - structural low

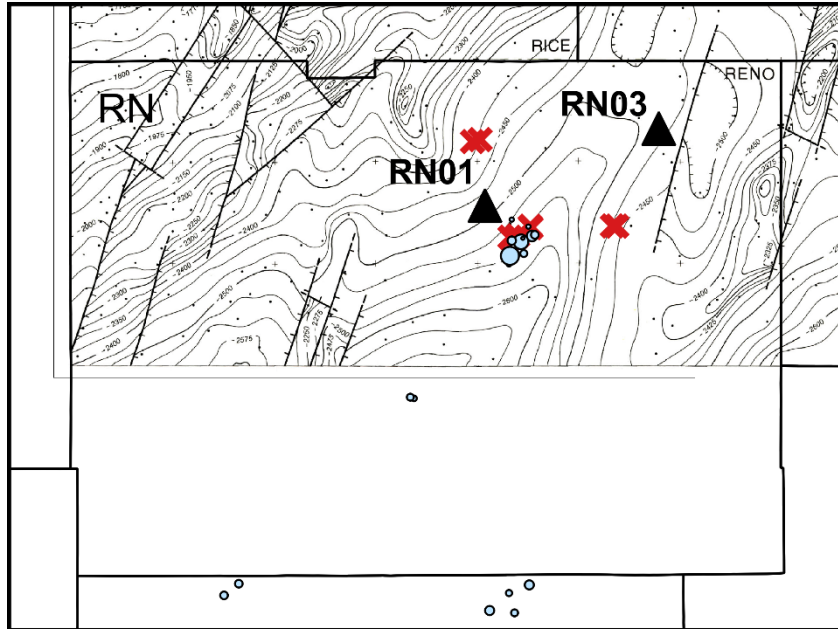
Reno County



Reno County



Reno County

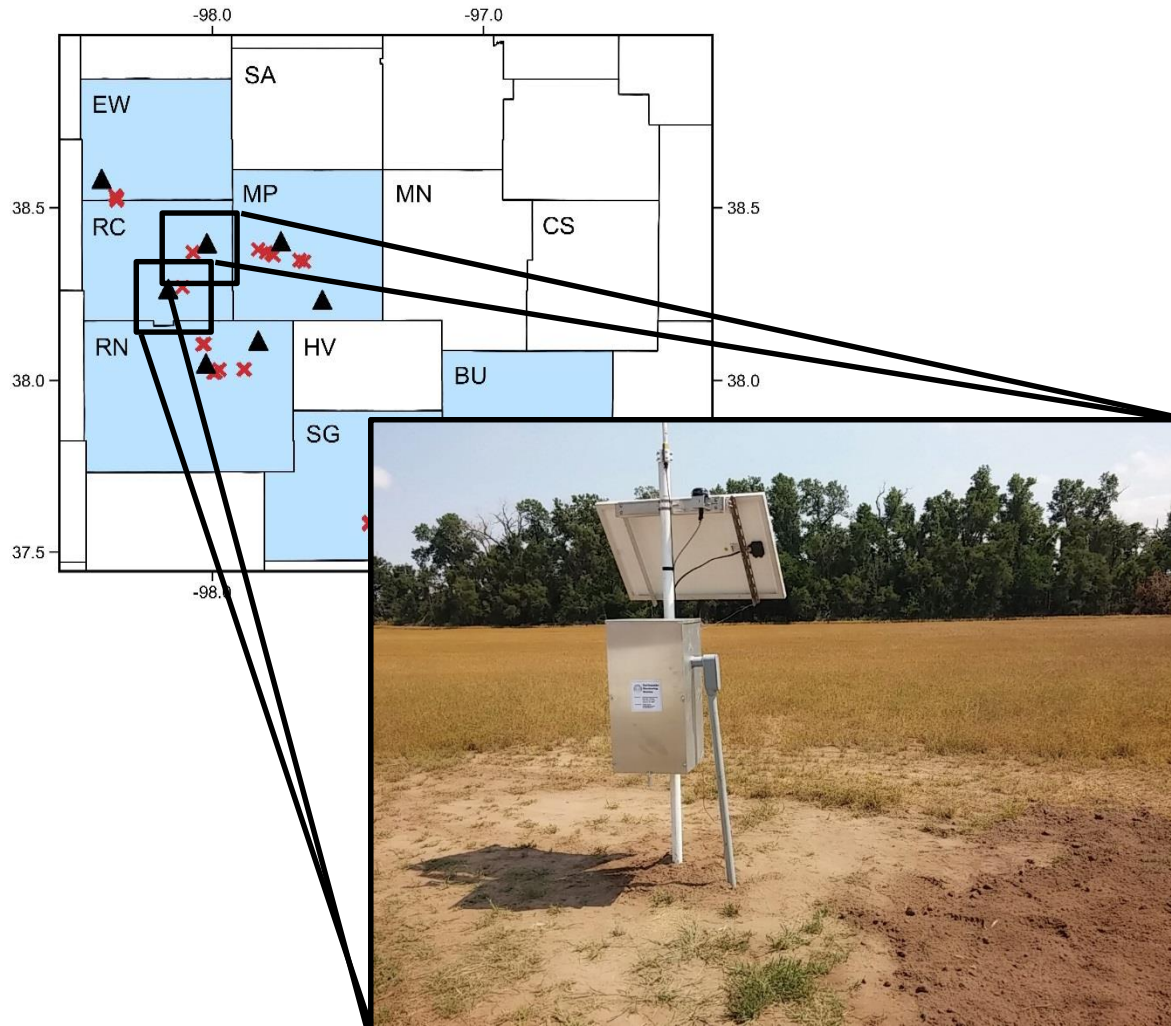


magnitude ○ ○ ○ ○
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● KGS/CSTS network (2020-2021)

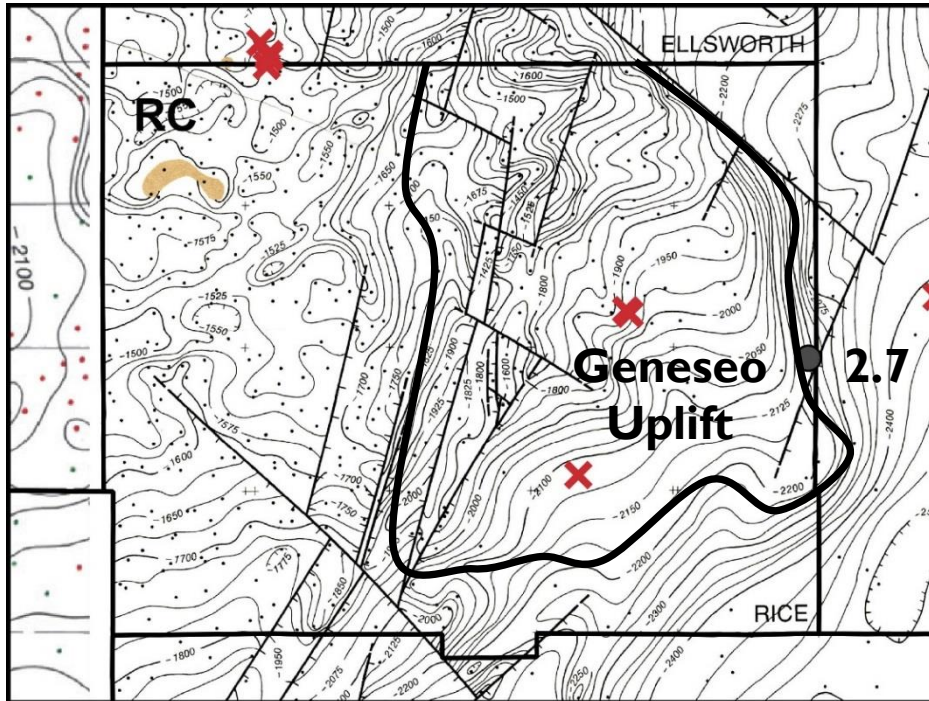
- Local earthquakes (w/in 20 mi)
 - 13 events
 - Two distinct clusters
 - Arlington (2, M 1.1 to 1.3)
 - Hutchinson (11, M 0.7 to 2.7)
- Subnetwork events
 - RN03
 - 212, mostly blasts
 - 16 probably microearthquakes
 - M -1.5 to .8
 - RN01
 - 151 (> 500/yr avg.)
 - M -1.5 to 0.3
 - corresponds to Hutchinson cluster

Rice County



- RC02
 - northeast RC
 - pasture
 - Little River
- RC03
 - between Lyons and Sterling
 - pasture

Rice County

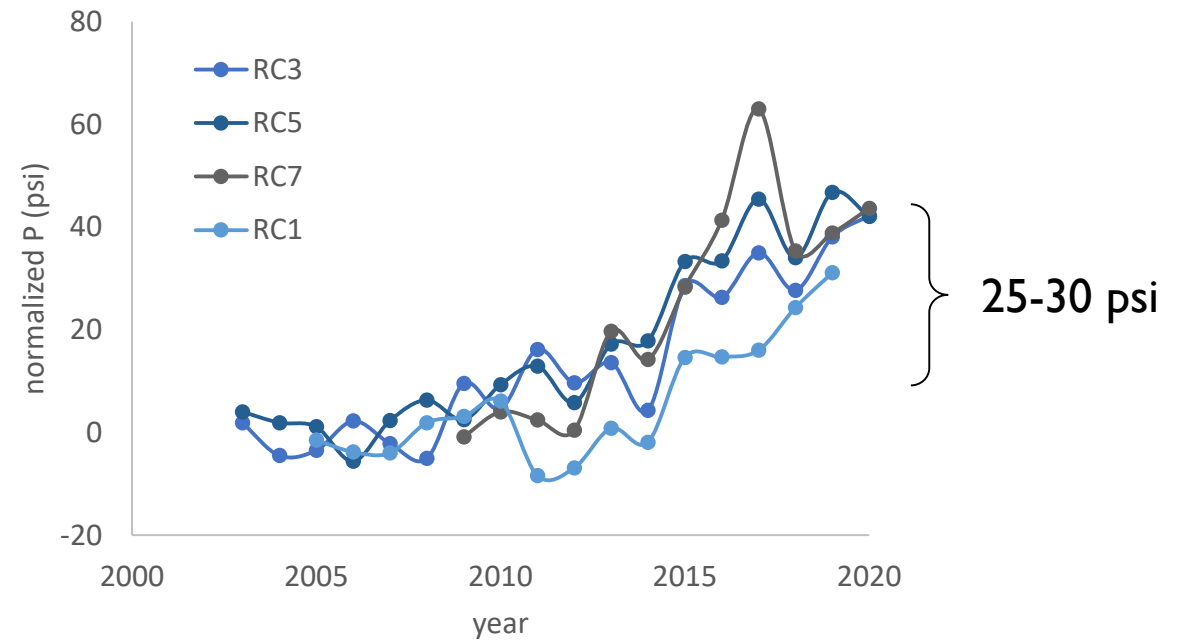
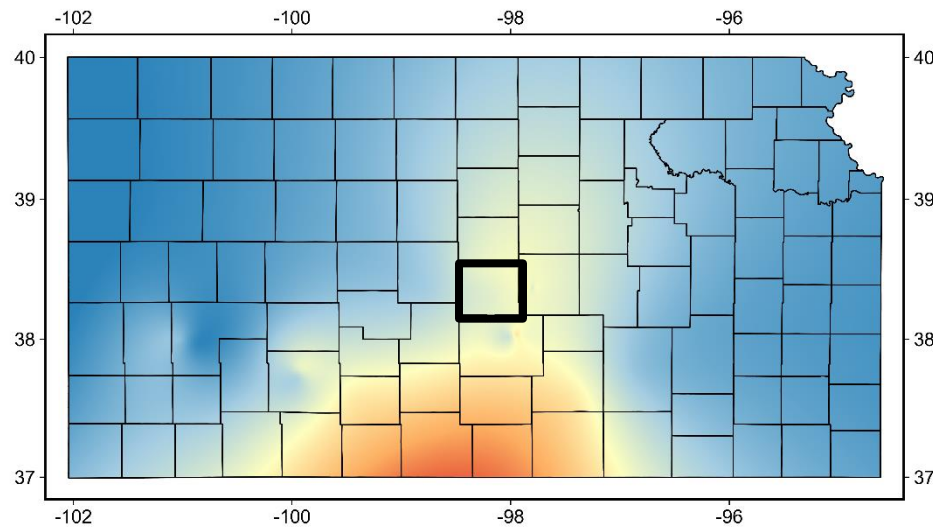


magnitude ○ ○ ○ ○
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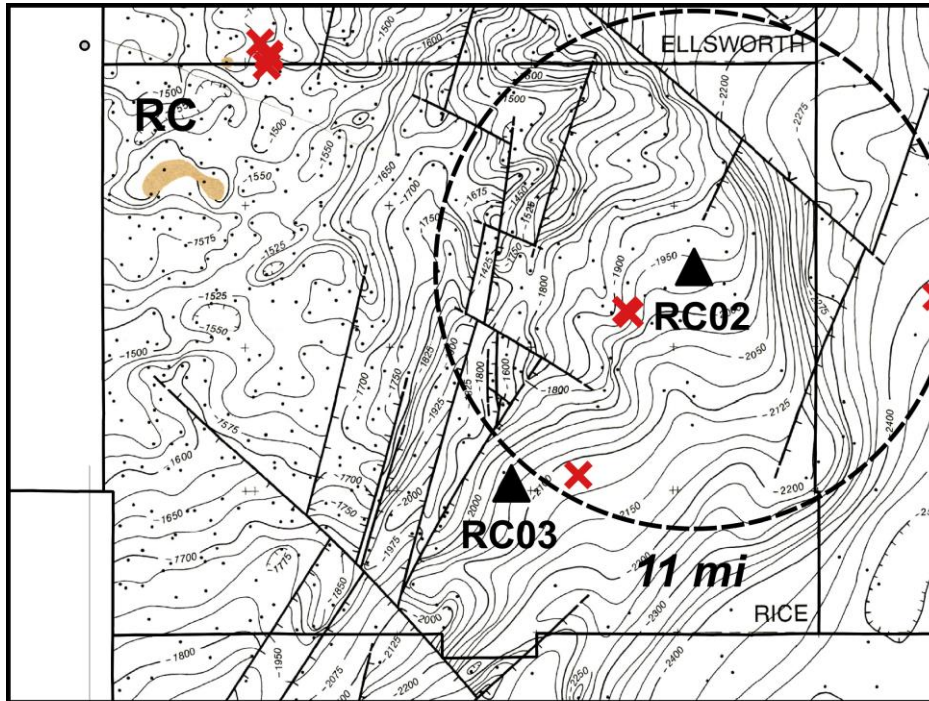
● Historic (1977-2014)

- Eastern margin of the CKU
- Mapped structures
 - Geneseo Uplift
 - bounded by faults
- Historic earthquakes
 - M 2.7 in 1981
 - Recently
 - M 1.2 in 2018
 - M 0.8 in 2019

Rice County



Rice County



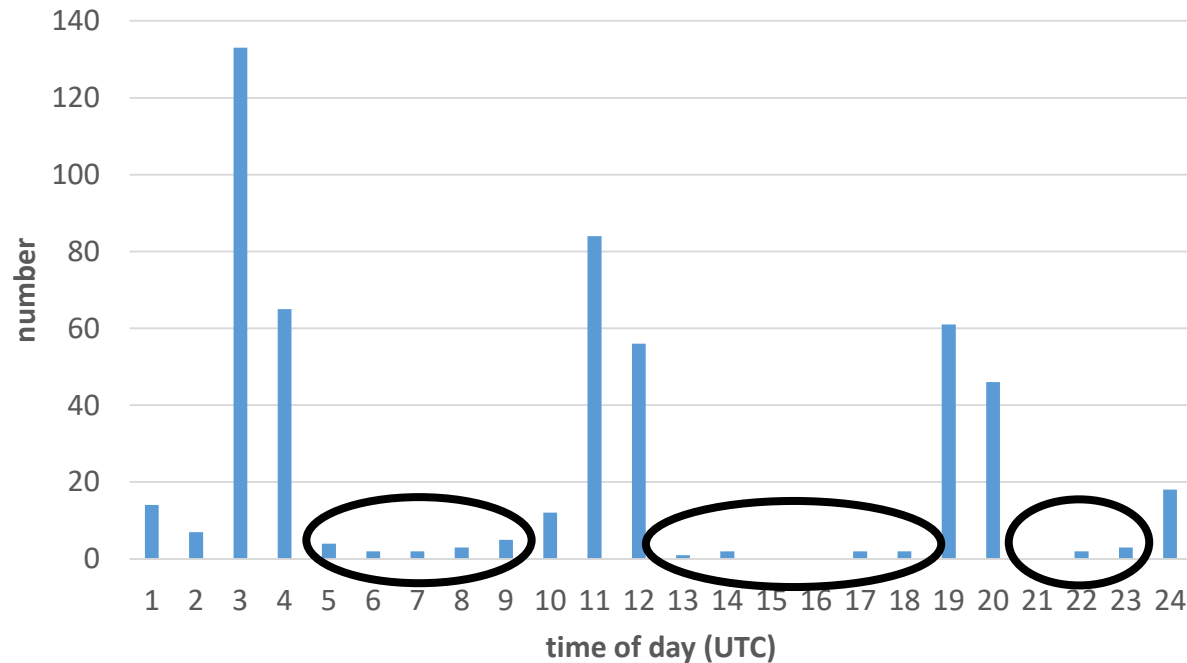
magnitude ○ ○ ○ ○
1 2 3 4

● Historic (1977-2014)

- Local earthquakes (< 20mi)
 - None
- Subnetwork events
 - RC02: 45 (22/yr avg.)
 - M -1.5 to 0.5
 - distance: 1-11 mi
 - Geneseo Uplift
 - small uptick, natural fluctuation?
 - RC03: more than 500
 - 8 mi, regular timing (8 hours)
 - spectral characteristics: likely underground mining blasts
 - discriminate earthquakes

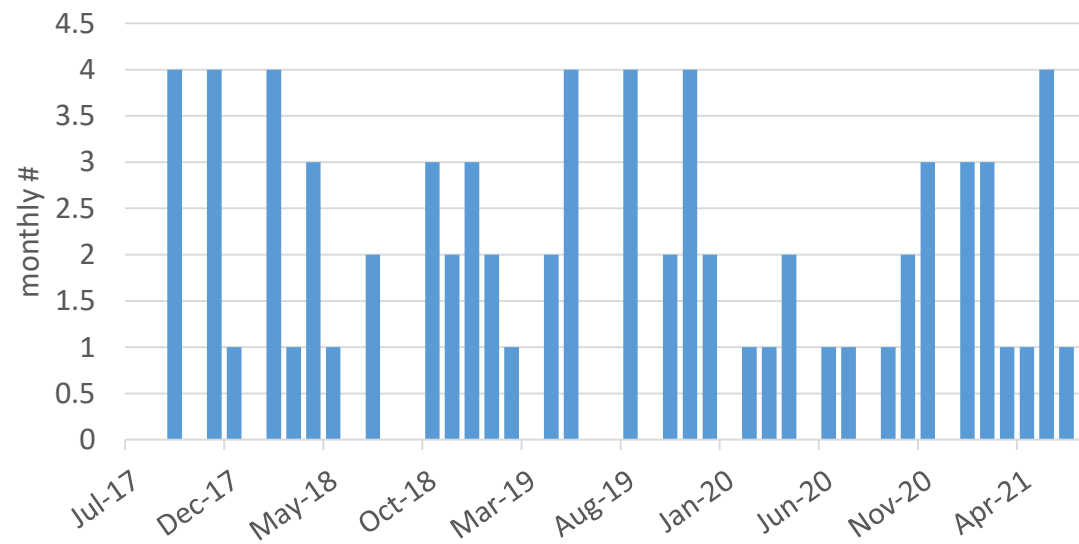
RC03 Subnetwork Event Timing

19 events

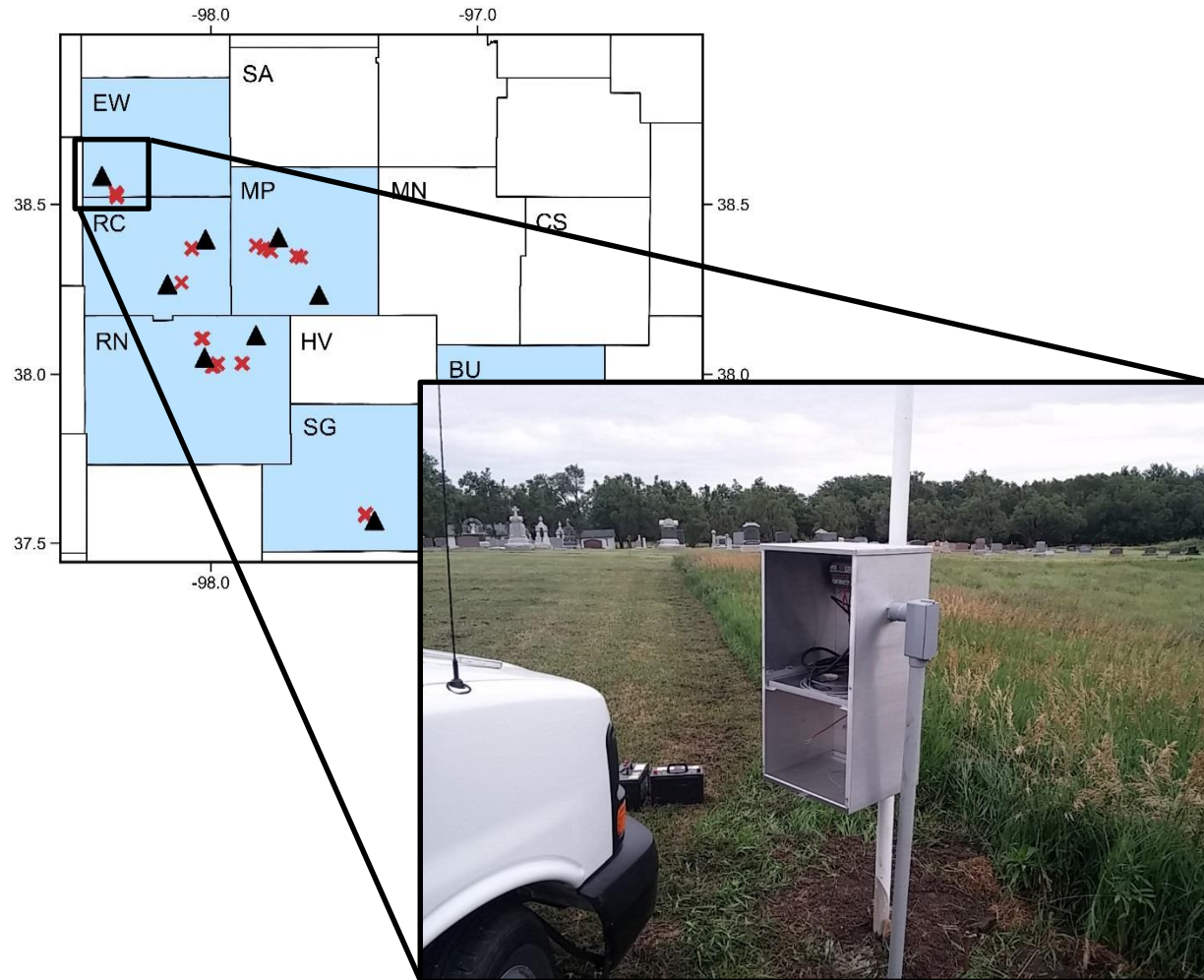


station	origin time (UTC)	distance (mi)	magnitude
RC03	2020-07-12 17:43	4.4	-0.6
RC03	2020-09-29 16:38	7.2	-0.4
RC03	2020-10-20 17:44	6.8	-0.4
RC03	2020-10-24 21:30	7.2	-0.2
RC03	2020-11-05 16:13	6.6	-0.4
RC03	2020-11-10 05:16	2.1	-0.9
RC03	2020-11-24 07:49	2.6	-0.2
RC03	2021-01-02 21:19	1.9	-1.5
RC03	2021-01-24 22:50	1.7	-1.5
RC03	2021-01-24 22:51	2.4	-1.5
RC03	2021-02-10 07:45	7.2	-0.2
RC03	2021-02-20 12:35	1.9	-1.5
RC03	2021-02-20 13:21	3.2	-1.5
RC03	2021-03-08 06:57	7.5	0.3
RC03	2021-04-27 07:01	9.0	0.0
RC03	2021-05-03 05:27	5.2	-0.6
RC03	2021-05-03 22:39	7.3	-0.2
RC03	2021-05-11 13:28	2.0	-1.5
RC03	2021-06-01 06:49	2.7	-1.5

Monthly Subnetwork RC03 Events

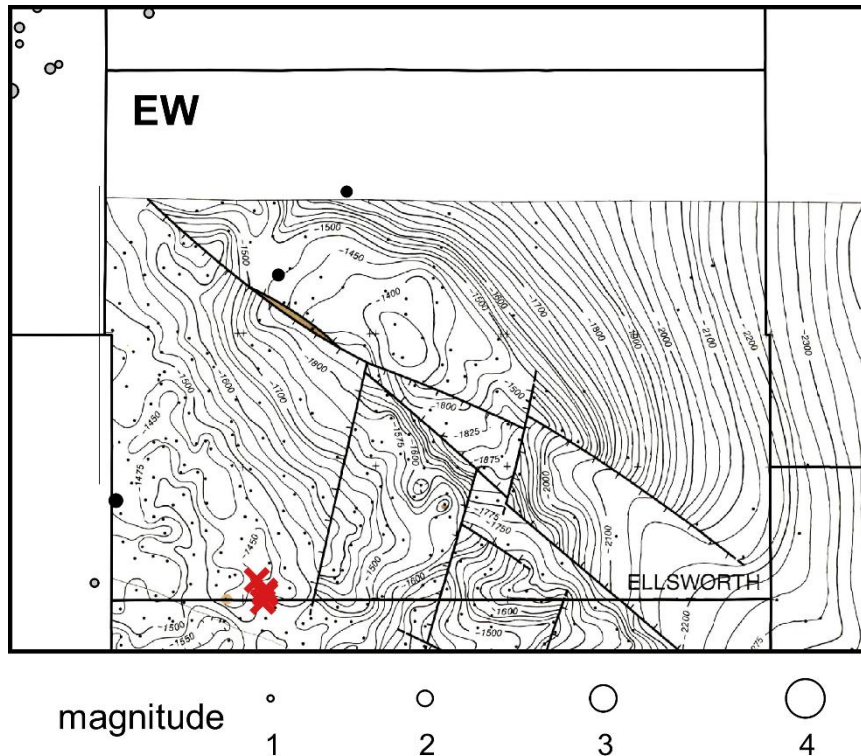


Ellsworth County



- EW01
 - southwest EW
 - Holyrood
 - pasture, cemetery

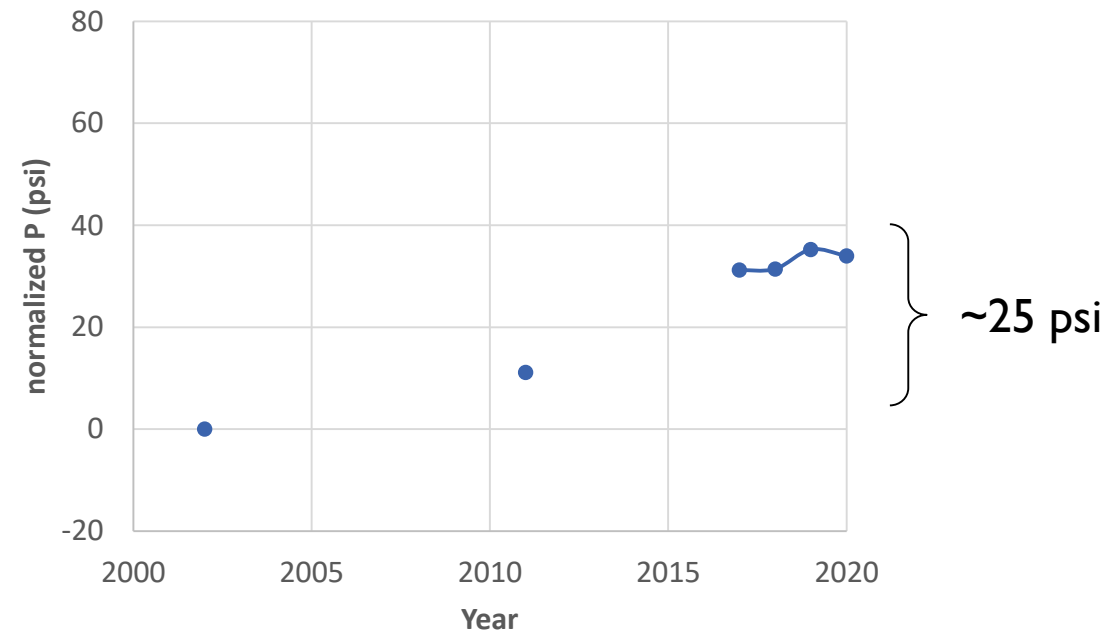
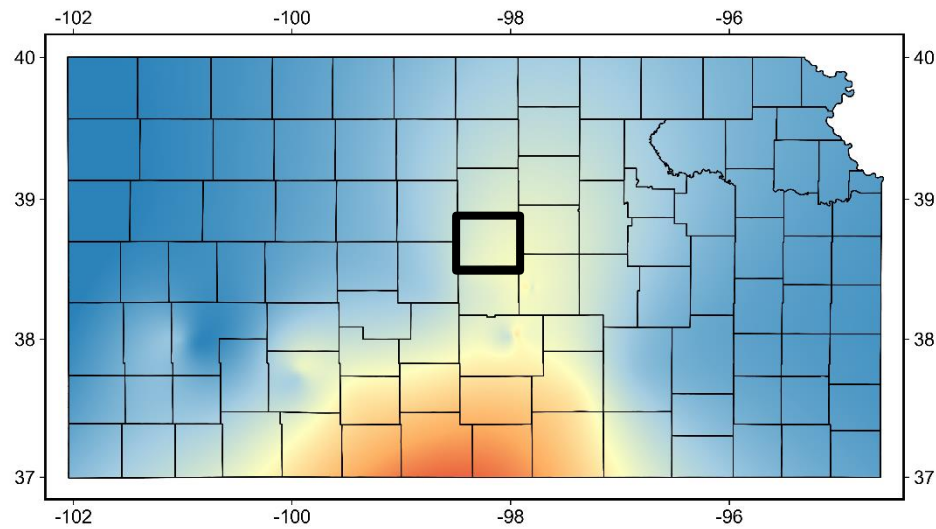
Ellsworth County



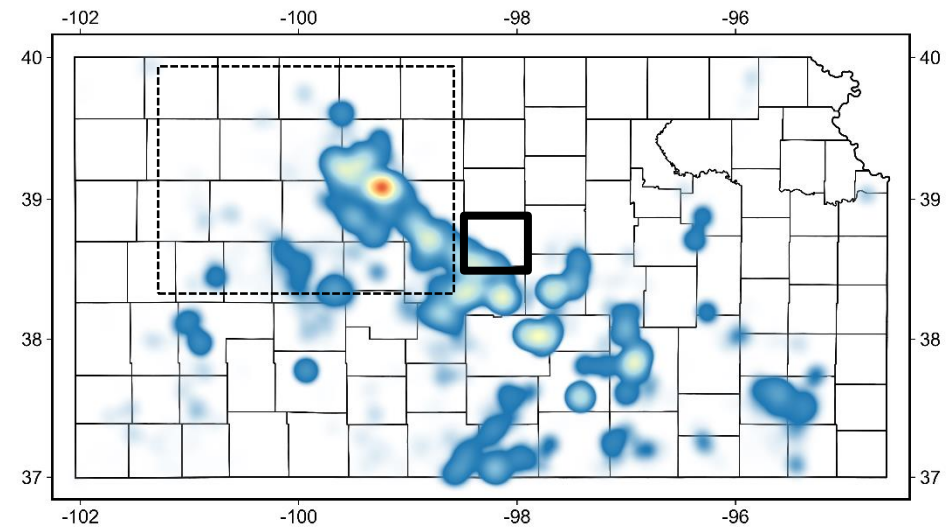
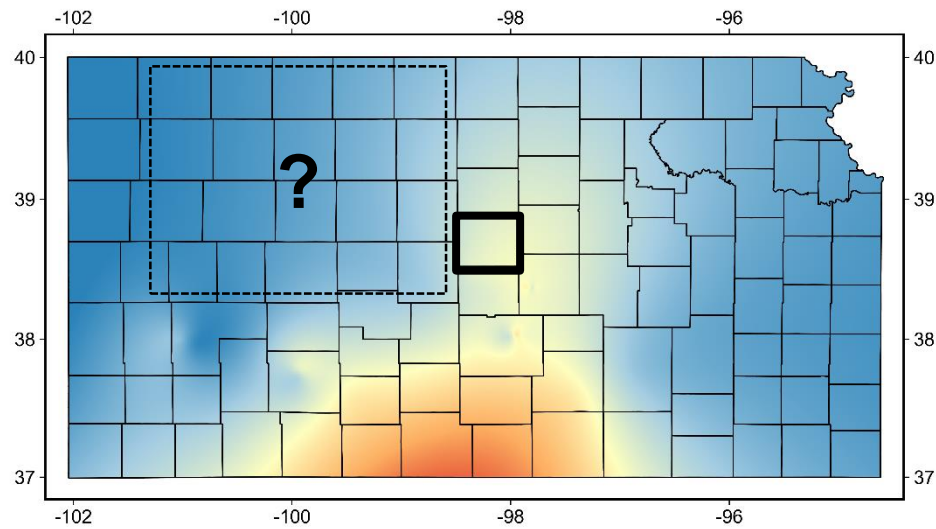
- Historic (1977-2014)
- KGS network (2015-2020)

- Eastern margin of the CKU
- Mapped structures
 - faults
 - anticlines
- Historic earthquakes
 - M 1.7 to 2.0 in 1980s
 - M 1.4 in 2018 (Barton)

Ellsworth County

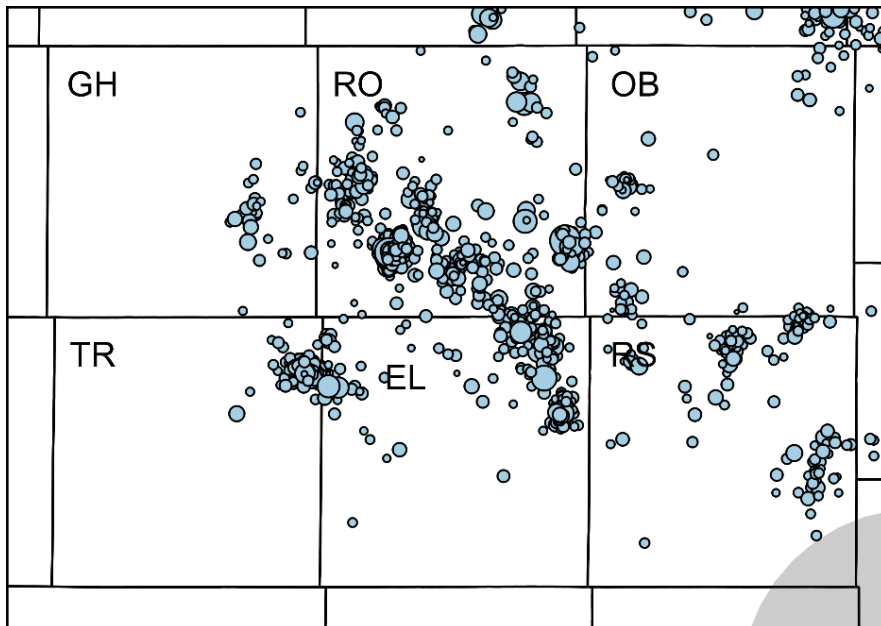


Ellsworth County

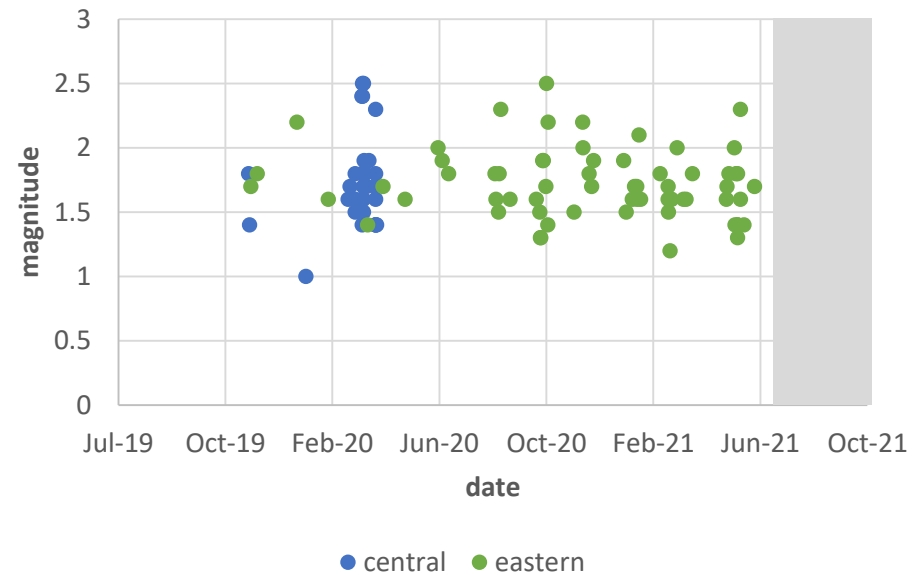


Earthquakes in Russell County

cumulative seismicity 2015-2021

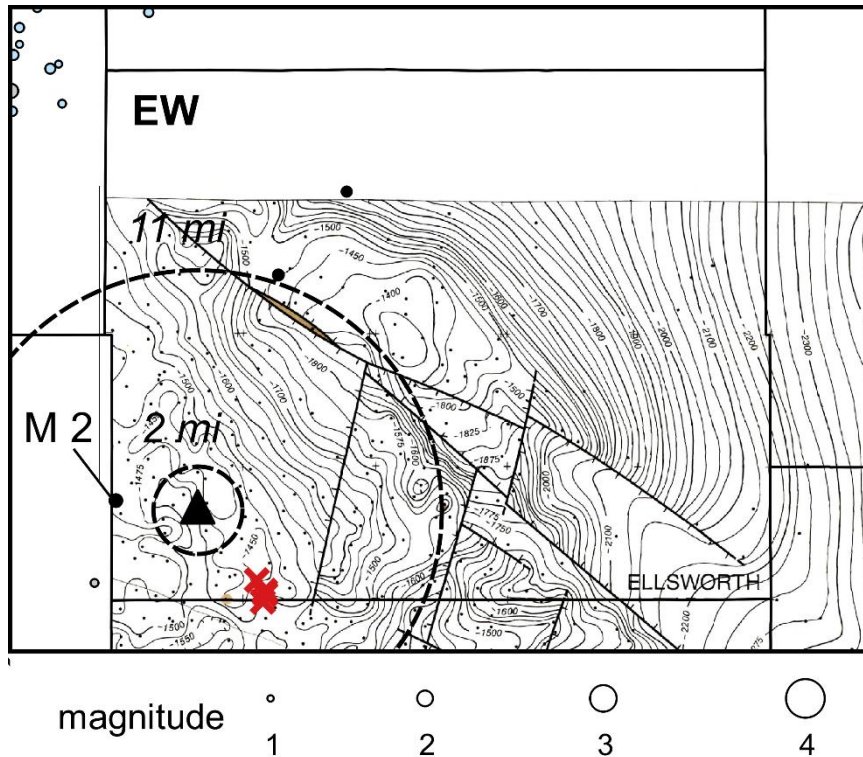


Jan 2015 to Jul 2021



occurred along the margin of the Central Kansas Uplift
eastward progression from Ellis/Rooks counties

Ellsworth County

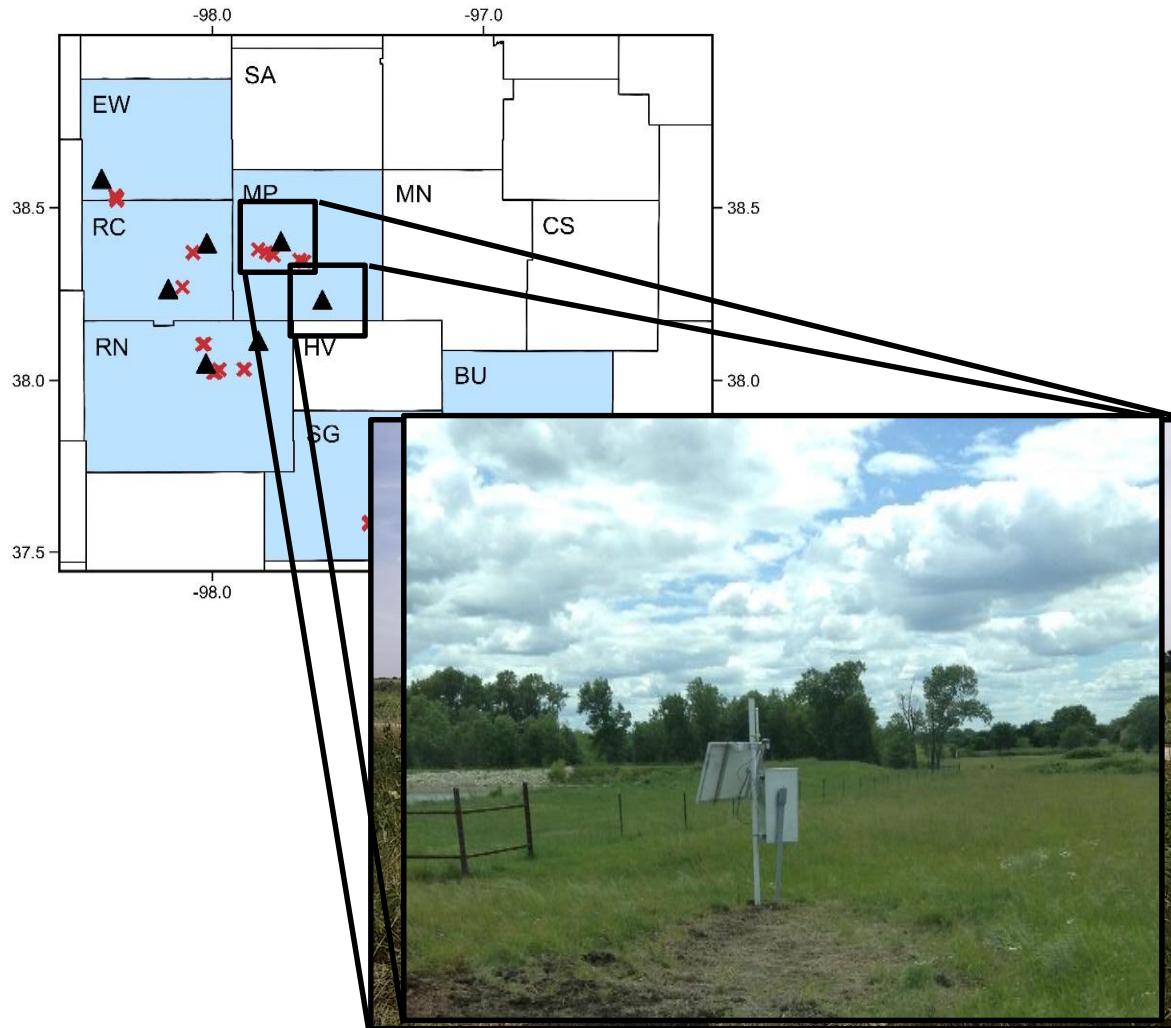


● Historic (1977-2014)

○ KGS/CSTS network (2020-2021)

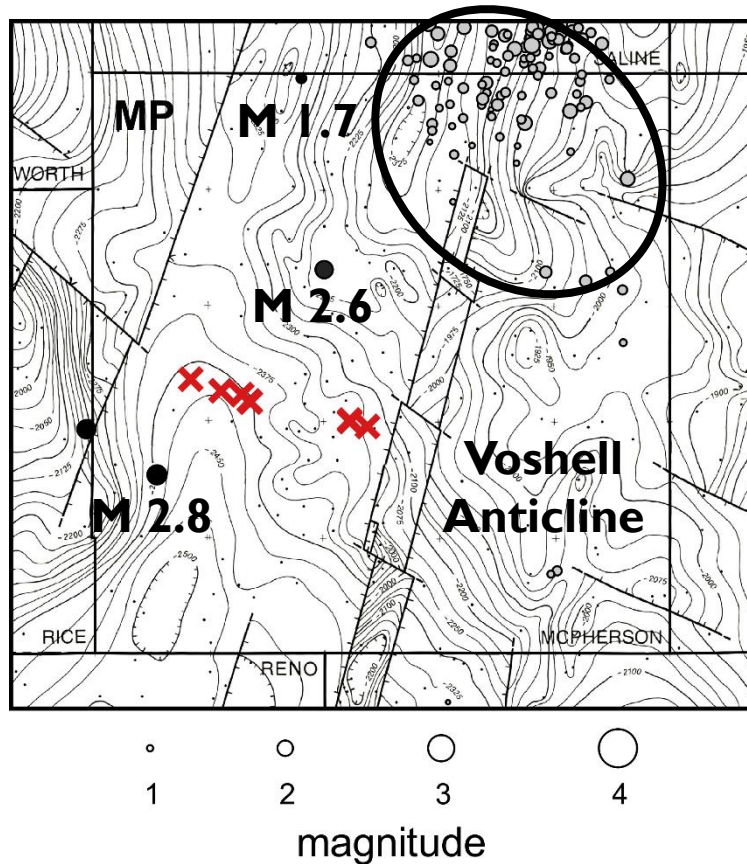
- Local earthquakes (< 20 mi)
 - None
 - M 1.3 in BT @ 23 mi
 - M 2.2 in RS @ 24 mi
- Subnetwork events
 - 20 events (5/yr avg.)
 - M < 1
 - 2-11 mi from station
 - pressure increase from the NW?

McPherson County



- MP01
 - northeast of Conway
 - pasture
 - McPherson Valley Wetlands
- MP02
 - south of McPherson
 - pasture
 - local church

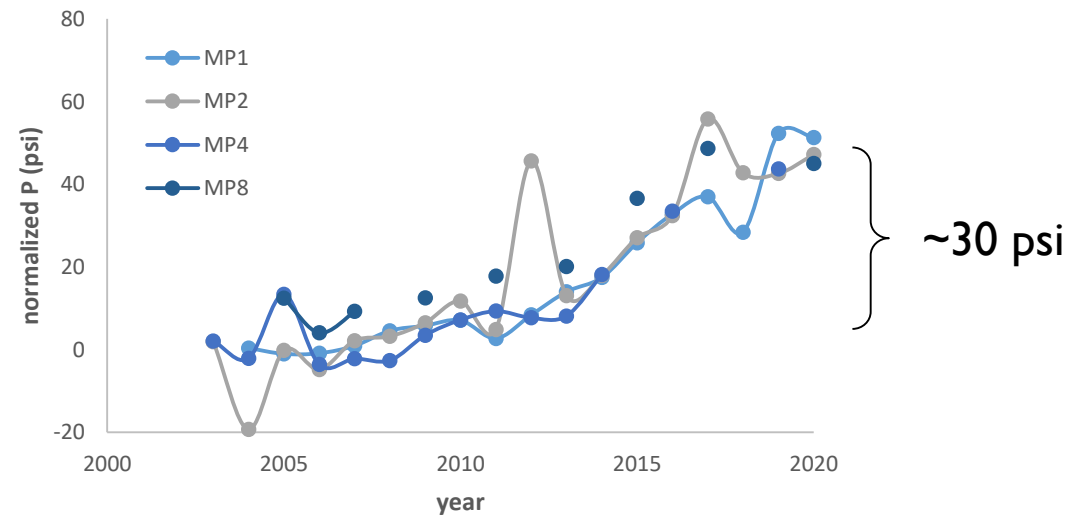
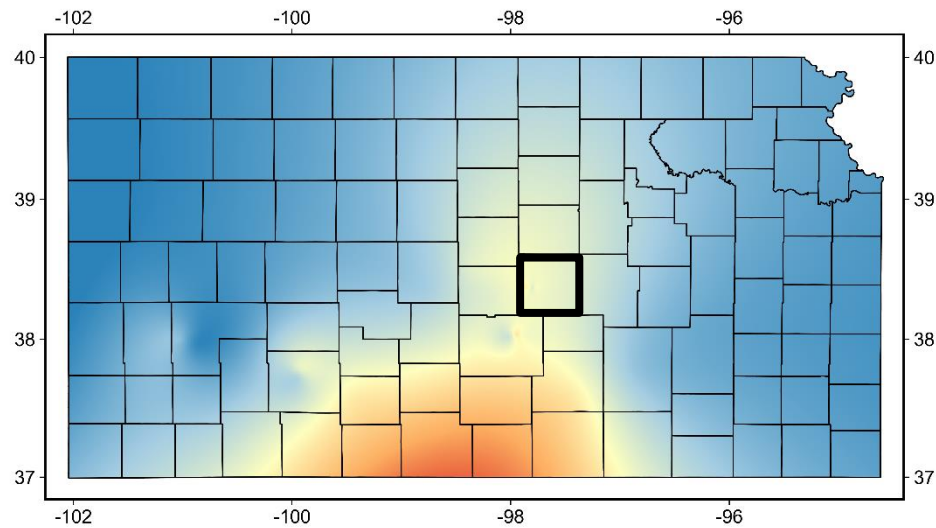
McPherson County



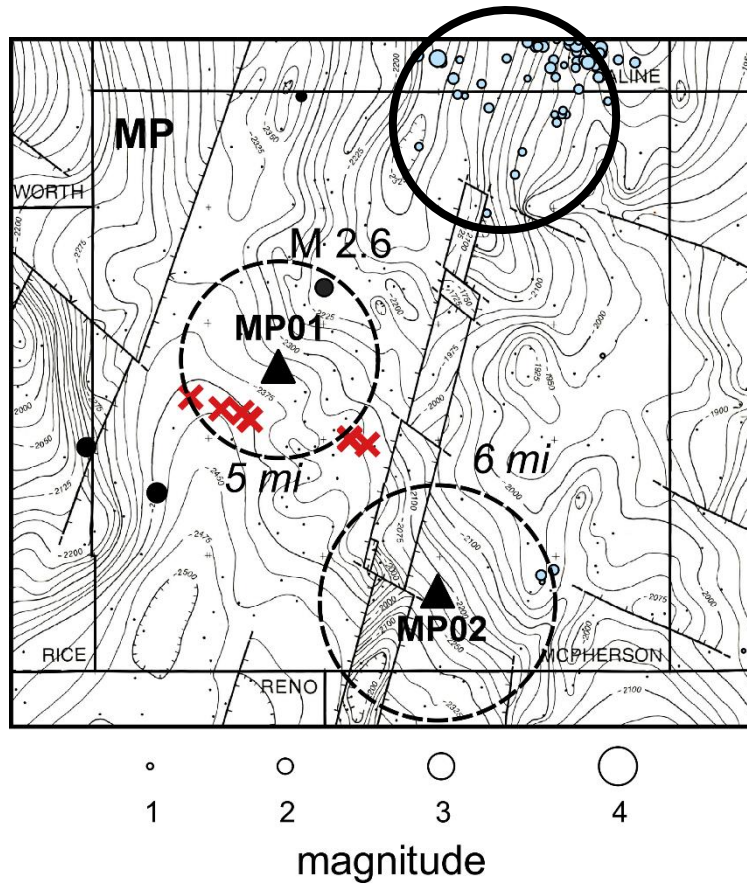
- Midcontinent Rift System
- Mapped structures
 - Voshell Anticline
 - bounded by faults
- Previous earthquakes
 - M 2.8 in 1981
 - M 1.7 in 1983
 - M 2.6 in 2014
 - Recent seismicity near MP–SA county line

- Historic (1977-2014)
- KGS network (2015-2020)

McPherson County



McPherson County

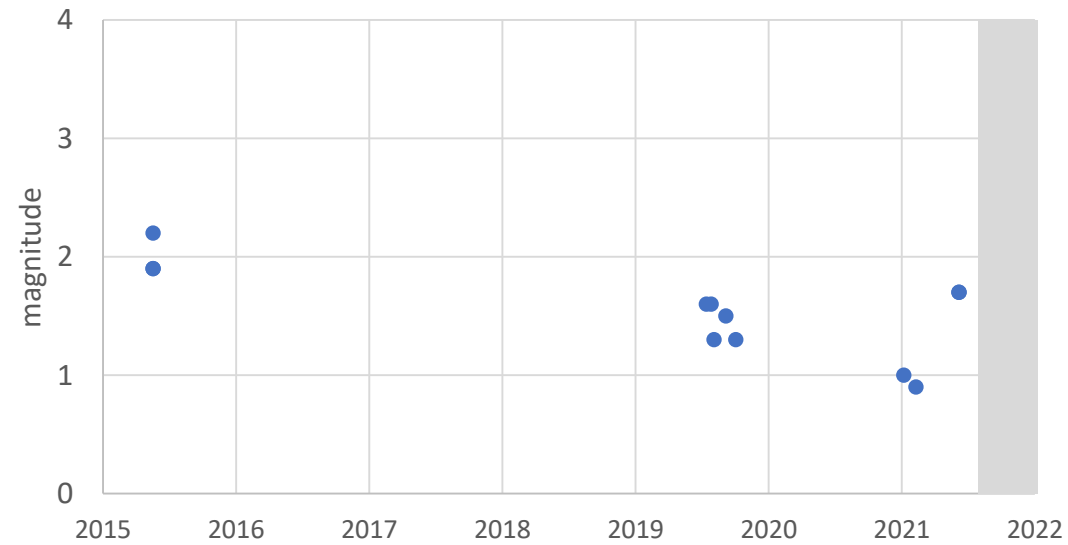


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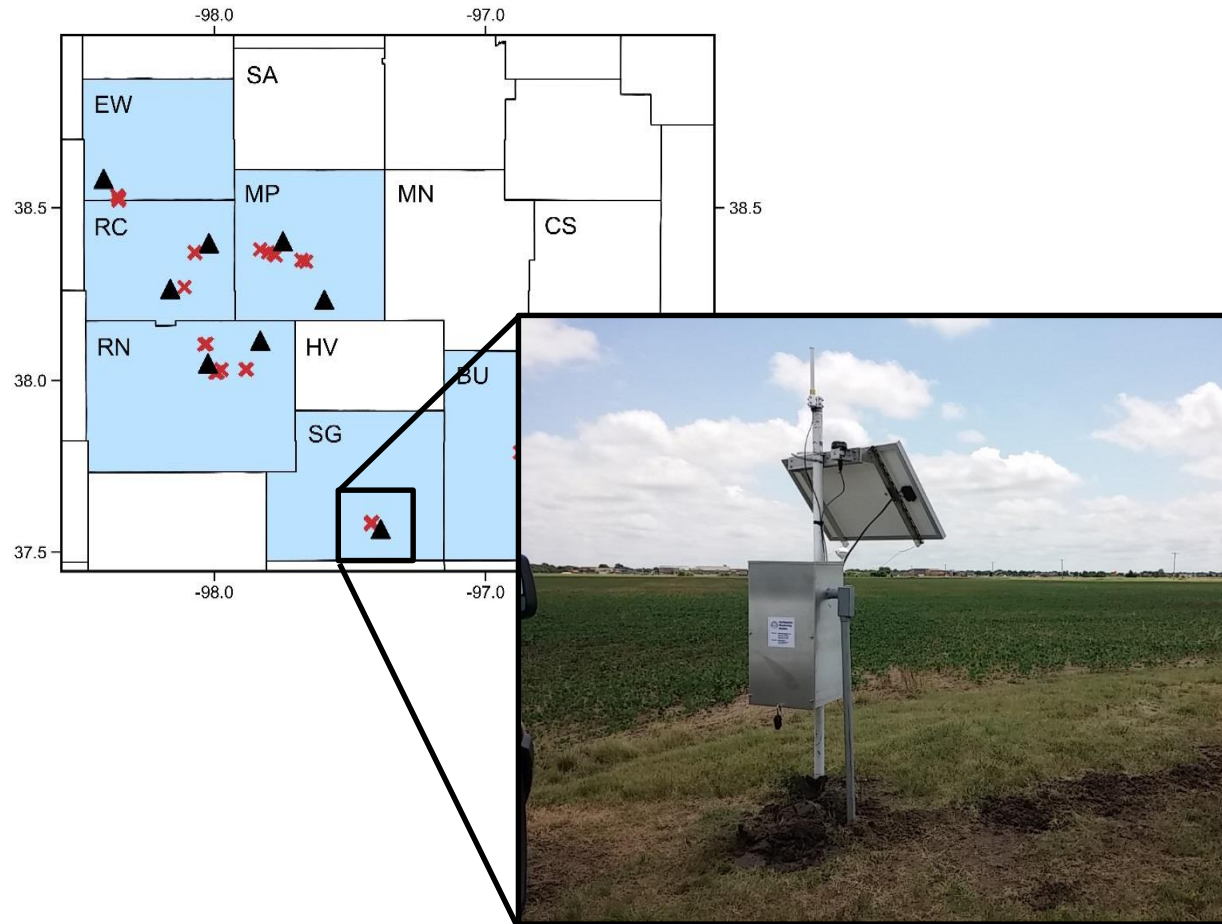
○ KGS/CSTS network (2020-2021)

- Local earthquakes
 - 11 earthquakes, M 0.4 to M 2.2
 - likely an extension of seismicity in SA along the MGA
- Subnetwork events
 - MP01: 37 events
 - M -1.5 to 0.4
 - 5 mi away
 - corresponds to 2014 earthquake
 - avg. 1 dozen/yr
 - MP02: 47 events
 - M -1.5 to 0.4
 - 6 mi away
 - corresponds to SE cluster
 - avg. 2 dozen/yr
- Increased subnetwork seismicity

McPherson County



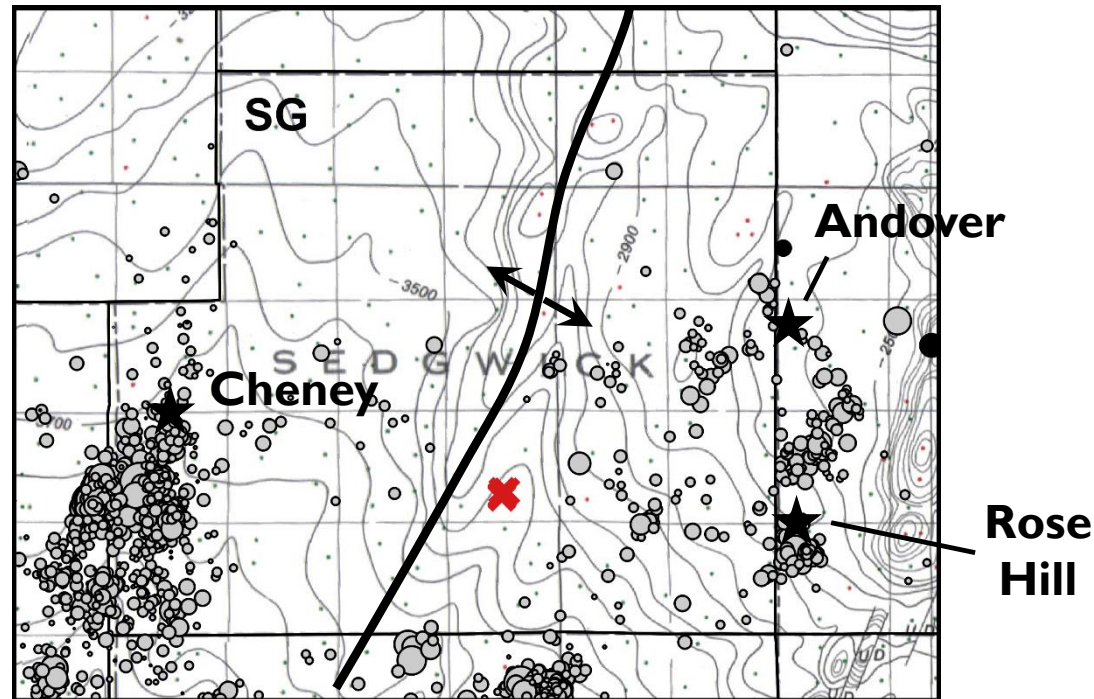
Sedgwick County



- SG02
 - south of Wichita
 - pasture
 - local church

Sedgwick County

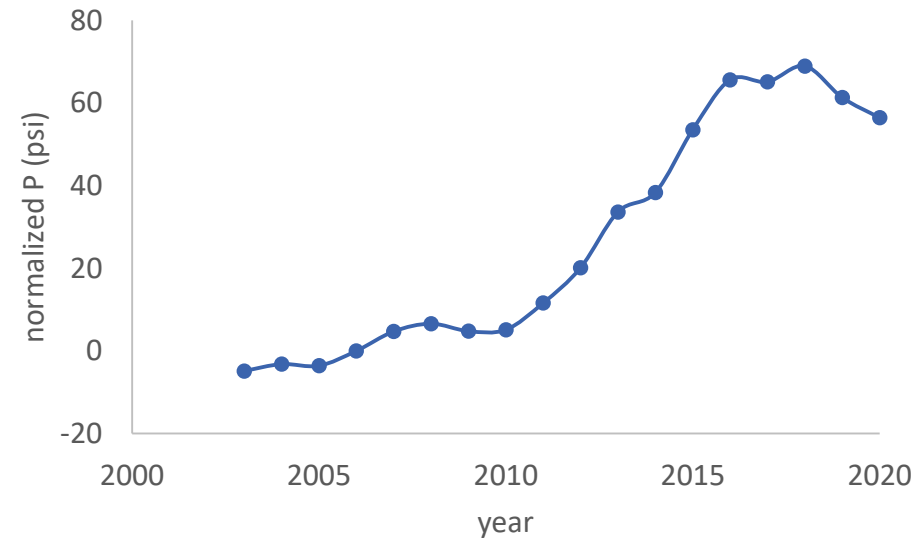
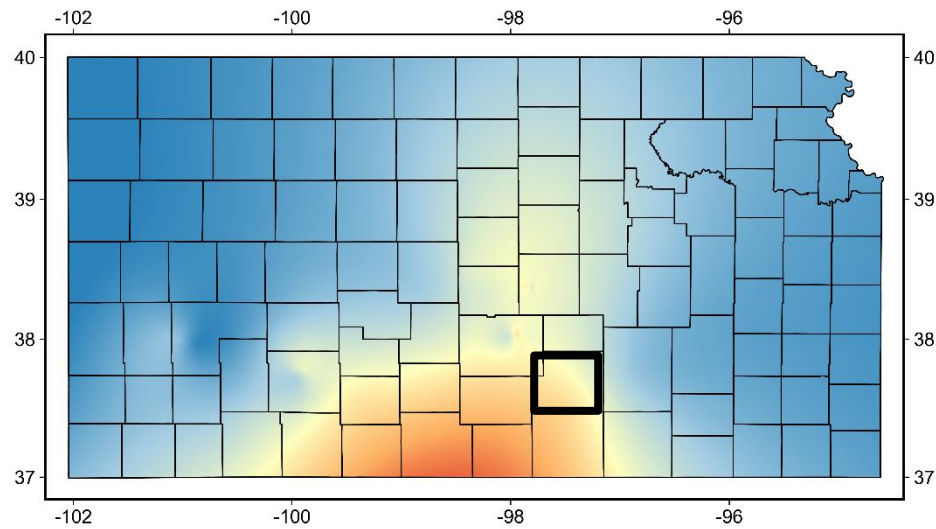
Valley Center Anticline



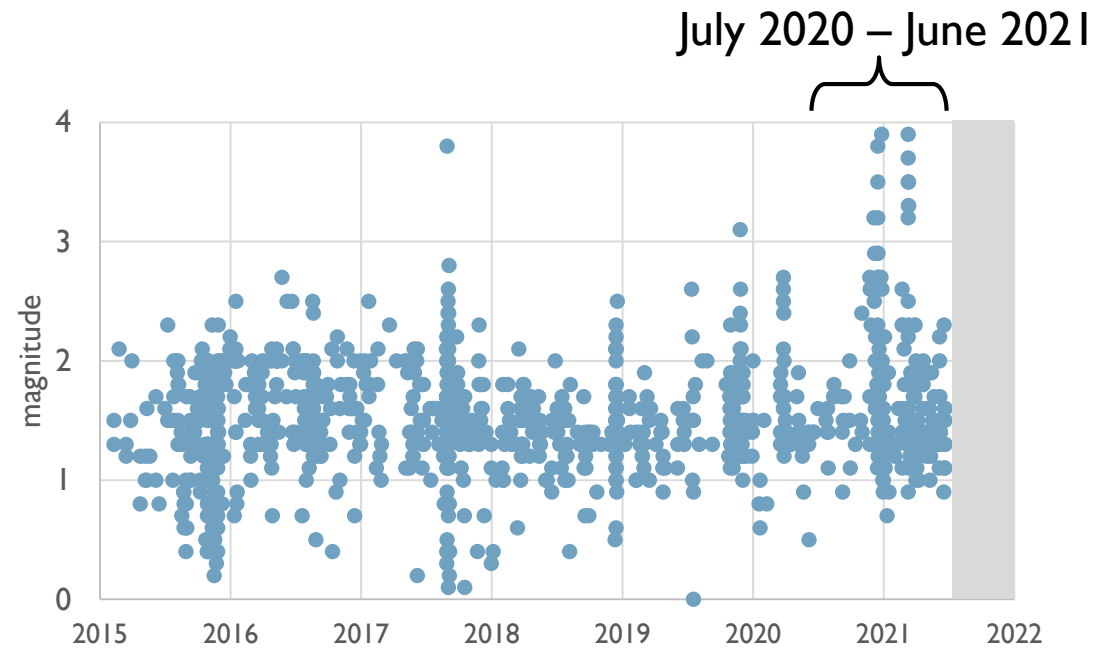
- Nemaha Ridge
- Mapped structures
 - Valley Center Anticline
 - likely associated faults
- Previous earthquakes
 - Historic
 - none recorded
 - felt events in early 1900s
 - Recent seismicity recorded by KGS network
 - predominantly NE trends
 - migrated from KS-OK
 - likely induced

- Historic (1977-2014)
- KGS network (2015-2020)

Sedgwick County

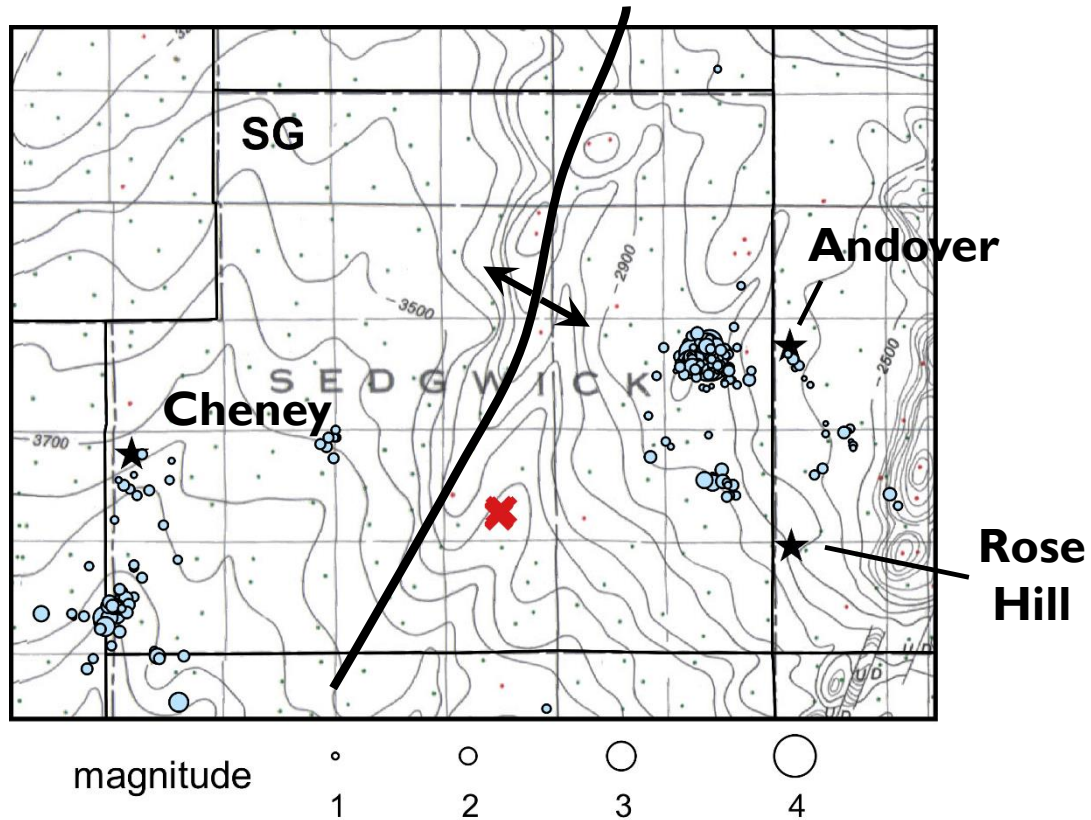


Sedgwick County



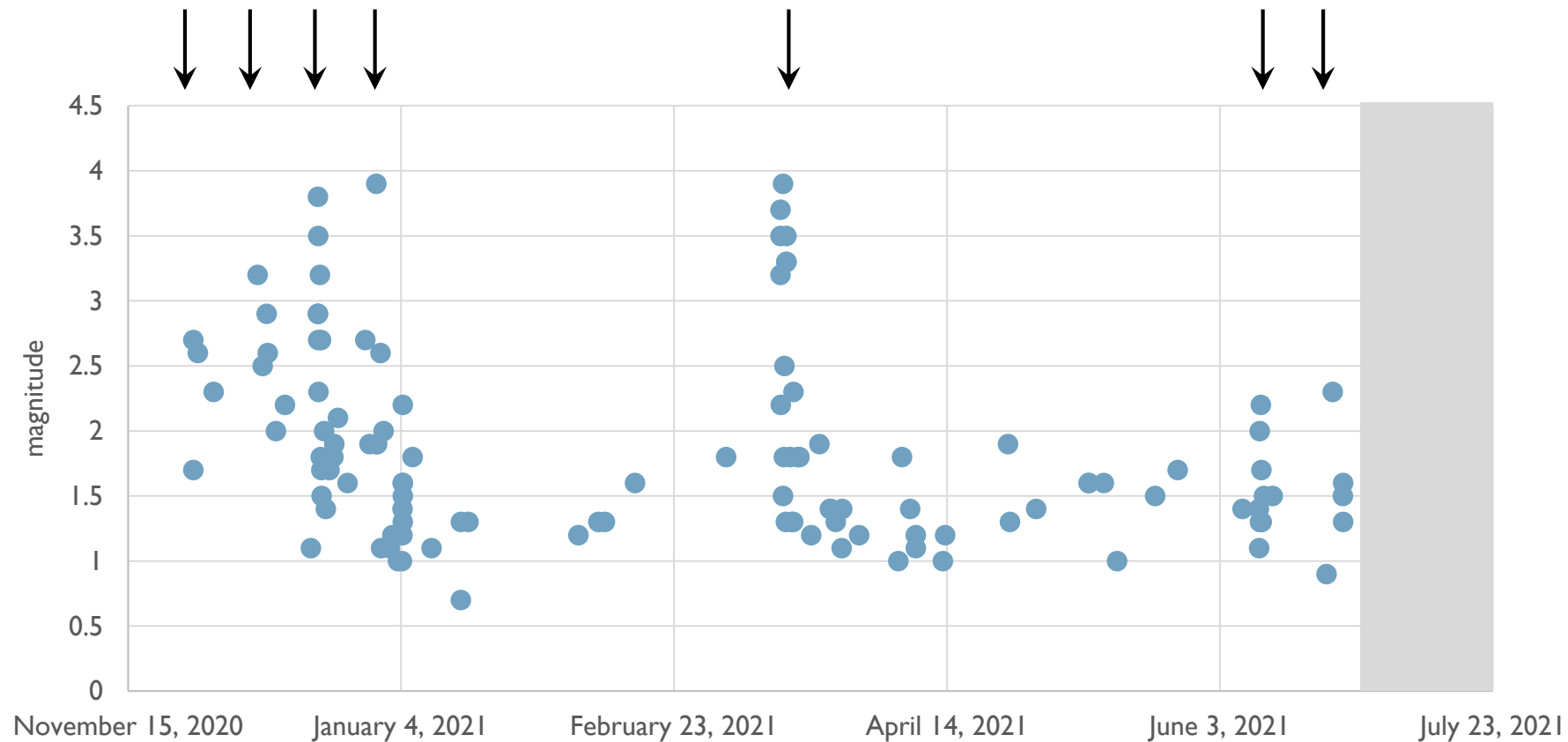
Sedgwick County

Valley Center Anticline

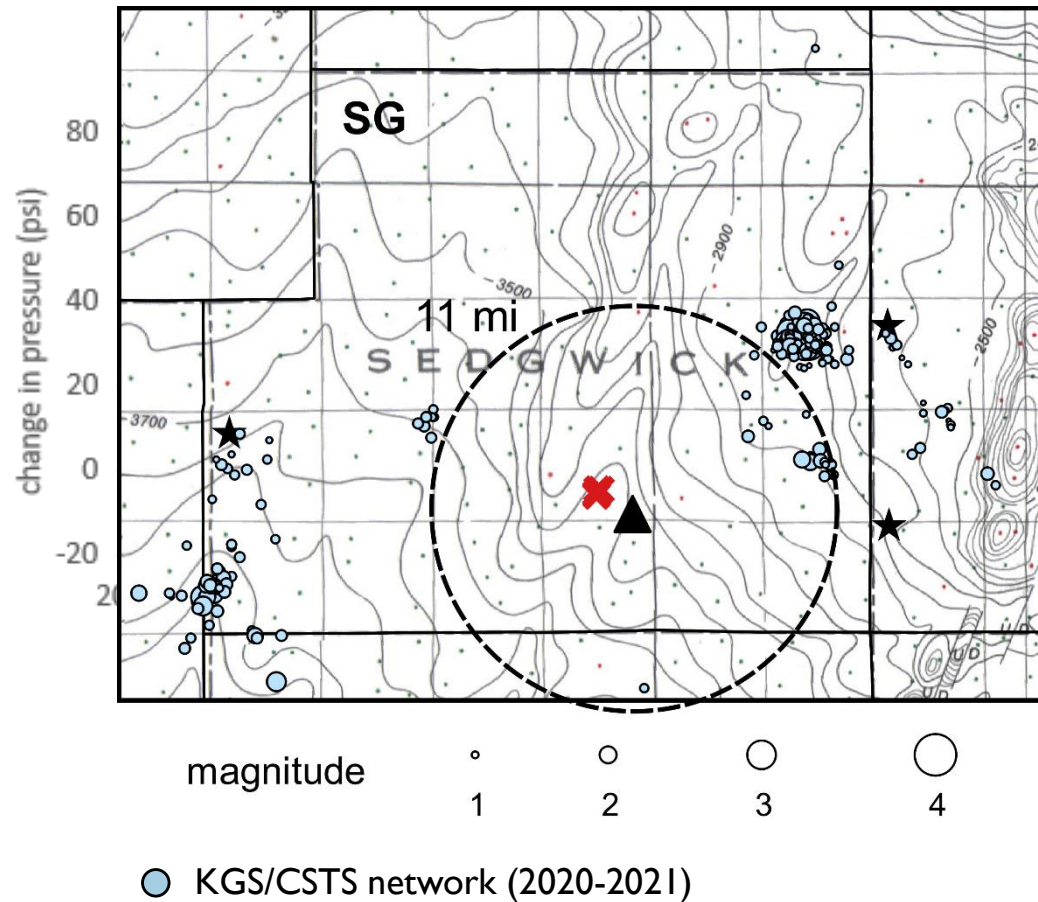


- Local earthquakes
 - more than 200
 - M 0.7 to 3.9
 - clusters identified previously
- Cheney
 - ~40, largest was M 2.4
- Wichita
 - 161, largest M 3.9

Wichita Earthquakes

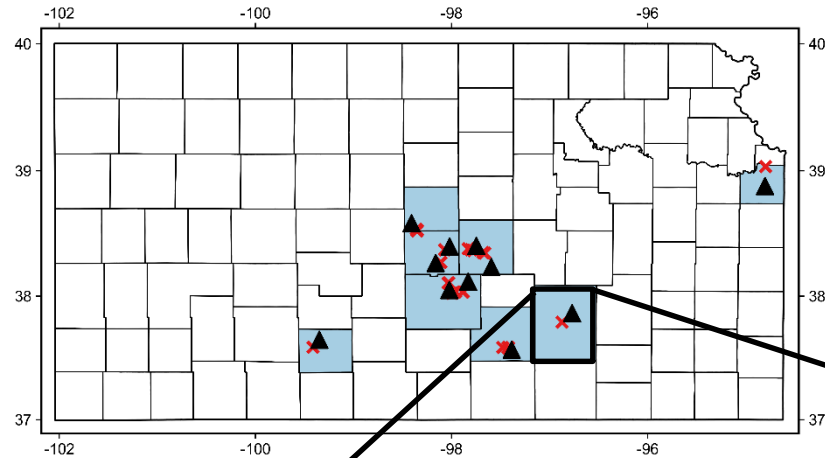


Sedgwick County



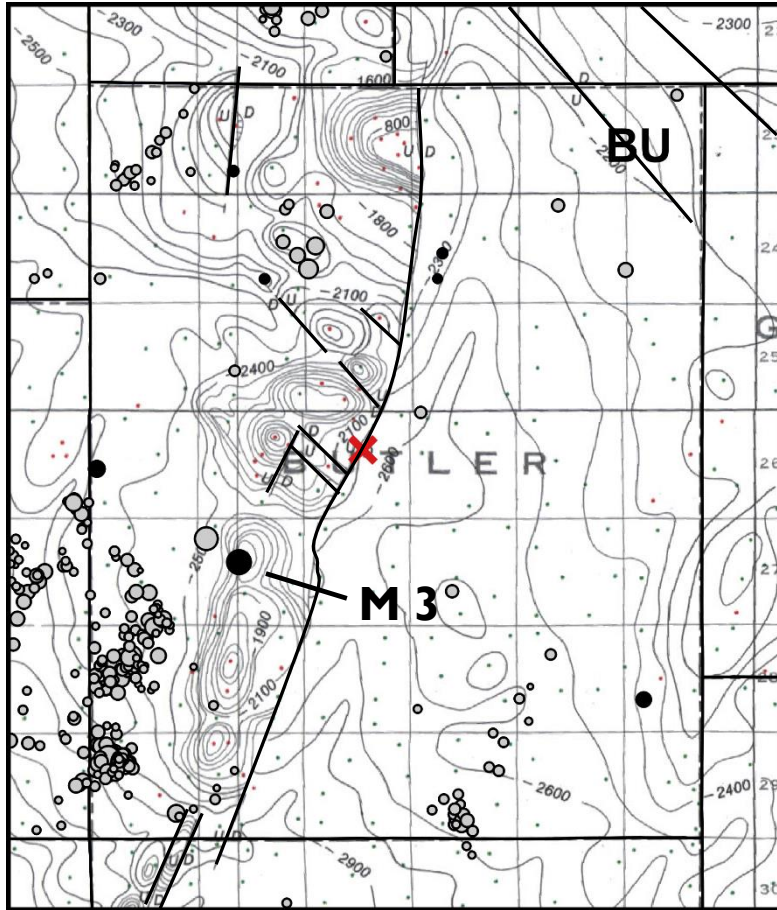
- Subnetwork events
 - 30 events
 - M 0.3 to 1.6
 - similar to previous years
- Distance: 1-11 mi
 - does not correlate with Wichita events
 - Valley Center anticline

Butler County



- BU02
 - northeast of El Dorado
 - pasture
 - El Dorado State Park

Butler County



- Historic (1977-2014)
- KGS network (2015-2020)

magnitude

○ 1

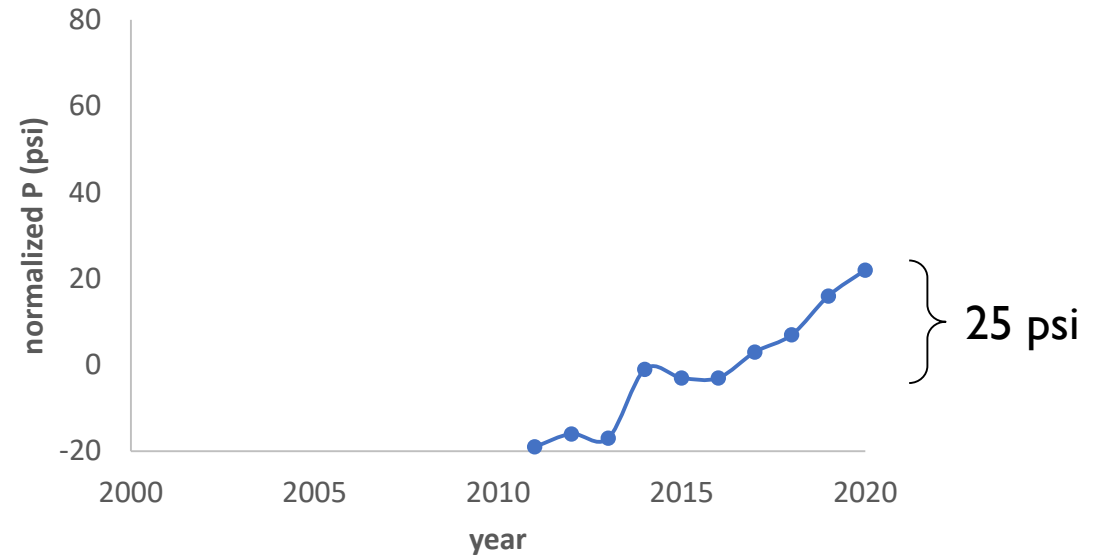
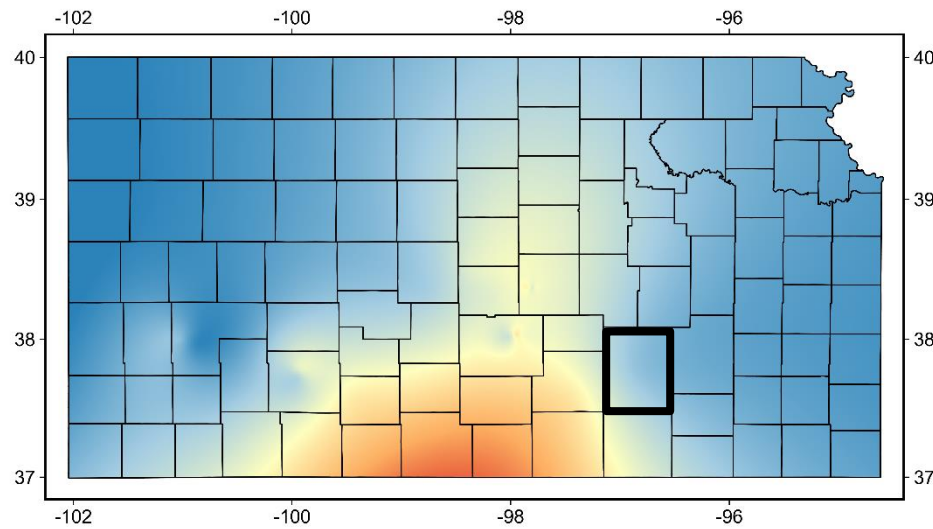
○ 2

○ 3

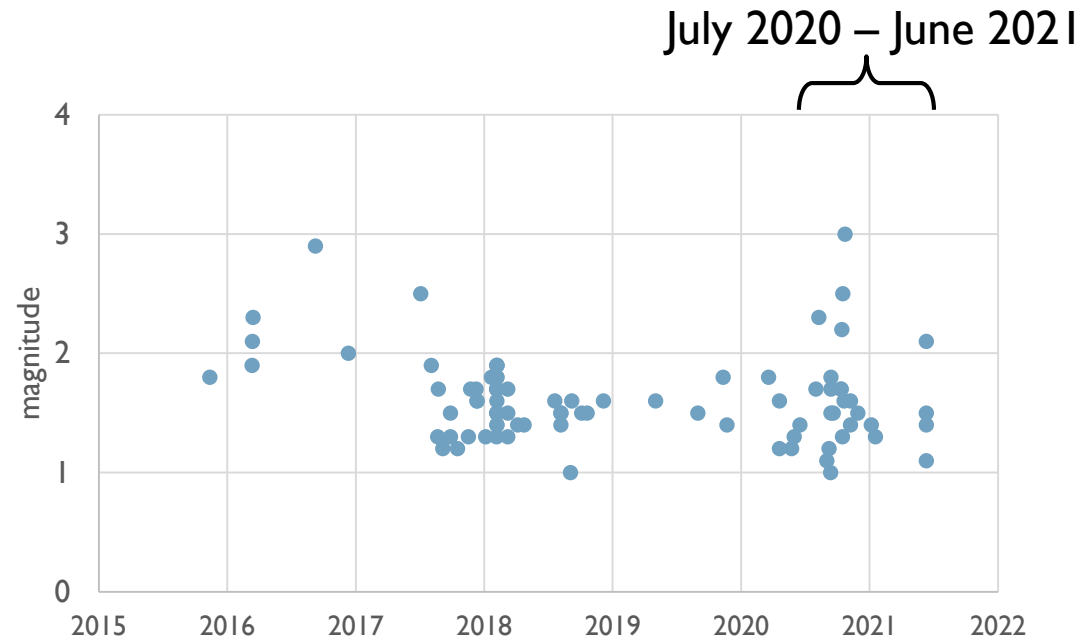
○ 4

- Nemaha Ridge
- Mapped structures
 - Nemaha Ridge/Humboldt FZ
 - anticlines/synclines
 - mapped faults
- Previous earthquakes
 - 7 historic events (M 3 in 2001)
 - Recent seismicity recorded by KGS network
 - clusters in northern and southern BU

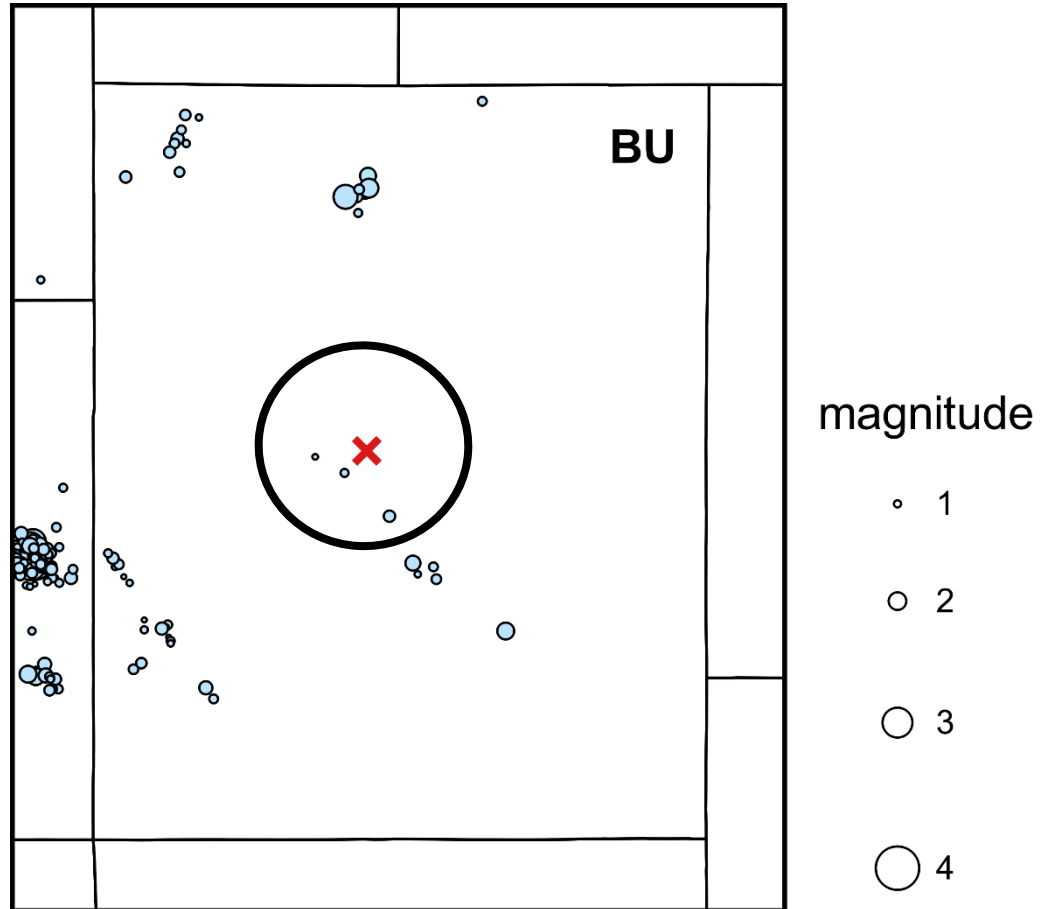
Butler County



Butler County



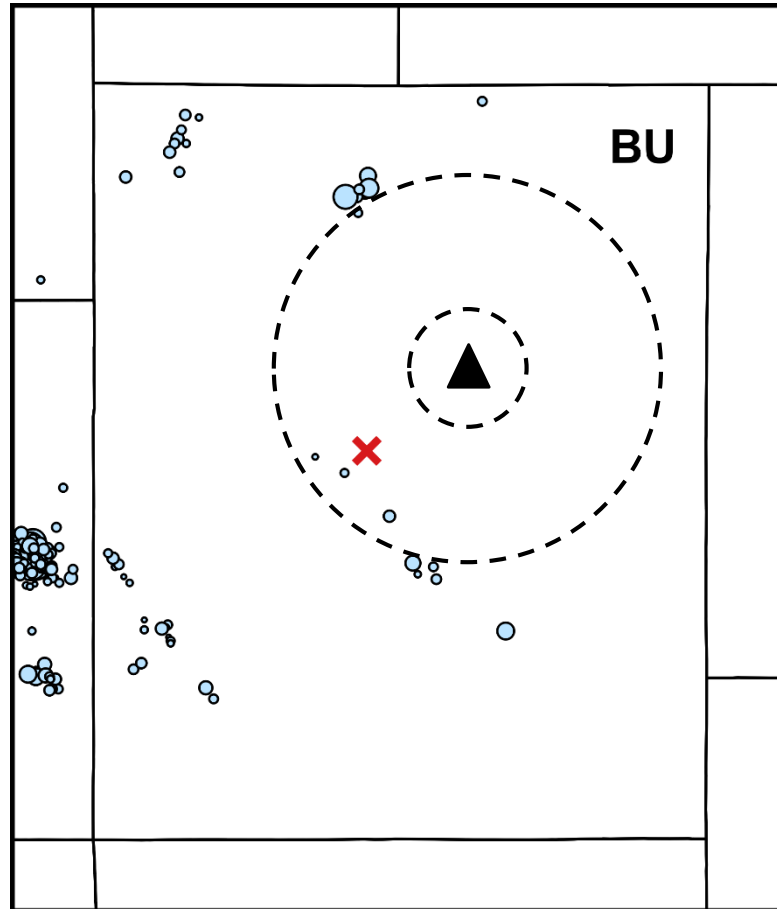
Butler County



● KGS/CSTS network (2020-2021)

- Local earthquakes
 - 43 earthquakes (18 last year, 26 avg.)
 - M 0.9 to 3.0
 - tie for largest
 - most of apparent uptick = Wichita
 - clusters identified previously
 - 3 within 5 mi of well (M <2)
- Subnetwork events
 - 16 (~dozen avg.)
 - 3-11 mi
 - Consistent with mapped faults
 - likely natural
 - possible pressure influence

Butler County



magnitude

• 1

○ 2

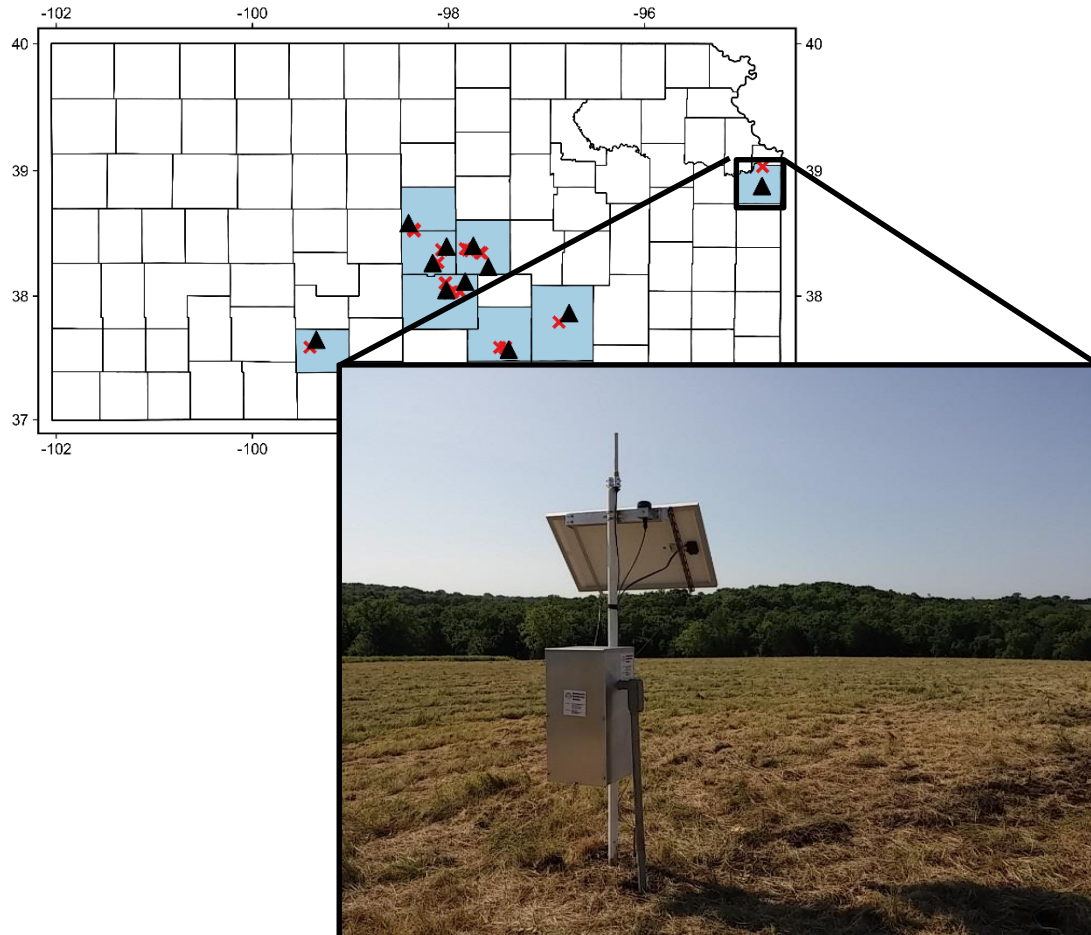
○ 3

○ 4

● KGS/CSTS network (2020-2021)

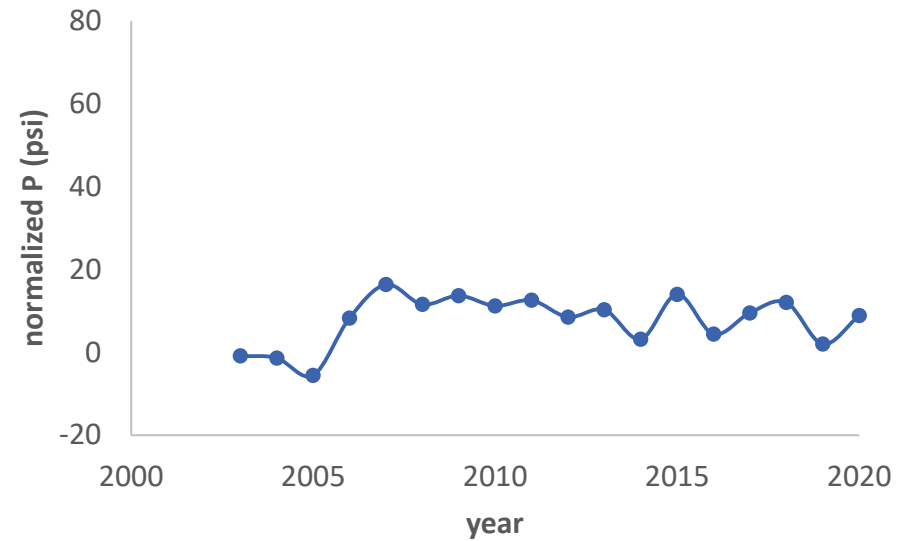
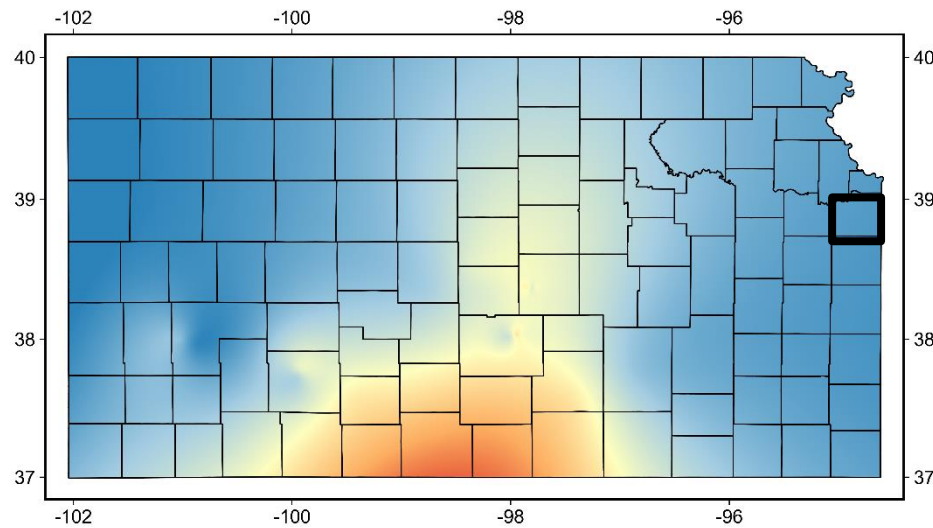
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Johnson County

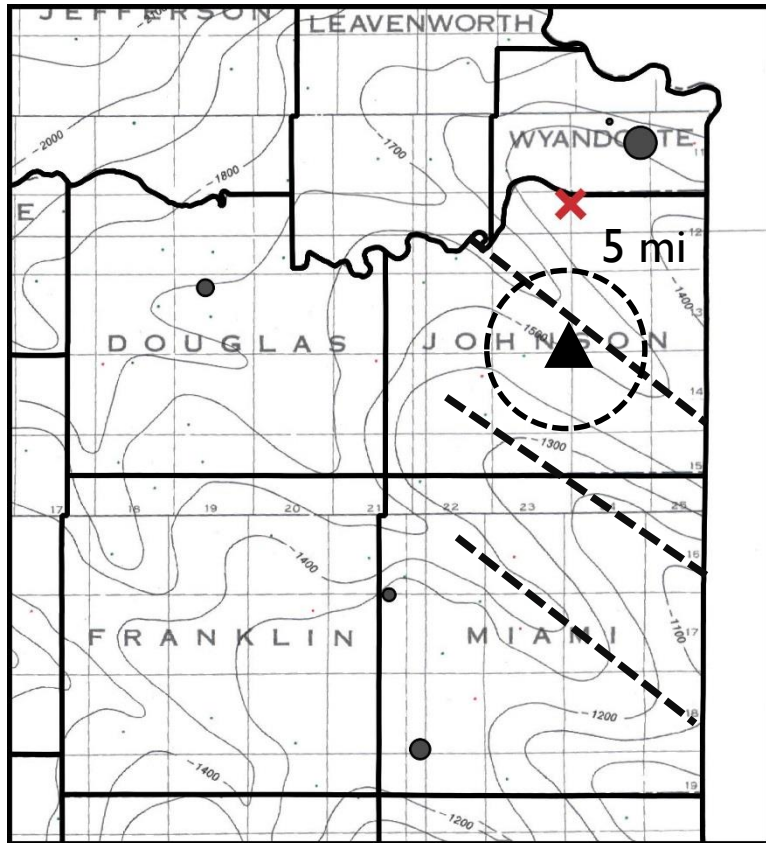


- JO01
 - western JO
 - pasture
 - Olathe Prairie Center
- 2 quarries within 5 mi
 - characteristic waveforms
 - confidently identified
 - not cataloged

Johnson County



Johnson County



● historic (1977-2014)

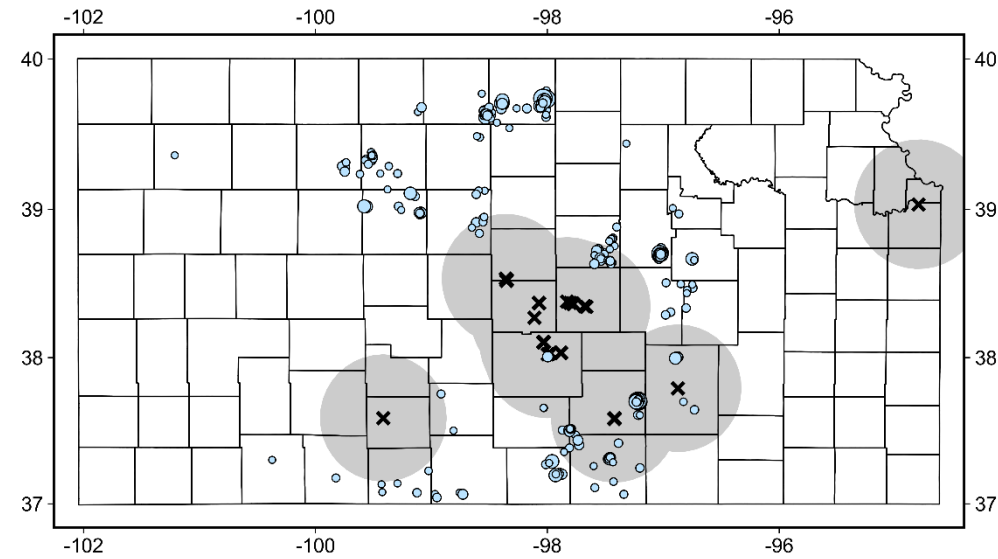
magnitude

- 1
- 2
- 3
- 4

- Forest City Basin
 - Nemaha Ridge
 - Bourbon Arch
- Mapped structures
 - no mapped faults
 - NW structural trends
- Seismicity
 - Historic
 - M 0.8 to M 2.1 in 1980s
 - M 3 in 1999
 - Local: none
 - 4 subnetwork events
 - M-0.6-M 0
 - ~5 mi
 - Consistent with previous

Summary

- Earthquake rate dropping overall
 - -25% statewide
 - some exceptions
 - Wichita
 - Russell Co
 - evidence of slight increase in last 12 months
 - more earthquakes outside of known clusters
 - Meade
 - Pratt
 - Butler
 - largest events recorded in a few counties
- Formation pressure mostly stable
 - possibly dropping in SG
 - possibly rising in KW, MP
 - because it remains elevated, fluctuations could trigger
 - Wichita possible example
- CSTS network seismicity
 - uptick in Wichita
 - new seismicity in BU
 - uptick in subnetwork events in EW, MP



Regional Trends and Local Seismicity Near CSTS Member Wells



Shelby Peterie, Rick Miller, Juliana Gonzales, Carl Gonzales, Erik Knippel
Kansas Geological Survey

Fourth Annual CSTS Meeting
August 5, 2021
McPherson, KS

