Characterizing a Magnitude 5.3 Slow-Slip Event in the Permian Basin

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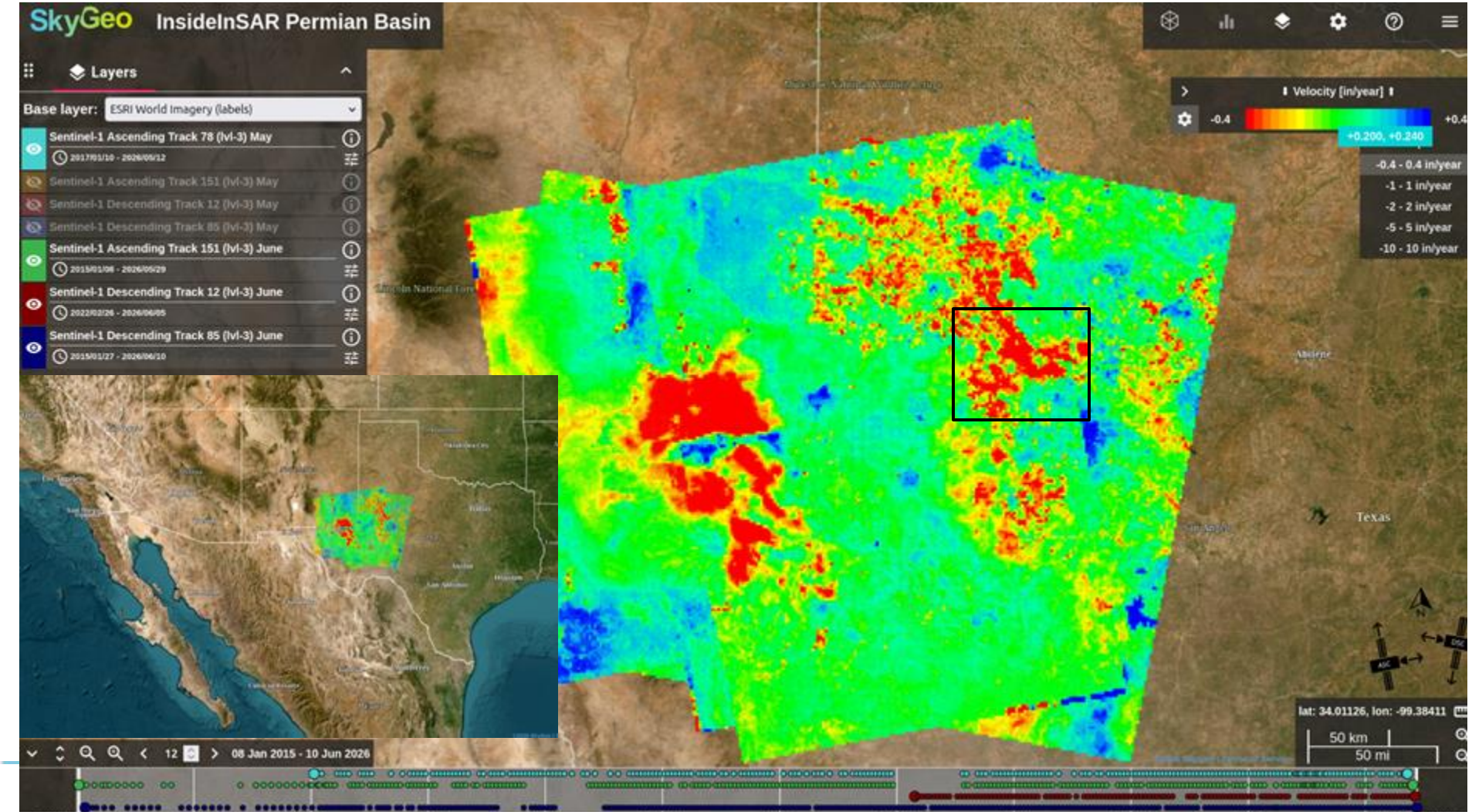
Andrew Keene[2]

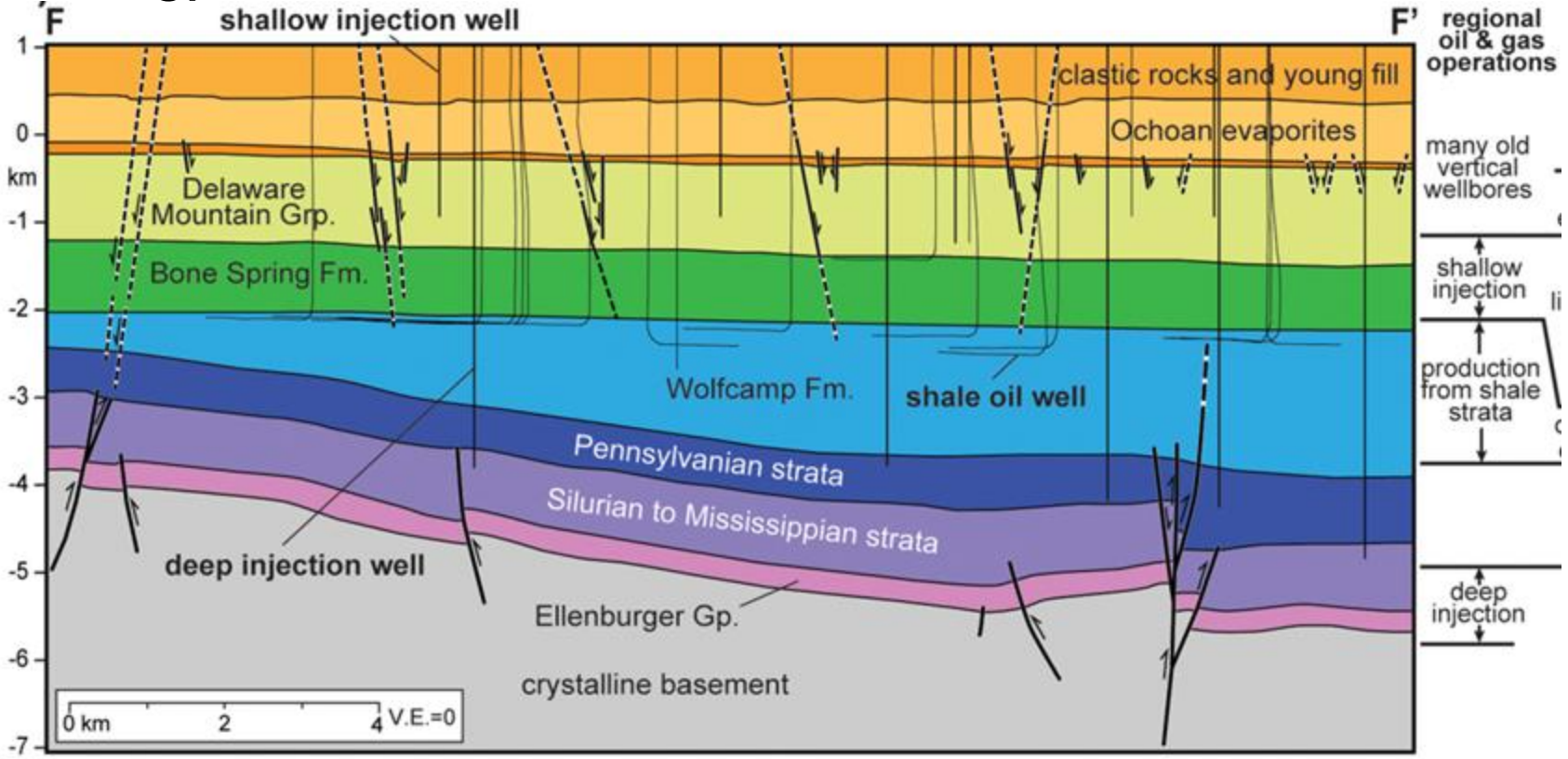
1 - SkyGeo
2 - SM Energy

Fringe 2026, 15-19.06.2026

SkyGeo SM ENERGY

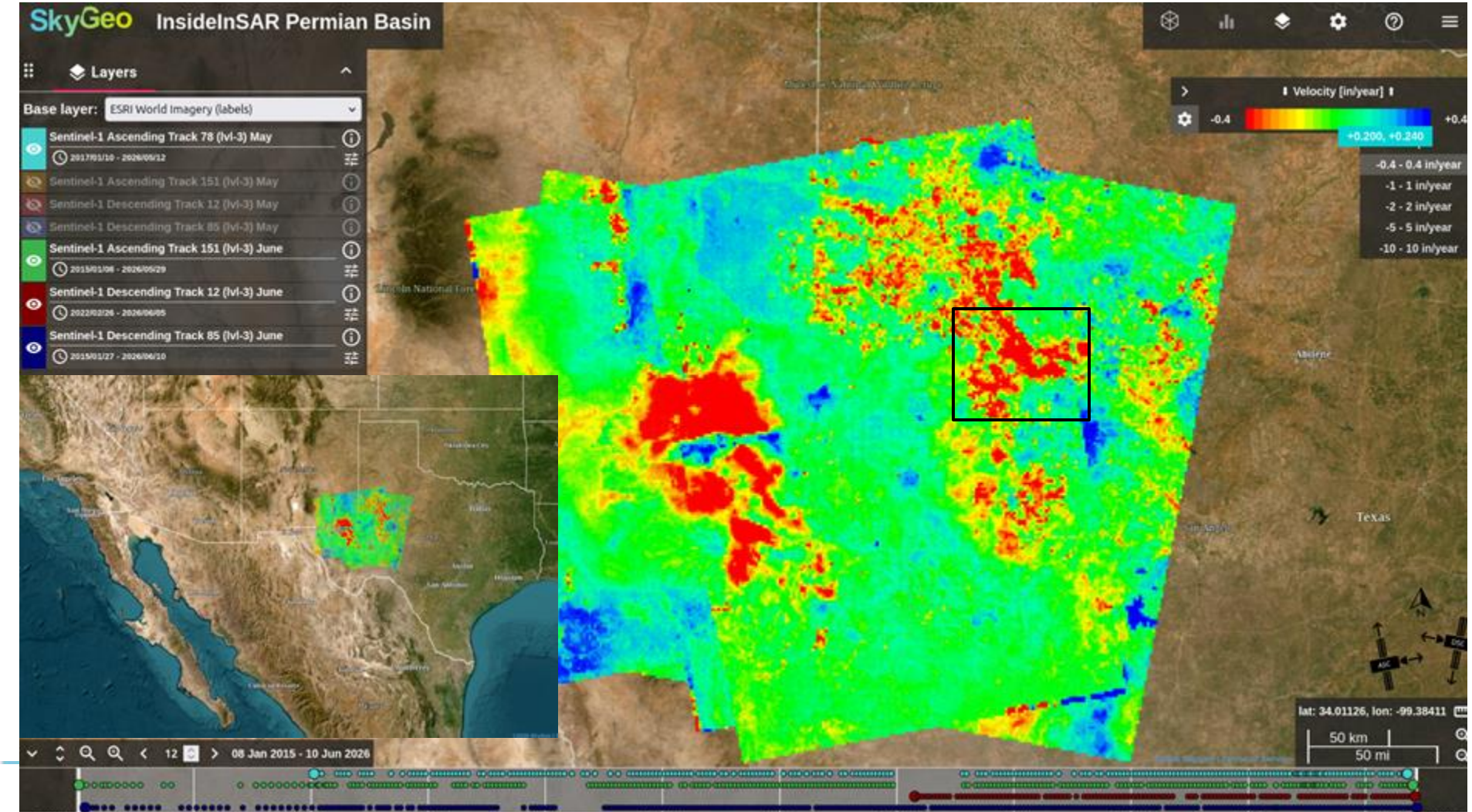

SkyGeo
InsideInSAR Permian Basin
Layers
Base layer:
ESRI World Imagery (labels)
Sentinel-1 Ascending Track 78 (lvl-3) May
2017/01/10 - 2026/05/12
Sentinel-1 Ascending Track 151 (lvl-3) May
Sentinel-1 Descending Track 12 (lvl-3) May
Sentinel-1 Descending Track 85 (lvl-3) May
Sentinel-1 Ascending Track 151 (lvl-3) June
2015/01/06 - 2026/05/29
Sentinel-1 Descending Track 12 (lvl-3) June
2022/02/26 - 2026/06/05
Sentinel-1 Descending Track 85 (lvl-3) June
2015/01/27 - 2026/06/10
Velocity [in/year]
-0.4
+0.4
+0.200, +0.240
-0.4 - 0.4 in/year
-1 - 1 in/year
-2 - 2 in/year
-5 - 5 in/year
-10 - 10 in/year
Texas
lat: 34.01126, lon: -99.38411
50 km
50 mi
12
08 Jan 2015 - 10 Jun 2026

Geology in the Permian basin



Hennings et al. 2023

SkyGeo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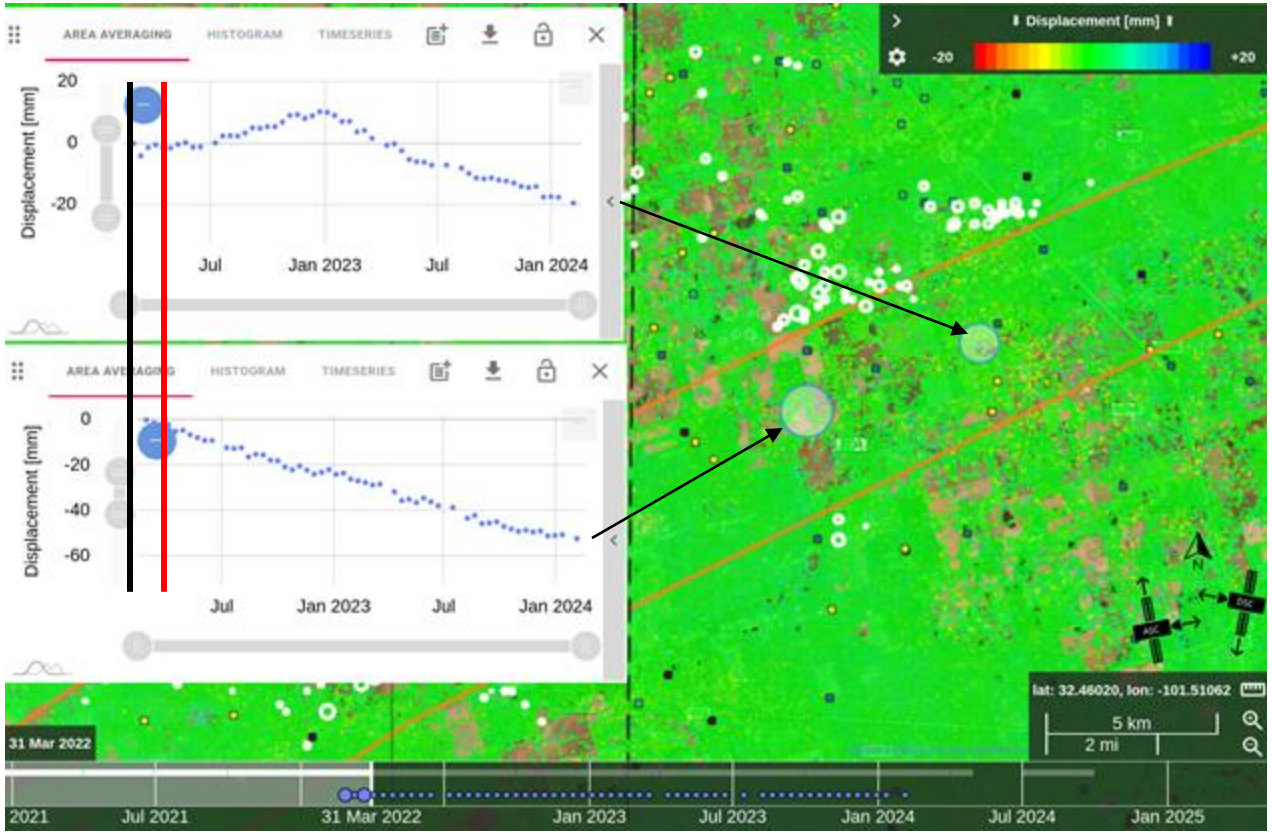
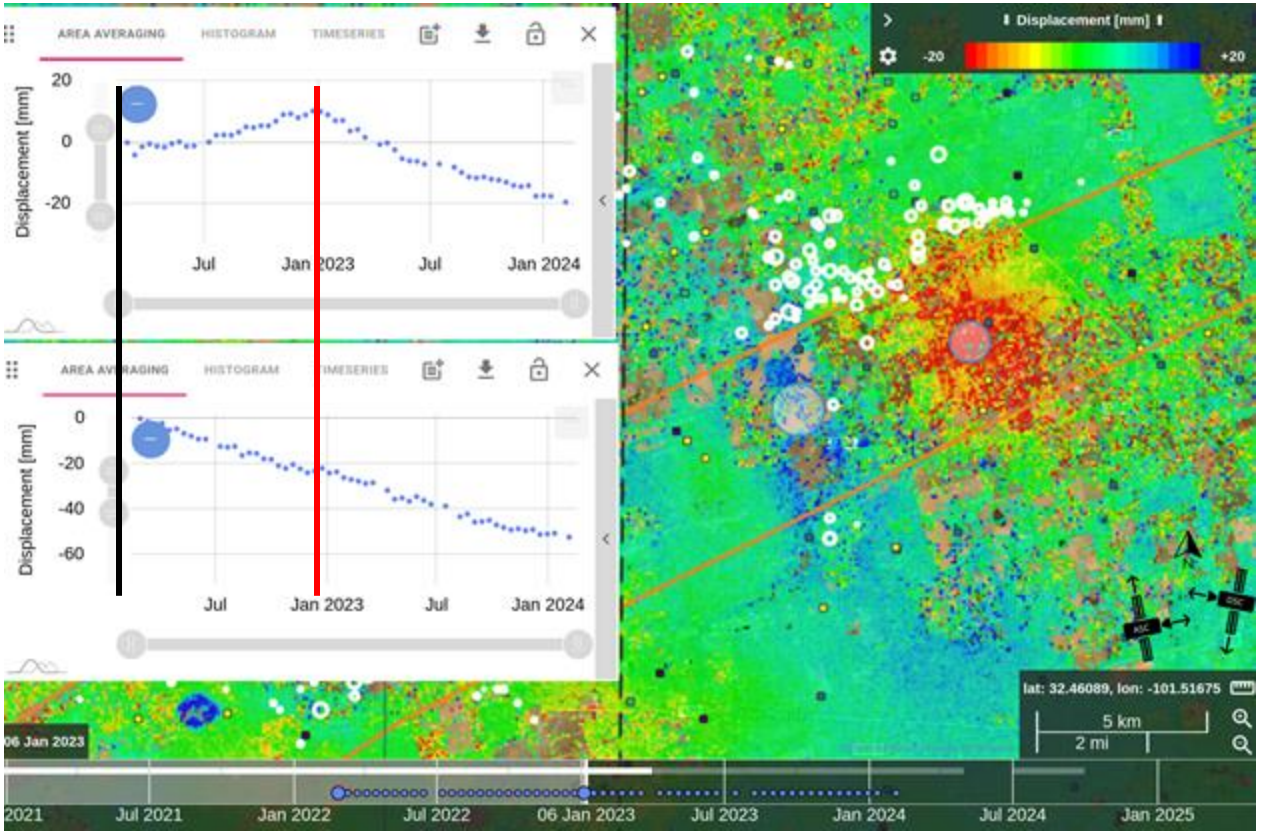
PSI data and seismicity - pre event



SkyGeo

PSI data and seismicity - slow slip event?



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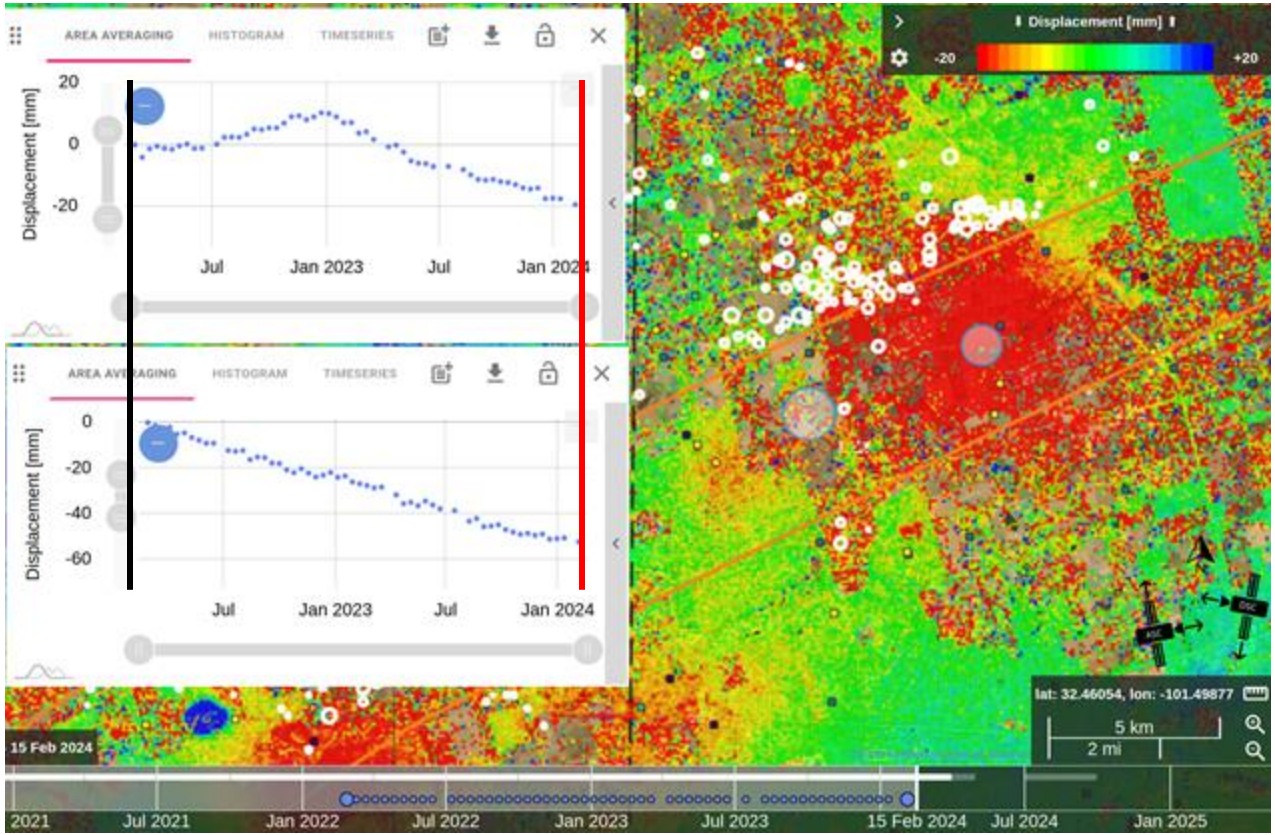
PSI data and seismicity - production post event



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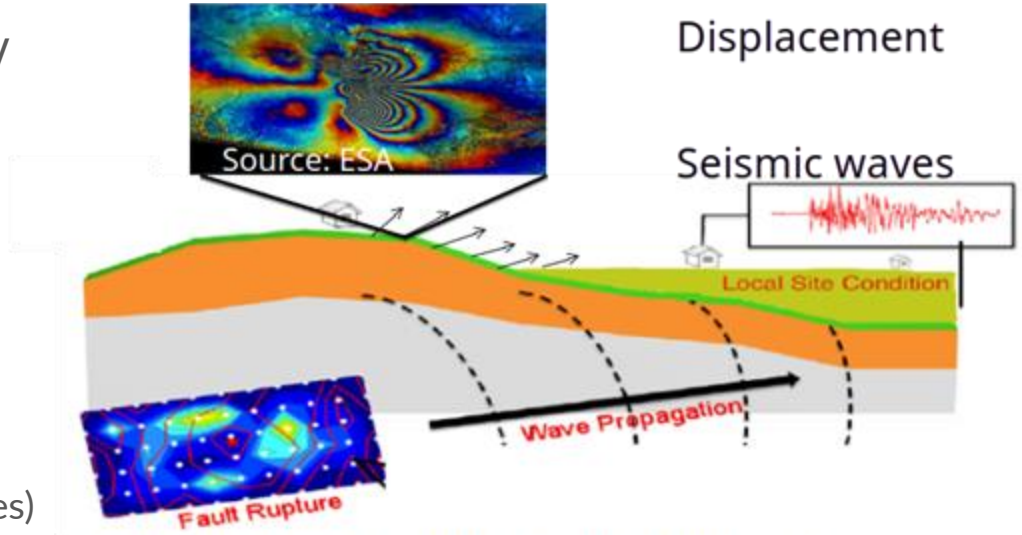
What is going on in the subsurface?

- Knowns: surface deformation velocity from InSAR timeseries
- Determine fault parameters at subsurface:
  - Location (x, y, z)
  - Size of fault plane (length, width)
  - Orientation of fault plane (strike, dip-angles)
  - Faulting mechanism (rake angle)
  - Magnitude of slip-rate

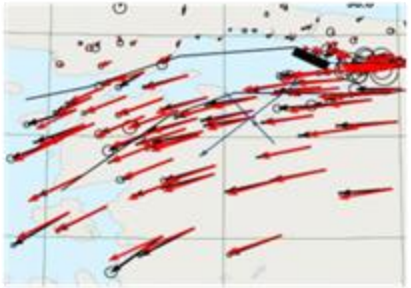


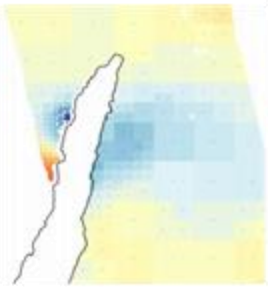
The Bayesian Earthquake Analysis Tool

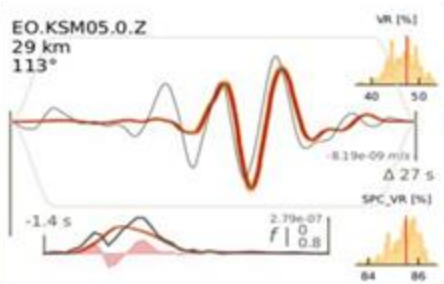
Multi-dataset joint inference

- GNSS
- InSAR
- waveforms

- amplitude spectra
- onset polarities

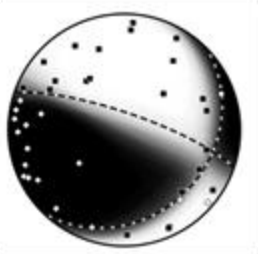


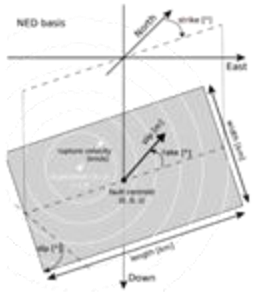


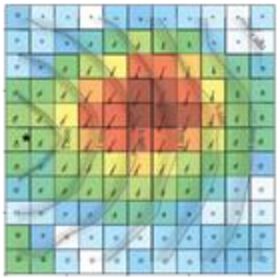


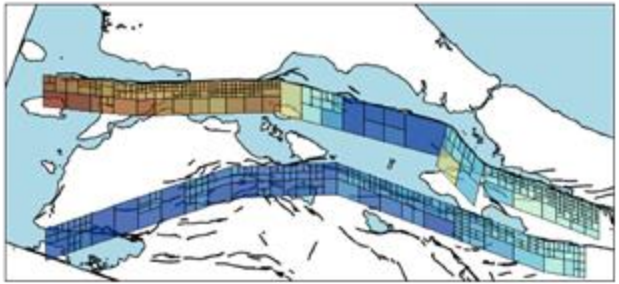
BEAT
BAYESIAN EARTHQUAKE ANALYSIS TOOL

From point source to multi-segment finite-fault









Vasyura-Bathke et al. 2020, 2021, 2023, 2024

pyrocko.org

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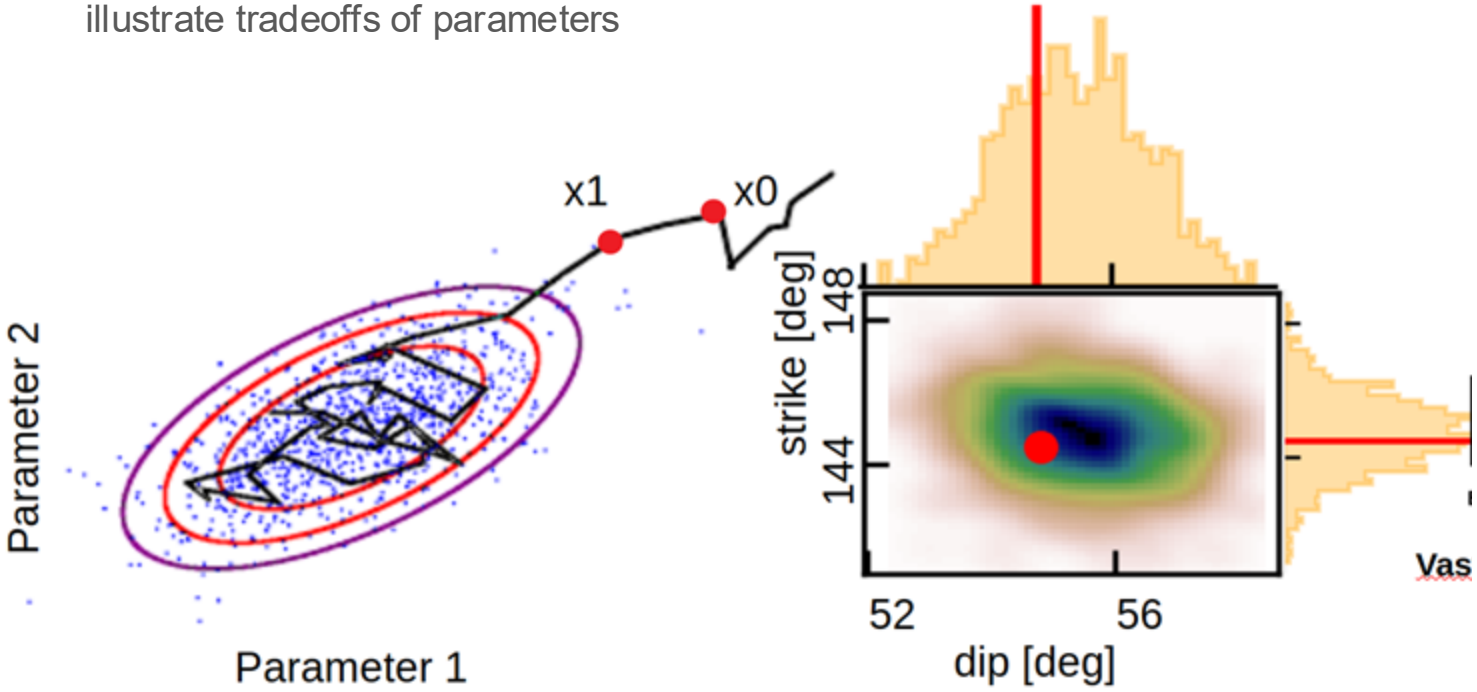
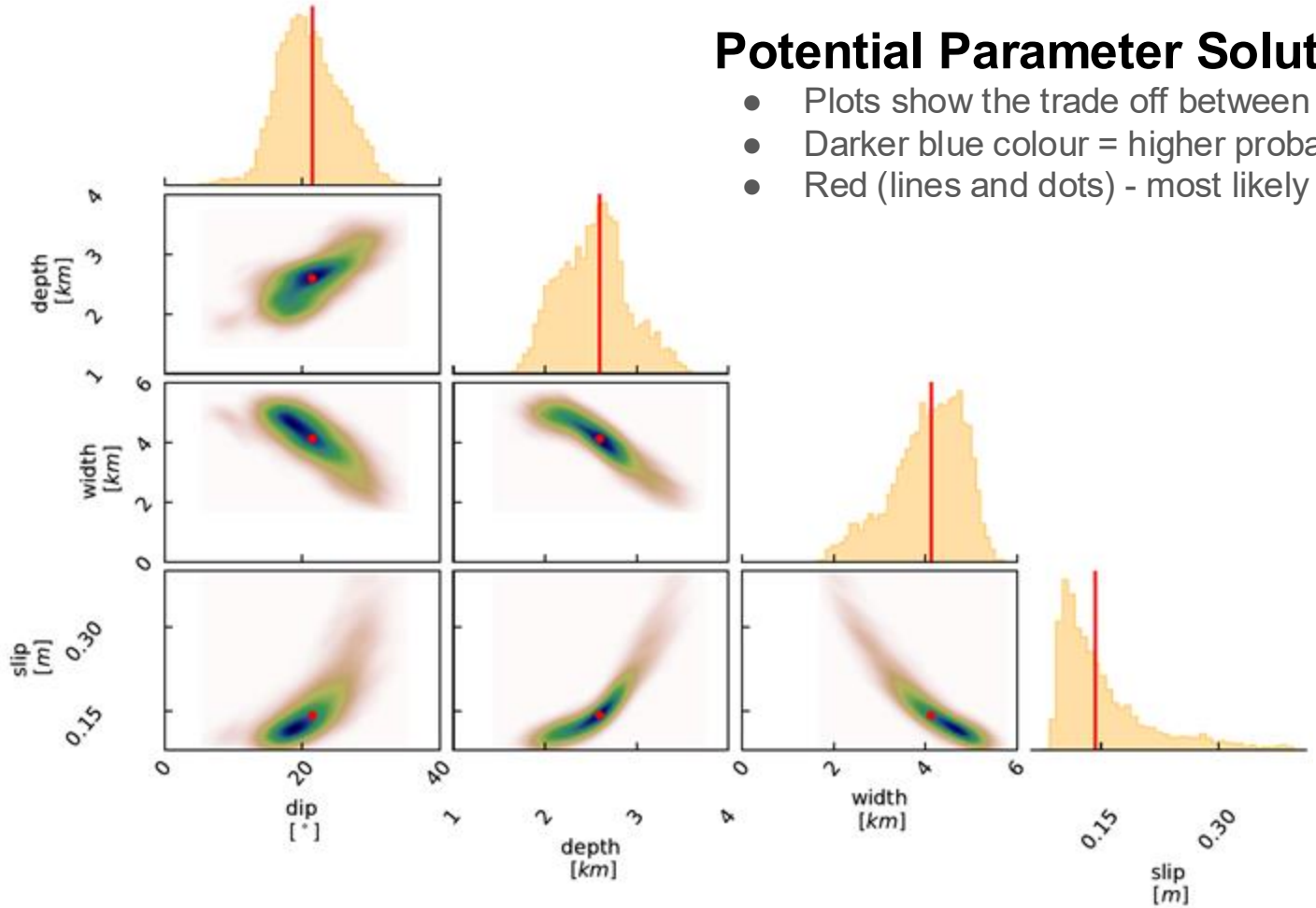
How do we search for the parameters and quantify their uncertainties?

- Left: sample the n-dimensional solution space with Markov Chain Monte Carlo methods
- Right: collect ensemble of model parameters that explain data within associated data uncertainties→ in 1d histograms and in 2d to illustrate tradeoffs of parameters



Potential Parameter Solutions

- Plots show the trade off between histograms
- Darker blue colour = higher probability
- Red (lines and dots) - most likely



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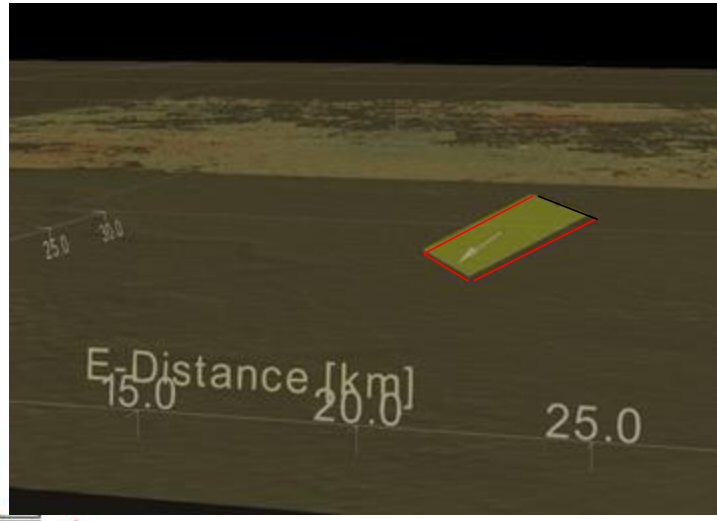

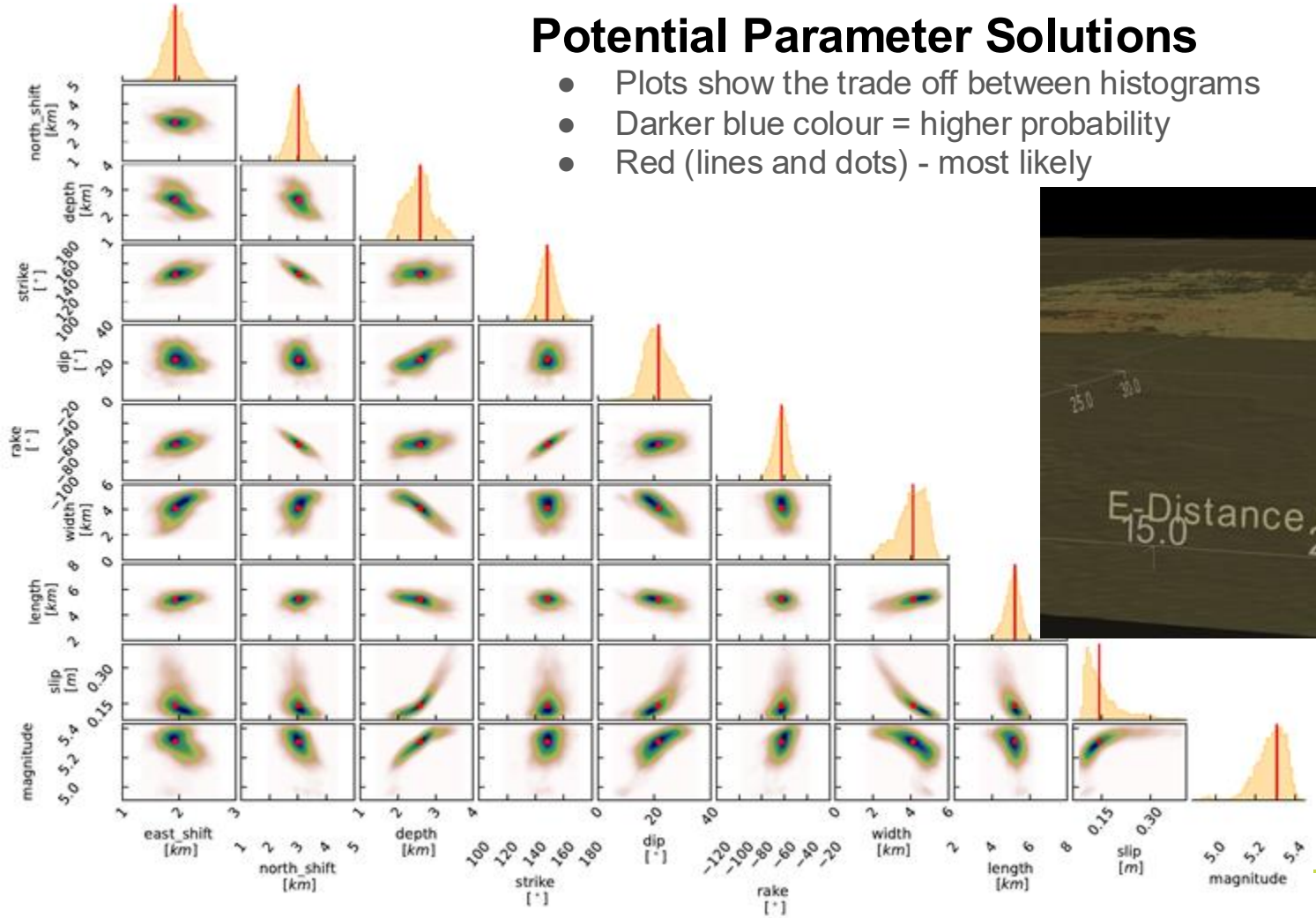

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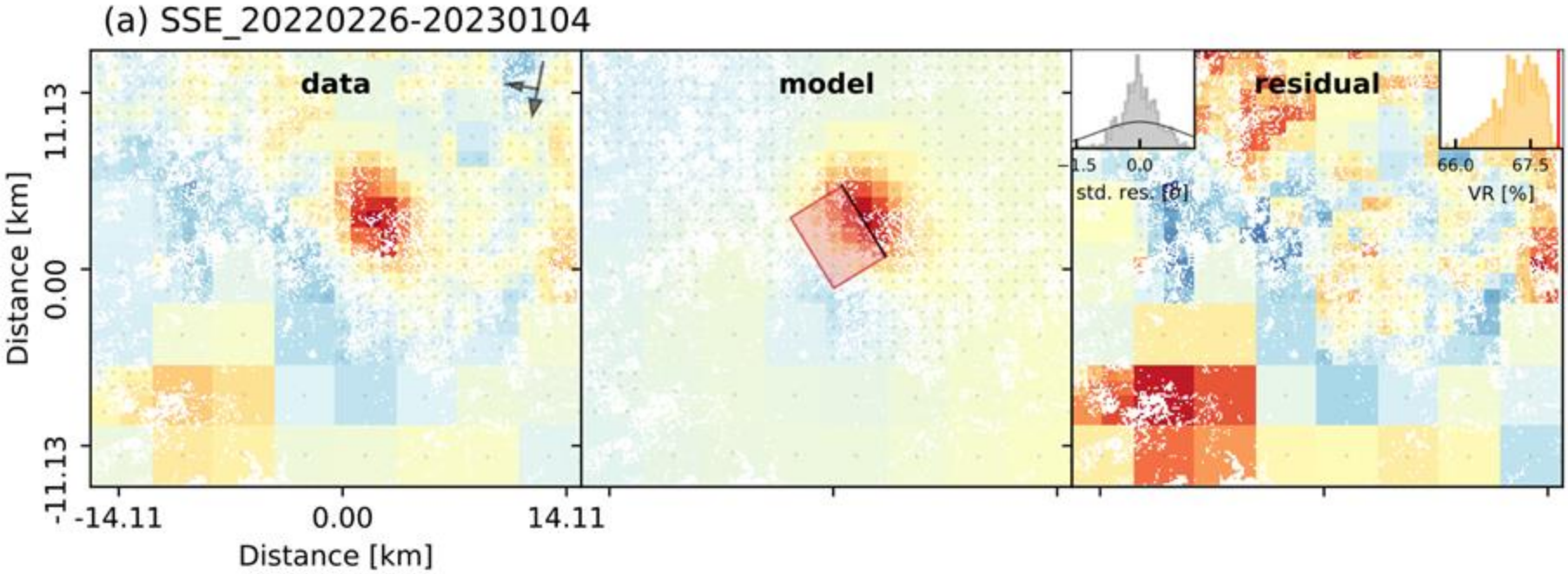
Results: fit to data is good



- Orange histogram shows percentage of data explained
- Red rectangle: best fitting fault plane, upper edge in black

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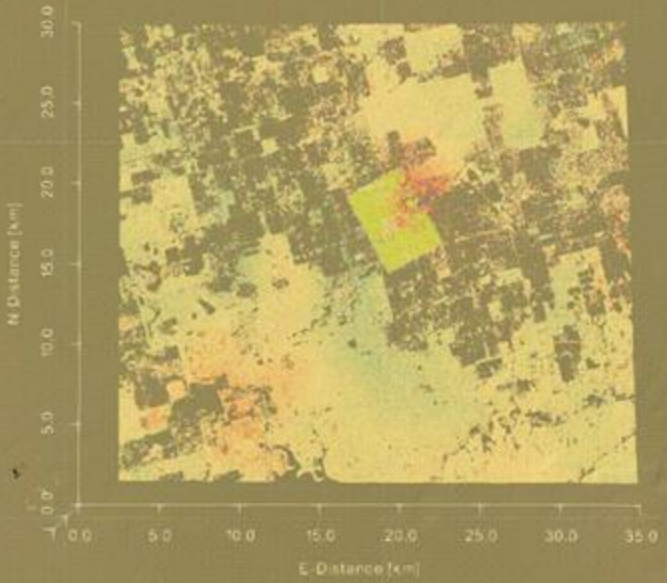
Midland slow slip event February 2022- January 2023

Displacement (m)

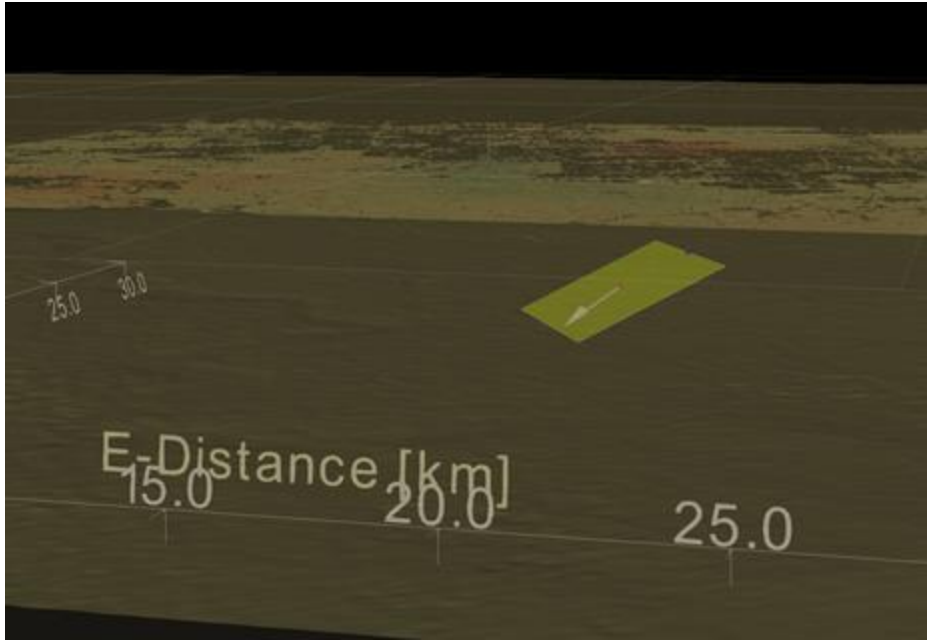
0.03
0.01
0.00
-0.01
-0.03



Summary of inversion results

- NW-SE striking fault
- Normal faulting with oblique component
- Moment magnitude Mw 5.1-5.4
- Swarm of seismicity to the adjacent to the North of the main thrust up to 10km depth

  January 2021- December 2024



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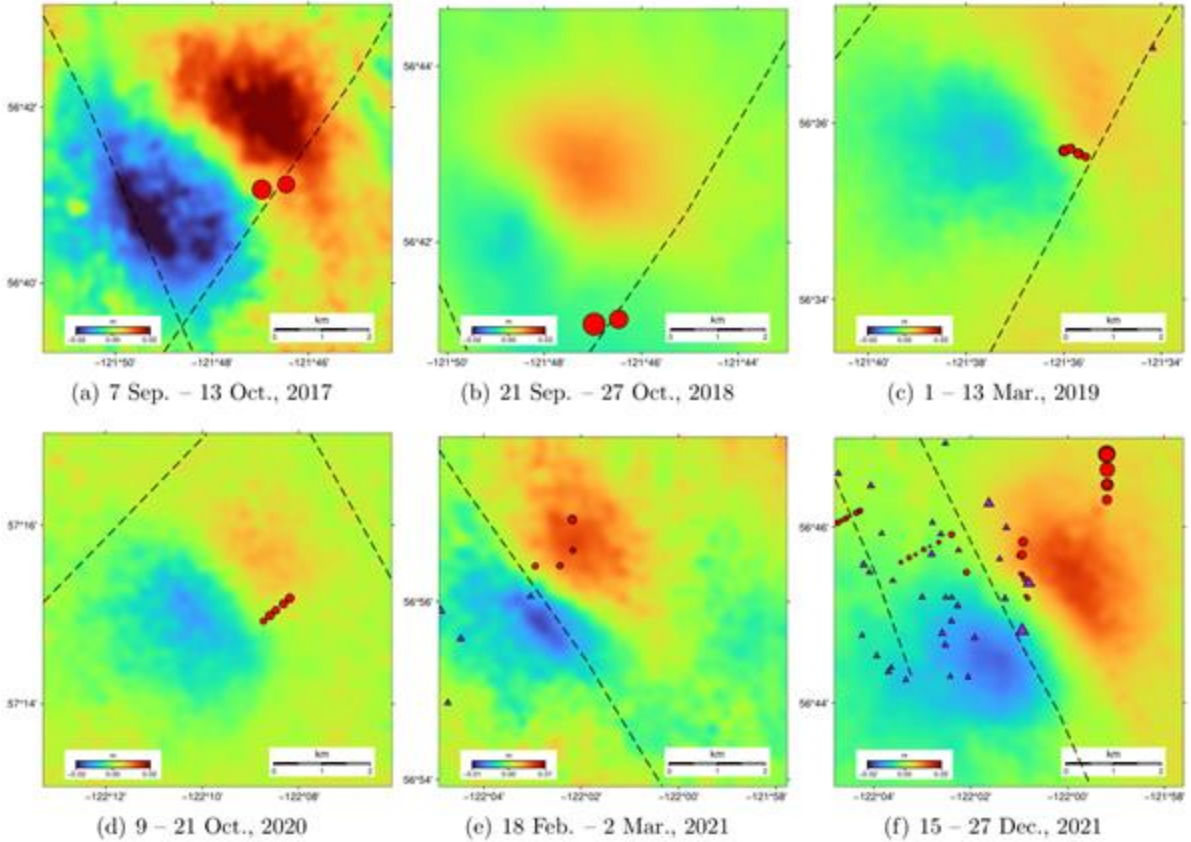
Do we see that elsewhere? Yes, indeed!



(a) 7 Sep. – 13 Oct., 2017 (b) 21 Sep. – 27 Oct., 2018 (c) 1 – 13 Mar., 2019

(d) 9 – 21 Oct., 2020 (e) 18 Feb. – 2 Mar., 2021 (f) 15 – 27 Dec., 2021

Van der Baan, Samsonov, **Vasyura-Bathke** et al. under revision

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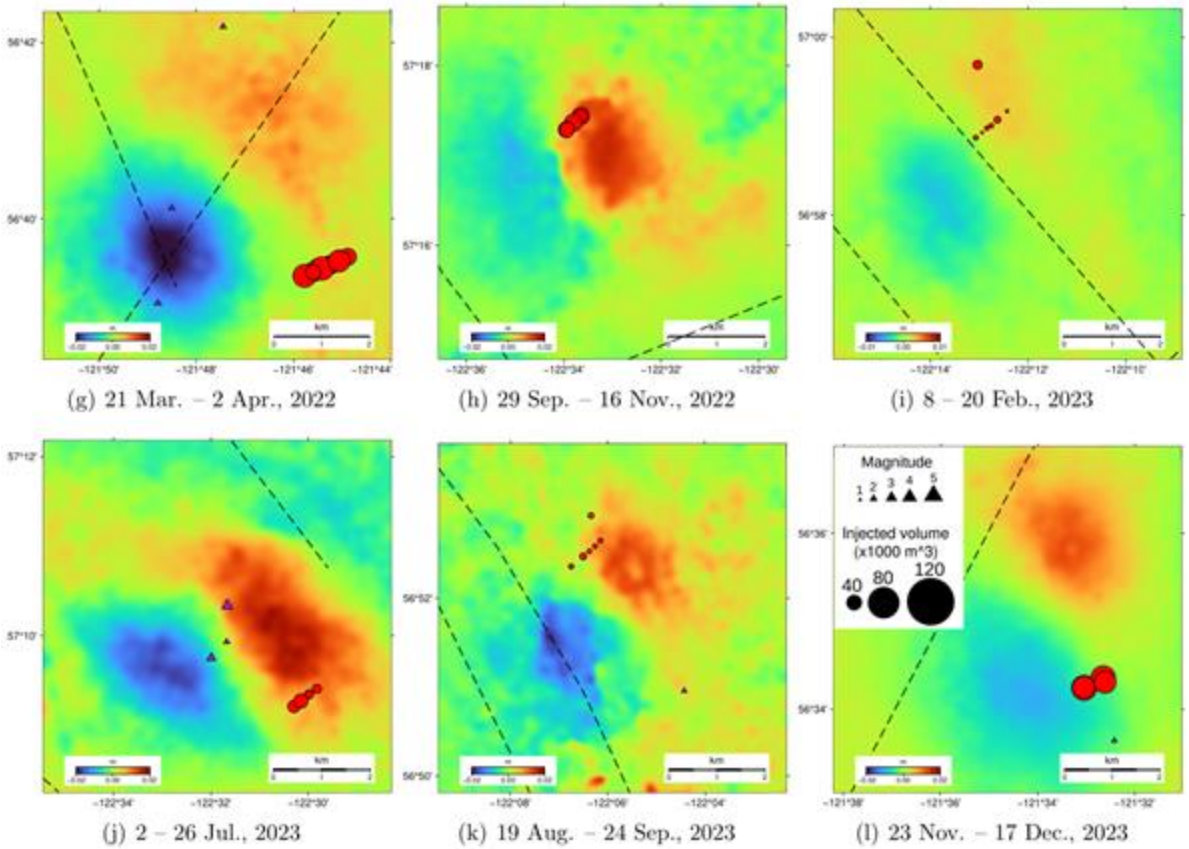

(g) 21 Mar. – 2 Apr., 2022 (h) 29 Sep. – 16 Nov., 2022 (i) 8 – 20 Feb., 2023

(j) 2 – 26 Jul., 2023 (k) 19 Aug. – 24 Sep., 2023 (l) 23 Nov. – 17 Dec., 2023

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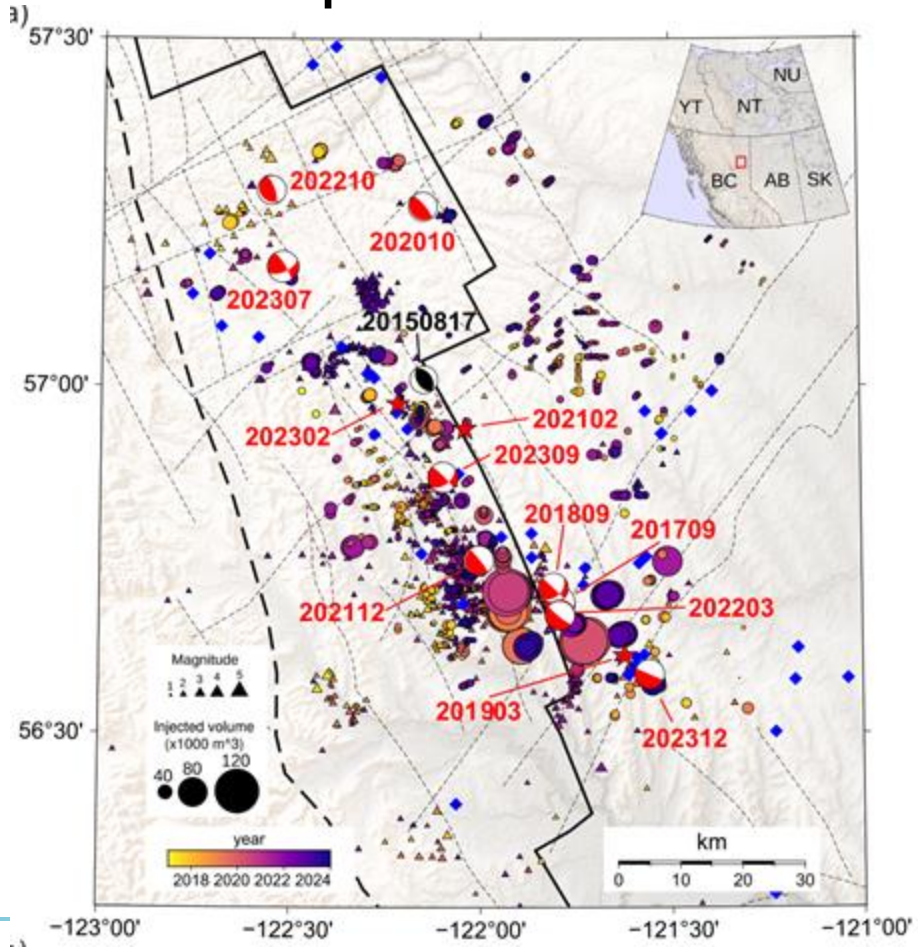
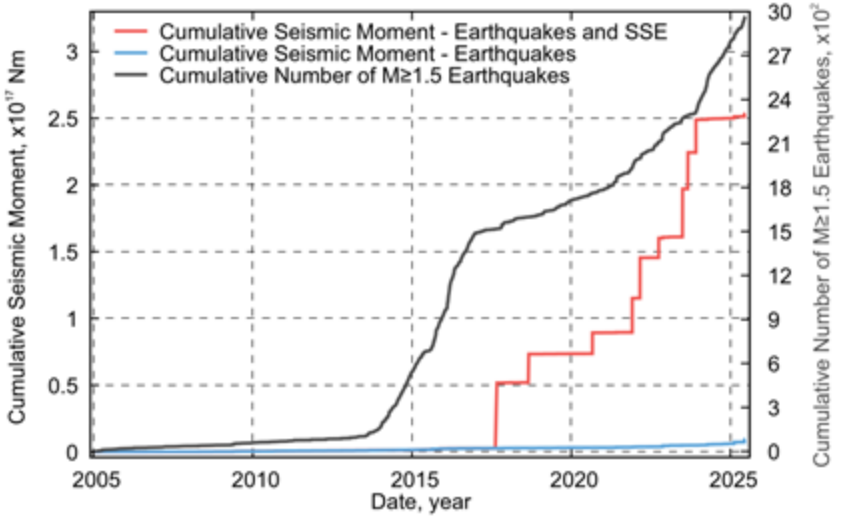
Slow slip events in the Western Canadian Basin





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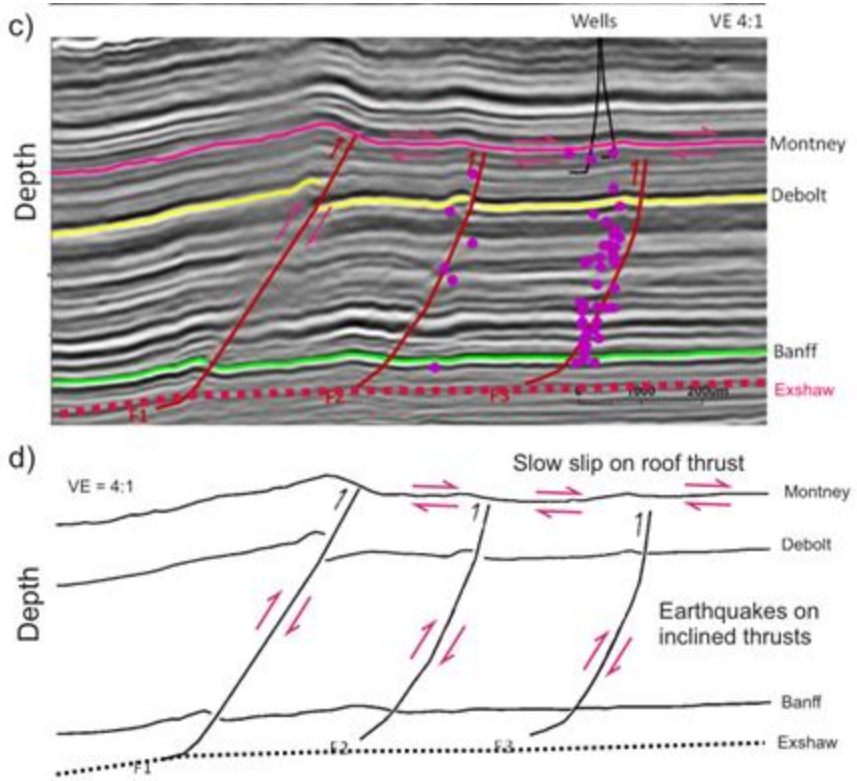
Conclusions

- Several slow slip events in the Rocky mountain fold and thrust belt
- Each showing low angle faulting at shallow depth
- Each event has closeby saltwater disposal wells



Thank you
for your attention!

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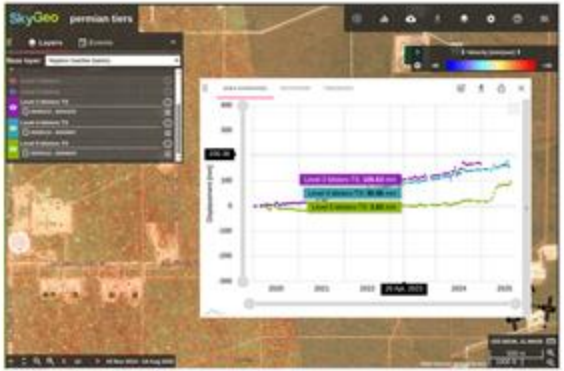
Your Basin-Wide Baseline for Permian Basin Ground Motion



InsideInSAR is your **starting point**, not your final answer. When decisions affect safety, production or long-term asset value, SkyGeo's **low-risk, higher-level services** provide the extra quality and interpretation you need.

The Permian Basin is one of the most intensively developed hydrocarbon basins in the world. Injection, production, water handling and infrastructure build-out all change the stress in the subsurface – and the ground responds.

InsideInSAR makes that response visible.

Using satellite radar (InSAR), we provide a **baseline, basin-wide view** of slow ground motion across the Permian Basin. It's free to use, so operators, midstream owners, regulators and researchers can all start from **the same baseline picture**.

The map is:

- **Wide-area and long-term** – covering the Midland, Delaware and Central Basin Platform with several years of history.
- **Lowest-quality, hence high-risk for decision-making - if you're after decisions, reach out to SkyGeo for higher-level products.**

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