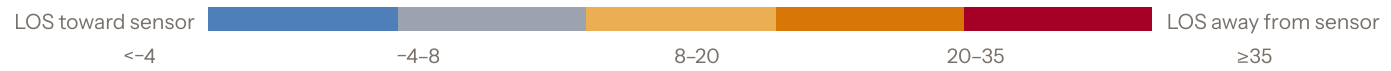
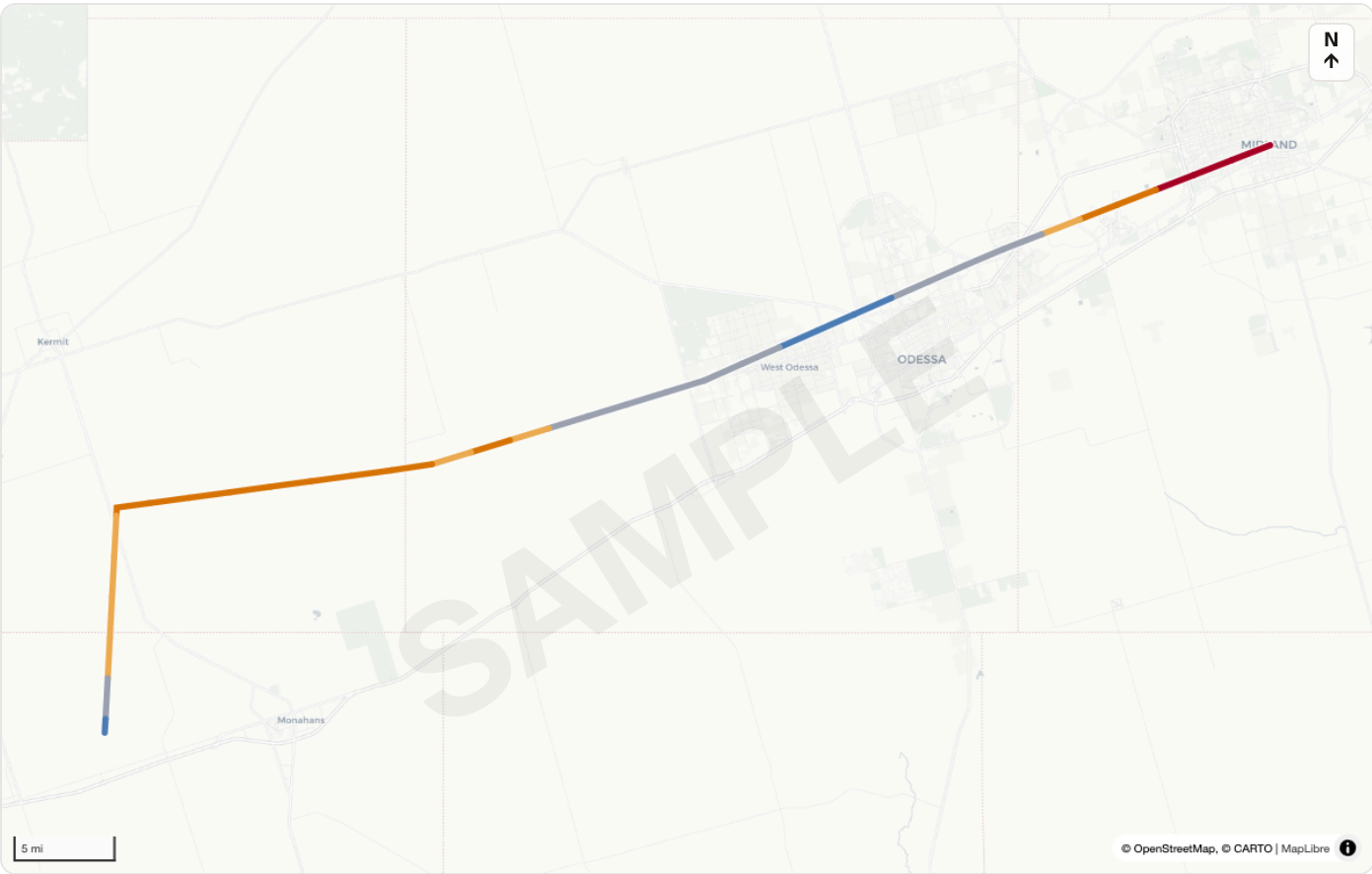


Pipeline Corridor Displacement Screening — Methodology Exhibit

Permian Basin crude corridor (Midland–Monahans–Wink), West Texas · Sentinel-1 C-band InSAR displacement baseline, 2025-08-02 → 2025-12-30

This exhibit demonstrates GroundPulse’s per-segment displacement screening on a real Sentinel-1 interferometric time series over the corridor. Every figure is measured.



Per-segment line-of-sight displacement rate (mm/yr) along the ≈71-mi corridor, Midland (NE) → Monahans/Wink (SW), over the 15-acquisition baseline (2025-08-02 → 2025-12-30). Centerline colored by ordinary-least-squares LOS rate — the same per-segment values tabulated below. Basemap © OpenStreetMap, © CARTO. Positive = motion away from the sensor (LOS, relative baseline) — consistent with subsidence documented in this basin (Staniewicz et al. 2020). Geometry is an approximate public corridor centerline, not an operator alignment sheet; LOS ≠ axial pipe strain.

CORRIDOR SCREENED 71 mi	SEGMENTS 36	ACQUISITIONS 15	LOS RATE RANGE -7.3–+46.3 mm/yr
----------------------------	----------------	--------------------	------------------------------------

Per-Segment Line-of-Sight Displacement Rate

Measured LOS velocity per 2-mile segment over the 15-acquisition baseline (2025-08-02 → 2025-12-30), ordered NE → SW along the corridor. **Positive = motion away from the sensor** (LOS, relative baseline; consistent with basin subsidence per Staniewicz et al. 2020). Each segment carries the full 15-epoch series. No risk tier or hazard class is asserted here — see “What this shows” below. Geographic anchors are approximate: segments 1–6 are the NE Midland lobe; segments 8–19 cross the West Odessa near-stable section; segments 20–31 cover the central Monahans–Wink lobe; segments 32–36 taper toward the SW end. Exact attribution to operator stationing requires the operator alignment sheet.

SEGMENT	APPROX. MILEPOST	LOS RATE (MM/YR)	OBS.
1	0.0	● +37.2	15
2	2.0	● +44.9	15
3	4.0	● +46.3	15
4	6.0	● +29.7	15
5	8.0	● +21.0	15
6	10.0	● +15.3	15
7	12.0	● +7.2	15
8	14.0	● -2.1	15
9	16.0	● -1.8	15
10	18.0	● -1.0	15
11	20.0	● -6.9	15
12	22.0	● -7.3	15
13	24.0	● -5.8	15
14	26.0	● -2.2	15
15	28.0	● +1.6	15
16	30.0	● +4.9	15
17	32.0	● +2.5	15
18	34.0	● +4.2	15
19	36.0	● +6.4	15
20	38.0	● +14.3	15
21	40.0	● +20.7	15
22	42.0	● +17.1	15
23	44.0	● +20.6	15
24	46.0	● +22.4	15
25	48.0	● +23.3	15
26	50.0	● +25.4	15
27	52.0	● +20.5	15
28	54.0	● +20.6	15

SEGMENT	APPROX. MILEPOST	LOS RATE (MM/YR)	OBS.
29	56.0	● +29.1	15
30	58.0	● +25.9	15
31	60.0	● +18.4	15
32	62.0	● +18.6	15
33	64.0	● +15.2	15
34	66.0	● +15.4	15
35	68.0	● +1.9	15
36	70.0	● -7.2	15

Spatial pattern: two coherent subsidence lobes — a sharp peak (≈ 46 mm/yr) at the NE (Midland) end and a broader secondary lobe (≈ 25 – 29 mm/yr) along the central corridor — separated by a near-stable to slightly-upward mid-section (West Odessa) and tapering to near-stable at the SW. The structure is spatially organized, not scattered noise.

What This Shows

Shows: where, and by how much, the ground along the corridor moved over the 2025-08-02–2025-12-30 window, per segment, from independent satellite radar — a prioritization of segments by measured movement.

Hazard Mechanism & Independent Corroboration

The measured subsidence gradient is consistent with the documented driver of deformation in this part of the Permian: hydrocarbon and produced-water extraction and subsurface fluid movement, which have produced widespread, spatially-variable surface deformation across the Pecos–Reeves–Ward–Winkler oil patch — including localized subsidence of several cm/yr near legacy wells and injection-related uplift. The independent peer-reviewed record:

Staniewicz, S., et al. (2020), “InSAR reveals complex surface deformation patterns over an 80,000 km² oil-producing region in the Permian Basin,” *Geophysical Research Letters*, 47, e2020GL090151. [doi:10.1029/2020GL090151](https://doi.org/10.1029/2020GL090151)

Method Notes

Sensor: Sentinel-1 A/B, C-band. Source: GroundPulse Dolphin CSLC surface-displacement product (GroundPulse in-house), over the corridor. Per-segment aggregates computed over pixels within each segment’s right-of-way buffer; up to 4,666,813 coherent samples per acquisition across the corridor AOI. Velocity is an ordinary-least-squares rate over the 15-epoch series.

Model & Parameters	
Sensor/product: Sentinel-1 A/B C-band; GroundPulse in-house dolphinRust CSLC	Dolphin product lineage: GroundPulse dolphinRust CSLC run; frame F20697
Window: 2025-08-02 → 2025-12-30; 15 acquisitions	Rate model: ordinary least squares over the 15-epoch segment series

Coherence gate: temporal coherence ≥ 0.5 before AOI/ROW containment

Outlier policy: MAD reject $\sigma=3.0$ for along-pipe kinematic indicators

Reference handling: relative Dolphin LOS baseline; no GNSS datum tie asserted here

ROW buffer: 500 m centerline buffer in the EIA import path

Samples: up to 4,666,813 coherent pixels per acquisition across the corridor AOI

Storage: per-pixel evidence remains raster/COG; report uses aggregate serving values

- Line-of-sight (LOS) geometry: Sentinel-1's near-polar orbit heading ($\sim 13^\circ$ off north) makes the radar largely blind to N-S motion, so N-S-trending segments are under-measured; at $\sim 29\text{--}46^\circ$ incidence, reported rates mix vertical and E-W components and are LOS, not vertical.
- **LOS velocity is not axial pipe strain.** True strain requires pipe geometry, boundary conditions, and soil-pipe interaction modeling (ALA/ASCE guidelines). These rates screen *where* ground is moving, not pipe stress.
- InSAR measures surface line-of-sight motion. It does not model trench settling, pipe embedment, or depth-of-cover change; those are separate geotechnical / integrity analyses.
- Reference-point stability is assumed; a drifting reference is an InSAR-internal bias source distinct from trench settlement or depth-of-cover change.
- Temporal decorrelation in vegetated, disturbed, or actively-worked terrain reduces coherence and rate reliability. Dig-ins and open ROW work can both decorrelate the radar signal and carry settling/depth-of-cover changes this screening layer may not capture.
- Processing-method sensitivity: different InSAR time-series methods can yield materially different results on the same stack.
- Corridor geometry is an **approximate centerline reconstructed from public route references — NOT an operator alignment sheet**. Per-segment values are sampled along that approximate line; exact-alignment attribution requires the operator's stationing.

Data Currency & Forward Availability

Baseline window: 2025-08-02 $\rightarrow$ 2025-12-30 (15 Sentinel-1 acquisitions, 12-day nominal revisit). Sentinel-1 acquisition over this corridor continues, so the record extends forward with every pass, and each pass re-checks alert thresholds. Operator strain-gauge or other in-situ strain data would be a natural cross-validation input for any pilot that needs to connect surface motion to pipe response.

Corridor map (this build): the figure above renders the screened centerline over a labeled basemap with scale bar and north orientation, each ≈ 2 -mi segment colored by its measured OLS LOS rate — the same values tabulated above. Geometry remains an **approximate public corridor centerline reconstructed from public route references**, not an operator alignment sheet; exact-alignment attribution requires operator stationing. The source geometry comes from public-domain EIA Energy Atlas crude-oil pipeline data fetched by `scripts/fetch-eia-pipelines.py`, filtered to the corridor and imported as GeoJSON centerline segments with 500 m buffers.