LONQUIST FIELD SERVICE

December 13, 2024

From:

Nathaniel Byars, Lonquist & Co. LLC

Sergey Samsonov, PhD, InSAR Corporation

Julie Shemeta, MEQ Geo Inc.

Re: Combined Monthly Surface Deformation Report – November 2024
Sulphur Mines Salt Dome, Louisiana

Please find attached the combined monthly deformation report for Sulphur Mines dome which includes results from the precision tiltmeters and GNSS stations for the November monitoring period and the cumulative InSAR results as of month end.

Status of a deformation alert plan. We are testing a draft deformation alert system that reports daily tiltmeter activity in relation to the full statistical history of the network. Alert thresholds will be set and adjusted to prioritize long-duration signals observed at multiple monitoring sites over anomalous or short-duration tilt signals associated with precipitation, shallow deformation, or mechanical activities near individual sites. We plan to integrate tiltmeter deformation alert levels with real-time monitoring data from Sulphur Mines, which include the Cavern 7 pressure and microseismic monitoring. GNSS and InSAR data will also be used for validation.

Sincerely,

Nathaniel Byars
Principal Engineer
Lonquist & Co. LLC

Julie Shemeta
MEQ Geo Inc.

Attachment List

A. Tiltmeter/GNSS Data Report - November 2024
B. SNT InSAR report - November 27, 2024
C. TSX/PAZ InSAR report -November 29, 2024
D. Vertical & East-West 2D InSAR report – November 29, 2024

ATTACHMENT A

Tiltmeter/GNSS Data Report – November 2024

December 13, 2024

Sergey Samsonov, PhD, InSAR Corporation
Nathaniel Byars, Lonquist & Co. LLC
Julie Shemeta, MEQ Geo Inc.

Re: Tiltmeter/GNSS Data Evaluation – November 2024, Sulphur Mines Salt Dome

The tiltmeter/GNSS network, which includes twenty tiltmeters and five GNSS stations, has been operational since June 1, 2024. It was installed and is currently being operated by Halliburton's Pinnacle Group. Please refer to Figure 1 for the map of the tiltmeter and GNSS stations. Station coordinates are provided in Appendix 3.

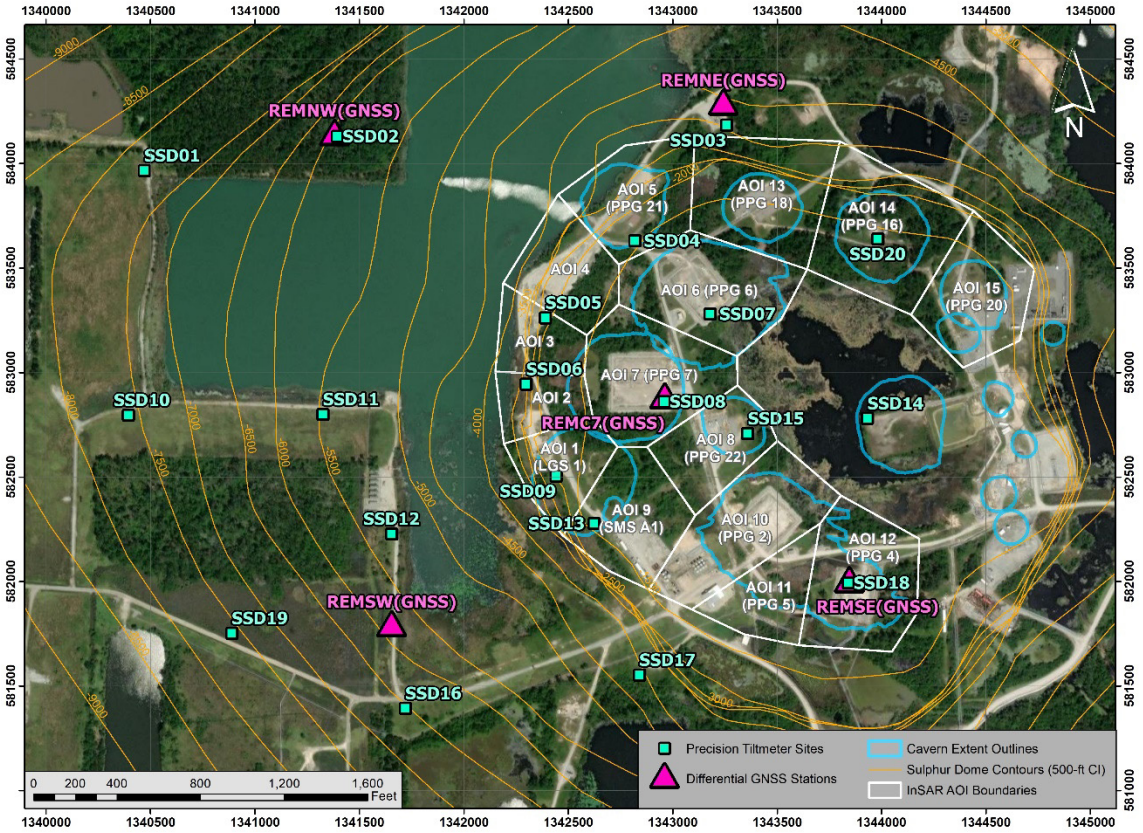


Figure 1. Map of the tiltmeter and GNSS network installed at Sulphur Mines dome. The cyan squares indicate the tiltmeter site locations. The GNSS stations are shown by pink triangles. The InSAR AOI boundaries are shown for reference. The surface projection of the various salt caverns is indicated by blue lines. The salt dome contours are in light orange. The backdrop is an aerial photograph of the Sulphur Mines salt dome.

Introduction

This report describes tiltmeter and GNSS measurements from the Sulphur Mines Salt Dome collected in November 2024.

For each tiltmeter station, the report provides:

- Raw measurements of east and north tilt components (measured in microradians) at four-minute temporal resolution, along with their linear trends
- Detrended east and north tilt components at four-minute temporal resolution
- Daily range of east and north tilt components
- Daily precipitation amount (measured in inches)
- Daily tilt direction distribution diagram, along with the direction to Cavern 7 and direction of the monthly linear trend

For each GNSS station, the report provides:

- Daily time series of east, north, and vertical deformation (measured in inches) and their linear trends in the local reference frame.

In this report, the tiltmeter plots have been revised based on our enhanced understanding of the data and the processes that cause tilt. We removed the colored dashed lines from the plots displaying detrended tilt values (found in the second row from the top). These lines indicated 1-3 sigma offsets from the mean value. However, our analysis shows that because the detrended time series are non-stationary, using standard deviation to identify changes in deformation regimes over short time intervals is less informative than we initially anticipated. A stationary time series is one whose statistical properties remain constant regardless of when the series is observed.

The colored dashed lines have also been removed from the plots that display daily ranges (found in the fourth row from the top). In this instance, the time series of daily tilt ranges is nearly stationary, but their distribution is non-normal (not Gaussian). In a normal distribution, values are evenly distributed around the mean; however, daily tilt ranges have a definitive minimum value of zero and an undefined maximum that can be extremely large.

To analyze the data and flag unusual behavior, we estimate the empirical cumulative distribution function (ecdf) based on tilt data collected since June 1, 2024, for both east and north tilt components. We then calculate the first quartile (Q1, or 25th percentile) and the third quartile (Q3, or 75th percentile), and using the formula Q3 + 1.5(Q3 - Q1), we determine the outlier threshold value above which daily ranges can be considered larger than what can be expected based on the historical record. For further details, see https://en.wikipedia.org/wiki/Box_plot. Daily ranges exceeding the outlier threshold value (red dashed line) are considered unusually large and require further investigation.

We expect this approach will allow us to detect unusual deformation processes accurately.

Additionally, the precipitation amount is now calculated over 24 hours (one day) instead of the previous 1-hour interval. The precipitation data and daily tilt ranges are represented as columns to reflect better the span they cover.

For a description of the other data visualization components not discussed here, please refer to the August 2024 report.

Summary of tiltmeter observations for November 2024

The tiltmeter network was operational throughout the entire November 2024 period. No signals related to anomalous processes in Cavern 7 were detected during this reporting period. The November data plots for each tiltmeter station are shown in Appendix 1 and described below.

Multiple precipitation events in the first half of November resulted in significant daily variations, disrupting the established tilt trends for several days. During these episodes, we closely monitored the tilt directions to ensure they did not consistently point in the same direction, such as toward Cavern 7.

The tiltmeters detected a tilt signal resulting from the Mw 6.8 earthquake on November 10, 2024, near the southeastern coast of Cuba, over 1,000 miles away from our site, demonstrating the high sensitivity of the tilt meters (Figure 2).

Multiple tiltmeters have recorded several changes in tilt directions at irregular times, which we cannot explain. We suspect the levee construction likely contributed to some unexplained tilt signals. For instance, tiltmeter SSD02 experienced an increase in tilt in the second half of November, which could be attributed to the levee construction. Tilt signals caused by precipitation and of unknown origin are shown in Figure 3.

Additionally, we observed minor, random anomalies in single site tiltmeter time series data unrelated to weather. Because these anomalies are only observed on a single station they are most likely linked to local, possibly shallow features in the subsurface, such as movement in the cap rock.

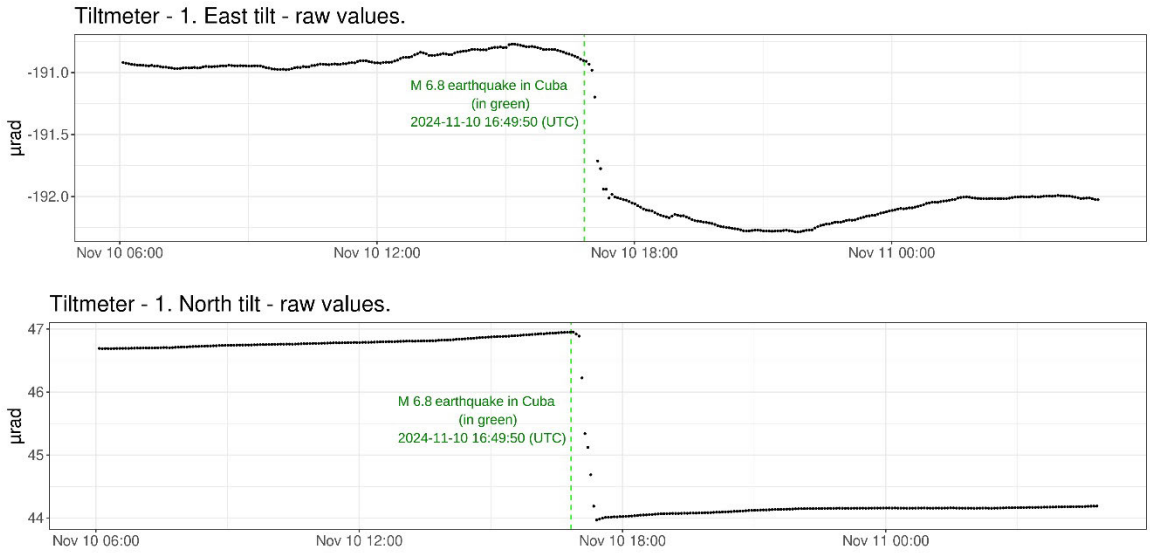


Figure 2. An example of a tilt signal observed by the SSD01 tiltmeter due to the Mw 6.8 earthquake on November 10, 2024, near the southeastern coast of Cuba, over 1,300 miles from our site.

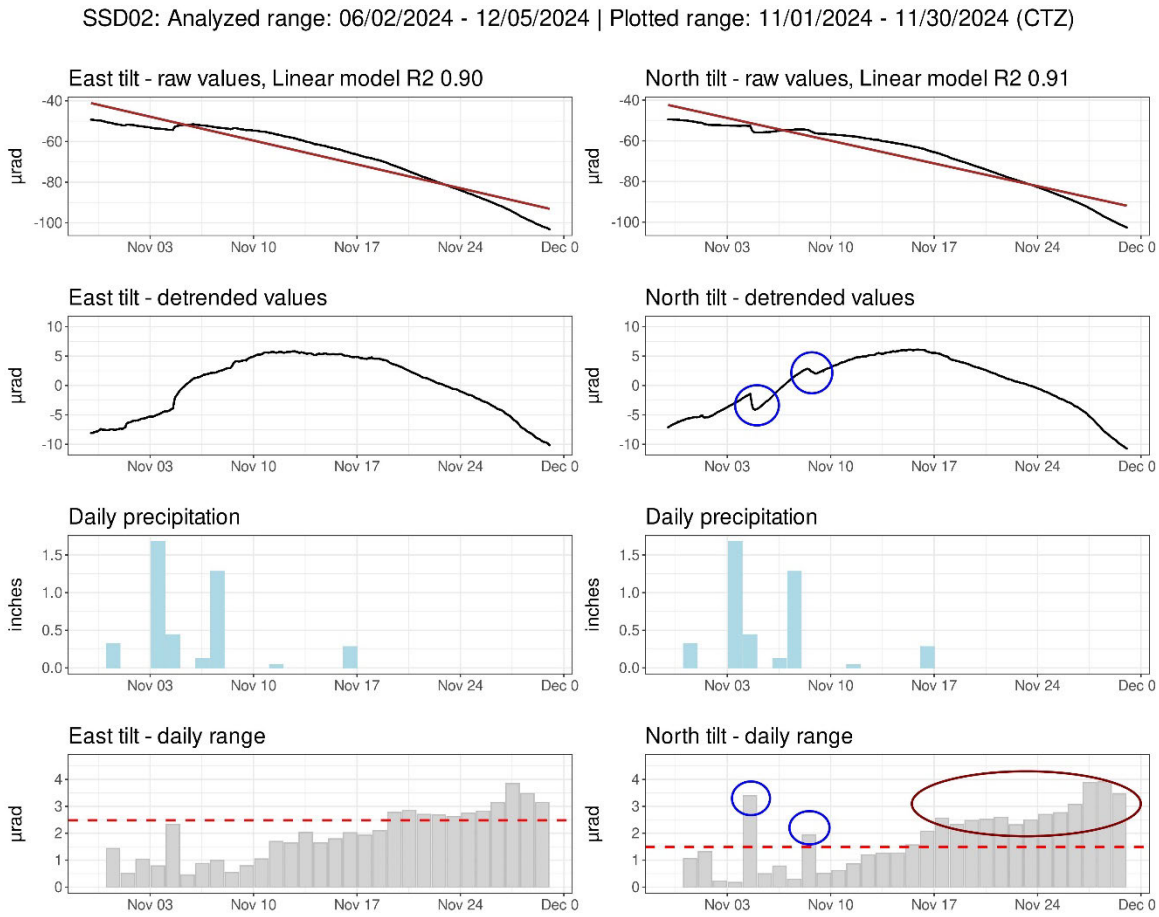


Figure 3. An example of tilt signals recorded by the SSD02 tiltmeter during November. It highlights large tilt signals, some of which are attributed to precipitation (in blue), while others, such as the gradual increase in the tilt rate at the end of the month (in brown), do not have a clear cause. This increase is only observed on tilt station 02, suggesting it is a local effect.

The tilt data are manually reviewed daily, using a 7-day rolling window, to identify any trend changes that are consistently observed at several tiltmeter sites over a period lasting at least a few days. The November tiltmeter data shows no consistent pattern of ground movement that suggests deep-sourced deformation or any immediate concern with Cavern 7.

Summary of GNSS observations for November 2024

In November 2024, the GNSS network operated without interruption.

For this report, we have evaluated the full data history starting in June 2024 to improve measurement precision. The plots for each GNSS station are shown in Appendix 2.

The east, north, and vertical deformation time series at each GNSS site are used to compute the annual deformation rate in a local reference frame. During November, daily measurements supported an established deformation trend, with a few of the GNSS sites recording horizontal motion directed approximately toward Cavern 7 and vertical motion indicating subsidence.

As previously described, the abnormally fast vertical motion at the NW GNSS station is related to field operations near the site in mid-July, and data from mid-July to the end of November appear stable.

Analysis Maps

Three maps have been created to visually summarize the results of the current analysis. These maps are shown below and are also provided in Appendix 3. Figure 4 is a rate vector map that portrays the direction and magnitude of the deformation rates identified for each tiltmeter and GNSS station by linear regression. Figure 5 portrays rose diagrams of the daily tilt direction frequency for each tiltmeter for the full data history from June 2024 to the present. Figure 6 describes the daily tilt direction frequency for the current monthly reporting period.

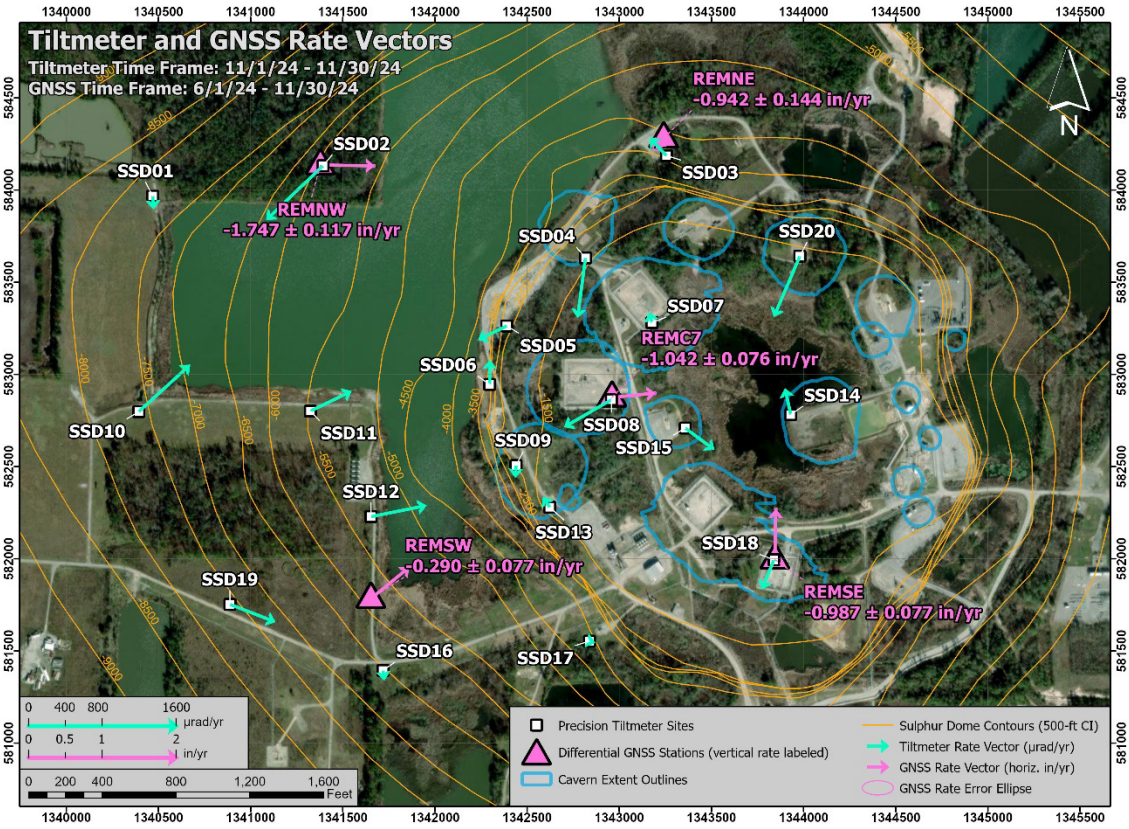


Figure 4. Map of deformation rate vectors for the tiltmeters and GNSS stations over their respective evaluated time frames. The tiltmeter vectors are shown in cyan and scaled by their respective values in units of microradians per year. The GNSS vectors and their corresponding error ellipses (derived from east and north rate errors) are shown in pink representing inches of horizontal movement per year. The GNSS stations are additionally labeled with the vertical motion rate and corresponding error value.

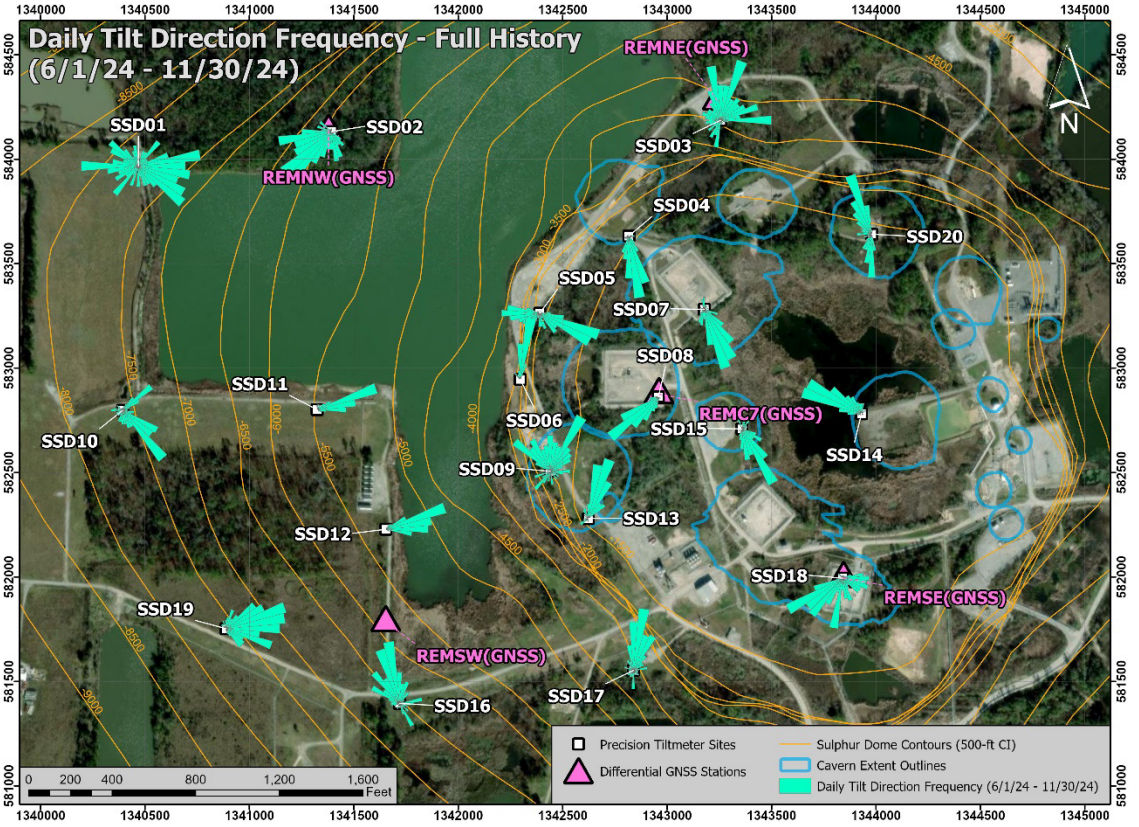


Figure 5. Map of daily tilt direction distribution for each tiltmeter for the full data history beginning in June 2024. Rose diagrams indicate the number of days that tilt was oriented along specific azimuths (bin size is 10°).

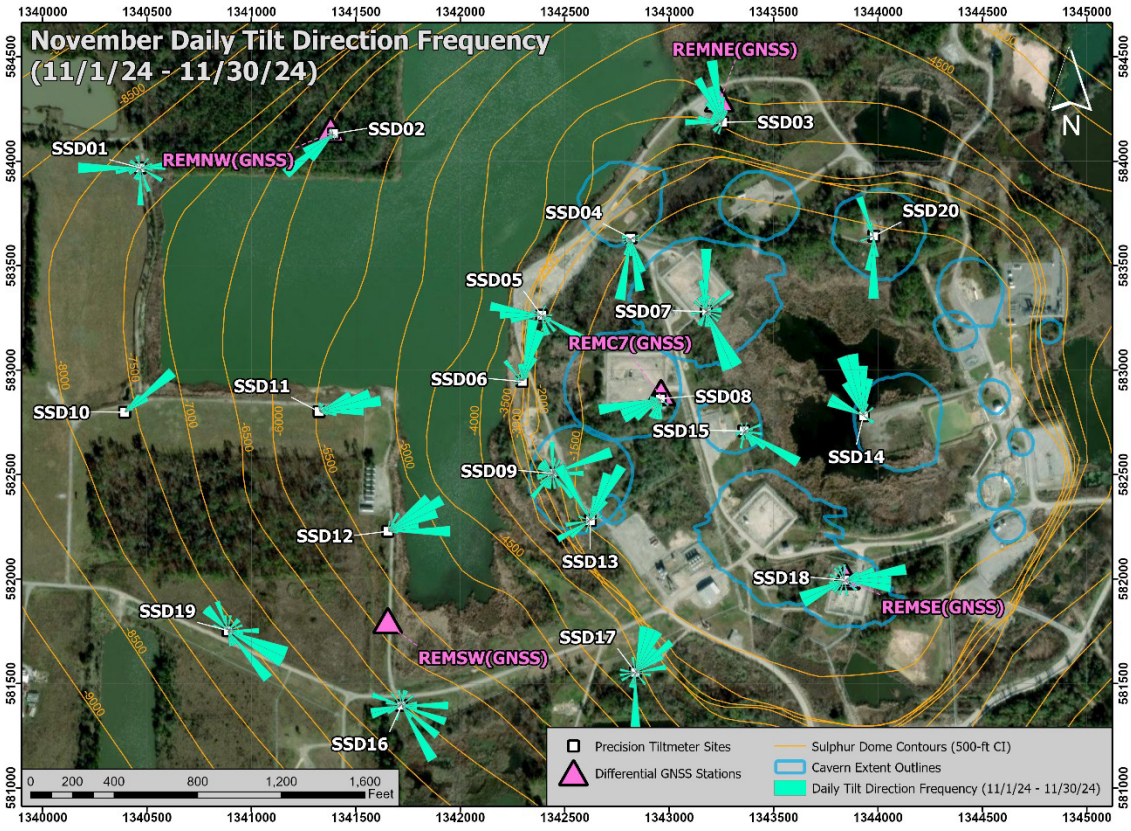


Figure 6. Map of daily tilt direction distribution for each tiltmeter for the current monthly reporting period. Rose diagrams indicate the number of days that tilt was oriented along specific azimuths (bin size is 10°).

Deformation Alert System Update

We are testing a draft deformation alert system that incorporates the magnitude of daily tiltmeter readings using non-Gaussian statistics across the full tiltmeter network. This allows for the appropriate interpretation of long-duration tilt observations and helps bypass the effects of short-duration anomalous tilt signals associated with precipitation and mechanical activities near the monitoring sites. We plan to evaluate the tilt alert system for a time period such that we are confident it is giving reliable results. In addition, we will use this ongoing analysis to set and adjust the alert triggering thresholds and refine the appropriate response actions due to a change in the alert status.

Our theoretical deformation (Mogi) modeling (discussed in the deformation monitoring plan dated December 22, 2023) indicates that deep deformation associated with potential changes in volume at Cavern 7 (located at a depth of approximately 2,500 to 3,160 feet) is expected to impact the entire tiltmeter array. If the deformation moves

upward from Cavern 7, we anticipate that the corresponding tiltmeter response will be concentrated at the stations nearest the cavern, and the tilt magnitude will increase. In contrast, local, shallow deformation, such as movement in the caprock, is likely to affect only the nearby tiltmeters.

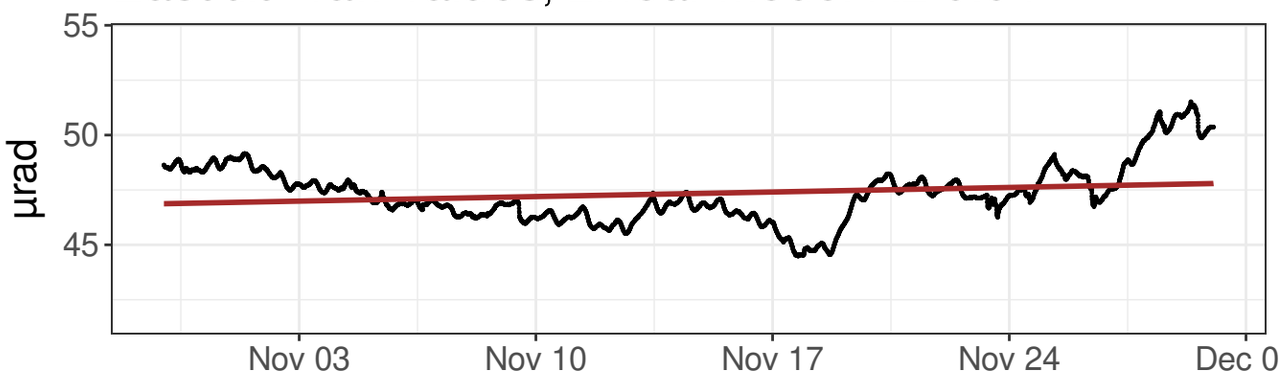
We anticipate that short-term deformation alert levels will be evaluated with the other real-time monitoring observations currently active at Sulphur Mines, which include the Cavern 7 pressure and microseismic monitoring. Additionally, long-term trends from GNSS and InSAR, which typically become available with some delay, will also be necessary for ongoing alert assessments.

APPENDIX 1

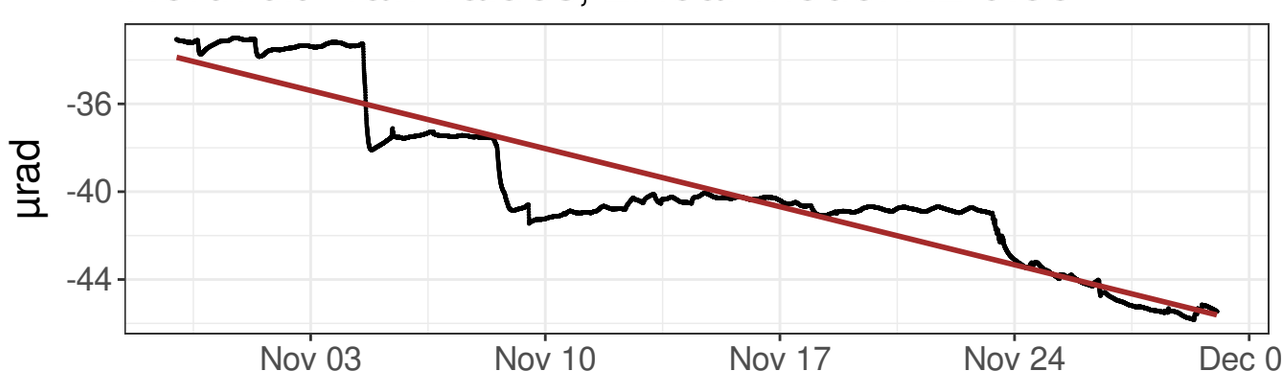
Tiltmeter Data Plots

SSD01: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

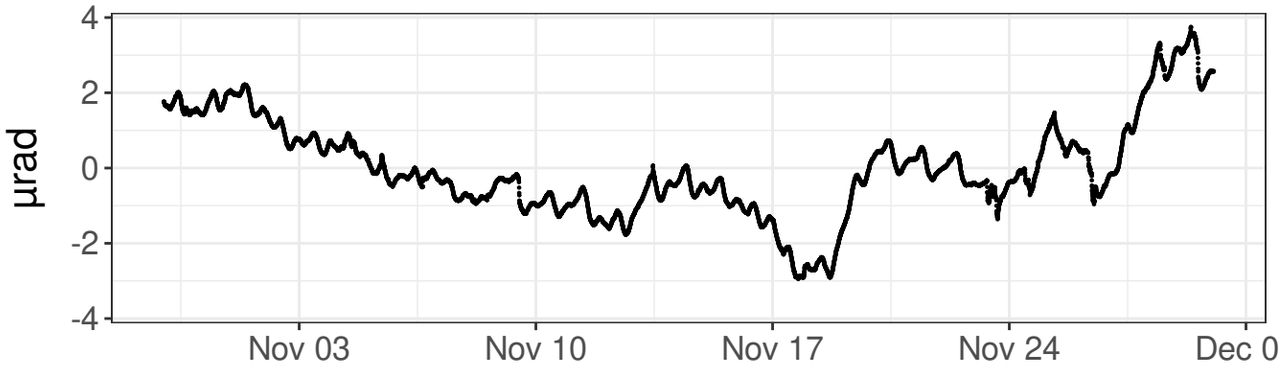
East tilt - raw values, Linear model R2 0.04



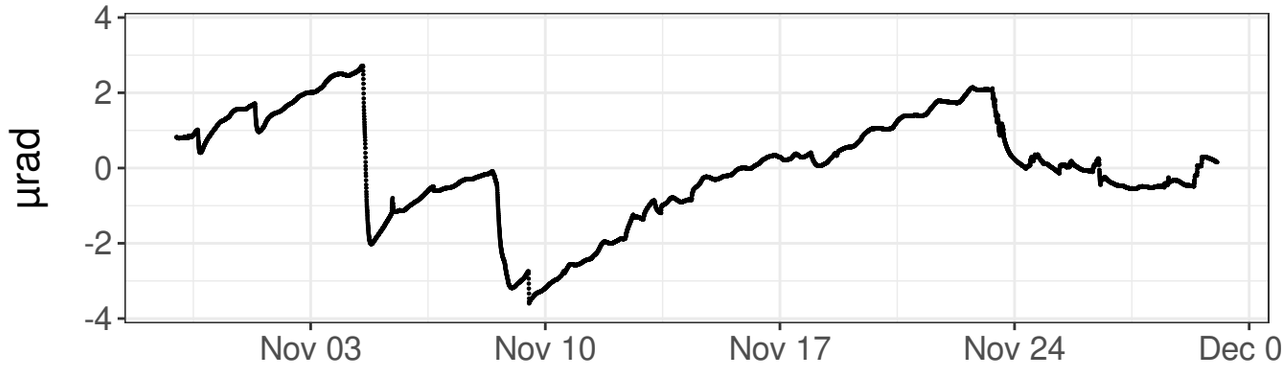
North tilt - raw values, Linear model R2 0.85



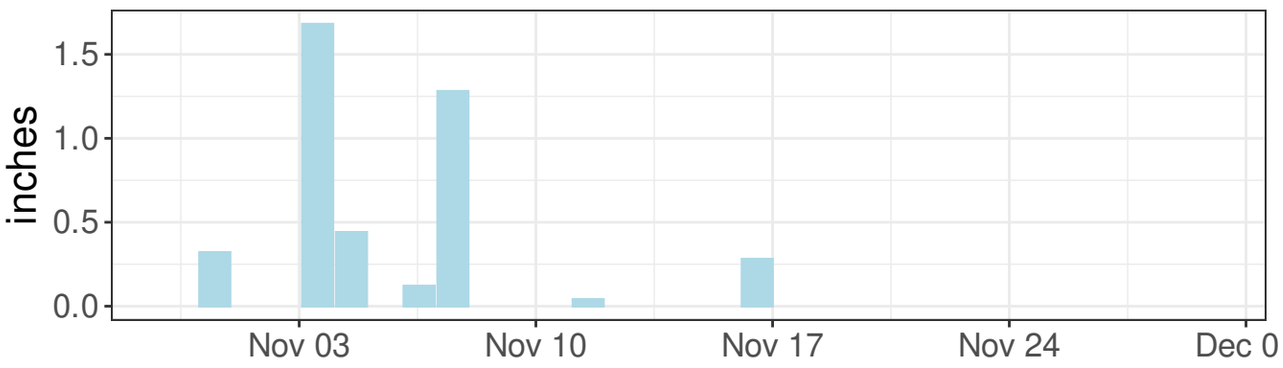
East tilt - detrended values



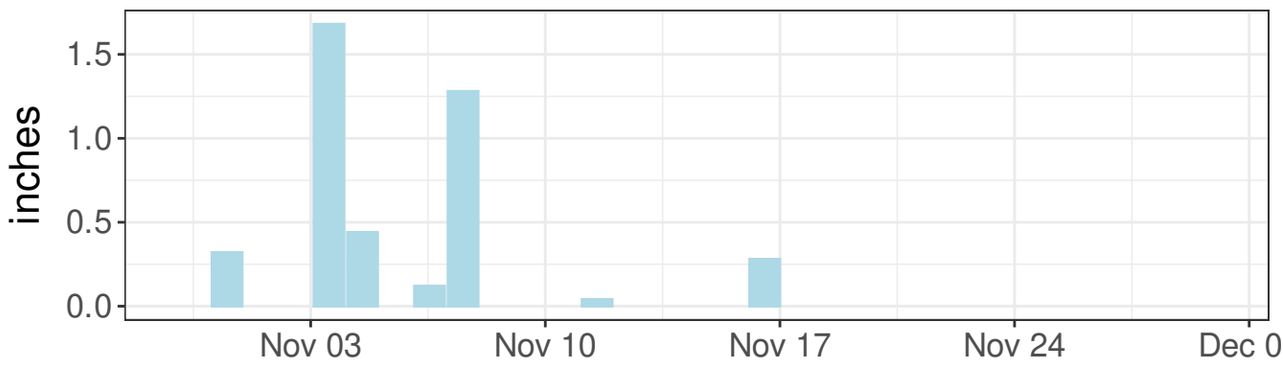
North tilt - detrended values



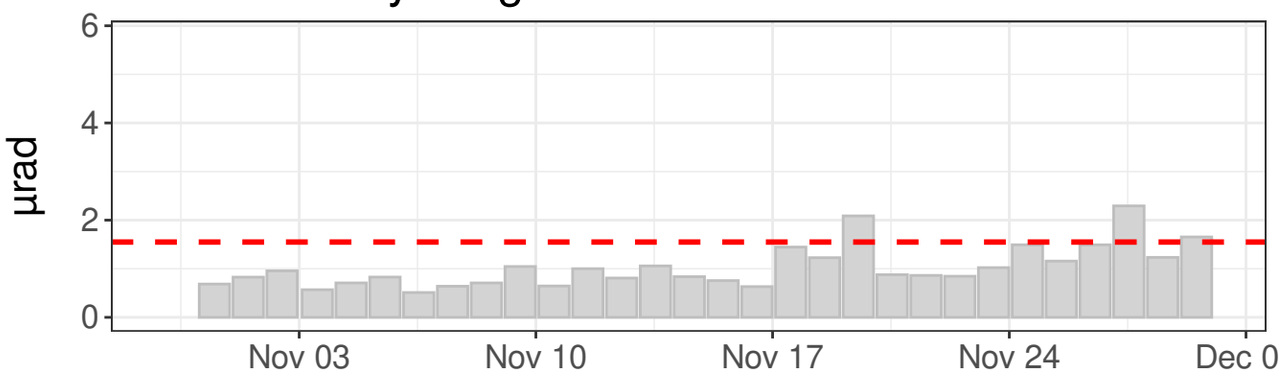
Daily precipitation



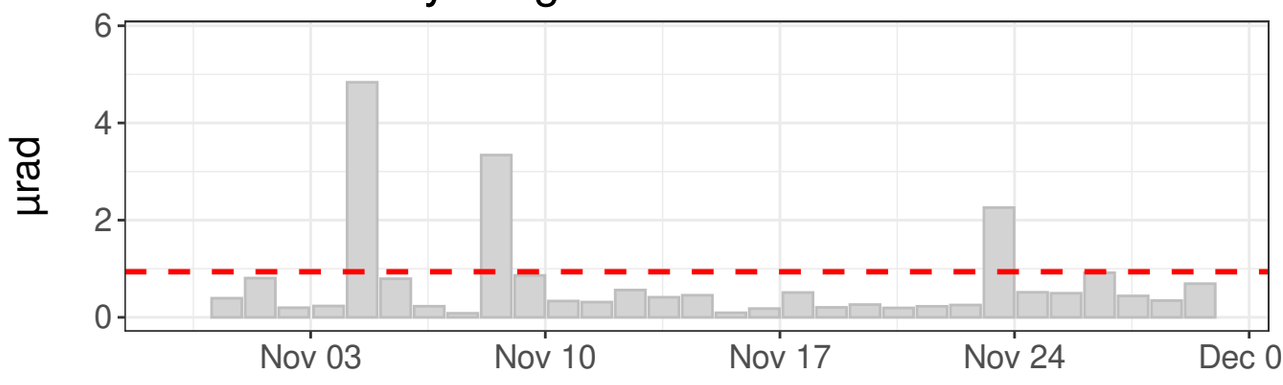
Daily precipitation



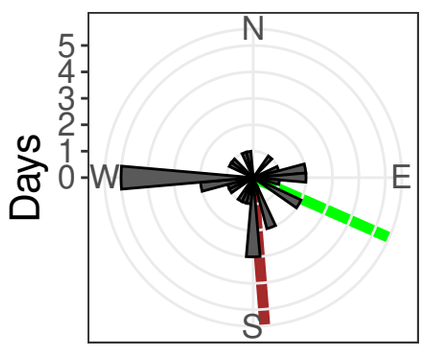
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: 10.85 ± 0.50 µrad/year

North tilt rate: -138.35 ± 0.54 µrad/year

Azimuth to C7: 114 deg

Distance to C7: 2538 ft

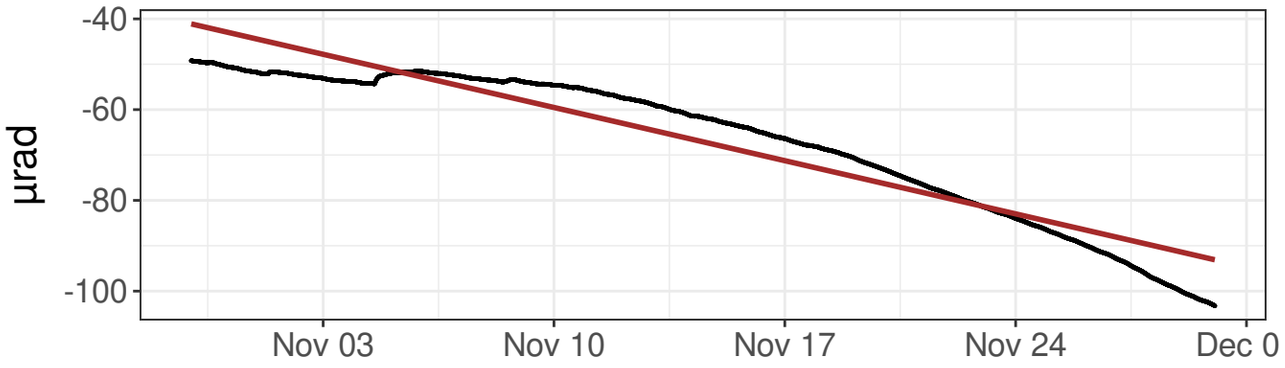
Outlier value

Linear model

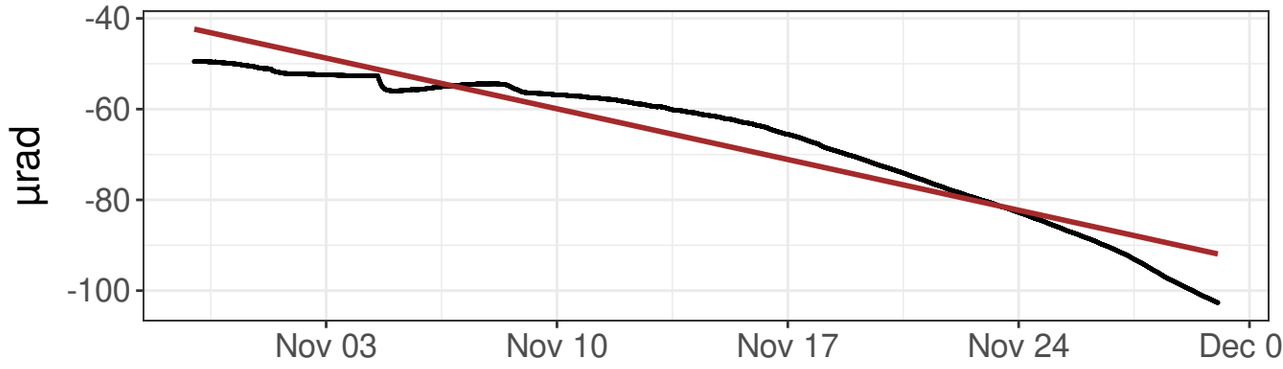
Azimuth to C7

SSD02: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

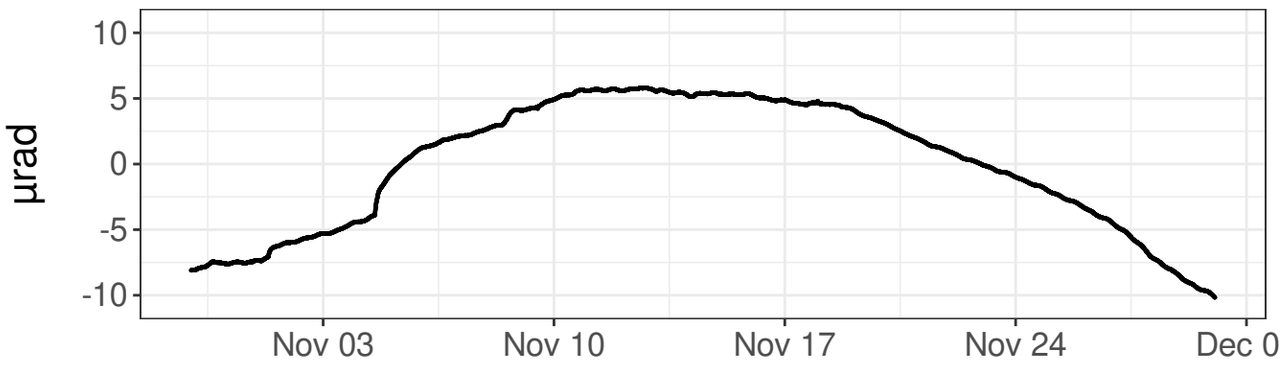
East tilt - raw values, Linear model R2 0.90



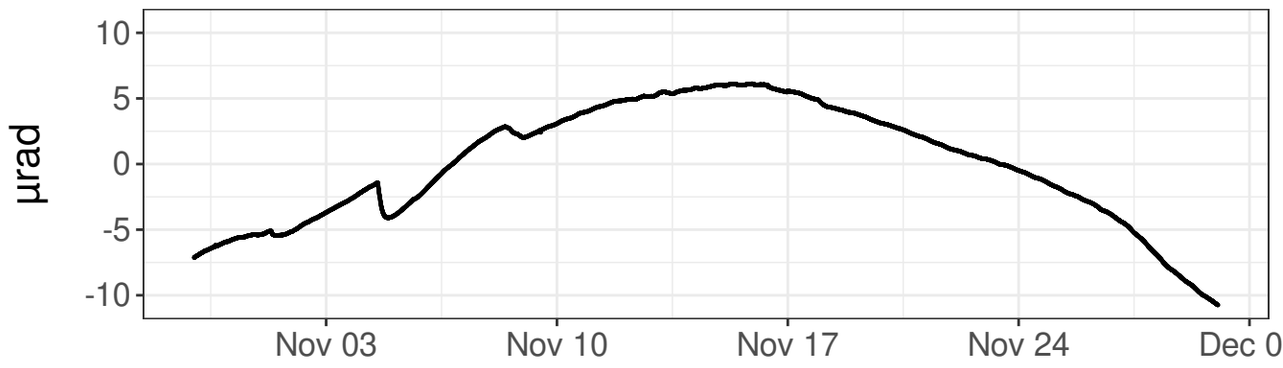
North tilt - raw values, Linear model R2 0.91



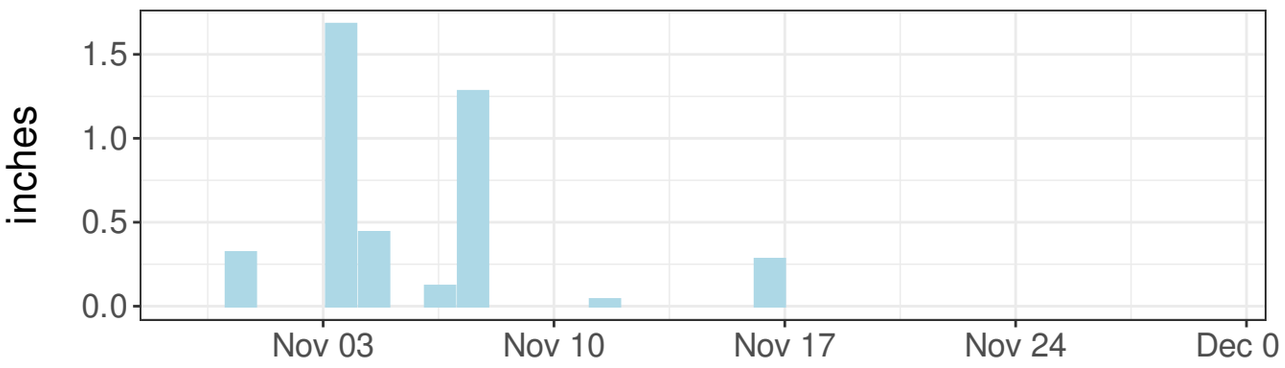
East tilt - detrended values



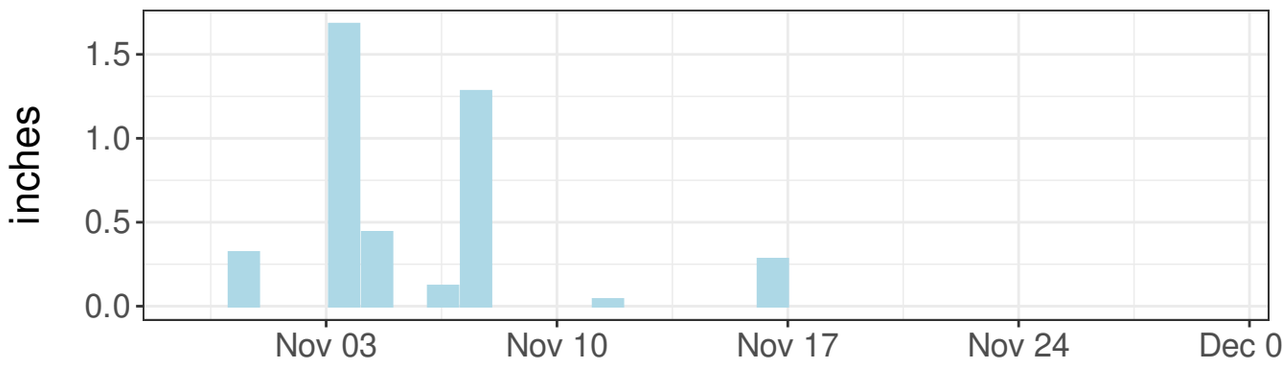
North tilt - detrended values



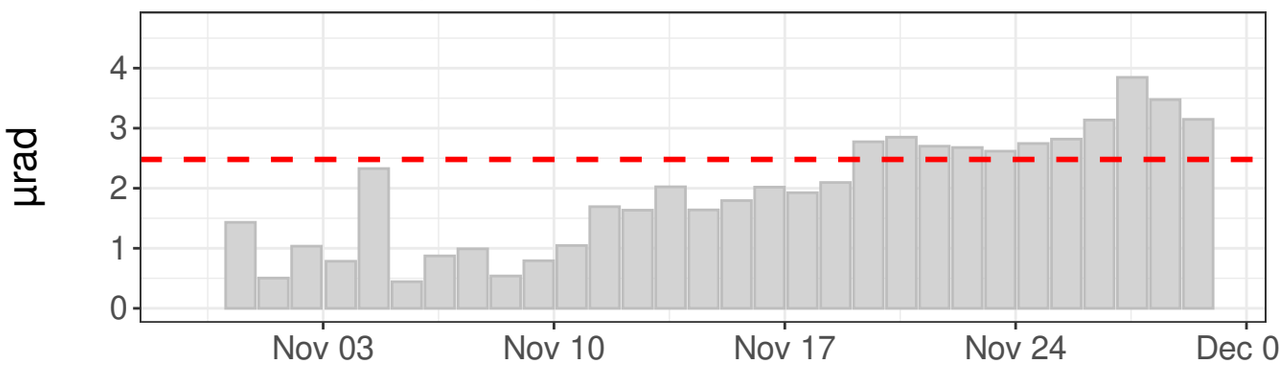
Daily precipitation



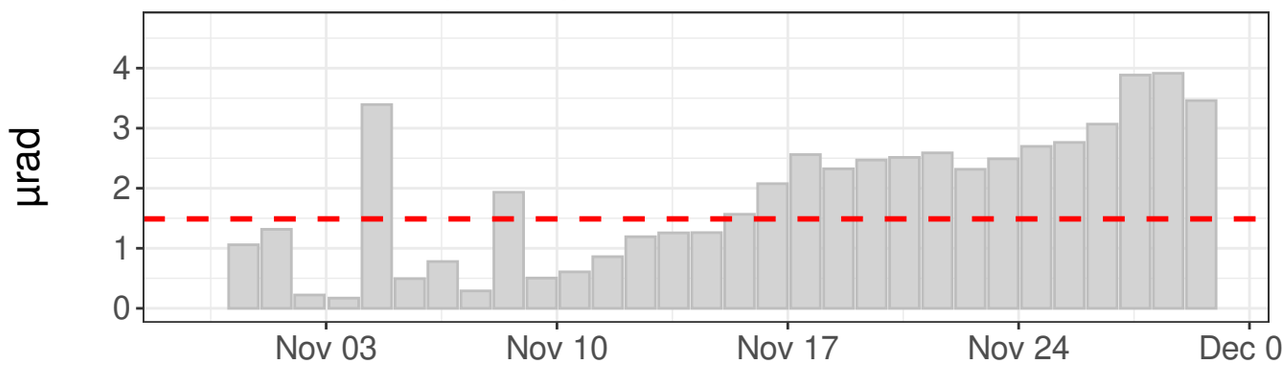
Daily precipitation



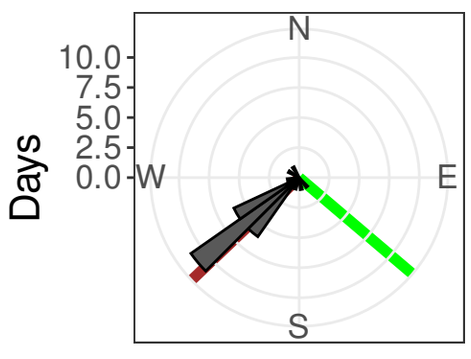
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: -612.95 ± 1.89 µrad/year

North tilt rate: -584.22 ± 1.74 µrad/year

Azimuth to C7: 130 deg

Distance to C7: 1834 ft

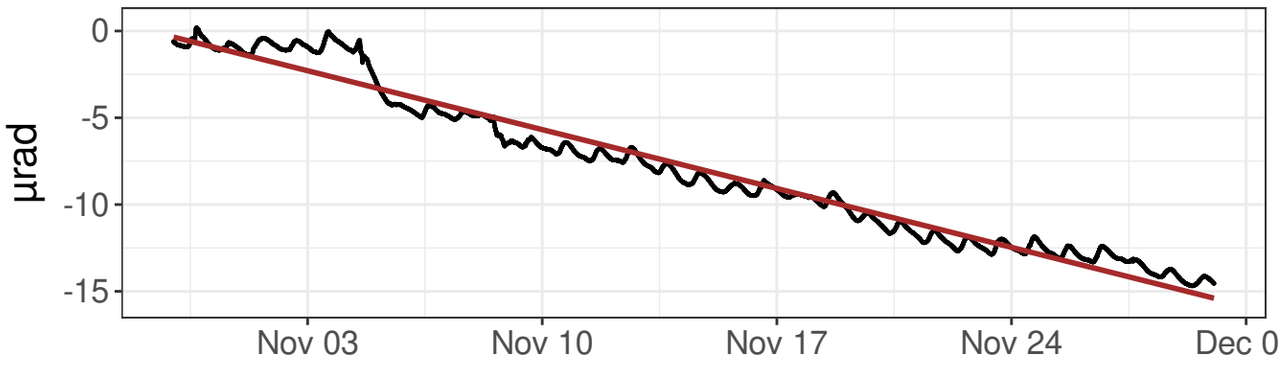
Outlier value

Linear model

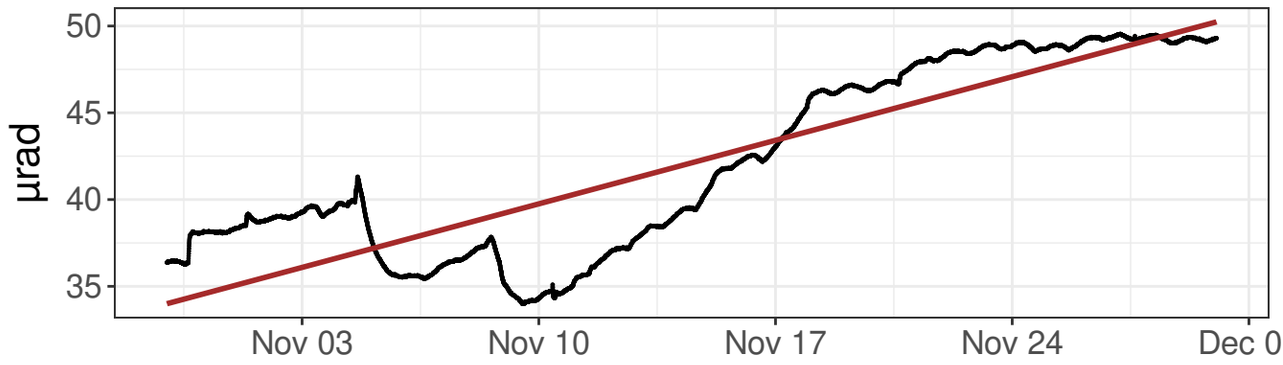
Azimuth to C7

SSD03: Analyzed range: 06/09/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

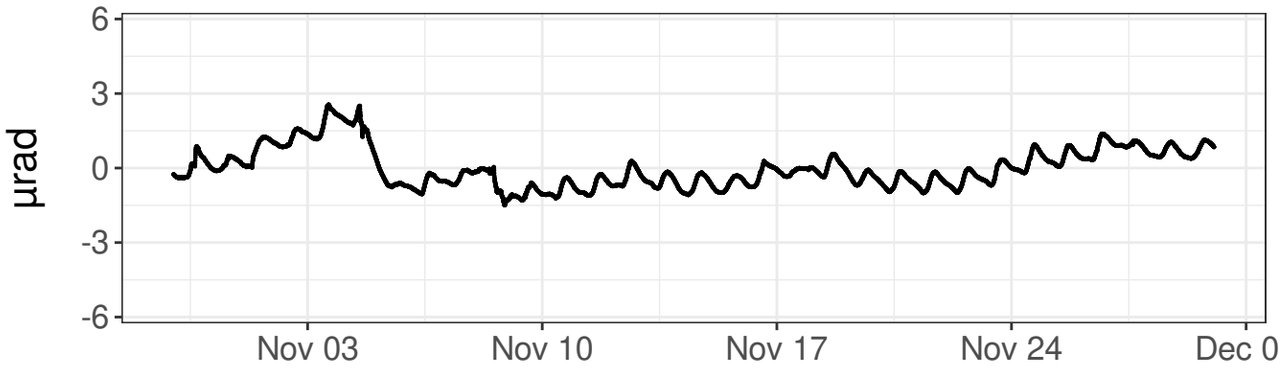
East tilt - raw values, Linear model R2 0.97



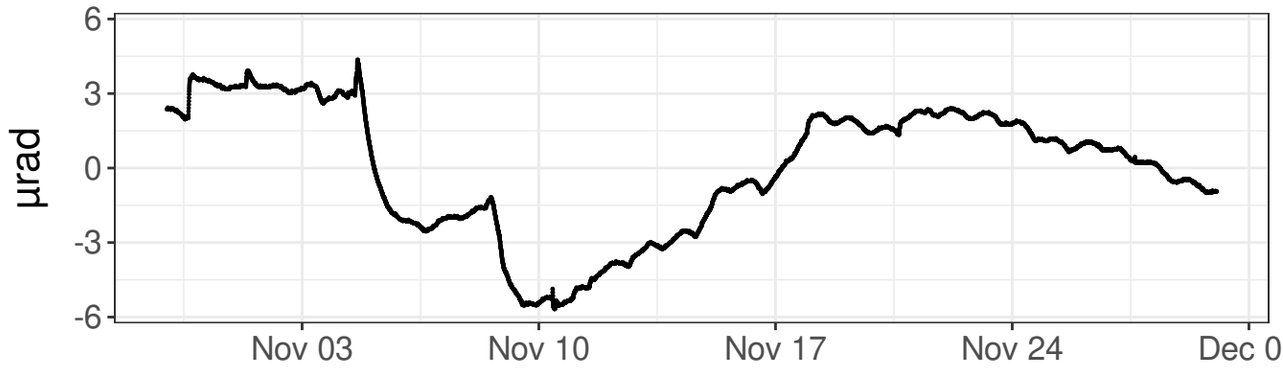
North tilt - raw values, Linear model R2 0.76



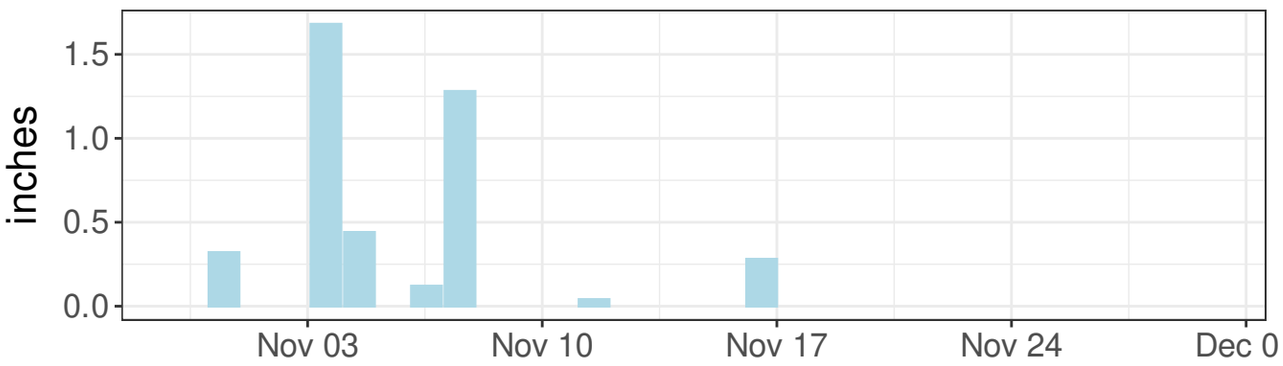
East tilt - detrended values



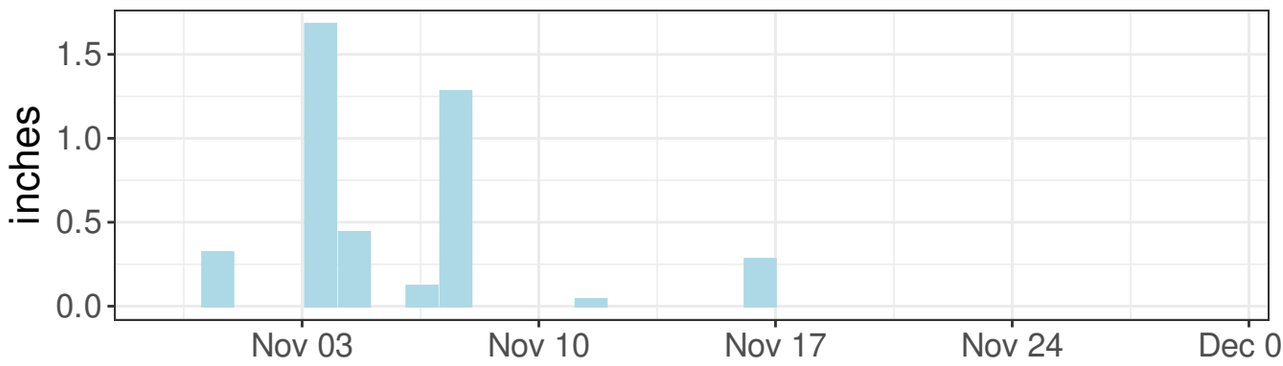
North tilt - detrended values



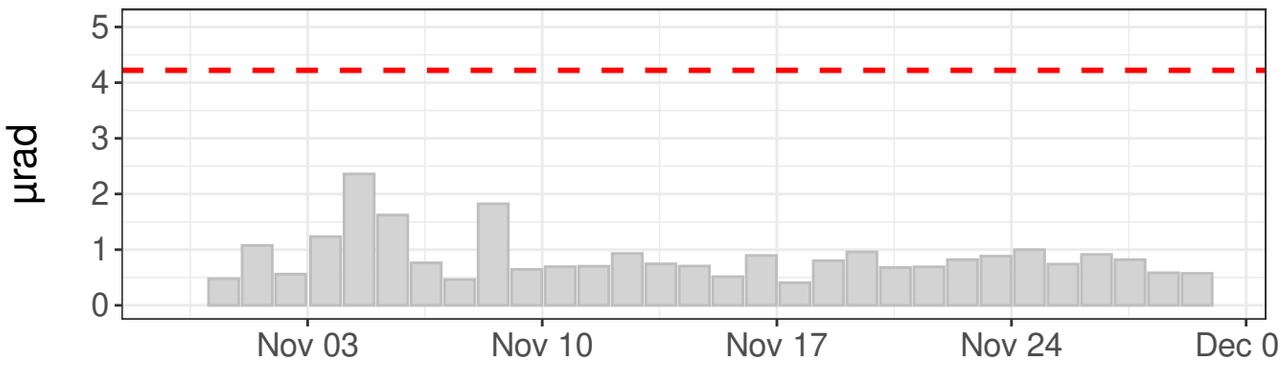
Daily precipitation



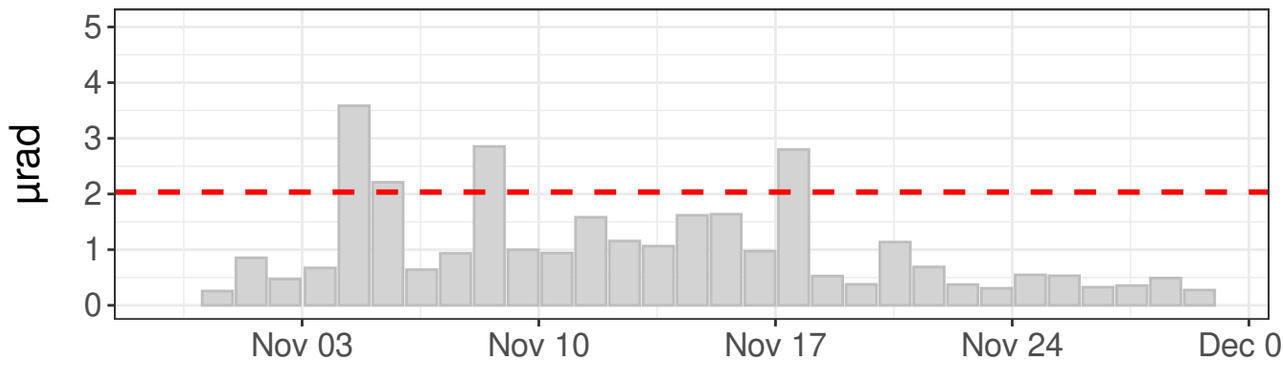
Daily precipitation



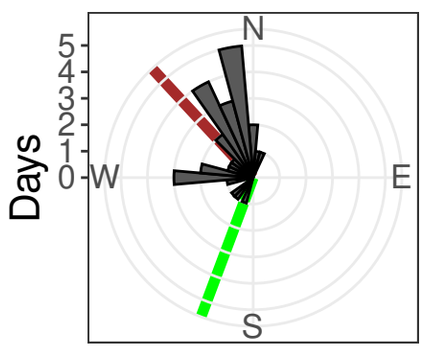
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: -177.38 ± 0.31 µrad/year

North tilt rate: 191.48 ± 1.01 µrad/year

Azimuth to C7: 201 deg

Distance to C7: 1326 ft

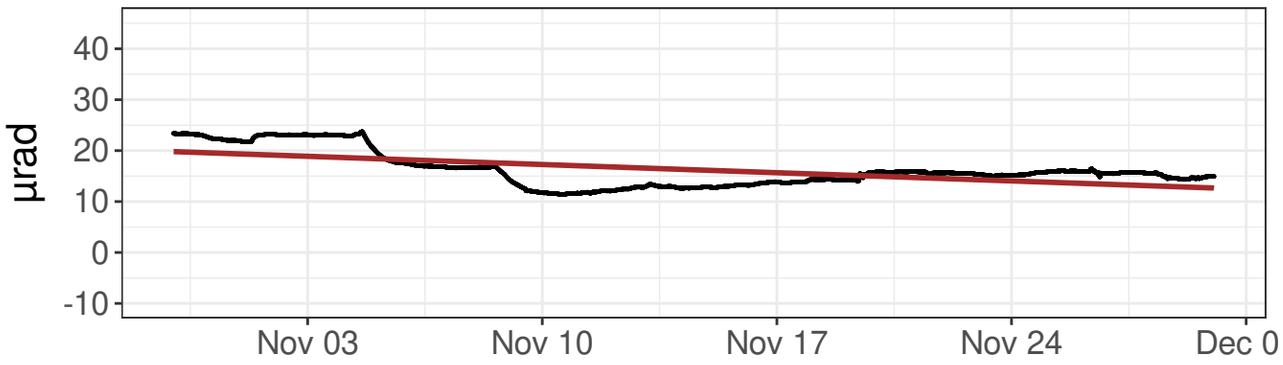
Outlier value

Linear model

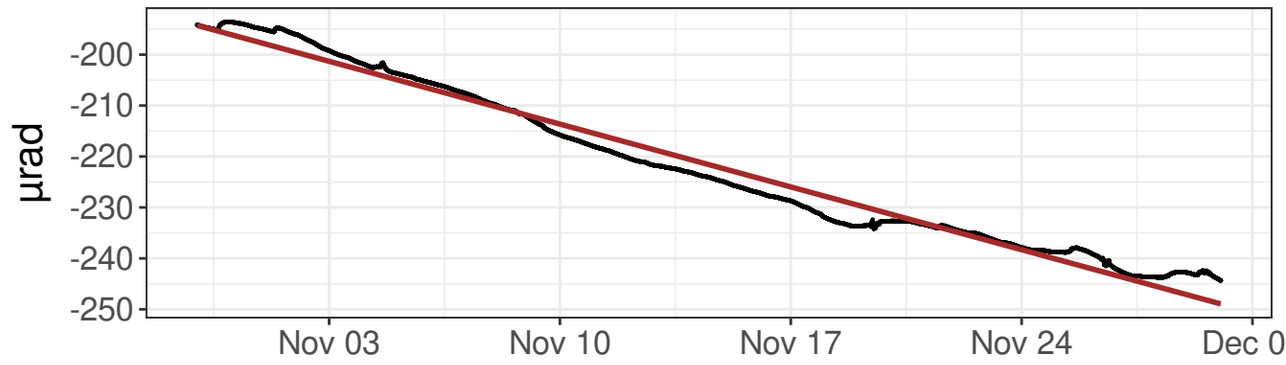
Azimuth to C7

SSD04: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

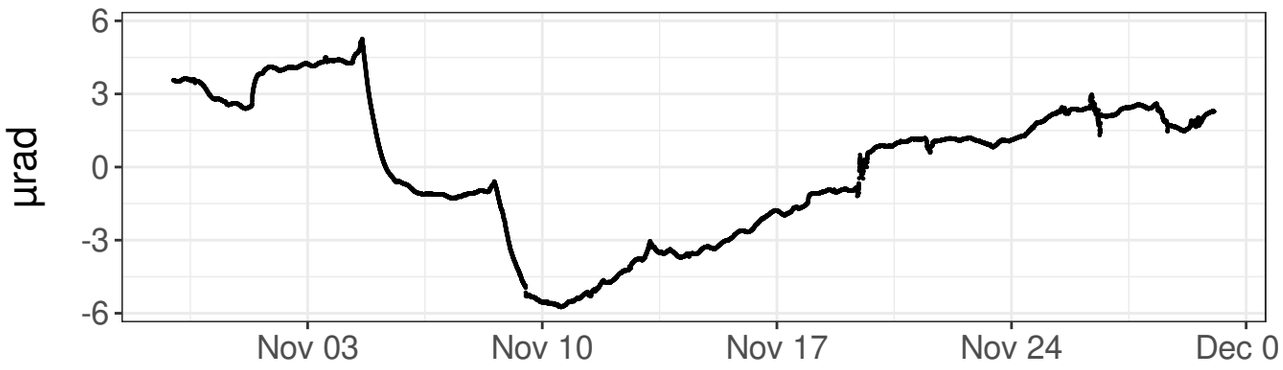
East tilt - raw values, Linear model R2 0.34



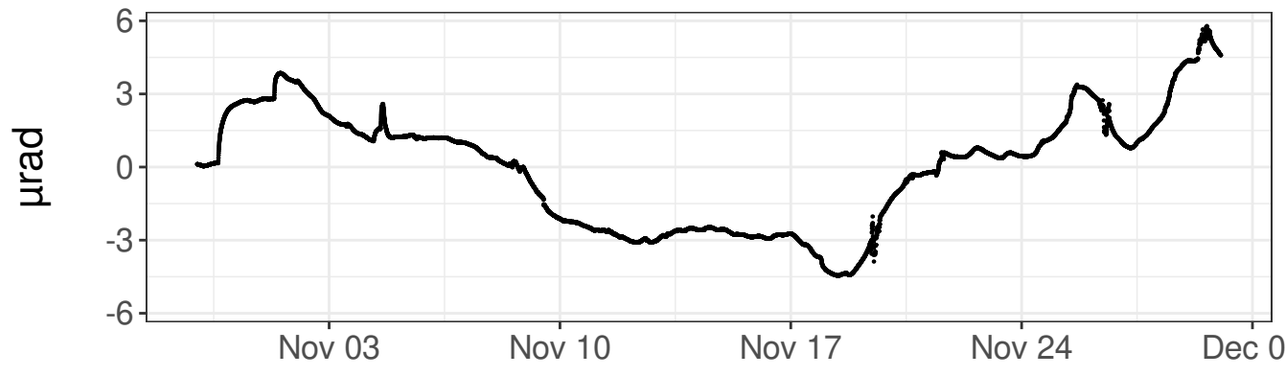
North tilt - raw values, Linear model R2 0.98



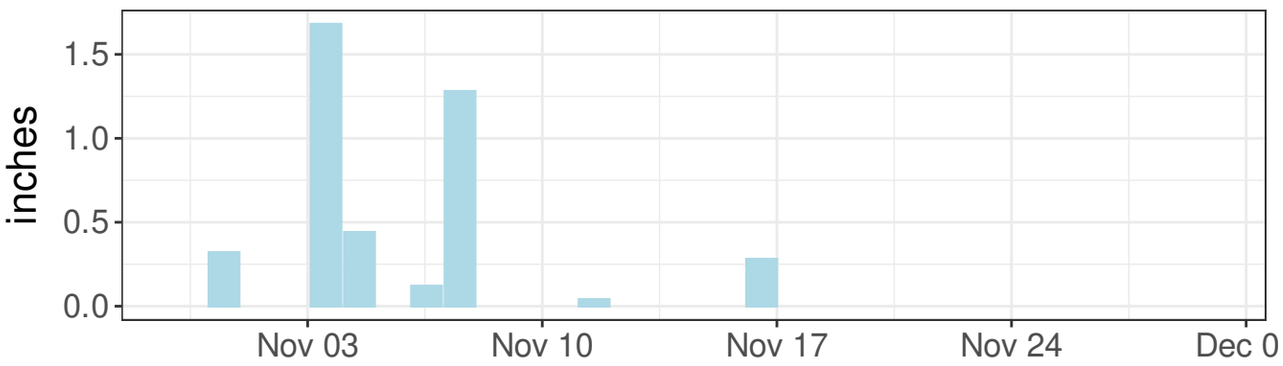
East tilt - detrended values



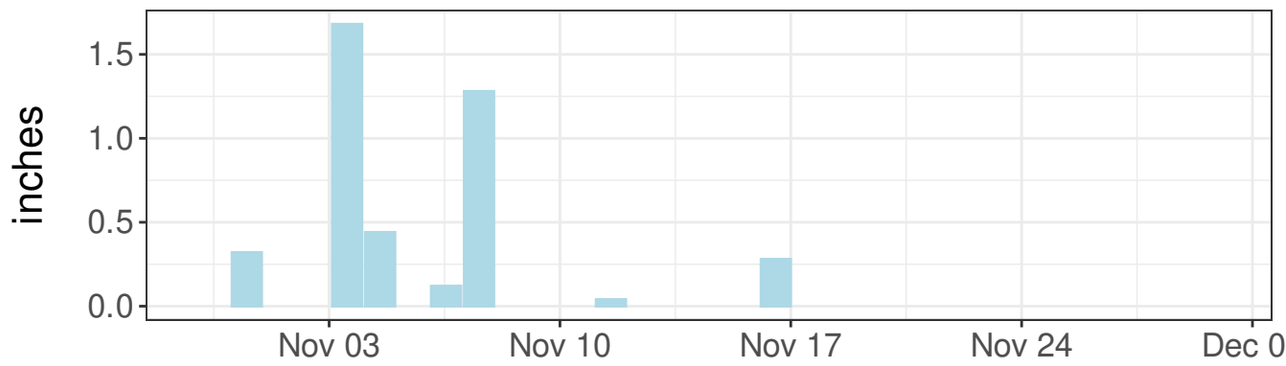
North tilt - detrended values



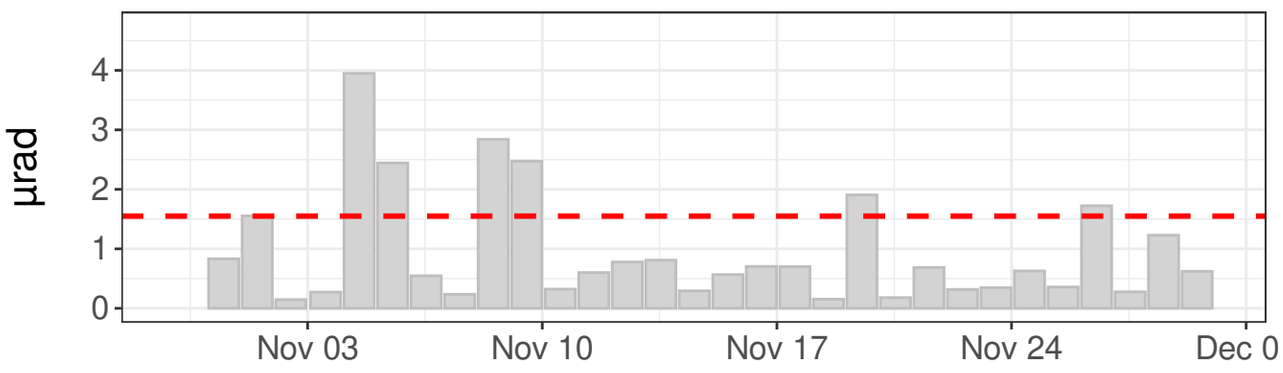
Daily precipitation



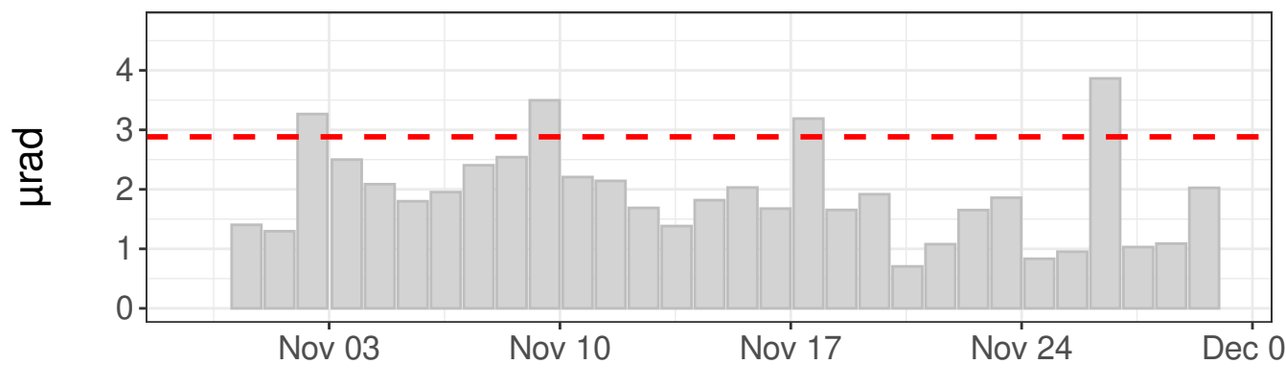
Daily precipitation



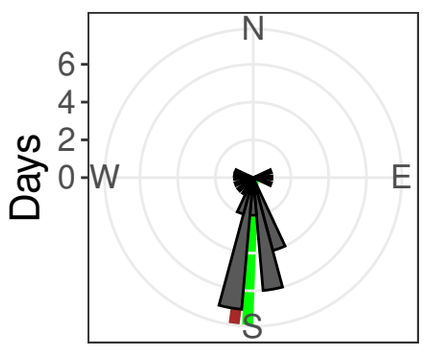
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: -84.26 ± 1.12 µrad/year

North tilt rate: -644.79 ± 0.93 µrad/year

Azimuth to C7: 182 deg

Distance to C7: 688 ft

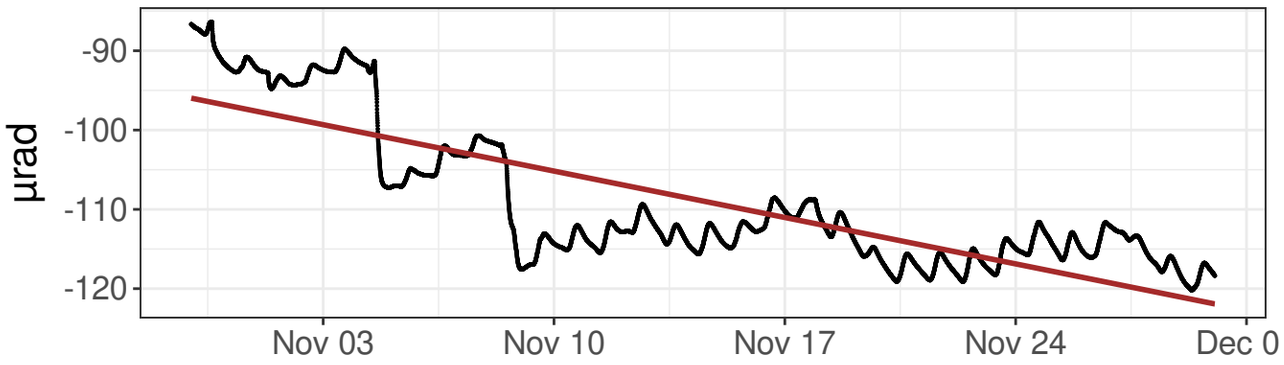
Outlier value

Linear model

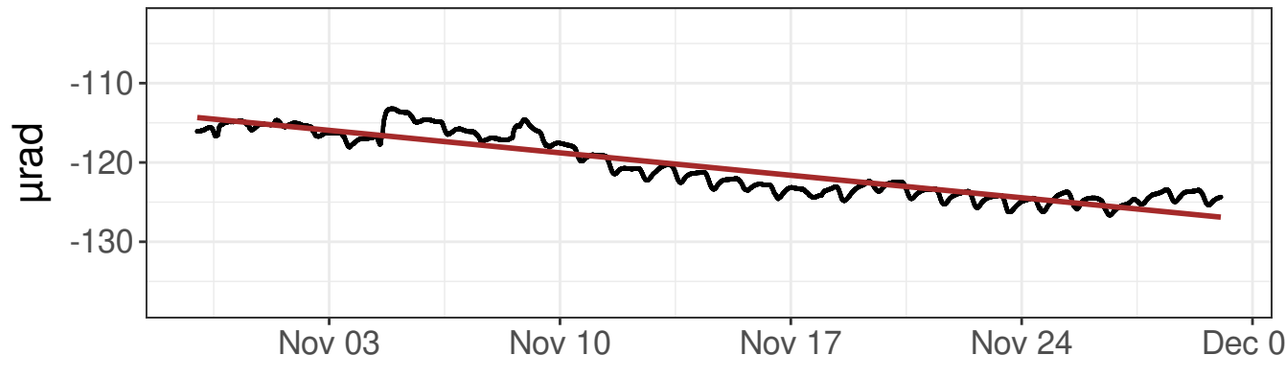
Azimuth to C7

SSD05: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

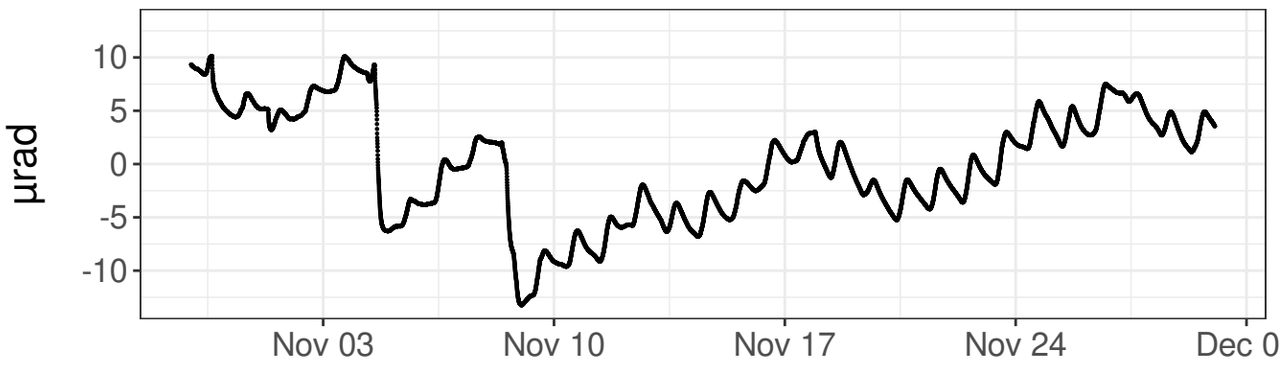
East tilt - raw values, Linear model R2 0.67



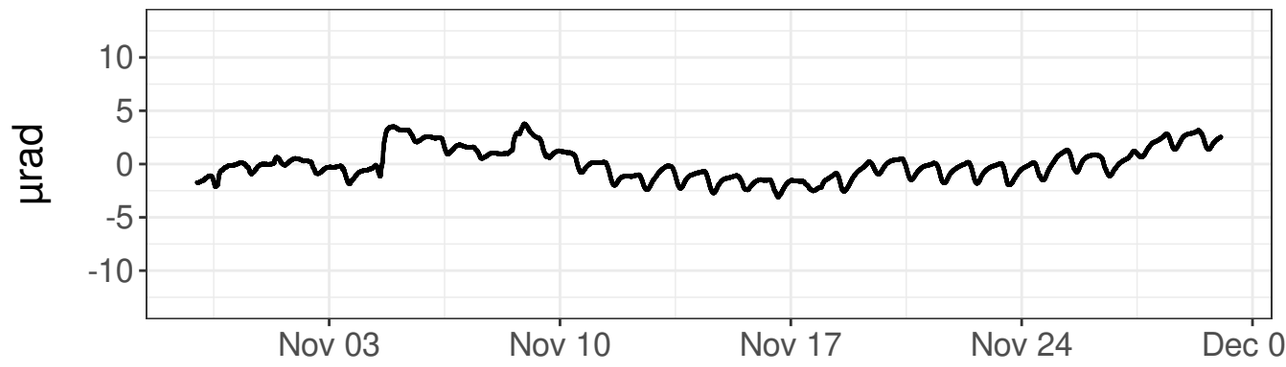
North tilt - raw values, Linear model R2 0.86



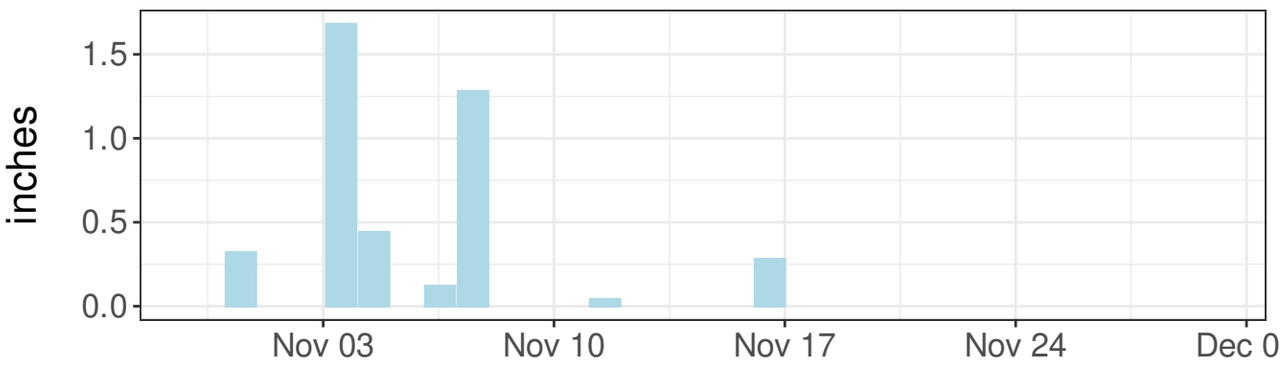
East tilt - detrended values



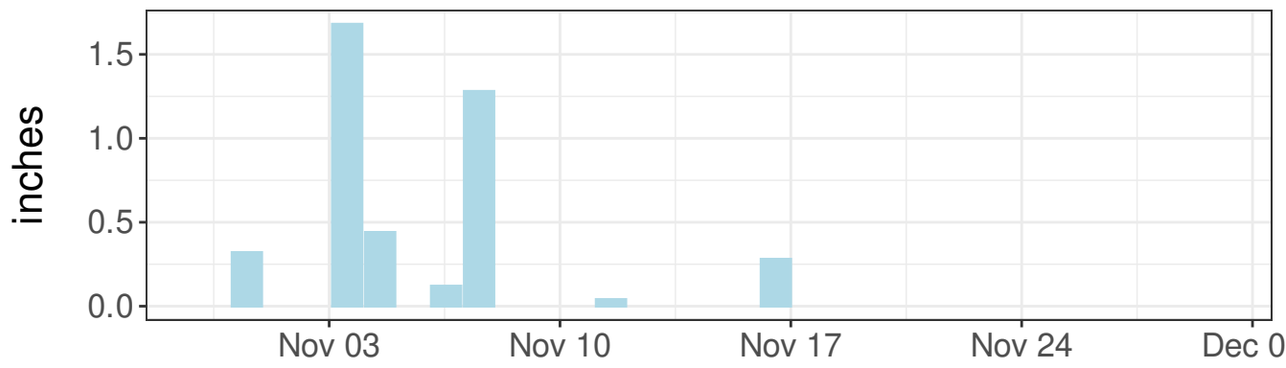
North tilt - detrended values



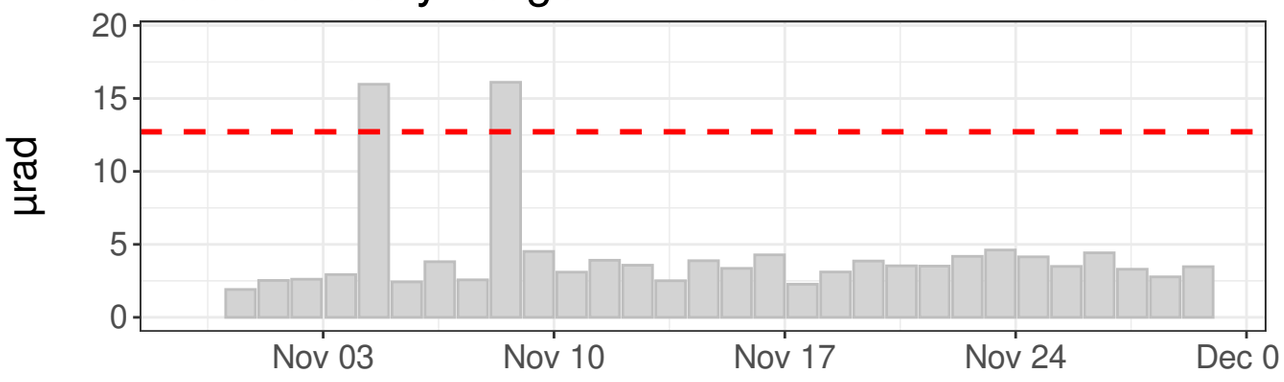
Daily precipitation



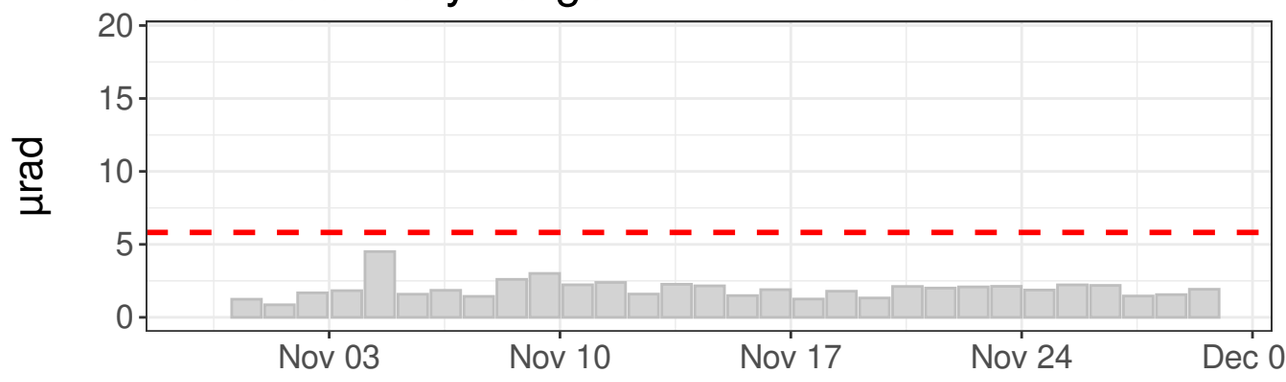
Daily precipitation



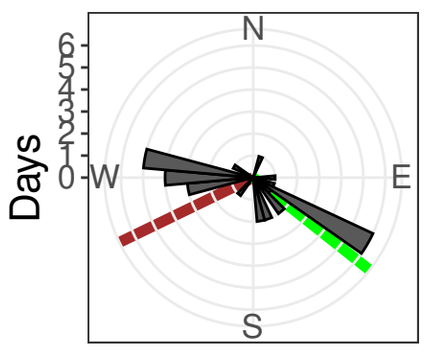
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: -305.96 ± 2.01 µrad/year

North tilt rate: -148.11 ± 0.57 µrad/year

Azimuth to C7: 128 deg

Distance to C7: 512 ft

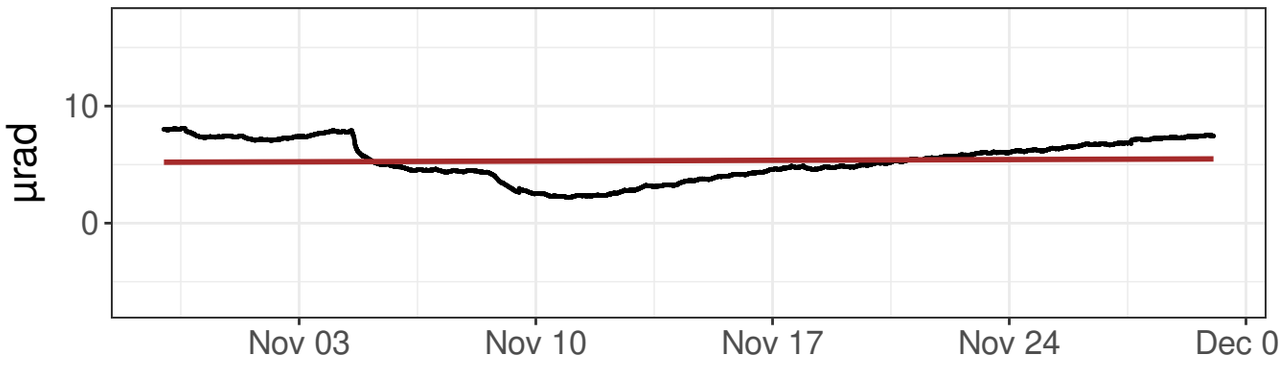
Outlier value

Linear model

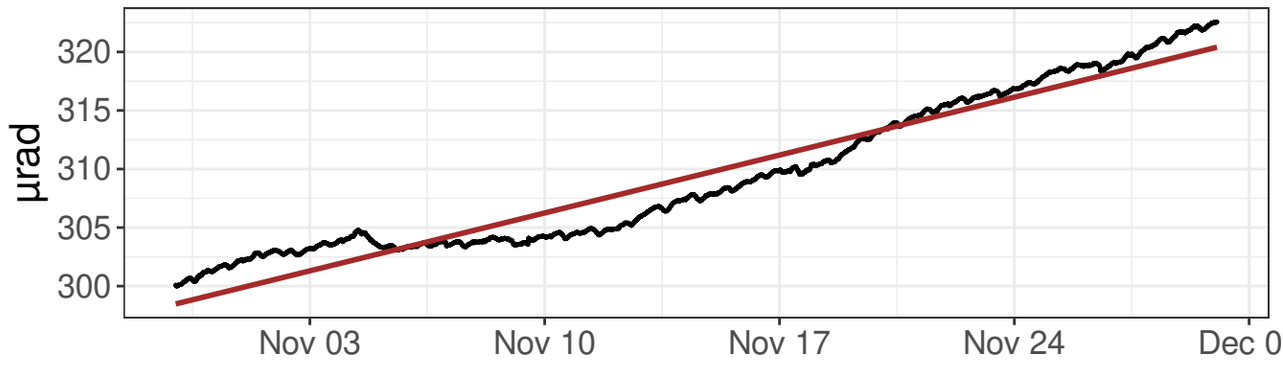
Azimuth to C7

SSD06: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

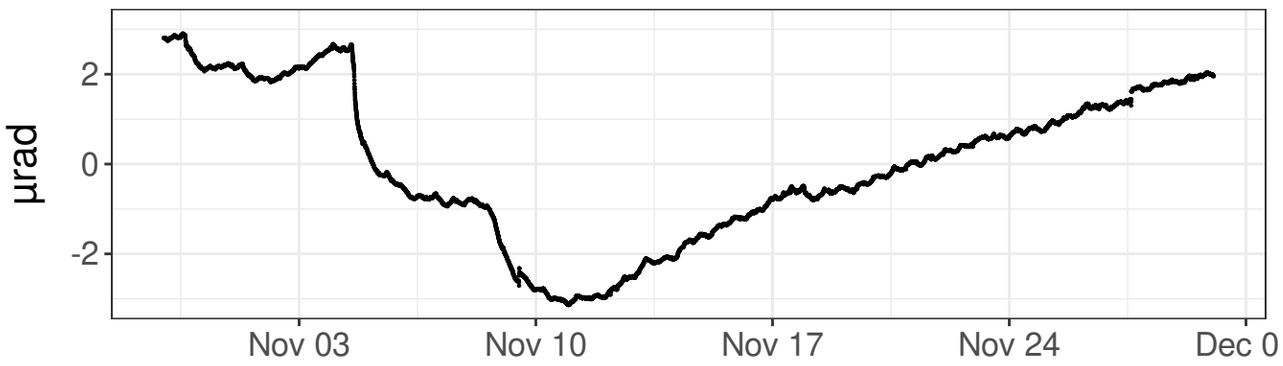
East tilt - raw values, Linear model R2 0.00



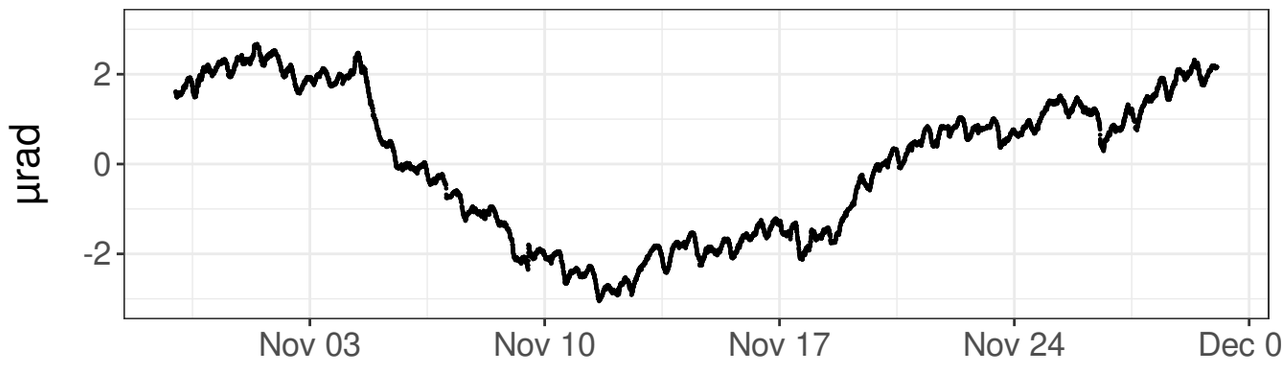
North tilt - raw values, Linear model R2 0.94



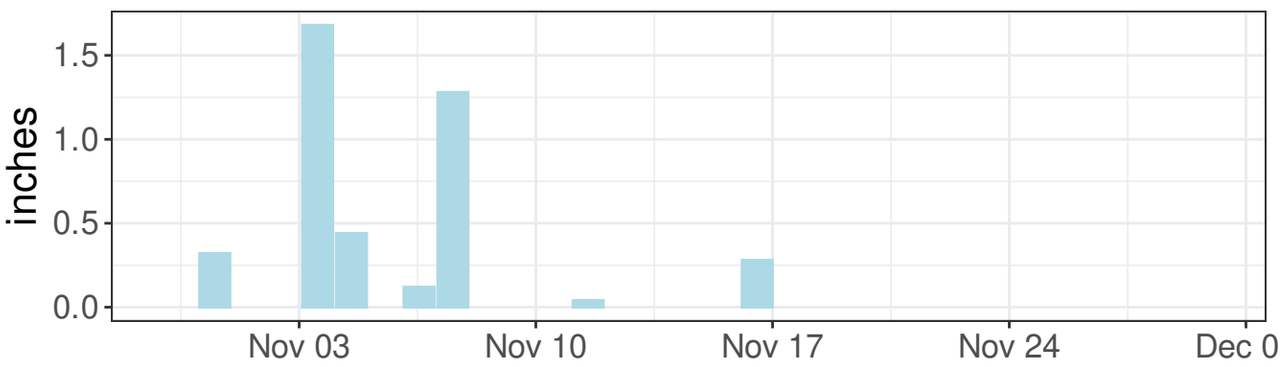
East tilt - detrended values



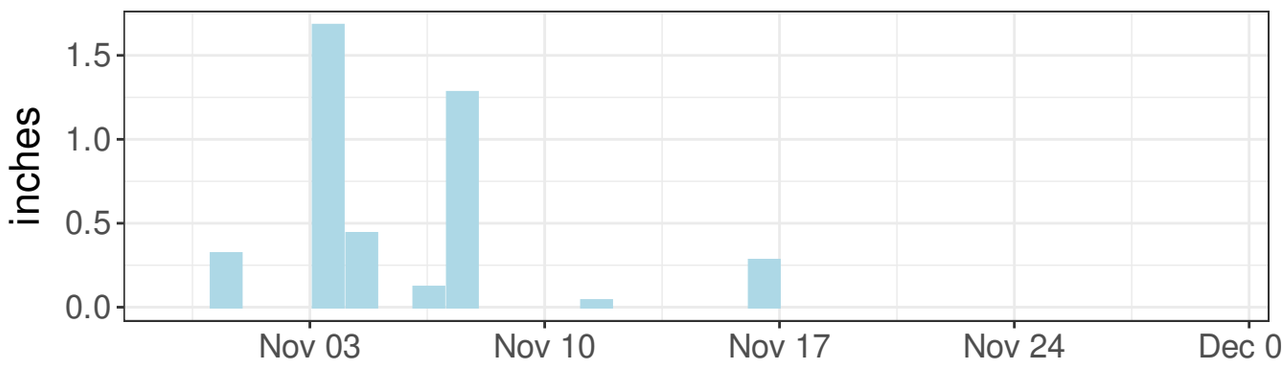
North tilt - detrended values



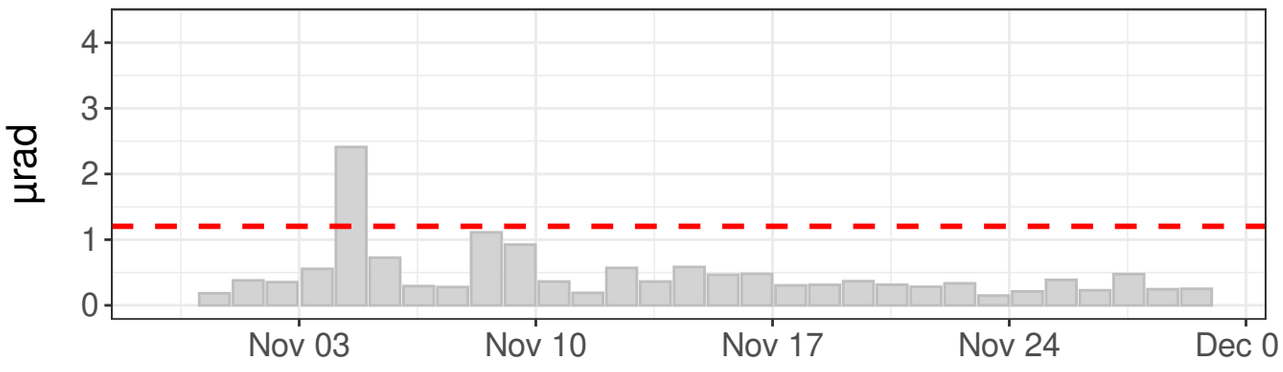
Daily precipitation



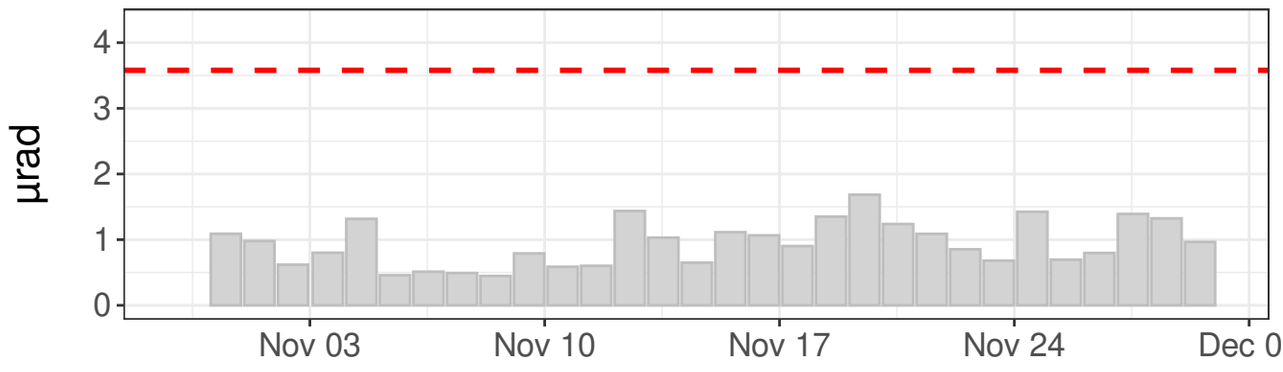
Daily precipitation



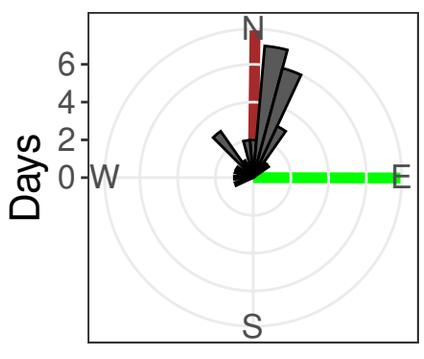
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: 3.32 ± 0.65 µrad/year

North tilt rate: 258.53 ± 0.63 µrad/year

Azimuth to C7: 90 deg

Distance to C7: 494 ft

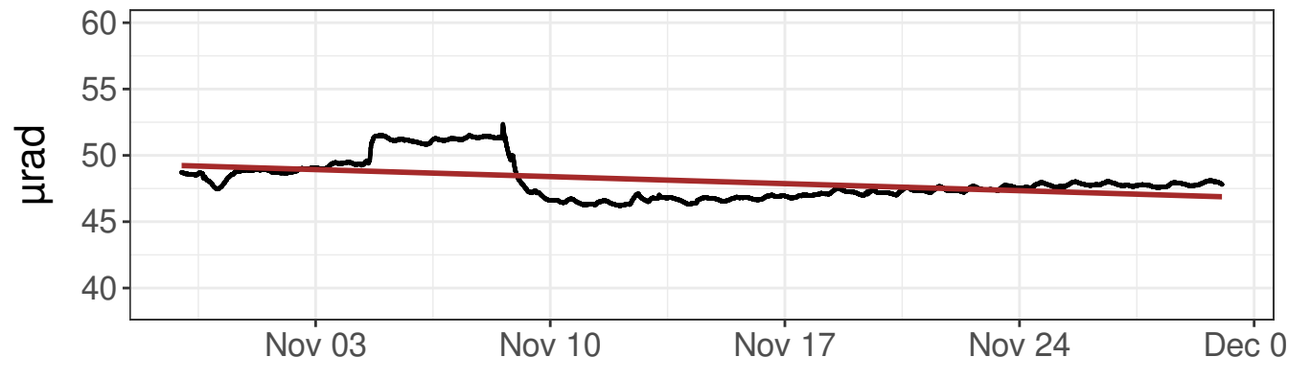
Outlier value

Linear model

Azimuth to C7

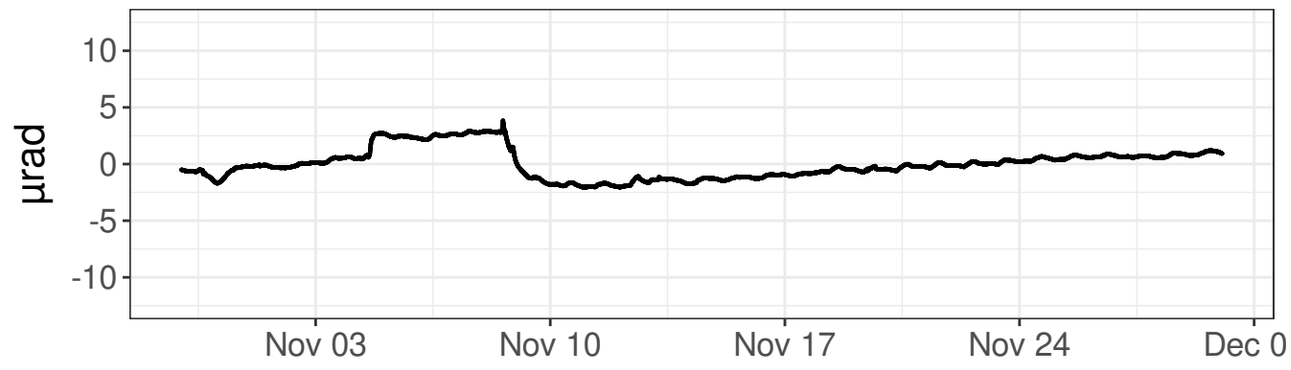
SSD07: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

East tilt - raw values, Linear model R2 0.21

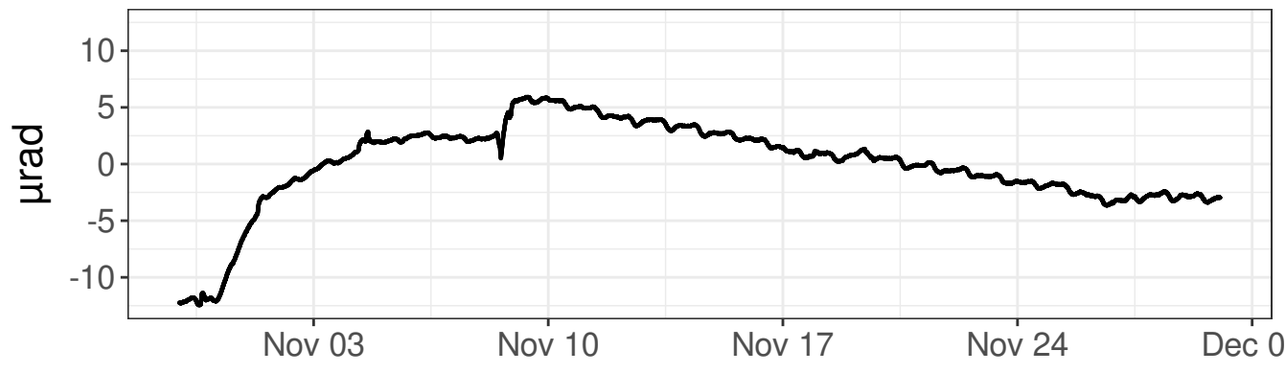


North tilt - raw values, Linear model R2 0.31

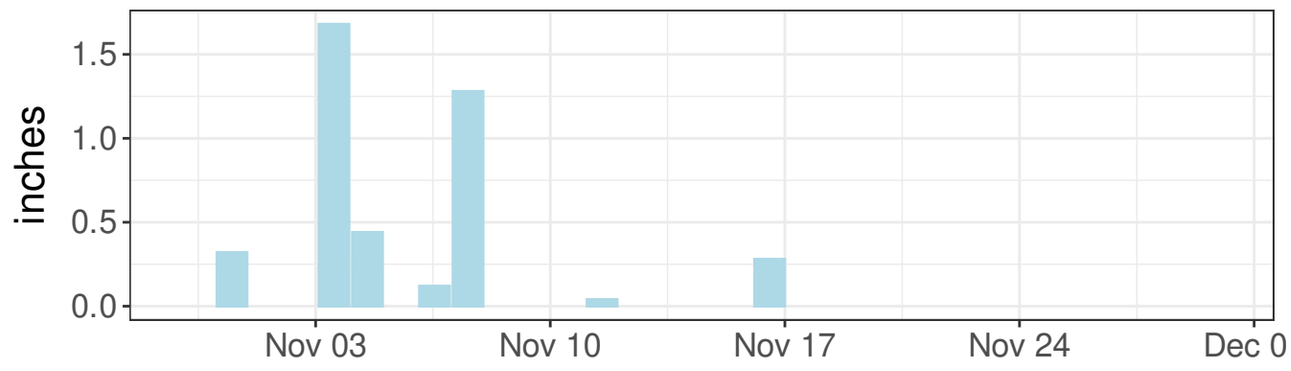
East tilt - detrended values



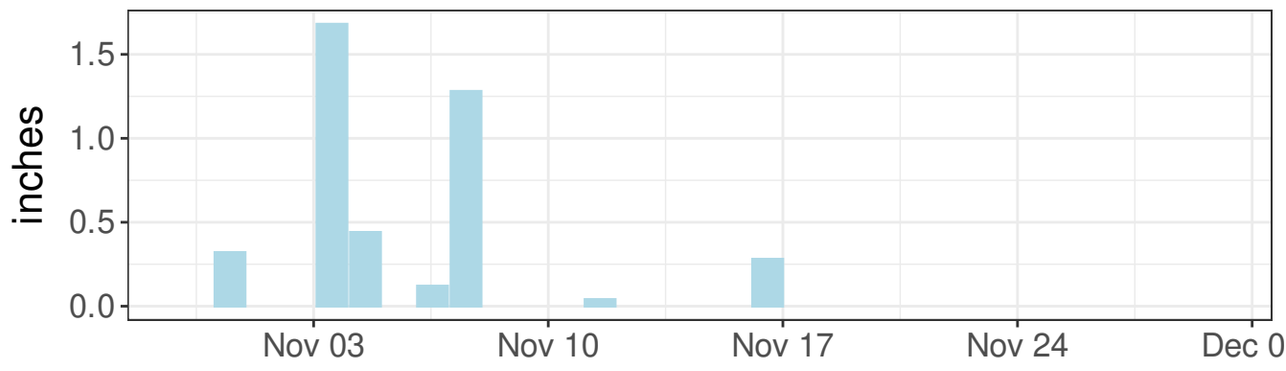
North tilt - detrended values



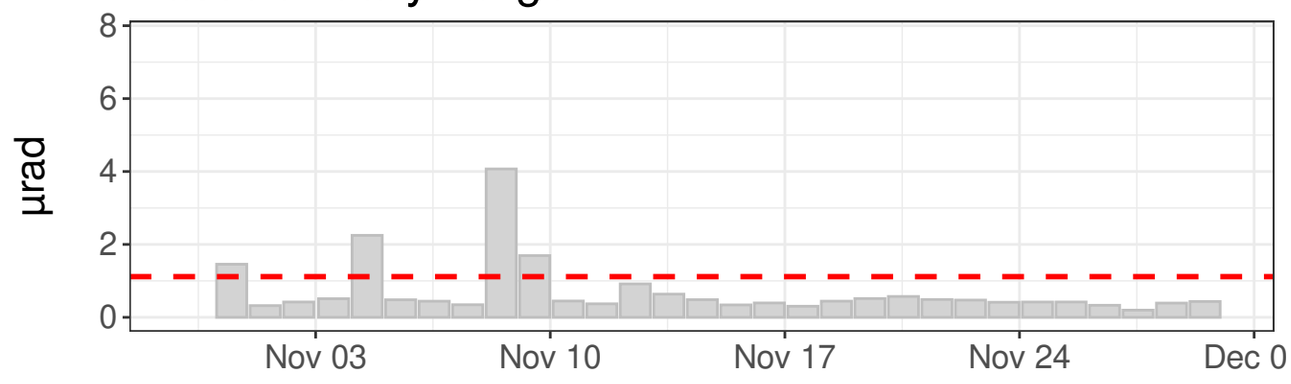
Daily precipitation



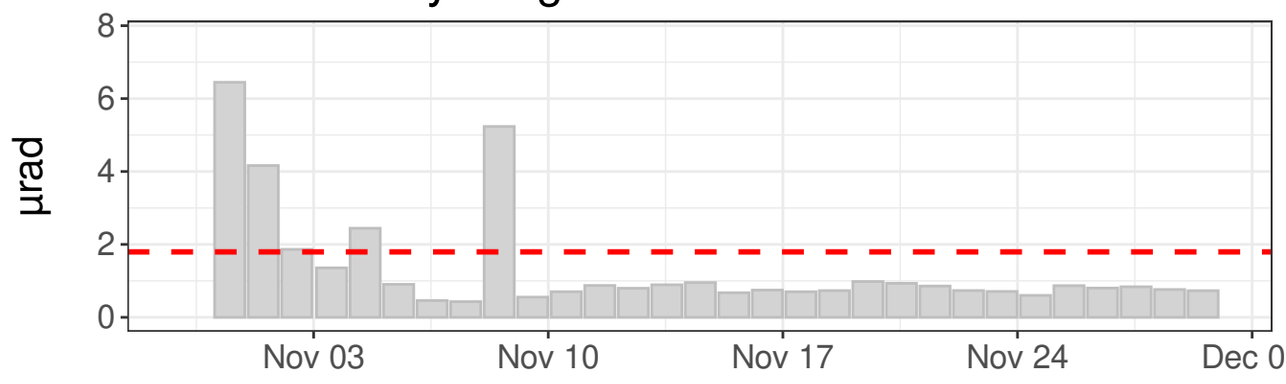
Daily precipitation



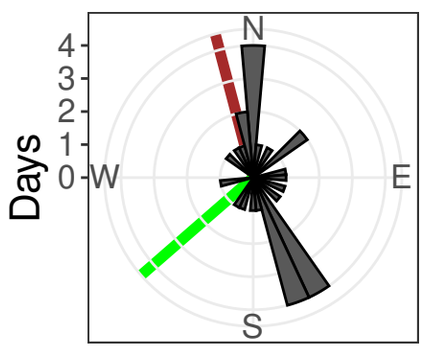
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: -27.70 ± 0.50 µrad/year

North tilt rate: 104.89 ± 1.48 µrad/year

Azimuth to C7: 229 deg

Distance to C7: 513 ft

Outlier value

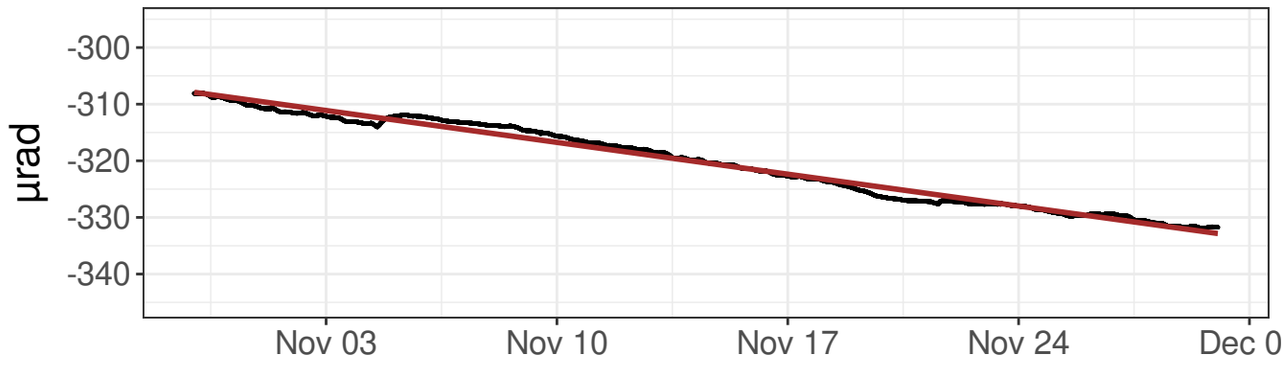
Linear model

Azimuth to C7

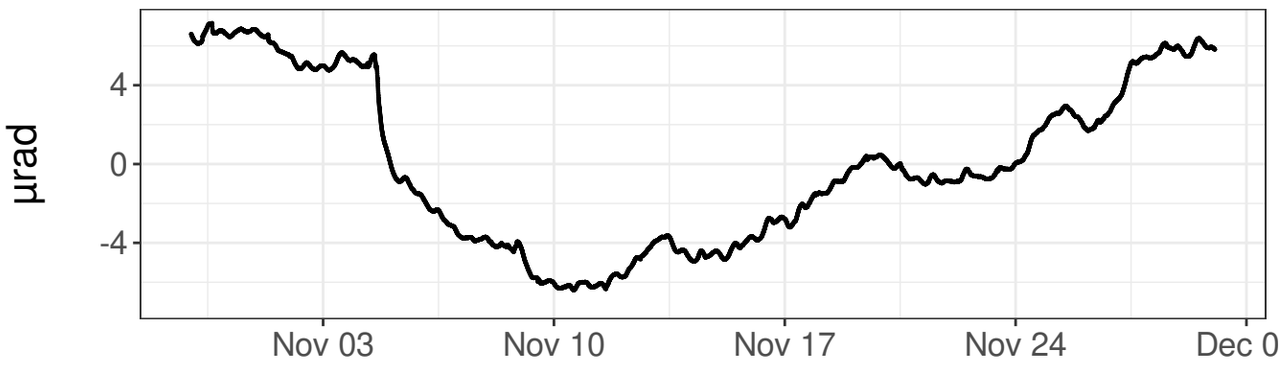
SSD08: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

East tilt - raw values, Linear model R2 0.90

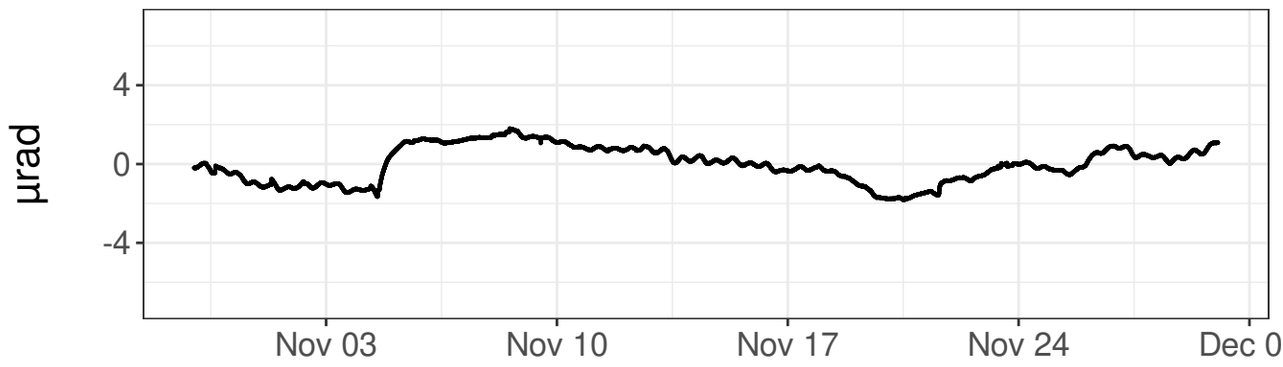
North tilt - raw values, Linear model R2 0.98



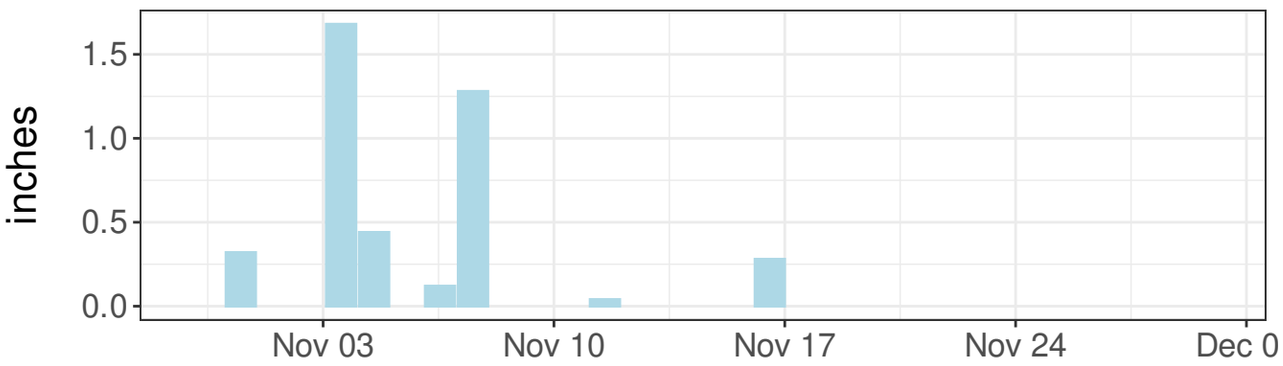
East tilt - detrended values



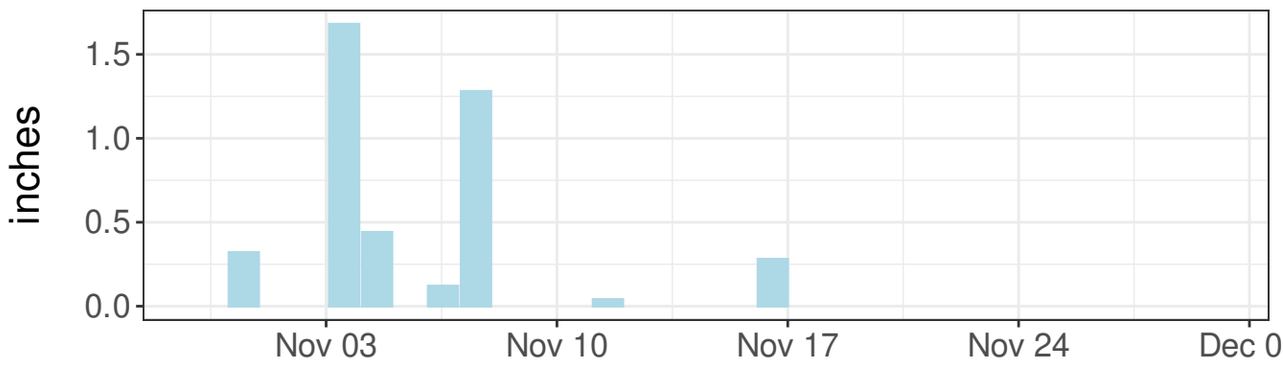
North tilt - detrended values



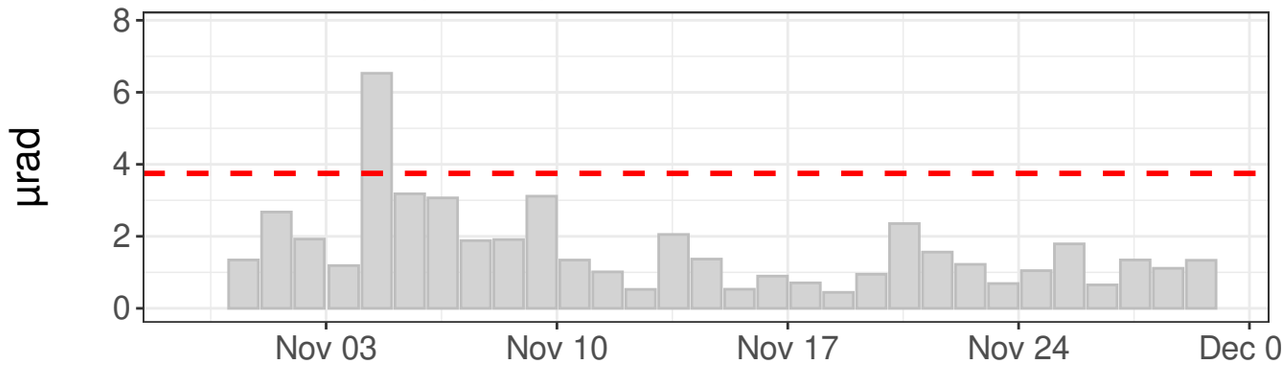
Daily precipitation



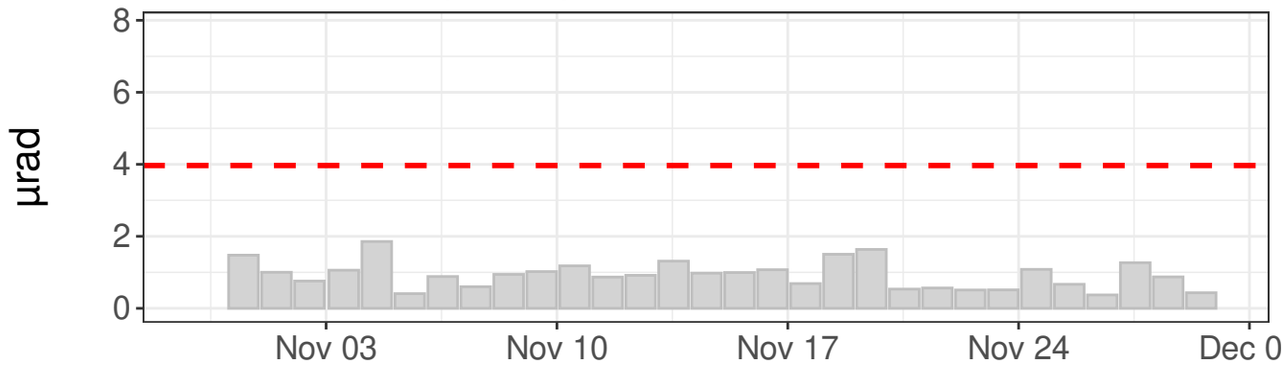
Daily precipitation



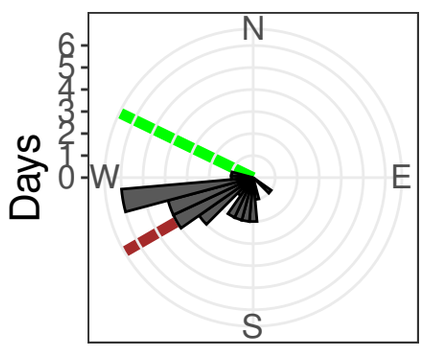
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: -509.41 ± 1.62 µrad/year

North tilt rate: -293.92 ± 0.35 µrad/year

Azimuth to C7: 296 deg

Distance to C7: 186 ft

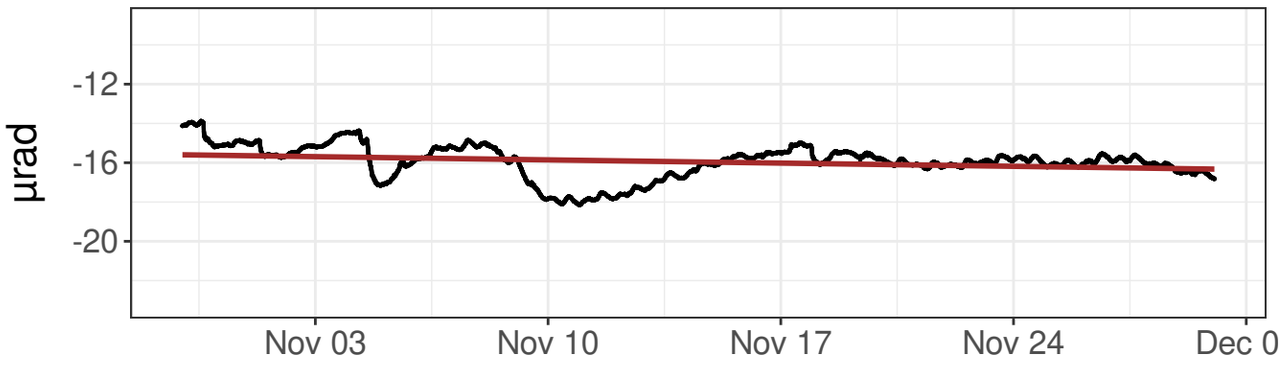
Outlier value

Linear model

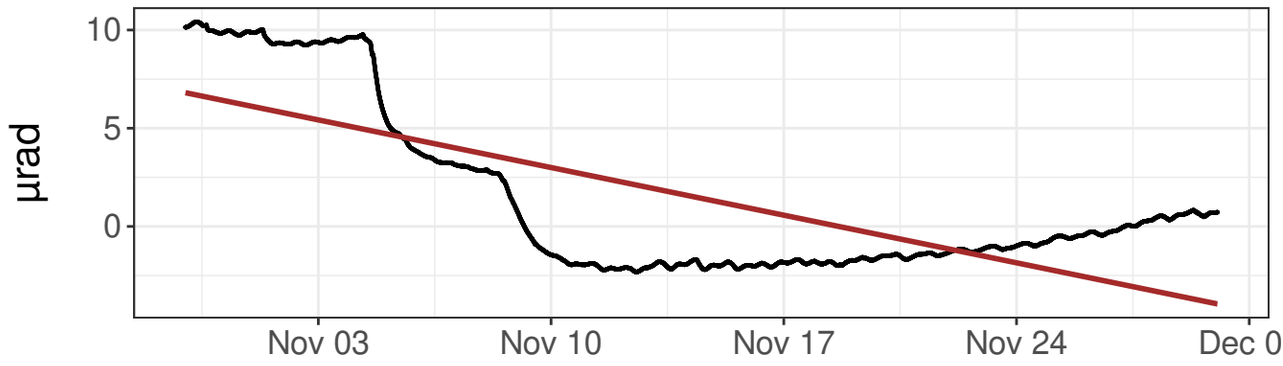
Azimuth to C7

SSD09: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

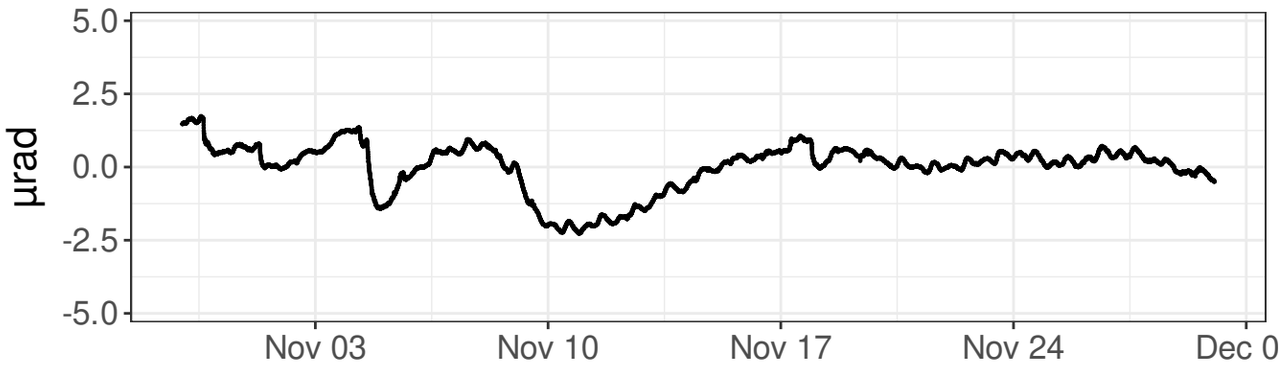
East tilt - raw values, Linear model R2 0.06



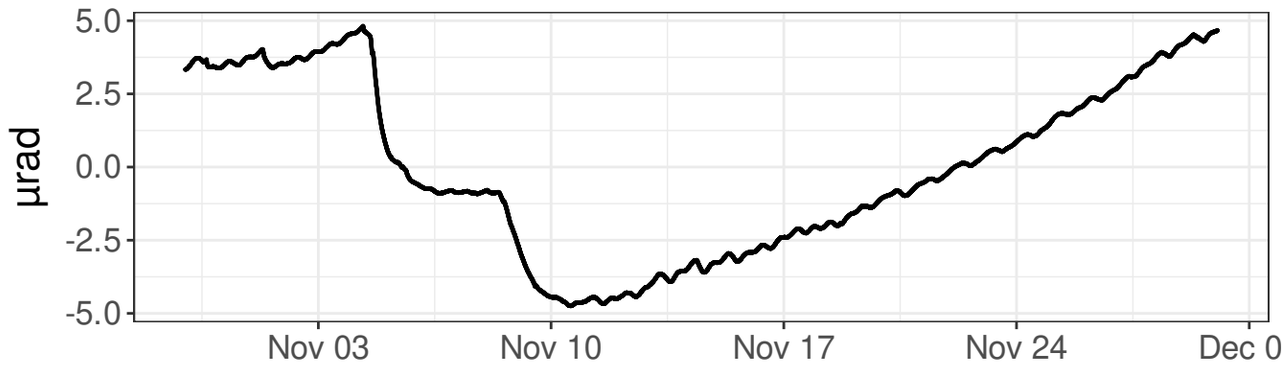
North tilt - raw values, Linear model R2 0.52



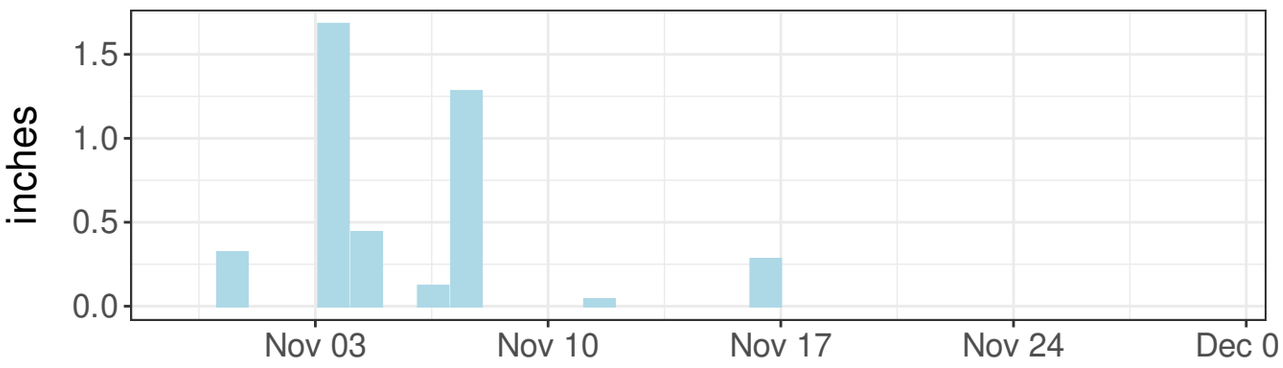
East tilt - detrended values



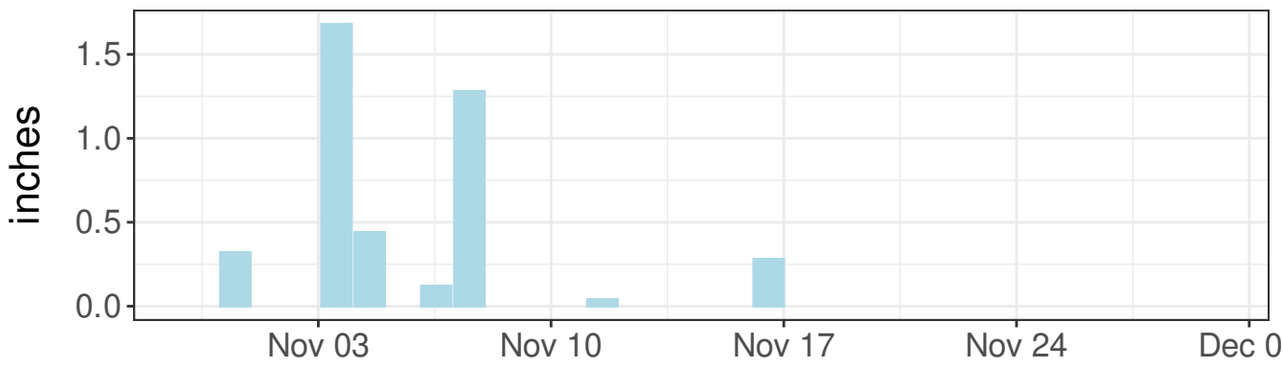
North tilt - detrended values



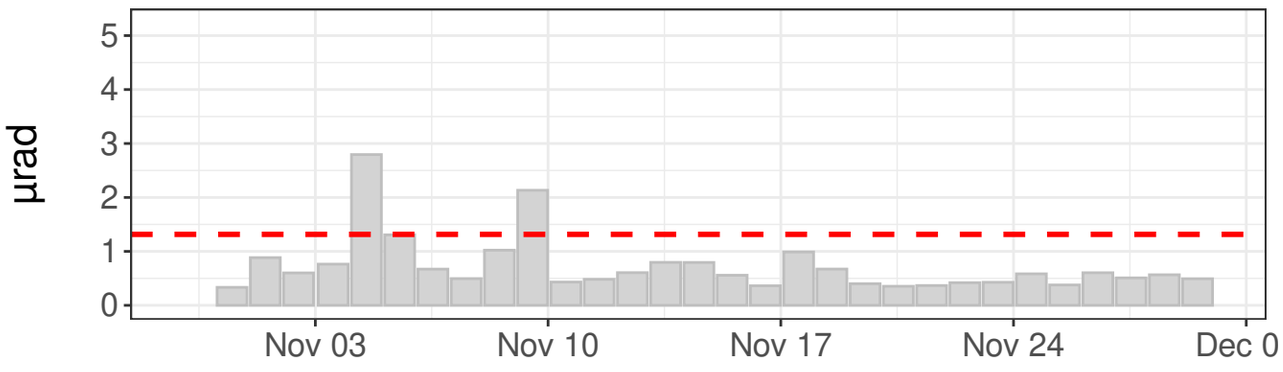
Daily precipitation



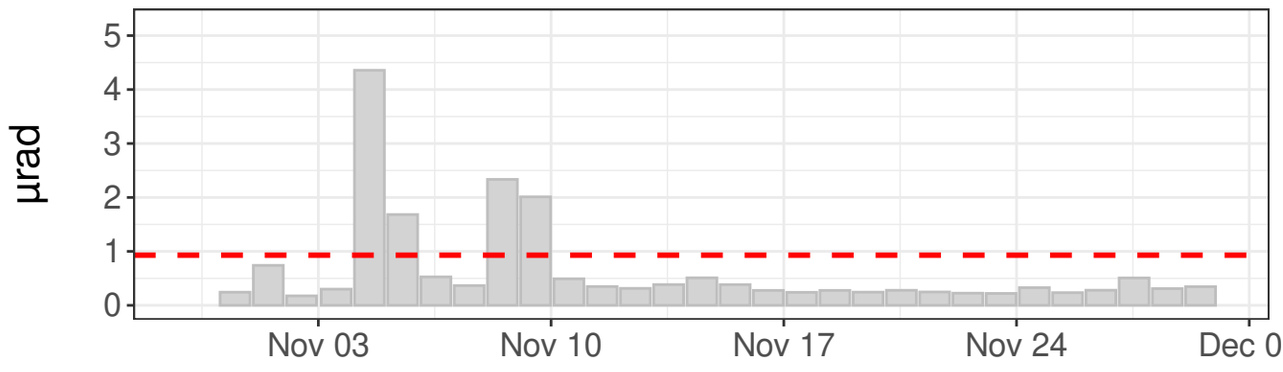
Daily precipitation



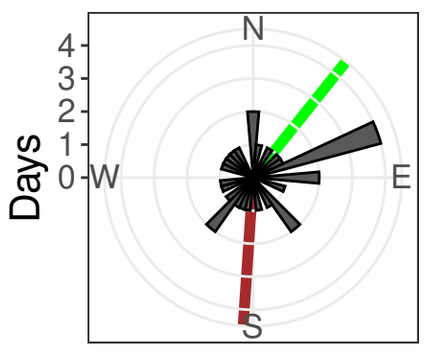
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: -8.57 ± 0.32 µrad/year

North tilt rate: -126.79 ± 1.15 µrad/year

Azimuth to C7: 39 deg

Distance to C7: 561 ft

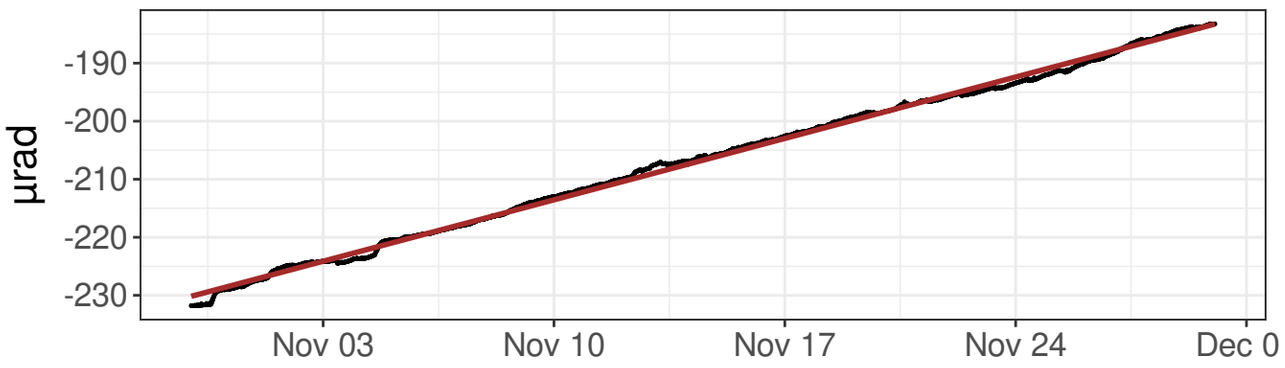
Outlier value

Linear model

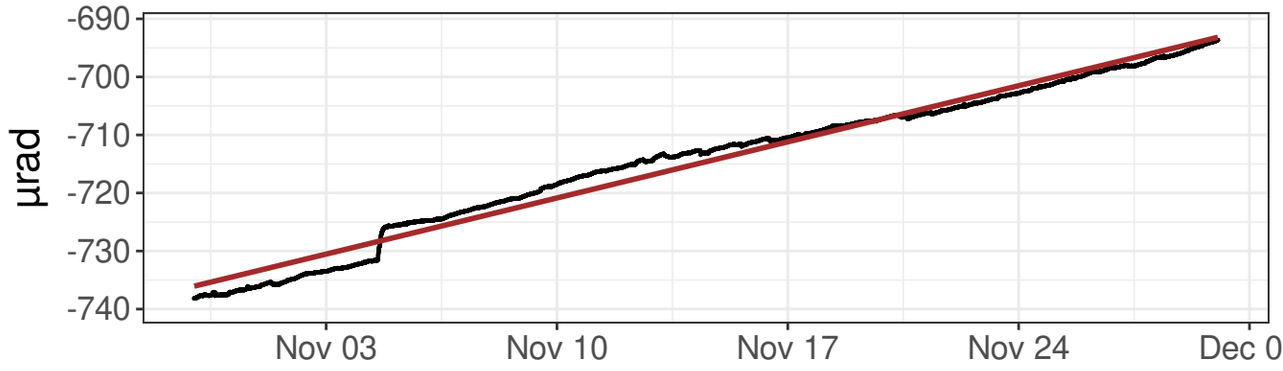
Azimuth to C7

SSD10: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

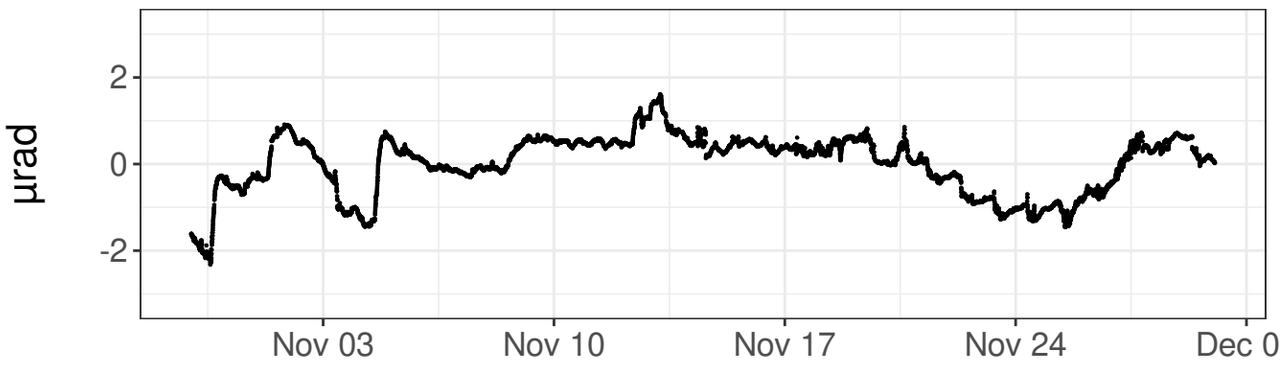
East tilt - raw values, Linear model R2 1.00



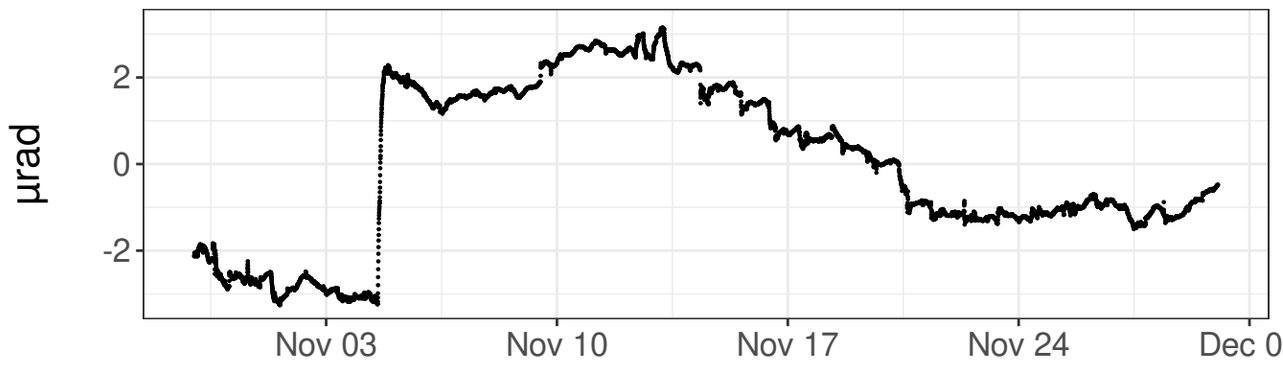
North tilt - raw values, Linear model R2 0.98



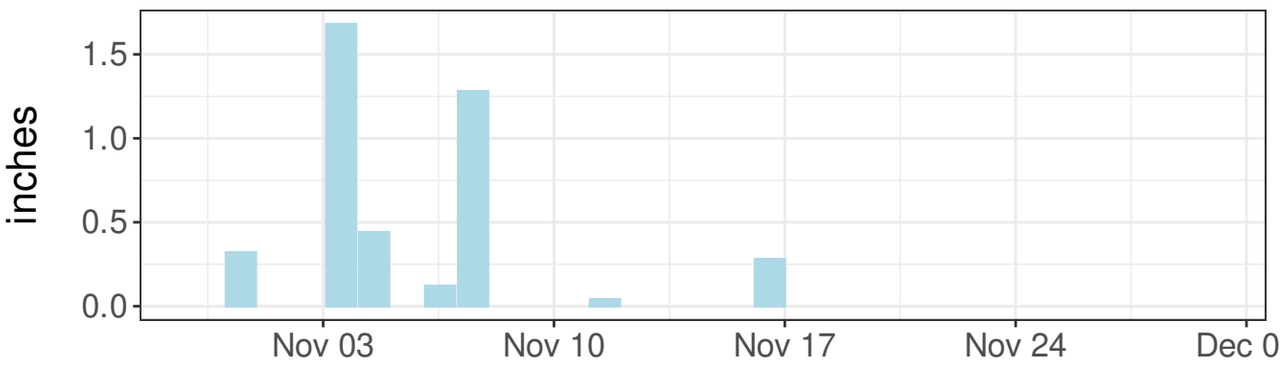
East tilt - detrended values



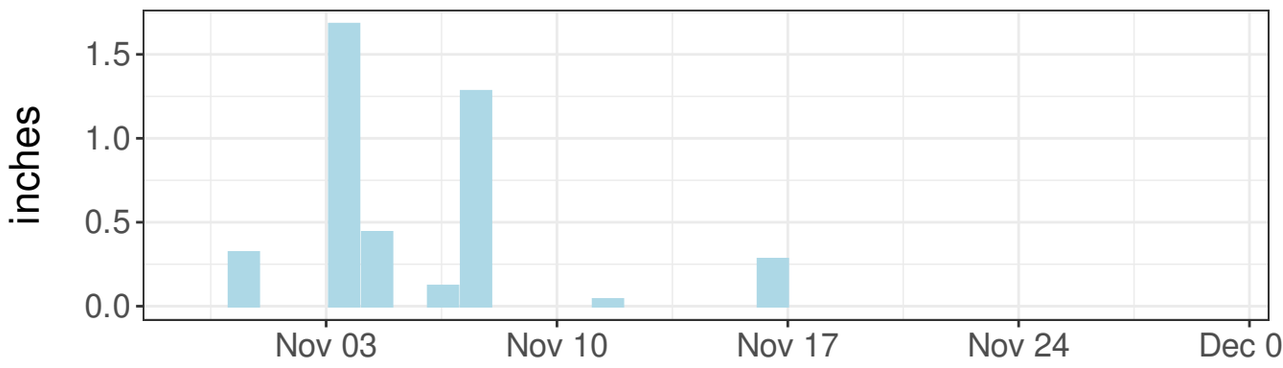
North tilt - detrended values



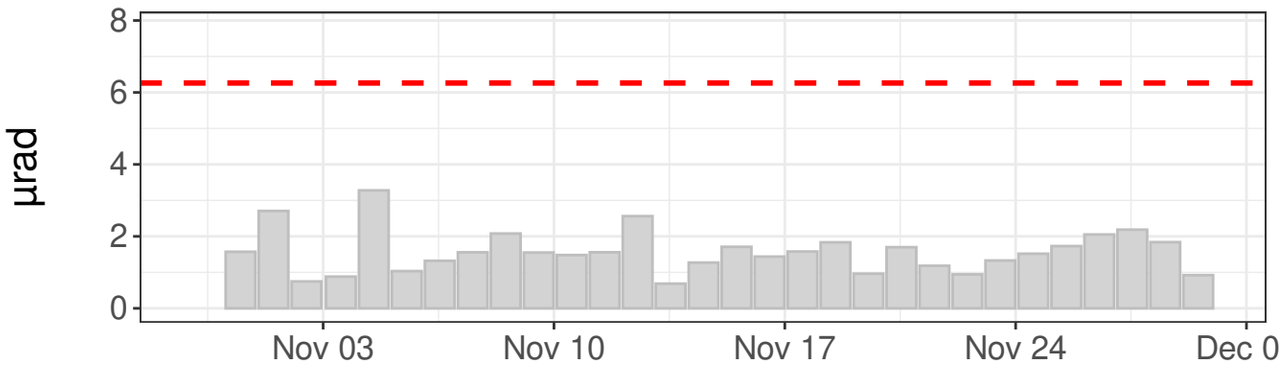
Daily precipitation



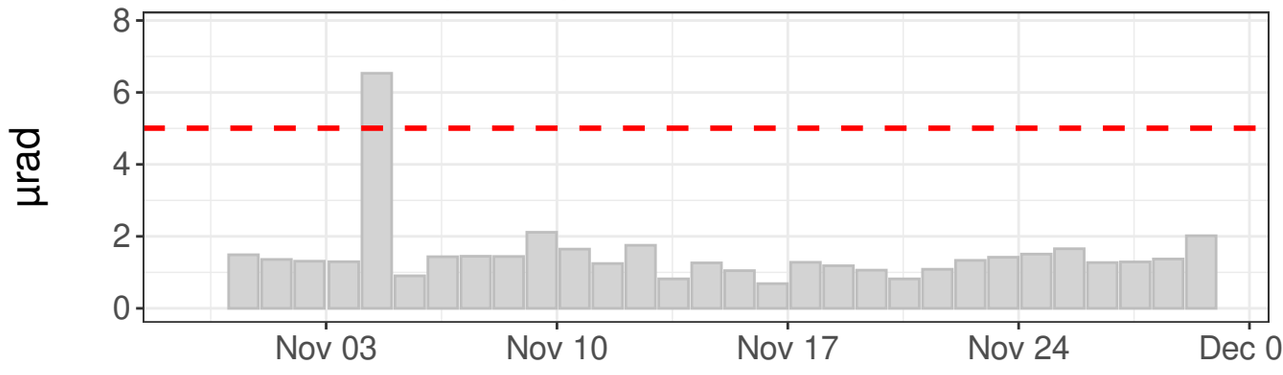
Daily precipitation



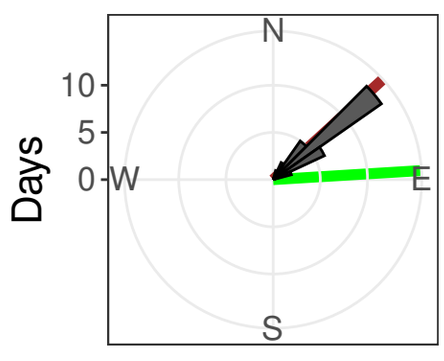
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: 552.97 ± 0.26 µrad/year

North tilt rate: 505.46 ± 0.71 µrad/year

Azimuth to C7: 87 deg

Distance to C7: 2402 ft

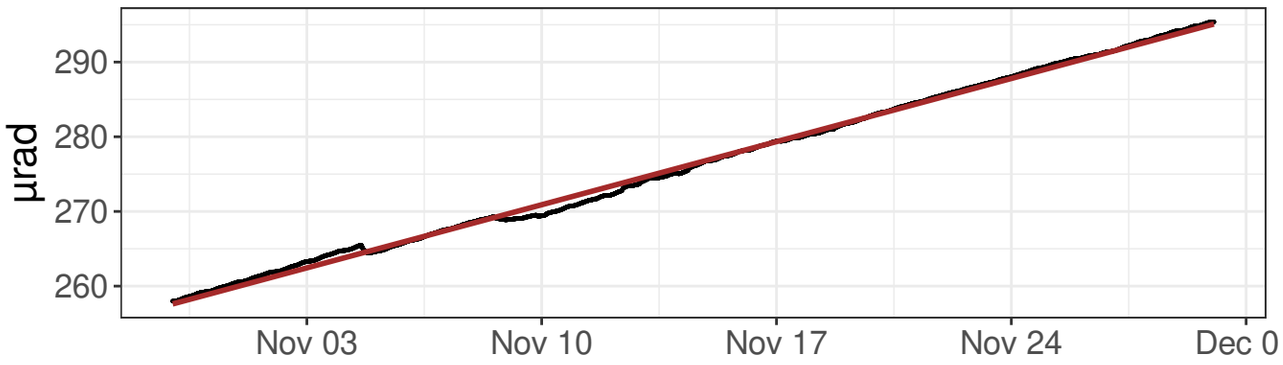
Outlier value

Linear model

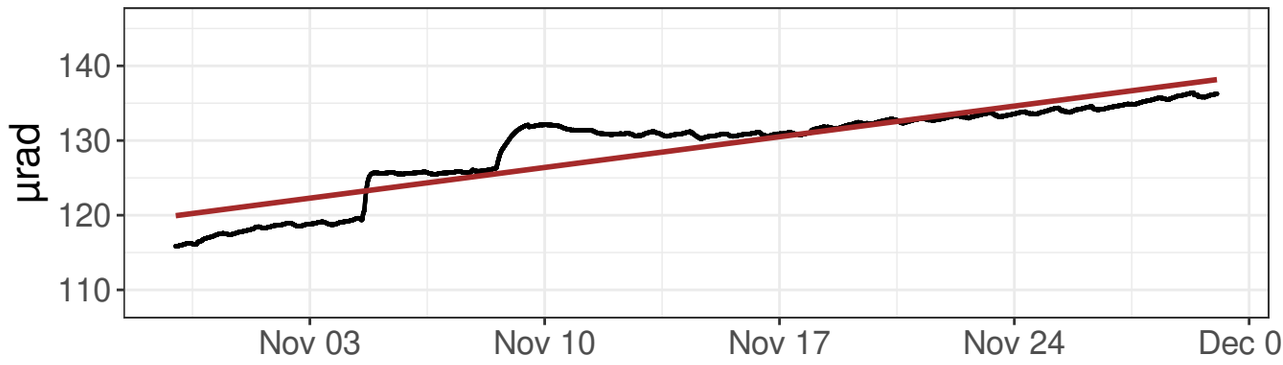
Azimuth to C7

SSD11: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

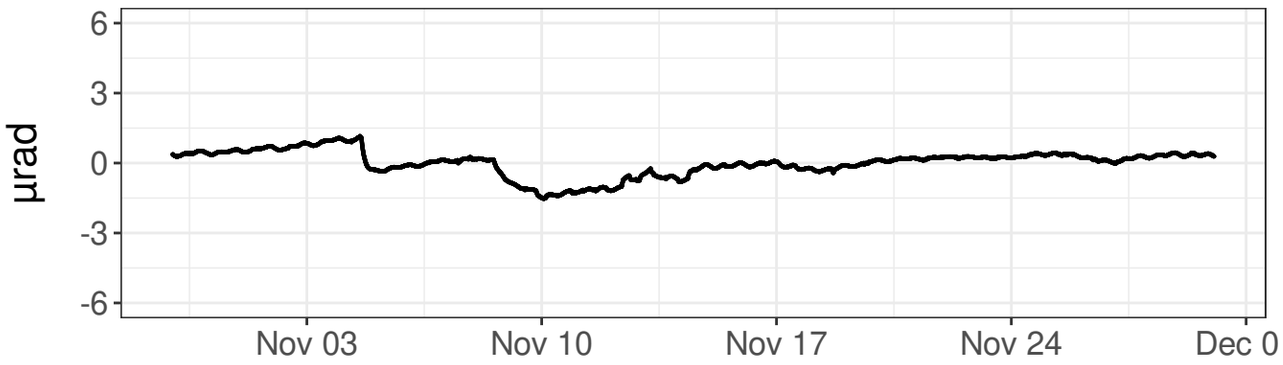
East tilt - raw values, Linear model R2 1.00



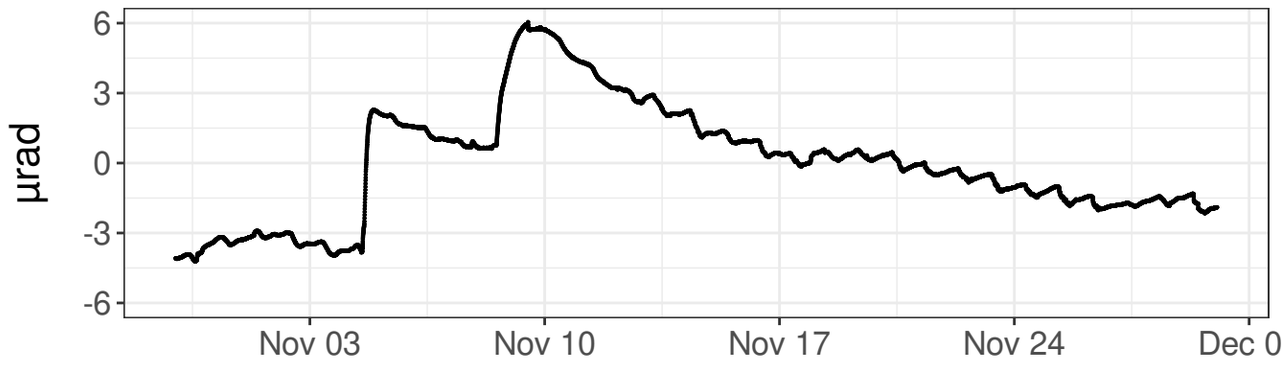
North tilt - raw values, Linear model R2 0.82



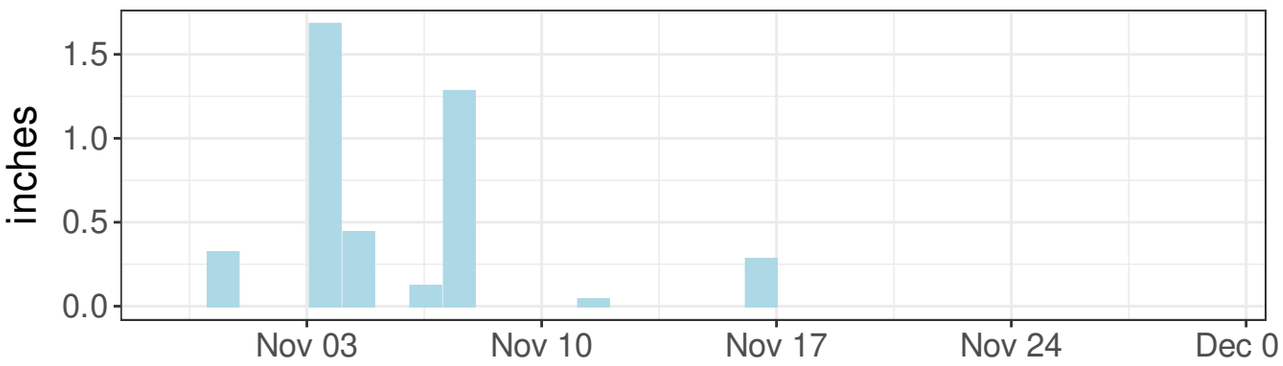
East tilt - detrended values



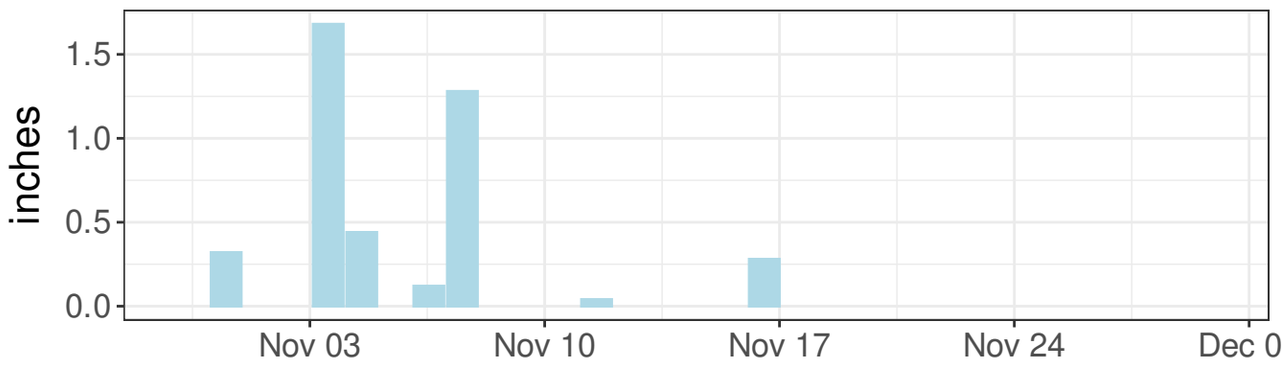
North tilt - detrended values



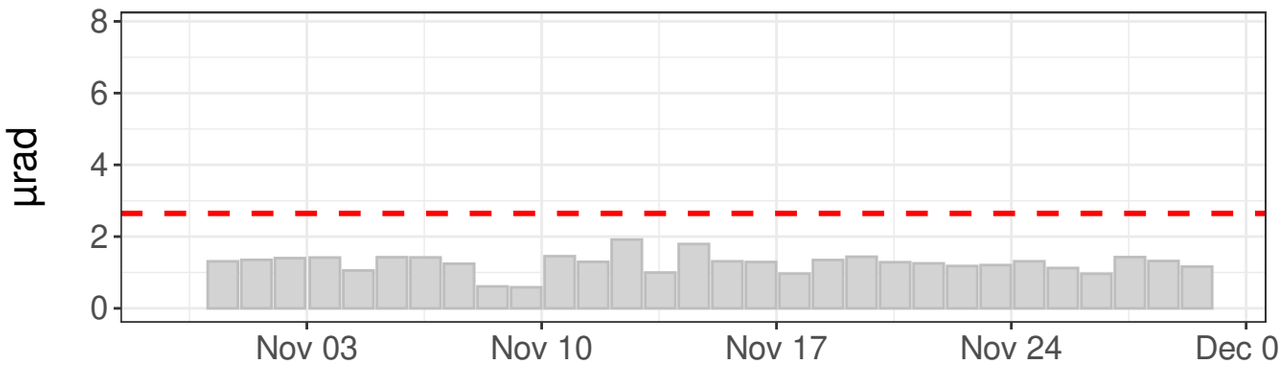
Daily precipitation



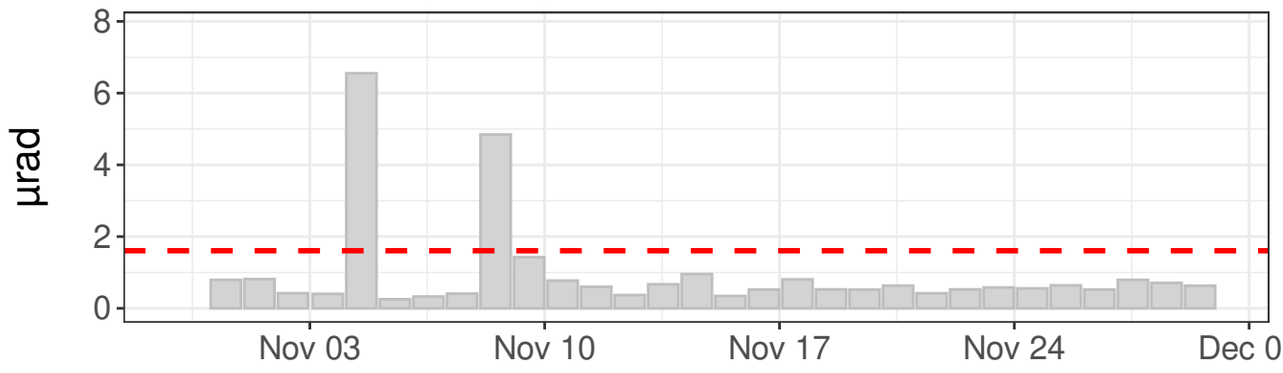
Daily precipitation



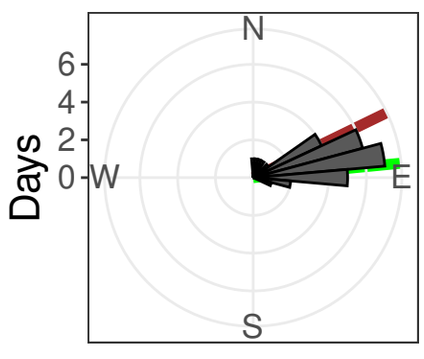
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: 441.94 ± 0.21 µrad/year

North tilt rate: 214.87 ± 0.96 µrad/year

Azimuth to C7: 84 deg

Distance to C7: 1473 ft

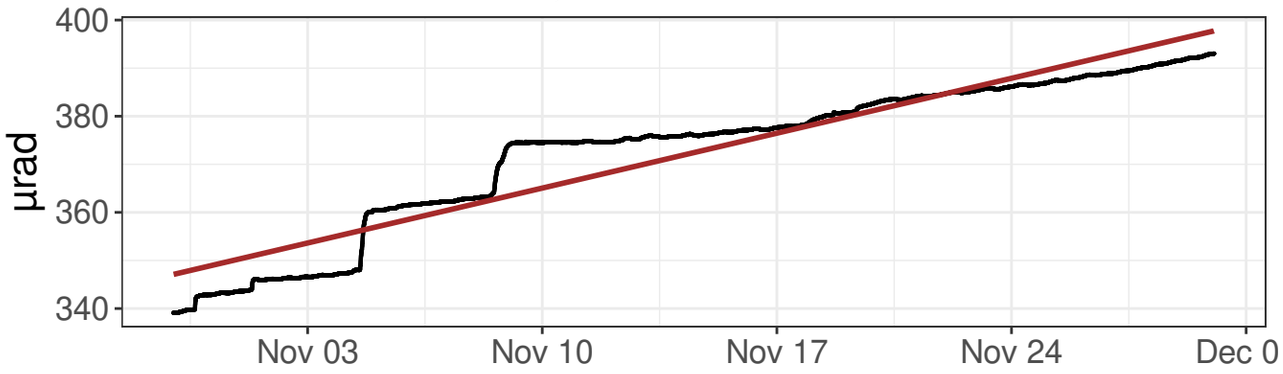
Outlier value

Linear model

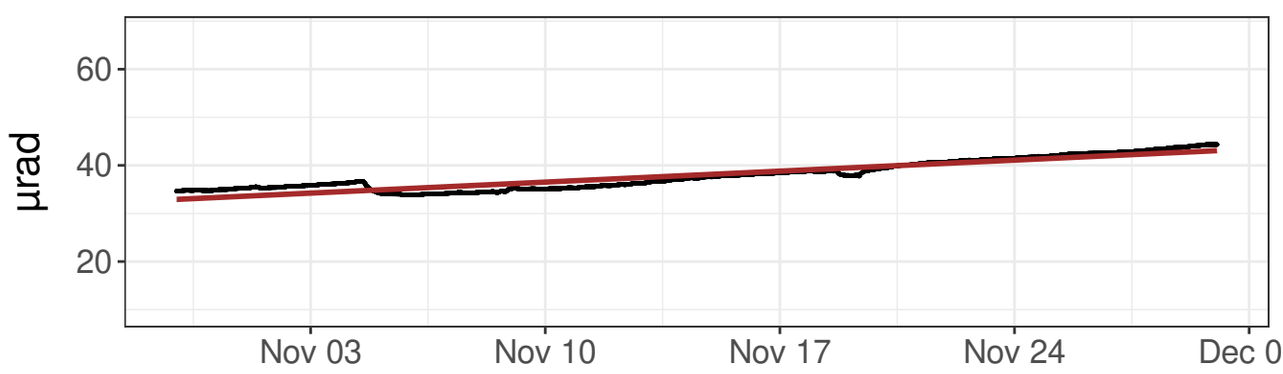
Azimuth to C7

SSD12: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

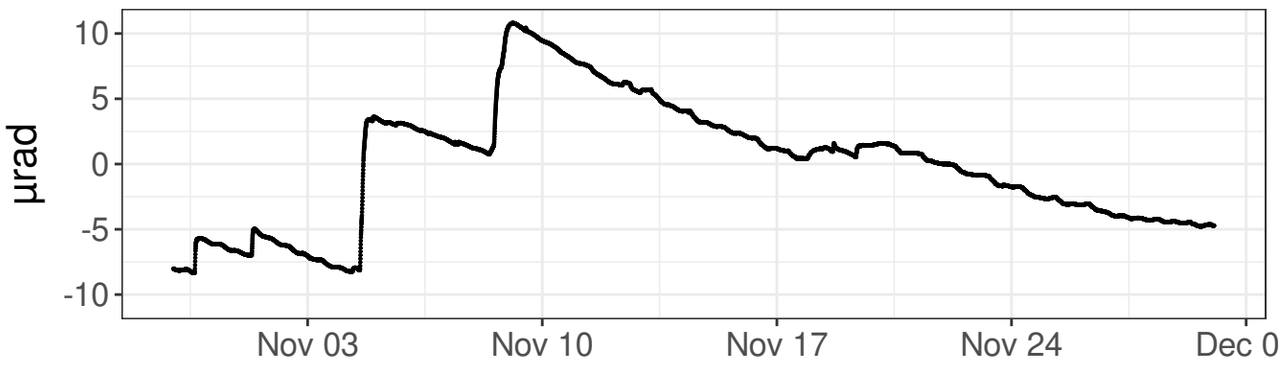
East tilt - raw values, Linear model R2 0.90



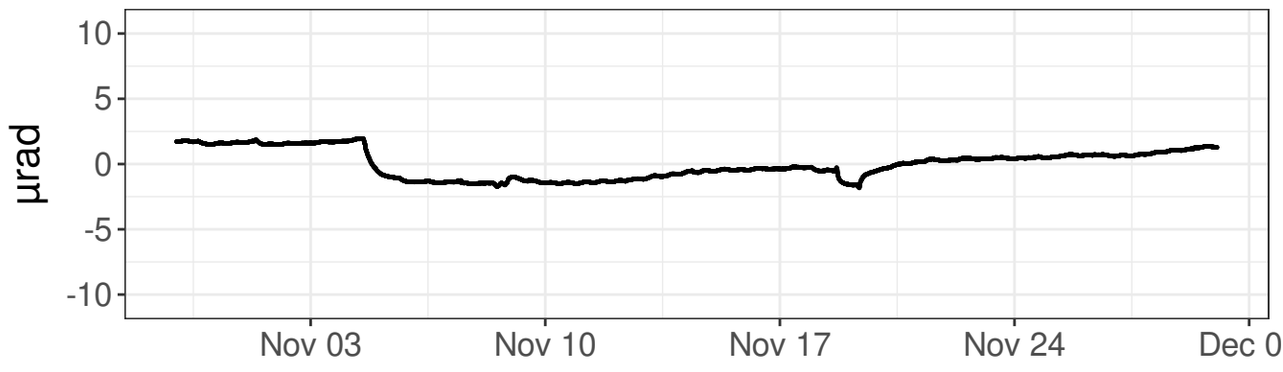
North tilt - raw values, Linear model R2 0.87



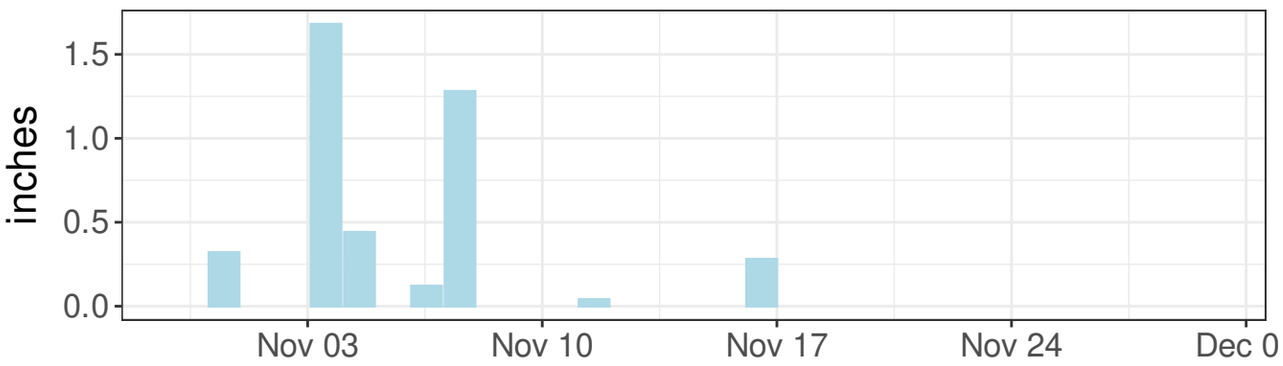
East tilt - detrended values



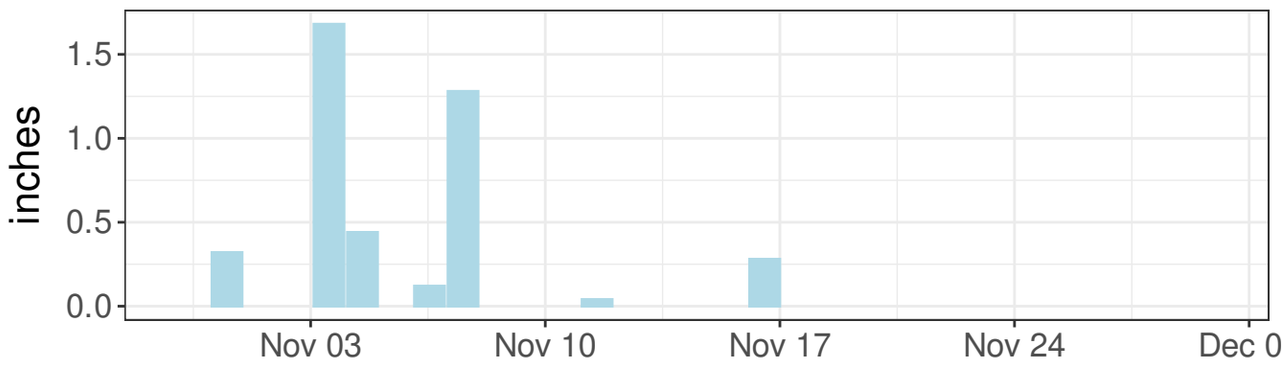
North tilt - detrended values



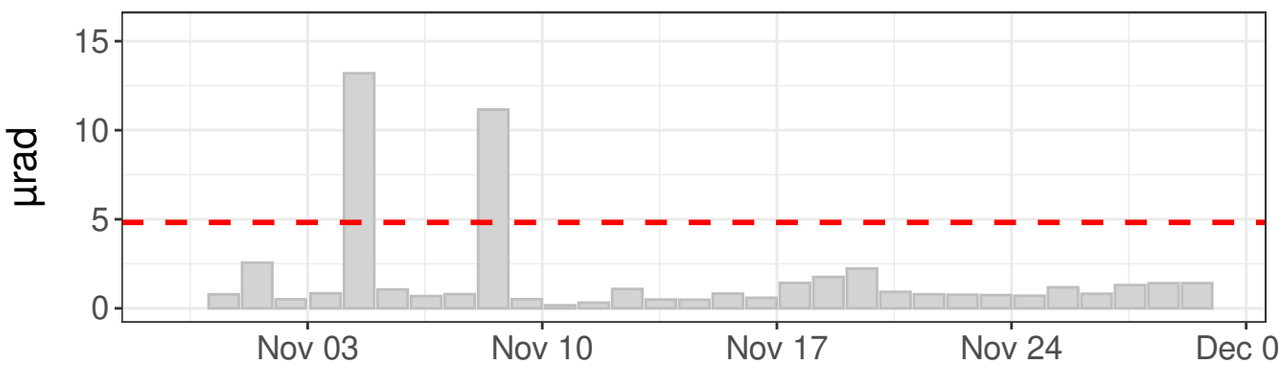
Daily precipitation



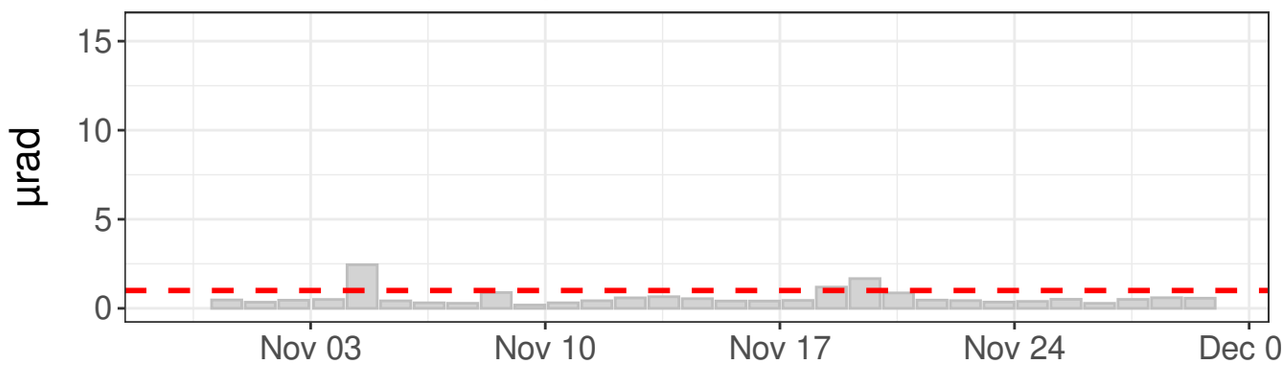
Daily precipitation



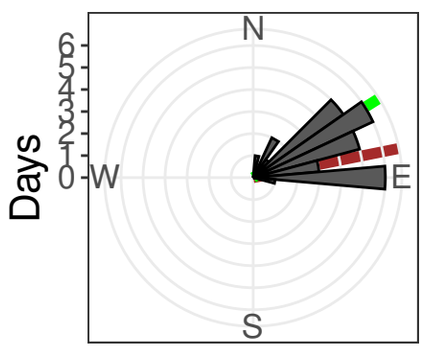
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: 597.12 ± 1.87 µrad/year

North tilt rate: 119.52 ± 0.43 µrad/year

Azimuth to C7: 58 deg

Distance to C7: 1344 ft

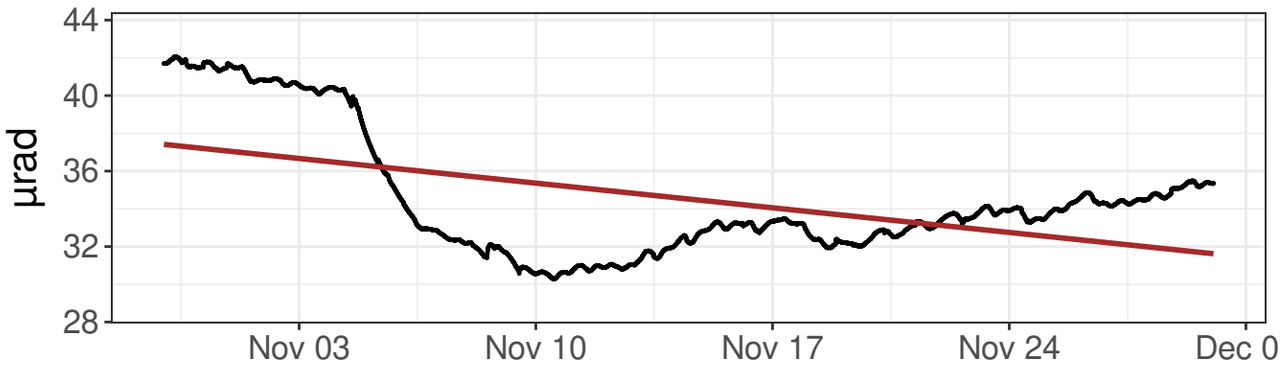
Outlier value

Linear model

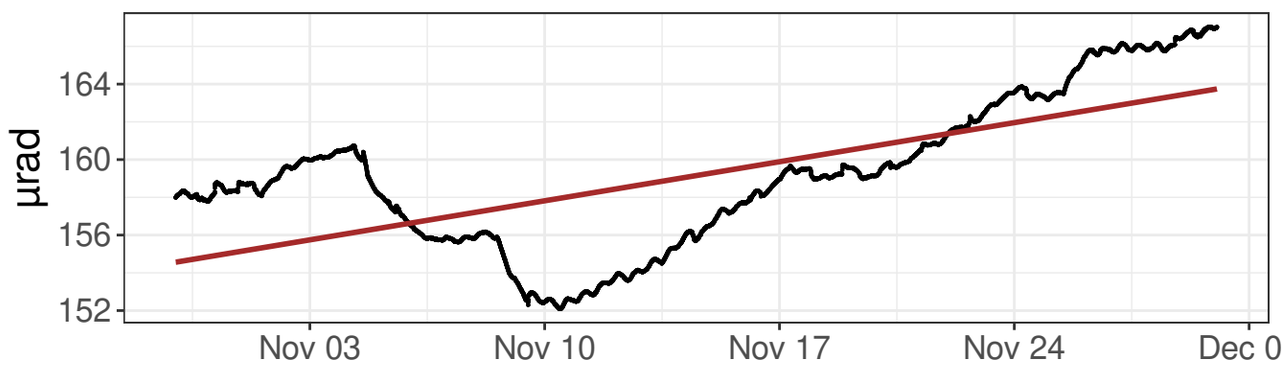
Azimuth to C7

SSD13: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

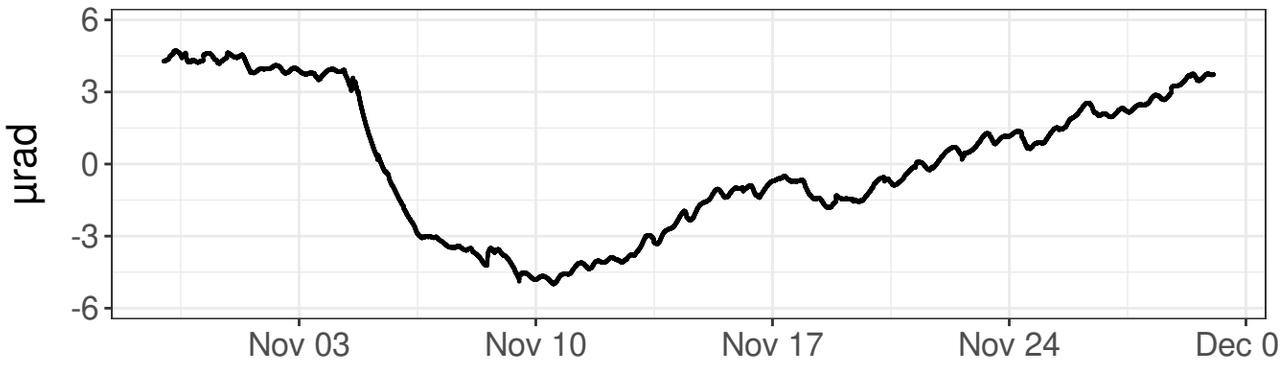
East tilt - raw values, Linear model R2 0.25



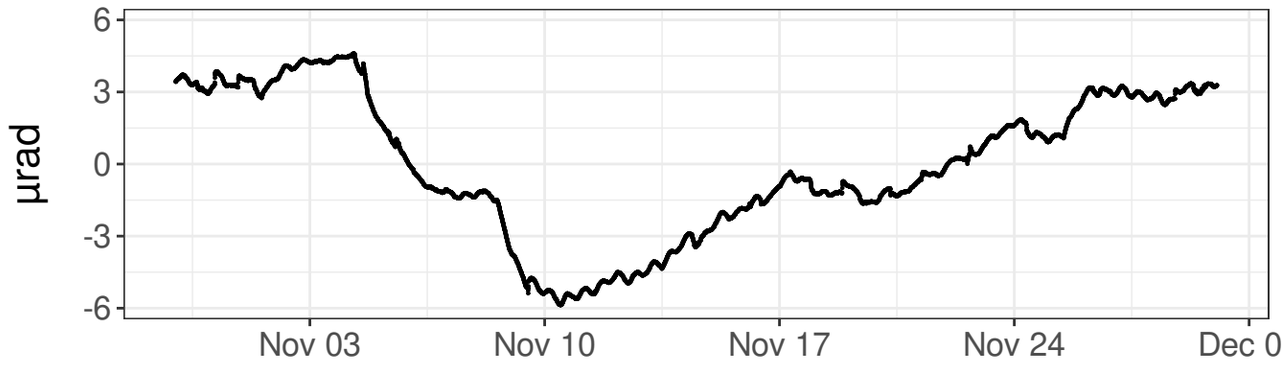
North tilt - raw values, Linear model R2 0.44



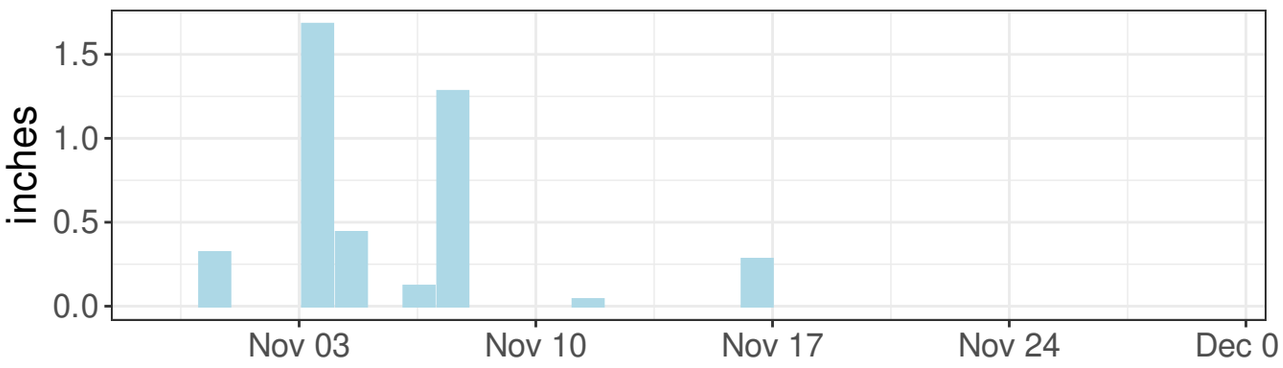
East tilt - detrended values



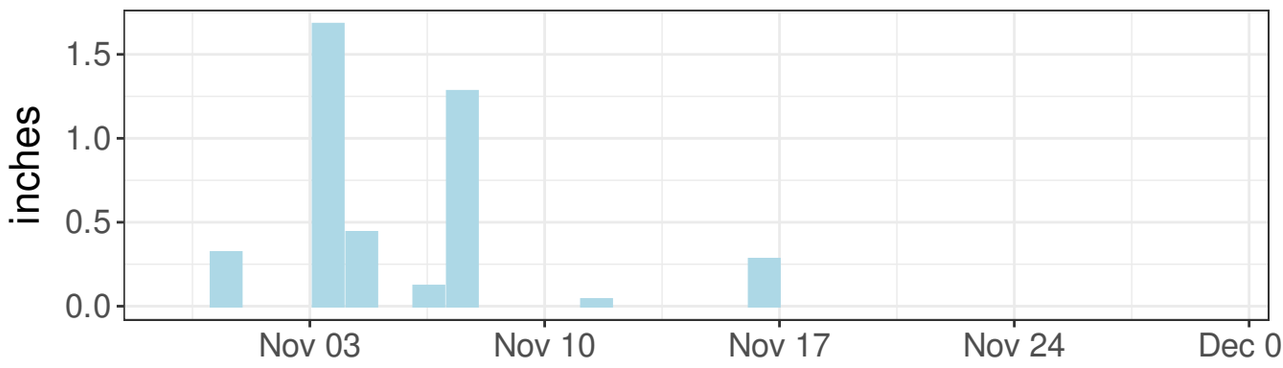
North tilt - detrended values



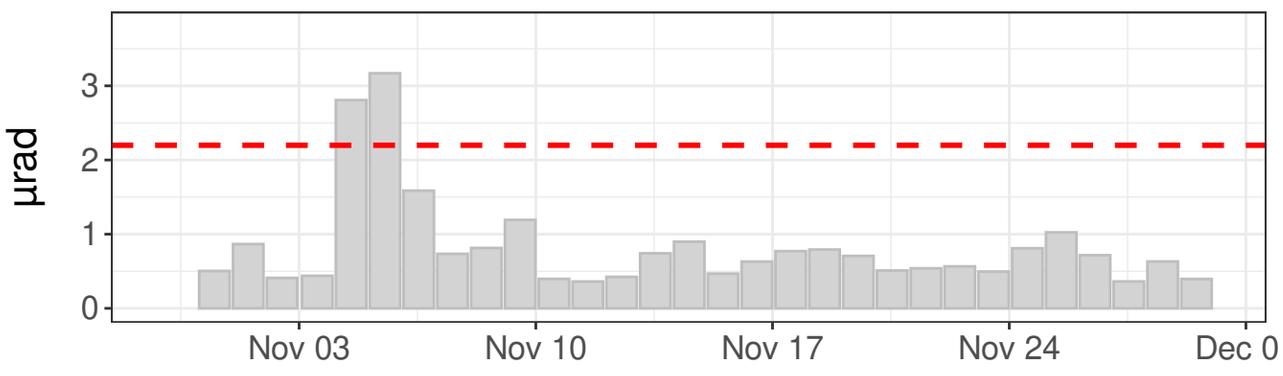
Daily precipitation



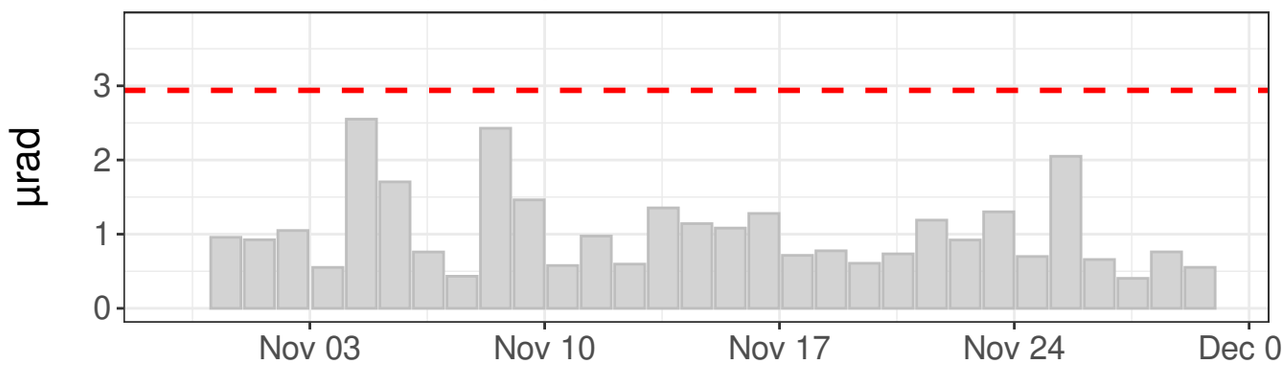
Daily precipitation



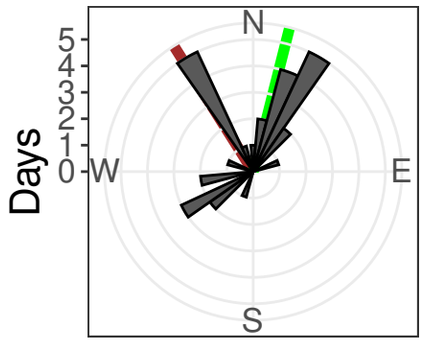
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: -68.32 ± 1.13 µrad/year

North tilt rate: 108.24 ± 1.14 µrad/year

Azimuth to C7: 14 deg

Distance to C7: 686 ft

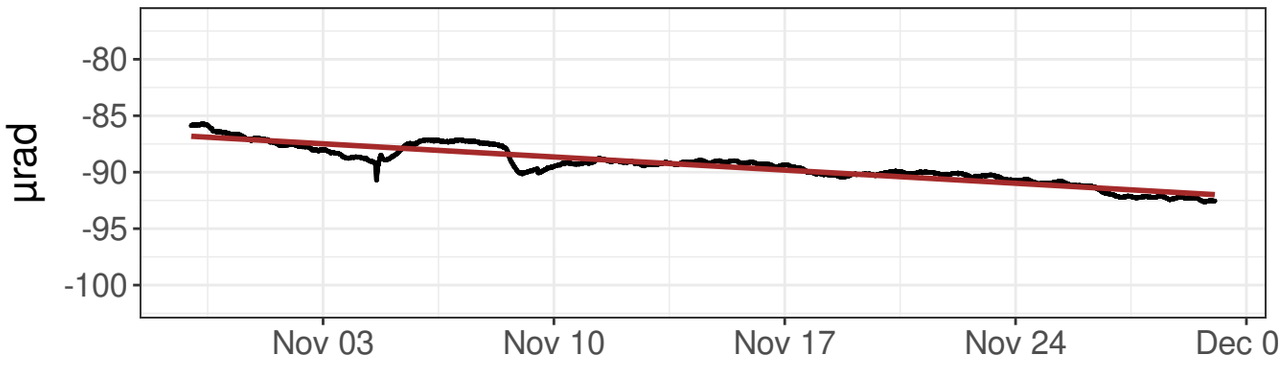
Outlier value

Linear model

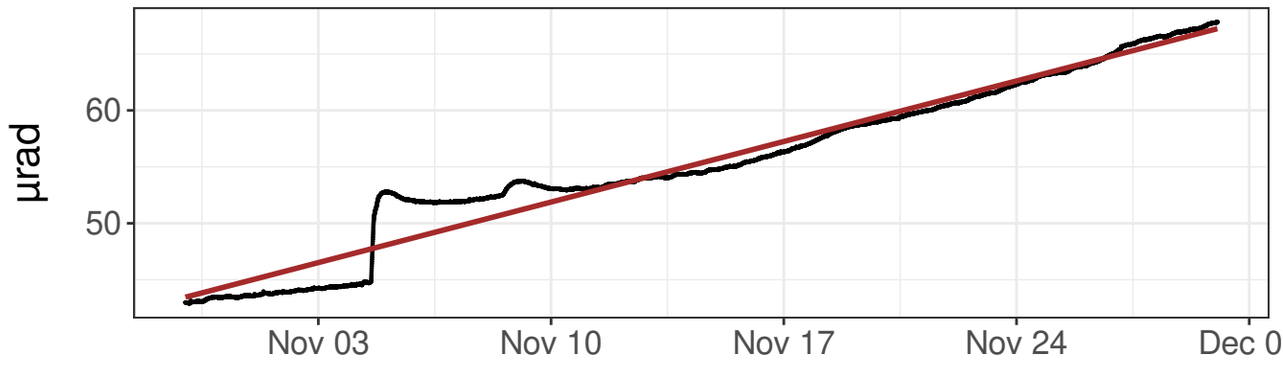
Azimuth to C7

SSD14: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

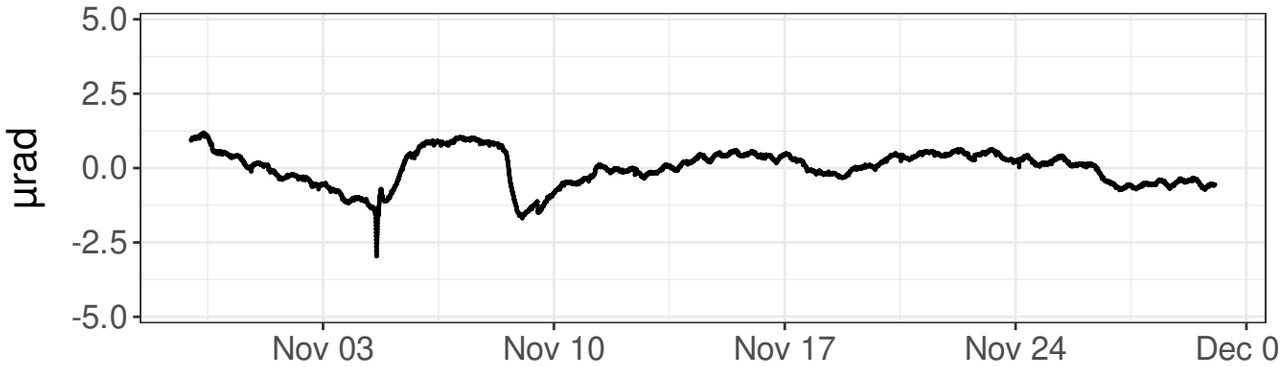
East tilt - raw values, Linear model R2 0.86



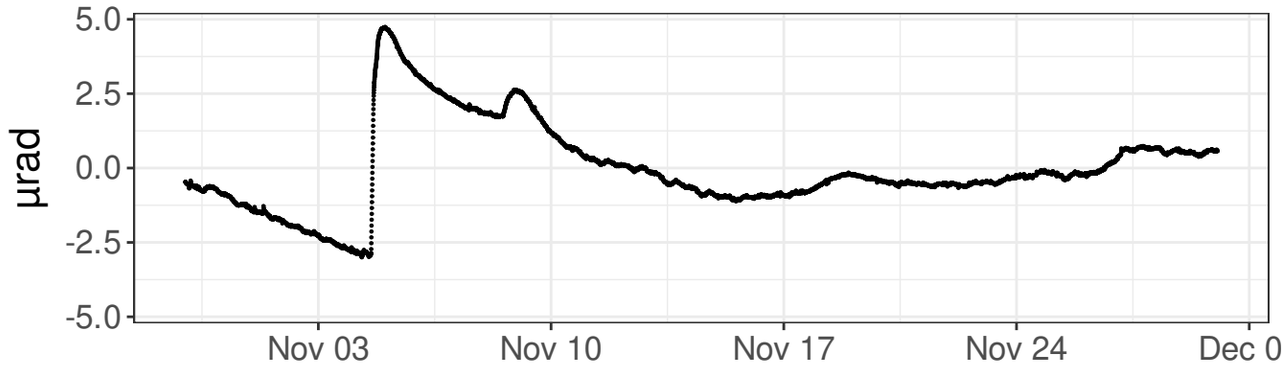
North tilt - raw values, Linear model R2 0.96



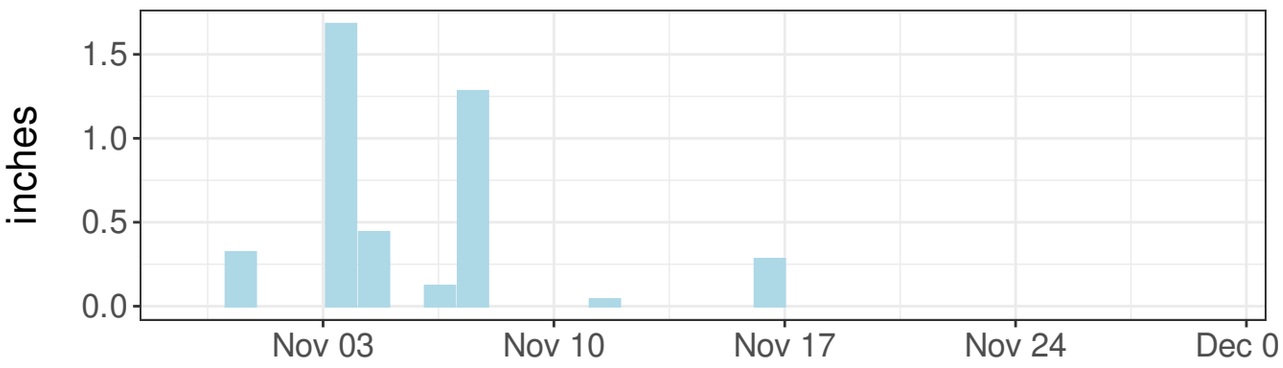
East tilt - detrended values



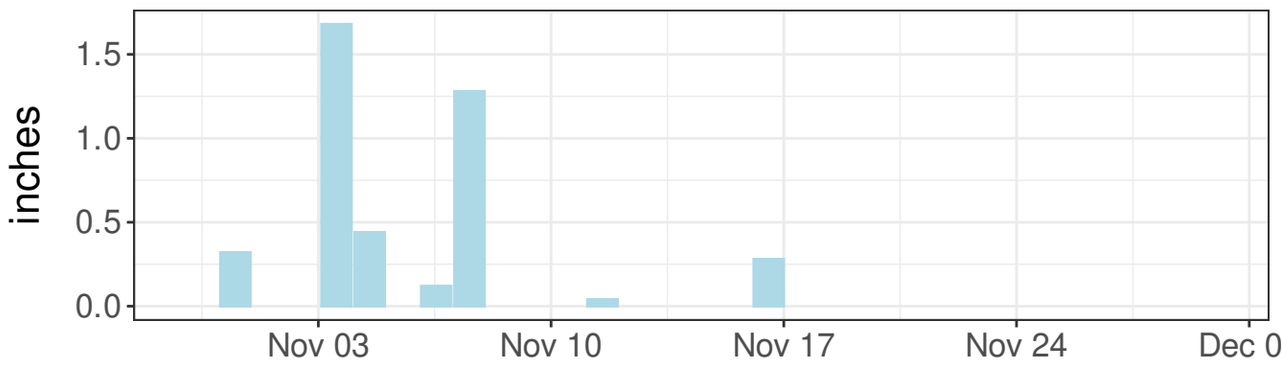
North tilt - detrended values



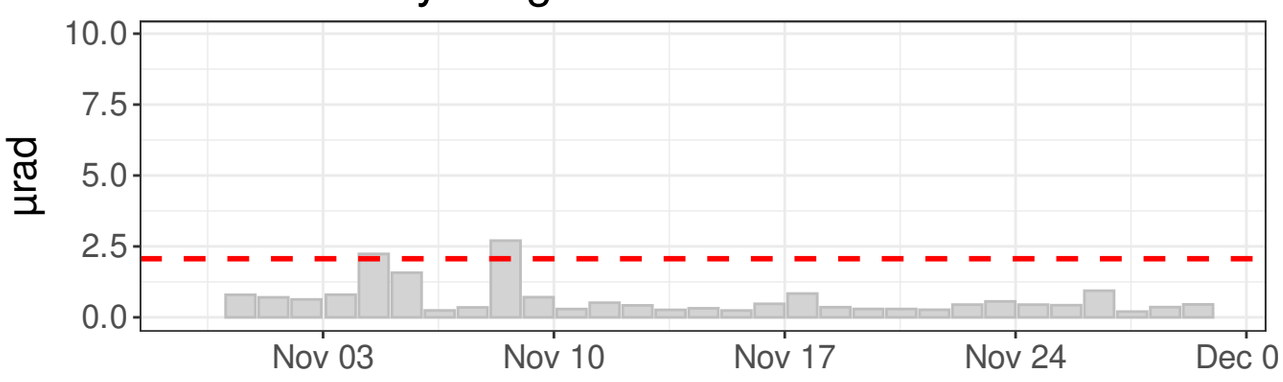
Daily precipitation



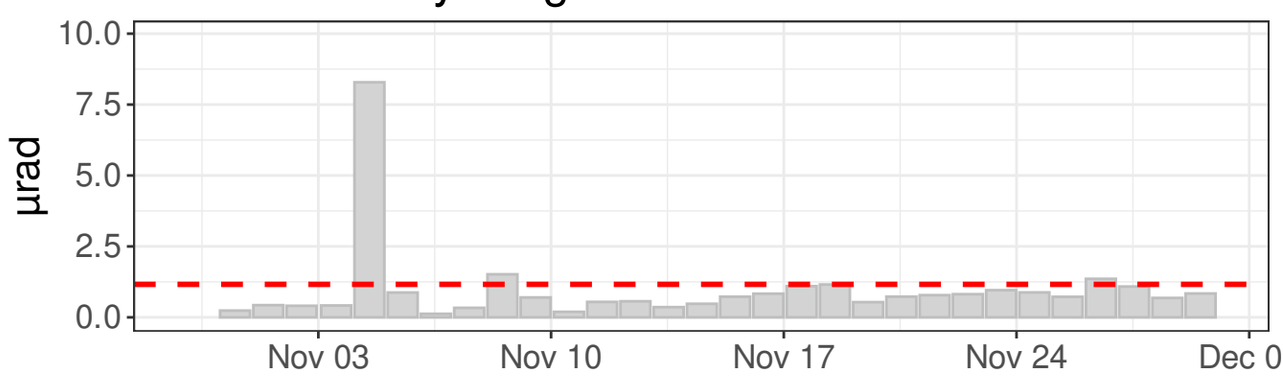
Daily precipitation



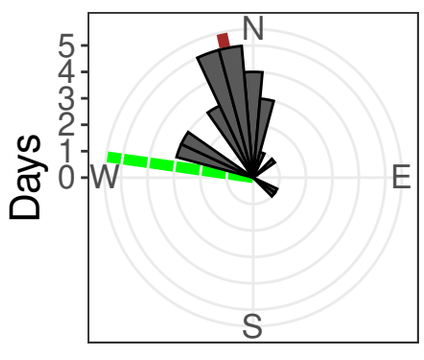
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: -60.95 ± 0.23 µrad/year

North tilt rate: 280.44 ± 0.57 µrad/year

Azimuth to C7: 278 deg

Distance to C7: 1151 ft

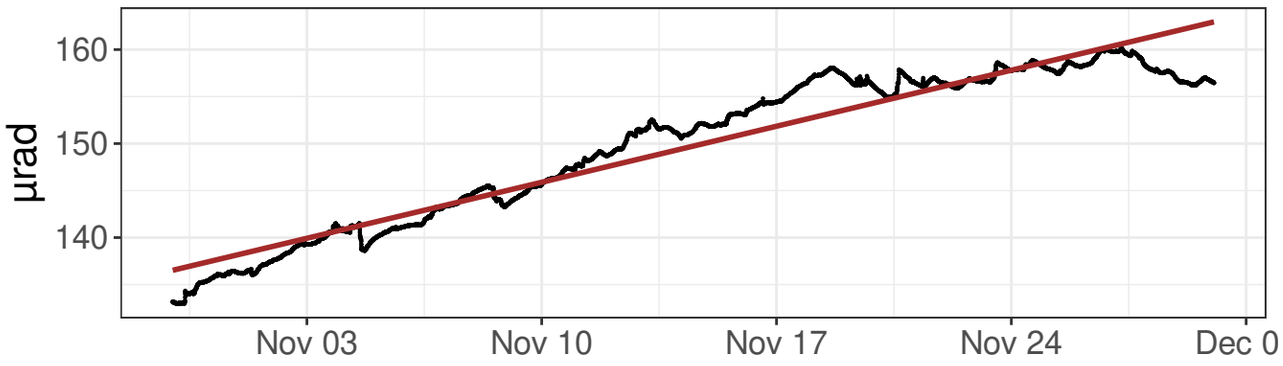
Outlier value

Linear model

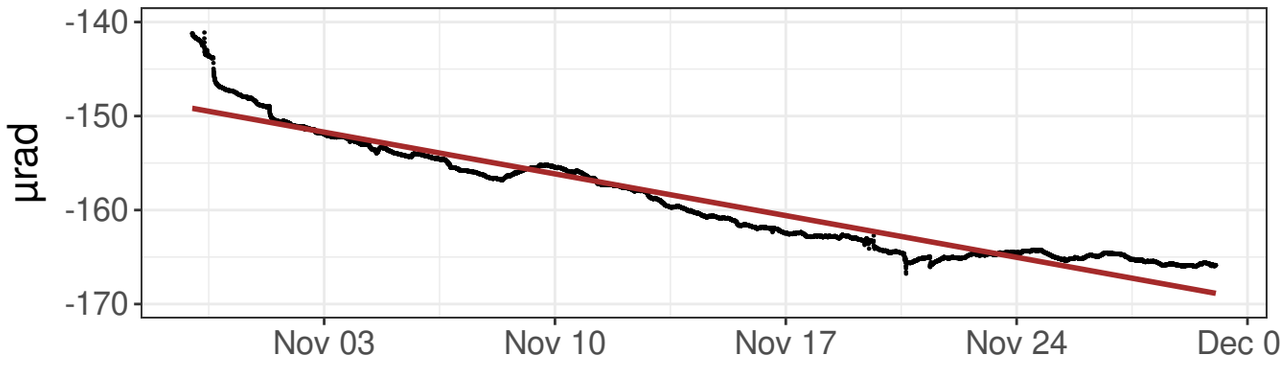
Azimuth to C7

SSD15: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

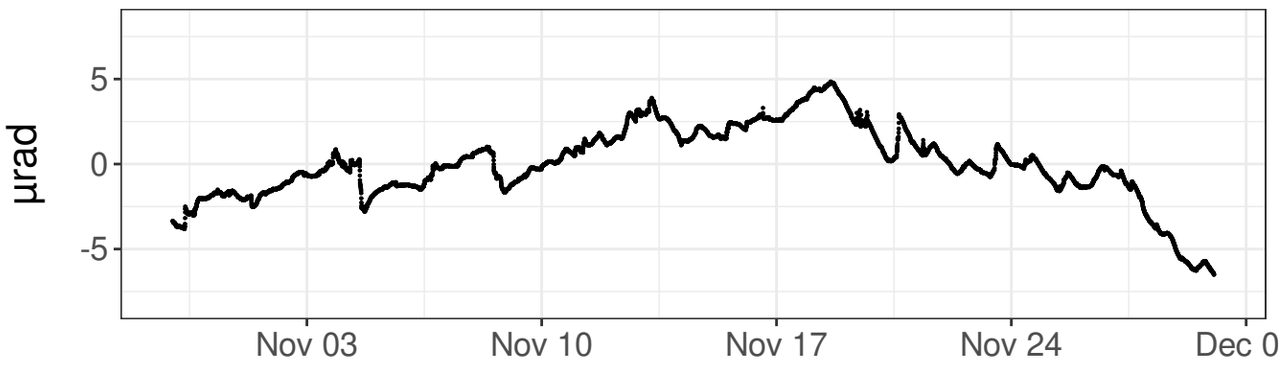
East tilt - raw values, Linear model R2 0.92



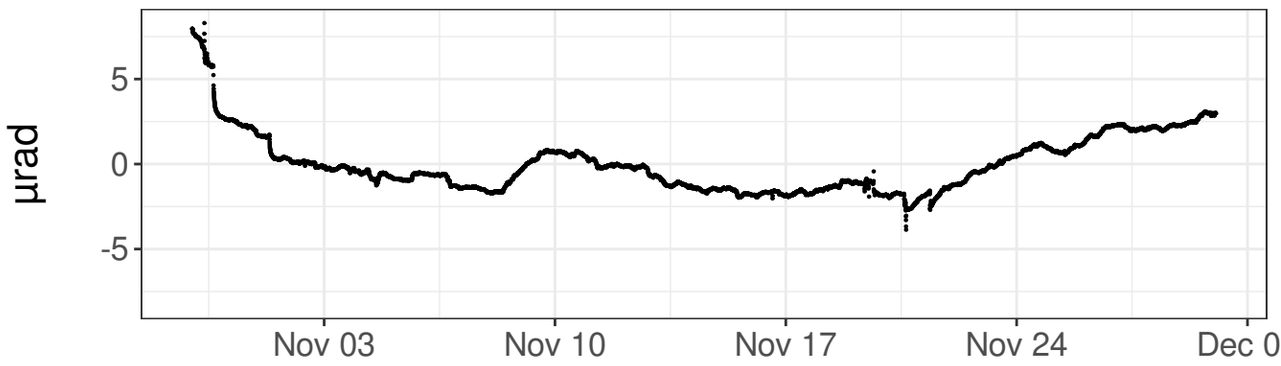
North tilt - raw values, Linear model R2 0.92



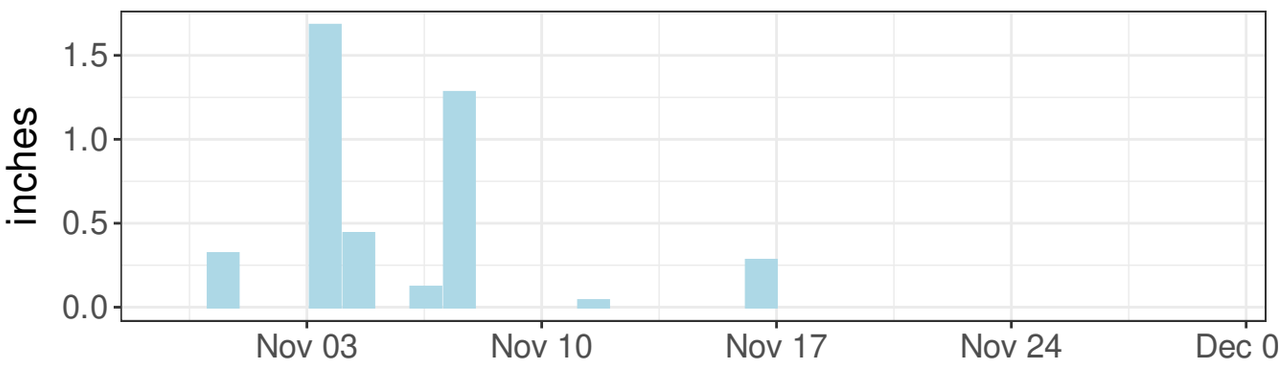
East tilt - detrended values



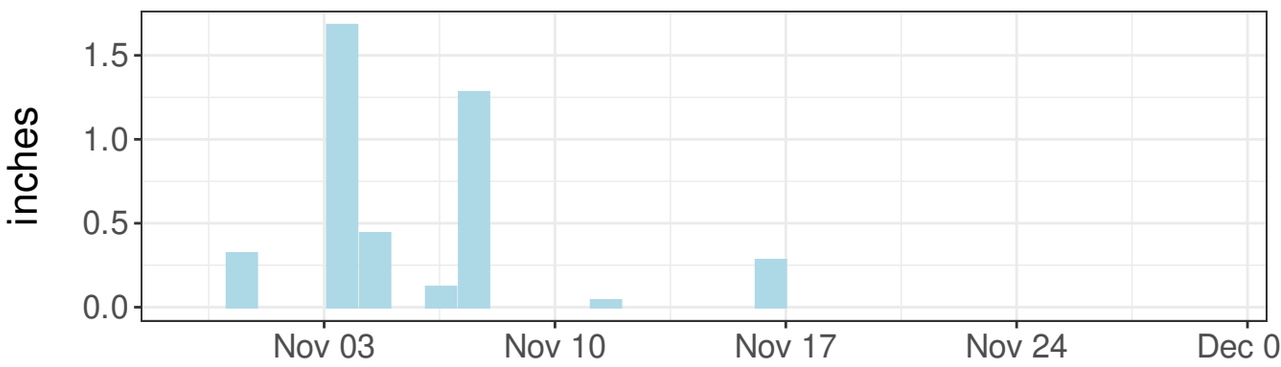
North tilt - detrended values



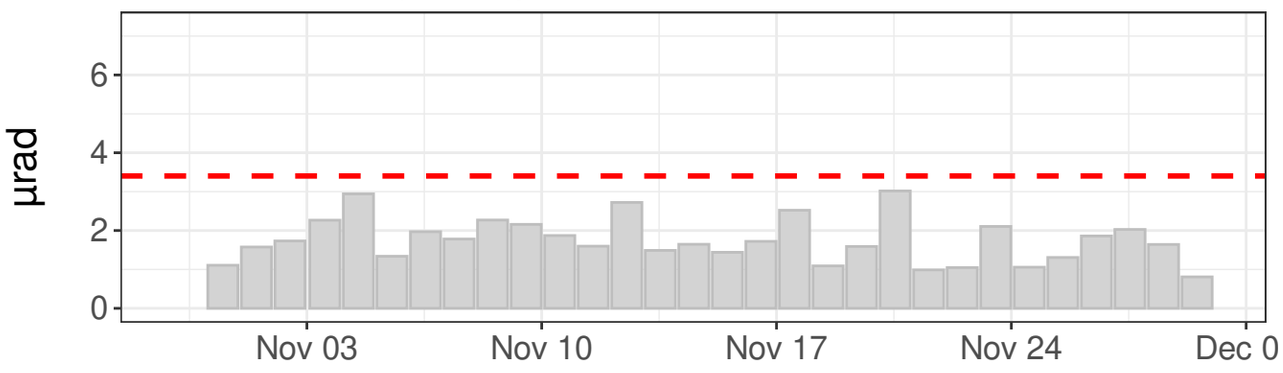
Daily precipitation



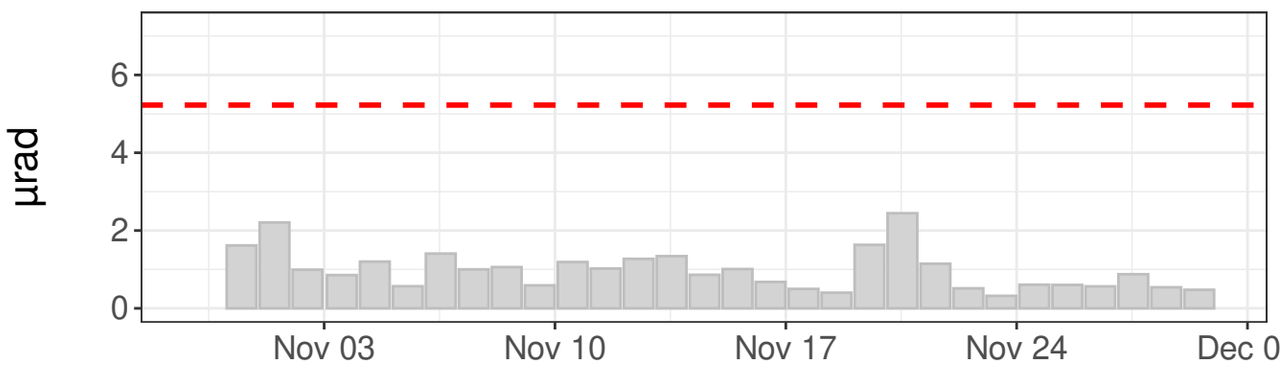
Daily precipitation



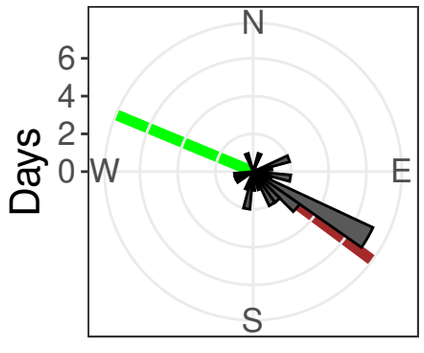
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: 311.54 ± 0.85 µrad/year

North tilt rate: -232.07 ± 0.67 µrad/year

Azimuth to C7: 293 deg

Distance to C7: 614 ft

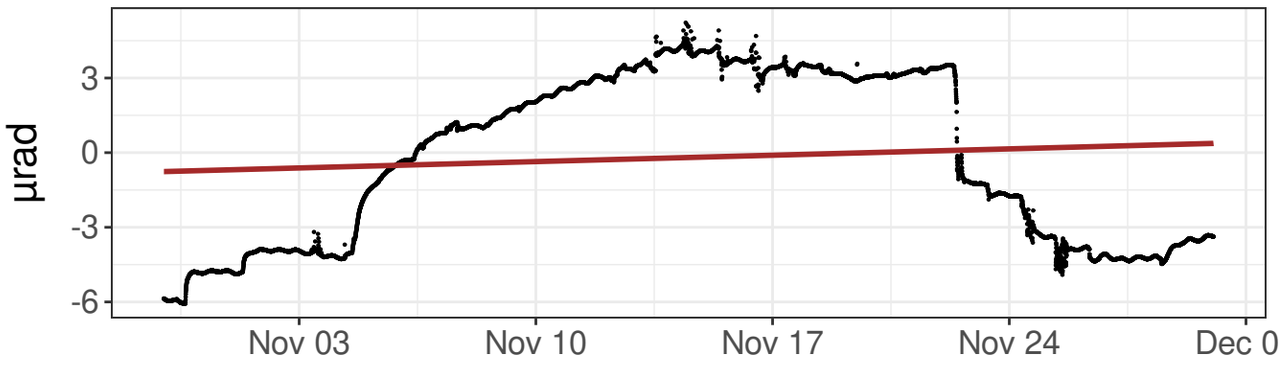
Outlier value

Linear model

Azimuth to C7

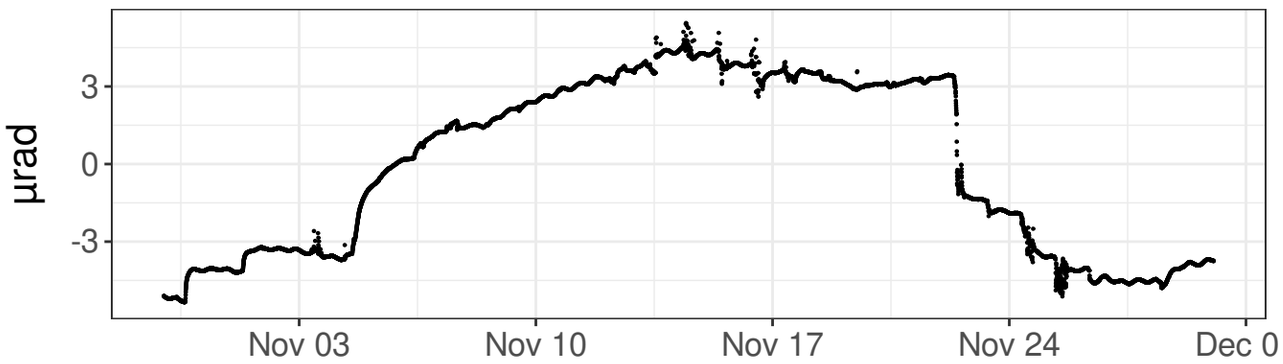
SSD16: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

East tilt - raw values, Linear model R2 0.01

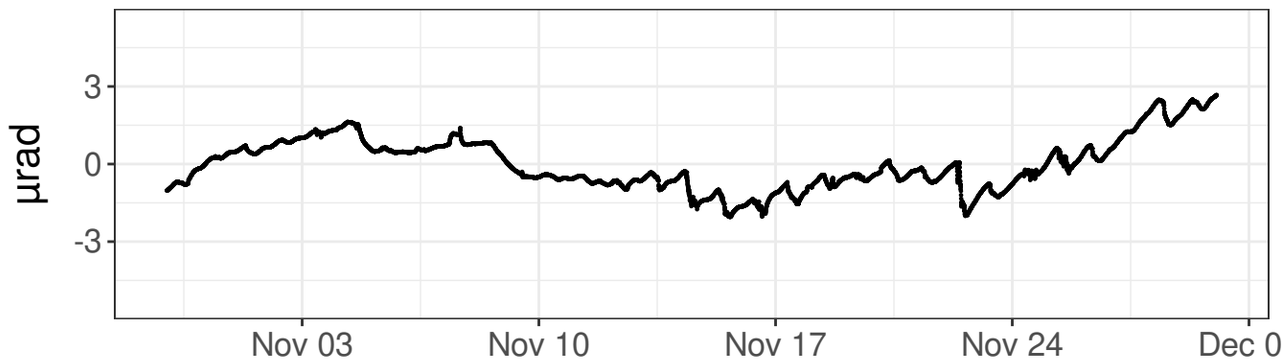


North tilt - raw values, Linear model R2 0.86

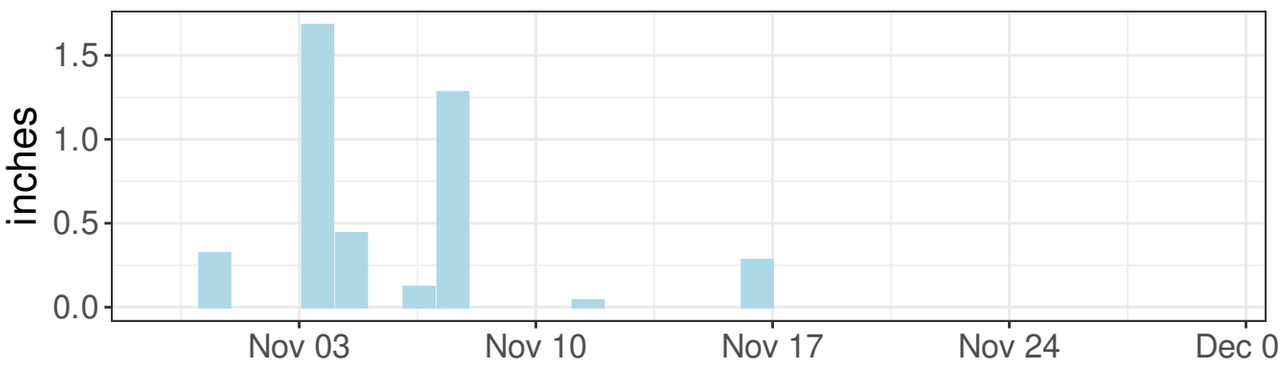
East tilt - detrended values



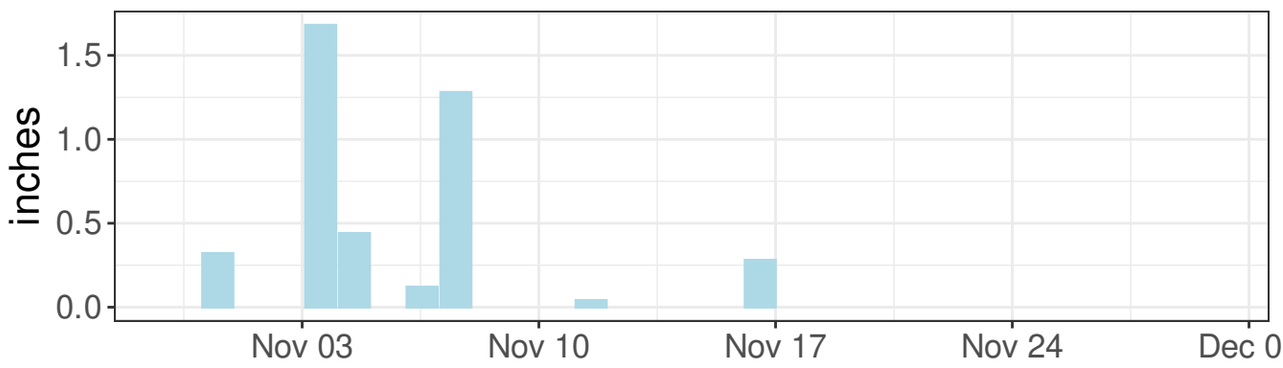
North tilt - detrended values



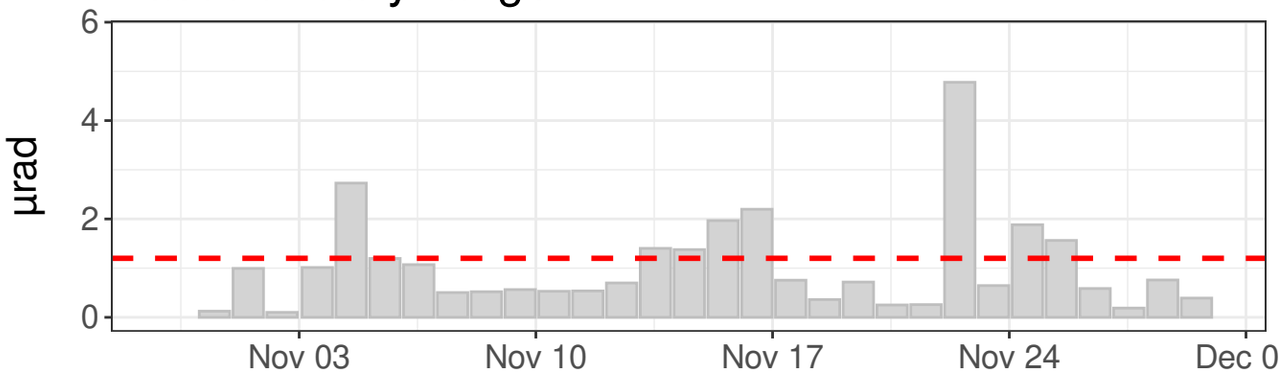
Daily precipitation



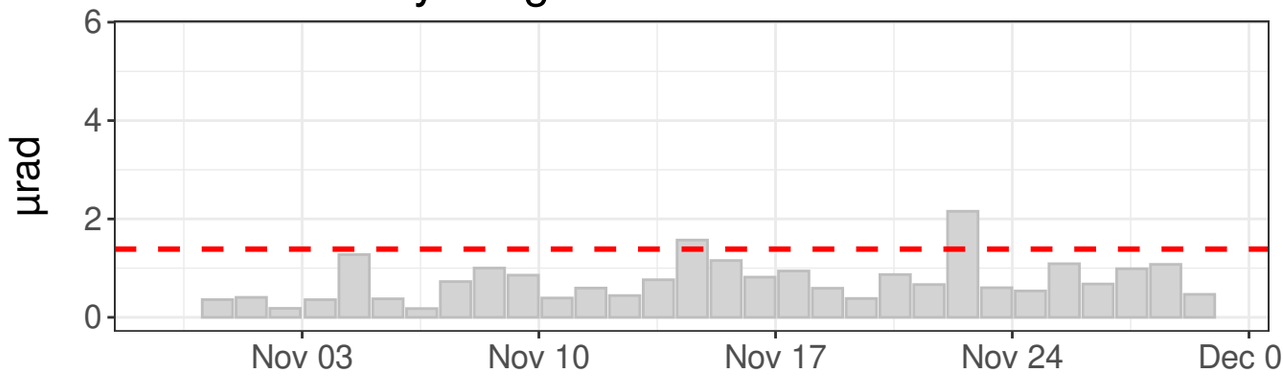
Daily precipitation



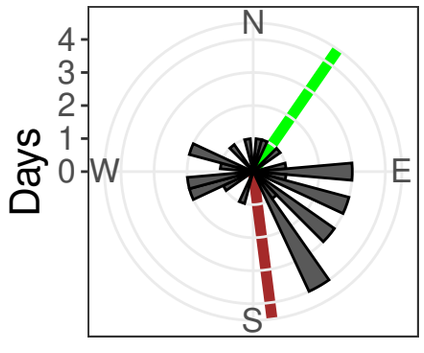
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: 13.36 ± 1.29 µrad/year

North tilt rate: -104.27 ± 0.39 µrad/year

Azimuth to C7: 35 deg

Distance to C7: 1885 ft

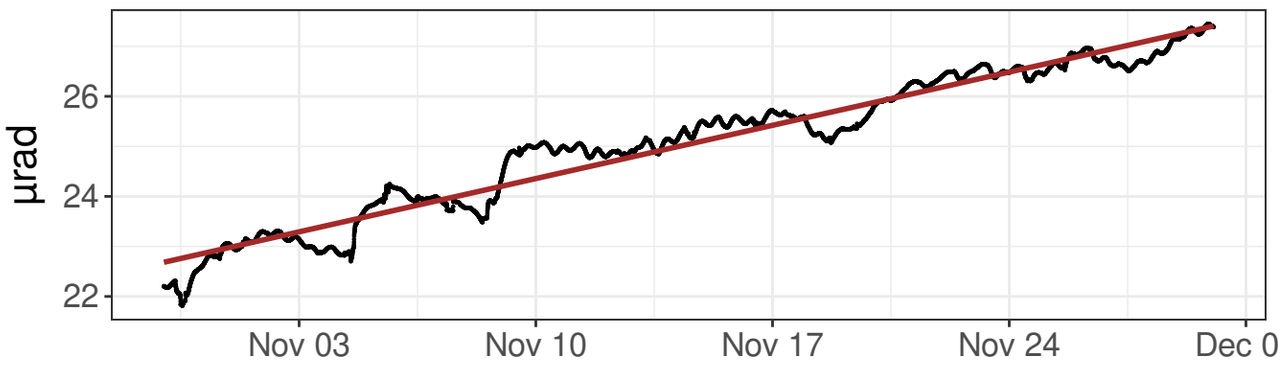
Outlier value

Linear model

Azimuth to C7

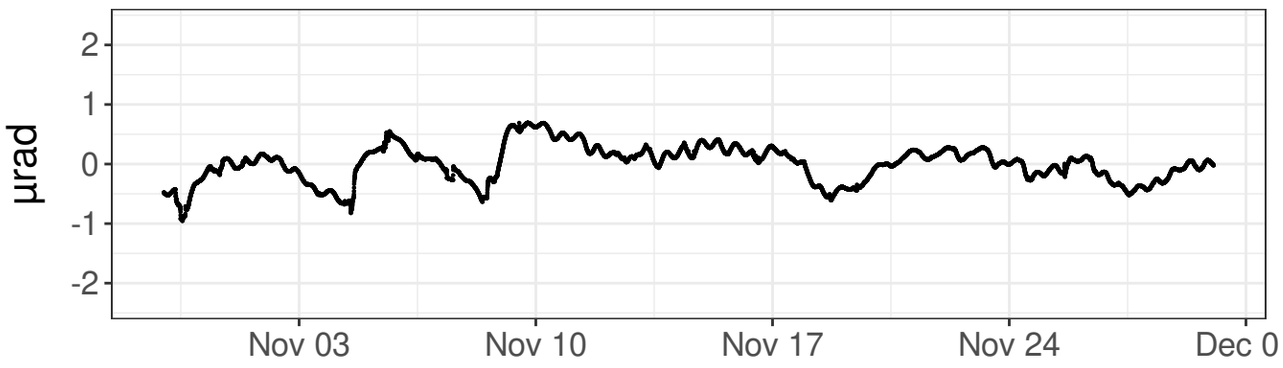
SSD17: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

East tilt - raw values, Linear model R2 0.95

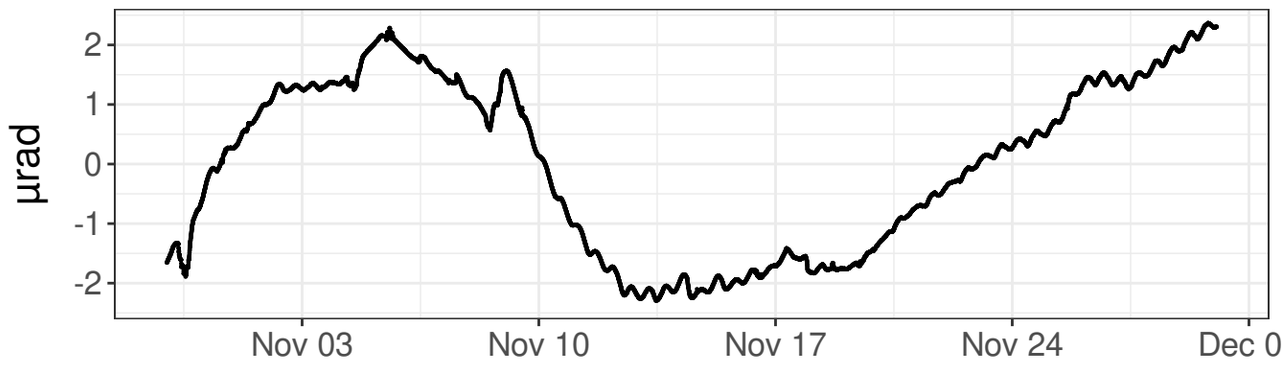


North tilt - raw values, Linear model R2 0.06

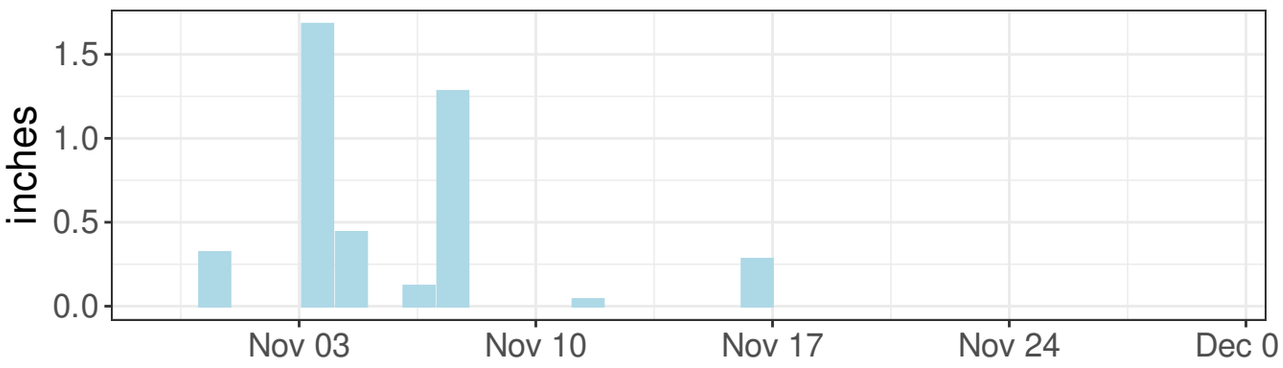
East tilt - detrended values



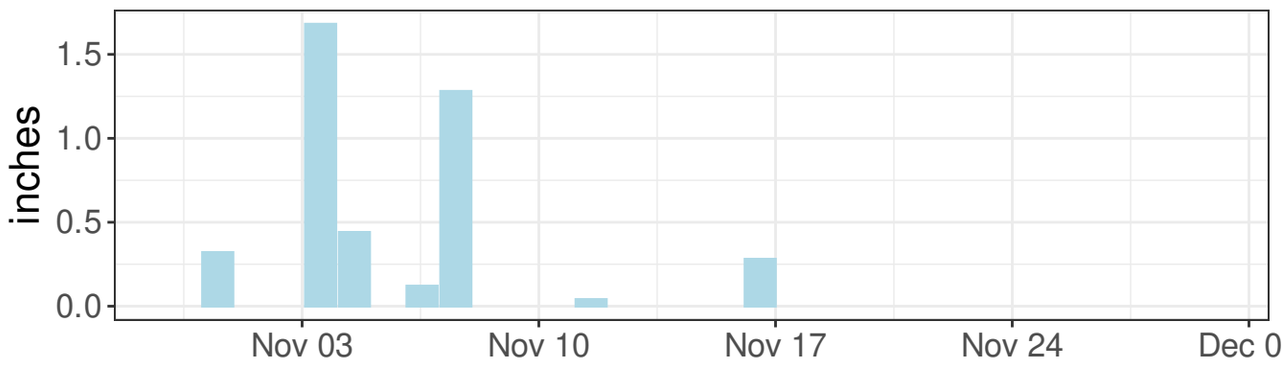
North tilt - detrended values



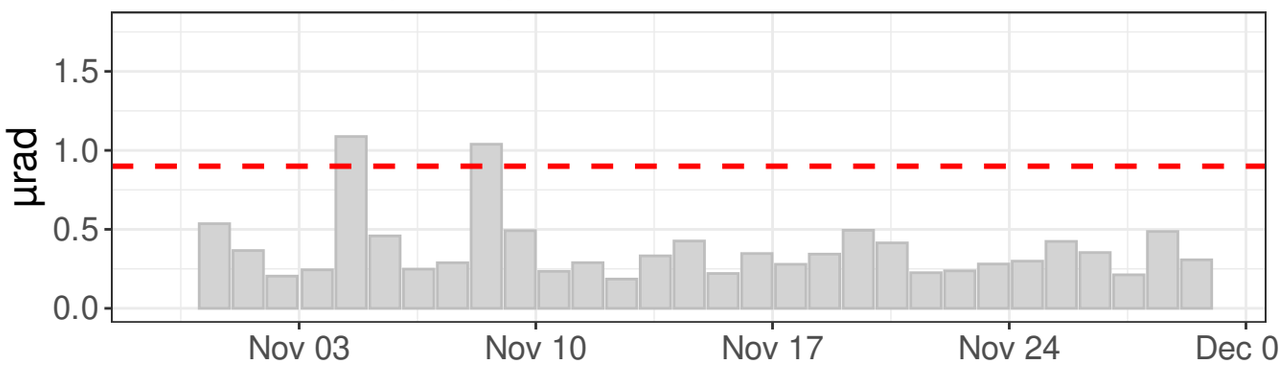
Daily precipitation



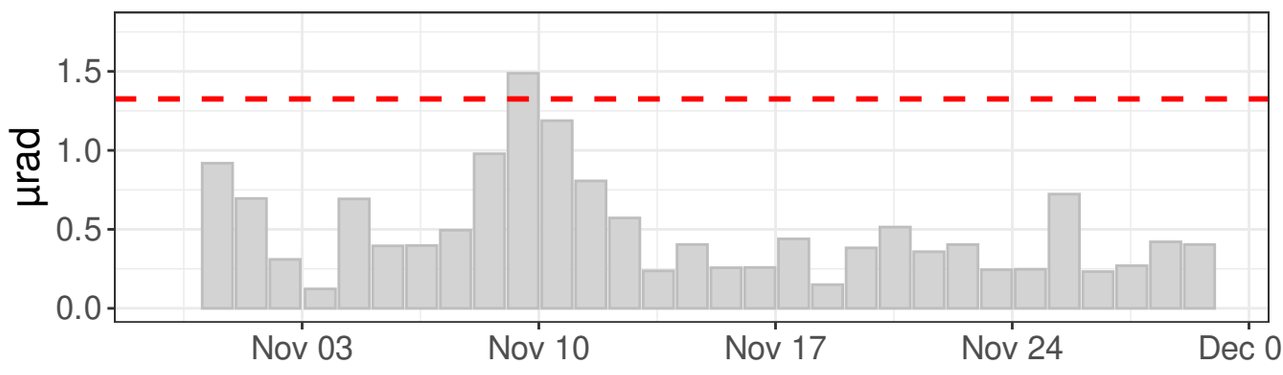
Daily precipitation



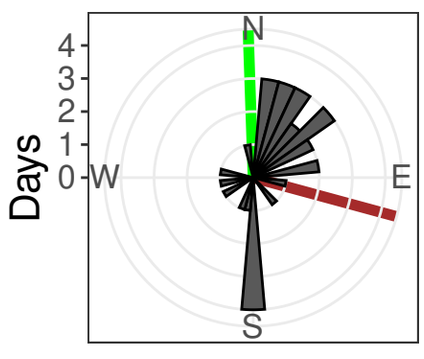
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: 55.67 ± 0.12 µrad/year

North tilt rate: -15.11 ± 0.56 µrad/year

Azimuth to C7: 358 deg

Distance to C7: 1392 ft

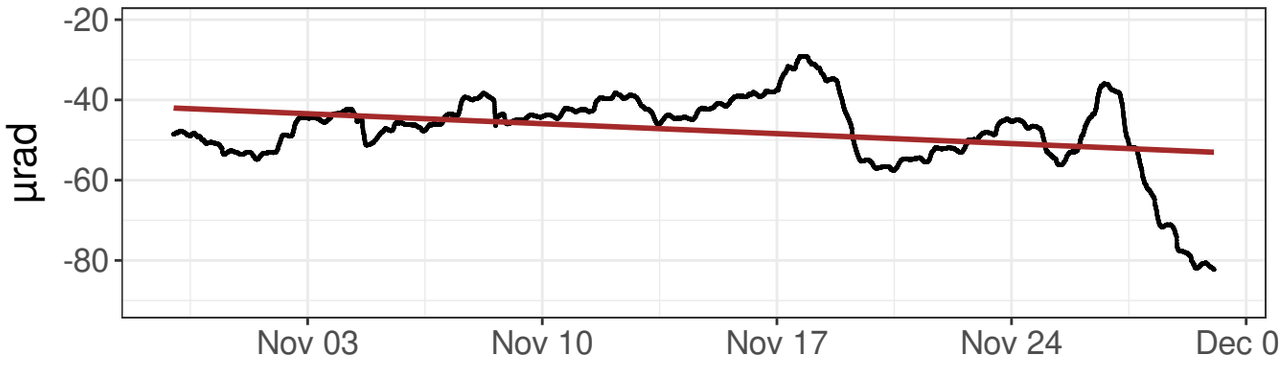
Outlier value

Linear model

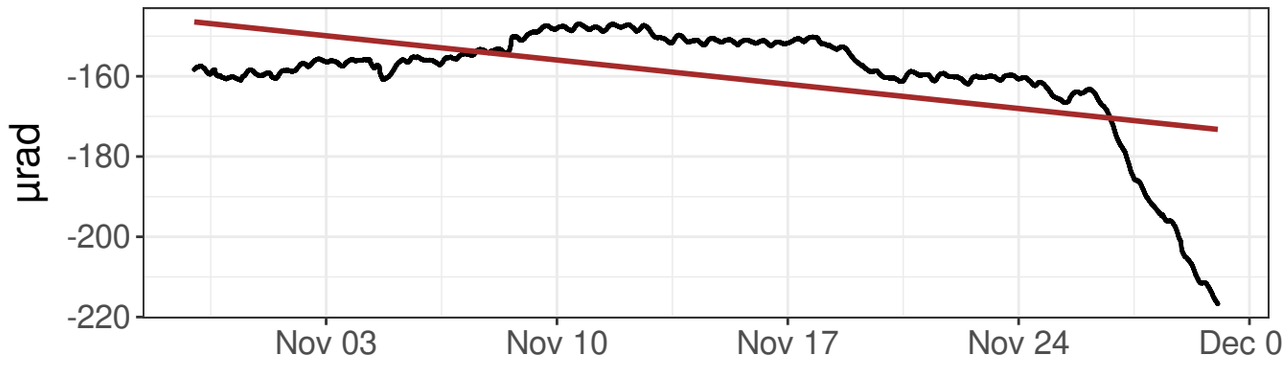
Azimuth to C7

SSD18: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

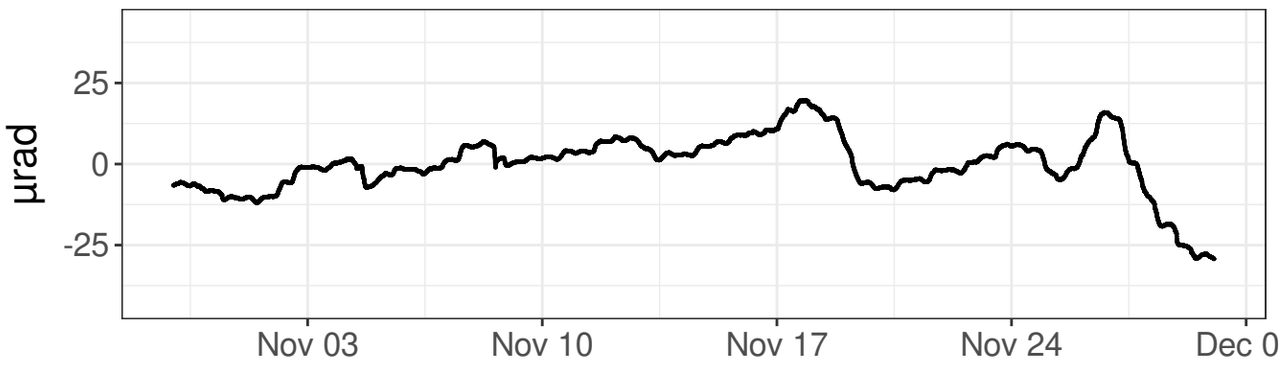
East tilt - raw values, Linear model R2 0.11



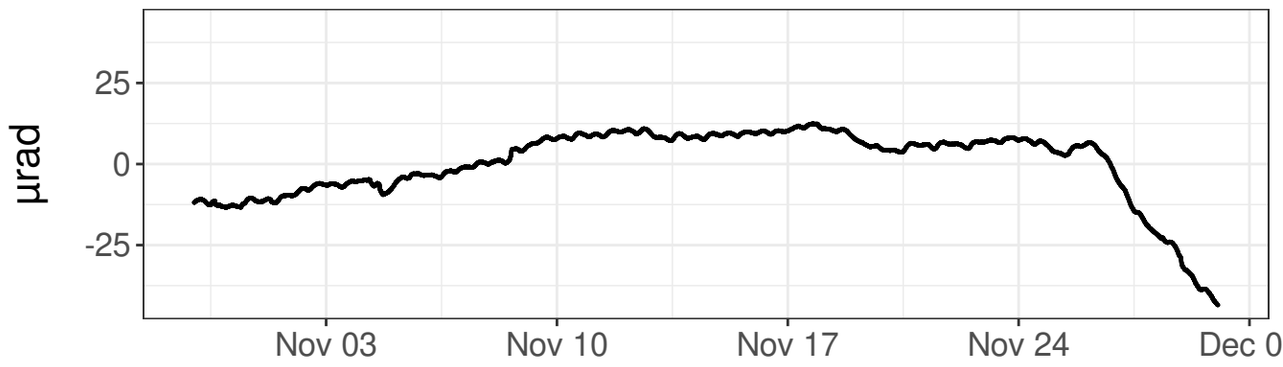
North tilt - raw values, Linear model R2 0.32



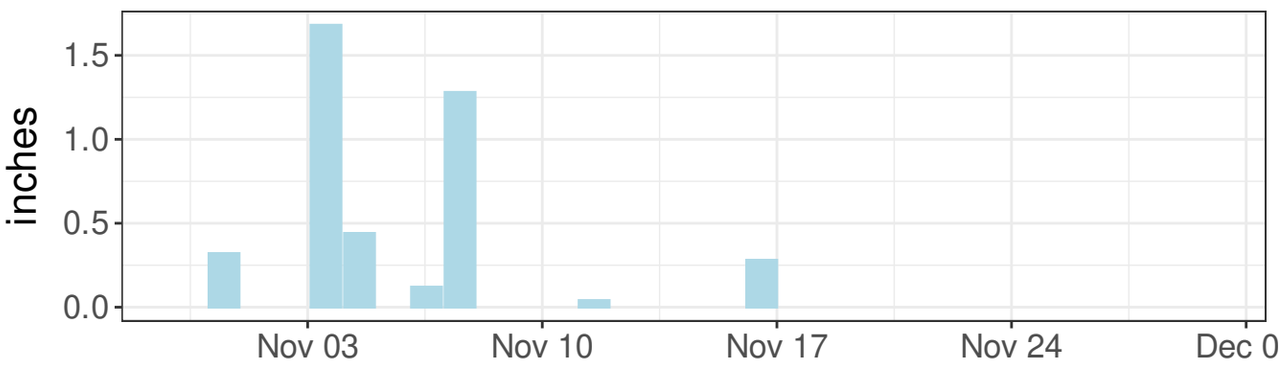
East tilt - detrended values



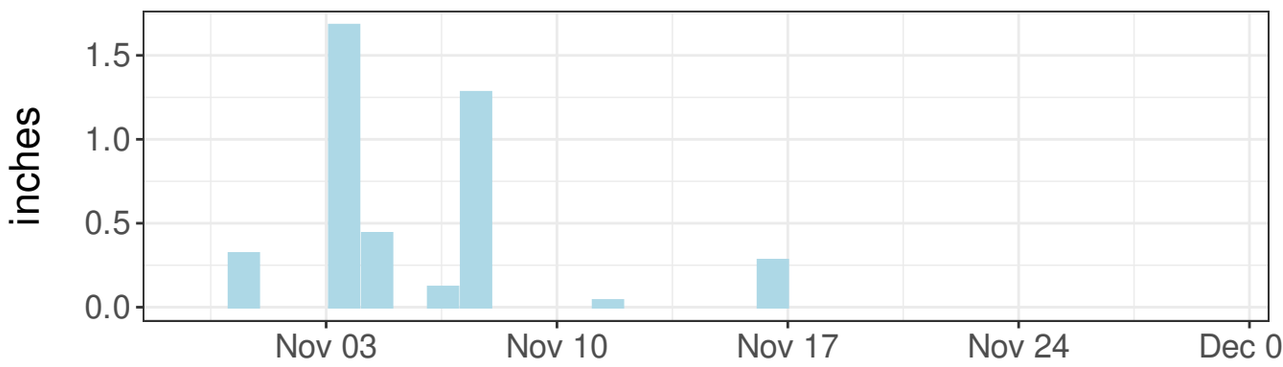
North tilt - detrended values



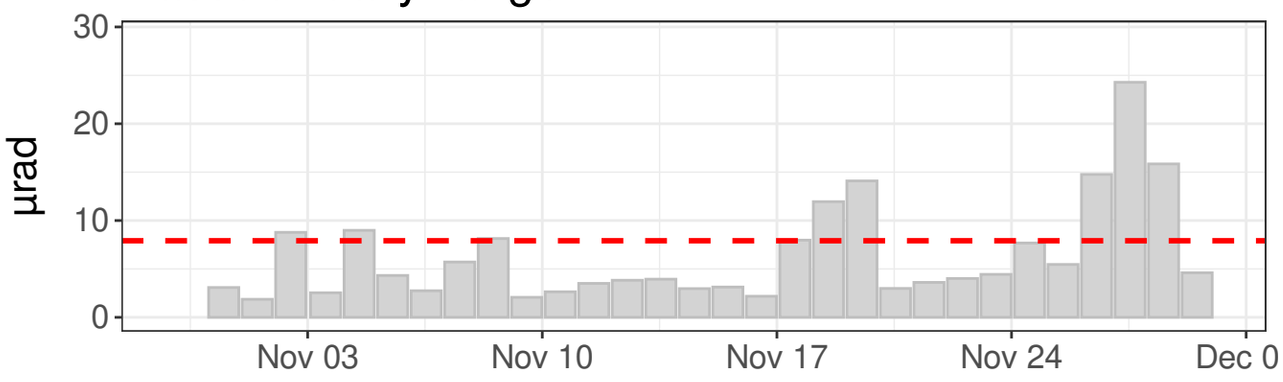
Daily precipitation



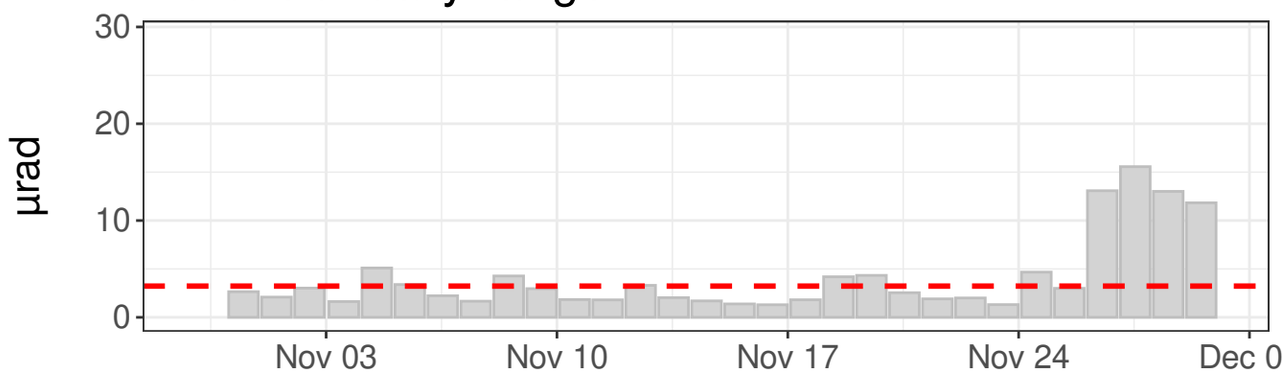
Daily precipitation



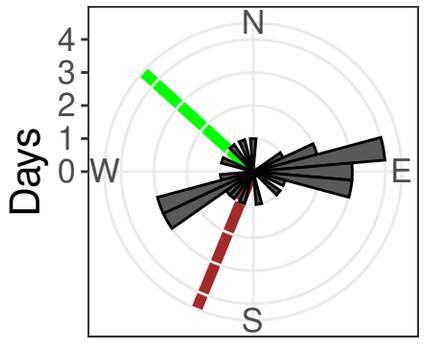
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: -129.84 ± 3.49 µrad/year

North tilt rate: -315.90 ± 4.39 µrad/year

Azimuth to C7: 312 deg

Distance to C7: 1415 ft

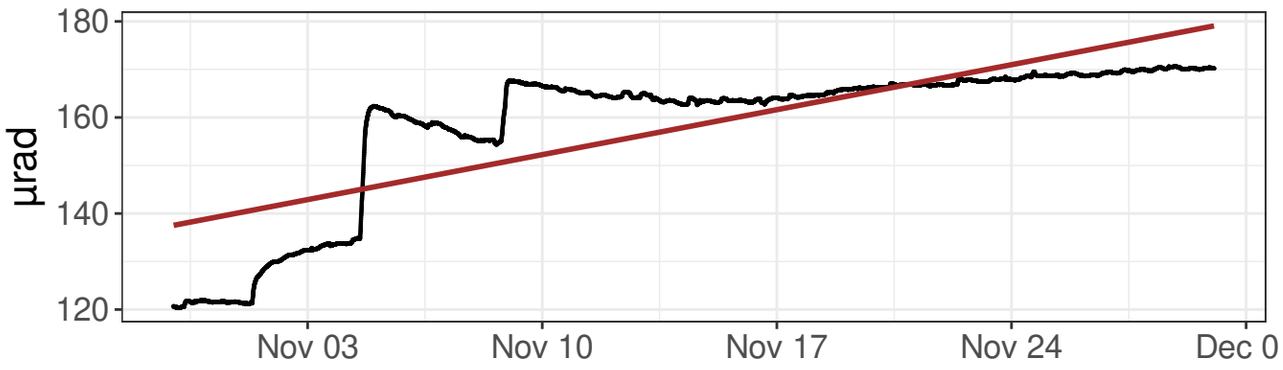
Outlier value

Linear model

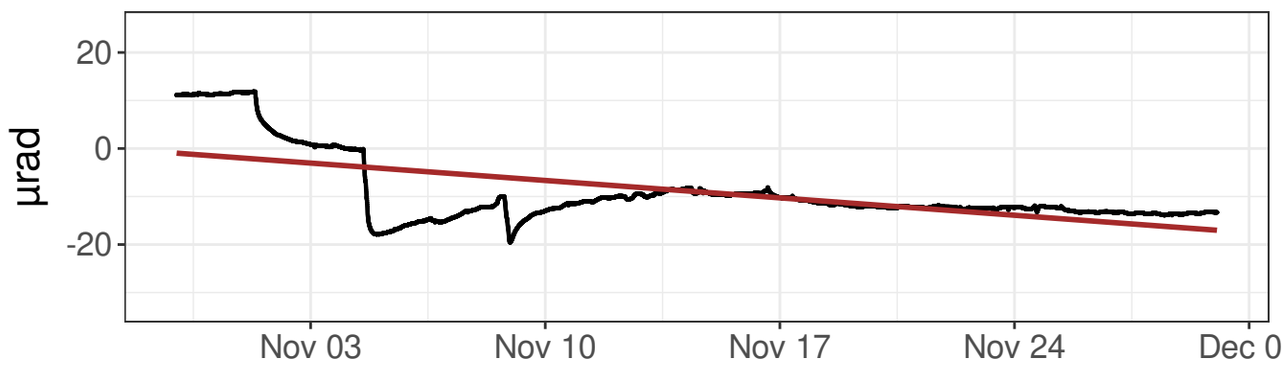
Azimuth to C7

SSD19: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

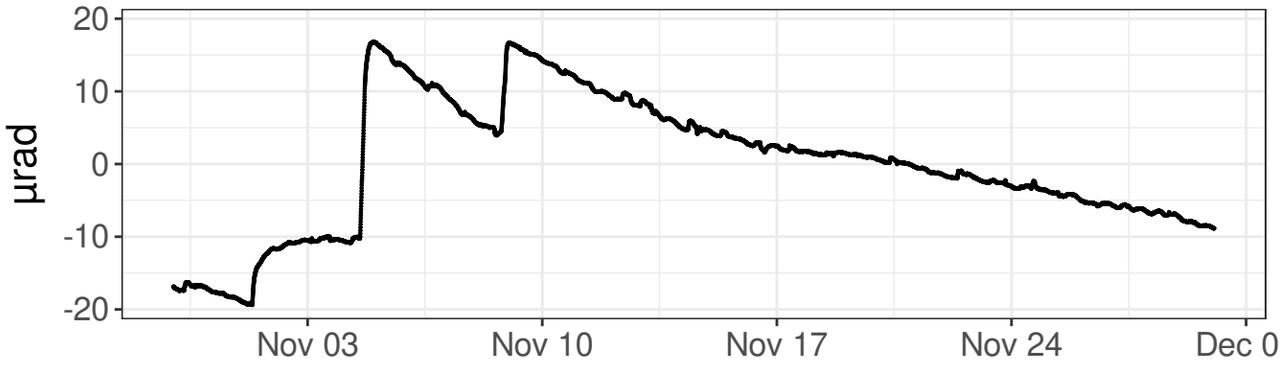
East tilt - raw values, Linear model R2 0.63



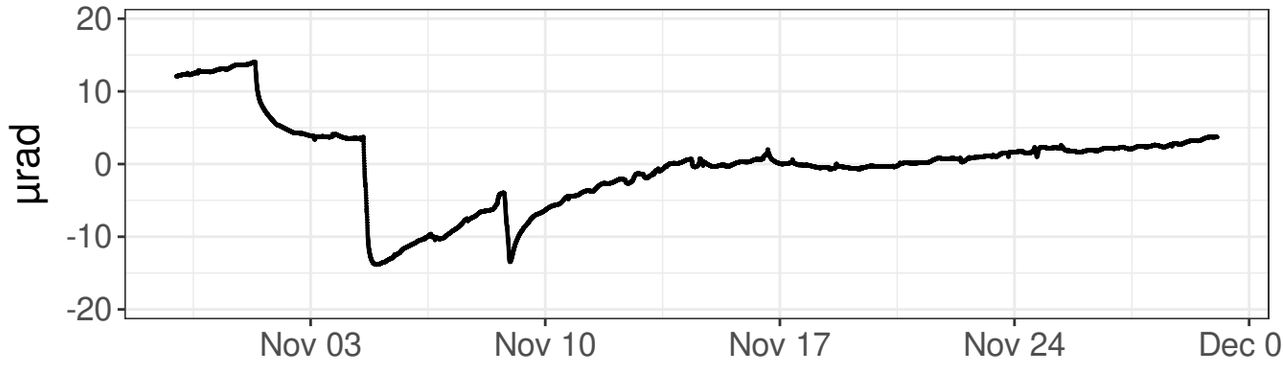
North tilt - raw values, Linear model R2 0.38



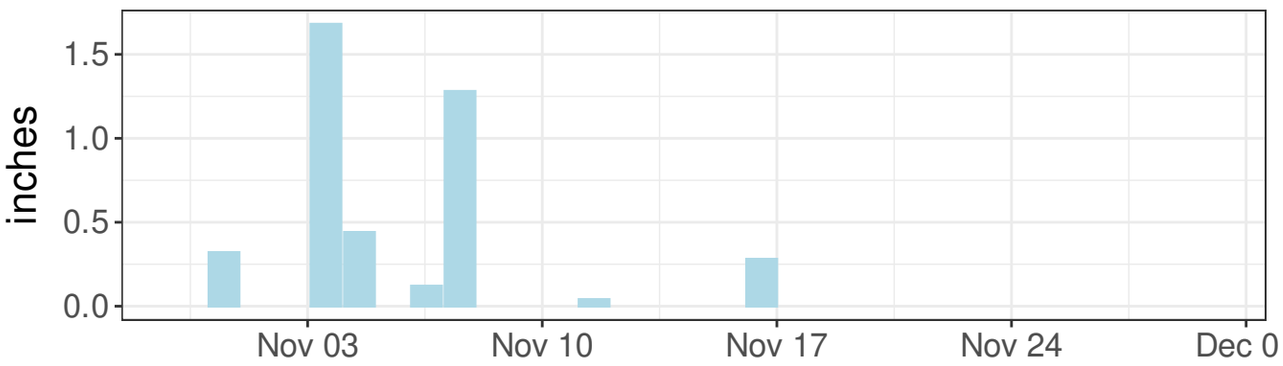
East tilt - detrended values



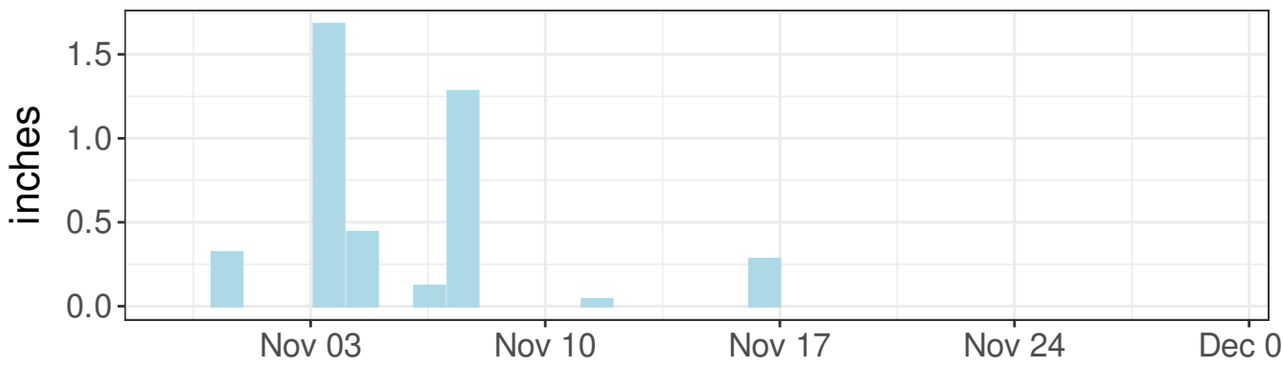
North tilt - detrended values



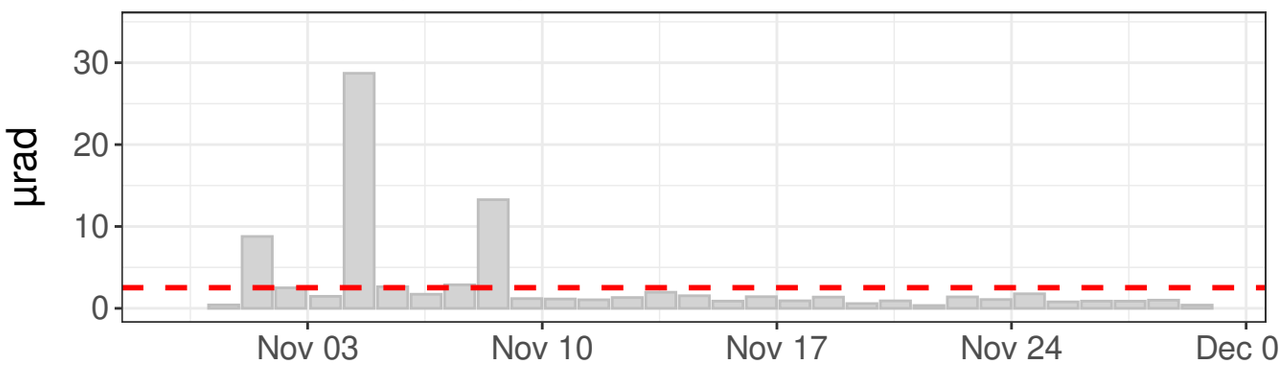
Daily precipitation



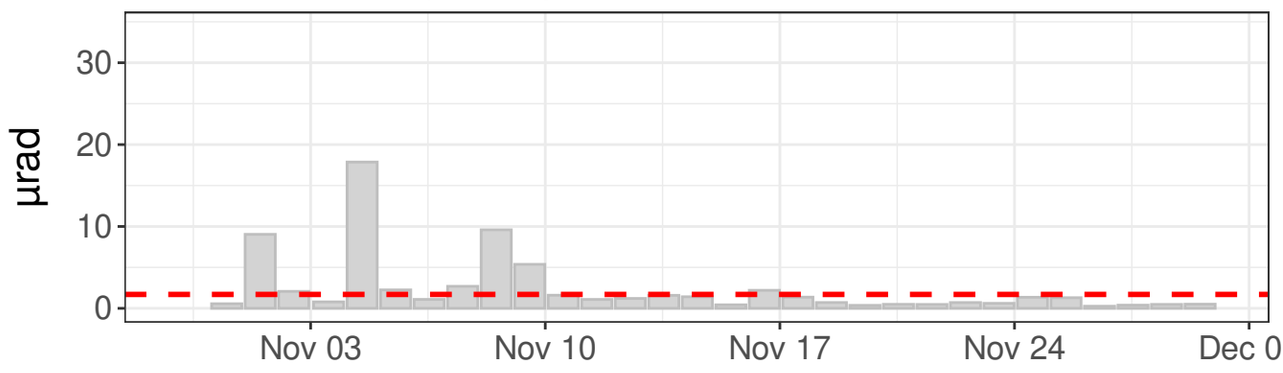
Daily precipitation



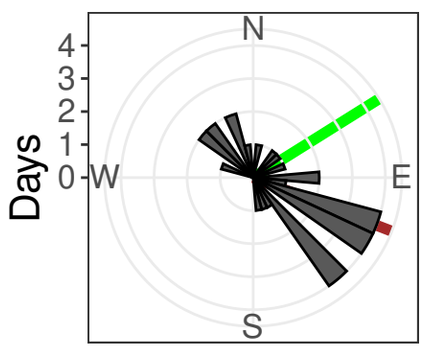
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: 489.74 ± 3.54 µrad/year

North tilt rate: -189.36 ± 2.27 µrad/year

Azimuth to C7: 58 deg

Distance to C7: 2245 ft

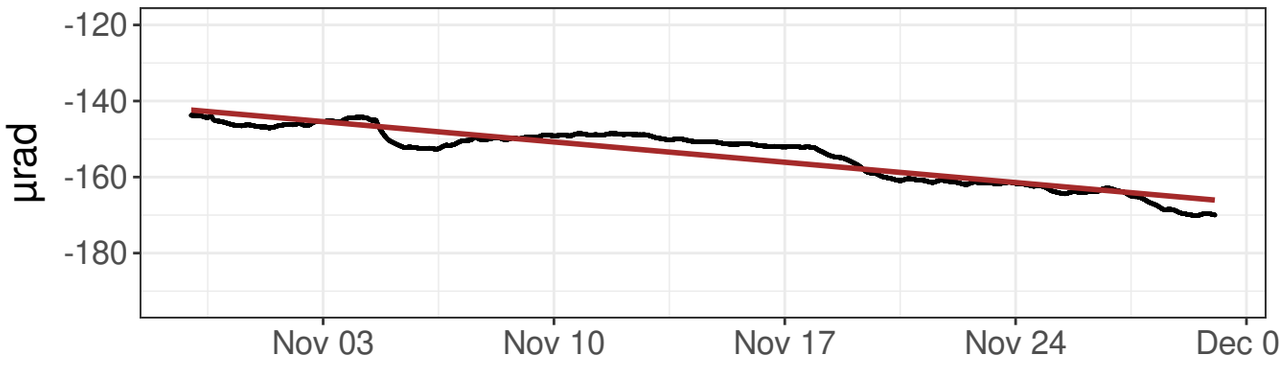
Outlier value

Linear model

Azimuth to C7

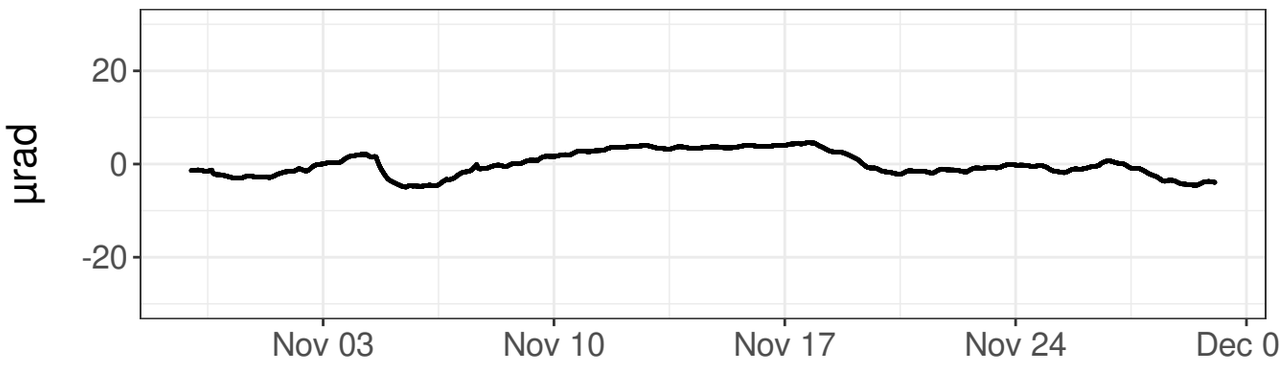
SSD20: Analyzed range: 06/02/2024 - 12/05/2024 | Plotted range: 11/01/2024 - 11/30/2024 (CTZ)

East tilt - raw values, Linear model R2 0.87



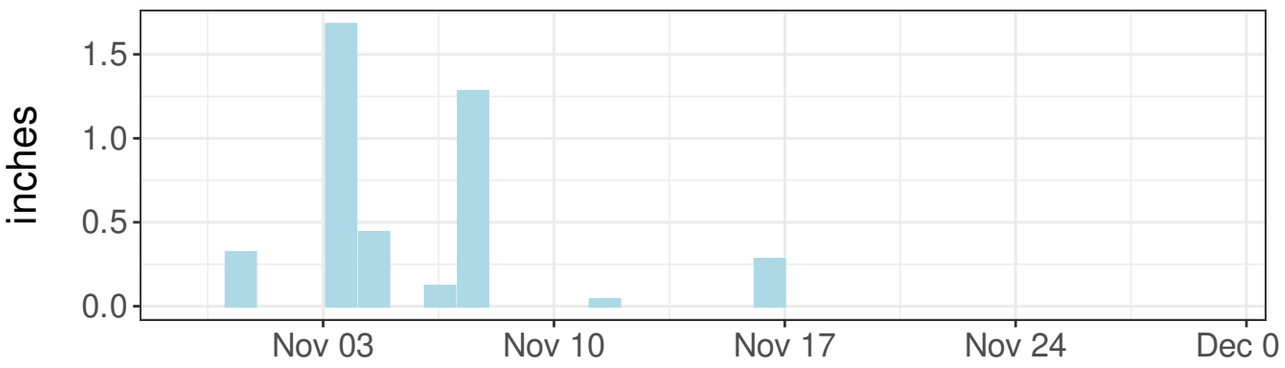
North tilt - raw values, Linear model R2 0.56

East tilt - detrended values

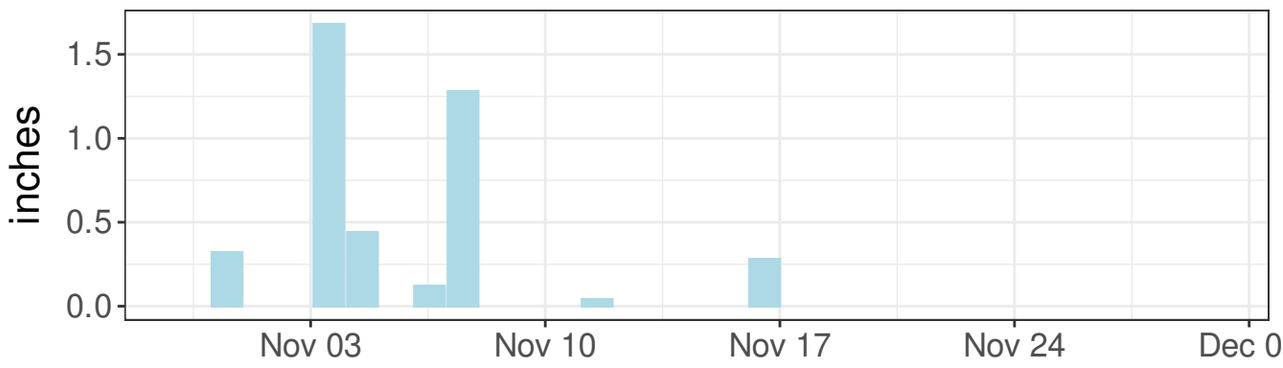


North tilt - detrended values

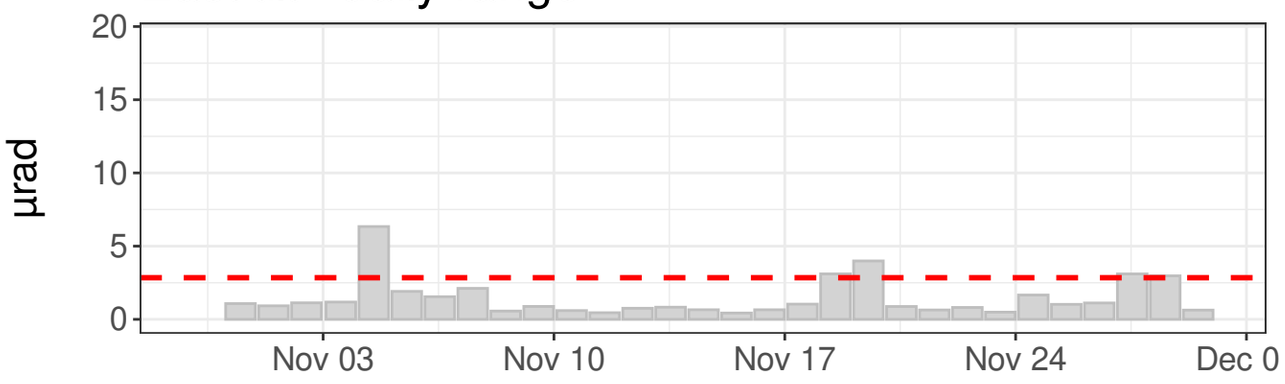
Daily precipitation



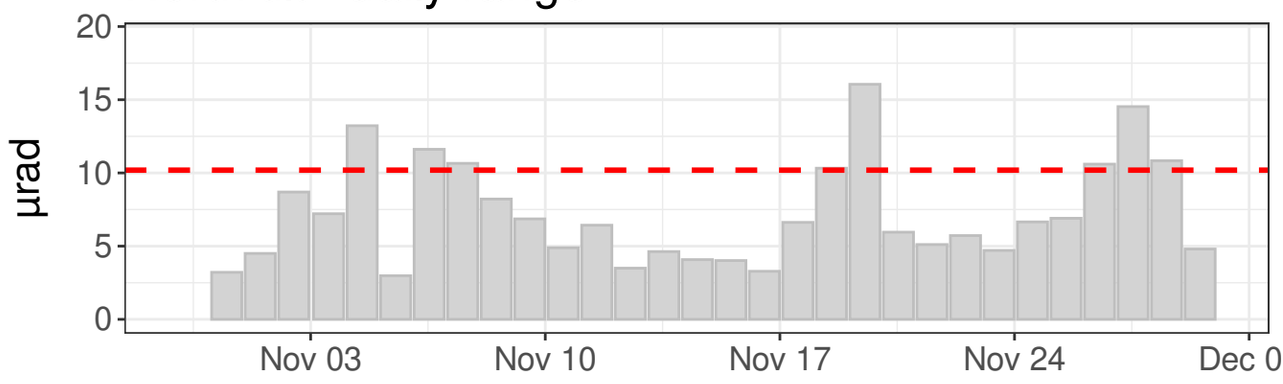
Daily precipitation



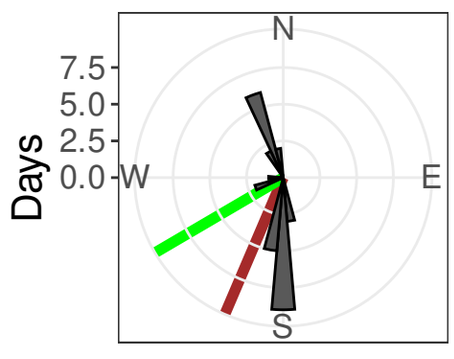
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate: -279.15 ± 1.01 µrad/year

North tilt rate: -653.16 ± 5.42 µrad/year

Azimuth to C7: 240 deg

Distance to C7: 1378 ft

Outlier value

Linear model

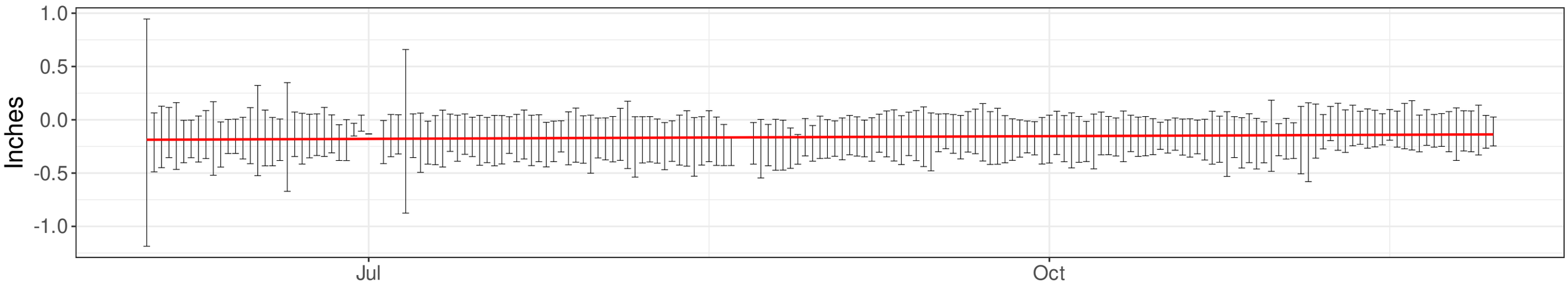
Azimuth to C7

APPENDIX 2

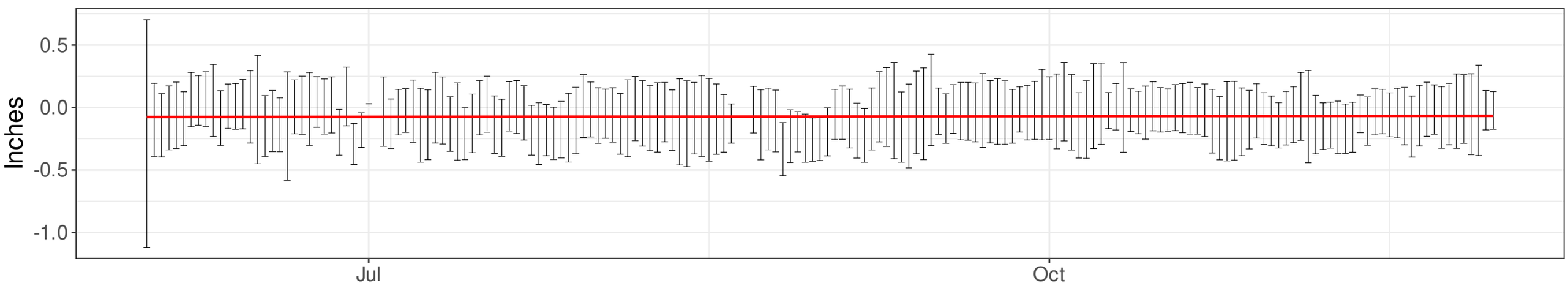
GNSS Data Plots

REMC7, 2024-06-01 - 2024-11-30

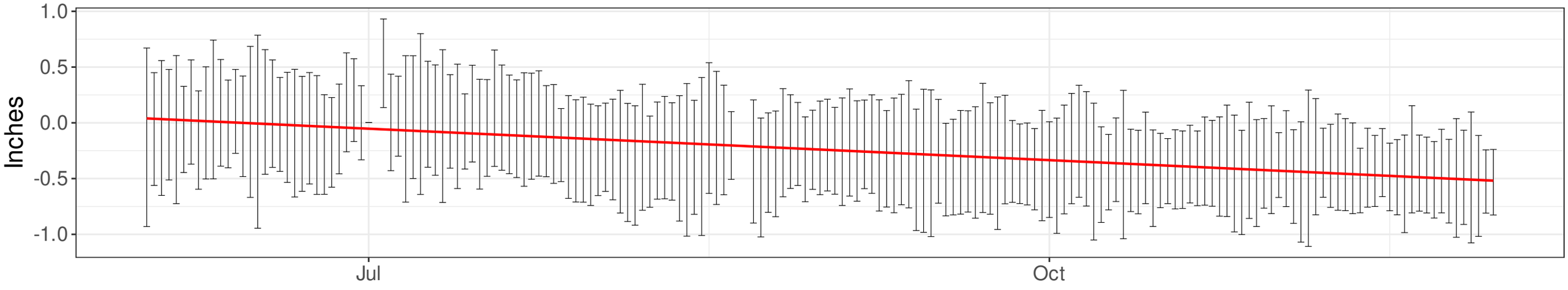
East displacement - daily values



North displacement - daily values



Vertical displacement - daily values



Local east rate: 0.584 ± 0.030 in/year, R2: 0.10

Local north rate: 0.060 ± 0.043 in/year, R2: 0.00

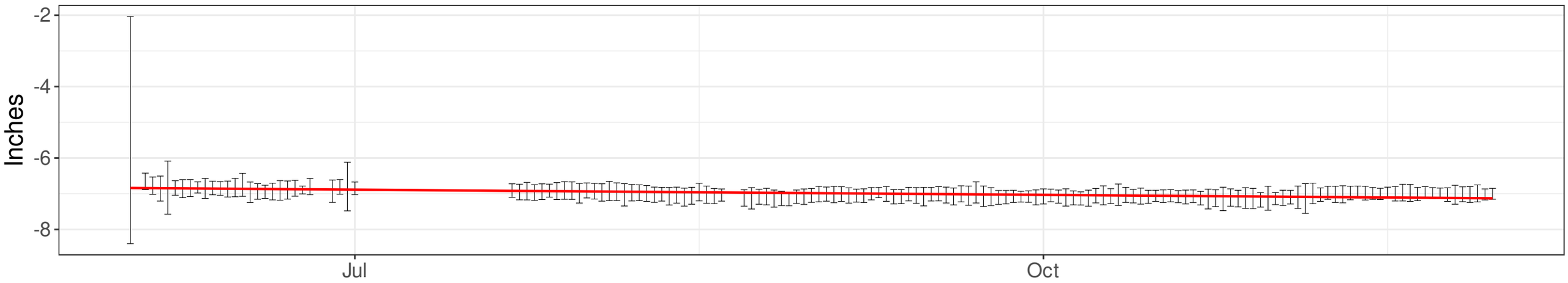
Local vertical rate: -1.042 ± 0.076 in/year, R2: 0.72

Linear model

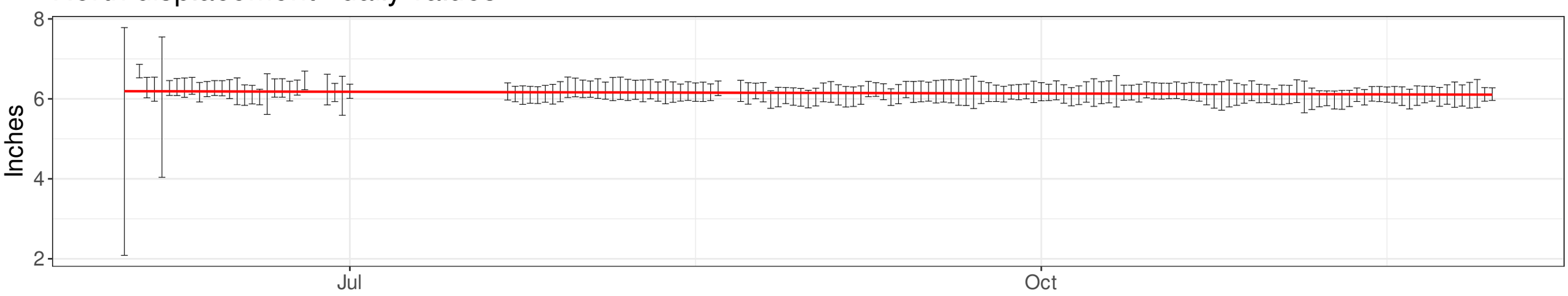
Local rate values have been calculated by removing the regional tectonic plate rates from the raw data displayed in the charts.

REMNE, 2024-06-01 - 2024-11-30

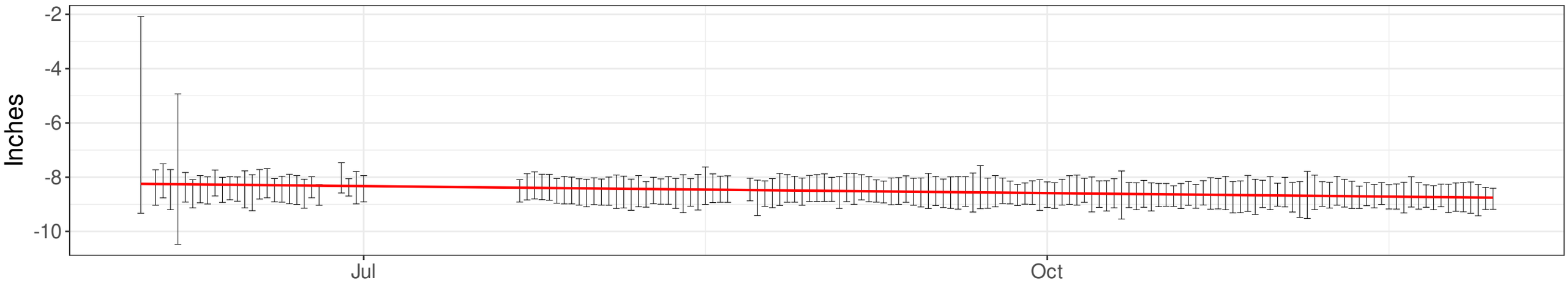
East displacement - daily values



North displacement - daily values



Vertical displacement - daily values



Local east rate: -0.100 ± 0.084 in/year, R2: 0.24

Local north rate: -0.132 ± 0.076 in/year, R2: 0.03

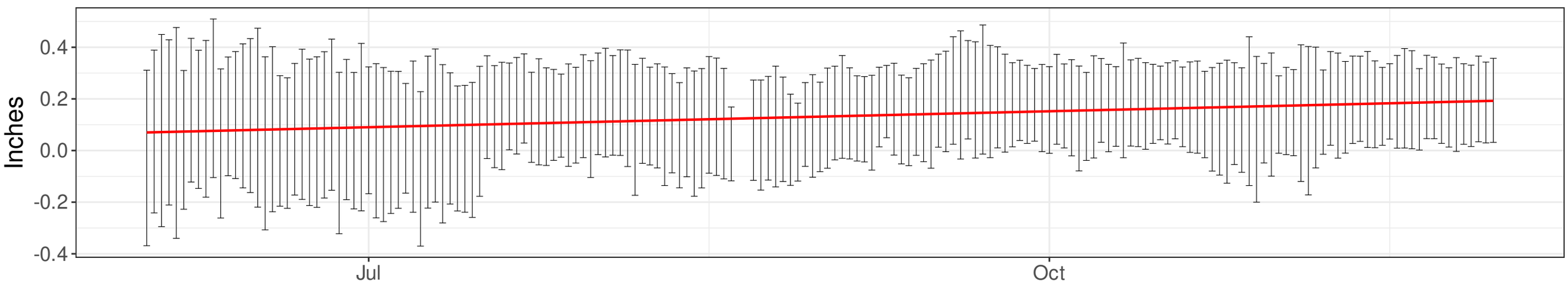
Local vertical rate: -0.942 ± 0.144 in/year, R2: 0.27

Linear model

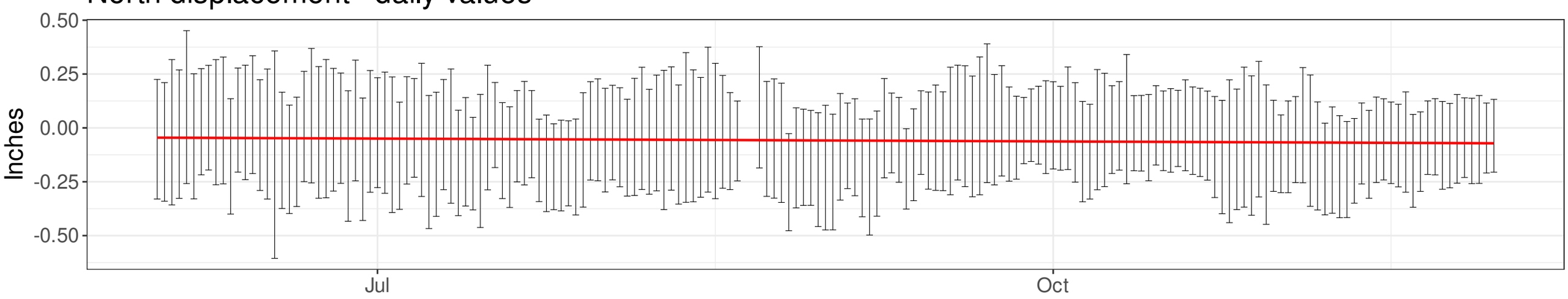
Local rate values have been calculated by removing the regional tectonic plate rates from the raw data displayed in the charts.

REMNW, 2024-06-01 - 2024-11-30

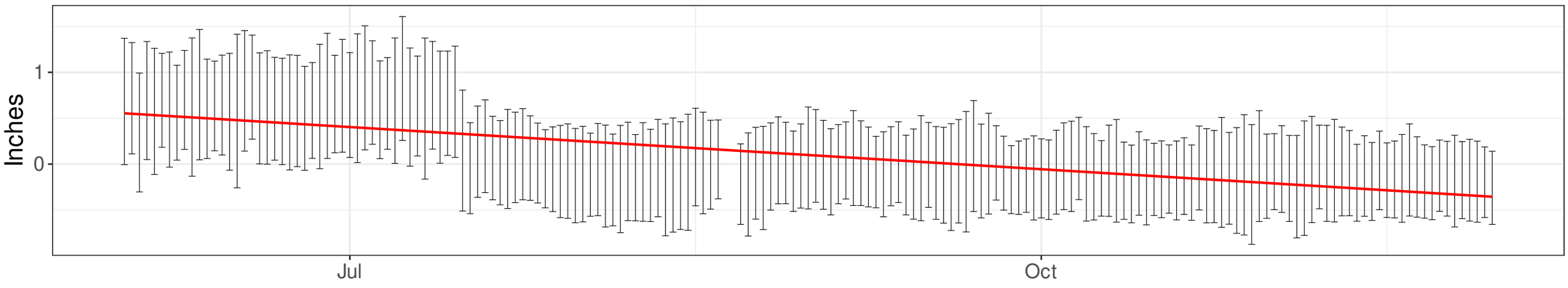
East displacement - daily values



North displacement - daily values



Vertical displacement - daily values



Local east rate: 0.729 ± 0.030 in/year, R2: 0.38

Local north rate: -0.011 ± 0.039 in/year, R2: 0.01

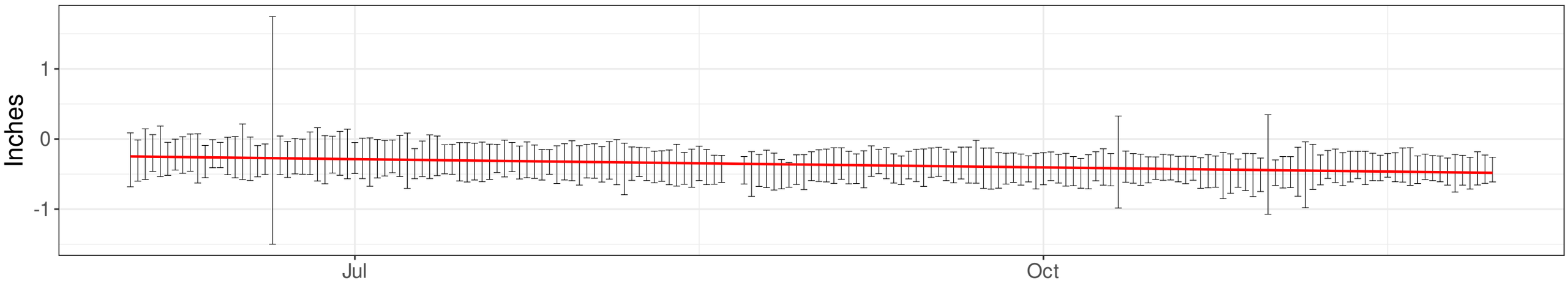
Local vertical rate: -1.747 ± 0.117 in/year, R2: 0.64

Linear model

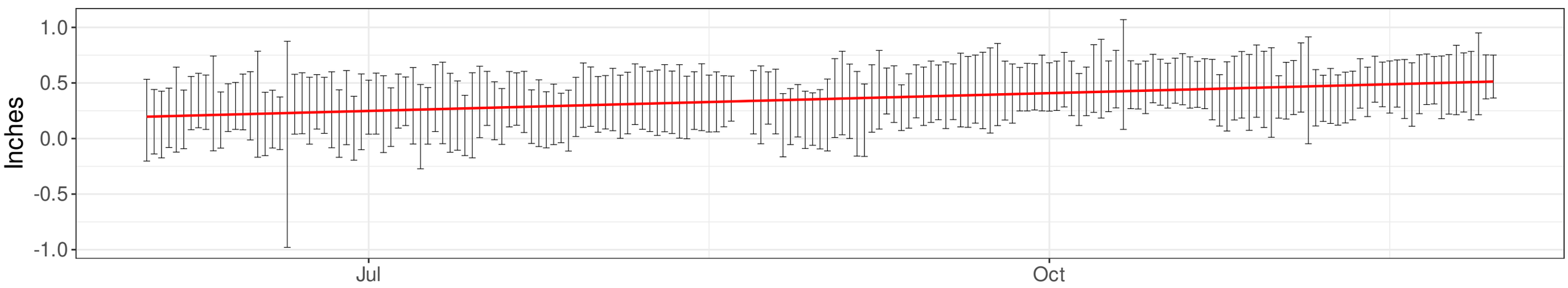
Local rate values have been calculated by removing the regional tectonic plate rates from the raw data displayed in the charts.

REMSE, 2024-06-01 - 2024-11-30

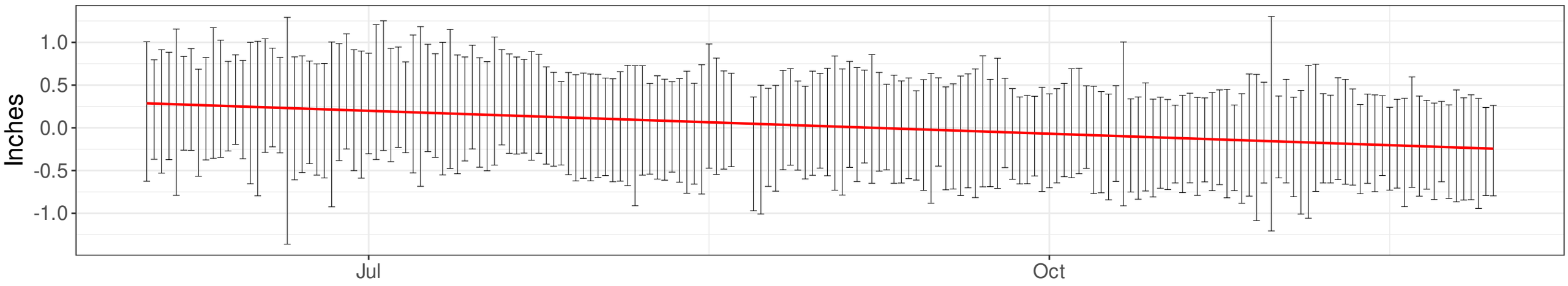
East displacement - daily values



North displacement - daily values



Vertical displacement - daily values



Local east rate: 0.013 ± 0.035 in/year, R2: 0.58

Local north rate: 0.678 ± 0.044 in/year, R2: 0.58

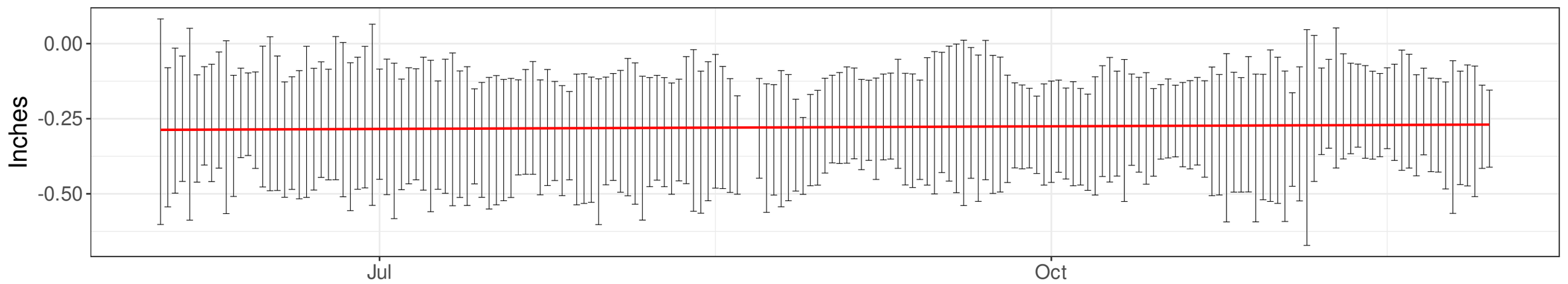
Local vertical rate: -0.987 ± 0.078 in/year, R2: 0.68

Linear model

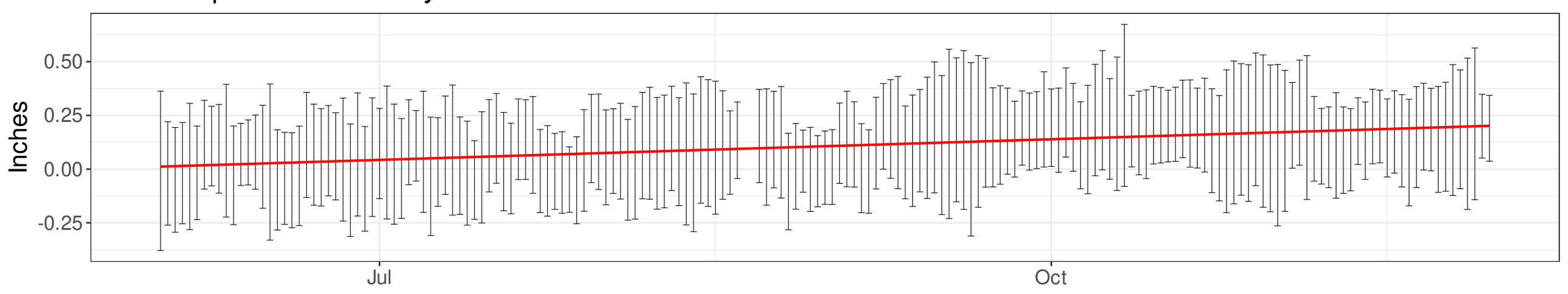
Local rate values have been calculated by removing the regional tectonic plate rates from the raw data displayed in the charts.

REMSW, 2024-06-01 - 2024-11-30

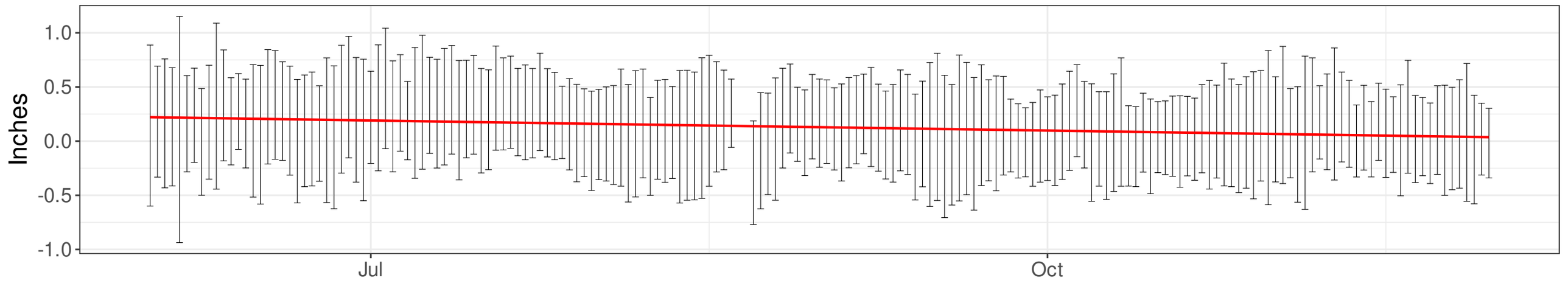
East displacement - daily values



North displacement - daily values



Vertical displacement - daily values



Local east rate: 0.518 ± 0.026 in/year, R2: 0.02

Local north rate: 0.424 ± 0.035 in/year, R2: 0.47

Local vertical rate: -0.290 ± 0.078 in/year, R2: 0.20

Linear model

Local rate values have been calculated by removing the regional tectonic plate rates from the raw data displayed in the charts.

APPENDIX 3

Analysis Maps

Tiltmeter and GNSS Rate Vectors

Tiltmeter Time Frame: 11/1/24 - 11/30/24
GNSS Time Frame: 6/1/24 - 11/30/24

1340000 1340500 1341000 1341500 1342000 1342500 1343000 1343500 1344000 1344500 1345000 1345500

584500 584000 583500 583000 582500 582000 581500 581000

N

SSD01
SSD02
SSD03
SSD04
SSD05
SSD06
SSD07
SSD08
SSD09
SSD10
SSD11
SSD12
SSD13
SSD14
SSD15
SSD16
SSD17
SSD18
SSD19
SSD20

REMNE
-0.942 ± 0.144 in/yr

REMNW
-1.747 ± 0.117 in/yr

REMC7
-1.042 ± 0.076 in/yr

REMSW
-0.290 ± 0.077 in/yr

REMSE
-0.987 ± 0.077 in/yr

-9000 -8500 -8000 -7500 -7000 -6500 -6000 -5500 -5000 -4500 -4000 -3500 -3000 -2500 -2000 -1500

0 400 800 1600 µrad/yr
0 0.5 1 2 in/yr

0 200 400 800 1,200 1,600 Feet

Precision Tiltmeter Sites
Differential GNSS Stations (vertical rate labeled)
Cavern Extent Outlines
Sulphur Dome Contours (500-ft CI)
Tiltmeter Rate Vector (µrad/yr)
GNSS Rate Vector (horiz. in/yr)
GNSS Rate Error Ellipse

Daily Tilt Direction Frequency - Full History
(6/1/24 - 11/30/24)

1340000 1340500 1341000 1341500 1342000 1342500 1343000 1343500 1344000 1344500 1345000

584500 584000 583500 583000 582500 582000 581500 581000

SSD01
SSD02
REMNW(GNSS)
REMNE(GNSS)
SSD03
SSD04
SSD20
SSD05
SSD07
SSD08
SSD11
SSD10
SSD06
REMC7(GNSS)
SSD15
SSD14
SSD09
SSD13
SSD12
SSD18
REMSE(GNSS)
SSD19
REMSW(GNSS)
SSD16
SSD17

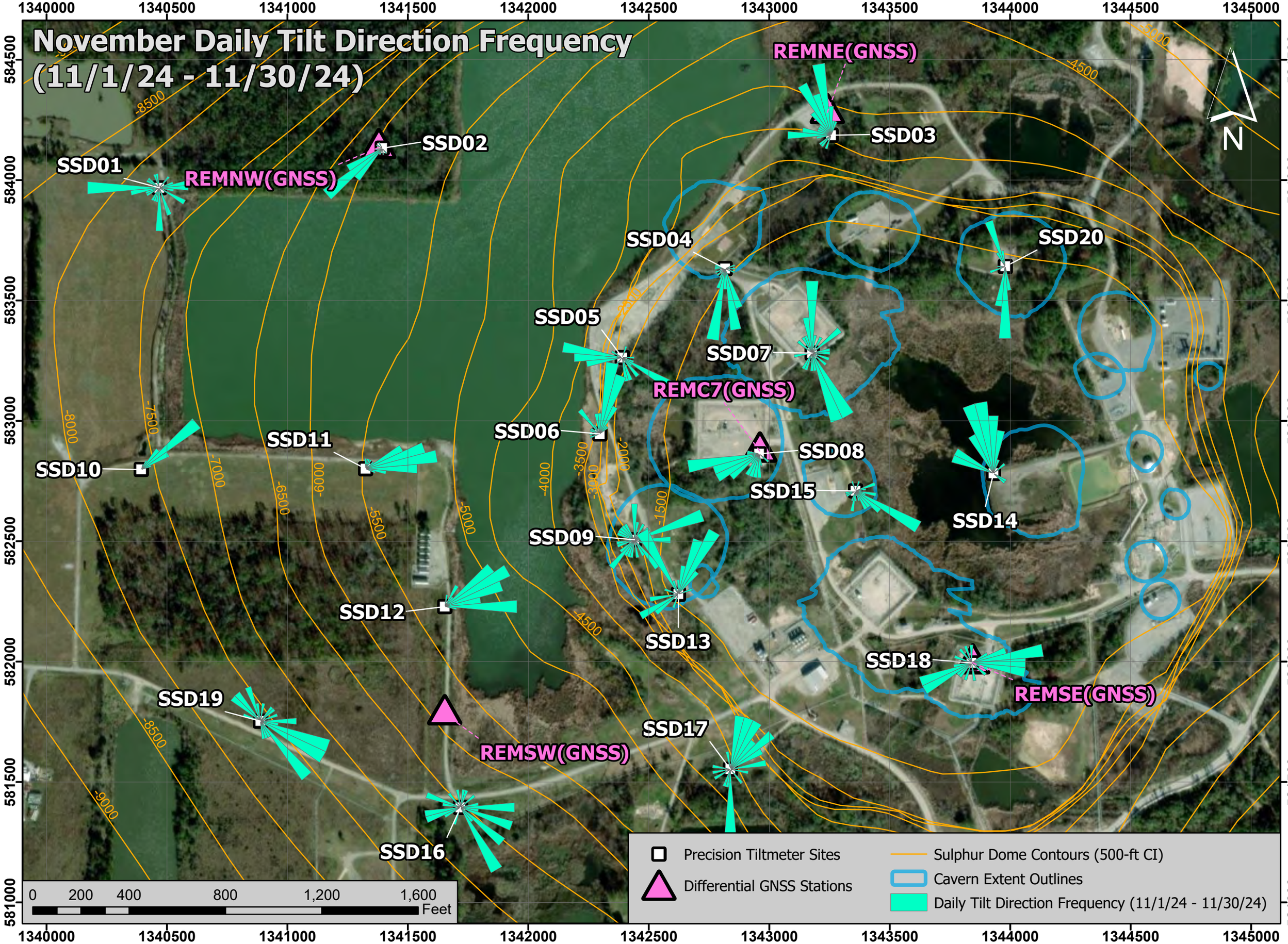
-8500 -4500 -5000 -3500 -3000 -7500 -8000 -7000 -6500 -6000 -5500 -4000 -2500 -2000 -1500 -9000

N

0 200 400 800 1,200 1,600 Feet

Precision Tiltmeter Sites
Differential GNSS Stations
Sulphur Dome Contours (500-ft CI)
Cavern Extent Outlines
Daily Tilt Direction Frequency (6/1/24 - 11/30/24)

November Daily Tilt Direction Frequency
(11/1/24 - 11/30/24)



Location of GNSS and Tiltmeter Stations

Sulphur Mines Salt Dome

(Coordinate Datum: WGS 84)

Differential GNSS Stations		
Name	**Latitude**	**Longitude**
REMC7	30.253327	-93.414588
REMNE	30.257206	-93.413782
REMNW	30.256713	-93.419670
REMSE	30.250953	-93.411739
REMSW	30.250263	-93.418668
Off-dome Reference Station	30.257750	-93.426649

Precision Tiltmeter Sites		
Name	**Latitude**	**Longitude**
SSD01	30.256207	-93.422543
SSD02	30.256705	-93.419624
SSD03	30.256947	-93.413727
SSD04	30.255402	-93.415087
SSD05	30.254365	-93.416418
SSD06	30.253489	-93.416695
SSD07	30.254456	-93.413924
SSD08	30.253295	-93.414595
SSD09	30.252288	-93.416215
SSD10	30.252987	-93.422714
SSD11	30.253043	-93.419765
SSD12	30.251485	-93.418691
SSD13	30.251674	-93.415624
SSD14	30.253120	-93.411511
SSD15	30.252891	-93.413320
SSD16	30.249195	-93.418437
SSD17	30.249687	-93.414899
SSD18	30.250951	-93.411754
SSD19	30.250140	-93.421087
SSD20	30.255485	-93.411405

ATTACHMENT B

SNT InSAR report - November 27, 2024

SNT Satellite Update

Continuous InSAR Monitoring of Ground Displacement At Westlake Caverns and Western Dome Flank

Sulphur Mines Salt Dome

Prepared for:
Westlake Chemical

Prepared by:
Lonquist & Co., LLC
8591 United Plaza Blvd., Suite 280
Baton Rouge, LA 70809

Dataset
Satellite Source
Sentinel-1 (SNT)
Most Recent Image Date
Wednesday, November 27, 2024

Analysis Report Date:

December 3, 2024

Dataset Information

Satellite Source	Sentinel-1 (SNT)
Revisit Frequency	12 days
Most Recent Image Date	Wednesday, November 27, 2024
Dataset Image Count	214
Dataset Time Range	October 4, 2016 - November 27, 2024
Dataset Length	8.15 Years
Satellite Line-of-Sight (LOS)	43° West of Vertical (Viewing site from the West)

Analysis Methodology

Time Series Charts

Trend lines were calculated for the averaged displacement values within each AOI. Quadratic regression was used to determine Velocity and Acceleration of LOS displacement. Trends calculated for the AOI point groups are depicted for each AOI in the Time Series section of this report.

Contour Maps

A quadratic trend was also calculated for each individual measurement point across the analysis region. Trend values for each point were used to generate Velocity and Acceleration contour maps to depict the spatial distribution of the movement trends. Negative velocity values indicate subsidence or eastward movement. Negative acceleration values indicate increasing rates of subsidence, increasing eastward movement, or slowing westward movement and positive acceleration values indicate slowing rates of subsidence, slowing eastward movement, or increasing westward movement. Maps depicting the individual data points colored by these trend values are also included in the last section of the report.

Recent vs. Historical Data

The multi-year SNT dataset timeframe allows for Recent data to be evaluated separately from Historical data and for trends from the two timeframes to be compared. The change in the velocities and accelerations from the two timeframes are provided in the Time Series and Contour Map sections. Velocity values are calculated for the final date in either the Recent or Historical datasets.

Observations

To-date there have been no acute deviations from established subsidence trends in the areas investigated.

The comparison of Recent to Historical trends in the SNT data does imply a minor increase (≥ -0.10) in the negative velocity and/or negative acceleration of LOS displacement in 2 of the 15 AOI point groups. This suggests that marginal increases in subsidence rates may be occuring in these areas in recent years with the greatest velocity increases (in descending order) occuring in AOI 8 (PPG 22), AOI 10 (PPG2), and AOI 15 (PPG 20).

The mapped contours of the change in recent vs. historical subsidence velocity and acceleration mostly display minor fluctuations around 0, intermittently distributed within the AOIs. Some concentrations of negative rate change can be observed that generally support the observations in the above mentioned AOIs.

Date Signed: December 3, 2024
Austin, Texas

Nathaniel L. Byars, P.E.
Principal Engineer
Louisiana License No. 40697

InSAR Data Sources

InSAR Data

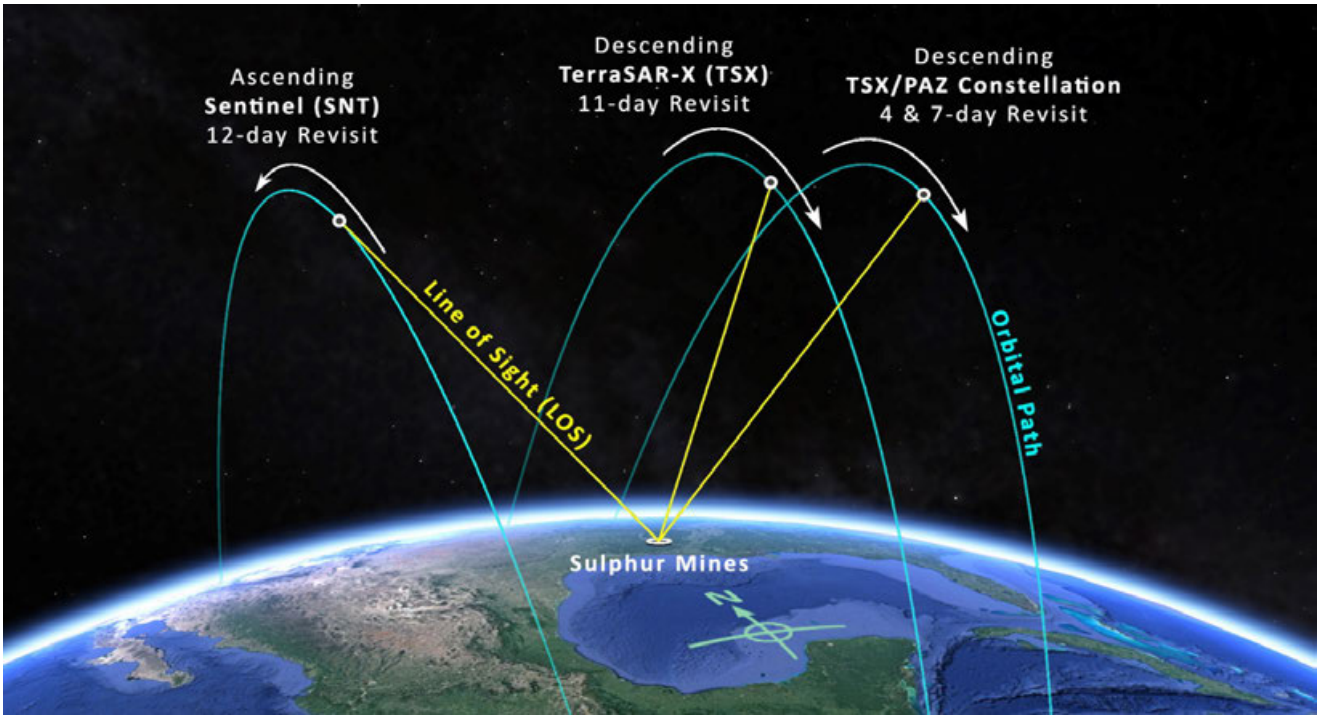
Interferometric Synthetic Aperture Radar (InSAR) is the most well established method to continually evaluate small, normally undetectable, ground movement over a large area. Radar imagery collected via satellites over successive orbital passes is used to identify and define measurement points on the ground. Objects or ground features providing a stable reflection of radar energy such as buildings, roads, and infrastructure produce the highest quality measurement points. InSAR analysis identifies the change in distance between the satellite and each measurement point over time relative to a stable reference point within the imaged area.

Satellite Sources

Two InSAR datasets are being used to evaluate subsidence over the Sulphur Mines Salt Dome. These datasets provide Line-of-Sight (LOS) displacment measurements from both ascending and descending orbits. An ascending orbit denotes the satellite's longitudinal course from south to north as it passes over the site, while a desceding orbit denotes the satellite is moving from north to south.

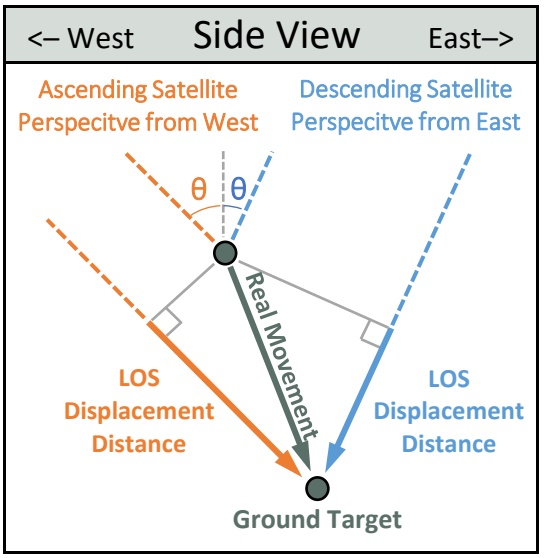
The first dataset comes from a low-resolution Sentinel-1 (SNT) satellite on an ascending orbit that captures data from the west of the site on a 12-day frequency. The second comes from a pair of high resolution satellites that share the same descending orbit and capture data from east of the site. These are a TSX satellite and the PAZ satellite (TSX/PAZ constellation), both with an 11-day revisit frequency. Their orbits are offset with the PAZ satellite passing over the site 4 days after the TSX satellite. Prior to May 2023, data was captured from a different high-resolution TerraSAR-X (TSX) satellite on a descending orbit that captured data from the east of the site on an 11-day frequency. The transition was made for the increased data frequency that resulted from a 4 and 7-day revisit period. The image below depicts the orbital paths of the satellites in relation to the Sulphur Mines Salt Dome.

Satellite Orbital Diagram



InSAR Line-of-Site (LOS) Data

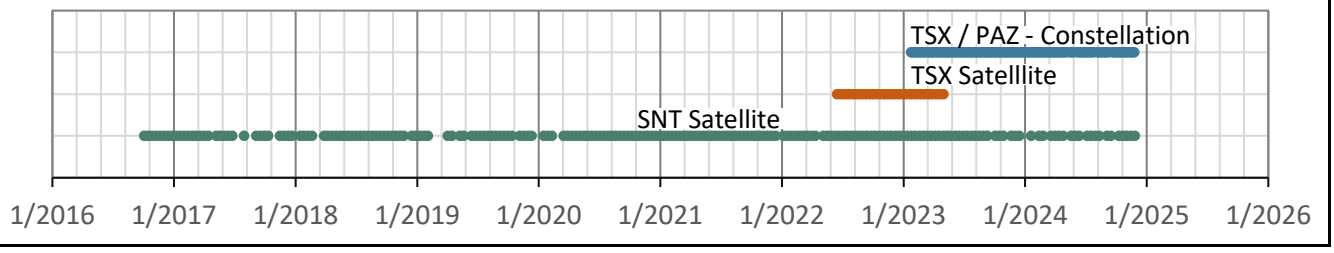
LOS displacement measurements refer to a change in distance between the satellite sensor and the ground target. Measurement positions on the west side of the Sulphur Dome are are known to be experiencing some eastward movement toward the dome center due to the geometry of the subsidence basin. The InSAR satellites view the site from eastward and westward positions so LOS measurements are understood to convey a movement distance that is not purely vertical. The diagram to the right illustrates the geometric relationship between the theoretical Real movement of a ground target and LOS displacement measurements from two different satellite viewing directions.



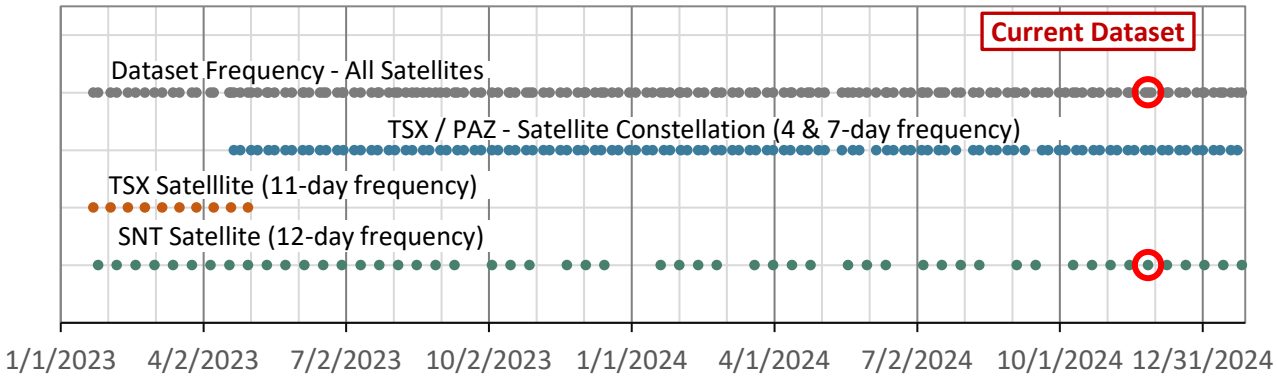
Satellite Properties & Image Frequency

Satellite and Data Properties	SNT	TSX	TSX/PAZ Constellation
Band (Wavelength)	C-band (2.20 in)	X-band (1.22 in)	X-band (1.22 in)
Track	T136	T29	T67 & T120
Pixel resolution	65 x 16 ft	3 x 3 ft	3 x 3 ft
Revisit frequency	12 days	11 days	4 & 7 days
Orbit (LOS Angle, θ)	Ascending (43°)	Descending (17°)	Descending (37°)
Data Start Date	10/4/2016	6/16/2022	1/24/2023
Measurement error range	± 0.20 in	± 0.03 in	± 0.03 in

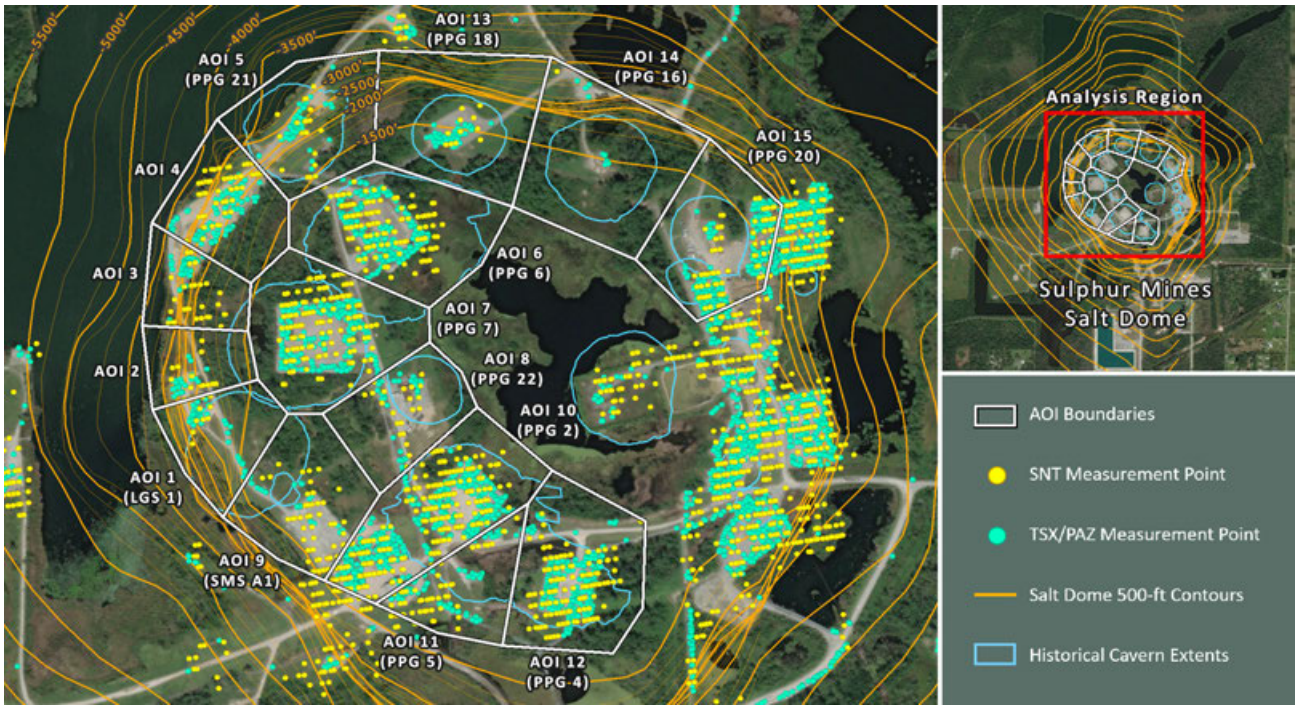
Dataset Measurement History



Dataset Update Frequency



AOI Boundaries & InSAR Measurement Points

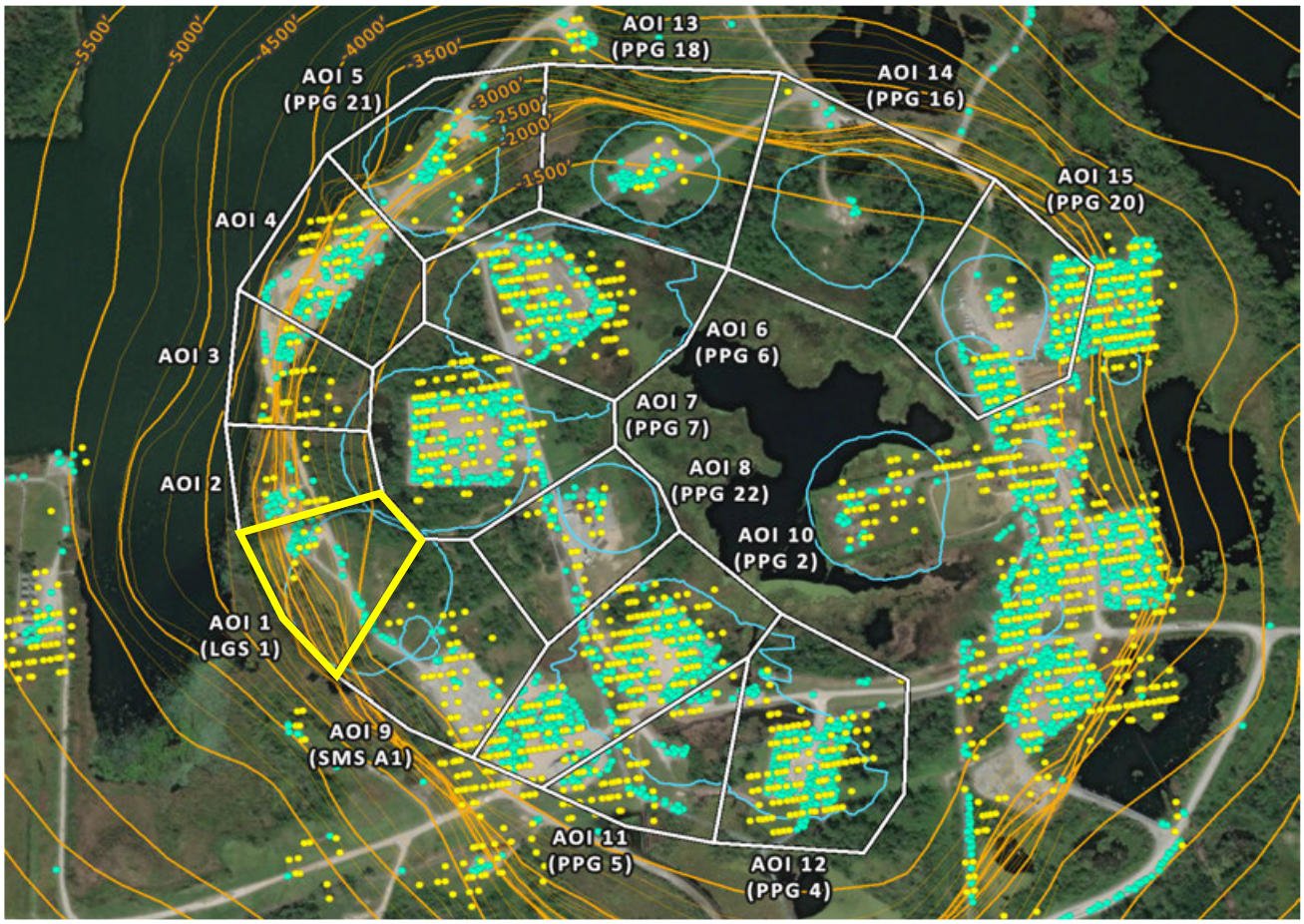


Subsidence Monitoring Areas of Interest (AOIs)

To visually convey and evaluate trend consistency for the displacement time series of each ground target, measurment points were grouped and their displacement values were averaged. The point groups are referred to as Areas of Interest (AOIs) in this analysis and their boundaries are depicted on the above map. The below table lists the trend values calculated in each AOI for the dataset evaluated in this report.

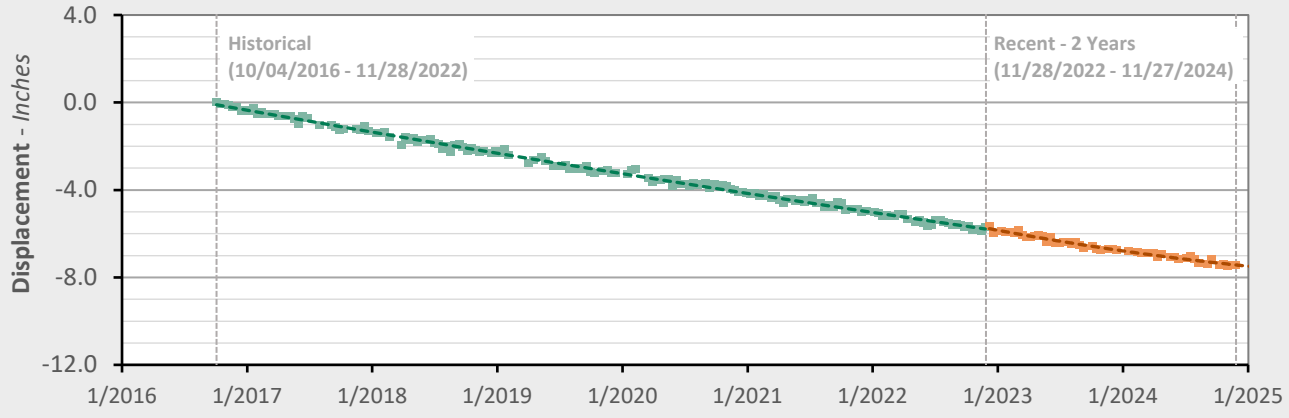
AOI Name	SNT (11/27/2024)	LOS Velocity *(in/yr)*			LOS Acceleration *(in/yr^2)*		
	Point Count	Historical	Recent	Change	Historical	Recent	Change
AOI 1 *(LGS 1)*	14	-0.82	-0.64	+0.19	+0.03	+0.20	+0.17
AOI 2	15	-0.80	-0.52	+0.28	+0.05	+0.38	+0.34
AOI 3	29	-0.65	-0.40	+0.26	+0.03	+0.29	+0.26
AOI 4	62	-0.78	-0.77	+0.01	-0.00	-0.02	-0.02
AOI 5 *(PPG 21)*	25	-0.65	-0.56	+0.09	+0.02	-0.01	-0.02
AOI 6 *(PPG 6)*	134	-0.86	-0.92	-0.06	+0.05	-0.05	-0.10
AOI 7 *(PPG 7)*	139	-0.99	-1.06	-0.07	+0.06	+0.06	-0.00
AOI 8 *(PPG 22)*	20	-1.06	-1.23	-0.17	+0.10	+0.04	-0.05
AOI 9 *(SMS A1)*	58	-0.85	-0.84	+0.01	+0.07	+0.03	-0.04
AOI 10 *(PPG 2)*	233	-0.90	-1.01	-0.10	+0.08	+0.02	-0.06
AOI 11 *(PPG 5)*	52	-0.88	-0.81	+0.07	+0.06	+0.10	+0.04
AOI 12 *(PPG 4)*	120	-0.74	-0.61	+0.13	+0.05	+0.06	+0.01
AOI 13 *(PPG 18)*	12	-0.59	-0.57	+0.02	+0.04	+0.07	+0.03
AOI 14 *(PPG 16)*	1	-0.16	+0.41	+0.58	+0.07	+0.76	+0.69
AOI 15 *(PPG 20)*	71	-0.30	-0.37	-0.08	+0.04	-0.05	-0.09

AOI 1 *(LGS 1)* - Location Map



AOI 1 *(LGS 1)* - Displacement Time Series

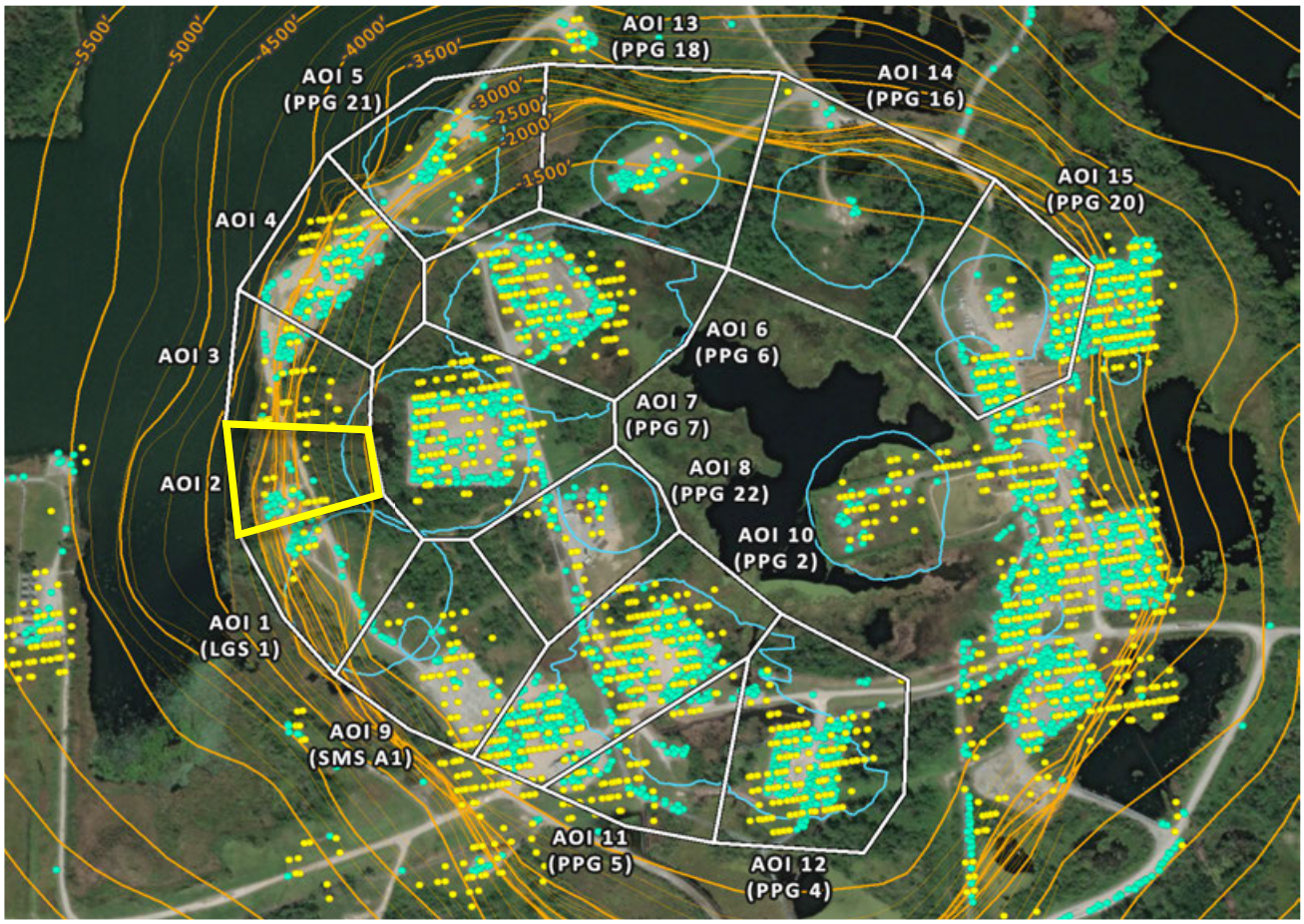
SNT (11/27/2024) Point Count: **14**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.82 in/yr	-0.64 in/yr	+0.19 in/yr
Acceleration:	+0.03 in/yr^2	+0.20 in/yr^2	+0.17 in/yr^2

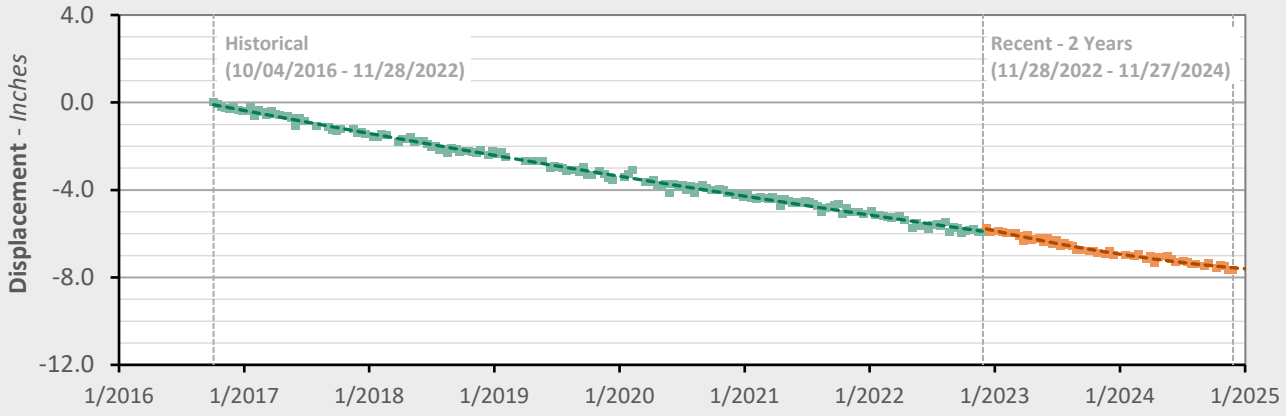
Historical LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)
Recent LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)

AOI 2 - Location Map



AOI 2 - Displacement Time Series

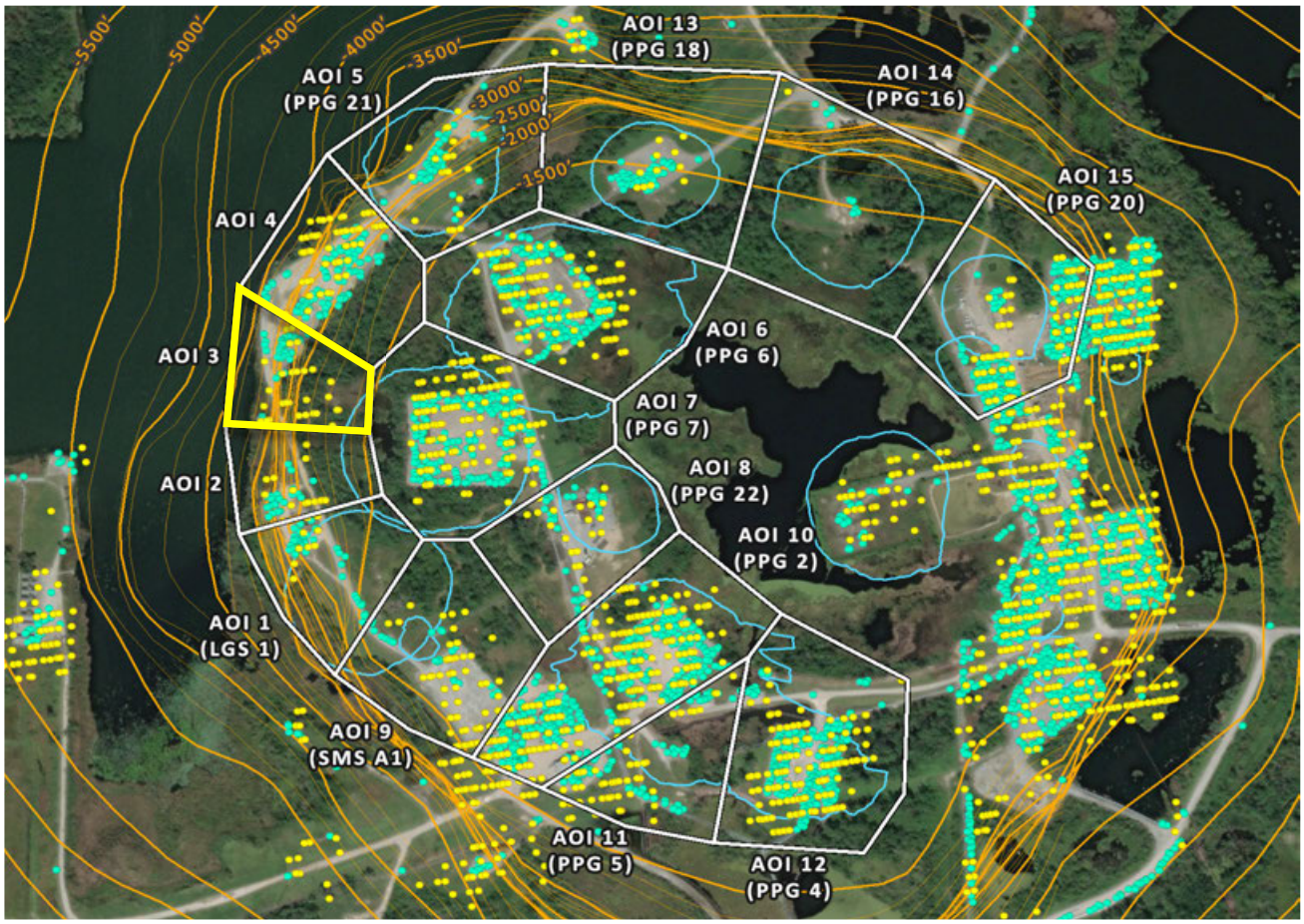
SNT (11/27/2024) Point Count: **15**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.80 in/yr	-0.52 in/yr	+0.28 in/yr
Acceleration:	+0.05 in/yr^2	+0.38 in/yr^2	+0.34 in/yr^2

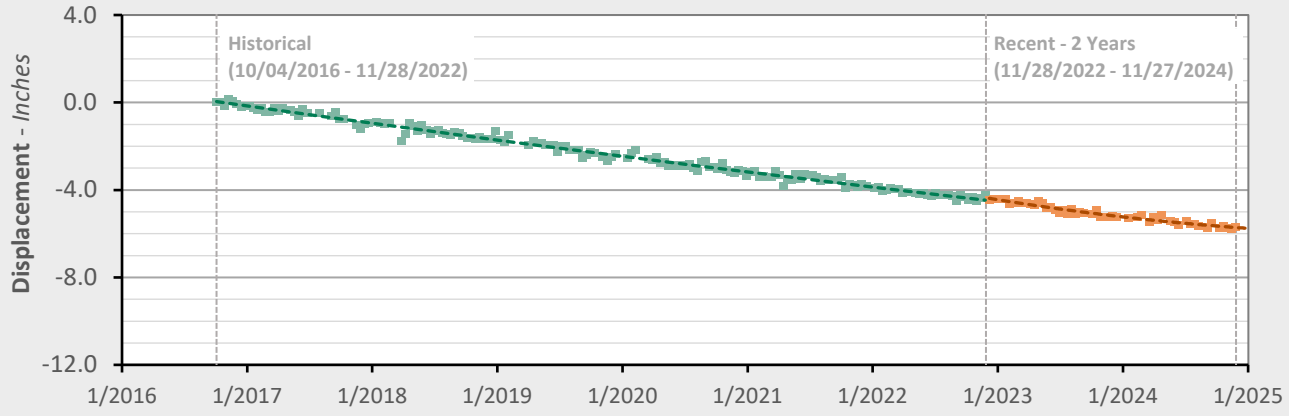
Historical LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)
Recent LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)

AOI 3 - Location Map



AOI 3 - Displacement Time Series

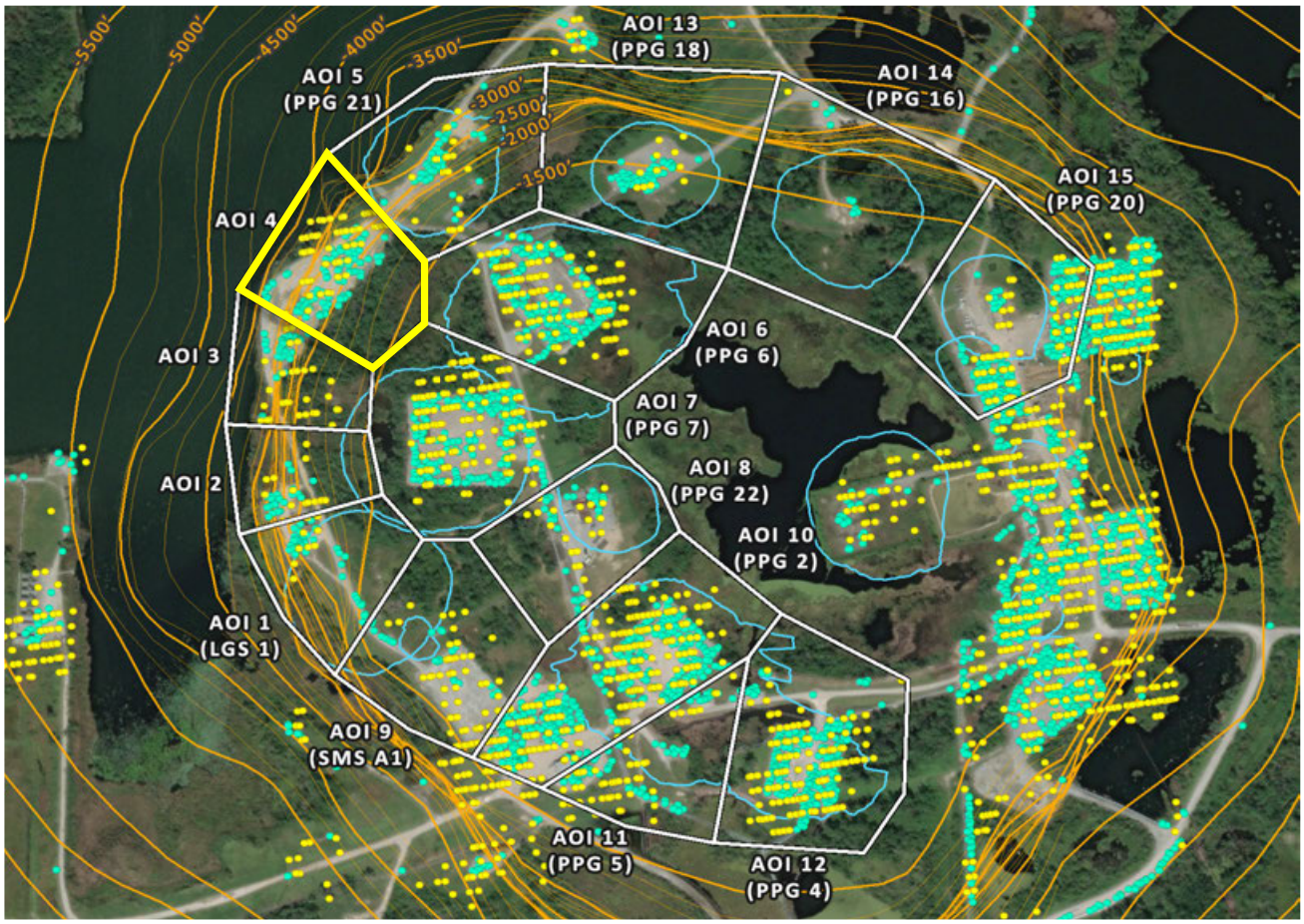
SNT (11/27/2024) Point Count: **29**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.65 in/yr	-0.40 in/yr	+0.26 in/yr
Acceleration:	+0.03 in/yr^2	+0.29 in/yr^2	+0.26 in/yr^2

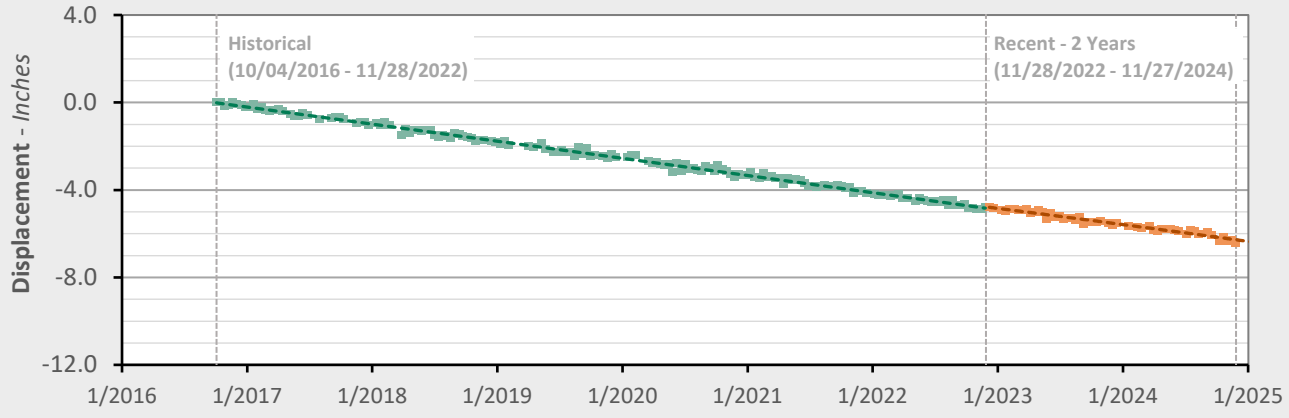
Historical LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)
Recent LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)

AOI 4 - Location Map



AOI 4 - Displacement Time Series

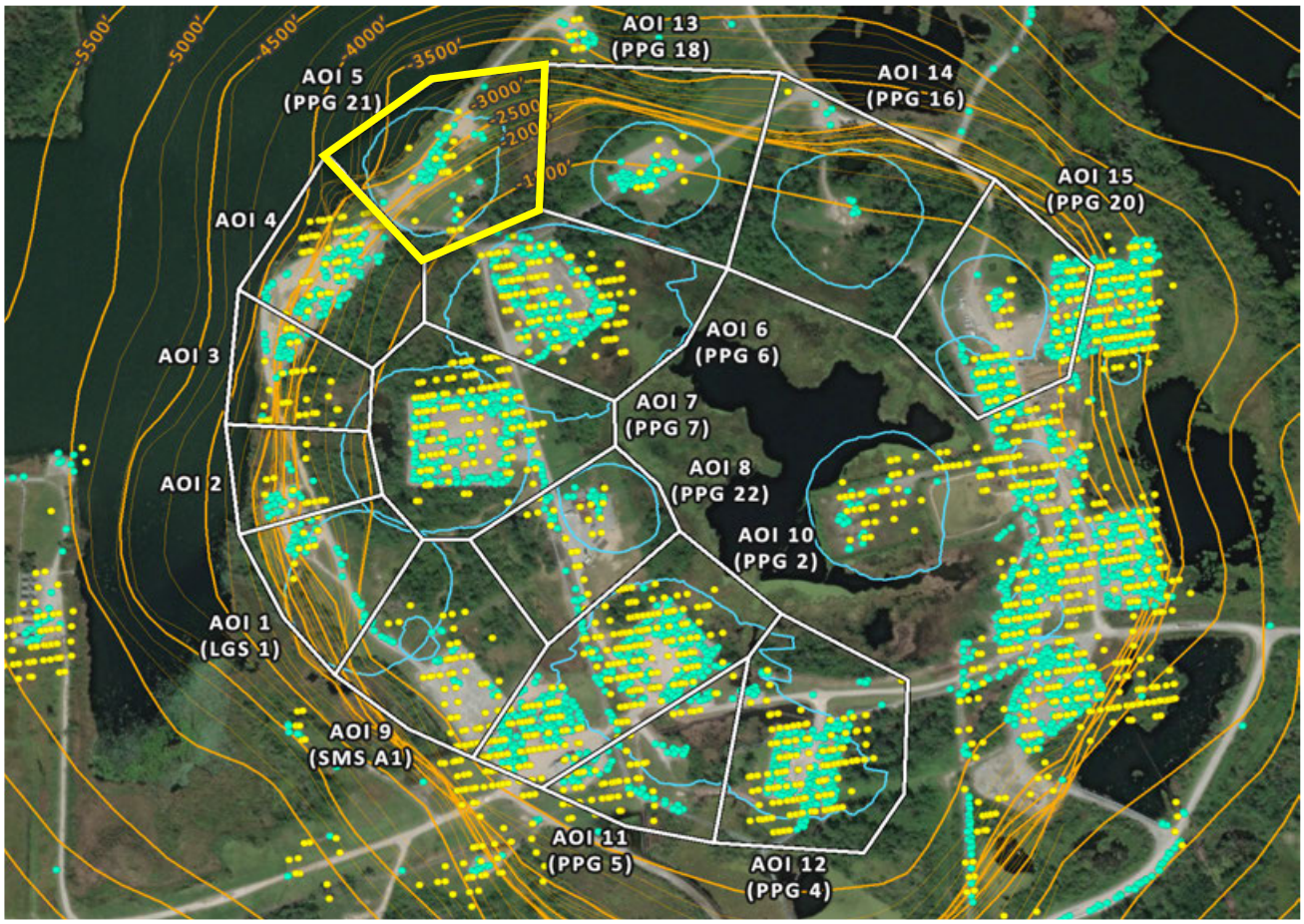
SNT (11/27/2024) Point Count: **62**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.78 in/yr	-0.77 in/yr	+0.01 in/yr
Acceleration:	-0.00 in/yr^2	-0.02 in/yr^2	-0.02 in/yr^2

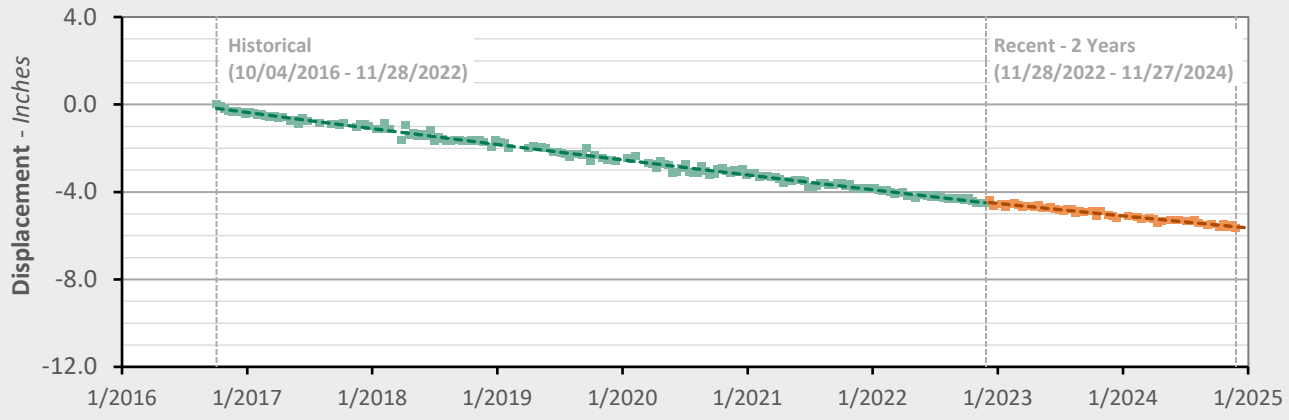
Historical LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)
Recent LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)

AOI 5 *(PPG 21)* - Location Map



AOI 5 *(PPG 21)* - Displacement Time Series

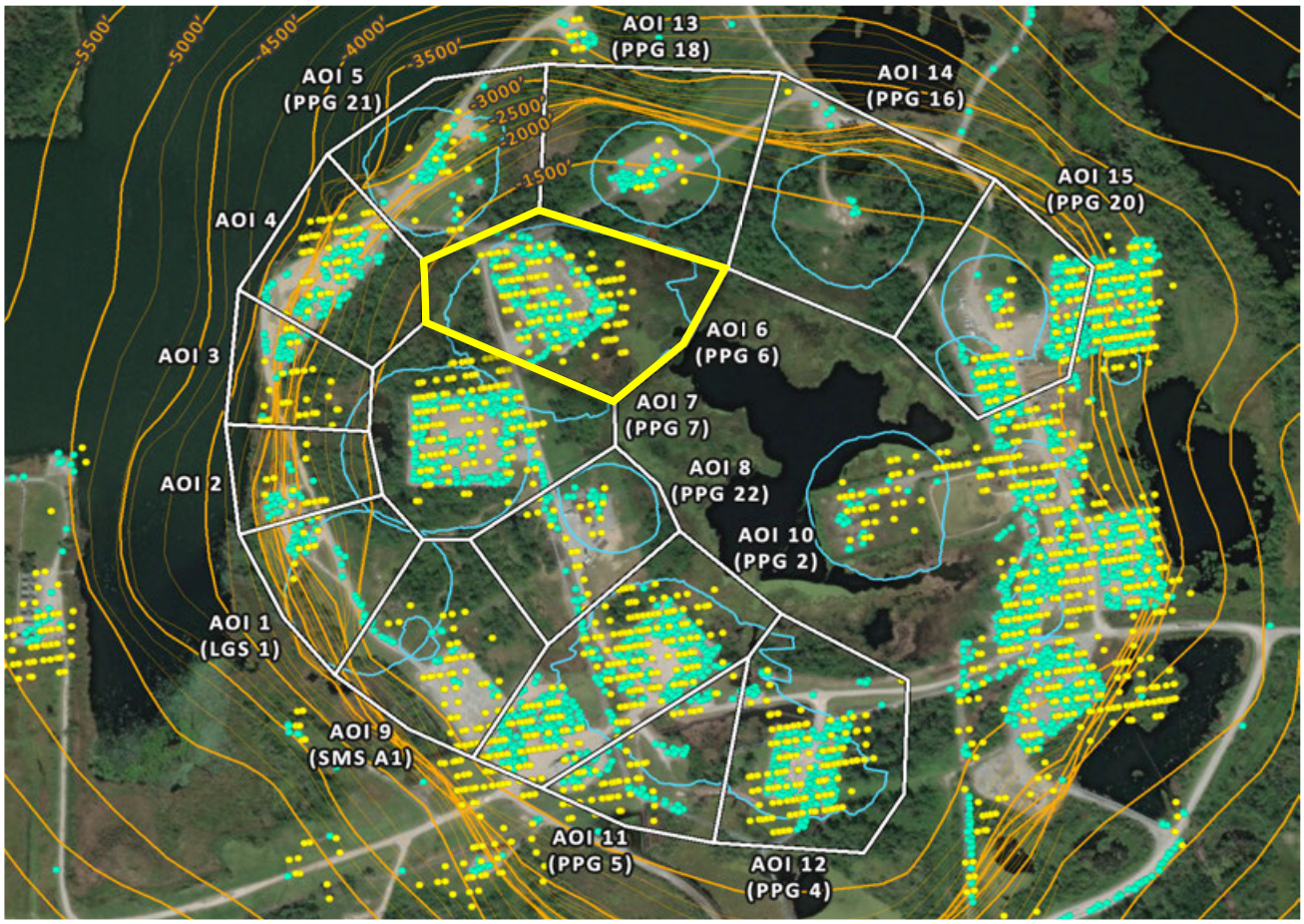
SNT (11/27/2024) Point Count: **25**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.65 in/yr	-0.56 in/yr	+0.09 in/yr
Acceleration:	+0.02 in/yr^2	-0.01 in/yr^2	-0.02 in/yr^2

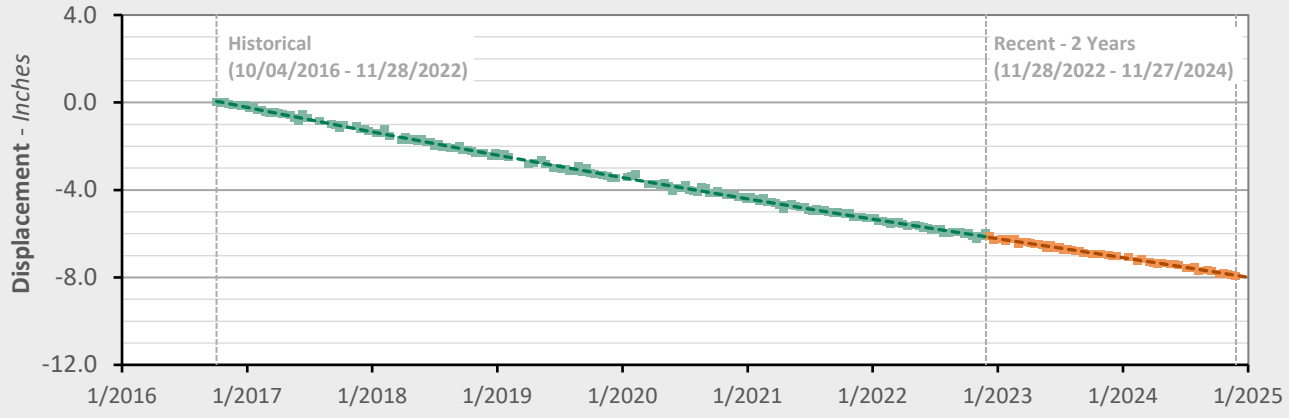
Historical LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)
Recent LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)

AOI 6 *(PPG 6)* - Location Map



AOI 6 *(PPG 6)* - Displacement Time Series

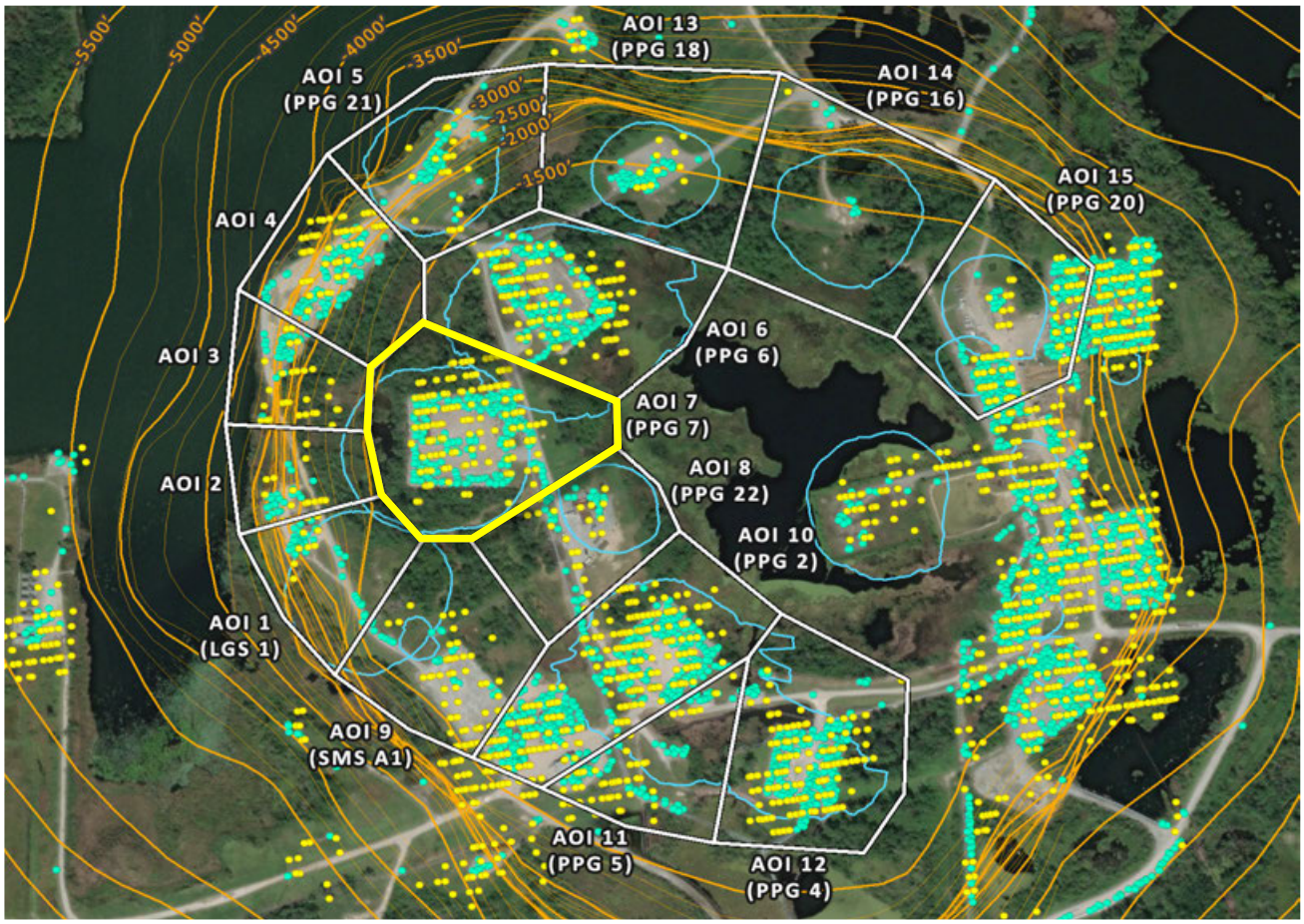
SNT (11/27/2024) Point Count: **134**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.86 in/yr	-0.92 in/yr	-0.06 in/yr
Acceleration:	+0.05 in/yr^2	-0.05 in/yr^2	-0.10 in/yr^2

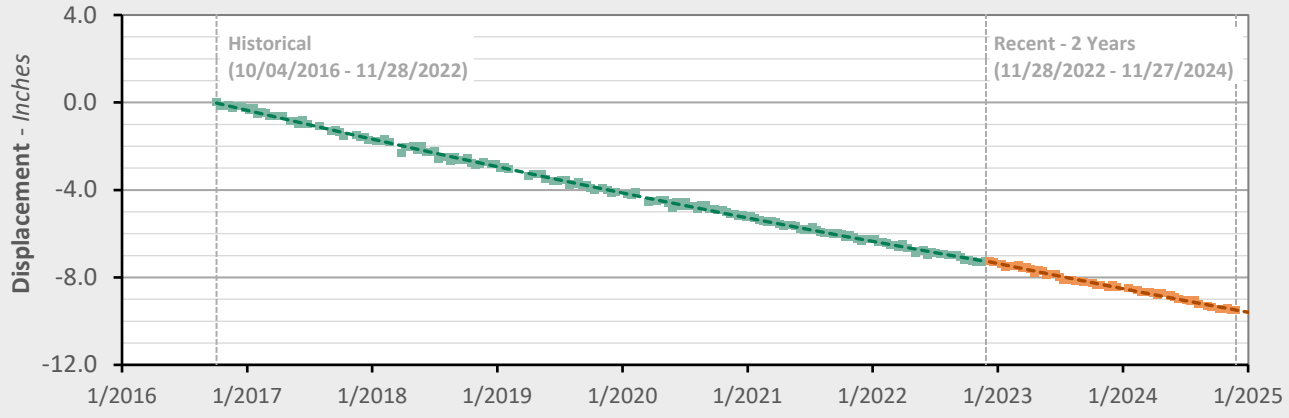
Historical LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)
Recent LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)

AOI 7 *(PPG 7)* - Location Map



AOI 7 *(PPG 7)* - Displacement Time Series

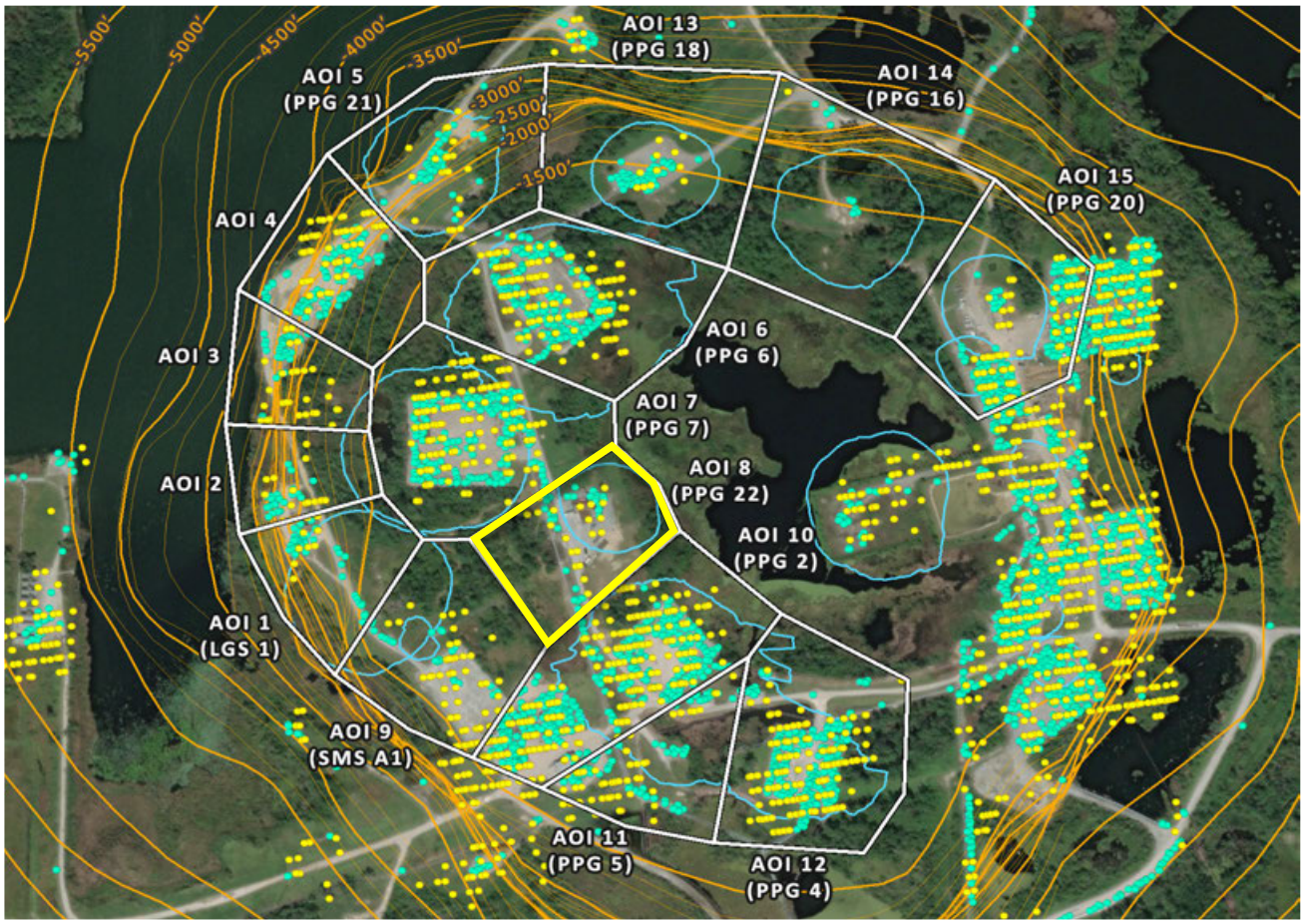
SNT (11/27/2024) Point Count: **139**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.99 in/yr	-1.06 in/yr	-0.07 in/yr
Acceleration:	+0.06 in/yr^2	+0.06 in/yr^2	-0.00 in/yr^2

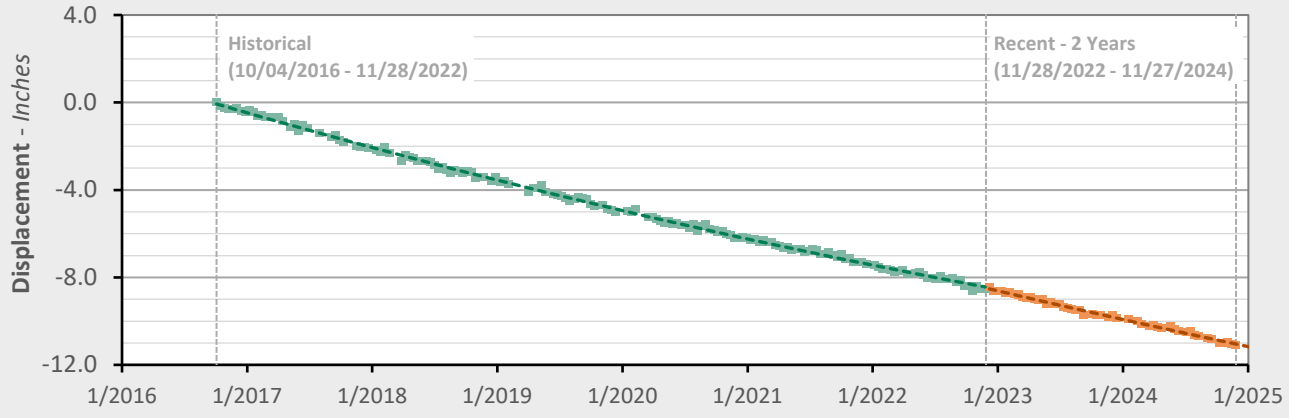
Historical LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)
Recent LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)

AOI 8 *(PPG 22)* - Location Map



AOI 8 *(PPG 22)* - Displacement Time Series

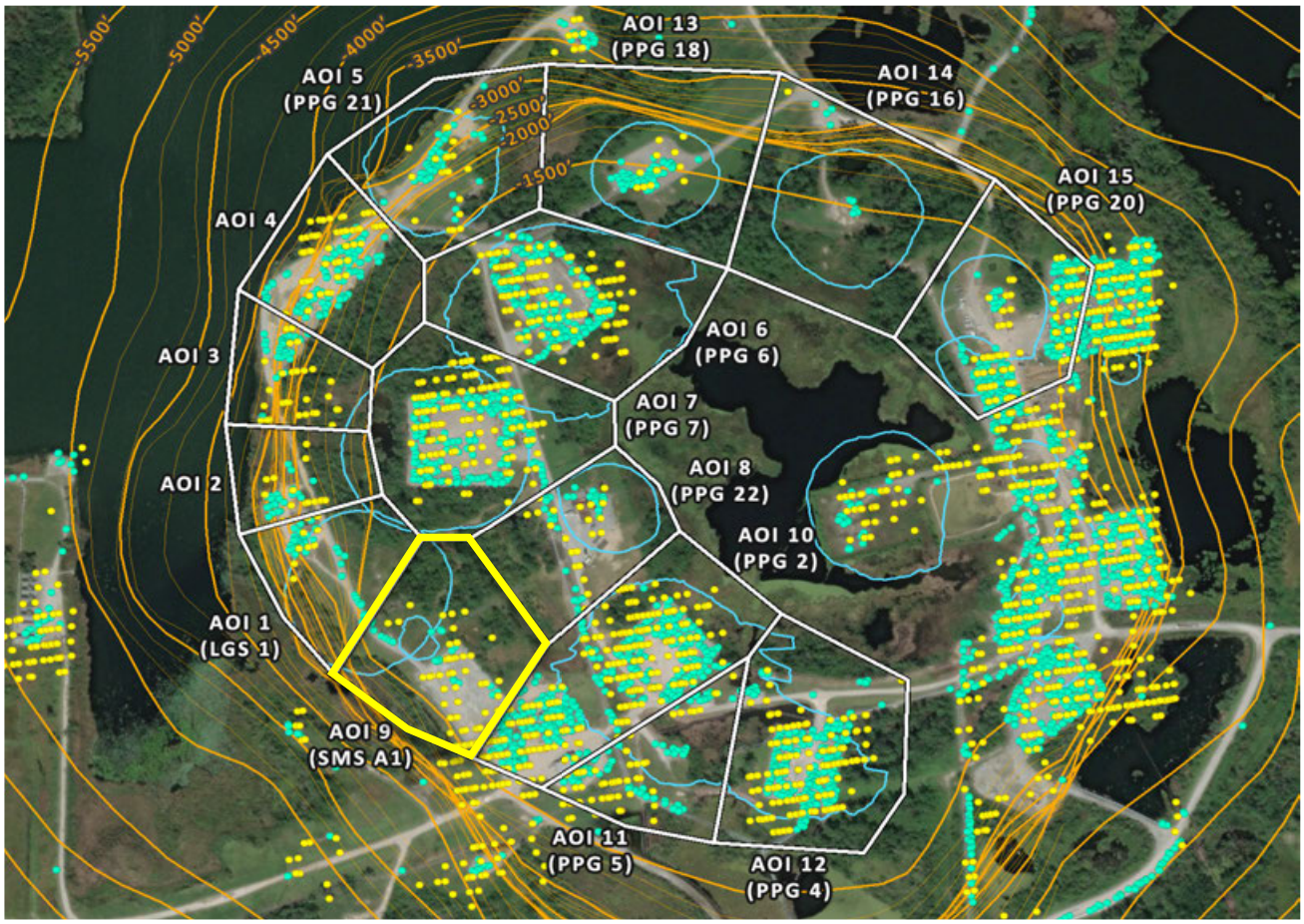
SNT (11/27/2024) Point Count: **20**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-1.06 in/yr	-1.23 in/yr	-0.17 in/yr
Acceleration:	+0.10 in/yr^2	+0.04 in/yr^2	-0.05 in/yr^2

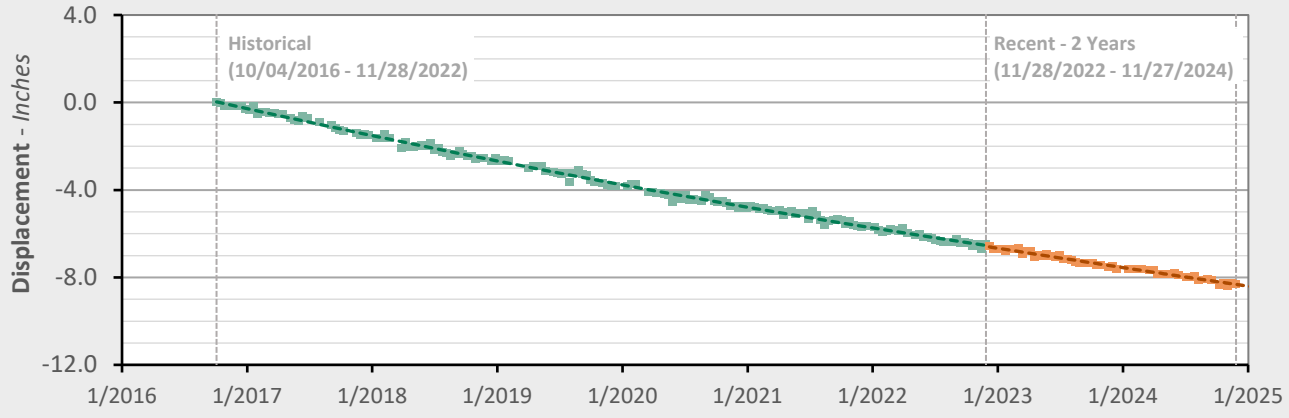
Historical LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)
Recent LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)

AOI 9 *(PPG A1)* - Location Map



AOI 9 *(SMS A1)* - Displacement Time Series

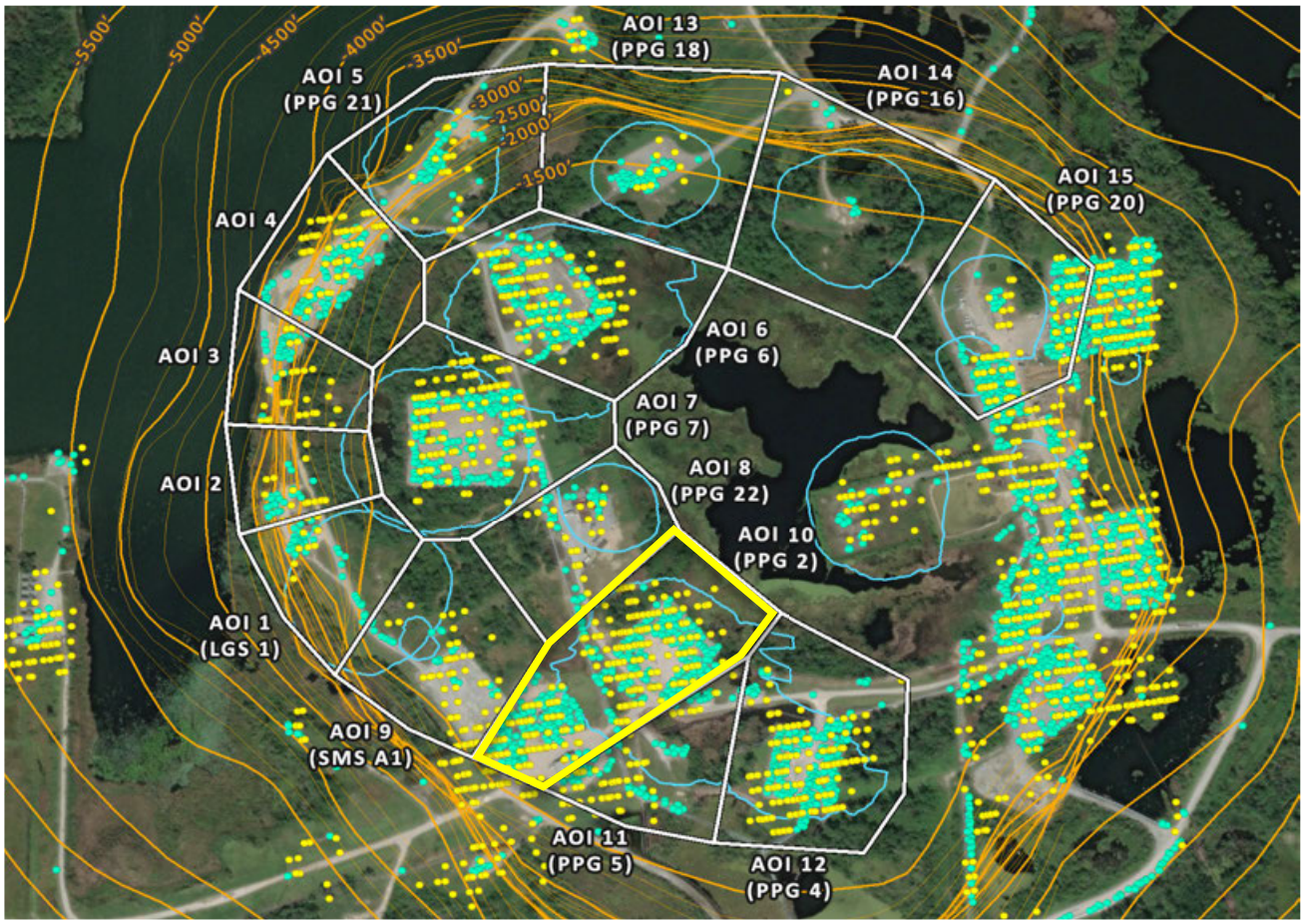
SNT (11/27/2024) Point Count: **58**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.85 in/yr	-0.84 in/yr	+0.01 in/yr
Acceleration:	+0.07 in/yr^2	+0.03 in/yr^2	-0.04 in/yr^2

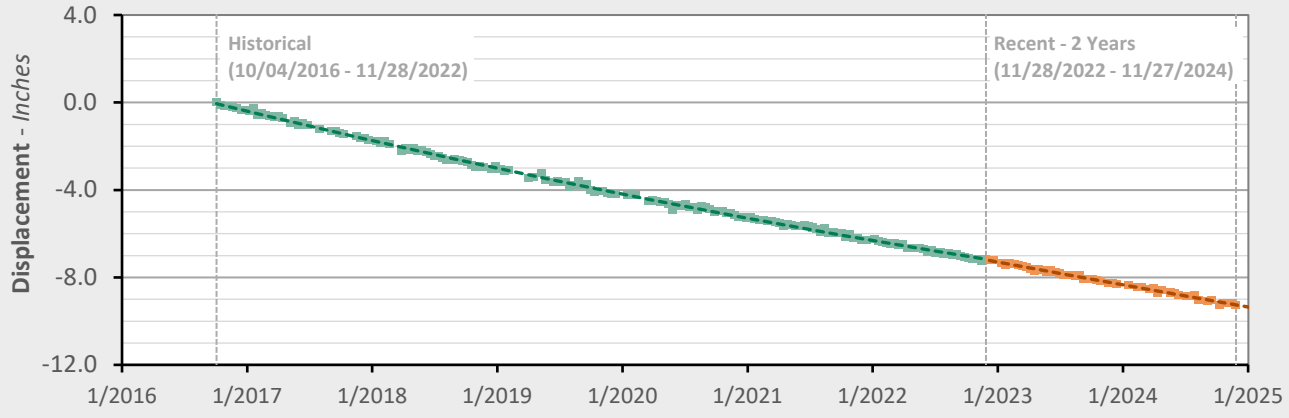
Historical LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)
Recent LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)

AOI 10 *(PPG 2)* - Location Map



AOI 10 *(PPG 2)* - Displacement Time Series

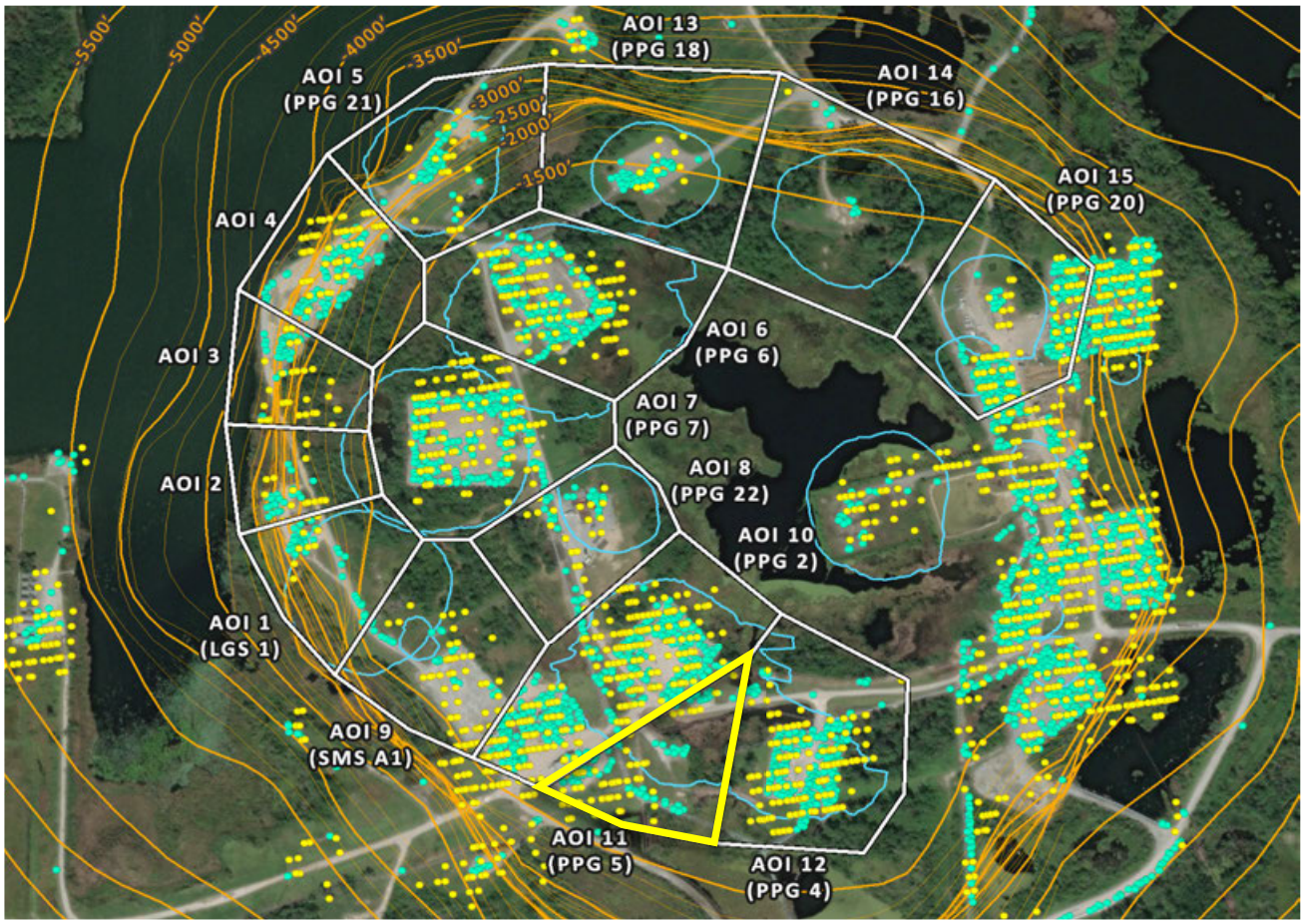
SNT (11/27/2024) Point Count: **233**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.90 in/yr	-1.01 in/yr	-0.10 in/yr
Acceleration:	+0.08 in/yr^2	+0.02 in/yr^2	-0.06 in/yr^2

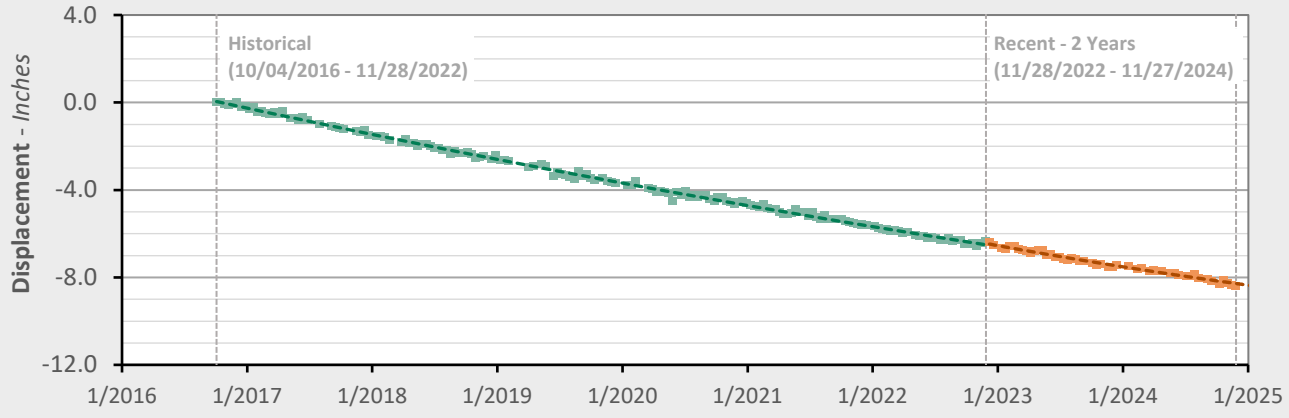
Historical LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)
Recent LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)

AOI 11 *(PPG 5)* - Location Map



AOI 11 *(PPG 5)* - Displacement Time Series

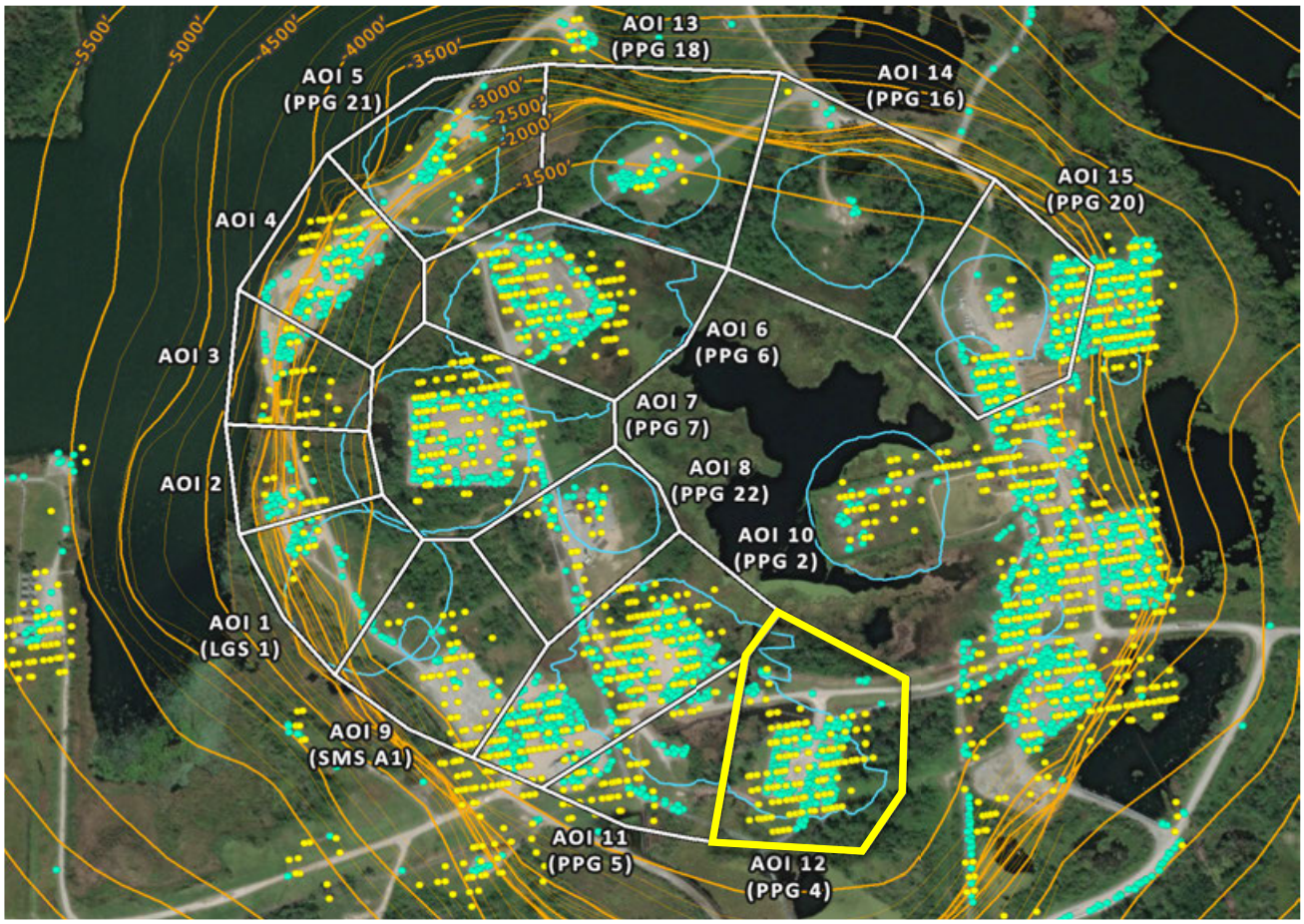
SNT (11/27/2024) Point Count: **52**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.88 in/yr	-0.81 in/yr	+0.07 in/yr
Acceleration:	+0.06 in/yr^2	+0.10 in/yr^2	+0.04 in/yr^2

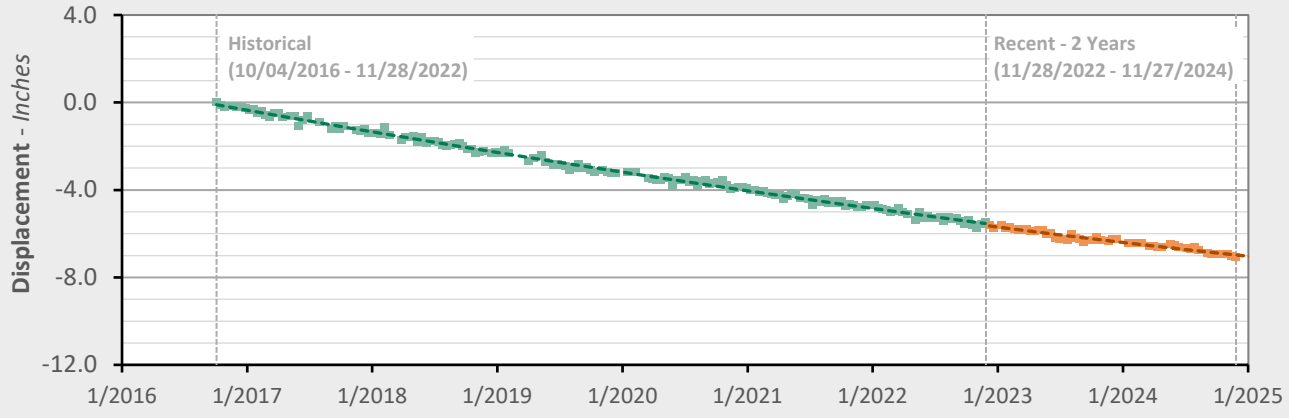
Historical LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)
Recent LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)

AOI 12 *(PPG 4)* - Location Map



AOI 12 *(PPG 4)* - Displacement Time Series

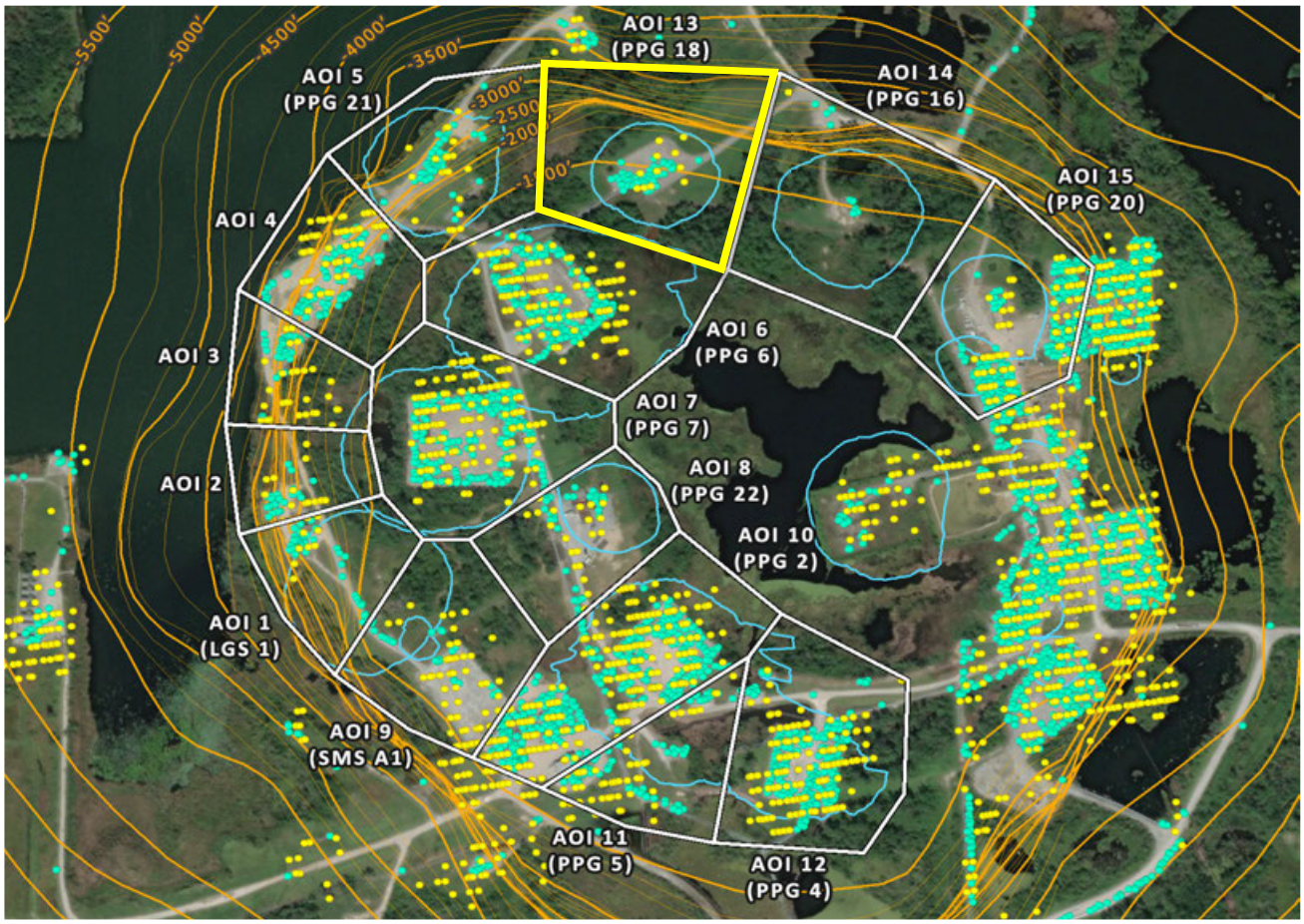
SNT (11/27/2024) Point Count: **120**



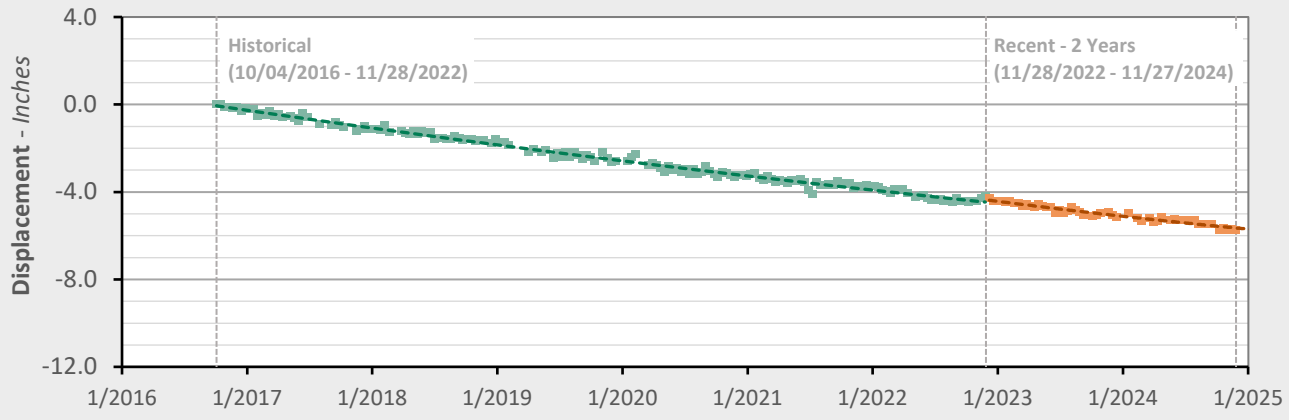
	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.74 in/yr	-0.61 in/yr	+0.13 in/yr
Acceleration:	+0.05 in/yr^2	+0.06 in/yr^2	+0.01 in/yr^2

Historical LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)
Recent LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)

AOI 13 *(PPG 18)* - Location Map



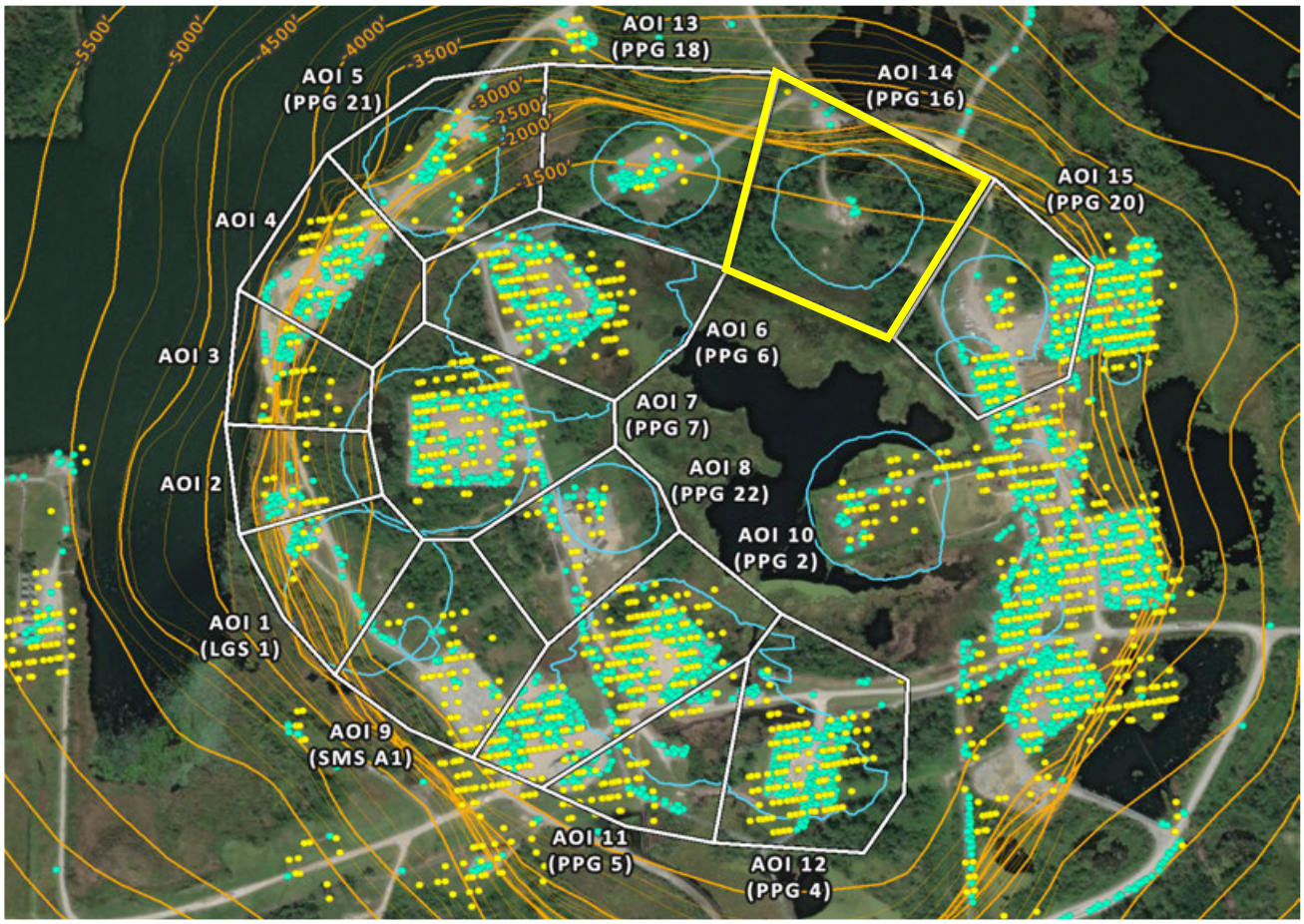
AOI 13 *(PPG 18)* - Displacement Time Serie SNT (11/27/2024) Point Count: 12



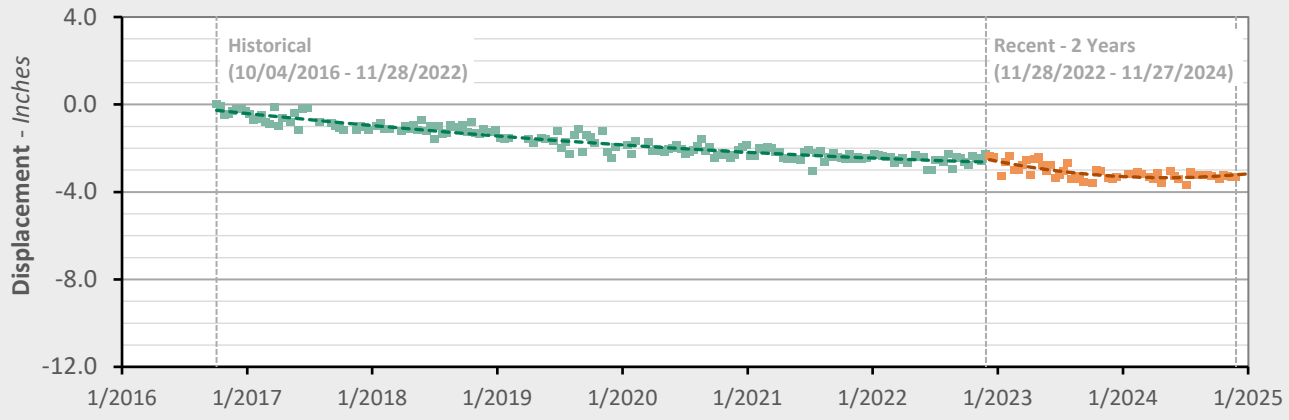
	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.59 in/yr	-0.57 in/yr	+0.02 in/yr
Acceleration:	+0.04 in/yr^2	+0.07 in/yr^2	+0.03 in/yr^2

Historical LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)
Recent LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)

AOI 14 *(PPG 16)* - Location Map



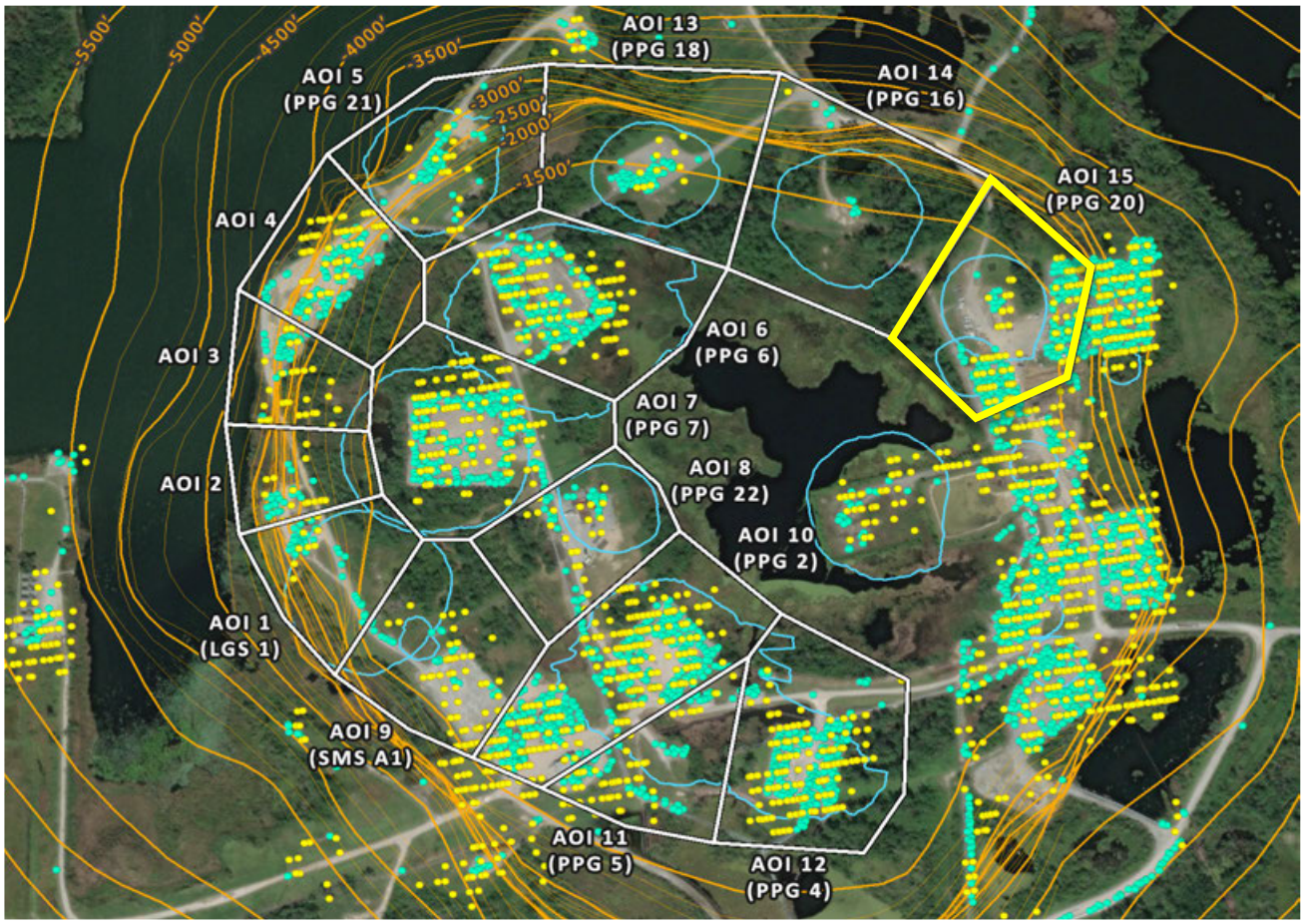
AOI 14 *(PPG 16)* - Displacement Time Serie SNT (11/27/2024) Point Count: 1



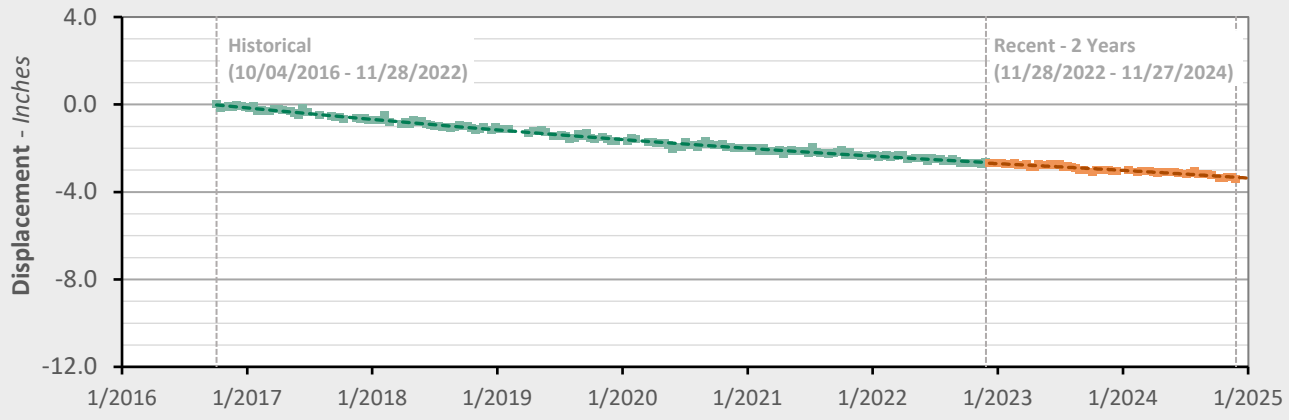
	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.16 in/yr	+0.41 in/yr	+0.58 in/yr
Acceleration:	+0.07 in/yr^2	+0.76 in/yr^2	+0.69 in/yr^2

Historical LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)
Recent LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)

AOI 15 *(PPG 20)* - Location Map



AOI 15 *(PPG 20)* - Displacement Time Serie SNT (11/27/2024) Point Count: 71

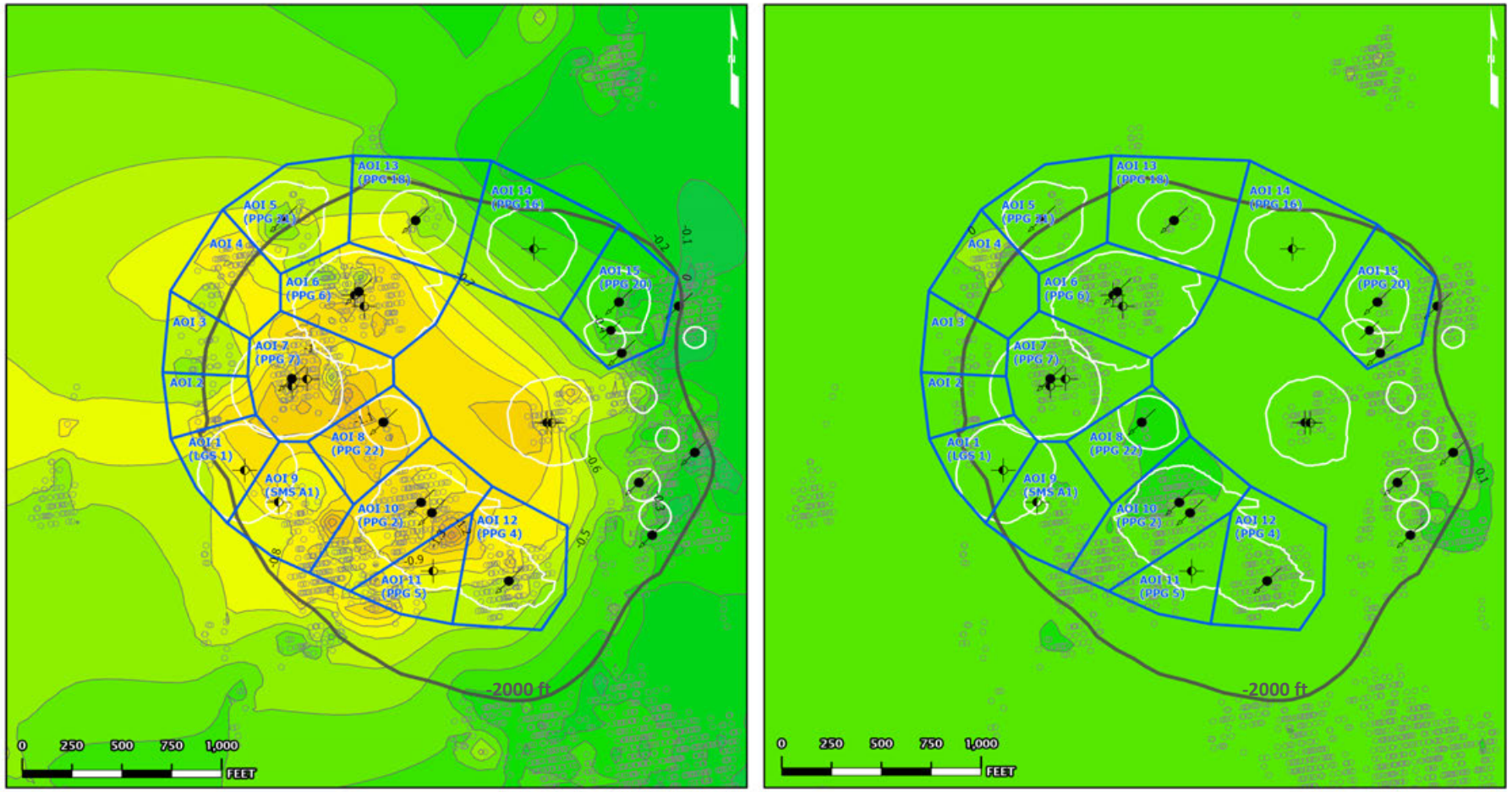


	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.30 in/yr	-0.37 in/yr	-0.08 in/yr
Acceleration:	+0.04 in/yr^2	-0.05 in/yr^2	-0.09 in/yr^2

Historical LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)
Recent LOS Displacement Measurement
Historical Trend Line (Quadratic Regression)

Historical SNT Data (10/04/2016 - 11/28/2022)

Velocity Contours	Acceleration Contours
As of date: 11/28/2022	Date range: 10/04/2016 - 11/28/2022



-2.0 -1.5 -1.0 -0.5 0.0 +0.5 +1.0 Inches/year

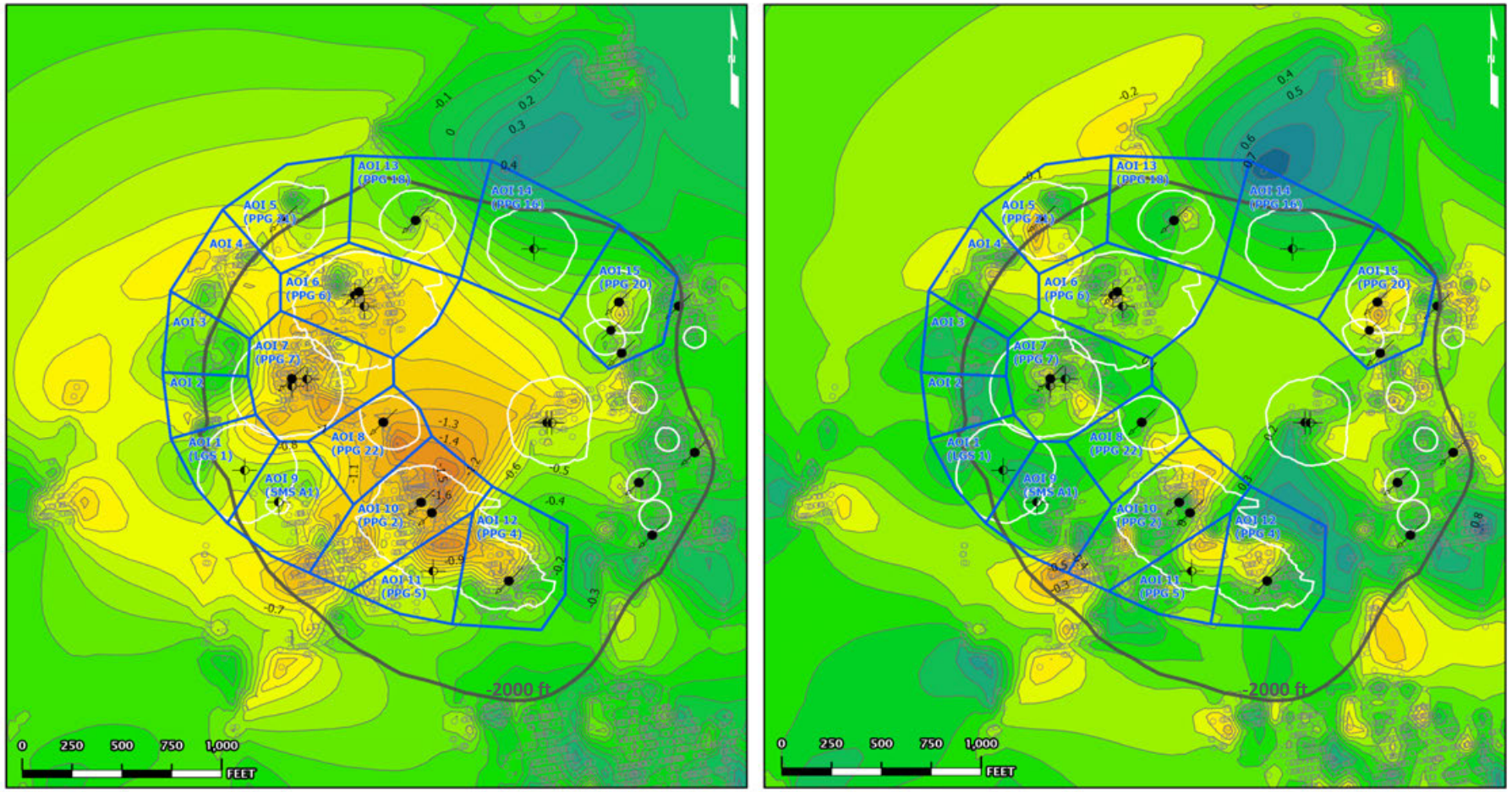
-1.0 -0.5 0.0 +0.5 +1.0 Inches/year^2

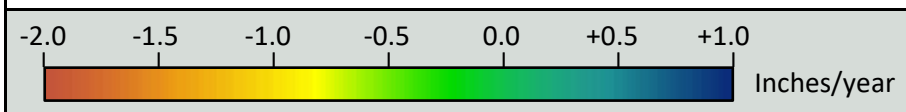
AOI Boundary | InSAR LOS Measurement Point | Contour (0.1) | Cavern Well Surface Locations

Historical Cavern Extent | Top of Dome (-2000 ft Contour) | 09 - Active - Injection | 29 - Dry and Plugged

Recent SNT Data - 2 Years (11/28/2022 - 11/27/2024)

Velocity Contours	Acceleration Contours
As of date: 11/27/2024	Date range: 11/28/2022 - 11/27/2024



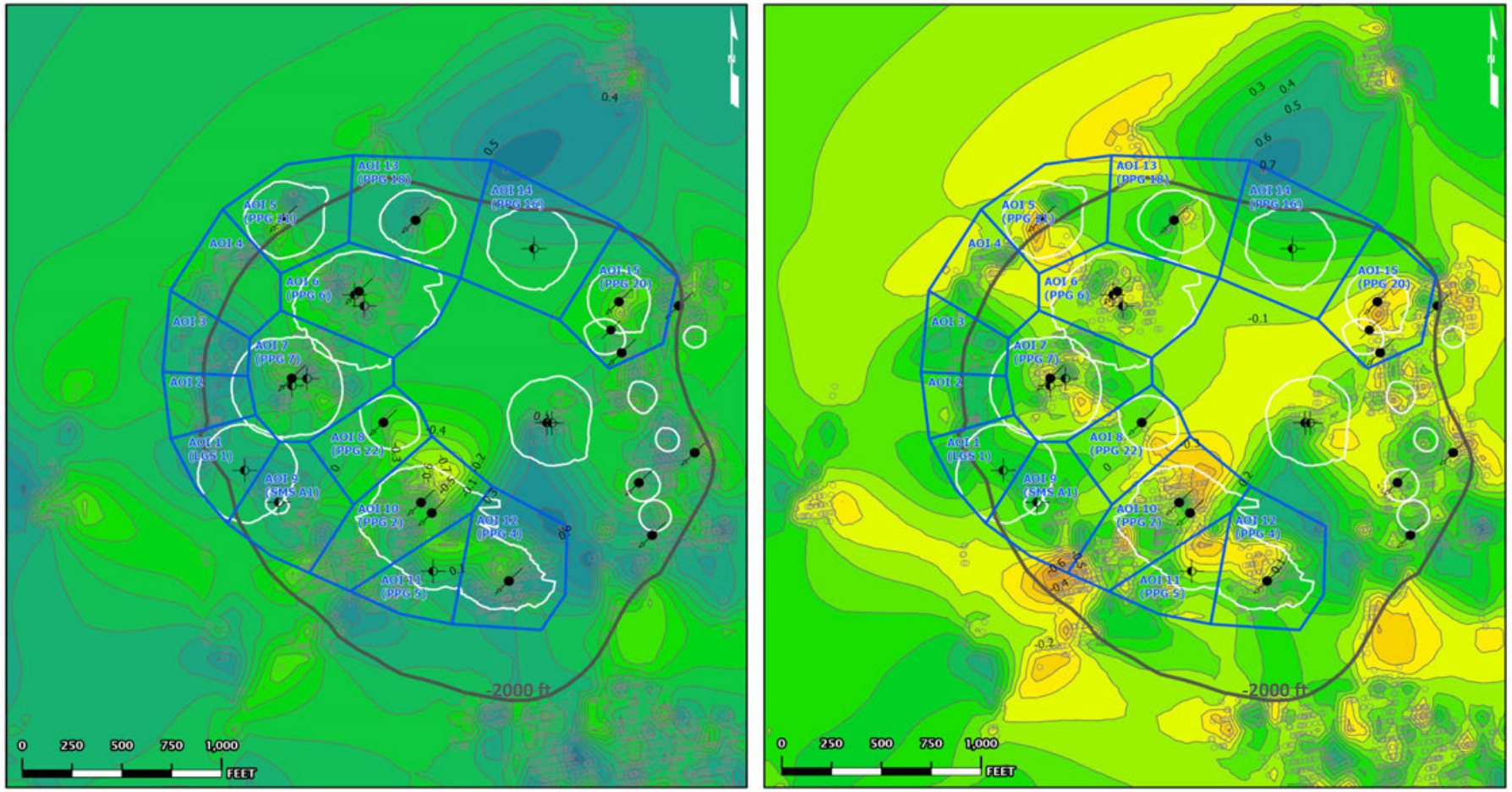


AOI Boundary | InSAR LOS Measurement Point | Contour (0.1) | Cavern Well Surface Locations

Historical Cavern Extent | Top of Dome (-2000 ft Contour) | 09 - Active - Injection | 29 - Dry and Plugged

Change from Historical to Recent SNT Data

Velocity Contours	Acceleration Contours
Historical Velocity subtracted from Recent Velocity	Historical Acceleration subtracted from Recent Acceleration



-2.0 -1.5 -1.0 -0.5 0.0 +0.5 +1.0 Inches/year

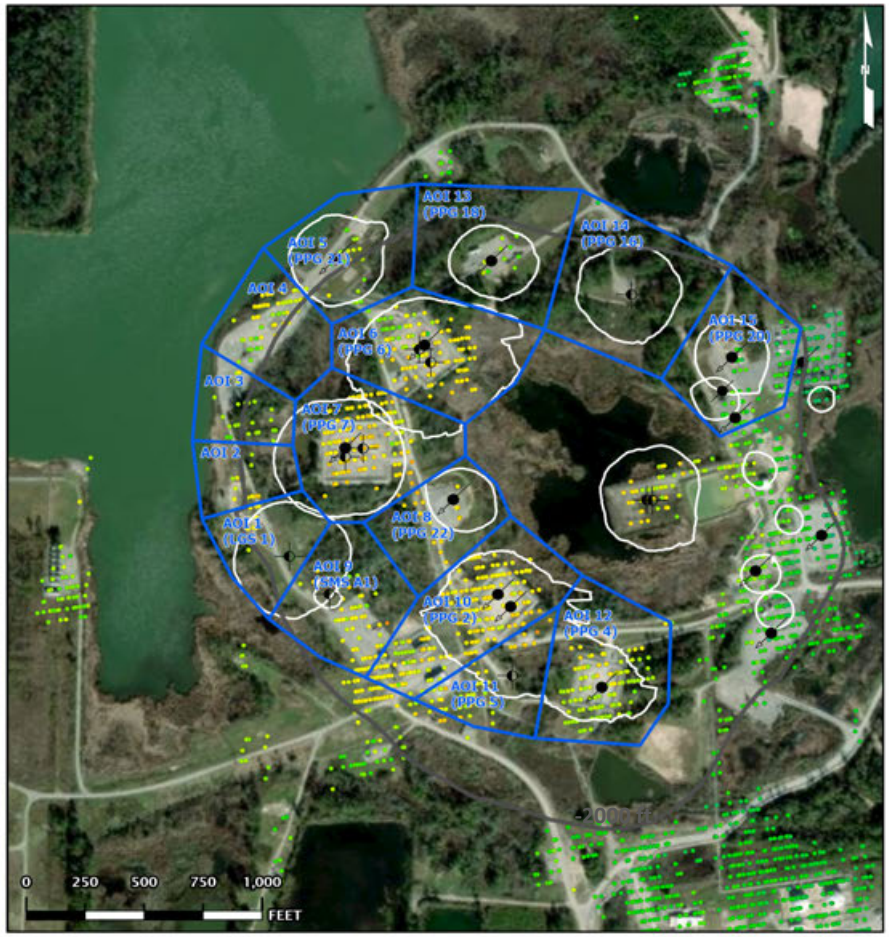
-1.0 -0.5 0.0 +0.5 +1.0 Inches/year^2

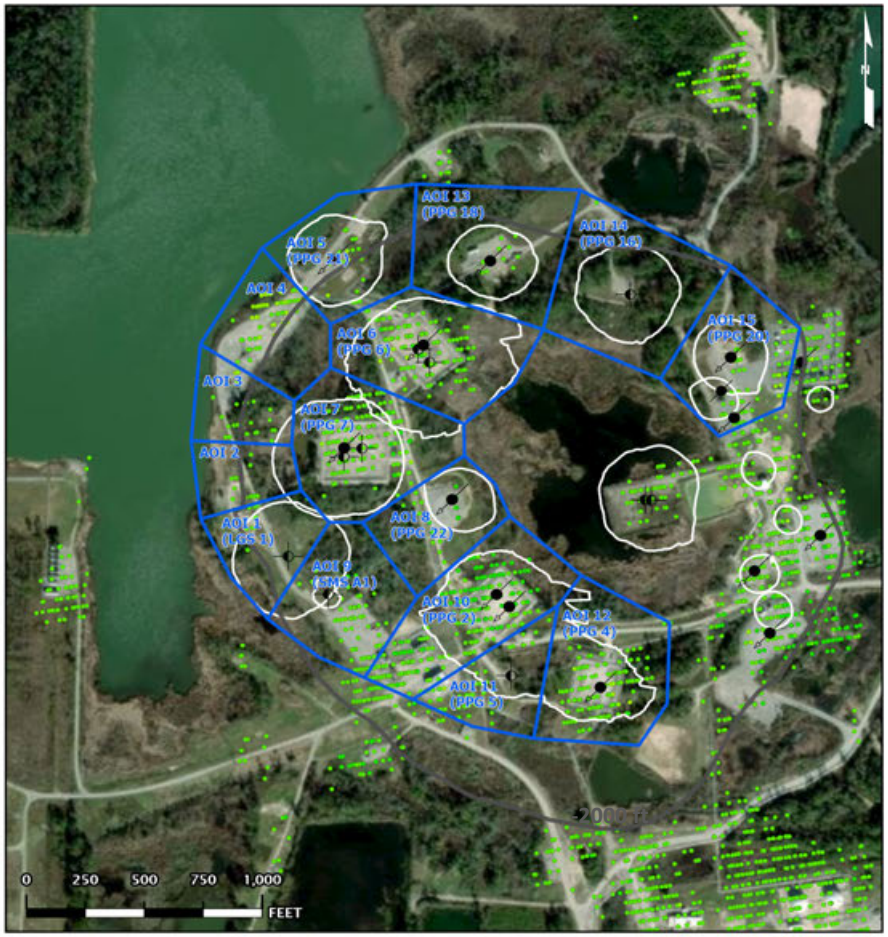
AOI Boundary | InSAR LOS Measurement Point | Contour (0.1) | Cavern Well Surface Locations

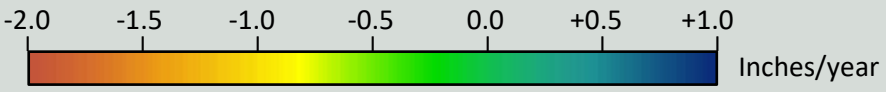
Historical Cavern Extent | Top of Dome (-2000 ft Contour) | 09 - Active - Injection | 29 - Dry and Plugged

Historical SNT Data (10/04/2016 - 11/28/2022)

Velocity Data Points	Acceleration Data Points
As of date: 11/28/2022	Date range: 10/04/2016 - 11/28/2022







AOI Boundary
InSAR LOS Measurement Point
Historical Cavern Extent
Top of Dome (-2000 ft Contour)

Cavern Well Surface Locations
09 - Active - Injection
29 - Dry and Plugged

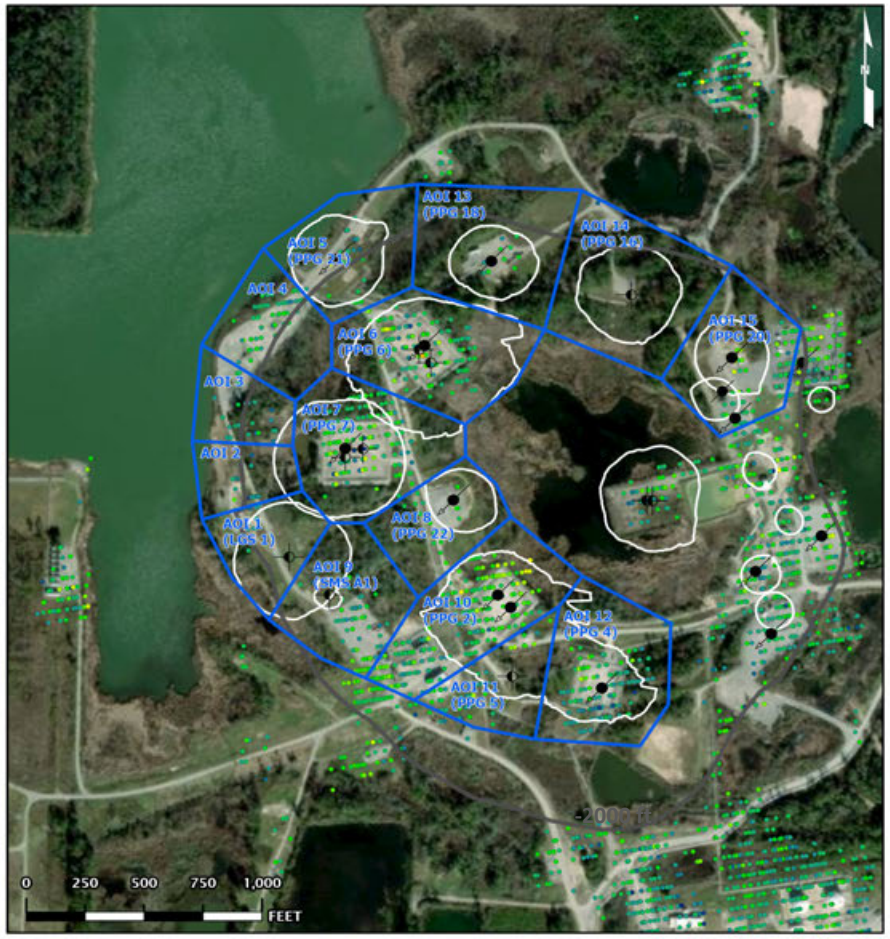
Recent SNT Data - 2 Years (11/28/2022 - 11/27/2024)

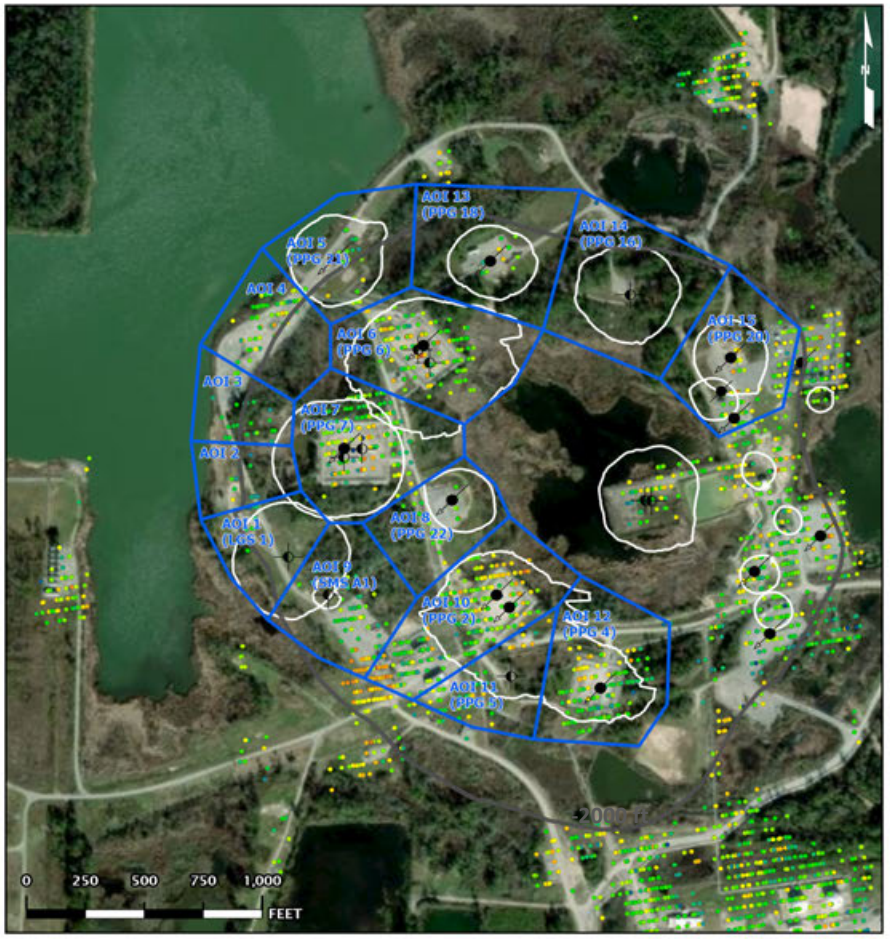
Velocity Data Points	Acceleration Data Points
As of date: 11/27/2024	Date range: 11/28/2022 - 11/27/2024

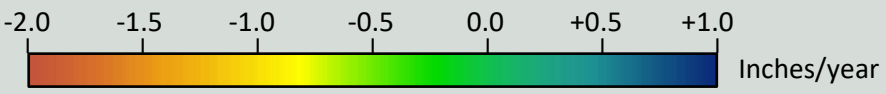
AOI Boundary
InSAR LOS Measurement Point
Historical Cavern Extent
Top of Dome (-2000 ft Contour)
Cavern Well Surface Locations
09 - Active - Injection
29 - Dry and Plugged

Change from Historical to Recent SNT Data

Velocity Data Points	Acceleration Data Points
Historical Velocity subtracted from Recent Velocity	Historical Acceleration subtracted from Recent Acceleration







AOI Boundary
InSAR LOS Measurement Point
Historical Cavern Extent
Top of Dome (-2000 ft Contour)

Cavern Well Surface Locations
09 - Active - Injection
29 - Dry and Plugged

ATTACHMENT C

TSX/PAZ InSAR report - November 29, 2024

TSX/PAZ Satellite Update

Continuous InSAR Monitoring of Ground Displacement At Westlake Caverns and Western Dome Flank

Sulphur Mines Salt Dome

Prepared for:
Westlake Chemical

Prepared by:
Lonquist & Co., LLC
8591 United Plaza Blvd.
Suite 280
Baton Rouge, LA 70809

Dataset
Satellite Source
TerraSAR-X - PAZ Constellation
Most Recent Image Date
Friday, November 29, 2024

Analysis Report Date:

December 5, 2024

Dataset Information

Satellite Source	TerraSAR-X - PAZ Constellation
Revisit Frequency	4 and 7 days
Most Recent Image Date	Friday, November 29, 2024
Dataset Image Count	119
Dataset Time Range	January 24, 2023 - November 29, 2024
Dataset Length	1.85 Years
Satellite Line-of-Sight (LOS)	37° East of Vertical (Viewing site from the East)

Analysis Methodology

Time Series Charts

Trend lines were calculated for the averaged displacement values within each AOI. Both a nonlinear (quadratic) and linear regression were applied to each AOI point group to identify rates of change in LOS displacement. These trends are displayed in the Time Series section of this report.

Contour Maps

A nonlinear (quadratic) and linear trend was also calculated for each individual measurement point across the analysis region. Nonlinear trend values for each point were used to generate Velocity and Acceleration contour maps to convey the spatial distribution of the calculated movement. The linear trend values for each point (which lack an acceleration component) were used to generate an additional Velocity contour map. Maps depicting the individual data points colored by these trend values are also included in the last section of the report.

Negative velocity values indicate subsidence or westward movement and positive velocity indicates uplift or eastward movement. Negative acceleration values indicate increasing rates of subsidence, increasing westward movement, or slowing eastward movement and positive acceleration values indicate slowing rates of subsidence, slowing westward movement, or increasing eastward movement.

Observations

To-date there have been no acute deviations from established subsidence trends in the areas investigated.

The timeframe of the dataset does not allow for comparison of recent to long-term LOS displacement rates. This dataset is primarily used to monitor for acute trend deviations and benefits from a higher measurement precision in individual readings than the SNT data.

Recent data has begun to indicate a negative acceleration of varying magnitudes across most of the AOI point groups evaluated. This is most evident in the trend acceleration values in the westernmost AOIs and in the mapped contours on the western side of AOI 2, AOI 3 and AOI 4. This suggests that marginal increases in subsidence rates may be occuring in this area of the dome. Seasonal effects are believed to contribute to fluctuations above and below the trend lines for each AOI and may play a significant role in the gradual changes that are being observed.

Date Signed: December 5, 2024
Austin, Texas

Nathaniel L. Byars, P.E.
Principal Engineer
Louisiana License No. 40697

InSAR Data Sources

InSAR Data

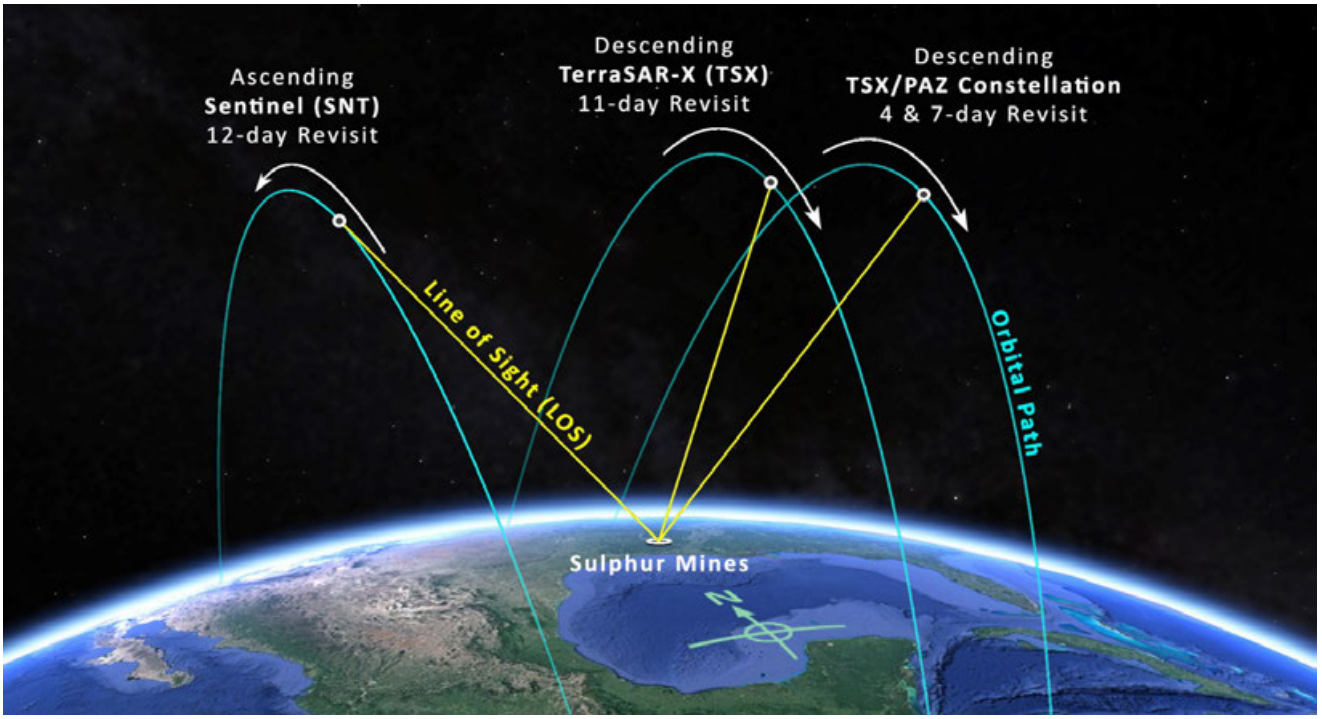
Interferometric Synthetic Aperture Radar (InSAR) is the most well established method to continually evaluate small, normally undetectable, ground movement over a large area. Radar imagery collected via satellites over successive orbital passes is used to identify and define measurement points on the ground. Objects or ground features providing a stable reflection of radar energy such as buildings, roads, and infrastructure produce the highest quality measurement points. InSAR analysis identifies the change in distance between the satellite and each measurement point over time relative to a stable reference point within the imaged area.

Satellite Sources

Two InSAR datasets are being used to evaluate subsidence over the Sulphur Mines Salt Dome. These datasets provide Line-of-Sight (LOS) displacment measurements from both ascending and descending orbits. An ascending orbit denotes the satellite's longitudinal course from south to north as it passes over the site, while a desceding orbit denotes the satellite is moving from north to south.

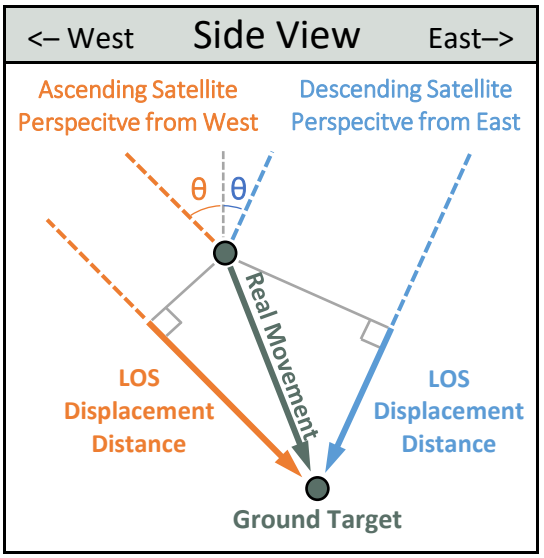
The first dataset comes from a low-resolution Sentinel-1 (SNT) satellite on an ascending orbit that captures data from the west of the site on a 12-day frequency. The second comes from a pair of high resolution satellites that share the same descending orbit and capture data from east of the site. These are a TSX satellite and the PAZ satellite (TSX/PAZ constellation), both with an 11-day revisit frequency. Their orbits are offset with the PAZ satellite passing over the site 4 days after the TSX satellite. Prior to May 2023, data was captured from a different high-resolution TerraSAR-X (TSX) satellite on a descending orbit that captured data from the east of the site on an 11-day frequency. The transition was made for the increased data frequency that resulted from a 4 and 7-day revisit period. The image below depicts the orbital paths of the satellites in relation to the Sulphur Mines Salt Dome.

Satellite Orbital Diagram



InSAR Line-of-Site (LOS) Data

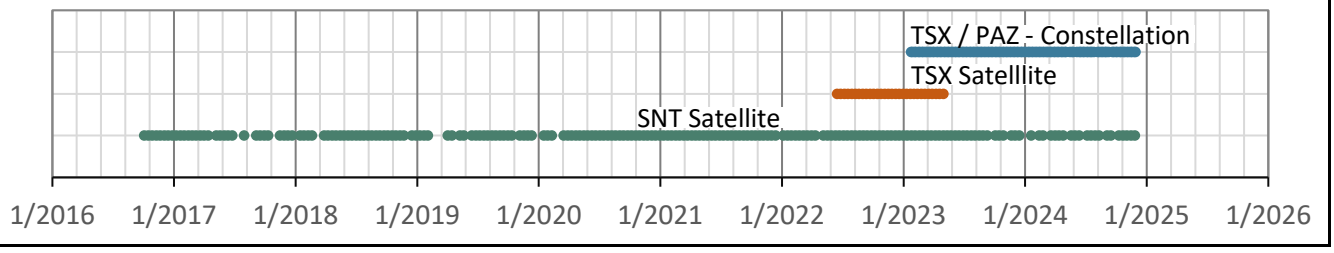
LOS displacement measurements refer to a change in distance between the satellite sensor and the ground target. Measurement positions on the west side of the Sulphur Dome are are known to be experiencing some eastward movement toward the dome center due to the geometry of the subsidence basin. The InSAR satellites view the site from eastward and westward positions so LOS measurements are understood to convey a movement distance that is not purely vertical. The diagram to the right illustrates the geometric relationship between the theoretical Real movement of a ground target and LOS displacement measurements from two different satellite viewing directions.



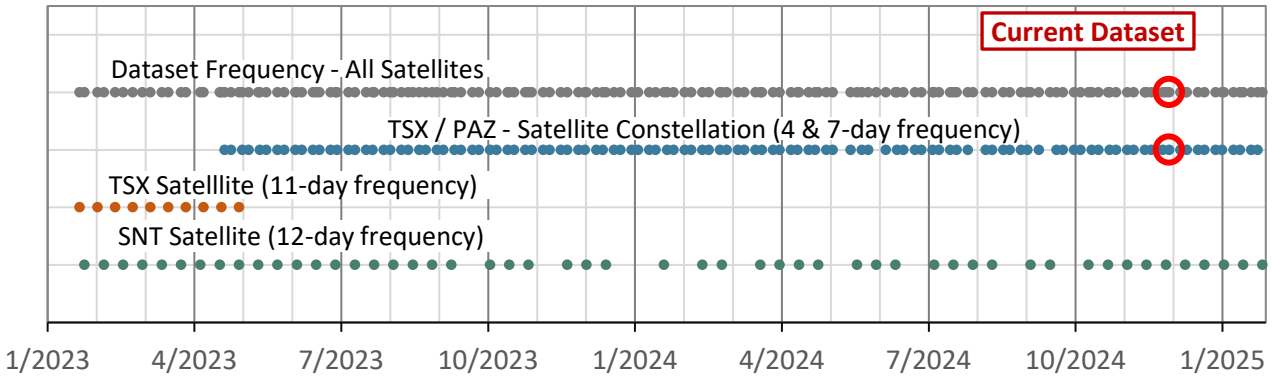
Satellite Properties & Image Frequency

Satellite and Data Properties	SNT	TSX	TSX/PAZ Constellation
Band (Wavelength)	C-band (2.20 in)	X-band (1.22 in)	X-band (1.22 in)
Track	T136	T29	T67 & T120
Pixel resolution	65 x 16 ft	3 x 3 ft	3 x 3 ft
Revisit frequency	12 days	11 days	4 & 7 days
Orbit (LOS Angle, θ)	Ascending (43°)	Descending (17°)	Descending (37°)
Data Start Date	10/4/2016	6/16/2022	1/24/2023
Measurement error range	± 0.20 in	± 0.03 in	± 0.03 in

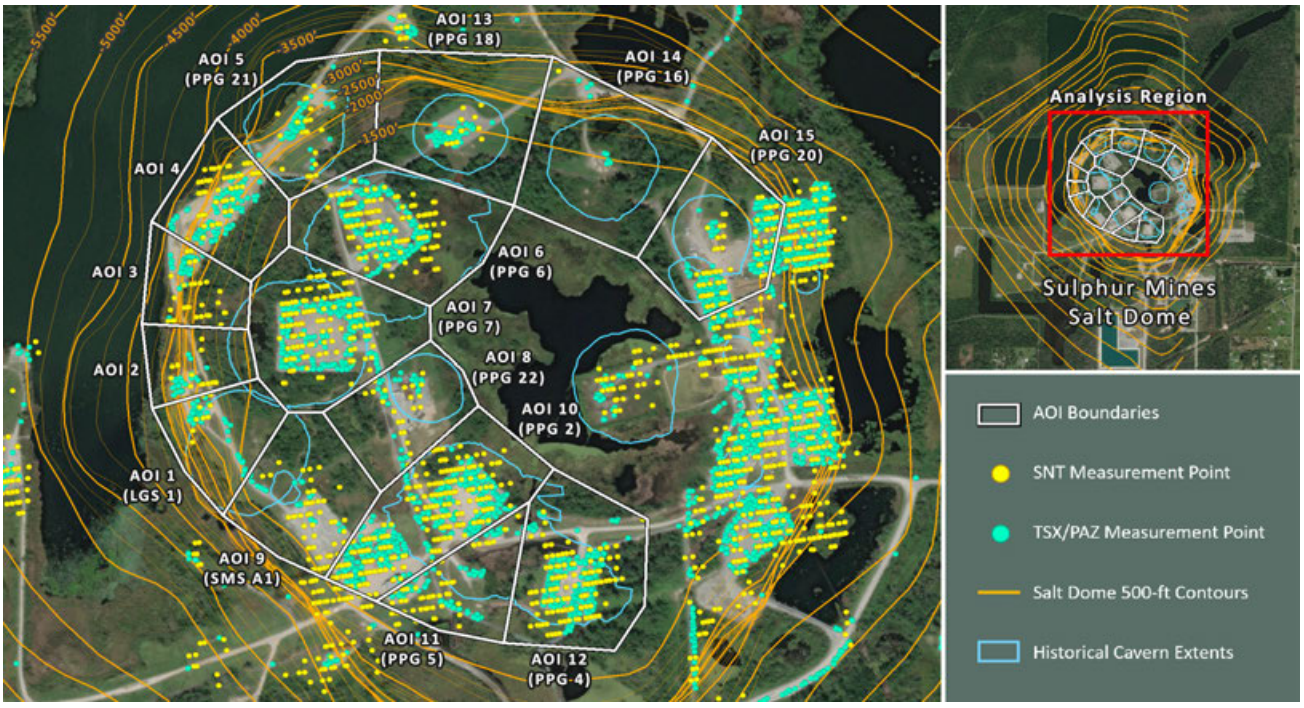
Dataset Measurement History



Dataset Update Frequency



AOI Boundaries & InSAR Measurement Points

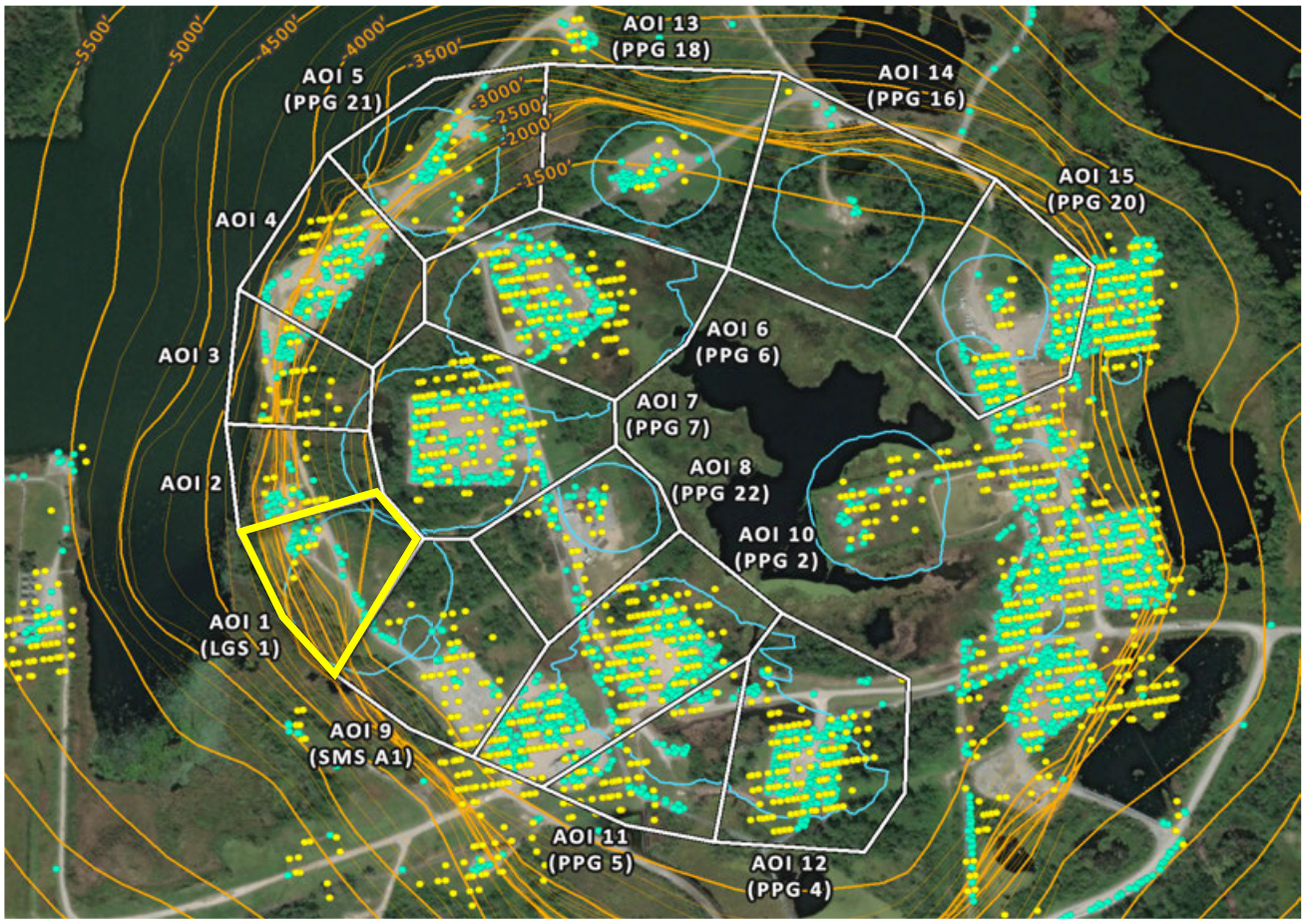


Subsidence Monitoring Areas of Interest (AOIs)

To visually convey and evaluate trend consistency for the displacement time series of each ground target, measurment points were grouped and their displacement values were averaged. The point groups are referred to as Areas of Interest (AOIs) in this analysis and their boundaries are depicted on the above map. The below table lists the trend values calculated in each AOI for the dataset evaluated in this report.

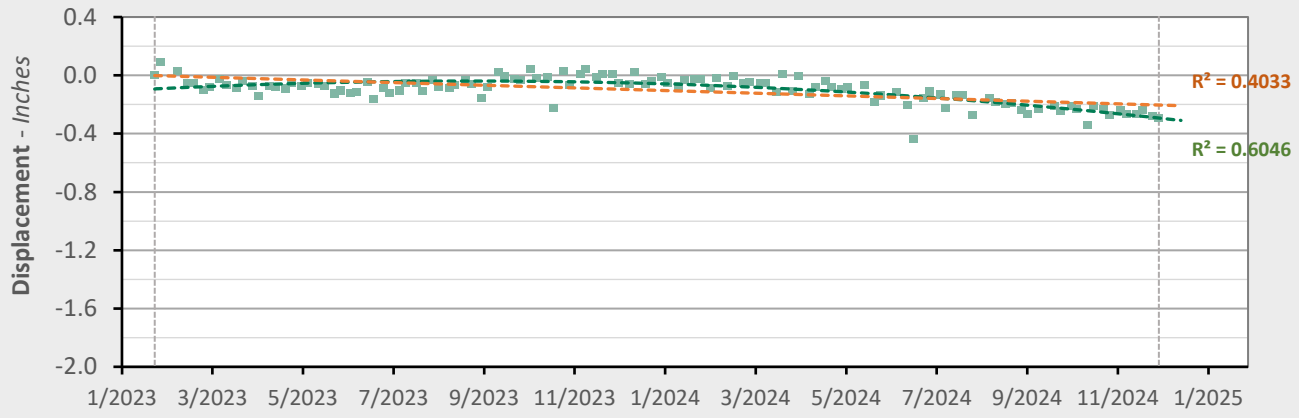
AOI Name	TSX/PAZ (11/29/2024)	LOS Velocity (in/yr)		LOS Acceleration (in/yr²)	
	Point Count	Nonlinear	Linear	Nonlinear	Linear
AOI 1 *(LGS 1)*	42	-0.40	-0.11	-0.32	0.00
AOI 2	24	-0.51	-0.12	-0.43	0.00
AOI 3	40	-0.37	-0.07	-0.33	0.00
AOI 4	102	-0.37	-0.04	-0.36	0.00
AOI 5 *(PPG 21)*	47	-0.32	-0.20	-0.13	0.00
AOI 6 *(PPG 6)*	212	-0.75	-0.48	-0.30	0.00
AOI 7 *(PPG 7)*	216	-0.60	-0.34	-0.29	0.00
AOI 8 *(PPG 22)*	36	-0.81	-0.62	-0.20	0.00
AOI 9 *(SMS A1)*	23	-0.38	-0.28	-0.11	0.00
AOI 10 *(PPG 2)*	403	-0.80	-0.59	-0.22	0.00
AOI 11 *(PPG 5)*	85	-0.80	-0.53	-0.30	0.00
AOI 12 *(PPG 4)*	262	-1.07	-0.87	-0.22	0.00
AOI 13 *(PPG 18)*	52	-0.72	-0.48	-0.26	0.00
AOI 14 *(PPG 16)*	11	-0.59	-0.65	+0.07	0.00
AOI 15 *(PPG 20)*	227	-1.16	-1.00	-0.17	0.00

AOI 1 *(LGS 1)* - Location Map



AOI 1 *(LGS 1)* - Displacement Time Series

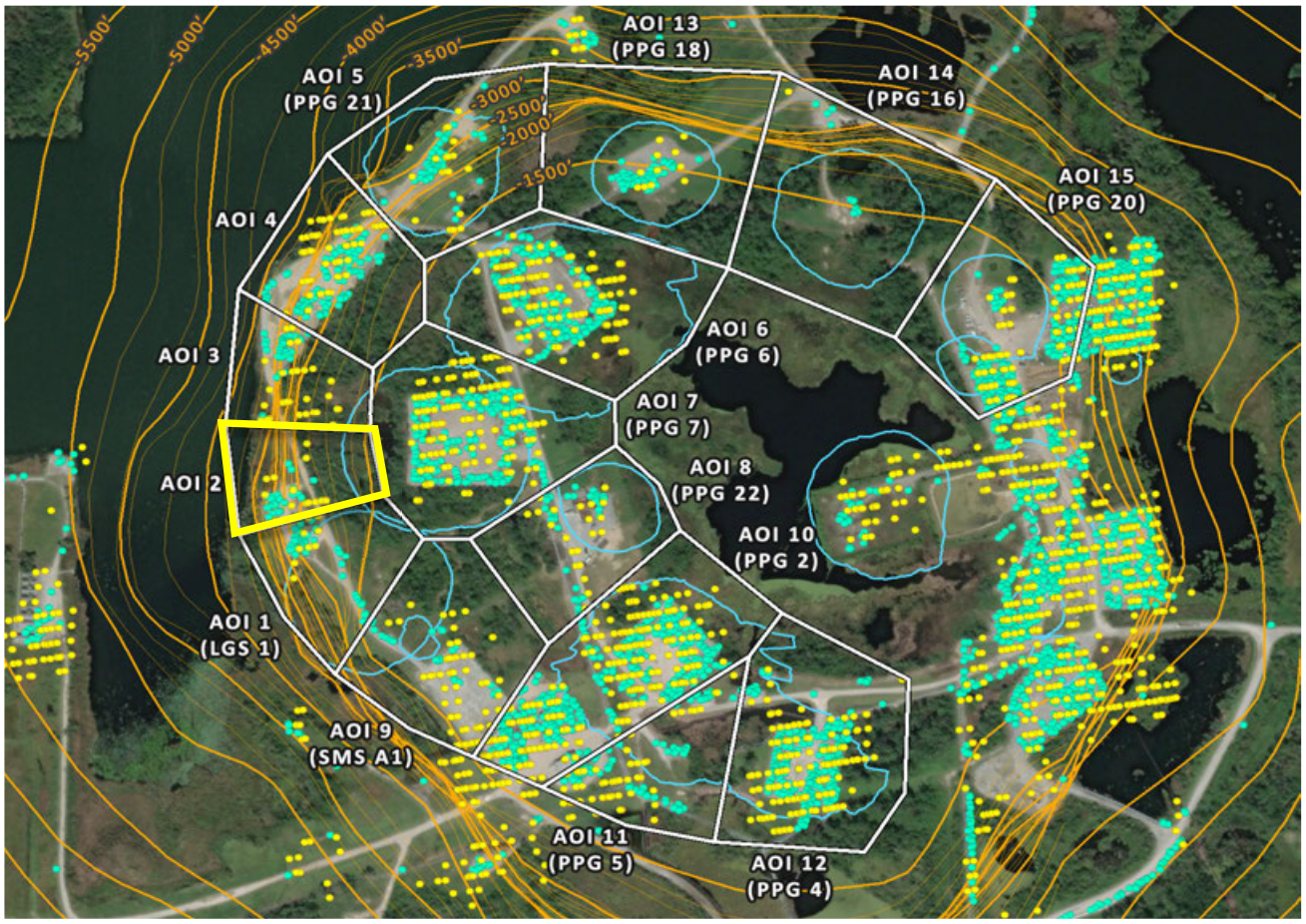
TSX/PAZ (11/29/2024) Point Count: **42**



	Nonlinear Trend	Linear Trend
Velocity:	-0.40 in/yr	-0.11 in/yr
Acceleration:	-0.32 in/yr^2	0.00 in/yr^2

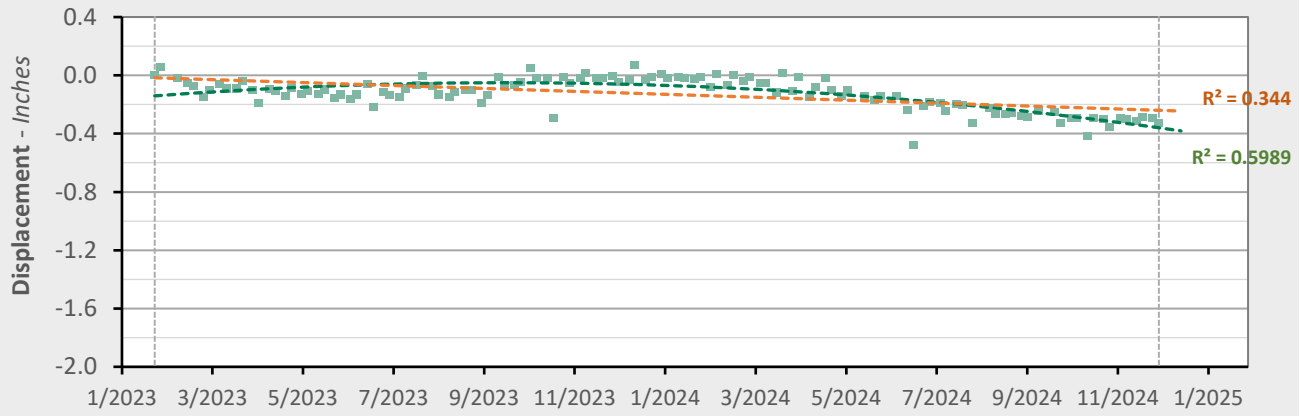
LOS Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 2 - Location Map



AOI 2 - Displacement Time Series

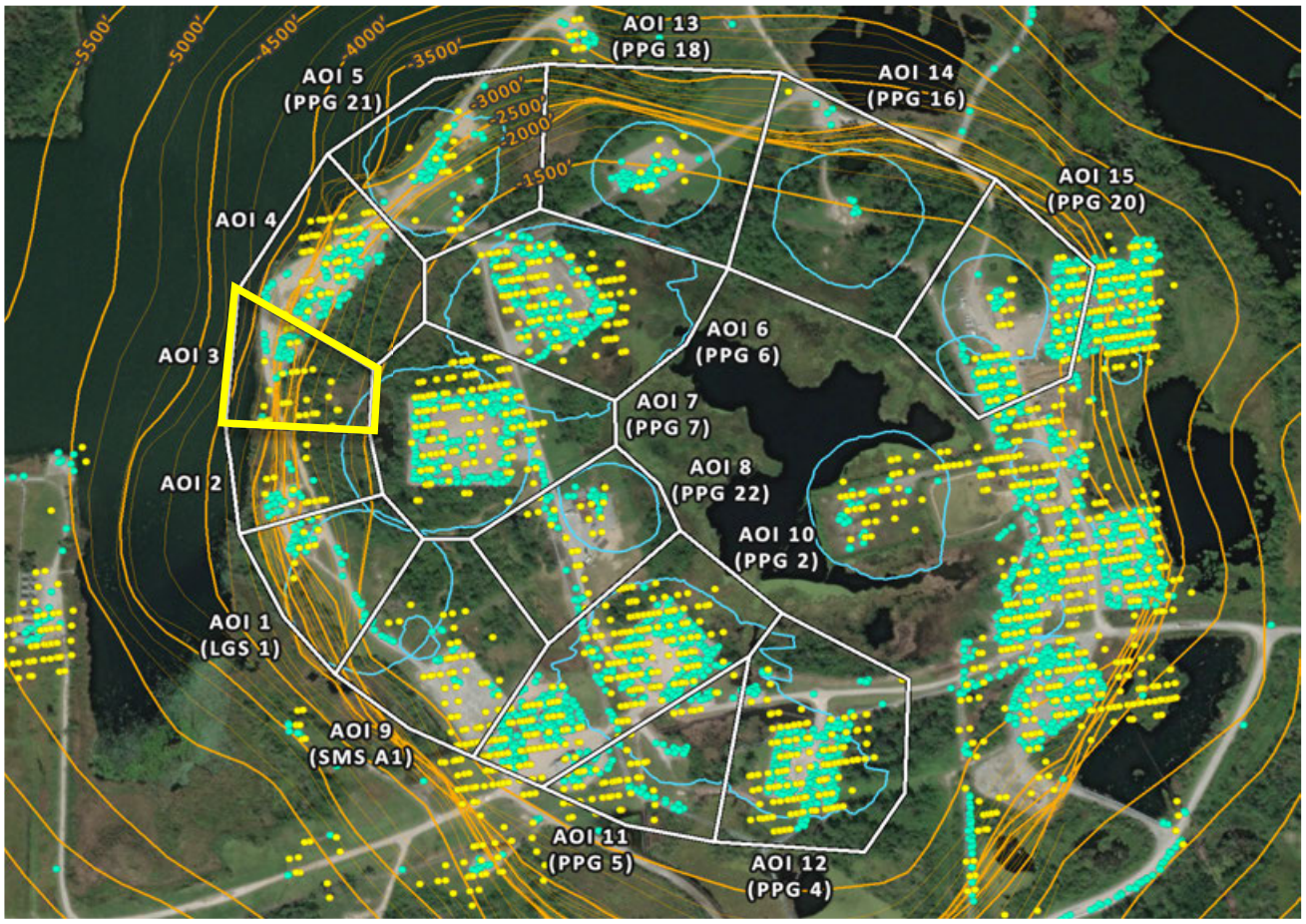
TSX/PAZ (11/29/2024) Point Count: **24**



	Nonlinear Trend	Linear Trend
Velocity:	-0.51 in/yr	-0.12 in/yr
Acceleration:	-0.43 in/yr^2	0.00 in/yr^2

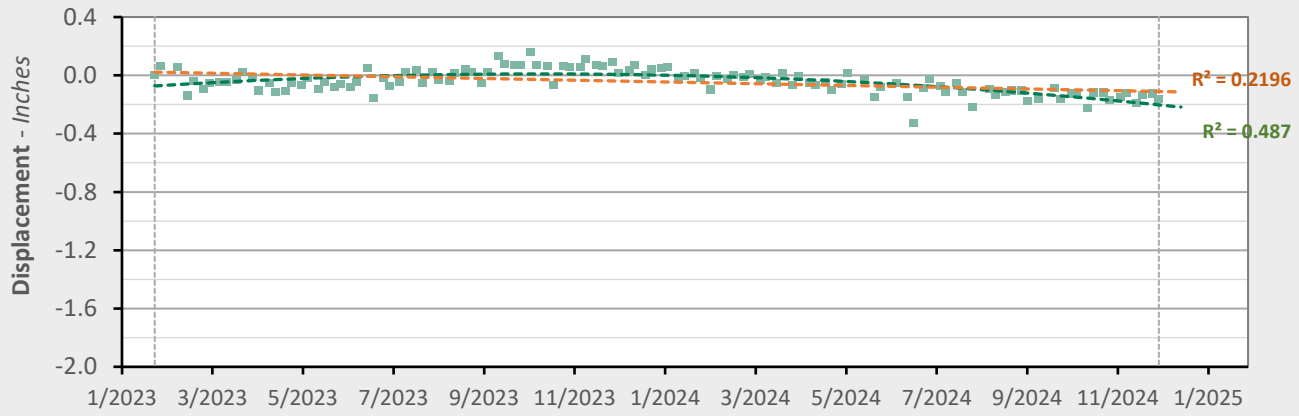
LOS Displacement Measurement | Nonlinear Trend Line (Quadratic Regression) | Linear Trend Line (Linear Regression)

AOI 3 - Location Map



AOI 3 - Displacement Time Series

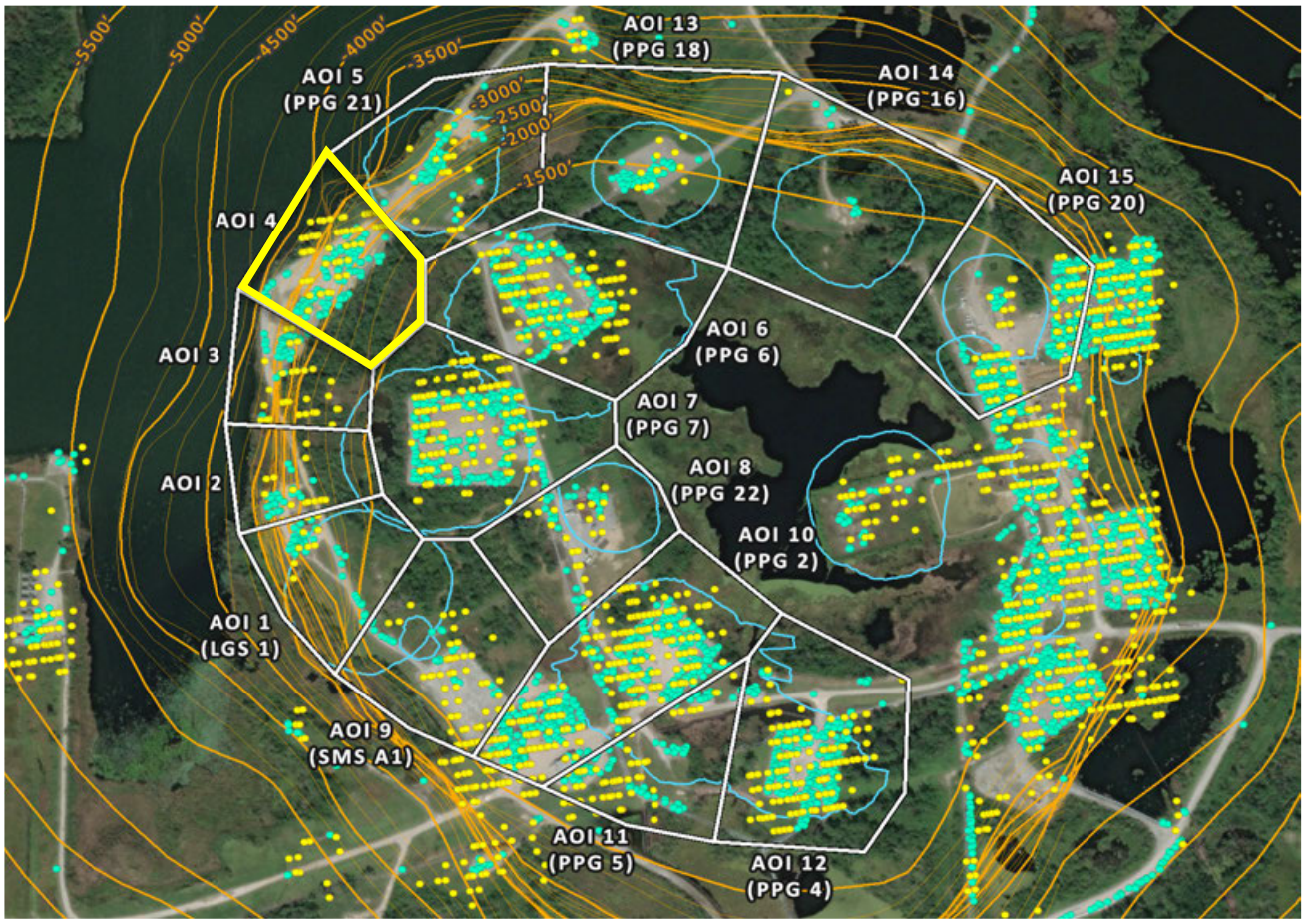
TSX/PAZ (11/29/2024) Point Count: **40**



	Nonlinear Trend	Linear Trend
Velocity:	-0.37 in/yr	-0.07 in/yr
Acceleration:	-0.33 in/yr^2	0.00 in/yr^2

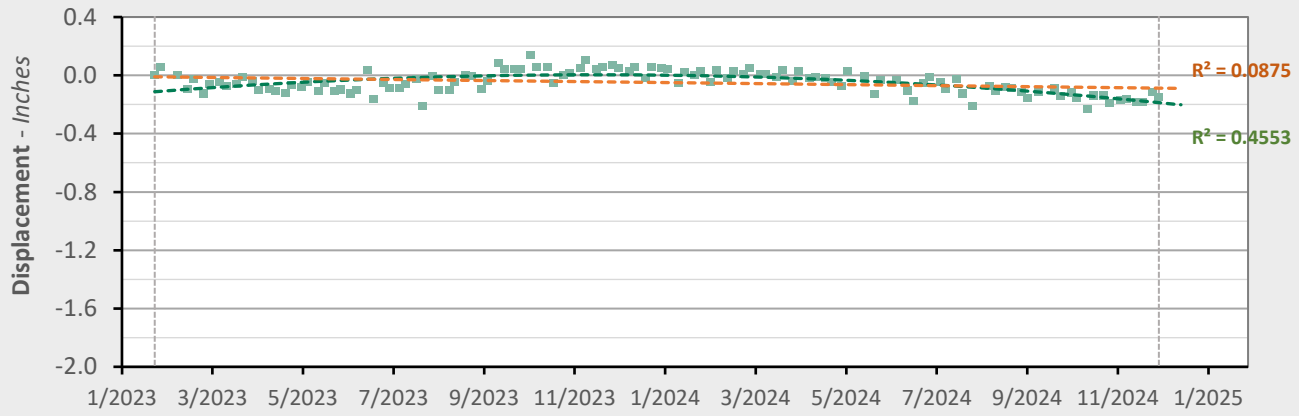
LOS Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 4 - Location Map



AOI 4 - Displacement Time Series

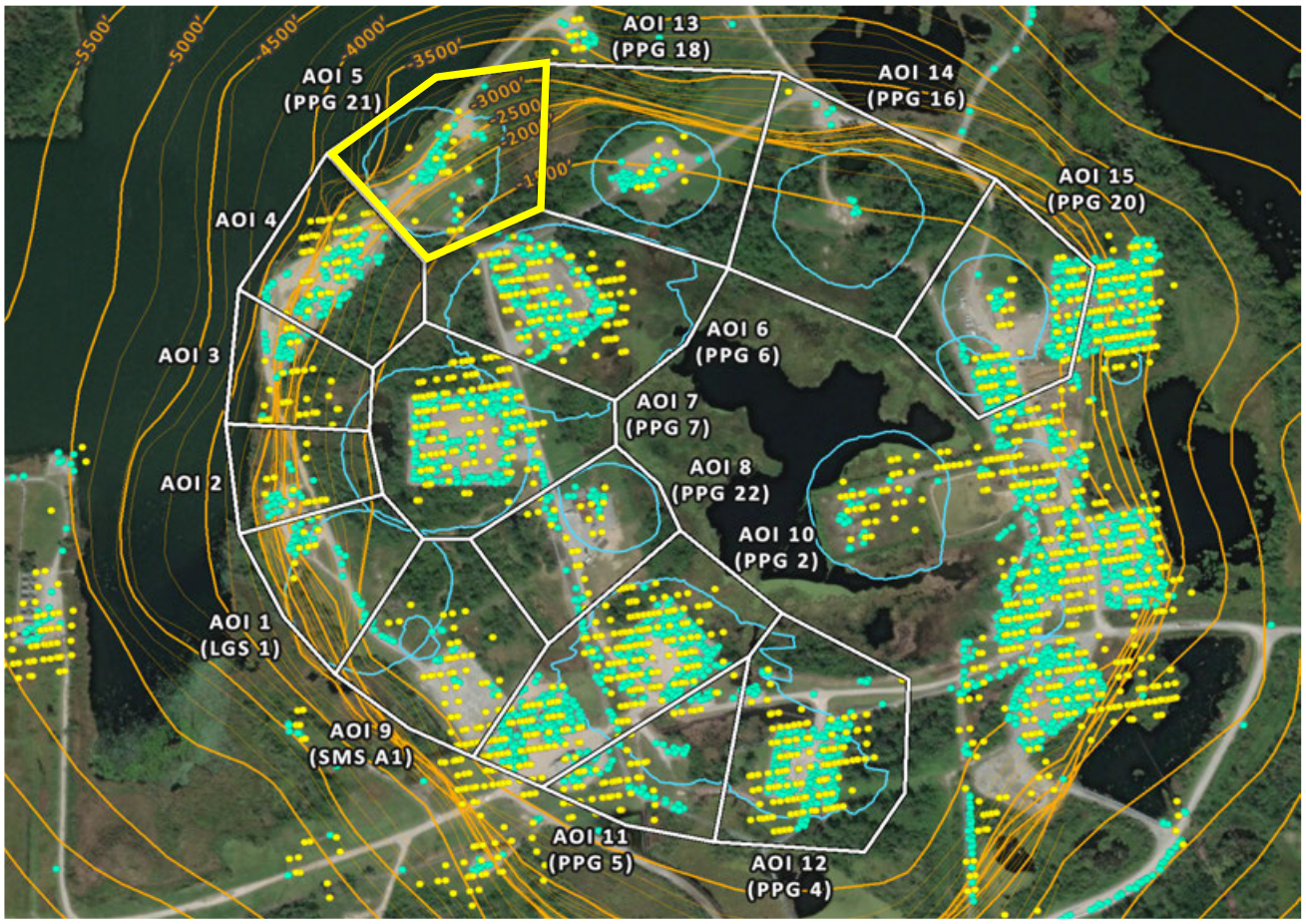
TSX/PAZ (11/29/2024) Point Count: **102**



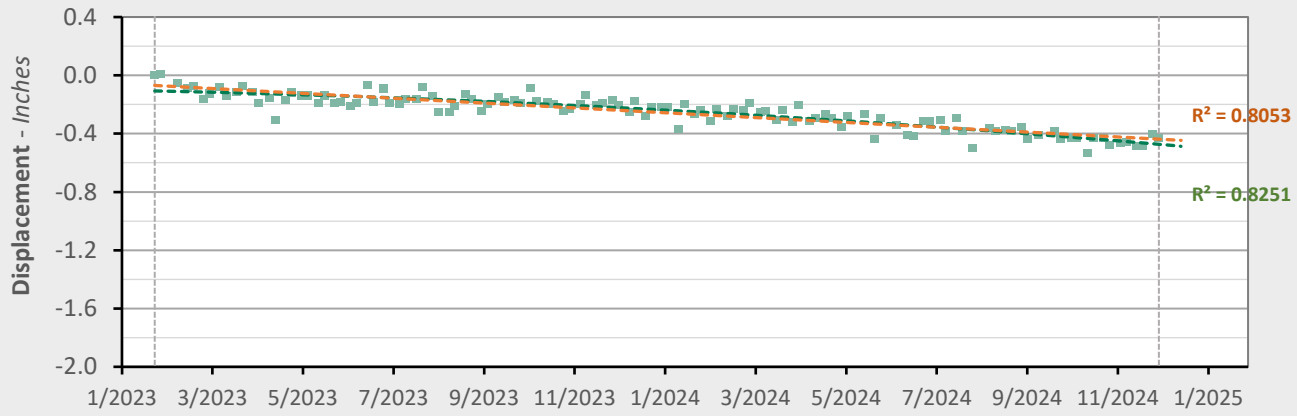
	Nonlinear Trend	Linear Trend
Velocity:	-0.37 in/yr	-0.04 in/yr
Acceleration:	-0.36 in/yr²	0.00 in/yr²

LOS Displacement Measurement | Nonlinear Trend Line (Quadratic Regression) | Linear Trend Line (Linear Regression)

AOI 5 *(PPG 21)* - Location Map



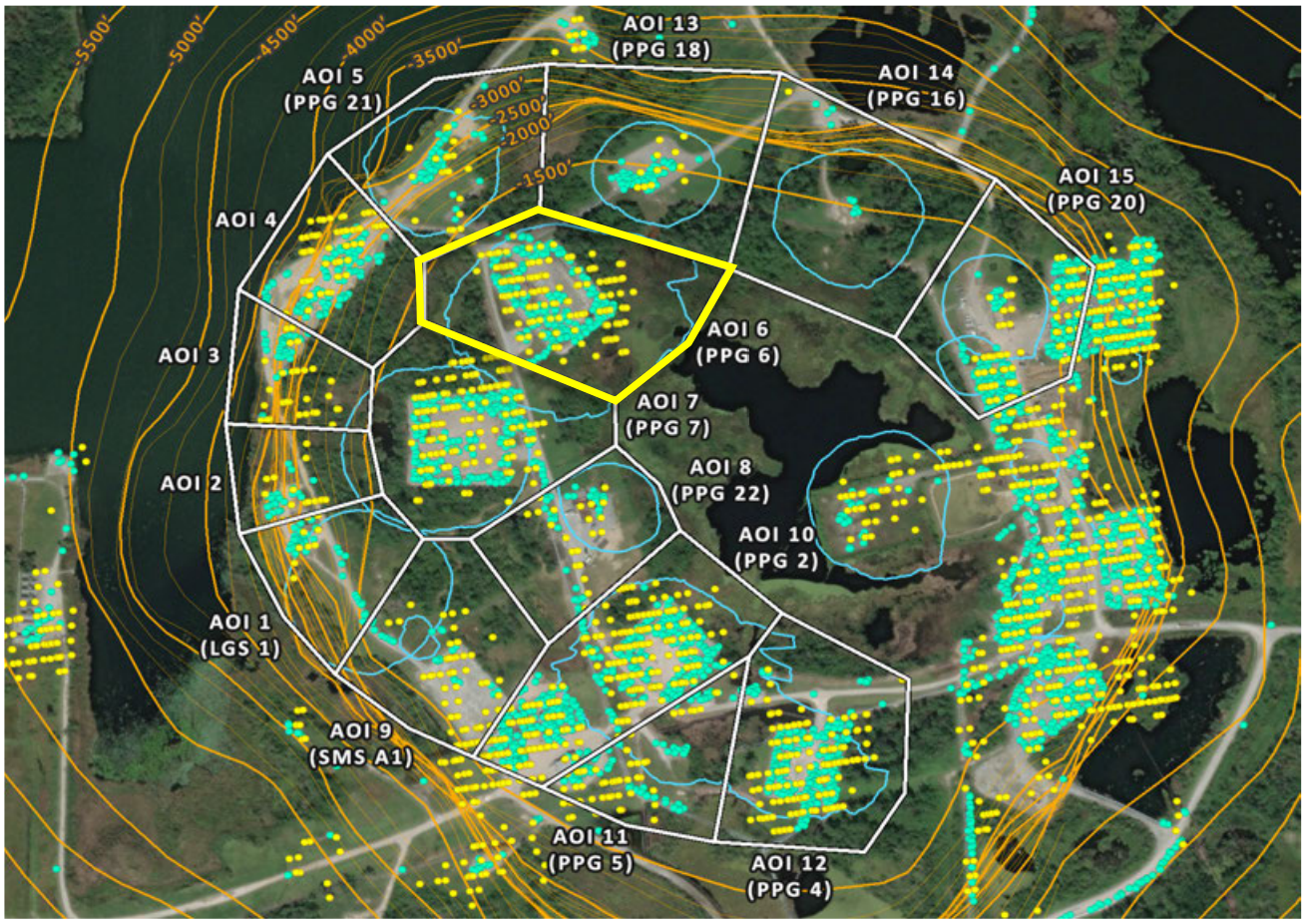
AOI 5 *(PPG 21)* - Displacement Time Series TSX/PAZ (11/29/2024) Point Count: 47



	Nonlinear Trend	Linear Trend
Velocity:	-0.32 in/yr	-0.20 in/yr
Acceleration:	-0.13 in/yr^2	0.00 in/yr^2

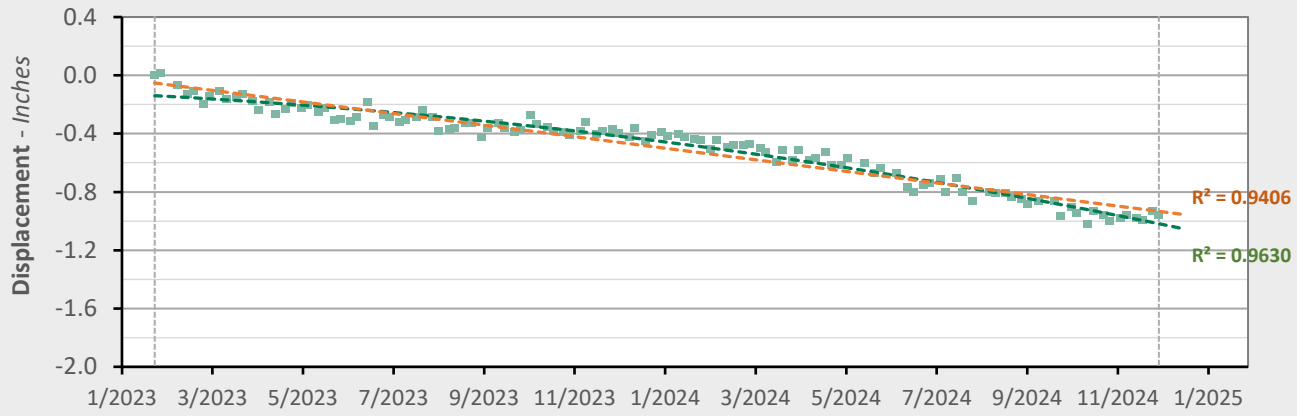
LOS Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 6 *(PPG 6)* - Location Map



AOI 6 *(PPG 6)* - Displacement Time Series

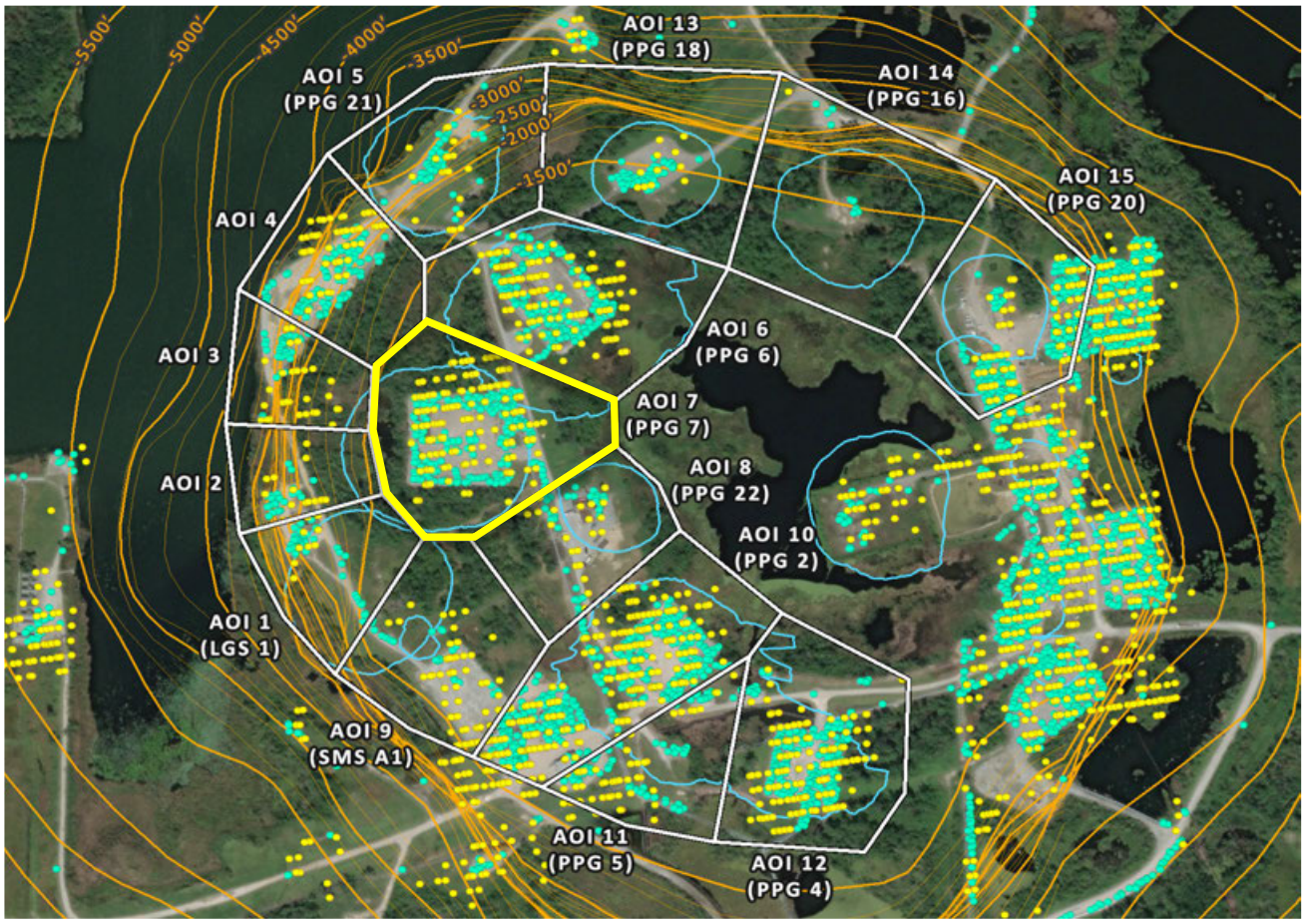
TSX/PAZ (11/29/2024) Point Count: **212**



	Nonlinear Trend	Linear Trend
Velocity:	-0.75 in/yr	-0.48 in/yr
Acceleration:	-0.30 in/yr^2	0.00 in/yr^2

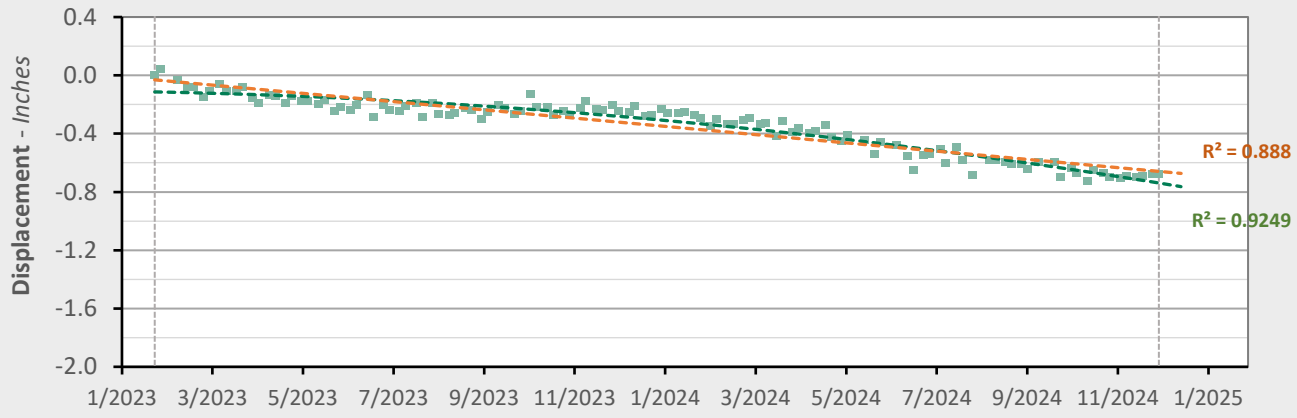
LOS Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 7 *(PPG 7)* - Location Map



AOI 7 *(PPG 7)* - Displacement Time Series

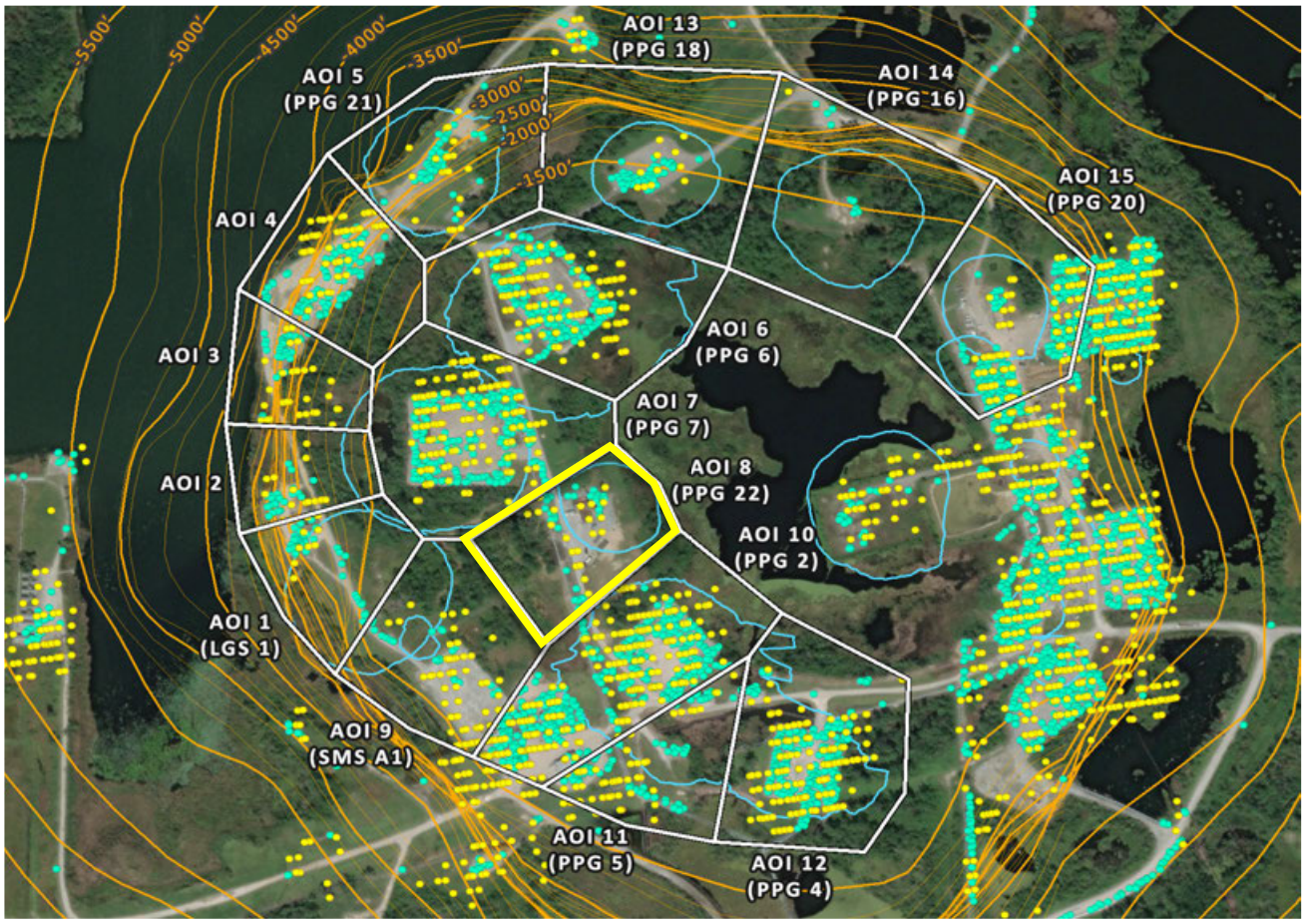
TSX/PAZ (11/29/2024) Point Count: **216**



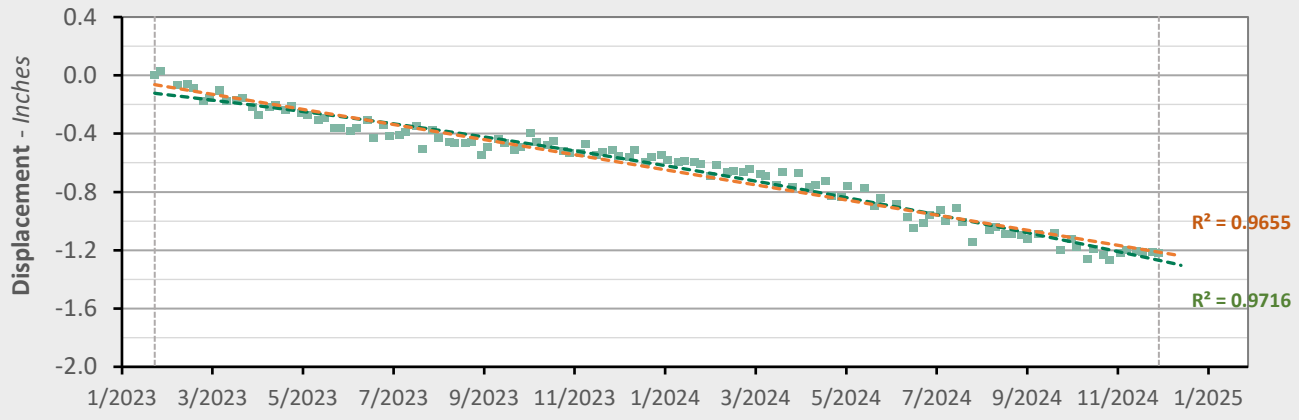
	Nonlinear Trend	Linear Trend
Velocity:	-0.60 in/yr	-0.34 in/yr
Acceleration:	-0.29 in/yr^2	0.00 in/yr^2

LOS Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 8 *(PPG 22)* - Location Map



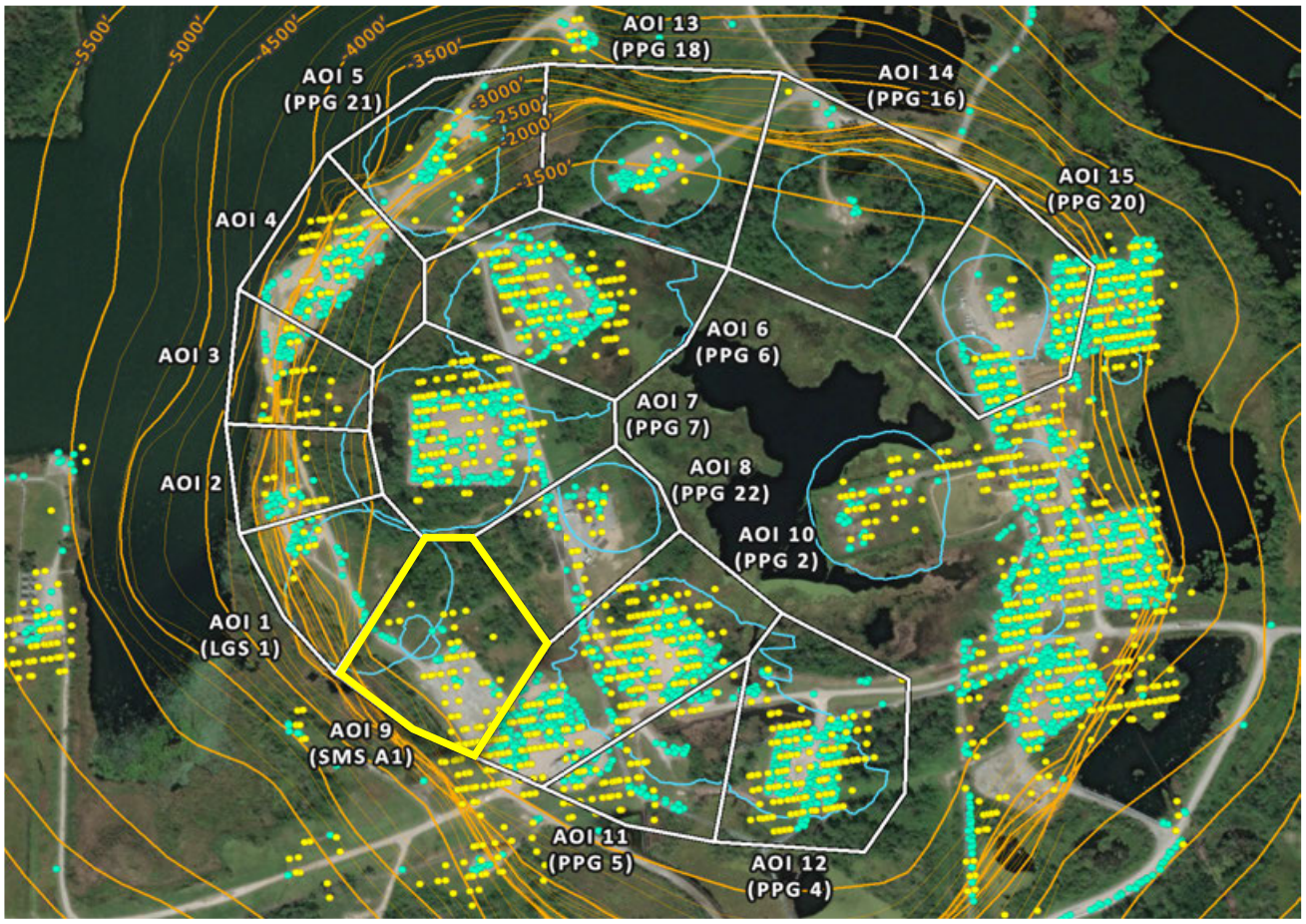
AOI 8 *(PPG 22)* - Displacement Time Series TSX/PAZ (11/29/2024) Point Count: 36



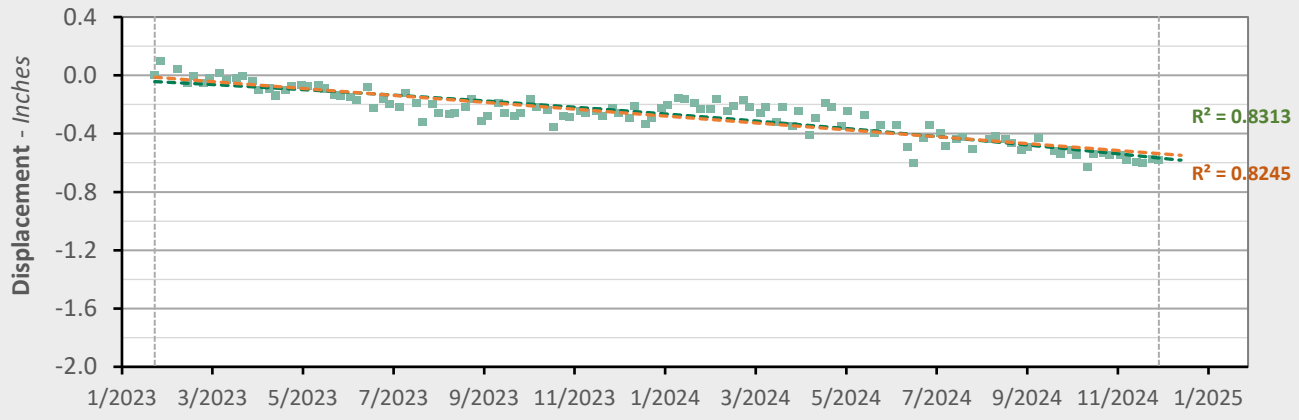
	Nonlinear Trend	Linear Trend
Velocity:	-0.81 in/yr	-0.62 in/yr
Acceleration:	-0.20 in/yr^2	0.00 in/yr^2

LOS Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 9 *(PPG A1)* - Location Map



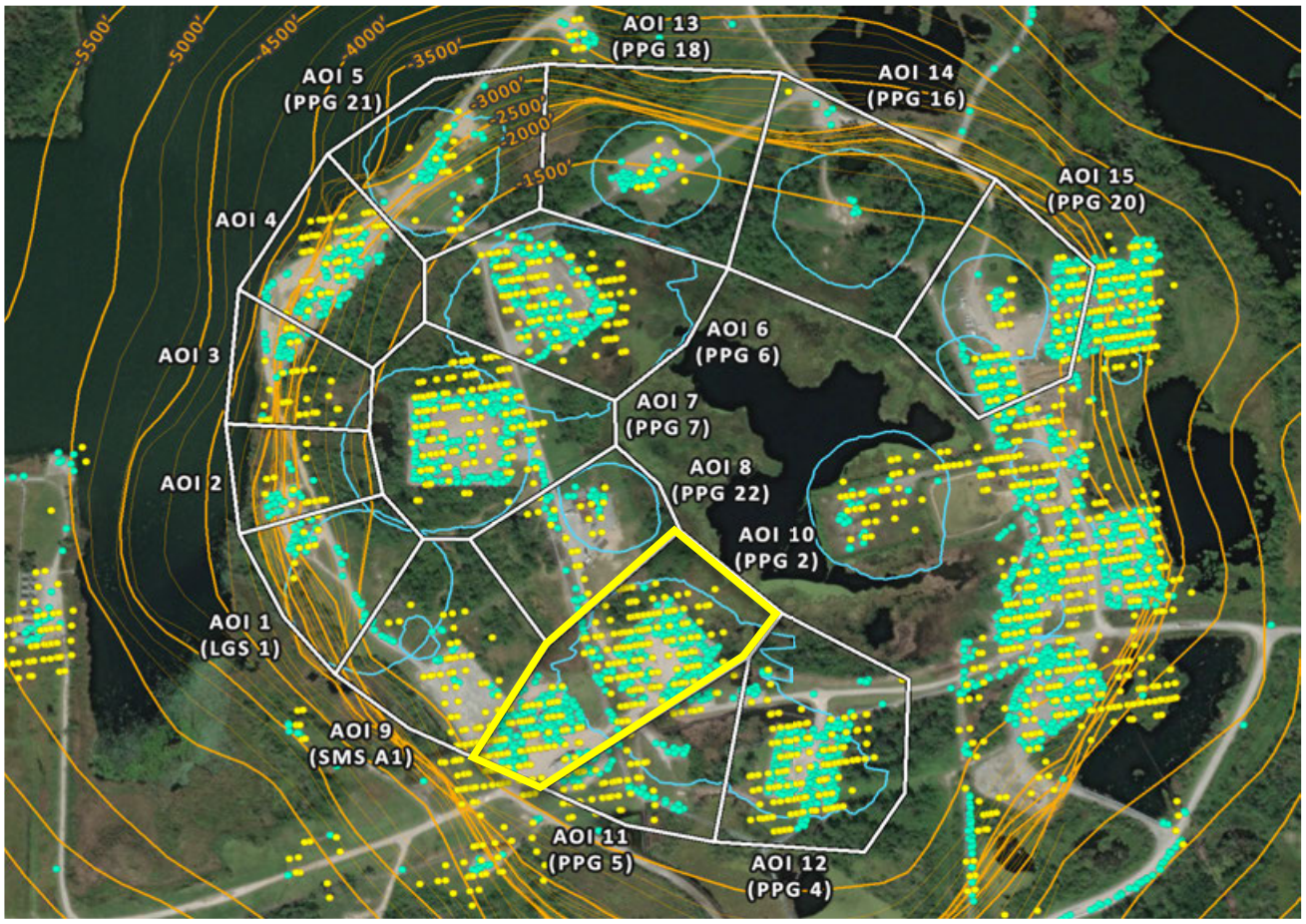
AOI 9 *(SMS A1)* - Displacement Time Series TSX/PAZ (11/29/2024) Point Count: 23



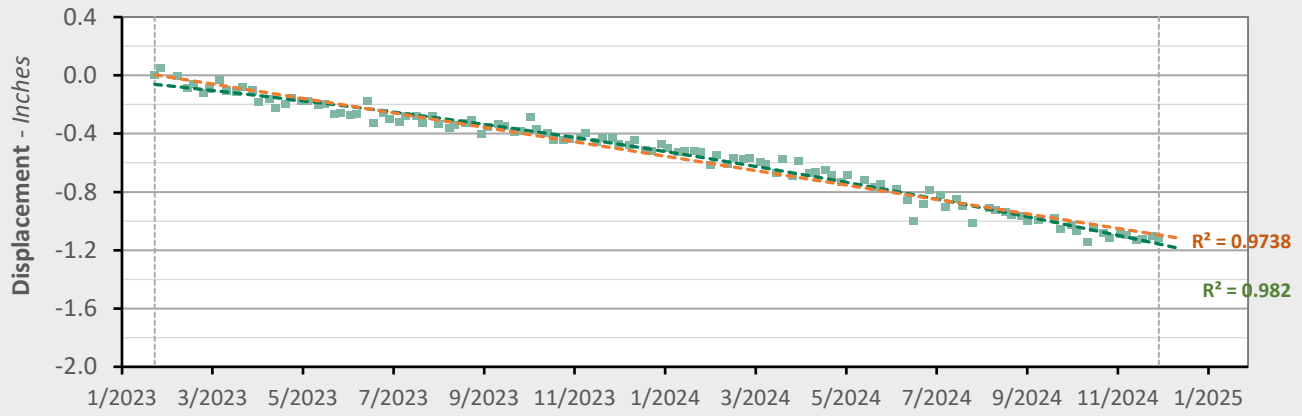
	Nonlinear Trend	Linear Trend
Velocity:	-0.38 in/yr	-0.28 in/yr
Acceleration:	-0.11 in/yr^2	0.00 in/yr^2

LOS Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 10 *(PPG 2)* - Location Map



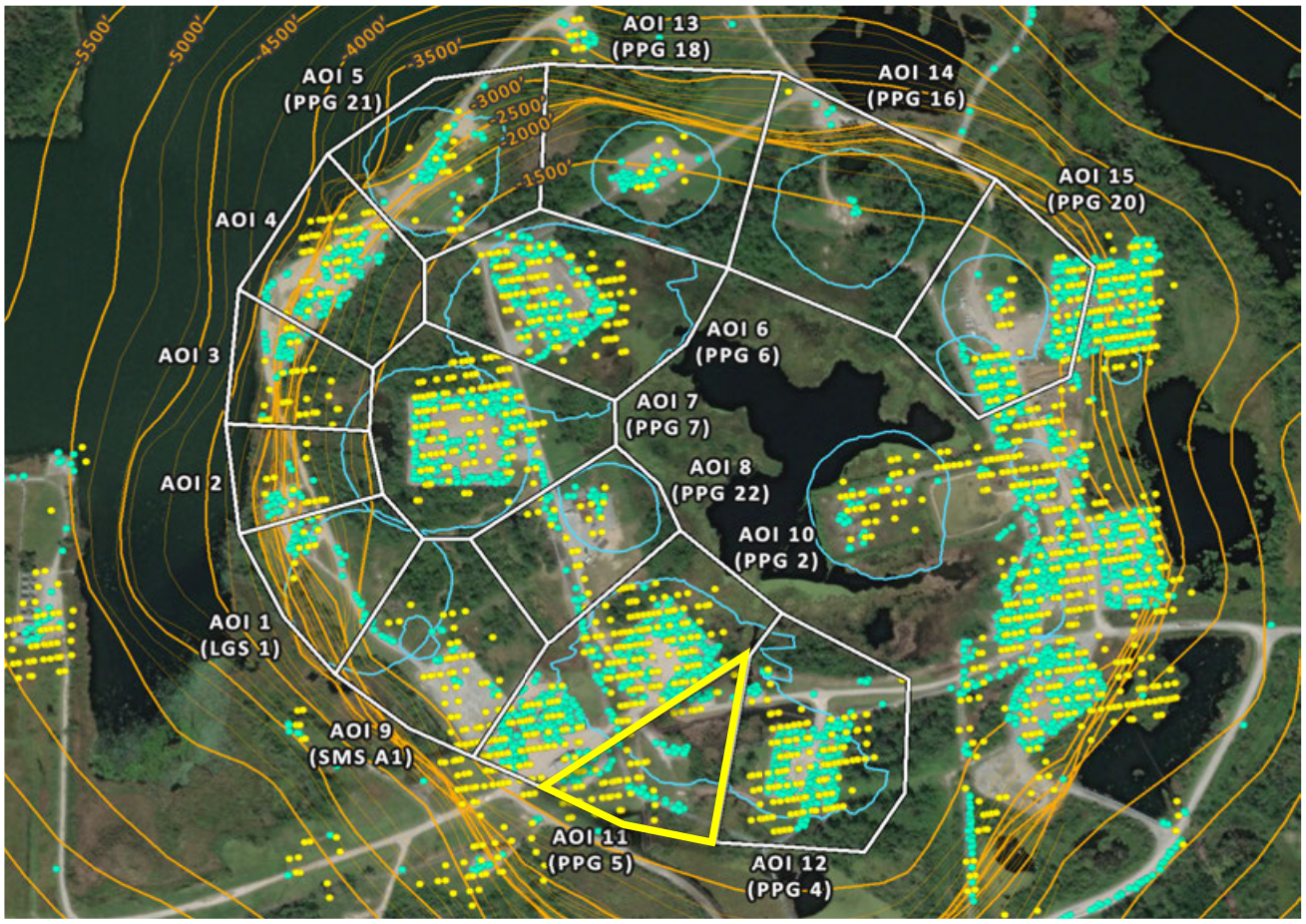
AOI 10 *(PPG 2)* - Displacement Time Series TSX/PAZ (11/29/2024) Point Count: 403



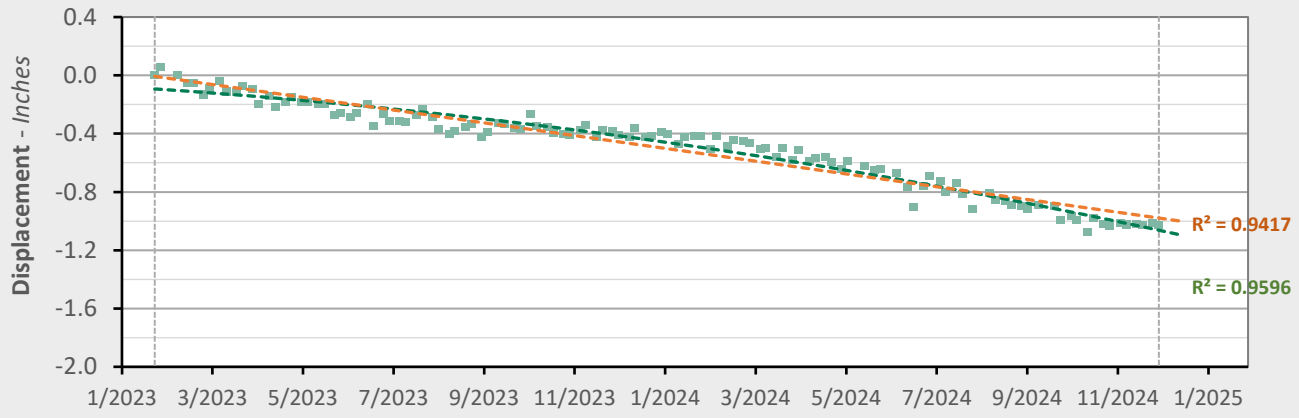
	Nonlinear Trend	Linear Trend
Velocity:	-0.80 in/yr	-0.59 in/yr
Acceleration:	-0.22 in/yr^2	0.00 in/yr^2

LOS Displacement Measurement | Nonlinear Trend Line (Quadratic Regression) | Linear Trend Line (Linear Regression)

AOI 11 *(PPG 5)* - Location Map



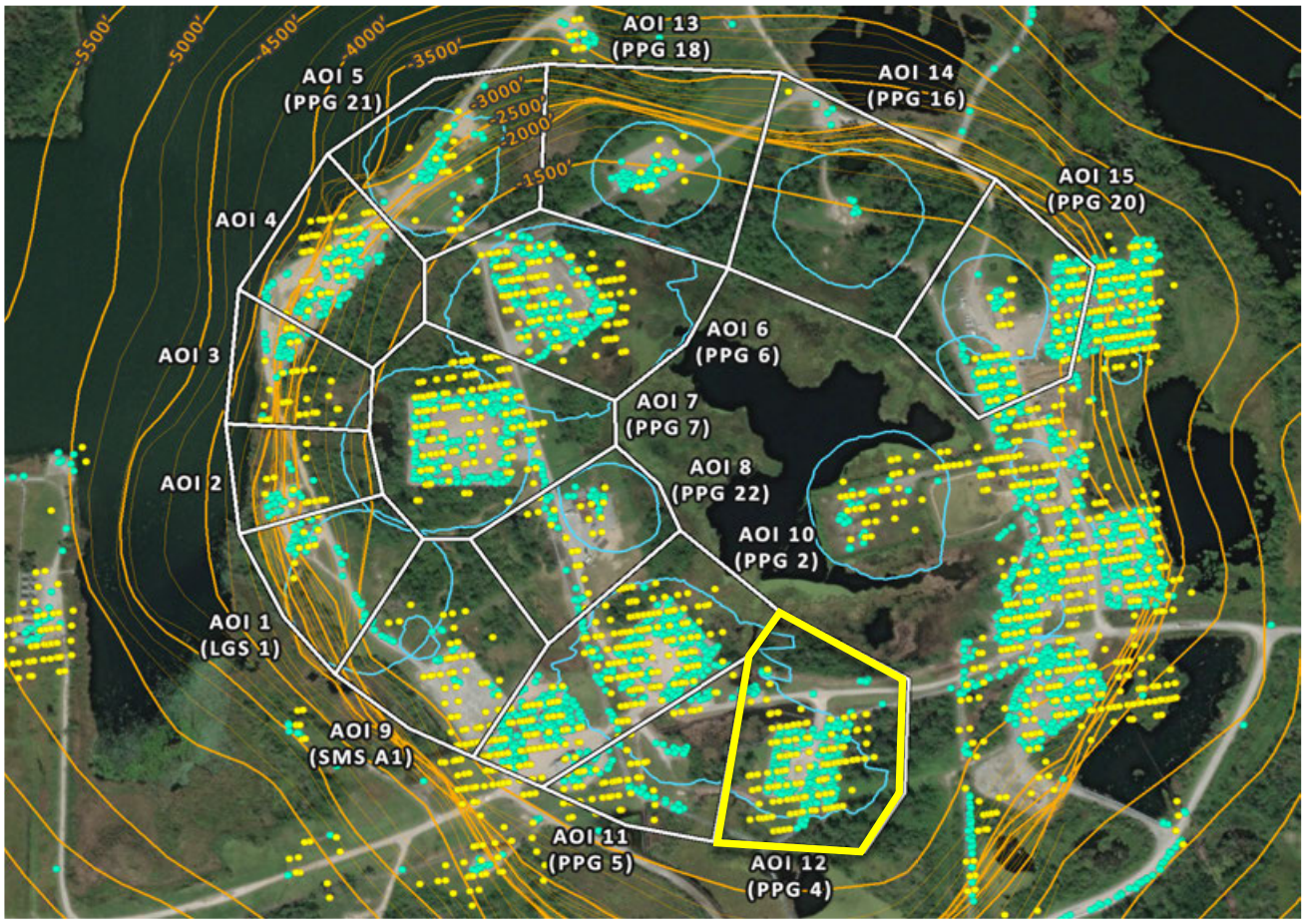
AOI 11 *(PPG 5)* - Displacement Time Series TSX/PAZ (11/29/2024) Point Count: 85



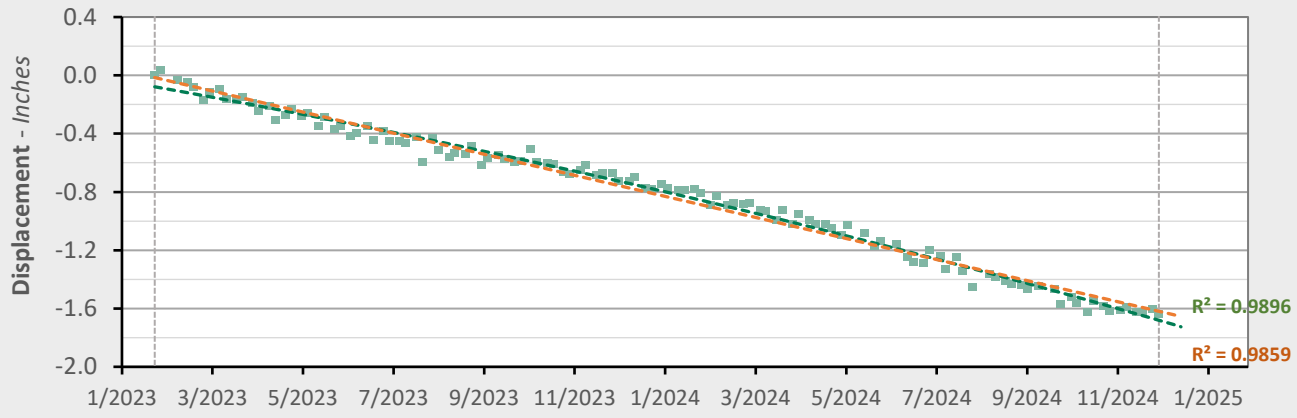
	Nonlinear Trend		Linear Trend	
Velocity:	-0.80	in/yr	-0.53	in/yr
Acceleration:	-0.30	in/yr^2	0.00	in/yr^2

LOS Displacement Measurement — Nonlinear Trend Line (Quadratic Regression) — Linear Trend Line (Linear Regression)

AOI 12 *(PPG 4)* - Location Map



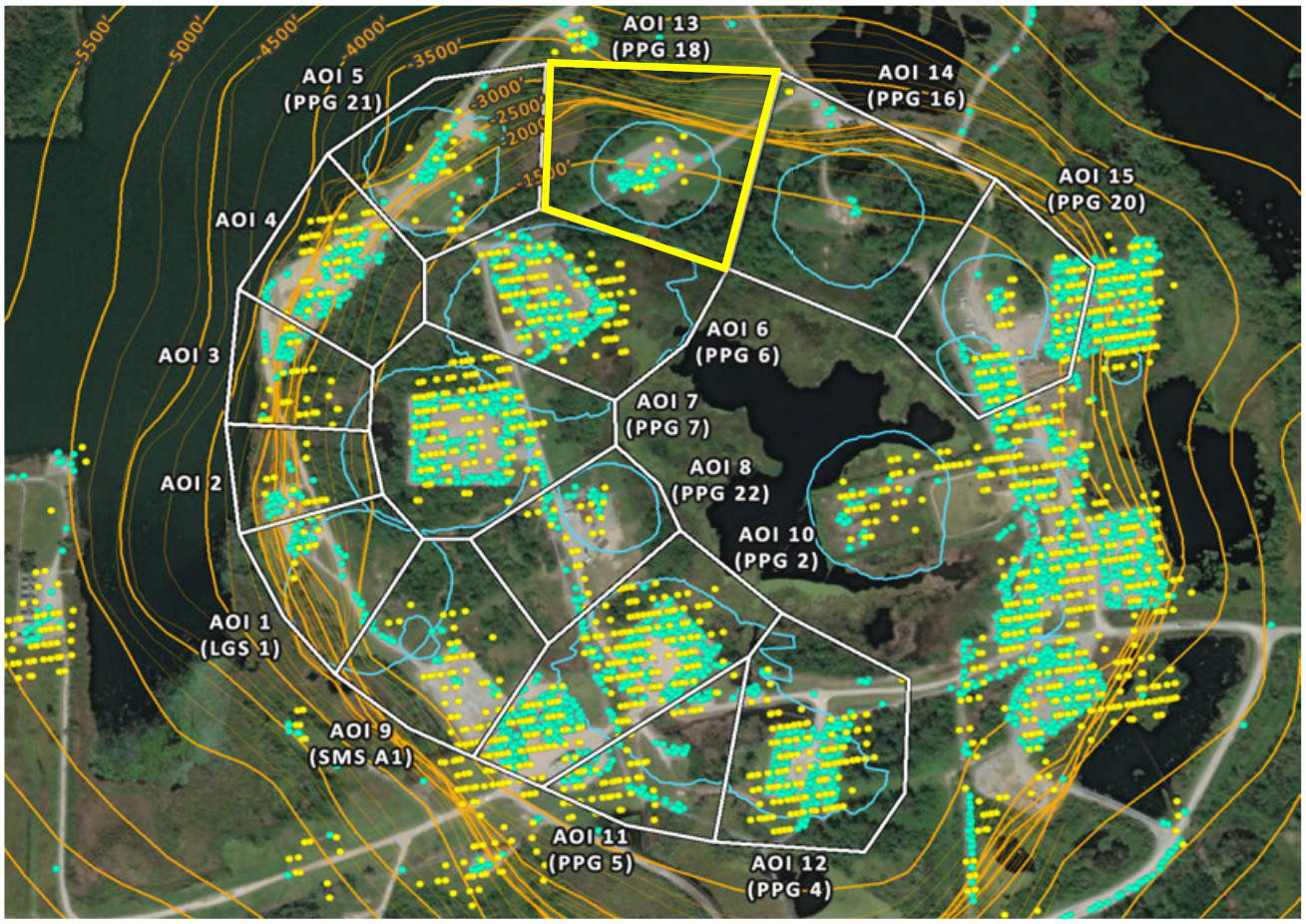
AOI 12 *(PPG 4)* - Displacement Time Series TSX/PAZ (11/29/2024) Point Count: 262



	Nonlinear Trend	Linear Trend
Velocity:	-1.07 in/yr	-0.87 in/yr
Acceleration:	-0.22 in/yr^2	0.00 in/yr^2

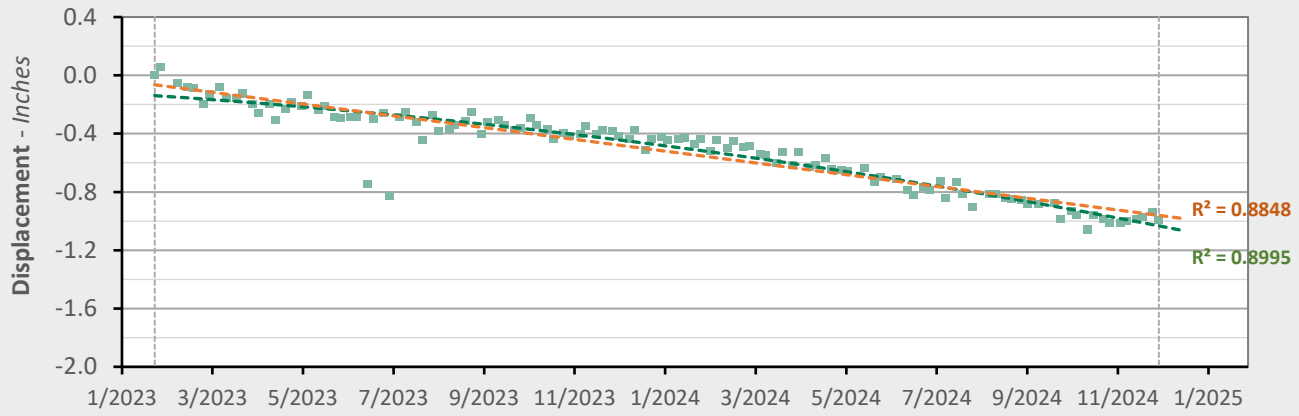
LOS Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 13 *(PPG 18)* - Location Map



AOI 13 *(PPG 18)* - Displacement Time Series

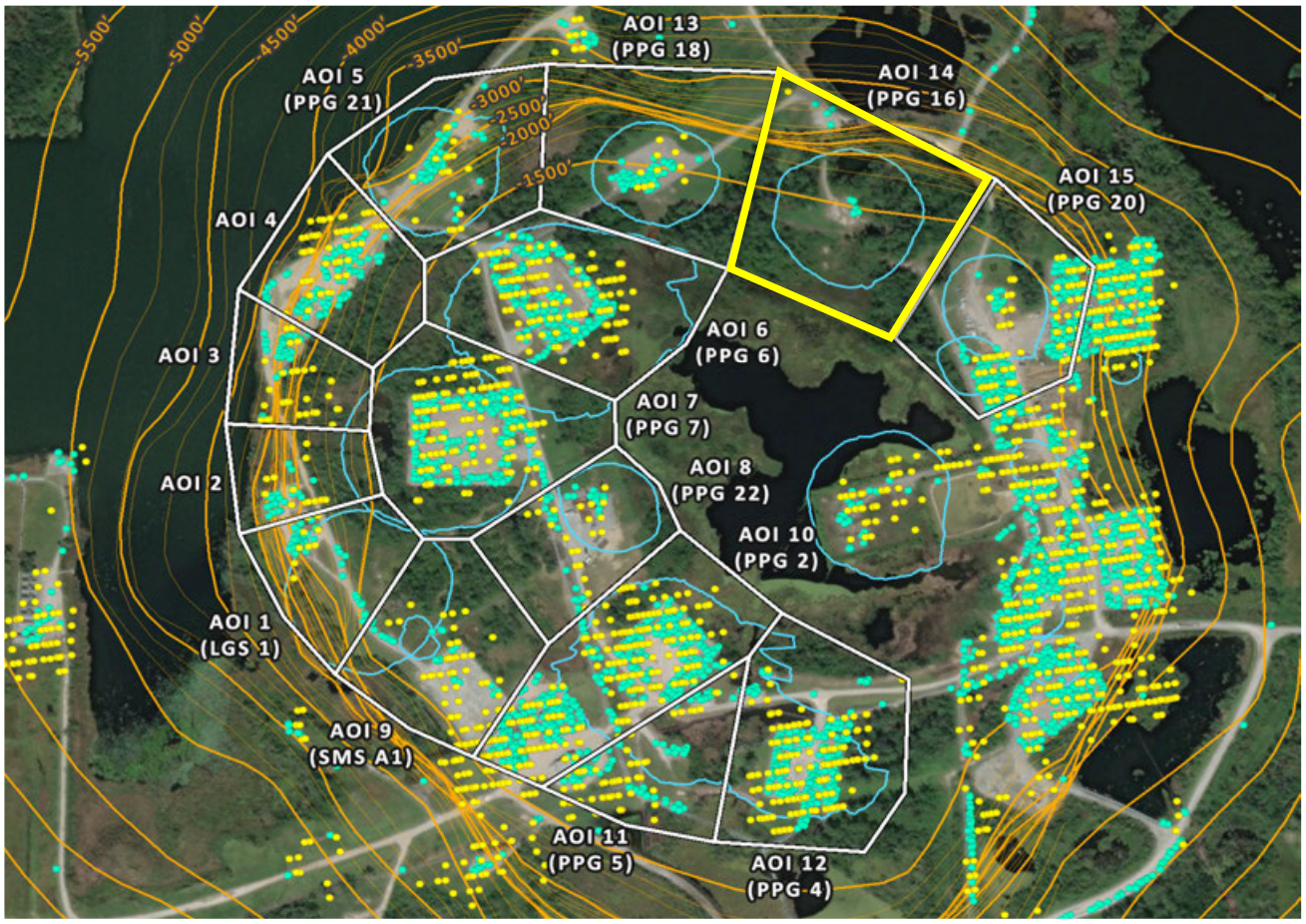
SX/PAZ (11/29/2024) Point Count: **52**



	Nonlinear Trend		Linear Trend	
Velocity:	-0.72	in/yr	-0.48	in/yr
Acceleration:	-0.26	in/yr^2	0.00	in/yr^2

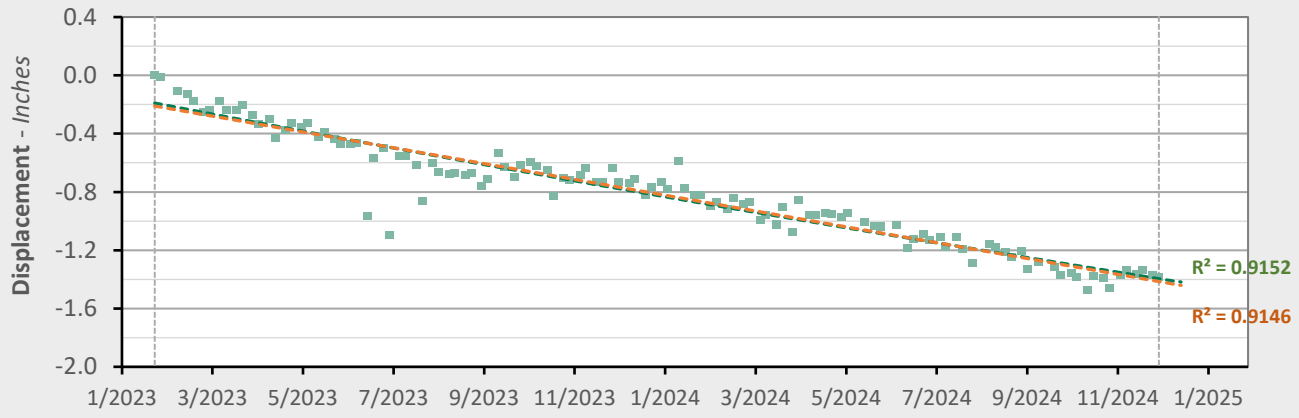
LOS Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 14 *(PPG 16)* - Location Map



AOI 14 *(PPG 16)* - Displacement Time Series

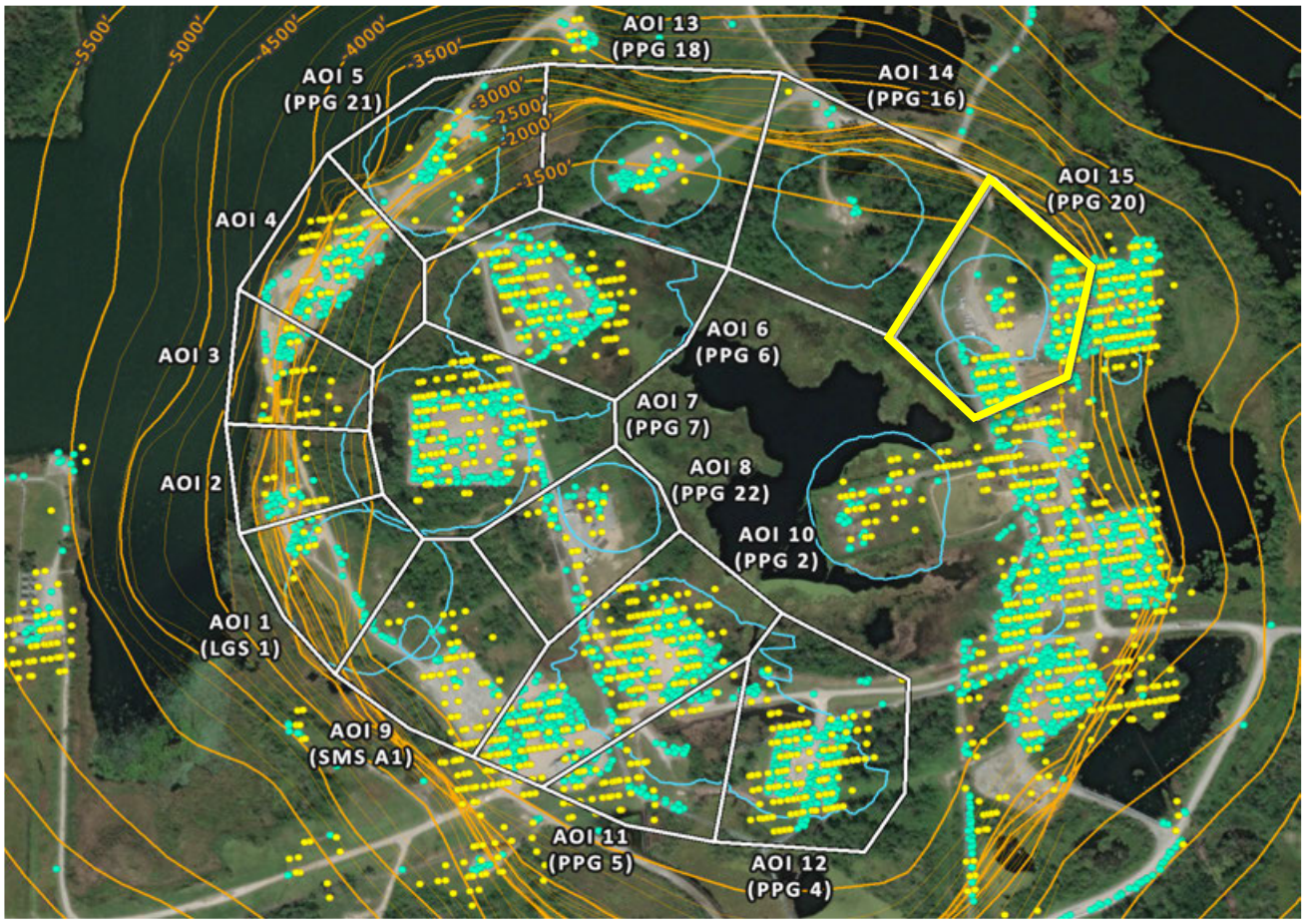
RSX/PAZ (11/29/2024) Point Count: **11**



	Nonlinear Trend	Linear Trend
Velocity:	-0.59 in/yr	-0.65 in/yr
Acceleration:	+0.07 in/yr^2	0.00 in/yr^2

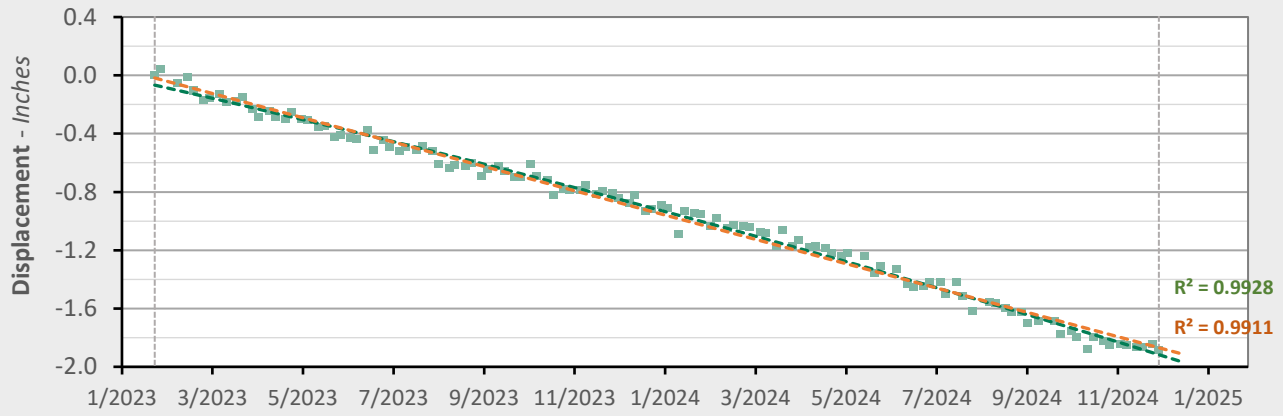
LOS Displacement Measurement — Nonlinear Trend Line (Quadratic Regression) — Linear Trend Line (Linear Regression)

AOI 15 *(PPG 20)* - Location Map



AOI 15 *(PPG 20)* - Displacement Time Series

SX/PAZ (11/29/2024) Point Count: **227**



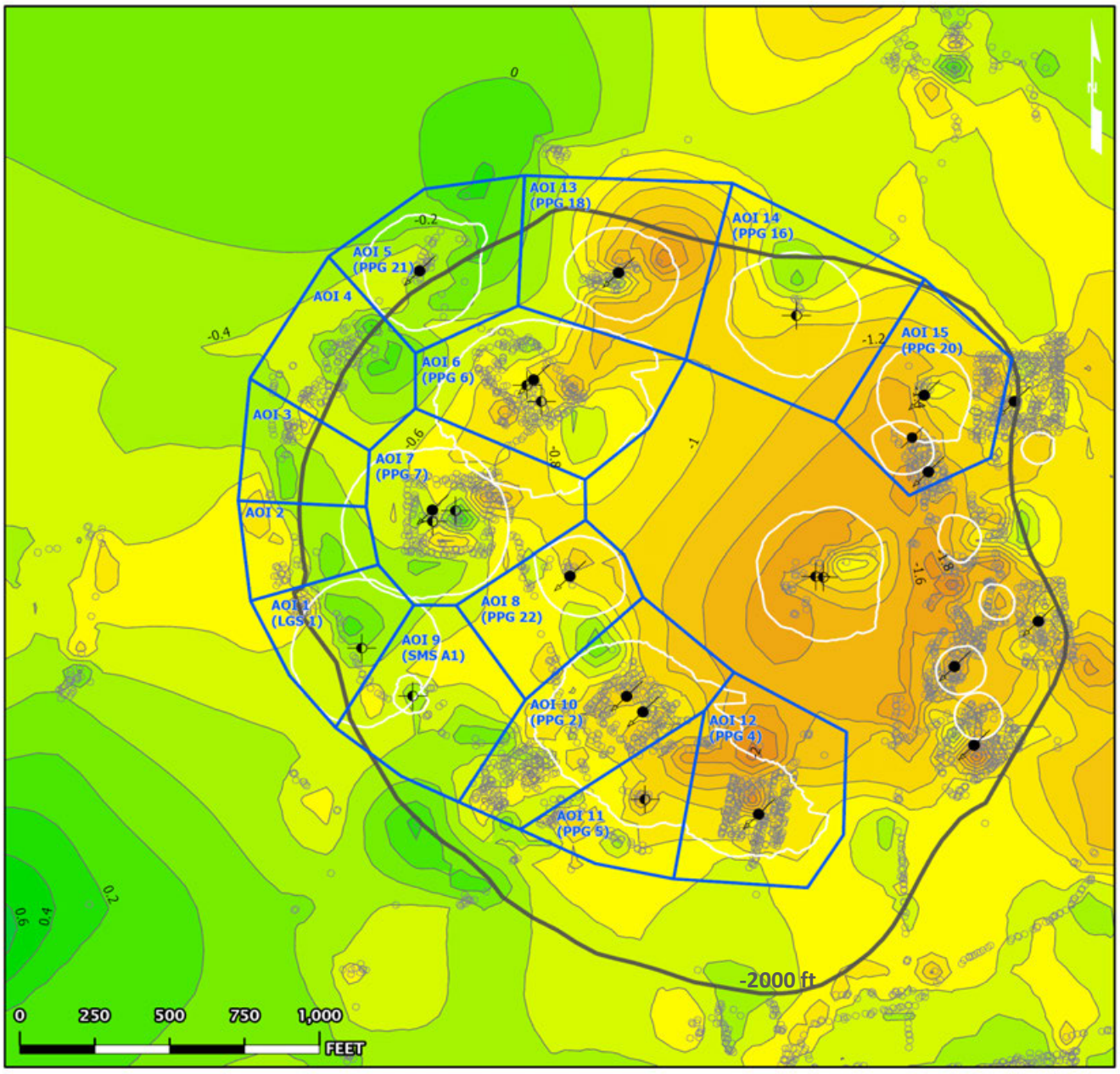
	Nonlinear Trend	Linear Trend
Velocity:	-1.16 in/yr	-1.00 in/yr
Acceleration:	-0.17 in/yr^2	0.00 in/yr^2

LOS Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

TSX/PAZ Data (01/24/2023 - 11/29/2024)

Nonlinear Velocity Contours

As of date: 11/29/2024



-3.0 -2.0 -1.0 0.0 +1.0 +2.0 +3.0

Inches/year

AOI Boundary InSAR LOS Measurement Point Contour (0.2)

Historical Cavern Extent Top of Dome (-2000 ft Contour)

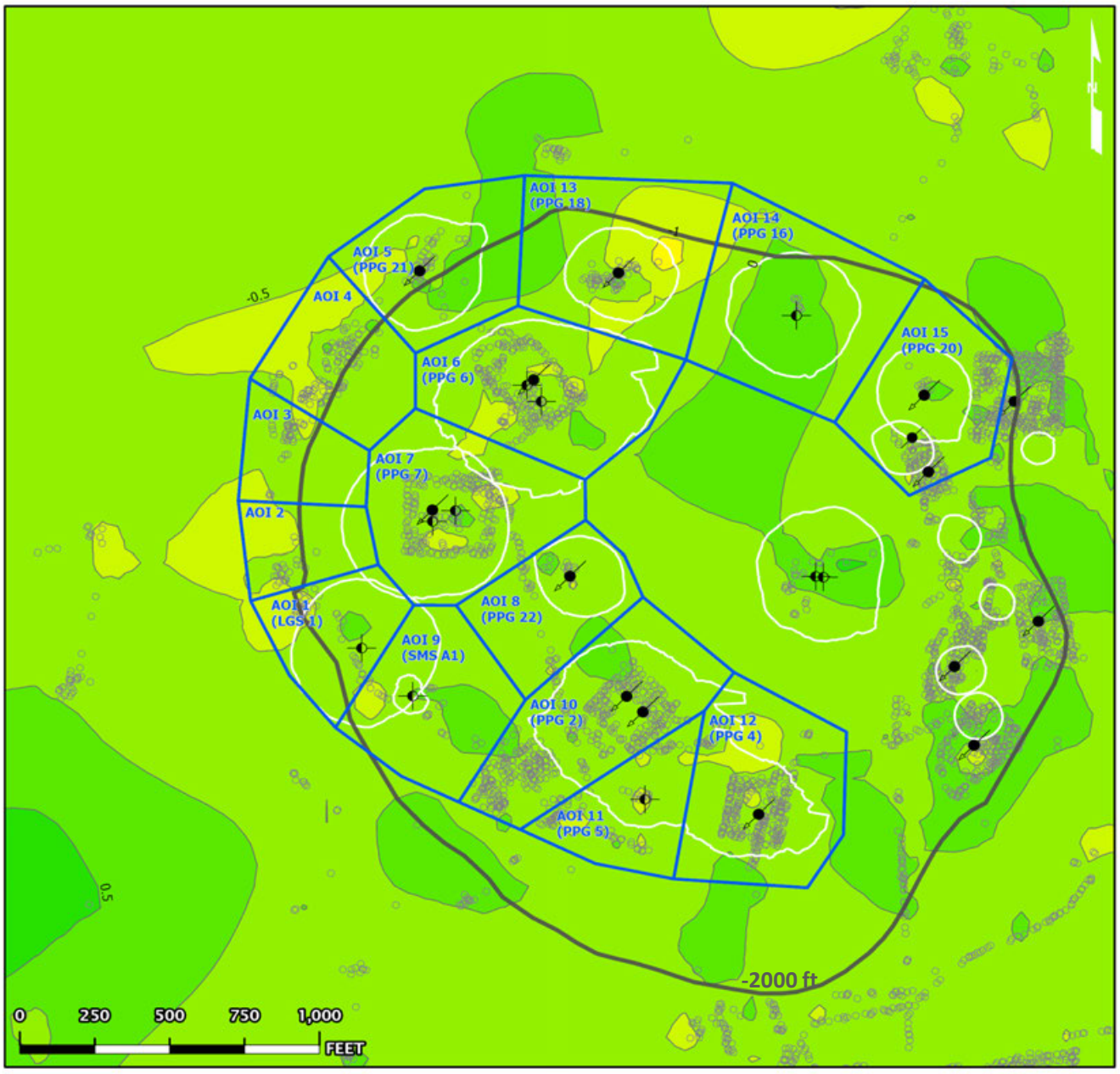
Cavern Well Surface Locations

09 - Active - Injection 29 - Dry and Plugged

TSX/PAZ Data (01/24/2023 - 11/29/2024)

Nonlinear Acceleration Contours

Date range: 01/24/2023 - 11/29/2024



-6.0 -4.0 -2.0 0.0 +2.0 +4.0 +6.0

Inches/year^2

AOI Boundary | InSAR LOS Measurement Point | Contour (0.5)

Historical Cavern Extent | Top of Dome (-2000 ft Contour)

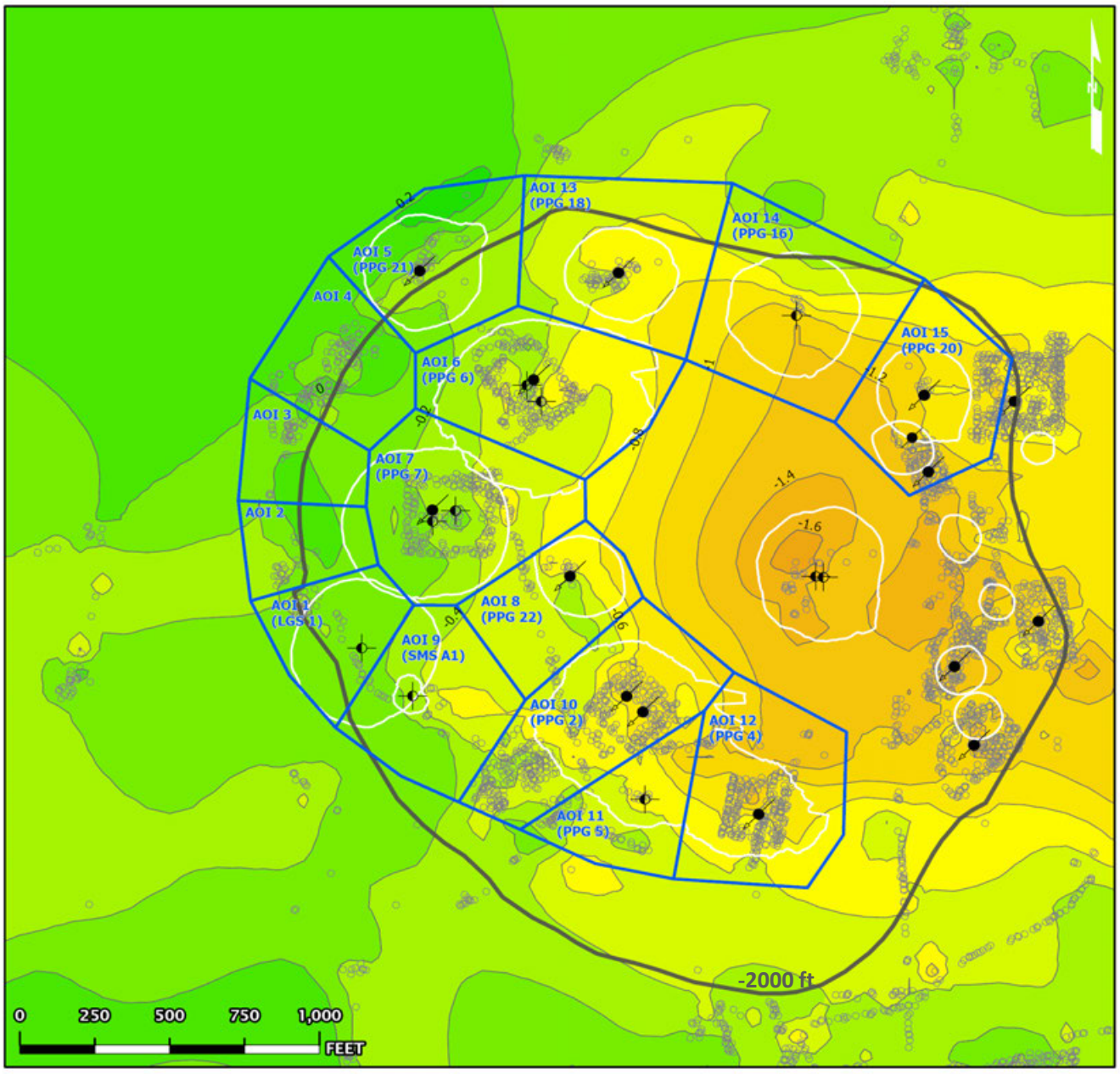
Cavern Well Surface Locations

09 - Active - Injection | 29 - Dry and Plugged

TSX/PAZ Data (01/24/2023 - 11/29/2024)

Linear Velocity Contours

Date range: 01/24/2023 - 11/29/2024



-3.0 -2.0 -1.0 0.0 +1.0 +2.0 +3.0

Inches/year

AOI Boundary | InSAR LOS Measurement Point | Contour (0.2)

Historical Cavern Extent | Top of Dome (-2000 ft Contour)

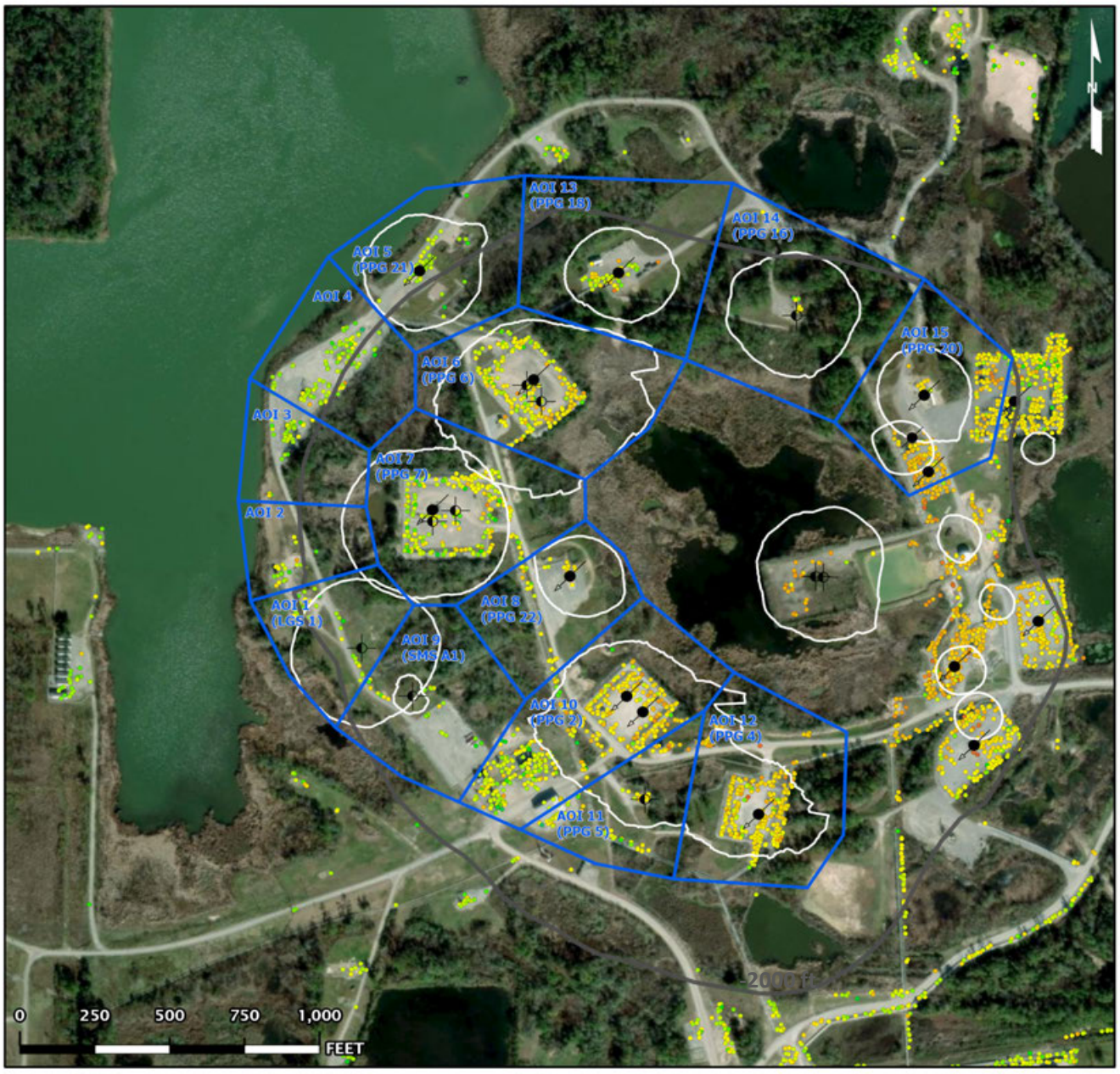
Cavern Well Surface Locations

09 - Active - Injection | 29 - Dry and Plugged

TSX/PAZ Data (01/24/2023 - 11/29/2024)

Nonlinear Velocity Data Points

As of date: 11/29/2024



-3.0 -2.0 -1.0 0.0 +1.0 +2.0 +3.0

Inches/year

AOI Boundary
InSAR LOS Measurement Point
Historical Cavern Extent
Top of Dome (-2000 ft Contour)

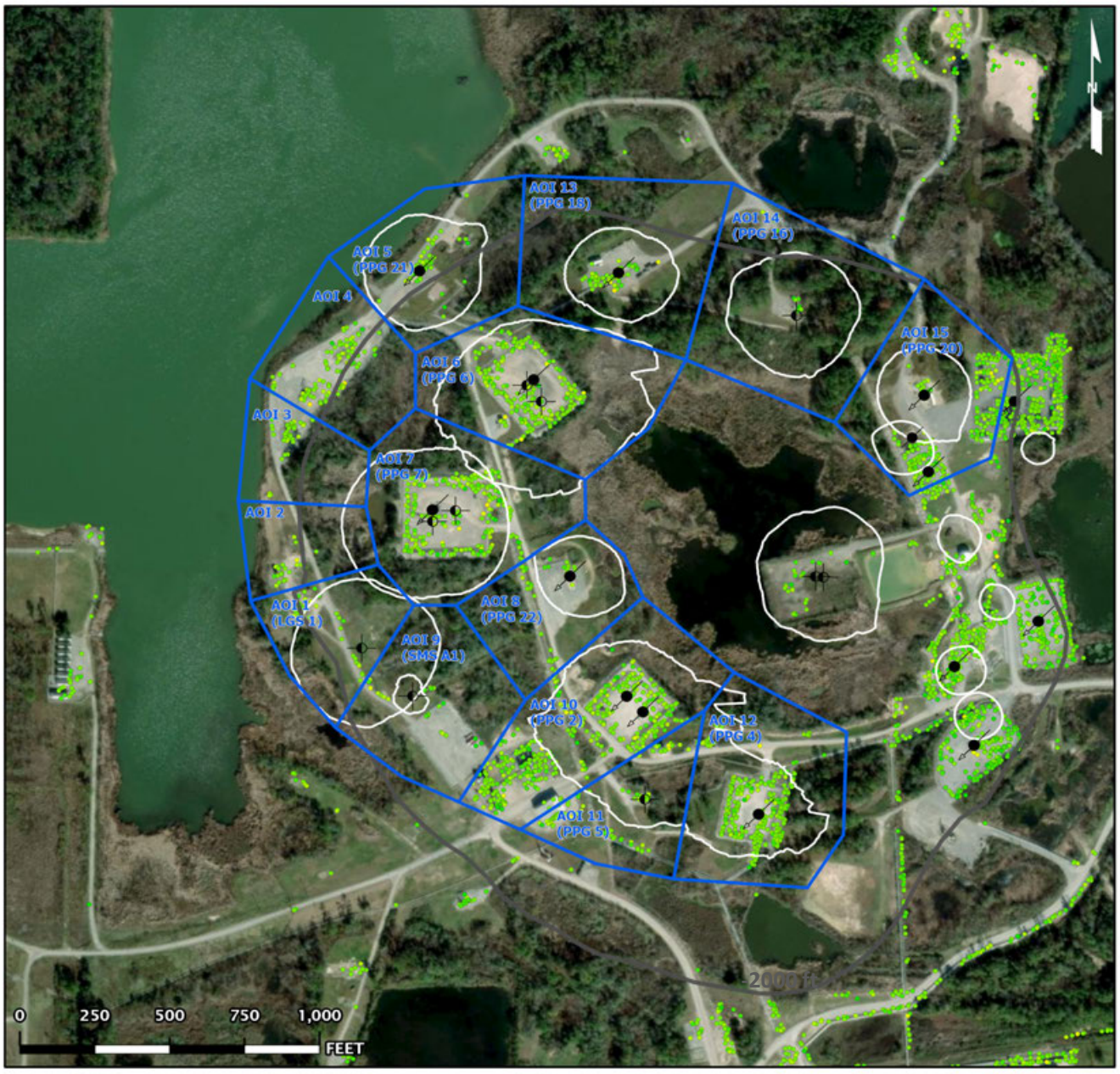
Cavern Well Surface Locations

09 - Active - Injection
29 - Dry and Plugged

TSX/PAZ Data (01/24/2023 - 11/29/2024)

Nonlinear Acceleration Data Points

Date range: 01/24/2023 - 11/29/2024



-6.0 -4.0 -2.0 0.0 +2.0 +4.0 +6.0

Inches/year^2

AOI Boundary
InSAR LOS Measurement Point
Historical Cavern Extent
Top of Dome (-2000 ft Contour)

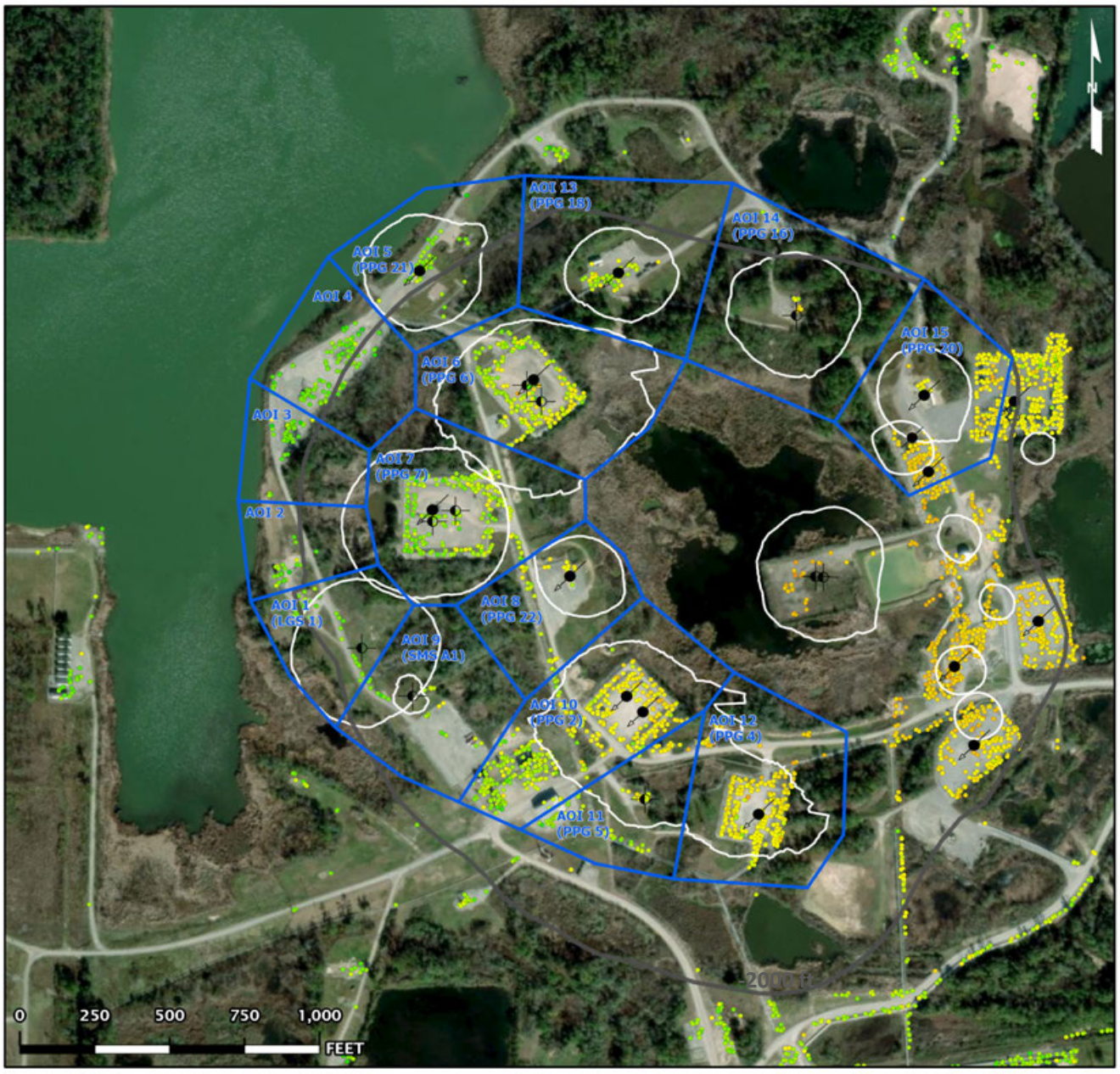
Cavern Well Surface Locations

09 - Active - Injection
29 - Dry and Plugged

TSX/PAZ Data (01/24/2023 - 11/29/2024)

Linear Velocity Data Points

Date range: 01/24/2023 - 11/29/2024



-3.0 -2.0 -1.0 0.0 +1.0 +2.0 +3.0

Inches/year

AOI Boundary — InSAR LOS Measurement Point

Historical Cavern Extent — Top of Dome (-2000 ft Contour)

Cavern Well Surface Locations

09 - Active - Injection — 29 - Dry and Plugged

ATTACHMENT D

Vertical & East-West 2D InSAR report - November 29, 2024

Vertical & E-W 2D Update

Continuous InSAR Monitoring of
Ground Displacement At Westlake
Caverns and Western Dome Flank

Sulphur Mines Salt Dome

Prepared for:
Westlake Chemical

Prepared by:
Lonquist & Co., LLC
8591 United Plaza Blvd.
Suite 280
Baton Rouge, LA 70809

Dataset
Satellite Source
Sentinel-1 & TerraSAR-X - PAZ Constellation
Most Recent Image Date
Friday, November 29, 2024

Analysis Report Date:

December 13, 2024

Dataset Information

Satellite Source	Sentinel-1 & TerraSAR-X - PAZ Constellation
Update Frequency	12 days
Most Recent Image Date	Friday, November 29, 2024
Dataset Image Count	153
Dataset Time Range	January 24, 2023 - November 29, 2024
Dataset Length	1.85 Years
Measurement Directions	Vertical and East-West

Analysis Methodology

Time Series Charts

Trend lines were calculated for the averaged vertical and east-west displacement values within each AOI. Both a nonlinear (quadratic) and linear regression were applied to each AOI point group to identify rates of change in LOS displacement. These trends are displayed in the Time Series section of this report.

Contour Maps

A nonlinear (quadratic) and linear trend was also calculated for each individual measurement point across the analysis region. Nonlinear trend values for each point were used to generate Velocity and Acceleration contour maps to convey the spatial distribution of the calculated movement. The linear trend values for each point (which lack an acceleration component) were used to generate an additional Velocity contour map. Maps depicting the individual data points colored by these trend values are included after the contour maps.

Rate Interpretation

For the vertical data, positive velocity values indicate uplift and negative velocity values indicate subsidence. Positive acceleration values indicate increasing rates of uplift or slowing rates of subsidence, while negative acceleration values indicate slowing rates of uplift or increasing rates of subsidence. For the east-west data, positive velocity values indicate eastward horizontal movement and negative velocity values indicate horizontal westward movement. Positive acceleration values indicate increasing rates of eastward movement or decreasing rates of westward movement, while negative acceleration values indicate increasing rates of westward movement or decreasing rates of eastward movement.

Observations

To-date there have been no acute deviations from established subsidence trends in the areas investigated.

The calculated vertical displacement values indicate that subsidence is occuring with near-linear trends in all AOIs where data is present. Minor positive acceleration (slowing subsidence) is present in a majority of the calculated nonlinear AOI trends.

The calculated east-west dispacement values generally indicate horizontal movement toward the dome center with the greatest rates of eastward movement occuring in the western AOIs and the greatest rate of westward movement occuring in the easternmost AOI. Most AOIs indicate varying amounts of negative acceleration (slower eastward or faster westward displacement) with the most pronounced values occuring in AOI 1, AOI 2 and AOI 3. This likely correlates to the minor increases in negative acceleration recently noted in the TSX/PAZ LOS dataset reports.

Date Signed: December 13, 2024
Austin, Texas

Nathaniel L. Byars, P.E.
Principal Engineer
Louisiana License No. 40697

InSAR Data Sources

InSAR Data

Interferometric Synthetic Aperture Radar (InSAR) is the most well established method to continually evaluate small, normally undetectable, ground movement over a large area. Radar imagery collected via satellites over successive orbital passes is used to identify and define measurement points on the ground. Objects or ground features providing a stable reflection of radar energy such as buildings, roads, and infrastructure produce the highest quality measurement points. InSAR analysis identifies the change in distance between the satellite and each measurement point over time relative to a stable reference point within the imaged area.

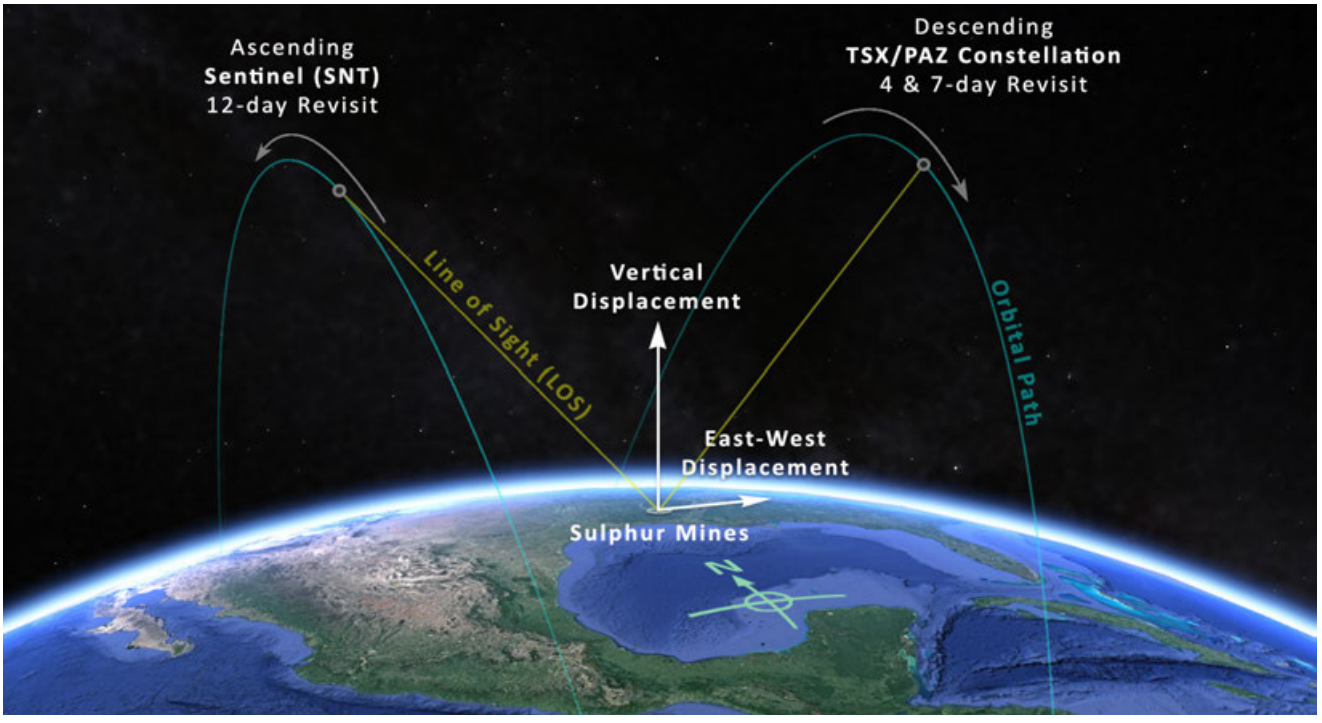
Satellite Sources

Two InSAR datasets are being used to evaluate subsidence over the Sulphur Mines Salt Dome. These datasets provide Line-of-Sight (LOS) displacment measurements from both ascending and descending orbits. An ascending orbit denotes the satellite's longitudinal course from south to north as it passes over the site, while a descending orbit denotes the satellite is moving from north to south.

The first dataset comes from a low-resolution Sentinel-1 (SNT) satellite on an ascending orbit that captures data from the west of the site on a 12-day frequency. The second comes from a pair of high resolution satellites that share the same descending orbit and capture data from east of the site. These are a TSX satellite and the PAZ satellite (TSX/PAZ constellation), both with an 11-day revisit frequency. Their orbits are offset with the PAZ satellite passing over the site 4 days after the TSX satellite.

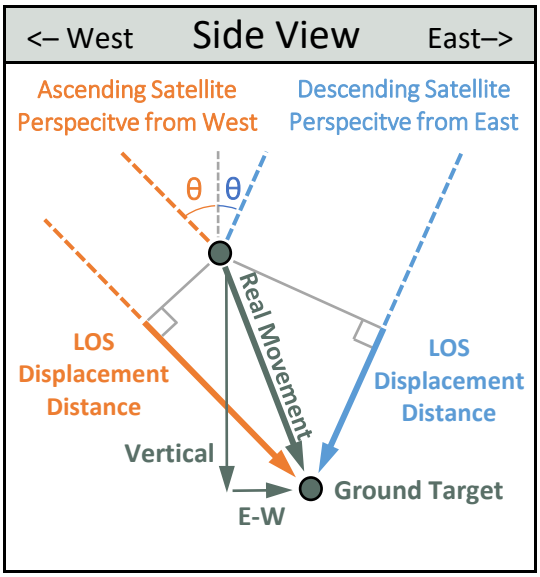
Each instance of data capture in either the SNT or TSX/PAZ constellation is used to generate 2D (two-dimensional) displacement values in the vertical and east-west directions for each measurement point within the 2D data grid. The image below depicts the orbital paths of the satellites in relation to the Sulphur Mines Salt Dome as well as the 2D components of the calculated displacement.

Satellite Orbital Diagram



InSAR 2D Vertical and East-West Data

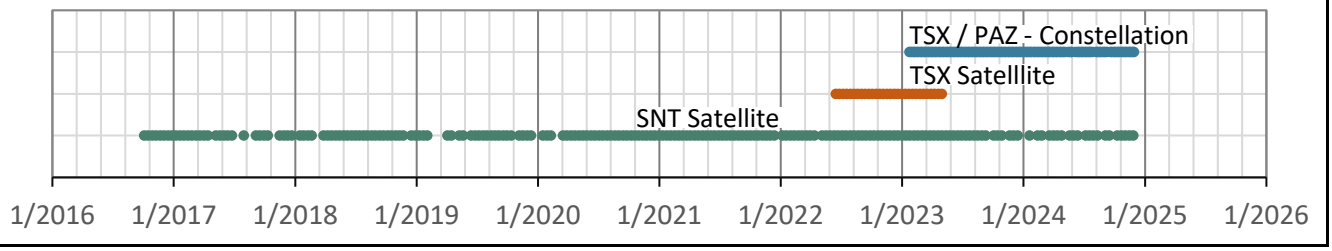
LOS (line-of-sight) displacement measurements, which refer to a change in distance between the satellite sensor and the ground target, are used to triangulate the real movement along the 2D plane defined by the satellite positions and the ground target. The diagram to the right illustrates the geometric relationship between the Real Movement of a ground target, the LOS displacement measurements from two different satellite viewing directions, and the resulting vertical and east-west components of calculated 2D displacement. Ground targets are not consistent between LOS datasets so these calculations are performed on averaged LOS data within 82-ft square cells. One 2D measurement point is generated within each cell where data from both LOS sources are present.



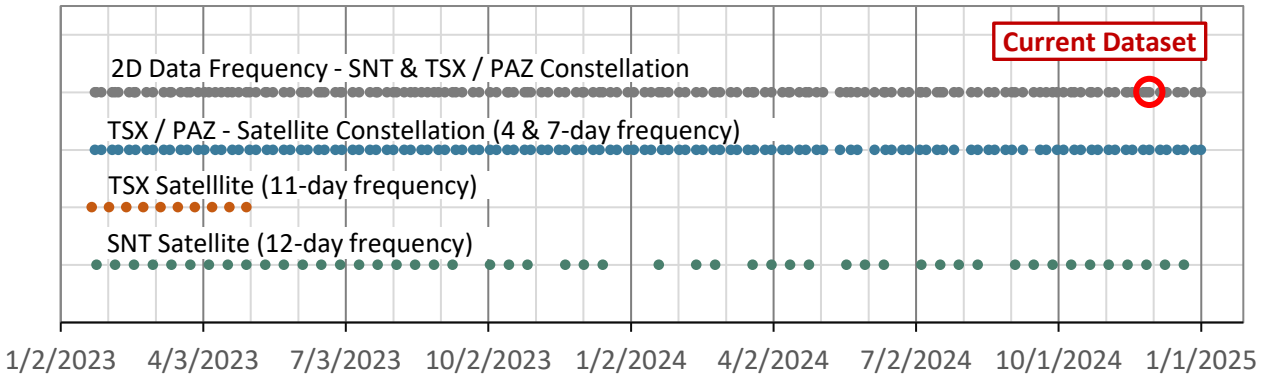
Satellite Properties & Image Frequency

Satellite and Data Properties	SNT	TSX/PAZ Constellation
Band (Wavelength)	C-band (2.20 in)	X-band (1.22 in)
Track	T136	T67 & T120
Pixel resolution	65 x 16 ft	3 x 3 ft
Revisit frequency	12 days	4 & 7 days
Orbit (LOS Angle, θ)	Ascending (43°)	Descending (37°)
Data Start Date	10/4/2016	1/24/2023
Measurement error range	± 0.20 in	± 0.03 in

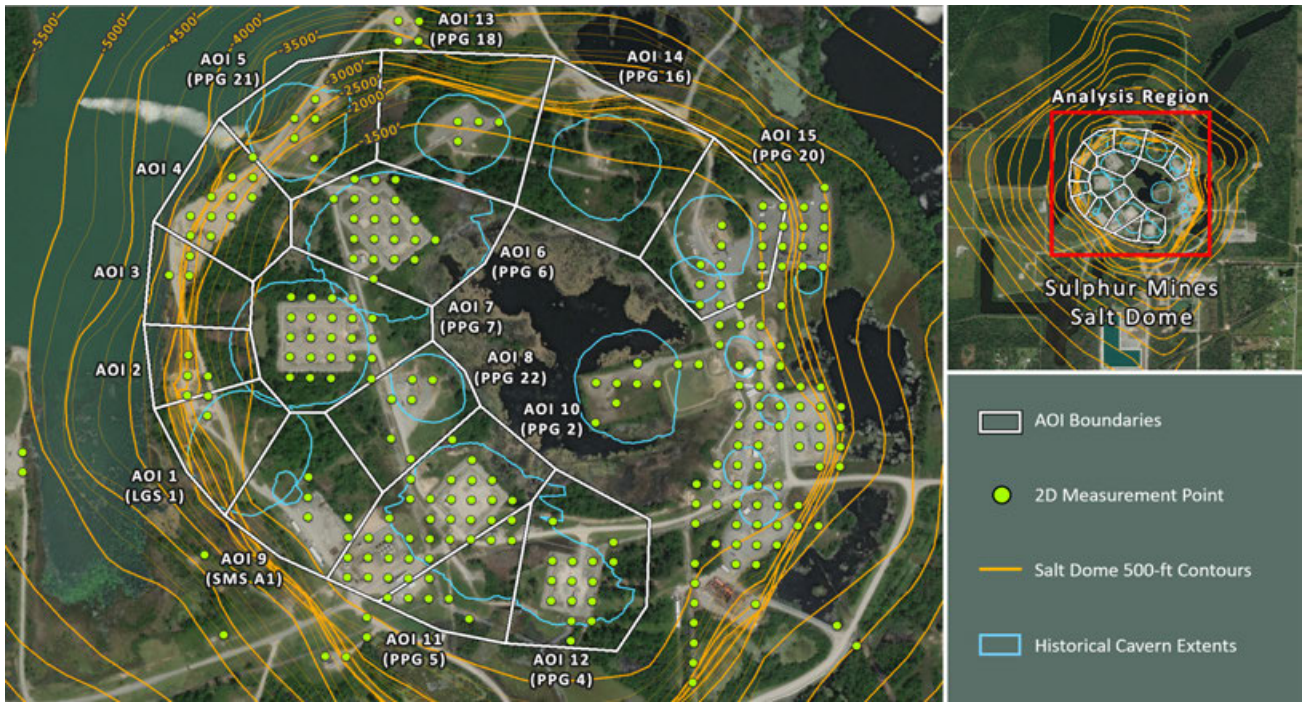
LOS Measurement History



2D Measurement Frequency



AOI Boundaries & 2D InSAR Measurement Points



Subsidence Monitoring Areas of Interest (AOIs)

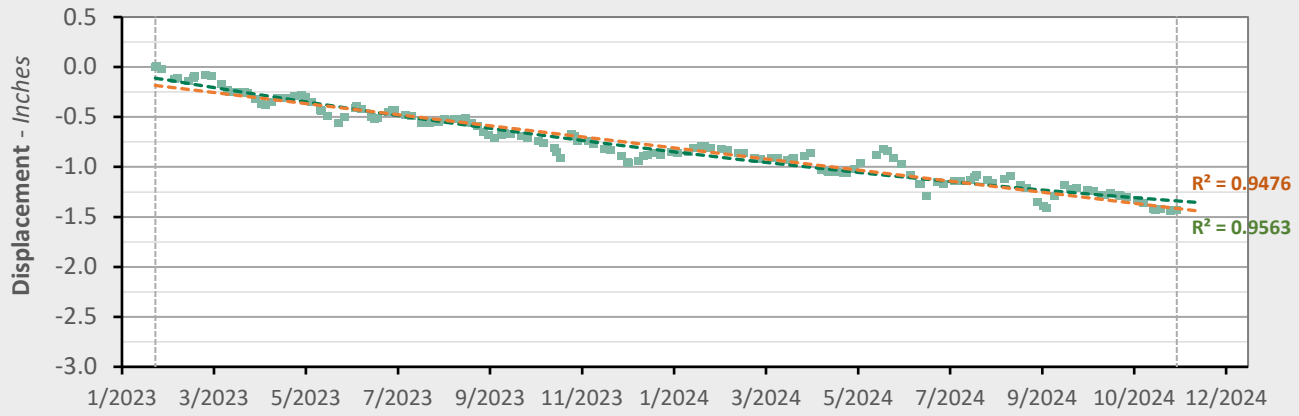
To visually convey and evaluate trend consistency for the Vertical displacement time series of each ground target, measurment points were grouped and their displacement values were averaged. The point groups are referred to as Areas of Interest (AOIs) in this analysis and their boundaries are depicted on the above map. The below table lists the Vertical trend values calculated in each AOI for the dataset evaluated in this report.

AOI Name	Vertical (11/29/2024)	Vertical Velocity (in/yr)		Vertical Acceleration (in/yr²)	
	Point Count	Nonlinear	Linear	Nonlinear	Linear
AOI 1 *(LGS 1)*	3	-0.42	-0.67	+0.27	0.00
AOI 2	4	-0.50	-0.59	+0.10	0.00
AOI 3	3	-0.29	-0.56	+0.29	0.00
AOI 4	11	-0.50	-0.54	+0.05	0.00
AOI 5 *(PPG 21)*	5	-0.32	-0.55	+0.24	0.00
AOI 6 *(PPG 6)*	20	-0.87	-0.89	+0.03	0.00
AOI 7 *(PPG 7)*	23	-0.92	-0.97	+0.05	0.00
AOI 8 *(PPG 22)*	5	-1.12	-1.26	+0.15	0.00
AOI 9 *(SMS A1)*	6	-0.38	-0.86	+0.52	0.00
AOI 10 *(PPG 2)*	31	-0.94	-1.11	+0.18	0.00
AOI 11 *(PPG 5)*	10	-0.97	-0.95	-0.01	0.00
AOI 12 *(PPG 4)*	15	-0.96	-1.09	+0.14	0.00
AOI 13 *(PPG 18)*	2	-0.51	-0.75	+0.26	0.00
AOI 14 *(PPG 16)*	0	N/A	N/A	N/A	N/A
AOI 15 *(PPG 20)*	14	-0.83	-0.93	+0.11	0.00

AOI 1 *(LGS 1)* - Location Map

AOI 1 *(LGS 1)* - Vertical Time Series

Vertical (11/29/2024) Point Count: **3**



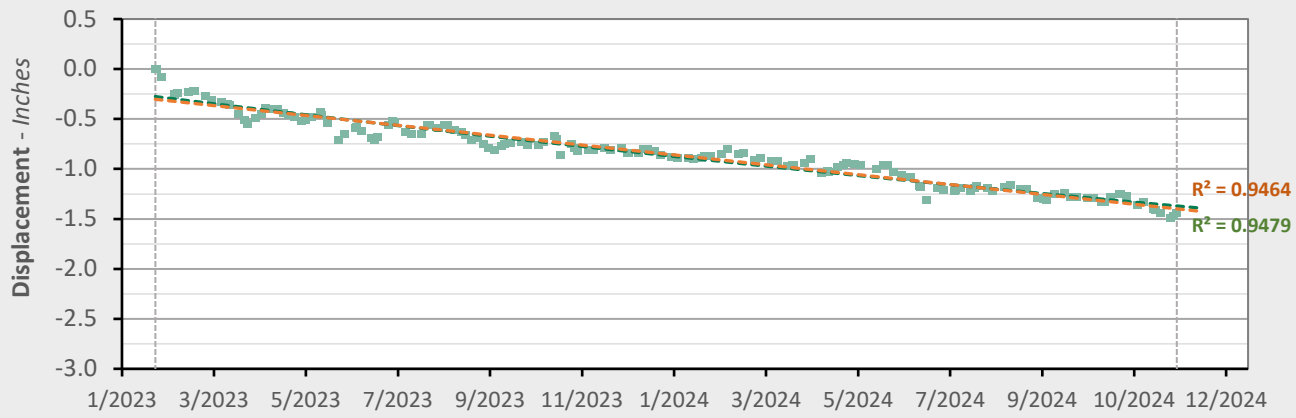
	Nonlinear Trend		Linear Trend	
Velocity:	-0.42	in/yr	-0.67	in/yr
Acceleration:	+0.27	in/yr^2	0.00	in/yr^2

2D Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 2 - Location Map

AOI 2 - Vertical Time Series

Vertical (11/29/2024) Point Count: 4



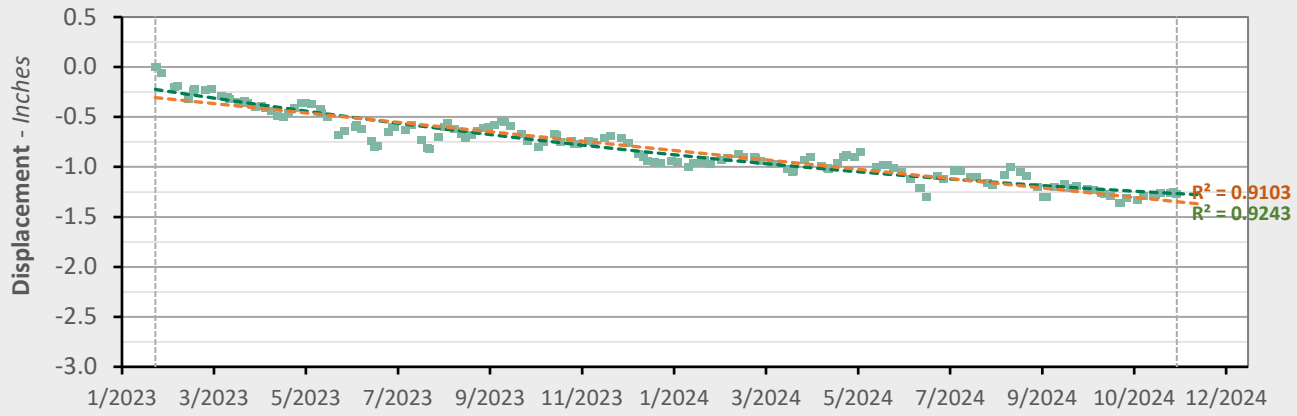
	Nonlinear Trend		Linear Trend	
Velocity:	-0.50	in/yr	-0.59	in/yr
Acceleration:	+0.10	in/yr^2	0.00	in/yr^2

2D Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 3 - Location Map

AOI 3 - Vertical Time Series

Vertical (11/29/2024) Point Count: 3



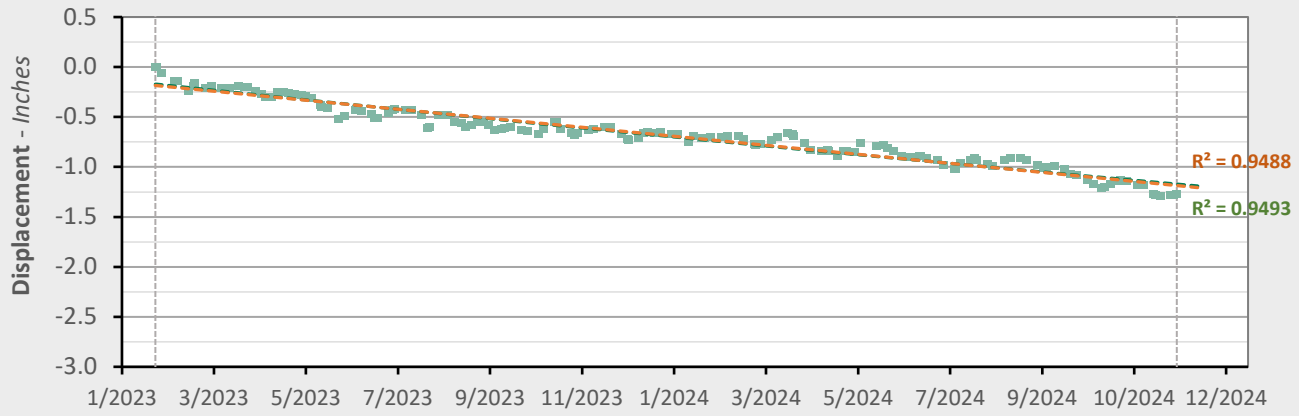
	Nonlinear Trend		Linear Trend	
Velocity:	-0.29	in/yr	-0.56	in/yr
Acceleration:	+0.29	in/yr²	0.00	in/yr²

2D Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 4 - Location Map

AOI 4 - Vertical Time Series

Vertical (11/29/2024) Point Count: **11**



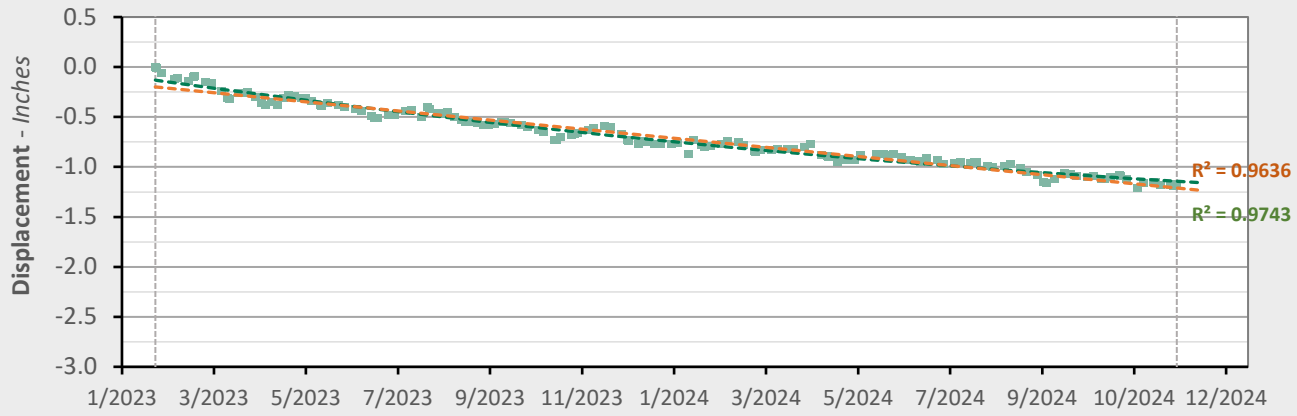
	Nonlinear Trend	Linear Trend
Velocity:	-0.50 in/yr	-0.54 in/yr
Acceleration:	+0.05 in/yr²	0.00 in/yr²

2D Displacement Measurement | Nonlinear Trend Line (Quadratic Regression) | Linear Trend Line (Linear Regression)

AOI 5 *(PPG 21)* - Location Map

AOI 5 *(PPG 21)* - Vertical Time Series

Vertical (11/29/2024) Point Count: **5**



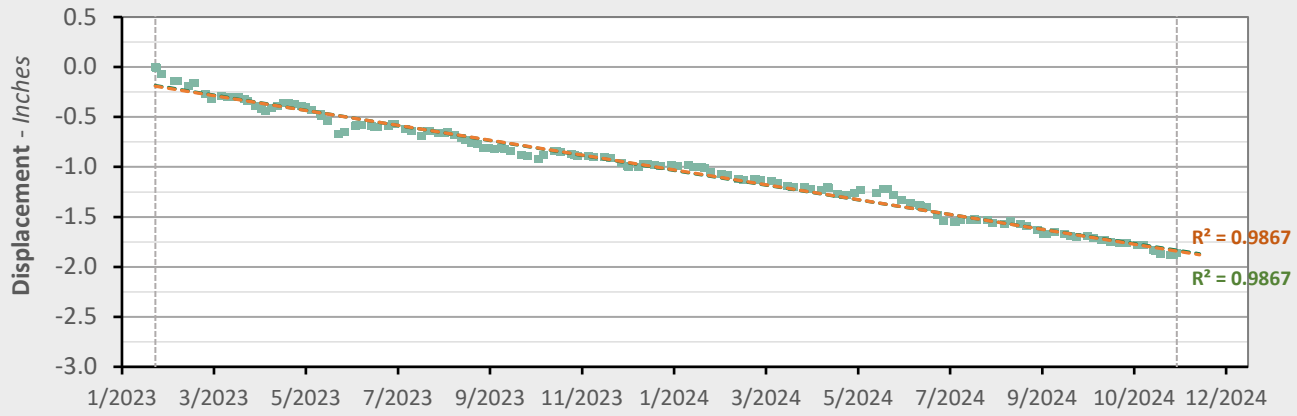
	Nonlinear Trend		Linear Trend	
Velocity:	-0.32	in/yr	-0.55	in/yr
Acceleration:	+0.24	in/yr^2	0.00	in/yr^2

2D Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 6 *(PPG 6)* - Location Map

AOI 6 *(PPG 6)* - Vertical Time Series

Vertical (11/29/2024) Point Count: **20**



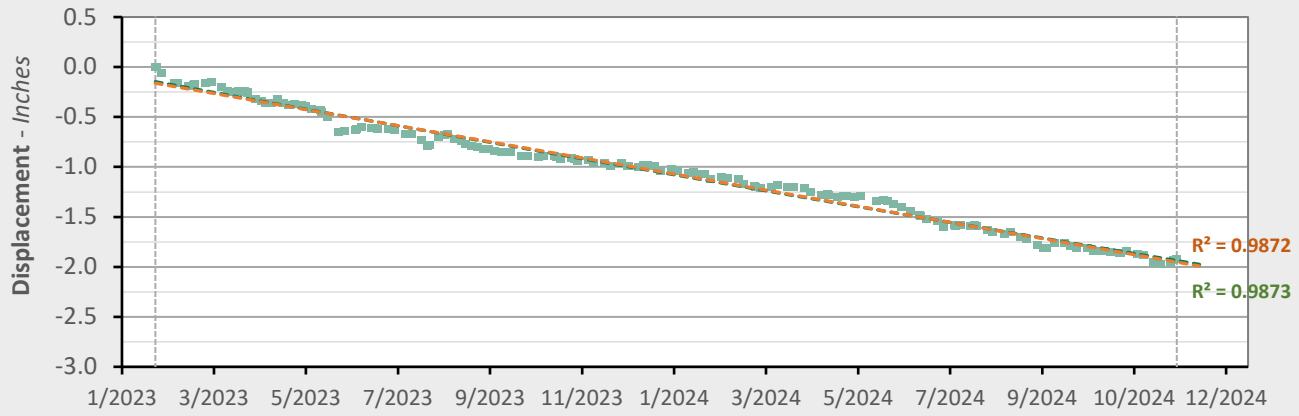
	Nonlinear Trend	Linear Trend
Velocity:	-0.87 in/yr	-0.89 in/yr
Acceleration:	+0.03 in/yr^2	0.00 in/yr^2

2D Displacement Measurement — Nonlinear Trend Line (Quadratic Regression) — Linear Trend Line (Linear Regression)

AOI 7 *(PPG 7)* - Location Map

AOI 7 *(PPG 7)* - Vertical Time Series

Vertical (11/29/2024) Point Count: **23**



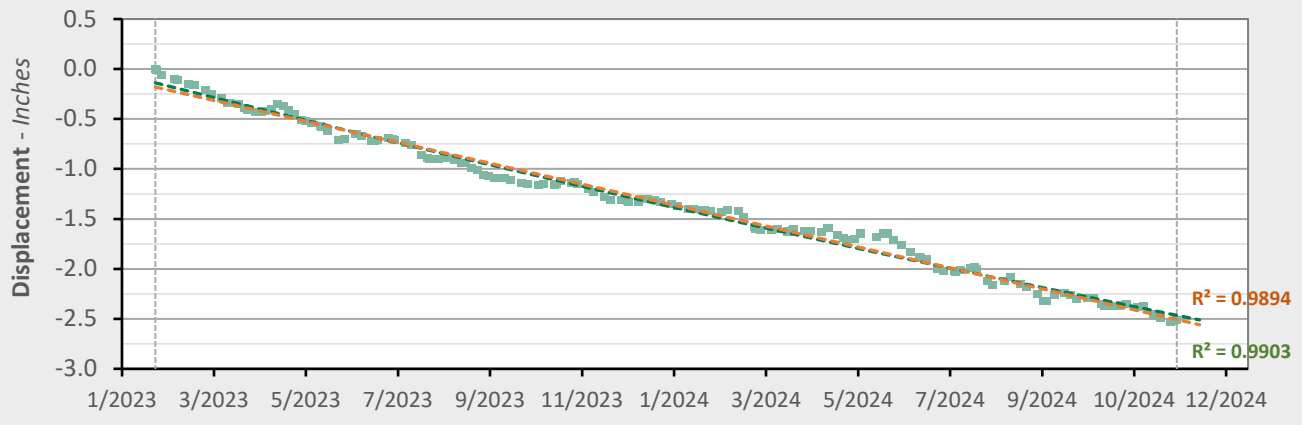
	Nonlinear Trend	Linear Trend
Velocity:	-0.92 in/yr	-0.97 in/yr
Acceleration:	+0.05 in/yr^2	0.00 in/yr^2

2D Displacement Measurement | Nonlinear Trend Line (Quadratic Regression) | Linear Trend Line (Linear Regression)

AOI 8 *(PPG 22)* - Location Map

AOI 8 *(PPG 22)* - Vertical Time Series

Vertical (11/29/2024) Point Count: **5**



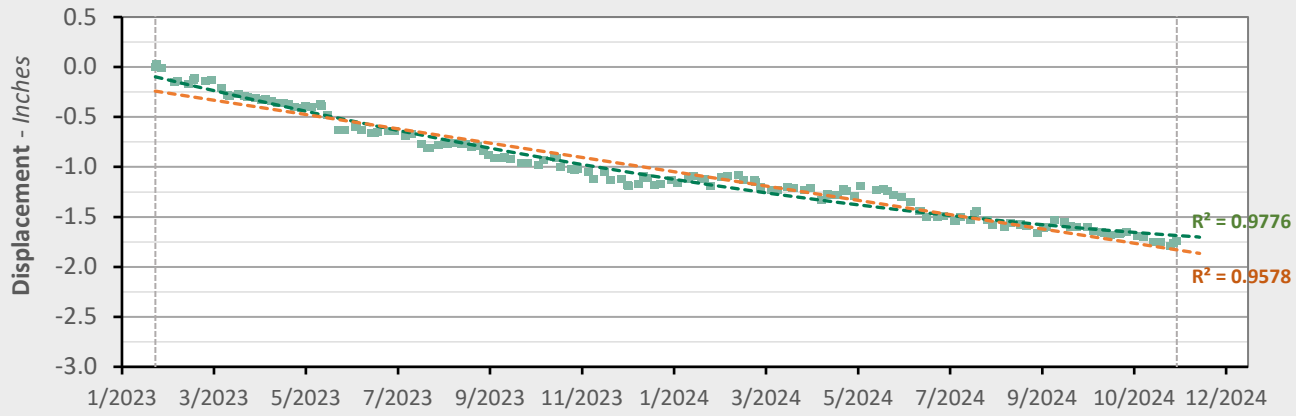
	Nonlinear Trend		Linear Trend	
Velocity:	-1.12	in/yr	-1.26	in/yr
Acceleration:	+0.15	in/yr^2	0.00	in/yr^2

2D Displacement Measurement | Nonlinear Trend Line (Quadratic Regression) | Linear Trend Line (Linear Regression)

AOI 9 *(PPG A1)* - Location Map

AOI 9 *(SMS A1)* - Vertical Time Series

Vertical (11/29/2024) Point Count: **6**



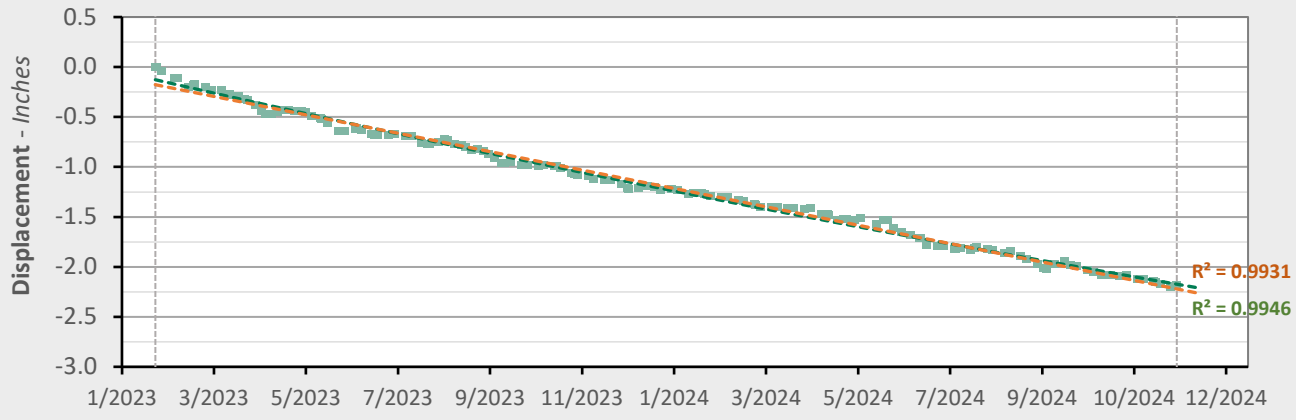
	Nonlinear Trend	Linear Trend
Velocity:	-0.38 in/yr	-0.86 in/yr
Acceleration:	+0.52 in/yr^2	0.00 in/yr^2

2D Displacement Measurement — Nonlinear Trend Line (Quadratic Regression) — Linear Trend Line (Linear Regression)

AOI 10 *(PPG 2)* - Location Map

AOI 10 *(PPG 2)* - Vertical Time Series

Vertical (11/29/2024) Point Count: **31**



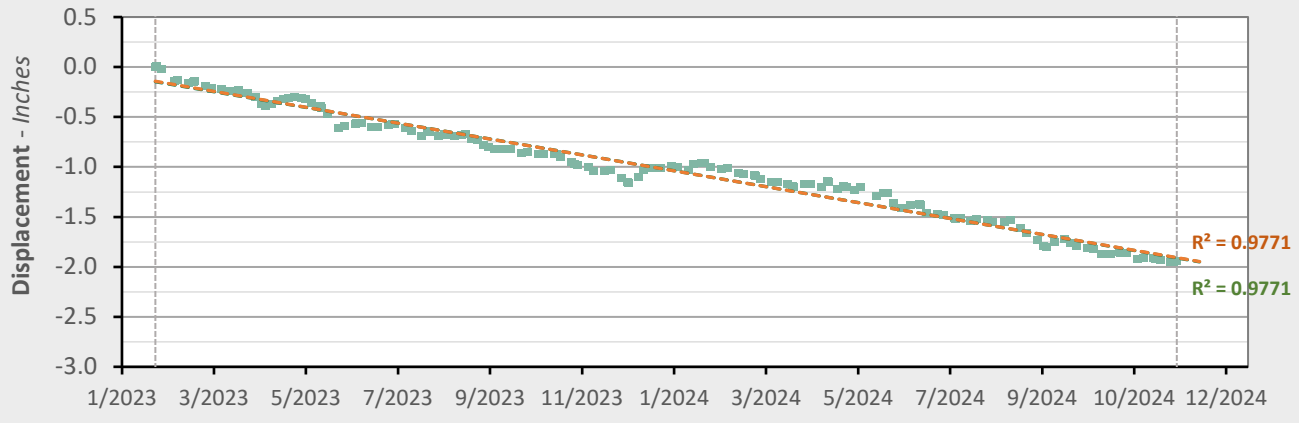
	Nonlinear Trend	Linear Trend
Velocity:	-0.94 in/yr	-1.11 in/yr
Acceleration:	+0.18 in/yr^2	0.00 in/yr^2

2D Displacement Measurement — Nonlinear Trend Line (Quadratic Regression) — Linear Trend Line (Linear Regression)

AOI 11 *(PPG 5)* - Location Map

AOI 11 *(PPG 5)* - Vertical Time Series

Vertical (11/29/2024) Point Count: **10**



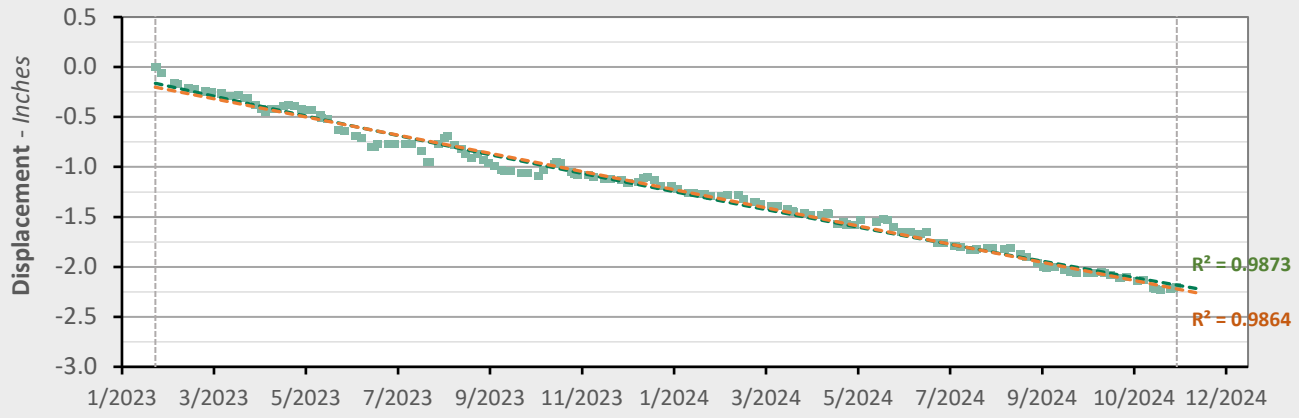
	Nonlinear Trend	Linear Trend
Velocity:	-0.97 in/yr	-0.95 in/yr
Acceleration:	-0.01 in/yr^2	0.00 in/yr^2

2D Displacement Measurement | Nonlinear Trend Line (Quadratic Regression) | Linear Trend Line (Linear Regression)

AOI 12 *(PPG 4)* - Location Map

AOI 12 *(PPG 4)* - Vertical Time Series

Vertical (11/29/2024) Point Count: **15**



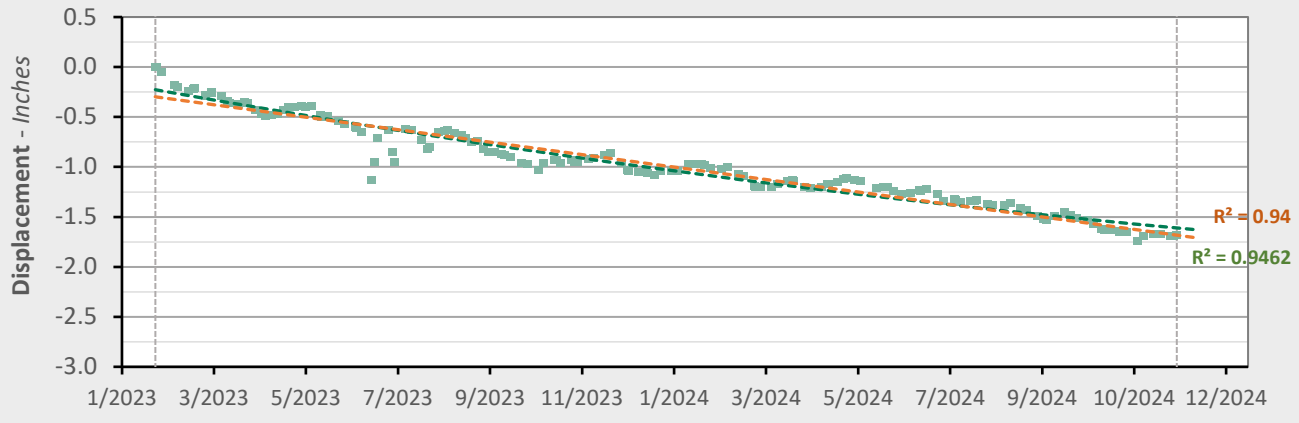
	Nonlinear Trend	Linear Trend
Velocity:	-0.96 in/yr	-1.09 in/yr
Acceleration:	+0.14 in/yr^2	0.00 in/yr^2

2D Displacement Measurement — Nonlinear Trend Line (Quadratic Regression) — Linear Trend Line (Linear Regression)

AOI 13 *(PPG 18)* - Location Map

AOI 13 *(PPG 18)* - Vertical Time Series

Vertical (11/29/2024) Point Count: **2**



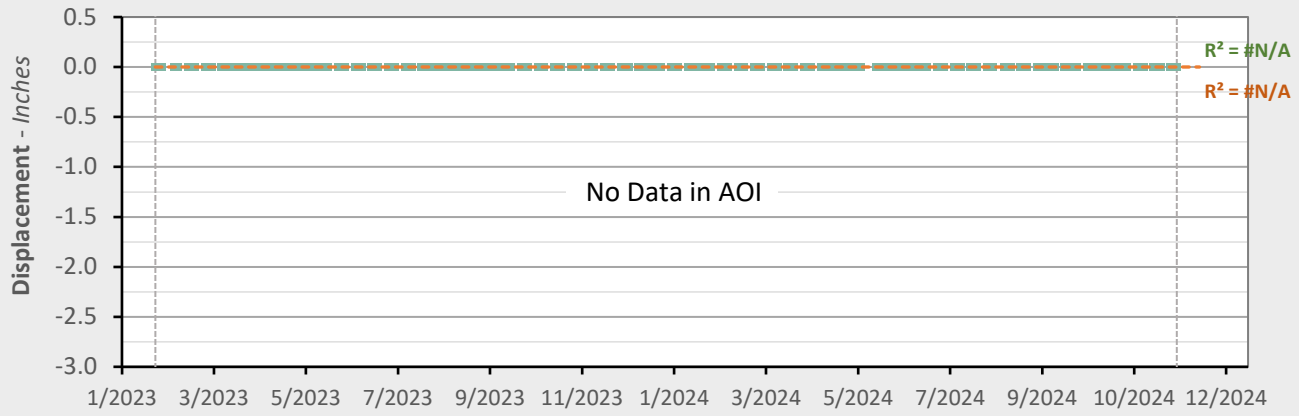
	Nonlinear Trend	Linear Trend
Velocity:	-0.51 in/yr	-0.75 in/yr
Acceleration:	+0.26 in/yr^2	0.00 in/yr^2

2D Displacement Measurement | Nonlinear Trend Line (Quadratic Regression) | Linear Trend Line (Linear Regression)

AOI 14 *(PPG 16)* - Location Map

AOI 14 *(PPG 16)* - Vertical Time Series

Vertical (11/29/2024) Point Count: **0**



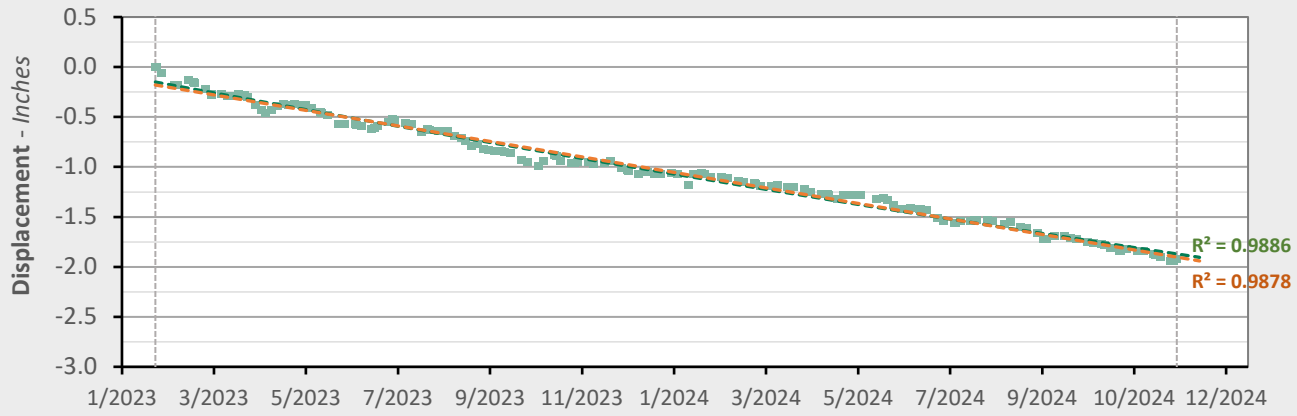
	Nonlinear Trend		Linear Trend	
Velocity:	N/A	in/yr	N/A	in/yr
Acceleration:	N/A	in/yr^2	N/A	in/yr^2

2D Displacement Measurement — Nonlinear Trend Line (Quadratic Regression) — Linear Trend Line (Linear Regression)

AOI 15 *(PPG 20)* - Location Map

AOI 15 *(PPG 20)* - Vertical Time Series

Vertical (11/29/2024) Point Count: **14**



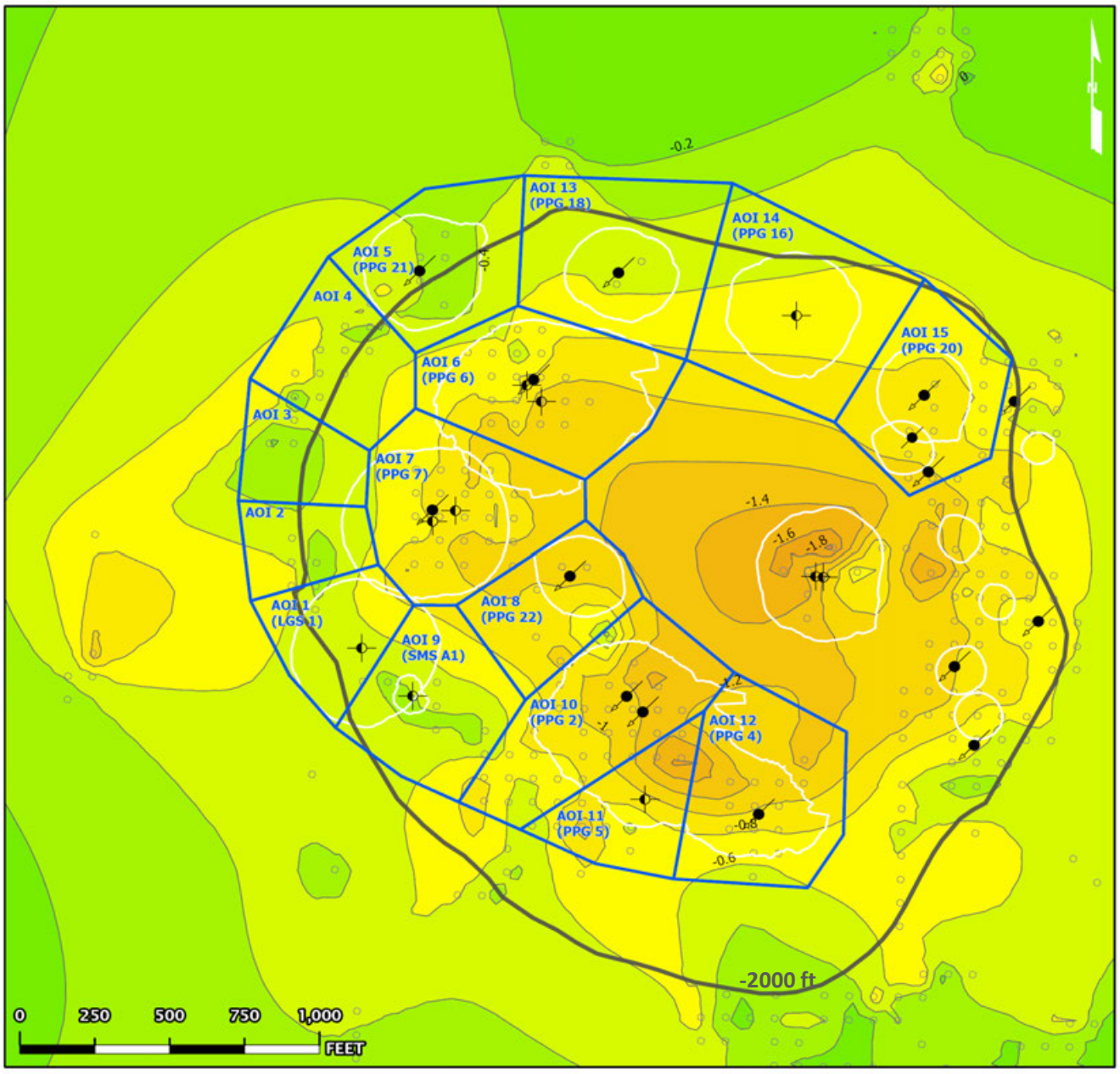
	Nonlinear Trend	Linear Trend
Velocity:	-0.83 in/yr	-0.93 in/yr
Acceleration:	+0.11 in/yr^2	0.00 in/yr^2

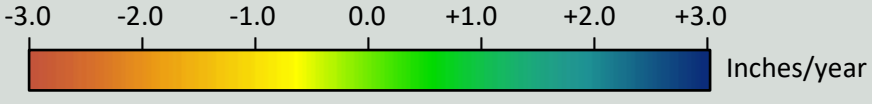
2D Displacement Measurement | Nonlinear Trend Line (Quadratic Regression) | Linear Trend Line (Linear Regression)

Vertical Data (01/24/2023 - 11/29/2024)

Nonlinear Velocity Contours

As of date: 11/29/2024





AOI Boundary InSAR LOS Measurement Point Contour (0.2)

Historical Cavern Extent Top of Dome (-2000 ft Contour)

Cavern Well Surface Locations

09 - Active - Injection 29 - Dry and Plugged

Vertical Data (01/24/2023 - 11/29/2024)

Nonlinear Acceleration Contours

Date range: 01/24/2023 - 11/29/2024

-6.0 -4.0 -2.0 0.0 +2.0 +4.0 +6.0

Inches/year^2

AOI Boundary | InSAR LOS Measurement Point | Contour (0.5)

Historical Cavern Extent | Top of Dome (-2000 ft Contour)

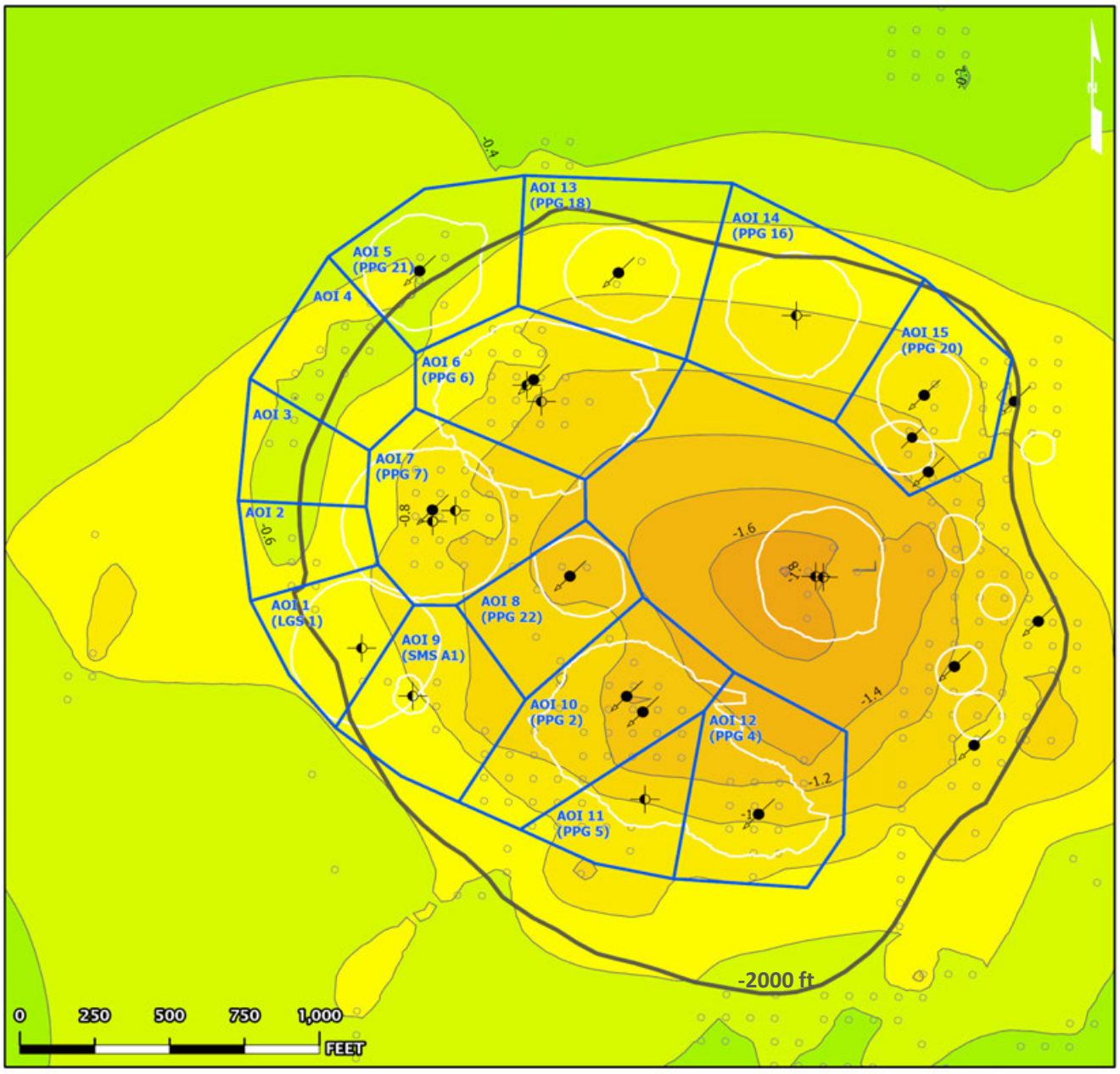
Cavern Well Surface Locations

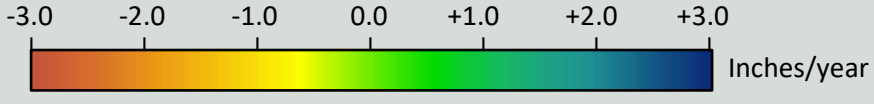
09 - Active - Injection | 29 - Dry and Plugged

Vertical Data (01/24/2023 - 11/29/2024)

Linear Velocity Contours

Date range: 01/24/2023 - 11/29/2024





AOI Boundary ○ InSAR LOS Measurement Point — Contour (0.2)

Historical Cavern Extent Top of Dome (-2000 ft Contour)

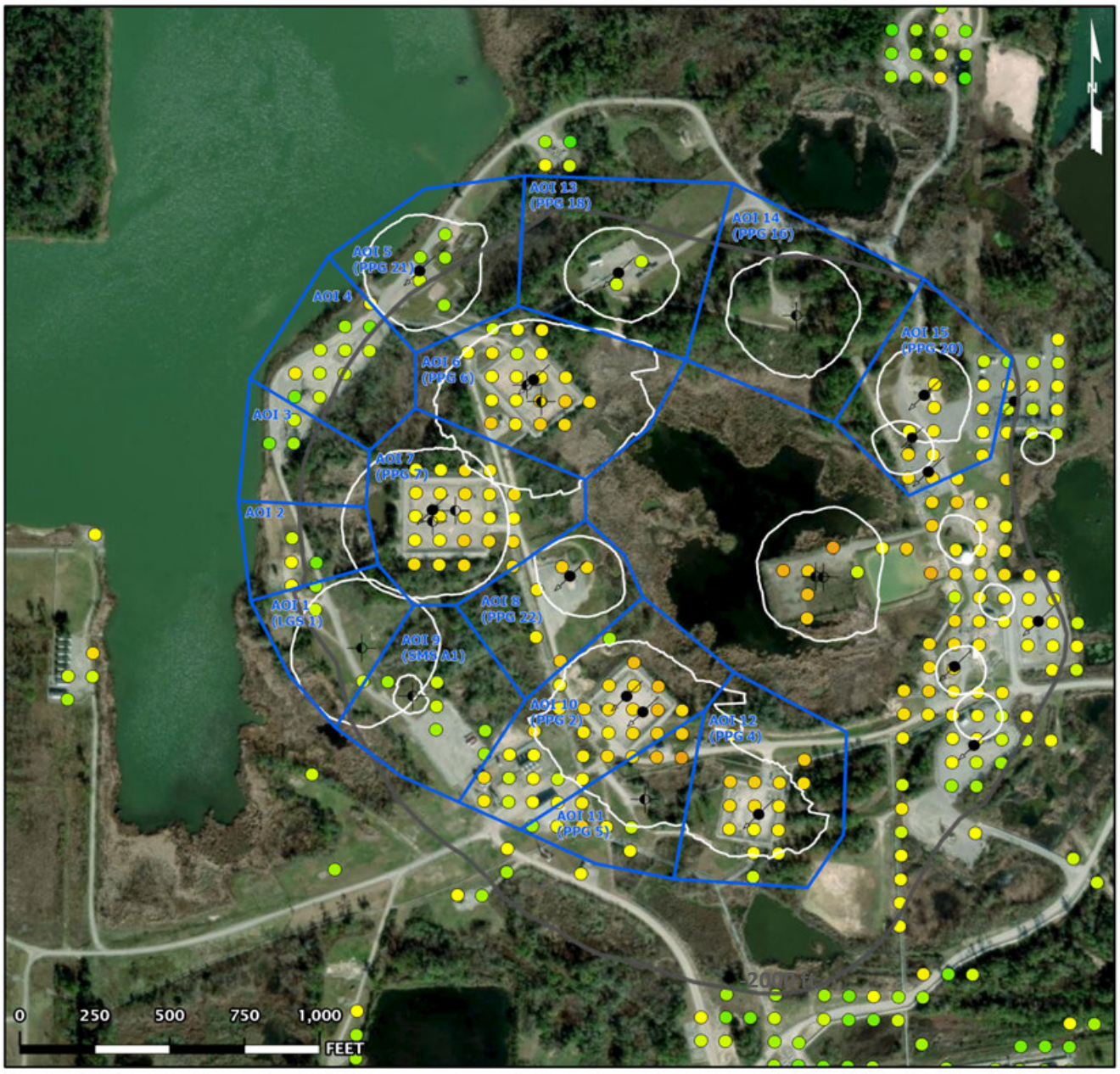
Cavern Well Surface Locations

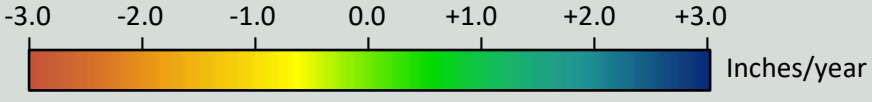
09 - Active - Injection 29 - Dry and Plugged

Vertical Data (01/24/2023 - 11/29/2024)

Nonlinear Velocity Data Points

As of date: 11/29/2024





AOI Boundary
InSAR LOS Measurement Point
Historical Cavern Extent
Top of Dome (-2000 ft Contour)

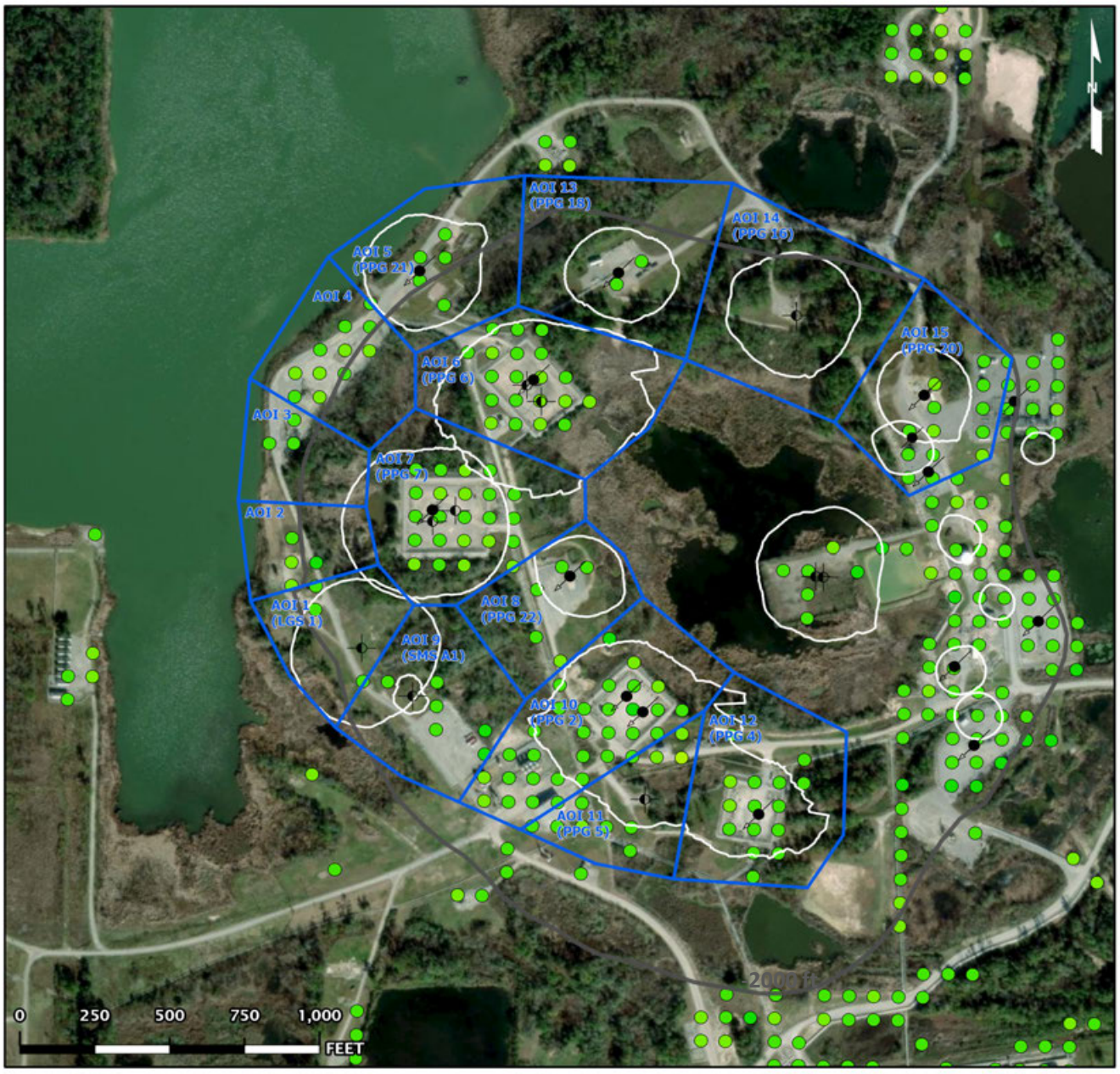
Cavern Well Surface Locations

09 - Active - Injection
29 - Dry and Plugged

Vertical Data (01/24/2023 - 11/29/2024)

Nonlinear Acceleration Data Points

Date range: 01/24/2023 - 11/29/2024



-6.0 -4.0 -2.0 0.0 +2.0 +4.0 +6.0

Inches/year^2

AOI Boundary
InSAR LOS Measurement Point
Historical Cavern Extent
Top of Dome (-2000 ft Contour)

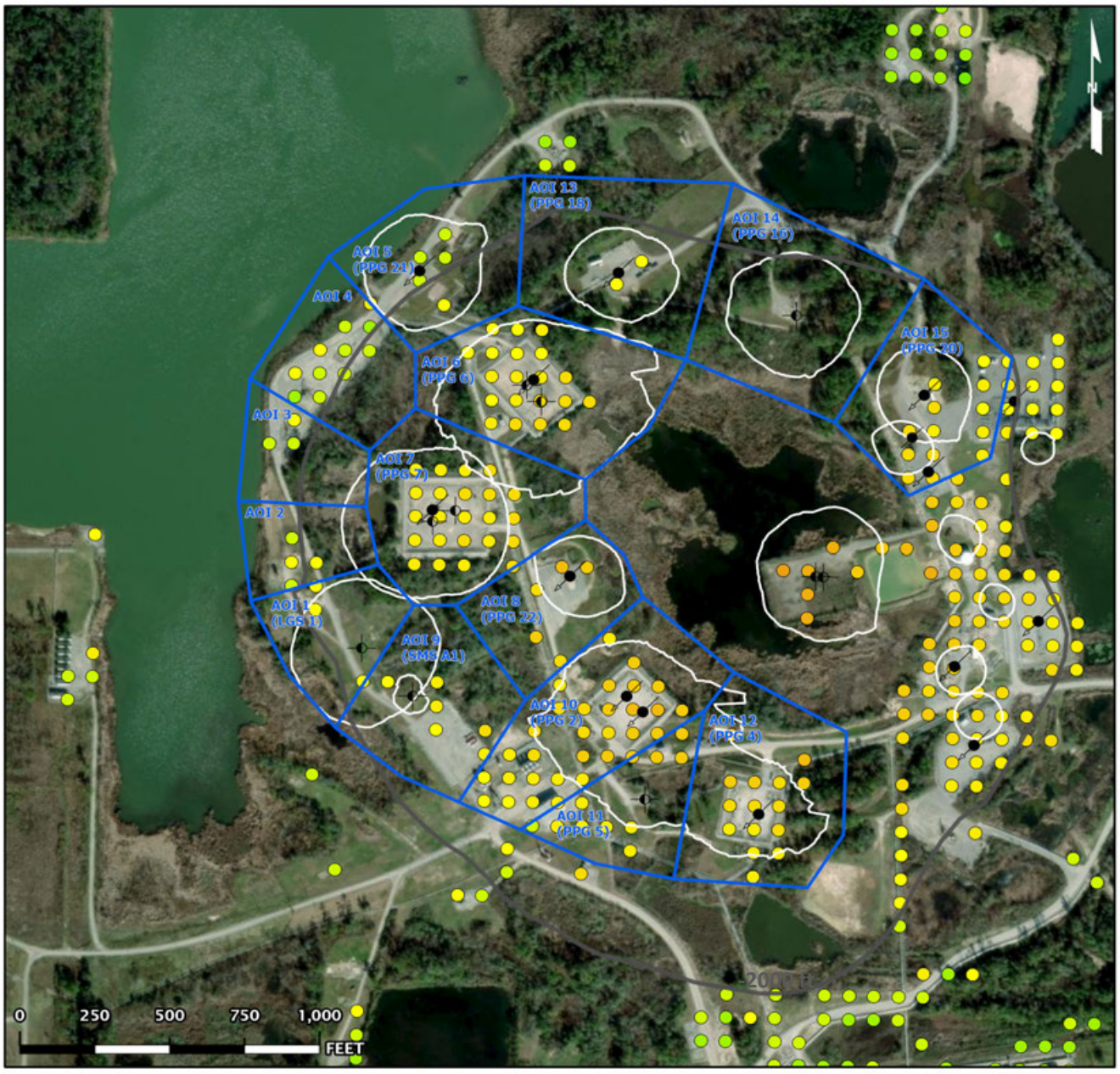
Cavern Well Surface Locations

09 - Active - Injection
29 - Dry and Plugged

Vertical Data (01/24/2023 - 11/29/2024)

Linear Velocity Data Points

Date range: 01/24/2023 - 11/29/2024



-3.0 -2.0 -1.0 0.0 +1.0 +2.0 +3.0

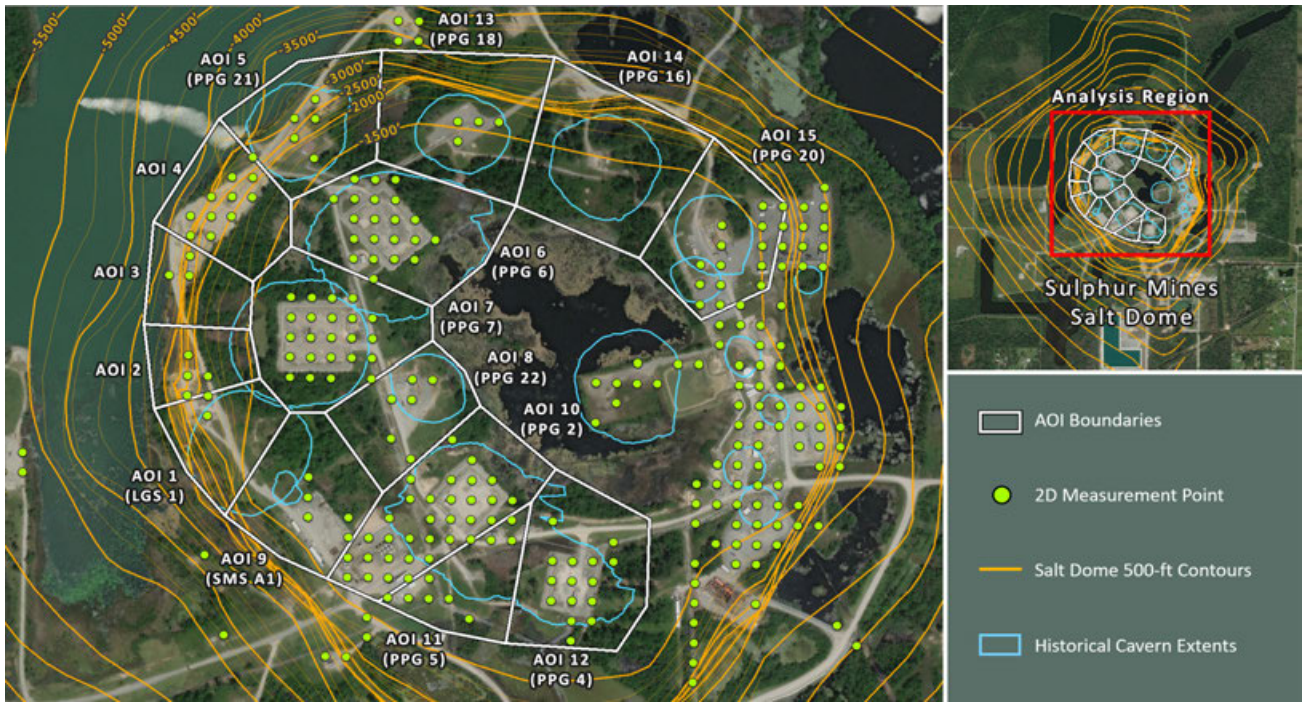
Inches/year

AOI Boundary
InSAR LOS Measurement Point
Historical Cavern Extent
Top of Dome (-2000 ft Contour)

Cavern Well Surface Locations

09 - Active - Injection
29 - Dry and Plugged

AOI Boundaries & 2D InSAR Measurement Points



Subsidence Monitoring Areas of Interest (AOIs)

To visually convey and evaluate trend consistency for the East-West displacement time series of each ground target, measurment points were grouped and their displacement values were averaged. The point groups are referred to as Areas of Interest (AOIs) in this analysis and their boundaries are depicted on the above map. The below table lists the East-West trend values calculated in each AOI for the dataset evaluated in this report.

AOI Name	East-West (11/29/2024)	East-West Velocity (in/yr)		East-West Acceleration (in/yr²)	
	Point Count	Nonlinear	Linear	Nonlinear	Linear
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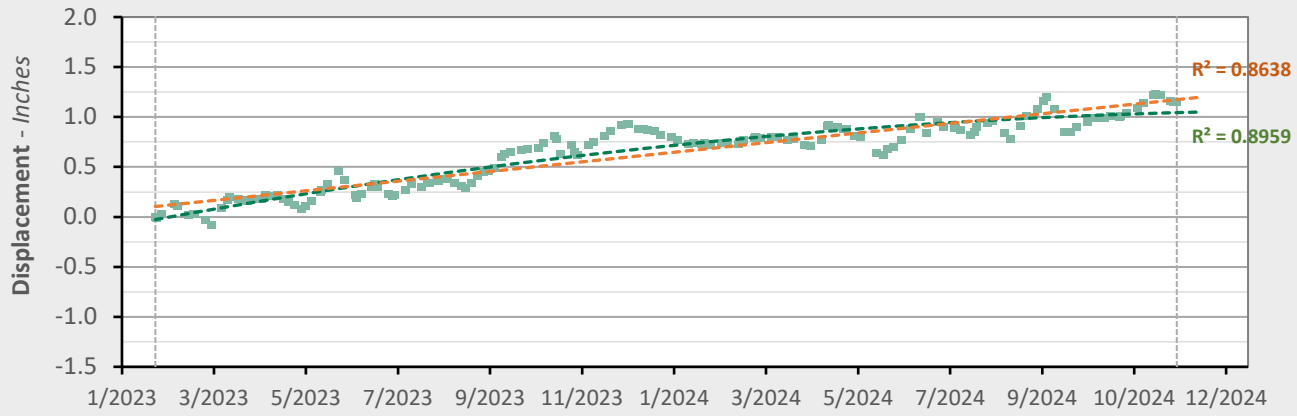
AOI 2	4	+0.25	+0.61	-0.39	0.00
AOI 3	3	+0.11	+0.48	-0.39	0.00
AOI 4	11	+0.39	+0.48	-0.10	0.00
AOI 5 *(PPG 21)*	5	+0.17	+0.24	-0.08	0.00
AOI 6 *(PPG 6)*	20	+0.22	+0.31	-0.10	0.00
AOI 7 *(PPG 7)*	23	+0.47	+0.58	-0.12	0.00
AOI 8 *(PPG 22)*	5	+0.34	+0.50	-0.17	0.00
AOI 9 *(SMS A1)*	6	+0.16	+0.46	-0.33	0.00
AOI 10 *(PPG 2)*	31	+0.23	+0.34	-0.12	0.00
AOI 11 *(PPG 5)*	10	+0.19	+0.29	-0.10	0.00
AOI 12 *(PPG 4)*	15	-0.24	-0.19	-0.06	0.00
AOI 13 *(PPG 18)*	2	+0.10	+0.10	-0.00	0.00
AOI 14 *(PPG 16)*	0	N/A	N/A	N/A	N/A
AOI 15 *(PPG 20)*	14	-0.54	-0.55	+0.01	0.00

AOI 1 *(LGS 1)* - Location Map

AOI 1 *(LGS 1)* - East-West Time Series

E-W (11/29/2024) Point Count: **3**



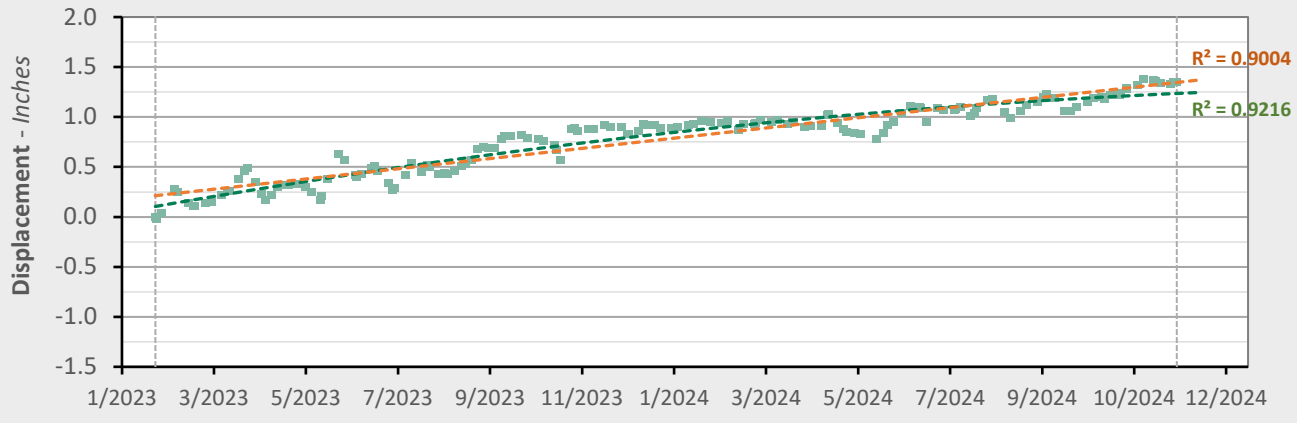
	Nonlinear Trend		Linear Trend	
Velocity:	+0.15	in/yr	+0.58	in/yr
Acceleration:	-0.47	in/yr^2	0.00	in/yr^2

2D Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 2 - Location Map

AOI 2 - East-West Time Series

E-W (11/29/2024) Point Count: 4



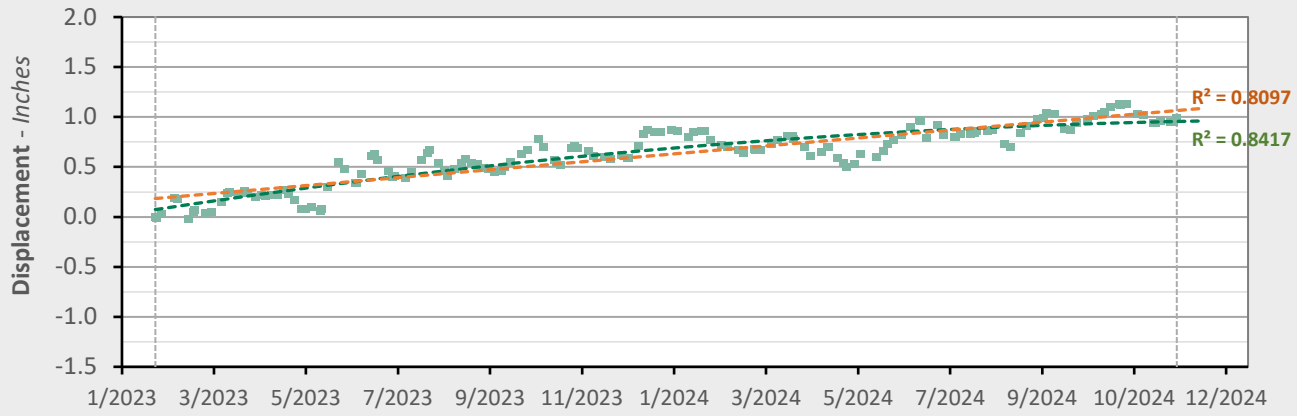
	Nonlinear Trend	Linear Trend
Velocity:	+0.25 in/yr	+0.61 in/yr
Acceleration:	-0.39 in/yr^2	0.00 in/yr^2

2D Displacement Measurement | Nonlinear Trend Line (Quadratic Regression) | Linear Trend Line (Linear Regression)

AOI 3 - Location Map

AOI 3 - East-West Time Series

E-W (11/29/2024) Point Count: **3**



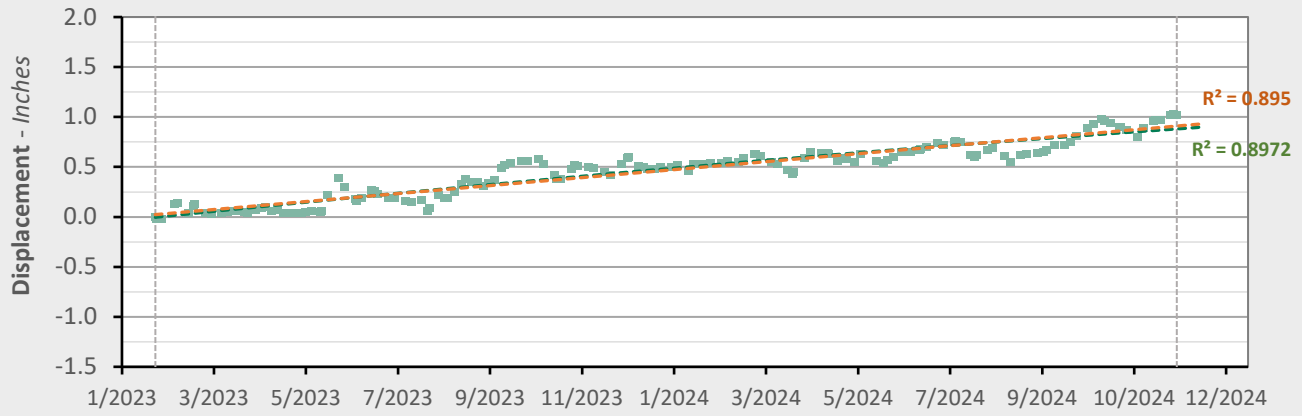
	Nonlinear Trend		Linear Trend	
Velocity:	+0.11	in/yr	+0.48	in/yr
Acceleration:	-0.39	in/yr^2	0.00	in/yr^2

2D Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 4 - Location Map

AOI 4 - East-West Time Series

E-W (11/29/2024) Point Count: **11**



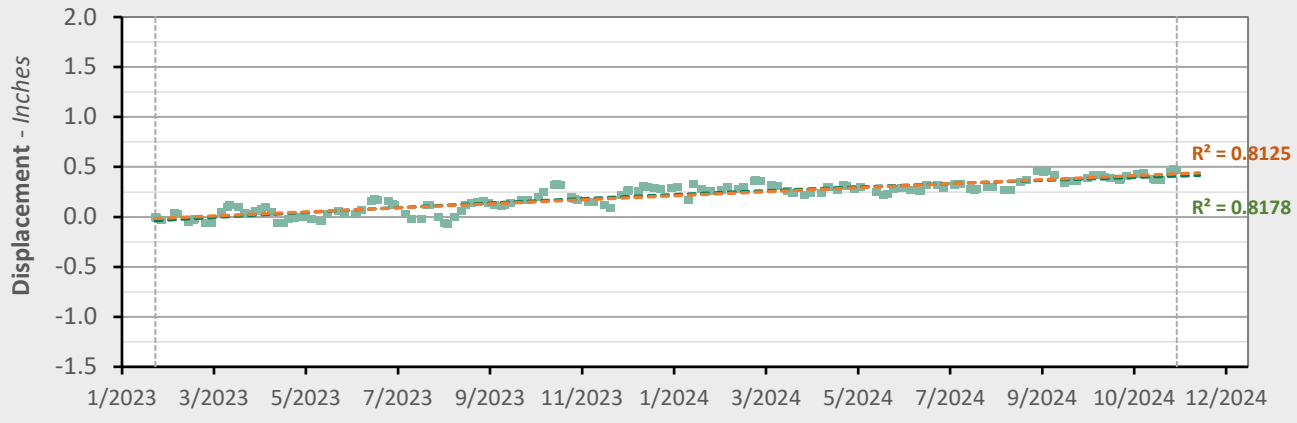
	Nonlinear Trend		Linear Trend	
Velocity:	+0.39	in/yr	+0.48	in/yr
Acceleration:	-0.10	in/yr^2	0.00	in/yr^2

2D Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 5 *(PPG 21)* - Location Map

AOI 5 *(PPG 21)* - East-West Time Series

E-W (11/29/2024) Point Count: **5**



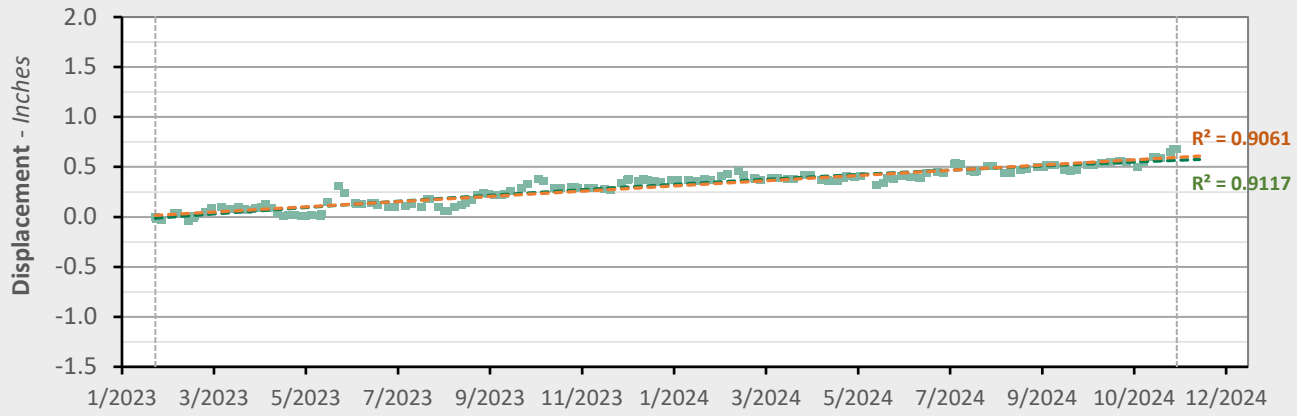
	Nonlinear Trend		Linear Trend	
Velocity:	+0.17	in/yr	+0.24	in/yr
Acceleration:	-0.08	in/yr^2	0.00	in/yr^2

2D Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 6 *(PPG 6)* - Location Map

AOI 6 *(PPG 6)* - East-West Time Series

E-W (11/29/2024) Point Count: **20**



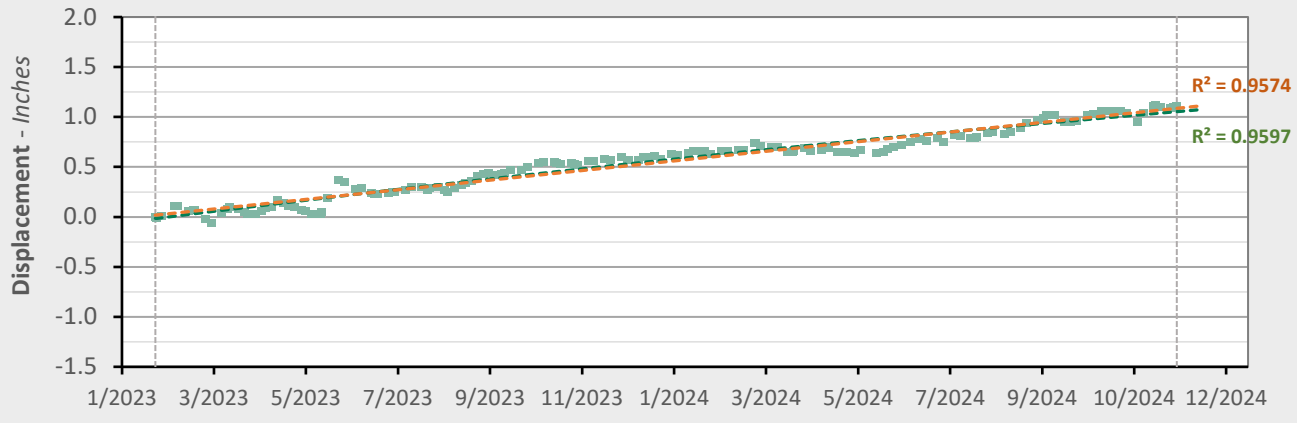
	Nonlinear Trend		Linear Trend	
Velocity:	+0.22	in/yr	+0.31	in/yr
Acceleration:	-0.10	in/yr^2	0.00	in/yr^2

2D Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 7 *(PPG 7)* - Location Map

AOI 7 *(PPG 7)* - East-West Time Series

E-W (11/29/2024) Point Count: **23**



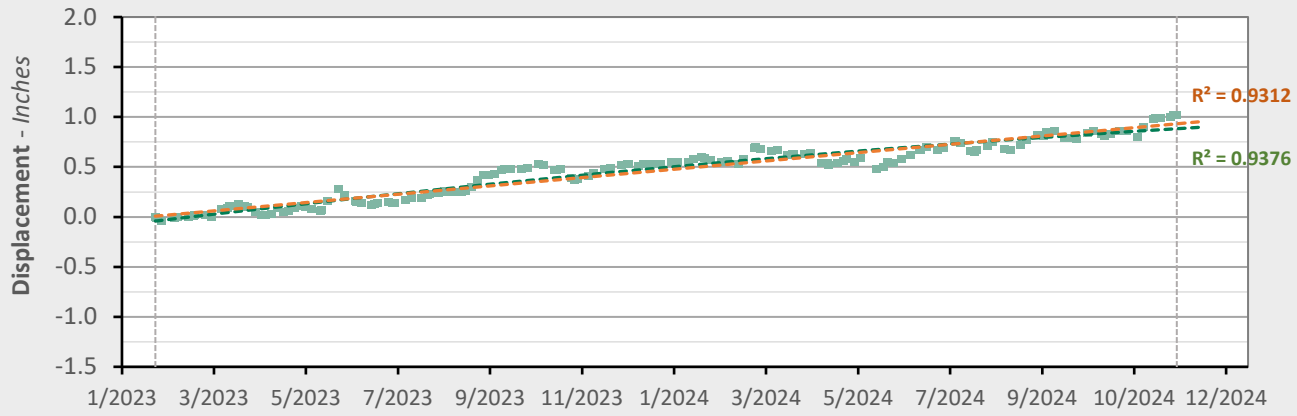
	Nonlinear Trend		Linear Trend	
Velocity:	+0.47	in/yr	+0.58	in/yr
Acceleration:	-0.12	in/yr^2	0.00	in/yr^2

2D Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 8 *(PPG 22)* - Location Map

AOI 8 *(PPG 22)* - East-West Time Series

E-W (11/29/2024) Point Count: **5**



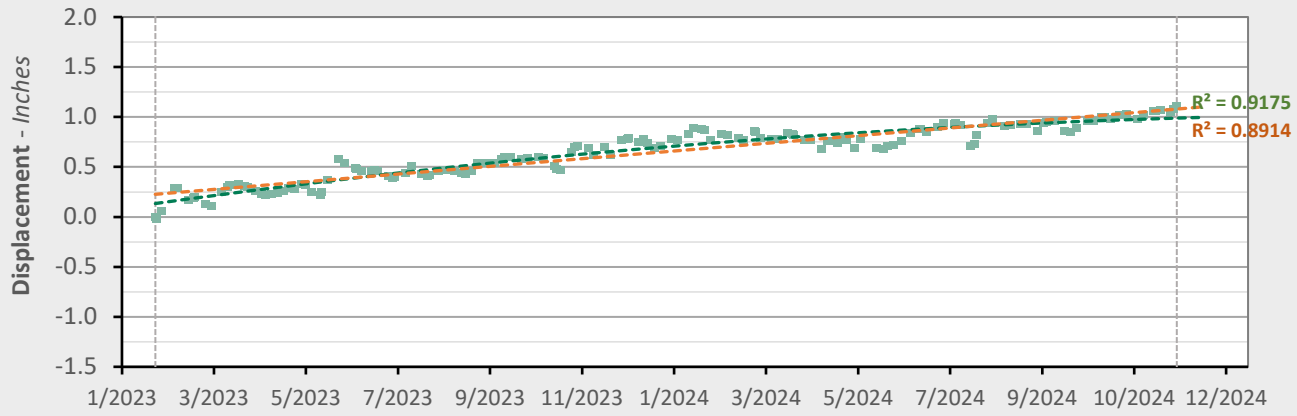
	Nonlinear Trend		Linear Trend	
Velocity:	+0.34	in/yr	+0.50	in/yr
Acceleration:	-0.17	in/yr^2	0.00	in/yr^2

2D Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 9 *(PPG A1)* - Location Map

AOI 9 *(SMS A1)* - East-West Time Series

E-W (11/29/2024) Point Count: **6**



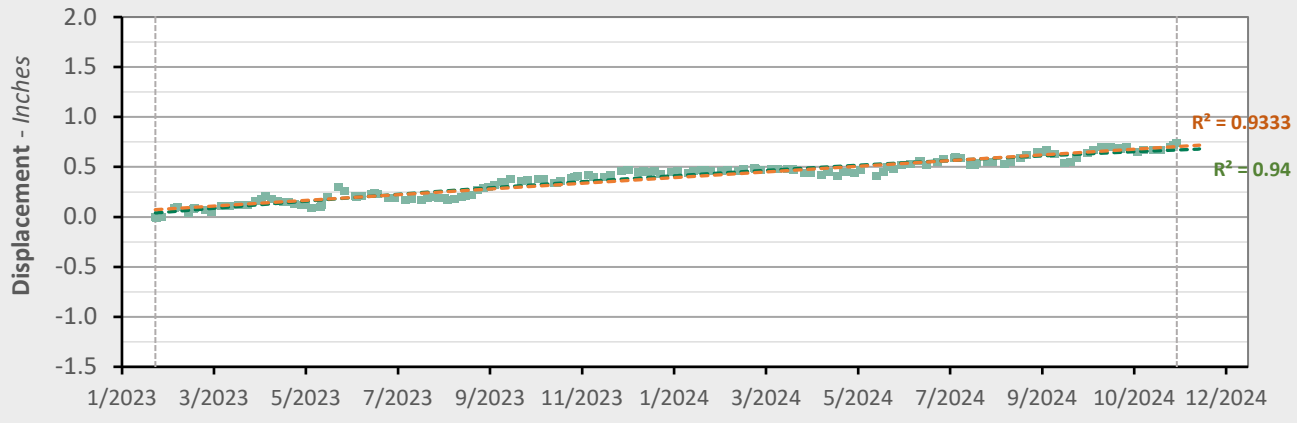
	Nonlinear Trend	Linear Trend
Velocity:	+0.16 in/yr	+0.46 in/yr
Acceleration:	-0.33 in/yr^2	0.00 in/yr^2

2D Displacement Measurement | Nonlinear Trend Line (Quadratic Regression) | Linear Trend Line (Linear Regression)

AOI 10 *(PPG 2)* - Location Map

AOI 10 *(PPG 2)* - East-West Time Series

E-W (11/29/2024) Point Count: **31**



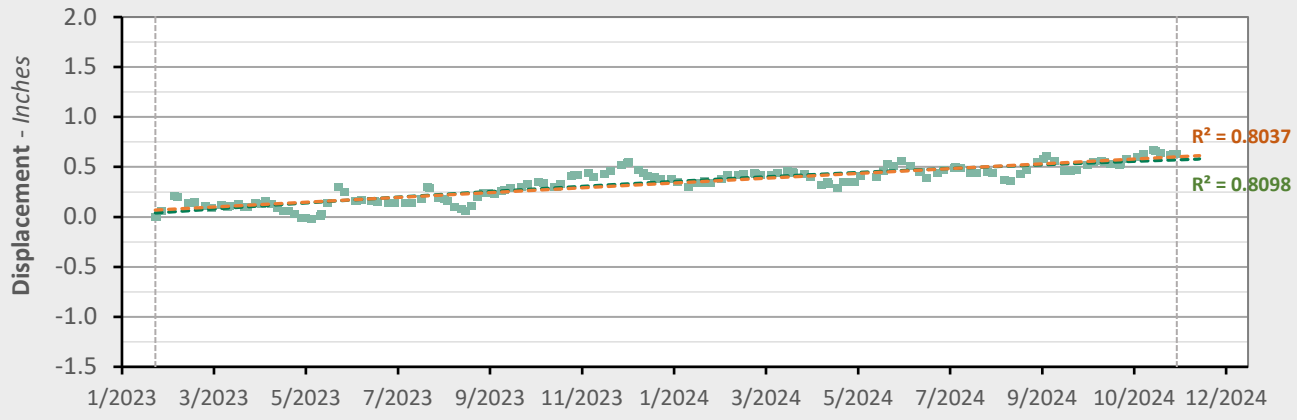
	Nonlinear Trend	Linear Trend
Velocity:	+0.23 in/yr	+0.34 in/yr
Acceleration:	-0.12 in/yr^2	0.00 in/yr^2

2D Displacement Measurement | Nonlinear Trend Line (Quadratic Regression) | Linear Trend Line (Linear Regression)

AOI 11 *(PPG 5)* - Location Map

AOI 11 *(PPG 5)* - East-West Time Series

E-W (11/29/2024) Point Count: **10**



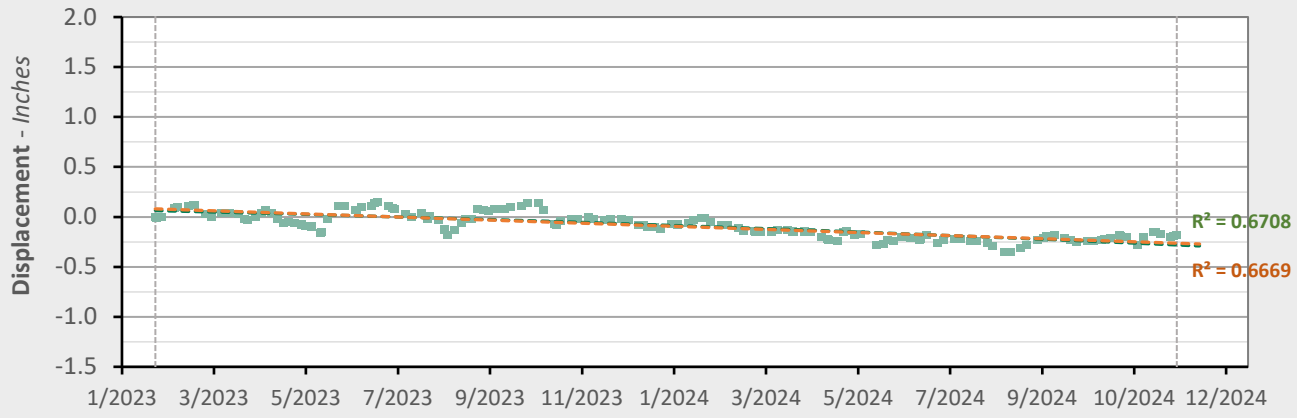
	Nonlinear Trend		Linear Trend	
Velocity:	+0.19	in/yr	+0.29	in/yr
Acceleration:	-0.10	in/yr^2	0.00	in/yr^2

2D Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 12 *(PPG 4)* - Location Map

AOI 12 *(PPG 4)* - East-West Time Series

E-W (11/29/2024) Point Count: **15**



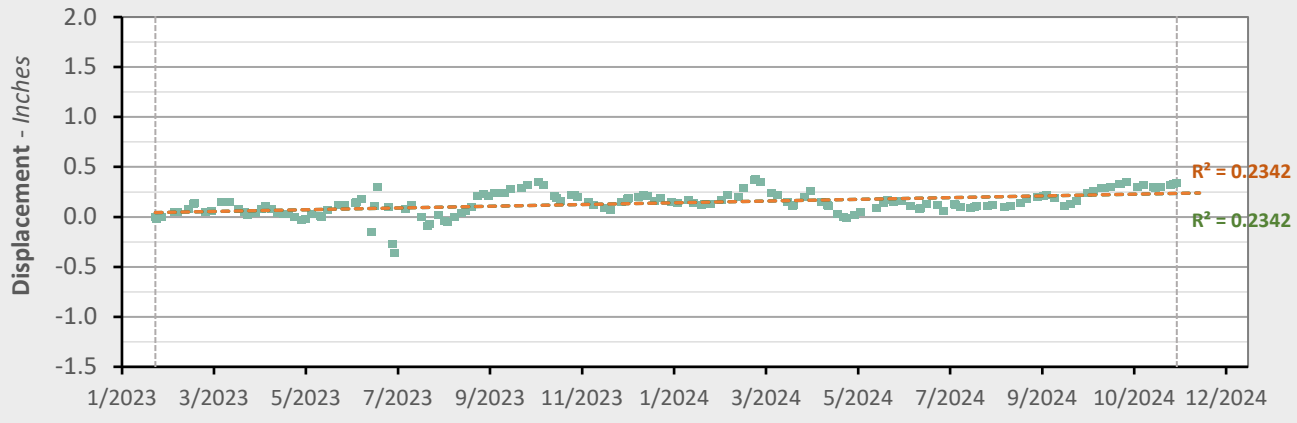
	Nonlinear Trend	Linear Trend
Velocity:	-0.24 in/yr	-0.19 in/yr
Acceleration:	-0.06 in/yr^2	0.00 in/yr^2

2D Displacement Measurement | Nonlinear Trend Line (Quadratic Regression) | Linear Trend Line (Linear Regression)

AOI 13 *(PPG 18)* - Location Map

AOI 13 *(PPG 18)* - East-West Time Series

E-W (11/29/2024) Point Count: **2**



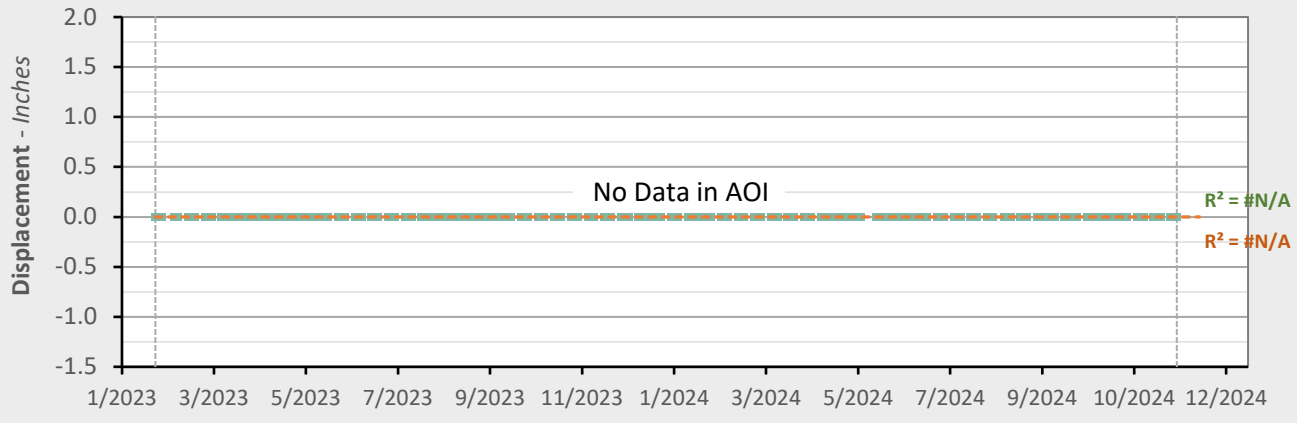
	Nonlinear Trend		Linear Trend	
Velocity:	+0.10	in/yr	+0.10	in/yr
Acceleration:	-0.00	in/yr^2	0.00	in/yr^2

2D Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

AOI 14 *(PPG 16)* - Location Map

AOI 14 *(PPG 16)* - East-West Time Series

E-W (11/29/2024) Point Count: **0**



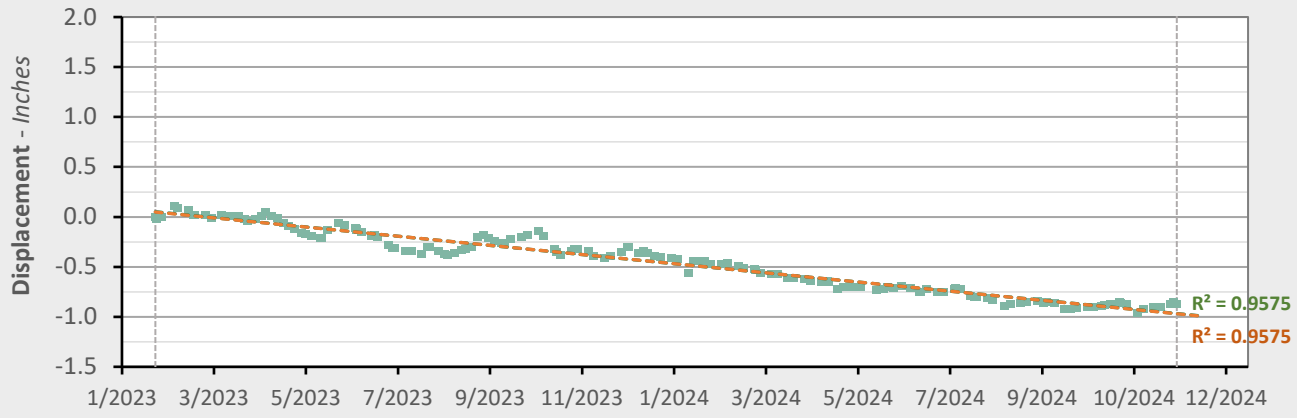
	Nonlinear Trend		Linear Trend	
Velocity:	N/A	in/yr	N/A	in/yr
Acceleration:	N/A	in/yr^2	N/A	in/yr^2

2D Displacement Measurement | Nonlinear Trend Line (Quadratic Regression) | Linear Trend Line (Linear Regression)

AOI 15 *(PPG 20)* - Location Map

AOI 15 *(PPG 20)* - East-West Time Series

E-W (11/29/2024) Point Count: **14**



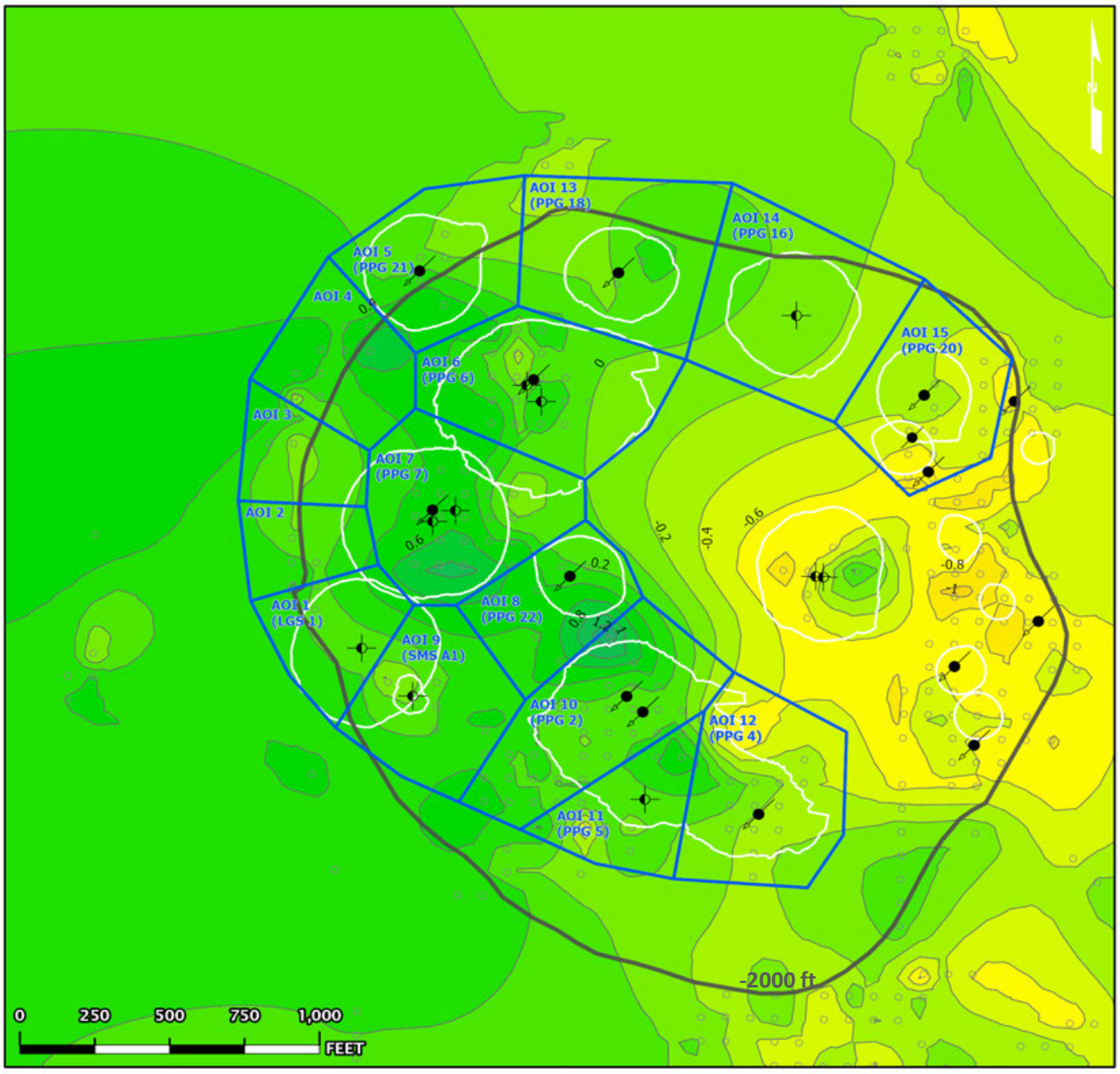
	Nonlinear Trend	Linear Trend
Velocity:	-0.54 in/yr	-0.55 in/yr
Acceleration:	+0.01 in/yr^2	0.00 in/yr^2

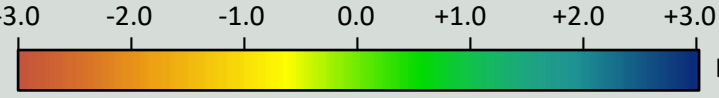
2D Displacement Measurement | Nonlinear Trend Line (Quadratic Regression) | Linear Trend Line (Linear Regression)

East-West Data (01/24/2023 - 11/29/2024)

Nonlinear Velocity Contours

As of date: 11/29/2024





AOI Boundary | InSAR LOS Measurement Point | Contour (0.2)

Historical Cavern Extent | Top of Dome (-2000 ft Contour)

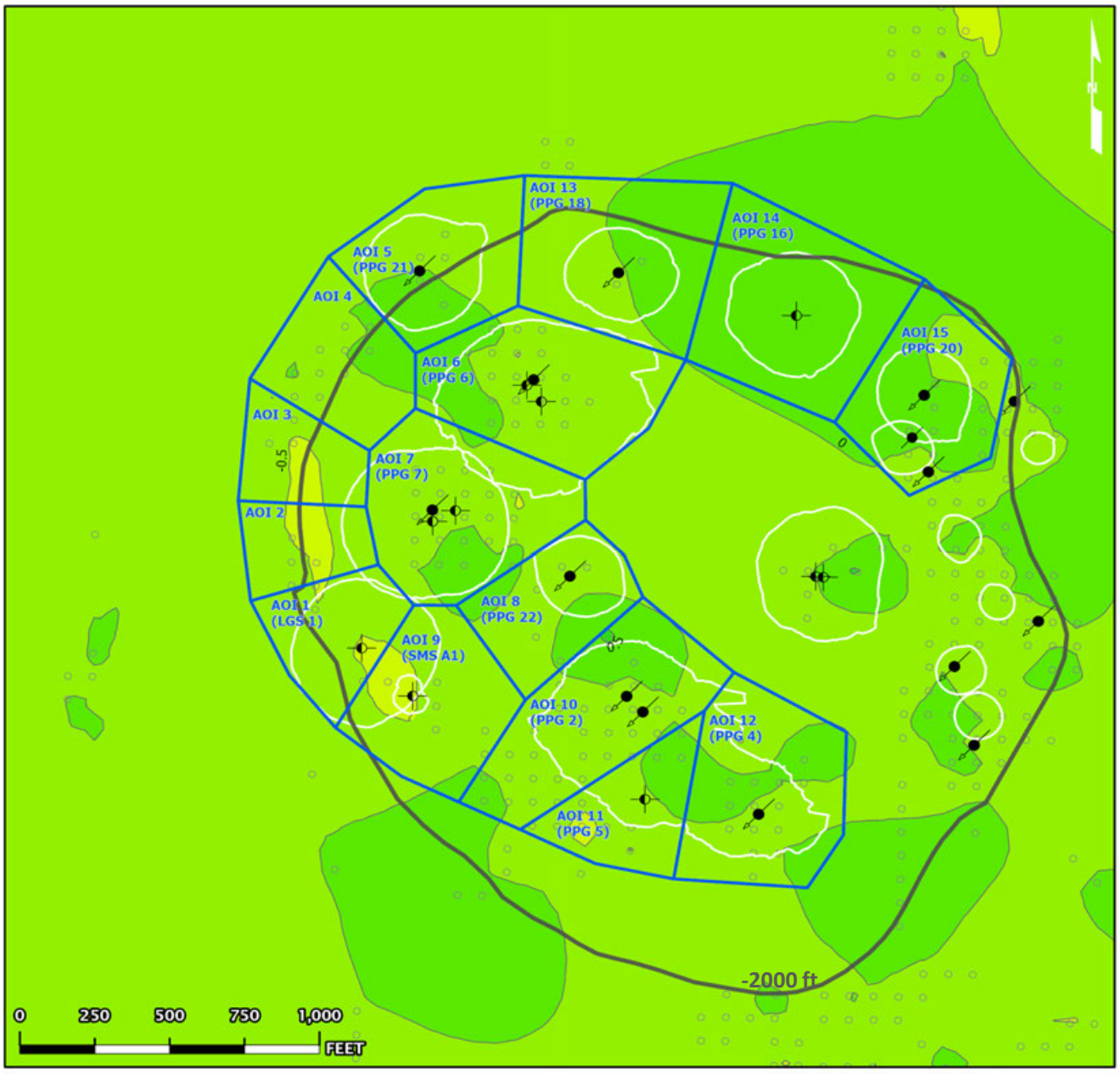
Cavern Well Surface Locations

09 - Active - Injection | 29 - Dry and Plugged

East-West Data (01/24/2023 - 11/29/2024)

Nonlinear Acceleration Contours

Date range: 01/24/2023 - 11/29/2024



-6.0 -4.0 -2.0 0.0 +2.0 +4.0 +6.0

Inches/year^2

AOI Boundary | InSAR LOS Measurement Point | Contour (0.5)

Historical Cavern Extent | Top of Dome (-2000 ft Contour)

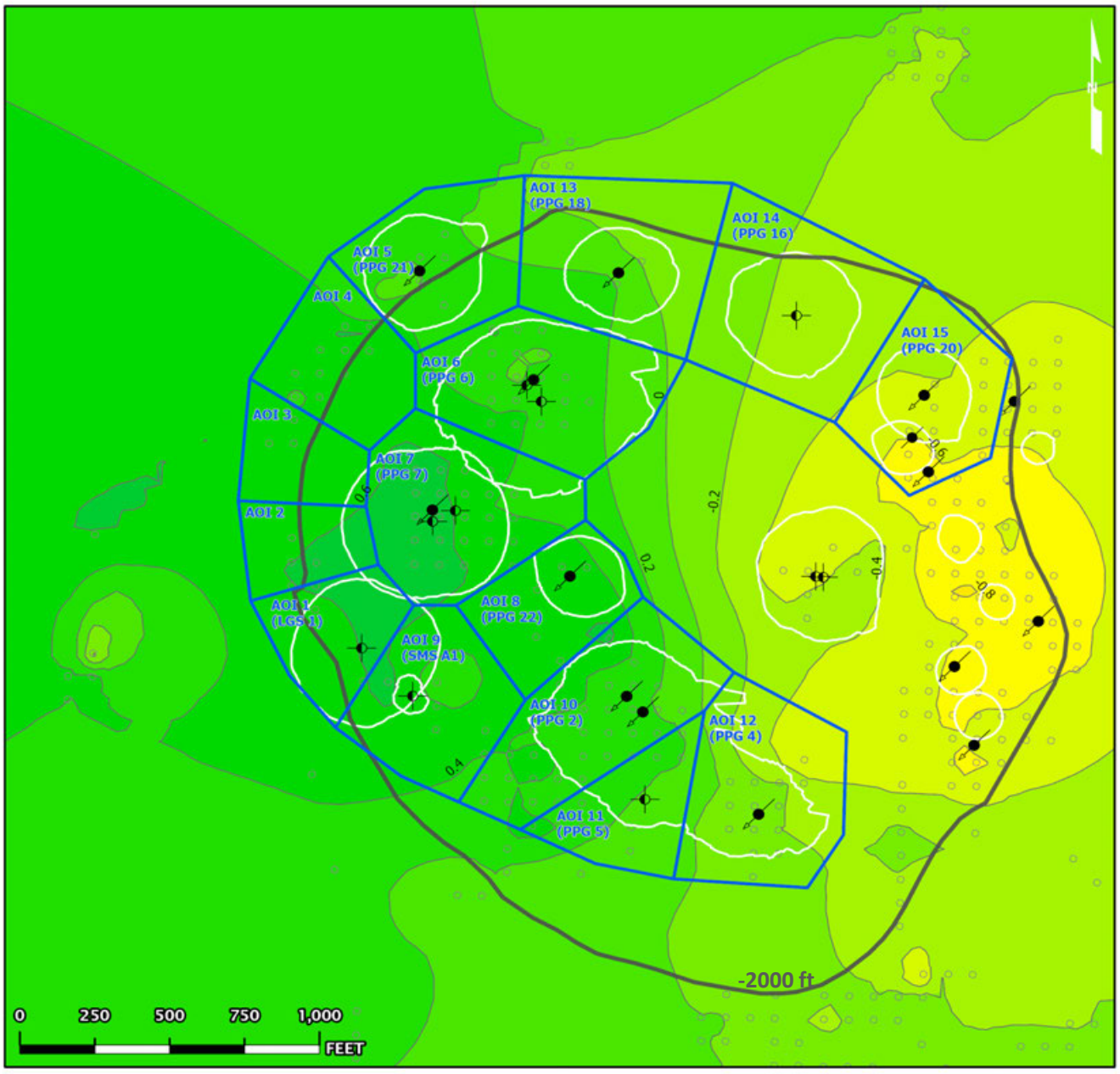
Cavern Well Surface Locations

09 - Active - Injection | 29 - Dry and Plugged

East-West Data (01/24/2023 - 11/29/2024)

Linear Velocity Contours

Date range: 01/24/2023 - 11/29/2024



-3.0 -2.0 -1.0 0.0 +1.0 +2.0 +3.0

Inches/year

AOI Boundary | InSAR LOS Measurement Point | Contour (0.2)

Historical Cavern Extent | Top of Dome (-2000 ft Contour)

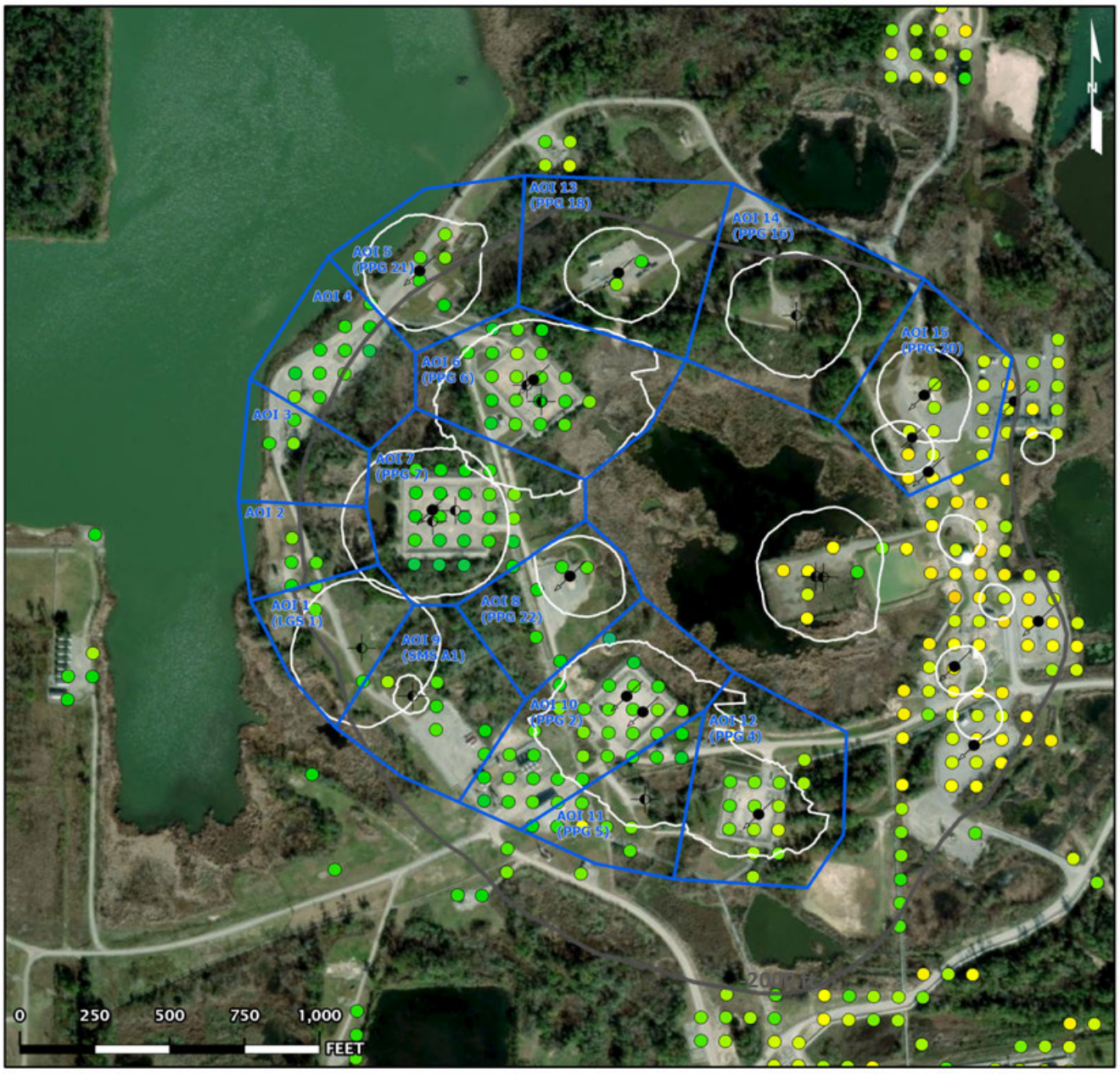
Cavern Well Surface Locations

09 - Active - Injection | 29 - Dry and Plugged

East-West Data (01/24/2023 - 11/29/2024)

Nonlinear Velocity Data Points

As of date: 11/29/2024



-3.0 -2.0 -1.0 0.0 +1.0 +2.0 +3.0

Inches/year

AOI Boundary
InSAR LOS Measurement Point
Historical Cavern Extent
Top of Dome (-2000 ft Contour)

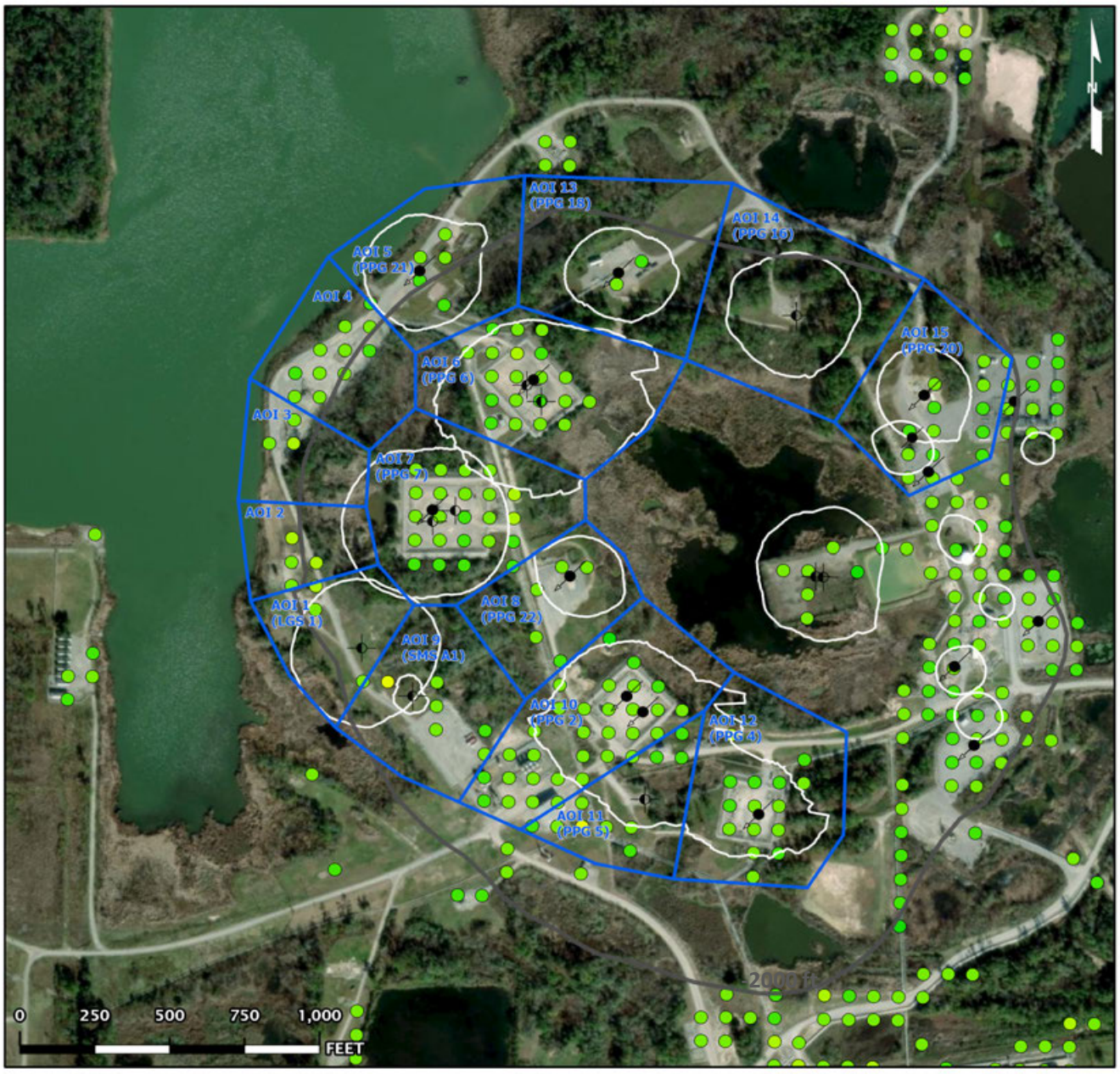
Cavern Well Surface Locations

09 - Active - Injection
29 - Dry and Plugged

East-West Data (01/24/2023 - 11/29/2024)

Nonlinear Acceleration Data Points

Date range: 01/24/2023 - 11/29/2024



-6.0 -4.0 -2.0 0.0 +2.0 +4.0 +6.0

Inches/year^2

AOI Boundary
InSAR LOS Measurement Point
Historical Cavern Extent
Top of Dome (-2000 ft Contour)

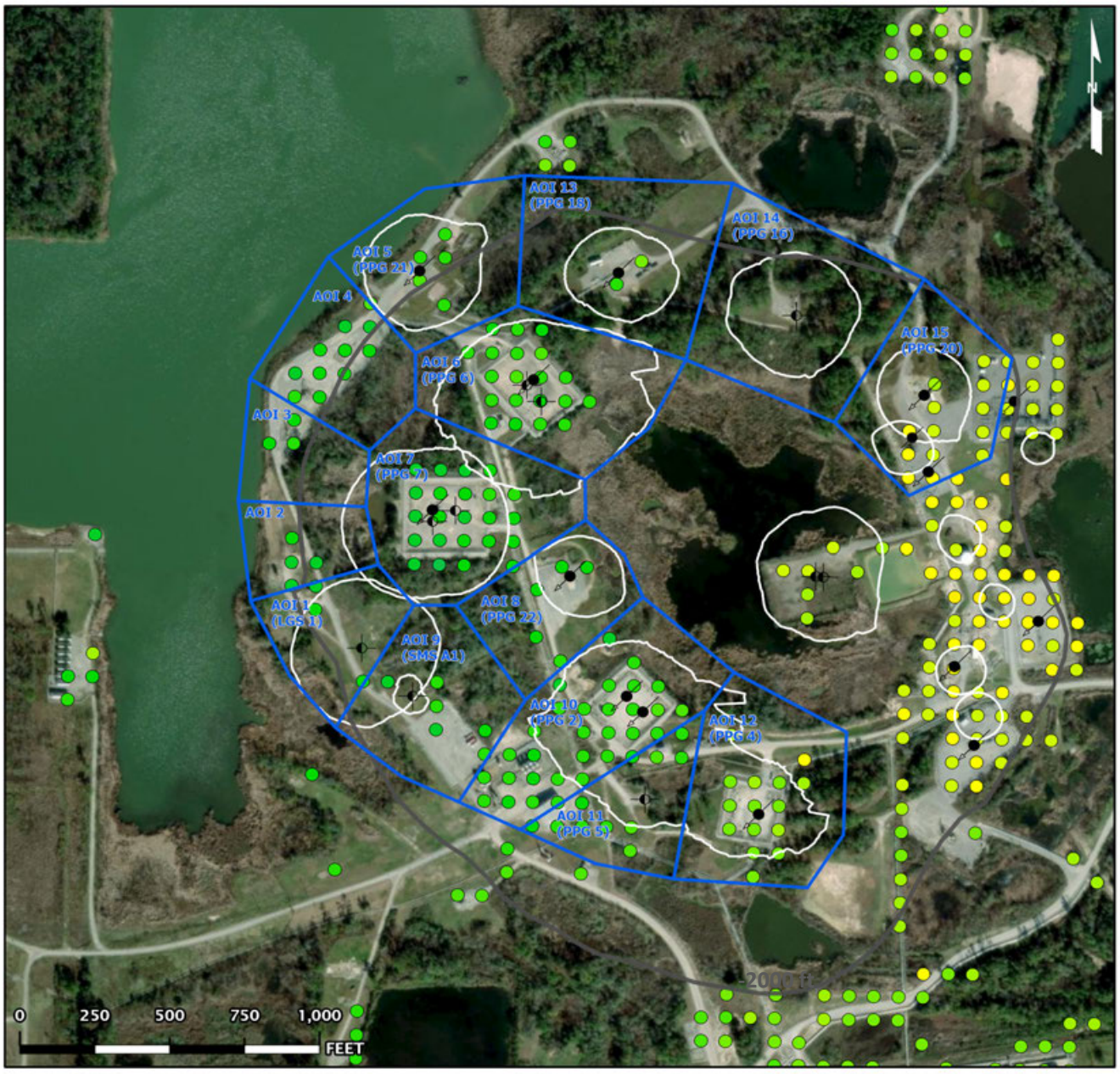
Cavern Well Surface Locations

09 - Active - Injection
29 - Dry and Plugged

East-West Data (01/24/2023 - 11/29/2024)

Linear Velocity Data Points

Date range: 01/24/2023 - 11/29/2024



-3.0 -2.0 -1.0 0.0 +1.0 +2.0 +3.0

Inches/year

AOI Boundary
InSAR LOS Measurement Point
Historical Cavern Extent
Top of Dome (-2000 ft Contour)

Cavern Well Surface Locations

09 - Active - Injection
29 - Dry and Plugged