

April 15, 2025

From:

Nathaniel Byars, Lonquist & Co. LLC

Sergey Samsonov, PhD, InSAR Corporation

**Re: Combined Monthly Surface Deformation Report – March 2025  
Sulphur Mines Salt Dome, Louisiana**

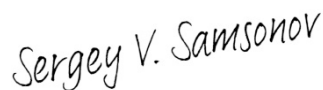
Please find attached the combined monthly deformation report for the Sulphur Mines dome, which includes results from the precision tiltmeters and GNSS stations for the March monitoring period and the cumulative InSAR results as of the end of the month.

*Status of a deformation alert plan.* We continue 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



Sergey Samsonov, PhD  
InSAR Corporation

Attachment List

- A. Tiltmeter/GNSS Data Report - March 2025
- B. SNT InSAR report - March 27, 2025
- C. TSX/PAZ InSAR report - March 30, 2025
- D. Vertical & East-West 2D InSAR report - March 30, 2025

# **ATTACHMENT A**

## **Tiltmeter/GNSS Data Report - March 2025**

April 15, 2025

Sergey Samsonov, PhD, InSAR Corporation  
 Nathaniel Byars, Lonquist & Co. LLC

**Re: Tiltmeter/GNSS Data Evaluation – March 2025, Sulphur Mines Salt Dome, Louisiana**

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.

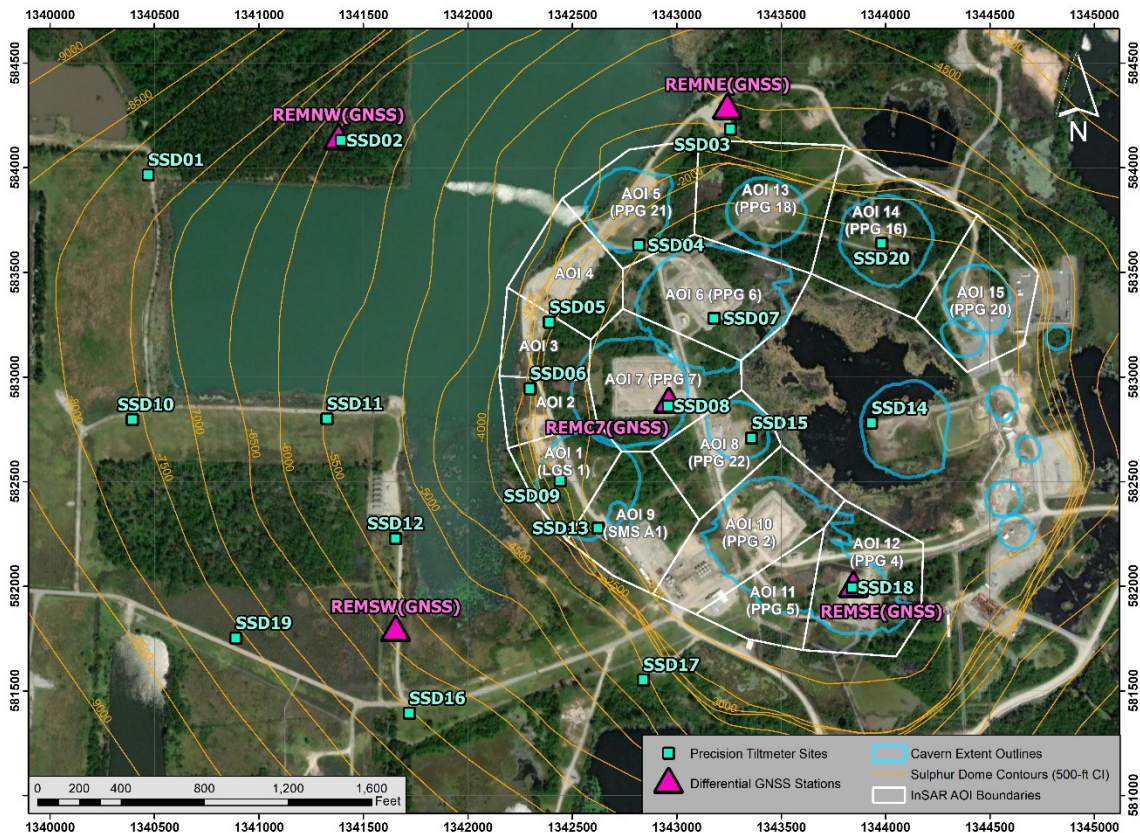


Figure 1. Map of the tiltmeter and GNSS network installed at Sulphur Mines dome. The cyan squares indicate the tiltmeter site locations. The GNSS stations are shown by pink triangles. The InSAR AOI boundaries are shown for reference. The surface projection of the various salt caverns is indicated by 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 March 2025.

For each tiltmeter station, the report provides:

- Raw measurements of east and north tilt components with outliers removed by filtering (measured in microradians) at the four-minute temporal resolution and their linear trends.
- Detrended east and north tilt components at four-minute temporal resolution.
- Daily ranges 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 the direction of the linear trend.

For each GNSS station, the report provides:

- Daily averages of the east, north, and vertical deformation (measured in inches) and their linear trends estimated in the global reference frame.
- Deformation rates (measured in inches per year) estimated in the local reference frame. Deformation rates in a local reference frame are computed by subtracting the tectonic plate deformation rate, common to all sites, from the measurements taken in the global reference frame.

## Summary of tiltmeter observations

The tiltmeter network operated without interruption throughout March, and no signals related to anomalous activity in Cavern 7 were detected during this reporting period. Appendix 1 includes plots for each tiltmeter station.

Several precipitation events disrupted the established tilt trends for several days. The effect of these precipitation events is particularly evident in the SSD12 record. We closely monitored tilt directions at all stations during the precipitation events to ensure they did not collectively indicate tilt directed toward Cavern 7.

Multiple tiltmeters recorded changes in tilt directions at irregular intervals that we cannot explain or attribute solely to the precipitation events. Since these anomalies were only observed at individual stations, they are most likely linked to local, possibly shallow features in the subsurface or mechanical activities near the stations. We suspect the ongoing levee construction has contributed to some unexplained tilt signals.

At SSD18, we observed large tilt values from late December to mid-January, as described in the previous reports. In late January, the tilt rate returned to its long-term value. On

February 7, the tiltmeter was replaced with a new one as a precaution. During February, SSD18 did not record a large tilt; however, it recorded several abrupt tilt signals of about five microradians. During March, SSD18 recorded two additional episodes of abrupt tilt signals of about twenty microradians each (see Figure 2). It is not clear if these signals are caused by ground deformation or are due to instrument error.

A test was conducted to evaluate the theorized relation between the large tilt observed at SSD18 during December and January and pumping activities from Central Lake. For this, the Central Lake pump was operated from 7:40 a.m. CST on February 22 until 4:00 p.m. CST on February 24. We expected this pumping activity to result in an observable abnormal tilt at SSD18, similar to what was previously recorded. However, no noticeable abnormal tilt was detected during this test.

Instead, a large tilt was observed at SSD14 during the last week of February. SSD14 is situated at Central Lake, less than 1,000 feet north of SSD18. Beginning on February 23, SSD14 started to detect an increasing tilt rate, which reached approximately 25 microradians by the end of February in the daily range of the northern component. This behavior continued with diminishing intensity until mid-March (see Figure 3). Then, starting on approximately March 25, an increased tilt rate returned, reaching approximately 15 microradians in the daily range of the eastern component.

While the exact cause of the tilt signals observed at SSD14 and SSD18 remains unclear, we suspect that the pumping activity may have contributed to it. We will continue investigating this signal and provide an update when more information becomes available.

The tilt data is manually reviewed daily using a 7-day rolling window. This process helps identify any changes in trends that are consistently observed at multiple tiltmeter sites over at least a few days. During the reported period, the tiltmeter data did not show any consistent ground movement patterns that would indicate deep-sourced deformation or any immediate concerns regarding Cavern 7.

SSD18: Analyzed range: 06/02/2024 - 04/02/2025 | Plotted range: 03/01/2025 - 03/31/2025 (CTZ)

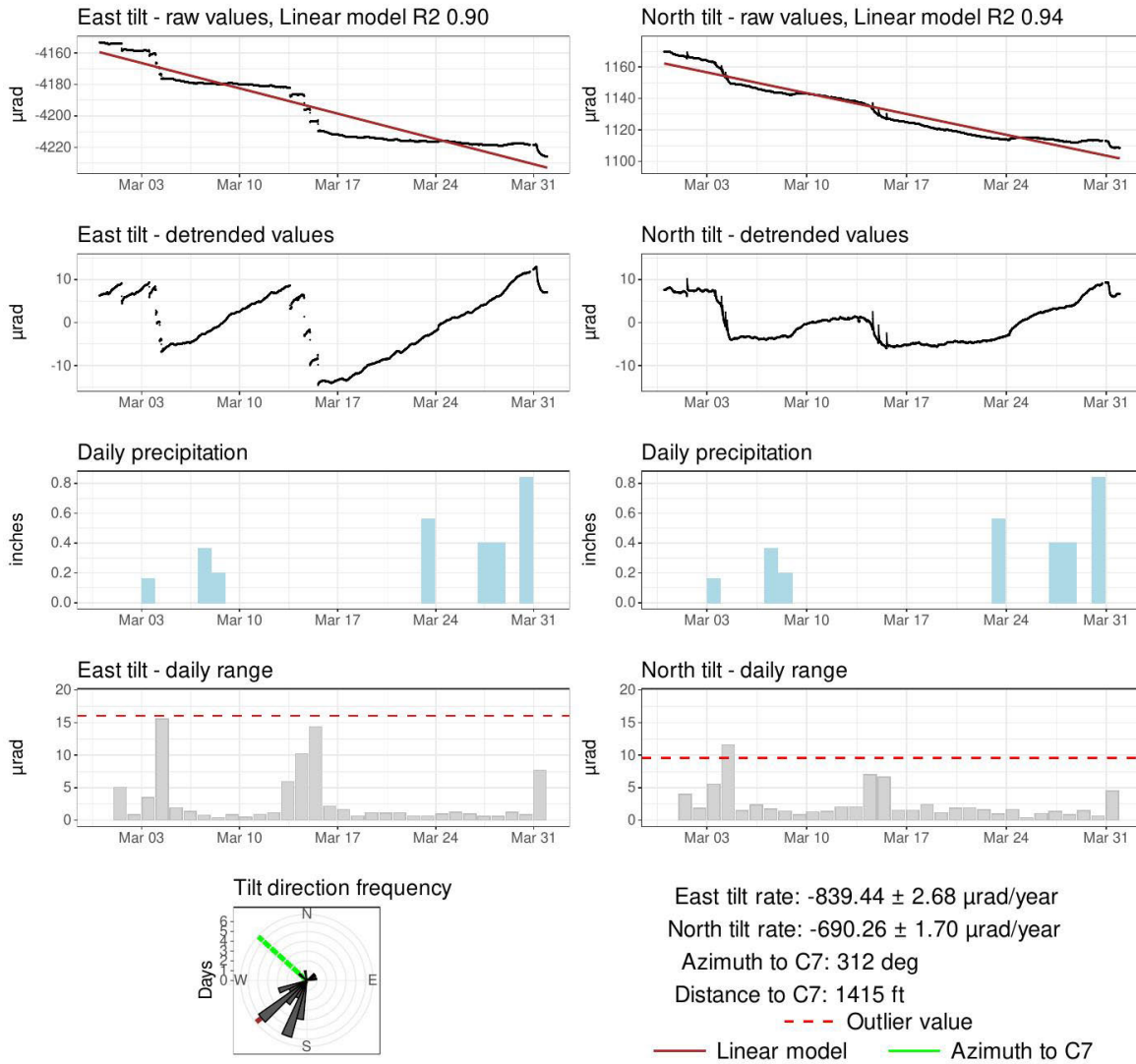


Figure 2. Charts of the tilt signals observed by the SSD18 tiltmeter over the current monthly reporting period. Note two episodes of anomalous tilt observed in the east component during March.

SSD14: Analyzed range: 06/02/2024 - 04/02/2025 | Plotted range: 03/01/2025 - 03/31/2025 (CTZ)

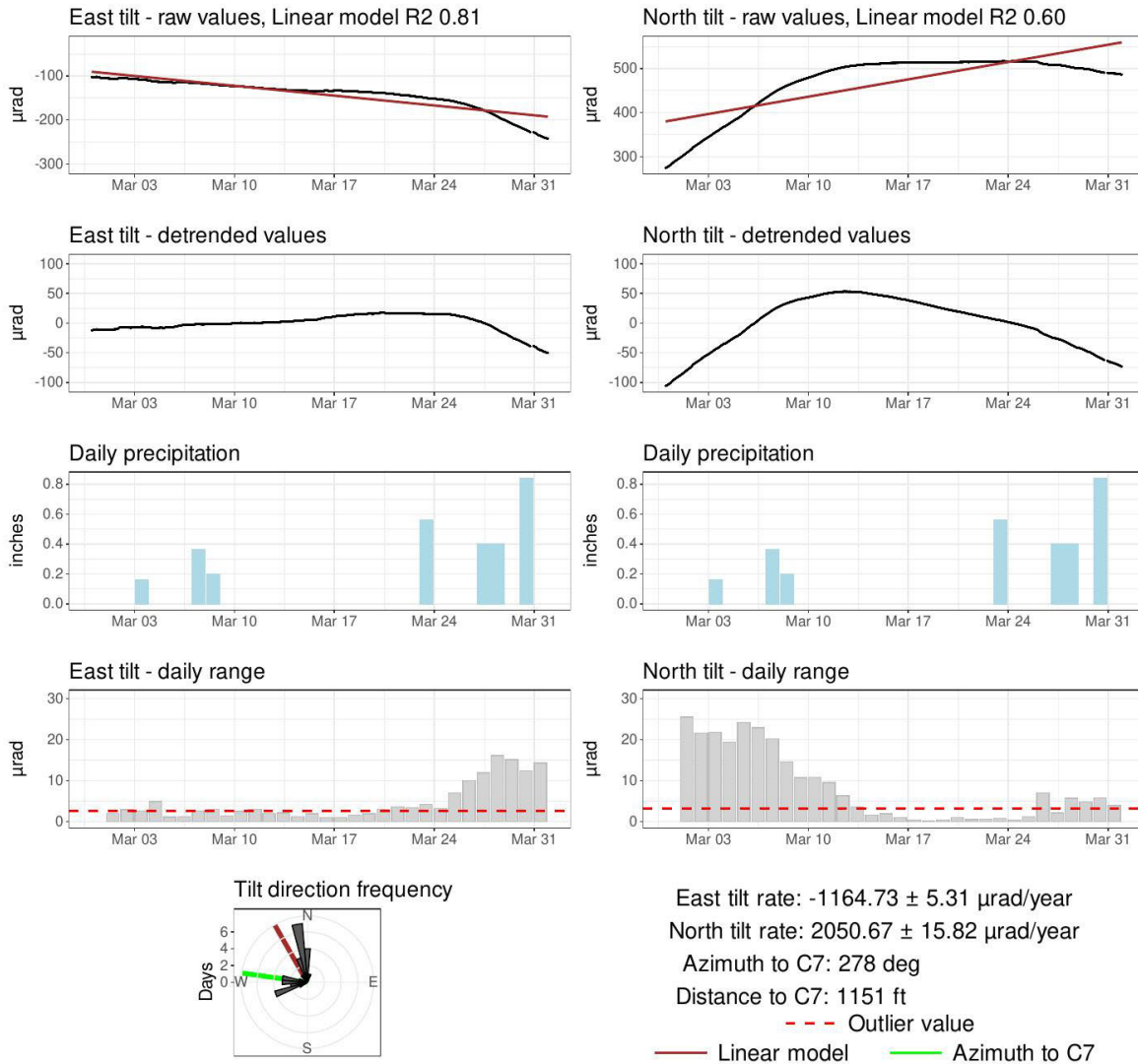


Figure 3. Charts of the tilt signals observed by the SSD14 tiltmeter over the current monthly reporting period. Note large tilt daily ranges observed during March.

### Summary of GNSS observations

The GNSS network operated without interruption throughout March. Appendix 2 includes plots for each GNSS station. We calculated the annualized three-dimensional (east, north, and vertical) deformation rates at each site within a local reference frame by subtracting a constant tectonic rate common to all sites from the measurements taken in the global reference frame. The daily measurements taken in March supported an observed deformation trend, which was primarily characterized by horizontal motion directed

toward Central Lake and accompanied by subsidence. This subsidence rate increased with proximity to Central Lake.

### **Analysis Maps**

Three maps have been created to visually summarize the results of the current analysis. These maps are displayed below and are also included in Appendix 3.

- Figure 4 is a vector map illustrating the direction and magnitude of the tilt and deformation rates identified at each tiltmeter (during the current reporting period) and each GNSS station (from July 22, 2024 to the end of the current reporting period).
- Figure 5 presents rose diagrams showing the daily tilt direction frequency for each tiltmeter, covering the entire data history from June 2024 to the present.
- Figure 6 details the daily tilt direction frequency for the current monthly reporting period.

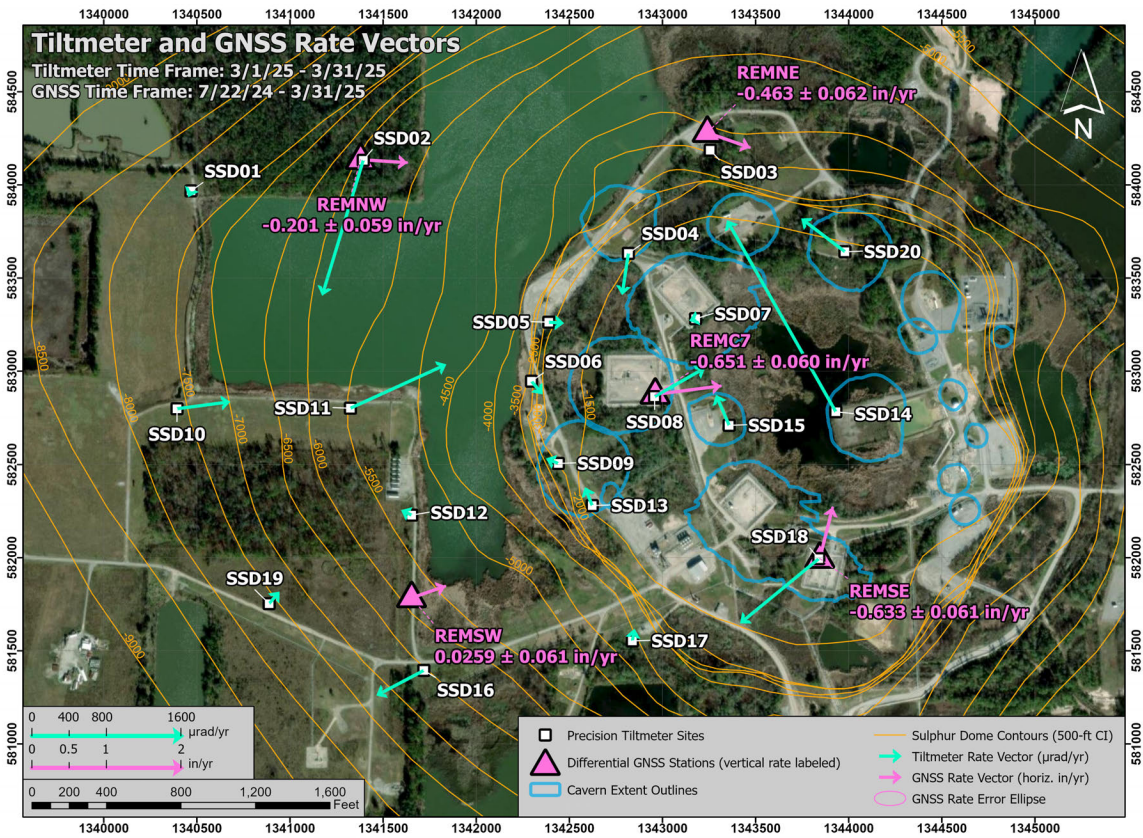


Figure 4. Map of deformation rate vectors for the tiltmeters and GNSS stations over their respective evaluated time frames. The tiltmeter vectors are shown in cyan and scaled by their respective values in units of microradians per year. The GNSS vectors and their corresponding error ellipses (derived 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.

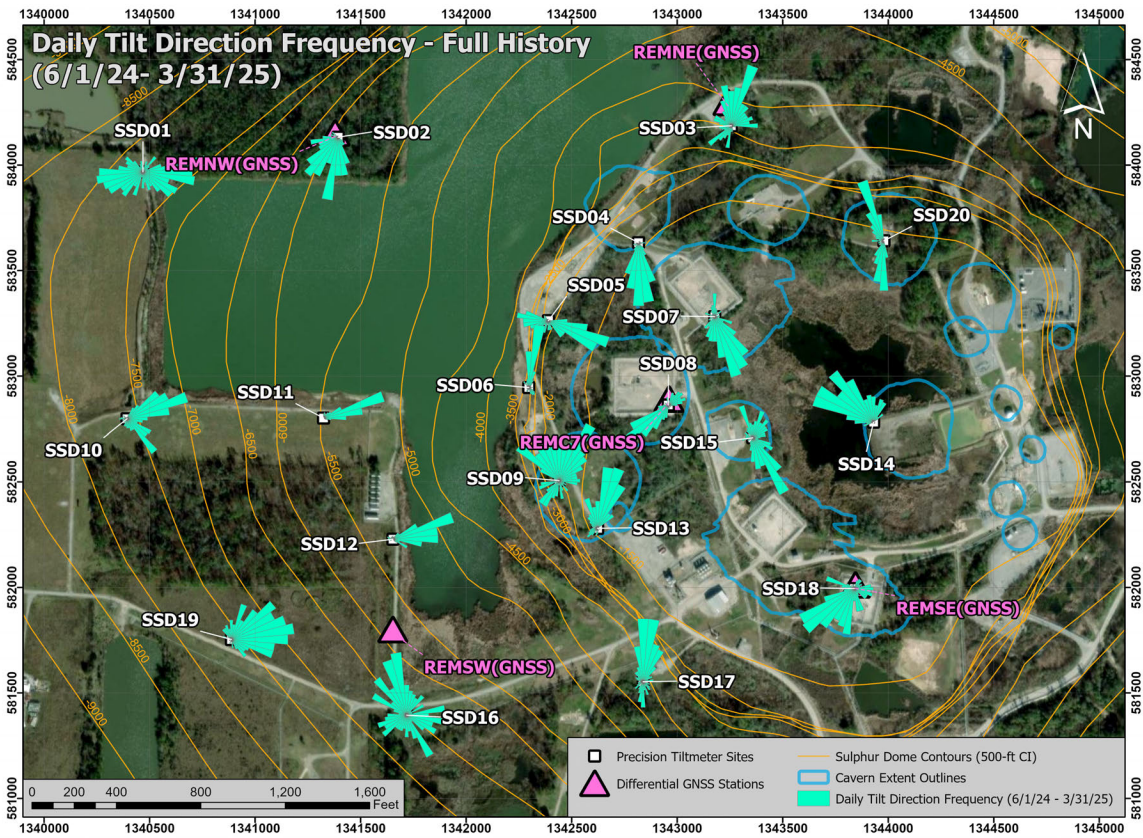


Figure 5. Map of daily tilt direction distribution for each tiltmeter for the full data history beginning in June 2024. Rose diagrams indicate the number of days that tilt was oriented along specific azimuths (bin size is 10°).

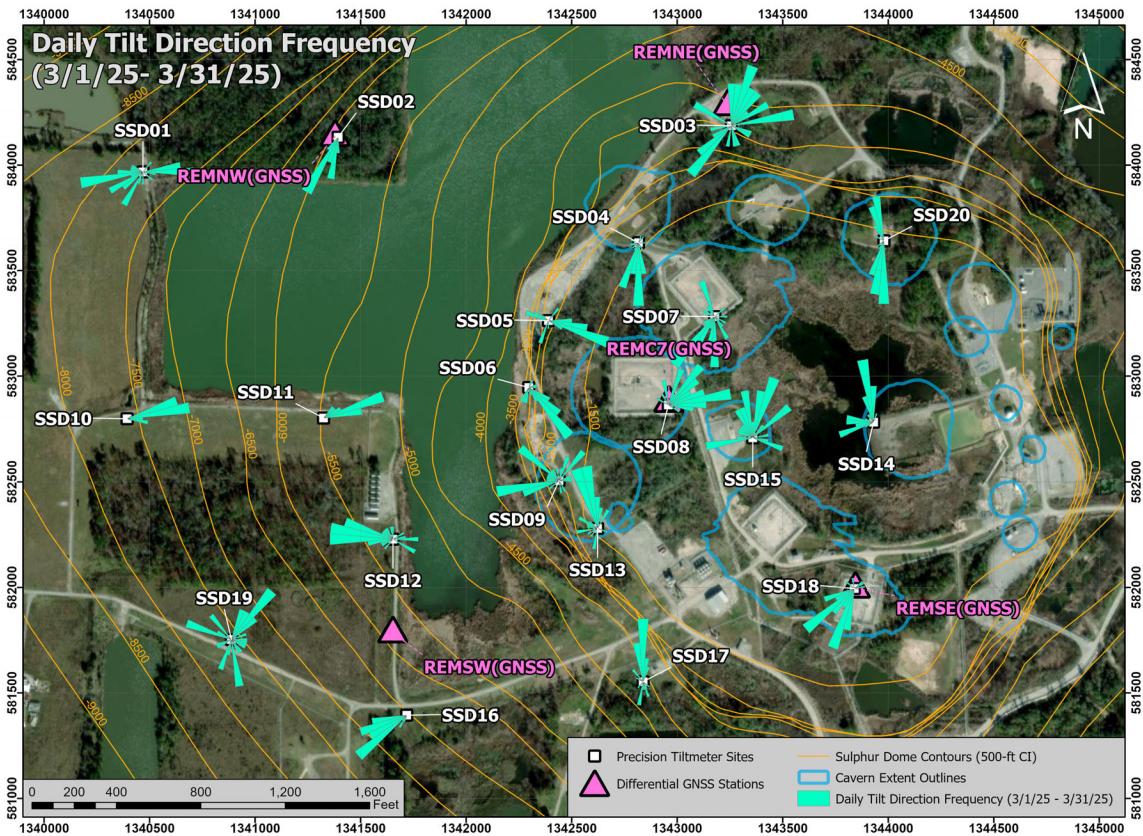


Figure 6. Map of daily tilt direction distribution for each tiltmeter for the current monthly reporting period. Rose diagrams indicate the number of days that tilt was oriented along specific azimuths (bin size is 10°).

## Deformation Alert System Update

We continue 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 until we are confident it will give 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) modelling (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.

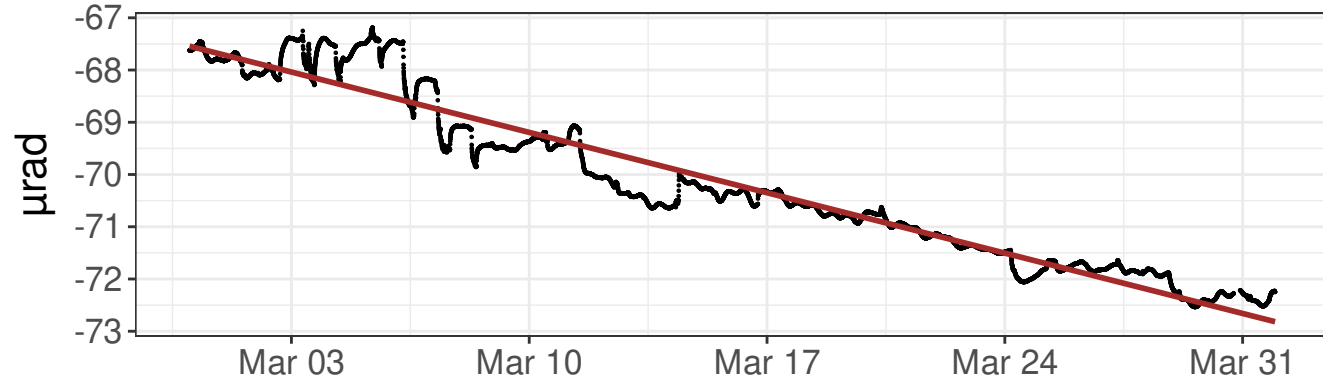
# **APPENDIX 1**

## **Tiltmeter Data Plots**

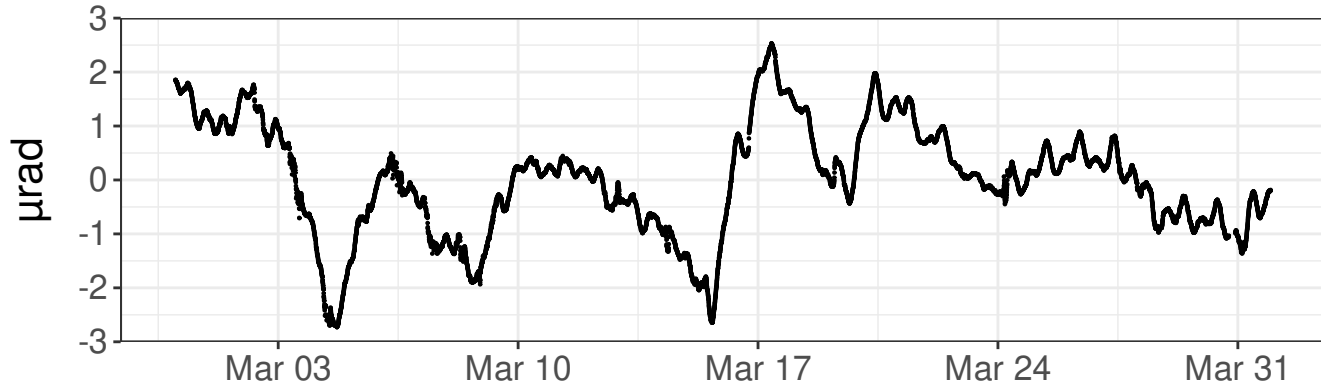
East tilt - raw values, Linear model R2 0.29



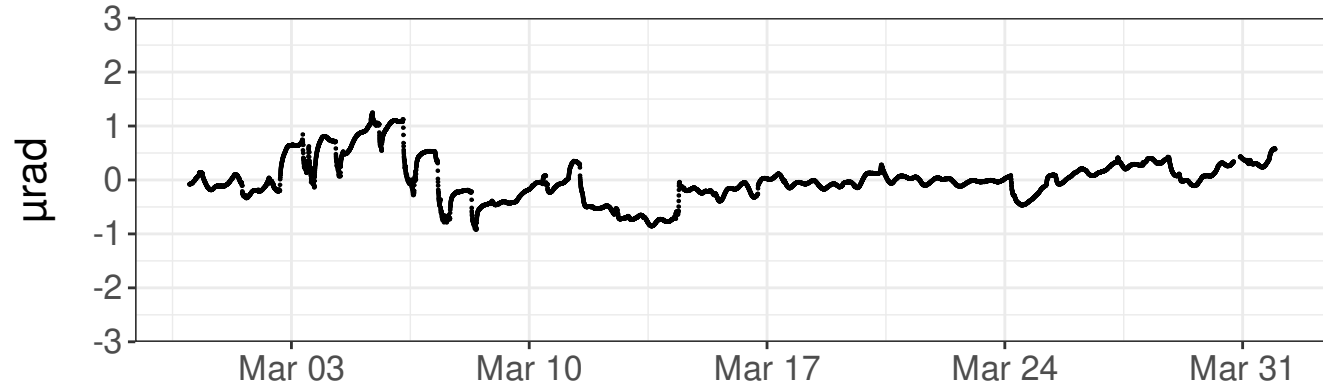
North tilt - raw values, Linear model R2 0.94



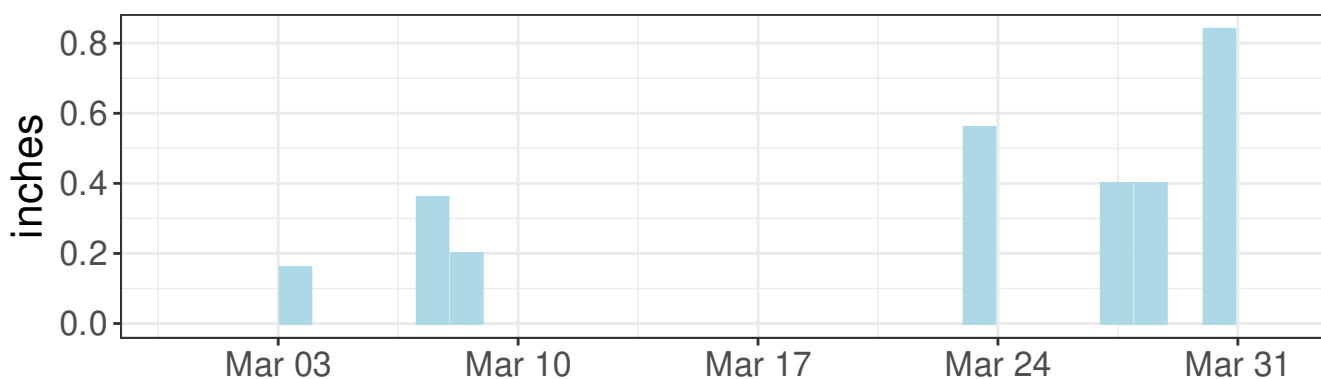
East tilt - detrended values



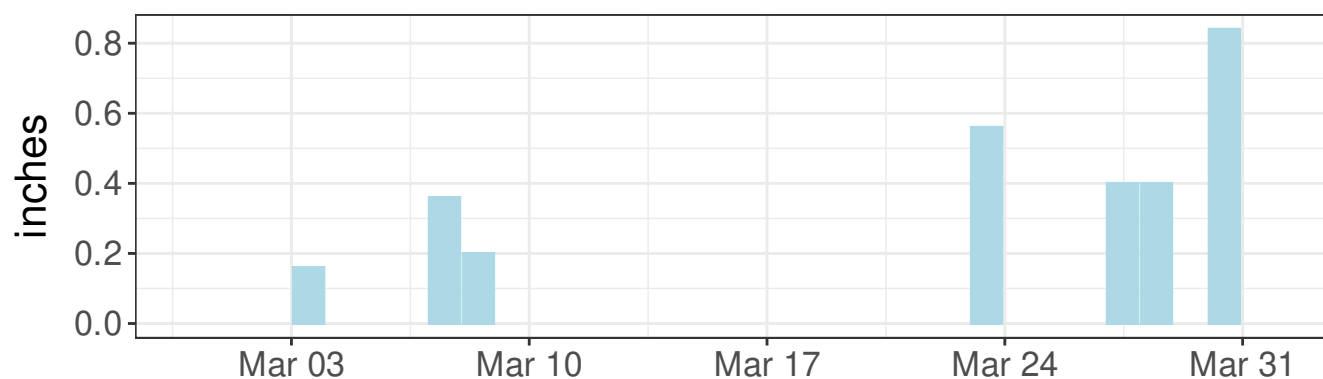
North tilt - detrended values



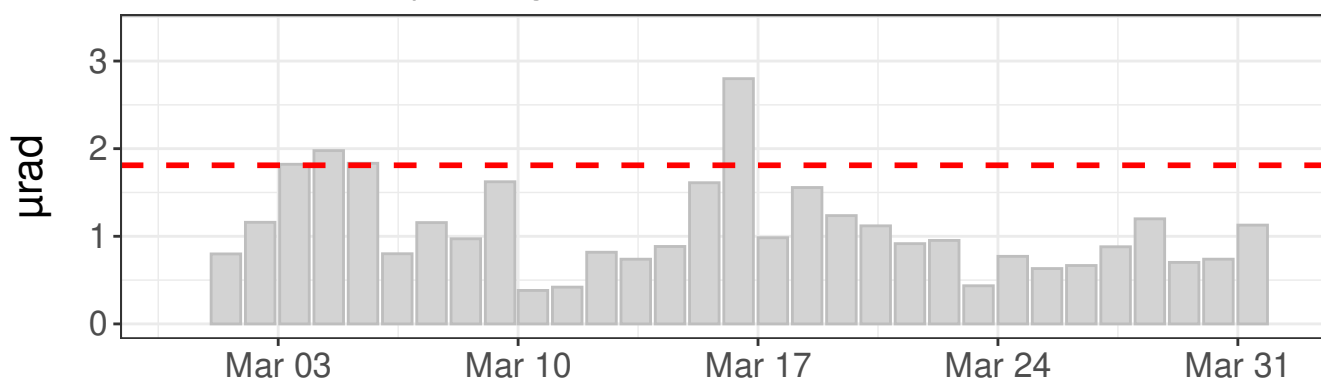
Daily precipitation



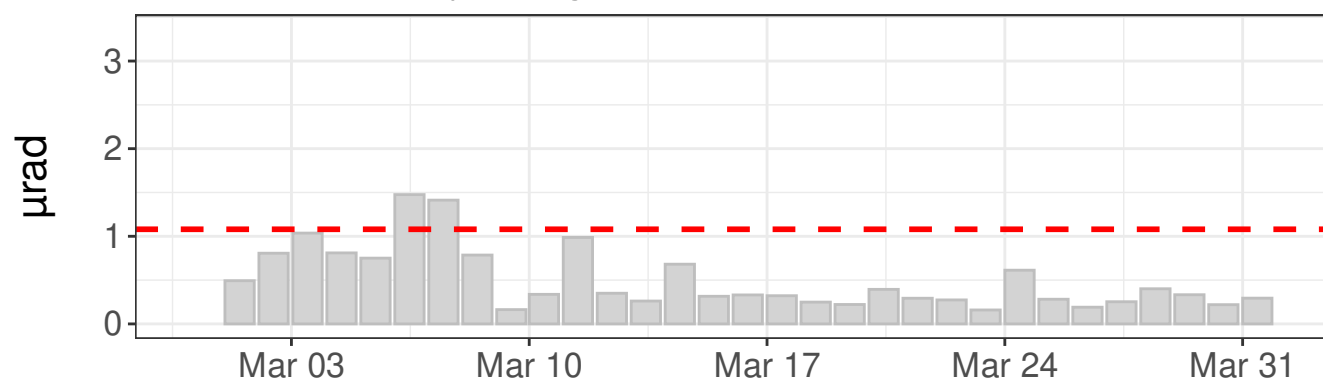
Daily precipitation



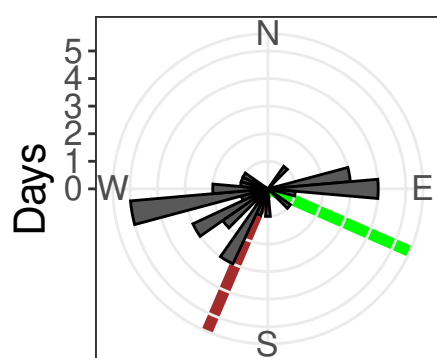
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $-25.75 \pm 0.38 \mu\text{rad}/\text{year}$

North tilt rate:  $-60.24 \pm 0.14 \mu\text{rad}/\text{year}$

Azimuth to C7: 114 deg

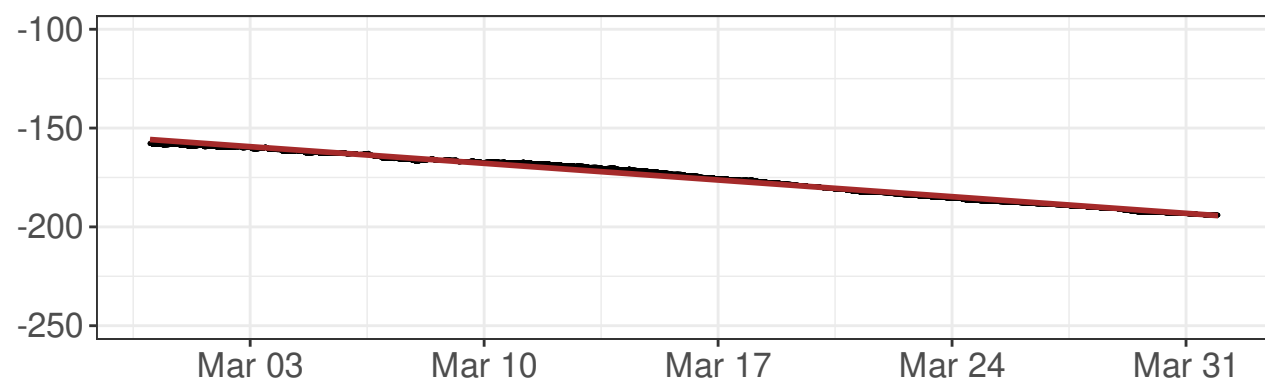
Distance to C7: 2538 ft

--- Outlier value

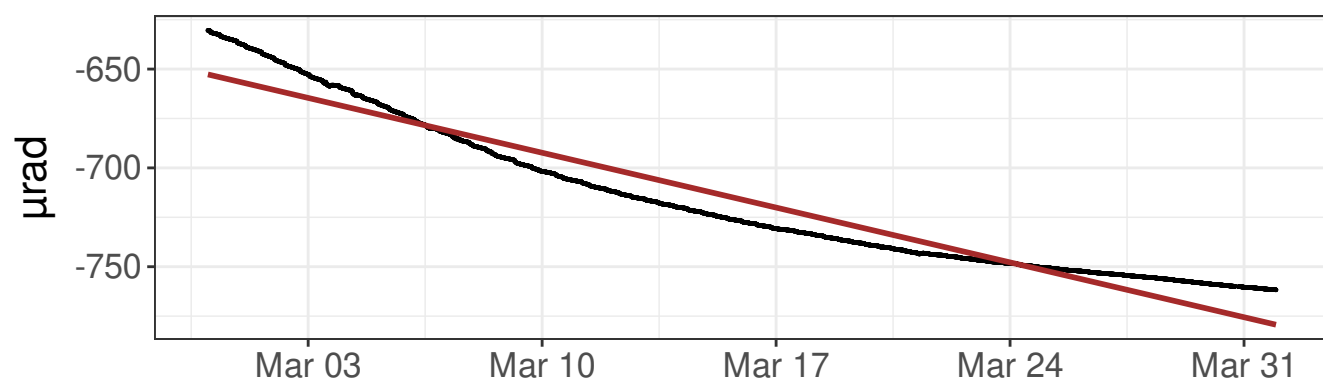
— Linear model

— Azimuth to C7

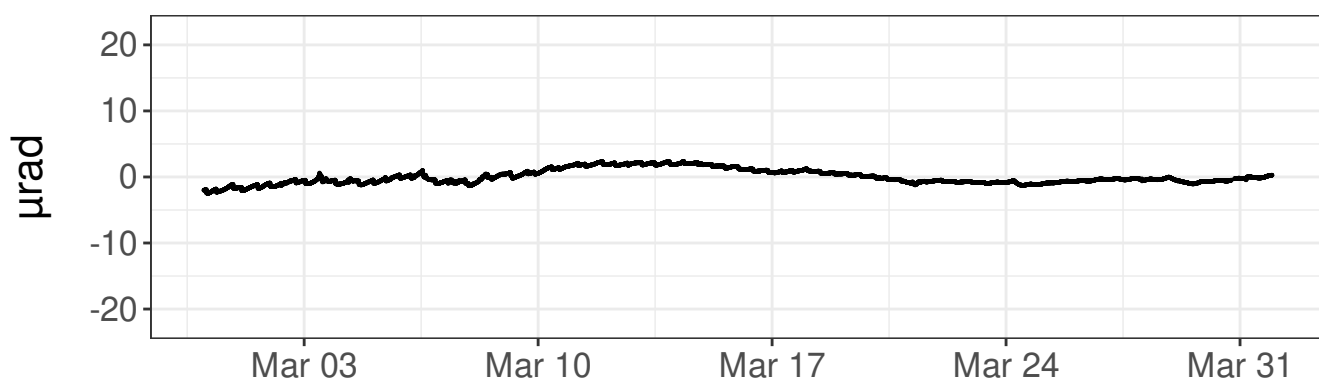
East tilt - raw values, Linear model R2 0.99



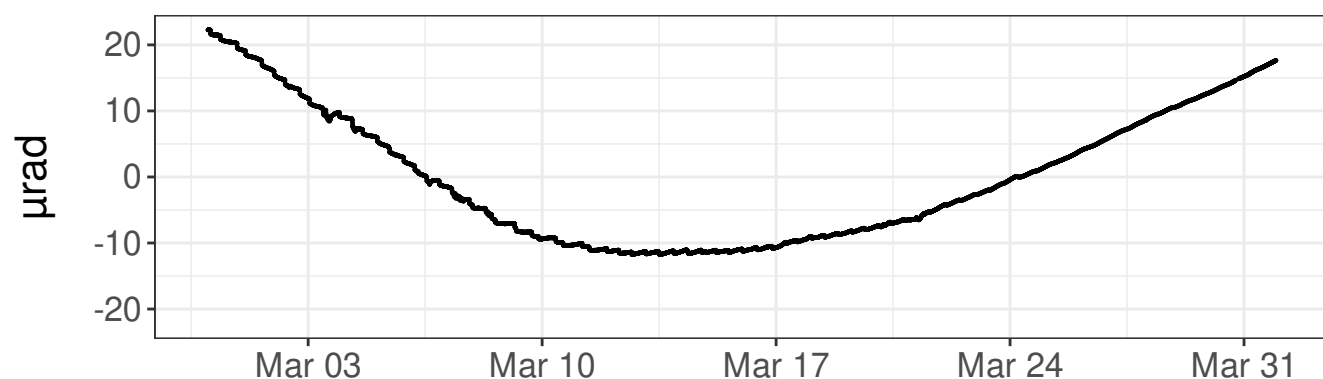
North tilt - raw values, Linear model R2 0.93



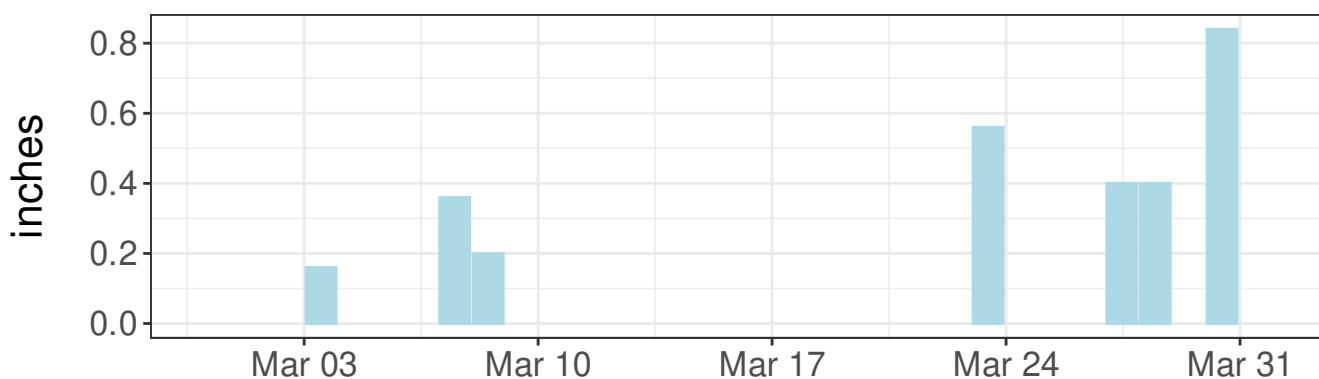
East tilt - detrended values



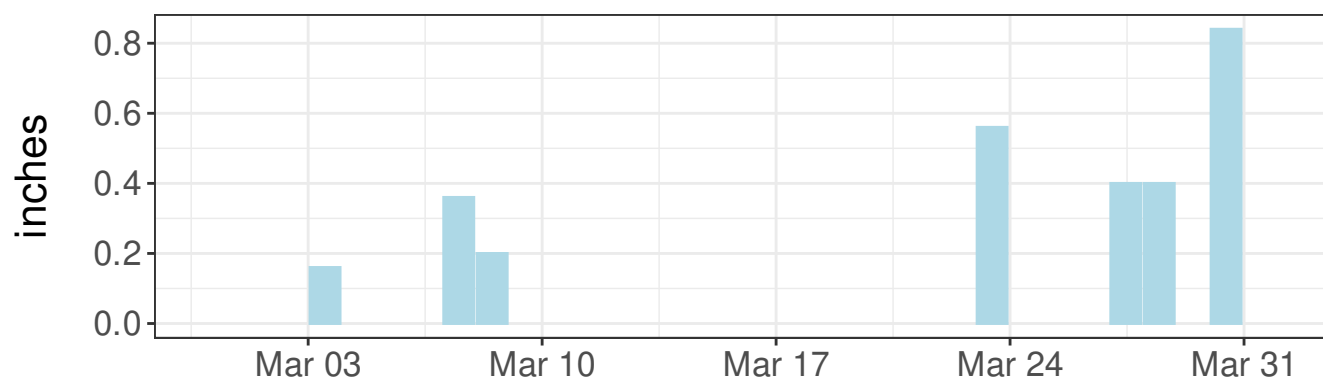
North tilt - detrended values



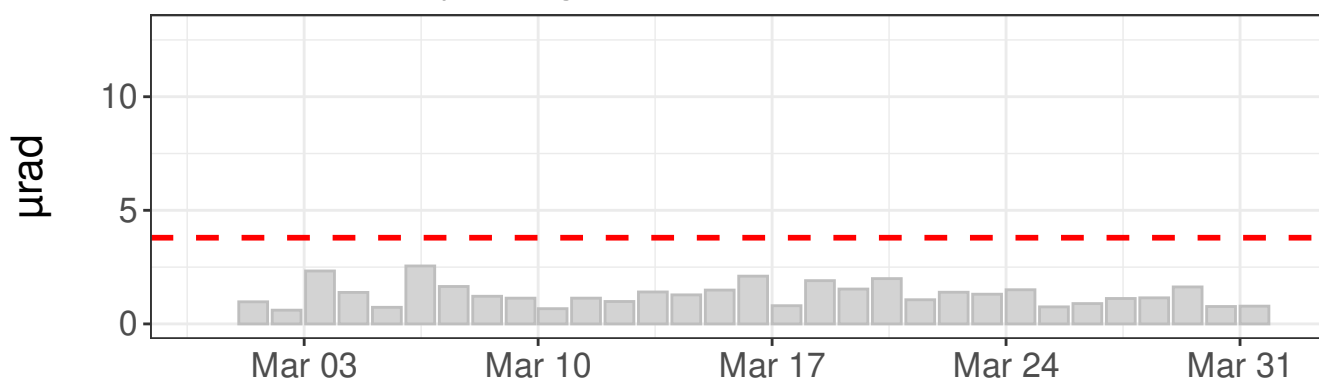
Daily precipitation



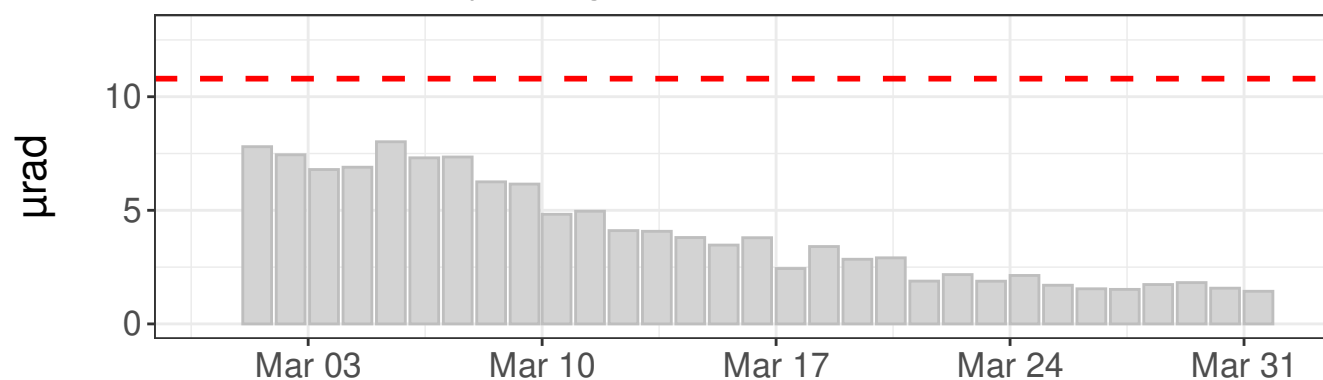
Daily precipitation



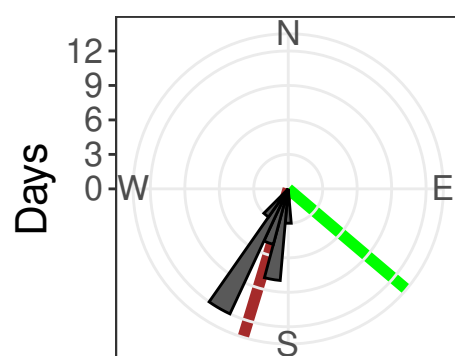
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $-439.70 \pm 0.40 \mu\text{rad}/\text{year}$

North tilt rate:  $-1446.43 \pm 3.69 \mu\text{rad}/\text{year}$

Azimuth to C7: 130 deg

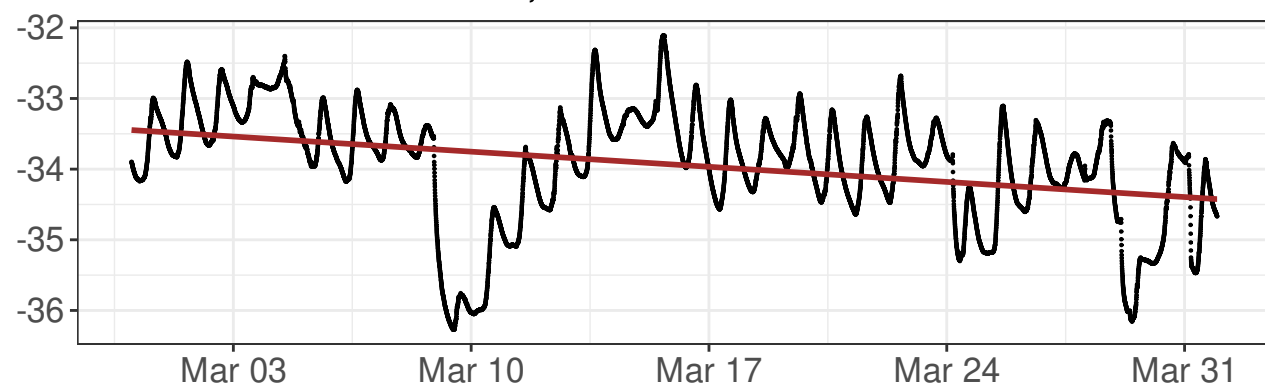
Distance to C7: 1834 ft

--- Outlier value

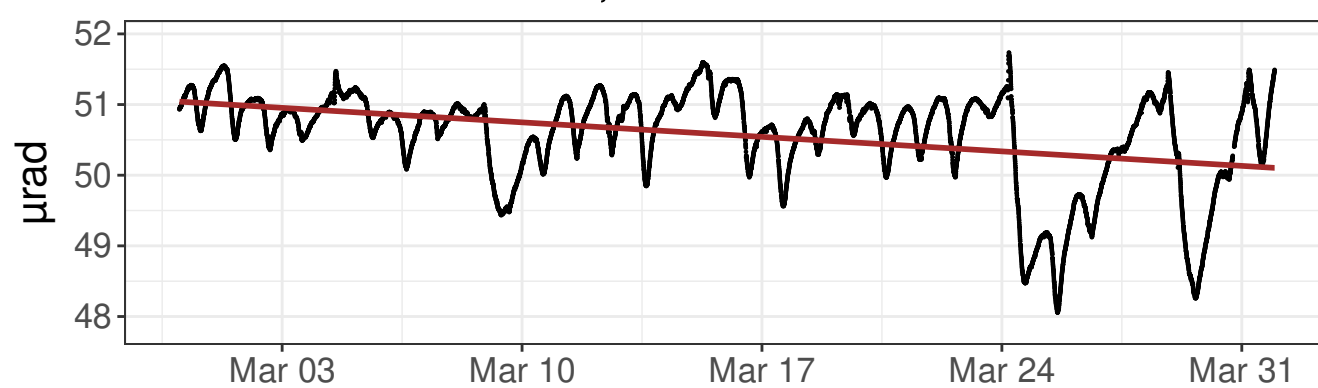
— Linear model

— Azimuth to C7

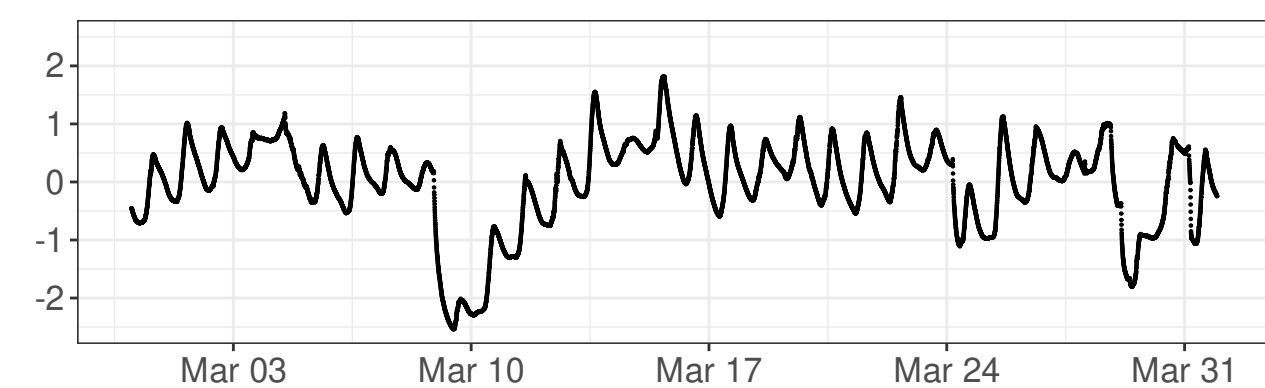
East tilt - raw values, Linear model R2 0.12



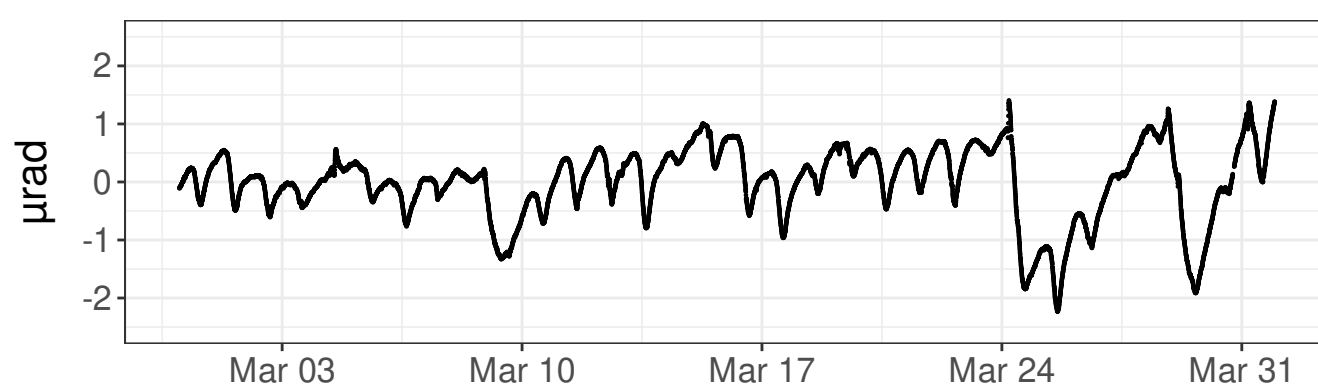
North tilt - raw values, Linear model R2 0.16



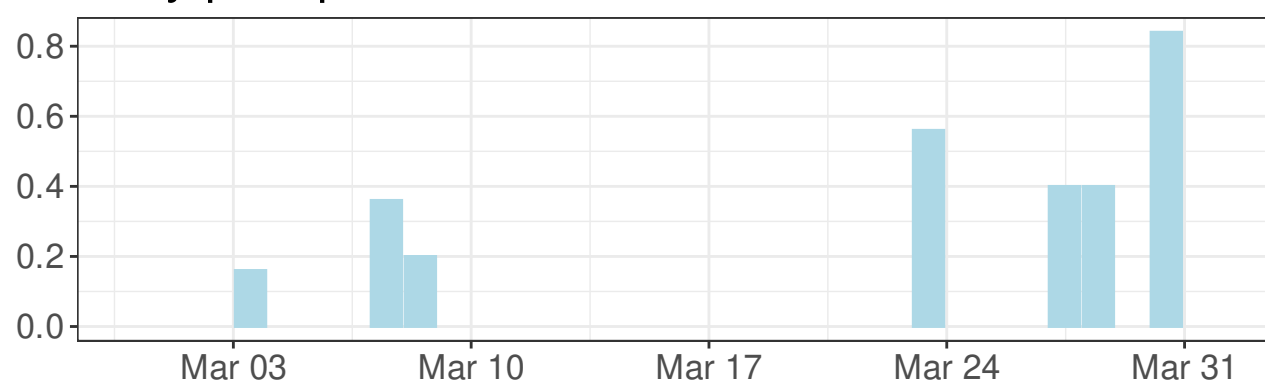
East tilt - detrended values



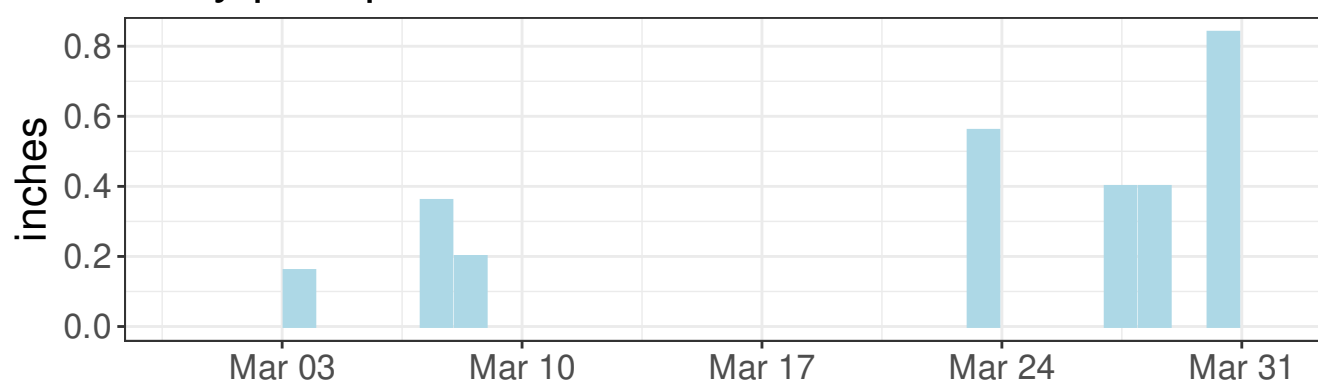
North tilt - detrended values



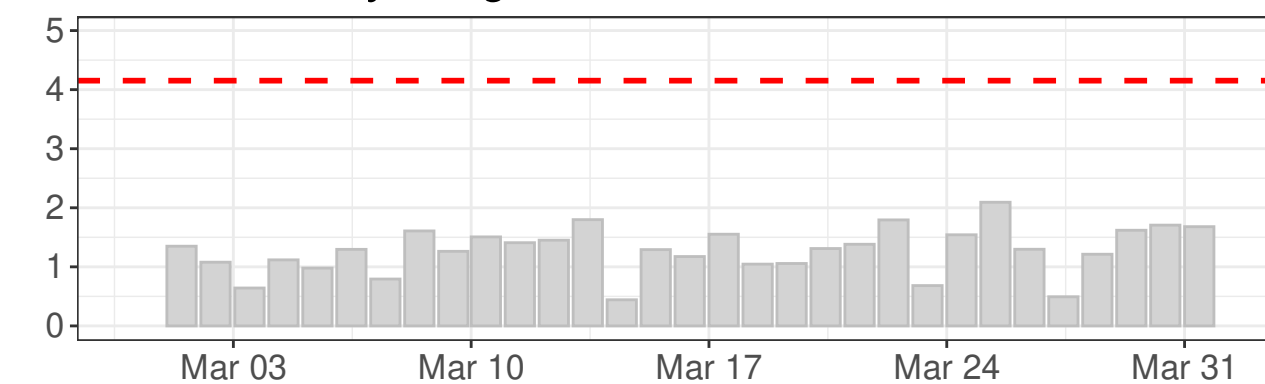
Daily precipitation



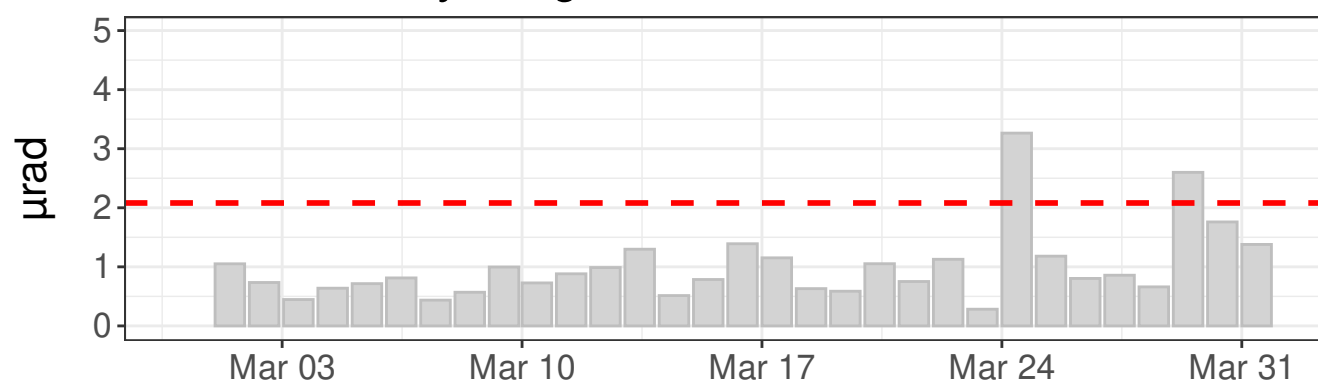
Daily precipitation



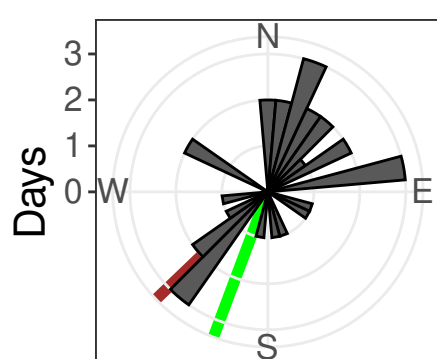
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $-11.16 \pm 0.29 \mu\text{rad}/\text{year}$

North tilt rate:  $-10.71 \pm 0.23 \mu\text{rad}/\text{year}$

Azimuth to C7: 201 deg

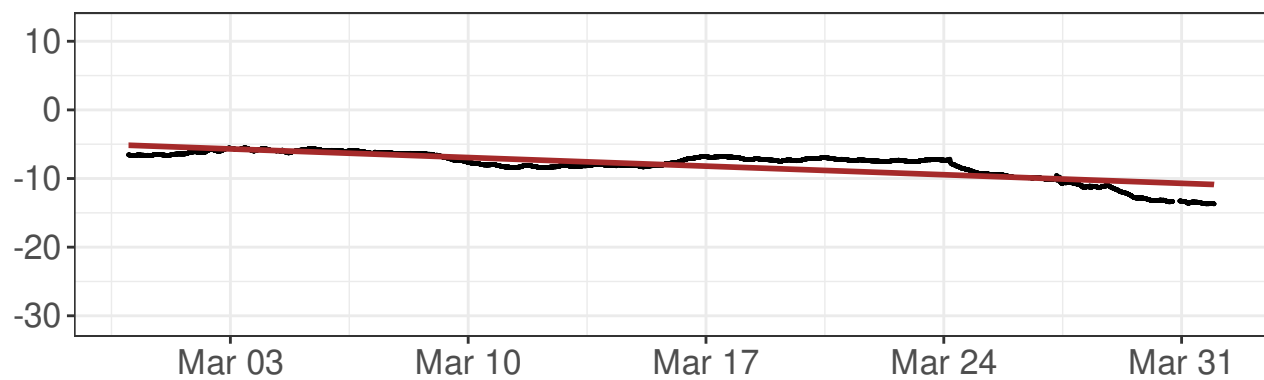
Distance to C7: 1326 ft

--- Outlier value

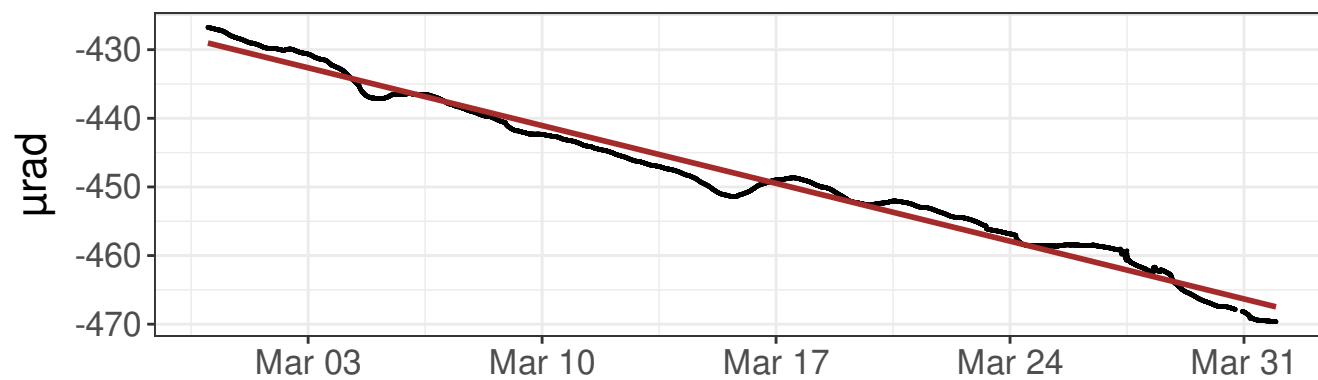
— Linear model

— Azimuth to C7

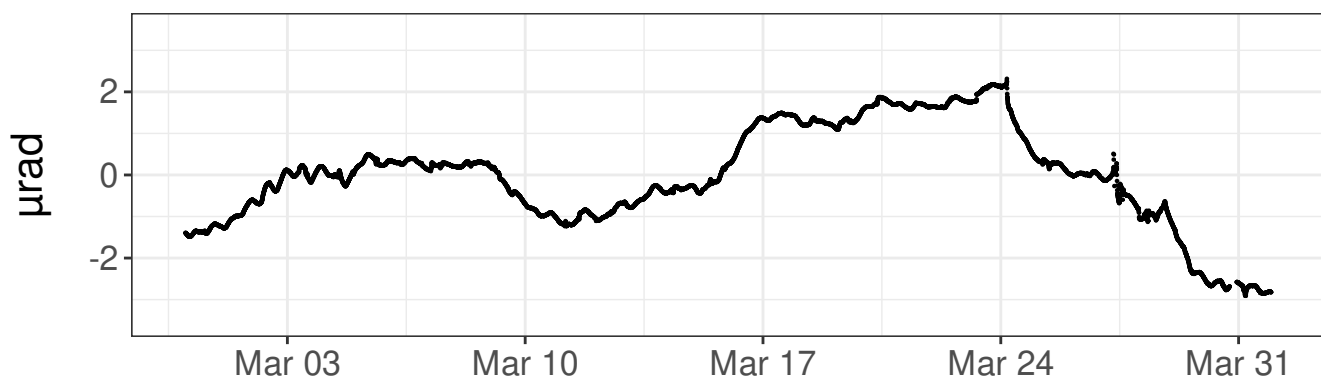
East tilt - raw values, Linear model R2 0.65



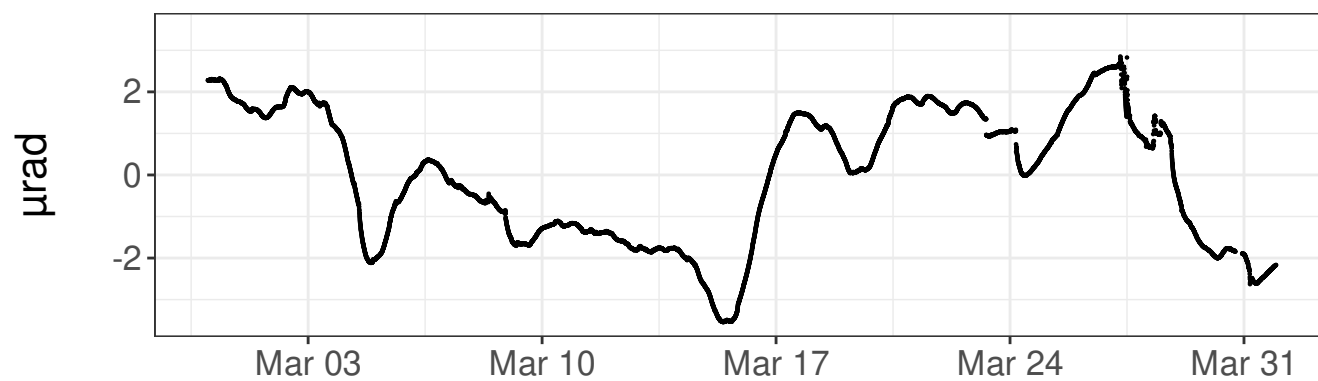
North tilt - raw values, Linear model R2 0.98



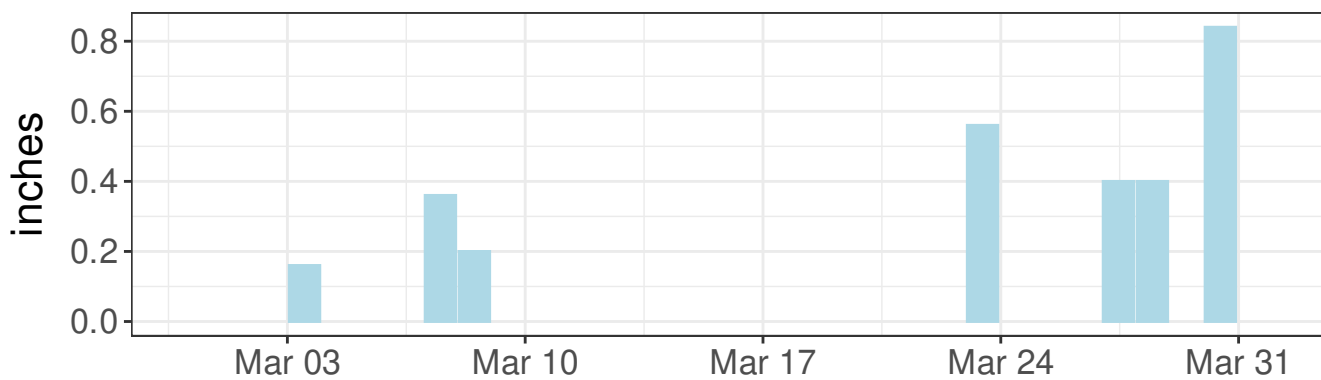
East tilt - detrended values



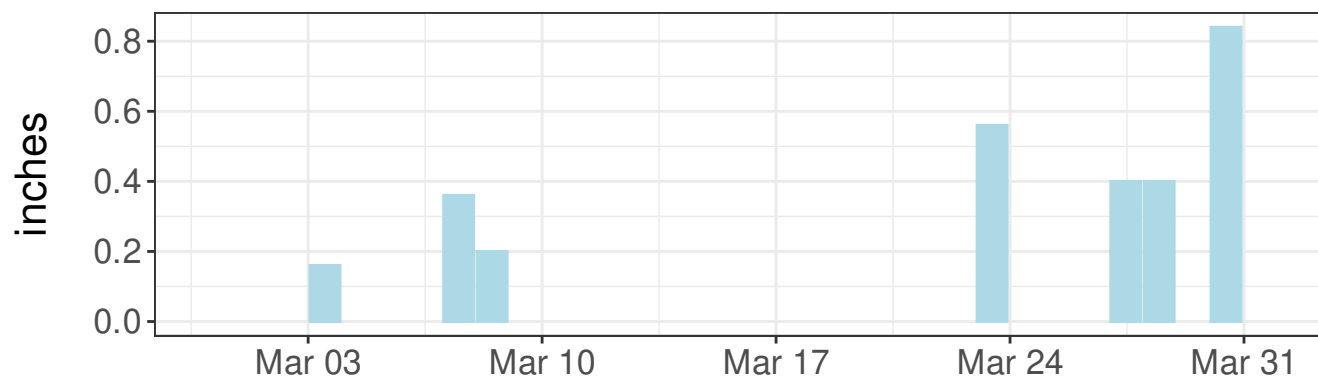
North tilt - detrended values



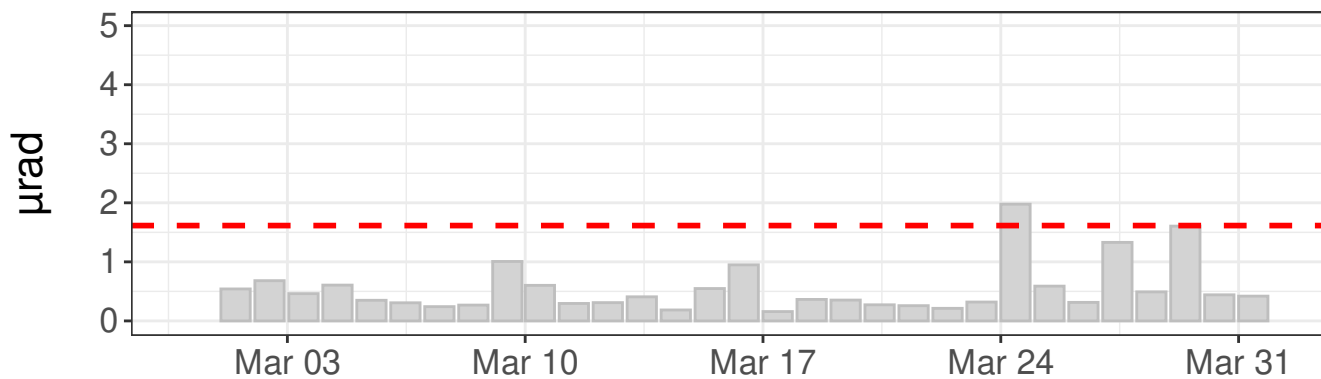
Daily precipitation



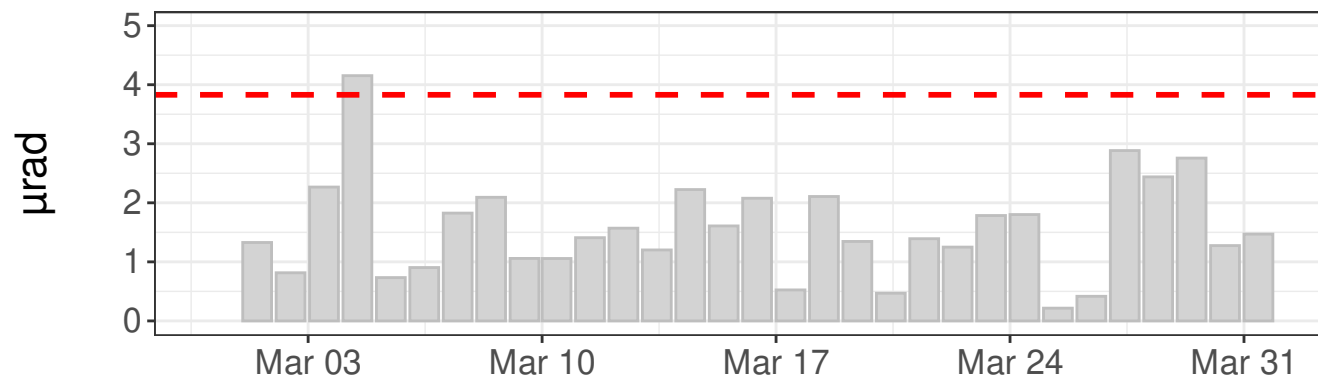
Daily precipitation



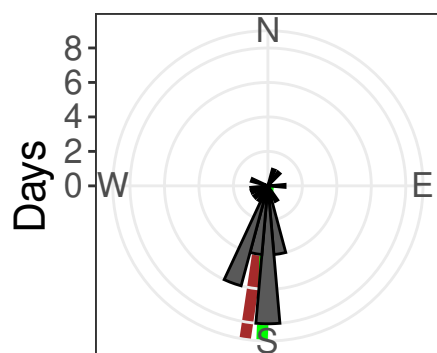
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $-65.32 \pm 0.45 \mu\text{rad}/\text{year}$

North tilt rate:  $-439.05 \pm 0.59 \mu\text{rad}/\text{year}$

Azimuth to C7: 182 deg

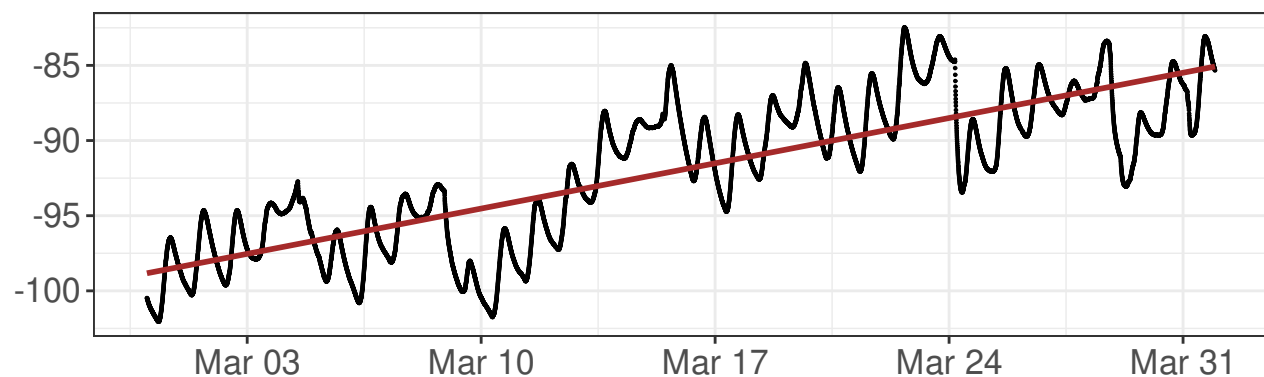
Distance to C7: 688 ft

--- Outlier value

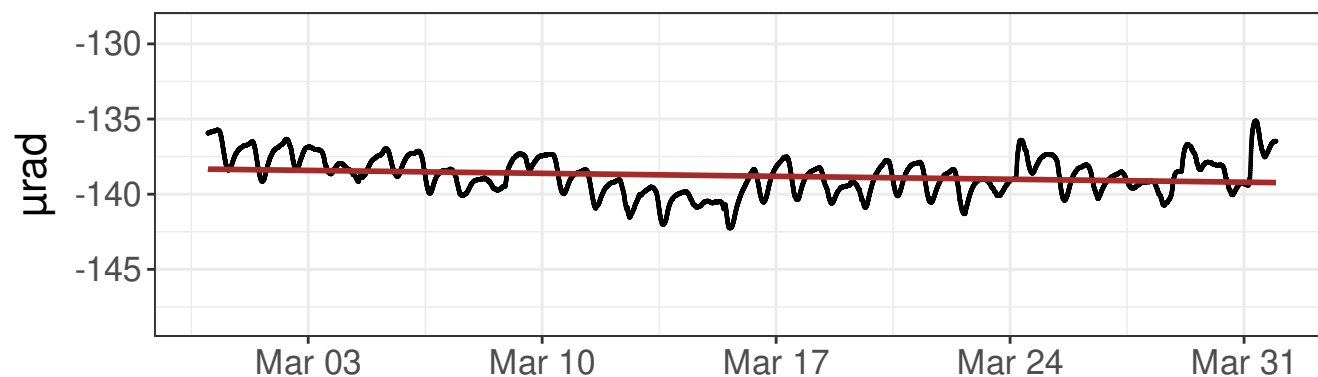
— Linear model

— Azimuth to C7

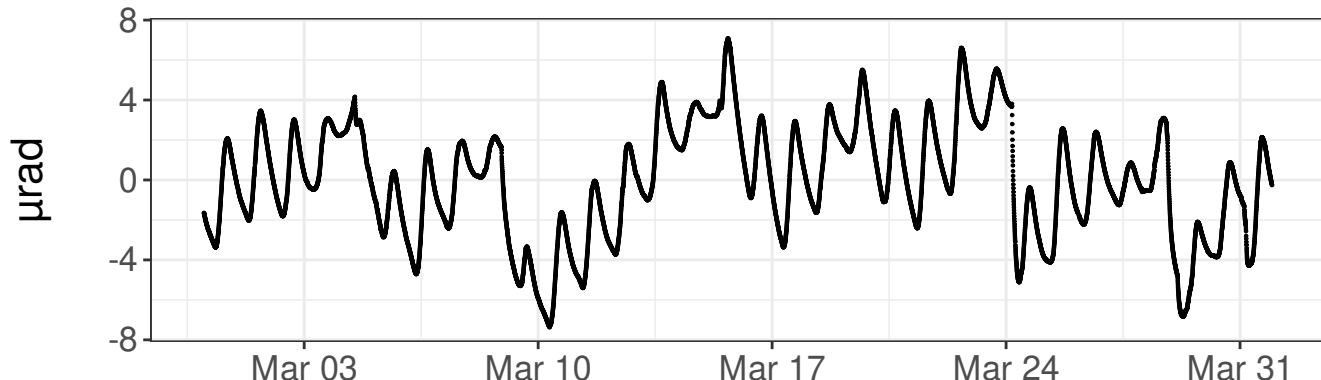
East tilt - raw values, Linear model R2 0.66



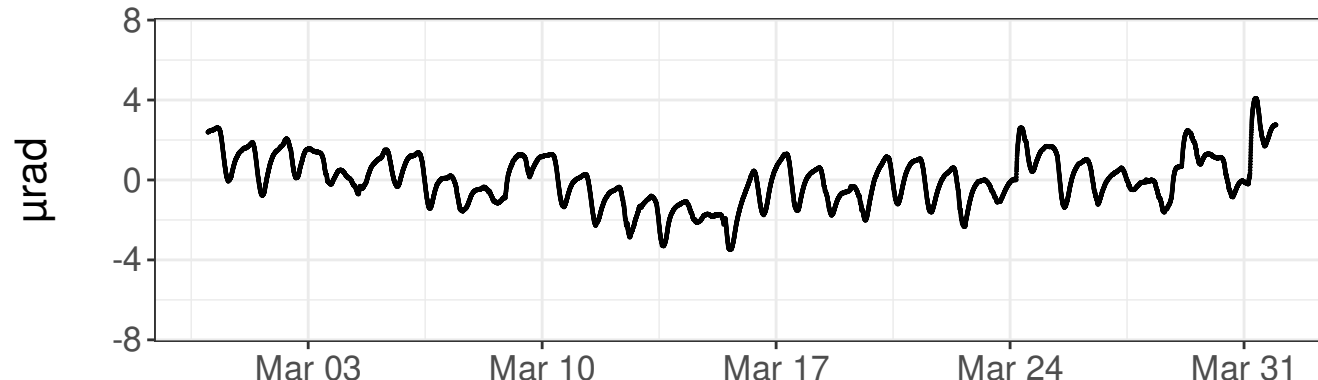
North tilt - raw values, Linear model R2 0.04



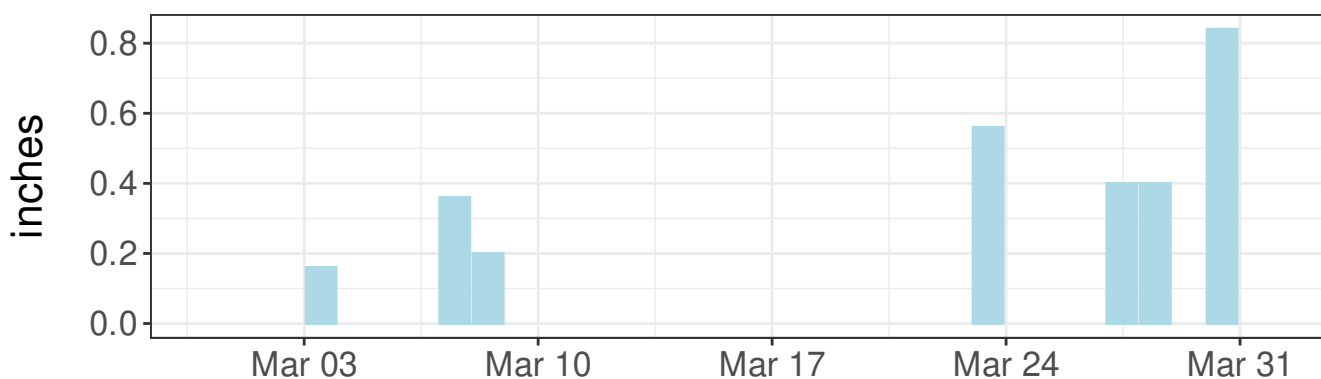
East tilt - detrended values



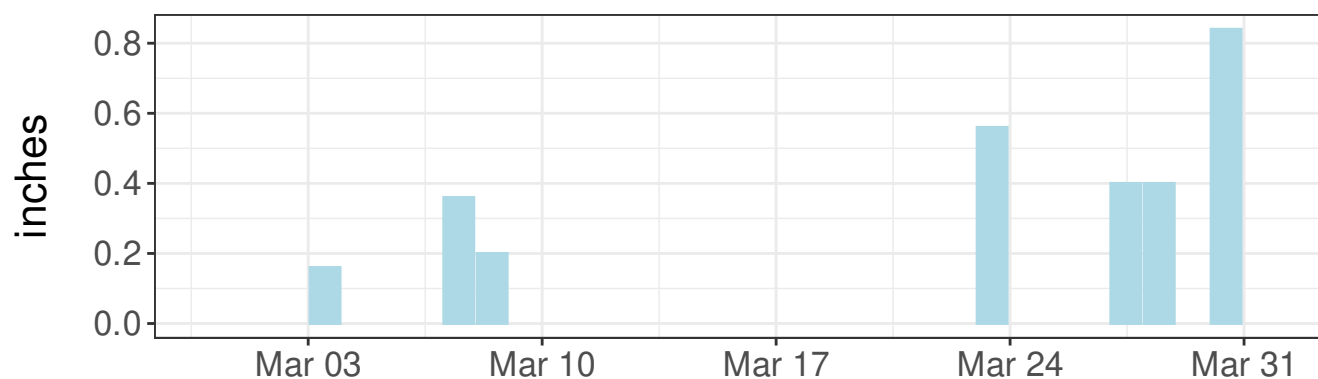
North tilt - detrended values



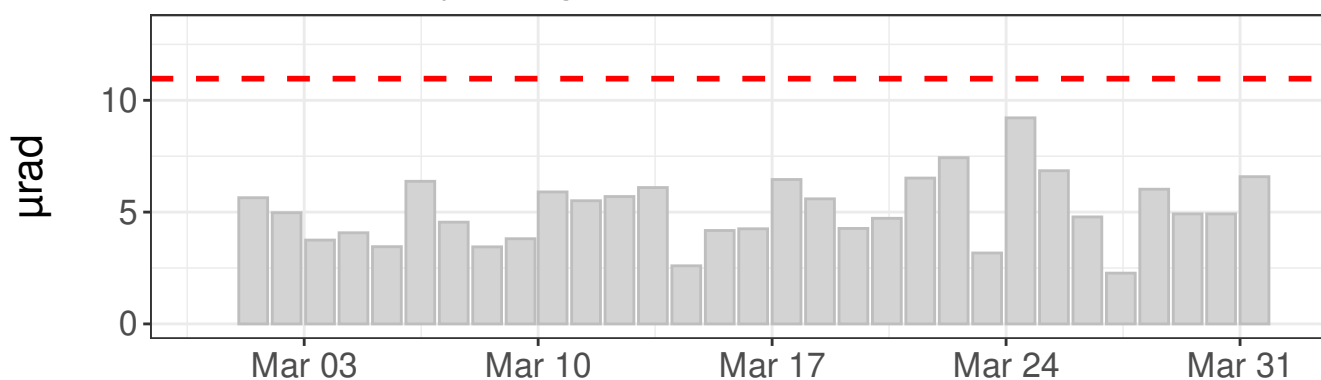
Daily precipitation



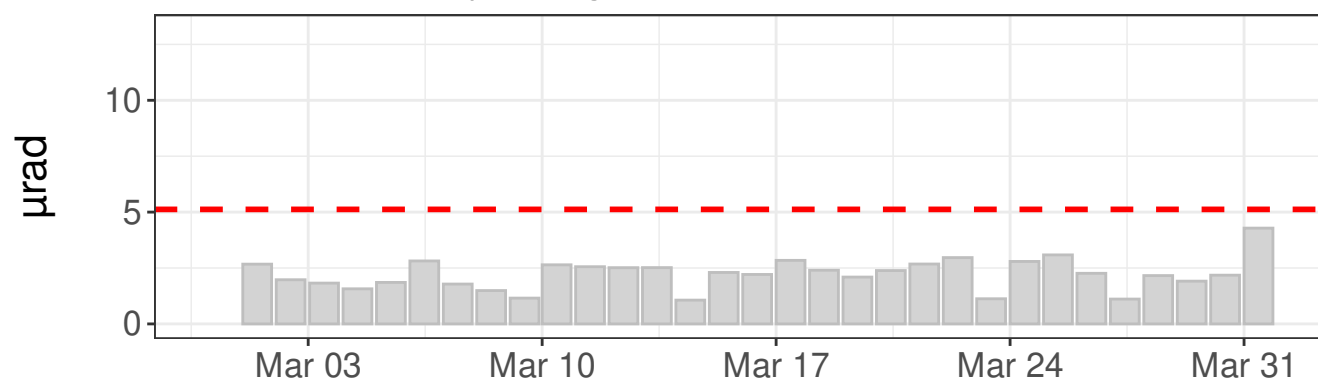
Daily precipitation



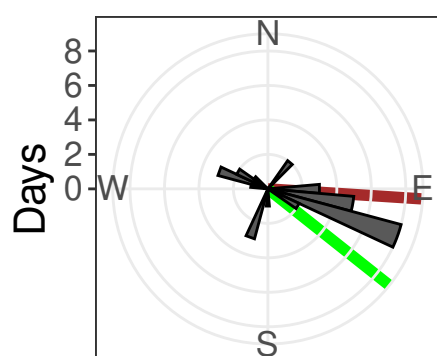
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $157.06 \pm 1.04 \mu\text{rad}/\text{year}$

North tilt rate:  $-10.22 \pm 0.46 \mu\text{rad}/\text{year}$

Azimuth to C7: 128 deg

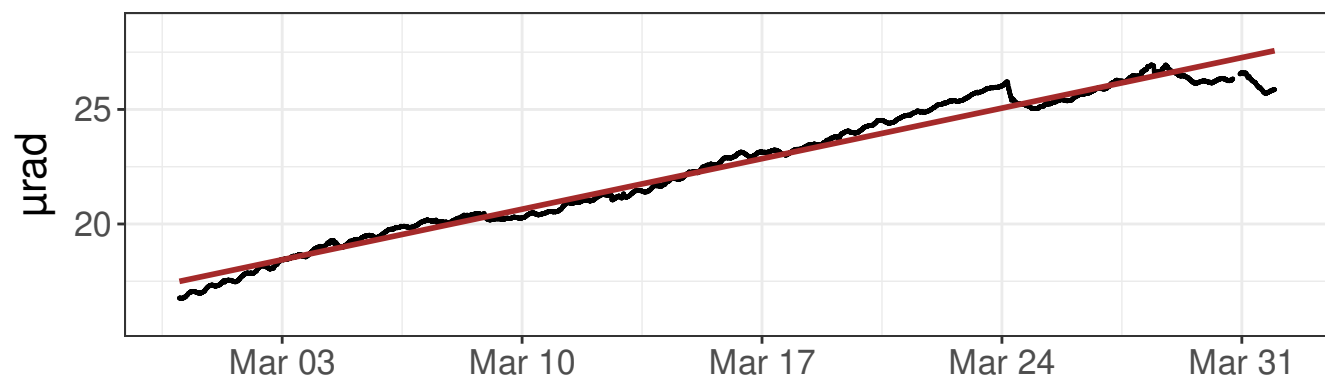
Distance to C7: 512 ft

--- Outlier value

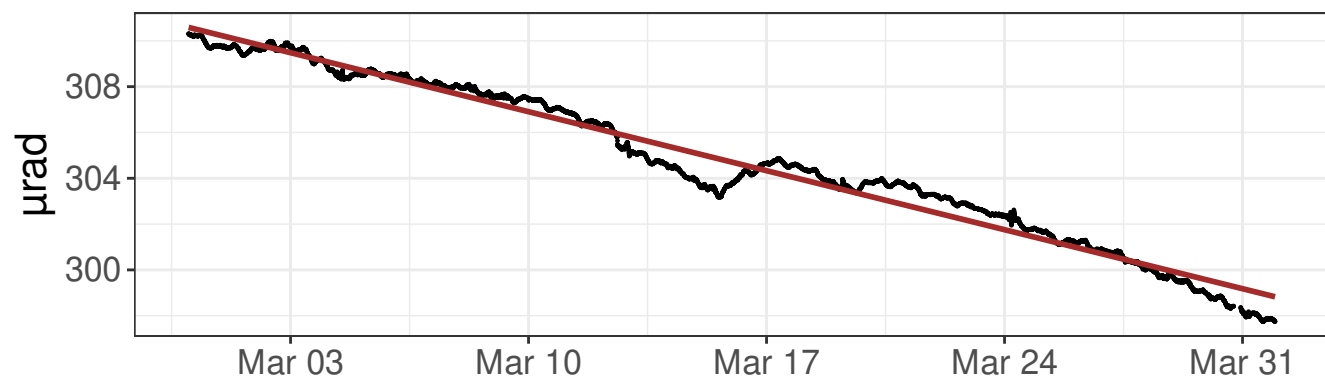
— Linear model

— Azimuth to C7

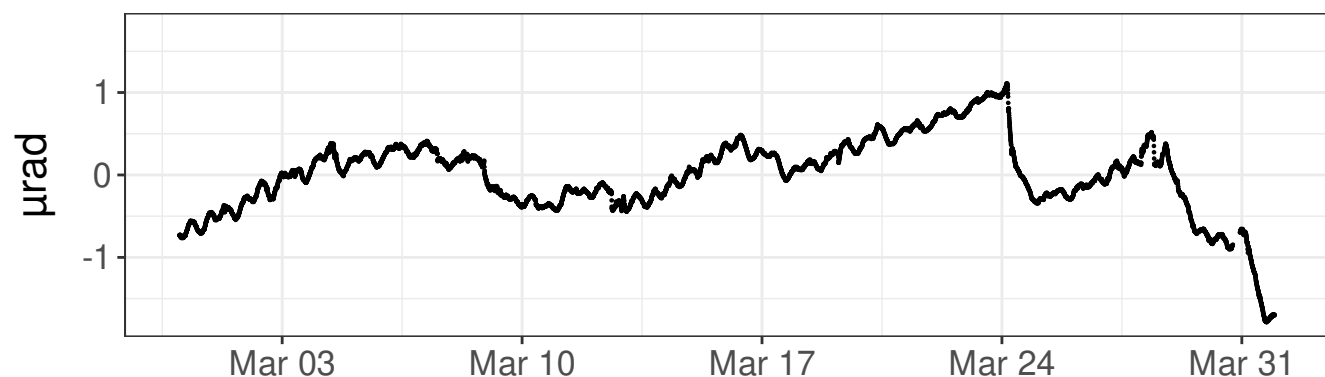
East tilt - raw values, Linear model R2 0.98



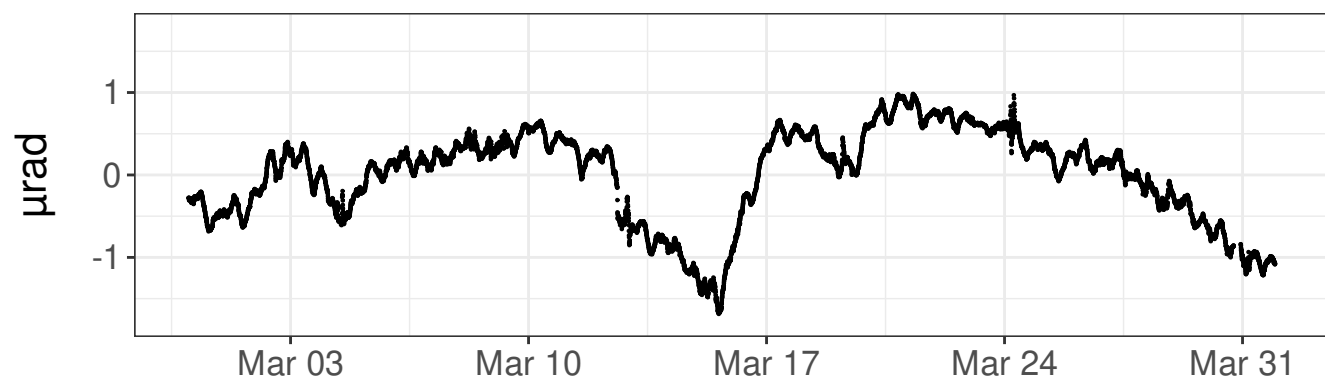
North tilt - raw values, Linear model R2 0.97



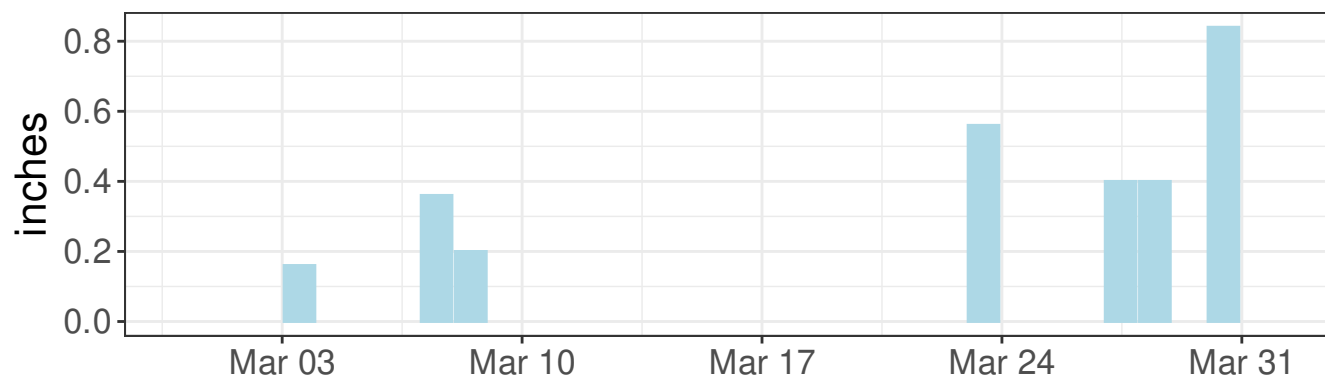
East tilt - detrended values



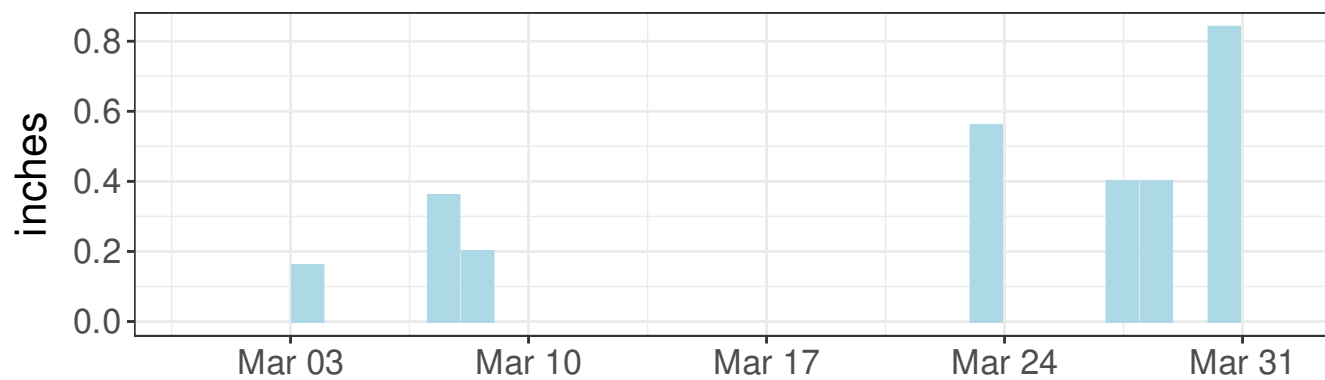
North tilt - detrended values



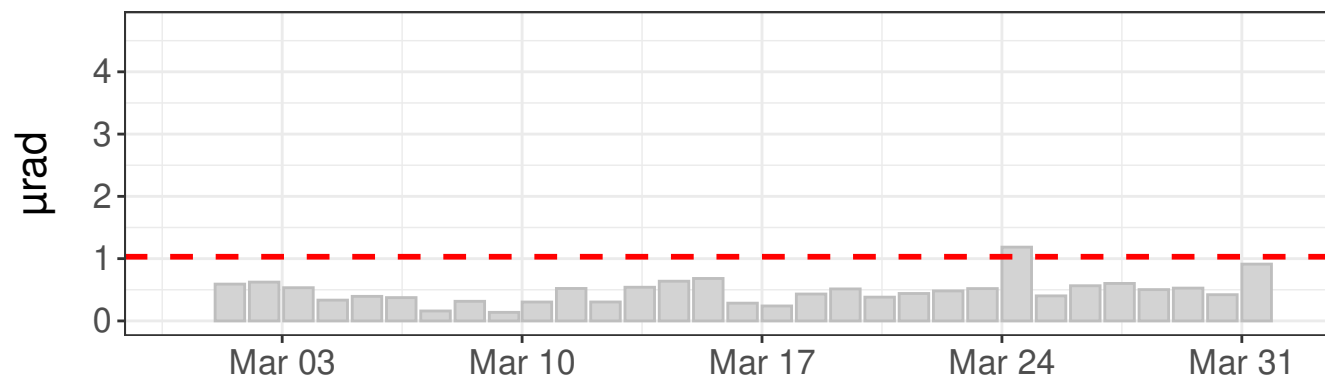
Daily precipitation



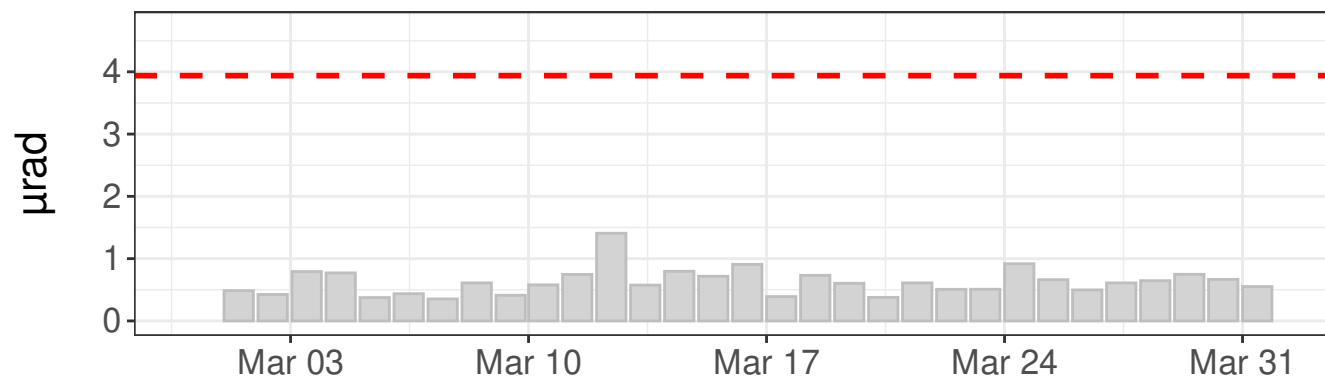
Daily precipitation



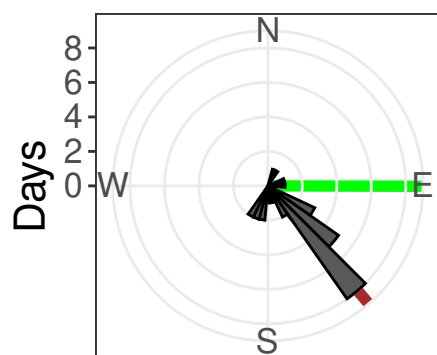
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $115.02 \pm 0.17 \mu\text{rad}/\text{year}$

North tilt rate:  $-134.30 \pm 0.21 \mu\text{rad}/\text{year}$

Azimuth to C7: 90 deg

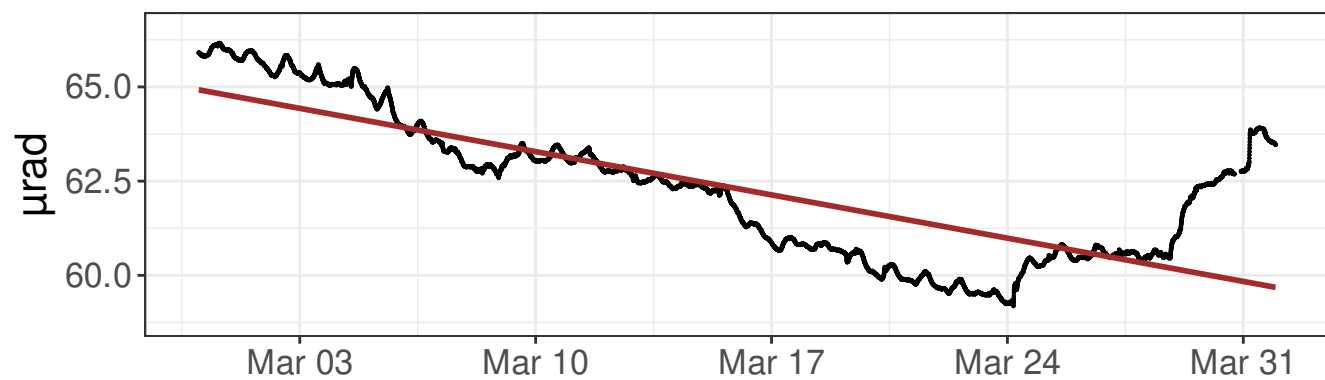
Distance to C7: 494 ft

--- Outlier value

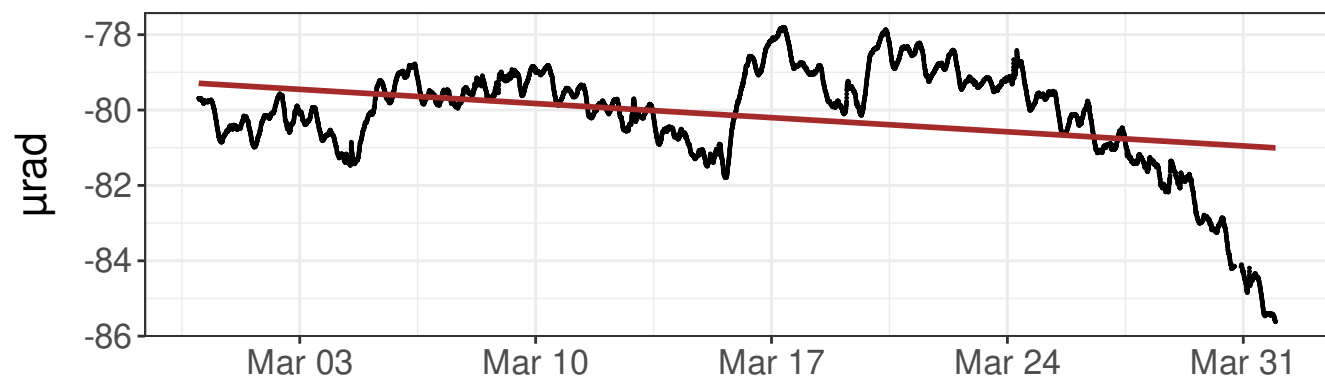
— Linear model

— Azimuth to C7

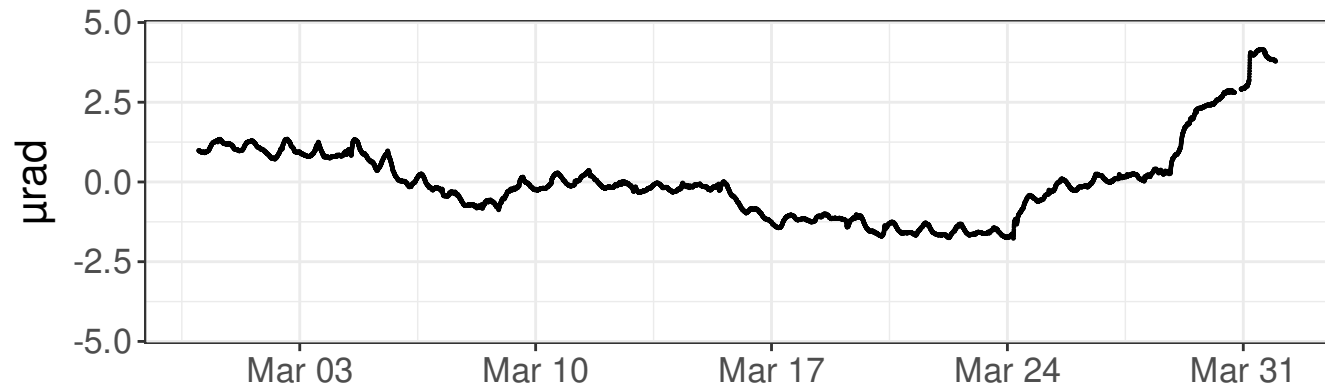
East tilt - raw values, Linear model R2 0.61



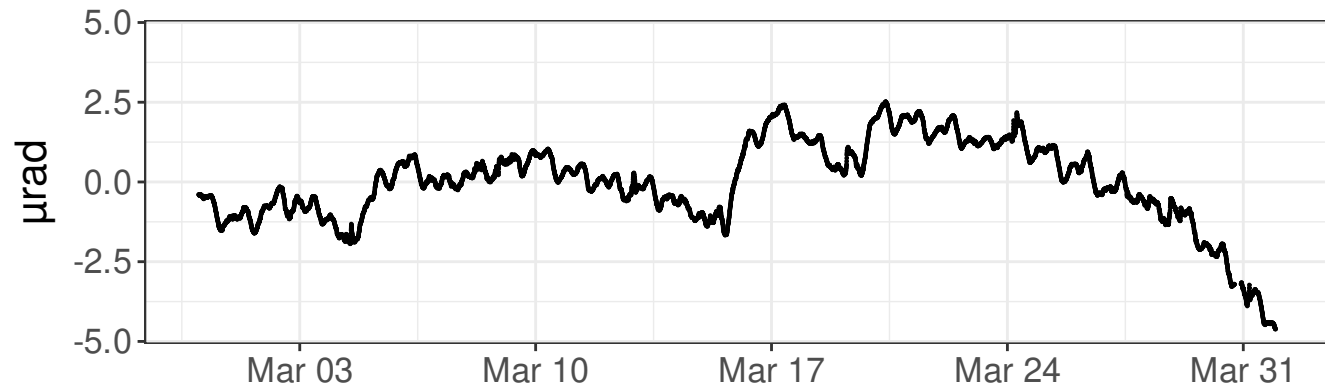
North tilt - raw values, Linear model R2 0.12



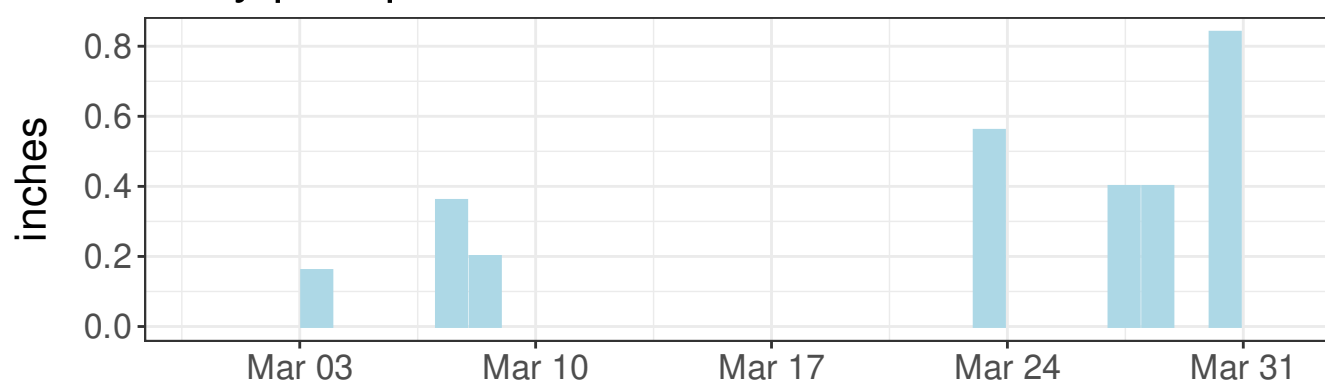
East tilt - detrended values



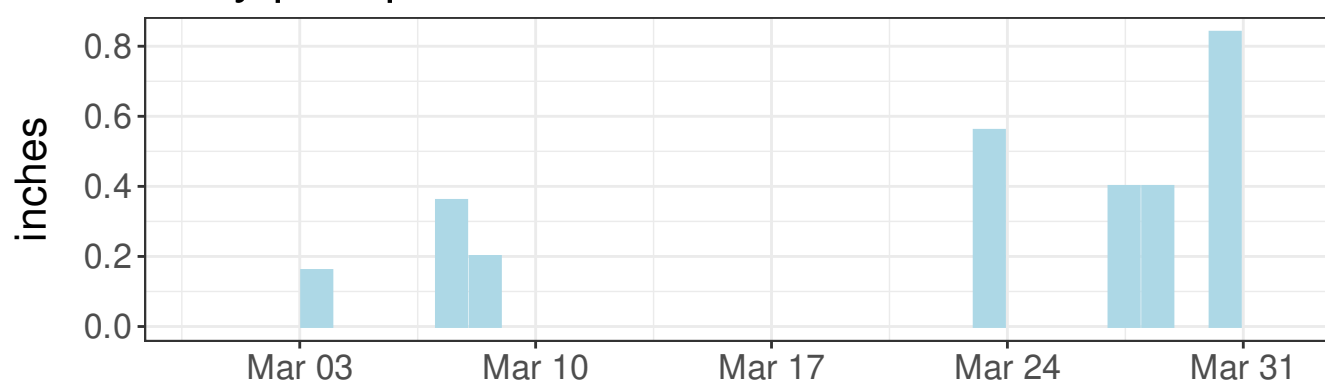
North tilt - detrended values



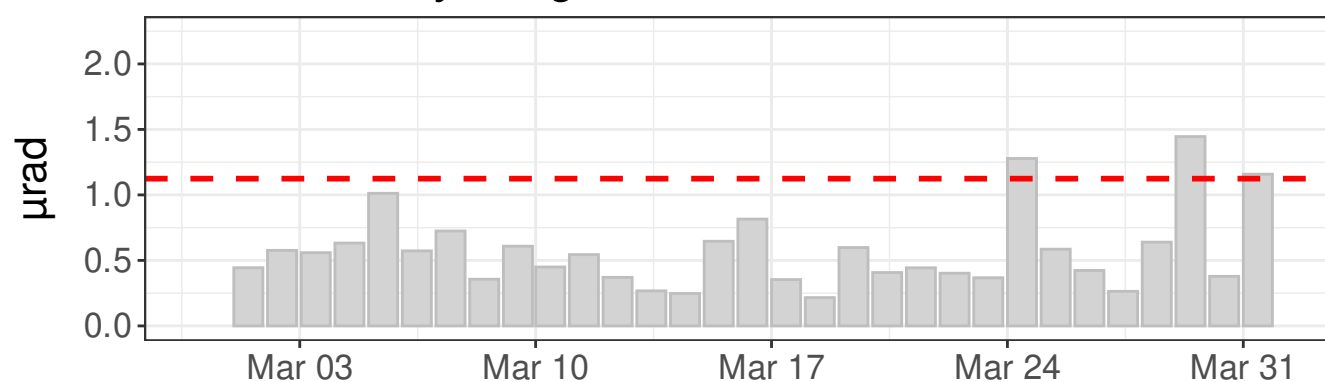
Daily precipitation



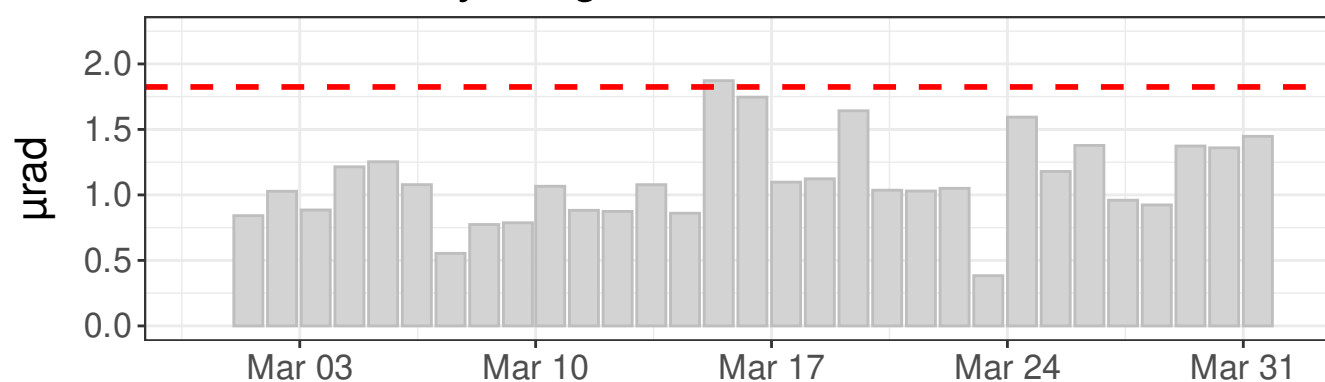
Daily precipitation



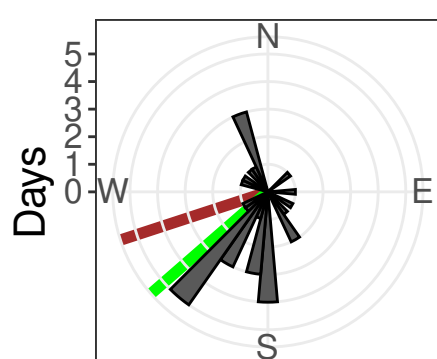
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $-59.87 \pm 0.45 \mu\text{rad}/\text{year}$

North tilt rate:  $-19.57 \pm 0.49 \mu\text{rad}/\text{year}$

Azimuth to C7: 229 deg

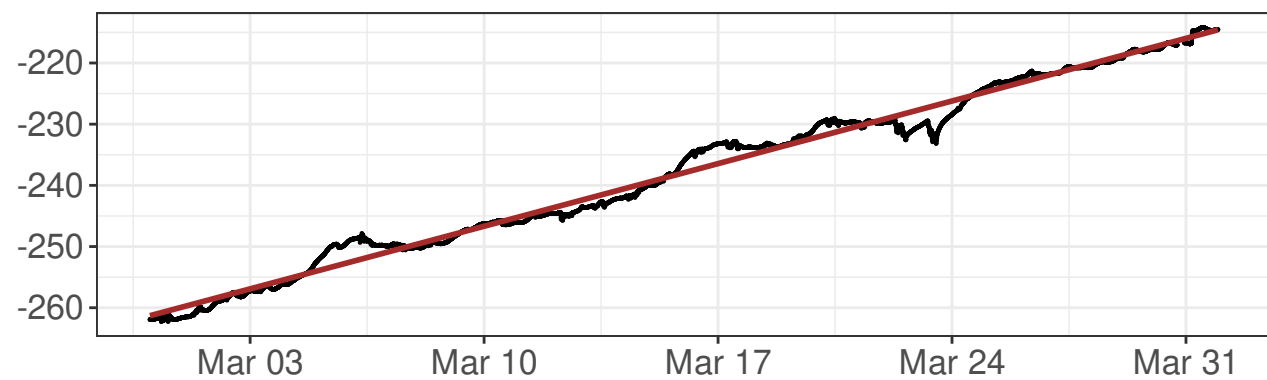
Distance to C7: 513 ft

--- Outlier value

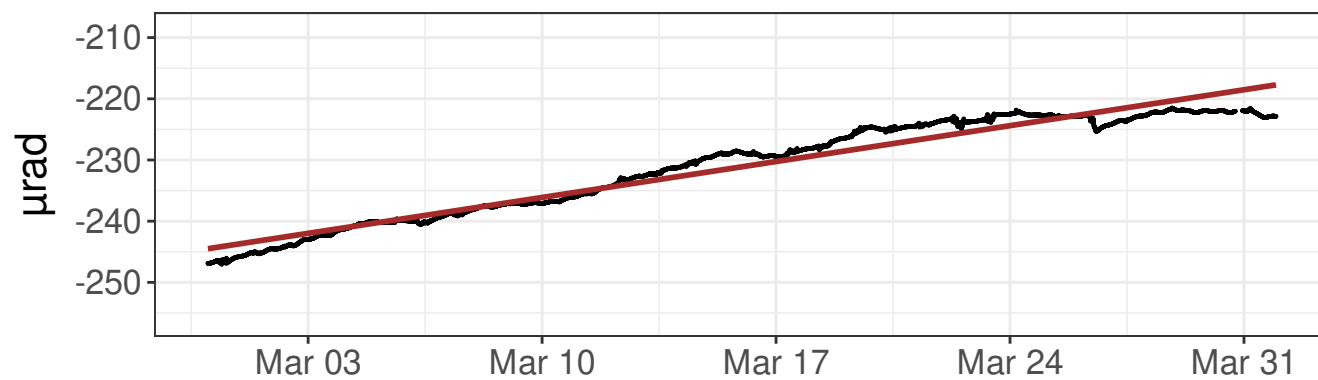
— Linear model

— Azimuth to C7

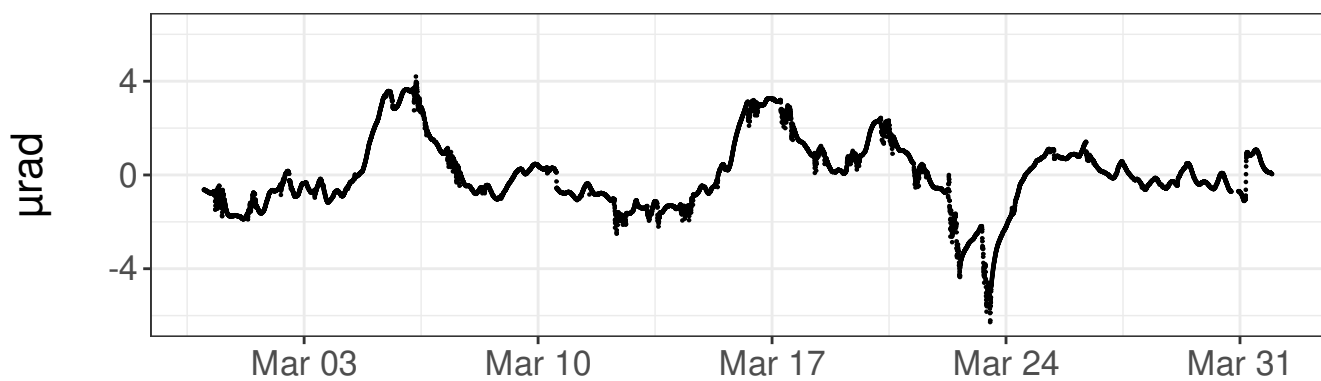
East tilt - raw values, Linear model R2 0.99



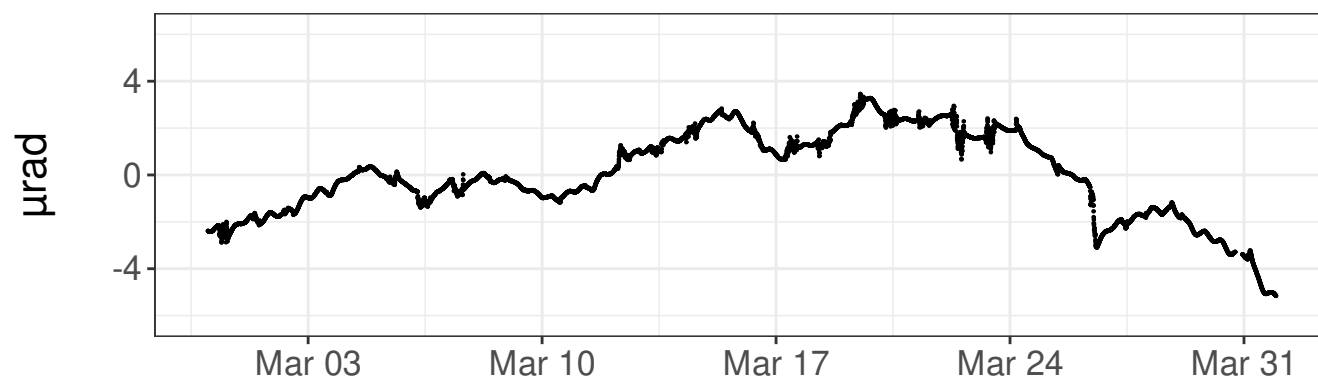
North tilt - raw values, Linear model R2 0.95



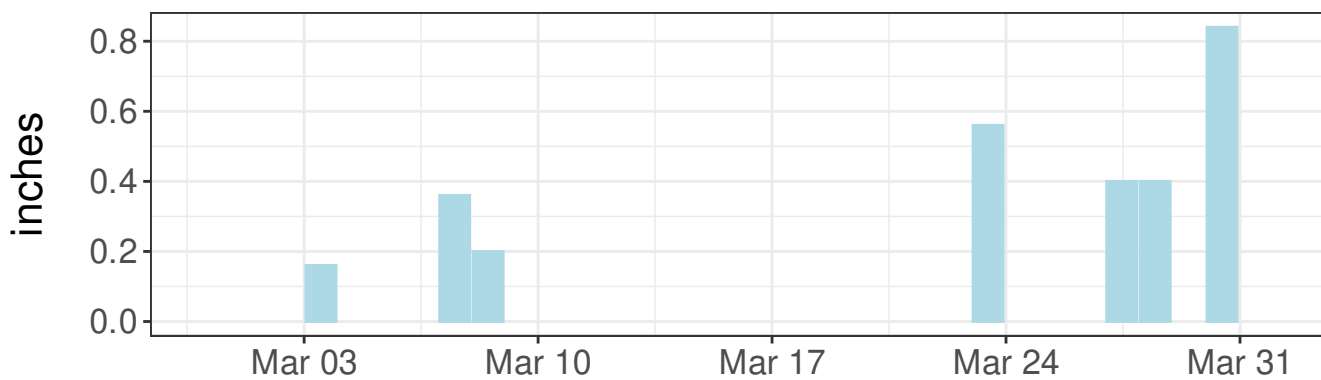
East tilt - detrended values



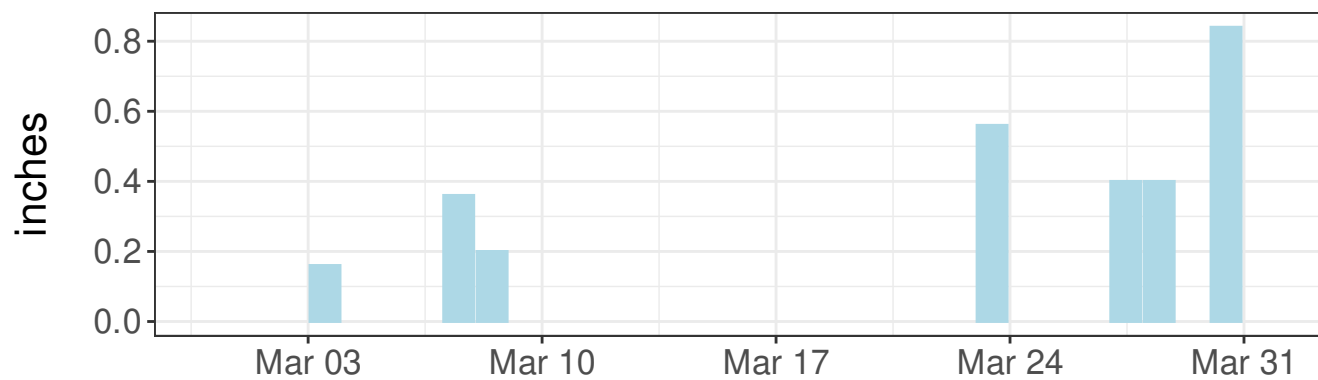
North tilt - detrended values



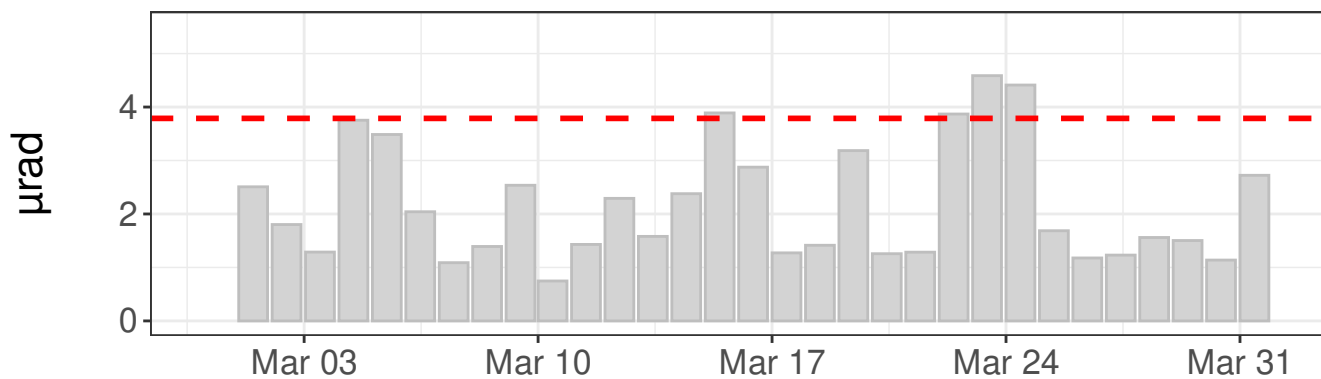
Daily precipitation



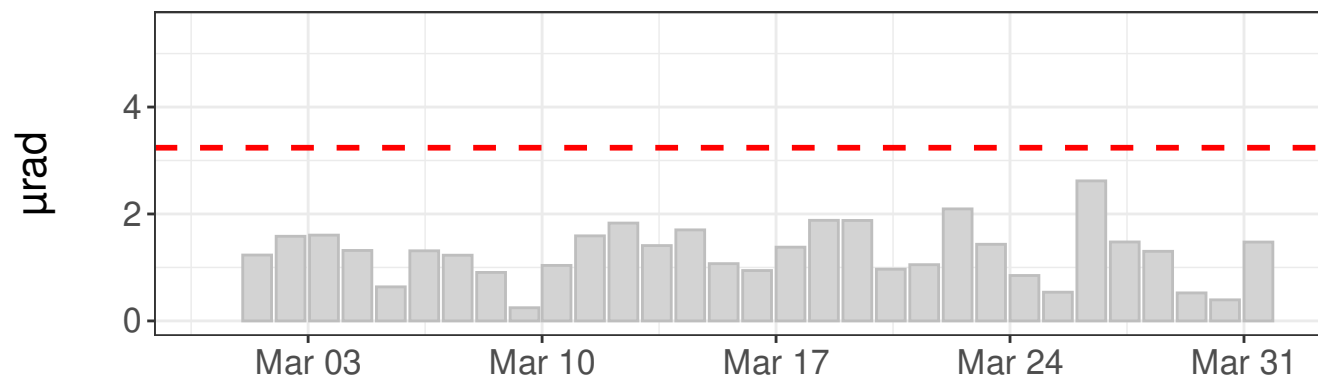
Daily precipitation



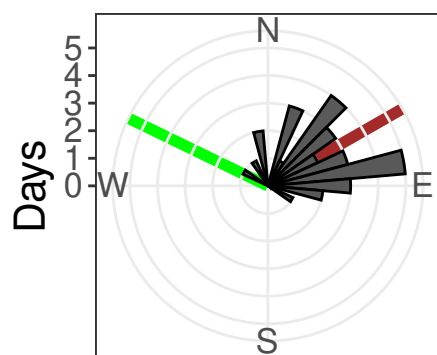
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $533.68 \pm 0.56$   $\mu\text{rad}/\text{year}$

North tilt rate:  $305.86 \pm 0.67$   $\mu\text{rad}/\text{year}$

Azimuth to C7: 296 deg

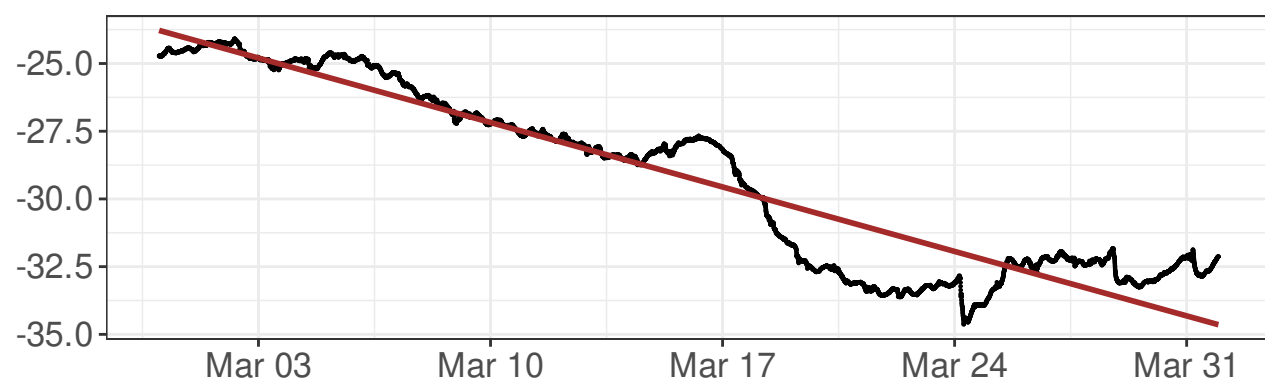
Distance to C7: 186 ft

--- Outlier value

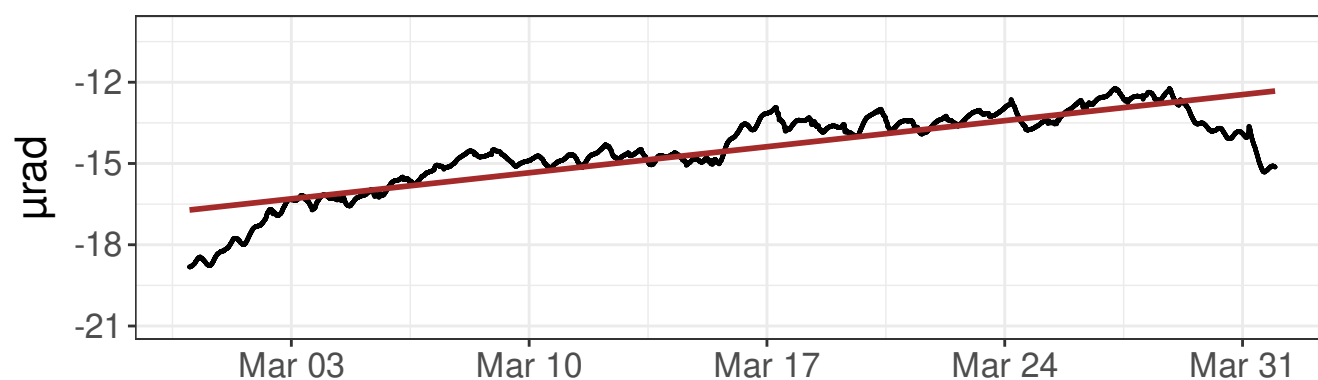
— Linear model

— Azimuth to C7

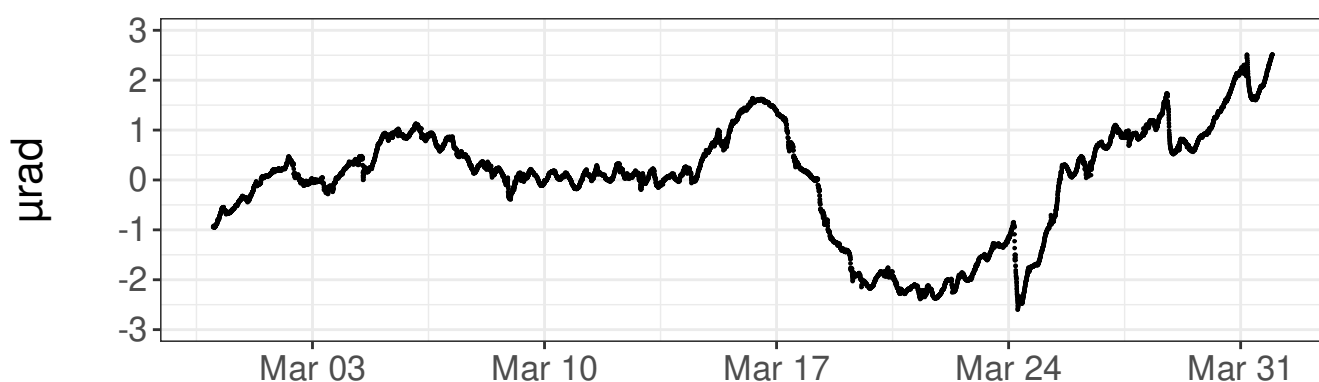
East tilt - raw values, Linear model R2 0.89



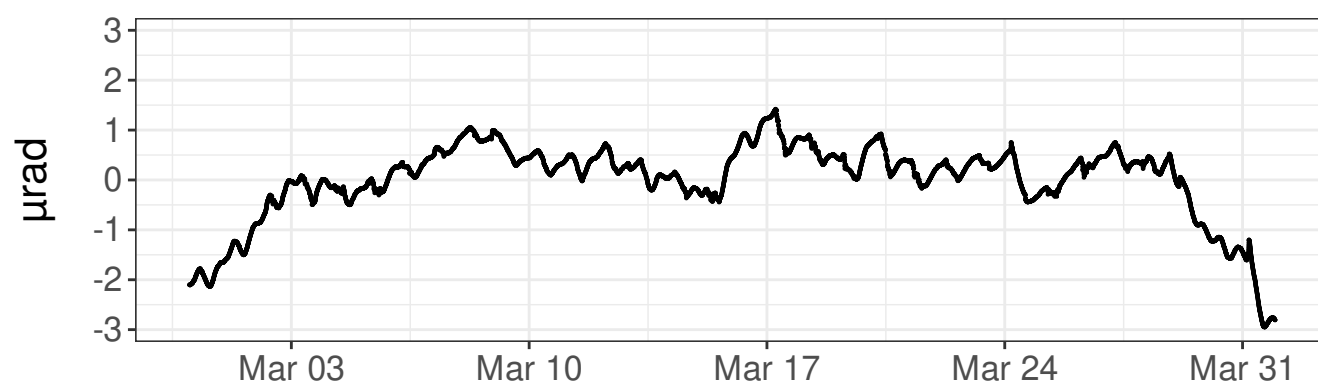
North tilt - raw values, Linear model R2 0.73



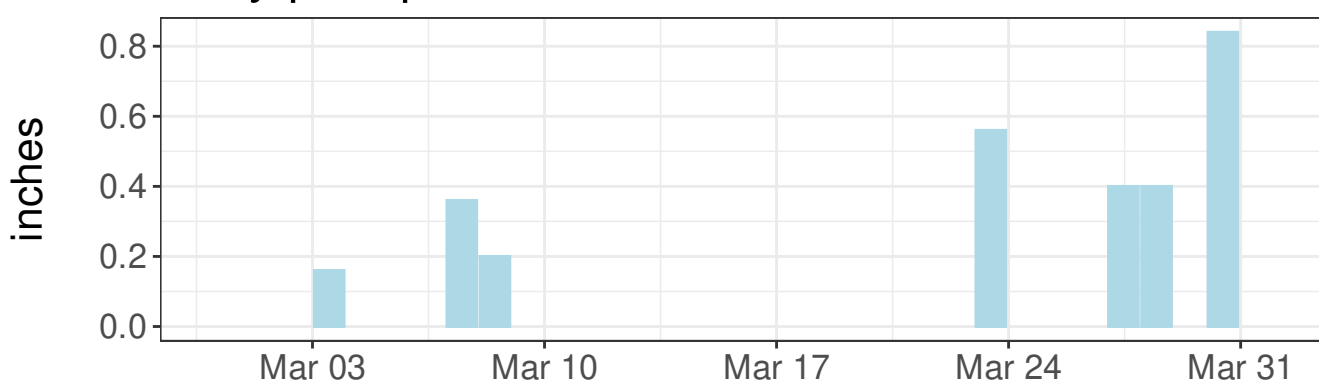
East tilt - detrended values



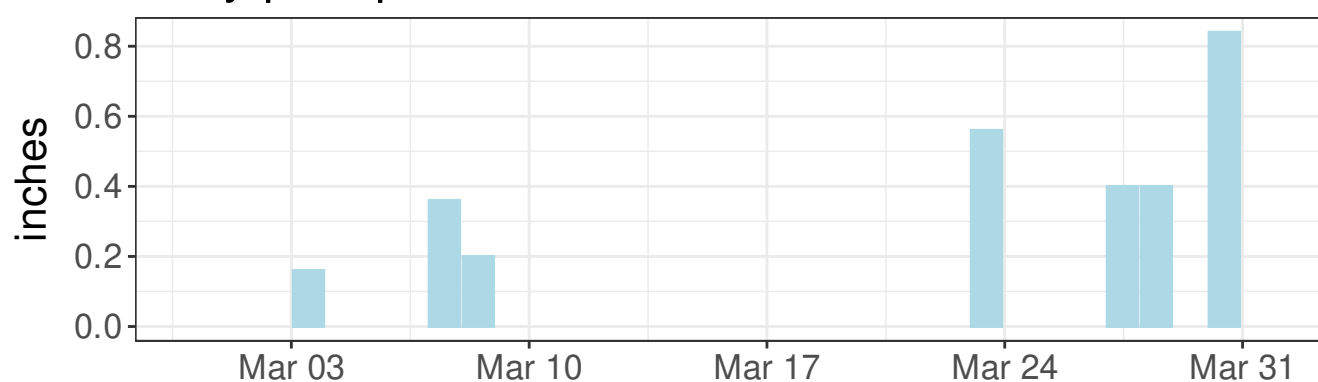
North tilt - detrended values



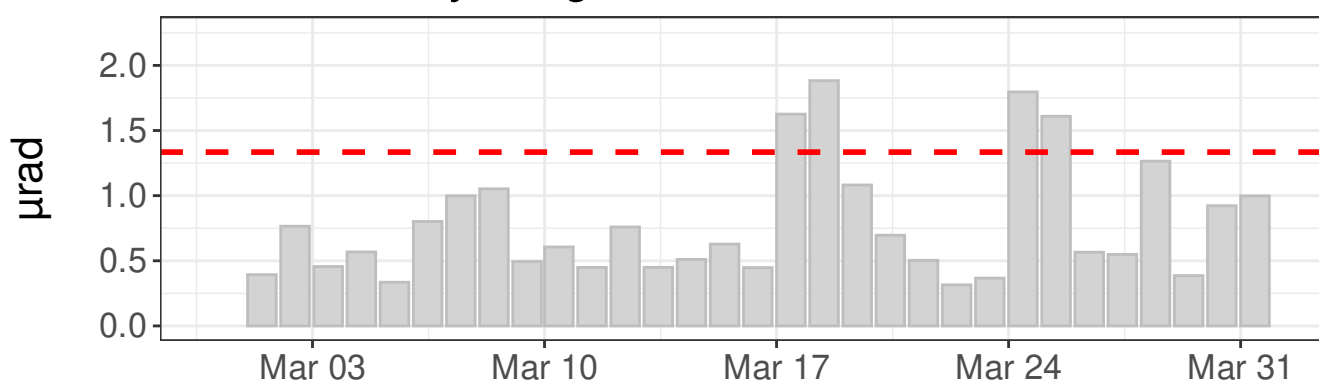
Daily precipitation



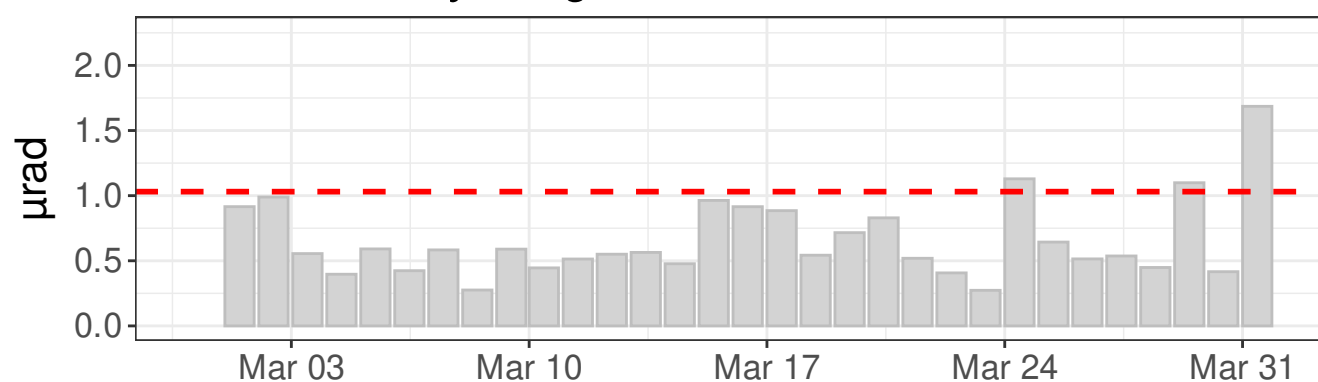
Daily precipitation



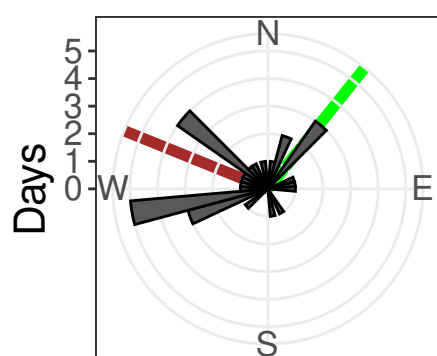
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $-124.11 \pm 0.41 \mu\text{rad}/\text{year}$

North tilt rate:  $50.17 \pm 0.29 \mu\text{rad}/\text{year}$

Azimuth to C7: 39 deg

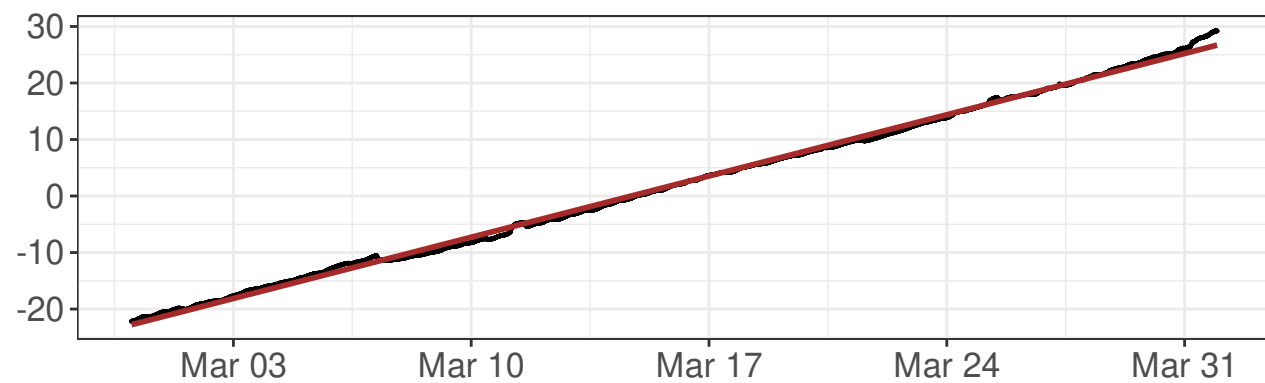
Distance to C7: 561 ft

--- Outlier value

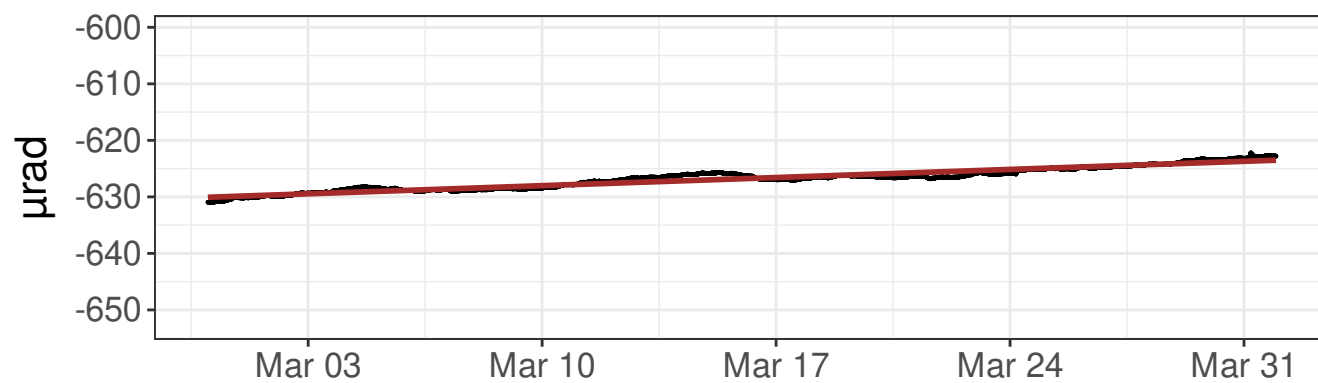
— Linear model

— Azimuth to C7

East tilt - raw values, Linear model R2 1.00



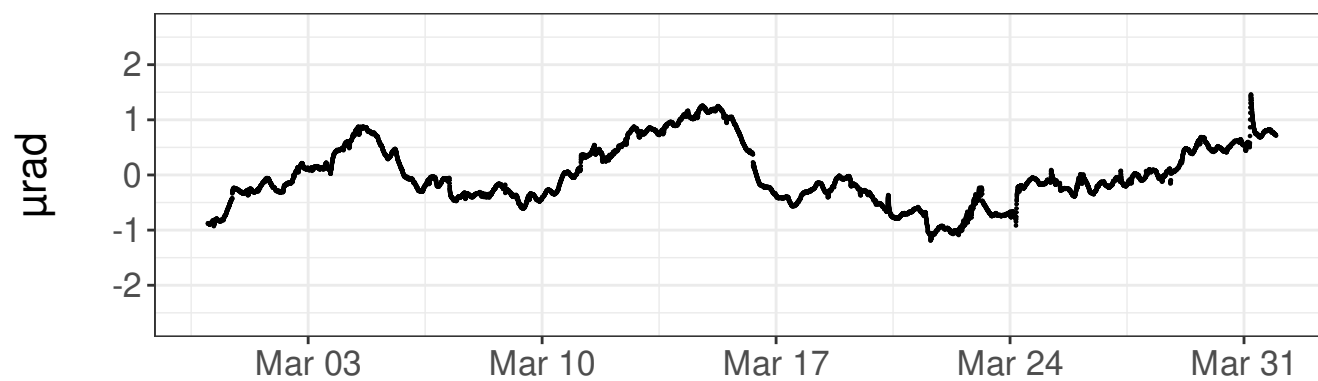
North tilt - raw values, Linear model R2 0.92



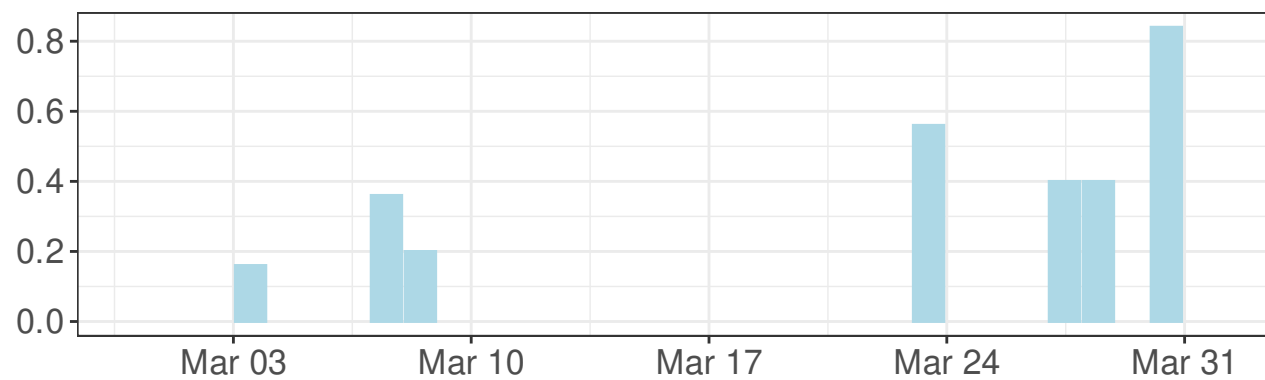
East tilt - detrended values



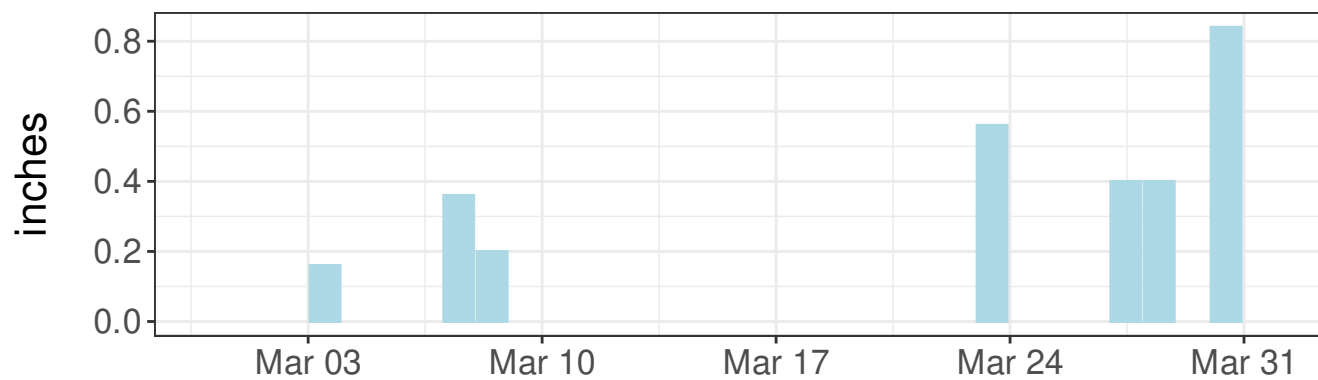
North tilt - detrended values



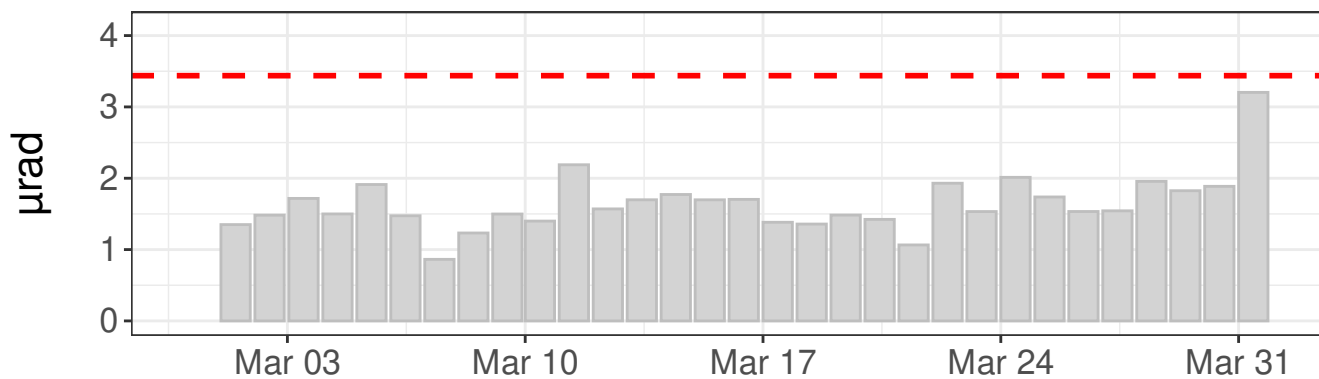
Daily precipitation



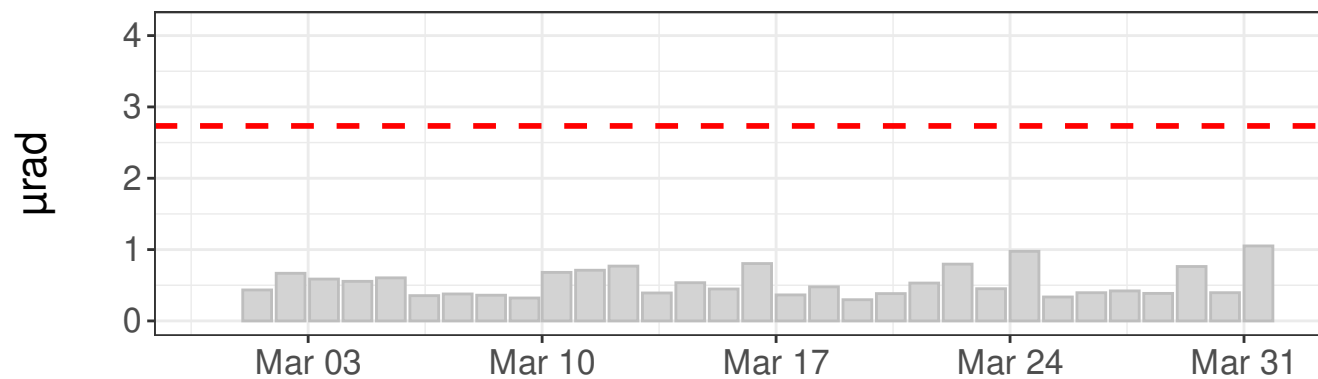
Daily precipitation



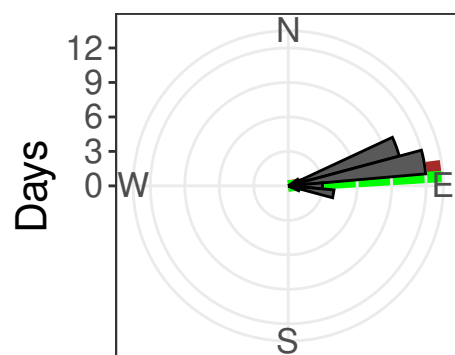
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $564.98 \pm 0.24 \mu\text{rad}/\text{year}$

North tilt rate:  $74.93 \pm 0.20 \mu\text{rad}/\text{year}$

Azimuth to C7: 87 deg

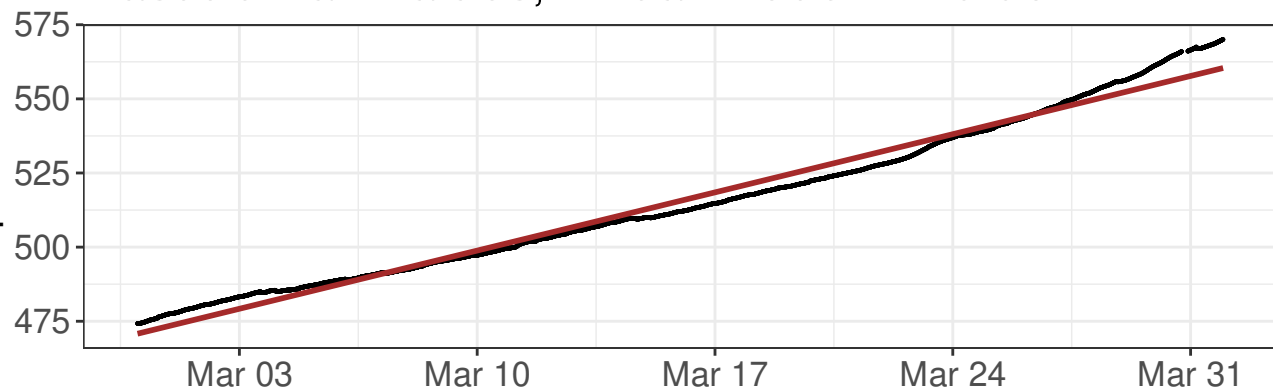
Distance to C7: 2402 ft

--- Outlier value

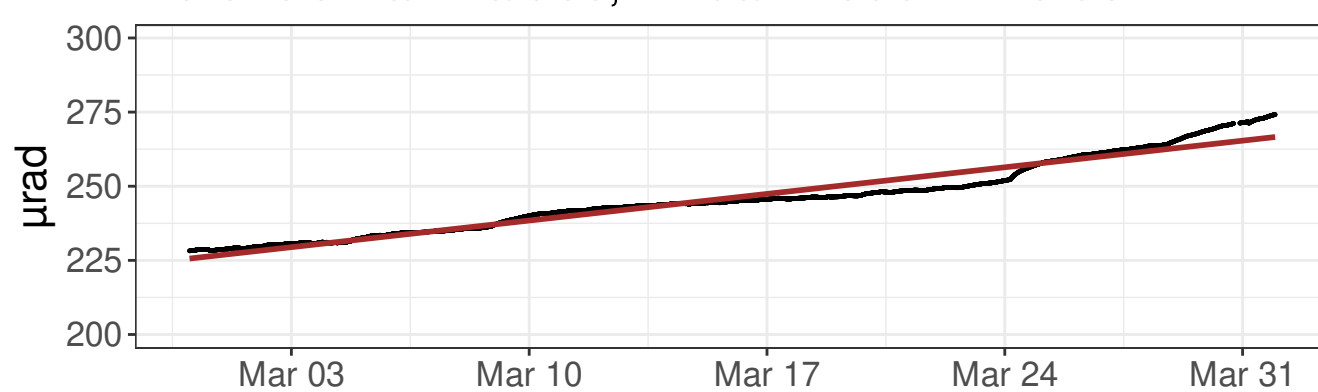
— Linear model

— Azimuth to C7

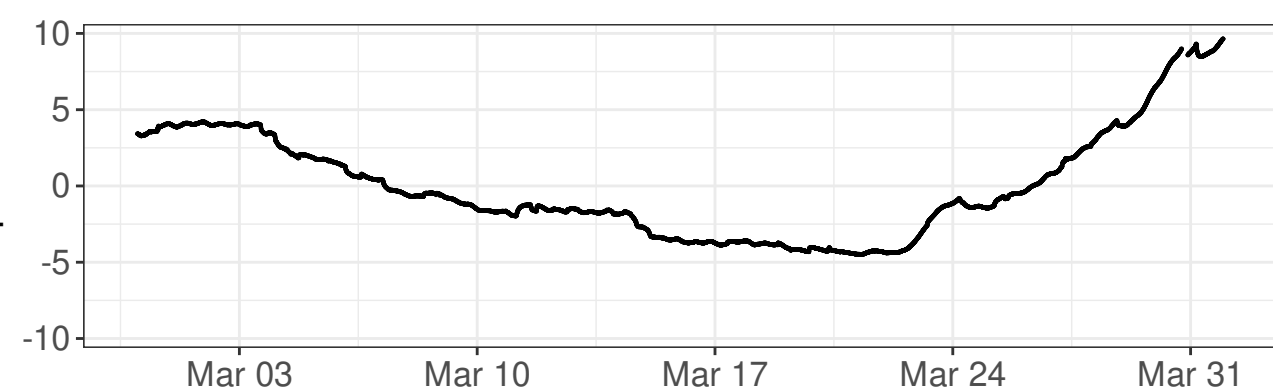
East tilt - raw values, Linear model R2 0.98



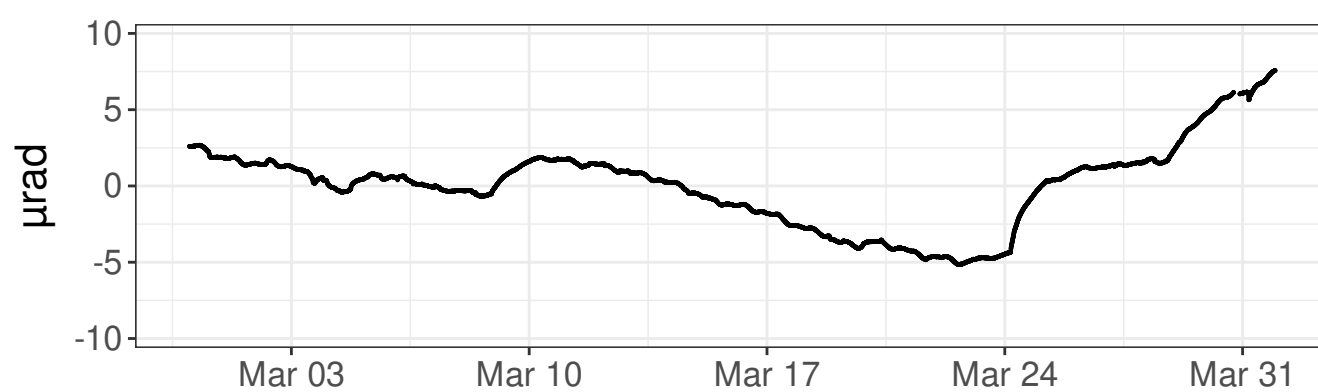
North tilt - raw values, Linear model R2 0.95



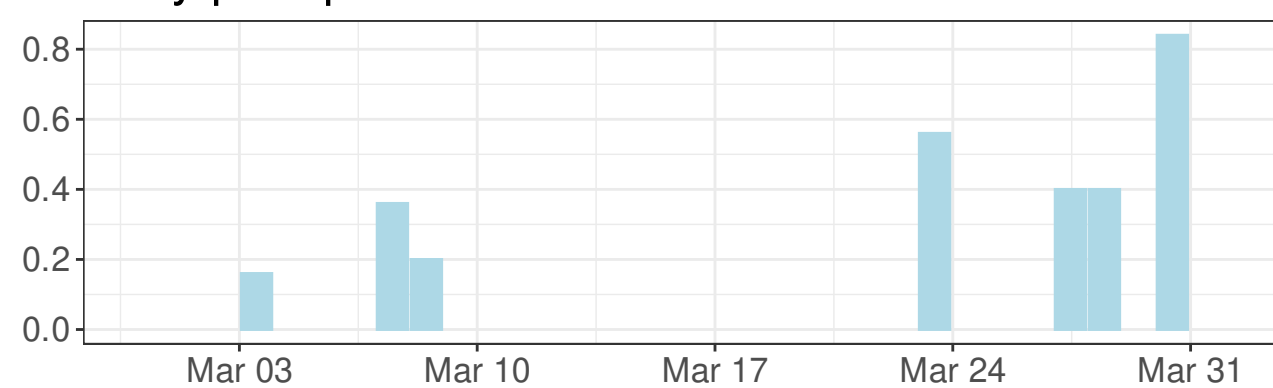
East tilt - detrended values



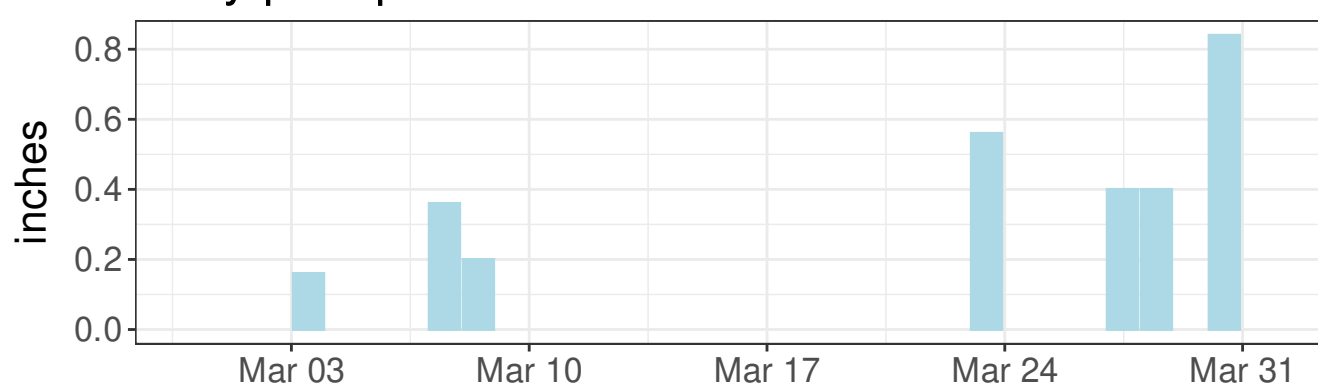
North tilt - detrended values



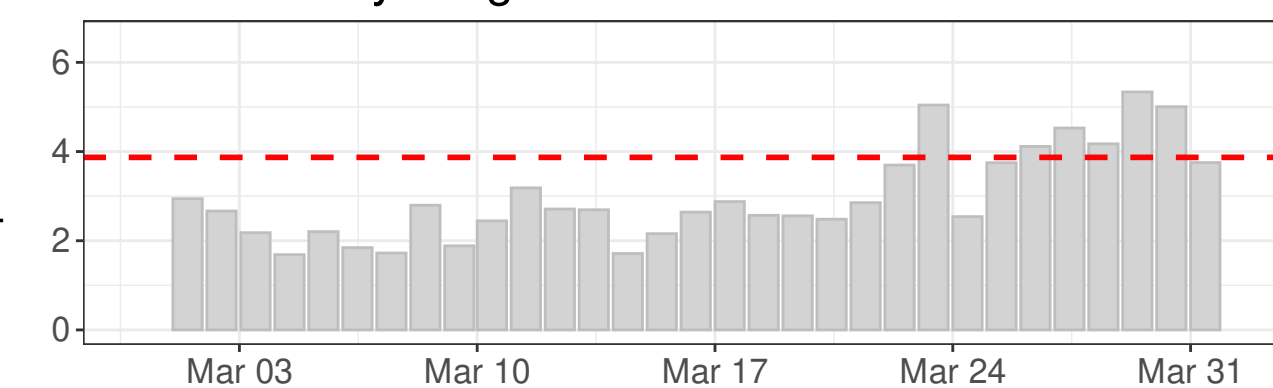
Daily precipitation



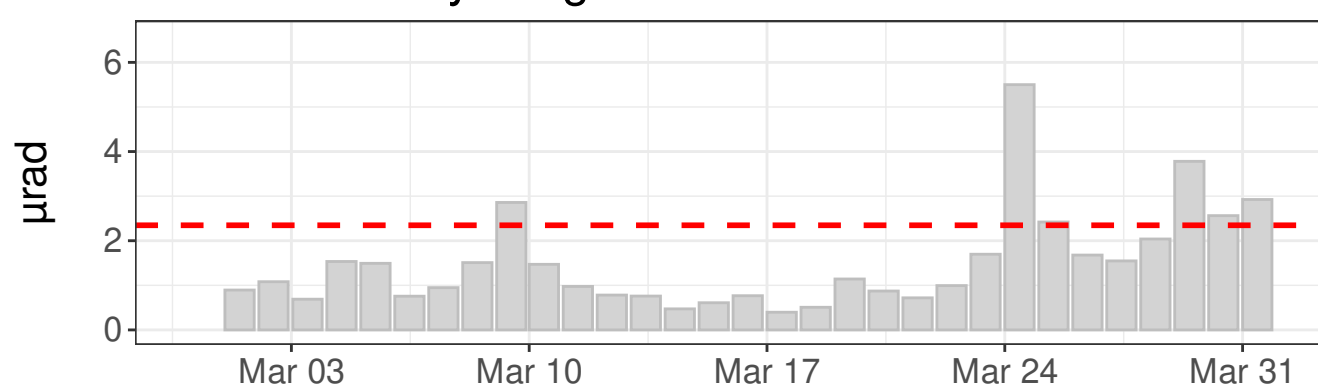
Daily precipitation



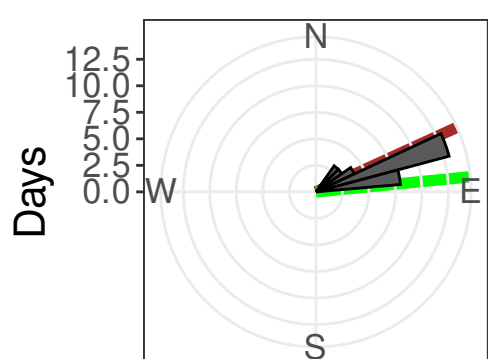
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $1023.43 \pm 1.30 \mu\text{rad}/\text{year}$

North tilt rate:  $468.17 \pm 1.00 \mu\text{rad}/\text{year}$

Azimuth to C7: 84 deg

Distance to C7: 1473 ft

--- Outlier value

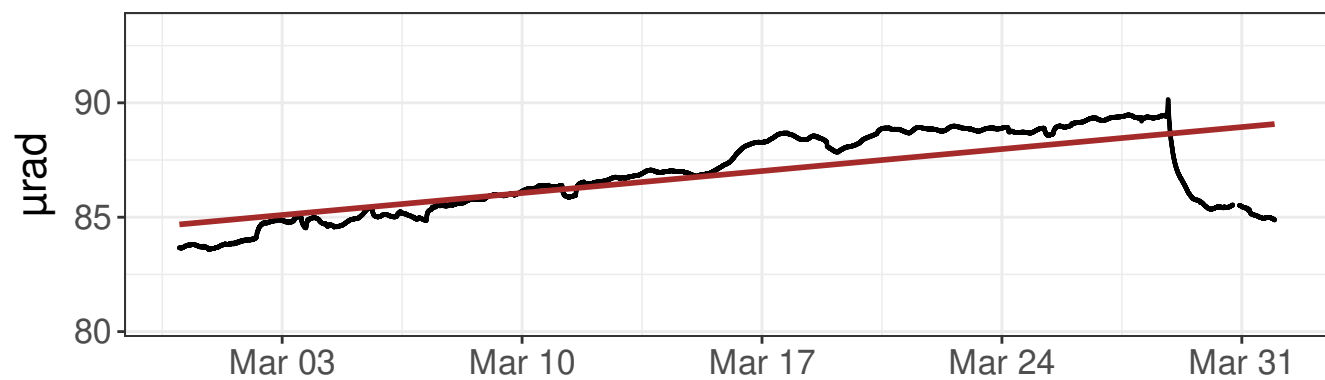
— Linear model

— Azimuth to C7

East tilt - raw values, Linear model R2 0.59



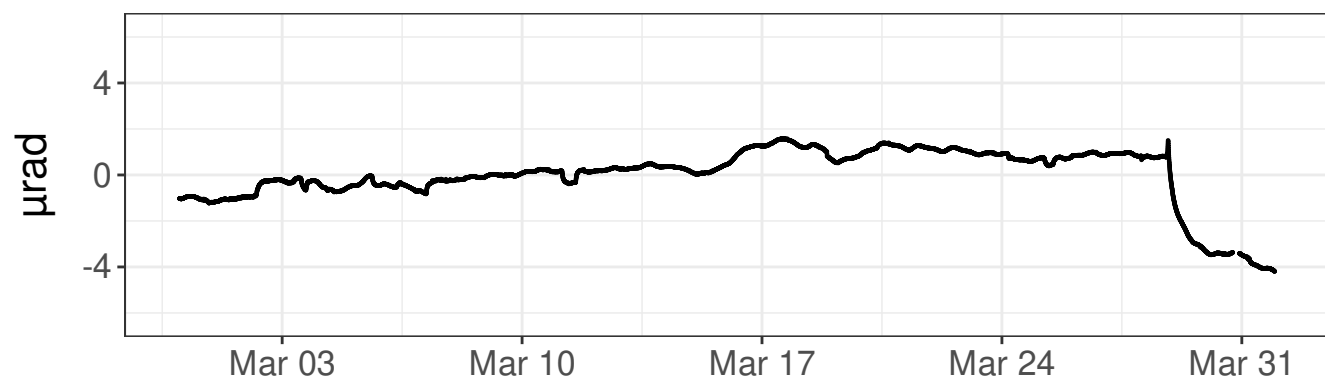
North tilt - raw values, Linear model R2 0.51



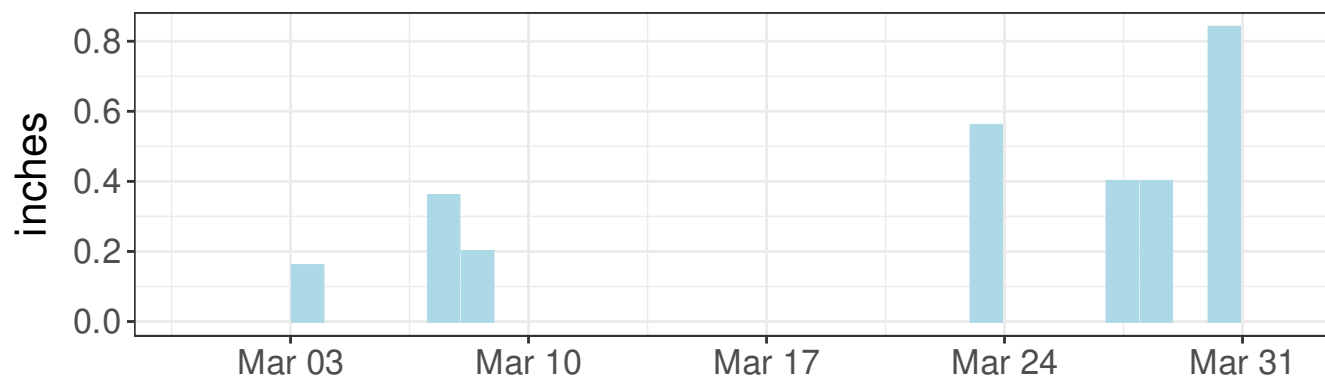
East tilt - detrended values



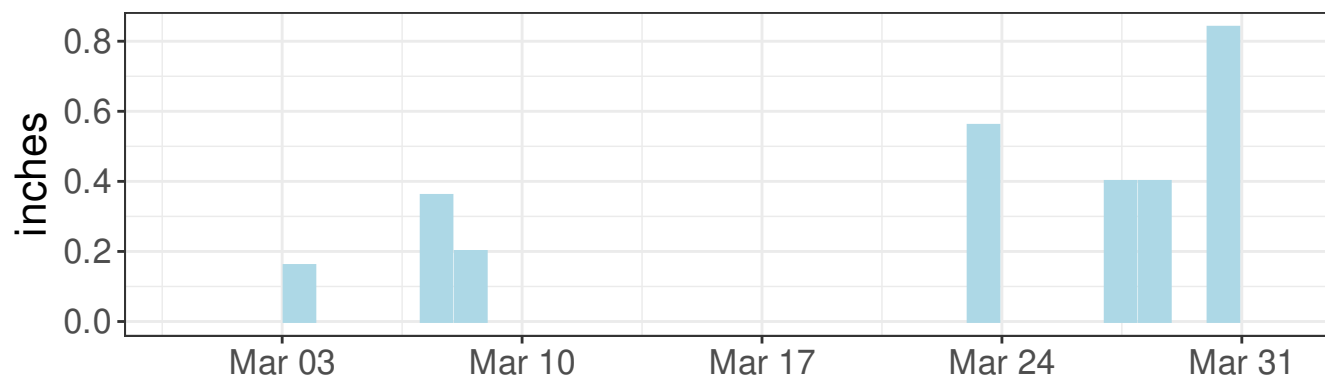
North tilt - detrended values



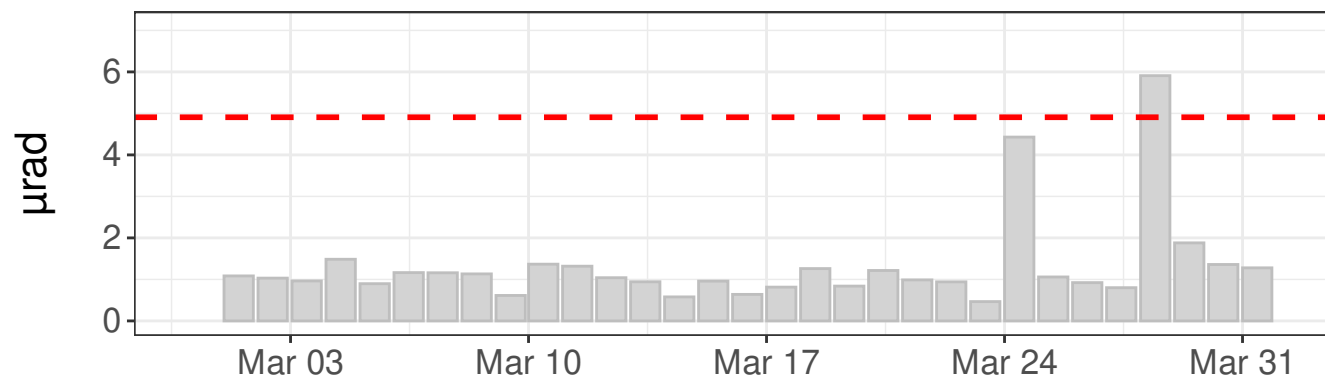
Daily precipitation



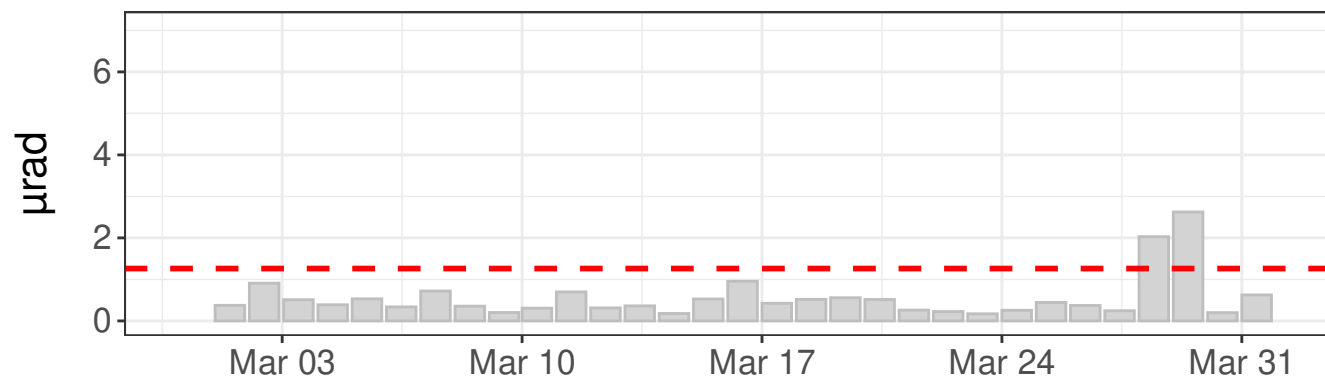
Daily precipitation



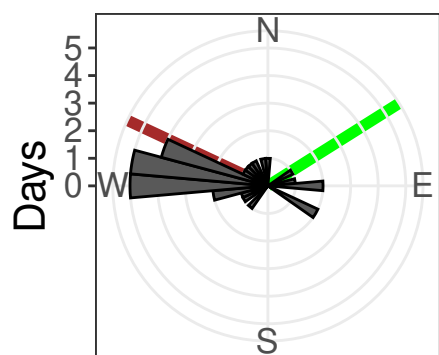
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $-107.45 \pm 0.85 \mu\text{rad}/\text{year}$

North tilt rate:  $50.11 \pm 0.46 \mu\text{rad}/\text{year}$

Azimuth to C7: 58 deg

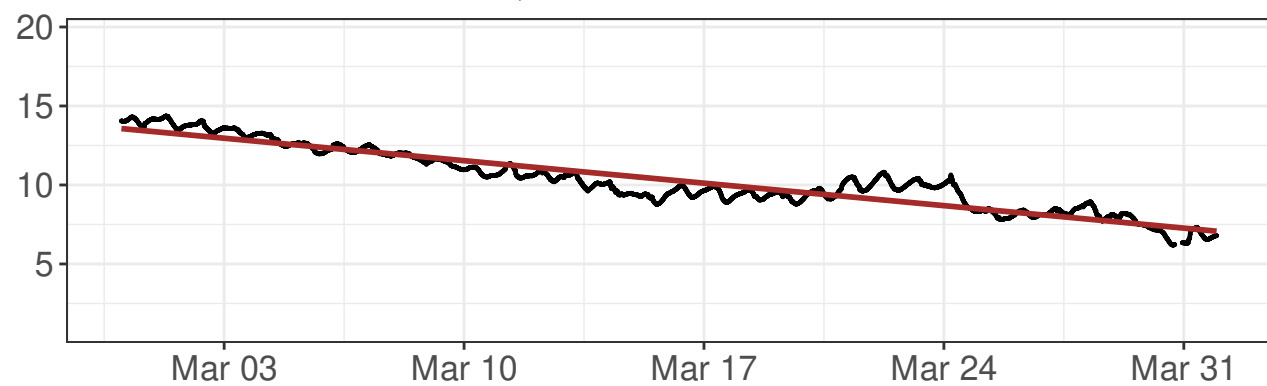
Distance to C7: 1344 ft

--- Outlier value

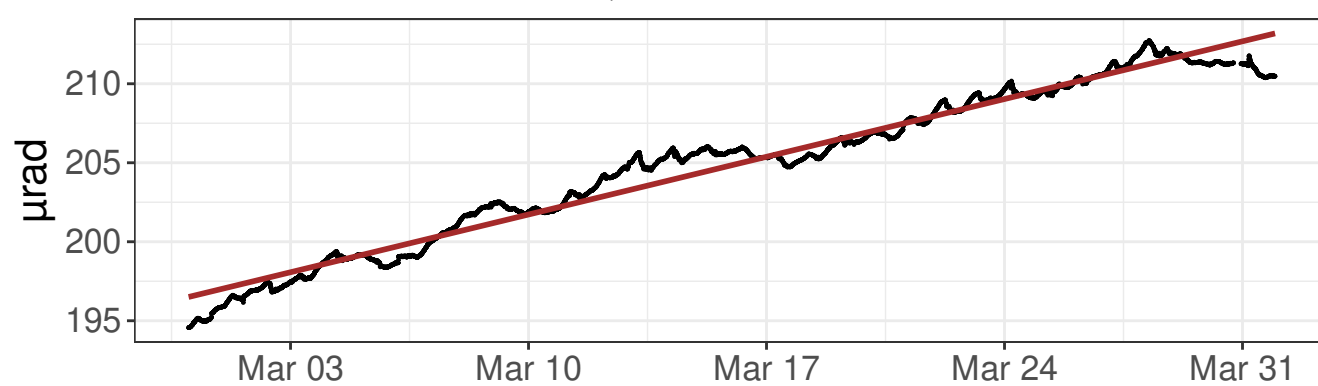
— Linear model

— Azimuth to C7

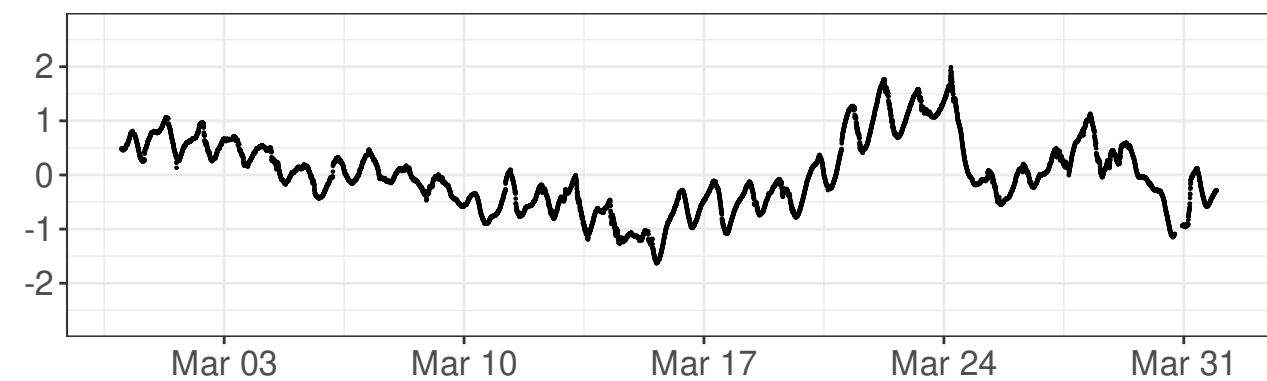
East tilt - raw values, Linear model R2 0.89



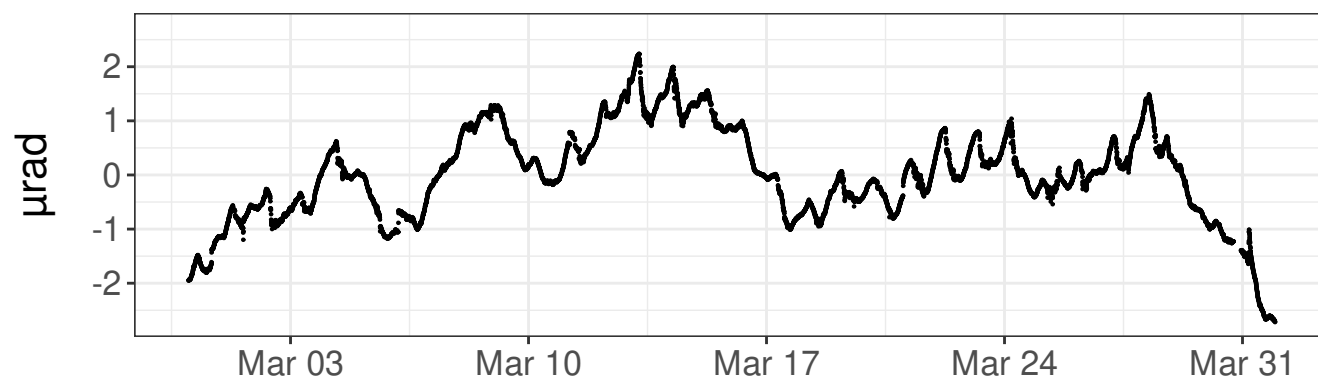
North tilt - raw values, Linear model R2 0.97



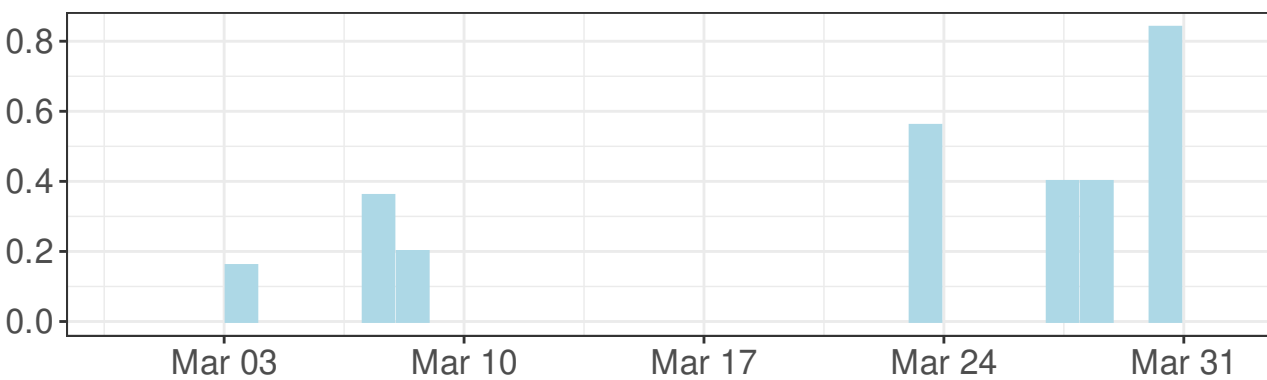
East tilt - detrended values



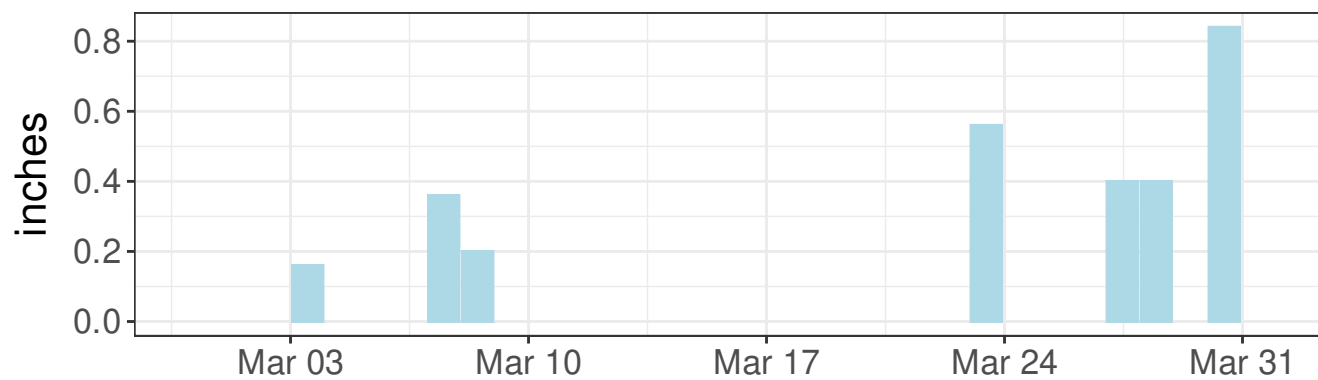
North tilt - detrended values



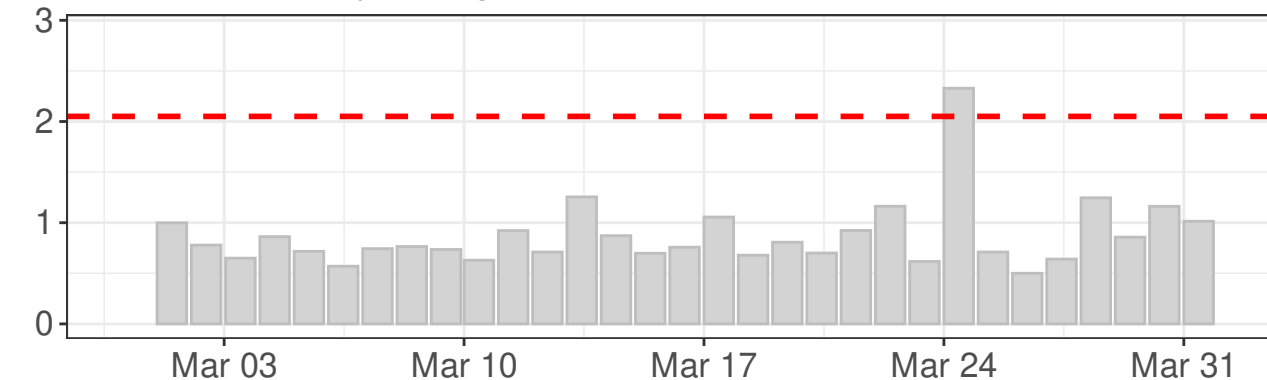
Daily precipitation



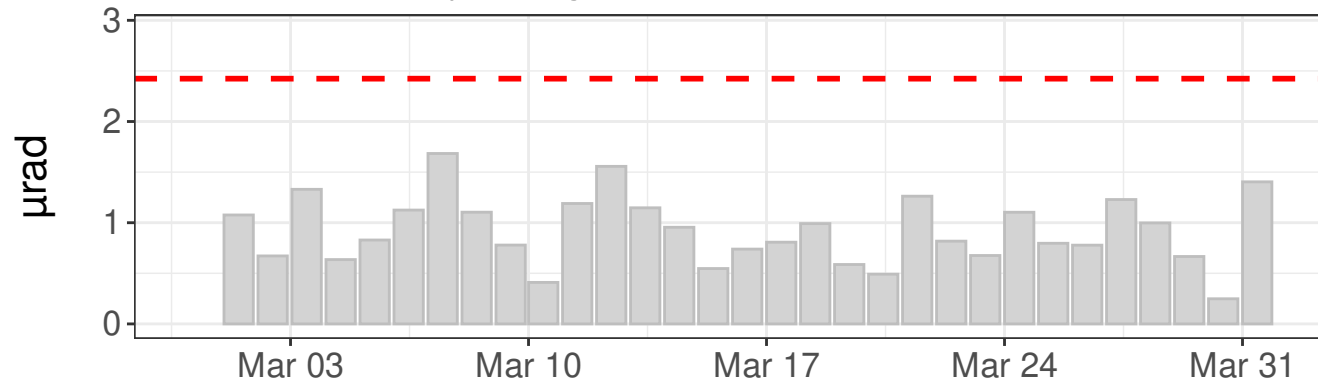
Daily precipitation



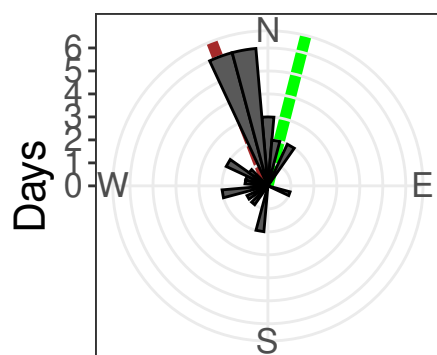
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $-74.18 \pm 0.24 \mu\text{rad}/\text{year}$

North tilt rate:  $190.54 \pm 0.32 \mu\text{rad}/\text{year}$

Azimuth to C7: 14 deg

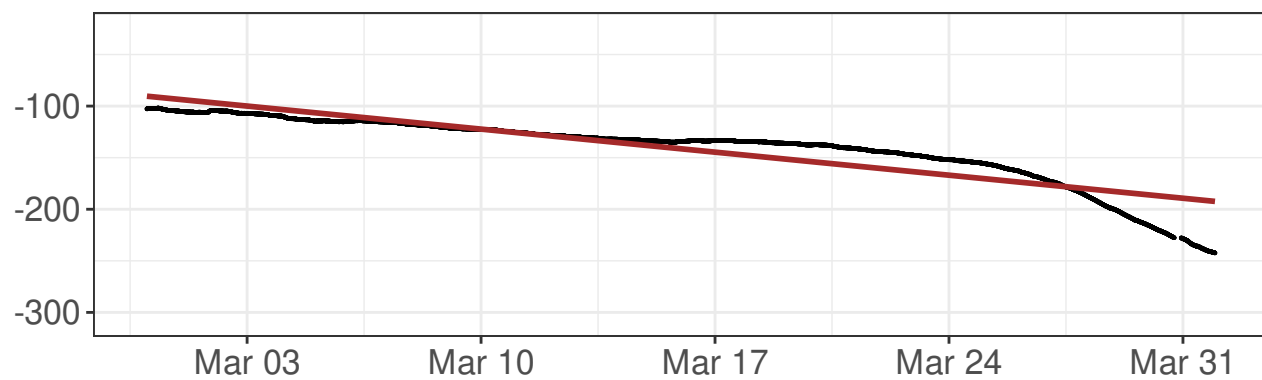
Distance to C7: 686 ft

--- Outlier value

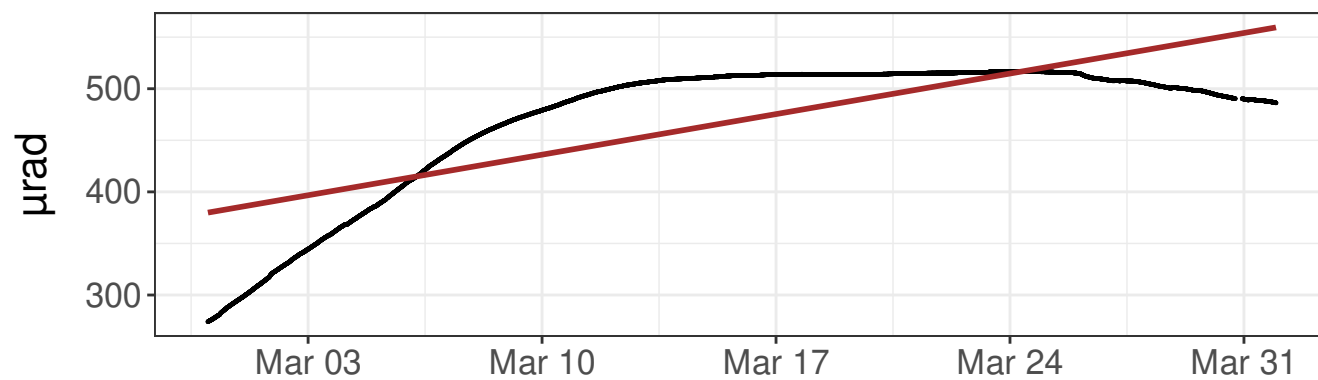
— Linear model

— Azimuth to C7

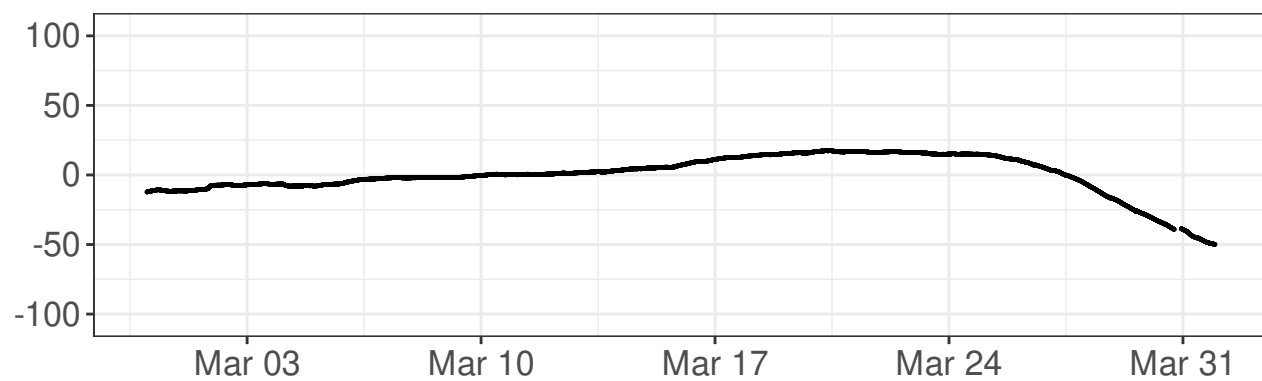
East tilt - raw values, Linear model R2 0.81



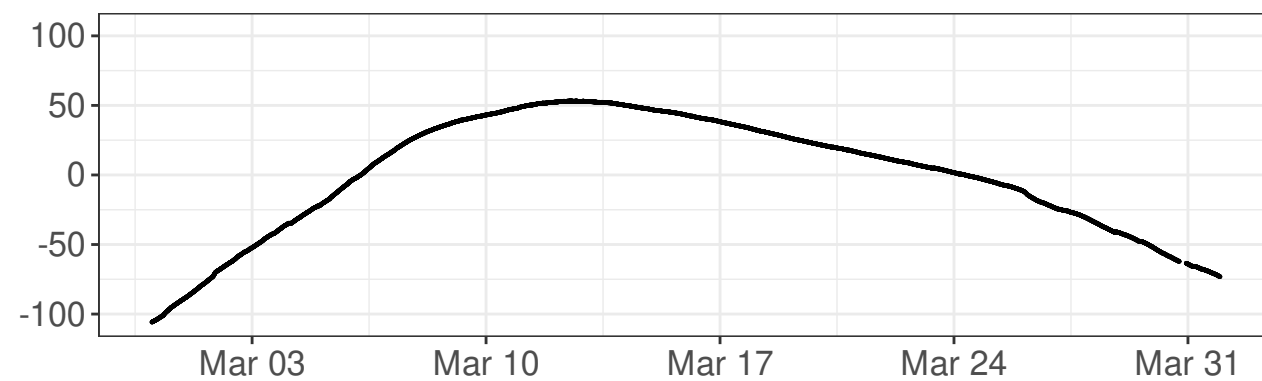
North tilt - raw values, Linear model R2 0.60



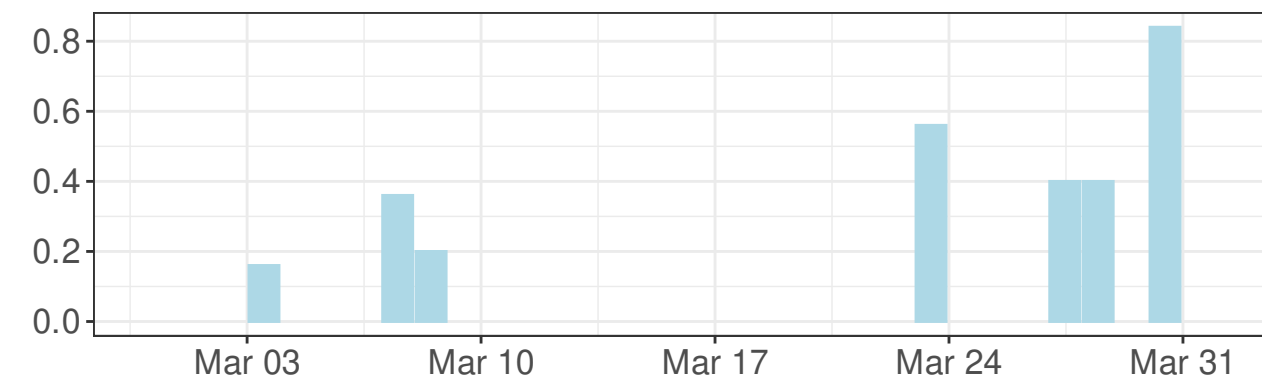
East tilt - detrended values



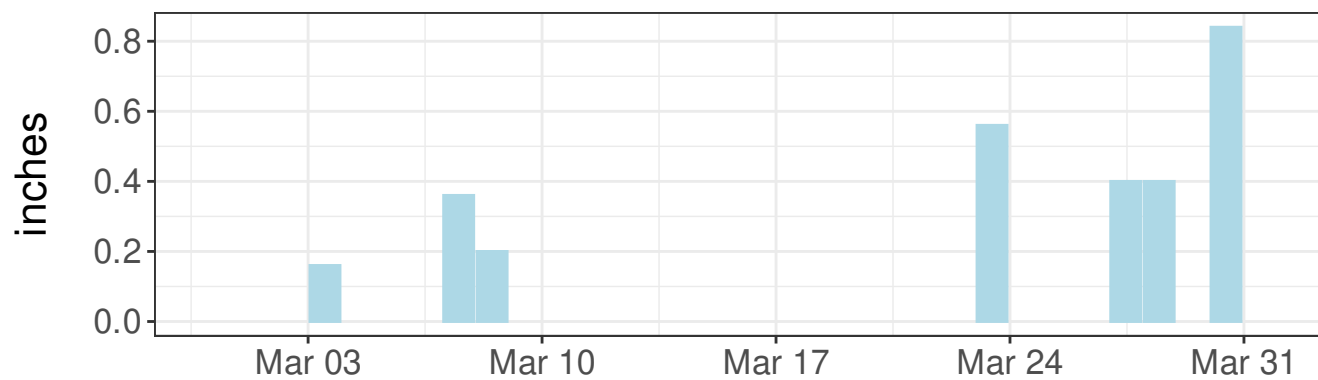
North tilt - detrended values



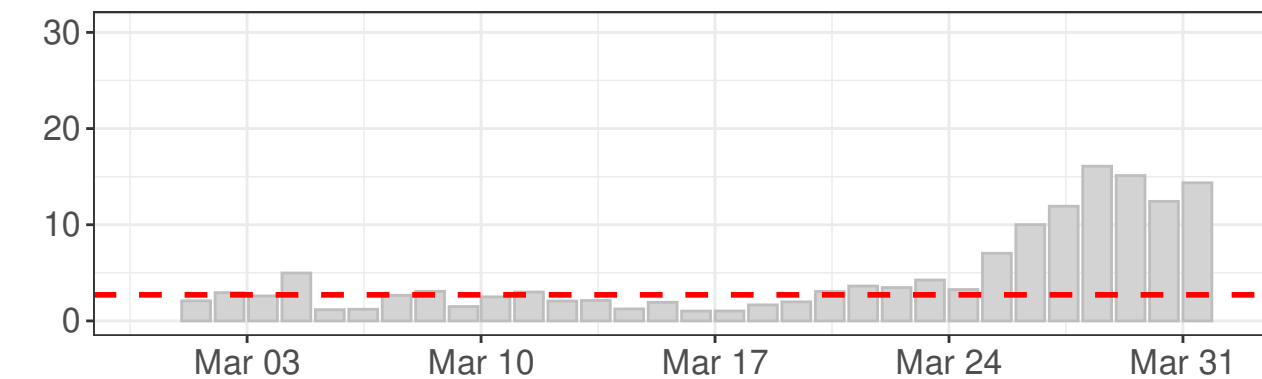
Daily precipitation



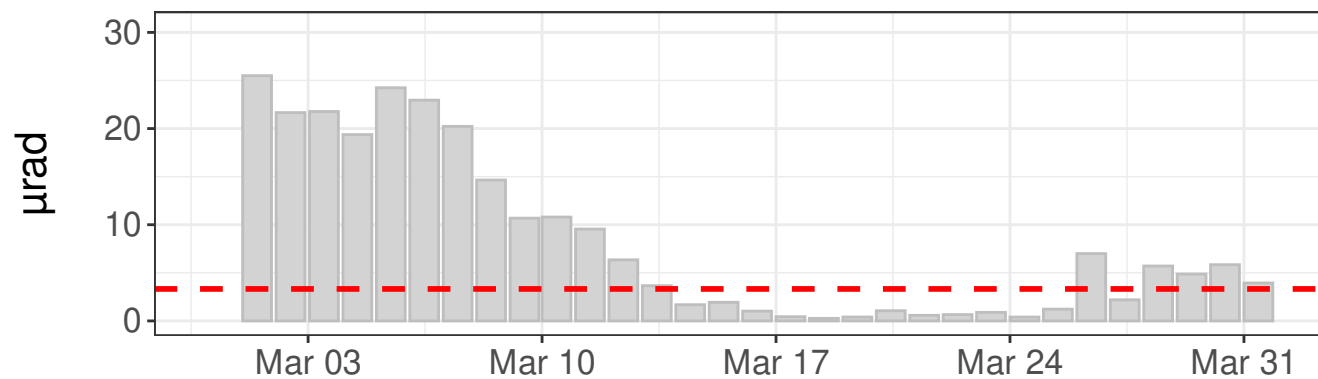
Daily precipitation



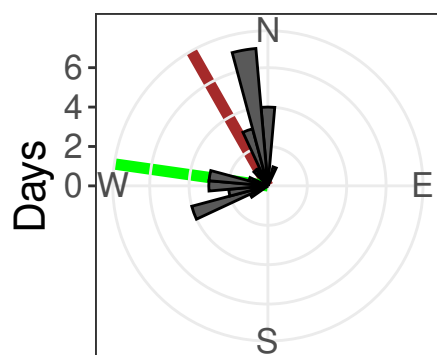
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $-1164.73 \pm 5.31 \mu\text{rad}/\text{year}$

North tilt rate:  $2050.67 \pm 15.82 \mu\text{rad}/\text{year}$

Azimuth to C7: 278 deg

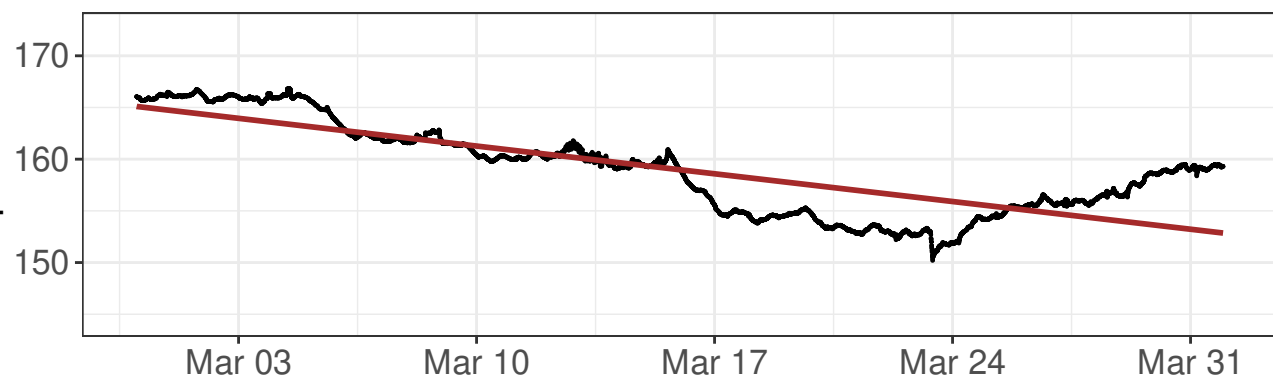
Distance to C7: 1151 ft

--- Outlier value

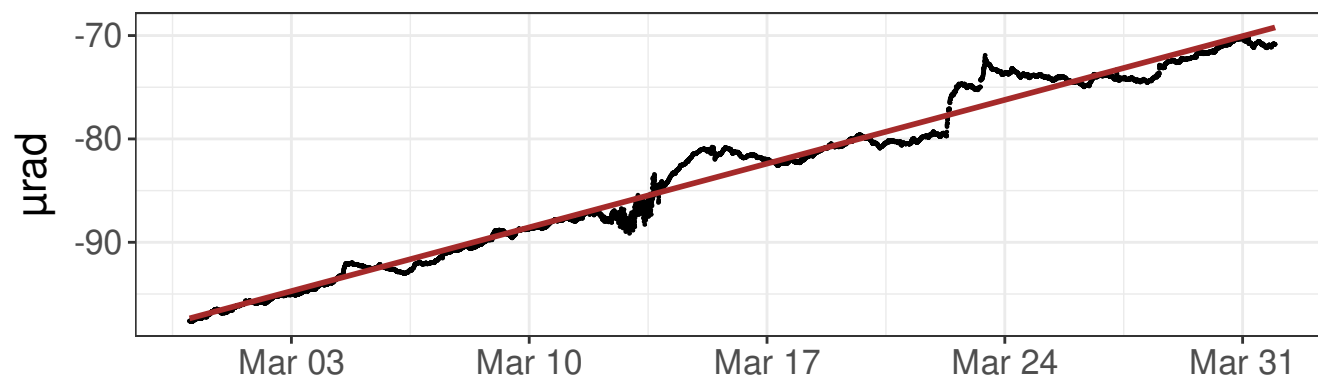
— Linear model

— Azimuth to C7

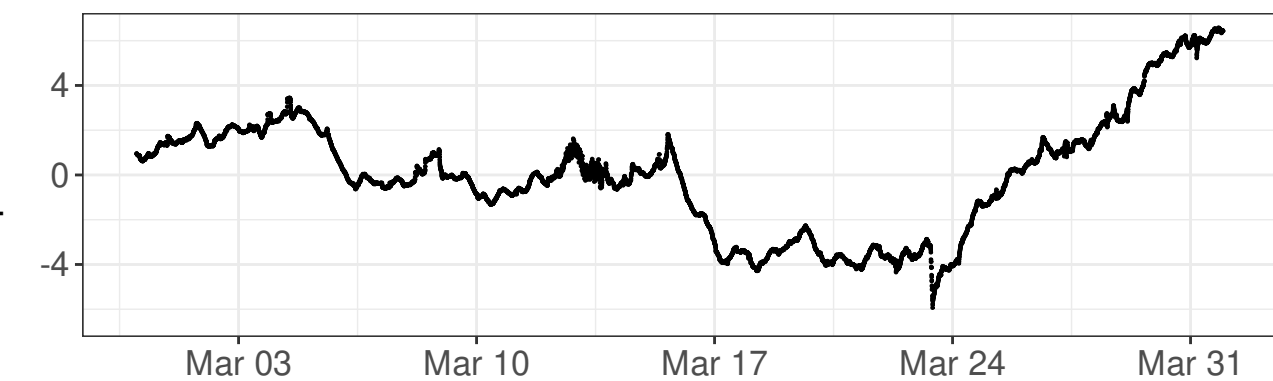
East tilt - raw values, Linear model R2 0.64



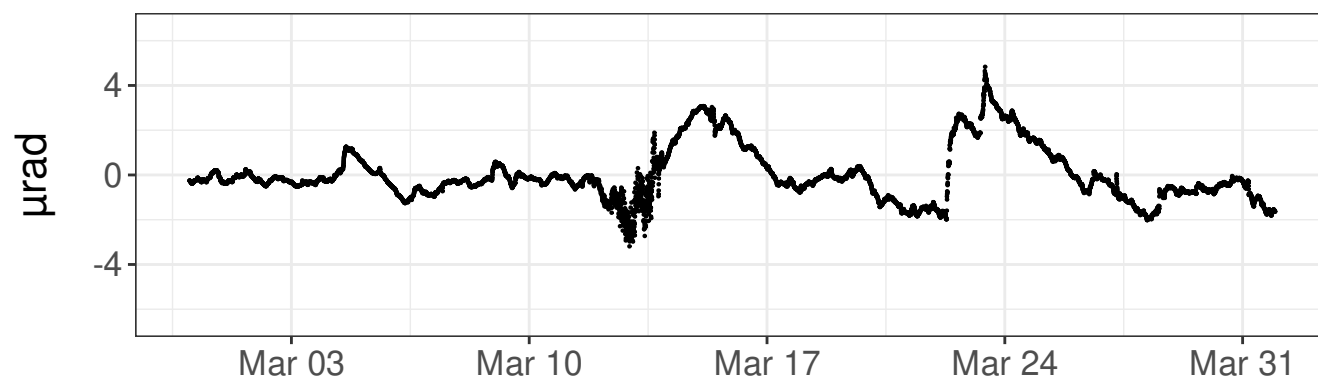
North tilt - raw values, Linear model R2 0.98



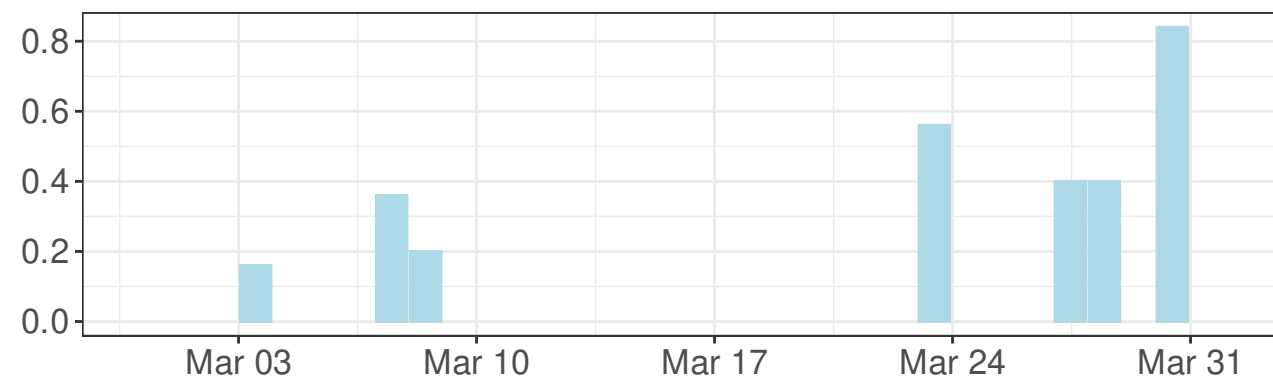
East tilt - detrended values



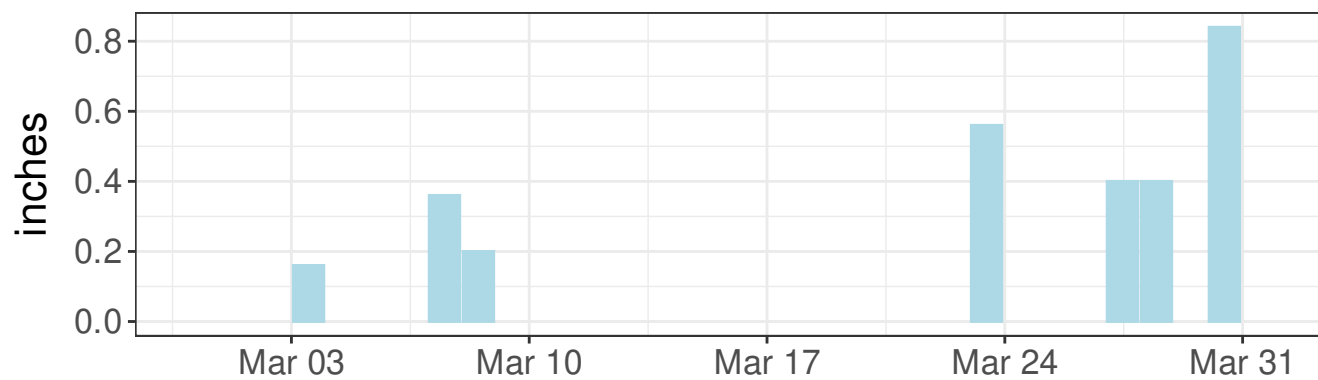
North tilt - detrended values



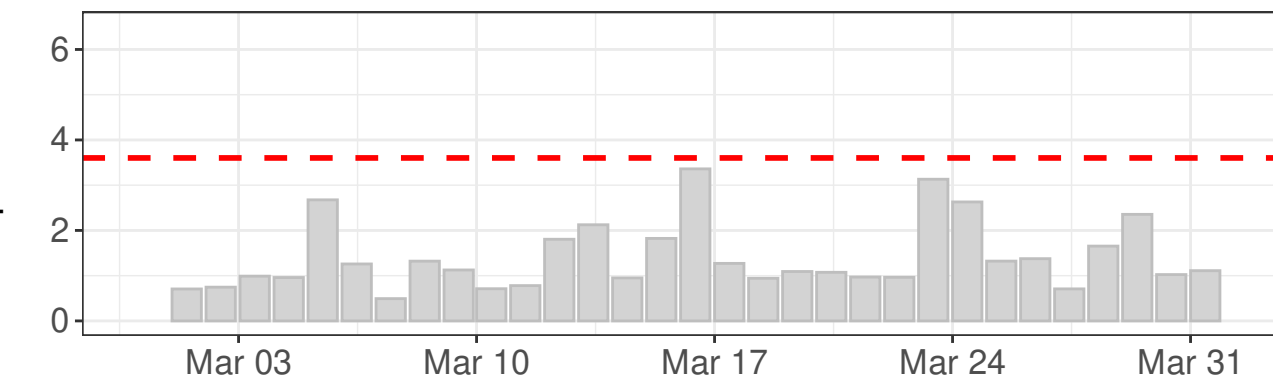
Daily precipitation



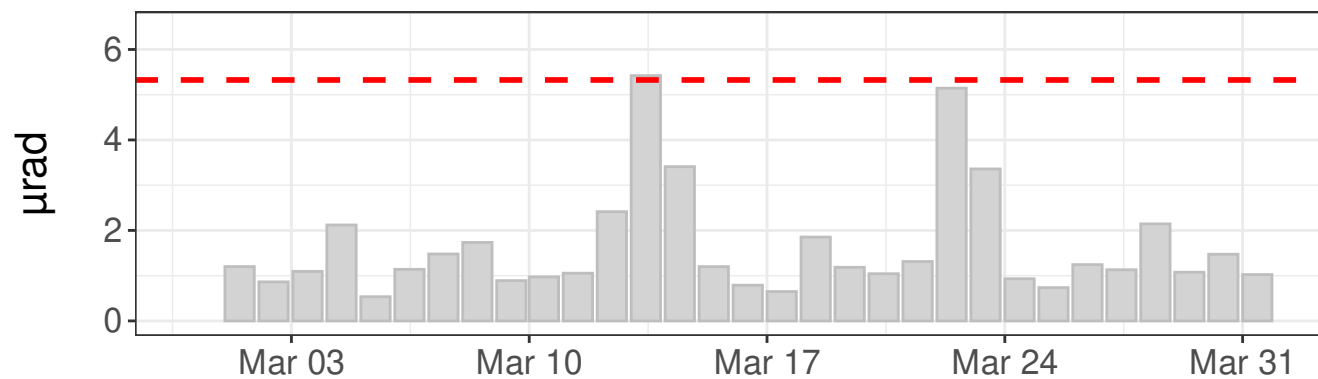
Daily precipitation



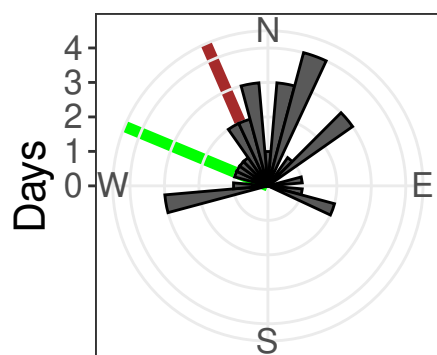
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $-139.86 \pm 0.97 \mu\text{rad}/\text{year}$

North tilt rate:  $321.53 \pm 0.44 \mu\text{rad}/\text{year}$

Azimuth to C7: 293 deg

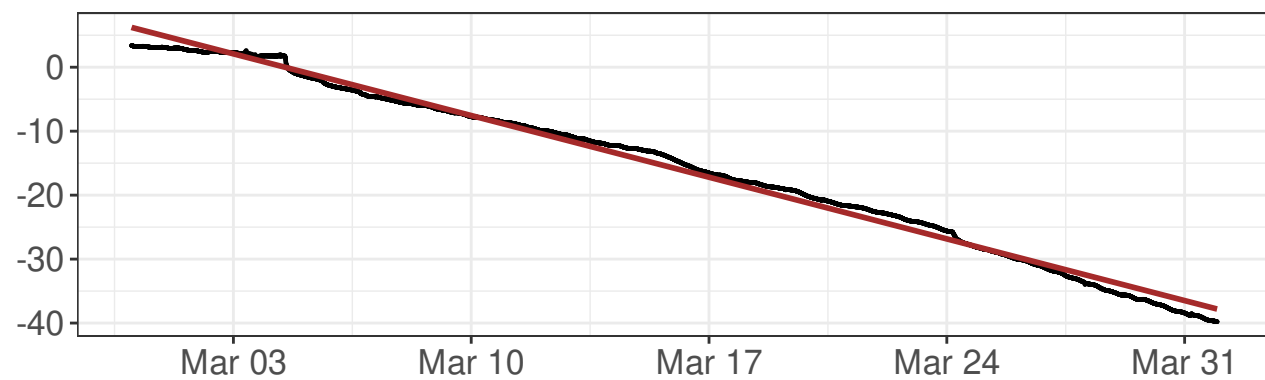
Distance to C7: 614 ft

--- Outlier value

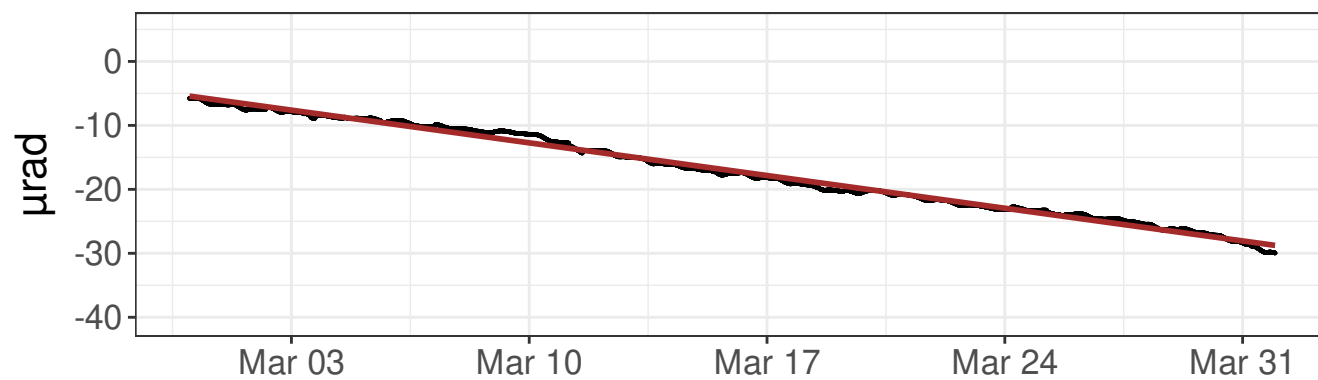
— Linear model

— Azimuth to C7

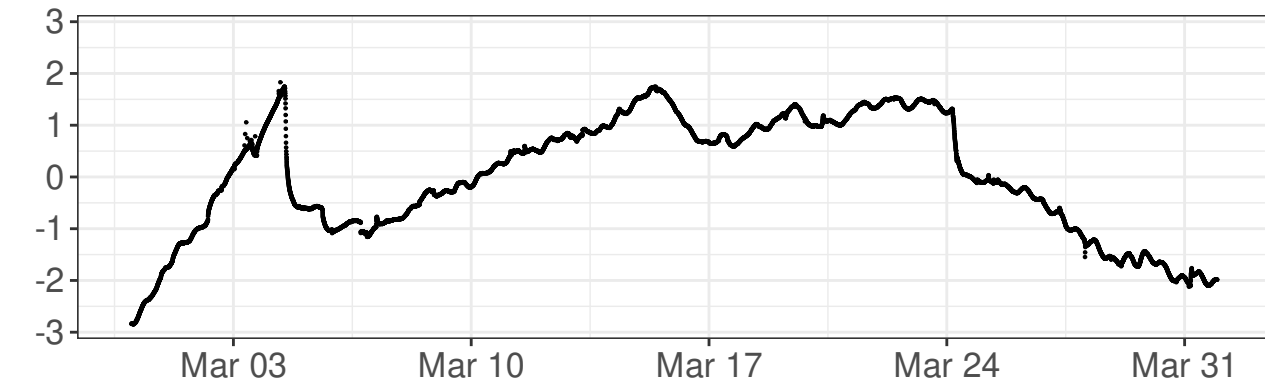
East tilt - raw values, Linear model R2 0.99



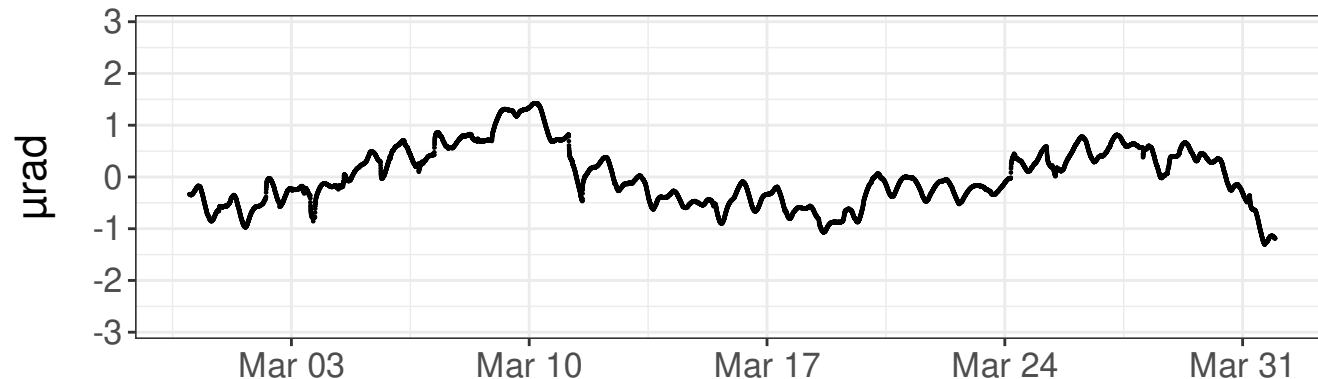
North tilt - raw values, Linear model R2 0.99



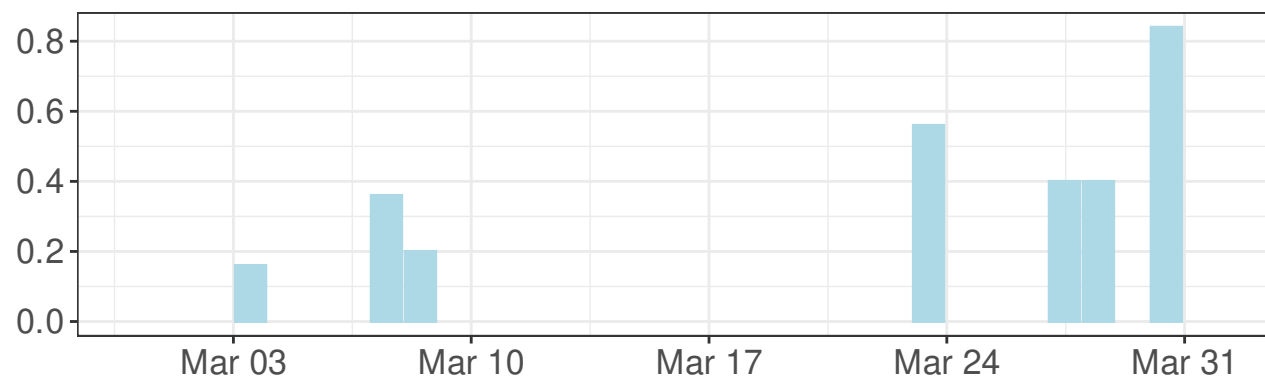
East tilt - detrended values



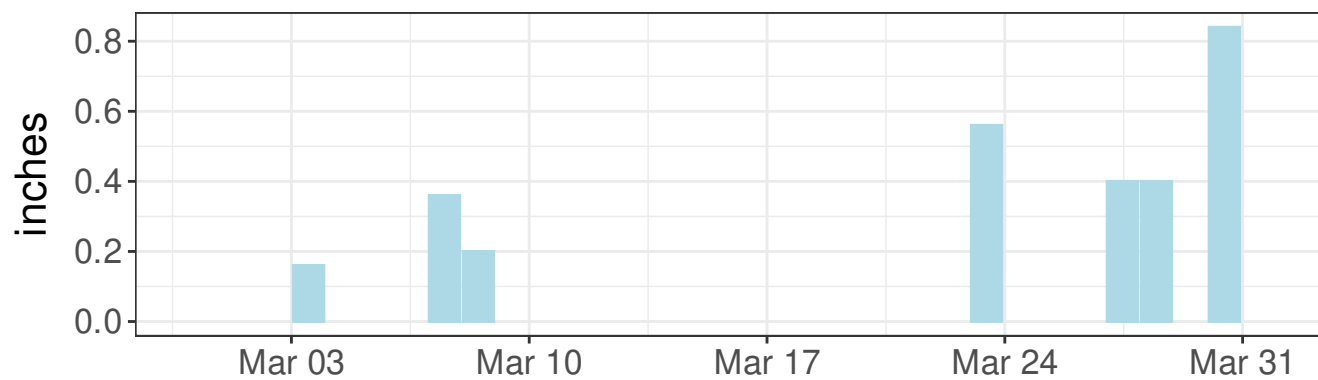
North tilt - detrended values



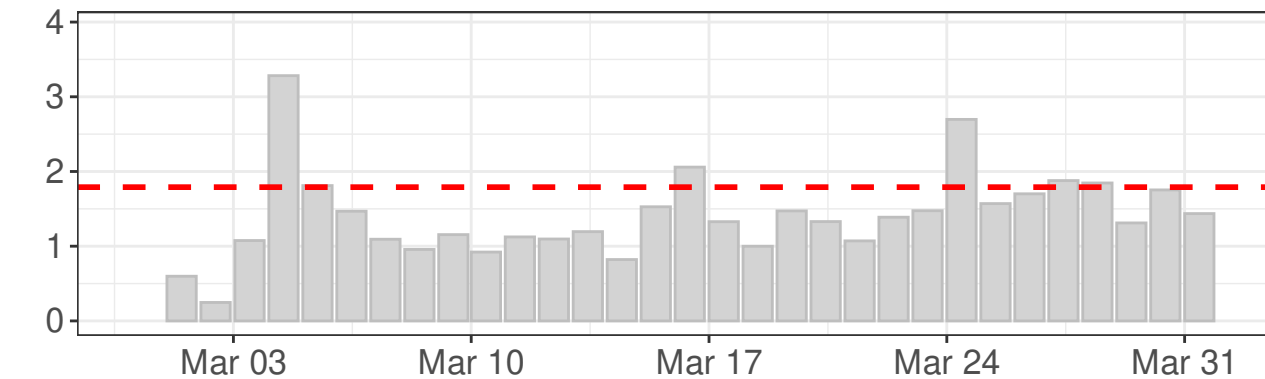
Daily precipitation



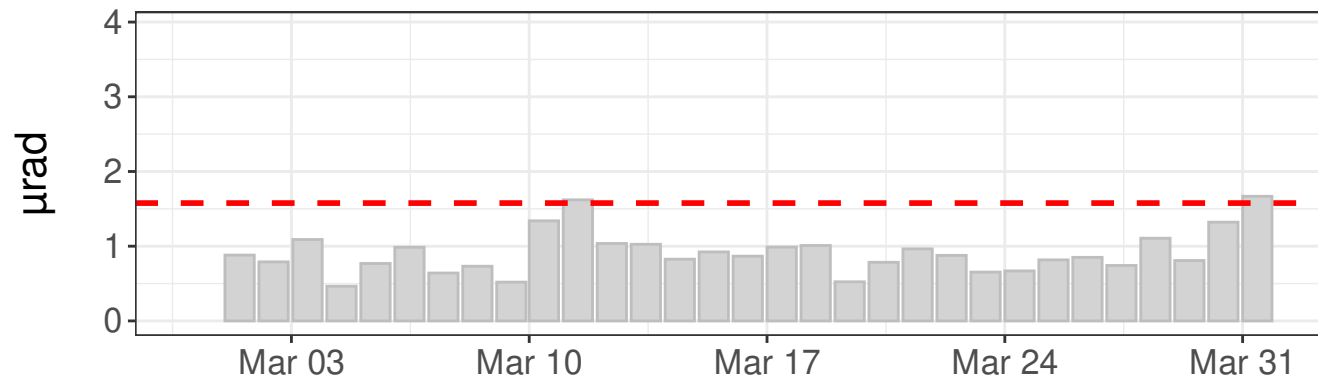
Daily precipitation



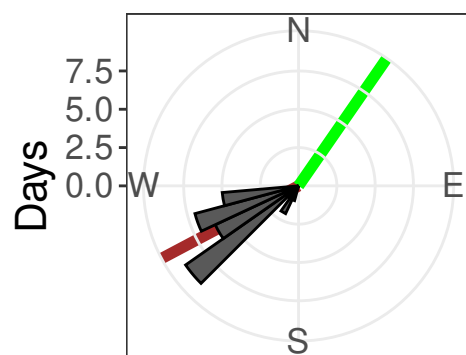
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $-502.88 \pm 0.42 \mu\text{rad}/\text{year}$

North tilt rate:  $-266.55 \pm 0.21 \mu\text{rad}/\text{year}$

Azimuth to C7: 35 deg

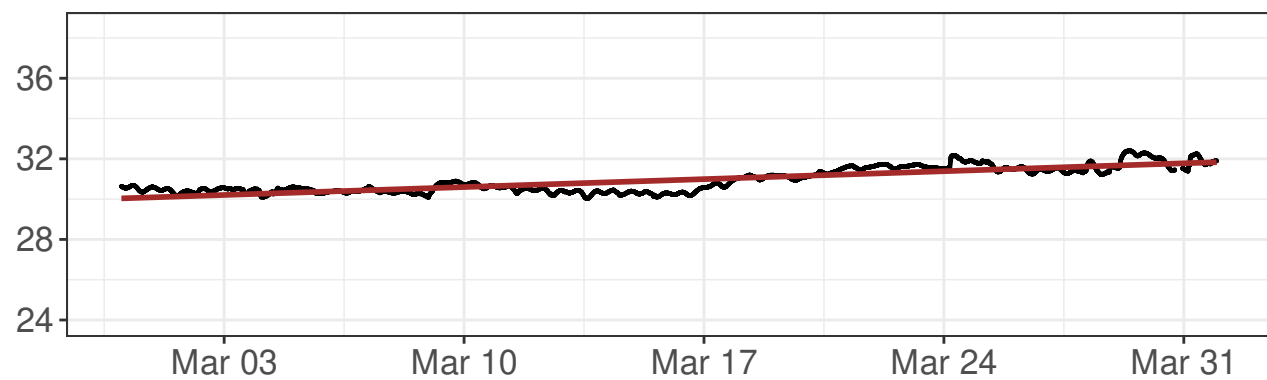
Distance to C7: 1885 ft

--- Outlier value

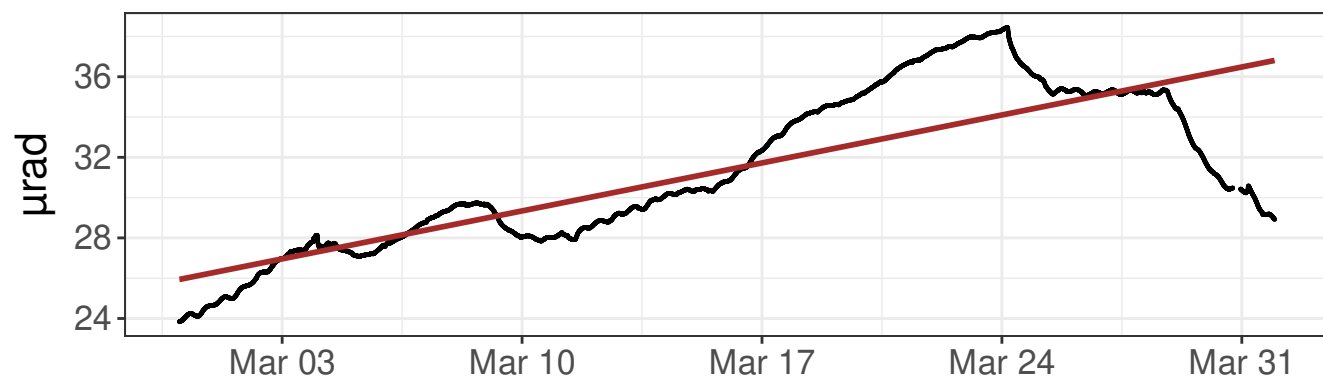
— Linear model

— Azimuth to C7

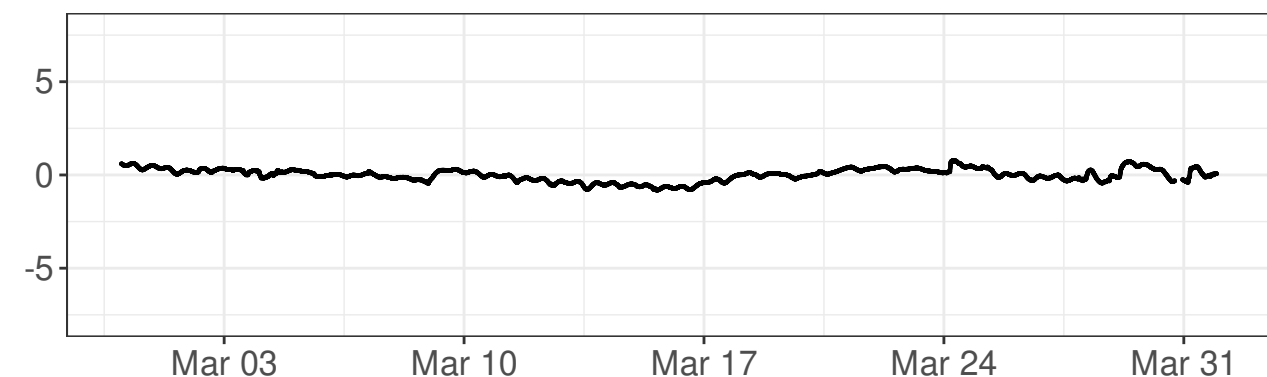
East tilt - raw values, Linear model R2 0.71



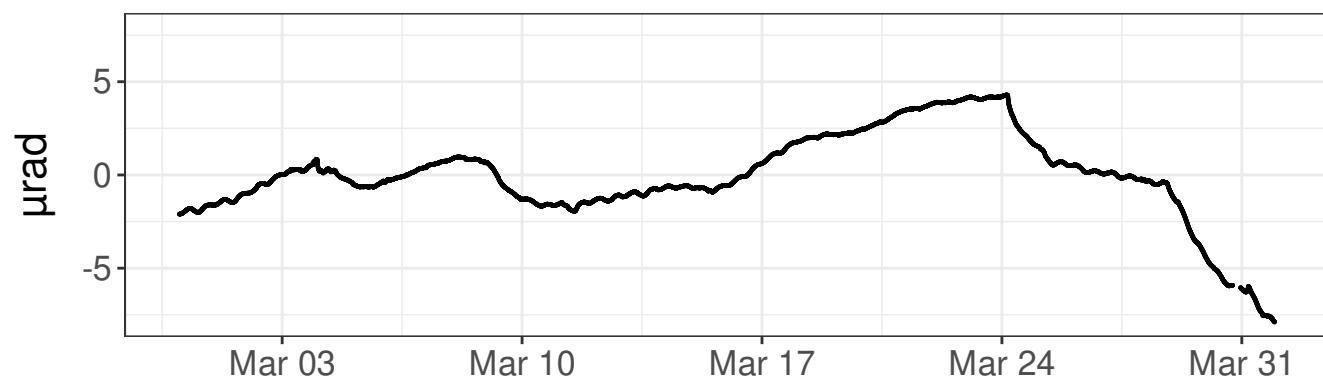
North tilt - raw values, Linear model R2 0.65



East tilt - detrended values



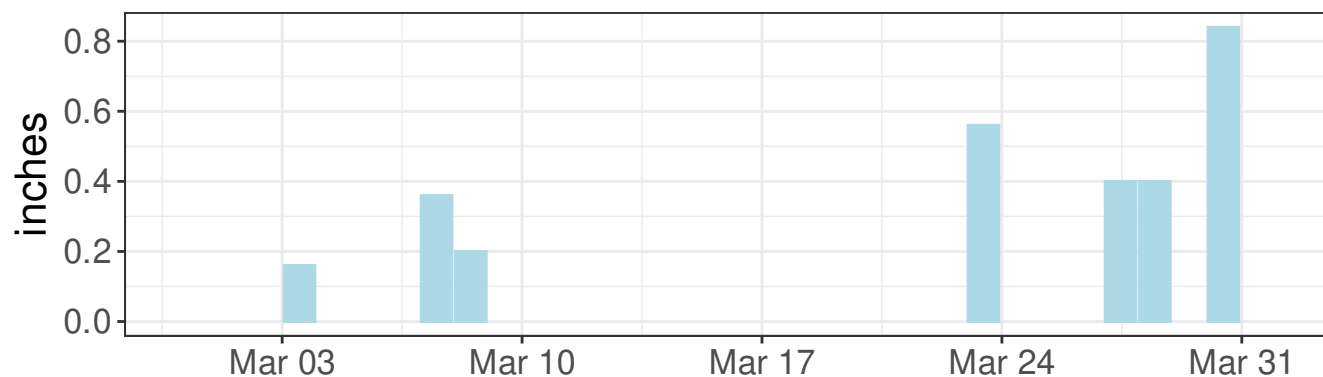
North tilt - detrended values



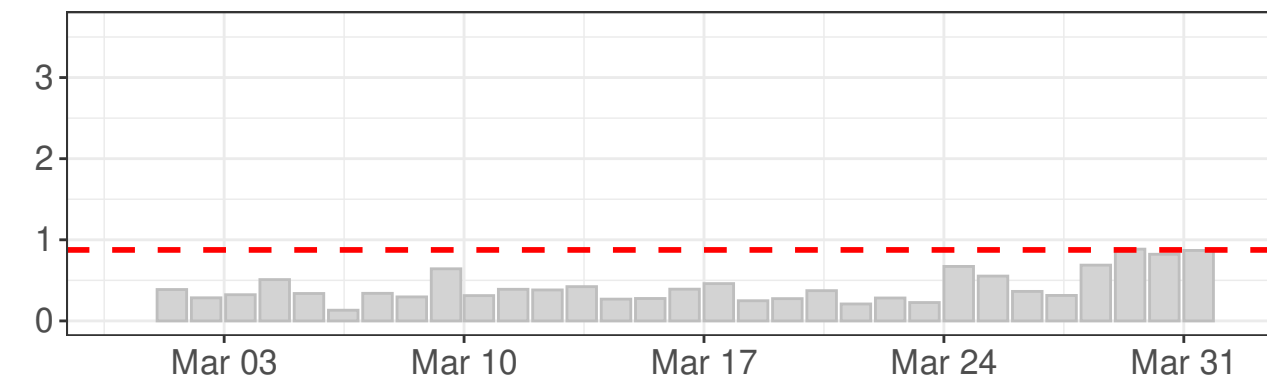
Daily precipitation



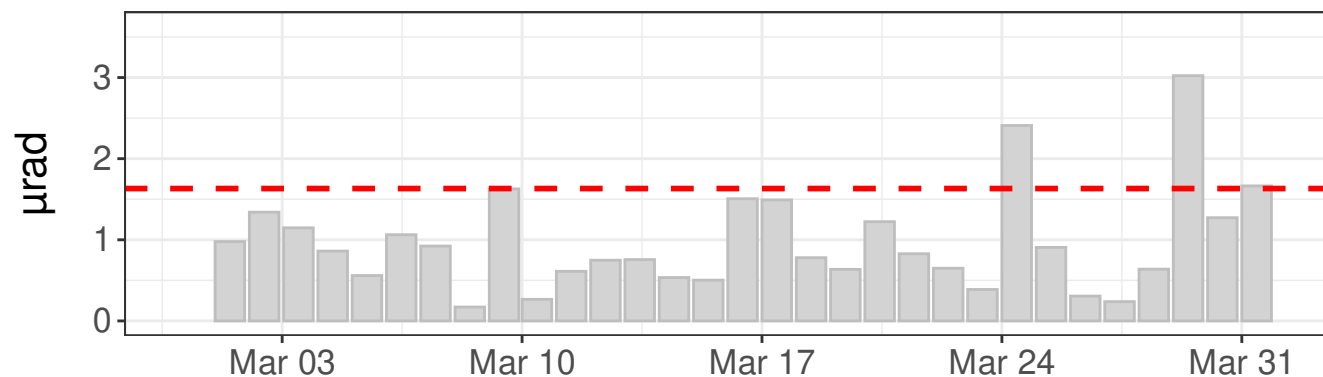
Daily precipitation



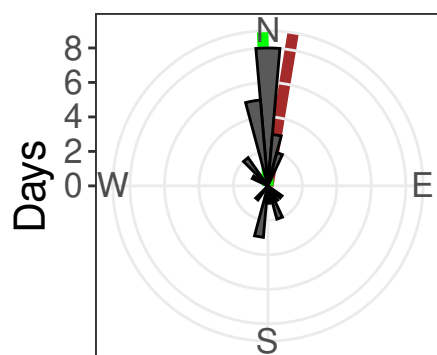
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $20.51 \pm 0.12 \mu\text{rad}/\text{year}$

North tilt rate:  $124.15 \pm 0.86 \mu\text{rad}/\text{year}$

Azimuth to C7: 358 deg

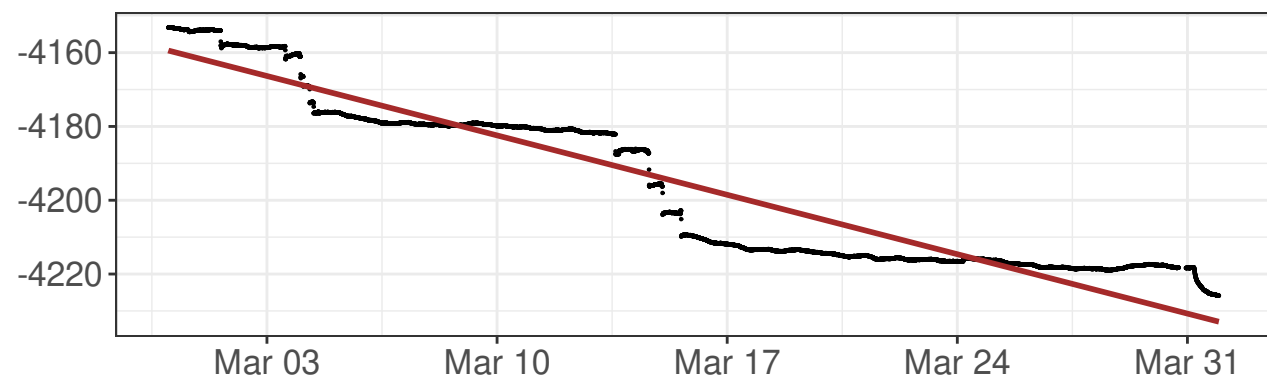
Distance to C7: 1392 ft

--- Outlier value

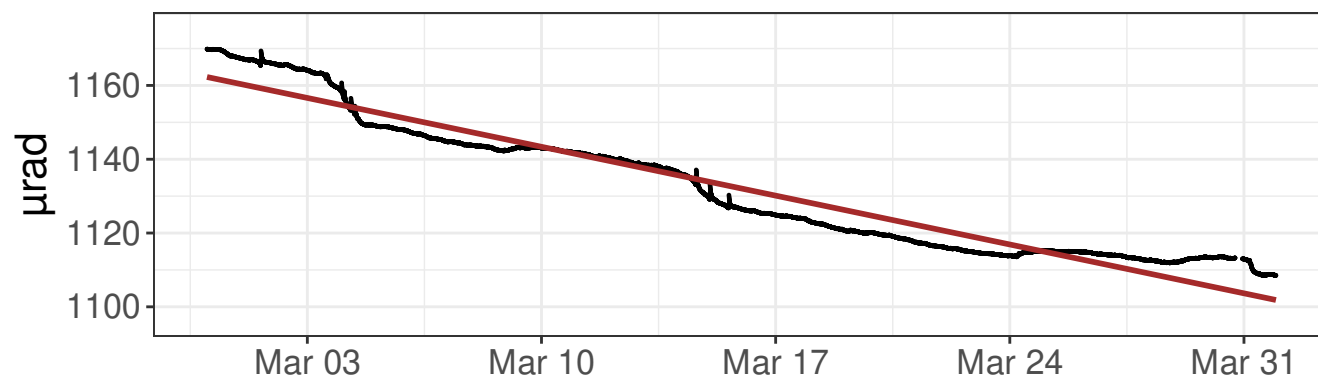
— Linear model

— Azimuth to C7

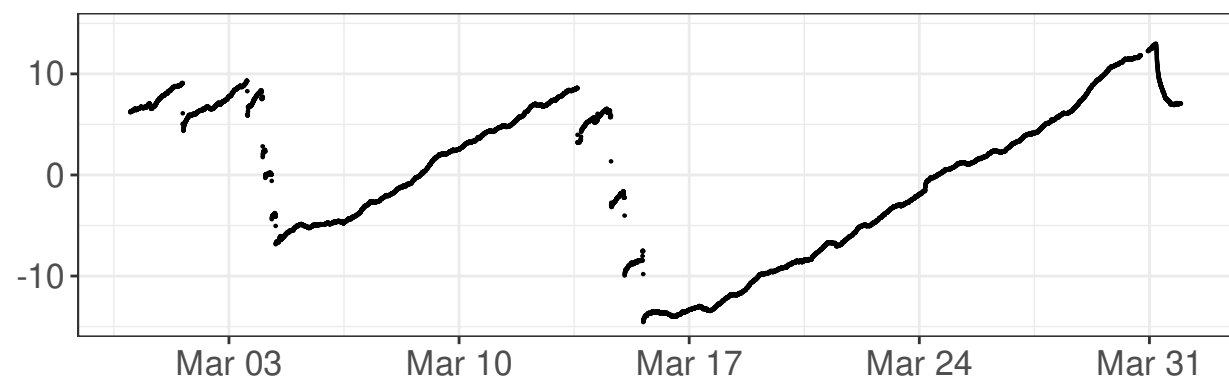
East tilt - raw values, Linear model R2 0.90



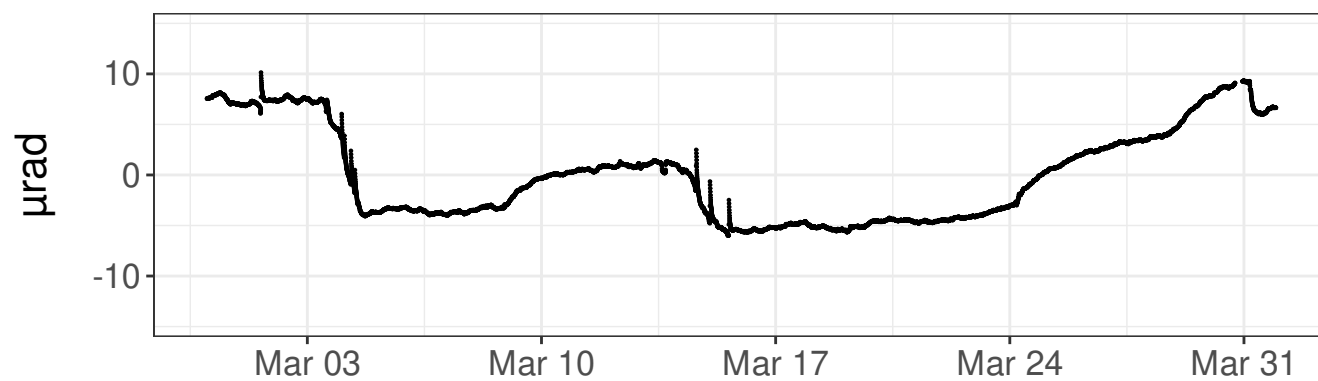
North tilt - raw values, Linear model R2 0.94



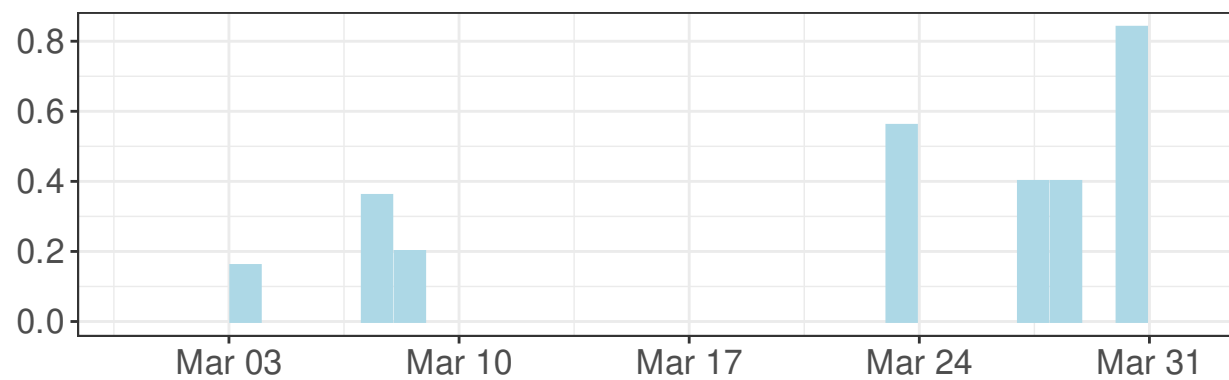
East tilt - detrended values



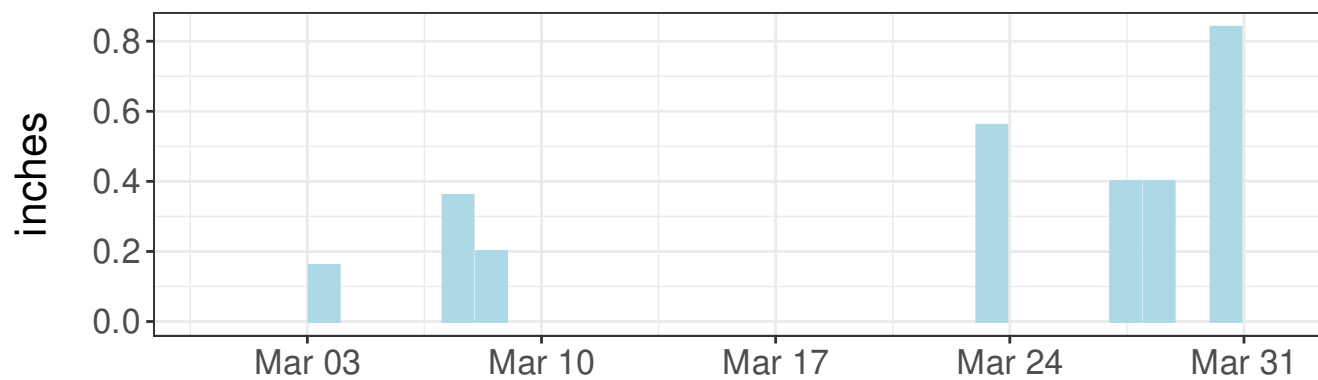
North tilt - detrended values



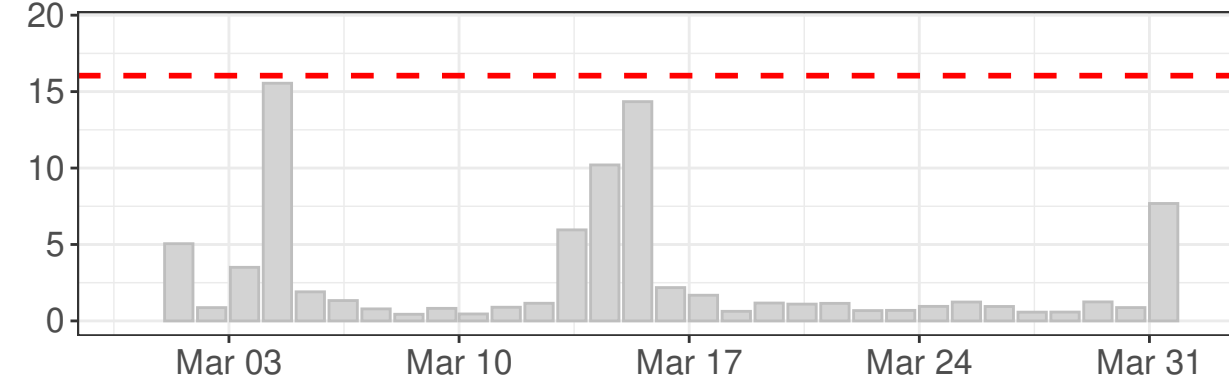
Daily precipitation



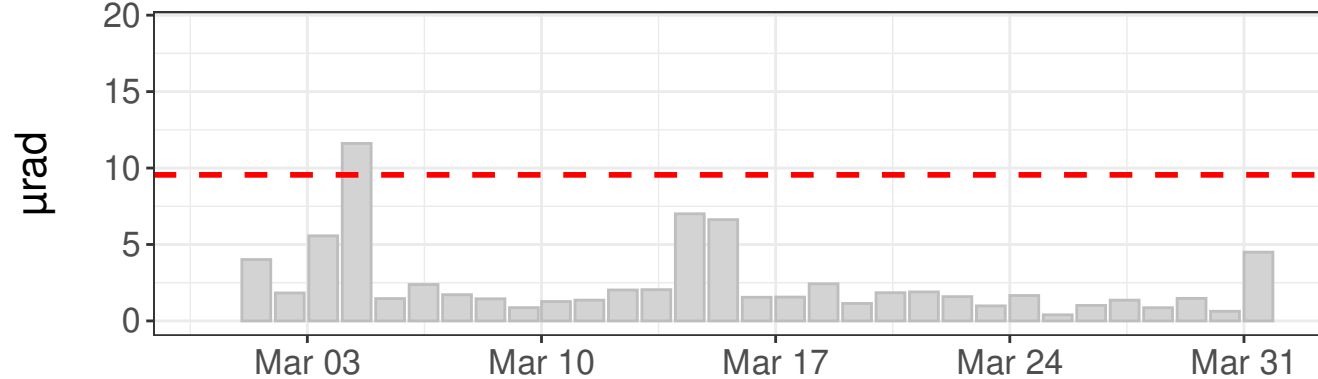
Daily precipitation



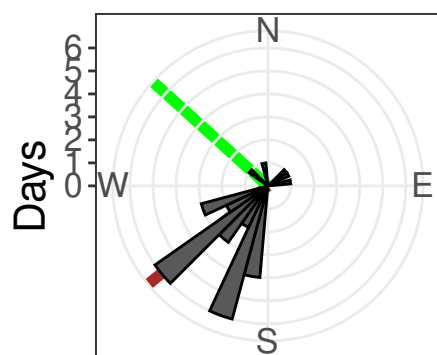
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $-839.44 \pm 2.68 \mu\text{rad}/\text{year}$

North tilt rate:  $-690.26 \pm 1.70 \mu\text{rad}/\text{year}$

Azimuth to C7: 312 deg

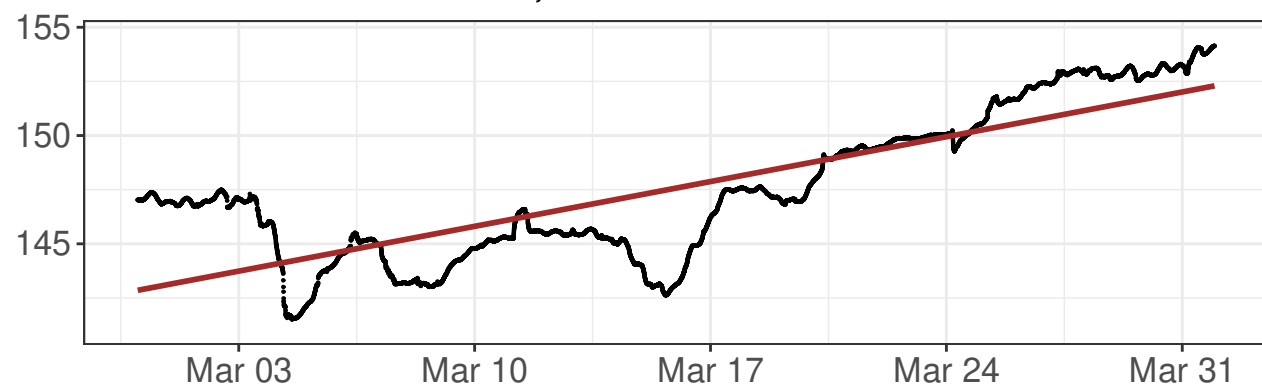
Distance to C7: 1415 ft

--- Outlier value

— Linear model

— Azimuth to C7

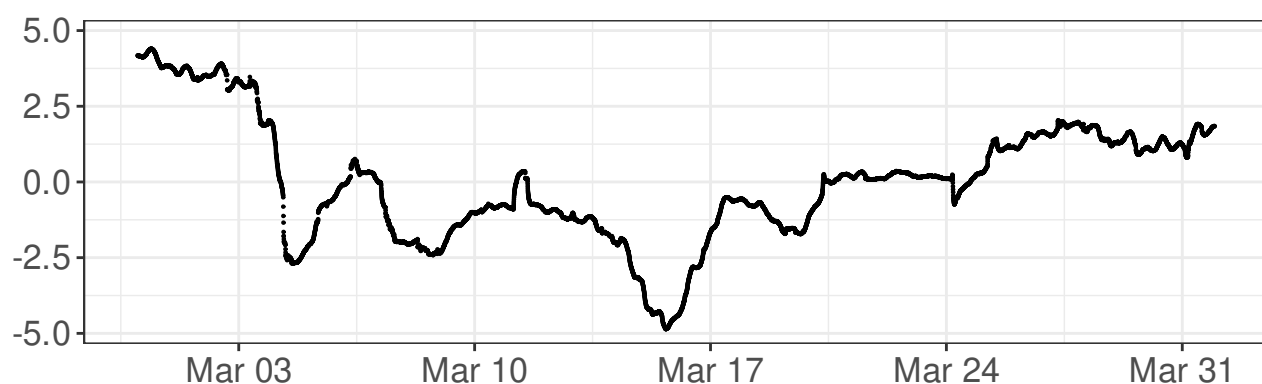
East tilt - raw values, Linear model R2 0.66



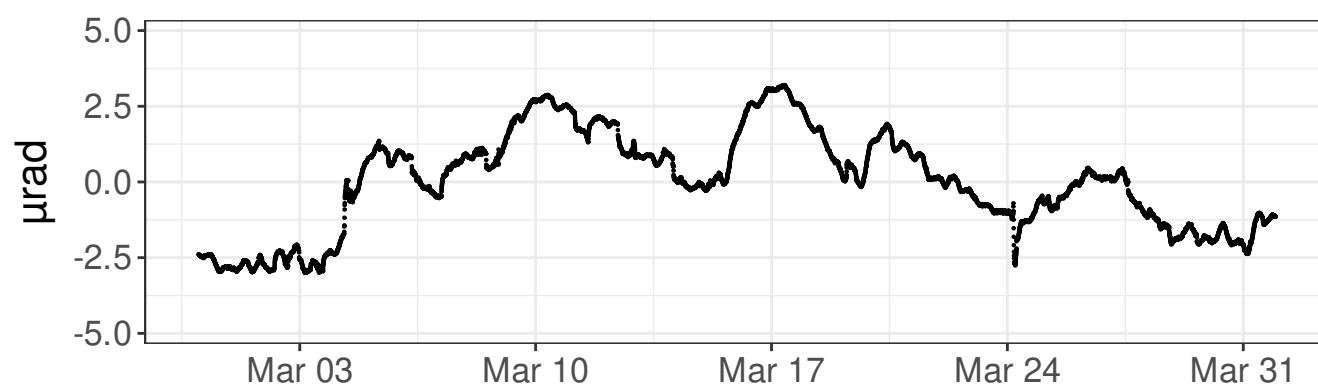
North tilt - raw values, Linear model R2 0.79



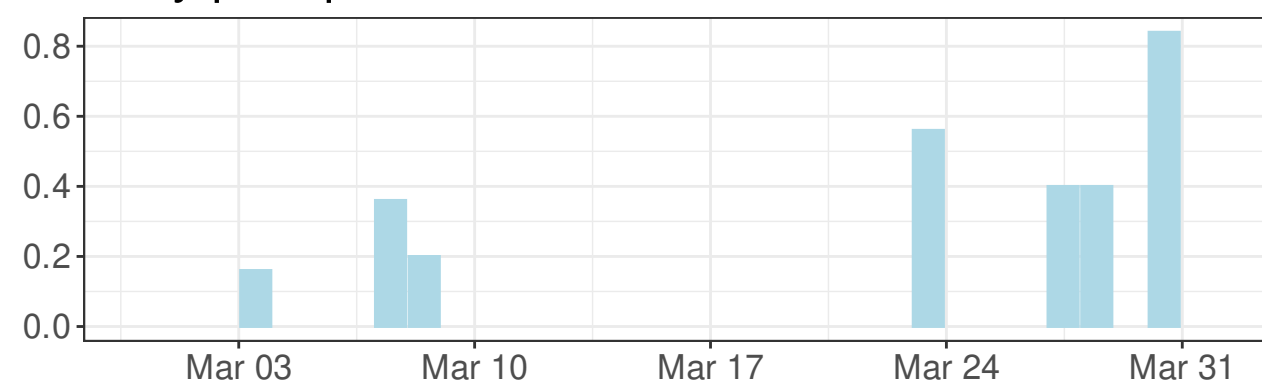
East tilt - detrended values



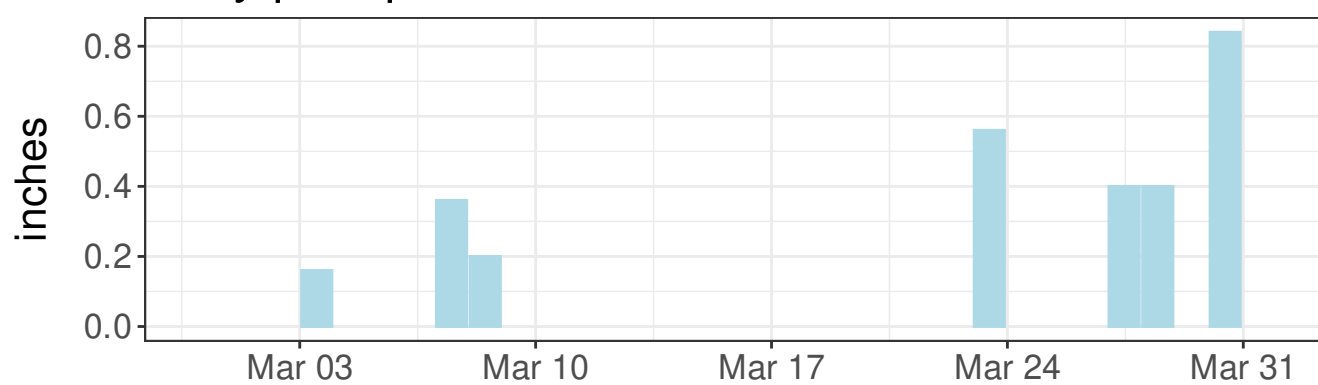
North tilt - detrended values



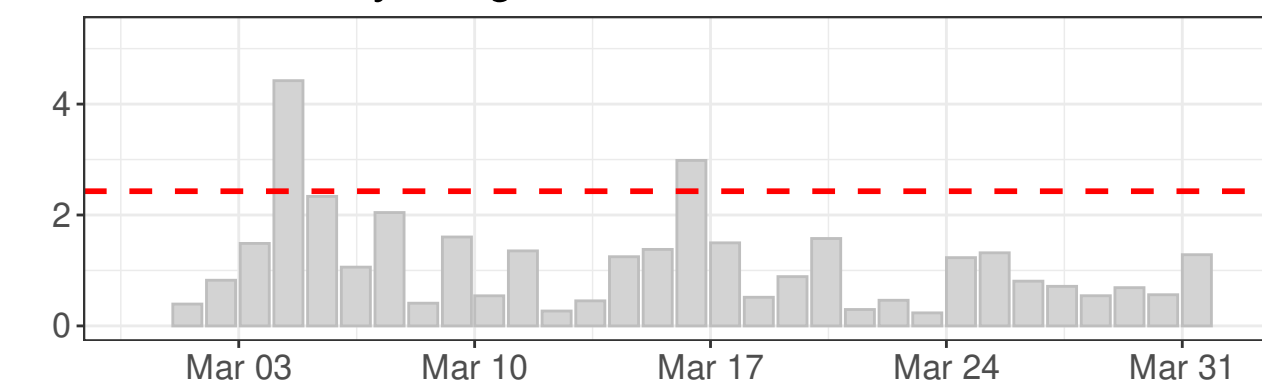
Daily precipitation



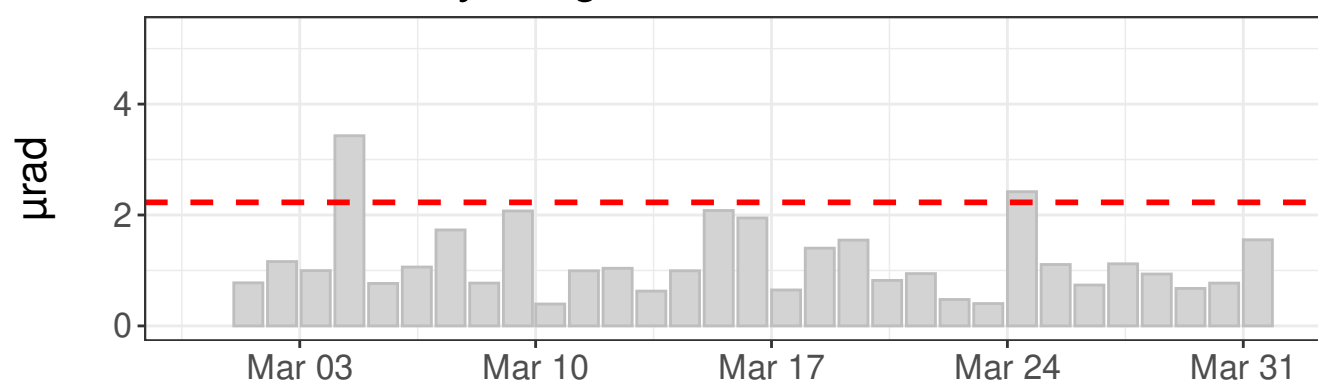
Daily precipitation



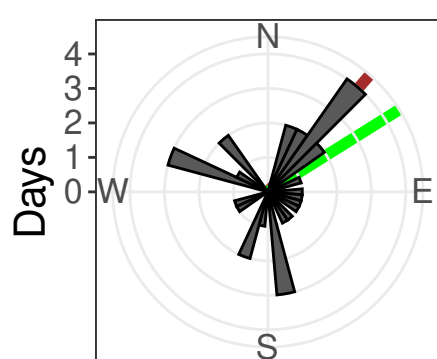
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $107.83 \pm 0.73 \mu\text{rad}/\text{year}$

North tilt rate:  $123.73 \pm 0.60 \mu\text{rad}/\text{year}$

Azimuth to C7: 58 deg

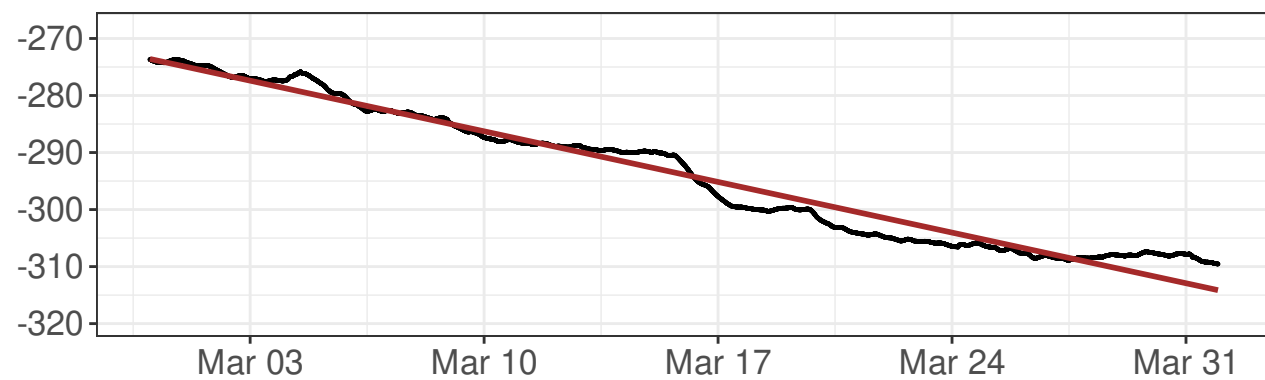
Distance to C7: 2245 ft

--- Outlier value

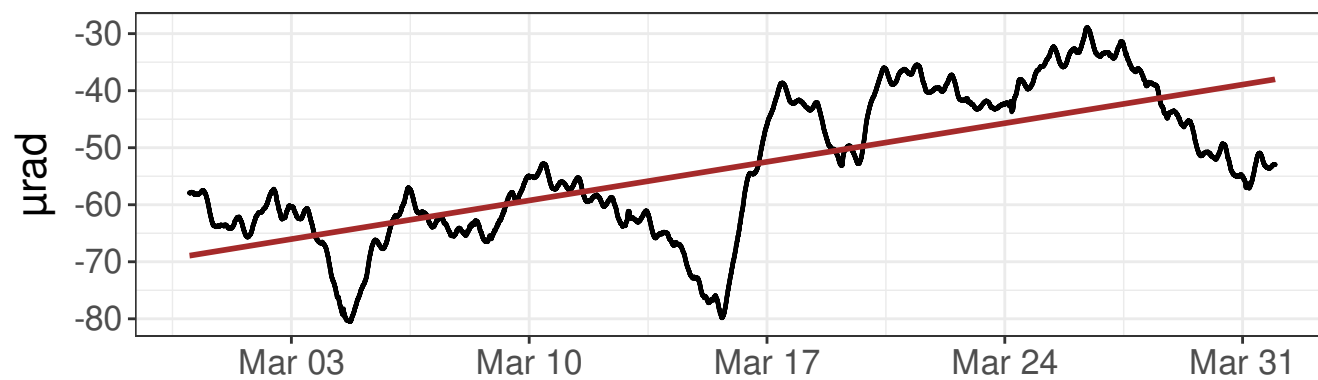
— Linear model

— Azimuth to C7

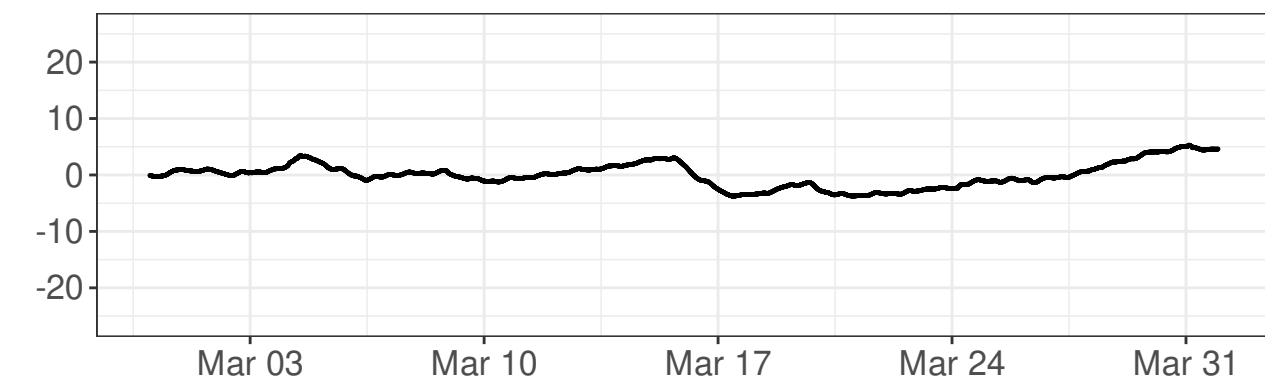
East tilt - raw values, Linear model R2 0.97



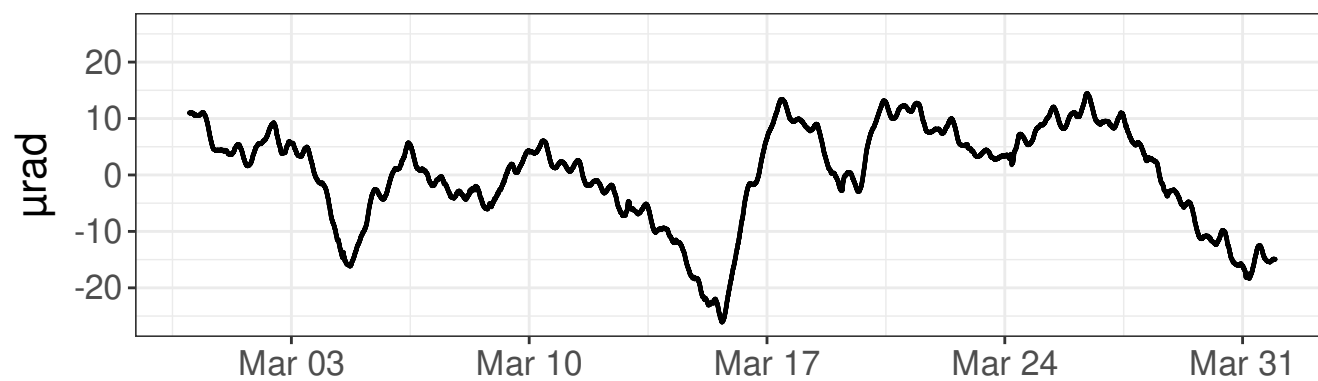
North tilt - raw values, Linear model R2 0.51



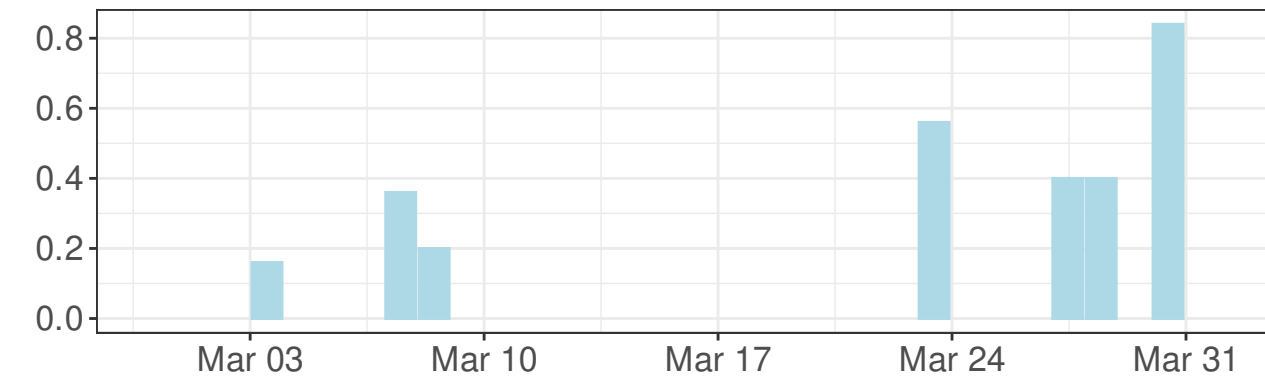
East tilt - detrended values



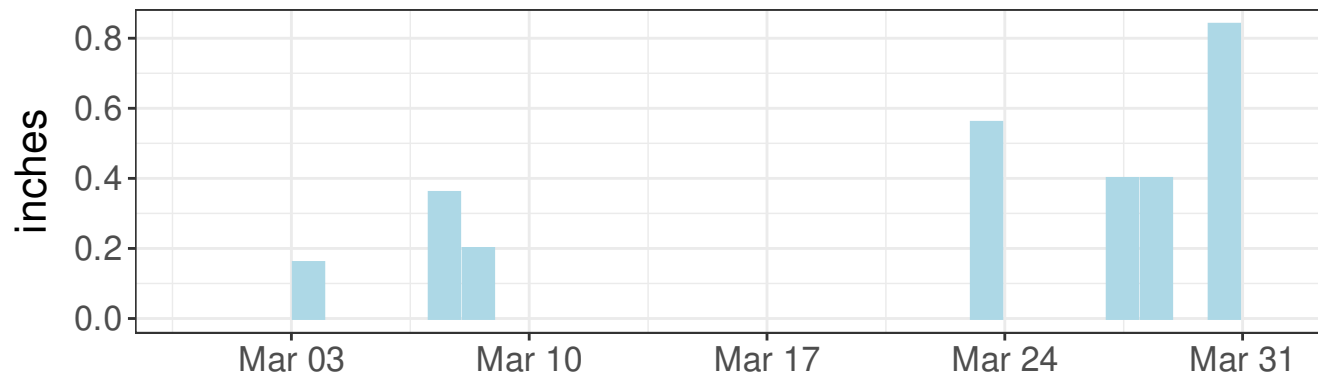
North tilt - detrended values



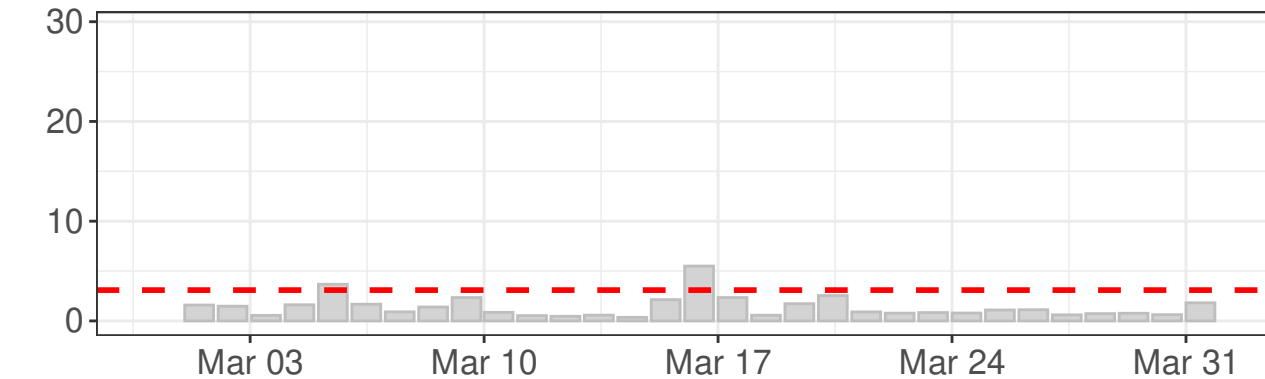
Daily precipitation



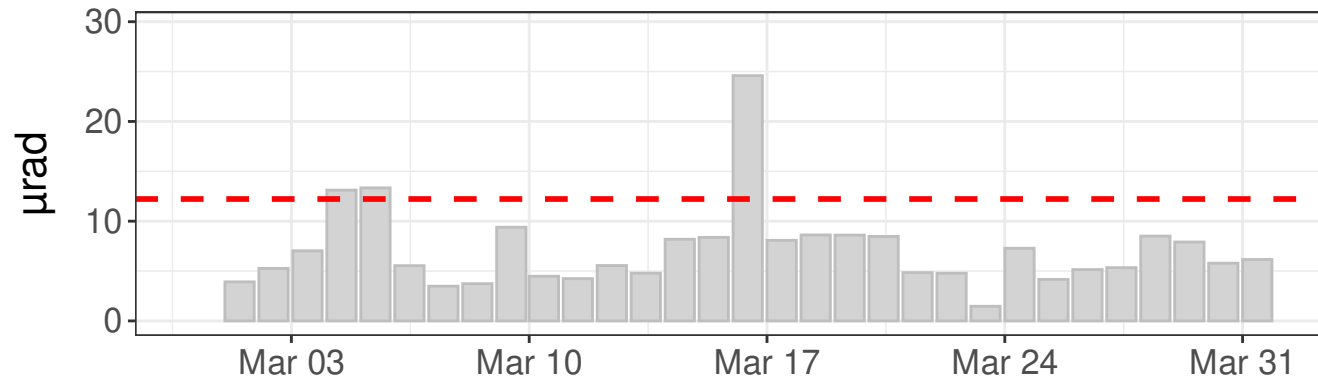
Daily precipitation



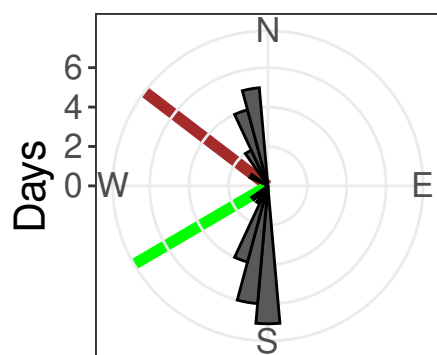
East tilt - daily range



North tilt - daily range



Tilt direction frequency



East tilt rate:  $-463.01 \pm 0.80 \mu\text{rad}/\text{year}$

North tilt rate:  $353.14 \pm 3.25 \mu\text{rad}/\text{year}$

Azimuth to C7: 240 deg

Distance to C7: 1378 ft

--- Outlier value

— Linear model

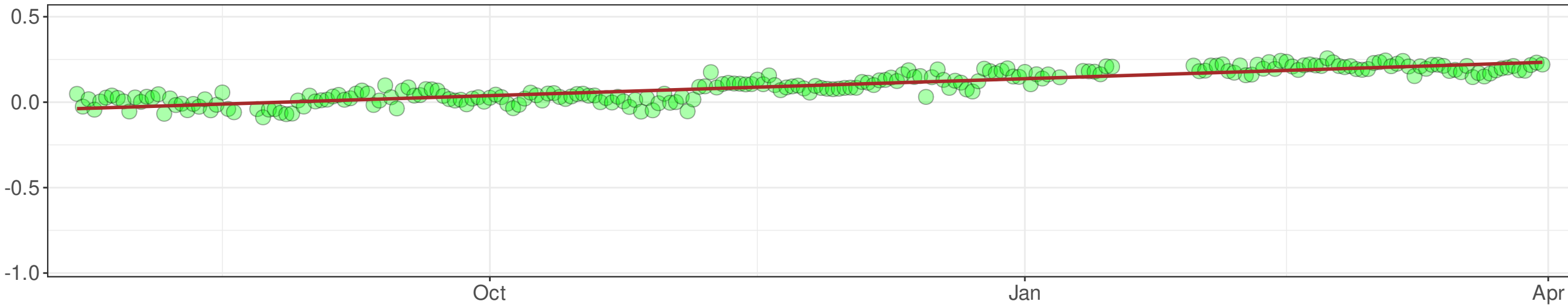
— Azimuth to C7

## **APPENDIX 2**

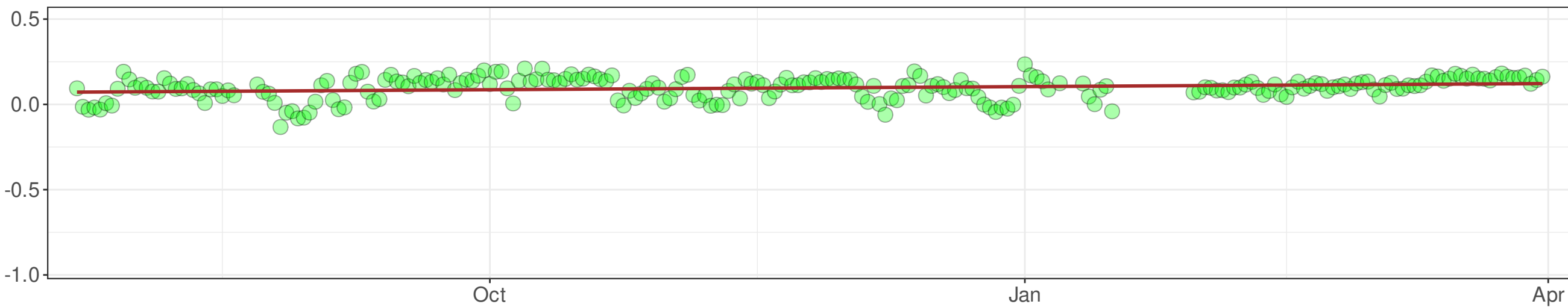
### **GNSS Data Plots**

# REMC7: Plotted range: 07/22/2024 - 03/31/2025 (CTZ)

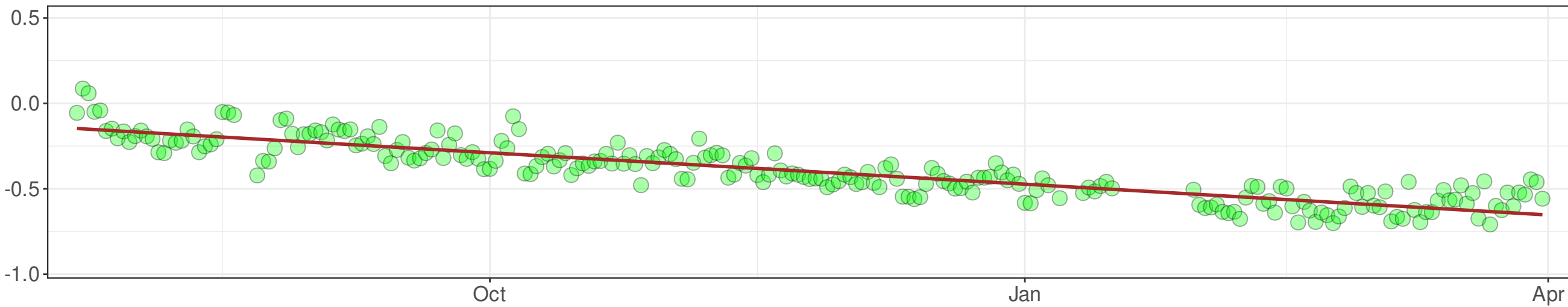
## East displacement - daily values



## North displacement - daily values



## Vertical displacement - daily values



Local east rate:  $0.876 \pm 0.023$  inches/year, R2: 0.79

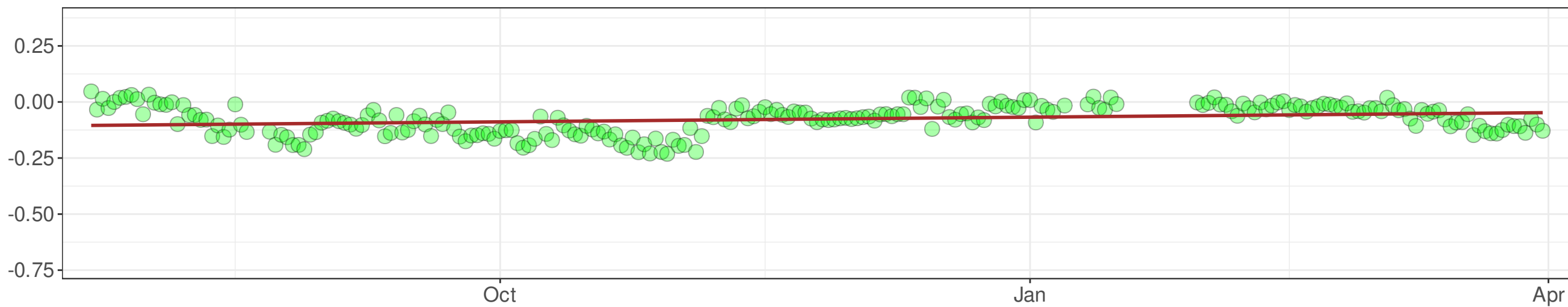
Local north rate:  $0.114 \pm 0.027$  inches/year, R2: 0.05

Local vertical rate:  $-0.651 \pm 0.061$  inches/year, R2: 0.79

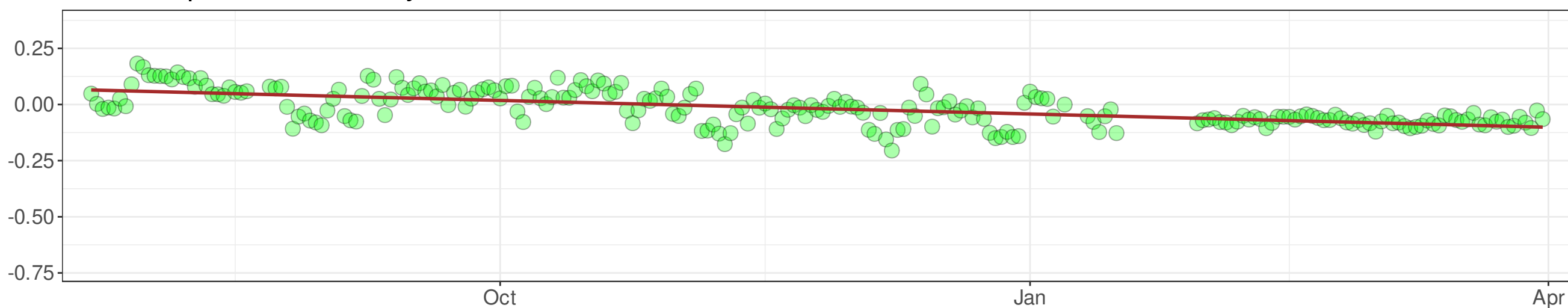
— Linear model

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

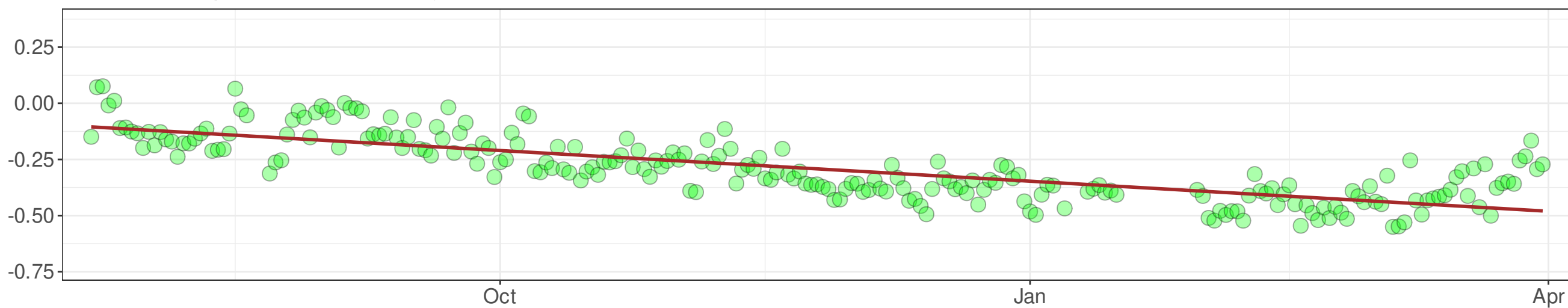
East displacement - daily values



North displacement - daily values



Vertical displacement - daily values



Local east rate:  $0.565 \pm 0.027$  inches/year, R2: 0.07

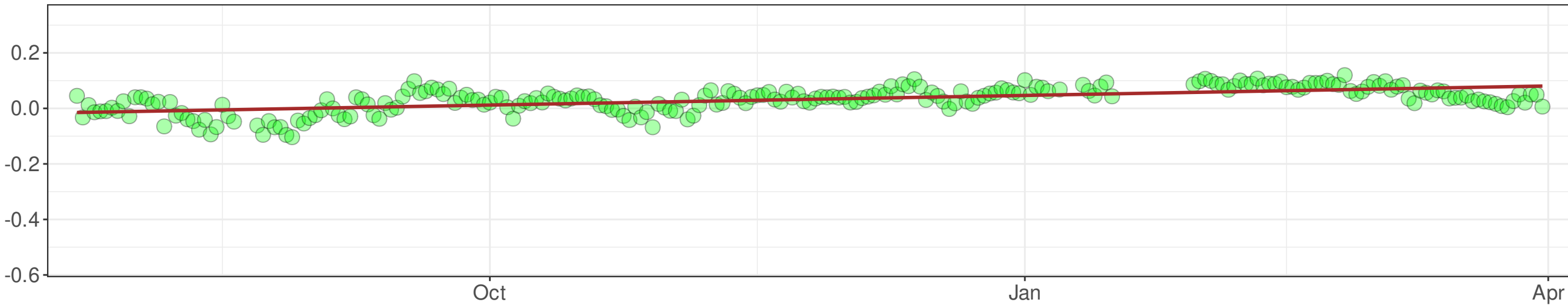
Local north rate:  $-0.198 \pm 0.026$  inches/year, R2: 0.42

Local vertical rate:  $-0.463 \pm 0.062$  inches/year, R2: 0.61

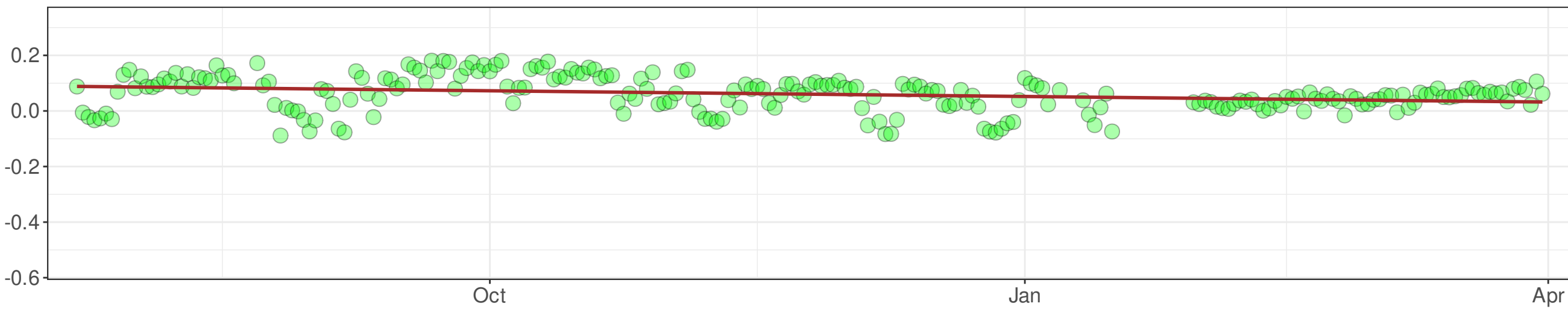
— Linear model

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

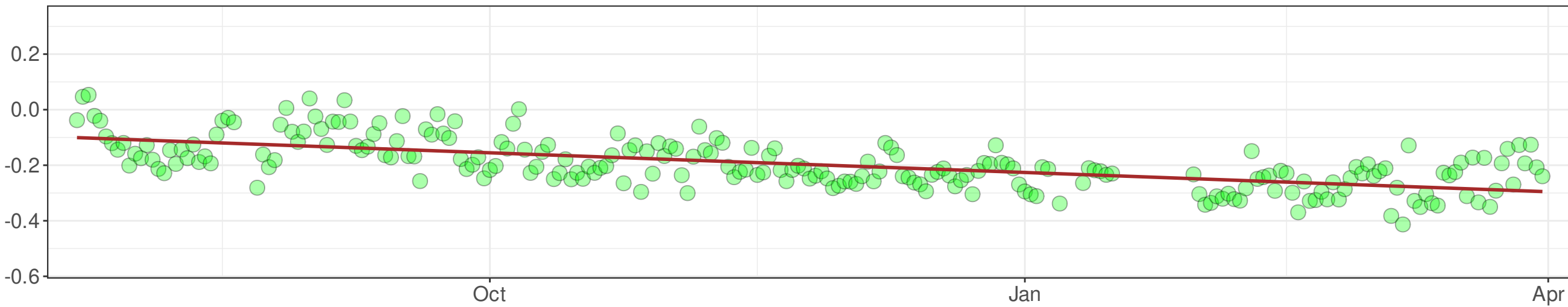
East displacement - daily values



North displacement - daily values



Vertical displacement - daily values



Local east rate:  $0.621 \pm 0.022$  inches/year, R2: 0.39

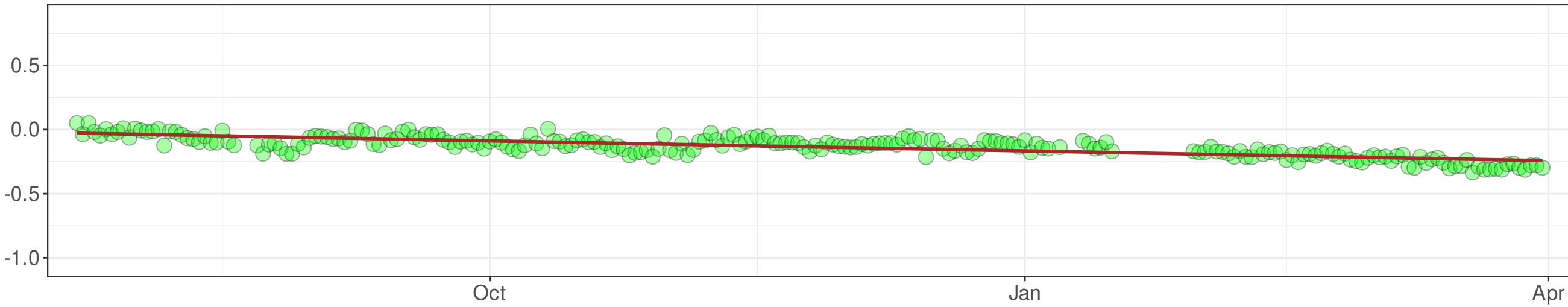
Local north rate:  $-0.040 \pm 0.026$  inches/year, R2: 0.07

Local vertical rate:  $-0.202 \pm 0.060$  inches/year, R2: 0.41

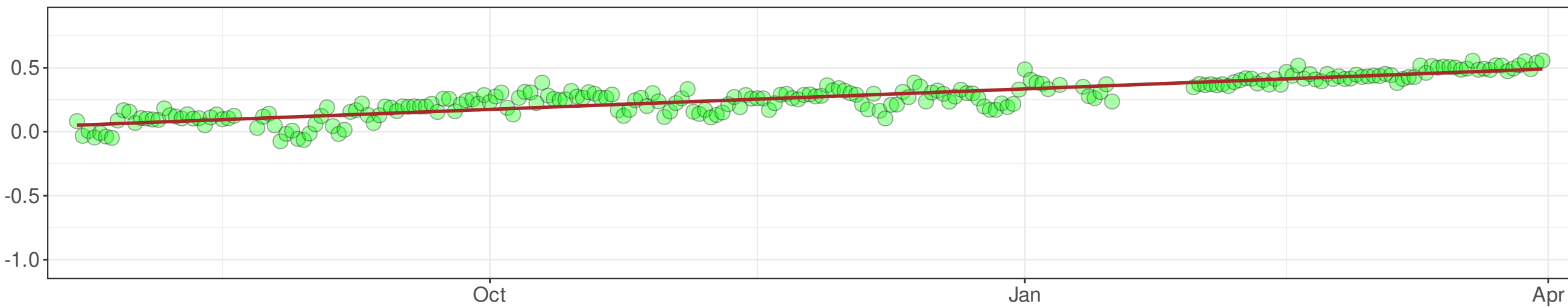
— Linear model

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

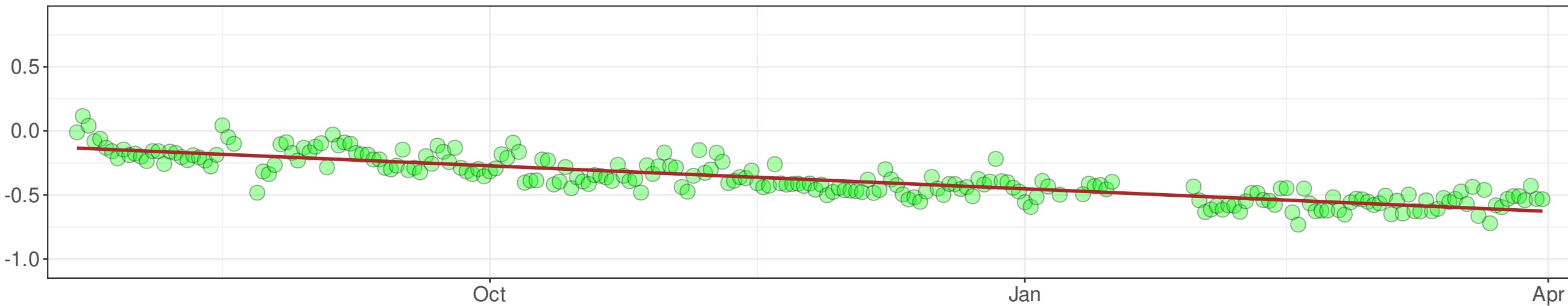
East displacement - daily values



North displacement - daily values



Vertical displacement - daily values



Local east rate:  $0.172 \pm 0.024$  inches/year, R2: 0.64

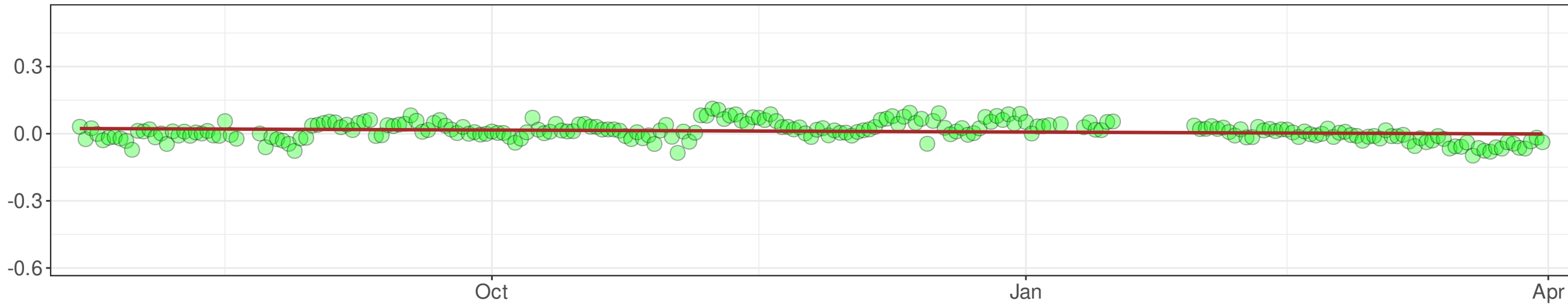
Local north rate:  $0.679 \pm 0.028$  inches/year, R2: 0.78

Local vertical rate:  $-0.633 \pm 0.062$  inches/year, R2: 0.74

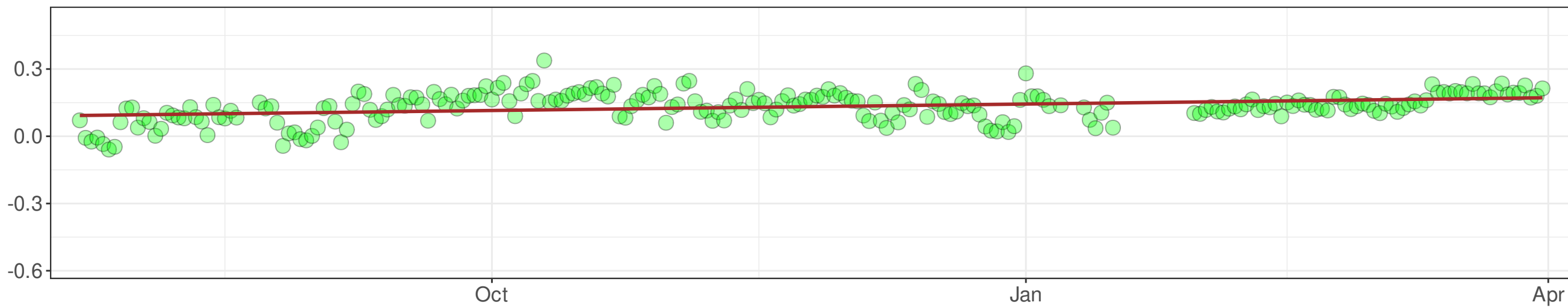
— Linear model

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

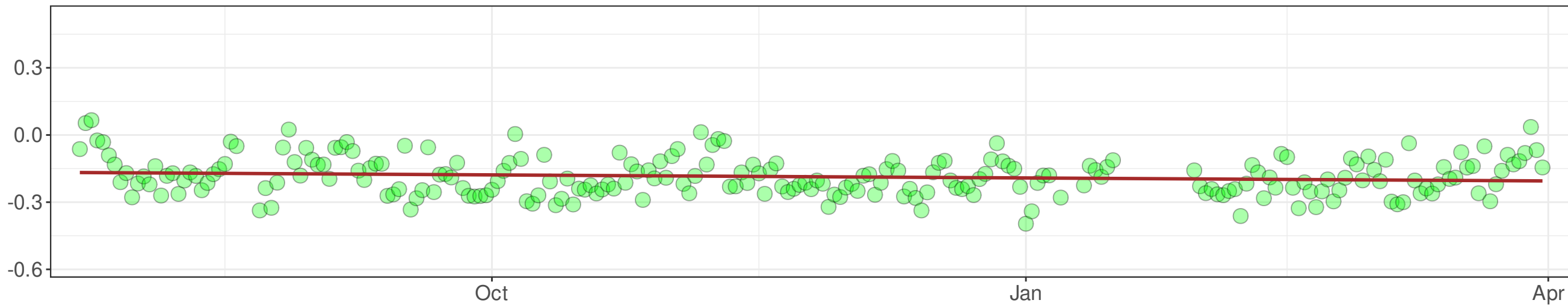
East displacement - daily values



North displacement - daily values



Vertical displacement - daily values



Local east rate:  $0.447 \pm 0.022$  inches/year, R2: 0.03

Local north rate:  $0.156 \pm 0.026$  inches/year, R2: 0.13

Local vertical rate:  $0.026 \pm 0.062$  inches/year, R2: 0.02

— Linear model

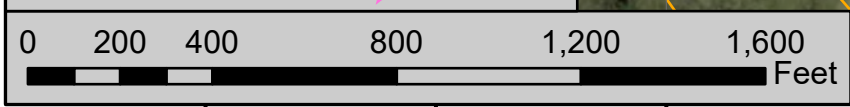
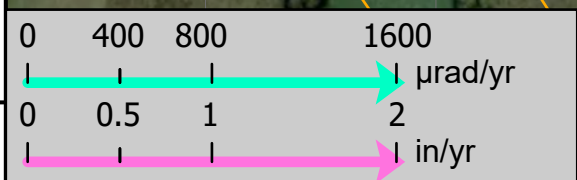
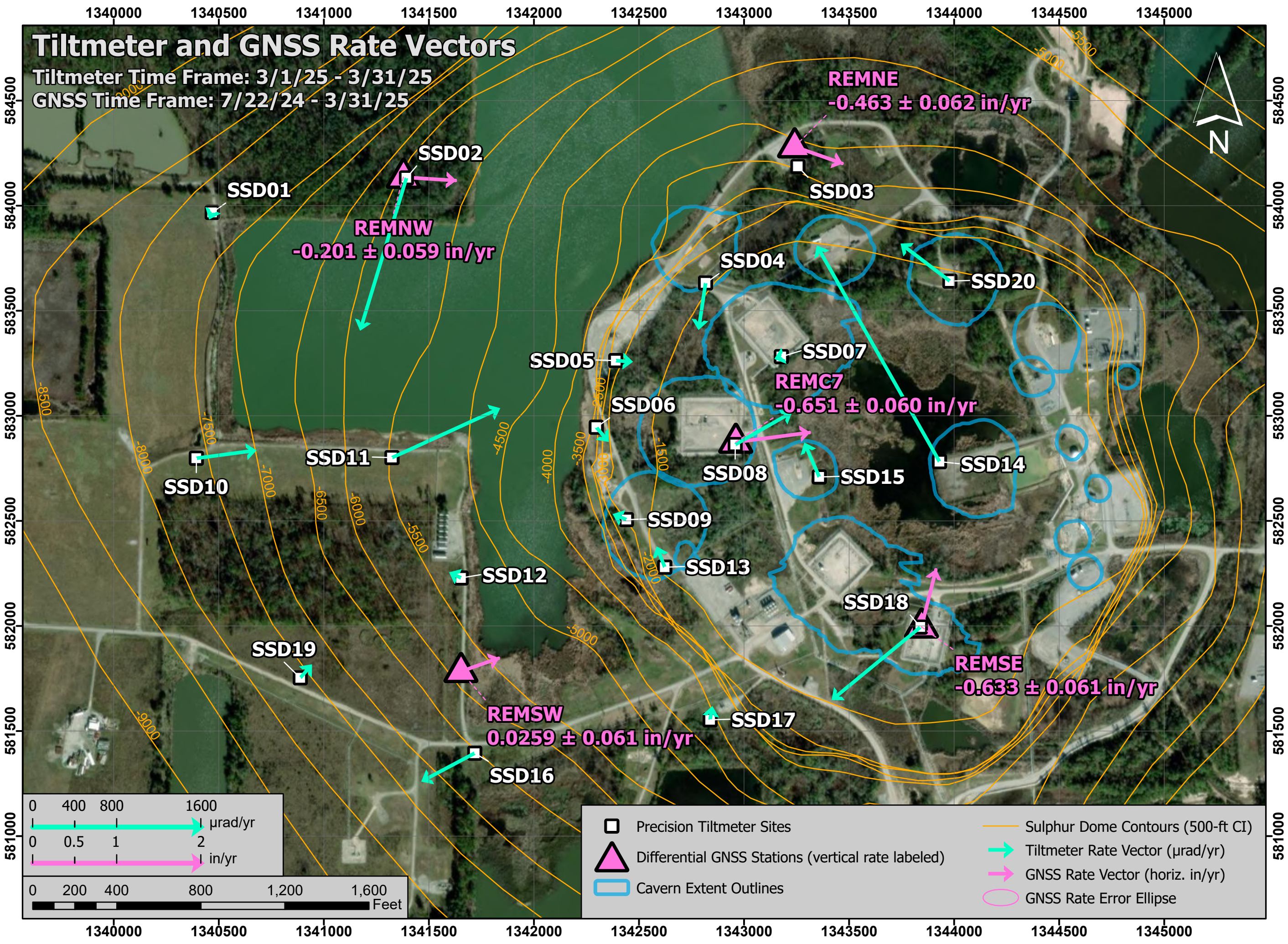
Local rate values have been calculated by removing the regional tectonic plate rates from the raw data displayed in the charts.

# **APPENDIX 3**

## **Analysis Maps**

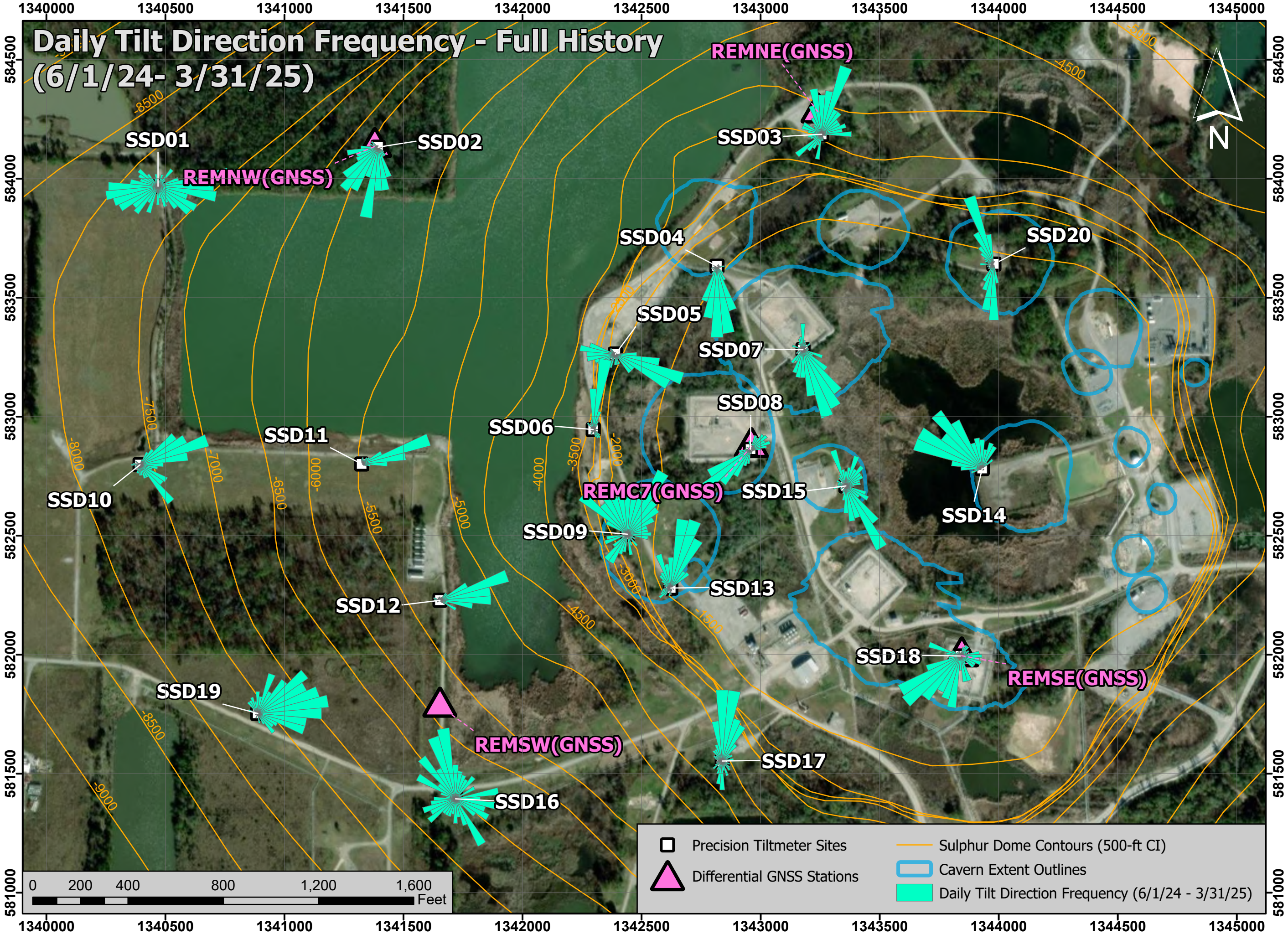
# Tiltmeter and GNSS Rate Vectors






Tiltmeter Time Frame: 3/1/25 - 3/31/25  
GNSS Time Frame: 7/22/24 - 3/31/25

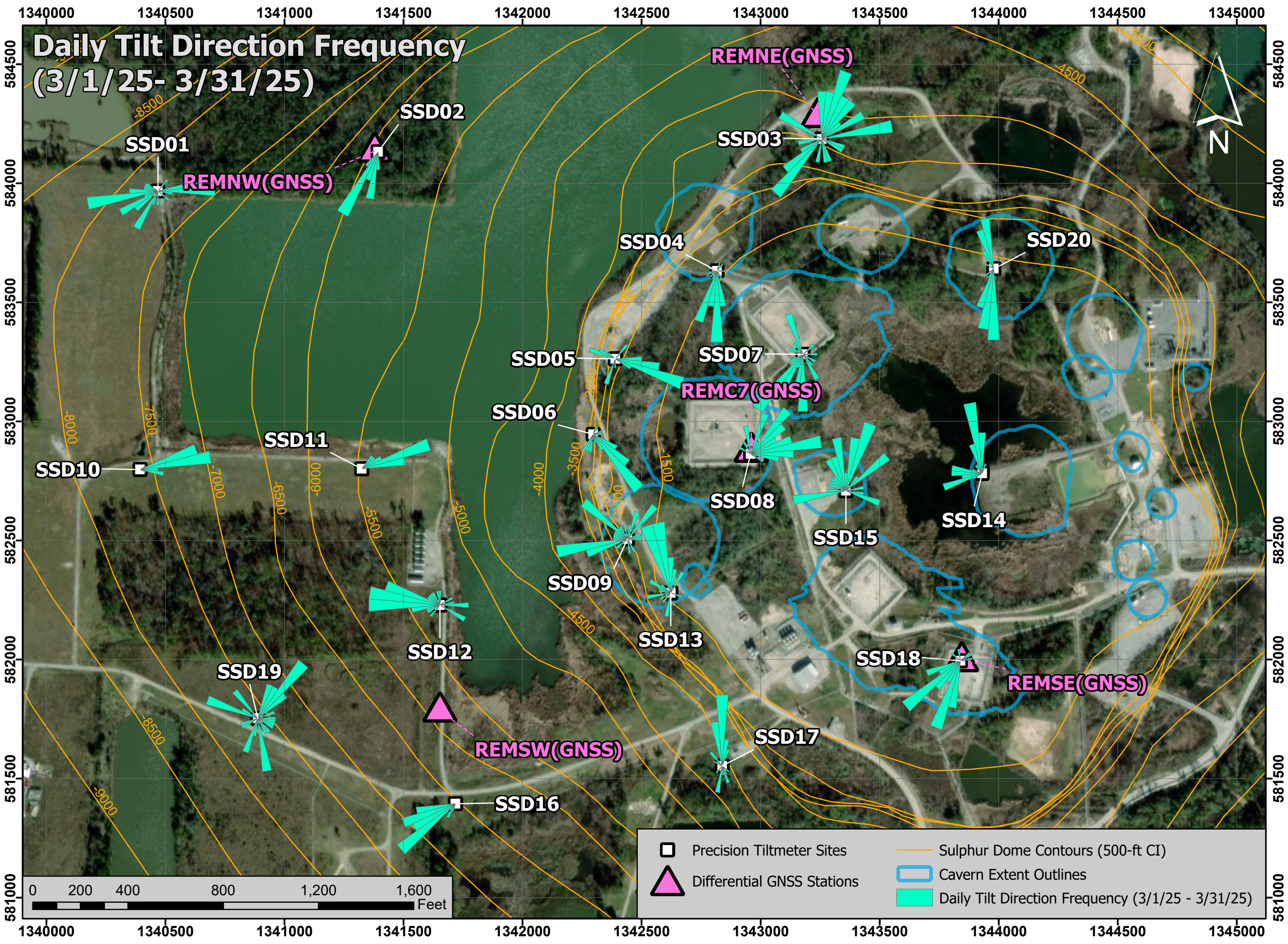


- Precision Tiltmeter Sites
- △ Differential GNSS Stations (vertical rate labeled)
- Cavern Extent Outlines
- Sulphur Dome Contours (500-ft CI)
- Tiltmeter Rate Vector (μrad/yr)
- GNSS Rate Vector (horiz. in/yr)
- GNSS Rate Error Ellipse

# Daily Tilt Direction Frequency - Full History (6/1/24- 3/31/25)



	Precision Tiltmeter Sites		Sulphur Dome Contours (500-ft CI)
	Differential GNSS Stations		Cavern Extent Outlines
			Daily Tilt Direction Frequency (6/1/24 - 3/31/25)



# Location of GNSS and Tiltmeter Stations

*Sulphur Mines Salt Dome*

*(Coordinate Datum: WGS 84)*

<b>Differential GNSS Stations</b>		
<b>Name</b>	<b>Latitude</b>	<b>Longitude</b>
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

<b>Precision Tiltmeter Sites</b>		
<b>Name</b>	<b>Latitude</b>	<b>Longitude</b>
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 - March 27, 2025**



# 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 Field Service, LLC  
8591 United Plaza Blvd., Suite 280  
Baton Rouge, LA 70809

<b>Dataset</b>
Satellite Source
<b>Sentinel-1 (SNT)</b>
Most Recent Image Date
<b>Thursday, March 27, 2025</b>

Analysis Report Date:  
**April 1, 2025**

Dataset Information	
Satellite Source	Sentinel-1 (SNT)
Revisit Frequency	12 days
Most Recent Image Date	Thursday, March 27, 2025
Dataset Image Count	223
Dataset Time Range	October 4, 2016 - March 27, 2025
Dataset Length	8.48 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 not show any material increases ( $\geq -0.10$ ) in the negative velocity and/or negative acceleration of LOS displacement in any of the 15 AOI point groups. This suggests that subsidence rates have not increased over the past two years relative to the historical data that has been collected since October 2016.

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. This suggests that statistically relevant areas of change are not currently evident within the rate change maps.



Date Signed: April 1, 2025  
Austin, Texas

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

## InSAR Data Sources

### InSAR Data

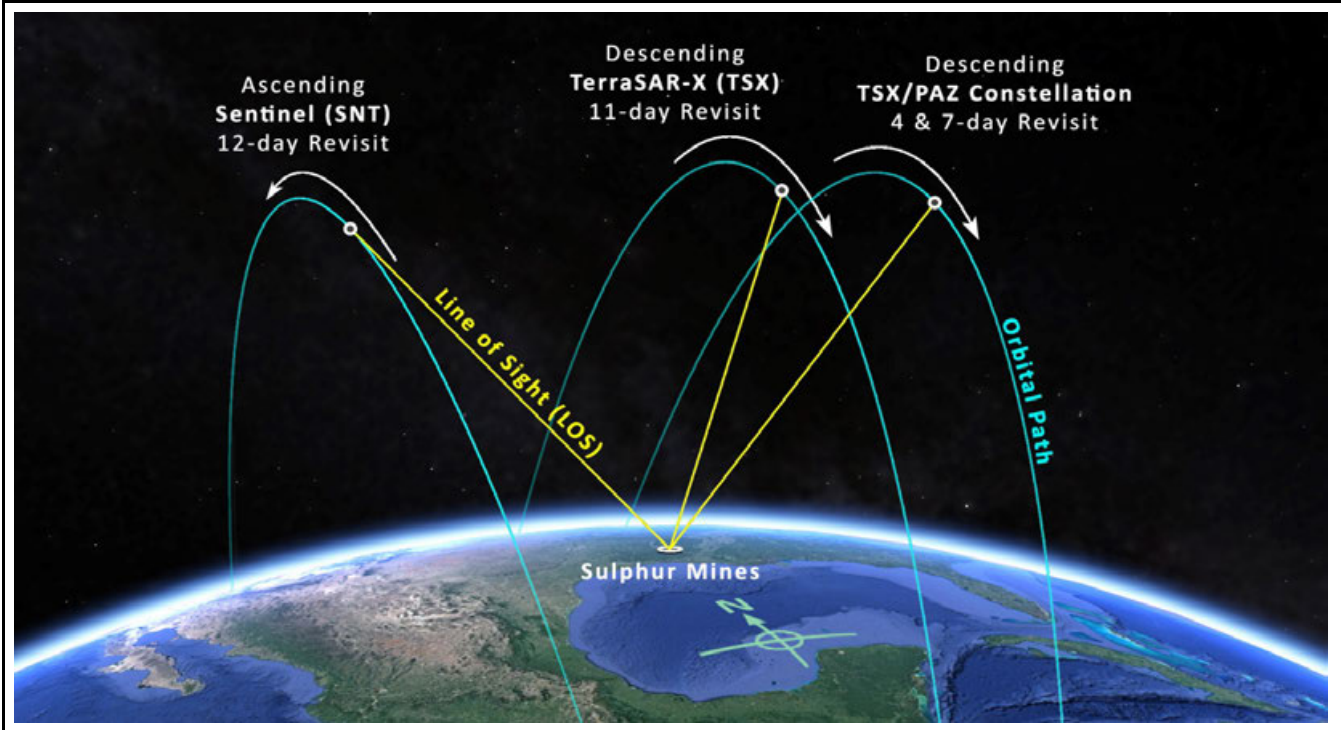
Interferometric Synthetic Aperture Radar (InSAR) is the most well established method to continually evaluate small, normally undetectable, ground movement over a large area. Radar imagery collected via satellites over successive orbital passes is used to identify and define measurement points on the 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) displacement 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.

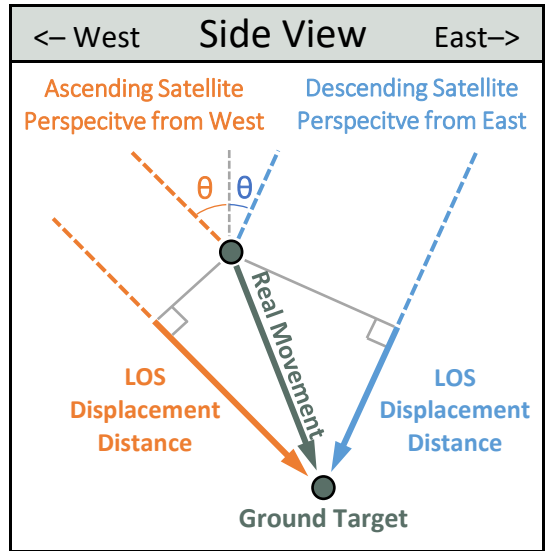
The first dataset comes from a low-resolution Sentinel-1 (SNT) satellite on an ascending orbit that captures data from the west of the site on a 12-day frequency. The second comes from a pair of high resolution satellites that share the same descending orbit and capture data from east of the site. These 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. 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

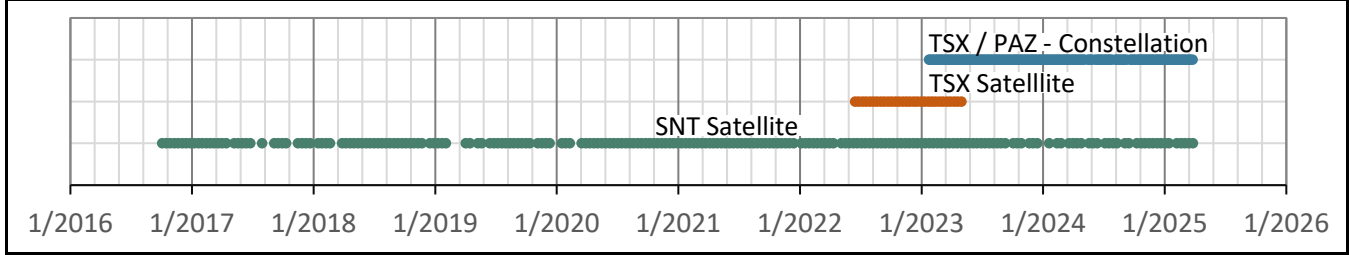
LOS displacement measurements refer to a change in distance between the satellite sensor and the ground target. Measurement positions on the west side of the Sulphur Dome are known to be experiencing some eastward movement toward the dome center due to the geometry of the subsidence basin. The InSAR 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.



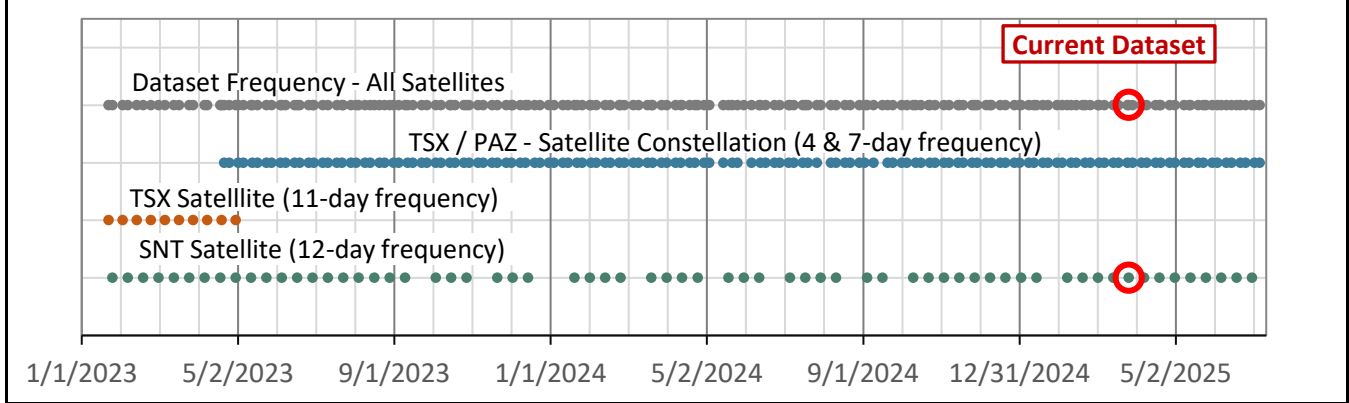
### Satellite Properties & Image Frequency

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

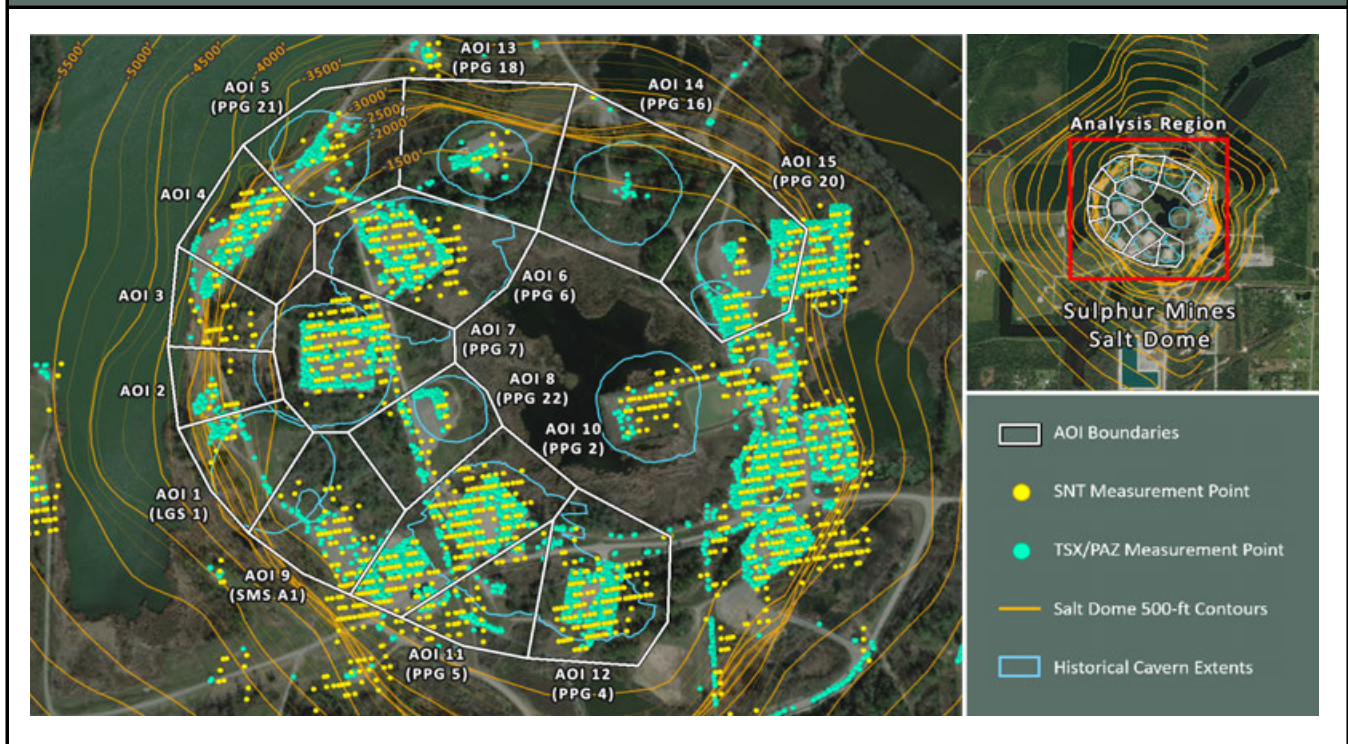
### Dataset Measurement History



### Dataset Update Frequency



## AOI Boundaries & InSAR Measurement Points

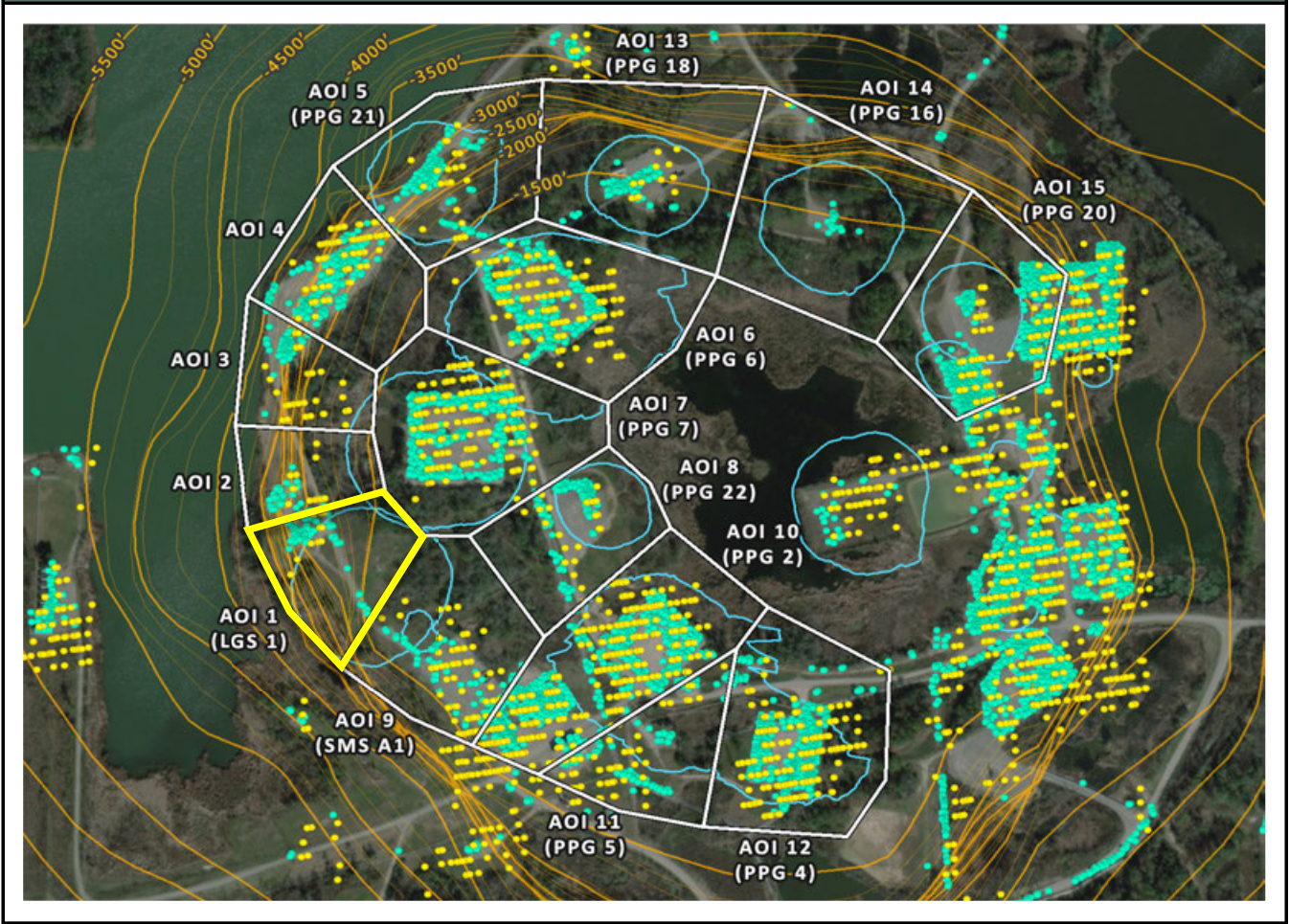


## Subsidence Monitoring Areas of Interest (AOIs)

To visually convey and evaluate trend consistency for the displacement time series of each ground target, measurement 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.

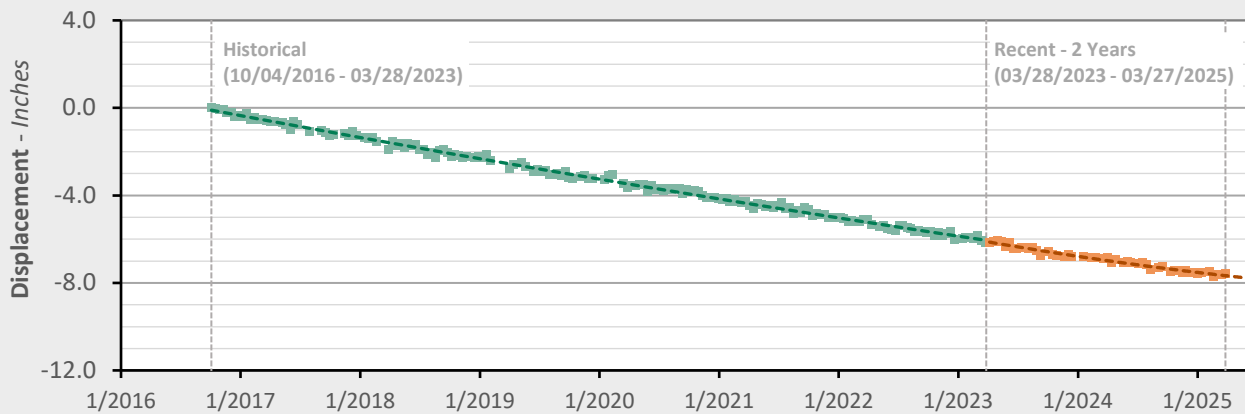
AOI Name	SNT (3/27/2025)	LOS Velocity ( <i>in/yr</i> )			LOS Acceleration ( <i>in/yr<sup>2</sup></i> )		
	Point Count	Historical	Recent	Change	Historical	Recent	Change
AOI 1 (LGS 1)	14	-0.81	-0.61	+0.21	+0.03	+0.18	+0.14
AOI 2	15	-0.75	-0.50	+0.25	+0.05	+0.30	+0.25
AOI 3	29	-0.63	-0.55	+0.08	+0.03	+0.07	+0.04
AOI 4	62	-0.78	-0.73	+0.05	+0.01	+0.02	+0.02
AOI 5 (PPG 21)	25	-0.65	-0.48	+0.17	+0.02	+0.12	+0.10
AOI 6 (PPG 6)	134	-0.86	-0.84	+0.02	+0.04	+0.02	-0.02
AOI 7 (PPG 7)	139	-0.97	-0.99	-0.02	+0.06	+0.06	+0.00
AOI 8 (PPG 22)	20	-1.05	-1.09	-0.04	+0.09	+0.14	+0.05
AOI 9 (SMS A1)	59	-0.83	-0.85	-0.01	+0.07	-0.00	-0.07
AOI 10 (PPG 2)	231	-0.88	-0.95	-0.07	+0.08	+0.06	-0.02
AOI 11 (PPG 5)	51	-0.85	-0.83	+0.02	+0.06	+0.05	-0.01
AOI 12 (PPG 4)	120	-0.74	-0.64	+0.10	+0.04	-0.01	-0.05
AOI 13 (PPG 18)	12	-0.55	-0.61	-0.06	+0.05	+0.00	-0.05
AOI 14 (PPG 16)	1	-0.15	+0.24	+0.39	+0.07	+0.49	+0.42
AOI 15 (PPG 20)	70	-0.30	-0.30	-0.00	+0.04	+0.04	-0.00

### AOI 1 (LGS 1) - Location Map

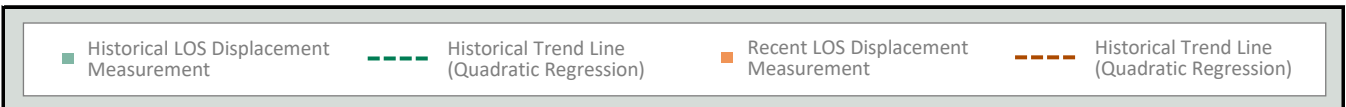


### AOI 1 (LGS 1) - Displacement Time Series

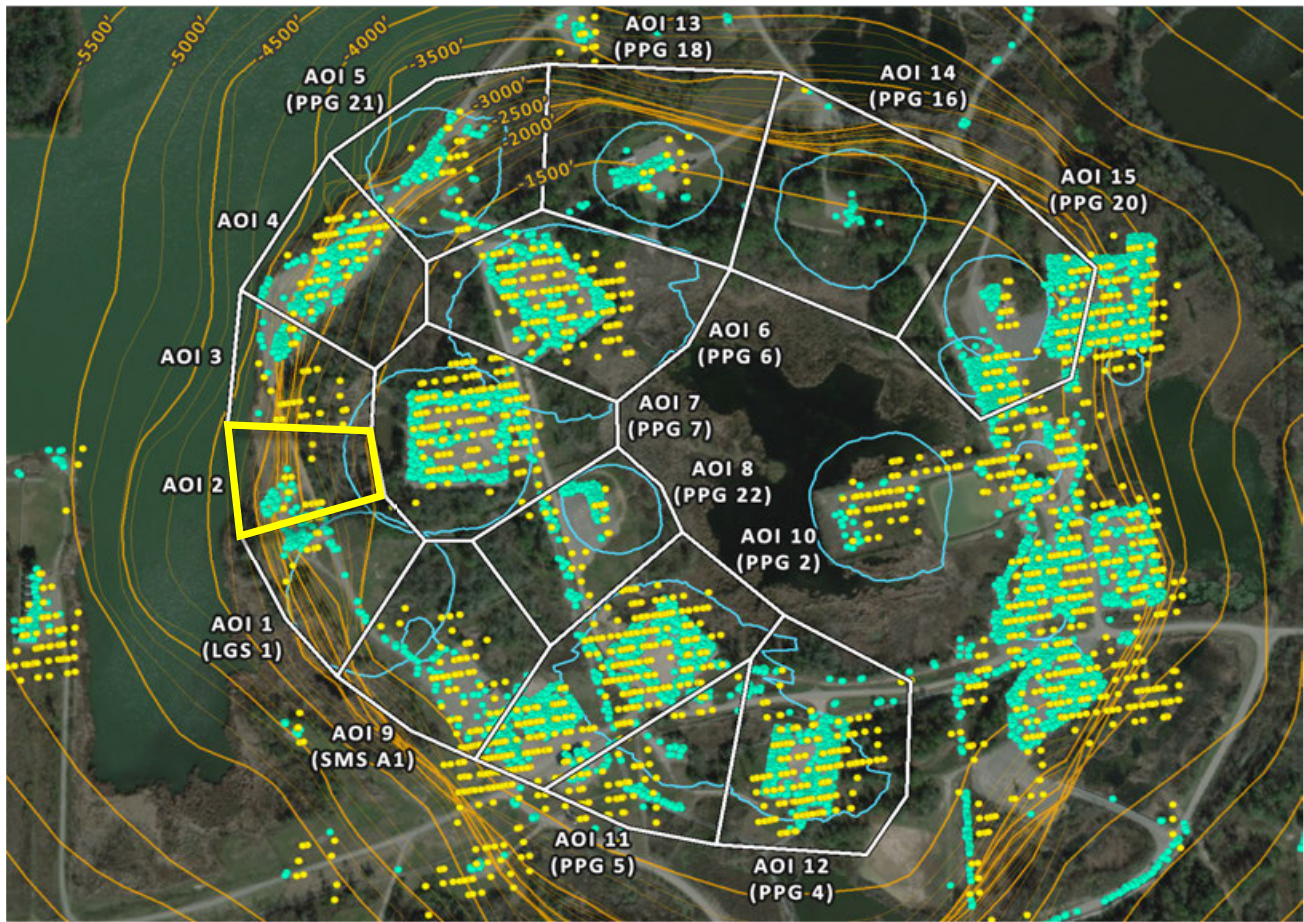
SNT (3/27/2025) Point Count: 14



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.81 in/yr	-0.61 in/yr	+0.21 in/yr
Acceleration:	+0.03 in/yr <sup>2</sup>	+0.18 in/yr <sup>2</sup>	+0.14 in/yr <sup>2</sup>

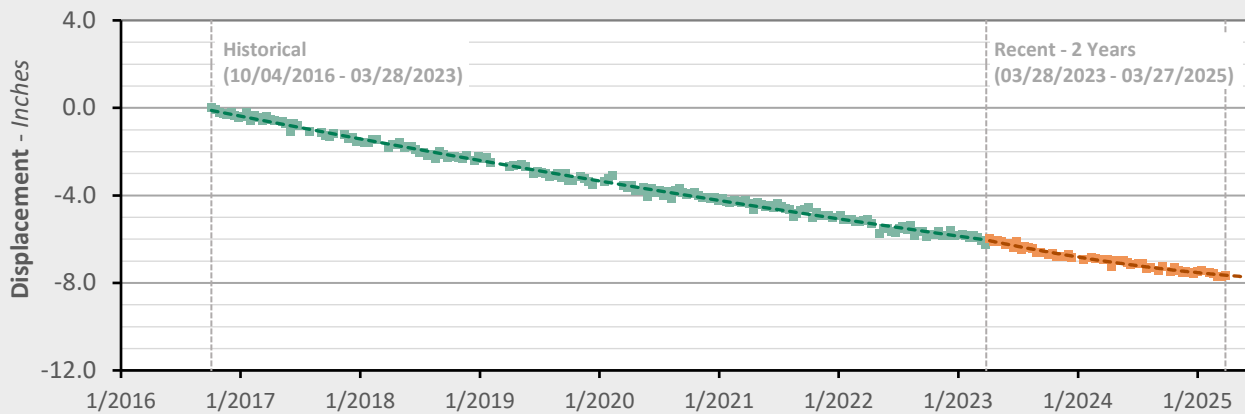


### AOI 2 - Location Map

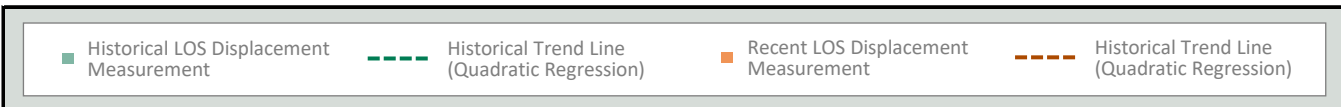


### AOI 2 - Displacement Time Series

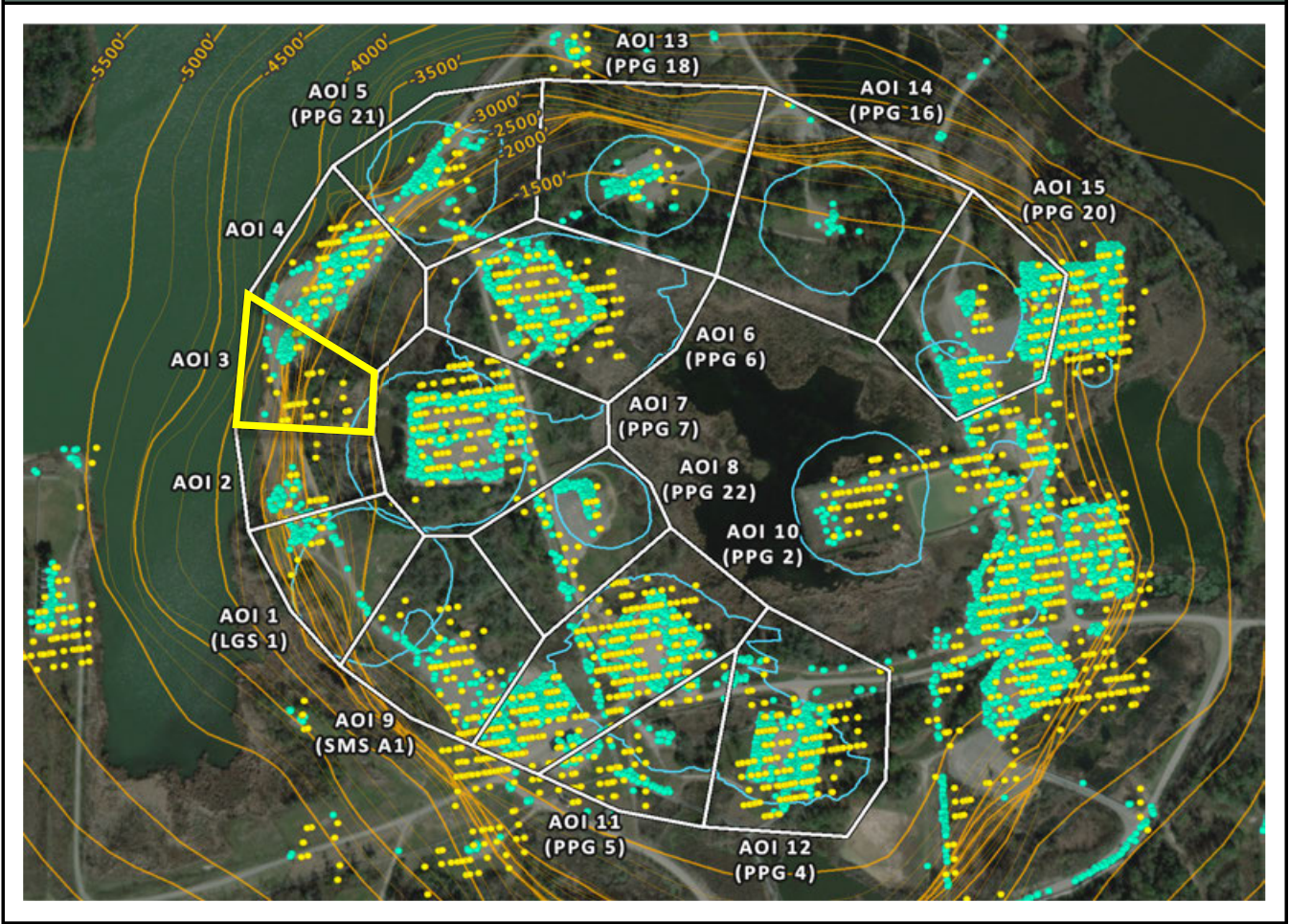
SNT (3/27/2025) Point Count: 15



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.75 in/yr	-0.50 in/yr	+0.25 in/yr
Acceleration:	+0.05 in/yr <sup>2</sup>	+0.30 in/yr <sup>2</sup>	+0.25 in/yr <sup>2</sup>

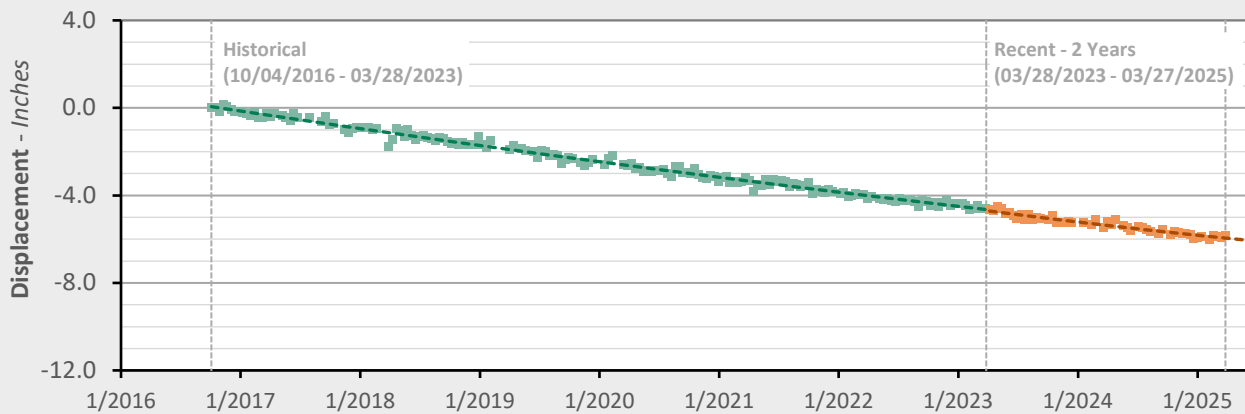


### AOI 3 - Location Map

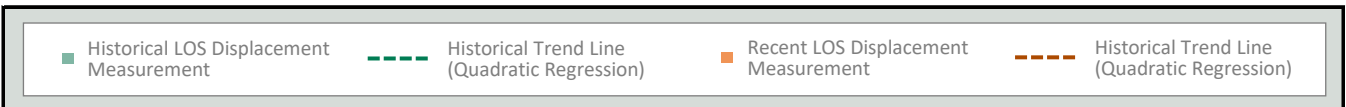


### AOI 3 - Displacement Time Series

SNT (3/27/2025) Point Count: 29



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.63 in/yr	-0.55 in/yr	+0.08 in/yr
Acceleration:	+0.03 in/yr <sup>2</sup>	+0.07 in/yr <sup>2</sup>	+0.04 in/yr <sup>2</sup>

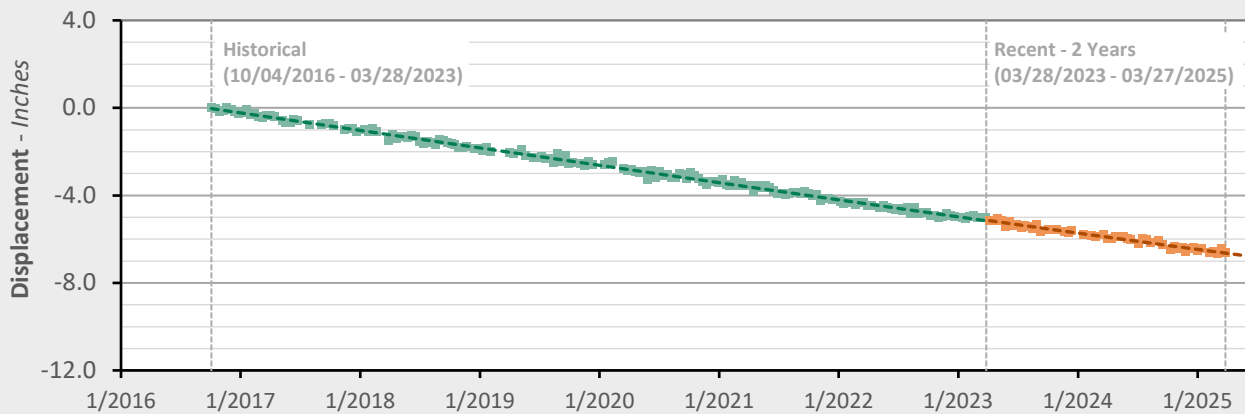


### AOI 4 - Location Map

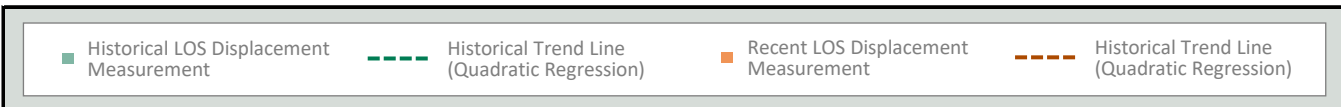


### AOI 4 - Displacement Time Series

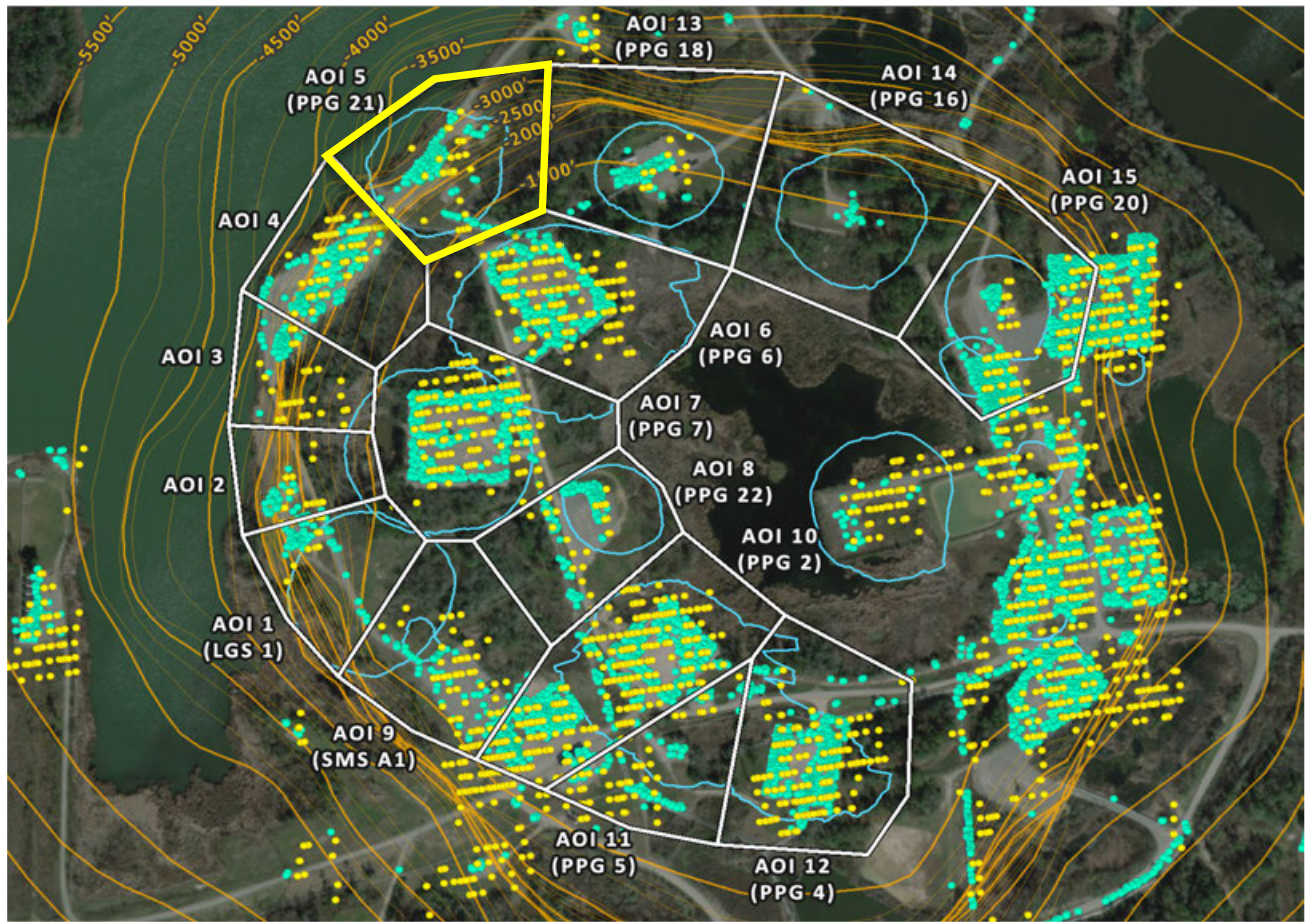
SNT (3/27/2025) Point Count: 62



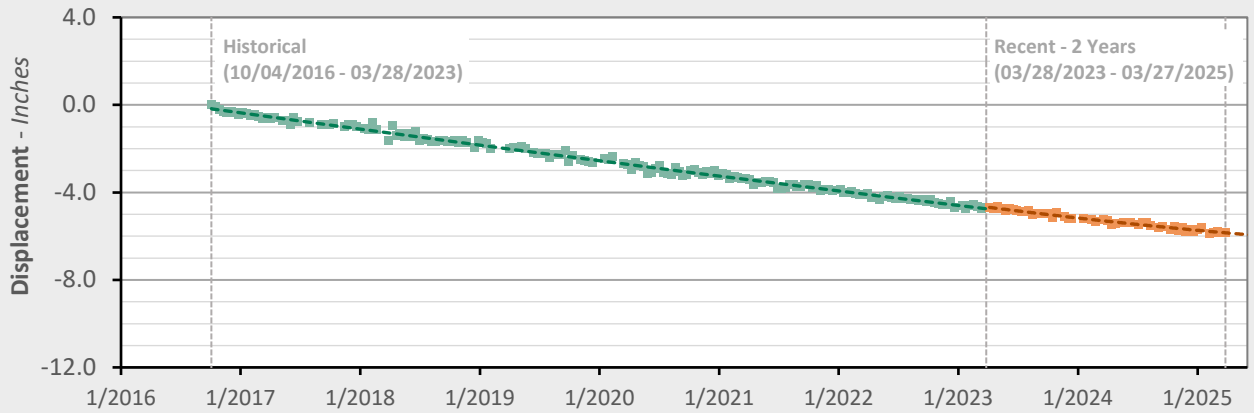
	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.78 in/yr	-0.73 in/yr	+0.05 in/yr
Acceleration:	+0.01 in/yr <sup>2</sup>	+0.02 in/yr <sup>2</sup>	+0.02 in/yr <sup>2</sup>



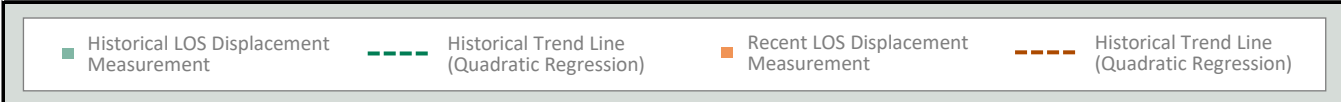
### AOI 5 (PPG 21) - Location Map



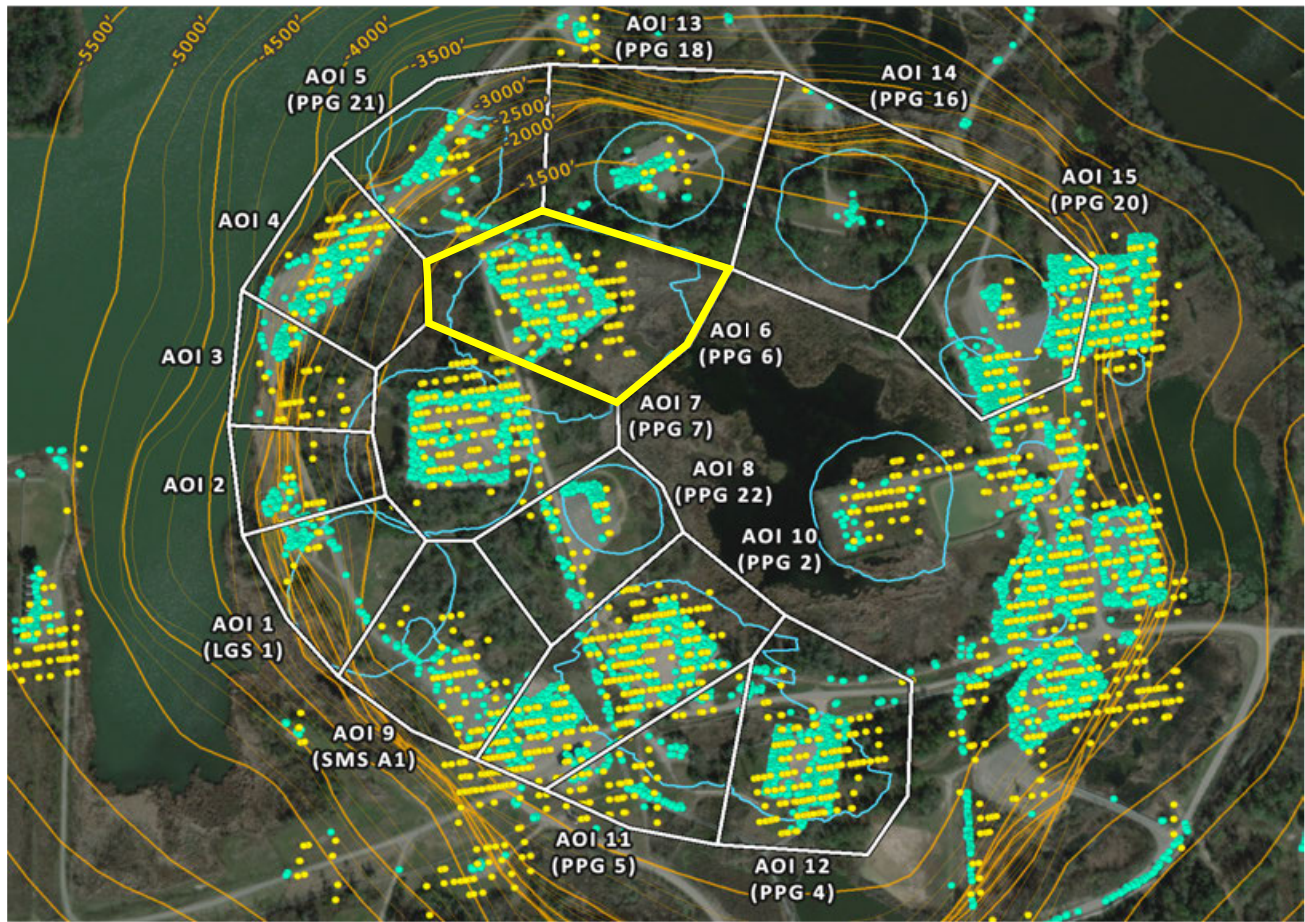
### AOI 5 (PPG 21) - Displacement Time Series SNT (3/27/2025) Point Count: 25



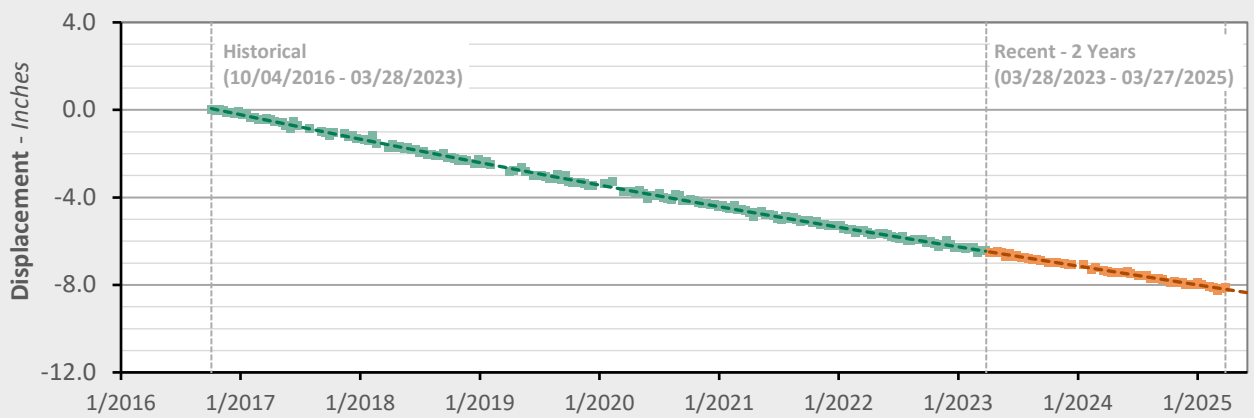
	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.65 in/yr	-0.48 in/yr	+0.17 in/yr
Acceleration:	+0.02 in/yr <sup>2</sup>	+0.12 in/yr <sup>2</sup>	+0.10 in/yr <sup>2</sup>



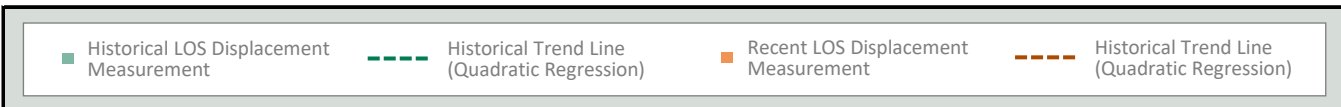
### AOI 6 (PPG 6) - Location Map



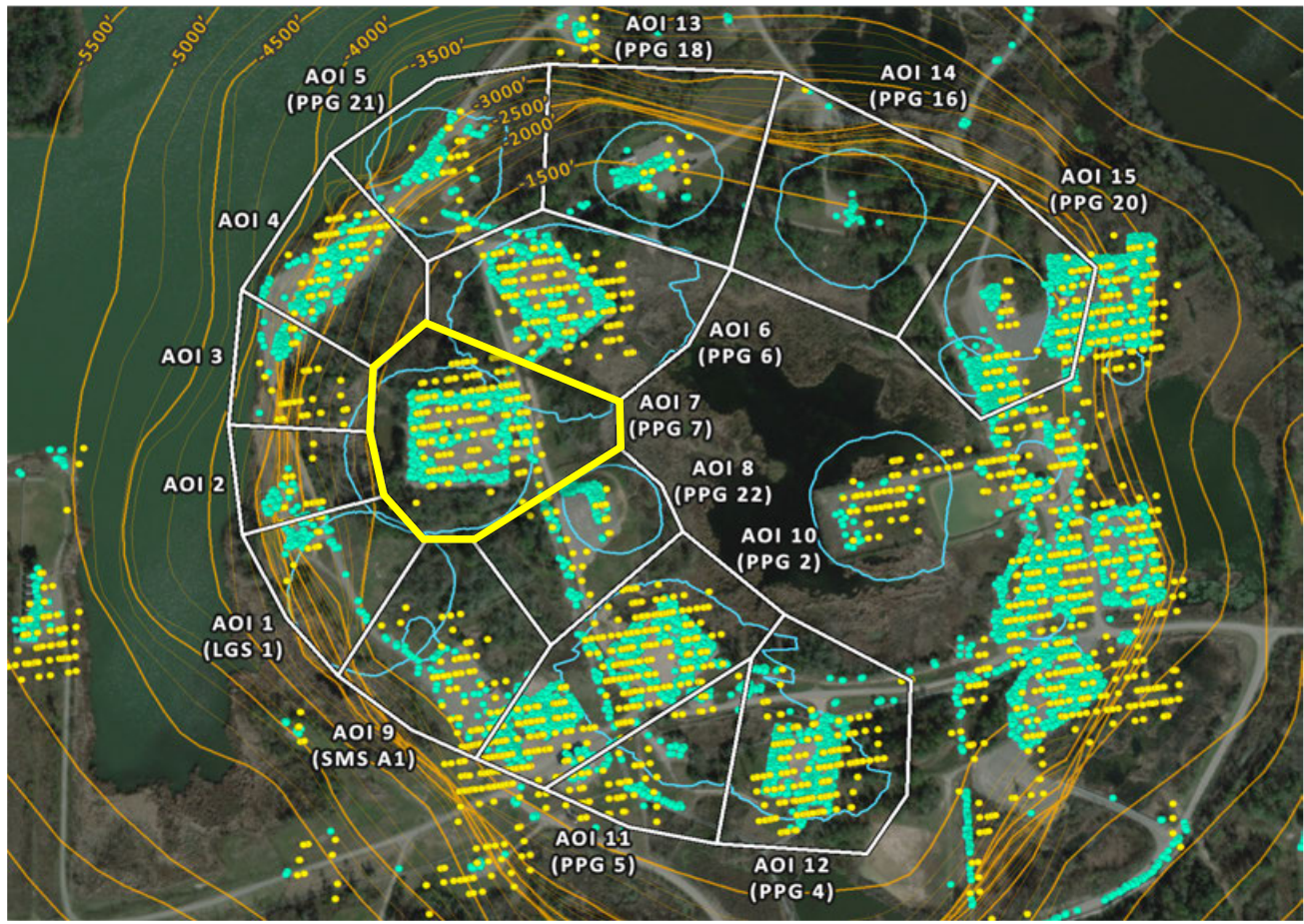
### AOI 6 (PPG 6) - Displacement Time Series SNT (3/27/2025) Point Count: 134



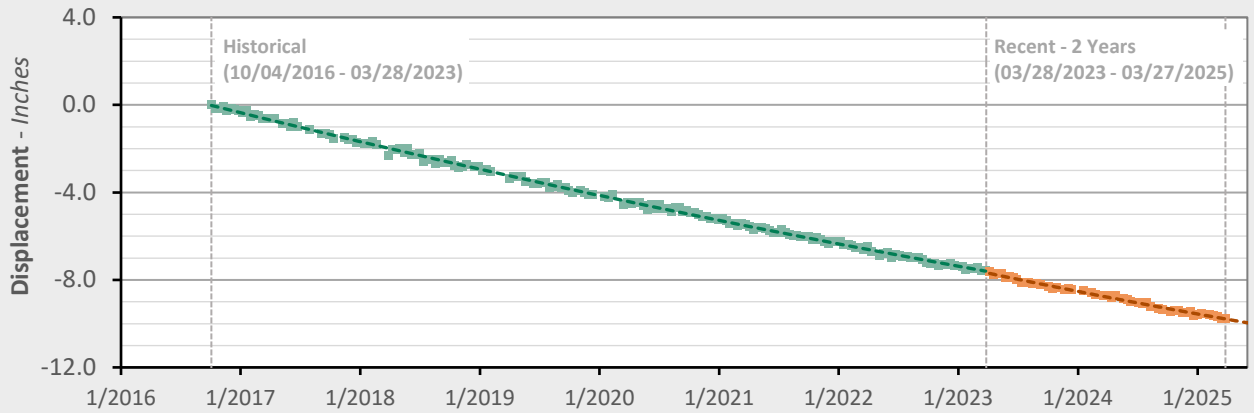
	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.86 in/yr	-0.84 in/yr	+0.02 in/yr
Acceleration:	+0.04 in/yr <sup>2</sup>	+0.02 in/yr <sup>2</sup>	-0.02 in/yr <sup>2</sup>



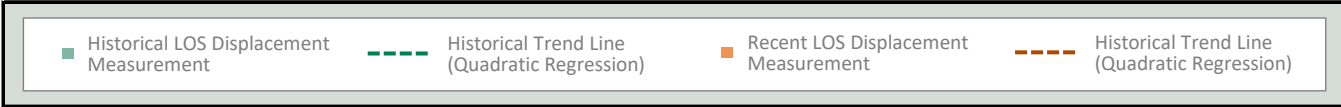
### AOI 7 (PPG 7) - Location Map



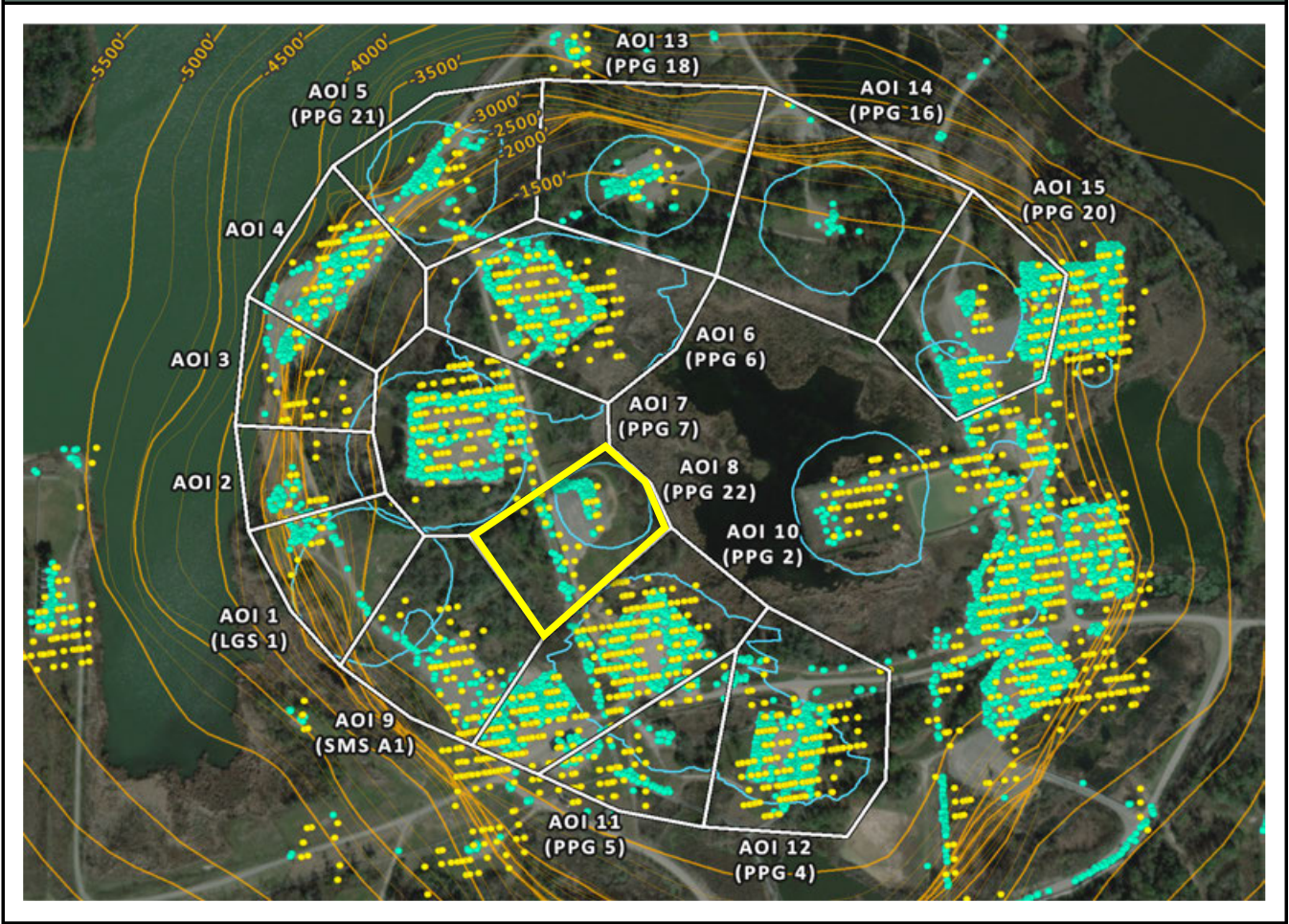
### AOI 7 (PPG 7) - Displacement Time Series SNT (3/27/2025) Point Count: 139



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.97 in/yr	-0.99 in/yr	-0.02 in/yr
Acceleration:	+0.06 in/yr <sup>2</sup>	+0.06 in/yr <sup>2</sup>	+0.00 in/yr <sup>2</sup>

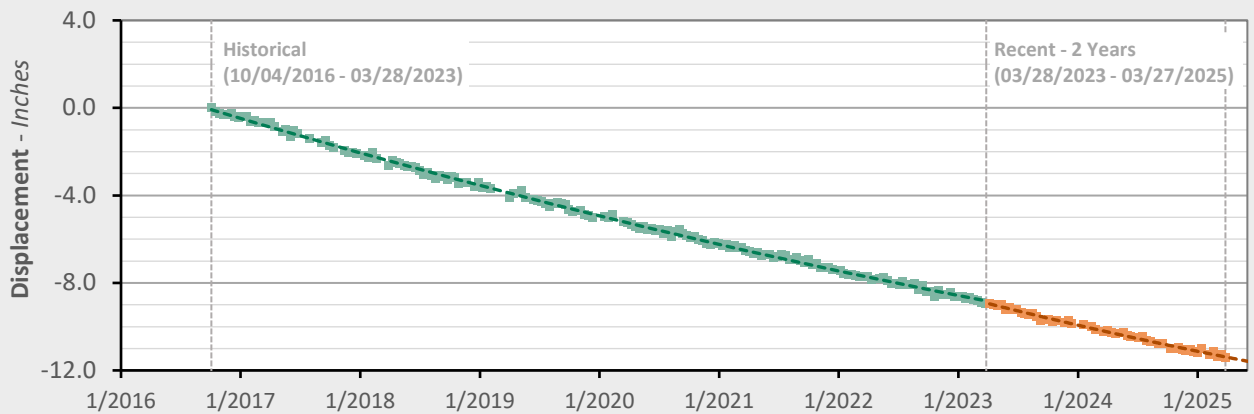


### AOI 8 (PPG 22) - Location Map

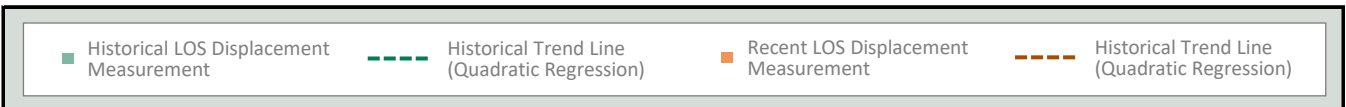


### AOI 8 (PPG 22) - Displacement Time Series

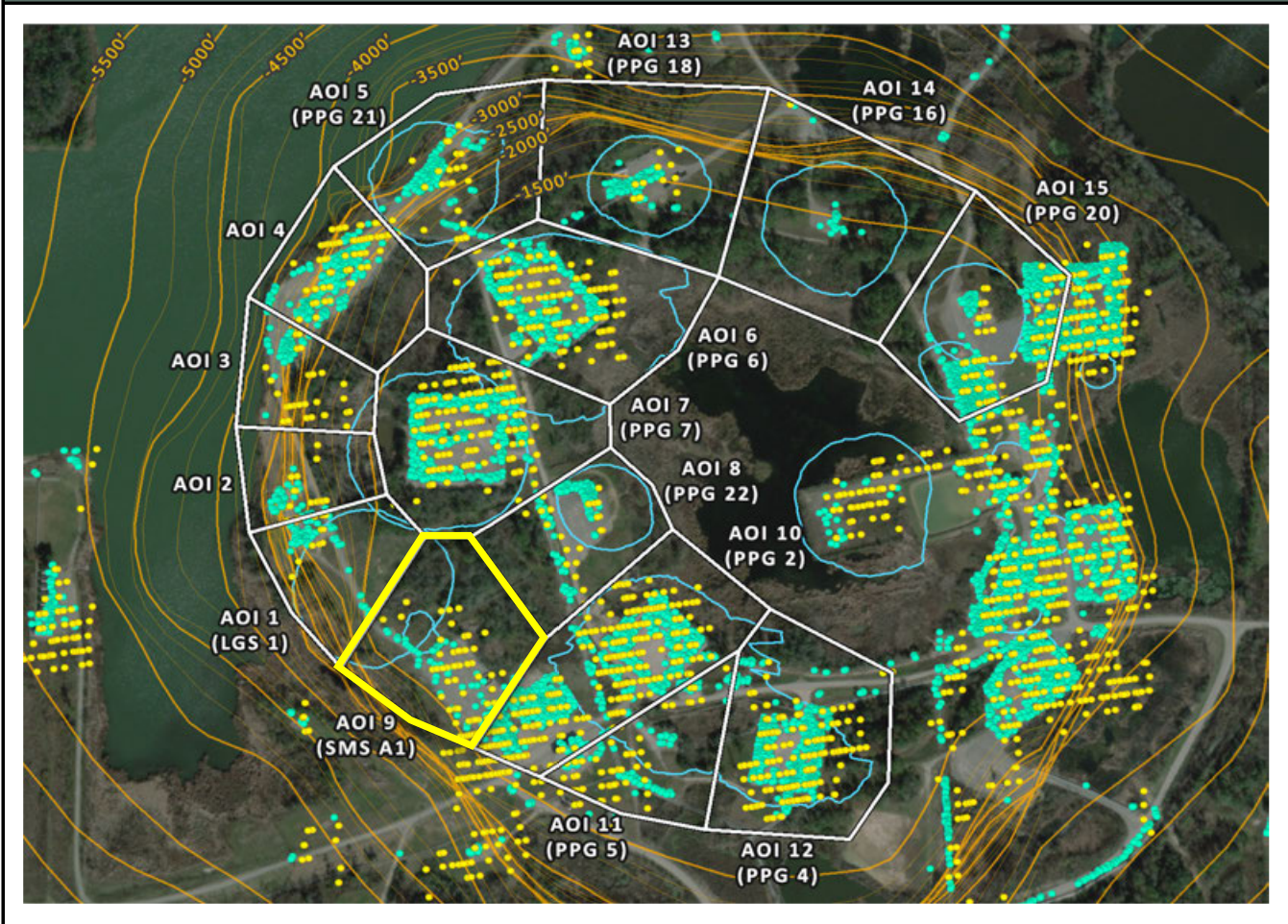
SNT (3/27/2025) Point Count: 20



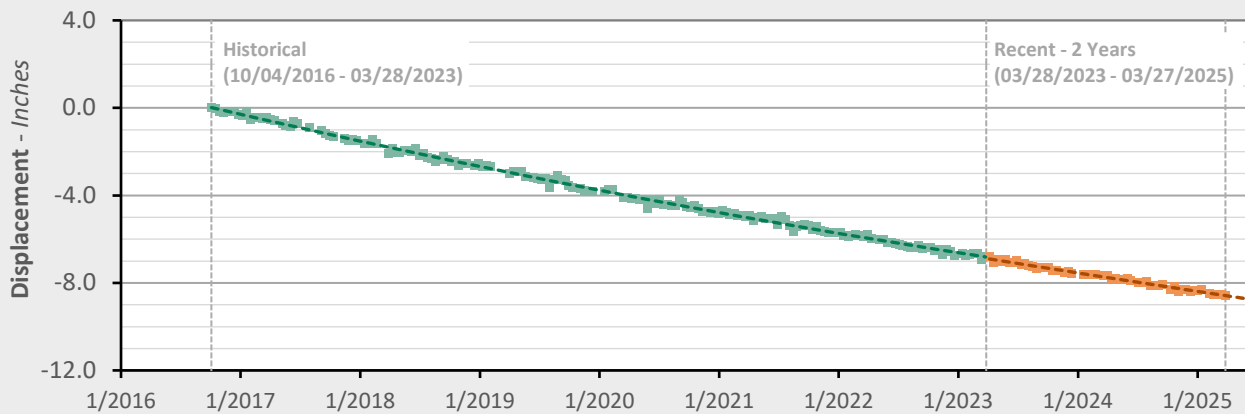
	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-1.05 in/yr	-1.09 in/yr	-0.04 in/yr
Acceleration:	+0.09 in/yr <sup>2</sup>	+0.14 in/yr <sup>2</sup>	+0.05 in/yr <sup>2</sup>



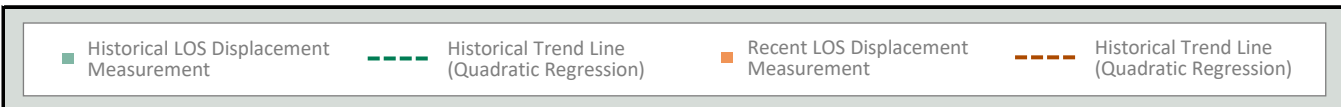
### AOI 9 (PPG A1) - Location Map



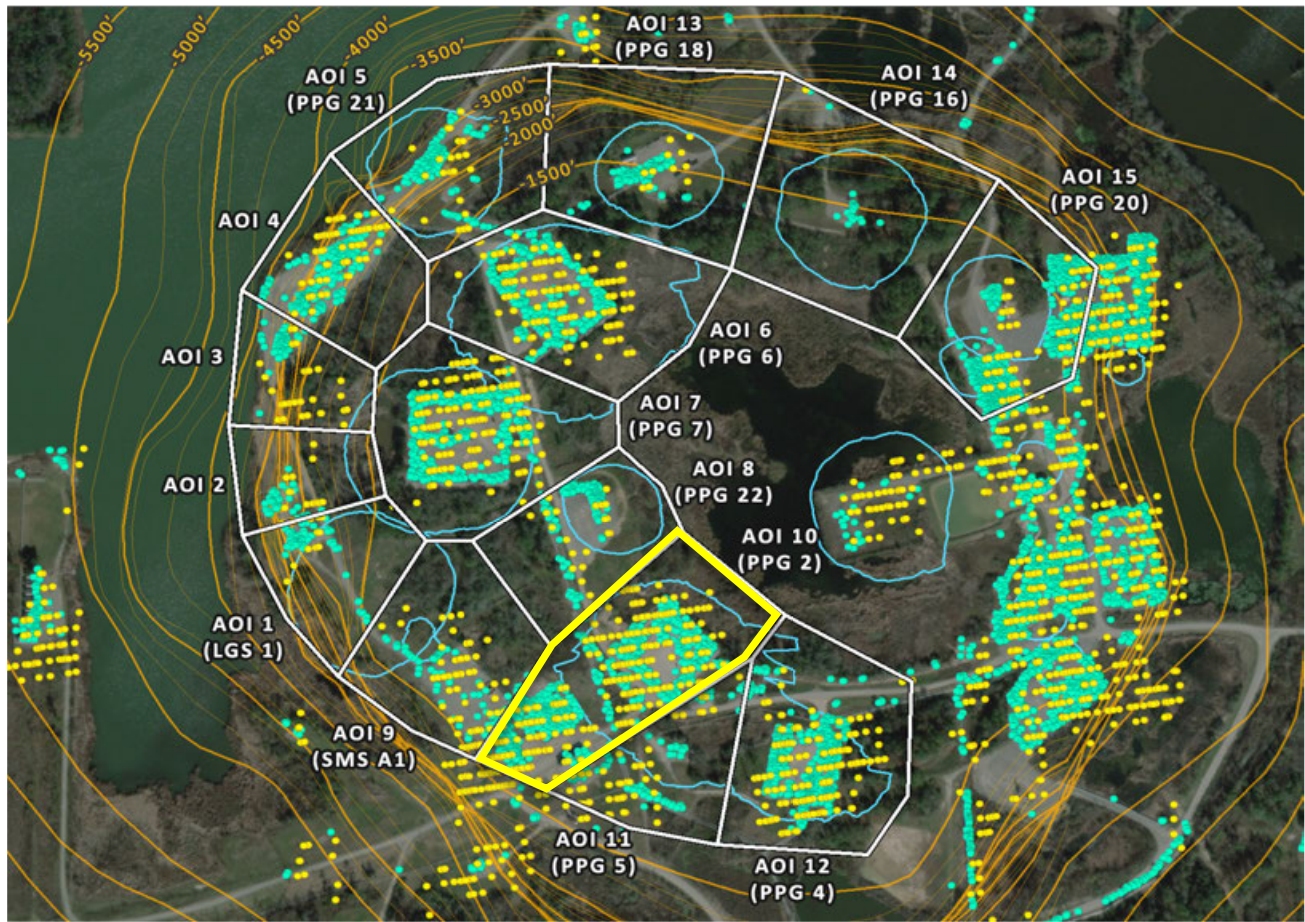
### AOI 9 (SMS A1) - Displacement Time Series SNT (3/27/2025) Point Count: 59



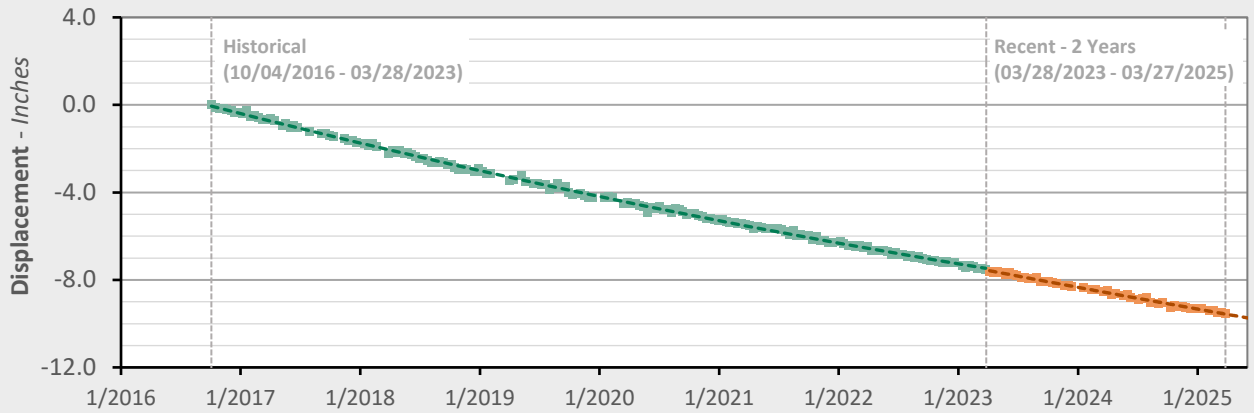
	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.83 in/yr	-0.85 in/yr	-0.01 in/yr
Acceleration:	+0.07 in/yr <sup>2</sup>	-0.00 in/yr <sup>2</sup>	-0.07 in/yr <sup>2</sup>



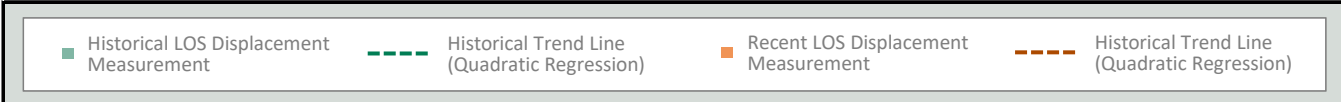
### AOI 10 (PPG 2) - Location Map



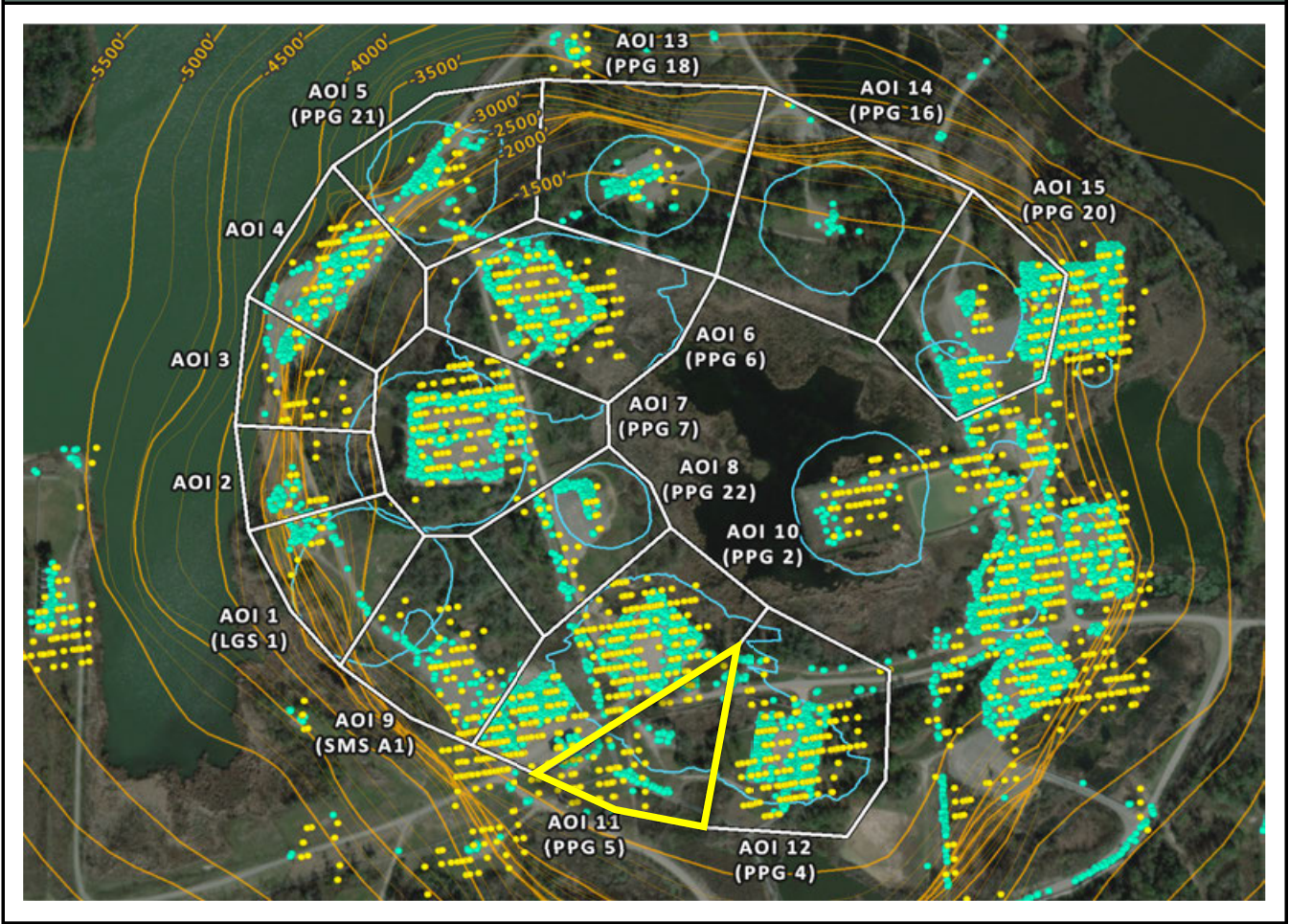
### AOI 10 (PPG 2) - Displacement Time Series SNT (3/27/2025) Point Count: 231



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.88 in/yr	-0.95 in/yr	-0.07 in/yr
Acceleration:	+0.08 in/yr <sup>2</sup>	+0.06 in/yr <sup>2</sup>	-0.02 in/yr <sup>2</sup>

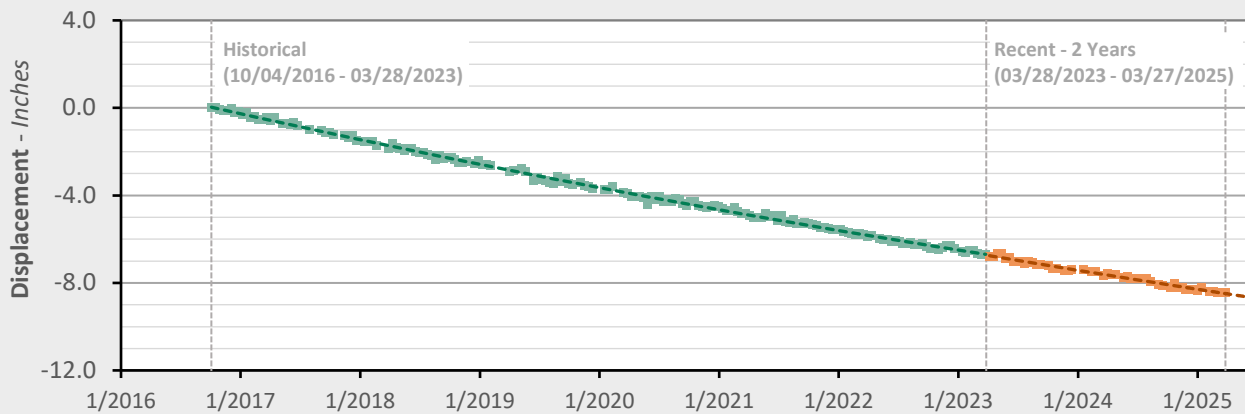


### AOI 11 (PPG 5) - Location Map

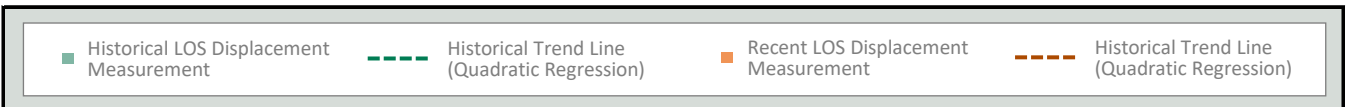


### AOI 11 (PPG 5) - Displacement Time Series

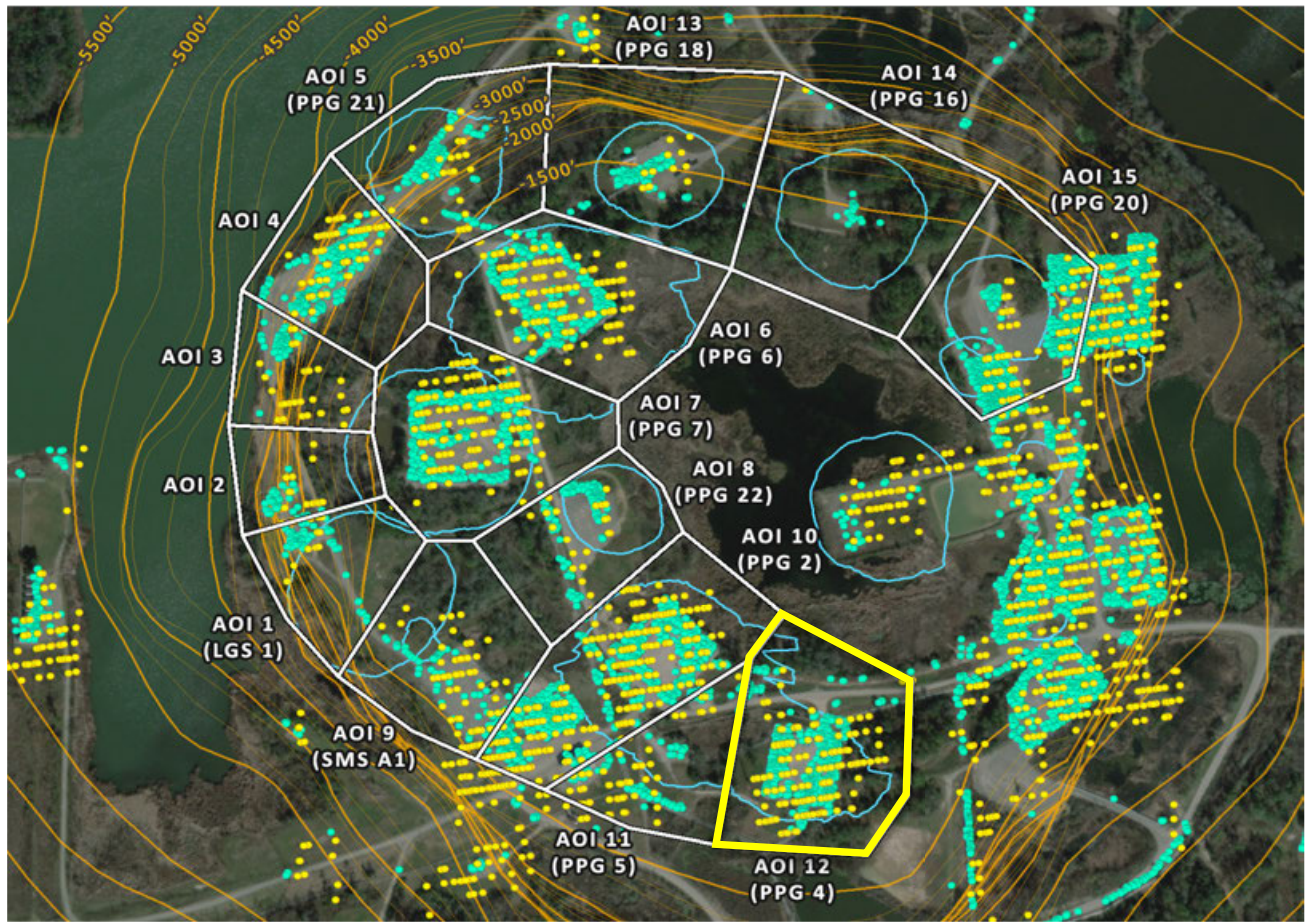
SNT (3/27/2025) Point Count: 51



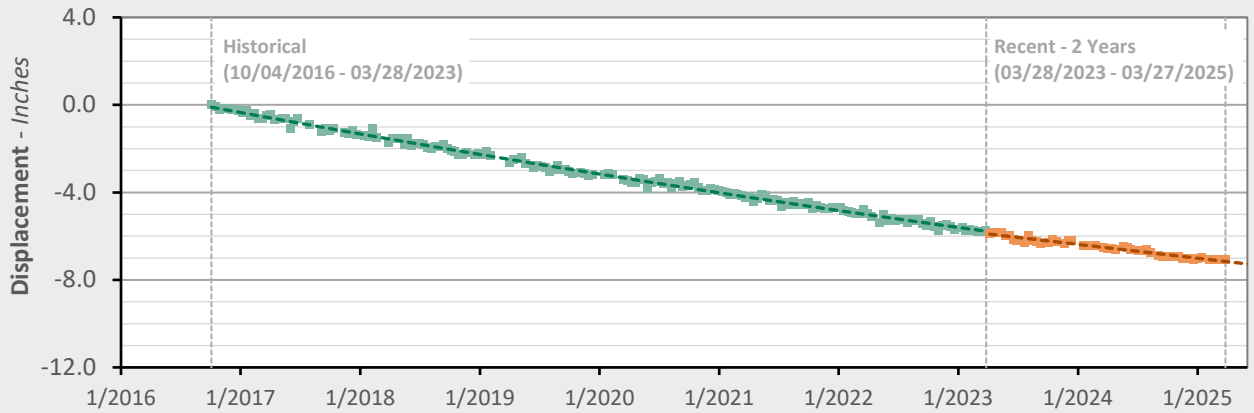
	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.85 in/yr	-0.83 in/yr	+0.02 in/yr
Acceleration:	+0.06 in/yr <sup>2</sup>	+0.05 in/yr <sup>2</sup>	-0.01 in/yr <sup>2</sup>



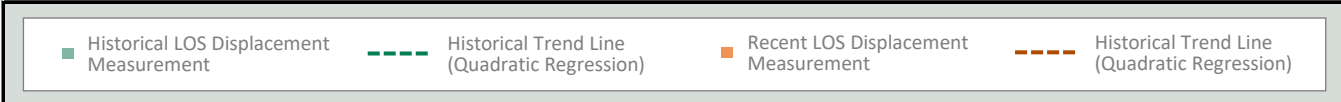
### AOI 12 (PPG 4) - Location Map



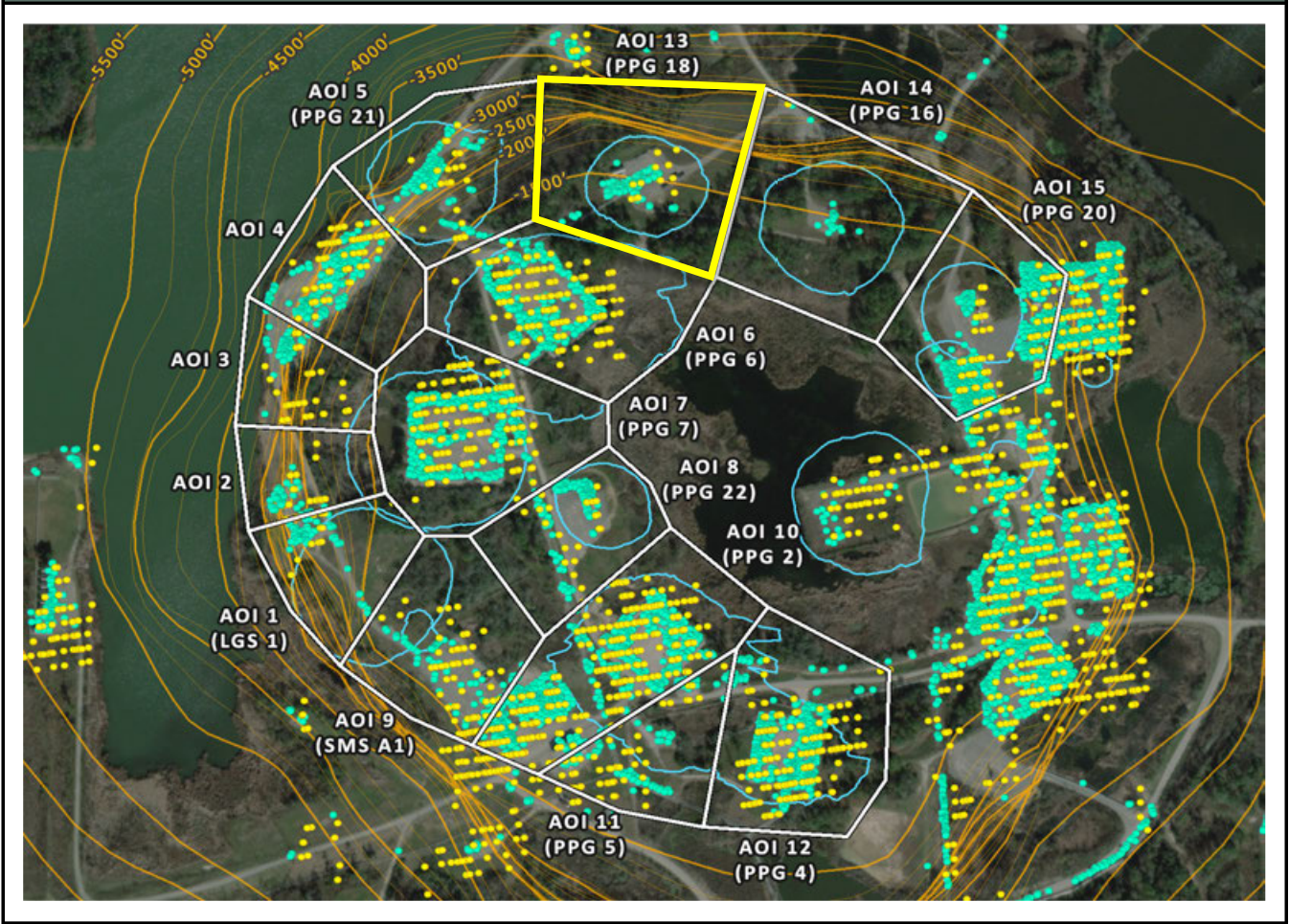
### AOI 12 (PPG 4) - Displacement Time Series SNT (3/27/2025) Point Count: 120



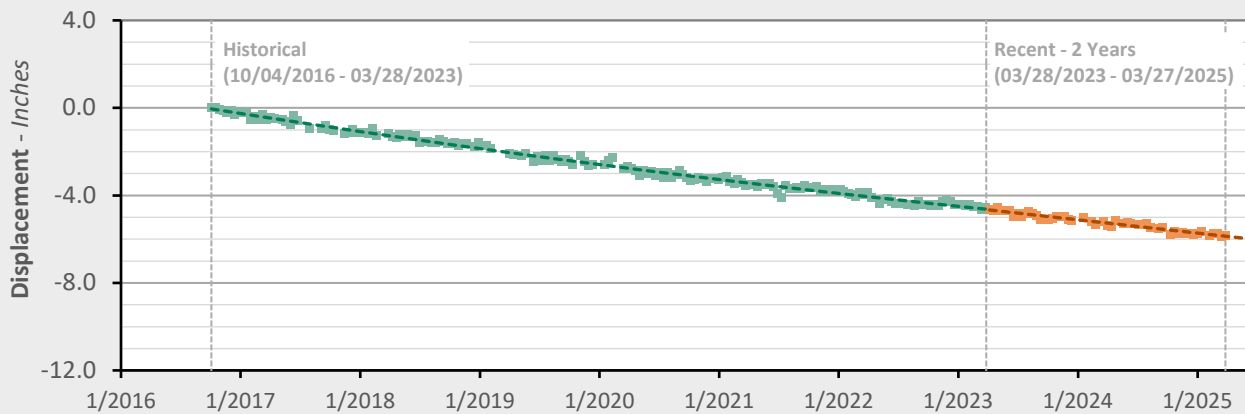
	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.74 in/yr	-0.64 in/yr	+0.10 in/yr
Acceleration:	+0.04 in/yr <sup>2</sup>	-0.01 in/yr <sup>2</sup>	-0.05 in/yr <sup>2</sup>



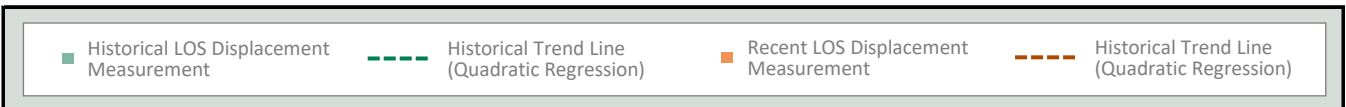
### AOI 13 (PPG 18) - Location Map



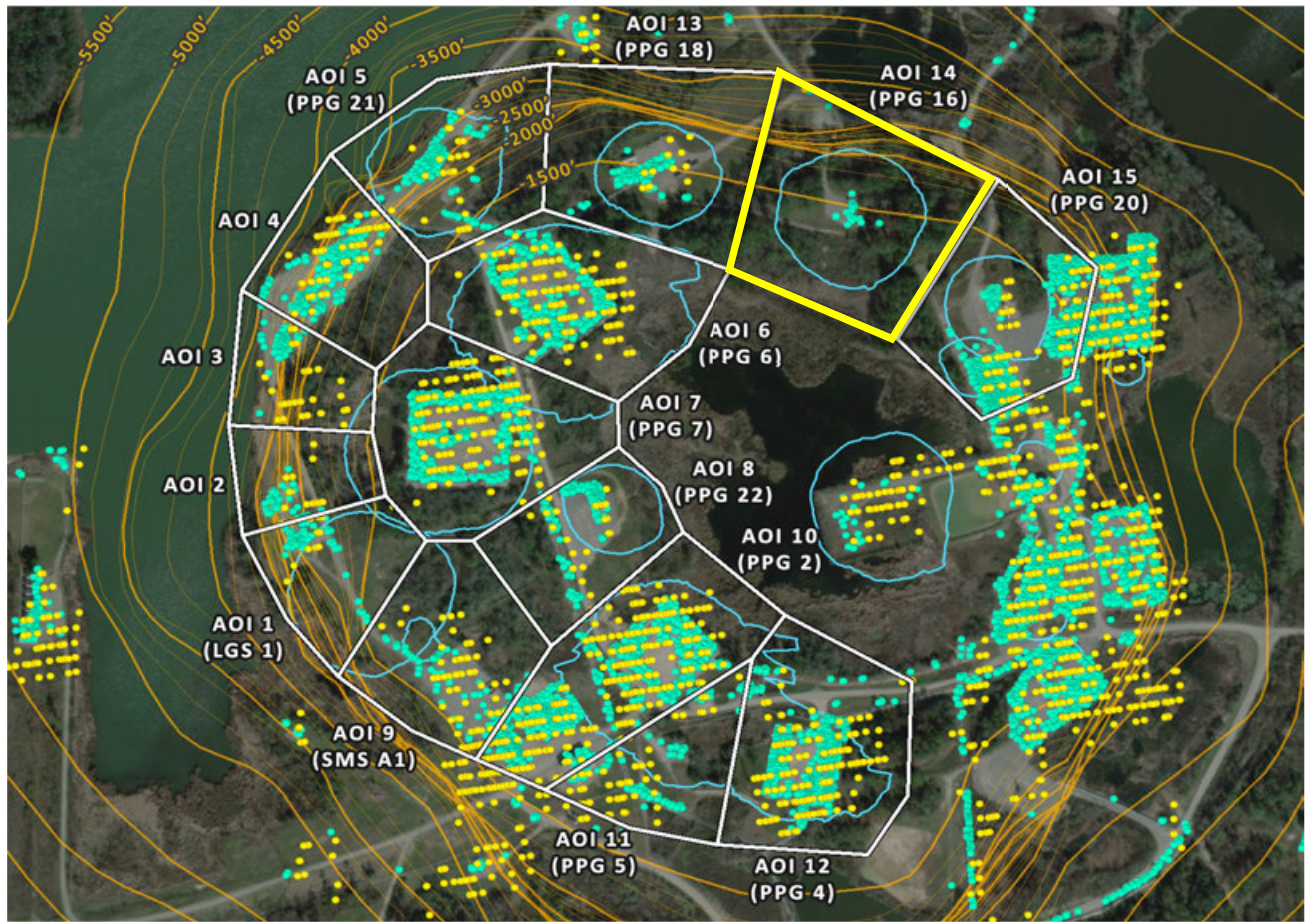
### AOI 13 (PPG 18) - Displacement Time Serie SNT (3/27/2025) Point Count: 12



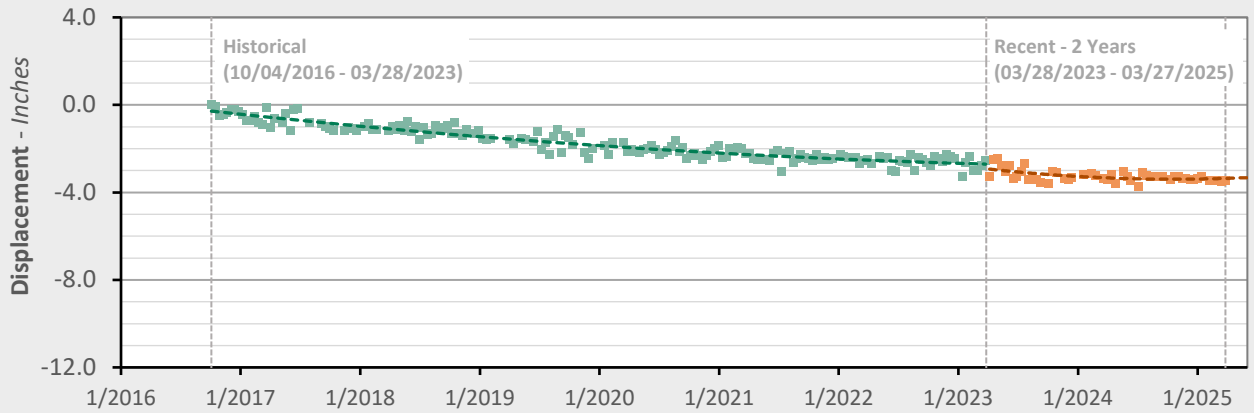
	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.55 in/yr	-0.61 in/yr	-0.06 in/yr
Acceleration:	+0.05 in/yr <sup>2</sup>	+0.00 in/yr <sup>2</sup>	-0.05 in/yr <sup>2</sup>



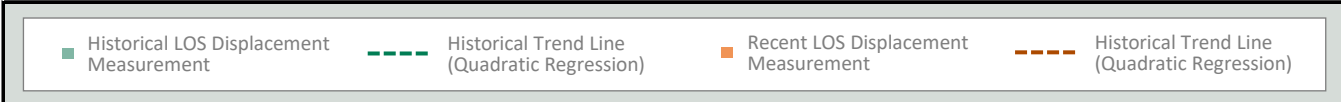
### AOI 14 (PPG 16) - Location Map



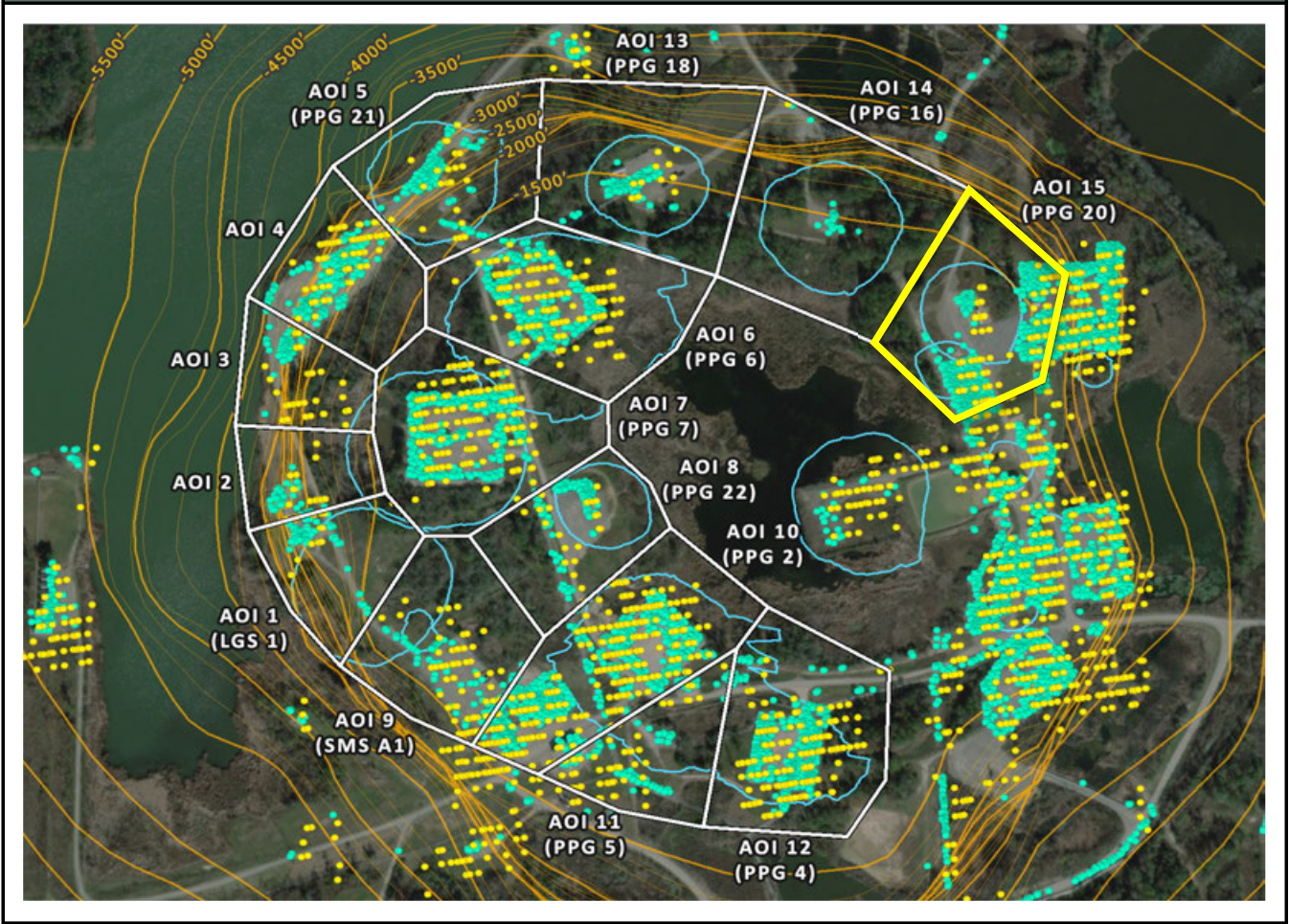
### AOI 14 (PPG 16) - Displacement Time Serie SNT (3/27/2025) Point Count: 1



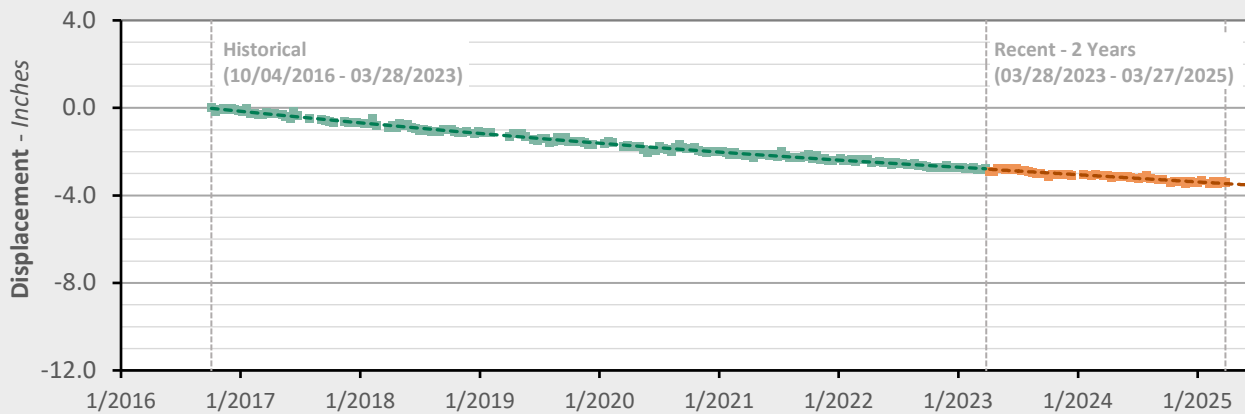
	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.15 in/yr	+0.24 in/yr	+0.39 in/yr
Acceleration:	+0.07 in/yr <sup>2</sup>	+0.49 in/yr <sup>2</sup>	+0.42 in/yr <sup>2</sup>



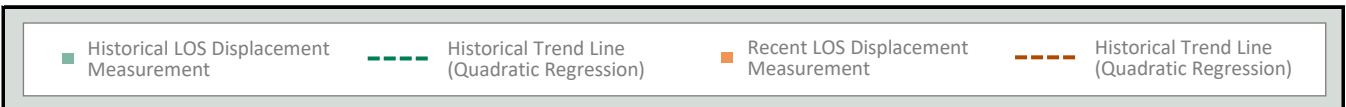
### AOI 15 (PPG 20) - Location Map

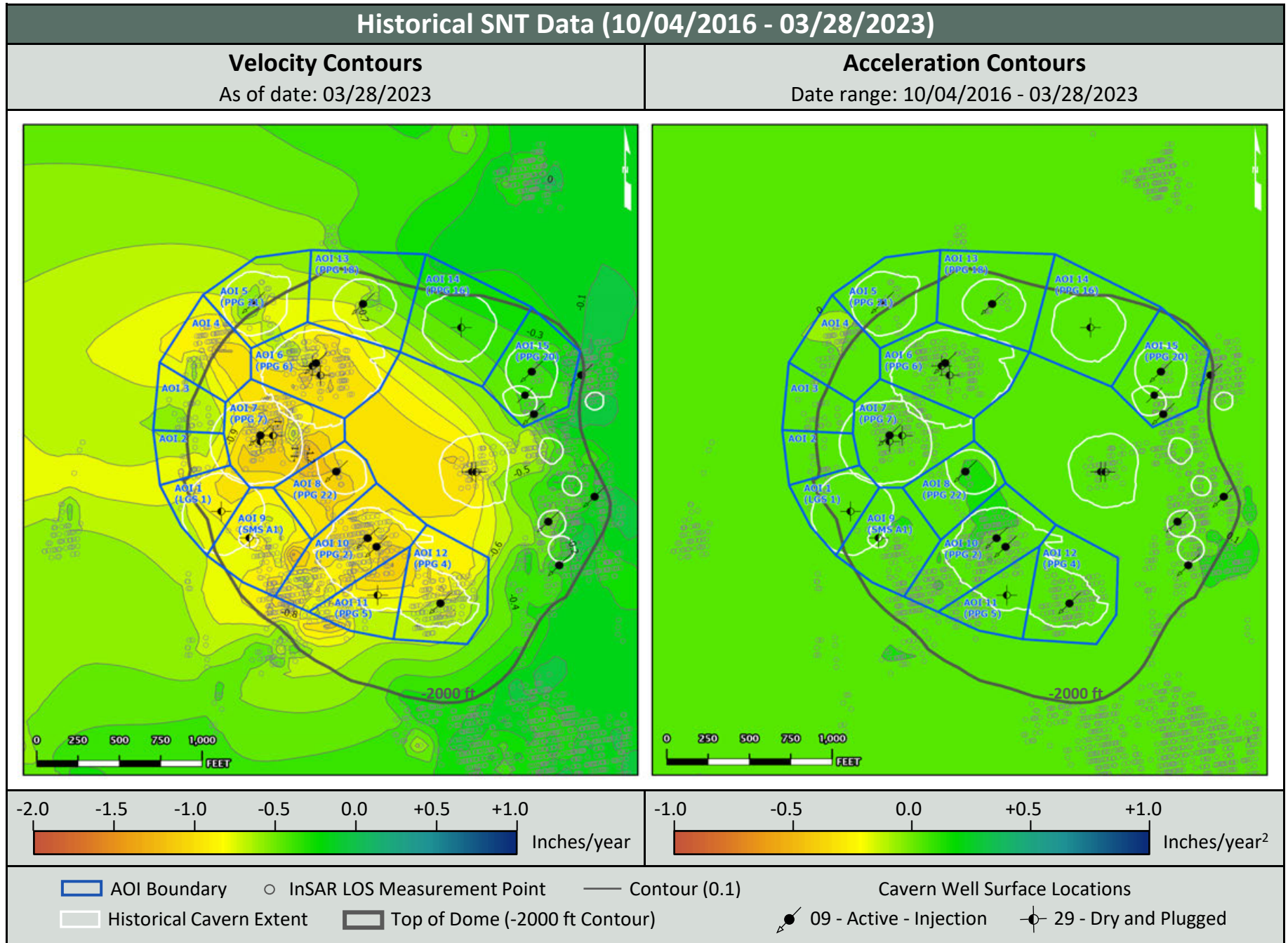


### AOI 15 (PPG 20) - Displacement Time Serie SNT (3/27/2025) Point Count: 70



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.30 in/yr	-0.30 in/yr	-0.00 in/yr
Acceleration:	+0.04 in/yr <sup>2</sup>	+0.04 in/yr <sup>2</sup>	-0.00 in/yr <sup>2</sup>





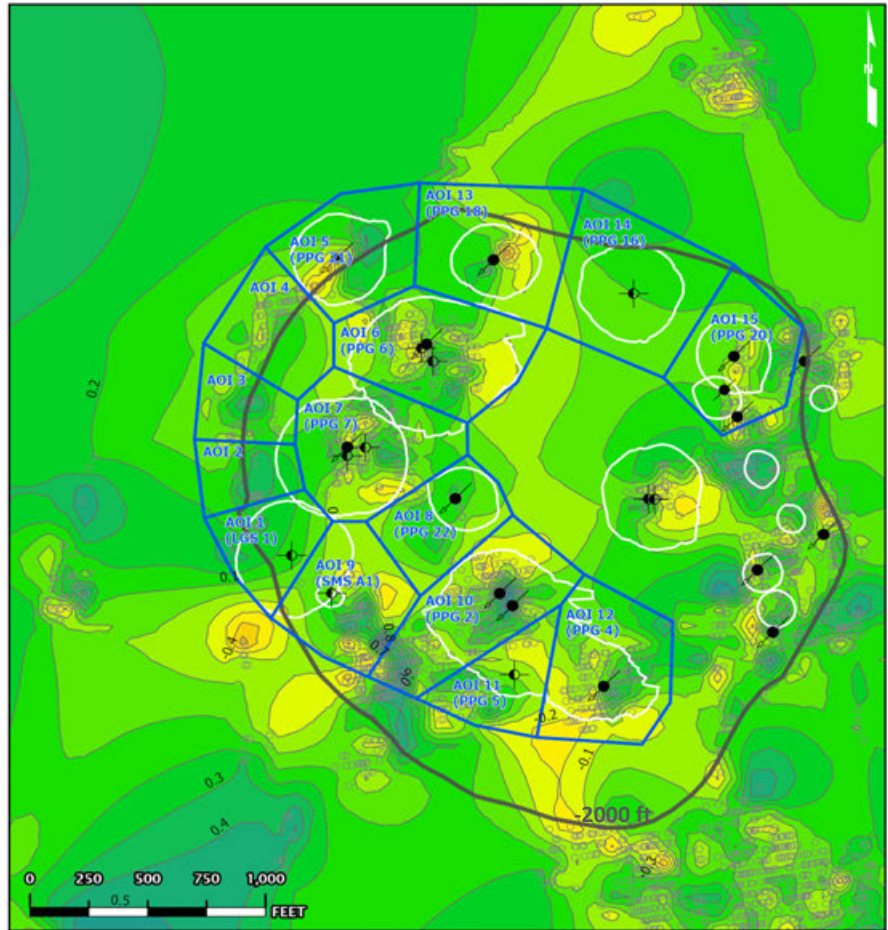
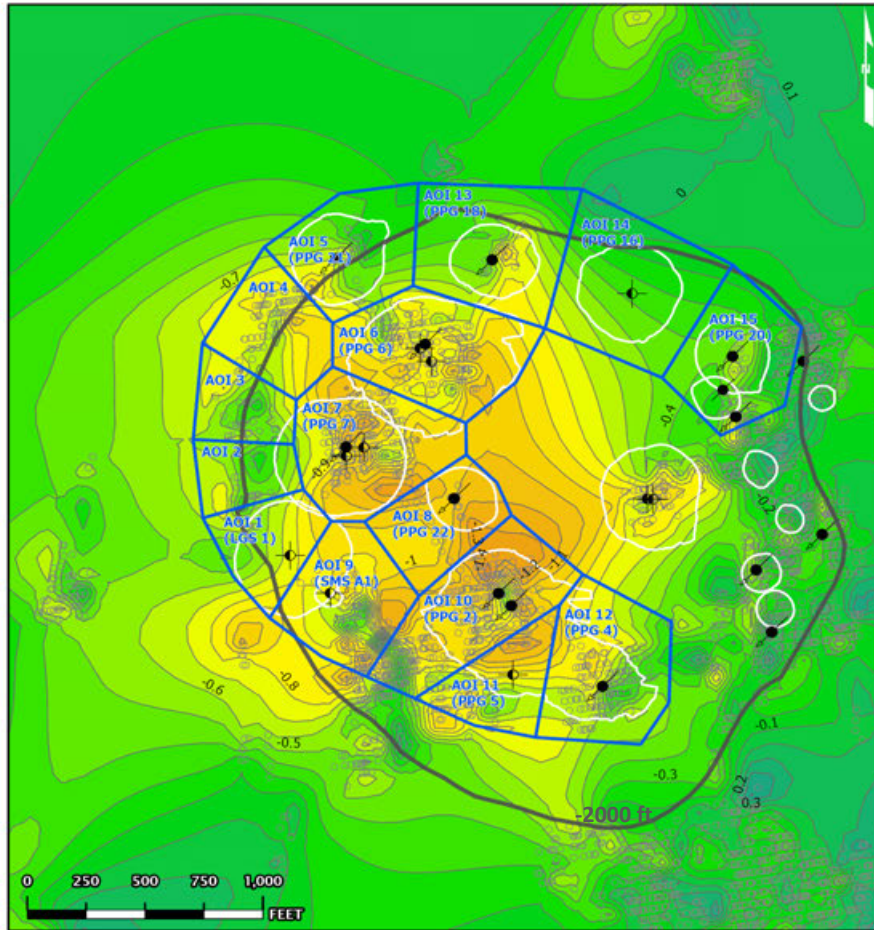
Recent SNT Data - 2 Years (03/28/2023 - 03/27/2025)

**Velocity Contours**

As of date: 03/27/2025

**Acceleration Contours**

Date range: 03/28/2023 - 03/27/2025

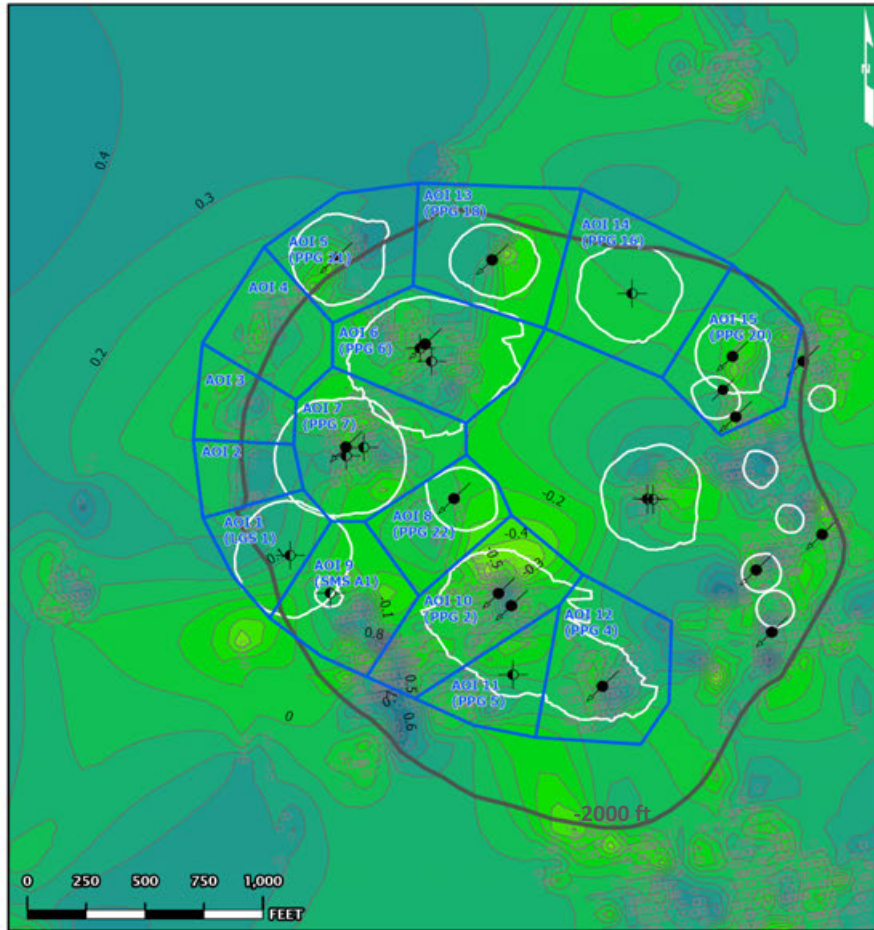


- AOI Boundary
- InSAR LOS Measurement Point
- Contour (0.1)
- Cavern Well Surface Locations
- Historical Cavern Extent
- Top of Dome (-2000 ft Contour)
- 09 - Active - Injection
- 29 - Dry and Plugged

### Change from Historical to Recent SNT Data

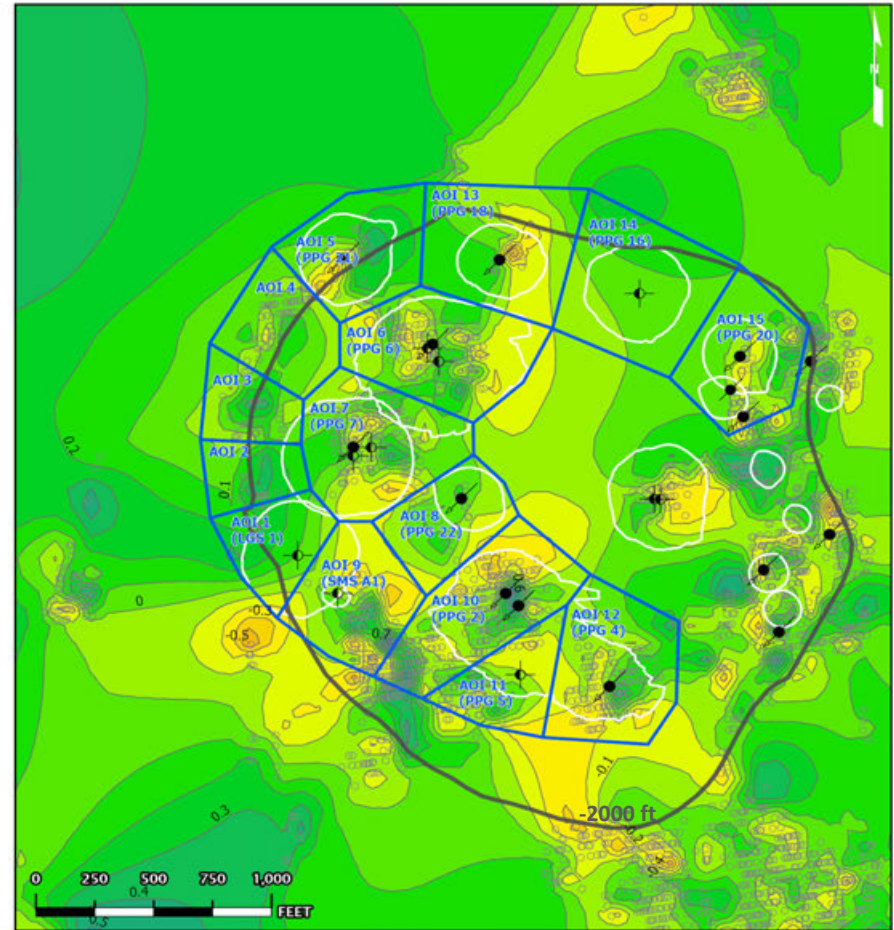
#### Velocity Contours

Historical Velocity subtracted from Recent Velocity



#### Acceleration Contours

Historical Acceleration subtracted from Recent Acceleration



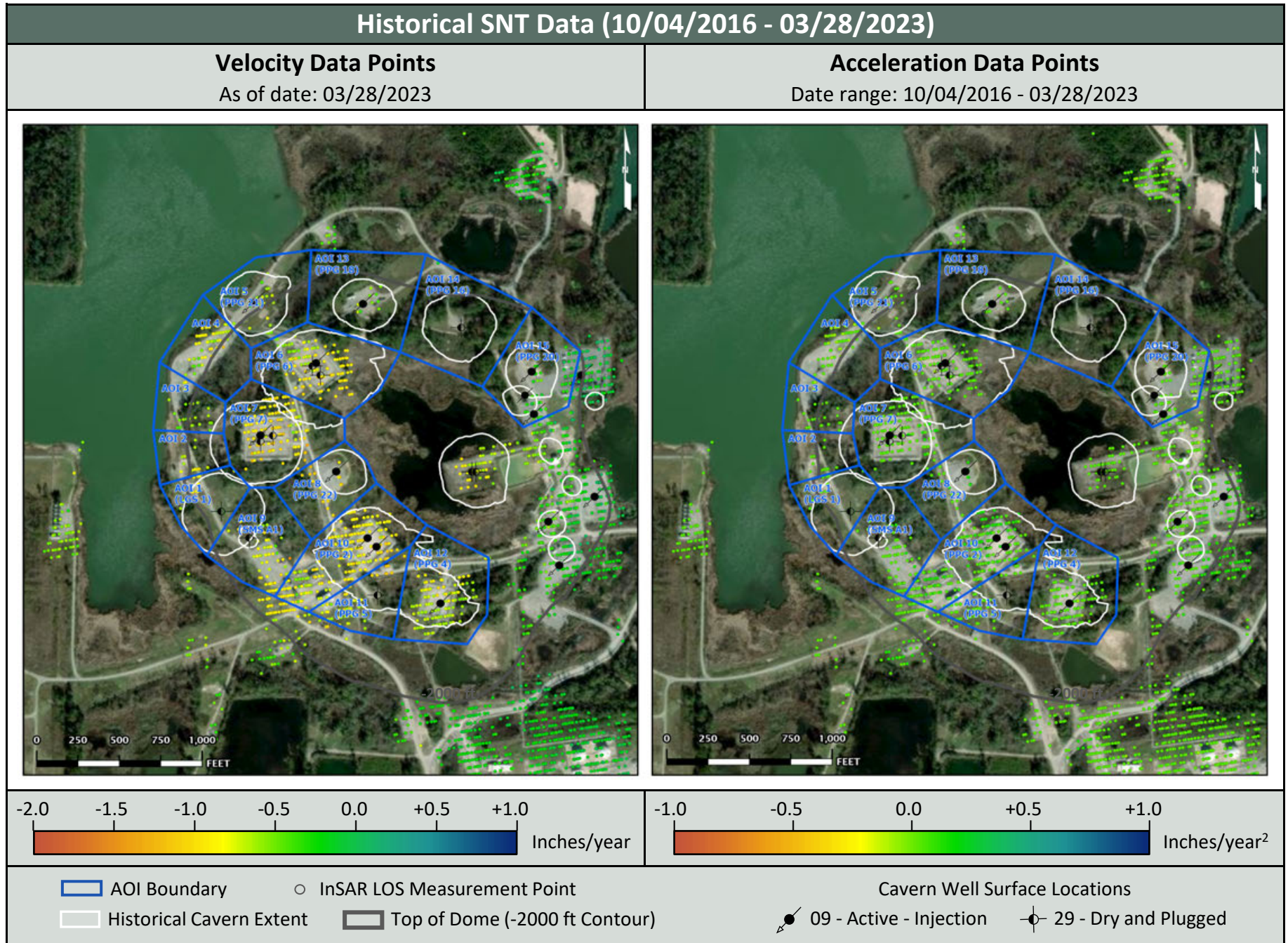
- AOI Boundary
 
 InSAR LOS Measurement Point
 

 Contour (0.1)
 

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


09
 - Active - Injection
 


29
 - Dry and Plugged



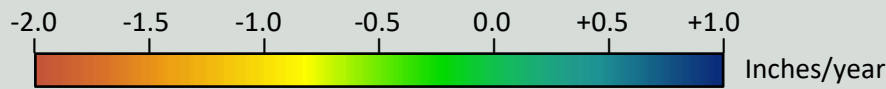
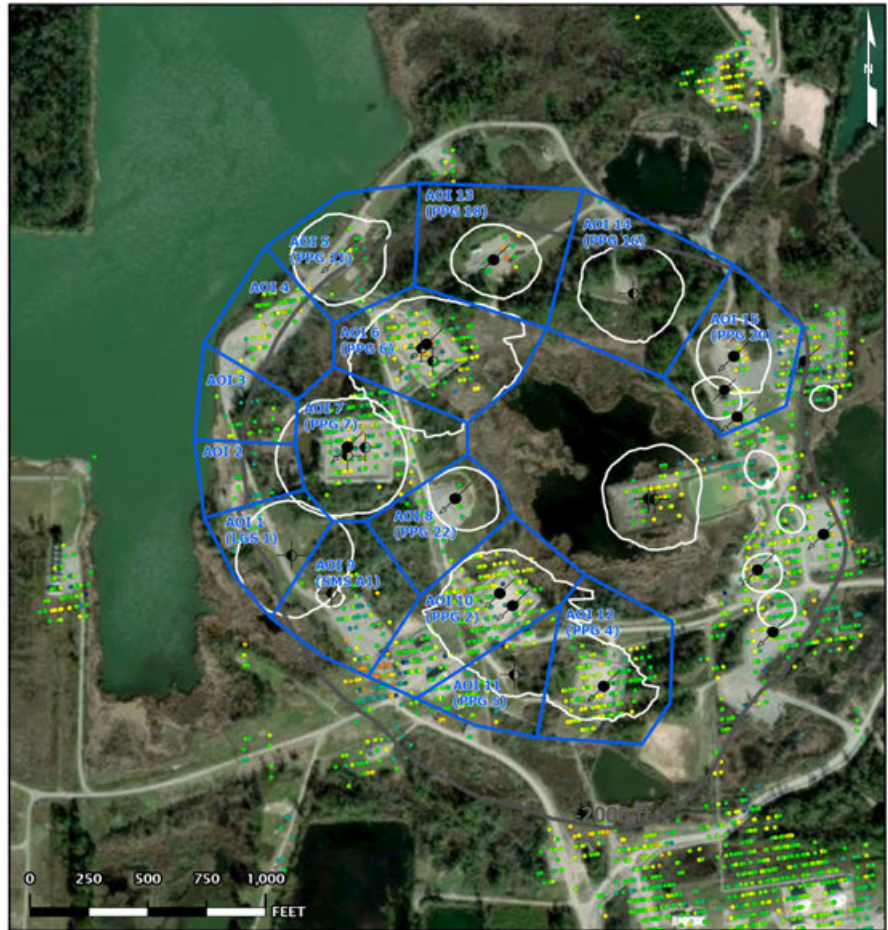
Recent SNT Data - 2 Years (03/28/2023 - 03/27/2025)

Velocity Data Points

As of date: 03/27/2025

Acceleration Data Points

Date range: 03/28/2023 - 03/27/2025



- ▭ 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

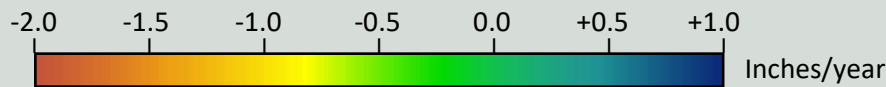
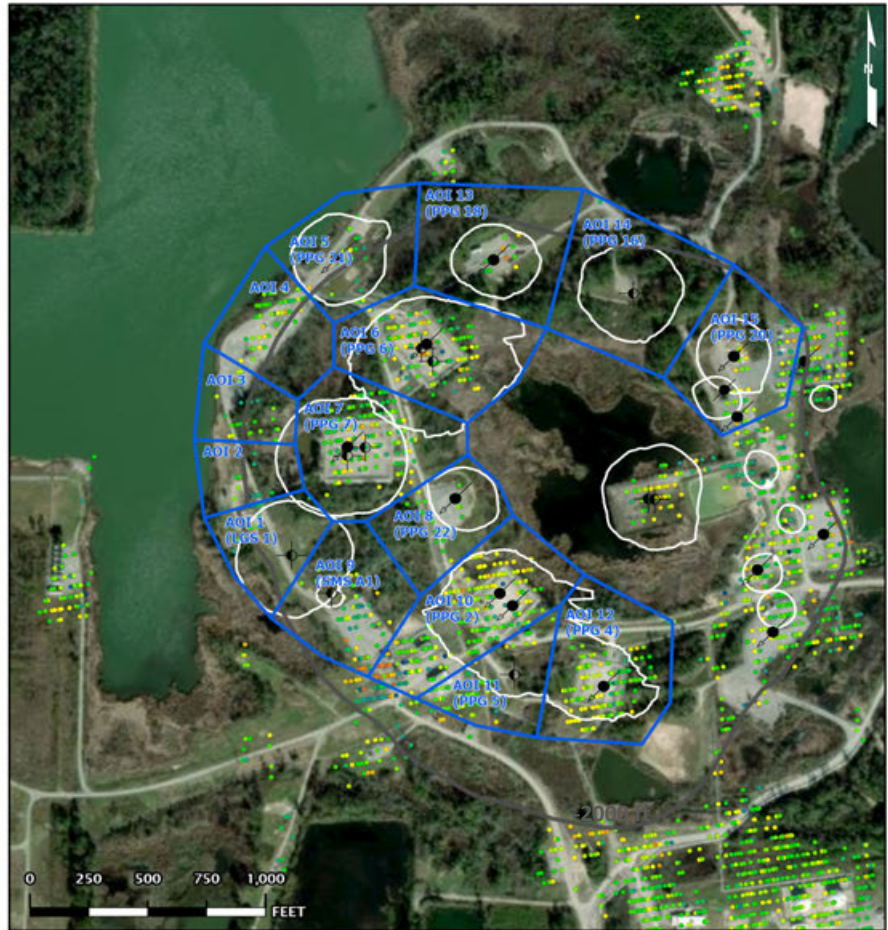
### Change from Historical to Recent SNT Data

#### Velocity Data Points

Historical Velocity subtracted from Recent Velocity

#### Acceleration Data Points

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 - March 30, 2025**



# 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 Field Service, LLC  
8591 United Plaza Blvd., Suite 280  
Baton Rouge, LA 70809

Dataset
Satellite Source
<b>TerraSAR-X - PAZ Constellation</b>
Most Recent Image Date
<b>Sunday, March 30, 2025</b>

Analysis Report Date:  
**April 4, 2025**

Dataset Information	
Satellite Source	TerraSAR-X - PAZ Constellation
Revisit Frequency	4 and 7 days
Most Recent Image Date	Sunday, March 30, 2025
Dataset Image Count	140
Dataset Time Range	January 24, 2023 - March 30, 2025
Dataset Length	2.18 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 time series charts show broadly consistent near-linear trends among the analysis AOIs. Acceleration values for the quadratic (non-linear) trend fit are positive in all AOIs (slowing negative displacement) but minor overall. A slight seasonal fluctuation is evident in some of the charts.

The contour maps show the greatest negative displacement centered around the eastern central portion of the dome where the combination of subsidence and western horizontal movement (toward the dome center) are expected to produce the greatest rate of movement away from the satellite's line of sight from the east.



Date Signed: April 4, 2025  
Austin, Texas

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

## InSAR Data Sources

### InSAR Data

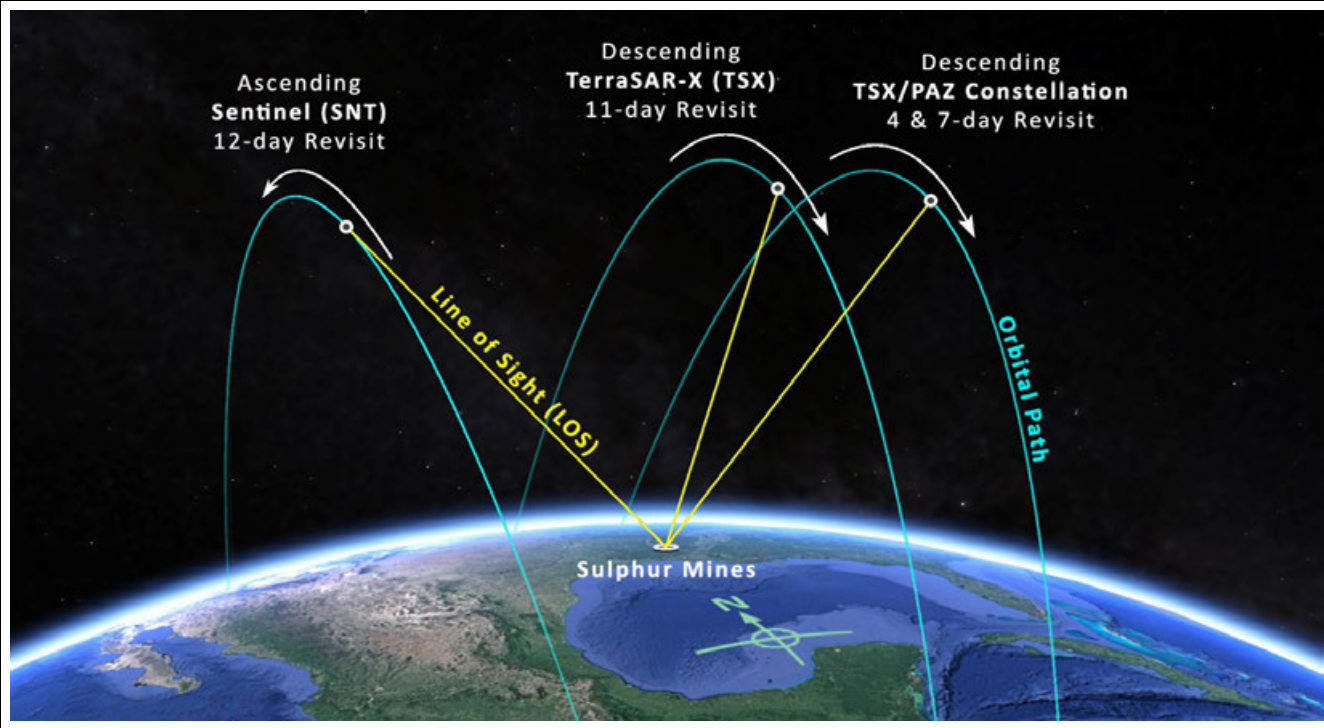
Interferometric Synthetic Aperture Radar (InSAR) is the most well established method to continually evaluate small, normally undetectable, ground movement over a large area. Radar imagery collected via satellites over successive orbital passes is used to identify and define measurement points on the 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) displacement 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.

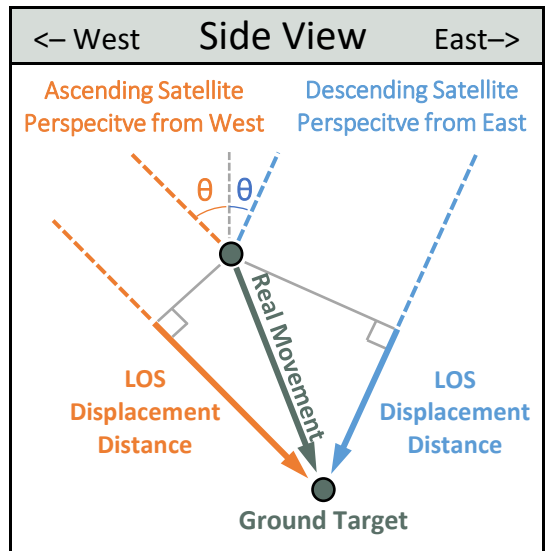
The first dataset comes from a low-resolution Sentinel-1 (SNT) satellite on an ascending orbit that captures data from the west of the site on a 12-day frequency. The second comes from a pair of high resolution satellites that share the same descending orbit and capture data from east of the site. These 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. 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



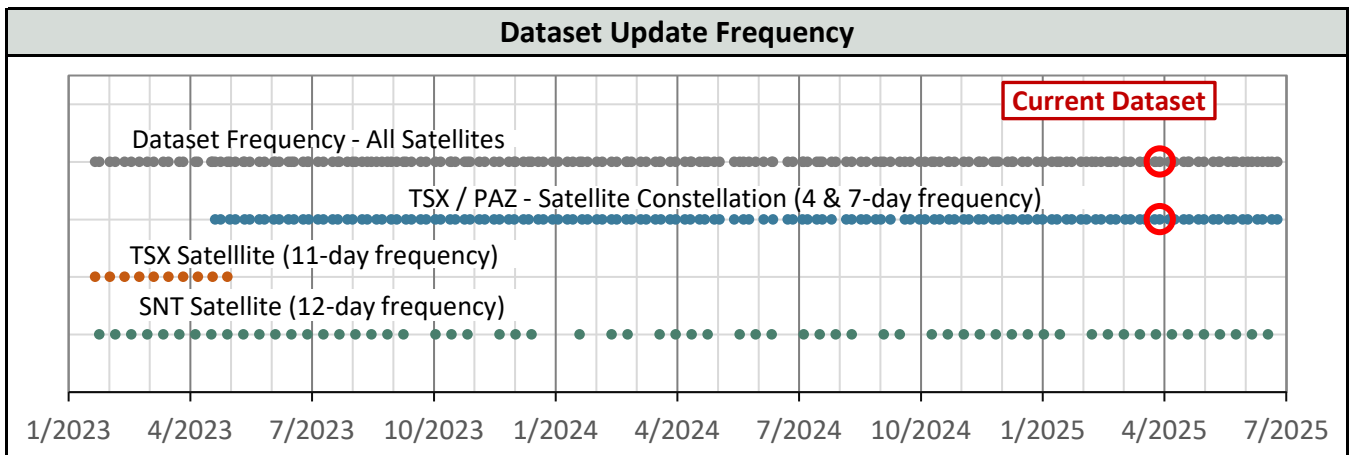
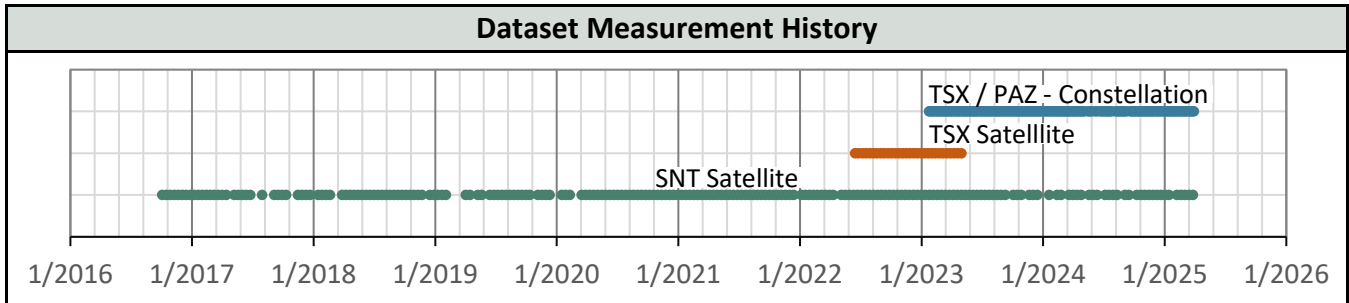
### InSAR Line-of-Site (LOS) Data

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 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.

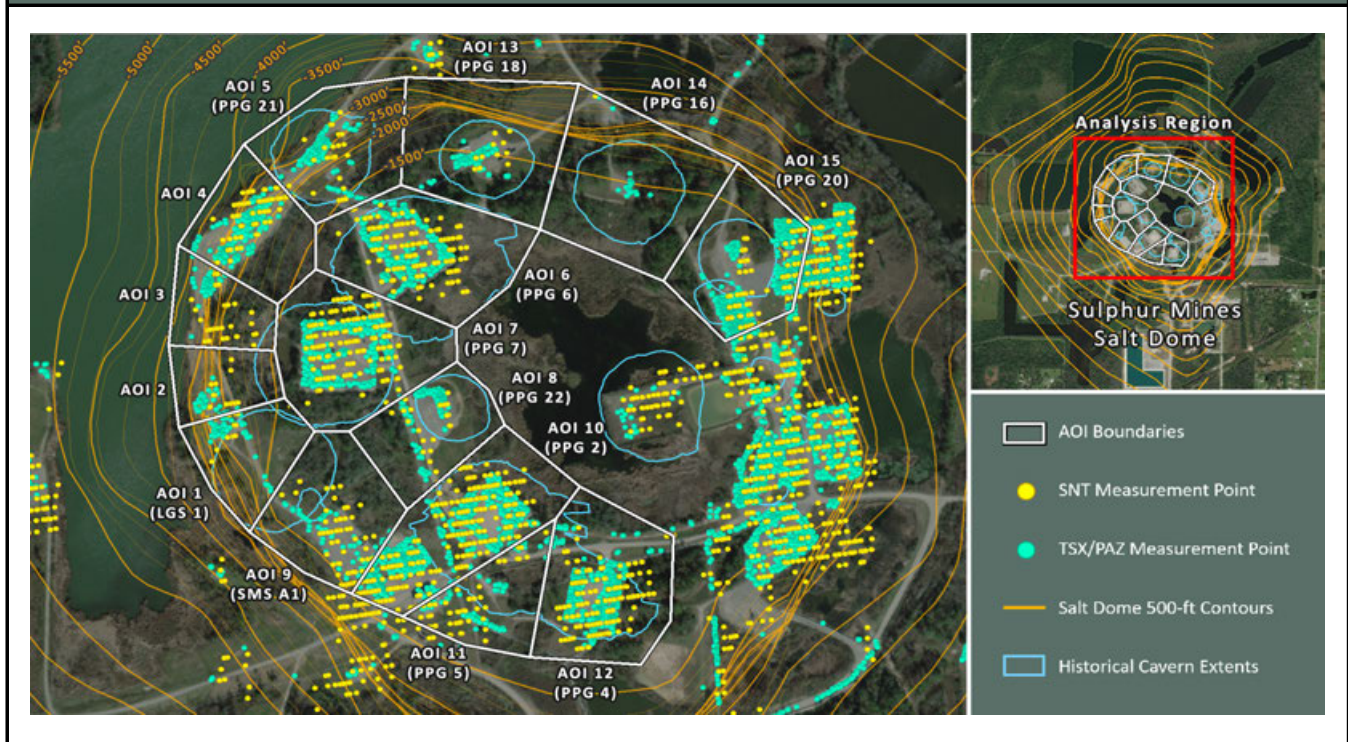


### Satellite Properties & Image Frequency

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, $\theta$ )	Ascending ( $43^\circ$ )	Descending ( $17^\circ$ )	Descending ( $37^\circ$ )
Data Start Date	10/4/2016	6/16/2022	1/24/2023
Measurement error range	$\pm 0.20$ in	$\pm 0.03$ in	$\pm 0.03$ in



## AOI Boundaries & InSAR Measurement Points

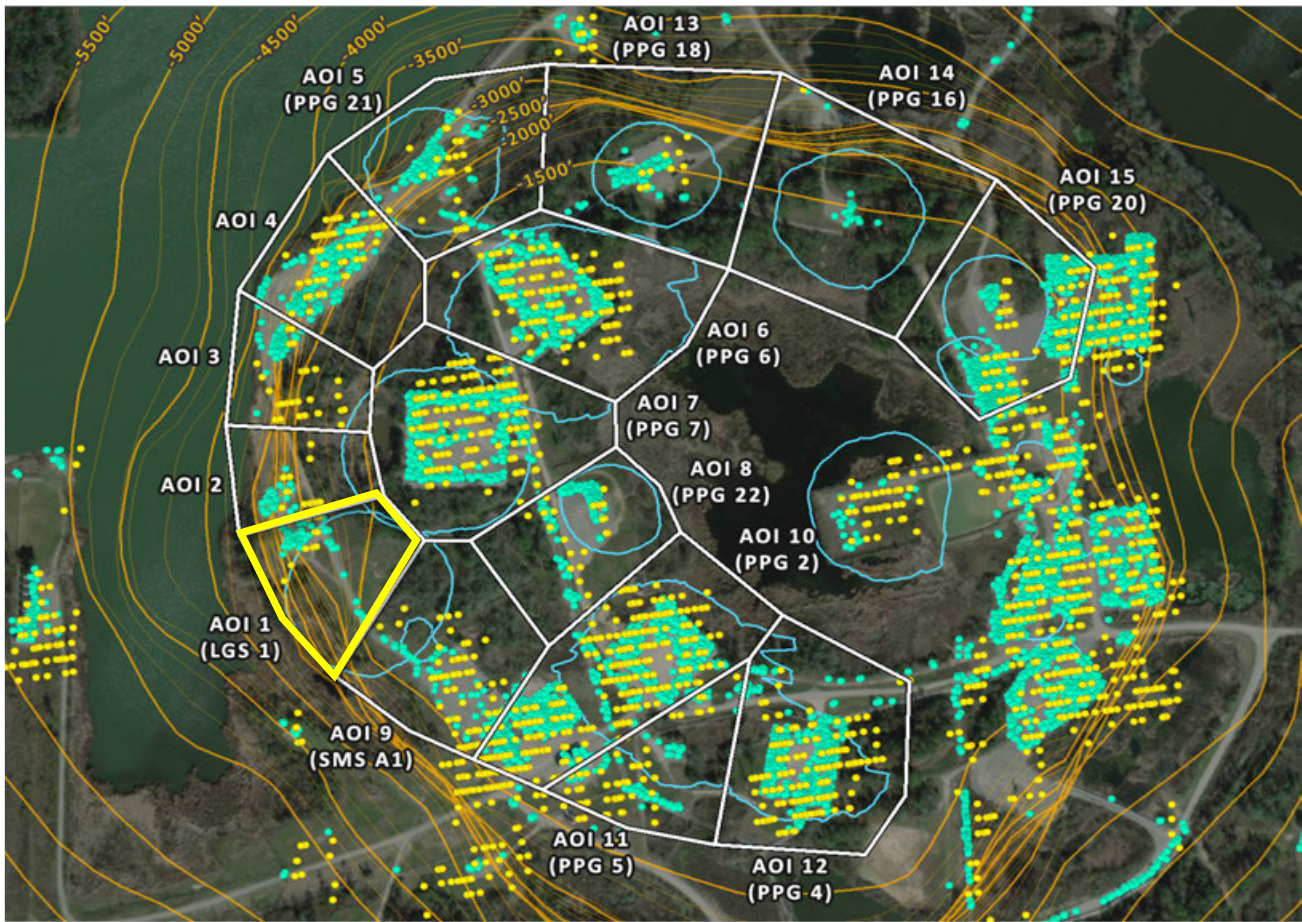


## Subsidence Monitoring Areas of Interest (AOIs)

To visually convey and evaluate trend consistency for the displacement time series of each ground target, measurement 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.

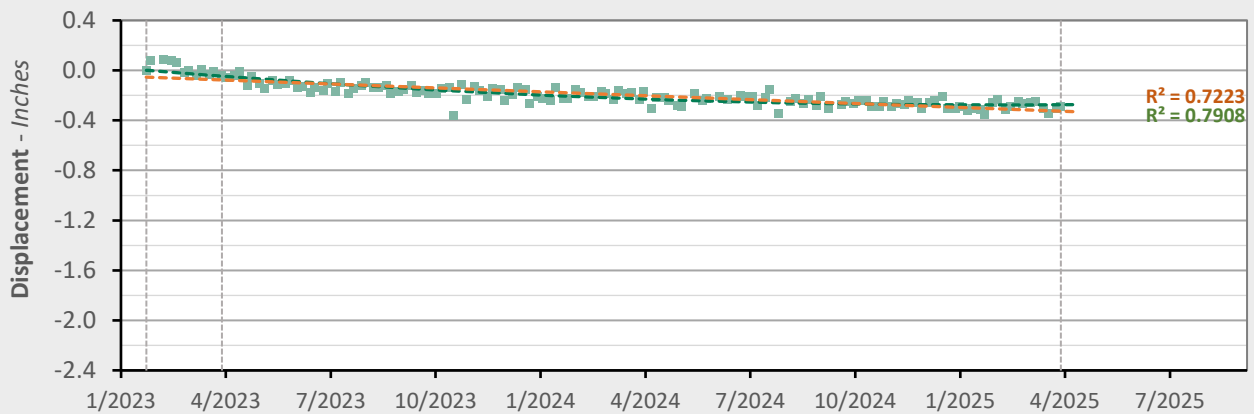
AOI Name	TSX/PAZ (3/30/2025)	LOS Velocity (in/yr)		LOS Acceleration (in/yr <sup>2</sup> )	
	Point Count	Nonlinear	Linear	Nonlinear	Linear
AOI 1 (LGS 1)	78	+0.02	-0.12	+0.14	0.00
AOI 2	43	-0.04	-0.18	+0.13	0.00
AOI 3	70	-0.22	-0.30	+0.08	0.00
AOI 4	225	-0.04	-0.13	+0.08	0.00
AOI 5 (PPG 21)	138	-0.11	-0.19	+0.08	0.00
AOI 6 (PPG 6)	356	-0.39	-0.46	+0.07	0.00
AOI 7 (PPG 7)	396	-0.27	-0.35	+0.08	0.00
AOI 8 (PPG 22)	127	-0.51	-0.66	+0.14	0.00
AOI 9 (SMS A1)	69	-0.02	-0.26	+0.22	0.00
AOI 10 (PPG 2)	809	-0.44	-0.54	+0.10	0.00
AOI 11 (PPG 5)	127	-0.37	-0.52	+0.13	0.00
AOI 12 (PPG 4)	553	-0.72	-0.80	+0.07	0.00
AOI 13 (PPG 18)	108	-0.22	-0.40	+0.16	0.00
AOI 14 (PPG 16)	22	-0.47	-0.80	+0.30	0.00
AOI 15 (PPG 20)	742	-0.84	-0.92	+0.07	0.00

### AOI 1 (LGS 1) - Location Map



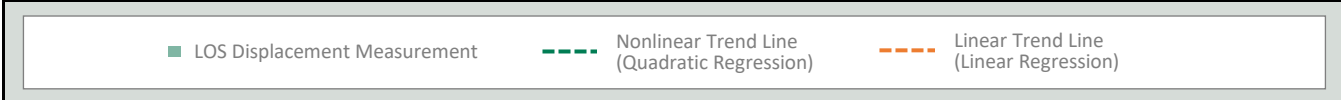
### AOI 1 (LGS 1) - Displacement Time Series

TSX/PAZ (3/30/2025) Point Count: 78

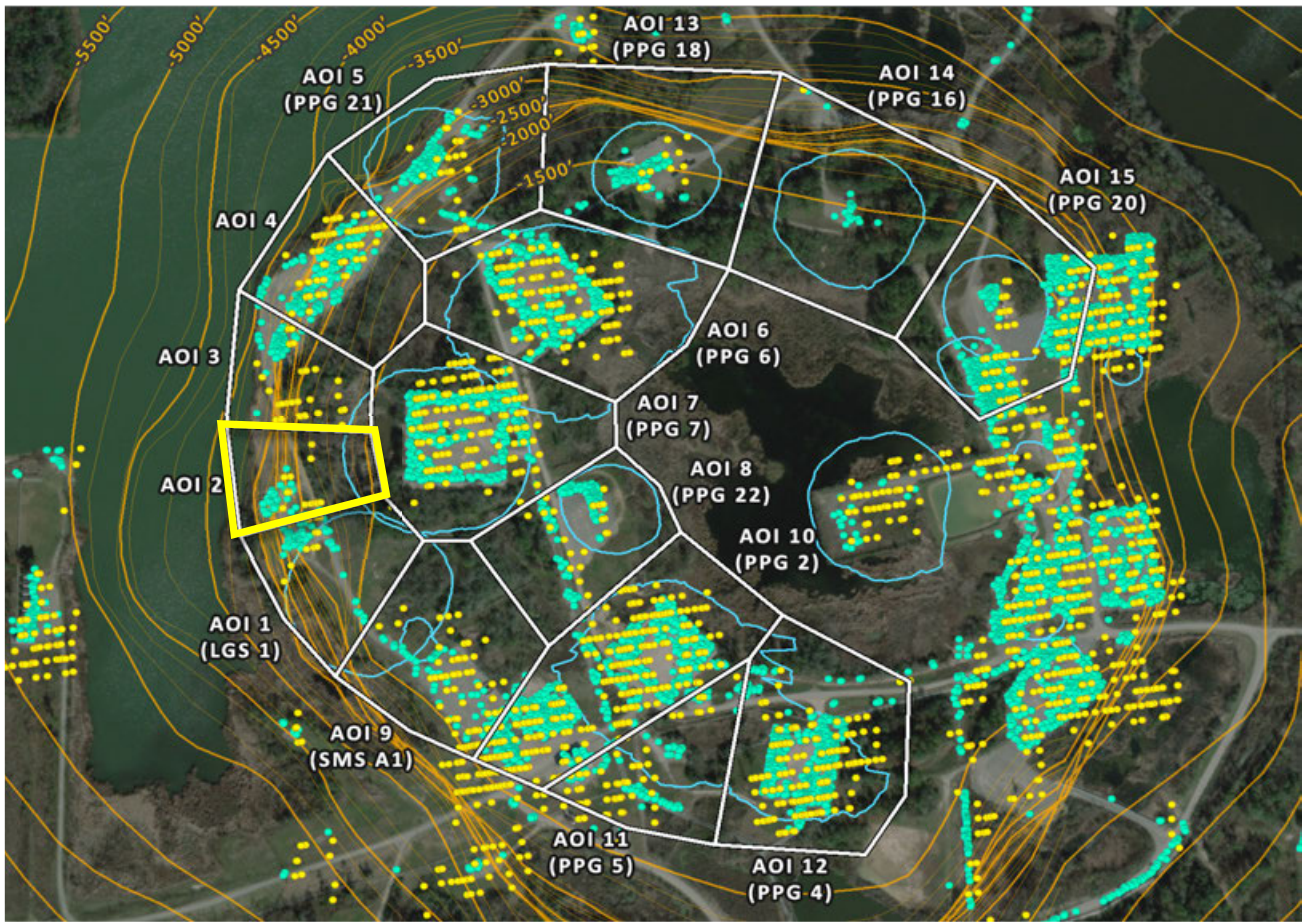


$R^2 = 0.7223$   
 $R^2 = 0.7908$

	Nonlinear Trend	Linear Trend
Velocity:	+0.02 in/yr	-0.12 in/yr
Acceleration:	+0.14 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

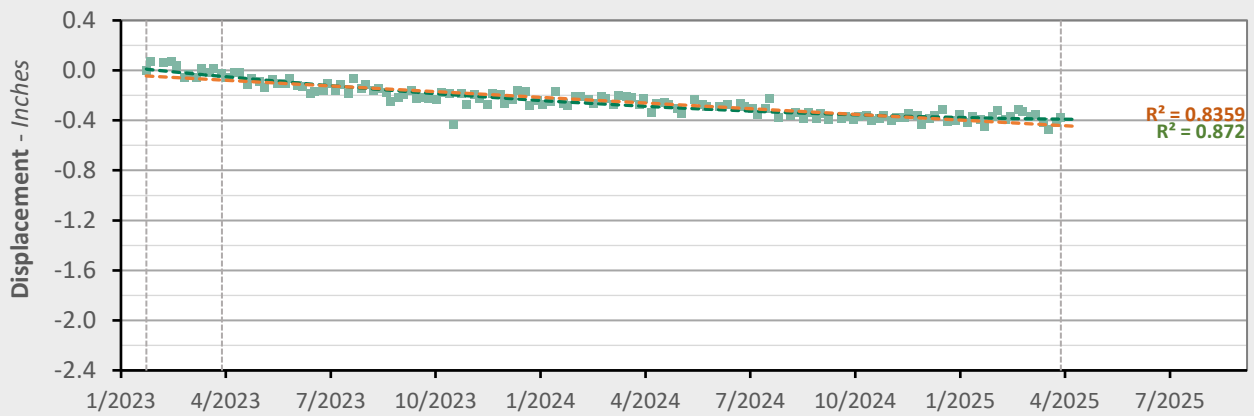


### AOI 2 - Location Map

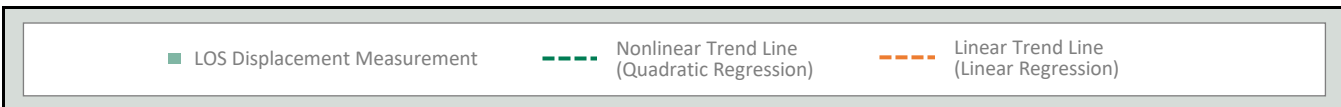


### AOI 2 - Displacement Time Series

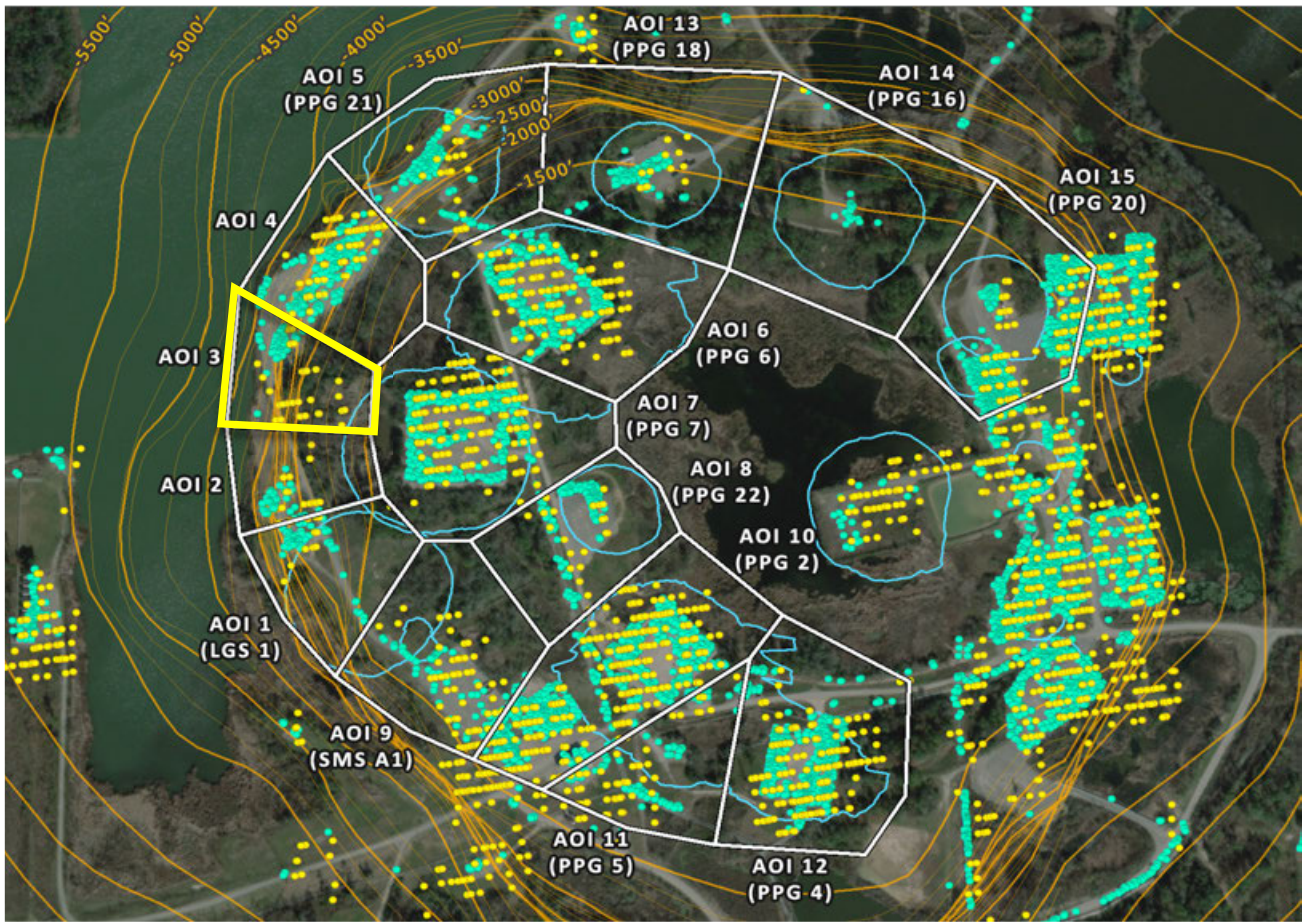
TSX/PAZ (3/30/2025) Point Count: **43**



	Nonlinear Trend	Linear Trend
Velocity:	-0.04 in/yr	-0.18 in/yr
Acceleration:	+0.13 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

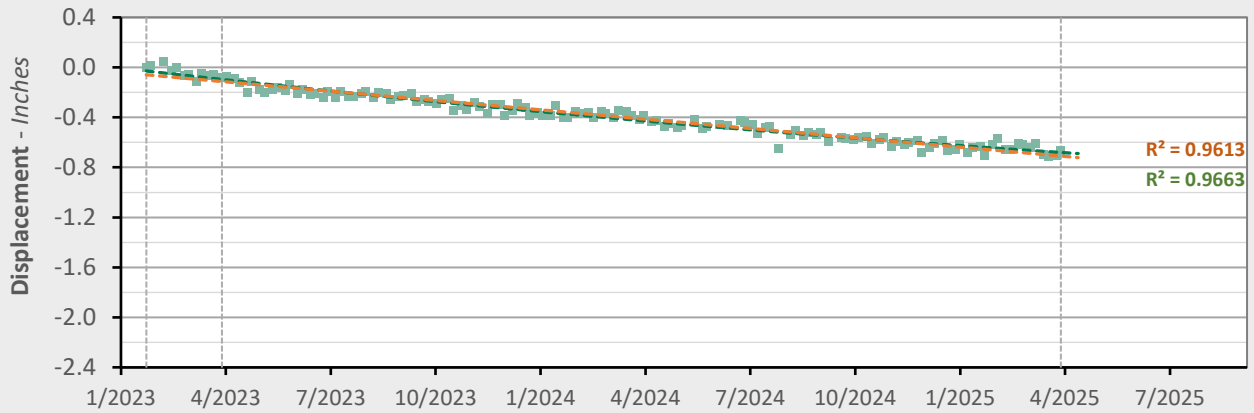


### AOI 3 - Location Map



### AOI 3 - Displacement Time Series

TSX/PAZ (3/30/2025) Point Count: 70



$R^2 = 0.9613$

$R^2 = 0.9663$

Nonlinear Trend

Linear Trend

Velocity: -0.22 in/yr

-0.30 in/yr

Acceleration: +0.08 in/yr<sup>2</sup>

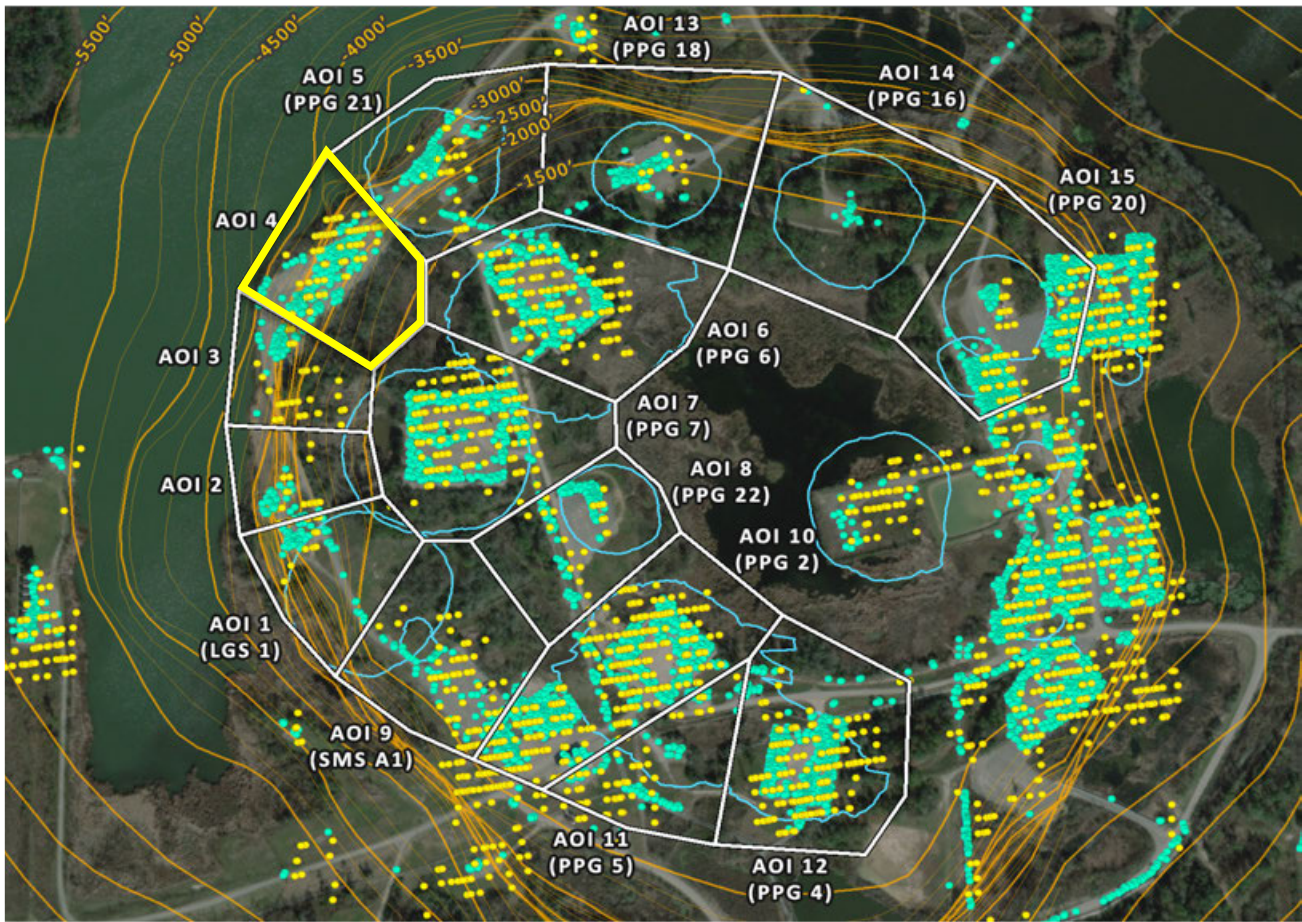
0.00 in/yr<sup>2</sup>

■ LOS Displacement Measurement

--- Nonlinear Trend Line (Quadratic Regression)

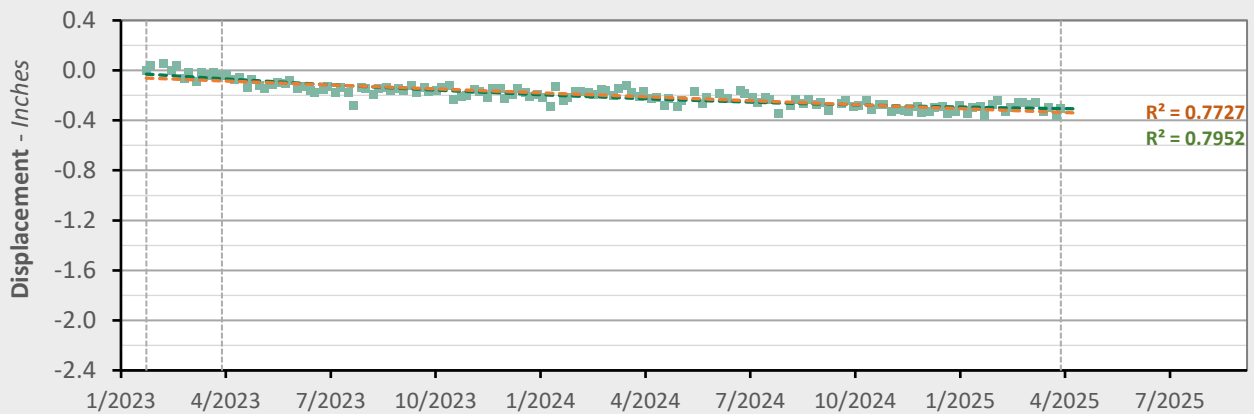
--- Linear Trend Line (Linear Regression)

### AOI 4 - Location Map

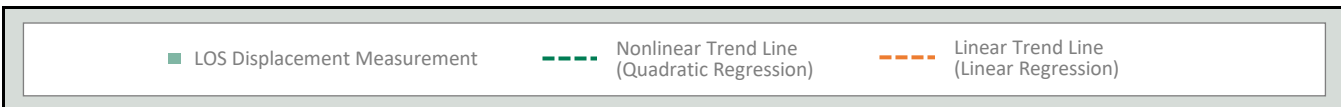


### AOI 4 - Displacement Time Series

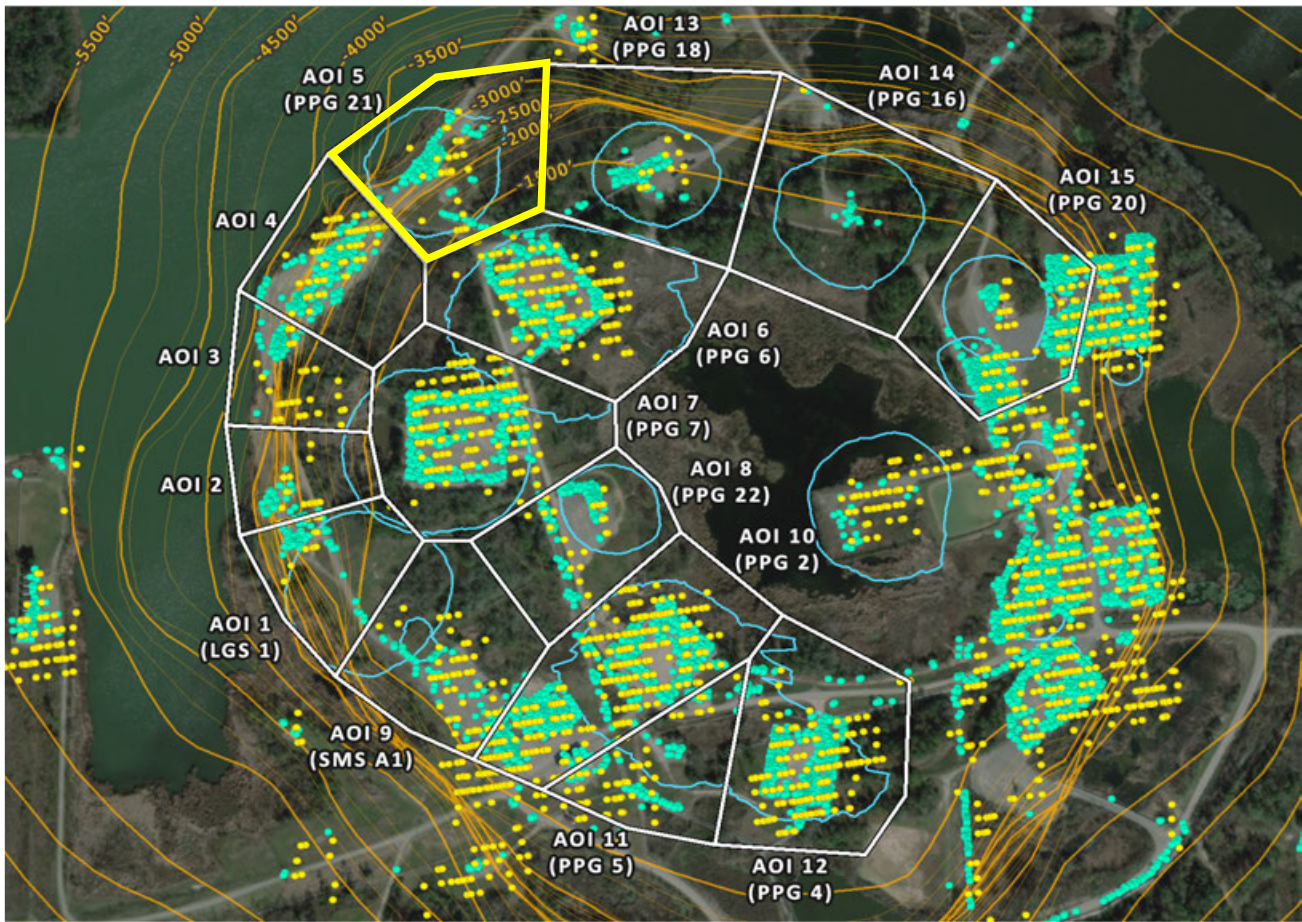
TSX/PAZ (3/30/2025) Point Count: 225



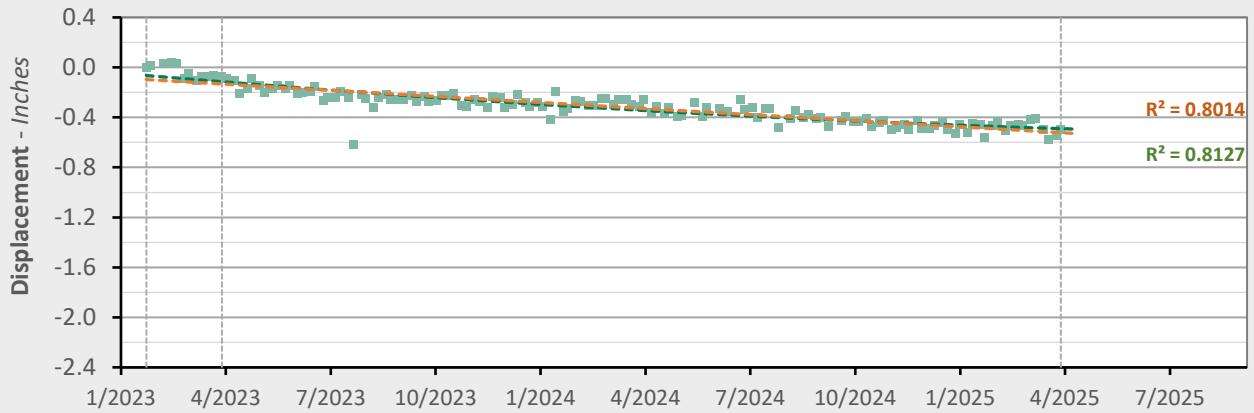
	Nonlinear Trend	Linear Trend
Velocity:	-0.04 in/yr	-0.13 in/yr
Acceleration:	+0.08 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



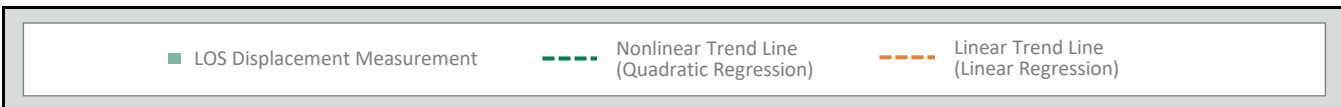
### AOI 5 (PPG 21) - Location Map



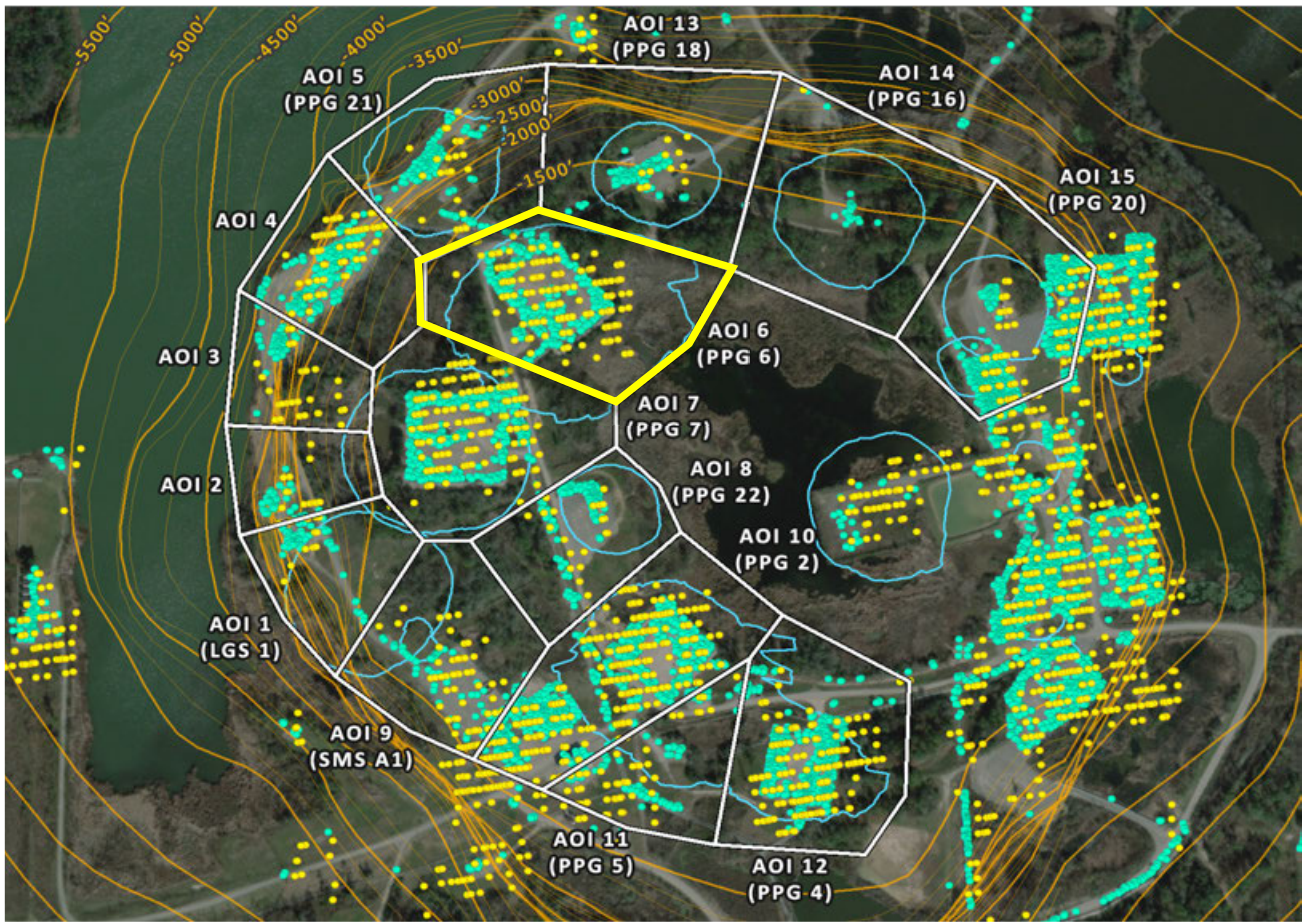
### AOI 5 (PPG 21) - Displacement Time Series TSX/PAZ (3/30/2025) Point Count: 138



	Nonlinear Trend	Linear Trend
Velocity:	-0.11 in/yr	-0.19 in/yr
Acceleration:	+0.08 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

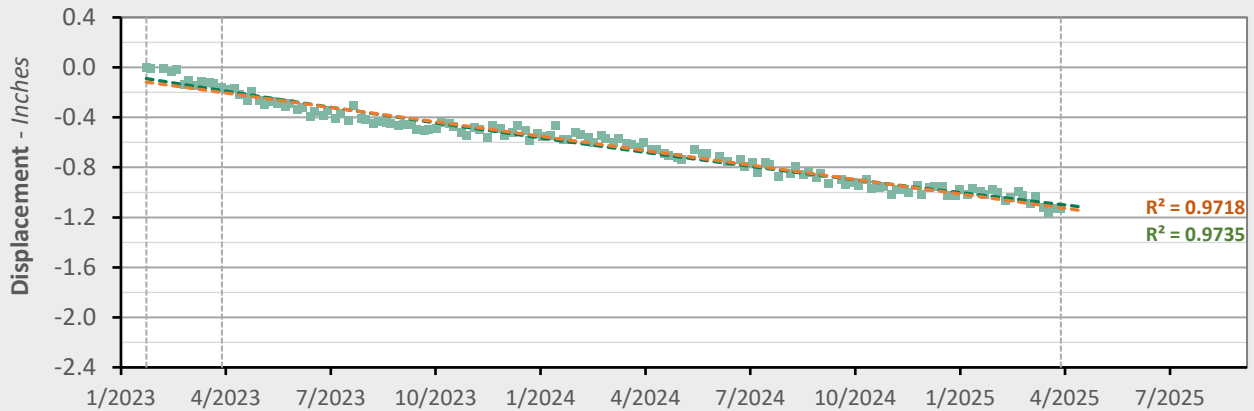


### AOI 6 (PPG 6) - Location Map

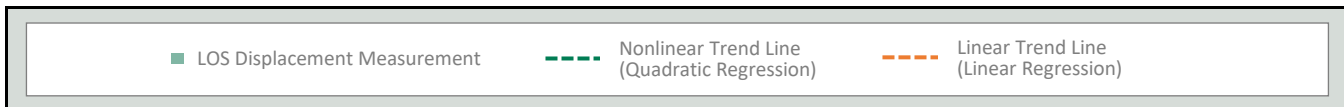


### AOI 6 (PPG 6) - Displacement Time Series

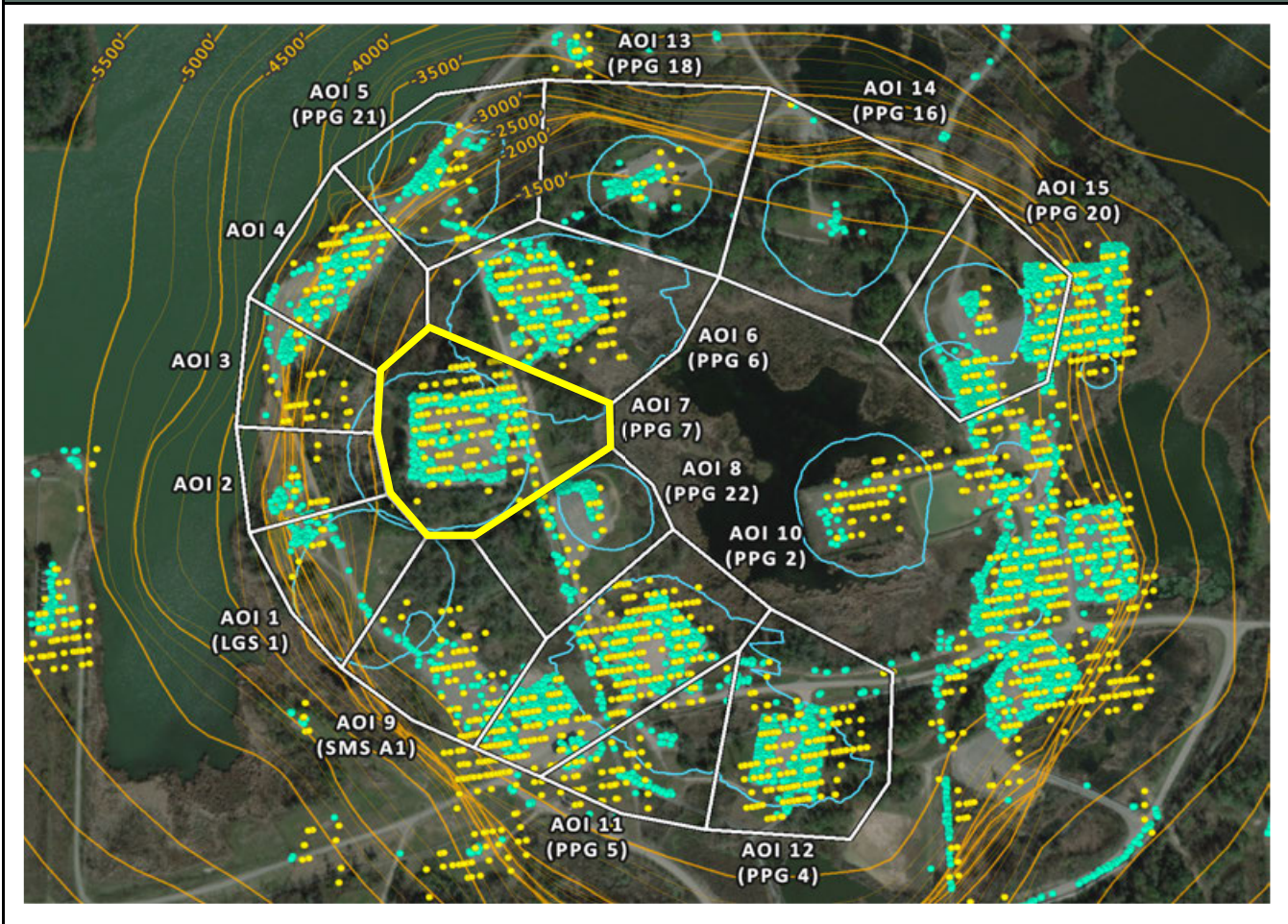
TSX/PAZ (3/30/2025) Point Count: 356



	Nonlinear Trend	Linear Trend
Velocity:	-0.39 in/yr	-0.46 in/yr
Acceleration:	+0.07 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

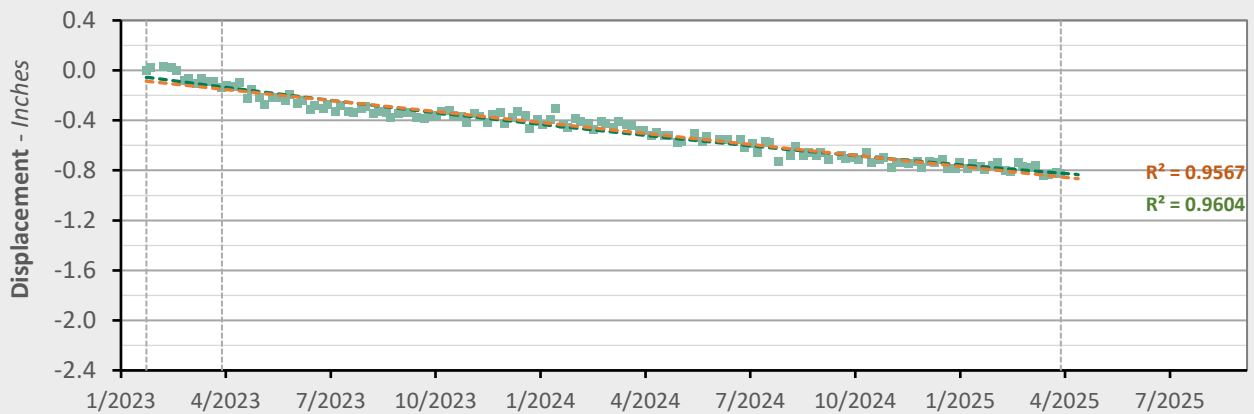


### AOI 7 (PPG 7) - Location Map

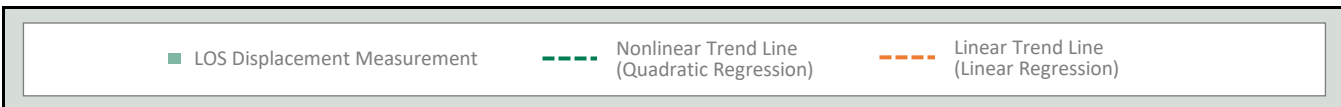


### AOI 7 (PPG 7) - Displacement Time Series

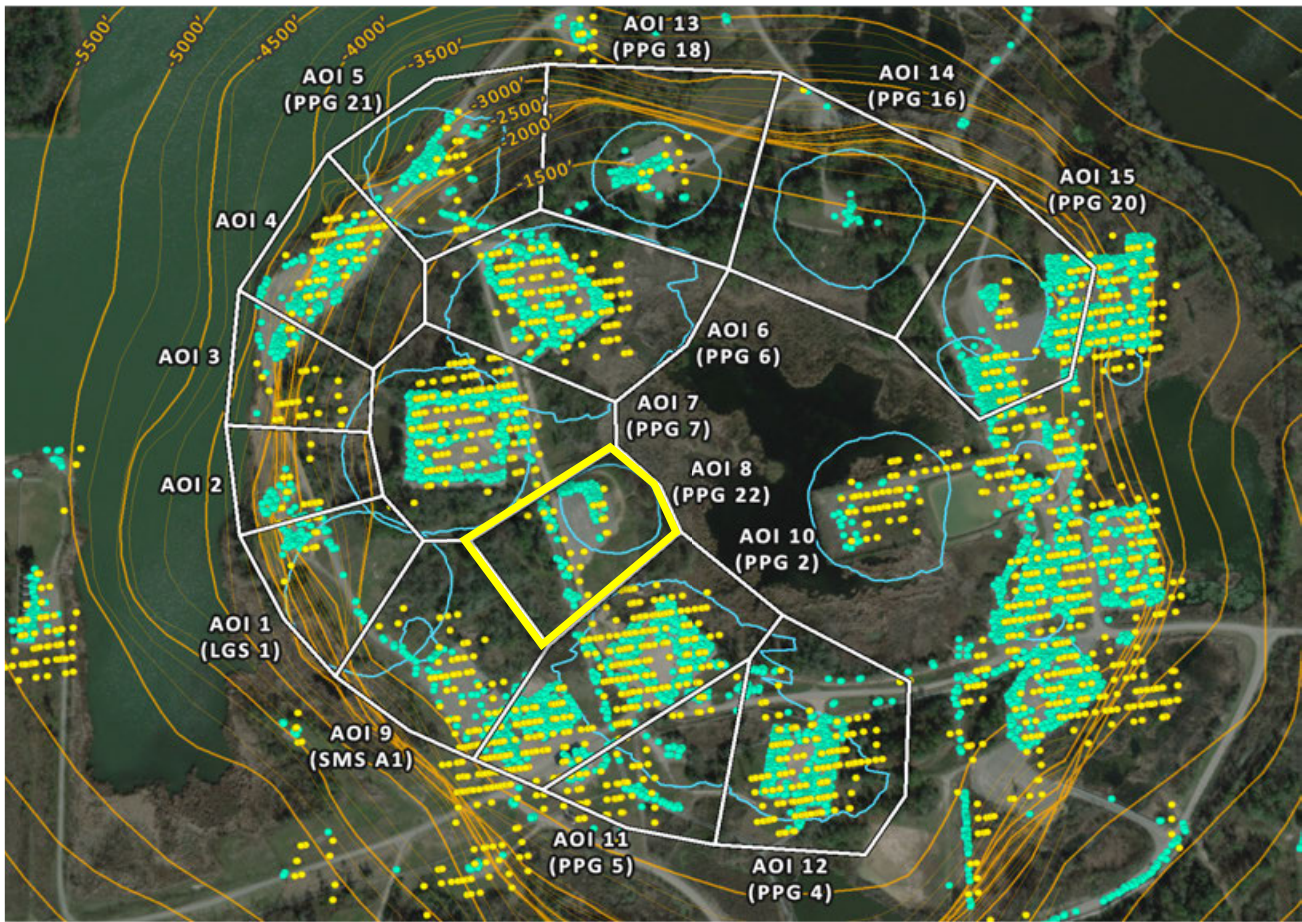
TSX/PAZ (3/30/2025) Point Count: 396



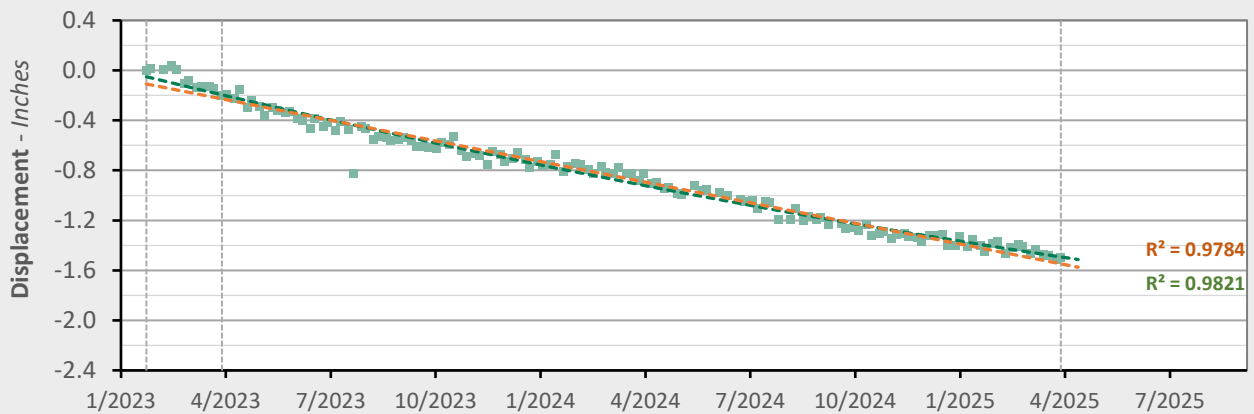
	Nonlinear Trend	Linear Trend
Velocity:	-0.27 in/yr	-0.35 in/yr
Acceleration:	+0.08 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



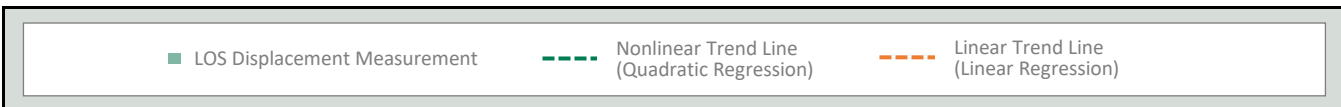
### AOI 8 (PPG 22) - Location Map



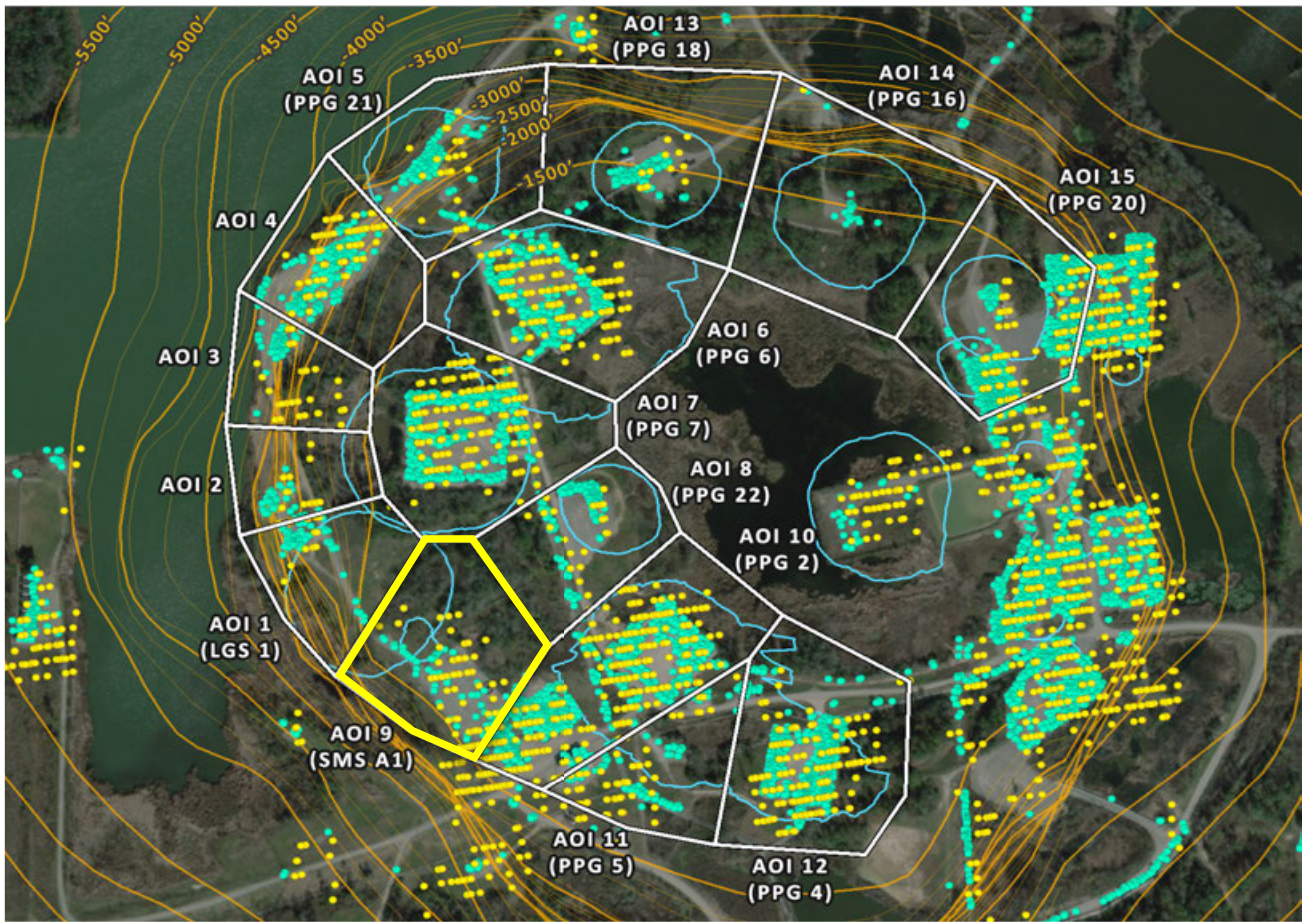
### AOI 8 (PPG 22) - Displacement Time Series TSX/PAZ (3/30/2025) Point Count: 127



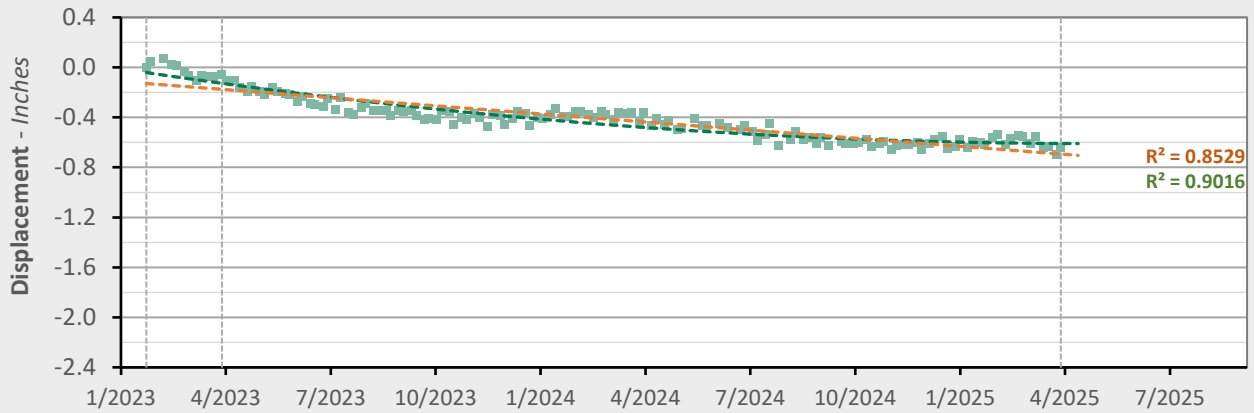
	Nonlinear Trend	Linear Trend
Velocity:	-0.51 in/yr	-0.66 in/yr
Acceleration:	+0.14 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



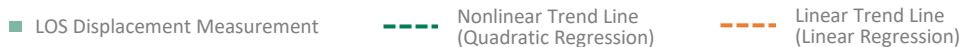
### AOI 9 (PPG A1) - Location Map



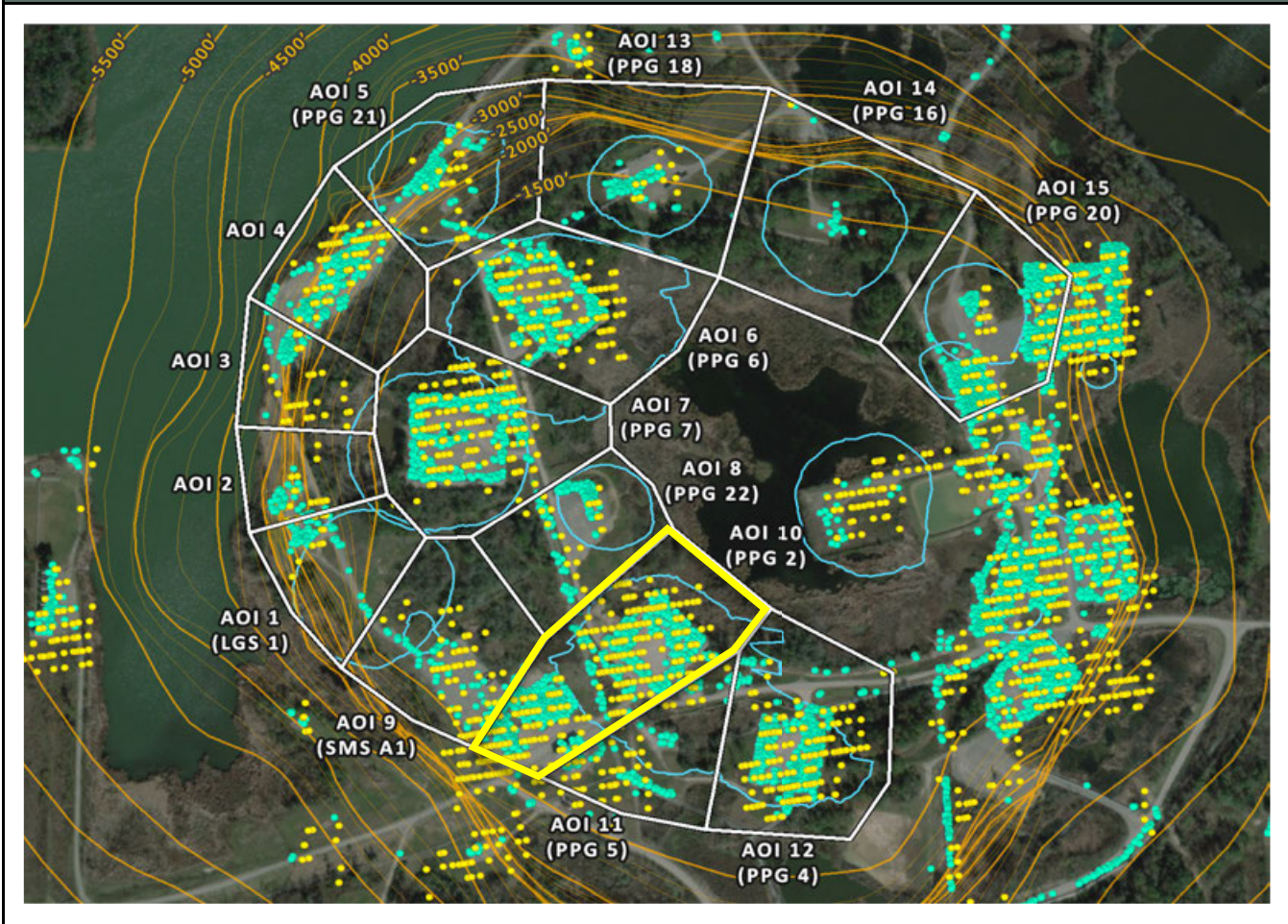
### AOI 9 (SMS A1) - Displacement Time Series TSX/PAZ (3/30/2025) Point Count: 69



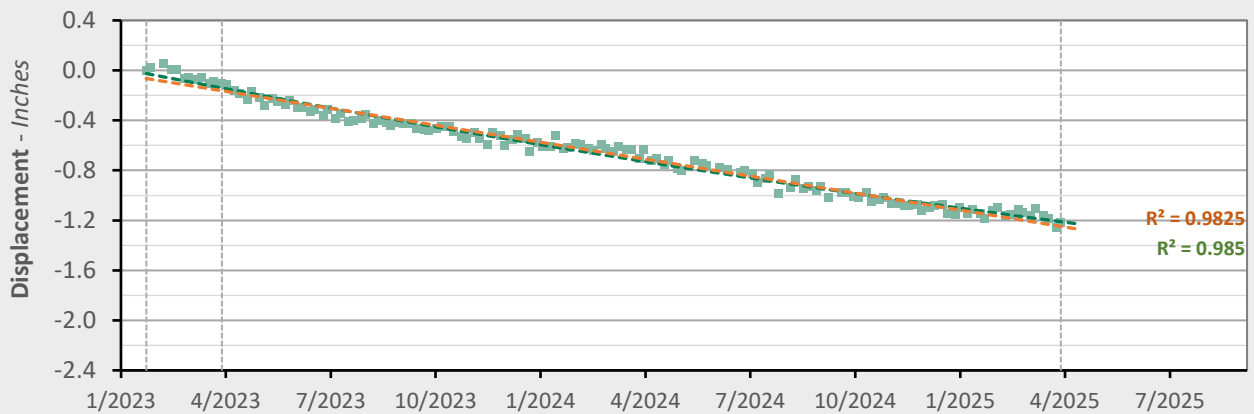
	Nonlinear Trend	Linear Trend
Velocity:	-0.02 in/yr	-0.26 in/yr
Acceleration:	+0.22 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



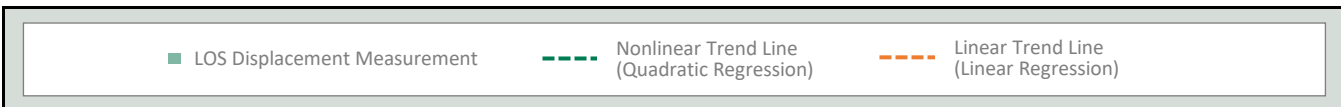
### AOI 10 (PPG 2) - Location Map



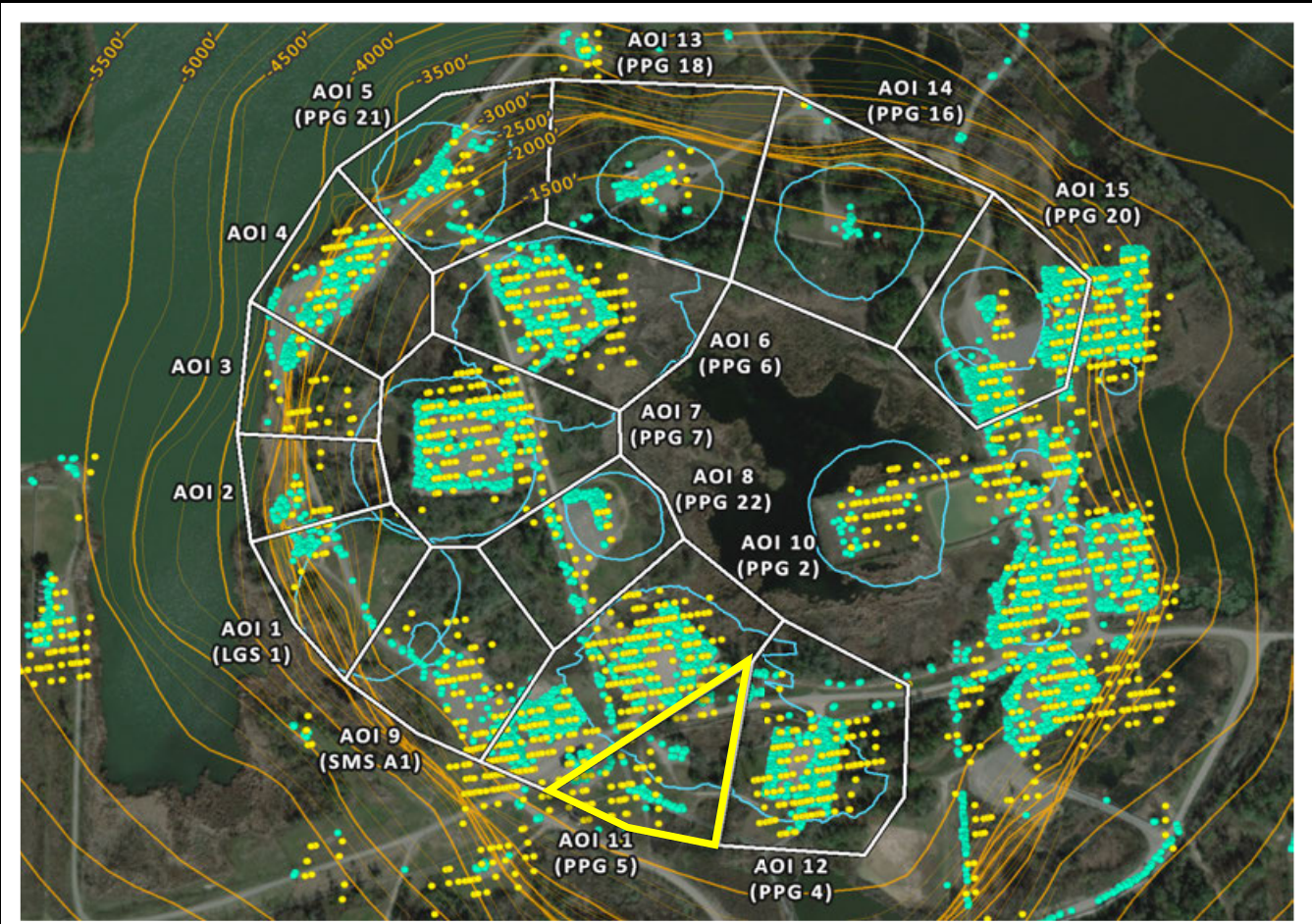
### AOI 10 (PPG 2) - Displacement Time Series TSX/PAZ (3/30/2025) Point Count: 809



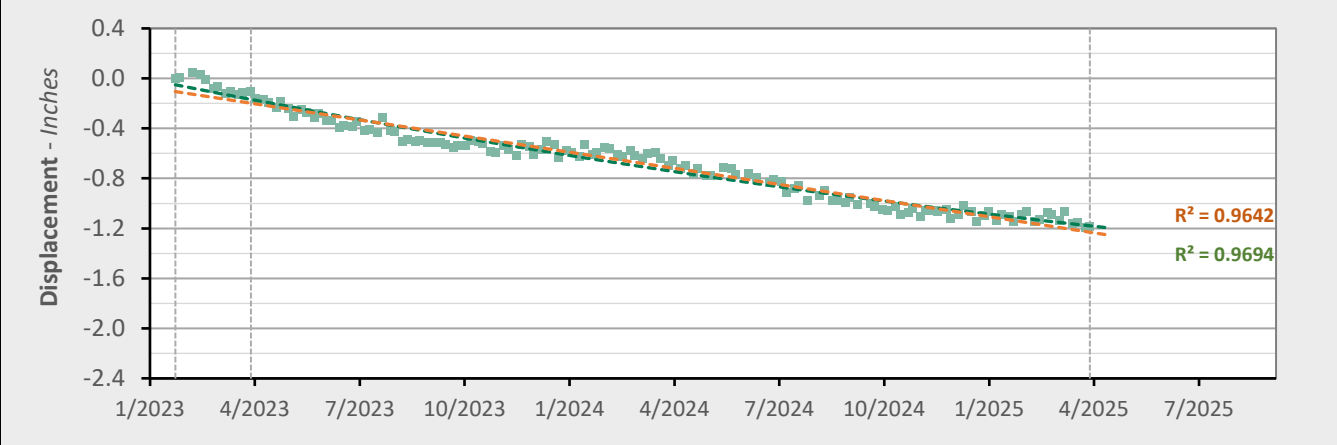
	Nonlinear Trend	Linear Trend
Velocity:	-0.44 in/yr	-0.54 in/yr
Acceleration:	+0.10 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



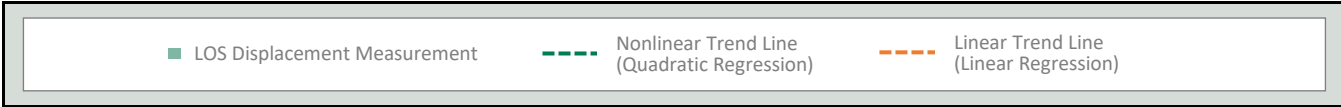
### AOI 11 (PPG 5) - Location Map



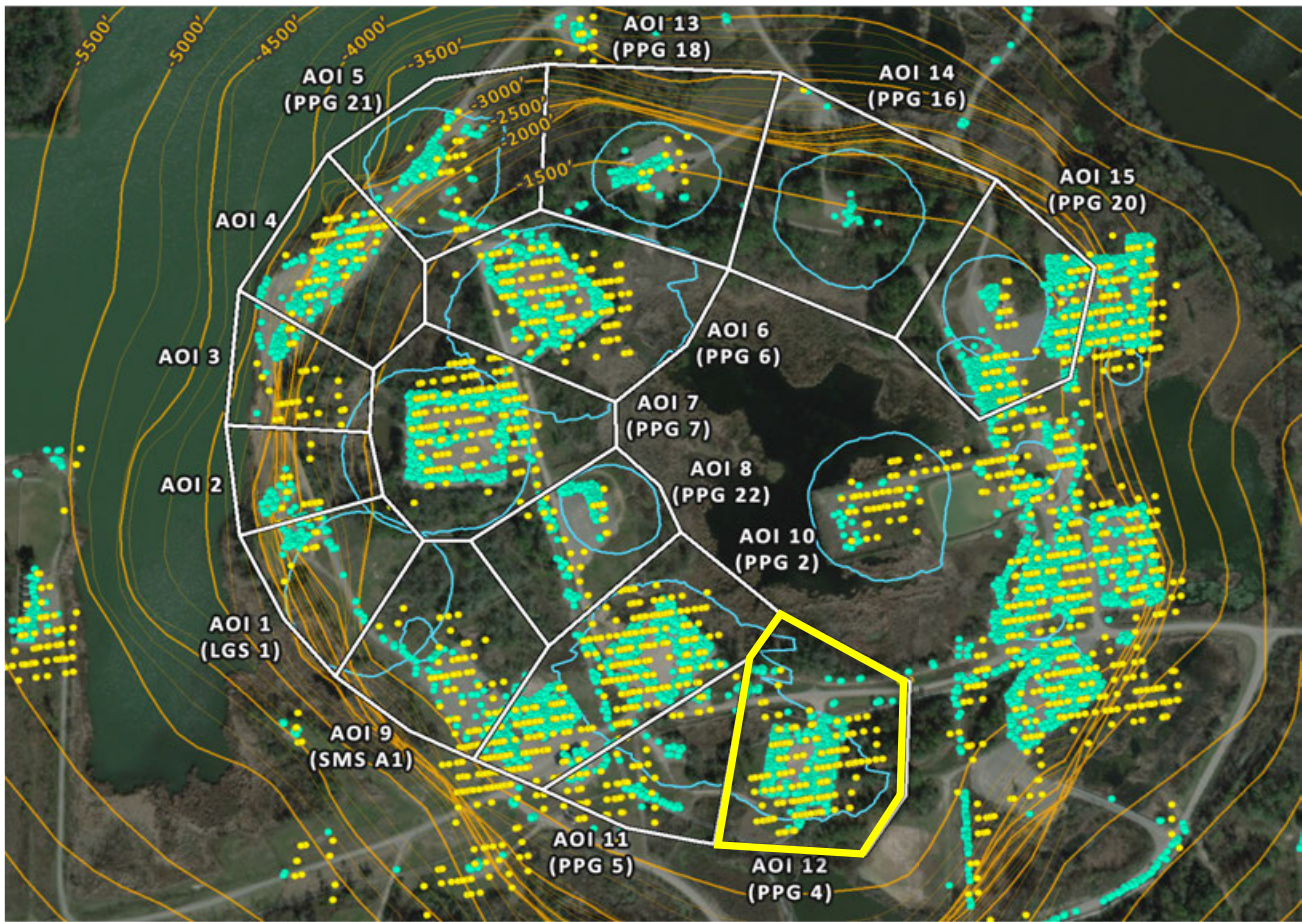
### AOI 11 (PPG 5) - Displacement Time Series TSX/PAZ (3/30/2025) Point Count: 127



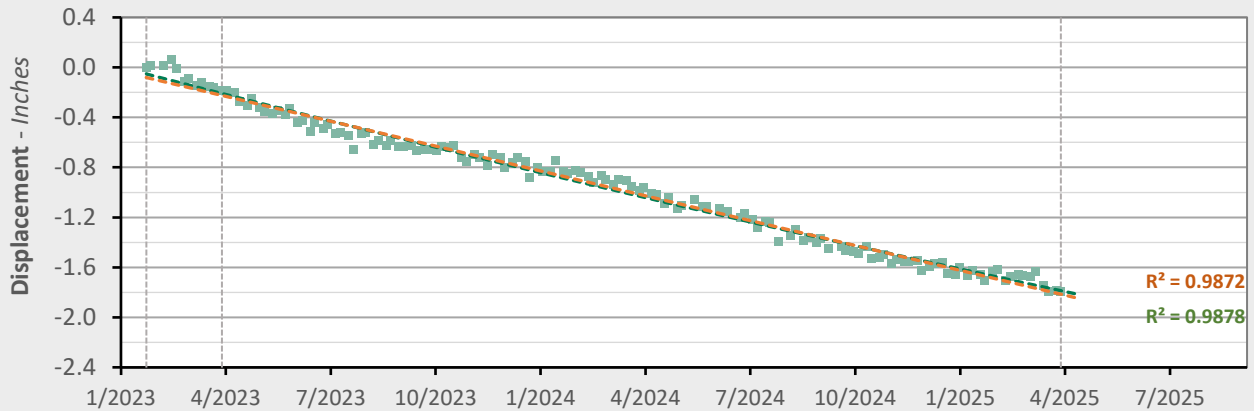
	Nonlinear Trend	Linear Trend
Velocity:	-0.37 in/yr	-0.52 in/yr
Acceleration:	+0.13 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



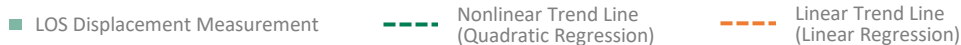
### AOI 12 (PPG 4) - Location Map



### AOI 12 (PPG 4) - Displacement Time Series TSX/PAZ (3/30/2025) Point Count: 553



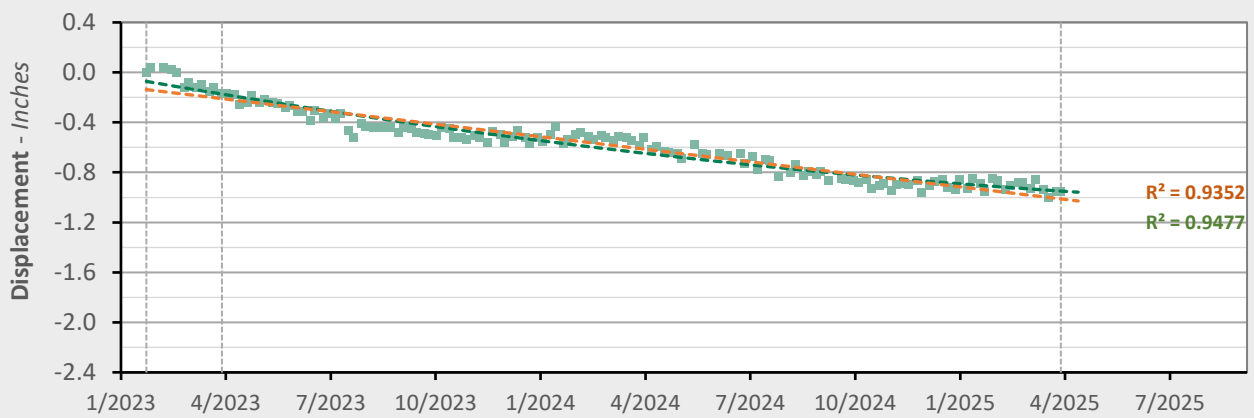
	Nonlinear Trend	Linear Trend
Velocity:	-0.72 in/yr	-0.80 in/yr
Acceleration:	+0.07 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



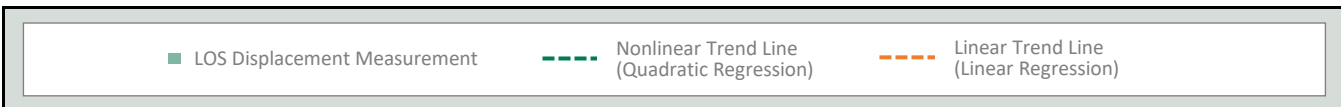
### AOI 13 (PPG 18) - Location Map



### AOI 13 (PPG 18) - Displacement Time Series TSX/PAZ (3/30/2025) Point Count: 108



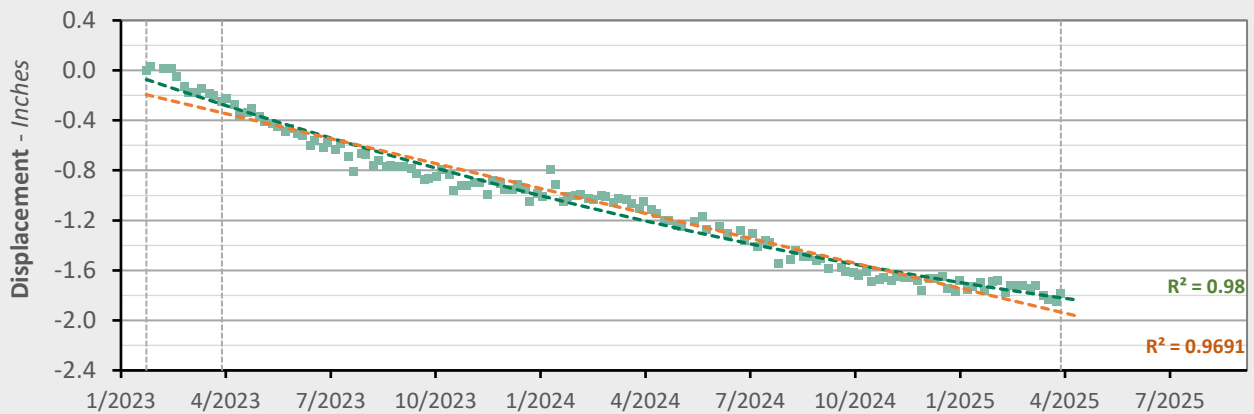
	Nonlinear Trend	Linear Trend
Velocity:	-0.22 in/yr	-0.40 in/yr
Acceleration:	+0.16 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



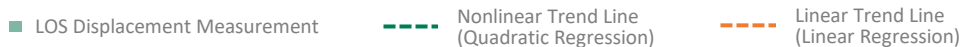
### AOI 14 (PPG 16) - Location Map



### AOI 14 (PPG 16) - Displacement Time Series TSX/PAZ (3/30/2025) Point Count: 22



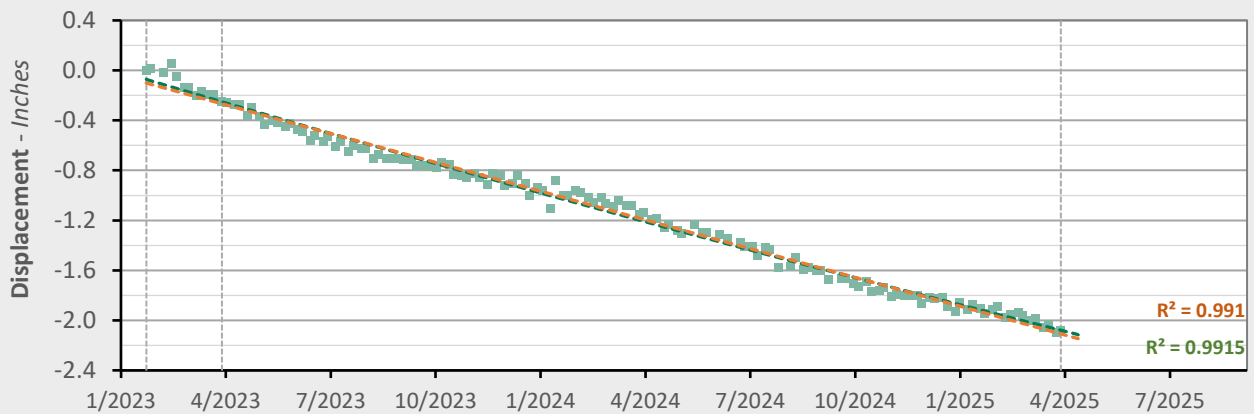
	Nonlinear Trend	Linear Trend
Velocity:	-0.47 in/yr	-0.80 in/yr
Acceleration:	+0.30 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



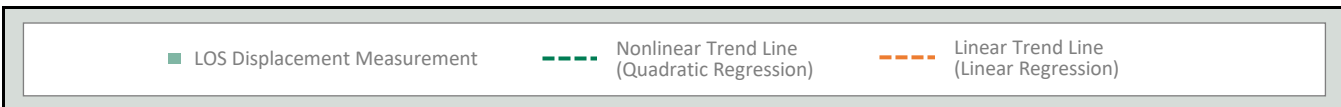
### AOI 15 (PPG 20) - Location Map



### AOI 15 (PPG 20) - Displacement Time Series TSX/PAZ (3/30/2025) Point Count: 742



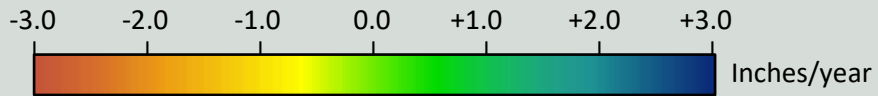
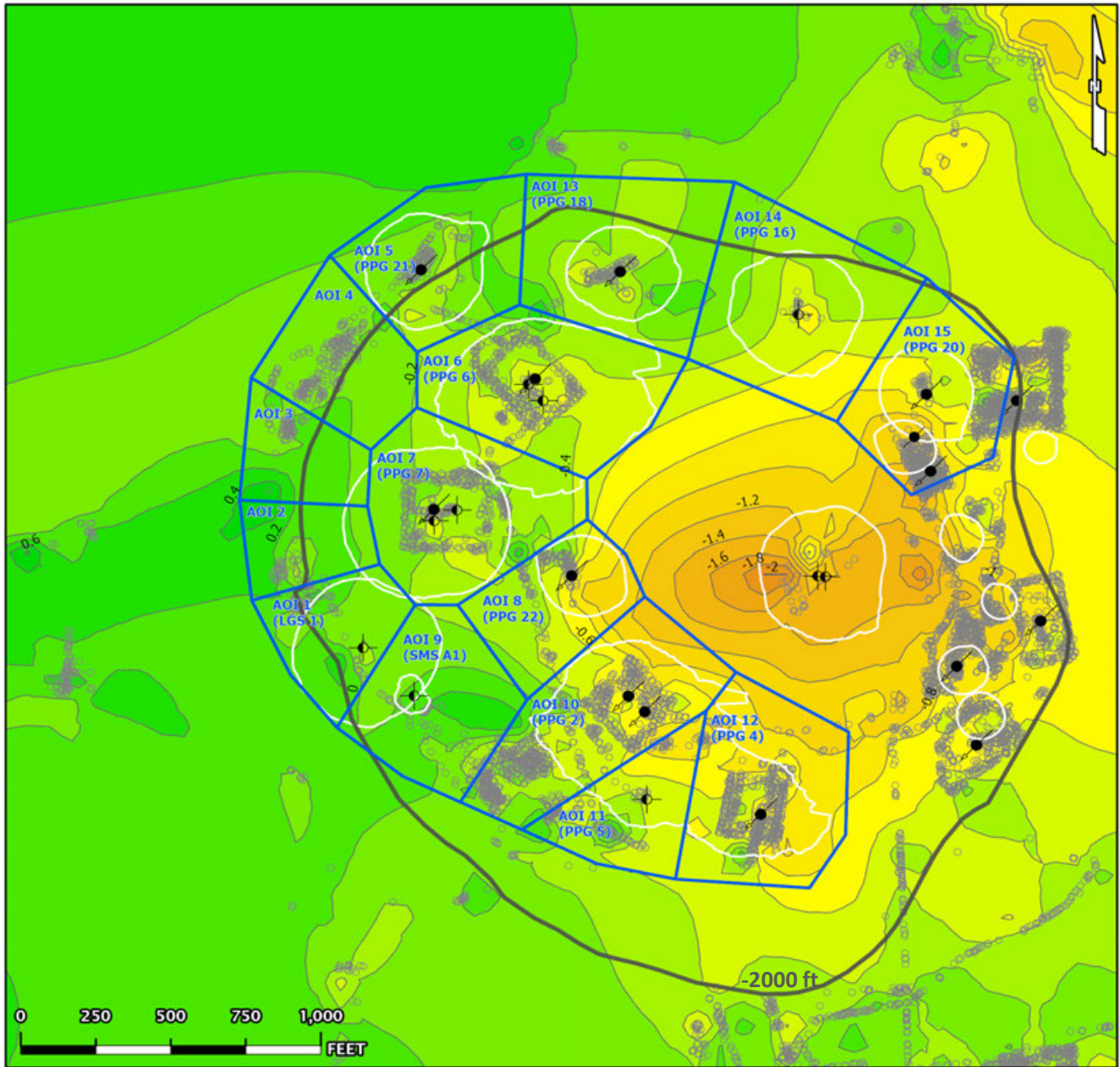
	Nonlinear Trend	Linear Trend
Velocity:	-0.84 in/yr	-0.92 in/yr
Acceleration:	+0.07 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



**TSX/PAZ Data (01/24/2023 - 03/30/2025)**

**Nonlinear Velocity Contours**

As of date: 03/30/2025

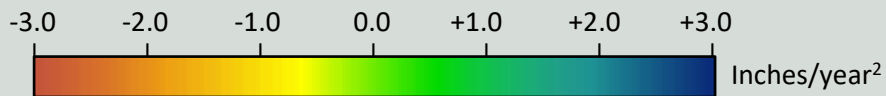
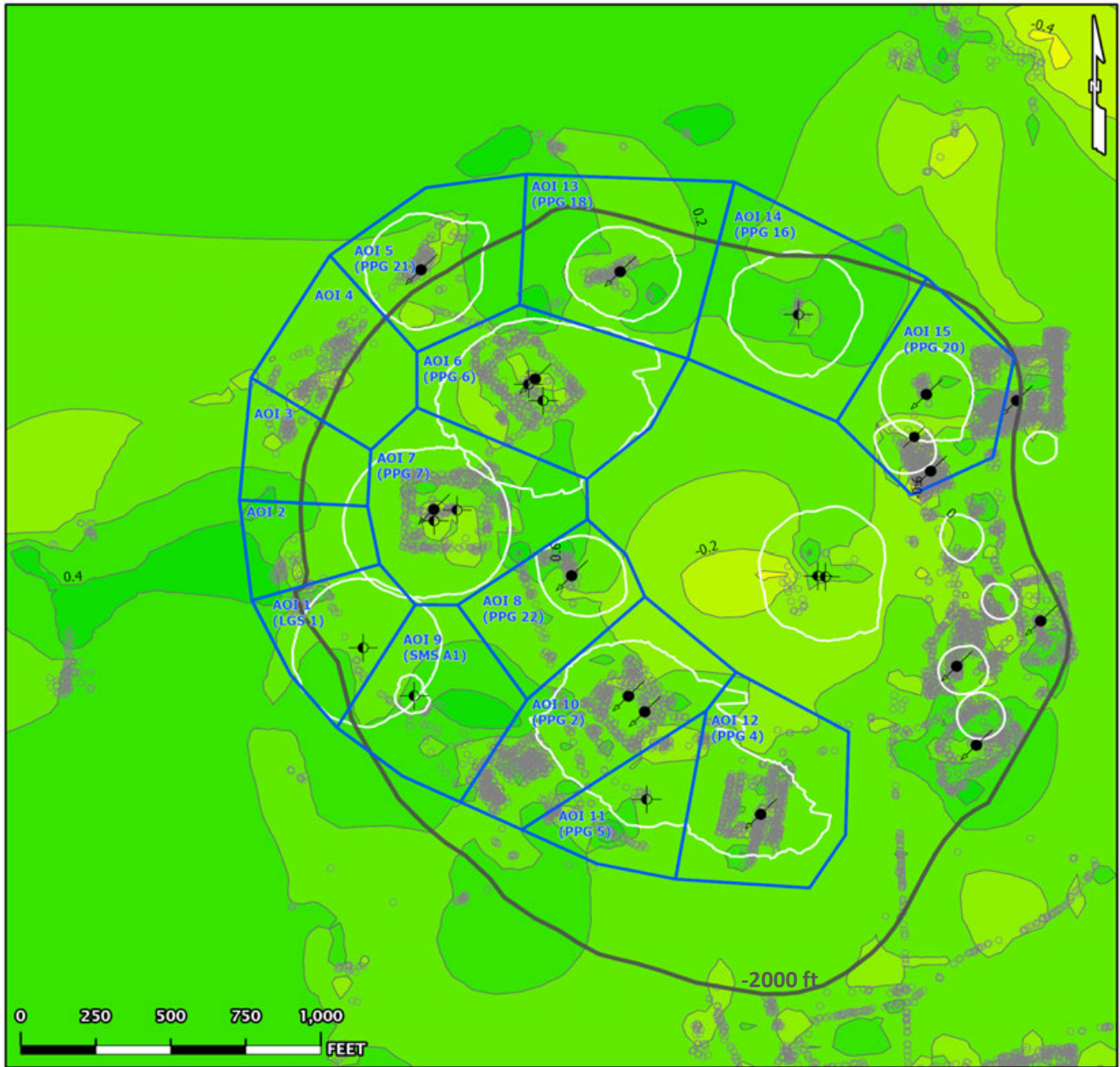


- AOI Boundary
  - InSAR LOS Measurement Point
  - Contour (0.2)
  - Historical Cavern Extent
  - Top of Dome (-2000 ft Contour)
- Cavern Well Surface Locations
- 09 - Active - Injection
  - 29 - Dry and Plugged

**TSX/PAZ Data (01/24/2023 - 03/30/2025)**

**Nonlinear Acceleration Contours**

Date range: 01/24/2023 - 03/30/2025

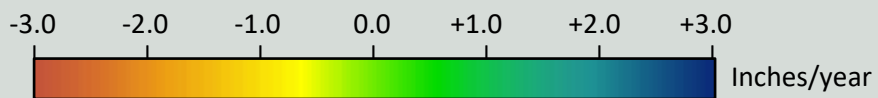
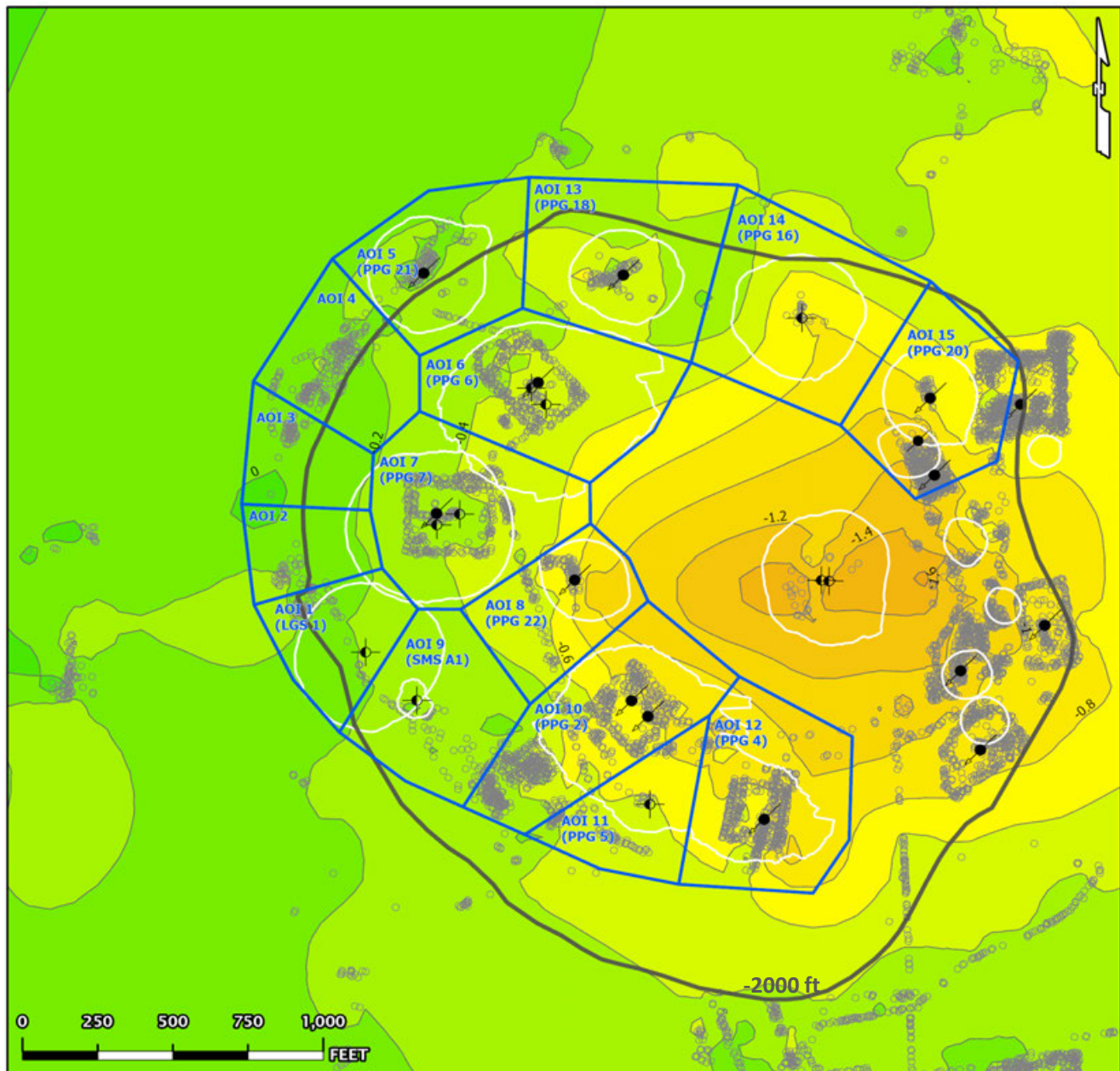


- AOI Boundary
  - InSAR LOS Measurement Point
  - Contour (0.2)
  - Historical Cavern Extent
  - Top of Dome (-2000 ft Contour)
- Cavern Well Surface Locations
- 09 - Active - Injection
  - 29 - Dry and Plugged

**TSX/PAZ Data (01/24/2023 - 03/30/2025)**

**Linear Velocity Contours**

Date range: 01/24/2023 - 03/30/2025

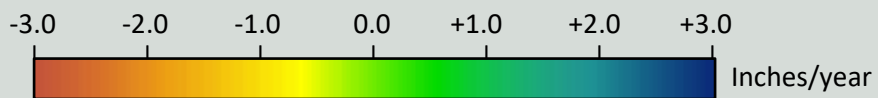
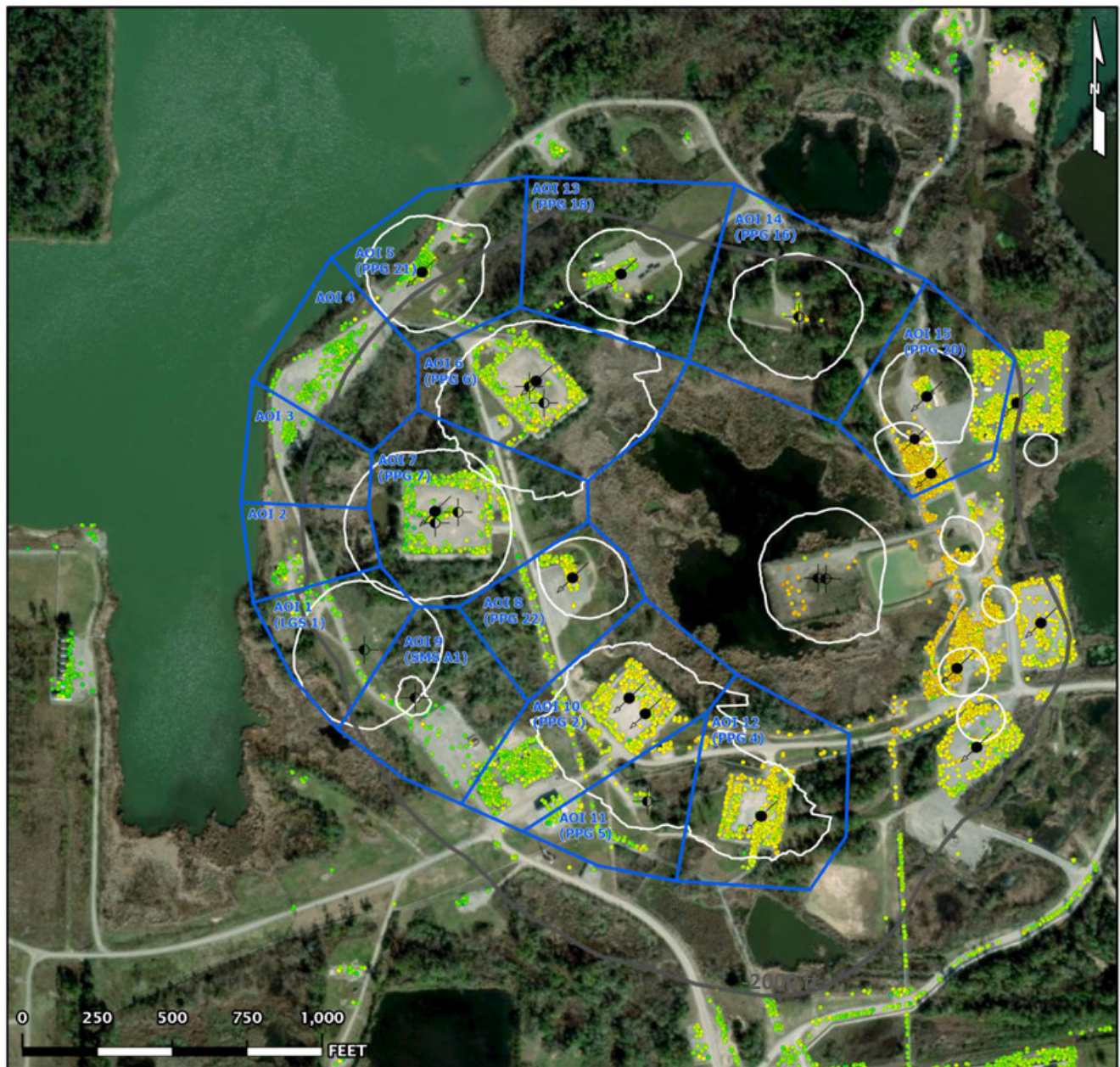


- AOI Boundary
  - InSAR LOS Measurement Point
  - Contour (0.2)
  - Historical Cavern Extent
  - Top of Dome (-2000 ft Contour)
- Cavern Well Surface Locations
- 09 - Active - Injection
  - 29 - Dry and Plugged

**TSX/PAZ Data (01/24/2023 - 03/30/2025)**

**Nonlinear Velocity Data Points**

As of date: 03/30/2025

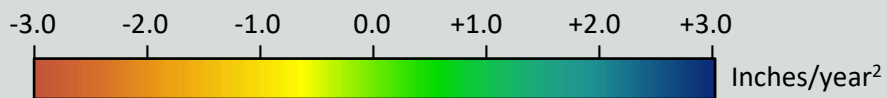
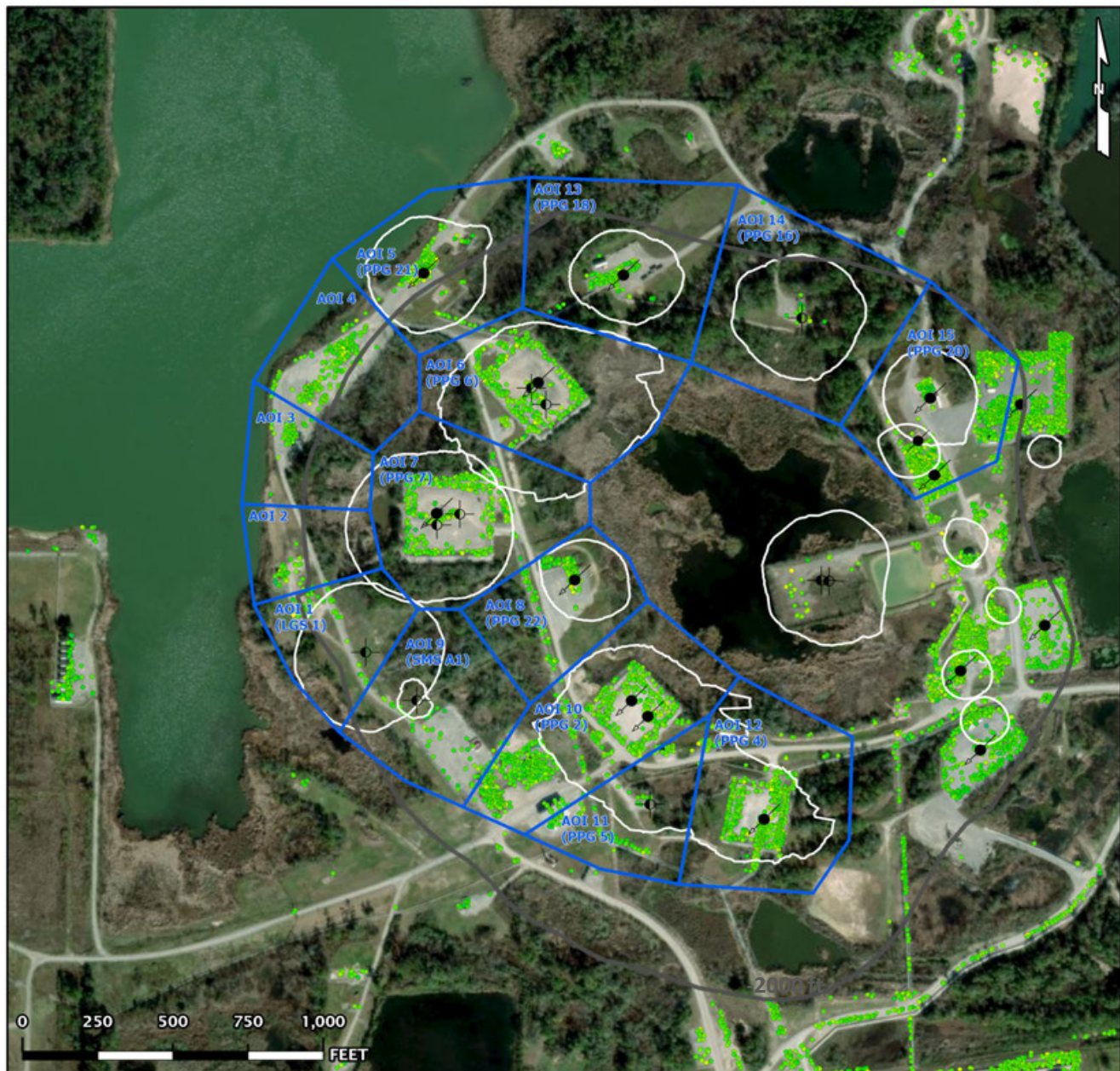


- AOI Boundary
  - InSAR LOS Measurement Point
  - Historical Cavern Extent
  - Top of Dome (-2000 ft Contour)
- Cavern Well Surface Locations
- 09 - Active - Injection
  - 29 - Dry and Plugged

**TSX/PAZ Data (01/24/2023 - 03/30/2025)**

**Nonlinear Acceleration Data Points**

Date range: 01/24/2023 - 03/30/2025

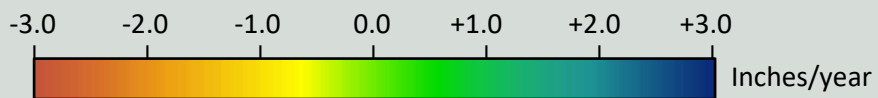
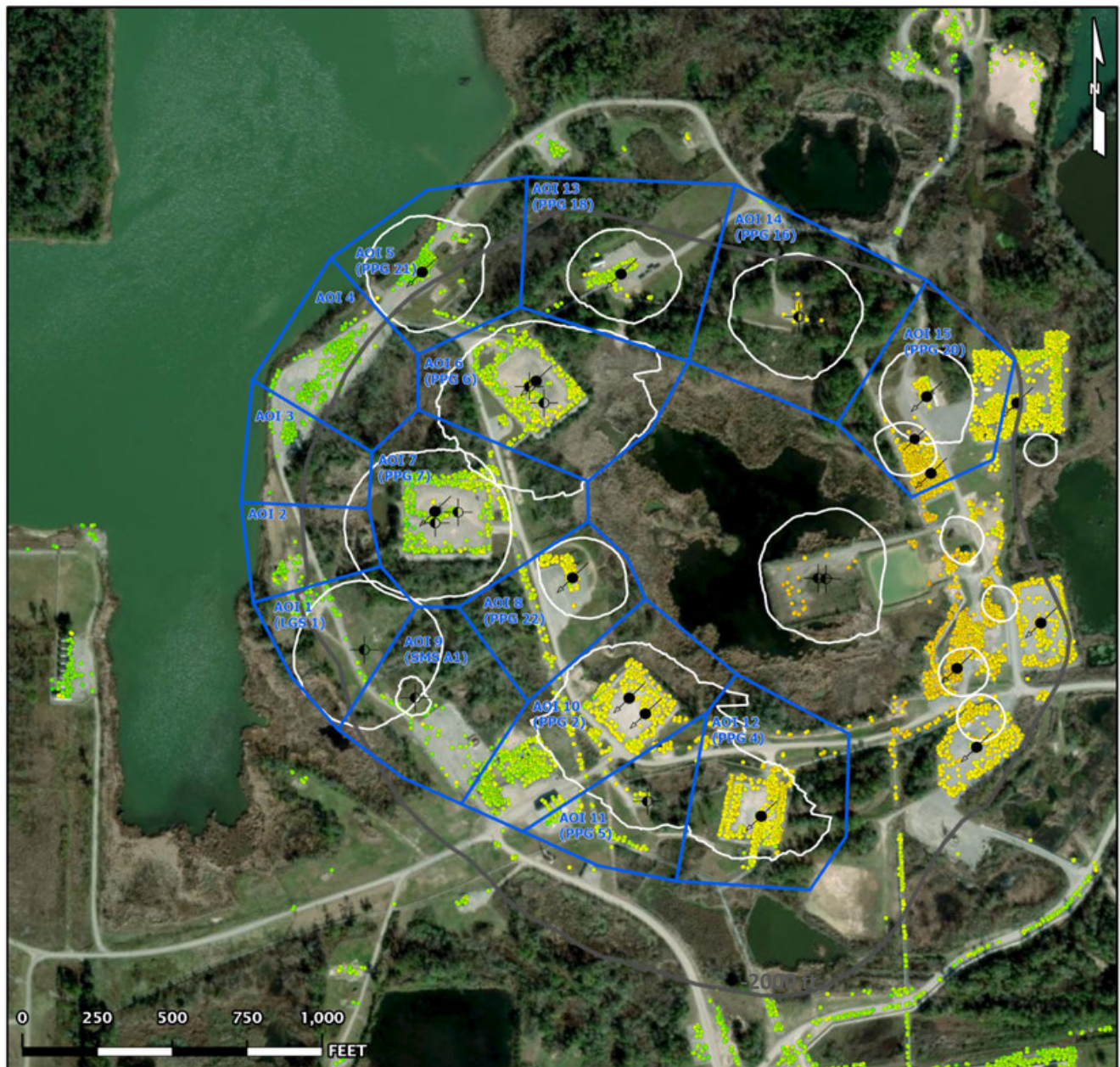


- AOI Boundary
  - InSAR LOS Measurement Point
  - Historical Cavern Extent
  - Top of Dome (-2000 ft Contour)
- Cavern Well Surface Locations
- 09 - Active - Injection
  - 29 - Dry and Plugged

**TSX/PAZ Data (01/24/2023 - 03/30/2025)**

**Linear Velocity Data Points**

Date range: 01/24/2023 - 03/30/2025



- 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 - March 30, 2025**



# 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 Field Service, LLC  
8591 United Plaza Blvd., Suite 280  
Baton Rouge, LA 70809

Dataset
Satellite Source
<b>Sentinel-1 &amp; TerraSAR-X - PAZ Constellation</b>
Most Recent Image Date
<b>Sunday, March 30, 2025</b>

Analysis Report Date:  
**April 12, 2025**

Dataset Information	
Satellite Source	Sentinel-1 & TerraSAR-X - PAZ Constellation
Update Frequency	12 days
Most Recent Image Date	Sunday, March 30, 2025
Dataset Image Count	181
Dataset Time Range	January 24, 2023 - March 30, 2025
Dataset Length	2.18 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 occurring with near-linear trends in all AOIs where data is present, with the greatest rates occurring in the central portions of the dome. Minor positive acceleration (slowing subsidence) is present in all of the nonlinear AOI trends.

The calculated east-west displacement values generally indicate near-linear horizontal movement toward the dome center with the greatest rates of eastward movement occurring in the western AOIs and the greatest rate of westward movement occurring in the easternmost AOI. Slight positive and negative east-west acceleration values are evenly distributed among the AOIs.



Date Signed: April 12, 2025  
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.

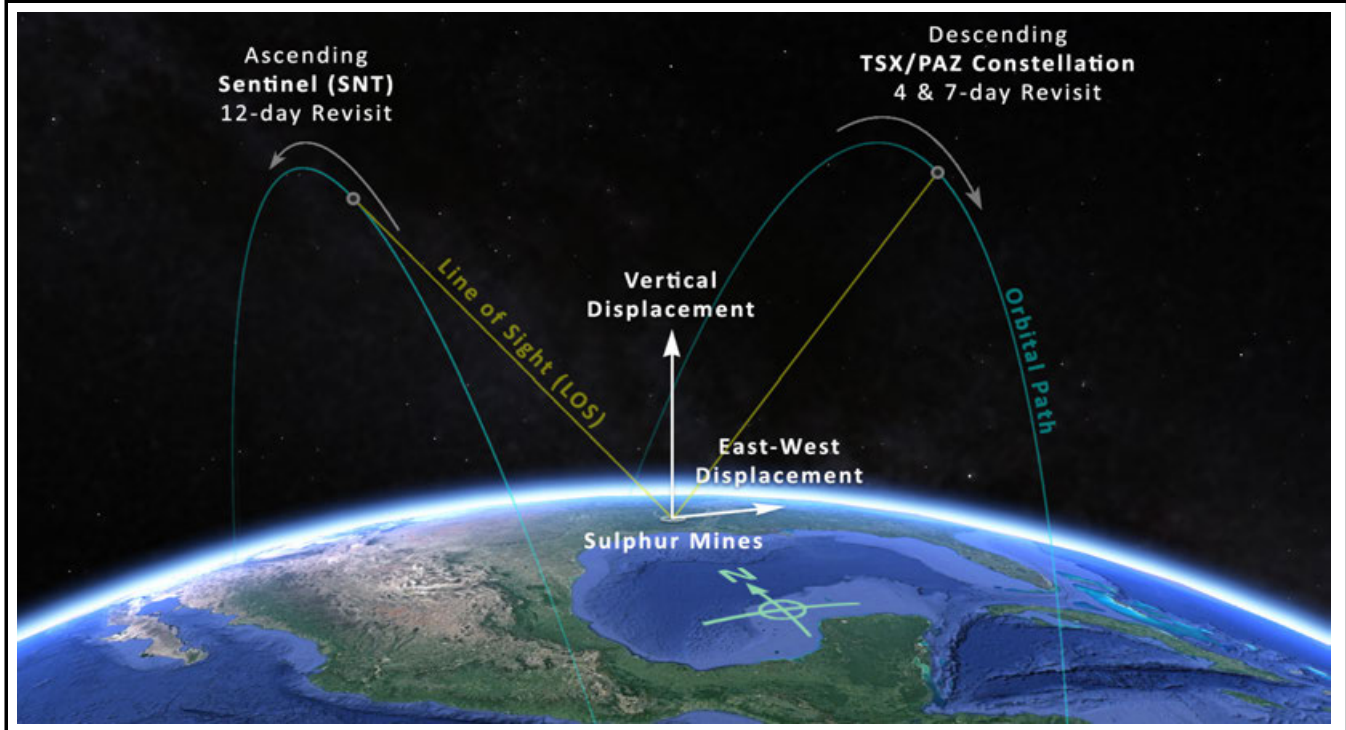
### Satellite Sources

Two InSAR datasets are being used to evaluate subsidence over the Sulphur Mines Salt Dome. These datasets provide Line-of-Sight (LOS) displacement 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.

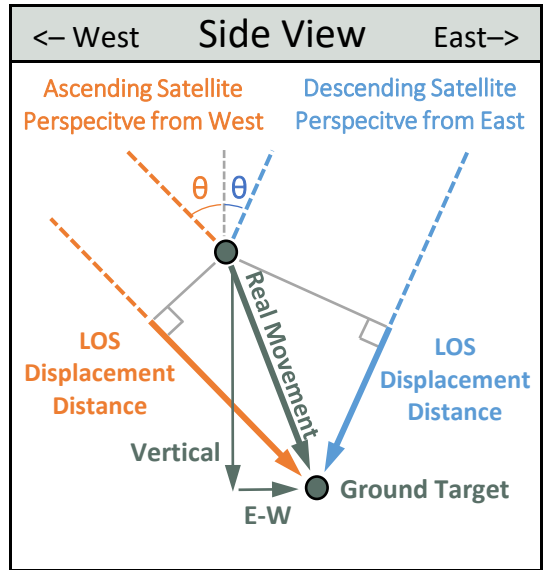
Each instance of data capture in either the SNT or TSX/PAZ constellation is used to generate 2D (two-dimensional) displacement values in the vertical and east-west directions for each measurement point within the 2D data grid. The image below depicts the orbital paths of the satellites in relation to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

## Satellite Orbital Diagram



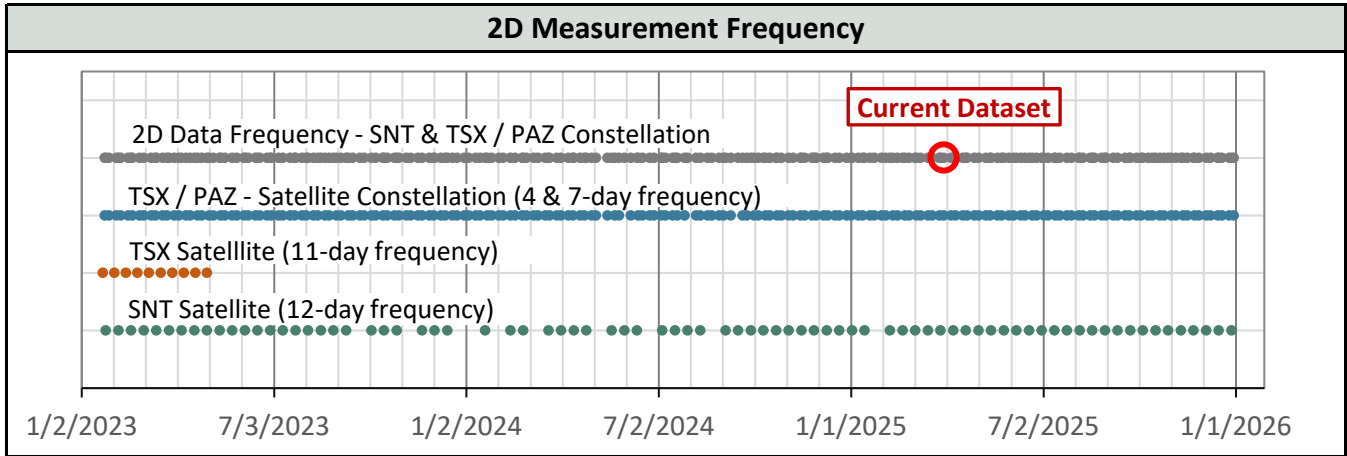
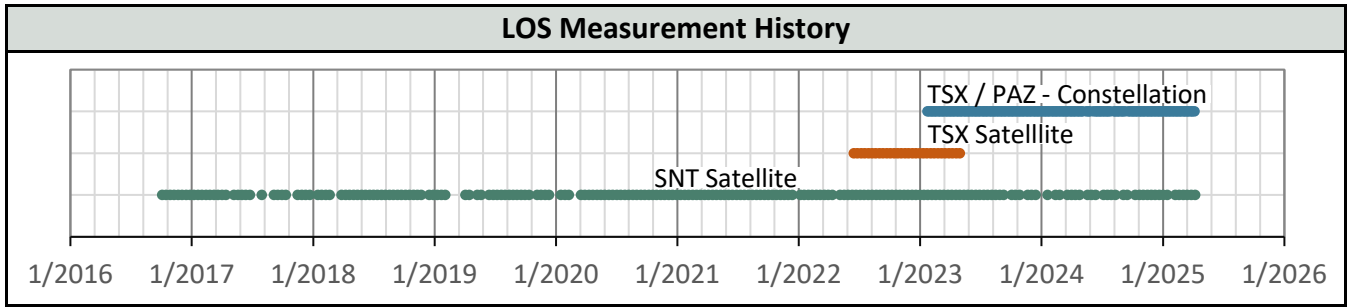
### InSAR 2D Vertical and East-West Data

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.

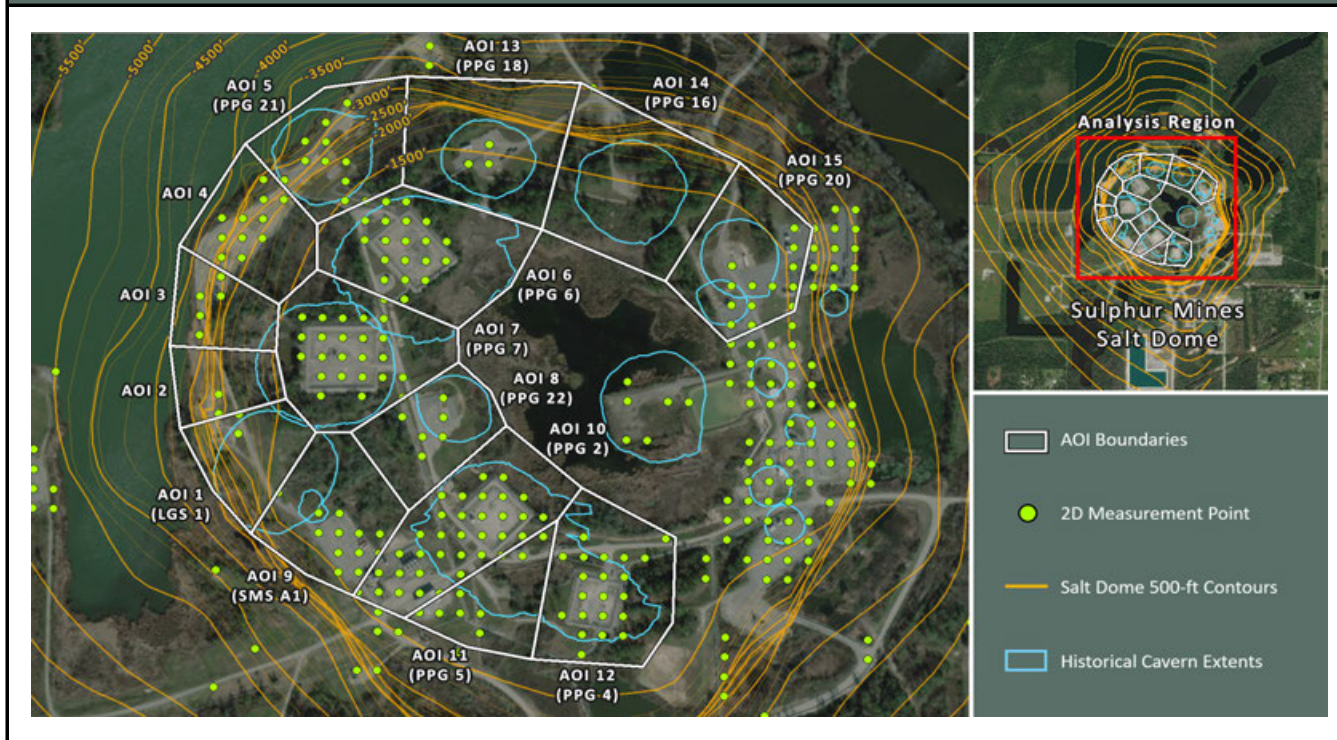


### Satellite Properties & Image Frequency

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, $\theta$ )	Ascending ( $43^\circ$ )	Descending ( $37^\circ$ )
Data Start Date	10/4/2016	1/24/2023
Measurement error range	$\pm 0.20$ in	$\pm 0.03$ in



### AOI Boundaries & 2D InSAR Measurement Points

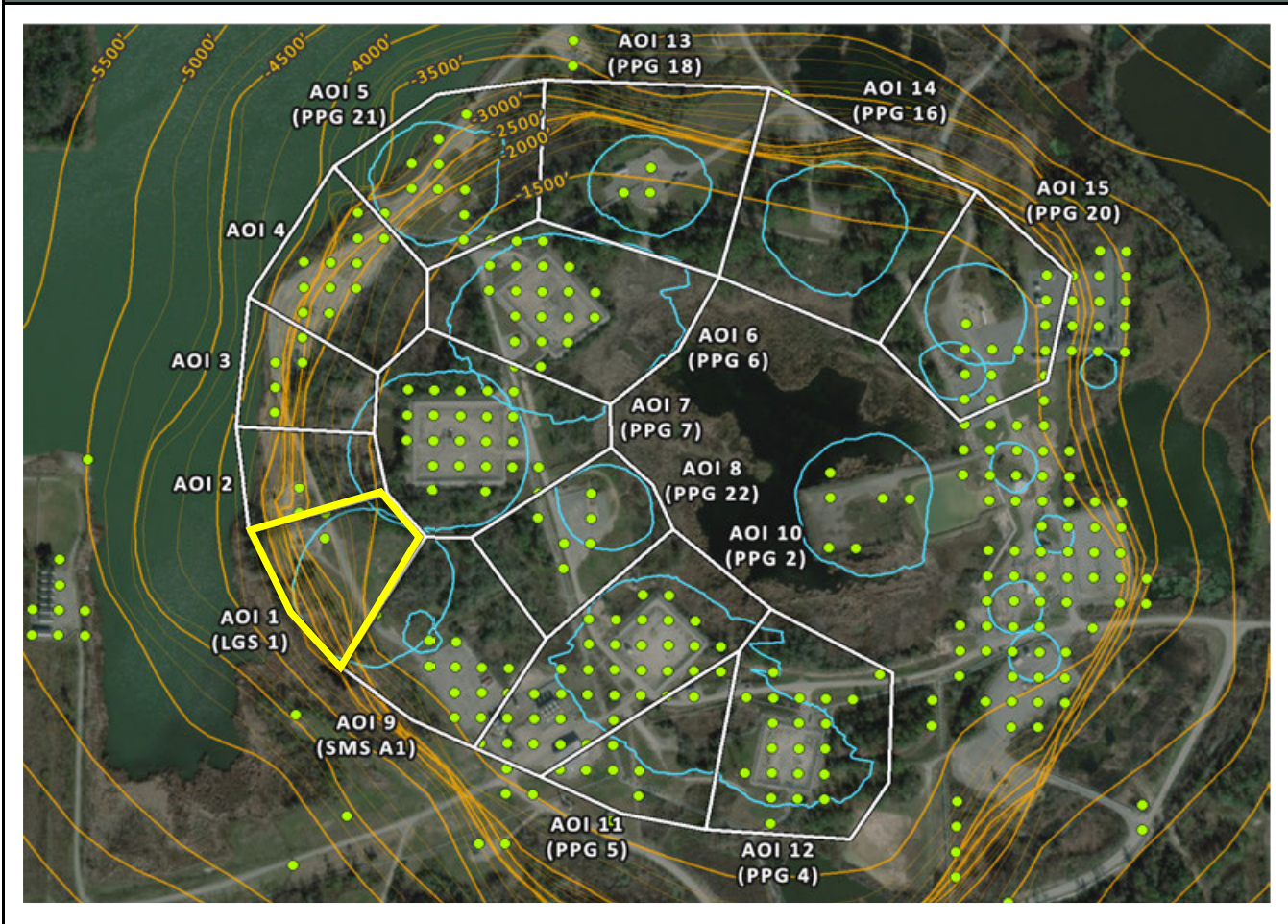


### Subsidence Monitoring Areas of Interest (AOIs)

To visually convey and evaluate trend consistency for the Vertical displacement time series of each ground target, measurement 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.

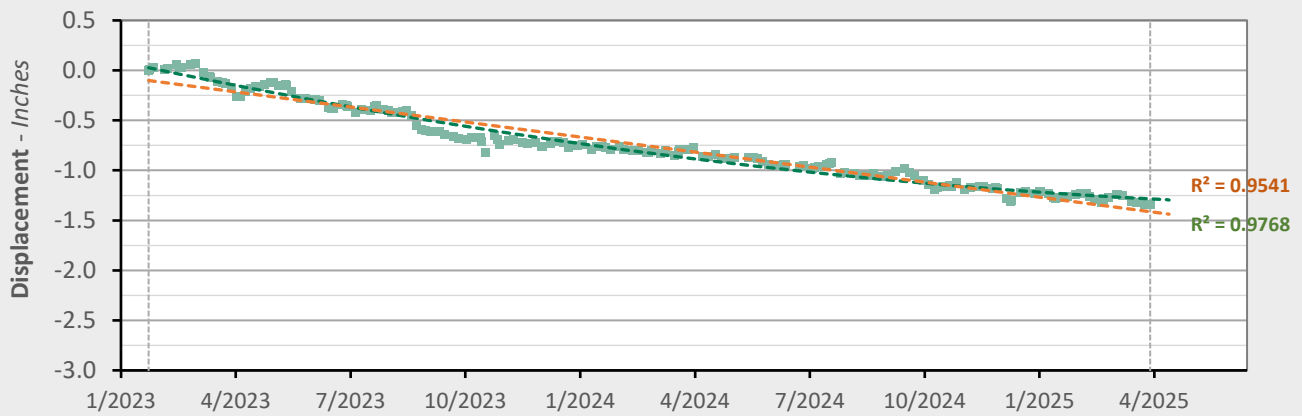
AOI Name	Vertical (3/30/2025)	Vertical Velocity (in/yr)		Vertical Acceleration (in/yr <sup>2</sup> )	
	Point Count	Nonlinear	Linear	Nonlinear	Linear
<b>AOI 1 (LGS 1)</b>	2	-0.24	-0.60	+0.33	0.00
<b>AOI 2</b>	3	-0.39	-0.63	+0.23	0.00
<b>AOI 3</b>	5	-0.21	-0.47	+0.24	0.00
<b>AOI 4</b>	10	-0.44	-0.55	+0.10	0.00
<b>AOI 5 (PPG 21)</b>	10	-0.43	-0.50	+0.07	0.00
<b>AOI 6 (PPG 6)</b>	20	-0.71	-0.83	+0.11	0.00
<b>AOI 7 (PPG 7)</b>	25	-0.76	-0.91	+0.13	0.00
<b>AOI 8 (PPG 22)</b>	7	-0.95	-1.16	+0.19	0.00
<b>AOI 9 (SMS A1)</b>	12	-0.44	-0.74	+0.28	0.00
<b>AOI 10 (PPG 2)</b>	33	-0.87	-1.03	+0.14	0.00
<b>AOI 11 (PPG 5)</b>	9	-0.82	-0.95	+0.12	0.00
<b>AOI 12 (PPG 4)</b>	21	-0.84	-0.97	+0.12	0.00
<b>AOI 13 (PPG 18)</b>	3	-0.55	-0.65	+0.09	0.00
<b>AOI 14 (PPG 16)</b>	0	N/A	N/A	N/A	N/A
<b>AOI 15 (PPG 20)</b>	13	-0.74	-0.81	+0.06	0.00

### AOI 1 (LGS 1) - Location Map

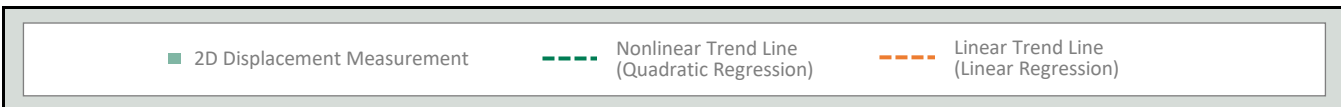


### AOI 1 (LGS 1) - Vertical Time Series

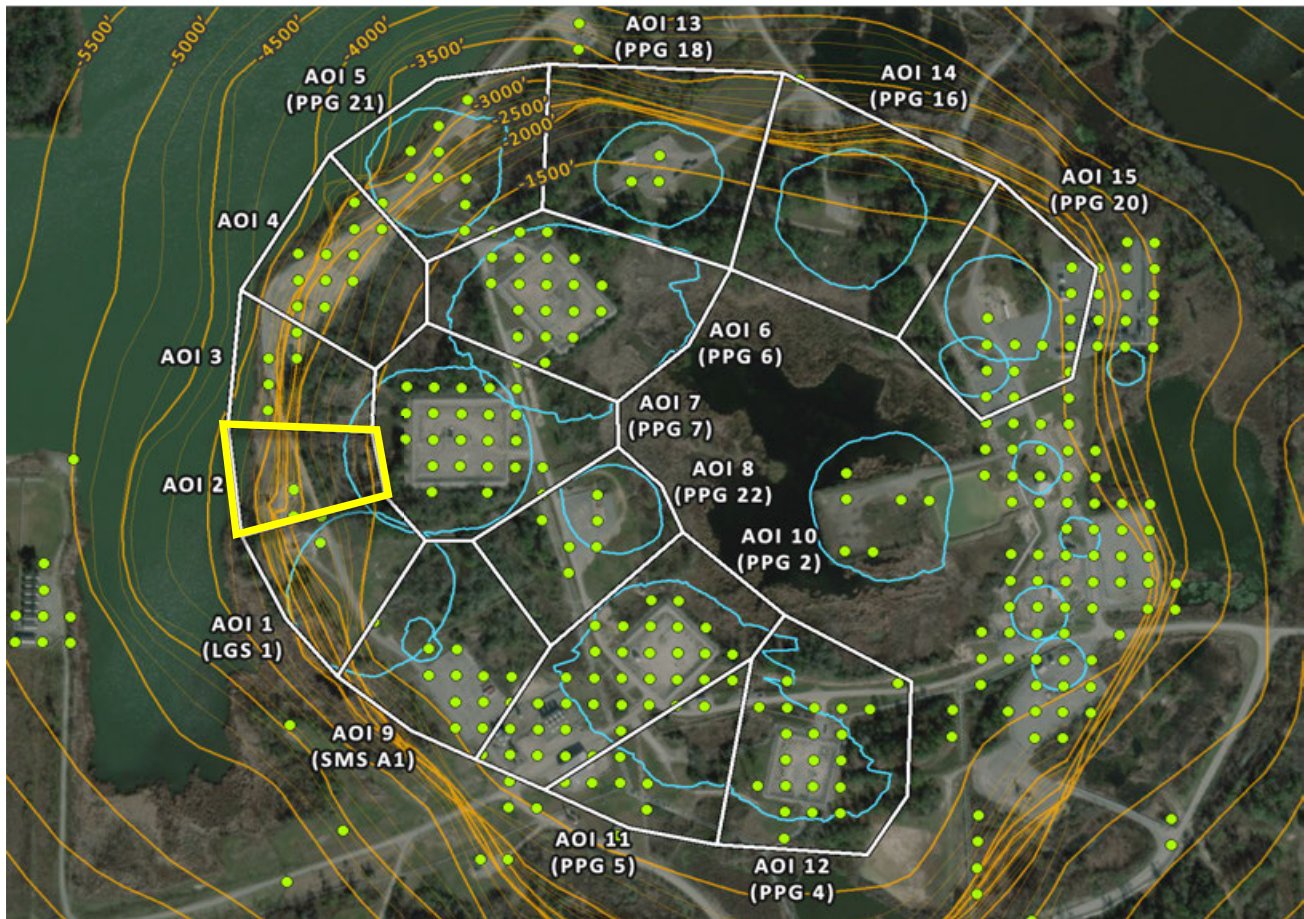
Vertical (3/30/2025) Point Count: 2



	Nonlinear Trend	Linear Trend
Velocity:	-0.24 in/yr	-0.60 in/yr
Acceleration:	+0.33 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

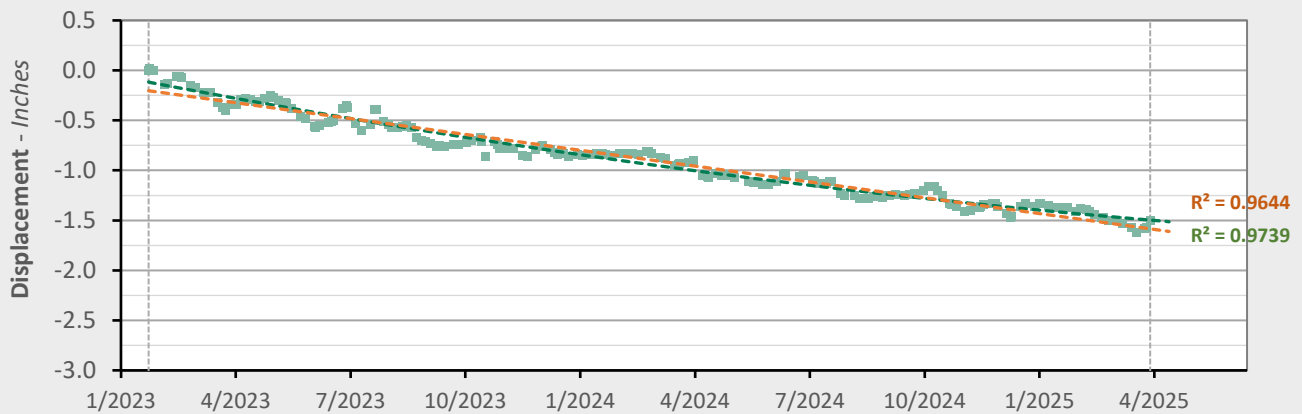


### AOI 2 - Location Map

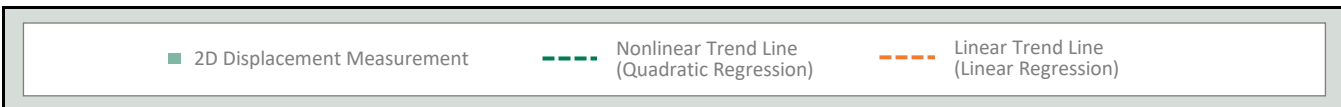


### AOI 2 - Vertical Time Series

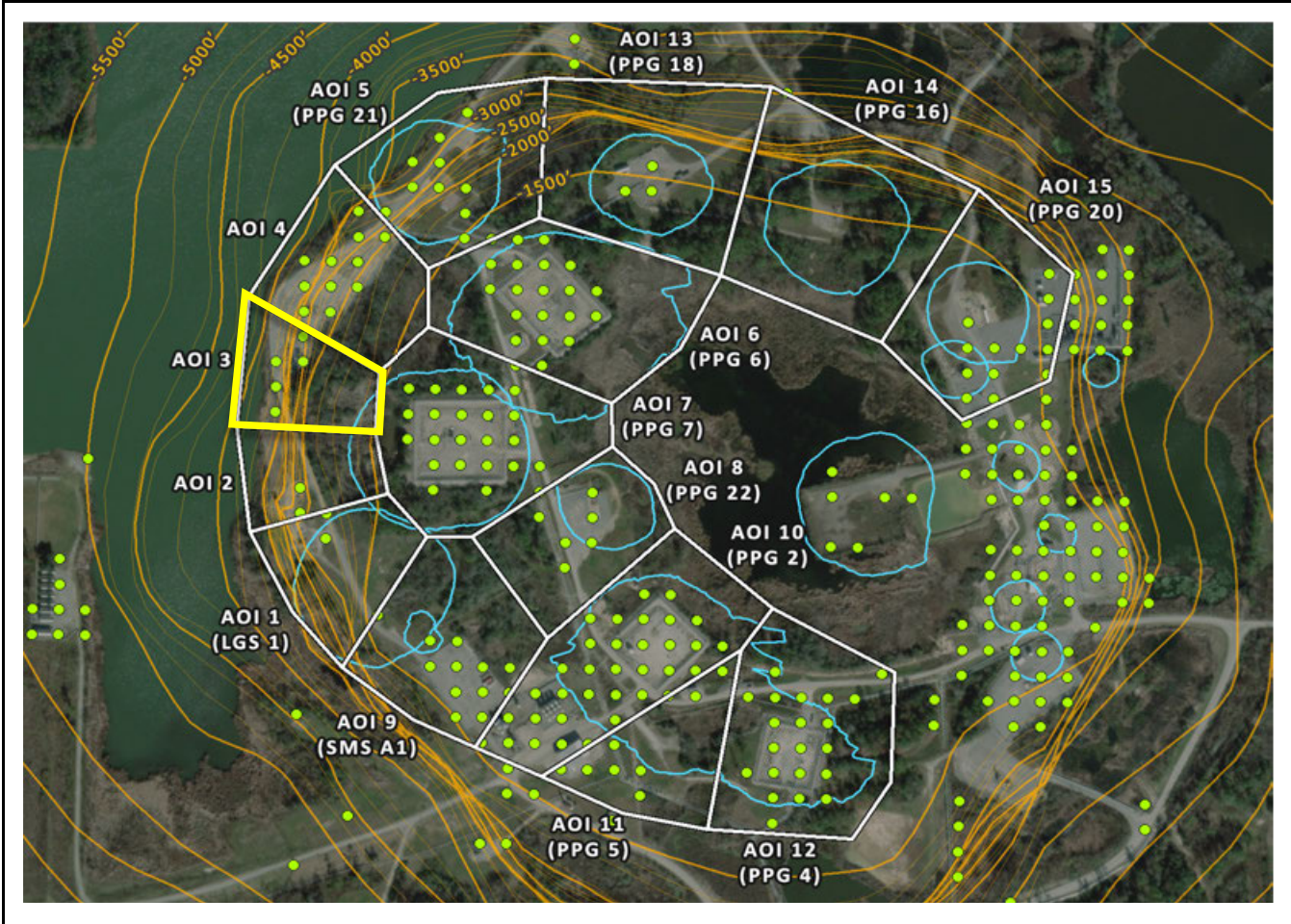
Vertical (3/30/2025) Point Count: **3**



	Nonlinear Trend	Linear Trend
Velocity:	-0.39 in/yr	-0.63 in/yr
Acceleration:	+0.23 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

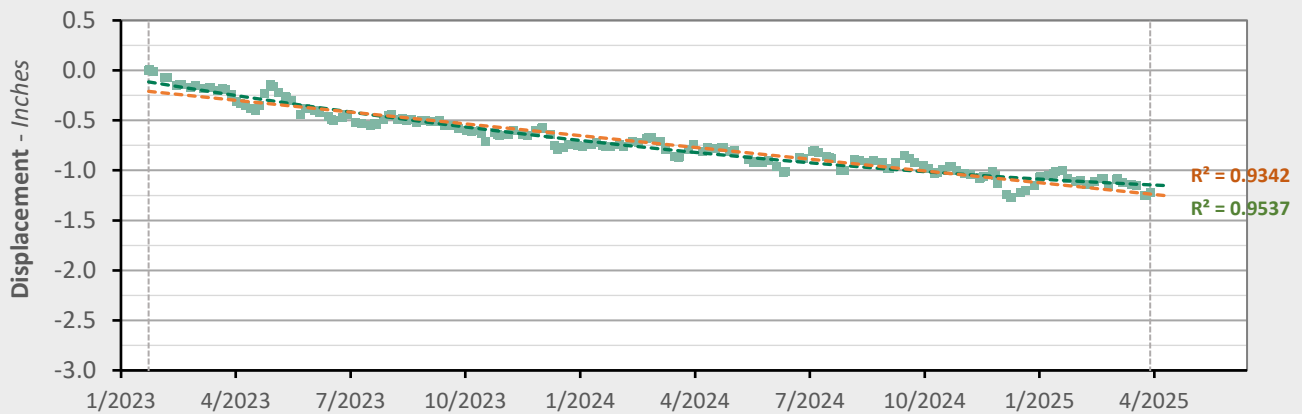


### AOI 3 - Location Map

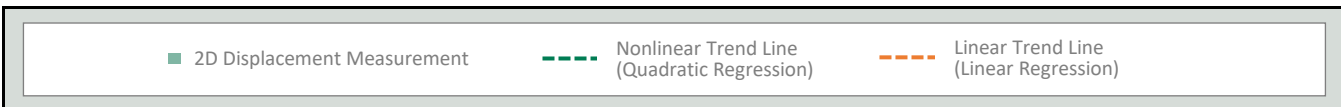


### AOI 3 - Vertical Time Series

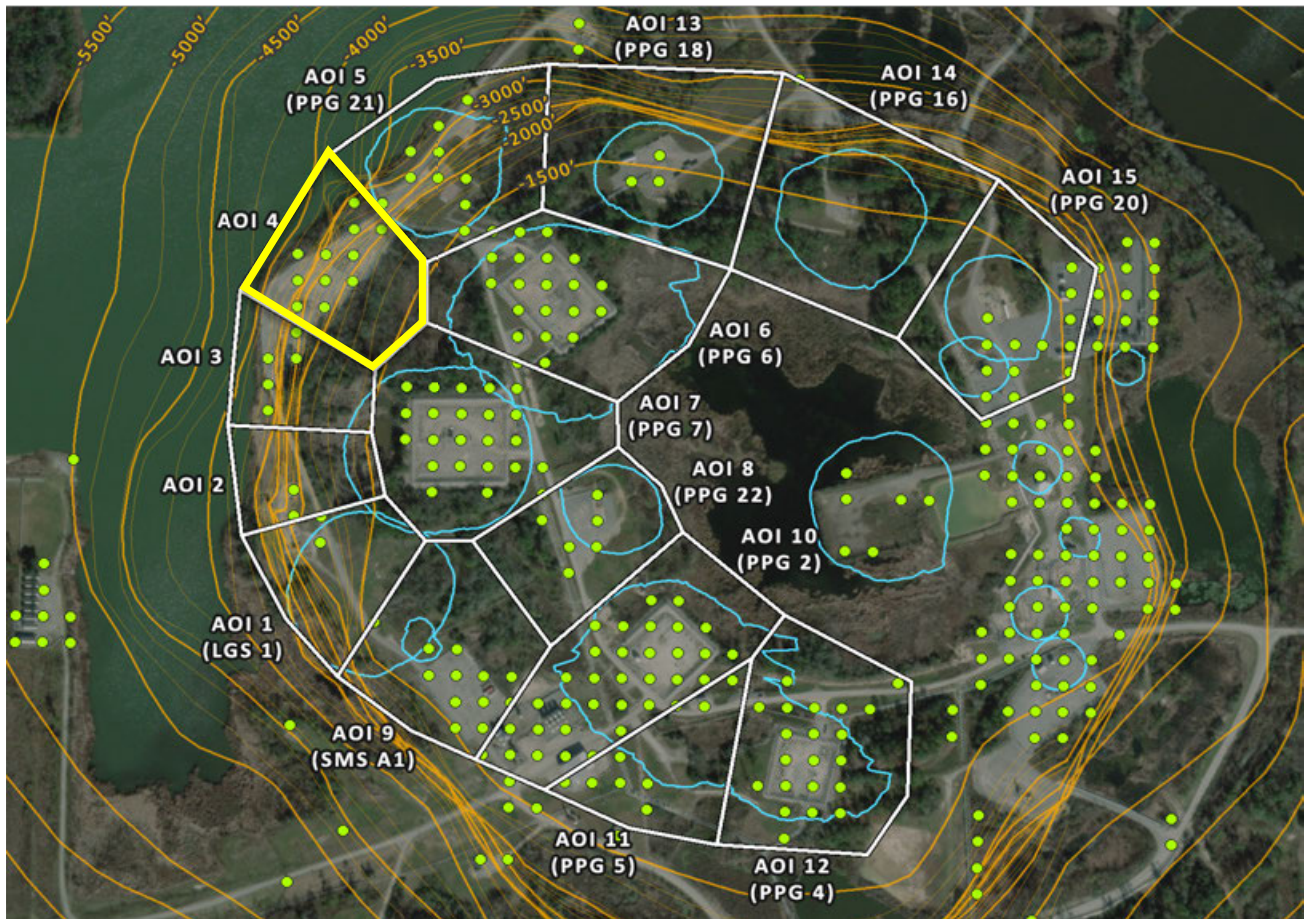
Vertical (3/30/2025) Point Count: 5



	Nonlinear Trend	Linear Trend
Velocity:	-0.21 in/yr	-0.47 in/yr
Acceleration:	+0.24 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

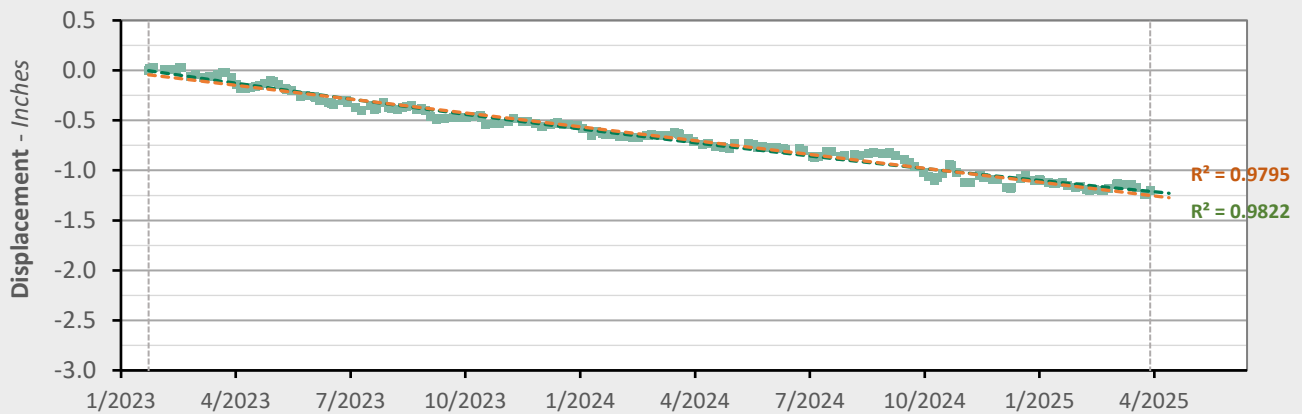


### AOI 4 - Location Map

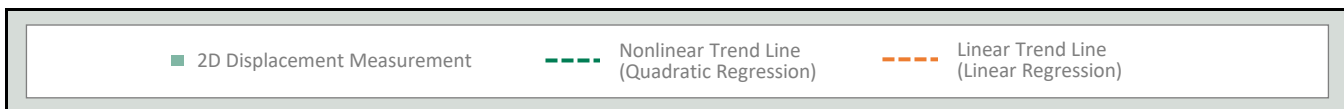


### AOI 4 - Vertical Time Series

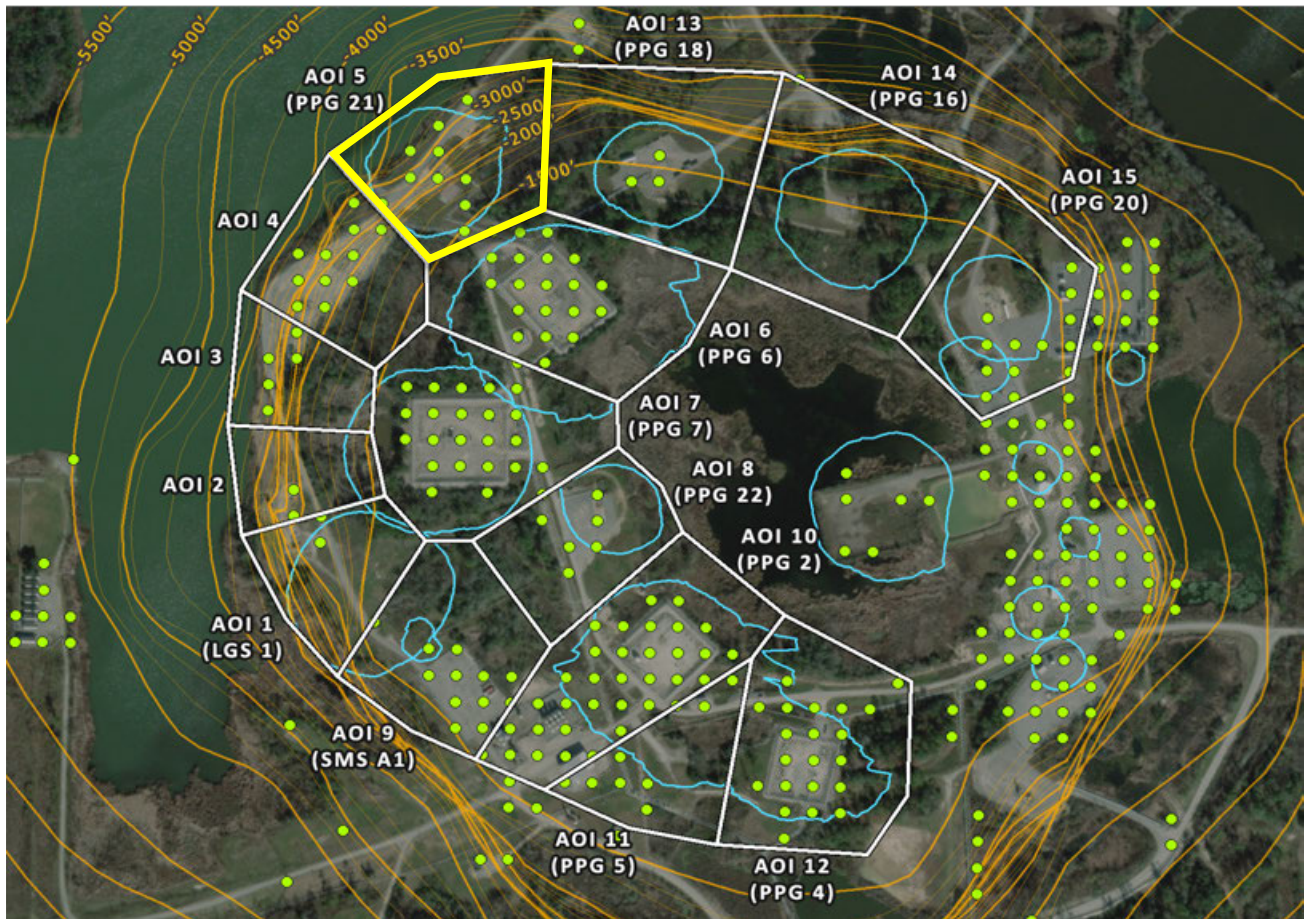
Vertical (3/30/2025) Point Count: **10**



	Nonlinear Trend	Linear Trend
Velocity:	-0.44 in/yr	-0.55 in/yr
Acceleration:	+0.10 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

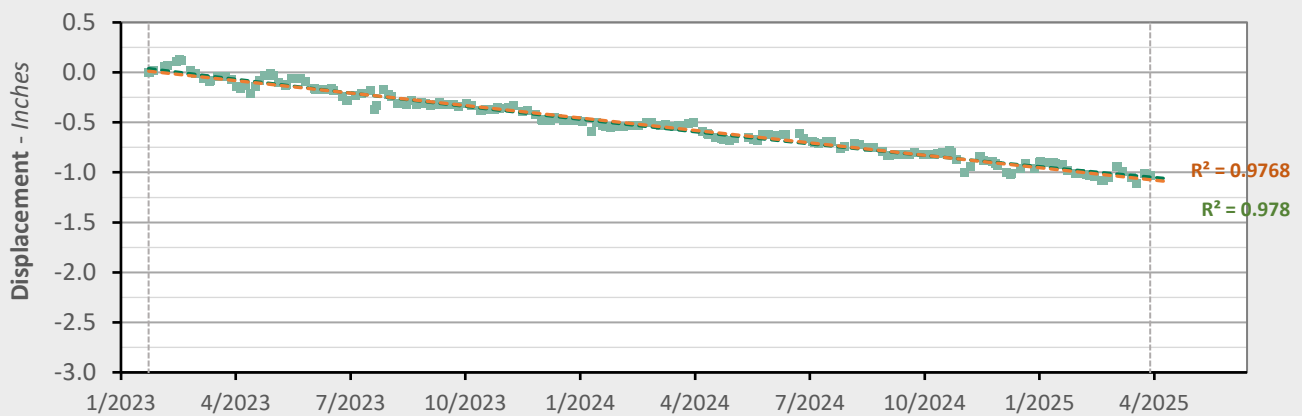


### AOI 5 (PPG 21) - Location Map

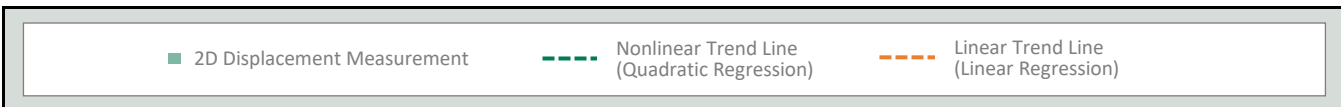


### AOI 5 (PPG 21) - Vertical Time Series

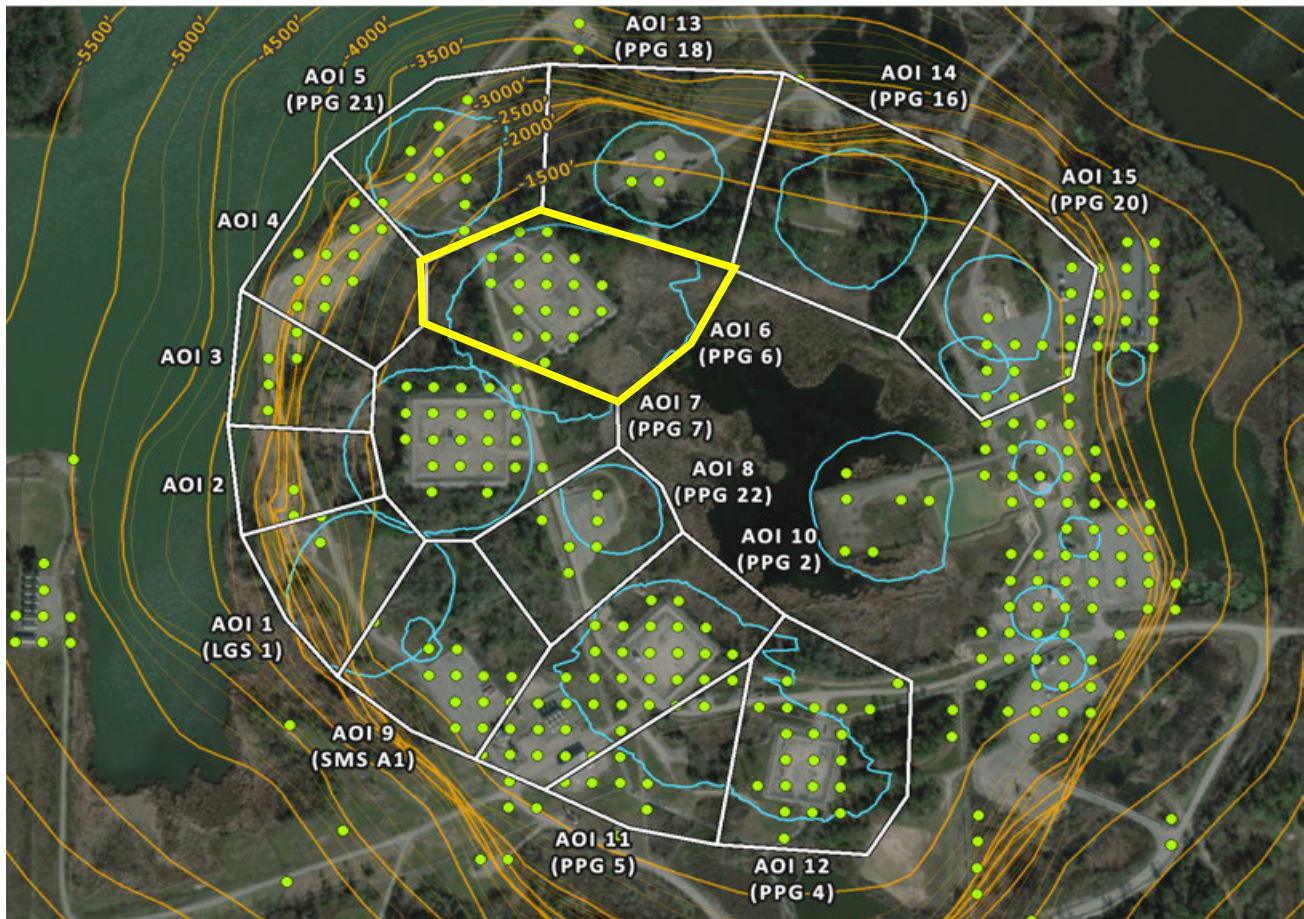
Vertical (3/30/2025) Point Count: 10



	Nonlinear Trend	Linear Trend
Velocity:	-0.43 in/yr	-0.50 in/yr
Acceleration:	+0.07 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

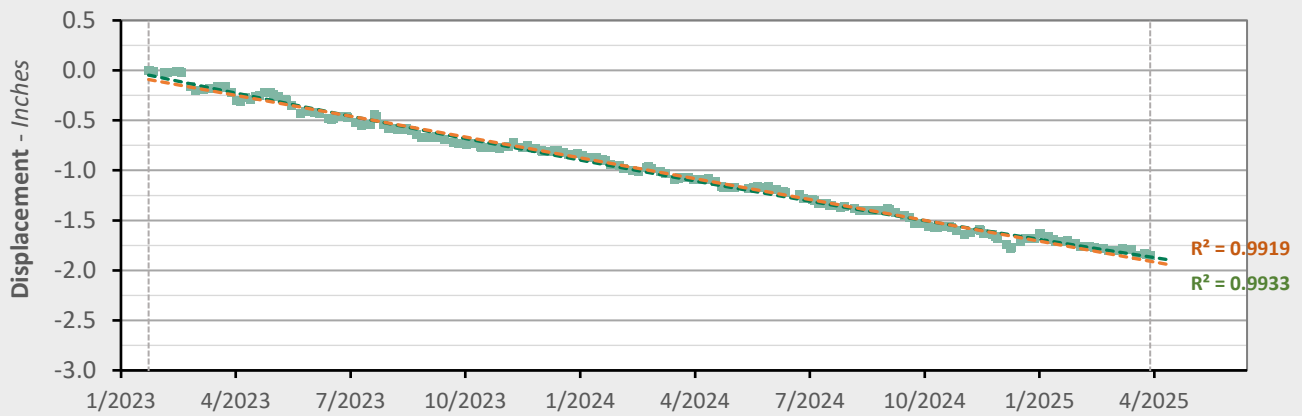


### AOI 6 (PPG 6) - Location Map

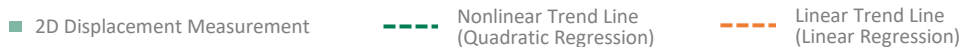


### AOI 6 (PPG 6) - Vertical Time Series

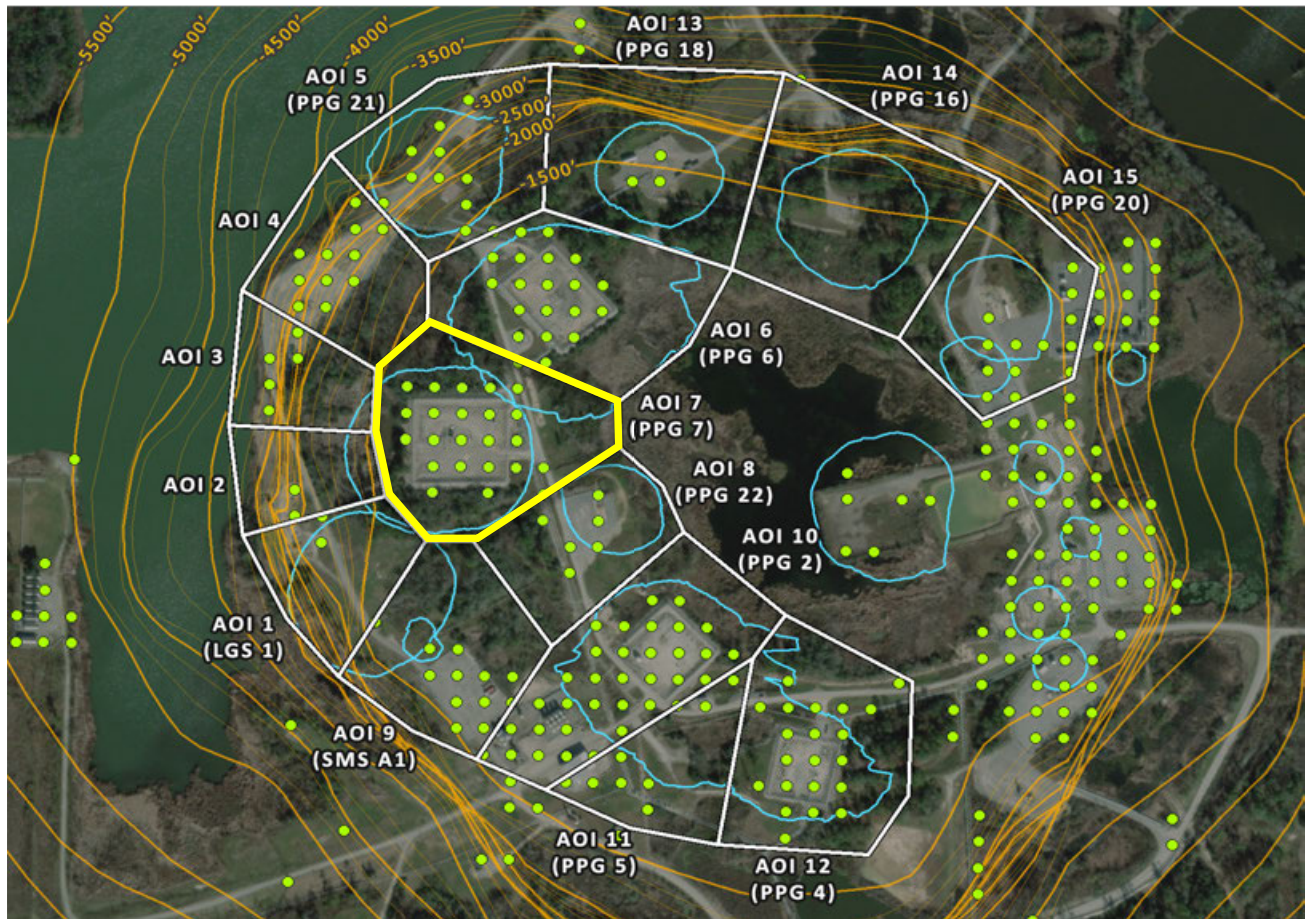
Vertical (3/30/2025) Point Count: 20



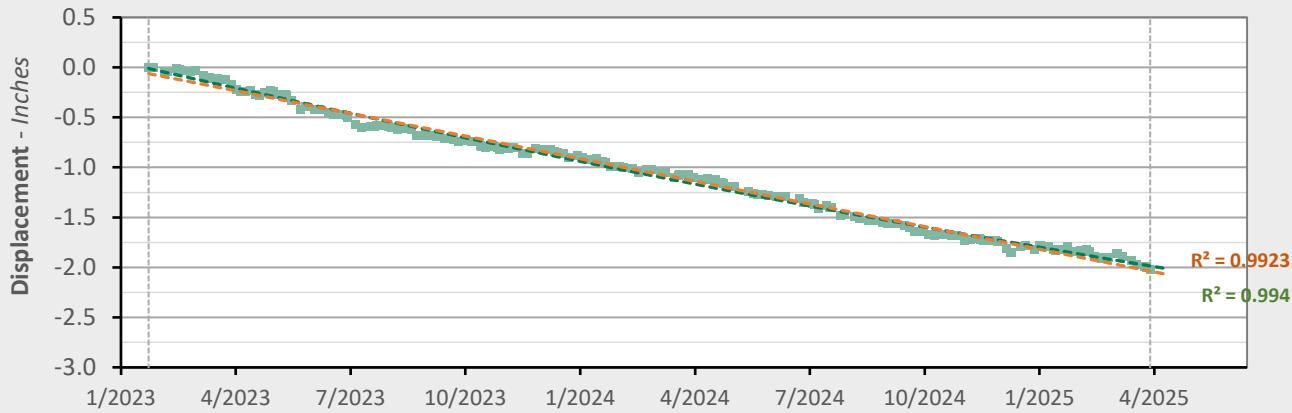
	Nonlinear Trend	Linear Trend
Velocity:	-0.71 in/yr	-0.83 in/yr
Acceleration:	+0.11 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



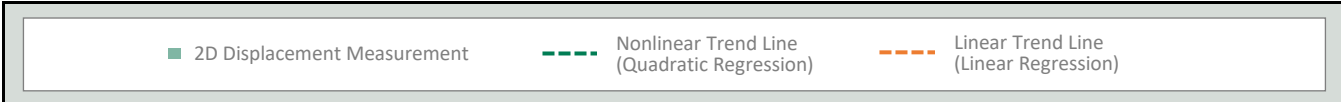
### AOI 7 (PPG 7) - Location Map



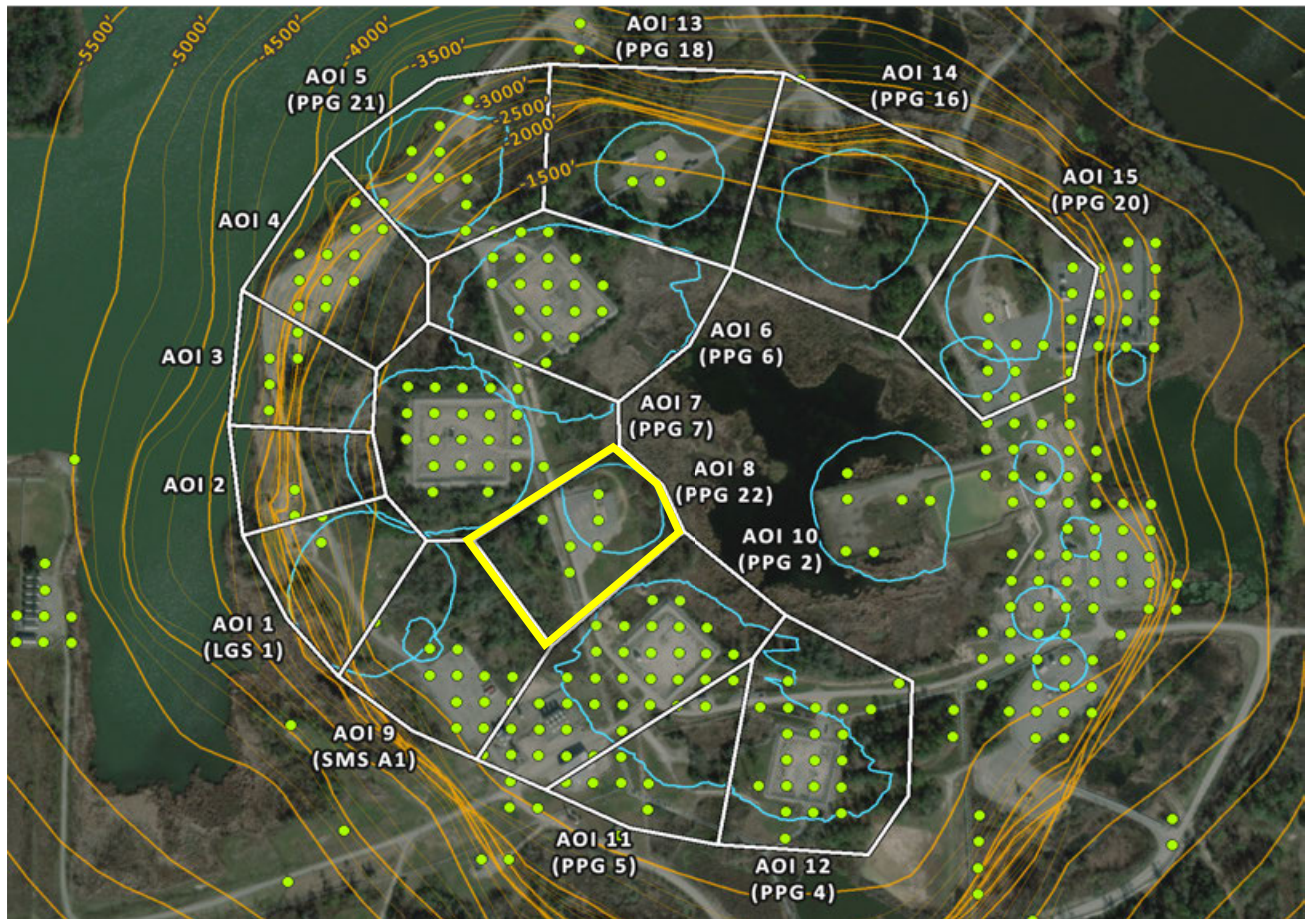
### AOI 7 (PPG 7) - Vertical Time Series Vertical (3/30/2025) Point Count: 25



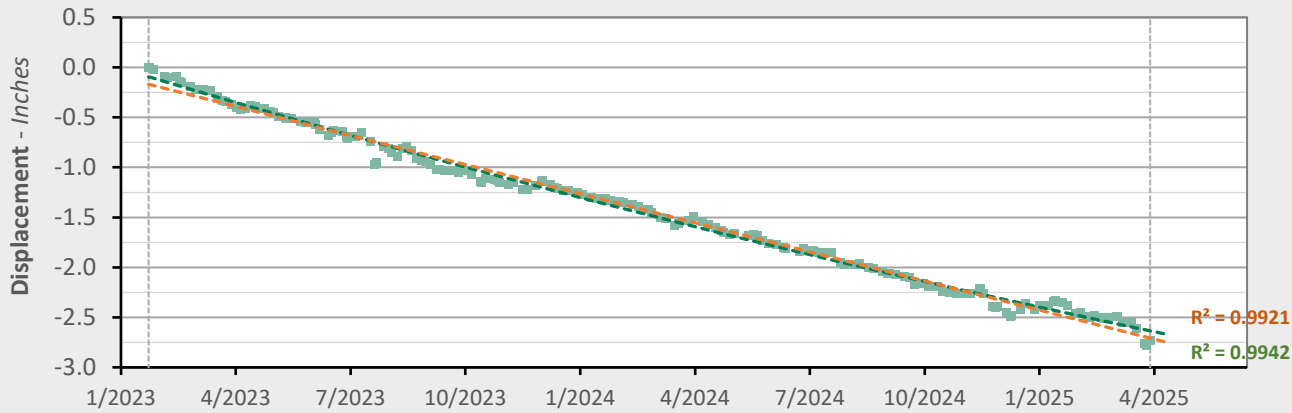
	Nonlinear Trend	Linear Trend
Velocity:	-0.76 in/yr	-0.91 in/yr
Acceleration:	+0.13 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



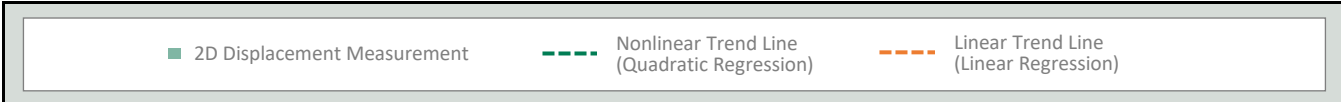
### AOI 8 (PPG 22) - Location Map



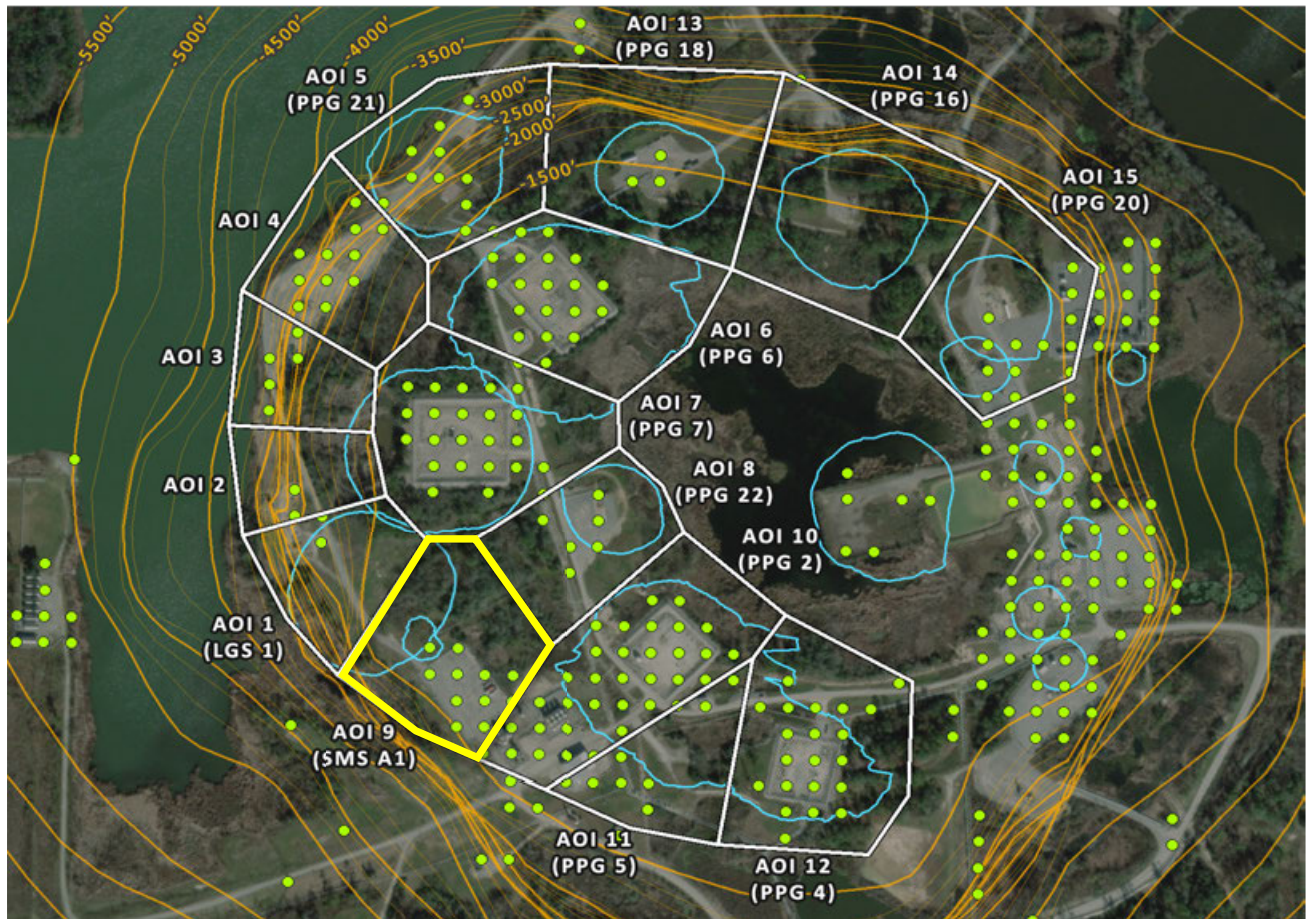
### AOI 8 (PPG 22) - Vertical Time Series Vertical (3/30/2025) Point Count: 7



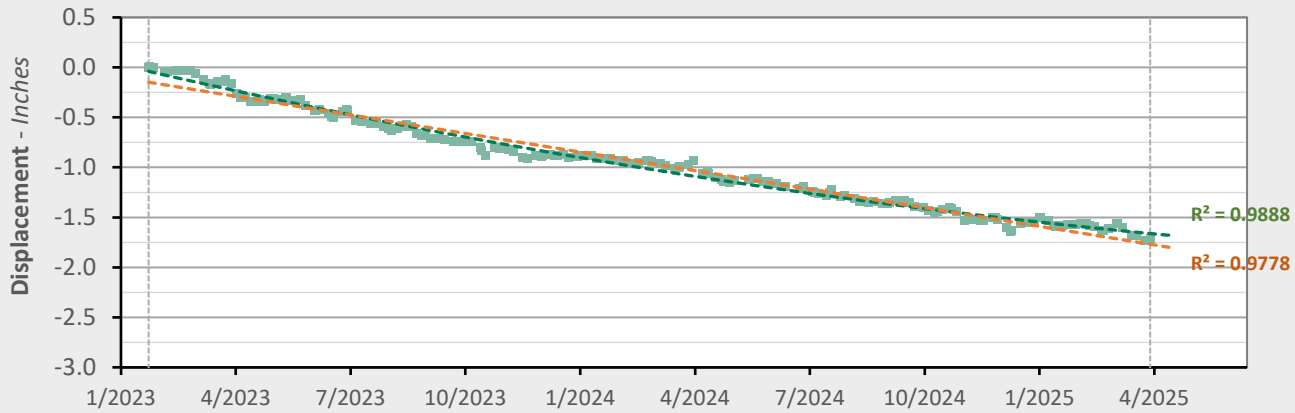
	Nonlinear Trend	Linear Trend
Velocity:	-0.95 in/yr	-1.16 in/yr
Acceleration:	+0.19 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



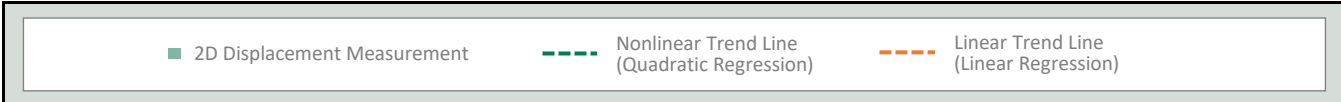
### AOI 9 (PPG A1) - Location Map



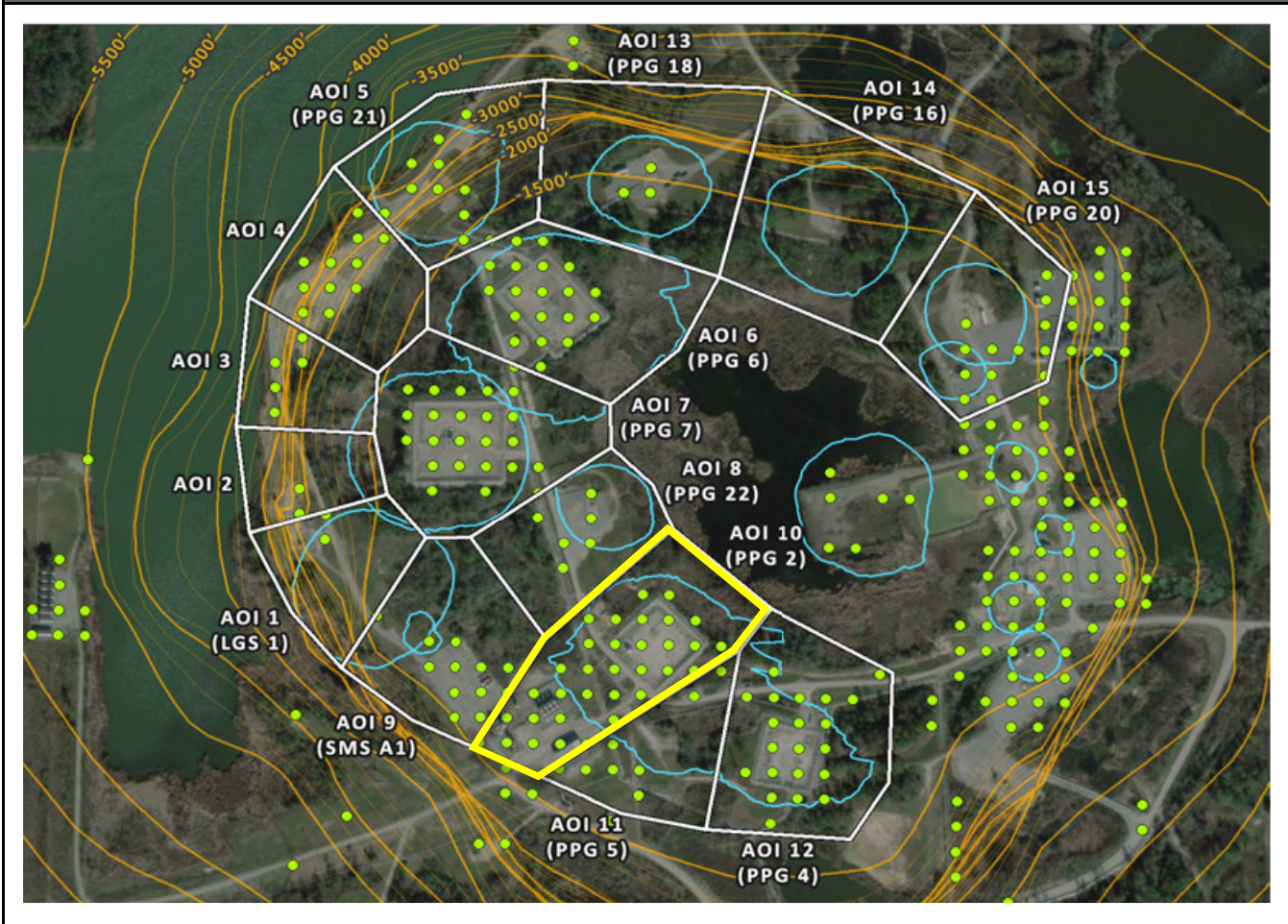
### AOI 9 (SMS A1) - Vertical Time Series Vertical (3/30/2025) Point Count: 12



	Nonlinear Trend	Linear Trend
Velocity:	-0.44 in/yr	-0.74 in/yr
Acceleration:	+0.28 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

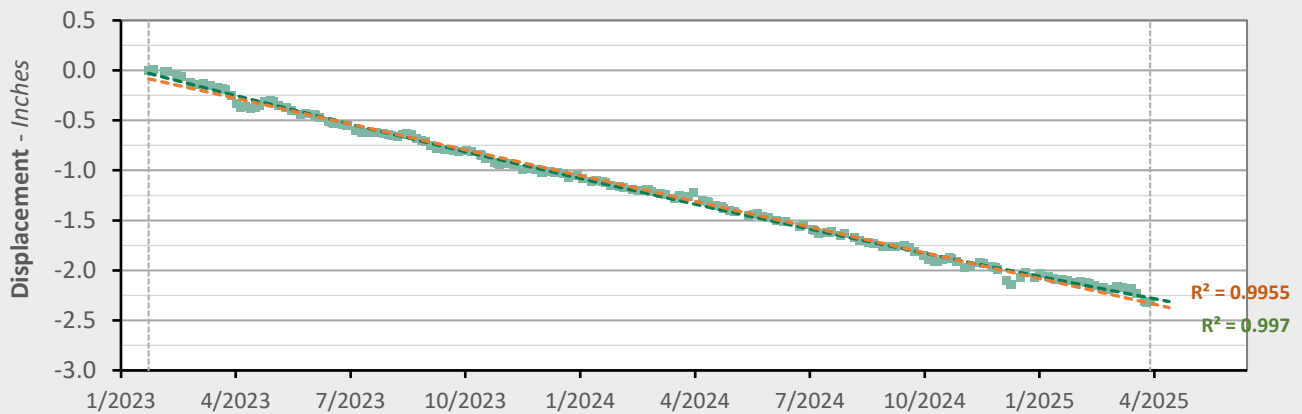


### AOI 10 (PPG 2) - Location Map

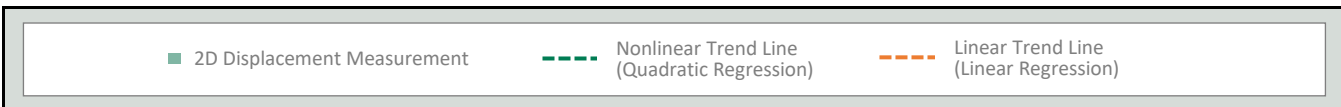


### AOI 10 (PPG 2) - Vertical Time Series

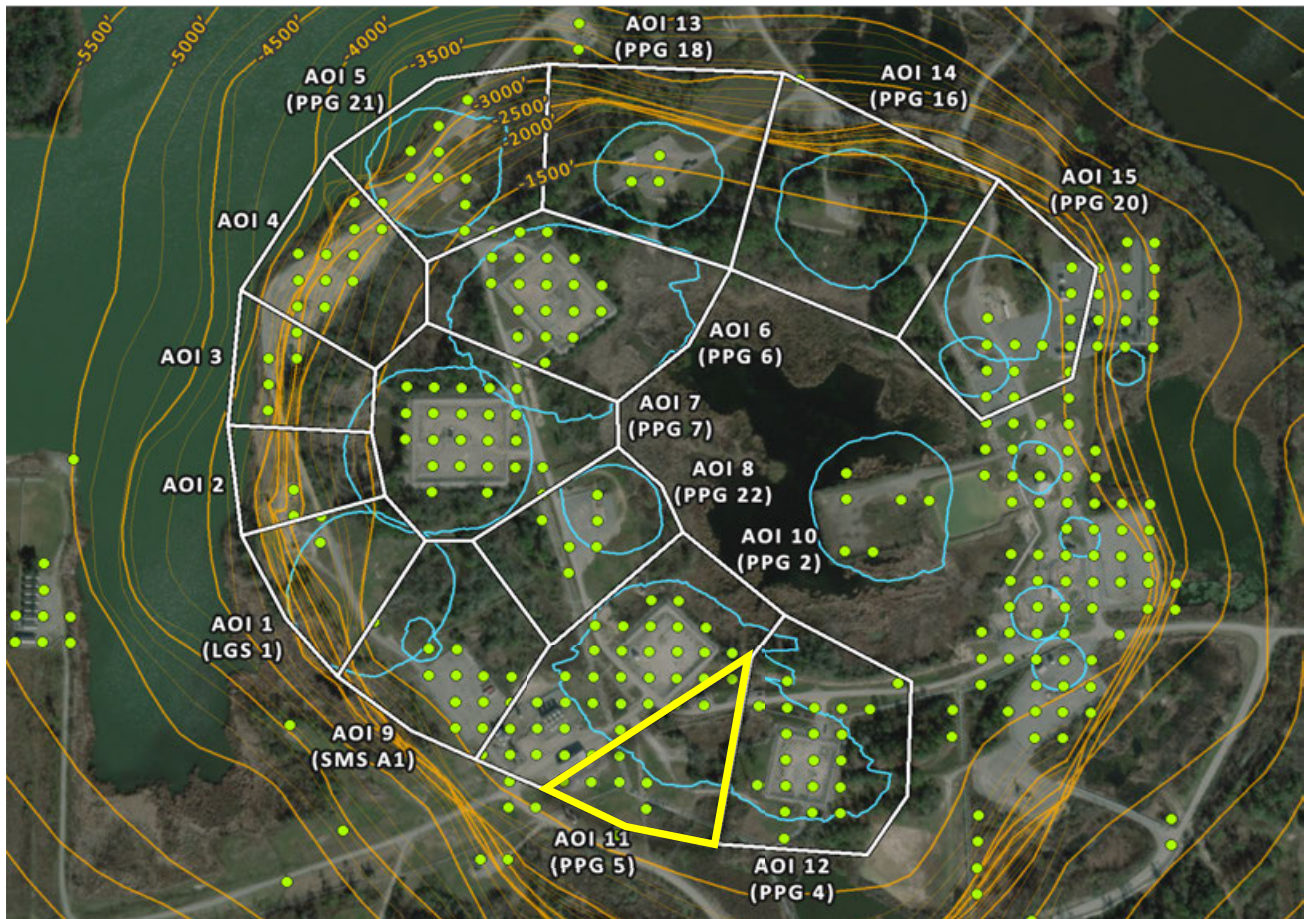
Vertical (3/30/2025) Point Count: **33**



	Nonlinear Trend	Linear Trend
Velocity:	-0.87 in/yr	-1.03 in/yr
Acceleration:	+0.14 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

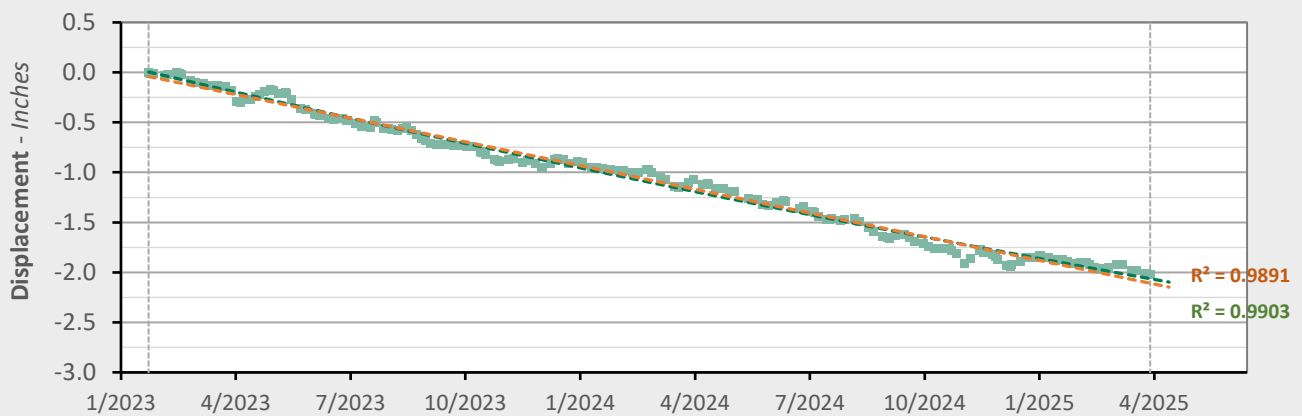


### AOI 11 (PPG 5) - Location Map

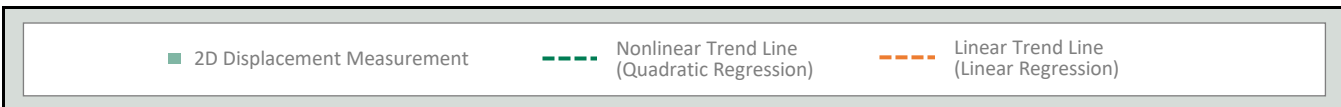


### AOI 11 (PPG 5) - Vertical Time Series

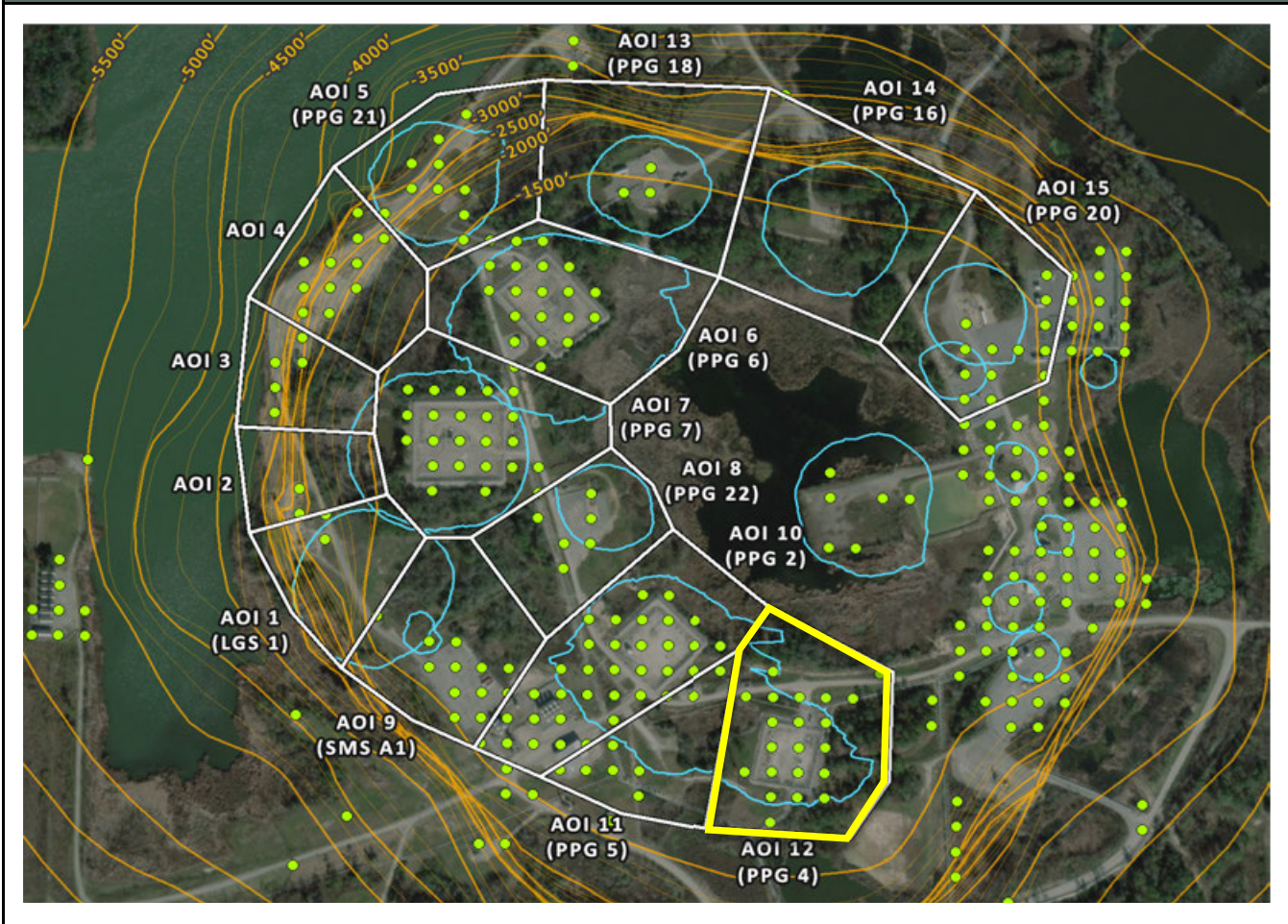
Vertical (3/30/2025) Point Count: 9



	Nonlinear Trend	Linear Trend
Velocity:	-0.82 in/yr	-0.95 in/yr
Acceleration:	+0.12 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

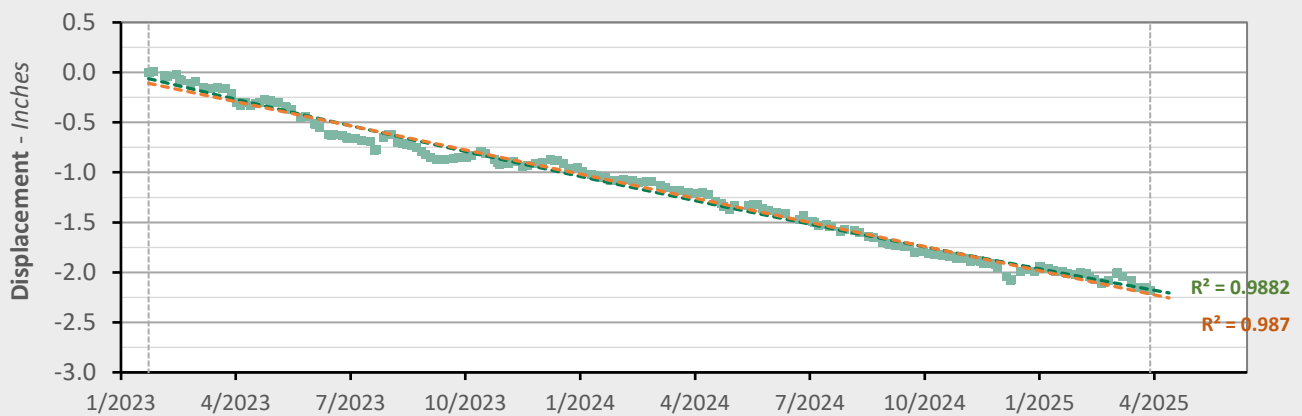


### AOI 12 (PPG 4) - Location Map

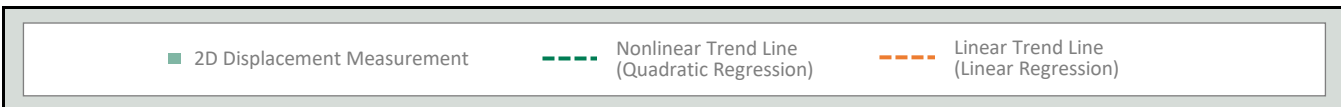


### AOI 12 (PPG 4) - Vertical Time Series

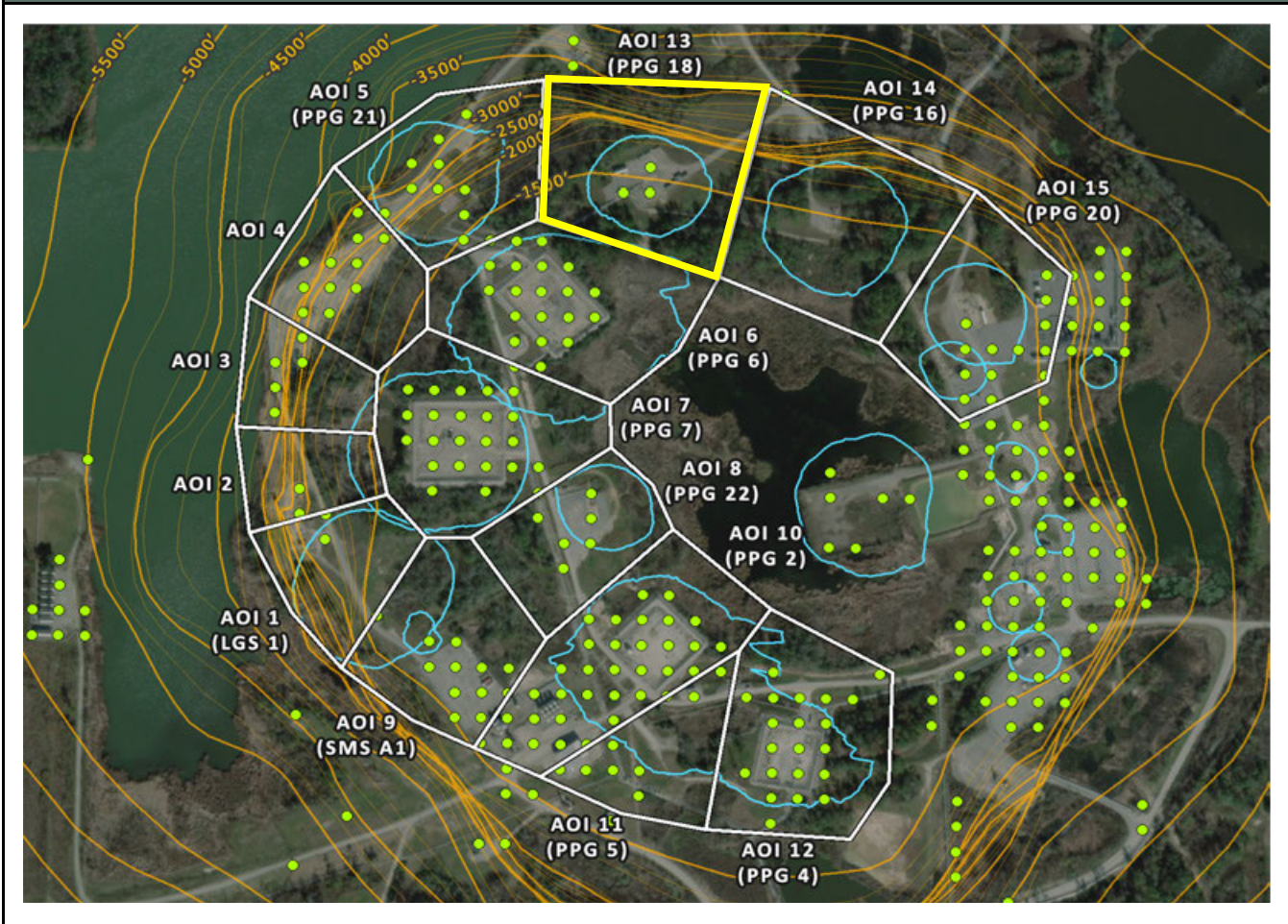
Vertical (3/30/2025) Point Count: **21**



	Nonlinear Trend	Linear Trend
Velocity:	-0.84 in/yr	-0.97 in/yr
Acceleration:	+0.12 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

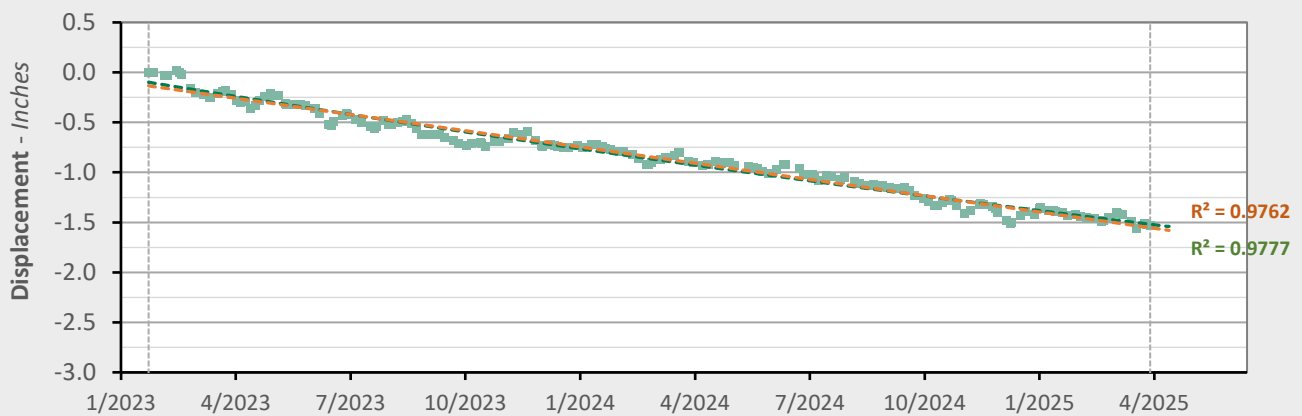


### AOI 13 (PPG 18) - Location Map

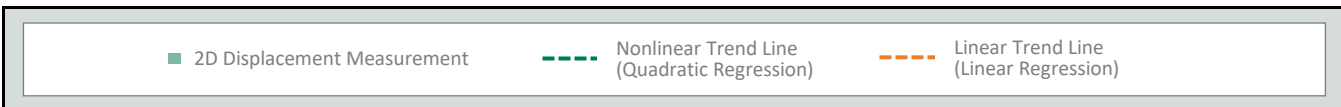


### AOI 13 (PPG 18) - Vertical Time Series

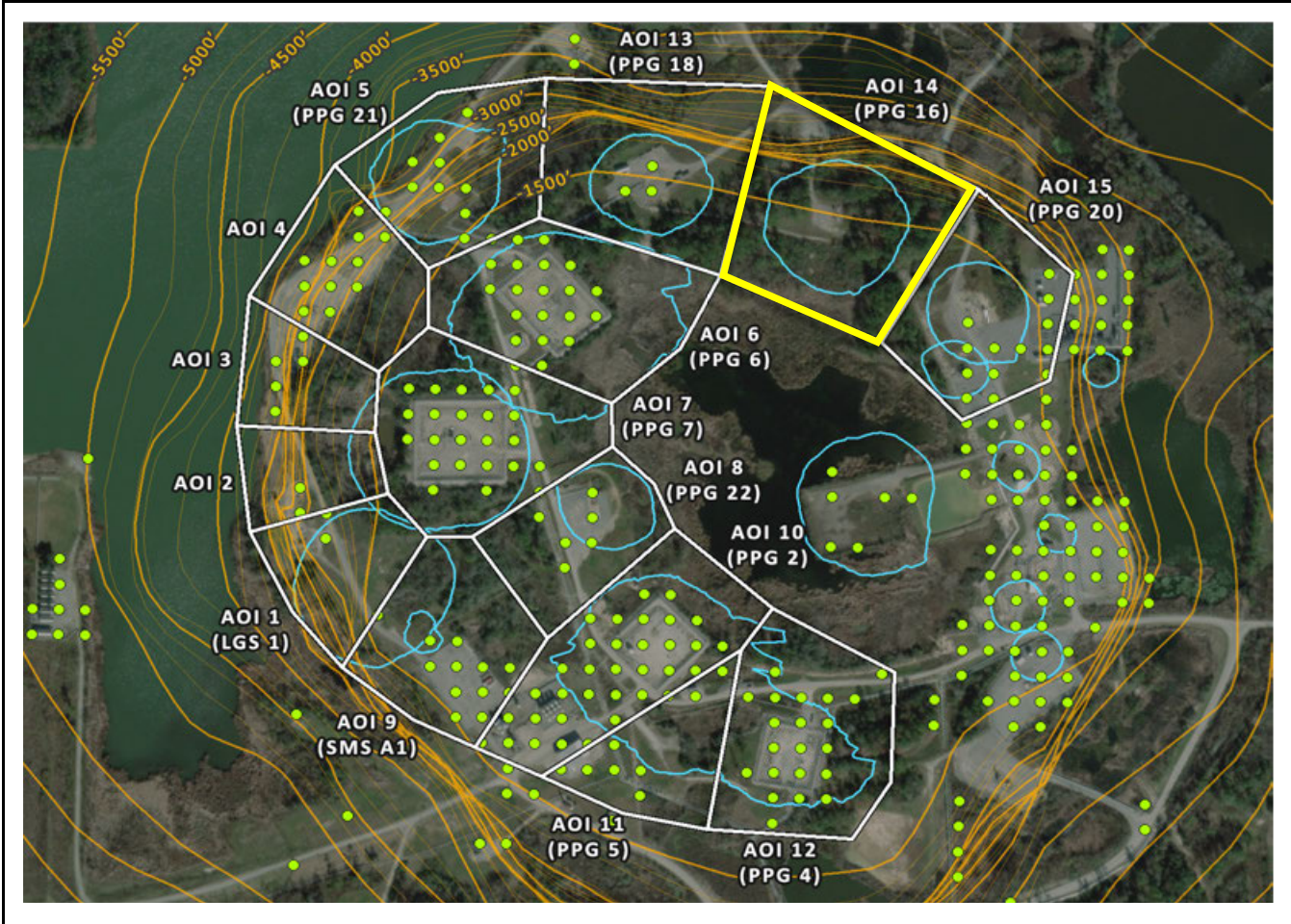
Vertical (3/30/2025) Point Count: **3**



	Nonlinear Trend	Linear Trend
Velocity:	-0.55 in/yr	-0.65 in/yr
Acceleration:	+0.09 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

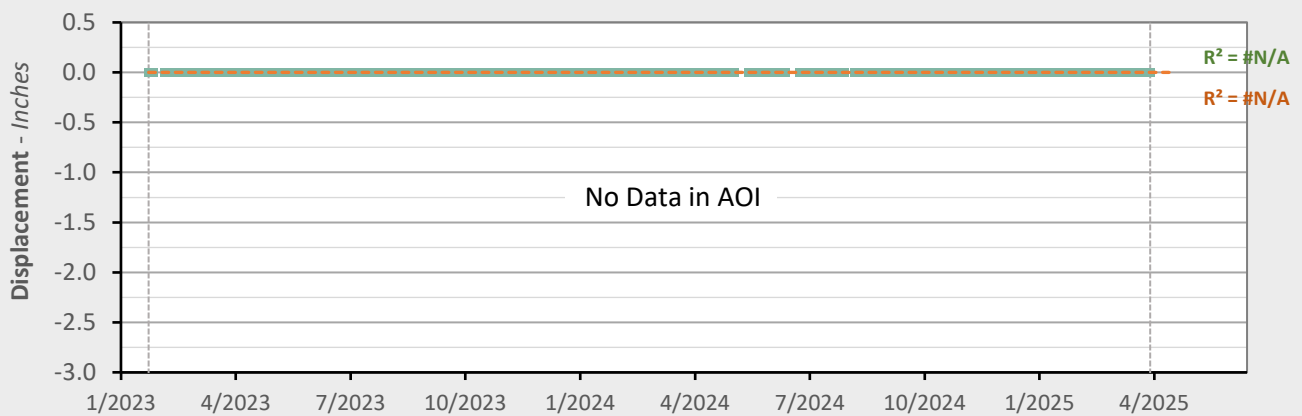


### AOI 14 (PPG 16) - Location Map

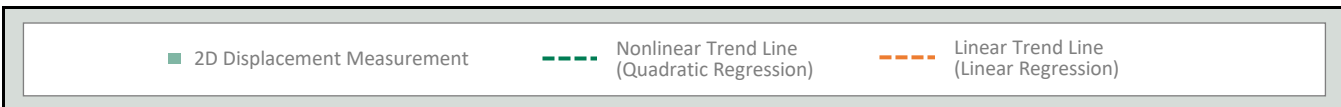


### AOI 14 (PPG 16) - Vertical Time Series

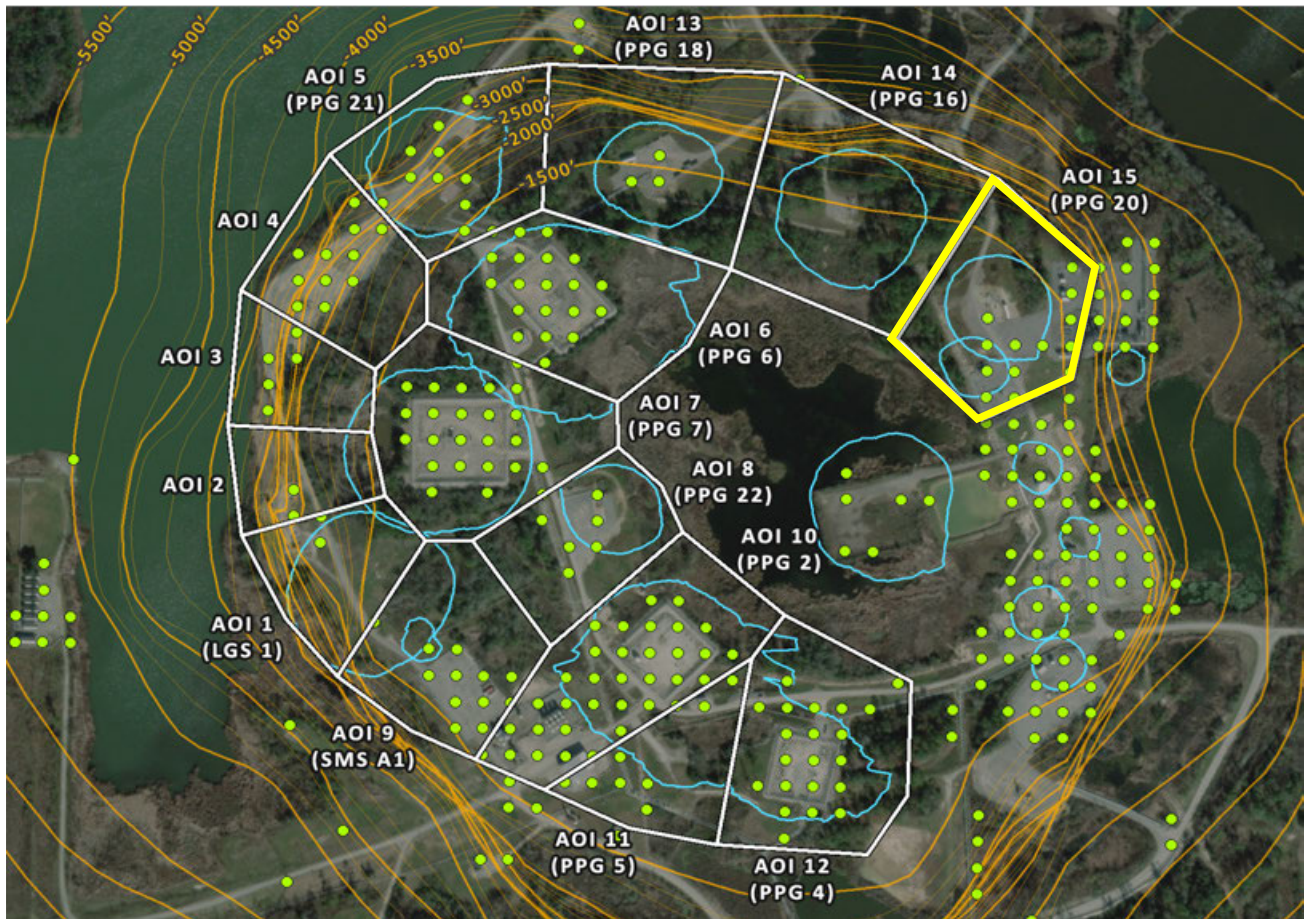
Vertical (3/30/2025) Point Count: **0**



Nonlinear Trend		Linear Trend	
Velocity:	N/A in/yr	N/A	in/yr
Acceleration:	N/A in/yr <sup>2</sup>	N/A	in/yr <sup>2</sup>

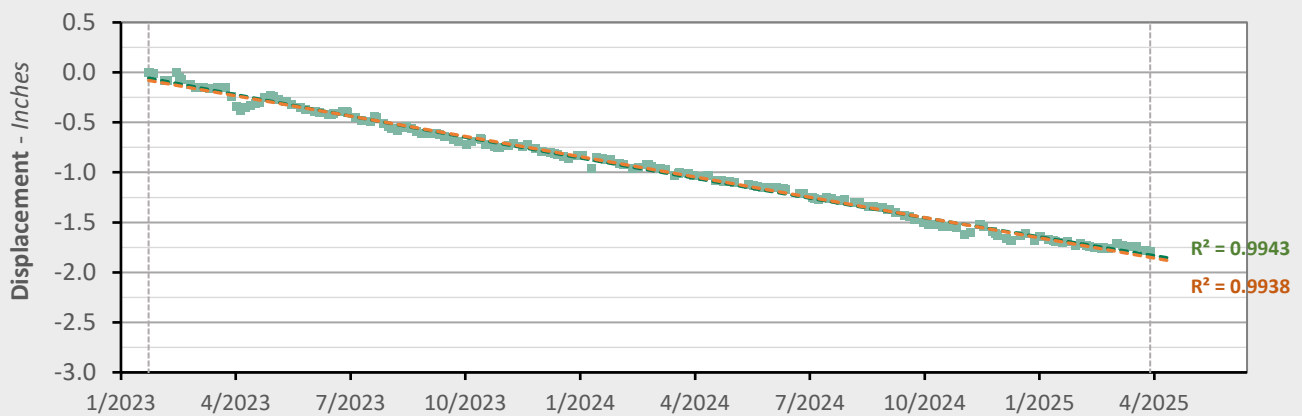


### AOI 15 (PPG 20) - Location Map

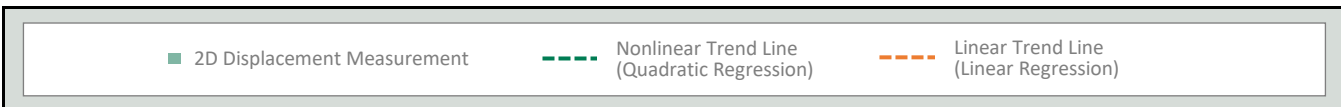


### AOI 15 (PPG 20) - Vertical Time Series

Vertical (3/30/2025) Point Count: **13**



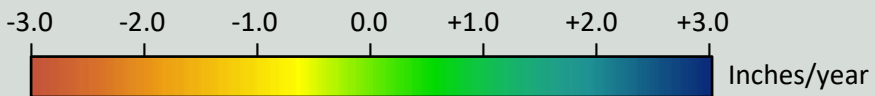
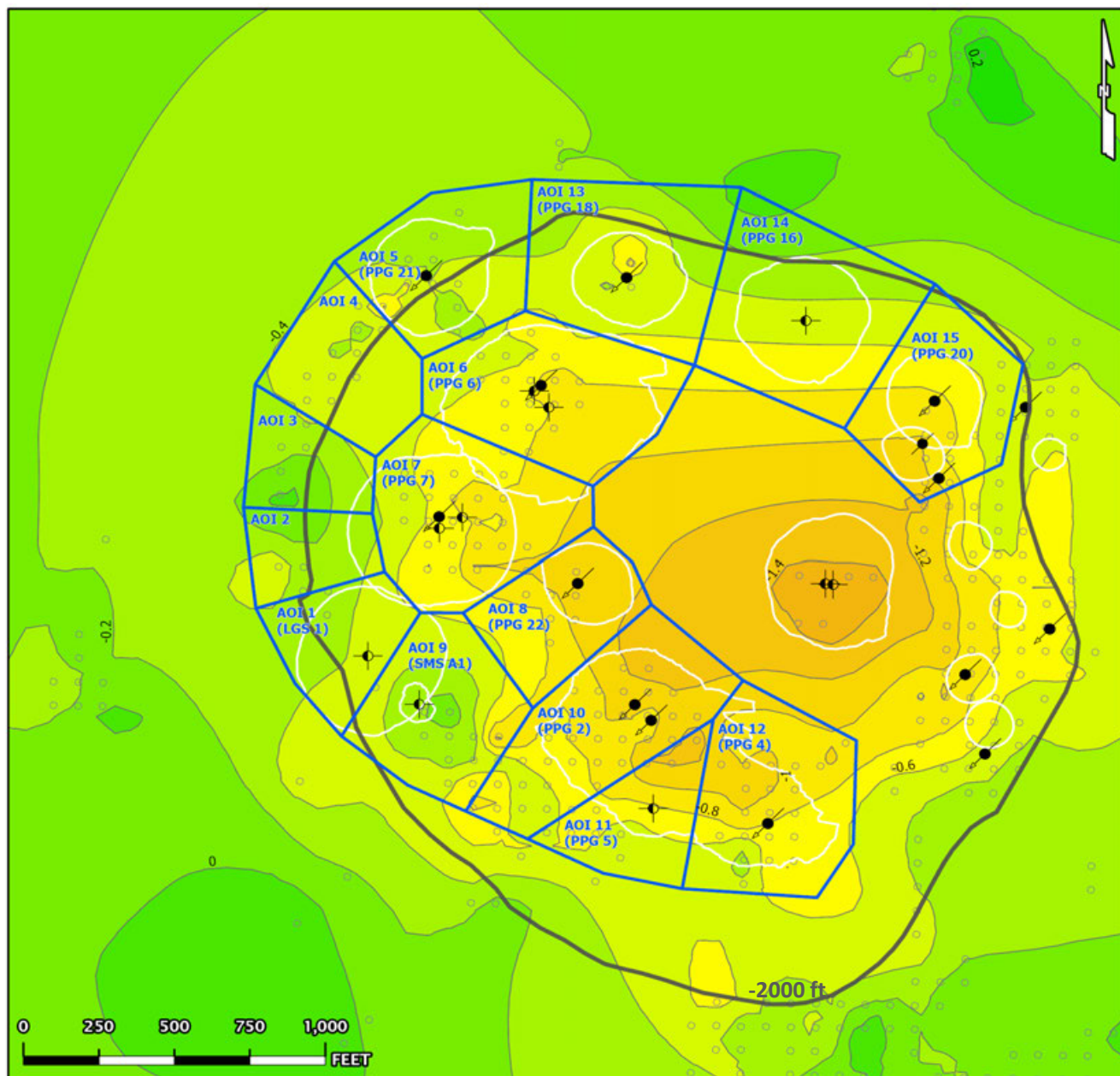
	Nonlinear Trend	Linear Trend
Velocity:	-0.74 in/yr	-0.81 in/yr
Acceleration:	+0.06 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



### Vertical Data (01/24/2023 - 03/30/2025)

### Nonlinear Velocity Contours

As of date: 03/30/2025

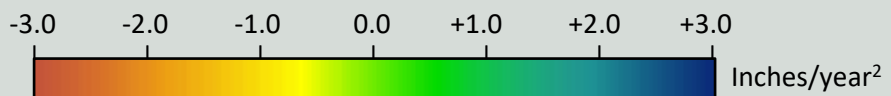
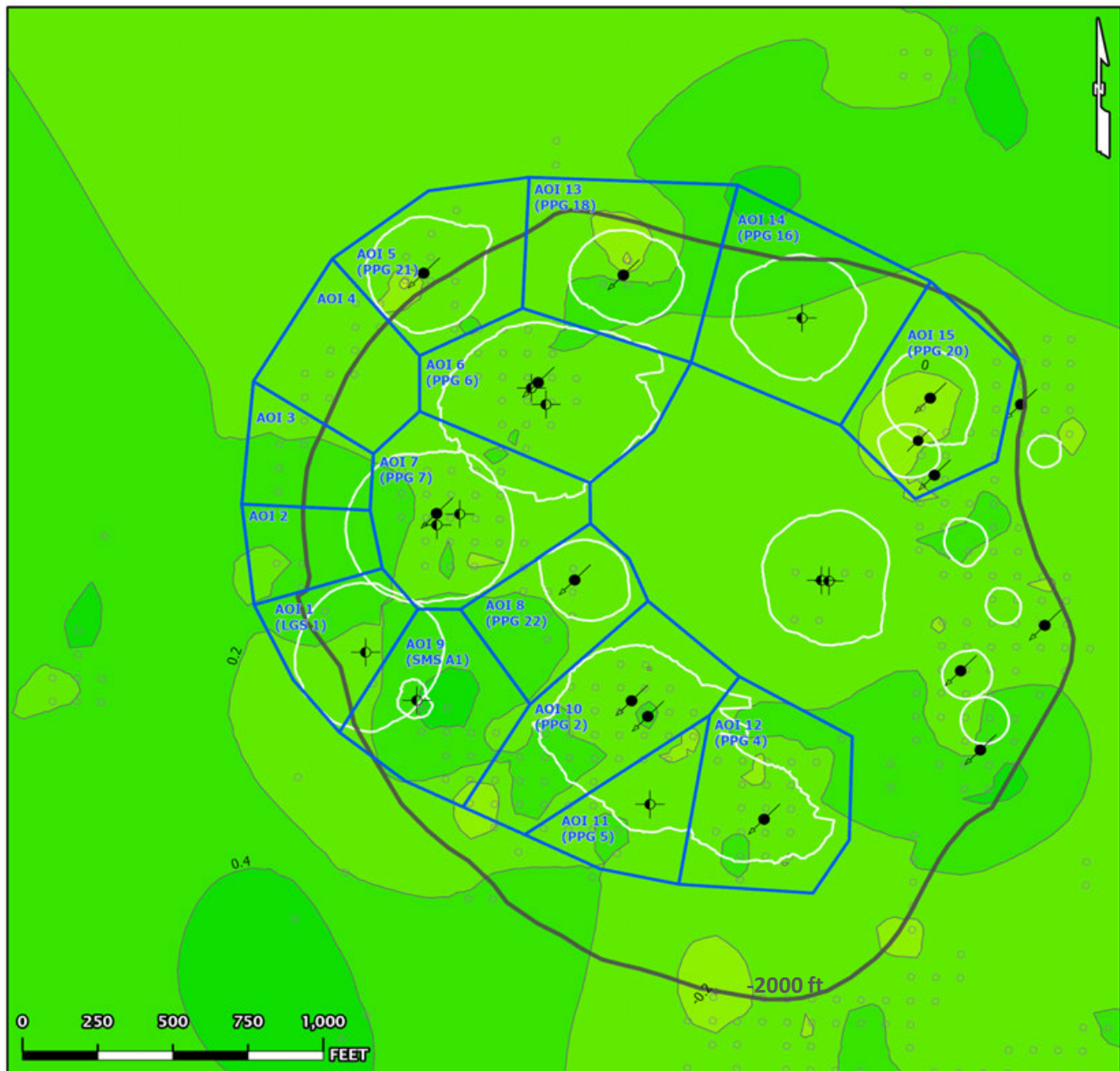


- AOI Boundary
- Historical Cavern Extent
- Top of Dome (-2000 ft Contour)
- InSAR LOS Measurement Point
- Contour (0.2)
- Cavern Well Surface Locations**
- 09 - Active - Injection
- 29 - Dry and Plugged

**Vertical Data (01/24/2023 - 03/30/2025)**

**Nonlinear Acceleration Contours**

Date range: 01/24/2023 - 03/30/2025

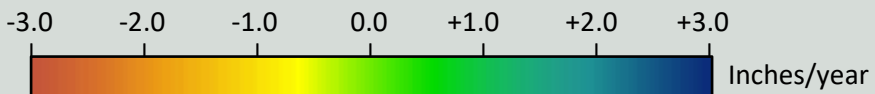
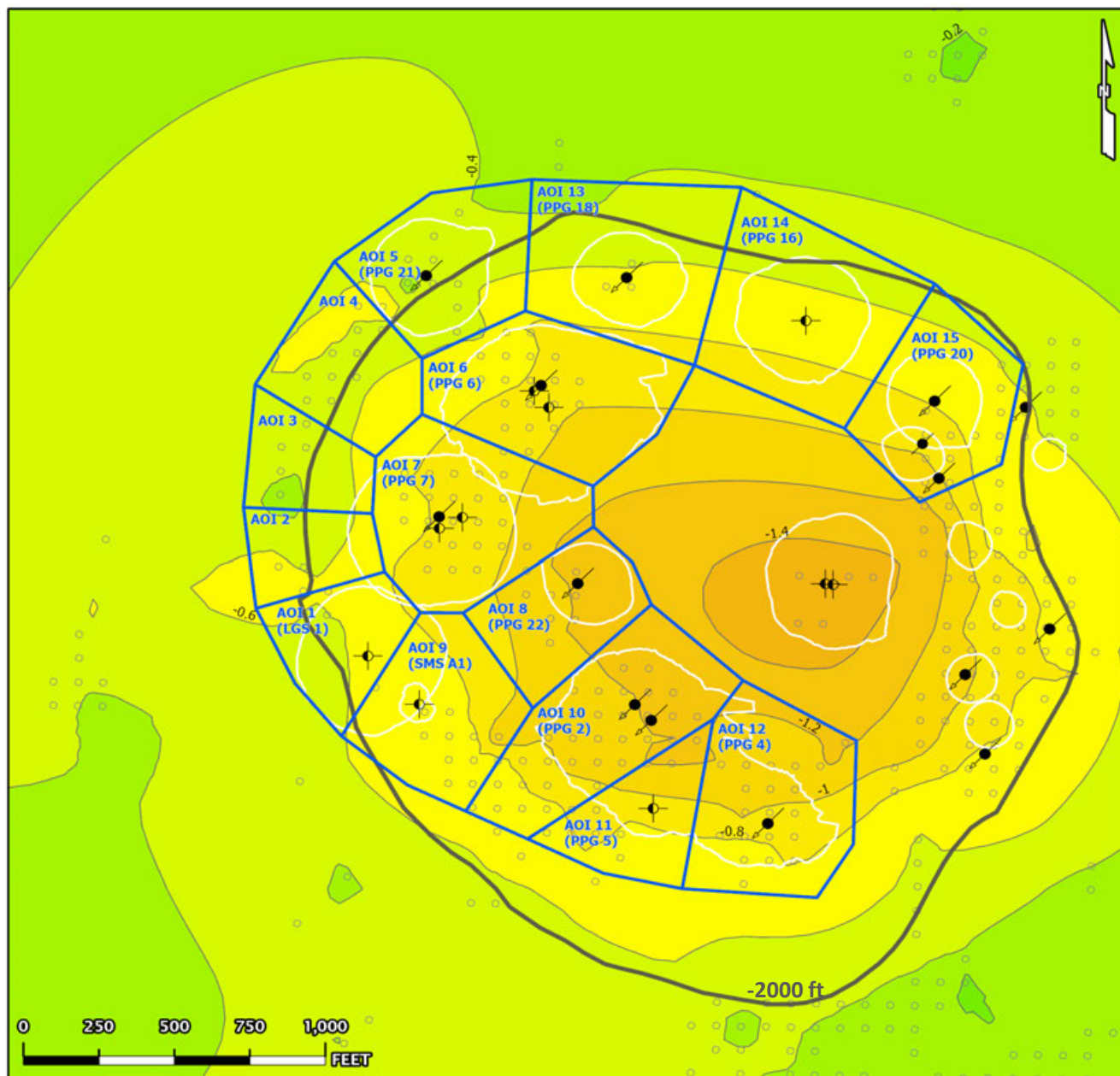


- AOI Boundary
  - InSAR LOS Measurement Point
  - Contour (0.2)
  - Historical Cavern Extent
  - Top of Dome (-2000 ft Contour)
- Cavern Well Surface Locations
- 09 - Active - Injection
  - 29 - Dry and Plugged

**Vertical Data (01/24/2023 - 03/30/2025)**

**Linear Velocity Contours**

Date range: 01/24/2023 - 03/30/2025

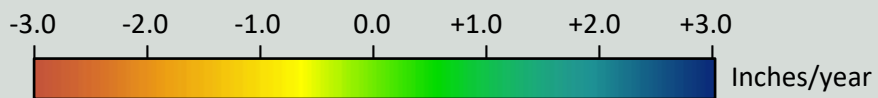
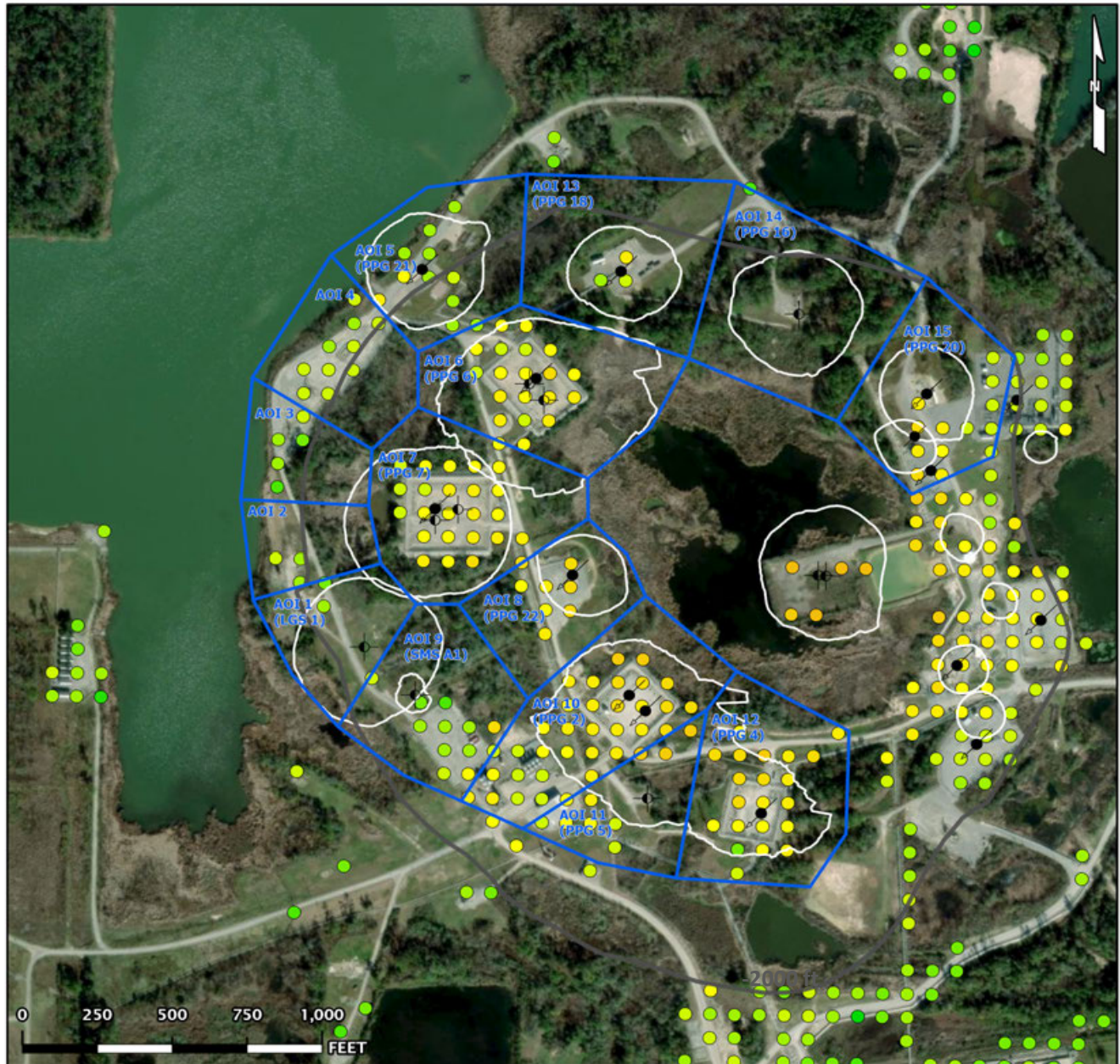


- AOI Boundary
  - InSAR LOS Measurement Point
  - Contour (0.2)
  - Historical Cavern Extent
  - Top of Dome (-2000 ft Contour)
- Cavern Well Surface Locations
- 09 - Active - Injection
  - 29 - Dry and Plugged

**Vertical Data (01/24/2023 - 03/30/2025)**

**Nonlinear Velocity Data Points**

As of date: 03/30/2025

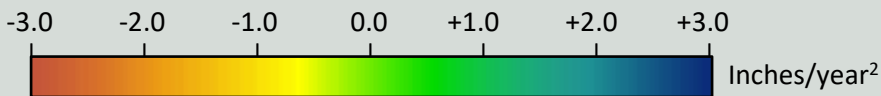
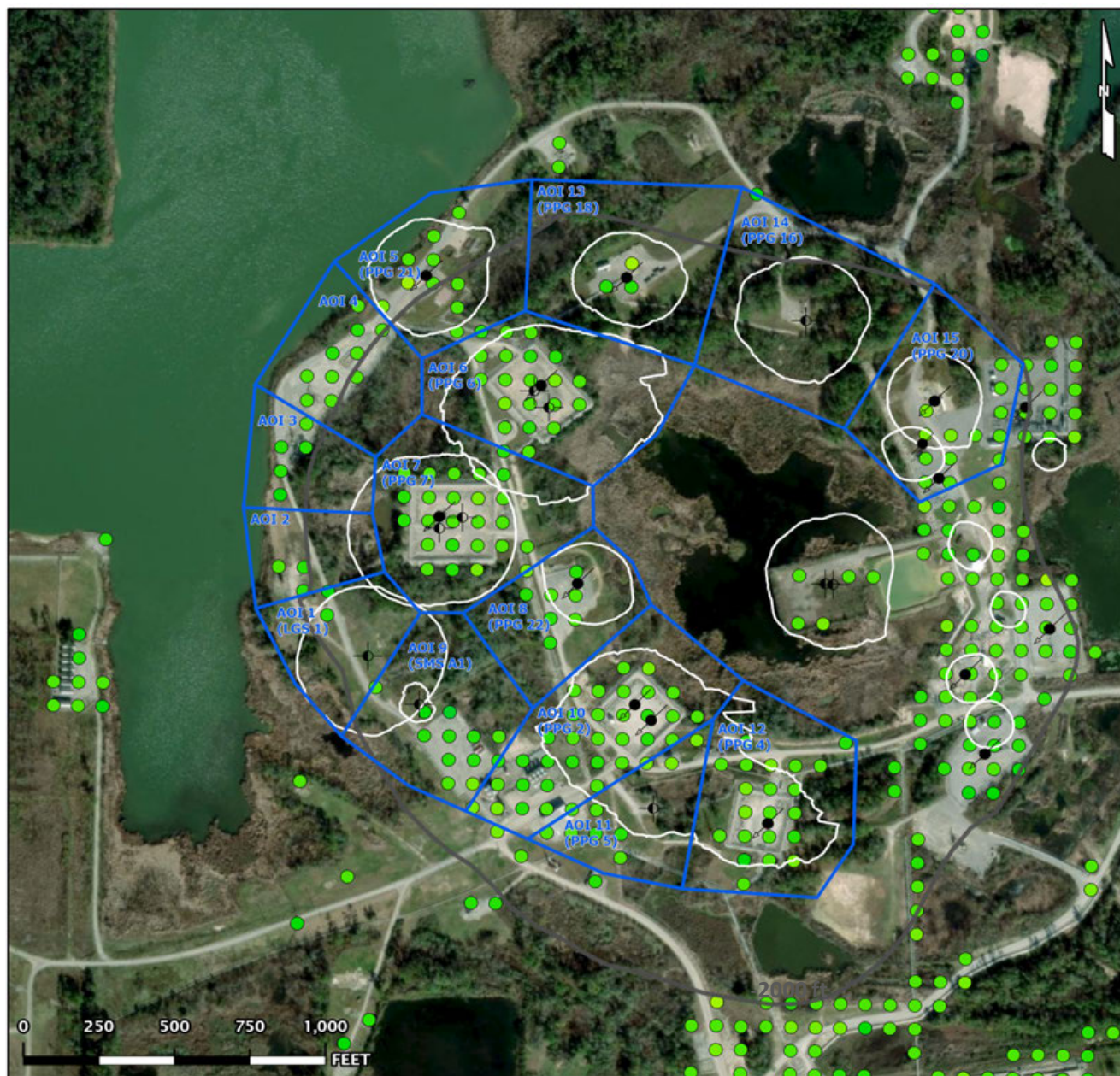


- AOI Boundary
- Historical Cavern Extent
- Top of Dome (-2000 ft Contour)
- Cavern Well Surface Locations
- 09 - Active - Injection
- 29 - Dry and Plugged

### Vertical Data (01/24/2023 - 03/30/2025)

#### Nonlinear Acceleration Data Points

Date range: 01/24/2023 - 03/30/2025

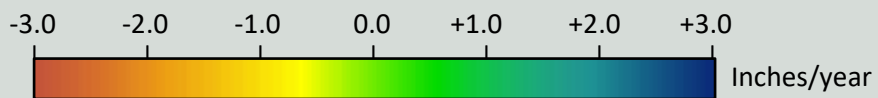
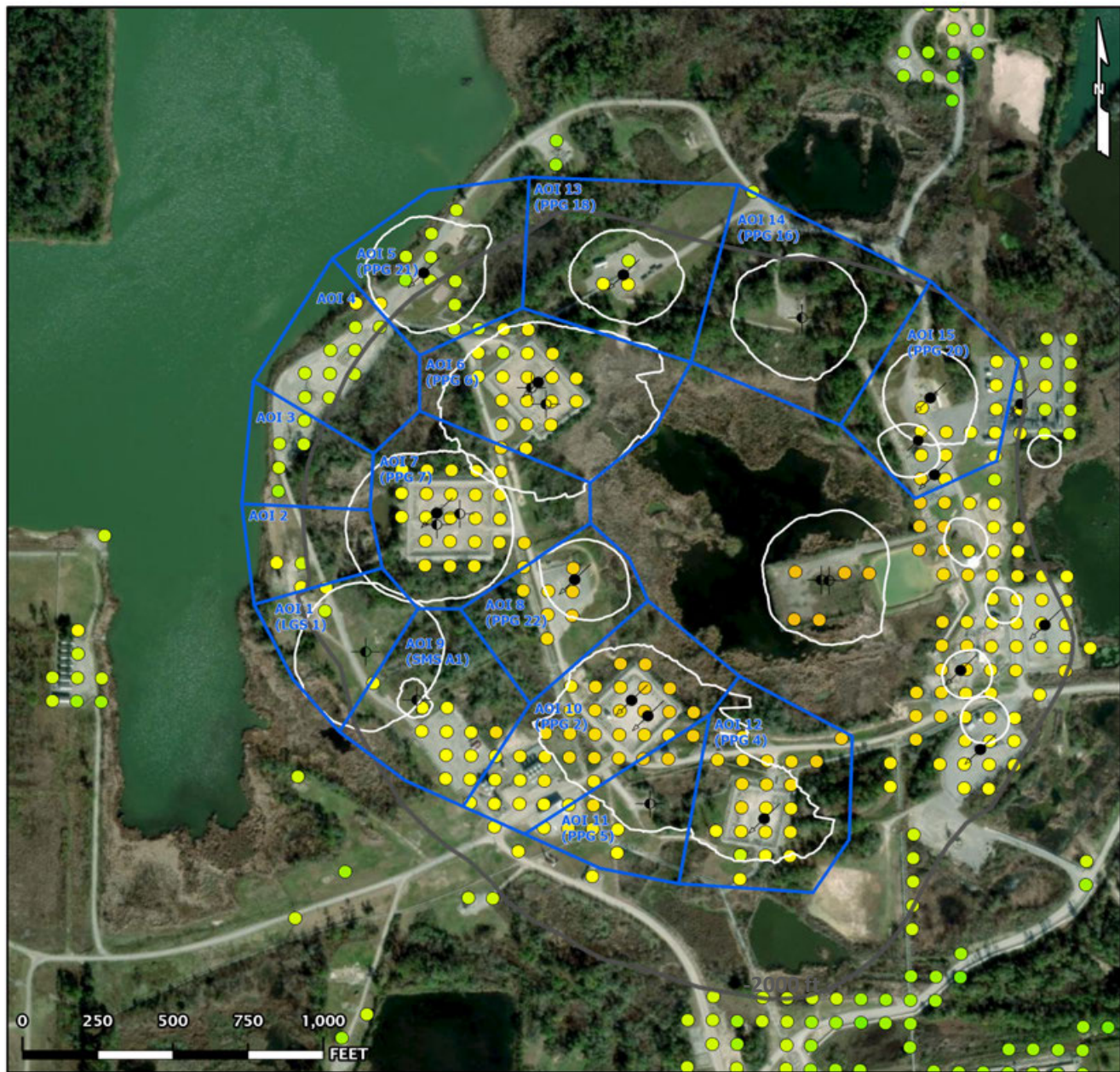


- AOI Boundary
  - InSAR LOS Measurement Point
  - Historical Cavern Extent
  - Top of Dome (-2000 ft Contour)
- Cavern Well Surface Locations
- 09 - Active - Injection
  - 29 - Dry and Plugged

### Vertical Data (01/24/2023 - 03/30/2025)

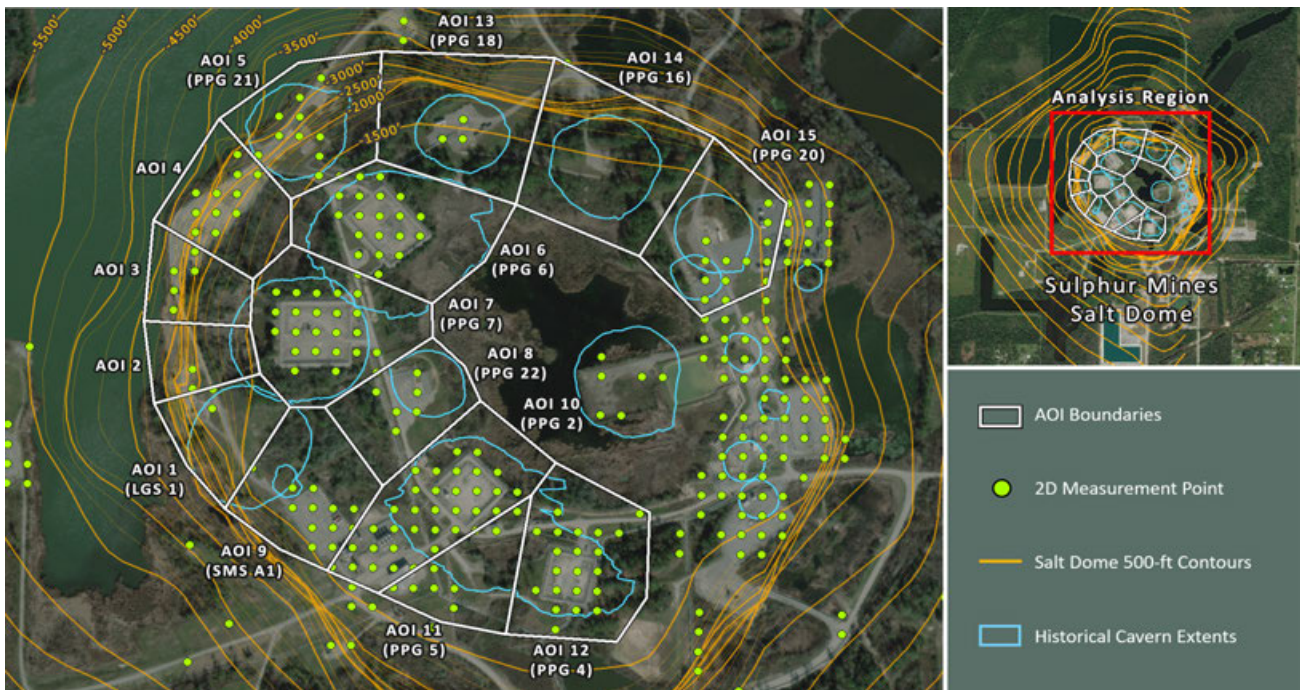
#### Linear Velocity Data Points

Date range: 01/24/2023 - 03/30/2025



- 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

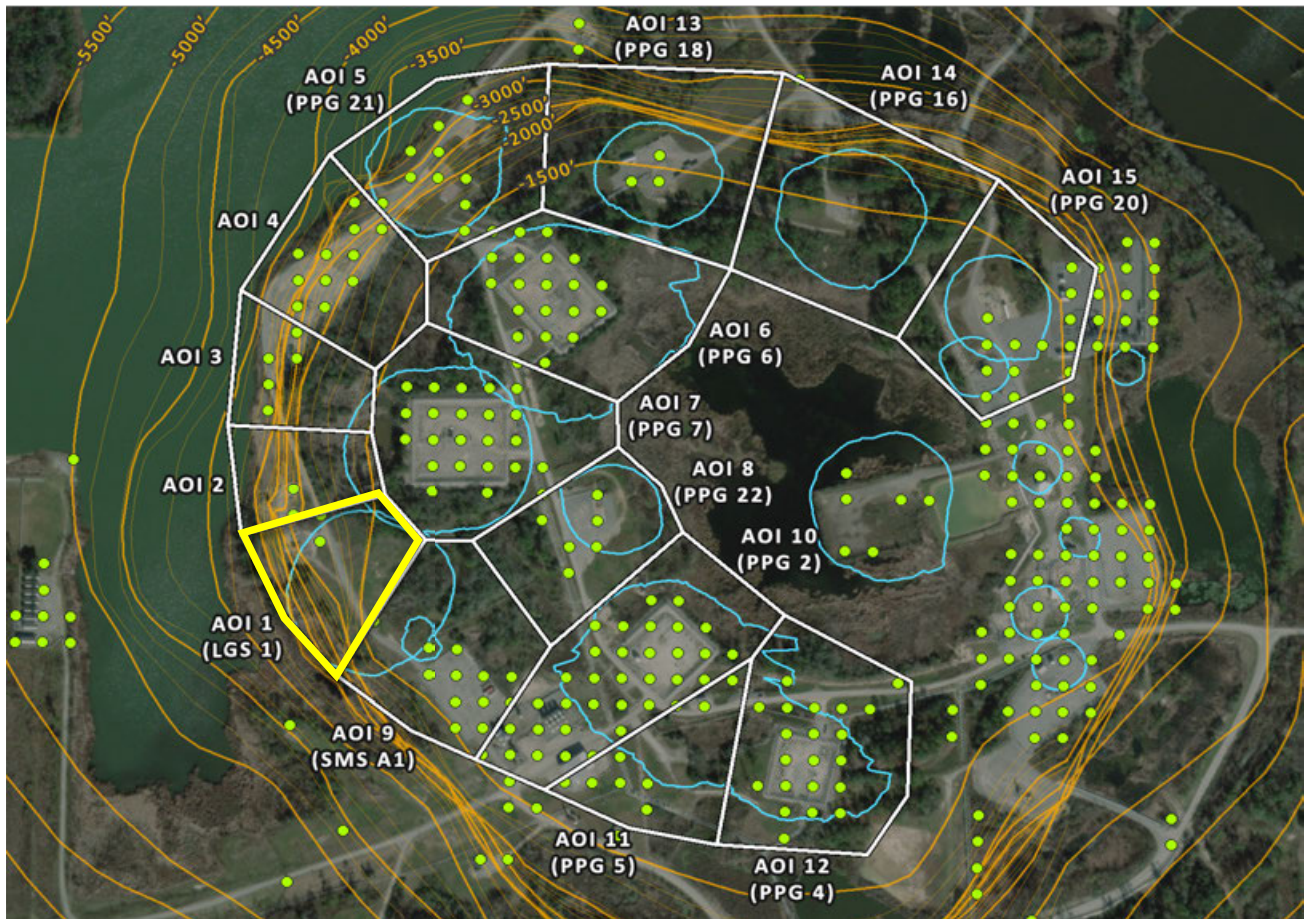


### Subsidence Monitoring Areas of Interest (AOIs)

To visually convey and evaluate trend consistency for the East-West displacement time series of each ground target, measurement 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.

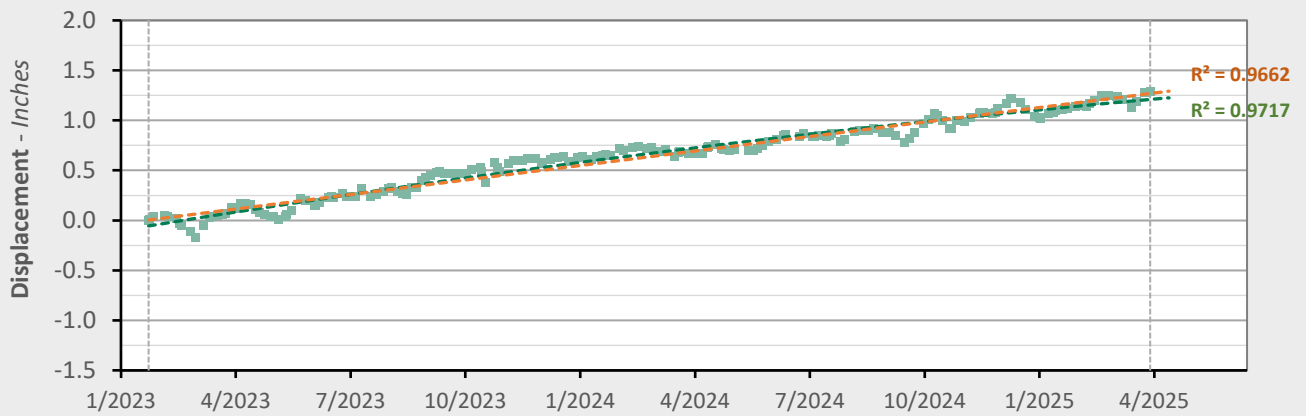
AOI Name	East-West (3/30/2025)	East-West Velocity (in/yr)		East-West Acceleration (in/yr <sup>2</sup> )	
	Point Count	Nonlinear	Linear	Nonlinear	Linear
<b>AOI 1 (LGS 1)</b>	2	+0.41	+0.58	-0.16	0.00
<b>AOI 2</b>	3	+0.52	+0.58	-0.05	0.00
<b>AOI 3</b>	5	+0.40	+0.50	-0.10	0.00
<b>AOI 4</b>	10	+0.53	+0.51	+0.02	0.00
<b>AOI 5 (PPG 21)</b>	10	+0.35	+0.26	+0.09	0.00
<b>AOI 6 (PPG 6)</b>	20	+0.35	+0.36	-0.01	0.00
<b>AOI 7 (PPG 7)</b>	25	+0.61	+0.61	-0.01	0.00
<b>AOI 8 (PPG 22)</b>	7	+0.46	+0.54	-0.07	0.00
<b>AOI 9 (SMS A1)</b>	12	+0.60	+0.55	+0.05	0.00
<b>AOI 10 (PPG 2)</b>	33	+0.39	+0.39	+0.01	0.00
<b>AOI 11 (PPG 5)</b>	9	+0.46	+0.33	+0.12	0.00
<b>AOI 12 (PPG 4)</b>	21	-0.04	-0.06	+0.02	0.00
<b>AOI 13 (PPG 18)</b>	3	+0.28	+0.23	+0.04	0.00
<b>AOI 14 (PPG 16)</b>	0	N/A	N/A	N/A	N/A
<b>AOI 15 (PPG 20)</b>	13	-0.35	-0.41	+0.05	0.00

### AOI 1 (LGS 1) - Location Map

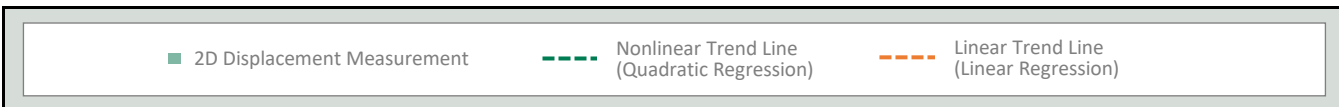


### AOI 1 (LGS 1) - East-West Time Series

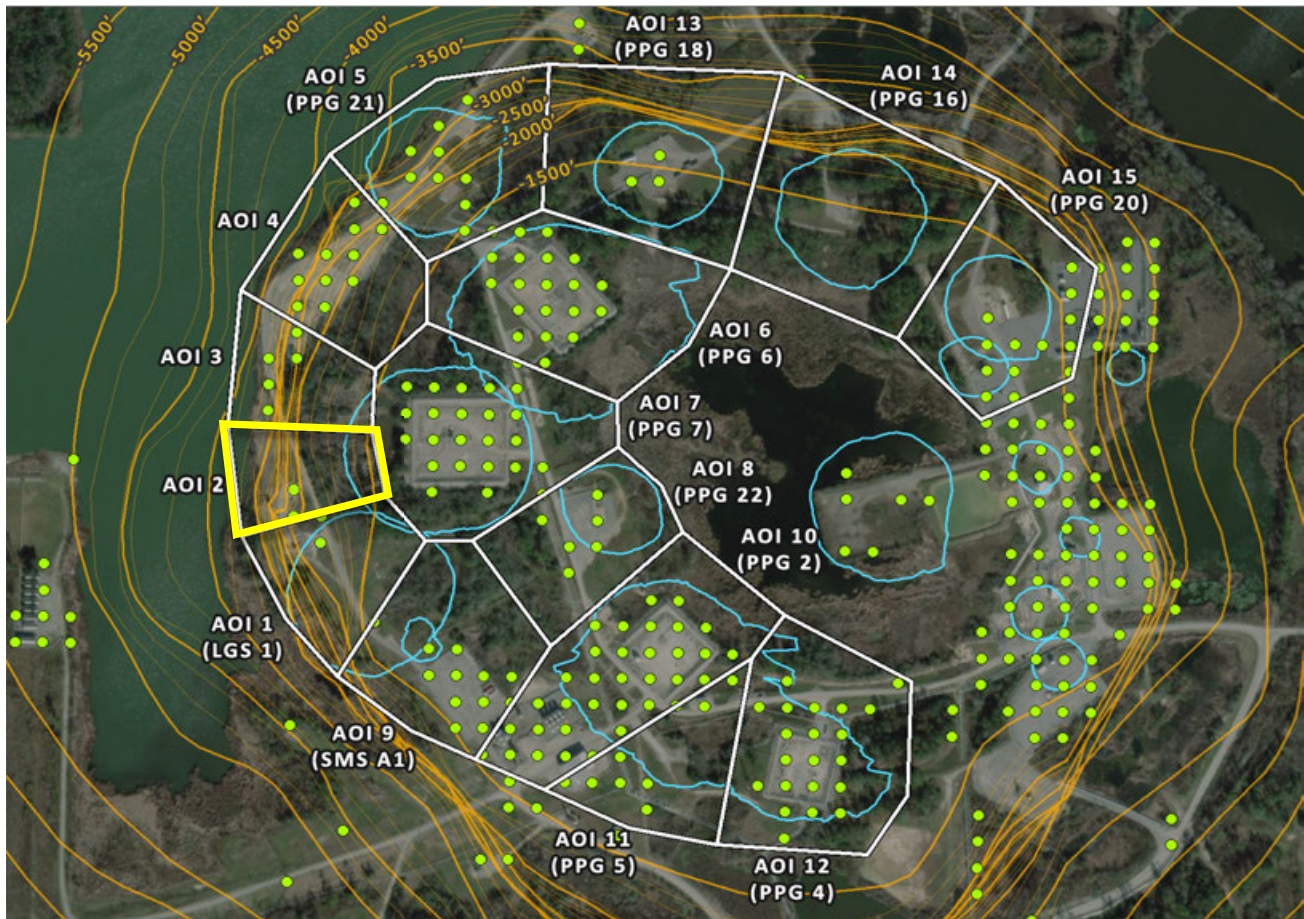
E-W (3/30/2025) Point Count: 2



	Nonlinear Trend	Linear Trend
Velocity:	+0.41 in/yr	+0.58 in/yr
Acceleration:	-0.16 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

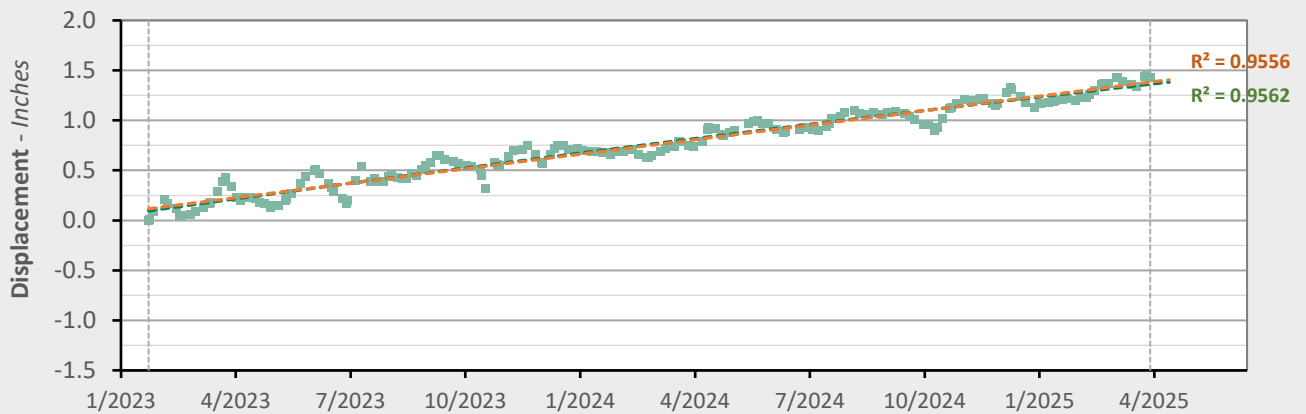


### AOI 2 - Location Map

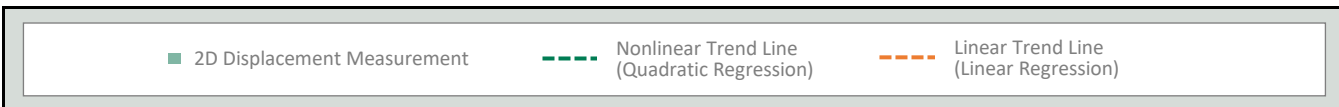


### AOI 2 - East-West Time Series

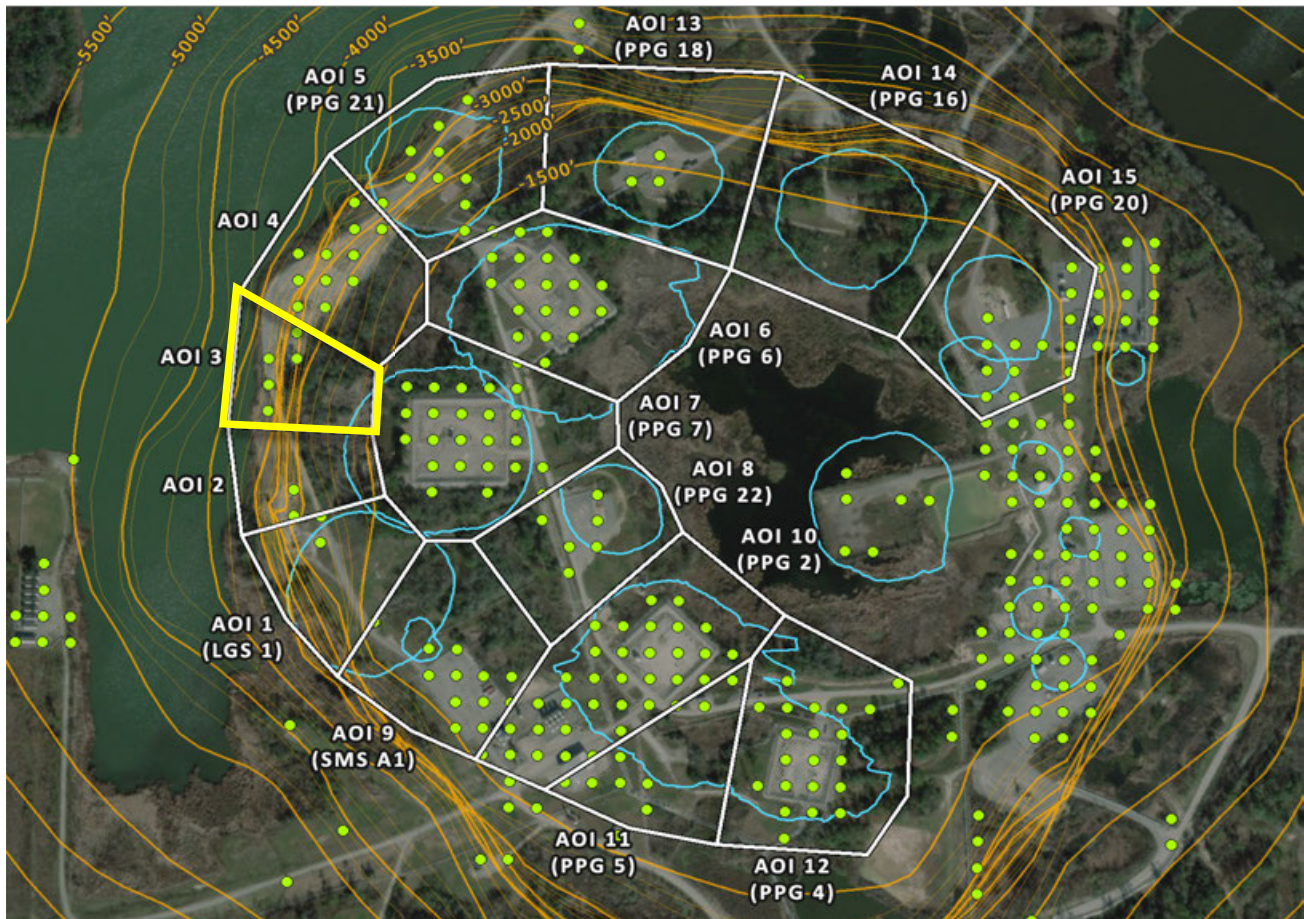
E-W (3/30/2025) Point Count: 3



	Nonlinear Trend	Linear Trend
Velocity:	+0.52 in/yr	+0.58 in/yr
Acceleration:	-0.05 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

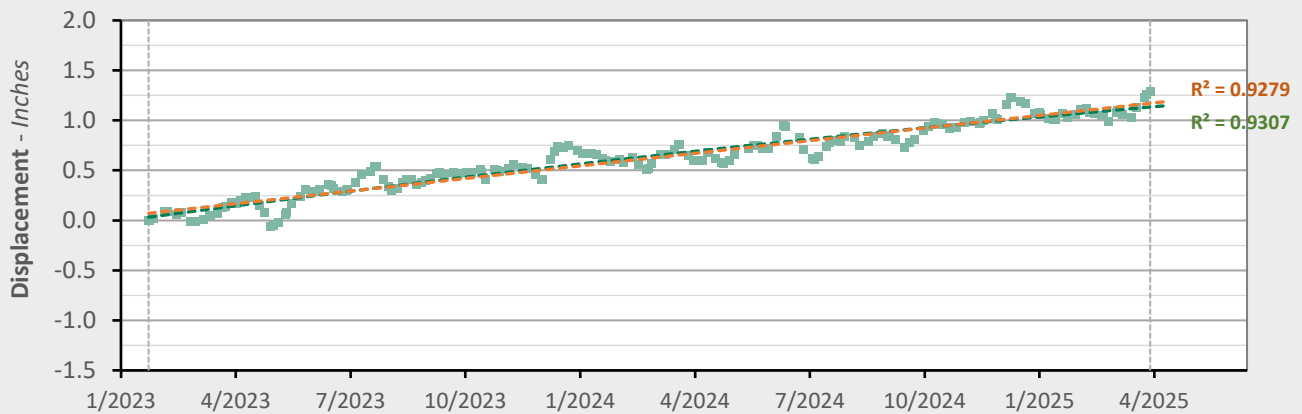


### AOI 3 - Location Map

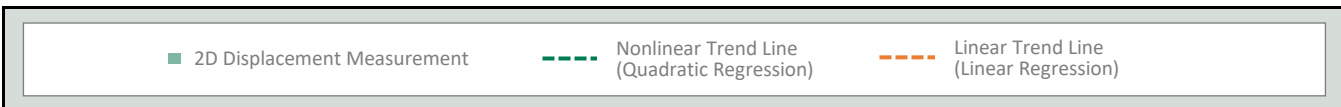


### AOI 3 - East-West Time Series

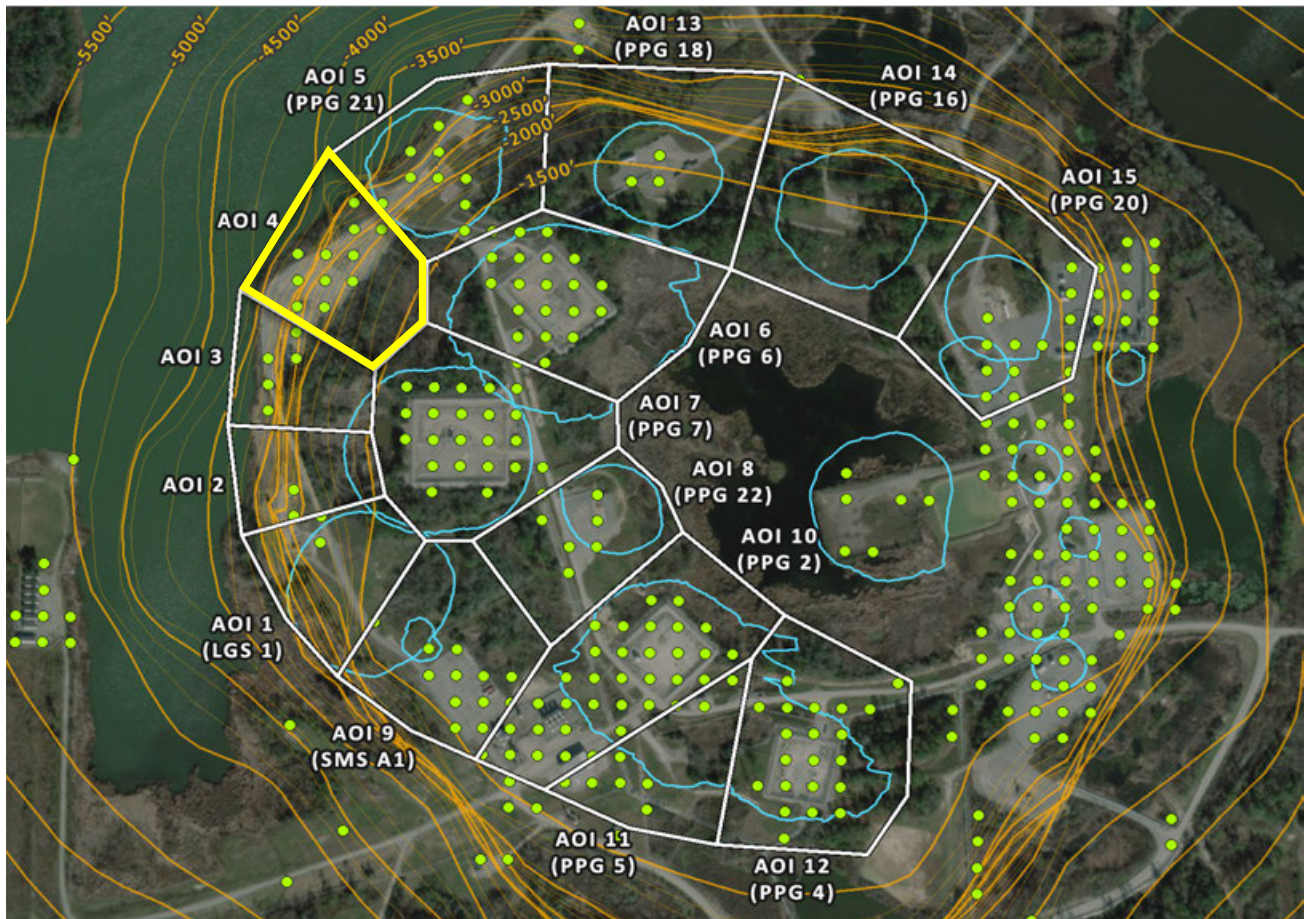
E-W (3/30/2025) Point Count: 5



	Nonlinear Trend	Linear Trend
Velocity:	+0.40 in/yr	+0.50 in/yr
Acceleration:	-0.10 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

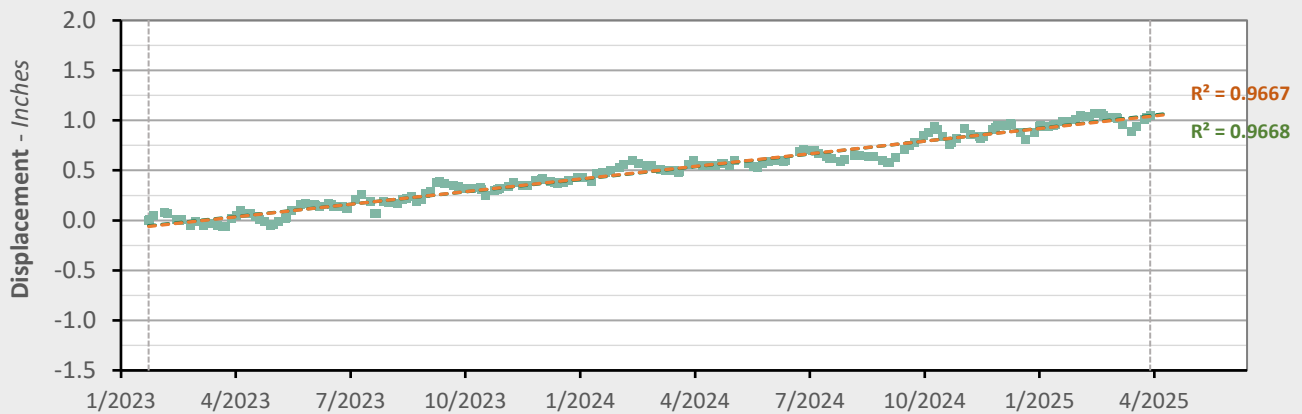


### AOI 4 - Location Map

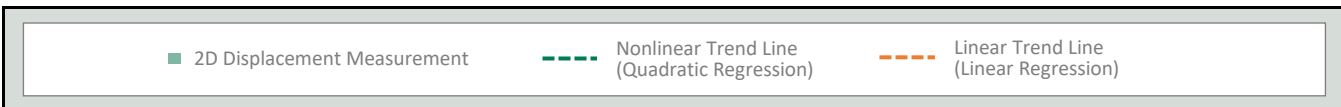


### AOI 4 - East-West Time Series

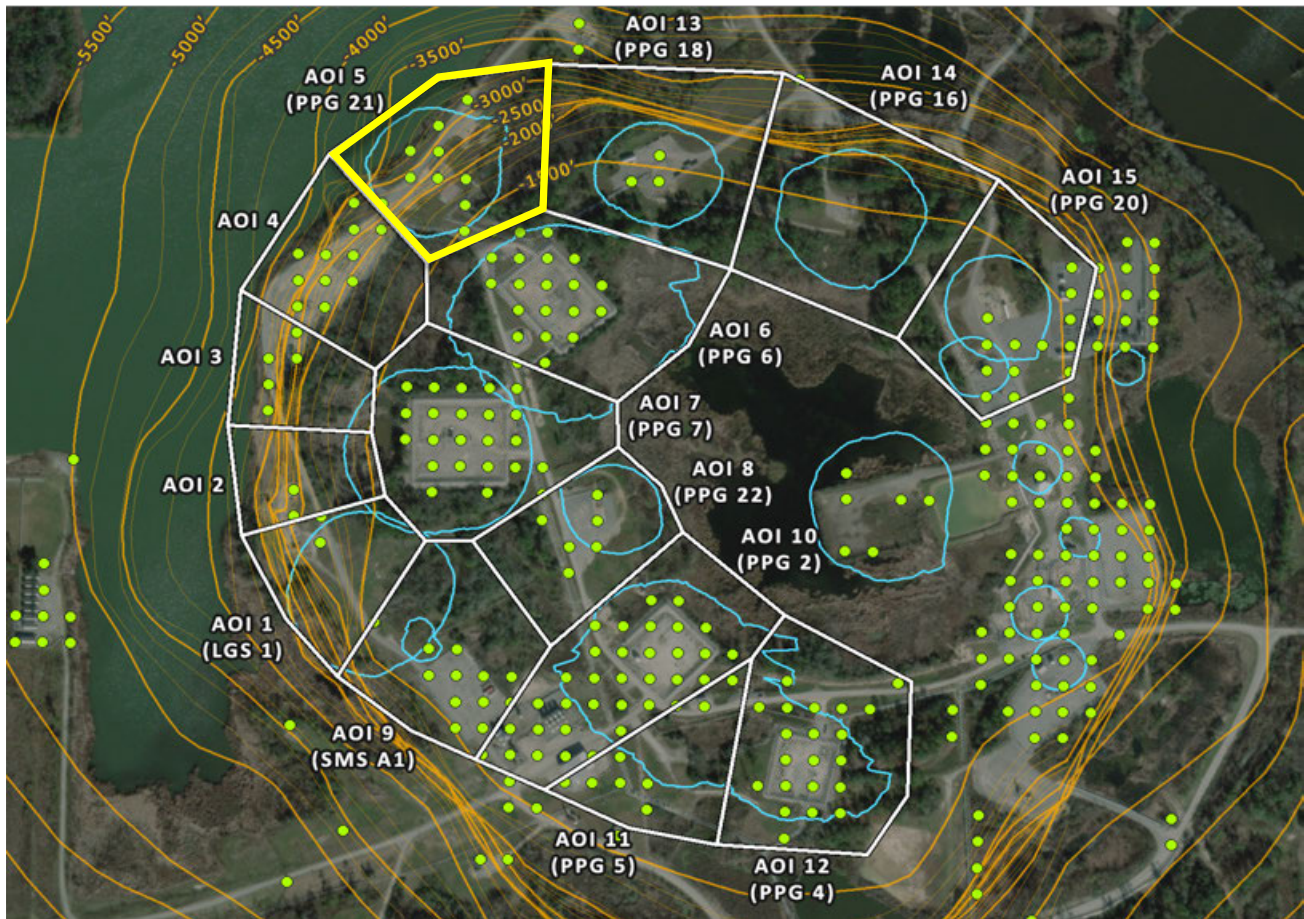
E-W (3/30/2025) Point Count: 10



	Nonlinear Trend	Linear Trend
Velocity:	+0.53 in/yr	+0.51 in/yr
Acceleration:	+0.02 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

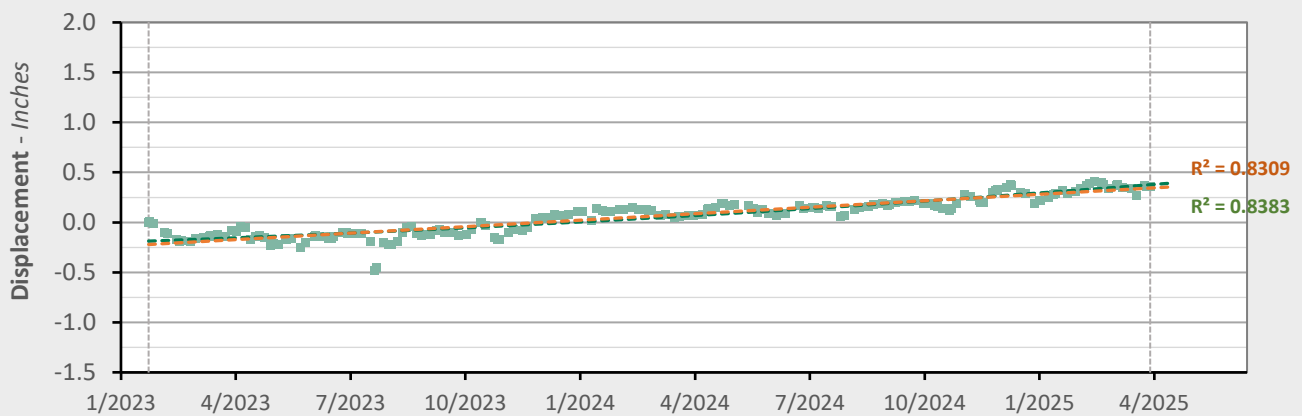


### AOI 5 (PPG 21) - Location Map

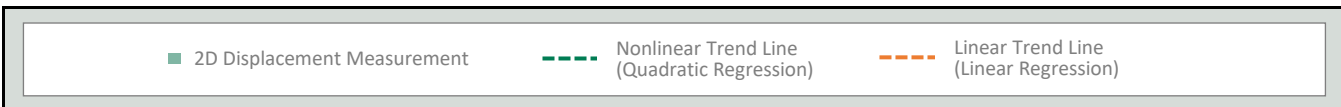


### AOI 5 (PPG 21) - East-West Time Series

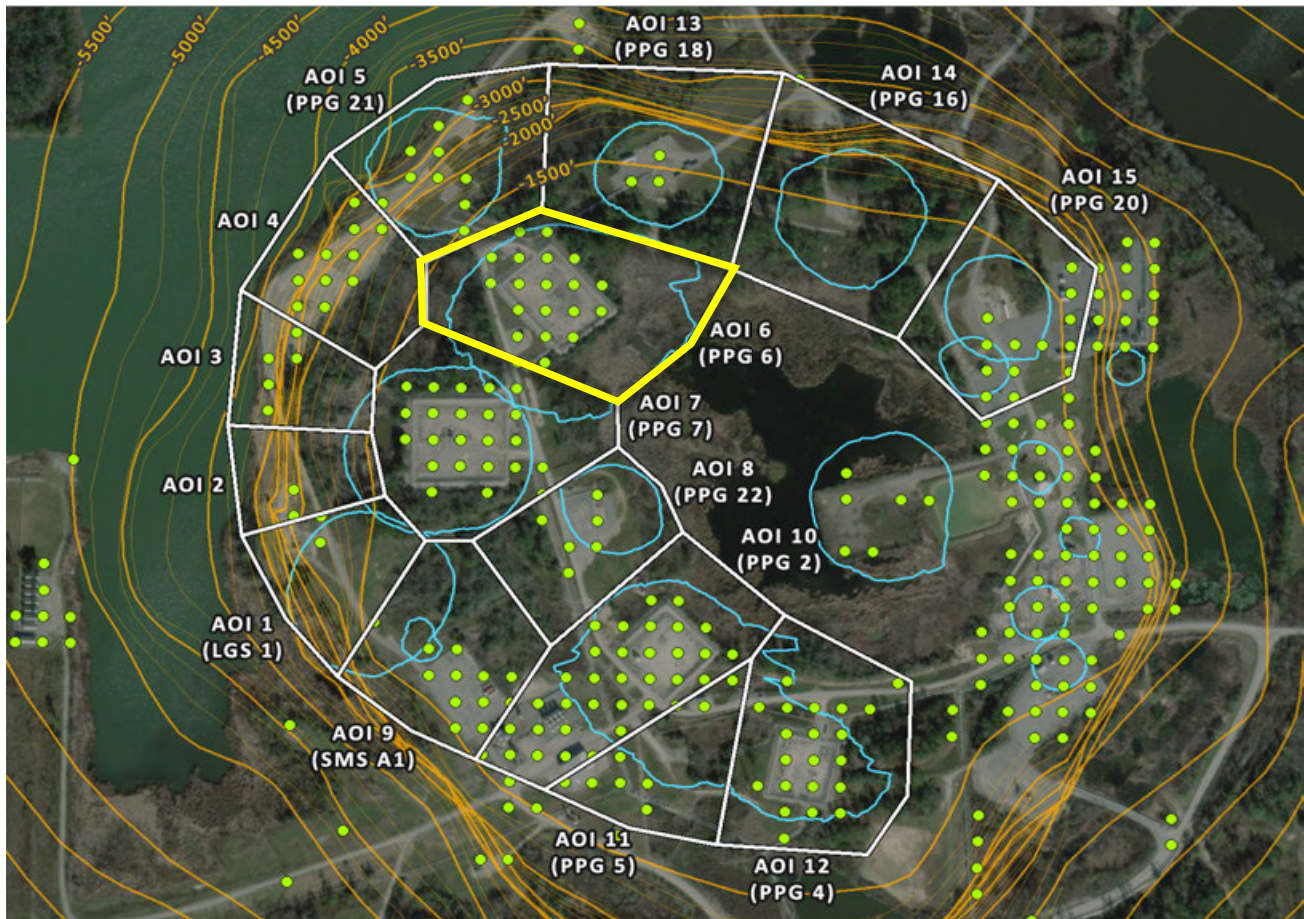
E-W (3/30/2025) Point Count: 10



	Nonlinear Trend	Linear Trend
Velocity:	+0.35 in/yr	+0.26 in/yr
Acceleration:	+0.09 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

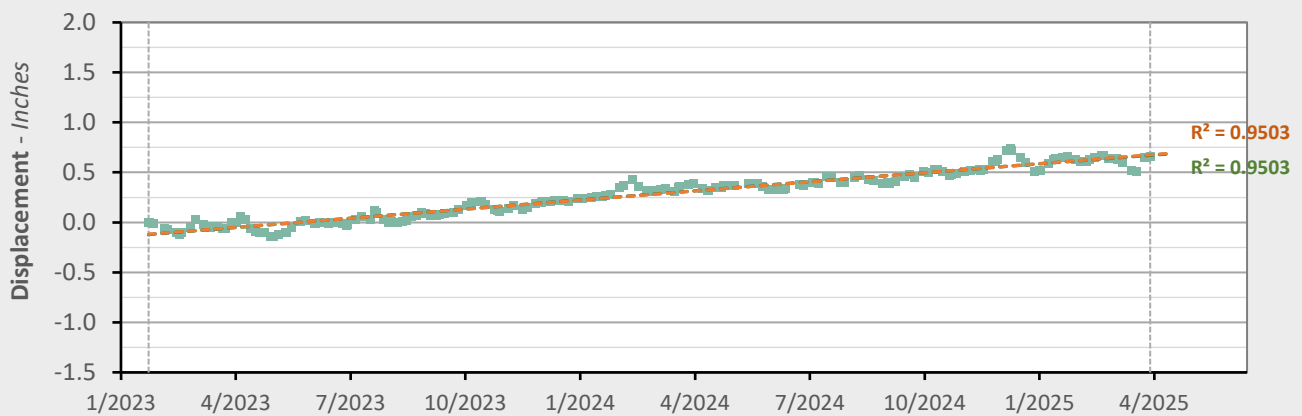


### AOI 6 (PPG 6) - Location Map

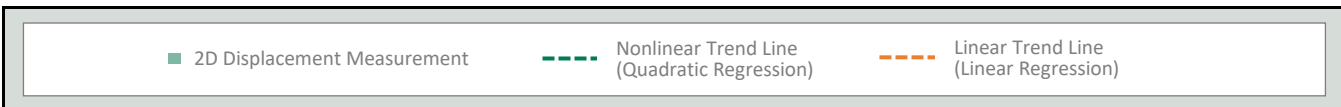


### AOI 6 (PPG 6) - East-West Time Series

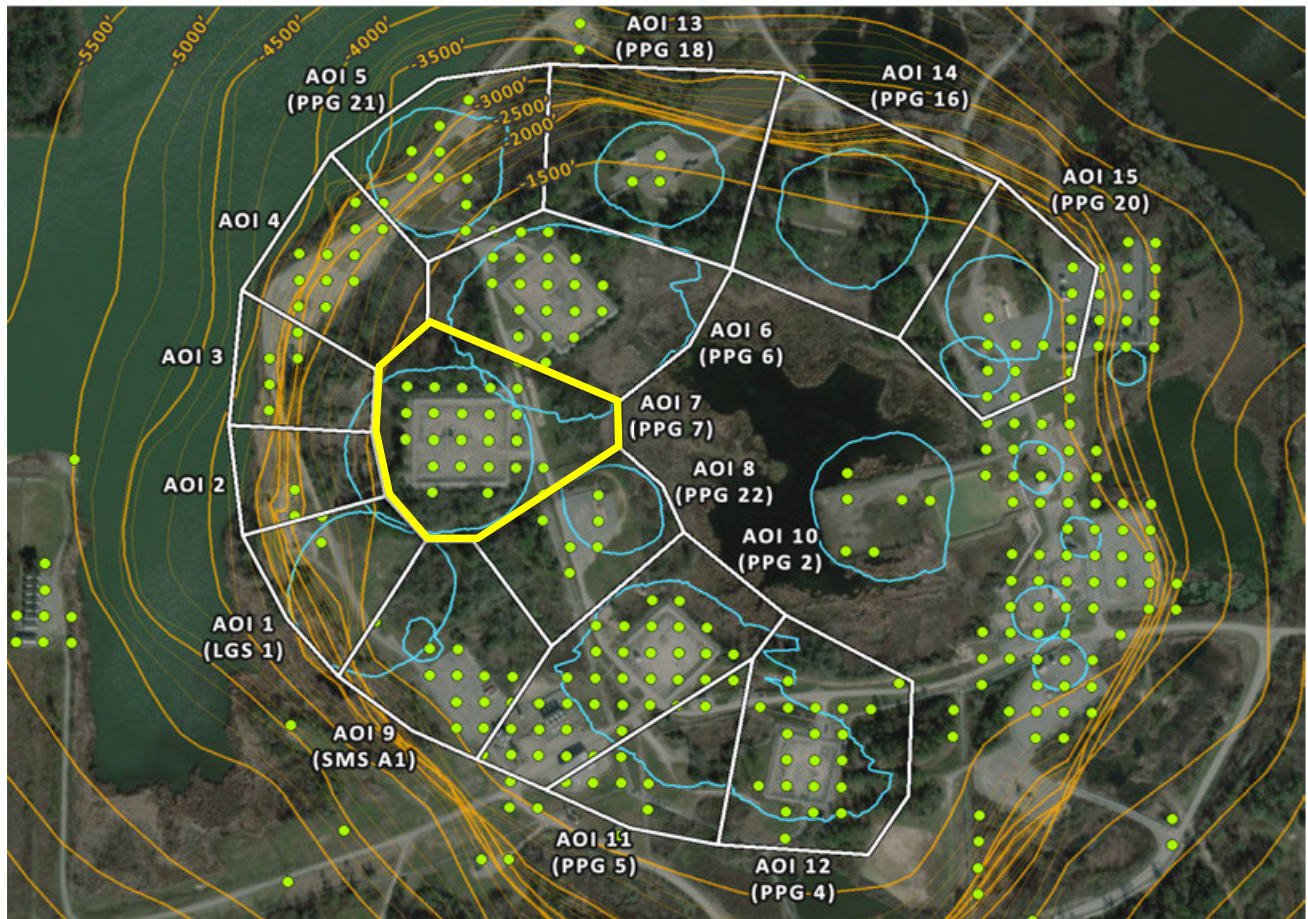
E-W (3/30/2025) Point Count: 20



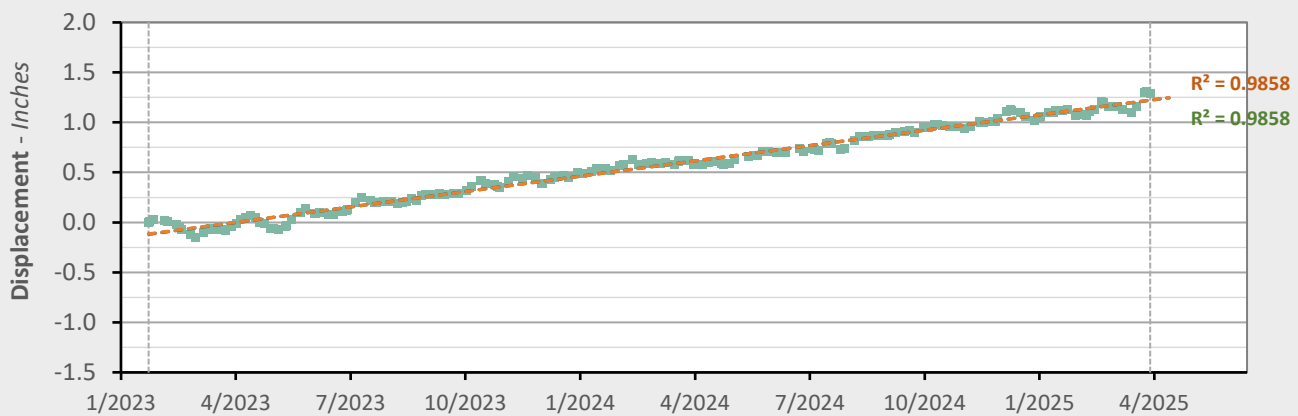
	Nonlinear Trend	Linear Trend
Velocity:	+0.35 in/yr	+0.36 in/yr
Acceleration:	-0.01 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



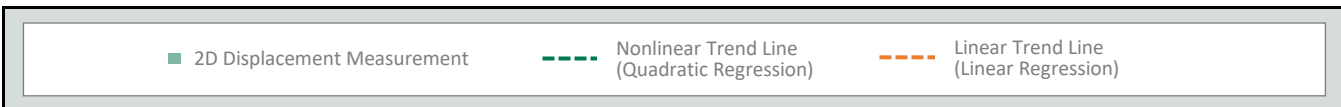
### AOI 7 (PPG 7) - Location Map



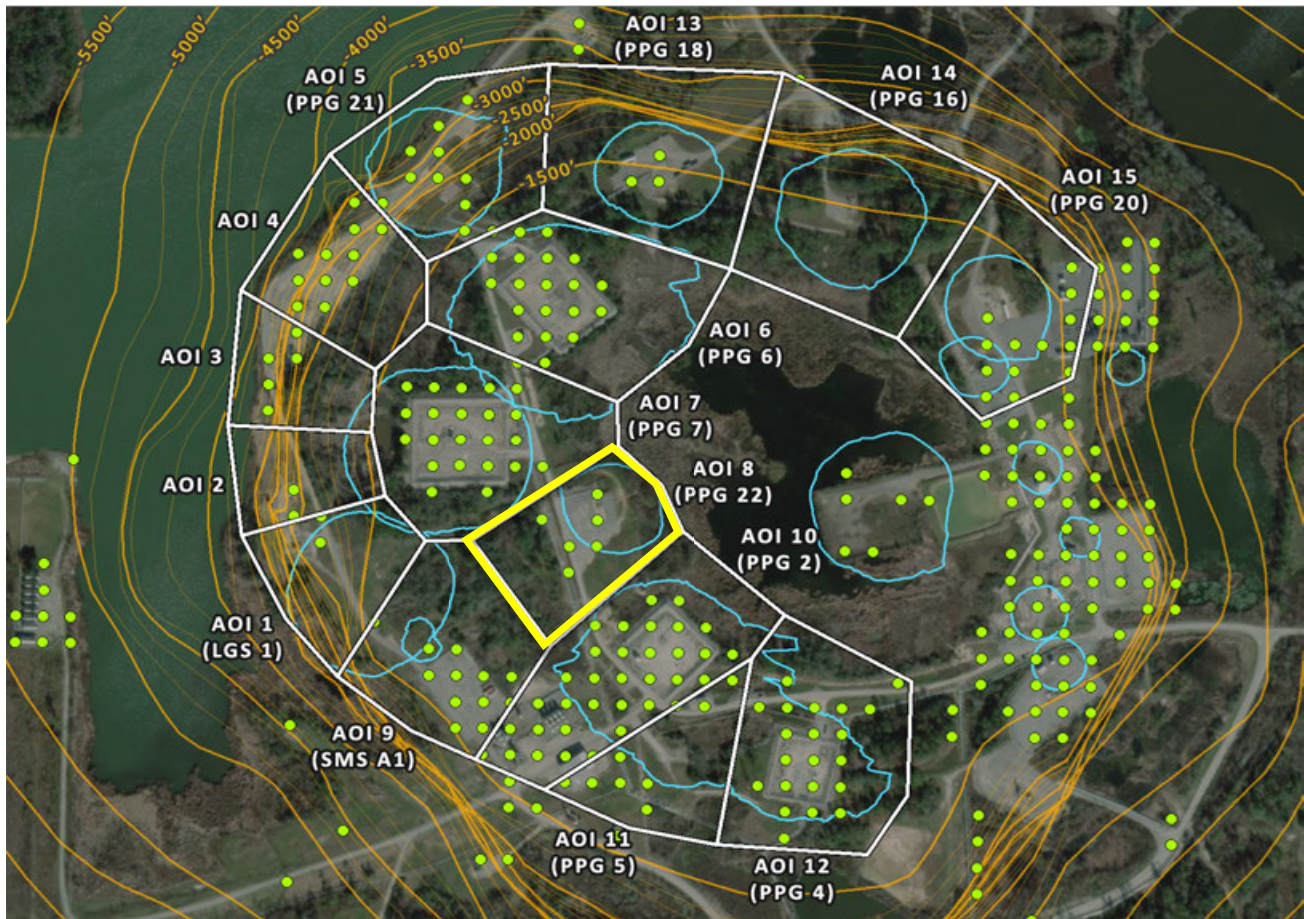
### AOI 7 (PPG 7) - East-West Time Series E-W (3/30/2025) Point Count: 25



	Nonlinear Trend	Linear Trend
Velocity:	+0.61 in/yr	+0.61 in/yr
Acceleration:	-0.01 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

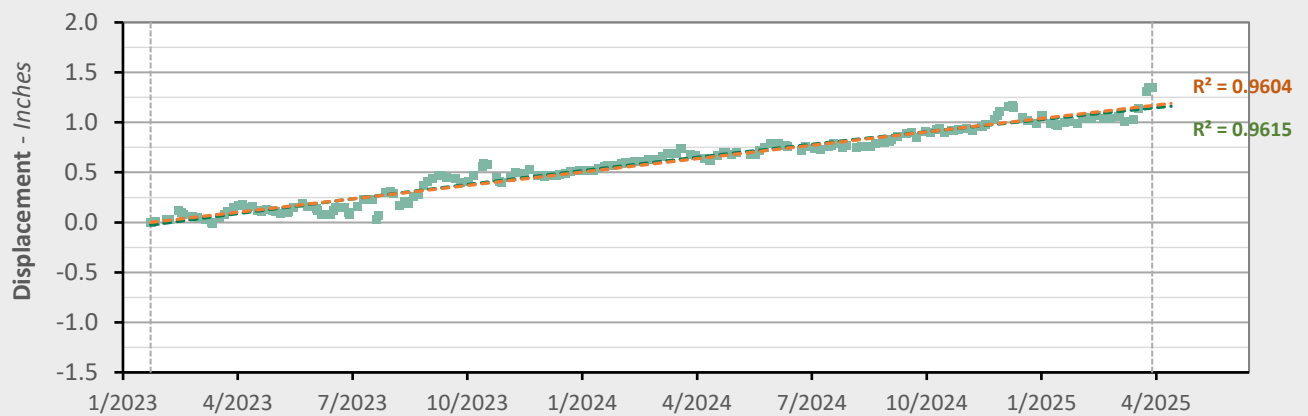


### AOI 8 (PPG 22) - Location Map

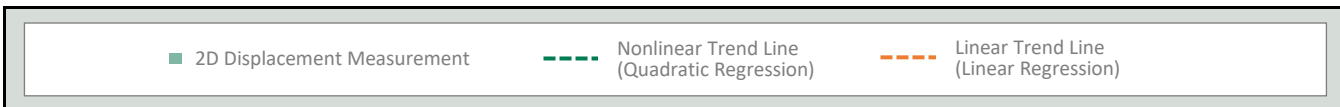


### AOI 8 (PPG 22) - East-West Time Series

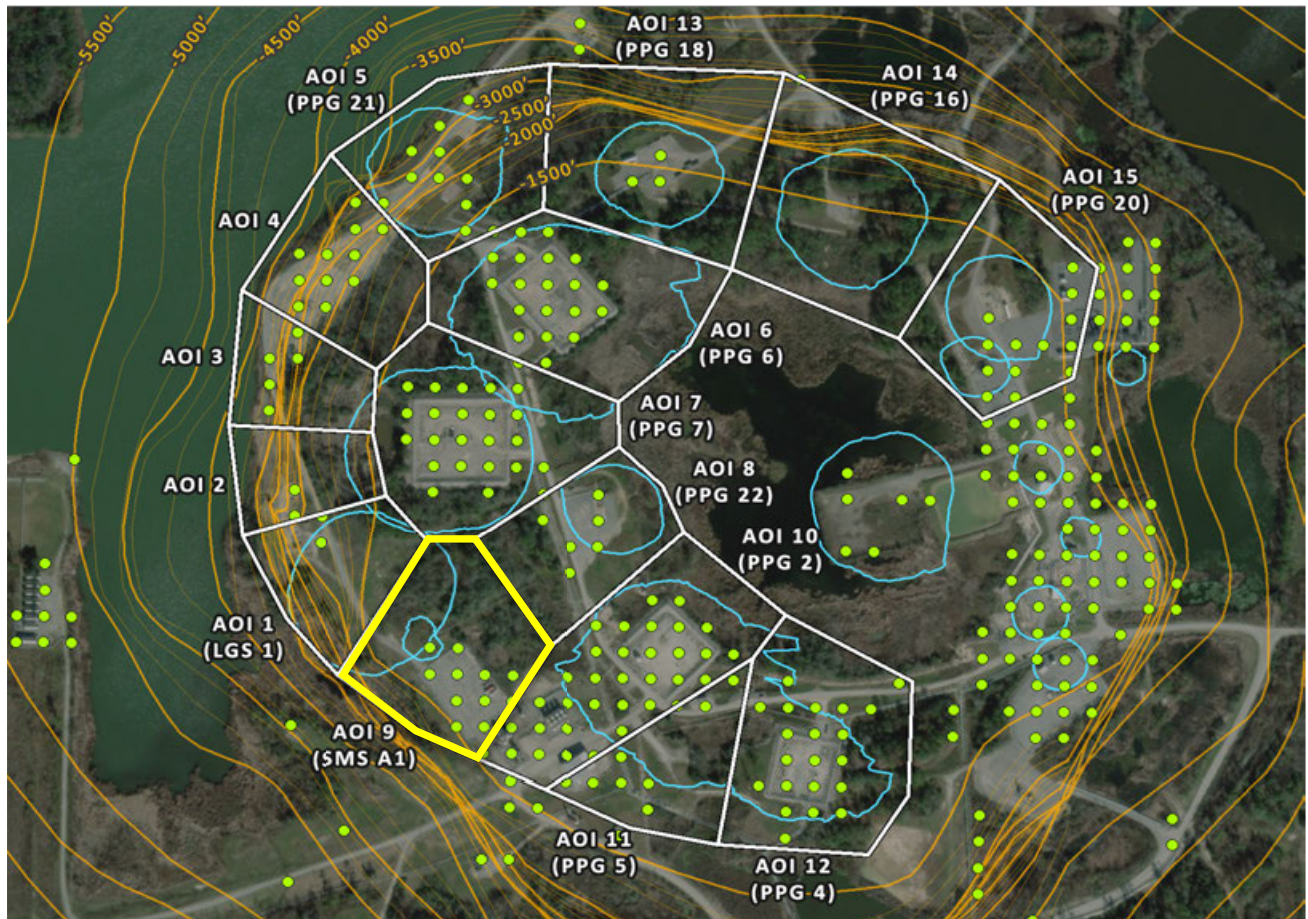
E-W (3/30/2025) Point Count: 7



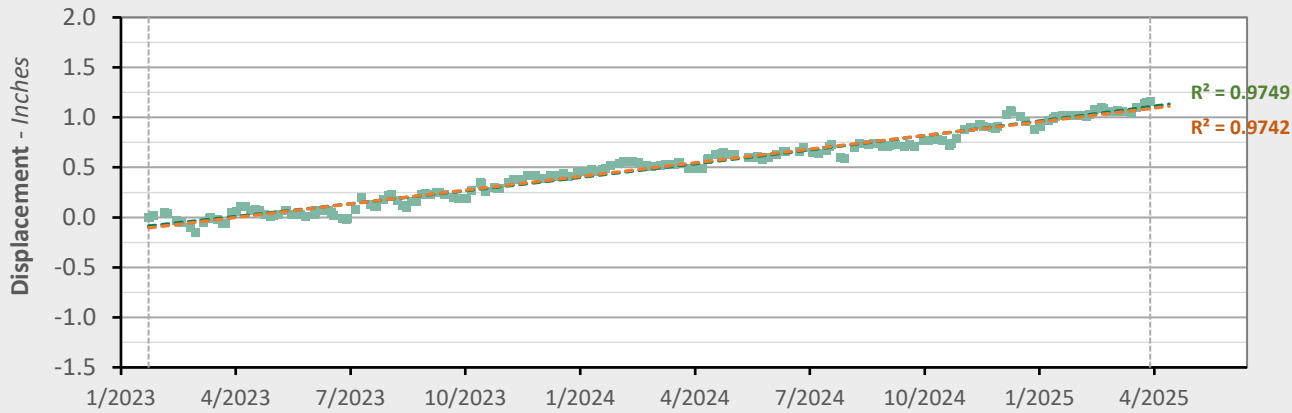
	Nonlinear Trend	Linear Trend
Velocity:	+0.46 in/yr	+0.54 in/yr
Acceleration:	-0.07 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



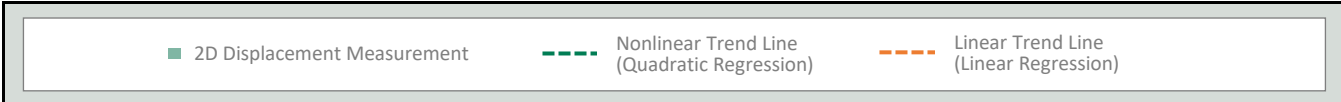
### AOI 9 (PPG A1) - Location Map



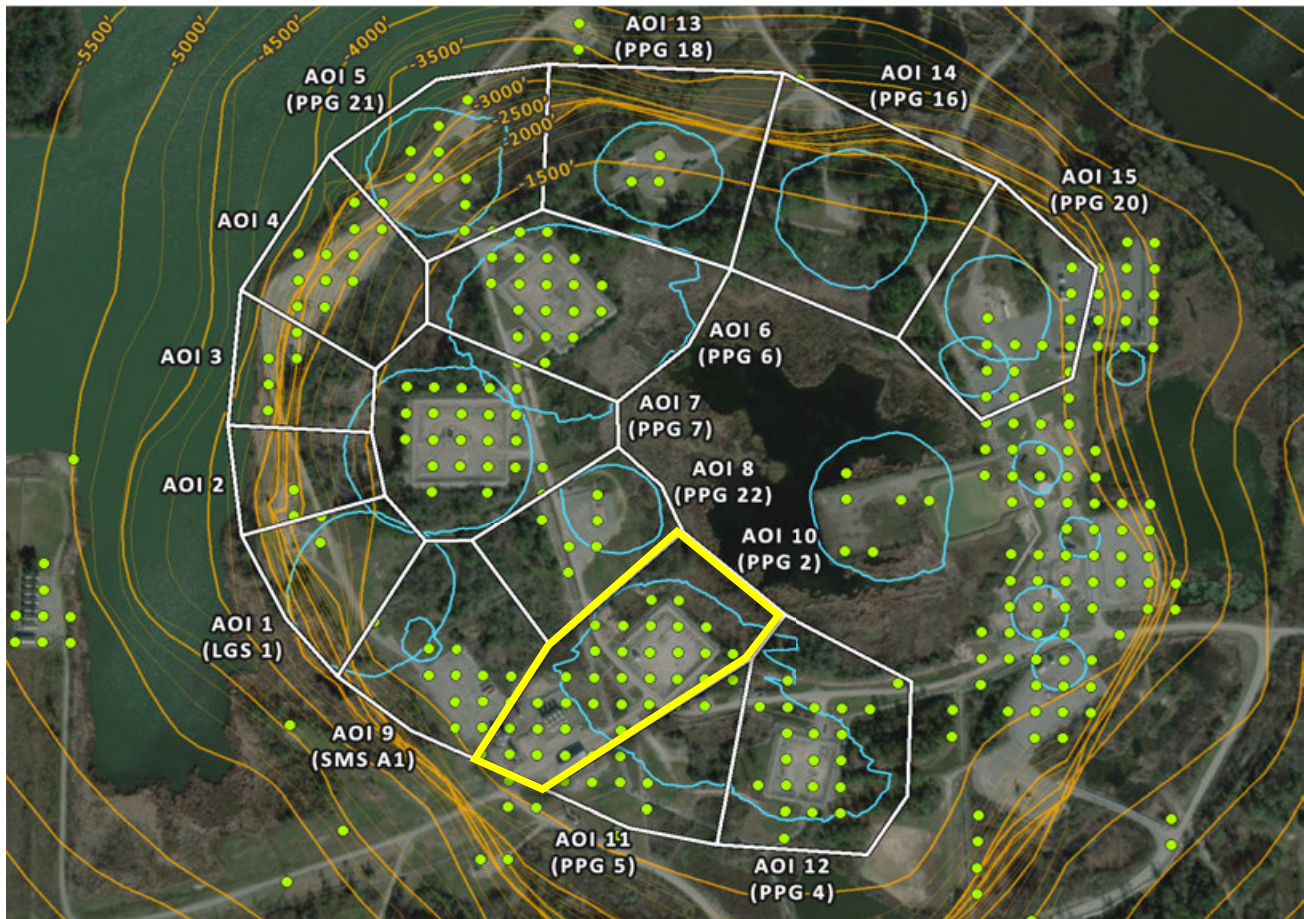
### AOI 9 (SMS A1) - East-West Time Series E-W (3/30/2025) Point Count: 12



	Nonlinear Trend	Linear Trend
Velocity:	+0.60 in/yr	+0.55 in/yr
Acceleration:	+0.05 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

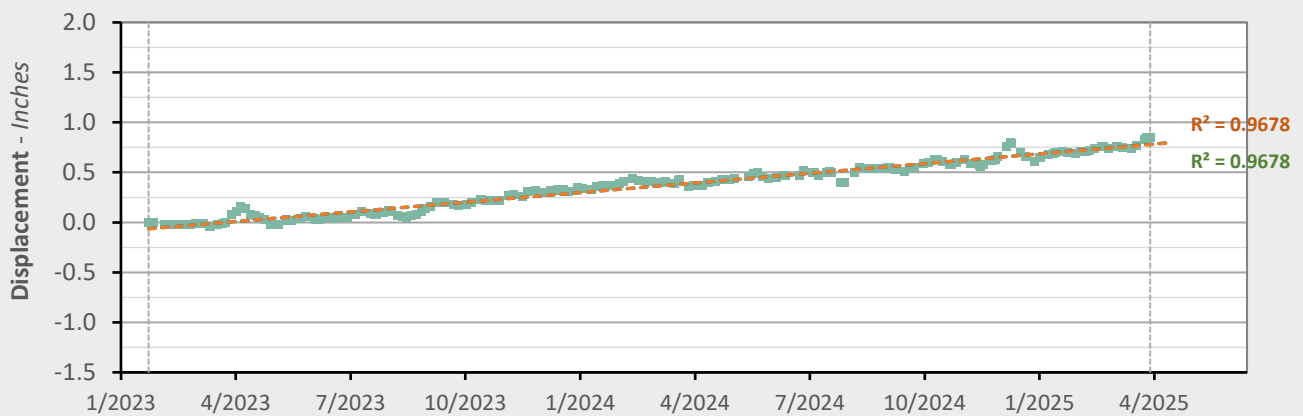


### AOI 10 (PPG 2) - Location Map

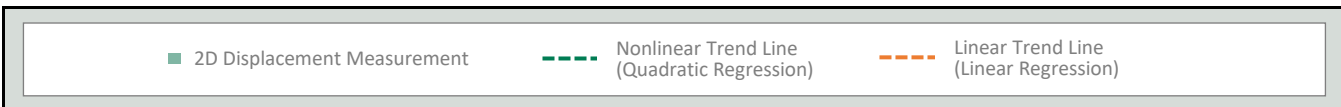


### AOI 10 (PPG 2) - East-West Time Series

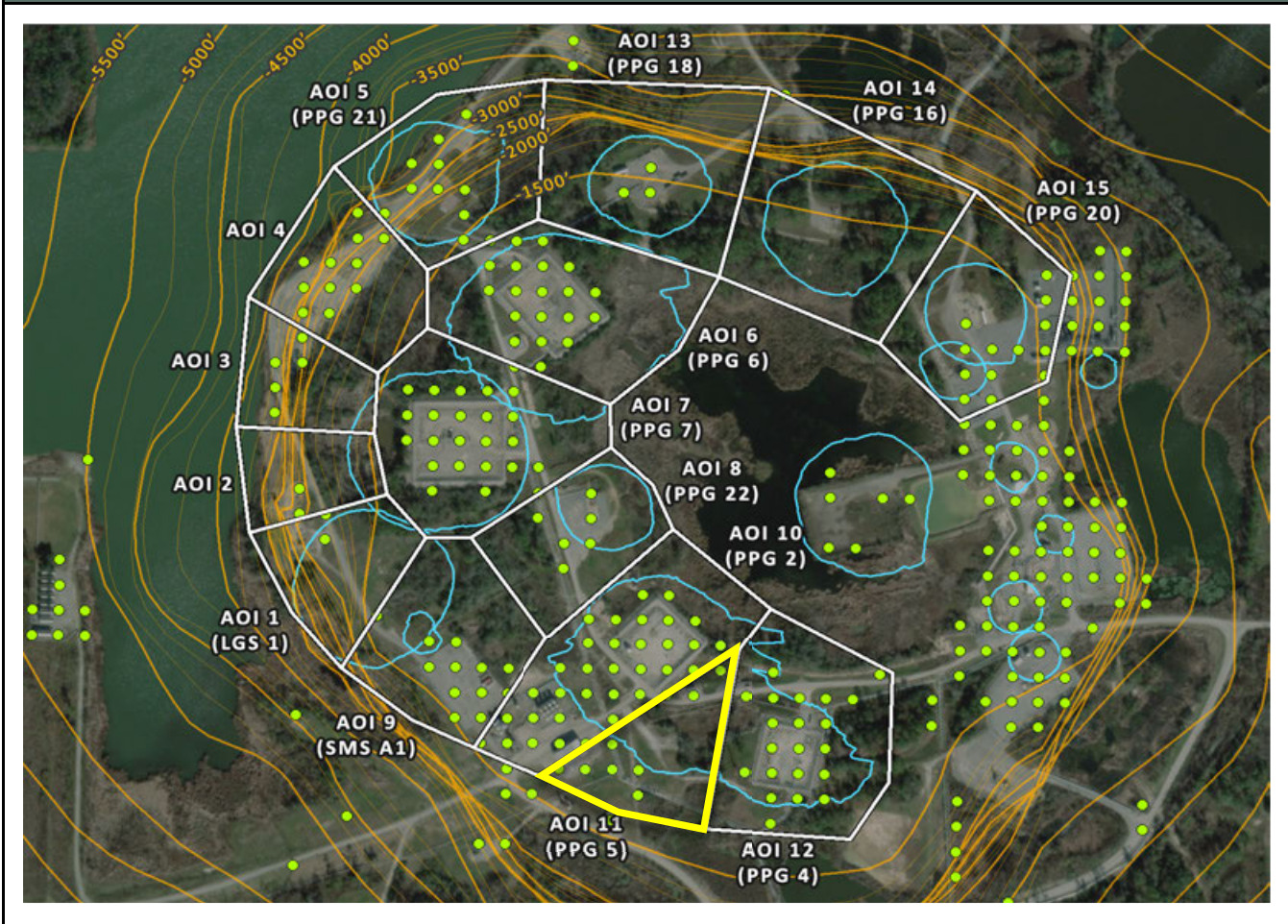
E-W (3/30/2025) Point Count: **33**



	Nonlinear Trend	Linear Trend
Velocity:	+0.39 in/yr	+0.39 in/yr
Acceleration:	+0.01 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

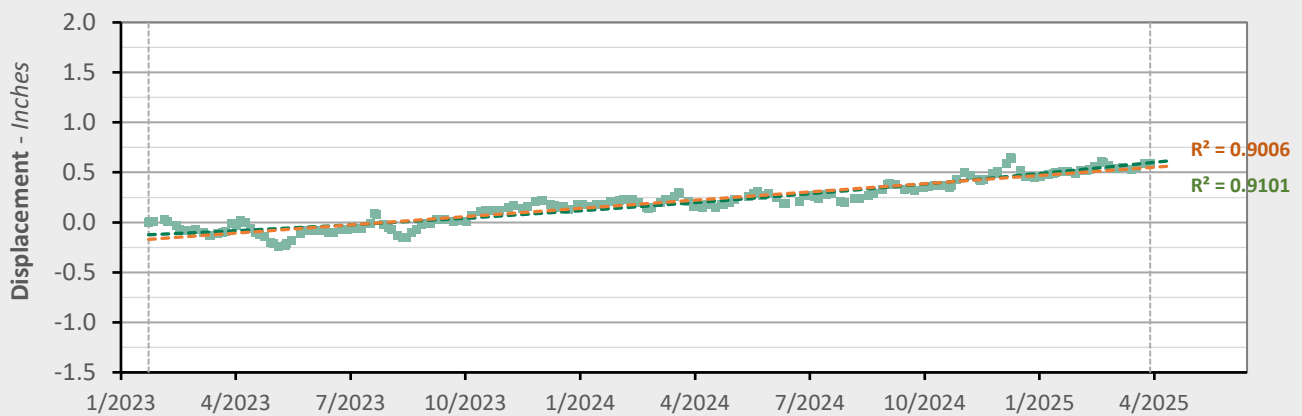


### AOI 11 (PPG 5) - Location Map

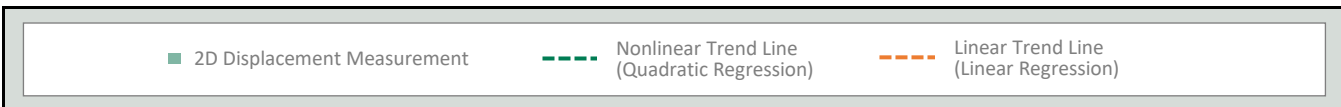


### AOI 11 (PPG 5) - East-West Time Series

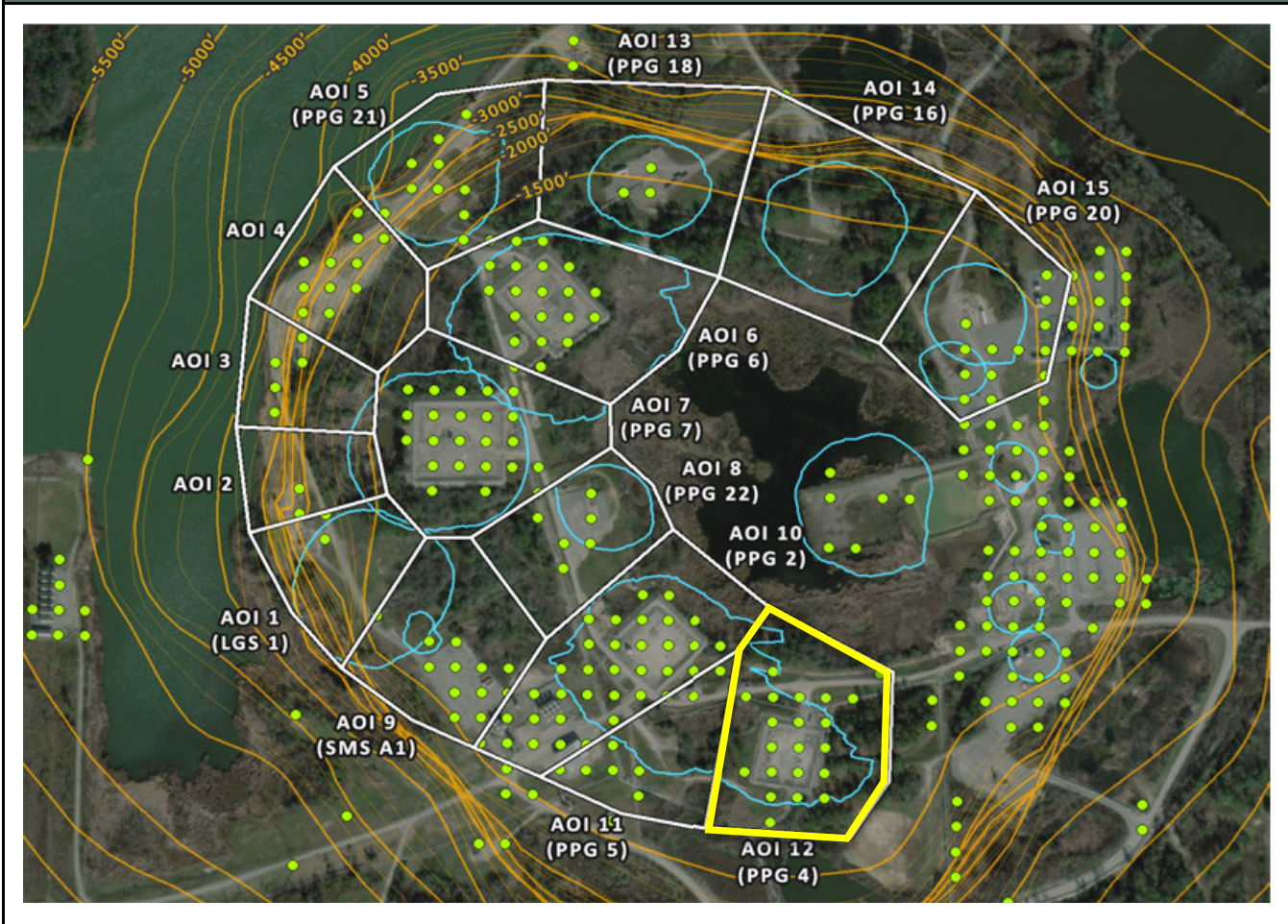
E-W (3/30/2025) Point Count: 9



	Nonlinear Trend	Linear Trend
Velocity:	+0.46 in/yr	+0.33 in/yr
Acceleration:	+0.12 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

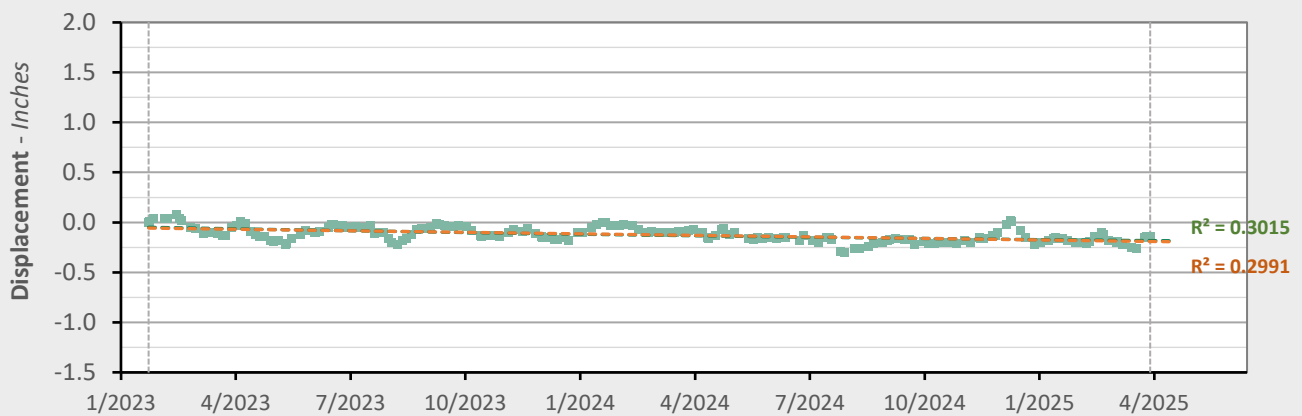


### AOI 12 (PPG 4) - Location Map

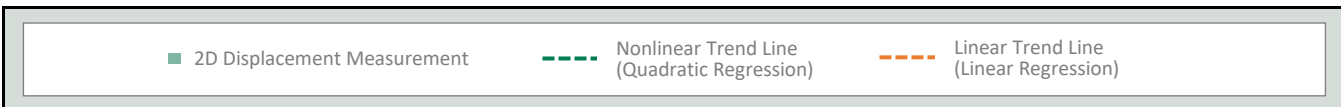


### AOI 12 (PPG 4) - East-West Time Series

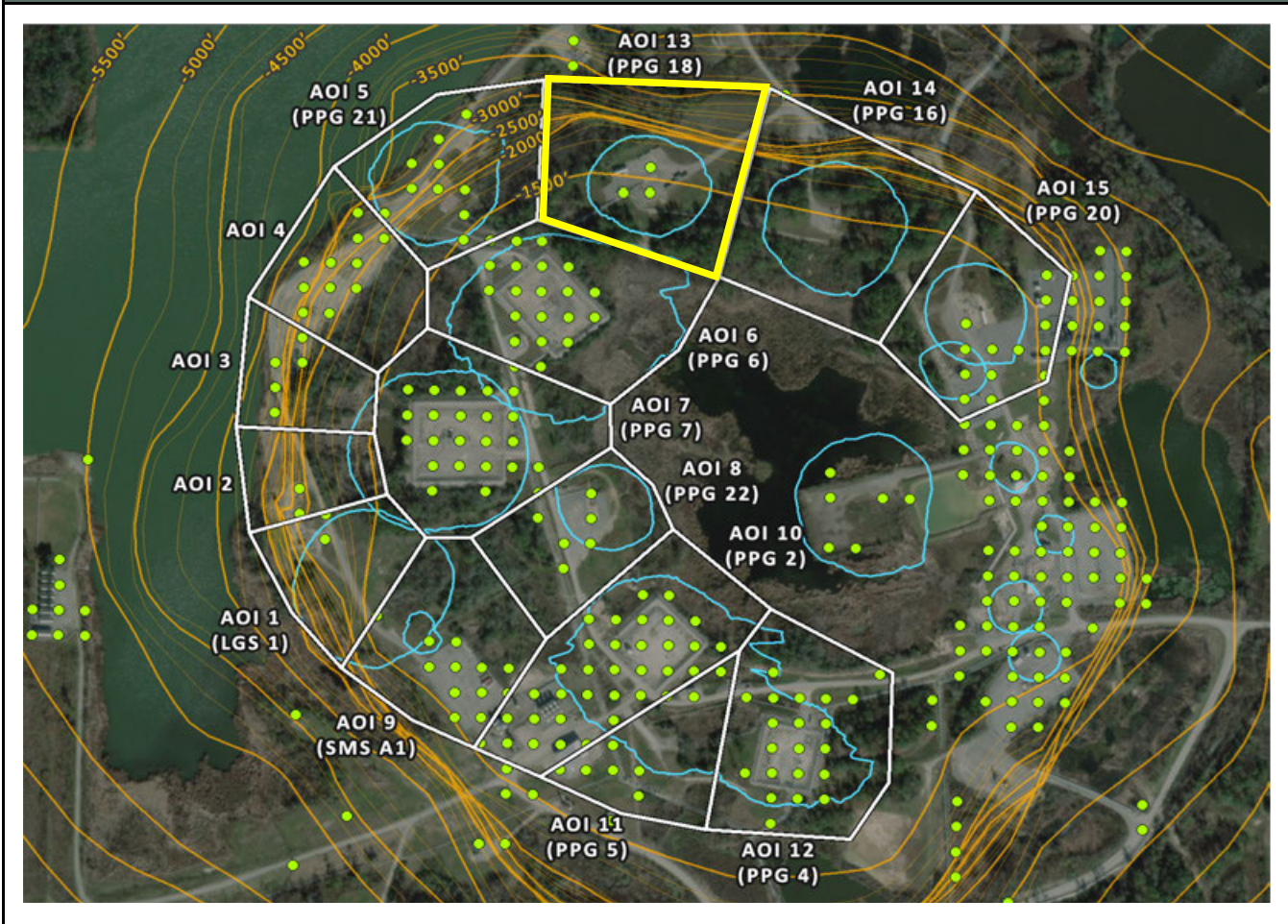
E-W (3/30/2025) Point Count: 21



	Nonlinear Trend	Linear Trend
Velocity:	-0.04 in/yr	-0.06 in/yr
Acceleration:	+0.02 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

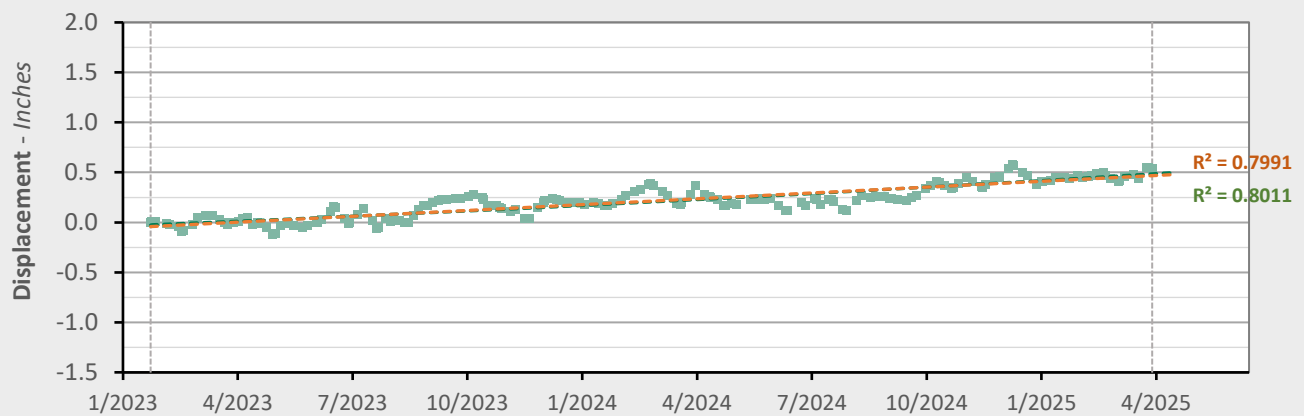


### AOI 13 (PPG 18) - Location Map

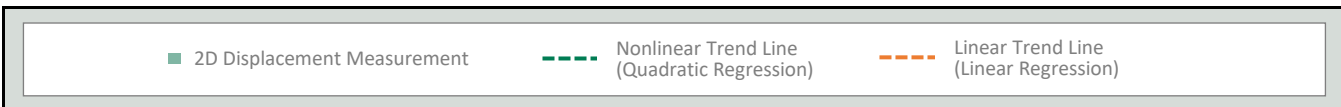


### AOI 13 (PPG 18) - East-West Time Series

E-W (3/30/2025) Point Count: 3



	Nonlinear Trend	Linear Trend
Velocity:	+0.28 in/yr	+0.23 in/yr
Acceleration:	+0.04 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>

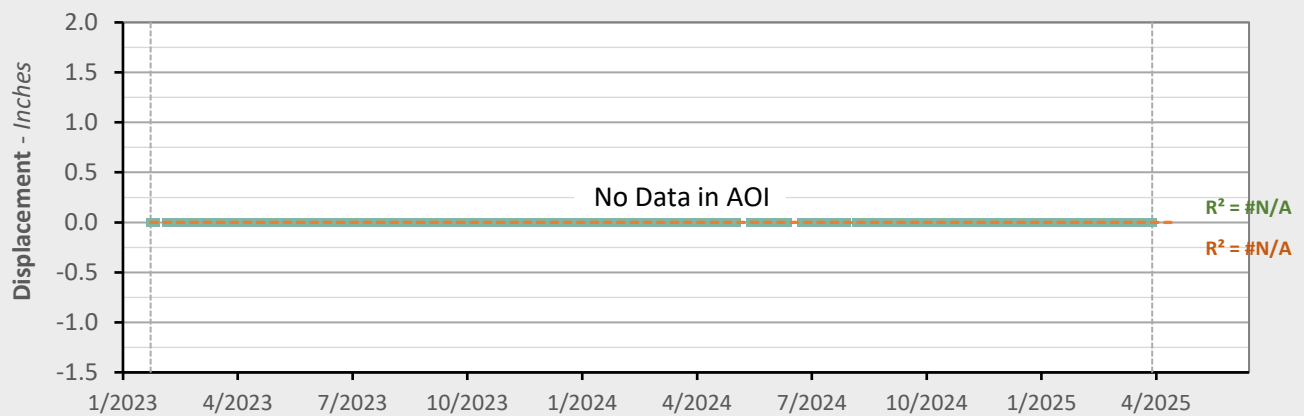


### AOI 14 (PPG 16) - Location Map

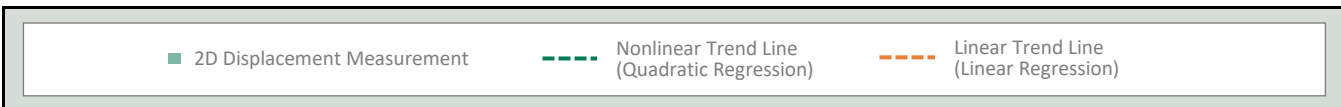


### AOI 14 (PPG 16) - East-West Time Series

E-W (3/30/2025) Point Count: 0



Nonlinear Trend		Linear Trend	
Velocity: N/A	in/yr	N/A	in/yr
Acceleration: N/A	in/yr <sup>2</sup>	N/A	in/yr <sup>2</sup>

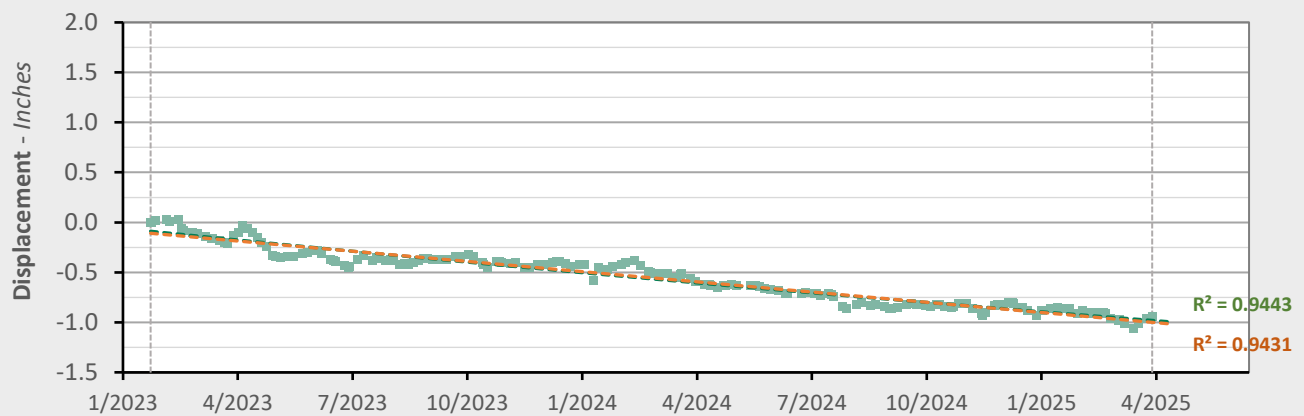


### AOI 15 (PPG 20) - Location Map

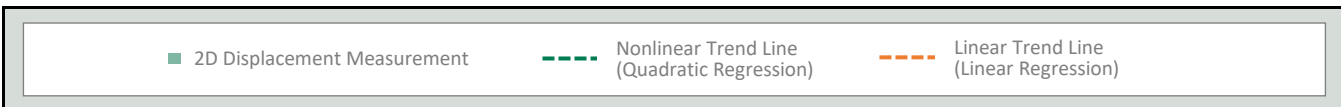


### AOI 15 (PPG 20) - East-West Time Series

E-W (3/30/2025) Point Count: **13**



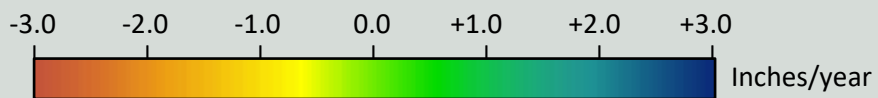
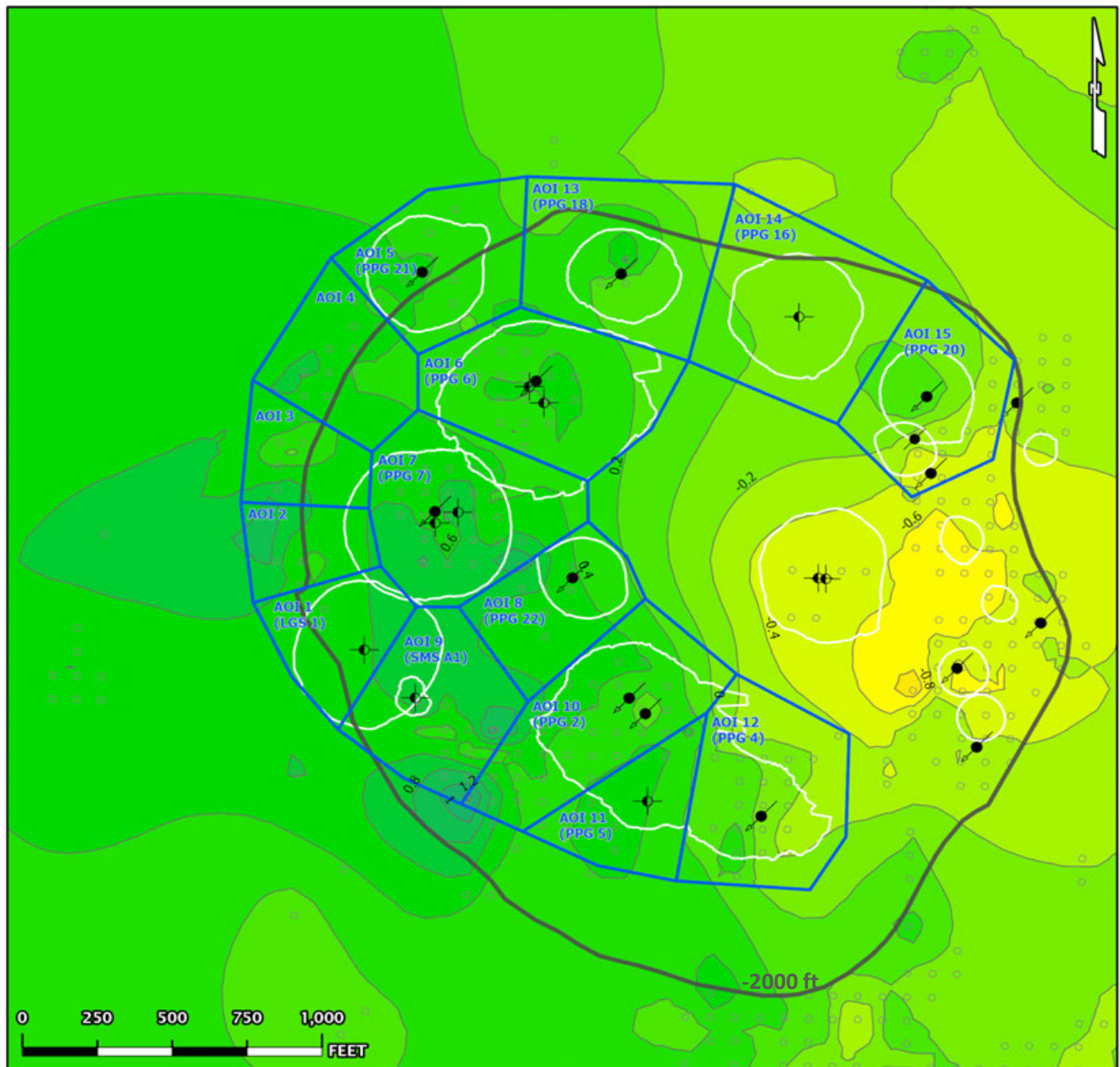
	Nonlinear Trend	Linear Trend
Velocity:	-0.35 in/yr	-0.41 in/yr
Acceleration:	+0.05 in/yr <sup>2</sup>	0.00 in/yr <sup>2</sup>



### East-West Data (01/24/2023 - 03/30/2025)

#### Nonlinear Velocity Contours

As of date: 03/30/2025

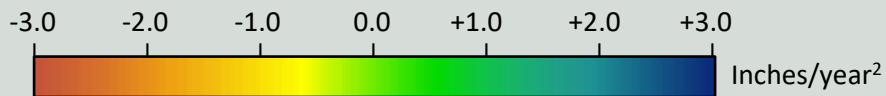
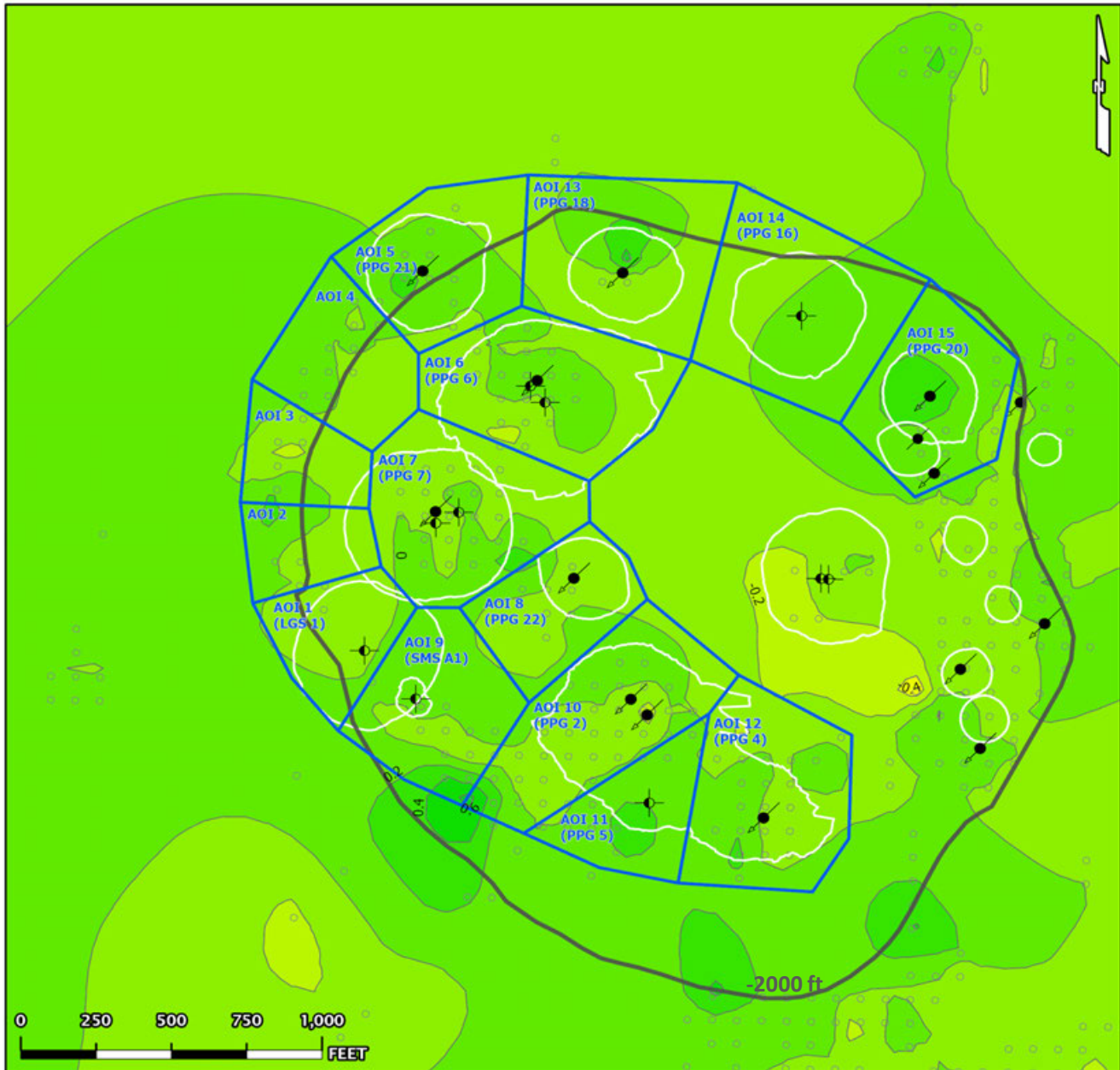


- AOI Boundary
  - InSAR LOS Measurement Point
  - Contour (0.2)
  - Historical Cavern Extent
  - Top of Dome (-2000 ft Contour)
- Cavern Well Surface Locations
- 09 - Active - Injection
  - 29 - Dry and Plugged

**East-West Data (01/24/2023 - 03/30/2025)**

**Nonlinear Acceleration Contours**

Date range: 01/24/2023 - 03/30/2025

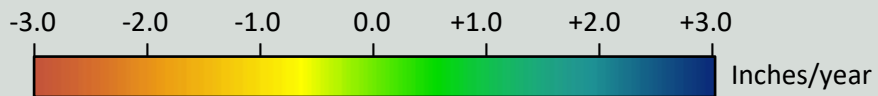
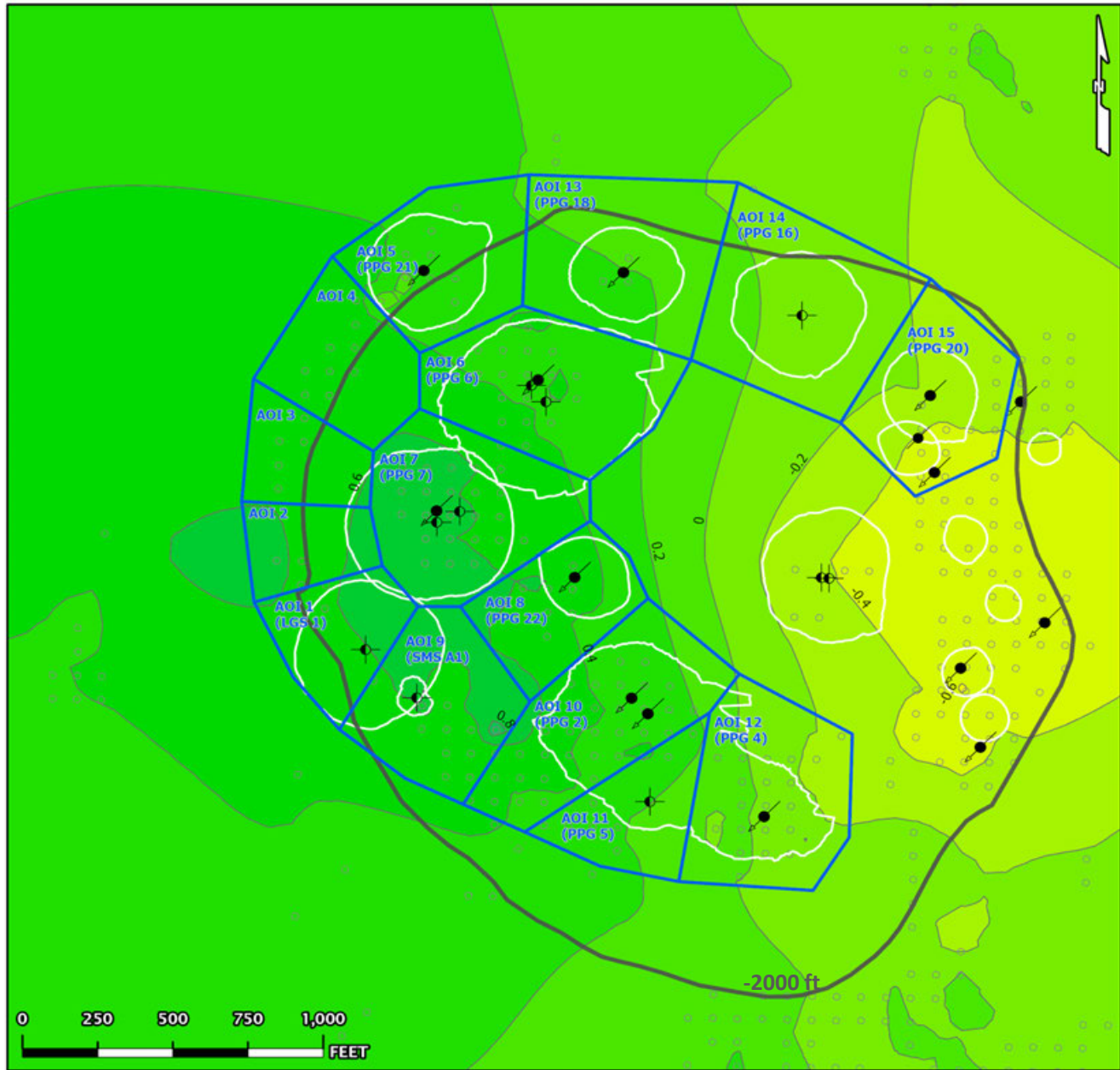


- AOI Boundary
  - InSAR LOS Measurement Point
  - Contour (0.2)
  - Historical Cavern Extent
  - Top of Dome (-2000 ft Contour)
- Cavern Well Surface Locations
- 09 - Active - Injection
  - 29 - Dry and Plugged

### East-West Data (01/24/2023 - 03/30/2025)

#### Linear Velocity Contours

Date range: 01/24/2023 - 03/30/2025

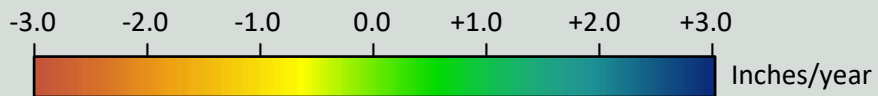
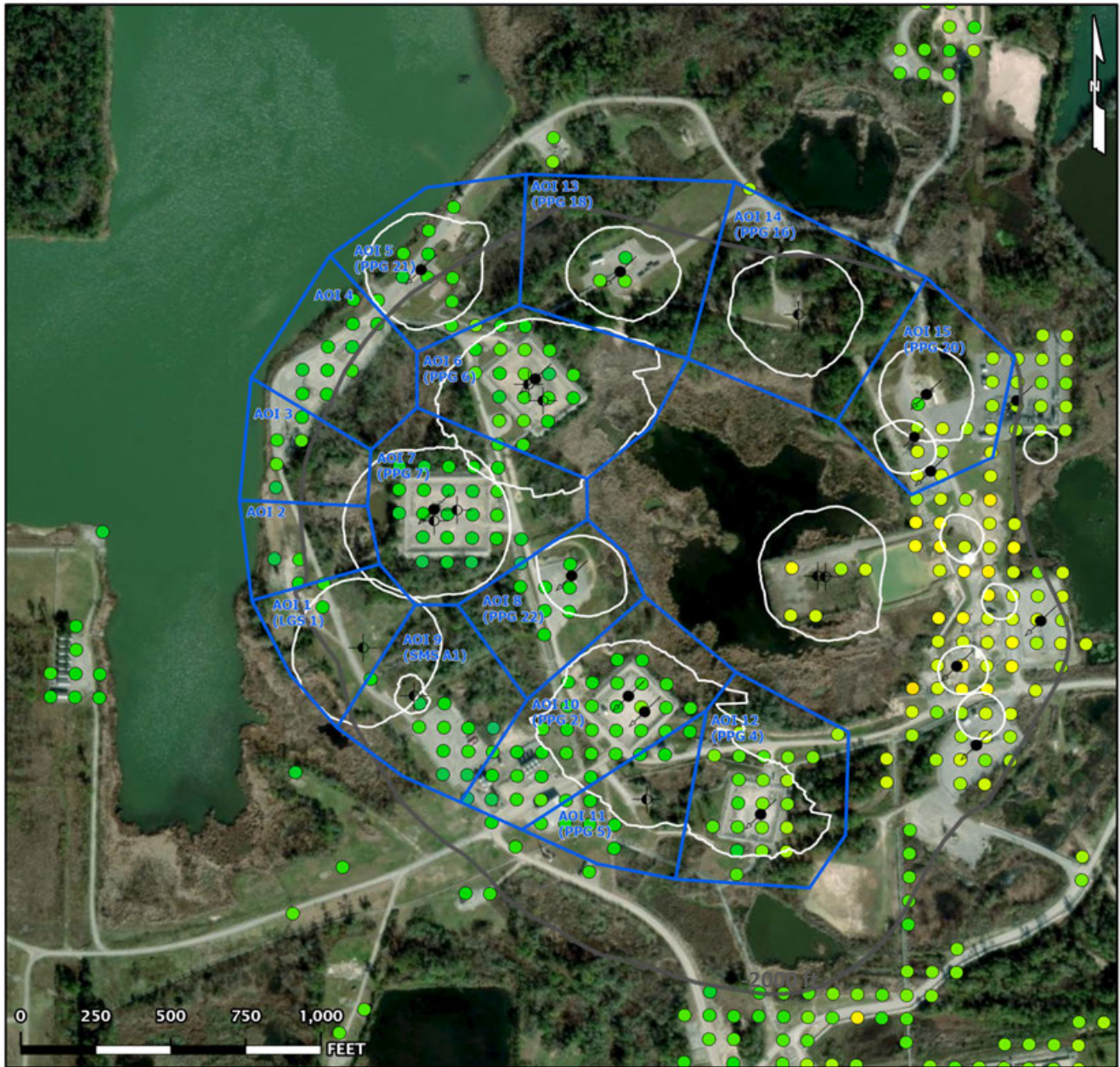


- AOI Boundary
  - Historical Cavern Extent
  - Top of Dome (-2000 ft Contour)
  - InSAR LOS Measurement Point
  - Contour (0.2)
- Cavern Well Surface Locations
- 09 - Active - Injection
  - 29 - Dry and Plugged

**East-West Data (01/24/2023 - 03/30/2025)**

**Nonlinear Velocity Data Points**

As of date: 03/30/2025

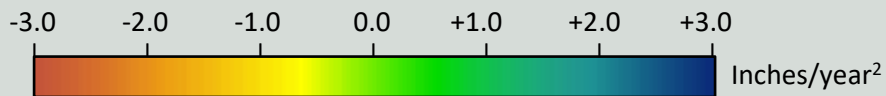
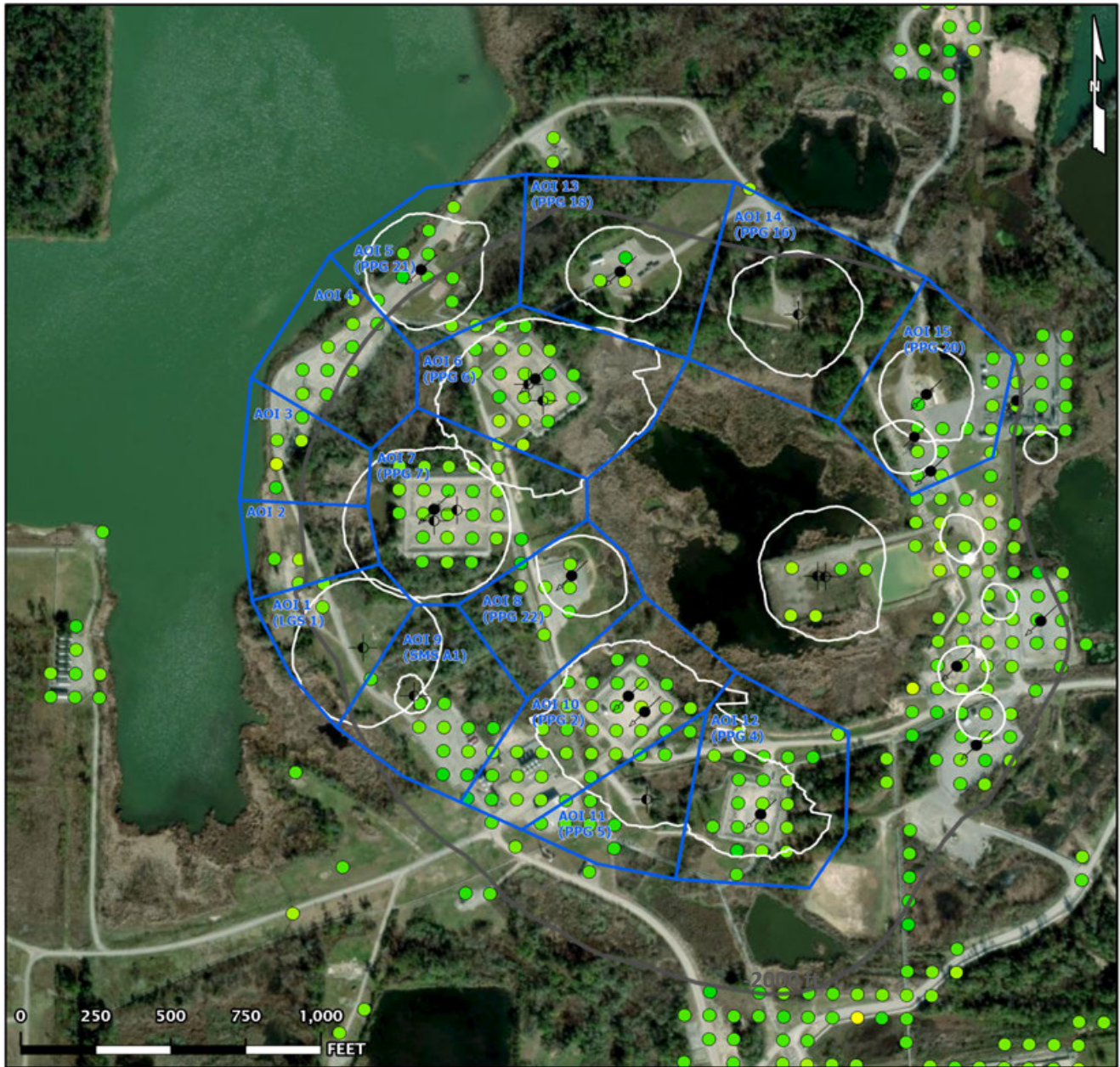


- AOI Boundary
  - InSAR LOS Measurement Point
  - Historical Cavern Extent
  - Top of Dome (-2000 ft Contour)
- Cavern Well Surface Locations
- 09 - Active - Injection
  - 29 - Dry and Plugged

### East-West Data (01/24/2023 - 03/30/2025)

#### Nonlinear Acceleration Data Points

Date range: 01/24/2023 - 03/30/2025

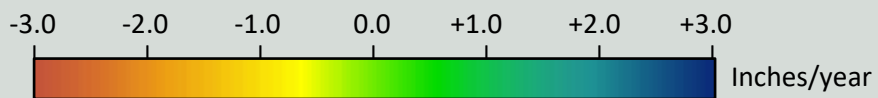
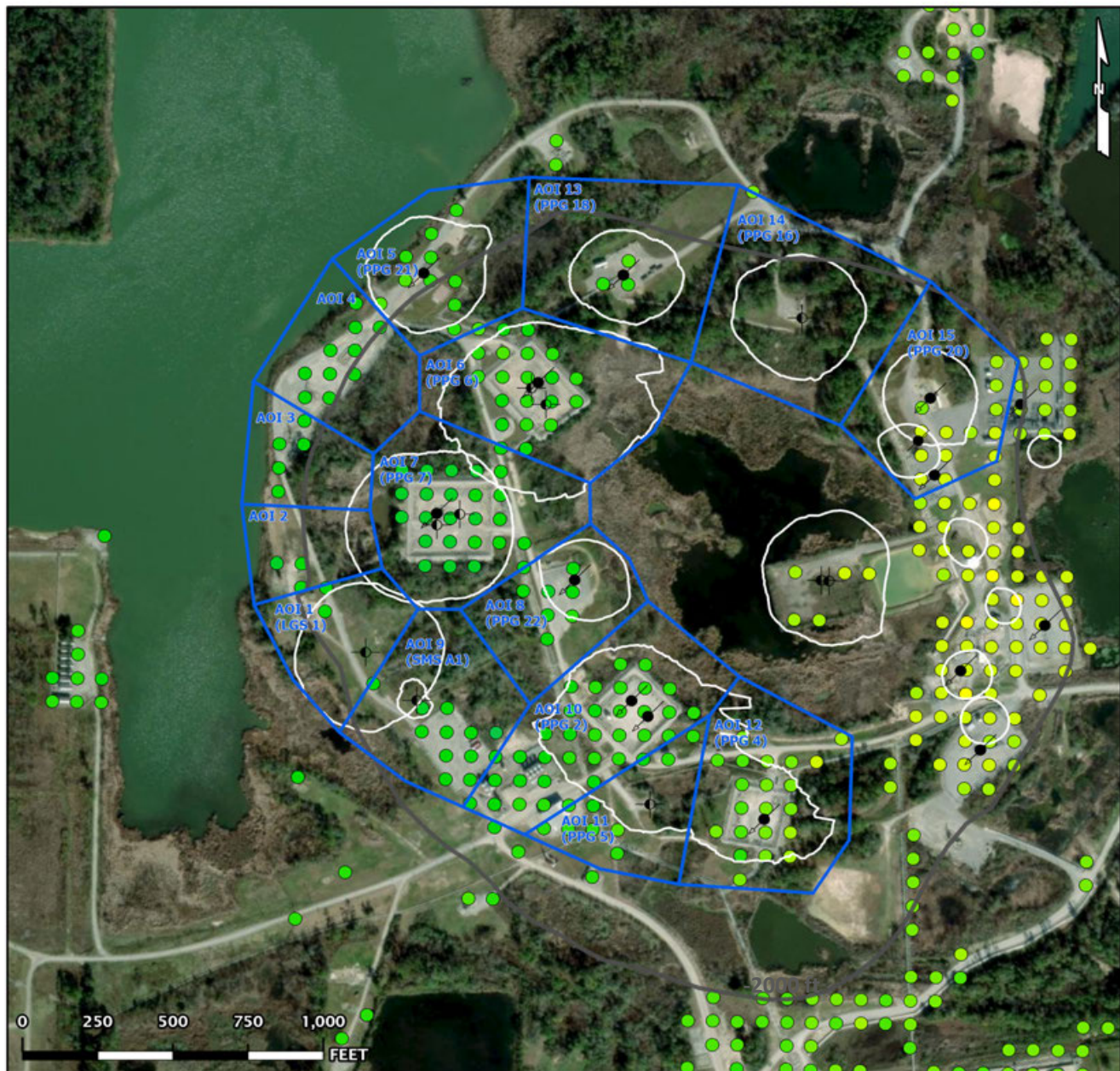


- AOI Boundary
  - InSAR LOS Measurement Point
  - Historical Cavern Extent
  - Top of Dome (-2000 ft Contour)
- Cavern Well Surface Locations
- 09 - Active - Injection
  - 29 - Dry and Plugged

### East-West Data (01/24/2023 - 03/30/2025)

#### Linear Velocity Data Points

Date range: 01/24/2023 - 03/30/2025



- 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