To: Lonquist & Co. LLC

From: TRE Altamira Inc.

Date: 29 January 2024

Subject: TREA Response Regarding Reprocessed Data (New Baseline) V2

1.1. Basic Concepts of Multi-Image InSAR

- Ground displacement is calculated by processing multiple radar satellite images acquired over the same area from the same satellite.
- SqueeSAR® is TRE Altamira's proprietary multi-image InSAR algorithm that employs statistical analysis techniques to precisely measure ground displacement by processing large archives of radar satellite images.
    - The statistical approach allows sources of noise to be estimated, characterized, and removed from the displacement measurements, allowing measurement precision to reach millimeter level.
    - The SqueeSAR® processing chain is ISO9001 certified, meaning that each step is rigorously quality controlled and that the results are replicable – an analysis can be run any number of times and will produce the same results provided the initial settings are unchanged.
- The output is a point cloud where measurements are derived from point targets or Permanent Scatterers (PS - objects on the ground that are good reflectors of radar signals) and Distributed Scatterers (DS – homogenous areas of ground surface that reflect the radar signal).
- PS and DS both contain time series of displacement that are used to characterize ground displacement over time.
- As a statistically based approach, the higher the number of images, the more accurately are noise sources estimated and removed and, consequently, the higher the precision of the InSAR measurements. Generally, a precision of 1 mm/yr (0.04 in/yr) is reached after 1-1.5 years of image acquisitions (Figure 1).
- Common sources of noise are variations in atmospheric moisture, soil water content, and vegetation coverage. InSAR works well where:
    - The ground surface provides consistent return signals to the satellite over multiple images and for extended periods of time.
    - Ground is dry and clear of heavy vegetation.
    - Surface land cover remains consistent throughout the analysis period.

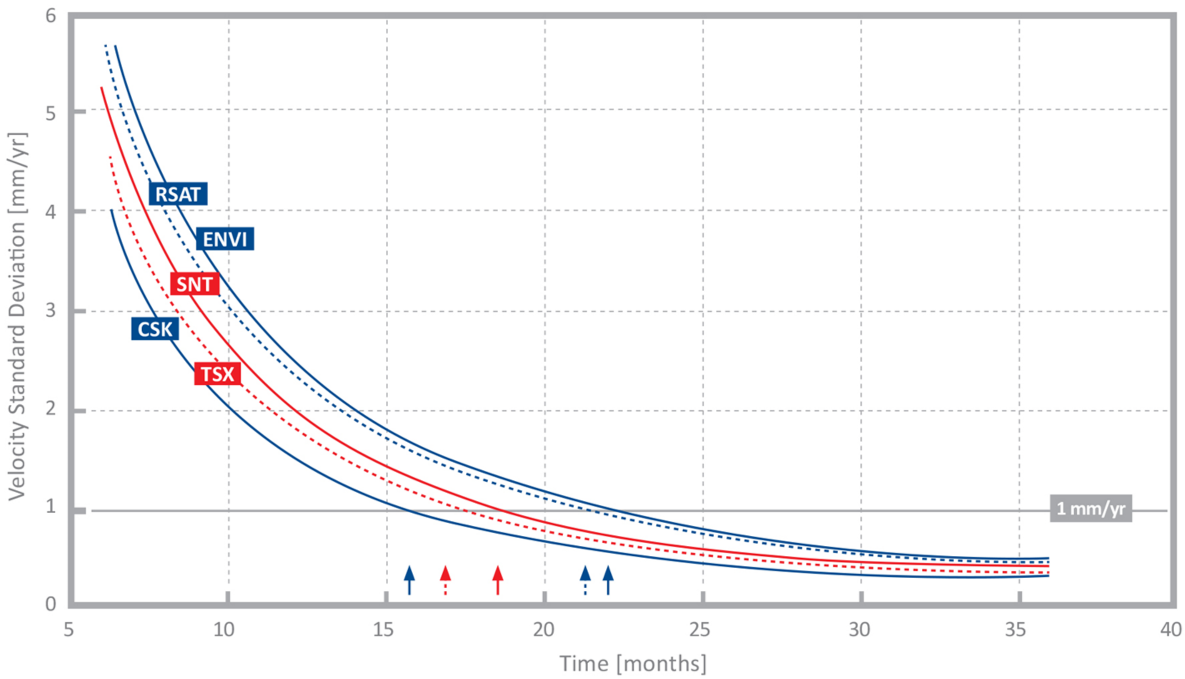


Figure 1: The precision of InSAR displacement rate (i.e. velocity) measurements increases with the number of images and the length of time covered. With regular 11-day acquisitions, TSX measurements reach 1 mm/yr precision after 17 months or around 45 images.

1.2. Synopsis of Rapid Monitoring InSAR

The SqueeSAR rapid monitoring approach identifies an initial grid of measurement points by processing the available images to identify natural radar targets that are good reflectors of the radar signal, at the start of the monitoring period. A baseline analysis requires 15-20 images to provide sufficiently robust statistics for the identification of the optimal grid of points.

The grid of points identified with this initial processing (the initial baseline), is maintained in the monitoring service to allow the provision of rapid monitoring updates. This approach allows updates to be delivered in a few days as opposed to the several weeks required to perform a complete baseline analysis.

Over time, some of the initially identified points may decrease in quality, due to vegetation growth, periodic changes in ground water content or surface changes. As images continue to be acquired, points that have been impacted by surface variations will decrease in reliability and quality and may show unreliable displacement trends. Distributed Scatterers tend to be more impacted than Permanent Scatterers in these scenarios. To maintain the highest quality of measurements, it is therefore recommended to regularly recalculate the measurement point grid by performing a new baseline analysis. This entails reprocessing the entire archive of satellite images to leverage the increased robustness of the statistics derived from the larger number of images available to identify a new grid of high-quality points.

To start the monitoring as rapidly as possible at the Sulphur Dome site, the initial baseline analysis was performed using 16 images collected between 24 January 2023 and 22 April 2023. Due to the limited number of initial images used for the definition of the grid of points, some of the points started to show a decrease in quality over time (i.e. noisier time series) when ground conditions changed (e.g. vegetation growth, alternating periods of wet and dry weather, etc). TREA therefore recommended to perform a baseline reset in September 2023 by reprocessing all images acquired up to September 2023 (i.e. 41 images covering the period 2023-01-24 to 2023-09-05) to increase the robustness of the statistics and define a new grid of high-quality measurement points. The re-baselined data was delivered on 2023-10-07 and forms the basis for the current monitoring.

The data coverage has remained consistent over the main area of interest (Figure 2) for both baselines, and has decreased over peripheral areas (Figure 4), where ground was more affected by surface variations. In addition, the higher number of images and longer period covered by the imagery allowed sources of noise such as atmospheric effects and orbital path inaccuracies to be better estimated and removed, with an overall improvement of measurement quality.

Figure 2 shows a closeup of the new baseline (September 2023) coverage over the main areas of interest (AOI) and Figure 3 shows some comparisons between Average Time Series (ATS) calculated at AOIs 6, 7 and 9 using the initial baseline results (red) and the new baseline results (black). The improvement of the measurement quality is highlighted by the comparison of displacement rate standard deviation values in the headers of the below time series (see the values labelled as "standard deviation" in Figure 3). The standard deviation is a precision index that provides an indication of the error bar associated to the annual displacement rate. The new baseline provides a higher precision (i.e. lower standard deviation values) for the ATS of all 3 AOIs indicated below.

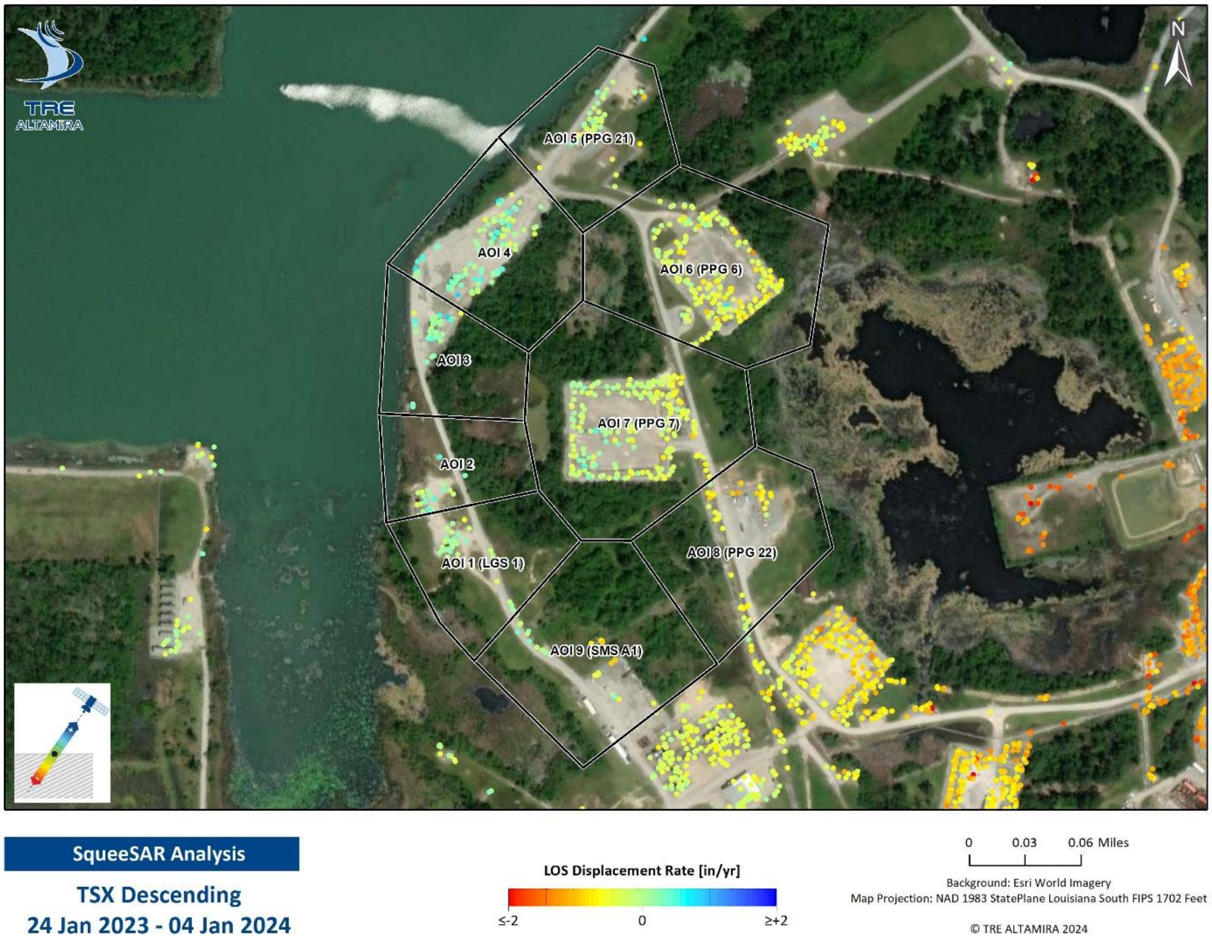
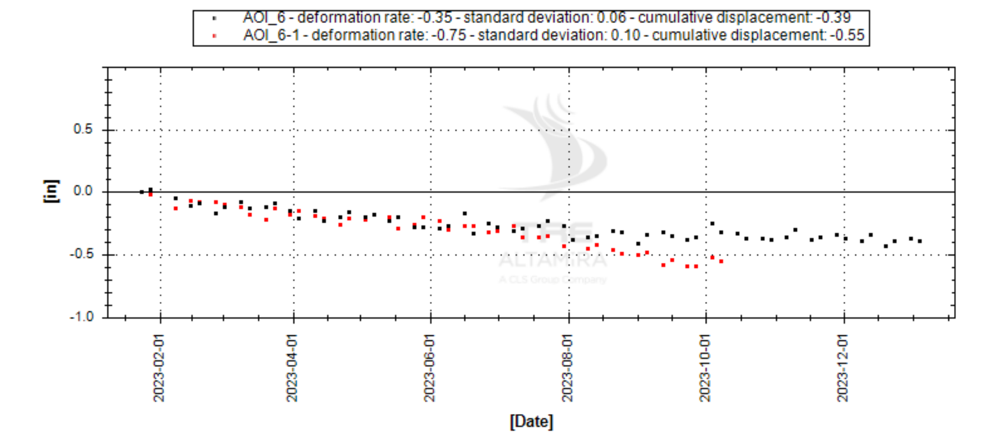
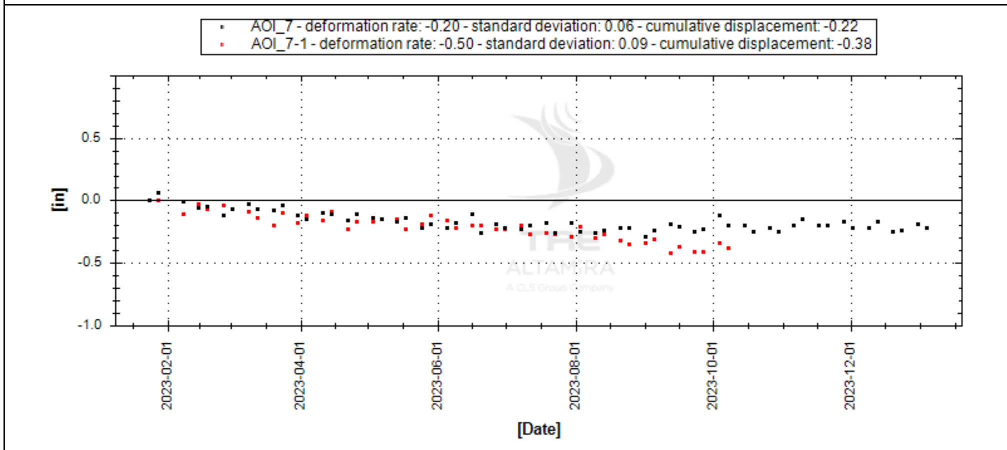


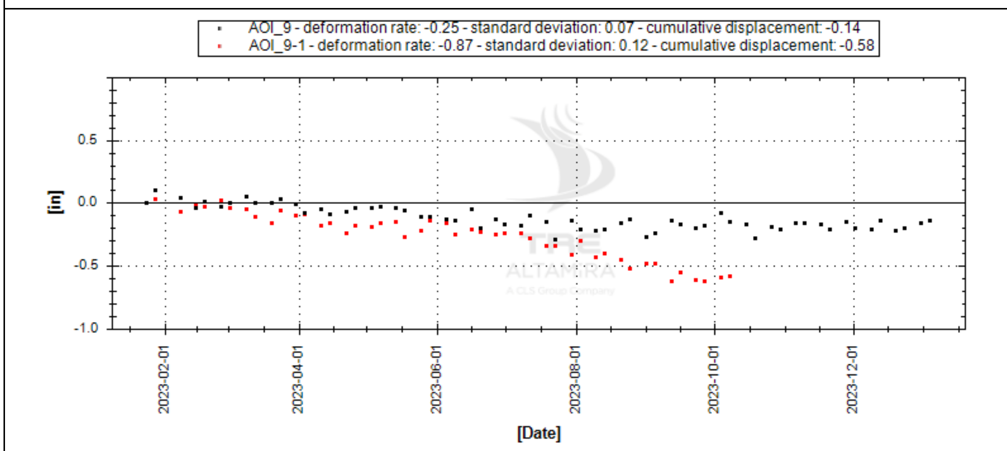
Figure 2: New baseline (September 2023) coverage over the main areas of interest.



AOI 6

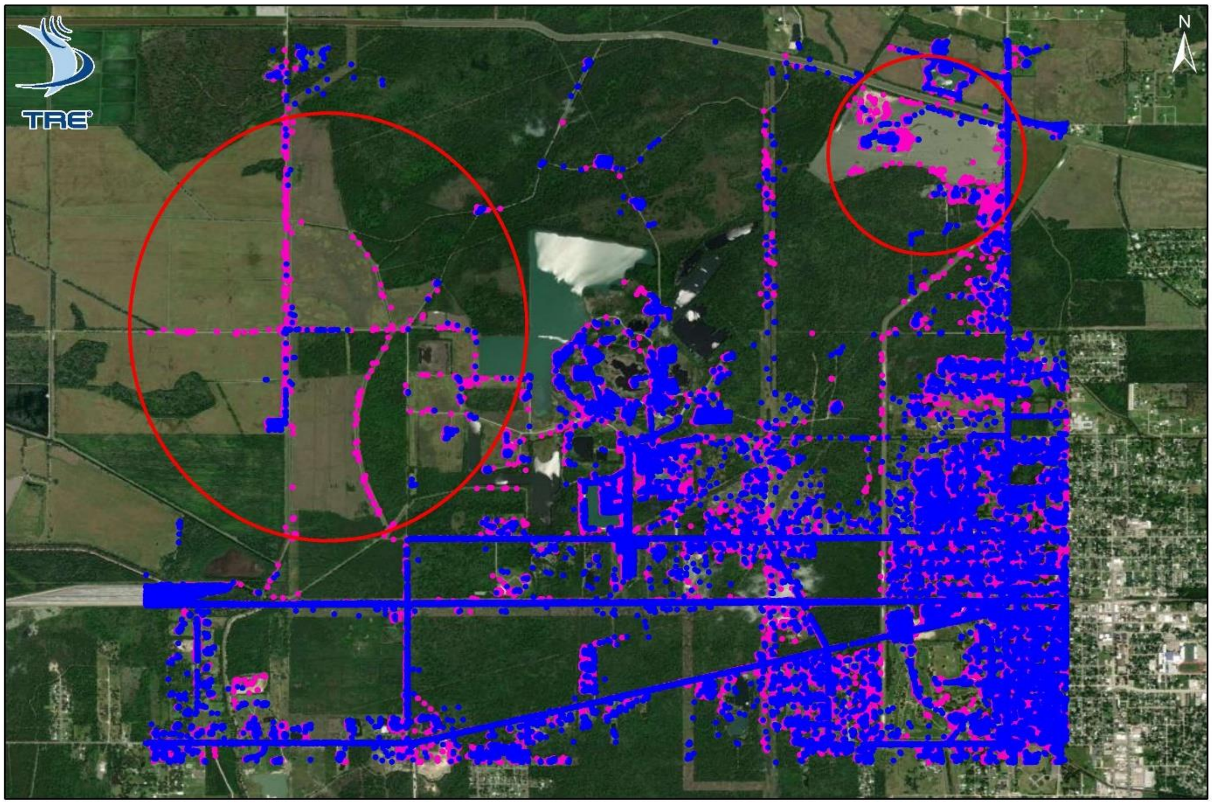


AOI 7



AOI 9

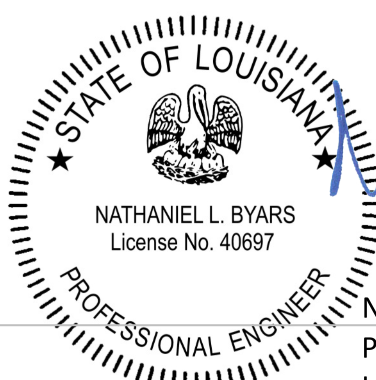
Figure 3: Consistent trends observed using average time series for the old and new baseline results over the areas of interest.



● **New baseline grid of measurement points** ● **First baseline grid of measurement points**

Figure 4: Comparison between the initial baseline grid of measurement points (pink) and the current grid (blue). Red circles highlight areas where changed ground conditions led to a decrease in quality of the points, which were therefore lost in the new baseline.

Based on the observed results, TREA recommends to periodically reset the baseline over Sulphur Mine approximately every 12-24 months, depending on how the data quality and coverage is maintained over time, as well as other local conditions (e.g. flooding), to ensure that the measurements remain of the highest quality.



Date Signed: January 29, 2024
Austin, Texas

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