Appendix M - Neva Ridge Technologies Report

Final Report

MSHA Contract DOLB08MR20605

April 18, 2008

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1 Introduction

1.1 Data Description

Data from the ALOS/PALSAR sensor were obtained from the AADN (Americas ALOS Data Node, http://www.asf.alaska.edu/alos), located at the Alaska Satellite Facility in Fairbanks, Alaska. The dates of the acquisitions and the unique data designation numbers are shown in the table below.

Date	Designation
June 8, 2007	HH-ALPSRP072960780
September 8, 2007	HH-ALPSRP086380780

The ALOS satellite maintains a sun-synchronous, near polar orbit; this is a retrograde orbit that precesses in a plane that is at an inclination of 98.16 degrees. For the geographic location of this data collection, the following figure shows the geometry. Note that for these particular data acquisitions, the satellite was in the ascending portion of its orbit; the satellite looks to the right (starboard) side during data collection. Locally, then, the line-of-site is 38.7 degrees from the local vertical and 10.0 degrees above the local East direction.

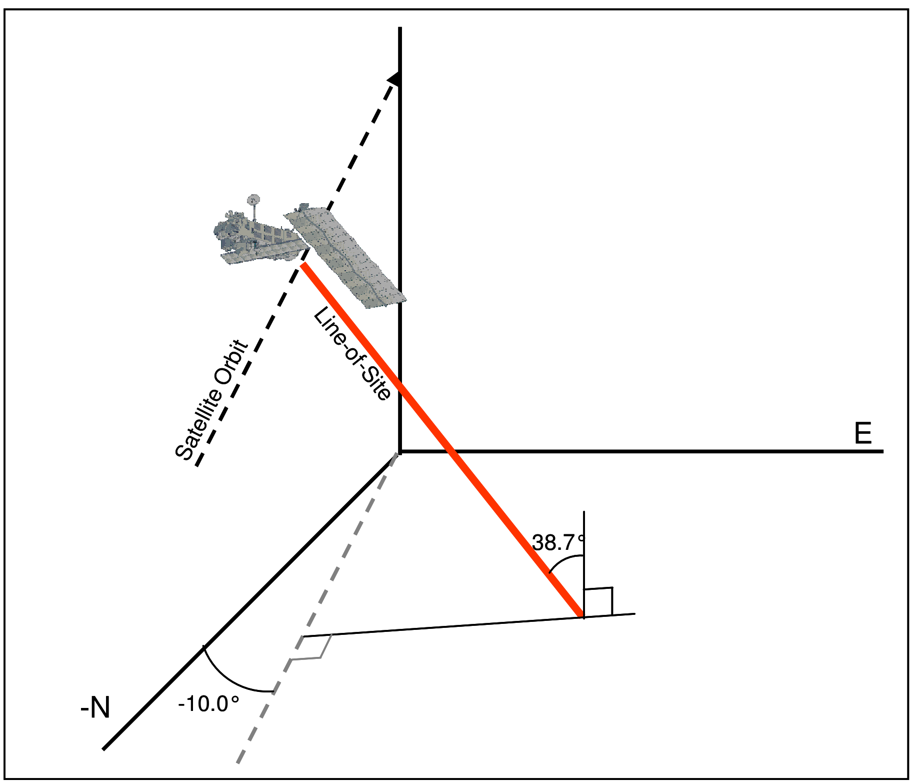

Figure 1. Diagram showing the geometry of the data acquisition at the site of interest.

1.2 Processing Description

Data were processed to complex SAR imagery using tools from Gamma Software. This is standardized processing software that ingests data from most civil SAR sensors. (Neva Ridge is a US distributor for this software.) The interferometry is performed with a combination of additional Gamma Software tools and internal Neva Ridge tools. Complex images are coregistered and the modeled phase due to topography is subtracted using the USGS 3 arcsecond elevation product. Following an iteration to remove errors in the estimated baseline, the *interferogram* is smoothed using a Goldstein filter[1] with a filter exponent of .6. The converted unwrapped results naturally represent the motion along the radar line-of-site (see previous figure) but can be converted to vertical motion with some assumptions. In particular, under the assumption that the ground motion is purely in the vertical direction, we can back-project the measured motion along the vertical direction. However, if we assume that the actual ground motion has a combination of horizontal and vertical components, there is no way to uniquely attach the measured line-of-site displacement to a unique set of horizontal and vertical displacements.

For display and some data manipulation, reprojection, and minor post-processing of the results, we use a combination of PCI Geomatics, Gamma display utilities, and internal tools.

2 Results

In the following sections, we include plan view diagrams (those specified in the SOW) representing the results of the interferometric processing. Each of the plan view figures below represent a region approximately centered on the coordinate NAD27 39°28’01.6”N, 111°13’16.2”W, with spatial extent of 3514 meters on a side.

In addition, in each of the plan view figures, reference points (shown as crosshairs) are included. The coordinates of these are:

Point	WGS 84
1.	111°14’04.9”W, 39°27’12.2”N
2.	111°13’13.3”W, 39°27’43.0”N
3.	111°13’09.1”W, 39°28’04.8”N

2.1 Line-of-Site InSAR Color Contours

In this representation, line-of-site displacements are presented as color-coded contours. In order to enhance the visual dynamic range of the image, the color scale *wraps* at a specified interval, which is shown on the adjacent color bar. For context, the color contours in Figure 2 are superimposed on the corresponding SAR image. As the interpretation of the SAR image is not necessarily intuitive, we have also annotated the physical regions represented by the SAR image shades/textures. The peak line-of-site subsidence measured in this data is 24 cm. Figure 3 shows the same information without the SAR image background layer.

[1] R.M. Goldstein, C.L. Werner, “Radar Interferogram Filtering for Geophysical Applications,” *Geophys. Res. Letters, V25, No21, 1998*

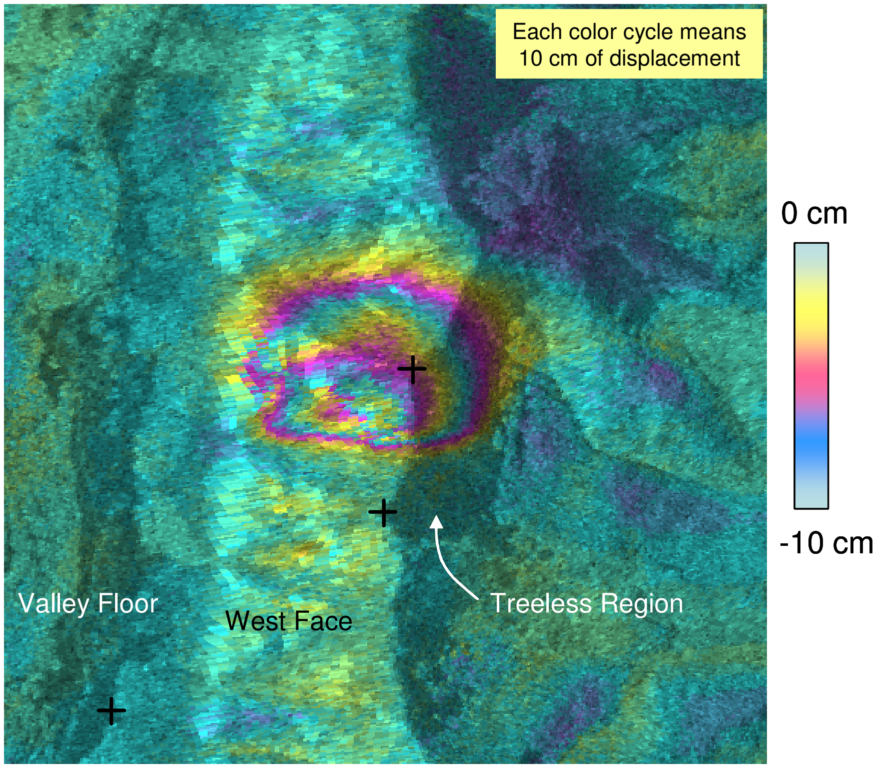

Figure 2. Color contours superimposed on the corresponding SAR image. A peak displacement of 24 cm (along the line-of-site, away from the radar) is measured.

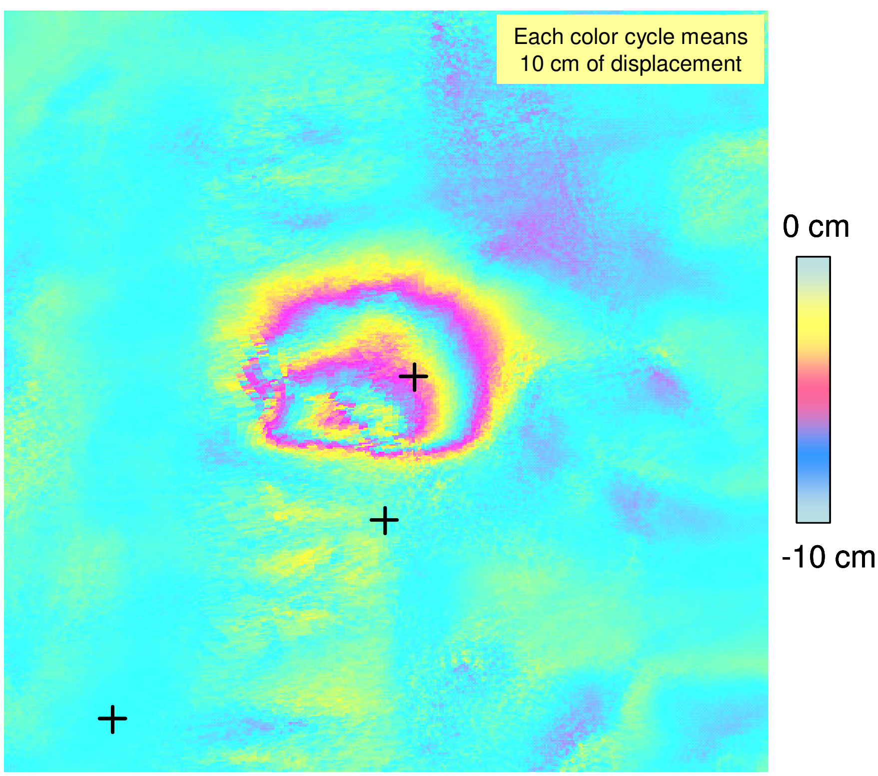

Figure 3. Color contour with no SAR image background layer. A peak displacement of 24 cm (along the line-of-site, away from the radar) is measured.

2.2 Line-of-Site Deformation Contours

The line-of-site deformation contours are produced at 5 cm intervals and are shown in Figure 4. It is not uncommon in InSAR measurements to contain atmospheric effects that are on the order of 1-2 cm. These are produced by moisture (dielectric) variations in the atmosphere that produce noise due to variable phase delays of the radar signal. Using an initial contour of 5 cm mitigates visual interference due to this low-level noise.

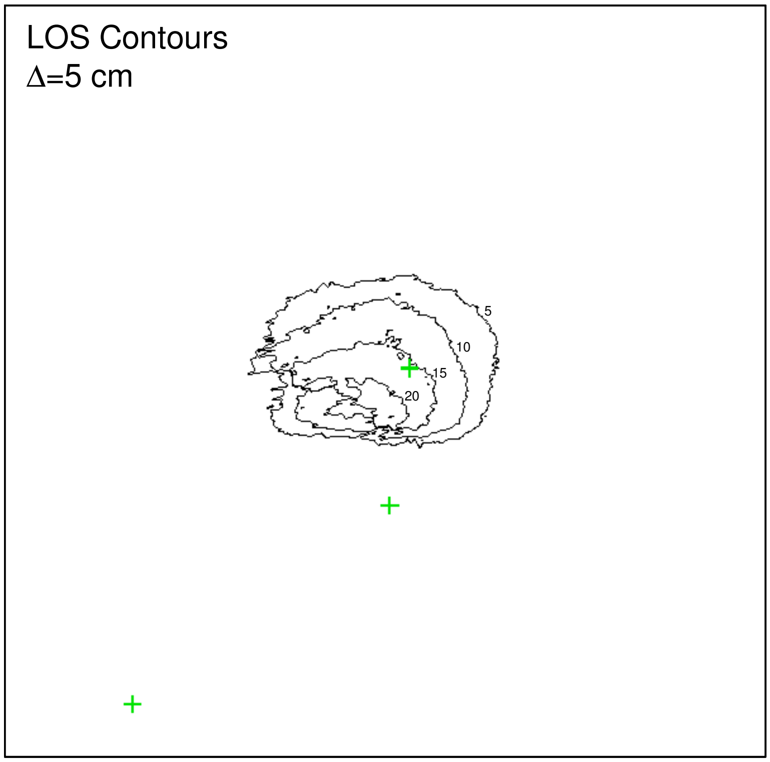

Figure 4. Line-of-site deformation contours with intervals of 5 cm. Motion is away from the radar.

2.3 Vertical Deformation Contours

Vertical deformation measurements may be derived from the line-of-site measurements under the assumption that motion is purely vertical. Based on the diagram in Figure 1, the relationship between the line-of-site measurement and vertical measurements is:

$$\delta_{vert} = \frac{\delta_{LOS}}{\cos(38.7)}$$

The result of this transformation is shown in Figure 5.

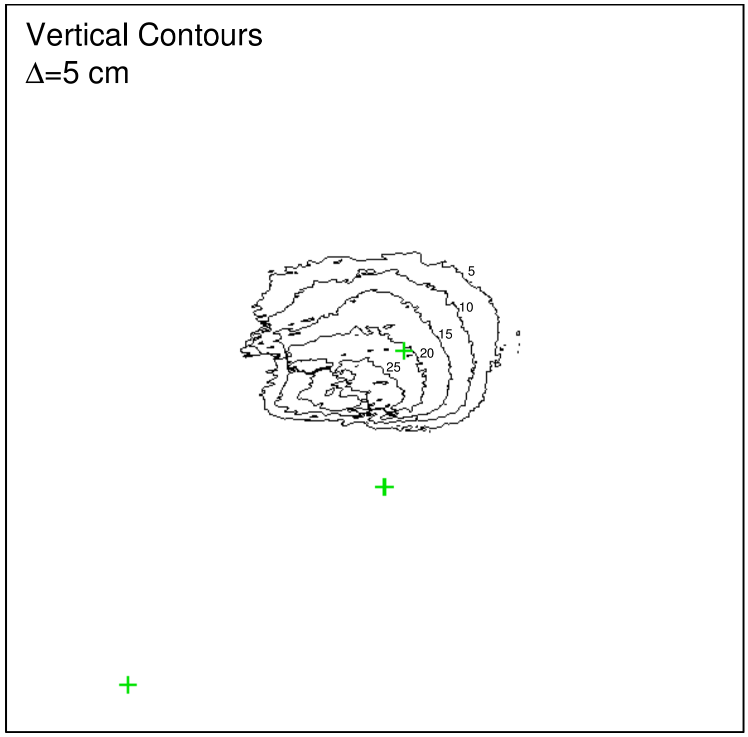

Figure 5. Vertical contours. A peak displacement of 30 cm (vertical, downward) is measured.

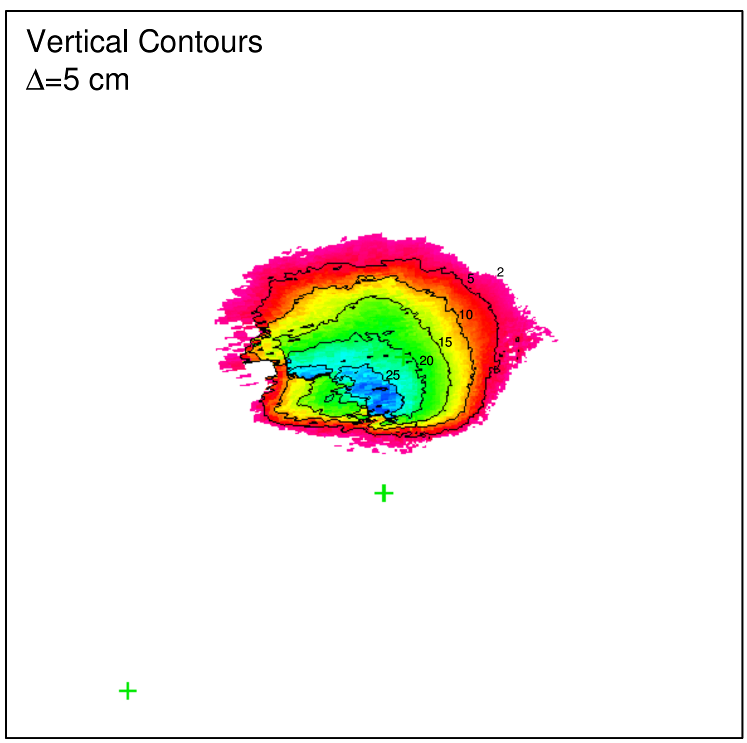

Figure 6. Vertical contours are combined with a color scale. For visual clarity, measurements outside the main feature, with values of 2 cm or less, have been removed.

2.4 Google Earth View

Figure 7 shows a Google Earth composite with the InSAR vertical displacements. The InSAR data have been filtered so as to remove measurements outside the main feature, with displacements of less than 2 cm. This results in a better visual representation of the data.

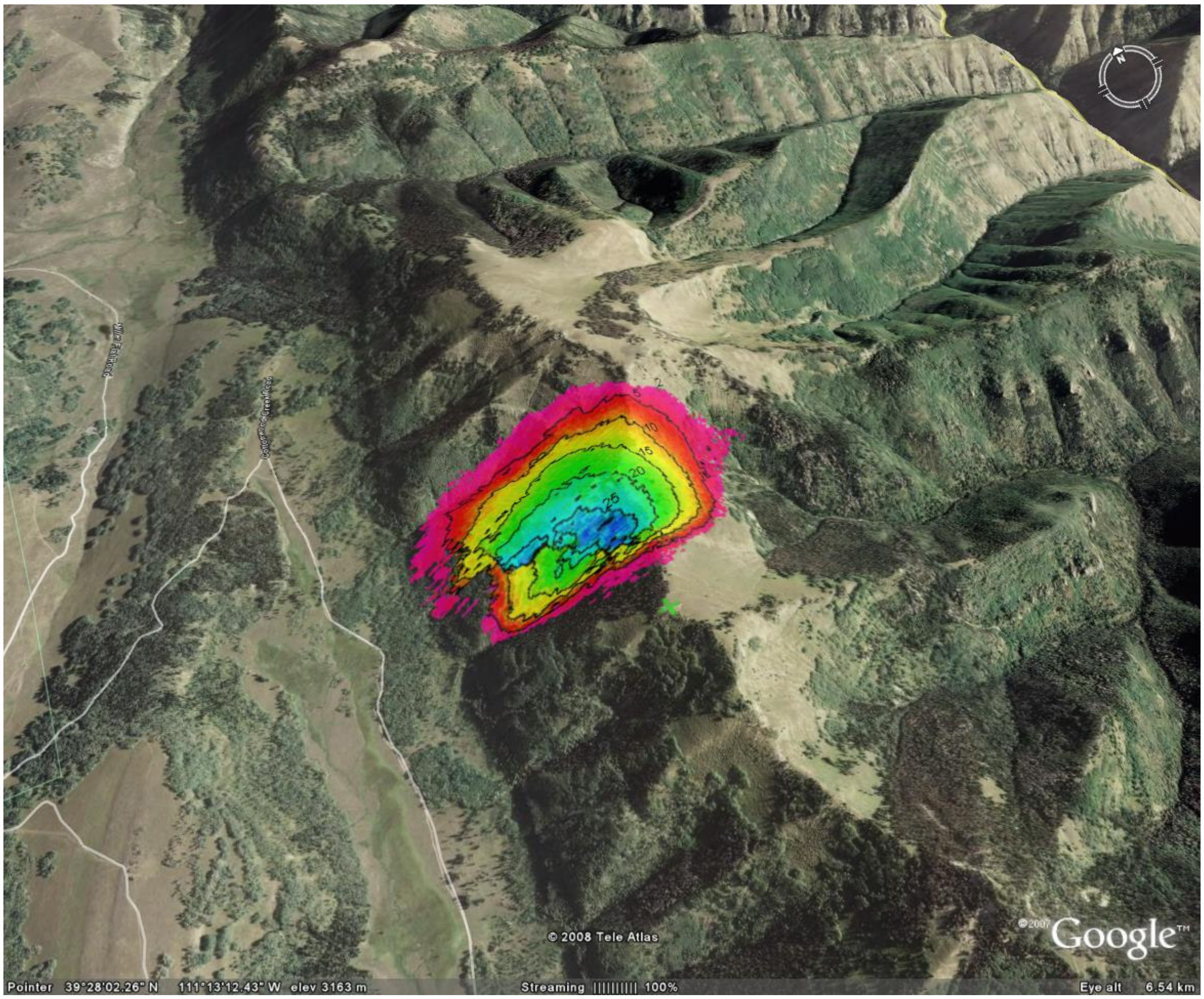

Figure 7. Google Earth composite image.