Assignment: Generation of a Displacement Map

2023 Turkey–Syria earthquakes

The selected study area is in southeastern Türkiye, near the border with Syria, where two large earthquakes-one of Mw 7.8 at 04:17 local time and another of Mw 7.5 at 13:24 local time-occurred **on 6 February 2023**. The earthquakes triggered widespread ground displacements along the East Anatolian Fault Zone, which is a left-lateral strike-slip boundary between the Anatolian and Arabian plates. It represents an area of active plate collision, crustal shortening, and numerous tectonic lineaments that may have had an influence on fault segmentation and rupture propagation. More than 50,000 fatalities were caused by the events; more than 160,000 buildings were either damaged or destroyed, with millions of residents affected. Since then, this area has undergone more than 10,000 aftershocks within weeks from the main events (Naddaf, 2023).

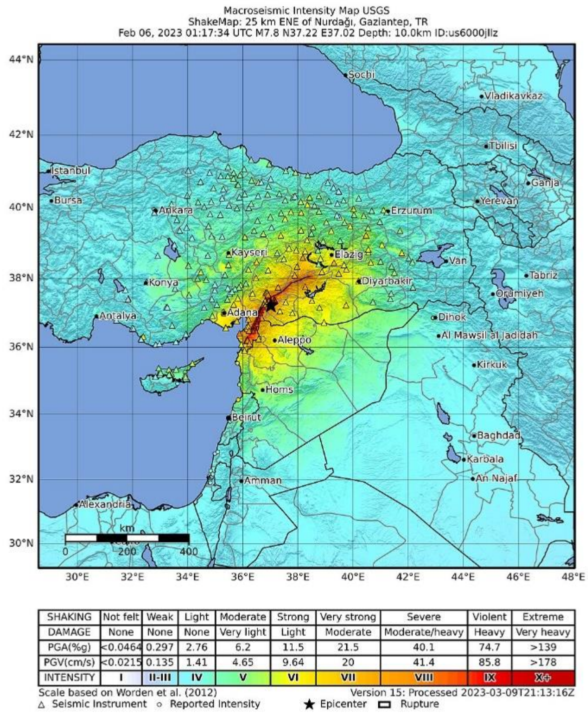


Figure 1: Shakemap of the magnitude 7.8 earthquake in Turkey/Syria (https://earthquake.usgs.gov/earthquakes/eventpage/us6000jllz/shakemap/intensity)

Figure 2: Lands cracked by earthquake in Turkey (https://www.thenationalnews.com/mena/2024/02/06/turkey-earthquake-satellite-images/)

We will be using the following pre- and post-event Sentinel-1 SLC products:

S1A_IW_SLC__1SDV_20230129T033427_20230129T033455_046993_05A2FE_6FF2

Sensing time: 2023-01-29T03:34:27.062000Z

Orbit direction: DESCENDING

Polarisation: VV&VH

Processing level: LEVEL1

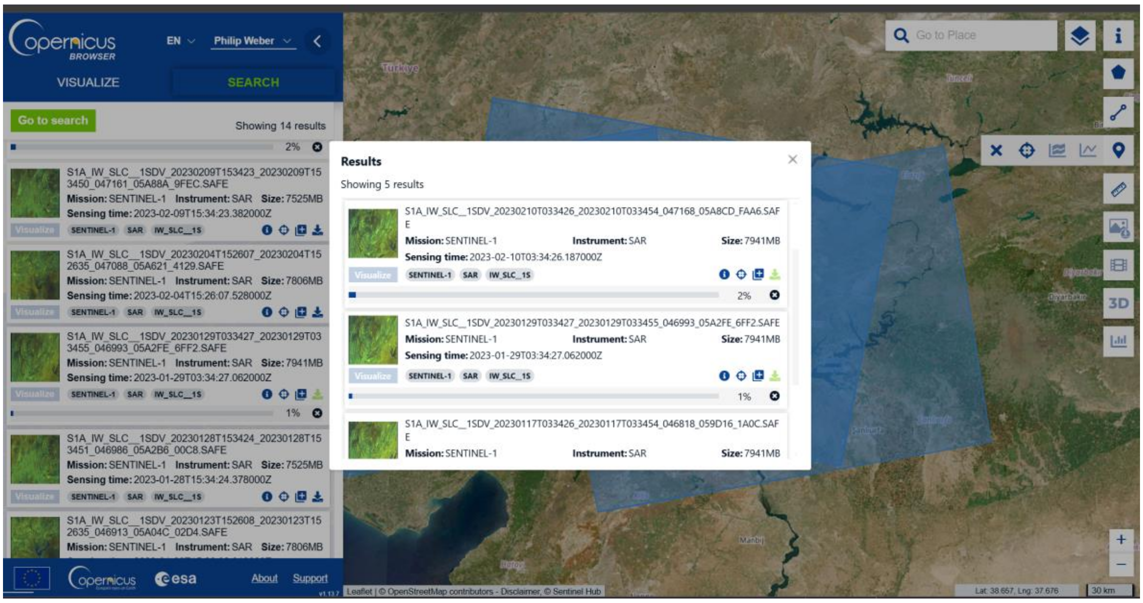
S1A_IW_SLC__1SDV_20230210T033426_20230210T033454_047168_05A8CD_FAA6

Sensing time: 2023-02-10T03:34:26.187000Z

Orbit direction: DESCENDING

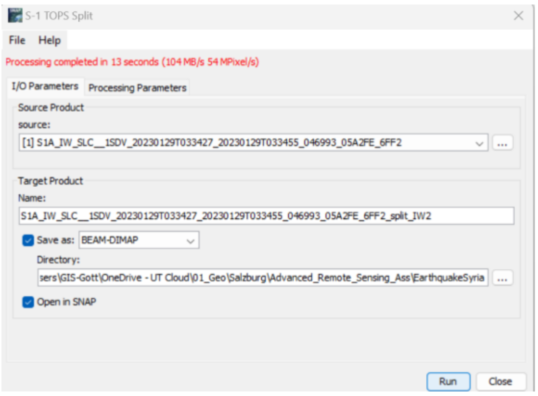
Polarisation: VV&VH

Processing level: LEVEL1



Data preparation

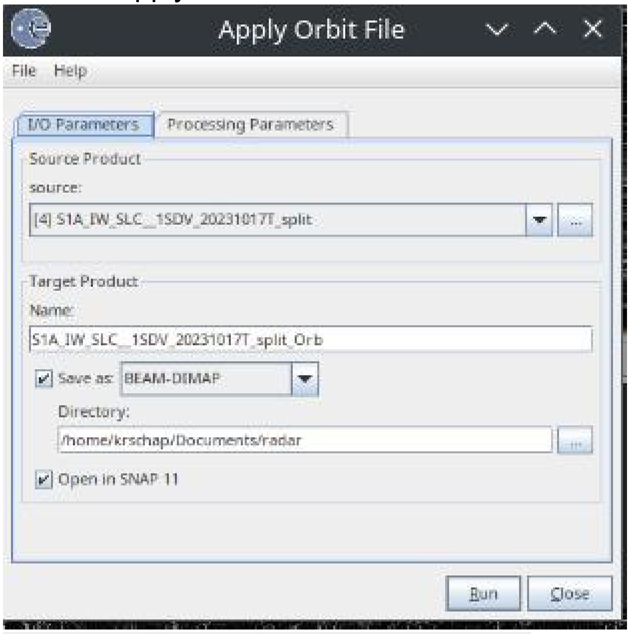
1. Split the Subswath (IW2 and VV chosen)

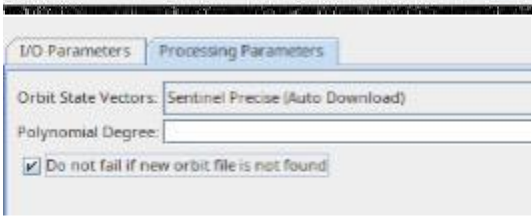


2. Apply Orbit File/Orbit Correction

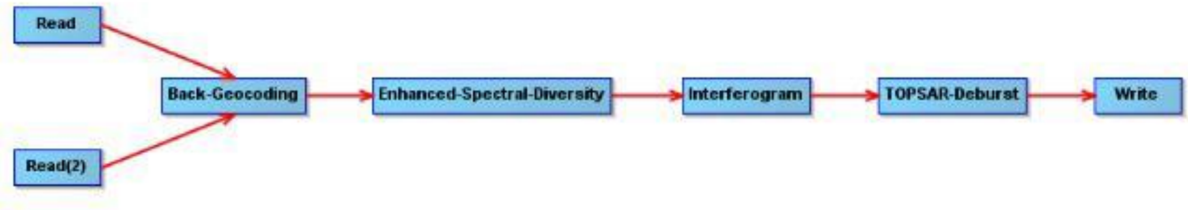
   Technically we suppose that satellite is following perfect line, but in reality, there is vibration in satellite, and it is not really stable. Hence, we need to apply correction on the orbit path

   Radar > Apply Orbit File



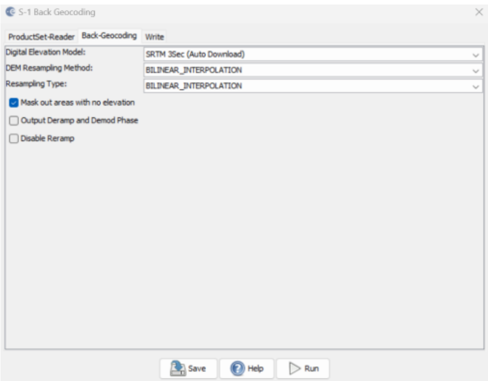


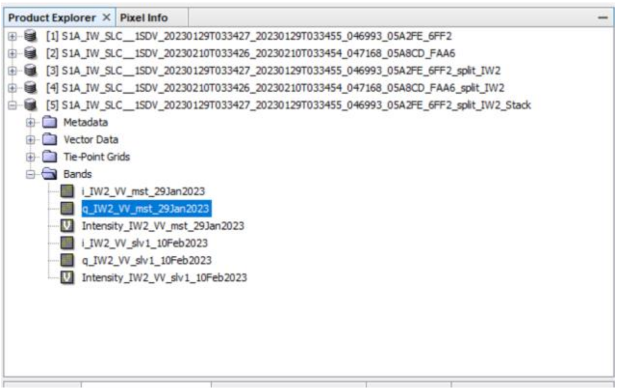
Generation of Topographic Interferogram



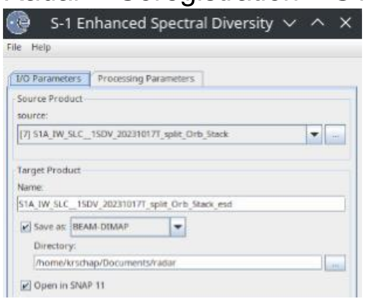
1. Back-Geocoding
   The S-1 Back Geocoding operator coregisters the two split products based on the orbit information added in the previous step and information from a digital elevation model (DEM) which is downloaded by SNAP.

   GOTO: Radar > Coregistration > S-1 Tops Coregistration > S1- Back Geocoding
   Master Image: The reference image
   Slave Image: The secondary image

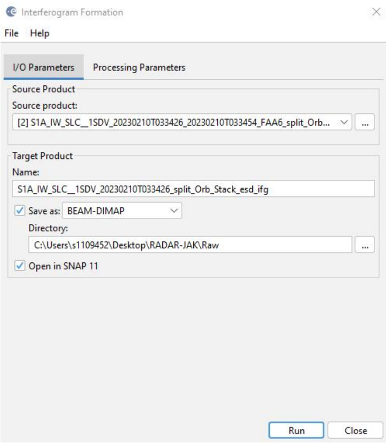




1. S1-Enhanced-Spectral-Diversity
   To improve the quality of the after image as related to before, in order to remove ionospheric error this step is used.
   GOTO:
   Radar > Coregistration > S1 TOPS Coregistration > S-1 Enhanced Spectral Diversity



2. Interferogram Formation
   This is where we calculate the phase difference between two images along with coherence
   GOTO:
   Radar > Interferometric > Products > Interferogram Formation

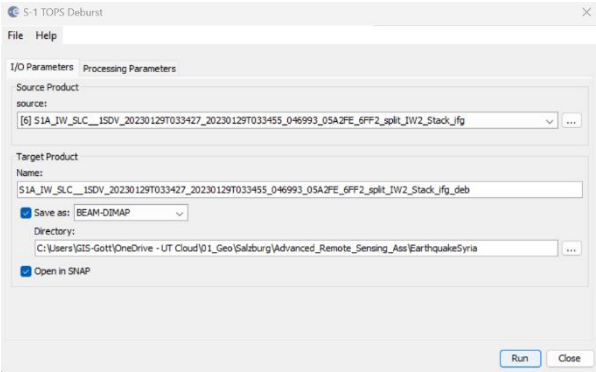


3. S-1 TOPS-Deburst

   To remove the seamlines between the single bursts we use TOPSAR Deburst

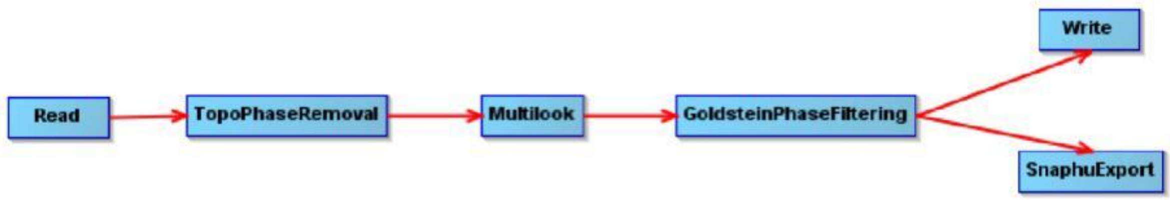
   GOTO:

   RADAR > Sentinel 1 - TOPS > S-1 TOPS-Deburst

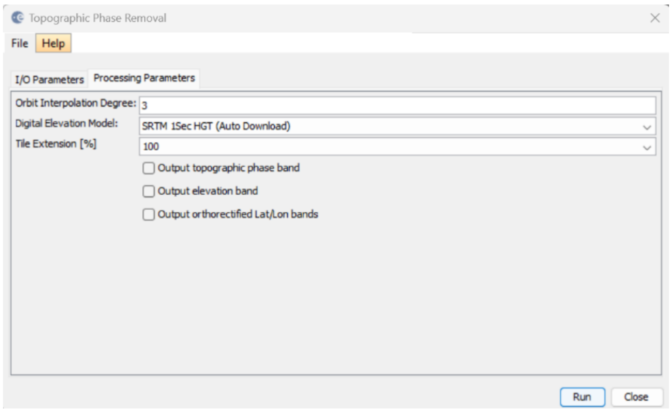


Generation of Differential Interferogram

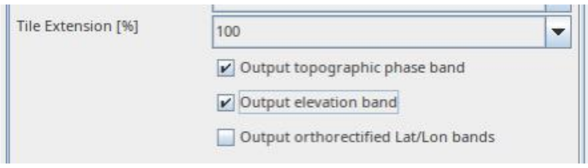
1. Topographic Phase Removal
   By generating a differential interferogram, we remove the topographic effects, extracting the phase changes caused by ground displacement.



Topographic Phase Removal
GOTO:
Radar > Interferometric > Products > Topographic Phase Removal

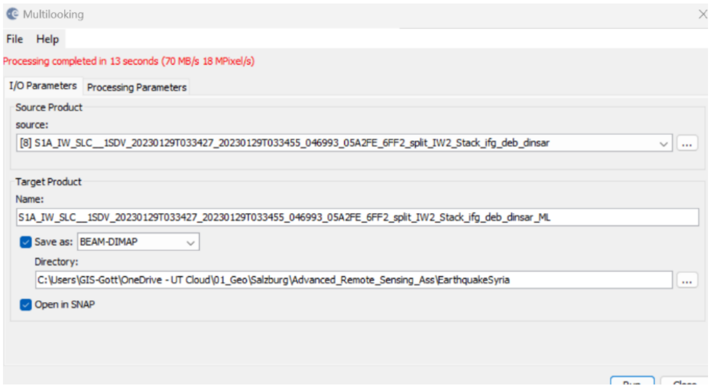


Check Output Topographic Phase band and the elevation band, Lets visualize the elevation as well.



2. Multilooking (SAR Utilities)
   We need to create square pixels to make the resolutions same in range (approx 3m) and azimuth (approx 7m). we are used to see pixels in square

   GOTO -> RADAR > SAR utilities > Multilooking



Navigated to processing parameters and change number of looks for range and azimuth.

By using

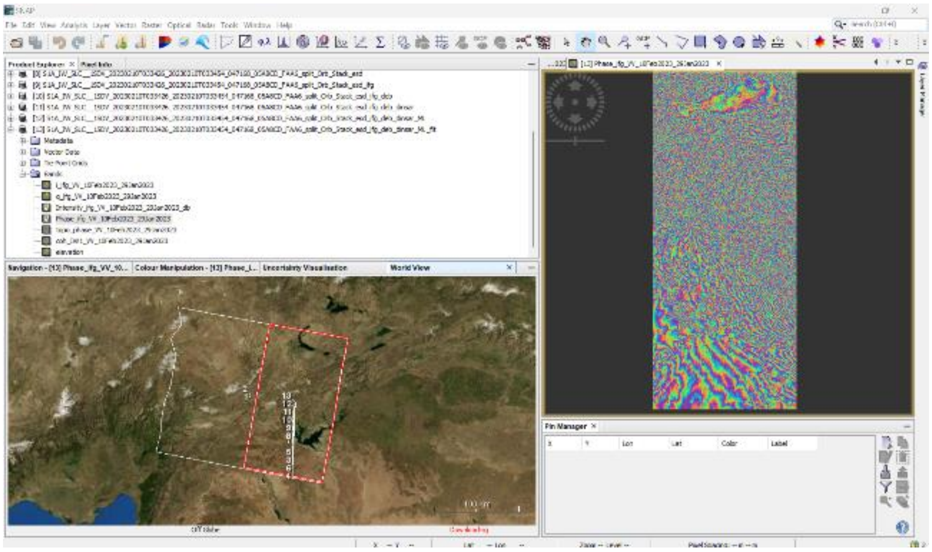
Range : 8

Azimuth : 2

Because it results approx 30m resolution which is enough for me because usualy displacement will happen in larger level, you can see the resolution after the value changes

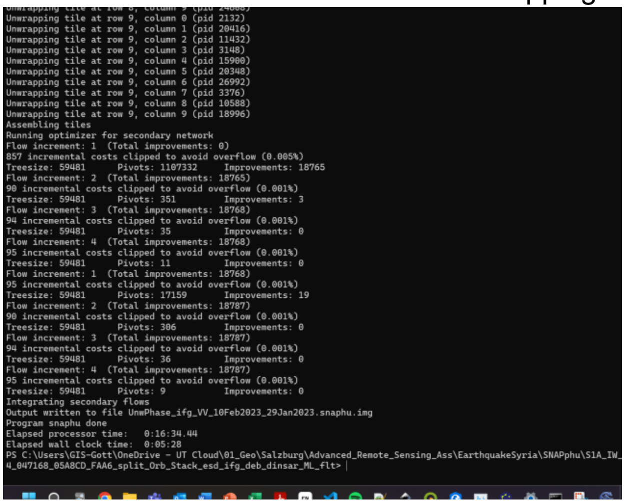
3. Goldstein Phase Filtering
   Let's filter the noise so that we can improve visual interpretability of differential interferogram.

GOTO: Radar > Interferometric > Filtering > Goldstein Phase Filtering.

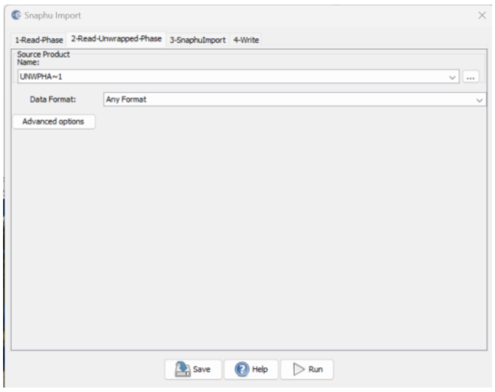


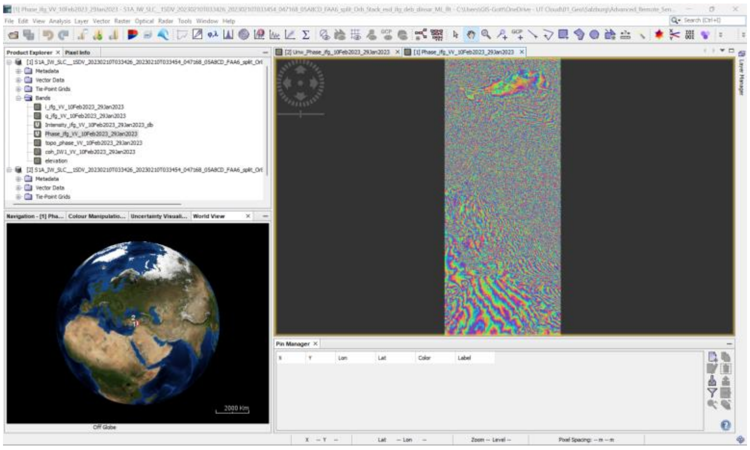
Generation of displacement map

1. SNAPHU Export
   GO TO Radar > Interferometric > Unwrapping > SNAPHU Export

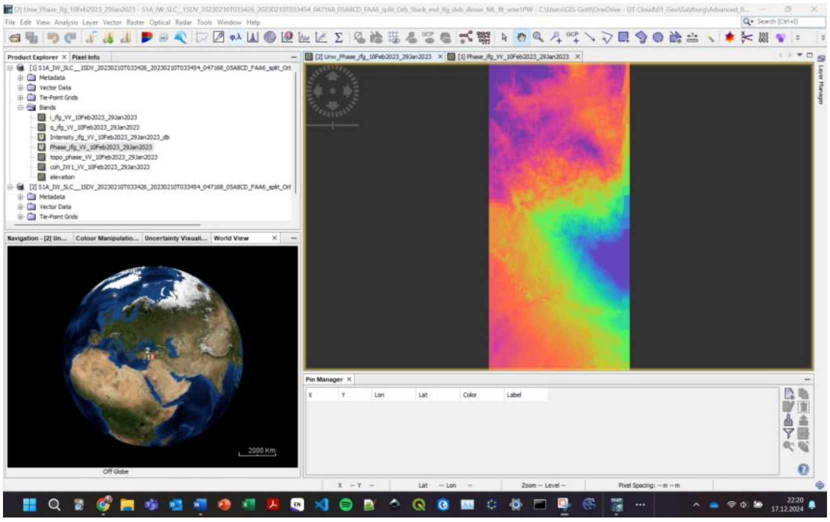


2. SNAPHU Import
   Radar > Interferometric > Unwrapping > Snaphu Import



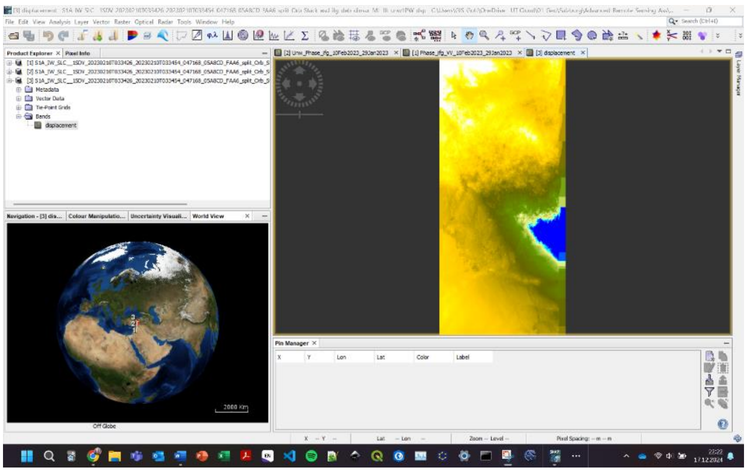


3. Phase to Displacement
   Radar > Interferometric > Products > Phase to Displacement



4. Range-Doppler Terrain Correction
   Terrain correction georeferenced the displacement map to a coordinate system and removes distortions caused by topography, ensuring accurate spatial analysis.

   Goto : Radar > Geometric > Terrain Correction > Range-Doppler Terrain Correction



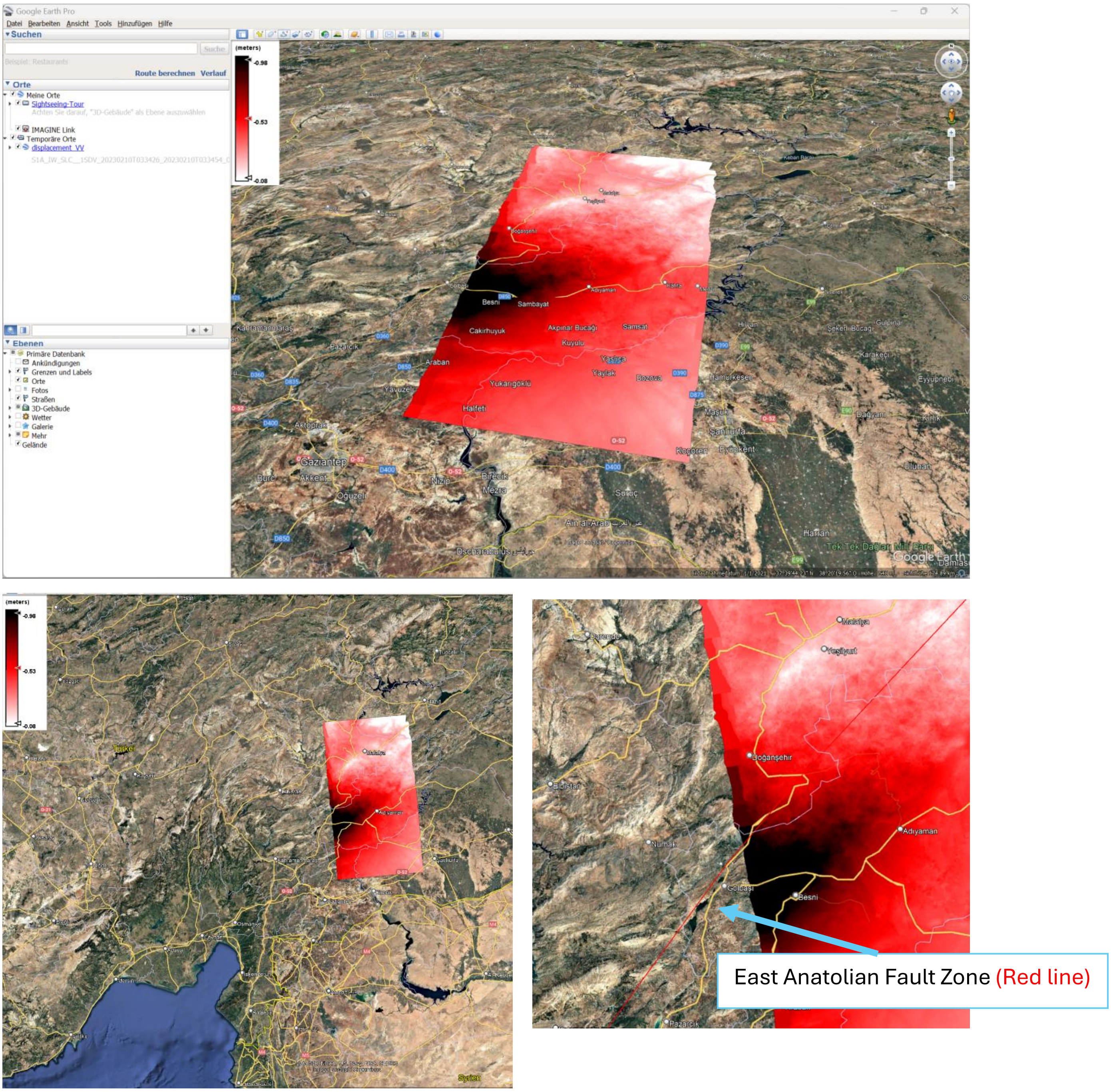


Figure 3: The final displacement map product at the Turkey-Syria border showing serious displacement (color ramp)

Results Analysis of the observed deformation patterns. Discuss briefly the implications of your findings:

The above ground displacement map highlights significant surface deformation caused by the earthquakes that struck Turkey and Syria on 6 February 2023, with magnitudes of Mw 7.8 and Mw 7.5, respectively. The following map shows clear lateral movement, with significant displacement occurring mainly along the fault line (in red), as shown by the gradient from light red/white to dark red/black areas, which indicate the maximum subsidence or horizontal displacements (up to a maximum of -0.98m). However, the scene is not broad enough to represent the whole impact of the earthquake, and the integration of additional contextual information/geodata in the final map would also provide a better understanding of the deformation trends and their regional consequences.