Study of subsidence in Gipuzkoa using PSInSAR

Synthetic Aperture Radar (SAR) usually combines the information recorded by a receiving antenna from the different points along the trajectory. From the distance (R) (between the sensor and the ground) and the electromagnetic wavelength (λ), we can obtain the value of the phase (Ø), with the expression: $Ø = -4.\pi.R/\lambda$

SAR remote sensing by satellite has the advantage of covering large areas and having good temporal coverage. The treatment of a set of SAR images, is done by SAR interferometry (InSAR), comparing the phases of different SAR images of the same scene and on different dates, obtaining deformations in different periods of time. Thus, with the most recent radar data and advanced algorithms, surface movements can be determined on a millimeter scale.

The interferometric phase difference (ΔØ) obtained will have a part related to ground deformation and another part related to measurement errors (satellite orbits, terrain topography, atmospheric conditions, humidity, noise, snow, etc.). For this reason, the InSAR technique cannot be used in any situation. You have to pay attention to the quality or consistency of the estimation of the interferometric phase. In vegetated areas the coherence will be low, because the signal has less penetrability through the vegetation; while the signal in urban areas the coherence will be high, because the geometry of the place will remain constant and the radar signal bounces in a similar way.

From the conventional InSAR techniques, other more advanced techniques have developed. The Differential InSAR (DInSAR) technique has been generally used for rapid or sudden movements (volcanic activities, landslides, etc.), where differential interferograms are used, eliminating the topographic component with the help of a DTM; while Permanent Scatterer Interferometry (PSInSAR) is used as a processing algorithm to monitor slow and subtle movements (subsidence or rising), with millimeter precision.

In this case, the PSInSAR has been used for the processing and analysis of surface movements in Gipuzkoa, and it is generally characterized with respect to conventional InSAR in: using a multi-image data set, atmospheric and orbital errors are essentialy removed, sub-pixel radar reflections are analyzed, linear and non-linear deformation patterns are identified, and time histories of movements are generated for every radar target (PS).

For this study of surface deformations of the Historical Territory of Gipuzkoa, radar data from the ESA SENTINEL-1A/B satellites have been processed, which within the Copernicus program have a high acquisition frequency (up to one image every 6 days). Two orbits have been selected (one ascending and one descending), with a spatial resolution of 30x30 m. and a temporary period of 4.6 years (2016 - 2020). In this way, movements can be interpreted vertically and horizontally (East-West). The North-South component is not estimated because the orbits have very little polar inclination. These movements are analyzed by identifying pixels that have a strong and constant reflection over a long period, known as Persistent Scatters (PS). The PSs have a high correlation and it can be said that they are consistent. PS are usually hard objects such as buildings, bridges, and rocks. Analyzing the time series, it can be seen if it is a linear movement, so if there is a correlation greater than 0.75, it can be considered as an area affected by movement. These movements over time define a speed of movement represented in mm/year. The total number of PS points analyzed is about 95000, with a resolution of 30 x 30 m. and reach an analysis surface of 204 km^2 (10.3% of the surface of Gipuzkoa).

In the following years it is expected to continue analyzing and updating more data, continuing the time series. It also wants to integrate with the data from the permanent stations of the Gipuzkoa GNSS Network.

The results of this study can be analyzed on a viewer. It should be noted that **these data must be taken with caution**, **so precipitate conclusions should not be taken**. These movements may have some errors for various reasons, such as construction works, humidity, atmospheric errors, noise, etc. These possible superficial movements would have to be confirmed with other procedures.