

INTERFEROMETRY



VENING

INSAR

OIL & GAS
MINING
INFRASTRUCTURES
NATURAL DISASTERS

PIPELINE MONITORING

Pipelines, used to transport oil, gas, and water, are works of great linear extension that reach thousands of kilometers. Along this path, they pass through different type of soils such as sand, mud, clay or different types of sedimentary, metamorphic or igneous rocks. In addition to that, changes in aquifers and reservoirs produce movements on ground over which pipelines are laid down.



Trans-Alaska Pipeline Leakage, 2001

Differential interferometry (DInSAR) allows monitoring at centimetric and sub-centimetric levels with a temporal periodicity of 8 days in the case of the SAOCOM satellites. Thus, it is possible to identify areas where changes in the ground may represent a risk of pipeline damage.

OIL&GAS BASIN MONITORING

Fluid injection/extraction operations generate volumetric variations in the basins and, therefore, changes in the height of the surface cover. These changes can be difficult to measure due to the large surface area of the basins in which the operations take place. However, differential interferometric techniques (DInSAR) makes possible to measure surface height variations with centimetre and sub-centimetre precision.



Subsidence in Powder River Basin, USA

In this way, it is possible to estimate volumetric changes in the basin and associate them with fluid extraction and injection processes. These data are of interest to monitor the infrastructure of the operations in order to prevent higher structural damages and to contrast injection/extraction values with volume changes in the basin to lower environmental risks. By means of the SAOCOM constellation, it is possible to carry out these studies with a periodicity of 8 days.



SLOPE STABILITY MONITORING

Mining activities are related to several anthropic and geophysical phenomena which tend to modify ground stability, such as changes in rocks due to the mining activity itself, heavy vehicles traffic, tensions of the faults and slopes wash in tailings dams, among others. All of these, lead to the necessity of ongoing monitoring to set early warnings in order to prevent possible accidents which may be a risk for people, environment



Mina Bingham Canyon, 2013

Nevertheless, high-precision measurements over time, result expensive and, in some cases, logistically difficult to obtain. However, differential interferometry (DInSAR) is an excellent alternative which allows to measure ground displacement with centimetric and sub-centimetric precision at 8 days intervals in the case of the SAOCOM satellite constellation.

SUBSIDENCE IN CIVIL WORKS ANALYSIS

High-rise buildings, bridges, tunnels, dams, routes, among others, are construction works that are settled on the ground. Extraction of fluids or solids in sub ground layers produces settlements which eventually lead to changes in upper layers of the land cover where the aforementioned construction works are located. Therefore, even foreseeing all the construction factors, it is necessary to analyze sudden or high-value changes to safeguard infrastructure avoiding both human and economic losses.



Okinawa, 2015

In this sense, the displacement measured by interferometric techniques achieves centimetric and sub-centimetric precision over large remotely observed areas. Measurements that, in the case of the SAOCOM satellites are possible at 8 days intervals. Therefore, by means of SAR measurements and the differential interferometry technique, it can be performed a continuous temporary analysis of ground movements and works that settle on it. Thus, it is possible to anticipate potential risks of damage to the structures.



MONITORING OF POTENTIAL LANDSLIDE AREAS

Landslides represent a major risk for human settlements. Examples are the tragedies in Italy in 1963 and Sierra Leone in 2017, where thousands of human lives were lost. It is important to consider that landslides increase their probability of occurrence due to rainfall and earthquakes. Therefore, it is essential to monitor critical areas where geological and environmental risk factors are combined to generate early warnings.



In this sense, monitoring by Differential Interferometry or DInSAR, allows to obtain periodic ground displacement data in centimeter and sub centimeter order with which potential risks can be estimated and thus generate early warnings. The SAOCOM Constellation sensors can take samples every 8 days over a study area and represent a great advantage for displacement monitoring since, in addition, they have greater penetration capacity over vegetation than other sensors.

SERVICES

Topography

Interferometric services with SAOCOM provide updated Digital Elevation Models (DEM) that, due to their ability to penetrate vegetation, allow obtaining high resolution models and better representation of the terrain.

Soil displacement

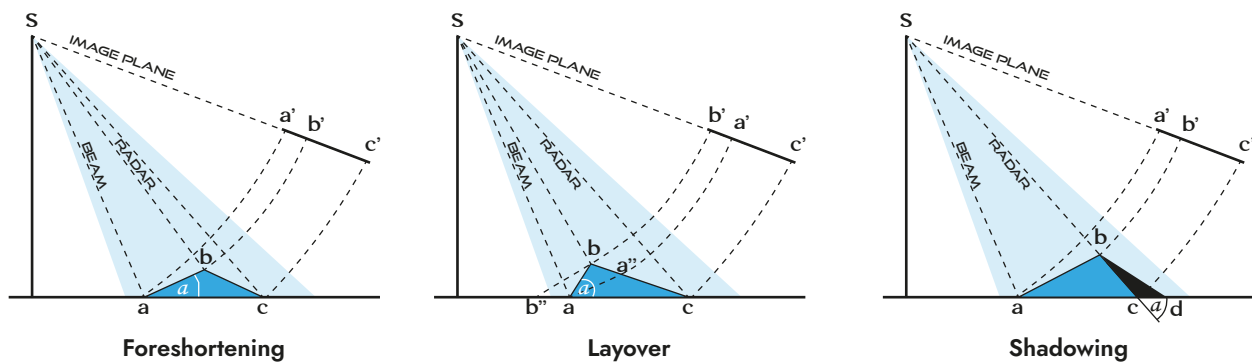
Displacement monitoring services consist of average ground displacement velocity maps and cumulative displacement time series and associated reports. These services are of valuable use for:

- ▶ Monitoring of pipeline **sliding** due to natural causes.
- ▶ Soil **stability** analysis for mining operations
- ▶ **Subsidence** analysis for civil ground stability evaluation
- ▶ Monitoring of areas with potential **landslide** hazards

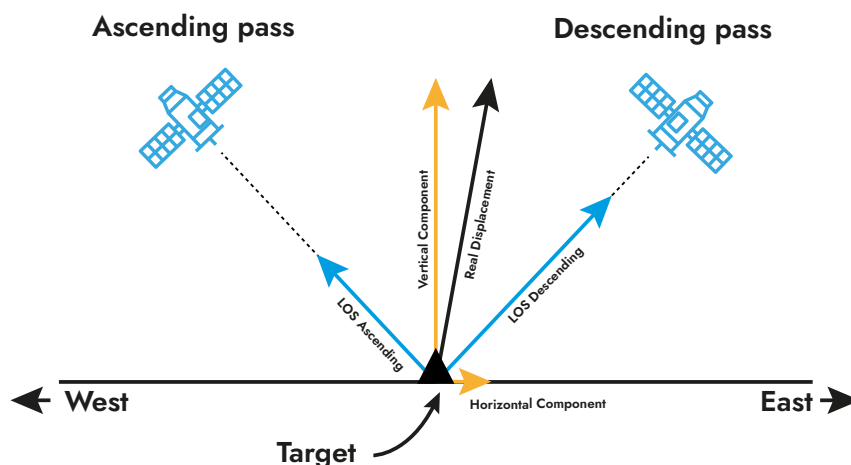


GEOMETRY OF ACQUISITION

Given the characteristics of the orbit, SAOCOM sensors can acquire data in both ascending and descending geometries. This represents a significant advantage for topographic and displacement interferometric models since it improves the results in areas with geometric distortions.



Furthermore, it represents an enormous advantage for differential interferometry (DInSAR) since, from the combination of the ascending and descending Line of View (LOS) displacements, it is possible to reconstruct the total displacement component and, therefore, the decomposition into vertical and horizontal components.



However, consideration should be given to acquiring and processing with a single geometry to determine LOS displacement.



DISPLACEMENT VELOCITY MAPS SERVICE (DVMS)

Quantification and **qualification** service of ground displacement for monitoring and the consequent early warning. The study is carried out within a certain period of time and the differential interferometry technique is used for this purpose. For this purpose, a set of SAR scenes obtained with the same acquisition characteristic (orbit, mode, beam and polarization) is formed, which we call Interferometric Stack. The study can be performed in one or both geometries. In the latter case, it includes ascending and descending scenes to optimize the altimetric accuracy.

Metric characteristics of the technique

Minimum number of samples ¹	At least 15 acquisitions
Planimetric resolution	10 M intra-pixel distance
Maximum detectable altimetric displacement ²	5,87 CM
Maximum detectable displacement velocity ³	268 CM/YEAR
Theoric detectable altimetric displacement precision ⁴	±2 CM
Theoric calculable displacement velocity precision ⁵	±4 MM/YEAR

Considerations

¹ Increasing the number of samples improves the precision of the calculated displacement velocity, eventually approaching to table value.

² Between two contiguous pixels of the displacement map generated by two correlating observations.

³ It assumes the maximum number of acquisitions in a year and the maximum detectable altimetric displacement.

⁴ The final value depends on the conditions of the study area.

⁵ It assumes a study period of 2 years.

DELIVERABLES

Average velocity ground displacement map in **distributed point format**. The distribution of points will depend on the uniformity of the surface.

Temporal series of ground displacement values in each one of the points inside the area of interest measured in the study period.

Report of the used procedures.

File format

Average velocity ground displacement map: GeoTIFF, KML, Shapefile

Extended report in PDF format.

Delivery of results

5 days after acquisition of the last requested sample according with the study duration.



DISPLACEMENT VELOCITY MAPS EXPRESS SERVICE (DVMES)

Service of **quantification of ground displacement for characterization of recent or active risks and/or estimation of long-term risks**. The study is carried out within a certain period of time and the differential interferometry technique is used for this purpose.

For this purpose, a set of SAR scenes obtained with the same acquisition characteristic (orbit, mode, beam and polarization) is formed, which we call Interferometric Stack. The study can be performed in one or both geometries. In the latter case, it includes ascending and descending scenes to optimize the altimetric accuracy.

Metric characteristics of the technique

Minimum number of samples ¹	At least 6 acquisitions
Planimetric resolution	10 M intra-pixel distance
Maximum detectable altimetric displacement ²	5,87 CM
Maximum detectable displacement velocity ³	268 CM/YEAR
Theoric detectable altimetric displacement precision ⁴	±3,5 CM
Theoric calculable displacement velocity precision ⁵	±13 MM/WEEK

Considerations

¹ Increasing the number of samples improves the precision of the calculated displacement velocity, eventually approaching to table value.

² Between two contiguous pixels of the displacement map generated by two correlating observations.

³ It assumes the maximum number of acquisitions in a year and the maximum detectable altimetric displacement.

⁴ The final value depends on the conditions of the study area.

⁵ It assumes a study period of 7 weeks.

It should be noted that the same scenes used in the DVMES service can later be used in the DVMS service if the user so requires. In this sense, if the customer wants a sufficient number of scenes, he can directly request the DVMS service.

DELIVERABLES

- Average velocity ground displacement map in heat map format.
- Report of the used procedures.

File format

- Average velocity ground displacement map: GeoTIFF, KML, Shapefile
- Extended report in PDF format.

Delivery of results

- 15 days after acquisition of the last requested sample according with the study duration.





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