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MONITORING DAMS WITH SENTINEL-1

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Dam safety is important for people's lives.
SENTINEL-1 may help us improve it by providing
information about their behavior

Luis Portal Garrido

Jefe de Servicio | Confederación Hidrográfica del Duero



✓ By using Radar imagery from SENTINEL-1, we can analyze the movement of dams. Copernicus Sentinel data [2023]

Day or night, with clear or cloudy skies, Sentinel-1 radar images enable us to observe the behavior of our dams through displacement monitoring with millimetric resolution, alerting us about any abnormal movement.

THE CHALLENGE

To improve dam operation and safety management, Confederación Hidrográfica del Duero was interested in the possibility of analyzing the movements of the Iruña dam using remote sensing. The analysis should extend over the last three years to compare the final results with the data provided by onsite instrumentation.

The retrospective capacity of the Sentinel-1 radar imagery catalog was considered the best solution for our aims. Two hundred fifty radar images from the Sentinel-1 catalog were used to visualize the structure's movement from 2020 to 2023.

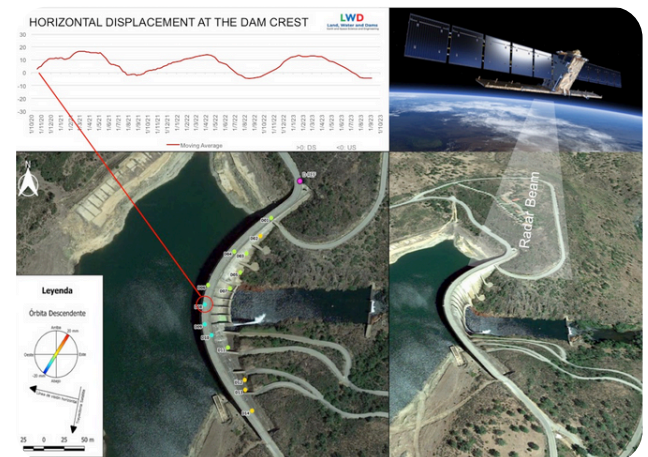
THE SPACE SOLUTIONS

The basis of the Iruña dam's project is the information provided by Earth Observation Satellite constellations, specifically the radar images from the Sentinel 1A/B satellites of the European Space Agency. Products and services were obtained from Single Look Complex images in the Interferometric Wide Swath acquisition mode, freely downloadable from the Copernicus Browser provided by the Copernicus Data Space Ecosystem.

To provide a three-year time series of displacement at Iruña Dam, 250 radar images from the Sentinel-1 catalog were processed using the Persistent Scatterer's interferometric analysis method. Both ascendant and descendent path imagery were used to convert millimetric Line Of Sight (LOS) movements into Horizontal and Vertical displacements, giving a millimetric resolution on displacements with a revisit period of six to twelve days.

More than fourteen displacement time series at points located on the dam's crest, in the downstream face, and the abutments.

Finally, a validation process was carried out by comparing the data from readings of the radial coordinates of the pendulum's plumb line already installed in the dam with the results of radar interferometry. A Coefficient of Determination (R^2) better than 0,9 and a Temporal Correlation Coefficient better than 0,8 were obtained (1,0 means total coincidence).



- ✓ A three-year time series of displacements of a point located in the crest of the Iruña Dam, obtained with InSAR-PSI processing of Sentinel-1 image [2023].

THEMATIC AREA



Transports, Civil Infrastructure and Safety

REGION OF APPLICATION



Salamanca

SENTINEL MISSION USED



S1

COPERNICUS SERVICE USED



CLMS

THE BENEFITS AND THE BENEFICIARIES

As indicated at the beginning of the presentation, the safety of dams is of interest to the entire population.

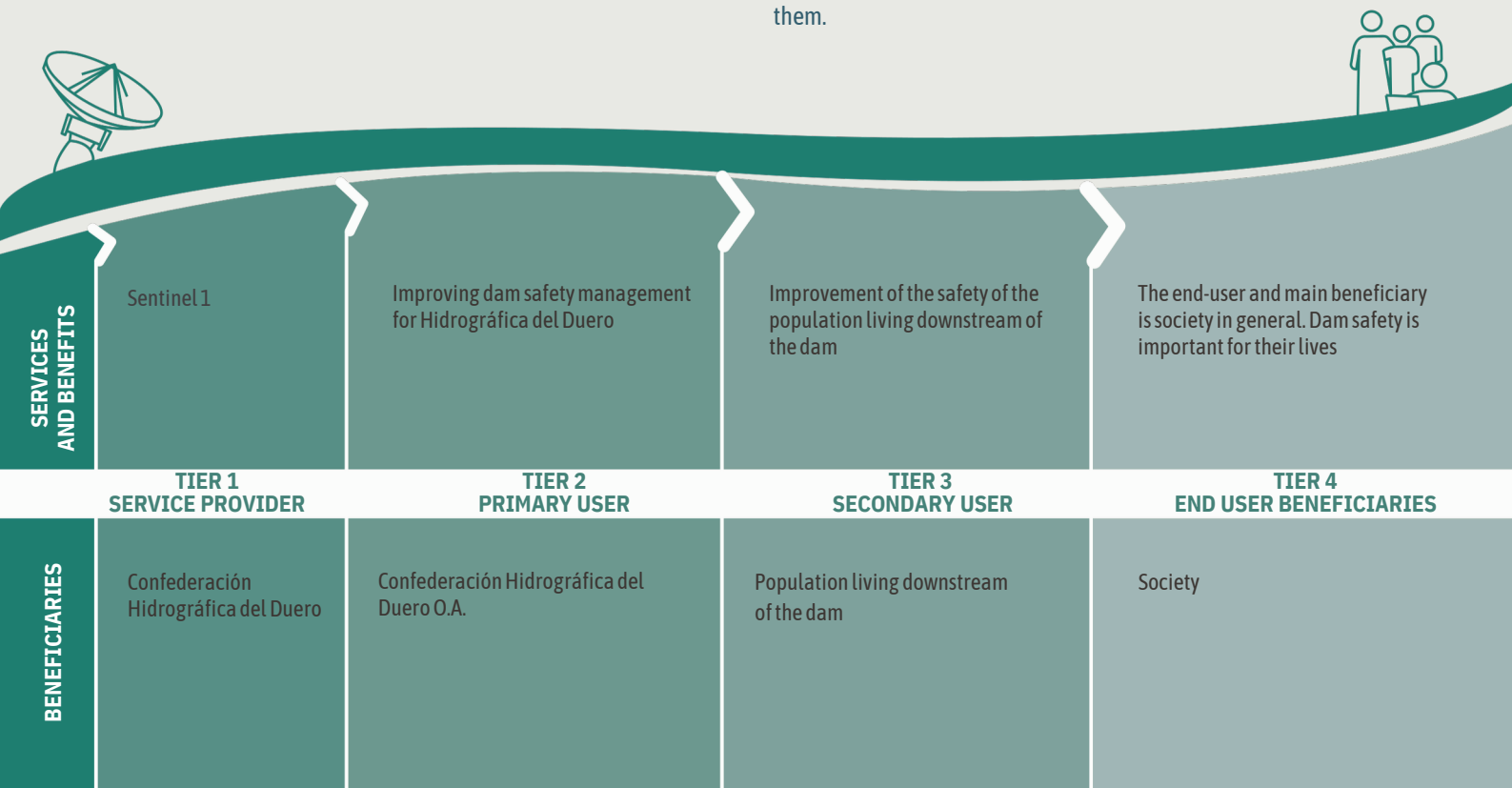
Therefore, the final user and primary beneficiary of any improvement achieved in their management is society as a whole. On the other hand, the entire population living in the area surrounding the reservoirs created by the dams, who are supplied with their water for consumption or irrigation, is a secondary user directly affected by the dam's safety and will be interested in its improvement.

The possibility of monitoring dam behavior from space enables the implementation of surveillance systems at very low costs, alerting us to possible anomalous behavior in containment structures without in-place instrumentation or those located in remote and difficult-to-access areas

This puts a new monitoring tool in the hands of the organization responsible for managing the dams, which undoubtedly represents a significant benefit for the primary user in this case, the Confederación Hidrográfica del Duero..

Furthermore, the extensive image catalog provided by Sentinel-1 is instrumental in establishing continuity of readings when replacing damaged instruments or performing retrospective studies that cannot be obtained with newly installed instruments.

Finally, the free distribution of SENTINEL-1 images greatly facilitates the possibility for service providers, such as Land, Water, and Dams in this case, to provide water infrastructure authorities with services that convert data provided by satellites into beneficial information for them.



EU POLICY / DIRECTIVE



The Floods Directive

TYPE OF SERVICE PROVIDER



Public Service

TYPE OF FUNDING SOURCE



Other

USAGE MATURITY LEVEL



4



A FUTURE WITH COPERNICUS

In the future, implementing permanent monitoring of hydraulic infrastructures based on Sentinel-1 could provide us with a magnificent warning tool for behaviors that could be considered abnormal. Today, new dam construction or dam maintenance projects consider including radar interferometry analysis in their budgets. In this way, improving the revisit period currently offered by SENTINEL-1 would be of great interest. On the other hand, maintaining the free availability of radar images is shown to be a very relevant factor when implementing this type of monitoring system.



DID YOU KNOW?

Did you know that terrain and structures under your responsibility can be monitored with millimetric resolution using radar remote sensing provided by Sentinel-1 satellites?



Acknowledgements

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