Disaster risk reduction and reconstruction in Indonesia with Earth Observation

by Vincenzo Massimi

Fig. 1 – Sulawesi Earthquake (Credits EU Civil Protection)

On September 28, 2018, a 7.5 magnitude earthquake struck the island of Sulawesi, Indonesia. The epicentre was the provincial capital of Palu, located on a bay on the island's northwest coast. The quake triggered a tsunami that swept 10-meter tall waves of seawater and swamped the city. The combination of the earthquake, tsunami, soil liquefaction and landslides claimed well over 2000 lives, destroyed homes, buildings, infrastructures and farmland in several districts. Recognizing the need to relocate settlements from the liquefaction-prone areas, the Indonesian government developed the Master Plan for Recovery and Reconstruction for Central Sulawesi through the EARR and SWIP projects.

Indra and Planetek Italia contributed to the implementation of this plan with a batch of EO-based services. The main information provided was related to terrain deformation mapping (before the earthquake) followed by the update of terrain information mapping (in the months immediately after the earthquake) and reconstruction monitoring with Very High Resolution images. The collaboration went on with a capacity-building workshop and a knowledge transfer activity held in Jakarta in June 2019 regarding the technical aspects of the delivered products and training sessions for local users to teach them to use the Geohazards Exploitation Platform (GEP) of ESA.

The main purpose of the delivery of the information products was to help the local authorities better understand the hazards associated with seismic activity, flooding and landslides, so they can make more informed decisions in elaborating a redevelopment master plan.

As noted during the workshop, the terrain deformation maps are helping the authorities in the evaluation of the effects caused by the disaster on the land surface stability.

These activities were carried out in the context of the European Space Agency funded project EO4SD DRR (EO for Sustainable Development – Disaster Risk Reduction). The project was led by Indra, with

Planetek Italia, ZAMG, BRGM, Gisat, Argans and Nazka as subcontractors.
All activites were carried out in cooperation with the Asian Development Bank and the Indonesian National Institute of Aeronautics and Space and involved representatives from numerous Indonesian institutions.
Supporting the disaster risk management over the area affected by the 2018 Sulawesi earthquake with PS InSAR analysis
Planetek Italia provided the millimetric measurements derived from Synthetic Aperture Radar (SAR) through the Persistent Scatterers Interferometry (PSI) technique. The PSI technique exploits the SAR satellite images to generate as output the ground motion maps related to the periods before and after the event of 2018.
Two different pre and post event maps have been delivered through the extremely intuitive Business Intelligence visualization tools of the Rheticus® platform, to support the decision makers that are involved in the reconstruction activities in Palu. Rheticus® is a geospatial platform for massive Earth observation data processing owned and operated by Planetek Italia.
The two delivered maps are the "ground motion" map and the "buildings motion" map, and are described in the following.

1) The pre- and post-earthquake ground motion maps have been delivered over wide spatial areas covering the liquefaction and landslides areas. The map provides the movements – even as small as few millimeters – of each measured point (Persistent Scatterers / Distributed Scatterers) located on buildings and infrastructure elements in the urban and peri-urban zones as shown in figure 3:
For each measured point (PS/DS), the web interface provides a pop-up window (figure 4) that shows the displacement detailed information.

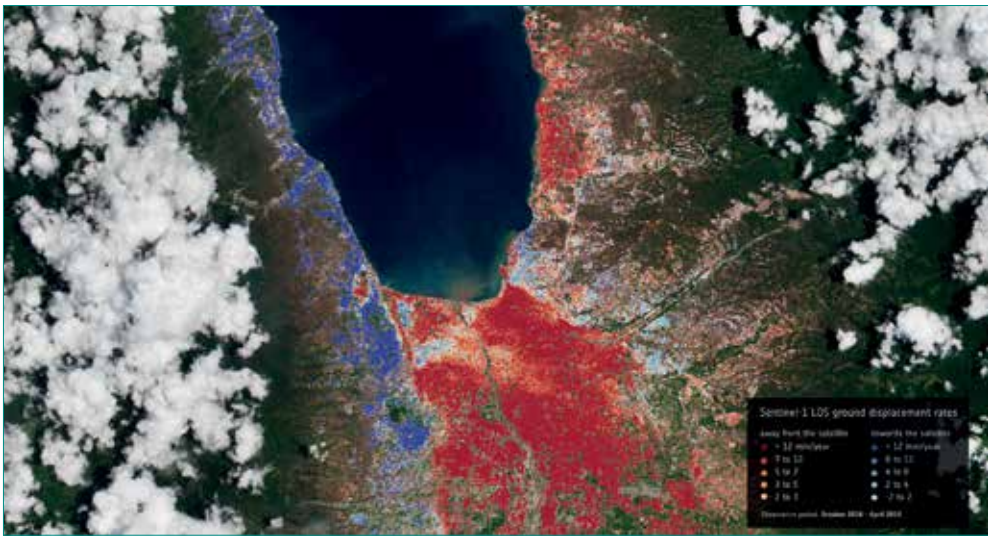

Fig. 2 - Palu, Indonesia. Map of the ground motion during the six months following the event.

2) The "building motion" map provides the level of concern on each monitored element such as buildings, roads and other infrastructures on a monthly basis, based on the ground motion map (see figure 5). The map integrates the ground/building motion measurements described above with the VHR images to monitor the reconstruction stages. Doing so, the Rheticus® platform delivered regular monitoring of the reconstruction status based on the Very-High Resolution optical satellite images and the classes of motion of each single monitored element (e.g. buildings) based on the measurements of displacement of the monitored elements itself and their nearby areas. The integrated information has been delivered over the Palu area allowing the characterization of the movements of the wide areas and of each single building based on the PSI ground motion map and to retrieve the reconstruction and rehabilitation statistics based on the interpretation of the VHR satellite images.
In addition to these information products, the project also included a week-long course in Jakarta organised by the Asian Development Bank and the

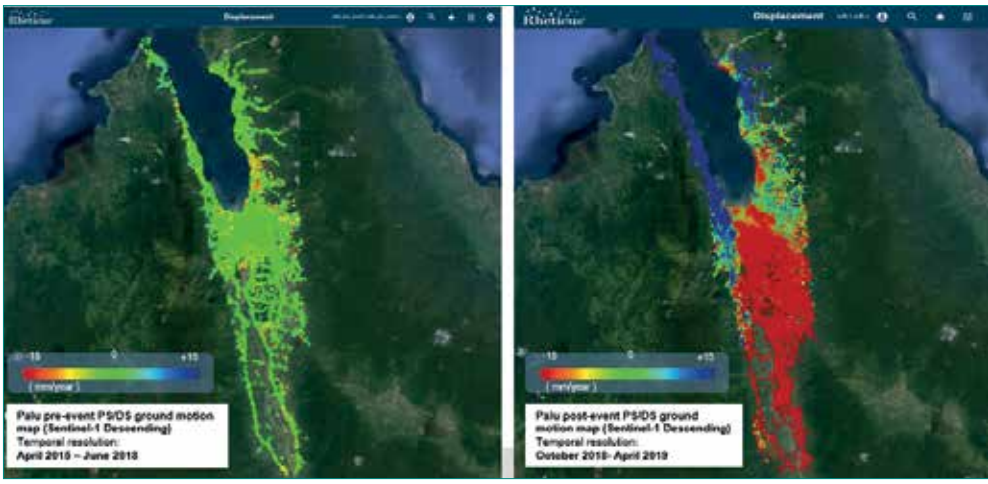

Fig. 3 - Ground motion maps in Palu (pre vs post-earthquake 28/09/2018).

Fig. 4 - Example of one PS displacement (mm) over time computed through the PSI over Palu area after the earthquake. In this figure it is possible to see all the geo-analytics and filtering tools for the exploitation of the ground motion map.

Indonesian National Institute of Aeronautics and Space. Attended by more than 60 representatives from numerous Indonesian institutions, experts from Indra, Planetek and BRGM explained technical details, methodologies and usage of these satellite data products.
Representatives from the Asian Development Bank noted: "*Users explained that they are particularly interested in the ground deformation maps – they offer great insight into how the land surface has changed and are essential for Indonesia to redevelop effectively.*"
The ground motion analysis was performed through the Rheticus® cloud platform, which implements the SPINUA Multi-Temporal Interferometry algorithm for SAR data processing. The SPINUA processing chain is developed by GAP srl, a spinoff company of Politecnico di Bari, Italy, in order to generate ground motion maps. SPINUA algorithm has been extensively tested and validated in the past 20 years with long stacks of SAR data (acquired in L, C and X bands) with particular attention to research activities aimed at improving the state of the art of SAR techniques. These activities are carried out in collaboration with academic and research institutions. As documented in the scientific literature, SPINUA represents one of the first and effective solutions for multi-temporal SAR interferometry. SPINUA is based on Persistent Scatterers and Distributed Scatterers Interferometry relying on the identification and monitoring of single objects (PS) or areas (DS) that remain highly coherent through time.
The Rheticus platform is a multi-tenant high level performing cloud-computing platform for the automatic massive processing of long-time series satellite data, retrieved directly thanks to the API connection to the satellite providers (e.g. ESA API Hub Access). The high level of automation along with a dedicated detailed logging and alert system allows an easy monitoring of the processing chain status. Rheticus output is also available in Machine to Machine mode (M2M) via standard exchange protocols (e.g. WMS), making the platform an information hub that delivers content to other online systems. Export capabilities of data and information are also available, allowing users to download products in standard formats, and facilitating their exploitation in other external application environments.

Fig. 5 - Palu® reconstruction monitoring service user interface with the integrated reconstruction status and displacement information.

KEYWORDS
EARTHQUAKE; RISK; EO BASED SERVICES; MONITORING; RHETICUS; CLOUD-COMPUTING; AUTOMATIC PROCESSING; DATA SATELLITE

ABSTRACT
On September 28,2018, a 7.5 magnitude earthquakestruckthe island of Sulawesi, Indonesia. The epicentre was the provincial capital of Palu, located on a bay on the island's northwest coast. The quake triggered a tsunami that swept 10-meter tallwavesof seawater and swamped the city. The combination of the earthquake, tsunami, soil liquefaction and landslides claimed well over 2000 lives, destroyed homes, buildings, infrastructuresand farmland in several districts.Recognizing the need to relocate settlements from the liquefaction-prone areas, the Indonesiangovernment developed the Master Plan for Recovery and Reconstruction for Central Sulawesi through the EARR and SWIP projects.
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