Research activity

My research aims to provide new satellite tools to identify, classify, and map deformation processes through the application of Multisensor/Multifrequency remote sensing. To date, remote sensing imagery played a key role in the observation of dangerous areas, where conventional in situ surveys for a systematic investigation of deformation phenomena are often not cost–effective and practically suitable, due to difficult accessibility. The monitoring of deformation processes for hazard assessment can be performed via both optical and Synthetic Aperture Radar (SAR) data. On the one hand, SAR imagery measures the physical properties of the observed scene, containing both amplitude and phase information, and can be acquired independently of weather or daylight conditions (full–time acquisition data). On the other hand, optical images, collecting spectral and spatial information, quantify chemical characteristics of the area of interest with data much easier to interpret but needs both daylight and a cloudless sky with the satellite flying at high altitudes (Schmitt et al., 2017). Over the past years, we saw a significant increase in interest in all topics related to time series and the analysis of multi–temporal data. To date, the Interferometric Synthetic Aperture Radar (InSAR) technique provides a unique tool for the quantitative measurement of the Earth's surface deformations, as it is highly valued and widely used to detect and monitor ground deformations induced by a variety of natural (earthquakes, landslides, volcanoes) and anthropogenic processes. In addition, Differential SAR Interferometry (DInSAR) provides a digital representation of changes detection in surface displacements with a sub–centimetres–scale accuracy (Nardò et al., 2017). The main products of an A-DInSAR (Advanced Differential InSAR) analysis are time series of displacement, which reach a millimetre accuracy, and the average velocity (Ferretti et al., 2001; Kampes et al., 2006). These products can be estimated by using the Persistent Scatterers Interferometry (PSI) technique, based on the analysis of measurement points characterized by a persistent backscatter and long time–coherent behaviour.

To maximize the science return of data available in the shortest possible time and exploit complementary information, the sensing energy in different portions of the electromagnetic spectrum can be blended by using the fusion of data. Data fusion is a process of combining two or more images acquired by remote sensing satellites with sensors of different wavelengths into a single image that is more informative. Starting from the Wald study in 1999, data fusion has been a well–discussed research topic in the remote sensing community. In particular, the fusion of heterogeneous datasets, such as SAR and optical data (acquired respectively by active and passive sensors), has been investigated for many years and thoroughly studied. The research studies on this topic are constantly evolving, driven by the implementation of space programs that incorporate both radar and optical sensor technologies. To date, the coregistration of SAR and optical data is still an opening problem and one of the most challenging topics. In addition, the definition of fusion rules for merging different acquisitions into a single image is still an open problem.

To identify the areas affected by damage as quickly as possible and have an effective prevision of hazard, the rapid mapping of deformation processes is crucial. Traditionally, such maps are generated with a visual interpretation of remote sensing imagery and/or using pixel–based and object–based methods. Recent works have explored the exploitation of data–intensive machine learning algorithms and the use of Convolutional Neural Network (CNN) for mapping landslides events (Prakash et al., 2020; 2021) and surface deformation (Anantrasirichai et al., 2019; 2020). To date, a core challenge is the build of a generalized model, based on artificial intelligence techniques, to predict, identify, classify and monitor the state of activity of ground and structural deformation processes.

This research will allow the development of advanced physical–mathematical models to post–process and combine remote sensing products of optical and SAR data. The fusion of SAR–optical data will allow the estimation of the 3D displacement field. Starting from data modelling, a supervised deep–learning algorithm will be implemented to advance our capability to classify and monitor deformation processes. This analysis, based on artificial intelligence techniques, will identify the correlations between displacement information, natural phenomena and processes of deformation of structures.

Work steps:

- Identification of physical–mathematical models.
- Development of algorithms.
- Training the algorithms on test sites (e.g. Central Italy).
- Optimization and generalization of tools.