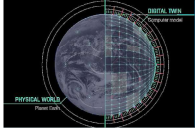


GET-it Geohazards Early Digital Twin Component

The GET-it Team

please contact
Salvatore Stramondo - Istituto Nazionale di Geofisica e Vulcanologia
salvatore.stramondo@ingv.it

INTRODUCTION

Geohazards (e.g., earthquakes, volcanoes, landslides, debris flows, avalanches, rockfalls, earth fissures, sinkholes, tsunamis, subsidence, lahars, hydrothermal activity) have a significant impact on societies and communities across the world. The Mw 9.1, 2011 Tohoku-oki **earthquake** (known for the impact on the Fukushima nuclear power plant) has been the third world largest since 1900, resulted in damage costing US$8.8 billion, making it the event with the fourth-highest economic impact among all possible global disasters. **Volcanoes** pose a broad range of threats, including lava flows, ash fallout, lahars (mudflows), pyroclastic flows and the release of toxic gas, potentially occurring on different time scales and at very different spatial scales (with potentially long distance transport). The 2010 Eyjafjallajökull eruption caused ash fallout over Northern continental Europe and the largest air-traffic shut-down since World War II, with economic losses in excess of €2 billion. **Volcanic eruptions and earthquakes accounted for 14% of the global natural disaster occurrence in 2002-2021, causing 23% of the total economic losses and 63% of the deaths.**

The roadmap for satellite EO data in geohazards management and the expected developments of EO in the forthcoming decades have been first traced in the *International Forum on Satellite Earth Observation and Geohazards* (the *Santorini Conference*) in 2012. The occurrence of a geohazard implies sudden, unpredictable, and cascading effects, among which the impact to activities and manufactures, that results from their exposure and vulnerability. To such aim the *Sendai Framework for Disaster Risk Reduction (DRR)* recommends a number of actions at the State level, based on the concept that government policies should evolve from merely managing disasters to managing risks, i.e., establishing effective prevention measures. Therefore, a fundamental, detailed comprehension of all risk elements relating to disasters is essential.

In such a framework the GET-it project aims at building a Digital Twin Component (DTC) for geohazards based on EO data. *GET-it is strongly oriented at filling the gap between the dispersed EO-based products,and will gather together a large number of tools and methods in a unique framework. For the first time, stakeholders will benefit from the most modern exploitation techniques for EO data, integrated in a highly customizable geohazard simulator.*

The DT of the Earth - from a real World to a Digital and Green Future

GET-it concept

The **GET-it** DTC system includes the main geohazards (**earthquake** and **volcanoes**) and other may be included. The DTC is an environment for both AI/ML and soft computing that focus on:

- access to EO data (& product) with direct ingestion pipelines from existing platforms
- model tuning, model validation, and model improvement

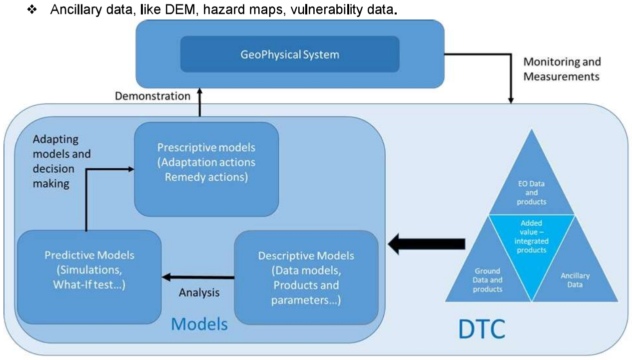
similar to the concept of Machine Learning Operations (MLOps).

A DTC is a virtual representation (or replica) of a Physical System (PS) within its environment. The DTC is continuously updated with real-time data, and can interact with and influence the PS. The PS produces data, the DTC takes as input such data and uses a set of models to carry on different operations and actions on the PS.

GET-it is based on EO data acquisition and processing, geohazard simulation algorithms and data/products ready-to-use from pre-operational processing chains. Further verification is carried out by in situ data and comparisons between scenarios and monitoring data.

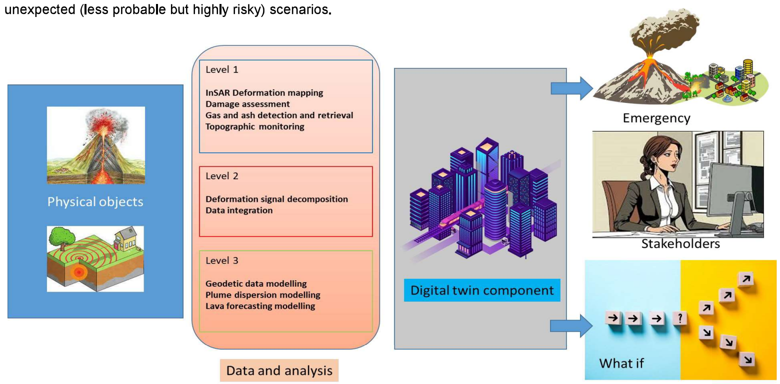
GET-it is structured with a set of data and models associated with the Geo-Physical System (GeoPS), to provide a set of services corresponding to the functions of the DTC. The input data can be classified in:

- EO data, like SAR satellite measurements, multi- and hyper-spectral measurements of atmospheric parameters, data obtained from integration;
- Ground data detected from seismic and geodetic networks;
- Ancillary data, like DEM, hazard maps, vulnerability data.



Proposed Work Logic

GET-it will build a DTC relative to *physical objects* related to volcanic and seismic geohazards. The DTC is based on a *transfer layer* (data and analysis), composed of 3 levels (Figure below) developed/generated by means of *10 modules* (chart below). The algorithms and the procedures implemented in the modules are the *product generators,* able to build the DTC and to provide tools for supporting the stakeholders (e.g., decision and action makers during emergencies) or to perform ***what-if tests*** to evaluate possible evolutions. This approach enhances the aware response and put the focus on unexpected (less probable but highly risky) scenarios.



GET-IT Modules and Outputs

The ten **GET-it** Modules are all fed by either EO or in situ data.

The **INSAR** module exploits SAR Interferometry (InSAR) techniques to provide monitoring capabilities for most geohazard phenomena.

The **INSAR** module output also provides input data to the 3D decomposition of surface displacements (**DECOMP**) and to the **DATAINT** modules (to validating/integrating SAR measurements and 3D spatially sampled GNSS measurements, with possibly other in situ data).

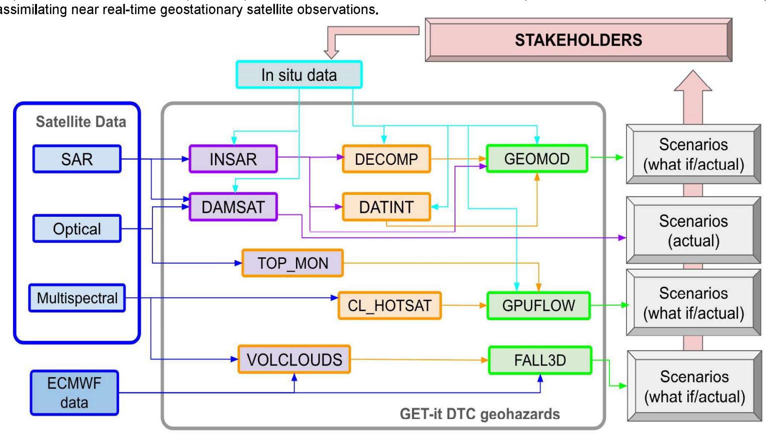
The **INSAR**, **DECOMP** and **DATAINT** output are ingested by the **GEOMOD** module that simulates the expected surface deformation pattern due to a wide range of geohazard deformation sources: seismic fault, magmatic cameras, eruptive feeding dykes.

The **DAMSAT** module extracts change detection indexes by processing pre- and post-event optical imagery, and directly contributes to enhancing the stakeholders knowledge of the spatial and temporal extension of the geohazards effects.

Optical *satellite* data are ingested in the **TOP_MON** module to calculate topographic volume variations. It is used in combination with the **CL_HOTSAT,** that exploits satellite multispectral data to detect the increase of the thermal activity at the Earth's surface.

The **GPUFLOW** module exploits a 2D cellular automata algorithm and the GPU computing to simulate the evolution of the lava flow and to provide the stakeholders with evolutionary scenarios. **GPUFLOW** input are the updated topography produced by **TOP_MON** and the effusion rate estimated by **CL_HOTSAT.**

The **VOLCLOUDS** module provides information about the detection and retrieval of volcanic clouds (ash and SO_2), from geostationary satellites EO data. Its outcome is assimilated in the **FALL3D** module, a complex workflow to simulate plume dispersal and fallout, and to provide quantitative forecasts of the volcanic cloud parameters from numerical models by assimilating near real-time geostationary satellite observations.

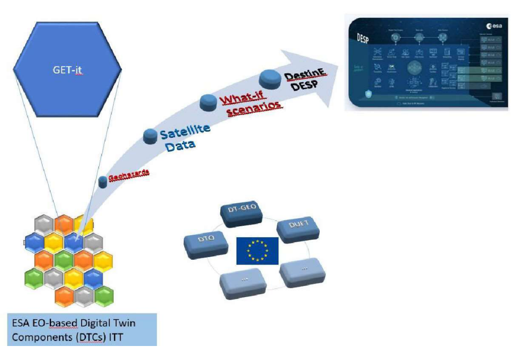


GET-it respect to Destination Earth and other EU initiatives

The development and implementation of the Destination Earth (**DestinE**) initiative has been a driver for plenty of novel DTCs projects that are contributing to the construction of the tiles of the overall mosaic. The Figure on the right shows **GET-it** in the wide scenario of the EU DTs projects and initiatives. **GET-it** builds on top of pre-existing initiatives (model-data fusion components, with particular emphasis on datastreams from geophysical monitoring networks) and complements them to provide further services mainly based on EO data (e.g, ESA Sentinel data) and derived products.

In the wider scope of the ESA DTC Programme element, **GET-it** will create a "Digital Twin Earth" that not only aims to provide a virtual representation of Earth but also to predict future environmental conditions and occurrences, focusing on natural disasters such as volcanic eruptions and earthquakes. GET-it serves the following specific functions:

- **What-If Analysis for Disaster Preparedness**: allowing users to assess potential interventions and their impacts on disaster outcomes, enhancing preparedness and mitigation strategies.
- **Integration with Global Efforts**: the DTC will be integrated seamlessly with international monitoring and response efforts, providing a tool that complements and enhances global capabilities to manage geohazard risks.
- **Support for ESA Policies and Directives**: the geohazard DTC supports ESA's policies on disaster risk reduction, climate change, and sustainable development, making it a strategic component of the Earthwatch Programme.



Funded by the European Union
Destination Earth
IMPLEMENTED BY EUMETSAT esa ECMWF