CENTAUR

A new set of Copernicus early warning and emergency services to improve the response to the challenges of climate change

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01. Introduction

Climate change is a fact and its impact on human lives and security is continuously growing. Over the last 50 years, the number of disasters has multiplied by a factor of five. In particular, the last twenty years have seen the number of major floods more than double (WMO, 2021). In total, between 2000 and 2019, there were 3,068 disaster events in Asia, 1,756 events in the Americas and 1,192 events in Africa (UNDRR report, 2000-2019).

Climate change is increasingly acknowledged within the EU's integrated approach to security. Nowadays, climate change is already causing people to migrate, and while migration should not be directly labelled as a security problem, implicitly the link with pressures on society and increased competition for resources are often made (Schaik L., Bakker T., 2017).

02. Objectives

#HorizonEU

CENTAUR (Copernicus ENhanced Tools for Anticipative response to climate change in the emergency and secURity domain) is part of Horizon Europe research and innovation programme (Grant Agreement n. 101082720) and has the objective to respond to the current societal challenges by developing and demonstrating new service components for the **Copernicus Emergency Management Service (CEMS)** and **Support to EU External and Security Actions (SESA).**
CENTAUR is a three year project and was kicked off in December 2022. The project engages with two different application domains: Urban Floods (UF) and Water and Food Security (WFS).

Emergency Management

Security

Urban Floods domain

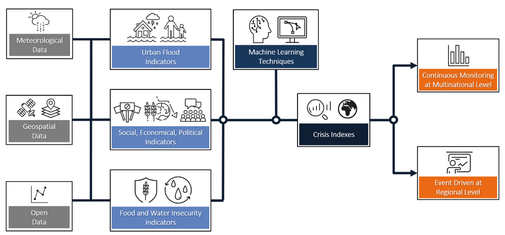
- Improve the current capacities to predict events, detect the extent, estimate the damages, mitigate their effects and eventually increase the effectiveness of recovery action.
- Strengthen the current CEMS urban flood detection capabilities by identifying indicators and monitoring their performances, based on EO data as well as downscaled meteorological forecasts at city level.
- Providing an early warning system which generates alerts when pre-established thresholds for crisis indicators are reached.

Water and Food Security domain

- Enriching the CSS – SESA current portfolio by integrating new vulnerability and fragility indexes,
- Reinforcing early warning capacities and pro-active geo-intelligence services for the systematic surveillance of early signs and drivers of social unrest, population movements, and conflicts in connection with food and water insecurity.

03. Methodology

CENTAUR adopts a layered approach to enrich the information and expand the capacity to characterize the phenomena and their dynamics. At the first level we find **Data** in three dimensions. The next layer includes **Indicators**, consisting of thematic information coming from time series of data and simple combination of data according to the models applicable to the phenomena observed. Then, in the third layer stand **Crisis Indexes** which result from the complex integration of urban flood and water & food security indicators with social, economic and political indicators. Finally, CENTAUR integrates them into deployment environment to provide **continuous monitoring** service at regional and local level and an **early warning system** in case values on key risk indicators and crisis indexes exceed a defined threshold.



Use Cases

CENTAUR examines a variety of use cases linked to both thematic domains, Urban Floods and Water and Food Security, to test the conceptual model, and validate the indicators.
There are two types of use cases:

- **"Cold" cases** are well-documented crisis situations that have happened in the past.
- **"Hot" cases** are events that are currently unfolding or will occur during the life of the project.

Validation phase after cold and hot cases demonstrators:

- Evaluating the technical soundness of the solutions offered.
- Evaluating Authorised Users and relevant Entrusted Entity of the Copernicus SESA and EMS services satisfaction and compliance with their needs and requirements, through workshops and questionnaires.

Cold Case Phase - Italian Use Case 1: Turin

Piedmont Region has a rich history of frequent and important flood events occurred in the past due to intense precipitations that led to the fluvial flood of the **Po River**. One of the significant events occurred in **November 2016**, when persistent and abundant rainfall triggered a flood in Piedmont Region and in the city of Turin. The event was covered by **CEMS Rapid Mapping activation EMSR192**. A total of around 400 people evacuated from their homes in Piedmont Region, of which 150 in Turin (The Italian Insider, 2016).

URBAN FLOOD INDICATORS
- **7 INDICATORS RELATED TO THE URBAN FLOOD CONTEXT (UF-ID-1 to UF-ID-7)**
- **3 SOCIO ECONOMIC INDICATORS (UF-ID-9 to UF-ID-13)**

INPUT DATA:

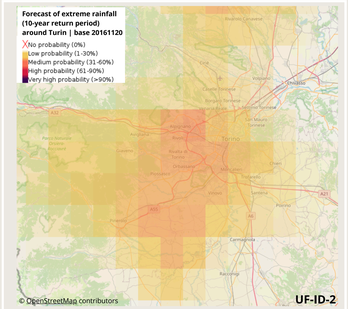
- Very high-resolution LiDAR-based DTM and DSM using raw data by Polytechnic University of Turin (PoliTO) and complementary data provided by Italian Ministry of the Environment and Energy Security (MASE).
- Optical and SAR satellite images; Ortholmagery by Agricultural Grants Agency (AGEA).
- Flood mask and water gauges by Regional Agency for the Protection of the Environment (ARPA).
- Reference data by Piedmont Region and Municipality of Turin: Hydrography, Transportation, Building footprints, and Land use/ land cover.
- Census data by Municipality of Turin and Italian National Institute of Statistics (ISTAT).

INDICATORS:

- **UF-ID-1:** "Static map of precipitation associated to return period"
- **UF-ID-2:** "Forecast of return period"
- **UF-ID-3:** "High-Resolution urban flood risk maps for various return periods"
- **UF-ID-4:** "Inferred INSAR urban flood extent"
- **UF-ID-5:** "Enhanced urban flood damage assessment"
- **UF-ID-6:** "Social/Traditional media indicators for Urban Flooding Map"
- **UF-ID-7:** "Flood Hazard indicator"
- **UF-ID-9:** "Assets and financial resources"
- **UF-ID-10:** "Public services and government support"
- **UF-ID-13:** "Ability to evacuate"
- **UF-ID-14:** "Economic impact of floods"

INDEXES:

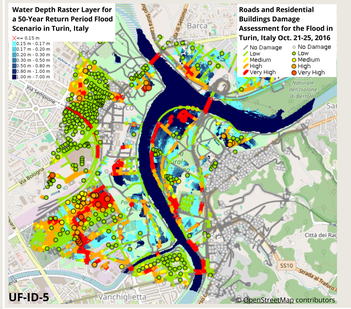
- Flood Early Warning Index
- Flood Impact Index



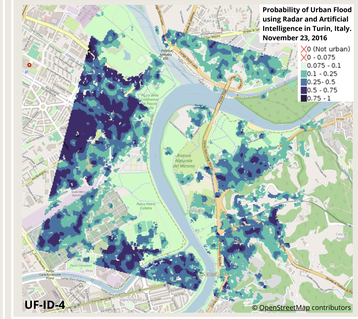
UF-ID-2

This dynamic CENTAUR indicator (**UF-ID-2**) estimates the **probability** of **exceeding extreme precipitation** associated with return periods of 10 years up to three days in advance. Forecasts are produced daily and probabilities are based on an ensemble of 51 members from the European Centre for Medium-Range Weather Forecasts (ECMWF).

UF-ID-5 is an urban flood indicator, derived from a synergistic combination of a refined GFA tool, INFLOS tool and FLORIA models, that represents an accurate flooding map related to a specific past flood event. Water depth is classified by colour. The damage assessment of roads and buildings serves as an urban flood indicator, categorizing the damage based on the flood depth at each location.

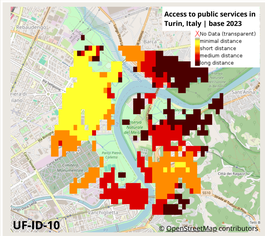


UF-ID-5



UF-ID-4

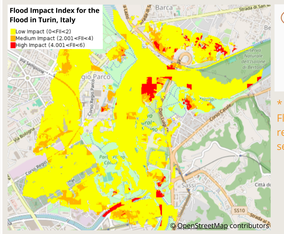
This raster layer shows the probability, between 0 and 1, for a given pixel to correspond to urban flood within urban areas of the area of interest on a specific date. It is a component of the **UF-ID-4** indicator. Urban flood extents are determined from SAR imagery by leveraging interferometry and deep learning techniques. The process involves analyzing intensity and coherence values from three SAR images—two captured pre-event and one during the event.

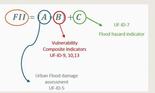


UF-ID-10

Access to public services in Turin, Italy | base 2023. **UF-ID-10** composite indicator is based on principal component analysis: time distance to key services like police stations, fire stations, and hospitals. The layer was obtained using the ArcGIS Service Area analysis tool and Network analyst toolbox. This dataset was created using the BD Topo transport network and data on public services.

The **Flood Impact Index *** raster layer provides the potential impact of a specific flood event over the AOI. The Impact is divided into three classes depending on the FII value. The FII is generated from the composition of 8 different layers. Four layers part of the UF-ID-5 indicator, that directly show the impact of flood on buildings and roads. Three layers, UF-ID-9 (Average incomes), UF-ID-10 (Distance to nearest fire station) and UF-ID-13 (Accessibility by road) that give the social vulnerability of the AOI. The last layer included is the UF-ID-7 (Flood Hazard indicator) that provides a hazard characterization for the AOI.





* The methodology for the Flood Impact Index has been reviewed and improved in the second phase of the project.

Validation

The validation of CENTAUR products relies on a set of quantitative as well as qualitative parameters that are grouped into three main categories:

Validation is based on the CEMS Rapid Mapping validation protocol and ISO 19157.

Final Validation results

	Urban flood indicators							Socio-economic indicators			
Italian Use Case 1: Turin	01	02	03	04	05	06	07	09	10	13	14
							N/A				

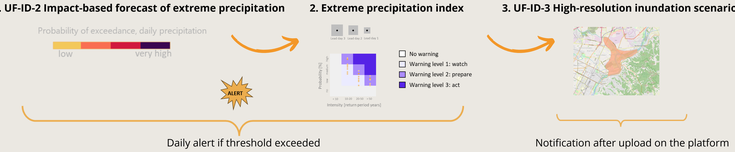
'Operational': favourable validation results, meaning that the indicator is considered as ready to use.
'Highly-developed': showing a good level of maturity but requiring further refinement.
'In-development': representing early-stage indicators that need further testing and validation.

Moving towards the Hot Phase: Alerts for extreme precipitation over urban areas

Development still in progress

Flood Early Warning Index predicts an extreme precipitation event and the most probable impacted urban areas with 3-day lead time (**UF-ID-2**). The alert is triggered based on the probability of extreme precipitation around the area of interest, as determined by the risk matrix. Each alert level corresponds to a flood map (**UF-ID-3**), which shows the potential impact of the event.

Flood Early Warning Index



04. Consortium

e-geos AN ASI / TELESPAZIO COMPANY · CLS · gmv · ECMWF · tracasa global · HENSOLDT · DLR · CHERRY DATA · adelphi · space-tec PARTNERS · ithaca · vito remote sensing · Université de Strasbourg · Sertit

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Image 1. Flood in Solarolo 2023 (Ravenna, Italy) author unknown, retrieved through Emilia Romagna Meteo.
Image 2. retrieved through Galleria Accademia Venezia https://www.gallerieaccademia.it/emergenza-alluvione-emilia-romagna-un-sovrapprezzo-di-1-euro-laccesso-ai-musei-e-ai-luoghi-di
Image 3. retrieved through Unsplash https://unsplash.com/it/foto/brown-wooden-boat-on-brown-sand-during-daytime-8wuOLdN77A4
Image 4. retrieved through https://clubofmozambique.com/news/the-two-crops-guija-lost-to-the-drought-mozambique/
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06. Acknowledgements

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