A digital twin engine for extreme weather events analysis on climate projections in the interTwin project

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Overview

Climate Change has led to the exacerbation of Extreme Weather Events (EWEs) in recent years, such as storms and wildfires, raising major concerns in terms of increasing intensity, frequency and duration. Detecting and predicting EWEs is challenging due to the rare occurrence of these events, and consequently the lack of related historical data. *Data-driven models* can provide cost-effective solutions for dealing with extreme events analysis. To support the this kind of applications, there is the need to integrate heterogeneous data, orchestrate complex workflows and exploit efficient software infrastructures, leading to the concept of a *Digital Twin* (DT) for EWEs.

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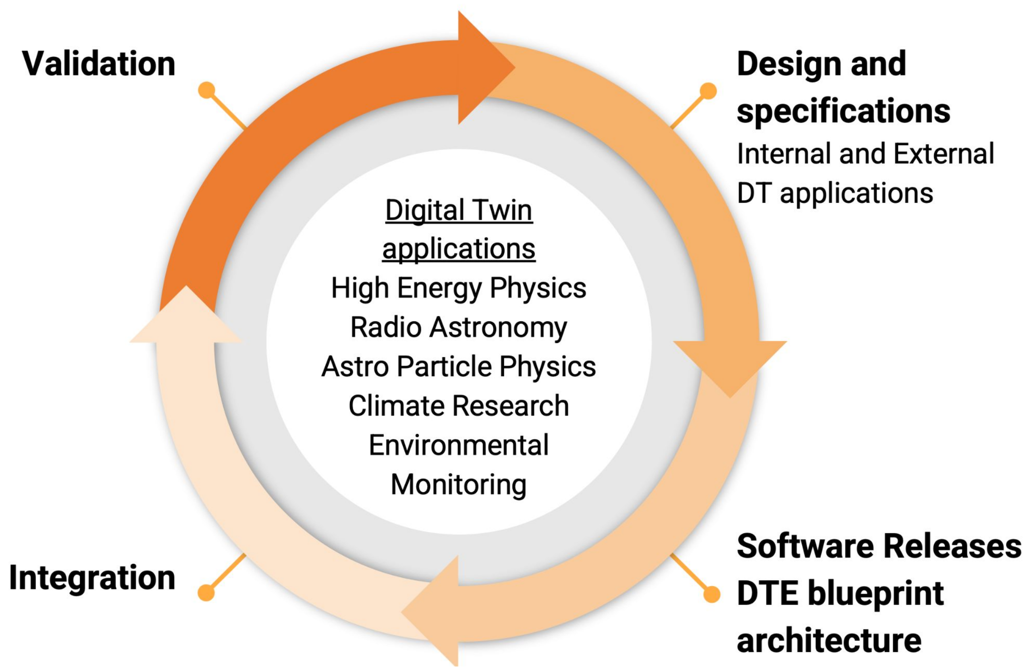
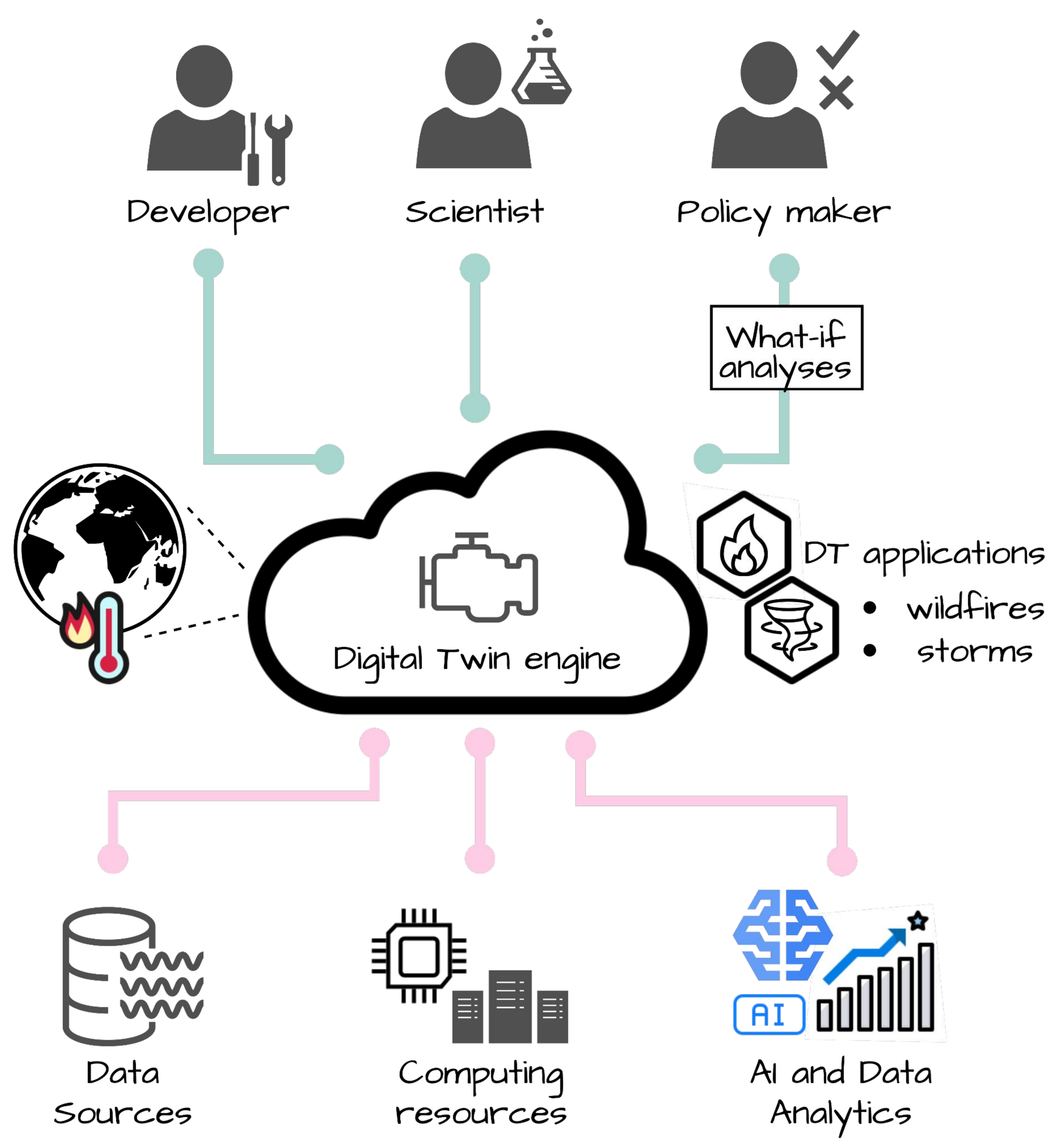
A Digital Twin for EWEs

A DT for the analysis of EWEs is being developed in the context of the EU funded *interTwin project* whose goal is to co-design and implement the prototype of an interdisciplinary Digital Twin Engine: an open source platform based on open standards offering the capability to support application-specific DTs.



The EWEs DT application concerns the prediction of storms and wildfires in *future climate projection scenarios* (e.g., CMIP6) with the aim of giving an indication about the temporal trend and the geographical occurrence of such events due to climate change. To this extent, *machine learning* (ML) *approaches* are adopted as modeling tools capable of learning the underlying mapping between drivers and outcomes in the past and generalizing it to future projection data.



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Concept: The Digital Twin architecture and main actors

The DT for EWEs brings together data from multiple sources, heterogeneous computing resources, and AI and Data Analytics modelling tools to allow different users to develop and/or run various scientific applications and workflows.

Digital Twin Users

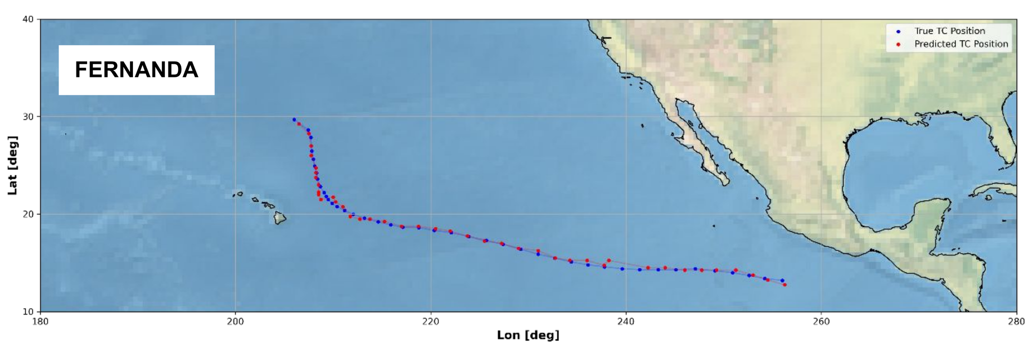
- *Developers* can design new modules for the DT engine
- *Scientists* take advantage of the DT engine to adapt their experiments to different climate scenarios
- *Policy makers* perform what-if analyses on climate projections

Digital Twin capabilities

- Integration of heterogeneous weather and climate data (e.g., reanalysis from C3S, CMIP6 projections etc.)
- Transparent usage of federated computing facilities (e.g., Cloud/HPC)
- New DTs can be created by simply composing the existing modules, leveraging also AI, Data Analytics and workflow management tools

The storms Digital Twin

Tropical Cyclones (TCs) are warm-core, large-scale phenomena, originating over tropical or subtropical waters. The ML-enabled DT allows classifying the presence of a TC from input atmospheric drivers, as well as further localizing its center (or "eye") in terms of geographical coordinates. Trained ML models will be used for inference on CMIP6 experiments in order to assess the geographical occurrence and frequency of TCs in future projection scenarios.



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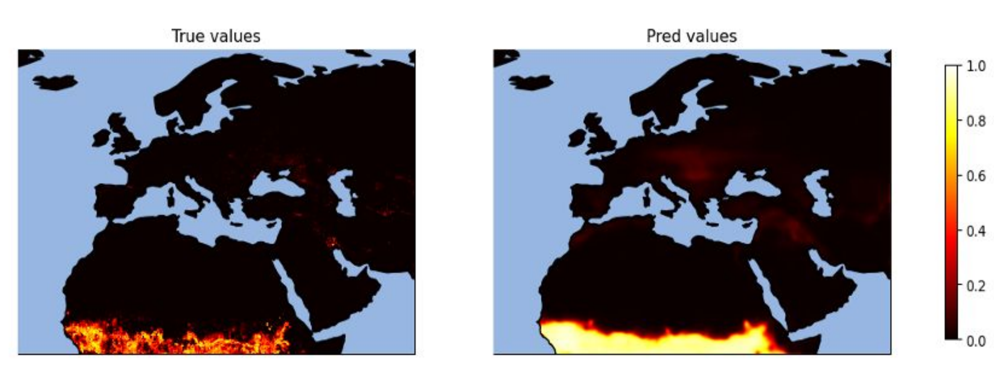
The wildfires Digital Twin

Wildfire risk assessment and *prediction* is of key importance for preventing and mitigating wildfires impacts and cost on the environment and ecosystems. The wildfires DT relies on Generative Models for generating synthetic burned areas maps that closely resemble the original fire risk distribution of historical data. The DT allows generating wildfires probabilities for CMIP6 projections, with the aim of giving an indication about the areas of the globe that are more likely to experience wildfires.



Initial proof of concept has been developed exploiting the *ENES Data Space* for model training and validation.

The ENES Data Space, set up in the context of the *EGI-ACE project*, provides a single entry point to climate datasets, computing resources (e.g., GPUs), and a software infrastructure for dealing with challenging climate applications requiring big data and machine learning solutions.

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