



# The Promise of (Earth System) Digital Twins

Understanding Earth from Space: Data, AI and Communication for Climate Adaptation: Media Workshop

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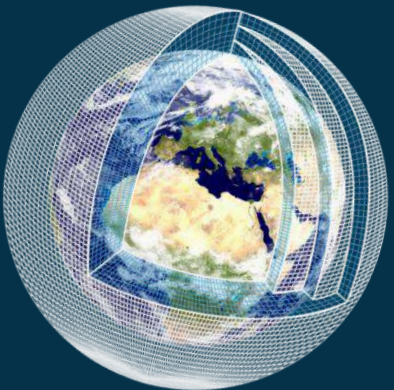


→ THE EUROPEAN SPACE AGENCY

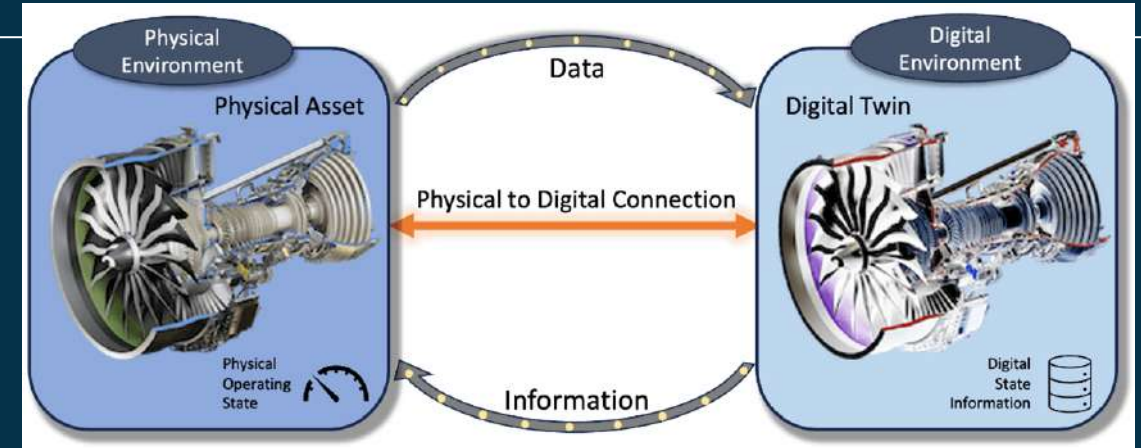
# What is a Digital Twin?

Concept of a Digital Twin was first developed in the world of engineering:

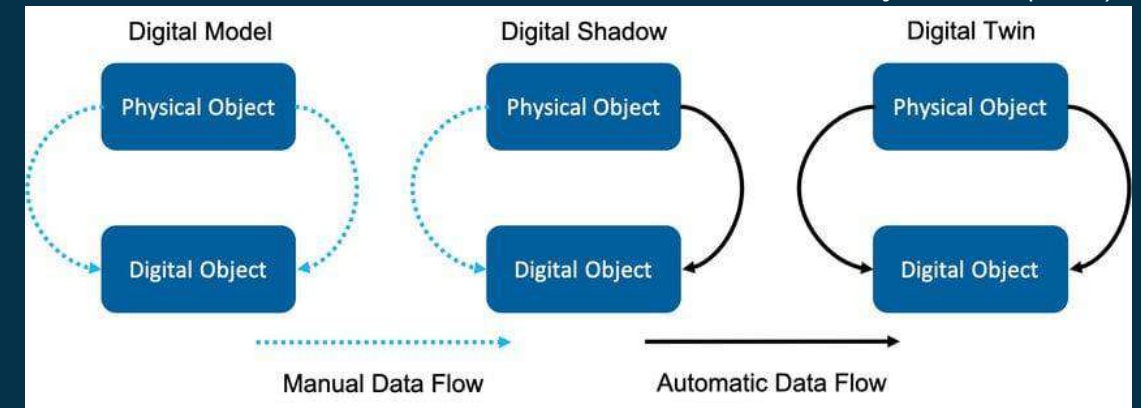
- A digital replica of a physical asset that is updated by latest information/data.
- Digital replica is a model that can be used to do scenario testing and inform decision making for physical asset.
- A true digital twin automates the flow of information between physical and digital systems.



A Digital Twin for Earth integrates all available observations (satellite, in-situ, etc.) into a high-resolution and high-fidelity digital Earth model to produce a near real time replica that allows decision making with scenario testing.



*Banerjee et al., (2024).*



*Fuller et al., (2020).*



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# Creating a Digital Twin of the Earth System

## Destination Earth

Funded by  
the European Union



Implemented by



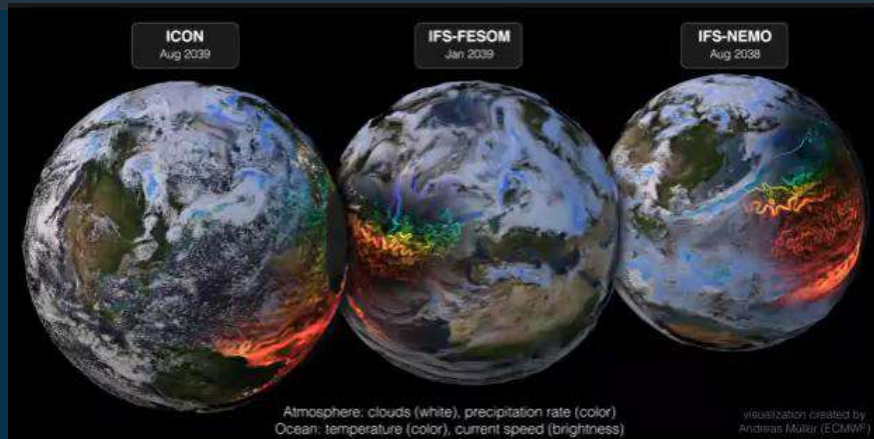
ECMWF



esa



EUMETSAT



Destination Earth (DestinE) is a flagship initiative of the European Commission to develop a highly-accurate digital twin of the Earth to model, monitor and simulate natural phenomena, hazards and the related human activities.



ESA Digital Twin Earth (DTE) Programme is designed to maximise the use of Earth Observation in developing digital twins of the Earth system.

Many other Digital Twin initiatives: European Digital Twin of the Ocean (EDITO), Horizon Europe DT projects, national DT initiatives...

# Destination Earth (DestinE)

## Destination Earth

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Implemented by



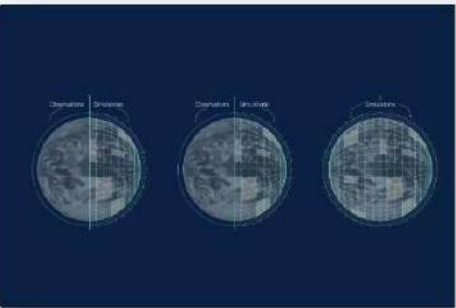
### DestinE Platform

The platform provides evidence-based decision-making tools, applications and services, based on an open, flexible and secure cloud-based computing infrastructure. The platform is implemented by ESA.



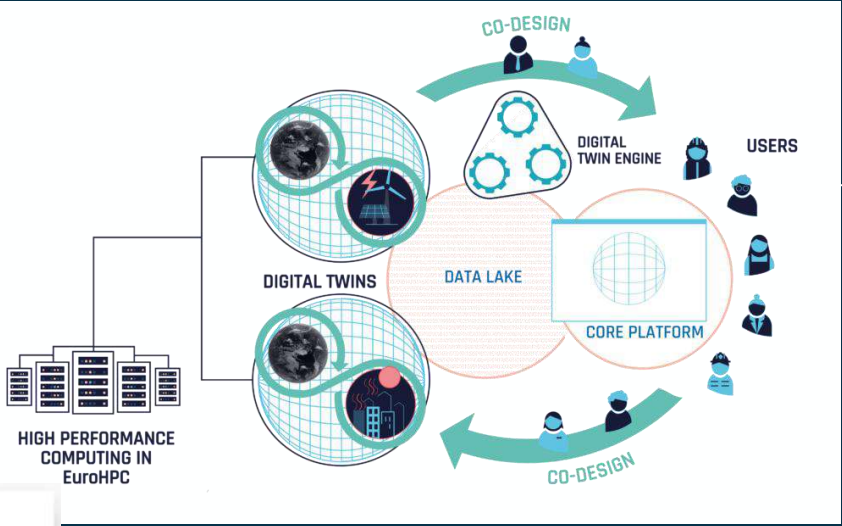
### Data Lake

The data lake brings together data from ESA and EUMETSAT, as well as from Copernicus, and many other diverse sources, with new data from the Digital Twins. It allows discovery and data access as well as big data processing in the cloud. The Data Lake is implemented by EUMETSAT.



### Digital Twins and Digital Twin Engine

DestinE is creating several digital replicas covering different aspects of the Earth system and based on state-of-the-art simulations and observations. ECMWF is implementing the Digital Twin Engine, the complex software and data services needed for Earth System digital replicas, as well as the first two digital twins; Climate Change Adaptation, which provide multidecadal simulations, and the Weather-induced Extremes twin, with both high-resolution forecasts and on-demand simulations.



Destination  
Earth website:



The **Weather-Induced Extremes Digital Twin** produces bespoke, cutting-edge, numerical simulations of extreme events on a timescale of a few days ahead, to support rapid response from decision-makers.

The **Climate Change Adaptation Digital Twin** provides multi-decadal global climate simulations with local granularity, including information for sectors most affected by climate change such as renewable energy, urban planning or hydrology.



# ESA Digital Twin Earth (DTE) Programme

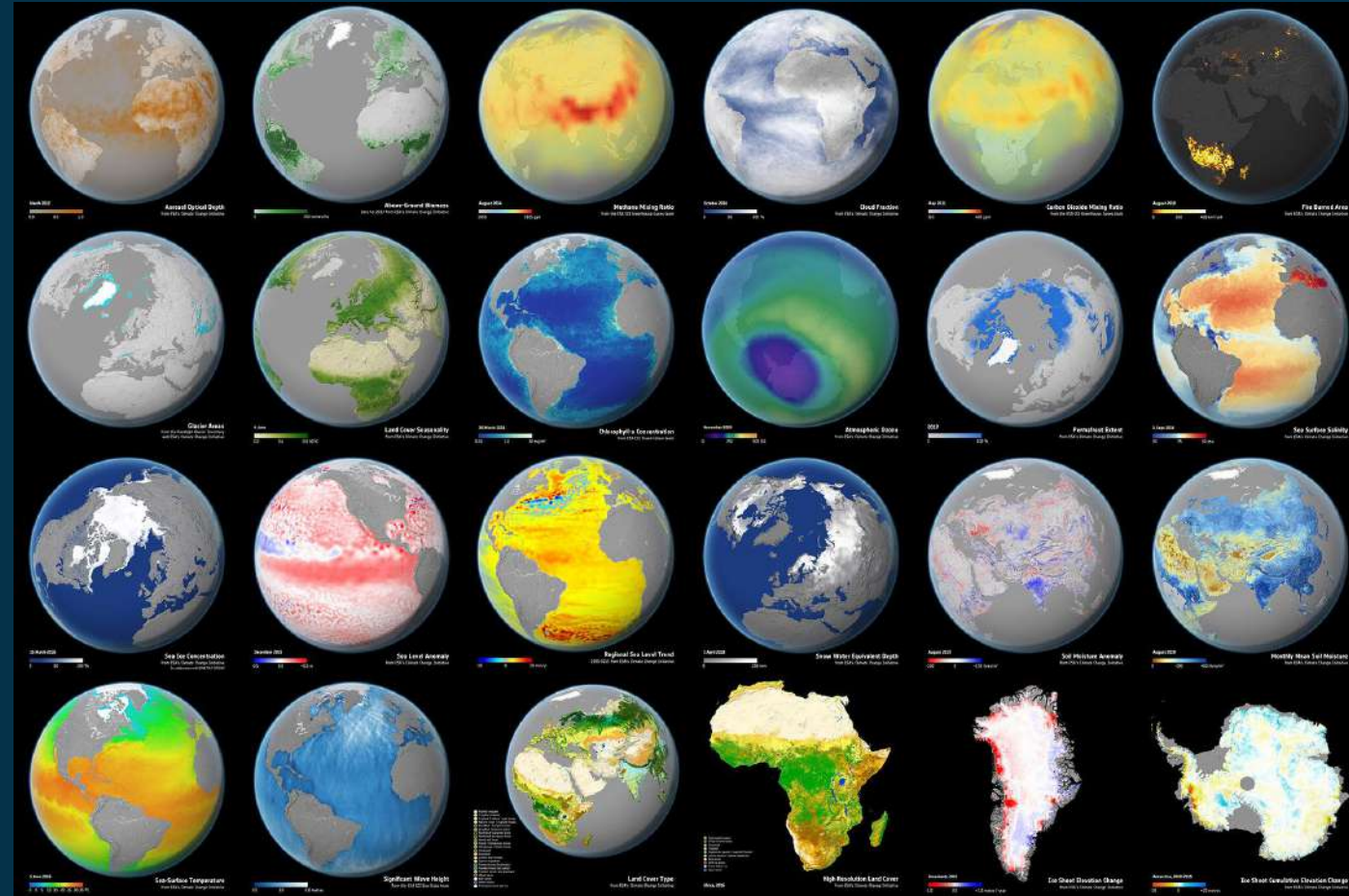
DTE website:



ESA Digital Twin Earth (DTE) Programme is designed to maximise the use of Earth Observation in developing digital twins of the Earth system.

EO developments together with new advances in sectorial modelling, computing capabilities, Artificial Intelligence (AI) and digital technologies offer excellent building blocks to realise novel EO-based Digital Twin Components.

These digital twins enable precise monitoring and forecasting of environmental changes, supporting the decision making of policymakers, businesses and communities.



# ESA DTE Digital Twin Components

DTE website:



The Earth Observation Digital Twin Components (EO DTCs) are pre-operational digital twins designed to dynamically reconstruct, characterise, and simulate elements of the Earth system and their interactions with human activities.

Each DTC is based on multivariate EO data and is focused on a specific element of the Earth system.

These components allow users to explore various conditions and scenarios, including “what-if” analyses, to better understand and predict changes in the Earth system.

EO DTCs are developed to be complementary to DestinE with planned integration into the DestinE Platform.

## Earth System Themes:

- Lead DTCs:
  - Hydrology (x2)
  - Coastal Processes
  - Ice Sheets
  - Agriculture (x2)
  - Forests
- Early DTCs:
  - Energy
  - Air Quality
  - Arctic
  - Urban Areas
  - Glaciers
  - Geohazards

# ESA DTE Digital Twin Components

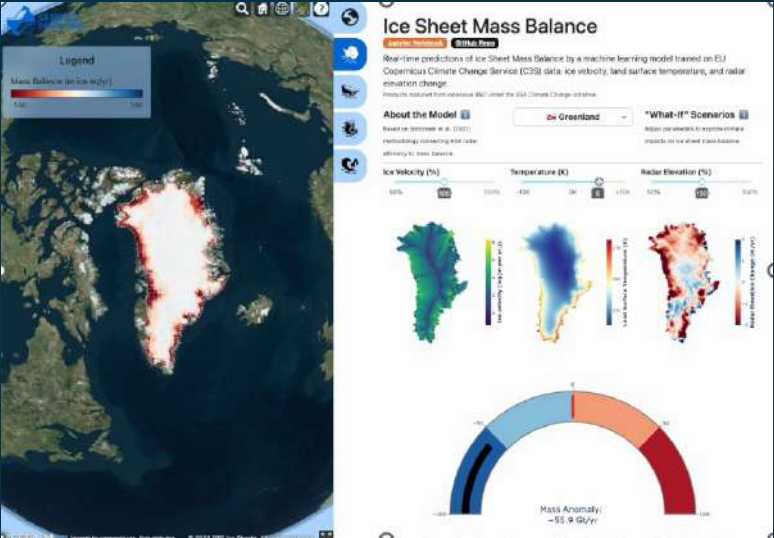
## Polar Ice: DTC Ice Sheets



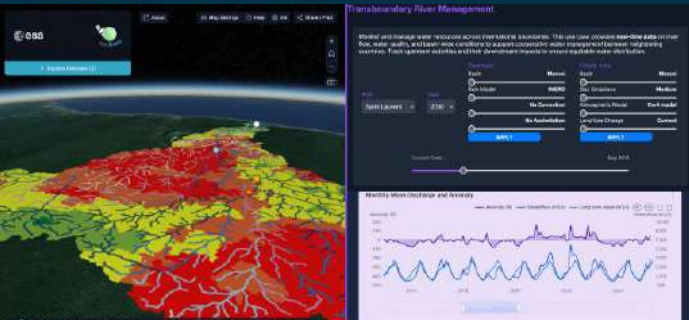
## Hydrology: Hydr'Avatar



3D rendering of flood simulation on the Garonne River (UC5).



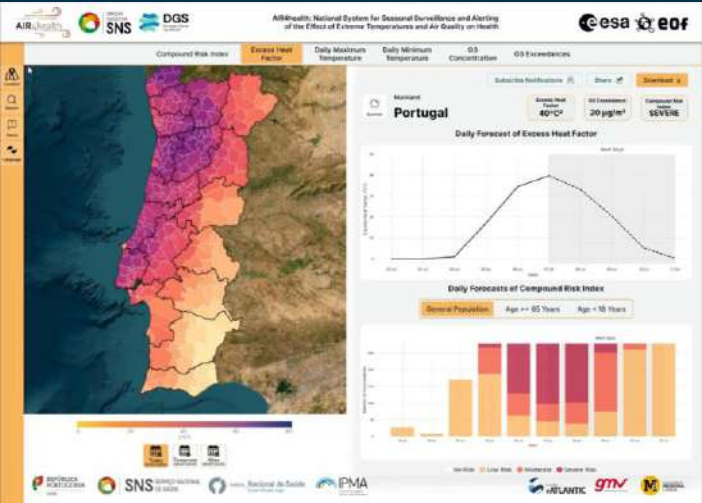
## Urban Areas: SURE



View of Hydr'Avatar platform under use case 1.



## Air Quality: Air4Health



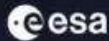
# Examples: DTE Hydrology Next



DTE Hydrology Next  
website:





EOAgriTwin 

[ESA DTE Initiative ↗](#)[About the project](#)

## The Digital Twin for Agriculture

EOAgriTwin is an innovative project serving as one of the Earth Observation Lead Digital Twin Components. We create a comprehensive virtual replica of agricultural systems to support monitoring, simulation, and stress factor analysis.

Get Started →





EOAgriTwin website:

