

DESTINATION EARTH

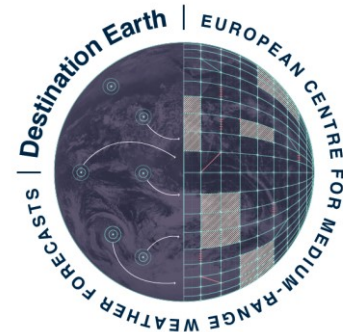
DIGITAL EARTH TWINS Objectives, Scope, expected results



Funded by the
European Union



ECMWF's role in EU's DestinE initiative



Towards a Digital Twin Earth



ECMWF is responsible for the delivery of:

The DestinE **Digital Twin Engine** (DTE):

- common approach for a unified orchestration of Earth-system simulations and their fusion with observations, requiring **large-scale HPC** and data handling resources

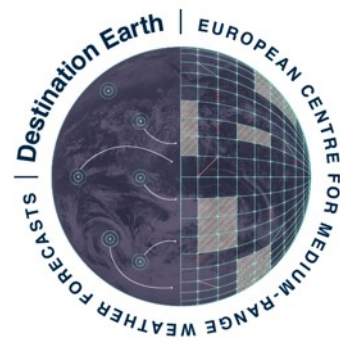
Weather-induced and Geophysical **Extremes Digital Twin**:

- capabilities and services for the assessment and prediction of **environmental extremes (a few days ahead)**

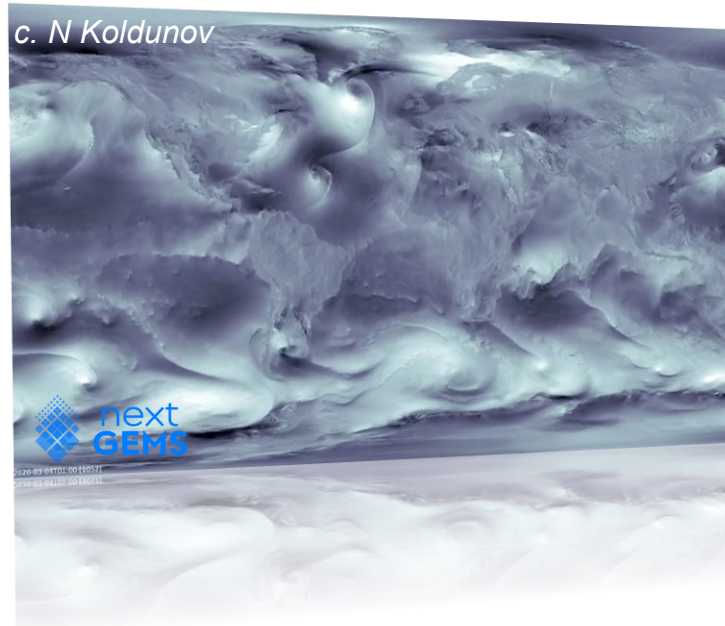
Climate Change Adaptation **Digital Twin**:

- capabilities and services in support of climate change **adaptation policies and mitigation scenario testing (multi-decadal)**

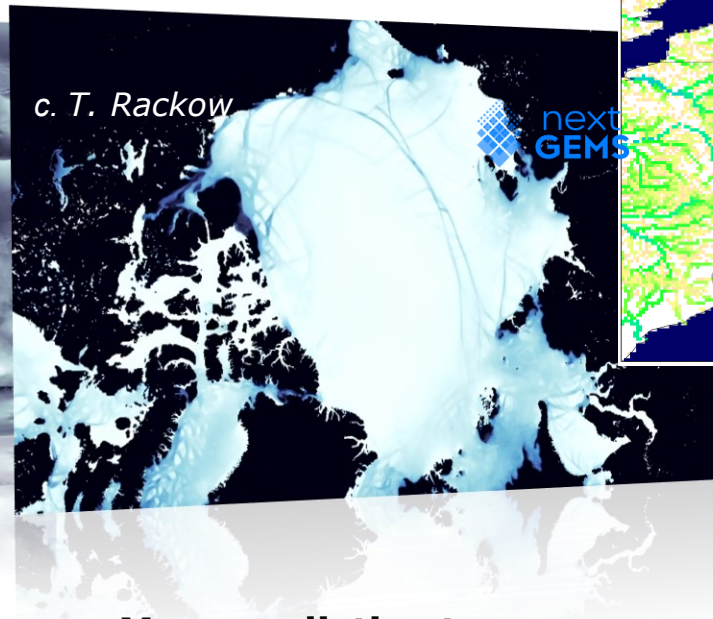
DestinE's Digital Twins: Quality + Impacts + Interaction



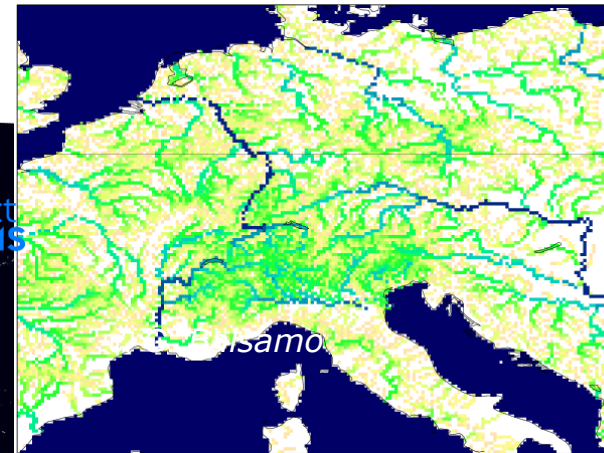
1. **Better simulations** based on **more realistic models**
2. **Better ways of combining all observed and simulated information** from entire Earth system = physical + food/water/energy/health **supporting action scenarios**
3. **Interactive and configurable access to all data, models and workflows**



More realistic at
global scale



More realistic at
local scale



Include impacts
where they matter

Trial different
adaptation
and mitigation
scenarios

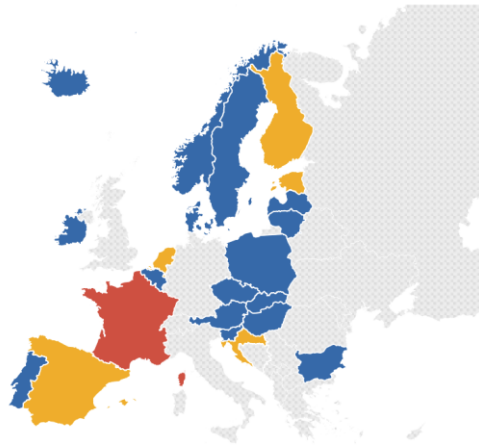
On-demand Extremes DT (procured)

Flexible and scalable workflows for the monitoring and short-range prediction of extremes at sub-km scales, that are configurable and operable on demand; builds on the ACCORD prediction system and selected impact models

Meteo-France led consortium

Participant countries and agencies from the ACCORD consortium

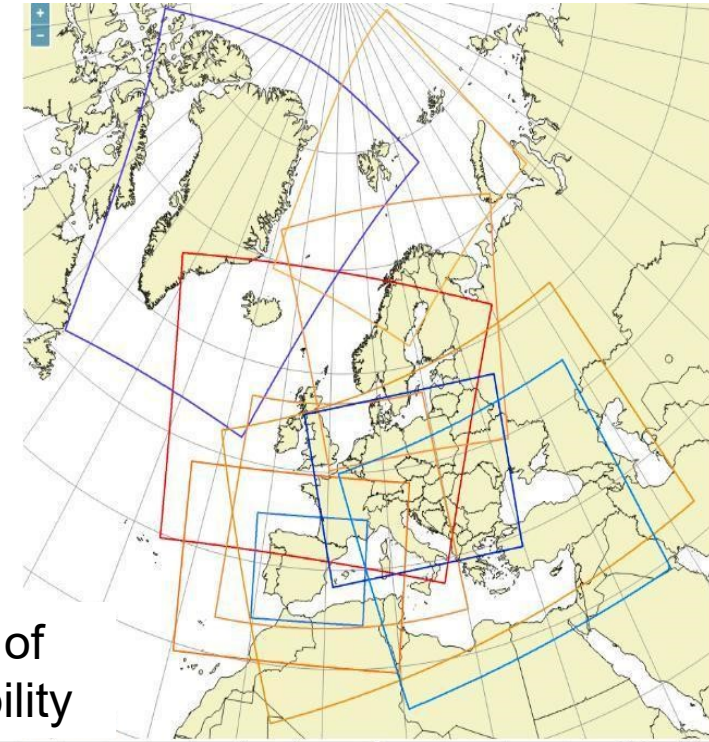
Sweden Spain Slovenia Slovakia Portugal Poland Netherlands Lithuania Latvia
Ireland Iceland Hungary Finland Estonia Denmark Czech Republic Croatia Bulgaria
Belgium Austria France Norway



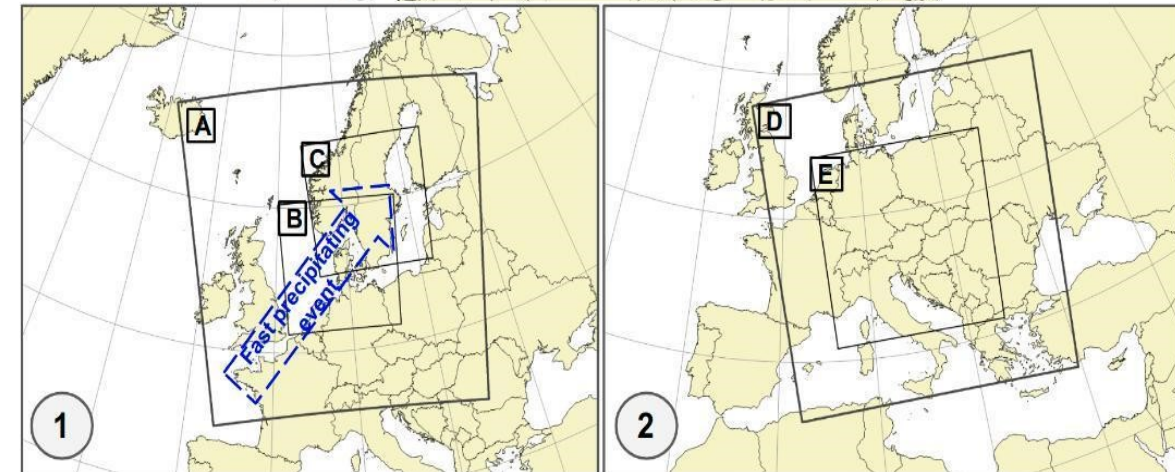
Source: MeteoFrance • Hover in the countries to read the entities involved.
Yellow: Countries with another agency involved in addition to the National Meteorological service.

A Flourish map

Today's prediction systems

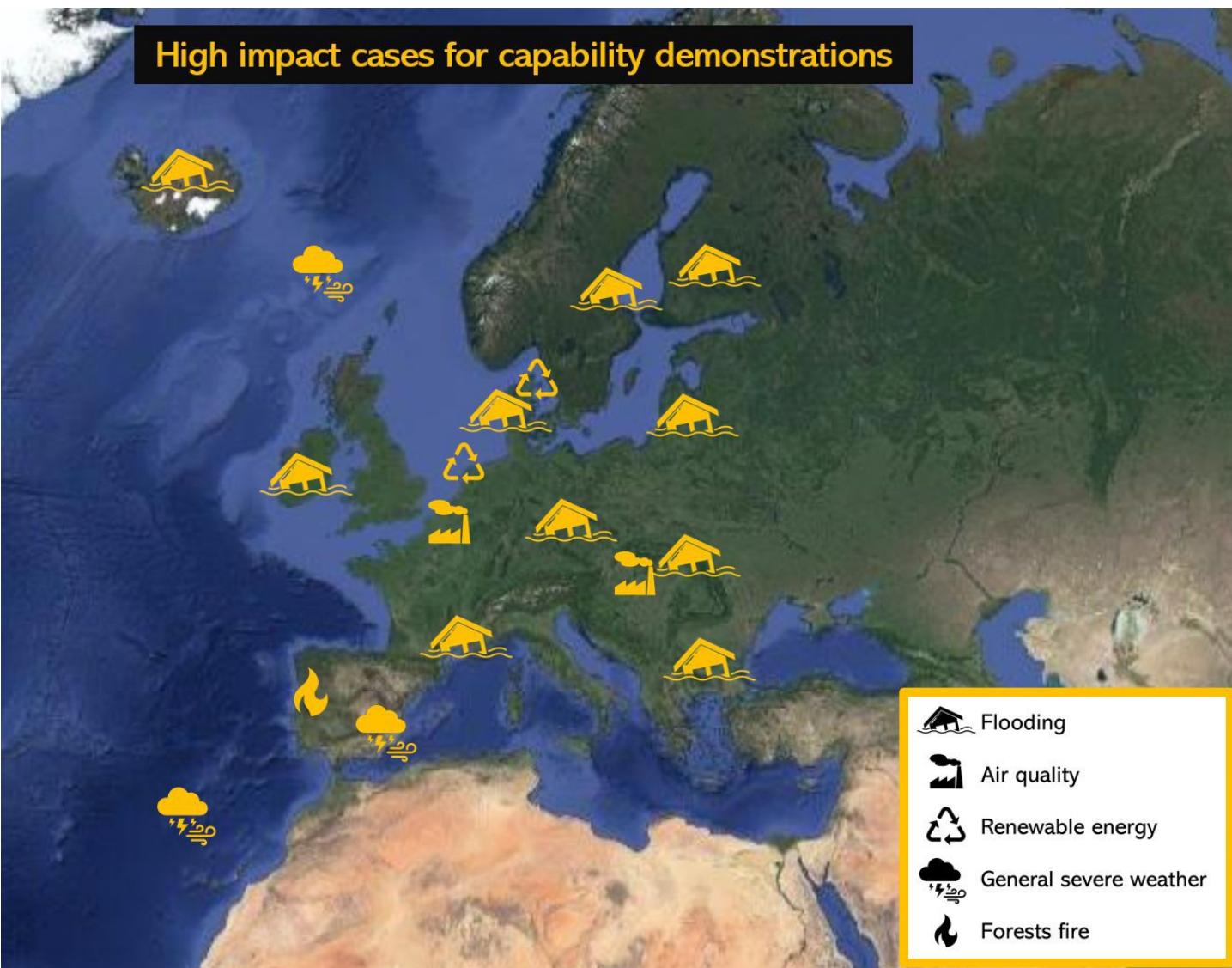


Examples of configurability



USE CASES IN DT EXTREMES (ON DEMAND)

High impact cases for capability demonstrations



-  Flooding
-  Air quality
-  Renewable energy
-  General severe weather
-  Forests fire

Hydrology / Extreme Flood Events



Workflows for flood modelling in BG, CZ, DK, FI, FR, IE, IS, SE, SK



Air quality



Two air quality extremes:

- Cold inversion in Carpathian region, Jan 2017
- Ozone/heat in Benelux, Summer 2018



Renewable Energy



- North sea storms
- Ramping events (storms, fronts, ...)
- Solar energy



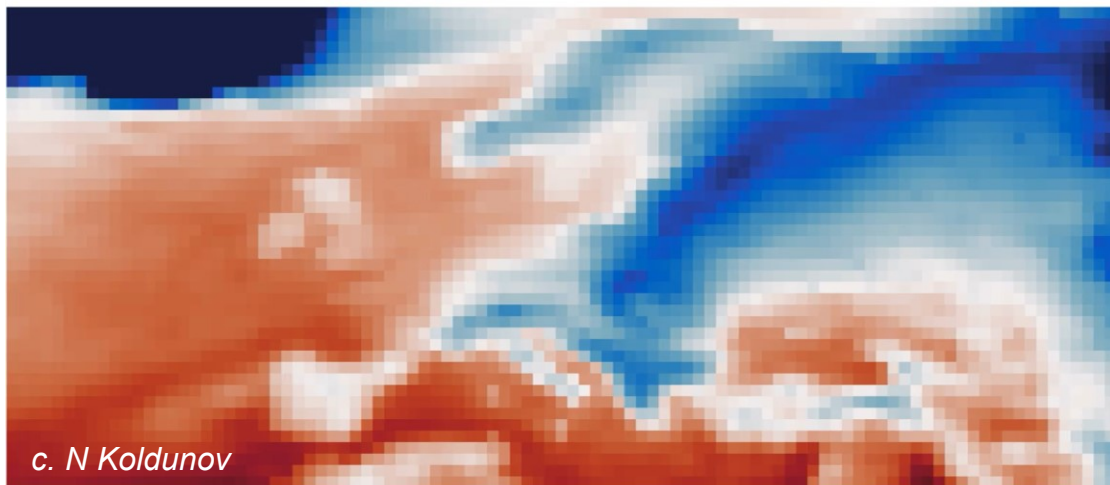
Climate DT

multi-decadal, global, storm/eddy-resolving numerical Earth-system simulation capability with the timely delivery of climate **information** for policy adaptation; observation based assessment framework; use cases for impact-sectors such as water, energy, food or health

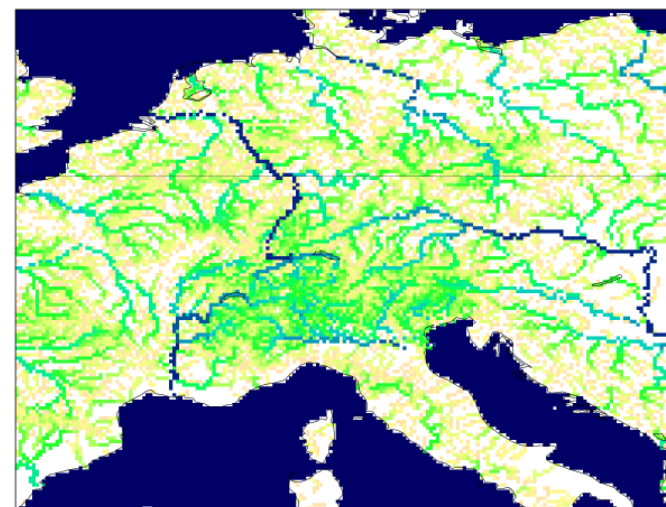
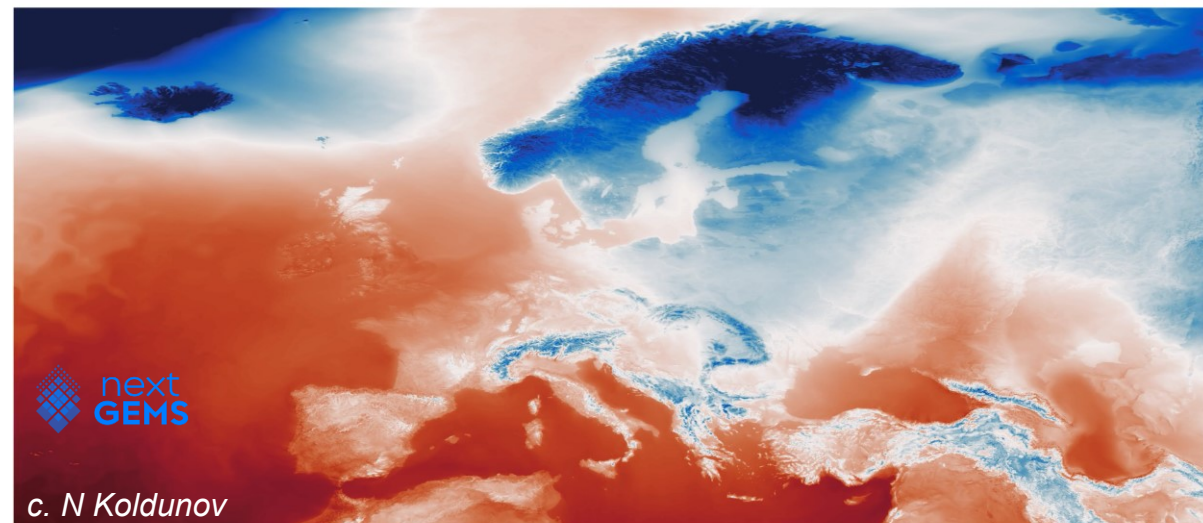
CSC led consortium

Today's global climate models

IPCC AR6 (2021)



Storm & eddy resolving simulations



Collocated weather, climate and impact-sector information on scales where impacts of climate change and extreme events are felt

USE CASES IN DT CLIMATE



- Fire indices for Europe
- Fire spread models in Finland
- Burnt area, CO2 emissions (Finland)



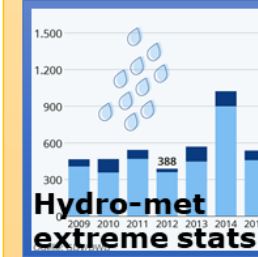
ILMATIETEEN LAITOS



- Future freshwater resources
- Future flood/drought
- Focus: Germany



HELMHOLTZ
Centre for Environmental Research



- Extreme event statistics
- Event catalogue

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



- Wind resources globally (onshore, offshore)
- Wind turbine vulnerability under extremes and icing



Barcelona
Supercomputing
Center
Centro Nacional de Supercomputación

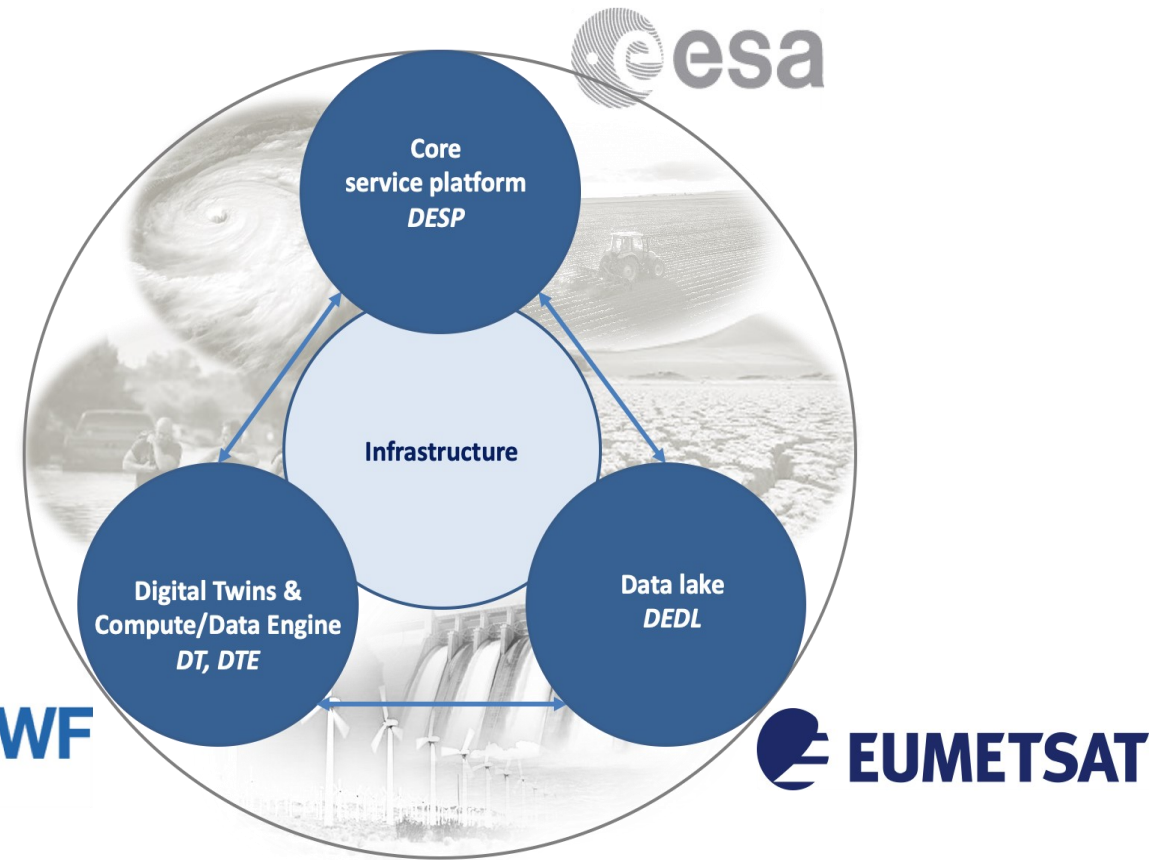
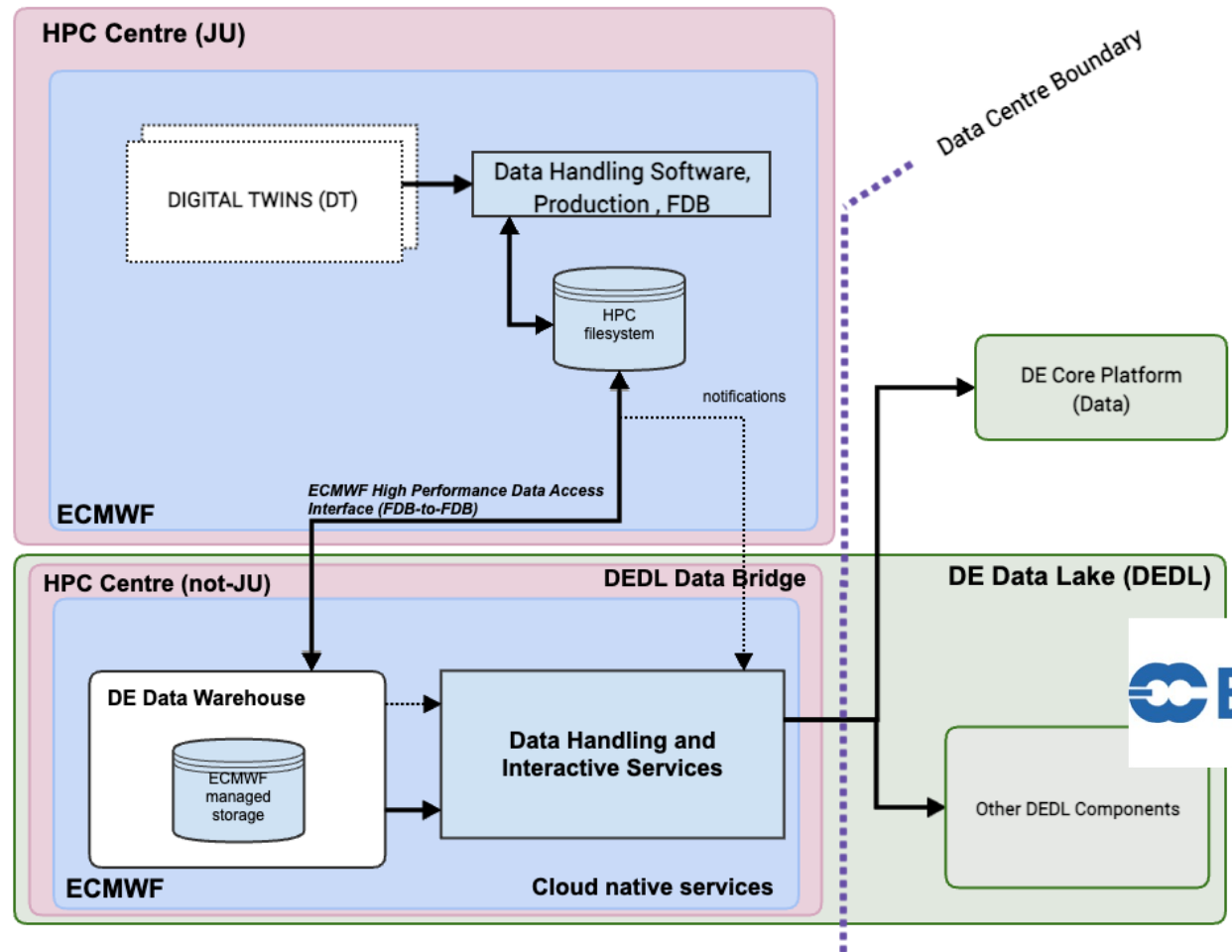


- Spatio-temporal variability of heat waves
- Human thermal comfort indicators

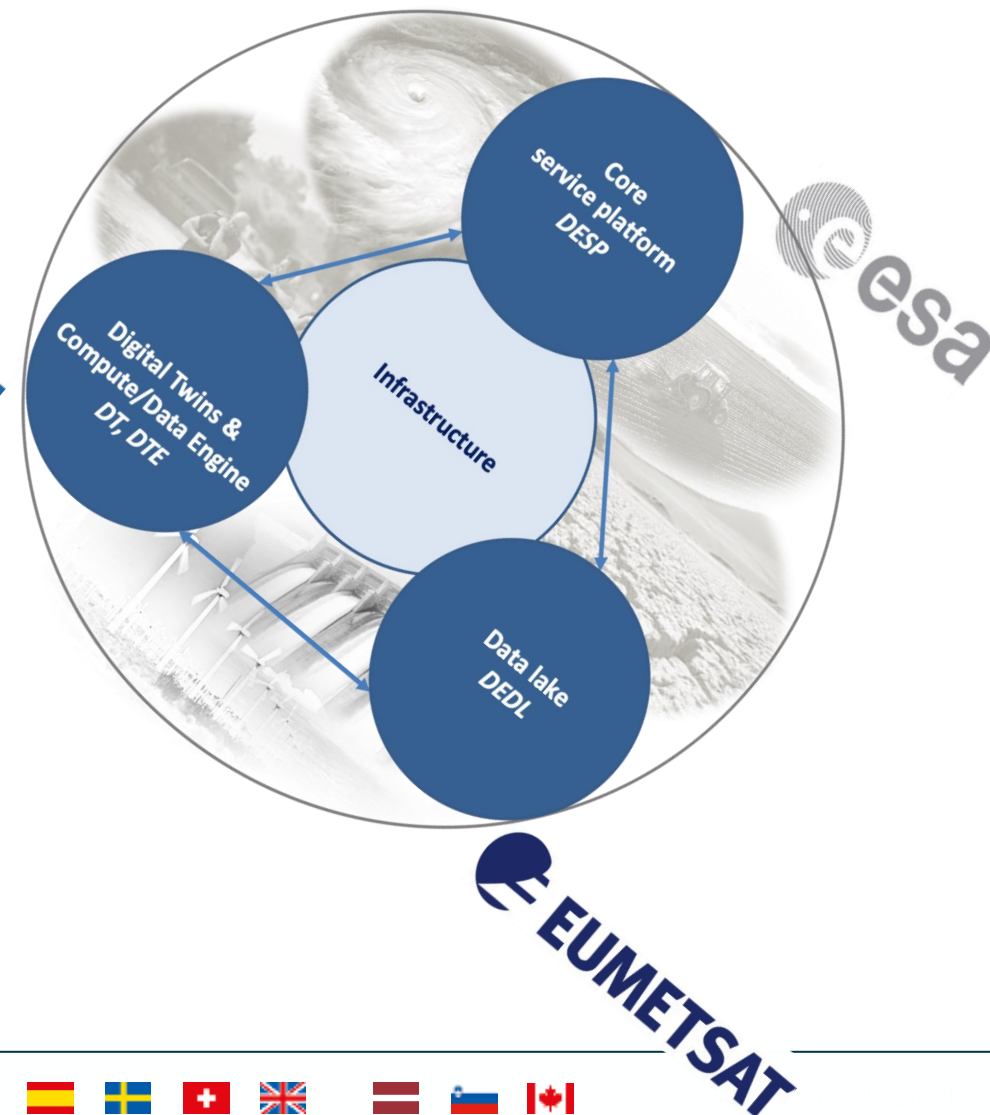
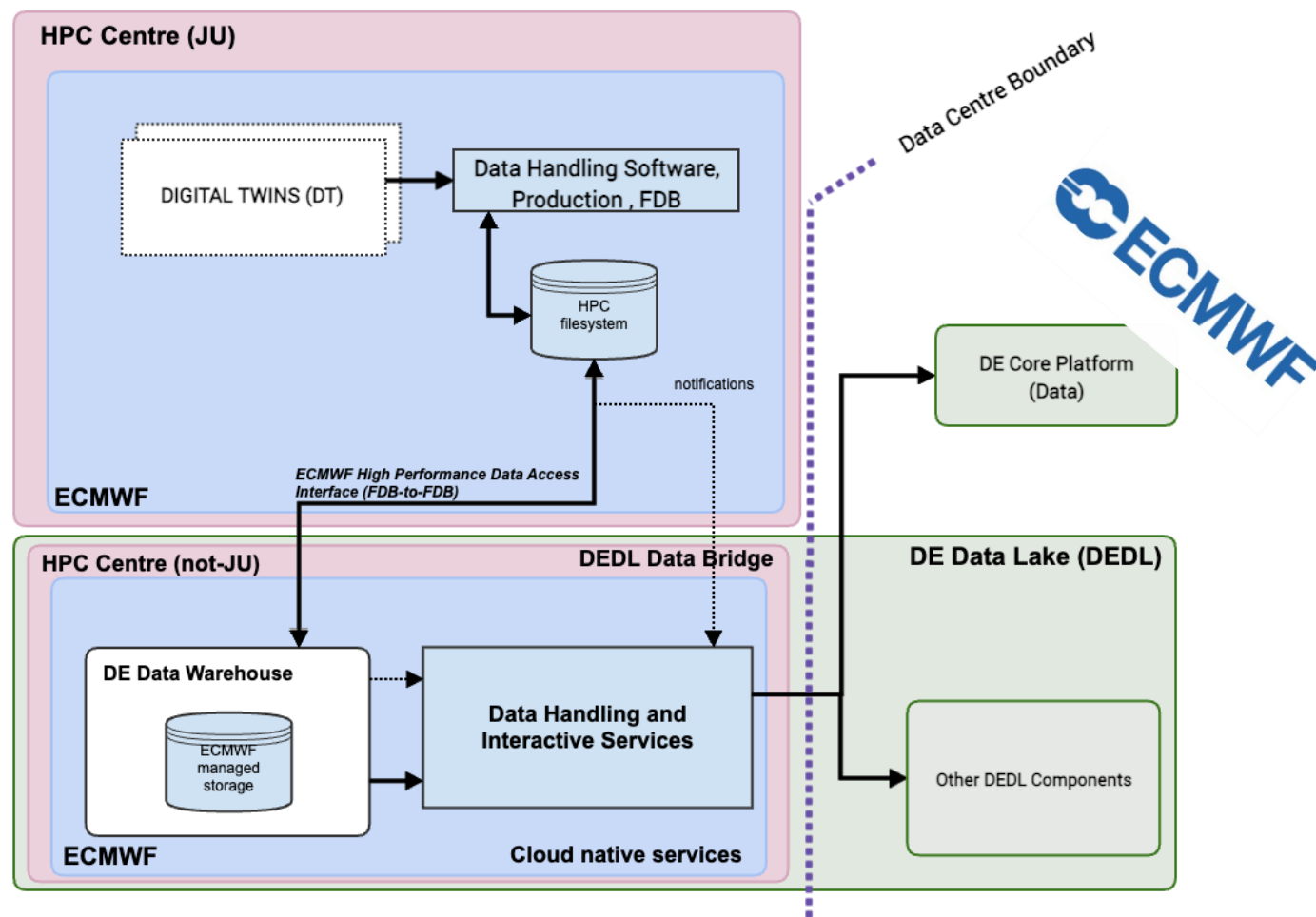


Barcelona
Supercomputing
Center
Centro Nacional de Supercomputación

DTE in the Destine system



DTE in the Destine system



DTE interfaces

1. **Better simulations** based on **more realistic models**
2. **Better ways of combining all observed and simulated information** from entire Earth system = physical + food/water/energy/health **supporting action scenarios**

3. **Interactive and configurable access to all data, models and workflows**

Framework for **Earth System Model** Workflows

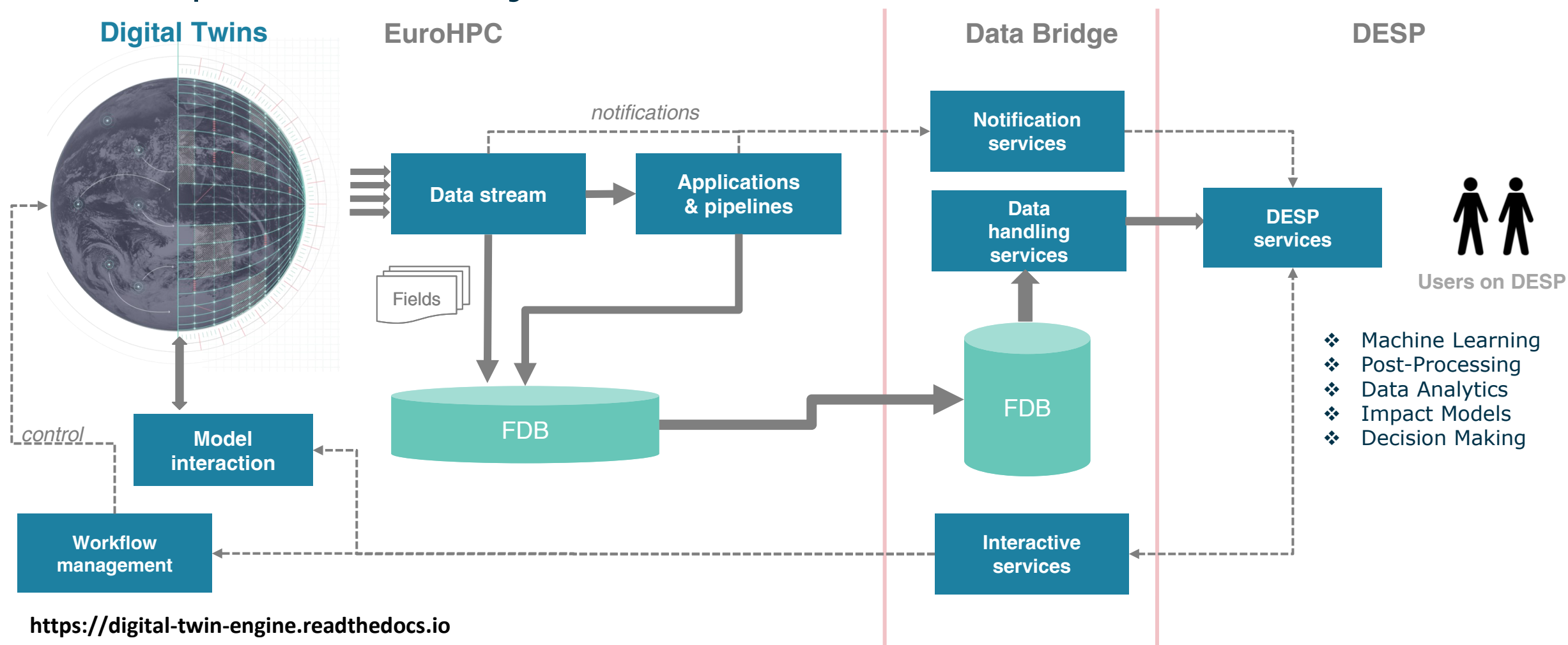
Think of a Game Engine but for Earth Systems...

- It's a Framework – not model specific
- Collection of API's and Services
- Opt-in Components

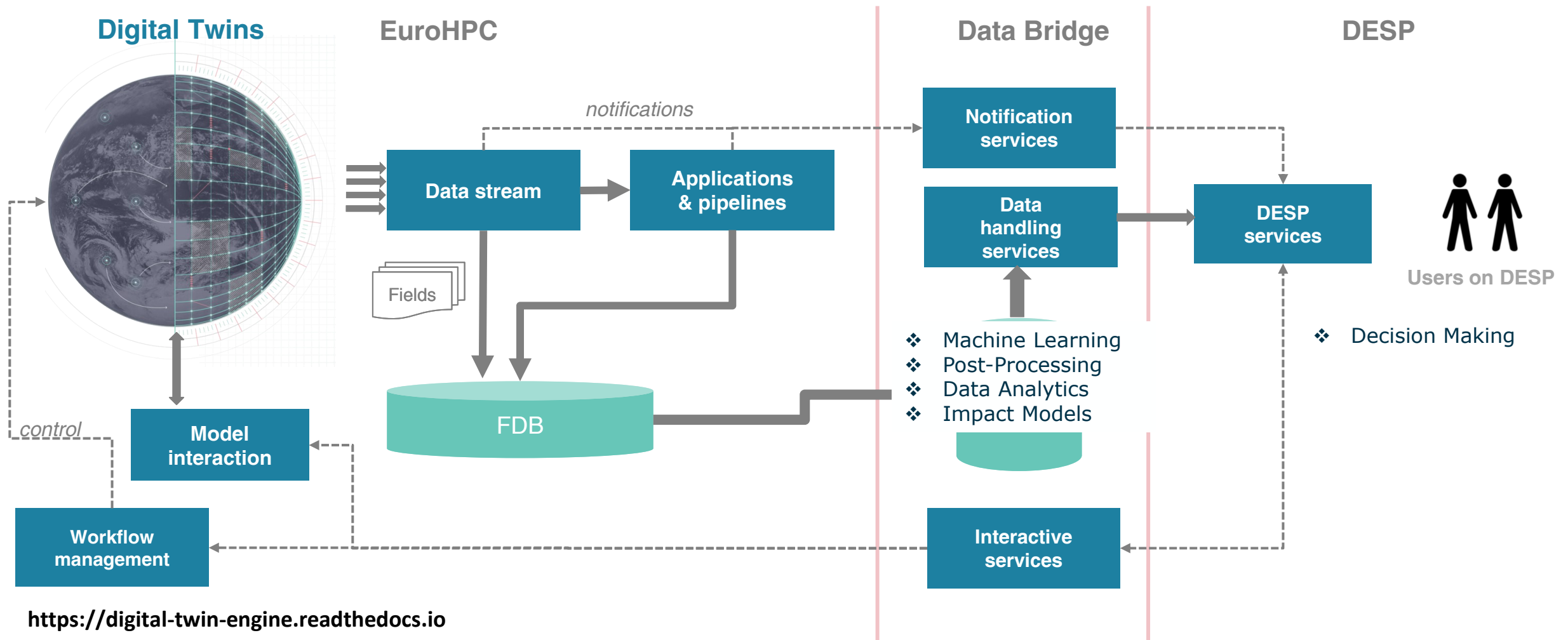
Opt-in components are evolving and comply with evolving standards

**International standards on
software quality (QASaas)
data access/management (FAIR, OGC, INSPIRE)**

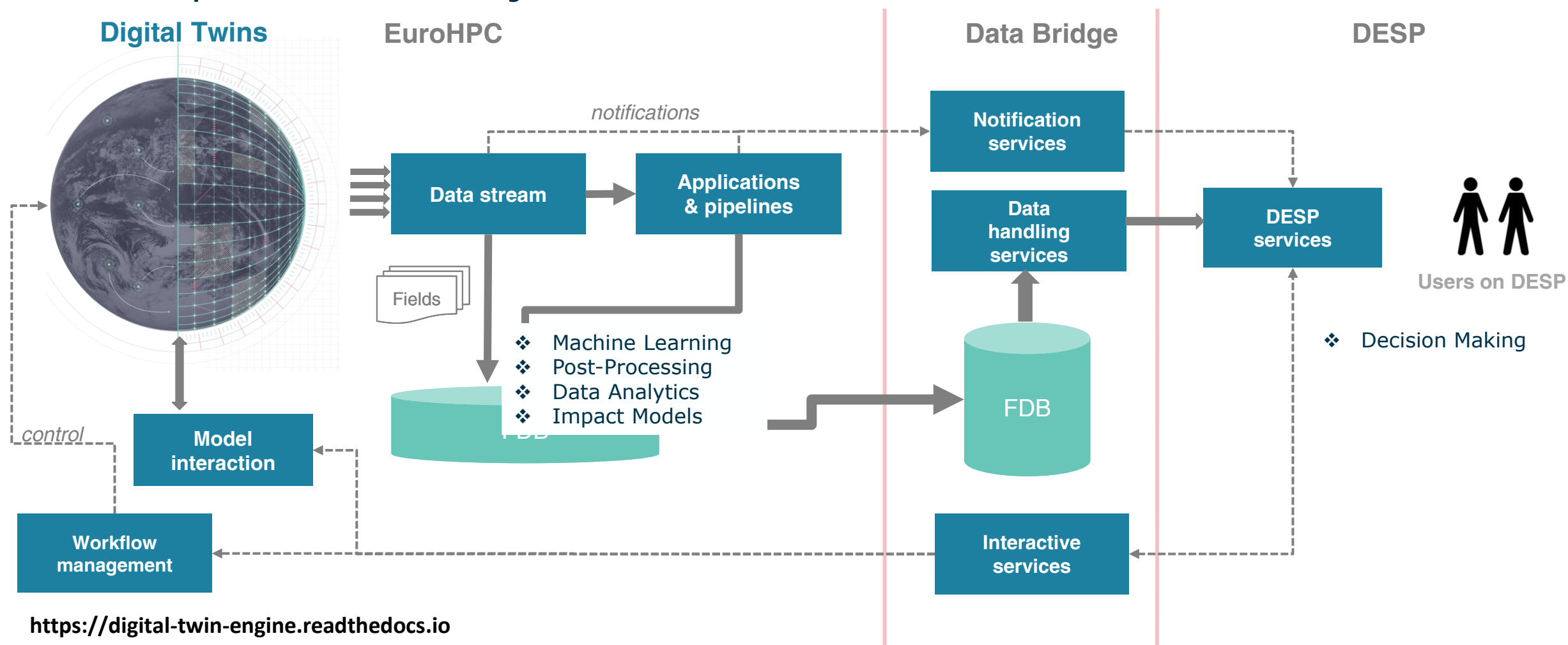
DTE components and objectives



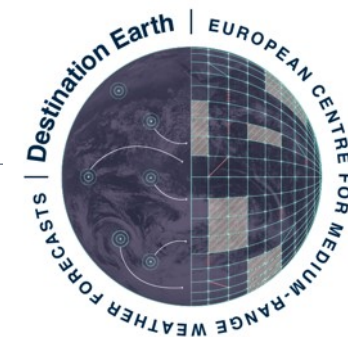
DTE components and objectives



DTE components and objectives



Different types of Digital Twins



Full Integration mode

Directly integrated in the DestinE simulation and data handling system

Coupling mode

Integrated in a workflow where Digital Twins have their own simulation and data fusion tasks interfacing with DestinE

Post-processing mode

Integrated as data post-processing application without own Earth-system simulation



Integration continuum

Interoperability for data, metadata and workflow semantics across disciplines and platforms

Delivered by **ECMWF** DT-Engine

Different types of Integration



Full Integration mode

Directly integrated in the DestinE simulation and data handling system

Coupling mode

Integrated in a workflow where Digital Twins have their own simulation and data fusion tasks interfacing with DestinE

Post-processing mode

Integrated as data post-processing application without own Earth-system simulation



Integration continuum

Use DTE

Workflow management, HPC and data handling software infrastructures

Compatible with DTE

Workflow management, HPC and data handling software infrastructures

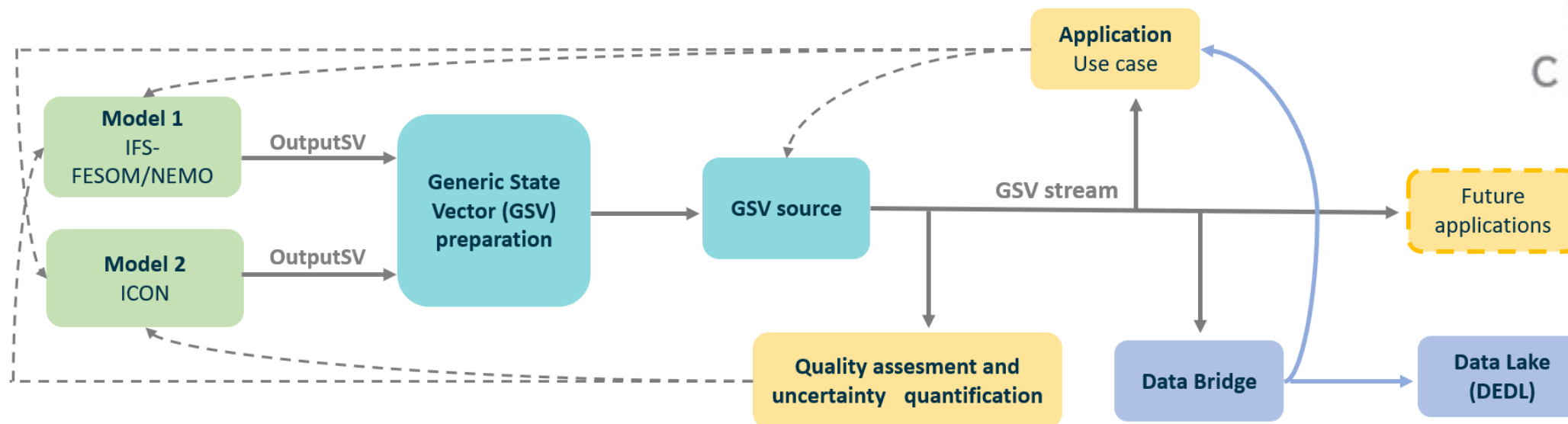
Weak DTE coupling

independent
Workflow management, data management support

DTE in the background

implicit data handling software infrastructure use By the end user from the DESP

CLIMATE DT – A NOVEL WORKFLOW



Streaming of climate model output in standardized form (*Generic State Vector, GSV*) enables

- **users to access the full model state** as soon as it is available
- **scalability** – new applications can be added
- **(interactivity** – in future phases users may request simulations based on their needs)

Different types of Digital Twins



Full Integration mode

Directly integrated in the DestinE simulation and data handling system

Coupling mode

Integrated in a workflow where Digital Twins have their own simulation and data fusion tasks interfacing with DestinE

Post-processing mode

Integrated as data post-processing application without own Earth-system simulation



Current DestinE constraints

- Cannot within the current allocation limits provide "free" platform (HPC) resources
- Does not have the capacity, in its current funding, to develop bespoke or specific interface solutions

Integration continuum

