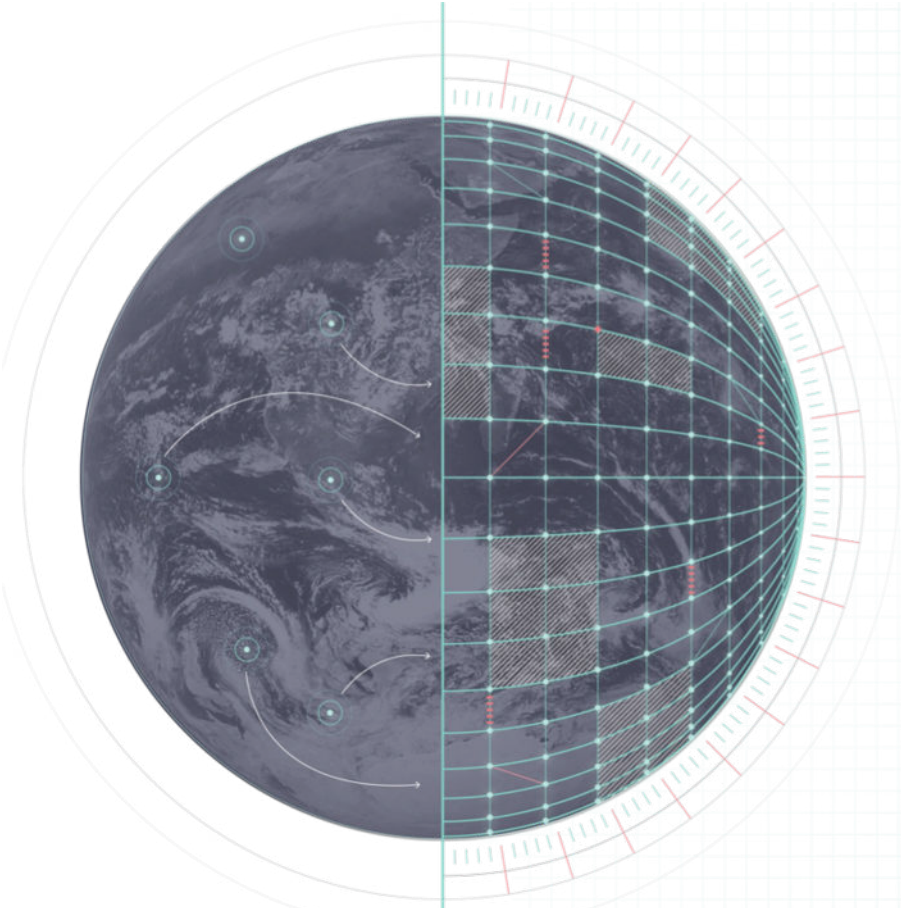


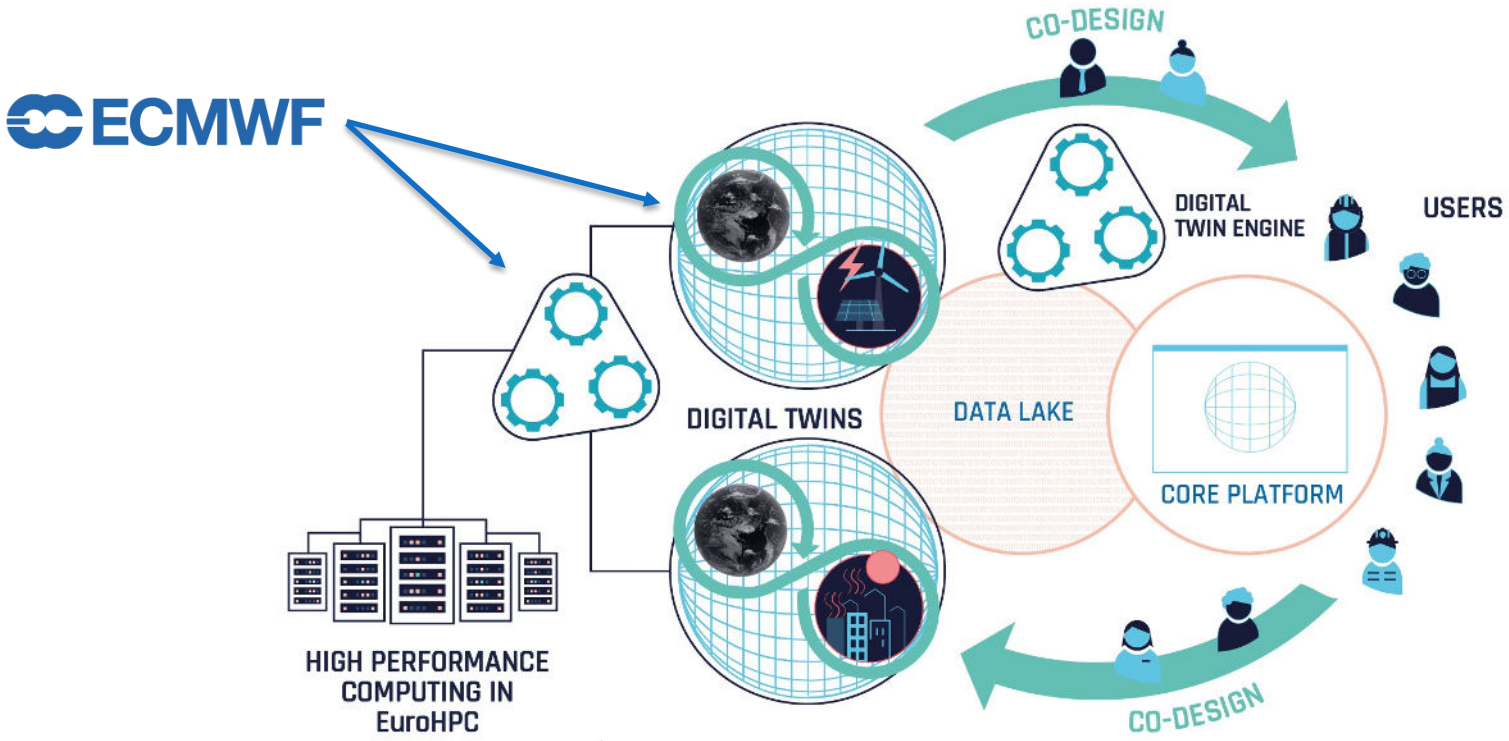
DESTINATION EARTH

Connection to other digital twins

Thomas.Geenen@ecmwf.int and many many others

Funded by the European Union
Destination Earth implemented by ECMWF esa EUMETSAT

THE ROLE OF CO-DESIGN AND TECHNOLOGY TRANSFER



Technology transfer - ECMWF

Funded by the European Union

What has been agreed:

Two meetings have been held with all stakeholders in the spring of 2023

BioDT, DT-Geo, Intertwin, EDITO + (DG-MARE, DG-RTD, DG-DEFIS and CINEA)

Agreed to:

- Work on a shared architecture view of the Digital twin Engine
- Work on a shared glossary
- Define pilots to test for interoperability
- Plan and execute the pilots to show interoperability

Recognized that we have an interoperable **continuum** and not all use-cases need full/tight integration

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

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

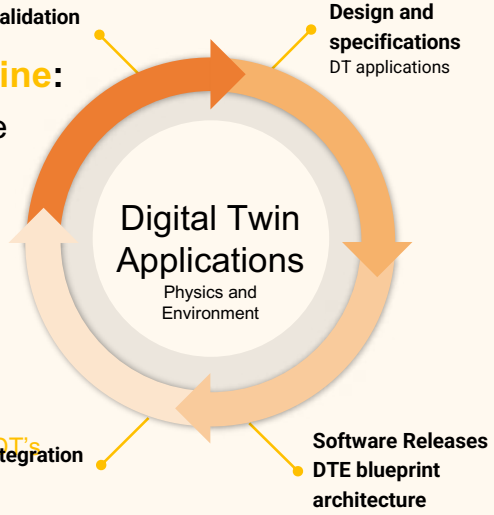
Funded by the European Union

interTwin: an interdisciplinary Digital Twin Engine for Science

interTwin

Creation of a prototype Digital Twin Engine:

- Resulting DTE Blueprint Architecture must be
  - Interdisciplinary
  - Co-Designed (Providers and Communities)
- Developed Platform must be
  - Open Source with
  - TRL 6 (prototype model) to 7 (prototype pilot)
- and based on
  - Open Standards
  - with the capability to integrate with application specific DT's



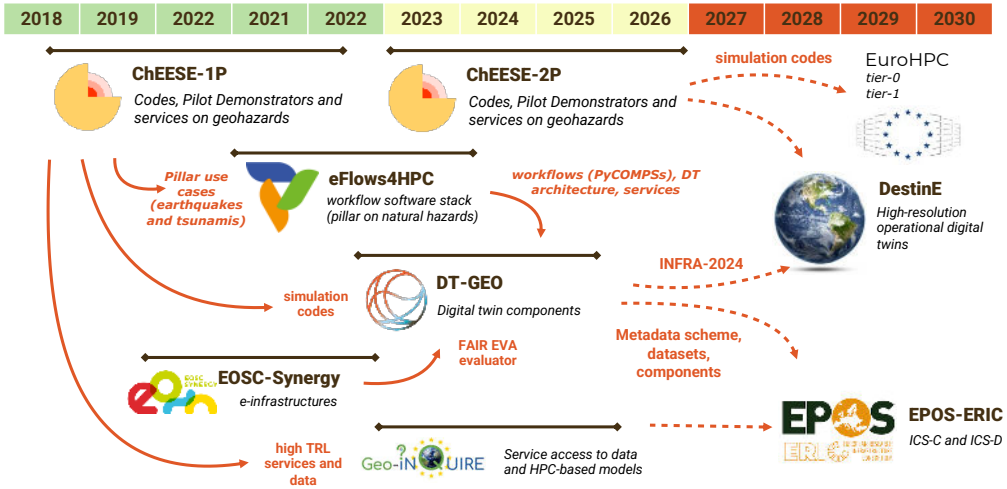
The Biodiversity Digital Twin: a new solution to support protection and restoration of ecosystems

- **Project name:** Biodiversity Digital Twin for Advanced Modelling, Simulation and Prediction Capabilities (BioDT)
- **Call title:** Next generation of scientific instrumentation, tools and methods (HORIZON-INFRA-2021-TECH-01)
- **Duration:** 1 June 2022 – 31 May 2025 (36 months)
- **Consortium:** 22 partners
  - Experts in biodiversity, high-performance computing, artificial intelligence, digital twinning and FAIR data
  - Partners from 12 countries: Finland (FI), Italy (IT), Czech Republic (CZ), the Netherlands (NL), Estonia (EE), Sweden (SE), United Kingdom (UK), Germany (DE), Austria (AT), Denmark (DK), Norway (NO), Spain (ES)
    - Incl. one Affiliated Entity and three Associated Partners
- **Work Package (WP) members:** 140+
- **Coordinator:** CSC – IT Center for Science
- **Website:** www.biodt.eu

DT-GEO

A Digital Twin for GEOphysical extremes

Links with other projects



This project has received funding from the European Union's Horizon research and innovation programme under the grant agreement No 101058129

European Digital Twin of the Ocean

A leap in ocean knowledge and sustainable action

European Commission

EU MISSIONS
RESTORE OUR OCEAN & WATERS
#EUmissions #HorizonEU #MissionOcean

MERCATOR OCEAN INTERNATIONAL

VLIZ

Technology transfer - ECMWF

Funded by the European Union

What has been done:

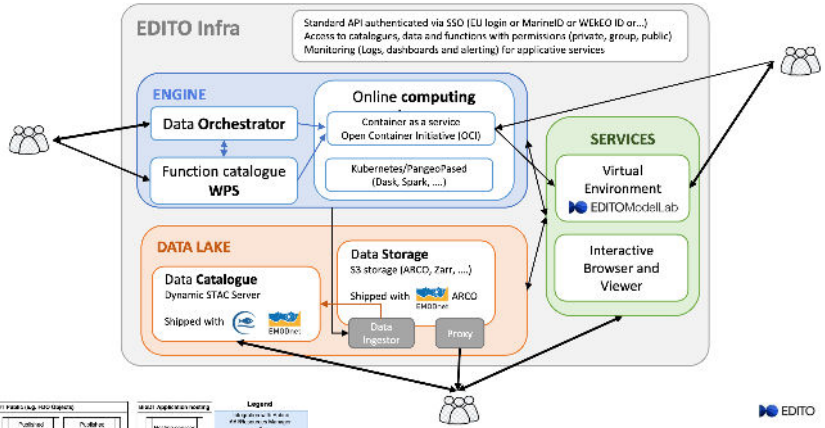
In Bilateral meetings we have:

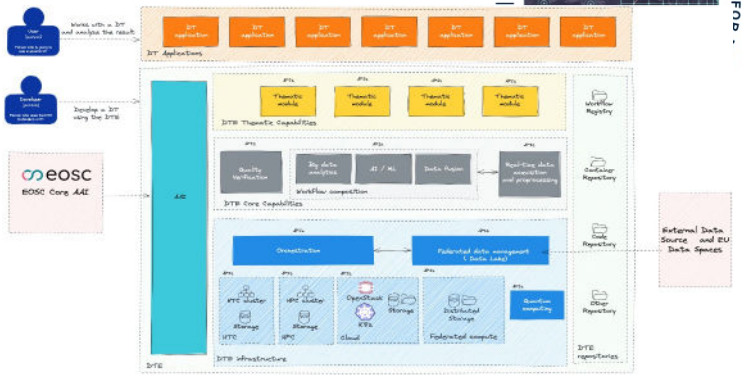
- Drafted a first version of a **common DT architecture description** (using C4 modeling)
- Started working on the glossary (forked from **Digital twin consortium**, like BioDT and Intertwin)
- Define pilots to test for interoperability
  - With DT-Geo a **tsunami** DT (also looking into **urgent computing** aspects)
  - With BioDT a DT on consequences of climate change to **agricultural crops** over Europe (together with **Eumetsat**)
  - With Intertwin a DT on **flood adaptation** and mitigation (a **shared** usecase between Intertwin and DestinE)

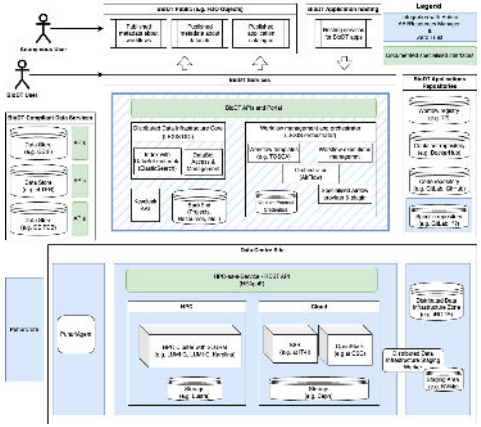
We are sketching solution paths for these pilots in the architecture landscape

At the UserExchange meeting we have a session to explain the approach to a wider audience

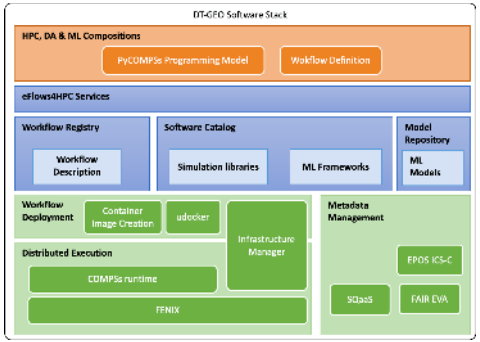
Define Interoperability landscape for Earth system DTs

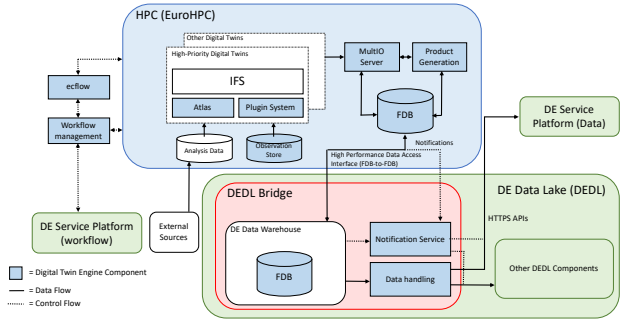






EDITO

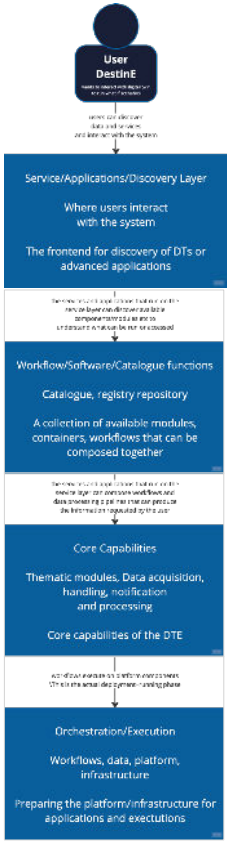


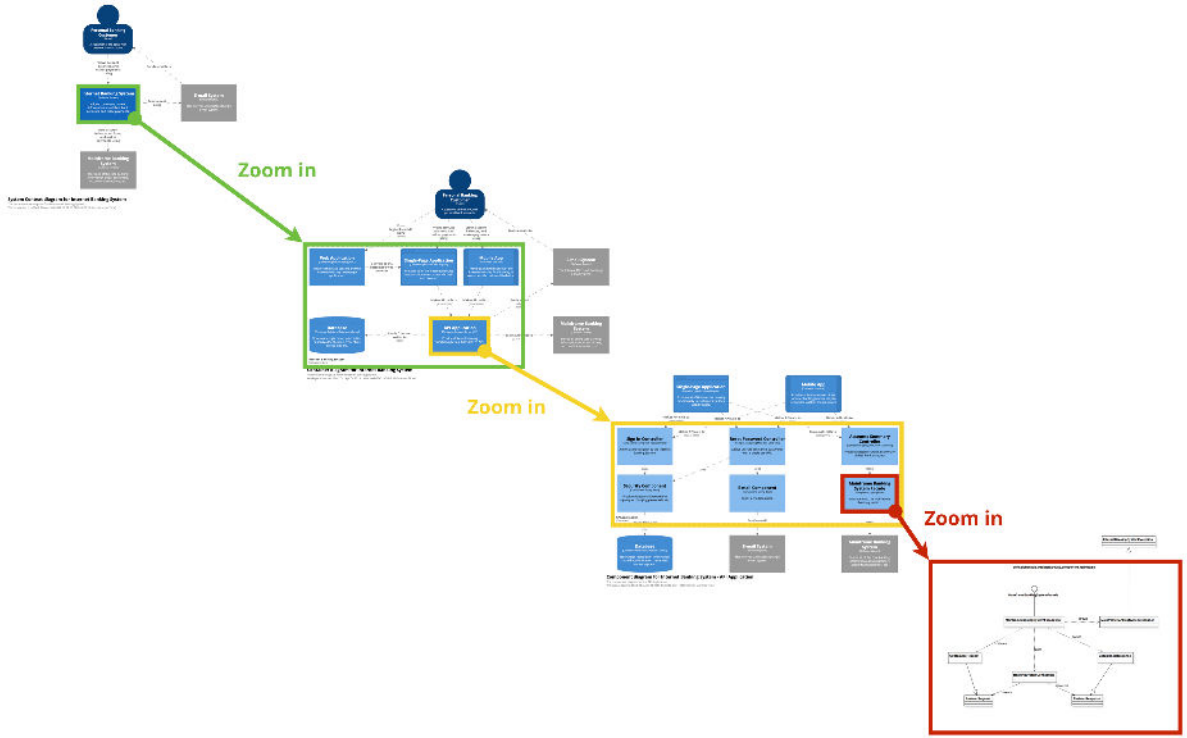


ECMWF

EuroHPC Joint Undertaking

Funded by the European Union


User
DestinE
Service/Applications/Discovery Layer
Where users interact with the system
The frontend for discovery of DTs or advanced applications
Workflow/Software/Catalogue functions
Catalogue, registry repository
A collection of available modules, containers, workflows that can be composed together
Core Capabilities
Thematic modules, Data acquisition, handling, notification and processing
Core capabilities of the DTE
Orchestration/Execution
Workflows, data, platform, infrastructure
Preparing the platform/infrastructure for applications and exectutions

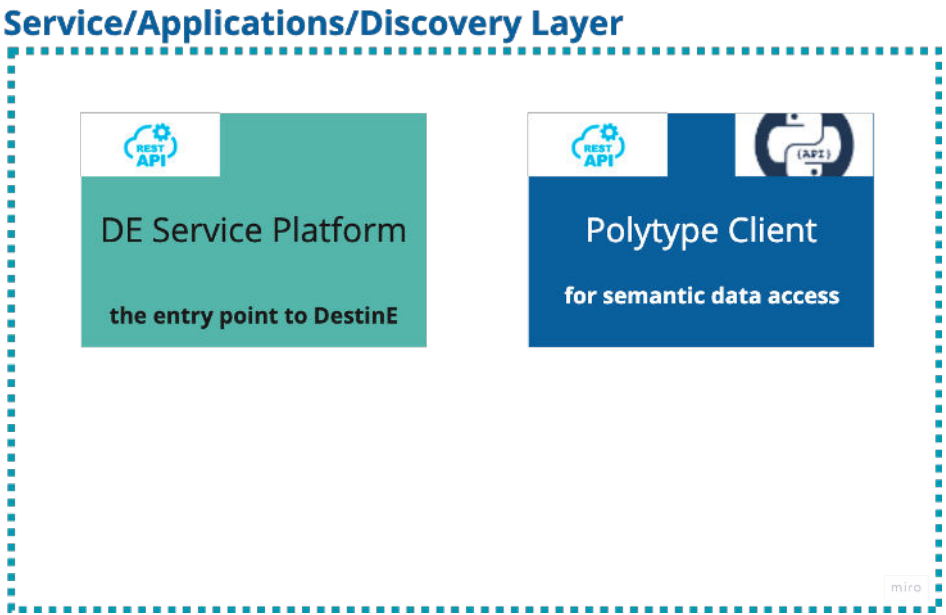

Zoom in
Zoom in
Zoom in
Level 1
Context
Level 2
Containers
Level 3
Components
Level 4
Code

users can discover
data and services
and interact with the system

Service/Applications/Discovery Layer

Where users interact
with the system

The frontend for discovery of DTs or
advanced applications



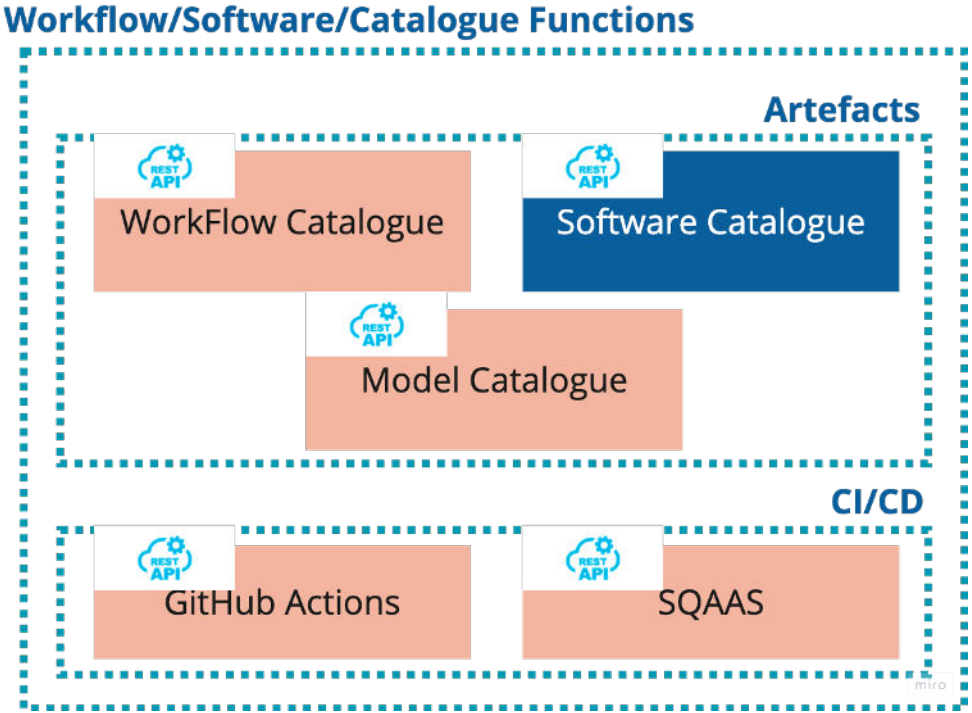
the services and applications that run on the service layer can discover available components/modules etc to understand what can be run or accessed

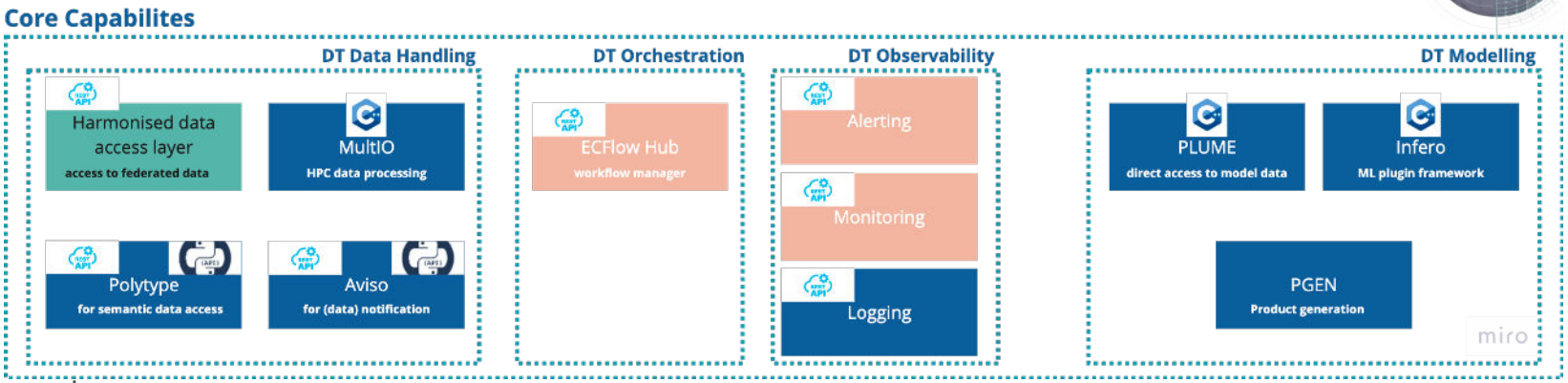
↓

Workflow/Software/Catalogue functions

Catalogue, registry repository

A collection of available modules, containers, workflows that can be composed together



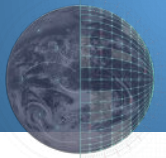


the services and applications that run on the service layer can compose workflows and data processing pipelines that can produce the information requested by the user

Core Capabilities

Thematic modules, Data acquisition, handling, notification and processing

Core capabilities of the DTE



workflows execute on platform components
\This is the actual deployment+running phase

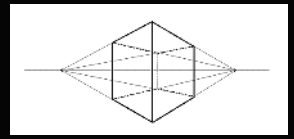
Orchestration/Execution

Workflows, data, platform, infrastructure

Preparing the platform/infrastructure for applications and exectutions

THE FLOOD ADAPTATION CASE

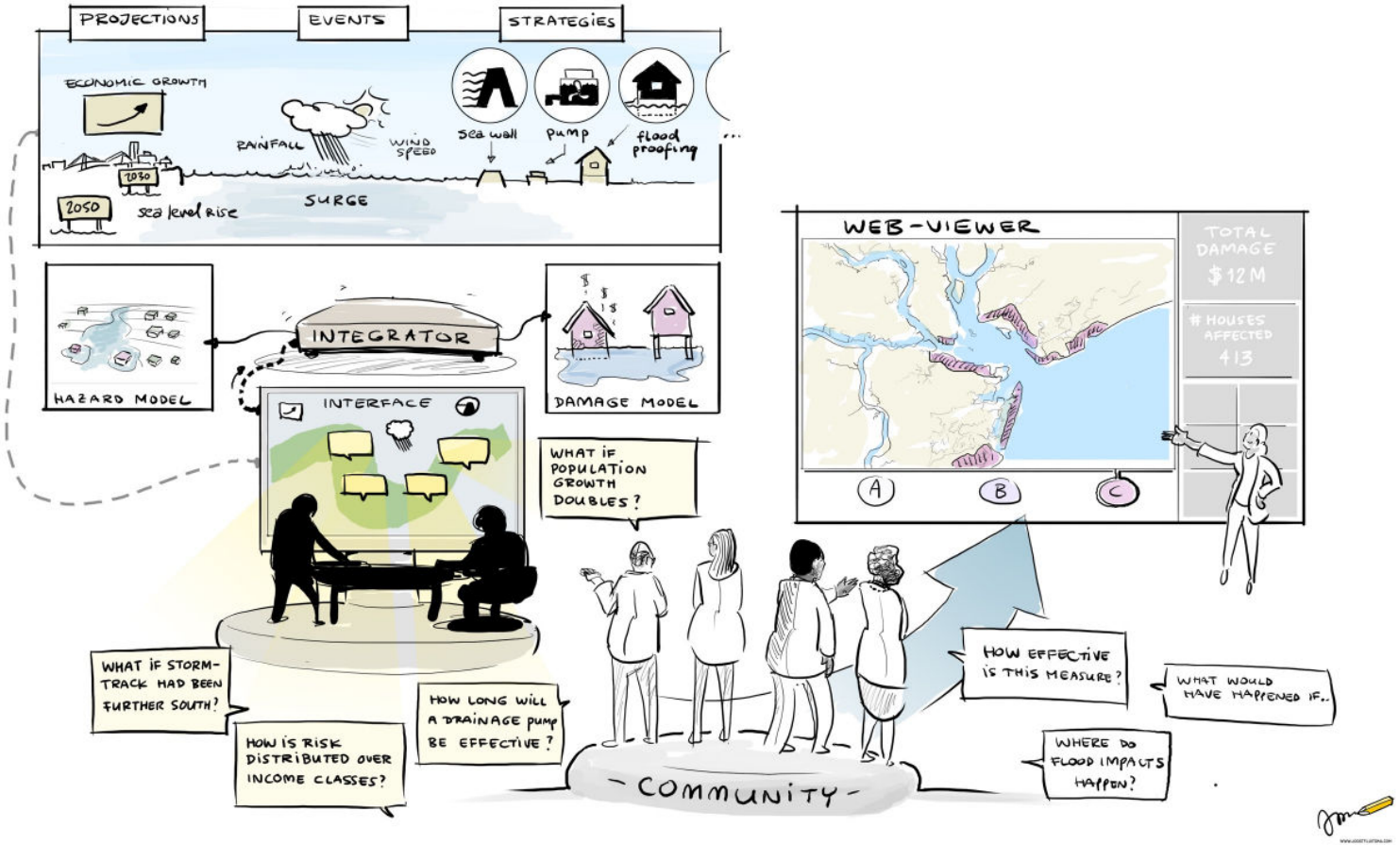
Objective

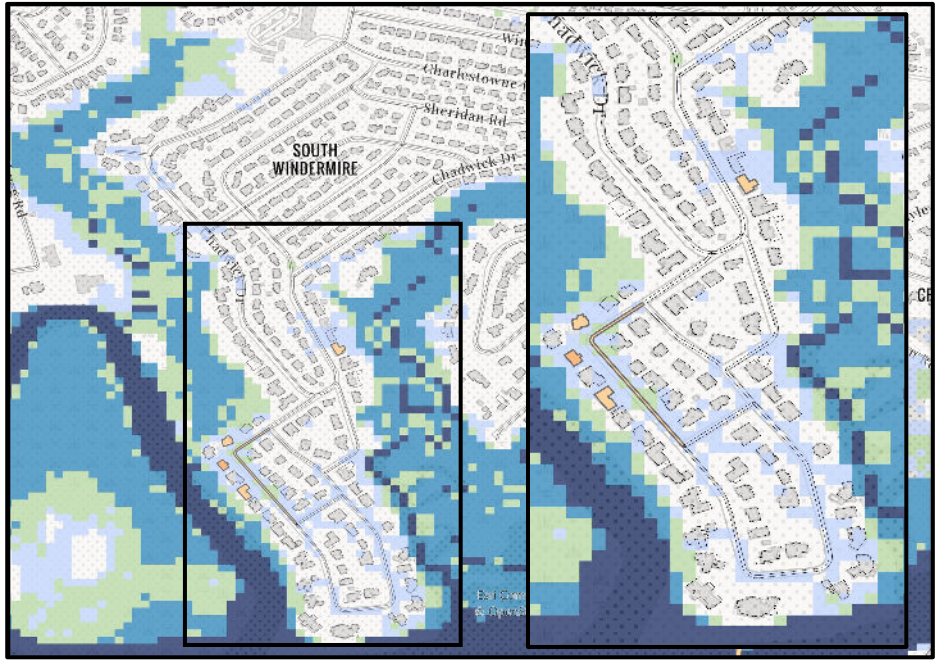


Enable a digital twin builder to easily set up FloodAdapt using the digital twin engine

Empower communities to make informed flood risk mitigation and adaptation plans

FloodAdapt


PROJECTIONS
EVENTS
STRATEGIES
ECONOMIC GROWTH
RAINFALL
WIND SPEED
SURGE
2050
2050
sea level rise
sea wall
pump
flood proofing
HAZARD MODEL
INTEGRATOR
DAMAGE MODEL
INTERFACE
WEB-VIEWER
TOTAL DAMAGE
$12M
HOUSES AFFECTED
413
A
B
C
WHAT IF POPULATION GROWTH DOUBLES?
WHAT IF STORM-TRACK HAD BEEN FURTHER SOUTH?
HOW IS RISK DISTRIBUTED OVER INCOME CLASSES?
HOW LONG WILL A DRAINAGE PUMP BE EFFECTIVE?
HOW EFFECTIVE IS THIS MEASURE?
WHAT WOULD HAVE HAPPENED IF..
WHERE DO FLOOD IMPACTS HAPPEN?
-COMMUNITY-



2021

Water depth
- 0 - 1 ft.
- 1 - 3 ft.
- 3 - 5 ft.
- > 5 ft.

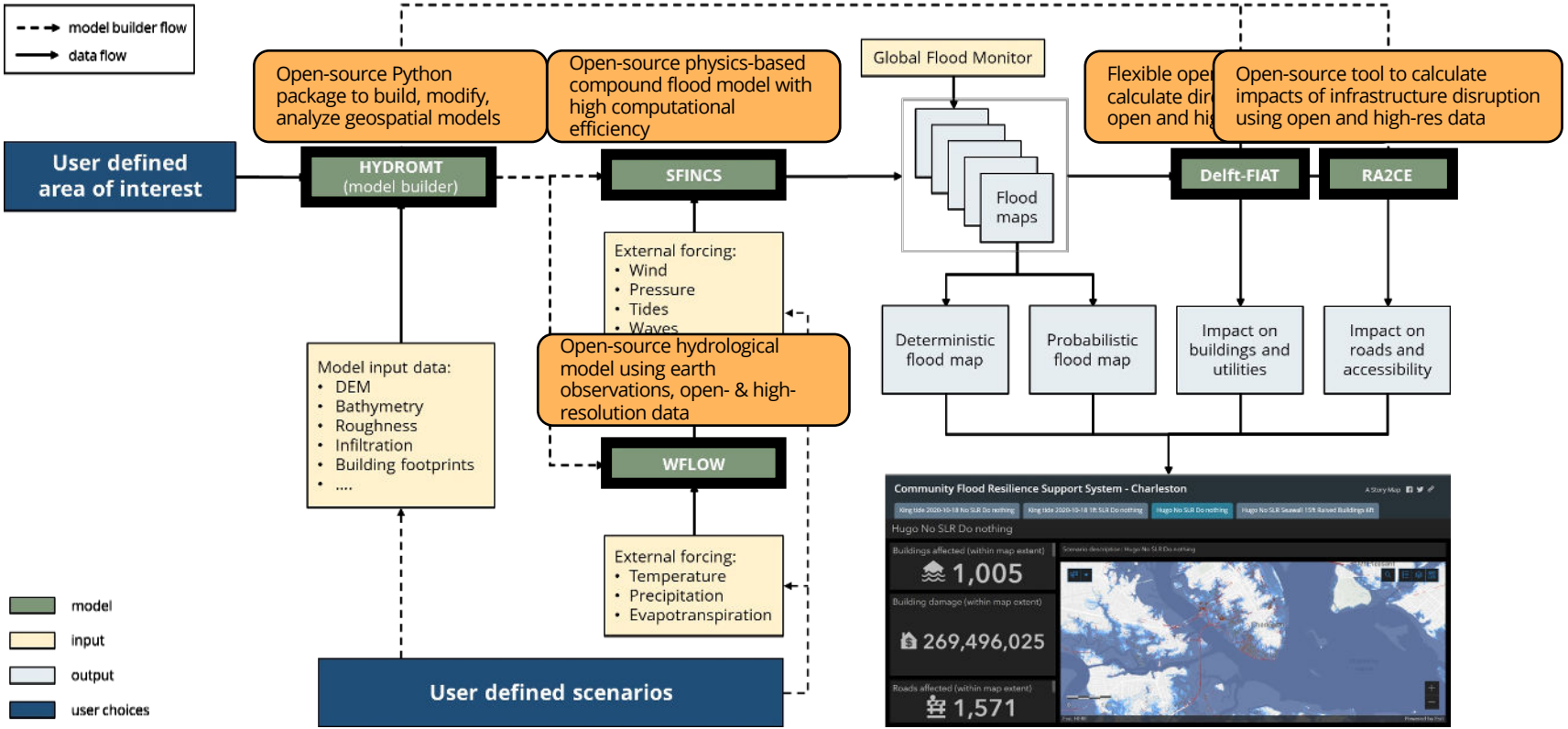
Damages
- No damage
- <$20K
- $20K - $60K
- $60K - $150K
- $150K - $400K
- >$400K

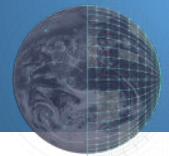
2050

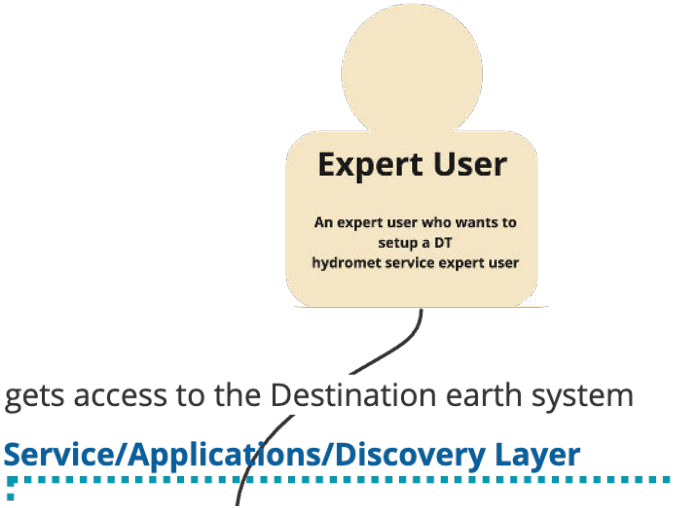
(NOAA intermediate projection)

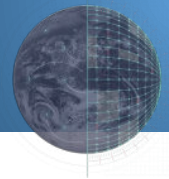
KING TIDE WITH SEA LEVEL RISE

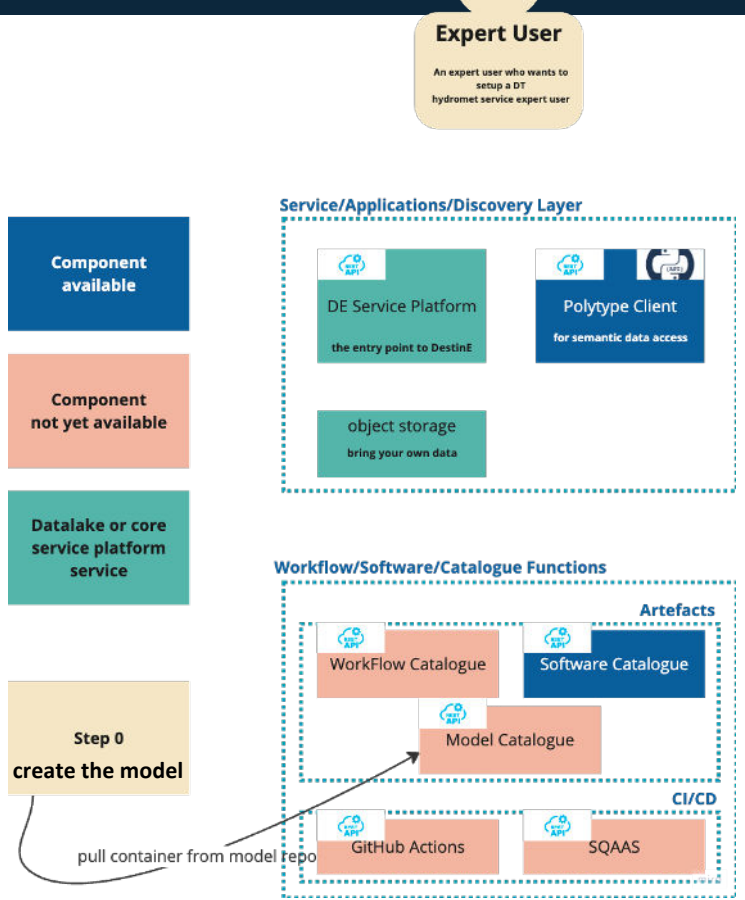
FloodAdapt components





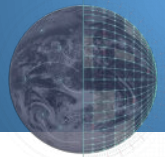

Expert User
An expert user who wants to setup a DT hydromet service expert user
gets access to the Destination earth system
Service/Applications/Discovery Layer





I need a processing environment, e.g. Python or JupyterHub to process the data for the models and tools

OK that should not be a problem since python and jupyter are available on the Destination earth service platform and python across all DE platforms



Expert User

An expert user who wants to setup a DT hydromet service expert user

I want to set up a digital twin to assess damages of a compound flood. For that I need a flood inundation model, a hydrological model, a flood impact assessment tool and tools to process input and output data

Component available

Component not yet available

Datalake or core service platform service

Step 0
create the model

Step 1
define the model

Service/Applications/Discovery Layer

DE Service Platform
the entry point to DestinE

Polytype Client
for semantic data access

object storage
bring your own data

is all date required available

Workflow/Software/Catalogue Functions

Artefacts

WorkFlow Catalogue

Software Catalogue

Model Catalogue

CI/CD

GitHub Actions

SQAAS

pull container from model repo

Models should be available in a model catalogue that has a container registry that allows you to pull the model to the part of the destine environment where you need to deploy it for processing

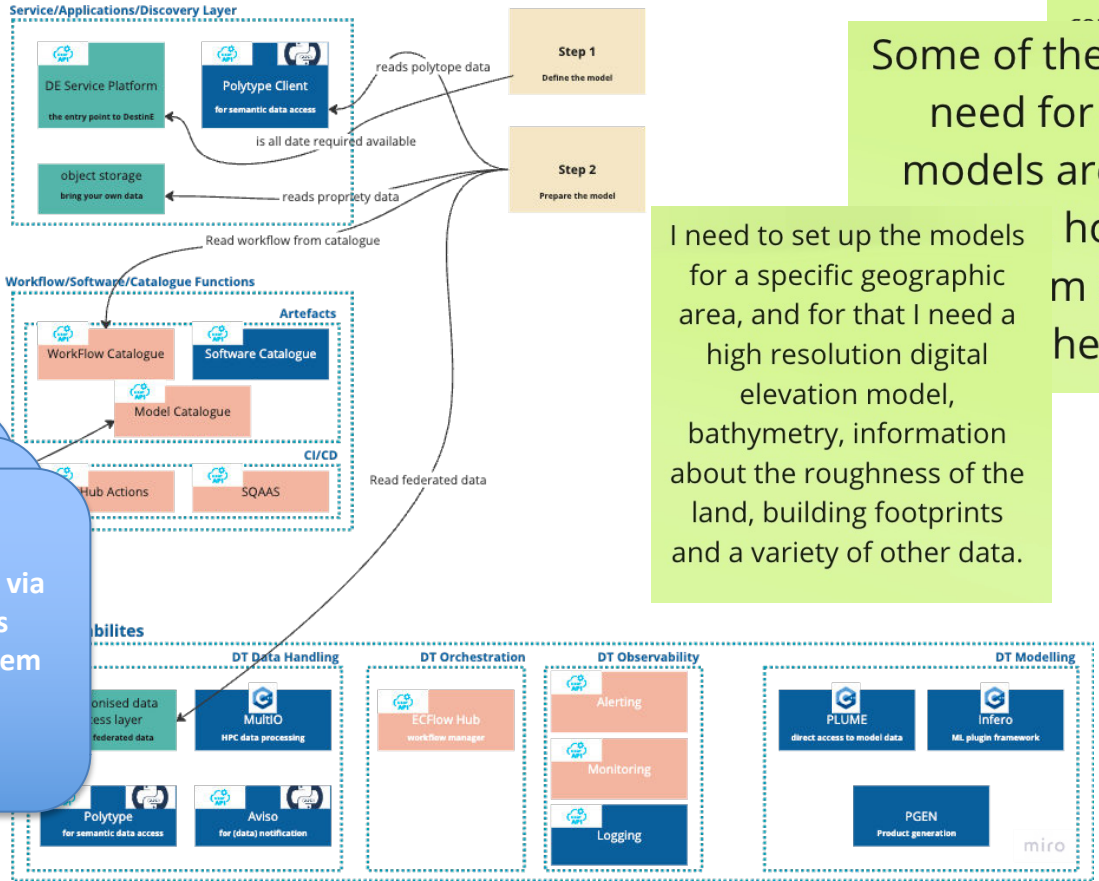
miro

I need a processing environment, e.g. Python or JupyterHub to process the data for the models and tools

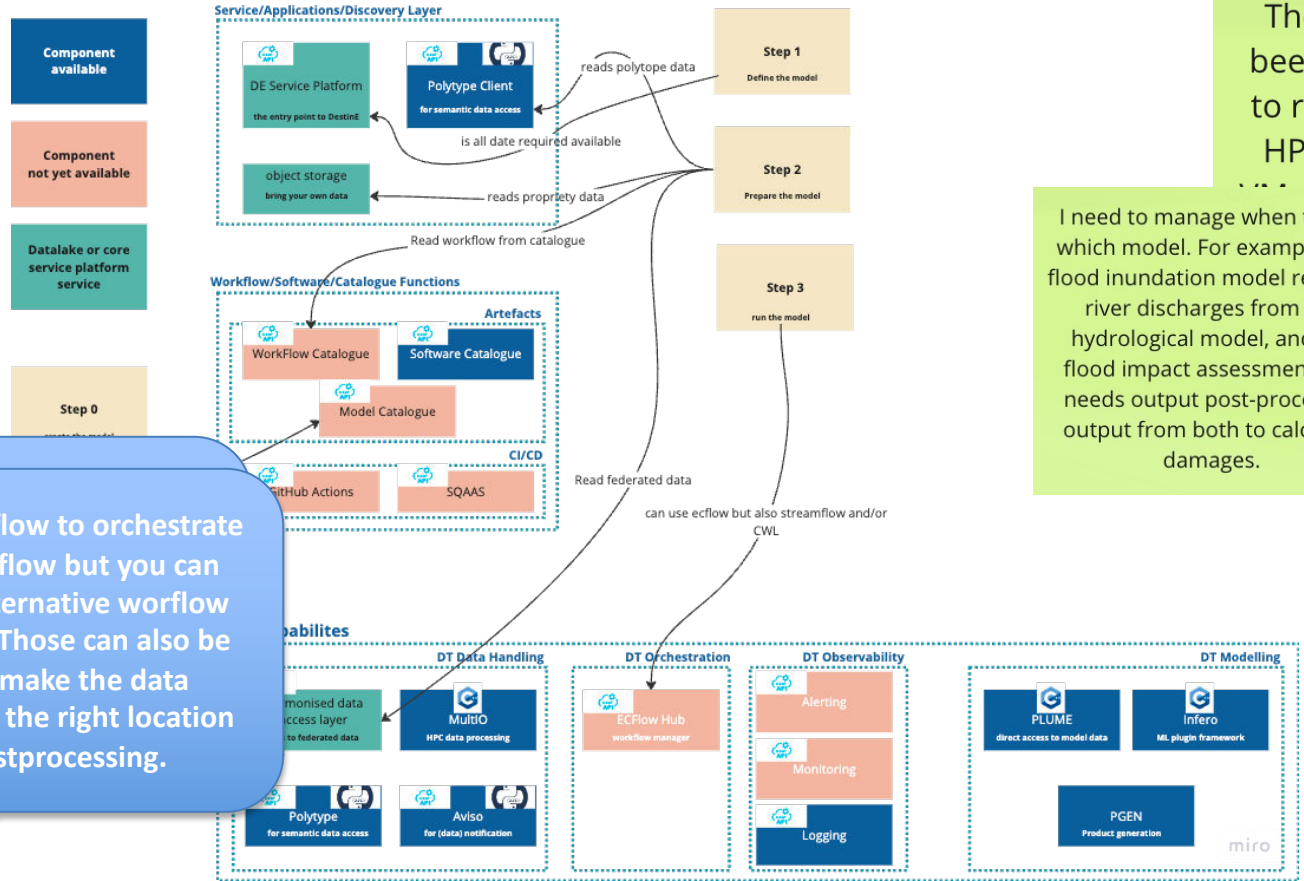
I want to run the models for a specific event or period and for that I need to prepare the boundary condition / forcing data. For ... resolution ...ospheric ... waves, and ...e

Some of the data I need for the models are not ... how can ...m or use ... here?

I need to set up the models for a specific geographic area, and for that I need a high resolution digital elevation model, bathymetry, information about the roughness of the land, building footprints and a variety of other data.



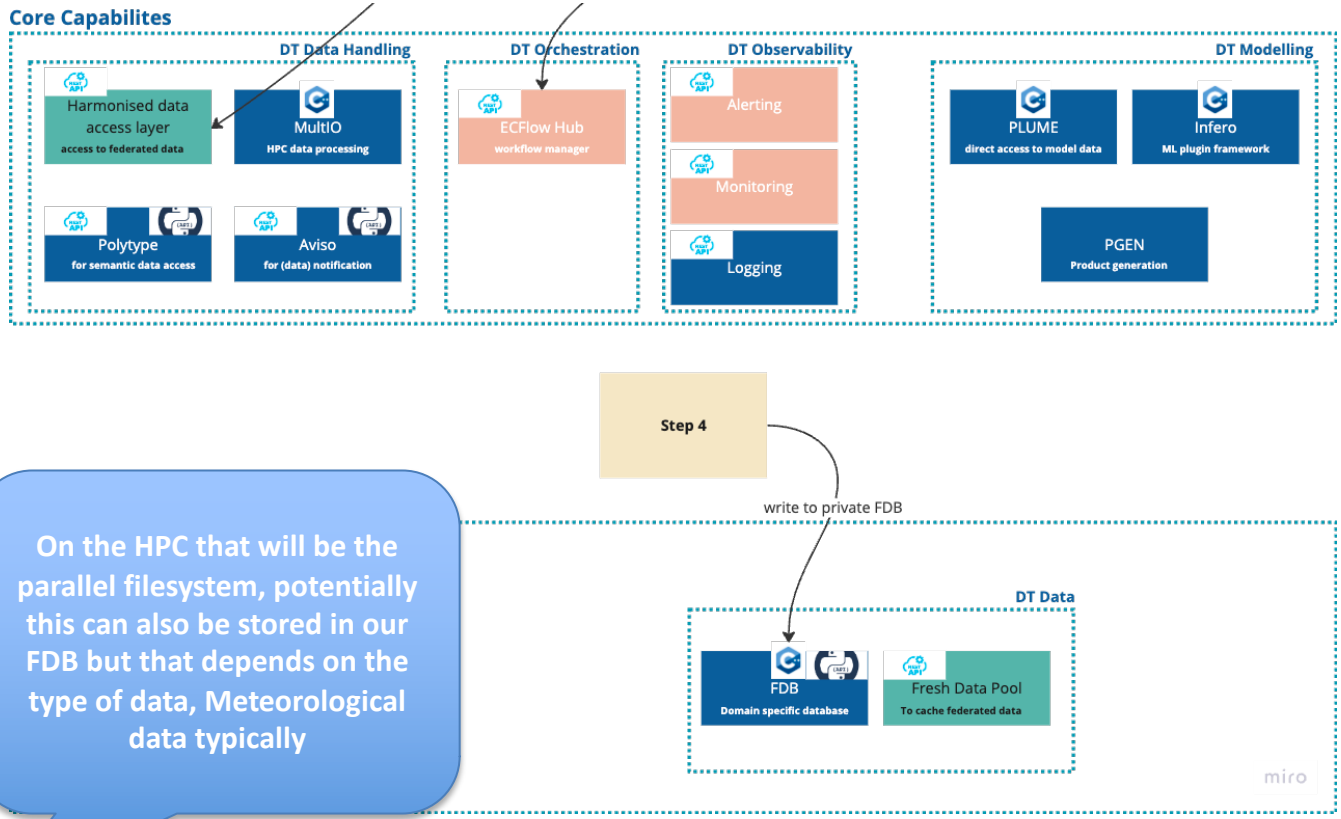
You can pull data together via the various mechanisms described and combine them in your model



The models have been set up. I want to run them on an HPC or in a cloud containers er or arity).

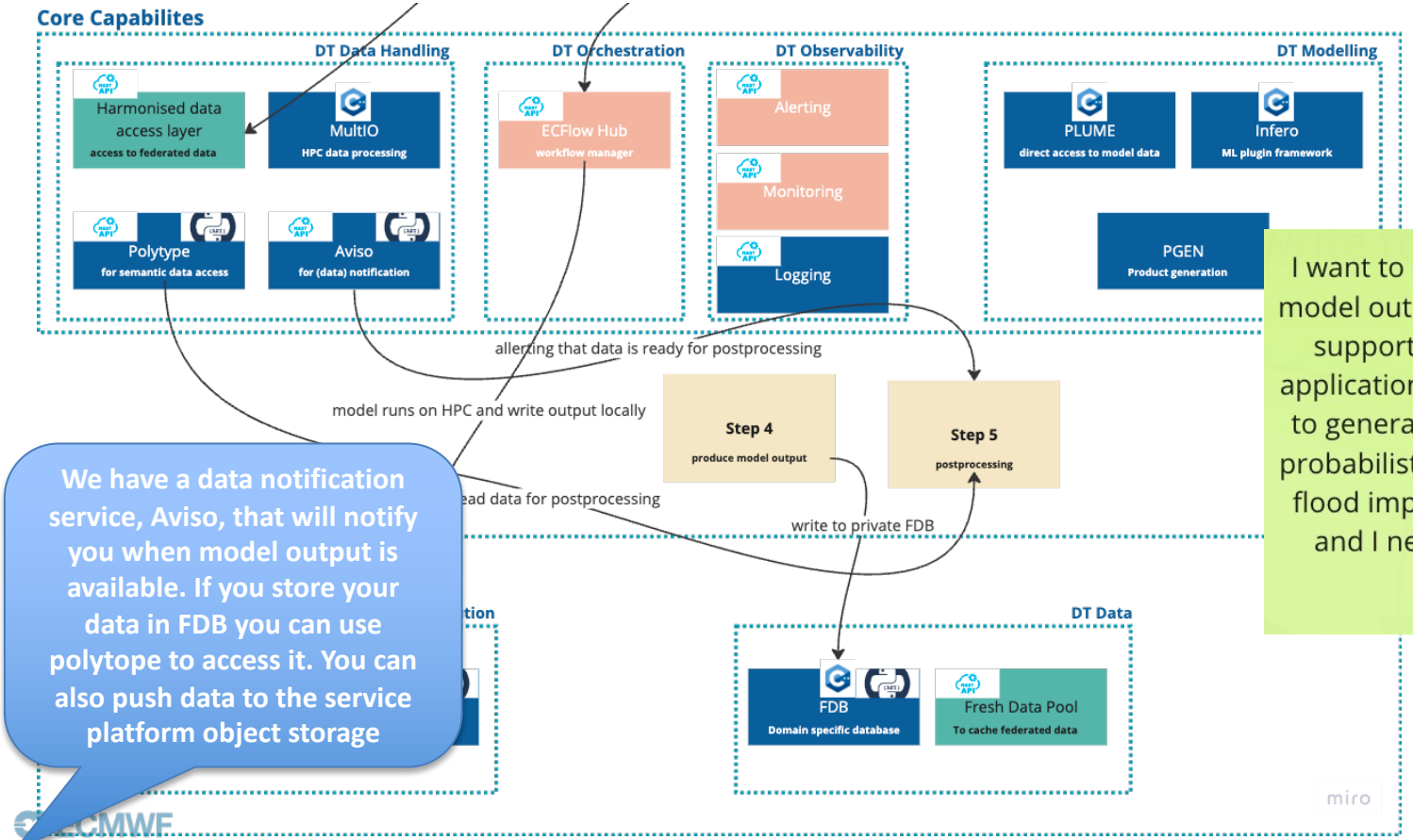
I need to manage when to run which model. For example, the flood inundation model requires river discharges from the hydrological model, and the flood impact assessment tool needs output post-processed output from both to calculate damages.

We offer ecflow to orchestrate your workflow but you can also run alternative worflow managers. Those can also be used to make the data available in the right location for postprocessing.



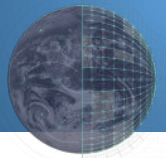
On the HPC that will be the parallel filesystem, potentially this can also be stored in our FDB but that depends on the type of data, Meteorological data typically

The raw model output data needs to be stored somewhere close to the compute environment



We have a data notification service, Aviso, that will notify you when model output is available. If you store your data in FDB you can use polytope to access it. You can also push data to the service platform object storage

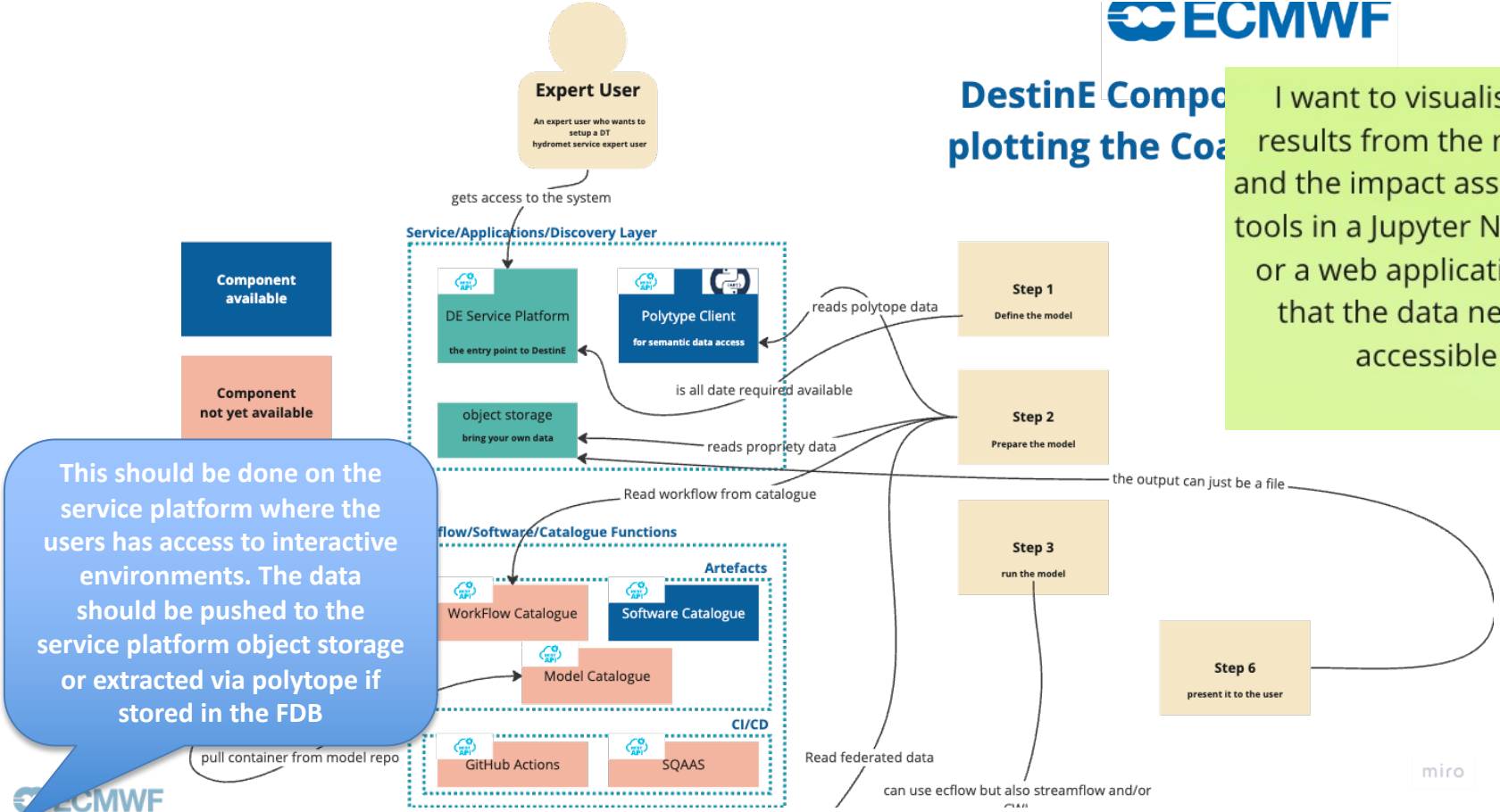
I want to postprocess the raw model output data into formats support by the digital twin application. For example I need to generate deterministic and probabilistic flood maps for the flood impact assessment tool and I need to visualise the results



ECMWF

DestinE Compo
plotting the Coa

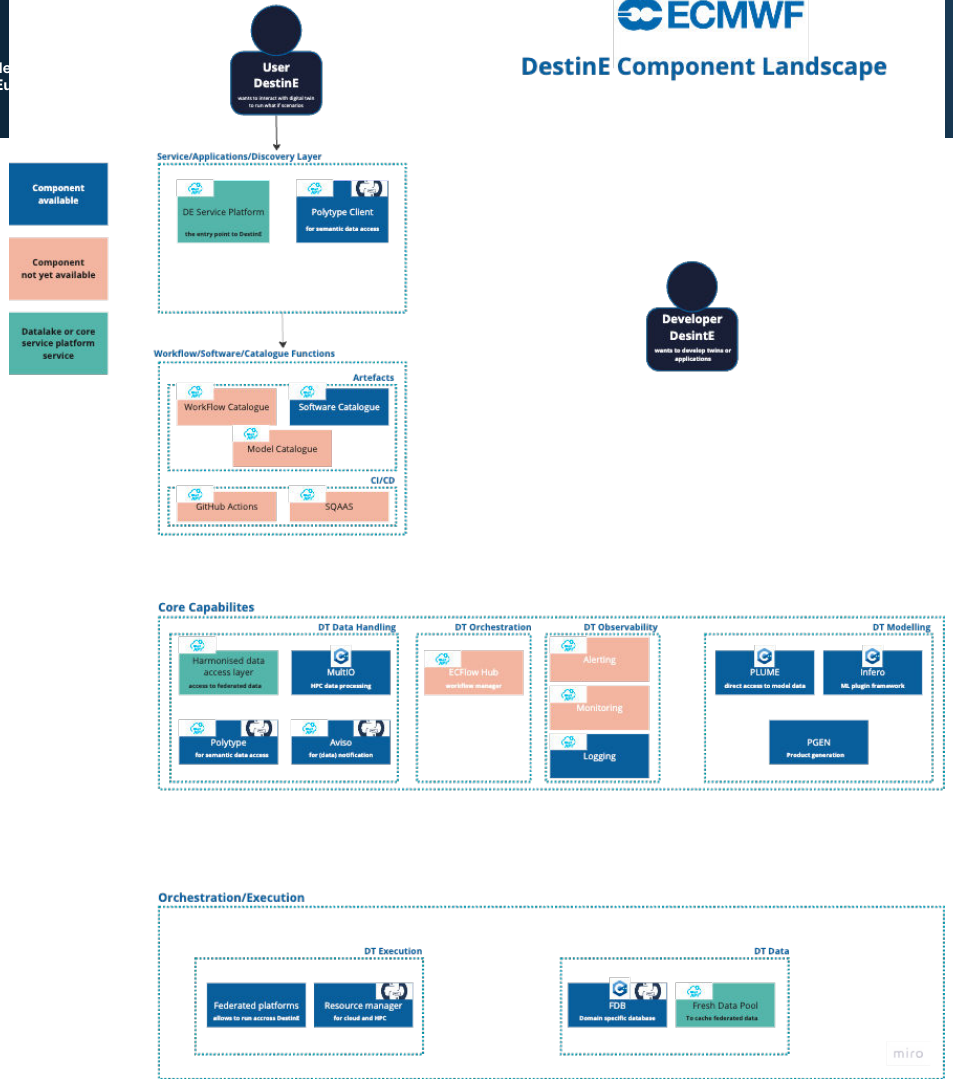
I want to visualise the results from the models and the impact assessment tools in a Jupyter Notebook or a web application, for that the data need to accessible



This should be done on the service platform where the users has access to interactive environments. The data should be pushed to the service platform object storage or extracted via polytope if stored in the FDB

ECMWF

DestinE Component Landscape



Expert User

An expert user who wants to setup a DT
hydromet service expert user

gets access to the Destination earth system

Service/Applications/Discovery Layer

https://miro.com/app/board/uXjVNRmuCmc=/

Andrea Manzi interTwin

Jesse Harrison BIODT biodiversitydigitaltwin

Jacqueline Le Moigne NASA

Albrecht Weerts Deltares