



Biodiversity Digital Twin for Advanced Modelling, Simulation and Prediction Capabilities

Gabriela Zuquim, CSC – IT Center for Science
BioDT Winter School and Hackaton, 3rd of March 2025
Lecce, Italy



Funded by
the European Union

Interdisciplinary digital twins for modelling and simulating complex phenomena at the service of research infrastructure communities

HORIZON-INFRA-2021-TECH-01-01

Topic **Call for proposal**

Internal navigation

General information

Topic description

Destination

Conditions and do...

Start submission

General information

Programme

Horizon Europe
Framework Programme
(HORIZON)

€ [Budget overview](#)

Call

Next generation of scientific instrumentation, tools and methods (2021) (HORIZON-INFRA-2021-TECH-01)



Biodiversity Digital Twin for Advanced Modelling, Simulation and Prediction Capabilities

Fact Sheet

Reporting

Results

Project Information

BioDT

Grant agreement ID: 101057437



DOI

[10.3030/101057437](https://doi.org/10.3030/101057437)

EC signature date

31 May 2022

Start date

1 June 2022

End date

31 May 2025

Funded under

Research infrastructures

Total cost

€ 11 059 061,00

EU contribution

€ 11 059 061,00

Coordinated by

CSC-TIETEEN TIETOTEKNIKAN KESKUS OY

🇫🇮 Finland



🔥 Partners and goals



🔥 OBJECTIVE 1:

- 🔥 Build and deploy prototypes of BioDT for addressing biodiversity dynamics

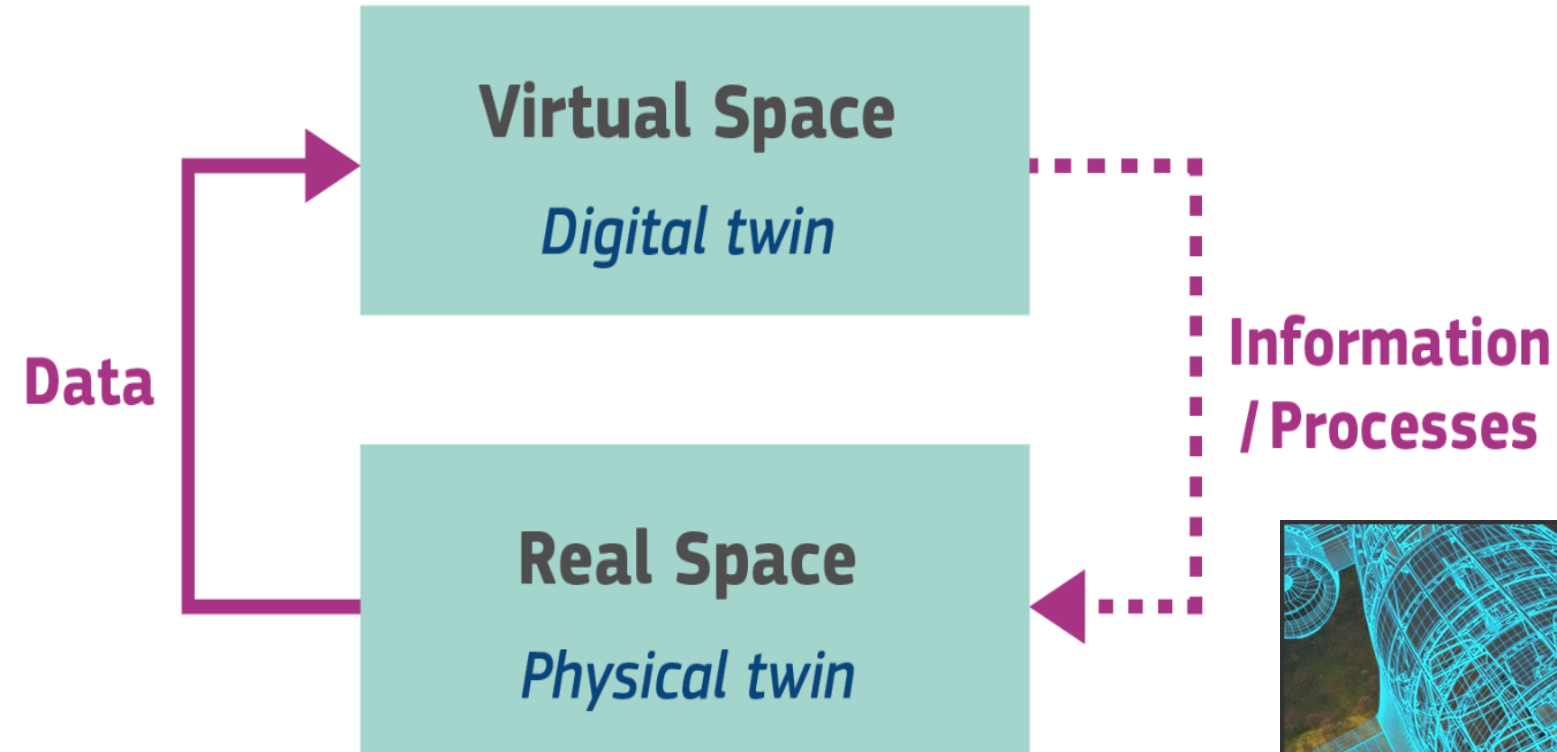
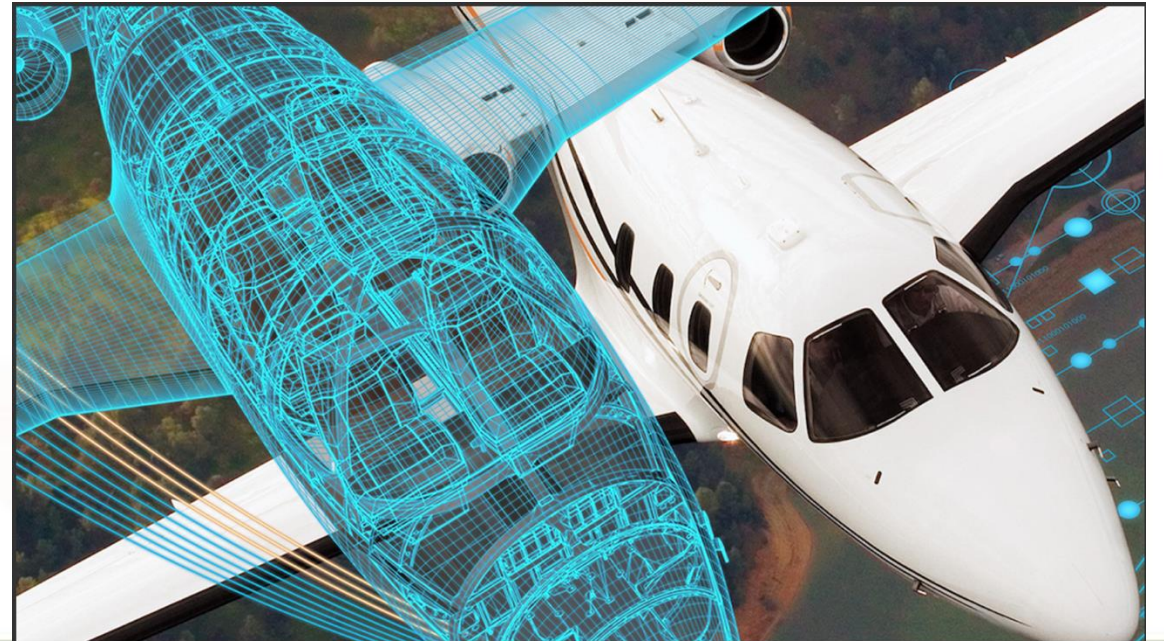
🔥 OBJECTIVE 2:

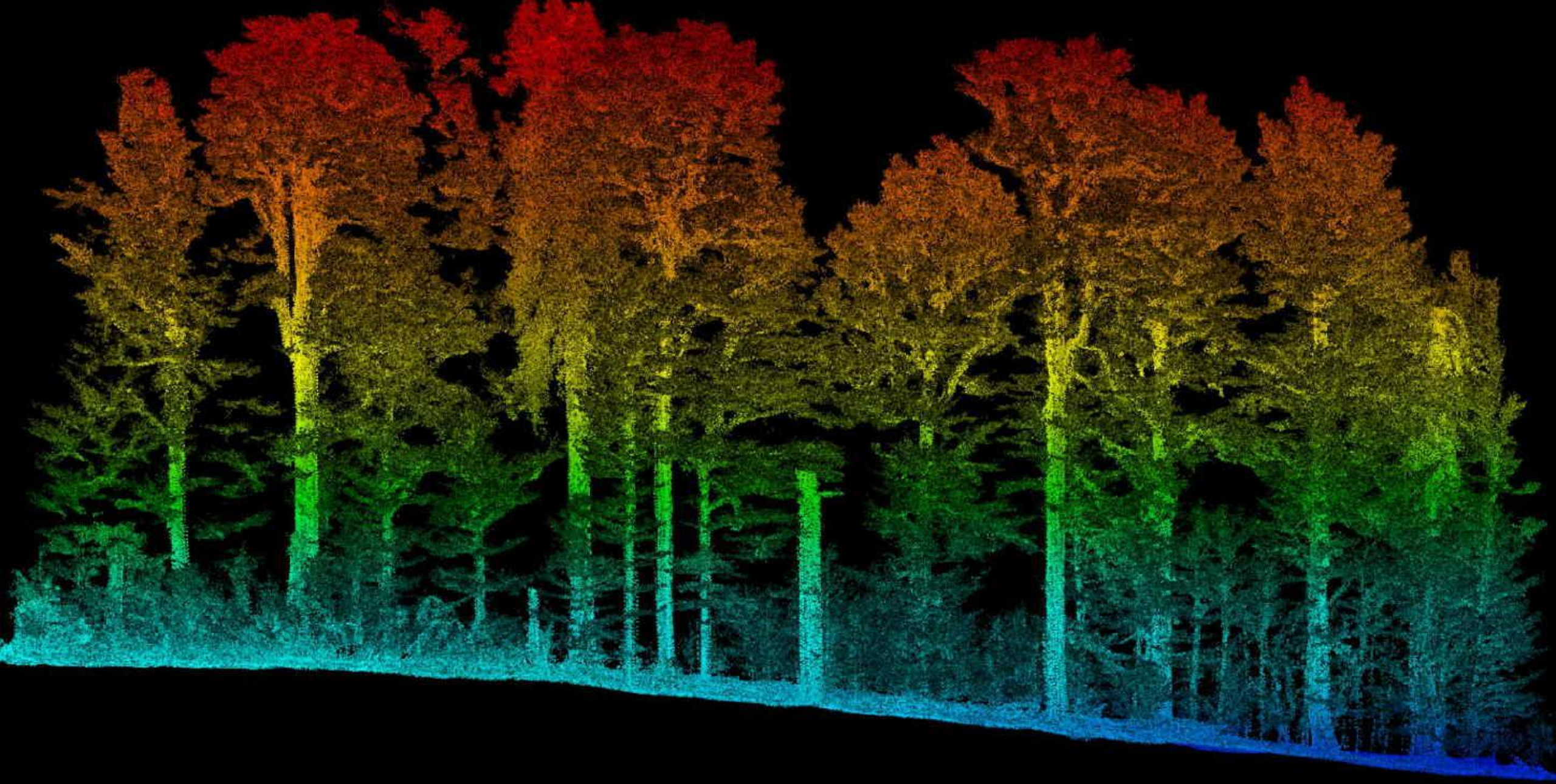
- 🔥 Support the interoperability of data and services
- 🔥 integration of the BioDT and research infrastructure platforms and workflows

🔥 OBJECTIVE 3:

- 🔥 Ensure interoperability of BioDT with [Destination Earth](#) and [the European Data Infrastructure](#)

What is a Digital Twin (DT) ?



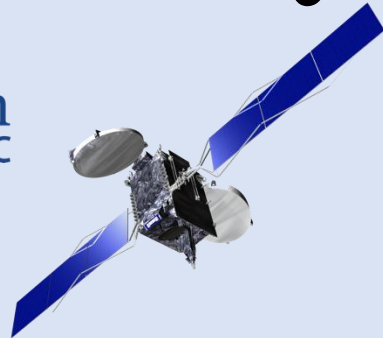


A (Bio) DT fosters collaboration in its nature:



🔥 DATA (a lot of!) <=> MODEL <=> INTERFACE

Research Infrastructure



Data from four RIs

GBIF, eLTER, LifeWatch ERIC and DISSCo

GBIF



The Global Biodiversity Information Facility (GBIF) is an international network and data infrastructure providing open access to biodiversity data.

LifeWatch ERIC



LifeWatch ERIC is the e-Science European infrastructure for biodiversity & ecosystem research.

eLTER



The Integrated European Long-Term Ecosystem (eLTER) focuses on critical zone and socio-ecological research.

Helmholtz Center for Environmental Research (UFZ), UK Centre of Ecology & Hydrology (UKCEH), Environment Agency Austria (EAA) and University of Helsinki (UH)

DiSSCo



The Distributed System of Scientific Collections (DiSSCo) is a Research Infrastructure (RI) for Natural Science Collections.

Naturalis Biodiversity Center (Naturalis) and Senckenberg Society for Nature Research (SGN)

SUSTAINED PERFORMANCE

380 PETAFL0P/S

= performs 380×10^{15} calculations per second



MT.EVEREST



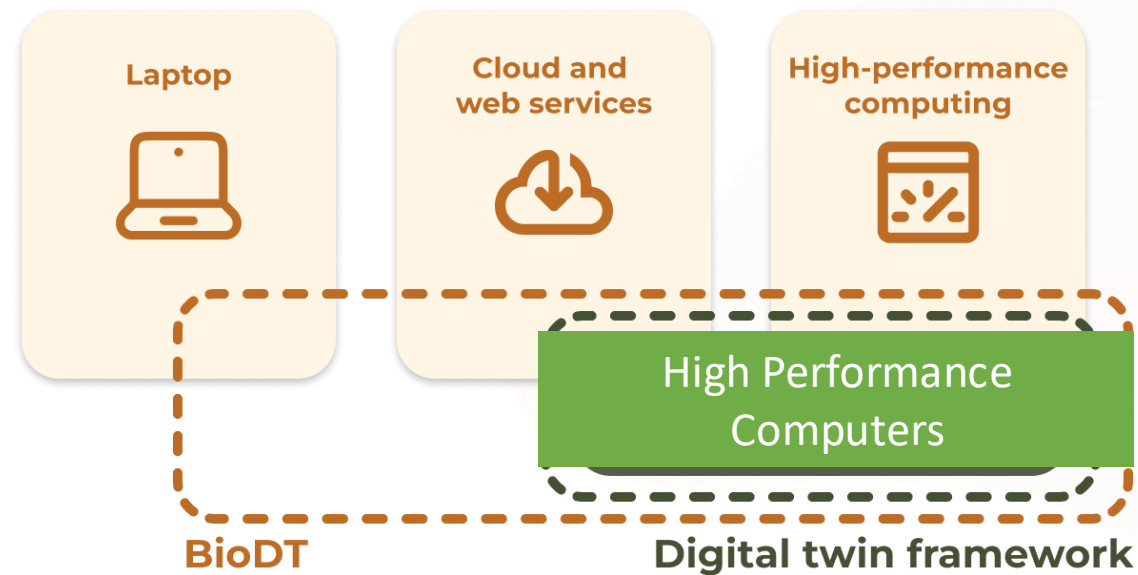
1.5 million laptops

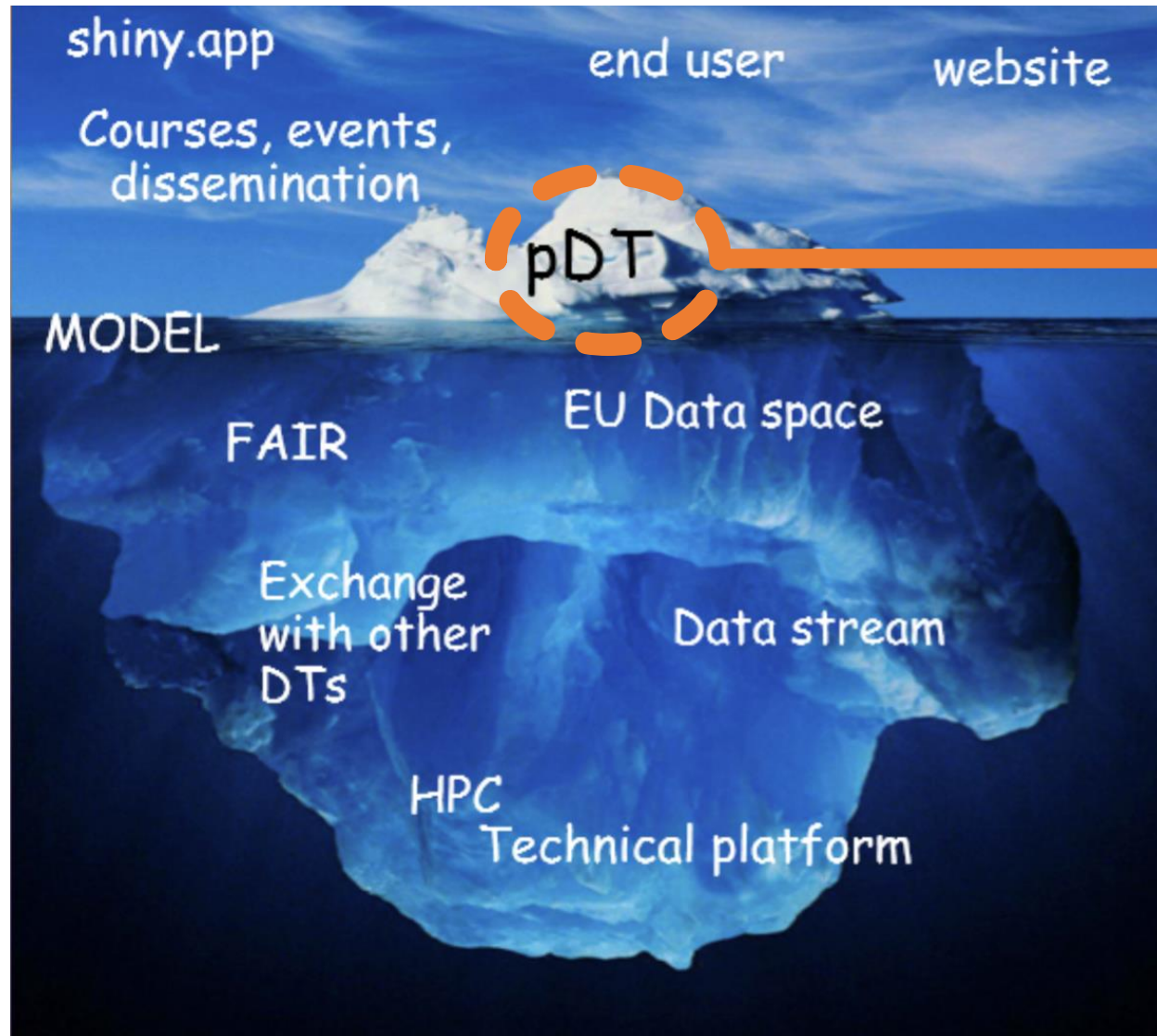
COMPUTING POWER EQUALS
1.5 MILLION
MODERN LAPTOP'S
CAPACITY

- Model upscaling
- Platform development
- Deployment of pDTs

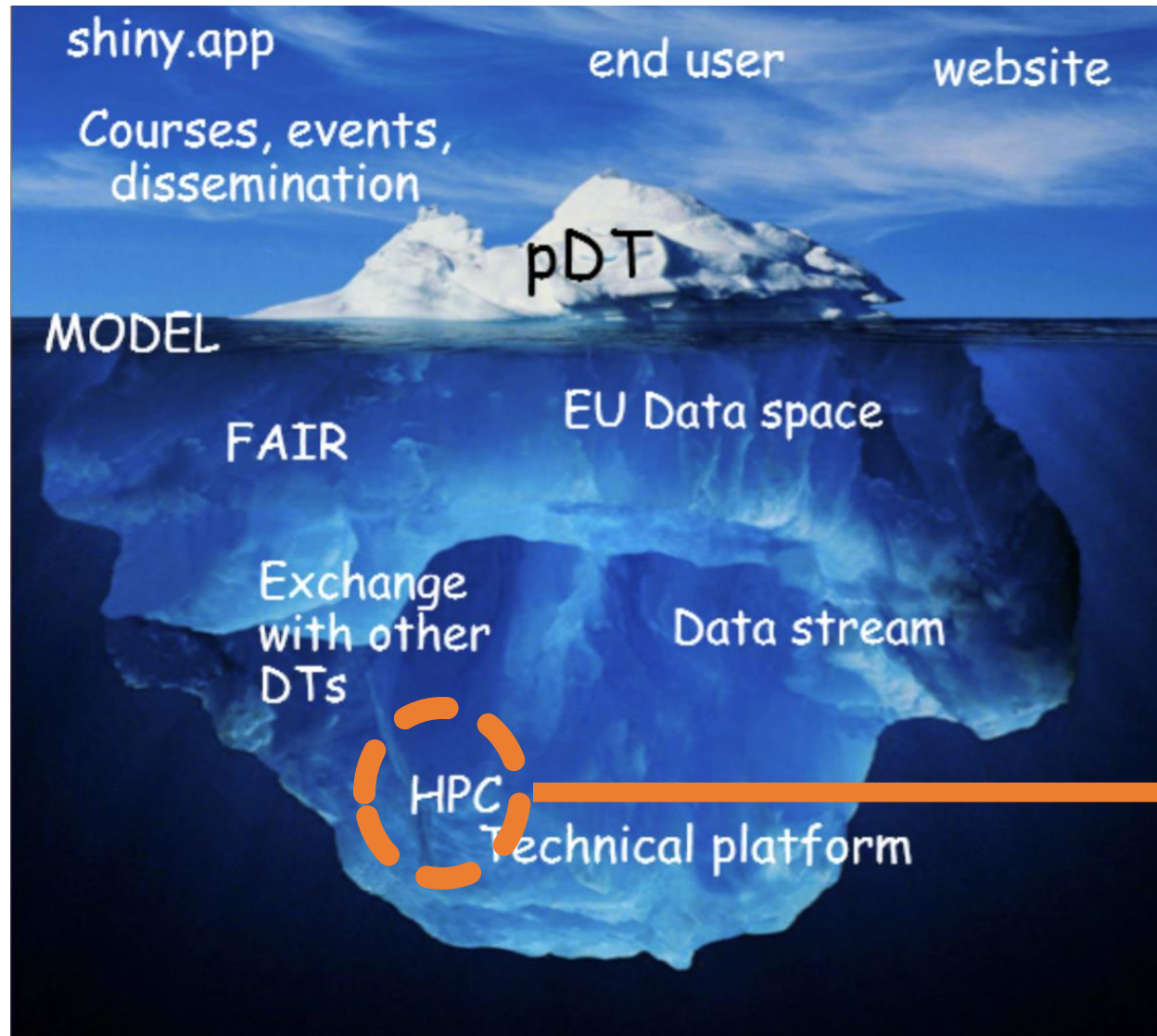


- pDTs graphical user interface development using shiny.app

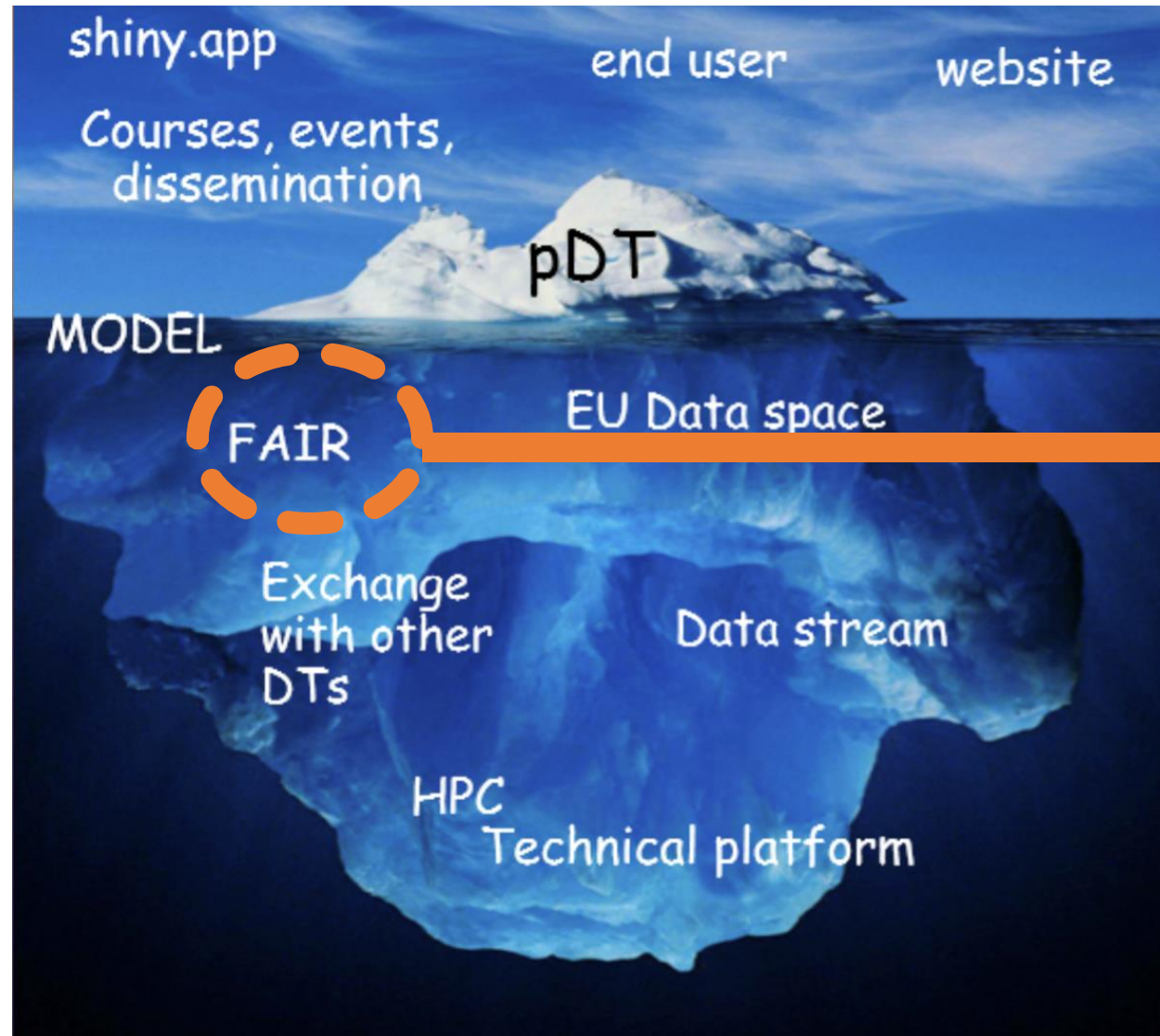




prototype
Digital
Twin



**High
Performance
Computing**



Findable
Accessible
Interoperable
Reusable

Species response to environmental change



**Grassland
Biodiversity
Dynamics**



**Forest Biodiversity
Dynamics**



Ecosystem Services



**Real-time Bird
Monitoring with
Citizen-Science Data**

Species interactions with each other and with humans



Disease Outbreaks



**Honey Bees in
Agricultural
Landscapes**

Genetically detected biodiversity



Crop Wild Relatives



**Prioritisation of DNA
metabarcoding
sampling locations**



**Phylogenetic
Diversity**

Dynamics and threats from and for species of policy concern



**Invasive Alien
Species**



Demonstrators (pDT)

<https://app.biodt.eu/app/biodtshiny>



Funded by
the European Union

Species response to environmental change

Cultural Ecosystem Services

Species interactions with each other and with humans

Honeybee

BioDT exploits the LUMI Supercomputer and employs FAIR data combined with digital infrastructure, predictive modelling and AI solutions, facilitating evidence-based solutions for biodiversity protection and restoration.

The project responds to key EU and international policy initiatives, including the EU Biodiversity Strategy 2030, EU Green Deal, UN Sustainable Development Goals, Destination Earth.

Species response to environmental change



- Grassland Biodiversity Dynamics
- Forest/Bird Biodiversity Dynamics
- Real-time Bird Monitoring with Citizen Science Data
- Cultural Ecosystem Services

Genetically detected biodiversity



- Crop Wild Relatives and Genetic Resources for Food Security
- Genetically Detected Biodiversity in Cryptic Habitats
- DNA Detected Biodiversity, Poorly Known Habitats

Dynamics and threats from and for species

Species interactions with each other and

What are the best locations and treatments to optimize honey production?

Where and how honey production can be optimized?

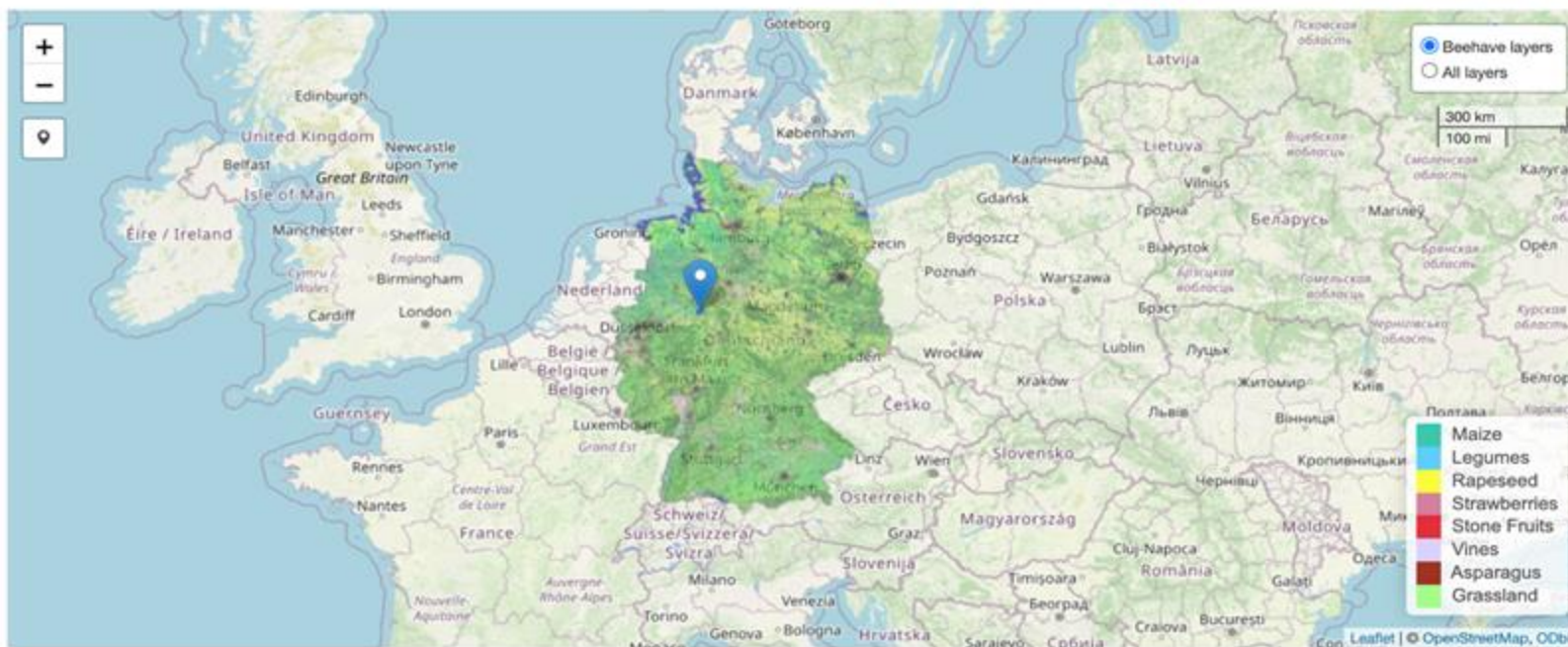
Input Map

Click the  icon and select desired placement on the map.

Selected coordinates are:

Latitude: 51.804322

Longitude: 8.803878



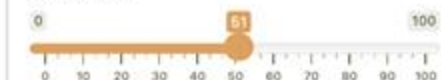
Land Use Classification 2016 (Preidl et al. RSE 2020)

Simulation Parameters

Number of adult bees at the beginning of the simulation



Number of Mites at the beginning of the simulation



Number of infected Mites at the beginning of the simulation



☒ Honey Harvest

☐ Varroa treatment with acaricide

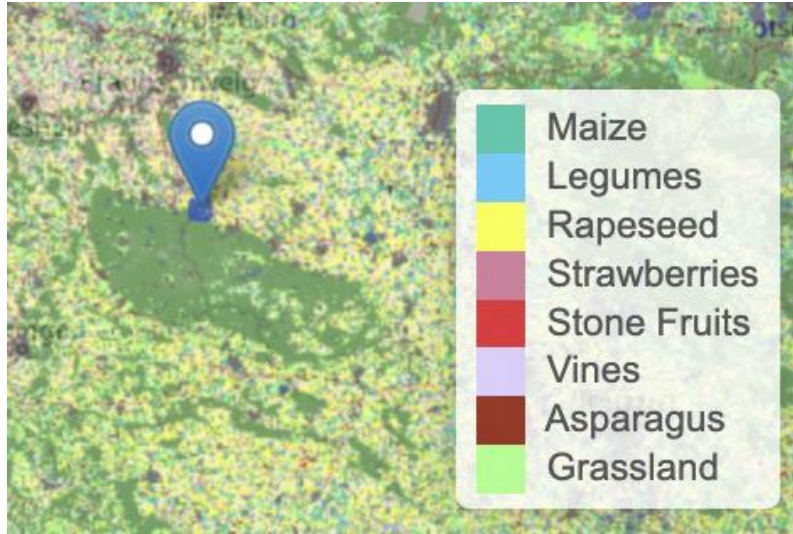
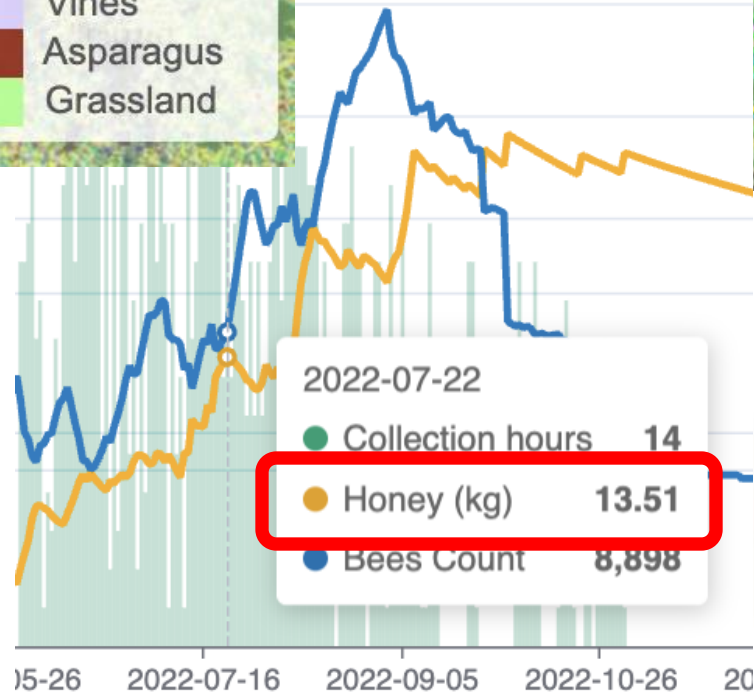
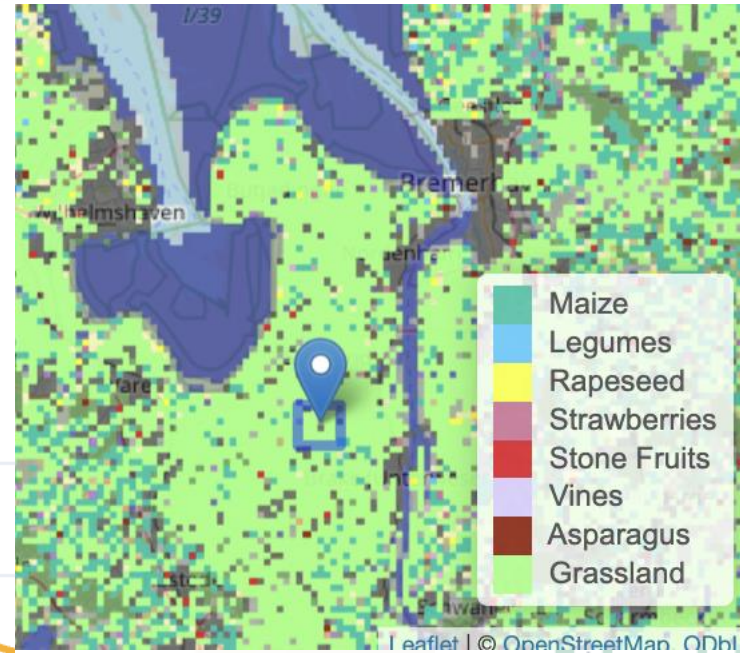
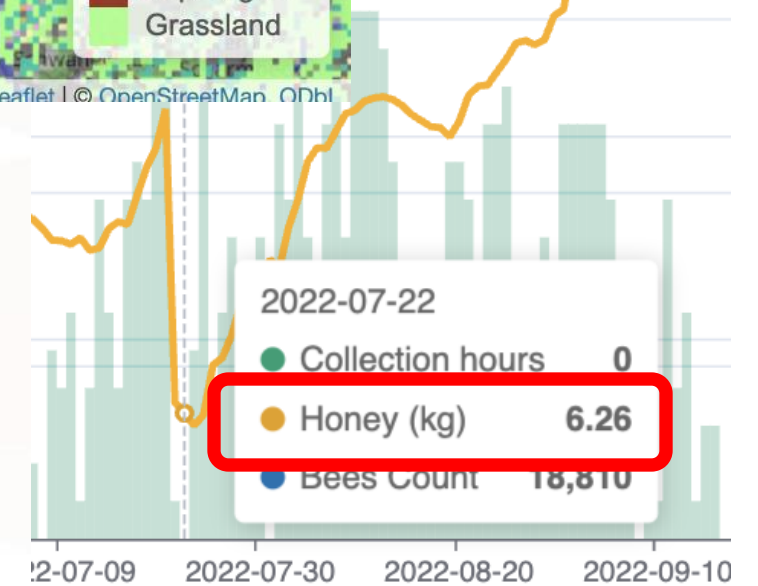
☒ Drone Brood Removal

Choose start year of the simulation:



For how many days:





Are the patterns of bird migration changing?

Real-time Bird Monitoring prototype digital twin

Info

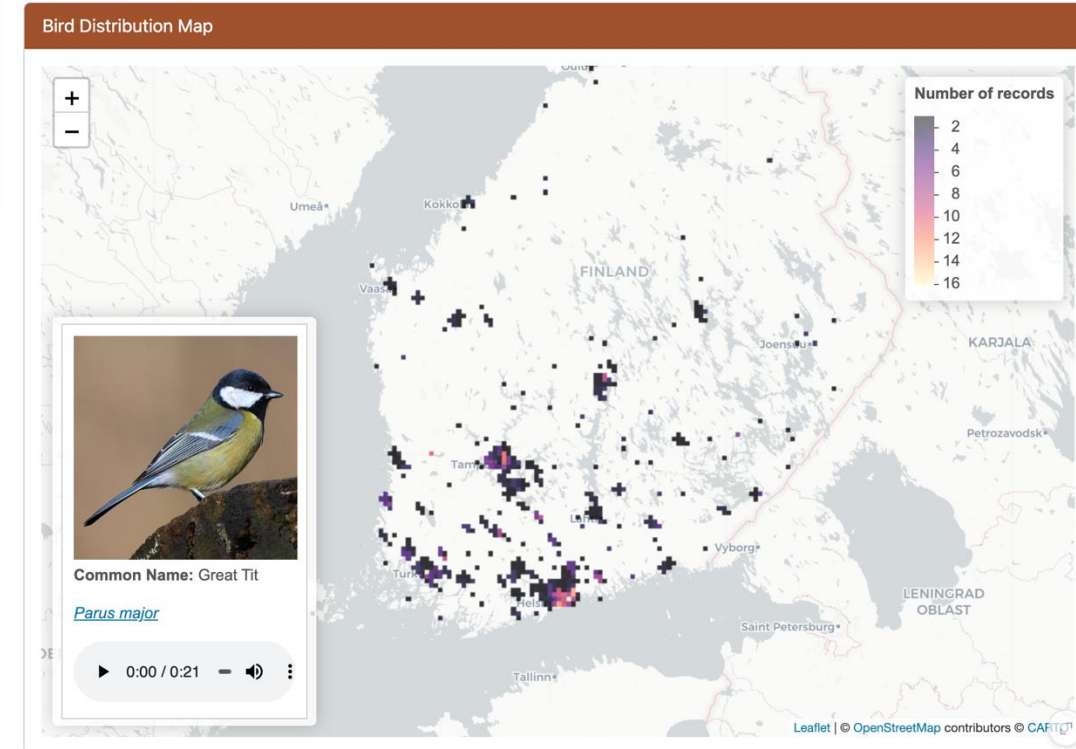
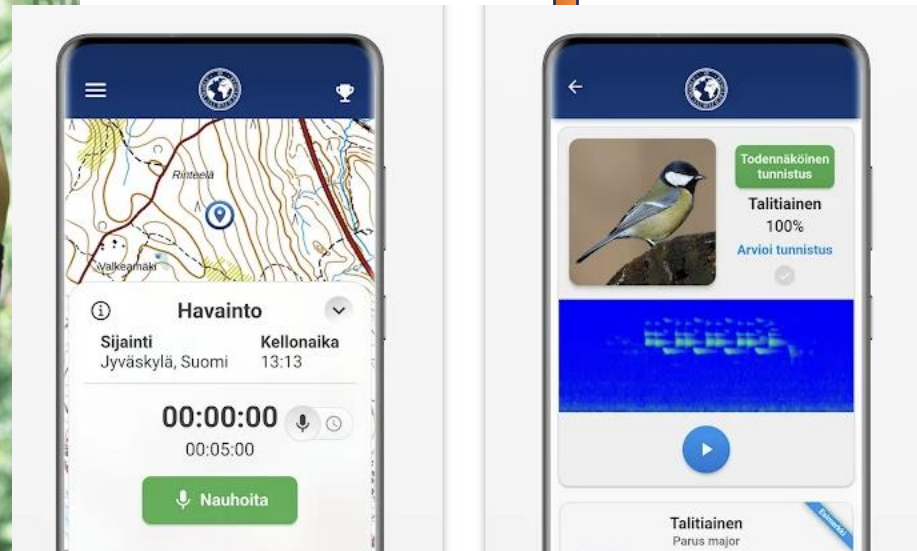
Dashboard

Select date:

2025-02-03

Bird species:

Great Tit

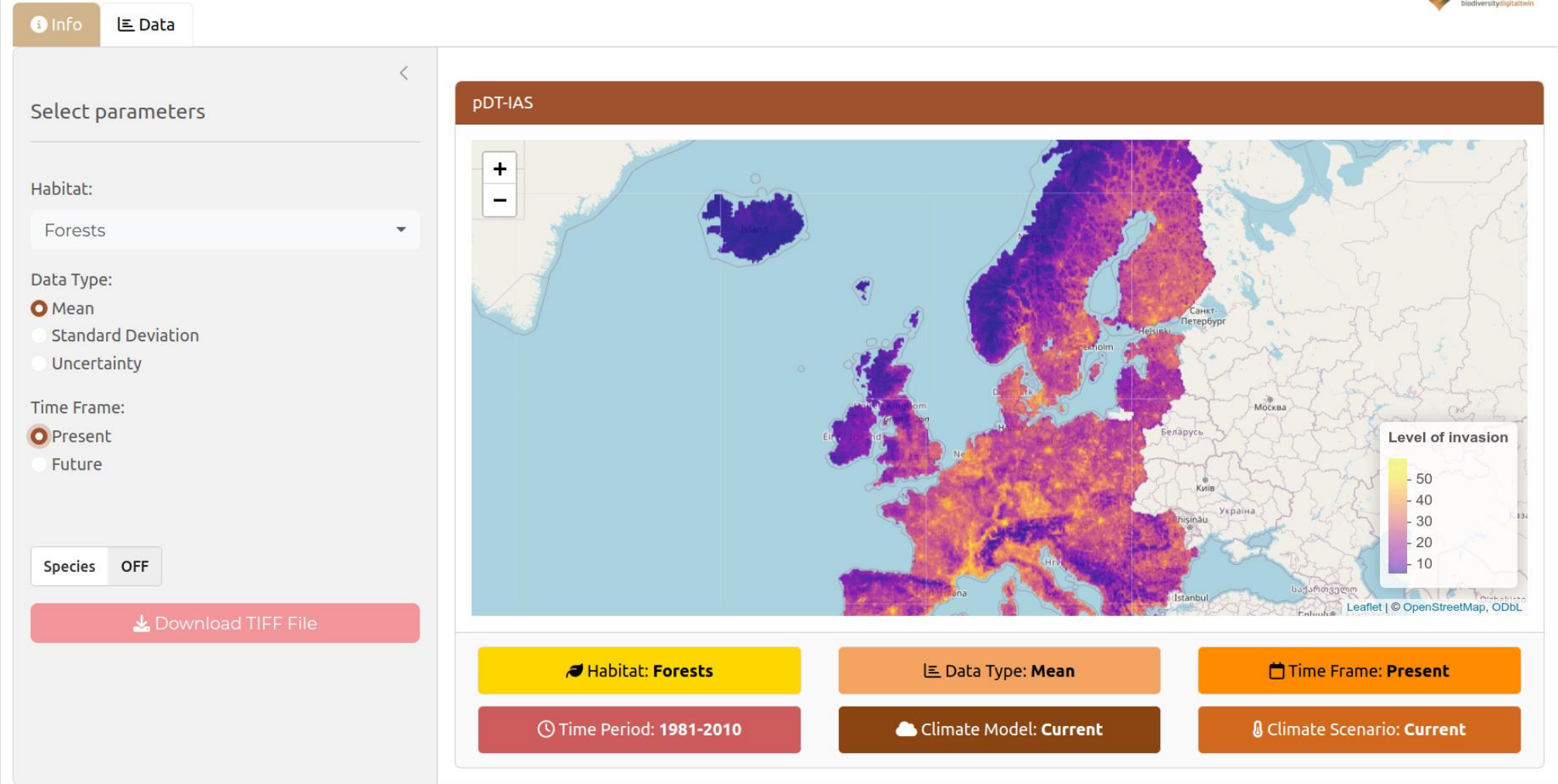


REAL TIME BIRD MONITORING – CROWD SOURCED DATA STREAMS



What are the areas with higher levels of invasion by alien species

Invasive Alien Species Prototype Digital Twin

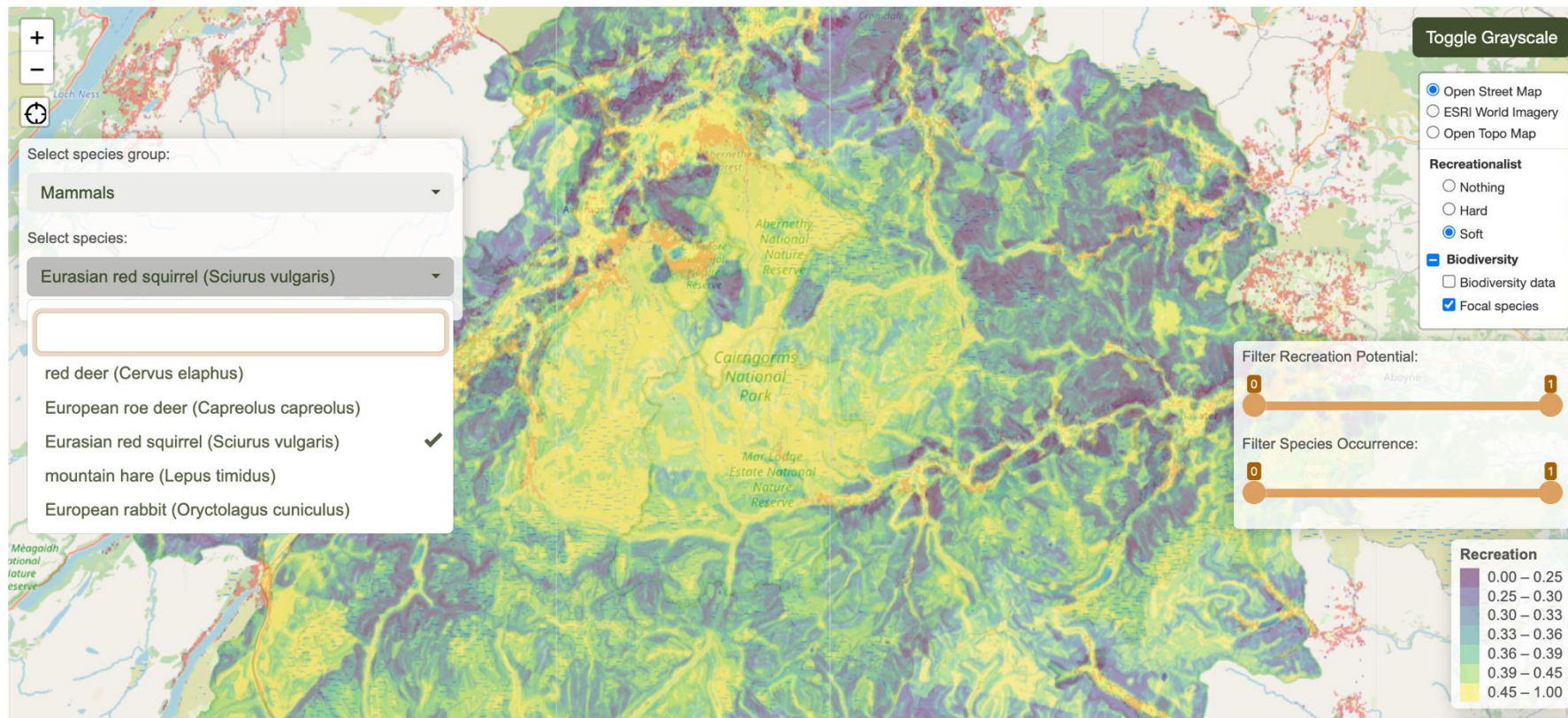




Ecosystem Services and Digital Twin Models

Info Recreation potential Biodiversity Recreation & Biodiversity

Recreation & Biodiversity Mapping



Species response to environmental change



**Grassland
Biodiversity
Dynamics**



**Forest Biodiversity
Dynamics**



Ecosystem Services



**Real-time Bird
Monitoring with
Citizen-Science Data**

- *Monitor Current Conditions:* Assess the present state of grasslands, including metrics like plant biomass and the diversity of plant functional types.
- *Project Future Scenarios:* Explore how grassland ecosystems might evolve under various scenarios, including different climate and management conditions.

Species response to environmental change



**Grassland
Biodiversity
Dynamics**



**Forest Biodiversity
Dynamics**



Ecosystem Services



**Real-time Bird
Monitoring with
Citizen-Science Data**

- *Evaluate management strategies*: simulates forest succession, productivity and species-environment relationships under different scenarios

Species response to environmental change



**Grassland
Biodiversity
Dynamics**



**Forest Biodiversity
Dynamics**



Ecosystem Services



**Real-time Bird
Monitoring with
Citizen-Science Data**

- *A tool for planning:* Combine models of species distributions and recreational value to suggest the most relevant areas to visit according to the users interests.

Species response to environmental change



**Grassland
Biodiversity
Dynamics**



**Forest Biodiversity
Dynamics**



Ecosystem Services



**Real-time Bird
Monitoring with
Citizen-Science Data**

- *A mobile application:* Allows citizen science to provide timely data on species occurrences
- *Monitor bird migration:* Use citizen science data to display near real-time observations of bird species observations and daily to weekly changes

Genetically detected biodiversity



Crop Wild Relatives



**Prioritisation of DNA
metabarcoding
sampling locations**



**Phylogenetic
Diversity**

- *Finding resilient crops for climate-driven stress:* Integrates occurrence data and environmental variables to produce habitat suitability maps for crops and its wild relatives under different tolerance thresholds

Genetically detected biodiversity



Crop Wild Relatives



**Prioritisation of DNA
metabarcoding
sampling locations**



**Phylogenetic
Diversity**

- *Beyond species*: unlocks and map the diversity of evolutionary lineages
- Allows visualization to explore phylogenetic relationships within taxonomic groups or geographic areas

Species interactions with each other and with humans



Disease Outbreaks



**Honey Bees in
Agricultural
Landscapes**

Dynamics and threats from and for species of policy concern



**Invasive Alien
Species**

- *Predict the spread of Swine Disease:* Use near real-time wild boar geolocation and infection status data to test different virus control scenarios.
- Users can input various control measures, such as barriers, depopulation efforts, and carcass retrieval, to evaluate their effectiveness in containing the virus.

DestinE – European Commission initiative

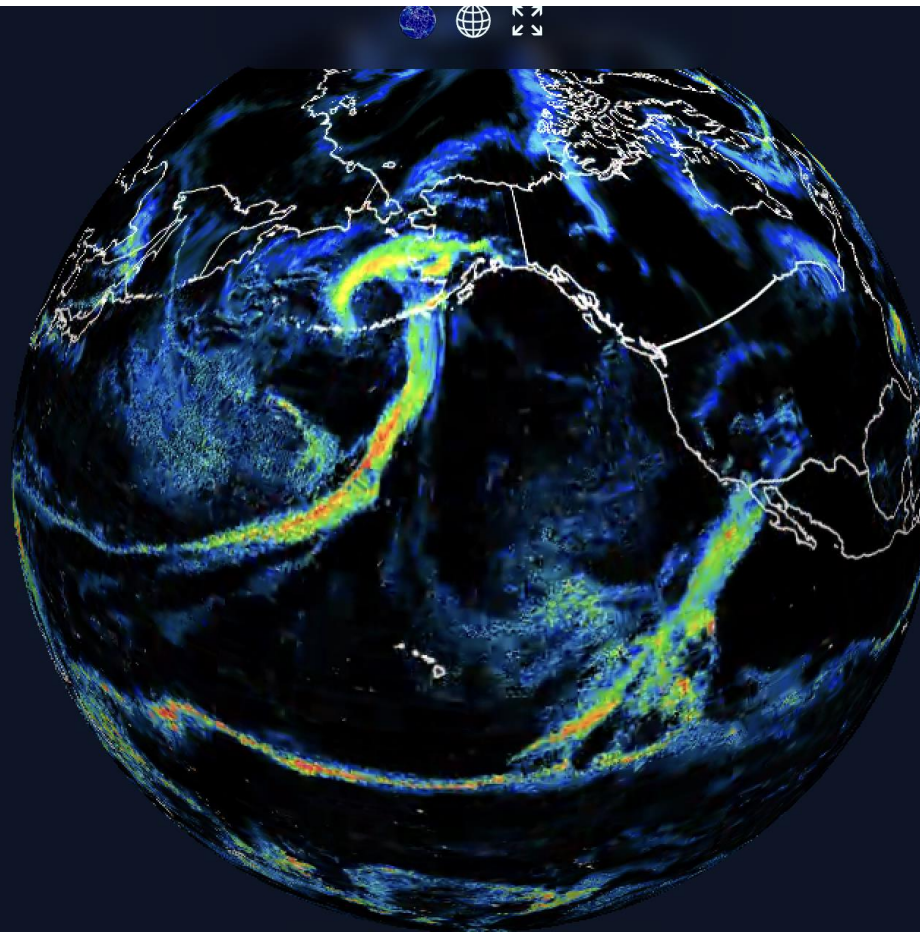


DestinE Platform

Your gateway to a sustainable future

A unique ecosystem of services
harnessing the power of
Destination Earth.

Register



Total precipitation rate (mm/hr)



Powered by 

1.945

Registered Users

Join us

20

Services already available

Discover

Data available from

2

DestinE Digital Twins

Explore

Climate adaptation and Extremes DT

- Future projections
- Global
- High-resolution
- Hourly

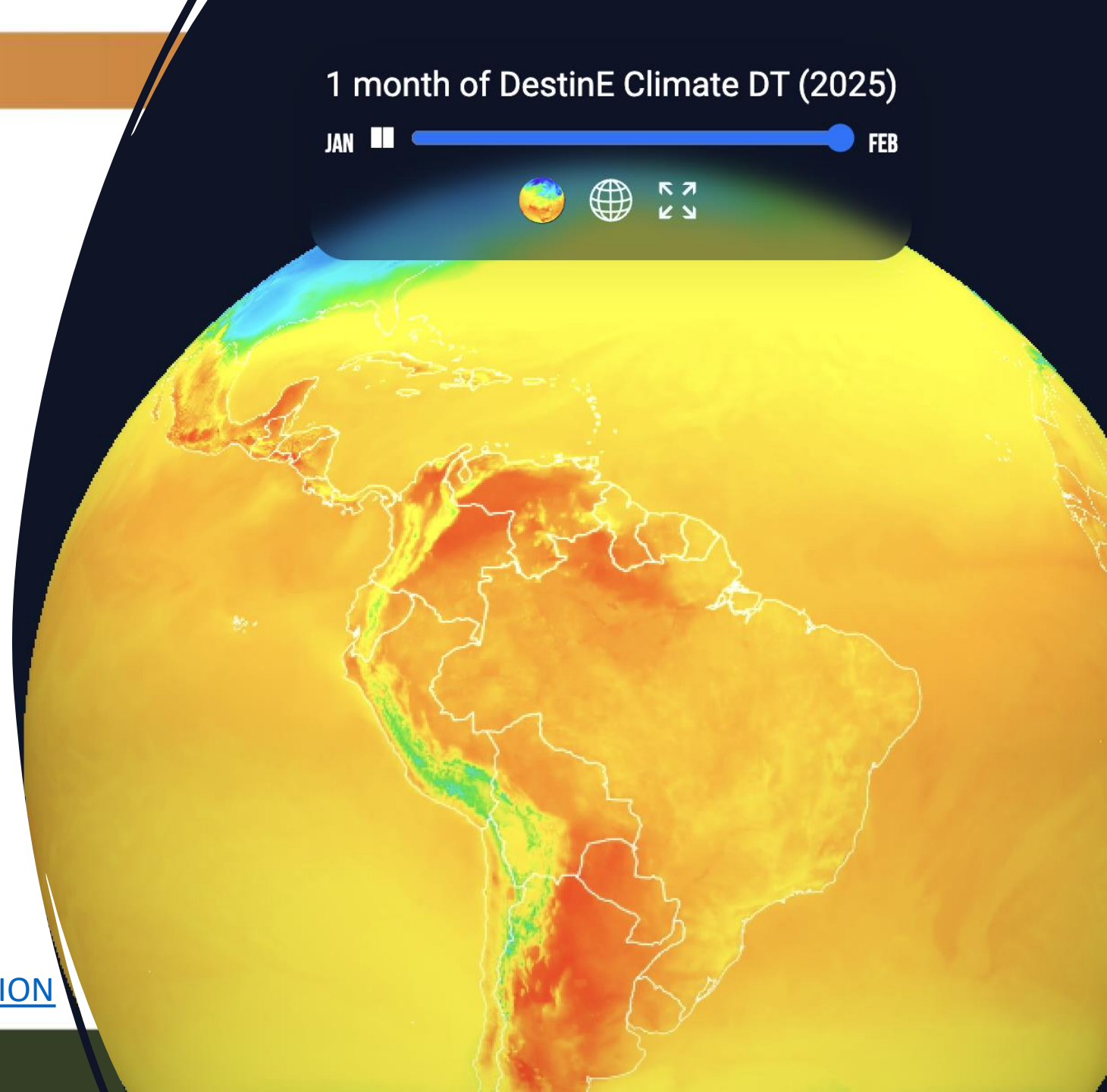
https://data.destination-earth.eu/data-portfolio/EO.ECMWF.DAT.DT_CLIMATE_ADAPTATION

1 month of DestinE Climate DT (2025)

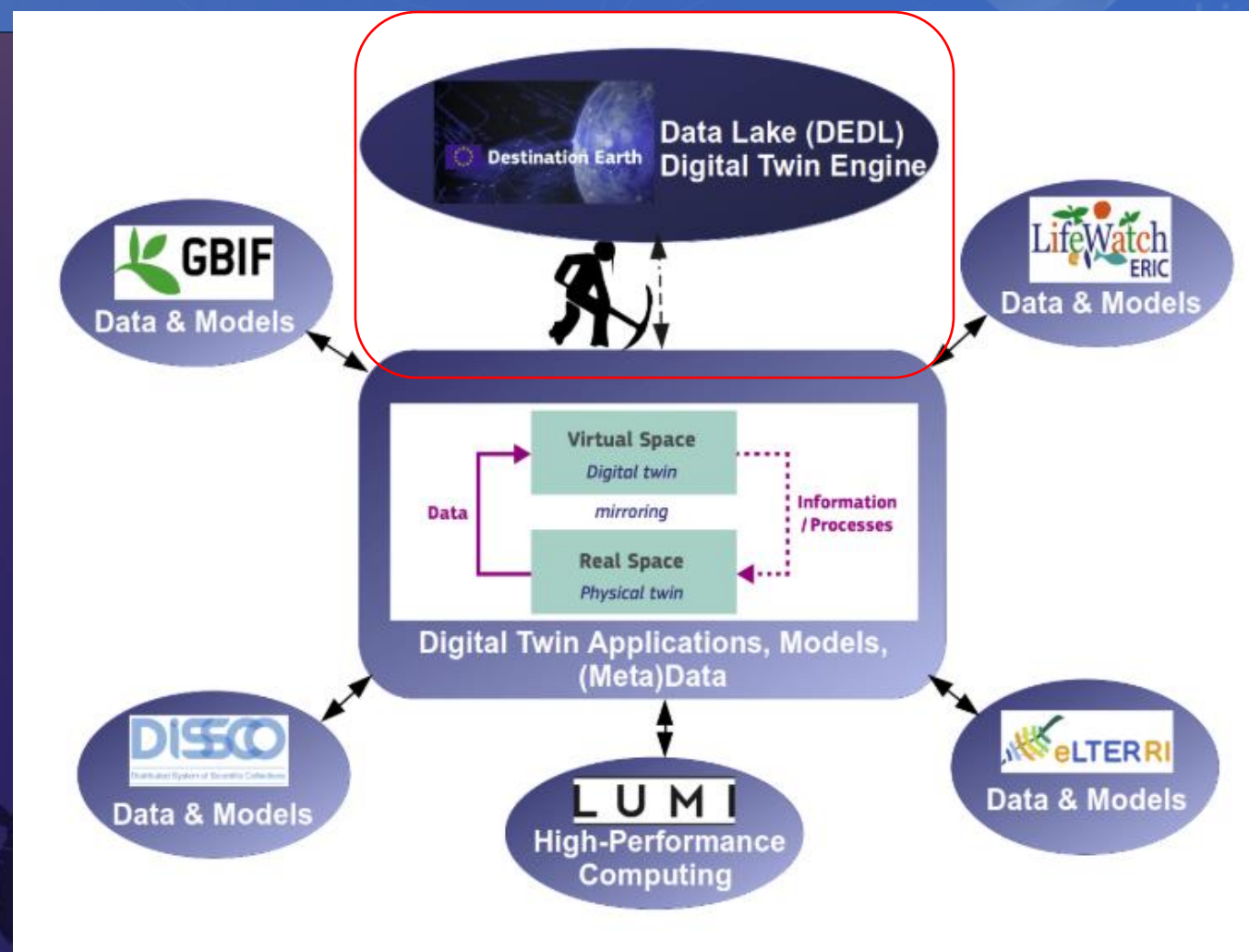
JAN



FEB



Ensure interoperability of the BioDT with Destination Earth, and the European Data Infrastructure





Funded by
the European Union



Annual Meeting 2023

13-14 June
Leiden, Netherlands



Funded by
the European Union



 Gabriela Zuquim
gabriela.zuquim@csc.fi



 @BiodiversityDT

 BioDT



Funded by
the European Union