Extending the Destination Earth ecosystem with biodiversity digital twins

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Project Overview

- BioDT is developing **prototype digital twins** in the area of biodiversity based on
  - Advanced models and prediction capabilities
  - Modern digital infrastructure services including HPC
- **Project objectives**
  - Build and deploy a pre-operational BioDT for addressing biodiversity dynamics
  - Support the interoperability of data and services through the integration of the BioDT with research infrastructure platforms and workflows
  - Ensure interoperability of the BioDT with Destination Earth, and the European Data Infrastructure

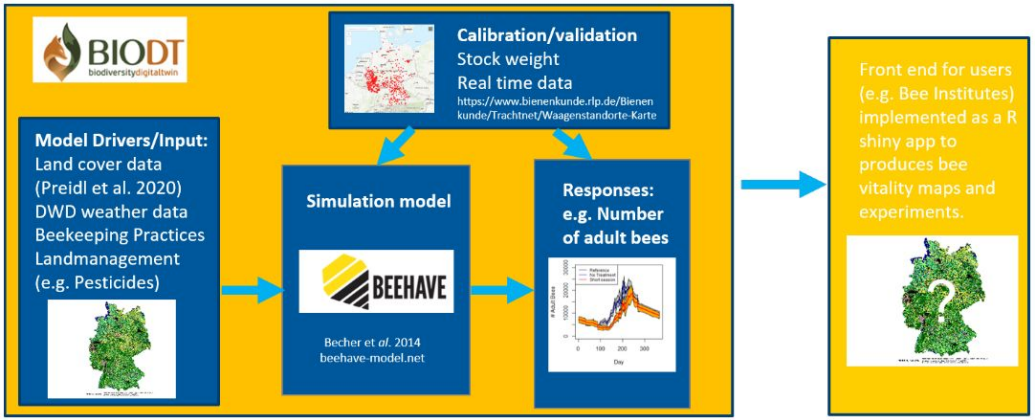
BioDT's Prototype Digital Twins

- Grassland biodiversity dynamics
- Forest/bird biodiversity dynamics
- Real-time bird monitoring with citizen science data
- Cultural Ecosystem Services
- Crop wild relatives and genetic resources for food security
- Genetically detected biodiversity in cryptic habitats
- DNA detected biodiversity, poorly known habitats
- Invasive species
- Disease outbreaks
- Honey bee dynamics in agricultural landscapes

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

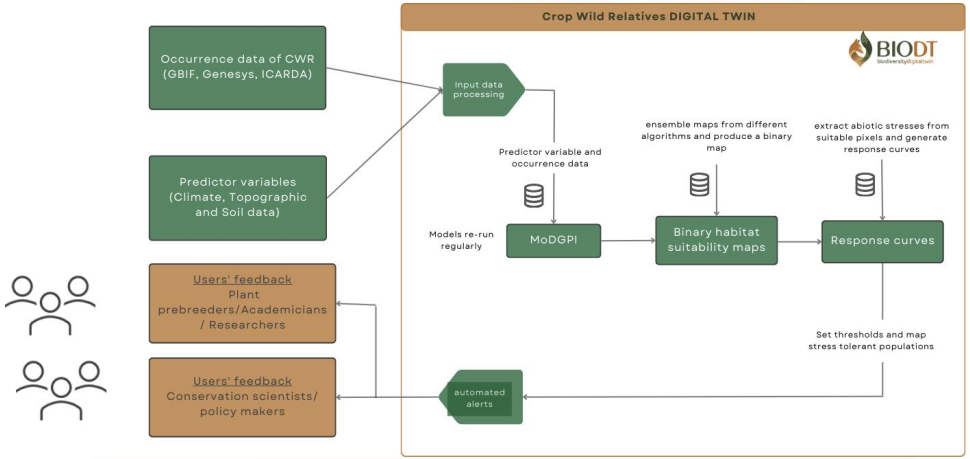
Honey Bee Dynamics

- **Goal**: Facilitate interactive exploration of honey bee dynamics in different agriculture landscapes
- **Input**:
  - Land cover data
  - Weather data
  - Model parameters
- **Model**: Simulation models based on BEEHAVE
- **Target end-users**:
  - Beekeepers
  - Private companies
  - Policy-makers and environmental organisations



Crop Wild Relatives

- **Goal**: Aid the search and utilisation of crop wild relatives' genetic resources
- **Input**:
  - Occurrence data
  - Environmental data including climate data
- **Model**: Collection of statistical models
- **Target end-users**:
  - Agricultural researchers and plant breeders
  - Conservation scientists



Interoperability Levels

[A. Tolk, 2006]

Level	Description
0	Stand-alone systems have **no interoperability**
1	On the level of **technical interoperability**, a communication protocol exists for exchanging data between participating systems
2	The **syntactic interoperability** level introduces a common structure to exchange information
3	If a common information exchange reference model is used, the level of **semantic interoperability** is reached
4	**Pragmatic interoperability** is reached when the interoperating systems are aware of the methods and procedures that each other are employing
5	**Dynamic interoperability**: The systems are able to comprehend the state changes that occur in the assumptions and constraints that each other is making over time
6	All conceptual models are aligned at the **conceptual interoperability** level

Syntactic, Semantic, and Pragmatic Interoperability

- Advanced **syntactic interoperability**
  - Specifications largely driven by the relevant research infrastructures and data providers
- **Semantic interoperability** progressing
  - Extended biodiversity ontologies are available
  - Challenges beyond the biodiversity realm
  - No obvious issues related to operation of the BioDT DTs
- **Pragmatic interoperability** has largely not been formalised

Technical Interoperability

- **Data**
  - Ongoing efforts towards improving FAIRness and standardisation of data cubes or RO-Crates
- **Compute**
  - Realise workflows based on LEXIS and HEAppE
  - Workflows components on HPC and Cloud (e.g. K8s)
- Various **interoperability challenges at the digital infrastructure level** remain, e.g.
  - HPC and cloud services integration not mainstreamed
  - Lacking integration of HPC and data infrastructures
  - AIM federation at an early stage

Summary and Conclusions

- Various BioDT digital twins have reached a pre-operational level
  - Ready to demonstrate the benefits of digital twins in the area of biodiversity
- Most of these digital twins can benefit of being coupled to Destination Earth
  - Climate, extreme weather events
- Interoperability remains a key challenge at different levels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