

Overview of the LTER-LIFE project

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Also on behalf of:
Marcel Visser, Netherlands Institute of Ecology
Geerten Hengeveld, LTER-LIFE, Netherlands Institute of Ecology
Zhiming Zhao, University of Amsterdam, LifeWatch VLIC



Plovdiv Bulgaria, 7-10 July 2026

Outline: from observations to predictive ecology

WHY

Why predictive ecology needs infrastructure

WHAT

What ecosystem digital twins are

HOW

How LTER-LIFE supports communities

EXAMPLE

A bud-burst workflow becomes predictive ecology

WHO

Who are building the infrastructure (and who pays for it)

What are the main pressures on Europe's nature?

Europe's biodiversity continues to be shaped by human activity. Pressures to habitats and species remain high and more than 67 000 individual pressures have been reported at the EU level.

With 21 %, agriculture is

the most frequently reported pressure for habitats and species.

Abandonment of grasslands and intensification is particularly impacting pollinator species, farmland birds and semi-natural habitats.

Invasive alien species

such as the False Indigo-bush, particularly affect dunes and sclerophyllous scrubs as well as species such as breeding seabirds.

Forestry activities represent 11 % of all

pressures, particularly affecting forest habitats, and woodland species.

Climate change

is reported as a rising threat, particularly due to ongoing changes in the temperature and decrease of precipitation.



Urbanisation and leisure activities account for 13 % of all reported pressures, representing

48 % of all marine pressures.

The modification on water regimes, physical alterations of water bodies and removal of sediments predominantly affect

freshwater habitats and fish.

13 % of all pressures

for birds stem from the exploitation of species, mainly relating to illegal killing and hunting.

In Europe, the annual hunting bag amounts to at least **52 million birds.**

Almost 50 % of all pressures related to pollution

can be attributed to air, water and soil pollution caused by agriculture.

From monitoring change to exploring scenarios

WHY

Observe

What is changing?

Understand

Why is it changing?

Predict

What may happen next?



real world



scenario A



scenario B



scenario C

Trends in
Ecology & Evolution

Opinion

Digital twins as a tool for ecosystem research

CellPress
OPEN ACCESS

Marcel E. Visser ^{1,*}, Geerten M. Hengeveld ¹, Jelske de Kraker ²,
Ioannis N. Athanasiadis ³, Elisabeth S. Bakker ^{1,3}, W. Daniel Kissling ⁴,
Stanley Nmor ⁵, Catharina J.M. Philippart ⁶, Karline Soetaert ⁵,
Stefan J.G. Vriend ¹, Amber Woutersen ², Zhiming Zhao ⁷,
Qing Zhan ⁶, and Andries F. Hof ^{2,8}

Trends in Ecology & Evolution

What is an ecosystem digital twin?

WHAT

Digital twins as a tool for ecosystem research

Marcel E. Visser ^{1,*}, Geerten M. Hengeveld ¹, Jelske de Kraker ², Ioannis N. Athanasiadis ³, Elisabeth S. Bakker ^{1,3}, W. Daniel Kissling ⁴, Stanley Nmor ⁵, Catharina J.M. Philippart ⁶, Karline Soetaert ⁵, Stefan J.G. Vriend ¹, Amber Woutersen ², Zhiming Zhao ⁷, Qing Zhan ⁶, and Andries F. Hof ^{2,8}

Digital Twins of ecosystems

(1) Ecosystem-specific



Veluwe ecosystem



Wadden Sea ecosystem

(2) Digital data streams



Near-real-time data transmission

Infrequent data uploads

(3) Multisource data integration



In-situ measurements

Digital sensor data

Remote sensing imagery

(4) Combination of models



Dynamic & process-based models

Statistical models

Big data-driven models

(5) Forecasts and scenarios



Short-term ecological forecasts

Long-term projections & scenario studies

LTER-LIFE is more than digital technology

WHAT

Research communities

Questions
Ecosystem expertise
Co-creation
Validation
Collaboration

Digital infrastructure

Historical data
Realtime data
Models
Workflows
Computing resources

Support

Documentation
Guidance
Training
Workshops
Maintenance

Reusable assets

FAIR datasets & other
objects
Services
Components
Virtual labs

Extended Jupyter notebooks

Computational notebooks

- ✓ Widely used by researchers (Rscript, Python)
- ✓ Documentation and visualization alongside code
- ✓ Interactive code execution

→ developing and tweaking models

Virtual research environment

- Trusted and stable architecture
- FAIR data, models and services
- Local or remote infrastructure
- Scaling up models (e.g. from prototype to large-scale cloud environment)

→ sharing mature models & collaboration

Combined: NaaVRE

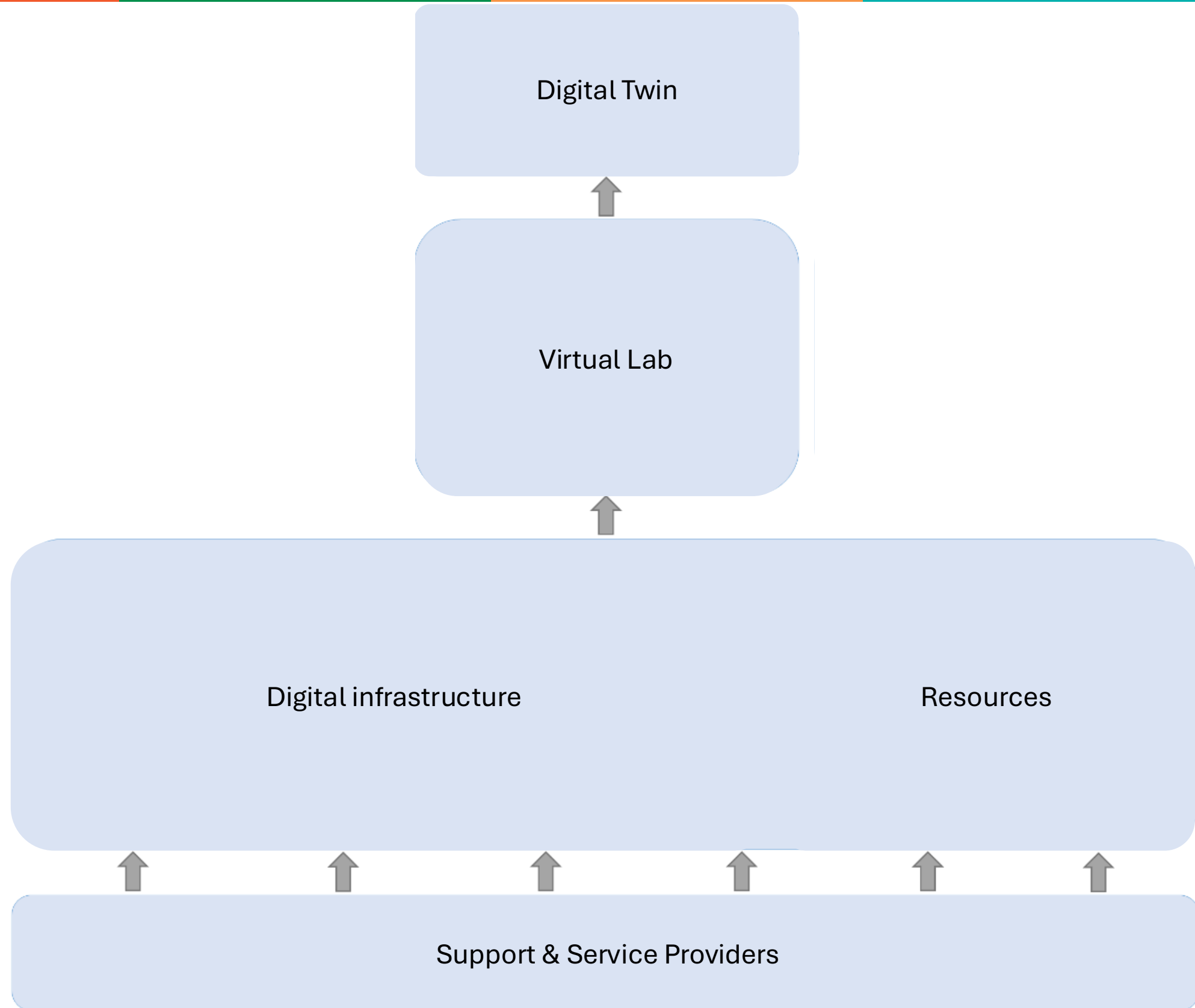
HOW



Notebook as a
Virtual
Research
Environment

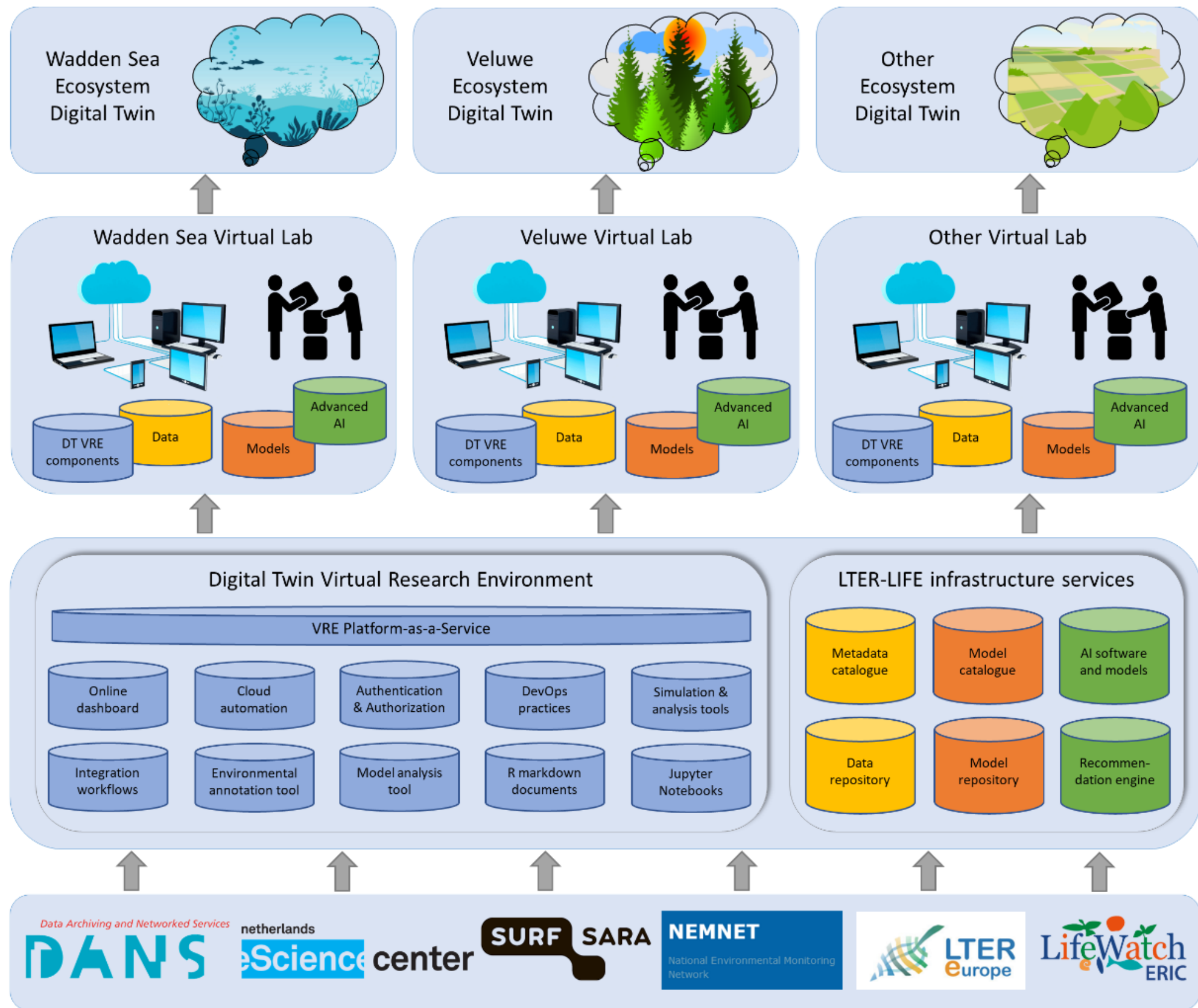
NaaVRE in LTER-LIFE

HOW



NaaVRE in LTER-LIFE

HOW



**Seasonal timing
of growth and
reproduction:
ultimate
functions and
proximate
mechanisms**

1993–Present





Home

About

Login

HOW



NaaVRE: Notebook as a Virtual Research Environment



🔊 Integrated cloud storage is now available for all virtual labs. Check out [the documentation on naavre.net](#) on how to use it. 🔊

🧑🏫 If you encounter an issue or need help with anything, [get in touch](#) or submit a bug report on [GitHub](#).

[Documentation](#)



Airborne Laser Scanning Tree Individualization Virtual Lab

Identifying individual trees from airborne laser scanning data



Marco-Bolo

Tutorial

Biodiversity Time Series Analyses from European Marine Ecosystems Virtual Lab

A virtual lab to compile comprehensive marine biodiversity time series in Europe and...



BioDT Hackathon

BioDT Hackathon lab



LTER-LIFE

Veluwe forest model

Forest landscape modeling of the Veluwe



LTER-LIFE

Veluwe proto DT

Veluwe Digital Twin prototype for LTER-LIFE



LTER-LIFE

Waddenzee proto DT

Waddenzee Digital Twin prototype for LTER-LIFE



Experimental features



NaaVRE Tutorial



Nature Data Cube



Nature Data Cube

Define area of interest

Select a project, upload a polygon, or draw your own polygon

Projects

NutNet

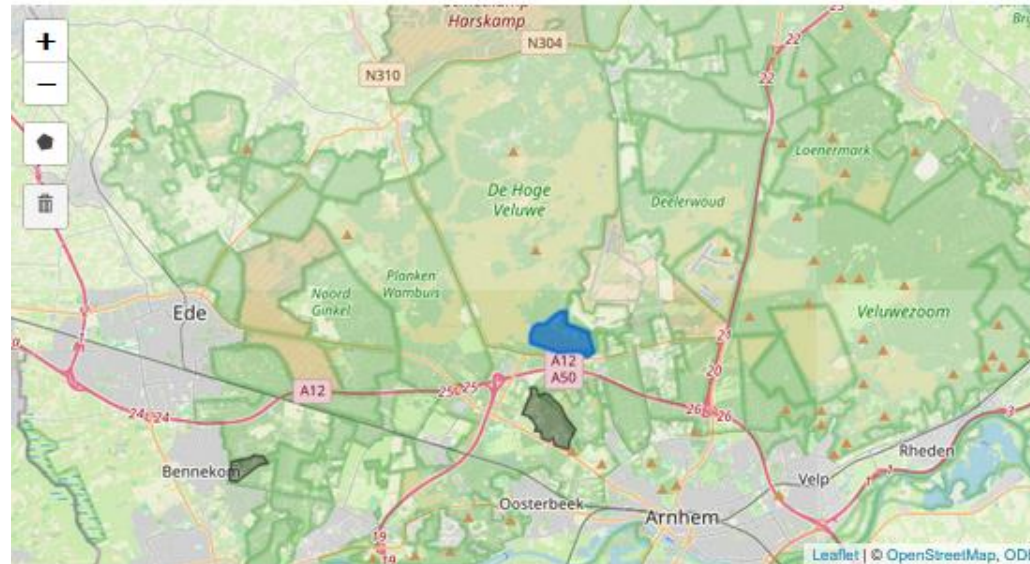
Nestboxes

Loobos

Light on Nature

Upload your own polygon(s)

Draw your own polygon



Choose dataset(s)

Atmosphere

Weather

Nitrogen

Biosphere

Overview of selected datasets

Dataset	Type	Date
Weather	Statistics	2024-12-01 - 2025-01-01

Clear overview

 Download dataset(s)

Return data to R (close app)

Updates on dataset retrieval will appear here.

Configure data request - Weather

Statistics

☐ Single date ☒ Period

From - To:

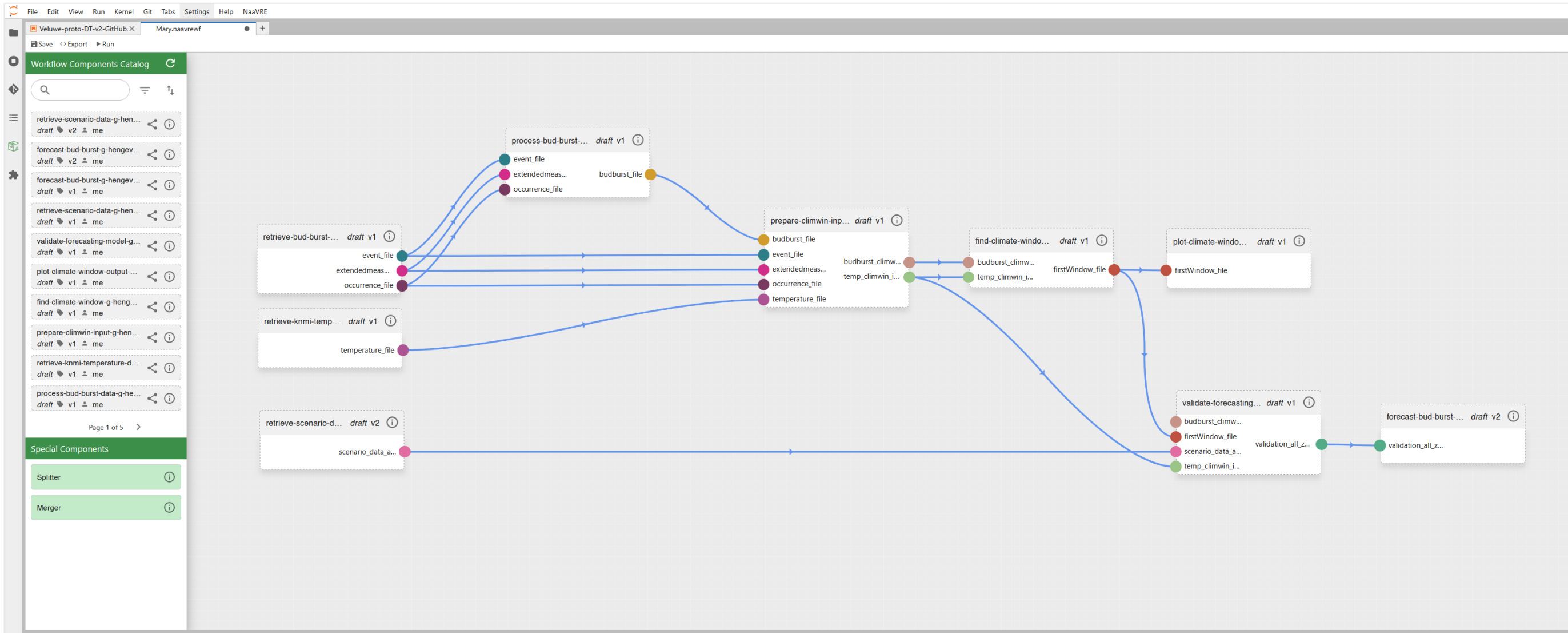
2024-12-01

to

2025-01-01

Add to overview



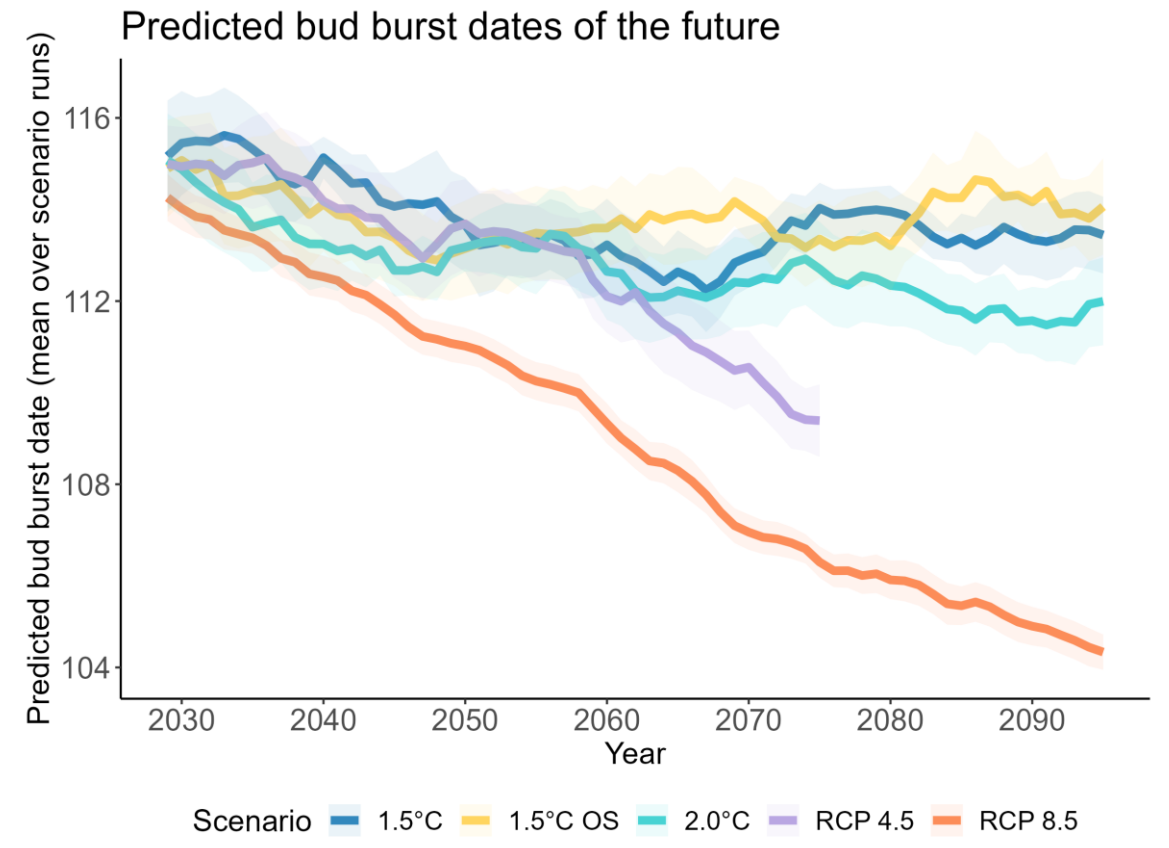
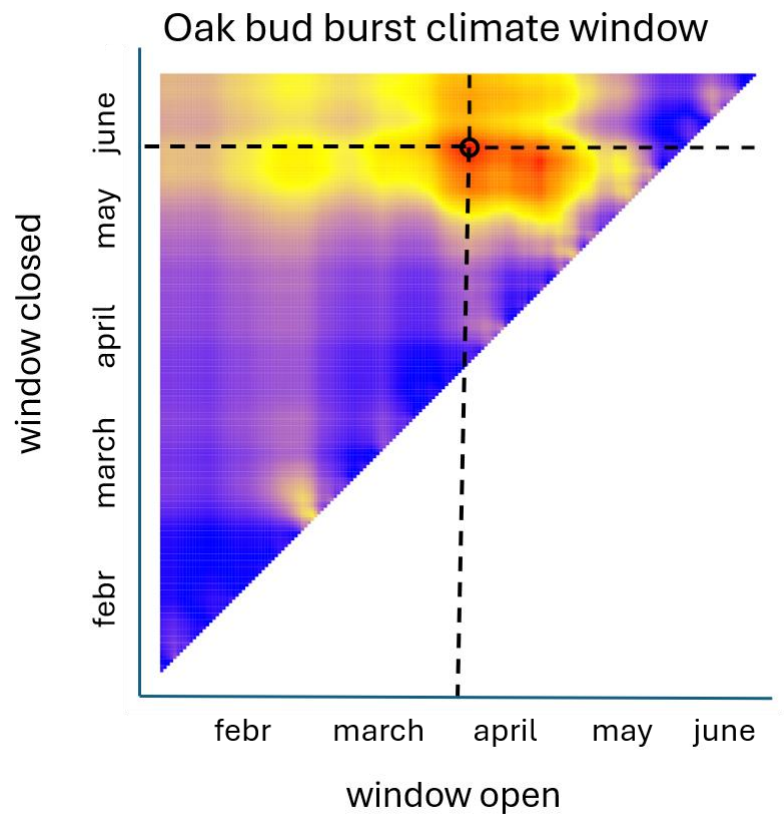


EXAMPLE

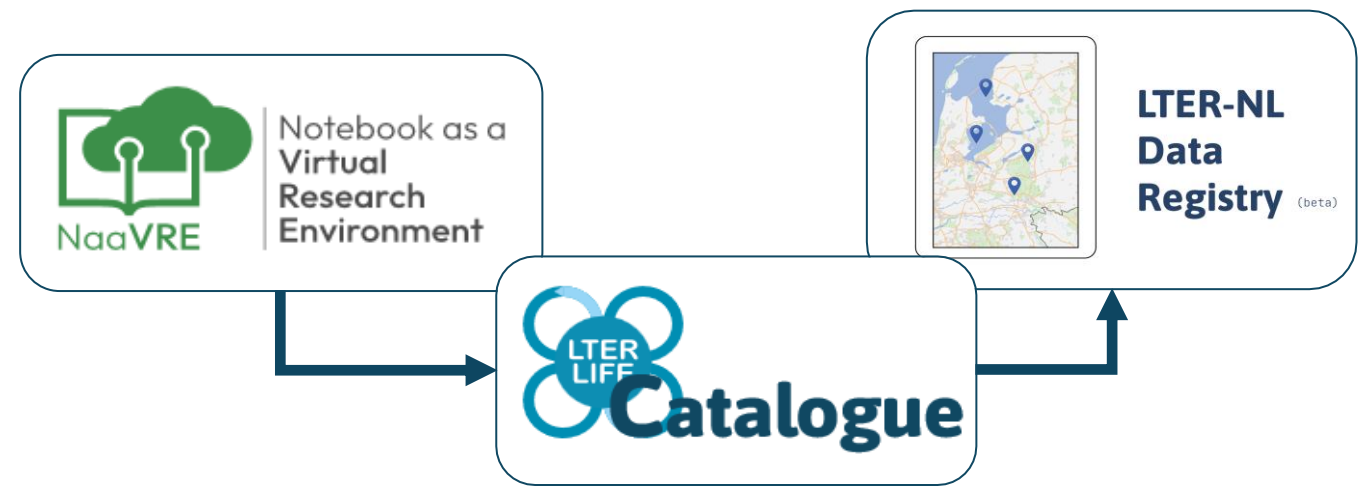


Team:

- Cherine Jantzen
- Stefan Vriend
- Marcel Visser
- Gabriel Pelouze
- Spiros Koulouzis



EXAMPLE



Consortium and funding

Credits

Marcel Visser,
Principal applicant

Geerten Hengeveld
Executive Manager LTER-LIFE

Zhiming Zhao
NaaVRE / Virtual Laba
University of Amsterdam /
LifeWatch VLIC

and many others

Consortium

Led by Netherlands Institute
of Ecology (NIOO-KNAW)

University of Amsterdam
Wageningen University &
Research

Royal Netherlands Institute for
Sea Research (NIOZ)

National Institute for Public
Health and the Environment
(RIVM)

Funding & timeline

Funded by the Dutch Research
Council (NWO),
Roadmap large-scale research
infrastructures

Funded in 2023
Designed as a 10-year project

Joint proposal of 3 roadmap
initiatives: LifeWatch, LTER-NL
and NEMNET

Take-home messages...

1. Digital twins can make ecology more predictive

By connecting observations, models and ecosystem expertise for real systems.

2. LTER-LIFE builds an open infrastructure, not just one digital twin

By providing FAIR assets, reusable workflows and virtual labs for research and policy.

3. The innovation is both technical and organisational

It requires a trusted digital architecture as well as collaborative research communities.

Questions and more information

NaaVRE: naavre.net vlic@lifewatch.eu

NaaVRE demo (LiDAR) by Koen Greuell, Friday 11:30

Find Gabriel Pelouze for questions on the bud burst VL

LTER-LIFE: lter-life.nl lter-life@nioo.knaw.nl

Join the LifeWatch Thematic Services Working Group
for Modelling and Workflows at lifewatch.eu
Find Agustín Riscos Núñez

