Co-developing the DIWA Digital Twin for water management

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Digital Waters (DIWA) Consortium

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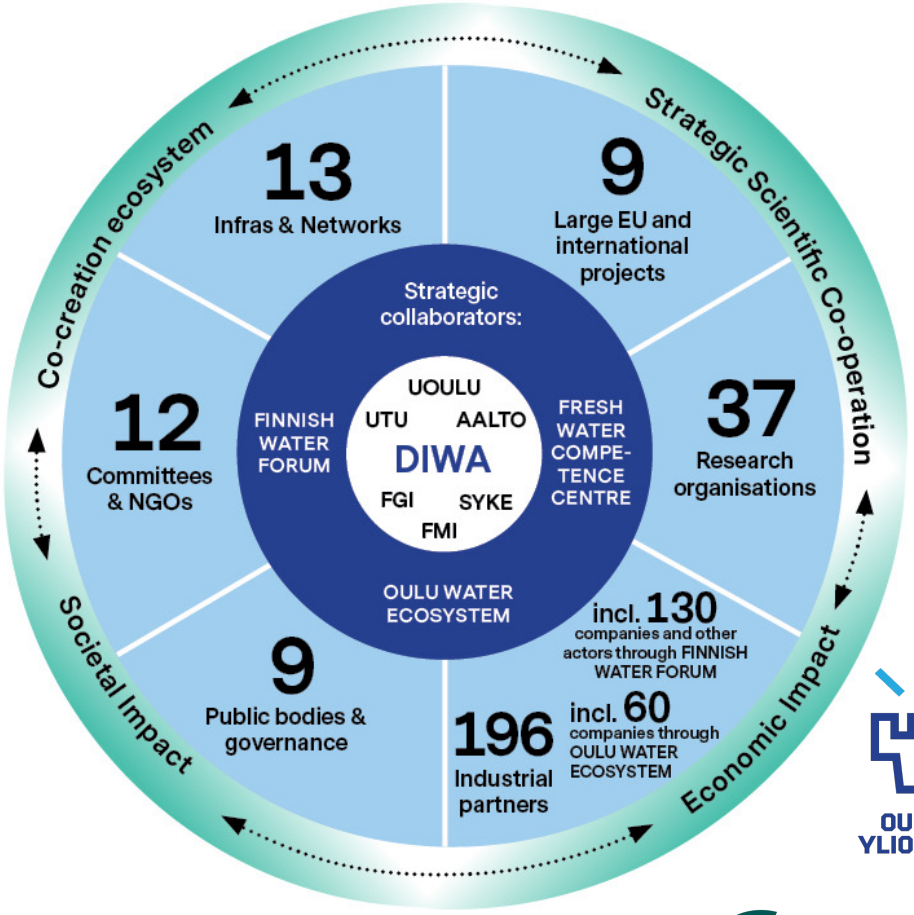

DIWA brings together a group of **experts in the multidisciplinary** water sector, **spatial information** and **information technology**

>230 Researchers (~60 PhD Pilot Students)

Connections to various actors: **companies, ministries, and local level actors** (cities, municipalities, citizens) - Multiactor approach

Co-creation based solutions. Direct connection to planning and decision-making. Citizen science as part of R&D activities

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Digital Twin Architecture

A **digital twin** is a virtual representation of a **physical system.**

It is continuously updated with **real-time data** from that system.

The virtual representation allows for **simulation, analysis, and control** of the physical counterpart.

The digital twin architecture is an **interconnected computational system** that facilitates the flow of data and information between developers, users, and the environment.

Digital Twin: overview

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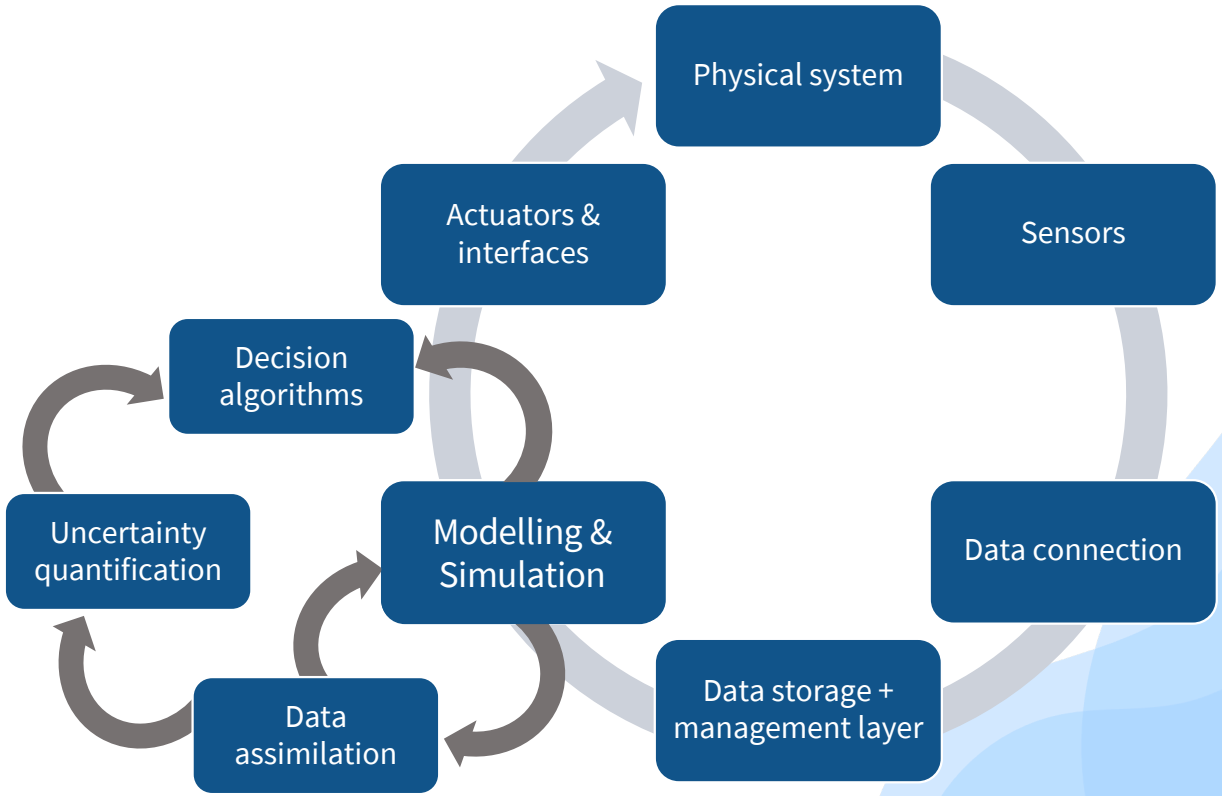
Components of a Digital Twin:

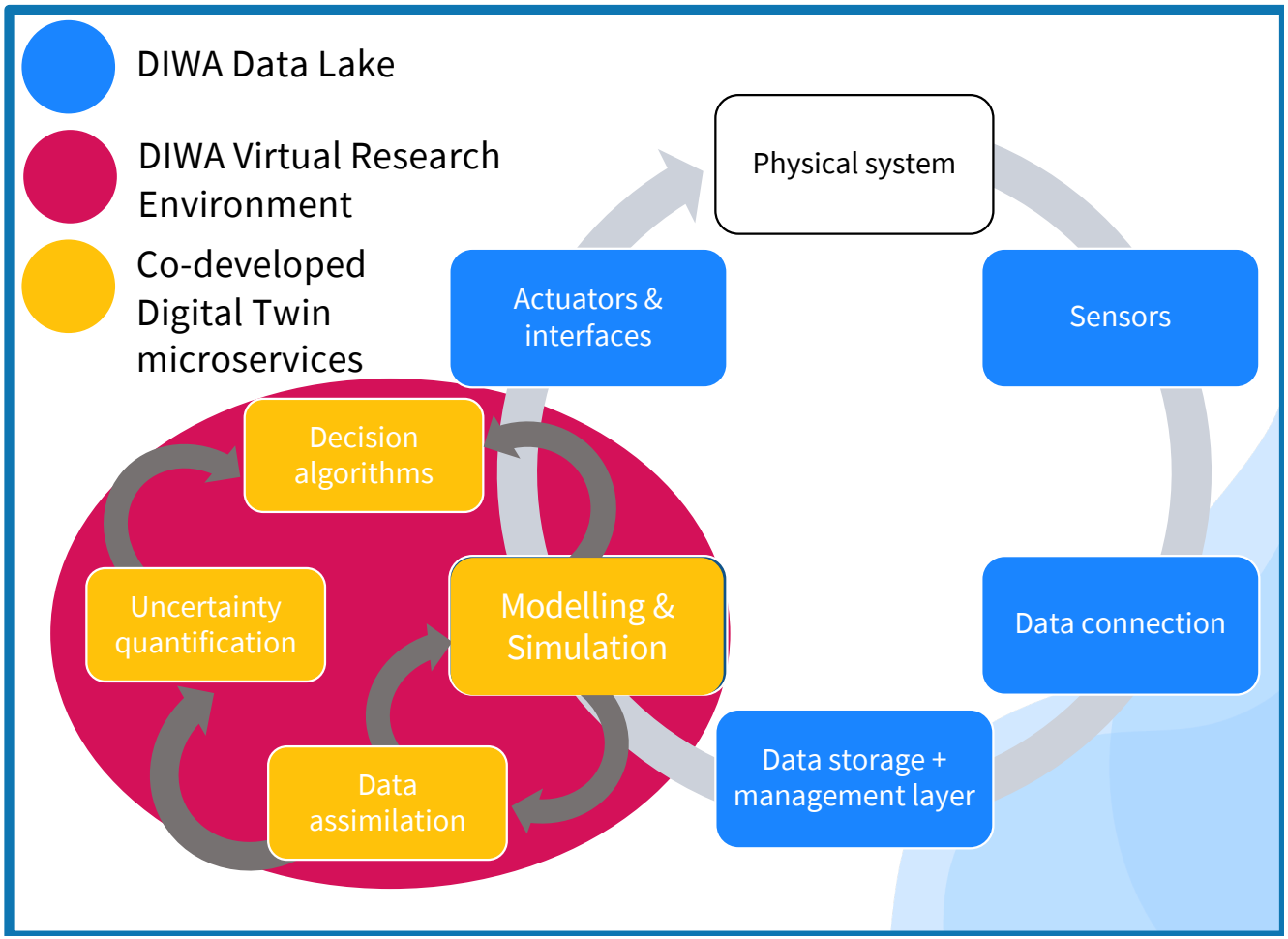
- **Physical system:** some part of reality that humans want to understand and/or manage.
- **Sensors:** detect physical properties and produce digital signals
- **Data connection:** converts digital signal to data object, and transfers information to central processor
- **Data storage & management:** stores, formats, and organizes data objects; generates analysis ready data.
- **Modelling Layer:** utilizes analysis ready data to make predictions, and interpret predictions, allowing insight.
- **Actuators and interfaces:** modify physical conditions (either through IoT or insight to decision makers).



Digital Waters Digital Twin Architecture

The digital twin architecture is an **computational pipeline** that facilitates the flow of data and information between users and the environment.

- **Research data pipelines** overlap with **digital twin data pipelines**
  - Data collection, data processing, modelling, interpretation, presentation of results.
- Standard protocols + research infrastructure enable co-development
  - FAIR Compliant
  - OGC Standards
  - European Interoperability Framework
  - Shared HPC + Software + Data Systems



The 6-step DT Architecture development plan

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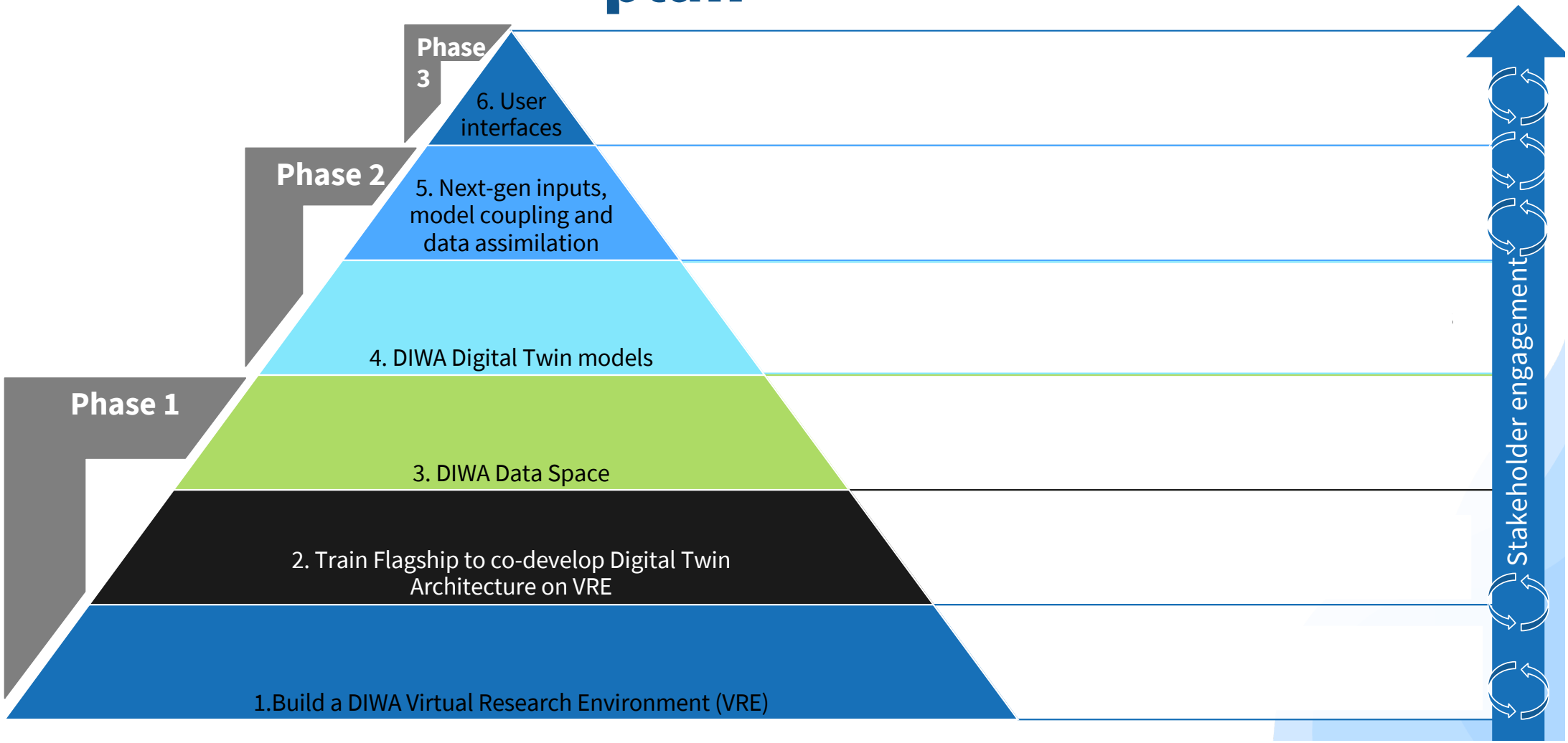
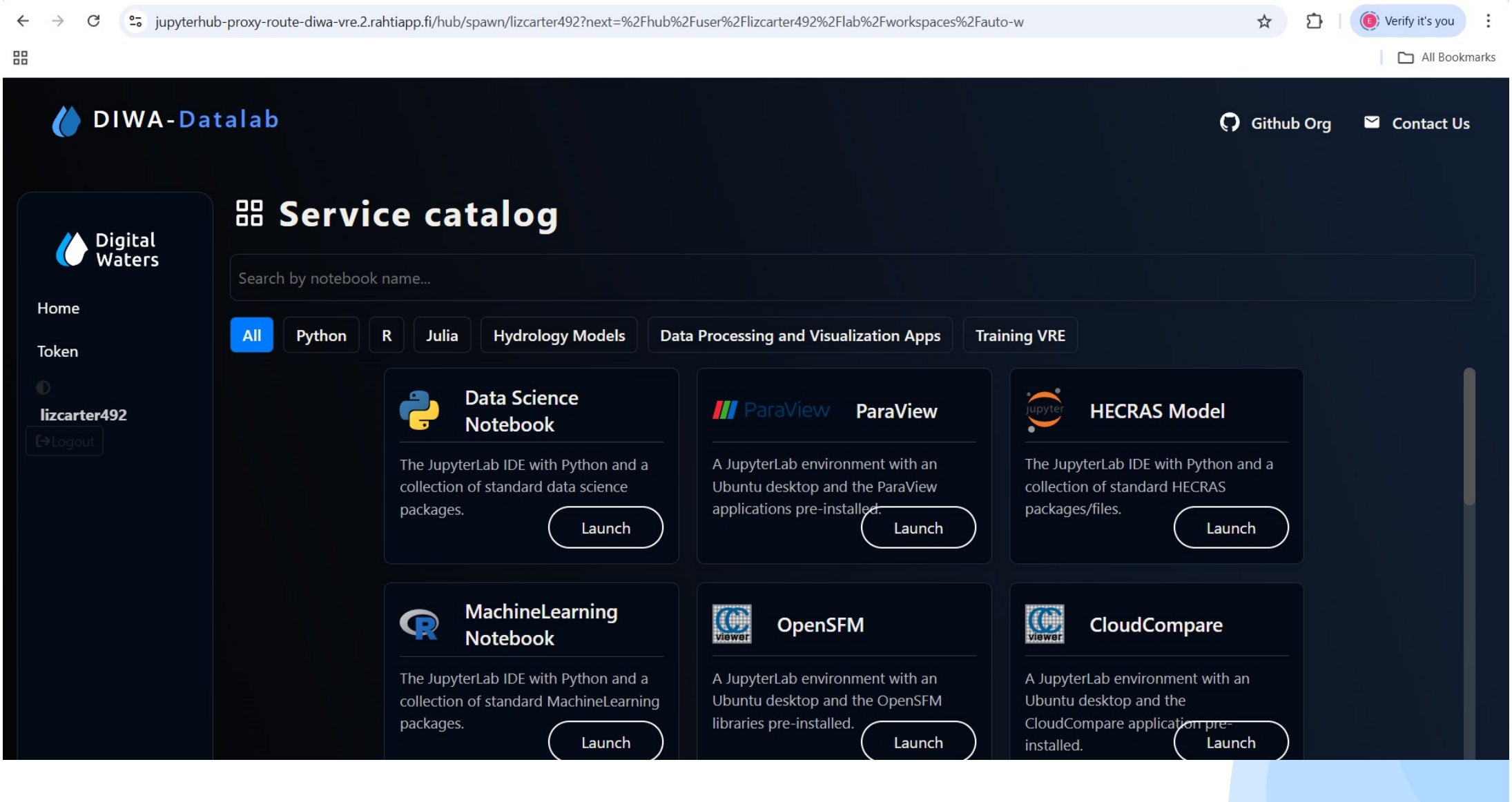


Step 1: Where we work together.

- DIWA DataLab
- JupyterHub VRE on CSC.fi
- Translate research code into Digital Water Labs:
  - Public interaction with GitHub repository enabled by BinderHub
  - Voila, Dash, Streamlit allow the public at large to interact with data visualizations
  - Supports open, reproducible research + scientific communication
- Co-develop DIWA Digital Twin Models:
  - Coupled, interoperable process + data drive models w/ automatic data assimilation
  - User interfaces enable stakeholder engagement for scenario evaluation and design
- Design and host user interfaces for DIWA Digital Twin Models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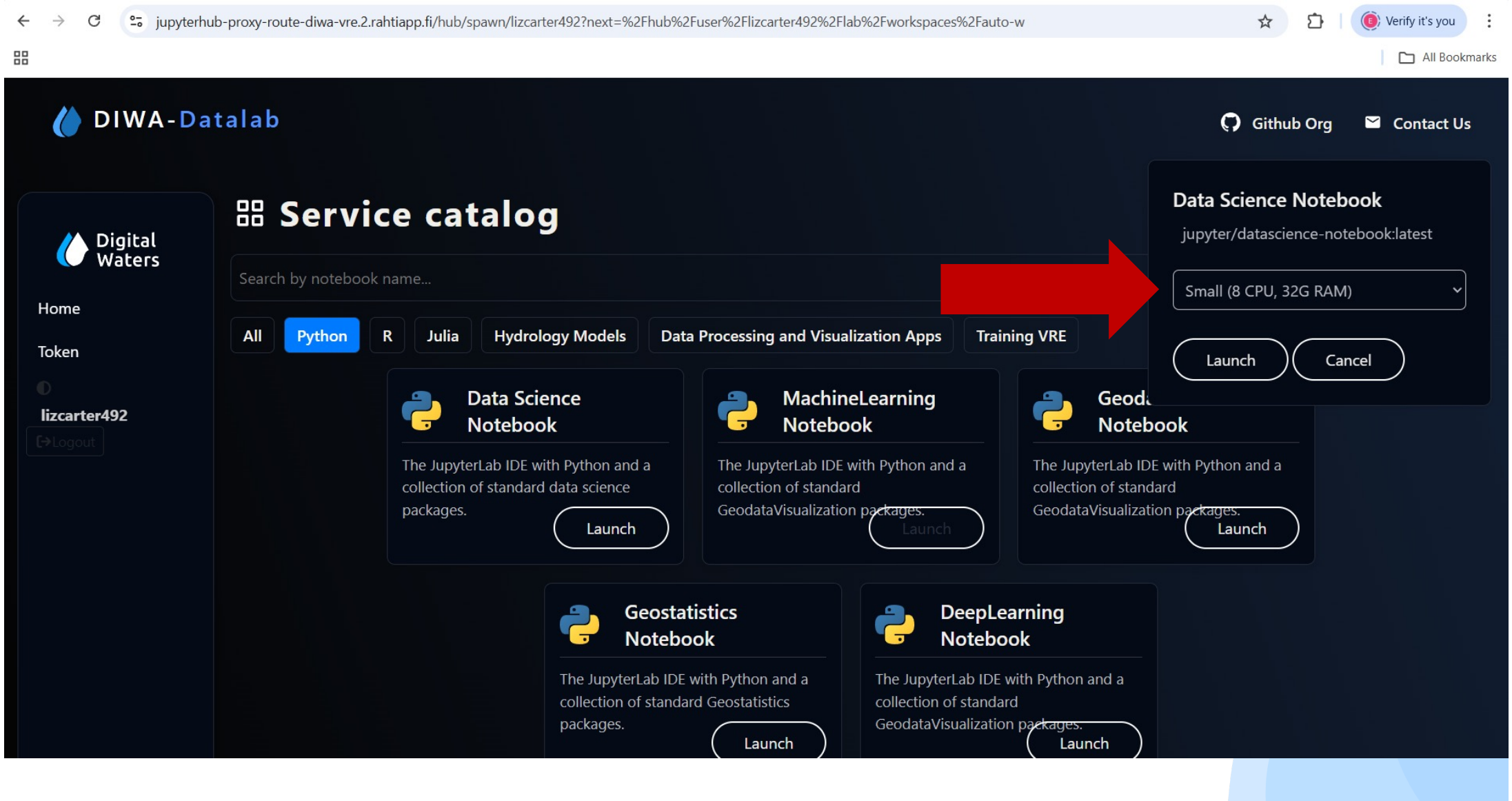
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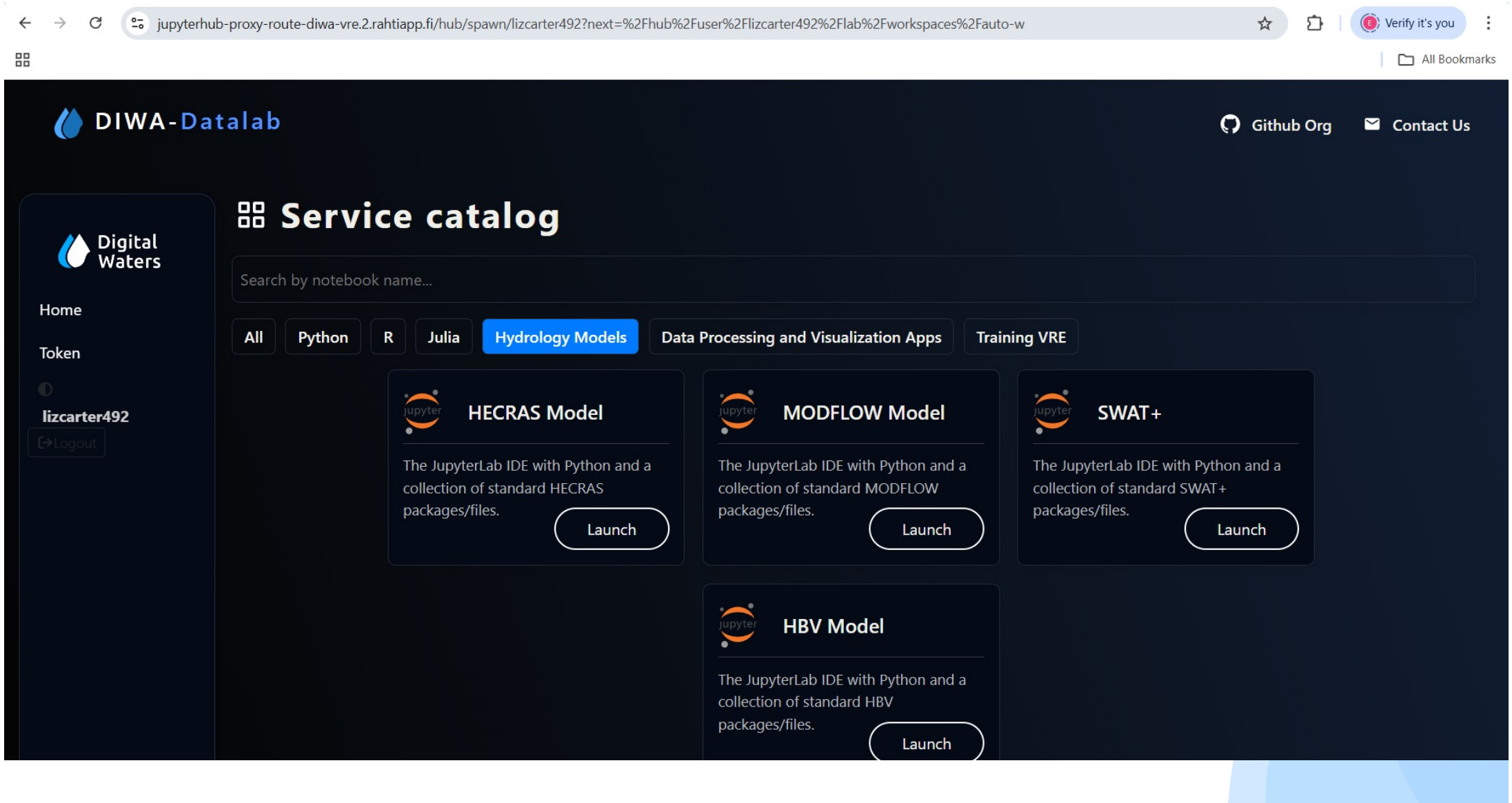
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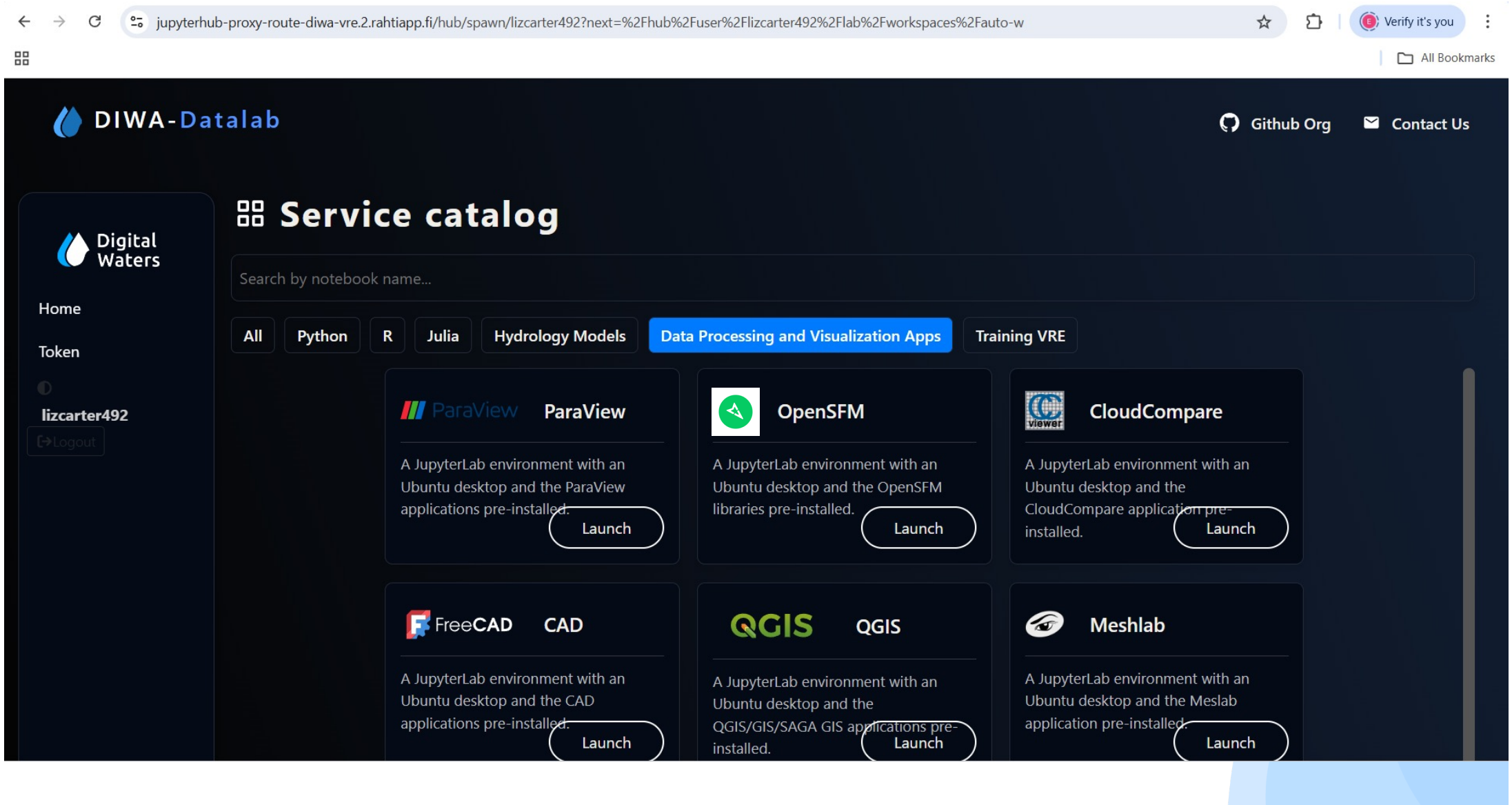
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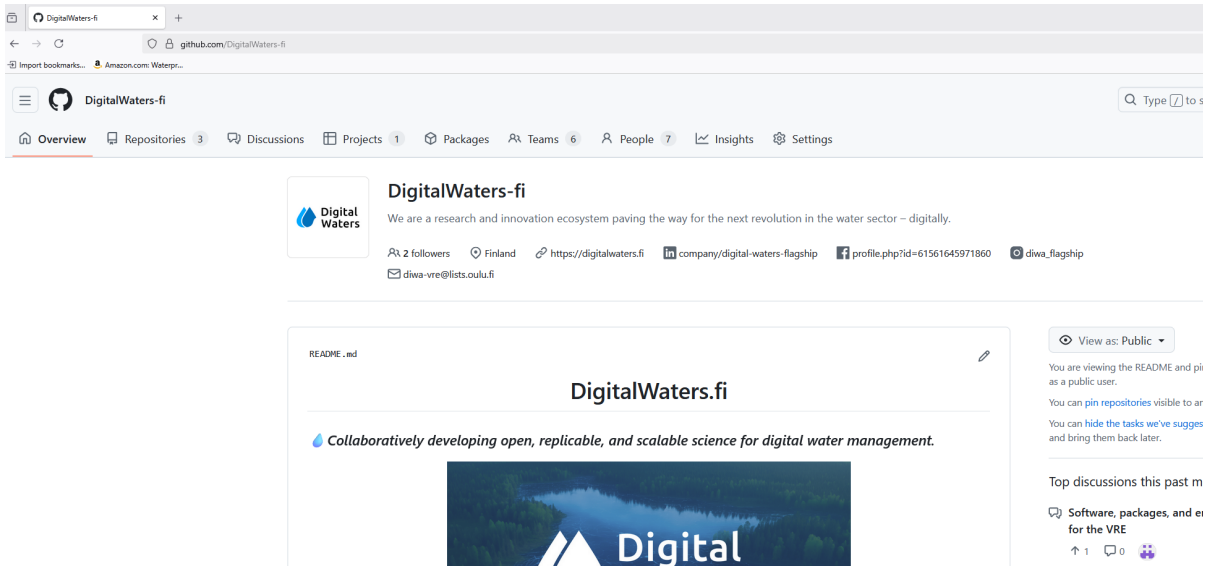
DigitalWaters.fi GitHub Organization



Scan QR code or visit
https://github.com/DigitalWaters-fi

- Public-facing hub for DIWA Digital repositories + images
- Coming soon: live hosting with BinderHub
- Develop, research, and collaborate
  - Version control, track contributions, undo mistakes.
- Access the DIWA DataLab and DataLake.
- Discussions, trainings, projects

Step 2: How we work together.

Training on DIWA Digital Twin technology

1. PhD Pilot Course: water digitalization
   - Learn open-source software + FAIR best practices
   - Publish a GitHub repository with standard elements
   - Co-design AI policy and usefulness metrics
2. DIWA GitHub organization
   - Publish trainings
   - Access software + tools
   - Collaborate + get help
3. Digital Twin Webinars
   - Launch products + train flagship

GitHub

git

BASH

python

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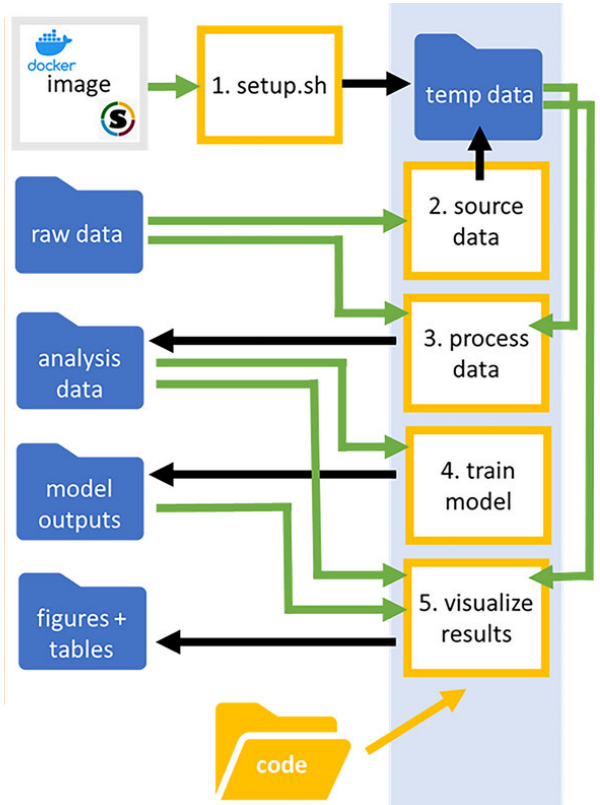


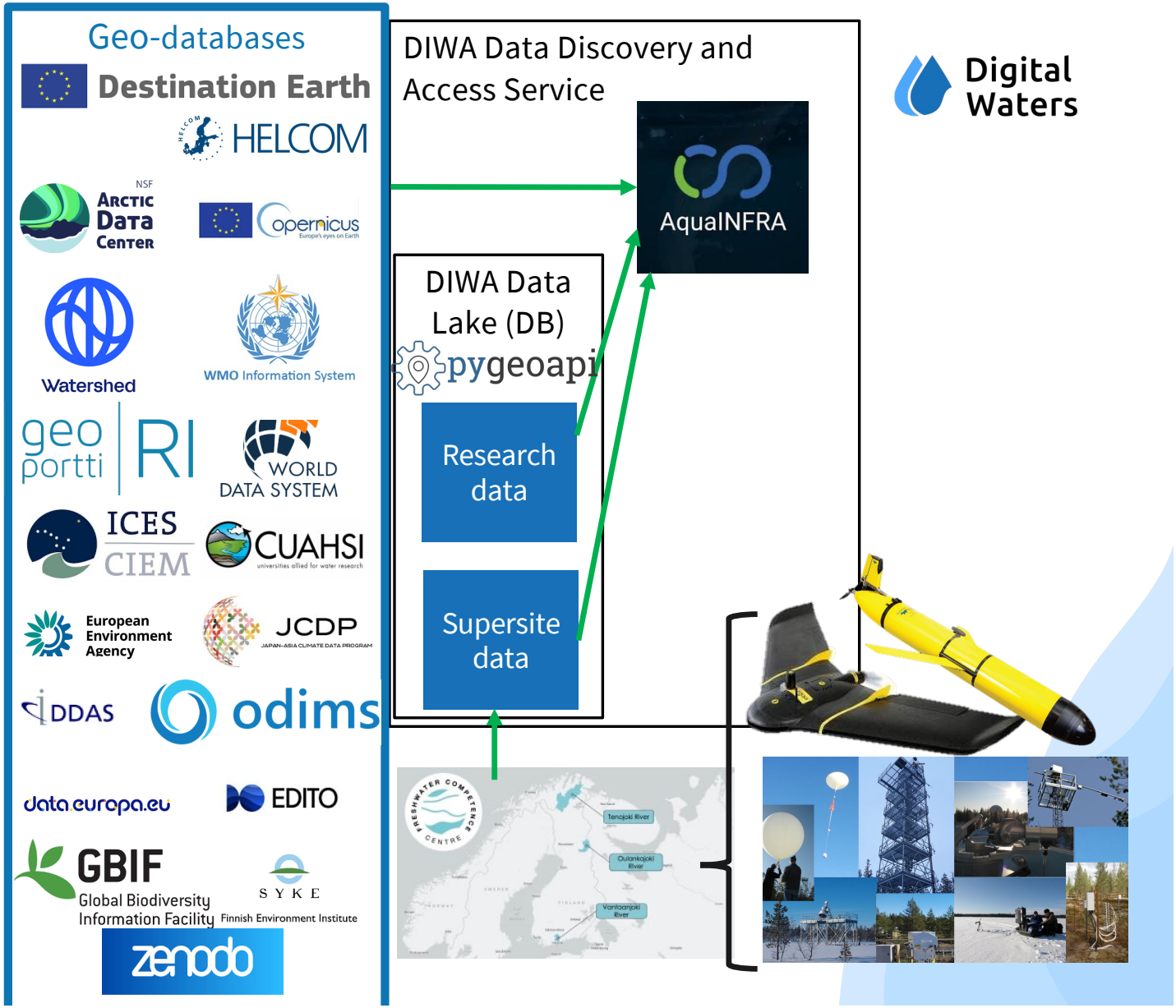
COOKIECUTTER + binder =

Findable Accessible Interoperable Reusable

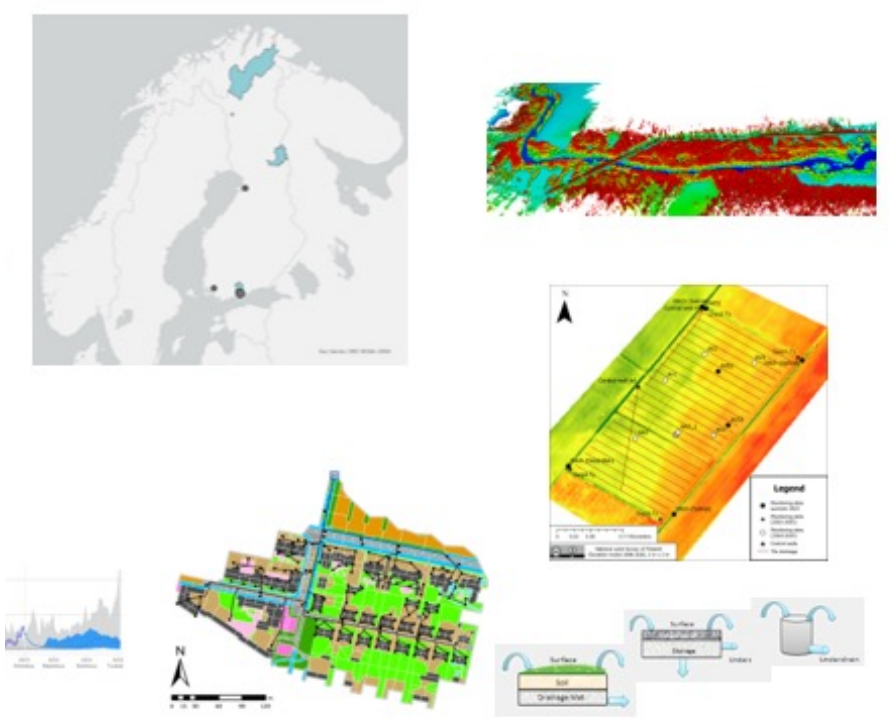
Step 3. Streamline data access.

DIWA DATA SPACE.

- Data Discovery and Access Service
  - Build on AquaINFRA DDAS
  - Search 90 million datasets from one place
- Data Lake:
  - New observations: GEOPORTTI + HYDRO + CRYO RIs
  - Experiments + field work
  - Model data + outputs
- DIWA Data Space interoperability framework
  - open standards to ensure that geospatial data can be seamlessly shared and used across different systems, applications
  - OGC standards for data models and APIs
  - European Interoperability Framework



Step 4. Get insight from data.



- DIWA Model Lab
- Coupled and interchangable
  - hydrologic/hydraulic/systems models provide information on system fluxes at management-relevant scales
  - We are starting with HBV, SWAT+, SpaPHy
  - Images on DIWA Data Lab
  - Coupled + Interchangable
- Data assimilation system
  - Compare observations to predictions in real-time
  - Models get smarter over time
  - Integrating process and data-drive (ML/AI models)
  - Integrate rich data inputs from Geoportti, JERICO, CRYO, HYDRO-RI

Step 6. Bring data-driven insights to water resources management.

DIWA WaterLab

- Intuitive and transparent user interfaces
- Diverse stakeholders access ModelLab and DataSpace
  - Dashboards
  - User interfaces
  - Chatbots
- Tools for hypothesis testing
- Tools for system and scenario analysis

FGI Geospatial Visualization and XR Lab

User interfaces: stakeholder-driven design

User survey, in collaboration with SYKE, EDC-centres and ministries

Broader themes – catchment-based planning and digitalization

1. What are the current challenges in and enablers of integrating catchment-based planning?
2. Current use of and needs for digital services, tools, and data

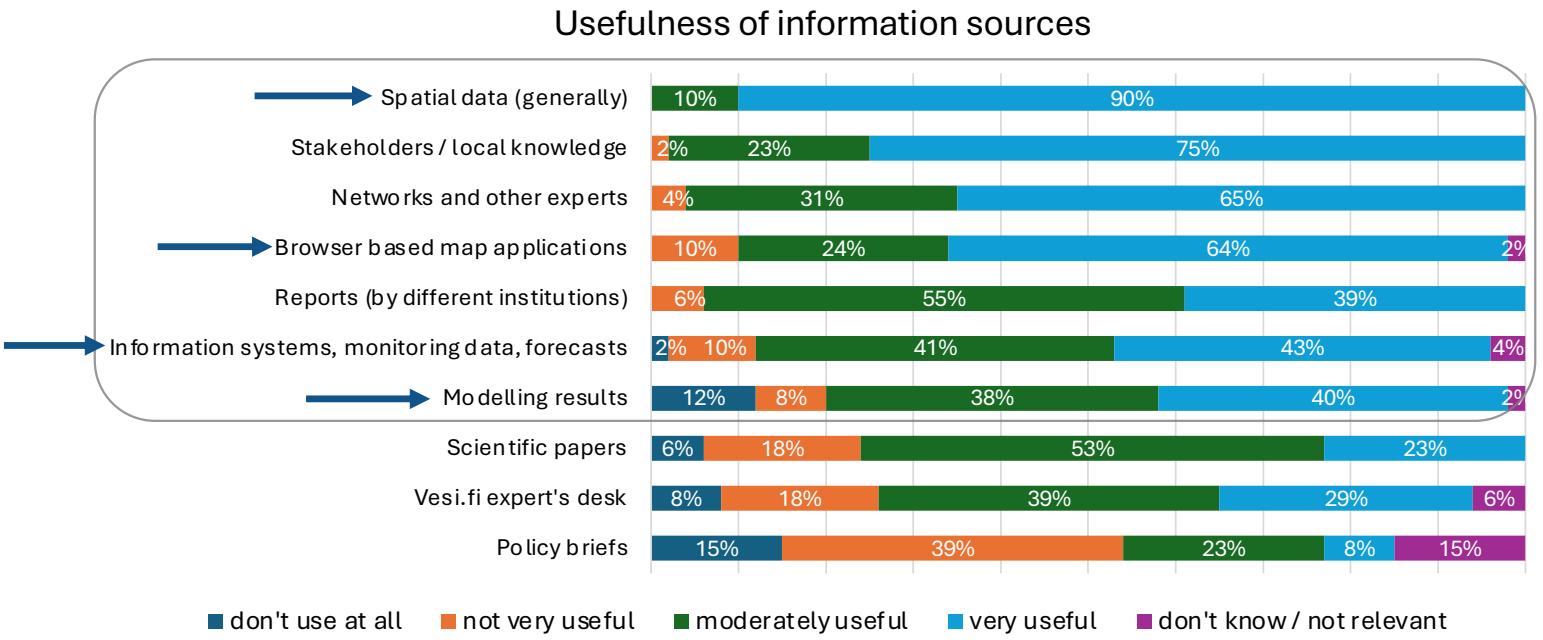
Actor group	Organisations	Responses	Total
National/regional level (ELY)	ELY-centres (10)	13	14
	Ministry	1	
Municipalities	Municipalities (16)	16	17
	Regional council	1	
Water associations	Water associations (3)	9	9
Research & education	Universities	2	4
	Research institutes (1)	2	
Private sector, sectoral organisations & others	Private sector & consultancies	3	7
	Sectoral organisations	3	
	Other	1	
			Total 51

Slide by Alexandra Malmström, Mirjami Lantto Klein, Mia Pihlajamäki, Marko Keskinen / Aalto University
Lauri Ahopelto, Mika Marttunen / SYKE

Information sources and services: current state / use

Digital Waters

Q: Which of the following sources of information do you use in your work?
Rate their usefulness in your tasks related to catchment-based planning



Important spatial datasets:

- catchment areas
- property borders and landownership
- land use and land cover
- soil characteristics
- ecological indicators, species, and protected areas
- flood maps
- stormwater sewer systems
- water quality/load
- water discharge
- groundwater
- sensitivity to erosion
- elevation

Slide by Alexandra Malmström, Mirjami Lantto Klein, Mia Pihlajamäki, Marko Keskinen / Aalto UniversityLauri Ahopelto, Mika Marttunen / SYKE

Information sources and services: current state / use

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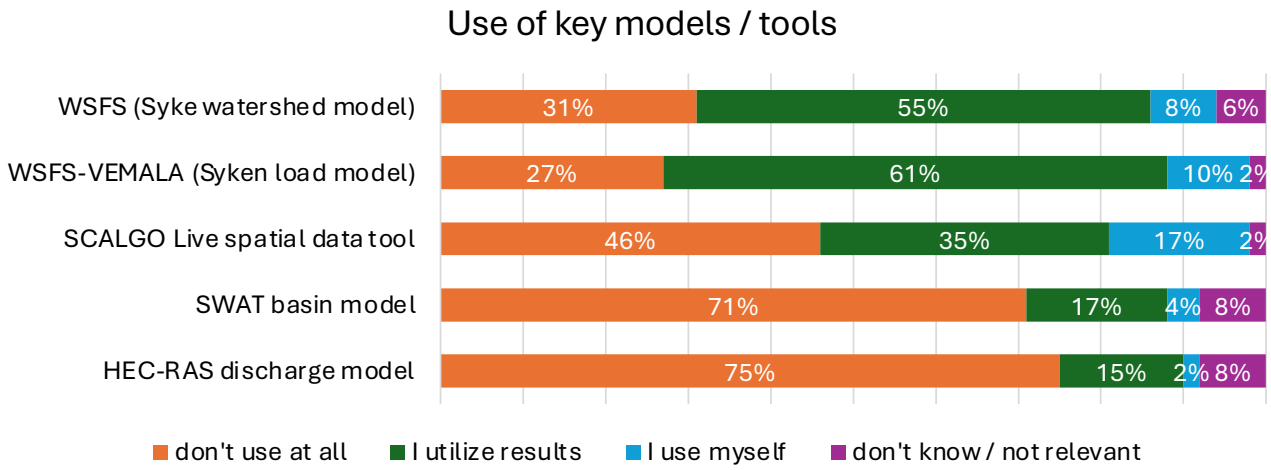
Q: Below is a list of various watershed and environmental models and tools used in water management. Do you use these models or their results in your work?



Few respondents reported using the models / tools themselves, but many reported utilising their results

→ Production of e.g., scenario reports based on models important

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Information sources and services

Key needs

- Sources and services accessible through one platform
- Integration of different types of data under the same service
- Spatial information regarding ongoing, planned, or implemented activities and measures
- Tools supporting the planning of water management measures
  - Helping with the identification of potential measures for a specific location / locations for specific measures
  - Modelling scenarios / impacts of measures
- Tools enabling the visualisation and demonstration of action impacts (to stakeholders)

Also...

Spatial datasets on:

- landowners
- automatic / continuous water quality / load monitoring
- more accurate elevation measurements / modelling (laser-scanned)
- better ecological and environmental data (e.g., protected species and areas)

Tools for:

- definition / delineation of catchment areas
- discharge / hydrology / flood risk modelling
- water quality / load modelling

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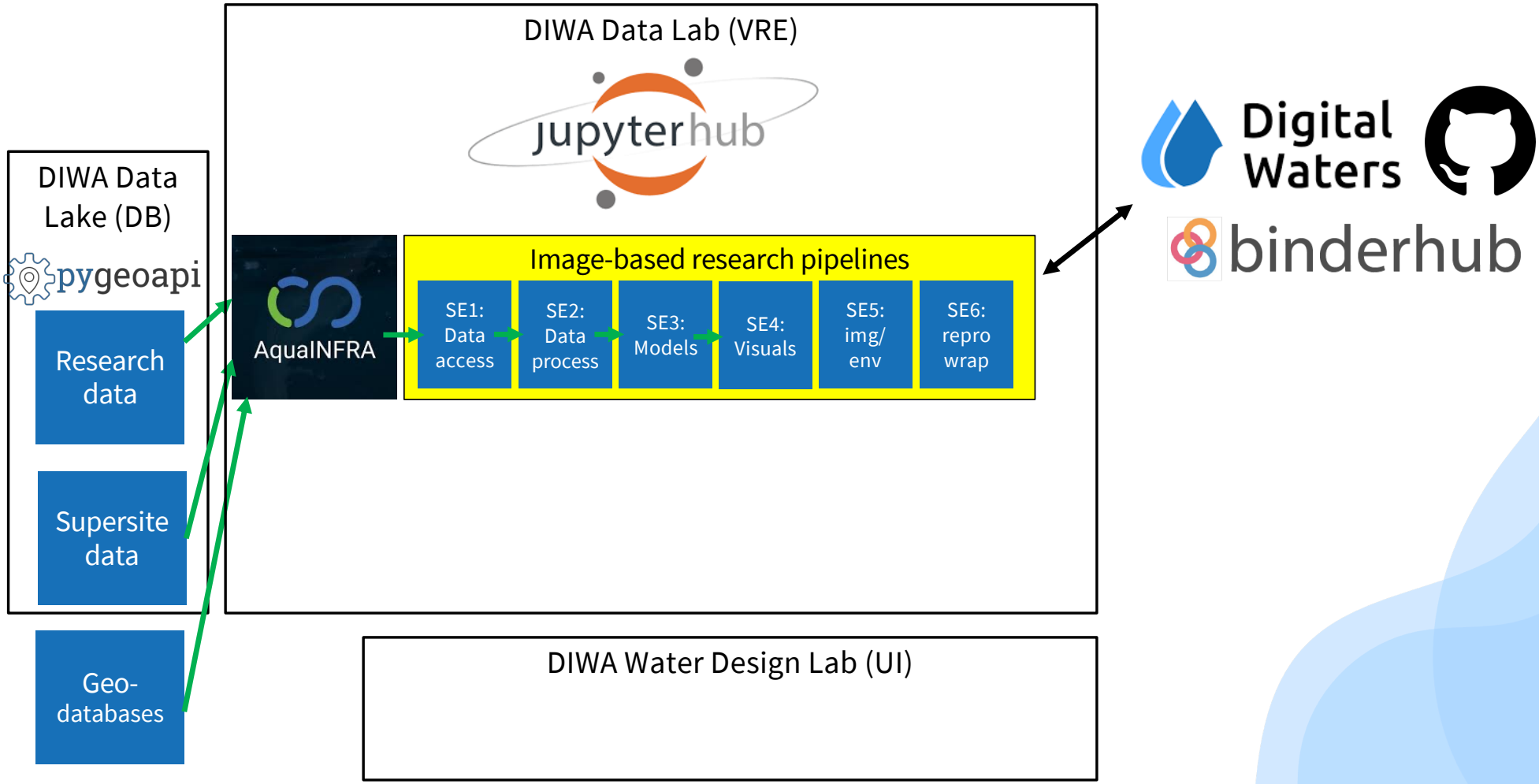
Planned DIWA Digital Twin Services

Researchers

Design + Management

- **DIWA DataLab:** a JupyterHub based virtual research environment with a BinderHub public access point promoting open science, training, and co-development of DT services (Dec 2025)
- **DIWA Data Discovery and Access Service**: a federated search that brings observations geodatabases, national infrastructure, supersites, and research into the DIWA DataLab (Spring 2026)
- **DIWA ReChat**: a knowledge-aware hydrology focused chatbot to empower development of data-to-knowledge pipelines on VRE (Fall 2026)
- **DIWA ModelLab:** coupled, interoperable process models with a robust data assimilation framework facilitating design and scenario evaluation (Spring 2027)
- **DIWA WaterLab:** user interfaces for the DIWA ModelLab that support stakeholder needs (Spring 2028)

Phase 1: Architecture



Phase 2: AI-supported research

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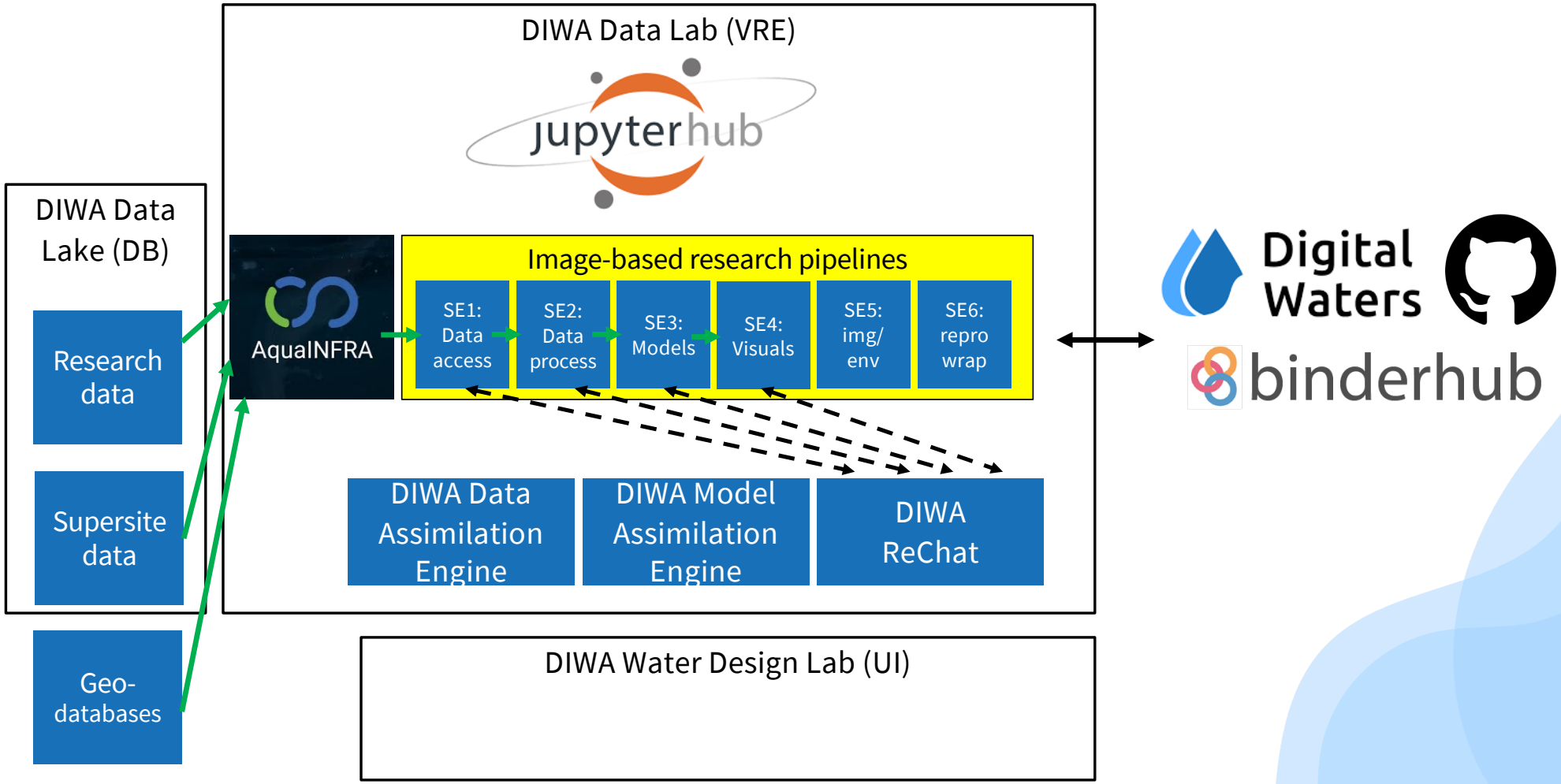

Phase 2: Models + Middlewear

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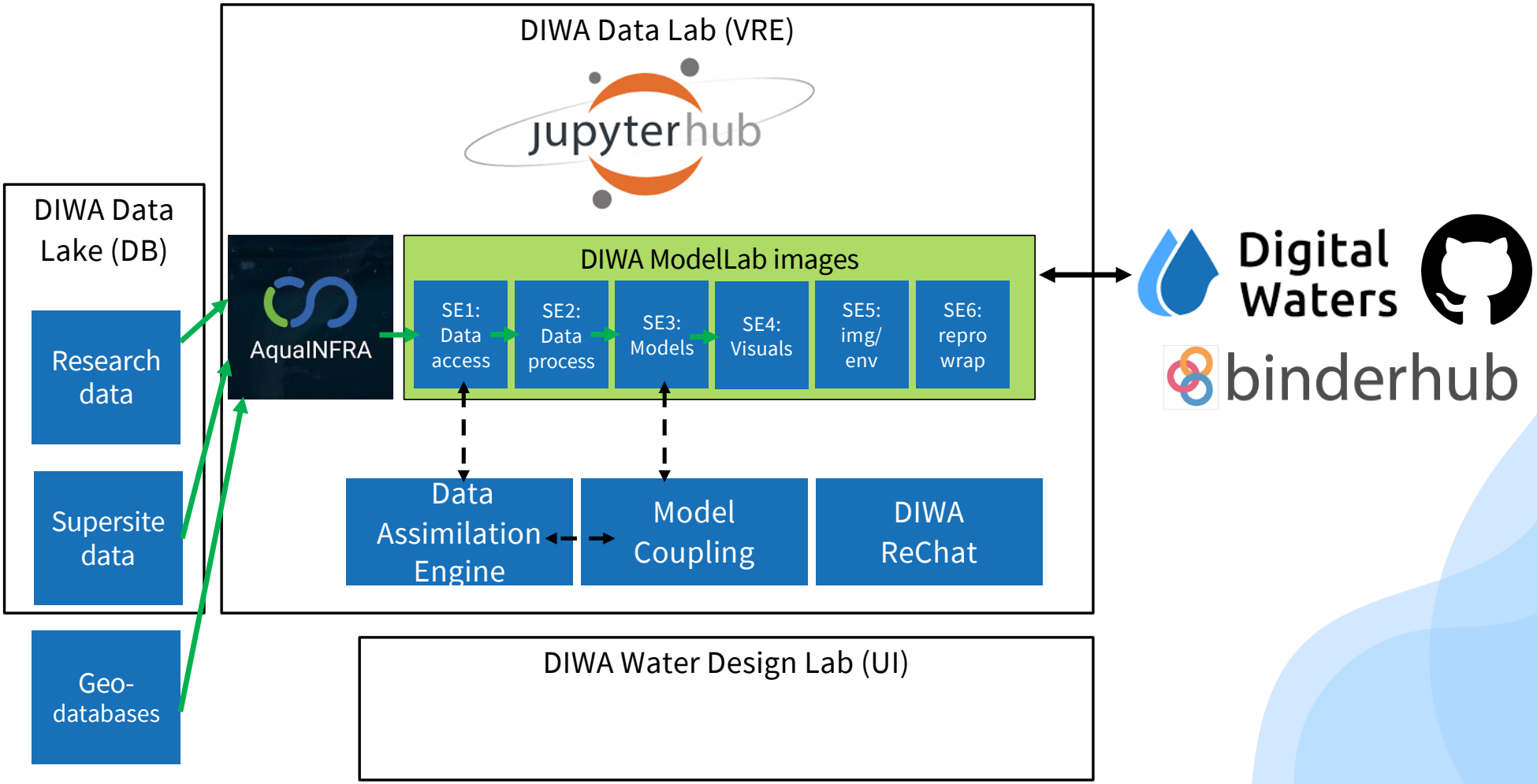

Phase 3: Data-driven design

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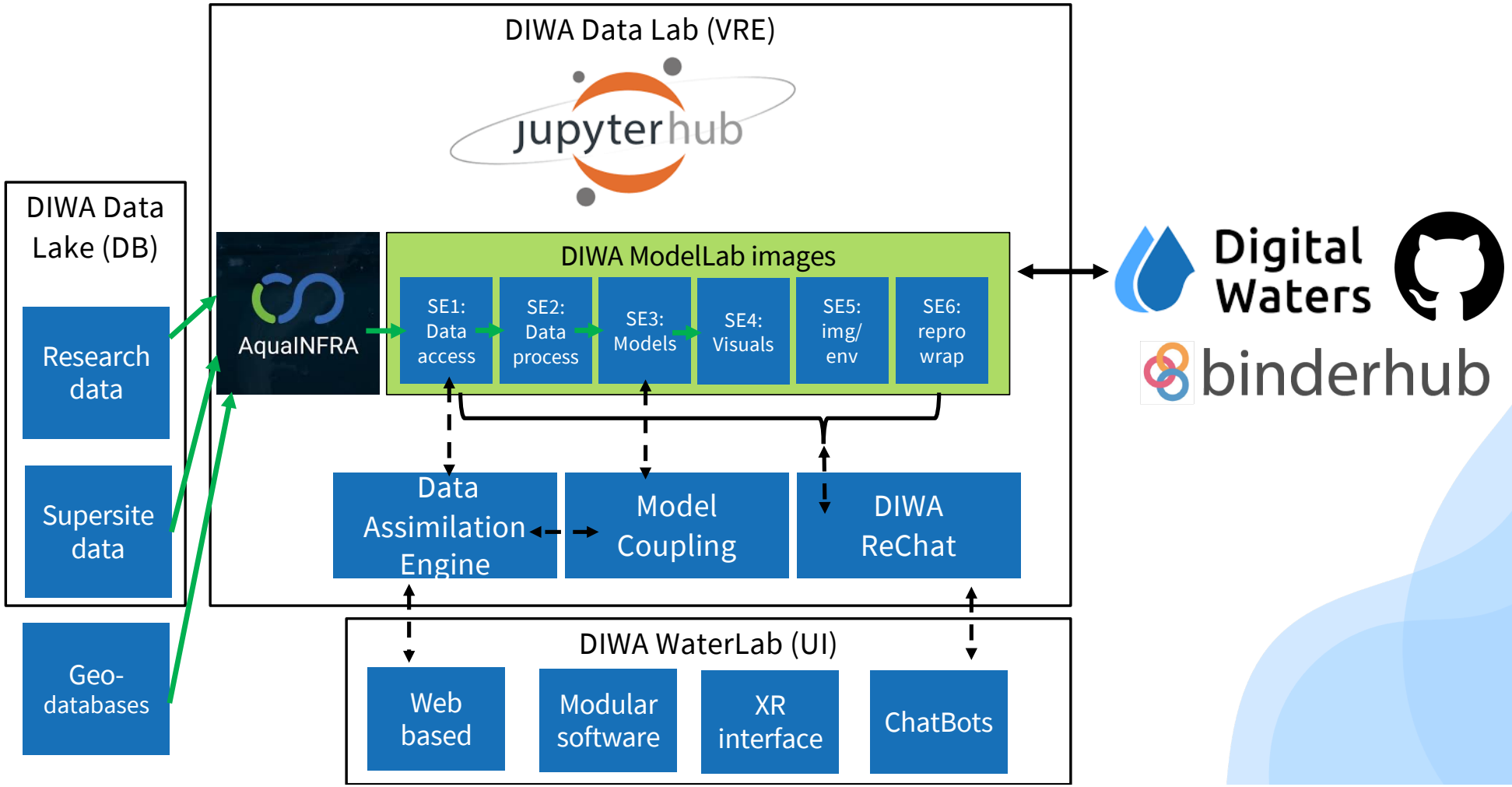

How DIWA services work together

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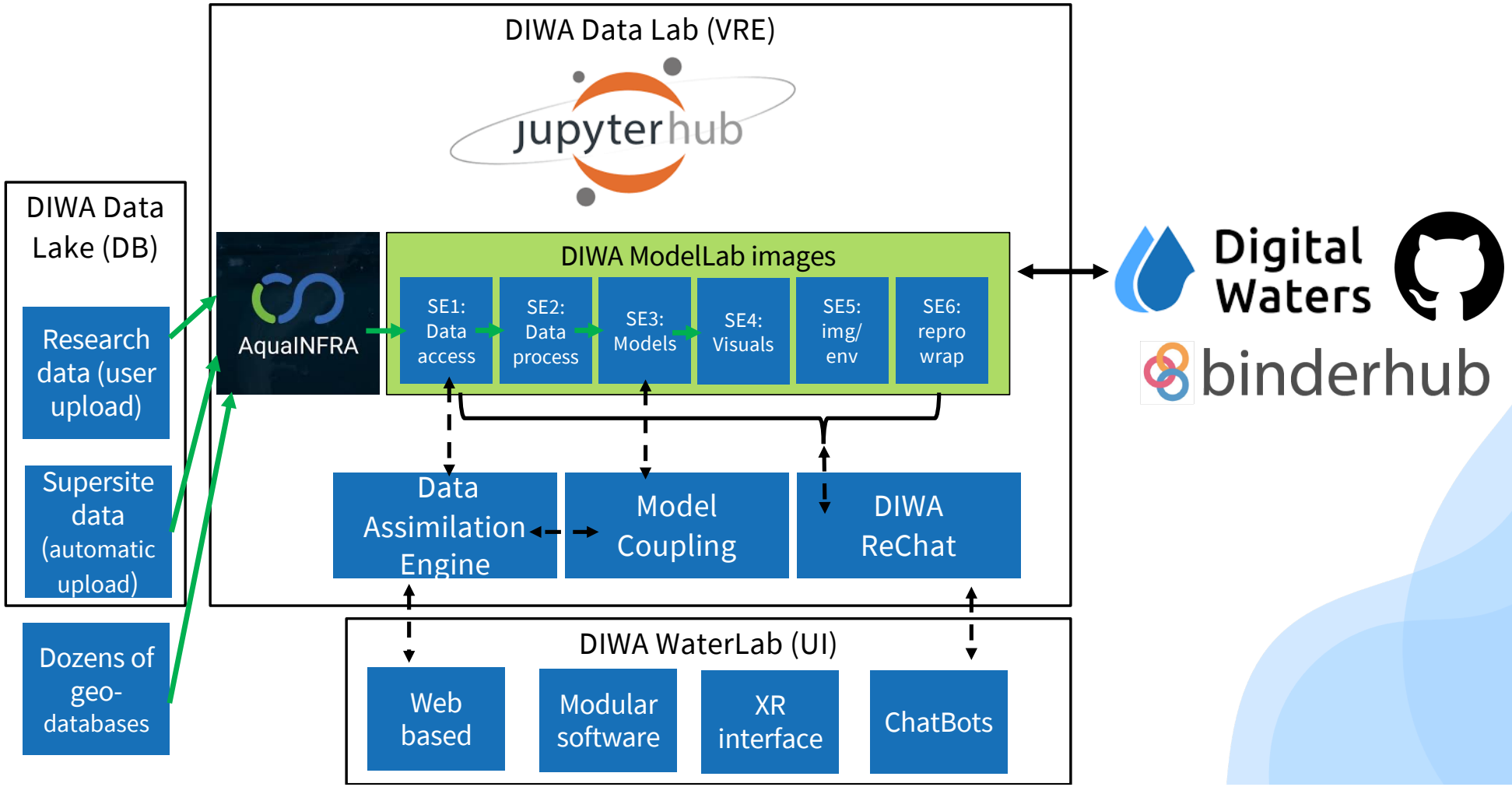

Summary: DIWA Digital Twin co-development

1. DIWA Data Lab: a JupyterHub environment for collaborative development.
    1. OGC Data Models + Development Standards: maximize interoperability
    2. User-driven workflow libraries accelerate development
    3. BinderHub + Voila + Dash enables research/public engagement with research code
2. DIWA ReChat: a domain-specialized, knowledge aware chatbot that leverages insight from DIWA researcher pipelines to modify software and code
3. DIWA Data Space: OGC compliant research data management + AquaINFRA-driven federated searches
4. DIWA ModelLab: coupled, interchangeable process + data driven models, with data assimilation, enabled by APIs, OpenMI, and CMI.
5. DIWA WaterLab: Scaffolding stakeholder-driven **user interfaces** to DIWA ModelLab to enable data-driven water management


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Thank you!
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Research Coordinator, Digital Twin Architecture
Digital Waters Flagship
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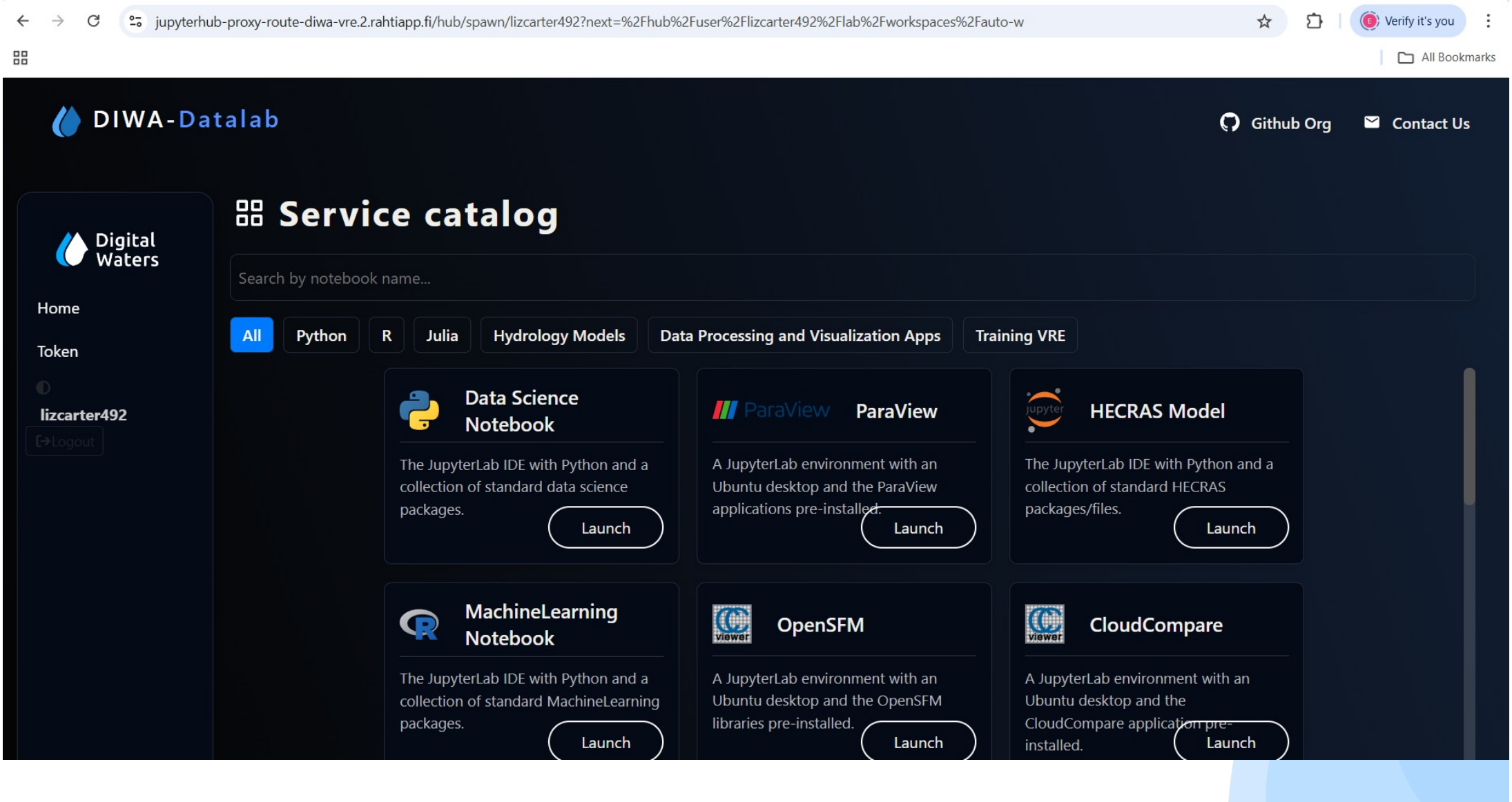
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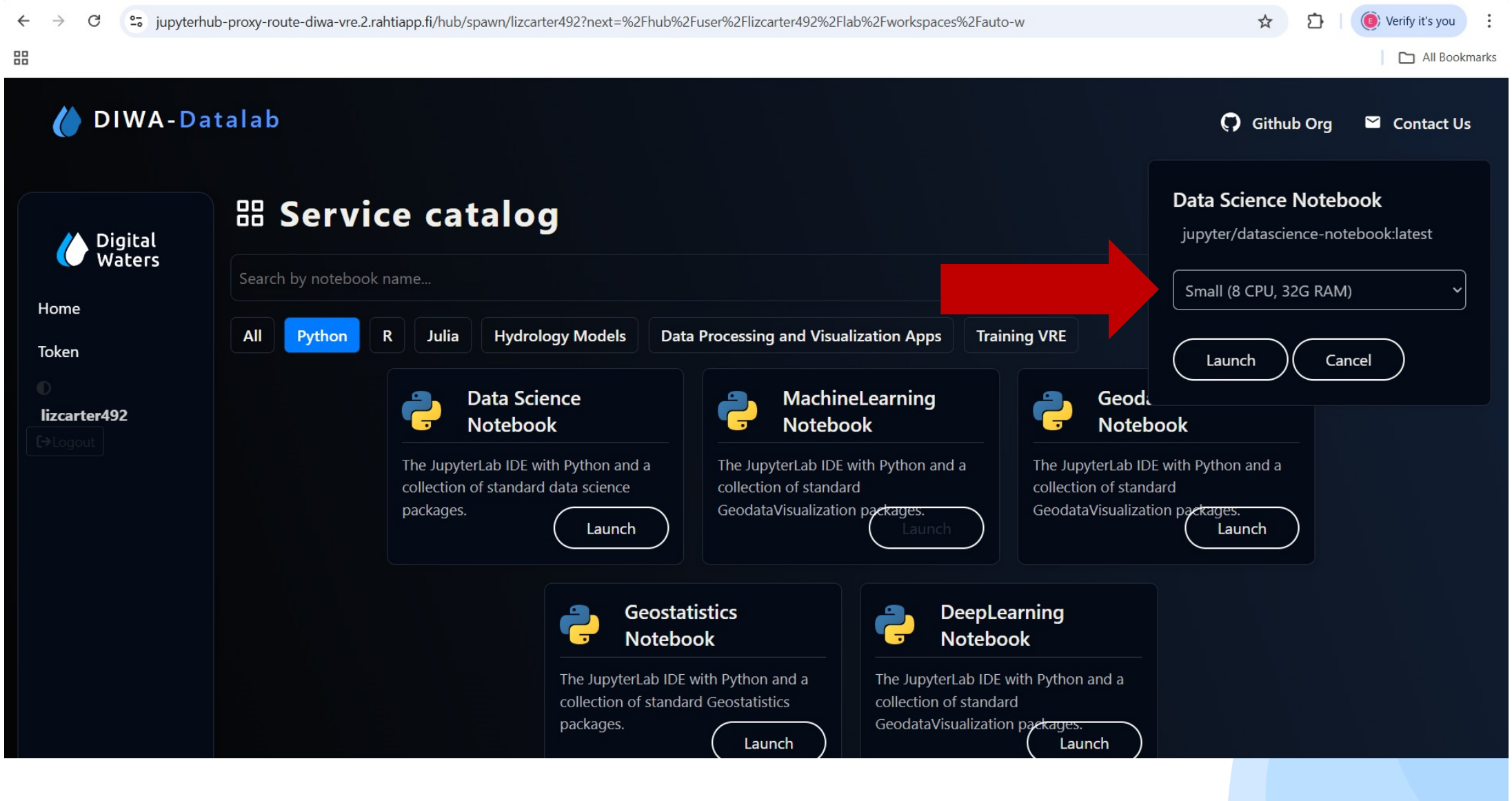
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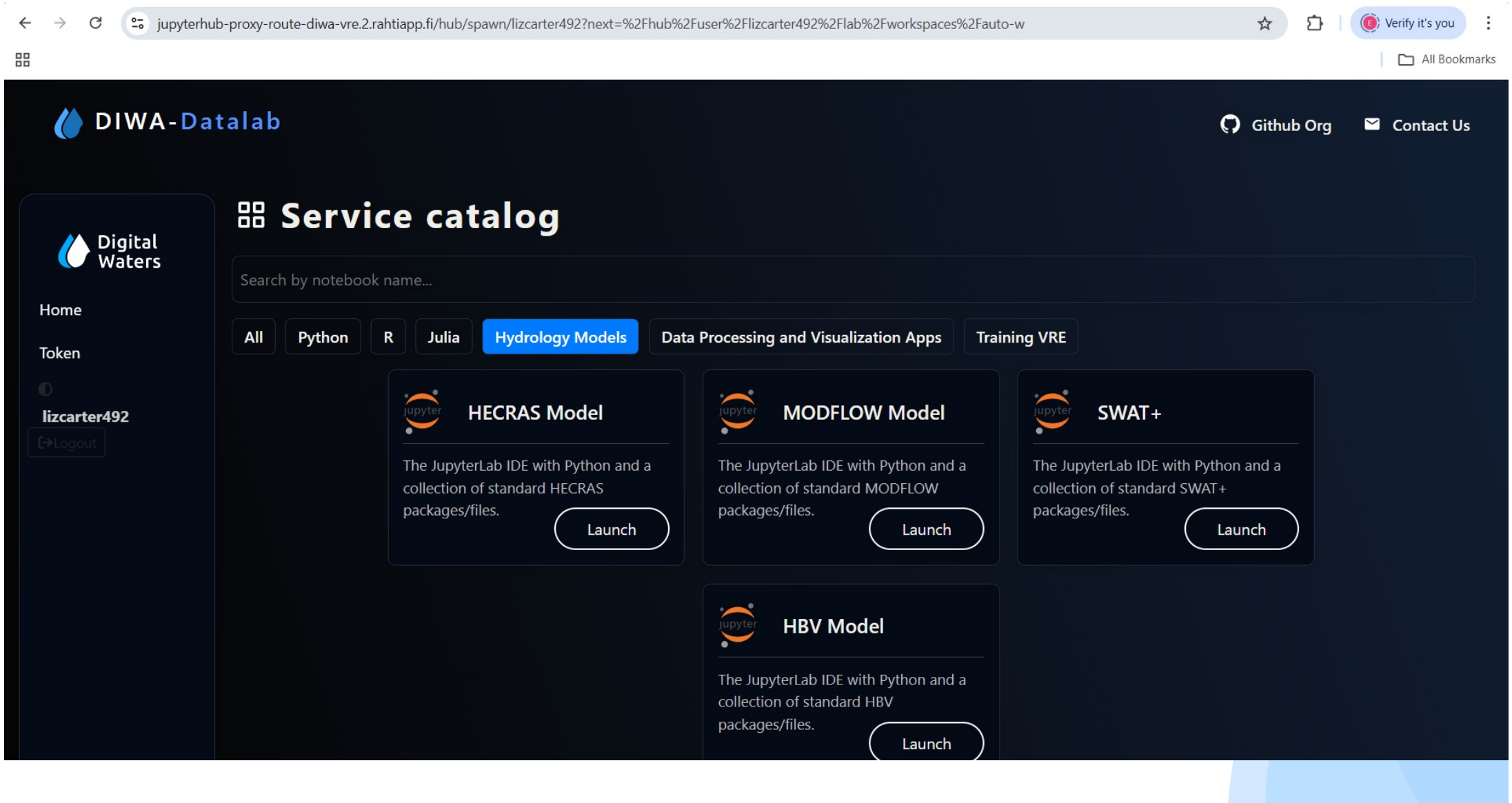
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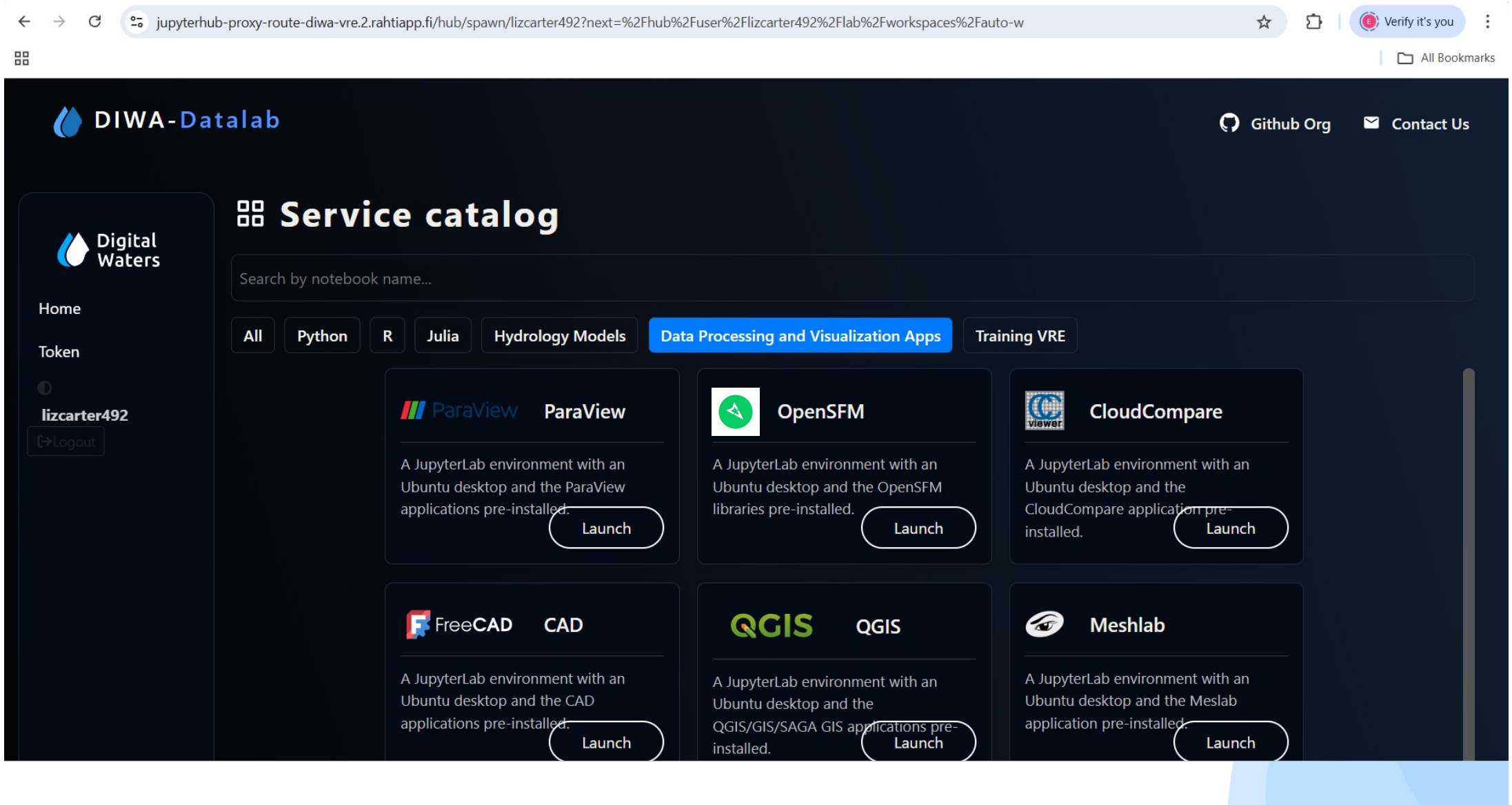
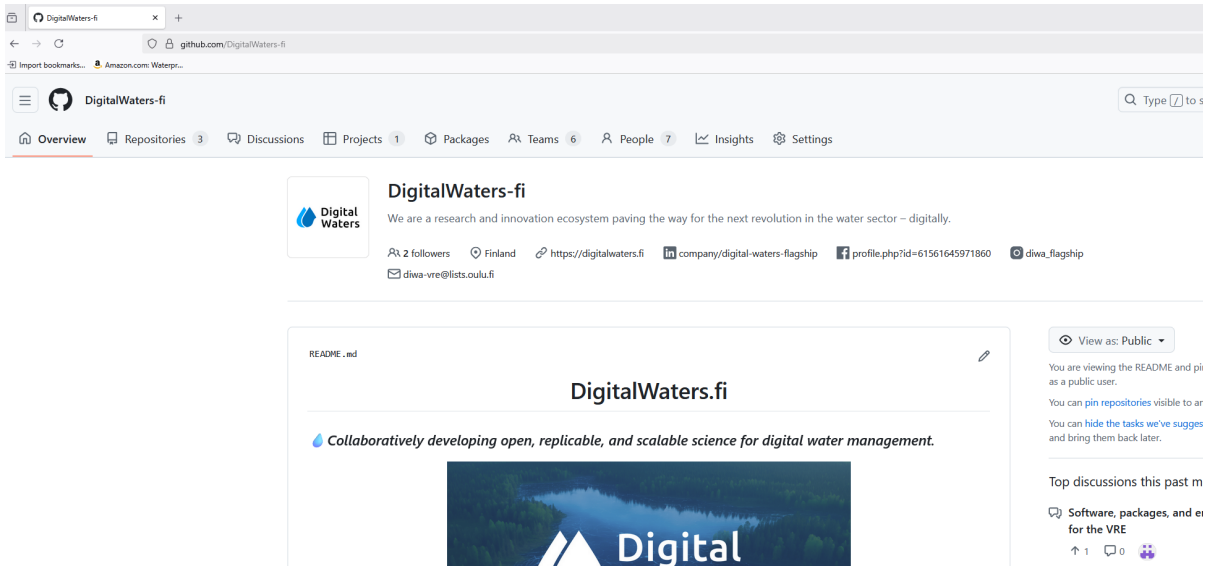
The JupyterLab IDE with Python and a collection of standard HBV packages/files.
Launch


jupyterhub-proxy-route-diwa-vre.2.rahtiapp.fi/hub/spawn/lizcarter492?next=%2Fhub%2Fuser%2Flizcarter492%2Flab%2Fworkspaces%2Fauto-w
Verify it's you
All Bookmarks
DIWA-Datalab
Github Org
Contact Us
Digital Waters
Home
Token
lizcarter492
Logout
Service catalog
Search by notebook name...
All
Python
R
Julia
Hydrology Models
Data Processing and Visualization Apps
Training VRE
ParaView
ParaView
A JupyterLab environment with an Ubuntu desktop and the ParaView applications pre-installed.
Launch
OpenSFM
A JupyterLab environment with an Ubuntu desktop and the OpenSFM libraries pre-installed.
Launch
CloudCompare
A JupyterLab environment with an Ubuntu desktop and the CloudCompare application pre-installed.
Launch
FreeCAD
CAD
A JupyterLab environment with an Ubuntu desktop and the CAD applications pre-installed.
Launch
QGIS
QGIS
A JupyterLab environment with an Ubuntu desktop and the QGIS/GIS/SAGA GIS applications pre-installed.
Launch
Meshlab
A JupyterLab environment with an Ubuntu desktop and the Meslab application pre-installed.
Launch

DigitalWaters.fi GitHub Organization



Scan QR code or visit
https://github.com/DigitalWaters-fi

- Public-facing hub for DIWA Digital repositories + images
- Coming soon: live hosting with BinderHub
- Develop, research, and collaborate
  - Version control, track contributions, undo mistakes.
- Access the DIWA DataLab and DataLake.
- Discussions, trainings, projects