The Riverplume Workflow

A tool to determine the impact of riverine extreme events on coastal biogeochemistry

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The Riverplume Workflow - A tool to investigate the impact of riverine extreme events on the marine environment

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Idea behind the workflow

Open Science & Collaboration

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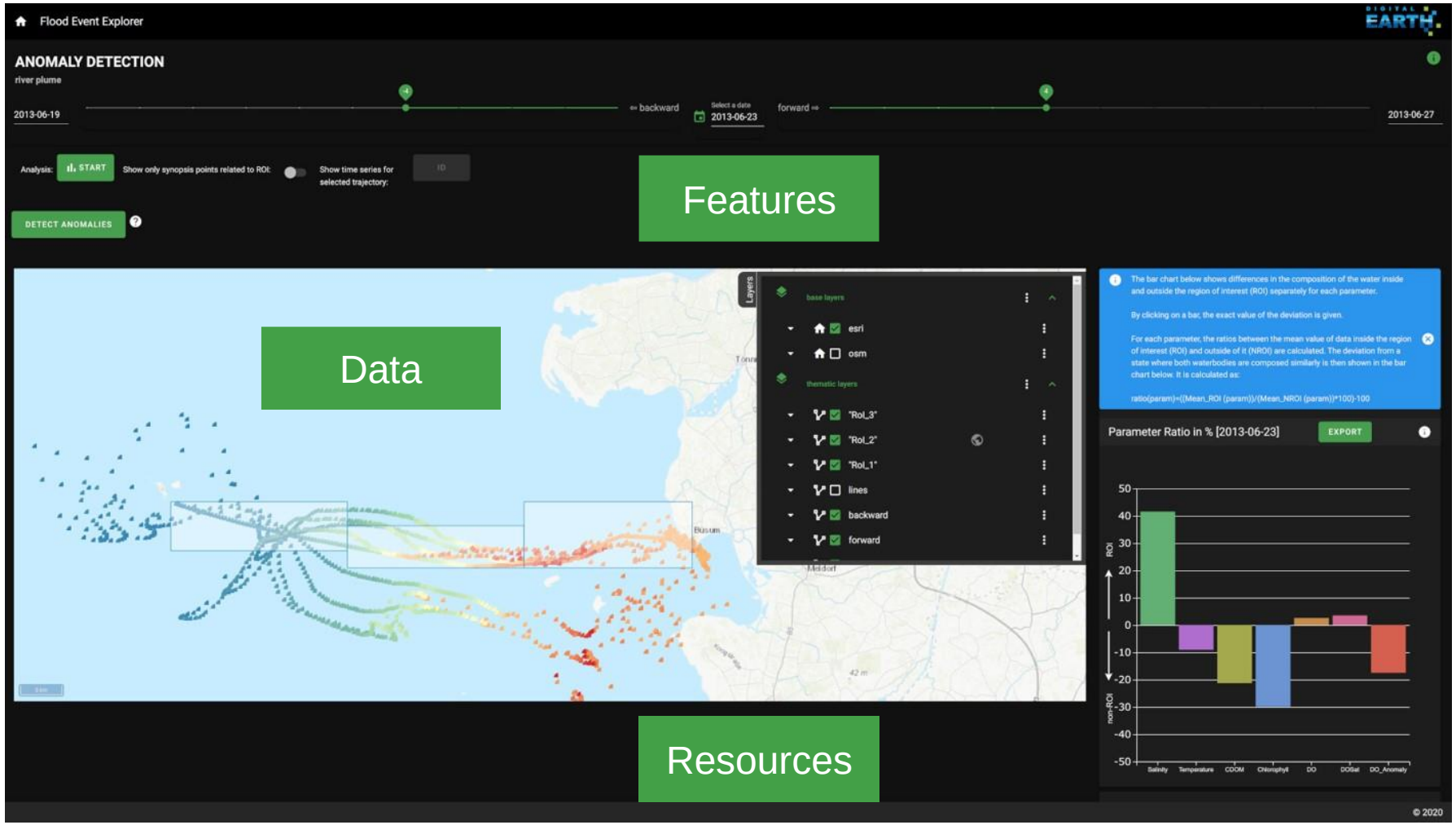

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The Idea Behind the Riverplume Workflow

Fluvial extreme events, such as floods and droughts, have an impact beyond the river bed. The change in river discharge and concentration of nutrients and pollutants in freshwater also **affects coastal waters**, esp. their biogeochemistry. Examining these impacts has been traditionally difficult, as one needs to first **detect the river plume in the seawater and then infer its spatio-temporal extent**. The River Plume Workflow was developed to support researchers with these tasks and enable them to identify regions of interest, as well as provide tools to conduct a preliminary analysis of the riverine extreme events' impacts on the coastal waters.

The Riverplume Workflow is an open source software tool to detect and examine freshwater signals as anomalies in marine observational data. Data from a FerryBox, an autonomous measuring device installed on a commercial ferry, provide regular coverage of the German Bight, the region for which we developed this toolbox. Combined with **drift model computations**, it is possible to detect anomalies in the observational data and to comprehend their propagation and origin.

An instance of the Riverplume Workflow is hosted by Helmholtz-Zentrum Hereon and will soon be publicly available. It is also possible to install the tool locally. The workflow was designed to be easily modified to investigate other regions and types of anomalies, so other applications are possible.

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For more on the Scientific Workflow, please see next slide.

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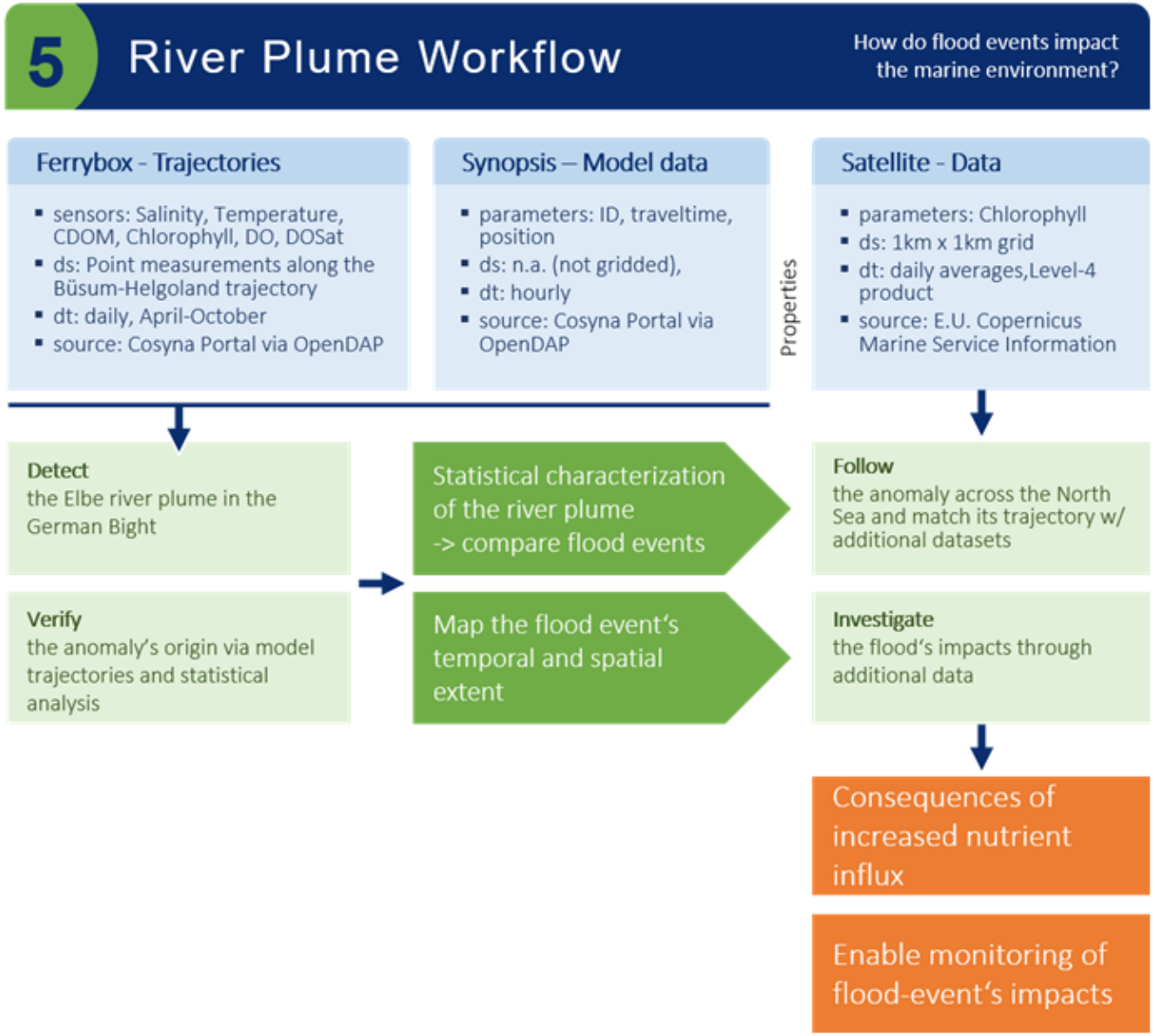
The Scientific Workflow

A prototype of the Riverplume Workflow was developed in the ***Digital Earth project*** as part of the Flood Event Explorer.

Learn more about DIGITAL EARTH

The flowchart on the right explains the steps and data necessary to find a river plume and follow it on its way through the sea.



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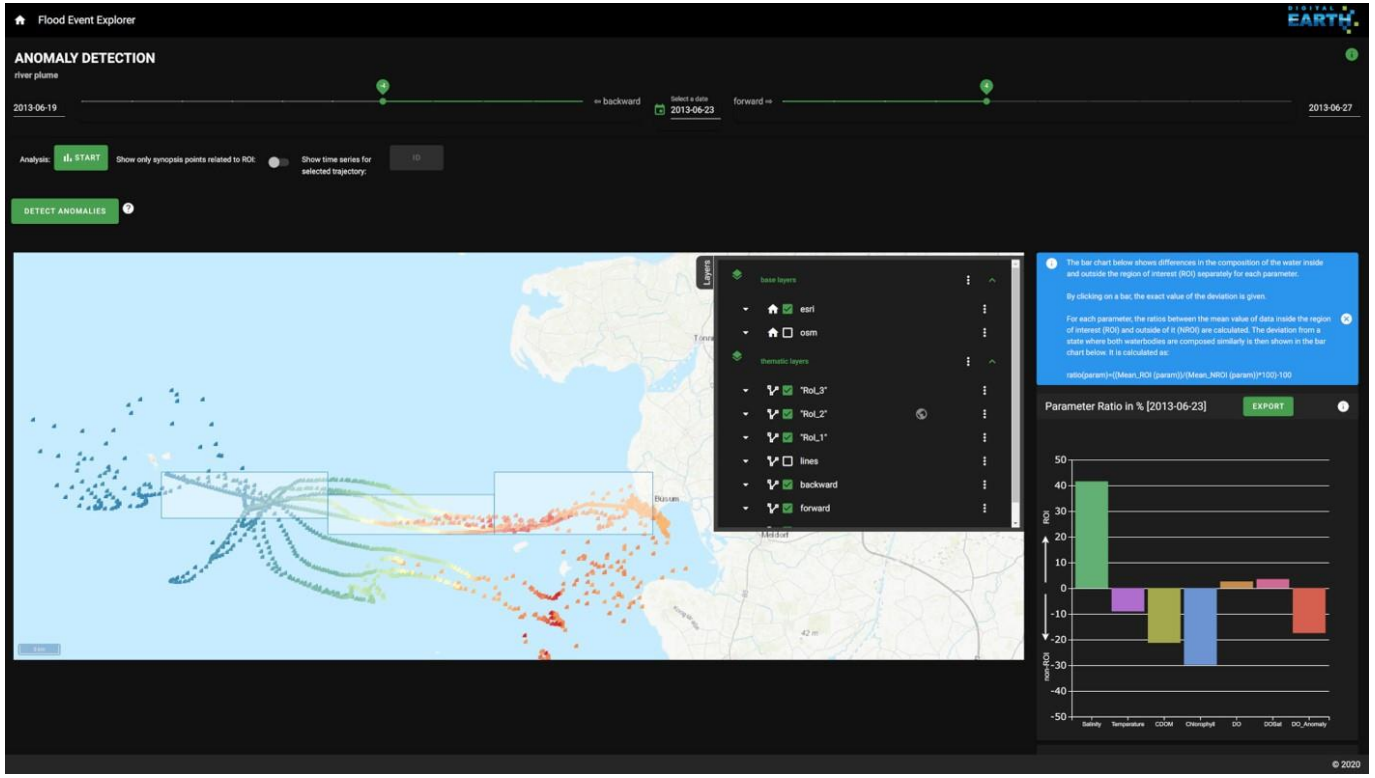
Features of the Riverplume Workflow

Overview

- Automatic Data Processing
- Interactive Map
- Anomaly Detection
- Composition Analysis
- Timeseries Generation



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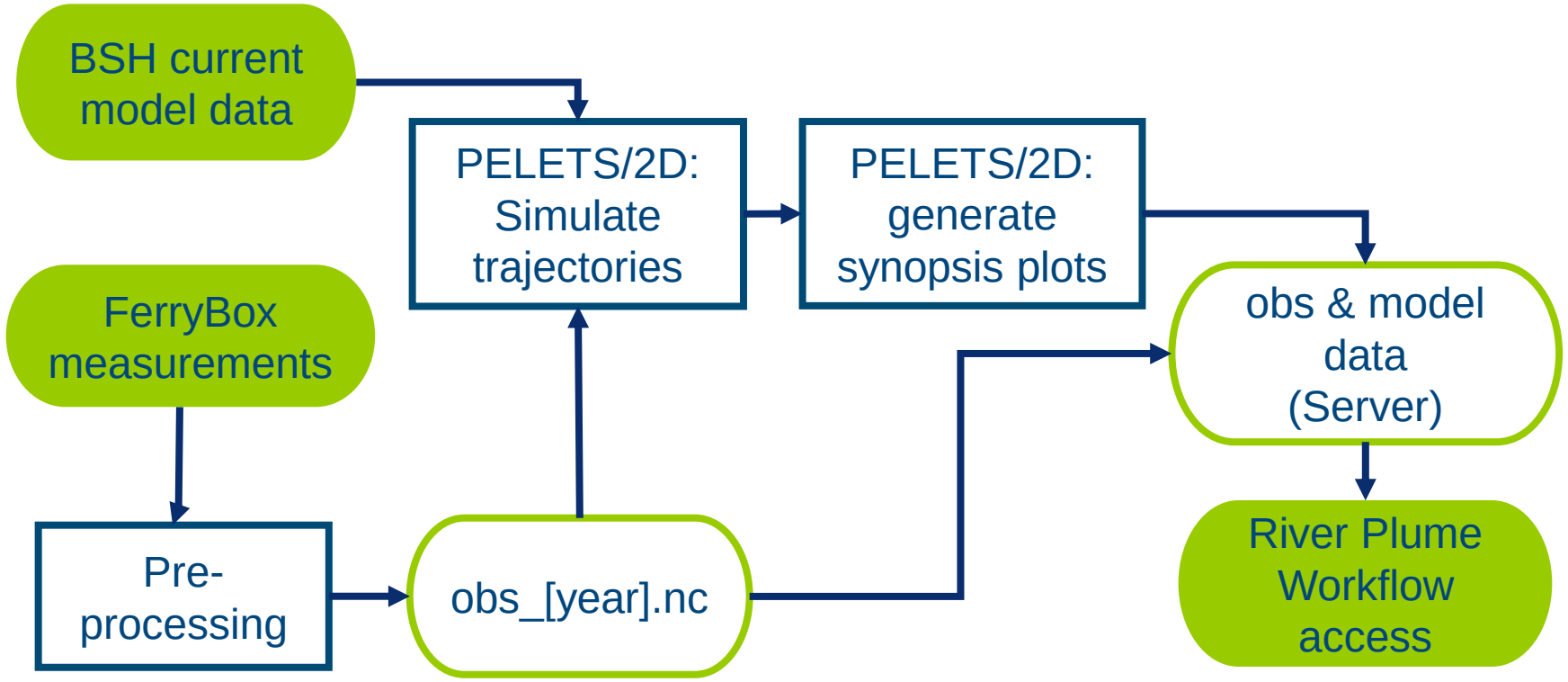
Features of the Riverplume Workflow

Automatic Data Processing



- FerryBox data: automatically downloaded, pre-processed & product uploaded (crontab & python scripts)
- Daily updates
- Plan: automatize model data production as well
- Upload it to a Hereon server to be accessed by the Riverplume Workflow

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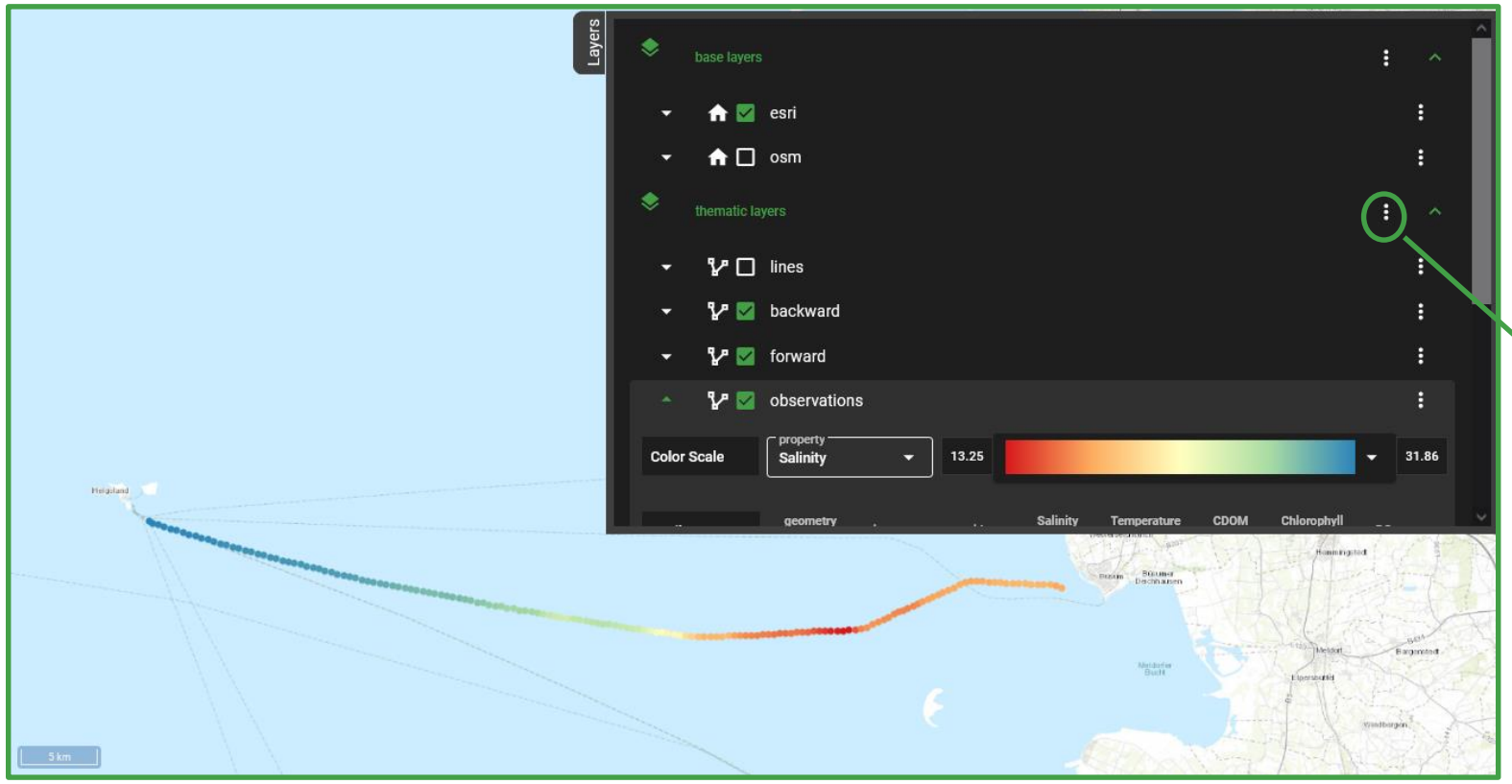
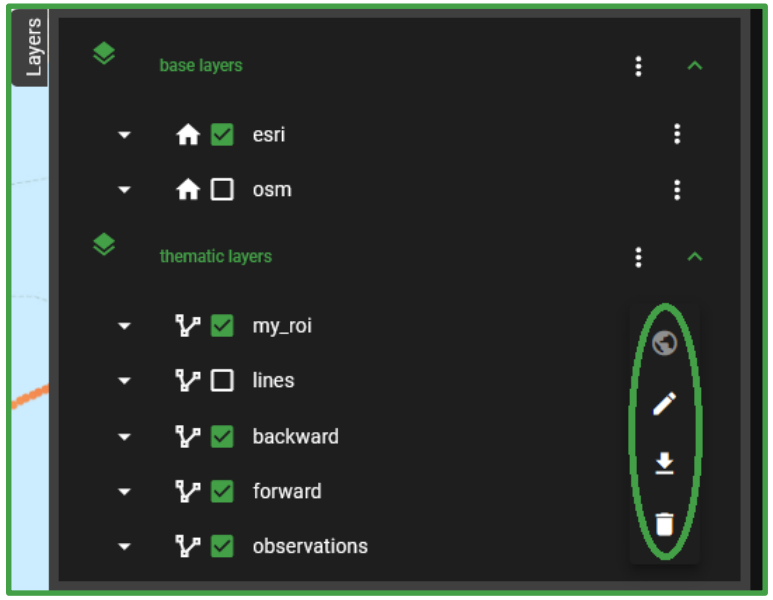
Features of the Riverplume Workflow

Interactive Map





The interactive map offers various visualization options, as well as options to add user-defined layers.

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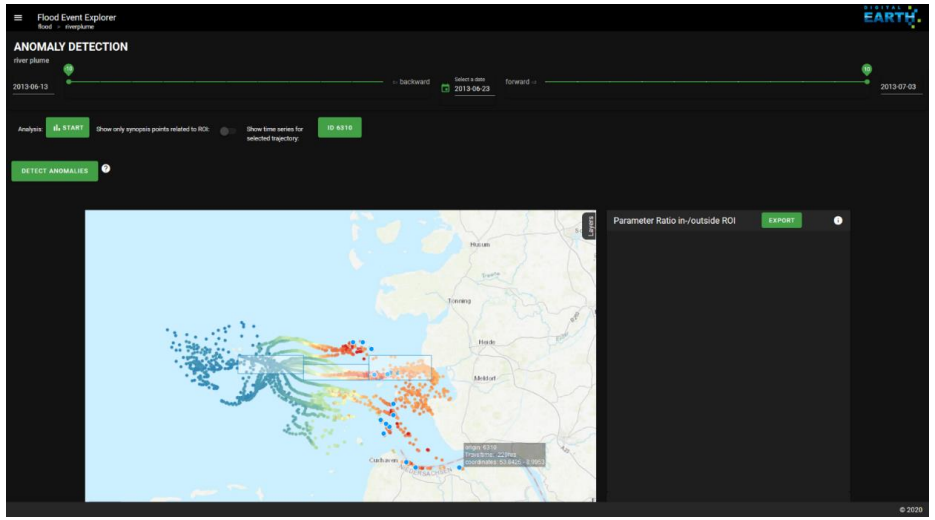
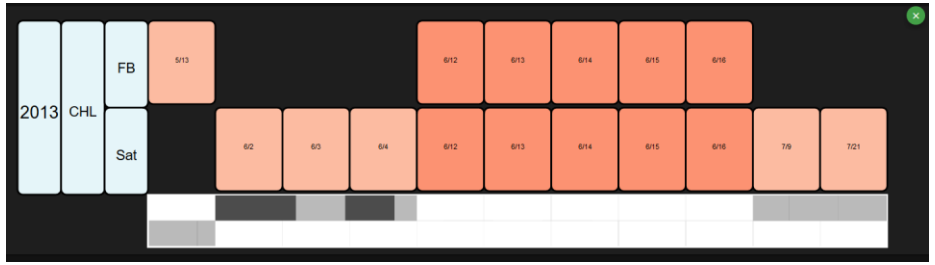
Features of the Riverplume Workflow

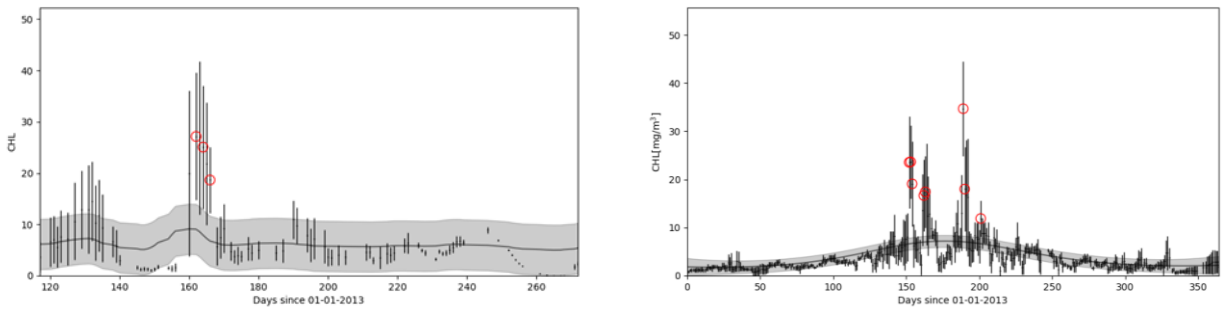
Anomaly Detection



MANUALLY identify anomalies through the interactive map or identify candidates with the **AUTOMATIC** anomaly detection feature.



Automatic Anomaly Detection



Daily chlorophyll measurements for in-situ FerryBox (left) and satellite data (right). The continuous line represents the **GAUSSIAN REGRESSION** generated distribution from a whole year of data, while the shaded grey band is the confidence region. The red circles indicate detected anomalies.

The results of the automatic anomaly detection are presented in the Riverplume Workflow as shown on the left.
The graphic shows the year, parameter, measurement device (FerryBox or Satellite measurements), and the dates of the month with anomalies. The brighter the date is marked, the more anomalous is the measurement of that day compared to the data of that year.

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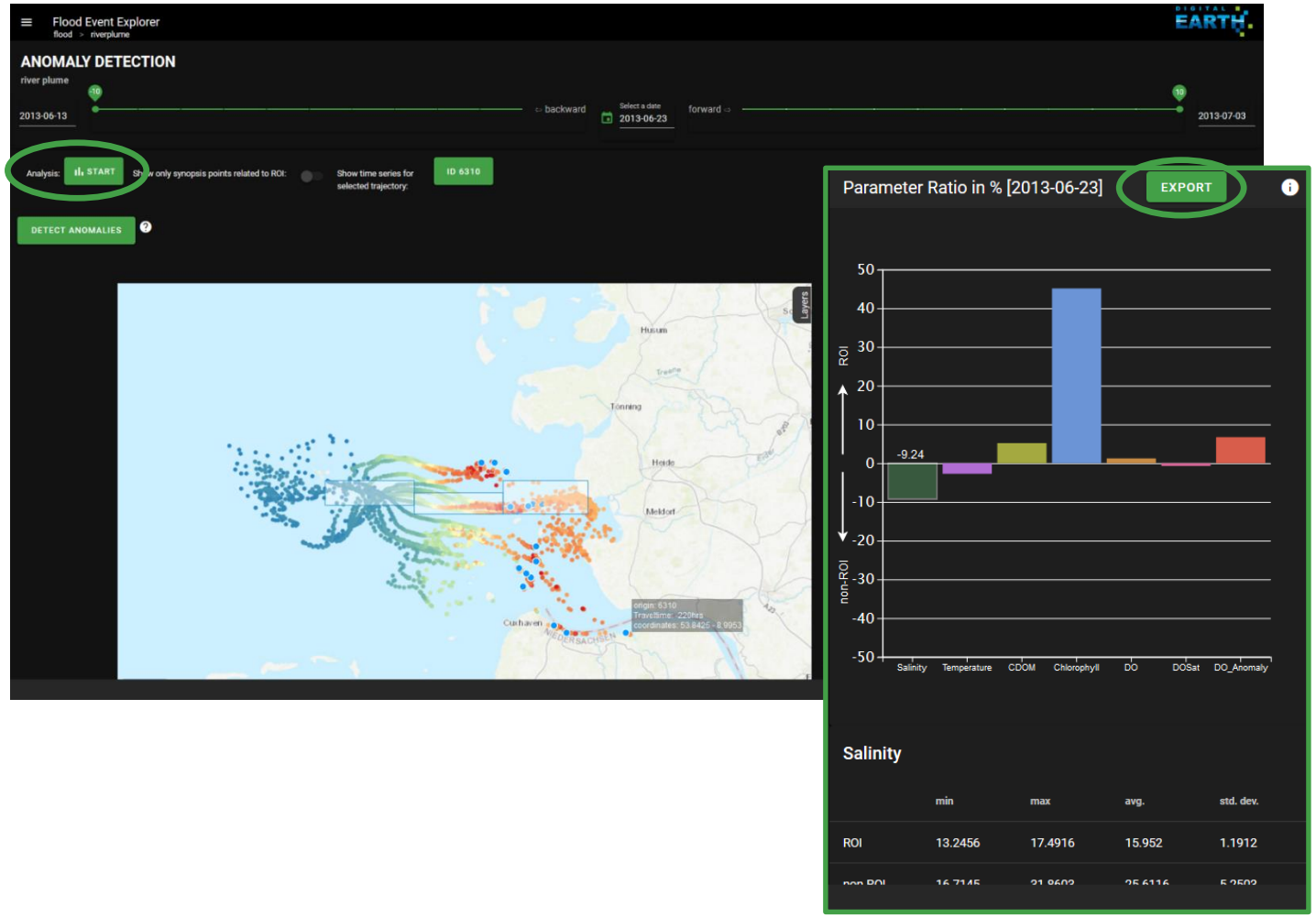
Features of the Riverplume Workflow

Composition Analysis



Compare water composition inside and outside a region of interest (ROI). The ROI can be selected inside the Workflow's interactive map from the available FerryBox data.

See results as bar chart and table (left). The bar chart shows the deviation of values inside the ROI from the outside in percent, separately for each parameter. The table gives more details on minimum, maximum, average and standard deviation in the two groups.

The results can be exported in csv format, including the definition of the ROI that was used for the analysis .

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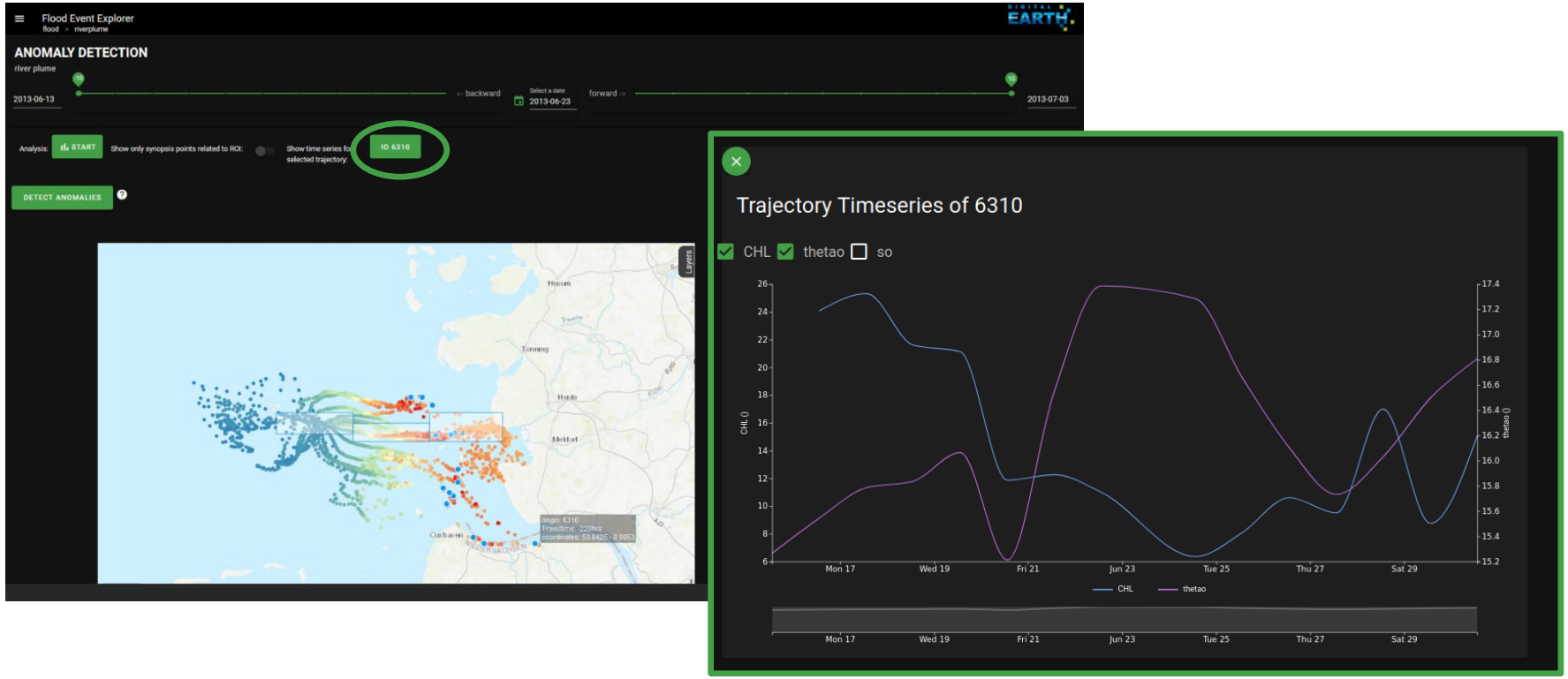
Features of the Riverplume Workflow

Timeseries Generation



Generate Timeseries by matching satellite data with model trajectories of water bodies.

Available parameters: Chl-a, oxygen and salinity.
Select a FerryBox measurement/ matching model trajectory for time series generation in the interactive map.

Investigate processes in the river plume along its way through the German Bight.

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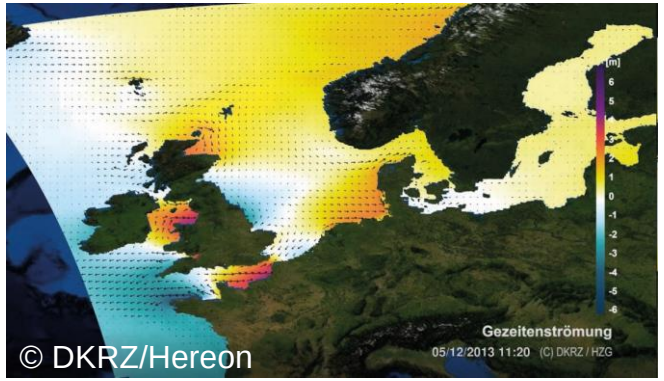
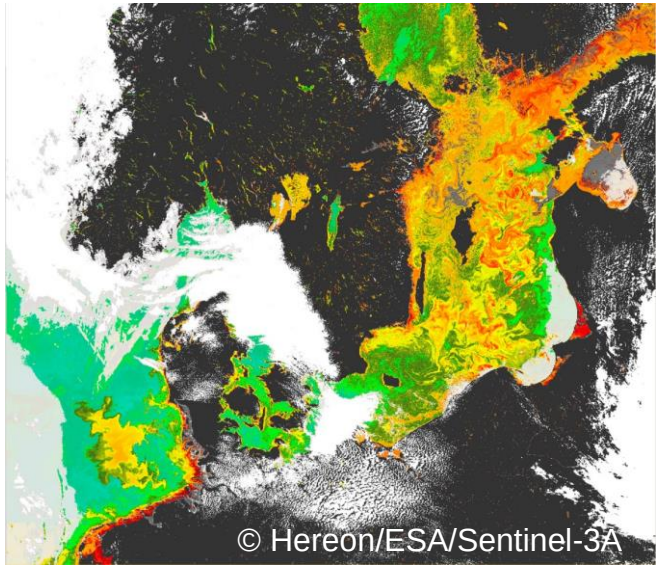
Overview of Data Sources

The Riverplume Workflow uses three types of data:

FerryBox Measurements



Model Trajectories



Satellite Data

The data processing and uploading is in part automatized: Automatic Data Processing

Data Sources:
FerryBox Measurements

Observational data originating from an autonomous measuring device called FerryBox on the Büsum-Helgoland ferry “Funny Girl”

Season: daily from April to October since 2008
(Data from 2013 to today is available through the Riverplume Workflow)

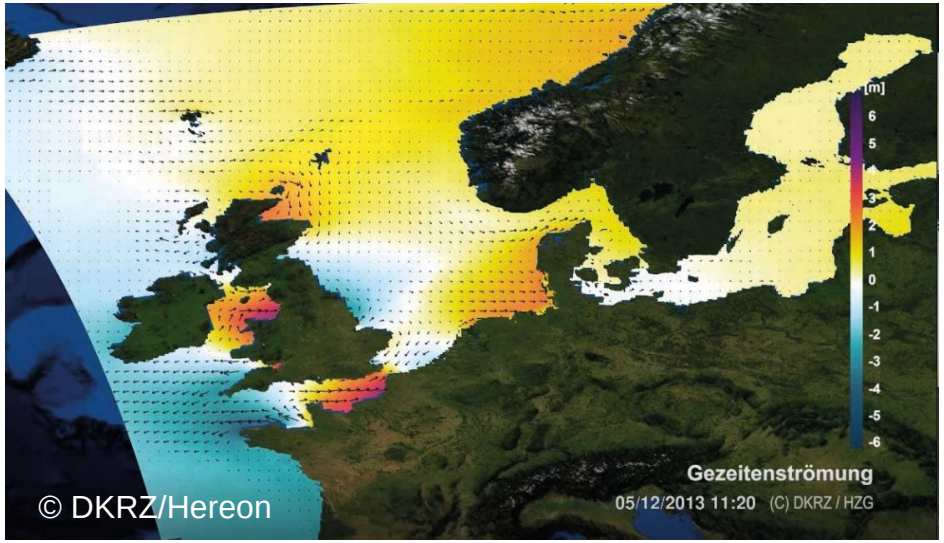
Automatic preprocessing: automatic download through the Helmholtz Coastal Datacenter Datasearch API, daily updates, implemented in python

Parameters:
Chl-a, Salinity, DO, pH, SST, (CDOM)

Data Sources:
Model Trajectories

Model trajectories resp. synopsis plots are used to investigate the origin of an anomaly and to estimate the spatio-temporal extent of the river plume.
They are simulated trajectories of particles starting on the FerryBox transect at the time of the original observation and modelled backwards and forwards in time for up to 10 days that are generated with the PELETS/2D program.

Automatic preprocessing is under development; currently model trajectories are only available for the Elbe flood event form 2013.



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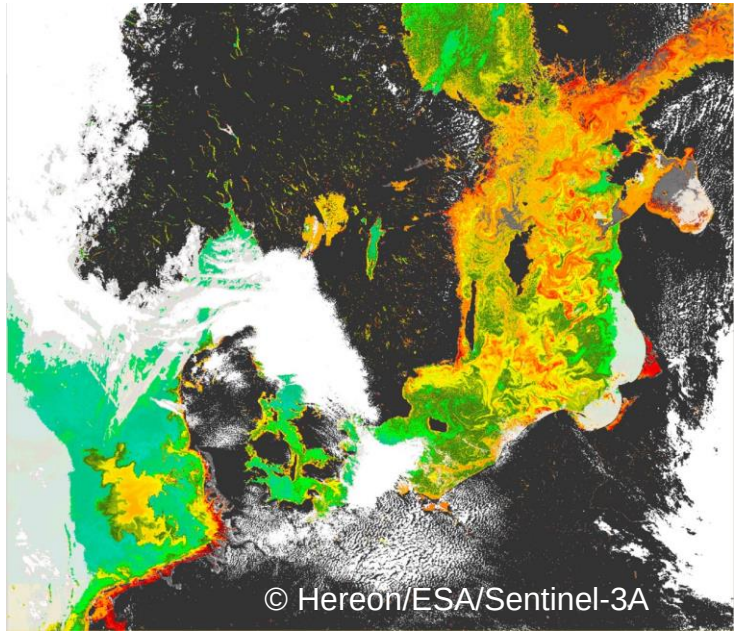
Data Sources:
Satellite Data

We use satellite data from the Copernicus Monitoring Environment Marine Service (CMEMS) in our functions to detect anomalies and to generate time series along the model trajectories.

Datasets:

- CMEMS North Atlantic Chlorophyll (Copernicus-GlobColour) from Satellite Observations: Daily Interpolated (Reprocessed from 1997)
- CMEMS Atlantic-European North West Shelf-Ocean Physics Reanalysis.

Satellite datasets have to be downloaded manually from the CMEMS website; currently satellite data is only available for the Elbe flood of 2013 through the Riverplume Workflow.



Open Science & Collaboration

Developed in the *Digital Earth* project, the Riverplume Workflow adheres to the **Open Source** and **FAIR** principles.

We put emphasis on:

- Modular code structure for reusability
- Open Source licensing
- All code is (or will be soon) publicly available
- Documentation and other related publications are also Open Source
- Use of DOIs for improved findability

The Riverplume Workflow uses the **Distributed Analysis Software Framework (DASF)**, another outcome of the Digital Earth project. It allows to combine analyses on distributed data sets to workflows, so that computationally expensive computations can happen close to where the data is hosted.

This way, DASF supports collaborations among scientists and enables a more holistic view of floods (or other subject matters).

Learn more about DASF

Learn more about DIGITAL EARTH

The Digital Earth Flood Event Explorer

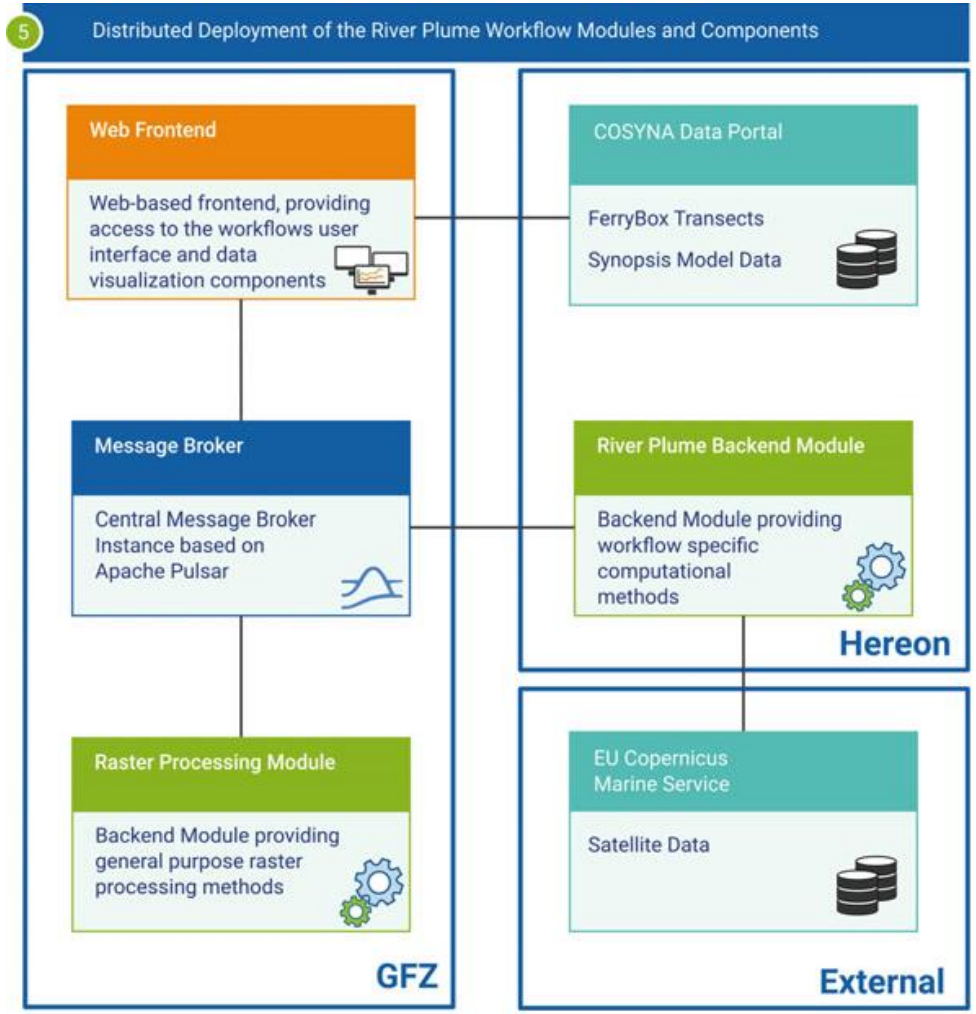
Explore riverine extreme events from generation to impact

„The objective of Digital Earth is to improve the working environment for integrated data-driven science that allows comprehensive exploration and analysis of existing data across disciplines. In Digital Earth, we test and demonstrate how integrated data-driven science has to be implemented in the future, what innovative results it can produce and how multidisciplinary collaboration can be successfully implemented. “

More on the Flood Event Explorer:
https://digitalearth-hgf.de/results/workflows/flood-event-explorer/

From the Digital Earth Website:
digitalearth-hgf.de/

Distributed Analysis Software Framework



*"The **D**ata **A**nalytics **S**oftware **F**ramework DASF supports scientists to conduct data analysis in distributed IT infrastructures by sharing data analysis tools and data. For this purpose, DASF defines a remote procedure call (RPC) messaging protocol that uses a central message broker instance. Scientists can augment their tools and data with this protocol to share them with others or re-use them in different contexts."*
(from the DASF documentation)

Eggert, Daniel; Dransch, Doris (2021): DASF: A data analytics software framework for distributed environments. GFZ Data Services. https://doi.org/10.5880/GFZ.1.4.2021.004

Due to the end of the Digital Earth project, Helmholtz-Zentrum Hereon took over hosting the complete Riverplume Workflow, but the potential to incorporate distributed analyses is still there.

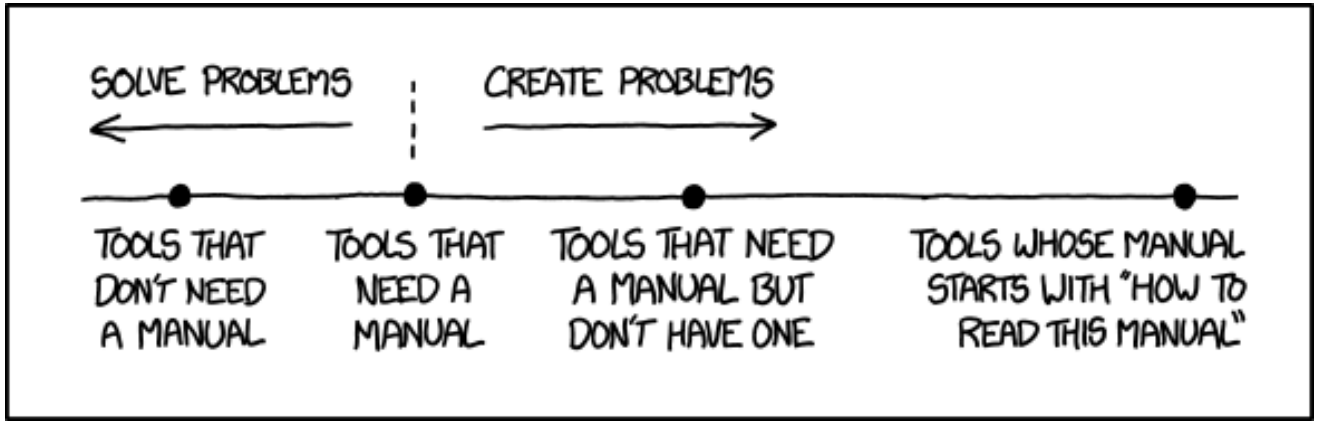
Overview of Resources

Tutorial Video

Documentation

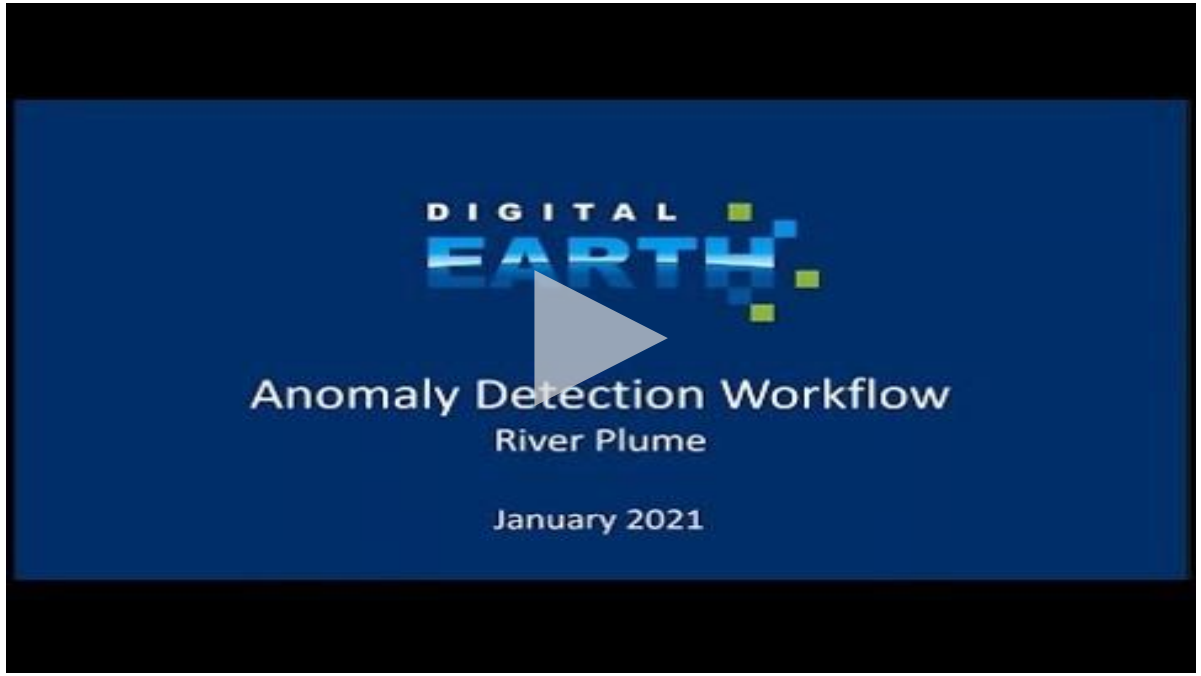
Code Repositories

E-Book



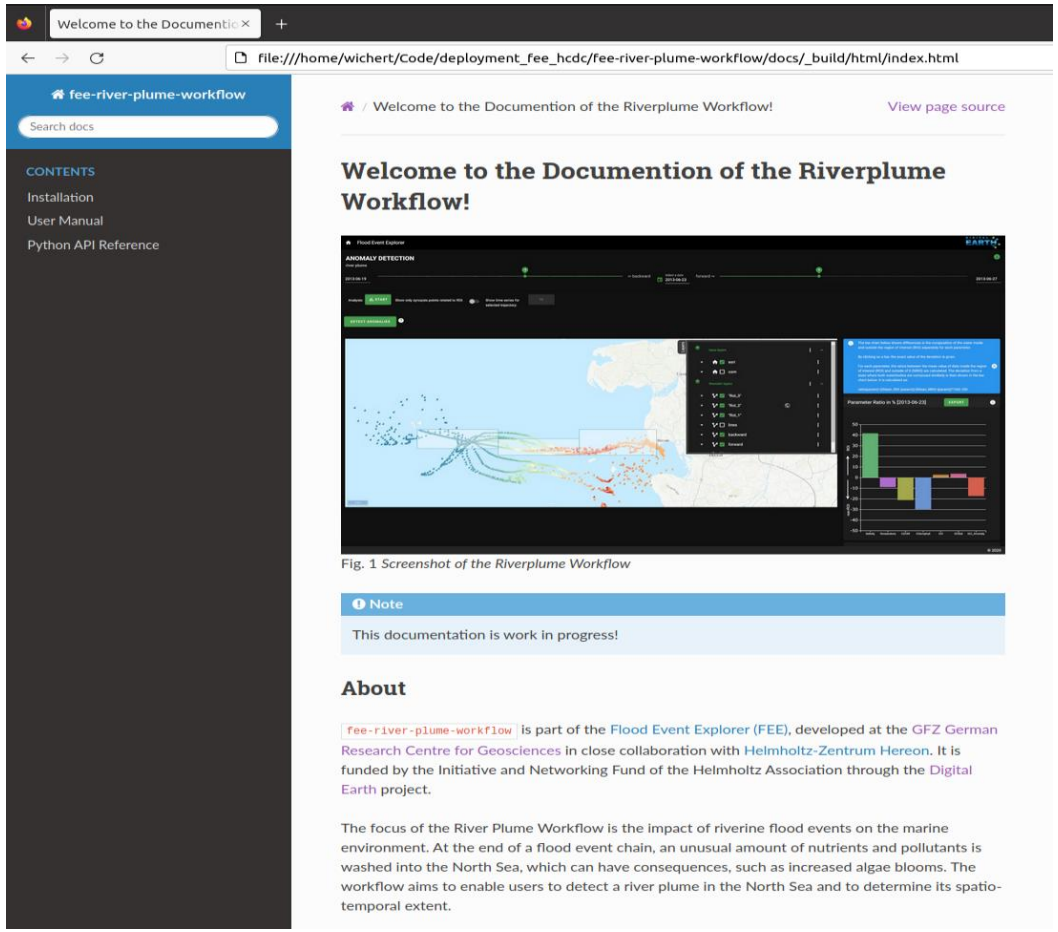
https://xkcd.com/1343

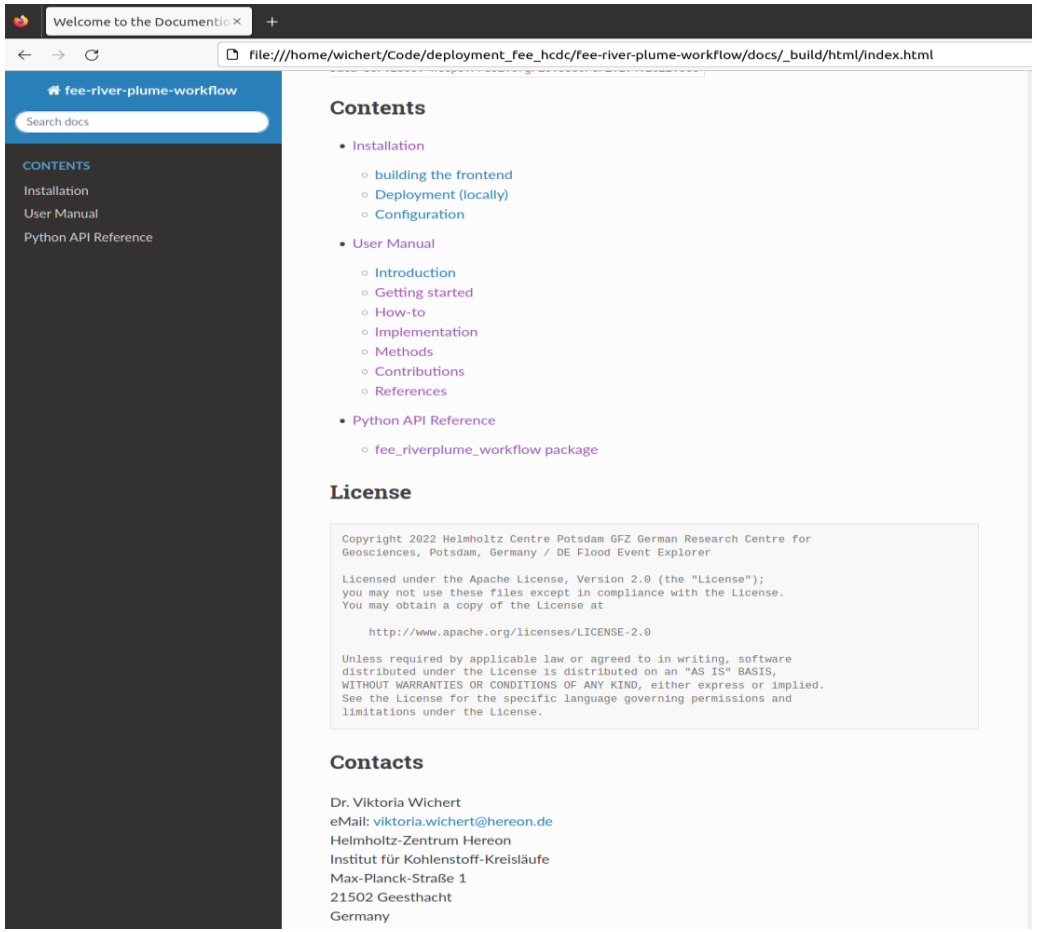
Tutorial Video



Watch it on YouTube:

Documentation (in preparation)





Documentation is generated with Sphinx & Markdown and will be publicly available soon.

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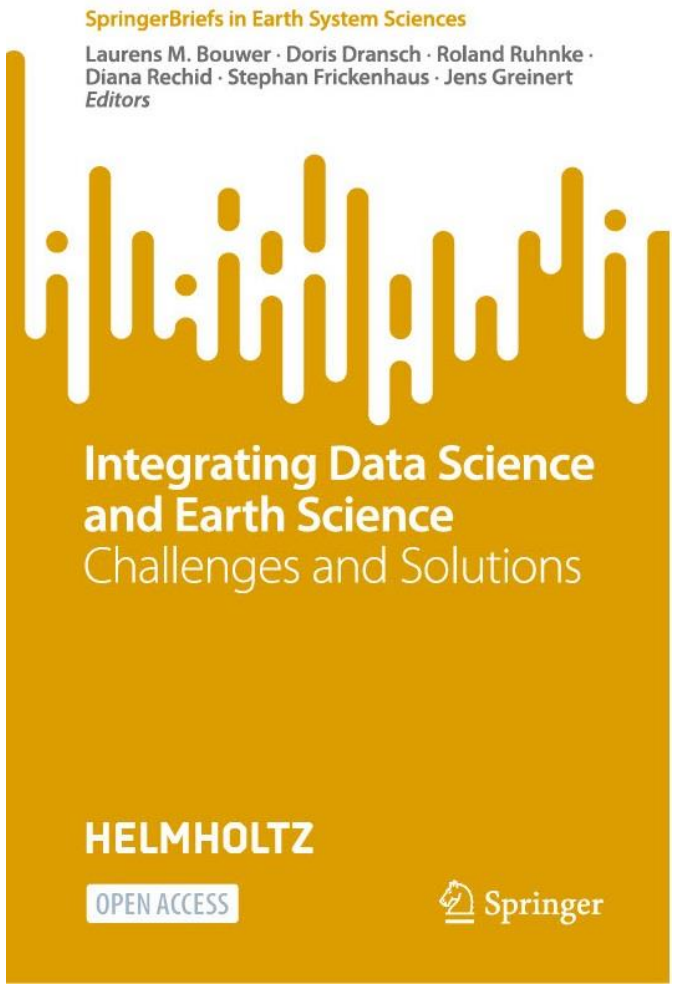
DOIs & Code Repositories

Module	Repository	DOI
The River Plume Workflow (Frontend)	fee-river-plume-workflow	https://doi.org/10.5880/GFZ.1.4.2022.006
Synopsis Backend Module	de-synopsis-backend-module	(in preparation)
DASF: Distributed Analysis Software Framework	digital-earth/dasf/	https://doi.org/10.5880/GFZ.1.4.2021.004

E-Book

Link to Springer homepage:



Learn more about the Riverplume Workflow, the Digital Earth project and the concept of Scientific Workflows.

Bouwer, L. M., Dransch, D., Ruhnke, R., Rechid, D., Frickenhaus, S., & Greinert, J. (2022).
Integrating data science and earth science: Challenges and solutions (L. M. Bouwer, D. Dransch, R. Ruhnke, D. Rechid, S. Frickenhaus, & J. Greinert, Eds.). Springer Nature.

https://doi.org/10.1007/978-3-030-99546-1