**52north**

exploring horizons

# Annual Report 2020

## New Concepts and Technologies for Spatial Information Infrastructures

# Preface

2020 has been a very special year with extraordinary challenges and exciting new developments. The corona pandemic required – as everywhere – the restriction of personal contacts and a shift of communication to digital media. We have refined our knowledge and use of digital communication methods, which will continue to benefit us in the future. At the same time, we really look forward to being able to intensify personal and informal contacts again in the office as well as at workshops and conferences.

In 2020, 52°North further expanded and focused the work on core research topics. This concerned, for example, the development of concepts and technologies for near real-time processing of Copernicus Earth Observation data for the purposes of environmental monitoring. It also addressed the use of machine learning techniques for the analysis of mobility data to predict accident risks. Our research and development (R&D) activities corresponded with innovative professional services projects. For example, 52°North contributed to the development of operational Spatial Information Infrastructures (SII) and its components, such as the Copernicus Data Infrastructure in North-Rhine-Westphalia, the European Data Portal or the EUMETSAT infrastructure for managing, processing, and disseminating satellite mission data.

We used 2020 to review and focus 52°North's vision and long-term strategies in dialog with our shareholders and Scientific and Technical Advisory Board and to prepare for a management succession. 52°North will extend its business as a private, non-profit R&D organization that supports the collaboration between research, industry and public administration. We continue to stand for Open Science and Open Innovation, i.e., for disseminating the results of research work to the public based on open publications, open data and open source software.

The unbroken trend of the expanding digitization and interconnection of real-world elements increases demands on the information infrastructure's performance. 52°North will strongly focus on R&D and professional services supporting the development of Spatial Information Infrastructures – particularly in the field of research data management. At the end of 2020, we started two research projects that address these topics. The KI:STE project (AI Strategy for Earth System Data) aims to facilitate the use of AI for analyzing remote sensing data for Earth Sciences. The second project (MariGeoRoute) supports the development of improved methods and techniques for optimizing the energy management and reducing the emissions of cargo vessels. These are based on near real-time data from the Copernicus Marine Environment Monitoring Services and machine learning techniques.

We are excited for the coming year, challenging project work and cooperating with our partners and customers. Please do not hesitate to contact us if you have any questions or ideas you would like to share.

Münster, December 2020

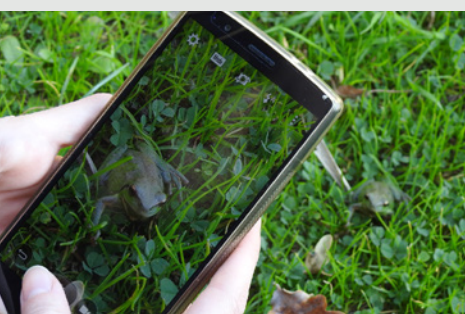*Prof. Dr. Albert Remke*          *Prof. Dr. Andreas Wytzisk-Arens*

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## About 52°North

# Spatial Information Research

52°North is a private non-profit R&D organization located in Münster, Germany. Our mission is to increase the value of geodata and geographic information technologies in science, business and public administration through applied research and knowledge-intensive services.

Our research software engineers have a strong background in both applying scientific methods and excellent software engineering practices. They possess extensive knowledge regarding state-of-the-art technologies and Geo-IT trends, such as cloud native technologies, GeoAI or big data analytics. We contribute to research and innovation projects and provide professional services to build operational high-end Geo-IT solutions.

52°North stands for Open Science and Open Innovation based on a collaborative open source software development process.

### STAFF

**24**
software engineers, data scientists, business administration, trainees…

**17**
full time equivalents

**32%**
permanent contracts, 7 temporary employments (incl. 4 student assistants)

# Facts and Figures

## REGISTERED NAME AND OFFICE

52°North – Initiative for Geospatial Open Source Software GmbH
Martin-Luther-King-Weg 24, 48155 Münster, Germany
T +49 251 396371-0, info@52north.org, https://52north.org

## FOUNDED

September 2006

## SHAREHOLDERS

> University of Münster, Germany
> Esri Inc., Redlands, United States of America
> con terra GmbH, Münster, Germany
> University of Twente, The Netherlands

## ASSOCIATED PARTNERS

> Technical University Dresden, Germany
> University of Applied Science Bochum, Germany
> ITZBund, Ilmenau, Germany

## MANAGEMENT



**Prof. Dr. Albert Remke**

**Prof. Dr. Andreas Wytzisk-Arens**

## REVENUES

**~1.1 M €**
Euro in total
(forecast)

**68 %**
billable hours
spent on research
projects

**32%**
billable hours spent
on fully funded R&D
and professional
services

## The 52°North Partner Network

# Creating Synergies

52°North facilitates joint research and development as well as capacity building activities within an open international network of partners from research, industry and public administration. They are driven by a shared interest in Open Innovation that strengthens the ability of all partners to develop and better leverage the value of spatial data and spatial information technologies in their respective fields of work.

### Collaboration in the field of higher education

_ Lectures and study projects on Spatial Data Infrastructures (SDI), Earth Observation, Big Data Analytics

_ Interchange of didactic concepts and materials for courses on Spatial Information Infrastructures (SII) at universities

_ Collaboration with the Esri Development Centers network

_ Support for BSc, MSc and PhD theses and internships

### Joint R&D Projects – research contributions and research software engineering services

_ Afri Alliance – Africa-EU Innovation Alliance for Water and Climate

_ SIMPORT – Sovereign and Intuitive Management of Personal Location Information

_ SenSituMon – Near real-time large scale monitoring flooding situations

_ WaCoDiS – Development of a Copernicus-based service infrastructure for monitoring material input in watercourses and dams

_ mVIZ – Visualization of spatio-temporal mCloud data

_ Support for R&D funding proposals, such as GeoAI in the Cloud or NFDI4Earth – National Research Data Infrastructure for Earth Sciences

## Joint Professional Services Projects

_ EDP2 – European Data Portal

_ EOPORT – Near real-time access to Copernicus Sentinel data

_ EOWS Pathfinder – Earth Observation Web-based Services

_ CDI@IT.NRW – Copernicus Data Infrastructure

_ KomMonitor – Monitoring the development of urban districts

These partners form a network of excellence, which drives innovation and fosters the uptake of cutting-edge geoinformation technologies in many application domains:

# Research and Development



Citizen Science

Environmental Monitoring

Sustainable Mobility

Geospatial Sensing

Disaster Management

SPATIAL DATA

Smart Cities

Efficient Processing

Data Analytics

Earth Observation

Ocean Science

Precision Farming
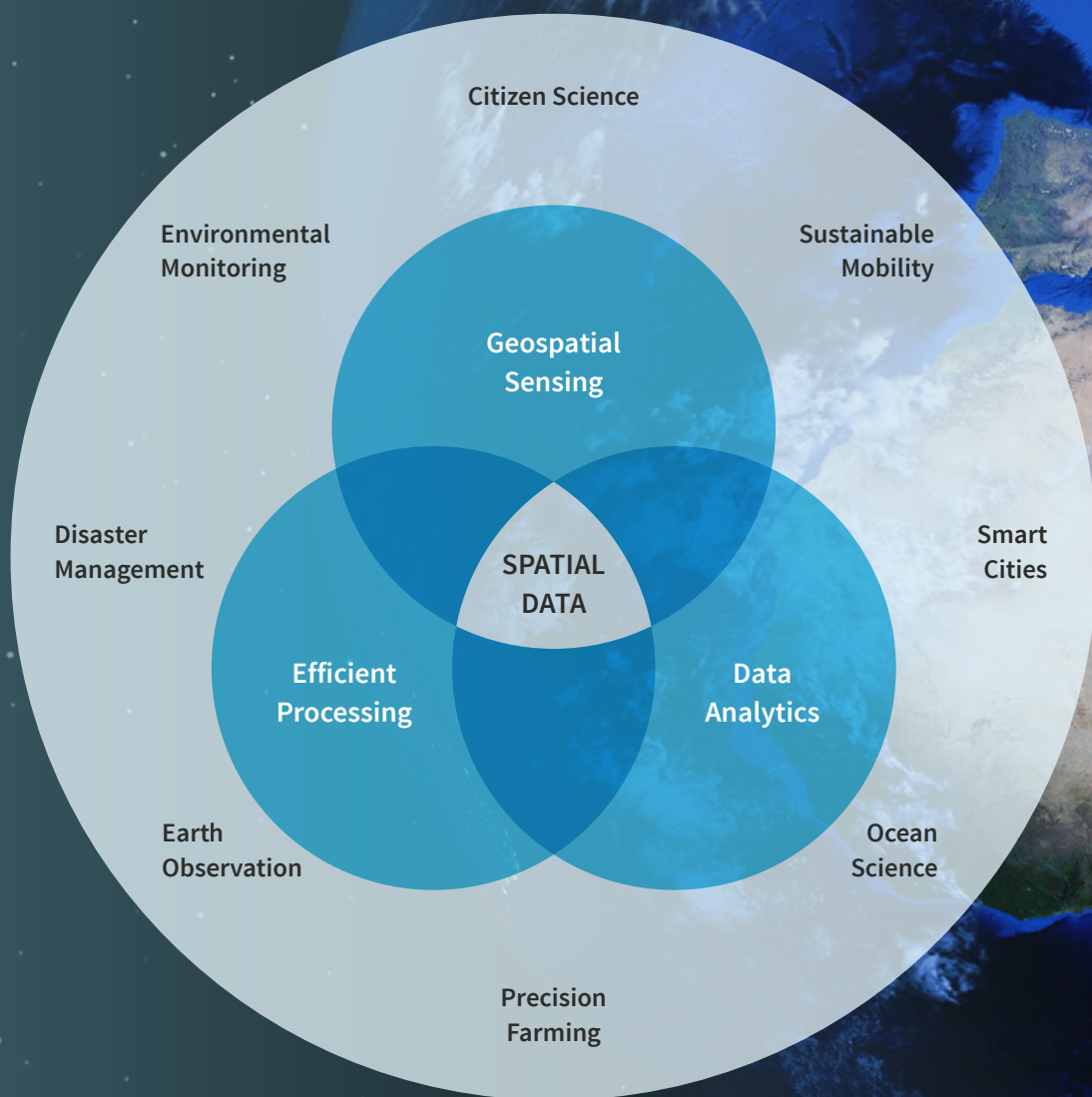
## Leveraging the value of Spatial Information by innovating methods and technologies of the underlying infrastructure

Geospatial data plays a key role in supporting environmental planning, renewable energy forecasts, disaster management, smart mobility, precision farming, risk assessment and many other application domains. Our goal is to facilitate the availability and use of spatio-temporal data by innovating the methods and technologies for creating, managing, sharing, analyzing and visualizing this data.

52°North has three labs focusing on specific research fields. Each lab is equipped with a dedicated, skilled team to carry out applied research and develop state-of-the-art open source software solutions. Partners and customers are invited to join our teams in their virtual laboratories to collaboratively address their use cases and research questions.

We believe that applied research is best complemented by the development of operational solutions in order to create a tangible added value in practice. This combination turns scientific results into relevant "innovations". 52°North supports the development of operational solutions by offering professional services, such as training and consulting services, software engineering or data analysis. In the following chapters, our labs provide short reports on their research and development activities.

# Geospatial Sensing

# Enabling the efficient flow, management and visualization of sensor data

When speaking of Geospatial Sensing, we refer to all aspects related to capturing, managing, discovering, sharing, and visualizing data that describes the past, current, or future state of the environment. This type of data includes, not only data generated by sensors, but also information captured by humans, as well as predictions calculated through models. In the Geospatial Sensing lab, we explore emerging technologies that facilitate the handling of geospatial sensing data in order to support our customers and partners.

Dr. Simon Jirka, head of the Geospatial Sensing Lab, and his team focus on new approaches for collecting, managing, sharing and visualizing sensor data. Currently, the lab addresses the following challenges:

_ Connecting to sensor hardware: investigating how to efficiently integrate new sensors into (research) data infrastructures, while considering sensor plug-and-play as well as relevant Internet of Things technologies (e.g., MQTT).

_ Data storage and management: optimizing data models for efficient data storage, providing metadata to ensure the correct interpretation of sensor data sets, or using and enhancing vocabularies for ensuring semantic inter-operability.

_ Data availability to users: advancing access interfaces and encodings for sensor data and enabling push-based/event-driven communication patterns to ensure a timely delivery of data.

_ Access control: developing strategies for providing user/group-based access to (dynamic) sensor data sets/streams.

_ Data visualization: improving methods for visualizing and exploring sensor data to allow for a better communication of the gathered information.

_ Humans as sensors: making it easier to set up citizen observatory initiatives by providing dedicated reusable building blocks.

Our activities also lead to active contributions to international standardization efforts. We drive interoperability aspects through our participation in the Open Geospatial Consortium (OGC) and the European INSPIRE framework.



**Dr. Simon Jirka**
Head of Geospatial Sensing Lab

SeaDataCloud

# Handling Near-Real Time Sensor Data in a Marine Research Data Infrastructure

## Further developing the pan-European infrastructure for marine and ocean data management

National oceanographic data centers and major research institutes from 34 countries have developed the pan-European SeaDataNet infrastructure. It connects more than 100 marine data centers that provide data discovery and access functionality for researchers. Furthermore, SeaDataNet is a key element supporting the European Marine Observation and Data network (EMODnet), which was initiated by the EU DG-MARE. It also complements the Copernicus Marine Environmental Monitoring Service.

In order to provide more efficient and faster data access for researchers, several upgrades and enhancements to reflect recent technological developments are necessary. These comprise aspects, such as new types of sensors, as well as international IT concepts (e.g., cloud infrastructures) and interoperability standards (e.g., INSPIRE guidelines for observation data). Consequently, SeaDataCloud aims to improve the current SeaDataNet infrastructure by adopting cloud and high-performance computing technology. SeaDataCloud cooperates with EUDAT, a network of computing infrastructures that develops and operates a common framework for managing scientific data across Europe.

The SeaDataCloud project output results in improved access to research data. A comprehensive collection of services and tools developed to cover researchers' specific needs is available to support marine research and enable the generation of added value products.

52°North investigates new approaches to enhance the SeaDataNet infrastructure with capabilities for handling near real-time observation data. This comprises two main tasks: the development of a SWE Ingestion Service and a SWE Viewing Service.

The SWE Ingestion Service: In order to facilitate the publication of observation data streams, we develop a concept and prototypical implementation of a Web service
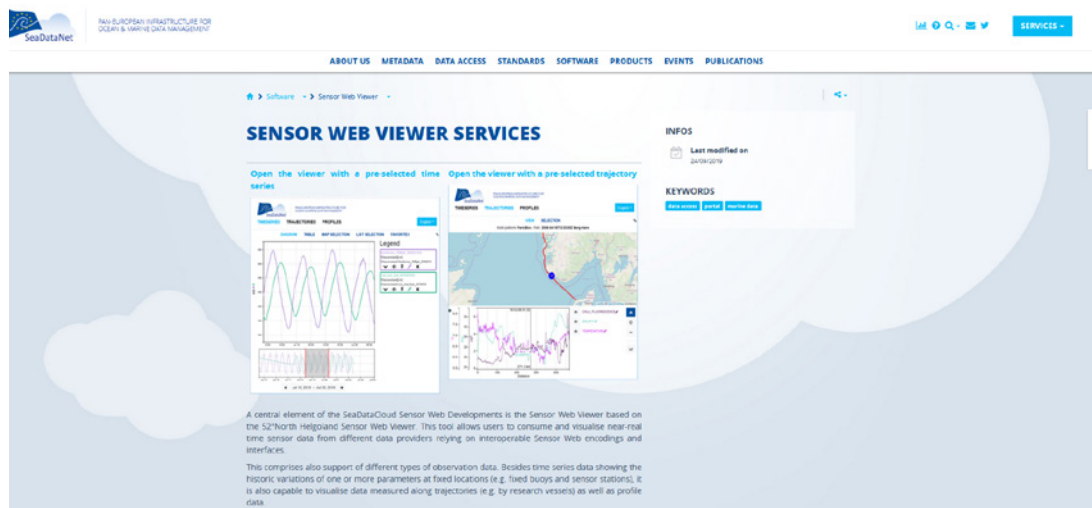
**KEY TECHNOLOGIES**

> Java

> JavaScript

> Sensor Web

> OGC Sensor Web Enablement (SWE)

> OGC Sensor Observation Service (SOS)

> OGC Sensor Model Language (SensorML)

**SeaDataCloud Sensor Web viewer services**

architecture that comprises a plug-and-play approach for sensor data publication. It includes the description of sensor interfaces, sensor data streams (e.g., delivered through Internet of Things protocols such as MQTT) and other sensor data repositories (e.g., CSC-based data stores). This is complemented by tools for editing such sensor data stream descriptions (including the semantics of the data) and an interpreter relying on the descriptions for pushing the available data into the SeaDataCloud infrastructure.

The SWE Viewing Service: We explore new approaches for a user-friendly visualization of the previously published sensor data streams. This service covers not only the data display itself, but also new ideas on improving the discoverability of the broad range of published sensor data streams.

In addition, we participate in networking activities to promote and further test the SeaDataCloud developments and provide feedback to international standardization activities.

In 2020, our team further refined the SWE Ingestion Service and the SWE Viewing Service. We also addressed the question of how to improve sensor descriptions to facilitate the (semi-)automatic processing of incoming sensor data streams by formally describing their structure in SensorML.

## PARTNERS

> **Coordinator: Institut Français de Recherche pour l'Exploitation de la Mer (Ifremer),** France, https://wwz.ifremer.fr/
> **56 partners and 5 sub-contractors from 32 countries**

## FUNDING

SeaDataCloud is funded by the Horizon 2020 Framework Programme for Research and Innovation (H2020-INFRAIA-2016-1) of the European Union under grant agreement number 730960.



Co-funded by the Horizon 2020 programme of the European Union

**FACTS**

**Duration**
11/2016 – 04/2021

**Website**
https://www.seadatanet.org/

**Contact**
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**Project Type**
Research and Development

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EMODNET Ingestion

# European Marine Observation and Data Network

## Marine data ingestion and safekeeping in and for EMODnet

The European Marine Observation and Data Network (EMODnet) brings together more than 160 organizations to improve the harmonized sharing of marine data. As part of the larger EMODnet context, EMODnet Ingestion 2 works on facilitating the data publication process. This in particular includes the EMODnet Data Ingestion Portal, which helps data managers publish their data following open data principles.

52°North's role in EMODnet Ingestion 2 is that of an expert on Sensor Web technologies. Based on results from previous projects, such as SeaDataCloud, we support the consortium in challenges related to sharing near-real time observation data streams. This includes not only the development of best practices and guidance, but also the creation of dedicated demonstrators and show cases.

In 2020, 52°North focused on two main tasks. We contributed to the enhancement of Sensor Web best practice guidance and exemplary demonstrators. Our team additionally cooperated with several partners to enable research vessels to share their near-real time tracking data using interoperability standards, such as MQTT and the OGC SensorThings API. This resulted in a data publication workflow built on top of the Eurofleets Automatic Reporting System (EARS). The workflow is already deployed on several research vessels, e.g., "Belgica" (Royal Belgian Institute of Natural Sciences), "Sarmiento de Gamboa" and "García del Cid" (both CSIC).



**KEY TECHNOLOGIES**

> Sensor Web

> SensorThings API

> MQTT

> Angular
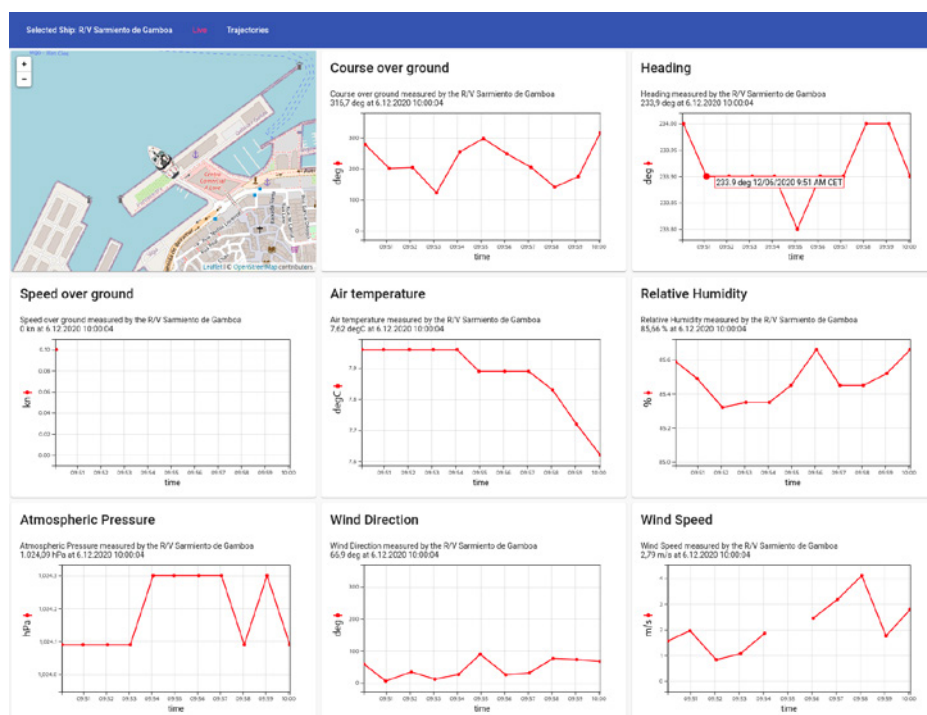
Prototype of the European Virtual Infrastructure in Ocean Research (EVIOR) portal's Dynamic Vessel Tracking & Events System based on the Helgoland Toolbox

## PARTNERS

> **44 partners from all over Europe**
  https://www.emodnet-ingestion.eu/about/who
> **52°North is a subcontractor of Maris B.V., The Netherlands**,
  https://www.maris.nl/

## FUNDING

The European Marine Observation and Data Network (EMODnet) is funded by the European Union under Regulation (EU) No 508/2014 of the European Parliament and of the Council of 15 May 2014 on the European Maritime and Fisheries Fund.

Co-funded by the Horizon 2020 programme of the European Union

## FACTS

**Duration**
10/2019 – 10/2021

**Website**
https://www.emodnet-ingestion.eu/

**Contact**
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**Project Type**
Professional Services

JERICO-S3

# Joint European Research Infrastructure for Coastal Observatories

## Marine coastal observatories, facilities, expertise and data for Europe

The Joint European Research Infrastructure for Coastal Observatories (JERICO-RI) is a system of systems strengthening the European network of coastal observatories. It provides a powerful and structured European Research Infrastructure (RI) dedicated to observing and monitoring the complex marine coastal seas. JERICO-RI aims to

- _ provide services for the delivery of high-quality environmental data
- _ enable access to solutions and facilities as services for researchers and users
- _ create product prototypes for EU marine core services and users
- _ support excellence in marine coastal research to better answer societal and policy needs.

JERICO-S3 (Joint European Research Infrastructure of Coastal Observatories: Science, Service, Sustainability) will provide a state-of-the-art, fit-for-purpose and visionary observational RI, as well as expertise and high-quality data on European coastal and shelf seas. It will significantly enhance the current value and relevance of the JERICO-RI by implementing the science and innovation strategy elaborated in the JERICO-NEXT project.

JERICO-S3 targets a more science-integrative approach to better observe the coastal ecosystem. In turn, this will elevate the scientific excellence of the regional and local ecosystems. The project will implement major user-driven improvements in terms of observing the complexity of coastal seas and continuous observation of the biology, access to facilities, data and services, best practices and performance indicators, as well as innovative monitoring strategies. These will also cover cooperation with other



**KEY TECHNOLOGIES**

> Sensor Web

> OGC Sensor Observation Service (SOS)

> Java

> JavaScript

> Helgoland Sensor Web Viewer

> OGC Sensor Model Language (SensorML)

European RIs (EuroARGO, EMSO, AQUACOSM, DANUBIUS, ICOS, EMBRC, LIFEWATCH) and international scientific communities, industry and other stakeholders, and aligning strategy with COPERNICUS/CMEMS, EMODNET and GEO/GEOSS.

52°North focuses on technological innovation activities. We will work on the advancement of Sensor Web components, such as the SensorML editor smle, the Helgoland Sensor Web Viewer and data access services based on the OGC SWE standards. Our aim is to improve the usability of interoperable data exchange workflows and concepts for marine sensor data.



JERICO-RI, Joint European Research Infrastructure for Coastal Observatories Buoys, Gliders, HF-Radars, Ferryboxes, Coastal seabed observatories and Coastal floats

## PARTNERS

39 partners, including:
> **Coordinator: Institut français de recherche pour l'exploitation de la mer (Ifremer), France**, https://wwz.ifremer.fr/
> **Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung (AWI), Germany**, https://www.awi.de/
> **Consiglio Nazionale delle Ricerche (CNR), Italy**, https://www.cnr.it/
> **ETT S.p.A., Italy**, https://ettsolutions.com/
> **European Global Ocean Observing System (EuroGOOS), Belgium**, http://eurogoos.eu/
> **Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung GmbH (HZG), Germany**, https://www.hzg.de/
> **Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGC), Italy**, https://www.inogs.it/
> **Plataforma Oceánica de Canarias (PLOCAN), Spain**, https://www.plocan.eu/
> **Royal Belgian Institute of Natural Sciences, Belgium**, https://www.naturalsciences.be/
> **Universitat Politècnica de Catalunya (UPC), Spain**, https://www.upc.edu/

## FUNDING

## FACTS

**Duration**
02/2020 – 01/2024

**Website**
https://www.jerico-ri.eu/

**Contact**
Dr. Simon Jirka
*s.jirka@52north.org*

**Project Type**
Research and Development

BelAir

# Belgian Air Quality App

## Enhancing the Air Quality App for the Belgian Interregional Environment Agency
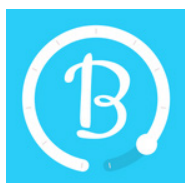
Over the last several years, 52°North has worked closely with the Belgian Interregional Environment Agency (IRCEL – CELINE) to develop the BelAir air quality app. Interested citizens can use the app to access information about several air quality parameters and an air quality index in Belgium. The app can create time-dependent map visualizations and present historic changes of different air quality parameters as diagrams. A set of personalization functionalities (e.g., setting user-defined locations) allows the user to adjust the app to individual information needs. Additional push notifications inform users of critical air quality situations.

We use the Ionic framework (https://ionicframework.com/) to build and deploy the JavaScript-based implementation as an app for Android and iPhone platforms.

Our activities in 2020 focused mainly on the BelAir 2.0 version. In cooperation with design experts, we contributed to updating the app's business logic for the 2.0 release. This included enhancing the caching mechanism and developing strategies to improve the user experience in an offline mode. We also worked on enhancing certain functionalities, such as user-based notification (e.g., in case of air quality issues at user-defined locations), and a feedback mechanism to collect user-generated input on air quality.

**BelAir App main screen**

### KEY TECHNOLOGIES

> JavaScript

> Angular

> Ionic

> Sensor Web

### FACTS

**Duration**
Since 2018

**Contact**
Dr. Simon Jirka
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**Project Type**
Professional Services
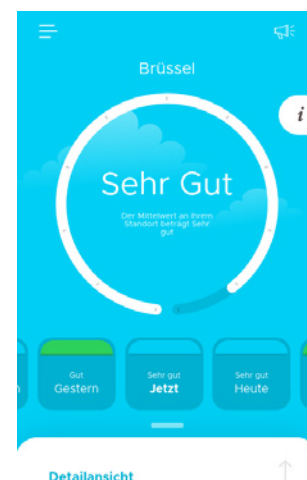
## CUSTOMER

**Belgian Interregional Environment Agency**, https://www.irceline.be/en

**View of time series data
(black carbon and temperature)
from Antwerp**

## AQSens

# Air Quality Sensing

**Developing a platform for integrating Citizen Science
measurements and authoritative air quality data**

The Joint Research Centre (JRC) of the European Commission has been working exten-
sively over the past few years on ways to use lower cost sensors to complement author-
itative air quality data (e.g., the AirSensEUR project). Expanding upon their experience,
they initiated a new activity involving three European cities as pilot sites (Antwerp, Oslo,
and Zagreb).

JRC needs a data management platform to collect the data of low-cost air quality
sensor boxes as well as the authoritative data measured by the official agencies. This
data platform is based on the OGC interoperability standards Sensor Observation
Service (SOS) and SensorThings API specifications, which are compliant to the INSPIRE
guidelines.

52°North's work revolves around the integration of a data validation process based on
R/Shiny. The process calibrates the low-cost sensor data measurements to the official
measurements. Visualization functionality is also important so that users can view and
explore the collected data. We have adapted the Helgoland Sensor Web Viewer accord-
ing to JRC's requirements.

We completed the implementation of the AQSens Data Platform in 2020. This resulted
in a Docker-based deployment. We also developed data ingestion workflows in R using
reference data from Antwerp, Oslo, and Zagreb, as well as raw and predicted data. Addi-
tionally, our team carried out adjustments to the server components SOS, Sensor-
Things API and Helgoland API, and customized a version of the Helgoland Sensor Web
Viewer for JRC.

## KEY TECHNOLOGIES

> Distributed Web Architecture

> Data Management
  (OGC Sensor Web
  Enablement, OGC Sensor
  Observation Service,
  OGC Sensor Things API,
  PostgreSQL)

> Data Validation (R, Shiny)

> Data Visualization
  (Angular, JavaScript,
  Helgoland)

## FACTS

**Duration**
08/2019 – 08/2021

**Contact**
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**Project Type**
Professional Services

## CUSTOMER

**European Commission (Joint Research Centre, JRC)**, https://ec.europa.eu/jrc/en

**Wupperverband Framework Contract**

# Sensor Web Developments for the Wupperverband

## Supporting the Wupperverband's Sensor Web infrastructure

The Wupper River catchment area covers an area of 813 square kilometers in Germany's North Rhine-Westphalia. The Wupperverband (Wupper Association), responsible for water management in this area, operates a comprehensive network of water monitoring stations that deliver a broad range of hydrological and meteorological parameters.

For more than ten years, the Wupperverband has been operating Sensor Web components to ensure an efficient data management and internal as well as external data exchange. These include a large database for managing the collected observation data, the 52°North Sensor Observation Service implementation, the 52°North Sensor Web REST-API and a customized version of the Helgoland Sensor Web Viewer.

52°North supports the Wupperverband in maintaining and advancing this Sensor Web infrastructure. We carry out regular updates of the Sensor Web components as well as selected tasks to customize or extend the software modules used.

In 2020, our team continued upgrading the Helgoland Sensor Web Viewer. We not only implemented support for recently published Angular versions, but also refined the different application views (e.g., diagram view, map view, data selection).

Further efforts focused on upgrading the server components. We enhanced the Sensor Web database model to improve the handling of sampling data, to harmonize the integration of the Eventing API, and to increase the performance.

We also investigated approaches to controlling access to SensorThings API instances. This resulted in an initial set-up of the 52°North SensorThings API implementation coupled with an existing Liferay user database.

### KEY TECHNOLOGIES

> Sensor Web

> Helgoland Sensor Web Viewer

> JavaScript

> Angular

> Sensor Observation Service (SOS)

> 52°North Sensor Web REST API

### FACTS

**Duration**
01/2018 – 12/2021

**Contact**
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**Project Type**
Professional Services

### CUSTOMER

**Wupperverband**, https://www.wupperverband.de/

INSPIRE Data Availability Optimization

# Removing Technical Barriers

**Studies to optimize the availability of INSPIRE and open data via the UBA metadata catalog**

The German Environment Agency (UBA) maintains and provides several databases for their reporting activities and projects. During the INSPIRE directive implementation, they provided environmental data subjected to reporting requirements via their spatial data infrastructure "UBA.gdi". The emergence of new technologies (e.g., OGC API for Features) eases the use of geospatial data significantly. Thus, this project investigates current technological approaches that can complement the measures implemented in recent years. The goal is to improve the retrieval of UBA's data stocks and remove technical barriers to (re)using the data itself.

con terra and 52°North collaborate to develop solutions and an implementation strategy based on the existing technologies in UBA.gdi. Resulting exemplary implementations that demonstrate feasibility, in terms of the INSPIRE Directive requirements and simple data access from the user's perspective, will be available to each project subarea at the end of the project. Our developers investigate how to enhance existing OGC-compliant Web Feature Services to support the new OGC API for Features interface and evaluate an enhancement of the UBA's existing air quality Sensor Observation Service instance with an OGC SensorThings API module. We examine the combined use of OGC API Features and SensorThings API and will use the INSPIRE data theme "Environmental Monitoring Facilities" in a simplified form for an alternative encoding. This we will combine with air measurement data delivered via the SensorThings API.

First results comprise a mapping between the UBA's current Sensor Web database and the SensorThings API data model. We also created an initial running prototype of an OGC API for Features instance based on the ldproxy.

## KEY TECHNOLOGIES

> 52°North Sensor Web Server

> SensorThings API

> ldproxy

> FME

## FACTS

**Duration**
10/2020 – 05/2021

**Contact**
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**Project Type**
Professional Services

## PARTNER

**con terra GmbH, Germany**, https://www.conterra.de/ (52°North is subcontractor)

## CUSTOMER

**European Commission (Joint Research Centre, JRC)**, https://ec.europa.eu/jrc/en

**UFZ Research Data Management Consulting**

# Data Management and Time Series Visualization

## Supporting UFZ to manage and visualize geodata across borders

The Helmholtz Centre for Environmental Research (UFZ) was founded in 1991. They currently have nearly 1,200 employees and main locations in Leipzig, Halle and Magdeburg (Germany). As the UFZ continues to develop their geo and research data, they have identified a particular need for advice on how to implement the future geodata management and geospatial data visualization as well as how to access and visualize measurement data via interoperable interfaces.

The Helmholtz Association's Research Field Earth and Environment is developing a DataHub based on the FAIR principles. The Research Centres UFZ, GFZ, FZJ of the sub-hub "Hub-Terra" have committed to a common architecture formed on standardized interfaces and the provision of shared services. Activities currently focus on metadata, data and data products based on spatial and time series data sets.

This project initially aims to identify, discuss and document UFZ's and other Helmholtz Centres' geodata management requirements for various research projects. The overall objective is to help the UFZ identify a solution for managing their geodata and to create prerequisites for a possible implementation. Geodata, in this case, comprises raster data (basic data, model calculations, analysis results), vector data and reference data. Currently, each UFZ scientific unit has an individual workflow for handling geodata. This is particularly reflected in data storage, e.g., file shares, RDBMS, local storage, cloud/HPC storage. In order to enable an effective and sustainable use of the data, 52°North helps standardize the various workflows.

**KEY TECHNOLOGIES**

> OGC Standards

> Cloud Storage

> Sensor Web

> SensorThings API
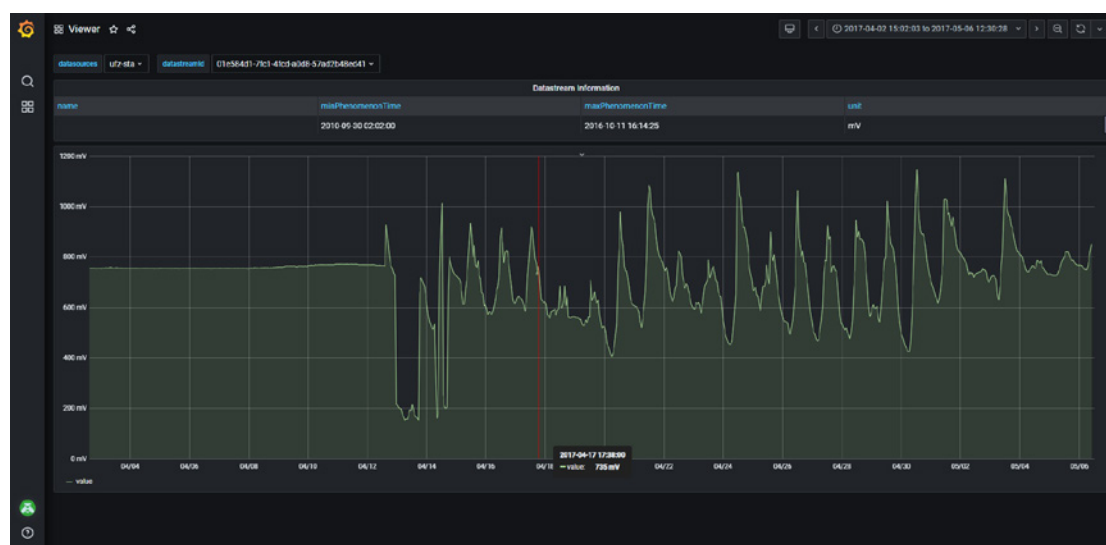
> Grafana

**Grafana dashboard showing UFZ time series data delivered via an STA instance**

Another aspect of the project covers the sharing of observation data. For several years, the UFZ and other Helmholtz Centres have been using the OGC Sensor Observation Service (SOS) to provide time series data. The Open Geospatial Consortium (OGC) simultaneously developed the SensorThings API as an additional specification for time series provision. This API offers some simplifications, especially for the development of client applications (the use of JSON instead of XML). Furthermore, UFZ identified a high demand for enabling the visualization of time series data across individual Helmholtz Centres' borders. They require strategies for providing recommendations on how the UFZ and other Helmholtz Centres could advance their infrastructure for sharing observation data.

Our team completed a significant extent of this project in 2020. This included an introductory workshop on relevant OGC interoperability standards. We also conducted workshops with the UFZ to refine the requirements towards a future research data management infrastructure. This also involved defining an interoperable approach (based on the OGC SensorThings API standard) for the exchange of sensor data between multiple Helmholtz Centres.

**FACTS**

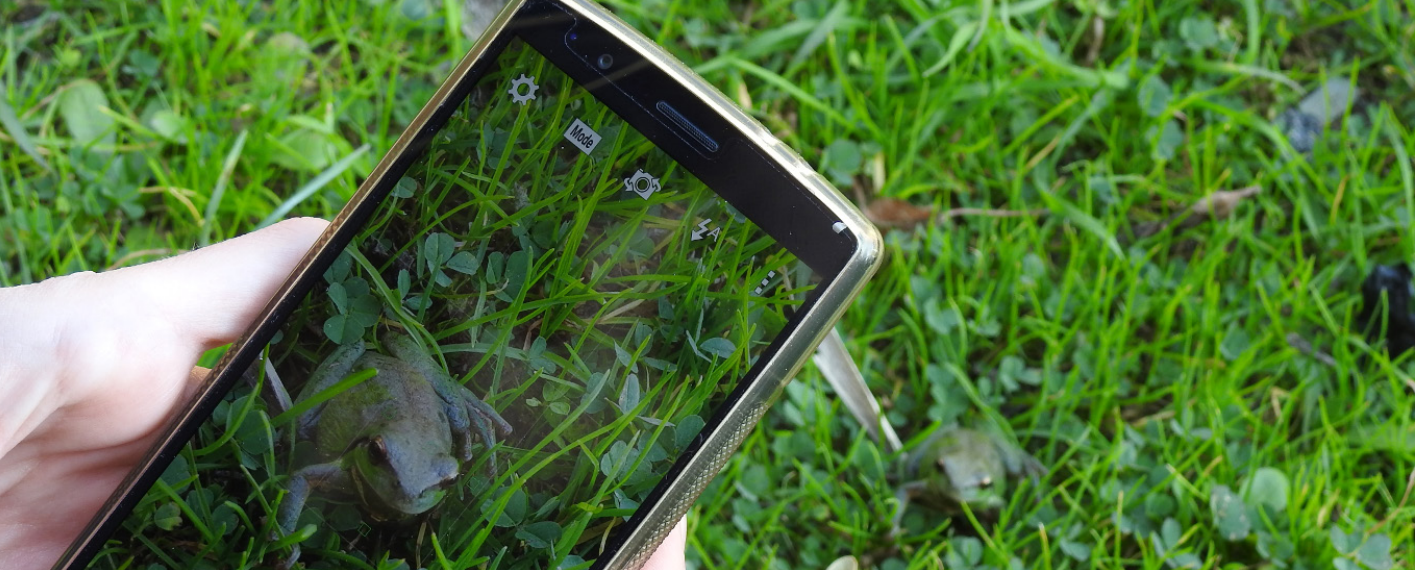**Duration**
06/2020 – 01/2021

**Contact**
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**Project Type**
Professional Services

## CUSTOMER

> **Helmholtz Centre for Environmental Research (UFZ), Germany**
  https://www.ufz.de/

COS4CLOUD

# Co-designed Citizen Observatories Services for the EOS Cloud

**Developing interoperable components to support Citizen Science projects via the European Open Science Cloud (EOSC)**

COS4CLOUD (Co-designed citizen observatories for the EOS-Cloud) aims to design, prototype and implement services that address the Open Science challenges shared by citizen observatories active in the fields of biodiversity and environmental quality monitoring. To support citizen observatories, project work focuses on the development of services that help improve the data and information quality. Technologies used to implement these services include deep machine learning, automatic video recognition, advanced mobile app interfaces, and other cutting-edge technologies based on data models and data protocols validated by traditional science. The new services will provide mechanisms to ensure the visibility and recognition of data contributors and tools to improve networking between various stakeholders. Novel innovative digital services will be developed by integrating Citizen Science products generated by different providers. The consortium implements the services according to open standards to ensure their interoperability. The European Open Science Cloud hub provides an agile, fit-for-purpose and sustainable site, including a discovery service, to both traditional and citizen scientists.

Stakeholders in society, government, industry, academia, agencies, and research drive a user-oriented design of the new services by co-designing the service requirements. COS4CLOUD integrates Citizen Science in the European Open Science Cloud, bringing Citizen Science projects as a service to the scientific community and society at large.

52°North contributes to the architecture definition and development of interoperability standards, profiles and best practices. We lead the project work on defining an agile development methodology. Our other contributions include interoperability, conformance and performance testing activities as well as the evaluation of technology readiness levels. Additionally, we support networking, dissemination and international standardization activities.

**KEY TECHNOLOGIES**

> European Open Science Cloud (EOSC)

> OGC Sensor Web Enablement (SWE)

> Spatial Data Infrastructure Concepts

Our team contributed to several project activities during 2020. An important element was the design of an agile development methodology. For this, we relied on our experience with the management and coordination of distributed, international software development. We also contributed to the design of the project's system architecture. With a particular emphasis on interoperability, our team cooperated closely with CREAF and Digital Dimensions to explore best practices for applying the OGC SensorThings API to Citizen Science observation data. Furthermore, we conducted experiments to explore options for combining single-sign-on technologies with Sensor Web components.
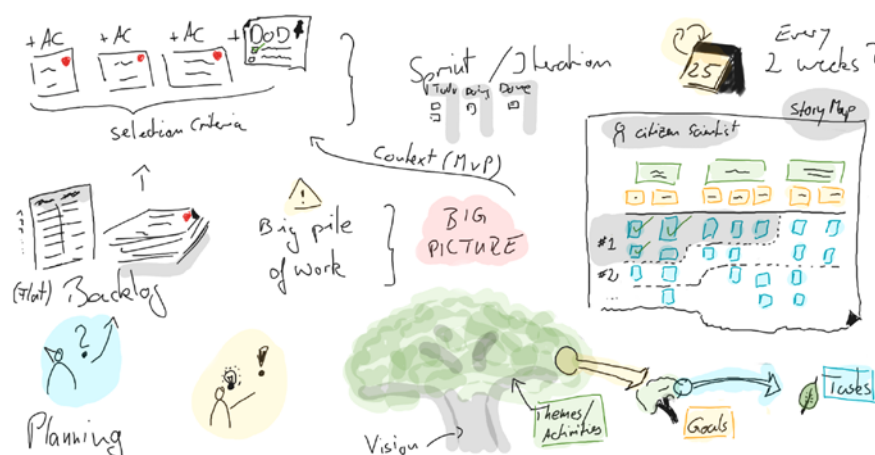


Agile story map

## PARTNERS

> **Coordinator: Consejo Superior de Investigaciones Científicas (CSIC), Spain**, https://www.csic.es/
> **Conservation Education & Research Trust, United Kingdom**, https://earthwatch.org/
> **Centro de Investigacion Ecologica y Aplicaciones Forestales, Spain**, http://www.creaf.cat/
> **Institut national de recherche eninformatique et automatique (INRIA), France**, https://www.inria.fr/
> **DYNAIKON LTD, United Kingdom**, https://dynaikon.com/
> **Bineo Consulting S.L., Spain**, https://bineo-consulting.com/
> **Norbert Carl Schmidt, The Netherlands**
> **The Open University, United Kingdom**, http://www.open.ac.uk/
> **Secure Dimensions GmbH, Germany**, http://www.secure-dimensions.com/
> **Sveriges lantbruksuniversitet (SLB), Sweden**, https://www.slu.se/
> **Ethniko kai Kapodistriako Panepistimio Athinon, Greece**, https://www.uoa.gr/
> **Verein der Europäischen Bürgerwissenschaften e.V. (ECSA), Germany**, https://ecsa.citizen-science.net
> **Trébola Organización Ecológica, Colombia**, http://www.trebola.org/
> **Science for Change S.L., Spain**, http://scienceforchange.eu/

## FUNDING

## FACTS

**Duration**
11/2019 – 02/2023

**Website**
https://cos4cloud-eosc.eu/

**Contact**
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**Project Type**
Research and Development

Creating Interfaces

# Data Management for Citizen Science Projects

**Building capacity for integrated governance at the food-water-energy-nexus in cities on the water**

Creating Interfaces explores socio-technical interfaces at the food-water-energy (FWE) nexus in cities near water. Aiming to increase urban sustainability, resilience, and quality of life, this project builds local capacity through innovative approaches in coordinated knowledge creation, governance and exchange.

A multi/transdisciplinary, international team representing natural and social sciences, humanities, engineering, data and computer sciences, urban planning as well as civil society and business actors conducts research on stakeholder interactions and decision-making in the FWE sectors. It explores data governance and investigates novel approaches to participatory knowledge generation and Citizen Science along with their implementation. The project helps to answer central questions surrounding the integration of novel citizen-driven knowledge creation into the governance process and urban infrastructure planning procedures. Common research frameworks and a close interdisciplinary and transdisciplinary cooperation provide a basis for comparative analysis and co-production of transformative knowledge.

The needs of stakeholders, the FWE actors, and members of the public drive the development of socio-technical interfaces and decision support tools following an Urban Living Lab framework. Users, as co-creators, test and evaluate creative solutions and ideas, e.g., citizen science tools and approaches.

52°North develops interoperable Citizen Science and decision support workflows for providing data collection and analysis functionality. This is part of different Urban Living Labs and Citizen Science approaches in the three partner cities: Tulcea (Romania), Wilmington (USA) and Slupsk (Poland). We evaluate existing Citizen Science concepts, advance the baseline components identified and contribute our findings to international standardization activities aimed at increased interoperability among Citizen Science projects. According to our partners' specific requirements, we also customize identified tools and frameworks.

Our activities in 2020 primarily centered on further developing the Citizen Science data collection tool. Whereas work in 2019 focused on the evaluation of suitable solutions, the 2020 developments resulted in a first collection tool for local workshops in the partner cities.

We created an initial tool for the city of Slupsk, adjusted it according to their specific requirements in several iterations. In a second step, we derived a dedicated version for the city of Tulcea. We have not been able to conduct the local workshops as planned due to the COVID-19 pandemic; thus, the evaluation of the tool will take place as part of the 2021 activities.
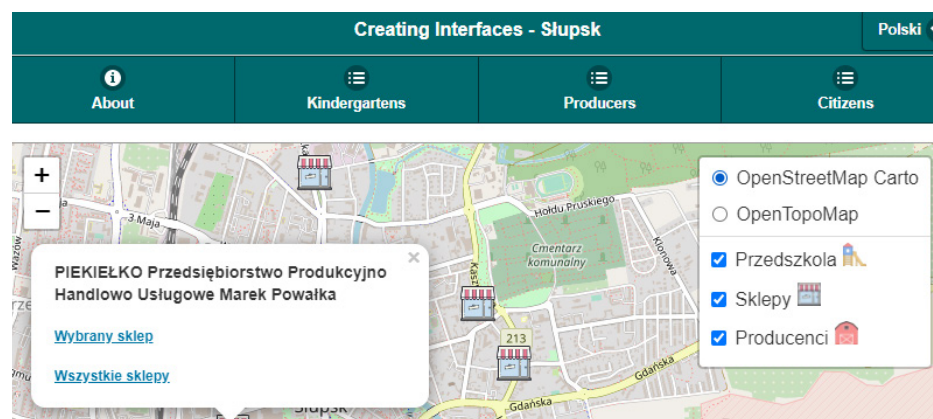


Data collection tool for gathering information about food served in kindergardens in Słupsk (Poland)

## PARTNERS

> **Coordinator: EIfER – Europäisches Institut für Energieforschung, Germany**, https://www.eifer.kit.edu/
> **University of Delaware, School of Public Policy and Administration, USA**, https://www.udel.edu/
> **The National Center for Atmospheric Research (NCAR), USA**, https://ncar.ucar.edu/
> **University of Warwick, Centre for Interdisciplinary Methodologies, United Kingdom**, https://warwick.ac.uk/
> **Pracownia Zrównoważonego Rozwoju (PZR), Poland**, http://www.pzr.org.pl/
> **SweGreen, Sweden**, https://swegreen.com/
> **Nicolaus Copernicus University Toruń, Institute of Sociology, Poland**, https://www.umk.pl/
> **Danube Delta National Institute for Research and Development (DDNI), Romania**, http://ddni.ro/wps/
> **KTH Royal Institute of Technology, Sweden**, https://www.kth.se/

## FUNDING

Creating Interfaces is funded by the German Federal Ministry of Education and Research as part of the Sustainable Urbanisation Global Initiative (SUGI)/Food-Water-Energy Nexus. This program is jointly established by the Belmont Forum and the Joint Programming Initiative Urban Europe.

**FACTS**

**Duration**
05/2018 – 04/2021

**Website**
https://creatinginterfaces.eifer.kit.edu/

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**Project Type**
Research and Development
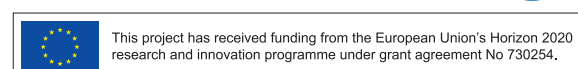
**mVIZ**

# Choosing the Best Visualization Approaches

**User-friendly and efficient visualization of spatio-temporal data available via the mCLOUD**

The Federal Ministry of Transport and Digital Infrastructure (BMVI) initiated the mCLOUD as a common open data discovery portal. This portal improves the discoverability of their open data and those of its related projects and agencies.

In order to facilitate the efficient and user-friendly exploration of available data sets, it is essential to visualize the data as quickly and easily as possible. Fast and informative visualization of open data from the mCLOUD remains difficult, especially for spatio-temporal data. Usually, users must download and convert this data into common data formats before visual exploration is possible.

mVIZ conducted a preliminary study to develop a methodology that supports the selection and creation of user-friendly visualizations for data discoverable via the mCLOUD. The resulting guidelines describe the methodology and serve as a basis for the conception, extension or improvement of visualization tools or their further development and integration into open data portals.

The project focused particularly on

1. the creation of an inventory of open spatio-temporal data in mCLOUD as well as an overview of available visualization and analysis tools

2. the development of a methodology for selecting appropriate visualizations for the spatio-temporal data

3. the development of a demonstrator for supporting the visualization of selected mCLOUD data.

The design and implementation of the demonstrator application was 52°North's main contribution. We used work from existing tools, such as the Helgoland Sensor Web Viewer.

**KEY TECHNOLOGIES**

> JavaScript

> Helgoland

> mCLOUD
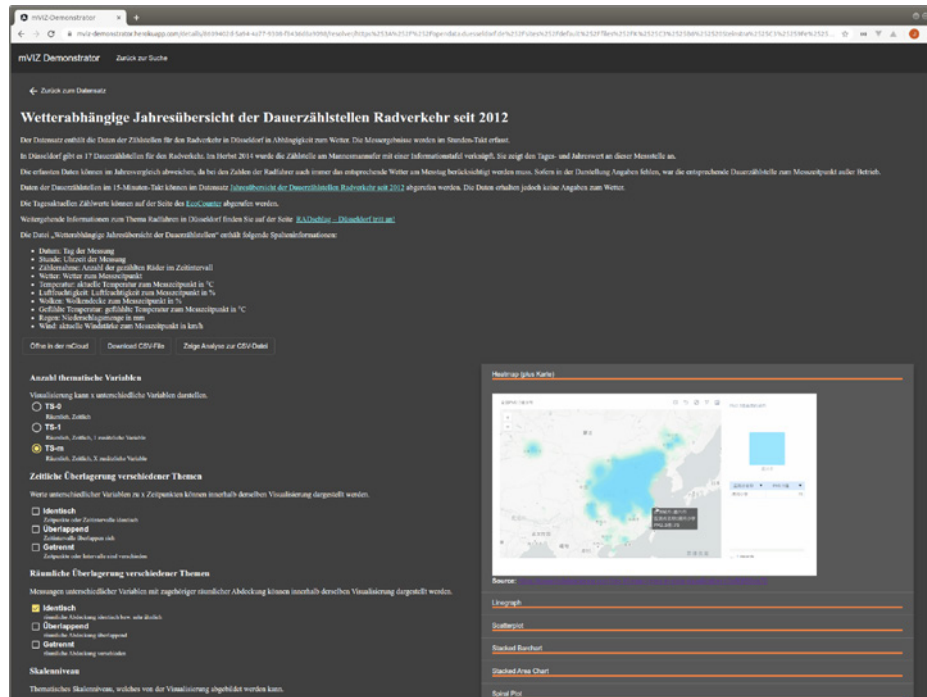
mVIZ demonstrator: View of
a data set including questionnaire
to determine suitable
visualization

We also supported the analysis of user requirements, available data sets, and appropriate data visualization approaches. Our experts contributed to the evaluation of approaches for the interoperable integration of open spatio-temporal data sources and provided feedback on design rules for data visualization.

This project was completed in 2020. During this year, we focused on developing a demonstrator that illustrates how to support users as they explore the available spatio-temporal data sets in the mCLOUD. We cooperated with the project partners to enable a full workflow ranging from automated metadata extraction to the presentation of suitable preview visualization options. Furthermore, our team contributed to the best practice guidance document, which summarizes the most important project findings (https://mviz.geo.tu-dresden.de/images/mVIZ-Leitfaden.pdf).

## PARTNERS

> **Technische Universität Dresden (TUD), Chair of Geoinformatics, Germany**,
   https://tu-dresden.de/bu/umwelt/geo/geoinformatik
> **Beuth Hochschule für Technik Berlin, Germany**,
   https://www.beuth-hochschule.de/

## FUNDING

mVIZ is funded by the German Federal Ministry of Transport and Digital Infrastructure as part of the mFUND program.

**FACTS**

**Duration**
06/2019 – 06/2020

**Website**
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**Project Type**
Research and Development

EDP 2

# European Data Portal 2

## Enhancing the European Data Portal

The European Data Portal is a core component of the European Union's public sector data infrastructure. This portal offers discovery functionality for and access to public data resources across Europe. It currently comprises ca. one million datasets from 34 countries. Portal development itself is complemented by networking activities that support Member States in publishing datasets via the portal and promoting the use of open data. The EDP 2 project improves the first EDP version. Its main challenges are the migration of the metadata storage to new linked data-based approaches and the integration of new types of data sources, such as near real-time data streams.

52°North cooperates with con terra to visualize geospatial data based on map.apps. We also tackle the integration of near-real time data sources in close cooperation with Fraunhofer FOKUS. In 2020, we supported a new iteration of the FIWARE Context Broker development that resulted in an updated Context Broker EDP Integration Module version. Our team investigated the availability of additional real-time data source types and extended the Geo-Visualization component. This includes an exemplary implementation to demonstrate easier integration of INSPIRE-compliant OGC SOS data sources into the EDP. In early 2021, the consortium was awarded a new 6-year contract to continue the EDP development.

## KEY TECHNOLOGIES

> con terra map.apps

> DCAT-AP

> JavaScript

> FIWARE Context Broker

> OGC Sensor Observation Service (SOS)

## FACTS

**Duration**
01/2018 – 04/2021

**Website**
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**Project Type**
Professional Services

## CUSTOMER

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## PARTNERS

> **Capgemini Invent, The Netherlands**, https://www.capgemini.com/service/invent/
> **Sogeti, France**, https://www.sogeti.com/
> **Intrasoft International, Luxembourg**, https://www.intrasoft-intl.com/
> **Fraunhofer FOKUS, Germany**, https://www.fokus.fraunhofer.de /
> **con terra GmbH, Germany**, https://www.conterra.de/ (52°North is subcontractor)
> **University of Southampton, United Kingdom**, https://www.southampton.ac.uk/
> **Time.lex, Belgium**, https://www.timelex.eu/
> **Lisbon Council, Belgium**, https://www.lisboncouncil.net/

KomMonitor Access Control

# Access Control for Urban Planning

## Enabling user and role defined access to KomMonitor

The KomMonitor system enables multidisciplinary urban planning by making a broad range of local data accessible and usable within a common infrastructure. Two cities from the Ruhr area (Essen and Mühlheim) collaborated with geoscientists and real estate economists from Bochum to develop this integrated monitoring system in the KomMonitor research project. The system compiles data from different areas and enables analyses and forecasts for urban development.

As part of two projects, 52°North supported Recklinghausen county in adapting the KomMonitor system to its specific needs. This involved data loading mechanisms as well as access control enablement. Based on the existing service-oriented KomMonitor architecture, we created a new, generic and configurable import component that enables any data source import into KomMonitor data management. Our team implemented a WFS connection as a first step. The import component consumes the source file, including its source structure, converts it internally to the structure required by KomMonitor and sends it to KomMonitor's existing Data Management REST API. Depending on the resource type, the component must observe specific schematic elements (e.g., user/role concept). The conversion process is configurable and enables mapping from a source schema to the KomMonitor target schema.

In a second step, our team developed and implemented a user and role concept. It is now possible to regulate access to various resource types within KomMonitor and to certain KomMonitor web client portal functions according to user and role attributes. We relied on KeyCloak and OpenID Connect technologies for this implementation.

## KEY TECHNOLOGIES

> Java

> JavaScript

> OGC Web Feature Service (WFS)

> OpenID Connect

> KeyCloak

## FACTS
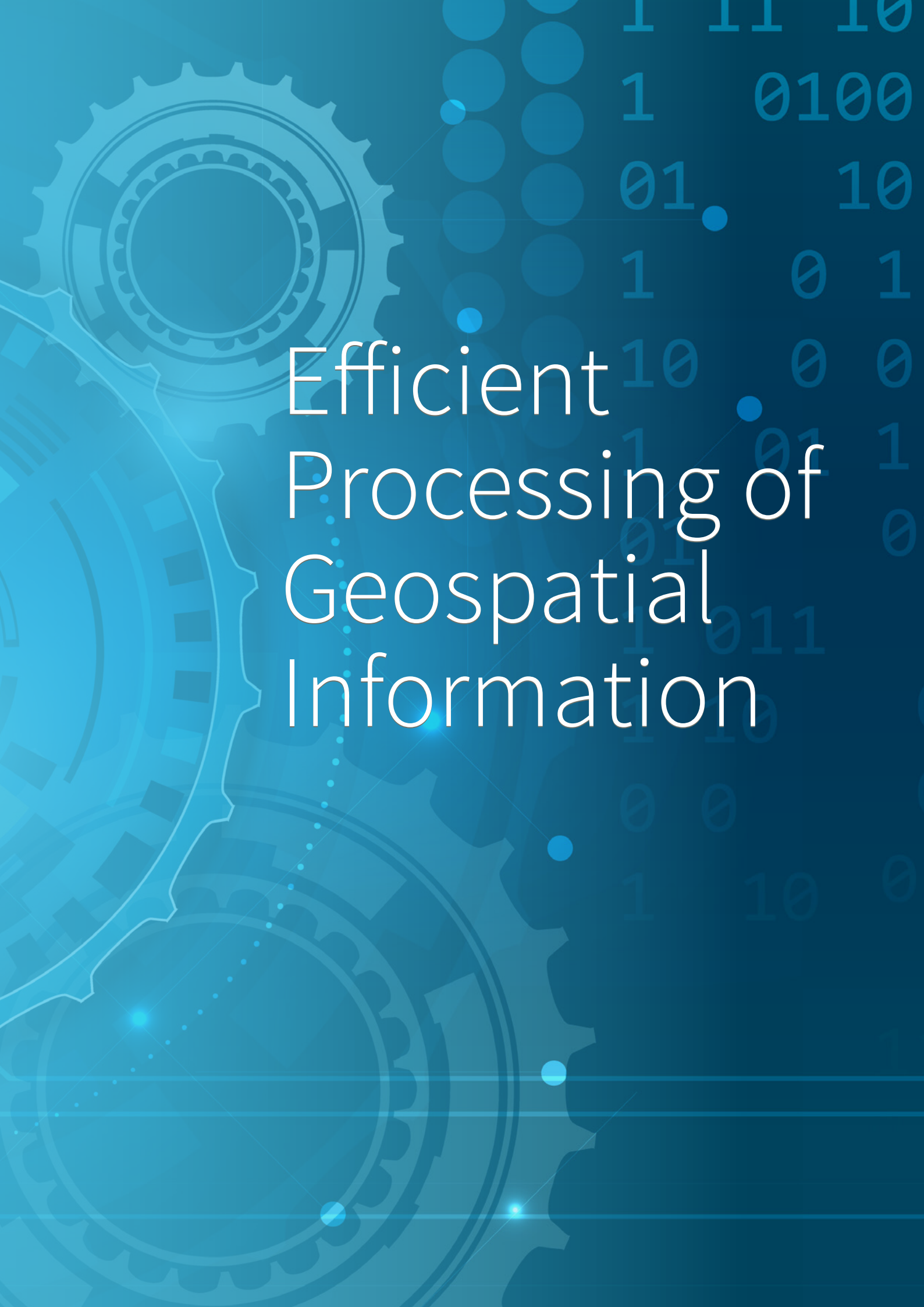
**Duration**
11/2019 – 12/2020

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**Project Type**
Professional Services

## CUSTOMER

**Recklinghausen County (Kreis Recklinghausen), Germany**, https://www.kreis-re.de/

## PARTNER

**Hochschule Bochum, Germany**, https://www.hochschule-bochum.de/

# Efficient Processing of Geospatial Information

# Architectures for heavy duty data processing

Geoprocessing refers to the data processing that is performed to transform, merge, analyze and visualize data from different sources. The increasing volume and variety of data, as well as the velocity of data streams, require new and advanced methods, technologies and architectural designs to cope with these challenges. This is where our Efficient Processing Lab contributes with research and development (R&D) and professional services (PS).

Lab head Matthes Rieke and his team work on:

_ Processing Scalability: identifying and realizing requirements for horizontal and vertical scaling of processing algorithms.

_ Workflows Chains and Orchestration: designing and automating complex process workflows.

_ Earth Observation Data Processing: handling huge amounts of EO data in an efficient and scalable way.

_ Cloud Environments (PaaS, IaaS, SaaS): enabling their possibilities with regards to deployment patterns, handling of input data and processing results.

_ Standardization: harmonizing processing interfaces, creating and using interoperable data formats.

_ Processing Transparency: strengthening reproducibility, data quality and metadata quality, as well as process discovery.

We address these challenges in a number of R&D and PS projects. Our research partners and customers are from academia and industry covering various application domains, for example, environmental monitoring, agricultural applications, or disaster management. This diversity enables us to develop new approaches that take into account the requirements of many real-world problems and use cases.

**Matthes Rieke**
Head of Efficient Processing Lab

**RIESGOS**

# Multi-Risk Analysis and Information System Components for the Andes Region

## Developing novel concepts and components for multi-risk assessment of natural hazards

The RIESGOS project addresses challenges of increased risks to society caused by natural hazards, such as volcanic eruptions, earthquakes or tsunamis. It aims to effect more efficient risk management based on more reliable information. In particular, the project addresses complex interactions, such as cascading effects of certain hazards and risks, as well as many of the underlying sources of uncertainty.

RIESGOS develops novel scientific approaches related to the assessment of different hazards and risks. This includes the analysis of dynamic exposure, vulnerability and the modelling of cascading effects and possible failures.

Modular Web services integrated into a flexible and scalable multi-risk information system demonstrator provide the foundation of the RIESGOS software architecture. End-users from civil protection and disaster management authorities receive tools to simulate and analyze complex multi-risk scenarios. These tools are complemented by the development and investigation of strategies for information-based and dialog-based risk communication.

At 52°North, we are responsible for the conceptual design and implementation of an interoperable architecture for a multi-risk analysis and information system for the Andes region. Our tasks comprise:

1. the analysis of requirements

2. the development of a software architecture following international standards to ensure interoperability (e.g., INSPIRE, OGC)

3. the implementation of selected components (data access, data analysis and processing, communication) into demonstrators

4. a contribution to market analysis and development of exploitation perspectives (focus on the publication as open source software).

**KEY TECHNOLOGIES**

> Web-based Processing

> Process Orchestration

> Scientific Data Formats

Our team focused on finalizing the service and infrastructure documentation in 2020. We incorporated recent OGC developments, such as the standardization process of the "OGC API Processes", in the overall RIESGOS architecture concept. Our experts also supported the integration of the different web services in their finalized versions into the RIESGOS demonstrator application. During several online workshops, we exhibited the demonstrator and the underlying concepts to small and medium enterprises who are active in the field of Disaster Risk Management in the project region.
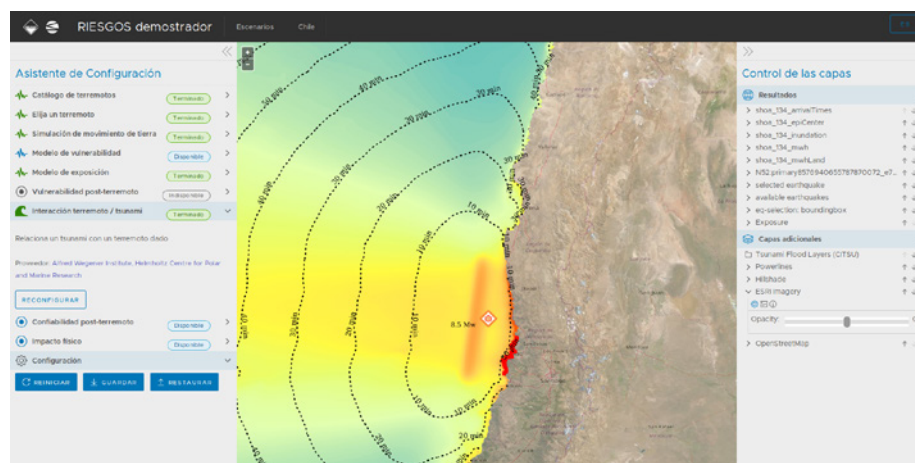


RIESGOS Demonstrator
Application

## PARTNERS

> **Coordinator: Deutsches Zentrum für Luft- und Raumfahrt (DLR), Germany**, https://www.dlr.de/
> **Helmholtz-Zentrums Potsdam Deutsches GeoForschungsZentrum (GFZ), Germany**, https://www.gfz-potsdam.de/
> **Alfred Wegener Institut (AWI), Germany**, https://www.awi.de/
> **Technische Universität München (TUM), Germany**, https://www.tum.de/
> **geomer GmbH, Germany**, https://www.geomer.de/
> **EOMAP GmbH & Co. KG, Germany**, https://www.eomap.com/
> **plan + risk consult, Germany**, http://www.plan-risk-consult.de/
> **DIALOGIK, Germany**, http://www.dialogik-expert.de/

## ASSOCIATE PARTNERS

> **GIZ GmbH, Germany**, https://www.giz.de
> **UNOOSA/UN-SPIDER, Germany**, http://www.un-spider.org/
> **UNESCO, France**, https://en.unesco.org/
> **MunichRE, Germany**, https://www.munichre.com/de/

## FUNDING

RIESGOS is funded by the German Federal Ministry of Education and Research (BMBF) as part of the funding measure "BMBF CLIENT II – International partnerships for sustainable innovations" of the framework program "Research for Sustainable Development (FONA)".

Federal Ministry
of Education
and Research

**FACTS**

**Duration**
11/2017 – 02/2021

**Website**
https://www.riesgos.de/en/

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**Project Type**
Research and Development

SenSituMon

# Large-Scale Monitoring of Flooded Areas

**Integration of satellite and in situ sensor data for improving the automated large-scale monitoring of flooded areas**

The SenSituMon project developed and tested innovative methods and technologies to generate near real-time information products from satellite and in situ sensor data for large-scale monitoring of flooded areas. Research results serve as a basis for the development and commercialization of operational services based on the Copernicus Earth Observation system and other satellite missions.

Insurance companies require up-to-date information regarding location, intensity and duration of floods for rapid response to damages caused by flood-related events. In addition, they need to document the flooding history so that detailed information about the occurrence, frequency and duration of flooding events is available for the affected areas. This information can be used, for example, to validate flood risk assessments.

The project analyzed additional requirements for monitoring flooded areas for further applications in agriculture and water management. Work initially focused on North Rhine-Westphalia in Germany. Based on the results of this project phase, the consortium assessed the scalability of the approach for Germany and Europe.

52°North developed and evaluated new methods for automating spatio-temporal delineation of flood events from meteorological and hydrological measurement and observation data, such as RADOLAN (German Weather Service) and Pegel-Online (German Water and Shipping Administration). This information is used to focus data analysis that requires intensive resources on regions where significant flooding cannot be ruled out. We also established an event-based and highly scalable stream processing infrastructure for efficient and distributed processing of observation and measurement data. This forms the technical basis for the integration of in situ data that are merged "on-the-fly" from different data sources (data fusion) and integrated into the automated processing workflow. Our team was responsible for the development of the overall architecture and contributed significantly to the integration and validation of the solution's approach.

## KEY TECHNOLOGIES

> Docker

> Kubernetes

> Prometheus

> Apache Kafka

> Grafana

> RADOLAN

> KOSTRA

> Pegel-Online

> Open Stack

> Open Telekom Cloud

> Mundi WebServices

> Copernicus

> ArcGIS Image Server

We implemented Docker, Kubernetes and Kafka-based components of the processing infrastructure and integrated them with the ArcGIS-based data and visualization services to form a complete system. In addition, our team deployed the complete infrastructure in the Copernicus DIAS platform Mundi Web Services. The system has been running in a test and validation mode since mid-2019. In 2020, we finalized all project work.
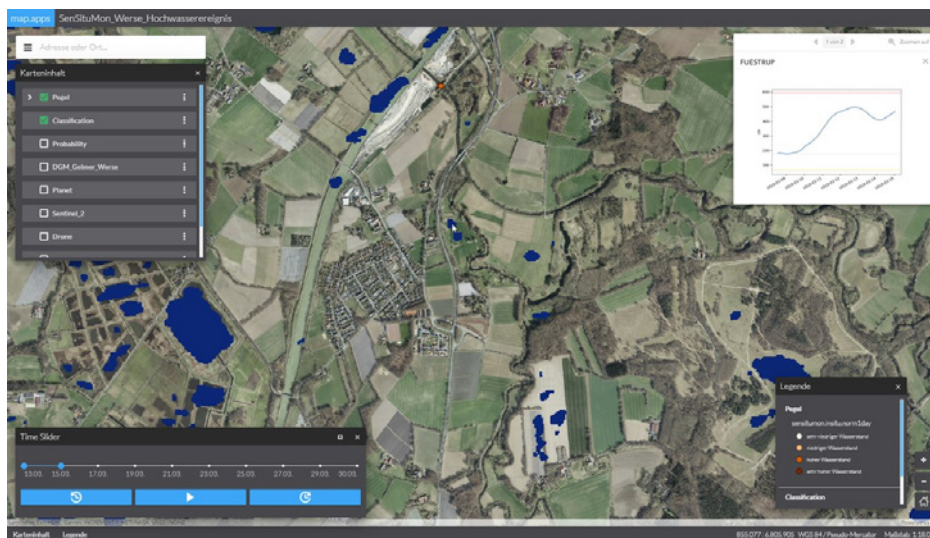


**Flood mapping demonstrator**

## PARTNERS

> **con terra GmbH, Germany**, http://www.conterra.de
> **EFTAS, Germany**, https://www.eftas.de/

## ASSOCIATE PARTNERS

> **VdS Schadenverhütung GmbH**, https://vds.de/
> **CLAAS KgA, Germany**, https://www.claas.de
> **Wupperverband, Germany**, https://www.wupperverband.de/

## FUNDING

## FACTS

**Duration**
11/2017 – 01/2020

**Website**
http://sensitumon.eu/en/index.html

**Contact**
Prof. Dr. Albert Remke
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**Project Type**
Research and Development

WaCoDiS

# Automated Workflows for Creating EO Products

## Copernicus-based services for monitoring material inputs in watercourses and dams

The WaCoDiS project implemented a geoinformation infrastructure specifically optimized to account for water quality control, water protection and protection of access to clean drinking water for river basin management monitoring tasks. Using innovative and automated workflows, the consortium combines, merges and analyzes Earth Observation data from the Copernicus Program, weather data (i.e. from the German Weather Service, DWD) and in situ sensor data for monitoring water bodies. Interoperable services provide and cross-link input data, results, and the functionality developed in the project.

Based on a detailed analysis of user requirements as well as the technical and scientific status quo, the project members developed a WaCoDiS architecture and system design. Special consideration was given to the integration of potentially large Earth Observation data sets (i.e., from the Copernicus Program), the integration of cloud-based processing platforms (e.g., CODE-DE) and modern communication patterns ensuring the timely delivery of information.

Activities also covered the evaluation, preparation and persistence of appropriate Sentinel and DWD data, the development of automated analysis algorithms, and the implementation of interoperable data processing and access services. Complementary tasks addressed the adaptation and development of essential hydrological models.

In close collaboration with the Bochum University of Applied Sciences, 52°North supported the requirements analysis, developed the system architecture and implemented system components. Our team also evaluated different approaches to enable efficient processing of Copernicus data, interoperable provision of domain-specific processing and analysis models as well as new technologies for data sharing. We particularly focused on event-driven communication patterns in spatial data infrastructures and cloud-based data processing approaches. Complementary work comprised the contribution of results and experience gained during WaCoDiS to the international

## KEY TECHNOLOGIES

> Earth Observation data

> Copernicus

> Sensor Web

> Microservices

> Cloud

> Event-driven Workflows

> ArcGIS

standardization process and the evaluation of recent and ongoing standardization activities regarding their relevance to WaCoDiS (e.g., OGC Publish/Subscribe standard, OGC SensorThings API).

During the project's final year, we focused on maturing the system and its components as well as evaluating different deployment strategies. The system successfully established the connection to the new CODE-DE platform, which was relaunched in April 2020. We deployed the algorithms for the data-related processing of Copernicus products as WPS instances in the CODE-DE cloud. In addition, our team successfully deployed the WaCoDiS system on the Google Cloud Platform (GCP), thus demonstrating its independence. We used different technologies (e.g., Google Kubernetes Engine, Cloud Run) to effectively set up the different UI and backend components. In close collaboration with the Wupperverband, 52°North evaluated the overall system based on selected test scenarios. We also demonstrated the WaCoDiS system to associated water management organizations as part of our outreach activities.

**Google Cloud Platform deployment (on left)**

**Kubernetes cluster (on right)**
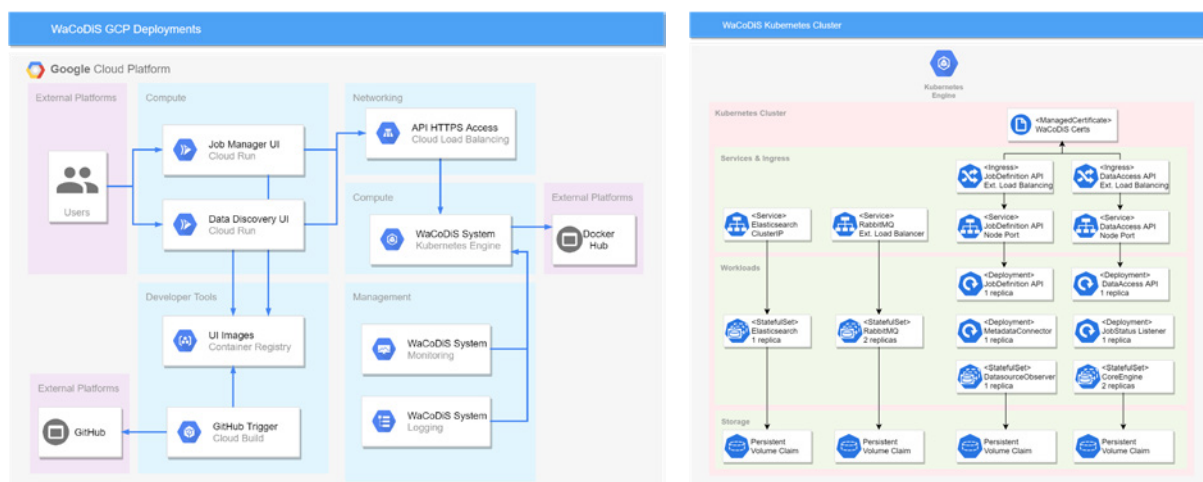


## PARTNERS

> **Coordinator: Bochum University of Applied Sciences, Germany**,
  https://www.hochschule-bochum.de/
> **Wupperverband, Germany**, https://www.wupperverband.de/
> **EFTAS, Germany**, https://www.eftas.de/

## ASSOCIATE PARTNERS

> **ITZBund (Informationstechnikzentrum Bund, Ilmenau), Germany**,
  https://www.itzbund.de/
> **Netteverband, Germany**, http://www.netteverband.de
> **Niersverband, Germany**, https://www.niersverband.de

## FUNDING

WaCoDiS is funded by the German Federal Ministry of Transport and Digital Infrastructure (BMVI) as part of the of the mFUND program.

Federal Ministry
of Transport and
Digital Infrastructure

mFUND
Das Startkapital für die Mobilität 4.0

### FACTS

**Duration**
08/2017 – 07/2020

**Website**
https://wacodis.fbg-hsbo.de

**Contact**
Matthes Rieke
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Dr. Simon Jirka
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**Project Type**
Research and Development

OGC Testbed 16

# Interoperable Spatial Data Processing

**Shaping the future of spatial data technologies**

The Open Geospatial Consortium (OGC) Testbed is an annual research and development program that explores geospatial technology from various angles. "Testbed-16 evaluates the maturity of the Earth Observation Cloud Architecture that has been developed over the last two years as part of various OGC Innovation Program initiatives in a real world environment." (https://www.ogc.org/projects/initiatives/t-16)

52°North participated in two different Testbed threads, the Earth Observation Clouds (EOC) and Data Integration & Analytics (DIA) threads. The (EOC) thread task Earth Observation Application Packages with Jupyter Notebooks (EOAP) focused on the publication of Jupyter Notebook-based processes in Cloud environments. We created a Notebook implementation for flood mapping using Sentinel-1 data use cases. Our team deployed the Notebook processes using Common Workflow Language definitions in combination with Application Deployment and Execution Services (ADES).

In the DIA's Machine Learning task, 52°North developed a machine learning model based on TensorFlow for the identification of water bodies using Sentinel-1 data provided via an OGC API Tiles server. We also published the model on the web via the ADES integration pattern.

### PARTNERS

> **Terradue Srl, Italy**, https://www.terradue.com/
> **Geomatys, France**, https://www.geomatys.com/
> **Spacebel s.a., Belgium**, https://www.spacebel.be/
> **CubeWerx Inc., Canada**, https://www.cubewerx.com/
> **RSS-Hydro, Luxembourg**, https://rss-hydro.lu/

### FUNDING

OGC Testbed 16 was funded by multiple sponsors, including:
> **Natural Resources Canada (NRCan), Canada,** https://www.nrcan.gc.ca/
> **European Space Agency (ESA), France**, http://www.esa.int/
> **US National Aeronautics and Space Administration (NASA), USA**, https://www.nasa.gov/

## KEY TECHNOLOGIES

> Jupyter Notebooks
> TensorFlow
> OGC APIs
> Docker
> OGC Web Processing Service (WPS)

## FACTS

**Duration**
04/2020 – 11/2020

**Contact**
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**Project Type**
Professional Services

## EUMETSAT EOWS and Big Data Services

# Earth Observation Web Based Services

### Designing the next generation of Online Data Access Services

As part of evolving its Data Services, EUMETSAT started developing a portfolio of data services featuring innovative data access and discovery capabilities. A first operational version was developed within the Earth Observation Web Based Services (EOWS) project and is available as of August 2020. In a consortium led by CGI Deutschland, 52°North works with con terra, ask visual and GeoSolutions to develop a flexible, scalable and extensible architecture for providing online access to EUMETSAT's products.

52°North focuses on the development of a web application for intuitive EO data access: the EUMETSAT Data Store. The application is designed to provide an easy-to-use web interface for end users in order to identify EO products of interest. It comprises a search interface with spatial, temporal and thematic filters. Users are able to examine the details (e.g., the spatial footprint, sensing time, satellite instruments used) and start the download of single or multiple products.

Our team concentrated on supporting and integrating EUMETSAT's new data services. We designed and implemented several adjustments, e.g., Product Licenses and Data Tailor services integration, and improved base layer visualizations for Polar regions. EUMETSAT successfully deployed the software architecture as part of the EUMETSAT Data Lake, providing access to a multitude of products for EUMETSAT users. At the end of 2020, EUMETSAT awarded the consortium the "Support to Cloud and Big Data Services Engineering and Operations" project, laying the foundation for continuing developments.

### CUSTOMER

> **EUMETSAT, Germany**, https://www.eumetsat.int/

### PARTNERS

> **CGI Deutschland B.V. & Co. KG, Germany**, https://www.de.cgi.com/de
> **con terra GmbH, Germany**, https://www.conterra.de/
> **ask – Innovative Visualisierungslösungen GmbH, Germany**, https://askvisual.de/
> **GeoSolutions S.A.S., Italy**, https://www.geo-solutions.it/

**KEY TECHNOLOGIES**

> JavaScript/TypeScript (Single Page Application)

> Angular

> OpenAPI

**FACTS**

**Duration**
05/2017 – 06/2021

**Website**
https://data.eumetsat.int/

**Contact**
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**Project Type**
Professional Services

41

Fraym DMP

# Fraym Data Management Platform

## Designing geodata management

Fraym "delivers unprecedented, localized information about population characteristics and behaviors" (https://fraym.io/). The data used ranges from raster and vector data to survey and related reference data. This data and the results of analysis workflows must be stored and managed in a sustainable and similar manner. Since the amount of data Fraym stores has exceeded a manually manageable threshold, they needed to create a modern and scalable solution that takes Geo-IT standards into account.

The main project goal is to identify, discuss and document the requirements for Fraym's Data Management Platform (DMP) with a particular focus on geo-spatial aspects. 52°North supports and advises Fraym in their development of solutions for storing and managing geo-spatial data required for data analysis workflows.

The initial requirements analysis phase featured a remote User Story Workshop. Based on the user requirements collected during a workshop, 52°North designed an overall architecture for the DMP. Using arc42 as a lightweight, but flexible architecture documentation concept, we identified and designed the DMP's central components to the required level of detail.

The project has recently reached the implementation phase. We currently develop the DMP using cutting-edge technology (e.g., AWS Elastic Kubernetes Service, auto-scaling of underlying business logic components, S3 for data storage). Specific solutions that focus on the requirements of data ingestion and metadata management will soon accompany the GeoNode framework that builds the technological foundation.

## KEY TECHNOLOGIES

> User Story Workshop

> arc42

> GeoNode

> AWS Elastic Kubernetes Service

> S3

## FACTS

**Duration**
05/2020 – 02/2021

**Contact**
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**Project Type**
Professional Services

## CUSTOMER

> **Fraym, Germany**, https://fraym.io/

EOPORT

# NRT Platform for Copernicus Sentinel Data

**Near-real time processing concepts for Copernicus Sentinel-1 data**

As a technical progression of SenSituMon project developments (page 36), the EOPORT project developed and tested innovative methods and technologies for generating near real-time (NRT) information products for large-scale monitoring of flood areas based on satellite and in situ sensor data. EOPORT partners, part of a bigger consortium led by Kongsberg Satellite Services (KSAT), should use the results to develop and market operational services in the context of the NRT Synthetic Aperture Radar (SAR) satellite missions – in particular Sentinel-1 data.

Insurance companies depend on up-to-date information about the location, intensity and duration of floods for a quick response to flood-related damage events. This information is valuable for the assessment of flood risks. Thus, the resulting information products are generated to accommodate these companies' requirements. The project carried out data analysis in North Rhine-Westphalia, Germany.

52°North collaborated with con terra and EFTAS on the development and operation of the processing system on a dedicated tenant in the Open Telekom Cloud (OTC). This acts as a proof of concept for external EOPORT NRT platform users. We also realized a Kubernetes-based job execution concept to enable efficient processing of NRT Sentinel-1 data provided as small bursts. Our team was responsible for the sustainable and scalable operation of the different components (e.g., Kafka, Spark-based image processing).

## CUSTOMER

> **European Space Agency (ESA), France**, https://www.esa.int

## PARTNERS

> **Kongsberg Satellite Services (KSAT), Norway**, https://www.ksat.no/
> **Kongsberg Spacetec AS (KSPT), Norway**, https://www.spacetec.no/
> **T-Systems, Germany**, https://www.t-systems.com/
> **con terra GmbH, Germany**, https://www.conterra.de/
> **EFTAS, Germany**, https://www.eftas.de/

## KEY TECHNOLOGIES

> Kubernetes
> Spark
> Kafka
> Docker
> Spring Boot

## FACTS

**Duration**
04/2020 – 11/2020

**Contact**
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**Project Type**
Professional Services

# Copernicus Data Infrastructure at IT.NRW

## Efficient processing of Copernicus satellite and in situ data

**KEY TECHNOLOGIES**

> Docker

> Kubernetes

> Argo

> Solr

> Python

> ArcGIS

One of the core tasks of the State Office for Information Technology and Statistics (IT. NRW) is to develop and operate the IT infrastructure for the North Rhine-Westphalian (NRW) state administration. The state office also advises and supports the state authorities and institutions in the use of information technology. As a provider of infrastructure, geospatial data and services, IT.NRW plays an important role in the spatial data infrastructure in NRW. One of IT.NRW's goals is to further develop its own infrastructure to better support on-demand processing of very large amounts of data for creating information products in the context of Copernicus. This development takes place in joint pilot projects with the state administration stakeholders, such as the competence centers for remote sensing of the LANUV NRW, Geobasis NRW or Wald und Holz NRW. IT.NRW applies an agile process to develop structures and answer questions that contribute to the sustainable development of an efficient Copernicus data infrastructure for the NRW state administration.

After the successful realization of a first pilot project supporting the use case of detection and qualification of orchards in NRW, IT.NRW continued to improve the stability and scalability of the Kubernetes-based infrastructure. The consortium, in close collaboration with IT.NRW, replaced the central workflow execution component with a workflow engine based on the Argo framework. This pilot project was driven by Geobasis NRW requirements. Fully integrated with Kubernetes, Argo enables the scalable and reliable execution of complex workflows using process steps capsulated in Docker containers. A dedicated focus was on the management of metadata on Copernicus raw data as well as on process results in a central metadata index.

In close collaboration with con terra and IT.NRW, 52°North designed the system architecture. We focused on the transition of existing workflows to Argo and the integration of the newly introduced metadata index. In addition, our team supported the deployment and setup of the new software solution on IT.NRW premises.

In order to reflect and sustainably integrate the requirements of IT.NRW and the related competence centers, our team held a dedicated workshop to identify the most important aspects of the platform. We concurrently improved the architecture design based on insights gained and developed first system components. Due to the short project life, we established an agile feedback process with bi-weekly Jour Fixe meetings. This ensured the efficient and focused realization of the workflow system that is now capable of processing large amounts of Sentinel data using modern elastic scalability approaches.



Architecture of the CDI@IT.NRW system
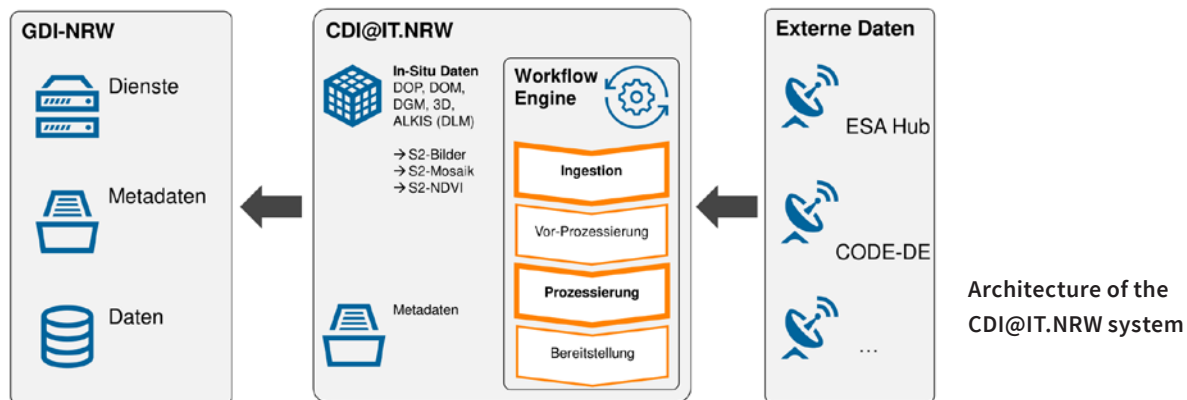
## CUSTOMERS

> **State Agency Information and Technology North Rhine-Westphalia – IT-NRW, Germany**, https://www.it.nrw/
> **Geobasis NRW, Germany**,
  https://www.bezreg-koeln.nrw.de/brk_internet/geobasis/index.html

## PARTNERS

> **con terra GmbH (main contractor), Germany**, https://www.conterra.de/
> **EFTAS, Germany**, https://www.eftas.de/

## FACTS

**Duration**
09/2020 – 11/2020

**Contact**
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**Project Type**
Professional Services

# Spatio-Temporal Data Analytics

# Developing analytical tools to address real world problems

The volume and variety of data available is constantly increasing. Hence, they provide a large potential to answer a range of questions. To understand these data and to model relationships emerging from them in order to derive answers, we need analytical tools. Dr. Benedikt Gräler, head of the Spatio-Temporal Data Analytics Lab, and his team develop data-driven solutions to real world problems.

Exploring and researching analytical tools from linear statistics, recent multivariate distributions to modern machine learning (ML) and artificial intelligence (AI) approaches, the lab develops an appropriate solution for the problem at hand given the data available. A prerequisite is a solid data and business understanding. We use and contribute to open source tools where possible and encourage Citizen Science.

The lab addresses different R&D and PS projects covering a range of topics. The challenge of making Earth Observation time series accessible and providing unified processing and analysis tools has been and remains an engineering topic solving several open questions. The meaningful integration of heterogeneous data sources (from geospatial observations to official statistics) and adopting ML and AI algorithms to the special characteristics of spatial and spatio-temporal data are central themes of forthcoming tasks.



**Dr. Benedikt Gräler**
Head of Spatio-Temporal
Data Analytics

PreASiSt

# Predictive Analytics for Traffic Safety

**Assessing the applicability of predictive policing and predictive analytics for improving traffic safety**

The motivation behind predictive policing is to predict crimes before they occur. The PreASiSt project assessed whether general concepts of predictive policing can be adopted and applied to the field of traffic safety.

Models should help to understand and capture conditions that could trigger an accident. Forecasts of these variables can be used to predict and evaluate the risk of accidents. Based on these risks, the police can plan and take measures to increase traffic safety in these areas. In order to identify relevant parameters, this project approached the problem from a theoretical and data driven view point, using the Cross Industry Standard Process for Data Mining (CRISP). The city of Bremen provided a detailed history of traffic accidents and other relevant data sets and their local police contributed expert knowledge.

52°North focused on data analytics. We investigated both the suitability of available data sources for predictive data analysis and the use of machine learning methods for creating accident risk prediction models. Data understanding; however, can only be achieved by understanding the underlying processes. Thus, we worked in close collaboration with the Institute of Traffic and Engineering Psychology of the German Police University (DHPOL) and the local experts from the Bremen Police.

The project came to a close in 2020. For our part, our team concluded the data analysis. This focused on the development of accident density maps based on external conditions, such as the day of the week or the traffic conditions on the surrounding highways, and their impact on the inner city traffic. Furthermore, we employed machine learning approaches to extract relevant parameters affecting the occurrence of accidents.

**KEY TECHNOLOGIES**

> R and Python for Data Analytics

> QGIS

> ArcGIS

> HERE Traffic Analytics

> BMW Live

Comparison of the distribution of accidents when traffic jams on the surrounding highways occur and when traffic flows freely on the highways.

## PARTNERS

> **Institute of Traffic and Engineering Psychology of the German Police University (DHPol), Germany**, http://dhpol.de

## ASSOCIATE PARTNERS

> **Polizei Bremen, Germany**, https://www.polizei.bremen.de
> **Gesamtverband der Deutschen Versicherungswirtschaft e.V. – GdV (gdv.de) – Unfallforschung der Versicherer (UDV), Germany**, https://udv.de
> **TSC – Beratende Ingenieure für Verkehrswesen, Germany**, http://mvup.de
> **con terra GmbH, Germany**, http://www.conterra.de

## FUNDING

PreASiSt is funded by the German Federal Ministry of Transport and Digital Infrastructure (BMVI) as part of the mFUND program.

Federal Ministry of Transport and Digital Infrastructure

mFUND
Das Startkapital für die Mobilität 4.0

## FACTS

**Duration**
03/2019 – 02/2020

**Website**
https://www.bmvi.de/SharedDocs/DE/Artikel/DG/mfund-projekte/preasist.html

**Contact**
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**Project Type**
Research and Development

CITRAM

# Citizen Science for Traffic Management

**Improving the provision of information for traffic management and environmentally conscious driving**

The CITRAM project aims to improve the quality of city traffic and make it more sustainable by streamlining the traffic flow. This improves traffic energy efficiency and lowers fuel consumption as well as the emission of air pollutants. Citizens are invited to contribute data collected while driving their car to gain information about the actual city traffic situation. For this purpose, 52°North enhanced the Citizen Science platform enviroCar to support automated near real-time services for analyzing traffic quality in the city.

The [ui!] – urban institute connected its IoT platform UrbanPulse to the municipal traffic information infrastructure. It also developed a traffic light phase assistant (ECOMAT) that takes into account the dynamic control of traffic light systems. Deggendorf University supported the data collection and the data analysis of electric vehicles. 52°North's main task was to develop new and improved analysis methods for XFCD trajectories. New features include the estimation of the car's energy demand from car movement data, the support of near real-time data stream processing, and the enhancement of MapMatching and Hot Spot analysis for network related road data based on an event-driven architecture. TSC Beratende Ingenieure für Verkehrswesen developed services for monitoring traffic quality and supported the cities of Krefeld, Hamm and Chemnitz in conducting data collection campaigns.

In 2020, CITRAM entered its final phase. We completed the implementation of changes to the enviroCar infrastructure and provided the software as a service for testing purposes. The three partnering cities supported field tests and evaluated the technologies and methods developed within the project. Due to the Corona pandemic, the cities had difficulty with the acquisition of participants for testing. This resulted in biased traffic characteristics – less traffic and fewer stop-and-go traffic situations. Nevertheless, the cities successfully completed the tests and these provided valuable insights into the project's main ideas and research questions.

**KEY TECHNOLOGIES**

> Android

> Java

> MongoDB

> Apache Kafka

> PostGreSQL

> Geoserver

> OpenStreetMap

Comparison between speed limits
and average velocities
(Red: < 50 % of limit,
Green: > 80 % of limit)

## PARTNERS

> **Urban Software Institute GmbH, Germany**, https://www.ui.city
> **TSC Beratende Ingenieure für Verkehrswesen, Germany**, https://www.mvup.de
> **Technische Hochschule Deggendorf, Germany**, https://www.th-deg.de
> **Stadt Chemnitz, Germany**, https://www.chemnitz.de
> **Stadt Hamm, Germany**, https://www.hamm.de
> **Stadt Krefeld, Germany**, https://www.krefeld.de

## FUNDING

CITRAM is funded by the German Federal Ministry of Transport and Digital
Infrastructure (BMVI) as part of the mFUND program.

Federal Ministry
of Transport and
Digital Infrastructure

**mFUND**
Das Startkapital für die Mobilität 4.0

### FACTS

**Duration**
09/2018 – 11/2020

**Website**
http://www.citram.de

**Contact**
Prof. Dr. Albert Remke
*a.remke@52north.org*

**Project Type**
Research and Development

MariGeoRoute

# MariData GeoPlatform and Routing

**Comprehensive technologies for ship energy management**

MariData is a BMWi funded project that aims to enable a deterministic analysis of a ship's energy demand based on environmental and physical conditions. It sensibly delineates the energy demand's various sources to provide tools for an energy optimized ship management. This leads to suggested routing alternatives, speed and trim adjustments or additional services for the ship hull.

MariGeoRoute is a subproject that addresses the challenges related to needs arising from the various data demands, such as nautical maps, weather records and forecasts ranging from wind and temperature to wave heights and currents. This integrated data store, the GeoPlatform, will provide data for the shipping company as well as for the ships at sea and needs to sensibly subset and preprocess the data to reduce data load. 52°North will also develop approaches based on machine learning (ML) to model the energy demand based on the data collected and derived from the consortial partners. A routing service we developed will use the data accessible in the GeoPlatform to provide routing alternatives along the smallest energy demands under constraints of nautical limitations, ship safety and delivery schedules.

Since its recent start in December 2020, our team has initiated the requirements analysis of the MariData GeoPlatform. First concepts and options are already under evaluation for their suitability.



**KEY TECHNOLOGIES**

> OpenDataCubes

> Java

> JavaScript

> Python
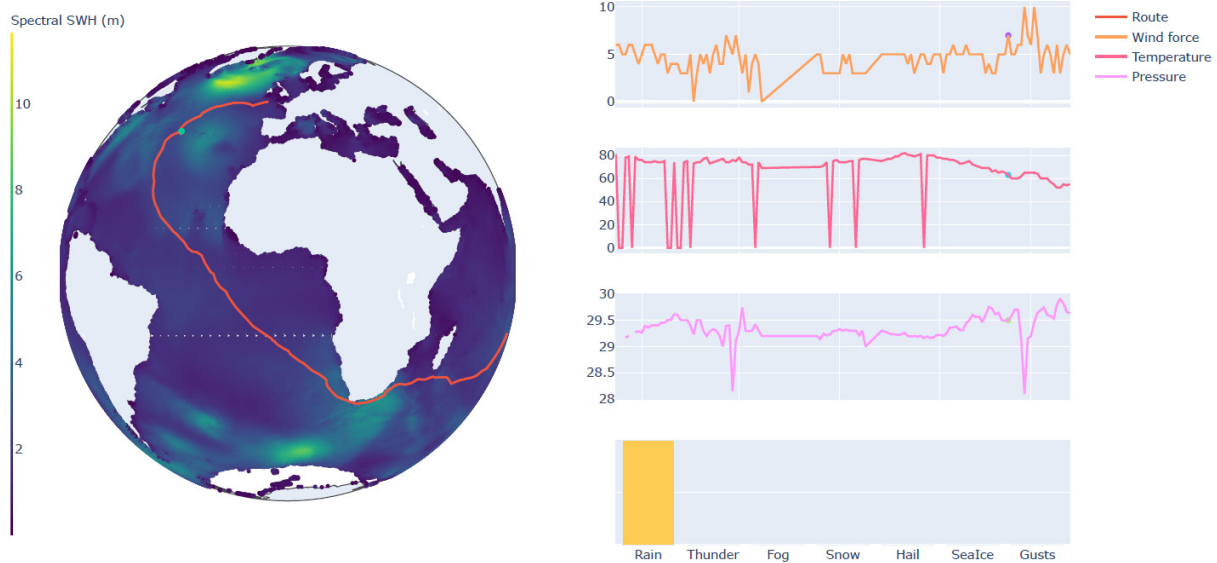
Visualization of an historic ship route
with environmental data (wave heights,
temperature, air pressure, wind force)
and weather

## PARTNERS

> **Hamburgische Schiffbau-Versuchsanstalt GmbH (HSVA), Germany**,
  https://www.hsva.de/
> **AVL Deutschland GmbH, Germany**, https://www.avl.com/
> **DST – Entwicklungszentrum für Schiffstechnik und Transportsysteme e.V.,
  Germany**, https://www.dst-org.de/
> **Friendship Systems AG, Germany**, https://www.friendship-systems.com/
> **Technische Universität Berlin, Germany**, https://www.tu.berlin/
> **Technische Universität Hamburg, Germany**, https://www.tuhh.de/
> **Universität zu Lübeck, Germany**, https://www.uni-luebeck.de/
> **Maritimes Zentrum der Hochschule Flensburg, Germany**,
  https://www.maritimes-zentrum.de/
> **Carl Büttner Shipmanagement, Germany**, https://www.carlbuettner.de/
> **AVL Software and Functions, Germany**, https://www.avl-functions.com/

## FUNDING

Federal Ministry
for Economic Affairs
and Energy

**FACTS**

**Duration**
12/2020 – 11/2023

**Website**
https://maridata.org

**Contact**
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**Project Type**
Research and Development

## MuDak-WRM

# Improved Reservoir Management with Easily Parameterized Models

### Multidisciplinary data acquisition as key for globally applicable water resource management



Water is a highly valuable good worldwide. It must be managed with care in order to fulfill the needs of diverse consumers. The quality of a water reservoir not only depends on the reservoir itself, but is also influenced by the surrounding environment and the entire catchment. While in situ monitoring of a reservoir provides detailed data, it is also very costly. The MuDak-WRM project aimed to identify proxies that provide insights into the quality of a reservoir, which are detailed enough for mid-range management and applicable worldwide.

The specific goals were the complexity reduction of current water reservoir (management) models, their parameterization based on a minimal data set, the development of a central data delivery service, wrapping models in web processing services (WPS), and a common visual web-based water quality exploration tool. A key constraint was the parameterization based on Sentinel data and a minimum of additional in situ measurements in order to achieve a globally applicable but nevertheless sensible monitoring framework.

The technical driver of this development is a central data access point that provides and merges in situ and remote sensing data. 52°North contributes the development of an open source service that grants access to spatial and spatio-temporal data from in situ sensors, measurement campaigns, drones, and Sentinel missions. A key challenge originates from the data's different spatial and temporal resolutions. Where autonomous in situ sensors continuously report measurements within minutes at fixed locations, field campaigns can produce data acquired in seconds along 3-dimensional trajectories and remote sensing data is collected on a daily scale with a large 2-dimensional coverage.

We assessed the storage of gridded data in different databases (SciDB, Geoserver) according to the quick retrieval of pixel time series. Web coverage and web map services (OGC WCS and WMS) facilitate the access. The Sensor Observation Service (OGC SOS)

### KEY TECHNOLOGIES

> OGC Sensor Observation Service (SOS)

> Geoserver

> SciDB

> OGC Web Coverage Service (WCS)

> OGC Web Mapping Service (WMS)

provides in situ measurement data. Web processing services (OGC WPS) provide models developed by the consortium that build upon the centralized data. Our team worked with the Wupperverband to develop a joint interface to the reservoir data.

In 2020, the MuDak-WRM Spatial Data Infrastructure (SDI) evolved further to meet the partners' needs. The project members coordinated developments during a joint project workshop in Curitiba. In order to support the use of remote sensing imagery, we integrated the GeoServer into the SDI serving data as WMS and WCS. The work package leader Wupperverband developed a viewer for the SDI. Furthermore, the Institute for Geoinformatics and our team compared the performance of the GeoServer solution with an alternative based on gdalcubes.
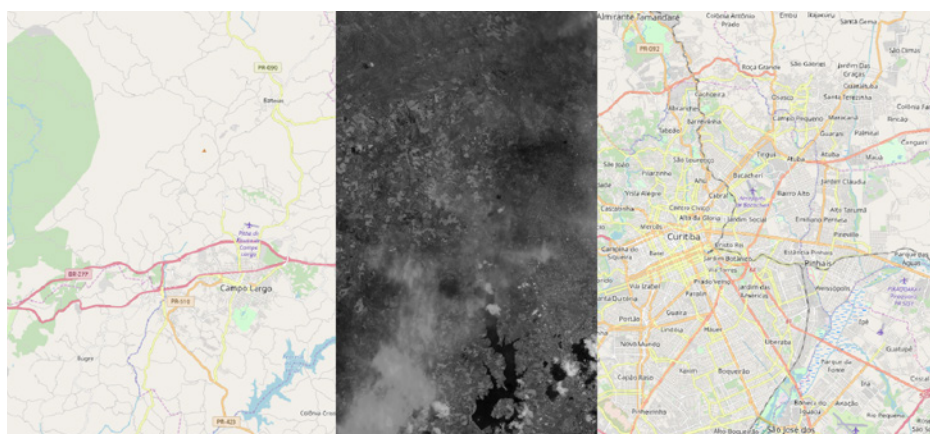


**WMS overlay of a remote sensing scene in the MuDak-WRM study area**

## PARTNERS

> **Karlsruher Institut für Technologie (KIT), Germany**, http://www.kit.edu/
> **Universität Koblenz Landau, Germany**, https://www.uni-koblenz-landau.de/
> **Hydron GmbH, Germany**, https://www.hydron-gmbh.de/
> **Wupperverband, Germany**, https://www.wupperverband.de/
> **EFTAS, Germany**, https://www.eftas.de/

## ASSOCIATE PARTNERS

> **Sanepar, Brasil**, http://site.sanepar.com.br/
> **Universidade Federal Do Paraná (UFPR), Brasil**, http://www.ufpr.br/portalufpr/
> **Universidade Positivo, Brasil**, https://www.up.edu.br/
> **EMATER, Brasil**, http://www.emater.pr.gov.br/
> **Instituto das Águas do Paraná (Auguas Paraná), Brasil**, http://www.aguasparana.pr.gov.br/
> **Agência Nacional De Águas (ANA), Brasil**, http://www.aguasparana.pr.gov.br/

## FUNDING

Funded by the German Federal Ministry of Education and Research (BMBF) within the program Global Resource Water (GRoW).

**FACTS**

**Duration**
04/2017 – 07/2020

**Website**
http://www.mudak-wrm.kit.edu

**Contact**
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**Project Type**
Research and Development

# AI Strategy for Earth System Data

## AI for the analysis of Earth Observation data

Artificial intelligence (AI) methods currently experience rapid development and increasing use in the context of environmental data. However, this often happens in isolated solutions. Environmental and earth system sciences have yet to establish the systemic use of modern AI methods. In particular, discrepancy exists between the requirements of a solid and technically sound environmental data analysis and the applicability of modern AI methods such as Deep Learning for researchers.

The KI:STE project strives to facilitate and evaluate the use of AI for remote sensing Earth Observation data for a range of applications. The fields studied in the project range from air quality to clouds and radiation, to snow and ice propagating, as well as water that drives vegetation, then closing the loop with air quality again. A core focus is not only to adopt and apply AI concepts to these areas, but also to train several PhD students and build an e-learning platform. This will ease and facilitate access to the algorithms and tools developed for a wider audience – from scientists to practitioners.

52°North develops the Spatial Research Data Infrastructure (SRDI) that will supply the AI processing platform with data. A requirement analysis provides the basis for defining and developing interfaces for data acquisition and provision. The platform must react flexibly to the requirements of the AI algorithm requesting data in order to be able to provide them in a format optimized for the required processing. We will work on the SRDI in close collaboration with the Ambrosys GmbH.

The project officially started in November. As a result, our team and Ambrosys have initiated the requirements analysis for the KI:STE data and machine learning platform. We are already evaluating first concepts and options according to their suitability.

**KEY TECHNOLOGIES**

> Cloud

> SDI

> RDI

> Python

> Machine Learning

> Artificial Intelligence
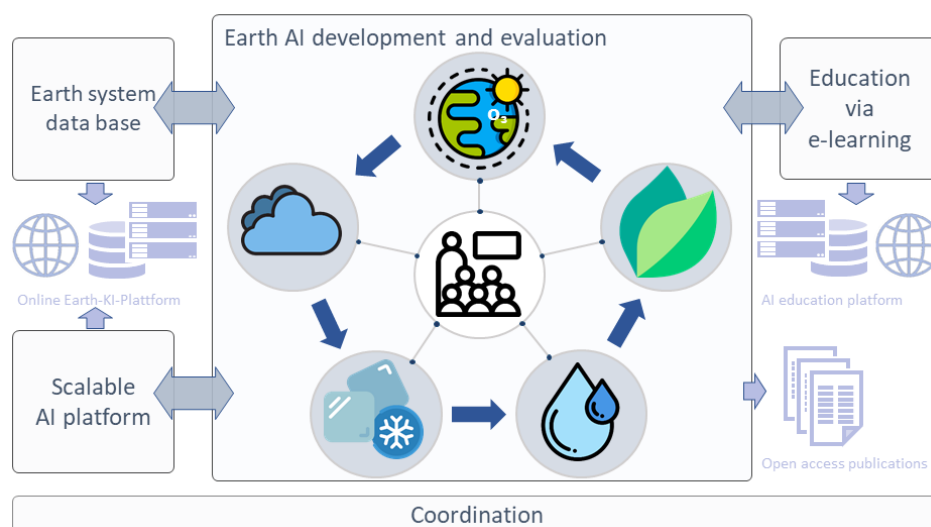
**KI:STE's thematic workflow
in a technical context**

## PARTNERS

> **Forschungszentrum Jülich GmbH, Germany**, https://www.fz-juelich.de
> **Jülich Supercomputing Centre (JSC), Germany**,
> https://www.fz-juelich.de/ias/jsc/
> **Institut für Bio- und Geowissenschaften – Agrosphäre (IBG-3), Germany**,
> https://www.fz-juelich.de/ibg/ibg-3/
> **Universität zu Köln, Institut für Geophysik und Meteorologie, Germany**,
> https://www.geomet.uni-koeln.de/
> **Universität Bonn, Institut für Geodäsie und Geoinformatik, Germany**,
> https://www.igg.uni-bonn.de/de
> **RWTH Aachen, Aachen Institute for Advanced Study in Computational
> Engineering Science, Germany**, https://aices.rwth-aachen.de/
> **Ambrosys GmbH Gesellschaft für Management komplexer Systeme,
> Potsdam, Germany**, https://ambrosys.de/

## ASSOCIATE PARTNERS

> PhDs apply to become associated with the **"Helmholtz School for Data
> Science in Earth, Life and Energy"**, https://www.hds-lee.de/

## FUNDING

KI:STE is funded by the German Federal Ministry for the Environment, Nature
Conservation and Nuclear Safety (BMU).

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

**FACTS**

**Duration**
11/2020 – 10/2023

**Contact**
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**Project Type**
Research and Development

EOTSA Toolbox

# Earth Observation Time Series Analysis Toolbox

## Co-development of an Earth Observation Time Series Analysis Toolbox for Proba-V data

The focus of this project is the implementation of a time series analysis toolbox for remote sensing imagery in R. The Luxembourg Institute of Science and Technology (LIST) developed the toolbox for the European Space Agency (ESA) according to the needs of the NDVI time series analysis community. 52°North contributed to the toolbox development (outside project funding). The mission exploitation platform (MEP) at VITO (Flemish Institute for Technological Research NV, Belgium) derives the data from their Proba-V satellite.

The toolbox largely builds on existing specialized R packages and functions for raster and time series analysis combining these in a common framework. In order to ease access and usage of the toolbox, it is deployed in the MEP Spark Cluster and wrapped in a Web Processing Service (WPS) using 52°North's WPS4R extension. The WPS is also re-used in the Automatic Service Builder (developed by Space Applications Services NV/SA, Belgium). Hence, the analytics developed in R can be integrated into a larger workflow potentially integrating external data. The WPS provides a Webclient including a preview of the results in a map window for usage within the MEP.

Our team finalized the EOTSA toolbox in 2020. We also held a one and a half day workshop at LIST illustrating the toolbox usage and implementation details.

**KEY TECHNOLOGIES**

> R Programming Language

> OGC Web Processing Service (WPS)

> WPS4R

> Spark

> Angular

> GeoServer

> OGC Web Mapping Service (WMS)

> OGC Web Coverage Service (WCS)
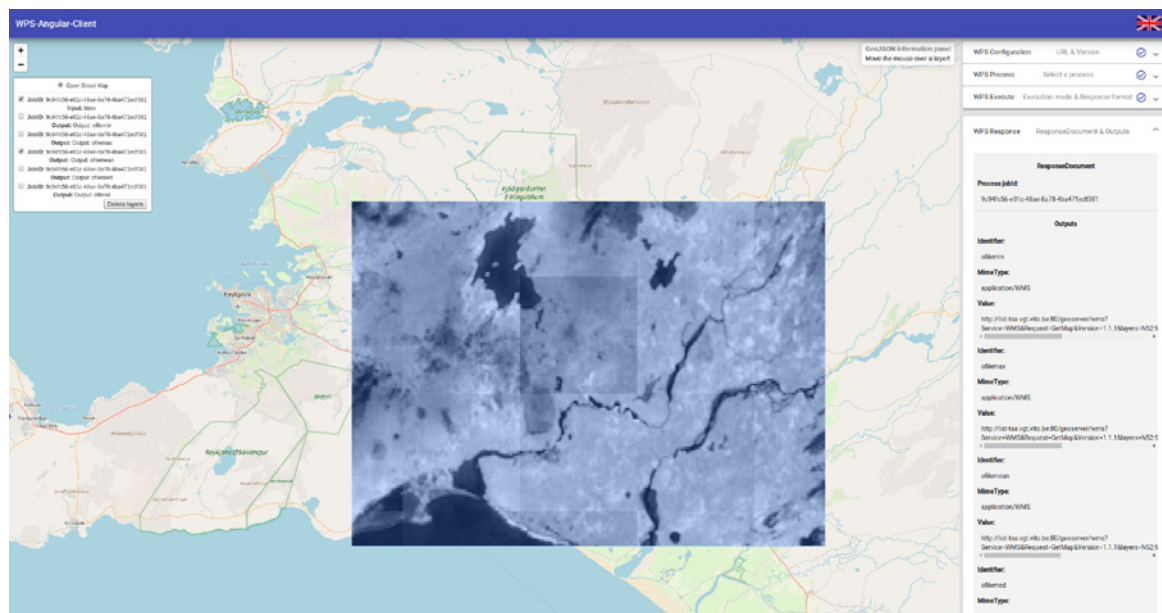
**WPS Web Client view of the EOTSA Toolbox showing the yield result layer of maxima from a pixel summary statistic over the entire NDVI raster time series**

**FACTS**

**Duration**
01/2019 – 03/2020

**Contact**
Dr. Benedikt Gräler
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**Project Type**
Professional Services

## CUSTOMER

> **LIST – Luxembourg Institute of Science and Technology, Luxembourg**,
  https://www.list.lu/

RUINS

# Risk, Uncertainty and Insurance under Climate Change

**Visualization and implementation of web applications for the RUINS project**

The Technische Universität Braunschweig and University of Freiburg commissioned 52°North as a subcontractor to support the BMBF funded research project RUINS (Risk, Uncertainty and Insurance under Climate Change. Coastal Land Management on the German North Sea). The RUINS project addresses risk and uncertainty under climate change. It includes the public and decision makers in different regions along the German North Sea coast. In order to support the communication with the public, the project designed and implemented web applications to better assess and communicate the associated risks.

52°North contributes experience with and knowledge about uncertainty modelling and visualization as well as implementation of web applications. This led to our prototypical implementation, which the RUINS consortium adopted and adapted. Furthermore, we set up a web application-based survey to assess the risk propensity of citizens in the study regions.

## KEY TECHNOLOGIES

> R Programming Language

> Python

> JavaScript

> Angular

> oTree

## FACTS

**Duration**
01/2020 – 03/2021

**Website**
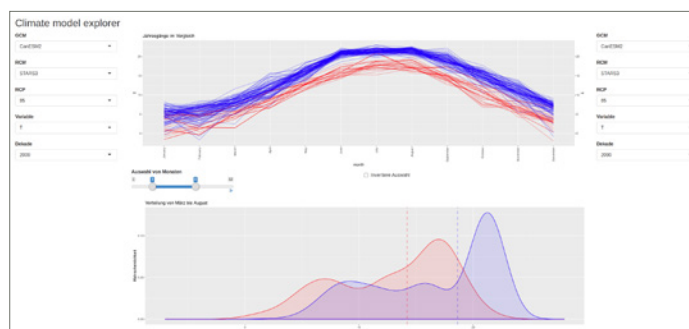https://www.ere.uni-freiburg.de/forschung-en/forschungsprojekte/ruins

**Contact**
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**Project Type**
Professional Services



**Prototypical implementation of a Web App to assess climate scenarios and their associated variability**

## CUSTOMERS

> **Universität Freiburg, Germany**, https://uni-freiburg.de/

> **Technische Universität Braunschweig, Germany**, https://www.tu-braunschweig.de/

## RCon-STDA

# Spatio-Temporal Data and Analytics

### Filling the gap for irregular spatio-temporal data in R

The existing R package sftime is a suite of modern spatial and spatio-temporal data representations in R. However, it did not include irregular spatio-temporal data. In this project, 52°North develops the R package sftime to a mature state to close this gap. The next step is to modify the geostatistical modelling package gstat and the spatial copula modelling package spcopula to support the new data representation classes of sf, stars and sftime. All packages will receive vignettes with worked out, full-fledge case studies, and results will be published on the r-spatial.org blog.

In 2020, we discussed and fixed the design of the sftime classes and the entire package. The implementation enables the user to store, plot and subset data. We also completed first adaptations to the analytics packages.
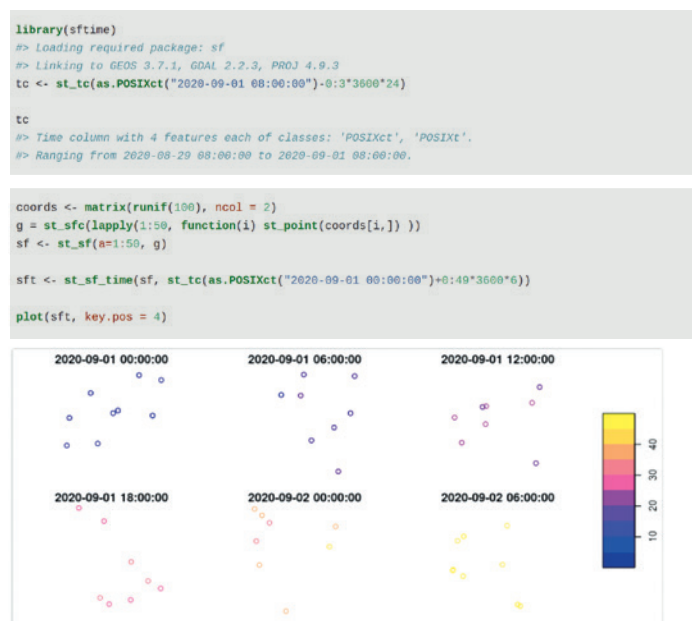


**Toy example of an sftime class from initialization to a simple plot**

**KEY TECHNOLOGIES**

> R Programming Language

**FACTS**

**Duration**
09/2020 – 04/2021

**Website**
https://github.com/r-spatial/sftime

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**Project Type**
Professional Services

**COSTUMER**

> **ISC, R consortium**, https://www.r-consortium.org/about/isc-charter

# Software Projects

Helgoland
Sensor Web
Viewer

Arctic Sea

Helgoland
Toolbox

enviroCar
Server

enviroCarPy

enviroCar
Mobile Android
App

wps-ng-client

sos4R
and sos4py

SOS
Sensor
Observation
Service

## Developing innovative technologies to advance spatial information infrastructures

52°North fosters applied research in the geospatial domain by managing and supporting the collaborative development of geospatial open source software. Our software is published under Open Source Initiative (OSI) approved open source licenses and hosted at GitHub.

javaPS

STA
SensorThings
API

Helgoland API

Arctic Sea

# Backbone for OGC Services, Clients and Middleware

## Easing the development of OGC related services, clients and middleware

Arctic Sea is 52°North's framework for developing OGC services, clients and middleware sharing concepts for encoding and decoding of different formats and encoding, workflows and configuration. This stack of projects eases the development of OGC related services, such as 52°North's implementation of the OGC SOS and WPS, as well as clients and middleware. It compromises the following modules.

Iceland: Iceland is a service framework that enables the development of OGC RPC (remote procedure call) based services. It features bindings for KVP, POX, SOAP, as well as JSON-based bindings. Iceland facilitates the rapid development of modular services that use Faroe for easy configuration and Svalbard for request parsing and response generation.

Svalbard: Svalbard consists of various decoders and encoders for OGC models (e.g., SensorML, O&M and SWE Common), service interfaces (like SOS and WPS) and a framework for developing these. This enables the creation of decoupled and reusable encoders and decoders for various encodings (e.g., XML, JSON or NetCDF). The object models used are found in Shetland and shared across 52°North components.

Faroe: Faroe is a configuration API currently featuring a JSON and an SQLite backend. It enables the injection and automatic configuration of settings of various types in classes, including a Spring BeanPostprocessor.

Shetland: Shetland consists of classes for OGC models like SensorML, O&M and SWE Common and various service requests and responses. These are shared across different service implementations.

Jan Mayen: Jan Mayen contains various utility classes shared throughout Arctic Sea.

**KEY TECHNOLOGIES**

> OGC Web Services

> OGC  Web Processing Service (WPS)

> OGC Sensor Observation Service (SOS)

> OGC SWE Common

> OGC SensorML

> OGC Observation and Measurements (O&M)

> Spring

> Java

> XML

In 2020, our software engineers published several software releases of the Arctic Sea components. The software packages provide developers with a solid base for service implementations on top of the Arctic Sea components. We actively maintained them on Maven Central. Most notable is the newly added support for the OGC SensorThings API.
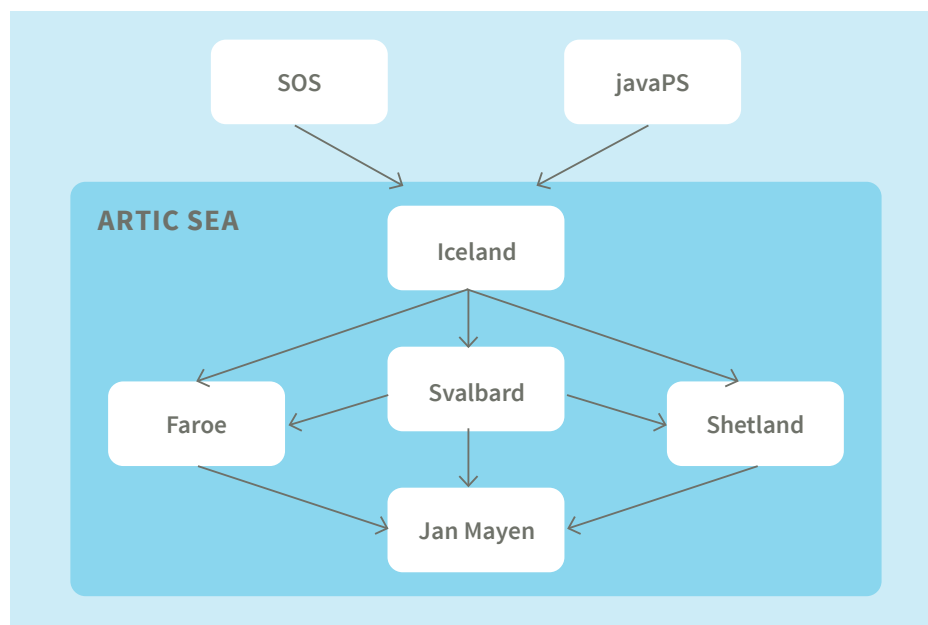


Arctic Sea modules

## BENEFITS

> The middleware component provides a robust layer to easily create web services compliant to OGC standards.
> The configuration API enables harmonized management of service properties
> Centralized XML encoding and decoding reduces boilerplate code and increases stability

## FIELDS OF APPLICATION

Building blocks for OGC Web Services, OGC clients, processing of OGC schema data formats (GML, O&M, SensorML, …)

## PROJECT REFERENCES

> **NeXOS**, http://www.nexosproject.eu/
> **COLABIS**, https://colabis.de/
> **SeaDataCloud**, https://www.seadatanet.org/About-us/SeaDataCloud
> **ODIP II**, http://www.odip.eu/
> **ConnectinGEO**, http://www.connectingeo.net/
> **GeoViQua**, http://www.geoviqua.org/
> **WaCoDiS**, https://wacodis.fbg-hsbo.de/
> **MuDak-WRM**, https://www.mudak-wrm.kit.edu/
> **BRIDGES**, http://www.bridges-h2020.eu/

## DOWNLOAD

**GitHub:** https://github.com/52North/arctic-sea
**Maven Central:** https://search.maven.org/search?q=g:org.n52.arctic-sea

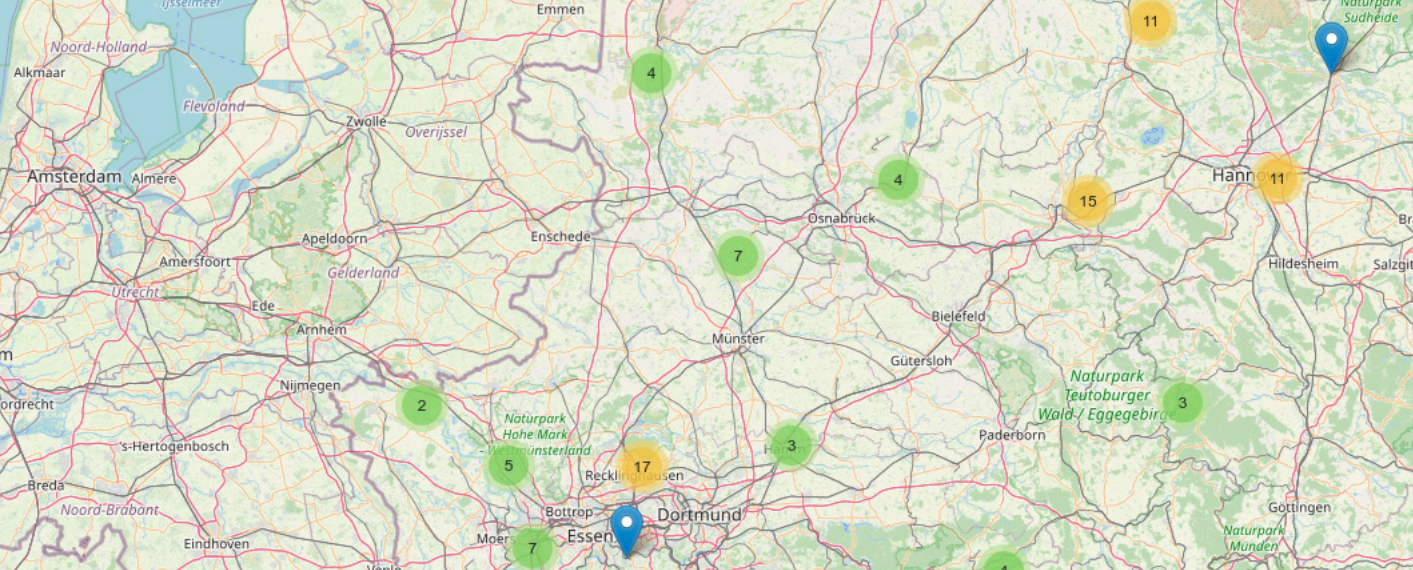## FACTS

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# Web-Based Visualization of Observation Data

## Enabling exploration, analysis and visualization of sensor web data

The 52°North Helgoland Sensor Web Viewer is a lightweight web application that enables the exploration, visualization, and analysis of Sensor Web data in various fields of use, e.g., hydrology, meteorology, environmental monitoring.

It enables users to:

_ Explore stations or mobile sensor platforms in a map

_ Select time series data via a list selection

_ Visualize and navigate through time series data, trajectory data, profile measurements

_ Create favorites of selected time series

_ Export visualized data as CSV files.

The Helgoland Sensor Web Viewer can connect to different Sensor Web endpoints (via the 52°North Helgoland API). These endpoints provide a thin access layer to sensor data (e.g., offered by SOS servers' databases) via a RESTful Web binding with different output formats. In addition to the Sensor Web endpoints, the Viewer can also connect to different OGC SensorThings APIs.

Our Sensor Web Viewer is based on the Helgoland Toolbox. It integrates the different toolbox modules into a viewing application that can be easily customized according to the requirements of specific users.

52°North's software engineers mainly focused on code base maintenance in 2020. We also evaluated new design concepts and ideas on how to develop a more user-friendly exploration of different types of sensor data.

**KEY TECHNOLOGIES**

> JavaScript

> TypeScript

> Angular

> Leaflet

> d3

**Helgoland Viewer displaying water level and temperature time series data**

## BENEFITS

> Lightweight, Web-based visualization of observation data
> Exploration of Sensor Web data sources (SOS, SensorThings API)
> Support of different types of observation data (time series, trajectories, profiles)
> Data download (CSV)

## FIELDS OF APPLICATION

Hydrology, air quality, marine sciences, environmental monitoring

## PROJECT REFERENCES

> **Federal Maritime and Hydrographic Agency (BSH), Germany**, https://www.bsh.de/
> **Wupperverband, Germany**, https://www.wupperverband.de/
> **SeaDataCloud**, https://www.seadatanet.org/About-us/SeaDataCloud
> **WaCoDiS**, https://wacodis.fbg-hsbo.de/
> **MuDak-WRM**, https://www.mudak-wrm.kit.edu/

## DOWNLOAD

**GitHub:** https://github.com/52North/helgoland

## FACTS

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Helgoland Toolbox

# Tools for Building Web Applications

**Providing reusable components for building (Sensor Web) client applications**

52°North created the Helgoland Toolbox to facilitate the reuse of developments for Sensor Web client applications. It provides a range of modules that offer functionalities for building Web applications dealing with dynamic spatio-temporal data.

The Helgoland Toolbox modules are used to build the 52°North Helgoland Sensor Web Viewer. We also built additional applications (e.g., the BelAir app, smle, or the developments resulting from the TaMIS project) upon this library.

The most important functional modules comprise:

> Core
_ Communication with the APIs (Helgoland API and OGC SensorThings API)
_ Important common services (local storage, time)
_ Central interfaces and abstract classes
> Caching
_ Request Caching with Angular Interceptors
> d3
_ Trajectory Graph component
_ Time series Graph component
> Depiction
_ Legend entries
_ Table view of data
> Map
_ Controls (Geo-Search, Locate, Zoom, Extent)
_ Map Selector component
> Selectors
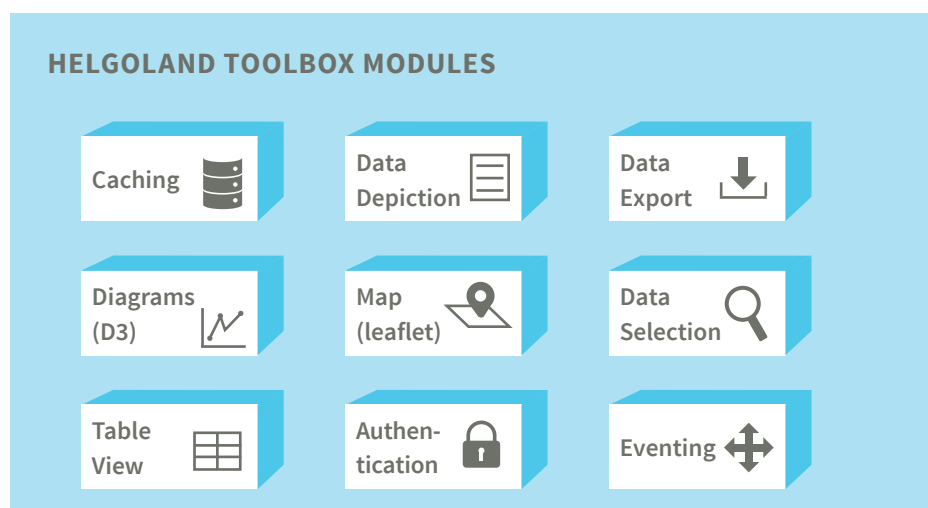_ List Selector for observation data
_ Service Selector for data sources.

**KEY TECHNOLOGIES**

> JavaScript

> TypeScript

> Angular

> Leaflet

> d3

> Open Layers

In 2020, 52°North software engineers specifically focused on improving Helgoland Toolbox's support of the OGC SensorThings API standard. We added a dedicated layer to improve the abstraction of underlying data sources. As a result, the Helgoland Sensor

Web Viewer is now able to consume data directly from OGC compliant SensorThings API instances as well as connect to the 52°North Helgoland API.

In addition, we also performed experiments to determine how to achieve the integration of access-controlled data sources. Further research concerned the integration of near-real time data streams via MQTT. For this purpose, we developed a dedicated dashboard for visualizing research vessel tracking data based on our toolbox. This development was part of the EMODnet Ingestion 2 project (page 14).



HELGOLAND TOOLBOX MODULES

Caching | Data Depiction | Data Export
Diagrams (D3) | Map (leaflet) | Data Selection
Table View | Authentication | Eventing

## BENEFITS

> Reusable components for building client applications
> Modules for visualizing different types of sensor data (time series, trajectories, profiles)
> Mapping modules
> Different components for data selection

## FIELDS OF APPLICATION

Hydrology, air quality, marine sciences, environmental monitoring

## PROJECT REFERENCES

> **Federal Maritime and Hydrographic Agency (BSH), Germany**, https://www.bsh.de/
> **Wupperverband, Germany**, https://www.wupperverband.de/
> **SeaDataCloud**, https://www.seadatanet.org/About-us/SeaDataCloud
> **WaCoDiS**, https://wacodis.fbg-hsbo.de/
> **MuDak-WRM**, https://www.mudak-wrm.kit.edu/
> **mVIZ**, https://mviz.geo.tu-dresden.de/
> **EMODnet Data Ingestion Portal**, https://www.emodnet-ingestion.eu/

## DOWNLOAD

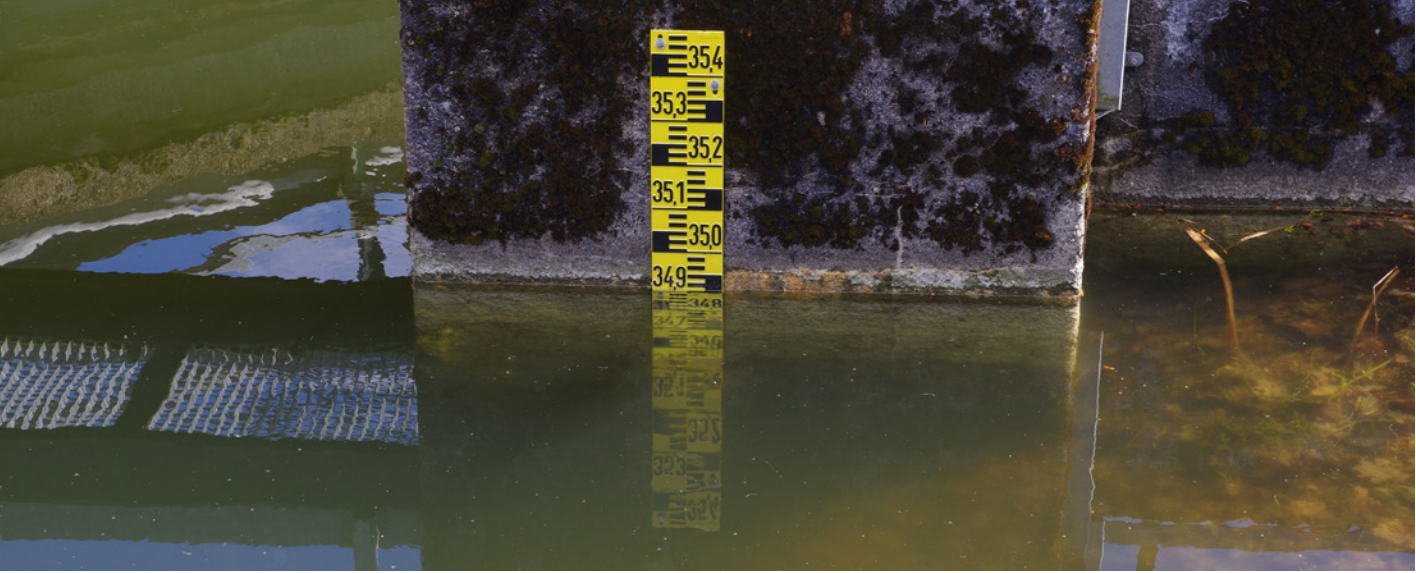**GitHub:** https://github.com/52North/helgoland-toolbox

### FACTS

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**License**
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# R and Python clients for OGC SOS

**Easing access to environmental time series data from an OGC Sensor Observation Service**

sos4R is an extension of the R environment for statistical computing and visualization. The user can apply it to query data from standardized SOS instances (with specific consideration of the OGC SOS 2.0 Hydrology Profile) using simple R function calls. It provides a convenience layer for R users to integrate observation data from SOS servers compliant with the SOS standard, but without any knowledge about the underlying OGC Sensor Web Enablement standards.

The package sos4py follows the same idea in a python environment. Since sos4py is a new development, it does not yet provide the same range of functionalities as sos4R does.

52°North's R specialists made some minor updates to sos4R during 2020 and presented it at the EGU 2020 Sharing Geoscience online. In addition, our intern Alfredo Chavarria (ITC, University Twente) initiated the sos4py development.

**KEY TECHNOLOGIES**

> R Programming Language

> Python

> OGC Sensor Observation Service (SOS) 2.0

> OGC WaterML 2.0

> OGC Observations and Measurements (O&M) 2.0
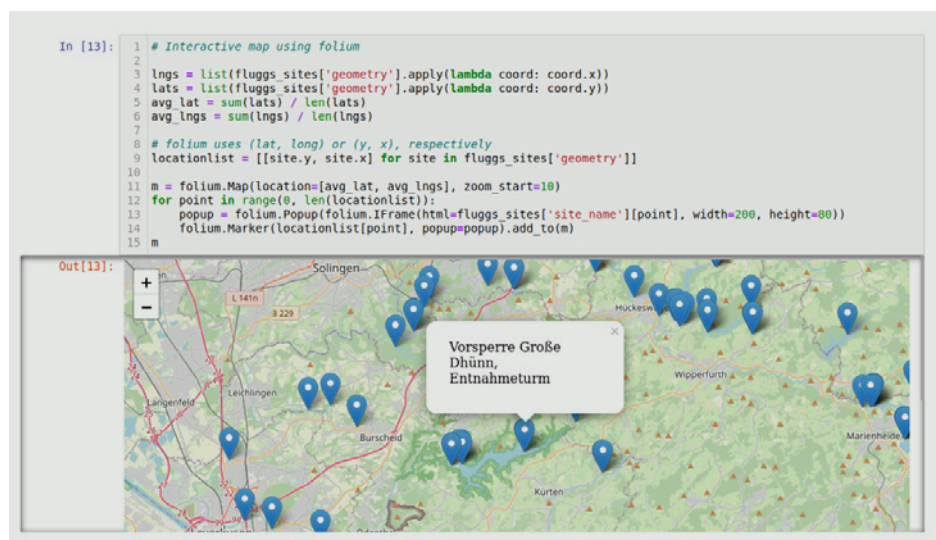
```
In [20]:   1  x1 = fluggs_obs[(fluggs_obs['site']==sites[0])]['time_stamp'].to_numpy()
           2  y1 = fluggs_obs[(fluggs_obs['site']==sites[0])]['value'].to_numpy()
           3
           4  x2 = fluggs_obs[(fluggs_obs['site']==sites[1])]['time_stamp'].to_numpy()
           5  y2 = fluggs_obs[(fluggs_obs['site']==sites[1])]['value'].to_numpy()
           6
           7  plt.figure(figsize=(12,5))
           8  plt.plot(x1,y1,label=sites[0])
           9  plt.plot(x2,y2,label=sites[1])
          10  plt.xlabel('Time')
          11  plt.ylabel(fluggs_obs['phenomenon'][0] + " " + fluggs_obs['procedure'][0] + " in " + fluggs_obs['unit'][0])
          12  plt.legend()
          13  plt.show()
```
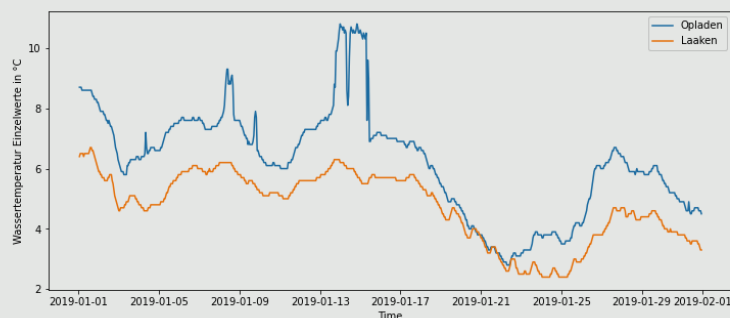
**Jupyter notebook illustrating the use of sos4py**

## BENEFITS

> Easier access to environmental time series data
> Automatic generation of SOS requests
> Result handling and parsing into standard R objects
> Convenience API: Data Science oriented functions to load data

## FIELDS OF APPLICATION

Hydrology, air quality, any other kind of processing of (in situ) observation data

## PROJECT REFERENCES

> **MuDak-WRM**, https://www.mudak-wrm.kit.edu/
> **NIWA**, https://niwa.co.nz/

## DOWNLOAD

**GitHub:** https://github.com/52north/sos4R
**GitHub:** https://github.com/52North/sos4py

## FACTS

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(GNU GPLv2)

SOS

# Sensor Observation Service

**Standardized, Web-based upload, management and download of (in situ) sensor data and metadata**

The 52°North Sensor Observation Service (SOS) provides an interoperable web-based interface for inserting and querying sensor data and sensor descriptions. It aggregates observations from live in situ sensors as well as historical data sets (time series data).

It enables users to:

_ Publish georeferenced (in situ) observation data

_ Access georeferenced measurement data in a standardized format (ISO/OGC Observation and Measurements, OGC WaterML 2.0 OGC TimeseriesML 1.0, INSPIRE O&M Specialized Observations, NetCDF)

_ Insert and retrieve sensor descriptions (encoded in OGC SensorML, OGC WaterML 2.0)

_ Publish measurement data (near real-time, as well as archived data)

_ Offer Download Services for observation data that are compliant with the INSPIRE regulations.

A major achievement in 2020 was the move to the new 5.x release. This new development line yields a first – a common data model for providing observation data via the OGC SOS, Helgoland API, and SensorThings API interfaces. In addition, we continued to optimize the 52°North SOS's performance and stability.

**KEY TECHNOLOGIES**

> XML

> Java

> JSON

> OGC Sensor Observation Service (SOS)

> OGC SensorML

> ISO/OGC Observations and Measurements (O&M)

> INSPIRE Download Service

> NetCDF

> Hibernate

> PostgreSQL/MySQL/Oracle/ MS SQL Server
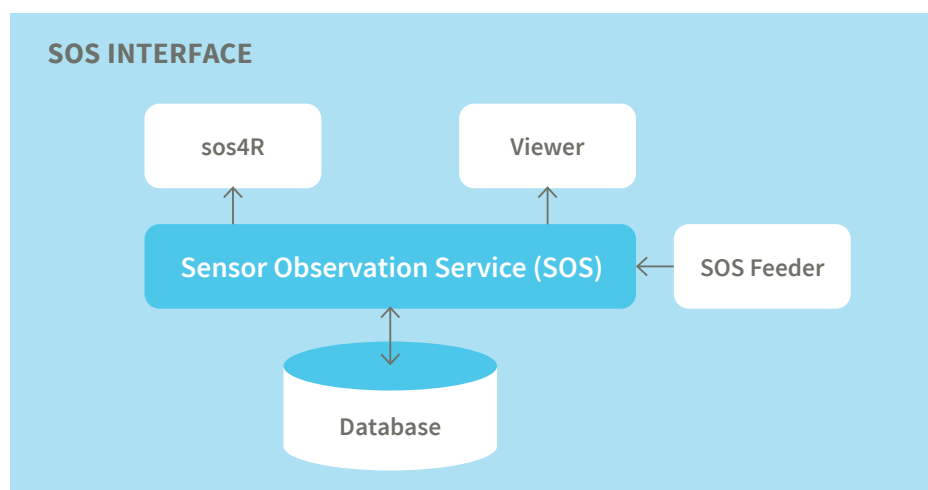
## BENEFITS

> Full implementation of the OGC Sensor Observation Service 2.0 standard
> INSPIRE compliance (SOS as INSPIRE Download Service)
> Dedicated support for hydrological applications via the OGC SOS 2.0 Hydrology Profile
> Support of the European e-reporting workflows for ambient air quality
> Highly efficient data transfer via the optional EXI (Efficient XML Interchange) support
> Flexible integration into existing IT infrastructures (coupling to existing databases, several options for data publication)
> Comprehensive ecosystem of supporting tools and applications (Helgoland Sensor Web Viewer, sos4R, SOS importer)
> Additional data management functionality beyond the SOS standard

## FIELDS OF APPLICATION

Hydrology, air quality (e-reporting), environmental monitoring, ocean sciences, tracking

## PROJECT REFERENCES

> **SeaDataCloud**, https://www.seadatanet.org/About-us/SeaDataCloud
> **WaCoDiS**, https://wacodis.fbg-hsbo.de/
> **MuDak-WRM**, https://www.mudak-wrm.kit.edu/
> **IRCEL-CELINE BelAir** (see page 18)
> **NIWA**, https://niwa.co.nz/
> **Wupperverband, Germany**, https://www.wupperverband.de/
> **Federal Maritime and Hydrographic Agency (BSH), Germany**, https://www.bsh.de/
> … and many more

## DOWNLOAD

**GitHub:** https://github.com/52North/SOS

## FACTS

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**License**
GNU General Public License 2.0 (GNU GPLv2)

# SensorThings API

## Efficient access to sensor data via the OGC SensorThings API

The STA module complements the 52°North Sensor Web Server with support for the OGC SensorThings API Part 1: Sensing specification. It provides support for the following Conformance Classes (tested for standard compliance):

_ Sensing Core

_ Create-Update-Delete

_ Filtering Extension

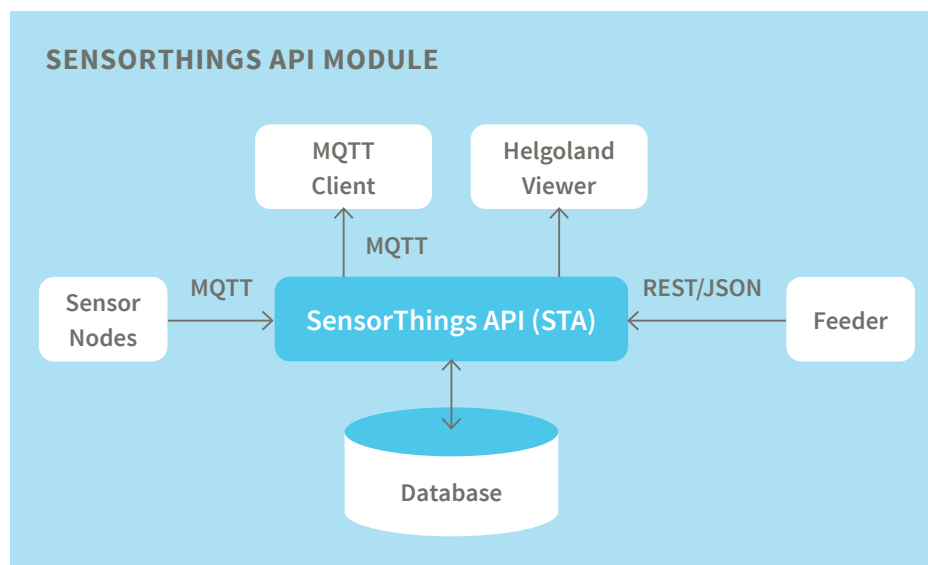_ Observation Creation via MQTT

_ Receiving Updates via MQTT.

52°North's software development activities in 2020 mainly focused on the 52°North SensorThings API. In addition to code base maintenance and optimization (e.g., removal of the dependency on Apache Olingo), we specifically addressed the following challenges:

Citizen Science Extension: In the Cos4Cloud project (page 24), we identified a need for guidance on how to use the STA for Citizen Science data. To accommodate this new data, our team collaborated with CREAF and Secure Dimensions to design and implement a prototypical extension to the official standard to support this new data.

Access control: A widening adoption of the STA specification, along with an increasing amount of data to be managed, creates a need for fine-grained access control. The specification itself specifically excludes this topic, delegating it to other components in the infrastructure. To address this challenge, we investigated the use of technologies, such as OpenID Connect and Keycloak, to control access to STA instances. This resulted in an extended STA implementation, which the Wupperverband and the Cos4Cloud project partners currently evaluate.

**KEY TECHNOLOGIES**

> OGC SensorThings API Part1: Sensing

> REST

> JSON

> MQTT

> Java

**SENSORTHINGS API MODULE**

## BENEFITS

> Robust implementation making use of the broad 52°North experience with Sensor Web data models
> Easy integration into the 52°North Sensor Web Server (joint database layer)
> MQTT for data publication and delivery
> Interlinking between SOS, STA and Helgoland API (e.g., data publication via STA, data retrieval via SOS and Helgoland API)

## FIELDS OF APPLICATION

Hydrology, air quality (e-reporting), environmental monitoring, ocean sciences, tracking

## PROJECT REFERENCES

> **Wupperverband, Germany**, https://www.wupperverband.de/
> **Cos4Cloud**, https://cos4cloud-eosc.eu/
> **AQSens**, https://aqsens.52north.org/
> **EMODnet/Eurofleets+**, https://www.eurofleets.eu/
> **Federal Maritime and Hydrographic Agency (BSH), Germany,** https://www.bsh.de/
> **WaCoDiS**, https://wacodis.fbg-hsbo.de/

## DOWNLOAD

**GitHub:** https://github.com/52North/sensorweb-server-sta

### FACTS

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Helgoland API

# Lightweight Access Layer to Sensor Data

## Supporting the efficient implementation of Sensor Web clients

This lightweight API provides a complementary lightweight access layer to sensor data via a RESTful Web binding. It offers an additional mechanism for data access, which has been optimized to reflect our experience gained during the development of Sensor Web client applications. Thus, it can be considered a convenience layer that facilitates the use of Sensor Web servers.

The API provides a thin access layer offering several functionalities:

_ Pre-rendering of time series data (e.g., for embedding pre-rendered diagrams into Web sites)

_ Generalization of sensor data sets for reducing the transmitted data volume

_ Support of different types of observation data: time series, profiles, trajectories, samplings

_ Overlaying of data from multiple data sets

_ Conversion of raw data to other formats such as CSV, PDF and PNG

_ Comprehensive functionality for exploring, discovering, filtering and accessing observation data.

The REST API can be deployed in two modes: as a 52°North Sensor Web Server module residing on an observation database, or in a proxy mode so that external data sources can be integrated into Sensor Web environments.

Our development efforts in 2020 focused mainly on maintenance and data model harmonization with SOS and STA. Moreover, we developed several extensions adapted to customers' specific requirements as part of professional services projects.

**KEY TECHNOLOGIES**

> REST

> JSON

> Java

**DEPLOYMENT OF THE HELGOLAND API**

Helgoland Sensor Web Viewer

Helgoland API

Helgoland API

Database

External SOS Server
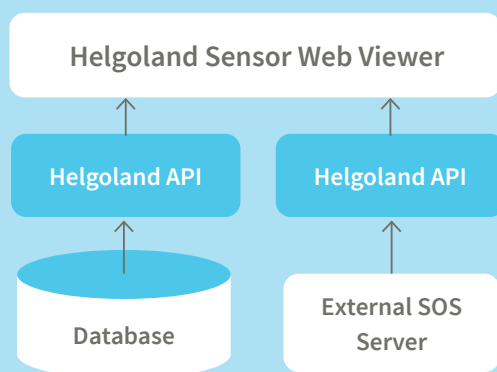
## BENEFITS

> Lightweight protocol and encoding
> Convenience functionality for client developers to increase their efficiency
> Functionality going beyond the available standard interfaces (e.g., data generalization, rendering functionality, data conversion)

## FIELDS OF APPLICATION

Hydrology, air quality (e-reporting), environmental monitoring, ocean sciences, tracking

## PROJECT REFERENCES

> **SeaDataCloud**, https://www.seadatanet.org/About-us/SeaDataCloud
> **WaCoDiS**, https://wacodis.fbg-hsbo.de/
> **MuDak-WRM**, https://www.mudak-wrm.kit.edu/
> **IRCEL-CELINE BelAir** (see page 18)
> **NIWA**, https://niwa.co.nz/
> **Wupperverband, Germany**, https://www.wupperverband.de/
> **Federal Maritime and Hydrographic Agency (BSH), Germany**, https://www.bsh.de/
> … and many more

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(GNU GPLv2)

## DOWNLOAD

**GitHub:** https://github.com/52North/sensorweb-server-helgoland

**javaPS**

# Next Generation Standardized Web-based Geoprocessing

## Interoperable processing framework for web applications/ distributed workflow systems

JavaPS enables a standardized deployment of geo-processes on the web. One of its main goals is to provide an interoperable processing framework for web applications or distributed workflow systems. Therefore, it fully supports the OGC Web Processing Service 2.0 interface specification. True interoperability only succeeds when transmission data models are well-defined and supported. javaPS supports a broad range of standardized formats and de-facto industry standards including, but not limited to OGC GML (versions 2.x to 3.2.1), GeoJSON, Esri Shapefile, GeoTIFF or KML. In addition, GeoServer (WMS or WFS) enables the dissemination of processing results. This allows a seamless integration into existing Spatial Data Infrastructures.
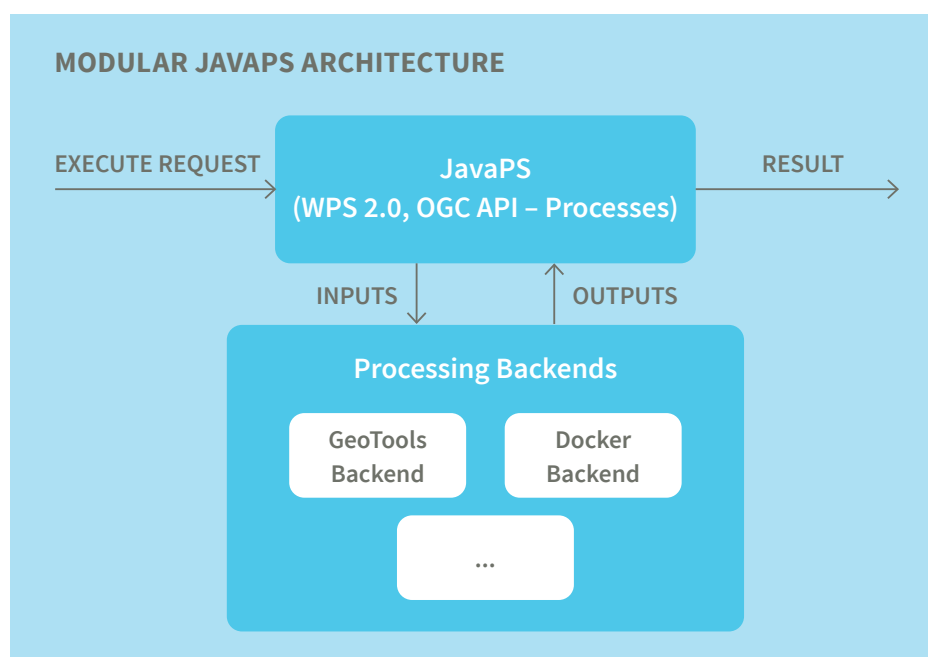
javaPS evolved from the longstanding 52°North WPS implementation, but uses modern frameworks such as Spring, 52°North Arctic Sea or Guava. It features a pluggable architecture for processes and data encodings.

javaPS has been the main driver within several 52°North projects. In the Modular OGC API Workflows (MOAW) project, we used javaPS to perform workflow tasks with data services implementing, for example, the Features and Tiles API. This included the deployment of new processes running in Docker containers. The javaPS release 1.6.0 includes the draft OGC API – Processes and is officially listed as implementing this service[1]. We also added support for the draft transactional extension in release 1.6.0[2].

**KEY TECHNOLOGIES**

> Java

> Spring

> Arctic Sea

> OpenAPI

[1] https://github.com/opengeospatial/ogcapi-processes/blob/master/implementations.adoc

[2] https://docs.ogc.org/per/18-036r1.html

**MODULAR JAVAPS ARCHITECTURE**



## BENEFITS

> Abstraction of (existing) processing tools
> Support for the majority of standardized geo-data formats
> Lightweight API, following the latest state of the draft OGC API
  Processes standard

## FIELDS OF APPLICATION

Web-based processing, automated workflows, Earth Observation, Data Analytics

## PROJECT REFERENCES

> **OGC Testbed 15**, https://www.opengeospatial.org/projects/initiatives/testbed15
> **OGC Routing Pilot**, https://www.opengeospatial.org/projects/initiatives/
  routingpilot
> **WaCoDiS**, https://wacodis.fbg-hsbo.de/

## DOWNLOAD

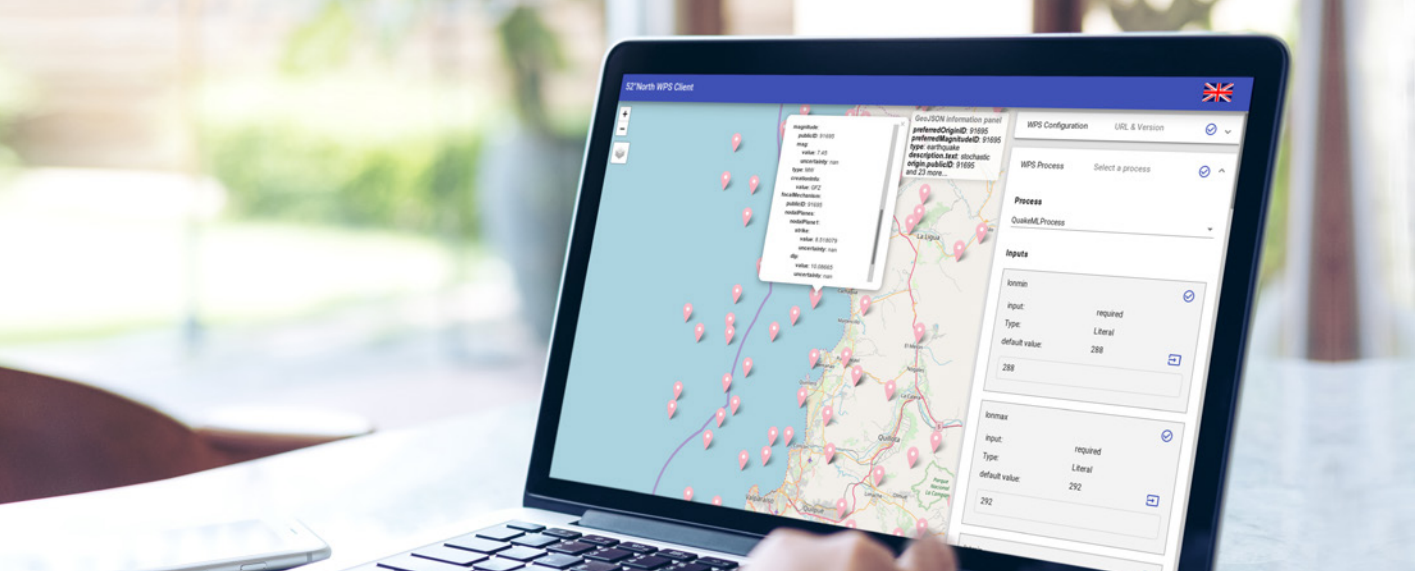**GitHub:** https://github.com/52North/javaps

**FACTS**

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**License**
Apache License, Version 2.0

wps-ng-client

# Modern Web Application for Geoprocessing

## Providing an extensible lightweight single page application for web browsers

A map centered design forms the foundation of this software component. It provides a lightweight single page application for modern web browsers. We wrote the application on top of the Angular framework and its UI counterpart Angular Material. This makes it easily extensible due to its component-based architecture.

Under the hood, the application uses the 52°North wps-js library, which is responsible for the interaction with the WPS backend. It guarantees a clear separation of concerns and the application can focus on the UI/UX aspects and the visualization of input and output data. The wizard-style execution of WPS processes guides the user through all the relevant steps and provides convenient functions (e.g., auto-fill parameters with default values) that create an intuitive user experience.

The wps-ng-client architecture catalyzes the creation of individual web applications for specific use cases or scenarios. As the central UI element, the map enables developers to easily create context and associate the user with a scenario's relevant information and how to use the available processes.

The current version supports a variety of input formats (e.g., different geometry types) and offers and improved process result visualizations. We have tested the client with different WPS implementations (e.g., 52°North WPS, 52°North javaPS and PyWPS) to ensure its robust function.

**KEY TECHNOLOGIES**

> Angular

> Angular Material

> JavaScript

> TypeScript

> OpenLayers

> wps-js
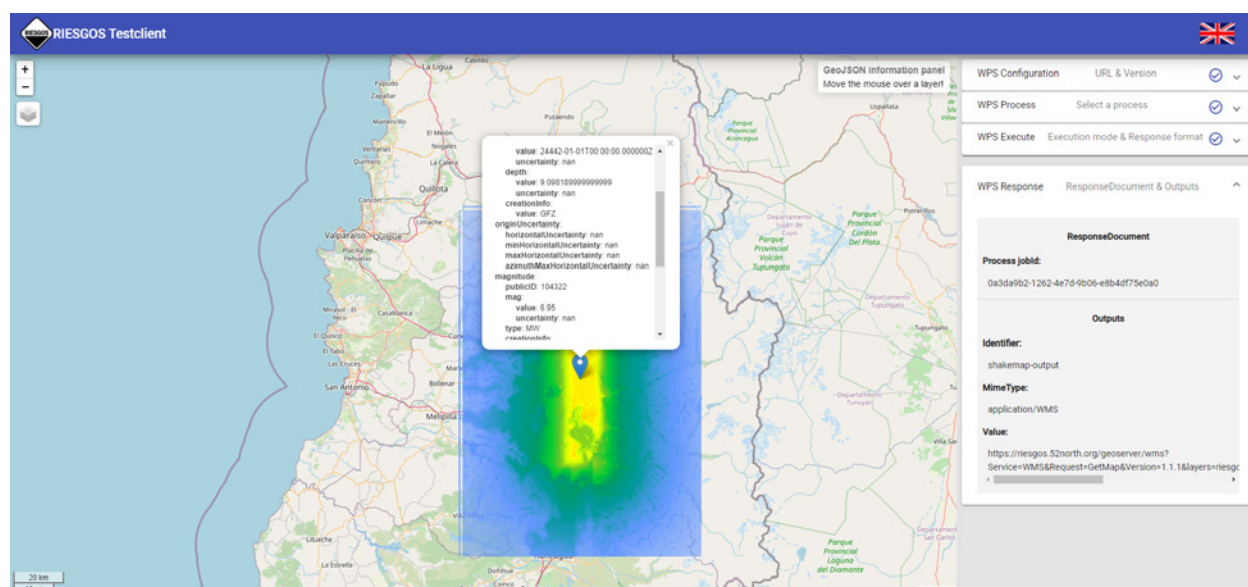
**wps-ng-client interacting with the RIESGOS WPS to produce earthquake intensity maps**

## BENEFITS

> Visualization of web processes' inputs and outputs
> Support for all major browsers due to the Angular framework
> Wizard-style process execution eases the interaction with WPS backends
> Lightweight component architecture makes the software easily extensible

## FIELDS OF APPLICATION

Web-based processing, automated workflows, Earth Observation, Data Analytics

## PROJECT REFERENCES

> **RIESGOS**, https://www.riesgos.de/en/
> **MuDak-WRM**, https://www.mudak-wrm.kit.edu/
> **OGC Testbed 15**, https://www.opengeospatial.org/projects/initiatives/testbed15
> **CITRAM**, https://citram.de/

## DOWNLOAD

**GitHub:** https://github.com/52North/wps-ng-client

## FACTS

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**License**
MIT License

**enviroCar Mobile Android App**

# XFCD Mobile Data Collection and Analysis

### Collecting and analyzing vehicle sensor data

enviroCar Mobile is an Android application for smartphones that can be used to collect Extended Floating Car Data (XFCD). The app communicates with an OBD2 Bluetooth adapter while the user drives, which enables read access to data from the vehicle's engine control. The app records this data and the smartphone's GPS position. The driver can view statistics about his drives and publish his data as open data. The latter happens by uploading tracks to the enviroCar server, where the data is available under the ODbL license for further analysis and use. Users can also view and analyze the data via the enviroCar website. enviroCar Mobile is one of the enviroCar Citizen Science platform's components (www.envirocar.org).

During 2020, we concluded intensive reengineering activities and updated a majority of the software libraries. This contributed significantly to the application software's stability on various devices, using different Android versions, OBD adapters and vehicles.

enviroCar developers redesigned and simplified the user interface as well as added interfaces to new OBD adapters. We also introduced a new feature – data acquisition without OBD adapters. The app can now calculate the energy consumption and $CO_2$ emission based solely on the track data. In addition, there is automatic track recording and data publication so that it is possible to use near-real-time recorded tracks.

**KEY TECHNOLOGIES**

> Android

> Java
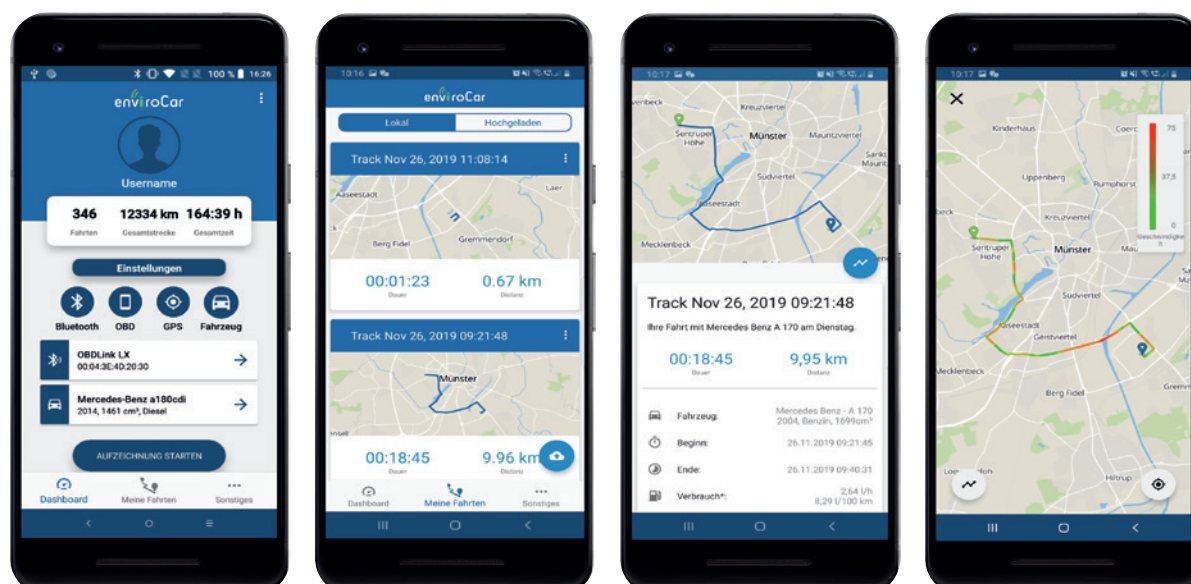
**enviroCar user interface**

## BENEFITS

> Easy collection of Extended Floating Car Data
> Optional automation of data collection and upload
> Estimation of fuel consumption and $CO_2$ emissions
> Publishing anonymized track data as Open Data
> Map-based visualization of track data and track statistics

## FIELDS OF APPLICATION

enviroCar Mobile supports the collection, analysis and sharing of XFCD data in an open Citizen Science community. This community of scientists, traffic engineers, public administration staff and citizens work together to gain better road traffic information to reduce the environmental impact of motorized traffic and to improve road safety. The enviroCar app can be used free of charge. The data is also available free of charge, as open data to the general public.

## FACTS

**Contact**
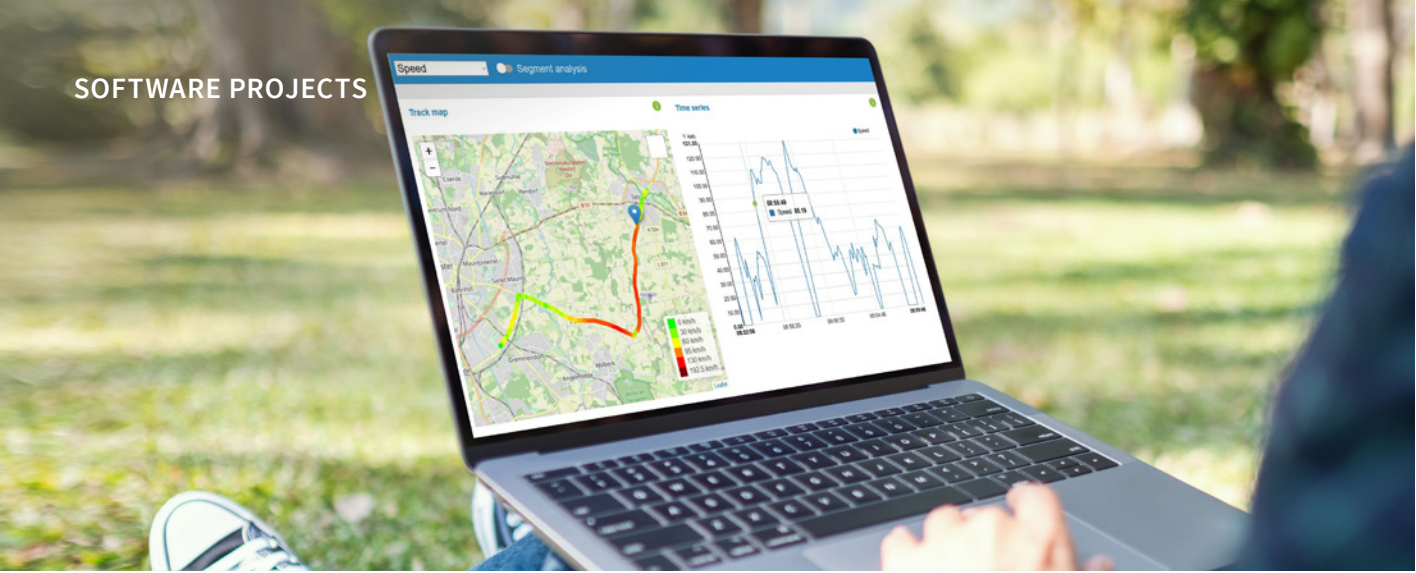Dr. Benedikt Gräler
*b.graeler@52north.org*

**License**
GNU General Public License 3.0
(GNU GPLv3)

## PROJECT REFERENCES

> **CITRAM**, http://www.citram.de
> **enviroCar**, https://envirocar.org

## DOWNLOAD

**GitHub:** https://github.com/enviroCar/enviroCar-app

enviroCar Server

# User and Data Management

## Managing and sharing Open XFCD

The enviroCar server's central tasks are the enviroCar platform user management and the management of the XFCD data provided as Open Data by the enviroCar drivers. To ensure data privacy, the server anonymizes the recorded tracks external access. The enviroCar server's RESTful API (http://envirocar.github.io/enviroCar-server/api/) offers the possibility to access statistics as well as space and time related subsets of the data in different formats.

Our software engineers finalized reengineering the user management workflows for GDPR compliance, dockerized all components, created new data analysis features (e.g., OSM MapMatching) and implemented the publication of newly created tracks via Apache Kafka. In addition, we developed an anonymous API that allows the upload of tracks without a user account. Thus, users of an e-Car rental service are able to upload data.

## KEY TECHNOLOGIES

> MongoDB

> Apache Kafka

> Java

> Guice

> Guava

## FACTS

### Contact

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### License

GNU Affero General Public License 3.0 (or later versions)

## BENEFITS

> User management support
> XFCD data management
> Open API for data export: JSON, CSV, SHP

> Linked Data/RDF API
> Publishing anonymized tracks via Apache Kafka
> GDPR compliance

## FIELDS OF APPLICATION

> Data analytics
> Traffic quality
> Traffic safety

## PROJECT REFERENCES

> **CITRAM**, http://www.citram.de
> **enviroCar**, https://enviroCar.org

## DOWNLOAD

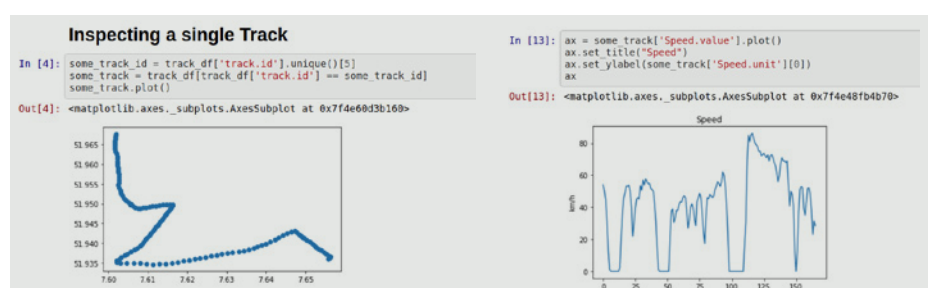**GitHub:** https://github.com/enviroCar/enviroCar-server

## enviroCarPy

# Python Library for Accessing eC Data

### Easing access to enviroCar data for analysis in python

The envirocar-py Python package is a lean extension wrapping the enviroCar REST API to ease the access of the data. It allows users to query and download XFCD data via the enviroCar Rest-API.

Our team designed and implemented the package. We also used it in a course with international students. These university students, along with other users and developers, recorded, shared and analyzed the open data. They also provided us with several examples of Python scripts, such as hot spot analysis, traffic safety, fuel consumption and exploratory data analysis and preprocessing. More information regarding these examples can be found in the respective github repositories and in the blog post on envirocar-py: https://blog.52north.org/2020/11/27/envirocar-py-querying-envirocar-trajectory-data/



## KEY TECHNOLOGIES

> Python

## FACTS

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## BENEFITS

> Easier access to enviroCar data for an analysis in Python
> Several Jupyter notebooks with examples of use-cases

## FIELDS OF APPLICATION

> Data analytics          > Traffic quality          > Traffic safety

## DOWNLOAD

**GitHub:** https://github.com/enviroCar/envirocar-py

# Education and Mentoring

## Sharing knowledge and experience

52°North staff take an active part in higher education to engage with students to develop their understanding and application of knowledge, concepts and processes. We regularly teach semester-long courses and carry out study projects at the Institute for Geoinformatics, University of Münster. Furthermore, our staff prepares and holds guest lectures at, among others, ITC, University of Twente, the Bochum University of Applied Sciences and the Technische Universität Dresden.

# Courses

In 2020, our staff taught the following courses:

**WS 2019/2020 Institute for Geoinformatics:** Lecture and Exercises about Spatial Information Infrastructures (SII)

**SS 2020 Institute for Geoinformatics:** Study project "Floating Car Data Analytics & Visualization for Traffic Management and Safety"

# Theses Supervision

Supporting higher education, we cooperate with our academic partners in the supervision of theses. Typically, these theses have a direct link to ongoing research at 52°North.

**Kraft, Torben** (2020): Provision of Metadata to Support the Processing of Sensor Data Streams. Unpublished Master Thesis, Institute for Geoinformatics, University of Münster.

# Internships

52°North mentors Geoinformatics students to support their personal development and professional careers. We share our knowledge and experience and benefit from their curiosity and creativity. Many Masters programs require a semester of practical work. In addition to offering student jobs, we have been providing student internships since 2011. Each intern works on one of our current projects for a period of up to 6 months. During this time, they improve their software engineering skills, acquire knowledge in SDI and OGC standards, learn basic project management techniques, and gain experience in international collaborative software development.

**Mohammed Abdelal**

This is Mohammed Abdelal from Palestine. Mohammed received his Bachelor's Degree in Computer Systems Engineering at the Al-Azhar University - Gaza. Since the end of 2018, he has been working on a Master's degree in Geoinformatics at the University of Münster. He found out about 52°North from friends and decided to apply for an internship. Interested in web development with PHP scripting language, he worked from October 2019 – March 2020 on developing a generic processing backend using container technology (e.g., Docker) and its integration into javaPS. "I extended my knowledge concerning Spring framework and web-based geoprocessing technologies. Furthermore, I learned more about javaPS, which is a standardized web-based geo-processing framework for web applications/distributed workflow systems."

Mohammed is currently working on his Master's thesis at 52°North and hopes to work as a java developer in Germany, specifically in NRW, once he has completed his degree.

**Fadi Moubayed**

Fadi Moubayed is from Aleppo, Syria. After receiving his Bachelor's Degree in Civil Engineering from the University of Aleppo, he spent a summer doing external studies in Civil Engineering at the American University of Beirut. From there he entered the graduate studies program in Photogrammetry and Geoinformatics at the Hochschule für Technik in Stuttgart. Fadi started working on his Master's degree at the Institute for Geoinformatics in Münster at the end of 2018.

Environmental protection/monitoring are particularly important to Fadi. He was drawn to 52°North's research goals and non-profit principles and felt that it was a good match. From October 2019 through March 2020, Fadi worked on developing an application that serves as a base for the DWD open data integration within the WaCoDiS project. It reads data from the DWD, servers the data on REST endpoints as well as stores and retrieves data from a database. "During my external semester, I had the chance to challenge myself and explore concepts that are important in software development. I learned a lot and made significant progress. The skills I gained at 52N helped me become more comfortable performing the tasks I was given later. All in all, I am very happy I did my external semester at 52N."

Once he completes his Master's thesis (at 52°North) on integrating ocean glider observation data into a spatial data infrastructure, Fadi would like to promote data access by developing spatial data infrastructures. He sees this as the first step towards achieving more efficiency in environmental protection and monitoring.

**Alfredo Chavarria Vargas**

Alfredo is from Costa Rica. He received his Bachelor degree in Surveying Engineering from the University of Costa Rica. After working as a surveyor engineer for 7 years, he started his Master of Science in Geo-information Science and Earth Observation for Geoinformatics at the University of Twente in September 2018.

Alfredo became interested in Sensor Web technologies and 52°North during a guest lecture by 52°North's Simon Jirka. In April/May of 2020, Alfredo developed a Python component that accesses servers implementing the OGC Sensor Observation Service (SOS) 2.0 standard and transforms the observation models into Python data structures. The functions within this convenience layer focused on data extraction and querying.

During his internship, Alfredo learned about the OGC Web Services Common Specification (OWS), i.e., SOS, SensorML and O&M. He also learned to identify and understand data structures in different languages (XML, Python and R) and their interoperability. Finally, he gained practical experience designing and developing the convenience layer through Python programming.

Alfredo is interested in the technical management of Geospatial projects. "I look forward to using the knowledge and skills learned during my MSc, embracing the working experience, and I hope that this eventually leads to a position in geospatial project management, as this is my main goal."

# Google Summer of Code

## Helping to change the world one line of code at a time

Google Summer of Code (GSoC) is a global program that focuses on introducing student developers to open source software development. Students receive stipends to work on a three-month programming project with an open source organization while on break from university. At 52°North, we pair the students with mentors and embed their work in the context of ongoing research projects. Hence, GSoC students gain valuable exposure to real-world software development scenarios and have the opportunity to work in areas related to their academic pursuits. In turn, we are able to improve our software projects, as well as identify and draw in new developers more easily.

We have been a successful mentoring organization since 2012. In 2020, we were one of 199 open source organizations chosen to host three of the 1,198 student projects.

## Trajectory Analytics Toolbox – traviz

John Murzaku studies mathematics and computer science at Seton Hall University in South Orange, New Jersey (USA). He spent his summer developing a general-purpose trajectory analytics toolbox in R.  His toolbox – "traviz" – performs the following:

_ **Analysis of trajectory data:** It provides functionality for finding trajectory inter-sections in a desired area and similar trajectories based on length and location.

_ **Visualization of trajectory data:** There are methods to meaningfully visualize trajectory data, which include space-time cubes, projections, and animations. One can also visualize trajectory points of intersections and similar trajectories. One of the methods also provides heat-map visualization and trajectory clustering using the DBSCAN algorithm. Clusters can be categorized based on density of trajectories, density of intersections, and speeds of trajectories. This is used to determine trajectory hotspots in a desired aggregation level.
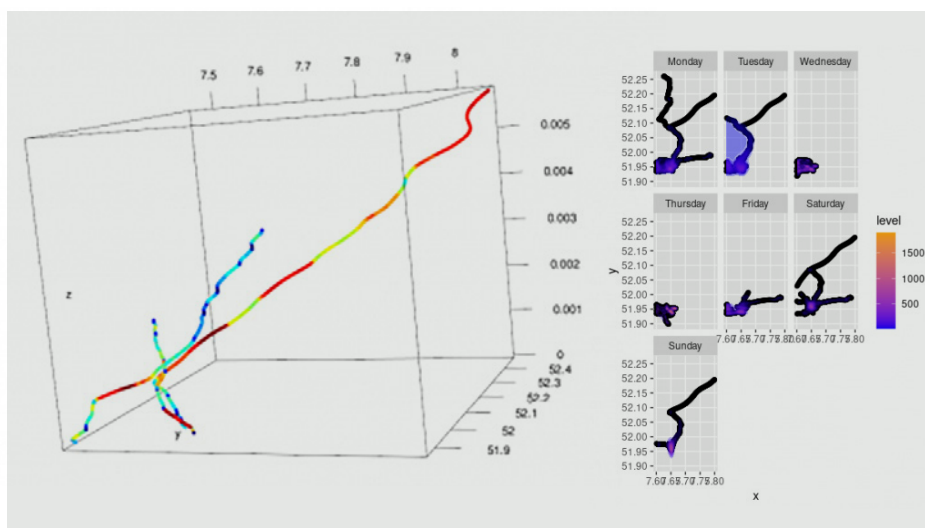


**sfTracks space time cube (on left)**

**Density heat map function aggregated by day of week (on right)**

_ **Aggregation and subsetting of trajectory data:** The toolbox can aggregate data on pixels, edges, and regions. This method takes in ROI/POI/raster in sp/sf format as an input. The toolbox subsets trajectories in multiple ways including a bounding box or existing geographical/municipal bounds.

John is interested in spatial statistics, geospatial and biological data visualization, and smart cities. As of January 2021, he will begin his Ph.D. in Computer Science focusing on a similar area of research and applying spatial data science techniques to his research. In preparation for this research, he aims to expand traviz. "It was an excellent summer and I learned a lot about package development, trajectory analytics, and spatial data science."

See his blog post:

https://blog.52north.org/2020/09/07/trajectory-analytics-toolbox-final-post/

**sfTrack space time cube with point values shown**
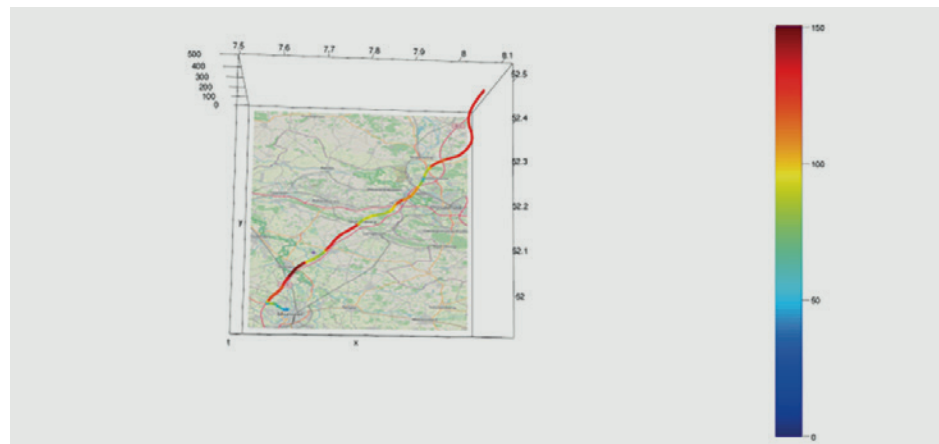


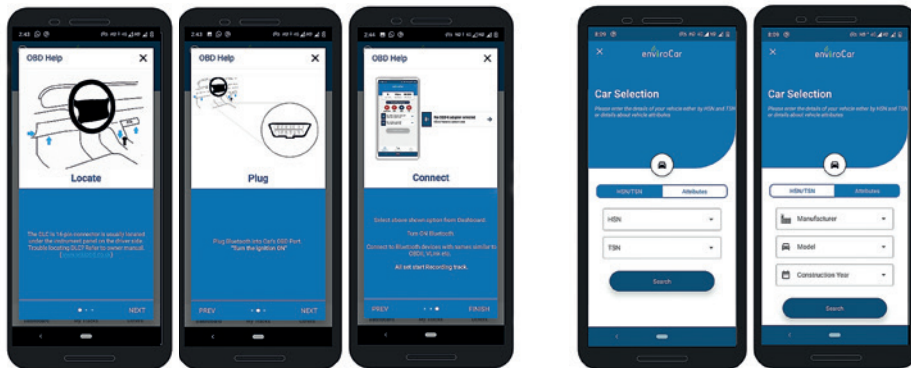## Improvement of Car Selection Process in enviroCar App

Arvind Negi is a 3rd year undergraduate student pursuing a B.Tech from NIT Hamirpur in Computer Science. As a first time GSoC student, he worked on improving different aspects of the enviroCar Android app. He focused on the car selection process while carrying out the following core tasks and considerations:

_ Improve the car selection process in the enviroCar Android app by integrating previously defined datasets of vehicles.

_ Re-implement track-based database based on SqlBrite to a new SQLite database with Room ORM to ensure support and flexibility for modern components.

_ Add a contextual help for pairing OBD with car and walkthrough screen to high-light different controls.

_ Add onboarding screen for first-time users to give information to users about the functions and benefits of the app.

_ Improve UX/UI of the app.

Arvind is passionate about computer programming and loves developing android apps, reading tech forums and doing competitive programming in his free time. He had an amazing journey and learned a lot of things both in terms of coding and design.

See his blog post:

https://blog.52north.org/2020/08/31/improvement-of-car-selection-process-in-envirocar-app-final-blog-post/



**OBD Help**

**Car selection**

## 52°North's Angular WPS Client Library – the wps-ng

Karan Singh is a Master's student in Computer Science at York University, Toronto. His summer project evolved around building a new Web Processing Service (WPS) client – wps-js-ng – using the Angular 9 framework with module classes written in typescript.

This new client conforms to the latest OGC WPS 2.0 standards and is designed for clients using the Angular programming language. Simply import the library and have access to all the model classes and modules generated by running simple angular commands. Karan also developed a client to demonstrate the library use case and serve as a boilerplate starter for Angular projects. Check out the Demo Angular Client using the wps-ng library here: https://singkara.github.io/wps-js-ng/.

Karan states: "I consider myself fortunate to have gotten the opportunity to work with 52°North. I learned several new nitty-gritty Angular and Typescript functions, which has really helped me broaden my vision of UI development. I also enjoyed getting familiar with the field of Geo-Informatics and OGC Web Processing Services. In my opinion, it is a great community for Geospatial Information and Standards."

See his blog post:

https://blog.52north.org/2020/08/27/52norths-angular-wps-client-library-the-wps-ng/

**Get status and result based on JobID**

# Dissemination and Outreach

## Research – develop – publish

At 52°North, we disseminate project and research results, i.e., software and architecture developments, concepts and methodologies, via various platforms. This includes publications, presenting at conferences, as well as organizing workshops and seminars.

**Autermann**, Christian. "Interoperable Provision of Research Vessel Tracking Data via OGC SensorThings API and Sensor Observation Service''. Oral presented at the Geospatial Sensing Virtual 2020, Münster, Germany,September 1, 2020. https://52north. org/delivery/GSV2020/Autermann_Interoperable_Provision_of_Research_Vessel_ Tracking_Data_via_OGC_SensorThings_API_and_SOS.pdf.

**Drost**, Sebastian, Christian Danowski-Buhren, Arne **Vogt**, and Matthes **Rieke**. "Distributed Services for Enabling Automated Processing of Big EO Data." Oral presented at the Geospatial Sensing Virtual 2020, Münster, Germany, September 1, 2020. https://52north.org/delivery/GSV2020/presentations/Drost_Distributed_ Services_for_Enabling_Automated_Processing_of_Big_EO_Data.pdf.

**Gräler**, Benedikt, Imke Ines **Klatt**, Martin **Pontius**, and Albert **Remke**. "Predictive Analytics to Improve Road Safety." In 2020 10th International Conference on Advanced Computer Information Technologies (ACIT), 362–367, 2020. https://doi. org/10.1109/ACIT49673.2020.9208848.

**Gräler**, Benedikt, Christoph Doll, Jürgen Mück, Albert **Remke**, Diana Schramm, Arne **de Wall**, and Herwig Wulffius. "CITRAM - Citizen Science for Traffic Management." Other, March 23, 2020. https://doi.org/10.5194/egusphere-egu2020-19952; http:// web.archive.org/web/20201001062615/https://meetingorganizer.copernicus.org/ EGU2020/EGU2020-19952.html; http://web.archive.org/web/20201001062617/https:// meetingorganizer.copernicus.org/EGU2020/EGU2020-19952.html; http://web. archive.org/web/20201001062634/https://meetingorganizer.copernicus.org/ EGU2020/EGU2020-19952.html.

**Gräler**, Benedikt, Heinz Albert Stumpen, Imke Ines **Klatt**, Martin **Pontius**, and Albert **Remke**. "PreASiSt – Predictive Analytics Zur Verbesserung Der Sicherheit Im Straßenverkehr." Presented at the mFund-Fachaustausch: Verkehrssicherheit, DHPol, Münster, March 12, 2020.

**Gräler**, Benedikt. "Accessing Environmental Time-Series Data for Data Analysis''. Workshop presented at the Geospatial Sensing Virtual 2020, Münster, Germany, August 31, 2020. https://52north.org/delivery/GSV2020/tutorials/Gräler_Accessing_ Environmental_TimeSeries_Data_for_Data_Analysis_Tutorial.pdf.

**Jirka**, Simon, Eike Hinderk **Jürrens**, Benedikt **Gräler**, Carsten **Hollmann**, Alexander Kotsev, Michel Gerboles, Annette Borowiak, and Sven Schade. "AQSens: An Interoperable Platform Integrating Citizen Science and Authoritative Air Quality Data." Other, March 23, 2020. https://doi.org/10.5194/egusphere-egu2020-14358; http:// web.archive.org/web/20201001062556/https://meetingorganizer.copernicus.org/ EGU2020/EGU2020-14358.html; http://web.archive.org/web/20201001062558/ https://meetingorganizer.copernicus.org/EGU2020/EGU2020-14358.html.

**Jirka**, Simon. "Introduction to Sensor Web Technologies''. Workshop presented at the Geospatial Sensing Virtual 2020, Münster, Germany, August 31, 2020. https://52north.org/ delivery/GSV2020/tutorials/Jirka_Introduction_to_Sensor_Web_Technologies_Tutorial.pdf.

Lazoglou, Georgia, Christina Angnostopoulou, Konstantia Tolika, and **Gräler** Benedikt. "Evaluation of a New Statistical Method—TIN-Copula–for the Bias Correction of Climate Models' Extreme Parameters." Atmosphere 11, no. 3 (February 29, 2020): 243. https://doi.org/10.3390/atmos11030243.

Leopold, Ulrich, Benedikt **Gräler**, Henning **Bredel**, J. Arturo Torres-Matallana, Philippe Pinheiro, Mickaël Stefas, Thomas Udelhoven, et al. "The Earth Observation Time Series Analysis Toolbox (EOTSA) - An R Package with WPS, Web-Client and Spark Integration." Other, March 23, 2020. https://doi.org/10.5194/egusphere-egu2020-21974; http://web.archive.org/web/20201001063522/https://meetingorganizer.copernicus.org/EGU2020/EGU2020-21974.html; http://web.archive.org/web/20201001063524/https://meetingorganizer.copernicus.org/EGU2020/EGU2020-21974.html.

Matheus, Andreas, Joan Masó and Henning **Bredel**. "Sensor Things API for Citizen Science". Oral presented at OGC TC, CitSci DWG (07.12.2020).

Matheus, Andreas, Joan Masó and Henning **Bredel**. "Sensor Things API for Citizen Science". Oral presented at OGC TC, Architecture DWG (10.12.2020).

Nüst, Daniel, Eike H. **Jürrens**, Benedikt **Gräler**, and Simon **Jirka**. "Accessing Environmental Time Series Data in R from Sensor Observation Services with Ease." Other, March 23, 2020. https://doi.org/10.5194/egusphere-egu2020-19453; http://web.archive.org/web/20201001062148/https://meetingorganizer.copernicus.org/EGU2020/EGU2020-19453.html.

**Pontius**, Martin, Benedikt **Gräler**, Albert **Remke**, and Arne **de Wall**. "Estimating Fuel Consumption of Cars Based on Movement Data and Its Sensitivity to Car and Movement Specific Properties." Other, March 23, 2020. https://doi.org/10.5194/egusphere-egu2020-9246; http://web.archive.org/web/20201001063439/https://meetingorganizer.copernicus.org/EGU2020/EGU2020-9246.html.

**Proß**, Benjamin. "OGC Implementation Specification: OGC API - Processes - Part 1: Core 1.0-Draft.4" (18-062). Wayland, MA, USA: Open Geospatial Consortium Inc., 2020. https://portal.ogc.org/files/94529.

**Rieke**, Matthes, Sebastian **Drost**, Simon **Jirka**, and Arne **Vogt**. "Event-Driven Processing of Earth Observation Data." Oral presented at the EGU General Assembly 2019, Vienna, Austria, May 4, 2020. https://meetingorganizer.copernicus.org/EGU2020/EGU2020-16661.html.

**Rieke**, Matthes and Benjamin **Proß**. "Web Processing - Standardization and Cloud Concepts". Workshop presented at the Geospatial Sensing Virtual 2020, Münster, Germany, August 31, 2020. https://52north.org/delivery/GSV2020/tutorials/Rieke_Pross_Web_Processing_Standardization_and_Cloud_Concepts_Tutorial.pdf.

**de Wall**, Arne, Christian Danowski-Buhren, Andreas Wytzisk-Arens, Kai Lingemann, Santiago Focke Martinez, Markus Gandorfer, Andreas Meyer-Aurich, et al. "Prospective.HARVEST – Optimizing Planning of Agricultural Harvest Logistic Chains," no. 2020 (March 4, 2020): 55–60.

**Wytzisk-Arens**, Andreas. "Research Data Infrastructures - A Means for Collaboration in Science" Workshop presented at the Geospatial Sensing Virtual 2020, Münster, Germany, September 2, 2020. https://52north.org/delivery/GSV2020/presentations/Wytzisk_Research_Data_Management.pdf.

# Affiliations

## Joining forces with the Geo-IT community

The **Open Geospatial Consortium (OGC)** is an international consortium of businesses, government agencies and research organizations creating open standards to support the provision and use of geospatial information. 52°North is an OGC member with the status of a non-profit research organization. We contribute to the standards development and consensus process as well as the OGC Innovation Program with its Testbeds, Pilots and Interoperability Experiments.

**Contact:** https://www.opengeospatial.org

The **Association of Geographic Information Laboratories in Europe (AGILE)** promotes academic teaching and research on GIS in Europe and stimulates and supports networking activities between member laboratories. Furthermore, AGILE contributes to shaping the European GI research agenda. 52°North actively participates in the permanent scientific forum and contributes to the annual AGILE conferences.

**Contact:** https://agile-online.org

The **European Citizen Science Association (ECSA)** is a non-profit association that fosters the Citizen Science movement in Europe. It performs research on Citizen Science and initiates and supports Citizen Science projects. 52°North contributes to the ECSA initiatives and hosts the enviroCar Citizen Science platform for road traffic analysis.

**Contact:** https://ecsa.citizen-science.net/

**FOSSGIS e.V.** is a German non-profit association that promotes open source software and open data. 52°North participates regularly in the annual FOSSGIS conferences to promote and discuss its open source software projects within the OS community.

**Contact:** https://www.fossgis.de

**"Deutscher Dachverband für Geoinformation" (DDGI)** is the German national umbrella organization for institutions from the public and private sector as well as academia that have stakes in improving the availability and use of geospatial information. 52°North contributes to discussions and networking activities by participating in DDGI working groups and events.

**Contact:** https://www.ddgi.de



**GDI DE (Geospatial Data Infrastructure Germany), GeoIT RT NRW (Geospatial Information Technologies Round Table North-Rhine Westphalia)** and **Geonetzwerk Münsterland (Geonetwork in the Münster Region)** are associations on national, state and local levels that support the availability and use of geospatial information by stimulating the development of the spatial data infrastructure in their respective stakeholder communities. 52°North supports the goals of these associations and contributes to their activities by participating in expert groups and events. 52°North is a member of the GeoIT RT NRW and Geonetzwerk Münsterland steering committees.

**Contact:** https://www.gdi-de.org
https://www.geoportal.nrw/geoit_round_table
http://www.geonetzwerk-muensterland.de

# Legal Notice

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