52north

exploring horizons

Annual Report 2023

Innovation and Technologies
for Research Data Infrastructures

Preface

2023 was an important milestone for 52°North on the way to further develop our role as a reliable and competent partner in our core themes: research data infrastructures, data analytics and innovative geoinformation technology trends. After 2021 and 2022, which were particularly characterized by a strategic and structural transformation process, we were able to build on the results of this process in 2023.

Work focusing on research data infrastructures continued in numerous research projects, such as KI:STE, AquaINFRA, Cos4Cloud and MINKE. The results achieved in these research activities equipped us to support the National Research Data Infrastructure for Earth System Sciences (NFDI4Earth) project in enabling the search for data, services and other resources.

Developing real-time data infrastructures reached a new level in our work with the ITZBund. We were able to test and practically implement solutions that enable the delivery of measurement data with minimal latency and high efficiency.

Our work on co-design based development of climate services to address climate change adaptation and disaster risk reduction resulted in the first pre-operational services. This was an important milestone for the European projects I-CISK and DIRECTED, which pushed and engaged all project teams.

This past year also marks the start of the "Open Pioneer" initiative, jointly initiated by con terra GmbH and 52°North to explore the boundaries of GeoIT. The first project "Open Pioneer Trails" is a development platform for web clients that makes it possible to develop individual geo-IT solutions. We expect this joint project to serve as the basis for a wide range of software development projects in the future.

This year's annual report presents the full range of our project work in 2023. We are pleased to see the broad impact of our results in many communities and look forward to continuing our current development in 2024.

Münster, January 2024

Dr. Benedikt Gräler   *Dr. Simon Jirka*   *Matthes Rieke*

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About 52°North

Spatial Information Research

52°North is a private non-profit R&D organization based 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 the application of scientific methods and excellent software engineering practices. They have extensive knowledge of the state-of-art technologies and GeoIT 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 GeoIT solutions.

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

STAFF

31
software engineers, data scientists, business administration, trainees…

18,9
full time equivalents

16
permanent contracts, 15 temporary employments

Facts and Figures

FOUNDED

September 2006

SHAREHOLDERS

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

MANAGEMENT

Dr. Benedikt Gräler

Dr. Simon Jirka

Matthes Rieke

REVENUES

~ 1,7 M €
in total

69%
billable hours spent
on research
projects

31%
billable hours spent
on fully funded R&D
and professional
services

Research and Development

Innovating Methods and Technologies to Unlock the Value of Geospatial Data

Spatial data play a key role in supporting environmental planning, smart mobility, renewable energy forecasting, climate change adaptation, disaster risk reduction and risk management, and many other applications. Our mission is to facilitate the availability and use of spatio-temporal data by innovating the methods and technologies for creating, managing, sharing, analyzing and visualizing the derived information.

52°North focuses on three interrelated areas.

Research Data Infrastructures (RDI): The development of RDIs is based on 52°North's experience in Spatial Data and Spatial Information Infrastructures (SDI/SII). A key component is the provision of Analysis Ready Data (ARD) for subsequent processing and analysis workflows. This is closely related to Spatial Data Science.

Spatial Data Science: The true value of existing data sets can only be unlocked by transforming data into information. Using classical and modern data analysis approaches, we facilitate this transition.

SDI Innovation: This addresses the technical solutions used to bring SDI and analysis to life. The research and development of new SDI architectures and concepts on modern IT systems facilitates the discovery of geospatial data's true potential.

We believe that applied research is best complemented by the development of operational solutions to create tangible added value in practice. This combination transforms scientific results into relevant "innovations". 52°North supports the development of operational solutions by offering professional services, such as training and consulting, software engineering or data analysis. A central idea is co-development with our project partners, customers or a wider community, such as end users of our information tools. This allows us to address real world problems with our innovations. The following sections provide an overview of our research and development activities.

Research Data Infrastructures

Enabling the efficient flow, management and visualization of research data

When we talk about Research Data Infrastructures, we are referring to all aspects related to the collection, management, discovery, sharing, and visualization of data that describe the past, present, or future state of the environment. This includes not only data generated by sensors (e.g., measurements of air pollutant concentrations and water levels), but also information collected by humans (e.g., observations of animals or plants) and predictions calculated by models (e.g., weather models). The Research Data Infrastructures team supports our partners and customers along the entire process chain from data acquisition to visualization.

Dr. Simon Jirka leads a team focused on new approaches and technologies in the area of research data infrastructures. He and his team are currently addressing the following challenges

- Connecting to sensor hardware: investigating how to efficiently integrate new sensors into (research) data infrastructures, e.g. using IoT technologies such as MQTT.
- Data storage and management: optimizing data models and supporting the provision of metadata to ensure correct interpretation of research data.
- Sensor data management: supporting the management of sensor data as an important element of research data infrastructures.
- Semantic interoperability: contributing to and promoting the use of vocabularies.
- Data availability to users: advancing data access interfaces and encodings.
- Efficient data delivery: enabling push/event-driven communication patterns to ensure timely delivery of data.
- Data visualization: improving methods for visualizing and exploring dynamic research data to enable better communication of the collected information.
- Citizen Science: facilitating the establishment of citizen observatory initiatives by providing dedicated reusable building blocks.

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

Simon Jirka

Head of Research Data Infrastructures

MINKE

Metrology for Integrated Marine Management and Knowledge Transfer Network

MINKE enables scientists to have a better understanding of measurement data and to combine data of different quality levels.

The H2020 project MINKE integrates key European marine metrology research infrastructures to propose an innovative "oceanographic data quality" framework for European stakeholders monitoring and managing marine ecosystems. MINKE proposes a new vision for the design of marine monitoring networks. It considers accuracy and completeness as the driving components of quality in data acquisition. This new vision is framed in a helix model of innovation that incorporates all the elements involved in the monitoring network design:

- Context (ocean health): identifying the Essential Ocean Variables (EOVs) as the key parameters to monitor
- Civil society (NGOs, maker communities, social media and Citizen Science platforms): key actors to ensure data integrity
- Academia: researching new methods to ensure the accuracy and the global quality of the final products, developing tools to integrate information from high quality oceanographic instruments and low-cost instrumentation
- Industry: improving the performance of the observations with new instrumentation, data transmission systems and cost-effective technologies
- Governments: providing the legal and socio-economic framework for the development of the proposed network

52°North co-leads a dedicated work package on data harmonization. The core topics of this work package include the evaluation of interoperability standards, the investigation of integration options for the European Open Science Cloud, the handling of uncertainty information, as well as the connection to data aggregation platforms such as EMODNET.

In 2023, 52°North's team focused on aspects related to data harmonization. In a dedicated deliverable, 52°North developed best practices for publishing MINKE metadata and datasets in the European Open Science Cloud (EOSC) using platforms such as Zenodo and Seanoe.

KEY TECHNOLOGIES

> 52°North Sensor Web Suite
> OGC API Connected Systems
> ISO/OGC Observations and Measurements (O&M)
> OGC Sensor Model Language (SensorML)
> pygeoapi

FACTS

Duration:
04/2021 - 03/2025

Website:
https://minke.eu/

Contact:
Simon Jirka
s.jirka@52north.org

Project Type:
Research and Development
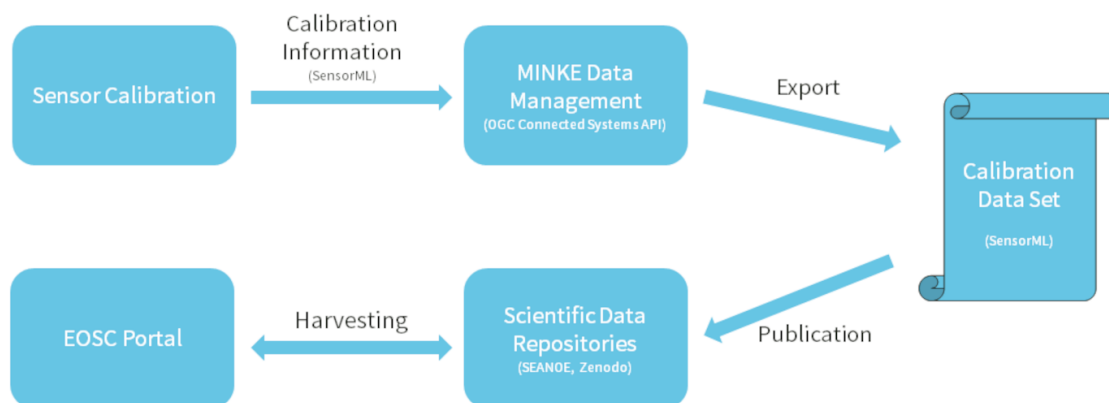
Overview of the MINKE Sensor Quality Information Publication Workflow

The team is also involved in the specification process of the OGC API - Connected Systems in the corresponding OGC Standards Working Group. In addition to a new iteration of the Sensor Web Enablement Common (SWECommon) and Sensor Model Language (SensorML), including JSON encodings for both, a new API is being developed that brings ideas from the OGC Sensor Observation Service (SOS) and OGC Sensor Planning Service (SPS) into the OGC API family of standards. The team plans to evaluate this evolving standard with MINKE data and metadata and has initiated an implementation based on pygeoapi.

PARTNERS

- **Coordinator:** Consejo Superior de Investigaciones Científicas (CSIC), Spain
- Institut français de recherche pour l'exploitation de la mer (Ifremer), France
- Hellenic Centre for Marine Research (HCMR), Greece
- Consorcio para el diseño, construcción, equipamiento y explotación de la Plataforma Oceánica de Canarias (PLOCAN), Spain
- Universitat Politècnica de Catalunya (UPC), Spain
- Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGC), Italy
- Consiglio Nazionale delle Ricerche (CNR), Italy
- Istituto Nazionale di Ricerca Metrologica (INRiM), Italy
- Service hydrographique et océanographique de la Marine (Shom), France
- Norsk institutt for vannforskning (NIVA), Norway
- National Oceanography Centre (NOC), United Kingdom
- Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile (ENEA), Italy
- Physikalisch-Technische Bundesanstalt (PTB), Germany
- Université d'Aix-Marseille, France
- Universidad Católica del Norte, Chile
- Anel.lides Sl, Spain
- Laboratoire national de métrologie et d'essais (LNE), France
- Institut d'Arquitectura Avançada de Catalunya (IAAC), Spain
- Suomen ympäristökeskus (SYKE), Finland
- Joint Programming Initiative Healthy and Productive Seas and Oceans (JPI Oceans), Belgium
- European Multidisciplinary Seafloor and water-column Observatory - European Research Infrastructure Consortium (EMSO ERIC), Italy

FUNDING
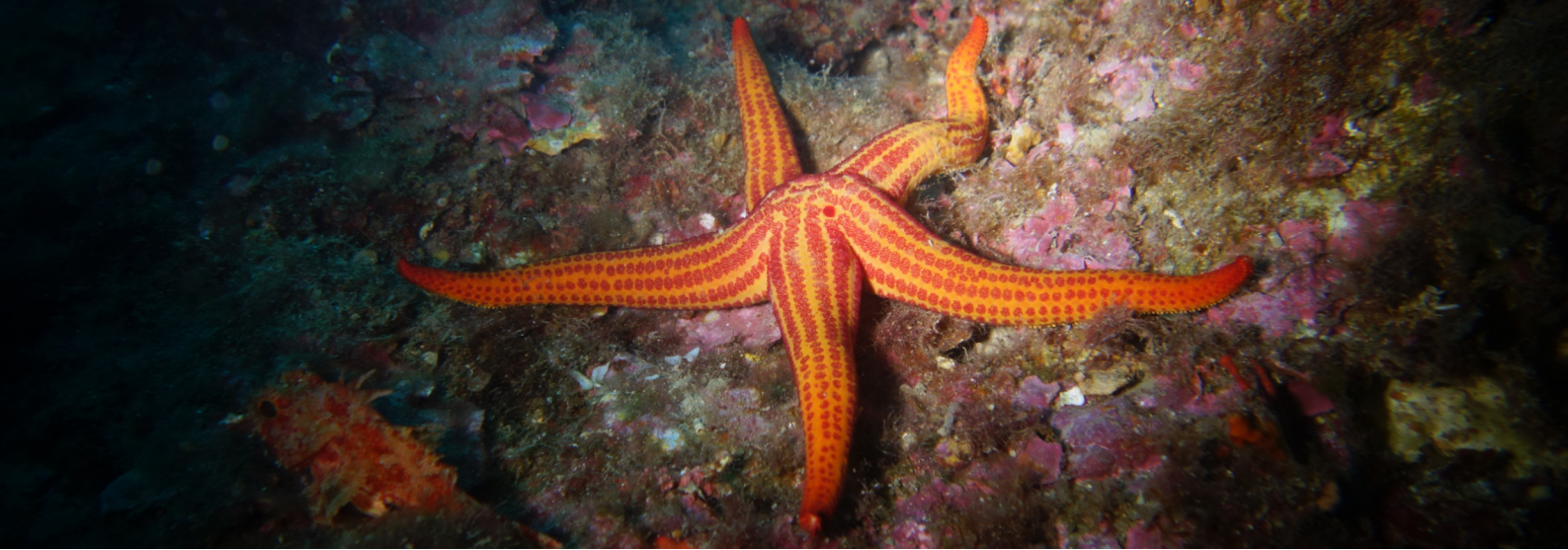
EMODnet Ingestion III

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 exchange of marine data. As part of the larger EMODnet context, EMODnet Ingestion 3 continues the work of its predecessors in 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 focuses on Sensor Web technologies. Based on results from previous projects and currently ongoing international standardization efforts, we support the consortium in addressing 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 2023, 52°North worked 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. We further refined the resulting data publication workflow, built on top of the Eurofleets Automatic Reporting System (EARS), and described it in related publications.

52°North's focus in EMODnet Ingestion 3 is the use of the OGC SensorThings API to provide live event data from research vessels. Another major topic is the integration of OPeNDAP/ERDDAP services with SensorWeb infrastructures. This includes in particular the collaboration on the OGC API - Connected Systems in the respective OGC standards working group. 52°North will provide an implementation of this proposed standard, a successor to the OGC Sensor Observation Service and the OGC Sensor Planning Service, based on pygeoapi.

KEY TECHNOLOGIES

> Sensor Web
> OGC SensorThings API
> MQTT
> Angular
> ERDDAP
> OPeNDAP
> OGC API Connected Systems
> pygeoapi

FACTS

Duration:
3/2022 - 3/2024

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

Contact:
Simon Jirka
s.jirka@52north.org

Project Type:
Professional Services
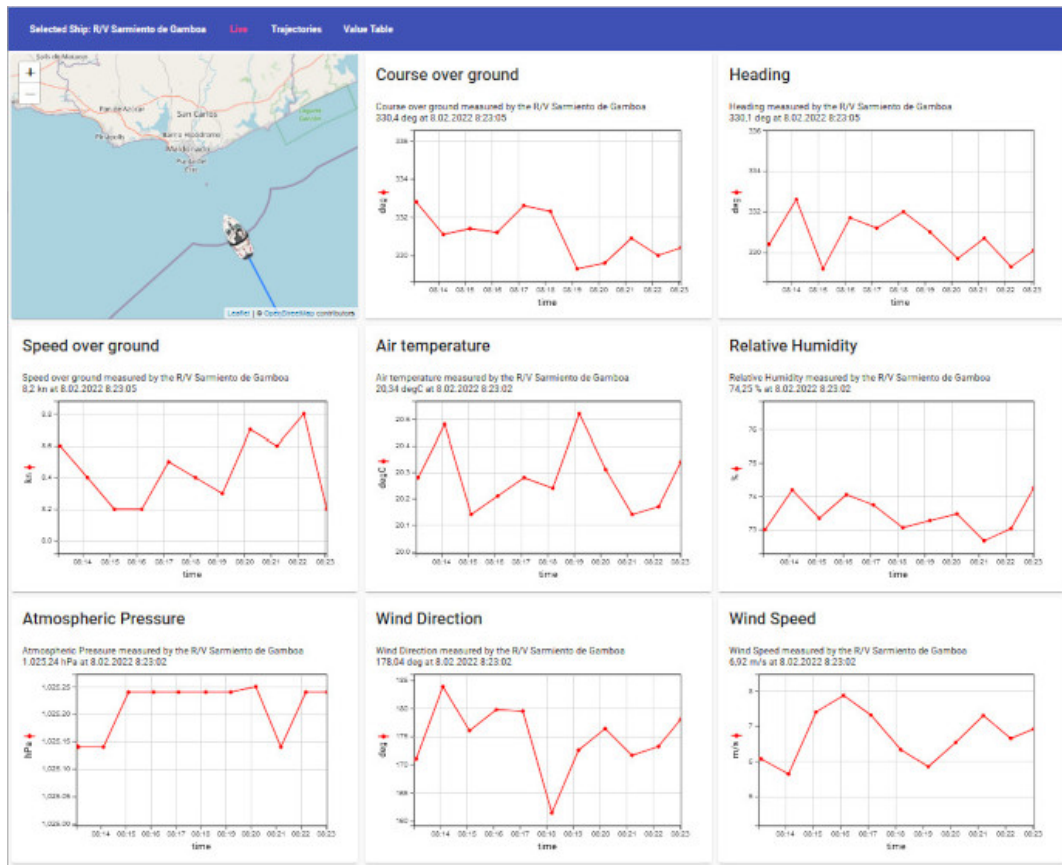
Eurofleets dashboard

PARTNERS

- 44 partners from all over Europe
  52°North is a subcontractor of Maris B.V., The Netherlands

FUNDING

JERICO-S3

Joint European Research Infrastructure of Coastal Observatories

JERICO-S3 facilitates the integration of marine sensing technology into research data infrastructures to better observe the coastal ecosystem.

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 successive JERICO projects since 2010.

JERICO-S3 targets a more integrated scientific approach to better observe the coastal ecosystem. This in turn will elevate the scientific excellence of the regional and local ecosystems. The project implements major user-driven improvements in terms of observing the complexity of coastal seas and continuous monitoring of biology, access to facilities, data and services, best practices and performance indicators, as well as innovative monitoring strategies. These also cover cooperation with other European RIs (EuroARGO, EMSO, DANUBIUS, ICOS, EMBRC) and international scientific communities, industry and other stakeholders, as well as strategy alignment with COPERNICUS/CMEMS, EMODNET and GEO/GEOSS.

52°North focuses on technological innovation activities. We work on the advancement of Sensor Web components, such as 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.

In 2023, 52°North supported the consortium in a pre-demo test activity deploying an autonomous underwater coastal observatory (coastal EMSO Generic Instrument Module, cEGIM) in 8 m water depth in the Sainte Anne du Portzic Bay, near IFREMER (Brest, France). The objective of the activity was to test the entire cEGIM platform, including automated sensor configuration changes, data acquisition, storage, and communication. 52°North provided an OGC SensorThings API and a Helgoland instance for data storage and visualization.
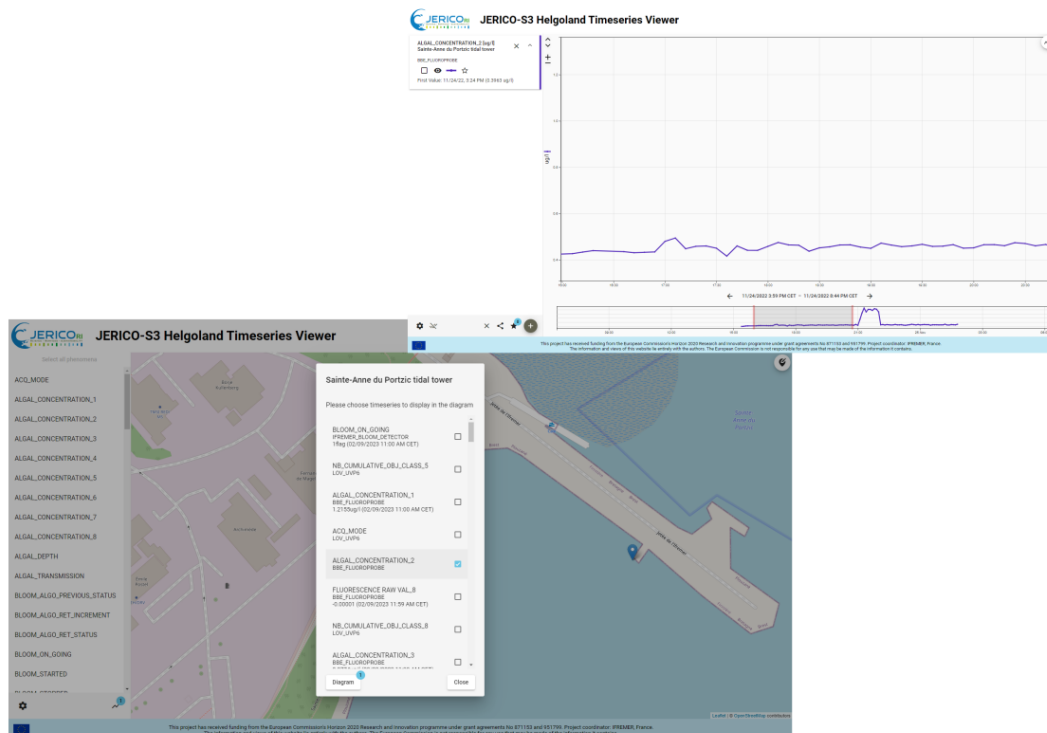
Helgoland visualization of the cEGIM pre-demo data off the coast of Brest, France

PARTNERS

39 partners, including:

- **Coordinator:** Institut français de recherche pour l'exploitation de la mer (Ifremer), France
- Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung (AWI), Germany
- Consiglio Nazionale delle Ricerche (CNR), Italy
- ETT S.p.A., Italy
- European Global Ocean Observing System (EuroGOOS), Belgium
- Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung GmbH (HZG), Germany
- Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGC), Italy
- Plataforma Oceánica de Canarias (PLOCAN), Spain
- Royal Belgian Institute of Natural Sciences, Belgium
- Universitat Politècnica de Catalunya (UPC), Spain

FUNDING

AquaINFRA

Infrastructure for Marine and Inland Water Research

AquaINFRA helps to transform the way marine and freshwater scientists and stakeholders share and exploit research outputs (e.g., data, publications, software) and to establish a seamless connection between EOSC, operational data spaces, researchers, and other stakeholders.

The project's overall objective is to develop a virtual environment equipped with FAIR multidisciplinary data and services to support marine and freshwater scientists and stakeholders in restoring healthy oceans, seas, coastal and inland waters. The AquaINFRA virtual environment will enable target stakeholders to store, share, access, analyze and process research data and other digital research objects from their own discipline, across research infrastructures, disciplines and national borders, using the European Open Science Cloud (EOSC) and the other existing operational data spaces. In addition to supporting the ongoing development of EOSC as an overarching research infrastructure, AquaINFRA addresses the specific need to enable researchers from the marine and freshwater communities to work and collaborate across these two domains. A specific objective is to develop an EOSC-based research infrastructure linking the marine and freshwater domains. This will include the development of a cross-domain and cross-country search and discovery mechanism, as well as the development of spatio-temporal analysis and modeling services through virtual research environments. A set of strategic use cases, including a pan-European use case as well as more focused use cases in the Baltic and the North Seas will provide the framework for co-design and testing of services in the targeted research communities. The project outcomes are expected to contribute to the utilization of EOSC as an overarching research infrastructure enabling collaboration between marine and freshwater scientists and stakeholders working to restore healthy oceans, seas, coastal and inland waters.

52°North leads Task 4.1, which takes care of developing the AquaINFRA Interaction Platform (AIP) as the project's central gateway and the Virtual Research Environment (VRE) and its integrated workflow canvas. In addition, 52°North contributes to the user requirements analysis, the co-design of the AquaINFRA system architecture and the creation of the interoperability framework (Task 3.1). Our team also supports the integration of project results into the European Open Science Cloud (Task 2.2) and engages in dissemination activities (WP7).

KEY TECHNOLOGIES

> Research Data Infrastructures
> OGC API
> Pygeoapi
> Galaxy
> Open Pioneer Trails
> React
> R Programming Language
> Python

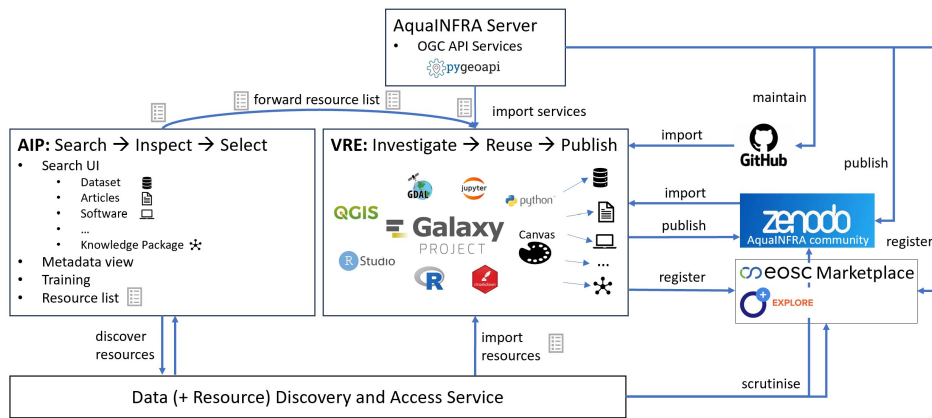## FACTS

Duration:
01/2023 - 12/2026

Website:
https://aquainfra.eu/

Contact:
Markus Konkol
m.konkol@52north.org

Project Type:
Research and Development

The figure shows the current state of the AquaINFRA Platform, which is still evolving. 52°North is responsible for developing the AquaINFRA Interaction Platform and Virtual Research Environment.

PARTNERS

- **Coordinator**: Aalborg Universitet(AAU), Denmark
- Agencia Estatal Consejo Superior de Investigaciones Científicas (CSIC), Spain
- Blue Lobster IT Limited, United Kingdom
- CSC – Tieteen tietotekniikan keskus Oy, Finland
- Centro de Investigación Ecológica y Aplicaciones Forestales (CREAF), Spain
- Deutsche Klimarechenzentrum (DKRZ), Germany
- Estonian Marine Institute, Estland
- HELCOM - The Baltic Marine Environment Protection Commission, Finland
- Helmholtz-Zentrum Hereon, Germany
- Hochschule Bochum, Germany
- Karlsruher Institut für Technologie, Germany
- L-Università ta' Malta, Malta
- Latvijas Hidroekoloģijas institūts, Lettland
- Leibniz Institute of Freshwater Ecology and Inland Fisheries (FVB-IGB), Germany
- Maanmittauslaitos, Finland
- Norsk institutt for vannforskning (NIVA), Norway
- SINTEF AS, Norway
- Suomen ympäristökeskus (SYKE), Finland
- Technische Universität Dresden, Germany
- Universität für Bodenkultur Wien, Austria

FUNDING

14

EDIS

Extension of the PEGELONLINE Infrastructure (EDIS)

EDIS provides the German Federal Waterways Administration with new ways to deliver critical measurement data faster and more reliably, for example in the event of flooding.

The ITZBund is a service center providing IT services to federal agencies in Germany. They operate the PEGELONLINE platform, an important infrastructure providing a broad range of hydrological measurement data collected along German waterways.

52°North provides consulting to evaluate event-based communication techniques for a more efficient delivery of (geospatial) information, such as measurement data, in real time. Our team specifically considers approaches to reduce data delivery latency and minimize server load using push-based communication protocols such as MQTT and AMQP. In addition to evaluating protocols, we investigate potential approaches for structuring the delivered data, ensuring access control, supporting the development of client applications such as dashboards, and integrating event-based workflows into the existing IT infrastructure.

Our software engineers complement these activities by upgrading PEGELONLINE's existing Sensor Web components. These include the current 52°North SOS implementation and the Helgoland Sensor Web Viewer.

In 2023, 52°North focused on implementing the key elements of the real-time data infrastructure (data feeding, MQTT broker) so that the first external partners could start testing the offered data streams. Our team also began to address other conceptual challenges such as access control and increased reliability through redundancy. Additionally, we enhanced PEGELONLINE's Sensor Web components to allow additional exploration and visualization of the access controlled data offered via the PEGELONLINE REST API.

One particularly important achievement in 2023 was the 3rd place in the German eGovernment competition in the category "Best Project Sustainability through Digitalization".

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Quellen:
https://www.flaticon.com/premium-icon/water-level_4749703   https://www.flaticon.com/premium-icon/monitor_2930617
https://www.flaticon.com/premium-icon/database_2383158   https://www.flaticon.com/free-icon/scrolling_1786968
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EDIS architecture

CUSTOMER

- Informationstechnikzentrum Bund (ITZBund), Germany

data.europa.eu

Data.europa.eu Managed Services

Enable the sharing of Open Data across Europe

This project facilitates the sharing of open data resources across Europe. The central element is the new data.europa.eu portal, which was launched in the spring of 2021. It serves as a core component of the public sector data infrastructure. Data.europa.eu portal offers three key pillars:

- Facilitating the use of public data resources across Europe via a single point of access: The portal offers more than 1.7 million datasets from 35 countries and 102 EU institutions;
- Supporting EU and European public administrations: This includes helping national open data policy owners to build communities of practice where they receive training and advice to improve, sustain and document data publishing practices;
- Socio-economic benefits: Investigating the socio-economic benefits of re-using public data resources and providing incentives to promote the use and demonstrate the value of using open data.

Data.europa.eu is managed and funded by the Publications Office of the European Union. In a dedicated contract, 52°North supports the development and operation of data.europa.eu in close cooperation with Netcompany-Intrasoft, con terra, Fraunhofer FOKUS and Capgemini Invent. A central task is to develop and maintain a component for the map-based visualization of geospatial data. In addition, 52°North contributes to the advancement of the underlying data infrastructure, for example, by exploring how to best integrate near real-time data streams.

In 2023, 52°North focused on the maintenance and evolution of the geospatial data visualization component. This included updating the underlying libraries and exploring how other types of data sources could be integrated into the geovisualization. In addition, 52°North and con terra conducted a dedicated webinar on trends in geospatial data provision with a particular focus on Geo-AI technologies.
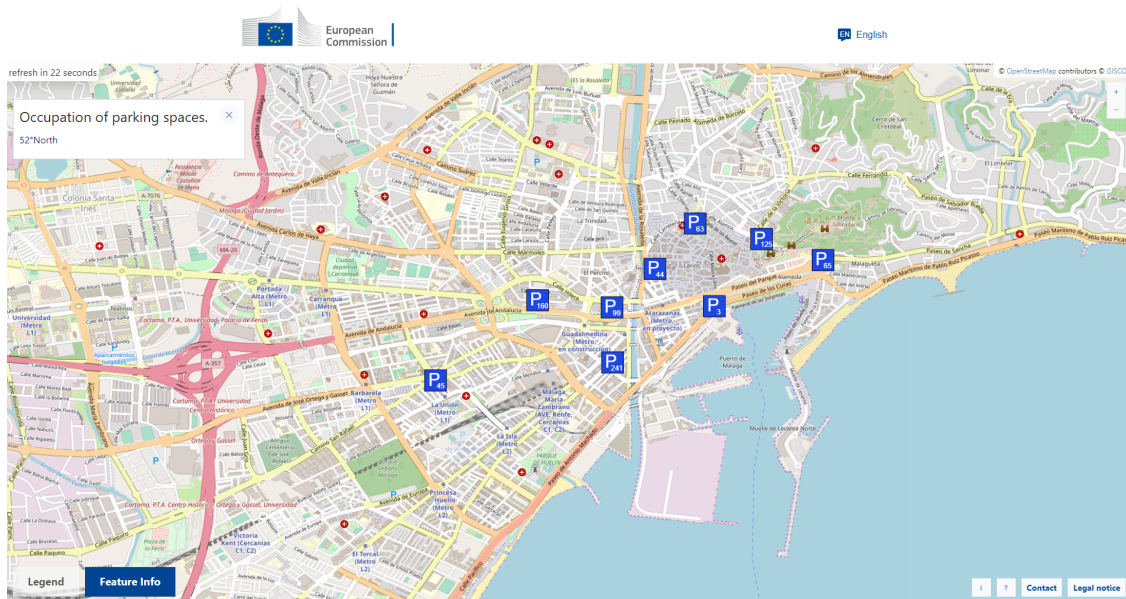
Preview of live data on parking availability in Malaga, Spain from the data.europa.eu portal

PARTNERS (SELECTION)

- **Main Contractor**: Capgemini Invent, The Netherlands
- Netcompany-Intrasoft, Luxembourg
- con terra GmbH, Germany
- Fraunhofer FOKUS, Germany
- Agiledrop Ltd., Slovenia
- OMMAX GmbH, Germany

CUSTOMER

- Publications Office of the European Union
  52°North is subcontractor to Capgemini Invent and con terra

KomMonitor

Enhancing the KomMonitor Platform

Adapting the KomMonitor platform to the needs of local governments

The Open-Source software KomMonitor is a GIS-based, spatio-temporal monitoring system for geodata and statistical time series data. It was originally developed by the Bochum University of Applied Sciences in a dedicated research project. KomMonitor supports local governments as a web-based planning tool to answer current questions regarding socio-demographic development and city planning.

52°North has been actively involved in the development and distribution of KomMonitor for several years. When KomMonitor was still a research project, our team developed some essential software components and concepts. This contributed to KomMonitor's production-ready architecture. Since then, 52°North supports the Bochum University of Science in maintaining the software code of all components that make up the KomMonitor platform. We also implement innovative analysis features at the request of municipalities, which fuels KomMonitor's continued growth. In addition to these development activities, 52°North has expanded its service portfolio for KomMonitor by assisting municipalities in establishing KomMonitor as a monitoring system for urban and social planning. We are currently assisting several municipalities with KomMonitor deployment and data migration, as well as providing technical support and training for KomMonitor users.

Stadt- und Sozialplannung mit KomMonitor

Enhancing the KomMonitor Web Client

Improving the usability of statistical analysis tools for social planning use cases

G.I.B. mbH is a state-owned company that supports the government of North Rhine-Westphalia in achieving its goals of promoting employment, as well as combating unemployment, poverty and social exclusion. 52°North has improved the layout of several statistical diagrams in the KomMonitor Web Client. These enhancements facilitate the customization of different widgets, which contributes to a better understanding of indicator-based time series data in KomMonitor, and were funded by the European Social Fund.

KomMonitor's reachability analyses

KEY TECHNOLOGIES
> JavaScript
> AngularJS

FACTS
Duration:
09/2023 - 11/2023

CUSTOMER

- G.I.B. mbH - Gesellschaft fur innovative Beschäftigungsförderung mbH, Germany

regio iT - Installation and Support

Launching the KomMonitor platform and providing support for the social planning sector

regio iT GmbH is a municipal IT service provider in North Rhine-Westphalia, Germany. The company provides IT infrastructure and services to public clients from various business fields, such as education and development or public administration. On behalf of the regio iT GmbH, 52°North launched the KomMonitor platform for the City of Remscheid. 52°North deployed the complete Docker-based KomMonitor software stack, relying on existing software components in regio iT GmbH's IT infrastructure, which had already been put into production for the StädteRegion in Aachen in 2022.

52°North also provided 2nd level and 3rd level support for the KomMonitor platform to assist the customers, City of Remscheid and StädteRegion Aachen, with their technical questions. In addition, we conducted a dedicated training course to guide the City of Remscheid staff in data migration tasks for the KomMonitor platform.

The costs for the implementation of the KomMonitor platform in the City of Remscheid, as well as for all training and support sessions, were funded by the Ministry of Labor, Health and Social Affairs of North Rhine-Westphalia as part of the social funding program "Zusammen im Quartier". 52°North provided all technical support and workshops in 2023.
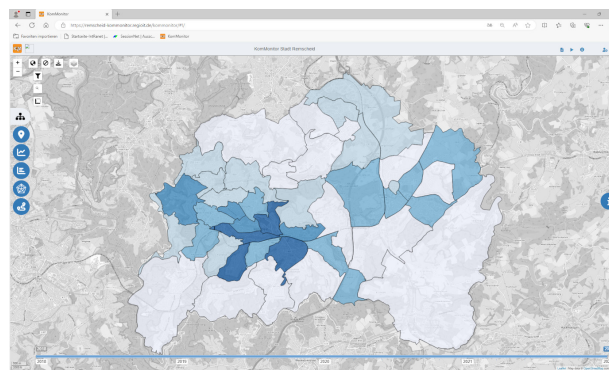
Unemployment rate in 2022 - Unemployed persons (SGB II and SGB III) proportional to all employable persons

CUSTOMER

- regio iT gesellschaft für informationstechnologie mbh, Germany

Kreis Viersen - Installation and Support

Launching the KomMonitor platform for Kreis Viersen

The District of Viersen (Kreis Viersen) is a district in North Rhine-Westphalia and is responsible for district monitoring. This provides annual insights into the structural situation of its municipalities and the district as a whole. In order to provide municipal experts and citizens with a statistical tool that facilitates continuous district monitoring and supports social planning tasks, Kreis Viersen decided to implement the KomMonitor platform. 52°North deployed the complete KomMonitor stack in the technical infrastructure of the Kommunale Rechenzentrum Niederrhein (KRZN), which is one of the largest IT service providers for municipalities in Germany.

In addition to setting up KomMonitor, 52°North provided support to KRZN users. This included guidance on importing spatial and statistical datasets into KomMonitor, as well as expanding the KomMonitor Importer API for additional data sources, such as the OGC API - Features. 52°North also provided training on KomMonitor's permission management concept and the practical use of Keycloak for user management.

The costs for the introduction of the KomMonitor platform in Kreis Viersen, as well as for all training and support sessions, were funded by the Ministry of Labor, Health and Social Affairs of North Rhine-Westphalia as part of the social funding program "Zusammen im Quartier". All installation, technical support and workshops were provided in 2023.

KEY TECHNOLOGIES
> KomMonitor software stack
> Docker
> Keycloak
> Portainer

FACTS
Duration:
01/2023 - 12/2023
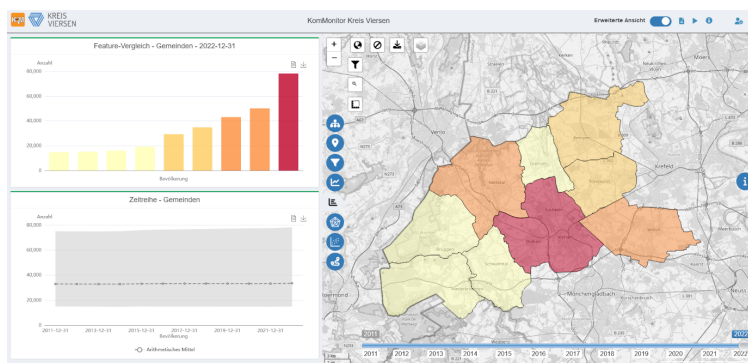
KomMonitor Web Client shows Viersen's population at the municipal level as of 31.12.2022

CUSTOMER

- Kreis Viersen, Germany

Urban Data Space Platform

Integrating KomMonitor into the Urban Data Space Platform

Südwestfalen-IT (SIT) is a municipal IT service provider for several municipalities in South Westphalia, Germany. It provides IT solutions to the public sector, such as cloud services, E-Government and IT infrastructure. Together with the cities of Arnsberg, Bad Berleburg, Menden, Olpe and Soest, the SIT aims to promote Smart City concepts in the region. These activities constituted the project "5 für Südwestfalen". As part of this project, 52°North supports the project consortium with the integration of KomMonitor into the cloud-based Urban Data Space Platform, which is maintained by the IT service provider Hypertegrity.
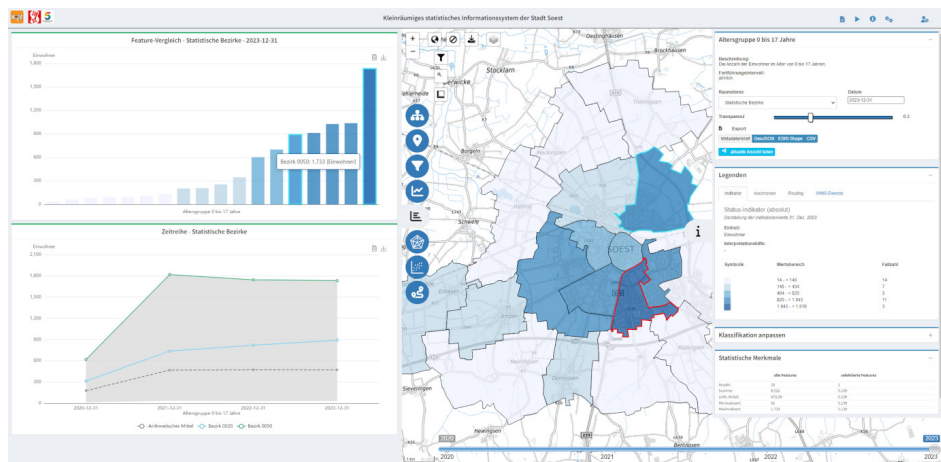
Small-scale analysis with KomMonitor in the Smart Cities project "5 for South Westphalia"

52°North provides guidance in setting up KomMonitor within a Kubernetes Cluster as well as implementing ETL (Extract, Transform, Load) workflows for migrating municipal spatio-temporal data into KomMonitor via Node-RED. So far, 52°North has supported Hypertegrity in preparing the Kubernetes deployment of KomMonitor.

CUSTOMER

- Südwestfalen-IT, Germany

Conducting Training for Municipalities

Making local government users fit for KomMonitor

52°North provided training to a number of municipalities and districts in 2023. The workshops, both online and on site, covered aspects regarding the use of KomMonitor:

- Use of KomMonitor for spatio-temporal analysis and urban monitoring
- Administration of KomMonitor and data import workflows
- Data access concepts and practical user management with Keycloak
- Basics in Docker and container-based KomMonitor deployment

The courses were aimed at a wide range of municipal professionals. Local government decision makers, social and urban planners, geodata managers, statisticians and IT experts attended the workshops and were prepared to use KomMonitor.

CUSTOMERS

- Städteregion Aachen, Germany
- Stadt Remscheid, Germany
- Kreis Viersen, Germany
- Stadt Herne, Germany
- Stadt Essen, Germany

FACTS

Duration:
01/2023 - 12/2023

GAIA-X

Next Generation Data Infrastructure for Europe

Evaluating the use of Gaia-X federation services for sharing geospatial data in heterogeneous cloud environments

Gaia-X is a multinational project of European Member States, in line with the European Data Strategy and co-funded by the European Commission, that supports the development of European Data Spaces by piloting architectural concepts, governance mechanisms, best practices and tools for data sharing and federation of cloud services. 52°North is an active institutional member of Gaia-X AISBL, the coordinating body of the Gaia-X Initiative.

One of the key drivers behind Gaia-X is the need for data sovereignty, i.e., the ability to control what happens to data when it is shared and processed in cloud environments within and across data spaces. Federation services (GFSX) are used to manage identities and verifiable credentials of participants, to conclude smart contracts, and to manage trust based on common policies and a labeling framework.

KEY TECHNOLOGIES

> GFSX federation services
> ArcGIS Enterprise 11.1
> Verifiable credentials,
  credential manager
> JSON LD

FACTS

Duration:
03/2022 - 04/2024

Contact:
Simon Jirka
s.jirka@52north.org

Project Type:
Professional Services
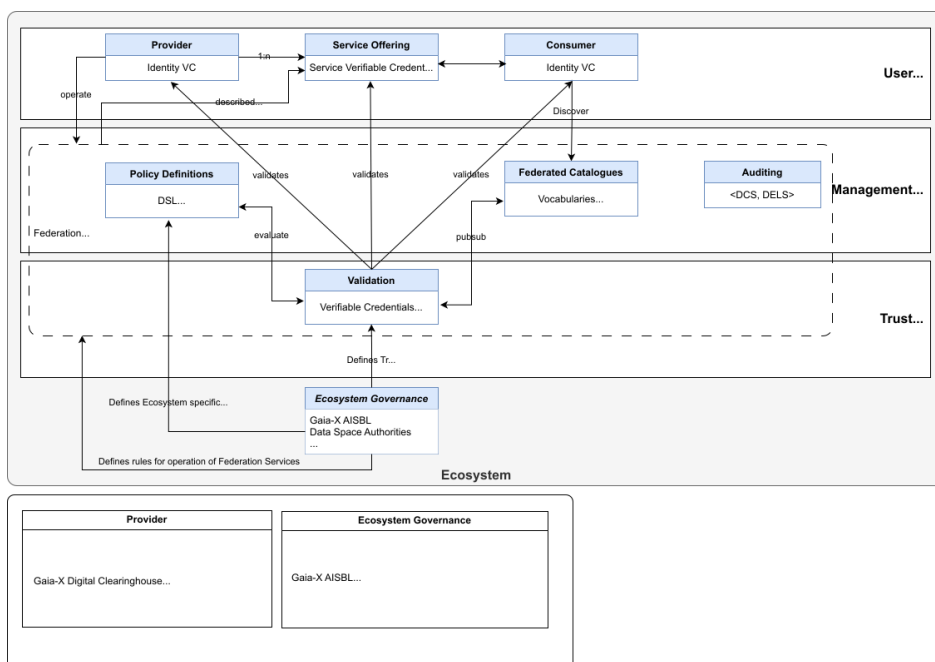
Gaia-X conceptual model (CreativeCommons CC-BY-NC-ND)

In this project, 52°North explored the architectural patterns of Gaia-X and mapped them to the concepts, technologies, and workflows used to share spatial data and spatial data services in Spatial Information Infrastructures.

52°North completed the project in 2023 by designing and implementing a technical prototype to demonstrate how an ArcGIS Enterprise-based Feature Service can be published as a Gaia-X service offering. This involved not only the creation of Gaia-X compliant self-descriptions, but also experimentation with different Gaia-X and data space implementations such as Pontus-X and the Mobility Data Space. These technical activities were complemented by a presentation at the European Esri Developer Summit and the writing of the final project report.

PARTNERS

- con terra GmbH, Germany

CUSTOMER

- Esri, USA

PlasticObs_plus

Developing a Geospatial Data Platform

Supporting machine learning on multisensor data from airborne remote sensing

The PlasticObs_plus research project (funding code: 67KI21014A) is part of the BMUV (Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection) funding initiative "AI lighthouse projects for the environment, climate, nature and resources". It investigates machine learning on multi-sensor data from airborne remote sensing to combat plastic waste in oceans and rivers as part of the funding program "KI-Lighthouses for Environmental Protection". The project goal is to develop an integrated measurement system for routine, quasi-synoptic acquisition and visualization of the distribution of plastic debris on the ocean surface and on shorelines or coastal strips using remote sensing and artificial intelligence methods. In addition to the intended real-time data acquisition of plastic objects by airborne sensors, the downstream data analysis plays a central role in the research project.

52°North's role as a subcontractor is to support the development of a geodata management platform that will enable further processing of the raw data. This includes developing a central geo-portal, which will provide the results as web services. Ultimately, the platform will be accessible to the general public, stakeholders and responsible public authorities to promote sustainable solutions to environmental pollution and targeted, effective counter-strategies.

In 2023, 52°North activities focused on gathering and analyzing requirements to derive a software architecture for managing the project's research data. This resulted in an architectural design centered around a GeoNode-based data repository. Other components, such as dedicated data ingestion workflows and a visualization component, ensure that the needs of the researchers in the PlasticObs_plus project are met. Towards the end of 2023, the first steps were taken to install the necessary software ecosystem.
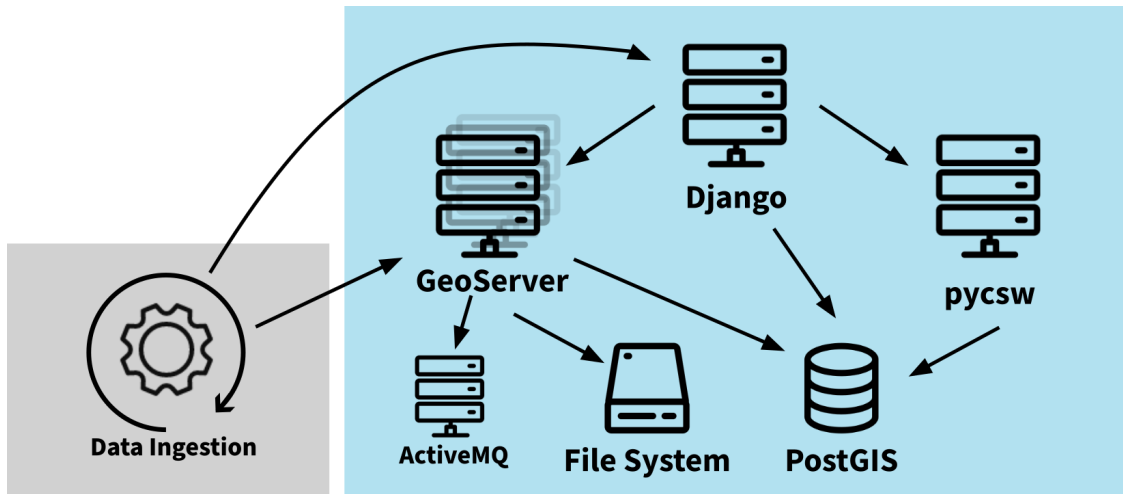
PlasticObs+ Architecture Overview

PARTNERS

- OPTIMARE Systems GmbH, Germany
- Jade Hochschule Wilhelmshaven/Oldenburg/Elsflet, Germany
- everwave GmbH, Germany

CUSTOMER

- Deutsches Forschungszentrum für Künstliche Intelligenz (DFKI), Germany

University of Manitoba

Managing Geospatial Research Data/ Sensor Data Streams with GeoNode

Customization and extension of a GeoNode instance to support the management of research data and sensor data streams

KEY TECHNOLOGIES

> GeoNode
> GeoServer
> Docker
> Python
> Django
> OGC SensorThings API

FACTS

Duration:
Since 09/2021

Contact:
Simon Jirka
s.jirka@52north.org

Project Type:
Professional Services

The Centre for Earth Observation Science (CEOS) at the University of Manitoba operates a data repository that hosts and shares its research data based on the FAIR principles. In collaboration the University of Manitoba, 52°North has redeveloped a protion of this platform. A central element of the system is GeoNode, which handles the sharing of spatial data. In addition, the OGC SensorThings API standard is used to share real-time meteorological and water quality data. In the initial project phase, 52°North customized a first version of GeoNode. We also integrated a SensorThings API instance into GeoNode and coupled it with a custom dashboard application for visualizing time series data.

Our activities in 2023 were driven by the transition from a project to a service contract relationship between 52°North and the CEOS. 52°North performed various tasks to ensure the operation of GeoNode and the supporting services, such as locking down the STA instance by switching to public read, private write access. This resulted in contributions to the FROST server open source project. We also updated GeoNode to the latest 3.x version 3.3.3. This included updating the dashboard and all of its dependencies to the latest available versions. Due to the import of two stations by different configurations and software versions of a software called "data-transloader", we also performed data management in the STA database, which included merging and harmonizing different time series. We then reviewed and merged several stations and time series inserted for virtually different stations. To avoid this problem in the future, 52°North contributed to the open source "data-transloader" of the GeoSensorWeb Lab at the University of Calgary. The University of Manitoba, with our support, transfered the project to the Canadian Consortium for Arctic Data Interoperability for future maintenance. 52°North has tightened up the subscription configuration to prevent future abuse. In addition, we removed spam content and accounts from the installation. We also identified and implemented requirements for additional metadata editing features for the STA datastream in the GeoNode extension and performed several maintenance tasks. These included GeoServer CVEs, Docker disk usage management, and identifying the limits of GeoNode remote service support.
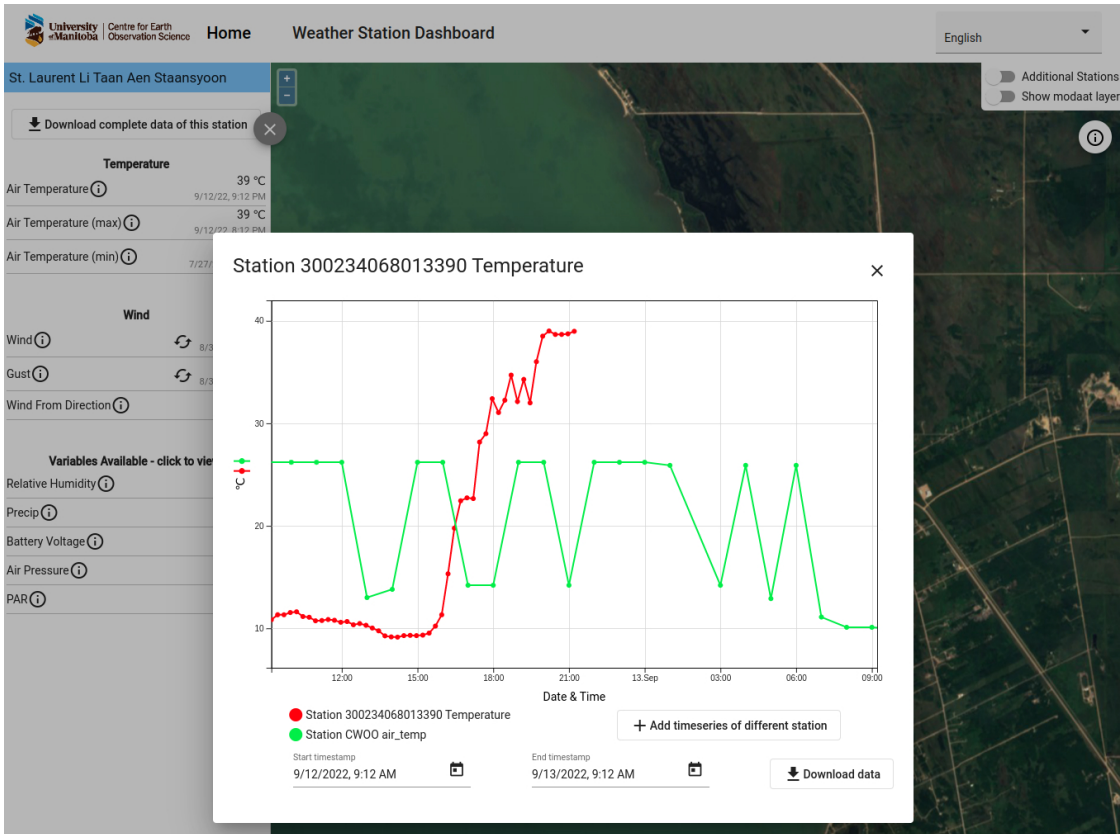
University of Manitoba's weather station dashboard

CUSTOMER

- [Centre for Earth Observation Science](#) University of Manitoba, Canada
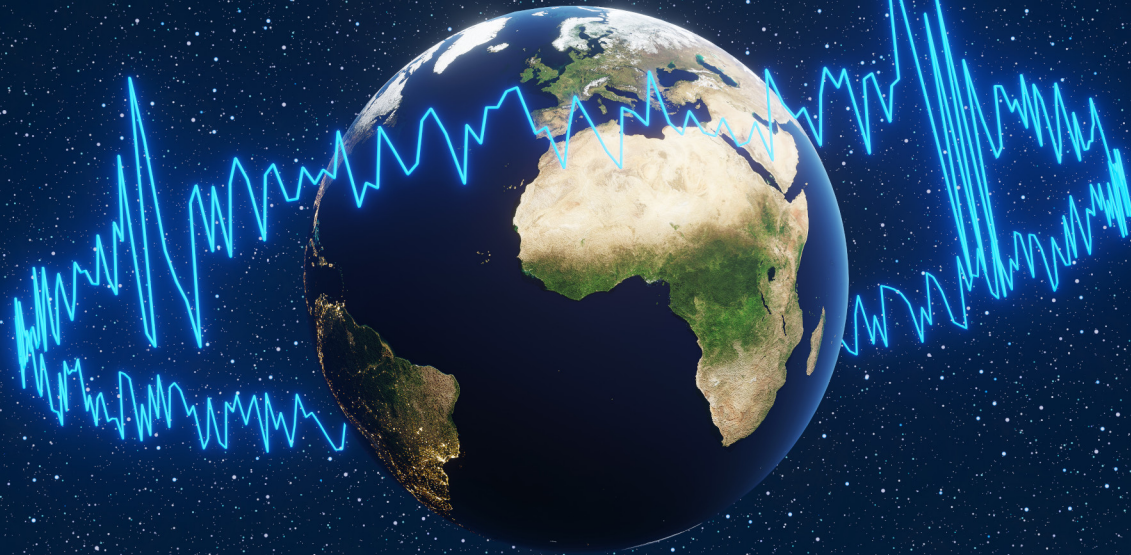
NFDI4Earth

OneStop4All to FAIR, Open and Innovative Research Data Management in Earth System Sciences

NFDI4Earth's OneStop4All will assist researchers in finding resources and services related to the earth system.

52°North supports the TU Dresden and NFDI4Earth with consulting, architecture and software development. The main task is the development of the so-called OneStop4All, a front-end web application for searching various geo-related research resources (e.g., data, services, software, documents, etc.) based on a triple store that serves as a metadata repository. It also simplifies metadata provisioning through a user interface where each resource has a landing page that visualizes its metadata.

The figure shows the starting page of the OneStop4All including a search bar and the possibility to narrow down the search query to specific resource types (e.g., software, articles, and learning resources).

PARTNER

- Pikobytes GmbH, Germany

CUSTOMER

- Technische Universität Dresden, Germany

KEY TECHNOLOGIES
> Open Pioneer Trails
> React
> Solr
> Docker
> SPARQL

FACTS

Duration:
12/2022 - 12/2025

Website:
https://www.nfdi4earth.de/

Contact:
Markus Konkol
m.konkol@52north.org

Project Type:
Professional Services

Deutsche Bahn Sensor Data Framework

Managing Weather-Related Sensor Data

Interoperable integration of sensor data to improve the railway operation

52°North supports the Deutsche Bahn AG in setting up a framework for managing various weather-related sensor data. Important goals are the integration of sensor data from different sources into a central data repository. From there, the data will be available for various applications, such as the integration into weather models and warning workflows in case of critical weather events.
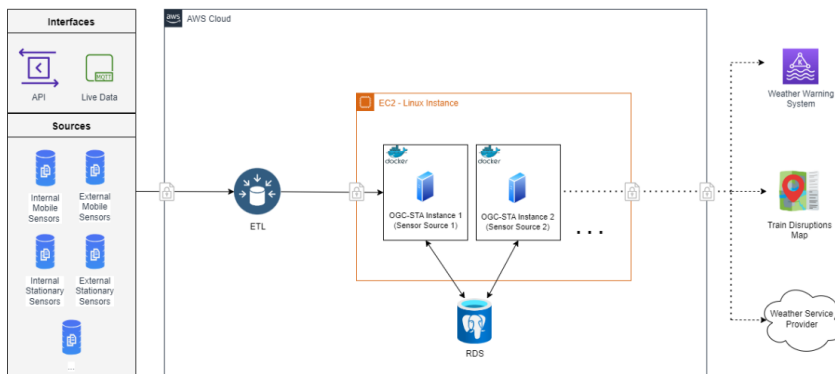
Draft of the sensor data framework architecture (Authors: Christoph Effing, Claudio Vindimian, Vivien Müller)

The project involved on-site and virtual workshops with Deutsche Bahn to discuss requirements, solutions and implementations. The kick-off was an on-site workshop to understand the technical challenges and to introduce Deutsche Bahn staff to relevant technologies from the Geo-IT community. Different approaches for data modeling and implementation were discussed. Furthermore, we discussed and evaluated the use of the OGC SensorThings API standard. This included support for the implementation of first OGC SensorThings API-based data flows.

CUSTOMER

- Deutsche Bahn AG, Germany

KEY TECHNOLOGIES

> OGC Observations, Measurements, and Samples
> OGC SensorThings API

FACTS

Duration:
06/2023 - 12/2023

Contact:
Simon Jirka
s.jirka@52north.org

Project Type:
Professional Services

SDI Innovations

Solutions for innovative geodata management and processing

A set of projects and activities that we call Spatial Data Infrastructure Innovations focuses on identifying and realizing innovative solutions for transforming, managing, analyzing and visualizing data from different sources. In close collaboration with our partners and customers, we address challenges posed by the increasing volume and heterogenity of data, as well as the velocity of data streams. The demand for new and advanced methodologies, technologies and architectures is strong and we expect it to continue to grow in the near future.

Matthes Rieke leads the SDI Innovations activities at 52°North. He and his team are working on:

- Processing Scalability: identifying and implementing requirements for horizontal and vertical scaling of processing algorithms
- Workflow Chains and Orchestration: designing and automating complex process workflows
- Earth Observation Data Processing: handling massive amounts of EO data in an efficient and scalable manner
- Fit For Purpose Data: pre-processing, ingesting, and delivering raster and vector data to fit the purpose of a specific solution
- Cloud Environments (PaaS, IaaS, SaaS): leveraging their capabilities in terms of deployment patterns, input data handling, and processing results
- Efficient Storage Concepts and Formats: organizing vast amounts of data with the right concepts and access patterns, e.g. cloud optimizations
- Standardization: harmonizing processing interfaces, creating and using interoperable data formats
- Processing Transparency: strengthening reproducibility, data quality and metadata quality, and process discovery

We address these challenges in a number of R&D and PS projects. Our research partners and customers come from academia and industry and cover a wide range of application domains, such as environmental monitoring, emerging market development, climate change, disaster management or transportation. This diversity enables us to develop new approaches that address the needs of many real-world problems and use cases.

Matthes Rieke

Head of SDI Innovations

RIESGOS 2.0

Scenario-Based Multi-Risk Assessment in the Andes Region

Using the RIESGOS architecture, local municipalities and stakeholders can easily identify the impact of potential disaster situations and plan accordingly.

RIESGOS 2.0 is the direct successor to the successful RIESGOS project, which addressed challenges of increased risks to society caused by natural hazards, such as volcanic eruptions, earthquakes or tsunamis with a focus on the Andes region in South America. 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 2.0 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 2.0 software architecture. End-users from civil protection and disaster management authorities will be able to simulate and analyze complex multi-risk scenarios.

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:

- the analysis of requirements,
- the design of a message-driven processing architecture that improves the overall flow data and information products,
- the implementation of selected web services as instances of the OGC API Processes,
- the conceptual design of integrating uncertainty and quality information into the data products of the distributed web services,
- a contribution to market analysis and development of exploitation perspectives (focus on the publication as open source software).

In 2023, 52°North focused on the realization of a message-driven processing architecture that allows the dynamic addition of supplementary analytical components. In close collaboration with GFZ and DLR, 52°North software engineers developed software components that enable existing *Web Processing Service* instances to be integrated into the new architecture pattern. In a series of development sprints, the architecture was assessed and optimized to meet the

requirements of the individual analysis tasks. The architecture has also been applied to the OGC API Processes standard by extending the pygeoapi implementation with the required capabilities.
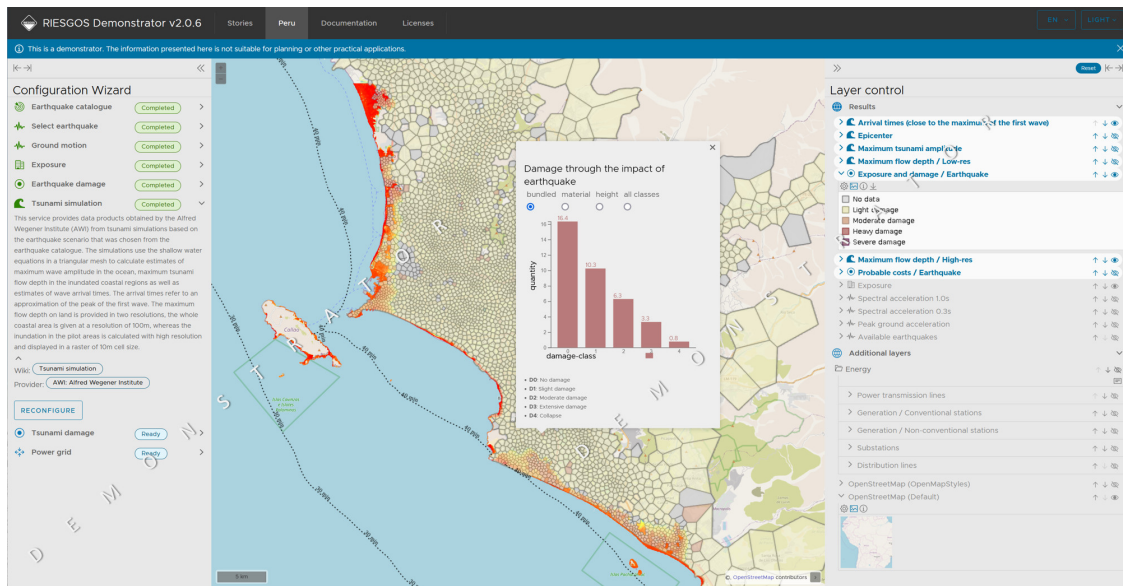
The RIESGOS demonstrator

PARTNERS

- **Coordinator**: Deutsches Zentrum für Luft- und Raumfahrt (DLR), Germany
- Helmholtz-Zentrum Potsdam Deutsches GeoForschungsZentrum (GFZ), Germany
- Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Germany
- Technische Universität München (TUM), Germany
- geomer GmbH, Germany
- Sachverständigenbüro für Luftbildauswertung und Umweltfragen (SLU), Germany
- DIALOGIK, Germany

ASSOCIATED PARTNERS

- GIZ GmbH, Germany
- UNOOSA/UN-SPIDER, Germany
- UNESCO, Uruguay
- MunichRE, Germany

FUNDING

EUMETSAT Cloud and Big Data Services

Cloud and Big Data Services Engineering and Operations Support

EUMETSAT's new user portal improves the workflow for discovering and consuming information and data provided by its satellites and services.

The project *Cloud and Big Data Services Engineering and Operations support* started in 2021 and aims to continue the established portfolio of data services featuring innovative data access and discovery capabilities at EUMETSAT. The operational version of the EUMETSAT Data Store - a scalable and extensible architecture for providing online access to EUMETSAT's products - will be maintained and developed further. In addition to the Data Store, other components play an important role: e.g., a workflow engine to improve internal data processing pipelines and established services such as the Product Navigator. The consortium, led by CGI Deutschland, is also responsible for the maintenance and operation of the components. con terra and 52°North provide third-level support for specific architecture components.

52°North continued the development of EUMETSAT's new *User Portal* in 2023 as part of the *BDS Engineering and Operations Support Service*. It defines a holistic approach to information and data discovery and replaces the Product Navigator (jointly developed by con terra and 52°North), the EOPortal, as well as the User Management System. After the first implementation phase in 2022, additional features focusing on content management and presentation as well as user management were designed and implemented. The *User Portal* system consists of Strapi as the central content management system and a user interface developed on top of Angular and Bootstrap.

In addition to the *User Portal* development, our team worked on operational and maintenance tasks, where the evolution of existing services such as the EUMETSAT Data Store played a central role.

KEY TECHNOLOGIES

> JavaScript/TypeScript
  (Single Page Application)
> Angular
> OpenAPI
> Strapi CMS
> Kubernetes

FACTS

Duration:
01/2021 - 12/2024

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

Contact:
Matthes Rieke
m.rieke@52north.org

Project Type:
Professional Services

EUMETSAT User Portal

PARTNERS

- CGI Deutschland B.V. & Co. KG, Germany
- con terra GmbH, Germany
- ask – Innovative Visualisierungslösungen GmbH, Germany

CUSTOMER

- EUMETSAT, Germany

SIMPORT

Sovereign and Intuitive Management of Personal Location Information

Raising awareness for privacy in location information

The majority of cell phone users are unaware of how their cell phone's GPS location history can lead to deep conclusions about their activities, place of residence, inclinations, beliefs or social networks. The SIMPORT project aimed to raise awareness as well as design and implement measures to better protect the privacy of location information. 52°North participated in the SIMPORT project as a subcontractor of the Institute for Geoinformatics (University of Münster, Germany).

The consortium members worked to develop guidelines and software modules to confidentially handle personal location information on a mobile device. They cooperated with partners from the industry to create open source software components to enable digital sovereignty with regard to personal location information. Users of these components can clearly visualize possible conclusions about their personal location information and better assess the advantages and disadvantages of passing on this information. Consequently, users know of the risks precisely when they have to decide whether or not they want to share their personal data.

In close cooperation with computer science and the social sciences, the researchers analyzed how to improve awareness of risks and opportunities and to develop fine-grained control options for the transfer of personal location information. This strengthens the competence and sovereignty of smartphone users when deciding about their personal data. An overview of the research within the project is available in the article *"Linking location privacy, digital sovereignty and location-based services: a meta review"* (https://doi.org/10.1080/17489725.2023.2239180).

In 2023, the partners continued to develop and improve the various concepts created during the project, such as the *SIMPORT learning app*, which raises awareness for location history and the conclusions that can be drawn from it. 52°North's main focus was on the development of the *enviroCar LPT* app - a dedicated version of the original enviroCar Android app that includes the features of the *location Privacy Toolkit*. This toolkit provides access to the device location, but gives the user full control over accuracy and resolution. As part of a *Google Summer of Code* project mentored by 52°North, the integration of the toolkit was implemented and tested. After internal evaluation, it was finally released to the public via the Google Play Store.
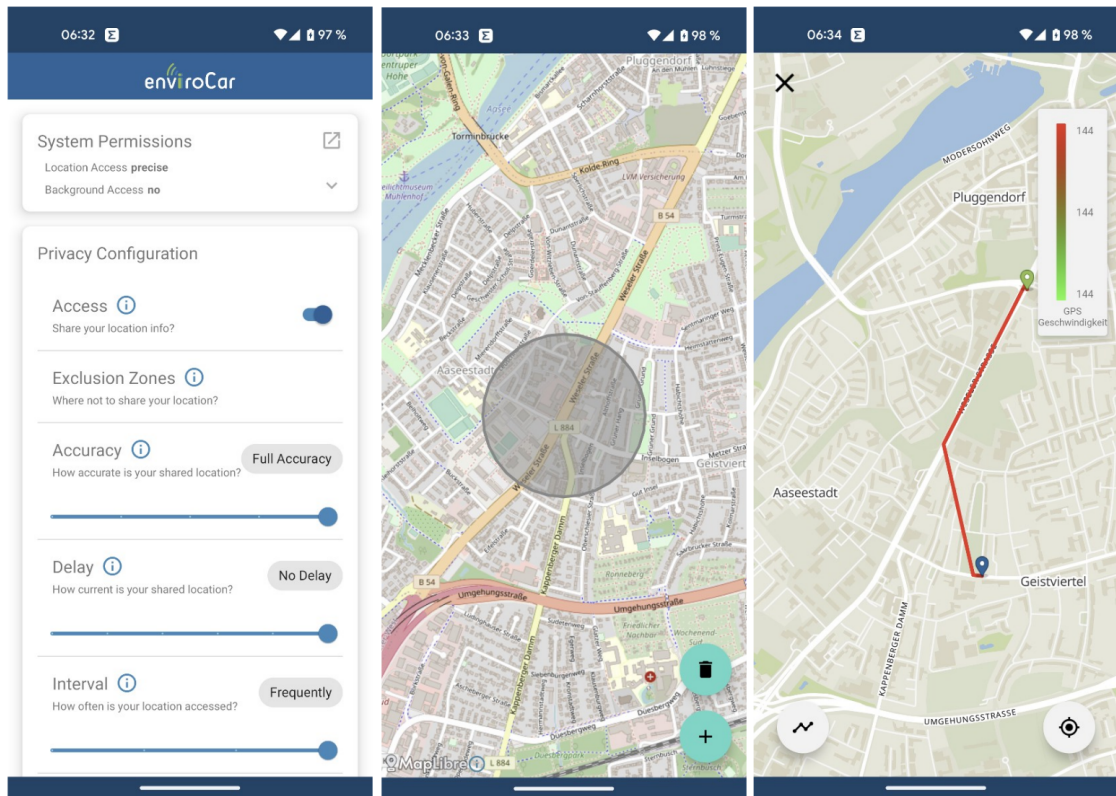
SIMPORT privacy toolkit features in the enviroCar app

PARTNERS

- Institute for Geoinformatics, University of Münster, Germany
- FH Münster, Germany
- HERE Deutschland, Germany
- re:edu, Germany
- Universität Osnabrück, Germany

FUNDING

DVFO LHS

Digital Traffic Flow Optimization for the State Capital Stuttgart

The city of Stuttgart will be able to use the collected data to determine how weather, traffic, and driver behavior interact to affect air quality and traffic safety.

As part of their "Digital Traffic Flow Optimization" project, the state capital of Stuttgart intends to set up an environmentally sensitive traffic management system. This system will include existing components and those currently under development in the overall architecture. It will also complement further components and integrate various vehicle, traffic and environmental data to create a new overall system.

52°North supports SSP Consult by providing services to enable the use of the enviroCar platform for its purposes in the project. We provide operational and technical support for the platform and software as well as software development and consulting services. Software developments include:

- Detection of extreme accelerations and decelerations
- Continuous provision of measurement data
- Support of software development, data preparation and data analysis

During 2023, the project entered the execution phase. The public campaign was launched in March 2023 and continues until November 2025. 52°North helped improve the usability of the enviroCar app and increased support in the different end user scenarios, which include a mix of different Android API levels and smartphone brands. Hundreds of active users contributed data via the enviroCar app with a cumulative driving distance of around 40.000 km in the city of Stuttgart. The insights provided by the data will be used to analyze traffic flow, safety and environmental impact.
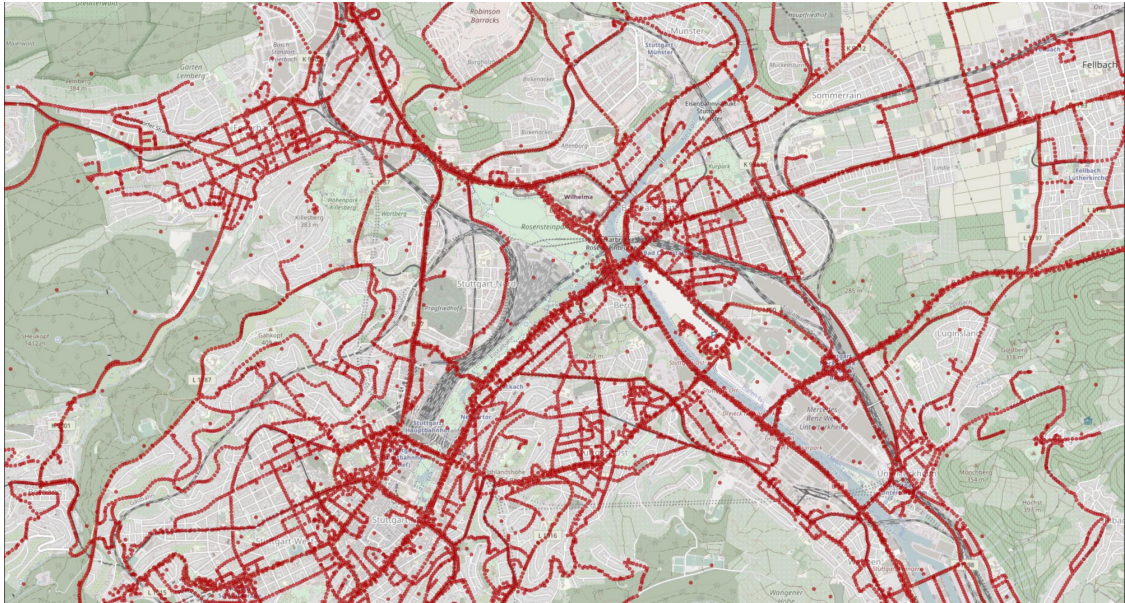
Road network coverage of enviroCar data in Stuttgart for the DVFO campaign

PARTNERS

- GEVAS software GmbH, Germany
- PRISMA solutions EDV-Dienstleistungen GmbH, Germany
- Trafficon - Traffic Consultants GmbH, Germany
- SSP Consult, Beratende Ingenieure GmbH, Germany
- IVU Umwelt GmbH, Germany

CUSTOMER

- SSP Consult, Beratende Ingenieure GmbH, Germany

FUNDING

SPONSORED BY THE

Federal Ministry for Digital and Transport

STUTTGART

The Digital Traffic Flow Optimization project is funded by the Federal Ministry for Digital and Transport (BMDV) and the state capital of Stuttgart (LHS).

Volkswagen Commercial Vehicles Map Data Analysis

Data Analysis for Automated Driving

The analysis toolbox will help Volkswagen Commercial Vehicles provide data for their Automated Driving Systems.

The Operational Design Domain describes the conditions under which a driving automation system is designed to operate. This includes environmental and geographic information as well as the required presence or absence of certain traffic or roadway characteristics. At Volkswagen Commercial Vehicles, a dedicated team defines such boundary conditions for the development and testing process. This allows the team to evaluate potential service areas for Mobility as a Service applications. Based on our expertise in geospatial data analysis and efficient processing of large volumes of geodata, Volkswagen Commercial Vehicles contracted 52°North to develop a toolbox that enables the automatic derivation of these characteristics from available spatial datasets.

The content-rich road network data provided by Open Street Map builds the foundation for the analysis toolbox. It enables the derivation of basic properties such as the distribution of road types and street furniture, speed limits or number of lanes for a given area of interest. The toolbox will also support complex analysis capabilities, such as statistics on curve radius, the intersection impact angle, or intersection complexity. The system combines two different analysis concepts:

- Basic analysis using the Overpass Turbo API
- Complex statistics using the Python library osmnx in combination with a PostGIS database

During 2023, the team focused on more complex analysis. Important parameters such as the visibility range of certain roads, the incident angle of roads meeting at an intersection, or the minimum curve radius were derived. Our team integrated all analysis features into one executable toolbox. It can be used from the command line, but is already prepared to run as a service in a larger deployment environment.
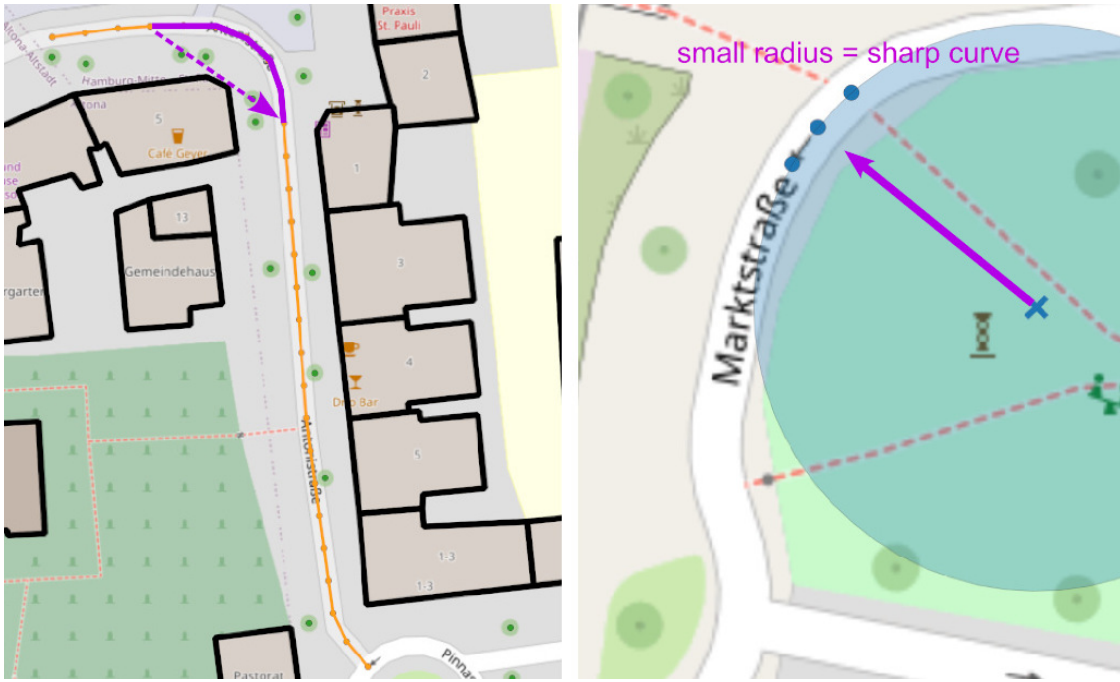
Two visualizations, *visibility range* (left) and *curve radius* (right), of derived statistics.

CUSTOMER

- Volkswagen Commercial Vehicles, Germany

Thünen Atlas Extension

Hands-on Developments for GeoNode

Developments for the next iteration of the Thünen Atlas

KEY TECHNOLOGIES

> GeoNode
> Django
> MapStore
> React

FACTS

Duration:
11/2022 - 05/2023

Contact:
Matthes Rieke
m.rieke@52north.org

Project Type:
Professional Services

The Thünen Institute is on the verge of migrating their existing *Thünen Atlas* (atlas.thuenen.de), which is based on GeoNode 3.x, to the next major release, version 4.1. As part of this effort, they identified several features to improve the user experience and the platform's capabilities for data exploration and analysis. 52°North and the Thünen Institute worked together to implement this set of new features. It covered several thematic aspects. The main focus was on:

- Improvements for map delivery by extending the default MapStore2 widgets and views,
- Automatic synchronization of datasets across multiple GeoNode instances to improve publication workflows,
- Support for tabular (non-spatial) datasets and their visualization in dashboards.

The team of software engineers executed the project using agile software development methods. In addition to the technical development, a strong focus was placed on communication with the GeoNode developer community. While developing the features, a number of improvements were made to the GeoNode core source code. We presented these changes to the community, discussed and finally integrated them into the upstream GeoNode project.

At the of end 2023, a follow-up project was initialized. The focus here will be on the publication of meaningful and standards-compliant metadata (e.g., fulfilling the requirements of the *GDI-DE Testsuite*). In addition, we will enhance and optimize some of the newly implemented features.
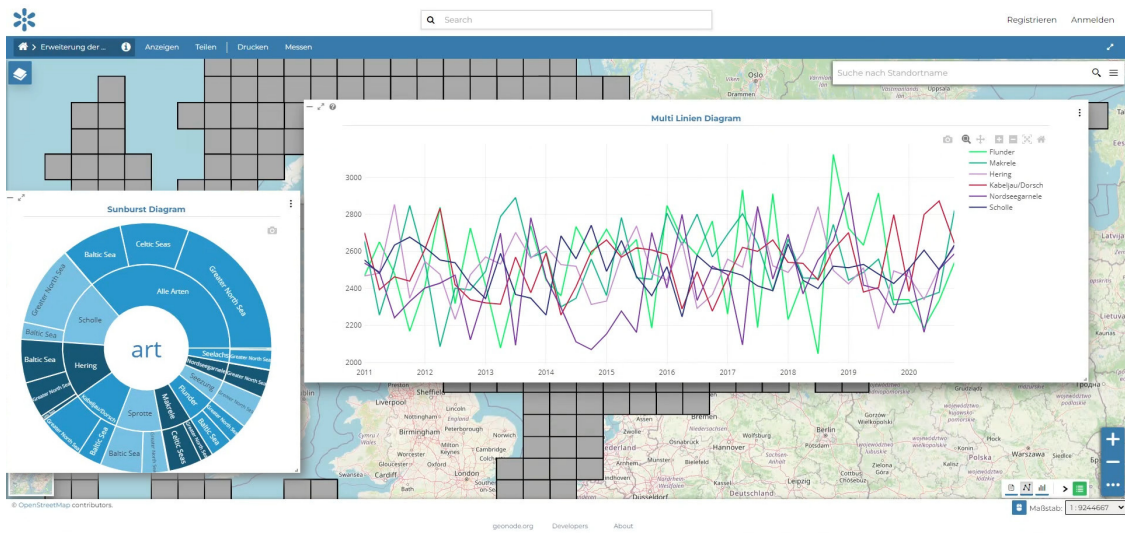
Two new MapStore2 widgets that have been realized in the project

CUSTOMER

- Thünen-Institut, Germany

GeoNode Consulting for IStG

GeoNode for Historical Survey Maps

Unlocking the potential of historical geodata management

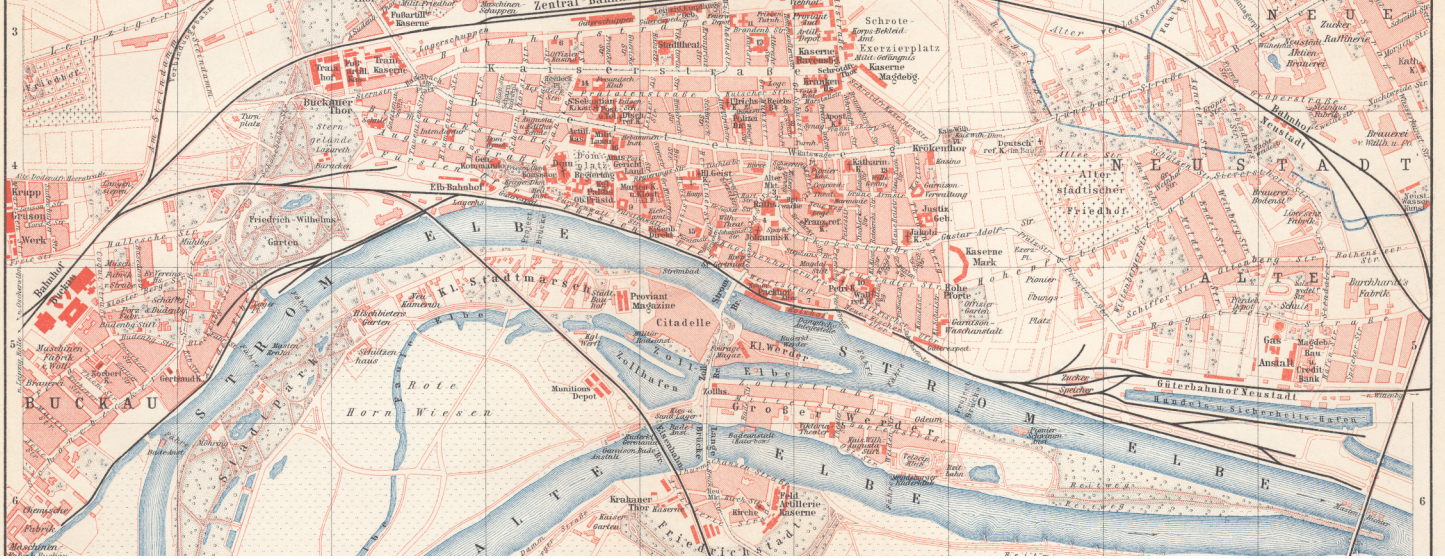The IStG (Institut für vergleichende Städtegeschichte) approached 52°North with a request for assistance in setting up a geodata management platform based on GeoNode. In close collaboration with the IStG, 52°North analyzed the existing geodata architecture, identified, discussed and documented the geodata management requirements for their HiSMaComp research project. The overall goal was to assist the IStG in identifying a solution for managing historical geospatial data and to lay the groundwork for implementing this solution in the near future. Geospatial data in this case includes both raster and vector data as well as reference data. In addition to the actual data, the corresponding metadata also needed be managed.

After an initial setup and deployment, 52°North supported the data loading phase. IStG has already identified a number of interesting use cases that could be developed in the near future using the geodata management platform. For example, a fine-grained search mechanism at the dataset level could help researchers to identify datasets of interest. Side-by-side data visualizations have been identified as an interesting way to visualize historical changes in cities over the centuries.
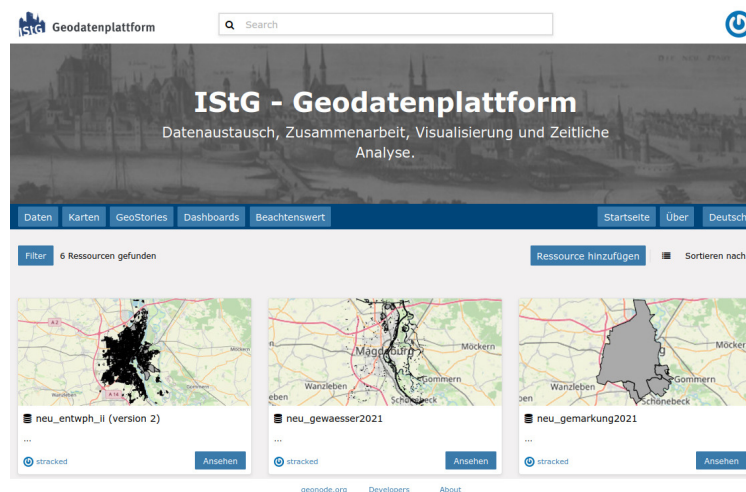
IStG's geodata management platform

CUSTOMER

- Institut für vergleichende Städtegeschichte - IStG - gGmbH, Germany

OGC CITE Consulting

Issue Management and Feature Development for OGC's TEAM Engine

Ensuring true interoperability through OGC web service testing

The Open Geospatial Consortium (OGC) sought development support for their *TEAM Engine* (Test, Evaluation, And Measurement Engine), in particular, for maintenance and evolution of the core framework, existing test suites and test suite candidates. The TEAM Engine is a Java-based application for testing web services and other information resources. It executes test suites developed using the popular TestNG framework, OGC Compliance Test Language (CTL) scripts, and possibly other JVM-friendly languages. It is lightweight and easy to run from the command line or as a web application. The TEAM Engine can be used to test almost any type of service or information resource. It is the official test harness used by the OGC's compliance program.

52°North has previously participated in activities related to the OGC API Processes test framework as part of the OGC Testbeds. The software consulting services continue on this basis. We carried out this project in close collaboration with OGC and lat/lon as the overall manager of the TEAM Engine.

After two successful iterations, this collaboration between the OGC and 52°North was recently extended for another year.

PARTNERS

- lat/lon GmbH, Germany

CUSTOMER

- Open Geospatial Consortium (OGC), USA

Research & Development Framework Contract with con terra

Exploring the Boundaries of Geo-IT

Fostering continuous learning and growth through knowledge transfer

The purpose of the R&D framework agreement is to utilize the services of 52°North to make the innovation process at con terra more effective and cost-efficient. This contract is designed to provide planning certainty and a long-term commitment for both companies.

con terra's innovation goals center on evaluating methods and technologies for their solutions and then bringing these ideas to life through pilots and components. They are committed to executing well-defined innovation projects across multiple company domains. To achieve this, 52°North and con terra collaborate under a framework contract and use tools such as consulting, feasibility studies, prototyping, and joint product development. Knowledge transfer through workshops and training sessions is integral, fostering continuous learning and growth within both organizations.

Many interesting topics were covered in 2023. We investigated the possibilities of AI tools for everyday software engineering tasks and how they meet the requirements of con terra product development. In another activity, we established hands-on workshops and training sessions on the latest release of the OpenLayers framework. These workshops were closely related to the "Open Pioneer" *Trails* endeavour. With "Open Pioneer", con terra and 52°North have established a workbench for the development of new concepts, ideas and technologies in the context of future and innovative SDI. Open Pioneer *Trails* is an open development platform for web clients that enables the development of customized GeoIT solutions. It is designed as a framework, but not as a fixed solution or product. The map components are built upon OpenLayers and provide many basic web map functionalities such as base layer management, geolocation and search.

Find more details on Open Pioneer and Trails at the Open Pioneer GitHub repository.
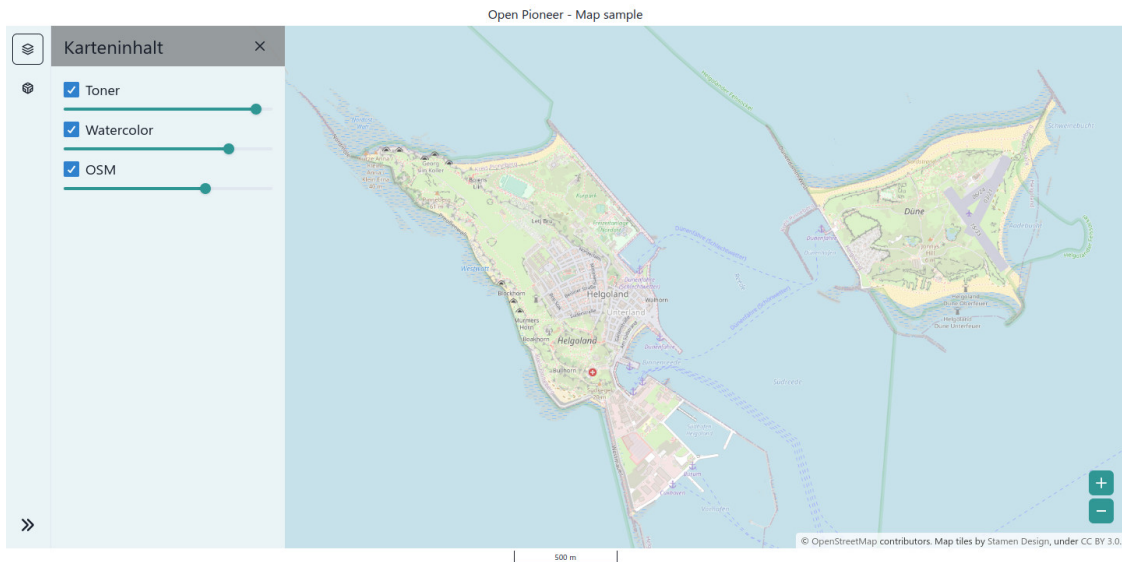
The *Trails* basic map view

PARTNER

- con terra GmbH, Germany

OGC Testbed-19

Identifiers for Reproducible Science

Shaping the future of geospatial data technologies

The Open Geospatial Consortium (OGC) Testbed is an annual research and development program that explores geospatial technology from various angles. It takes the OGC standards baseline into account, but at the same time allows for exploration of selected aspects from a different perspective.

"As the largest Research & Development (R&D) Initiatives conducted under OGC's COSI Program, OGC Testbeds exist at the cutting edge of technology, actively exploring and evaluating future geospatial technologies to solve today's problems. The solutions developed in Testbeds eventually move into the OGC Standards Program, where they are reviewed, revised, and potentially approved as new international open standards that can reach millions of individuals." (OGC Testbed-19 | OGC, 2023)

52°North participated in the "GeoDataCubes" (GDC) task. This task supports the GDC Standards Working Group's efforts, fostering close collaboration throughout the duration of the Testbed. Testbed participants help shape the GDC API and create prototypes using an agile approach to explore its functionality.

52°North developed an Executable Test Suite (ETS) for the TEAM Engine test framework. The ETS ensures the conformance of implementations of OGC standards. Developing the ETS and simultaneously specifying the new GeoDataCube standard enabled implementers to test their services from the beginning. This allowed early identification of functionality and interoperability issues, which could then be discussed with the editors of the standard. The ETS was developed using the TestNG test framework for Java.

KEY TECHNOLOGIES

> Geo Data Cube
> TEAM Engine
> Java
> OGC APIs
> TestNG

FACTS

Duration:
05/2023 - 12/2023

Website:
https://www.ogc.org/projects
/initiatives/testbed-19

Contact:
Matthes Rieke
m.rieke@52north.org

Project Type:
Professional Services

Welcome screen of the Web page of the ETS for the OGC Geo Data Cubes API,
https://19.testbed.dev.52north.org/teamengine/ (accessed 24.11.2023)

CUSTOMER

- Open Geospatial Consortium (OGC), USA

PARTNERS

- Arizona State University, USA
- Ecere, Canada
- GeoLabs, France
- Health Solutions Research, USA
- Terradue, Italy

FUNDING

OGC Testbed-19 was funded by multiple sponsors, including:

- Natural Resources Canada (NRCan), Canada
- European Space Agency (ESA), France
- US National Aeronautics and Space Administration (NASA), USA

Spatial Data Science

Developing analytical tools to address real world problems

The constant increase in the volume and variety of available data creates a huge potential for answering a wide range of questions. To understand this data and to derive answers, we need analytical tools to model the relationships that emerge from it. Dr. Benedikt Gräler, who leads the Spatial Data Science activities, and his team develop data-driven solutions to real-world problems. Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR) are common themes across several R&D projects. Geoinformation and Spatial Data Science can play a key role in planning and communicating actions to decision makers, stakeholders and the general public.

By exploring and researching analytical tools ranging from linear statistics and the latest multivariate distributions to modern machine learning (ML) and artificial intelligence (AI) approaches, we develop solutions that are appropriate for the problem at hand given the data available. This requires a solid understanding of data and business. We use and contribute to open source tools where possible and encourage Citizen Science.

We are involved in several 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 task to solve several open questions. The meaningful integration of heterogeneous data sources (from geospatial observations to official statistics) and the adaptation of ML and AI algorithms to the specificities of spatial and spatio-temporal data are central themes of future tasks. A common goal is to develop tools that are of high value to end users. Therefore, a co-design approach often helps to identify the relevant questions within a project and enables us to provide meaningful solutions.

Benedikt Gräler

Head of Spatial Data Science

KI:STE

AI Strategy for Earth System Data

The KI:STE developments will facilitate the use of ML and AI methods for spatial data analysis applications.

Artificial Intelligence (AI) methods are rapidly evolving and increasingly being used in the context of environmental data. However, this often occurs in isolated solutions. The environmental and earth system sciences have yet to establish the systematic use of modern AI methods. In particular, there is a discrepancy between the requirements of solid and technically sound environmental data analysis and the applicability of modern AI methods such as Deep Learning for researchers.

The KI:STE project aimed to facilitate and evaluate the use of AI for remote sensing of Earth Observation data for a range of applications. The fields studied in the project ranged from air quality to clouds and radiation, to landslides and natural hazards, and water that drives vegetation, closing the loop with air quality. A key focus was 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 made the algorithms and tools developed more accessible to a wider audience, from scientists to practitioners.

The KI:STE project was completed at the end of 2023. The GeoNode dashboard features were extended to include multi-line plots and sunburst plots. Further improvements were made to the map view to increase the usability for a multitude of geodata as used and produced in KI:STE. Our team also implemented an integration of data sources that are not available though interoperability standards. GeoNode was originally developed as a classic server-side solution.

KEY TECHNOLOGIES

> Cloud
> SDI
> RDI
> Python
> Machine Learning
> Artificial Intelligence

FACTS

Duration:
11/2020 – 12/2023
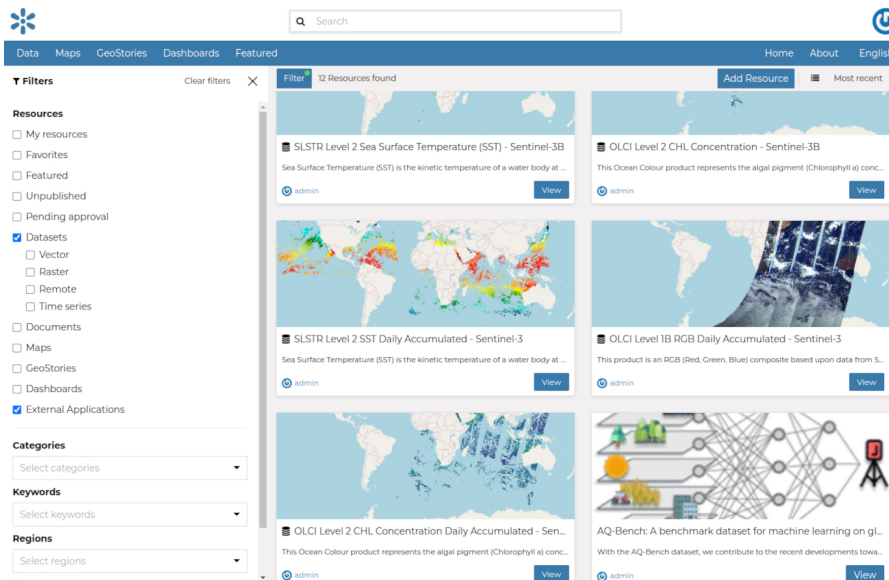
Website:
https://kiste-project.de/

Contact:
Benedikt Gräler
b.graeler@52north.org

Project Type:
Research and Development

KISTE catalog

In order to meet KI:STE requirements of running in a cloud environment, several changes were necessary from the software project setup to the service composition. Modifications were made to support Kubernetes managed environments and Helm charts were developed. In addition, the project needed to be adapted to a fully containerized setup and was extended to support different build pipelines for ease of development. The enhanced GeoNode software was deployed in cooperation with Ambrosys on the combined KISTE AWS tier. To evaluate the setup, GeoNode was deployed via Helm charts and datasets such as AQ-Bench, Meteosat and Sentinel scenes were imported and provided.

A first draft of the OGC Connected Systems API (CS API) based on pygeoapi was designed and prototypically implemented in KI:STE. This development is done in synergy with several other research projects (MINKE, EMODnet Ingestion III). In the current sample application, the CS API connects to the TOAR database hosted at the Super Computing Centre Jülich. Although the standard is still in its early stages, stations can now e.g. be accessed in standardized GeoJSON and SensorML formats and easily visualized in existing tools. With the advancement of the CS API, the TOAR database could be easily integrated into various clients supporting the CS API without additional implementation effort.

In addition, the use of data provided in the RDI in the data analysis workflows should be facilitated. 52°North investigated AI-based tools, such as CodeGPT, that can correct or even provide source code. To this end, we tested CodeGPT on a variety of tasks with varying degrees of complexity, from the rather simple task of removing whitespace from a character string, to complex tasks such as the analysis of OpenStreetMap data, data conversions and the intersection of geometries.

PARTNERS

- Forschungszentrum Jülich GmbH, Germany
- Jülich Supercomputing Centre (JSC) und Institut für Bio- und Geowissenschaften – Agrosphäre (IBG-3), Germany
- Universität zu Köln, Institut für Geophysik und Meteorologie, Germany
- Universität Bonn, Institut für Geodäsie und Geoinformatik, Germany
- RWTH Aachen, Aachen Institute for Advanced Study in Computational Engineering Science, Germany
- Ambrosys GmbH Gesellschaft für Management komplexer Systeme, Germany

FUNDING

I-CISK

Co-Design to Reveal the Value of Climate Services

I-CISK will empower local communities to build and use tailored local Climate Services to adapt to climate change.

Climate Services (CS) are crucial to empowering citizens, stakeholders and decision-makers in defining resilient pathways to adapt to climate change and extreme events. Despite advances in scientific data and knowledge (e.g. Copernicus, GEOSS), current CS fail to achieve their full value proposition to end users. Challenges include incorporation of social and behavioral factors, local needs, knowledge and the customs of end users. I-CISK develops a next generation of end user CS, which follow a social and behaviorally informed approach to co-creating services that meet climate information needs at a relevant spatial and temporal scale. It takes a trans-disciplinary approach to developing CS by working with stakeholders in seven Living Labs established in climate hotspots in Europe, it's neighbors, and Africa, to address climate change and extremes (droughts, floods and heatwaves) faced by agriculture, forestry, tourism, energy, health, and the humanitarian sectors. Together with end users, I-CISK will co-design, co-create, co-implement, and co-evaluate pre-operational CS that provide a step change in integrating local knowledge, perceptions and preferences with scientific knowledge. This co-creation framework is unique as it

- links climate impact and adaptation at different temporal scales from (sub)-seasonal forecasts to climate-scale projections, and
- explicitly considers the feedback between human behavior and climate, i.e. between adaptation strategies and options, in a multi-timescale, multi-sector, and multi-hazard setting.

The novel CS will be built on a highly customizable cloud-based web platform that I-CISK develops; freely available, and easily replicable. The I-CISK co-creation framework, supported by online open courses, guidelines, business stories and strategic dissemination, will catalyze the production and adoption of CS that combine end user's local knowledge with scientific knowledge, contribute to improved decisions and policies, and a flourishing market for end user CS.

In 2023, 52°North designed the architecture of the CS web framework based on the stakeholder requirements collected during face-to-face meetings with representatives of each Living Lab in 2022. This first version of the architecture will be adapted and refined over the course of the project. As a next step, 52°North initiated meetings with the Living Lab leaders to discuss the stakeholder requirements for the visualization of the CS results. Participants

formulated and prioritized user stories. Based on these findings, our team developed mock-ups and preoperational climate services for the Living Labs Alazani (GE), Budapest (HU), Crete (GR), and Guadalquivir (ES), which were deployed in an Open Telekom Cloud. The corresponding web applications access different data sources and allow the user to visualize CS indicators in an interactive way by selecting a preferred time period or weather station. We currently collect feedback from the stakeholders on the prototype implementations and will refine the services, accordingly. In addition, our team initiated the implementation of a beta version CS for the Living Lab Rijnland (NL).

In addition to these activities, 52°North is actively involved in shaping the co-design process between developers, climate modelers and stakeholders. Our team also participates in discussions and developments on how to assess, manage and present the uncertainties that are an inherent component of climate models.

Citizen Science Platform
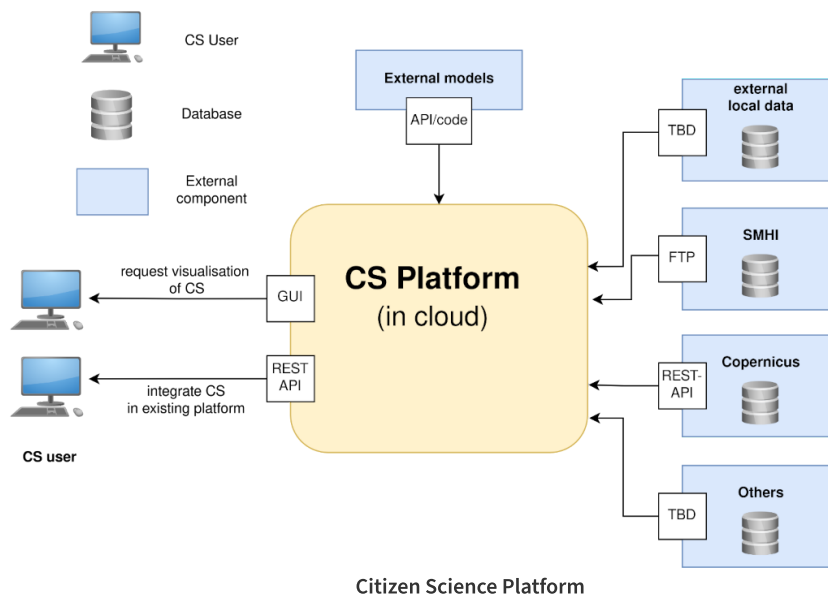
PARTNERS

- **Coordinator**, IHE Delft Institute for Water Education, The Netherlands
- European Centre for Medium-Range Weather Forecasts (ECMWF), UK
- Swedish Meteorological and Hydrological Institute (SMHI), Sweden
- VU Foundation, Then Netherlands
- CREAF, Spain
- Uppsala University, Sweden
- The Netherlands Red Cross, The Netherlands
- GECOsistema, Italy
- Caucasus Environmental NGO Network (CENN), Georgia
- Universidad Computense de Madrid, Spain
- IDEAS Science Ltd., Hungary
- EMVIS S.A., Greece

FUNDING

DIRECTED

Interoperable Tools and Governance for Disaster Risk Management

DIRECTED's federated data infrastructure will enable the planning, assessment and communication of Climate Change Adaptation and Disaster Risk Reduction measures.

The recent droughts and unprecedented floods in central Europe have disclosed our vulnerability to extreme weather events. Not only is climate change a driver of more frequent and intensifying weather extremes, demographic change and socio-economic development also exacerbate severe impacts. International frameworks for disaster risk reduction and climate change adaptation (e.g. the SENDAI framework, the EU Strategy on adaptation to climate change) acknowledge the critical need for integrating risk governance, communication and operational mechanisms to cope with extreme climate events throughout the entire disaster risk management cycle. DIRECTED aspires to foster disaster-resilient European societies by expanding the capabilities to

- utilize, communicate and exchange state-of-the art data, information and knowledge between different actors;
- boost the integration, accessibility and interoperability of models;
- improve dialogue and cooperation between actors involved at all levels based on enhanced community engagement and
- develop new governance and risk management strategies using a bottom-up, value-driven co-development approach.

Central to DIRECTED are four Real World Labs (RWL). They are located in European areas that have been affected by severe weather events in the recent past or have a high probability to be affected in the near future. These Real World Labs will co-develop new governance, interoperability and knowledge co-production frameworks as well as demonstrate their benefits for enhanced disaster risk management. The Real World Labs ensure that the project continuously and actively involves key stakeholders in the co-development process and addresses topical problems of multi-hazard risk management and climate-change adaptation. Key to supporting the interoperability of information will be the development of an innovative federated cloud platform that enables secure and flexible access, transformation, combination and sharing of models and data. Tailored to the needs of the Real World Labs, the platform will be based on a federated architecture that meets particular requirements regarding the handling of sensitive data and models.

KEY TECHNOLOGIES

- > Research Data Infra-structures
- > GeoServer
- > pygeoapi
- > Django
- > Python
- > R Programming Language
- > OGC Web Services and APIs

FACTS

Duration:
10/2022 - 09/2026

Contact:
Benedikt Gräler
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Project Type:
Research and Development

52°North leads the architecture design development, as well as the platform implementation and evaluation throughout the project. Throughout 2023, 52°North has participated in and led several discussions with project partners and Real World Lab leaders to collect the requirements for the data and model infrastructure, the DIRECTED Data Fabric. The Erftverband, leader of the Real World Lab in the Rhine-Erft region, hosted the General Assembly. This was a very valuable meeting to further define the requirements of all RWLs, but in particular to better understand the situation and needs of the Rhine-Erft region. During a field trip, the project partners had the opportunity to visit the restoration measures of the disastrous heavy rainfall event Bernd in 2021, which further shaped the understanding of the information needs of the local water authorities. A series of meetings with DIRECTED modelers also helped to further investigate the technical requirements and interactions between models. Based on the current state of the requirements analysis, our team implemented first prototypical components of the Data Fabric. We will continue to focus on this in the coming year.
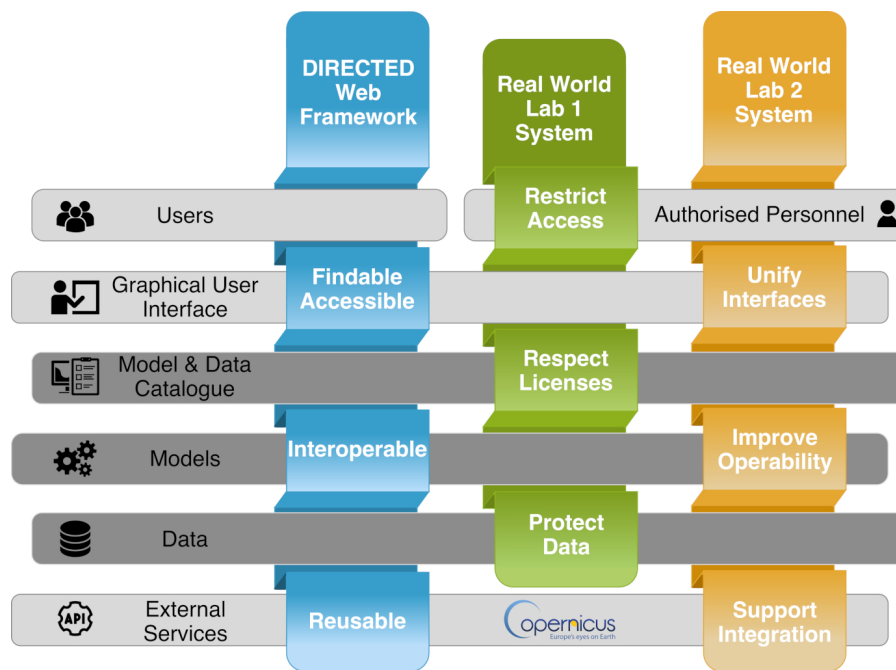
The DIRECTED Data Fabric - the data and model infrastructure

PARTNERS

- **Coordinator**, Technische Universität Braunschweig (TUBS), Germany
- Potsdam Institut für Klimafolgenforschung (PIK), Germany
- Danmarks Tekniske Universitet (DTU), Denmark
- GECOsistema SRL (GECO), Italy
- Research Institute for Sustainability - Helmholtz Centre Potsdam (RIFS), Germany
- University College Cork (UCC), Ireland
- Region Hovedstaden, Denmark
- Agenzia Regionale per la Sicurezza Territoriale e la Protezione (ARSTPC-ER), Italy
- GENILLARD & CO, Germany
- International Intitute for Applied Systems Analysis (IIASA), Austria
- Erftverband, Germany
- Zala Special Rescue Team (ZSRT), Hungary
- Agenzia regionale per la prevenzione, l'ambiente e l'energia dell'Emilia-Romagna (ARPAE), Italy
- Helmholtz-Zentrum Potsdam Deutsches GeoForschungsZentrum (GFZ), Germany
- Oasis Hub Ltd., United Kingdom
- Stockholm Environment Institute (SEI), United Kingdom
- Eidgenössische Technische Hochschule Zürich (ETH), Schweiz

FUNDING

MariGeoRoute

MariData GeoPlatform and Routing

MariGeoRoute helps reduce the energy consumption of cargo ships by providing environmental data and forecasts and routing routines on a cloud-based data infrastructure to support energy optimized routing.

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

MariGeoRoute is a subproject addressing 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. 52°North develops an integrated data store, the GeoPlatform, which will provide data for on shore services as well as for the ships at sea. It needs to sensibly subset and preprocess the data to reduce data load. We 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 developed by 52°North 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.

In 2023, 52°North continued to develop the GeoPlatform, focusing on the implementation and provision of routing algorithms. In the GeoPlatform, environmental forecasts are provided as WMS layers with predefined styles (e.g., wind barbs, arrows, isolines, heat maps) for visualization in the Decision Support System (DSS) front-end and as part of an Open Data Cube instance for efficient use by the routing algorithms. Water depth information from NCEI (National Centers for Environmental Information) and nautical maps from Open Sea Map were imported to take into account important constraints on the selected routes. Our team developed a routing algorithm using the isochrone method, which considers environmental forecasts, water depth and nautical map constraints (separation zones and restricted areas) and fixed waypoints. Since the focus of the project is to provide routes that minimize fuel consumption, we then transferred the isochrone method to the development of an isofuel algorithm. 52°North is currently developing a genetic algorithm that overcomes some limitations of the iso* algorithms and plans to complete this in the near future. Optimized routes can be requested via a routing API now available in the GeoPlatform.

In addition to these technical developments, 52°North supported the project partners at the University of Lübeck in conducting several simulation studies with users of the DSS. We also

KEY TECHNOLOGIES

> Open Data Cube
> GeoNode
> GeoServer
> Python
> Django
> pygeoapi
> Java
> JavaScript
> Kubernetes

FACTS

Duration:
12/2020 – 05/2024

Website:
http://maridata.org/

Contact:
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Project Type:
Research and Development

participated in a DSS component test in the ship simulator at the Flensburg University of Applied Sciences.

In the final project phase, we will focus on evaluating the routing algorithms and comparing the predicted fuel consumption with actual measurements from ships.

The Hochschule Flensburg's ship simulator during the decision support system component tests

PARTNERS

- Hamburgische Schiffbau-Versuchsanstalt GmbH (HSVA), Germany
- AVL Deutschland GmbH, Germany
- DST – Entwicklungszentrum für Schiffstechnik und Transportsysteme e.V., Germany
- Friendship Systems AG, Germany
- Technische Universität Berlin, Germany
- Technische Universität Hamburg
- Universität zu Lübeck, Germany
- Maritimes Zentrum der Hochschule Flensburg, Germany
- Carl Büttner Shipmanagement, Germany
- AVL Software and Functions, Germany

FUNDING

OGC Disaster Pilot

Drought Crop Impact Indicator Workflow

Supporting decision-making for adaptation to climate change

OGC DP23 aims to reduce the risk of climate hazards and to adapt to climate change. The designated research areas are in Manitoba, Canada, and California, USA, with their major climate hazards of droughts, floods and wildfires, respectively. Some deliverables focus on ways to improve the work of first responders and the health impacts of both disasters and climate change. All deliverables will use the latest OGC APIs and try to contribute to a modular workflow chain from Analysis Ready Data (ADR) to Decision Ready Indicators (DRI). The idea behind this is to transform primary data sources as provided by NASA, Canadian Met Service and Copernicus, e.g. , remote sensing or atmospheric data (ADR), with models and processes until they answer a very specific question (DRI). With the modular approach, the pilot aims to connect different workflows; for example, the intermediate result of one workflow could be the starting point (ADR) for another workflow.

52°North focused on an indicator showing the impact of drought on various crops in the Manitoba region. In addition to financial losses for commercial farmers, droughts can severely impact indigenous communities that rely on harvesting their own crops for food security. A tool that compares different crop fitness levels with respect to drought stress could help in the decision-making process of finding the right crops to adapt to climate change.

To create this indicator, we used 30-day temperature and precipitation forecasts provided by the Canadian Met Service and fed them into the crop suitability model (Peter et al., 2020) using plant requirements for temperature and precipitation. The forecast is downloaded weekly and preprocessed (averaging across the different members of the ensemble model). Users receive a NetCDF file or a vectorized representation using contour polygons if they request a bounding box with categories of potential plant growth 'marginal' - 'optimal' for a given crop. Additionally, users can specify a point instead of a bounding box and will receive the plant growth category in a JSON format.

Crop mapping tool

FUNDING

OGITO

An Open Geospatial Interactive Tool – a Community Mapping Case

Adapting and developing the OGITO application for new case studies

The Open Geospatial Interactive Tool (OGITO) is an open source application that supports collaborative spatial planning processes with a map table. It was originally developed by the Faculty of Geo-Information Science and Earth Observation at the University of Twente (ITC) for use in various community mapping projects. The existing OGITO application was adapted for two further case studies. Using co-design, a user group from Herne (Germany) exploited digital map tables to plan noise reduction measures. User groups from Zwolle (The Netherlands) investigated how digital map tables can be used by people with physical or mental disabilities to contribute to the planning of accessible public spaces. Our team improved the usability and accessibility of OGITO's user interface according to requirements of the user groups and added new Features. For example, users can now upload images to illustrate mapped observations. 52°North presented results at the AGILE Conference 2023.

52°North supports ITC and the Hochschule für Gesundheit Bochum in modifying the existing mapping application for additional, future use cases. This includes implementing new features, as well as improving OGITO's (re-)usability. Our team plans to adjust the GET codebase to simplify the process of setting up new mapping projects for additional case studies. A workshop will enable the project partners to acquire the necessary knowledge to be able to modify OGITO's setup themselves in the future.

Mapping the accessibility of public spaces in the City of Zwolle with OGITO

CUSTOMER

- ITC, University of Twente, the Netherlands
- Hochschule für Gesundheit Bochum (University of Applied Sciences), Germany

PVP-MAP

Understanding Student Allocation Via Maps

Mapping intern allocation

As part of the German teacher training program, students must complete an internship of several months at a school. The positions available at the schools are distributed through a common system for North Rhine-Westaflia, but are managed regionally by PVP (Portal zur Vergabe von Praktikumsplätzen - Portal for the Allocation of Internship Positions). In order to optimize the allocation process, the parties involved asked for a map-based system that would allow them to evaluate the distribution of students to schools. This web-based map client (PVP-Map) has been developed by Reedu GmbH & Co. KG. in close cooperation with 52°North in a co-design process with users and stakeholders. 52°North will maintain and operate the application for three years.

Reference points colored according to schools and railways in North Rhine-Westphalia from the PVP-Map tool

CUSTOMER

- University of Münster, ZfL, Germany

<div style="gray-box">

KEY TECHNOLOGIES

> nextjs and tailwind
> OAuth2 with fusionauth
> PostgreSQL
> Docker
> GitOps Pipeline

FACTS

Duration:
05/2022 - 12/2025

Contact:
Benedikt Gräler
b.graeler@52north.org

Project Type:
Professional Services

</div>

Software Projects
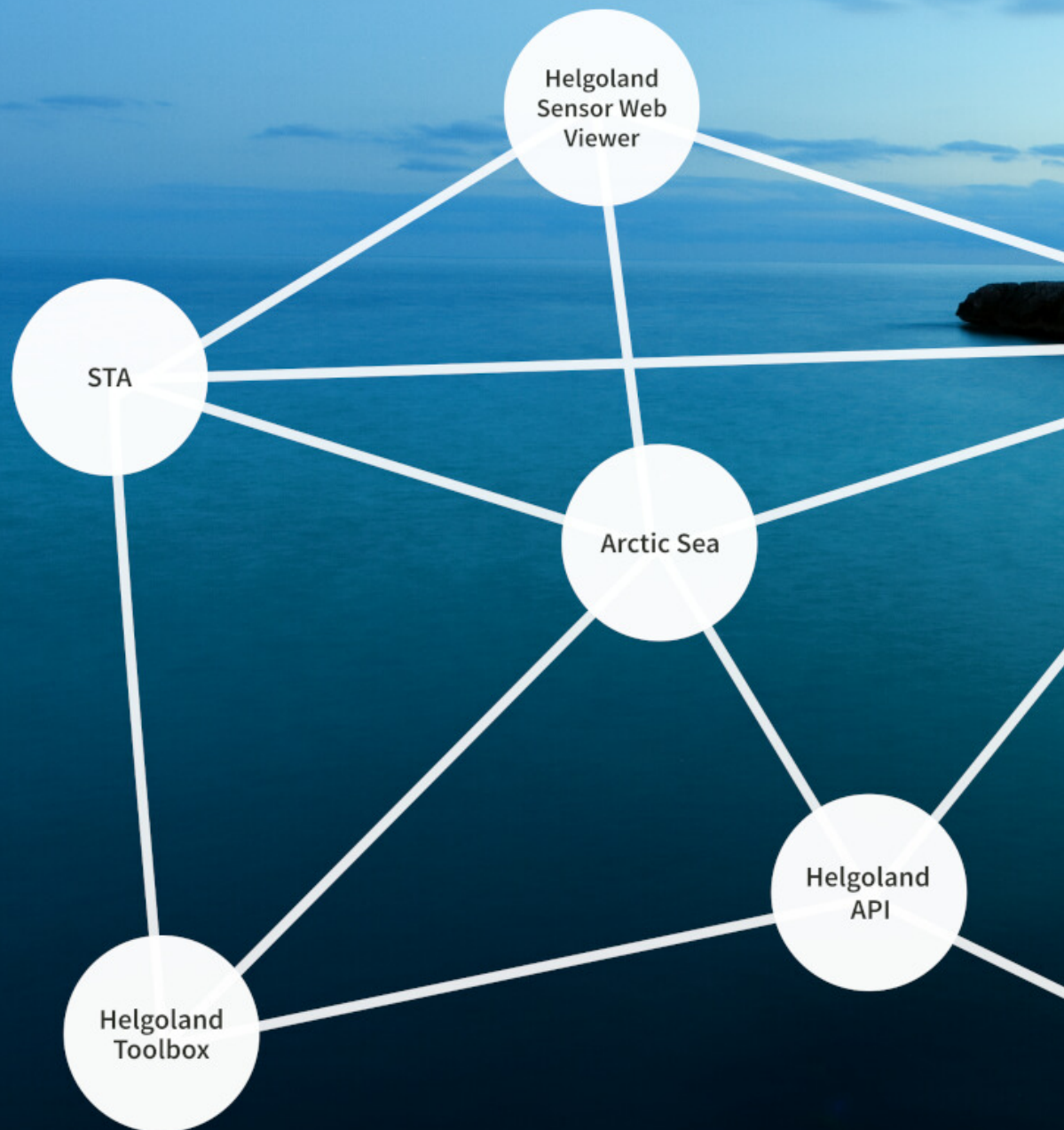
Open Source
Projects
Contributions

Open
Pioneer
Trails

SOS

Developing innovative technologies for advancing spatial information infrastructures

52°North promotes applied geospatial research by managing and supporting the collaborative development of open source geospatial software. Our software is published under licenses approved by the Open Source Initiative (OSI) and hosted on GitHub. We also contribute to major open source software solutions by applying our expertise to extend, improve, and leverage this software for our research and our customers.

javaPS

enviroCar
suite

Open Pioneer Trails

Conquering New Frontiers in Web Mapping Application Development

A modern framework for developing custom GeoIT solutions

Open Pioneer Trails is an open development platform for web clients that enables the development of custom GeoIT solutions. The development platform is characterized by a lean and powerful runtime environment and modern development tools. It offers an excellent developer experience and a broad use of various interfaces (APIs). Development work can also be efficiently reused.

The Trails framework is available free of charge as open source software on GitHub. This project is a collaboration between con terra and 52°North. It is part of the "Open Pioneer" initiative, which focuses on the collaborative development of modern technologies and components for the next generation of geodata infrastructures and solutions.

Trails is a framework — it does not provide a fixed solution or product. The development team provides many examples and basic application blueprints that serve as starting points for solutions.

The software is based on modern technologies:

- React (TypeScript)
- Chakra UI
- Vite
- pnpm
- Web components

The Trails framework provides "core packages" that can be used to develop an application. These packages cover basic functionality such as logging, an internal event bus, theming and look and feel, native Chakra integration, i18n, and interaction with remote content using HTTP clients.
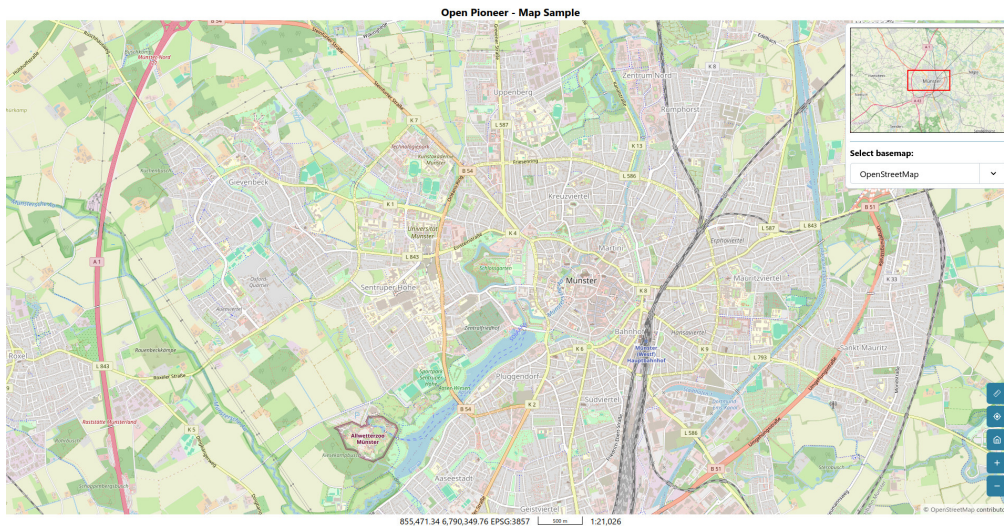
OpenLayers starter application

In addition to the core packages, we are developing dedicated *OpenLayers* packages and making them available as open source. These packages provide the basis for the development of map applications and cover many common functionalities, such as:

- Base maps and switcher
- Interactions (pan, zoom, center)
- Table of Contents
- Coordinate display
- Scales
- Measurements
- Overview map
- Geolocation

52°North currently develops mutliple applications using the Trails framework for several projects, including *NFDI4Earth* and *Volkswagen GeoNet Analyzer*. These projects will contribute to the evolution of Trails by providing new use cases as well as components and widgets to the community.

BENEFITS

By providing a modern framework and developer experience, Trails enables project and product teams to efficiently design web applications that meet the needs of modern spatial data infrastructures. Its flexibility allows many different use cases and interaction patterns to be addressed, while keeping the basic functionality in a central location.

FIELDS OF APPLICATION

- Modern spatial data infrastructures
- Web mapping and web GIS
- Lightweight and embeddable mapping solutions

SOFTWARE

GitHub: https://github.com/open-pioneer/trails-starter

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.

Bjørnøya: Bjørnøya contains various classes for Quartz scheduling shared across Arctic Sea. These include configurations to define the execution of jobs.

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.
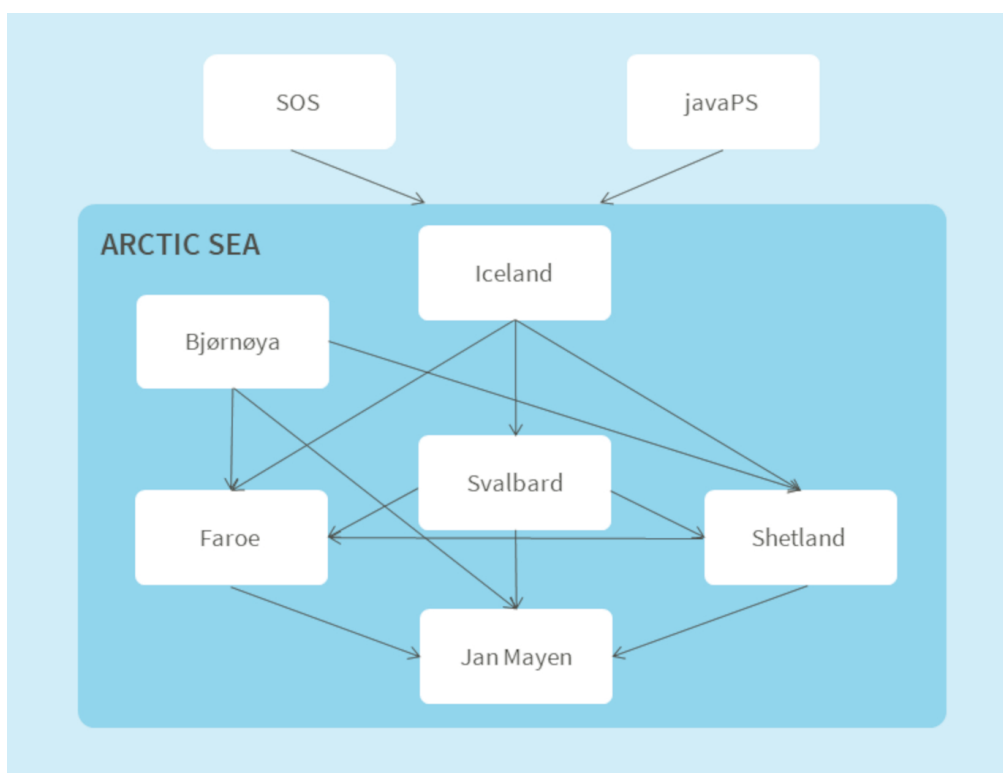
Arctic Sea modules

In 2023, our software engineers released several bug fixes and minor improvements. As 52°North's implementations of SOS and WPS became less relevant in favour of more modern OGC standards, primarily implemented in Python, Arctic Sea's development became mostly maintenance.

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

- JERICO-S3
- Cos4Cloud
- NeXOS
- COLABIS
- SeaDataCloud
- ODIP II
- ConnectinGEO
- GeoViQua
- WaCoDiS
- MuDak-WRM
- BRIDGES

SOFTWARE

GitHub: https://github.com/52North/arctic-sea

Maven Central: https://search.maven.org/search?q=g:org.n52.arctic-sea
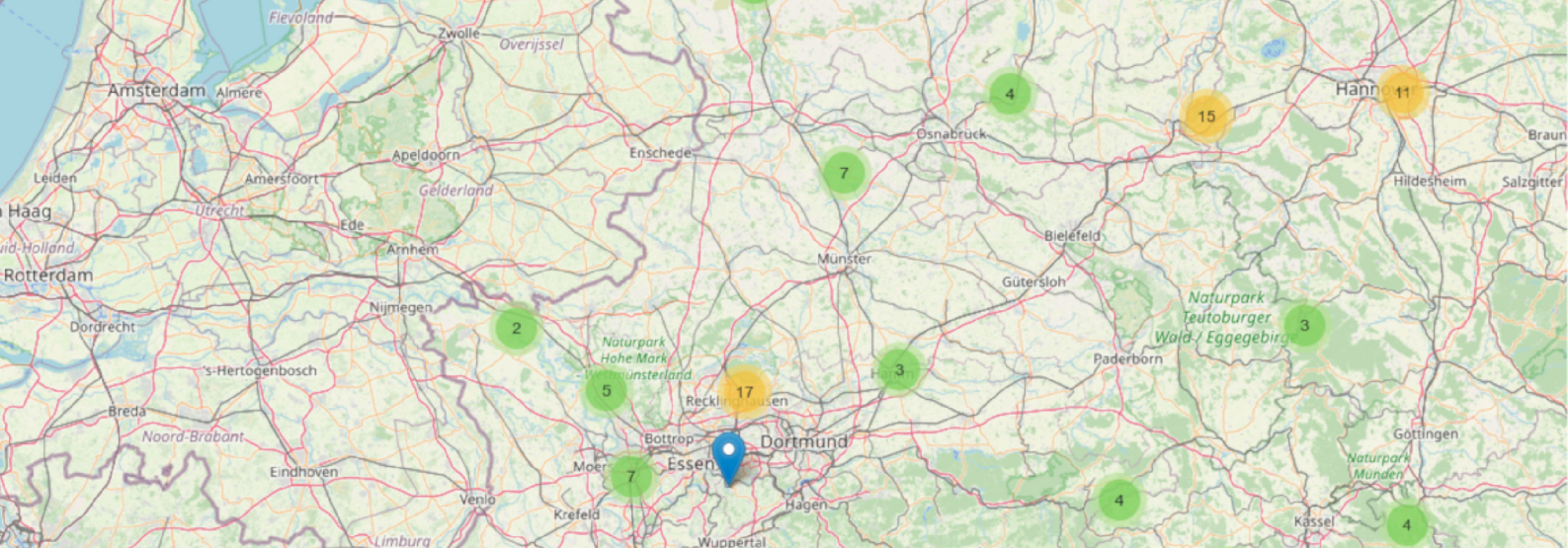
Helgoland Sensor Web Viewer

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 focused on bug fixing and code base maintenance in 2023.
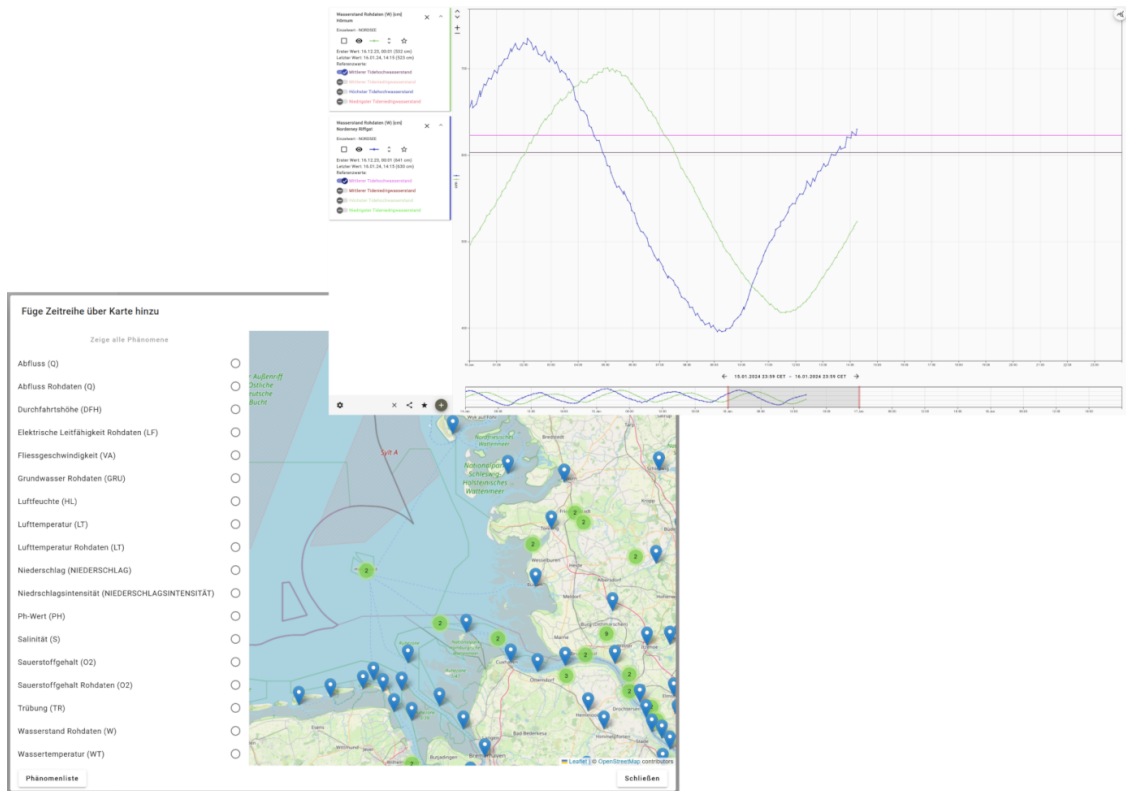
Helgoland Sensor Web Viewer

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
- Wupperverband, Germany
- SeaDataCloud
- WaCoDiS
- MuDak-WRM

SOFTWARE

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

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.

In 2023, 52°North software engineers focused on regular code maintenance.

HELGOLAND TOOLBOX MODULES

Caching

Data Depiction

Data Export

Diagrams (D3)

Map (leaflet)

Data Selection

Table View

Authen-tication

Eventing
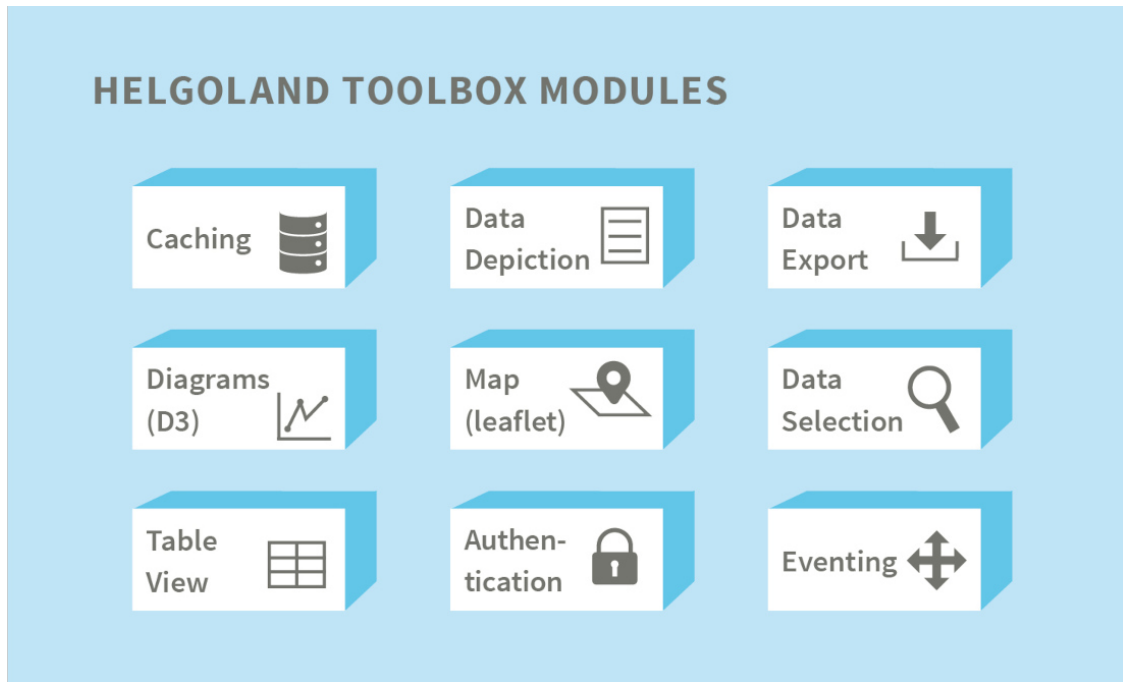
BENEFITS

- 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

- EMODnet Data Ingestion Portal
- SeaDataCloud
- Federal Maritime and Hydrographic Agency (BSH)
- Wupperverband
- WaCoDiS
- MuDak-WRM
- mVIZ

SOFTWARE

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

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.

In 2023, our team focused on minimal, technical bugfixes and library upgrades.
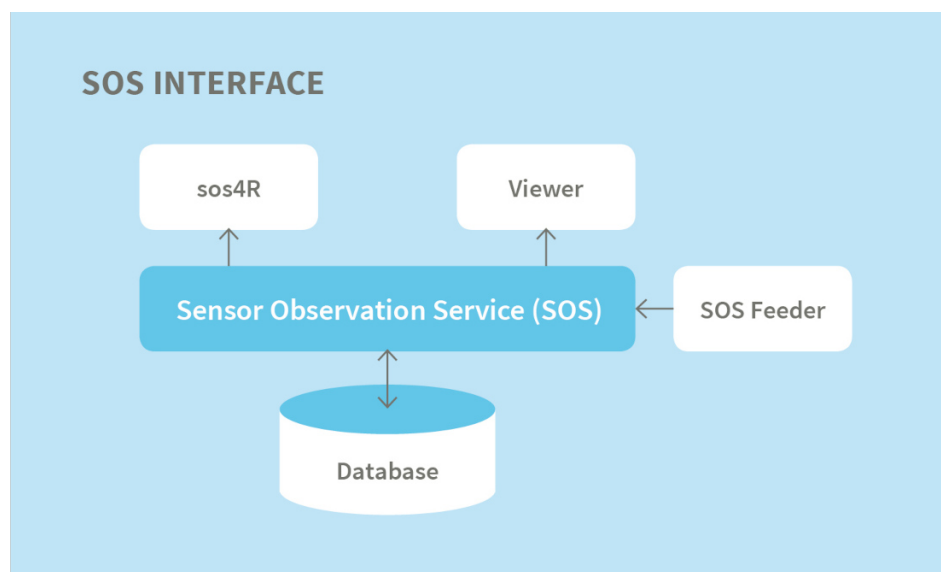
BENEFITS

- 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
- MariData
- Cos4Cloud
- Aquatic Informatics
- Otago Regional Council
- Wupperverband
- Federal Maritime and Hydrographic Agency (BSH)
- … and many more

SOFTWARE

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

STA

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 Version 1.1 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.

Additionally the 52°North STA implementation provides various supplemental features for ease-of-use and added functionality.

In 2023 our activities were mainly focused on maintenance activities. Furthermore, as part of the Jerico-S2 project an experimental evaluation and validation of our implementation was conducted.
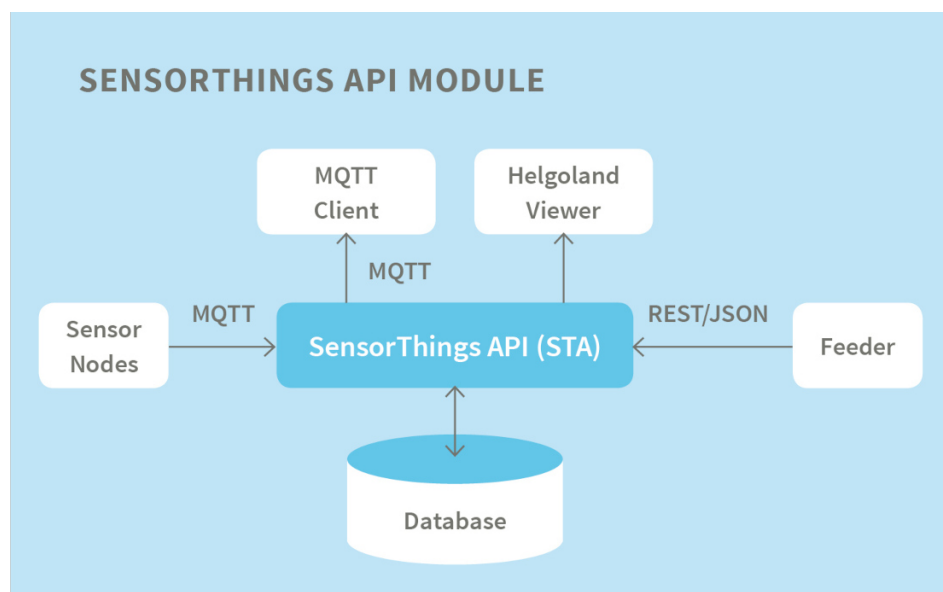
BENEFITS

- 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

- Cos4Cloud
- AQSens
- EMODnet/Eurofleets
- Federal Maritime and Hydrographic Agency (BSH)
- WaCoDiS

SOFTWARE

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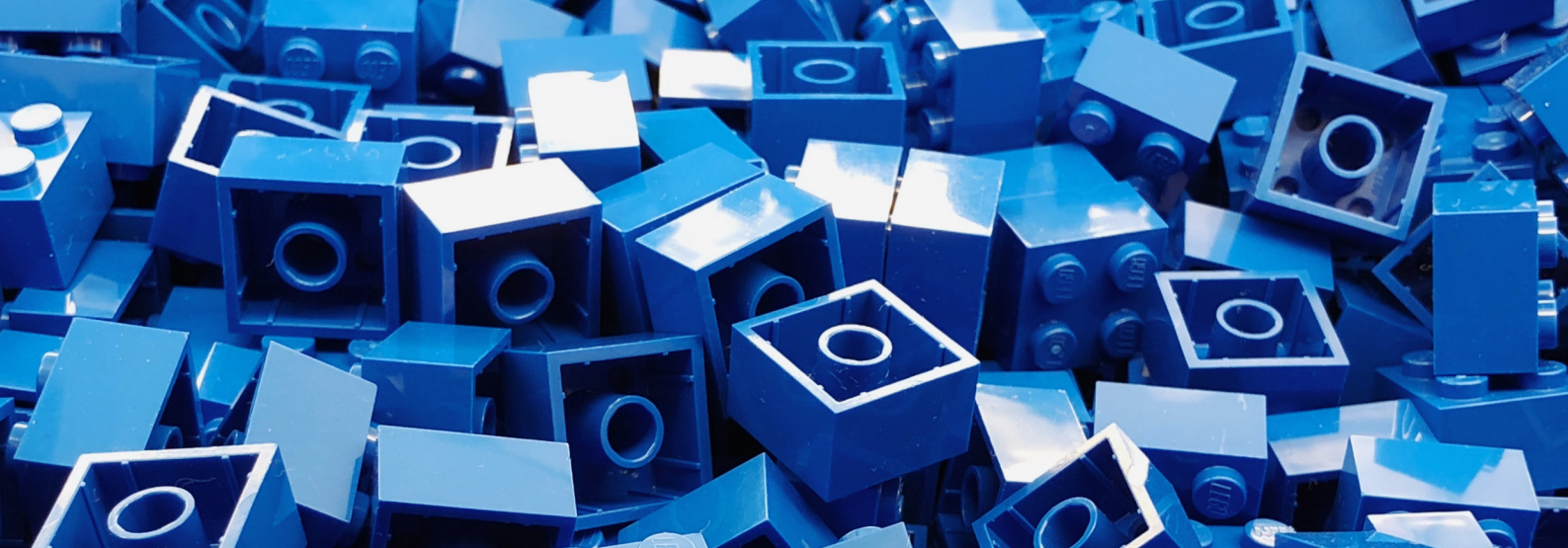
Helgoland API

Lightweight Access Layer to Sensor Data

Supporting the efficient implementation of Sensor Web clients

This lightweight API provides a complementary light 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.

DEPLOYMENT OF THE HELGOLAND API

Helgoland Sensor Web Viewer

Helgoland API　　Helgoland API

Database　　External SOS Server
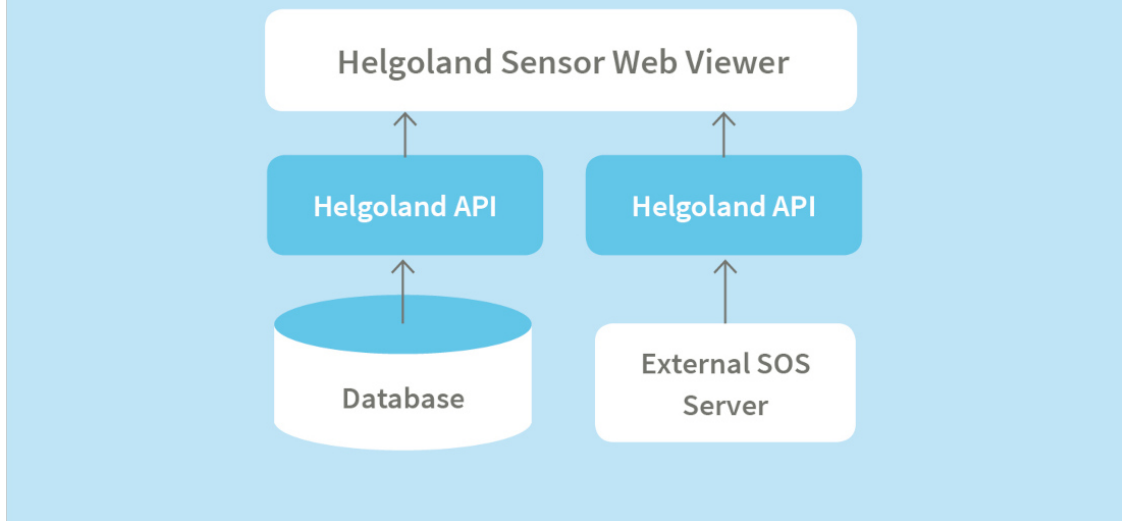
BENEFITS

- 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
- WaCoDiS
- MuDak-WRM
- IRCEL-CELINE BelAir
- NIWA
- Wupperverband
- Federal Maritime and Hydrographic Agency (BSH)
- … and many more

SOFTWARE

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.
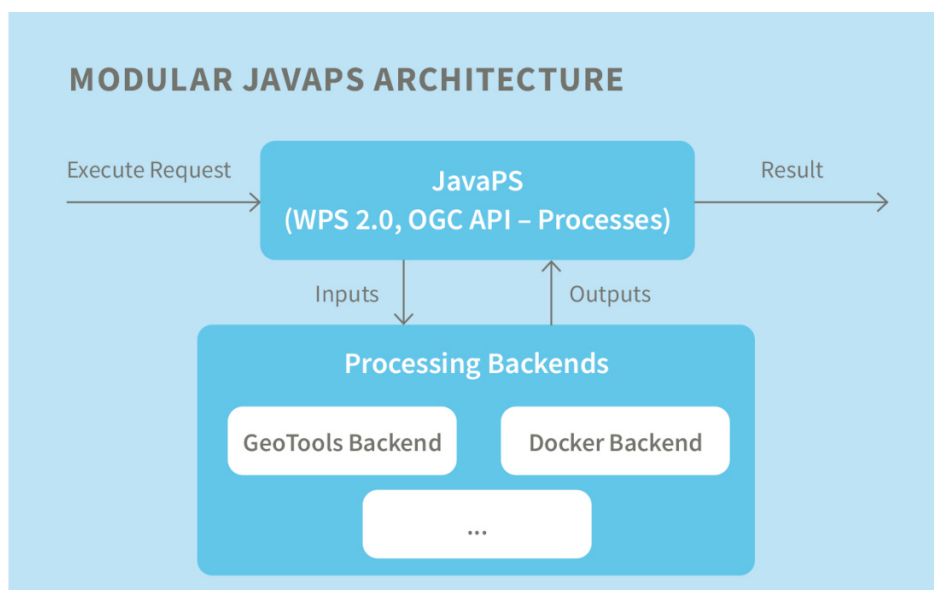
BENEFITS

- 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

- RIESGOS 2.0
- OGC Testbed 17
- OGC Testbed 16
- OGC Testbed 15
- OGC Routing Pilot
- WaCoDiS

SOFTWARE

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

enviroCar suite

XFCD Mobile Data Collection, Analysis, and Management

Collecting, analyzing, managing and sharing vehicle sensor data

The enviroCar suite provides a platform to collect, manage, analyze and share Extended Floating Car Data (XFCD). It comprises several individual software packages.

enviroCar App: 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 by uploading tracks to the enviroCar server. It is then 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. It is continuously being developed as part of our Google Summer of Code projects.

enviroCar Server: 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 offers the possibility to access statistics as well as space and time related subsets of the data in different formats.

enviroCarPy: The enviroCarPy Python package is a lean extension that wraps the enviroCar REST API to ease access to the data. It allows users to query and download XFCD data via the enviroCar Rest-API.

During 2023, we completed the integration of interesting new features and updated most of the software libraries for the enviroCar application. This contributed significantly to the stability of the application software on different devices, using different Android versions, OBD adapters and vehicles. As part of the DVFO LHS project, our team implemented a number of new features such as campaign measurement profiles, additional parameters such as acceleration, and real-time upload of measurements during a drive.
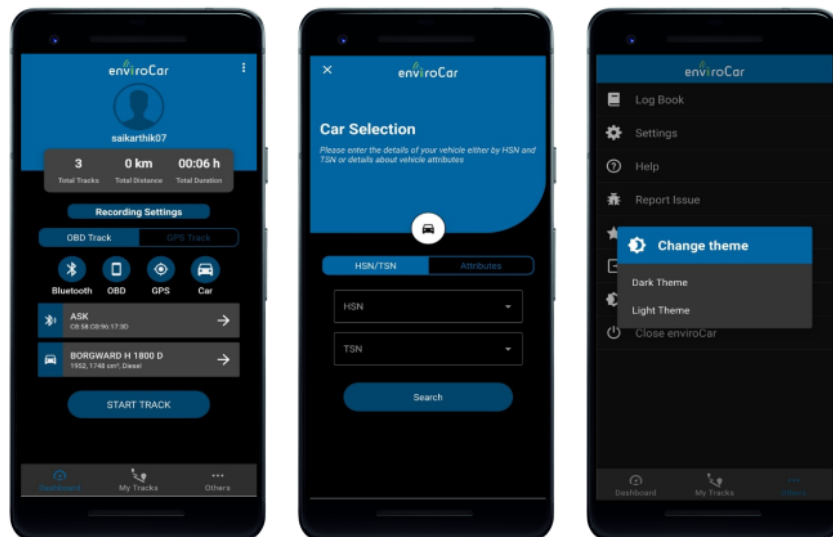
enviroCar dark theme

BENEFITS

- Easy collection of Extended Floating Car Data
- Optional automation of data collection and upload
- Estimation of fuel consumption and CO2 emissions
- Publishing anonymized track data as Open Data
- Map-based visualization of track data and track statistics
- 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
- Easier access to enviroCar data for an analysis in Python
- Several Jupyter notebooks with examples of use-cases

FIELDS OF APPLICATION

The enviroCar suite supports the collection, analysis, sharing and management 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.

PROJECT REFERENCES

- SIMPORT
- DVFO LHS
- GSoC projects
- enviroCar

SOFTWARE

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

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

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

Open Source Projects Contributions

Contributing to Open Source Software Projects

Enhancing open source software

52°North's software research engineers not only develop 52°North software, but also contribute to a number of other open source software packages. These contributions take the form of anything from discussions and bug reports to bug fixing and feature development.

GeoNode

GeoNode - a geospatial content management system - provides a web-based application and platform for the development of Geospatial Information Systems (GIS) and the implementation of Spatial Data Infrastructures (SDI). Managed under the umbrella of OSGeo, it has recently been released in version 4.1, with version 4.2 being on the horizon. 52°North has contributed to numerous projects by using and providing GeoNode as an important component for the deployment of Research Data Infrastructures (RDI).

To keep the project on its path, we have contributed to the integration of new OGC services, (cloud) deployment patterns, and improved developer experience. This includes active development of Helm deployment charts for Kubernetes, sharing experiences on Docker setup and cloud deployment use cases, or constructive collaboration on project setup patterns in different development contexts.

The many funded and professional service projects gave us room to participate in the GeoNode community and provided us with good visibility over the past year. One staff member has joined the GeoNode Development Team.

In addition to the GeoNode core development team, 52°North staff also became members of the German GeoNode User Group, where we participate in ongoing discussions and resolution of real user needs. The German GeoNode User Group is gaining increasing visibility and will serve as an incubator for new GeoNode features needed by stakeholders from different domains.

KomMonitor

KomMonitor is an openly developed GIS web application consisting of modular software components with which local authorities can integrate any spatial data and indicators, link them together and use them for monitoring processes. It is available as Open Source Software originally maintained by the Bochum University of Applied Sciences. 52°North is one of the main contributors to the project and also provides deployment and operation services to interested municipalities.

KomMonitor implements a coherent system of modular technical components in the sense of a geodata infrastructure. Thus, it provides an integrated data infrastructure that enables the linking and maintenance of

interdisciplinary municipal (geo) data sets and statistical time series information at any spatial level. Through automated processing functions, new indicators can be derived from existing data sets. Finally, a web application enables the explorative display, analysis and evaluation of spatio-temporal indicators.

All aspects of this integrated data infrastructure are part of a service-oriented software architecture running natively runs on Docker. 52°North maintains the Docker deployments and provides support for installation and operation. In addition, 52°North initiated several activities to prepare KomMonitor for cloud deployments. Our team developed Kubernetes manifest files for deploying KomMonitor within a hosted Kubernetes Cluster. We also run a demo instance of KomMonitor within an AWS cluster, and share our cloud experience with various projects and IT service providers.

In addition to deployment activities, 52°North also contributed to the development of KomMonitor's main features. This includes the following enhancements and improvmenets:

- Migration to Spring Boot 3, Springdoc and Spring Security for the Importer API
- Geopackage and OGC API - Features support for KomMonitor Importer API and Web Client
- Layout improvements for several statistical diagrams of the KomMonitor Web Client
- Virtual accessibility analysis functions as part of the KomMonitor Web Client

To meet today's security requirements for trusted software code, 52°North has implemented automated CVE scanning for KomMonitor software components. This helps us to detect and address security threats in a timely manner and increases trust in the KomMonitor software components.

In addition, we continued our pygeoapi activities and created a proof of concept for replacing the KomMonitor Processing Engine with the pygeoapi implementation of the OGC API - Processes. This initiative aims to introduce an interoperable processing interface to KomMonitor that can also be managed by modern workflow orchestration tools.

pygeoapi

During 2023, 52°North's developers started to engage in the evolution of pygeaopi. In the past the pygeoapi-odc-provider (see below) had been developed previously and applied in different projects by 52°North. Several new aspects have been addressed recently.

In particular, the maturity of the *OGC API Processes* module was assessed and improved. We deployed test instances and ran the official OGC TEAM Engine test suite against them. The results were discussed with the developers and fixes were contributed. The *OGC API Processes* module has been used in several research projects to provide processing and analysis functionality *as a service*.

The pygeoapi-odc-provider is a standalone Python library. Our 52°North team prototypically implemented this library during the OGC Testbed-17 Geo Data Cube project. It offers a provider plugin for pygeoapi to use Open Data Cube instances as a data resource. pygeoapi makes the data from the ODC available via OGC APIs.
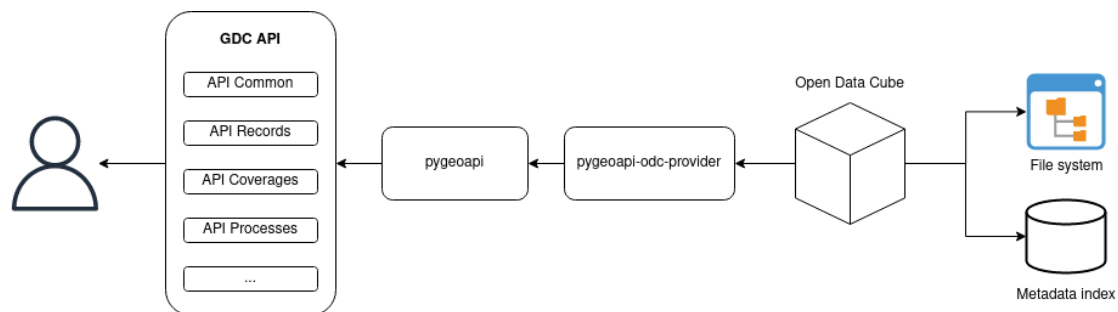
52°North server architecture

Education and Mentoring

Sharing knowledge and experience

52°North staff is actively involved in higher education, working with students to develop their understanding and application of knowledge, concepts and processes. We regularly teach semester courses and conduct study projects at the Institute for Geoinformatics at the University of Münster. Our staff also prepares and delivers lectures at the Bochum University of Applied Sciences. In addition to classroom teaching, we host interns who gain insight into our day-to-day business and mentor international GSoC developers.

Courses

In 2023, our staff taught the following courses:

WS 2022-2023 and 2023-2024 Institute for Geoinformatics, University of Münster: Study Project "Open Educational Resources for Spatial Data Infrastructures" (Albert Remke and Simon Jirka)

SS 2023 Bochum University of Applied Sciences: Lecture and Exercises "Sensorintegration und - kommunikation" (Christian Autermann and Simon Jirka)

Theses Supervision

Supporting higher education, we cooperate with our academic partners to supervise theses. These typically have a direct link to ongoing research at 52°North. We currently supervise a number of theses, none of which have been completed in 2023.

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 and Bachelors programs require a certain amount 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.

Student intern for a day

52°North welcomed Lonnie as a student intern for a day. Lonnie has always been interested in computer science. One of the thirteen-year-old's favorite hobbies is programming, "mainly websites, but also many other small projects and programs". While participating in the "Jugend hackt Lab Münster" he found out about 52°North and decided he'd like to learn more about our work.

During his day at 52°North, Lonnie not only participated in a daily stand-up project meeting, but also sharpened his skills in Leaflet map visualization techniques through the hands-on session and performed data exploration exercises in a Jupyter Notebook. The data he analyzed came from OpenSenseMap and has been integrated into the I-CISK project platform for the Budapest Living Lab. He also played a few rounds of table football with colleagues during the lunch break!

52°North enjoyed having him. We were very impressed by his skills.

Sandhya Rajendran began her 6-month internship at 52°North in October 2022. Originally from Chennai, TamilNadu, India, she received a B.E. in Geoinformatics from the Anna University, Guindy in 2021. She began working towards her master's degree in geoinformatics and spatial data science at the Institute for Geoinformatics (ifgi), University of Münster shortly thereafter.

A friend of hers - a former student assistant at 52°North - spoke highly of the open, welcoming work environment at 52°North. This and a love of programming initially drew Sandhya to 52°North. During her internship, Sandhya had the opportunity to work on the 'OER4SDI' project (funded by the NRW Ministry of Culture and Science). It is an initiative aimed at promoting Open Educational Resources (OER) for Geoinformatics, Geoscience students. As a representative of 52°North, she was responsible for developing modules that provide an in-depth understanding of Sensor Web Enablement (SWE) and the implementation of SensorThings API.

Sandhya developed 2 OER modules as storyboards in the official OER4SDU GitHub page. These modules present complex topics in a clear and accessible manner, ensuring that the content is suitable for Geoinformatics students at various levels of expertise. She included interactive quizzes, puzzles, and examples of SWE in the real world and included hands-on exercises and practical activities to enhance the learning experience of students using LUMI software. For the implementation, Sandhya used the MQTT protocol and NodeRed software to develop a streamlined data uploading and downloading procedure for the SensorThings API.

Sandhya had very little professional experience before starting her internship but has since "learned how to work with spatial data standards and services … and has acquired the skills necessary to work effectively in a global collaborative setting." She particularly enjoyed being able to "research more on various topics and have the freedom to experiment between different techniques and technologies".

Future plans include continuing to build her knowledge in the field of sensors and Sensor Web, as well as completing her master's thesis on "Visualizing the use of weather metaphors to interpret COVID-19 information" by the end of 2023. Thereafter, Sandhya can foresee pursuing a career as a geospatial analyst.

Merel Vogel was born and raised in the city of Amsterdam, Noord-Holland, The Netherlands. She obtained a bachelor's degree in Social and Natural Sciences with a major in Mathematics from the University of Amsterdam in 2020. A year later, she started her master's degree in Geoinformatics and Spatial Data Science at the Institute for Geoinformatics (ifgi) in Münster.

Merel first heard of 52°North when Ben Gräler gave a talk at ifgi's GI-Forum in November of 2021. 52°North's non-profit stance and open science focus appealed to her immediately. The projects presented were also geared towards solving/addressing interesting societal problems, such as climate resilience, and making use of citizen science approaches, to which she was eager to contribute. Thus, she applied for a six-month internship.

From September 2022 through March 2023, Merel worked on the I-CISK project. I-CISK strives "to innovate how climate information is used, interpreted and acted on through a next-generation of Climate Services that follow a human centered, social and behaviorally informed approach" (https://icisk.eu/about-icisk/). During the first few months of the internship, she developed some prototypes for uncertainty visualization in an RShiny application as part of a future Climate Service. This involved integrating local data sources into the GeoNode framework by connecting to APIs in an automated manner with a Python Django application. The app was designed to retrieve the data from OpenSenseMap and update the GeoNode instance with the latest information.

Since it was the first time Merel had worked in the IT sector, she found it quite challenging. "I learned various valuable things. Obviously, I got hands-on experience with a lot of new technologies like Docker and Django, to name a few. Overall, my experience at 52°North gave me a comprehensive understanding of web development and the importance of considering all aspects of the software architecture when creating a web application," Merel states. A typical programmer's workday doesn't just consist of coding. It also involves some project management, interaction with stakeholders and users of the software, as well as meetings with project partners. Merel also gained insight into how an international research project operates and how coordination across the European continent is organized. "It was enlightening to see all kinds of people from all kinds of disciplines work together towards a common goal, and to see that there are great efforts going on trying to make the world a better place, and resilient to climate change."

Merel enjoyed the variety of work and the freedom to choose which topic, technology, programming language to work on within the I-CISK project. She also enjoyed the open and supportive atmosphere at 52°North. She continues to pursue her master's degree and could envision a career in the geoinformation field.

Yağmur Yildiz is currently a student in the 'Geoinformatics and Spatial Data Science' master's Program at the University of Münster. Originally from Turkey, she earned her bachelor's degree in Geomatics Engineering from Izmir Katip Çelebi University in 2022 and began her master's degree in Münster that same year.

As part of her master's program, Yağmur pursued her external semester at 52°North from April to October 2023. During her Spatial Data Infrastructure course, guest lecturer Markus Konkol from 52°North gave a presentation on open reproducible research. Intrigued by what she had learned during the lecture, Yağmur further explored 52°North's initiatives and contributions. "I was truly impressed by 52°North's diverse range of projects addressing real-world problems, especially their significant contributions to climate initiatives and how they address environmental challenges". She decided to apply for an internship. 52°North's open source philosophy and non-profit commitment played a significant role in her decision.

During her internship, Yağmur gained practical experience using a wide range of software tools and technologies, which she put into practice while contributing to the I-CISK project. This included using Python, R, Docker, GeoServer, GeoNode, and React. Her tasks involved acquiring and analyzing meteorological data using software packages and APIs, exploring and developing customized visualizations in close cooperation with stakeholders, and integrating these visualizations into a climate service platform.

Yağmur's experience with GeoNode included creating GeoStories and interactive web maps, and customizing them using styled layer descriptors (SLD) in GeoServer. She also worked on an app showing meteorological data and gained some first impressions of how to use Docker. These technologies enriched her proficiency in geospatial data management, data visualization, web application development, and collaborative software development.

Furthermore, her internship at 52°North provided her with a deeper level of involvement in the projects and a stronger sense of appreciation for her work, which differed from previous internships. This experience not only contributed to Yağmur's skill development but also fostered a sense of motivation to excel in her role. "I appreciated the team spirit and the support. My colleagues were always approachable and willing to help with any questions I had. I look forward to continuing my work with them as a student assistant and writing my master's thesis on Urban Heat Island Detection in Budapest."

Igor Quaresma is a native of Brasilia, Distrito Federal, Brazil. He graduated with a bachelor's degree in Industrial Engineering from the University of Brasilia in 2021. A desire to change careers and a passion for solving location-based challenges and optimization led him to study Geoinformatics and Spatial Data Science at the University of Münster, Germany in 2022.

The name 52°North came up a lot during various presentations and events at the Institute for Geoinformatics. Fascinated by the idea of working with open source tools, Igor searched the 52°North website and came across the MariData project. The idea of combining route optimization with weather constraints in the shipping industry really caught his attention. With his background as an industrial engineer, he has always been interested in logistics and transportation. The opportunity to work with routing and extend the optimization model with weather and other geo-constraints convinced Igor that an internship at 52°North would help him improve his technical programming skills while working on a focused project with good results for the environment.

From April to September 2023, Igor worked on various tasks in the MariData project. He first focused on GeoServer, creating layers with custom SLD styles while respecting geofence security constraints. After that, he directly supported the development of a Weather Routing Tool (WRT) by implementing the negative constraints in the routing process, which mainly used OpenSeaMap data for separation zones, separation lines and restricted areas. He also implemented unit tests for the newly created methods. To improve the documentation of the routing tool, Igor created several diagrams, such as simplified and sequence diagrams. He also worked with OpenDataCube as a new way to load the environmental data needed for the routing steps.

Igor thoroughly enjoyed his experience at 52°North. "Thanks to the internship at 52N, I was able to apply the knowledge I acquired in the first semesters of the master's program in a real project with real stakeholders. The opportunity to work side-by-side with more experienced developers in pair programming sessions and sprints was also crucial for my development as an IT professional". In addition to using tools and programming languages such as Python and R, Igor also learned about other open source tools such as GeoNode, Django, and PostGIS, as well as Docker and Git. In addition to the technical knowledge, the opportunity to attend meetings and be in constant contact with other partners of the project contributed to the development of soft skills that are important both in industry and academia.

"I really liked that my colleagues were always approachable and willing to help with any questions I had. Software development is a career that can be a bit overwhelming for someone just starting out, so having advice and mentoring sessions from people who have been involved in different projects with different scopes and technologies can really be a game changer in the first steps of your career, and at 52N I had that almost daily."

Igor continues to work as a student assistant at 52°North. He is looking forward to writing his master's thesis within the MariData project, where he will compare fuel consumption results of different routes using data from the Copernicus Marine Service and Global Forecast System and high-frequency data collected directly from ships. After that he plans a career in software development, especially in projects/companies that combine the same aspect of technology, green logistics and green supply chain.

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 new contributors to open source software development. Contributors receive stipends to work on a 12+ week programming project with an open source organization under the guidance of mentors. At 52°North, we pair students with mentors and embed their work in the context of ongoing research projects. Hence, GSoC contributors gain valuable exposure to real-world software development scenarios and have the opportunity to work in areas related to their technological backgrounds and professions. In turn, we are able to improve our software projects, move forward in our projects, as well as identify and draw in new developers more easily. This helps us to expand our Open Source community.

We have been a successful mentoring organization since 2012. This year, over 2,400 mentors and organization administrators reviewed 7,723 proposals – submitted by 43,765 applicants from 160 countries – and selected 967 GSoC contributors from 65 countries (https://opensource.googleblog.com/2023/05/google-summer-of-code-2023-accepted-contributors-announced.html)! We were one of 171 open source organizations chosen to host three contributor projects. Two of the projects addressed functionality extension and improvement of the enviroCar app. The third project focused on KomMonitor's web client.

Stabilizing and Extending enviroCar App: Voice Command (Ayush Dubey)

Enhancing the user experience with improved safety measures

Ayush Dubey, a pre-final year Computer Science Engineering student from New Delhi, India, describes himself as a nerd, a techy, and a science enthusiast with a love for developing software systems. With experience working as a backend developer intern at the Indian Institute of Technology Kanpur (IIT Kanpur), he deeply values Open Source projects and contributions and enjoys working with open-source communities and technical societies on impactful projects. This is his first Google Summer of Code.

His project focused on expanding and refining the app's voice command functionalities to ensure the smooth functioning of the voice assistant in various situations. This included improving the accuracy of wake word detection, expanding the voice command flows, stabilizing and developing a CI/CD pipeline for the enviroCar Rasa bot and writing tests.

Wake word accuracy was improved by changing to Vosk as a speech recognition toolkit. Due to the large size of the newly adapted model, Ayush used language model pruning to downsize it. He also developed a framework for remote delivery of the model files to the app using a backend API and a voice model dashboard. This framework

- reduced the application size,
- provided flexibility to choose and download the appropriate model when using voice command features,
- enabled delivery of model update Over-The_Air (OTA), and
- provided options for additional language models.

Model Dashboard UI
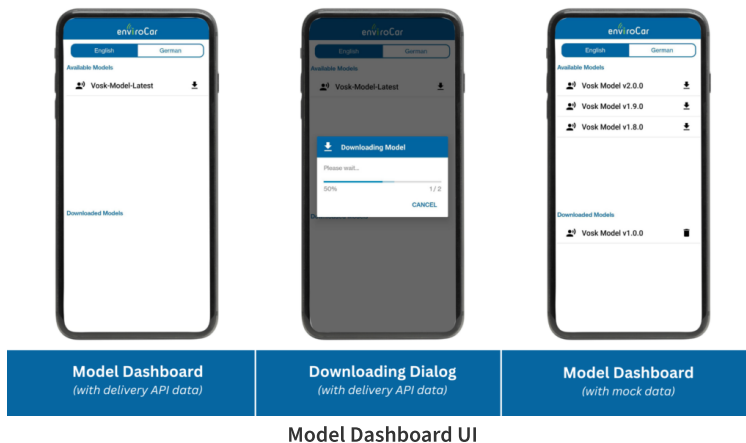
Ayush additionally implemented, tested and deployed a code analyzer in the form of a CI/CD testing pipeline on the enviroCar-rasa-bot repository.

" I had the opportunity to dive into unfamiliar technologies - from working on pruning, adapting, and improving machine learning language models to working with Rasa NLU or developing GitHub Actions CI/CD pipelines. As the project was architected and formalized in GSoC' 22, I got a chance to work very closely with the design and the architecture of the implementation. This experience deepened my understanding of design concepts and allowed me to enhance the structure wherever necessary."

Blog: https://blog.52north.org/2023/08/28/stabilizing-and-extending-envirocar-voice-command-final-blog/

Implementing Location Privacy Toolkit in enviroCar App (Praveen Kumar)

Protecting user privacy and data control

Praveen Kumar's first Google Summer of Code project focused on integrating a Location Privacy Toolkit (LPT) into the enviroCar app. The enviroCar app relies on the native Android location API, which provides coarse-grained location information. While this is functional for determining fuel efficiency, it raises privacy concerns as it allows potential tracking of users' movements. Thus, the goal was to enhance user privacy and control over location data in the app.

The existing toolkit was built as an Android library as part of the SIMPORT project to empower users to make informed decisions about the location data they share. Prior to integration, Praveen implemented a test-setting preference and utilized the functions provided by the Location Privacy Config (LPC) module within the app. He defined privacy preferences, matched the app theme, and added code to retrieve and set the privacy configuration in the SettingActivity. After integration, he incorporated location privacy features into different app sections. He then focused on improving the flexibility of the location privacy configuration, introducing dialog notifications for location access, while resolving migration and dependency conflicts.
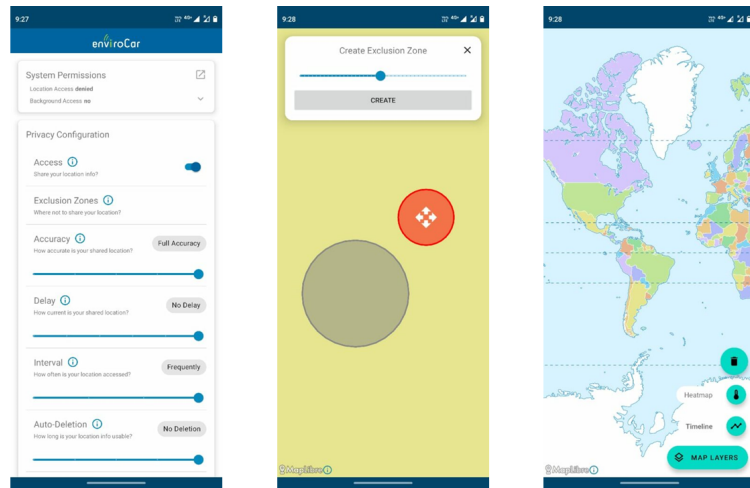
New enviroCar dialogs - privacy configuration, exclusion zone and location history

Praveen successfully integrated the customized LPT into the enviroCar app, enabled users to configure accuracy, intervals, and location access preferences, created dialog notifications to warn users about location access issues. Track recording now works seamlessly with the LPT. By allowing users to share location data selectively, their confidence in the app's usage is enhanced and sensitive information is safeguarded.

Download the envirocar app with the LPT from Google Play Store.

KomMonitor Web Client: Migration to Angular (Ashwanth Kumar)

Improving performance, scalability and user experience

Ashwanth Kumar is a recent graduate of the Visvesvaraya Technical University in Belagavi Karnataka, India. As an open-source enthusiast with a passion for learning and contributing to amazing technologies, he has been actively exploring various technologies to keep up with the latest trends.

During GSoC 2023, Ashwanth focused on migrating the KomMonitor web client from AngularJS to Angular with the goal to extend KomMonitor's capabilities and improve the application. This move provides improved performance and efficiency, enhanced modularity and access to a number of modern features, such as reactive forms.

Since the syntax and architecture of the Angular framework as compared to AngularJS are quite different, the migration required rewriting most of the codebase. Ashwanth classified the file structure of AngularJS to Angular into creating components, modules and services, aligning with Angular's best practices. He worked on migrating a few of the services, such as ConfigStorageService, ElementVisibilityHelperService, and DiagramHelperservice, and set up a few others services in a hybrid fashion with help of service providers.

KomMonitor Diagrams component

A comprehensive Wiki documentation was also developed. It suggests best practices for upgrades and development, providing a roadmap for developers to navigate and unlock the full potential of the KomMonitor and drive excellence in future development.

"I gained important knowledge and strategies that will be beneficial for upcoming projects. By migrating to Angular, the performance and scalability of KomMonitor, as well as the user experience, were improved. The migration to Angular is an example of 52°North's dedication to innovation and capacity to overcome challenges.I would continue contributing to the project and still be involved in open source."

Blog: https://blog.52north.org/2023/09/26/kommonitor-final-blogpost/

Dissemination and Outreach

Research - develop - publish

At 52°North, we disseminate project and research results, i.e. software and architectural developments, concepts and methodologies, through various platforms. These include publications, blog posts, conference presentations, webinars and the organization of workshops and seminars. The vast majority of our open source developments are hosted on GitHub and freely accessible to a large user and developer community.

Publications

Sharing research results and developments

Bredel, Henning. "Cos4Cloud Wrap Up". 52°North Blog, March 6, 2023. https://blog.52north.org/2023/03/06/cos4cloud-wrap-up/.

Britsch, Christopher, Antje Kügeler and Simon **Jirka**. "Geospatial Trends 2023: Opportunities for Data.Europa.Eu from Emerging Trends in the Geospatial Community". Publications Office of the European Union, 2023, https://data.europa.eu/sites/default/files/report/Geospatial_trends_report_2023_EN.pdf .

Churchyard, Paul and Ajay Gupta (Ed). "Testbed-18: Identifiers for Reproducible Science Summary Engineering Report". OGC Public Engineering Report, T18-D041, 13 March 2023, http://www.opengis.net/doc/PER/T18-D041.

Demmich, Katharina, Benedikt **Gräler**, Johannes **Schnell**, Merel **Vogel**, Stefano Bagli, and Paolo Mazzoli. "Building an Open Source Infrastructure for Next Generation End User Climate Services." Oral presented at the EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-15863, https://doi.org/10.5194/egusphere-egu23-15863.

Demmich, Katharina. "An Open Source Infrastructure for End User Climate Services". 52°North Blog, June 13, 2023. https://blog.52north.org/2023/06/13/an-open-source-infrastructure-for-end-user-climate-services/.

Demmich, Katharina. "An Indicator Workflow for Visualizing the Impact of Droughts on Crop Health and Production". Oral presented during the OGC Disaster Pilot 2023 Demo Day Webinar, November 14, 2023.

Drost, Sebastian and Christian Danowski-Buhren. "KomMonitor - Kommunales Monitoring zur Raumentwicklung," Oral presented at the FOSSGIS Conference 2023, Berlin, Germany, 15-18 March 2023, https://doi.org/10.5446/61098.

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Gräler, Benedikt. "Turning Data through Models into Information for Improved Climate Change Adaptation," Oral presented at the IZG Summer Program 2023, Bochum, Germany, June 16, 2023.

Gräler, Benedikt. "52°North's perspective on Geospatial Data Spaces," Oral presented at the EUROGI Session – Geospatial Data Spaces at the VII Conferencia del Geómetra Experto, Madrid, Spain, October 27, 2023.

Gräler, Benedikt and Henning **Bredel**. "GeoNode in Forschungsdateninfrastrukturen," Oral presented at the FOSSGIS Conference 2023, Berlin, Germany, 15-18 March 2023, https://doi.org/10.5446/61149.

Jirka, Simon. "Gaia-X: Opportunities and Challenges for the provision of Geospatial Services". Oral presented at the Esri Developers Summit, Berlin, Germany, 14-16 November 2023.

Jirka, Simon. "Geospatial Trends 2023: Opportunities for data.europa.eu." Webinar, September 8, 2023.

Konkol, Markus. "Communicating Data Quality through Open Reproducible Research." Short course presented at the EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023. https://meetingorganizer.copernicus.org/EGU23/session/46566.

Konkol, Markus, Simon **Jirka**, Christian **Autermann**, Joaquin Del Rio Fernandez and Enoc Martínez. "Harmonising the Sharing of Marine Observation Data Considering Data Quality Information." Oral presented at the EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-9291, https://doi.org/10.5194/egusphere-egu23-9291.

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Konkol, Markus. "The Road to the GEO Statement on Open Knowledge." Oral presented at the Geo Dialog Series, Online, September 28, 2023. https://earthobservations.org/geo_blog_obs.php?id=592.

Konkol, Markus and Meret Buurman. "Building Spatio-Temporal Workflows in Galaxy for the AquaINFRA Project." Oral presented at the Galaxy Days, Freiburg, Germany, April 10, 2023. https://galaxyproject.org/events/2023-10-egd/.

Konkol, Markus and Simon **Jirka**. "Public NFDI4Earth Product Presentations for the Community." Oral presented at the 2nd NFDI4Earth Plenary 2023, Dresden, Germany, January 6, 2023. https://nfdi4earth.de/plenary-2023.

Pontius, Martin. "Results of Exploring Wilderness Characteristics Using Explainable Machine Learning Models". Oral (remote) presented at the Testbed-18 Demonstration Days: Developing Location Interoperability, 17-18 January 2023.

Pross, Benjamin. "Addressing Disasters Together – Two European Project perspectives". Oral presented during the Climate Resilience DWG at the 125th OGC Member Meeting, Frascati, Italy, 20-24 February 2023.

Pross, Benjamin and Stann Tillman. "OGC API – Processes". Oral presented during the Joint OGC API SWG Session at the 125th OGC Member Meeting, Frascati, Italy, 20-24 February 2023.

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Schnell, Johannes. "Projects of 52N." Oral presented at the Data Week Leipzig, Germany, 26-30 June 2023. https://2023.dataweek.de/2023-06-27/Ratsplenarsaal.html#10:50.

Steinhausen, Max, Kai Schröter, Martin Drews, Lydia Cumiskey, Heiko Apel, Stefano Bagli, Sukaina Bharwani, Julian Struck, Daniel Bittner, Tobias Conradt, Benedikt **Gräler**, Christopher Genillard, Stefan Hochrainer-Stigler, Levente Huszti, Tracy Irvine, Chahan M. Kropf, Emilie Rønde Nielsen, Pia-Johanna Schweizer, Valeria Pancioli, and Analia Rutili and the DIRECTED project team. "DIRECTED – Disaster Resilience for Extreme Climate Events providing Interoperable Data, Models, Communication and Governance". Poster presented at the EGU General Assembly 2023, Vienna, Austria, 24–28 April 2023, EGU23-13541, https://doi.org/10.5194/egusphere-egu23-13541.

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Vogt, Arne, Johannes Flacke, Karin Pfeffer, Fenna Imara Hoefsloot, Jane Strugar Kolesnik, and Johannes **Schnell**. "Development of an Inclusive Mapping Application in a Co-Design Process." In 26th AGILE Conference on Geographic Information Science "Spatial Data for Design," Vol. 4. Delft, The Netherlands: AGILE: GIScience Series, 2023. https://doi.org/https://doi.org/10.5194/agile-giss-4-48-2023.

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. Dr. Benedikt Gräler is the European Representative, representing the interests of the DDGI in the European Umbrella Organization for Geoinformation (EUROGI).

Contact: https://www.ddgi.de

The European Umbrella Organization for Geographic Information (EUROGI) supports and develops the use of applications and technologies related to geographic information at the European level. 52°North delegates Dr. Benedikt Gräler as DDGI representative to the Executive Committee to ensure that German interests are considered in strategic policy planning.

Contact: https://eurogi.org/

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.

Contacts:
GDI-DE: https://www.gdi-de.org
GeoIT RT NRW: https://www.geoportal.nrw/geoit_round_table
Geonetzwerk Münsterland: http://www.geonetzwerk-muensterland.de

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