

Using ISO Metadata and OGC Catalog Services to find data on Protected Sites in Germany

(working draft 2023-12-12)

1. Overview

This learning material is a technical tutorial on how to access and use metadata in an SDI to find data on Protected Sites that is needed for windfarm planning in Germany.

After using this tutorial, you will be able to answer the following questions:

- How can we use metadata for discovering datasets and services in an SDI?
- What is the role of the ISO and INSPIRE metadata standards?
- What is the role of OGC catalog services (CSW)?
- How can I access OGC catalog services with QGIS and/or Python Code?
- What other approaches are being used to support the discoverability of datasets and services?

The tutorial is structured as follows:

1. Overview
2. Background
 - 2.1 The role of Metadata in SDIs
 - 2.2 ISO metadata standards and how are they used in the context of INSPIRE
 - 2.3 OGC catalog services (CSW)
3. Practical examples for using Metadata, Catalog Services and Geoportals
 - 3.1 Wind Farm Planning as a Use Case
 - 3.2 Accessing metadata via Geoportals
 - 3.3 Accessing metadata via QGIS
 - 3.4 Accessing metadata via Python from a Jupyter Notebook
4. Summary and Notes on Related Topics

The tutorial takes about 30-45 Minutes for reading and viewing the provided materials, downloading the software and for conducting the hands-on exercises and tasks.

This OER is primarily designed to be used by students in Geoinformatics, Geomatics and similar study programs. It is also useful for students of other study programs and for practitioners who want to enhance their understanding of SDI concepts and technologies. Some basic knowledge of web technologies such as HTTP and Web Services is required. However, you will be able to follow and find links to further resources if needed. Your computer should have 8 GB of usable RAM and 2 GB of usable disk space to download and use the software for this tutorial.

This Tutorial has been developed at the Institute for Geoinformatics, University of Münster. Authors are Tobias Krumrein and Albert Remke.

You are free to use, alter and reproduce the tutorial (H5P content, Storyboard) under the terms of the CC-BY-SA 4.0 license. Any code provided with the tutorial can be used under the terms of the MIT license. Please see the full [license terms](#) as well as all materials on our GitHub page <https://github.com/oer4sdi/OER-MetadataAccessVia-OGC-CSW>.

The OER4SDI project has been recommended by the Digital University NRW and is funded by the Ministry of Culture and Science NRW.

2. Background

Before we can dive into the exercises, we need to explain some terms and technical concepts. Note that in a 30 to 45 minute tutorial we cannot go into all the details and have to limit ourselves to certain approaches. Therefore, we will focus on the use of ISO metadata and classic OGC catalog services (CSW) to find data on protected sites in Germany.

2.1 The role of Metadata in SDIs

Metadata is everywhere in the modern world, especially in the digital world.

Imagine you are in your gallery on your phone and look through your photos. So each picture is the main data itself. But if you click on the details there is much more information about the photo like the resolution or the time the photo was taken. And this information about the data is called the metadata. It helps you to organize, store, find and understand data like the photos in your gallery without it you couldn't sort them by the time it was taken. You can think of metadata as little tags or labels attached to the main data. But metadata isn't just for photos, you can attach metadata to everything even outside the digital world like the author, title or genre of a book. While you think about other areas where metadata is integrated, you can see how important and present metadata is.

Therefore it's not surprising that metadata is playing a crucial role in Spatial Information Infrastructures (SII) as well. SII are very large distributed systems designed to facilitate the discovery, access, and use of geospatial information, often on a regional, national, or international

scale. A term used synonymously is Spatial Data Infrastructure (SDI), which puts more emphasis on ‘data’ as the base material of information.

Many SII^s are focused on public sector information. Their purpose is to make data that is collected for a specific purpose (e.g. management of nature reserves) available and usable for any other applications and for any other users such as researchers, companies, and private individuals. These infrastructures are always managed by one or more organizations on the basis of binding regulations and agreements between the respective stakeholders.

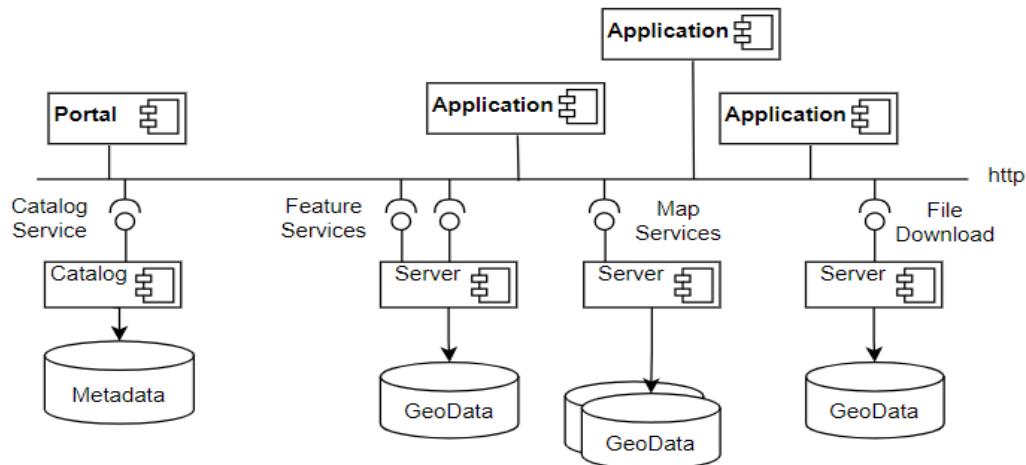


Fig.1: Technical components of Spatial Information Infrastructures

The picture (Fig. 1) shows a simplified overview on the technical components and interfaces of an SII. The core content is the geospatial data that resides somewhere in the infrastructure. A mapping and surveying organization may provide topographic maps and geodata on administrative units, an environmental agency may provide data on protected sites, a XYZ office may provide access to data on ‘whatever’, and so on. In the best case the data is contributed in well-known data models and formats via web services (e.g. data access, data processing, data visualization) that can be accessed through well-known protocols free of charge from anyone, anywhere, and at any time.

Metadata in SDIs provide essential information about spatial data resources, including their content, quality, and spatial extent, enabling users to find and evaluate data that meets their specific needs. It's like a detailed map that helps users navigate through the vast landscape of spatial data, ensuring they can locate and access the right information for their specific needs with confidence and ease. It forms the basis of an SDI architecture.

In this context, you may have heard of the publish-find-bind (PFB) paradigm, in which metadata plays a crucial role:

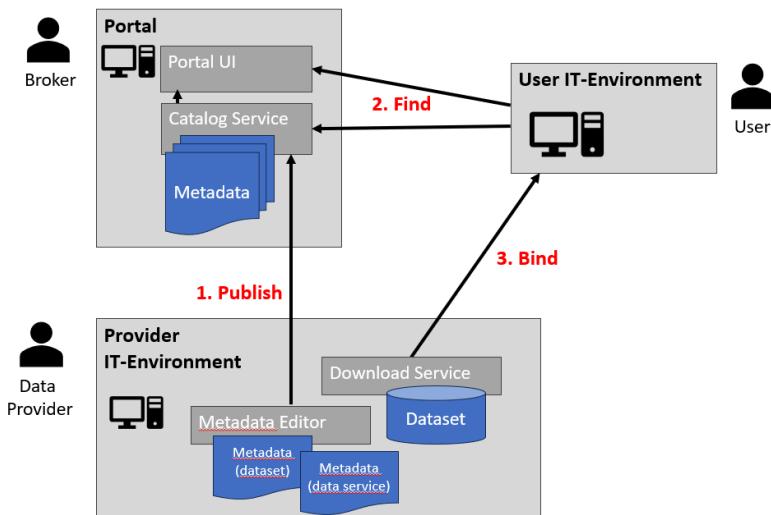


Fig. 2: Metadata supporting the Publish-Find-Bind pattern of open distributed systems

In an SII, all content providers publish their datasets and services by uploading metadata to one or more catalogs that are provided by information brokers (also called clearing houses). The metadata contains information such as title and abstract, spatial extent, quality, data formats, supported interfaces, and a point of contact.

The broker, for example the service center of the national spatial data infrastructure in Germany (GDI-DE), operates the catalog and a portal website with a user interface to the catalog. The catalogs may harvest metadata from other catalogs and thus form a system of federated catalogs with at least one central catalog and portal that provides access to all datasets and services that are available in that specific SII.

Users typically use the portal website to search for and find geospatial datasets and services. The metadata contains all information that is needed for online-access to these resources (binding). They could use the catalog service directly, but without a convenient user interface this is not really advantageous. The catalog interface is made for machine-to-machine interactions, e.g. for synchronizing catalogs or connecting to editing and metadata management systems.

As you can see, metadata and metadata catalogs are essential elements of an SII architecture that enable the efficient provision and use of (geo)information resources across countries and organizational boundaries.

2.2 ISO metadata standards and how are they used in the context of INSPIRE

To ensure the effective exchange and use of geodata, it is important to standardize data models for metadata. The International Organization for Standardization (ISO) has developed a series of

metadata standards, including ISO Standard 19115, which defines a conceptual data model for the description of geospatial data and associated metadata. This model provides a standardized framework for describing the content, quality and spatial extent of geodata as well as information on ownership, access and usage restrictions (see Fig.3).

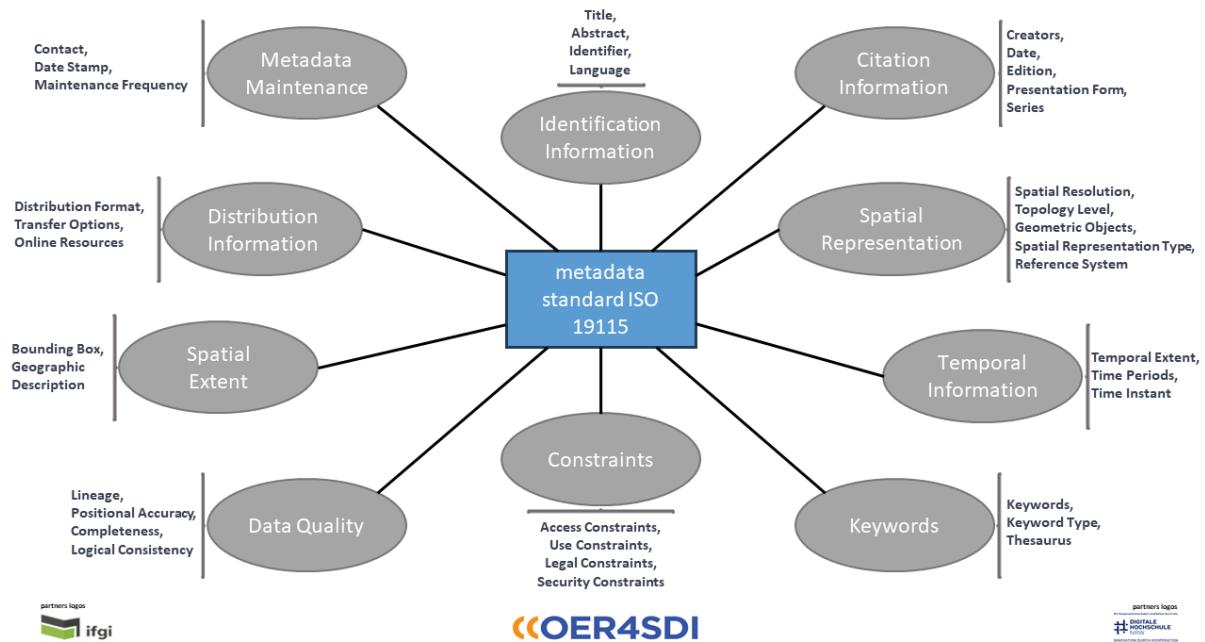


Fig. 3: ISO 19115 Metadata Elements, Overview

To facilitate the implementation of ISO metadata standards, ISO has also developed encoding standards, such as ISO 19139, which provide a standardized syntax and structure for encoding metadata in different formats.

These standards are often quite general and comprehensive and need to be adapted to the requirements of a specific SDI. This is done by deriving specific versions of the metadata standards that comply with all the mandatory rules of the standard and are otherwise tailored to the respective requirements through restrictions and additions (a version of a standard derived in this way is called a profile of the standard).

In our tutorial, we will focus on metadata whose data model is derived from the ISO 19115 standard. Ultimately, there are many similarities between the existing standards.

ISO standards play a special role in Europe, as the European Commission has decided to use ISO metadata standards for the Infrastructure for Spatial Information in Europe (INSPIRE) and has developed its own INSPIRE profile for this purpose. INSPIRE requires Member States to create national metadata catalogs that comply with ISO metadata standards to enable interoperable access to spatial data resources. By standardizing metadata, INSPIRE aims to promote the sharing and reuse of spatial data across Europe, facilitating the interoperability of data and metadata across borders

and sectors. The INSPIRE metadata catalog brings together metadata from the national spatial data infrastructures of the member states.

2.3 OGC catalog services (CSW)

When it comes to accessing metadata catalogs using web technologies, the standards of the Open Geospatial Consortium (OGC) are important. The OGC develops de facto standards that are intended to make geoinformation FAIR - FAIR stands for findable, accessible, interoperable and reusable.

The term "Catalog Services for the Web" (CSW) refers to an OGC interface standard for accessing metadata catalogs in which information about geodata and geodata services is maintained. The CSW standard defines a set of operations that can be executed by metadata catalogs. These operations include querying metadata as well as retrieving and manipulating metadata records.

Catalogs can also interact and form a federated system of catalogs in which search queries are forwarded or metadata is replicated. For example, the INSPIRE catalog service interacts in this way with the catalogs of the SDIs of the member states. In Fig. 4 you can see the structure of the network of SDI catalogs in Germany. Each catalog you see there belongs to a specific geoinformation infrastructure. The smooth cooperation of these catalogs would not be possible without the agreement on common standards.

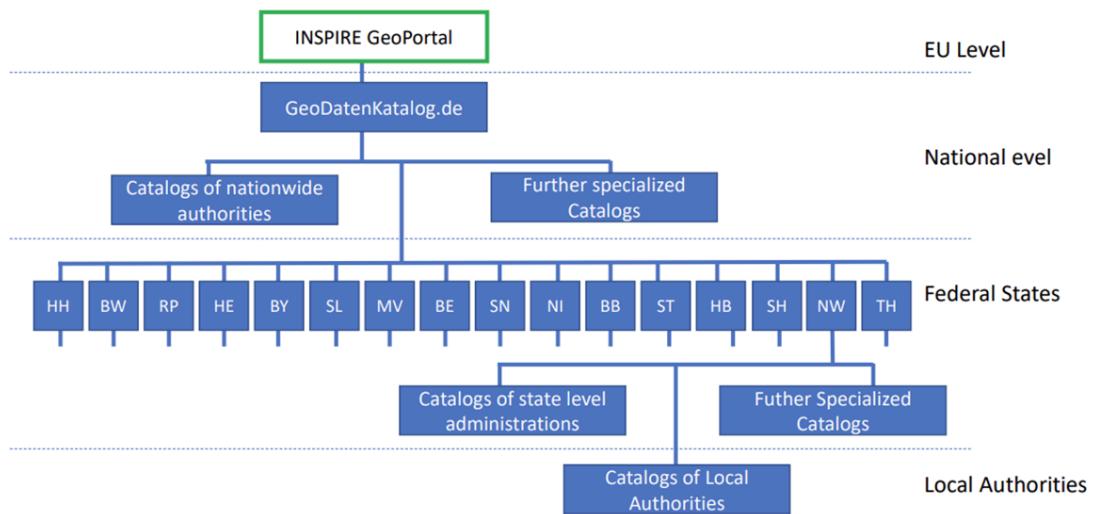


Fig. 4: Network of SDI catalogs in Germany

The ability to share metadata is a key capability of catalog services.

The CSW standard enables searching for information resources using metadata such as keywords, geographic coverage or other search criteria, as well as retrieving metadata records in different encodings, such as XML or JSON.

Compared to the major search engines such as Google, Bing or Yahoo, there are clear differences. These search engines are designed to automatically crawl and index countless websites with

unstructured data so that users can search for information across the entire World Wide Web. Metadata catalogs are usually classic database applications for managing and providing structured metadata about data and data services. While the major search engines still struggle to efficiently support the search for data sets and data services, metadata catalogs are clearly lagging behind in terms of automated data preparation and intelligent search mechanisms.

CSW catalog services typically support the following operations:

- **GetCapabilities:** this operation allows querying the available functions and properties of the CSW, including the supported operations and the data schema.
- **DescribeRecord:** This operation allows you to retrieve information about the available metadata records, including the metadata schema and the supported metadata elements.
- **GetRecords:** This operation enables the retrieval of metadata records based on specific criteria such as keywords, spatial extent or time intervals.
- **getRecordById:** This operation enables the retrieval of metadata records based on their unique identification number.
- **transaction:** This operation supports the addition, update or deletion of metadata records in the CSW.
- **harvest:** This operation is used to collect metadata from other CSWs in order to import them into another catalog.

The CSW standard has been implemented in a number of tools, such as QGIS MetaSearch or ESRI Geoportal Server. These tools provide software solutions for managing and accessing metadata catalogs. We will take a closer look at QGIS in Chapter 4.

Most of the classic spatial data infrastructures such as INSPIRE and the national spatial data infrastructures in Europe currently use the OGC CSW standard. However, a promising RESTful interface standard has already emerged in the new generation of OGC APIs, which is very likely to succeed the CSW in the coming years.

3. Practical examples for using Metadata, Catalog Services and Portals

After all the reading we can now put our new knowledge into action.

First we'll investigate how Geoportals can be used to search for and find geospatial datasets and services and how they use catalog services to accomplish this.

Then we'll have a closer look at QGIS which is capable of interacting with catalog services in a plug-and-play mode, trying to understand what happens "under the hood".

Last not least we'll use Jupyter notebooks and Python code to check how we can interact with catalog services on the level of programming languages.

We'll use the following software configuration for our exercises:

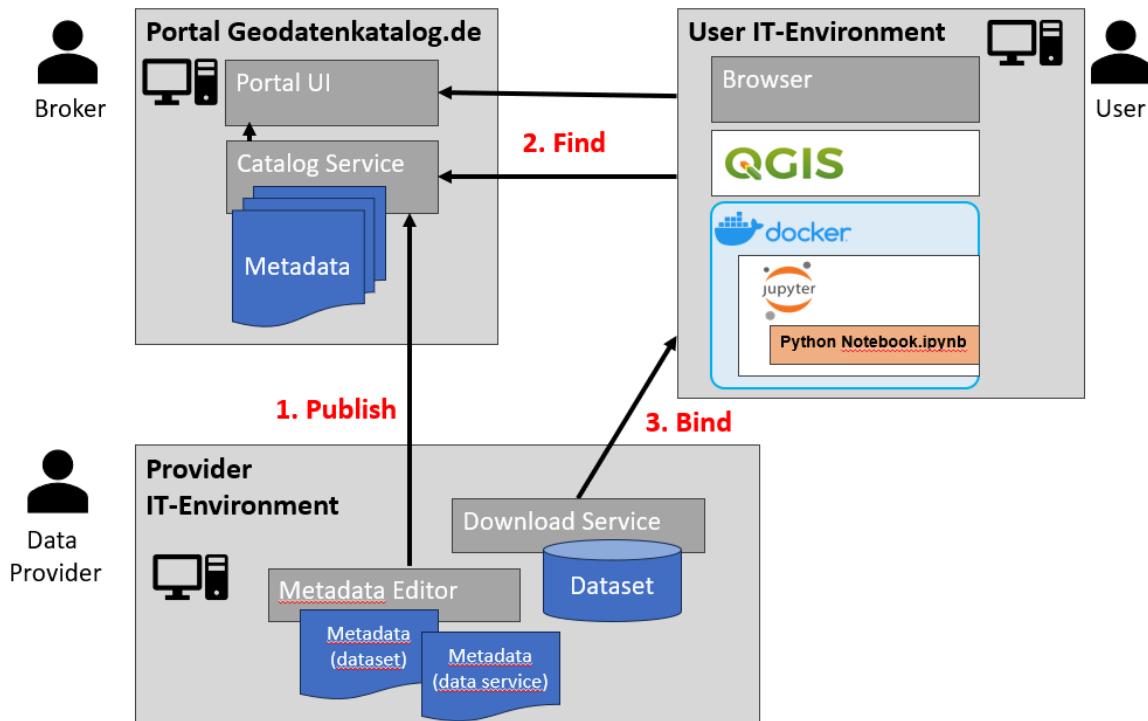


Fig.5: IT components used for the exercises

So, for the exercises you need QGIS and docker running on your computer. No worries, we'll guide you through all steps that are necessary to get the software up and running.

3.1 Wind Farm Planning as a use case

We use the context of wind farm planning to remind ourselves why metadata is so important and how it is used in practice.

Imagine you work in a consulting company that supports clients in the planning, construction and operation of wind farms. Your company has been contracted by a group of investors to propose solutions for the repowering and expansion of an existing wind farm in Lorup, a small community in the Emsland district, Lower Saxony.

In fact, many areas are not suitable as sites for wind farms, since, for example, nature conservation concerns, the well-being of the local population, or competing usage interests have to be taken into account. Before a wind farm planning is approved by the responsible authorities, it must therefore be checked whether it complies with legal regulations and whether competing claims for use have been sufficiently taken into account. Citizens and institutions affected by the impact of the planning have the right to appeal against it and to demand a court decision.

For example, the following exclusion criteria, among others, must be met for wind farm sites:

- Nature reserves, bird sanctuaries, FFH areas are to be excluded.
- Water protection areas (category I + II), smaller than 2000 ha are to be excluded
- Wetlands (More, swamps) 10 ha or larger are to be excluded
- A distance of 800 m from closed residential areas is to be kept
- Campsite, facility for sports, leisure and recreation + 400 m buffer is to be excluded
- Air traffic control facilities (radar and ground navigation facilities) + 3,000 m buffer
- Roads and roadside areas (freeways +40m, otherwise +20m) are to be excluded
- ...

So it is clear, you need high quality up-to-date geospatial data to be able to find the areas that are suitable for wind farm sites. In this tutorial we want to focus on data on Nature reserves.

But how and where to find them?

So, let's start searching for datasets on Nature reserves (Naturschutzgebiete).

3.2 Accessing metadata via geoportals

In our first exercise, we want to take a closer look at how geoportals can be used to search for data and data services and what role catalog services play in this.

We are looking for data on protected areas (such as nature reserves) in the region of Lorup, Lower Saxony, which we need for our virtual wind farm planning project. For this purpose we use the "Geodatenkatalog" of the National Spatial Data Infrastructure Germany, GDI-DE.

The web address of the portal can be found here:

<https://gdk.gdi-de.org/gdi-de/srv/ger/catalog.search#/home>.

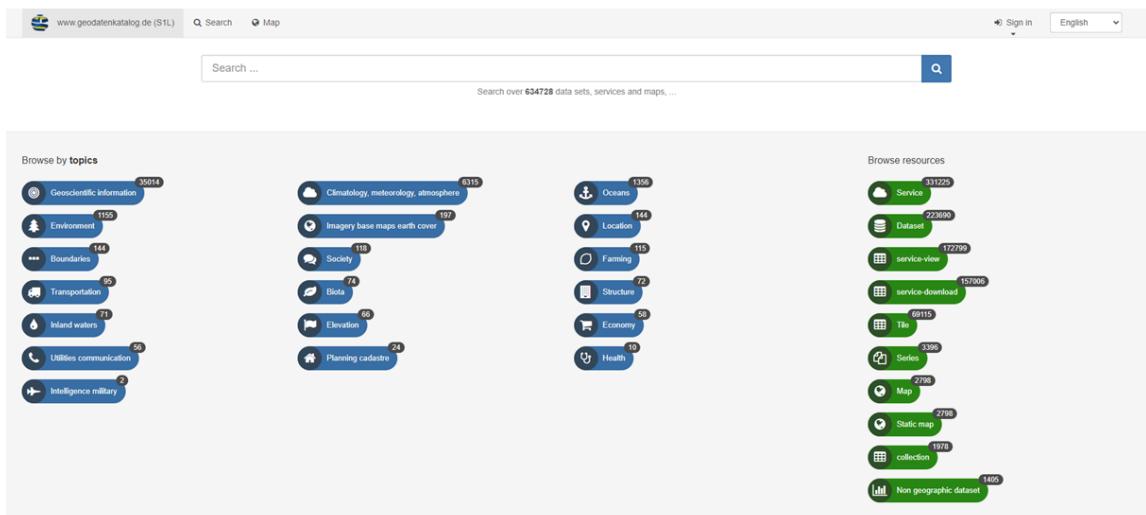


Fig.6: Geodatenkatalog GDI-DE homepage, topic overview

That's the homepage of the Geodatenkatalog. You can change the language easily in the top right corner. Here you'll find metadata of more than 600.000 available datasets, services and maps, too many to go through one by one. Luckily, we can filter by topic categories. In our windfarm planning context the topic category "Environment" might be the right one to go for. When selecting this category, the portal's interface will send a getRecords request to the GDI-DE catalog service which runs in the background, asking for metadata records with the topicCategory "Environment".

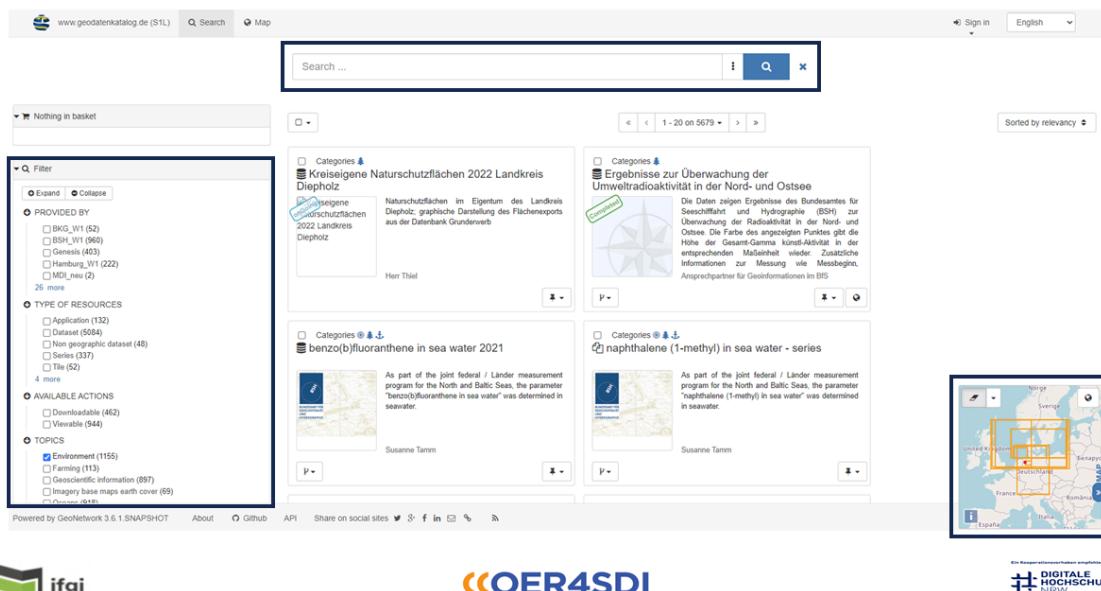


Fig. 7: Geodatenkatalog GDI-DE, Metadatasets in the topic Category "Environment"

Nice! We have filtered out many datasets and services. But we need to further narrow down the result set before we can look into the very details of the metadata. We have several options that we can use: the search bar at the top, a filter section where we can add more filters and a map tool on the bottom right corner. Let's try out the map tool first.

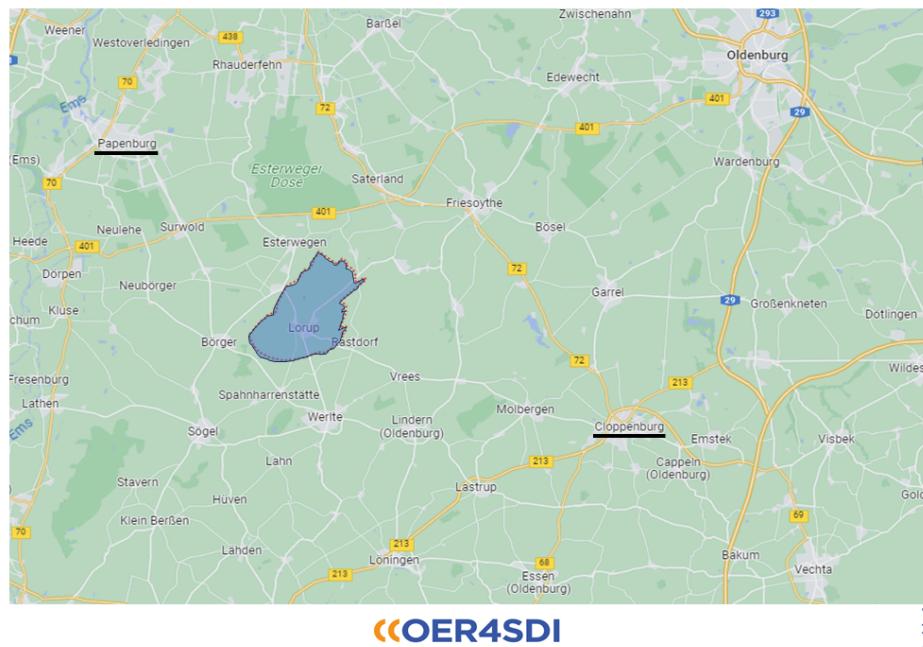


Fig. 8: Geodatenkatalog GDI-DE, searching by defining a bounding box

So, the region of the municipality “Lorup” that we are interested in is located between Papenburg and Cloppenburg in the district of Emsland. Try to zoom to this region and draw a rectangle that represents our area of interest. In the background the portal will send a getRecords request with a bounding box parameter as an additional filter argument.

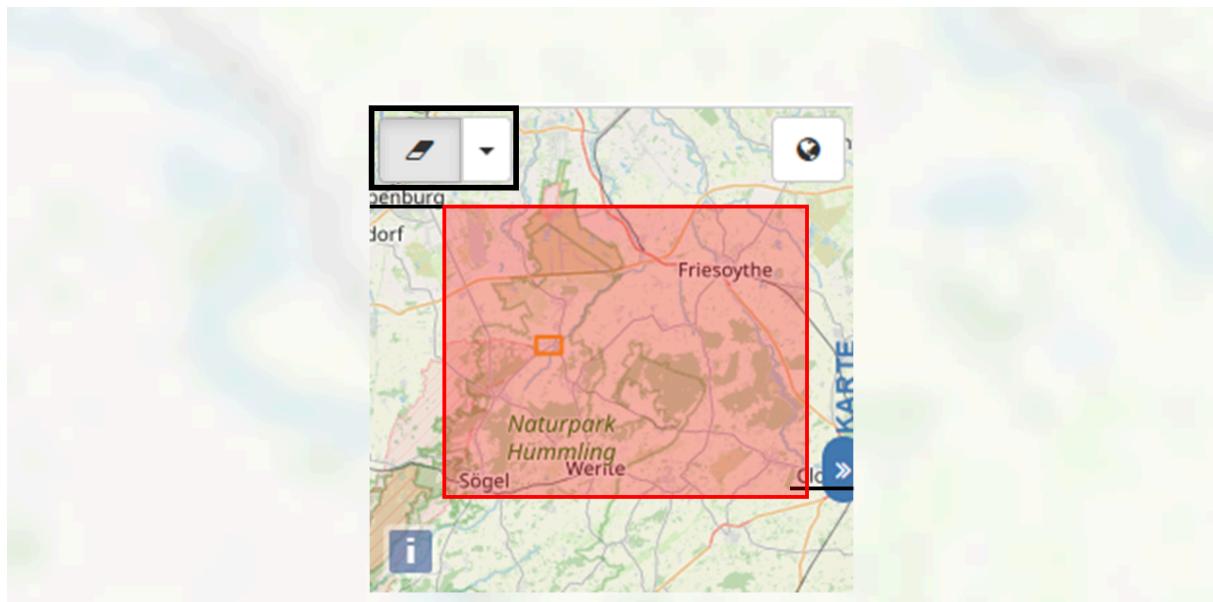
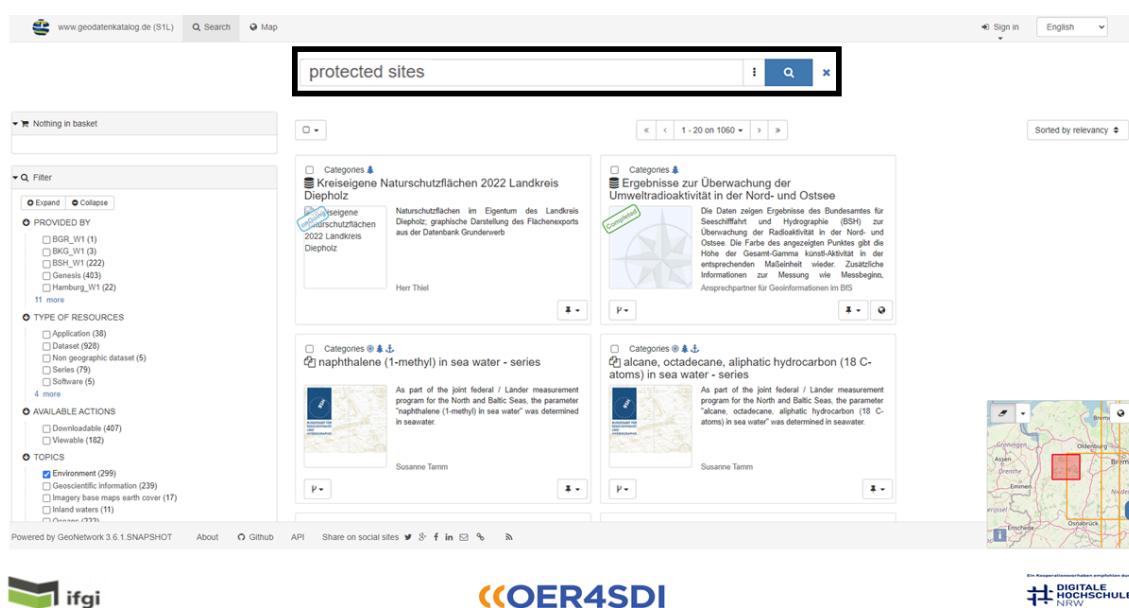


Fig. 9: Geodatenkatalog GDI-DE, draw rectangle for bounding box

There are still too many datasets and services in our result set.



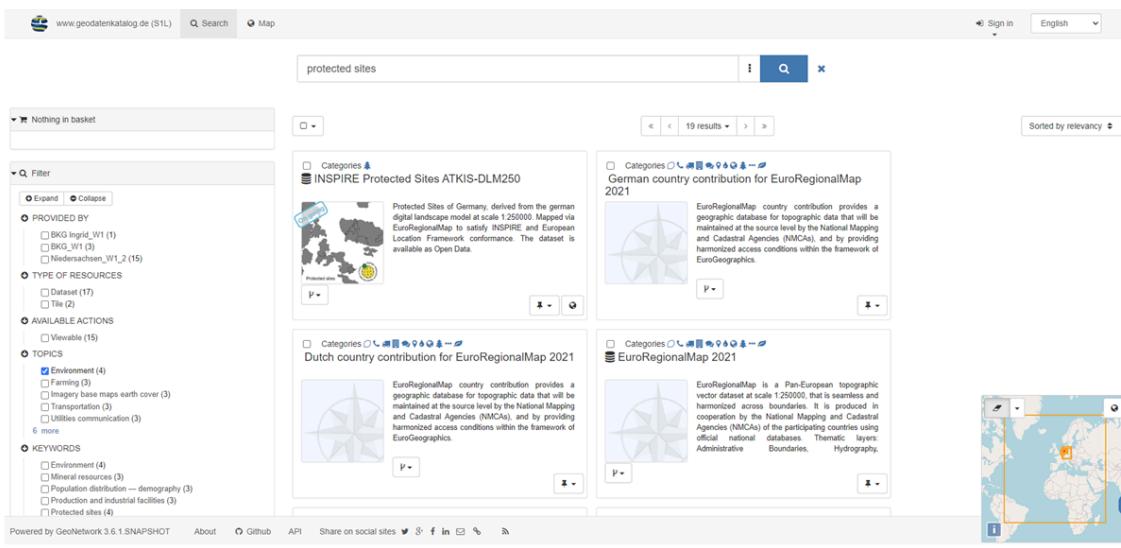
The screenshot shows the search results for "protected sites". The search bar at the top contains the query "protected sites". Below the search bar, there are two main search results displayed in a grid:

- Result 1:** Categories Kreiseigene Naturschutzflächen 2022 Landkreis Diepholz. Description: Naturschutzflächen im Eigentum des Landkreises Diepholz, graphische Darstellung des Flächenelements aus der Datenbank Gruneweb. Author: Herr Thiel.
- Result 2:** Categories Ergebnisse zur Überwachung der Umweltradioaktivität im Nord- und Ostsee. Description: Die Bilder zeigen Ergebnisse des Bundesamtes für Seeschiffahrt und Hydrographie (BSH) zur Überwachung der Radioaktivität in der Nord- und Ostsee. Die Farbe des angezeigten Punktes gibt die Höhe der Gammastrahlung in der entsprechenden Maßeinheit wieder. Zusätzliche Informationen zur Messung wie Messbeginn, Ansprechpartner für Geoinformationen im BSH.

On the left side of the search results, there is a sidebar with various filters and search parameters. At the bottom of the page, there is a map view showing the location of the search results.

Fig. 10: Geodatenkatalog GDI-DE, searching by defining a bounding box

Maybe searching for specific keywords such as „Lorup“ or „Protected Sites“ can create a more specific selection that better fits your interest. We should try filtering more until we have about 20-30 results remaining before investigating the metadata in more detail.



The screenshot shows the search results for "protected sites". There are four dataset cards displayed:

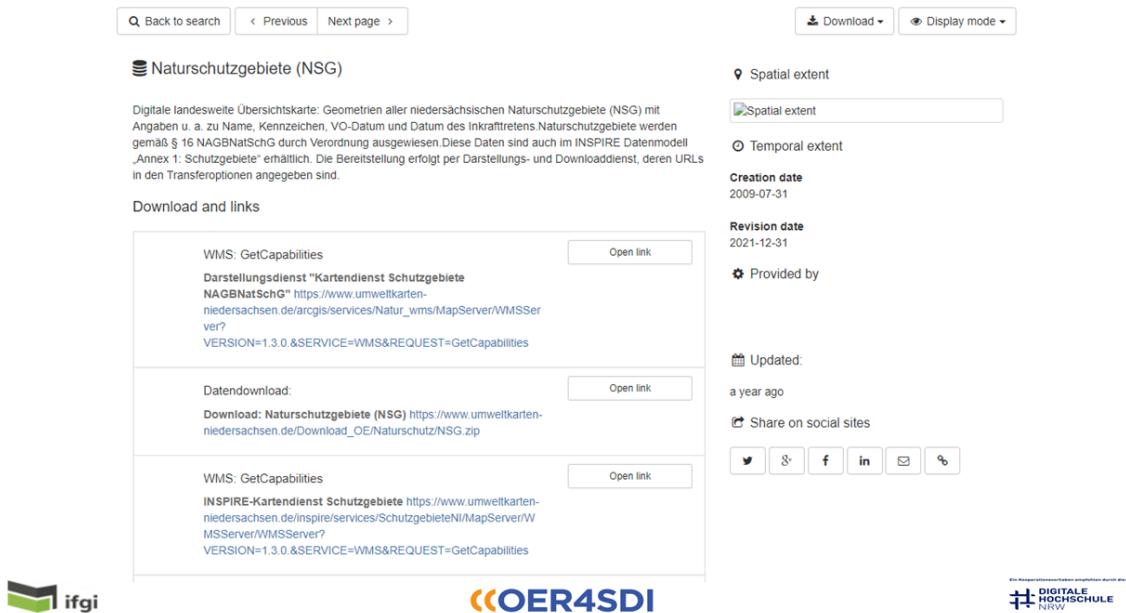
- INSPIRE Protected Sites ATKIS-DLM250**: Protected Sites of Germany, derived from the German digital landscape model at scale 1:250000. Mapped via EuroRegionalMap to satisfy INSPIRE and European framework conformance. The dataset is available as Open Data.
- German country contribution for EuroRegionalMap 2021**: EuroRegionalMap country contribution provides a geographic database for topographic data that will be maintained at the source level by the National Mapping and Cadastral Agencies (NMCAs), and by providing harmonized access conditions within the framework of EuroGeographics.
- Dutch country contribution for EuroRegionalMap 2021**: EuroRegionalMap country contribution provides a geographic database for topographic data that will be maintained at the source level by the National Mapping and Cadastral Agencies (NMCAs), and by providing harmonized access conditions within the framework of EuroGeographics.
- EuroRegionalMap 2021**: EuroRegionalMap is a Pan-European topographic map at scale 1:250000, that is standardised and harmonized across boundaries. It is produced in cooperation by the National Mapping and Cadastral Agencies (NMCAs) of the participating countries using official national databases. Thematic layers: Administrative Boundaries, Hydrography.

On the left, there is a filter sidebar with various categories like PROVIDED BY, TYPE OF RESOURCES, AVAILABLE ACTIONS, TOPICS, and KEYWORDS. The search bar at the top has the query "protected sites". The bottom of the page includes links for Powered by GeoNetwork 3.6.1.SNAPSHOT, About, GitHub, API, and Share on social sites.

Fig. 11: Geodatenkatalog GDI-DE, Results after filtering with searching bar

That worked out quite well; we're only having around 20 datasets left.

Now we can take a closer look at each remaining datasets and click on them to get more information. The dataset „Naturschutzgebiete (NSG)“ seems to fit quite well for our use case at the first look. Let's analyse it in more detail.



The screenshot shows the detailed metadata for the dataset "Naturschutzgebiete (NSG)".

Dataset Title: Naturschutzgebiete (NSG)

Description: Digitale landesweite Übersichtskarte: Geometrien aller niedersächsischen Naturschutzgebiete (NSG) mit Angaben u. a. zu Name, Kennzeichen, VO-Datum und Datum des Inkrafttretens. Naturschutzgebiete werden gemäß § 16 NAGBNatSchG durch Verordnung ausgewiesen. Diese Daten sind auch im INSPIRE Datenmodell „Annex 1: Schutzgebiete“ erhältlich. Die Bereitstellung erfolgt per Darstellungs- und Downloaddienst, deren URLs in den Transferoptionen angegeben sind.

Download and links:

- WMS: GetCapabilities: [Open link](https://www.umweltkarten-niedersachsen.de/arcgis/services/Natur_wms/MapServer/WMServer?VERSION=1.3.0&SERVICE=WMS&REQUEST=GetCapabilities)
- Datendownload: [Download: Naturschutzgebiete \(NSG\)](https://www.umweltkarten-niedersachsen.de/Download_OE/Naturschutz/NSG.zip)
- WMS: GetCapabilities: [Open link](https://www.umweltkarten-niedersachsen.de/inspire/services/SchutzgebieteNI/MapServer/WMServer?VERSION=1.3.0&SERVICE=WMS&REQUEST=GetCapabilities)

Metadata Fields:

- Spatial extent: [Spatial extent](#)
- Temporal extent: [Temporal extent](#)
- Creation date: 2009-07-31
- Revision date: 2021-12-31
- Provided by: [Provided by](#)
- Updated: a year ago
- Share on social sites: [Twitter](#), [Google+](#), [Facebook](#), [LinkedIn](#), [Email](#), [Print](#)

On the left, there are back search, previous, next page, download, and display mode buttons. The bottom of the page includes ifgi, OER4SDI, and Digital Hochschule NRW logos.

Fig. 12: Inspecting the metadata on the dataset “Naturschutzgebiete (NSG)” 1/4

The geoportal uses a request getRecordByID to retrieve the full metadata set from the catalog and provides a user-friendly HTML view that allows us to easily understand the dataset's attributes, such as its name, date of creation, and format. The abstract gives us a good overview on the content of the resource. Directly below you'll find a list of links to access points for view and download services..

One of the most important attributes of information sources is the spatial and temporal coverage as well as the up-to-dateness of the available data. A dataset can fit your topic perfectly, but if it is not up to date - especially when it comes to protected areas - it is completely useless. So always pay attention to the date of the last modification.

About this resource

Categories	Environment	Legal constraints
Keywords	<ul style="list-style-type: none"> INSPIRE Q inspireidentifiziert Q opendata Q Fachbehörde für Naturschutz Q NLWKN Q Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz Q 	<ul style="list-style-type: none"> {"id": "dl-by-de/2.0", "name": "Datenlizenz Deutschland Namensnennung 2.0", "url": "https://www.govdata.de/dl-de/by-2.0", "quelle": "Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz (NLWKN)"} <p>Nutzungsbedingungen: Datenlizenz Deutschland Namensnennung 2.0 (https://www.govdata.de/dl-de/by-2.0). Die Namensnennung lautet: Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz (NLWKN)</p> <p>Nutzungsbedingungen: Datenlizenz Deutschland Namensnennung 2.0 (https://www.govdata.de/dl-de/by-2.0). Die Namensnennung lautet: Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz (NLWKN)</p>
GEMET - INSPIRE themes, version 1.0	<ul style="list-style-type: none"> Schutzgebiete Q Protected sites Q 	
Spatial scope	<ul style="list-style-type: none"> Regional Q 	
Semantischer Netzwerk Service (SNS)	<ul style="list-style-type: none"> Naturschutz Q Naturschutzgebiet Q 	
Language	<ul style="list-style-type: none"> Deutsch 	
Resource identifier	<ul style="list-style-type: none"> https://registry.gdi-de.org/id/de.ni.mu.nlwkn.csv/EE85FE0F-BD05-4A6D-813B-6ABC4514B18B 	
Classification	Unbeschränkt	
	Credit	© 2021, daten@nlwkn.niedersachsen.de
	Contact for the resource	<ul style="list-style-type: none"> ✉ Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz (NLWKN) Ansprechpartner : NLWKN – Daten-Servicestelle (NLWKN – Daten-Servicestelle)



Fig. 13: Inspecting the metadata on the dataset “Naturschutzgebiete (NSG)” 2/4

Technical information

Update frequency	["Vierteljährlich","Vierteljährlich"]
Representation type	Vektor
Scale	• 25000
Coordinate reference system	• EPSG:4647
Lineage	<p>Zuständige Stellen waren bis 31.12.2004 die ehemaligen Bezirksregierungen, von 2005 bis Ende 2007 in Natura 2000-Gebieten i.d.R. der Niedersächsische Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz (NLWKN) und außerhalb von Natura2000-Gebieten die unteren Naturschutzbehörden. Seit Anfang 2008 liegt die Zuständigkeit für die Ausweisung von Naturschutzgebieten generell bei den unteren Naturschutzbehörden (UNB).</p> <p>Digitalisierung auf Grundlage der digitalen topografischen Karte 1:25.000 unter Anwendung der Kartenvorlage des Rechtsetzungskaktes.</p>



Fig. 14: Inspecting the metadata on the dataset “Naturschutzgebiete (NSG)” ¾

Metadata information

 Download metadata	
Contact	<p>✉ Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz (NLWKN)</p> <ul style="list-style-type: none"> Ansprechpartner : NLWKN – Daten-Servicestelle (NLWKN – Daten-Servicestelle)
Metadata language	• Deutsch
Identifier	EE85FE8F-BD05-4A6D-813B-6ABC4514B18B



Fig. 15: Inspecting the metadata on the dataset “Naturschutzgebiete (NSG)” 4/4

If you scroll further down, you will see more detailed information on the dataset, e.g. on the source, the coordinate reference system, points of contact and the unique ID¹ of the metadata set, which had been used by the portal to retrieve the metadata record from the catalog using the CSW operation getRecordByID.

¹ ID of the metadata record on Naturschutzgebiete (NSG): EE85FE8F-BD05-4A6D-813B-6ABC4514B18B

In addition to the HTML interface you have the possibility to download the plain .xml file of the metadata. Use the link (box seven in Fig.11) to download the XML file and open it in our preferred browser².

Try to find some of the information that was also displayed in the HTML representation. Keep in mind that the Geoportal UI gets its information from the .xml file, and not all metadata elements contained therein are necessarily displayed.

Below you will also find an excerpt from the .xml file in case you have problems opening it:

```
<gmd:MD_Metadata xmlns:gmd="http://www.isotc211.org/2005/gmd"
  xmlns:gco="http://www.isotc211.org/2005/gco"
  xmlns:srv="http://www.isotc211.org/2005/srv"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:gfm="http://www.isotc211.org/2005/gfm"
  xmlns:base="http://www.disy.de/preludio2/base"
  xsi:schemaLocation="http://www.isotc211.org/2005/gmd
  http://schemas.opengis.net/iso/19139/20060504/gmd/gmd.xsd"
  uuid="EE85FE8F-BD05-4A6D-813B-6ABC4514B18B">
  <link type="text/css" rel="stylesheet" id="dark-mode-custom-link"/>
  <link type="text/css" rel="stylesheet" id="dark-mode-general-link"/>
  <style lang="en" type="text/css" id="dark-mode-custom-style"/>
  <style lang="en" type="text/css" id="dark-mode-native-style"/>
  <style lang="en" type="text/css" id="dark-mode-native-sheet"/>
  ...
  <gmd:identificationInfo>
    <gmd:MD_DataIdentification uuid="093121e3-f872-4aa2-b9db-40ee82cc1a18">
      <gmd:citation>
        <gmd:CI_Citation uuid="60e4561f-7aea-49f3-93cb-1c66ba52f406">
          <gmd:title>
            <gco:CharacterString>Naturschutzgebiete (NSG)</gco:CharacterString>
          </gmd:title>
          <gmd:alternateTitle>
            <gco:CharacterString>Naturschutzgebiete_DTK25</gco:CharacterString>
          </gmd:alternateTitle>
          <gmd:date>
            ...
          </gmd:date>
          <gmd:date>
            ...
          </gmd:date>
          <gmd:identifier>
```

² we've done so for you so that you can find the dataset as well at our GitHub repository: [here](#)

```
<gmd:MD_Identifier uuid="cb1b4ff1-bf68-4e5a-aa84-73043f65501f">
  <gmd:code>
    <gco:CharacterString>https://registry.gdi-de.org/id/de.ni.mu.nlwkn.csv/EE85FE8F-BD05-4A6D-813B-6ABC4514B18B</gco:CharacterString>
  </gmd:code>
</gmd:MD_Identifier>
</gmd:identifier>
<gmd:citedResponsibleParty>
  ...
</gmd:citedResponsibleParty>
<gmd:presentationForm>
  ...
</gmd:presentationForm>
</gmd:CI_Citation>
</gmd:citation>
<gmd:abstract>
  <gco:CharacterString>Digitale landesweite Übersichtskarte: Geometrien aller niedersächsischen Naturschutzgebiete (NSG) mit Angaben u. a. zu Name, Kennzeichen, VO-Datum und Datum des Inkrafttretens. Naturschutzgebiete werden gemäß § 16 NAGBNatSchG durch Verordnung ausgewiesen. Diese Daten sind auch im INSPIRE Datenmodell „Annex 1: Schutzgebiete“ erhältlich. Die Bereitstellung erfolgt per Darstellungs- und Downloaddienst, deren URLs in den Transferoptionen angegeben sind.</gco:CharacterString>
</gmd:abstract>
```

Did you identify some elements of the dataset description from the portal in this .xml metadata file?

We should keep in mind that XML is mainly intended for machine-to-machine communication, e.g. with QGIS, Python or other catalogs. But sometimes it is important to read the textual content of XML files and search for specific information. The first part of the .xml file describes the structure of the .xml sheet. The metadata information about the record you are looking for is then described in `<gmd:identificationInfo>`. Here you will find information about the title, the summary or the identifier of the data set. The suffix `</gmd:>` stands for the namespace "geospatial metadata".

We have now seen how the portal functions and the underlying metadata catalog can be used to find out about the information resources available in an SDI.

In the next step, we will take a closer look at how GIS systems such as QGIS support access to CSW metadata catalogs

3.3 Accessing metadata via QGIS MetaSearch

3.3.1 QGIS Installation

If you already have QGIS 2.0 or higher installed you can skip this part and go directly to 3.3.2, because the plugin MetaSearch, which you're using later, is included by default.

For downloading QGIS please follow the next steps:

- Go to the QGIS Website <https://www.qgis.org/en/site/forusers/download.html>
- Choose your operating system from the options that are listed
- Than download QGIS (this step may take some time, in this time we can already continue with the next part(s) and come back later for the last two steps)
- After downloading run the installer and follow the prompts to install QGIS on your computer
- Activate the metaSearch Plugin via >plugins >manage and install plugins

3.3.2 QGIS MetaSearch

This exercise is about exploring how QGIS is able to connect to existing SDI catalogs to search for resources and integrate them into the GIS environment. For this purpose we will use the QGIS plugin “MetaSearch”.

Please open QGIS and start a new project.

Use the menu bar to navigate to the option >Web >MetaSearch.

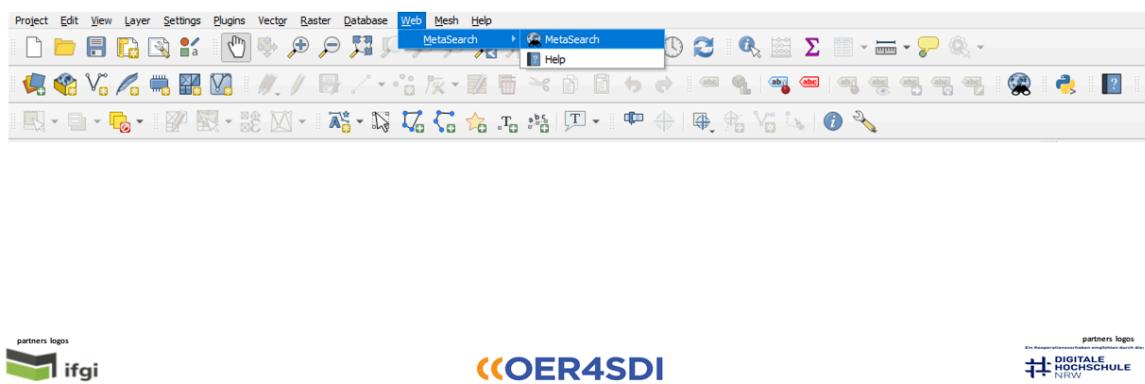


Fig. 16: Navigating to the plugin MetaSearch via the QGIS Menubar

It should open a new window with the MetaSearch tool. Navigate to “Services” (Dienste) and create a new connection with “New”.

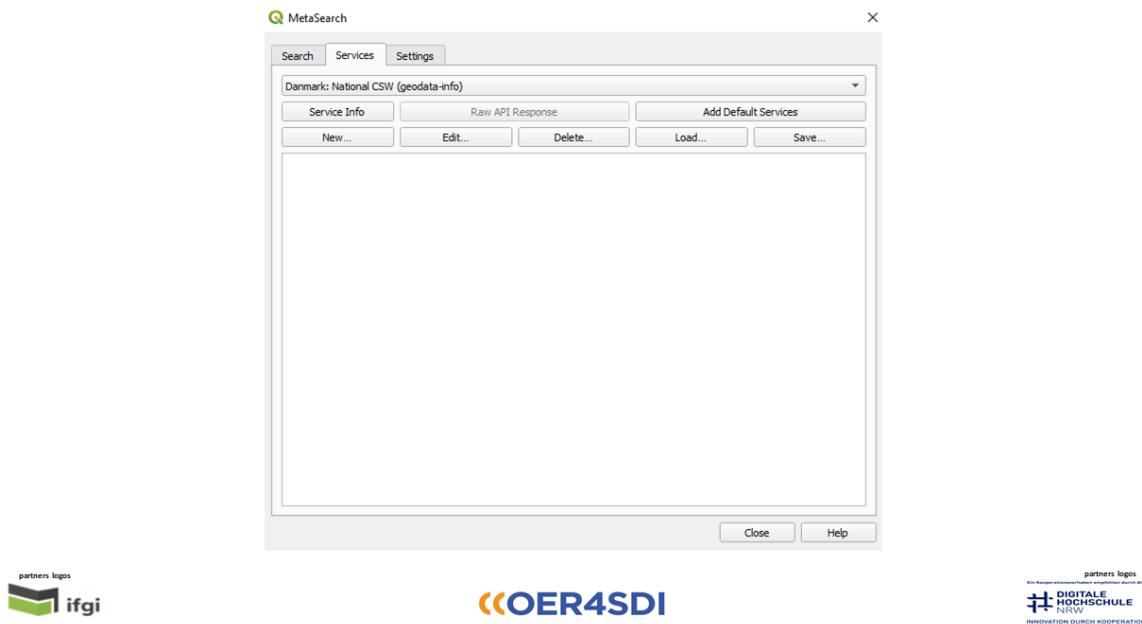


Fig. 17: QGIS MetaSearch New Service

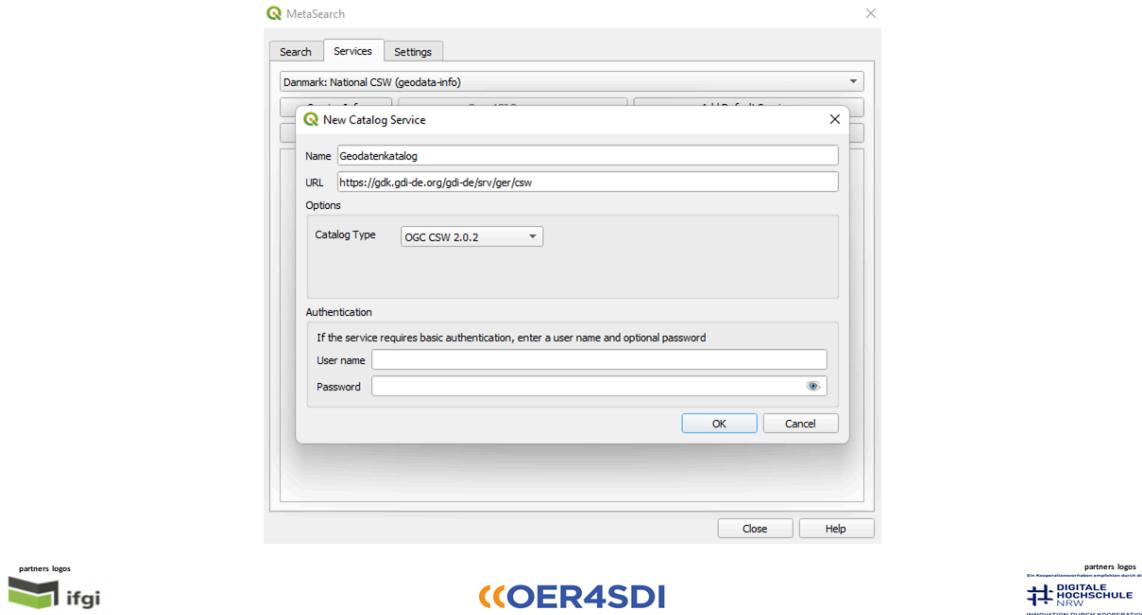


Fig.18: New MetaSearch connection

Now you can define a name for your new connection and type in the URL of the catalogue service and click "Ok". We want to use the "Geodatenkatalog" of GDI-DE again, which has the url: <https://gdk.gdi-de.org/gdi-de/srv/ger/csw>

You can find the url by searching for "Geodatenkatalog" in the Geodatenkatalog and examining the metadata as you have done in the previous section.

Now we can access the CSW by activating the tab “Service Info” (Dienstinfo). QGIS will send a GetCapabilites request to the GDI-DE catalog service and display the information from the response message in a readable form.

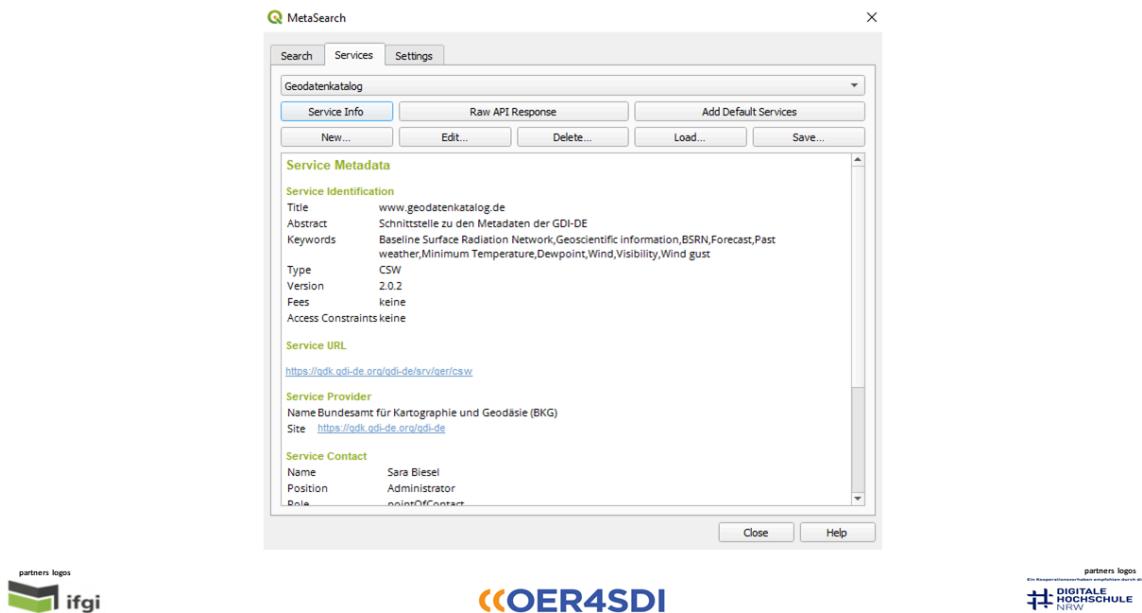


Fig. 19: MetaSearch test if new connection is active

If this was successful, you're evidently connected to the Geodatenkatalog and ready to start with searching for datasets.

The tab “Search” provides you with a form that you can use to specify your search request. QGIS will use the content of the form to generate a getRecords request with all the query parameters and send it to the CSW catalog service. The results from the getRecords response of the catalog service will be shown in the results section.

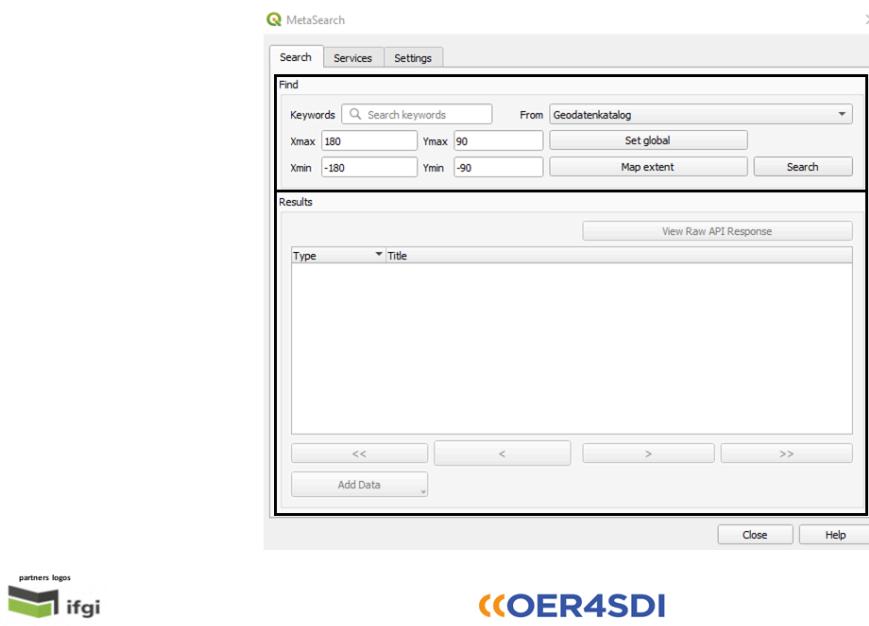


Fig. 20: Searching in MetaSearch

In the search section you have two options to filter in the datasets. You can search for keywords and use a BBox as a filter. Let's start filtering through keywords. You can also type in more than one keyword. Can we find the dataset which we found in the last exercise here, too?

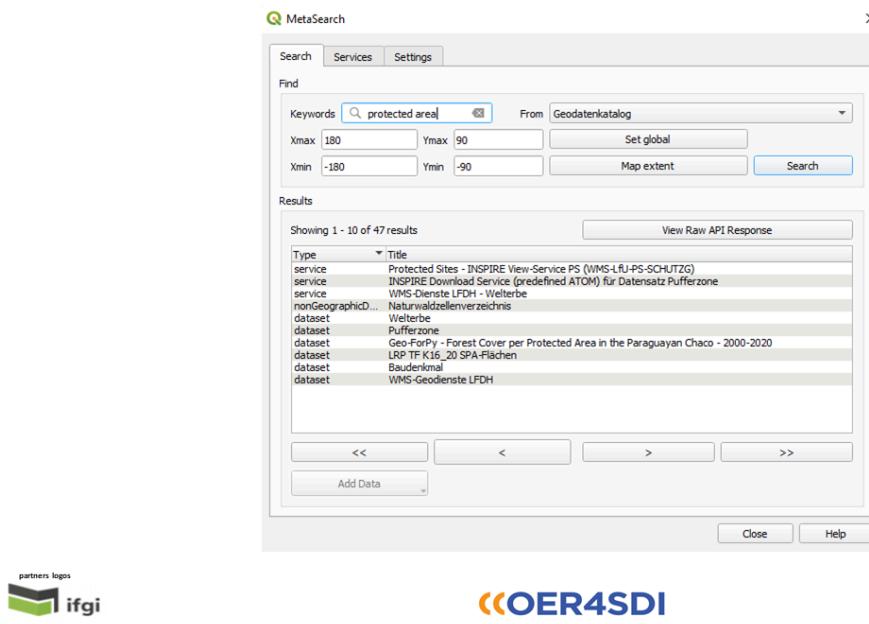


Fig. 21: MetaSearch searching for protected area

Double clicking an item opens a new window displaying details of the metadata record. In this case, QGIS has sent a `getRecordByID` message to the catalog which responded with the full XML encoded

metadata record. Have you found the dataset that we used before? Just check the abstract or the Identifier (EE85FE8F-BD05-4A6D-813B-6ABC4514B18B).

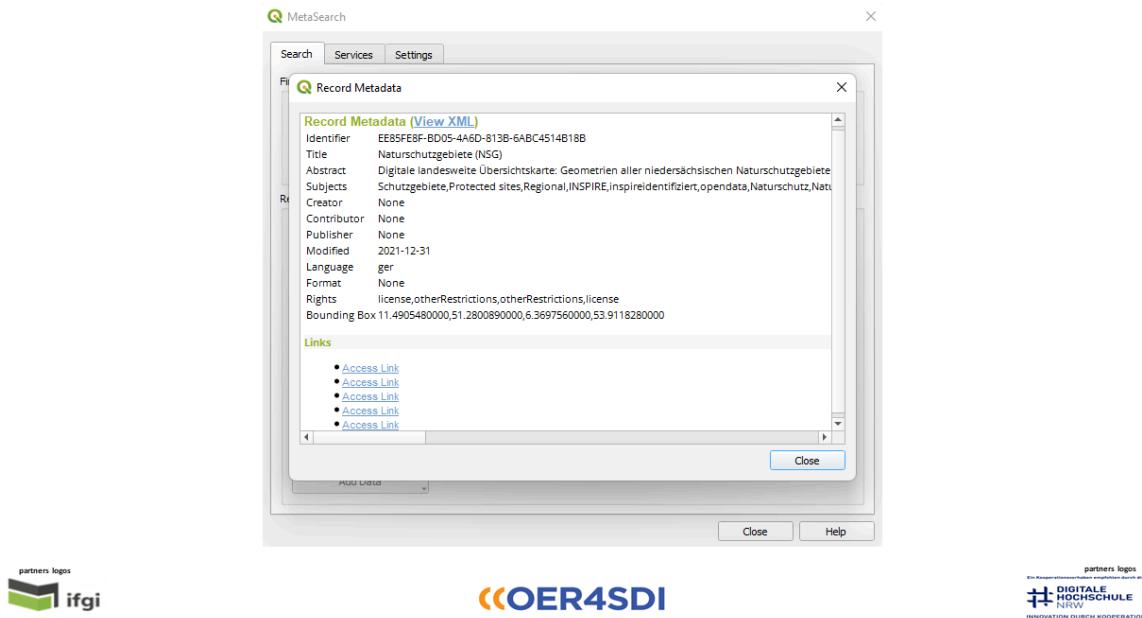


Fig. 22: MetaSearch Naturschutzgebiete (NSG)

You also have the option to view the XML encoded metadata with all its details that has been sent from the catalog service. As you can see, the XML file conveys exactly the same information on the NSG dataset itself but looks quite different due to the fact that the GetRecordsByID response has a specific encoding.

This XML file does not appear to have any style information associated with it. The document tree is shown below.

```

▼ <csw:GetRecordByIdResponse xmlns:csw="http://www.opengis.net/cat/csw/2.0.2">
  <link type="text/css" rel="stylesheet" id="dark-mode-custom-link"/>
  <link type="text/css" rel="stylesheet" id="dark-mode-general-link"/>
  <style lang="en" type="text/css" id="dark-mode-custom-style"/>
  <style lang="en" type="text/css" id="dark-mode-native-style"/>
  <style lang="en" type="text/css" id="dark-mode-native-sheet"/>
  ▼ <csw:Record xmlns:dct="http://purl.org/dc/elements/1.1/" xmlns:geonet="http://www.fao.org/geonetwork" xmlns:ows="http://www.opengis.net/ows"
    xmlns:dct="http://purl.org/dc/terms/">
    <dct:identifier>EE85FE8F-BD05-4A6D-813B-6ABC4514B18B</dct:identifier>
    <dct:date>2022-10-21T12:47:26+02:00</dct:date>
    <dct:title>Naturschutzgebiete (NSG)</dct:title>
    <dct:type>dataset</dct:type>
    <dct:subject>Schutzgebiete</dct:subject>
    <dct:subject>Protected sites</dct:subject>
    ...
    ▼ <ows:BoundingBox crs="urn:ogc:def:crs:EPSG::4647">
      <ows:LowerCorner>11.4905480000 51.2800890000</ows:LowerCorner>
      <ows:UpperCorner>6.3697560000 53.9118280000</ows:UpperCorner>
    </ows:BoundingBox>
    <dct:URI name="Darstellungsdienst 'Schutzgebiete NAGBNatSchö'" description="WMS: GetCapabilities">https://www.umweltkarten-niedersachsen.de/arcgis/services/Natur_wms/MapServer/WMServer?VERSION=1.3.0.&SERVICE=WMS&REQUEST=GetCapabilities</dct:URI>
    <dct:URI name="Download: Naturschutzgebiete (NSG)" description="Datadownload">https://www.umweltkarten-niedersachsen.de/Download_OE/Naturschutz/NSG.zip</dct:URI>
    <dct:URI name="INSPIRE-Kartendienst Schutzgebiete" description="WMS: GetCapabilities">https://www.umweltkarten-niedersachsen.de/inspire/services/SchutzgebieteNI/MapServer/WMServer?VERSION=1.3.0.&SERVICE=WMS&REQUEST=GetCapabilities</dct:URI>
    <dct:URI name="INSPIRE View Service Schutzgebiete" description="InspireViewService: GetCapabilities">https://www.umweltkarten-niedersachsen.de/inspire/rest/services/SchutzgebieteNI/MapServer/exts/InspireView/service?REQUEST=GetCapabilities&SERVICE=WMS</dct:URI>
    <dct:URI name="INSPIRE Download Service Schutzgebiete" description="WFS: GetCapabilities (2.0.0)">https://www.umweltkarten-niedersachsen.de/inspire/rest/services/SchutzgebieteNI/MapServer/exts/InspireFeatureDownload/service?REQUEST=GetCapabilities&SERVICE=WFS</dct:URI>
  </csw:Record>
</csw:GetRecordByIdResponse>

```

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Fig. 23: MetaSearch XML Naturschutzgebiete (NSG)

As you can see, QGIS can interact with CSW catalog services in plug-and-play mode because it has implemented the OGC CSW interface standard and now only needs the web address of the service to establish the connection to the service. To do this, QGIS first uses the Get_Capabilities and DescribeRecords operations to retrieve all relevant details about the interface of the catalog instance. QGIS then uses your entries in the query form to search for metadata records that match your search criteria using the GetRecords() function.

3.4 Accessing metadata via Python from a Jupyter Notebook

In our last exercise, we will learn how to access standardized catalog services using a programming language (here: Python).

3.4.1 Installing Docker, Jupyter and a Python Notebook

The software environment that we need for this exercise is Docker:

- a) Install Docker Desktop: Go to the official web site <https://docs.docker.com/get-docker/> and follow the guidance which is provided there to install docker on your computer (8GB usable RAM recommended).
- b) Download the GitHub Repository of this Tutorial (<https://github.com/oer4sdi/OER-MetadataAccessVia-OGC-CSW>) and unzip it in your wanted working directory
- c) Make sure Docker Desktop is up and running
- d) Open a terminal and change to your working directory
- e) Use "docker-compose up --build" to build and run the docker container

Once this is complete, your terminal output should look similar to this:

```
To access the notebook, open this file in a browser:  
file:///home/jovyan/.local/share/jupyter/runtime/nbserver-7-open.html  
Or copy and paste one of these URLs:  
http://172.0.0.1:8888/?token=3a2e5088e85cde486ab00cfbf5a5ef7346e51092980f43ce  
or http://127.0.0.1:8888/?token=3a2e5088e85cde486ab00cfbf5a5ef7346e51092980f43ce
```

Fig. 24: Example of a correct response in the terminal after the docker container is running

To access the python notebook look out for the link <http://127.0.0.1:8888/?token=...> in your output (it should look like the one on the bottom in the picture above). Copy the link and the token (the latter will be created new every time you start the container). Paste the link to your preferred browser to access the Jupyter server which displays the notebooks that can be used.

3.4.2 Jupyter Notebook

After installation, please start the notebook "Accessing_Metadata_with-jupyter.ipynb" and work through it on your own. It will show you a different approach to accessing CSW metadata catalogs.

You will work with the Python package OWSLib, which supports interaction with OGC web services such as CSW, WMS or WFS. You will connect to the catalog using the same URL you used in QGIS. You will also use the same operations as in the previous exercises, with the difference that you will now have to configure and send these requests yourself and also receive and process the responses from the service by yourself.

(please work through the Notebook Accessing_Metadata_with-jupyter.ipynb)

Once you have completed this exercise, you can shut down and clean up your working environment.

To do this, you must enter "docker-compose down" in the terminal in which you created and started the Docker container. This will cause the Docker container to be shut down. If you also want to delete the docker image, enter "docker image rm oer_jupyter".

4. Summary and Notes on Related Topics

The key messages of this tutorial are:

- Metadata and metadata catalogs are key components of SDIs supporting the publish-find-bind paradigm of open distributed systems by making existing information resources discoverable and accessible.
- Metadata standards are essential means for (meta) data interoperability
- Standardized interfaces such as the OGC CSW allow software clients of any kind to connect to catalogs in a plug-and-play mode

But, the OGC CSW is not the only interface standard on stage..

Gaining Ground: OGC API Records

As for the CSW type of catalog services be aware that it implements the classic style of OGC Web Services, heavily relying on sending remote procedure calls using XML encoded message formats. The new “OGC API Records” standard implements a more lightweight RESTful interface based in JSON encodings that is supposed to take over within the next few years. For more information we recommend visiting the OGC API workshop on this service type that is provided by the Open Geospatial Consortium: <https://ogcapi-workshop.ogc.org/api-deep-dive/records/>

Linked Data & DCAT

As well you should pay attention to DCAT - the data catalog vocabulary, which is based on the linked data principles. In its core, it consists of a set of well-defined terms that can be used for cataloging datasets and data services. It reuses to a maximum extent terms from already existing controlled vocabularies (such as the Dublin Core Vocabulary) and defines new ones only if evidently needed.

DCAT has its strengths in integrating heterogeneous metadata from various resources by describing the relation of (new) terms to existing ones which can be used to automate the integration of these metadata sources. The European Data portal <https://data.europa.eu> uses DCAT application profiles to harvest data from many metadata sources all over Europe. If you want to dive into thos topic you might find this web site helpful:

<https://data.europa.eu/en/publications/dastories/linking-data-data-catalogue-vocabulary-application-profile>

And another one: STAC

The SpatioTemporal Asset Catalog (STAC) is an open standard for describing geospatial data in a JSON based machine-readable format. STAC is designed to handle both spatial and temporal aspects of geospatial assets (e.g. data, organized in files), making it particularly well-suited for Earth observation data, satellite imagery, and other time-series data. A really exiting new citizen in town. So if you want

to learn more about STAC we recommend visiting the tutorials on the official STAC web site at:
<https://stacspec.org/en/tutorials/intro-to-stac/>

Hey, you made it! 😊

Now you should be able to answer the following questions:

- How can we use metadata for discovering datasets and services in an SDI?
- What is the role of the ISO and INSPIRE metadata standards?
- What is the role of OGC catalog services (CSW)?
- How can I access OGC catalog services with QGIS and/or Python Code?
- What other approaches are being used to support the discoverability of datasets and services?

We hope that you enjoyed reading and working with the tutorial and the practical examples and that you were able to deepen your understanding of SDIs.

Thanks for your time!