



Establishing the European Geological Surveys Research

Area to deliver a Geological Service for Europe

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## **GENERAL INTRODUCTION**

The GeoERA Information Platform project (GIP-P) is established to support the 14 geoscientific projects (GSPs) comprised within GeoERA in organising and disseminating the geoinformation generated within their frameworks. The GIP-P is entitled to safeguard the results of the research performed by the various GeoERA projects in terms of geospatial data, reports and structured databases. This will be done by extending the current European Geological Data Infrastructure (EGDI), so that it can display and share the results from the various GeoERA projects with citizens, researches and/or stakeholders.

The different GeoERA projects deal with multiples aspects of geosciences in the fields of groundwater, raw materials, and geo-energy. These projects will thus be generating a variety of products, which will require specific functionalities to be developed to store, show and share them properly. It is thus important that the GIP-P has a good understanding of the products that each project will generate, and the functionalities required to show them properly. This is assured by Work Package 2 (WP2), which coordinates the interactions between the various GeoERA projects and the GIP-P.

## **EXECUTIVE REPORT SUMMARY**

Despite the diversity and multidisciplinary of the various GeoERA projects, all of them address geological topics. Hence, different projects might produce similar or complementary geoinformation. It is thus likely that some overlap occurs between the geoinformation produced by the different projects. That is especially true for projects delivering data from the same or neighbouring areas.

If the potential overlaps between projects in terms of geoinformation are identified beforehand, they could be transformed into synergies. The present report aims to highlight the possible overlaps and potential synergies that could be established between different GeoERA projects.



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## DEFINITIONS

**GeoERA:** Establishing the European Geological Surveys Research Area to deliver a Geological Service for Europe

**Functionality:** the range of operations that can be run on a computer or other electronic system.

**Product:** A deliverable produced by a project, which will be delivered to EGDI to make it available to end users. Types of product:

- “GIS data”: raster, vector, and coverages (ESRI shapefile, GRID, etc.).
- Web services: WCS, WMS, WFS, SOS, ATOM, etc
- Documents: PDF, images, papers, etc.
- Other data: XLS, CSV, TXT, etc.

**Attributes:** information associated with a geographic feature in GIS. Attributes are usually stored in tables linked to the feature by a unique identifier.

**Geoinformation** (equivalent to spatial data and geodata): information concerning phenomena implicitly or explicitly associated with a location within Earth.

**Geological model:** A digital representation of portions of the earth’s crust based on geophysical and geological observations.

## ABBREVIATIONS

**EGDI:** European Geological Data Infrastructure

**PM:** project month

**GIP-P:** GeoERA Information Platform Project

**GSPs:** Geoscientific projects within GeoERA

**WP:** work package

**3DGEO-EU (in tables abbreviated as 3D):** 3D geomodelling for Europe.

**GARAH (in tables abbreviated as GA):** Geological Analysis and Resource Assessment of selected Hydrocarbon systems.

**GeoConnect<sup>3d</sup> (in tables abbreviated as Ge<sup>3</sup>):** Cross-border, cross-thematic multiscale framework for combining geological models and data for resource appraisal and policy support.

**HIKE (in tables abbreviated as HI):** Hazard and Impact Knowledge for Europe.

**HotLime (in tables abbreviated as Hot):** Mapping and Assessment of Geothermal Plays in Deep Carbonate Rocks – Cross-domain Implications and Impacts

**MUSE (in tables abbreviated as MU):** Managing Urban Shallow Geothermal Energy.



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**HOVER (in tables abbreviated as HO):** Hydrological processes and Geological settings over Europe controlling dissolved geogenic and anthropogenic elements in groundwater of relevance to human health and the status of dependent ecosystems.

**RESOURCE (in tables abbreviated as RE):** Resources of groundwater harmonized at cross-border and pan- European scale.

**TACTIC (in tables abbreviated as TA):** Tools for Assessment of Climate change Impact on groundwater and adaptation Strategies.

**VoGERA (in tables abbreviated as Vo):** Vulnerability of Shallow Groundwater Resources to Deep Subsurface Energy-Related Activities.

**EuroLithos (in tables abbreviated as Eur):** European Ornamental stone resources.

**FRAME (in tables abbreviated as FR):** Forecasting and Assessing Europe's Strategic Raw Materials needs

**MINDeSEA (in tables abbreviated as MS):** Seabed Mineral Deposits in European Seas: Metallogeny and Geological Potential for Strategic and Critical Raw Materials.

**Mintell4EU (in tables abbreviated as Mt):** Mineral Intelligence for Europe.



## INTRODUCTION

### Objectives and contents of D3.2.2:

D2.2.1 is the expression of the concepts and data the GSPs have to handle, and the results they aim to provide.

D3.1 identified existing standards and data models that address the topics of the GSPs.

D3.2.1 identified possible matches and conceptual mapping between the GSPs data and those existing standards.

This D3.2.2 document provides technical requirements and guidance to expose the data identified in D2.2.1 with technologies identified by D3.1, applying the expected conceptual mapping described in D3.2.1. It includes:

- Description of the technical interoperability and functionality (describe the new network service requirements, i.e. WFS 3.0, SOS, GeoAPI, ...);
- Identification and description of the technical requirements for the architecture;
- Production of a set of recommendations for the GSPs.

### Sources of needs expression from the projects and versions considered for D3.2:

Name of the document	Date / version
<a href="#">D2.1.1, Potential synergies and overlaps between the projects.</a>	Version: 30/06/2019
<a href="#">D3.1, Data models, Standard Guidelines and Toolkits.</a>	Version: 02/05/2019
<a href="#">D3.2.1, Gaps analysis and path extension</a>	Version: 30/07/2019

### Relevant data models identified by D3.1 and versions considered for D3.2:

Name of the document	Date / version
OGC GeoSciML	4.1 Rev 16-008
OGC GWML2	2.2 Rev 16-032r2
EarthResourceML	2.0 October 2013
INSPIRE AC (Atmospheric Conditions)	Revision 4618
INSPIRE AF (Agricultural and aquaculture facilities)	This version corresponds to the content of the Implementing Rules (EU) No 1089/2010, No 102/2011, No 1253/2013 and the latest publicly available version of the data specifications of Annex I, II+III.
INSPIRE AM (Area Management)	
INSPIRE EF (Environmental Monitoring Facility)	
INSPIRE EL (Elevation)	
INSPIRE ER (Earth Resources)	
INSPIRE GE (Geology)	
INSPIRE LU (Land Use)	
INSPIRE MR (Mineral Resources)	



INSPIRE OF (Ocean Features)	
INSPIRE SO (Soil)	
INSPIRE NZ (Natural Risk Zones)	
EPOS BoreholeView	1.0.0
EPOS ModelView	1.0.0
ISO 19156 : Observations & Measurements	2.0 Rev 10-025r1 (OGC)
WaterML 2 - Part 1 / Timeseries	2.0.1 Rev 10-126r4
ISO 19115 / ISO 19139	
OGC Coverage Implementation Schema with Corrigendum (09-146r8)	Version 1.1.1 Published 2019-10-28

## STANDARDS SUITABILITY AGAINST DATA TYPES

This array suggest which services shall be used to provide the data based on their type and nature.

Data type	Recommended standard
Map (as a deliverable, provided for display)	OGC WMS
Geographical features (vector data)	OGC WFS 2.0
Coverages (coverage and raster data)	OGC WCS
Time series	OGC SOS, or OGC SensorThings API or OGC WCS
Metadata about datasets (ISO 19115) and services (ISO 19119) and collectively as XML (ISO 19139)	OGC CSW 3.0.0
Vocabulary and Ontology <a href="https://www.w3.org/standards/semanticweb/">https://www.w3.org/standards/semanticweb/</a>	W3C RDF (Resource Description Framework) or OWL (Web Ontology Language) - direct URI dereferencing or Sparql endpoint.

## CENTRALIZED VS DISTRIBUTED ARCHITECTURE FOR DATA

In order to provide data from several sources into a standard format, two main methods can be envisaged:

- Distributed architecture,
- Centralized architecture,
- Mixed approach,

### Distributed architecture approach

In that context, the data providers agree on a standardized format (following standard models and interoperable procedures) to expose their data. They set up in their own environment the necessary software and tools to expose their data into the standardized format (grey arrows).

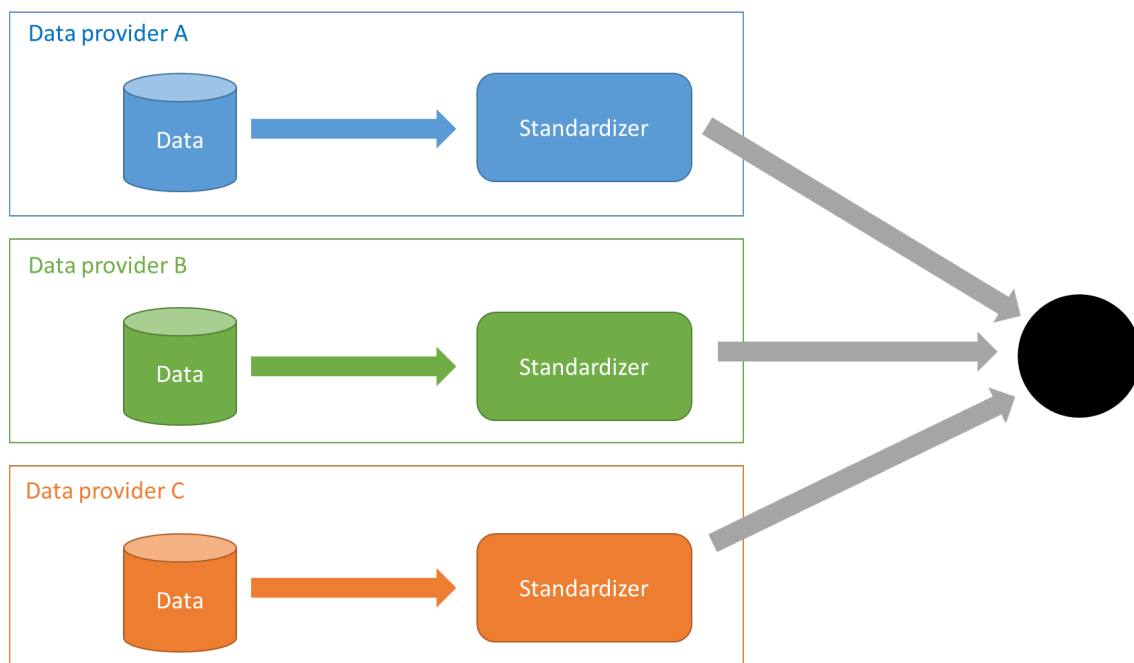


Figure 1 : Distributed data architecture approach

#### Advantages:

- The data providers can choose the software/tools they want to use to transform and expose their data, or even develop them if they want,
- No data duplication outside of the data provider's environment. This offers better control on data (data governance) and simplifies data update.

#### Disadvantages:

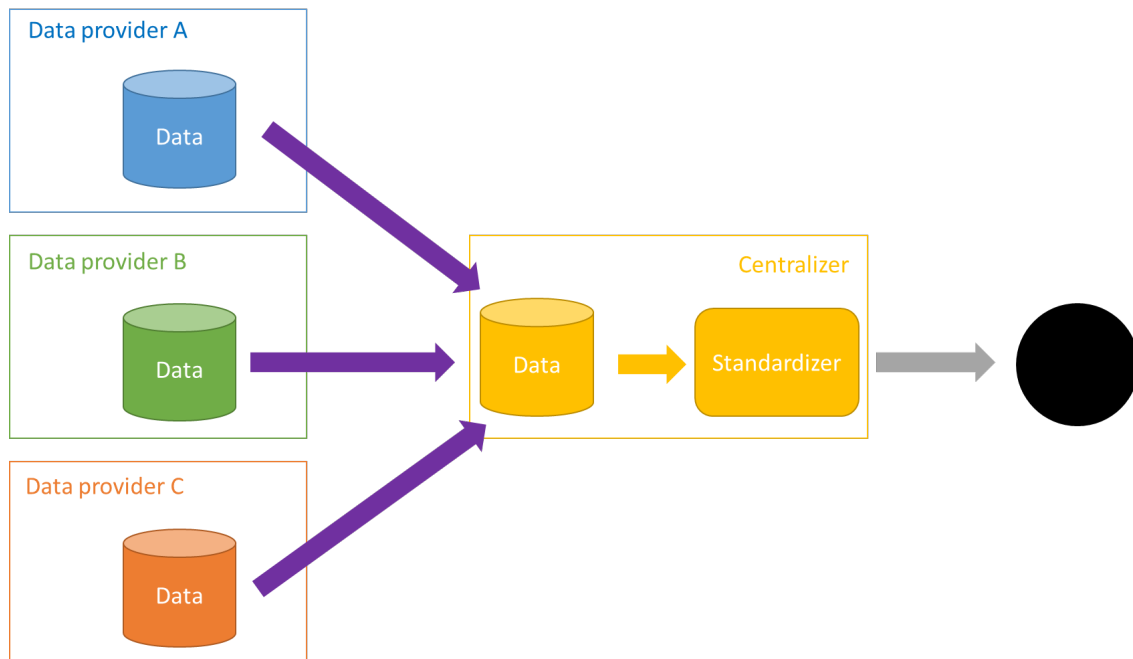
- The data providers have to setup and maintain the software/tools to expose their data.
- As several instances have to be setup and maintained there is a risk to have some data available from the project available whereas some will not in case of operational failure from some data providers.



## Centralized architecture

In that context, the data providers “give” their data (after a harmonization procedure) to another organization that is assuming a centralization role. The “centralizer” aggregates the data from the several data providers and is responsible for hosting and exposing them into the standard format (grey arrow).

The centralizer and data providers have to agree on the method of import and update of the central database (purple arrows).



*Figure 2: Centralized data architecture approach*

### Advantages:

- Data provider do not have to set and host software / tools to expose their data in the standardize format.
- A priori, no risk of partial availability of some datasets, as they would all be exposed by the same system.

### Disadvantages:

- Data duplication which means a worse data governance but also a more complex update mechanism,
- Still have to agree on how the data provider shall give the data to the centralizer,
- Centralised data have mixed metadata and data usability/quality may diminish.

## Mixed approach

On the one hand, the centralized approach aims to mutualize efforts to fulfill needs that several data providers have. The biggest advantage of that solution is that it enables some data providers not having to set and maintain their own tools to provide the data in standardize format, which is an



interesting solution for data providers that do not have much skills in IT. Yet, this is not a cost-free solution, as the centralizer still have to be set and maintained, probably funded by the community.

On the other hand, the main drawback of centralized architecture (if we put apart the question of data governance) is that it introduces another layer (the centralizer) in the process from original data to their final exposed format. This leads to (very) probable issues in terms of data update and capacity of evolution of the centralizer. Indeed, if the centralizer has too much data to manage, the maintenance and update can be difficult and costly to address. As the centralizer will also have to maintain “old” data, this will also prevent it to take benefit of new and fresh solutions and can limit innovation.

Considering the pros and the cons of both solutions, WP3 recommend a mixed approach:

- data providers are strongly encouraged to try the distributed approach, and set and configure tools to transform and expose their data in standard formats. The investment cost (which is the main drawback of this approach) can be drastically by mutualization of experiences and sharing of (parts of) configuration on chosen software. Furthermore, those tools and software can be reused to fulfilled other projects requirements (eg. the INSPIRE Directive).
- yet for datasets that will not be reused in the future, a (semi-)central system will also be proposed in order to ensure all the datasets produced will be exposed according to the D3.2.1 recommendations.

The mixed approach has already been experienced with projects like OneGeology. It requires agreements between the data providers in order to avoid duplication / lack of data provision.

## **The vocabulary case**

The rationale for data is also applicable for vocabularies. Data providers are encouraged to expose their own vocabularies in standard format.

For shared vocabularies that shall be used by several data providers, it is recommended to have dedicated instances, independent from the (national) own data providers registries.

One interesting instance to be considered for reuse is the one from the EPOS project: <https://data.geoscience.earth/ncl/>

## **RECOMMENDATION AGAINST TOOLS / SOFTWARES**

### **Overview recommendation**

In order to reduce the cost of tool setup learning, WP3 propose the data providers to capitalize on the use of specific softwares/tools to transform and expose their data.

Those recommendations are based on WP3 experience on providing data through OGC Web Services. Several criteria have been addressed, including service capacity in terms of functionalities, service reliability, ease of setup, ease to maintenance, existence of a community to help in case of troubleshooting.



The components that are here identified would enable to fulfill the requirements expressed by D3.2.1 to expose the data through interoperable data models (the grey arrows from Figure 1 and Figure 2). They are both suitable for a distributed approach or a centralized approach.

Of course, data providers remain free to use another tool or software to expose their data, yet must be aware that the capacity of assistance of GIP-P in case of troubleshooting can be drastically reduced, or even inexistent if they are using tool of software we do not have experience with. Furthermore, it must be considered that many of the services, in compliance with the INSPIRE Directive, require specific extensions of the capability.

Needs / Purpose	Recommended software tool
Store and manage geospatial data	PostgreSQL / PostGIS <a href="https://www.postgresql.org/">https://www.postgresql.org/</a>
Expose maps with WMS	MapServer <a href="https://mapserver.org/">https://mapserver.org/</a>
Expose data with WFS	GeoServer v2.16+ <a href="http://geoserver.org/">http://geoserver.org/</a>
Expose data with WCS	Rasdaman <a href="http://www.rasdaman.org/">http://www.rasdaman.org/</a>
Expose data with SOS	52°North SOS Server <a href="https://52north.org/software/software-projects/sos/">https://52north.org/software/software-projects/sos/</a>
Expose data with SensorThingsAPI	Frost Server <a href="https://github.com/FraunhoferIOSB/FROST-Server">https://github.com/FraunhoferIOSB/FROST-Server</a>
Manage metadata (ISO19115) and expose them with CSW	GeoNetwork <a href="https://geonetwork-opensource.org">https://geonetwork-opensource.org</a>
Expose local data dictionary / registries	LD Registry <a href="https://github.com/UKGovLD/registry-core">https://github.com/UKGovLD/registry-core</a>
Convert data in order to match the standard models	HALE <a href="https://www.wetransform.to/downloads/">https://www.wetransform.to/downloads/</a>
Desktop GIS for editing and retrieving data	QGIS 3.0 with GMLAS



based on GML Application Schemas	
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## Detailed explanation, useful links and guidance

This chapter provide useful links and guidance to support GeoERA projects ambition to set OGC Web Services to provide their data. It also includes some examples of relevant instances that implement the recommended standards.

### Spatial Database - PostgreSQL / PostGIS

The couple PostgreSQL / PostGIS is today recognized as an efficient alternative, if not the main solution for storing and managing geospatial data.

It should be paid attention to the PostgreSQL/ PostGIS version choosen in order to ensure proper interface with other proposed tools.

Official website: <https://www.postgresql.org/>

### WMS – MapServer

A long tradition to expose maps with WMS thanks to MapServer, since the OneGeology project. MapServer enable to interface with different data formats, including PostgreSQL/PostGIS.

Official website: <https://mapserver.org/>

### WFS – GeoServer

GeoServer is widely used to expose and share data in conformance with OGC WFS 2.0 Application Schema. The Application Schema extension enable to address complex data models (eg. OGC GeoSciML, GroundWaterML2 and INSPIRE) stored in databases.

In addition, the GeoServer community is very active and engage constant improvements of both the standards and tool. GeoServer is also implementing and testing latest version of WFS 3 (OGC API – Feature Service).

GeoServer is then recommended for its capacities to implement feature service with today's requirements (WFS 2.0) with an evolution potential.

### ***Basic guidelines for the set up of GeoServer instances***

Assuming the web application (.war) has been downloaded and exposed with a Tomcat (or assimilate) java servlet.

General steps for exposing data from PostGIS:



- From the raw database to the ready to expose database, assuming the raw database is a generic term to indicate the place where the data are and the ready to expose database is the one that will formally be accessed by GeoServer,
- From the ready to expose database to the application schema.

The first step is mostly about performing SQL queries to build the ready to expose database from other existing sources.

For some performance reasons, it is highly recommended for the “ready to expose database” to be very close to the targeted standard.

If the project is to collect / build new data, then there might be a big advantage to orientate data acquisition and description in order to have a raw database very close to the ready to expose database, if not identical.

The second step of setup of the application schema is to build some XML files that indicate where GeoServer shall take the information to provide the standard conformed responses. Such files are usually called the mapping files.

In both steps, the HALE software can also be envisaged to build the necessary connections.

## **Resources**

Official website: <http://geoserver.org/>

BGS Cookbook

## **WCS – Rasdaman**

A recognized tool to expose coverages.

<http://www.rasdaman.org/>

## **SOS - 52°North SOS Server**

Several members performed some implementations of geoscience data with this tool.

### ***Basic guidelines for the set up of 52nSOS instances***

Assuming the web application (.war) has been downloaded and exposed with a Tomcat (or assimilate) java servlet.

General steps for exposing data from PostGIS:

- “Mental mapping” to define how to ventilate your data in conformance with the O&M standard (identification of the FeatureOfInterest, the Observation, the Procedure, etc...) in the 52nSOS database.
- Translation of that mapping in SQL to perform the data transfer from the raw data to the 52nSOS database.

The 52nSOS database has a mandatory structure to fit in. It contains about 50 tables. Not all tables have to be fed (almost 15 in general and the other are automatically filled).



No specific method or tool proposed for the mental mapping. Classical usage is to rely on Excel spreadsheets. Starting with the tables to fill and their attributes, to the definition of the source of those information.

Some SQL queries have then to be set to reflect this “mental mapping” to transfer the raw data to the 52nSOS database. Good practice is to build some Materialized views to ventilate your data in that 52nSOS database structure.

## Resources

Existing implementation (non exhaustive):

- IRCEL-CELINE (Belgium): *Current and archived air quality data for all of Belgium,*
- Wuppervverband (Germany): *Regional water board providing a multitude of hydrological measurement data with the help of SOS standards,*
- Swedish EPA/IVL/SMHI (Sweden): *Current and archived air quality data for all of Sweden, as well as delivery this data to the European Protection Agency,*
- RIVM (Netherlands): *Current and archived air quality data for all of the Netherlands,*
- Lithuanian EPA (Lithuania): *Current and archived air quality data for all of Lithuania,*
- European Environment Agency (EEA): *Use of SOS interface to collect data from the member countries, as well as to publish the collective data,*
- PEGELONLINE (Germany): *Interoperable publication of the federal waterways' hydrological measurement data.*

Official website: <https://52north.org/software/software-projects/sos/>

## SensorThings API - FROST Server

The SensorThings API is part of the new OGC API serie of standards (including WFS3 / OGC API - Features) and is addressing SensorWebEnablement data.

Implementers of both SOS and SensorThings generally agree that Sensor Things API is easier to set up and update. From that statement, there is a general consensus to have SensorThings API officially recognized as a valid alternative (or even recommended) way to expose observational data.

### ***Basic guidelines for the set up of FROST instances***

Assuming the web application (.war) has been downloaded and exposed with a Tomcat (or assimilate) java servlet.

Exposing data from PostGIS to FROST Server mainly consist in the same steps as 52nSOS. Except the model is simpler and then less table (only 7 or 8) have to be filled.

## Resources

A paper about SensorThings API for INSPIRE:  
<https://www.preprints.org/manuscript/201805.0031/v1>

Guidance for the setup of a SensorThingsAPI (application to the French groundwater information network):

Existing implementation (non exhaustive):



- Disaster management: Horizon 2020 project BeAWARE, <https://beaware-project.eu/>
- Protection and monitoring of cultural heritage against climate change: Horizon 2020 project HERACLES, <http://www.heracles-project.eu/>
- Building management (IOSB Internal)
- Water quality monitoring
- Smart cities with the cities of Hamburg and Munich (Hamburg is aiming for 10000 Observations per second!)
- Industry 4.0 (IIC testbed Smart Factory Web: <https://www.smartfactoryweb.de/servlet/is/1114/>)
- IoTOS & TriOS: <https://iotos.io/en/products-services/use-case-water-quality-tracking-system/>
- IoT Systems: <https://iotsyst.com/sensorthings/>

Official website: <https://github.com/FraunhoferIOSB/FROST-Server>

## Metadata – GeoNetwork

Another component of the Open Source Geospatial (OSGEO) Foundation with strong support from the European Community. It has been adopted by lot of data providers, especially to fulfill the INSPIRE Directive requirements.

Official website: <https://geonetwork-opensource.org>

Existing instances: <https://geonetwork-opensource.org/gallery/gallery.html>

## Vocabulary - LDRegistry

For European projects like GeoERA, the r3gistry tool from the European Commission ([https://ec.europa.eu/isa2/solutions/re3gistry\\_en](https://ec.europa.eu/isa2/solutions/re3gistry_en)) can be seen as the de-facto standard to use. Yet some benchmark with the LD Registry developed by epimorphics were in favor of the later. One big advantage being the possibility to rely on Linked Data. Benefits of relying on LDRegistry are exposed here: <https://github.com/UKGovLD/registry-core/wiki/Principles-and-concepts>.

We then recommend to rely on LD Registry for exposing GeoERA (and more) vocabularies.

For shared vocabularies, the LD Registry instance set for the EPOS project should be studied as a candidate for exposing GeoERA projects vocabularies: <https://data.geoscience.earth/ncl/>

Official website: <https://www.epimorphics.com/>

Existing instances (non exhaustive):

- BRGM: <https://data.geoscience.fr/ncl/>
- European Platform Observing System: <https://data.geoscience.earth/ncl/>
- CSIRO: <http://registry.it.csiro.au/>
- NOAA : <https://codes.nws.noaa.gov/>
- French National Geocatalogue : <https://data.geocatalogue.fr/ncl/>
- <https://www.epimorphics.com/projects/>



## **Data mapping - HALE**

See the GeoERA GIP-P [D3.1, Data models, Standard Guidelines and Toolkits](#) document for references and usage proposal.

## **Visualization and management desktop tool - QGIS 3.0 with GML Application Schema Toolbox plugin**

Now QGIS has become a very valuable alternative to proprietary softwares like ESRI ArcMAP. It can be interfaced with several other items previously mentioned (eg. read and write into PostgreSQL / PostGIS databases).

The GML Application Schema (GMLAS) Toolbox plugin was developed to access and work with data exposed with WFS Application Schema.

Official website for QGIS: <https://www.qgis.org/fr/site/>

Official website for GMLAS driver and toolbox: <https://gdal.org/drivers/vector/gmlas.html>





## RECOMMENDATIONS PER PROJECT

Based on the GeoERA [D3.1, Data models, Standard Guidelines and Toolkits](#) document:

Project Name	DATA TYPE	DATA MODEL	STANDARDS FOR DELIVERY
<b>(GW) - Resource project</b>	Groundwater composition and age	<i>GroundWaterML2 O&amp;M</i>	<i>GeoServer App Schema implementing GroundWaterML2</i>
	Cross-border Patterns of Groundwater depletion and recharge	<i>GroundWaterML2 + O&amp;M</i>	<i>GeoServer App Schema implementing GroundWaterML2</i>
	Geological and hydrological data specifying delimitation of aquifer (thickness, depth, groundwater flow directions and flux)	<i>GroundWaterML2 + O&amp;M</i>	<i>GeoServer App Schema implementing GroundWaterML2</i>
	Hydrological dataset for numerical modelling	<i>OGC GeoScience DWG 3D Model + EPOS TCS GIM ModelView</i>	<i>GeoServer App Schema implementing EPOS ModelView</i>
	Multiple layers of information specifying lithology, depth and extent of Aquifers and Aquitards	<i>GroundWaterML2 + GeoSciML</i>	<i>GeoServer App Schema implementing GroundWaterML2</i>
<b>(GW) - VoGERA project</b>	Fault zones	<i>GeoSciML (GeologicalStructure)</i>	<i>GeoServer App Schema implementing OGC GeoSciML</i>
	Boreholes	<i>GeoSciML (Borehole) + EPOS Borehole model</i>	<i>GeoServer App Schema implementing OGC GeoSciML</i>



	Physico-chemical data: stable isotopes, time indicators temperature	<i>GeoSciML + O&amp;M</i>	
	Geophysical methods	<i>INSPIRE GE</i>	
	3D models	<i>OGC GeoScience DWG 3D Model + EPOS TCS GIM ModelView</i>	<i>GeoServer App Schema implementing EPOS ModelView</i>
	Model of Vulnerability maps	<i>GroundWaterML2</i>	
<b>(GW) - HOVER project</b>	Database for concentrations of dissolved elements and associated parameter to define thermal and mineral water	<i>GroundWaterML2 + O&amp;M</i>	
	Boreholes to define	<i>GeoSciML (Borehole)</i>	
	Database for concentrations of elements of natural origin per typologies	<i>GroundWaterML2 + O&amp;M</i>	
	European exposure maps of selected elements (and indicators)	<i>INSPIRE AM</i>	
	Atlas of geological/hydrogeological settings Vulnerability maps	<i>Metadata</i>	
	Maps of groundwater-N travel time	<i>GroundWaterML2 + O&amp;M</i>	
	Database for concentrations of groundwater age indicator sand vulnerability classes	<i>GroundWaterML2 + O&amp;M</i>	



	Maps and cross sections showing distribution of groundwater age and vulnerability classes in selected European aquifers.	<i>GroundWaterML2 + GeoSciML</i>	
	Maps and cross sections showing vulnerability of the upper aquifer to pollution.	<i>GroundWaterML2</i>	
<b>(GW) - TACTIC project</b>	Hydrogeological parameters: (e.g. porosity, hydraulic conductivity, cation exchange capacity)	<i>GroundWaterML2 + O&amp;M</i>	
	Hydrogeological time series: Water tables; Head/River/concentrations; Rainfall, temperature, Potential Evaporation; Real time data.	<i>GroundWaterML2 + WaterML2 + INSPIRE AC</i>	
	Borehole, hydrochemical and geophysical logs (data and time series)	<i>GeoSciML (Borehole) + INSPIRE GE + OGC O&amp;M + GWML2 (logs) + EPOS TCS GIM Boreholes</i>	GeoServer App Schema implementing EPOS BoreholeView for borehole / well description
	Soil maps/soil properties: Land use; Specific model outputs (e.g. min, max, mean heads, or changes); Climate grid; Satellite	<i>INSPIRE SO + INSPIRE LU + INSPIRE AC + EF + O&amp;M</i>	
	3D data: Hydrogeological model – structures; Hydrogeological parameters; Model outputs	<i>OGC GeoScience DWG 3D Model + EPOS TCS GIM ModelView</i>	GeoServer App Schema implementing EPOS ModelView



<b>(RM) - EuroLithos project</b>	Geology (geologic unit)	<i>GeoSciML (GeologicalUnit)</i>	<i>GeoServer App Schema implementing OGC GeoSciML</i>
	Location of current and relevant old/historic ornamental stones mining districts, mining sites or isolated quarries	<i>INSPIRE PS</i>	
	Land use planning constraints and threats	<i>INSPIRE LU + INSPIRE AM</i>	
<b>(RM) - FRAME project</b>	Mineralisations and deposits on land and the marine environment (Data from Minerals4EU, ProMine and OneGeology Europe exists as WMS/WFS)	EarthResourceML	GeoServer App Schema implementing EarthResourceML
	Secondary resources (mining waste) - <i>Data from ProSUM Mining Waste (to be delivered) will be provided as WMS/WFS</i>	EarthResourceML	GeoServer App Schema implementing EarthResourceML
<b>(RM) - MINDeSEA project</b>	Marine geology (will reuse part of EMODnet, ISA, Interridge programs and Geo-Seas)	<i>GeoSciML</i>	
	All other Marine information about SMS, Placers, Nodules (will reuse part of EMODnet, ISA, Interridge programs and Geo-Seas)	<i>INSPIRE EF + INSPIRE OF + OGC O&amp;M</i>	
<b>(RM) - Mintell4EU project</b>	Data based on Mineral4EU	EarthResourceML	GeoServer App Schema implementing EarthResourceML



<b>(RM) - GARAH project</b>	Boreholes, wells, outlines of formations, basin outlines, horizon interpretations,	<i>GeoSciML (Borehole) + EPOS TCS GIM Boreholes</i>	GeoServer App Schema implementing EPOS BoreholeView for borehole / well description
	Faults	<i>GeoSciML (GeologicalStructure)</i>	GeoServer App Schema implementing OGC GeoSciML
	Temperature maps,	<i>GeoThermal + INSPIRE ER</i>	
	Bathymetry,	<i>INSPIRE EL</i>	
	Geothermal gradients, seafloor temperature, seafloor T heat flow,	<i>GeoThermal + INSPIRE ER</i>	
	Sedimentation rates in 3D	<i>3D model</i>	GeoServer App Schema implementing EPOS ModelView
	Fishing activities	<i>INSPIRE PF</i>	
	Gas hydrates below seafloor, gas stability map	<i>INSPIRE ER</i>	
<b>(GE) - Geoconnect<sup>3</sup>d project</b>	Geology (geologic unit)	<i>GeoSciML (GeologicalUnit)</i>	GeoServer App Schema implementing OGC GeoSciML
	Faults, Fault systems	<i>GeoSciML (GeologicalStructure)</i>	GeoServer App Schema implementing OGC GeoSciML
	Chemical analyses of springs water	<i>WaterML + INSPIRE EF + OGC O&amp;M</i>	
	Wells measurements	<i>GroundWaterML2</i>	
<b>(GE) - HIKE project</b>	Geology (geologic unit)	<i>GeoSciML (GeologicalUnit)</i>	GeoServer App Schema implementing OGC GeoSciML



	Faults	<i>GeoSciML (GeologicalStructure)</i>	<i>GeoServer App Schema implementing OGC GeoSciML</i>
<b>(GE) - 3D geomodeling</b>	Geology (geologic unit)	<i>GeoSciML (GeologicalUnit)</i>	<i>GeoServer App Schema implementing OGC GeoSciML</i>
	Wells observations	<i>GroundWaterML2 + OGC O&amp;M + INSPIRE EF + OGC O&amp;M</i>	
	Reservoirs proprieties	<i>GroundWaterML2</i>	
	2.5D Time model (xyz): 2.5D Time model (xyz) 2.5D Velocity maps (xyz) 3D Structural model 3D Harmonized model of lithostratigraphic layers Geothermal properties related to wells (porosity & permeability) + 2D Geothermal property maps Example datasets and models containing uncertainty information 2D Maps of Cenozoic reservoirs (extent + depth) 2D Map of extent & depth of salt/fresh groundwater barrier Uncertainty in geomodels	<i>3D model + OGC O&amp;M + Metadata + EPOS TCS GIM ModelView</i>	<i>GeoServer App Schema implementing EPOS ModelView</i>



	Metadata		
<b>(GE) - Muse project</b>	Geology (geologic unit)	<i>GeoSciML (GeologicalUnit)</i>	<i>GeoServer App Schema implementing OGC GeoSciML</i>
	Conflicting layers		
	Wells, boreholes observations, samples measurements	<i>GeoSciML (Borehole) + GroundWaterML2 + OGC O&amp;M</i>	GeoServer App Schema implementing EPOS BoreholeView for borehole / well description
<b>(GE) - Hotlime project</b>	Geology (geologic unit)	<i>GeoSciML (GeologicalUnit)</i>	<i>GeoServer App Schema implementing OGC GeoSciML</i>
	Conflicting layers		
	Wells, boreholes observations, samples measurements	<i>GeoSciML (Borehole) + GroundWaterML2 + OGC O&amp;M + EPOS TCS GIM Boreholes</i>	GeoServer App Schema implementing EPOS BoreholeView for borehole / well description
	Faults	<i>GeoSciML (GeologicalStructure)</i>	<i>GeoServer App Schema implementing OGC GeoSciML</i>