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GCI pilot case perspective recommendations for enabling quality aware visualisation and search

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1. Abstract

This document references the relevant work done in GeoViQua to test and consolidate the components in preparation towards their transfer to the GEOSS GCI, from the perspective of the pilot cases work package (WP7). This report includes brief descriptions of the quality-aware developed tools and the envisaged implementation in the GEO Portal, firstly through a mirror virtual machine environment provided by ESA and a copy of the Discovery and Access Broker provided by CNR. From this stage, recommendations for the final integration of GeoViQua components into the GCI are derived.

2. Introduction

This document describes the GeoViQua components testing in the frame of WP7 pilot cases activities. We explain the relevance of quality aware elements and tools, and give examples of good practice for their use. The subsequent stage is the integration in the GEOSS-GCI architecture, which is here represented by the GEO Portal portlets development embedding GeoViQua prototypes, and some views from partners directly participating in GEOSS evolving services infrastructure. In a broad sense, this report contains the current picture of the process preceding the actual methodology for integrating these very same components into the GCI, that will be subsequently depicted in **D.6.4. “GeoViQua components integration with the GCI.**”

2.1 **Introduction to the GeoViQua components**

The GeoViQua components UML schema is shown in Figure 1.

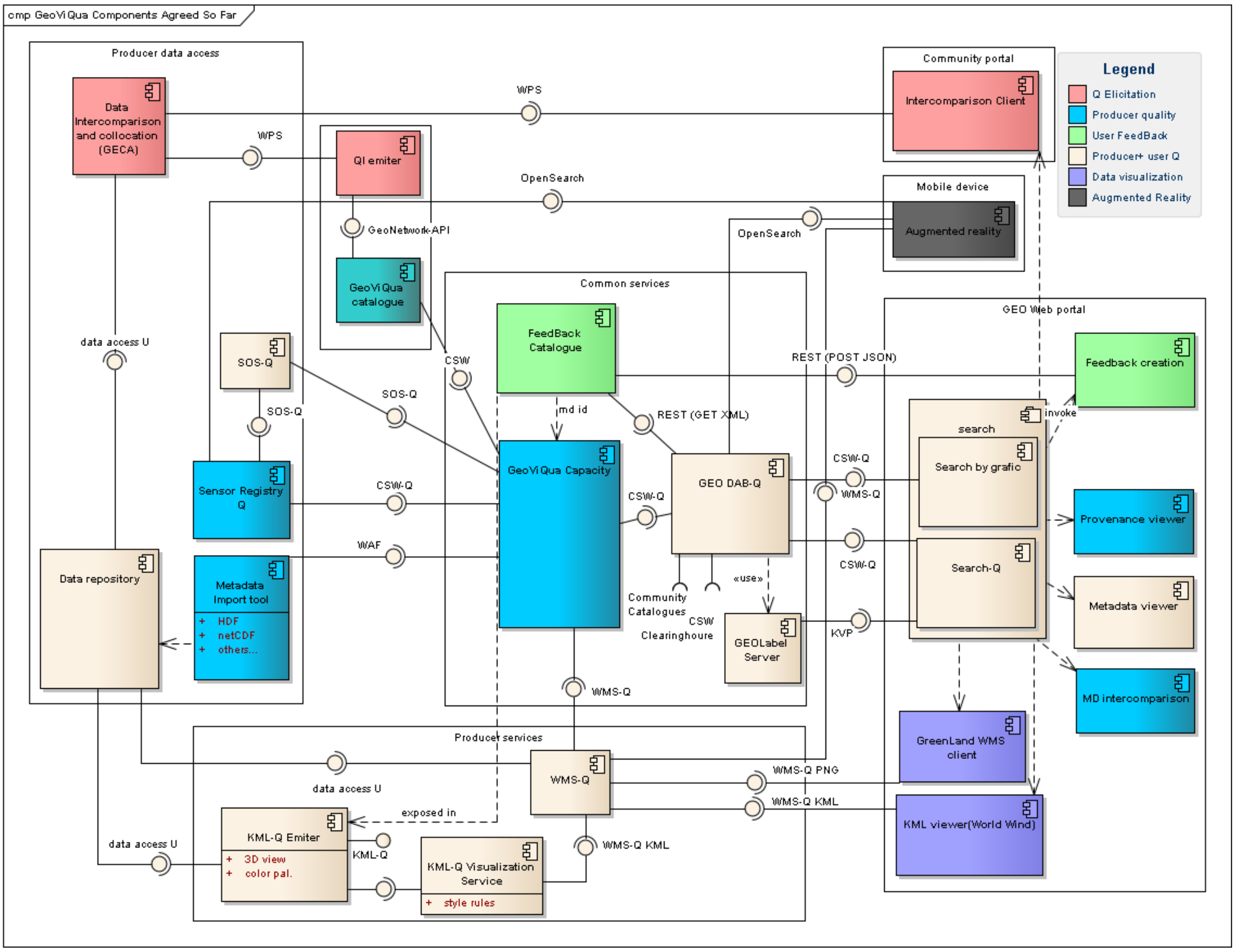


Figure 1: The GeoViQua components diagram

Quality elicitation components, including intercomparison (WP3), producer and user encoding models (WP6), quality-aware queriables and geo-search linking data providers and user feedback information stored in catalogues (WP4), together with visualization tools (clients and servers) (WP5) have been the subject of prototypes testing activities using real examples purposely selected (WP7). In addition, the GEO label component has also been tested and is part of the GeoViQua quality-aware contributions to GEOSS.

2.2 **Introduction to the GeoViQua prototypes pilot case testing**

GeoViQua provides a set of scientifically developed software components and services that facilitate the creation, search and visualization of quality information on Earth Observation data integrated and validated in the GEOSS Common Infrastructure.

2.2.1 **WP2 User requirements**

To cover the needs of both data producers and users is one of the main targets of the project. Accordingly, the scope of GeoViQua was delimited in WP2, as explained in **D.2.1 “User requirements document”** and **D.2.2 “Technical requirements document”.** User requirements have been taken into account in the development of the following work packages activities.

2.2.2 WP3 Quality elicitation

A first review of metadata elements, quality standards, quality indicators encoding in data and metadata formats can be found in **D.3.1. "Metadata extraction quality component"**.

Datasets compiled in the pilot cases selection (see **D.7.1. "Document pilot case studies in a standard format"**) were used in the quantitative and qualitative estimation of quality indicators for both continuous and categorical variables at dataset level and sample level (sample including pixel level as the ultimate individual measurement in raster data models and object level in vector data models).

In the case of continuous variables, for instance, dataset and pixel level quality were obtained for the "*Digital Climatic Atlas of the Iberian Peninsula"* and *"Carbon cycle"* datasets. In turn, categorical variables quality measures involved the "*Monitoring flooding practices in rice fields in the Ebro River Delta using Remote Sensing"* and "*Landcover classification of Landsat Barcelona-Girona scenes"*, at dataset, pixel and object level. In this regard, it must be noted that the object level is the most appropriate unit for real territorial management. Error distributions have been derived for the *"ESA Climate Change Initiative Sea Surface Temperature"* dataset, or the "*Carbon cylce models*". More details are provided in **D.3.3 "Quality elicitation component for continuous and discrete valued variables"** and **D.7.3 "Data quality paramterisation for the GeoViQua pilot case studies".** To name a few, geographic and attributes collocation, interpolation, modelling and classification processes have been considered in error estimation and validation, altogether leading to quality elicitation, uncertainty mapping and accuracy assessment reflected in quality parameterization, quality indicators and quality measures. The **GeoViQua thesaurus** (**http://QualityML.geoviqua.org/**) contains the definition of data quality parameterization concepts, in line with UncertML (**http://www.uncertml.org/**). Ongoing tasks in WP3 might introduce additional inputs for prototypes testing (e.g., integration of the GECA toolset for quality elicitation, collocation and data assimilation, with the corresponding derivation of quality indicators).

2.2.3 WP4 Quality search

GEOSS architecture and geospatial standards have been studied. Whereas standards suchlike ISO19115, ISO19157, or WMS enable data quality descriptions and visualization, the pilot cases data quality parameterisation has revealed key points towards implementation by the communities and general improvement of existing standards. Simplifying quality descriptions without compromising detail, fit for purpose dataset discovery using metadata intercomparison tools, quality labels and quality thresholds, or quality aware queriables for geosearch capabilities have been implemented in the GeoViQua solutions, as described in **D.4.1 "Graphical search interface report"** and **D.4.2. "Smart searchable interface component report"**. GeoViQua prototypes support quality-constrained queries. The main component is the Quality-enabled Discovery & Access Broker DAB-Q, an extension of the GEO-DAB (see **D7.2 "Report on current GCI and identification of issues in integration with GEOSS"**) for the implementation of the GeoViQua Quality Models and the CSW-ISO-PQM interface, embedding the user quality broker (associating user feedback information to query results), mapping and adaptors (e.g., conceptual mapping between WMS or SOS quality concepts and ISO ones).

2.2.4 WP5 Quality visualization

Quality elicitation and encoding should be subsequently displayed using appropriate visualization techniques that enhance the product's accuracy comprehension and are supported by widely used visualization standards suchlike WMS or KML. Therefore, GeoViQua visualization work package has used data formats, current standards (servers/clients interactions) and participated in international related initiatives. Outcomes are described in **D.5.1. "Integration of quality information with OGC visualisation services best practice report"** that has been adapted to conform an OWS-9 Best Practice Report (i.e., "**OWS-9 OWS Innovations Data Quality for Web Mapping Engineering Report "**), **D.5.2. "Visualisation of quality information best practice report"**, as well as **D.5.3. "Prototypes of quality-aware visualisation components"**, and the final **D.5.4. "Final versions of quality-aware visualisation components".**

After a sound review of usability studies and state-of-the art of quality visualisation methods, demo prototypes -including servers and clients- have been launched showing real datasets examples of the potential of the GeoViQua components. The OGC standards WMS, WMTS, and KML have been extended respectively to WMS-Q, WMTS-Q and KML-Q in order to integrate quality information. GMLCov and ARML, although briefly, have also been reviewed in GeoViQua. Capabilities and layer properties have been paid due attention.

2.2.5 WP6 Quality encoding

A quality framework that enhances producer metadata and proposes the addition of user feedback is embedded in the GeoViQua Quality Models. The Producer Quality Model –PQM- (built on existing ISO standards ISO19115 and ISO19157) adds reference dataset information, citations traceability of quality statements and discovered issues. The User Quality Model –UQM- informs the database structure for a feedback server from which comments, citations, discovered issues, ratings and reports of usage may be stored and retrieved. The models are explained in **D.6.1. "Data quality encoding as a best practice paper"**. In addition, the UQM editing tool is described in **D.3.2. "User feedback quality elicitation tool"**. In the context of GEOSS, leveraging expert user feedback is an excellent opportunity to improve data quality assessment in practice, as was demonstrated in WP2 outcomes.

The models, and related components like the Geonetwork Metadata Editor and the User feedback editing tool, have been tested in WP7 activities, generating illustrative best practices reports and tutorials (**http://tutorial.geoviqua.org/**). The link between the PQM and the UQM is envisaged and has been inserted in the WP4 architectural structures for GEOSS. In addition, the GEO label API is able to retrieve information from both models and generate a complete label for the dataset. The GEO label design is well described in **D.6.2. "GEO label description final document"**.

In sum, the outcomes of GeoViQua add rigorous data quality representations to state-of-the-art search and visualization in the GEO Portal functionalities of GEOSS.

As one of the main challenges is the evolution of the GEOSS architecture and GEO Portal code, GeoViQua is forced to adopt the approach of simulating the integration of the quality aware prototypes in the current GEO Portal through a virtual machine and specific portlets and in a quality-aware copy of the DAB.

2.3 **Dissemination and integration efforts**

Indeed, the main challenge that GEOSS poses regarding basic services and architecture is that whereas INSPIRE, being a European Directive, is to work with the same metadata standards, web services, and catalogues by specifying technical guidelines defining data topics and sharing data services, GEOSS, being a global and heterogeneous voluntary effort, must direct brokering efforts to harmonize differences in services and models, coping with the huge diversity of providers' circumstances.

In such a context, besides establishing a sound quality framework, the success of GeoViQua requires dissemination and coordination with other geospatial projects. These innovative components have been introduced in relevant symposiums and tried outside the GeoViQua environment, with external datasets and user feedback. Tutorials and workshops have been carried out alongside the development of the tools in order to retrieve practical user feedback considerations. In the end, these initiatives contribute to the proper integration in the GEOSS CoPs and from the components point of view in the GEOSS infrastructure. Addressing this issue, **D.8.2. "Earth Science community and GEO CoPs, achievements and benefits"** provides an extract on some activities done to contact the CoPs and knowledge transfer strategies. The project has an exploitation plan, based on testing findings, to address the extension of the project achievements beyond the funding period.
The following section describes the prototypes providing some examples from the pilot cases testing of the GeoViQua components at present.

3. Pilot cases prototypes testing.

In WP7, the selection of a range of datasets was intended to scientifically cover the diversity of methods, sources and quality issues in geospatial data management, including quality-aware products generation, documentation, discovery, access, and visualisation targeted at enhancing the user experience of GEOSS.

From the specific methodologies tackled in WP3 in data quality parameterization for categorical and continuous variables at sample, variable and dataset levels, a more holistic view of the potential capabilities of tools within the GEOSS context has been sketched in the GeoViQua scenarios:
http://www.geoviqua.org/CarbonScenario.htm
http://www.geoviqua.org/AirQualityScenario.htm
http://www.geoviqua.org/AgricultureScenario.htm

The GeoViQua components diagram and the prototypes testing activities show how these scenarios can be fulfilled when the functionalities and link between tools and catalogues is achieved. As an outcome of GeoViQua, two demo videos, respectively related to the Carbon Scenario and the Agriculture Scenario, will show a holistic view of the potential usage of the tools developed in the project in the GEOSS context.

The prototypes that are being tested in the pilot cases studies are:

Metadata (dataset documentation)
- Producer Quality Model (PQM) and User Quality Model (UQM) schemas
- Geonetwork metadata editor (originally supporting just ISO19115 and adapted to the GeoViQua Producer Quality Model)
- User feedback component

Discovery and access (geosearch)
- Extension to the Discovery and Access Broker for quality-awareness (DAB-Q)
- Extension of the OGC Catalogue Service for the Web (CSW-Q)
- SOS-Q/SIR-Q
- Metadata intercomparison tool (adapted to ISO19115 and PQM)
- Metadata completeness "Rubric" tool (adapted to ISO19115 and PQM)
- Provenance viewer tool (adapted to ISO19115 and PQM)

User interfaces
- Standards-based approach using OGC Web Map Server (WMS-Q), reusing concepts of UncertML
- KML-Q standard
- Greenland client
- Carbon Atlas portal

- Mobile devices visualisation standard GeoAR
- Iconic representation of data quality with drill-down functionalities: GEO label
- GECA toolset as a WPS: GECAaaS

Note that these prototypes combine data quality parameterization and visualization techniques for the user experience while the architectural features flow in the GEOSS infrastructure mechanisms.

3.1 **Quality Model schemas and quality thesaurus testing**

As aforementioned, GeoViQua firstly studied the standards. As explained in **D8.1 "OGC, ISO standards participation & contributions"**, GeoViQua has actively participated in some Standards Working groups and Domain Working Groups (e.g., OGC Interoperability Program, interoperability initiatives such as the OpenGIS Web Services –OWS- and the Architecture and Interoperability programs –AIP-, CEN, Standards and Interoperability Forum -SIF-, etc.). In fact, the European branch of the OGC (i.e., OGCE) was incorporated as a project partner after the project started.

The producer model is designed to extend the existing practices of metadata generation. Wherever possible, widely-accepted ISO elements used by INSPIRE and national institutions are employed.

The schemas documents can be accessed at **http://schemas.geoviqua.org/**

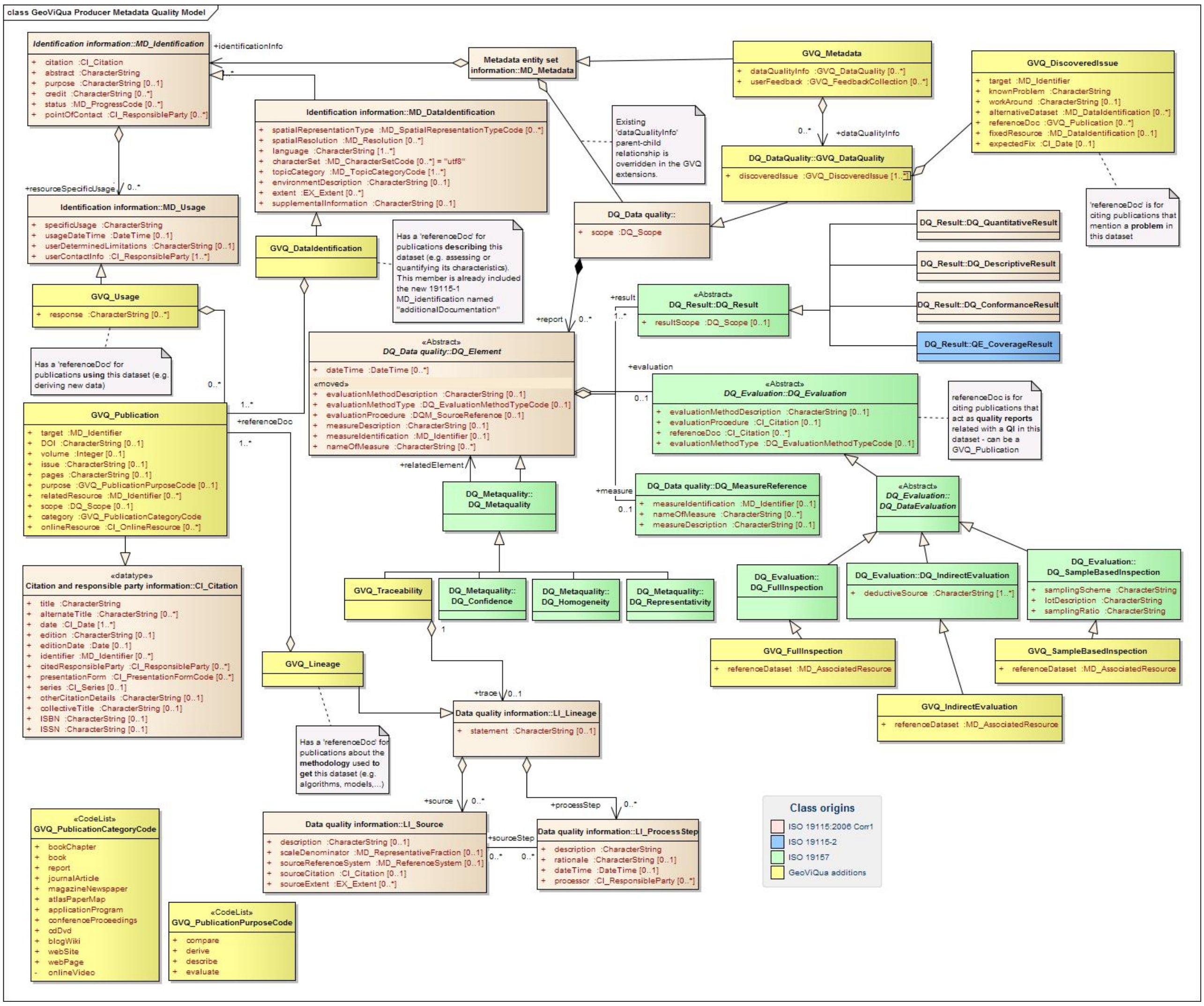


Figure 2: UML diagram of the GeoViQua Producer Quality Model
(online at http://schemas.geoviqua.org/GVQ/3.1.0/UML/Producermodel.jpg)

The Quality Models enable quality parameters encoding, in line with UncertML statistical conceptual modeling and XML encoding designed for encapsulating probabilistic uncertainties (www.uncertml.org). After testing the capabilities of UncertML we saw that an extension was needed to widen its scope into non probabilistic quality indicators and to cover all that had been suggested in ISO19138 and 19157. The models account for the data quality parameterization gaps detected in WP7 activities using the datasets repository to compute quality indicators, including spatialized quality layers. The quality elicitation tasks in WP3, in coordination with the latter, have led to the GeoViQua thesaurus: http://QualityML.geoviqua.org. The compilation in the thesaurus has tried to define quantitative quality indicators of general usage although some specific concepts adapted to methodologies must have been necessarily included. The thesaurus is a key outcome from WP3 and could serve as a guideline for further specifications in quality standards like the ISO. In fact, it started from a deep review of the concepts defined in the ISO19115 and extensions (e.g., D7.1., D.7.2, D6.1).

Reviewed vocabularies and definitions include the UncertML dictionary, the CEOS Cal/Val terms, the International vocabulary of metrology (i.e., ISO/IEC Guide 99:2007), ISO19138 Geographic information-Data quality measures, ISO19157 Geographic information-Data quality, ISO terminology, Q2O vocabulary and MMI group, Guidelines for implementing the ISO19100 Geographic Information Quality Standards in National Mapping and Cadastral Agencies. A deep review of the standards used in GeoViQua, best practices, guidelines and tutorials is made in D.6.3.

Users' requirements have also been embedded in the models: studies carried out in GeoViQua at the beginning of the project helped to acknowledge user's needs and expectations regarding data quality. Besides quantitative quality information, qualitative information is also relevant. Thus, the User Feedback Quality Model is a contribution that has no previous precedent in any form in GEOSS, enabling the encoding of the so-called "soft-knowledge" about data quality (users stated their interest in peer-review, experts judgment, usage, discovered issues and other information not provided by the data producer but by the products' users). The connection between the data producer and the data user is also important to contrast the information, enabling corrections of errors, and in the end to assure transparency, error traceability and trustability of a product. Other tools in GeoViQua, like the metadata intercomparison tool or provenance viewer highlight these concepts and connections by offering the geodataset searcher user-friendly views of the metadata contents.

The user quality model is shown in Figure 3. It re-uses some ISO quality and metadata elements, and elements of the producer model, but is far less strictly bound to existing ISO schemas.

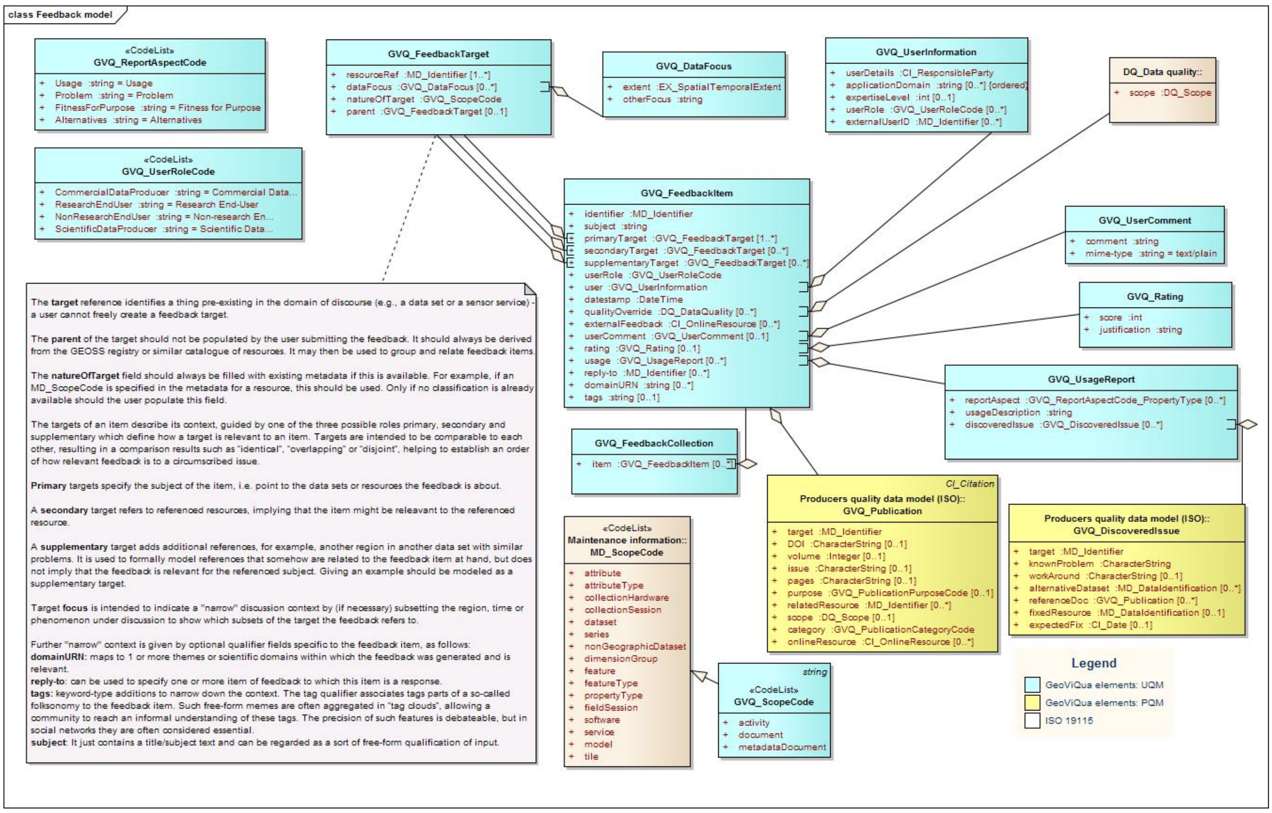


Figure 3: UML diagram of the GeoViQua User Quality Model
(online at http://schemas.geoviqua.org/GVQ/3.1.0/UML/Feedbackmodel.jpg)

In practice, the metadata documentation and the quality content of the pilot cases testing datasets has been essential in the schema design (e.g., inclusion of LE_Process step in lineage).

Regarding the testing of the schemas, full PQMs have been documented for some layers of the "*Monitoring flooding practices in rice fields in the Ebro river delta using remote sensing*", "*Digital Climatic Atlas of the Iberian Peninsula*", "*Geometric corrections of Landsat series*", and the "Landcover *classification of Landsat Barcelona-Girona scenes*" datasets. In addition, PQMs for "*Carbon Cycle*" datasets and ESA's remote sensing atmospheric sensors datasets, as well as for the "ESA Climate Change Initiative Sea Surface Temperature" dataset are envisaged.

In turn, UQMs have been documented for a suitability mapping exercise using the "*Digital Climatic Altas of the Iberian Peninsula*" as the user feedback target, and the administrative report of uncertainty of rice parcels classification in the case of the "*Monitoring flooding practices in rice fields in the Ebro river delta using remote sensing*".

These examples can be reviewed in the metadata catalogue (**http://schemas.geoviqua.org/GVQ/4.0/example_documents/**). In particular, the PQMs are embedded in the pilot cases data servers (e.g., CREAF/WMS-Q; KML-Q; Digital UREAD WMS-Q). The WMS-Q instances expose a Capabilities document that follows the WMS-Q conventions. This document contains a number of layers (arranged in hierarchy), each of which can be associated with one or more external metadata documents. At present, the GeoViQua PQM and UQM xml documents are linked from the Capabilities document using the MetadataURL tag.

This exercise has enabled the thorough testing of the schemas, covering raster and vector data models, continuous and categorical data quality assessment, data sources and processes in complex lineage documentation, and the link to discovered issues and user feedback info, as well as reference datasets. The models cope well with the diversity of needs for data provider quality documentation although clearly require some training to be correctly understood and used. As an example of the testing, among other issues detected that have been addressed in D7.3, the temporal accuracy measurements as defined by the ISO model have proved inefficient to convey some temporal accuracy indicators both in a qualitative and quantitative way, for instance for the "*Monitoring flooding practices in rice fields in the Ebro river delta using remote sensing*" dataset. In this case, the PQM permits conveying an explanation of the temporal accuracy as a character string in a GeoViQua "discovered issue" extension. Nonetheless, it must be noted that in this manner, though present in the metadata, it can't be queried as a quality indicator by the geosearch components (e.g., DAB-Q). While the tutorials explain the models (see section 5), the Geonetwork metadata editor and the User Feedback Editor tool greatly facilitate the documentation tasks. The workshops for the models, already carried out in events suchlike EGU and INSPIRE or that will take place like in the next GEO Ministerial, have proved to be really helpful.

A full zip of the ISO, GeoViQua and UncertML xsds is available at:

- http://schemas.geoviqua.org/GVQ_schemas_v4_0_0.zip

3.2 Metadata editor tools

3.2.1 The Geonetwork metadata editor tool testing

The Geonetwork metadata editor tool is a schema plugin for Geonetwork that permit creating, editing, saving and exporting GeoViQua QMs format metadata. Moreover, the Geonetwork tool is being connected to a Quality Indicator emitter that in turn is a client of the GECA toolset WPS component and enables the transmission of a quality parameter to the Geonetwork plugin. The Geonetwork component is connected to the DAB-Q and plays a role as an internal catalogue integrator.

This tool is an instance at:

- http://uncertgeo.aston.ac.uk:8080/Geonetwork/ (full functionalities accessible at present with credentials).

There is also an XSLT stylesheet for transforming an existing ISO19139 document to GeoViQua QMs format, which can be downloaded from:

- https://uncertgeo.aston.ac.uk/INSPIREtutorial/19139-to-gvq.xsl.

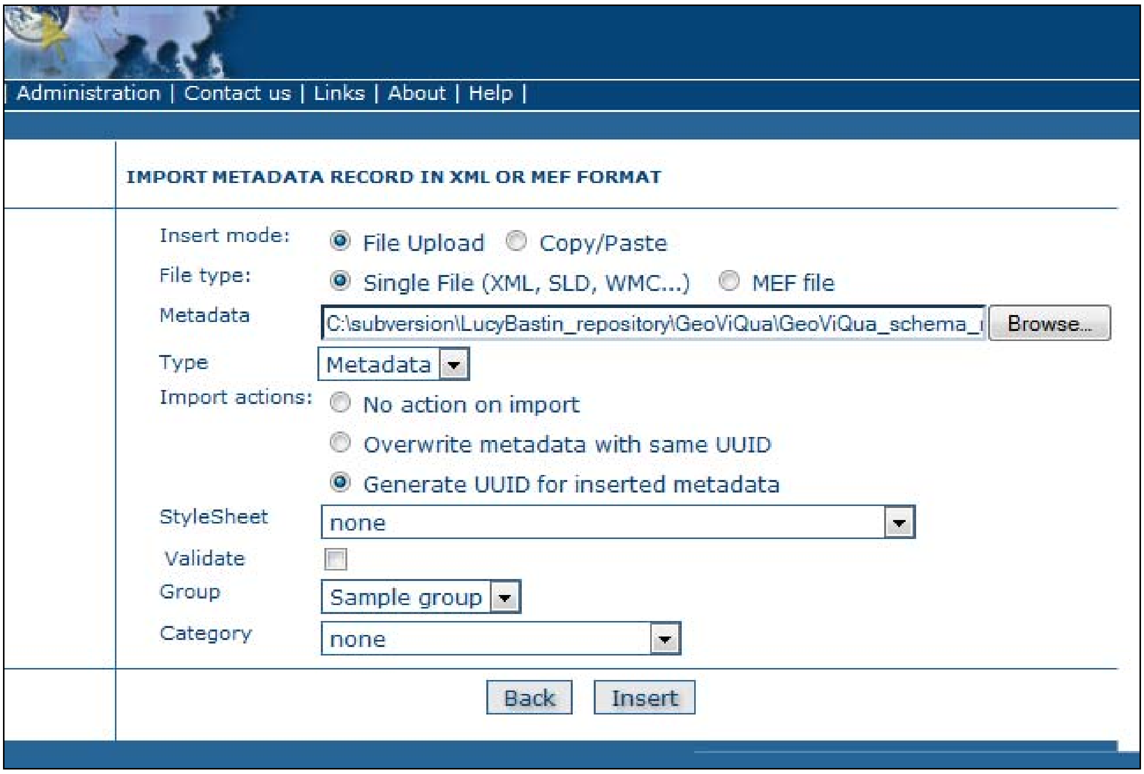


Figure 4: The Geonetwork interface for metadata import functionality

Testing activities have so far successfully checked the metadata xml import functionality, both for the PQM and the ISO models, as well as the metadata creation and edition functionalities. The test has taken into account diverse metadata examples, with specific features regarding quality indicators for categorical and continuous variables and complete quality encoding, including lineage, dataset, sample and variable reports. For example, UREAD and CEA tested the metadata creation tool for generating a PQM in the 4.0 version of the schema for the "*ESA Climate Change Initiative Sea Surface Temperature"* dataset, and the "*Monitoring flooding practices in rice fields in the Ebro river delta using remote sensing*" KML-Q PQM has been derived using the editing functionality.

3.2.2 **User feedback component**

Design, implementation, testing and integration of a user feedback component that will allow GEO Portal users to submit comments, ratings, and other feedback elements on datasets has been achieved.

First, a feedback catalogue developed as a stand-alone tool with web access permits the integration into the GEO Portal, and it is easily maintained or updated. The interface to the server is simple and represents the UQM. A HTTP interface using some RESTful principles has been created. To support the feedback catalogue, Django, Tastypie and PostgresSQL have been chosen. The advantages of this approach are described in D.3.2 (e.g., Django supports switching of database type, Tastypie provides highly customizable abstraction for creating REST-syle interfaces, PostgresSQL is a powerful open-source database system that can run on all major platforms). The feedback catalogue is running as a web service. Requests can be done by specifying a URI and making the request in e.g. a web browser and the quality elements queriables defined in WP4 have been translated into a query request URI. Therefore, the following APIs have been developed for the server: get a resource, search for a feedback item, search for target, and posting data. Planned improvements include authorization issues related to the user administration (e.g., creation of a login page relevant for the posting of data), performance tests, posting data in xml format (at present only Json is supported), or easing information updating of uploaded items.

On the client side, the feedback submission client interface allows GEO Portal users to submit comments, ratings and other feedback on datasets to the user feedback server. The design is based in HTML pages, which only use Javascript and do not require any server information (besides the path to Post to). In this manner, the client is simple and independent of the server enabling the integration of the feedback client in the GEO Portal or external portals (e.g., in the participation in the AIP-6 initiative, the feedback client is envisaged to be integrated into a data provider system of the George Mason University). Other features of the client design is that it uses a wizard-style input, with a simple first form without a request for details and additional tabs for more demanding users, "add more" buttons to support the fields in the UQM that are 0 to many, and collapsible elements that save screen space at the same time avoiding confusing multiple pop-up windows. A secondary target, enabling the user feedback to be related to more than one dataset, and the development of a feedback summary from the feedback items, are envisaged.

The tool has considered the GET functionality as needed by the GeoViQua DAB-Q broker. The requests can be done via RESTful URL requests and as response, xml files will be returned (formatted according to the GeoViQua scheme). The design has been conducted in parallel to the definition of the User Quality Model queriables to be implemented in the search components (e.g., DAB-Q). Through the integration with the DAB-Q (e.g., by means of the Code and codeSpace in the metadata xmls), users are also able to query the feedback server through the GEO Portal search interfaces.

The component URL is:
- https://geoviqua.stcorp.nl/submit_feedback.html

More info and the discussions on the design of the API can be found in **D.3.2.** and http://www.geoviqua.org/UserFeedbackSystem.htm

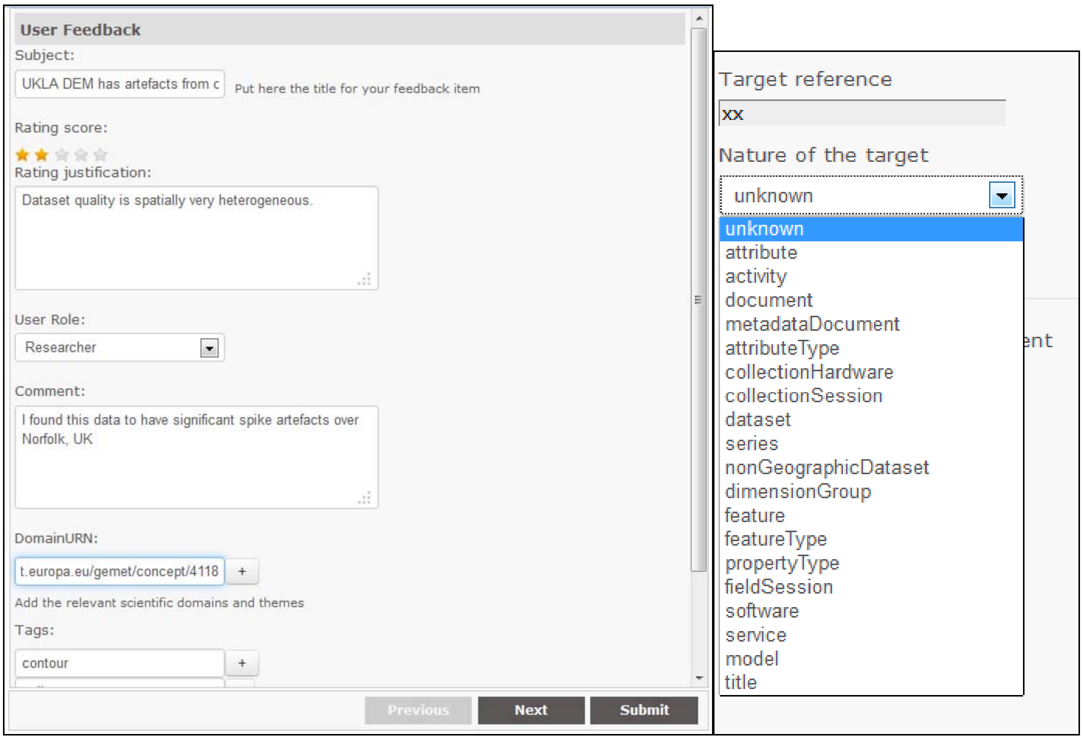


Figure 5. User feedback component interface screenshot

The client side has been tested for User feedback metadata creation, though at present it is not possible to edit exiting UQM xmls. The interoperability between the xml format and the interfaces is under development, as the user feedback component is being updated to the last version of the GeoViQua Quality Models schemas to assure a correct quality elements transmission and matching between the user feedback and its target. Other testing is related to the GEO label component.

Besides, the User Feedback component is being implemented in external products platforms, suchlike the current AIP-6 Disasters-Agriculture experiment with draught monitoring providers from the George Mason University that will enable user feedback submission to their servers, or the FP7 project COBWeb activities. In this last case, the user feedback component has to be tailored to meet the challenges specificities of security issues (e.g., personal data protection, confidential providers' information). These tests will be described in **D8.4 "Second annual report on AIP participation (AIP5)"** that in fact will also deal with the contributions to the AIP6.

3.3 Discovery and access (geosearch) tools

3.3.1 Extensions to the DAB (DAB-Q) and the OGC CSW (CSW-Q)

To enhance the GEOSS Common Infrastructure with innovative search and evaluation tools, the GEO Discovery and Access Broker (DAB) has been extended to support quality information (DAB-Q).

The main functionalities of the Quality Broker are to ensure that the metadata of every data resource contain the proper identifiers, complement the metadata of data resources with UQM information, and apply filters with quality-related constraints. The discovery is achieved through a brokering approach and semantic discovery.

GeoViQua has identified relevant properties (queryables) for quality-constrained queries by analysing user and technical requirements, reviewing quality indicators in the datasets testing, and the requirements of the GEO label design. With this information, the quality extension to the CSW-ISO has been implemented (generating a CSW-Q with specific queryables from the QMs elements), and the brokering logic (mapping and accessors) to fulfil the GeoViQua services (e.g., feedback catalogue, WMS-Q, SOS-Q) has been applied. The DAB-Q is described in detail in **D.4.2 Smart searchable interface component report**. The interface to test the DAB-Q (called DAB-Q demo) is described in section 2 of **D.4.1 Graphical search interface report.**

Figure 6. DAB-Q demo portal display of quality indicators query functionality

GeoViQua DAB (DAB-Q):

- http://23.21.170.207/gvq-demo/services/cswisogvq?

Capabilities document:

- http://23.21.170.207/gvq-demo/services/cswisogvq?service=CSW&version=2.0.2&request=GetCapabilities

Demo portal:

- http://23.21.170.207/gvq-demo/gi-portal/#

Currently, the DAB-Q testing reads from the GeoViQua data servers and metadata catalogues prototypes, and from the GEOSS existing databases. At present, the DAB-Q harvests the GeoViQua QMs and the user feedback component. The integration with the WMS-Q visualization component is being designed, in line with the QMs schemas review resulting from testing activities: the mapping of the results of the harvesting provided by the DAB-Q guides the process. The GetCapabilities provided by the WMS-Q uses keywords for each layer in the WMS-Q that must also match with QualityML quality elements, data identifiers and distribution. Preserving existing protocols when possible (e.g., CSW), GeoViQua is trying to implement ways to discover and access the metadata from the servers and viceversa, guaranteeing the correct transmission of the quality extensions. The inclusion of the GEO label facets as queryable elements and the integration of this component in the DAB-Q, web map browsers (e.g., Greenland), and metadata statistical plots to explore and search large geographical datasets are also in scope.

All Layers and the full hierarchy from the Capabilities doc in the WMS-Q are stored in the DAB-Q, including the layers that only exist to group other Layers (i.e., these layers are not displayable).

To identify the presence of a PQM document attached to a Layer, a MetadataURL is used, for which the broker can deduce the type by inspecting the schema of the attached metadata document (i.e., neither additional attributes/elements or a string for the "type" attribute are required). This is to say the broker downloads all the documents from the MetadataURLs and then decides itself what sort of documents they are, deciding what is relevant for the mapping to ISO 19139. For WMS-Q, a PQM document takes precedence over an ISO 19139 document, which in turn takes precedence over the information in the Capabilities. This means that the DAB-Q can integrate on the fly the PQM and the UQM, and that the GEO Portal will directly read from the DAB-Q.

An improvement out of scope of the project would be to be able to cope with DataURLs (e.g., some of the datasets under WMS-Q might also have data-download links). Regarding the GEO label, common paths between the involved components (i.e., ASTON GEO label server, 52N Producer documents + user feedback + GEO label generator, DAB-Q) are being defined to guarantee a successful integration.

For the DAB-Q integration, the distinction between dataset collection and dataset is mapped into WMS-Q datasets/variables and WMS-Q quality components. A suitable approach would be importing the Get Capabilities in first instance and then follow the MetadataURL. A solved example is shown: http://www.ogc.uab.cat/cgi-bin/GeoViQUA/WMSQ/MiraMon.cgi?SERVICE=CSW&REQUEST=GetRecordById&OUTPUTSCHEMA=http://www.isotc211.org/2005/gmd&ELEMENTSETNAME=full&id=Mode_Summary:EPSG:23031&LANGUAGE=eng&OUTPUTFORMAT=application/xml
To identify the WMS-Q, a keyword mapping between GetCapabilities and ISO or GeoViQua metadata is required. The WMS EO profile is being reviewed to address this matter.

The WMS-Q for KML new instance will be integrated in the DAB-Q as another instance (e.g., http://pc1869.igd.fraunhofer.de:8081/cs3d/Controller?do=wsc&service=WMS&version=1.3.0&request=GetMap&crs=4326&height=10&width=10&bbox=0.57,40.6,0.88,40.8&layers=141106&format=application/vnd.google-earth.kml%2bxml&styles=extrude,colour,QI)
Whereas the kml is advertised in the GetCapabilities, the available formats are not as yet propagated into DAB-Q.

The prototype has been successfully tested using the PQM and UQM examples in preliminary versions, as well as with external datasets provided by 52N and at present the testing activities will evolve to check the quality elements discovery in the GEO Portal Mirror through the DAB-Q, and the correct link between catalogues and servers, including the visualization components. At the time being, the following not WMS-Q specific point must be addressed by DAB-Q developers: the DAB-Q will probably need to harvest information about output formats (e.g., gif, jpeg, png, kml) that are advertised by a WMS instance, since this information needs to propagate to the GEO Portal. On the other hand, the linking of the WMS-Q Capabilities documents to the metadata documents will be done using the MetadataURL, and now the discussion is focused on specific mechanisms for the GeoViQua PQM documents for the individual layers.

3.3.2 SOS-Q/SIR-Q services

The DAB-Q allows brokering services implementing the quality-enabled interface SOS-Q. The SOS-Q is a GeoViQua metadata element in the Sensor Observation Service GetCapabilities Document. This service is a quality-aware extension of the OGC Sensor Observation Service 2.0 specification. It is based on a mapping of SensorML-Q to the GeoViQua QMs. The interactive capabilities editor for SOS Administration Backend has been implemented. Some basic info can be found at **http://geoviqua.dev.52north.org/SOS-Q**

The current stage is the prototype testing, including the creation of metadata for Airbase datasets.

In turn, the Sensor Registry SIR-Q is intended to integrate the "sensor" world to the DAB-Q prototype. The main feature is that it is Sensor Web focussed. It is a prototype required for the mobile client prototyping in GeoViQua. It is envisaged that it is developed as another search website to be integrated to the GEO label API.

3.3.3 Metadata intercomparison tool

The Metadata intercomparison tool, was developed by the GeoViQua project during task 5.3 (described in D3.1). Its purpose is to allow users to easily compare the main metadata elements side by side facilitating the selection of the best dataset for their purpose. It was introduced in the AIP-5 Quality Session (see **D8.1 "OGC, ISO standards participation and contributions report"** for further details). It is now being extended to include the graphic comparison of metadata elements in the form of statistical plots (described in **D4.1 "Graphical search interface report"**). This is to say it is now compliant with the ISO metadata model and previous versions of the GeoViQua PQM. The next steps will update the tool to the latest QMs schemas and integrate this component in the GEO Portal Mirror.

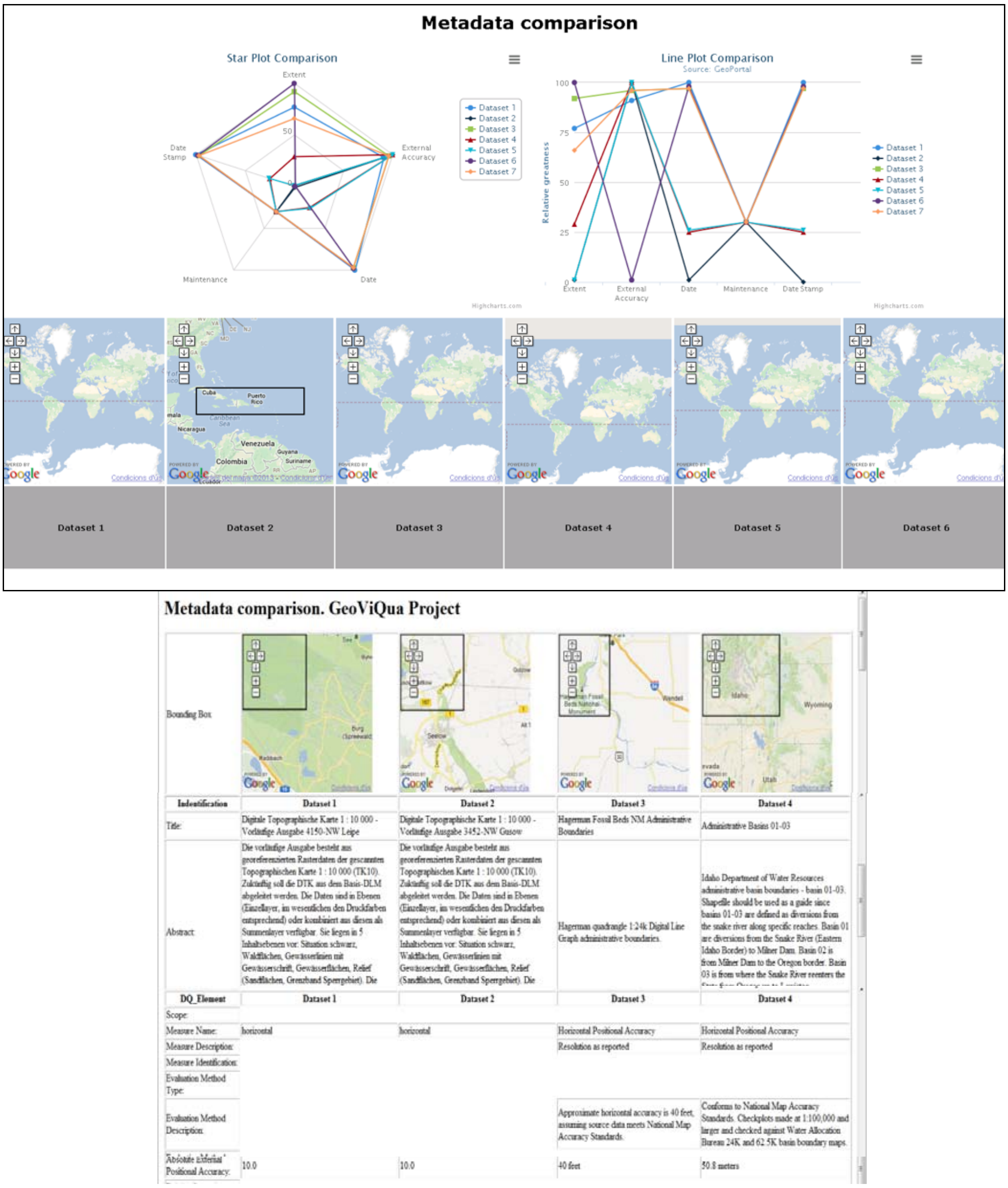


Figure 7. Metadata intercomparison side by side and plots

The testing has been done with metadata extracted from the Clearinghouse, and some GeoViQua datasets metadata (both ISO19139 xml and PQM xml). It must be remarked that it has been hard to find suitable metadata records in the federated catalogues in the GEOSS Clearinghouse for the testing of the tool. Most of the documents come with almost no numeric elements to be graphically compared (not even scale denominator). This confirms the status and trends detected in the Clearinghouse analysis studies (see D7.2 for further details) where it was found that although quality elements in metadata records were not inexistent, most of them were either blank, not valid documents, or wrongly encoded in the ISO standard model.

3.3.4 Metadata completeness tool: Rubric test

The rubric quality punctuation is based on the Rubric project under NOAA (National Geodetic Survey, National Ocean Service, NOAA, U.S. Department of Commerce) development. The tool identifies ISO metadata elements classified in groups following the ISO 19115 schema (ISO 19139): Identification, Connection, Extent, Distribution, Description, Content, Lineage and Acquisition Information. The GeoViQua Rubric extension for quality adds Quality and Usage information to the initial set, including lineage details related with data quality. In order to maintain cohesion amongst the GEOSS components, the GEOSS style has been applied to the rubric tables.

The information is represented in tables that visually describe the goodness of documentation. The total scores are summarized at the top of the report, the rows represent the metadata elements groups, and the columns show the percentage of the included elements in the metadata records. Finally, the Description, Best Practice and Path columns show information extracted from the ISO standard specifications.

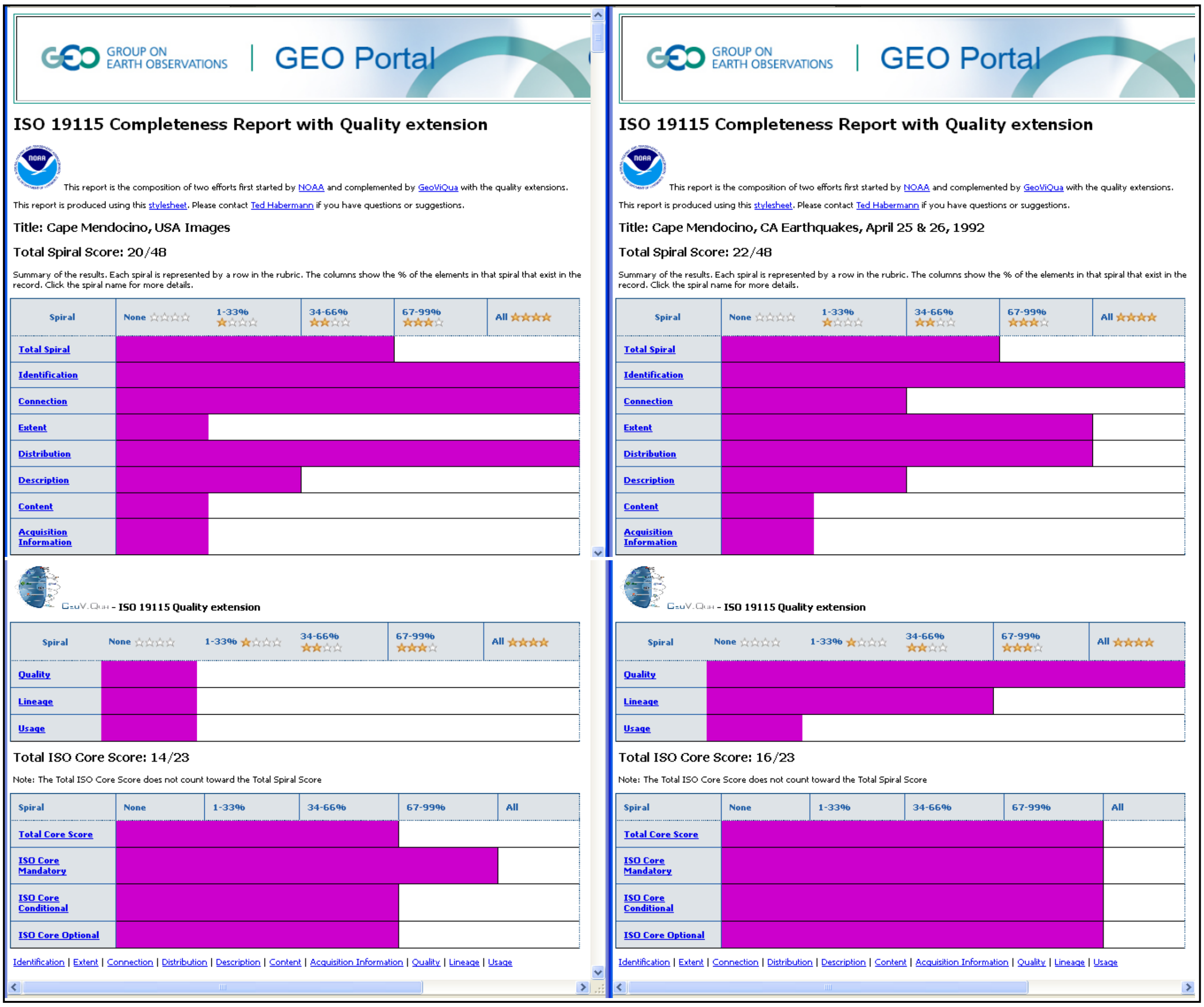


Figure 8. Examples of rubric tool quality extension

This figure shows the two examples of the rubric tool quality extension. The quality information has been added to the score table, acting as a summary of all the information contained in the xml metadata extracted from the NOAA repository.

The way rubric works is adding a simple link to the XSL style sheet in the XML to be represented. The user could supply a URL which points to the metadata styled using the rubric. That means that using a catalogue URL is a useful way to publish the rubric tool and embed it with the GeoViQua quality model. For testing purposes, the following URL is available:

- **http://www.geoviqua.org/Eng/MetadataVisualization.htm**

If the catalogue URL to the cited metadata is provided, the metadata can be shown in a rubric styled way, and referenced as an *onlineResource* in the publication to be included in the *discoveredIssue* in the GeoViQua Producer Quality Model. This demonstrates an easy way to connect GeoViQua components: the rubric tool and the PQM. The testing of the tool has been carried out using external metadata documents, and a GEOSS metadata document from the Clearinghouse.

3.3.5 Provenance viewer tool test

The huge quantity of information, the heterogeneity of the origin of the data, and the complex functionalities involved in the creation of some geographical products can generate some reliability assessment problems. In order to increase the trust of metadata, the collection and the accessibility of detailed lineage information including responsible parties is crucial to evaluate the quality of the resulting knowledge, to estimate the trustworthiness level, as well as to allow the reproducibility of the geographical information.

Provenance is defined as the part of the metadata that refers to the origin and the processes undertaken to obtain a specific geospatial product. Some challenges in provenance-aware applications that GeoViQua is attempting to address are the interoperability of the provenance formats, automatic provenance registration and visualization techniques. The GeoViQua prototype for provenance visualization in GEOSS takes into account the relation between provenance information and workflow processing in distributed environments (e.g., Web Processing Services).

An integration enhancement regarding GeoViQua components is the inclusion of a provenance facet in the GEO label design, a possible entrance door for the provenance visualisation prototype. At the time being, it is envisaged that the component will be integrated in the GEO Portal Mirror and updated to the latest QMs schemas version (valid also for the ISO xml model).

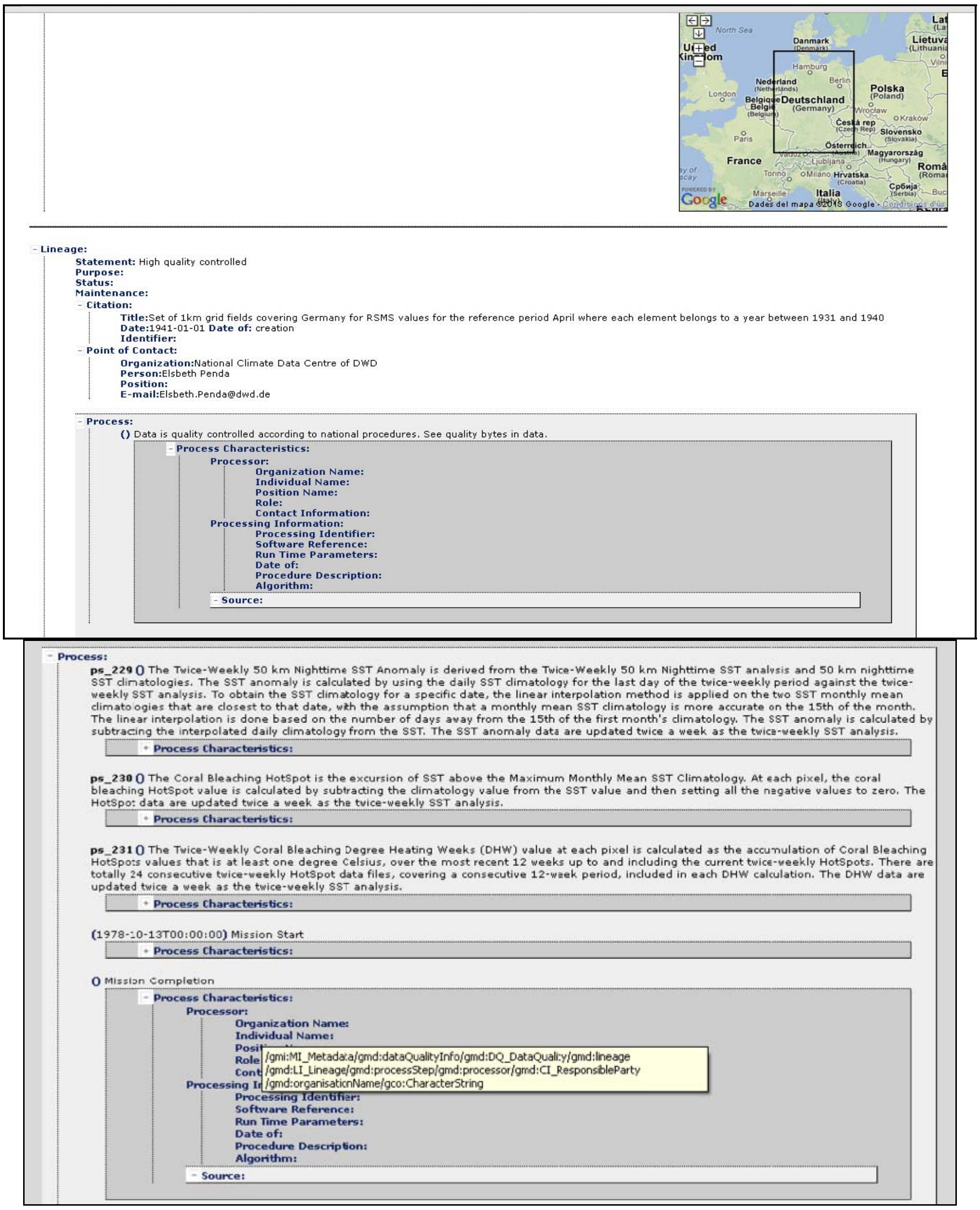


Figure 9. Screenshots of the GeoViQua Provenance viewer component

3.4 Visualization interfaces

3.4.1 Server implementations

3.4.1.1 Standards-based approach using OGC WMS (WMS-Q) and UncertML

The updated ncWMS-Q instance follows the WMS-Q conventions (see http://www.geoviqua.org/OGC-WMS-Q_ER.htm for basic info). UncertML vocabulary elements are recorded as Keywords on the layers. The WMS-Q is identified by a keyword at the top level of the GetCapabilities document. The GeoViQua intranet contains the integration thread of the WMS-Q to the discovery and access components, harvesting protocols, the external metadata document links (see section 3.1 above), and the interoperability issues between existing standards and protocols and the GeoViQua quality-aware extensions. The Capabilities document keywords should be linked through the MetadataURL that in turn contains the coverage descriptions with the quality parameters of UncertML or QualityML. The dataset identifiers must also match and be linked, and the distribution info is to assure that the distribution can be found in the metadata documents but also the other way round (i.e., from the server, the metadata can be accessed).

It has been tested by UREAD using "*ESA Climate Change Initiative Sea Surface Temperature*" and "*Carbon Cycle*" products with uncertainty information and an example of a MetadataURL.

Regarding the styling options, the flexibility has been improved by revising SLD/SE and generating extensions and collaboration with other groups outside GeoViQua. Uncertainties can be displayed as contours, stipples, and confidence triangles for instance in current implementations.

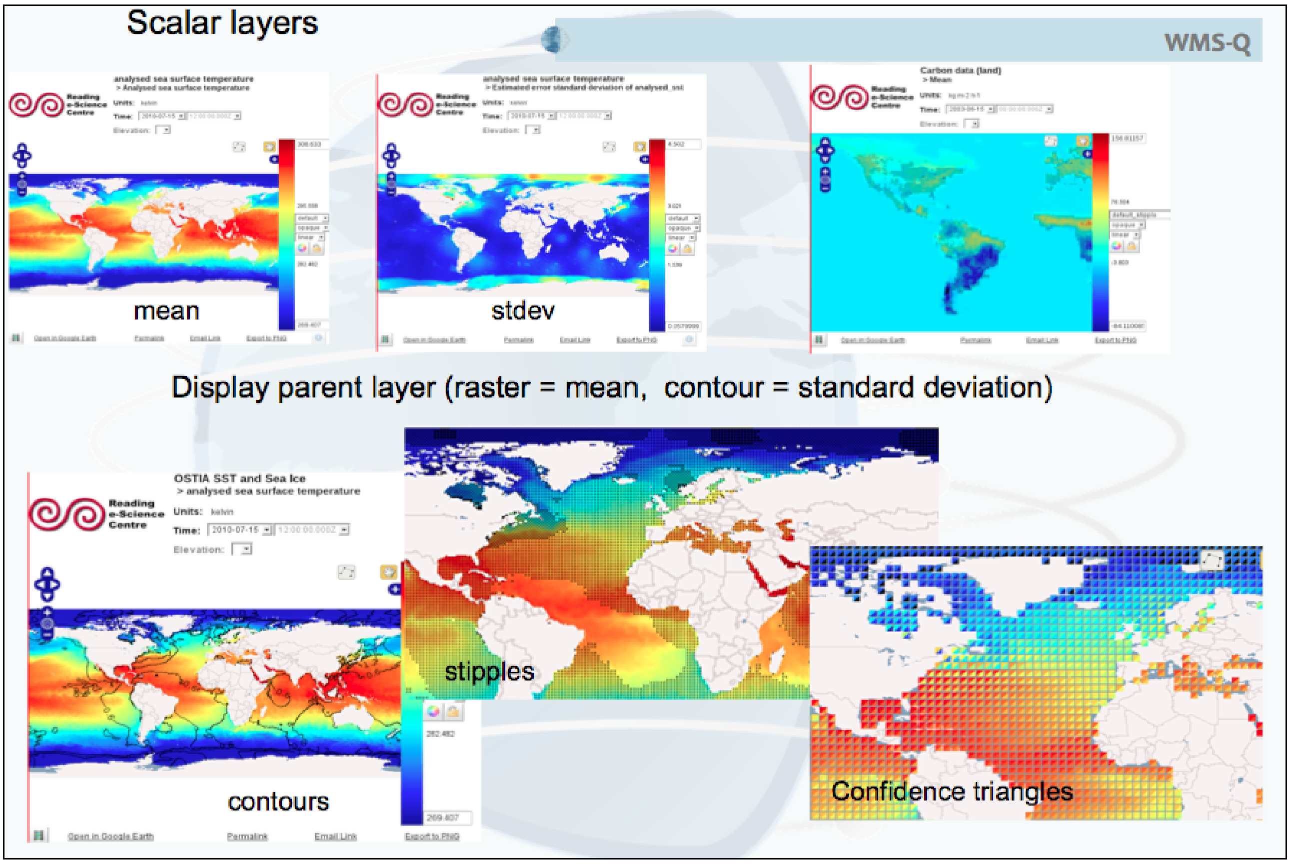


Figure 10. WMS-Q: Uncertainty visualization stylings for Carbon cycle data

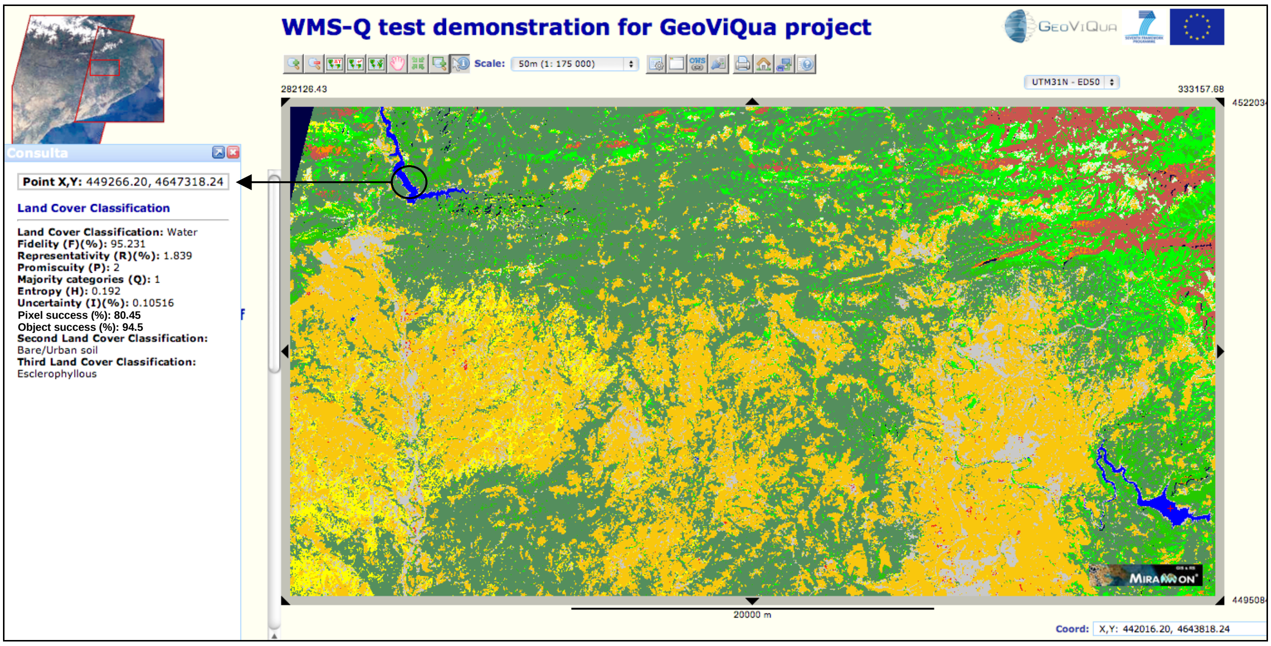
The GeoViQua ncWMS-Q has been presented at the FOSS4G (Nottingham, UK, September 2013). The GeoViQua WMS-Qs are also integrated in the 52N Greenland client and therefore accessible to the DAB-Q component.

- http://dexter.nerc-essc.ac.uk/ncWMS/godiva2.html

Another example of the WMS-Q prototype testing is the CREAF WMS-Q/WMTS-Q implementation:

- http://wms-q-demo.geoviqua.org/geoviqua/wmsq/

This server contains the data products, metadata PQMs updated to v.4.0 of the QMs schema, together with quality indicators and uncertainty layers (spatialized quality estimates from WP3 activities, summarized in D7.3 and D3.3) of the "*Digital Climatic Atlas of the Iberian Peninsula*", the "*Landcover classification of Barcelona-Girona Landsat scenes*" and the "*Monitoring flooding practices in the River Ebro Delta using Remote Sensing*" datasets.



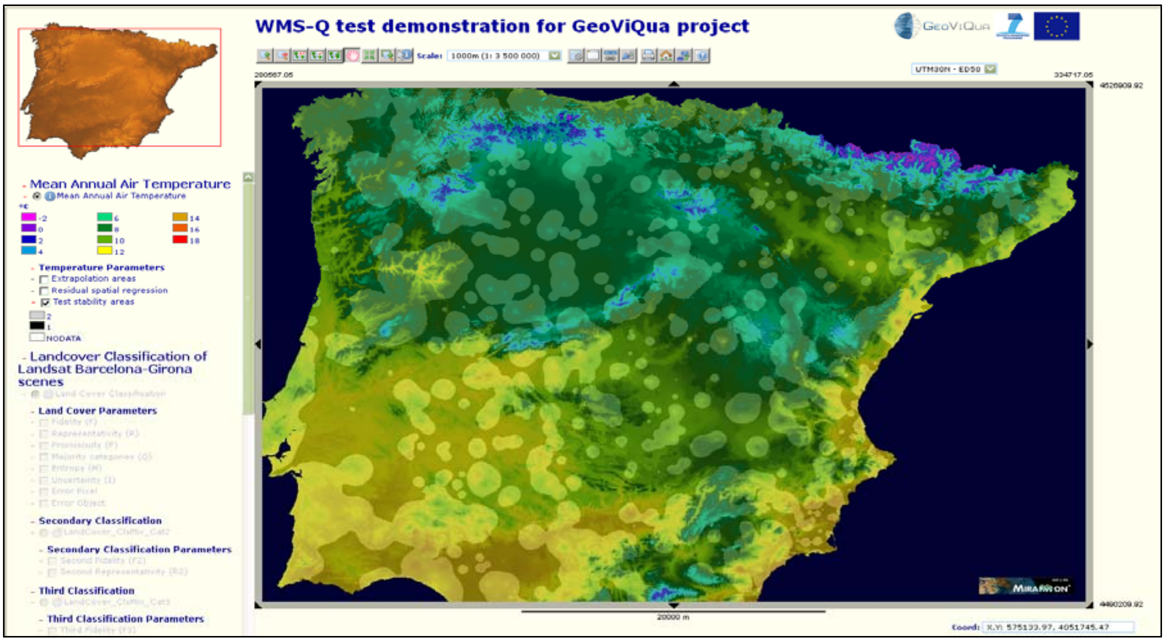


Figure 11. WMS-Q server interface screenshot with quality indicators query results

This component has client and server sides of the WMS-Q.

Service GetCapabilities

- http://www.ogc.uab.cat/cgi-bin/GeoViQUA/WMSQ/MiraMon.cgi?REQUEST=GetCapabilities&VERSION=1.3.0&SERVICE=WMS

To support the WMS-Q profile, the MiraMon server technology requires a pre-rendering of the data into pictoric representation tiles (GIF, PNG, JPEG) and the integration of new sections expressing the relationships between layers (i.e., WMS-Q layer nesting requirements). Additionally, each layer in the MiraMon data model can have a metadata document ready to be shared. These documents are exposed in the GetCapabilities document as a Metadata URL's, and contain quality indicators.

The vocabulary used in the keyword section is evolving in line with the quality indicators interface as is explained in sections 2.2.2 and 3.1 (see D.7.3 and D3.3).

In turn, the WMTS-Q service has also been addressed. WMS MiraMon services are able to expose the same layers as WMTS layers using the same data preparation. The WMTS GetCapabilities document describes the layer names and properties. The layers that contain the per pixel quality information are related to the "main" data by dependencies expressed in the <Themes> sections of the same capabilities document. Metadata documents are exposed in the GetCapabilities document as ows:Metadata's. From the prototype testing stage, the current work is on the URI Quality Parameters.

Capabilities document:

- **http://www.ogc.uab.cat/cgi-bin/GeoViQUA/WMSQ/MiraMon.cgi?REQUEST=GetCapabilities&Service=WMTS**

3.4.1.2 **KML-Q standard**

The prototype for quality-aware visualization component addressing vector datasets has used bivariate geospatial data visualisation techniques and perceptual colour models.

There are various approaches for visualising location-dependent geospatial data quality, and many exploit colour as a means to transport information (as a so-called "retinal variable"). For machines to treat colour, it has to be described in some (ideally well-defined) colour space. However, the qualities of colour spaces themselves are often being overlooked – even though their inner structure substantially affects the results of colour-based visualizations. This not only creates problems for the reproducibility and validation of such approaches, it also may reduce the quality of the resulting visualisations.

The advent of perceptually proportional colour spaces such as CIECAM02 introduces a class of colour spaces which are ultimately superior for tasks such as visualization of information. This is because in such models, the components of colour (such as lightness, hue, saturation) are separated very close to how human perception separates them. Thus, unlike traditional colour spaces, these spaces allow changing one component (e.g., hue) without altering the perception of the others (i.e., lightness or saturation). Such components are called colour appearance correlates. In effect, they can be varied and perceived independently, enabling colour-coding without visual crosstalk.

Our prototype for the "Monitoring flooding practices using Remote Sensing" dataset shows how CIECAM02 can be used to improve a geospatial visualization which includes quality. Preliminary results indicate that intercomparability between colour patches is improved, especially if they are not adjacent. Just as traditional colour coding, the technique applies to a range of information. It is, however, especially suitable for conveying bi-variate data as occurs when combining data and corresponding quality information. This prototype of KML-Q represents an open-source implementation of these concepts. The following figure shows the KML-Q over Google Earth, displaying the quality indicator purity at rice crop parcel level in 3D, and the colour palette used in trials to enable visualization of the classification product and the associated uncertainty in a single view (below). This approach can be also tried in the "*Landcover classification of Barcelona-Girona Landsat scenes*" dataset WMS-Q implementation.

Right now, it may be more accurate to define this is a WMS serving KML-Q. The step to convert it into a proper WMS-Q would be a question of modelling the data access (e.g., the current layers contain quality information, that shall need to be modified and instead, the quality indicators should be sub-layers of the respective layers). An approach would be to create groups of layers: top-level layer for holding the group, first layer in the group displays the value and uncertainty simultaneously (this might be the current kml layer), second layer in the group displays the value only, and third layer displays the uncertainty only. The layers would be tagged (including the top-level group layer) with appropriate Keywords to indicate the semantics of the information, e.g. from UncertML or QualityML. In this case, there is a time split between layers: a group of layers for each time can be created or else a time axis could be used to convey this time split still having a single group of layers.

At present, the get map request uses comma to separate style names (e.g., http://pc1869.igd.fraunhofer.de:8081/cs3d/Controller?do=wsc&service=WMS&version=1.3.0&request=GetMap&crs=4326&height=10&width=10&bbox=0.57,40.6,0.88,40.8&layers=141106&format=application/vnd.google-earth.kml%2bxml&styles=extrude,colour,QI).

In WMS (and in WMS-Q by extension) it is possible to ask for more that one layer in a map with coma separated names. In this case a comma (",") separated list of styles is expected. The current KML-Q is asking for a single layer and several style names. Strictly speaking, this is not acceptable for a "true" WMS. To combine style names for a single layer, ";" could be used instead. In fact, some other softwares applies this workaround. Last, the style combination should be advertised in the GetCapabilities document.

GetCapabilities:

- **http://pc1869.igd.fraunhofer.de:8081/cs3d/Controller?do=wsc&service=WMS&version=1.3.0&request=GetCapabilities**

Get Map request:

- **http://pc1869.igd.fraunhofer.de:8081/cs3d/Controller?do=wsc&service=WMS&version=1.3.0&request=GetMap&crs=4326&height=10&width=10&bbox=0.57,40.6,0.88,40.8&layers=141106&format=application/vnd.google-earth.kml%2bxml&styles=extrude,colour,QI**

The dataset PQM has been extended to include the corresponding distribution info link to the KML-Q, so in this manner a single metadata document will point to two distribution points and part of the testing tasks for the DAB-Q component will be to discover and access both. Next stage will likely include testing and improvements with some other GeoViQua dataset (e.g., “*Geometric corrections of Landsat series*”, “Landcover *classification of Landsat Barcelona-Girona scenes*”).

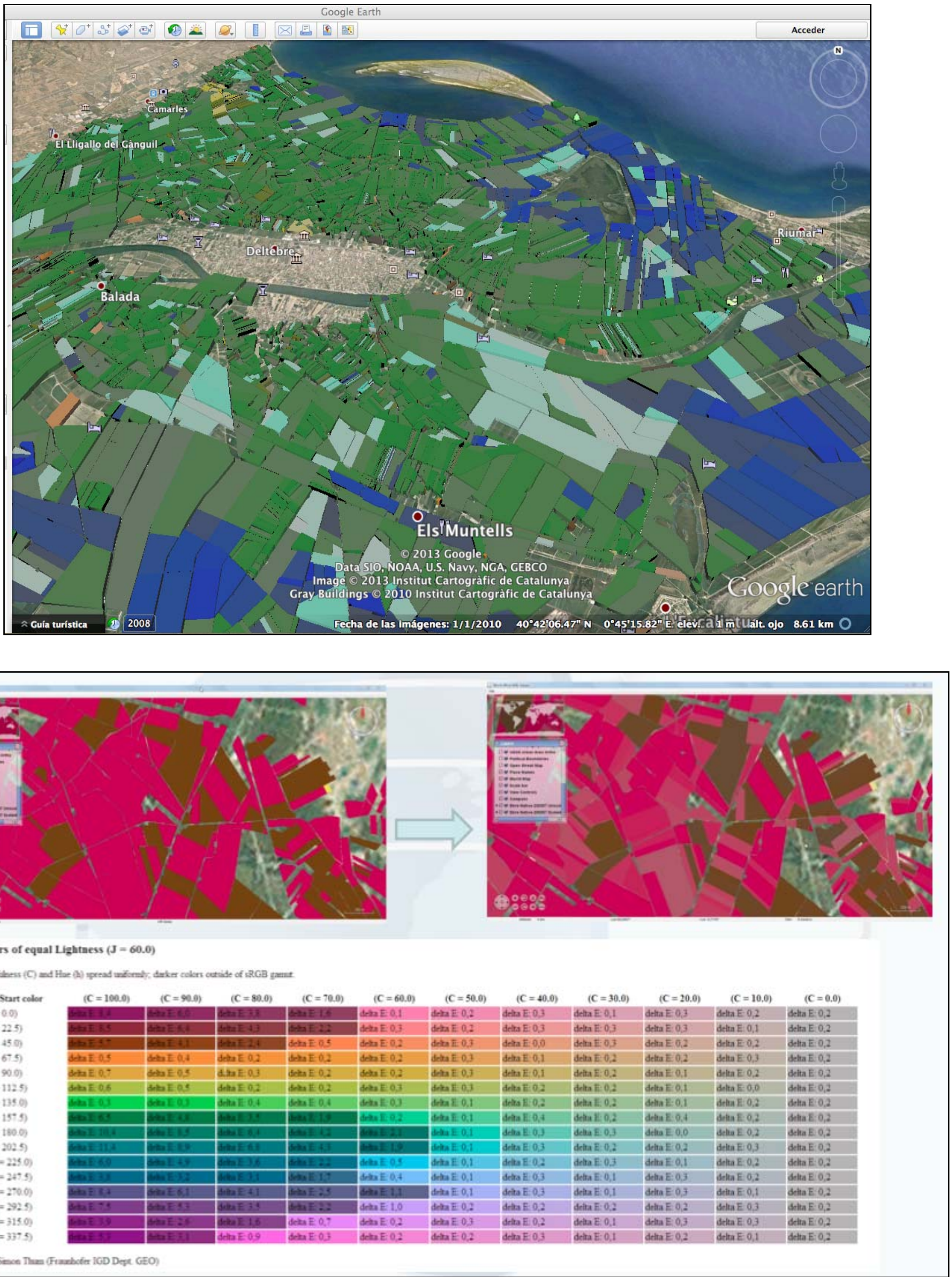


Figure 12. KML-Q Purity quality indicator visualization for flooding monitoring categories in 3D and colour palette of 2D trials

3.4.1.3 **Carbon portal**

This Global Carbon Atlas server uses the THREDDS Data Server (TDS), which is a web server that provides metadata and data access for scientific datasets. By being harvested by the ncWMS server and being OGC compliant, datasets can be visualized in a client through the WMS protocol. The netCDF file harvesting was simplified because the request can be done with the real file's name (instead of direct usage of ncWMS that actually uses an identifier).

Accordingly, this service is able to return datasets in several visualization styles (e.g., legends, layers styling, etc) through GetMap WMS requests. The user is able to compare carbon fluxes models (figure 13). The prototype testing with "*Carbon Cycle*" datasets has improved the quality-awareness of the ncWMS server. Furthermore an uncertainty layer resulting from the comparison will be provided.

Get Capabilities Document:

- http://webportals.ipsl.jussieu.fr/thredds/wms/CARBON/fco2_lmdz_pyvar_frederic_1988-2008.nc?SERVICE=WMS&VERSION=1.3.0&REQUEST=GetCapabilities

Web access to scientific map server:

- http://www.globalcarbonatlas.org/?q=flux_maps

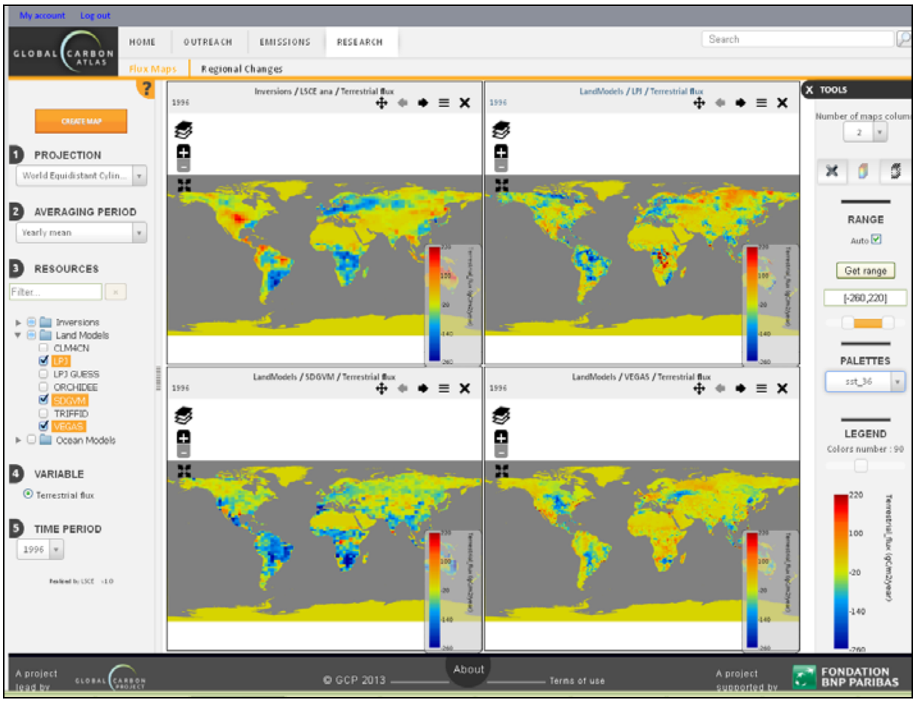


Figure 13. Global Carbon Atlas screenshot: carbon fluxes models comparison in WMS viewer

3.4.1.4 **Iconic representation of quality information: GEO label generator**

The GEO label component is a graphic representation which visually summarizes the availability of quality information for the dataset it represents. Producer and feedback metadata documents are being used to dynamically assess information availability and generate a label. The GEO label representation comprises eight informational facets: producer profile, producer comments, lineage information, standards compliance, quality information, user feedback, expert review and citations information. Because the GEO label is intended to convey the availability of quality information for a given dataset, each informational facet can represent one of three availability states: ‘available’; ‘not available’; and ‘available only at a higher level’ (indicating that information is not immediately available for the dataset, but is available for a parent dataset). These three information availability states are expressed through varying the appearance of the facet icons.

The GEO label not only visually summarizes information availability but also provides hover-over (for summary information) and drilldown functionalities. Hovering over an individual facet in the GEO label displays a summary of the information related to the facet for the associated dataset – e.g., producer comments, the name of the standard to which the dataset complies, etc. The drilldown function displays styled structured information extracted from the associated dataset’s metadata record when a facet is clicked (see Figure 14 for an example).

When integrated in the GEOSS, an individual GEO label will be provided for each dataset in the GEOSS clearinghouse based on its available quality information. The generated GEO labels will serve as quality indicators assisting in dataset searching and selection activities by providing users with visual cues of dataset quality and possibly relevance.

Figure 13 shows an example GEO label representation generated for the “*Digital Climatic Atlas of the Iberian Peninsula*” dataset. As can be noted, all eight GEO label facets are coloured in indicating that there are both producer metadata documents and user feedback available for this dataset.

Figure 14. An example GEO label generated for the “Digital Climatic Atlas of the Iberian Peninsula” dataset

Figure 15. Citation information drilldown of the "Digital Climatic Atlas of the Iberian Peninsula" dataset

The GEO label API is available for testing purposes at:

- http://www.geolabel.net/demo.html

More information on the GEO label and the GEO label service can be obtained at:

- http://www.geoviqua.org/Docs/SubmittedDeliverables/D6_2_GeoViQua.pdf
http://tutorial.geoviqua.org/

The GEO label is already updated to the latest version of the QMs schemas and the linking is now solving the secondary target issue (i.e., the identification of feedback about more than one dataset), the feedback summary functionality in line with the developments of the User Feedback components, the AIP-6 experiment of security integration (e.g., collaboration with the COBWeb project), as well as the integration into the DAB-Q by the "Code" and "codeSpace" metadata elements and the definition of the common XPaths between components.

Besides, 52N is implementing a GEO label server is written in Java, in which the GeoViQua QMs and ISO xml files can be uploaded or referenced by using the metadata URL, copied-pasted, or written, both for the PQM and UQM, to generate a GEO label. A Java library was needed to generate labels and then a couple of steps more enabled to put the API around it. The server can handle both references (URLs) and full documents posted to it. The test pages provide a form for both use cases. The integration of the user feedback submission and the data providers' documents and the resulting GEO label in a single entrypoint has proved to be highly convenient.

- http://geoviqua.dev.52north.org/glbservice/

The source code is available on GitHub, where as a result of testing activities, issues are reported and commented.

For instance, some testing with the ASTON GEO label server is shown in the following figures. This figure shows the GEO label dynamic icon and a citation drill-down for the "*Digital Climatic Atlas of the Iberian Peninsula*" dataset. All facets appear coloured, showing there are both producer metadata documents and user feedback that has been properly linked to the dataset information.

In turn, the figure shows the output for the "*Landcover classification of Landsat Barcelona-Girona scenes*" when posting the full document (PQM) in the 52N GEO label Server. The Quality facet in the GEO label is not highlighted because the server has yet to adopt the final schema specifications, resulting from other the QMs testing activities.

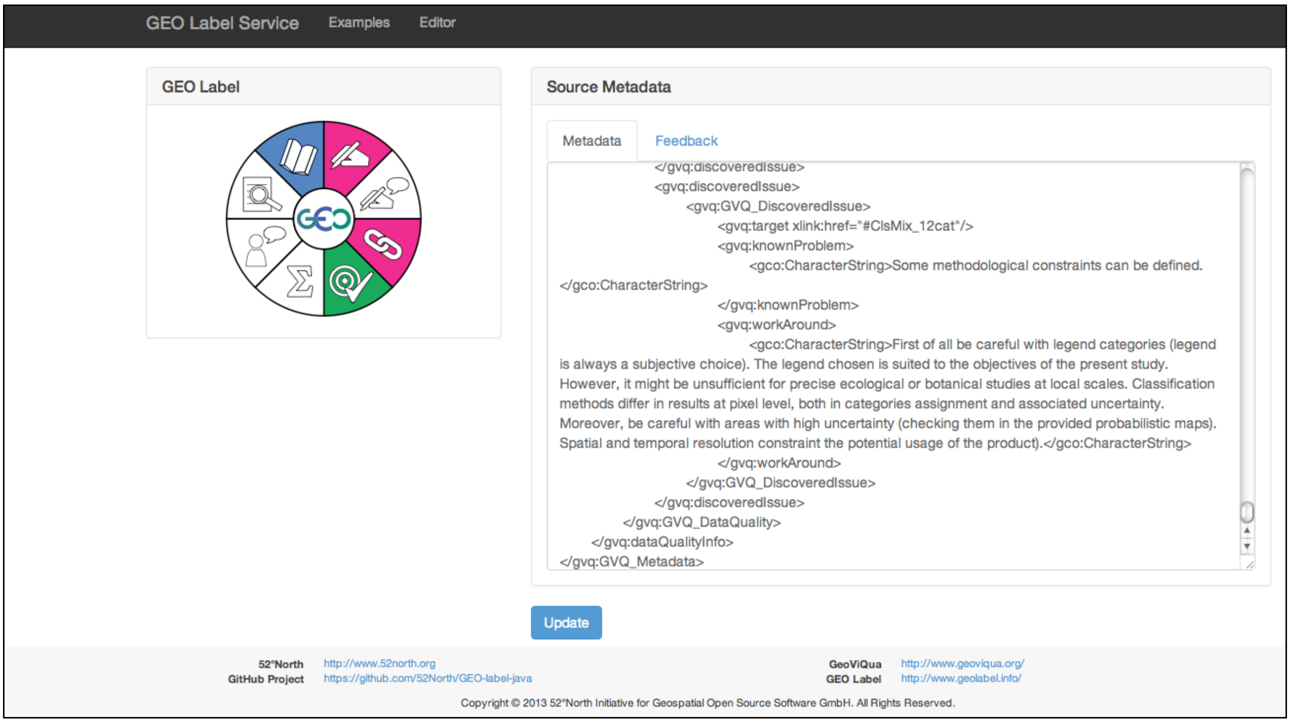


Figure 16. Test of the GEO label server

3.4.1.5 GECA toolset as a WPS

The GECA Toolset is a toolkit for ingesting, processing and inter-comparing satellite data against correlative data, which can be either in-situ data or other satellite data. It is composed of command lines and a library of analysis functions. In the inter-comparison the satellite and correlative data are processed and the two datasets that are to be compared end up having the same temporal/spatial grid, data format, and same physical unit.

The overall goal of the encapsulation of the GECA toolset in a WPS Process and potentially combine them with INTAMAP is to provide intercomparison functionality to GEOSS. This action has required mapping gtcontrol to WPS process and moving code package for GECA's Python control layer, as well as addressing test requests and example responses. The idea is to create a mechanism to intercept dataset identifiers and other elements (on WPS level) so that the process works on local rather than on online files. In addition, this functionality envisages the creation of a parser for intercomparison definition (i.e., replacing the required paths), a writer to store the file that is to be run in a local folder and call the GECA toolset with it, a local file resolver interface for the WPS identifying the names of datasets where it can provide a local copy for, and a simple client for WPS that allows to select two predefined datasets (for instance from a drop down list) and then send an intercomparison request to the WPS.

A case study based on air quality measurement from both remote and in-situ sensors has been defined and will be used to inform the design of the solution and test the results. A tool prototype that uses the Web Processing Interface (WPS) exposes intercomparison functions to the GEO Portal user. Further details are explained in D7.3.

The prototype has been tested using the test data from the Air Quality Pilot Case, for instance comparing measurements from different instruments on ENVISAT –GOMOS, MIPAS- that are close both in time and geolocation; see D7.3. The web client for configuring the parameters is in development. The integration to the Quality Emitter that elicits quality indicators from collocated formats and sends them to the Geonetwork leads the way to the connection to the DAB-Q and the functionality in the GEO Portal Mirror.

For example, some instances/requests have been tested:

- http://geoviqua.stcorp.nl/wps?service=WPS&version=1.0.0&request=describeprocess&identifier=all

The tool allows for generation of PDF report from the datasets or a ZIP file containing the report and the intermediate files generated by the GECA toolset (simply replacing "application/pdf"to "application/zip").

The tool is tested with sensors data (remote and in-situ, provided by ESA). The example definition successfully executes with these datasets. At present, the GECA toolset WPS still needs some adjustment to adapt to the GeoViQua QMs xml files.

3.4.2 Client implementations

3.4.2.1 Greenland client

For the testing of the client side, it was important that the server prototypes (e.g., WMS-Q) supported cross-origin resource sharing. Enabling CORS on the server side makes the data a lot more accessible for other clients too.

Greenland is a JavaScript client for explorative analysis of geospatial data, most importantly WMS-Q and particularly ncWMS-Q. Here we can see it with the CREAF WMS-Q

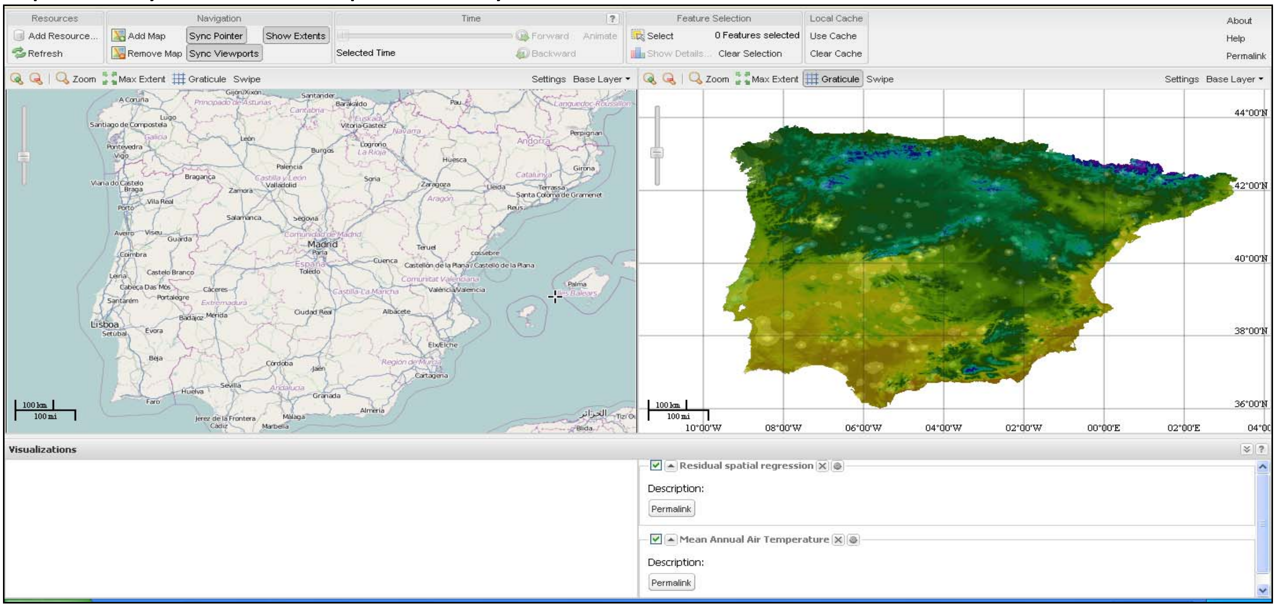


Figure 17. CREAF WMS-Q Climatic Atlas layer in Greenland

This component is a stable client software for (nc)WMS(-Q), which features automatic visualisation of uncertainty based on the semantic information in a WMS-Q capabilities document.

URL of demonstrator website:

- http://geoviqua.dev.52north.org/greenland/

URL of developer website (including source code):

- https://wiki.52north.org/bin/view/Geostatistics/Greenland

The most important outstanding task is integration of test datasources and users testing Greenland for exploring these datasets. A potential task is the interaction between Greenland and ncWMS-Q with respect to styling mechanisms. The GeoViQua WMS-Q servers are in process of being integrated in the Greenland client.

3.4.2.2 Mobile devices visualisation standard GeoAR

The GeoAR is the open source augmented reality for geospatial data provided by 52N to assess mobile devices visualisation standards in GeoViQua. It is an Android App with Map and Augmented Reality views. There is a codebase for adapted visualisation to implement GEOSS for mobiles.

Demonstrator website:

- https://play.google.com/store/apps/details?id=org.n52.geoar

Developer website (including source code):

- https://wiki.52north.org/bin/view/Projects/GeoAR

The app is being tested with air quality databases (e.g., meteorological stations data).

3.4.2.3 Global Carbon Atlas (client side)

The Global Carbon Atlas is a client implementation using OpenLayers and the ncWMS-Q server to visualize carbon fluxes data. The simplest solution to have uncertainty information related to the carbon cycle datasets is to provide the comparison between carbon fluxes models in a WMS viewer, as shown in the research section of the website (see also 3.4.1.3 section of this deliverable).

Figure 18. Global Carbon Atlas website screenshot

Global Carbon Atlas website access:

- http://www.globalcarbonatlas.org/?q=home

3.4.2.4 **MiraMon Map Browser**

Through the browser, initially all layers were visible individually but now combined visualization of uncertainty layers (e.g., spatialized quality indicators) and the corresponding dataset has been implemented: different visualization styles (e.g., shading, stippling and others) have been tested for the GeoViQua datasets (spatialized quality for categorical and continuous variables). Queries by location currently include quality parameters. The browser is conformant to WMS and WMTS protocols, providing access to the MiraMon server described in the previous section.

Demonstrator website

- **http://www.ogc.uab.cat/GeoViQUA/WMSQ/**

4. Integration of GeoViQua components in an GCI mirror environment

The GEO Portal is a website that provides convenient discovery to the full range of GEOSS data and information. To do this, it dialogues with the DAB-Q that exposes a metadata catalogue interface to the client. As explained in D4.1, with simple modifications in some pages it is possible to include quality enhancements in the GEO Portal to make filtering and visualization more productive and attractive. Thus, the GEO Portal is the target platform for most activities within GeoViQua. The online version can be found here: http://geoportal.org .

The GEO Portal Mirror is a clone of the current GEO Portal, provided by ESA that is being modified by the project members, and centralizes several visualization improvements at present.

4.1 GeoPortal Mirror integration and testing

Although in the previous section we have compiled client prototypes with specific aims in GeoViQua, this section is dedicated to the main client component in the project: the user interface to GEOSS (i.e., GEO Portal).

In order to integrate the prototypes in the currently evolving GEO Portal structure, a GEO Portal mirror has been used: http://geoportal.geoviqua.org

Figure 19 shows a pop-up window highlighting the Metadata Intercomparison, GECA toolset, Greenland client and DAB-Q components integration.

Figure 19: GEO Portal Mirror screenshot display of the GeoViQua components integration

The components diagram shown in Figure 1 depicts the roadmap for the integration framework of components in the GEO Portal Mirror in GeoViQua.

Among the components explained in section 3, the GeoViQua Quality Model schemas will be available at metadata presentation level in form of xsl, the user feedback client, metadata intercomparison, metadata viewer (Rubric) and provenance viewer, together with the Greenland client and KML viewer (either directly by means of display in Google Earth or through the WMS-Q instance for KML-Q prototype), will be integrated into the GEO Portal Mirror. It must be noted that the WMS-Q instances and the Carbon Atlas Portal can be harvested by the quality-aware geosearch components through the integration of Greenland. Likewise, the GECA toolset WPS is implemented by means of connection through the Quality Emitter and Geonetwork API. Last, the GEO label could be directly harvested by the DAB-Q or through some of the server implementations (e.g., 52N). Integration details are explained in D.4.1 and the on-going tasks are part of the WP4 activities. Keywords in the Get Capabilities documents are essential for the integration of the quality-aware elements in the GEO Portal Mirror.

Besides, an extension to the GEO Portal Mirror is being discussed in order to provide a "how to cite this dataset" functionality, that would enable for instance citing a paper derived by a GEOSS dataset usage. The idea is to modify the GEO Portal results page display to offer such information. The approach would be to use the elements of the CI_Citations in the dataIdentification in the QMs schemas, following the dataset citation guidelines in GEOSS (**http://www.gstss.org/library/GEOSS_Data_Citation_Guidelines_V2.0.pdf)** and citation styles specification (**http://citationstyles.org/downloads/specification.html),** or associated processor tools that permit to make plain text from a given citation in any given citation style. In this manner, the protocol could be reused in other contexts (e.g. LaTex). The icon could be picked up by a client library would handle citations to the html of the GEO Portal to support such features.

So far, the architecture is based in the extension of existing functionality (e.g., search results, dataset overview pages), and adding new functionalities, in separate modules. Communication between portlets is based on the "Interportlet communication" that uses features from the Portlet 2.0 specification to connect several portlets (e.g., Greenland visualisation, metadata comparison, standalone feedback search).

The service components that integrate with the GEO Portal via a web service interface are the Feedback Catalogue, containing user feedback metadata samples, the Greenland, the metadata comparison, completeness and provenance visualization and the GEO label.

GeoViQua user stories (e.g., scenarios video demos) have been employed to test the prototypes and architecture pathways, involving several components interaction testing.

A testing example is shown in Figure 20: the SOS-Q quality metadata is used to display a

GEO label rendering in the Geoportal Server search results based on metadata queried from the DAB-Q. The GEO label is rendered into the results view of the GEO Portal search interface using GEO label Java JSF Client API components.

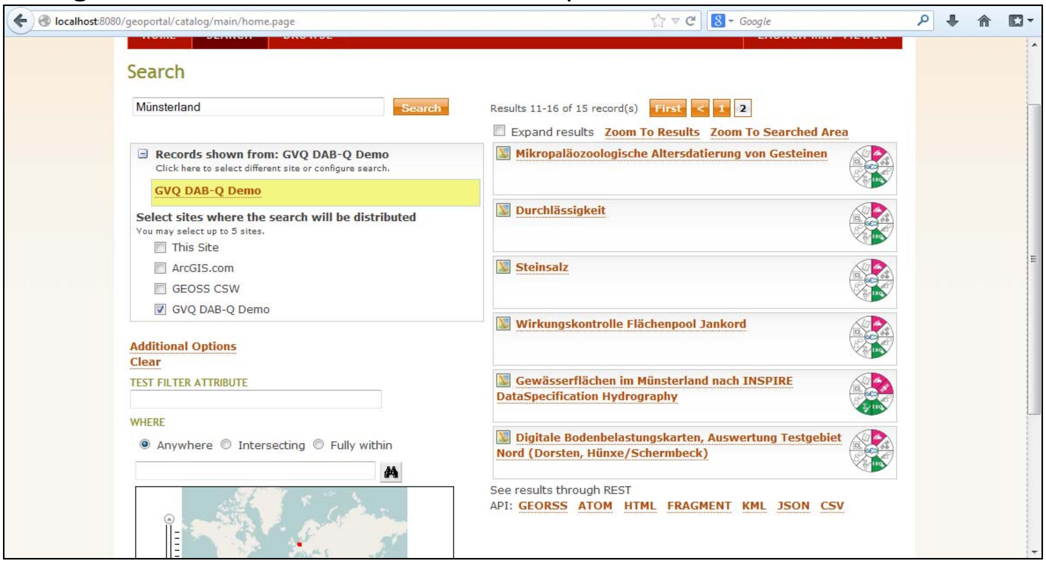


Figure 20. GEO label rendered in the GEO Portal search results view

As explained in D5.3, on-going components tasks include the integration of DAB-Q as a datasource, the integration of WMS-Q as a datasource, the visualisation of raster data in a map view (and in augmented reality), and the visualisation of sensor discovery quality information in augmented reality.

The previous sections have described the GeoViQua components prototypes. This section compiles the portlets sketch for the already integrated components in the GEO Portal Mirror environment.

4.1.1 User Feedback Components

The **Feedback Catalogue** mockup is based on the DAB-Q. The feedback search integration into the regular search refinement page is based on CSW-Q.

The integration of the Feedback client portlet in the GEO Portal Mirror permits searching in user feedback databases directly or through the DAB-Q on a datasets search results page, including also submission functionalities and feedback visualization. The integration allows for redirecting from somewhere in the GEO Portal to feedback creation.

4.1.2 Metadata intercomparison tool

The metadata comparison style template has been successfully integrated into the GEO Portal, although at present the tasks are focused on enhancements suchlike the statistical plots display and updates to the 4.0 QMs schemas version.

The tool implementation relies on XSLT to transform the metadata XML in ISO 19115 format files of a collection of selected datasets in the search results engine of the current GEO Portal. However, some improvements are expected, like assistance in the identification of each field in the metadata, avoid highlighting metadata fields that are not the maximum/minimum or are both the maximum and minimum or marking units as not known when they are not specified. In addition, issues about the implementation in the current GEO Portal are that no more than two datasets can be selected in the search results (a pop up indicates that you have selected more than two datasets when pressing over the Compare Metadata link) and that when search results include more than one page, it is not possible to select datasets from different pages to compare.

GEO Portal portlet testing:

Figure 21. Integration of the metadata intercomparison tool in the GEO Portal Mirror

4.1.3 GECA toolset WPS

The intercomparison tools can produce outputs of the differences and associated quality estimates either at specific spatial locations or over a grid of defined resolution The systems being developed are based on extending the EC funded INTAMAP (project for spatial interpolation and methodologies / tools from the ESA) and GECA (project for collocation and intercomparison) services consisting of providing collocation and inter-comparison as a Web Processing Service (WPS) within GEOSS.

The client has been integrated into the GEO Portal in a similar fashion than the metadata intercomparison tool. A user searches for data (e.g., "landcover") and is shown a search result with a few possible resources. The user enables checkboxes next to two of the resources and clicks a button "Data Intercomparison" which sends a request to an online processing service (e.g., WPS) which compares the two datasets. The intercomparison result is shown either within the GEO Portal or in a pop-up window. It must be noted however that the demo is absolutely limited to some specific datasets that are available locally within the WPS. Thus, the problems of global identifiers and the service-based retrieval of data into the GECA toolset have not been tackled here.

The architecture has involved wrapping GECA's Python control layer into a moving code package that can be exposed in a 52N WPS. In this manner, the prototype works for a specific subset of a dataset via identifiers resolved on the server. The WPS Process description uses a subset of configuration parameters defined in an InterComparisonDefinition XML instance. Although the prototype is limited to the datasets defined in the exemplary request, it can be easily extended as the resources are directly mapped to a dataset folder on **geoviqua.dev.52north.org**. As for the Quality Emitter, the validation has been successful and this component is able to correctly generate the graphs, reliability diagrams and statistics (e.g., distributions). The present work is considering the integration side in the Greenland client first, to confirm that the reports and outputs are correctly communicated. At the time of submission of the present report, a demo is being prepared based on testing with ESA datasets and the following step will complete the integration in the GEO Portal Mirror.

4.1.4 Greenland

The **Greenland** portlet has already been tested in the GEO Portal Mirror, integrating **Greenland** as a viewer. The portlet accepts WMS and WMS-Q URLs (and potentially layers on the WMS/WMS-Q) from the outside (i.e., from other portlets, via URL parameters). Through the GEO Portal Mirror integration, a user can query and select datasets from the response WMS-Q icons. Clicking on this icon opens the dataset visualization in Greenland instead of the regular WMS/WMS-Q.

The portlet has been tested with UREAD datasets (e.g., "ESA Climate Change Initiative Sea Surface Temperature" by adding the following ncWMS-Q resource **http://dexter.nerc-essc.ac.uk/ncWMS/wms).**

4.1.5 KML-Q

The KML-Q (i.e., quality annotated vector data in KML format) will be served using the WMS interface, as explained in section 3. The GEO Portal Mirror will contain a "browse KML" button that will enable the display of the data with the existing Google Earth Browser.

The GEO Portal looks for ".kml" in the CI_OnlineResource (in fact, when checking the code in the portlet file /Geoportal/geoportal-portlet/src/main/webapp/xsl/vrdgnextended19139-resources.xsl it is confirmed that it does match the URL). The .kml would have to be in the GetCapabilities request because that is the URL currently mapped into ISO. However, after the mapping of the response formats to ISO is implemented, the Geoportal implementation can be extended to recognize these elements based on the file mentioned above. The approach to be implemented is considering supporting the new response format elements. In order to complete the integration in the GEO Portal, the mapping of the response formats implementation by CNR would be needed, as well as the harvesting of the KML-Q WMS instance by the DAB-Q pointing to the metadata document. So far, the issues under scope are related to the format and metadata sides.

4.2 DAB-Q replica integration and testing

The following components have been integrated in the DAB-Q: User Feedback database, WMS-Q instances, the SOS-Q sensor registry and the WAF.
It must be noted that all these elements allow only for indirect testing through the GEOPortal Mirror. Elements of this testing has been embedded in the scenarios demo videos, as part of WP7 activities. Figure 22 shows the GeoViQua server components described in the section 3 embedded in the DAB-Q.

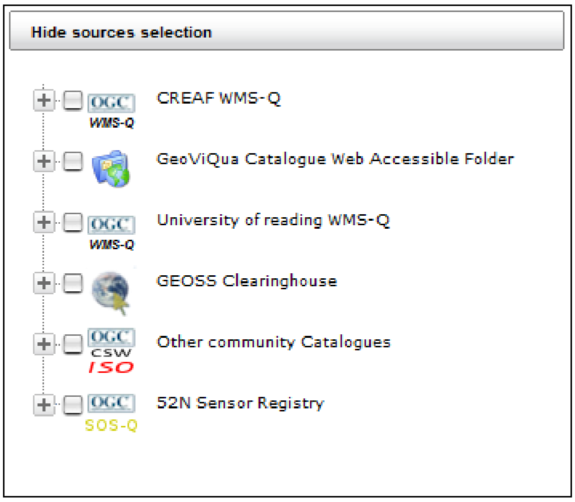


Figure 22. GeoViQua server components in the DAB-Q

4.3 Summary of GEO Portal improvements and GeoViQua components integration

So in the end, the improvements in the GEO Portal permit that the search results page will add a small GEO label to each search result. Another important feature is the possibility to select more than one result with a check box and execute an operation base don the underlying metadata documents. The “metadata rating” and “provenance viewer” are also accessible from the single resource page view, and new tabs for the existing dynamic texts are implemented for the GEO label and the access to the WMS/WMS-Q through the Greenland client. This requires the corresponding annotations in the metadata documents. In turn, the metadata intercomparison and provenance viewer component integration is explained in D4.1.

Specific features detailed in the report add to the GEO label display of the user feedback availability, a specific sub-page for user-generated metadata will be added to the dataset view page. In this manner, a user can browse other user’s comments and ratings of a dataset based on the information provided by the Feedback Server through the DAB-Q. There will also be a clickable link for the user to submit his own feedback. Additionally, new metadata visualizations are included such as: “Feedback Items” (that allows either to browse the user feedback items or add/submit new feedback). Before GeoViQua modifications, *Refine This Search* page was only able to add to the previous query a filter by area restriction, by SBA restriction, by keyword restriction and by date period. With GeoViQua modifications, search can be also constrained by a quality criterion. Quality criteria can be expressed as a quality measure threshold that will result in a request to the PQM or a UQM. The user will be able to provide threshold values as a number or using an interactive slider. In some, search criteria controls are complemented by characteristics such as the refine by quality, by rating and the introduction of statistical plots of the search and by statistical value representations and ranges to assist the user in providing the right values.

The integration of components in the GEO Portal Mirror is ready for testing through an automatic deployment system that immediately exposes the evolution of developments. In short, the integration of the updated User Feedback component will be evaluated through the DAB-Q that currently supports the preliminary version. The harmonised update of components and the architecture is relevant for the integration in the GEO Portal Mirror. The feasibility of the data citation recommendation integration through the GEO Portal is being assessed.

5. Dissemination efforts

Dissemination efforts in GeoViQua are part of the exploitation plan, aimed at promoting the components under development beyond the span of the project. As has been described in this report, our tools and architecture strategies are embedded in the GEOSS environment. Besides, the dissemination offers a unique opportunity of external testing and feedback.

GeoViQua has interacted from the beginning with other FP7 projects (e.g., EGIDA, EuroGEOSS, GEOWOW, UncertWeb, COBWEB), standardization institutions (OGC, GEO, CEN, ISO), GEO initiatives (QA4EO, DDQ GEOSS Subgroup, GEPW7), and has participated in relevant symposia (e.g., EuroGEOSS, GEO Plenary meetings, AIP groups, OGC and ISO TC meetings, INSPIRE, IGARSS, ISSDQ, EGU, AGU, ISARA, FOSS4G, GEO Ministerial, ESA Living Planet, EARSC).

For more details, see http://www.geoviqua.org/Cooperation.htm, and http://www.geoviqua.org/Documents.htm, where some materials can be downloaded (e.g., **D.1.7. "Cooperation with other relevant projects and initiatives (first report)"**). Dissemination deliverables are **D.6.3. "Assessment of standards, protocols and guidelines employed in GeoViQua"**, **D.8.1. "OGC, ISO standards participation and contributions report"**, **D.8.2. "Earth Science community and GEO CoPs, achievements and benefits"**, **D.8.3. "First annual report on AIP participation (AIP4)"**, **D.8.4. "Second annual report on AIP participation (AIP5)"**, **D.8.6. "GEO Tasks (STC, SIF, and UIC) participation results"**. The natural extension of the present document will be reported by the end of the project, in **D.8.5. "GCI technology integration strategies of the final solution report"**.

A summary video of GeoViQua is available at: http://www.geoviqua.org/Overview.htm

From the prototype testing point of view, the collaboration with external institutions and dissemination tasks has enabled to collect a wide variety of external feedback, from scientist perspectives, standardization bodies interoperability issues, user requirements and domains constraints. The GeoViQua scenarios design provides a framework of the potential workflow within GEOSS and a quality-aware user experience. The Scenarios Video, to be delivered by the end of the project, shows this approach and demonstrates the fulfilment of the prototypes testing with GeoViQua datasets. Appendix 1 contains the GeoViQua scenarios UML diagrams.

However, the participation in the AIP initiatives, in particular in the Agriculture SBA, has allowed for testing of our prototypes with external data and by external users: e.g. staff from the Center for Spatial Information Science & Systems of George Mason University has tested the Geonetwork metadata editor to create QMs for draught indices products and obtained a dynamic GEO label. It is also envisaged the implementation of the feedback client component in their portal enabling user feedback submission and the dynamic update and maintenance of the GEO label for their products.

Likewise, several workshops have provided a relevant insight of the assimilation of the models and quality issues among users and thematic topics (e.g., INSPIRE, GEO Ministerial tutorials).

Beyond the publication of results in scientific journals, the interaction with real users of geospatial data and systems is a most valuable factor in GeoViQua. These experiences reveal that reliability on datasets and products can be enhanced by quality indicators documentation, traceability and transparency between providers and users. The quality elicitation methodologies, the quality-aware GeoViQua discovery and visualization tools developed, the prototypes testing with selected datasets, the scenarios framework, the feedback received and the external responses have been proved to be in line with geospatial users demands and current infrastructure potentialities, realising fit-for-purpose quality assessment in a data sharing environment, matching the contemporary features of products distribution and users needs (e.g., massive catalogues, rapid EO products updates, discovered issues, global data sharing, outreach, error propagation assessment accuracy, etc.).

6. Conclusions

The corresponding deliverables contain more details about the GeoViQua components. Nonetheless, in this report a key feature for each one of them is highlighted, constituting recommendations and a summary of best practices derived from prototypes testing with real datasets:

- Producer Quality Model and User Quality Model schemas

- Our Producer Quality Model extends ISO 19115 and 19157 standards to allow traditional metadata documents to be supplemented with richer information such as citations, discovered issues, information about reference datasets and full statistical representations of uncertainty. Using UncertML fulfils interoperability requirements by offering encodings for probabilistic statistical information, with the added benefit that it already defines XML encodings (as well as JSON and netCDF representations) for concepts and measures, allowing quantitative data to be consistently represented, validated and automatically parsed from traditional XML metadata documents with no change to the underlying ISO schema. The testing activities in WP3 using continuous and categorical datasets enabled a consistent encoding, including UncertML measures. UncertML was seen as limited to probabilistic quality estimations so, recently, the introduction of the QualityML quality measures thesaurus has enhanced the encoding capabilities. It is recommended to continue developing QualiyML beyond the end of the project.

-The PQM allows for a complete and accurate metadata description, with special emphasis in quality indicators and lineage. It is a most significant tool for data providers. In addition, the integration with the UQM, which in turn includes user feedback and allows for soft-knowledge quality description, responds to user requirements that have long since been demanded (e.g., ratings, comments, citations). Some gaps have been explained in previous sections and are specifically addressed in D7.3, related to the testing datasets used in the GeoViQua Pilot Case studies. While the models are flexible and enable quality-aware encoding in a manner that a path can be found to convey almost anything thanks to the GeoViQua extensions, it must be noted that the queryables paths and harvesting infrastructure are necessarily limited when compared to the description potential provided by the models.

-The user quality model encapsulates data quality items supplied by users. The user model is generally intended for user feedback, but also for producer feedback that is changing more rapidly than official metadata for which more quality control is implied. The model is intended to connect GEOSS datasets and services (referred to as resources) to user generated data. System-centric information, i.e. information about users such as accounts and authentication or GEOSS resources are therefore not represented directly, but are linked in at pre-defined junction points. These junction points are the user information and the target. Testing demonstrates that the UQM model allows documenting either simple rating or complicated expert reviews and metadata overwrites.

- Metadata editors and User feedback editor tool

-Generating a complete metadata document implies great efforts from data providers. Besides, a deep understanding of metadata schemas is required. Metadata models are complex: a metadata editor greatly improves the documentation tasks. The GeoViQua Quality models being innovative components and compiling interoperability mechanisms with existing quality standards are critically assisted with the Geonetwork metadata component, that enables generation of QMs in xml, import and translations from existing ISO documents, providing due guidance, significantly improving the user experience. The Geonetwork interface is excellent although the user experience could be improved with extra clarification and guidance into the new GeoViQua extensions. Also the codelist usage needs to be simplified.

-The feedback editor tool permits users to submit feedback facets (e.g., ratings, comments, citations, usage recommendations) of datasets to a Feedback server where their comments can be collated and combined with the more traditional metadata (i.e., producer metadata documents) to help other users assess the data's fitness for purpose.
The feedback catalogue uses the Django framework with a relational database, postgreSQL, as backend. The API framework Tastypie is used to construct a RESTful interface. Via this interface, feedbackitems and collections can be requested and searched, and feedbackitems can be posted. Thus, the API parameters can be used and combined when creating CSW request. At present, considering the API, only the "AND"ing and "OR"ing of the parameters is possible. GEOSS would benefit from a requirement that is still open: a common user identification syste. The feedback editor could be adapted to implement it and enable the identification of users. Also the interface need to be clarified to permit users to understand the levels of complexity supported in the user feedback model.

-The integration of the Feedback client portlets in the GEO Portal Mirror permits searching in user feedback databases directly or through the DAB-Q on a datasets search results page, including also submission functionalities and feedback visualization. The integration allows for redirecting from somewhere in the GEO Portal to feedback creation. It is expected that these components will reveal the lack of quality information and will encourage producers to better document quality. Also users will be encouraged to report usage of the data.

- Quality-aware geosearch components

The quality extension to the Discovery and Access Broker (DAB-Q) enables user-specified quality thresholds queries, compliant with GeoViQua Quality Indicators, the OGC Catalogue Service for the Web (CSW), and supports the integration of GeoViQua components in the GEOSS GCI infrastructure. This way, quality retrieval becomes functional through GEOSS and enhances fit-for-purpose quality assessment. Accordingly, the corresponding extensions for sensor datasets services and catalogues (SOS-Q, WMS-Q) have been developed. SOS-Q, WMS-Q and the WAF (containing testing metadata records) have been connected to the DAB-Q successfully. Although the quality queriables have been simplified, complexities remain that need to be addressed, such us the effect of the units of measure and diversity of quality measures that are similar but not equivalent. In addition, the implementation of the GEO label facets as queriables in the DAB-Q would be an asset.

- Quality-aware visualization components

-Although metadata side components, suchlike the metadata intercomparison and completeness tools, together with the provenance viewer, and the GECA toolset service implemented as a WPS are tested examples of components that enhance the user experience and quality assessment of datasets and services. These successful experiences fulfil user requirements related to side-by-side comparison and provenance, facilitating comprehensive assimilation for fit-for-purpose data discovery and selection. As it happens with other GeoViQua tools, it is expected that these components will reveal the lack of quality information and will encourage producers to better document quality, particularly the rubric-Q.

-Widely used standards for raster and vector models have been quality extended without compromising the interoperability by being built with easy additions to current standards, collaborating with standardization bodies in the development, and deriving best practices and recommendations for a generalization of usage. Thus, the WMS-Q/WMTS-Q, and KML-Q prototypes are simple to implement. The integration of services with the client side has been proved for selected datasets. Mobile devices have also been tested. Distinctive features of the WMS-Q are the UncertML tags and links to the metadata documents (e.g., PQM). Next step is to give access to structure quality data at the pixel level e.g. using WCS.

- Iconic representation of quality with drill-down functionalities: GEO label

The GEO label will visually summarise and allow interrogation of key informational aspects of geospatial dataset records upon which users rely when selecting datasets for use. By pulling together producer documents and user feedback into a simple, clickable symbol, the GEO label will provide a quick way to assess and interrogate the metadata that is available for a dataset. As envisioned, the developed GEO label will act as a decision-support mechanism for dataset selection and thereby improve user recognition of the quality of datasets. There is a need for consensus in the GEOSS community on adopting the GeoViQua approach for the label. The fact that the GEO label is and objective measure that is not reflecting the actual quality indicators values that can be easily misinterpreted might help. Among other features, a relevant functionality for users is that the GEO label quickly allows for the identification of dataset or pixel level quality indicators.

- Integration in GEOSS: the GeoViQua approaches

Through the GEO Portal Mirror integration, a user can query and select datasets from the response WMS-Q icons, visualizing the data in Greenland. In addition, the KML-Q integration enables dataset visualization through the GEO Portal. Other functionalities already implemented and tested in the GEO Portal Mirror are: metadata comparison, completeness and provenance visualization.

In general, in GEOSS, the right thing to do is to register metadata first and then discover other services later. This approach has been here for a while and it works. Nonetheless, GeoViQua has attempted other approaches, closer to the practical usage of GEOSS.

It is a fact that people do not want to be bothered and forced to register resources and that metadata catalogues are only setup by big organizations. It is also true that in most cases the result of a scientific project is a dataset that can be represented as a "a map" or a small collection of maps. For this kind of users that carefully elaborate their datasets, it is important to expose these output maps and it is very possible that they distribute them in a WMS. The CEA Carbon Atlas is an example of this trend, as the UREAD ncWMS makes this integration possible. When the dataset and metadata records are distributed in the WMS-Q (or WMS) respectively as dataURL and metadataURL, it is solved in a single piece of technology. Moreover, it is also possible to expose the quality at dataset or sample level in the WMS-Q. In addition, the possibility to publish a metadata record directly is also available if using the ASTON Geonetwork when connected to the DAB-Q.

D6.4 “GeoViQua components integration within the GCI” provides a guide on how to integrate the GeoViQua components into the GCI.

In short, by using WMS-Q as a catalogue for data and metadata, these GeoViQua approaches are not strictly a general solution for ESA or NOAA as big data providers, they are however conveniences for many scientists and small data producers of derived products. Indeed, scientists and small data producers of derived products can participate by simply providing a WMS-Q instance. In fact, the communities will be very important for the future of GEOSS as a decision making tool. It is through the participation of the CoPs that the definite linking between users (providers and users of their products) will be done, and accordingly the definitive consolidation of GEOSS as a global EO system will be achieved.

ACRONYMS

AGU. American Geosciences Union http://sites.agu.org/

AIP. Architecture Implementation Pilot

API. Application Programming Interface

ARML. Augmented Reality Markup Language

CEN. European Committee for Standardization

CEOS. Committee on Earth Observing Satellites

CIECAM02. Published in 2002 by the CIE Technical Committee 8-01 (Color Appearance Modelling for Color Management Systems), as of 2008 CIECAM02 is the most recent color appearance model ratified by the CIE, and the successor of CIECAM97s.

COBWEB. FP7 Project. Citizen OBservatory WEB. http://cobwebproject.eu/project

CoP. Community of Practice (GEOSS)

CORS. Cross-Origin Resource Sharing

CSW. Catalogue Service for the Web

DAB. Discovery and Access Broker

DDQ. Documentation and Data Quality GEOSS Subgroup of the Data Sharing Working Group (DSWG).

EARSC. European Association of Remote Sensing Companies http://www.earsc.org/

EC. European Commission.

EGIDA. FP7 Project. Coordinating Earth and Environmental cross-disciplinary projects to promote GEOSS (Global Earth Observation System of Systems**.** http://www.egida-project.eu/

EGU. European Geosciences Union. http://www.egu.eu/

EO. Earth Observation

EuroGEOSS. FP7 Project. http://www.eurogeoss.eu/default.aspx

FOSS4G. Free and Open Source Software for Geospatial (Open Source Geospatial Developers, Users and Leaders)

GECA. Generic Environment for Calibration/validation Analysis

GIF. Graphics Interface Format

GMLCov. Geography Markup Language Coverage

GEPW. GEOSS European Projects Workshop.

GEO. Group on Earth Observations.

GEOSS. Global Earth Observation System of Systems.

GeoViQua. QUAlity aware VIsualisation for the Global Earth Observation system of systems

GEOWOW. FP7 project. GEOSS interoperability for Weather, Ocean and Water **http://www.geowow.eu/**

GCI. GEOSS Common Infrastructure

IGARSS. IEEE Geoscience and Remote Sensing Symposium

INSPIRE. Infrastructure for Spatial Information in Europe

INTAMAP. FP6 project. Interoperability and Automated Mapping **http://www.intamap.org/**

ISARA. International Spatial Accuracy Research Association**, http://www.spatial-accuracy.org/**

ISO. International Organization of Standardization. **http://www.iso.org/iso/home.html**

ISSDQ. International Symposium on Spatial Data Quality.

JPEG. Joint Photographic Experts Group (Lossy compression for digital photography format)

KML. Keyhole Markup Language.

OGC. Open Geospatial Consortium **http://www.opengeospatial.org/**

OWS. OGC Web Services

PQM. Producer Quality Model

PNG. Portable Network Graphics

Q. Quality

QA4EO. Quality Assurance for Earth Observation

QM. Quality Model

Q2O vocabulary and **MMI** (Marine Metadata Interoperability) group: http://mmisw.org/orr/#http://mmisw.org/ont/q2o/flag

ncWMS. Web Map Service for geospatial data that are stored in CF-compliant NetCDF files.

netCDF. network Common Data Form

SBA. Societal Benefit Area (GEOSS)

SIF. Standards and Interoperability Forum (GEO)

SIR. Sensor Instance Registry

SLD/SE. Styled Layer. Descriptor (SLD) and Symbology Encoding (SE) standards

SOS. Sensor Observation Service http://www.opengeospatial.org/standards/sos

STC. Science and Technology Committee (GEO)

TDS. THREDDS Data Server

UIC. User Interface Committee (GEO)

UML. Unified Modeling Language

UncertML. http://www.uncertml.org/

UQM. User Quality Model

URI. Uniform Resource Identifier

URL. Uniform Resource Locator

WAF. Web Accessible Folder

WMS. Web Map Service

WMTS. Web Map Tile Service

WP. Work package

WPS. Web Processing Service

XML. Extensible Markup Language

XSLT. Extensible Stylesheet Language Transformations

Definitions relevant to this list and this report can be found at: http://www.geoviqua.org/Docs/SubmittedDeliverables/D7_1_GeoViQua.pdf and http://www.geoviqua.org/Docs/SubmittedDeliverables/D7_2_GeoViQua.pdf

- **GeoViQua partners:**

52N 52° North GmbH (Germany)

AST. Aston University (UK)

CEA. Commissariat a l'Energie Atomique (CEA). LSCE -Laboratoire des Sciences du Climat et de l'Environnement (France)

CNR. Consiglio Nazionale delle Ricerche (CNR). IIA - Istituto sull'Inquinamento

CREAF. Centre for Ecological Research and Forestry Applications (Spain)

ESA. European Space Agency (Italy)

FRAUN. Fraunhofer Institut Graphische Datenverarbeitung -IGD- (Germany)

OGCE. Open Geospatial Consortium (Europe) Limited

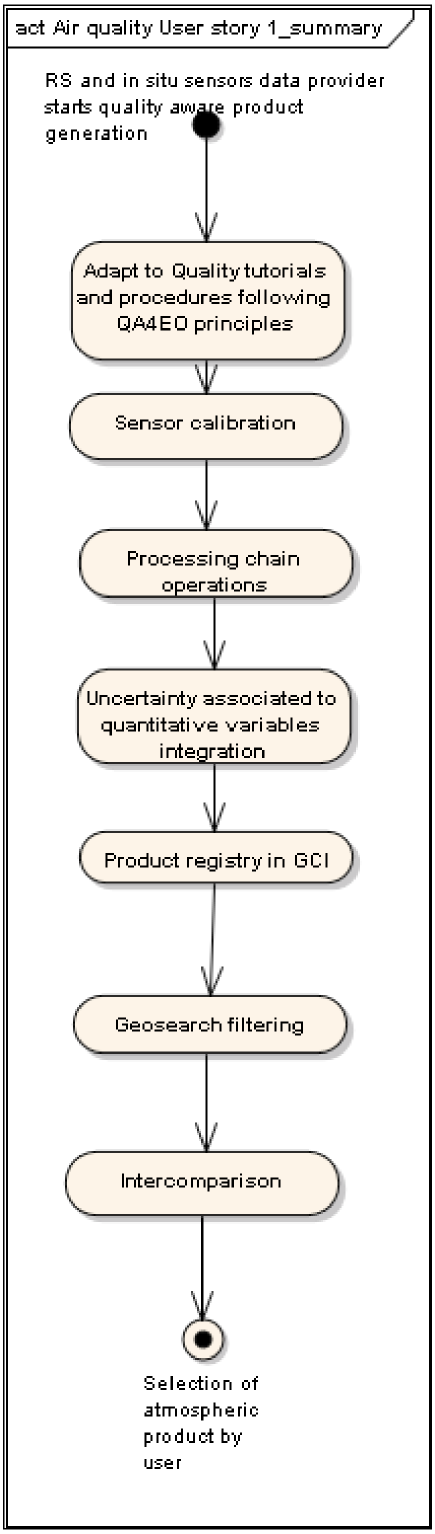
S&T. S[&]t Corporation (The Netherlands)

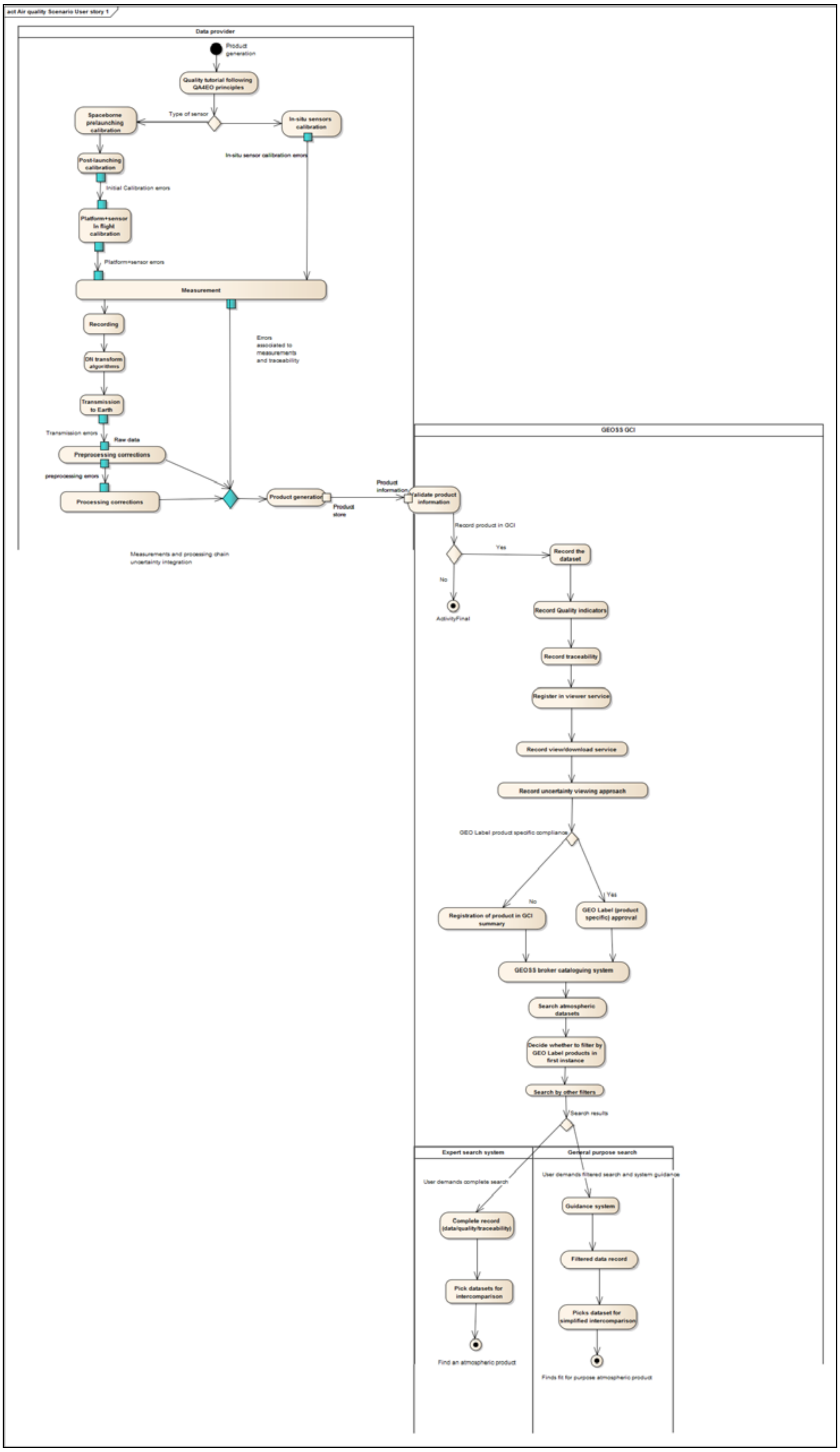
UAB. Universitat Autònoma de Barcelona (Spain)

UREAD. University of Reading (UK)

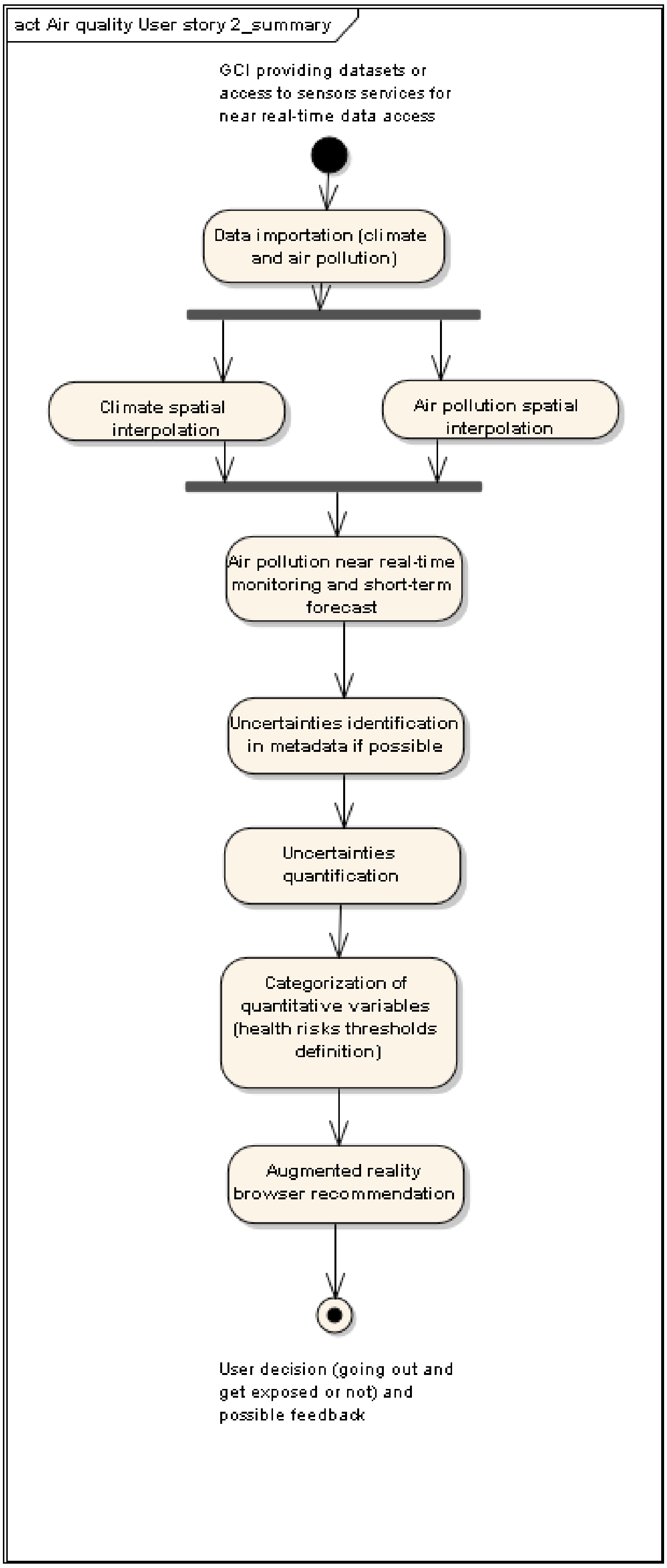
Appendix 1: Scenarios diagrams.

Air quality scenario. User story 1.

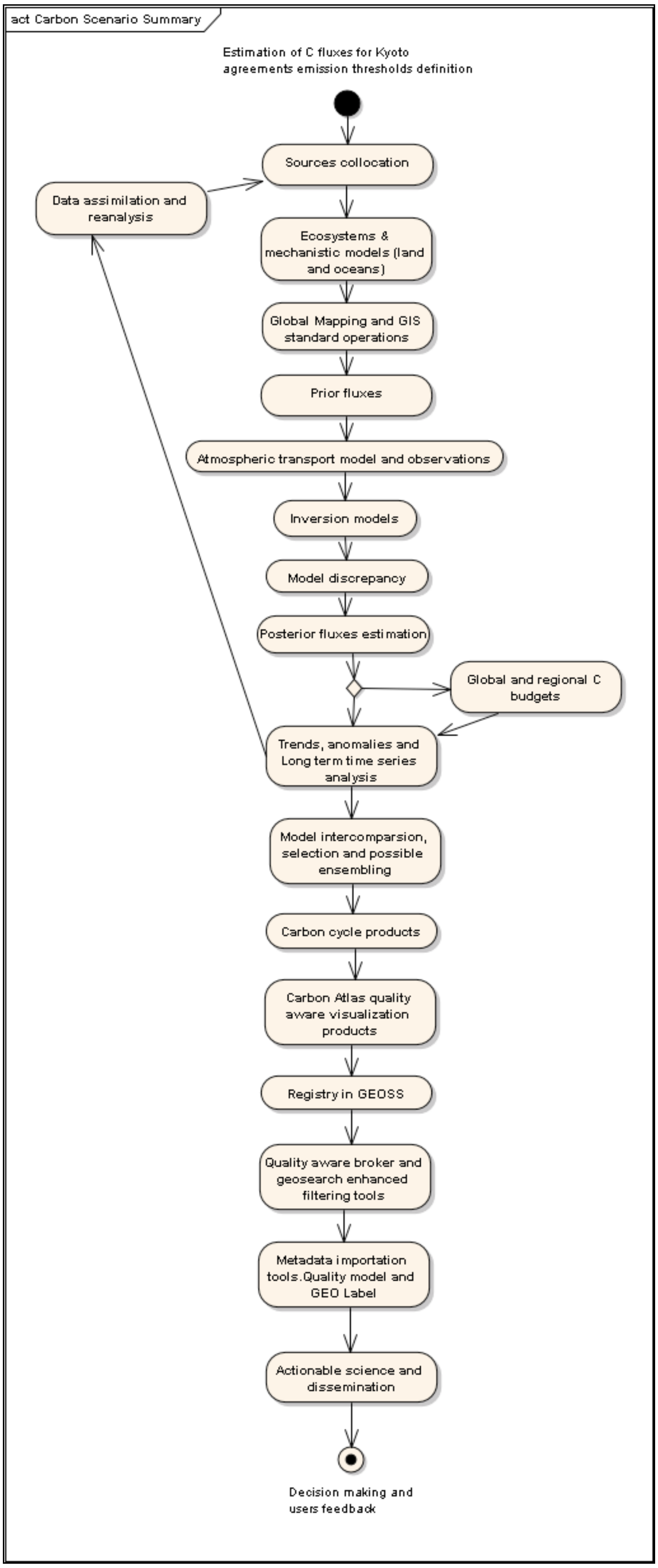



act Air quality Scenario User story 1
Data provider
Product generation
Quality tutorial following QA4EO principles
Type of sensor
Spaceborne prelaunching calibration
In-situ sensors calibration
In-situ sensor calibration errors
Post-launching calibration
Initial Calibration errors
Platform+sensor In flight calibration
Platform+sensor errors
Measurement
Recording
DN transform algorithms
Errors associated to measurements and traceability
Transmission to Earth
Transmission errors
Raw data
Preprocessing corrections
preprocessing errors
Processing corrections
Product generation
Product information
Product store
Measurements and processing chain uncertainty integration
GEOSS GCI
Validate product information
Record product in GCI
Yes
No
Record the dataset
ActivityFinal
Record Quality indicators
Record traceability
Register in viewer service
Record view/download service
Record uncertainty viewing approach
GEO Label product specific compliance
No
Yes
Registration of product in GCI summary
GEO Label (product specific) approval
GEOSS broker cataloguing system
Search atmospheric datasets
Decide whether to filter by GEO Label products in first instance
Search by other filters
Search results
Expert search system
General purpose search
User demands complete search
User demands filtered search and system guidance
Complete record (data/quality/traceability)
Guidance system
Filtered data record
Pick datasets for intercomparison
Picks dataset for simplified intercomparison
Find an atmospheric product
Finds fit for purpose atmospheric product

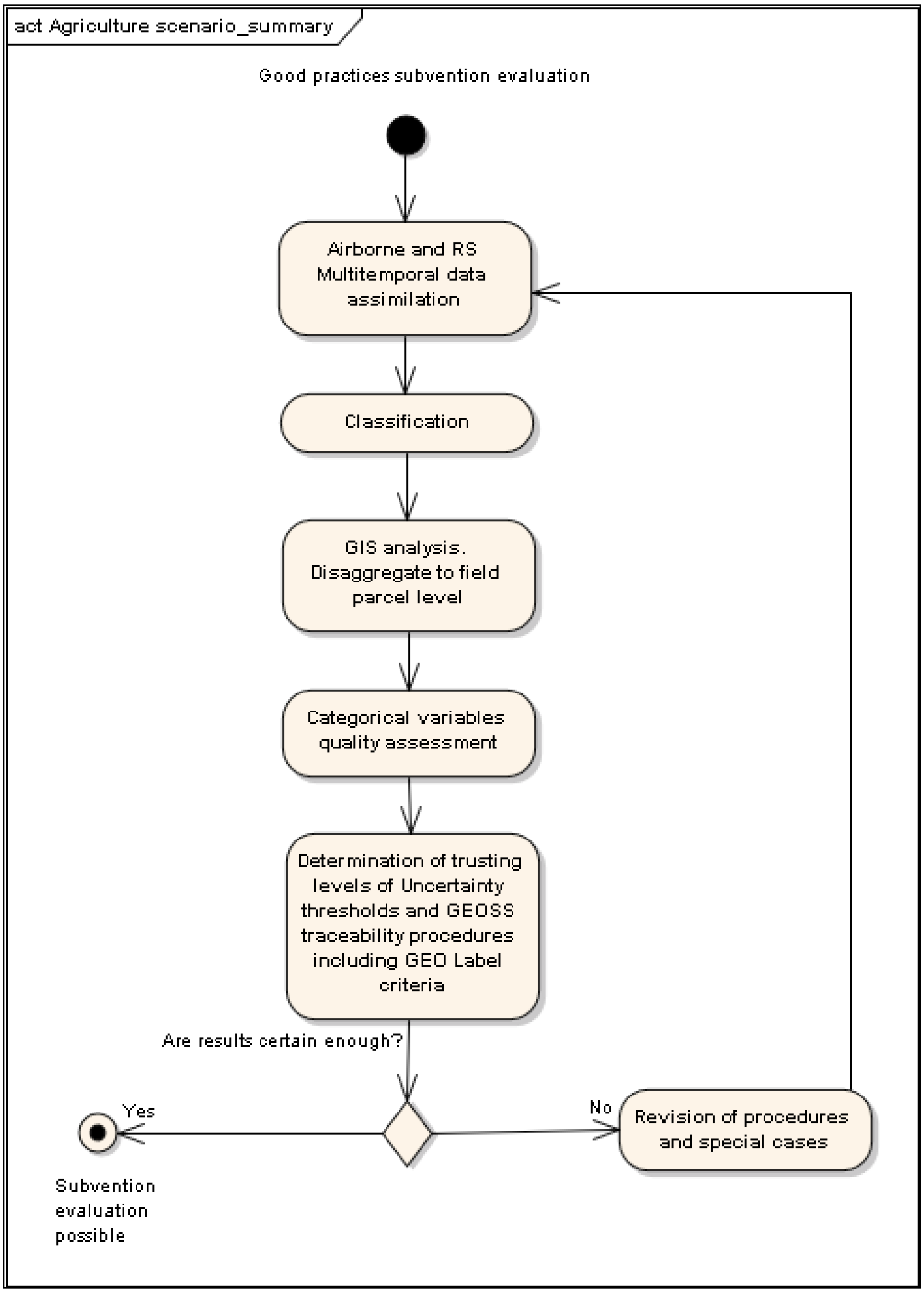
Air quality. User story 2.

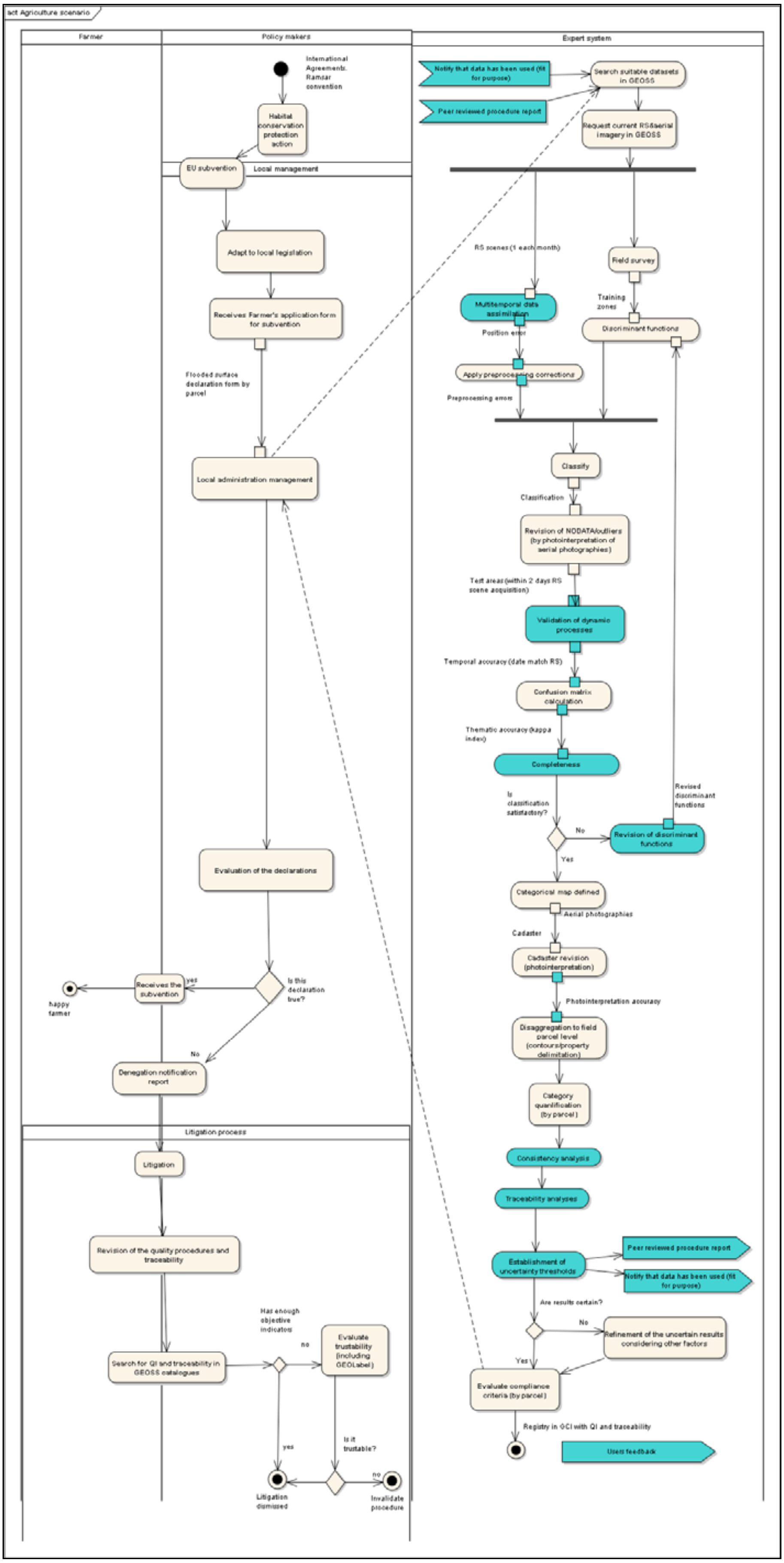


Carbon cycle scenario



Agriculture scenario.





act Agriculture scenario
Farmer
Policy makers
Expert system
International Agreements. Ramsar convention
Habitat conservation protection action
EU subvention
Local management
Adapt to local legislation
Receives Farmer's application form for subvention
Flooded surface declaration form by parcel
Local administration management
Evaluation of the declarations
Is this declaration true?
yes
Receives the subvention
happy farmer
No
Denegation notification report
Litigation process
Litigation
Revision of the quality procedures and traceability
Search for QI and traceability in GEOSS catalogues
Has enough objective indicators
no
Evaluate trustability (including GEOLabel)
yes
Is it trustable?
no
Litigation dismissed
Invalidate procedure
Notify that data has been used (fit for purpose)
Peer reviewed procedure report
Search suitable datasets in GEOSS
Request current RS&aerial imagery in GEOSS
RS scenes (1 each month)
Field survey
Training zones
Multitemporal data assimilation
Position error
Discriminant functions
Apply preprocessing corrections
Preprocessing errors
Classify
Classification
Revision of NODATA/outliers (by photointerpretation of aerial photographies)
Test areas (within 2 days RS scene acquisition)
Validation of dynamic processes
Temporal accuracy (date match RS)
Confusion matrix calculation
Thematic accuracy (kappa index)
Completeness
Is classification satisfactory?
No
Revision of discriminant functions
Revised discriminant functions
Yes
Categorical map defined
Aerial photographies
Cadaster
Cadaster revision (photointerpretation)
Photointerpretation accuracy
Disaggregation to field parcel level (contours/property delimitation)
Category quantification (by parcel)
Consistency analysis
Traceability analyses
Establishment of uncertainty thresholds
Peer reviewed procedure report
Notify that data has been used (fit for purpose)
Are results certain?
No
Refinement of the uncertain results considering other factors
Yes
Evaluate compliance criteria (by parcel)
Registry in GCI with QI and traceability
Users feedback