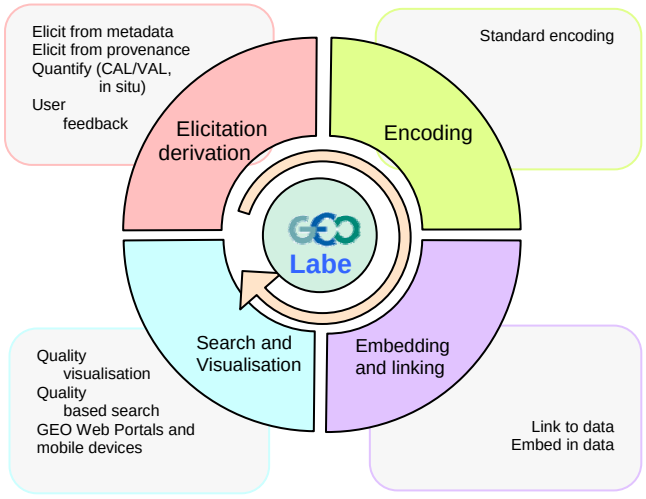
3.1 Publishable summary

The Global Earth Observation System of Systems GEOSS aims to be a global and flexible network of content providers allowing decision makers to access an extraordinary range of information directly on their desk. It brings together existing observing systems around the world while supporting the development of new systems where gaps currently exist. The network interoperability is ensured by a common set of standards so that data from different instruments can be combined into coherent datasets. This network is supported by the GEOSS Common Infrastructure (GCI) that provides catalogue, search engines and a *GEO Portal* that offers a single Internet access point for users search and discovery of data, imagery and analytical software packages to all parts of the globe. **The GeoViQua project significantly contributes to this by adding rigorous data quality representations to existing search and visualisation GEO Portal functionalities,** prioritising interoperability at all times.

Information about data quality is extracted from several sources; some of them are from metadata, data inter-comparison, validation processes towards *in-situ* sensor data, provenance information and from user feedback. Current or extended standards for data quality description are used or developed '*quality indicators*', including quality and provenance parameters as proposed by the GEO strategy on data quality, the "Quality Assurance Framework for Earth Observation" (QA4EO)". GeoViQua combines geospatial data together with information on their quality and processing services within GEOSS catalogues.

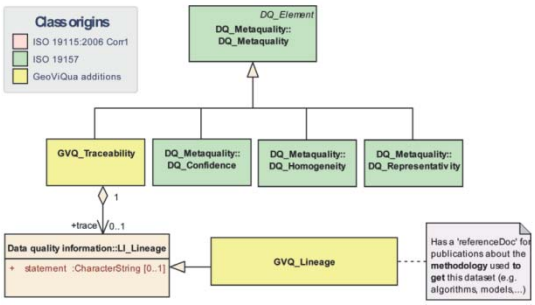
The project has concluded the funded period. GeoViQua has attained several scientific and technical achievements. The most significant ones are:



- The release of a **complete quality model**. GeoViQua's major conceptual contributions are its producer quality framework, based on existing metadata standards such as ISO 19115 and UncertML, and its innovative user feedback model for geospatial data. OGC has recently approved the creation of the Geospatial user feedback standards working group.
- The provision of **innovative catalogues** to enhance the current infrastructure capability.- GeoViQua's major technical innovation is a set of search tools for the community. These communicate and exploit both data quality information from GEOSS catalogues, and user feedback.

- The provision of **innovative visualization** solutions to represent quality in 2D and 3D geo web portals and their formalization into existing standards such as WMS and KML.
- The development of the **GEO Label**.-GeoViQua has fully developed the concept of the GEO Label in close collaboration with the ID-03 GEO task. A carefully designed consultation on user requirements has converged on a clear and objective design for a dynamic label that is easy to generate, compare and understand. A Web service generates up-to- date labels for all datasets in the GCI.
- The harmonization, exploitation **dissemination of project outputs** has been ensured by close work with the GEOSS communities of practice and other EC research projects. GeoViQua has worked with standards bodies and GEOSS tasks to maximize its outreach. GeoViQua has also collaborated with two OGC Architecture Interoperability Pilots.

The GeoViQua developments integrated in this platform enable discovery of, and access to, the quality indicators and traceability embedded in metadata, GEO Label and scientific reports. They also provide smart quality visualization at pixel level (Quality enriched Web Map services [WMS-Q] visualized in Greenland) and at feature level (Quality enriched [KML-Q] visualized in Google Earth).

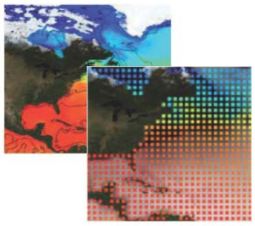


The Producer Quality Model extends ISO 19115-1, 19115-2 and 19157 standards to include richer information such as discovered issues, new and better formalized quality indicators (reference datasets used for quality evaluation, traceability, and statistical summaries of quantified uncertainty), citations to publications and more. Data quality can be applied to a dataset level but also as a pixel level quality. The model also successfully integrated UncertML and ISO 19157 in a quality vocabulary named QualityML (qualityml.goeviqua.org). Additionally to the Producer Quality Model, a completely new User Feedback Model was developed to allow users to provide rates, comments, expert reviews and quality overwrites. Both models are available at schemas.geoviqua.org.

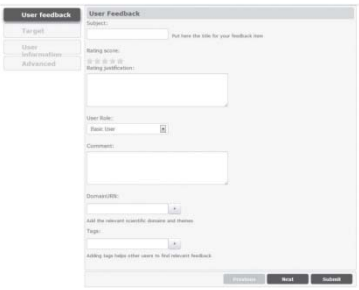
The Quality-enabled Discovery and Access Broker (DAB-Q) is an extension of the GEO-DAB that implements the Producer Quality Model and the User Quality Model as quality extensions of the OGC Catalogue Service For the Web (CSW-ISO-Q) interface. The catalogue is able to resolve searches filtered by quality parameters and results integrated official metadata and user feedback and to include a GEO Label reference.

Several other improvements have been proposed for the GEOSS portal. For examples, a the metadata comparison tool presents dataset descriptions in columns, with attributes and metadata parameters aligned as rows marking with a colour the optimum dataset in each case. It also offers graphical plots for visual comparison. Additionally, a system for scoring the quality metadata is also introduced as a way to stimulate producers to

include more information about quality and uncertainties.



Quality can be described at dataset level (overall indicator in the metadata) or at pixel level and feature level (a quality value for each pixel or feature). GeoViQua extended the OGC Web Map Service protocol to add to each layer other quality layers that use per pixel UncertML. Three different implementations of this best practice where generated. In particular, ncWMS implemented innovative symbolization methods that allow presentation of pixel quality and data in the same 2D view for raster data. In addition, the use of KML make possible to experiment with other techniques in 3D visualization for feature level quality (vector data) that can be more attractive for the user.

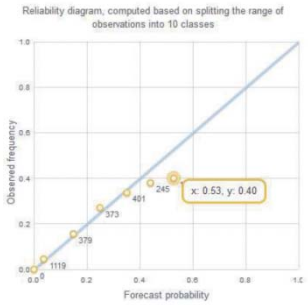


The user feedback component allows introduction and storage of new feedback items. The database incorporate state of the art web forms to present the necessary level of complexity to the user, that is able to easily provide a rating of a comment but can also publish a careful expert review. The User Feedback system API also provides query capabilities and summarised and detailed results. This API is internally use for the DAB-Q is able to search in the user feedback database and integrate the response in its search results page in a standardized way. The integration in the GEOSS Portal facilitates creation of rich feedback about a dataset.

The GEO label is a graphic representation, which visually summarizes the availability of quality information for the dataset allowing increasing user trust in GEOSS data. It represents, comprising 8 informational facets: producer profile, producer comments, lineage information, standards compliance, quality information, user feedback, expert review and citations information. The information availability states are expressed through varying the appearance of facet icons.
In its SVG representation, the GEO label is a dynamic picture, giving access to more information by first hovering or then clicking over its facets. The GEO label also provides a restful API that automatically and transparently generates GEO labels from the metadata. Integrated in the GEOSS portal, an individual GEO label is provided for each dataset based on its available quality information. The generated GEO labels serve as quality indicators, and assist in dataset search and selection. The design of the label can be seen as a simple decision but it was the results of 2 years of discussions in the GEO community and extensive consultation done by GeoViQua in a sequence of 4 questionnaires resulting in a PhD.

Several other functionalities have been integrated in the GEOSS portal. One of the most innovative integrations is the capability to assess quality using reference data in the GEOSS portal. To illustrate the methodology, a web form or “Data Intercomparison“ allow for selecting a satellite image and a collection of in-situ data that are send to the GECA Toolset (a toolkit for ingesting, processing and inter-comparing satellite data against correlative data) as a request to an online web

processing service (a WPS). The intercomparison result is shown either within the-GEOSS Portal-or in a pop-up window. If accepted by the user, the results can be transformed into a quality indicator as explained below.



A challenge with many existing datasets is that they do not have reliable quantitative quality indicators available to them. To address this, GeoViQua has developed a tool to combine reference data with collocated measurements to compute dataset-level quality indicators. These quality indicators, such as the mean (bias), variance, or quantiles of the uncertainties can then be added to XML in the extended producer quality model. The additional XML includes a description of the lineage of the quality indicators. The quality emitter tool also provides a validation of the quality indicators (often referred as meta-quality descriptors) which allow the user to judge the reliability of the quality indicators, and to easily access information on how these indicators were computed.

GeoViQua conducted several integration tests and interoperability experiments internally but also externally. The most notorious has the ones conducted in the Architecture and Interoperability pilots in GEOSS where the GEO Label and the User Feedback system were integrated in the George Mason University Global Agricultural Drought Monitoring and Forecasting System (http://www.ogcnetwork.net/pub/ogcnetwork/GEOSS/AIP6 and http://www.ogcnetwork.net/pub/ogcnetwork/GEOSS/AIP6/documents/Technical/GCIResearch/GEOAIP6_GCIResearch_GeoViQuaIntegration_ER.pdf).

GeoViQua contributed to the scientific advance of the data quality visualization and integration and to the development of the GEOSS Common Infrastructure (GCI). When approved by the Infrastructure Implementation Board (IIB), the GEOSS portal will incorporate several components such as the user feedback database and the GEO label, quality search, data intercomparison, metadata inter comparison, metadata graphical representation, provenance visualization and more. New components will also be incorporated in the GCI such as the Discovery and Access Broker, the user beedback database and the GEO label service.

GeoViQua components address a variety of strategies for visualising data, together with its quality information, in the GEOSS Portal - particularly at a pixel and feature level. Data is represented with its quality indicators through innovative symbology techniques. GeoViQua has adopted several standards, but also constantly close collaborating in the standards process, and will continue working to standardize some of the project results.

For further information and access to all project documentation and reports, please see www.geoviqua.org. For further information, contact Joan Masó, CREAF, joan.maso@uab.cat.

GeoViQua partner name	**Acronym**
Centre de Recerca Ecologica i Aplicacions Forestals	CREAF
Universitat Autònoma de Barcelona	UAB
52°North Initiative for Geospatial Open Source Software Gmbh	52N
Fraunhofer-Gesellschaft zur Foerderung der Angewandten Forschung E.V.	Fraunhofer
Consiglio Nazionale delle Ricerche	CNR
Aston University	AST
The University of Reading	UREAD
Commissariat A L Energie Atomique Et Aux Energies Alternatives	CEA
European Space Agency	ESA
Science and Technology B.V	S&T
Open Geospatial Consortium (Europe) Limited	OGCE