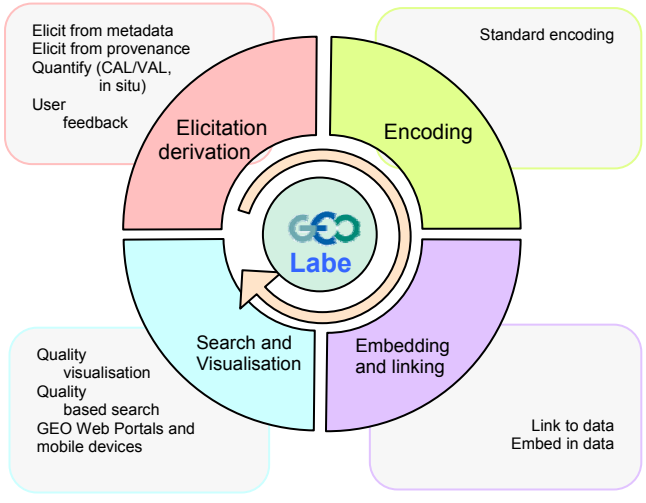
3.1 Publishable summary

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 to define '*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.

Graphical representation of the metadata parameters helps the user to know the data collection structure and its patterns for easily screening the data. GeoViQua is contributing significantly to an enhanced, user-driven, and practical GEO Label, and thus allowing increasing user trustworthiness over GEOSS data and services delivery.

In GeoViQua a search broker supports filtering by quality parameters and sorting search results by quality indicator values. GeoViQua components address a variety of strategies for visualising data together with its quality information, on the GEO Portal. Query by location with metadata, quality statistical charts, and quality representations through symbology are some of the techniques explored. The components comply with existing standards to allow direct implementation in the GEO Portal as well as mass-market geo-browsers and mapping tools (such as



Google Earth) and other 3D viewers.

Selected scenarios and use cases are present all along the different phases of the project, from the iterative collection and documentation of user and technical requirements, through the stages of system design and development, to the final system integration.

The project is currently at the middle of its duration. Early on the project, we agreed on defining a list of user requirements by following an engineering process to help GeoViQua achieve an output that is consistent and addresses geospatial user's needs. Furthermore, we have also progressed on defining technical requirements and functional components for the project.

GeoViQua has analyzed the CGI catalogues and it has been proven that enough quality indicators and provenance information are already present in those. The possibility to extract quality information from the main EO metadata formats has also been studied, some of the formats examined are HDF (4, 5, EOS), CEOS, NDF (NLAPS Data Format for USGS Landsat imagery), GeoTiff + MTL + Meta (USGS Landsat imagery), Tiff + Dimap (SPOT imagery), JPEG2000, NetCDF, and THREDDS. To encode the uncertainty information UncertML (http://www.uncertml.org/) is used, with this being integrated with NetCDF to create NetCDF-U which can provide pixel level uncertainty information, and O&M-U which provides observation level uncertainty information. A tool to extract the quality information from NetCDF-U and export an ISO19139 metadata file is being prototyped. Effort has been put into data extraction and conversion into individual layers that can be combined in GIS tools or WMS services.

Quality metadata visualization techniques, quality metadata completeness rubric (punctuation) system, and metadata inter-comparison templates are being developed for its future inclusion in the GEO Portal.

Tools to help provide the formal uncertainty estimates are being further developed, integrating the INTAMAP and GECA projects results as starting point. We have also defined three scenarios for testing these methods considering: user contributed weather data from *in-situ* sensors; remotely sensed air quality data, combined with *in-situ* sensors; and remotely sensed imagery for land-cover classification combined with field validation data.

Models for quality enhanced producer metadata, and for user feedback input have gone through several iterations and are now at a stable version. Both models are published at http://schemas.geoviqua.org/ in the form of XSD schema documents (accompanied by UML models and examples). The producer model builds on existing ISO standards (19115 and 19157) to permit the encoding of reference dataset information, citations, traceability of quality statements and discovered issues within metadata documents, which are compatible with existing tools and stylesheets. The user model will inform the database structure for a feedback server from which comments, citations, discovered issues, ratings and reports of usage may be retrieved.

Quality-aware discovery services, namely a quality-aware extension of the OGC Catalog Service for the Web (CSW-Q), which could cope with quality-constrained search, is being prototyped as an extension of the EuroGEOSS Broker. This catalogue will be able to

harvest quality aware WMS-Q, SOS-Q, KML-Q and so on. As the EuroGEOSS Broker is a core part of the GCI, this will provide valuable feedback for the assessment and the future evolution of quality-related standards.

A standard-based visualization approach for the visualization of quality / uncertainty information in 2D is developed using OGC Web Map Service (WMS). In the context of OGS-OWS-9, a draft engineering report has been submitted to OGC members for their consideration. A prototype is being developed for a WMS-Q component that explodes and validates the WMS-Q draft, which links the quality / uncertainty information in the WMS and that visualizes the uncertainties along with its data. A similar investigation has been started for 3D visualization based on KML-Q, and results are expected later in the project.

The design of GeoViQua components is carefully conducted to ensure they are aligned with the standards used, and therefore guarantee a smooth integration in the GCI further in the project. Aspects such as ISO geospatial quality standards, the user feedback model and the GEO Label, have been taken into account.

GeoViQua conducts a careful validation process in collaboration with a number of communities of practice and standards committees, to ensure that the project contributes effectively to the GCI. The experimental testing of innovative tools, techniques or aspects of the GEO Label with adequate datasets is complemented with the building of scenarios embedding the surrounding environment, system boundaries, and interactions with users, providers, requirements and services within GEOSS. The scenarios agreed includes: carbon cycle, agriculture, and air quality. Carefully defined scenarios provide a framework to test the on-going activities and to disseminate the results of the project by illustrating the applicability in real cases.

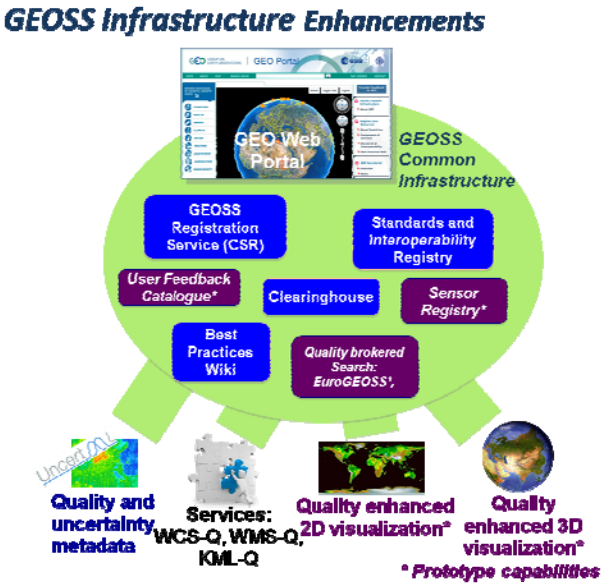
Dissemination tasks are oriented to make the project known in different scientific conferences and GEOSS communities, while ensuring a lasting impact of the project. To achieve the first goal, the project has submitted scientific papers to international fora (such as the Philosophical Transactions of the Royal Society A) and has participated in many GEO-GEOSS related activities (such as the GEO plenaries and board meetings). The quality model developed in WP6 has been also presented to the Spatial Accuracy 2012 conference and to OGC AIP5 kick-off meeting; finally in AIP4 we helped the Standards and Interoperability Forum (SIF) in tutorial coordination, as well as in the production of some materials.

The development of a GEO Label in a multi-phase approach is one of the key mandates of GeoViQua. To date, in-depth user interviews have been conducted to elicit dataset user and producer requirements and opinions as they relate to the notion of a GEO Label. Subsequent to that, an extensive survey was completed to further investigate user and producer opinions as to the purpose of a GEO Label and to explore their attitudes to existing e-Commerce quality and trust visualisation mechanisms, from which the GEO Label research is drawing heavily. At time of writing, the research is about to enter its third phase whereby prototype designs of GEO labels have been developed to encapsulate the community's feedback.

GeoViQua expected impact is to contribute significantly to integrating quality-aware visualisation of Earth Observation systems into GEOSS developments at the European and international level, bringing together key partners from academia, industry and the broader scientific community. In particular, GeoViQua will provide consistent, high quality

specifications, protocols and components allowing scientists and decision makers to access easily to a range of EO information including complete, flexible quality information. GeoViQua components and services will be made available within the GCI. This is going to be complemented by a GEO Portal with enhanced visualisation technologies, which also communicate data quality. To increase uptake GeoViQua will provide a range of tools and components to allow users seeking data / imagery and associated quality indicators to access the information through modern visualisation environments via the GEO Portal. We will place particular emphasis on intuitive and easy-to-use tools, providing components, which will enable data providers and users to derive, attach and mine quality indicators for existing datasets using both CAL / VAL data and user opinions. GeoViQua will also provide components to allow the discovery of data (using quality indicators in the search process) and components to allow easy visualisation of the resulting data and its reliability in modern 2D and 3D visualisation settings.

Participation in GEO boards, components and in Communities of Practice (CoP) workshops are facilitated by CEA in the Global Carbon Project and ESA in the industry (such as CEOS Working Group on Calibration and Validation, QA4EO and the European Association of Remote Sensing Companies [EARSC]) and the European Commission representation in GEO. Thanks to this collaboration, GeoViQua will lead a strategy for the implementation of the GEO Label. This will be based on adding richer structured quality indicators to datasets, together with considerations about how to convey trust to users that will contribute to the development and 'brand identity' of a GEO dataset.



Influencing the direction of the GCI through these boards is a key mechanism that GeoViQua is already exploiting. In addition, interoperable components and tools will be tested in OGC AIP and OGC OWS experiments to maximise the ease with which both data providers and consumers can benefit from GeoViQua developments.

To demonstrate the impact, and further motivate the usage of GeoViQua solutions, a series of scenarios will illustrate the usage of the standards, protocols and tools in a real world setting. These scenarios are key to create a powerful bridge between science and technology and daily needs of CoP, as well as with other activities from GEO and geodata users in general.

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
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European Space Agency	ESA
Science and Technology B.V	S&T