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Systems into GEOSS development**



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**QUALity aware VISualisation for the Global Earth Observation system of
systems**

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*Data Quality Parameterisation for the GeoViQua pilot case studies***

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1. Introduction

1.1 Purpose and scope

This document contains results and findings of application of data quality parameterisation methods to the GeoViQua Pilot cases. The scope of this document therefore is data quality parameterisation, in particular the following aspects:

- Methods for *deriving or extracting* data quality from dataset data.
- *Describing and encoding* data quality using a model in a suitable standardized format. Such a format facilitates the use of data quality by tools such as the GEO portal.

Within GeoViQua, data quality parameterisation has been in scope for several Work Packages (WPs):

- In WP2 requirements for data quality parameterisation have been engineered from user requirements.
- In WP3 several existing and new methods for parameterization and/or extracting data quality from datasets have been analysed.
- In WP6 methods for describing and encoding data quality in a standard way have been developed, leading to the Producer Quality Model (PQM) and User Quality Model (UQM) that provide a standard way of describing data quality on a dataset or even sub-dataset level.
- WP7 includes the verification of the results of the WP2, 3, 6, by application of the developed methods and tools to the GeoViQua pilot cases. This verification is important as it tests the consistency, fitness-for-purpose, and ease-of-use of the developed methods for representative use cases.

This document contains the results of this WP7 verification activity.

1.2 Document structure

This document has been organized as follows:

- Before discussing the application of data parameterisation, two sections introduce the data parameterisation methodology and pilot cases respectively:
 - o Section 2 summarizes findings from activities with respect to data parameterisation that were performed as part of WP2, WP3 and WP6, and are input to the WP7 verification activity.
 - o Section 3 presents an overview of the Pilot Case Studies that were used in the evaluation.

- Section 4 includes a detailed overview of results and findings of the data parameterisation application to the Pilot Case Studies.
- Section 5 presents overall conclusions.
- Section 6 contains a Glossary.
- Section 7 lists of references used throughout this document.

2. Data quality parameterisation in GeoViQua

This Section presents an overview of data quality parameterisation within the GeoViQua project, in terms of:

- Section 2.1: Requirements for data quality parameterisation defined in WP2.
- Section 2.2: Methodology and tools for deriving and extracting data quality from dataset data resulting from WP3.
- Section 2.3: Methods for describing and encoding data quality in a standard way resulting from WP6.

Note that within the scope of this document the focus for deriving and extracting data quality is on elicitation of quality information from existing data, rather than tools and data (file) formats for extraction.

2.1 WP2 requirements

Several user requirements in [D2.1-USERREQ] were defined for deriving, extracting, describing, and encoding data quality. These requirements include:

For deriving data quality:

- Requirements on deriving and using quality information from sensors (e.g. GeoViQua-44, GeoViQua-148)
- Requirements on deriving data quality by intercomparing data from different datasets (e.g. GeoViQua-41, GeoViQua-106, GeoViQua-109, GeoViQua-137)
- Requirements on the ability to generate *user feedback* on a dataset, including requirements on rating the dataset (GeoViQua-29, GeoViQua-88, GeoViQua-118, GeoViQua-136)

For describing and encoding data quality

- Requirements on a *data quality model* developed within GeoViQua, including requirements on:
 - o Describing qualitative and quantitative indicators of data quality (e.g. GeoViQua-22, GeoViQua-135, GeoViQua-136, GeoViQua-137)
 - o Including provenance information that traces the origin of the data (e.g. GEOVQUA-23, GeoViQua-55, GeoViQua-105, GeoViQua-166)
 - o Supporting usage/user information items (e.g. GeoViQua-113, GeoViQua-136, GeoViQua-158)
 - o How to encode data quality: The quality model shall use ISO standards for metadata (19115) and quality (19157) with extensions for UncertML and

O&M (GeoViQua-140). Furthermore UncertML encoding is to be used for quantitative Quality Indicators (QI) (GeoViQua-13)

- Requirements on summarizing data quality from data quality model records into a *GEO-label* (e.g. GeoViQua-31, GeoViQua-63, GeoViQua-80, GeoViQua-130, GeoViQua-133, and GeoViQua-153).

For an in-depth analysis, please refer to [D2.1-USERREQ] and [D2.2-SYSREQ].

2.2 WP3 Derivation and Extraction of data quality

The main objective of WP3 is to provide efficient tools to extract the quality information from:

- metadata including provenance information,
- the data including in-situ and other EO data with known quality,
- user knowledge and comments.

Methodology and tools for data quality parameterisation have been developed as part of the following tasks in WP3:

2.2.1 Task 3.1: Methodology and tools for extracting quality metadata from different file formats.

This activity comprised the development of a tool to identify quality indicators from existing metadata documents in an integrated manner. On one side, quality metadata is extracted from the pure GEOSS catalogue but this approach has been extended to other catalogues that can be related to GEOSS by means of using the EUROGEOS broker. On the other side, quality information is extracted as well from the main EO metadata formats such as 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 WCS-THREDDS. With all these information, a comprehensive quality metadata analysis has been performed. The detailed results of this activity have been reported in [D3.1-METADATAEXT].

Results of Task 3.1 include a classification scheme for dataset quality parameters, taken from [ISO-19115]). This classification will also be used throughout this document, and is given in the table below (Table 1 taken from [D3.1-METADATAEXT]). Its classification scheme employs the combination of *{quality parameter, quality indicator}*, using 6 main class quality parameter types and various Quality Indicator subclasses per quality parameter. An extended classification that uses an additional classification parameter *Quality Measure* is listed in Appendix A as part of the QualityML vocabularies effort.

Table 1: Classification and definition of quality parameters and indicators (in accordance with [ISO-19115])

Quality parameter	Quality indicator	Definition
Completeness	Commission	Excess data present in a dataset
	Omission	Data absent from a dataset
Logical consistency	Conceptual consistency	Adherence to rules of the conceptual schema
	Domain consistency	Adherence of values to the value domains
	Format consistency	Degree to which data is stored in accordance with the physical structure of the dataset
	Topological consistency	Correctness of the explicitly encoded topological characteristics of a dataset
Positional accuracy	Absolute or external accuracy	Closeness of reported coordinate values to values accepted as or being true
	Relative or internal accuracy	Closeness of the relative positions of features in a dataset to their respective relative positions accepted as or being true
	Gridded data position accuracy	Closeness of gridded data position values to values accepted as or being true
Temporal accuracy	Accuracy of a time measurement	Correctness of the temporal references of an item (reporting of error in time measurement)
	Temporal consistency	Correctness of ordered events or sequences
	Temporal validity	Validity of data with respect to time
Thematic accuracy	Classification correctness	Comparison of the classes assigned to features or their attributes to a universe of discourse (e.g., ground truth or reference dataset)
	Non-quantitative attribute correctness	Correctness of non-quantitative attributes
	Quantitative attribute accuracy	Accuracy of quantitative attributes

In addition to these quality parameters, Task 3.1 also involved extraction of *provenance* information (also known as *lineage*) from dataset metadata.

2.2.2 Task 3.2: Methodology and tools for *collocating* and intercomparing data from different datasets, including in-situ data

Within this task methodology for collocating and intercomparing datasets has been studied, where:

- collocation refers to finding combinations of data points for 2 or more datasets that match with respect to measurement (geo-)location or measurement time
- Intercomparison refers to actually comparing the measured data values for the collocated data points

Intercomparison in the GeoViQua context can be seen as assessing the quality of data by comparing it to other data representing the same measured quantity, but originating from a different source. Such sources include:

1. In situ observations that typically originate from ground measurement stations or aircraft.

2. Remotely-sensed data that typically originate from space-borne instruments on satellites.
3. Output from numerical simulations/models (excellent spatiotemporal coverage, variable accuracy, almost always gridded).

As part of task 3.2, existing intercomparison methodology inherited from the ESA GECA project (ref. [GECA-PUB]) has been embedded into a tool prototype that uses the Web Processing Interface (WPS) to expose intercomparison functions to the GEO Portal user. The user can configure the comparison using the following parameters:

- ID of dataset 1 – The first dataset for the intercomparison.
- ID of dataset2 – The second dataset for the intercomparison.
- type – The quantity of interest used in the intercomparison (e.g. ozone concentration, methane)
- quantity – The quantity used in the intercomparison (e.g. parts per million, total column density, volume mixing ratio).
- startTime, endTime – a referenced dataset might have a wide coverage over time. These parameters are used to restrict the intercomparison to the provided times.
- boundingBox – similar to the temporal extent, a dataset might have a wide spatial coverage. This parameter is used to restrict the intercomparison to the spatial area defined by provided bounding box.
- comparisonType – This parameter acts as a switch between “intercomparison” and “collocation”.
- deltaTime (optional) – The maximum time offset between both datasets in hours
- deltaPosition (optional) – The maximum spatial offset between both datasets in meters.
- reportType – the type of report generated.

The prototype has been tested using the test data from the Air Quality Pilot Case. The web client for configuring the parameters is in development.

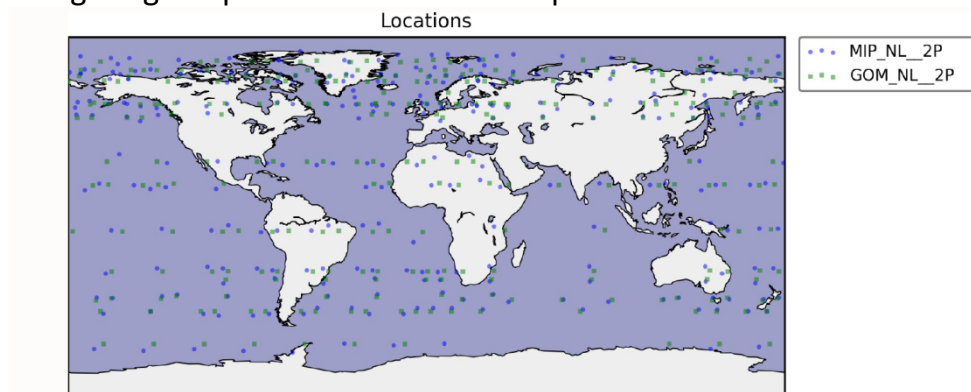


Figure 1: Intercomparison using GECA end user toolbox: the figure shows measurements from two different instruments on ENVISAT (GOMOS, MIPAS) that are close both in time and geolocation

2.2.3 Task 3.3: Computation and validation of quality indicators for continuously-valued data

Within task 3.3 Aston has focused on developing a set of services to compute quality metrics. Design highlights:

1. Continuous and discrete variables
2. Web frontend (Ruby on Rails)
3. MATLAB for computation (Java APIs)
4. Integrate collocation results from the GECA end user toolbox (output from task 3.2) as input into the service
5. Integrate outputs with the GVQ model

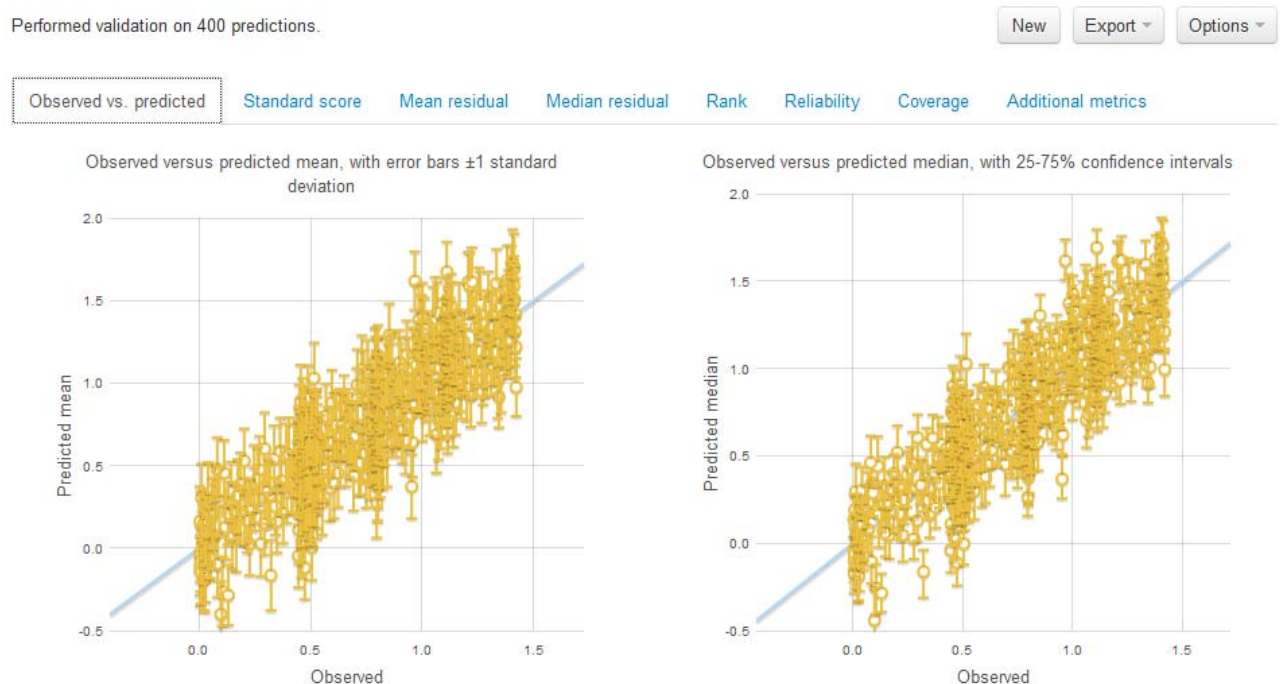


Figure 2: Example output from quality metrics services (D3.3.ppt)

UAB has been contributing to the continuous variables uncertainty assessment mainly through studies linked to the Digital Climatic Atlas of the Iberian Peninsula testing dataset. These databases are available for several dates and specific periods in which some interesting circumstances as regards quality and uncertainty assessment converge. Besides, the GeoViQua Producer Quality Model and User Feedback Quality Model (i.e., Consumer Model UQM) have been implemented for this dataset, generating complete examples of in particular the quality elements, thus enabling prototypes testing (further details in D7.4).

In addition, the geometric corrections dataset provides positional accuracy tests (positional accuracy being the most widely used quality parameter in the GEOSS Clearinghouse analysis as shown in D7.2) and derived quality indicators by means of spatialized error quantification displayed as an error vector.

This range of examples of quality indicators provides diversity of insights for quality elicitation, encoding, visualization (including raster and vector displays) and geosearch purposes components.

2.2.4 Task 3.4: Quality indicators for categorical variables

The assessment of quality indicators for categorical variables has focused on classification processes and the corresponding uncertainty quantification in the form of confusion matrices, Brier Score, AUC of a ROC, R^2 , global accuracy indices and confidence intervals, reliability diagrams, purity, entropy, fidelity or representativity, thus deriving quality measurements at dataset level, pixel level and object level (polygon or area) and per category analysis.

The novel aspect of the study performed in this task is that the combination of remote sensing imagery with statistical classifiers for categorical thematic mapping does not usually provide data about the spatial distribution of the uncertainty of the resulting maps.

Some classifiers (e.g., the Bayesian classifiers most used in remote sensing) enable the computation of uncertainty at the same time as the classification map. In contrast, a hybrid classifier (Serra and Pons, 2008) does not directly generate the accuracy but in exchange supports internal multidistribution inside a thematic class (e.g., contribution of different spectral clusters to a single thematic category).

An insight of a case study comparing the behaviour of probabilistic classifiers is provided in ref. [UNCERT-REMOTE] and [CROPS-SAT]. The comparison of classifiers in such studies allow for further perception of diverse facets of uncertainty: for instance, it is useful to find out for a certain pixel whether all the classifiers compared assign it to the same thematic category or not. In GeoViQua, similar approaches have been employed in the “Digital Climatic Atlas of the Iberian Peninsula” dataset, when the model stability is tested by means of comparing different model runs and encoding the distribution of the obtained values (e.g., mean + standard deviation), or for the “Carbon cycle” dataset, when the uncertainty is estimated for a certain model by comparison to the mean of the value provided by each of the models.

Two datasets in GeoViQua have been used in these studies: monitoring flooding practices by a wetland classification in flooding categories of rice fields in the Ebro Delta and a landcover map derived from a multitemporal series of LANDSAT scenes over Barcelona-

Girona. The first dataset constitutes moreover an operational decision system applied by the regional administration, as explained in the Agriculture Scenario (<http://www.GeoViQua.org/AgricultureScenario.htm>, further details in [D7.4-COMP-EVAL]. A relevant feature is that the quality elicitation is taken to the parcel level (i.e., object level), which is in reality the territorial management natural unit (i.e., the real world is not made up of pixel units; decision makers have to deal with parcels and real landowners, and economic issues e.g., deciding about subsidies).

Objectives of the studies go beyond pixel level estimation (e.g., posterior class probabilities in probabilistic classification methods) to provide effective communication of quality indicators at pixel/object level and even validation of the accuracy estimates and more refined and accountable models. Our focus is not so much on the classification accuracy, but rather the validation of the probabilistic classification made by all methods.

2.2.5 Task 3.5: User feedback and quality assessment of data sets in GEOSS

Task 3.5 has resulted in several items:

1. Definition of *A feedback model* that describes comments and ratings of users with respect to datasets.
2. Inputs to the *data consumer* part of the quality model (which is discussed in the next section).
3. Development, implementation, testing and integration of a *user feedback server* that will allow Geo Portal users to submit comments, ratings, and other feedback on datasets.
4. Development, implementation, and testing of a *user feedback server* that holds user feedback from Geo Portal users, and can be queried by the GEOSSBroker or directly using query statements in the json language.
5. Development, implementation, testing and integration (in progress) of a *user feedback submission client web interface* that will allow Geo Portal users to submit comments, ratings, and other feedback on datasets to the user feedback server.

Users are also able to query the feedback server through the Geo Portal search interfaces.

2.3 WP6 Coordination – Delivery of solutions to end users

One of the WP6 activities of interest for data quality parameterization is task 6.1: Encodings for data quality. As part of this task, 2 quality models have been developed:

- A *producer quality model* that encapsulates data quality items supplied by the dataset provider. The producer quality model introduces elements to record qualitative and quantitative quality information, and to identify resources (i.e.,

datasets) in order to relate metadata in hierarchical or other ways. The model extends ISO 191151, 19115-22 and 191573, adding means to report publications, discovered issues, reference datasets used for quality evaluation, traceability, and statistical summaries of quantified uncertainty.

- The *user quality model* that 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.

For details on the quality model, please refer to [D6.1-QUALITYMDL]. The encoding of data quality into either of the 2 models has been extensively studied in pilot cases.

In addition task 6.3 has resulted in the realization of a *GEO label*. Research conducted to establish and evaluate the concept of a GEO label that acts as a decision-support mechanism for geospatial dataset selection. A multi-phased user-centred design (UCD) approach was employed in order to develop a GEO label that is likely to garner user acceptance once deployed. To this end, 3 user studies were conducted to:

1. identify the informational aspects of geospatial datasets upon which users rely when assessing dataset quality and trustworthiness.
2. elicit initial user views on the concept of a GEO label and its potential role in supporting dataset comparison and selection.
3. evaluate prototype label visualizations.

The study has resulted in a GEO label that is shown in Figure 3. More information on the GEO label is available at www.geolabel.info.

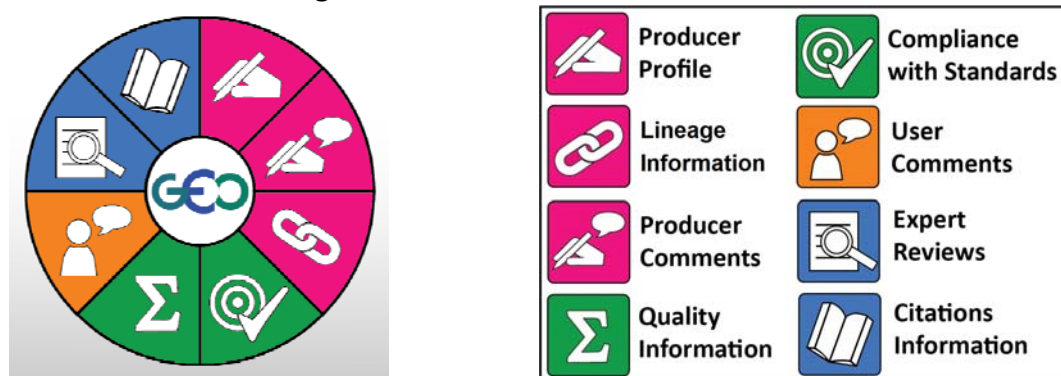


Figure 3: Geo label on the left depicting 8 aspects of data quality, explained in the legend on the right

3. Pilot Cases overview

Several pilot cases have been defined during the GeoViQua. The following pilot cases involve data quality parameterization (with prime responsible GeoViQua partner in between parentheses):

- Remote sensing
 - o Geometric correction of Landsat series (UAB)
 - o Radiometric correction of Landsat series (UAB)
 - o Intercomparison of atmospheric data measurements from remote sensing instruments (S&T)
- Carbon cycle
 - o Carbon cycle: Estimates of global carbon fluxes from Inversions, Land and Oceans Models (CEA)
- Climate
 - o Digital Climatic Atlas of the Iberian Peninsula (UAB)
- Agriculture
 - o Monitoring Flooding practices in the Ebro-delta using remote sensing (UAB)
- Land use
 - o Land cover classification of Landsat Barcelona-Girona scenes (UAB)
 - o Land use: Land cover map of Catalonia (CREAF)
 - o Land use: SIOSE (CREAF)

A short introduction on each of these Pilot Cases is given in the next Sections. For data quality parameterization results, please refer to Section 4.

3.1 Remote sensing: Geometric correction of Landsat series

The geometric corrections dataset is a result of applying automatic matching of ground control points and orthophotomaps protocols for large series of Landsat images.

An error vector magnitude indicates mismatch degree between ground control points (GCP) and targeted pixels (the vector direction indicates the offset direction in X and Y coordinates).

Methods include statistical and empirical modelling, and the quality parameterization is based in finding the optimal distribution of ground control points, automatic matching through correlation analysis and geometric correction with polynomials, taking into account the relief (ref. [GEO-CORR-SAT]).

Outputs of these processes, subsequently subjected to radiometric correction processes (see Section 3.2) have been used as inputs in classification processes in the Monitoring

Flooding practices in rice fields in the Ebro river delta and the Landcover classification of Landsat Barcelona-Girona scenes.

3.2 Remote sensing: Radiometric correction of Landsat series

Automatic radiometric correction processes was applied to large series of Landsat and MODIS scenes, as described in [LANDSAT-RAD]. The error model robustness was validated by means of checking several runs of the model enabling the identification and quantification of stability and variability of pixels.

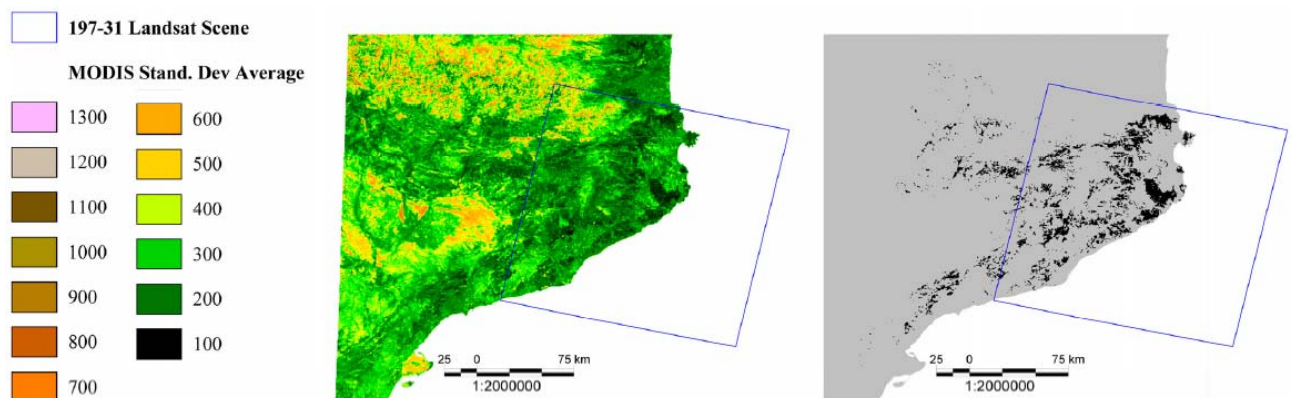


Figure 4: Left image: MODIS average of the 6 standard deviation images. Light colour zones are those with large variability (herbaceous non irrigated crops, temporary snowed areas, etc.). Right image: selection of pixels with deviation average under 1.75 (x100 factor applied to legend values). Source: [LANDSAT-RAD]

The study consists of a methodology to automatically estimate the atmospheric parameters needed in simplified radiometric correction models (atmospheric and topographic) of remotely sensed solar bands (ref. [MODEL-RADCOR]). The method estimates the radiance received by the sensor (from an area where only atmospheric contribution exists, and the atmospheric optical depth, using pseudoinvariant areas (PIA) with known reflectance values. PIAs were obtained using MODIS images and were verified with Landsat test imagery.

Images resulting from the application of these protocols were used in other studies (e.g., Landcover classification of Landsat Barcelona-Girona scenes, Monitoring flooding practices in rice fields in the Ebro river Delta).

3.3 Remote sensing: Intercomparison of atmospheric data measurements from remote sensing instruments

Monitoring of the earth atmosphere using space-borne remote sensors has been performed for several decades through different missions (ERS, ENVISAT, EOS-AURA, and METOP). These sensors typically deliver global coverage of atmosphere properties such as

total column and/or altitude-dependent trace gas concentrations (water vapour, ozone, carbon monoxide, and nitrogen dioxide), pressure and temperature. Important aspects affecting data quality are uncertainties in calibration parameters (also known as Key Data Parameters), some of which have been measured on-ground only, and instrument degradation. The magnitude of some of these uncertainties can be estimated using the retrieval models that also derive the atmosphere properties from the raw instrument data.

However such models may not be sufficient for detecting systematic errors in instrument performance. Hence, numerous initiatives for intercomparing measurement results from different space-borne instruments are employed, as well as comparing measurement results to ground/balloon/aircraft-based measurement results.

Within GeoViQua, the intercomparison of measurements was studied using datasets from 2 different instruments on ENVISAT: GOMOS and MIPAS. These instruments measure traces of gas components in the Earth's atmosphere using different measurement principles. One such traces of gas, Ozone (O_3), is measured by both instruments and thus can be intercompared. The actual intercomparison case hence involved longitude-latitude-altitude profiles of Ozone (Level-2 data, see also the glossary in Section 6, topic Processing levels). Note that such profiles have not been aligned on a temporal or geo-spatial grid.

The generation of data quality information by means of intercomparing data was studied, in particular how to expose intercomparison methods within GeoViQua.

3.4 Carbon cycle: Estimates of global carbon fluxes from Inversions, Land and Oceans Models

The creation of this dataset was possible thanks to the close collaboration with national governments, space agencies, and relevant technical experts in the world. This collaboration has resulted in several estimates of natural carbon fluxes exchanged between the land, the ocean and the atmosphere at global scale.

These estimates could come from atmospheric inversion (inverse procedure using atmospheric CO_2 measurements to estimate surface fluxes) or from land/ocean ecosystem models. In practice, they are used for knowing the fraction of CO_2 initially released by anthropogenic and natural emissions that are taken up by land and ocean ecosystems, including its spatial and temporal variability.

All estimates are produced by models that come from renowned laboratories in the world. So a significant part of the work consisted of collecting and selecting data. However, with the estimates coming from very complex models, there is not real uncertainty information available at pixel level and neither at dataset level at global scale. At the moment, the best

uncertainty information available is an “error spread” for one zone and for one type of flux at a time.

Hence, as an alternative approach, we have used an intercomparison data tool to represent uncertainty information: in fact, the different estimates can be used as an ensemble to assess the errors associated to the different approaches. The *Atmospheric Tracer Transport Model Intercomparison Project* (TransCom)¹, in which the CEA-LSCE has participated was a pioneer for this approach but had a clear orientation to the scientific community.

In this pilot case, we choose to use two methods that use indirect ways to have uncertainty information at pixel level:

1. A simple intercomparison method
2. A method that associates an intercomparison method with a symbolisation method.

Furthermore, in order to have a dynamic application, we have combined these methods with a Web Map Service, such that the carbon fluxes data can be integrated in WMS-viewers such as the Greenland Portal from 52N.

3.5 Climate: Digital Climatic Atlas of the Iberian Peninsula

The Climatic Atlas contains climatic surfaces (temperature, precipitation and solar radiation) estimated by interpolation methods based on correlation structures between in-situ observations (from meteorological stations) and geographic variables. Usual quality indicators for such datasets include Root Mean Square Error (RMSE) as a global quality indicator, thematic accuracy/quantitative attribute correctness/uncertainty at 68.3% significance level, and coefficient of determination (R^2). In addition error coverages have been developed, for example maps of regression residuals, pixel level RMSE layers, stability tests.

¹ <http://transcom.project.asu.edu/>

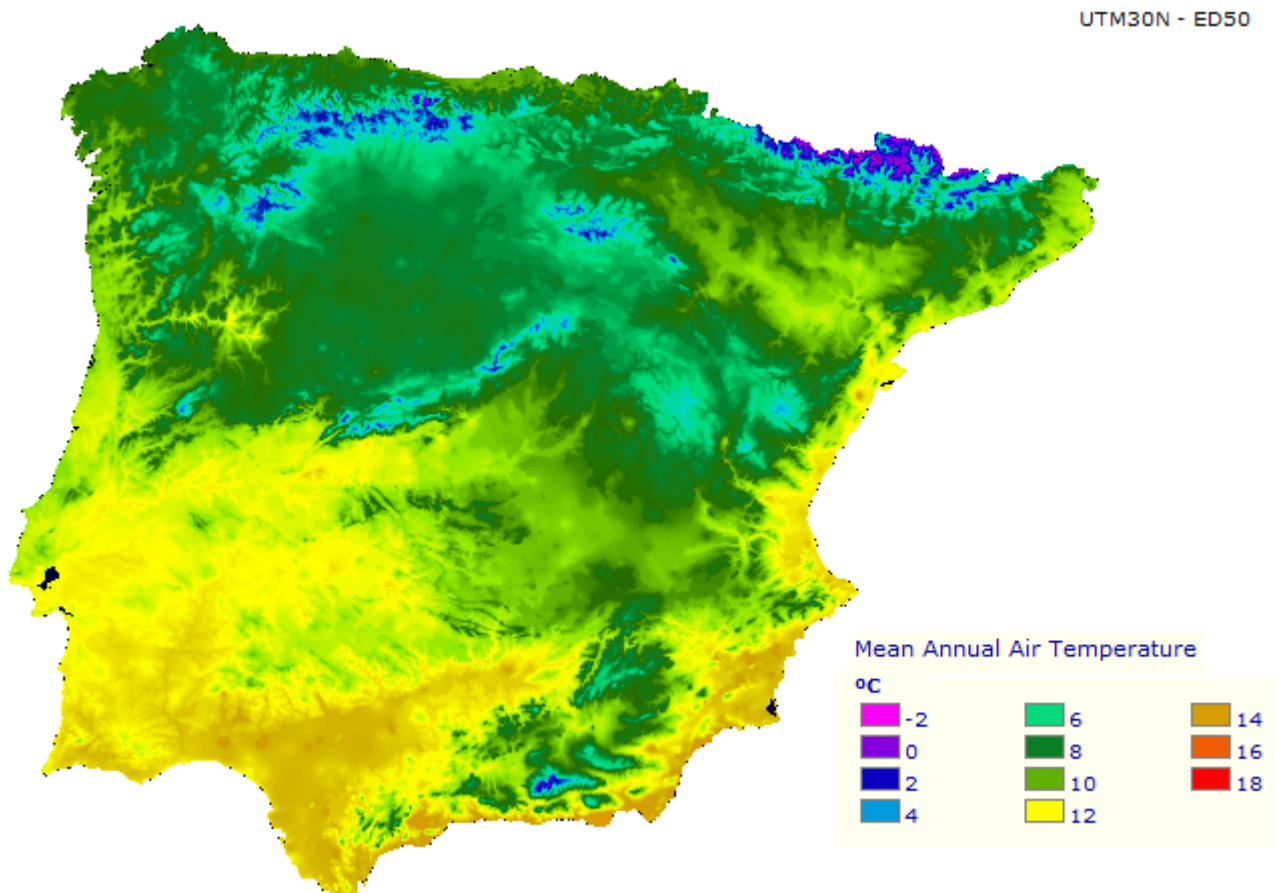


Figure 5: Digital Climatic Atlas of the Iberian Peninsula showing mean annual air temperature. Source: GeoViQua WMS-Q test server (<http://wms-q-demo.GeoViQua.org/GeoViQua/wmsg/>, UTM30N-ED50)

3.6 Agriculture: Monitoring flooding practices in rice fields in the Ebro river delta using remote sensing

In this study remote sensing scenes are used to reach a wetland classification using 8 flooding categories. A mask is applied to eliminate urban areas and well-identified categories out of interest, thus diminishing confusion between categories. Figure 6 shows an example of a classification result for the 29th of October 2006.

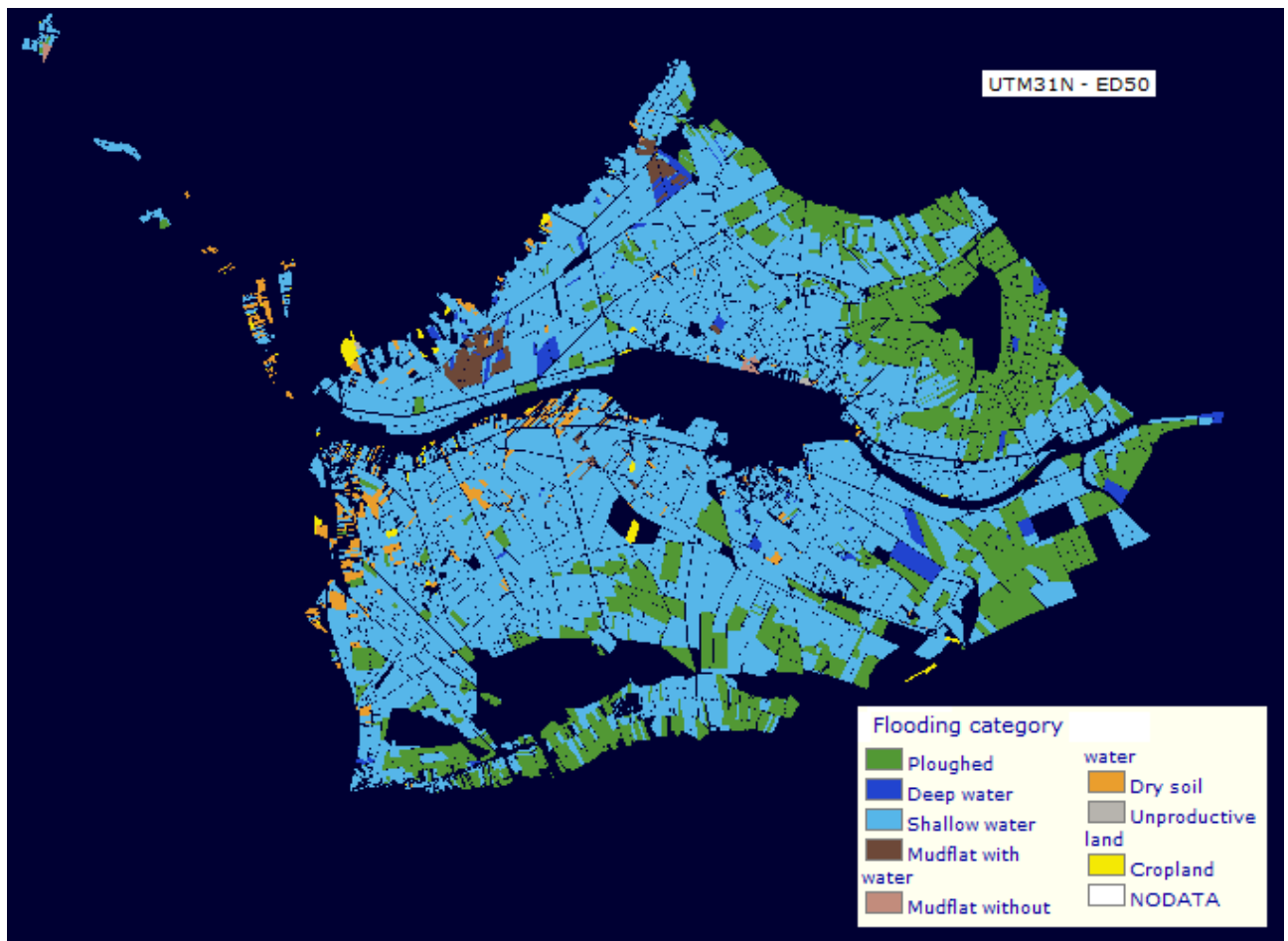


Figure 6: Classification of the Ebro flooding maps on 29-10-2006. Source: GeoViQua WMS-Q test server (<http://wms-q-demo.GeoViQua.org/GeoViQua/wmsq/>, UTM31N-ED50)

Initially, two discriminant functions (constituted by linear combinations of reflectances) were selected providing 86.4% of total variance explained and generating in a map in which all pixels are classified. Classification accuracy is evaluated using confusion matrix, global index and confidence intervals, introducing the relevance of classification parameters like purity, fidelity, representativity and analysing the case at global, pixel, polygon and area levels in the assessment.

As for classification methodology, a wide range of classifiers has been tried, from simple Bayesian linear discriminant analysis to a complex variational Gaussian process based classifier. Available ground truth is used to properly model the spatial distribution of the errors.

The decision making system described in the Agriculture Scenario is based on the season summary of all the states of rice fields from October to March, in which a final multitemporal map indicates how many dates (from the 5 original dates) a pixel reached one of the four flooded categories.

The object level quality elicitation is obtained by enrichment processes (e.g., overlaying cadastre layer to pixel level quality indicators, enabling per field classification using a mode filter and per field acceptability threshold -% of purity in category assessment- to derive a per field compliance decision in subsidies distribution for rice fields farmers).

Further details are explained in references [RICE-DISCRIM] and [CADASTER-ENRICH].

3.7 Land use: Landcover Classification of Landsat Barcelona-Girona scenes

Classification products derived from remote sensing scenes are widely used. However, the accuracy indicators provided at pixel and object level are not always available, which prevents detailed analysis of (local) data quality. Probability of belonging to the assigned class should be quantified and communicated to the user. For this dataset, in addition to the standard classification product of a crisp classification, several quality indicators derived from the classifier parameters and uncertainty statistical models, together with the probability for every class are provided at pixel level and object level.

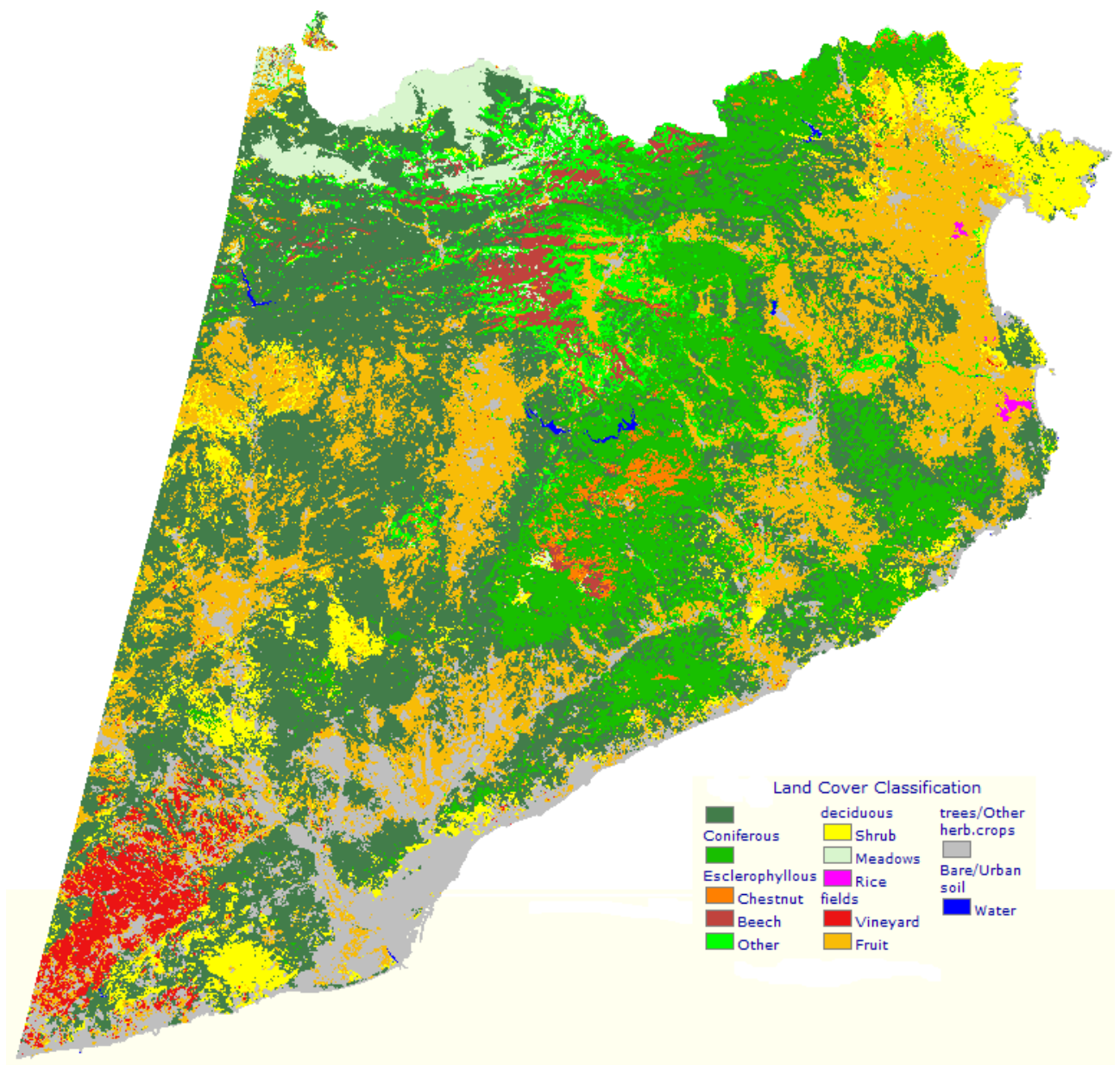


Figure 7: Land cover classification example. Source: GeoViQua WMS-Q test server (<http://wms-q-demo.GeoViQua.org/GeoViQua/wmsq/>, UTM31N-ED50)

The dataset tries logistic regression and multivariate linear regression models for respectively pixel and object level accuracy quantification. Whereas some classifiers (e.g., maximum likelihood, linear discriminant analysis, naive Bayes, etc.) permit the estimation and spatial representation of the uncertainty through a pixel level probabilistic estimator, such a direct estimator does not exist for the majority of alternative classification methods that are still employed for providing better scores or simply because of not requiring the strong constraints of the aforementioned (e.g., normal distribution of thematic classes). The prominent example here presented lays on the hybrid classification domain (ref. [CLASS-VEG]), that combines unsupervised and supervised stages. In the resulting

cartographic product, the characterization of the uncertainty distribution is as crucial as is not direct its computation due to the complexity of the two stages classification method.

Coherence between the common global indicators extracted from the confusion matrix and the pixel or object indicators is assessed in this multilayer product. Finally, the comparison of results between different classifiers is intended to cover sensitivity testing performance. Besides the large geographic extent analysed, a relevant characteristic for the creation of this product is the usage as ground truth of a detailed landcover map obtained by photointerpretation matching the temporal series of the scenes, covering around 41% of the whole area of study.

3.8 Land use: Land cover map of Catalonia

The Land Cover Map of Catalonia (MCSC) is a high resolution thematic cartography of the main types of land cover of the country (forests, crops, urban areas, etc.). The MCSC is carried out in CREAM, with the funding of the Generalitat de Catalunya. The MCSC is part of the Internet available Cartography of the Generalitat de Catalunya and is, therefore, free to use. The MCSC is presented in digital format. The different areas are delimited by photointerpretation and digitalization on computer screen, using the MiraMon GIS.

	MCSC
Reference scale	1: 5.000
Geodetic reference system	ED50 (UB/ICC parameters)
UTM	Zone 31
Minimum area unit to represent	500 m ²
Minimum width of the general elements	10 m, except classified road and rail networks that does not have this limitation, non-scheduled road which is 7 m unpaved forest roads that will of 15m.
Corridors	There is no limitation
Reference images	Natural colour orthoimages 2.5 m spatial resolution 2005-2007
Legend	Hierarchical, with 5 levels and 217 covers in more level of detail
Conceptual data model	layer oriented
Format Database	MiraMon

MCSC specifications

3.9 Land use: SIOSE

CREAF elaborated the cartography of Catalonia in the project SIOSE (Information System on Land Use in Spain). In the Catalan area, this cartography is obtained from the Land Cover Map of Catalonia (MCSC), in its third edition. These two maps have their own characteristics as for legend and base images. However, their greatest differences are related to the scale of reference and minimal area: for MCSC, the scale is 1:5000 and the minimum area of 500 m², whereas for SIOSE the scale is 1:25000, and the minimal area

changes between 0.5 and 2 ha according to the classes. In spite of that, SIOSE can be obtained from MCSC, by not common innovative processes of generalization both spatial and thematic. Thus, the thematic differences are settled because MCSC legend, of hierarchical type, has been made so that it is translatable to SIOSE legend. As for the disparity of scale and minimum area, it is solved by automatic processes of generalization of the MCSC graphic information. Finally, the differences derived from the comparison with the images of reference are overcome through adjustment of the product obtained from MCSC to the reference image of SIOSE.

	SIOSE
Reference scale	1: 25.000
Geodetic reference system	ETRS 89
UTM	Zones 28, 29, 30 y 31
Minimum area unit to represent	Artificial surfaces and water bodies: 1 ha. Beaches, riparian vegetation, wetlands and forced crops (greenhouses and under plastic): 0.5 ha. Agricultural areas, forest and natural: 2 ha.
Minimum width of the general elements	15 meters, except beaches, riparian vegetation, wetlands and crops that may be forced narrower
Corridors	Narrowing is tolerated less than 15m if not exceeding 60 m in length.
Reference images	Fusion of SPOT5 panchromatic and multispectral images of 2.5 m spatial resolution of year 2005
Legend	Hierarchical, with 40 single coverage and 45 predefined composite coverage in greater level of detail
Conceptual data model	Object oriented
Format Database	Esri-ArcGis; Intergraph-Geomedia Standard format supported by OGC: .GML + Base Access

Table 2 IOSE specifications

4. Pilot Cases: Data quality parameterization results

This Section presents for each Pilot Case results, findings, and conclusions of the application of data quality parameterization methodology to the pilot case, both in terms of extraction/derivation and description/encoding.

Per Pilot Case the following is reported:

- Coverage: Which aspects of data quality parameterization were covered by the pilot case, in terms of:
 - Parameterization elements. One or more of:
 - Derivation
 - Extraction
 - Encoding: Producer Quality Model
 - Encoding: User Quality model
 - Encoding: GEO label
 - Classification types of quality parameters and indicators. This is either one of the items in Table 1, or the item: Provenance.
- The approach to data quality parameterization used in the Pilot Case
- Results and findings with respect to the derivation/extraction of data quality parameters (if applicable)
- Results and findings with respect to the description/encoding of data quality parameters
- A summary presenting the most important findings and conclusions for each Pilot Case

4.1 Remote sensing: Geometric correction of Landsat series

4.1.1 Coverage

Parameterization elements:

Derivation, Extraction, Encoding – Producer Quality Model, Encoding – GEO label

Quality indicators:

Positional accuracy – Absolute or external accuracy, Provenance

4.1.2 Approach

The quality of the geometric correction can only be clearly determined by an independent test. However, it is possible to study how the number of Ground Control Points (GCPs) impacts the quality of the geometric correction in order to:

- give a general figure of the quality when an independent test is not available for an image

- assess the reliability of the usage of a quality indicator derived from the GCPs used to fit the model.

The optimal number of GCPs will depend on the complexity of the scene and, apart from the observation that the minimum number depends on the model to be used, there is no consensus about a general recommendation.

The objective of the pilot study has been twofold:

1. To evaluate how the quality of the geometric correction varies depending on the number of GCPs used, on the GCPs placement methodology or on their role in the model fitting.
2. To take a glance at the spatial representation of the quality of such geometric corrections.

The automatic ground control point searching methodology proposed in Pons et al. (2010) consists of finding homologous points between a satellite image and an orthophotomap through correlation analysis. One important feature of this methodology is that the distribution of the GCPs is not according to the presence of identifiable features in the image but to an optimal distribution of GCPs according to the polynomial with Z functions. Consequently, the distribution of the automatic GCPs covers the complete range of the X, Y and Z of the scene.

The effect of the number of GCPs on the geometric correction quality when they are manually located has been studied. The methodology has been applied to Landsat Thematic Mapper (TM) images in a region with complex relief (heights ranging from 0 to 3000+ m). The work presents a spatial representation of the error and discusses its role in the visualisation of the quality. Moreover, we critically discuss the usage of indicators as the RMS error without considering the number of GCPs or the method used in their placement in the realistic assessment of the geometric quality of the imagery.

4.1.3 Derivation/extraction results and findings

According to an experience of more than ten years (and hundreds of corrected images) the number of GCPs per scene that can be successfully set manually is limited to about 30 and to regions clearly identifiable by the human eye (even if the operator has a large expertise in this task). If more GCPs are desired, the operator has to deal with regions harder to identify and with an increasing uncertainty in the location of the GCPs and, consequently, in a worse fitting of the polynomials. A computerized method can successfully deal with regions hardly identifiable by a human, so the distribution of GCPs is not limited to recognizable zones but it can be set according to the proposed model.

The global quality of the geometric correction is numerically assessed by the RMS error. A reasonably high number of test GCPs allows spatializing the errors detected during the

model testing stage. In this work a preliminary vector error visualisation that consists of representing the error vector of each test GCP is presented. As the errors are usually smaller than a pixel, the length of this vector was exaggerated by a factor x100 in order to be conveniently represented at general scales. Figure 8 shows an example.

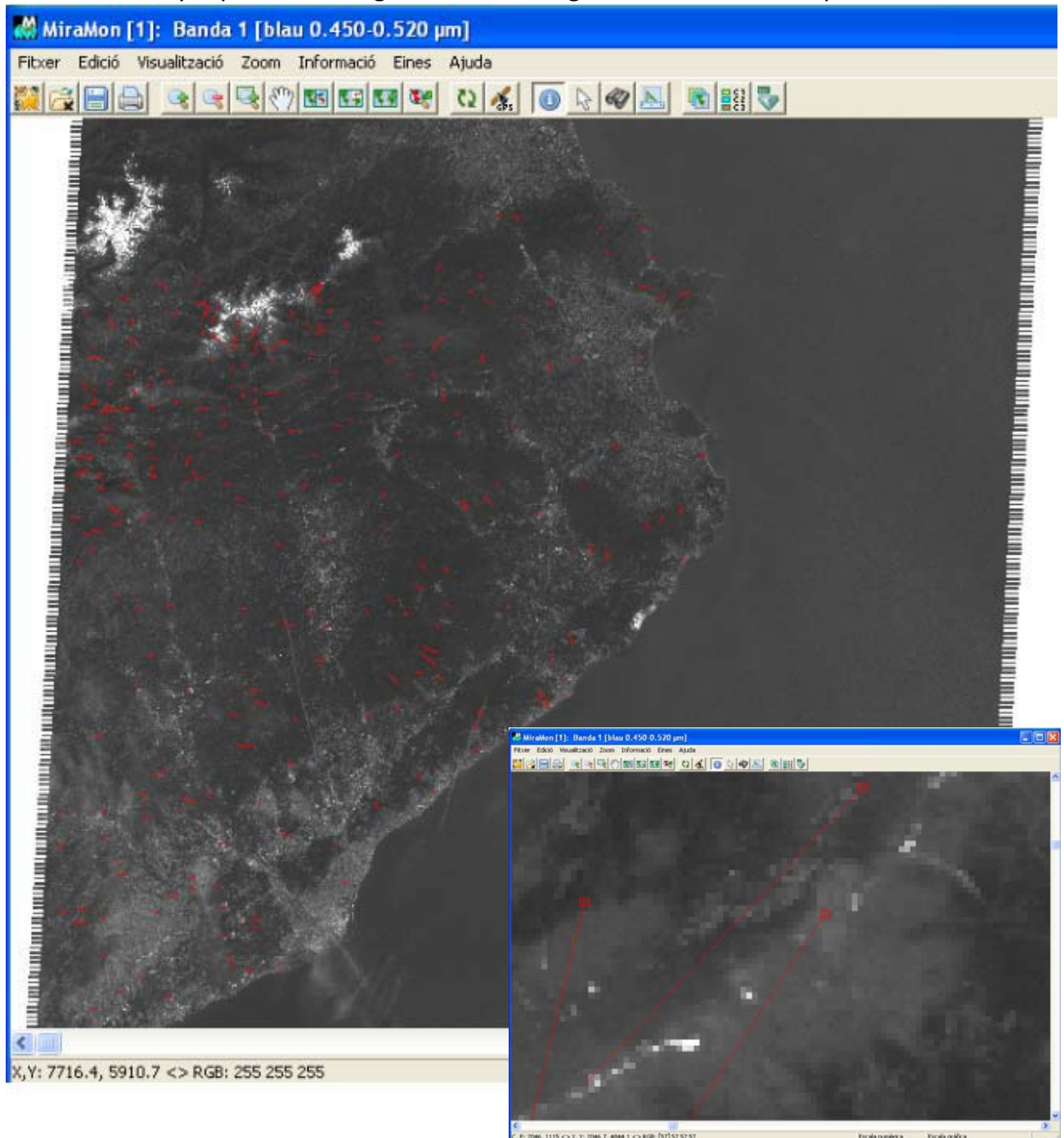


Figure 8 Visualization of GCPs: the visualization uses red lines connected to target ground pixels (indicated by red squares) to indicate magnitude and direction of the geometric mismatch between the target pixel and the Ground Control Point

The mean RMS increases when the number of GCPs decreases for both scenes. Variability in results also increases when using a lower number of GCPs. It can be explained by the fact that with a lower number of GCPs the distribution of X, Y, Z is hardly covered.

This work reveals the importance of knowing two additional parameters besides the RMS error when assessing the geometric accuracy. These two parameters are:

1. The number of used GCPs used to fit the model and
2. Whether the RMS has been computed based on the fitting GCPs set or based on an independent set of GCPs. The fitting GCPs RMS is biased, giving a lower (optimistic) RMS than the RMS obtained by an independent test. This bias increases when the number of fitting GCPs decreases.

If GCPs are manually located, a minimum of 25 GCPs is recommended to obtain an acceptable quality in the correction. Nevertheless, given that the manual location of GCPs is limited to 30-35 GCPs, the quality of the geometric correction is also limited. Indeed, using an automatic procedure to find hundreds of GCPs can improve significantly the results (22.9 m manual RMS error versus 15.5 m automatic).

Vector-based visualisation allows to easily detect points with high error magnitude and direction patterns. In this particular case, the data quality parameterization has focused on a method strictly applying geostatistical concepts in the quality indicators derivation which is unfortunately often overlooked and sometimes misunderstood in geometric corrections procedures, providing the innovation of visual communication of the error (e.g., a vector layer showing the raster's collocation error). However, at present, the service and the implementation of more sophisticated visualization techniques for vector models have not been totally explored for this dataset. Nonetheless, efforts have also been dedicated to the encoding in the form of a valid PQM, adding to the GeoViQua set of quality indicators for the most widely used in the geospatial domain: positional accuracy.

4.1.4 Description/encoding results and findings

Results have been encoded in a Producer Quality Model record available at:

http://schemas.GeoViQua.org/GVQ/4.0/example_documents/PQMs/GeometricCorrections_GCP.xml

The producer quality model works very well for encoding quality. In this case the PQM does not point to a server (e.g., WMS-Q). The error is explained in the Citation_abstract and Citation_purpose sections (thus, only referenced in the corresponding publication) and also in the corresponding quality reports, containing references to quality measures (e.g. QualityML: Differential Position Error X, Differential Position Error Y, Differential Position Error XY, Root Mean Square Error, etc). Last, there is also provenance information (lineage

steps and sources). In this manner, a quite complete GEO Label is obtained, with quality information, provenance and quality standards compliance to be added to the data provider info and citations highlighted facets.

4.1.5 Summary

In the pilot study it has been shown that not using independent Ground Control Points (GCPs) leads to unrealistic quality indicators. The emphasis is on the spatialization of the positional accuracy estimator in the form of an error vector that displays the error in the two directions (X, Y) for each GCP. The user can then visually identify the areas in where the positional accuracy is higher and assess the direction of the error. This is very useful for instance to assess the uncertainty in smaller subsets of the scene, enabling error traceability in posterior processing.

The metadata record could be improved when an appropriate server for containing the quality indicators is ready. Nonetheless, the current version implements QualityML encoding for positional accuracy, it is a validated document and therefore, the GEO Label is correctly displayed.

Further tests would imply the harvesting of the quality measures by the discovery components (e.g., DAB-Q).

4.2 Remote sensing: Radiometric correction of Landsat series

4.2.1 Coverage

Parameterization elements:

Derivation, Extraction

Quality indicators:

Thematic accuracy - Quantitative attribute accuracy

4.2.2 Approach

A novel methodology is employed to automatically estimate the atmospheric parameters needed in simplified radiometric correction models of remotely sensed solar bands. Additionally, an update of the Pons & Solé (1994) (ref. [MODEL-RADCOR]) model is proposed.

The method estimates the radiance received by the sensor from an area where only atmospheric contribution exists (L_a) and the atmospheric optical depth (τ_0), using pseudoinvariant areas (PIA) with known reflectance values. PIA were obtained using MODIS images and were refined with Landsat imagery. Reference reflectance for each PIA was obtained from an average of 12 Landsat 5 TM images after having been manually radiometrically corrected.

The algorithm proposed permits the automatic radiometric (atmospheric and topographic) correction of a massive number of images and results in radiometrically highly coherent time series.

4.2.3 Derivation/extraction results and findings

Results for 18 Landsat 5 TM images show that differences between estimated reflectance and the reference value for 3000 test PIA are very low and consistent, varying from -2% to +2% in reflectance (.

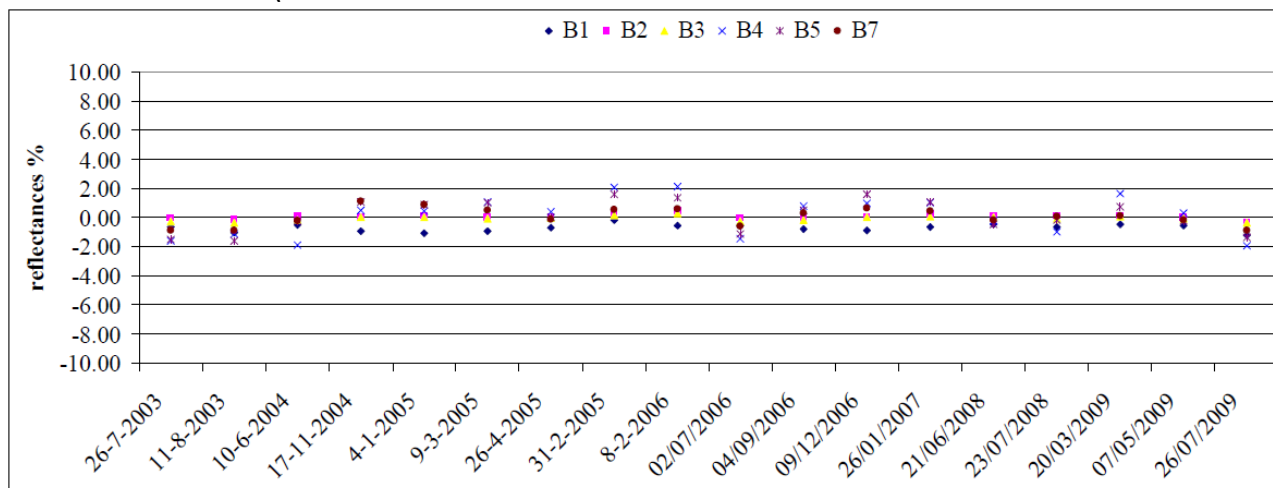


Figure 9: Reflectance variation over time on 3000 independent test pseudoinvariant targets for the 6 solar bands of 18 Landsat 5 TM images. Source: [LANDSAT-RAD]

In this case, the quality indicators are not spatialized: the thematic accuracy is quantified as a quantitative attribute accuracy - accuracy of quantitative attributes - uncertainty at 68.3% significance level.

Given the similarity between the different spectral configurations of MSS and ETM+ with TM, it is expected to have similar results with those sensors.

Obtaining PIA through MODIS images has become an objective method and it has allowed to find enough invariant polygons to fit the model and independently test the result. Moreover, the reference reflectance values of PIA can be obtained from different sources, giving flexibility to the user according to data availability.

4.2.4 Description/encoding results and findings

Out of scope for this pilot study

4.2.5 Summary

Using simplified radiometric correction methods (atmospheric and topographic) can be considered a very useful and accurate option for preliminary treatment of remote sensing images.

The independence from external inputs of this kind of models permits, through support of PIA with known reflectances, the automation of the correction process, converting the method in a stable solution to correct long time series of images in different atmospheric and illumination conditions.

The introduced algorithm is totally applicable to any kind of image in the Landsat TM series. It can also be used on cloud affected images. The algorithm is capable to detect invariant polygons affected by clouds and to discard them from the fitting process.

4.3 Remote sensing: Intercomparison of atmospheric data measurements from remote sensing instruments

4.3.1 Coverage

Parameterization elements:

Derivation, Extraction

Quality indicators:

Thematic accuracy – Quantitative attribute accuracy

4.3.2 Approach

the analysis of generating quality information from intercomparisons was performed using test data from the atmospheric pilot case, that includes data provided by ESA from two instruments on ENVISAT that both measure trace gases in the earth's atmosphere but differ in measurement principle: the Global Ozone Measurement by the Occultation of Stars (GOMOS) and the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS). Both instruments measure altitude profiles of Ozone concentrations in the Earth's atmosphere. The analysis was performed on so-called L2 data from both instruments that contains the Ozone concentration values for a specific longitude, latitude, altitude, and measurement time.

One way of gaining trust in the Ozone values obtained by either instrument is by intercomparing values for both instruments: differences in Ozone value for the same point in time, longitude, latitude, and altitude should be within the range imposed by the uncertainties associated to either Ozone value. As such, results from data intercomparison can be considered data quality information. However, as the measurement principles, measurement times and observed portions of the atmosphere at a specific time differ for both instruments, performing an intercomparison is not trivial: additional modelling and processing is required to align data from both instruments on the same temporal and spatial grid. These complex aspects of intercomparison have been excluded from this

analysis, as it often requires domain-specific knowledge. Instead the approach has been to integrate generic so-called *first-order* comparison implementation from the ESA GECA (Generic Environment for Calibration/Validation Analysis) project, and use this implementation to study the integration of intercomparison functionality (GECA end user toolbox) into the domain of GeoViQua (see also Section 2.2.2). Integration aspects include:

1. Enabling GeoViQua users to select datasets for intercomparison, configure intercomparison parameters, such as described in Section 2.2.2, and trigger the intercomparison processing.
2. Use of geolocation and temporal information from individual measurements inside the dataset by the intercomparison engine. This requires access to the actual dataset data.
3. Presenting GeoViQua intercomparison results to the user.

4.3.3 Derivation/extraction results and findings

During the course of the GeoViQua project it was decided to integrate the GECA end user toolbox as a Web Processing Service (WPS) for the following reasons:

1. In order for the intercomparison to be useful, users must be able to configure the analysis, and as such the intercomparison processing must be run each time the user specifies a configuration.
2. A WPS provides a more generic interface for the intercomparison processing than a WMS, as results are not always representable by maps. This is due to intercomparison results potentially including temporal information and altitude information, which map less well to a WMS.
3. The WPS standard provides a natural interface for encapsulating processing servers.

The overall architecture is shown in the next figure.

The integration has yielded the following findings:

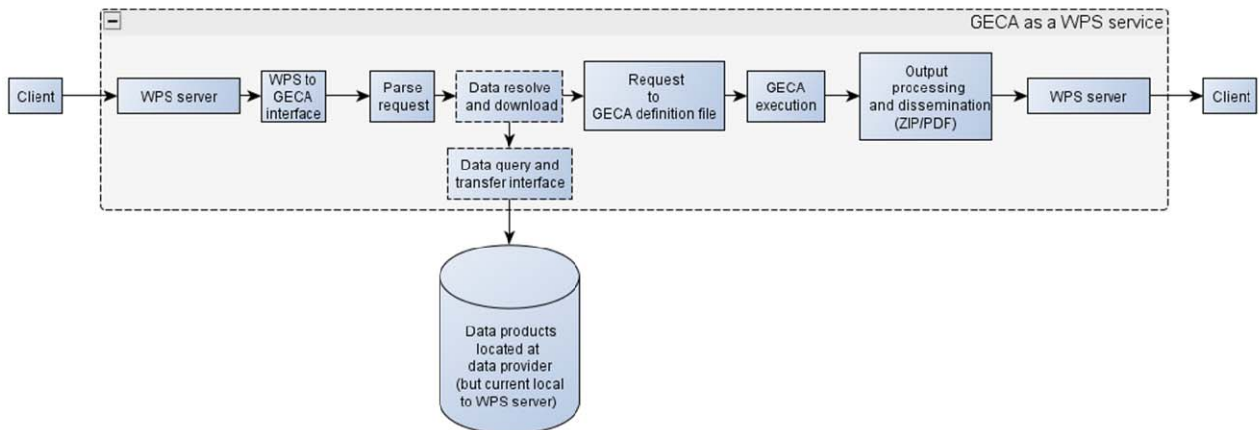


Figure 10: Integration of GECA end user toolbox as a WPS in GeoViQua

- One of the main issues for intercomparison is being able to access the actual dataset data to obtain measurement time, longitude, latitude, potentially altitude, and value for each measurement within the configured intercomparison scope. Several aspects complicate the retrieval of such data, such as:
 - Access restrictions and user policies for using the data
 - The lack of standardization in how dataset data is organized (i.e. in files, as a service, in databases)
 - The lack of standardization in file formats used for describing data and associated metadata, for example HDF(-EOS), netCDF, binary formats, SAFE formats, or the correlative data format used by the GECA end user toolbox.
 - The processing time and resources needed for finding potentially matching data for intercomparison within large datasets.

All these aspects need to be addressed before intercomparison can occur, which requires effort. In addition these aspects should be hidden from the user, who expects a clear and non-complex User Interface with parameter selection as outlined in Section 2.2.2. The exposure of the actual data by dataset providers within GEOSS/GeoViQua is outside the scope of this study. For the derivation, ad-hoc interfaces to the relevant ESA (subsets of) datasets were implemented, to which unique dataset Ids were coupled that can be selected by the user.

- The GECA end user toolbox yields multiple types of results for the intercomparison, such as tabular data describing the matching measurement samples for both datasets, and statistics on (difference in) intercompared values. In addition, the GECA end user toolbox yields pdf reports with plots and tables that are tailored to a specific intercomparison type, which in this case is Ozone altitude profiles comparison. The figures below show examples of such output. Such outputs need to be provided back to the user. The approach chosen within GeoViQua was to supply the user with a dynamic URL that presents intercomparison progress during

processing and a link to a zip-file containing the results after intercomparison finishes. In this way users can inspect the results in the report, and perform additional processing on the actual results-file. Note that the standardization of result format was out of scope for this study.

```
collocation_id,file_id,filename_a,measurement_id,file_id,filename_b,measurement_id,b_absolute_difference,time[h],point_distance[km]
0,0,MIP_NL_2PRDPA20100614_075604_000060192090_00193_43333_2828.N1,26,79,GOM_NL_2PPFIN20100614_064032_000000422090_00192_43332_5972.N1,0,1.69790913e+00,9.62912844e+02
3,0,MIP_NL_2PRDPA20100614_075604_000060192090_00193_43333_2828.N1,33,80,GOM_NL_2PPFIN20100614_064716_000000472090_00192_43332_5973.N1,0,1.70289409e+00,3.61224192e+02
9,0,MIP_NL_2PRDPA20100614_075604_000060192090_00193_43333_2828.N1,36,81,GOM_NL_2PPFIN20100614_064949_000000652090_00192_43332_5974.N1,0,1.70838550e+00,1.80150963e+02
12,0,MIP_NL_2PRDPA20100614_075604_000060192090_00193_43333_2828.N1,35,82,GOM_NL_2PPFIN20100614_065141_000000392090_00192_43332_5975.N1,0,1.66392743e+00,8.20529339e+02
15,0,MIP_NL_2PRDPA20100614_075604_000060192090_00193_43333_2828.N1,38,83,GOM_NL_2PPFIN20100614_065446_000000662090_00192_43332_5976.N1,0,1.68578004e+00,9.83628173e+02
```

Figure 11: Example output of intercomparison in ASCII (Comma Separated Values) format.

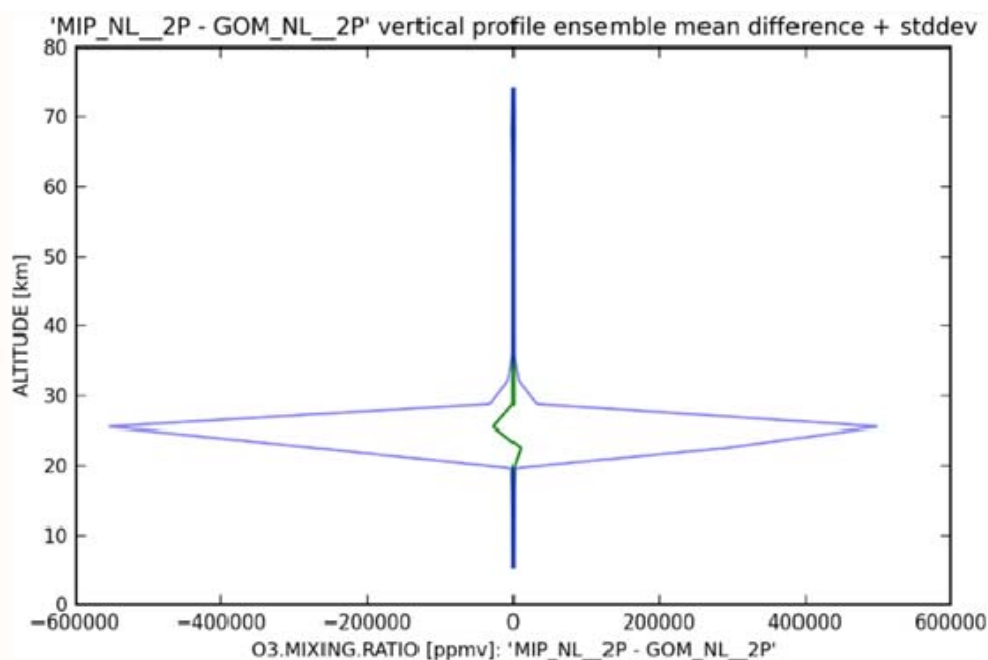


Figure 12: Example report plot showing the relation between altitude and differences in Ozone volume mixing ratio (green line is average difference, blue line is standard deviation of difference).

4.3.4 Description/encoding results and findings

The encoding of results has been out of scope for this pilot study.

4.3.5 Summary

Exposing a first-order intercomparison algorithm for deriving data quality to GeoViQua users has proven to be feasible through a WPS service. Such a service enables users to search and find reference data for a dataset (collocation) and to perform an initial assessment of the agreement between dataset thematic values. However a main challenge in providing intercomparison to users is the implementation of the access to the actual dataset data, which is hampered by the absence of widely endorsed standards in dataset

organization, file formats, user restriction policies, and interfaces for querying large datasets for individual measurements in terms of measurement time, geolocation, thematic value, and potentially altitude. One solution would be to provide the GECA end user toolbox and its WPS encapsulation as a tool to data providers, such that they can expose intercomparison for their own dataset as a service. This however requires considerable implementation/configuration effort from the dataset provider.

The study has also lead to development of a simple intercomparison *client* that enables user to configure and monitor the intercomparison processing, and can serve as a basis for future implementations.

4.4 Carbon cycle: Estimates of global carbon fluxes from Inversions, Land and Oceans Models

4.4.1 Coverage

Parameterization elements:

Derivation, Extraction

Quality indicators:

Quantitative attribute accuracy.

4.4.2 Approach

Within the pilot case study, the goal is to offer a simple but effective way for comparing carbon fluxes data to end users, such that the user can derive quality information himself. To this end, the carbon flux grid data from different models has been exposed using a Web Map Service because it appears to be well suited to visualize this type of data. In fact, a Web Map Service allows users to perform dynamic visualization and exploration of the data that is not possible by the use of a simple image, especially if these data are gridded data and at global scale which both apply in our case. The possibility to zoom and to move in the map is particularly useful for visual analysis and comparison.

A main challenge in the study has been how to combine an intercomparison model with a Web Map Service. This lead to the idea of using the visualization of several maps on the same screen, a capability offered by a Web Map Service. In addition, the possibility to spatially synchronize these maps was added. This enables the user to compare for example the same model and the same variable at a different period or intercompare a number of models simultaneously. In addition, by using the dynamical properties of the Web Map Service the user can easily choose to compare a specific area. To optimize this comparison the size of each map is automatically adjusted as a function of the number of maps on the screen and all the menus can be taken off. See Figure 13 for an example.

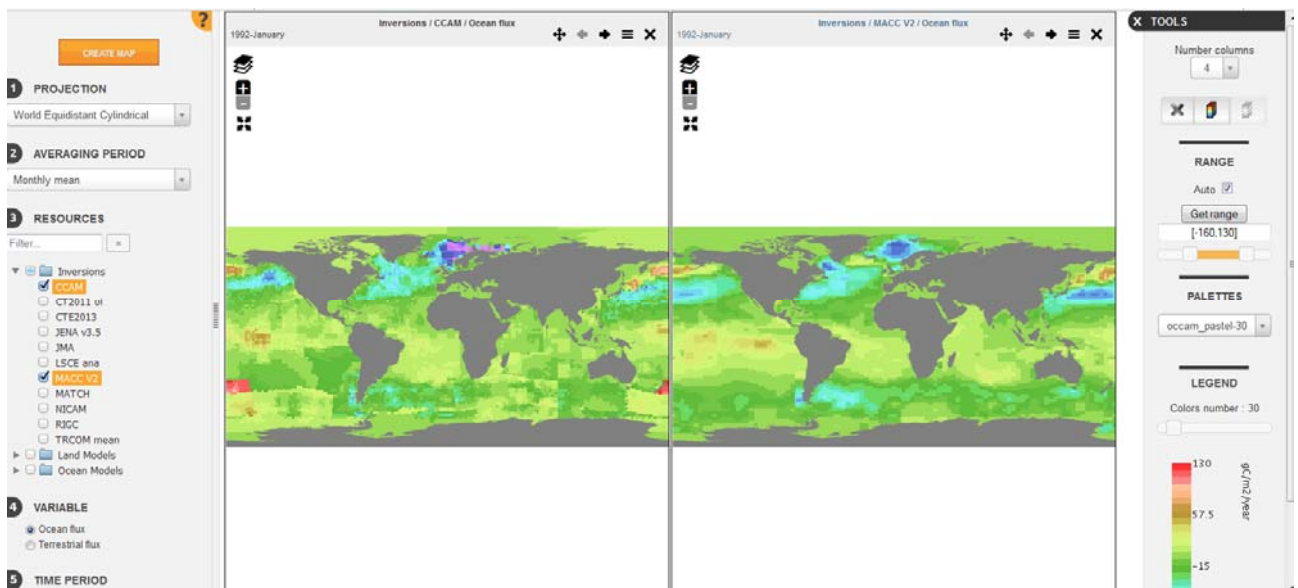


Figure 13: Scientific Application use to compare carbon fluxes data (from Carbon Atlas).

We chose to compare carbon fluxes data in two different ways:

1. By direct comparison (for example opening three different carbon fluxes data models on the same screen)
2. By adding a layer which is the result of a comparison above a specific carbon fluxes data's layer.

The first approach is very useful but consists in a simple (visual) intercomparison so no actual quality indicators are displayed. The second approach solves this issue.

In the pilot case the second method is used to create 2 types of information:

1. The relation between the means of all models intercompared (for example of all the land inversion models) and their standard deviations. To visualize this information, we represent the mean values with color and on top the standard deviation with markers. More precisely, the standard deviation is showed only if it exceeds a threshold. The objective is to visualize, for a specific variable, the areas and/or the pixels that have high and low confidence (based on the intercomparison). The mean value information is important because obviously the same standard deviation doesn't have the same significance for a high or low mean value.
2. The relation between a specific model's values and the difference between these values and reference values. The reference value consists of the mean of all models intercompared. This information is at pixel level: $\Delta m_i = |m_i - M_i|$ with: Δm_i the absolute difference between specific model and mean for pixel i , m_i = value of the specific model at pixel i and M_i = mean of all models intercompared (i.e. for a specific variable). The way to visualize this information is based on the same visualization method as described in the previous point. So for each pixel, colors

represent m_i and dots Δm_i . Again, dots are shown only if they exceed a threshold. The only difference with information type 1 is that markers are shown with different symbols (a function of Δm values) to offer a better analysis.

Combined with the possibility to visualize several maps on the same screen, the degree of confidence of different models can be analyzed quickly and dynamically.

4.4.3 Derivation/extraction results and findings

It's not feasible to study an exhaustive intercomparison because of the multitude of parameters involved: number of models, time, averaging period, variable of interest, and location of interest. Instead, the choice for a WMS service enables users to tune these parameters to their own needs.

4.4.4 Description/encoding results and findings

Out of scope for this pilot case study.

4.4.5 Summary

The approach chosen provides an interface between the Carbon Scientific community with the web mapping community, and has yielded a tool that enables users to visualize and retrieve quality indicators to their own needs (quantitative attribute accuracy).

Its principal strength is to offer a large number of different carbon fluxes models which enables users to assess data quality by intercomparison and enhance thereby enhancing its purpose. Offering model data as a Web Mapping Service avoids having to assemble a large carbon flux dataset from different sources. In fact, it's very difficult to organise and to create such an important and good dataset related to carbon fluxes because of the difficulty in data creation and the international aspect.

4.5 Climate: Digital Climatic Atlas of the Iberian Peninsula

4.5.1 Coverage

Parameterization elements:

Derivation, Extraction, Encoding – Producer Quality Model, Encoding – User Quality model, Encoding – GEO label

Quality indicators:

Thematic accuracy – Quantitative attribute accuracy, Provenance.

As a thematic accuracy quantitative attribute accuracy quality measure, in this dataset, the RMSE has been spatialized (e.g., pixel level RMSE). In addition, the data quality

parameterization in the climatic atlas dataset has introduced two new quality measures in GeoViQua that were not contemplated in the ISO standard:

1. Thematic accuracy – Quantitative attribute correctness. Coefficient of determination of the test dataset (r_t^2).
2. Thematic accuracy -- Quantitative attribute correctness. Spatialized list of case residuals.

In addition two other coverages have been developed:

1. A mask that is useful to discriminate the areas in which the interpolation model was applied within the range of values used in model fitting (e.g., altitude) from the areas in which the interpolation model was applied but the uncertainty is higher because of the fact of the independent variables in the model being out of range (e.g., no in-situ sensor data used in model fitting was within that range). The surface model can be applied, but the data provider considers that somehow it is more difficult to be sure of the model behaviour in these areas. This type of uncertainty cannot be quantified, but the identification of these areas is helpful for potential users of the dataset.
2. A stability image displaying an intercomparison of a series of model runs in form of a distribution (i.e., mean-standard deviation).

These coverages, though informative, cannot be encoded in the traditional ISO quality measures.

4.5.2 Approach

Continuous raster surfaces of temperature, precipitation and solar radiation are obtained from the spatial interpolation of ground meteorological stations and other geostatistical approaches. The aim is to generate reference climatic information. With this aim, multiple regression (altitude, latitude, sea-distance, solar radiation) with residual interpolation (inverse distance weighting or splines depending on test-bed outcomes) is applied.

4.5.3 Derivation/extraction results and findings

Using the aforementioned approach, the resulting atlas displays climate historic averages in terms of tenths of Celsius degrees in the case of temperatures, tenths of millimetres in the case of rainfall and 10kJ/(m²-day) in the case of solar radiation for the whole Iberian Peninsula (583,564 km²).

Accuracy measurements initially were: thematic accuracy/quantitative attribute correctness/uncertainty at 68.3% significance level and coefficient of determination (R^2). Spatialized measurements have been derived: map of regression residuals, pixel level

RMSE coverages, extrapolation mask and stability tests. Examples are shown in the next figures.

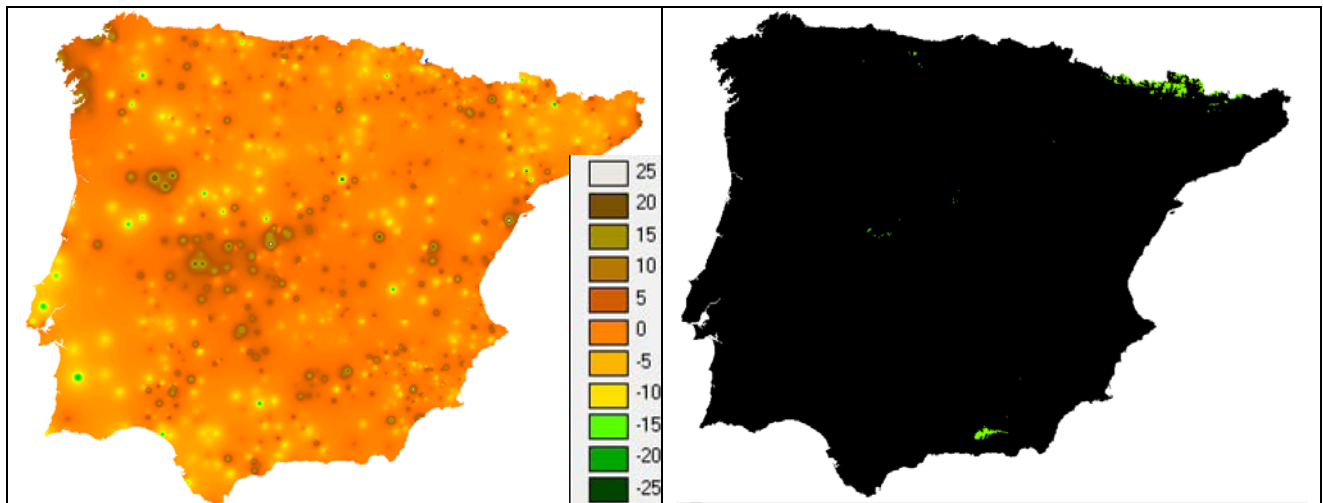


Figure 14: Left figure: spatially interpolated residuals of mean annual temperature (colours indicate values in degrees Celsius). Right figure: Extrapolation mask revealing where data have been extrapolated (ref. WP7_Mnster_datasets_2013.pdf)

4.5.4 Description/encoding results and findings

Results have been encoded in a Producer Quality Model record available at:

http://schemas.GeoViQua.org/GVQ/4.0/example_documents/PQMs/DigitalClimaticAtlas.xml

This PQM has been among the most reviewed metadata testing examples in GeoViQua. It is an example shown in the GeoViQua tutorials (e.g., PQM implementation, best practices documents, GEO Label server examples, and Geonetwork PQM import/editor). It is a very complete example of the quality sections introduced by GeoViQua in quality encodings. Quality reports include references to the UncertML and more GeoViQua specific thesaurus QualityML (e.g., RMSE). However, some pending issues remain at the moment of submission of this deliverable, such as:

- The specification of the pixel/dataset level for a quality measurement
- Further identification of QualityML concepts in the dataset and PQM
- Server updates to incorporate the error coverages computed
- Some issues with the quality facets in the GEO Label prototypes testing.

In any case these issues are very case specific and the improvement is a matter of time and resources.

The Climatic Atlas has been used as input data in a large number of applications. A fruit trees suitability mapping has inspired the corresponding User Feedback Quality Model implementation related to this dataset. The UQM is available at:

http://schemas.GeoViQua.org/GVQ/4.0/example_documents/UQMs/DigitalClimaticAtlasUserFeedback_v1.xml

The link between the PQM and UQM has been successfully achieved and tested in a complete GEO Label icon verdict for this dataset.

4.5.5 Summary

The pilot case study has provided a complete dataset ideal for GeoViQua testing of prototypes and has resulted in a complete quality encoding in both GeoViQua Quality Models (PQM and UQM).

On quality parameterization, a single dataset contains global measures (e.g., RMSE) and pixel level quantification (RMSE), together with other quality facets.

A climatic atlas is an input variable in many applications (ecosystems, biodiversity, air quality, food security, etc.) and in this study the fit-for-purpose quality indicators must embed the potential usage of the dataset and consider this fact in the communication to the users. Thus, many aspects of quality of continuous variables have been explored and efforts focused in generating useful uncertainty coverages, including pixel level estimates, error distributions, and mask coverages.

Although the indicators that have been derived are known statistics and can be considered case-specific to some extent, the usage in this dataset reveals that the results do not fit the current standards for classification of quality measures, and two new quality parameters were identified. Indeed, these indicators are surely to be considered/used in other scientific domains.

4.6 Landcover classification of Landsat Barcelona-Girona scenes

4.6.1 Coverage

Parameterization elements:

Derivation, Extraction, Encoding – Producer Quality Model, Encoding – GEO label

Quality indicators:

Thematic accuracy – Classification correctness, Thematic accuracy – Non-quantitative attribute accuracy, Provenance

4.6.2 Approach

Classification of landcover from Landsat data of the Barcelona-Girona region was done using hybrid classification. A hybrid classifier combines two stages:

1. An unsupervised stage that involves the identification of statistical clusters from the data
2. A supervised stage that relates the statistical clusters to actual land cover types by using training data with known land cover types.

In addition, in a similar way as for the “Monitoring flooding practices in rice fields in the Ebro River Delta using Remote Sensing” dataset (see Section 4.7), a comparison between different classifiers is intended to provide further insights in uncertainty estimation, deriving quantitative and qualitative quality indicators.

The achievements have been produced in a large geographic extent (complete Landsat scene TM/ETM+ frame), with multiple variables in place, in a robust scenario with a large proportion of available ground truth that enables the independent validation of the proposed methods, covering around 41% of the study area.

The pilot study involved several datasets, including:

- A temporal series set of Landsat-TM images composed of six dates between March and September in order to cover a wide range of phenological conditions and at the same time avoiding extreme winter shadowing
- Ancillary variables including the Normalized Difference Vegetation Index (NDVI) (Rouse et al. 1973) for each date of the temporal series
- Topoclimatic variables calculated from a DEM
- The historical series of the Digital Climatic Atlas of Catalonia (ref. [CLIM-ATLAS]): maximum mean temperature of the 3 months with highest temperatures, minimum mean temperature of the three months with lowest temperature, minimum precipitation of the three months of lowest precipitation and minimum solar radiation of the three months of lowest radiation), as well as a slopes variable, resulted in 47 variables to be subjected to the classification process

The introduction of complementary variables contributes to a better discrimination between some thematic categories. Previous to the classification, all variables were standardized to account for the diversity of measurement units (ref. [LAND-UNCERT-PIXEL]).

The main classification criterion, apart from the number of clusters (user defined as a result of the unsupervised stage) and the number and definition of the thematic categories in the chosen legend, are fidelity (F) and representativity (R), described in ref. [CLASS-VEG]. From the hybrid classification product report, other indicators can be derived, potentially

relevant for the estimation of uncertainty: promiscuity (P) [decimal logarithm of the number of thematic classes that could be assigned to a statistical cluster], majority classes (Q) [number of thematic categories with a fidelity threshold higher than 15% for each statistical cluster, that can subsequently stand within a range of integer values between 0 and 6 in our case], fidelity and representativity for the second and third most probable thematic classes for each statistical cluster (respectively F2, F3, R2 and R3), as well as entropy (H) (ref. [FUZZY-INFO]) and uncertainty (I) (ref. [GUIDE-GIS]).

Two approaches have been conducted in the accuracy modelling and spatial distribution.

1. An approach based on pixel samples, where the dependent variable is a dychotomic variable of success/failure that has been modelled through logistic regression (ref. [LOGIST-DIST]).
2. An approach based on polygons (object samples), where the dependent variable is the percentage of successes in the polygons of each cluster, conveniently normalized, that has been modelled through multiple linear regression.

Results were obtained at three different levels:

- Global level: pixel-averaged probability that a pixel-classification is correct, and the observed errors between predicted and actual class in the confusion matrix.
- Object level: estimated probability that the classification is correct.
- Pixel level: estimated probability that the classification is correct.

4.6.3 Derivation/extraction results and findings

The final product of the pilot case study is a multilayer image that links the classification product to the spatial distribution of the accuracy map resulting from the application of the accuracy model selected and other layers (bands) of quality indicators of the process (e.g., F, F2, F3, R, etc.). Figure 15 shows various quality parameter examples.

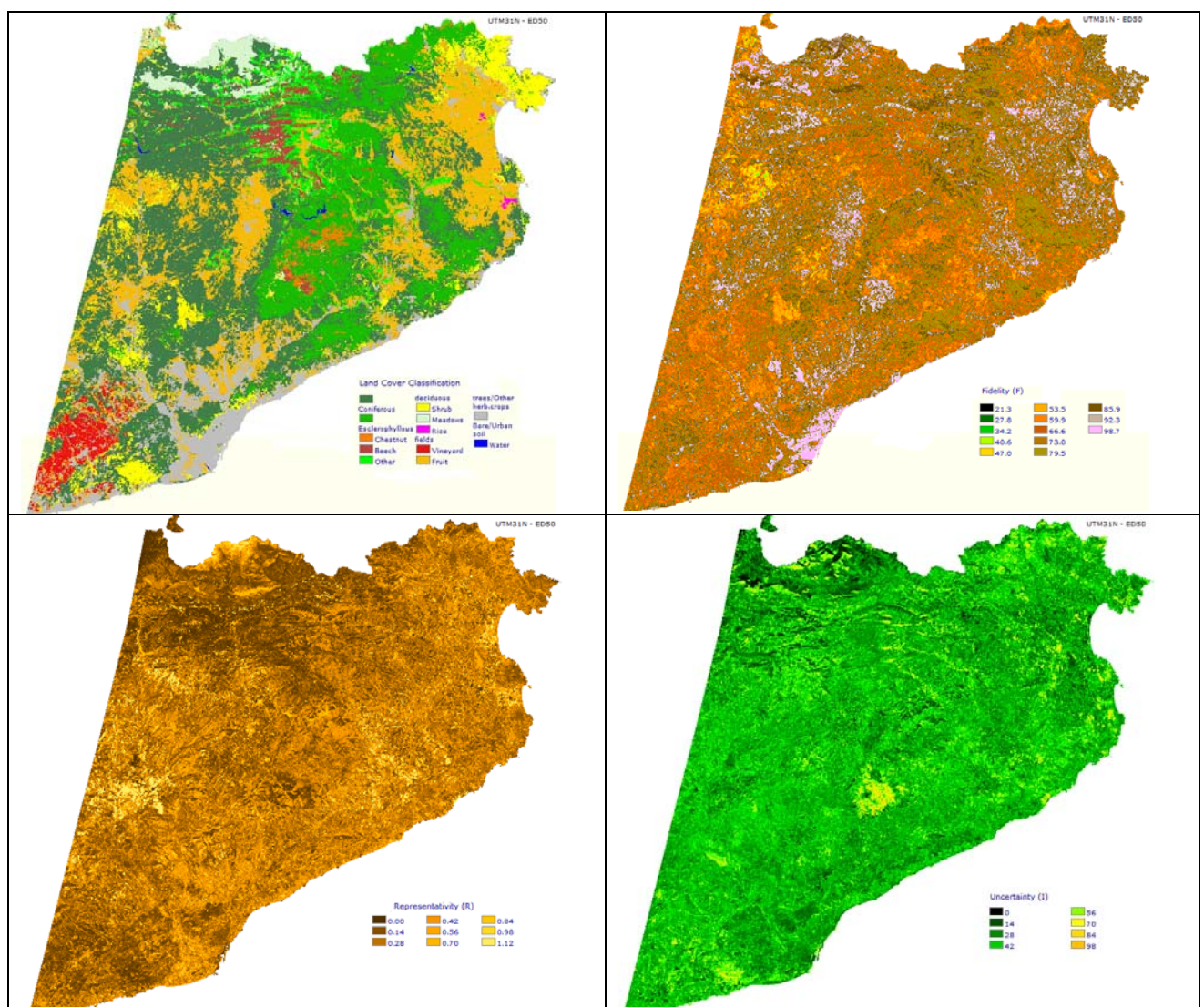
The global accuracy indicator derived from a standard confusion matrix is 85.4 %, the classified area is 85.1 % of the study area for a fidelity threshold of 50 %, and 81.9 % and 100 % respectively for a fidelity threshold of 0 %, the latter the scenario chosen for this experiment, and the former considering a more realistic frame, just for comparison purposes (Pons et al. 2013).

In the case of the object level assessment, a totally independent test based on approximately 25 % of the useful surface of the scene has revealed an extremely high reliability in the map accuracy estimation: 93.1 %, approvingly coherent with the obtained for the model itself (in turn built from the 25 % of the surface of the study area, as the first 50 % had been used in the training of the classifier): 94.3 % (Pons et al. 2013).

Likewise, for the pixel sample approach, a totally independent test based on approximately a 25 % of the useful surface of the scene, has revealed a considerably high accuracy

estimation reliability: 85.1 %, even higher than the value obtained for the AUC statistic: 74.1 %, and has been calculated with the 25 % of the reference surface (the remaining 50 % had been used in the training of the classifier). Observed and predicted values, global and per category analysis, as well as reliability diagrams have been computed (Pons et al. 2013).

One of the conclusions is that describing quality at a pixel level enables users to inspect data quality indicators per pixel and per category, which facilitates the visualization of data quality for thematic variables in a GIS-environment.



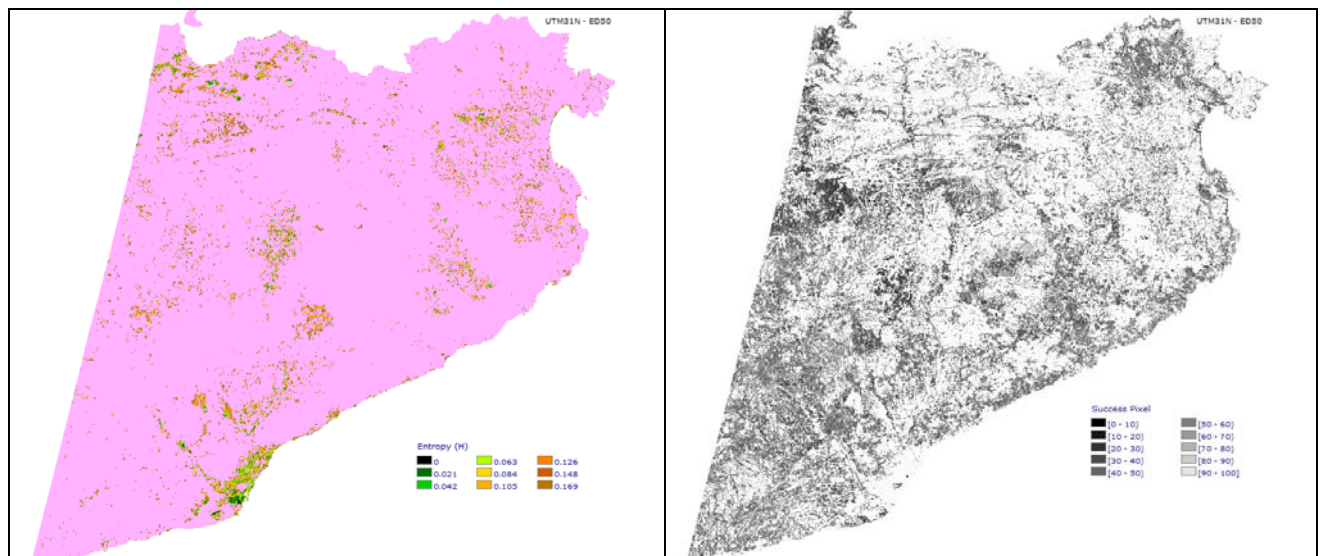


Figure 15: Quality parameters in land cover classification. The figures show: Classification, Fidelity, Representativity, Uncertainty, Entropy, and Pixel success. Source: GeoViQua WMS-Q test server (<http://wms-q-demo.GeoViQua.org/GeoViQua/wmsq/>, UTM31N-ED50)

4.6.4 Description/encoding results and findings

Results have been encoded in a very detailed Producer Quality Model record (over 1200 lines) available at:

http://schemas.GeoViQua.org/GVQ/4.0/example_documents/PQMs/LandsatCategorical_classification.xml

The current example has been validated and is being used in prototypes testing (e.g., Geonetwork server, GEO Label server, PQM testing). Nonetheless, pending issues at present are related to:

- the distribution encoding (e.g., a direct link to the corresponding general WMS-Q is envisaged for each of the layers in the multilayer product)
- Statistical concepts encoding, in particular related to QualityML/UncertML implementation (e.g., sensitivity, specificity, AUC/ROC, reliability)

With respect to provenance the inclusion of workflows diagrams in form of a pdf (uploaded to a URL, for instance) is being discussed, as it might help the lineage comprehension to the user in complex cases of data processing and error propagation chains. Accordingly, the provenance visualization tool is also a candidate for testing with this dataset. As relevant features, the PQM includes a detailed lineage section, a number of quality indicators coverages in form of a multilayer product description and a large number of quality measurements in quality reports, assessing dataset/pixel/object indicators and classifiers comparison results encoding.

The testing of the GEO Label has not yet been completely successful, as the quality and producer comments facets are not highlighted in the icon display, and the drill-down functionality displaying the lineage steps or the quality reports has not yet been implemented. So the testing tasks with this dataset cannot be fully implemented at present.

4.6.5 Summary

Within this pilot case study it has overall been proven that it is possible to gauge the spatial distribution of the accuracy on the basis of the classifier parameters, at both pixel and object levels. The thematic accuracy maps obtained are certainly highly reliable. These facts open interesting new opportunities for more refined usage and applications of categorical maps derived from remote sensing. This dataset constituted the main effort in categorical variables accuracy assessment in GeoViQua, as has been shown by the obtained quality elicitation and quality encoding in a very complete PQM implementation, with a very detailed lineage and coverage descriptions of the quality indicators and spatialized uncertainty layers, together with plenty of quality reports (in turn including UncertML and QualityML encodings). Indeed using this pilot case in the testing of the PQM has revealed general application requirements for the schema usage, and lead to several schemas modifications.

4.7 Monitoring flooding practices in rice fields in the Ebro River Delta using Remote Sensing

4.7.1 Coverage

Parameterization elements:

Derivation, Extraction, Encoding – Producer Quality Model, Encoding – User Quality model, Encoding – GEO label

Quality indicators:

Temporal accuracy – Accuracy of a time measurement, Temporal accuracy – Temporal consistency, Temporal accuracy – Temporal validity, Thematic accuracy – Classification correctness, Thematic accuracy – Non-quantitative attribute correctness, Provenance

4.7.2 Approach

An automatic classifier based on a discriminant analysis was used to classify eight classes in relation to different stages of rice fields during the flooding season. This methodology is characterized by the fact that, once the training phase has been carried out, training areas are not required to perform new classifications. If the images have been radiometrically corrected in a consistent way, the classifier can be used in a retrospective mode using past images. For this study, the training phase was conducted with data taken in October 2006 and January 2007 while the automatic classifier was applied to a total of 10 Landsat-5

Thematic Mapper (TM) images from the 2004–05 and 2006–07 seasons. The use of vector enrichment can be employed as a thematic updating tool for the cadastre.

Vector enrichment is a procedure that consists of calculating statistics from a raster image (in our case, a classification image) in the polygon zone of a vector map (Serra et al. 2006). The output of the enrichment is a vector map that is geometrically identical to the input vector map, but contains the majority class in the polygon and the relative surface area occupied by this modal class in the polygon according to the remote sensing raster map.

Two further analyses have been conducted (see also ref. [CADASTER-ENRICH]):

1. The consequences of using a more or less conservative strategy at the classification stage, using fidelity
2. The consequences of using modal thresholds at the enrichment stage when deciding which category each polygon is to be assigned to, using purity

The thematic accuracy of ten agricultural categories was evaluated by means of confusion matrices computed at pixel, polygon, and area level. Thematic accuracy was calculated in the classical way and without taking into account unclassified pixels as errors, as well as by paying special attention to the consequences for the classified area. The results show that polygon enrichment is a useful methodology, achieving thematic accuracies of 95.6 percent, when optimum parameters are used, while classifying 87.4 percent of the area.

From the quality eliciting point of view, and moving from the initial findings (see section 3.6 and above paragraph) using this dataset we present a range of validation plots and scores, many of which are used for probabilistic weather forecast verification, but are new to remote sensing classification including of course the standard measures of misclassification, but also plotting reliability diagrams and computing Brier Skill Scores.

We discuss the importance of the results in terms of classification in general and consider the relation between probabilistic classification and the issue of mixed pixels, consisting of more than one class. We also describe how the probabilistic classification results can be propagated through a complex workflow that considers the payment of farmers in the region based on the degree to which their fields are flooded from a given time period.

4.7.3 Derivation/extraction results and findings

As explained in Section 2.2.4, for the categorical variables data quality parameterization the focus is on the classification procedures. Whereas some classifiers (e.g., the Bayesian classifiers most used in remote sensing) enable the computation of uncertainty at the same time as the classification map, others do not directly generate the accuracy. In addition to the chosen method (i.e., discriminant analysis), the comparison of the results provided by different classifiers provides another facet of uncertainty assessment, enriching the understanding of the dataset and processes.

A discriminant analysis (DA) with canonical discriminant functions was used to discriminate between flooding classes. Linear combinations of the independent variables (reflectances from Landsat data) were obtained and served as the basis for classifying the images.

An average level of accuracy of 93.4% (range 89.7–98.7%) demonstrates the capability of the discriminant method to obtain high-quality and quasi-instantaneous classifications and to carry out retrospective studies even when training areas are not available for past dates. Specific details on results are described in ref. [RICE-DISCRIM].

However from ref. [CADASTER-ENRICH] it was found that, when evaluating at pixel level, a more restrictive fidelity (0.51) is always better if unclassified pixels are ignored. If thematic accuracy is computed according to global accuracy (considering unclassified pixels in the counts), the conclusion would be that a less restrictive fidelity is better, but it seems reasonable to believe the opposite, when the thematic accuracy is computed according to global accuracy computed only considering classified pixels.

Confusion matrices at polygon level (i.e. cadaster parcels) results show that if purity restrictions are not applied, thematic accuracy is better than in the pixel level case except when a very restrictive purity (>75%) is applied. Again without purity restrictions, differences between computing thematic accuracy on a global accuracy basis with and without considering unclassified pixels are quite small. In the same line, when purity restrictions are applied, the choice of considering or disregarding unclassified pixels causes differences in thematic accuracy (including unclassified pixels in the global accuracy, it seems that there is a decrease in thematic accuracy when higher purity is required). Nevertheless, if the reasonable approach of computing the thematic accuracy according to global accuracy (without considering unclassified pixels) is adopted, thematic accuracy increases when the purity is higher. It must be taken into account that when more restrictive parameters of fidelity and purity are applied, the thematic accuracy is higher but an important decrease in classified area may occur. In general, the per-polygon enrichment methodology gives better results than a simple per-pixel classification.

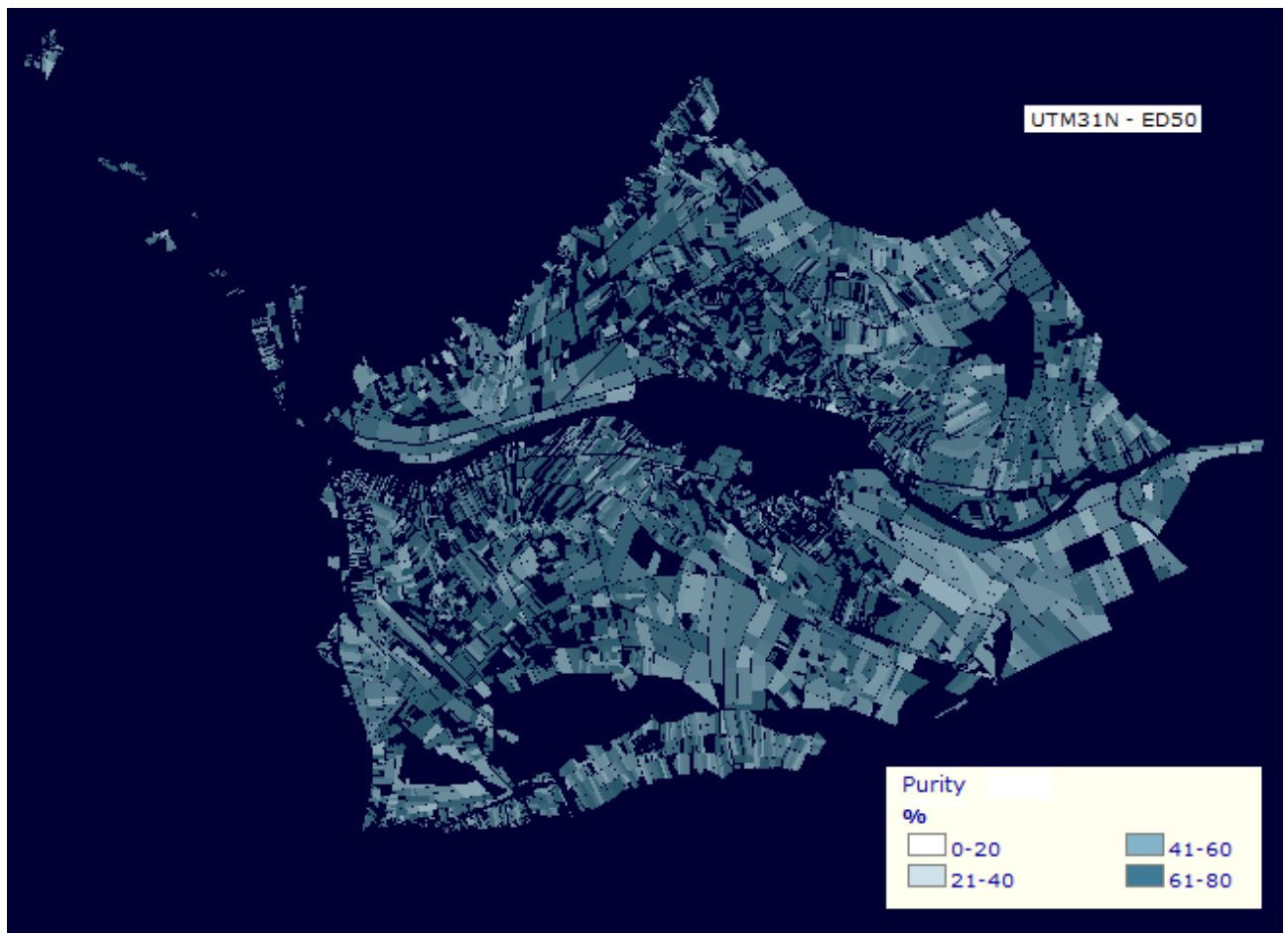


Figure 16: Purity of the Ebro flooding maps on 29-10-2006, corresponding to the classification shown in Figure 6.

Source: GeoViQua WMS-Q test server (<http://wms-q-demo.GeoViQua.org/GeoViQua/wmsq/>, UTM31N-ED50)

Apart from the classifiers comparison applied to this dataset, ASTON ran the following classifiers: multinomial logistic regression analysis (MLR), linear discriminant analysis (LDA), quadratic discriminant analysis (QDA), Naive Bayes (Gaussian), Naive Bayes (Kernel Density). While all methods can attain a very low training set error, only LDA finds a good generalisation to give a reasonable test set error of 7%. In particular we did not understand why Naive Bayes with Kernel density estimation did so poorly, when the method is normally reasonably robust for a large training set size such as we have.

To check the validity of the classifications reliability diagrams were plotted for each class. A reliability diagram plots the frequency of a correct classification against the probability assigned to that class. A good classifier (reliable in a statistical sense) should plot on the diagonal of the plot, with sharp prediction lying largely in the two corners.

The next figure depicts the reliability diagram for the classifier that provides the most probable class, with uncertainty given by the probability of this class:

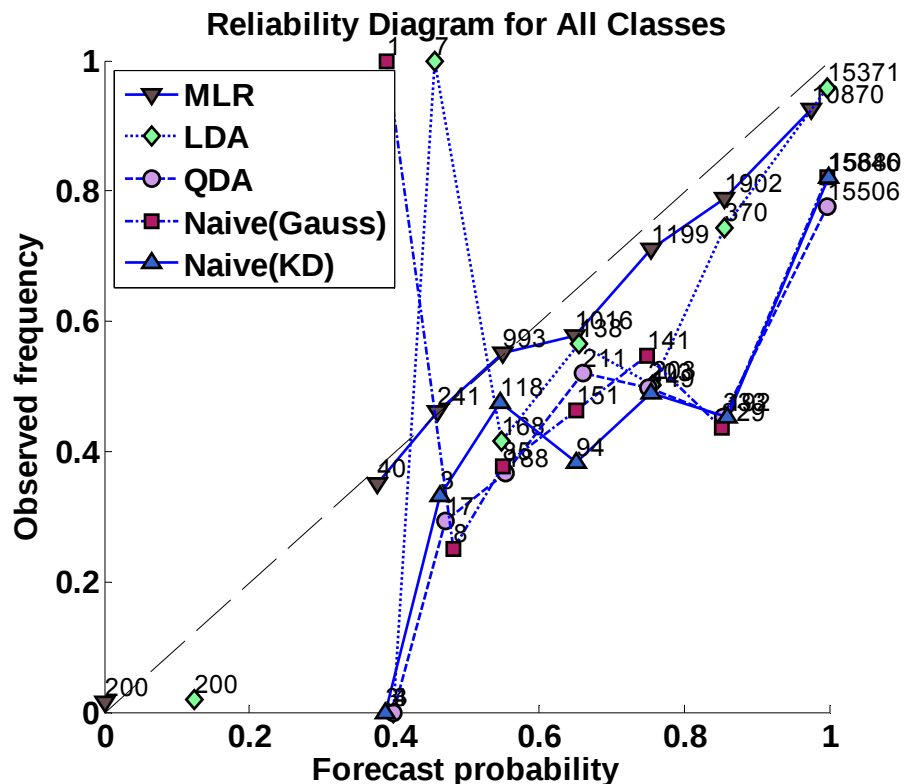


Figure 17: Forecast probability vs. observed frequency for various thematic classification methods

Here the reliability is shown for the most probable class. LDA performs best here, although MLR is close. Other methods don't do so well, because they lack reliability – even when the probability of the most probable class is close to one, the frequency that this is the correct class is closer to 0.75. Thus, using these classifiers to produce the uncertainty statements would not be appropriate, although the uncertainties derived from LDA or MLR are acceptable.

Normalised entropy was also plotted using the entropy per pixel value. Because the maximum entropy is fixed for a given number of classes (here $\text{maxEntropy} = 2.079$), the results were normalized with this value, hence the plot has a [0,1] axis. The horizontal axis contains 'bins' of normalized entropy values and the vertical axis shows the frequency in which the pixels with the given normalized entropy were correctly classified. The results are expected to decrease as the entropy increases.

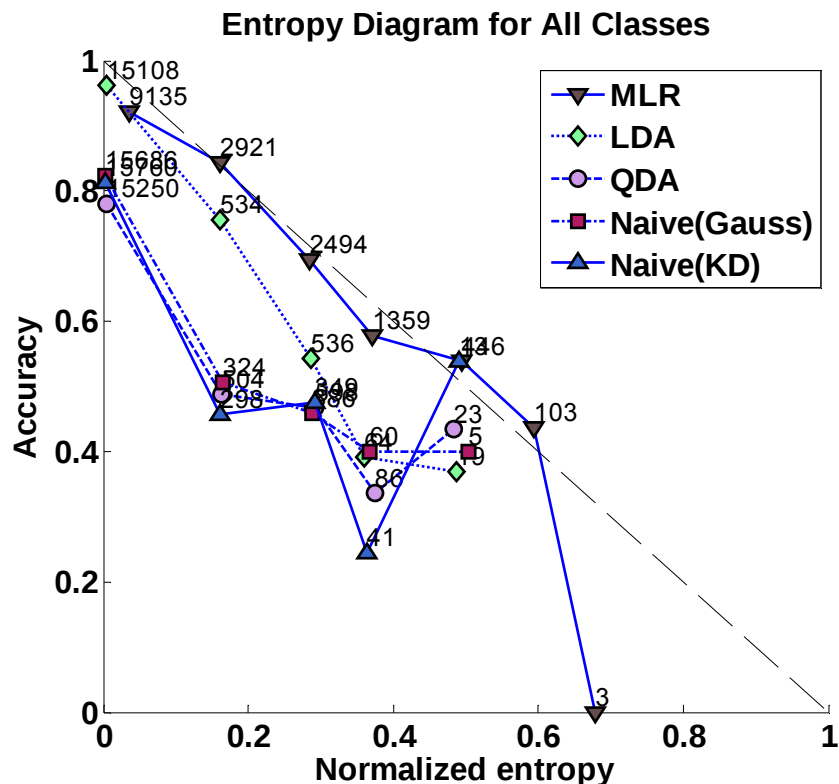


Figure 18: Forecast probability vs. observed frequency for various thematic classification methods

This plot can justify the use of entropy as a summary of uncertainty because there is a very natural interpretation for our users.

The results are rather robust to the choice and size of training set. The Naïve Bayes Kernel Density method always is best, and has a test set error that is always very similar to that achieved by the LDA several trials. We conclude from the trials that classification errors of around 7% is the best that can be achieved due to really mixed pixels, mislabelling and lack of clear class separation. A summary report will further explain this dataset in D3.3, as part of the categorical variables quality elicitation assessment studies.

4.7.4 Description/encoding results and findings

For this dataset, there are both Produce Quality Model and User Quality Model implementations.

The Producer Quality Model is available at:

http://schemas.GeoViQua.org/GVQ/4.0/example_documents/PQMs/Flooding_monitoring_SIGPAC_enriched.xml

The User Quality Model is available at:

http://schemas.GeoViQua.org/GVQ/4.0/example_documents/UQMs/RiceFields_UserFeed_back_v3.xml

The PQM currently points to the CREA WMS-Q server, and is based on the purity quality indicator layer level (i.e., not in the classifiers comparison). However, the PQM should include the link to Fraunhofer KML-Q server that has been using this dataset in visualization prototypes development and testing for categorical variables and vector models (i.e., field level).

In addition the PQM, although a validated document, need to be revised to solve minor issues (e.g., include the QualityML purity description not inside a quality report section but a lineage description section of the PQM, improve lineage description, etc). Nonetheless, this dataset is a very peculiar example and could provide rich metadata encodings, even though at present the current PQM is mainly focused in the object level purity layer. For instance, the comparison between classifiers and the development of reliability diagrams or entropy measures are not encoded yet in the PQM. Likewise, this dataset is the only dataset in GeoViQua that contains specific features for temporal quality indicators (e.g., temporal validity of the decision-making rules based on the temporal coverage of the scenes and the dynamics of flooding practices along the surveillance season, or the peculiarity of choosing a classification method for which the matching of the ground truth and remote sensing scenes is guaranteed for the whole season) that imply further encoding analysis.

The UQM is a nice example of real reports of the regional government when identifying conflictive parcels where the uncertainty threshold is at stake. The UQM is simple and again the issue of linking to a pdf where images describe the situation much better than character strings has risen. It has been agreed that it could be solved by defining the URL to the descriptive more human-readable document. The addition of the UQM to the PQM in this dataset provides a very nice example of decision-support systems for a real case study and demonstrates traceability and trustability facets of fit-for-purpose quality awareness, as depicted in the Agriculture Scenario.

Finally, the GEO Label server and the Feedback server have been tested using this dataset (see D7.4).

4.7.5 Summary

This pilot case study has analyzed thematic accuracy for several classification methods. With respect to the classification method chosen, after the rustic cadastre vector cartography is enriched, it has been proved that the purity quality measurement can serve as a useful tool for the administrative management of the farmers' agri-environmental

subsidies, as depicted in the Agriculture Scenario.

Furthermore it has been proven that a combination of the various classifiers provides the most reliable probabilistic predictions (and also the best deterministic predictions). It has been shown that the classification uncertainty is very spatially variable and reliably estimated statistically, and possible summary measures for representing the overall uncertainty to users have been discussed. It has also been shown how probabilistic classification results can be encoded using the recently modified GeoViQua Quality Model and UncertML and QualityML categorical variables quality encoding. However, the encoding efforts have not developed the full potential of this dataset yet.

4.8 Land use: Land cover map of Catalonia

4.8.1 Coverage

Parameterization elements:

Derivation and Extraction

Quality indicators:

Logical consistency – Conceptual consistency, Logical consistency – Domain consistency, Logical consistency – Format consistency, Logical consistency – Topological consistency, Positional accuracy – Absolute or external accuracy, Temporal accuracy – Accuracy of a time measurement, Thematic accuracy – Classification correctness, Thematic accuracy – Quantitative attribute accuracy, Provenance

4.8.2 Approach

The MCSC, due to its high level of detail, is of great interest for the territory knowledge, but also for the evaluation of the soil occupation in every site, in both points of view, ecological and economical. With the MCSC we can obtain the area of forest or crop at level of county, municipal, natural park, etc, and extract the corresponding maps, plan the design of field samplings (such as the Ecological and Forest Inventory of Catalonia), connectors between natural areas, studies for urban and territorial planning, infrastructure (the electricity grid distribution, the layout of means of communication, etc.), irrigation plans, evaluations of environmental impact, etc.

4.8.3 Derivation/extraction results and findings

The process of validation was the following (shared with the SIOSE validation process):

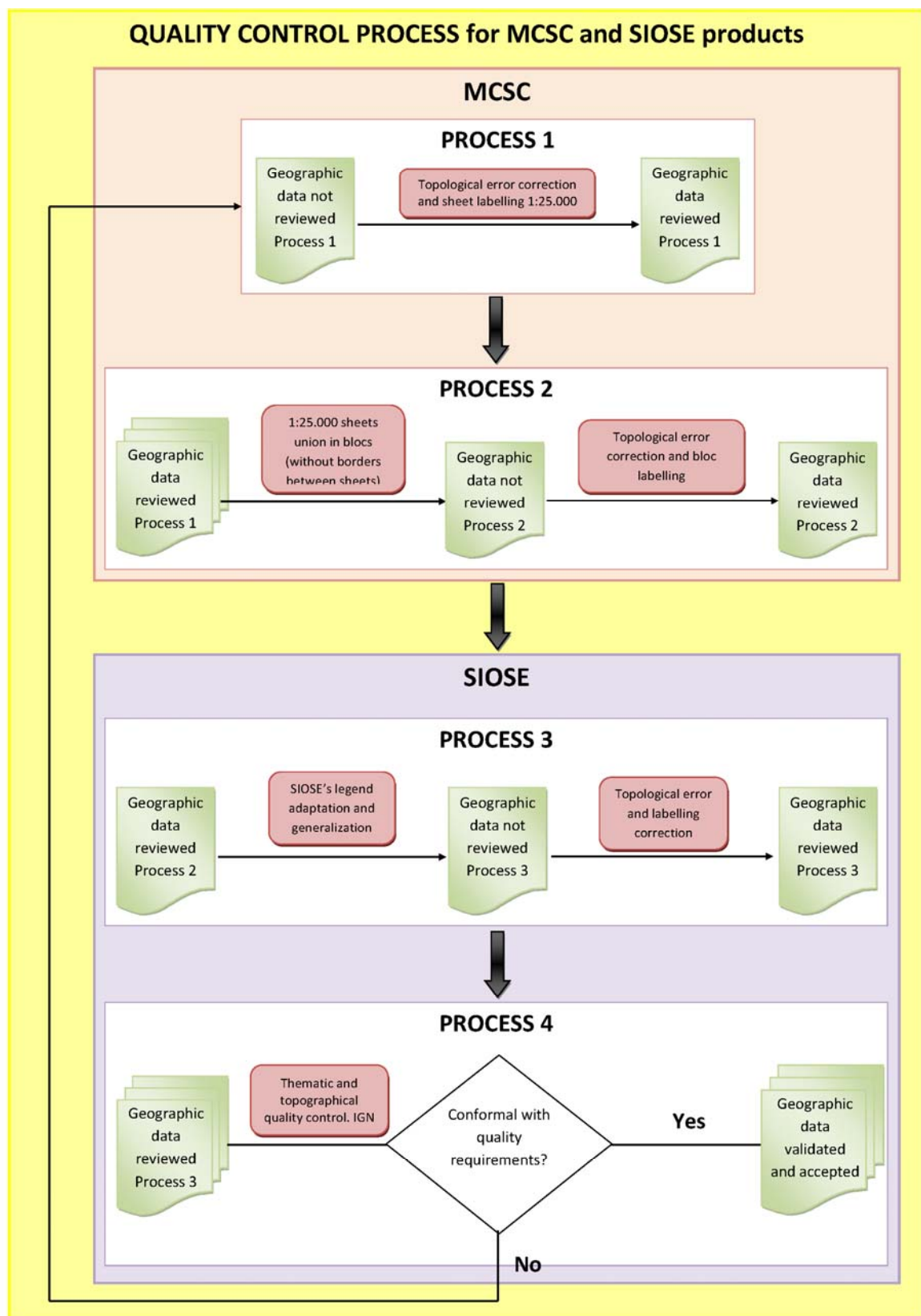


Figure 19: Quality validation processes for MCSC and SIOSE products

4.8.4 Description/encoding results and findings

N/A

4.8.5 Summary

In this case we present a use case where quality was not parameterised in the form of numerical quality indicators but in the form of conformance to specification parameters as listed in Section 3.8. This kind of reports makes difficult data comparison and automatic error propagation studies. There is a need to actually quantify the quality of the map.

4.9 Land use: SIOSE

4.9.1 Coverage

Parameterization elements:

Derivation, Extraction, Encoding

Quality indicators:

Completeness – Commission, Completeness – Omission, Logical consistency – Conceptual consistency, Logical consistency – Domain consistency, Logical consistency – Format consistency, Logical consistency – Topological consistency, Positional accuracy – Absolute or external accuracy, Temporal accuracy – Accuracy of a time measurement, Thematic accuracy – Classification correctness, Thematic accuracy – Quantitative attribute accuracy, Provenance

4.9.2 Approach

The SIOSE map was produced for the whole Spain. The production was divided by Autonomous Communities and they were free to use their own methodology to produce the map. Nevertheless, all produced maps have to conform to a quality specification and a quality production manual. In the case of Catalonia, the production of the map was coordinated by the Institut Cartogràfic de Catalunya, ICC, but the map was created by CREA. The aim was to have a completely automatic process to derive the map from the MCSC product. To that effect, a generalization algorithm was developed and tested using testing areas to be sure that all cases were covered and the conformance rules of the map are fulfilled. Once a sheet of the map was produced, the resulting product was validated by the Institut Cartogràfic de Catalunya and if the quality control was passed, the data was send to the Instituto Geográfico Nacional, IGN, which will do their validation process.

The objective of the validation is to produce conformance results to the specifications of the product.

4.9.3 Derivation/extraction results and findings

The quality parameterization process was presented in the form a quality report. Here we present a quality report from CREAM (Appendix B) and another coming from the Spanish Instituto Geográfico Nacional (see Appendix C for the quality report by IGN). The process of validation is shown in Figure 19.

4.9.4 Description/encoding results and findings

N/A

4.9.5 Summary

In this case we present a use case where quality was not parameterised in the form of numerical quality indicators but in the form of conformance to specification parameters as well. The step processes for the SIOSE quality control are the following:

Internal Quality Control

The Production Team of each Autonomous Community ensures the geometric, topological and thematic quality of the data produced according to the specifications defined in the 'Quality Control Manual' documents of SIOSE project.

External Quality Control (National Team)

It is conducted by the National Team, based on the 'Quality Control Manual', and established by the same Team. During the control, a detailed review of the database is produced with a detailed registration of the production processes, and the proper documentation (metadata) is performed.

Integration of Data and Statistical Analysis (National Team)

The final database becomes a logical unit without geometric or semantic mismatches between the neighbour Autonomous Communities.

Since it derives from a more detailed product, the MCSC, in some aspects the map is expected to have better quality than as dictated by the specifications, and as such may be useful for purposes not initially foreseen. However, users are able to choose between the MCSC and the SIOSE by looking at the technical specifications and deciding about fitness for purpose.

5. Conclusions

5.1 Data quality derivation and extraction

The work performed in the pilot cases has yielded several potential improvements and insights for various quality indicators:

- Extensive studies were performed for positional accuracy, thematic accuracy of continuous variables and thematic accuracy of categorical variables.
- Derivation and use of several quality indicators was investigated, including use of quality indicators that are not yet in the ISO standard.
- The inclusion of data intercomparison as a means of deriving quality was studied, including ways of having users control the intercomparison according to their own needs.

Detailed findings:

- *Additional quality indicators not yet present in ISO standard:* the following quality measures were found to be of use, and have not yet been contemplated in the ISO standard (source: Section 4.5):
 1. Thematic accuracy – Quantitative attribute correctness: Coefficient of determination of the test dataset.
 2. Thematic accuracy -- Quantitative attribute correctness: Spatialized list of case residuals.
- *Positional accuracy:* automation of the Ground Control Points (GCP) search can significantly improve RMS error when performing geometric correction of remote sensing images. In addition, a visualization of geometric errors as error vectors for each Ground Control Point enables users to assess positional accuracy in various subsets of a scene (source: Section 4.1).
- *Thematic accuracy (Quantitative attribute accuracy):* The use of simplified radiometric correction methods (atmospheric and topographic) can be considered a very useful and accurate option for preliminary treatment of remote sensing images, such as Landsat images. Using support from pseudoinvariant areas with known reflectance, the radiometric correction process of long time series of data can be automated (source: Section 4.2).
- *Thematic accuracy (Quantitative attribute accuracy) through intercomparison:* Deriving data through intercomparison requires interaction with a user in terms of configuring parameters for intercomparison and assessing intercomparison results. The pilot cases have shown that:

1. For *scattered* measurements that are not aligned on a geolocation grid: Exposing a first-order intercomparison algorithm for deriving data quality to GeoViQua users is feasible through a WPS service, and enables them to find reference data for a dataset (collocation) and to perform an initial assessment of the agreement between datasets. In the absence of consolidated standards for approaching individual data records within a dataset, the collocation and intercomparison process currently require the use of ad-hoc processes in retrieving the positional and thematic data for intercomparison (source: Section 4.3)
 2. For measurement data that are available on a geolocation *grid*: A WMS service is feasible for exposing an interface to configure intercomparison parameters, such as number of models, time, averaging period, variable of interest, and location of interest, and present results in an interactive way to the user (Source: Section 4.4).
- *Thematic accuracy, deriving quality measures at pixel level*: The addition of quality measures at pixel level to a dataset:
 1. increases insight for *continuous* variables into accuracy of measurement values over the observed scene. Such quality measures can be obtained from residual interpolation methods, and may include extrapolation masks to inform the user about areas where extrapolation may have impact on accuracy of results (source: Section 4.5).
 2. enables users to inspect data quality indicators per pixel and per category for *categorical* variables, which facilitates the visualization of data quality for thematic variables in a GIS-environment (Section 4.6).
 - *Thematic accuracy, deriving quality parameters for the accuracy of classification for categorical variables*: It has been shown that gauging the spatial distribution of the accuracy of classification on the basis of the classifier parameters is feasible at both pixel and object levels, and has improved thematic accuracy for the classification of landcover from Landsat data of the Barcelona-Girona region. (Source: Section 4.6 and Section 4.7). Applying restrictions on quality indicators such as fidelity and purity increases accuracy at the expense of classified area (Source: Section 4.8).

5.2 Data quality description and encoding

For several pilot cases data quality indicators have been successfully encoded into metadata documents conforming to the Producer Quality Model (PQM), User Quality Model (UQM), and Geo Label standards that have been developed in GeoViQua.

A general conclusion that was also reported in the GeoViQua deliverable 7.4 [D7.4-COMP-EVAL] is that due to the extent of the models involved, the need for Software for

supporting the creation of the PQM/UQM metadata documents by users has been identified, and first implementations of PQM and user feedback have been realized within GeoViQua.

Detailed findings:

- *General (source: [D7.4-COMP-EVAL]):* Due to the complexity of the various standards involved, there is a general need for Software-tools that aid the user in encoding Producer Quality Metadata Documents and User Quality Metadata Documents, for example in:
 1. Ensuring compliance to the Producer and User Quality Models proposed in Work Package 6
 2. Guiding the user through the elements in the model, and helping the user to enter the right information in the right place
 3. Providing additional support information for completing the metadata interactively on request, for example by on-line help documentation and/or *tooltips*.

Examples of such tools can be found in the Metadata editor included in the Geonetwork internet environment, and the User Feedback client developed within GeoViQua for submitting user feedback.

- *Producer Quality Model:* Various ways of including data quality information into Producer Quality Metadata documents were successfully tested, including inclusion by:
 1. Adding citations to (static) documents or files, publications, and reference documents (ref. Section 4.1, 4.5, 4.6, 4.7)
 2. Adding references to Web Mapping Services with Quality extensions (WMS-Q) (ref. Section 4.6, 4.7)
 3. Embedding quality information into the metadata document itself, by using the Quality Model, by using the UncertML and QualityML encodings, or by using other GeoViQua extensions such as discovered issues (ref. Section 4.1 4.5, 4.6, 4.7)
 4. Adding lineage information to describe sources and additional processing performed on both the data and the quality indicators (ref. Section 4.1, 4.6, 4.7)
- *User quality model:* User feedback has been successfully encoded, including references to the corresponding PQM documents, comments, user scores, and user-discovered issues, and including submission into the Feedback server (ref. Section 4.6, 4.7).
- *Geo label:* The creation of a Geo label out of Producer Quality Model was successfully tested for Producer Quality Metadata Documents (ref. Section 4.1, 4.5,

4.7). For the Landcover classification of Landsat Barcelona-Girona scenes (Section 4.6) some aspects of the Geo Label implementation are still to be completed.

6. Glossary

-Confusion Matrix Consider a classification model which assigns one category out of n to its input, for instance a model which assigns one of the 26 alphabetical characters ('a', 'b', 'c'...) to an image of a handwritten character. The confusion matrix is an $n \times n$ matrix which matches the true category (rows) against the prediction (columns). The matrix element (ij) indicates the number of occurrences where the model assigned the category j to an element actually belonging to category i . Correct predictions thus appear on the diagonal of the matrix (where $i=j$). The confusion matrix is typically used as a diagnostic which shows whether and how misclassification (i.e. incorrect predictions) happens.

-GCI Global Common Infrastructure in GEOSS (Global Earth Observation System of Systems). The GCI consists of web-based portals, a clearinghouse for searching data, information and services, and registries containing information about GEOSS components, standards, and best practices.

The goals of GCI in 2011 seek:

- a facilitated access to datasets and other resources supporting the Earth Observation Priorities identified in UIC report
- enable discovery or and facilitate access to data-core contributions
- To achieve convincing and demonstrable benefits at the GEO-VIII Plenary, a short term action is underway (ADC, GCI providers and Others) to collaborate bi-laterally with a few data providers to identify datasets supporting the Critical Earth Observation Priorities.
- To mutually adapt interfaces to enable effective data discovery and access ('fewer clicks to the data'), better usability/user experience.

-GCP Ground Control Point. It represents the a physical point with x,y,z coordinates that is used to match the geolocation of identifiable points both in the ground truth image -e.g., aerial photograph with known coordinates- and the raw remote sensing scene to be geometrically corrected

-GEO Group on Earth Observations. GEO is an intergovernmental organization working to improve the availability, access, and use of Earth observations to benefit society. It is composed of a voluntary partnership of 148 governments and international organizations, launched in response to calls for action by the 2002 World Summit on Sustainable Development and by the G8 (Group of Eight) leading industrialized countries. GEO is coordinating efforts to build a Global Earth Observation System of Systems (GEOSS).
http://earthobservations.org/about_geo.shtml.

-GEO Label The former Science and Technology Committee committed itself to developing the concept of a voluntary GEO Label, with the intention to:

- encourage scientists, researchers, and others to contribute their data and systems to GEOSS by offering an accepted voluntary label that provides recognition that their contribution is valued by the GEO community.
- differentiate components, data and products delivered through GEOSS and provide a “trusted brand” to GEOSS users; member governments may base their decisions on data/products of such contributions.
- highlight the importance of GEOSS to those previously unaware they were reliant on this initiative for their data or product.

The active task states that such a label should assist the user to assess the scientific relevance, quality, acceptance and societal needs of the components. These parameters clearly contain a mix of objective and subjective assessments.

The work in the GEO label is now on the scope of the ID-03 GEO task.

-GEOPortal The GEO Portal is a website that provides convenient access to the full range of GEOSS data and information. Operated by the European Space Agency (ESA) and the Food and Agriculture Organization (FAO) of the United Nations (UN), it provides a web-based interface for searching and accessing data, information, imagery, services and applications. It connects users to a variety of databases, services and portals that provide reliable, up-to-date, integrated and user-friendly information – vital for the work of decision-makers, managers and other users of Earth observations.

The content available via the Portal continues to expand at a rapid rate and promises to reach a critical mass in the near future.

-GEOSS. Global Earth Observation System of Systems. GEOSS builds on national, regional, and international observation systems to provide coordinated Earth observations from thousands of ground, in situ, airborne, and space-based instruments. GEO is focused on enhancing the development and use of Earth observations in nine SBAs: Agriculture, Biodiversity, Climate, Disasters, Ecosystems, Energy, Health, Water, and Weather.

-GeoViQua. GeoViQua stands for a FP7 project related to Quality aware Visualisation for the Global Earth Observation System of Systems (GEOSS). The focus is on adding quality specifications to spatial data in order to improve reliability in scientific studies and policy decision-making. To achieve our targets, our team is collecting pilot cases spread over the whole Earth Observation chain.

Work packages in GeoViQua:

- WP1: Project management
- WP2: Requirements for data quality visualisation
- WP3: Data quality elicitation mechanisms
- WP4: Enhanced geo-search components
- WP5: Quality aware visualisation components
- WP6: Delivery of solutions to end users
- WP7: Pilot case studies

- **WP8: Dissemination and Capacity building**

The Description of Work is the reference document which contains a complete account of GeoViQua project and related work packages.

-Landsat TM Landsat Thematic Mapper (TM) is a multispectral scanning radiometer that was carried on board Landsats 4 and 5. The TM sensors have provided nearly continuous coverage from July 1982 to present (source: <https://earth.esa.int/web/guest/missions/3rd-party-missions/current-missions/landsat-tmetm>)

-Lidar Light Detection And Ranging, also LADAR, is an optical remote sensing technology that can measure the distance to, or other properties of a target by illuminating the target with light, often using pulses from a laser. LIDAR technology has application in geomatics, archaeology, geography, geology, geomorphology, seismology, forestry, remote sensing and atmospheric physics, as well as in airborne laser swath mapping (ALSM), laser altimetry and LIDAR Contour Mapping.

The acronym LADAR (Laser Detection and Ranging) is often used in military contexts. The term "laser radar" is sometimes used even though LIDAR does not employ microwaves or radio waves and is not therefore radar even though both systems employ electromagnetic radiation.

-Metadata This term refers to data complementary information, providing details about data features. In the case of geographic information data (e.g., remote sensing scenes, categorical maps resulting from the application of digital classification techniques to remote sensing scenes, etc.), metadata would cover for instance identification aspects, discovery date, accuracy, distribution conditions, horizontal reference system, etc. There are several metadata standards defining metadata contents (e.g., ISO19115).

-Orthophotomap a map made by merging orthophotos — aerial or satellite photographs which have been transformed to correct for perspective so that they appear to have been taken from vertically above at an infinite distance (source: Wikipedia)

-OGC Open Geospatial Consortium.

The Open Geospatial Consortium, Inc. (OGC®) funded in 1994 is an international consortium of more than 420 companies, government agencies, research organizations, and universities participating in a consensus process to develop publicly available geospatial standards, GIS data processing, or data sharing. OGC Standards empower technology developers to make geospatial information and services accessible and useful with any application that needs to be geospatially enabled. Visit the OGC website at <http://www.opengeospatial.org>. Among the most well-known standards, the Web Map Server (WMS) that enable remote sensing images and maps visualisation, the Web Coverage Service (WCS) that is providing downloadable images servers, or the Web Feature Service Interface Standard (WFS) that provides and interface allowing requests for

geographical features across the web using platform-independent calls, can be cited. Some of the OGC standards (e.g., WMS) have been accepted as ISO standards.

-Quality. The definition contained in the ISO multilingual glossary states quality is the degree to which a set of inherent characteristics fulfils requirements (ISO 9000:2005). It is recommended that quality conformance levels based on user requirements refer to the data quality elements defined in this standard.

-Quality parameters and associated quality indicators

Completeness

Completeness is defined as the presence and absence of features, their attributes and relationships. It shall be described by applicable data quality elements from the following list:

- commission: excess data present in a dataset;
- omission: data absent from a dataset.

Logical consistency

Logical consistency is defined as the degree of adherence to logical rules of data structure, attribution and relationships (data structure can be conceptual, logical or physical). If these logical rules are documented elsewhere (for example in a product specification) then the source should be referenced (for example in the data quality evaluation). It shall be described by applicable data quality elements from the following list:

- conceptual consistency: adherence to rules of the conceptual schema.
- domain consistency: adherence of values to the value domains.
- format consistency: degree to which data is stored in accordance with the physical structure of the dataset.
- topological consistency: correctness of the explicitly encoded topological characteristics of a dataset.

Spatial accuracy

Spatial accuracy is defined as the accuracy of the position of features in relation to Earth. It shall be described by applicable data quality elements from the following list:

- absolute accuracy: closeness of reported coordinate values to values accepted as or being true.
- relative accuracy: closeness of the relative, spatial positions of features in a dataset to their respective relative, spatial positions accepted as or being true.
- gridded data position accuracy: closeness of gridded data spatial position values to values accepted as or being true.

Thematic accuracy

Thematic accuracy is defined as the accuracy of quantitative attributes and the correctness of non-quantitative attributes and of the classifications of features and their relationships. It shall be described by applicable data quality elements from the following list:

- classification correctness: comparison of the classes assigned to features or their attributes to a universe of discourse (e.g., ground truth or reference dataset).
- non-quantitative attribute correctness: measure of if a non-quantitative attribute is correct or wrong.
- quantitative attribute accuracy: closeness of the value of a quantitative attribute to a value accepted as or known to be true.

Temporal quality

Temporal quality is defined as the quality of the temporal attributes and temporal relationships of features. It shall be described by applicable data quality elements from the following list:

- accuracy of a time measurement: closeness of reported time measurements to values accepted as or known to be true.
NOTE: Time measurement may be either a defined point in time or a period.
- temporal consistency: correctness of the order of events.
- temporal validity: validity of data with respect to the format and calendar specified for the dataset.

NOTE March 33 is an example of invalid data where the specified format is ISO 8601 compliant.

Usability

Usability is the degree of adherence to a specific set of data quality requirements.

Usability shall be used to describe specific quality information about a dataset's adherence to a particular application or requirements.

If the other data quality elements listed in this International Standard do not sufficiently address a component of quality, Usability shall be used.

NOTE For example, with this element, a data producer can show for one dataset, with quantitative elements, how it fits different identified usages. This element may be used to declare the conformance of the dataset at a particular specification.

-Quality measures: A data quality measure is a test applied to evaluate data quality elements. Quality measures in GeoViQua are based on ISO19138 (ISO-TC211 2006) standards.

-Partners: GeoViQua is supported by the participation of 10 partners, including several universities, research centres, companies and the European Space Agency, from different European countries (France, Germany, Italy, Netherlands, Spain, and United Kingdom):

1. 52° North GmbH (Germany): GeoViQua acronym: 52N
2. Aston University (UK): GeoViQua acronym: AST

3. Commissariat a l'Energie Atomique (CEA). LSCE -Laboratoire des Sciences du Climat et de l'Environnement (France). GeoViQua acronym : CEA
4. Consiglio Nazionale delle Ricerche (CNR). IMAA - Istituto di Metodologie per l'Analisi Ambientale (Italy). GeoViQua acronym : CNR.
5. CREAM: Centre for Ecological Research and Forestry Applications (Spain). GeoViQua acronym: CREAM
6. ESA: European Space Agency (France): GeoViQua acronym: ESA
7. Fraunhofer Institut Graphische Datenverarbeitung -IGD- (Germany): GeoViQua acronym: FRAUN
8. S[&]T Corporation (The Netherlands): GeoViQua acronym: S&T
9. UAB: Universitat Autònoma de Barcelona (Spain): GeoViQua acronym: UAB
10. University of Reading (UK): GeoViQua acronym: UREAD

-Phenological A scientific study of periodic biological phenomena, such as flowering, breeding, and migration, in relation to climatic conditions.

-Pilot case: Understood in the context of this deliverable, pilot cases conform thematic areas in which datasets are classified in WP7 in GeoViQua. The pilot cases are: Remote sensing, Agriculture, Climate, Water cycle, Land use, Carbon cycle, Air quality, Marine, and Disasters. These pilot cases result initially from the DoW, and the needs detected in WP7 since the beginning of the project, intended to adapt GEOSS SBAs and CoPs, to the particular targets of GeoViQua.

-Pilot cases testing datasets: Specific datasets that have been collected with the aim of covering a representative range of methods, sources, quality indicators, scales and main features of geospatial databases. Validity of the scientific experiments to be carried out in WP7 in GeoViQua requests a varied sample, in order to be able to optimize the match between datasets and test requirements (i.e., extraction of the most appropriate materials for each of the methodology design involved in specific tests). For instance, categorical parameters imply different statistical approaches than quantitative parameters. GeoViQua targets can only be addressed by coping with this diversity of geospatial aspects.

-Pilot cases scenarios: It is likely that experimental testing and the integration of results from WP7 and other work packages in GeoViQua lead to a proper development of scenarios, that will contribute to the demonstration of GeoViQua results. Scenarios will naturally derive from practical work with real datasets, and will be accordingly selected, considering aspects suchlike social impact, potential use, display of representative results in GeoViQua, etc. The most representative characters of the design of scenarios in GeoViQua will be addressing the implementation of tools and outcomes developed in GeoViQua within the surrounding environment. This is to say, beyond the experimental testing of specific features of the dataset, scenarios comprise other equally relevant aspects related to geospatial datasets: dynamic flow of processes, interfaces, system

boundaries, interaction with the community, technical assistance and support, involving a wide range of users and providers.

-Product data model:

Raster

Data model used for representing and organizing spatial information, consisting in the space division following a square regular grid (only rarely rectangular grid) resulting in individual units of information (i.e., tiles or pixels).

Raster image comes in the form of individual pixels, and each spatial location or resolution element has a pixel associated where the pixel value indicates the attribute, (e.g., colour, elevation, ID number). A raster image is normally acquired by optical scanner, digital CCD camera and other raster imaging devices. Its spatial resolution is determined by the resolution of the acquisition device and the quality of the original data source.

Vector

Data model used for representing and organizing spatial information consisting in the geometric representation of spatial entities. Vector data comes in the form of points, lines, or polygons that are geometrically and mathematically associated. Points are stored using the coordinates, for example, a two-dimensional point is stored as (x, y). Lines are stored as a series of point pairs, where each pair represents a straight-line segment, for example, (x1, y1) and (x2, y2) indicating a line from (x1, y1) to (x2, y2). Vector data models are diverse both in information content and structure (with or without attributes, with or without topology, etc.). The most complex contain thematic and temporal attributes for each geographic entity, that can be linked to a relational model, hierarchic model, etc.

-(data) Processing levels: To facilitate the discussion of data processing in practice, several processing “levels” were first defined in 1986 by NASA as part of its Earth Observing System and steadily adopted since then, both internally at NASA (e.g., http://eosps0.gsfc.nasa.gov/ftp_docs/2006ReferenceHandbook.pdf) and elsewhere (e. g., http://www.grassaf.org/general-documents/products/grassaf_pum_v121.pdf); these definitions are Level 0, 1a, 1b, 2, 3, 4. It is important to note that not all space agencies and data distributors follow these definitions. A Level 1 data record is the most fundamental (i.e., highest reversible level) data record that has significant scientific utility, and is the foundation upon which all subsequent data sets are produced. Level 2 is the first level that is directly usable for most scientific applications. Its value is much greater than the lower levels. Level 2 data sets tend to be less voluminous than Level 1 data because they have been reduced temporally, spatially, or spectrally. Level 3 data sets are generally smaller than lower level data sets and thus can be dealt with without incurring a great deal of data handling overhead. These data tend to be generally more useful for many applications. The regular spatial and temporal organization of Level 3 datasets makes it feasible to readily combine data from different sources.

-Radiance: Radiance and spectral radiance are radiometric measures that describe the amount of light that passes through or is emitted from a particular area, and falls within a given solid angle in a specified direction. They are used to characterize both emission from diffuse sources and reflection from diffuse surfaces. The SI unit of radiance is watts per steradian per square metre ($\text{W}\cdot\text{sr}^{-1}\cdot\text{m}^{-2}$).

-Reflectance: In optics and photometry, reflectivity is the fraction of the energetic flux reflected by a surface and the incident radiation. It is a dimensionless parameter, values between 0 and 1, although commonly expressed as a percentage. It is a key parameter in remote sensing because it is dependent on the nature of the object. In general it must be treated as a directional property that is a function of the reflected direction, the incident direction, and the incident wavelength.

-Scales: Definitions of scales can be based on geographical, political or physiographic considerations, considerations of climate homogeneity, or considerations of model resolution. Hence, in most cases, an operational definition must be adopted. In this deliverable, the spatial scale is viewed from the extent perspective. At this stage, it is preferred to assume a general and objective concept to cope with the variety of datasets, from diverse disciplines. Thus, in WP7, so far we will attach to the following approximations:

- Global: e.g., planetary
- Continental: e.g., European scale
- Regional: e.g., Scandinavian Peninsula, Alps.
- Local: e.g., municipality.

-Societal Benefit Area (SBA): The Societal Benefit Areas (SBAs) are nine environmental fields of interest around which the Global Earth Observation System of Systems (GEOSS) project is exerting its efforts. These include: Agriculture, Biodiversity, Climate, Disasters, Ecosystems, Energy, Health, Water, and Weather around which a preliminary hierarchical vocabulary has been created. Each area has some related fields (fifty-eight in total) of interest addressed as subcategories that specialise the goals of the entire project, the focus of the subcategories being mainly the relation between environmental issues and human activity and health.

One of the aims of GEOSS is to implement a proper system of earth monitoring and to render information deriving from this process available to a global range of users.

Sources:

-Sensor: This term refers to the device used to acquire data e.g. to measure the radiation arriving to the satellite instrument <http://www.esa.int/>

esaMI/Education/SEMP67SJR4G_0.html. Several classifications of sensors are possible including:

- passive sensors. Sensors that use external energy sources to “observe” an object (e.g., the sun light to observe the Earth)
http://www.esa.int/esaMI/Education/SEMP67SJR4G_0.html
- active sensors. Sensors that rely on their own sources of radiation to “illuminate” objects so that the energy reflected and returned to the sensor may be measured. The most common active sensors used in remote sensing are radar and lidar.
http://www.esa.int/esaMI/Education/SEMJ97SJR4G_0.html

-User requirement: requirements described from an end-user perspective, as opposed to a technical or implementers’ perspective

-User story. In WP2, user stories have been defined as short natural language sentences of the intended functionality of a software system, written in the language of the user or stakeholder of the system. User stories are composed of three aspects:

- a written description of the story used for planning and as a reminder
- conversations about the story that server to flesh out the details of the story

tests that convey and document details and that can be used to determine when a story is complete.

7. References

[CADASTER-ENRICH] Photogrammetric engineering and remote sensing Volume 5 No.10 (AgricPERS_SerraMorePons.pdf), Thematic accuracy consequences in cadaster land-cover enrichment from a pixel and from a polygon perspective, P. Serra, G. Moré, X. Pons, 2009

[CLASS-VEG] IEEE Press 1:192-195. DOI 10.1109/IGARSS.2006.582, Improvements on Classification by Tolerating NoData Values - Application to a Hybrid Classifier to Discriminate Mediterranean Vegetation with a Detailed Legend Using Multitemporal Series of Images, G. Moré, P. Serra, X. Pons, 2007

[CLIM-ATLAS] International Journal of Climatology. 20: 1823-1841, A methodological approach of climatological modelling of air temperature and precipitation through GIS techniques, M. Ninyerola, X. Pons, J.M. Roure, 2000

[CROPS-SAT] International Journal of Remote Sensing, 29: 2293-2316, Monitoring farmers' decisions on Mediterranean irrigated crops using satellite image time series, P. Serra, X. Pons, 2008

[D2.1-USERREQ] GeoViQua QUALity aware Visualisation for the Global Earth Observation system of Systems Deliverable D2.1 User Requirements for GeoViQua, Version 1.0, 2012

[D2.2-SYSREQ] GeoViQua QUALity aware Visualisation for the Global Earth Observation system of Systems Deliverable D2.2 System Requirements for GeoViQua, Version 1.0, 2012

[D3.1-METADATAEXT] GeoViQua QUALity aware Visualisation for the Global Earth Observation system of Systems Deliverable D3.1 Metadata extraction quality component, Version 1.3, 2012

[D6.1-QUALITYMDL] GeoViQua QUALity aware Visualisation for the Global Earth Observation system of Systems Deliverable D6.1 Best practice document for quality encodings, Version 3.1, 2012

[D7.1-PILOT] GeoViQua QUALity aware Visualisation for the Global Earth Observation system of Systems Deliverable D7.1, Document pilot case studies in a standard format, Version 1.0, 2011

[D7.4-COMP-EVAL] GeoViQua QUALity aware Visualisation for the Global Earth Observation system of Systems Deliverable D7.4, GCI pilot case perspective recommendations for enabling quality aware visualisation and search, Version 3.1, 2013

[FUZZY-INFO] Prentice-Hall International, London, Fuzzy sets, uncertainty and information, G.J. Klir, T.A. Folger, 1988

[GECA-PUB] Proc. 'Fringe 2009 Workshop', Frascati, Italy, 30 November – 4 December 2009 (ESA SP-677, March 2010) *GECA: ESA'S NEXT GENERATION VALIDATION DATA CENTRE*. Y.J. Meijer, T. Fehr, R.M. Koopman, A. Pellegrini, G. Busswell, I. Williams, M. De Mazière, S. Niemeijer, R. van Deelen, 2009.

<http://earth.eo.esa.int/workshops/fringe09/YaskaMeijer.pdf>

[GEO-CORR-SAT] 7th International Symposium on Spatial Data Quality. Coimbra (Portugal, More__Pons_ISSDQ2011.pdf), Preliminary considerations about the assessment and visualization of the quality on geometric corrections of satellite imagery depending on the number of ground control points, G Moré and X. Pons, 2011

[GeoViQua-QUALITYML] GeoViQua QUALity aware Visualisation for the Global Earth Observation system of Systems URL <http://qualityml.GeoViQua.org>

[GUIDE-GIS] Clark University Worcester, (2 Vol.) 161+144 p, IDRISI32 Release2: Guide to GIS and Image Processing., J.R. Eastman, 2001.

[ISO-19115] ISO/TC211(2003) ISO/TS 19115:2003: International Standard: Geographic information – Metadata. . International Organization for Standardization (ISO). Geneva, Switzerland, 2003.

[ISO-19138] ISO/TC211(2006) ISO/TS 19138:2006: International Standard: Geographic information -- Data quality measures. International Organization for Standardization (ISO). Geneva, Switzerland, 2006.

[ISO-19157] ISO/TC211(2011) ISO/DIS 19157:2011: Draft International Standard: Geographic information -- Data quality. International Organization for Standardization (ISO). Geneva, Switzerland, 2011.

[LAND-UNCERT-PIXEL] EGU, Viena. (Poster presentation), Per pixel uncertainty modelling and its spatial representation on land cover maps obtained by hybrid classification, X. Pons, E. Sevillano, G. Moré, P. Serra, D. Cornford, M. Ninzerola 2013

[LANDSAT-RAD] Esa Living Planet Symposium SP-686, p.334 FULLY AUTOMATED AND COHERENT RADIOMETRIC (ATM+TOP) CORRECTION OF LANDSAT TM IMAGES TROUGH PSEUDOINVARIANT AREAS, Xavier Pons(1,2), Jordi Cristóbal(3), Lluís Pesquer(2), Gerard Moré(2), Oscar González, 2010.

[LOGIST-DIST] Marcel Dekker, Inc., Handbook of the Logistic Distribution, N. Balakrishnan , 1991

[MODEL-RADCOR] Remote Sensing of Environment, Vol 48 pp. 191- 204, A Simple Radiometric Correction Model to Improve Automatic Mapping of Vegetation from Multispectral Satellite Data, Pons, X. & Solé-Sugrañes, L., 1994

[RICE-DISCRIM] International Journal of Remote Sensing 31 (7):1983-2011 (AgricMore_etal_2011.pdf), Multitemporal flooding dynamics of rice fields by means of discriminant analysis of radiometrically corrected remote sensing imagery, G. Moré, P. Serra, X. Pons, 2011

[UNCERT-REMOTE] Poster session on EGU 2013, Uncertainty in Remote Sensing: Validating Probabilistic Pixel Level Classification, M. Vrettas, D. Cornford, L. Bastin, X. Pons, E. Sevillano, G. Moré, P. Serra, M. Ninyerola, 2013

Appendix A: Extended classification of Quality Parameters

The table below shows a subclassification of quality parameters into Quality Parameter – Quality Indicator – Quality Measure. See also [GeoViQua-QUALITYML].

Quality class	Quality indicator	Quality measure	Origin
Completeness	Commission	Excess measures/Excess	ISO 19138: D.1 (boolean), D.2 (count), D.3 (rate)
Completeness	Commission	Duplicate measures/Duplicate	GVQ: boolean, rate ISO 19138: D.4 (count)
Completeness	Omission	Missing measures/Missing	ISO 19138: D.5 (boolean), D.6 (count), D.7 (rate)
Logical consistency	Conceptual consistency	Conceptual schema measures/ConceptualSchema	ISO 19138: D.8 + D.9 (boolean), D.10 + GVQ (count), D.12 + D.13 (rate)
Logical consistency	Conceptual consistency	Overlaps of surfaces measures/InvalidOverlapsSurfaces	GVQ (boolean, rate), ISO 19138 D.11 (count)
Logical consistency	Domain consistency	Value domain measures/ValueDomain	ISO 19138 D.14 + D.15 (boolean), D.16 + GVQ (count), D.17 + D.18 (rate)
Logical consistency	Format consistency	Physical structure conflicts measures/PhysicalStructureConflicts	GVQ (boolean), ISO 19138 D.19 (count), D.20 (rate)
Logical consistency	Topological consistency	Faulty point-curve connections measures/FaultyPoint-curveConnections	GVQ (boolean), ISO 19138 D.21 (count), D.22 (rate)
Logical consistency	Topological consistency	Missing connections due to undershoots measures/MissingConnectionsDueUndershoots	GVQ (boolean, rate), ISO 19138 D.23 (count)
Logical consistency	Topological consistency	Missing connections due to overshoots measures/MissingConnectionsDueOvershoots	GVQ (boolean, rate), ISO 19138 D.24 (count)
Logical consistency	Topological consistency	Slivers measures/InvalidSlivers	GVQ (boolean, rate), ISO 19138 D.25 (count)
Logical consistency	Topological consistency	Self intersects measures/InvalidSelfIntersects	GVQ (boolean, rate), ISO 19138 D.26 (count)
Logical consistency	Topological consistency	Self overlaps measures/InvalidSelfOverlaps	GVQ (boolean, rate), ISO 19138 D.27 (count)
Positional accuracy	Absolute or external accuracy	Mean Absolute Error (MAE) measures/MeanAbsoluteError	ISO 19138 D.28, D.29
Positional accuracy	Absolute or external accuracy	Uncertainties above a given threshold measures/UncertaintiesAboveGivenThreshold	ISO 19138 D.30, D.31
Positional accuracy	Absolute or external accuracy	Mean Absolute Error (MAE) measures/MeanAbsoluteError	ISO 19138 D.28, D.29
Positional accuracy	Absolute or external accuracy	Uncertainties above a given threshold measures/UncertaintiesAboveGivenThreshold	ISO 19138 D.30, D.31
Positional accuracy	Absolute or external accuracy	Mean Absolute Error (MAE)	ISO 19138 D.28, D.29

	accuracy	measures/MeanAbsoluteError	
Positional accuracy	Absolute or external accuracy	Uncertainties above a given threshold measures/UncertaintiesAboveGivenThreshold	ISO 19138 D.30, D.31
Positional accuracy	Absolute or external accuracy	Mean Bias Error (MBE) measures/MeanBiasError	
Positional accuracy	Absolute or external accuracy	Covariance Matrix measures/CovarianceMatrix	ISO 19138 D.32
Positional accuracy	Absolute or external accuracy	Confidence ellipse measures/ConfidenceEllipse \$\$\$treure\$\$\$ To construct this measure we start with the same measurement field than a 2D Covariance Matrix	ISO 19138 D.50, D.51
Positional accuracy	Absolute or external accuracy	Linear Map Accuracy measures/LinearMapAccuracy	ISO 19138 D.33, D.34, D.35, D.36, D.37, D.38
Positional accuracy	Absolute or external accuracy	Root mean square measures/RootMeanSquare	ISO 19138 D.39
Positional accuracy	Absolute or external accuracy	Root mean square measures/RootMeanSquare	ISO 19138 D.47
Positional accuracy	Absolute or external accuracy	Root mean square measures/RootMeanSquare	
Positional accuracy	Absolute or external accuracy	Absolute linear error at 90% significance level. Alternative1 measures/AbsoluteLinearError90_SignificanceLevel_Alternative1	ISO 19138 D.40
Positional accuracy	Absolute or external accuracy	Absolute linear error at 90% significance level. Alternative2 measures/AbsoluteLinearError90_SignificanceLevel_Alternative2	ISO 19138 D.41
Positional accuracy	Absolute or external accuracy	Circular Map Accuracy measures/CircularMapAccuracy	ISO 19138 D.42, D.43, D.44, D.45, D.46
Positional accuracy	Absolute or external accuracy	Absolute circular error at 90% significance level. Alternative1 measures/AbsoluteCircularError90_SignificanceLevel_Alternative1	ISO 19138 D.48
Positional accuracy	Absolute or external accuracy	Absolute circular error at 90% significance level. Alternative2 measures/AbsoluteCircularError90_SignificanceLevel_Alternative2	ISO 19138 D.49
Positional accuracy	Relative or internal accuracy	Relative Error measures/RelativeError	ISO 19138 D.52
Positional accuracy	Relative or internal accuracy	Relative Error measures/RelativeError	ISO 19138 D.53
Temporal accuracy	Accuracy of a time measurement	Time accuracy measures/TimeAccuracy	ISO 19138 D.54, D.55, D.56, D.57, D.58, D.59
Temporal accuracy	Temporal validity	Value domain measures/ValueDomain	ISO 19138 D.14 + D.15 (boolean), D.16 + GVQ (count), D.17 + D.18 (rate)
Thematic accuracy	Classification correctness	Misclassification measures/Misclassification	GVQ (boolean) ISO 19138 D.60 (count), D.61 (rate), D.62 (confusion matrix, count), D.63 (confusion matrix, rate), D.64

			(Kappa coefficient)
Thematic accuracy	Non-quantitative attribute correctness	Categorical attributes measures/ValueDomain	GVQ (boolean), ISO 19138 D.65 (count), D.67 + D.66 (rate)
Thematic accuracy	Non-quantitative attribute correctness	Categorical attribute proportions measures/ValueDomain List of attributes assigned to a geometric object (e.g. polygon)	GVQ
Thematic accuracy	Non-quantitative attribute correctness	Categorical misclassification measures/CategoricalMisclassification	GVQ
Thematic accuracy	Quantitative attribute correctness	Quantitative attribute error measures/QuantitativeAttributeError	ISO 19138 D.68, D.69, D.70, D.71, D.72, D.73

Appendix B: Quality report for the MCSC by CREAM



TIPOS DE ERRORES TOPOLÓGICOS Y TEMÁTICOS DE LA INFORMACIÓN GEOGRÁFICA Y SU CORRECCIÓN EN EL SIG-MiraMon

El objetivo final en la elaboración de cartografía temática de coberturas y usos del suelo, como es el Mapa de cubiertas del suelo de Cataluña (base para SIOSE en el territorio catalán), es elaborar una capa de polígonos con estructura topológica libre de errores topológicos y temáticos. Estos tipos de errores se cometen durante la digitalización de la información, y algunos de ellos son de corrección obligatoria para obtener el producto final con estructura topológica. En los demás, si bien la falta de corrección permitiría un producto con estructura topológica, también se enmienda obviamente para conseguir un resultado sin errores.

Los errores topológicos y temáticos en SIG-MiraMon tienen una revisión y corrección secuenciales en el proceso de dotar de estructura topológica a la información geográfica. Ésta es la justificación del orden en que los presentamos en este documento.

Errores topológicos

Son aquellos que tienen que ver con la estructura de la información gráfica. Son de dos tipos: arcos con nodos finales y arcos que tendrían el mismo polígono a ambos lados (mancuernas).

1. Errores de nodo final

Uno o más arcos presentan extremos libres, sin unión a otro arco (figura 1).

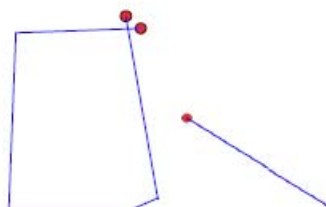


Figura 1. Ejemplos de arcos con error de nodos finales (extremos libres con punto rojo)

En el SIG-MiraMon hay opciones de estructuración topológica que toleran que el fichero de arcos contenga nodos finales para obtener polígonos que obvian esos arcos problemáticos. Sin embargo, este tipo de arcos con nodos finales se consideran errores de digitalización en procesos como la elaboración de cartografía de coberturas y usos del suelo. Por eso, en la estructuración topológica se usan opciones que no toleran los nodos finales, de manera que un arco con nodos finales no se cidaré impidiendo así la obtención de polígonos. Consecuentemente, se hace obligada su corrección para lograr polígonos.

El módulo o subprograma del SIG-MiraMon encargado de obtener polígonos a partir de arcos es **CICLAR**. Los errores de nodos finales son comunicados en una ventana de línea de comandos (figura 2). Estos pueden visualizarse en el SIG-MiraMon a partir del vector de nodos, representándose en rojo los que corresponden a nodos finales. También es posible hacer una búsqueda por localización a partir de los identificadores de los nodos o de los arcos a los que corresponden dentro del mismo SIG.

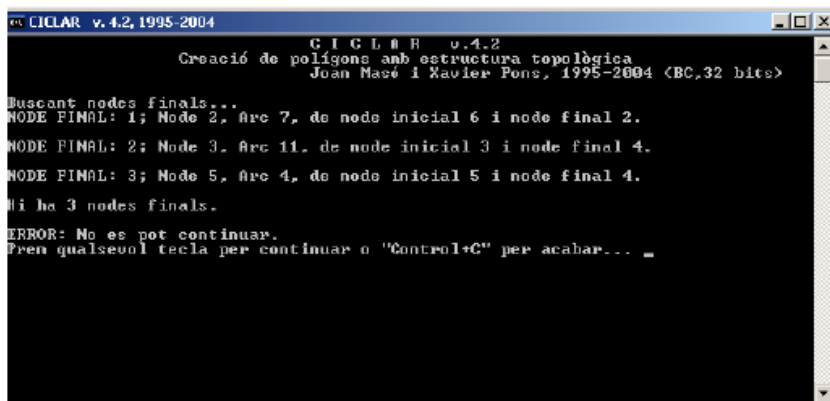


Figura 2. Ventana de línea de comandos del módulo **CICLAR** del SIG-MiraMon. En ella se puede leer cuántos y cuáles son los nodos finales de los arcos erróneamente digitalizados.

La solución del problema consiste en abrir el vector estructurado de la capa de nodos correspondiente a la capa de arcos ciclada sobre la imagen de referencia, editar esta capa y, o bien conectar los nodos finales, o bien eliminar los segmentos sobrantes, según el criterio de la persona fotointerpretadora de acuerdo a lo que observe en pantalla. Una vez corregidos, se vuelve a estructurar topológicamente para comprobar que realmente no hay ninguno de los errores anteriores y pasar a etapas posteriores de la estructuración topológica.

2. Error de arcos con el mismo polígono a ambos lados (mancuernas).

Corresponde a arcos que no contribuyen a constituir o cerrar un polígono o, expresado de otra manera, con el mismo polígono a ambos lados de él, dando una figura que recuerda a las mancuernas (figura 3) [Mancuernas = En deporte, cada una de las dos pesas consistentes en un eje cilíndrico con discos metálicos en los extremos y que se utilizan para desarrollar los músculos de los brazos, tórax, etc.]

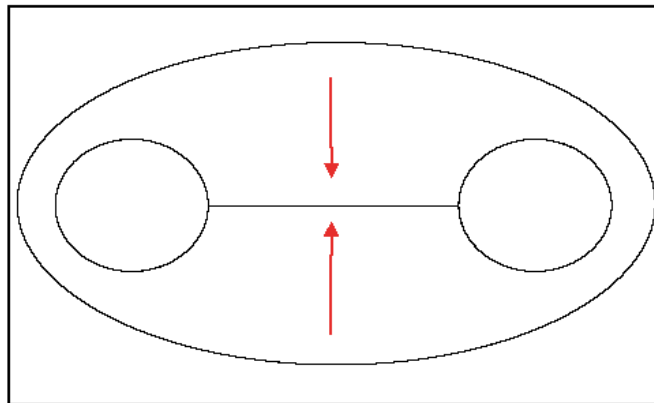
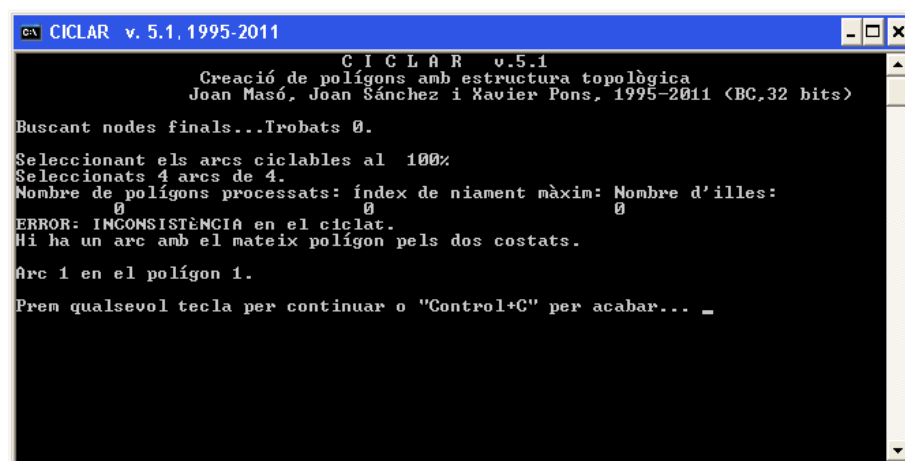


Figura 3. Ejemplo de error de arco, señalado con las flechas rojas, con el mismo polígono a ambos lados (forma de mancuernas).

Al igual que en el tipo de error de nodos finales, el SIG-MiraMon posee una opción de estructuración topológica que tolera un fichero de arcos con el mismo polígono a ambos lados para poder obtener polígonos que obvien esos arcos problemáticos. También en este caso, este tipo de arcos se consideran errores de digitalización en la elaboración de cartografía de coberturas y usos del suelo. Por eso, en la estructuración topológica se usan opciones que no toleran los arcos con el mismo polígono a ambos lados, de manera se impide la obtención de polígonos. Consecuentemente, se hace obligada su corrección para lograr polígonos.

En este caso, también es el módulo CICLAR el encargado de detectar estos errores mediante comunicación en una ventana de línea de comandos (figura 4). Estos pueden encontrarse mediante búsqueda por localización a partir de los identificadores de arcos en el SIG-MiraMon.



```

C I C L A R  v.5.1
Creació de polígons amb estructura topològica
Joan Masó, Joan Sánchez i Xavier Pons, 1995-2011 <BC,32 bits>

Buscant nodes finals...Trobats 0.

Selecció dels arcs ciclables al 100%
Selecció dels arcs 4 de 4.
Nombre de polígons processats: índex de nïament màxim: Nombre d'illes:
0 0 0
ERROR: INCONSISTÈNCIA en el ciclat.
Hi ha un arc amb el mateix polígon pels dos costats.

Arc 1 en el polígon 1.

Prem qualsevol tecla per continuar o "Control+C" per acabar... _
  
```

Figura 4. Ventana de línea de comandos del módulo CICLAR del SIG-MiraMon. En ella se puede leer cuántos y cuáles son los arcos que han originado el error de arco con el mismo polígono a ambos lados (mancuernas).

Errores temáticos

Este tipo de errores están relacionados con el etiquetado de los polígonos. Pueden corresponder a polígonos sin etiqueta, etiquetado del polígono 0 o exterior, polígonos reetiquetados incoherentemente, y polígonos colindantes con la misma etiqueta o frontera innecesaria.

1. Polígonos sin etiqueta.

Son polígonos de los cuales se ha olvidado su etiquetaje durante la fotointerpretación y digitalización, o bien se ha borrado la etiqueta pero se ha olvidado de borrar el polígono (figura 5)

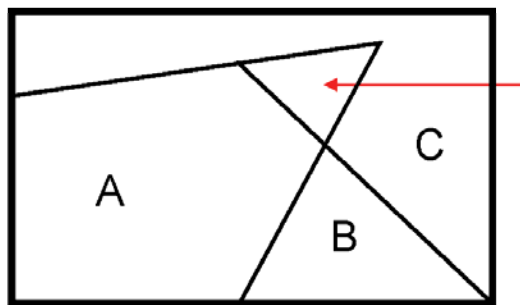


Figura 5. Ejemplo de polígono sin etiqueta, señalado con la flecha roja.

Dos son los módulos de MiraMon que lo detectan:

- El módulo ATRITOP que genera un fichero de texto (p.e.: Informe.txt) donde se recogen los identificadores de los polígonos sin etiqueta en el siguiente formato:

Objetos sin etiqueta previa (Excepto el 0): (2/37)

```
-----
| ID. POL |
+-----+
|      22 |
|      24 |
+-----+
```

La búsqueda por localización de estos identificadores en el SIG-MiraMon permite localizar y corregir estos polígonos erróneos.

- El módulo TESTTOP produce un informe de texto, QUEIXLIC.TXT, que contiene los identificadores de los arcos de los polígonos sin etiqueta, además de los identificadores de dichos polígonos más los de sus vecinos:

Relación de arcos de archivo c:\digibosc\usosl.arc
con los mismos atributos de polígono a ambos lados salvo blancos
a uno de los lados.

```
Arco 44, pol. derecho 22, pol. izq. 12; el último registro
coincidente es; c
Arco 74, pol. derecho 1, pol. izq. 22; el último registro
coincidente es;
Arco 76, pol. derecho 24, pol. izq. 1; el último registro
coincidente es; b
```

También fabrica un vector de los puntos inicial, medio y final de los arcos que delimitan los polígonos que carecen de etiqueta, BADLINIC.vec (figura 6).

Mientras que el informe de texto ofrece los identificadores de arcos y polígonos para su localización y enmienda en el SIG-MiraMon, el vector de puntos facilita la localización visual de los polígonos problemáticos.

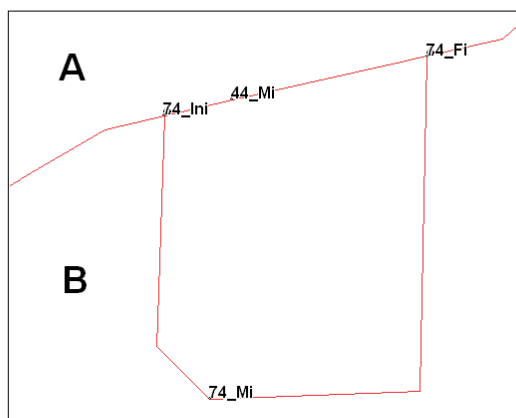


Figura 6. Ejemplo de polígono sin etiqueta, marcado por puntos inicial, medio y final de los arcos que delimitan (p.e.: 74_Ini, 74_Mi y 74_Fi).

2. Etiquetado del polígono 0 o exterior.

Corresponde a aquellas etiquetas que han sido colocadas fuera del ámbito de los polígonos, denominándose polígono 0 o exterior a este espacio (figura 7)

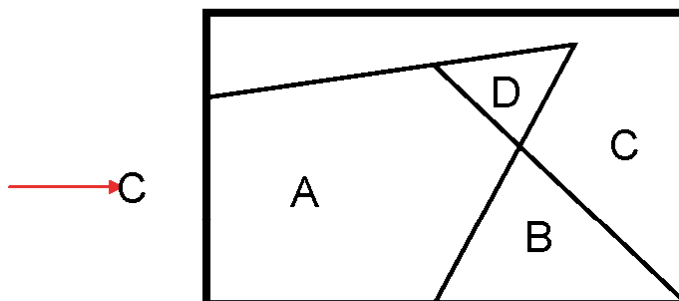


Figura 7. Ejemplo de etiquetado de polígono 0 o exterior, cuya etiqueta está señalada con la flecha roja.

Es el módulo ATRITOP quien lo detecta, generando un fichero de texto (p.e.: Informe.txt) donde se recogen los identificadores de las etiquetas sobre el polígono 0:

```
Objetos que etiquetan el polígono 0: (1/37)
```

```
-----
Hay 1 objeto sobre el polígono 0 que genera 1 registros.
(Identificador gráfico donador: 40)
```

La búsqueda por localización de estos identificadores en el SIG-MiraMon permite la corrección de este error.

3. Polígonos reetiquetados incoherentemente.

San polígonos que contienen dos o más etiquetas diferentes, lo cual puede ser bien porque una de ellas no es correcta, o bien porque ha quedado olvidada la digitalización del polígono correspondiente (figura 8).

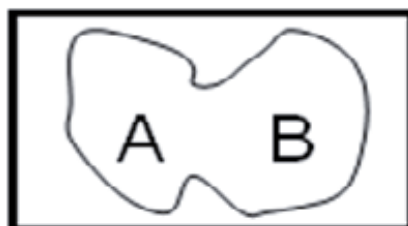


Figura 8. Ejemplo de polígono reetiquetado incoherentemente, es decir, con dos o más etiquetas diferentes.

Este error se detecta mediante el módulo ATRITOP el cual construye un fichero de texto (p.e.: Informe.txt) donde se recogen los identificadores de los polígonos con error y de las etiquetas que lo provocan:

Objetos etiquetados con más de un objeto donador:

con alguna etiqueta INCOHERENTE: (1/37)

ID. POL	Reqs. totales donad.	ID. PMT donador	Registros donador
11	2	23	1
		24	1

La búsqueda por localización de estos identificadores en el SIG-MiraMon permite la corrección de este error.

4. Polígonos colindantes con la misma etiqueta o con frontera innecesaria.

Polígonos vecinos, por tanto con una frontera común, poseen el mismo etiquetado. Eso es o porque alguna de las etiquetas es incorrecta, o porque se ha hecho una frontera que no era necesaria por haber en realidad el mismo atributo temático a ambos lados (figura 9).

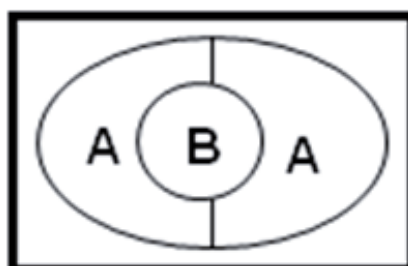


Figura 9. Ejemplo de polígonos colindantes con la misma etiqueta o con frontera innecesaria.

Este error se detecta mediante el módulo TESTTOP que produce un informe de texto, QUEIXESL.TXT, que contiene los identificadores de los arcos de los polígonos colindantes con la misma etiqueta, además de los identificadores de dichos polígonos, así como el atributo temático coincidente:

Relación de arcos del archivo c:\digibosc\usosl.arc con los mismos atributos de polígonos en los dos lados.

Arc 78, pol. derecho 26, pol. izquierdo. 25; el último registro coincidente es; c

También fabrica un vector de los puntos inicial, medio y final de los arcos que delimitan los polígonos con los mismos atributos en los dos lados, BADLINES.vec (figura 10).

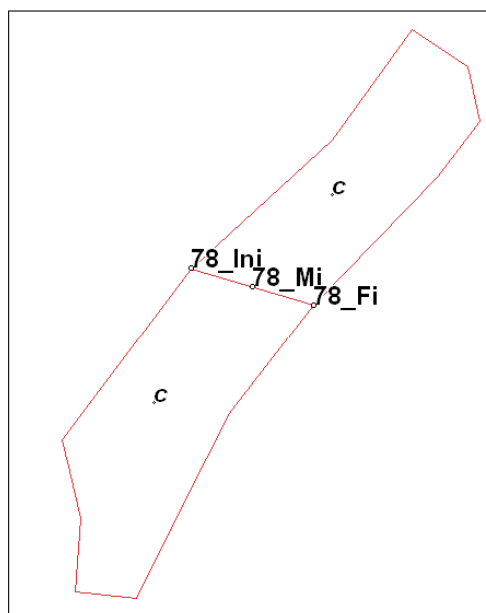
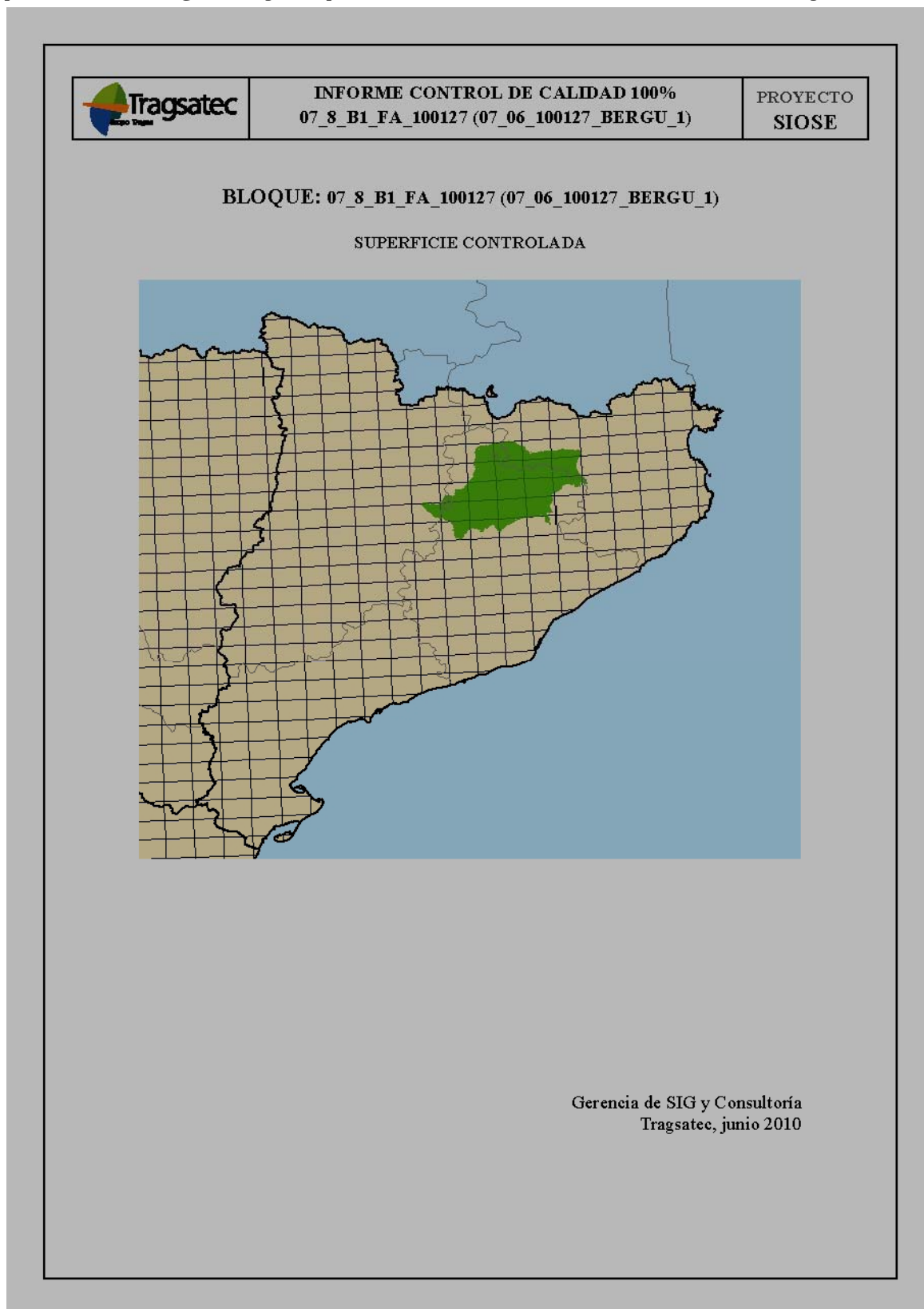


Figura 10. Ejemplo de polígonos colindantes con la misma etiqueta o con frontera innecesaria, marcados por puntos inicial, medio y final de los arcos que delimitan (p.e.: 78_Ini, 78_Mi y 78_Fi).

Mientras que el informe de texto ofrece los identificadores para su localización y revisión en el SIG-MiraMon, el vector de puntos facilita la localización visual de los polígonos problemáticos.

Appendix C: Quality report for the Land use SIOSE by IGN



**INFORME CONTROL DE CALIDAD 100%**
07_8_B1_FA_100127 (07_06_100127_BERGU_1)**PROYECTO**
SIOSE

Informe del control de Calidad del 100% de la zona de Bergueda (Cataluña).

Se entrega:

Informe BERGUEDA_100%.doc con

- Base de datos **07_06_100127_BERGU_1** (100% ORIGINAL:
07_8_B1_FA_100127.mdb)

Esta base de datos contiene parcialmente a la siguiente base mandada y controlada con
anterioridad **07_08_B01_FA_100127**.

Gerencia de SIG y Consultoría
Tragsatec, julio 2010

 Tragsatec Grupo Tragsa	INFORME CONTROL DE CALIDAD 100% 07_8_B1_FA_100127 (07_06_100127_BERGU_1)	PROYECTO SIOSE
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DATOS DE LA ZONA A CONTROLAR

CCAA: CATALUÑA Sup. total CCAA*: 3.218.046,75 ha Sup. controlada: 199.335,61 ha = 6,19 %

Nombre de la Entrega: **07_8_B1_FA_100127**

Fecha de Entrega del Control de Calidad (TRAGSATEC):

* Fuente: Anuario Estadístico de España. INE.
1. CONTROL DE CALIDAD: ASPECTOS GENERALES

Convención de nombres: Cumple ☒ No Cumple ☐			
Formato de Entrega:	ArcGIS ☒	Geomedia ☐	GML ☐ Otros ☐
Sistema Geodésico de Referencia: ETRS89 ☒ Otros ☐			
Proyección Cartográfica:	UTM ☒ Otra ☐	HUSO:	27 ☐ 28 ☐ 29 ☐ 30 ☐ 31 ☒
Modelo de datos:	SIOSE ☒ Otros ☐	Informe de la CCAA del modelo e integración con SIOSE Si ☐ No ☐	
Cumple con las unidades mínima de superficie: Si ☒ No ☐			
Anchura elementos lineales – Pasillos: Cumple ☒ No Cumple ☐			
Existencia de Límites ficticios: Si ☐ No ☒			
Control de polígonos: Cumple ☒ No Cumple ☐	Todos los polígonos tienen cobertura asociada:	Si ☒ √ *	No ☐ **
	Todas las coberturas tienen polígono asociado:	Si ☒ √	No ☐
	El % de superficie cubierta de cada polígono es del 100%:	Si ☒ √	No ☐
	Los polígonos contiguos tienen atributos y coberturas distintos:	Si ☒ √	No ☐
Metadatos: Cumple ☒ No Cumple ☐	Todos los polígonos tienen distinto identificador:	Si ☒ √	No ☐
	Siguen plantillas de Metadatos SIOSE:	Si ☒ √	No ☐
	Metadatos legibles por CatMDEdit:	Si ☒ √	No ☐
	Metadatos SIOSE por hoja MTN25:	Si ☒ √	No ☐
	Nombre fichero de metadatos correcto según especificaciones:	Si ☒ √	No ☐

* El símbolo √ aparece en las opciones que hacen que cada uno de los controles sean aceptados.
** El símbolo X aparece en las opciones que hacen no aceptar el control.

Observaciones:

Los aspectos generales del control final de la base de datos de BERGUEDA, en el centro-norte de Cataluña (huso 31) se han revisado sobre la base 07_06_100127_BERGU_1 (07_8_B1_FA_100127) (199.335,61 ha = 13.804 polígonos).

La comunidad autónoma no ha entregado informe de control de calidad de la base de datos controlada.

Se han localizado 17 pasillos no relevantes o que se ubican en el extremo de la base, por lo que no se consideran error.

RESULTADO DEL CONTROL DE CALIDAD: ASPECTOS GENERALES:	CUMPLE
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2. CONTROL DE CALIDAD: CONTROL TOPOLÓGICO

Entidades con geometría distinta a la de tipo polígono: Si ☐ No ☒ ✓

Existencia de huecos entre polígonos: Si ☐ No ☒ ✓

Existencia de solapes entre polígonos: Si ☐ No ☒ ✓

Observaciones:

RESULTADO DEL CONTROL DE CALIDAD: CONTROL TOPOLÓGICO: CUMPLE

3. CONTROL DE CALIDAD: CASADO ENTRE BLOQUES

Coincidencia geométrica: Si ☒ ✓ No ☐

Coincidencia semántica: Si ☒ ✓ No ☐

Elementos perimetrales cerrados: Si ☒ ✓ No ☐

Observaciones:

RESULTADO DEL CONTROL DE CALIDAD: CASADO ENTRE BLOQUES: CUMPLE

4. CONTROL DE CALIDAD: CONTROL GEOMÉTRICO Y SEMÁNTICO DE LA FOTOINTERPRETACIÓN

Seleccionada muestra:	Si ☒ No ☐	Superficie de la muestra 3.984,95 ha = 2 % de la superficie controlada
Control Geométrico:	Cumple ☒ No Cumple ☐	I. RMSE ≤ 3 m ☒ RMSE > 3 m ☐
		II. E _L > 5 m : <2% de pts. Muest ☒ ✓ ≥2% de pts. Muest ☐
		III. E _L > 15 m <0,2% de pts. Muest ☒ ✓ ≥0,2% de pts. Muest ☐
Control Semántico:	Cumple ☒ No Cumple ☐	Polígonos con puntuación ≥ 30
		Nº Polígonos erróneos < 5% de polígonos de la muestra Si ☒ ✓ No ☐
		Superficie polígonos erróneos < 5% de superficie de muestra Si ☒ ✓ No ☐
		Polígonos con puntuación < 30
		Nº Polígonos erróneos < 8 % de polígonos de la muestra Si ☒ ✓ No ☐
		Superficie polígonos erróneos < 8% de superficie de muestra Si ☒ ✓ No ☐
		Errores sistemáticos en la muestra Si ☐ No ☒ ✓

Observaciones:

Estos controles se han realizado a partir de los puntos y polígonos de la base de datos 07_08_B01_FA_100127

C.GEOMÉTRICO: Se han medido 406 puntos de control, 1 de ellos tienen un error longitudinal mayor a 5 metros (max. 2% = 8 puntos), y ningún punto cuyo error longitudinal supere los 15 metros (max. 0.2 % = 1 puntos). El RMSE de todos los polígonos de la muestra es de 0,47.

C.SEMÁNTICO: 500 polígonos (3.984,95 ha), de los cuales 4 polígonos (21,4 ha) obtuvieron una puntuación mayor o igual a 10 y menor que 30 (max. 8% = 40 polígonos y 318,79 ha) y hay 1 polígono (2,77 ha) cuya puntuación es igual o mayor que 30 (max. 5% = 25 polígonos y 199,24 ha).

RESULTADO DEL CONTROL DE CALIDAD: GEOMÉTRICO Y SEMÁNTICO: CUMPLE

Control realizado por: TRAGSATEC

RESULTADO DEL CONTROL DE CALIDAD 100 %: CUMPLE

Fecha finalización del control de calidad: JULIO 2010