The analysis accuracy assessment of CORINE Land Cover
In the Iberian Coast

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ABSTRACT
Corine land cover 2000 (CLC2000) is a project jointly managed by the Joint Research Centre (JRC) and the European Environment Agency (EEA). Its aim is to update the Corine land cover database in Europe for the year 2000. Landsat-7 Enhanced Thematic Mapper (ETM) satellite images were used for the update and were acquired within the framework of the Image2000 project. Knowledge of the land status through the use of mapping CORINE Land Cover is of great importance to study of interaction land cover and land use categories in Europe scale. This paper presents the accuracy assessment methodology designed and implemented to validate the Iberian Coast CORINE Land Cover 2000 cartography. It presents an implementation of a new methodological concept for land cover data production, Object-Based classification, and automatic generalization to assess the thematic accuracy of CLC2000 by means of an independent data source based on the comparison of the land cover database with reference data derived from visual interpretation of high resolution satellite imageries for sample areas. In our case study, the existing Object-Based classifications are supported with digital maps and attribute databases. According to the quality tests performed, we computed the overall accuracy, and Kappa Coefficient.

We will focus on the development of a methodology based on classification and generalization analysis for built-up areas that may improve the investigation. This study can be divided in these fundamental steps:

- Extract artificial areas from land use Classifications based on Land-sat and Spot images.
- Manual interpretation for high resolution of multispectral images.
- Determine the homogeneity of artificial areas by generalization process.
- Overall accuracy, Kappa Coefficient and Special grid (fishnet) test for quality test.

Finally, this paper will concentrate to illustrate the precise accuracy of CORINE dataset based on the above general steps.

Keywords: Remote sensing, GIS, CORINE, Image Analysis, generalization, accuracy assessment.

1. INTRODUCTION
For numerous model applications in the earth and environmental sciences, digital land-use data are indispensable as a source of information on the geographical distribution of the land-use/cover. Therefore, CORINE Land Cover, and Landsat TM classifications are widely used in Spain. However, the users of these data mostly do not have information on their quality. The real value of these maps logically depends on both their geometrical accuracy (where the elements are, and what are their limits) and on their thematic accuracy (that the classification of each element to one of the categories of the legend of the map corresponds to the reality on the ground). Both types determine the quality of the information presented in the map. If any of the two types of accuracy is unknown it is impossible to estimate the error when elaborating norm or directives. It is also impossible to estimate if the decisions derived from such maps fulfil their purpose or not. In the initial stages of the study, GIS was an excellent tool for organizing and evaluating spatial data required for calculate data accuracy based on grid cells method "Fishnet". This paper presents methods to test whether map error can explain the observed differences between various categories of land cover in maps.

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Such differences may be due to two reasons: error in the maps and change on the ground. Then error could explain virtually all of the observed differences between the maps. The paper discusses the assumptions behind the methods and articulates priorities for future research.

2. DATA AND STUDY AREA

The area of interest is located in the Iberian Spanish coast, which have been selected 8 regions for this study which includes 24 municipalities with a total land area of 78,352 ha and covered by 99.45 km2 of artificial areas of CORINE dataset (CLC00) (see Figure 1).

Fig. 1. Study areas in the Iberian Spanish coast.

The Corine Land Cover map; The Coordination of Information on the Environment program began by decision of the Council of Ministers of the European Union on 27 June 1985 (CE/338/85). Part of the program was the CORINE Land Cover (CLC) project. Its main goal was to gather numerical and geographical data for the creation of a coherent and comparable European database on land use at a 1:100 000 scale that could be used by the countries included in the project. The cartographic land use database includes the 12 countries of the European Community (2.36 million km2). A legend was defined of 44 hierarchically organized categories, whose top three levels would be identical for all the countries. The cartography was to be performed by computer assisted photo-interpretation of satellite images. It seemed essential to use auxiliary data (maps, aerial photographs, statistics, and local knowledge of the terrain) to aid in identification. There was also foreseen a phase of quality control checking, and a phase of digitization to integrate the maps into a geographic information system. The validation of the European land cover product was carried out by the European Technical Team (Maucha & Buttner, 2005).

In Spain, the CLC project began in 1987 and ended in 1991 under the direction and coordination of the National Geographical Institute and updated corresponding to the year 2000. The sheets which include Spanish territory were divided into several parts that were photo-interpreted by different groups. In some Spanish regions, the CLC maps were revised and brought up to date some years later. We present the validation procedure designed and implemented for the national CLC2000 database for the selected study areas (Cataluña, Castellon, Valencia, Alicante, Murcia, Galicia and Bilbao) in which the legend was adapted to the characteristics of the regions. We shall refer to these maps as CLC00.

The Classification Maps; The input data which used in CORINE such as Landsat consisted of supervised classification using pixel based approach, which was automatically generalized to CORINE land cover and coarser outputs. Some unlabeled areas were generalized manually. They are difficult or impossible to extract by per-pixel approaches (Pekkarinen, Reithmaier and Strobl, 2008). We intend to make a comparison from the object perspective, which is object-based rather than pixel-based. Therefore, object based image processing techniques are considered better for image analysis at higher levels than the pixel level, which provides additional tools and methods for image analysis at higher abstraction levels.

Our sites provide a good opportunity to test whether the proposed object-based land-cover classification approach is more robust than other per-pixel based approaches which already used as a reference to detect land covers features in CORINE program. We used approximately similar CORINE Landsat period images to be able for comparison process.
The Manual Interpretation Maps; historical images from Google earth was one of our dataset. Using GIS technology, the air photos were digitized with geographical coordinate tags for use in GIS software programs including online mapping applications such as Google Earth (GE) which used to calculate accuracy of CORINE dataset in high scale level using Grid cells (fishnet) method.

3. METHODOLOGY

Measuring the accuracy of a CORINE map requires a better observation of reality on a sample of points or areal units. Checking a photo-interpretation with another photo-interpretation on the same data provides the required more reliable data for some land cover types, for which errors are due to insufficiently experienced staff or to a less careful work when a large area has to be photo interpreted. In other cases there is a real limitation of the possibility to identify some features (artificial areas in our case) and the comparison gives a measure of subjectivity. A two phase has been proposed: in the first phase focused in classify similar data source which used in CORINE by apply new method of object-based approach and calculate the assessment accuracy using selected region of interest areas and work over additional parameters such as texture, size and colour. The second phase comparing the CORINE with a ground survey but for difficulty high resolution images digitized from Google earth to cover ground survey process in addition test grid cells “fishnet” test show a good comparison method to calculate the accuracy in high scale level. The following diagram 1 illustrates our methodology of work.

3.1 Object-based Classification

Landsat-7 ETM with 6 spectral bands was used to carry out the image classification and ground truth data were collected from the available maps. Object-oriented image analysis was evaluated through the ENVI Zoom software. Segmentation is the first and important phase in the ENVI Zoom software and its aim is to create meaningful objects. This means that the shape of each object in question should ideally be represented by an according image object. This shape combined with further derivative color and texture properties can be used to initially classify the image by classifying the generated image objects (Benz, Hofmann, 2004). Based on the properties of each spectral band, segments have been analyzed with different parameters in the related classes. As a result, the prominent segments are grouped and located in the corresponding classes. Then, classification procedure is completed by assigning the relevant class color to segments and classified image as it shown in Figure 2.

3.2 Digitizing and manual generalization

Since many internet users are familiar with Google Earth, compatible Keyhole Markup Language (KML) files were created for use in this free online mapping program. Google earth works extremely well in creating new vector data in the form of points, lines and polygons that can be used as Shape files in ArcGIS or any other GIS software for more advanced processing. However, detect artificial areas in high accuracy dataset will use as strong parameter to calculate the assessment accuracy of CORINE data, manual interpretation generalize artificial areas in the selected municipalities study made and calculated (see figure 2).
3.3 Methods for Accuracy Assessment

Accuracy assessment is the process used to estimate the accuracy of the feature classes present in a map, by confronting the map with reference information that we assume as true. The final goal is the production of an error matrix, from which statistics and indices that indicate the accuracy of individual classes and of the whole map can be derived. In accuracy assessment, one has to define: the reference data, type of sampling unit, sampling design and intensity. These factors have to be adequately balanced in order to allow the extrapolation of results for the whole map. Unfortunately there is not a standard procedure for accuracy assessment and the choice of a methodology depends on factors such as time, money and human resources (Congalton & Green 1999). Two Accuracy assessment methods applied over the artificial feature class areas (residential, industrial, streets … etc) in CORINE, Object-Base classification and digitization results.

Accuracy of the Classification Results: Confusion Matrix; The error matrix or confusion matrix is used to compare the information obtained in the classification process with reality, through the use of classic statistics. This matrix provides a concise method to examine. There are several widely used indices for accuracy assessment based on the error matrix: overall accuracy, producer accuracy, user accuracy, global kappa and conditional kappa. Tau statistics are an innovation of kappa (Ma & Redmond 1995). Overall accuracy is the proportion of sampling units correctly classified; Overall accuracy is the proportion of sampling units correctly classified. Kappa analysis is a multivariate discrete statistic used in accuracy assessment to statistically evaluate if error matrices are significantly different (Congalton and Oderwald, 1983). The methodology developed for accuracy assessment of the CLC2000 dataset was based on the comparison of the final CORINE and Object-Base Artificial map (see Figure 3) all with the “ground truth” for selected sample units, from which an error matrix was computed. For this purpose, 300 pixels in the study have been selected randomly and their agreement with ground truth has been analyzed for each selected region. Then, error matrix has been generated and given in Table 1.

However, object-oriented classification produced more accurate results. The reason for this is that the compactness of the segments and the way of work over additional parameters. Thus, kappa and the overall accuracy are much better.

Manual Interpretation accuracy: Grid Cells (Fishnet) approach; In order to relate the CORINE and Digitization values, the percentage of each dataset needed to be summarized for each area. This was accomplished through the creation of several new vector overages known as 'fishnets' because of their visual similarity to traditional fishing nets (see Figure 4).
Table 1. Accuracy results for classified image from Object-based classifications and CORINE image.

<table>
<thead>
<tr>
<th>Landscape</th>
<th>Overall accuracy (Artificial)</th>
<th>Kappa Coefficient (Artificial)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CORINE</td>
<td>Object-Base</td>
</tr>
<tr>
<td>Alicante</td>
<td>77.55%</td>
<td>89%</td>
</tr>
<tr>
<td>Almeria</td>
<td>74.76%</td>
<td>79.3%</td>
</tr>
<tr>
<td>Bilbao</td>
<td>80.19%</td>
<td>81.6%</td>
</tr>
<tr>
<td>Castellón</td>
<td>75.28%</td>
<td>83.1%</td>
</tr>
<tr>
<td>Cataluña</td>
<td>82.31%</td>
<td>85.5%</td>
</tr>
<tr>
<td>Galicia</td>
<td>83.43%</td>
<td>87%</td>
</tr>
<tr>
<td>Murcia</td>
<td>85.62%</td>
<td>90.3%</td>
</tr>
<tr>
<td>Valencia</td>
<td>78.97%</td>
<td>83.7%</td>
</tr>
</tbody>
</table>

The blue gridlines outlining the model domain were created in Arc/Info using the GENERATE function with the Fishnet option. The Fishnet of polygons is created from specifying 100x100m size over the municipal limits for not suffering any kind of shift in position over dataset layers this grid showing the estimated occupation area in each cell. Each cell was assigned a unique numeric identifier, the cells were examined by both interpreter areas CORINE and Digitized data, the total count for each region converted to percentage illustrate the different between previous datasets. Two different simulations were made. The first was the Direct Difference calculation, simple subtraction process applied between previous values, Table 2 illustrate summation subtracted results en each region.

Table 2. Direct difference assessment accuracy from manual interpretation Google earth images and Corine.

<table>
<thead>
<tr>
<th>Landscape</th>
<th>Digitized area [km²]</th>
<th>CLC [Km²]</th>
<th>Δ</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alicante</td>
<td>29.53</td>
<td>35.69</td>
<td>-6.16</td>
<td>-21%</td>
</tr>
<tr>
<td>Almeria</td>
<td>8.64</td>
<td>4.38</td>
<td>4.26</td>
<td>49%</td>
</tr>
<tr>
<td>Bilbao</td>
<td>10.59</td>
<td>7.86</td>
<td>2.74</td>
<td>26%</td>
</tr>
<tr>
<td>Castellón</td>
<td>48.51</td>
<td>42.76</td>
<td>5.75</td>
<td>12%</td>
</tr>
<tr>
<td>Cataluña</td>
<td>20.34</td>
<td>22.21</td>
<td>-1.87</td>
<td>-9%</td>
</tr>
<tr>
<td>Galicia</td>
<td>5.43</td>
<td>2.68</td>
<td>2.76</td>
<td>51%</td>
</tr>
<tr>
<td>Murcia</td>
<td>9.17</td>
<td>9.23</td>
<td>-0.06</td>
<td>-1%</td>
</tr>
<tr>
<td>Valencia</td>
<td>16.93</td>
<td>13.78</td>
<td>3.15</td>
<td>19%</td>
</tr>
</tbody>
</table>

The second was the Real Difference calculation; This step look to follow in each grid cell to detect which cells carryout similar cover areas in both layers and which cells have more digitixed areas than Corine and finally the cells that shown more covered areas by Corine. These three indicators divided in three groups as it shown in Table 3. For each region we separate grid cells relate to above groups to illustrate the real difference calculations to give more details over surplus and missing lands as it shown in Table 4. Percentage change areas between dataset found in the relation between difference (Δ) and digitized areas relate to digitized areas as a reference. Resume table for last calculation methods already found in Table 5. Selected regions for these study present higher values in real than direct accuracy assessments as it shown in Diagram 2, this difference present clearly the method to calculate the accuracy must correspond to the different scale between datasets, additionally real difference help to detect the big gap difference between maps areas to be reviewing such as Alicante and Castellon regions.
Table 3. Each grid cell classified to below groups depends on the majority or minority of artificial land in each dataset.

<table>
<thead>
<tr>
<th>Group</th>
<th>Digitized area</th>
<th>CLC0 0</th>
<th>Digitized area (Ex.)</th>
<th>Corine (Ex.)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grupo A</td>
<td>Digitized area = CLC00</td>
<td>[grid]</td>
<td>46,5 Km2</td>
<td>46,5 Km2</td>
<td>0</td>
</tr>
<tr>
<td>Grupo B</td>
<td>Digitized area &lt; CLC00</td>
<td>[grid]</td>
<td>37,1 Km2</td>
<td>65,9 Km2</td>
<td>28,8 Km2 + [Surplus Land]</td>
</tr>
<tr>
<td>Grupo C</td>
<td>Digitized area &gt; CLC00</td>
<td>[grid]</td>
<td>65,4 Km2</td>
<td>25,9 Km2</td>
<td>39,48 Km2 - [Missing Land]</td>
</tr>
</tbody>
</table>

Table 4. (Left) Using Real difference method helps to identify the surplus and missing land between our manual interpretation Google earth and Corine to be close from the reality.

<table>
<thead>
<tr>
<th>Landscape</th>
<th>Digitized area [km2]</th>
<th>CLC [Km2]</th>
<th>Surplus Land</th>
<th>Missing Land</th>
<th>Δ %</th>
<th>Δ direct</th>
<th>Δ_real</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alicante</td>
<td>29,53</td>
<td>35,69</td>
<td>11,0</td>
<td>4,86</td>
<td>15,9</td>
<td>54%</td>
<td></td>
</tr>
<tr>
<td>Almeria</td>
<td>8,64</td>
<td>4,38</td>
<td>0,69</td>
<td>5,0</td>
<td>5,6</td>
<td>65%</td>
<td></td>
</tr>
<tr>
<td>Bilbao</td>
<td>10,59</td>
<td>7,86</td>
<td>0,83</td>
<td>3,6</td>
<td>4,4</td>
<td>42%</td>
<td></td>
</tr>
<tr>
<td>Castellón</td>
<td>48,51</td>
<td>42,76</td>
<td>7,02</td>
<td>12,77</td>
<td>19,79</td>
<td>41%</td>
<td></td>
</tr>
<tr>
<td>Cataluña</td>
<td>20,34</td>
<td>22,21</td>
<td>4,1</td>
<td>2,25</td>
<td>6,4</td>
<td>31%</td>
<td></td>
</tr>
<tr>
<td>Galicia</td>
<td>5,43</td>
<td>2,68</td>
<td>0,9</td>
<td>3,69</td>
<td>4,6</td>
<td>85%</td>
<td></td>
</tr>
<tr>
<td>Murcia</td>
<td>9,17</td>
<td>9,23</td>
<td>2,3</td>
<td>2,24</td>
<td>4,5</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>Valencia</td>
<td>16,93</td>
<td>13,78</td>
<td>2,0</td>
<td>5,15</td>
<td>7,2</td>
<td>42%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>149,14</td>
<td>138,59</td>
<td>28,92</td>
<td>39,49</td>
<td>68,41</td>
<td>46%</td>
<td></td>
</tr>
</tbody>
</table>

Table 5. (Right) Comparison result between direct and real differences assessment for each region.

<table>
<thead>
<tr>
<th>Real difference</th>
<th>Difference Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landscape</td>
<td>A_direct</td>
</tr>
<tr>
<td>Alicante</td>
<td>-6,2</td>
</tr>
<tr>
<td>Almeria</td>
<td>4,3</td>
</tr>
<tr>
<td>Bilbao</td>
<td>2,7</td>
</tr>
<tr>
<td>Castellón</td>
<td>5,8</td>
</tr>
<tr>
<td>Cataluña</td>
<td>-1,9</td>
</tr>
<tr>
<td>Galicia</td>
<td>2,8</td>
</tr>
<tr>
<td>Murcia</td>
<td>-0,1</td>
</tr>
<tr>
<td>Valencia</td>
<td>3,1</td>
</tr>
</tbody>
</table>

Diagram. 2. Simple differentiation between maps categories will not be clear to detect in direct difference method, in otherwise real difference detect which areas have really big difference between categories in various datasets.

4. CONCLUSION

The new CORINE 2000 land cover classification of Spain is based on automated interpretation of Landsat images and data integration with existing digital map data. When CORINE Land Cover (CLC00) is compared with other land information at a different scale, premature conclusions could be drawn if a straightforward comparison is seen as a quality assessment. If the comparison between two geospatial land cover data layers takes into account their different scales, the conclusions change. We give a procedure to perform such a comparison trying to remove the effects of different scales and collocation inaccuracy. We also illustrate the fact that CLC00 should not be directly used for area estimation by direct polygon area measurement. Accuracy assessment measures were calculated according to object-base classification images and manual interpretation of artificial areas (e.g. Google Earth, freely available Ortho-photos). The comparison was done in two different ways in order to analyze the effect of location errors and according to various dataset scales. First, all comparison between similar scale dataset Corine and Object-Base classification results and we
illustrate the newest methods of image processing able to improve the accuracy assessment and second, using grid cells (Fishnet) method to takes into account the different scales between Google earth and Corine and estimate the error in cover needs area. The similarity of texture, form and even colour in low resolution satellite images such as Landsat increase the confusion of interpretation in Corine case, this confusion already reduced working over high resolution imageries such as Google Earth.

Table 6. In this table finally we can see used method applied to illustrate the significant difference between the two databases. It also shows the largest difference occurs at a lower intensity in the same region.

<table>
<thead>
<tr>
<th>Landscape</th>
<th>Overall accuracy (Artificial)</th>
<th>Kappa Coefficient (Artificial)</th>
<th>Grid cells (Artificial)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CLC Object-Based Δ</td>
<td>CLC Object-Based Δ</td>
<td>Digitized area [km²]</td>
</tr>
<tr>
<td>Bilbao</td>
<td>80,19%</td>
<td>81,60%</td>
<td>-1%</td>
</tr>
<tr>
<td>Murcia</td>
<td>85,62%</td>
<td>90,30%</td>
<td>-5%</td>
</tr>
<tr>
<td>Galicia</td>
<td>83,43%</td>
<td>87%</td>
<td>-4%</td>
</tr>
<tr>
<td>Almeria</td>
<td>74,76%</td>
<td>79,30%</td>
<td>-5%</td>
</tr>
<tr>
<td>Cataluña</td>
<td>82,31%</td>
<td>85,50%</td>
<td>-3%</td>
</tr>
<tr>
<td>Valencia</td>
<td>78,97%</td>
<td>83,70%</td>
<td>-5%</td>
</tr>
<tr>
<td>Alicante</td>
<td>77,55%</td>
<td>89%</td>
<td>-11%</td>
</tr>
<tr>
<td>Castellón</td>
<td>75,28%</td>
<td>83,10%</td>
<td>-8%</td>
</tr>
</tbody>
</table>

Finally, working over large scale urban studies such as urban morphologies, sprawl and change, Corine will be a good choice to illustrate understandable results in global level. In the otherwise work over small scale such as the urban fabric (Discontinue and Sparse areas) Corine will not give satisfy results compare it with the rest as it shown in Table 6.

ACKNOWLEDGEMENTS

The authors of this paper gratefully acknowledge the research funding provided by the Spanish Ministry of Education and Science (SEJ2006-09630-GEO), the Spanish Ministry of Housing and the European Union by way of the INTERREG III B Programme (South Western Europe). Similarly the authors acknowledge the technical expertise and assistance provided by María de la Concepción Crespo and Malcolm Burns in the development of this research project.

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