CONTRIBUTIONS OF GMES LAND PROJECTS TO EUROPEAN LAND MONITORING

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ABSTRACT

New European directives and national legislation are demanding more detailed harmonised geo-information on regional and local level to serve the obligations arising from existing (e.g. the Water Framework Directive – WFD) and planned directives (e.g. the Soil Thematic Strategy – STS). This automatically demands capabilities for large area monitoring, i.e. covering at least Europe 25 (approx. 4 Mio km2) or EEA 32 (approx. 6 Mio km2).

The paper will summarise the status of the recent discussion in Europe on GMES Land Monitoring activities. It will show concrete results from both, DG ENTREPRISEs´ Integrated Project geoland - which has focused its activities on consolidation of state of the art towards state of practice - and ESA's GMES Service Element, which builds on geoland´s consolidated services demonstrating Europe's service provider capabilities to produce high quality and affordable geo-information products in time and over large areas.

The scientific and technical problems which do arise when migrating from Europe's geo-information data base CORINE Land Cover (the only existing European-wide harmonised data source today) towards a new GMES Land Monitoring data base will be addressed as well.

Within the scope of GMES the "Core Service Land Monitoring - CSLM" has been selected as one of three candidate pilot services (the other two are "Risk" and "Ocean" related services, respectively). CSLM has been suggested on the basis of existing and mature capacities and structures, on user uptake and on perspectives for long-term sustainability. By integrating this information into existing user-side infrastructure, international and national public institutions are enabled to fulfil their reporting and management obligations in an improved way.

INTRODUCTION

Reliable multi-purpose Land Cover data is the basis for a multitude of applications in environmental management and spatial planning. CORINE Land Cover (CLC) – the only existing harmonised European land data base – has clearly demonstrated the overall value of such a data base. However, CLC offers in total 44 thematic classes which comprise a mixture of land cover and land use. Its resolution with a 25 ha minimum mapping unit (MMU) serves well the needs of the European Commission and EEA but is not well suited for regional planning activities. In addition, the update rate of 10 years is not sufficient to track fast changes, which appear for instance when new member states join the European Union.

GMES – Global Monitoring for Environment and Security – a joint initiative of the European Commission and the European Space Agency - has been set up to establish sustainable operational EO based geo-information services from 2008 onwards to serve Europe's needs on environmental management (keeping or improving a good environ-mental status) and to assure security for the citizen.

GMES makes use of the unique capacity of Earth Observation data of providing unambiguous observations across administrative borders as regular time series. These observations are transformed into information services integrating existing in-situ and statistical data sets. The GMES

projects on "Land Cover & Vegetation" aim at supporting the public bodies in charge of implementing policies and directives (such as the Water Framework Directive, Natura 2000, the Urban Thematic Strategy, CAP, Cohesion, etc.) through adequate geo-information services and tools.

For land application two major projects do contribute to these overall goals: (1) DG ENTREPRISE´s Integrated Project geoland funded through the Framework Program 6 - which has focused its activities on consolidation of state of the art towards state of practice - and (2) ESA's GMES Service Element "GSE Land", which builds on geoland´s consolidated services demonstrating Europe's service provider capabilities to produce high quality and affordable geo-information products in time and over large areas.

Both projects create basic harmonised land cover data (as a prototype of the European Core Service Land Monitoring) aimed to complement existing data sets such as CORINE Land Cover or national data. From this data downstream applications or observatories perform associated analysis for operationally available geo-information services which are provided to those administrative bodies that have received the mandate to monitor, report, and manage land resources.

Following the subsidiary principle the services addressees range from decision makers at international and European levels (e.g. on foreign aid measures) to sub-national and local stakeholders in Europe and abroad (e.g. in charge of implementing the Water Framework Directive or doing spatial planning for urban agglomerations).

METHODS

In order to overcome the shortcomings of CORINE for regional management and reporting the geoland Core Service Land Cover (CSL) was set up in 2004. Its goal has been to achieve a consensus on a new European land cover data base and demonstrate its benefits offering improved spatial and thematic content compared to CORINE.

The data base is designed to serve common land monitoring needs providing the status quo and the possible changes of Europe's landscape for European users and member states enabling a wide range of downstream sectoral applications and user groups. In addition, it is aimed to provide cost efficiency by applying recent technology, achieve economics of scale and sustainability of funding through a shared effort across different administration units.

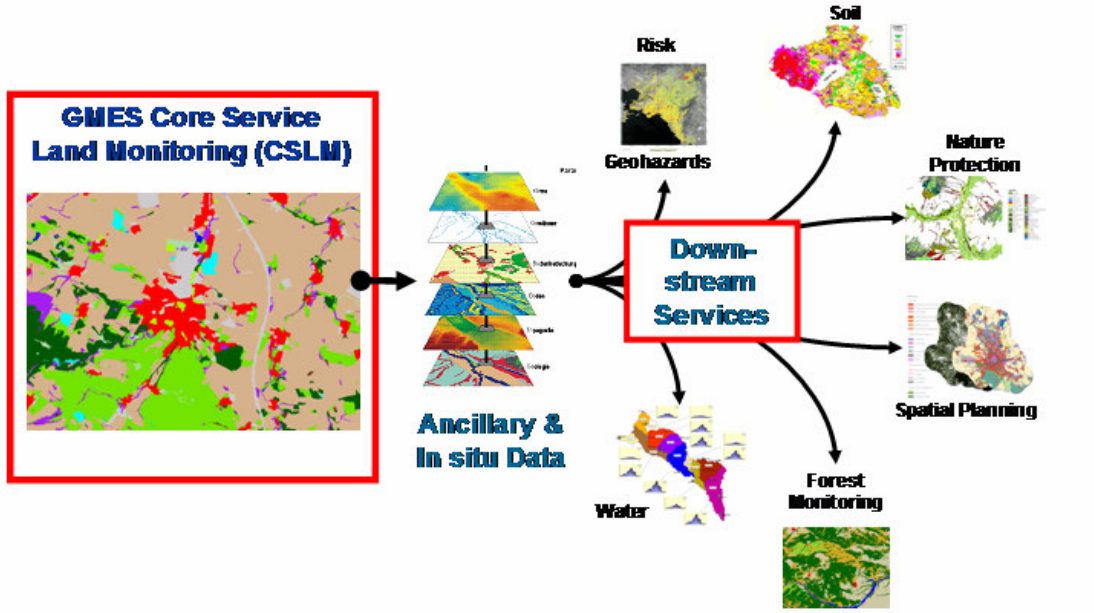


Figure 1: One Core Service to serve a multitude of downstream applications; © geoland Consortium, 2006

The geoland Core Service Land Cover was primarily aimed to serve different regional fields of applications (called "*Observatories*" in the context of geoland) with harmonised, topical and geometrically correct basic information of Land Cover; namely the Observatories Nature Protection (ONP), Spatial Planning (OSP) and Water & Soil (OWS). In addition, requirements of the global Observatories Land Cover & Forest Change (OLF), Food Security & Crop Monitoring (OFM), Natural Carbon Fluxes (ONC) and the Core Service Biophysical Parameters (CSP) have been taken into account, as well, by participating in technical workshops and during the geoland fora.

The geoland core service land cover team (comprising 13 partners from 8 countries and supported be the regional observatories) investigated extensively state-of-the-art land cover mapping and monitoring approaches in Europe based on concrete examples from 5 countries including comparison and benchmarking of methods and national needs.

Of paramount importance have been European harmonisation and aspects of technical feasibility, affordability demonstrating a good cost / benefit ratio based on the trade-off between cost drivers and performance parameters (e.g. Minimum Mapping Unit (MMU), number of thematic classes, methods, etc.), and interoperability with CLC to assure continuity of time series.

The final result - a set of 21 thematic classes derived from the originally 44 CLC classes is shown in Table 1. In its present version CSL comprises 20 thematic classes with a minimum mapping unit of 1 ha (100 m * 100 m). The thematic accuracy has been defined individually for each class taking into account that not all classes can be mapped with the same accuracy. It ranges between 80-90 % accuracy for most cases. The update frequency today depends mainly on EO data availability which permits a revision every 3-5 years, only. More technical details on the geoland Core Service can be downloaded on the geoland webpage: http://www.gmes-geoland.info/news.php

GSELand M2.1 Regional Land Cover			
GSELand No. / CSL Code	**Vectordata-code**	**Nomenclature**	**MinMU**
	GSEL21_2005	M21 Mapping Units marked in orange	
1		Artificial surfaces	
1.1	11000	Urban fabric	1 ha
1.2	12000	Industrial, commercial and transport units	1 ha
1.3	13000	Mine, dump and construction sites	1 ha
1.4	14000	Artificial non-agricultural vegetated areas	1 ha
2		Agricultural areas	
2.1	21000	Arable land	5 ha
2.2	22000	Permanent crops	5 ha
2.3	23000	Pasture	5 ha
2.4	24000	Heterogeneous agricultural areas	5 ha
3		Forests and semi-natural areas	
16	31000	Forests	5 ha
3.2		Shrubs and / or herbaceous Vegetation	
3.2.1	32100	Natural Grasland	5 ha
3.2.2	32200	Moors and Heathland	5 ha
3.2.3	32300	Mediterranean Shrubs	5 ha
3.2.4	32400	Transitional woodland -shrub	5 ha
3.3		Permanently non-vegetated areas	
3.3.1	33100	Beaches, Dunes, Sands	5 ha
3.3.2	33200	Bare rocks	5 ha
3.3.3	33300	Sparsely vegetated areas	5 ha
3.3.4	33400	Burnt areas	5 ha
3.3.5	33500	Snow and ice	5 ha
4		Wetlands	
4.1	41000	Inland wetlands	5 ha
4.2	42000	Coastal wetlands	5 ha
5	50000	Water	5 ha

Table 1: CSL Thematic Class hierarchy and nomenclature. The percentage values indicate the targeted class accuracy to be guaranteed; © geoland Consortium, 2006

RESULTS

In general, the geoland Core Service Land Cover has been approved by both, the end user community and especially the regional Observatories as very well suited to fulfil spatial, thematic and temporal requirements resulting from specific reporting obligations and technical specifications of downstream services, like modelling applications or the refinement of the nomenclature for regionally or application specific questions (Figure 2).

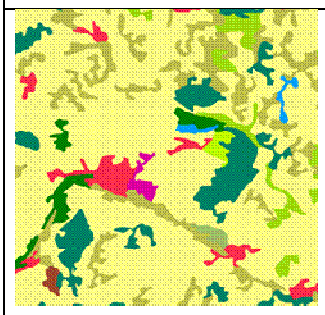
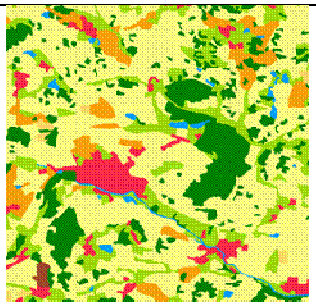
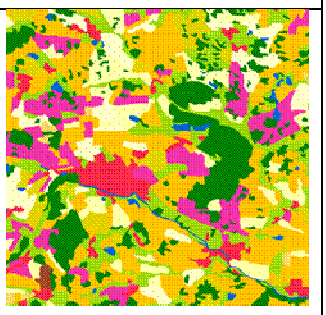
Corine Land Cover 2000 (CLC2000)	Core Service Land Monitoring (CSLM) - *Example geoland CSL*	Add-on mapping example: crop types - *Example GSE SAGE*
		
MMU 25 ha 44 classes	MMU 1...5 ha 22 classes	MMU 1...5 ha 22 + 6 agriculture classes
Update every 10 years European (MS) use	Update every 3 – 5 years European ... MS ... regional use	Update each year MS ... regional use

Figure 2: Comparison of CORINE (left),Core Service Land Monitoring (middle), extension of Core Service Land Monitoring with additional agriculture classes; © geoland Consortium, 2006; © GSE SAGE Consortium (2005)

The validation and technical feasibility of the geoland Core Service Land Cover induced the European Space Agency to implement this service with some technical modifications (according to cost reasons) within the GMES Service Element "GSE Land".

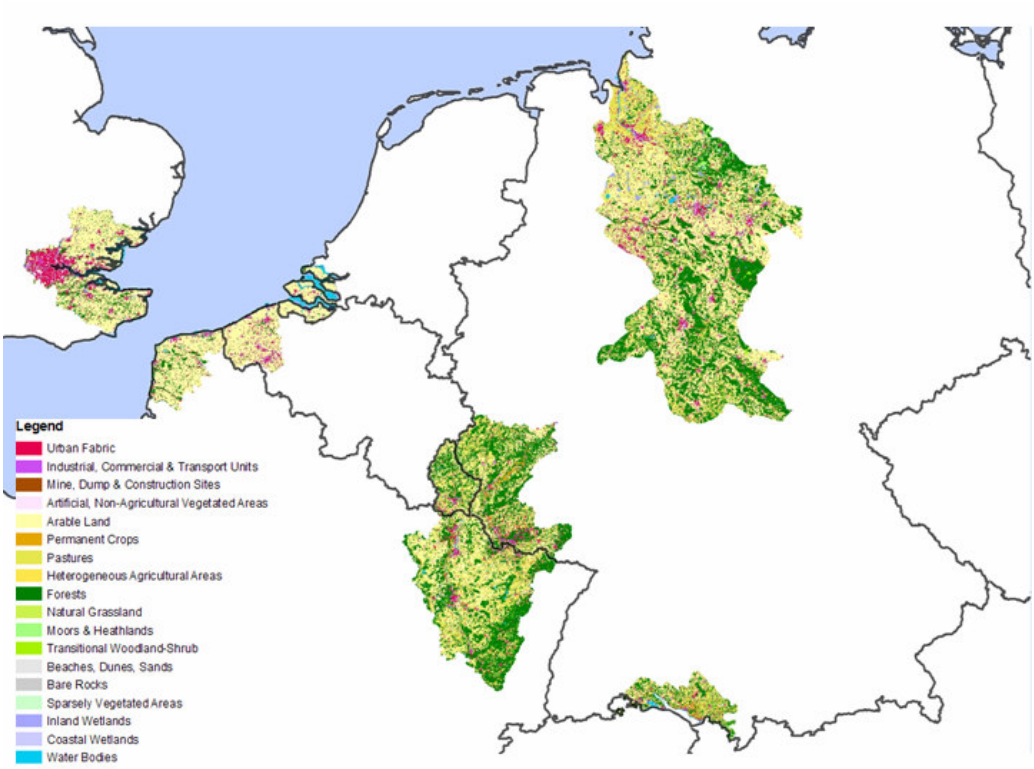
Figure 3 shows the results of near-operational mapping in Central Europe from the GSE Land service portfolio (i.e. from the international Moselle-Sarre catchment comprising regions in Belgium, France, Germany and Luxemburg (approx. 28,000 km^2) and from the German Weser catchment (approx. 48,000 km^2), where land cover is dominated by agriculture being the major source for diffuse water pollution with nitrogen and phosphorous. The land cover products serve as important input for Water Quality and Spatial Planning services.

For cost reasons the product specification was slightly changed from a 1 ha minimum mapping unit (MMU) for all classes towards a 1 ha MMU for urban classes and 5 ha for all remaining classes, respectively.

Within the GSE Land project a well defined ***Quality Assurance (QA) concept*** has been designed, implemented, and is presently being intensively tested over large areas. As a baseline it comprises (1) the qualification of service providers and their respective service production chains by an independent industrial auditor (here TÜV Süddeutschland) and (2) a final quality assessment of the mapping products by an independent quality assurance entity, represented by the trusted EEA institution ETC-LUSI, which was responsible for the CORINE quality assessment, as well. The latter is carried out in two different ways:

1. a stratified random point sampling (this was the originally offered method by the service providers applied in the consolidation phases; accepted by ESA for GSE Land)
2. a more elaborated cluster based sampling. Here, aerial photographs or very high resolution spaceborne imagery (e.g. SPOT 5 pan, IKONOS, Quickbird, etc.) are used for a completely independent re-interpretation and delineation of each selected cluster area, without knowing the results of the service providers ("blind re-interpretation"). Within a GIS both layers (from the service provider and the QA team) are then compared and error matrices are produced. Hence, this method does not only check whether or not a class was classified correctly but identifies geometric location errors as well.

In general, the cluster based sampling approach shows different figures compared to the first one (i.e. the accuracy figures are lower) as it checks more parameters and, thus, identifies more possible error sources. However, the latter approach was presented, intensively discussed and finally well received and accepted by a group of European users which met in June this year at ETC-LUSI, in Barcelona.



Site	**Internal QA** (Re-interpretation of EO data)	**Independent QA team "Cluster" method**	**Independent QA team "Cluster" method** buffered (10m) *
Weser	95,7%	81,1%	87%
Moselle-Sarre	86,6%	79,6%,	82,5%

Figure 3: Land Cover mapping example from GSE Land; , 2006; overall accuracy offered was 80 % +/- 3 %; error matrices showing the single class accuracy have been provided to users. © GSE Land Consortium

** To compensate possible localisation errors when comparing VHR or aerial imagery with 20 m resolution SPOT 4 and 10 m SPOT 5 data, respectively, a 10 buffer zone around all delineated QA vectors has been applied.*

USER FEEDBACK

The Core Service in its present state has been derived from a very intensive and – to some extent controversial – discussion among the geoland partners and European experts. A key issue was to clarify the perimeter of its content: i.e. which level of detail (or how many thematic classes) should be provided as a generic service for all partners and what shall be left to the respective Observatory – or to necessary national or regional adaptations or add-ons, according to the European subsidiary principle.

As a result of this discussion process the Core Service can not fulfil all requirements, especially not those of local users (e.g. requesting levels of detail of 0.1 ha for specific thematic classes), but it comprises a European minimum standard which supports many applications

Products from the Core Service Land Cover have been intensively used by the regional Observatories by integrating them into their specific process flow for their downstream services. It was tested under various European conditions, ranging from boreal conditions (Sweden; Dalälven river basin); central European conditions (Thuringia), Alpine conditions (Austria), and Mediterranean conditions (southern France (Adour-Garonne, Greece, Halkidiki & Spain; Catalunia). In general feed-back was very positive, ranging from “helpful” (in case of nature protection services) to “very important” for spatial planning services and to “mandatory” for soil protection and water quality services.

In June 2005 EEA has accepted the CSL nomenclature as the baseline for the new European land cover data base to replace CLC. At the GMES user workshop in Brussels last year the so-called “GMES Fast Track Service (FTS)” was presented as an replacement for Corine, being fully compliant with the CSL scheme. Feedback from participants was discussed at a critical design review meeting in Barcelona (Dec. 2005) among CSL users and invited member states participants. Here, a review of Mediterranean classes was carried out, as well. Results were presented and discussed at geoland Forum with positive feed-back

The CSL Core Service served as the basis for an unsolicited industrial proposal for a “Fast Track Service Land Monitoring Precursor”, which was submitted in January 2006. Here, for cost reasons a compromise was offered which contains 1 ha MMU in urban classes (CLC Class 1.x) and 5 ha MMU for all other classes. Although the member states did not accept this approach, it fuelled the discussion on a new European land cover data base. Which was taken up by the geoland forum 3 in Vienna.

In June 2006 the National Reference Centres of EIONET (NRCs) have approved as a GMES Fast Track Service (formerly called “Fast Track Precursor”) two thematic layers, where the urban layer is based on the CSL work.

All these intermediate or precursor approaches hopefully will lead to the GMES Core Service Land Monitoring (CSLM) as foreseen by the GMES Implementation Group Land, to be installed operationally from 2008 onwards.

CONCLUSIONS

Although, the geoland Core Service Land Cover (CSL) was primarily aimed at serving the geoland regional Observatories and a number of national user organisations with harmonized, topical and geometric correct basic information on Land Cover and it´s change, today geoland´s approach for the Core Service Land Cover has been accepted by EEA and it’s member states in July 2005 building the basis of the GMES Core Service Land Monitoring (CSLM), as currently prepared by the GMES Implementation Group Land Cover.

REFERENCES

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ii GSE Land Team (2006): GSE Land Service Prospectus; ITD-0421-RP-0013-S3; http://www.gmes-gseland.info/news.php ; © GSE Land 2006