GLOB-LAND Service*

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Contents

Executive summary

This document provides an analysis of users' requirements and presents a proposal for the scope and the architecture of the GLOB-LAND component, including main implementation issues and conditions for its sustainability.

This document is the result of the discussions held with the different users' communities and stakeholders involved in the implementation and governance of GMES, including the discussions of the dedicated workshop which took place in Stresa on the 6th and 7th of May 2009, as side event of the ISRSE33 conference. This document has been consolidated with comments received from Member States and different organizations after Stresa workshop and has been finalized end of February 2010.

The Global component of the GMES Land Monitoring Core Service (LMCS), named GLOB-LAND, will provide information services and products on the status and evolution of land surfaces. The proposed service aims at supporting specific EU policies at international level (e.g. EU development policies) and European commitments under international treaties and conventions, such as the three Rio conventions on Climate Change, Desertification and Biodiversity.

In particular, sustained provision of information concerning global land surface processes will strengthen capacity for international cooperation on regulatory issues and enhance Europe's role in the development of global standards. It will also help our world-leading commitments to Official Development Assistance be even more effective and will provide better alarm functions concerning environmental conditions around the planet. It will also help Europe achieve a stronger role in international organizations, consolidating the European contributions to the GEO/GEOSS, the Terrestrial component of GCOS and GTOS, in particular, through the production of terrestrial ECVs.

Objective of the GLOB-LAND component is to offer a portfolio of data and products, with different levels of elaboration (from pre-processed images to elaborated information), fulfilling both generic and specific application requirements. It will be structured in:

1. a 'multi-purpose' service component comprising:
    a. the *Global Systematic Monitoring Service*, which will provide near real time bio geophysical parameters at global scale describing the vegetation state and dynamic. It will also provide global land cover/land cover change products annually or every 2-3 years. The bio-geophysical parameters will address primarily the 13 terrestrial ECVs.
    b. the *Hot Spots ad hoc Monitoring Service*, which will deliver products on a ad hoc basis, upon request by European or international / intergovernmental institutions and initiativess. The products will be of limited coverage extension and lower revisit frequency (1-5 years) and will address specific region of interest, such as Africa.
2. a set of thematic services addressing EU sectoral policies in specific thematic areas (e.g. Soil/Land degradation, Forest management, Water management, Urban development, Crop production and Food security, etc..).

A consistent re-processing and re-analysis capacity capable of constructing reliable, internationally accepted long-term records is also requested to complete the monitoring capacity of the GLOB-LAND component and to provide reliable information on trends and changes.

The architecture of the GLOB-LAND component will include the following functions:

- acquisition of space and in-situ observations and reference data
- pre-processing of space data;
- product generation up to model output;
- coordination of quality control;
- data archiving and reprocessing;
- product dissemination.

Due to its complexity, the GLOB-LAND component will be implemented progressively. The Global systematic monitoring service should be implemented in priority, while the thematic core service layer should be implemented progressively, starting with already mature service elements. This core activity must be complemented by downstream services tuned to the specific needs of stakeholders of the GLOB-LAND component. Flexibility in the Core Service/Downstream Services boundaries is required to enable an adaptation to changing priorities and user needs for downstream services.

The GLOB-LAND component will build upon existing activities and capacities (such as EUMETSAT Land SAF) and will take stocks of the research and demonstration projects funded by ESA (e.g. GSE and DUE projects) and EC (i.a. FP6 and FP7 GEOLAND projects).

Major conditions for the sustainability of the GLOB-LAND component are:

- Continuity of satellite missions and, in particular, ensured long-term continued provision of well calibrated high-, moderate- and low-resolution multi-spectral instrument to provide land and vegetation products. Data procurement agreements with non European Space Agencies and EO satellite operators will be needed to achieve this and formal dialogues (e.g. within CEOS) are required.
- Sustainability of in situ observation infrastructure, including the supporting networks.
- Support to research activities to ensure the development of state-of-the-art.

Funding is currently from various sources. A key challenge is to set up an adequate institutional arrangement to ensure sustained funding and to enable the effective and sustained operation of the GLOB-LAND component. A management body is also necessary to manage the sharing of responsibilities between service provision partners and development of new services.

The Governance of the GLOB-LAND component will be linked to the LMCS governance and the overall GMES governance. Moreover, due to the peculiarity of the GLOB-LAND component and the stronger similarities with the Atmosphere and Marine Services, the establishment of a network of technical centres at EU level is also proposed for the GLOB-LAND component.

1. Introduction

1.1. GMES Land Monitoring Core Service

The Global Monitoring for Environment and Security (GMES) is an EU-led initiative which aims at providing operational services to users on a sustainable base to support EU environmental and security policies from local to global level. GMES services have been specified in Land, Marine, Atmosphere, Emergency and Security domains.

Until now, the GMES Land Monitoring Core Service (LMCS) has been fully specified only for its Fast Track part[1] which focuses on Land Cover/Land Use mapping at Pan-European level (based on Corine land cover and land cover change mapping) and on land cover mapping of European Urban areas (Urban Atlas). Beyond this Fast Track part, the full scope of the LMCS is under definition in what is called 'LMCS evolution'. Therefore, the scope of the LMCS will be extended to:

- a Global Land component encompassing global scale land monitoring (production of bio-geophysical parameters) and thematic elements at international level (addressing for example European contribution to UNFCCC and its Kyoto protocol, the millennium development goals, food security issues etc.); and
- a set of European thematic services addressing major EU policies (e.g. agriculture, water, soils, forestry, biodiversity ,etc..).

To support the LMCS Implementation Group in defining its Global component, an ad hoc Working Group was created in July 2007 (Annex I: Terms of references and working group composition). The objective of the working group was to address the main implementation issues of the GLOB-LAND component and this document is mainly based on their outcomes.

The initial document served as a basis for discussion of priorities and outlines of the anticipated main components of the GLOB-LAND component in a dedicated workshop which took place in Stresa the 6th and 7th of May 2009 as side event of the ISRSE33 conference.

The workshop focused on three main elements linked to GLOB-LAND component implementation:

- objectives and requirements;
- implementation issues;
- sustainability issues.

The discussions and exchanges which took place during the workshop provided a basis for the implementation process of the GLOB-LAND component. The outcomes of the workshop were taken by the LMCS Implementation Group for an updated version of the initial document.

Furthermore, the document has also been consolidated with comments received after the Stresa workshop from Member States and several organizations and projects. The current version (v 3.0) has been finalized by the GMES Bureau in February 2010 after integration of the comments.

1.2. Purpose of the document

This document provides an analysis of users' requirements and presents a proposal for the scope and architecture of the GLOB-LAND component. An analysis of the main implementation issues and of the conditions for its sustainability, including space and in situ requirements, are also included.

Aim of the document is to support the discussion with the different users' communities and stakeholders involved in the implementation and governance of GMES.

[1] The term 'Fast Track' only refers to the implementation timing of the part of the service granted for a fast track rollout from 2008 onward

2. Need for GMES Global land services

The need to develop dedicated 'global' land services in GMES starts from the assumption that "*Europe is a global partner*". Its policies, activities and decisions are influenced by and have impacts on different countries and regions of the rest of the world. Monitoring capacities and knowledge are therefore a strategic necessity for Europe, not only to support European Commission (EC) and Member State (MS) policy making, but also to support EU economic interests outside Europe. A wide range of EU policies are concerned such as Environment, Development co-operation, Trade, and Humanitarian Assistance.

Beyond the above considerations and with more specific thematic focus, it is worth to underline that *'Environmental protection and civil security are global issues that require global monitoring to provide an informed basis for action'*[2].

Reliable observations of the land at global level are essential:

(i) for the evolution, implementation and monitoring of a number of multilateral environmental agreements of which both EC and MS are signatories;

(ii) for improving our understanding of climate change variability and impacts as well as for mitigation and adaptation strategies;

(iii) for a better management of natural resources, rangelands and agricultural lands, as part of the EU approach to realising the Millennium Development Goals (MDGs);

(iv) to inform and guide EU humanitarian-assistance operations;

(v) to provide facts, forecasts and scenarios concerning human migrations;

(vi) for supporting post-conflict rehabilitation programs;

and to many more aspects as crucial as those just mentioned.

Products and services provided by the GMES Global land services will be an essential step in building operational uses of geo-spatial data and systems in the public policy-making domain. In fact, Global scale information on land resources satisfies four aspects of European policy making. Firstly, it provides our policy makers with their own independent view of global situations on which to build and defend policy positions – they don't have to rely on, or blindly accept third parties' assessments. Secondly, such services allow public policy makers to measure progress towards established policy goals. Thirdly, it is a clear European contribution to the global common good; and fourthly, it will enhance Europe's industrial competitiveness because of the sustained nature of the global observations (including the space segment needed to provide these), by providing links to the global marketplace and by sustaining a range of downstream services. This is of growing importance in a context where other "regional/economic blocks" - particularly China - are more and more present and growing economic presence in third world areas, including those regions with traditionally strong European links, such as Africa. Last, but by no means least such products and services will represent tangible European contributions to science and understanding.

2.1. Key Policy drivers

The European Union has a well identified set of sectoral policies with global dimension which could benefit from GMES Global Land services. In this chapter, these policies are shortly presented.

a) EU 'development' policies

The EU policies more immediately concerned by the global dimension are those related to international cooperation and development, where overarching objectives are poverty eradication and sustainability. EU is In fact the world's largest donor of development aid providing more than half of all official development assistance of which 60% goes to Africa in recognition of the strategic importance of the Africa, Caribbean, and Pacific region for Community development co-operation.

[2] BICEPS report, 2004 - EUR 21109

§ *European Consensus on Development*

The 2005 "European Consensus on Development"[3] is a key policy statement addressing EU relationships with non-EU countries and regions. The commitment on "Policy Coherence for Development (PCD)"[4] is a crucial part of the above Consensus, which explicitly addresses the external dimension of internal policies with a clear focus on achievement of the Millennium Development Goals and on aid effectiveness for development. It defines the EU vision of development and describes EC and MS common objectives and principles for development cooperation. It also sets out the renewed EC development policy to implement the European vision and identifies priorities which will be reflected in coherent development cooperation programmes at country and regional levels.

Nine focal "Areas for Community Action" are identified. Many of these areas and/or sub-areas require regular and targeted information and are, therefore, strongly concerned by GMES global land related services (i.e.. "*Environment and the sustainable management of natural resources", "Water and Energy", "Rural development, territorial planning, agriculture and food security", "Infrastructure, Communications and transport", "Conflict prevention and fragile states*"), while others (e.g. "*Trade and regional integration*") can also benefit from GMES Global Land products even if less directly.

Through the Consensus, the EU commits to "*deliver better and more aid*". It explicitly calls to "*consistently use an approach based on results and performance indicators*" to underpin decision making with objective figures and performance indicators in order to better orient the available funds. In light of doubling the funds allocated to development cooperation by 2010, strong analysis and monitoring capacity for country and sector assessment will be required for EU budget support as well as the need to set-up the necessary organizational chain (including data production on regular basis).

Te European Consensus insists on the importance of "Monitoring and Evaluation" and in particular of "Monitoring future implementation" in order to ensure increased impact and effectiveness. In this regard, the EU asks for the development of a set of "measurable" objectives and targets for implementing policies and to assess progress.

The Consensus also recalls the importance of Policy coherence to achieve policy objectives, as well as the crucial role of coordination and complementarity (/harmonization) between the EC and the MS to better respond to partner countries priorities at the country and regional level. To achieve it, ad-hoc sector platforms allowing the EC, the MS and the beneficiary partners to share common data/information and to carry out joint analysis and even joint programming processes, whenever possible, should be set-up.

All the above aspects clearly show the necessity to ensure data production and provision of land related information on a regular basis which would be provided by a GMES global land type of services. In fact, as provider of over half of all Official Development Assistance in the world the EU has a strong interest in optimizing fund allocation processes and prioritization, in post-project audit and evaluation and in mainstreaming environment into development aid programmes; reliable information on land surface processes can help improve the effectiveness of development aid delivery and help improve coherence between different policy domains underpinning development.

§ *European Consensus on Humanitarian Aid*

The European Consensus on Development also commits the EU to "*support disaster prevention and preparedness in disaster prone countries and regions*". Furthermore, the European Consensus on Humanitarian Aid[5] commits the EU to develop an overall policy approach to disaster risk reduction with a special focus on disaster prone countries and regions and the most vulnerable groups. In addition, the European Commission is currently developing an EU wide disaster risk reduction

[3] O.J. C46 of 24.2.2006

[4] "EU report on PCD" of 20.09.2007, COM 2007/545 and SEC 2007/1202

[5] http://www.ngovoice.org/documents/Consensus_final_OJ30JAN2008.pdf

strategy[6] which will formulate and prioritise the EU's support to disaster risk reduction in all developing countries as a contribution to the Hyogo Framework for Action[7].

In particular, in the forthcoming EU wide disaster reduction strategy, disaster risk reduction is identified as a cross-cutting issue to be integrated into development and humanitarian policy and planning. Therefore, developing the capacity for monitoring and evaluation of disaster risk reduction impacts of cooperation and humanitarian sectoral policies and projects is recognised as a necessity. This includes improving the identification and assessment of disaster risk and reducing the underlying risk factors. It also includes identifying, assessing and monitoring the high risk groups, communities and regions in the poorest and most disaster risk prone countries of the world in order to minimise the impact of disasters on these groups and communities. Moreover, the monitoring of potentially high risk areas, such as informal human settlements and urban landscapes, forms part of the global monitoring exercise of Target 11 of the Millennium Development Goals.

§ *Joint Africa-EU Strategy*

Another strong policy driver is the joint Africa-EU Strategy[8] that is currently high in the political agenda of the EC and MSs. From the operational point of view, the Joint Strategy will be implemented through successive Action Plans that identify the main political priorities for the short-term (2/3 years) plus the policy commitments, programmes and actions that will be needed to achieve them. The first Action Plan is structured around 8 specific "Africa-EU Partnerships", which include "Climate Change" (partnership #6), "Science, Information Society and Space" (partnership #8) and "Africa-EU Partnership on the Millennium Developments Goal" (partnership #4, which include food security).

Following the Maputo declaration on Earth Observation and Space, the Portuguese Presidency of the EU organized with the AUC and other African partners a workshop on GMES as side work session to the EU- Africa Summit of December 2007 in Lisbon. The main output of the workshop was the Lisbon declaration[9] which jointly highlighted the necessity for a joint EU-Africa definition of the roadmap of a special GMES initiative dedicated to Africa.

This roadmap will be submitted to the EU-AU Summit beginning 2010. It will offer a framework for a structured dialogue between Africa and Europe and will promote a consolidated approach for the provision and use of GMES Land data in Africa. In this framework, a consultation process started as integral part of the 8th AU/EU Joint Partnership on Science, ICT and Space. At the kick-off meeting of the consultation on 9-12 March, experts appointed by the EU/AU GMES and Africa consultation coordination group have been asked to provide feedbacks on this document to ensure coherence between the requirements for the GMES and Africa initiative and the GLOB-LAND component.

In fact, without pre-judging the final results the process, to date, emphasis has been put on a range of priorities such as food security, land degradation and forestry where eventual implementation would rely heavily on operational GMES global land services. In this regard, it is useful to recall that information on the location, condition and evolution of environmental resources, on food availability/demand, and on crisis situations can help Europe (both the EC and the Member States) and its partners, as well as the Africa Union Commission, to define, target, deliver and evaluate development Aid strategies and programmes.

§ *Other relevant policies*

Further policy drivers for thematic GMES land related services are the EC commitments, communications and/or regulations establishing Thematic Programs funded by the EC and/or setting up the rationale for EC intervention on specific sectors. Some of these key references are briefly recalled hereafter:

[6] http://ec.europa.eu/development/icenter/repository/Consultation5_issues_paper_EUStrategyFortDisaster_en.pdf

[7] http://unisdr.org/wcdr/intergover/official-doc/L-docs/Hyogo-framework-for-action-english.pdf

[8] http://ec.europa.eu/development/icenter/repository/EAS2007_joint_strategy_en.pdf

[9] www.itc.nl/aarse/PT_Presid_GMES_Africa_Lisbon_Declaration_final.doc

- the **Thematic Strategy for Food Security**[10]**,** which gives more details on the priority areas of interventions for food security such as: research and technological innovation; satellite imagery and data; capacity building; scientific networking; food security information and early warning systems. Strategic partnership with UN and multilateral agencies (e.g. FAO and WFP) in areas which make coherent contributions to EC food security programmes is also stressed.
- The **Environment and Natural Resources Thematic Program (ENRTP)**[11], which establishes a financing instrument for development cooperation. The ENRTP Strategy for 2007-2010[12] is based on the recognition that a healthy environment and sound management of natural resources are crucial for lasting poverty reduction, while strong international environmental governance is required to reinforce the sustainability of global development. Through the ENRTP, the EU has dedicated resources to help developing countries and partner organisations address environmental and natural resource management issues and meet their obligations under Multi-lateral Environment Agreements and to take international policy leadership.
- The **EU Energy Initiative for Poverty Eradication and Sustainable Development (EUEI)**[13], which is as a joint commitment by the EU Member States and the Commission to give priority to the important role of energy in poverty alleviation, and is a catalyst for action. With the Communication on "*Energy Cooperation with the Developing Countries*"[14] the EC established the necessary framework of intervention, acknowledging the importance of distributed energy for poverty alleviation and focusing on issues such as the crucial reforms of the energy sector Moreover, the EC document "*On the Future Development for the Establishment of an EU Energy Facility for ACP Countries*"[15] establishes the bases for the creation of an Energy Facility for ACP countries to improve access to affordable and sustainable energy services, benefiting the poor.
- The **EU Water Initiative (EUWI)**[16], which is the main tool for meeting the international community's goals on water at global level and was designed to contribute to the achievement of the MDGs and WSSD targets for drinking water and sanitation, within the context of an integrated approach to water resources management.
- Improving infrastructure and delivery of transport, energy, water, information and communication technologies (ICT) and urban development are one of the main objectives of EU intervention in developing countries.
- Addressing causes of conflicts (e.g. poverty, disease, lack of governance and rule of law) is an essential first step for the EU to help promote peace and development. In fact, the EC's approach to conflict prevention and peace-building, as enshrined in its **Communication on Conflict Prevention**[17], is to address the root causes of conflicts and build sustainable peace. In fact, as highlighted in the **EU security strategy**[18], competition for natural resources - notably water - is identified as one of the causes which likely to create further turbulence and migratory movements in various regions of the world.

Beyond general and specific policies on development issues, the European Commission has a longstanding commitment to natural resources and environmental mainstreaming into policies, programmes and projects. This commitment is based on specific legal obligations: **Article 6 of the EC Treaty** (environmental protection requirements must be integrated into the definition and implementation of the Community policies and activities), the **EC's 2000 Development Policy**[19]

[10] COM(2006)21 final

[11] Regulation (EC) N° 1905/2006, OJ L 378 of 27 December 2006, pp.41-71

[12] COMMISSION DECISION of 20.06.2007

[13] http://ec.europa.eu/development/policies/9interventionareas/waterenergy/energy/initiative/index_en.htm

[14] COM(2002) 408

15 COM (2004) 711 final

[16] http://www.euwi.net/

[17] COM(2001)211 final

[18] http://www.consilium.europa.eu/uedocs/cmsUpoad/78367.pdf

[19] COM(2000) 212. *The European Community's Development Policy.*

(identifying environment as a cross-cutting issue to be integrated into all priority themes and stressing the necessity of improving the monitoring and evaluation of environmental impacts of all co-operation programmes and projects), the **Strategy on Integrating the Environment into EC Economic and Development Co-operation**[20] and the **Coherence Communication**[21] (including environmental commitments to achieve the MDGs).

Moreover, a number of EU sectoral policies at European level present similar data requirements of the above listed ones such as, for example, the Common Agricultural Policy, including international market, and the 6th Environment Action Programme (2003-2010) which encompasses five environmental priorities for action: Climate change; Nature and biodiversity; Environment, health and quality of life; Natural resources and waste; International issues.

In all these cases, the relevance of GMES Global Land services and products is evident for programming, implementation and monitoring EU contribution to developing countries.

b) International environmental treaties

In a wider international context, the EU and Member States are Parties to many Multi-lateral Environmental Agreements (MEAs) which address among others: biodiversity and nature protection, climate change, desertification, management of chemicals and waste, transboundary water and air pollution, environmental governance, industrial accidents, maritime and river protection, environmental liability, etc.. In particular, the EC is a signatory to the three main Rio Conventions:

- the UN Framework Convention on Climate Change (UNFCCC)[22], which calls for *'systematic observations and development of data archives related to the climate system*' under article 4.1(g), and its Kyoto protocol which extends the commitments to reduce uncertainties related to the climate system (Article 10(d));
- the UN Convention to Combat Desertification (UNCCD)[23], which stresses the need "*to compile a baseline and to collect systematically data to identify the factors contributing to desertification*"; practical measures to combat desertification and mitigate the effects of drought based on identification of land degradation zones and the trend and dynamics of these processes can be directly derived from systematic global land observations;
- the UN Convention on Biological Diversity (UNCBD)[24], which aims at *'significantly reducing the current rate of loss of biological diversity by 2010'*. In particular, decision VII/30[25] and the MDGs lays out specific biodiversity indicators[26] as tools for the adequate management of biological diversity at local and national levels, for regional and global overviews of the status and trends of components of biodiversity.

The EC is also supporting:

- the UN Forum on Forest (UNFF) with the related "FLEGT" policy[27], whereby EU contributes to the transparency of the international timber market, and
- the UN Millennium Development Goals [28], where Goal I pledges to improve food and nutrition security and Goal 7 aims at protecting the environment.

[20] SEC (2001) 609.
[21] COM(2005) 134 final
[22] Council Decision 280/2004/EC and COM(98)353; OJ L 130 of 15.05.2002 and OJ L 033 of 07/02/1994
[23] Council Decision 216/98/EC
[24] OJ L 309 of 13/12/1993; COM(98)42
[25] http://www.cbd.int/decisions/?dec=VII/30
[26] UNEP/CBD/COP/5/3, 25 February 2000
[27] COM(2003)251
[28] COM(2005)131-132-133-134

The EC is committed to help the developing countries to meet their obligations and supports the mainstreaming of MEAs into the National Action Plans (NAPs) of developing countries as part of their national development strategies.

In the 1972 UN Conference on the Human Environment (Stockholm), in the 1992 UN Conference on Environment and Development (Earth Summit) and, in particular, in the 2002 World Summit on Sustainable Development (WSSD), world leaders proclaimed the need "*to promote the development and wider use of Earth-observation technologies.*" The outcome of the WSSD was one of the main drivers behind the decision to establish the Group on Earth Observations (GEO), which is responsible for the implementation of the Global Earth Observation system of Systems (GEOSS) 10-year Implementation Plan, to which GMES is a major European contribution.

The implementation and monitoring of the above listed Agreements are highly dependent from the quality and regularity of the information available. GMES Global land products and services will help to meet reporting and information gathering obligations[29] arising from European commitments to multilateral environmental treaties, especially the Rio Conventions on climate change, combating desertification and protecting biodiversity, as well as exploring options for new agreements.

In fact, land cover, land cover change, forests, carbon, biomass, soil, and water information are essential for supporting EU Member State reporting as well as EEA's commitment in the **UNSD Integrated Environmental and Economic Accounting 2003** (SEEA 2003)[30], currently under revision for 2012 update. In addition to global coverage, the frequency of monitoring is something very valuable for environmental now-casting allowing timely inputs into the policy process of economic decision making.

2.2. Links with GEO and other key international initiatives

Sustained provision of information concerning global land surface processes from the GMES LMCS will strengthen capacity for international cooperation on regulatory issues and enhance Europe's role in the development of global standards. Real contributions will also help Europe achieve a stronger role in international organizations, consolidating the European contributions to the GEO/GEOSS, the Terrestrial component of GCOS and GTOS, in particular, through the production of terrestrial ECVs.

In particular, the Global component of the LMCS will contribute to the **Global Earth Observation System of Systems (GEOSS)**[31] and its 10-year implementation plan[32], which aims at linking together existing and planned observing systems around the world and supporting the coordinated development of new systems where gaps currently exist. It is also promoting data sharing and common technical standards, so that data from the thousands of different instruments can be readily accessed, used inter-operably and combined into coherent data sets.

The vision for GEOSS is to realize a future wherein decisions and actions for the benefit of humankind are informed by Earth observations and information. The purpose of GEOSS is to achieve comprehensive, coordinated and sustained observations of the Earth system, in order to improve monitoring of the state of the Earth, increase understanding of Earth processes, and enhance prediction of the behaviour of the Earth system. GEOSS will meet the need for timely, quality long-term global information as a basis for sound decision making, and will enhance delivery of benefits to society in the following initial areas:

- reducing loss of life and property from natural and human-induced disasters;
- understanding environmental factors affecting human health and well-being;
- improving management of energy resources;
- understanding, assessing, predicting, mitigating, and adapting to climate variability and change;

[29] EEA reporting obligations database http://rod.eionet.europa.eu
[30] http://unstats.un.org/unsd/envaccounting/seea.asp
[31] http://www.earthobservations.org/geoss.shtml
[32] http://www.earthobservations.org/docs/10-Year%20Implementation%20Plan.pdf

- improving water-resource management through better understanding of the water cycle;
- improving weather information, forecasting, and warning;
- improving the management and protection of terrestrial, coastal, and marine ecosystems;
- supporting sustainable agriculture and combating desertification;
- understanding, monitoring, and conserving biodiversity.

Through GEO, the Global component of the LMCS will also contribute to:

- the **Global Climate Observing System (GCOS)**[33], which aims at providing the comprehensive observations required for monitoring the climate system, for detecting and attributing climate change, for assessing the impacts of climate variability and change, and for supporting research toward improved understanding, modelling and prediction of the climate system.

  The GCOS programme does not directly make observations nor generate data products but it builds upon and works in partnership with other existing and developing observing systems such as the WMO Global Observing System and Global Atmosphere Watch, the Global Ocean Observing System (GOOS), and the Global Terrestrial Observing System (GTOS). In particular, a set of **Essential Climate Variables (ECVs)** were originally identified in the implementation plan developed by GCOS and its partners[34] as the observations that are currently feasible for global implementation and have a high impact on the requirements of the UNFCCC and other stakeholders. All ECVs are technically and economically feasible for systematic observation. These variables are the ones for which international exchange is required for both current and historical observations and which are also recognized as an official task of GEOSS. GCOS is in fact the Climate component of GEOSS.

- the **Global Terrestrial Observing System (GTOS)**[35]**,** which addresses issues of climate change and climate variability, especially with regard to its effects on food security, the environment and sustainable development. It is developing possible mechanisms for a terrestrial framework and assisting the implementation of the 13 terrestrial ECVs, including the assessment of the status of available standards. An important role is also played with regards to international coordination; supporting the in situ Global Terrestrial Networks undertaking the observations; determining the requirements of stakeholders; federating and structuring the community of producers and users of forest and land cover variables through GOFC/GOLD and assessing the available methodologies and standards which are required. GTOS is also expected to become the Terrestrial component of GEOSS.

- the **Integrated Global Observing Strategy (IGOS)**[36], which is an over-arching international strategy for improving observing capacity and deliver observations relating to climate and atmosphere, oceans and coasts, the land surface and the Earth's interior. The goal of IGOS is to produce comprehensive global, regional and national data and information to satisfy the environmental information needs of policy-makers, and to support scientific and operational environmental programmes. IGOS has adopted a process of themes (including among others Global Carbon Cycle, Integrated Global Water cycle Observation (IGWCO), Land (IGOL) and Cryosphere) in which observations are made for selected fields of common interest among a group of partners. With the termination of IGOS partnerships at IGOS-P-15 in May 2008, all IGOS themes have moved under the GEO umbrella.

[33] http://www.wmo.int/pages/prog/gcos/index.php?name=news

[34] GCOS-92, 'Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC', October 2004 (WMO/TD No. 1219)

[35] http://www.fao.org/gtos/

[36] http://www.igospartners.org/

The Global component of the GMES LMCS will also be linked to the **Committee on Earth Observation Satellites (CEOS)** and more specifically its group on Land Surface Imaging (LSI) Constellation[37], which aims at promoting the efficient, effective, and comprehensive collection, distribution, and application of space-acquired image data of the global land surface. Its primary objective is to define standards (or guidelines) based on a thorough understanding of user requirements that describe optimal future LSI Constellation capabilities, characteristics, and practices.

[37] http://www.ceos.org/index.php?option=com_content&view=category&layout=blog&id=47&Itemid=38

3. Users' requirements

3.1. Users of the GMES GLOB-LAND services

A not exhaustive list of users of GMES GLOB-LAND services includes:

- § European institutions and agencies who need the information to assist policy development and implementation (e.g. DG DEV, DG AIDCO, DG ENV, DG AGRI, DG JRC, EEA, etc..);
- § National, regional or local governments among EU Member States and Partner countries who need the information to assist for policy development and implementation and to help meet mandatory reporting requirements (e.g. National Departments of foreign affairs);
- § International initiatives helping countries build and fund environment, development and disaster reduction programs, who need the information for the development of their policies and operational strategies and to direct the utilization of their resources (e.g. the UN System's organisations, World Bank, Global Environment Fund);
- § International initiatives and bodies (e.g. WMO, GCOS, IPCC, etc..) in support of international conventions (e.g. UNFCCC, UNCCD, UNCBD);
- § International agencies which operate their own Early Warning and Monitoring systems from continental to global scales (e. g. FAO-GIEWS, UNEP-DEWA, ECMWF, World Bank, UNHABITAT, UNDP, etc…);
- § Organizations at national and trans-national level both in Europe and abroad (e.g. Regional Implementation Centres of the AMESD project in Africa, ECMWF, etc..);
- § Members of the GEO, in particular those from developing countries;
- § Non-governmental organizations (NGO) for policy direction and project implementation (e.g Rainforest Foundation, Birdlife International, Wetland international, Greenpeace);
- § Scientists and research teams working on improvements to our understanding of the processes and uncertainties associated with Earth System Science (e.g. World Climate Research Programme, International Geosphere Biosphere Programme, International Human Dimensions Programme, DIVERSITAS, Earth Science System Partnership);
- § Other GMES services such as the Atmosphere and Emergency ones;
- § Civil society to access understandable and reliable information on global environmental trends (e.g. Aarhus Convention, Public Participation in Decision-making and Access to Justice in Environmental Matters);
- § Private sector (e.g. cash crop production, mining, infrastructure, forest exploitation, etc).

According to the different types of products they require, GLOB-LAND users could be distinguished in three groups:

a. Core service providers are value adder, they act in a network or as a stand alone provider. Service provider may be an industrial or institutional capacity from EU or the member states.
b. End users are political, administrative or private users of information, they have no or little data processing capacity and are usually completely outside the technical sphere. In general, they require elaborated products for the development, implementation and monitor of specific EU policies (e.g. development policies) and International commitments.
c. Downstream service providers or intermediate users, use Core Service information and generate information services, elaborating higher order products, that in specific cases downscale the larger scale GLOB-LAND products to the local/regional/national scales and apply a number of post-processing, modelling and analysis methods to meet specific end user needs. Such services will generally require the acquisition of additional data (i.e. in situ observations, socio economic information and statistics) to deliver economic or societal benefit. Alongside variables from the GLOB-LAND Component, they will allow the understanding and interpretation of observed environmental conditions and their impacts, and the identification of assets at risk.

3.2. Users' needs

All the above listed users require different types of information, for example on the location, condition and evolution of environmental resources, and on the high risk, vulnerable, communities and regions in developing countries, on food availability, on instability and conflicts, etc...

On the basis of the analysis of policy requirements and possible contribution from the GLOB-LAND Component, a set of policy areas has been identified:

- Climate Change, including Carbon fluxes;
- Land degradation and desertification;
- Forest resources;
- Biodiversity;
- Water resources;
- Agriculture, Rural Development and Food Security;
- Urban and regional development.

Support to Emergency / Security for disaster reduction and management was also considered.

In table 1, a summary list of the land variables and information required by these policy areas is presented. From the analysis of this table, it is clear that some data and products are needed by different application areas. For example, data on land cover and land cover changes, meteorological data (e.g. precipitation, temperature, evapo-traspiration, etc..) and topography (DEM) are needed for almost all areas. This is also valid for vegetation indices. Another common requirement across all policy areas is from reliable historical information to provide baselines against which to assess current situations and to detect and evaluate significant change and long-term trends.

The land variables and products presented in table 1 will be addressed by the Global Component of the LMCS, which should consider the geographical extent and accuracy needed, taking into consideration that some land variables and products may be provided by other European and international programmes.

Table 1 – *Land variables and elaborated product/indicators needed by the users according to different policy areas and the level of elaboration*

Policies	**Users**	**Land variables**	**Elaborated products/indicators**
Climate change	DG ENV, EEA UNFCCC, GCOS/GTOS, UNSD, WCRP	Terrestrial Essential Climate Variables (ECVs): - Maps of lakes in the GTN-L*, Lake levels, Surface temperatures of lakes - Maps of the areas covered by glaciers and ice caps - Ice sheet elevation changes for mass balance determination - Snow area extent, snow mass, snow water equivalent and permafrost - Directional hemispherical (black sky) albedo and white sky albedo - Land cover and land cover change - Land surface and near surface air temperature - Fraction of absorbed photosynthetically active radiation - Leaf area index - Above-ground forest biomass and forest biomass change - Burnt area maps, active fire maps and fire radiated power - Global near-surface soil moisture map, soil properties - Precipitation - Radiation, surface heat and moisture fluxes	- Natural CO2 stock and budget - Fire impact - Released C02 amount - Areas with higher reaction variability vs. climate interannual variability - Water resources, sea level rise
Desertification / Land degradation	DG DEV, AIDCO, DG ENV, EEA FAO, UNDP, UNCCD, UNCBD, UNSD	- Precipitation, radiation, evapo-transpiration - Soil properties/soil conditions and their trends in time (soil organic matter, salinisation, moisture availability, erosion) - Continuous time series of vegetation productivity indicators (VIs, FAPAR, LAI) to assess vegetation functional types and vegetation condition - Vegetation seasonality, productivity - Land cover and land cover change maps - Land use and management information - Dry matter production for non crop vegetation - DEM	- Land degradation risk index - Instability and conflict index - Identification of degradation hot spots (state and trends in time) - Integrated dryland condition assessments (e.g. rain use efficiency) - Desertification syndromes - Drought susceptibility
Biodiversity	DG ENV, EEA, DG DEV, AIDCO, UNCBD, UNEP, WCMC, GBIF, UNSD RAMSAR Secretariat	- Land cover and changes in protected areas and other sensitive areas - Vegetation indices (NDVI) - Vegetation seasonality, productivity - Fire seasonality, area affected by fires, fire intensity, diurnal cycle - Land use and management information	- Information on habitat deterioration such as fragmentation/connectivity - Evolution of fire regime in protected areas and surrounding buffer zone - Evolution of vegetation parameters in sensitive areas

Forest resources	DG ENV, EEA, DG AGRI, DG DEV, AIDCO, FAO, UNDP, UNEP, WMO and UNESCO WB and Regional International Development Banks	- Forest cover distribution and characterisation (incl. forest types, forest cover disturbance and density) - Forest cover change maps - Vegetation indices - Land use and management information	- Deforestation rates - Forest intactness - Monitoring of timber exploitation (incl. illegal logging) - Compliance tools for Reduced Emissions from Deforestation and Degradation
Water resources	DG DEV, AIDCO, ENV, EEA, UNESCO, WB and Regional International Development Banks, UNSD	- Runoff, precipitation, evapo-transpiration, stream flow, groundwater recharge - Soil moisture - Snow/glaciers area extent; snow water content - Maps of irrigated sites - Identification / location of small dams - Lake / reservoirs levels, Surface temperatures of lakes - Occurrence / seasonal variation of seasonal water bodies, water level in large rivers - Land cover and land cover changes - Land use and management information - DEM - Geology	- Average water available per watershed, water balances - Amount of water used for irrigated agriculture - Erosion risk maps
Agriculture / RD and Food security	DG DEV, AIDCO, DG ENV, DG AGRI, FAO, WFP, UNSD	- Temperature, radiation, rainfall estimates, evapo-traspiration - Vegetation indices - Maps of irrigated area and changes - Land cover information of agricultural and non agricultural areas - Land use and management of agricultural areas - Crop Phenology - DEM - Soil type and characteristics	- Water satisfaction index for food crops - Forecast /Estimates of major food crops and crop production; - Agriculture cover per groups of crops; land parcel map; changes in the extent and productivity of agricultural lands - Early warning of harvest shortfalls - Rangeland carrying capacity - Vulnerability mapping and assessments - Soil carrying capacity and water holding capacity
Urban Dev.	DG DEV, DG AIDCO, DG RELEX, UNHABITAT, UNDP, UNSD World Bank	- Land cover and change maps of urban and built up areas	- Monitoring of formal and informal rural / urban human settlements - Land losses or gain of urban land and built up area over time

a) Climate change

The policy area of climate change includes in first instance the provision of Essential Climate Variables (ECVs) identified by the GCOS initiative and a set of elaborated products and indicators, which are defined of crucial importance for instance into the Intergovernmental Panel on Climate Change (IPCC)[38] and the further development and validation of climate models.

In particular, with respect to Kyoto reporting, it is stated that "*terrestrial ecosystems are the largest single source uncertainty in the global carbon budget*"[39]. In order to attain the goal of reducing uncertainties in the global carbon cycle several key parameters (Table 1) need to be consistently integrated into a global environmental modelling system. Similarly the capacity to monitor the global water cycle is crucially linked to the observing water stocks in forms of snow, glaciers, ice sheets and land water bodies. Variation in these stocks may contribute to sea-level rise which is the second most important effect of global warming.

It is also important to remind that land surface variable such as precipitation, radiation, near-surface air temperature are key parameters to several core and downstream applications.

The space and in-situ components of the observing system need to be linked as they both contribute to the accuracy of the products. In-situ observations are also necessary to serve as independent validation dataset to monitor the quality of the climate change variables.

b) Desertification / Land Degradation

At UNCCD's COP8, an Addendum to the ten-year strategic plan and framework was recently adopted to enhance the implementation of the Convention through a set of indicators for the strategic plan's operational objectives such as the following ones:

- Reduction in the total area affected by desertification/land degradation and drought (O2/S4);
- Increase/Reduction in net primary productivity in affected areas (O2/S5);
- Increase/Reduction in carbon stocks (soil and plant biomass) in affected areas (O3/S6);
- Areas of forest, agriculture and aquaculture ecosystems under sustainable management (O3/S7);

All the above indicators could be supported by the provision of global land products.

It has to be acknowledged that the derivation of the indicators identified by the UNCCD COP process requires the integration of a number of bio-physical variables – essentially the same as the ECVs required for the UNFCCC - with data capturing socio-economic dynamics. It is thus of fundamental importance to understand that in the desertification context it will not be sufficient to define a set of primarily physical or categorical variables (to be primarily collected by space observation systems) which drive a single generic model of desertification.

The problem essentially requires the integration of quasi-continuous observations on coarse spatial scales for monitoring large dryland areas and identifying affected core areas, and high spatial resolution remote sensing systems for detailed diagnosis of land degradation and desertification processes.

The strong focus on dryland development implies that dryland observation strategies should not be constrained to detecting areas with negative impact or feedback on the human-environment system, but extends their scope to assessing available resources and monitoring their changes over time. Links with "climate change" variables such as soil moisture or precipitation, or to fire-burnt areas may provide key information to set indicators for droughts severity vegetation degradation which are precursor to desertification.

Needless to say that the existence of global observation systems with a significant space component is of major importance in this perspective. It is also essential to understand that the space component needs substantial integration with ground-based observatories and complementary data collections.

[38] http://www.ipcc.ch/

[39] 2007 - IPCC Fourth Assessment Report: Climate Change 2007

c) Biological Diversity

Based on the "2010 Biodiversity Indicators Partnership" coordinated by the UNEP World Conservation Monitoring Centre (WCMC), the full range of biodiversity indicators associated with the 2010 biodiversity target have been delivered. This important accentuation sets a prospective framework for future assessment and monitoring actions on national and international level.

Even if the major biodiversity data needs are in situ, reliable global land observations based on remote sensing can be used to monitor changes in the distribution and status of ecosystems. In particular, effective and timely monitoring of changes in the land cover within and along the borders of protected areas is needed to judge the effectiveness in protecting and conserving the regions from human impacts such as poaching, hunting, logging, urbanization, agriculture, mining, and road construction.

Building up a global picture of the relative importance of Protected Areas, their current status and changes over time, plus the threats to them help fulfil stated EU policy goals of protecting global biodiversity, and provide valuable evidence as to the effectiveness of actions put in place to achieve these ends. Improving the management of protected areas also has related policy benefits as such action is invariably linked to localised economic gains, either through the immediate impacts of tourism or through longer term benefits linked to the biological resources themselves.

The EC services in charge of conservation (DEV, ENV, AIDCO) are looking for information on the value of and threats to biodiversity (species and ecosystems) at regional level in order to improve the effectiveness of development-aid programming by targeting fund allocations where they are most needed, and where they can have most impact. Therefore, regular estimates of ecosystems changes in and around protected areas are required every 5 years. These are needed at relatively fine scales, with typically a minimum mapping unit of 10 to 30 metres. Such half-decadal measurements of land cover change need to complement with in situ studies concerning species richness as well as seasonal measures of processes such as fire frequency and timing, or changes in key phenological processes, such as greening up, senescence and the like.

Local managers of protected areas need near-real time information on the status of their PA in order to optimise the day-to-day management, by planning the ground interventions, the patrols, by monitoring the management practices, such as bush fires. Therefore, the need is more on a detailed vegetation mapping of protected areas (at fine resolution, every 5 years), the provision in real-time of monitoring data on water availability, fires, vegetation growth, regular estimates of the pressure around the PA by land-cover change analysis are also much needed for effective local management.

d) Forest resources

Three basic classes of information on forest resources can be identified:

(i) Near real-time wall-to-wall global coverage information on trends in global forest condition (i.e. phenology, seasonality, cover-disturbances), which are needed as an input to general circulation models and other global scale models such as the dynamic vegetation models used in carbon cycle and hydrological cycle studies. Changes in forest condition also provide indicators of localised climate change impacts as well as a means of monitoring forest management/protection/ conservation policies, and provide early warning and trend analyses to condition new policies.

Key observables include:

- an accurate, validated global map at medium resolution locating all forest resources for a fixed date (e.g. 2005) and updated every 3-5 years;
- daily measurement of biophysical properties (fAPAR and LAI) and disturbance features like active fires and burnt areas.

(ii) Maps of large forest areas in regional targets (wall to wall or sampled) every five years are needed for generation of greenhouse gas inventories, as called for by the UNFCCC; to construct accurate regional and global baseline deforestation rates, which are likely to form part of the Post-Kyoto reporting needs linked to Reduced Emissions From Deforestation And Degradation (REDD) in developing countries, to document occurrences of leakage associated with Kyoto Protocol implementation, to help review compliance with agreed conditions for forest based Clean Development Mechanism and/or Joint Implementation projects; to determine progress

towards the MDG "Ensuring environmental sustainability" by measuring the changes in forested land as percentage of land area and contributing to the measurement of the ratio of the land "area protected to maintain biological diversity" to each nation's "surface area"; to determine integrity of forest protection schemes by detecting disturbance – forest clearing and or fire – inside and outside protected area boundaries; and will help identify unwanted effects of biofuel policies or other similar trade-related activities which encourage changes in land use.

Key observables are land cover map at 10-30 m resolution, combined with disturbance observations, especially active fire and burnt area. Moreover, archived EO data must also be reanalysed to construct measurement points for the 1970s, 80s 90s and 00s – this exercise will be sample based as global cover from the earlier decades is unavailable.

(iii) Annual mapping of forest cover disturbance at individual tree canopy level (5 m or better) is needed for local, but clearly identified sites, in any forested region of the world to (a) provide transparency in reporting linked to the Forest Law Enforcement Governance and Trade process and (b) for verification of reported afforestation and reforestation activities in the context of CDM and JI projects.

Key observables include mapping infrastructure –logging roads, sawmill and transport staging points- coupled with accurate information on timber concession / CDM JI project scheme boundaries and maps of selective logging and or clear cuts depending on region of the world.

Whilst the EU has no mandate for monitoring and reporting on the forest resources of others, such information is valuable for developing and defending the EU policy position on forestry and climate change –as well as in other Multilateral Environmental Agreements; for forest trade and international law issues; for EU development-aid programming, project identification, implementation, monitoring and evaluation; and for studying the role of forestry in Earth System science - driving forces, pressures, state, impacts and responses.

e) Water resources

Water quantity, quality, and extent of water resources (including wetlands, lakes, dams, streams, estuaries, groundwater, melt water from glaciers and icecaps, etc...), mainly through water balances at watershed level, are information required for a wide range of areas such as agriculture, forestry, and municipal and industrial water supply, hydrometeorology including disaster assessment (e.g. drought and flooding), flood forecasting and warning system (EFAS), health issues, etc.

Due to the obvious importance of water availability and use, data collection programs of water supply and quality observation exist in most parts of the world at both local and regional scale, but there are significant differences in the density and frequency of in situ measurements which creates regional deficiencies in data availability.

On a larger scale and operating under the auspices of WMO and UN the Global Runoff Data Centre collects data from the major world rivers, but does not include several rivers and tributaries at national levels. The GTN-H tries to coordinate data collection of the different components of the hydrological cycle. Furthermore, stations are closed and opened on an ad hoc data, data is not standardized, meta data is often absent, and because of the economic value of water not publicly available. The stepwise implementation of the SEEA/W contributes to mitigating this gap in data harmonisation.

Therefore, there is a general need for increasing the density and quality of in situ programs (e.g., stream gauging, chemical and biological sampling, water clarity measures) and the timely delivery of the results (that are generally more valuable as immediately available provisional data rather than delayed fully validated data) but also for providing satellite based observations of water use (crop irrigation) and extent and for using models for water availability and assessments based on precipitation, evapo-transpiration, snow depth, DEM, land cover/land use, and soil information.

Moreover, new satellite technologies (GRACE, and in near future the European SMOS and US SMAP missions) can provide maps of changes in water storage over large areas and soil moisture mapping from space (e.g. ASCAT level 2) using active and passive microwave techniques is expected to reach maturity in the coming years. Altimetry too has proven effective for monitoring river discharge for the

larger rivers of the world (e.g. LEGOS programme). In combination with in situ data these may provide the required data for water managers and scientist studying the global hydrological cycle.

f) Crop production and Food security

Monitoring agriculture becomes more and more a global concern, as demonstrated by the recent fast increase and volatility of food commodity prices and its dramatic consequences on Food Security. In medium term, global population is expected to increase of circa 50% around 2030, but this would required to almost double present Food production in order to achieve the 1st MDG of eradicating Hunger on the planet (FAO). Increase of agricultural production, particularly agriculture surfaces, and rural development are back in the top priority Agenda of UN organisation and World Bank, as the only way to increase the livelihood of the poorest, living for 75% in rural areas and contributing to ensure Food sovereignty.

Therefore, sound knowledge of the areas on major agricultural crops at country levels is indispensable to major policy decisions concerning sustainable development planning and food security. They are closely interrelated and the globalisation of trade, the development of biofuels and the climatic change make crucial a closer monitoring of areas cultivated and production in developed and emerging countries.

Many of the World's poorest rely on grazing as the primary agricultural activity. The limited accessibility of many of these regions coupled with the vast geographic areas covered make detailed assessments using conventional in situ approaches very difficult. Nevertheless regular information on the extent and condition of rangelands, especially if translated into carrying capacity and linked to other variables such as availability of seasonal surface water resources are vital information for nomadic farming communities and for government.

Agricultural monitoring requires accurate and timely information on the area of land used for different types of cropping systems combined with forecasts concerning yields. This information helps policy makers and planners to support farmers in developed and developing nations with appropriate Policies, while ensuring consumers with secure and safe food supplies at fair prices.

Agriculture is closely linked to Land and environment. Rural development and land planning have to integrate a sustainable protection of the environment and biodiversity by avoiding over-exploitation of soil and water resources or restricting the conversions of natural ecosystems to agriculture.

More accurate and timely information on agricultural production is needed for:

- monitoring major food crops and crop production,
- forecasting or early warning of harvest shortfalls,
- measuring rangeland condition and establishing carrying capacity,
- agricultural development and sustainability by long term monitoring of changes in the extent and productivity of agricultural lands and their possible adaptation to the climate change..

In particular, for implementation of the European Food Aid and Food Security policy, timely information is needed by DG AIDCO on the food and crop situation.

g) Urban and built-up structures development

The increase process of urbanization, especially the growth of megacities in developing countries, and the relative increase of stresses on physical resources and infrastructure is an important phenomena which require up-to-date information at global level. Information on the evolution of road networks and other forms of transportation is often a key precursor to land cover change and habitat loss in these countries. Some of this information is:

- Density/population maps combined with natural hazard risks;
- Land-use planning in urban and peri-urban areas;
- Urban sprawl for cities and around cities, urban development characteristics.

h) Emergency / Security

Emergency response and security services generally require very high resolution (VHR) SAR and optical imaging capacities for detailed situation assessments. However, globally consistent and up to date thematic land utilisation geo-layers are required to help queue VHR acquisitions for detailed assessments. The lack of high quality geo-layers at sufficient spatial detail is particularly pertinent in developing countries. This is particularly important for emergency response, where limited satellite resources must be allocated to the mapping of most relevant impact areas, for instance, densely populated areas, often in near real time. Furthermore, medium and high resolution geo-layers assist in stratifying emergency response analytical image processing (interpretation, automatic and manual handling) and geo-statistical sampling and extrapolation. Regional and long term impact assessment of emergency events requires change detection applications at high and medium resolution. Moreover, very detailed spatial information on human urban and rural settlements are also needed for disaster risk reduction, including preparedness activities, impact assessment on population and infrastructures, rapid post-disaster relief and needs assessment, especially in vulnerable population areas.

The GMES-Land service should contribute to the GMES-emergency and security services and support emergency response globally, particularly damage assessment, by ensuring the provision of thematic information (e.g. human settlement geo-information layer covering rural and urban areas at regional or continental (e.g. Africa) level with a nominal scale of 1:50,000 or better, including temporary settlements such as refugee and IDP camps). This information could support the long-term systematic global monitoring, for example, of human settlements to allow for the identification, characterization and monitoring of vulnerable sectors of human settlements, and especially slums in poor urban areas, that are linked to security risks.

The GMES Land service will also contribute substantially to the conflict resolution and crisis management. These imply a systemic understanding of the inter-relationships of local/regional resource scarcity due to climate change or other global implications and its amplification by local factors like overuse and unsustainable exploitation or a modification in land use practices due to changing political regimes.

i) Integrated Environmental and Economic Accounting (SEEA)

The UN Statistical Division (UNSD) has set up a system of Integrated Environmental and Economic Accounting (SEEA2003) which has been approved by the UN Statistical Commission.

Environmental accounting currently includes land cover and land cover change, and water and will be extended in the 2012 revision process by carbon, forest, biomass and soil accounts. This is of importance for pan-European reporting as well as for the joint Eurostat - EEA's commitment in the revision of the SEEA 2003. The EEA is in charge of drafting the chapters on land cover accounts, ecosystem accounts, soil accounts – where land and biomass variables are expected to be approached via remote sensing as well as water assets accounts. In addition to global coverage, the frequency of monitoring is something very valuable for now casting a range of tables and maps and allowing timely inputs into the policy process of economic decision making.

SEEA revision offers the unique possibility of implementing a basic set of economic-environmental accounts based on the global monitoring of impacts, both physical indicators and monetary adjustments of the National Income and the real cost of commodities. In parallel joint EEA – ESA GlobCorine initiative, a reclassification of GlobCover, is needed for expanding the scope of land cover accounts.

UNSD via its accounting system will be an important user of pre-operational GLOB-LAND products.

4. Scope and service definition of the GLOB-LAND component

4.1. Scope of the GLOB-LAND component

The principal scope of the GLOB-LAND Service is **to deliver information products and services on the status and evolution of land surfaces in support to specific EU policies at international level and European commitments under international treaties and conventions**, such as the three Rio conventions on Climate Change, Desertification and Biodiversity.

The GLOB-LAND component addresses a wide range of resources and policies involving very diverse user communities at global, European, national, down to local level, which require diverse types of information, from common to specific in terms of thematic or geographical area.

On the basis of these requirements and in line with the overall scope of the Land Monitoring Core Service, objective of its Global component is to offer a portfolio of data and products, with different levels of elaboration (from pre-processed images to elaborated information), fulfilling both generic and specific application requirements:

- 'Multi-purpose' products common to a large community of users including:
  - (i) *Pre-processed space data* (e.g. corrected or ortho-rectified images, image mosaic, cloud masks, daily or weekly image composites, etc.);
  - (ii) *Reference data* based on the access to existing reference data (e.g. topographic data, soil and geological data, DEM, etc.);
  - (iii) *Bio-geophysical parameters* to support, among other issues, the implementation of the GCOS terrestrial ECVs;
  - (iv) *Land Cover/Land Use and Land Cover Change (LCC) products* at various scales (global, continental, national or local) and various time resolution (daily, weekly, monthly, seasonally or periodically every 1-5 years).
- Thematic products at outside EU, which are more dedicated to specific usage or applications at International level but still for a large community of users.

First priority of the GLOB-LAND component should be the implementation of the 'multi-purpose' services, while the thematic services should be implemented progressively, starting with already mature service elements. Moreover, as the domain of the thematic services is potentially very large, it will be necessary to select priorities and a modular approach will be required.

The **'multi-purpose' service component** will comprise:

1. a ***Global Systematic Monitoring Service***, which will produce bio geophysical parameters at global scale over all continents in near real time, typically on a daily to weekly basis, on a routine basis describing the vegetation state and dynamic. Seasonal vegetation products can be also derived with a time frequency of product update of 3 to 12 months. Global land cover/land cover change products will be also provided annually or every 2-3 years. Considering the requirements of long time series, a consistent re-processing of old space observation data and a re-analysis of time series are both requested.

   The bio-geophysical parameters will address primarily the 13 terrestrial ECVs and will be grouped into the following thematic domains: vegetation, fire, radiation, water, snow, glacier, ice sheets, and permafrost. These products are essential for modelling and understanding land surface processes and are needed by the international science community to answer the GCOS/GTOS requirements for the terrestrial domain. It is important to underline that the provision of ECVs will also lead to satisfying many other application areas.

   The derivation of most of these parameters will be based on Earth observation systems with rapid global coverage capacity and moderate-resolution (250-300m).

2. **a *Hot Spots ad hoc Monitoring Service***, which will address specific region of interest, at first place Africa in the framework of EU-Africa partnership on GMES services and possibly other regions such as South America, Central America and Caribbean, Small Islands and OCTs (Overseas Countries and Territories) and South Asia and Southeast Asia (see figure 1).

   The products generated by the Hot Spot service will be delivered on a *ad hoc* basis, upon request by European or international/intergovernmental institutions and initiatives (e.g. FAO Forest Resources Assessment). The products will be of limited coverage extension (regional maps or sample scheme) and lower revisit frequency (1-5 years).

   This service will include the provision of land cover and land cover change maps addressing thematic issues such as forest degradation, urban and built up structures sprawl, etc. They will however provide finer details that are needed for monitoring specific areas of interest and quantifying bio geophysical processes and validating global models.

The products provided by the Global systematic and the Hot spot ad hoc Monitoring services are of broad generic nature and will be used for deriving more elaborated thematic information addressing EU sectoral policies in specific thematic areas (e.g. Soil/Land degradation, Forest management, Water management, Urban development, Crop production and Food security, etc..). This more elaborated information could be provided within ***'Thematic' Core Services*** or targeted Downstream Services. This thematic component is still to be addressed and could encompass different types of function such as the production of indicators, statistics, scenarios and model-derived information in different application areas.

GMES Global land products could also be used as basic data by other GMES services, such as those from the Emergency/Security domain and the Atmosphere one. These products will also be of major importance to address climate change issues together with the information provided by the GMES Marine and Atmosphere services.

4.2. Service output parameters

Based on the analysis of user's requirements and on the identified criteria of technical maturity, relevance for policy making and policy implementation, acceptance by the user communities (user uptake), and sustainability in the long term (regarding data supply and demand), the products below have been identified as potential candidates for the GLOB-LAND component**.**

In the tables, the proposed variables for the Global Systematic Monitoring Service are reported with the following level of maturity:

- *Operational*: refers to Products that are generated routinely and that the user can rely on (i.e. they are always available).
- *Pre-Operational*: refers to Products that are generated routinely and are made available to users for evaluation. Further validation and algorithm improvement are expected before to become operational..
- *Development*: refers to Products that are under development.

a) Global Systematic Monitoring Service

The products provided by the Global Systematic Monitoring Service will be:

a. Land Cover/Land Cover Changes: land cover and land cover change maps and information at moderate-resolution (250m – 1km) will be produced annually or every 2-3 years at global scale, using multispectral and multi-temporal information.

   Land cover and land cover change information is needed by resource managers, policy makers, and scientists studying the global carbon cycle, biodiversity loss and land degradation. Global land cover maps provide a synoptic overviews and broad stratification of land cover over large areas. Changes in land availability for agriculture or forestry are a key factor in sustainable development of many regions, and can be a major driver of societal conflicts. Reliable land cover change information is crucial to monitor and understand a number of processes at Global level such as deforestation, desertification, built up area expansion - urbanization, land degradation, loss of biodiversity and ecosystem functions. Changes in land cover force climate by modifying water and energy exchanges with the atmosphere, and by changing greenhouse gas and aerosol sources and sinks. Therefore, land cover change information contributes to the understanding of climate processes as well as they are essential for improving land management. They will be used for addressing forest monitoring, agricultural yield forecasting and production monitoring, and for food security.

   An **operational global land cover** monitoring service will integrate information from different observation scales (for coarse to fine scale satellite data and in situ). It will also assume the use of all data sources from historical archives and present assets and future monitoring programs in a seamless and consistent manner, and it needs synergy with other observation products directly related to land cover (i.e. fire, biophysical variables, snow cover).

   The need for harmonization/standardized products is recognized. The UN FAO LCCS classifiers, taking into account the recent ISO development, could be proposed as a common language for land cover definition. Instead than hard classification, seasonal or dynamic land cover should be foreseen by combining various products such as LAI, fCover, etc...

   While land use is a very important variable, deriving land use information is clearly more challenging and needs further R&D at global scale. Moreover, it strongly relies on socio-economic or local knowledge. For these reasons, a land use service at global scale can not yet be considered as pre-operational.

   Land cover change needs to be specifically addressed (more than just as maps comparison), but is less mature in terms of change definition, methodology, etc….

The use of a Minimum Mapping Unit (MMU) for specification rather than satellite image spatial resolution, or in addition to the spatial resolution, should be considered; this is also in phase with an object-oriented approach at European level. Applications should illustrate each resolution requirement, e.g. fine scale land cover over the entire continents may not be useful on an annual basis for global applications, but could be needed in some areas for forest change monitoring and carbon stock change reporting.

Table 2a. List of Land Cover and Land Cover Changes products to be considered for the GLOB-LAND component

	Name	ECV	Horizontal resolution	Frequency of product update	Error[40]	Maturity
Land cover / land cover change	Land cover maps	X	250m / 1km	1year	15%	pre-operational
	Fine-scale land cover maps	X	10-30 m	1-5 years	15%	pre-operational
	Global land cover dynamics and disturbances (for several processes)	X	250m / 1km	Intra-annual/ long-time series	15%	pre-operational
	Fine-scale land cover change	X	10-30 m	1-5 years	15%	pre-operational

b. Vegetation variables: the high priority variables are: **LAI, fAPAR, fCover, TOC (top of canopy) reflectance** should be added. TOC reflectance would allow ultimately direct assimilation within process models. They will be provided on a daily to weekly/10 day interval basis.

These vegetation variables are needed for monitoring vegetation dynamic (e.g. the diurnal cycle of plant photosynthesis and respiration, growth, and differentiation with the seasons) and vegetation condition, for climate modelling and natural carbon budget assessment and for crop yield evaluation. They contribute to better assessment of actual evapo-transpiration. Care must be taken to ensure that the legend meets this full range of requirements.

Table 2b. List of vegetation variables to be considered for the GLOB-LAND component

	Type of service		Global systematic monitoring service			
	Name	ECV	Horizontal resolution	Frequency of product update	Error	Maturity
	TOC (top of canopy) reflectance					
Vegetation	Fraction of Vegetation Cover		250m / 1km	7/10-days	15%	pre-op
	Leaf Area Index	X	250m / 1km	7/10-days	15%	pre-op
	FAPAR	X	250m / 1km	7/10-days	15%	pre-op
	Biomass	X				development

c. Fire variables: Burnt area maps; Active fire maps; Fire radiative power.

These fire variables are needed for monitoring fire disturbance at global level for climate change monitoring and atmospheric chemistry analysis, for land cover mapping and change monitoring, for disaster management and for NWP models.

Table 2c. List of fire variables to be considered for the GLOB-LAND component

	Type of service		Global systematic monitoring service			
	Name	ECV	Horizontal resolution	Frequency of product update	Error	Maturity
Fire	Burnt area maps	X	250m	7/10-days	15%	pre-op
	Active Fire maps	X	250m / 1km	7/10-days	15%	pre-op
	Fire Radiated power	X	250m / 1km	7/10-days	15%	pre-op

[40] Depends on application

d. Surface radiation variables: Land surface albedo; Land surface temperature (LST); Downwelling long-wave radiation flux (DSLF); Downwelling radiation short-wave radiation flux (DSSF). They will be provided on a daily to weekly/10 day interval basis.

Surface radiation variables are used in a wide range of areas related to land surface processes including meteorology, hydrology, agro-meteorology, climatology and environmental studies.

Table 2d.List of radiation variables to be considered for the GLOB-LAND component

	Type of service		Global systematic monitoring service			
	Name	**ECV**	**Horizontal resolution**	**Frequency of product update**	**Error**	**Maturity**
Radiation	Land surface albedo	X	250m / 1km	7/10-days	5%	pre-op
	Land surface temperature		250m / 1-3km	6 hours/15 min.	1-2 K	operational
	Surface fluxes – downward short-wave		250m / 1km	7/10-days	5-10 %	operational
	Surface fluxes - downward long-wave		250m / 1km	30 min	5-10 %	operational

e. Water and soil variables: Lakes, wetlands, flood plains maps; Levels of lakes and big rivers; Lake surface temperature; Groundwater discharge and recharge; Actual Evapo-transpiration; Soil type, soil productivity, soils threats, soil moisture (up to 10-cm soil depth).

Water variables are needed for NWP and climate modelling, especially for large open lakes which have a regional impact on climate through albedo and evaporation; for monitoring lakes and big river also allows the prediction of freshwater supplies through the assessment of the regional water cycle as well as the assessment of changes in the regional water cycle and their impact on water quality, biodiversity and health. Water quality (through temperature and water colour) should be analysed. Wetlands, seasonal flooded areas and river levels are added as key variables in the service. The link with food security and carbon tasks, and with the atmospheric core services should be ensured

Several **soil variables** have to be considered in the GLOB-LAND component as they are essential for most of the thematic services: soil type (from which soil hydrologic characteristics – such as permanent wilting point, saturation, field capacity, hydraulic conductivity at saturation – can be broadly estimated); soil traits that characterize productivity, such as soil nutrients, soil texture, etc… Most of the soil variables can not be derived directly from Earth Observation but EO techniques can provide valuable information as auxiliary data to support the spatial prediction of the soils variables from the soil field surveys.

Soil moisture has an important influence on land-atmosphere feedbacks at climate time scales because it has a major effect on the partitioning of incoming radiation into latent and sensible heat, and on the allocation of precipitation into runoff and infiltration. Soil moisture is critical for agricultural productivity, forestry and ecosystem health and for understanding long-term changes, such as desertification. It is of major importance for hydrological modelling, groundwater management, agricultural management and hazard forecasting (soil erosion, land slides, flooding). Information on soil-moisture changes will help reduce process uncertainties and improve climate models and NWP. Soil moisture estimates also assist gas flux estimates in permafrost regions.

Table 2e.List of water and soil variables to be considered for the GLOB-LAND component

	Name	ECV	Horizontal resolution	Frequency of product update	Error	Maturity
Water and soil	Lakes maps. Wetlands/flood plains		30-250m	10-30 days	10%	operational
	Level of lakes Level of large rivers	X	> 4 km > 500 m	10-days	10 cm 20-70 cm ?	pre-op
	Lake surface temperature		1 km	1/10-days	0.5 K	pre-op
	Ground water	X	< 400 km	1-month	15%	development
	Actual Evapotranspiration		3 km	30min	0.1-0.4 mm/h	pre-op
	Water Quality					
	Soil type map					
	Soil traits and productivity					
	Soil moisture (up to 10-cm soil depth)	(X)	1-50 km	1-day	20%	pre-op

f. Snow variables: Snow area extent; Snow deep; Snow water equivalent (SWE), Snow melt area.

Snow is a key component of land-surface processes, especially at higher latitudes and altitudes. It affects surface albedo and energy balance at global and regional scales and modifies the overlying atmospheric thickness and surface temperatures. It also affects soil moisture and runoff thereby influencing water availability in many mountainous areas and surrounding lowlands in the dry season. In fact, snow, through the delay it induces between precipitation and melting, makes up a significant fraction of the water available for agriculture and water supply in many semi-arid regions of the world where changes in snow cover conditions can have serious economic and social impacts. Moreover, the high sensitivity of terrestrial snow properties to changes in temperature and precipitation regimes is recognized as a fundamental indication of climate variability and change

Table 2f. List of snow variables to be considered for the GLOB-LAND component

	Name	ECV	Horizontal resolution	Frequency of product update	Error	Maturity
Snow	Snow area extent	X	1km	1-7 day	5%	pre-op
	Snow area extent (mountain areas)	X	500m	1-7 day	5%	pre-op
	Snow depth[41]	X	10km	1-week	10%	pre-op
	Snow depth[42] (mountains)		500m	1-week	10%	development
	Snow water equivalent (SWE)[3]	X	10km	1-week	10%	pre-op
	Snow water equivalent (SWE)[4]	X	500m	1-week	10%	development
	Snow melt area (extent)		500 m	1-3 days	5%	Pre-op

g. Glacier, ice caps and ice sheets: Glacier and ice caps maps; Ice sheet topography and elevation changes.

Glacier and Ice information are needed to support early-detection strategies in global climate-related observations. Glacier and Ice caps analysis will be supported by the GLIMS community

[41] For global climate studies, not applicable in mountains
[42] For water management and climate downscaling

currently working on the creation of a global baseline data set. Change assessment over the past can be built from archived data sets.

Table 2g. List of glacier and ice sheets variables to be considered for the GLOB-LAND component

	Name	ECV	Horizontal resolution	Frequency of product update	Error	Maturity
Glacier and ice sheets	Glacier and ice caps maps	X	30-50 m	5-year	5%	pre-op
	Glacier surface topography		100 m	5-year	5 m (z)	pre-op
	Ice sheet margin		1 km	1-year	2 km	pre-op
	Ice sheet topography	X	1 km	1-year	0.5 m (z)	pre-op
	Ice sheet elevation changes	X	5 km	1-year	0.1 m (z)	development
	Ice sheet melt area		5 km	1-week	5 km	pre-op
	Ice flow velocity (glaciers, ice sheets)		100 m	1 year	3 %	pre-op

h. Permafrost: Permafrost extent;

Decadal changes in permafrost temperatures and depth of seasonal freezing/thawing are reliable indicators of climate change in high latitude and mountain regions. Like glaciers, mountain permafrost and seasonally-frozen ground can also provide a significant contribution to summer water availability.

For permafrost products (esp. thickness and extent), it must be highlighted that not all IGOS permafrost products are parameters directly observable from space. Permafrost model requirements determine product needs on regional to global scale. Based on the ESA permafrost user consultation workshop, the following list of variables is needed to model permafrost: *Land surface temperature* at 1 km daily, *Soil moisture at* 10 km weekly, *Vegetation/ land cover products at* 10-300 m every 1-10 year, *Snow parameters at* 1 -10 km daily – weekly, and *Duration of thaw at* 1 km weekly.

Table 2h. List of permafrost variables to be considered for the GLOB-LAND component

	Name	ECV	Horizontal resolution	Frequency of product update	Error	Maturity
	Permafrost extent continental (using indicators)	X	1 km	10 year	2 %	development

A **consistent re-processing and re-analysis capacity** capable of constructing reliable, internationally accepted long-term records is also requested to complete the monitoring capacity of the GLOB-LAND Component and to provide reliable information on trends and changes.

As shown in the variable tables 2, most of the products provided by the Global Systematic Monitoring Service are **terrestrial Essential Climate Variables (ECVs).** Through the provision of ECVs, the GLOB-LAND Component will aim to satisfy many other applications including the three Rio conventions on Climate Change, Desertification and Biodiversity and the requirements for environmental accounting.

The products should be compliant to standards (e.g. GCOS and WCRP of WMO). Uncertainty characterization is essential for an operational system. The accuracy following CEOS specifications should be defined including,:

- *threshold accuracy:* minimum acceptable quality,
- *target accuracy:* commitment from the producer,
- *optimal accuracy*: maximum expected accuracy.

Practical implementation rules for the accuracy assessment should be set up for each variable including the temporal sampling period & validation period, the validation spatial domain, the verification datasets and verification methods.

b) Hot Spots ad hoc Monitoring Service

The products provided by the Hot Spots ad hoc Monitoring Service will be:

a. Land Cover:
   - High-resolution land cover maps (10-30 m) and land cover change maps providing a reliable quantitative detection of land cover change in areas of interest. These maps will be produced every 1 to 3 years at regional scale, within specific regions of interest to be defined with the stakeholders. These maps may address specific thematic domains such as : forest-type and forest condition maps using FAO classification schemes, crop distribution maps for monitoring changes in distribution of cropland area and the associated cropping systems, glacier and ice caps maps delivered every 5-10 years at global level to support early-detection strategies in global climate-related observations.
   - Very High resolution land cover (<5 m) and land cover change maps will be also produced on an ad hoc basis, addressing e.g. urban and rural settlements, including temporary settlements as refugee and IDP camps, and characterization of poor urban areas as slums.

b. Vegetation: some local vegetation maps (fAPAR, LAI, fCover, Above ground Biomass) will be used as validation products, in combination with *in situ* data, for validating global bio geophysical products.

c. Fire: burnt area maps can be derived at regional scale for providing additional details on fire scars extension.

d. Water: lake and water body dynamic maps will be derived at regional scale for providing change analysis of the hydrological networks at watershed level.

e. Snow, glacier, ice caps and ice sheets: snow area extent can be derived locally for validating global products, ice sheet elevation changes can be monitored in specific rapidly changing areas at monthly to annual intervals

In the figure 1, the geographic coverage of the global systematic and a proposal for priority areas of the hot spot ad hoc land monitoring services is presented. The concept of hot spots can be approached from several angles corresponding on the one hand to a strategy serving European needs of information on global issues (e.g. contribution to international programmes, climate change…), and on the other hand to information needs for development policies (e.g. cooperation aspects in link with partners in the concerned countries):

- the scientific angle with the Climate Change as main driver. In this perspective, the hot spots should cover the areas which are the best indicators of diffuse processes (e.g. the mountainous areas) or the regions which group the main gaps and uncertainties in the models (e.g. the polar areas for the sea ice).
- the human angle with addresses the vulnerability of the population through the mutual interactions between population and natural resources. In this case, the number of potentially affected persons by natural disasters (e.g. south of Himalaya) or the vulnerability of the population (e.g. dry Africa) is an entry point for defining hot spots.
- the risk angle. From this point of view, two nested scales can detect at broad resolution the areas subject to anomalies or drastic changes, and the fine diagnostic is given only on risk areas.
- the environmental reporting angle. International conventions require increasing work for reporting carbon fluxes, biodiversity trends, dry lands evolution… The hot spots can concentrate on areas with specific needs of reporting and verification of reports. It also can serve the evaluation of development policies and projects. Another entry point is the pressure of anthropogenic activities on the natural resources, e.g. deforestation, water quality, …

The synergy between systematic observations and hot spots should also be explored in a more extensive manner:

- The LCMS Global component could produce on a routine basis maps to monitor risk areas, to be complemented, in case of drastic changes, anomalies or disasters, by reference maps at a finer resolution produced by the Emergency Response service.
- Many hot spot situations can be analysed by merging existing global products in integrated reports (e.g. the evaluation of the loss of productivity of the belt of Sahel must include soil erosion, ETP, LAI, forest cover change, NPP, runoff…). The hot spots could in this case focus on the development on integrated reports with added-value.
- Services on hot spots could target limited geographical areas between two cycles of systematic global products.
- A global strategy of data collection within hot spots should include satellite and in-situ data (taking profit of growing field data networks, like the carbon flux towers or the water level of rivers) and some socio-economic information.

GMES & Africa is a specific case, going beyond the context of GLOB-LAND component and corresponding to a political priority in the frame of the 8th chapter of the Partnership EU/AU. It consists of a joint development program, aiming at improving the use of Earth Observation by African stakeholders. The program intends to adapt some products of the LMCS to the African context, but most of activities will consist in building on existing capacities, in infrastructure reinforcement and institutional strengthening. The long-term objective is to increase the African capacity to produce and use sound information derived from Earth Observation.

It is recommended that GMES & Africa action plan and GLOB-LAND component document should be compliant in their main specifications.

As a conclusion, the hot spots concept must be examined with caution since it will address many different situations. The definition of hot spots should then be better driven by specific users, keeping in mind that the final choice of areas of interest is also driven by political considerations and is closely related to the interaction with local authorities in the frame of cooperation schemes.

In the red boxes, Africa, South America, Central America and Caribbean, and South Asia and Southeast Asia are highlighted as the regions of interest with low revisit frequency (annual to inter annual) and high spatial details.

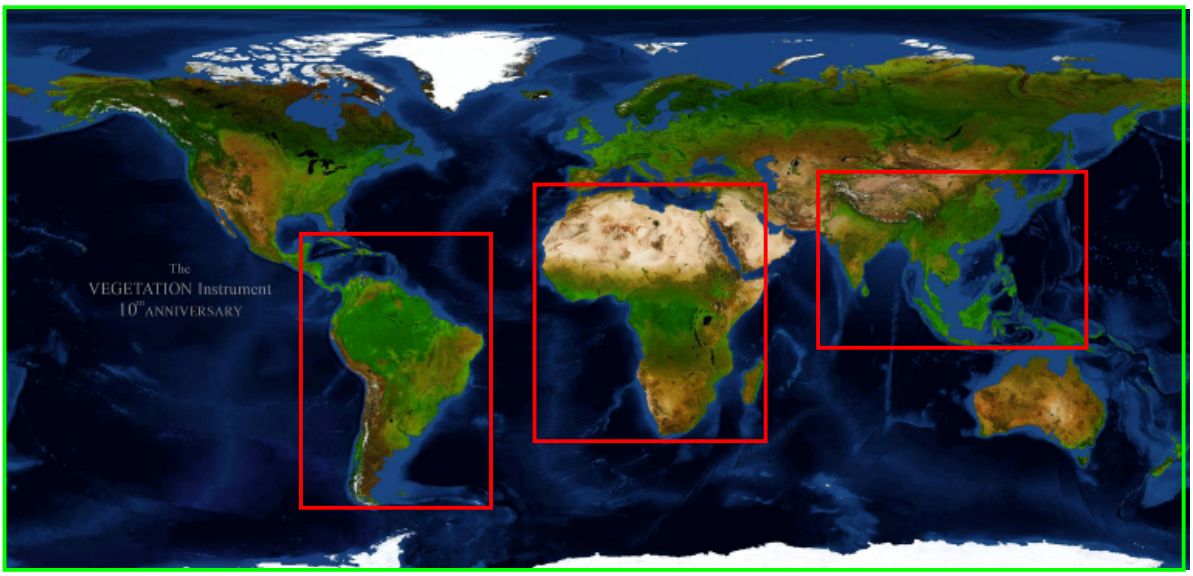


***Figure 1**: Geographic coverage of the GLOB-LAND service and proposed Hot Spot*
(VEGETATION image : copyright CNES, distributed by VITO)
Green box : comprehensive and systematic global coverage of land and Glacier ice sheets for bio geophysical parameters retrieval (with high revisit frequency (near real time) and limited spatial resolution)
Red boxes : proposed geographic coverage for the hot spots within regions of interest with low revisit frequency (annual to inter annual) and high spatial details.

c) Thematic services

The GLOB-LAND Component thematic services could cover different types of services such as: crop forecasts (yields), agricultural statistics (crop areas, rotations) and early warning on food security; water management (i.e. water quality, water supply, irrigation, etc..); forest management; carbon fluxes; and soil degradation and desertification.

The following three services have been identified as possible first bunch of thematic services to be implemented as part of the Core Service of the GLOB-LAND component.

Land Assimilation Systems for the carbon and water cycles. Both water and carbon require a similar data assimilation approach in which a model is constrained by as much relevant data as possible. In fact water and carbon are closely linked and it is possible to consider an integrated data assimilation scheme which includes both processes. The advantage is that consistency can be achieved across a range of products based on EO data. For example, products such as soil moisture, precipitation, evaporation, runoff, leaf area, carbon fluxes, etc. can be generated in such a way that budget constraints are satisfied. Consistency between water and carbon parameters is crucial for the study of regional budgets (i.e. continental scale, national scale) and for information to climate policy.

Regional carbon data assimilation should include the complexity of all the relevant processes that drive the carbon cycle including fires, soil carbon, lateral transport and bio-energy including biofuels.

Land surface modelling and land data assimilation for carbon and water is possible and therefore ensemble analysis is a feasible option to gauge uncertainty. Validation of products is a crucial component and can be realized through “in situ" networks such as FLUXNET, CARBOEUROPE etc… Anomalies reanalysis is also a powerful tool for uncertainty evaluation.

On the operational capability of the water and carbon communities, the step from a research to an operational mode is ready. For example, CARBOSCOPE[43] is already available on the web showing real time carbon flux maps using multiple data sources, including EO data. In the NWP centres and the Land SAF, it is a common practice to combine EO data with land surface models for the water budget. However, the systems can be improved by including more data (e.g. microwave data for soil moisture).

Crop production and Food security forecast service. Starting from the assumption that global environment and civil security issues are interlinked, GLOB-LAND may provide alarm function generating information on food security situations. These services build on more than 10 years of operational services funded by DG AGRI and AIDCO and developed by the JRC.

The primary goal of this service is to provide information for improving agricultural monitoring, famine early warning and food security. This activity should be complemented by developing the necessary capacity and infrastructure to make available and utilize these products, especially within the developing world. In particular, this service should provide:

- Global monitoring of agricultural production leading to accurate and timely reporting of national agricultural statistics and accurate forecasting of shortfalls in crop production and food supply and facilitating reduction of risk and increased productivity at a range of scales;

- Effective early warning of Food Security supporting the timely and appropriate mobilization of international response. Crop production is a key component of food Security (availability of food) but it directly conditions the livelihood of agricultural and livestock households (access to food) and more generally the market prices (access to food of the poorest).

To reach these goals, the service will ingest EO data and EO derived products in the crop monitoring systems such as biophysical variables (NDVI, fAPAR, DMP, LAI, Albedo, Soil moisture) and crop area estimates, cropland maps, rainfall estimates as input data into crop growth models. The use of the EO variables directly as yield indicator in statistical modules is also foreseen. EO variables will help to generate information on crop phenology, The classical approach of building "anomaly" products between the current year and the mean of the last years will also imply a standardisation of the data. Long Time archives continuity is highlighted as essential to improve the performance of the models.

The crop area estimates product could be based on combined EO (MR, HR, VHR) and in situ data (area frame survey) to be adapted to parcel size and cropping patterns. A strong in situ AFS requirement is a necessity as well as with the need of clear validation protocols.

[43] http://inversions.lsce.ipsl.fr/carboscope/index.php

5. The required space and in situ observation infrastructures

According to the GMES architecture[44], the GLOB-LAND component will rely on an Observation Infrastructure layer comprising two components: a space and an in-situ[45] component, having specific characteristics and requiring different management and governance schemes.

5.1. Space component

The space component required by the GLOB-LAND component comprise a set of land related missions and the associated ground segment and it is based on:

- § existing or planned European satellites of ESA, EUMETSAT and Member States (including meteorological and national high-resolution and very-high resolution multispectral and radar imaging missions.);
- § space infrastructure co-financed by the EU and ESA in the frame of the ESA GMES Space Component Programme (i.e. "the Sentinels");
- § non-European missions complementing the European GMES Space Component capacity.

a) Space-based observation needs

The following classes of space-based systems are needed by the GLOB-LAND component:

- High revisit/large swath-low resolution optical systems (VEGETATION/MERIS class missions): global daily 300m to 1km spatial resolution multispectral (B,G,R,NIR,SWIR) imaging;
- Medium resolution class optical sensors with large coverage capability (SPOT HRV / Landsat ETM+ class missions): global 10–30 m resolution multispectral (B,G,R,NIR,SWIR) imaging;
- High resolution optical sensors (SPOT5 PAN class mission): 2–5 m resolution in panchromatic imaging;
- Very high resolution optical sensors (QuickBird/IKONOS class mission): <1 m resolution multispectral (B,G,R,NIR) imaging;
- High to very high resolution SAR systems (ASAR / ALOS class mission): 1–50 m resolution L band, C band HH, HV imaging.
- Passive Microwave sensors (SSMI / AMSR-E, SMOS) L band

High revisit/large swath-low resolution optical systems and Medium resolution class optical sensors will be used by the Global Systematic monitoring service. High to very high resolutions optical and SAR Earth observation systems will be mainly used by the Hot Spot ad hoc monitoring service.

b) Existing and future capacities

Due to the characteristics and technical capabilities and limitations of remote sensing systems, the Global Systematic Monitoring Service will rely mainly upon optical large swath system providing high revisit frequency (ideally 1 day at equator) and low spatial resolution (250m – 1km) such as: MSG, EPS, VEGETATION, MERIS, AATSR, MODIS and in the future Sentinel 3, PROBA-V, CBERS 3, SAC-D, ResourceSat-2 and NPOESS.

In the 10-80 m resolution range, many systems can provide data such as: Landsat 5-7, SPOT4&5 (XS), EO-1, SAC-C, ALSAT-1, ResourceSat-1, CBERS-2 and 2B, THEOS, DMC (Bilsat, Nigeriasat, UK-DMC, Beijing-1), Monitor-E and in a near future Deimos-1, UK-DMC2, HJ-1A, TWSAT, CBERS-3, ResourceSat-2, LDCM, Sentinel 2.

[44] '*GMES Architecture and Governance principles*', GMES Bureau, 23rd November 2007, GAC-09-02

[45] the term 'in-situ' is used for all data collected from sources other than space-based Earth Observation

For optical sensors with a resolution better than 10 meters, systems like Kompsat 1&2, Spot 5 (Pan), ResourceSat-1, Formosat-2, Monitor-E (Pan), ALOS, Rapid Eye, CBERS-3 (Pan), Venμs and ResourceSat-2 can be considered.

SAR systems that can be used are: Radarsat 1&2, Envisat, Alos, TerraSar X, CosmoSkymed, HJ-1C, Saocom-1A 1B and, in the future, Risat-1, Sentinel-1, Radarsat-3, etc.

Additional Earth observation systems may be used, depending on data availability and on the maturity of processing chains, for:

- geology and soil characterisation with hyperspectral instruments (e.g. Aster, Hyperion, Proba/Chris, etc..),
- soil moisture with passive radiometer (AMSR-E, Smos) and scatterometer (ERS-WS, ASCAT),
- water extent, river discharge and topography, lake levels with both SAR and altimetry sensors (Jason-1, Jason-2, Envisat/RA-2, Altika, Cryosat, Sentinel-3, Swot, etc…),
- vegetation stress and vegetation water content with IR sensors (Modis, Aster, Bird, AATSR, AVHRR, HJ-1B/IR, Saocom, CBERS, SAC-D, NPOESS, Sentinel-3/SLSTR, etc…) and
- biomass estimation and 3D characterisation (ICESat, Spot5/HRS, Alos/Prism, Pleiades, Tandem X, etc..).

It is also to be noted that gravity systems such as GRACE are currently used by the research community to monitor monthly changes in groundwater storage at (sub-)continental and global scale.

In figure 2, the coverage capacity (from local to Global) and the revisit frequency (from diurnal to inter annual) of optical EO systems is presented with highlighted the area of pertinence of the Global systematic service in green and of the Hot spot ad hoc service in red.

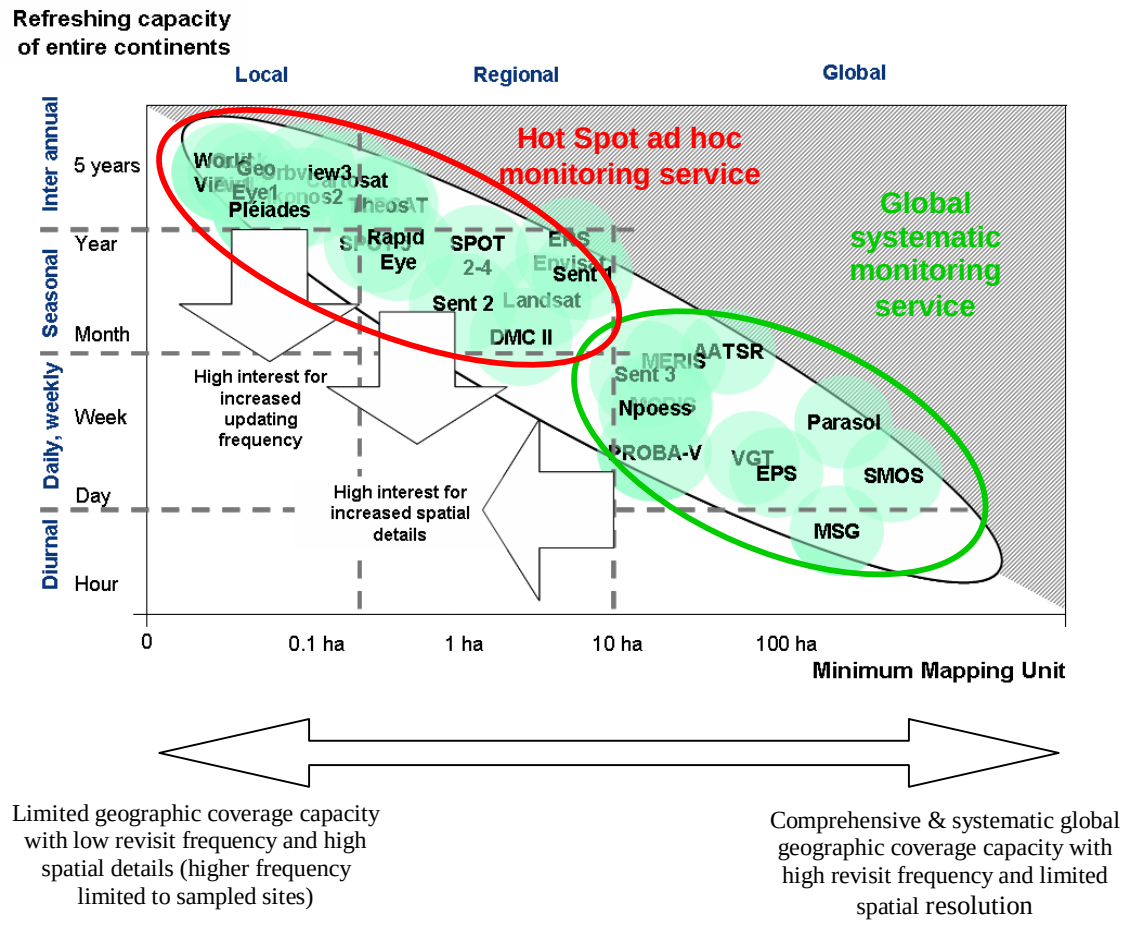


***Figure 2**: Coverage capacity of optical EO systems against revisit frequency and resolution.*

In annex II, an outlook of the Current space missions at EU and international level relevant for the GLOB-LAND component until 2020 is reported according to the different application areas, while in the figure 3 a summary outlook is presented highlighting the current and future space-based systems.

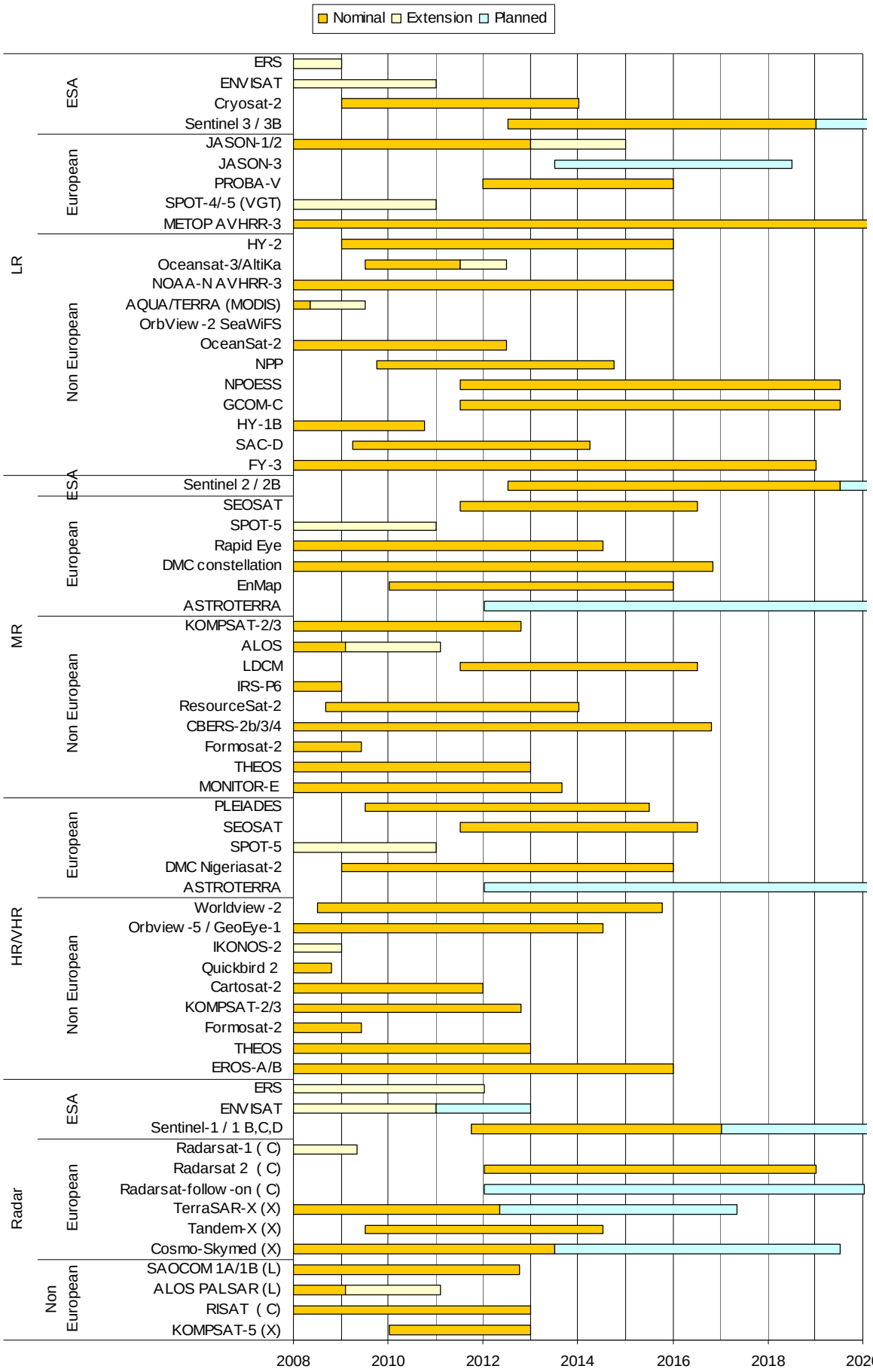


***Figure 3**: Summary outlook of the space missions relevant for the GLOB-LAND component until 2020*

c) Gap analysis

Based on the analysis of the on going and planned missions, the main outcomes in terms of availability, maturity, continuity, space/time coverage and their impact on the provision of the products of the GLOB-LAND component are:

- § Vegetation products (FVC, LAI, fAPAR, NDVI), lakes maps, burnt area maps, low resolution (250m-1km) land cover/land cover change maps, snow area extent maps, glacier and ice sheets maps will be assured by PROBA-V and Sentinel-3 missions. Beyond 2020, an instrument dedicated to vegetation monitoring is envisaged to be embarked on the sun-synchronous meteorological platforms in the EUMESAT Post-EPS missions.
- § Medium (30-10m) resolution land cover/land cover change maps, snow area extent maps, Glacier and ice sheets maps will be assured by Sentinel-2 and by LDCM until 2020 at least;
- § Active fire maps and Fire radiative power are provided by NASA Moderate Resolution Imaging Spectroradiometer (MODIS) and the ESA (Advanced) Along Track Scanning Radiometer (A) ATSR. Future systems, such as NPP/NPOESS VIIRS (that will provide similar measurements to MODIS at higher resolution) and sensors on ESA Satellite 3 should ensure continuity of fire mapping and detection capabilities until 2020 at least.
- § Radiation products will be assured by meteorological EUMETSAT (MetOp and MTG) and NOAA satellites (AVHRR-3). These satellites will also ensure provision of required precipitation products.
- § For levels of lakes and big rivers, Envisat, Jason-2, and in the future Jason-3 (pending upon decision), AltiKa, HY-2A, Cryosat-2, and Sentinel-3 missions will provide altimetry data that can be used to derive lakes and big rivers levels. A dedicated mission, SWOT, with a large swath interferometric altimeter, will provide more appropriate information if it is decided.
- § Lake surface temperature will be retrieved by MODIS, ASTER, BIRD, MSG, EPS/Metop and in the future MTG, Metop following units and NPOESS missions.
- § Actual Evapotranspiration can not be derived directly from satellite observations. Currently, only model products exist those are constrained by observations in various ways. Improvements can be expected from models that make a more comprehensive use of a wide range of satellite and in situ observations (e.g. related to radiation, precipitation, soil moisture and vegetation, near surface in situ observations). This should come along with model improvements. .
- § Soil moisture products will be delivered operationally through the ASCAT scatterometer instrument onboard the EPS satellite series of EUMETSAT. The Earth Explorer passive interferometer SMOS instrument is expected to provide in 2009 soil moisture data complementary to those of ASCAT. Follow-on acquisitions of soil moisture with this technique may turn out to be most interesting.
- § Snow area, depth and snow water equivalent: a number of satellites are used for these parameters. The snow area extent can be derived using multispectral sensors, TIR and SWIR being relevant for this and for discriminating with clouds.
- § Ice sheet topography and elevation changes: radar altimeters from satellites are used for measuring the thickness of sea ice. Cryosat-2, due for launch in 2009, will carry out this activity. Topography over sea and land ice caps can be derived with radar altimeter and SAR interferometry.

For high and very high resolution products, the continuity and availability of EO data will be ensured by:

- *High resolution optical sensors*: Astroterra/Spot 6 and Seosat/Ingenio, Rapideye and other missions;
- *Very high resolution optical sensors*: Pleiades together and US commercial systems or other international satellites (e.g. India, South Korea, Japan etc.);

- *High to very high resolution SAR systems*: Sentinel-1 for C SAR images, and TerraSar and Cosmo-Skymed for VHR X-band images.

d) Conditions for sustainability

The GLOB-LAND component will use the existing and forthcoming Earth observation systems in the world. The following conditions have been highlighted as main space component requirements for ensuring its sustainability:

- Continuity of satellite missions, ideally with overlap for new and old systems to determine inter-satellite biases and maintain the homogeneity and consistency of time-series. The first priority for global land applications are an ensured long-term continued provision of well calibrated high-, moderate- and low-resolution multi-spectral instrument to provide land and vegetation products.

  Given current and planned European space-based assets relevant to the GLOB-LAND component, data procurement agreements with non European Space Agencies and EO satellite operators will be needed to achieve this. More specifically, it is needed to engage formal dialogues and/or strength existing dialogues (e.g. within CEOS):

  a. between Europe (EC/ESA) and the United States relevant agencies (NASA, NOAA, USGS) to address possibilities for cooperation on future operational land missions, especially for Sentinel2/Landsat Data Continuity mission;

  b. similarly dialogues with other countries such as Canada (Sentinel-1/Radarsat Constellation mission), Japan, China and India, on possibilities for cooperation on R&D and operational missions providing relevant observations.

  These dialogues and agreements can be handled under GEO and supported by CEOS working groups on satellite constellation and in particular by the Land Surface Image (LSI) working group.

- Optimised data acquisition strategies to ensure global coverage which adequately samples vegetation seasonal cycles and accounts for cloud cover patterns: the LSI Working Group on Regional Data Set Compilation has the objective to define the necessary steps and agreements towards the 2010 Global Land Survey for assembling global coverage of mid-resolution land remotely sensed data for the 2009-2010 observing period in order to facilitate assessments of global land cover;

- Enhanced orbit control to minimize the effects of orbit drift, promoting more constant sampling within the diurnal cycle;

- Platform performance capable of giving geo-location accuracy and image-to-image registration accuracy of 0.5 to 0.3 of the target minimum mapping unit for each class of instrument;

- Calibration, pre-launch and post-launch to ensure adequate precision in product generation and for building consistent long-term records;

- Ground segments capable of generating the required products from the satellite observations.

It should be stressed that with the emergence of high quality medium resolution class instruments capable to systematically observe the continents (Sentinel-2 class) at relatively high revisit frequency, it will be soon possible to address regional to local needs of all continents. Thus, the scale limits of the Global systematic monitoring service will tend to shade off as bottom up models and top down desegregation processes will find common tools and will converge. For instance, the availability of cloud free 10-30 m resolution every 2-3 months over most of the continental part of the globe will open new applications in which the GLOB-LAND component should investigate quickly.

5.2. In situ component

The *in situ*[46] component is essential to GLOB-LAND component and is set to an equal footing as the space component. In situ land data serve mainly to:

(i) provide a comprehensive observation basis regarding the land surface

(ii) deliver long-term datasets to monitor trends and detect environmental changes in key terrestrial variables;

(iii) provide crucial verifiable data for calibration and validation of satellite products;

(iv) provide data to be integrated or assimilated within forecasting or analysis models;

(v) Provide regionalized and local data for use in downstream services.

Similar to the space component, the in situ component requires a specific observation infrastructure which is based on established networks and programmes at European and international levels. Ad hoc measurement campaigns/surveys or experiments enabling to collect data from e.g. field, or aircraft platforms complement these long term fixed networks and products derived (fully or partly) from in situ observation infrastructure, including e.g. meteorological forecasts and analyses, products such as Digital Elevation Models (DEM), geological maps, socio-economic information, etc., are delivered by external service providers (such as meteorological offices, mapping or geological survey agencies).

a) In situ observation needs

The in situ observation infrastructure required by the GLOB-LAND component should include[47]:

- Selected reference sites measuring biogeophysical processes, especially carbon and water flux for validation of satellite observations; continuity of FLUXNET sites;
- Georeferenced data describing phenology;
- Reference data and statistics from which to validate satellite derived maps of land cover;
- Georeferenced data defining protected areas, forest timber concessions and eventually REDD, CDI and JI project locations;
- Georeferenced point measurements of forest biomass;
- Georeferenced datasets defining the different types of cultivated areas used as crop masks to generate appropriate crop development time profiles;
- Post harvest yield estimates for validating crop growth models;
- River discharge and gauges;
- soil carbon, soil moisture, LAI, snow /ice mass ground data;
- Sustained reporting for all sites identified in the Global Terrestrial Networks for rivers, lakes, glaciers and permafrost.

GLOB-LAND component will also require the following products:

§ Meteorological data:
  - o Near Real-Time Global rainfall grids at high spatial (1 km horizontal resolution) and temporal resolution (i.e. hourly observations of precipitation);
  - o Temperature;

§ Global Digital Elevation Model (DEM) at high spatial resolutions (30m) for correction of imagery data and as input data in many models;

§ Thematic maps such as soil maps;

§ Socio-economic data (i.e. population).

[46] the term 'in-situ' is used for all data collected from sources other than space-based Earth Observation
[47] GMES in-situ requirement paper of EEA http://eea.eionet.europa.eu/Public/irc/eionet-circle/gmes/library

b) Existing capacities

At international level, a number of highly evolved monitoring networks exist and operate strong procedures of standardisation, archiving, reporting and system maintenance. Meteorological monitoring undoubtedly represents the most advanced of these, and sets a standard to which other systems at present can only aspire.

The components of several *in situ* observing systems already exist in Europe, and in the United States, Japan, and other parts of the world. Several independent research groups and national programs are currently taking the burden of running the observatories. As a result, measurement sites are numerous but records are not continuous and measurements can be shut down without notice. Instrumentation is not always traceable on a uniform scale and measurements protocols are sometimes non-existing or are not precisely followed. Developing new common methodologies, standards, data management systems and protocols will increase the cost-efficiency of European (and global) in situ observations.

Two types of in situ networks need to be distinguished: (i) those that essentially form a pan European network, as part of a global network, and (ii) truly global networks, where the EU takes responsibility for operating in situ measurements outside the EU geographical area.

However, the GLMCS in situ component is conditioned by one major consideration: the Global component of LMCS focus is for the most part on territories beyond the political and administrative authority of the EU bodies and of its Member States and associated countries. Therefore, setting in place appropriate in situ infrastructure and data collection practices will only be possible through bi-lateral agreements or if they are embedded in recognised international activities.

In particular, the specific activities on which to build are:

- the Global Terrestrial Networks (GTN's) sponsored by GCOS/GTOS and the Global Surface Network (GSNs) sponsored by GCOS;
- the phased implementation of the INSPIRE Directive will support a uniform infrastructure for sharing of spatial data; the SEIS (Shared Environmental Information System for Europe) initiative will provide access to all kinds of environmental data by MS and EU bodies;
- the FP7 Environment Theme, in its Sub-Activity "Earth and ocean observation systems and monitoring methods for the environment and sustainable development" , which can include in its annual Work Programmes topics of relevance to GLOB-LAND Component, including in situ observation needs.;
- the environmental research infrastructures in preparatory phase under the ESFRI program such as LifeWatch (biodiversity) and ICOS (carbon observatories);
- World Data Centres (WDC)[48] established by the International Council for Science play an important role in the archiving and data management of global data sets. Of particular relevance for GLOB-LAND Component are the WDC for Biodiversity and Ecology, the WDC for Land Cover Data and the WDC for Remotely Sensed Land Data;
- GEO, GEOSS and UNSDI which should provide the political focus for coordination of existing international capacities and European contributions to these capacities.

A number of FP7 projects will also contribute to the development of the GLOB-LAND Component. These include, for example:

a. EBONE - European Biodiversity Observation Network; a project to design and test a biodiversity observation system integrated in time and space;
b. e-SOTER - Regional pilot platform as EU contribution to a Global Soil Observing System;
c. EuroGEOSS - European approach to GEOSS, a project to demonstrate the added value to the scientific community and society of making existing systems and applications interoperable and used within the GEOSS and INSPIRE frameworks. The project will build an initial operating capacity for a European Environment Earth Observation System in the three strategic areas of Drought, Forestry and Biodiversity.

[48] http://www.ngdc.noaa.gov/wdc/list.shtml

For the Global DEM, the ASTER GDEM will be offered at no charge to users worldwide as a contribution to the Global Earth Observing System of Systems (GEOSS). It will be packaged in 1°-by-1° tiles, and will cover land surfaces between 83°N and 83°S with estimated accuracies of 20 meters at 95 % confidence for vertical data and 30 meters at 95 % confidence for horizontal data. The ASTER GDEM is expected to be available in the first half of calendar year 2009, and will be delivered in GEOTIFF format and geographic lat/long coordinates on a 1 arc-second (30m) grid.

c) Gap analysis

The main constraints relate to inadequate coverage (sparseness) or non-representativeness of the sampling systems. These problems arise from a number of circumstances, including:

- the often high cost of monitoring and instrumentation and the absence of funding to underpin the costs of constructing and maintaining adequate networks
- the local variability and complexity of the environmental media being monitored (which thus require high densities of monitoring sites). Furthermore, the current field observations have not always been designed to be related to satellite observations. Due to the specific and different spatial support area and the landscape heterogeneity, current field measurement should be complemented to allow better consistency with satellite observations.
- the inaccessibility of some potential monitoring sites.

Other problems include:

- the lack of continuity, often as a result of difficulties in securing funding for long term operation.
- the lack of consistency between different networks - e.g. in terms of the sampling design or In situ observation infrastructures should ideally be organized on the basis of the existing and mature measurement infrastructures for which observational techniques and protocols are available. The main critical issue regarding these observational data is the sustainability of its infrastructure including the supporting networks.
- measurement methods.

For the provision of global hourly precipitation the major issue is that data are not shared, and the development of comprehensive analyses has proven difficult (precipitation products available from the Global Precipitation Climatology Centre provide a valuable contribution to the community). At present, precipitation in routine reporting is often given in 6-hourly accumulations. Further, attention to coordinated, calibrated hourly observations is needed, with real-time data sharing. A strategy for a global hourly precipitation product needs to be developed. Over land it should include recording rain gauges, hourly observations, radar measurements, and satellite-based observations where practicable. Over the oceans, the main observations come from space using combinations of geostationary and polar orbiting satellite instruments. In the future, coordinated satellite measurements from the Global Precipitation Mission (GPM) will help enormously. Much more attention needs to be given to hardened in situ precipitation measurement during severe weather events, especially as more observing systems are automat.

d) Governance/financial issues to be addressed

Beyond the non-trivial technical issues such as data availability, data quality and data access, the two major governance/financial issues related to observational data that require attention are operational sustainability of observational infrastructure and network integration.

Member States often have highly developed structures for the collection and sharing of environmental data. Nevertheless, many important observation infrastructures are currently strongly dependent on research funding. The current dependence of GMES on FP7 funding would perpetuate this. Hence, the operational sustainability of some observation systems essential for GMES Core Services is as yet not assured. In a similar way, financial incentives are lacking to properly maintain key historical databases.

Quite often data are collected for different purposes, than used in the GMES land monitoring services (i.e. runoff data of catchments for water management instead of monitoring the effects of climate

change on water resources). Networks for the collection and dissemination of environmental data are developing in response to emerging needs, but are thus not always in a position to provide standardized data to GMES services. Two issues are evident:

1. First, there is generally a lack of coordination and harmonization of networks at the European level and certainly at international level.
2. Second, European networks are often linked without considering that national networks reflect national priorities/methods with immediate consequences that the resulting composites often are not representative for the state of European or international environment.

Data access is currently limited. Most of the relevant in situ infrastructures are in the ownership of Member States, who have very different economic models for their operation and maintenance, and consequently apply very different access policy from totally free to fully commercial. In some cases, historical data have less commercial value than recent ones: they are often freely available, while near real time data often require licensing fees.

There is currently a large incoherence between information providers in terms of data access policies, which GMES should aim to harmonize together with EEA under, among other, the SEIS process and the implementation of INSPIRE directive. The following issues currently hinder effective information provision:

- § the pricing and product licensing conditions is often not clear, pricing for public use may be excessive and hence discouraging;
- § legal issues and institutional problems regarding further use of information: restrictions of use, differences between conditions of access and use;
- § lack of agreements with relevant information providers for an operational and sustainable provision of/access to their information (e.g. meteorological offices, water boards, national mapping or geological survey agencies, etc.).

Moreover, appropriate research activities should be implemented to ensure the development of state-of-the-art in situ observation infrastructure and related capabilities in terms of data analysis. Some of this is currently being addressed through the ESFRI protocols (carbon, biodiversity, water).

e) Proposed way forward

In situ observation infrastructures should ideally be organized on the basis of the existing and mature measurement infrastructures for which observational techniques, agreed standards and protocols are available. The main critical issue regarding these observational data is the sustainability of its infrastructure including the supporting networks.

Discussions with the information provision communities (if possible through their European coordination bodies), and especially with the institutional ones, should be engaged in order to agree on a common approach regarding GMES Core Service requirements and their evolution, and to sustain the information provision – and its associated conditions – to the GMES services.

A proposal is to select a number of networks for participation in a fast track in situ effort based on a set of criteria such as:

- Maturity of the network (state of harmonization/standardization, availability protocols, data quality control and data access);
- Relevance to global networks (e.g. the network forms part of a global network, e.g. GTN-G, GTN-H, FLUXNET, etc);
- Critical to understanding of changes in System Earth (GTN-P, LifeWatch, ICOS);
- Critical to providing local scale data and calibration/validation data for the space component of Global Land services.

GLOB-LAND Component can identify these networks and help in providing the infrastructure to run the networks over a long period of time, with guaranteed data access. Initial Data centre establishment for networks should be promoted and actively stimulated. In consultation with EEA the services should aim to further develop the appropriate coordination functions, including the liaison with the European Meteorological Infrastructure.

6. Architecture and functionality of the GLOB-LAND component

The overall architecture of the LMCS has been defined by the LMCS IG[49]. The LMCS architecture should be **modular and flexible** enough to enable the progressive incorporation of new service elements combining functional or thematic service centres at national and international level in a flexible architecture. The LMCS architecture will be a mix of centralised and decentralised centres. For a better synergy and cost efficiency some generic functions (e.g. data access and pre-processing) can be centralised and shared between several service elements. The 'thematic' services will require a lot of specific local expertise.

The Global services have been separated from the European services in the architecture, as they involve different actors, even if the functions and methods are quite similar between thematic services at European level and Global level. However, there will be interaction between the Global and European services because, for example, the bio-geophysical parameters at global level will be also used for thematic service elements at EU level.

The functional architecture of the LCMS Global component should cover all functions that are needed to operate the service on an operational basis (Figure 3). Upstream to the LCMS Global component are the data collection and access, both for space and in situ data with adequate spatial, spectral and temporal characteristics. It is assumed that these functions will be covered by institutions and agencies outside the LCMS Global component (space agencies, national and international in situ networks, aircraft observations…etc).

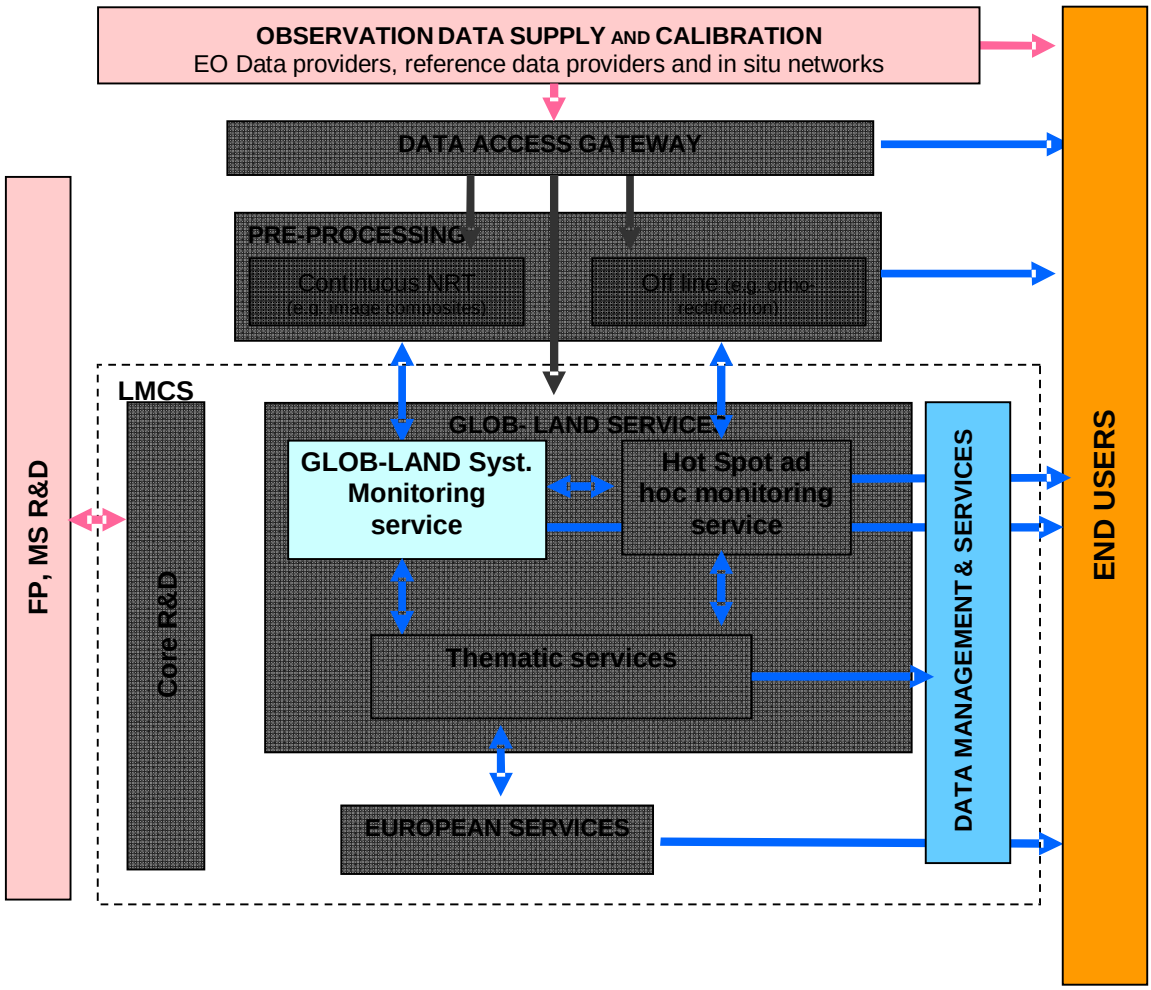


***Figure 3** - Functional architecture of the GLOB-LAND component*

[49] In 'GMES LMCS Architecture and Governance', LMCS Implementation Group, final draft, 12/12/2008

a) Data Access gateway

The aim of the data access module is to interface with data providers of both space and in situ data in order to ensure the acquisition of all necessary data. The identified data providers are:

(i) For Earth Observation data: the **Space agencies**, such as ESA, EUMETSAT, other Space Agencies within and outside Europe and data **procurement agencies** operating commercial satellites;

(ii) For in situ monitoring data: **operational and research in situ networks,** including **aircraft operators (aerial photography)**;

(iii) For reference data: **external service providers** such as meteorological offices, mapping or geological survey agencies;

The Data Access module will include the following tasks:

§ Procurement agreements with the data providers in terms of type, format, acquisition time, frequency, geographical coverage and delivery time;

§ Data acquisition: continuous near-real time collection of EO data (e.g. large swath sensors, meteorological data…) for the systematic processing of bio-geophysical parameters, and off-line dedicated or "ad hoc" data requests over areas of interest on predefined periods (e.g. satellite programming, aerial photographs campaigns, etc…); archive collection of EO data;

§ Acquisition control and validation, including real-time feedbacks to the data providers on data quality and availability.

For EO data, this module could be part of a Coordinated Data Access function part of the GMES Space Component coordinated by ESA, as it is now the case for the Land Fast Track Service precursor and for the FP7 GMES projects, or it could be embedded directly in the core service.

b) EO data pre-processing

The Pre-processing module will include the following tasks:

§ Multi-sensor inter-calibration and pre-processing of Earth Observation Data to level 2[50] for deriving long time coherent series and advanced products after correction of all effects affecting the radiances (e.g. atmospheric effects, viewing angles, topographic effects, etc…). This function includes:

- image ortho-rectification,
- topographic normalisation (both optical and SAR data),
- atmospheric corrections (ground reflectance),
- cloud masking,
- image inter-calibration;

§ Provision of the pre-processed data to the two core production services and to the data management services, together with the relevant quality information, for archiving and distribution to the GLMCS Users.

It is assumed that data providers are responsible for the calibration of their sensors and this function should be embedded in the GMES Space Component. In fact, space agencies usually commit themselves for the processing of their satellite data up to level 1B[51] for near-real time and archive. However, for the ESA sentinels the provision of some level 2 products is already foreseen. Therefore

[50] LEVEL 2 = Retrieved environmental variables (e.g., ocean wave height, soil moisture, ice concentration) at the same resolution and location as the level 1 source data. Source: CEOS GENIUS

[51] LEVEL 1B= Radiometrically corrected and calibrated data in physical units at full instrument resolution as acquired. Source: CEOS GENIUS

the EO data pre-processing function will be probably partially embedded in the core service and partially in the space component.

c) Global Core Services

- **Glob Land service**

This service element will be developed using existing assets from on going projects and activities, such as FP6/geoland, FP6/Cyclopes, FP6/VGT4AFRICA, FP7/DEVCOCAST, FP7/geoland2, FP7/DevCoCast, AMESD, ESA GSE and DUE projects (Forest monitoring, GMFS, Globcover/ Globcorine, Globcarbon, GlobGlacier, GlobSnow, Permafrost).

Based on the inputs from the acquisition and pre-processing module, the Global systematic monitoring service will lead to the production **on a systematic basis at global scale** of level 2, 3[52] and 4[53] land bio geophysical variables.

The functionalities of the Global systematic monitoring service are:

- § Producing global mosaics and composites (e.g. daily to weekly/10 days and monthly composites) of optical image (ground reflectance) and land biophysical parameters at global scale in near real time (level 3 data) for the use in global forecasting models ;
- § Deriving global land cover classification and land cover change analysis in terms of trends and intensity, with the detection of hot spots and vulnerable areas;
- § Implementing quality control and validation of all generated products consistent with the data management service requirements;
- § Providing a subset of the products to the European Land Core Monitoring service;
- § Provision of the products to the Hot Spot monitoring service and to the data management services, together with the relevant quality information, for archiving and distribution to the GLMCS Users.

The production of near real time bio-geophysical parameters is essential for global modelling and forecasting activities, such as: crop yield and food security forecasting, water cycle modelling and water resources/availability and quality forecasting, desertification modelling, carbon flux / sources and sinks modelling. Existing projects and activities will take benefit of the global systematic monitoring service: depending on their generic nature and maturity, they will be considered in the modular implementation strategy of the GMES services, and their possible inclusion into the GLOB-LAND component will be studied at a later stage.

For the processing chains corresponding to level 2 and some level 3 products, including multi-sensor combination, an option is that it will be part of the core service perimeter. The other option is that it will be part of the GMES Space Component or a mix of both, depending on the satellite ground segments (Sentinels L2 is proposed as part of Space Component).

- **Hot Spot ad hoc monitoring service**

Based on the inputs from the acquisition and pre-processing module, the Hot Spot inter annual monitoring service will lead to the production, **on an ad hoc basis and at fine scale**, of level 3 and 4 land bio geophysical variables **over areas of interest of limited extent**.

The functionalities are:

- § Producing land cover and land cover change maps at fine scale (using high to very high resolution sensors) over specific regions upon request by EC/DGs and MS. These maps will address forestry, crop distribution, glacier, urban settlement…etc;

[52] LEVEL 3 = Data or retrieved environmental variables which have been spatially and/or temporally resampled (i.e. derived from level 1 or 2 products). Such resampling may include averaging and compositing. Source: CEOS GENIUS

[53] LEVEL 4 = Model output or results from analyses of lower level data (i.e. variables that are not directly measured by the instruments, but are derived from these measurements). Source: CEOS GENIUS

- Generating bio geophysical parameters at fine scale for validating global products, providing more detailed information of land processes and evolution in specific regions of interest;
- Implementing quality control and validation of all generated products consistent with the data management service requirements;
- Provision of the products to the Hot Spot monitoring service and to the data management services, together with the relevant quality information, for archiving and distribution to the GLMCS Users.

d) Data management and services

This service element consists of three main components:

- **Coordination of Quality Control (QC)**: it shall ensure the coordination and specification of quality control and scientific assessment of products and services that will be delivered by the GLOB-LAND component. This activity concerns quality control of internal core services and of all input data delivered by external procurement agencies. This module will (i) establish recommendations and guidelines for all QC, standards and validation procedures to be implemented within each production core service, (ii) carry out regular internal reviews following internationally recognised standards and best practices, and (iii) provide the users with relevant information on the quality of GLOB-LAND products. Transparent QC is essential for the appropriation of the products by the users as well as the use of in situ observations and satellite data for product calibration and validation. An independent service validation process should be set up in parallel to the LMCS, with a strong scientific basis and a strong end-user relationship.

- **Data archiving and reprocessing**: the archive module is needed to handle and maintain long-term series of GLOB-LAND products. The creation and maintenance of long-term products archives is a key when implementing a sustainable GLOB-LAND component and for ensuring its long-term memory. It is mandatory for subsequent reprocessing activities, allowing future investigations of problems or assessment of trends, and for modelling work, e.g. climate change.

  Good quality metadata is required for saving information describing key attributes of relevant data and information. Finally, the data archiving and reprocessing module will provide all necessary facilities for reanalysing and reprocessing all generated products of past periods until the present time to deliver top quality historical series. It will apply INSPIRE directive recommendations related to archiving, restoring, viewing, metadata and dissemination principles. The archives will be maintained by few mandated institutions under a network organisation (system of systems).

- **Product dissemination**: this module is essential for the success as it will be at the interface between the core services of the GLOB-LAND component and the users providing the access to GLOB-LAND products. It will be responsible for the organisation and maintenance of :

  (i) a one-stop-shop data access portal which allow the access of all GLOB-LAND products, based on a distributed system of archiving centres, according to SEIS principles; EUMETCast and with GEONETCast could be also considered to disseminate GLOB-LANDproducts and data;

  (ii) a centralised catalogue of the full portfolio of products (including intermediate and elaborated products);

  (iii) a clearinghouse system with suitable metadata descriptions of the datasets and services;

  (iv) a discovery service, a viewer service and a download service to all GLMCS users;

  (v) a data dissemination system for Near Real Time products for dissemination of large amount of data with stringent timeliness enabling access for real time users and for users in areas with poor internet coverage;

(vi) a help desk to answer to the user questions on the use and the meaning of the products, as well as to collect user feedback required for product improvement.

This module will implement the GMES Data Access policy. In addition, it will maintain statistics on the availability of servers, on delays of products generation and availability, and more generally on the overall quality of the GLOB-LAND component Data and products dissemination services. The GEOSS data share principles should be adopted for data dissemination.

e) Interface to the GEOSS

The primary goal of the GEOSS is to connect the producers, users, and integrators of environmental data and to enhance the relevance of Earth observations to global issues. Therefore, GEOSS defines a global public data access infrastructure that provides near-real-time environmental data, information, products and analyses for a wide range of users. This "GEOSS Common Infrastructure" (GCI)[54] allows users of Earth observations to access, search and use the data, information, tools and services available through the GEOSS and consists of four main elements:

- the GEO Web Portals provide the direct web interface through which users access GEOSS and search for information and services;
- the GEOSS Clearinghouse, which connects directly to the various GEOSS components and services, collects and searches their information and distributes data and services via the Portal to the user;
- the GEOSS Components and Services Registry, which is similar to a library catalogue;
- the GEOSS Standards and Interoperability Registry, which enables contributors to GEOSS to configure their systems so that they can share information with other systems.

To integrate the GLOB-LAND component into the GEOSS, the GLOB-LAND services will be registered in the GCI. Through this process, the essential details about the name, contents, and management of the GLOB-LAND component will be accessible to users of the GEOSS, enabling them to identify GLOB-LAND component and other GEOSS resources that may be of interest.

f) Core research and Development

R&D activities are essential to ensure a continuous improvement of the service by incorporating any progress achieved by upstream research, or any correction to problems diagnosed in the current products by the End Users and to incorporate new products/services. Moreover, to speed up the European capacity building and ultimately the transition of new methods or observations from research to operations, new methodologies or the use of new types of observations should be tested in conditions close to their future operational use. Moreover, it will be necessary to maintain a good liaison with other international efforts on the global land domain (such as GEO/GEOSS, GCOS/GTOS, GEWEX/WRCP, iLEAPS/IGBP/Landflux, etc.).

The Core R&D activities will be carried out internally by GLMCS partners: it will address short term and day to day evolution and improvement of the different service elements, e.g. upgrade of processing chains, organisation of the archiving facilities. For medium term issues which need typically a few years of additional research effort, the Core R&D activities will allocate limited means on specific developments and will seek external support such as the EC research framework programme. Longer term research activities will be entirely made outside the GLOB-LAND component by research centres in MS and international bodies, possibly using FP funding support.

In addition, the R&D element will need to support education and training activities. These activities will be to the benefit of both the actors and the users of the Core Service, in particular the organizations involved in the downstream services.

54 http://www.earthobservations.org/documents/excom/ec14/09_Concept%20of%20Operations%20Document%20GEOSS%20Common%20Infrastructure.pdf

g) User network and capacity building

Recalling the European ambition to offer global coverage monitoring and services within the GLOB-LAND component, this implies to address user community at global level. However, some user community, particularly in developing countries, are not always well structured and lack capacities for the proper reception and exploitation of the data; thus there is a need to support (e.g. through EU-Africa Strategic Partnership) the structuring of user community and their capacity building. These "structured networks of users" could then become very useful for the worldwide validation and QC of the "input products" and of the products delivered by the GLOB-LAND component *(ref. effort currently done in AMESD, DevCoCast, previously in VGT4Africa*)

7. Implementation strategy

7.1. *Rationale for a GMES service on global land monitoring (Glob-Land)*

The Glob-Land has the potential to address the needs of a large range of users, at international, European and national levels, with a corresponding need to generate a range of products and services. For fulfilling this large range of requirements, a GMES service is needed that is capable of handling data / observations from a variety of sources operated by various agencies currently operating under different data policies and operating with different mandates.

Although the scope of the Glob-Land is wide, it does not start from scratch. It is essential to make use from all R&D or demonstrations projects and existing infrastructures and facilities. Numerous research and demonstration projects have been funded by ESA (i.e. GSE and DUE projects), the EC (i.e. FP6 and FP7 projects) and national research or development programmes. Existing agencies, such as EUMETSAT, and national research thematic centres already generate a number of parameters or run models that are identified as key for Glob-Land.

Key considerations for implementing the Glob-Land in the EU are:

- World leading research community in Europe on global vegetation, carbon and water modelling, and in Dynamic Modelling of Soil-Vegetation-Atmosphere Transfer;
- Development of a strong and recognised expertise in modelling and assimilation schemes in the Meteorological services and national research centres such as MPI, LSCE and Hadley Centre;
- Operational European meteorological organisations able to deliver on an operational basis biogeophysical parameters over land and assimilate these variables into prediction models;
- Within ESA, EUMETSAT and national space programmes, the constant development of an European Earth observation infrastructure for the last 20 years that is continuously improving the monitoring capacity of land with respect to spatial and temporal variability;
- Numerous research and development projects carried out on all thematic aspects of land monitoring (e.g. water management, desertification, deforestation, soil degradation…), not only over European geographical areas, but also globally, in particular in developing countries who are largely taking benefit from aid programmes from the EU and its Member States.

7.2. Proposed approach

7.2.1 Users involvement

User needs related to global land information have been consolidated through several international processes. The outcomes of these processes are used as the foundation for further specification of user requirements within the Glob-Land service. In particular, the following documents are considered as reference documents fro Glob-Land : *GCOS-107, Systematic Observation Requirements for Satellite-based Products for Climate* (WMO/TD-No. 1338 2006)[55], *IGOS Cryosphere Theme Report* (WMO/TD-No. 1405, 2007)[56], and *IGOS theme report on land: Integrated Global Observations for Land* (IGOL, 2008)[57].

The Glob-Land service should be user-driven and for this respect, it is important to define the mechanism enabling representation and involvement of users in the decision processes. Annual User Forums, at national and European levels, stimulating user federations, could conveniently be used also to define user representation in the Glob-Land governance process. Such forums should aim at raising the awareness of users on the availability of Glob-Land products and at contributing to the consolidation process of user requirements. It is indeed crucial to demonstrate, not only during the

[55] http://www.wmo.int/pages/prog/gcos/Publications/gcos-107.pdf
[56] http://cryos.ssec.wisc.edu/docs/cryos_theme_report.pdf
[57] http://www.fao.org/gtos/igol/docs/IGOS-theme-report-final-draft.pdf

building phase but also in the operational phase of Glob-Land, that users are responding positively to the achievements of the programme. This continuous feed back process is essential for the preparation of the operational phase and the long term sustainability of the service.

7.2.2 Development of an operational service

The objective is to set up **an operational service by 2014 onwards**. A crucial issue is the sustainability of the Glob-Land service in the long term, unlike the current project-like approach. The overall governance, architecture, organisational framework, together with the methods, data, processing facilities and the legal issues must be reshuffled for fitting this long term strategy.

Due to its complexity, the Glob-Land service may be implemented progressively, with the most mature functional blocks of current projects and initiatives to be operated in the frame of GMES Initial Operations, and subsequently by GMES fully fledged programme in 2014. It is necessary to ensure in the very short term, and up to horizon 2018-2020, the streamlining / consolidation of global near real-time bio geophysical product generation from existing capacities, using primarily operational assets (including EUMETSAT's SAFs and the VEGETATON ground segment). Pre-operational activities (including ESA's GLOB-product range, the results of various GMES past and on-going projects: Geoland, VGT4Africa, VGT@Work, DevCoCast, AMESD, ESA's Tiger projects and relevant GSE's such as the Forest Monitoring, and the Global Monitoring for Food Security activities) will be progressively incorporated according to their maturity and generic nature.

Following the recommendations of the workshop in Stresa in May 2009, the Glob-Land service should focus primarily on global scale following GCOS target requirements:

- **The provision of terrestrial Essential Climate Variables (ECVs) and their integration into Land Data Assimilation Systems is recognised as the primary objective of Glob-Land (carbon and water cycle, crop yield forecast).** It was also stressed that reanalysis should be considered as an integral part of the process.
- The Hot Spot Monitoring service should be addressed together with the hot spot module of the Euro-Land service as it relies on similar tools and techniques. This will maximise the synergy between the different components of the GMES land service. In addition, the interface of the hot spot monitoring capacity with GMES & Africa initiative needs to be further defined, following the recommendations in the Action Plan.

7.2.3 Building on existing projects, facilities and centres

The expertise and knowledge in global land monitoring is scattered in several institutions, universities and research or technical centres in the EU. The Glob-Land service should be developed using these European assets. The following initiatives and capacities are to be considered:

Climate Change Initiative – CCI (ESA)

In November 2008, ESA member states approved a dedicated programme **"Global Monitoring of Essential Climate Variables"** (75 Meuro over 6 years) which will develop, validate and deliver a subset of the, long-term global data product time-series for some of the 21 ECVs out of the 45 ECVs requested by GCOS. The objective of this programme is to realize the full potential of the long-term global Earth Observation archives that ESA together with its Member states have established over the last thirty years, as a significant and timely contribution to the ECV databases required by UNFCCC. The programme is conceived and managed as a coherent European contribution to the GEO/CEOS implementation plan, which in turn coordinates the response of CEOS Agencies worldwide to GCOS.

The CCI Initiative will implement some of the elements needed for the Glob-Land service: out of the 13 terrestrial ECVs, 3 ECVs will be processed in a first step (glaciers & ice caps; Land cover; Fire disturbance), and 7 additional ECVs in a second step (Fraction of absorbed photo-synthetically active radiation, Leaf Area Index, Albedo, Biomass, Lake levels, Snow cover, Soil Moisture). ESA and the EC are committed to ensure an effective coordination in terms of objectives and implementation of both the GMES Glob-Land Service and the ESA CCI programme. The following issues should in particular be addressed:

- The ECVs not covered by the ESA CCI must be considered as far as possible in priority by the Glob-Land service, i.e. water use, Ground water, River discharge, Permafrost and seasonally-frozen ground. Other variables of interest not covered by ESA CCI should also be addressed, i.e. hot spot land cover change monitoring, Top of Canopy reflectance, Fraction of Vegetation Cover, Lake Surface Temperature, Surface fluxes, …etc (see tables of variables to be considered by the Glob-Land service).

- Based on ESA CCI achievements, the Glob-Land service will address (i) the need for further integrating other sensors into the processing chains (multi-sensor approach) and (ii) the organisation of a reanalysis capacity;

- Beyond the current CCI Initiative, the long-term capacity for producing terrestrial ECVs should be addressed by the GMES Glob-Land service, in coordination with ESA.

EUMETSAT / SAF

The SAFs are developed by consortia of organisations from the Eumetsat Member States and Cooperating States, and are located at the National Meteorological Services in Member States. They are based on the local expertise. The SAF network complements the production of standard meteorological products derived from satellite data at the central facilities in Darmstadt and also distributes user software packages. The overall objective of a SAF is the provision of operational services, ensuring a cost-effective and synergic balance between the central and distributed services.

As a whole, 7 SAF have been approved in the 1997-1999 period and implemented in the MS in the different thematic areas of relevance for meteorological applications. An 8th SAF was approved in 2002 (hydrology and water). The SAF on land is located in Portugal at the Institute for Meteorological (IM), and the SAF on hydrology is located in Italy at the Meteorological Service (USAM).

The Land SAF was established to increase the benefit from MSG and EPS data related to land, land-atmosphere interaction and biospheric applications. It generates operational data services related to Surface Radiation, Vegetation and Soil Moisture. The participation in FP7 projects (e.g. GEOLAND) is made through the IM institute in Portugal, acting on behalf of the land SAF.

Currently, **the strategic framework for CDOP-2 is under definition (2012-2017)**. CDOP-2 will contain the development activities of Meteosat Third Generation (MTG) and post-EPS based products. The SAFs started to plan for their activities and products for the 2012-2017 timeframe. The Integration and interfacing with other initiatives (GMES, WMO SCOPE-CM, EUMETCal, GHRSST, GODAE, etc) will be defined in the course of 2010, for decisions in 2011.

In the frame of GMES, the SAFs could provide their own Products & Software to enable generation of added-value products. They may also use their Product-lines to support, at additional marginal costs, the generation and distribution of additional products, if agreements are set and external funding provided. SAF Competence Centers can provide necessary science and engineering support.

Other expertise and assets

The Glob-Land service will also rely on existing activities carried out by other institutions and centres in Europe such as:

- At DG Joint Research Centre, some key activities are to provide research results and to develop operational products in support to EU policy-makers in their effort towards global and sustainable environment, security and protection of European citizens:
    - The Monitoring Agricultural ResourceS (MARS) Unit of the Institute for the Protection and Security of the Citizen provides scientific and technical support in the field of agro-meteorological crop modelling, sampling methods, econometric, geomatics and satellite & airborne remote-sensing to the EU Agriculture and Food Security policies. In Europe, MARS addresses key issues related to the management and control of the Common Agriculture Policy. In developing countries, assistance is given to the EU Food Security Thematic Program with special emphasis on Africa,

and to providing building blocks for an European capacity for Global Agriculture Monitoring.

- The Institute for Environment and Sustainability is addressing many thematic areas in the field of global land monitoring such as environment impact on health, green house gas from agriculture, forestry and land use change, global monitoring of lands and global forest resource assessment, monitoring of biodiversity, water and ecosystems, desertification, land degradation and drought, monitoring and early warning of natural hazards…

- At VITO, the remote sensing unit is already delivering on sustainable basis different types of products/services globally and to African countries. For example, in the project VGT4AFRICA, VITO provides 10 products to 150 users in Africa through EUMETCAST. Moreover, VITO is the operator of SPOT-VEGETATION which is going to end in 2012, and will operate PROBA-V, a Belgium mission aimed at filling the gap until both Sentinel 3 (a and b) are in operations. VITO would be interested by consolidating its operational capacity for the provision of biophysical and food security parameters in the frame of the Glob-Land service;
- At POSTEL thematic centre, R&D activities and operational services are associated for describing the soil and vegetation from Earth Observation satellite data, at regional to global scales. Data are transformed into biogeophysical variables (vegetation and soils, radiations, water…) that are useful for climate and environmental sciences, ecophysiological processes, surface hydrology, etc. POSTEL Service Centre is responsible of the design of the operational processing lines, the production and distribution, as well as of the interface with the user community.
- The proven expertise from meteorological services in several Member States, from ECMWF and from research centres such as MPI, LSCE and Hadley Centre can also be used for the development or consolidation of modelling and assimilation schemes.

7.3. Research & Development

It should be stressed that accompanying research activities will be needed during GIO and beyond 2014 for bringing existing capacities to a sufficient level of maturity before integration into a fully operational service. This applies for integrating new observations into the service (e.g. new space sensors), for developing and validating processing chains for new terrestrial variables, for consolidating the multi-sensor approach in the ECVs chains.

Core R&D with a rather short response time should be covered within the Glob-Land service, in the order of 20-25% of the overall financial envelope. Longer term R&D should continue to be addressed by the research framework programme.

7.4. International cooperation

International cooperation deserves special attention in the frame of GLOB-LAND component to ensure the fulfilment of European need for information at global level and to develop a cost efficient system. According to the 2008 communication[58], *'GMES cannot be successfully implemented without exchanging equivalent observation data through cooperation schemes, thereby sharing the cost of observation infrastructure with non-EU partners. Further, only a coordinated approach bringing together the main actors in the world will lead to effective action to counter global environmental threats'*.

International cooperation should build on existing cooperation schemes developed by European national and intergovernmental actors with international counterparts. In the GEO process and its Global Earth Observation System of Systems (GEOSS), the GLOB-LAND component will be one of the main GMES contributions to its global 10-year GEOSS implementation plan. It is therefore necessary to ensure at an early stage the compatibility of GLOB-LAND component with the GEOSS.

[58] COM(2008)748

The implementation of Glob-Land service calls for an international partnerships, both at political level (e.g. the Africa /EU Strategic Partnerships and bilateral EU Official Development Assistance partnerships, UNSD) and at scientific level.

The Glob-Land service will also link to the PUMA/AMESD capacity building projects which aim at establishing effective capacities in Africa for the extensive use of EO techniques and information, through infrastructure deployment, training and institutional building:

- **PUMA** (2001-2005) has created a pan-African network with 53 countries and five regional centres and equipped them with the infrastructure, training and support required for receiving the latest space-based meteorological and environmental data, images and products from EUMETSAT via the EUMETCast distribution system.
- **AMESD**[59] (2007-2011) is a programme focussing on the use of EO-derived information in support to various aspects of environmental management. It objective is to provide all African nations with the resources they need to manage their environment more effectively and ensure long-term sustainable development in the region. In particular, it aims at providing decision-makers in the Regional Economic Communities, the Commission of the African Union and at national level with full access to the environmental data and products they need to improve national and regional policy and decision-making processes.

Finally, some diversity or even redundancy is useful from user point of view. GMES will play a key role at global scale but cannot be implemented without **strong international cooperation** for sharing Earth observation and in situ data. Further, the service should also **comply with internationally accepted standards**.

International buy-in / agreement on the product generating protocols and validation methods can be assured through continued engagement in established international forum such as the CEOS Land Product Validation working Group, the CEOS Land Surface Imaging Constellation initiative and the Global Terrestrial Observing System's GOFC/GOLD Panel.

7.5. Funding

The main guiding principles for the development of Glob-Land are that the products and services will serve public policy with aspirations for the common good. Article 2 of the Treaty on the European Union states "*In its relations with the wider world, the Union shall uphold and promote its values and interests and contribute to the protection of its citizens. It shall contribute to peace, security, the sustainable development of the Earth, solidarity and mutual respect among peoples, free and fair trade, eradication of poverty and the protection of human rights, in particular the rights of the child, as well as to the strict observance and the development of international law, including respect for the principles of the United Nations Charter*." In this light Glob-Land is expected to be funded from the public purse.

The cost estimation of the Glob-Land service can be based on extrapolation of current costs borne by existing structures and systems from ESA, EUMETSAT's SAFs, policy support programmes funded by the European Commission – e.g. relevant FP 6 and 7 projects and direct cost actions at JRC- as well as relevant actions in EU Member States such as the VITO and POSTEL operations. Some preliminary analysis of the potential contribution of the EU to the service leads to an estimate of 4 to 5 M€ per year. This cost estimation does not encompass the cost associated to the space component (i.e. sentinels operations and ground segments, access to contributions missions).

As regards the in situ component, it is supposed to remain the responsibility of the Member States who have already developed such infrastructures. However, the GMES programme may support, where appropriate, the collection and exchange of data from pan-European and globally coordinated in situ networks. GMES is also expected to contribute to the coordination activities that are necessary to ensure the availability of in situ data for the Glob-Land service.

[59] http://www.amesd.org/

7.6. Data and information policy

The principles of the GMES data policy have been proposed in the Regulation to be adopted jointly by the European Parliament and the Council in the course of 2010. As GMES products and services will be made available for the public good, the principles are based on a full and open access. However, restrictions for security reasons may apply. The GMES data policy is compliant with GEOSS data sharing principles, which seek to promote the full and open exchange of data, metadata and products.

The Earth observation data to be used by Glob-Land for generating the ECVs and for the Land Assimilation services will be primarily free of charge or at marginal cost. Additional data at higher resolution are needed for the validation protocols of global products and for the hot spots monitoring service. Appropriate bulk agreements with data providers are needed for providing access to the data by the service operators. The current Data Access Portfolio coordinated by ESA will be extended through the Delegation Agreement between the EC and ESA for the 2011-2013 period. Beyond 2014, it is expected that similar agreements will be implemented to allow a constant flux of relevant data to GMES services.

Outputs of the Glob-Land service should be free and openly available.

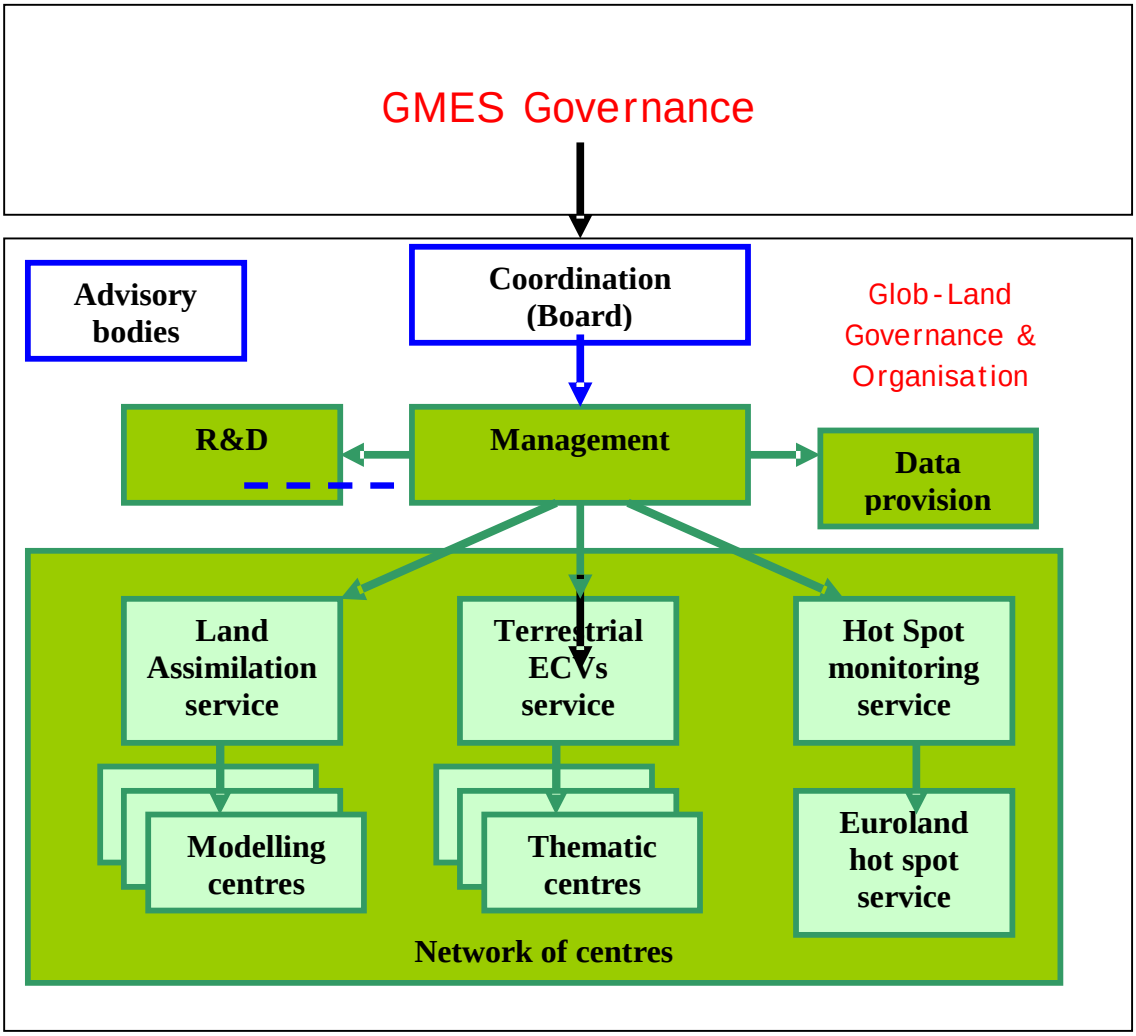
7.7. Governance and management structures

The Governance of the Glob-Land service should build upon the existing activities and capacities and will have essentially to define the coordination mechanism and the responsibilities of all relevant actors ensuring stakeholder communities' participation from various user communities based on a long term sustainable architecture.

A first option would be to link the Governance of the Glob-Land service to the overall Land Monitoring service. However, due to the peculiarity of the Glob-Land service, especially in terms of required NRT processing capacities, and to its stronger similarities with the functional architecture of the Atmosphere and Marine Services (systematic monitoring of Land at regional to global levels, large computing and processing capacities), it may be more appropriate to establish a **network of few mandated organisations at intergovernmental or national level** under the responsibility of a **management entity,** with the Commission keeping the overall responsibility and authority of the implementation and operations of the service:

- **GMES governance** : the overall **GMES programme management function** will be under the responsibility of the Commission assisted by its Programme Committee, a Partners Board and a Security Board, and advised by a User Forum who will propose service specifications based on user requirements;
- **Governance of GLOB-LAND**: the **service coordination function** of the Glob-Land service should remain under the Commission responsibility, with different options, ranging from a single Directorate General or Agency to a Board made of several stakeholders (to be decided before the implementation of the GMES Initial Operations);
- **Technical management of GLOB-LAND** : at service level, a **management entity**, with a legal personality, is needed in particular to provide the institutional/technical interface with external entities including the EC and MS, and provide the overall management of the service including interfacing to other services. This entity would be responsible for ensuring that the Glob-Land operators deliver their products to the users according to Service Level Agreements (SLAs). Specific SLAs may also be arranged with data providers (EUMETSAT and ESA, in situ observation infrastructure, EEA, Earth observation data providers etc.). An **Advisory Body** is also needed to prepare decisions of a scientific & technical nature.

The organisational structure for the service provision is still to be defined by the EC in coordination with other concerned bodies. Such a structure should capitalize on the strengths of the consortium created for the GEOLAND project as well as allowing evolution of the partnership without endangering the continuity of the service.



The allocation of tasks to the mandated centres could be organised under a thematic logical structure, for instance by grouping all similar variables to the same entity. The following three groups of variables could be proposed:

- Land cover and land cover changes, vegetation, fires and radiation
- Water and soils
- Snow, glaciers and ice sheets (including permafrost).

Product analysis and information production as part of the policy cycle, at EU and National level should be part of the core service, in particular in order to ensure information-independence wherever needed and appropriate. Whenever such information production is made for the benefit of third parties, in particular partner countries, this should occur in third party institutions or duly mandated service providers.

8. Conclusions

The GLOB-LAND Service is a clear affirmation of Europe's commitments to good global governance and environmental stewardship – issues at the very foundation of the GMES initiative. The programme is undoubtedly far reaching and ambitious in scope, but it is based on recognised competence within Europe. The EU has the technological skills to build and operate satellite based systems capable of satisfying global land monitoring information needs. The EU has the scientific capabilities to generate and exploit a range of pertinent products; and the EU has a suite of policies which are global in reach, global in intent.

GLOB-LAND will provide our policy makers with new reporting and information gathering capabilities, will help our world-leading commitments to Official Development Assistance be even more effective, will provide better alarm functions concerning environmental conditions around the planet, will strengthen Europe's role in international organizations and will lead to better representation of European science and technology in the international arena.

ANNEX I – Terms of Reference and composition of the Global Component LMCS working group

The working group will support the existing Implementation Group of the Land Monitoring Core Service (LMCS–IG) in developing its Global component. In particular, the working group will address:

- **Objectives and requirements** of the GLOB-LAND component, identifying a set of core service elements which complement the already identified ones at European level;
- **Functionality, architecture and main organization principles** of the GLOB-LAND component;
- **Links and interfaces with Downstream services and others GMES services**, including their requirements, their dependencies in terms of product delivery (e.g. timeliness, quality control, etc..);
- **Links and interfaces with GEO/GEOSS and other relevant international initiatives**;
- **Observation infrastructure, both space and in situ**, including data requirements, analysis of existing and future capacities at European and international level, and identification of possible gaps;
- **Interaction of the Global component governance with the structure and governance of the LMCS**;
- **Action plan and main milestones** for the implementation and the operational validation of the GMES GLOB-LAND component, coherent with the overall LMCS IG.

The working group will rely on the background knowledge of the working group members, on agreed documents at international level (e.g. GCOS), on the experiences gathered in the GMES projects and RTD projects (e.g. GEOLAND/FP6 IP, GMFS GSE project, etc..) and JRC existing activities (i.e. MARS projects and the African-Caribbean-Pacific Observatory for Sustainable Development) as well as on existing operational services in order to avoid, as far as possible, duplication of efforts. In this framework, an inventory of existing operational services/models and products should carried out.

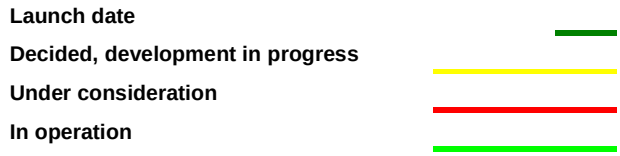
The mandate of the working group is limited to the preparation of deliverables. Three official meetings are expected, but ad hoc meeting could be organised if necessary.

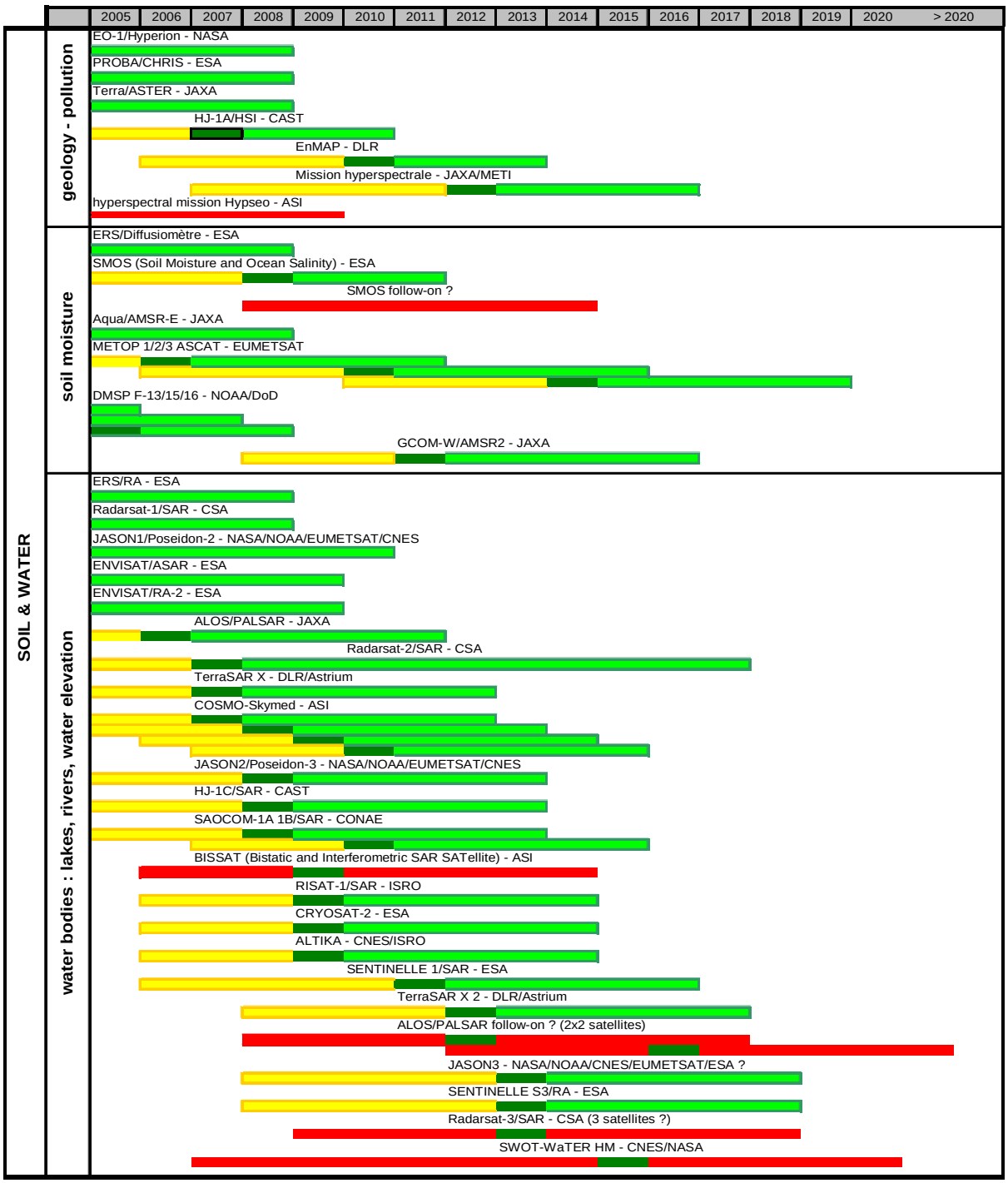
The working group is composed by experts and representatives of different user communities not directly involved in the provision of the LMCS.

Name	Affiliation	Functions in the Working Group
Han DOLMAN	Head of the Hydrology and Geo-environmental Sciences Department of the Vreji University of Amsterdam; Chair of the GCOS/TOPC Amsterdam	• Chair of the working group • Ensuring link with GCOS and its terrestrial component (TOPC) • Expert on terrestrial biosphere interaction with the hydrological cycle and atmosphere
Gianpaolo BALSAMO	European Centre for Medium range Weather Forecast (ECMWF) Reading	• Expert of land surface process, data assimilation and modelling • Expert in global hydrology
Alan BELWARD	Unit Head of the Global Environment Monitoring Unit of the Joint Research Centre Ispra	• Ensuring link with the DGs user needs • Coordinator of the JRC contribute to the GLOB-LAND component
John LATHAM	GTOS Programme Director, Senior Officer in the FAO Environment and Natural Resources Service Department Rome	• Ensuring link GTOS • Providing FAO users' requirements
Joachim HILL	University of Trier, Faculty of Geosciences, Remote sensing department Trier	• Ensuring link with UNCCD • Expert on remote sensing application for desertification related issues

ANNEX II - Current capacities of space infrastructures at EU and international level (outlook until 2020)

The charts/figures reported in this annex provide an image of the current capacities of space infrastructures until 2020. The clear green fields show the satellite in operation through operational programmes (e.g. EUMETSAT and NOAA programmes) or R&D missions, the red fields the ones under consideration and the yellow fields the ones in progress.

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geology - pollution
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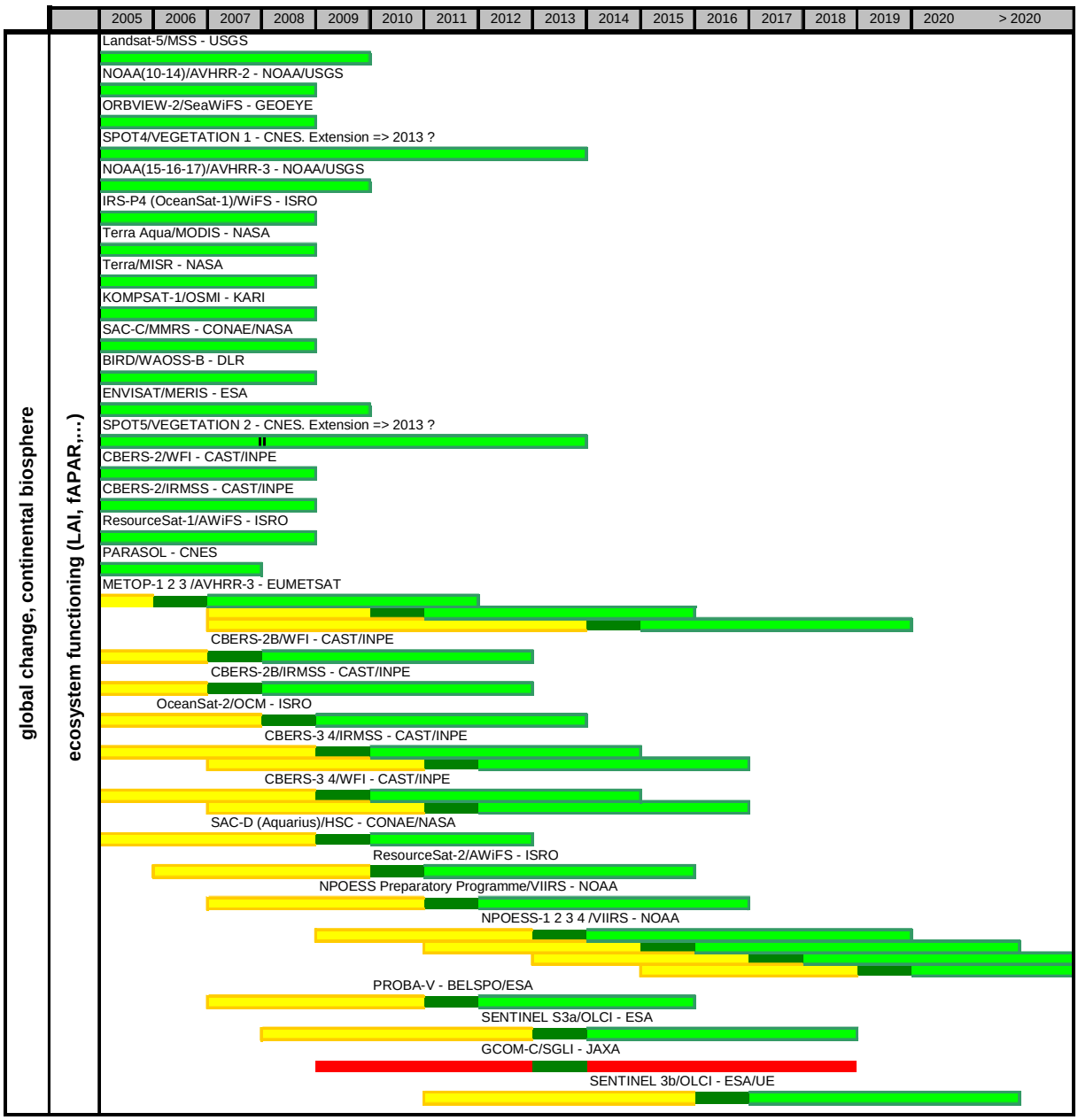
EO-1/Hyperion - NASA
PROBA/CHRIS - ESA
Terra/ASTER - JAXA
HJ-1A/HSI - CAST
EnMAP - DLR
Mission hyperspectrale - JAXA/METI
hyperspectral mission Hypseo - ASI
ERS/Diffusiomètre - ESA
SMOS (Soil Moisture and Ocean Salinity) - ESA
SMOS follow-on ?
Aqua/AMSR-E - JAXA
METOP 1/2/3 ASCAT - EUMETSAT
DMSP F-13/15/16 - NOAA/DoD
GCOM-W/AMSR2 - JAXA
ERS/RA - ESA
Radarsat-1/SAR - CSA
JASON1/Poseidon-2 - NASA/NOAA/EUMETSAT/CNES
ENVISAT/ASAR - ESA
ENVISAT/RA-2 - ESA
ALOS/PALSAR - JAXA
Radarsat-2/SAR - CSA
TerraSAR X - DLR/Astrium
COSMO-Skymed - ASI
JASON2/Poseidon-3 - NASA/NOAA/EUMETSAT/CNES
HJ-1C/SAR - CAST
SAOCOM-1A 1B/SAR - CONAE
BISSAT (Bistatic and Interferometric SAR SATellite) - ASI
RISAT-1/SAR - ISRO
CRYOSAT-2 - ESA
ALTIKA - CNES/ISRO
SENTINELLE 1/SAR - ESA
TerraSAR X 2 - DLR/Astrium
ALOS/PALSAR follow-on ? (2x2 satellites)
JASON3 - NASA/NOAA/CNES/EUMETSAT/ESA ?
SENTINELLE S3/RA - ESA
Radarsat-3/SAR - CSA (3 satellites ?)
SWOT-WaTER HM - CNES/NASA

Launch date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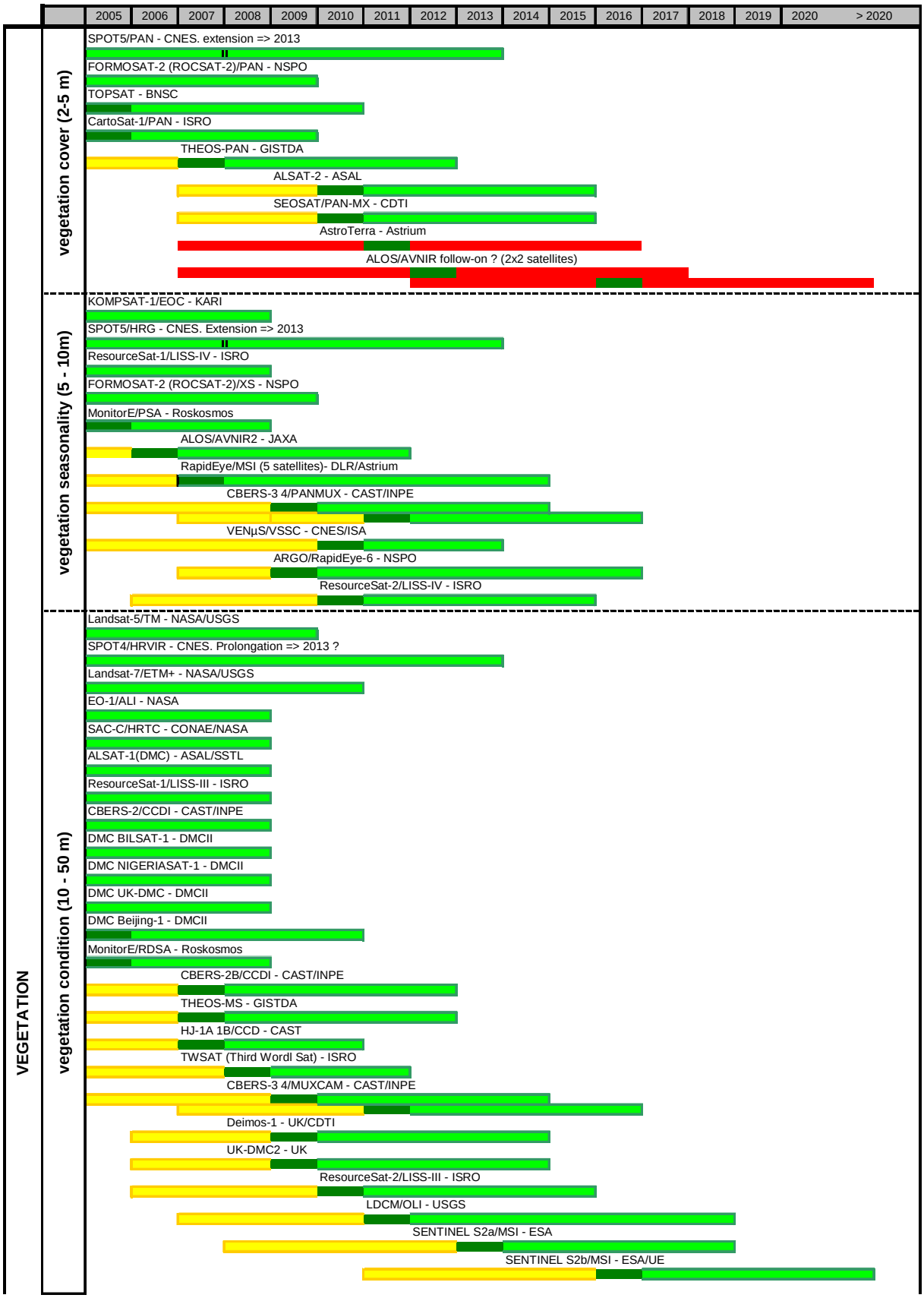
ecosystem functioning (LAI, fAPAR,...)
Landsat-5/MSS - USGS
NOAA(10-14)/AVHRR-2 - NOAA/USGS
ORBVIEW-2/SeaWiFS - GEOEYE
SPOT4/VEGETATION 1 - CNES. Extension => 2013 ?
NOAA(15-16-17)/AVHRR-3 - NOAA/USGS
IRS-P4 (OceanSat-1)/WiFS - ISRO
Terra Aqua/MODIS - NASA
Terra/MISR - NASA
KOMPSAT-1/OSMI - KARI
SAC-C/MMRS - CONAE/NASA
BIRD/WAOSS-B - DLR
ENVISAT/MERIS - ESA
SPOT5/VEGETATION 2 - CNES. Extension => 2013 ?
CBERS-2/WFI - CAST/INPE
CBERS-2/IRMSS - CAST/INPE
ResourceSat-1/AWiFS - ISRO
PARASOL - CNES
METOP-1 2 3 /AVHRR-3 - EUMETSAT
CBERS-2B/WFI - CAST/INPE
CBERS-2B/IRMSS - CAST/INPE
OceanSat-2/OCM - ISRO
CBERS-3 4/IRMSS - CAST/INPE
CBERS-3 4/WFI - CAST/INPE
SAC-D (Aquarius)/HSC - CONAE/NASA
ResourceSat-2/AWiFS - ISRO
NPOESS Preparatory Programme/VIIRS - NOAA
NPOESS-1 2 3 4 /VIIRS - NOAA
PROBA-V - BELSPO/ESA
SENTINEL S3a/OLCI - ESA
GCOM-C/SGLI - JAXA
SENTINEL 3b/OLCI - ESA/UE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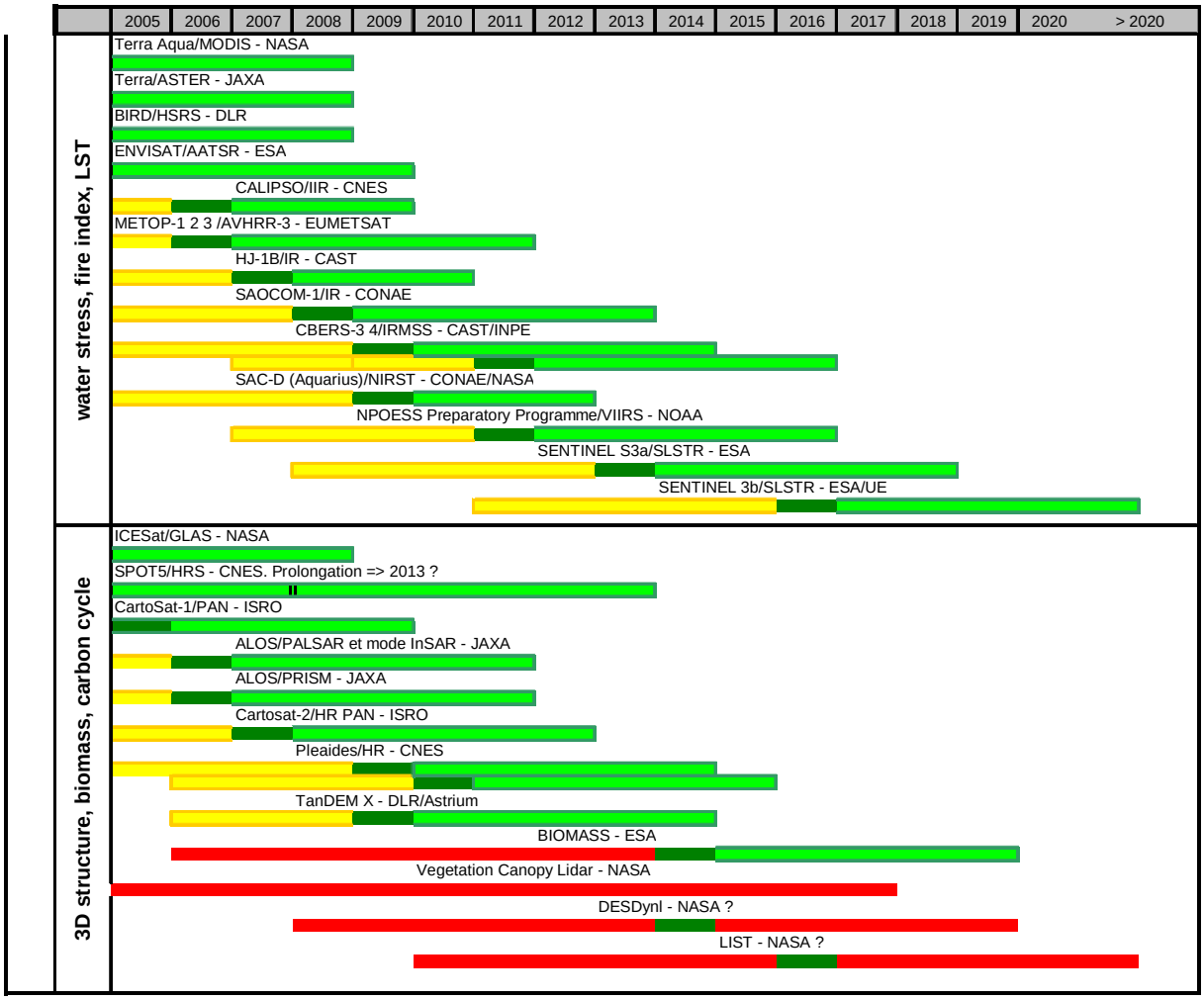
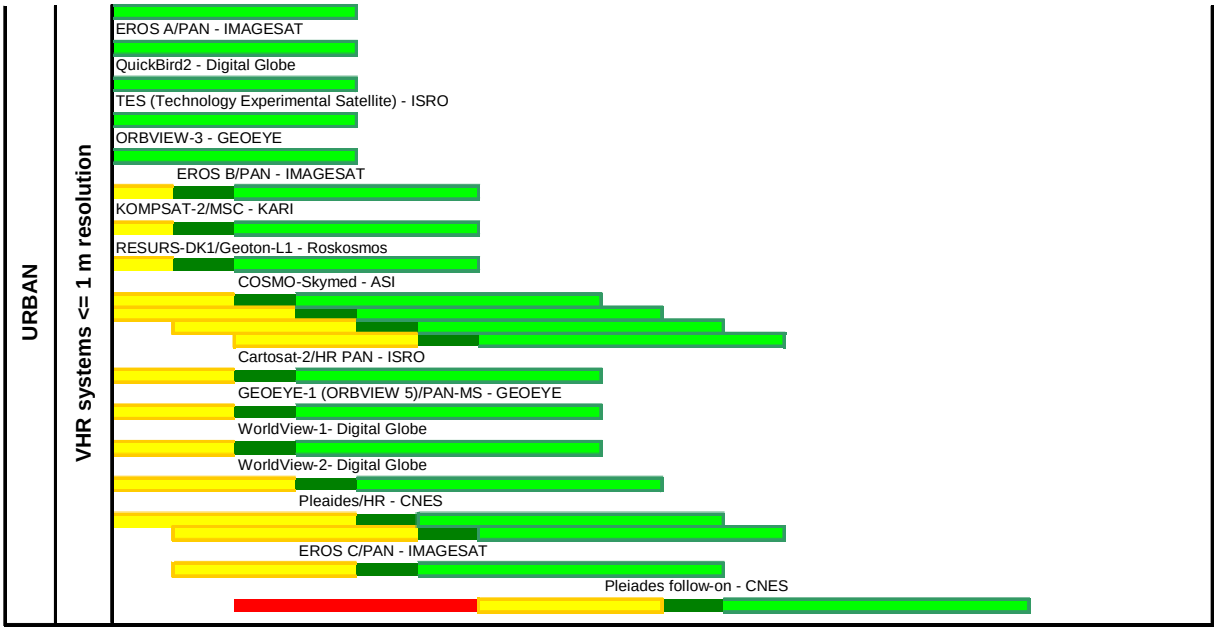
vegetation cover (2-5 m)
SPOT5/PAN - CNES. extension => 2013
FORMOSAT-2 (ROCSAT-2)/PAN - NSPO
TOPSAT - BNSC
CartoSat-1/PAN - ISRO
THEOS-PAN - GISTDA
ALSAT-2 - ASAL
SEOSAT/PAN-MX - CDTI
AstroTerra - Astrium
ALOS/AVNIR follow-on ? (2x2 satellites)
vegetation seasonality (5 - 10m)
KOMPSAT-1/EOC - KARI
SPOT5/HRG - CNES. Extension => 2013
ResourceSat-1/LISS-IV - ISRO
FORMOSAT-2 (ROCSAT-2)/XS - NSPO
MonitorE/PSA - Roskosmos
ALOS/AVNIR2 - JAXA
RapidEye/MSI (5 satellites)- DLR/Astrium
CBERS-3 4/PANMUX - CAST/INPE
VENµS/VSSC - CNES/ISA
ARGO/RapidEye-6 - NSPO
ResourceSat-2/LISS-IV - ISRO
vegetation condition (10 - 50 m)
Landsat-5/TM - NASA/USGS
SPOT4/HRVIR - CNES. Prolongation => 2013 ?
Landsat-7/ETM+ - NASA/USGS
EO-1/ALI - NASA
SAC-C/HRTC - CONAE/NASA
ALSAT-1(DMC) - ASAL/SSTL
ResourceSat-1/LISS-III - ISRO
CBERS-2/CCDI - CAST/INPE
DMC BILSAT-1 - DMCII
DMC NIGERIASAT-1 - DMCII
DMC UK-DMC - DMCII
DMC Beijing-1 - DMCII
MonitorE/RDSA - Roskosmos
CBERS-2B/CCDI - CAST/INPE
THEOS-MS - GISTDA
HJ-1A 1B/CCD - CAST
TWSAT (Third Wordl Sat) - ISRO
CBERS-3 4/MUXCAM - CAST/INPE
Deimos-1 - UK/CDTI
UK-DMC2 - UK
ResourceSat-2/LISS-III - ISRO
LDCM/OLI - USGS
SENTINEL S2a/MSI - ESA
SENTINEL S2b/MSI - ESA/UE


2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
> 2020
water stress, fire index, LST
Terra Aqua/MODIS - NASA
Terra/ASTER - JAXA
BIRD/HSRS - DLR
ENVISAT/AATSR - ESA
CALIPSO/IIR - CNES
METOP-1 2 3 /AVHRR-3 - EUMETSAT
HJ-1B/IR - CAST
SAOCOM-1/IR - CONAE
CBERS-3 4/IRMSS - CAST/INPE
SAC-D (Aquarius)/NIRST - CONAE/NASA
NPOESS Preparatory Programme/VIIRS - NOAA
SENTINEL S3a/SLSTR - ESA
SENTINEL 3b/SLSTR - ESA/UE
3D structure, biomass, carbon cycle
ICESat/GLAS - NASA
SPOT5/HRS - CNES. Prolongation => 2013 ?
CartoSat-1/PAN - ISRO
ALOS/PALSAR et mode InSAR - JAXA
ALOS/PRISM - JAXA
Cartosat-2/HR PAN - ISRO
Pleaides/HR - CNES
TanDEM X - DLR/Astrium
BIOMASS - ESA
Vegetation Canopy Lidar - NASA
DESDynI - NASA ?
LIST - NASA ?


URBAN
VHR systems <= 1 m resolution
EROS A/PAN - IMAGESAT
QuickBird2 - Digital Globe
TES (Technology Experimental Satellite) - ISRO
ORBVIEW-3 - GEOEYE
EROS B/PAN - IMAGESAT
KOMPSAT-2/MSC - KARI
RESURS-DK1/Geoton-L1 - Roskosmos
COSMO-Skymed - ASI
Cartosat-2/HR PAN - ISRO
GEOEYE-1 (ORBVIEW 5)/PAN-MS - GEOEYE
WorldView-1- Digital Globe
WorldView-2- Digital Globe
Pleaides/HR - CNES
EROS C/PAN - IMAGESAT
Pleiades follow-on - CNES

ANNEX III : Reference Projects

The Glob-Land service will benefit from the heritage of the following FP projects:

- **FP7 GEOLAND2**[60] , which will provide in near real time and off-line a series of biogeophysical parameters, at a global or continental scale, describing the continental vegetation state, the radiation budget at the surface and the water cycle. It will also conduct R&D activities to define and test new products & services on Land Carbon to understand and assess the impact of weather and climate variability on terrestrial biospheric carbon fluxes, in the context of international conventions; on Natural Resource Monitoring in Africa to develop an environmental monitoring capacity over African countries for the needs of the EC services and for regional and continental EC partners in African countries; and on Global CROP Monitoring to provide objective, real-time crop assessment and yield fore-casts in support to EC Policies in the field Agriculture (Common Agriculture Policy) and Food Security.
- **FP6 GEOLAND**[61], which aimed at: streamline the production of "Bio-geophysical Parameters" from low resolution satellite data (i. a. METEOSAT and VEGETATION); assimilate EO-derived parameters into continental and global carbon and water budget cycle models; expand crop monitoring capacities developed in Europe to other countries worldwide; and identify land cover and forest change risks and trends from such low resolution EO data.
- **FP6 VGT4AFRICA**[62], which aims at setting up an operational and timely distribution system of VEGETATION data from the SPOT satellites and high level derived products to African user communities (PUMA network, national meteorological services, environmental agencies). The goal is to set up an operational capacity based on the SPOT VEGETATION system in support to sustainable development policies in Africa. VEGEATTION data are distributed through the EUMETCAST telecommunication facility provided by EUMETSAT for what regards the space segment, and the European Development Fund for what regards the ground segments in Africa. This activity complements EDF-funded AMESD project.
- **FP6 CARBOEUROPE-IP**[63], which aimed at understanding and quantifying the present terrestrial carbon balance of Europe with its spatial and temporal patterns (by measurements of ecosystems processes, terrestrial CO2 exchange, and atmospheric high precision CO2 and other trace gases, plus a regional high resolution experiment; these components are integrated by means of innovative data assimilation systems, bottom-up process modelling and top-down inverse modelling). The monitoring of changes in atmospheric CO2 concentrations and ecosystem carbon stocks and fluxes contributes to the European commitments under the Kyoto Protocol.
- **FP6 CARBOAFRICA**[64], which aimed at 1) supporting and expanding a network of continued and enhanced observations of carbon stocks, fluxes, atmospheric concentrations and ecological processes in sub-Saharan Africa (SSA); 2) improving biogeochemical models representing the main African ecosystem types; 3) understanding better the role of fire emissions from SSA in the global carbon cycle; 4) enhancing African capabilities to undertake mitigation and adaptation actions by evaluating the potential for carbon sequestration (CDM) and the reduced emissions by avoiding deforestation (REDD). The work is organized in a multi-disciplinary integrated research approach based on satellite data, in situ observations and modelling activities.
- **FP7 DEVCOCAST**, which is a follow on of VGT4Africa. It will disseminate existing environmental added-value data (both in-situ as well as satellite based) from various sources in Africa, South- and Central America, Asia and also Europe via GEONETCast to a broad range of end-users in Developing Countries. Making this relevant environmental information available on a wide scale is only a first technical step, even more important is the support of the use of this data.

[60] http://www.land.eu/

[61] http://www.gmes-geoland.info/

[62] http://www.vgt4africa.org/ViewContent.do?pageId=1&lang=EN

[63] http://www.carboeurope.org/

[64] http://www.carboafrica.net

Therefore, a major focus lies on building the capacity which includes training, user support, networking, and outreach.

- **FP7 COCOS** (Coordination action on Carbon Observing Systems), which will assess the status of harmonization of key carbon cycle variables with international partners. It will improve the interoperability of data sets that are used in global scale carbon cycle studies through joint activities between ecosystem, atmospheric and ocean bottom-up and top down observation communities. COCOS will also perform integrated regional-scale multiple constraint assessments of the land and ocean carbon balance through the use of harmonized data sets. It will identify, narrow down uncertainties and decrease differences in emerging global data sets that are aimed at providing constraints on the vulnerability of the global carbon cycle.

  COCOS will contribute to an effective monitoring of the carbon cycle at global level as recommended by GEO and GCOS in supporting the European participation to an international CO2 research monitoring project. The research and harmonization work developed in this proposal will contribute significantly to building an integrated global approach that promotes close collaboration with the international carbon cycle research community.

The Glob-Land service will also benefit from the heritage of the following ESA projects:

- **ESA GSE Forest Monitoring**[65]**,** which delivers information on the state of forest systems in order to support decision-making and improved policies that enable sustainable forest management; compliance with specific protocols and binding conventions; and related user and policy-driven activities. Post-Kyoto Protocol (REDD), has been developed during the last years and has a potential for large geographical coverage outside Europe.
- **ESA GSE Global Monitoring for Food Security (GMFS)**[66]**,** which provides crop monitoring services to support food security decision making exclusively over African territory. The service portfolio includes: Early warning based on low-res SPOT-VGT & MERIS-RR vegetation indicators (African continent), Crop extent maps; Agro-meteorological yield modelling using remote sensing inputs; EO-based support to joint FAO/WFP Crop and Food Supply Assessment missions (Ad-hoc rapid service).
- **ESA DUE GLOBCOVER**[67]**,** which was launched in 2005 to develop and demonstrate a service for the generation of a global land cover map for the year 2005/2006. GlobCover product updates and complements other existing comparable global products, such as the global land cover map at 1 km resolution for the year 2000 (GLC2000) produced by the JRC and other similar products (e.g. IGBP DISCover, MODIS map). It is also improves such previous global products, in particular because of the finer spatial resolution (300m). GlobCover data are also used for GlobCorine re-classification as required for land cover accounting. GlobCorine is starting now with expected deliveries within 9 months. This is an improved classification, adapted to land cover change monitoring, a methodology for change detection and regional tests in pan Europe, Mediterranean, Sub Saharan Africa and Amazonia-Brazil.
- **ESA DUE GLOBCORINE**[68], which aims to demonstrate an automatic service that can generate in a consistent way a land cover / land use map and a land change indicator, based on a CLC-compatible legend. The project evaluates the automatic applicability of MERIS FR time series in the CLC update processing, and is based on the GlobCover software system. It concentrates on the pan-European area (including the Mediterranean basin and the European Russia), although the system could be potentially extendable globally. Its main data source is the Envisat MERIS fine resolution (300m) mode data acquired between end 2004 and mid 2006. GlobCorine is an initiative in partnership with EEA.

[65] http://www.gmes-forest.info
[66] http://www.gmfs.info/
[67] http://dup.esrin.esa.it/projects/summaryp68.asp
[68] http://dup.esrin.esa.it/projects/summaryp114.asp

- **ESA DUE GLOBCARBON**[69]**,** which develops a service generating fully calibrated estimates of at land products quasi-independent of the original EO source. The service is focussing on development of a system to generate global estimates of: Fire – location, timing, area affected; fAPAR and LAI; Vegetation growth cycle – timing, duration, spatial and temporal variability.
- **ESA DUE GLOBGLACIER**[70], which aims at defining the EO based services for glacier monitoring from space, the integration with state of the art ground-based observations, followed by the demonstration, implementation and validation of the services for the members of the User Group.
- **ESA DUE GLOBSNOW**[71], which will develop a operational near-real time service for global snow monitoring and a historical data set comprising of 15 to 30 years of snow data. Additionally, a fundamental climate data record (FCDR) for snow, spanning 15 to 30 years, will be constructed within the GlobSnow project.
- **ESA DUE GLOBALBEDO,** which will provide long times series of global land surface albedo, based on user requirements covering applications in meteorological and climate research, and in dynamic vegetation modelling.. The project aims at developing and delivering a multi-annual global albedo data set that has the potential to be sustained into the future using data from operational European satellites, such as the GMES Sentinels. The albedo products will be validated and compared against ground based, airborne and other satellite based measurements. A scientific study exploiting the data set produced will be performed.
- **ESA DUE GLOBWETLAND**[72], which aims at supporting the RAMSAR convention on wetlands. The GlobWetland I project (2003-2008) demonstrated how satellite EO technology can be a cost-effective and productive instrument for the conservation and management of wetlands. The GlobWetland II project builds upon the first project and will contribute to the set-up of a Global Wetlands Observing System (G-WOS) in accordance with the strategic plan 2009-2015 of the Ramsar Convention on Wetlands. It aims at designing, developing, validating and transferring a G-WOS pilot information system for the production of a number of wetland related geo-information maps and indicators, over wetland sites and surrounding areas, for different points in time. The geographical areas that will be covered by the project are the coastal catchment areas of the Southern and Eastern part of the Mediterranean basin, extending from Morocco to Turkey.
- **ESA DUE PERMAFROST**[73], which aims at defining, demonstrating and validating, permafrost monitoring information service from local to large scale, mainly towards climate change studies and addressing the pan-boreal/arctic zone. The service is supposed to support the GCOS implementation plan with systematic satellite-based Earth Observations of global permafrost extent, change and related products. It should further support permafrost monitoring activities of national and intergovernmental bodies and scientific groups involved in climate change research.

[69] http://dup.esrin.esa.it/projects/summaryp43.asp
[70] http://globglacier.ch/
[71] http://globsnow.fmi.fi/
[72] http://dup.esrin.esa.it/projects/summaryp61.asp

[73] http://www.ipf.tuwien.ac.at/permafrost/

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