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502869

Project acronym
HALO

Project title
Harmonised coordination of Atmosphere, Land and Ocean integrated projects of the GMES backbone

Instrument: **Specific Support Action**

Thematic Priority: **Space / GMES**

Final Activity Report
&
Guide to the Scientific and Technical Annexes

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1. Objectives of HALO in the transition of GMES from Research to Operations

The HALO project (Harmonised coordination of Atmosphere, Land, and Ocean integrated projects of the GMES backbone) is a Specific Support Action (SSA) funded in the Sixth Framework Programme (FP6) for the period February 2004 to April 2007. For the period 2004-2007, the GMES work programme for the build-up of the GMES pre-operational capabilities *' includes*

- *data delivery processes of observation systems;*
- *interoperability and interconnection of the data processing and delivery systems;*
- *organisation and system architecture.*

These are vital to the Atmosphere, Ocean and Land Integrated Projects of the GMES Backbone, & there will be strong cross- dependencies between the 3 Integrated Projects. Key elements of the Land and Ocean Integrated Projects will be dependent on the outputs of the Atmosphere Integrated Project. The Atmosphere IP will be dependent on outputs of the Land and Ocean Integrated Projects. Since the Land and Ocean atmospheric requirements must be addressed in a uniform way by the Atmosphere Integrated Project, the HALO SSA will prepare the architecture and system integration for the interacting part of all 3 Integrated Projects into the GMES framework, and prepare their joint transition to operational status.'

The goal of the GMES Ocean and Land Integrated Projects is to deliver by early 2008 (and by early 2009 for the Atmosphere Integrated Project) a validated pre-operational system across a wide range of scientific disciplines, thus demanding a wide range of scientific and technical skills.

For the period 2004-2007, the HALO work programme to prepare the coordinated transition of the GMES Atmosphere Land and Ocean integrated projects from Research to Operational status included *'optimisation of the interactions of these Segments of the GMES Backbone by formulating agreed recommendations to the 3 Integrated Projects, and to the GMES Steering Group in the areas of*

- *scientific thematic analysis and coordination of observational, modelling and data-assimilation requirements for the interacting parts of the Integrated Projects;*
- *cross fertilization of scientific thematics leading to an improvement of knowledge, and definition of the overall scientific architecture;*
- *identification of shared issues in the areas of data policy implementation, data acquisition, data sharing and data dissemination, leading to proposed candidate solutions; analysis of the candidate solutions,*
- *formulation of recommendations for a coordinated transition to operations of the*

interacting part of the pre-operational systems developed in the 3 Integrated Projects.

The Land, Ocean and Atmosphere Integrated Projects each need to generate or acquire the best possible estimates of interfacial fluxes of momentum, radiation, sensible heat, latent heat and interfacial fluxes of a number of atmospheric constituents including carbon dioxide, water vapour and aerosol. Each Integrated Project will begin its work by acquiring the necessary surface flux products (or the science to generate such products) from the best available European sources. It is expected that the best European sources will be involved in one or other of the three IPs discussed here.

In some cases the science exists, and will be implemented operationally in one of the Integrated Projects, to improve the products of all three Integrated Projects. An example is provided by the modelling and assimilation of remotely-sensed data on aerosol, which will be undertaken in the Atmosphere IP but will be of great importance for all three Integrated Projects. A further example for all three Integrated Projects is development and validation of improved methods to estimate surface fluxes of carbon dioxide and water vapour. As the GMES project develops, estimation of sources for a variety of other atmospheric constituents will become a priority.

There are important commonalities in the requirements of the three Integrated Projects for in-situ data and for space-based data. These requirements pose common issues of data-policy, as well as considerable technical and resource challenges in the management of the wide range of high-volume remotely-sensed data needed for the projects.

The objective of the HALO SSA may therefore be summarised as:

Optimising the efficiency of the interactions of the Ocean, Land, and Atmosphere Segments of the GMES Backbone by formulating agreed recommendations to the Ocean, Land and Atmosphere IPs, and to the GMES Steering group in the areas of:

- *Scientific thematic analysis and coordination*
- *Coordinated solutions to shared problems*
- *Recommendation for the transition to operational status*

Effective coordination and management of the transition of the Core services of the GMES Integrated Projects from Research to Operational status (R2O), poses technical, scientific and management challenges. The technical challenges concern identification of the nature, volume and transport mechanisms of the data exchanges needed between the core services. Our technical analyses and recommendations are summarised in section 2, which provides a guide to the detailed annexes and extensive supporting documentation. The scientific challenges of the R2O transition for GMES concern identification of the likely path of service evolution for the interacting parts of the individual Services/Projects, together with identification of emerging needs for modelling / assimilation capabilities, and emerging needs for observations. These matters are discussed in section 3. Section 4 discusses a management issue which can facilitate an effective transition. Finally in section 5 we summarise the main outreach and communication activities of the HALO project.

2. Technical Analyses and Recommendations for the GMES transition

2.1 Technical issues on Information Infrastructure for the Core Services

The technical issues of the HALO study, concerning data exchange and information infrastructure for the transition to operations, were addressed in three phases

* Documentation of the requirements for data and information exchanges between the Core Services of the three Integrated Projects
* Analysis of the requirements and formulation of candidate technical solutions by the industrial partners
* Preparation of the final technical report and recommendations:

2.1.1 Documentation of Data Exchange and Infrastructure Requirements

The work of HALO began with the documentation of the requirements for data and information exchanges between the projects and was carried out in close cooperation between the Integrated Projects and the HALO work group at ECMWF. Documentation of the internal and external data flows for each Integrated Project are provided in three reports (Flemming et al. 2004a,b,c,d) which are available on the HALO web-site (aside: Flemming et al, 2004a, makes no explicit reference to the GEMS project, which had not been approved at the time of writing, 2004). In addition, a special analysis was made of the needs of the carbon theme in GMES (Flemming et al 2004e). These documents were analysed by all partners and recast into a First Statement of Tasks for industrial partners, Flemming et al (2005a), and then into a Final statement of tasks, (Pechinot et al 2005). The latter is referred to as the Guidelines Document for the work of the industrial partners.

2.1.2 Candidate Technical Solutions for Information Infrastructure

The industrial partners undertook an extensive analysis of the requirements, and an extensive consideration of Candidate Solutions for the requirements. An overview of Candidate Solutions is given in Levy et al. (2005). The final industrial analysis and recommendations for the candidate technical solutions are provided in Levy et al. (2007), which is attached as Annex 3 to this report.

2.1.3 Final Technical Report

As the industrial analyses progressed, and formulation of recommendations began, both the industrial analyses and the draft recommendations were discussed and explored in a series of workshops which involved not only the HALO partners but involved also interested stakeholders such as ESA, EUMETSAT and WMO, together with representatives of EU integrated projects such as Carbo-Ocean. In addition the HALO team took account of the recently published INSPIRE directive (March 2007) and of the recently published calls (December 2006) for the GMES Fast-track services and the GMES pilot services. The final HALO technical report is attached as Annex 1 (Kaiser et al 2007a) of this report.

2.2 Technical Recommendations for the GMES transition to Operations

The HALO project focussed on the data acquisition and data exchange requirements of the interacting parts of the Core Services of the three integrated projects. In particular the focus was on the pre-operational and operational global and continental / basic scale model and data assimilation activities, which include:

- MERSEA's core models (Mercator, FOAM, MFS and TOPAZ)
- Geoland's global observatories, but mainly the Observatory Natural Carbon (ONC) and the Core Sevice Geophysical parameters (CSP)
- GEMS global operational model and data assimilation system at ECMWF, built by the GEMS global subprojects on Greenhouse Gases (GHG), Reactive Gases (GRG), Aerosol (AER) and the Production System (PRO).

The main effort has been the identification of links and inter-dependencies between the Integrated Projects. The data requirements associated to these links can be categorised in the following groups:

- Common data demands;
- Direct product exchanges;
- Emerging data requirements

The first two issues and the means to meet them are discussed in detail in the Guideline Document (Pechinot et al 2005), in the document on Candidate Infrastructure Solutions (Levy et al 2007), and in the HALO Final Technical Report (Kaiser et al 2007a). The issue of emerging data requirements is discussed in the following section.

All three GMES Integrated Projects in HALO show a common structure of a Core service (which may be centralised or distributed) meeting the needs of diverse Downstream services which can generate tailored products for the end users in a very flexible way.
We identify two key technical /political areas in which progress is needed to ensure the successful transition to operational status of the GMES backbone:

- Acquisition of land in-situ observations
- Implementation of a common GMES data policy.

In terms of the information infrastructure to ensure a coordinated transition of the three integrated projects to operational status, the HALO industrial partners (Astrium and Alcatel) have proposed an infrastructure architecture using the existing WMO Information System (WIS/SIMDAT), SEA-DATA-NET, WIN, EUMETCast, GEANT, internet, and EODAIL systems and a new GMES portal.

Of these, the WMO Information System (WIS) is the most advanced in terms of technical development, functionality, and world-wide reach. The European implementation of the WIS is being developed as part of the FP6 project SIMDAT. The European WIS implementation team uses advanced software tools, industry standards for metadata and catalogue updating; it uses GRID technology; and it will be rolled out in Europe in 2008. It will have all the capabilities needed by a GMES information system, and is INSPIRE compliant. It is designed for the atmospheric community in collaboration with representatives from the Ocean

community, and will be readily adaptable to the needs of the Ocean community. It will therefore be readily adaptable for many of the needs of the Risks community.

For these reasons, the main technical recommendations by the HALO consortium for the transition to operations of the GMES global monitoring system of the atmosphere, the land, and the oceans are:

Technical Recommendation 1: *As implied by the forthcoming INSPIRE directive* (2004/0175 (COD), C-6 0445/2006, PE-CONS 3685/06) *GMES leadership should address the provision of a* ***GMES Information System*** *based on Internet technology. The lack of such a system is a critical gap in GMES planning.*

Technical Recommendation 2: *The GMES leadership should monitor the 2008 roll-out of the* ***WMO Information System in Europe****, and assess the adaptability of the WIS for GMES purposes and interoperability with OGC and Earth Science Information Systems.*

3. Scientific Analyses and Recommendations for the GMES Transition

In preparing the coordinated transition to operational status of all three Integrated Projects (GEMS, GEOLAND, MERSEA) the HALO project considered both the scientific and technical aspects of the transition. In particular, we had to assess the likely scientific evolution and the likely scientific upgrade path for the interacting parts of the three Integrated Projects. We also had to ensure that the foreseen scientific developments were facilitated by, rather than impeded by, the recommended technical implementations. The scientific considerations identified the need for a number of new initiatives in modelling and data-assimilation and also identified emerging data needs which will have to be met if the desired scientific progress is to be made. The scientific assessments and recommendations are documented in detail in Kaiser et al (2007b) which constitutes Annex 2 of this report.

3.1 Scientific Recommendations for the interacting parts of the Integrated Projects

The discussions of the scientific interactions between the GMES Atmosphere, Land and Ocean systems have identified some major and minor gaps in the current range of activities for building the global GMES monitoring system. The first such issue to be identified in the first HALO workshop (2004) was quantification of emissions by biomass burning (Flemming 2005b). The associated transfers of gas and particulates from land to atmosphere are substantial and poorly monitored. The observations currently associated with major uncertainties for both the pollution flux into the atmosphere and the change in land cover type. HALO has made a detailed study of existing observational products and operational monitoring systems (Kaiser et al 2005, 2006). Based on that study, we recommend a phased development of capability for quantifying biomass- burning emissions to meet the requirements of the GEMS Integrated Project. Furthermore, recommendations for the assimilation of fire observations during the operational phase of GMES have been formulated and agreed in the wider scientific community (Textor et al 2006).

HALO has analysed different options to fill the gaps in GMES capabilities. Most of the gaps we identified relate to aspects of the Atmosphere-Land interactions, of which the largest is concerned with monitoring biomass-burning on a global and continental scale. In addition we have identified areas where GMES effort is needed and is feasible to improve the treatment of Atmosphere-Ocean and Land-Ocean interactions.

The main HALO scientific recommendations are discussed in detail in the HALO Final Scientific Report, Annex 2, and may be summarised as follows:

Scientific Recommendation 1: GMES should establish a ***Global Fire Assimilation Capability*** *to supply both the atmosphere and land monitoring services with adequate products describing the biomass burning emissions into the atmosphere and the associated changes in carbon stock and land cover.*

*Scientific Recommendation 2: GMES should encourage the scientific development of E**cosystem models incorporating the carbon cycle explicitly** in the marine and land monitoring services.*

*Scientific Recommendation 3: GMES should establish a **Fresh Water Monitoring Capability** to provide the ocean and land monitoring services with adequate products describing, amongst others, soil moisture, river run-off, and fertiliser transport.*

*Scientific Recommendation 4: GMES should facilitate a new **Atmosphere Re-analysis** in support of the ocean re-analysis that will be produced by the marine fast track service.*

*Scientific Recommendation 5: The **GMES marine and atmosphere monitoring systems** should be encouraged to maintain close scientific and operational contacts with existing numerical weather prediction service so as to coordinate and further develop the multitude of interfaces already implemented between the pre-operational and operational systems.*

3.2 Emerging Data Needs

Besides the need for reliable near-real time information on biomass burning, HALO's scientific analysis identified a number of other emerging data needs. These requirements cannot be met by any of the IPs but are needed for operational, re-analysis or research purposes. Examples include MERSEA's emerging need for river-inflow data and the GEOLAND/ONC need for operational access to precipitation data from the hydrological networks. Furthermore, GEOLAND/ ONC needs a global satellite vegetation product, which can be provided by GEOLAND's CSP in re-analysis mode only. Further work is needed to meet this data requirement in a more operational fashion.

4 Managing the Transition from Research to Operations in GMES

As is evident from the technical and scientific discussions in HALO, the Core Services of individual GMES fast track services and pilot services have many mutual dependencies. The degree of that inter-dependence will grow at a rate similar to the overall growth and development of operational GMES activities. The HALO project provided an efficient and manageable forum for discussion of the scientific and technical implementation and planning issues arising from those inter-dependencies in the transition from research to operations (R2O).

GMES Management Recommendation: The HALO experience demonstrates the benefits of dialogue between the leadership of three inter-dependent GMES integrated projects., GMES Management should support the establishment of a similarly efficient forum for managing the interdependencies and the Research to Operations transition of the GMES Fast Track and Pilot services.

As background material for this recommendation, one may reflect on the difficulties experienced in the US in transitioning research space missions, and their related modelling & data-assimilation activities, from research to operational status. These difficulties are reflected in a succession of reports from the US National Research Council (NRC 2000, NRC 2001, NRC 2003), which is an arm of the US National Academies (www.nas.edu). So great have been the difficulties that the first of these reports on the R2O transition is sub-titled 'Crossing the Valley of Death'.

For a variety of reasons, experience in Europe with R2O transitions has been more successful than in the US. Nevertheless, the R2O transition poses real challenges for GMES. We believe the present recommendation offers a useful means to meet the challenges of that transition.

5 Outreach and Communication of HALO Results

The HALO results have been communicated to representatives from the European Commission, ESA, EUMETSAT, WMO, and the industrial and scientific communities at the three HALO workshop held in Reading, UK, in 2004/5/6, at which all HALO results have been presented and discussed extensively.

The HALO results have recently been presented at the DG INFSO workshop
"*Service oriented architectures in support of a Shared Environmental Information Space"* (Frascati, 3/4/2007) and further workshops and conferences.

All HALO results are available from the HALO web site at
http://www.ecmwf.int/research/EU_projects/HALO .

6 HALO Partners

Partner	Country	Role and expertise
ECMWF:	International	* coordination * atmosphere monitoring IP GEMS * numerical weather prediction
INFOTERRA,	Germany	* land cover and vegetation monitoring IP GEOLAND with sub-contractors: o MEDIAS-FRANCE o METEO-FRANCE
IFREMER,	France	* ocean monitoring IP MERSEA
ALCATEL	France:	* data transfer infrastructure (GEMS - MERSEA)
ASTRIUM,	France:	* data transfer infrastructure (GEMS - GEOLAND)

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(All HALO Reports are available for download on the HALO project web site at http://www.ecmwf.int/research/EU_projects/HALO/docs_public.html .)

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