GMES Pilot Atmospheric Services

Final Draft, 23 May 2006

1. Objectives of the Note

The objective of this note is to describe a set of operational GMES Atmospheric Services (GAS) that will provide coherent information on the atmospheric composition at local and regional European, and global scale in support of European policies and for the benefit of European citizens.

The services will complement and build on existing efforts and proven mechanisms and be based on the results and experiences gained from atmosphere-related GMES projects in accordance with the prioritising criteria of the GMES Action Plan 2004-2008[1]. An important aspect of their implementation will be the consistent and systematic assimilation and exploitation of all available observations, including *in-situ*, remote sensing and space-based observations to provide tailored information to the public and government authorities.

The main issues presented to the GMES Advisory Council (GAC) include:

- the main users and the scope of the GMES Atmospheric Services
- implementation issues for the GMES Atmospheric Services
- an action plan for GMES Pilot Atmospheric Services definition process

It has to be noted that the planned GMES Atmospheric Services will complement classical meteorological information currently delivered by the European Meteorological Infrastructure.

2. Need for GMES Atmospheric Services at European Level

The key environmental priorities of the European Community's Sixth Environment Action Programme include the need to monitor atmospheric aspects in the priority areas of climate change, nature and biodiversity, environment and health, and sustainable use of natural resources.

The European Environment Agency's (EEA) presently lists more than sixty air quality related reporting obligations of EEA member countries[2] and its core set of indicators for reporting the state of the environment includes six indicators for air quality, one indicator for stratospheric ozone depletion and four indicators for climate change.

Health issues mainly relate to air pollution and stratospheric ozone depletion (increased surface UV radiation levels). Air pollution in the European Union results in 370,000 premature deaths each year, damage to ecosystems, agriculture, forestry, and cultural heritage. The societal costs of the health impact from air pollution and ozone depletion has been estimated to be in the range of several hundred billion Euros per year. There is a need for near real-time and long-term monitoring services of atmospheric composition and air quality to ensure mitigation of detrimental effects and compliance with the existing European policies and international treaties and to provide science-based information for future policy – and decision making – through a better understanding of the long-term changes in the atmosphere. The draft EU Directive on "Ambient air quality and cleaner air for Europe" puts considerable emphasis on the use of air quality monitoring in support of its objectives[3].

The international community has agreed on a number of international environmental treaties that aim to limit and eventually reverse and undo harmful practices related to the atmosphere (Vienna Convention for the Protection of the Ozone Layer, Montreal Protocol on Substances that Deplete the Ozone Layer, Convention

1 COM(2004)65 final
2 http://rod.eionet.eu.int/
3 COM(2005)447 final

on Long-Range Trans-boundary Air Pollution (CLRTAP), UN Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol to the UNFCCC). In the latter context the EU Greenhouse Gas Inventory System has to monitor and report on emissions and sinks of greenhouse gases.

The EU Green Paper "Towards a European Strategy for the Security of Energy Supply" as well as the EU White Paper "Energy for the future: Renewable Sources of Energy" and the Directive on the "Promotion of electricity produced from renewable energy sources" emphasize the need for an extended use of renewable energies which are affected by atmospheric processes and composition.

In this context, the GMES Pilot Atmospheric Services would enable (1) a day per day analysis of the atmosphere at various space and time scales in order to improve air quality management and scientific understanding, (2) addressing the consequences of strong pollution events, both of regional and long-range transported origin to enable the implementation of emergency control measures, (3) the preparation and dissemination of information products tailored and adequate to the needs and capacities of the users, mandated government agencies and the general public, (4) verification of atmospheric emission estimates as input to air pollution control and climate change mitigation measures, (5) increased public awareness of and sensitivity to these questions.

It is expected that the benefits accruing to European citizens from improved policy and decision making based on the information gathered by the GMES Atmospheric Services would far outweigh the cost of operating these services.

3. Scope of the GMES Atmospheric Services

The scope of the proposed GMES Atmospheric Services will be based on a Core Service architecture to produce basic global to European data sets which will feed a set of Downstream Services providing specific information at regional to local levels. Initially a subset of these services will constitute the GMES Pilot Atmospheric Services which should start their operational delivery by 2009 and from then onwards should be gradually complemented by additional services.

- Global to European monitoring (for climate purposes) and forecasting (for regional air quality purposes) of the abundance and hemispheric/global transport of atmospheric trace constituents including reactive gases (e.g. stratospheric and tropospheric ozone, nitrogen dioxide, carbon monoxide, sulphur dioxide, formaldehyde), man-made and natural aerosols, clouds, and long-lived greenhouse gases.
- Global to European monitoring and forecasting of climate-relevant processes controlling stratospheric ozone depletion and recovery
- Global to European assessment of the emissions and sinks of greenhouse gases and pollutants and related tracers.
- European long-term and near-real time mapping of solar direct and global irradiance.
- Near real-time air quality monitoring and forecasting (European scale)

} Core Service

- Near real-time air quality monitoring and forecasting (regional to local scale)
- Surface UV-radiation monitoring and forecasting (regional to local scale)
- Targeted and personalized services for a wide range of users, including vulnerable people (air quality, UV etc.)
- Targeted services for industrial and commercial users (aviation control, renewable energies etc.)
- Identification, assessment and monitoring of regional/local sources and sinks of greenhouse gases and pollutants and related tracers.
- ….

} Down-stream Services

3.1 Atmospheric Core Service

The first objective of GMES Atmospheric Services is the operational implementation by 2009 of a core monitoring and forecasting capacity addressing both European and global scales.

The Core Service shall be structured at European level and shall represent the bedrock of the GMES Atmospheric Services in terms of implementation, sustained operation and availability. It will provide the standard European data on which the downstream services will be based. Moreover, the Core Service will provide information to be integrated and/or coupled with other process assessments, such as global biogeochemical cycles, especially in the frame of global change forecasting and analysis of future scenarios.

At ***global scale***, an operational capacity is proposed to monitor (for climate purposes) and to forecast (for regional air quality purposes) the emissions, presence and hemispheric/global transport of atmospheric trace gases including reactive gases (e.g. stratospheric and tropospheric ozone, nitrogen dioxide, carbon monoxide, sulphur dioxide, formaldehyde), man-made and natural aerosols, clouds, and long-lived greenhouse gases.. In particular the global service will monitor the long term recovery of stratospheric ozone, including its day-to-day fluctuations and related ozone depleting components, and will forecast UV radiation at ground.

At ***European scale***, three main issues will be addressed:

- **European air quality**, with the objective to provide:
  - Improved routine real-time forecasts of air quality through the incorporation of information from the global service on long-range trans-boundary air pollution (including gases and particulates),
  - Historical information from which trend analysis and impact of the implementation of directives and protocols could be assessed
  - A modelling platform enabling the analysis of future scenarios
- **Regional sources and sinks of CO_2, CH_4 and related tracers**, especially through integration of operational collection of *in-situ* and remotely sensed (satellite based) concentration measurements and use of atmospheric transport models.
- **Availability of renewable energy sources.**

3.2 Atmospheric Downstream Services

Downstream Services are tailored to the requirements and needs of end users which include public sector policy and decision-makers, operational agencies, private sector, and the individual European citizen. A key aspect of the Downstream Services is to link the Core Service to the local and regional users throughout Europe by involving a decentralized network of service providers in close contact with them. This is of particular importance in the case of public information where “a local face for the information” is required.

The Downstream Services build on boundary conditions provided by the Core Service and convert the outputs into directly usable (e.g. threshold exceedance warning) or understandable (e.g. integrated air quality index, personalized skin-type specific UV information) mostly downscaled information products from national to local levels.

One particular asset is the support of improved air-quality-related alerts and forecasts for health services managing chronic obstructive pulmonary disease, asthma (including pollen-induced allergies), and of extreme events involving the combined effects of heat stress, high UV-B exposure and poor air quality;

Downstream services for renewable energy sources will provide solar irradiance potential analysis, policy scenario analysis, energy yield mapping, support to electricity transmission network management together with site audits and plant management for solar power plants.

4. Existing Service Capacities and Projects

To deliver its operational information, the GMES Atmospheric Services will use existing space- and ground-based infrastructures and will provide operational validation of existing mechanisms, including research initiatives and projects of national and regional environment services, national meteorological services, and capacities provided by existing European agencies and centres. GMES Atmospheric Services will not replace existing proven mechanisms but build on them, contribute to them and complement them.

The initial participation in the GMES Atmospheric Services will involve mandated international, national, regional and local (mainly urban) environmental agencies and meteorological services in Member States, together with EEA (EIONET), EMEP Centres, ESA, ECWMF, EUMETSAT – including its distributed network of Satellite Application Facilities (SAFs), the Joint Research Centre (JRC), and other research and academic institutions which provide much of the observational and model developments needed to advance the project. Many of these entities are involved in the ongoing atmosphere-related projects funded by the European Commission, ESA and EUMETSAT.

A significant contribution to the development of the Atmospheric Core Service is currently underway in the framework of the Global and regional Earth-system Monitoring using Satellite and in-situ data (GEMS) Integrated Project funded under the 6th Framework Programme (FP6). Some essential global atmospheric satellite data will be provided by the SAFs (Ozone SAF and Climate SAF), whose operational services will be initiated in early 2007.

Another significant building block to GAS is the ESA PROMOTE (Protocol Monitoring for the GMES Service Element for Atmosphere Monitoring) project which is already providing and about to up-scale policy-relevant and public information services on ozone, surface UV, air quality and greenhouse gases and aerosols.

The FP6 Harmonised coordination of Atmosphere, Land and Ocean integrated projects (HALO) Specific Support Action is preparing key information exchanges for the joint transition of the thematic Integrated Projects (GEMS, GEOLAND, MERSEA) to operational status.

The current convergence of research and development programmes, and the pre-operational integration of European systems and networks, based on existing capacities at national and regional levels, will allow the delivery of information and services on a systematic basis turned to user needs.

5. Conditions for Sustainability of GMES Atmospheric Services

The sustainability of GMES Atmospheric Services is dependent on the long-term availability of space-based remote sensing capabilities, *in-situ* observing systems (including airborne and balloon remote sensing capabilities) and associated data management systems, efficient assimilation of this data into modelling systems.

It will also require the European integration and organisation of existing and new elements of the GMES Atmospheric Services, as well as stable links with research and development activities.

5.1 Observing systems

The observing systems required for GMES Atmospheric Services are integrated into a much wider context of co-ordinated observing systems and data providers at international level, such as the World Meteorological Organisation World Weather Watch (WWW) and its Global Atmosphere Watch (GAW), the Global Climate Observing System (GCOS), Earth Observing Satellites, numerical weather forecasting centres, national ocean forecasting centres, world data centres, and others.

While some components, such as the WWW and the EUMETSAT "mandatory" satellites are firmly established, other components, endorsed by GAW and the Global Climate Observing System (GCOS), rest on uncertain foundations, without guarantee of continuity so far. It is important to note that this is not only the case for satellite based observations, but also for the ground-based observational networks.

Thus an absolute prerequisite for the GMES Atmospheric Services is to ensure the sustainability including funding of observing systems, telecommunication facilities, and the centres for data management. From the very beginning a true integration between satellite observations, *in-situ* observations and modelling must be pursued, as neither of them can provide the promised services alone.

Space component

In terms of the space component Meteosat Second Generation is providing near-real time information suitable for solar energy specific services while the Meteosat First Generation satellites provide the long-term record needed.

The IASI, GOME-2 and AVHRR instruments onboard EUMETSAT Polar System (EPS) to be launched in July 2006, as well as OMI on-board EOS-Aura will significantly contribute to the provision of observations relevant to GAS but will mainly deliver vertical columns so that data assimilation techniques are applied to derive detailed profiles.

The GOMOS, SCIAMACHY and MIPAS instruments onboard ESA ENVISAT mission provide fully relevant measurements for GAS. They should reach their end of mission around 2010 or earlier as ENVISAT is already in an extended mission. Unfortunately this is the timeframe when the GMES Atmospheric Services are expected to be phased in.

In the longer term satellite observations by instruments with higher spatial resolution will be very beneficial to some air quality applications. Future European polar and geostationary missions focused on composition of the atmosphere are envisaged for the medium and long term (ESA GMES Sentinels 4 and 5, and EUMETSAT Meteosat Third Generation and Post-EPS), but decision and planning have still to be secured. Simultaneous monitoring of the stratosphere is fundamental to the consistency of the surface UV radiation and provides the necessary upper boundary for the processing of tropospheric data. The situation is comparable at international level, especially in USA, where medium to long-term commitments are under discussion.

Appropriate data processing facilities are needed to ensure production of high quality data products (e.g. validation, gridded fields, merged data sets, data assimilation), and to facilitate access and availability. Some of those centres are presently in operation, with funding from ESA and EUMETSAT, or national and other sources.

In-situ component

Despite advances in space-based remote sensing and increased use of satellite data for assimilation into models, *in-situ* data (including airborne & balloon remote sensing data) remain essential to enable characterisation of the composition of the atmosphere: it is sometimes the only possible and/or appropriate source of measurement, particularly for local scale tropospheric composition. *In-situ* data are used both for assimilation into models, validation of these models and for calibration of remote data.

In Europe *in-situ* observing data, mainly collected through national infrastructure and funding, are coordinated within the EAA EIONET and the EMEP network. In these contexts real-time data collection and dissemination is presently developed within the project EUSAAR (European Super Sites for Atmospheric Aerosol Research). The global components of GAS will have international dependencies related to collection of ground-based measurements, e.g. through the Global Atmosphere Watch (GAW) programme of WMO. The Network for the Detection of Atmospheric Composition Changes (NDACC) includes many of the ground-based remote sensing facilities at the global scale, with a strong contribution from Europe. Global co-

ordination of *in-situ* observing systems, and exchange of data, should be addressed in the frame of WMO and the Group on Earth Observations (GEO).

One key issue linked to *in-situ* observations, especially for European air quality now-casting, will be the real-time collection and transmission of *in-situ* data to the operational data assimilation centres.

5.2 European integration and organisation

Several research and development projects (FP5 and FP6, ESA, EUMETSAT) have made great strides towards developing components of operational atmospheric services. The added dimension provided by projects such as GEMS and PROMOTE is that they address the scientific and technical issues needed for implementation and integration of the system components.

An appropriate inter-agency organisation based on sharing of responsibilities (linked to a service level agreement process) must be put into place to enable effective, sustained, operation of the system consisting of a complete processing chain from underlying base products to the final user information. There are some challenges in ensuring participation of all national environmental agencies and meteorological services and in particular ensuring appropriate interaction between the two within a given country. The European meteorological services have established the EUMETNET Working Group on Environment to stimulate closer cooperation with the EEA and the national environmental agencies. Under the CLRTAP the EMEP programme is also guiding effective research and development towards an integrated monitoring capacity.

Implementation of a truly operational capacity in Europe, with the global reach needed for GMES, requires both additional cooperation and common facilities. It should be materialised through global, European and regional components and a co-ordinated structure, which will equip Europe with a consistent atmospheric monitoring and forecasting core service to be used for both downstream applications and international cooperation.

5.3 Research and development

The performance of monitoring and forecasting systems is dependent on continuous assessments, validation and improvements based on research programmes at the highest level of excellence. The research topics concern all components of the system, e.g. retrieval and merging of geophysical information from remotely sensed and in-situ data, data assimilation, numerical modelling, assessment of physical and chemical processes, development of information technology, etc. Support of scientific projects is essential to ensure that operational systems benefit from recent scientific advances, and, conversely, that possible gaps or deficiencies in the GMES systems are addressed by the research community.

6. Action Plan for GMES Pilot Atmospheric Services

It is expected that the benefits of the GMES Atmospheric Services will only be reached if the operational production of consistent routine and long-term atmospheric datasets is at the same time integrated with their preparation and dissemination in accordance with the needs and capacities of their users.

The action plan linked to the definition of the GMES Atmospheric Services should address all key implementation and organisational issues, and start an open consultation including user and service provision communities aimed at finding agreement on and consolidation of the implementation of the initial Pilot Services, as well as on its sustainability conditions.

By 2009 the first part of the GMES Atmospheric Services will be implemented which will consist of some Downstream Services and corresponding components of the Core Service. The final definition of these GMES Pilot Atmospheric Services is part of the Action Plan. In 2009-2012 additional services and phased upgrades will complement and build-up the initial set of Pilot Services.

6.1 Issues for the definition of the GMES Pilot Atmospheric Services

These issues include:

- The identification of existing European capacities, in order to optimise their integration and to avoid unnecessary duplications of resources and tools
- The timeframe linked to the operational starting of the services
- The medium to long term sustainability of space and *in-situ* observation components requested to guarantee the quality of the service, and the international agreements needed for the global component of GMES Atmospheric Services
- The structure of service, including the internal agreements between service providers, linked to data collection and exchanges, especially for near real-time service delivery
- The promotion of the services towards users and the establishment of a feedback mechanism to improve products and relevance to users

6.2 Proposed short-term action plan

The following short-term planning for definition of the GMES Pilot Atmospheric Services is proposed:

- May 2006: presentation of this scoping document to the GAC
- June-October 2006: consultation of atmospheric service user communities, including EC Directorates-General, international, European and national agencies, and formulation of requirements
- June-October 2006: consultation between provider organisations/networks on the GMES Atmospheric Services elements
- October or November 2006: possible topical workshop for harmonizing the consolidated user requirements and discussing the implementation process