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A preliminary survey of ERA-40 users developing applications of relevance to GEO (Group on Earth Observations)

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A preliminary survey of ERA-40 users developing applications of relevance to GEO (Group on Earth Observations)

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It has been recognised that there is a need for a more comprehensive and coordinated approach to developing Earth observation systems. This led to the Group on Earth Observations (GEO) being established to implement a System of Systems to be known as GEOSS (Group on Earth Observation System of Systems).

It is expected that the ERA-40 re-analysis data for the period 1957–2003 will play an important role in achieving the objectives of GEO. Consequently an investigation was undertaken into current and future applications of the ERA-40 re-analysis data to provide a preliminary assessment of the current status of development of GEO-relevant applications. Initially we did an Internet search which identified more than 100 projects involving ERA-40 data. Subsequently, we performed a web survey of ERA-40 users and received 127 replies, with the majority of these providing positive feedback about the quality and accessibility of the ERA-40 data. These studies revealed that the ERA-40 data is being used in a wide range of areas relevant to GEO. However, there appears to be potential for more extensive use of this data in particular in areas associated with ecosystems and bio-diversity.

The background and goals of GEO- and GEOSS-related activities will now be described. We will also present the results of the web survey and discuss the feedback received from numerous ERA-40 users.

GEO and GEOSS

Thirty-three nations plus the European Commission adopted, at the Earth Observation Summit I in July 2003, a Declaration of political commitment to move towards development of a comprehensive, coordinated, and sustained Earth observation system(s). There was also affirmation of the need for timely, quality, long-term, global information as a basis for sound decision making. To further these goals, they launched the intergovernmental ad hoc Group on Earth Observations (GEO) to develop a 10-Year Implementation Plan. The group, co-chaired by the United States, the European Commission, Japan, and South Africa and joined by more than 21 international organizations, began preparatory work immediately. The GEO observation system will be built as a System of Systems to be known as GEOSS (Group on Earth Observation System of Systems).

Ministers met at the Earth Observation Summit II in Tokyo, Japan, on 25 April 2004, where they adopted the Framework Document for a 10-Year Implementation Plan for this initiative.

In February 2005 in Brussels some sixty countries adopted the GEOSS Implementation Plan and created a new international entity, the Group on Earth Observations to execute the plan. They are supported in this undertaking by about forty international organisations with a mandate in Earth Observations. The GEO Framework Document, the GEOSS Implementation Plan and the Resolution creating GEOSS may be found at: http://earthobservations.org.

GEO aims to create a System of Systems to achieve “Comprehensive, Coordinated, and Sustained Earth Observations for the benefit of humankind”. In the words of the GEO Framework Document “Understanding the Earth system — its weather, climate, oceans, land, geology, natural resources, ecosystems, and natural and human-induced hazards — is crucial to enhancing human health, safety and welfare, alleviating human suffering including poverty, protecting the global environment, and achieving sustainable development”. Data collected and information created from Earth observations constitute critical input for advancing this understanding.

Comprehensive, coordinated and sustained Earth Observations for understanding the Earth system more completely and comprehensively will expand worldwide capacity. In addition they will provide the means to achieve sustainable development and will yield advances in many specific areas of socio-economic benefit (see box). Globally, these benefits will be realized by a broad range of user communities. This will represent a fundamental step towards addressing the challenges articulated in the declarations of the 2002 World Summit on Sustainable Development and fulfilling the Millennium Development Goals agreed at the Millennium Summit in 2000.

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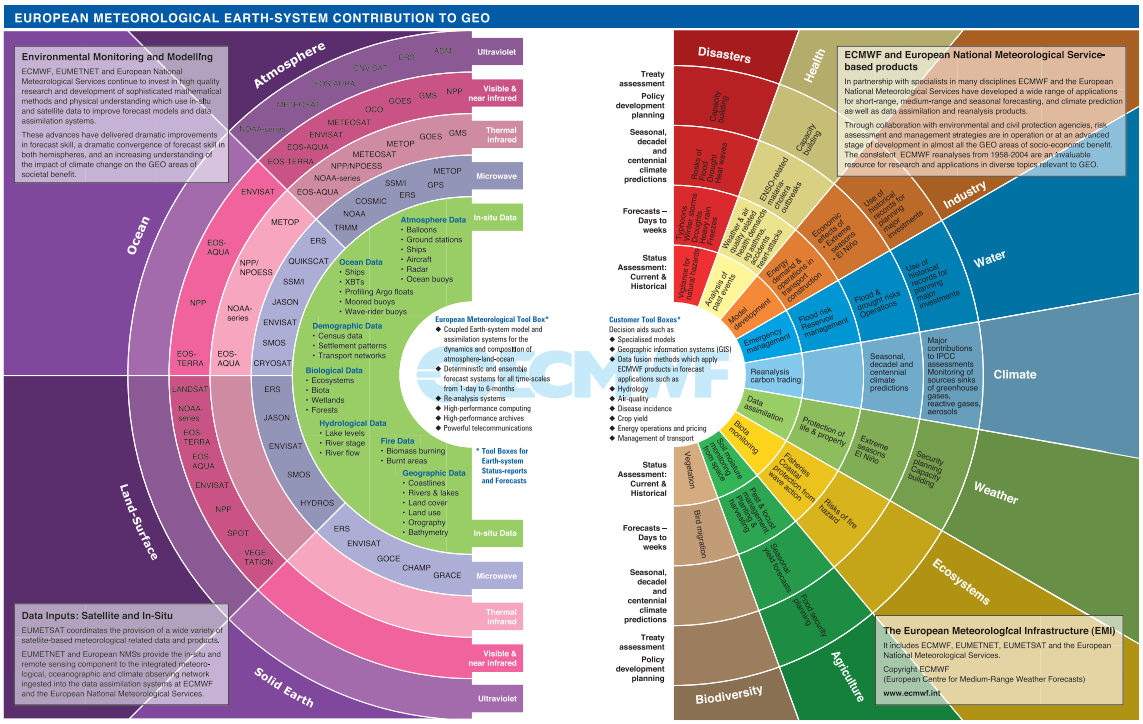

Figure 1 Illustration of the scope of GEO. On the right hand side the socio-economic benefits of GEO (stratified by time-scale) are depicted. On the left hand side the in-situ and satellite observational inputs can be found with satellite missions stratified by the frequency bands used. European Meteorological and Customer Tool Boxes needed to transform measurements to information are shown in the centre of the figure.

Meeting the GEO deliverables

Figure 1 was prepared to illustrate the ambition, the complexity and the feasibility of the GEO objectives, viewed from a meteorological perspective.

- ***Left-hand side.*** This illustrates the diverse in-situ (green) and satellite data sources (arranged by electromagnetic frequency used) needed to achieve the diverse GEO goals. The satellite missions listed include current and planned operational and research missions.
- ***Right-hand side.*** This illustrates the diversity of the GEO deliverables, stratified by the areas of socio-economic benefit, and by the time-scale for which the deliverables are relevant.
- ***Centre.*** This illustrates the meteorological means used to transform the measurements on the left into the deliverables on the right, including current status descriptions and forecasts. Broadly speaking the means used are of two kinds: complex Earth-system models and data assimilation systems (in the left semi-circle), and specialised application models and decision aids (such as GIS) in the right semi-circle.

By design, Figure 1 excludes reference to geo-hazards such as volcanoes, earthquakes and tsunamis which are key aspects of GEO and GEOSS activities. It is recognised that important meteorological capabilities are needed and are available to address the consequences of such events.

Status of GEO-relevant applications

GEO requires an extremely broad and challenging range of applications of Earth Observation data. To provide a preliminary assessment of the current status of development of GEO-relevant applications, we made a web survey of current and future applications of the ERA-40 re-analysis data. The ERA-40 datasets are gridded global meteorological and surface fields available four-times daily for the period 1957-2003. Further information about ERA-40 can be found at: www.ecmwf.int/research/era/index.html.

Internet search

As a first step in November 2004, we performed an Internet search for projects involving ERA-40 data. Google was employed as a search engine using a large number of keywords like “flood” or “greenhouse gases” in conjunction with the “ERA40” keyword. The web hits were categorised into research areas and timescales of forecasts according to the overview given on the right-hand side of Figure 1. We found at least one application for each topic, and identified a large number of users in the sections climate (42 independent projects) and weather (17 independent projects). Altogether, we identified more than 100 projects involving ERA-40 data by means of the Internet search.

A clickable image-map of the right half of Figure 1 was linked to a table containing all the information retrieved in the course of the Internet survey. This information provides an overview of research areas of ERA-40 applications relevant to GEO, and incidentally facilitates communication between ERA-40 users. The data are published on the ECMWF website and can be found at: www.ecmwf.int/research/era/era40survey/

Socio-economic benefits **A**

- 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.
- 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.

User communities

- National, regional, and local decision-makers.
- Relevant international organizations responsible for the implementation of international conventions.
- Business, industry, and service sectors.
- Scientists and educators.
- General public.

User feedback

As a second step, we asked ERA-40 users to contribute to our database. We sent letters via email to about 3,500 users registered at the ECMWF data server. Also the British Atmospheric Data Centre (BADC) and National Centers for Atmpspheric Research (NCAR) forwarded our request to ERA-40 users registered at their data servers. We asked ERA-40 users to send:

- A short description of projects for which ERA-40 re-analysis data was used or is intended to be used;
- Names and locations of participating research institutes if the project was conducted in collaborative work;
- A link to a more detailed project description;
- Comments on what aspects in the ERA-40 data have given the most benefit and what improvement in the data would be the most useful in the future.

We received 127 replies to date and the webpage has been updated to include complementary information about projects involving ERA-40 data.

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Figure 2 shows that the largest amount of user feedback was received from researchers in the United States (28%), United Kingdom (14%) and Netherlands (8%), with responses also coming from 29 other countries. Many researchers not only reported the requested information, but also added personal comments. A large majority of replies contained positive feedback about the quality and accessibility of the ERA-40 data. Many users compared the quality of ERA-40 data with the NCEP data, and an overwhelming majority (9 out of 10 researchers) concluded that ERA-40 proved more useful. Several users requested a peer-reviewed description of the ERA-40 re-analysis and they were happy to learn that such a paper will be published in the *Quarterly Journal of the Royal Meteorological Society* (in press).

A number of suggestions for improvement were made, mainly in terms of increased resolution or a larger time span. Many users would appreciate having the time series regularly extended to the present. Users also gave an indication about the most beneficial elements of the data and which improvements would be most appreciated. Research projects, including links either to a description of the project or to institutes where the research was performed, can be found on the ERA-40 webpage.

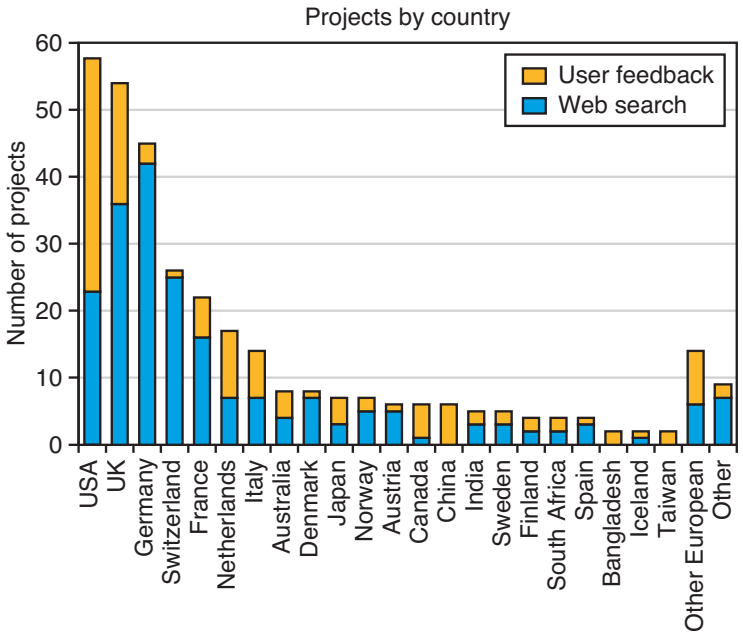

Figure 2 Number of projects by country (identified from both web survey and user feedback) using ERA-40 data.

Extension of the survey

The ultimate goal of the presented survey is to cover all areas of GEO-relevant applications of ERA-40 re-analysis data. The list is by no means considered to be complete at the current stage and we invite ERA-40 users to contribute further to our database. Nevertheless, the survey successfully demonstrates that just two years after release of the ERA-40 re-analysis, the data is already applied in a broad spectrum of areas and by a large number of researchers from all over the world, including several users from developing countries.

We hope the ERA-40 survey will prove valuable to:

- Assess the impact of the ERA-40 re-analysis project;
- Facilitate exchange of information between ERA-40 users;
- Compile a review of research work using ERA-40;
- Make a case for a more comprehensive and longer re-analysis later this decade, which will benefit from the lessons learned from ERA-40.

If you are aware of any project using ERA-40 data not being included in the current version of the ERA-40 survey, we would be most grateful if you contact us at era40survey@ecmwf.int.

Implications for GEO

From a GEO viewpoint, the limitations of the survey are substantial, being limited to one community among many in GEO. Nevertheless the survey results are of interest. They highlight the extensive exploitation of the meteorological forecast products (on time-scales from days to inter-annual) and re-analysis products (on time-scales from days to decades) in GEO-relevant areas such as disasters, health, water resources, weather, climate, and agriculture (see Figure 3).

The survey results also suggest that there is little exploitation of the gridded meteorological fields in GEO-relevant areas such as ecosystems and bio-diversity, where one might have expected wider application. The perceived under-use may arise for reasons of unfamiliarity of the two communities or because the meteorological outreach has not extended far enough. Alternatively there may be a variety of technical reasons which need to be identified and addressed.

From the viewpoint of geographical spread, users of the ERA-40 datasets are found pre-dominantly in Europe and North America, with relatively few users in Africa and Latin America. The meteorological community and GEO may wish to consider ways and means to broaden both the geographic and the cross-disciplinary utilisation of the re-analysis products.

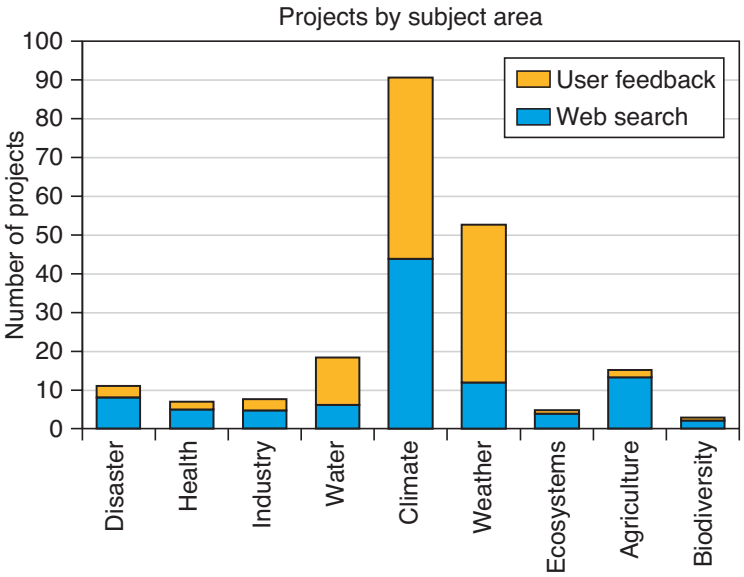

Figure 3 Number of projects categorised according to subject area (identified from both web survey and user feedback) using ERA-40 data.

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