



## Foreword

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**W**hen ESF initiated its new Action Lines, the importance of Scientific Forward Looks was quickly recognised as a key element in planning activities in a particular area of science at both a European and a national level. Forward Looks should stimulate new actions in terms of research and also provoke discussion on how best to organise ourselves to deliver the identified research aims. Within the ESF context, Forward Looks will almost certainly develop proposals for EUROCORES and impact on the whole range of our activities and on those of our Member Organisations.

I particularly welcome the Forward Look on Global Change Research as it is not only the first Forward Look but it has developed a set of recommendations which demands action from scientists and research organisations.

It has demonstrated the need for Europe to optimise its investment and take leadership in this multidisciplinary topic. It also has thrown down a challenge for researchers themselves. The need to bring together the natural and social sciences must be one of the most important recommendations. We have all paid lip service to this in the past. The Forward Look demands that we take action.

The recommendations need to be taken forward not only by ESF but also by many other bodies, including our own Member Organisations and the European Commission. What ESF will do is to commit itself to work towards the implementation of this report, which is based on carefully prepared reviews and in-depth discussion involving many leading European scientists. It thus provides a voice from the scientific community to which we must all pay heed.

**Enric Banda**  
ESF Secretary General

## Introduction and rationale

### ESF Scientific Forward Look

It is becoming increasingly apparent that both the science community in general and funding agencies at both national and European level need to be aware of the likely direction which research will take in the future, especially as traditional disciplines combine to produce new and exciting multidisciplinary areas of study. In taking a look ahead, agencies are also able to better plan their resources to meet possible future demand, including the development of new facilities and infrastructure, which may have a considerable lead time before becoming available. Additionally, such “foresights” will help the development of pan-European approaches between national agencies as well as informing European institutions such as the European Commission and ESF itself.

In its Plan 2002-2006, the ESF committed itself to promote a series of scientific “Forward Look” activities as part of its role in serving the needs of the European research community and ESF’s Member Organisations for the most part of the national research funding agencies. The aim is ESF to consolidate partnerships between itself and its Member Organisations, to join forces with other institutions involved in a particular topic.

To achieve this aim requires bringing together the best ideas and capabilities. Such as gathering of Europe’s key scientific “actors” in any given topic must aim at producing an assessment and recommendations of the highest scientific quality so that they will be accepted by their scientific peers. At the same time, this should not inhibit adventurous forward thinking and sometimes “thinking the unthinkable”. Rather it should provide a means for exploring all ideas and new directions in research.

Such an activity needs to balance assessments of “state of the art” with looking forward. The nature of research is that it is unpredictable but,

within reason, a Forward Look for the next five or more years can provide a useful guide for every one concerned in monitoring the health of European science.

## The reasons for a Forward Look on Earth System Science

Scientific research in global change is, by its very nature, an international endeavour. Yet its funding is predominantly a responsibility of individual national funding agencies. This situation has worked relatively well as long as collaboration was a matter for individual scientists in different countries, although travel money and sometimes visa and other problems do create barriers. Today, the scale and complexity of scientific questions related to global change require an unprecedented global collaboration of scientists from a broad range of disciplines, both in the natural sciences and in the social sciences. At the same time the requirements for infrastructures for global change research go increasingly beyond the capabilities of a single nation. Science funding mechanisms transcending national boundaries become increasingly necessary. In global change research the regional dimension is becoming ever more important at the same time. This calls for effective funding structures in Europe in order to promote as much as possible a strong coordinated contribution of European scientists to the global research effort. ESF and EU have important, partly complementary, but rather different roles to play, along with national funding bodies.

The international scientific community developed a set of four global research programmes in response to the scientific challenges of the complex issues of global change. The World Climate Research Programme (WCRP) deals with understanding the physical climate system, its evolution, variability and predictability; the International Geosphere-Biosphere Programme (IGBP) addresses the biogeochemical and ecological aspects of global change; the International Human Dimensions Programme of Global Environmental Change (IHDP) has developed a research agenda on the role of humans in causing global changes and how they are affected; the DIVERSITAS programme was created to address the causes and effects of the loss of biological diversity in an interdisciplinary

way, and to design tools for a more sustainable use of biological diversity. The essential role of developing countries was realised early on and as a result the Global Change System for Analysis, Research and Training (START) has been initiated by IGBP, IHDP and the WCRP. START helps build endogenous capacities in developing regions of the world so that they can participate effectively in research projects of the international programmes. START also promotes interdisciplinary research at the regional level through its regional networks.

Characteristic of these programmes is their large scale and multidisciplinary and their light central scientific management structure. They are very resource efficient because they build on a large body of existing and planned global change research at national and regional level, to which they add considerable value by:

- providing a framework for priority setting through an internationally agreed coherent research agenda
- providing a framework for efficient allocation of scarce resources (e.g. ship time, buoy arrays)
- stimulating scientific network building
- developing common methodologies and experimental protocols
- organising model intercomparisons and data standardisation
- promoting the development of research observation networks, some of which may become fully-fledged operational monitoring systems
- executing synthesis and integration of individual research project results
- providing essential inputs in the international policy process dealing with key environmental issues, e.g. through key contributions to the IPCC assessments and through the transfer of results to the public at large

The total amount of funding for global change research is not the main issue. However, mechanisms for research funding – national and regional – should be reviewed in order to stimulate the development of a strong European contribution. Unnecessary barriers should be removed. In addition, there is a need for more stable mechanisms to support the value-adding activities, requiring less effort in fundraising for the scientific management of these global

programmes. The aim of the Forward Look was to overcome barriers of all types and at all levels and to provide a template for more effective collaboration and coordination leading to a more effective use of research money in Europe and a strengthening of the European leadership in global change research.

## Forward Look discussion

### Summary and conclusions

The Forward Look meeting on global Change Research took place in Stockholm, 30 January-1 February 2002 in partnership with the FORMAS (the Swedish Research Council for Environment, Agricultural Science and Spatial Planning), the Swedish Research Council and with additional support from the NWO (Netherlands Organisation for Scientific Research).

### Introduction

In his keynote speech, Professor Bert Bolin of Stockholm University and former Chair of the IPCC, placed Earth System Science in the context of sustainable developments, the scientific knowledge necessary to lead towards sustainable developments in various domains of society. At the same time, Earth System Science is exciting frontline science. It requires a long term perspective (and commitment); it requires research of the highest quality; and it requires a re-thinking of traditional science production beyond disciplinary boundaries. In order to achieve the ambitious goals of understanding the Earth's systems and the way they are being influenced by human activities, it is crucial to support scientists who have the appropriate interests, expertise and desire to cross disciplinary boundaries and to stimulate the gifted young people to develop their talents in this direction. The relevance of the results for society makes it mandatory that the scientific community takes an active role in communicating these results to the wider public and contributes to the integration and synthesis of the results to the benefit of policymaking. It is essential to create a dialogue between the scientific community and representatives of society.

The international programmes of the Earth System Science Partnership (WCRP, IGBP, IHDP and DIVERSITAS) demonstrated that they have done an impressive job in the

integration of the results across all four programmes. Many exciting scientific results have been obtained, as is witnessed by articles in the leading scientific journals, and as was demonstrated in the first Global Change Open Science Conference held in July 2001 in Amsterdam. The Earth System Science Partnership merits support from the scientific community and from the science funding agencies. The next phase in the Earth System Scientific Partnership (ESSP) research will involve a set of fully integrated joint projects, addressing such issues as water, food and fibre, and carbon. Integrated regional research will be an important component of these joint projects. Specific multidisciplinary questions such as climate variability and predictability, industrial transformation, the role of the coastal zones will continue to be emphasised in their own right but will also contribute to this fully integrated approach.

### The approach to the Forward Look

Six small teams of leading European scientists were invited to contribute to the ESF Forward Look by providing an insight for their area of science, into what Europe could contribute to the global research effort, based on strengths and available infrastructure, how this could be organised and what barriers need to be overcome in order to realise the European contribution. The areas chosen were not meant to be all-encompassing, but rather to be illustrative of what Europe could contribute. It was expected that the case study papers will serve as seeds for initiatives in the scientific community and for action in the funding community.

### Outcomes of the discussion on the case study papers

A common element in many of the case studies was the observation that Europe has considerable strengths to offer to global change science. There are excellent groups in each of the case study areas and there is a rich diversity in scientific approaches and study sites. In particular, the diversity in both cultures and landscapes was mentioned. The EU accession countries have a lot to offer in this context. In many areas of modelling, such as the interplay between the social system and the environment, Europe is recognised as the world leader. However, a sub-optimal use is being made of these European resources due to a mainly

national planning of research, based on a variety of national priorities, which are insufficiently integrated at the European level. This could be rectified by a more coordinated planning of future projects (individual as well as joint) at a European level and by more communication about national priorities. There was a call for a strong science-driven coordination of global change research in Europe. In this context an open competition for funds across borders on the basis of quality was proposed, which should not be restricted solely to the policy goals of the EU. A European role in the scientific coordination by the global research programmes requires a small but stable and easy to access budget for value adding activities. To date these funds are insufficient and dispersed. The gap between the natural sciences and the social sciences was seen to be a major problem in most of the case studies. For all areas monitoring and long-term datasets are increasingly essential. Especially the continuity of the *in situ* component of monitoring was considered to be in jeopardy.

### **Better use of existing instruments for supporting global change research**

There is a number of 'players' within Europe with an interest in global change research, most of course operating at the national level. The overview of mechanisms and instruments for supporting Earth System Science at the European level in the ESF, in the EU Framework Programme and in other organisations demonstrated that a wide range of mechanisms is already available. Also the presentations of national research showed that many national instruments to support global change research already exist. Most of these also encouraged and supported international collaboration. Maximum use should be made of these instruments in the design of collaborative programmes. Barriers to their effective use in supporting integrated Earth System Science programmes should be analysed and recommendations on how to improve their usefulness should be addressed to the appropriate bodies. A wide range of programmes addressing various aspects of Earth System Science is already ongoing in several European countries. These programmes vary considerably in size and in design. Some are only bringing together research supported in a responsive mode by the funding agencies, whilst in other countries, there is a fully coordinated activity from the outset. As a first step to European integration,

the potential for linking these programmes should be explored in depth. The presentations and the ensuing discussion gave the sense that there is willingness in the national science funding structures to explore such linkages and the ESF was seen to be an appropriate platform for such discussions.

### **Data and monitoring**

Monitoring is an essential tool for Earth System Science. It requires an integrated system with remote sensing (especially from space) and *in situ* components and with the associated data handling, distribution and storage. The problems related to the development and maintenance of such a system were illustrated, in particular, by reference to ocean monitoring. The synergy between monitoring requirements for research and those for operational policy and commercial purposes was clearly demonstrated. The cost of operational systems cannot and should not be funded from science budgets. This calls for partnerships. In Europe, the Global Monitoring for Environment and Security (GMES) initiative of the EC, already endorsed at a high political level, should develop into an important mechanism in this respect. An effort to develop new technologies is essential for bringing down the cost of monitoring in order to meet new emerging needs. ESF could play a leading role in stimulating the development of such technologies through its EUROCORES Scheme. The availability and access to data are other key factors for frontline science. Responsibility for storage, interoperability of databases and data policies requires attention at the European level.

### **The links between science and policy**

Finally, the links between science and policy were considered. There is still a gap between the scientific community and the policy community in the appreciation and understanding of each other. The new Earth System Science has a lot to contribute to developing the scientific basis for a sustainable society. At European level the EU plays a key role in this area. The EU requires a firm scientific basis for its policy directives, which in turn drive the priorities in the Framework Programme. The EU should look to the ESF to provide the scientific platform, to develop science plans for Europe and to bring together and support European research groups which can contribute to policy relevant advice to the EC.

## Recommendations

1. The European scientific community is encouraged to initiate the development of flagship projects which address the challenges of the science agenda of the programmes of the Earth System Science Partnership in a bottom up manner. Projects such as these must aim to make a strong European contribution to the global programmes, making maximum use of European intellectual strengths, other scientific and technical facilities and capabilities, including the relevant available research infrastructures. The projects must be open for the participation of excellent research groups in Europe and if necessary provide the basis for the definition of new European research infrastructures. Such projects must make maximum use of existing mechanisms of the ESF, the EU and of the Member Organisations of the ESF, as well as of opportunities offered by other organisations such as ESA, EUMETSAT and ECMWF. Projects should aim at fully integrating into the global research effort. Integrated projects of research in the Arctic and sub-Arctic Basin and in the Mediterranean Basin (some programme proposals for aspects of the Mediterranean are already under discussion) were identified as flagship projects which could constitute major European contributions to international global change research, within the context of the ESSP. Such an approach must ensure the full integration of the social and natural sciences from the very start.
  2. The concept of the European Research Area, proposed by the EU Commissioner for research, Philippe Busquin, points towards the need of a full integration of scientific efforts across the whole spectrum of European science, not limited to the mission orientated policy goals of the EU Framework programme. The application of this concept to the field of Earth System science requires the setting up of a European Global Change Board. This Board provides a platform which could bring together all the relevant European ‘players’, including the ESF and the EU. Given that such a body must be science-driven and policy relevant, it is appropriate that this should be hosted by the ESF but the European Commission and the EU Framework Programme would have major roles to play. Thus, it must be seen as a fully collaborative effort. The main tasks of this Board would be:

    - to act as a platform to stimulate the development of European flagship projects addressing the agenda of the Earth System Science Partnership, making maximum use of existing mechanisms. Advantage must be taken of ESF instruments, in particular, EUROCORES. This recently established instrument is well suited to bring together national funding agencies in a funding partnership for European cooperation in research without a need to transfer national money and without a need for new structures. Also the new EU Framework Programme’s instruments – Large Integrated Projects and Networks of Excellence – as well as the collaborative programmes of national research councils should be used effectively for such flagship projects
    - to develop efficient mechanisms to stabilise and increase the European contribution to the budgets for the value-adding activities of the programmes of the ESSP, building on existing mechanisms within the ESF; to identify barriers and complexities imposed by national and European funding mechanisms which prevent the full development of the potential of international scientific research collaboration and to propose harmonisation measures; to propose, in exceptional situations where existing instruments clearly fail, to the ESF, its members and to the EU new instruments for European collaborative programmes
    - to identify the potential for better coordination of and more collaboration between national scientific infrastructures and to propose new research infrastructures required by the European effort in Earth System Science
- The Board should be composed of representatives of the ESF Member Organisations, scientific leaders in the global change research field, the EC and the international programmes of the Earth System Science Partnership and other agencies in Europe, both at the national and European level, involved in various ways in supporting global change research. A criterion for membership of the Board should be the preparedness to discuss

and act on structural issues and their financing consequences as well as the capacity to understand the science involved.

3. The Forward Look addressed four specific themes which are essential for programme development in Earth System Science: (a) the collaboration between the natural and the social sciences; (b) the interface between science and the policy domain; (c) the requirements for monitoring and data; and (d) capacity building. The most important recommendations which were agreed are:

#### **a. The collaboration between the natural and the social sciences**

In nearly all domains of Earth System Science, the role of humans is a key factor (as a driving force, as a subject of impacts and as an agent in mitigating impacts). Collaboration can really only take shape if programmes are developed in a side-by-side collaboration of natural and social scientists from the very start. The new approach in Earth System Science, in which the global system is addressed by synthesising fully integrated research, both on a global and a regional scale, on key themes like water, carbon and food and fibre production and consumption systems, offers an excellent potential for initiatives for such collaboration at the European scale. The ESF has an important role to play in breaking down the institutional barriers that hamper collaboration between the natural and the socio-economic sciences. These barriers also hamper the engagement of leading social scientists in global change research. Examples of such barriers include the way in which the peer review system operates and is organised at present, the publication culture, the funding structures and the mutual suspicion that exists between the two communities. There has to be a willingness to plan projects together from the start, taking into account the different traditions in the various disciplines. The proposed European Global Change Research Board should play a leading role in identifying and analysing such barriers and in proposing solutions to overcome or remove them. The relevant bodies of the ESF should be closely

involved. In particular the ESF Standing Committee for the Social Sciences should be invited to stimulate key communities to become active in this area.

#### **b. The interface between science and the policy domain**

Earth System Science is an area of integrated scientific effort to resolve frontline scientific questions about the functioning of our planet. At the same time problems in society, related to a sustainable use of the Earth's resources and the development of a sustainable society, require a much better insight in the fundamental Earth processes and in the way humans act in relation to sustainable futures. The results of Earth System Science must hence also feed into the policy domain. On the other hand, society has very specific questions for the scientific community regarding these issues. The proposed European Global Change Research Board could play a role in organising the input of science into regional assessments at the European level. While the clear lead role lies with the EU, the proposed Board could act by creating a directory of Earth System Science: a clearing house of information and available expertise. Finally, scientists should accept their responsibility, both individually and as a community, to communicate their research results to the wider public and to inform policy makers and politicians and also to build this into research activities as part of the general dissemination of results. This requires the creation of methods for dialogue between the scientific community and the general public.

#### **c. The requirements for monitoring and data**

Science provides the basis for the design of operational systems for environmental monitoring for policy and commercial purposes. In turn, Earth System Science is crucially dependent on monitoring from space and *in situ*. Once an operational phase is reached, the responsibility for the monitoring systems should be transferred to operational entities and should not remain within the research setting.

This calls for partnerships of the scientific community, science funding agencies and operational monitoring entities. At the European level such partnerships should be created involving EC, ESF (and its constituent parts), ESA, and EUMETSAT. Other actors such as EuroGOOS and ECMWF should also be involved. It requires long term commitments of governments to invest in the infrastructure needed for operational monitoring for policy, science and private sector applications. In this context, it is necessary to create awareness in government ministries and agencies of the importance of monitoring and of the need for a coordinated effort in its investment. At the same time, it should be realised that some of these ministries may have only a small role in monitoring. A special effort is required to create awareness of the importance of the *in situ* observations, as these often receive the least attention.

The European effort in this area should form part of the Integrated Global Observing Strategy (IGOS). The proposed European Global Change Research Board could promote the active participation of Europe in the approved activities of the already established IGOS partnerships. The new EU initiative on GMES offers a potentially powerful mechanism to organise and focus the European effort. The Board could develop a close relationship or – better still – be acknowledged as a key player in the GMES structures, as representing one of the principal user communities.

The next generation of monitoring systems must be much more cost effective. This will require new science and technology. The ESF should promote the development of this next generation technology in close collaboration with European partners. EUROCORES should be explored as a mechanism for this collaboration.

Efforts need to be made to develop databases for social science research within Earth System Science.

Increasingly the cost of obtaining, archiving and providing available and accessible data is becoming a significant problem. Publicly funded data has to be

made available to researchers without a ‘commercial’ charge. Funding of data acquisition and storage systems should allow the provision of data at no or little charge to bona fide scientists undertaking public good research. The science funding agencies should take an active role in ensuring that frontline Earth System Science research is not inhibited by data problems as European researchers are seriously disadvantaged in being faced with charging systems based on full cost recovery.

#### **d. Capacity building**

Insufficient human capacity is a – if not the – major factor limiting Earth System Science research to achieve its full multidisciplinary breadth. A major accomplishment of the programmes of the ESSP has been the education of a new generation of scientists capable of making significant contributions to the integrated multidisciplinary science effort. An increased and sustained effort is needed however. The European science funding agencies should support this effort by stimulating multidisciplinary science projects for young promising scientists. In addition, there is an obligation on the EU and on national agencies to develop multilateral efforts to aid capacity building in the developing world, including the support of young researchers. This will also help in influencing funding decisions taken by international bodies such as the World Bank or through the Global Environmental Facility (GEF).

A second issue of capacity building is that there are large untapped resources in the EU accession countries and in the developing world. In addition to the importance of supporting science as an instrument for sustainable development, there is the simple necessity that if we want really to study, as well as monitor, the Earth’s systems in a comprehensive global manner then we need to develop partnerships. This, in turn, implies an obligation to help build capacity. Partnerships between science funding agencies and the development assistance agencies should be promoted to support this.

# ESF Forward Look on Global Change Research

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