The Future of International Cooperation in Observing Systems

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Introduction

The long and successful history of international cooperation in earth observations[1] demonstrates evocatively the enormous benefits that nations have reaped from working together to monitor the earth's atmosphere and oceans, unravel its secrets and deliver services for the benefit of their communities. Like all good histories, there are valuable lessons to be learnt and, as many a strategist has learnt, we ignore these lessons at our peril. At the same time, the world we live in and the way we live is changing, and current trends in globalisation and technology are already laying down markers for enhanced global-scale cooperation in the future.

The dimensions of international cooperation, however, go well beyond the technology and it behoves us to understand these dimensions in full before committing ourselves to a future that is driven by the technology alone.

This paper first argues that there is a future for international cooperation in observing systems – that argument is not difficult to make, even without any reference to the fact that meteorology recognises no political boundaries and the global ownership of the world's oceans,. The paper then draws out some of the key features of past and present cooperation and explores the essential dimensions of international cooperation. We then look at some current trends and look ahead to contemplate what shape that engagement might take in the future.

The drivers for future cooperation

The benefits of international cooperation in observing systems are abundant. They are amply illustrated through the ongoing improvements in the atmospheric and oceanographic sciences, and in the quality and range of services provided to most users in most countries. That is not to say that all needs are met, that no gaps remain and that there are not areas in which improvements are still to be delivered.

The global, high-level political attention now focussed on understanding and addressing the impacts of climate change provides tangible evidence of the value of international cooperation in observing systems. This, and in particular the international mechanisms to understand and address global climate change, such as the IPCC and the UNFCCC, would never have been achieved without internationally negotiated and agreed observing and reporting standards, and

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[1] As described in detail in the papers by James Rasmussen, Greg Holland and Tillman Mohr in the session on The History and Current Status of International Cooperation in the Atmospheric and Oceanic Sciences and Services' of the *Richard Hallgren Symposium on International Cooperation in Earth Sciences,* AMS, New Orleans, January 2008

the establishment and maintenance of global observing systems, including high quality baseline networks. Monitoring the continued scale and impact of climate change and the effectiveness of measures to ameliorate it, as well as development of adaptation strategies on local to global scales, requires the continuation and strengthening of the current internationally coordinated observing systems.

The ability of most nations to prepare for, mitigate and respond rapidly and comprehensively to natural disasters also owes much to the established international cooperation in observing systems. In particular, through globally shared observations ingested into global numerical weather prediction (NWP) systems, early warnings of large scale severe weather can be disseminated on timeframes that reduce the risk to lives and property, and that allow international support for disaster response and relief to be delivered promptly to those countries less able to respond themselves. The ability of less developed countries to develop and strengthen their own disaster risk reduction and response systems, as well as to support climate and weather services more generally, has also been advanced through internationally supported capacity building efforts aimed at the maintenance and operations of observing systems in developing countries. The continued and growing risks to vulnerable populations, especially with the added impost of climate change, underline the need for continuation and enhancement of international cooperation in these areas.

If any further evidence is required of the importance of continued and enhanced international cooperation in observing systems, it is provided by the establishment in February 2005 of the intergovernmental Group on Earth Observations (GEO) and the development of its Implementation Plan for a Global Earth Observation System of Systems (GEOSS)[2]. More on GEO and GEOSS later, but the key point here is that underpinning the decision by its foundation Members and Participating Organisations to establish GEO and to implement a GEOSS through building on and strengthening existing global observing systems, was the agreement that substantial improvements could be provided to the decision making capacity of users across a wide range of societal benefit benefits areas, through international coordination in earth observing systems.

The benefits delivered by international cooperation in observing stsyems are real and the need for them is ongoing, that much is fairly obvious. It is equally obvious that the benefits are not complete, that not all nations are as well served as possible by the existing arrangements, and that real gaps and deficiencies remain in observing systems at national and international levels. The real question is what scope is there to improve the mechanisms of cooperation, to address the gaps and deficiencies of the existing observing systems and cooperation mechanisms, and to enhance the delivered outcomes.

Lessons from history

The WMO World Weather Watch (WWW) comprises an integrated system of systems[3] that is the envy of most other disciplines that are dependent on coordinated and timely global observations and especially those that follow agreed standards in formatting, reporting frequency, coverage and content. As such, it has set the benchmark for international cooperation in observing systems even beyond the meteorological and related domains. The WWW provides the overarching framework, but the observing systems and the associated

[2] Documentation on GEO and GEOSS can be accessed from the webpage //http/earthobservations.org
[3] The WMO WWW comprises the Global Observing System (GOS), Global Telecommunications System (GTS) and the Global Data Processing and Forecasting System (GDPFS)

data processing, telecommunications and service delivery systems are contributed by its Members and their National Meteorological and Hydrological Services (NHMSs). A strength of the WWW is its near global membership and its capacity to benefit from the expertise of its Members and linkages to other international scientific and technological bodies. These attributes have been critical in mapping out the evolution of the Global Observing System, the integrity of the Rolling Review of Requirements (RRR) process, and in the systematic integration of new technologies, such as air borne and space borne systems, with the more traditional surface-based technologies, from a global level to a national level.

The past achievements in international cooperation among the meteorological, oceanographic and satellite communities (noting that these are not mutually exclusive groups) provide some valuable lessons. In particular, in considering the shape of future international cooperation, we might note:

- The gestation period of these models of international cooperation and the timescale for them to become productive – the concept of the WWW was formally recognised in 1963, although its roots lay much further back in history, and while it is regarded as probably the most outstanding example of global-scale international cooperation, it is still a work in progress. The satellite community is relatively youthful, compared to the long history of surface-based observations, and bringing the mix of national and regional interests together created its own challenges, but the WWW, by 1967 when the first WWW Plan and Implementation Programme was approved, provided the initial and still ongoing structure for coordinating meteorological interests in space. The diversity of interests in oceanography, the overlaps and ambiguities between research and operational systems, and the rapid development of ocean sensing technologies have created a different set of challenges, but the mechanism of cooperation has evolved to fit the needs of the relevant communities.
- Data policy – arguably the most tangible benefit of the achievements to date has been the formalising of data exchange policies, such as the historic Resolutions 40 and 25 of the World Meteorological Organization (WMO), approved by the 12th and 13th WMO Congresses respectively (1995, 1999). These provide for the free and unrestricted exchange of data and products for the use of Members, but provide guidelines also for the conduct of commercial activities. These policies have become a powerful mechanism for breaking down scientific barriers between countries, even when political barriers are enforced, and have played a key role in facilitating accelerated collaboration on global climate analysis and modelling.
- Linkages between research and observations – in parallel with the initial steps towards the development of the WWW was the development of the Global Atmospheric Research Programme (GARP), and the two programmes were strongly interlinked. That close relationship has continued to this day, including through the First Global GARP Experiment (FGGE), and future pathways are already mapped out, including through Thorpex. The benefits flow both ways, with research efforts aided by access to comprehensive and targeted internationally coordinated observations programs, and with research outcomes providing new science, techniques and technologies that benefit ongoing meteorological, hydrological and oceanographic monitoring systems.
- Close relationship between data gatherers and data users – the relationship between research and observations is just one example of the close relationships that permeate the meteorological, hydrological and oceanographic communities. The communities are fundamentally focussed on service and the end users of the observations are the essential drivers of the observations themselves, making this the classic end-to-end science and service delivery model. In fact, it goes further, since the capacity building

loop also aims to close the gaps between requirements and capabilities in even the poorest countries. At a global scale, the relationships extend to the connectedness within the UN System between WMO and other UN agencies, including through the co-sponsorship of programmes such as the World Climate Programme and the Global Climate Observing System (GCOS), and through the role played by GCOS in supporting Article 5 (Research and Systematic Observations) of the UN Framework Convention on Climate Change.

- Global participation – a feature of the intergovernmental mechanisms that underpin international meteorological, hydrological and oceanographic cooperation is the level of global participation they have achieved, with around 200 countries now contributing to the established international organisations. While achieving consensus amongst such a large number of Members might be slow on occasions, the transparency of the underlying processes and the trust that has developed more than compensate for any apparent bureaucratic overlay, and the commitment and cooperation once consensus is achieved is global in extent. Only a small subset of countries operate space agencies and contribute space-based observations, but the success of the Coordination Group on Meteorological Satellites (CGMS) and incorporation of the WMO Space Programme within the WWW Global Observing System reflect the perceived benefits of a global community of participants.

Whether the future model for international cooperation follows the same path as currently exists, or takes a new turn, there would need to be powerful reasons to ignore these lessons.

Future drivers of international cooperation

Since the early establishment of UNESCO's IOC and the WMO World Weather Watch, the scope of earth observations has become increasingly more complex, evolving from manual and surface-based systems through airborne and ocean borne systems to space borne systems. At the same time, computing and communications systems have evolved even more rapidly, allowing increasing volumes of data to be processed and communicated at ever increasing speeds, to be accessed by users in nearly all countries of the globe within minutes of the time of observation, and to be assimilated in increasingly complex numerical models capable of delivering forecasts of longer lead time and greater skill. Concepts such as distributed data bases, open source software and almost unlimited data access and dissemination options give data users considerably more power and control.

The user communities themselves have also evolved, and are now more diverse in their interests and requirements, increasingly more aware of the value of earth observations, and more capable of accessing and applying them both in every day decisions and in developing future plans and policies. Not least, global warming and awareness of the impact that humans are having on the earth are major drivers of the upsurge in interest in earth observations.

The recent surge in satellite data volumes, through introduction of hyperspectral sensors, advanced data compression and high bandwidth transmissions, will only continue to increase the volume of data and the range of derived products that will be available for global users. The development of numerical modelling introduced gridded data from point observations, but increasingly we are moving to a world where three dimensional spatial data and integration of layers of information is the norm.

The globalisation of the world economy, the evolution of regional trading blocs, and a range of other complex multilateral arrangements all serve to make international relationships even more complex, entwined and mutually dependent. Globally, we are now able to respond much more rapidly to natural (and other) disasters, to communicate information and reports across global networks, although we still struggle to implement best practices in disaster risk reduction within all countries.

Within the framework of international cooperation, the actual contributing systems and networks are largely owned and operated by individual countries or groups of countries. However, as space-based observing platforms become more prevalent and contribute an increasing amount and diversity of data, the scene changes somewhat since platforms operated by one country or agency can readily observe the territory of others. This raises new issues in relation to national sovereignty and security, and adds additional perspectives to the open and unrestricted exchange of data that has long been a principle of the international meteorological and oceanographic communities.

Mechanisms of future cooperation

Traditionally, when talking about international cooperation in observing systems amongst the global meteorological and related communities, the focus has been on sharing data, developing and applying common standards and practices, intercomparison of measurement systems, collaborating on research and services development and building the capacity of less developed nations to improve their own observing systems.

These remain critical aspects of international cooperation, but the dimensions of cooperation have expanded in parallel with the changing drivers, and any future mechanism must consider them all, including:

- Between countries - bilaterally, regionally and multilaterally;
- Across observing platforms – bringing together data sources from in situ through to remotely sensed, from automated through manual, from point data to spatially distributed data;
- Across regimes – combining observations of the land, sea, ice, atmosphere to address common challenges, such as global climate modelling;
- From end to end – from data acquisition through to application, including observing, communications and data processing technologies, and linking to (if not directly delivering) services to end users;
- Across socioeconomic sectors – through global communities of practice, recognising that a much wider range of sectors beyond the traditional earth sciences, are now seeking global information, such as in health, agriculture and biodiversity applications; and
- Spanning the requirements of many scientific disciplines – from biodiversity to marine ecology through to atmospheric chemistry.

Another critical dimension is the relative wealth of countries and their ability to invest in sustainable observing systems. An issue that must be addressed in any consideration of future international cooperation is the ongoing decline in observational capacity in many of the less developed countries. Satellites will, over coming decades, fill the data gaps and begin to provide more and more of the observations to support the required meteorological, hydrological and oceanographic services in such countries. However, while satellite data might meet the full needs for some applications, national capacity to operate observing systems remains essential, both for ground-based calibration and to meet the full suite of requirements, including near-ground observations and climate monitoring.

Satellite-based data dissemination technologies will certainly have an important role to play in directing the required observations to the required communities on the required timeframes. For example, the Integrated Global Data Dissemination System (IGDDS) which provides the core of the GEONETcast system, is already on track to deliver not just space-based observations but a full suite of surface-based data and products directly to service providers, as long as they have the (low cost) communications facilities required and the capacity to process and use the data.

A healthy international earth science system cannot divorce observations from research and services. The integrated service delivery model of the WWW has served the meteorological and related community well, and if data acquisition is separated from use, we lose the feedback mechanisms that provide the essential quality assurance and continuous improvement. Continued capacity building efforts will assist in ensuring space-based and space–disseminated data can be utilised effectively, but the bottom line is that in principle all countries should retain capacity to manage and operate their own observing systems, and that ongoing global participation is essential.

The integration approach

The increasing global focus on sustainability has stimulated wide interest in understanding the many facets of earth system science and, in fact, has broadened the scope from the traditional physical, chemical and biological aspects to economic, demographic and social aspects and beyond. As a result, integration of data from multiple systems and disciplines has been a strong theme of international cooperation in earth sciences over the last decade or so. The challenge is to provide a common framework through which the different data sources can be brought together and, for example, assimilated into increasingly complex models, while recognising the different ownership and objectives of the various component systems.

The developing concept of the WMO Integrated Global Observing System (WIGOS) is aimed at providing a more coordinated approach to the global observing systems supported by WMO and its Members, extending the system of systems approach already established within the WWW GOS to other systems, such as the Global Atmosphere Watch (GAW), the Baseline Surface Radiation Network (BSRN), Voluntary Observing Ships (VOS) programme, and the Aircraft Meteorological Data Relay (AMDAR) system. The WIGOS is intended to be a comprehensive, coordinated and sustainable system of observing systems and, together with the WMO Information System (WIS), aims to deliver an integrated WMO end-to-end system of systems designed to improve the Members' capability to provide a wide range of services and to better serve the needs of research programmes.

As discussed earlier, the GEOSS concept has emerged from similar considerations, driven at the highest levels by the desire to use earth system observations to ensure the sustainability of the earth system itself. GEOSS, which aims to address a wide range of environmental and societal benefit areas, is consistent with the WIGOS approach and it is reasonable to consider WIGOS itself as a potential contribution to an overall GEOSS.

The WWW GOS serves the world's meteorological communities, both operational and research, spanning weather, climate and hydrological requirements – not perfectly, but it provides a global model that is the envy of most other data-based disciplines. To facilitate the sharing and integration of meteorological and related data with other types of earth observations data, to meet the needs of all the societal benefit areas identified by GEOSS, is a natural extension of what has been achieved so far through international cooperation.

An important question, however, is whether those communities currently well-served by the existing mechanisms that operate under the auspices of WMO and IOC and that build on the national efforts of their Members, would be well served by GEOSS as a framework for international cooperation.

The GEOSS model of cooperation

The GEOSS vision, as stated in the GEOSS Ten-Year Implementation Plan[4], is to realize a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations and information.

Few people would argue with the merits of the GEOSS vision and its intended purpose of achieving 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.

The GEOSS concept, if ultimately delivered well and in a sustainable way, could take international cooperation in observing systems to another level; one that ultimately can deliver on all of the dimensions of international cooperation identified above, through bringing together data providers, decision makers, communicators and users across all relevant societal benefit areas (nine, as currently specified). GEOSS has the potential to be a future framework for international cooperation – as long as it recognises the value of what has gone before and not only builds on and strengthens existing systems, as it is mandated to, but builds on the value delivered by existing systems.

GEOSS itself is a web of observation systems and the associated data access, processing, assimilation etc, systems that facilitate the conversion of data into real benefits. The component systems belong to the Members and Participating Organisations that comprise GEO[5], and are contributed by them to GEOSS. Ownership and governance of the systems remains with the Member or Participating Organisation. The value-add of GEOSS is principally the interoperability framework that extends the cooperation and collaboration that already exists in some systems, or systems of systems such as WWW's GOS, GTS and GDPFS, to all systems.

Two important factors must be considered in assessing the capacity of GEOSS to genuinely add value and to provide an effective future model for international cooperation in earth observing systems. These factors relate to branding and to governance.

The GEOSS Brand

The approach that has been adopted in the initial stages of GEOSS implementation is to create GEOSS as a new brand, to the extent of rendering largely invisible in GEOSS documentation

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[4] The GEOSS Ten-Year Implementation Plan was approved by the Third Earth Observation Summit, Brussels, February 2005.
[5] As at 30 November 2007, the Members of GEO total 72 countries plus the European Commission.

the names of the pre-existing international programmes on which it builds. This poses substantial risks, however, for many of the component systems which are portrayed only as deliverers of specific GEOSS tasks.

The recent Earth Observation Summit in Cape Town highlighted the early achievements of GEOSS, laid a marker for further negotiation of the GEOSS data policy and reinforced the commitments by its participants to delivery of the GEOSS vision. However, the Minsters who welcome the benefits that GEOSS promises might wonder why they need to continue funding their national meteorological, hydrological and oceanographic services when GEOSS promises to deliver its weather, climate and water SBAs without a mention of either them or the existing international mechanisms through which they are coordinated. At the very least, for GEOSS to be seen as taking a lead in the future of global cooperation in observing systems, it should provide more explicit recognition of the component systems, and the component systems of systems, on which it builds.

The image that GEOSS aims to present, through its documented plans and in its claims about future benefits to society, is very bold. However, as currently projected, it conveys a sense more of a global system of projects than a global system of systems. The GEOSS website, for example, could provide direct linkages to the systems of systems and not just to the systems of tasks. In the case of the WWW GOS (and, in turn, the proposed WIGOS, as well as the other WWW global systems and WIS), there are more than 90 Members of WMO that are not yet Members of GEO; in many cases, the more visible acknowledgement of WMO and WWW may remove the fear that the source of so much support and coordination for so long might disappear.

To not acknowledge the international programmes and systems that comprise the initial building blocks of GEOSS is to erode the value and history of these mechanisms, many of which developed and consolidated their authority and mandate through open and transparent intergovernmental processes over an extended period of time. To explicitly acknowledge these component systems, while also acknowledging the added value that GEOSS can bring, would not diminish GEOSS but would give it a more immediate and deliverable reality. The full benefits of GEOSS will only be achieved when membership is global. To this end, the effort expended in making it as easy as possible to participate in GEOSS, as a contributor and/or user of data, via the interoperability framework will be repaid many times over.

GEO Governance

The intergovernmental Group on Earth Observations (GEO), comprising its Members and Participating Organizations, was established in February 2005 on a voluntary and legally non-binding basis, with voluntary contributions to support its activities. It is supported by a Geneva-based secretariat and guided by an elected Executive Committee.

The founding Members of GEO vested significant national effort and resources into turning the concept of a comprehensive, coordinated and sustained system of systems into a living implementation plan. The governance model that was adopted reflected a strongly held desire by some founding Members to move forward at a rapid pace, without the encumbrance of a UN-style bureaucracy, and to record early successes for GEOSS. While the ability to engage directly with interested parties and individuals and to respond quickly and without the overheads of bureaucracy may have been key factors in its early progress, the GEO Plenary soon enforced a discipline more akin to traditional intergovernmental processes to ensure that

GEO decisions more explicitly embraced open and transparent review and decision making processes.

A key challenge for GEO in the future, as well as for the established international organisations and around 200 countries that contribute to, and benefit from, the existing global earth observing systems, will be to maintain the momentum and consolidate a high level of cooperation and coordination. It is not clear whether all the individual countries that contribute to the existing systems will ever choose to become Members of GEO *per se*, but as contributors nonetheless to the system of systems, their needs and voices are inextricably intertwined with the future of GEOSS. The negotiations within GEO Plenary over the coming year or so on the data sharing policy will be a key defining moment for GEOSS.

The critical value that GEOSS adds to the component systems is through the interoperability framework that will facilitate more effective access to, and utilisation of, observations to inform decision-making across many sectors, societies, regions and the globe. While the GEOSS mandate aims to vest ownership of any new systems back to the Members themselves, it is inevitable that there will be a sense of collective GEO ownership of some systems, such as the GEONETcast system and the developing capacity building and outreach programs. After the initial investment of effort in developing the interoperability framework, an even greater ongoing effort must be directed at supporting, maintaining, communicating and promoting it. This will pose a major challenge to GEO, as currently configured, and will require sustained secretariat effort and engagement by the membership.

Whether the current GEO governance arrangements will provide a robust future model is a key question, and one that must be kept under periodic review if the GEOSS vision is to become an ongoing and effective reality. The experiences of existing long-lived global observing systems might provide a valuable lesson. Some of them, such as the World Weather Watch, have been in operation for more than 50 years and have evolved to respond to changing requirements, technologies and societal circumstances, have negotiated and established data sharing policies and provide an end-to-end service delivery concept. Under the broad umbrella of GEOSS, they would likely evolve further and deliver even greater benefits to their Members both directly and through GEOSS.

Focussing more directly on the GEO societal benefit areas of climate, water and weather, one could argue that the future of international cooperation in observing systems is, in fact, at risk under the current GEO governance model. The cohesion and strong sense of community shared by the meteorological, hydrological and oceanographic communities, especially through the structures and end-to-end programmes of WMO and IOC, and the linkages they provide to other UN and international scientific programmes, such as the International Council of Science (ICSU), and jointly sponsored systems, such as the Global Climate Observing System (GCOS), are at risk if the GEOSS brand subsumes them and/or if their membership is divided.

A more sustainable long-term governance structure that will serve all of the societal benefit areas (including ‘oceans’ if/when it is added) is to establish GEO as a joint subsidiary mechanism of the multiple high-level UN agencies, programmes and other designated bodies, such as the Conventions, that govern the established (and new) global systems relevant to all societal benefit areas or utilise their data to inform regional and international policy development on global environmental and related issues. Such a governance model would:

- Have the support and engagement of established global organisations and deliver substantial benefits back to the organisations and their Members;
- Provide shared ‘ownership’ of GEOSS, with multiple sponsors ensuring that no single sponsor would dominate GEO;
- Complement the operation and mandate of the sponsors and enable GEO to focus principally on its value-adding facilitating role through the GEOSS interoperability framework;
- Clarify roles and relationships at a national level and reduce competition for scarce earth system monitoring resources; and, perhaps most importantly
- Minimise the risk of duplication and competition between GEO and the international organisations that are responsible for the established global observing systems.

Many of the relevant UN organisations are already associated with GEO and a number of them (WMO, UNEP, FAO, UNESCO, IOC) are working actively together to coordinate their participation in GEO and their contributions to GEOSS. By agreement amongst their Members, given the common membership of most, it might be considered that a subset of the possible UN agencies may be designated to provide the sponsorship on behalf of the broader group.

Variants of such a governance model, where an intergovernmental mechanism is jointly sponsored by two or more UN and international organisations, have already proved effective in coordinating international cooperation on global observational and climate science issues. Examples include the Global Ocean Observing System (GOOS), which is jointly sponsored by IOC, WMO, ICSU and UNEP; and the Joint Commission for Oceanographic and Marine Meteorology (JCOMM), under the joint sponsorship of WMO and IOC. Both these bodies provide the governance, international framework and coordination mechanisms for systems that are owned and operated by their Members. Another example is the Intergovernmental Panel on Climate Change (IPCC), which is a joint body of the WMO and UNEP, and for which the coordinated ‘systems’ relate more to scientific intellect and research outputs. It is no coincidence that all the sponsoring agencies listed are active participants in GEO.

With the benefit of a more robust and representative governance framework, GEO could then genuinely focus on its interoperability and integration role, optimising its capacity building and outreach activities through synergy with its sponsoring organisations. The same benefits would extent to the Member country level, where resources could be optimally distributed to achieve national earth system goals within a coherent international framework. Together, GEO and its sponsors would represent a truly end-to-end observations through service delivery concept that would ensure the benefits of coordinated, comprehensive and sustained global earth system observations were delivered to all users and communities.

Conclusions

Existing arrangements for international cooperation in observing systems, especially the mechanism of the WMO World Weather Watch and its surface-based and space-based Global Observing System, are well-established, enjoy global participation, are highly effective and have delivered significant achievements to their stakeholder communities. While there is always scope to improve, especially in terms of filling gaps and building the capacity of the less developed countries, the WWW delivers substantial benefits to all participating Members, on local through global scales, through its supporting framework for the National Meteorological and Hydrological Services that own and operate the contributing national observing systems. The future of international cooperation in meteorological, hydrological and oceanographic observations will be robust if these arrangements can continue to deliver benefits and to evolve to address the changing needs of their constituents, emerging science and technology and in sympathy with other global issues likely to influence them.

The many scientific and technological improvements and global policy issues that affect the acquisition and sharing of earth observations data will contribute to shaping the future model of international cooperation. Critical issues that must be addressed include the transparency of the cooperation mechanism, the strong linkages between research and observations and between data gatherers and users, maintenance and extension of current free and unrestricted data sharing policies, and global participation.

The drivers for future cooperation highlight the broadening of concern for sustainable earth system monitoring across a wide range of regimes and scientific disciplines, and the benefits of an integrated approach that builds on and strengthens existing systems while embracing new components within an interoperable 'system of systems' framework. The potential for GEOSS to be part of, or to possibly provide an overarching framework for, future international cooperation without diminishing the value of existing systems to those that depend on them, will depend on it focussing adequately on its core value-adding role of interoperability, more visible recognition of the systems that comprise the 'system of systems' and its transition over time to a governance mechanism that is more closely linked to the global UN system.