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REVIEW OF INTEGRATION NEEDS AND POTENTIAL PROBLEMS OF WMO GLOBAL OBSERVING SYSTEM AND RELEVANT CO-SPONSORED OBSERVING SYSTEMS

The Global Observing System (Surface-based and Space-based components)

(Submitted by Dr Sue Barrell (Co-Chair, CBS Open Programme Area Group – Integrated Observing Systems)

Summary and Purpose of Document

This document contains the review of integration needs and potential problems of the Global Observing System of the WMO World Weather Watch.

ACTION PROPOSED

The session is invited to consider the submitted information when discussing integration needs and potential problems of WMO observing systems and relevant co-sponsored observing systems.

References:

1. Abridged final report of the EC-LX (WMO-No. 1032)
2. Final report of the first session of the EC WG WIGOS-WIS
3. Final Report of the Implementation/Coordination Team on the Integrated Observing System, Fifth session

The Global Observing System
(Surface-based and Space-based components)

Introduction

1 Various observing systems throughout WMO Programmes and WMO-supported Programmes have been developed, funded and operated to meet their own purposes, without consideration in a broader context of integration. The EC-LX agreed draft WIGOS Development and Implementation Plan (WDIP) and WIGOS Concept of Operations (CONOPS) aim to address this lack of integration through bringing together the WMO-owned and co-sponsored networks as constituent parts of WIGOS, while recognising that the ownership and management of these networks should continue in accordance with their existing mandates.

2 The **Global Observing System (GOS)** of the **WMO World Weather Watch (WWW)** is the coordinated system of methods and facilities for making meteorological and other environmental observations on a global scale in support of all WMO Programmes. The system is comprised of operationally reliable surface-based and space-based subsystems. The GOS comprises observing facilities on land, at sea, in the air and in outer space. These facilities are owned and operated by the Member countries of WMO each of which undertakes to meet certain responsibilities in the agreed global scheme so that all countries can benefit from the consolidated efforts. Annex I provides more information on the GOS and efforts underway to ensure its ongoing resilience and relevance.

3 The GOS is the largest global observing network within the WMO systems and features a long history of efficient coupling and complementing of surface-based and space-based components, and should serve as a backbone and proven prototype for the integration and should take a lead role in the challenging WIGOS process.

CBS OPAG-Integrated Observing Systems Considerations

4 EC-LX emphasized the leading role that CBS has to play in the implementation of the WIGOS concept and stressed the importance of the CBS Technical Conference on WIGOS (TECO-WIGOS) that will be held in Dubrovnik, Croatia, from 23 to 24 March 2009, immediately prior to CBS-XIV. Within CBS, expert guidance on WIGOS matters is provided through the CBS OPAG Integrated Observing Systems – Implementation/Coordination Team (ICT-IOS), which focussed much of its discussion during its September 2008 session on WIGOS matters.

5 The ICT-IOS studied the CONOPS in details and raised a number of questions and recommendations:

(a) ICT-IOS sought clarity on the reporting mechanism, responsibilities and representation of different WMO bodies and was concerned with potential duplication of work;
(b) ICT-IOS was also concerned with both the financial and expert resources needed to address WIGOS issues and the risk that it would drain resources currently available to CBS and essential to complete the work programmes associated with the ICT-IOS. This is further exacerbated by the fact that the WIGOS Planning Office (PO WIGOS) is yet to be fully staffed;
(c) ICT-IOS supported the concept of WIGOS Pilot Projects (WPPs), however, it sought clarity on whether the WPPs should be comprehensive or should be limited in scope;
(d) ICT-IOS had little information to understand the nature of WIGOS Demonstration Projects (WDPs) as regards their substance and involvement of other Members from within the Region;
(e) ICT-IOS recognized that the WIGOS concept should foster more effective integration of satellite and *in-situ* observations, but noted that little involvement of IOS satellite expert groups is seen so far. In the case that WPPs would not be limited in scope, the ICT-IOS proposed that satellite components be incorporated into relevant WPPs;

(f) The ICT-IOS noted that the current Manual and Guide on the GOS already recognized many of the systems proposed to be part of WIGOS, but the challenge is effective integration of those data into WIGOS/WIS.

6 The ICT-IOS recognised that WIGOS is a new major activity that will impact significantly on the work of the OPAG-IOS and its expert teams, although it was noted that some of the expert teams' present activities were already related to WIGOS. A major concern expressed was how the lines of communication and reporting would be implemented between the OPAG-IOS and WIGOS. The ICT-IOS has proposed that the CBS Management Group might consider a revised CBS working structure that would allow an optimal involvement and representation of CBS in WIGOS, with consequential changes in the OPAG-IOS, depending on decisions of Cg-XVI.

WIGOS Pilot Projects

7 Regarding the five WPPs initiated as part of the WDIP, the ICT-IOS expressed the view that tight coordination and reporting procedures should be implemented so that WPP activities get reported back to appropriate expert teams, and not just back to Executive Council. ICT-IOS looked forward to WPP Project Teams being defined so that the ICT-IOS may establish appropriate linkages to those teams.

8 In the case that WPPs would not be limited in scope, the ICT-IOS requested that the level of involvement of the WMO Space Programme in the WPPs be increased. This involvement is particularly relevant to the WPPs for Hydrology and for Marine, and, if agreed, will be built into the work plans for the relevant OPAG-IOS expert teams.

9 The ICT-IOS felt that the proposed GCOS Reference Upper Air Network (GRUAN) presents many integration challenges, including in the operation of a new *in situ* network that may or may not come within the operational ambit of NMHSs, intercalibration with space-based observations, as well as the integration with the existing Regional Baseline Surface Network and Regional Baseline Climate Network (both GUAN and non-GUAN upper air elements). The ICT-IOS proposed that an additional WIGOS Pilot Project focusing on the integration of GRUAN WPP could make a significant contribution to the development of WIGOS, and suggested that a new WPP might be appropriate.

Integration issues in relation to GOS

10 According to the WIGOS CONOPS, integration will be accomplished at three levels: (i) observations standardisation; (ii) a common information infrastructure (ie WIS); and (iii) end-product quality assurance. The following discussion highlights some issues that fit more or less under these headings, as well as some additional aspects that might suggest the need to broaden integration considerations.

Observation standardisation

WIGOS will require agreement on common and/or compatible standards to facilitate homogeneity, interoperability and compatibility of observations for all WIGOS constituent observing systems. With the GOS as the backbone, the Manual on the GOS provides the essential framework within which the common set of standards can be agreed and promulgated. The *Manual on the GOS* already provides linkages to integrate most of the constituent WIGOS systems.

11 The redesign of the GOS, including both the surface-based and space-based components, is an ongoing process (refer Appendix I) aimed at ensuring the GOS continues to evolve to meet the requirements of Members. Key components of the strategy are:

- the Rolling Review of Requirements (RRR) process
- regular updates of the *Implementation Plan for the Evolution of the GOS*; and
- achieving the Vision for the GOS 2015.

12 The Rolling Review of Requirements (RRR) process inherent in the GOS provides a model for all components of WIGOS, in order to ensure regular revision, updating and publication of the WMO database. However, it will be necessary to establish the mechanism and procedures by which this will be done.

13 It is already time to consider updating the Vision for the GOS to reflect the rapid changes in technologies and expansion of space-based systems, as requested by CBS Ext. (06). A draft Vision for the GOS 2025, which was developed under the leadership of the OPAG-IOS Expert Team on the Evolution of the GOS, in conjunction with the other OPAG-IOS Expert Teams, was considered by ICT-IOS-5 and will be proposed to the CBS Management Group ninth session (13-15 November 2008) for adoption as a recommendation for CBS-XIV (25 March – 2 April 2009). The Vision provides high-level goals to guide the evolution of the Global Observing System in the coming decades. The future GOS will build upon existing sub-systems, both surface- and space-based, and capitalize on existing and new observing technologies not presently incorporated or fully exploited. Incremental additions to the GOS will be reflected in better data, products and services from the National Meteorological and Hydrological Services (NMHSs); this will be particularly true for developing countries and LDCs. The scope of these changes to the GOS will be major and will involve new approaches in science, data handling, product development and utilization, and training.

14 The Vision envisages that the GOS will have evolved to become part of the WIGOS, which will integrate current GOS functionalities, which are intended primarily to support operational weather forecasting, with those of other applications: climate monitoring, oceanography, atmospheric composition, hydrology, and weather and climate research. Integration will be developed through the analysis of requirements and, where appropriate, through sharing observational infrastructure, platforms and sensors, across systems and with WMO Members and other partners.

15 The WMO Space Programme is cross-cutting by definition. Integration across regions is inherent to space-based observations, which has a long history of global coordination and which results in reasonably advanced integration at two levels: some common instrument features and common formats. Integration across disciplines is pursued by analysing the requirements in parallel and, where appropriate, in sharing observational infrastructure (satellites, sensors). Progress has been limited to date by the resources available to the programme, the challenge to address the needs of 7 programmes and the fact that all programmes do not have equally mature requirements. To date, the WWW and GCOS have well-defined requirements and the new Vision is addressing seriously the needs of these two programmes. JCOMM and GAW are also rather well documented but DRR is not so well advanced.

Common information infrastructure

16 The GOS will aim to coordinate observational requirements and capabilities of various observing systems with information exchange requirements established within the WIS, and expand and manage the database accordingly.

End-product quality assurance

17 The delivery of the best possible products to end users, in accordance with defined user requirements, will depend on adoption of and adherence to agreed quality assurance and control standards. As an example of activities underway with the GOS, the CBS OPAG-IOS is reviewing the methodologies for monitoring the effectiveness of the GOS, and is considering basing the monitoring of the implemented stations on the procedures used by GCOS to measure the effectiveness and implementation of GSN and GUAN.

18 The Global Space-based Inter-calibration System GSICS is arguably an example of integration at the 3rd level.

A possible 4th level of integration

19 It is conceivable that a fourth level of integration could be defined, aimed at optimizing network planning. This is highlighted by the integration of surface and space-based systems as fundamental constituents of a composite observing system.

Space – surface integration

20 Integration between surface and space-based systems is not simply a matter of harmonising instruments specifications across surface and space. Such integration has not been well addressed to date, but is under consideration through three initiatives:

- collaboration with surface-based sites for VIS-IR imager calibration (an ongoing initiative);
- dialogue between the Global Space-based Inter-calibration System (GSICS) and the GRUAN initiative; and
- Satellite – AWS calibration (through collaboration amongst CBS OPAG-IOS expert teams).

21 The latter two initiatives are relevant to the algorithm and quality control of derived geophysical products (level 2, 3) rather than to instrument calibration as such and accordingly goes beyond the 'observation' process.

22 An additional perspective on space-surface based integration might be to process space-based data up to a level of geophysical products that are more directly comparable with surface-based observations, and to then adopt similar data description standards. It is notable, however, that NWP centres already routinely integrate surface and space-based observations through data assimilation systems.

Implementation of research and operational observing systems

23 An additional dimension of integration that may be considered within WIGOS is the relationship between observing system components that have been developed for research purposes and the operational systems components. While there may not be any specific intentions to routinely transition research-based systems into operations, there may be value in considering the relationships between such systems within an overall WIGOS context.

24 The WMO Space Programme and the OPAG-IOS expert teams are actively engaged in considering the potential contribution that R&D satellites may make to the GOS. There are currently 30 R&D satellites currently in orbit with potential to contribute to the GOS and another 22 planned for launch within the next six years. Discussions between the WMO Secretariat, Members and space agencies will serve to clarify whether and how the data will be available to WMO Members. OPAG-IOS expert teams have commenced efforts to establish a conceptual framework and mechanism to address the transition from relevant R&D missions and instruments to operational status.

Annex I

Redesign of the Global Observing System

The Global Observing System

Since the establishment by WMO of the World Weather Watch (WWW) in 1963, the Global Observing System (GOS) has been the major mechanism for providing continuous and reliable observational data world-wide. The GOS started with a relatively narrow set of observational requirements in support of mainly synoptic, mesoscale and short-term weather forecasts. Over the past four decades, however, the WWW, and specifically its GOS, have drastically developed their technological capabilities in response to requirements that have evolved within WMO and beyond.

The GOS currently consists of observing facilities deployed on land, at sea, in the air and in outer space. The backbone of the surface-based subsystem continues to be some 10.000 stations on land making observations at or near the Earth's surface, at least every three hours. In addition, approximately 900 upper air stations generated over 1000 upper air reports daily. A constellation of geostationary and polar-orbiting satellites constitutes the operational space-based subsystem of the GOS, whose major goal is to augment the observations provided by the surface-based subsystem to achieve complete global coverage. These facilities are owned and operated by the Member countries of WMO, each of which undertakes to meet certain responsibilities in the agreed global scheme so that all can benefit from the consolidated efforts.

Requirements for increased long-term reliability and accuracy are being placed upon the GOS by another WMO programme, the Global Climate Observing System (GCOS), a dedicated system designed specifically to meet the scientific requirements for monitoring the climate and its variability.

Although the GOS has been, and still is, the foundation on which all meteorologists depend, there has been gradual but steady erosion of the observing networks during the past few years. At the same time, the emergence of new technologies and techniques has facilitated observations and measurements with greater resolution and accuracy. This, together with greatly increased computing power, has benefited Numerical Weather Prediction immensely by making possible the development of highly sophisticated assimilation techniques that can accept and evaluate observations from any source made at any time.

The Challenge

The fourteenth WMO Congress, in 2003 reconfirmed the need for a coordinated approach to a fundamental redesign of the GOS. The redesign would involve experts and decision-makers in observing technology, network design, and numerical weather prediction (NWP). It should also address innovative ways of funding and operations management for the deployment of observations in remote and/or extraterritorial areas and for developing countries.

The Response

The WMO Commission on Basic Systems (CBS) has made a substantial start on redesign of the GOS. A process named the Rolling Requirements Review (RRR) has been instituted for continuously reviewing the requirements of WMO Members and international programmes and the results obtained under current circumstances.

Subsequently, CBS formulates and updates system requirements to provide data to meet product requirements and/or goals. From these requirements/goals CBS generates guidance materials for WMO Members, named *Statements of Guidance*, thus coordinating the needs of the overall Global Observing System.

The GOS will continue to be the system of operational surface and space-based observing platforms. As a general principal, the evolution of the system will be based on proven techniques and will represent the best mix of observing elements that

- satisfies to the maximum extent the agreed-upon data requirements in respect of accuracy, frequency and spatial resolution;
- is operationally and technically feasible;
- meets the cost-efficiency requirements of Members;
- is reliable and able to meet long-term needs of relevant WMO Programmes and a wide variety of purposes and uses into the first few decades of the 21st century;
- covers ocean and data-sparse areas adequately;
- permits making new technologies available at affordable costs, so that all Member countries can maintain and satisfactorily operate their national components of the system and benefit from them in a sustainable and self reliant manner;
- permits the availability and accessibility of data for operational, research and educational purposes.

Impact of Evolution

The impact of the changes to the GOS in the next decades will be so massive that new revolutionary approaches for science, data handling, product development, training, and utilization will be required. The new GOS will facilitate the strengthening of cooperation at national, regional, and global levels among countries and relevant non-Governmental organizations. Finally, as new technologies are introduced, the new system will allow for adequate overlap with the old to enable a smooth transition from the old to the new system, particularly for developing countries.

Implementation Plan

The CBS Expert Team on Observational Data Requirements and Redesign of the Global Observing System (renamed Expert Team of Evolution of the Global Observing System (ET-EGOS) in February 2005) developed the *Implementation Plan for Evolution of Space and Ground-based sub-systems of the GOS*. In addition, the CBS Extraordinary Session (Cairns, 2002) approved the *Vision for the Evolution of the GOS to 2015*. The Thirteenth Session of the Commission for Basic Systems (CBS-XIII, St. Petersburg, 2005) approved the *Implementation Plan for Evolution of Space and Surface-based Sub-Systems of the GOS (EGOS-IP, Technical Document No. 1267)*. CBS-XIII suggested that regular updates of the EGOS-IP document were useful as a record of progress, but should not be presented to Members as a revised Plan, the original Plan being adequate as a guide to implementation action by Members. ET-EGOS regularly updates the Implementation Plan and the updated versions are included in the *Final Reports* of the ET-EGOS yearly meetings. See also ET-EGOS web links for the current version.

The redesigned GOS is expected to show marked results by 2010 and should near completion by 2015.