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Item **4.10** of the Provisional Agenda

IOC SUPPLEMENT TO THE GLOBAL CLIMATE OBSERVING SYSTEM (GCOS) IMPLEMENTATION PLAN 2022

Summary

The 2022 Global Climate Observing System (GCOS) Implementation Plan (GCOS-244/GOOS-272) is the latest in a series of GCOS implementation plans produced since its inception in 1992. It provides a set of high priority actions which, if undertaken, will improve global observations of the climate system and our understanding of how it is changing. The plan aims at identifying the major practical actions that should be undertaken in the next 5-10 years across six major themes, including, sustainability of observations, filling data gaps, data quality, availability, and management, and engaging with countries.

This document summarises the main actions identified within each of the six major themes that are relevant to IOC (GOOS). The main activities are noted, with details on the issues, benefits and means of assessing progress in the 2022 GCOS Implementation Plan.

There are no financial and administrative implications.

The proposed decision is referenced Draft Resolution IOC-32/[4.10] in the Action Paper (document IOC-32/AP Prov.). The Resolution endorses the conclusions of the 2022 GCOS Implementation Plan and urges Member States to take action with regard to the IOC relevant actions noted in this IOC Supplement Report.

Introduction

1. The 2022 GCOS Implementation Plan (GCOS-244) is the latest in a series of implementation plans produced by GCOS since its inception in 1992. It provides a set of high priority actions which, if undertaken, will improve global observations of the climate system and our understanding of how it is changing, categorized under six major themes (see Table 1). The 2022 GCOS ECVs Requirements (GCOS-245) provide revision for the whole set of Essential Climate Variables (ECVs). There are currently 55 ECVs specified by GCOS, of which 19 are ocean-focused variables. GOOS expert panels are responsible for those.

2. The Sharm-El-Sheikh Climate Change Conference of November 2022 (COP-27) adopted a Decision that welcomed the 2022 GCOS Implementation Plan and the 2022 GCOS essential climate variables requirements encouraging parties and relevant organizations, as appropriate, to work towards the implementation of the 2022 GCOS Implementation Plan.

3. This IOC Supplement only lists those actions within each theme that are under purview of IOC Members and can be implemented by GOOS. Tables present the activities, which would have to be achieved within each action, the issues they intend to address and their benefits, and the means of assessing progress. The tables presented in this document are a condensed version of the more detailed tables, which can be found in the full report GCOS-244. The full report also contains actions related to other part of the observing system (atmosphere, terrestrial cryosphere), as well as acronyms, references and a list of contributors.

Theme	Actions
A: ENSURING SUSTAINABILITY	A1. Ensure necessary levels of long-term funding support for in situ networks, from observations to data delivery
B: FILLING DATA GAPS	B2. Development and implementation of the Global Basic Observing Network (GBON)
	B6. Expand and build a fully integrated global ocean observing system
	B7. Augmenting ship-based hydrography and fixed-point observations with biological and biogeochemical parameters
	B8. Coordinate observations and data product development for ocean CO_2 and N_2O
	B9. Improve estimates of latent and sensible heat fluxes and wind stress
C: IMPROVING DATA QUALITY, AVAILABILITY AND UTILITY	C1. Develop monitoring standards, guidance and best practices for each ECV
D: MANAGING DATA	D2. Ensure Global Data Centres exist for all in situ observations of ECVs
E: ENGAGING WITH COUNTRIES	E1. Foster regional engagement in GCOS
F: OTHER EMERGING NEEDS	F3. Improve monitoring of coastal and Exclusive Economic Zones

Table 1: Actions of interest for IOC Members under each of the GCOS Implementation Plan Themes

Theme A: Ensuring Sustainability

4. Long-term, continuous, *in situ* and satellite observations of the climate are necessary to understand and respond to the changing climate. Sustained funding is essential to ensure the continuity and the expansion needed for many *in situ* observations of ECVs. While many atmospheric observations have sustained long-term funding, most ocean and terrestrial observations are supported through short-term funding, with a typical lifetime of a few years, leaving the development of long-term records extremely vulnerable. Since these observations are executed by a large range

of actors, an effective observing system may benefit from an improved international coordination across networks and programmes. Here the potential of "economy of scales" could make procurements of instruments less expensive. Sustainable networks need sustained funding and support that covers training, capacity building, equipment maintenance and replacement.

Action A1: Ensure necessary levels of long-term funding support for in situ networks, from observations to data delivery	
Activities	1. Undertake an assessment of current levels of funding support for global in situ networks delivering relevant in situ ECV data, including cal/val measurements, and identify those in situ networks with immediate or short-term problems around adequacy and sustainability of funding - by end of 2023. 2. Identify entities that can provide support for the networks identified as at risk in Activity 1. 3. Advocate with funding agencies to support identified networks.

5. Details on the issues, benefits and means of assessing progress for these activities are in the GCOS-244.

Theme B: Filling Data Gaps

6. This theme addresses gaps in the existing observing system identified in the 2021 GCOS Status Report (GCOS-240). By and large the observations fulfil many requirements and provide the basis for the very useful sets of ECVs. However, *in situ* observations for almost all the ECVs are consistently deficient over certain continental regions, in the deep ocean and polar regions, a situation that has not improved since the 2015 GCOS Status Report (GCOS-195).

7. WMO has adopted the concepts for a Global Basic Observing Network (GBON) and for the Systematic Observations Financing Facility (SOFF). If their implementation is successful, GBON will provide essential observations for global Numerical Weather Prediction (NWP) and reanalysis, covering some ECVs, and SOFF will provide targeted financial and technical support for the implementation and operation of GBON and will address some of the gaps identified in the 2021 GCOS Status Report. Action B2 covers the development and implementation of the Global Basic Observing Network (GBON).

Action B6: Expand and build a fully integrated global ocean observing system	
Activities	Increase the measurements of ocean ECVs into the deep ocean, under the ice and marginal seas by improving: 1. The Core Argo (ensuring that the target density is met), biogeochemical (BGC) and Deep Argo to achieve the OneArgo design. 2. The ship-based hydrography, fixed-point observations, autonomous and uncrewed observations. 3. The integration of observing networks to respond adequately to ECVs requirements.

Action B7: Augmenting ship-based hydrography and fixed-point observations with biological and biogeochemical parameters	
Activities	Add biological and enhanced biogeochemical sensors and field/laboratory measurements to the already existing ship-based hydrography and fixed-point observations to establish a baseline of plankton distributions and phenology (seasonal timing in phenotype and abundance).

Action B8: Coordinate observations and data product development for ocean CO_2 and N_2O	
Activities	1. Develop a strategy and implementation plan to operationalize the data production and delivery of surface ocean CO_2 information. 2. Coordinate the existing nitrous oxide (N_2O) ocean observations into a harmonised network.

8. Details on the issues, benefits and means of assessing progress for these activities are in GCOS-244.

Theme C: Improving data quality, availability and utility, including reprocessing

9. This theme looks at how the original observational data is transformed into user-relevant information. Starting from climate monitoring, adopted standards are required to facilitate inter-comparisons, "mash-up-ability" and ensure the overall quality of the final information. Standards are also required through the other phases of the processing chain that transform observations into user-relevant products. These should address a comprehensive characterisation of uncertainty, the use of uniform metadata and quality attributes and also support the effort towards the generation of sensor-agnostic gridded datasets to facilitate intercomparison. Acknowledging the fact that the use of observational data is often mediated by other systems, a dedicated effort should also go toward ensuring the fitness for purpose of the data provided for its use in reanalysis. This includes a dedicated effort towards data reprocessing, bias characterisation and more generally a comprehensive characterisation of the uncertainty associated with both observations and modelling.

Action C1: Develop monitoring standards, guidance and best practices for each ECV	
Activities	1. Review existing monitoring standards, guidance and best practices for each ECV, ensuring these reflect current state-of-the-art. Maintain a repository of this guidance for ECVs. 2. Ensure the development of monitoring standards, guidance and best practices, including intercomparison procedures, for those ECVs where such guidance does not exist. 3. Review and revise the climate monitoring guidance in the WIGOS manual to bring it in line with the updated guidance developed in this Action. 4. Review the GCOS climate monitoring principles.

10. Details on the issues, benefits and means of assessing progress for these activities are in GCOS-244.

Theme D: Managing data

11. To address and understand climate change, the longest possible time series need to be preserved in perpetuity. Every ECV needs to have a recognized global data repository and where there is one, it should be complete, adequately supported and funded. Data should be stored in well-curated, open and freely available, sustainable archives with clear guidance for data centres and users. Clearly defined principles such as the TRUST Principles (Lin et al., 2020)[1] and FAIR Principles (Wilkinson et al., 2016[2]) are needed. Data rescue from hard copy or archaic digital formats allows data series to be extended in the past and needs to be adequately planned and funded with the results openly and freely available. Sustained support to these activities is required. This theme aims at organizing more efficiently data rescue, data sharing, data curation and data provision.

[1] Lin, D., J. Crabtree, I. Dillo, et al., 2020: The TRUST Principles for digital repositories. Sci Data 7, 144, DOI:10.1038/s41597-020-0486-7

[2] Wilkinson, M.D., et al., 2016: The FAIR guiding principles for scientific data management and stewardship. Scientific Data, 3, DOI:10.1038/sdata.2016.18

Action D2: Ensure Global Climate Data Centres exist for all in situ observations of ECVs	
Activities	1. Identify ECVs for which adequate global centres do not exist or are insufficiently supported and facilitate and support the creation or improvement of global data centres for these ECVs. 2. Promote regional data centres, their interoperability, where possible, synchronization of their data holdings, and the provision of data in their archives to global data centres.

12. Details on the issues, benefits and means of assessing progress for these activities are in GCOS-244.

Theme E: Engaging with countries

13. Many climate observations are made by national bodies, however these efforts need support and coordination. Some countries have national programmes that need to be connected regionally and globally to share and communicate issues and solutions. GCOS can help by linking these national efforts into the global system, providing information on observing needs, promoting needs for support and access to global information. Some national GCOS systems can also fill gaps in the global system, for example by providing support for regional and global data centres.

Action E1: Foster regional engagement in GCOS	
Activities	1. Undertake at least one regional GCOS Workshop each year. a) Promote the benefits of coordination of climate observations (in situ and satellite) and GCOS programs. b) Explore regional issues, gaps and needs and develop plans to address them. 2. Report regional needs and issues to the UNFCCC, WMO and other relevant stakeholders.

14. Details on the issues, benefits and means of assessing progress for these activities are in GCOS-244.

Theme F: Other Emerging Needs

15. As countries respond to the impacts of climate change, they need data related to the specific areas impacting their countries. Many impacts are directly related to extremes, for example heatwaves, flooding and droughts. While work continues to identify how the global system can support these national and local needs, some requirements are already evident. Many users will not use the observed data directly, but rather use reanalysis products. Observing in areas of interest, at relevant resolutions will greatly improve reanalysis. This theme addresses some of these needs ranging from higher resolution data (both spatial and temporal) to monitor extremes, to monitoring of areas of specific concern where impacts on humans are at their greatest: coastal and urban areas. GCOS will continue to identify the needs of adaptation and supporting the Paris Agreement: this theme just addresses actions that have already been identified and can be started in the lifetime of this plan, 5–10 years.

Action F3: Improve monitoring of coastal and Exclusive Economic Zones	
Activities	1. Expand global ocean climate in situ observations and satellite products into Exclusive Economic Zones (EEZs) and coastal zones. 2. Develop new satellite-based products for coastal biogeochemistry. 3. Produce land cover datasets in coastal areas without land surface masks and in near real time, including uncertainties.

	4. Improve national coastal and EEZ data collection, data processing, uncertainty evaluation and data curation by improving access to equipment and ensuring local practices are consistent with the global guidelines and best practices.

16. Details on the issues, benefits and means of assessing progress for these activities are in GCOS-244.

Financial and administrative implications

17. There are no financial and administrative implications.