Ref.: 31997/2019-L9 CLW/CLPA

WMO submission to SBSTA-51document on Research and Systematic Observation

2-13 December 2019, Madrid

Updates in WMO, GCOS, WCRP and GFCS activities

1 Global Climate Observing System (GCOS)

GCOS identifies and monitors the observation of 54 Essential Climate Variables (ECV). The ECVs include atmospheric, land and ocean variables. Together, they give a complete view of the state of the climate system. GCOS will produce an overview of the status of global climate observations in 2021 and, in 2022, review and publish the actions needed to address the gaps and deficiencies identified. WMO keeps track of platforms making systematic observations[1] and monitors their compliance with WMO Technical Regulations[2].

1.a Atmospheric Observation

The GCOS surface and upper air networks are monitored[3] by GCOS and WMO with the assistance of Germany[4] and Japan[5]. The status of other observations is monitored and made available on the internet through WMO, IOC and the Joint CEOS/CGMS WGClimate[6].

In 2018, atmospheric observations in the African region (WMO Region I) showed consistently poor results with only 22% of sites (a significant decline over recent years) meeting minimum GCOS requirements for upper air observations and 37% for surface meteorological observations. A series of regional workshops looking at areas with poor reporting of atmospheric observations, in the Pacific Islands, East Africa and the Caribbean, was held with WMO Integrated Global Observing System (WIGOS) in association with the UNFCCC. Issues identified included lack of planning for sustainability, poor data exchange and funding. These workshops showed that the costs of sustained, systematic, observations are too expensive for many countries while all countries benefit from these observations.

1.a.1 Global Basic Observing Network (GBON)

To address these issues, the World Meteorological Congress adopted the overall concept for the Global Basic Observing System (GBON) which defines a minimal set of surface-based operational observing stations, for which international exchange of observational data will be mandatory, in support of global numerical weather prediction and climate analyses that will result in improved climate services. Successfully achieving GBON compliance in developing countries, in particular LDCs and SIDS, depends on innovative finance that values the global

---

[1] OSCAR Database https://oscar.wmo.int

[2] WIGOS Data Quality Monitoring System, http://wdqms.wmo.int/wdqms

[3] See https://gcos.wmo.int/en/networks/atmospheric

[4] Deutscher Wetterdienst (DWD), Global Climate Observing System Surface Network Monitoring Centre https://www.dwd.de/EN/climate_environment/climatemonitoring/climatedatacenter/gsnmc/gsnmc_themen_node.html

[5] Japan Meteorological Agency (JMA) http://ds.data.jma.go.jp/tcc/tcc/products/climate/climatview/frame.php

[6] For atmospheric observations see https://gcos.wmo.int/en/networks and the WIGOS Data Quality Monitoring System, http://wdqms.wmo.int/wdqms; ocean observations http://www.jcommops.org/board; satellite datasets are available through http://climatemonitoring.info/ecvinventory/; atmospheric composition https://gawsis.meteoswiss.ch/GAWSIS/#/; see also ECMWF Observation monitoring https://www.ecmwf.int/en/forecasts/charts/obstat/?time=2019101200&Datatype=Synop&Data=FG%20departure&Area=Globe; other terrestrial networks are monitored by their respective organizations.

public good that these observations provide, ensures coherence of development activities, provides long-term finance beyond time-bound projects, incentivises country performance, and ensures sustainability of investments - beyond business as usual. WMO in collaboration with several partners has developed an initial concept for a new Systematic Observations Financing Facility that would both close the observation gap in developing countries and support its ongoing operation. GBON would cost approximately US$ 750 million by 2025 and lesser amounts thereafter.

1.a.2 Global Atmospheric Watch (GAW)- Integrated Carbon Observation System (ICOS)

The ECVs include variables related to atmospheric chemical composition including atmospheric concentrations of carbon dioxide, methane and other greenhouse gases, aerosols and precursor gases. The WMO Global Atmosphere Watch (GAW) programme coordinates observations of atmospheric composition to provide the evidence needed to understand its changes.

GAW greenhouse gases data are freely available at the GAW World Data Centre for Greenhouse Gases (WDCGG, https://gaw.kishou.go.jp) operated by the Japan Meteorological Agency (JMA). There are still substantial gaps in data and knowledge related to the variations of Greenhouse Gas concentrations (GHG) in the atmosphere, due to the lack of long- term observations in critical parts of the world. GHG measurements are missing in climate-sensitive areas, like the tropics (where we have strong biospheric signals including wetlands), and in polar regions where the climate feedback from the permafrost can play an important role. There is also a lack of harmonized observations in areas of high emissions, as originally the GAW programme was focused on background observations. Observations over the ocean are largely missing, hindering our understanding of GHG gas exchange with the ocean and impacts on ocean acidification.

ICOS is a European contribution to GAW GHG monitoring activities. Since mid-2018, the European atmosphere station network of the ICOS Research Infrastructure (https://www.icos-ri.eu) has become a GAW-contributing network consisting of 33 stations of which 22 are tall towers. Many ICOS atmosphere stations have been in operation a long time, but ICOS has now also been extended into new regions and with new sites. ICOS has developed community-defined standardized measurement designs and protocols that, for atmospheric GHG observations, build and extend upon the WMO recommendations with regard to compatibility, calibration to WMO mole fraction scales, and transparency of the data lifecycle. All ICOS stations have to meet the agreed standards. All data are processed by the ICOS Atmosphere Thematic Centre are checked and annotated on a daily basis by the responsible station managers. The Central Analytical Laboratories perform analyses of flask samples, e.g. for 14CO2 radiocarbon detection of fossil fuel emissions, and provide all stations with WMO scale calibrated working standards. All fully quality-controlled ICOS atmosphere data are published as open data through the ICOS Carbon Portal (https://data.icos-cp.eu/portal) and are updated currently about twice per year. Near-real-time data, utilizing automatic quality control, are published with a maximum delay of one day from the time of the last final full quality-controlled release onwards. The atmospheric data will also be accessible through the World Data Centre on Greenhouse Gases (WDCGG) are part of the regular updates of the NOAA Obspack data products, and are delivered on a daily basis to Copernicus Climate Change Service.

1.b Ocean observation

Ocean observations are coordinated jointly by WMO and the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO). The Joint Commission for Oceanography and Marine Meteorology (JCOMM)in situ Observations Programme Support Centre (JCOMMOPS, http://www.jcommops.org/board) monitors the performance of the system. Climate observations of the upper oceans are currently relatively well covered (e.g. ARGO profilers reach 88% of target density and drifters 80% with gaps in polar and coastal regions), while there are relatively few observations below 2,000m. However, the funding is very fragile with sustainable funding for only 28% of ocean observations, and with 52%

requiring renewed funding within 2-3 years. Estimates of ocean acidity are made at a number of locations but there still no routine annual estimates of global changes. The IPCC Special Report On Oceans and the Cryosphere in a Changing Climate (SROCC) highlighted that context-specific monitoring and forecasting of changes in the ocean and the cryosphere informs adaptation planning and implementation, and facilitates robust decisions on trade-offs between short- and long-term gains. WMO's activities focus on addressing this need, that "*sustained long-term monitoring, sharing of data, information and knowledge and improved context-specific forecasts, including early warning systems to predict more extreme El Niño/La Niña events, tropical cyclones, and marine heatwaves, help to manage negative impacts from ocean changes such as losses in fisheries, and adverse impacts on human health, food security, agriculture, coral reefs, aquaculture, wildfire, tourism, conservation, drought and flood.*"

The WMO Strategic Plan 2020-2023 encompasses an Earth system approach. With the ocean covering 2/3 of the Earth Surface, and increasing maturity of ocean models and their coupling with Numerical Weather Prediction models, engagement of WMO with the ocean community is becoming increasingly important. The OceanObs'19 Decadal Conference was the third in a series of decadal conferences to bring the community together to foster the global buy in required to take the ocean observing system forward for the next decade. The Conference provided an opportunity to understand the state of the art of ocean observing technology, its use in oceanographic research, and transition to operational oceanography and ocean services. WMO, with its Infrastructure Commission and the Research Board, will be proactive in promoting seamless prediction at all time scales, and working with the ocean community for optimizing contribution of the oceans to this effort. The conference also provided an opportunity to review how the governance of the Global Ocean Observing System (GOOS) ought to evolve in a framework where many actors and international organization and partners have interest to collaborate. A proposal for introducing poly-centric governance was discussed at the Conference at global, regional and national levels. Another aspect of the discussions at the Conference where WMO is active relates to evaluating, designing, and evolving the observing systems, including in the oceans. Again, working with the ocean community will be key in this regard, to reach consensus on observational user requirements, the best mix of technologies to be used and how to address the gaps, build capacity and establish partnerships. A conference statement is available on the conference website: http://www.oceanobs19.net/statement/.

1.c Land Observation

Many terrestrial climate variables are observable from space (e.g. land use, leaf area index, albedo and fires). The CEOS/GCMS Joint Working Group on Climate (WGClimate) coordinates all satellite-based climate observations with data requirements determined by GCOS. Recently the resolution of many of these products has improved, moving from 1km scale to about 30m. A significant gap is in reporting of river discharge, where, in some parts of the world (e.g. except for Southern Africa most of Africa and much of Asia) data has not been released for decades. The use of satellite information to fill some of this gap is being investigated. The Intergovernmental Panel on Climate Change (IPCC) Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) presented a synthesis of observed regional hazards and impacts in ocean and high mountain and polar land regions which includes assessments of physical changes, ecosystems, and human systems and ecosystem services for those regions where changes in ocean and cryosphere were relevant. The IPCC notes that monitoring changes in permafrost needs a better coverage across all ecosystems. The synthesis shows that for land regions in high mountain and polar areas, with the exception of European Alps, Pyrenees, and Alaska, and with the exception of water availability, where applicable, the assessments of physical changes have low attribution confidence (e.g. in Himalaya, Tibetan Plateau, other High Mountain Asia, and Caucasus), or were not conducted at regional scale, or the evidence available is insufficient for assessment. This is the case for example for the low latitude tropical Andes, eastern Africa, and Indonesia, Southern Andes, Russian Arctic, Arctic Canada and Greenland, and for physical changes in ground subsistence, for most regions.

The eighteenth World Meteorological Congress approved the further development of the Global Cryosphere Watch (GCW) within the framework of the WMO Integrated Global Observing System (WIGOS). This is a necessary step in addressing the urgency of improved global coverage and homogeneity of cryosphere observations, data, and information, supporting Members regarding climate science activities and in the delivery of services on water resource management, climate, weather forecasting, and improved understanding of natural hazards and risks.

Recognizing the diversity of actors engaged in cryosphere monitoring projects and programmes, including in the same geographical domain, WMO, through the Global Cryosphere Watch has initiated the development of an integrated global cryosphere data and information system to foster sustainable access through standardization following the FAIR (Findable, Accessible, Interoperable, Reusable) guiding principles. As a first step focus on the discoverability of existing observations thought the WMO Observing Systems Capability Analysis and Review Tool (OSCAR, https://www.wmo-sat.info/oscar/).

In October 2019, WMO convened a High Mountain Summit, co-organized jointly with Food and Agriculture Organization (FAO), FAO-Mountain Partnership, UNESCO, with participants from 45 countries. The Summit concluded with a Call for Action, calling, inter alia, for the inclusion of mountain-specific indicators in local, national, regional and global reporting mechanisms and review processes and commitments, such as National Adaptation Plans (NAPs) and Nationally Determined Contributions (NDCs) under the United Nations Framework Convention on Climate Change (UNFCCC), Voluntary National Reviews (VNRs) on the Sustainable Development Goals (SDGs), the national reviews of the Sendai Framework for Disaster Risk Reduction 2015-2030, etc. The Summit highlighted the need for enhanced coordination and collaboration for addressing critical gaps in mountain Earth system observations, as inputs to specific assessments and indicators. Additionally, it called for developing with a long-term perspective, national and regional frameworks for climate services with functions addressing the upstream-downstream impacts of changes in mountain environments, and advocating for addressing the underfunded development of climate services in mountain regions by substantially scaling up public and private investments in mountain-specific sustained services.

2 World Climate Research Programme (WCRP)

The WMO/IOC-UNESCO/ISC World Climate Research Programme (WCRP) has recently published its Strategic Plan 2019-2028 (https://www.wcrp-climate.org/wcrp-sp) and is working towards an Implementation Plan for the same period. Within this plan, the development, collection, analysis, and archiving of multi-variate, multi-scale observations of the climate system is highlighted as a foundation of climate system research. Sustained observations are needed to capture the evolving climate system. Observations are also critical to understand the climate system and to verify and improve climate simulations. The WCRP community requires well-coordinated international observational field and space-based programs, which have access to the most advanced sensors, platforms, and instruments. The development of synergies between disparate observing systems is critical, as is the characterization of bias and uncertainty in instruments and observational products. In addition, WCRP requires the co-design of new observations and indicators, sustained and quality-controlled climate system observational records, and the continuous improvement and timely availability of temporally consistent datasets, such as re-analyses. Common data formats, metadata requirements, and citation standards will improve the accessibility of datasets for all researchers.

2.a Update on Earth Energy Imbalance (EEI)

The Earth's Energy Imbalance (EEI) is a topic that cuts across different aspects of WCRP research. Systematic observations are required of the Earth system for the storage of heat in the ocean, land, cryosphere and atmosphere from seasonal to longer time scales, and include the consistent assessment of energy stored in each of these different components of the Earth system. The combined use of observations and models is fundamental to reach this goal.

2.b Decadal predictions

WCRP's Grand Challenge on Near Term Climate Prediction is working towards routine provision of decadal prediction services. In order to do so, ocean observations and analyses, such as the Hadley Centre's EN4 database, are essential. Comprehensive atmospheric information, including aerosol and greenhouse gas concentrations are needed for atmospheric initialization. Long-term stable records are needed so that observations in hind casts (used for bias correction) are close to those in real time forecasts – this is an issue for example in sea ice thickness and soil moisture records. Some data are simply unavailable, such as solar spectral irradiance in near real time for UV solar irradiance.

2.c Progress on 6th Climate Model Intercomparison Project (CMIP6)

Model simulations for CMIP6 are now progressing with rapid activity over the last few months as the IPCC 6th Assessment Report (AR6) timelines approach (December 2019 for submitted papers). Model outputs are now being served by Earth System Grid Federation (ESGF) from 21 institutions (45 models) and more will be made available over the coming months. The ESMValTool is now routinely applied to CMIP6 data as it is uploaded to ESGF. Results from HighResMIP show a significant reduction in some long-standing regional model errors. The recent CMIP6 Analysis Workshop held in Barcelona, 24-28 March 2019 brought together 250 scientists from 26 countries and involved representation from all MIPs and 25 modelling groups. Early results from CMIP6 indicate a higher climate sensitivity than in previous CMIP rounds. A perspective paper is currently being develop to report on these emergent results.

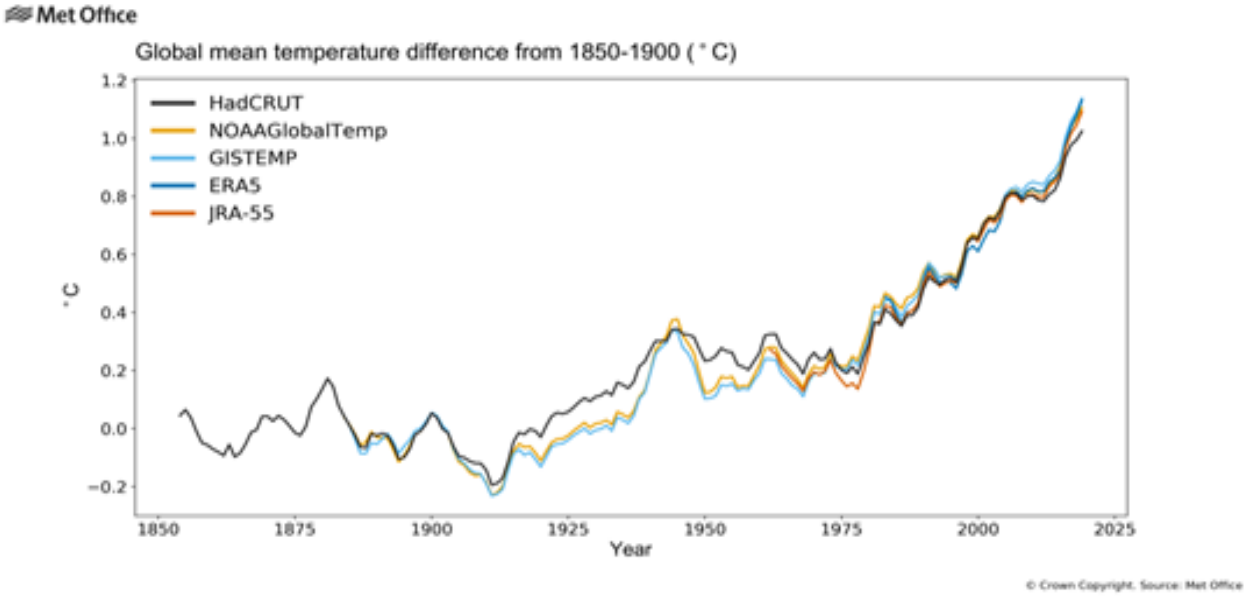
The Working Group on Coupled Modelling (WGCM) coordinates model intercomparisons to understand and predict natural variability and forced changes. Future plans for CMIP will aim at a distributed organization with separation of timescales between CMIP Diagnostic, Evaluation and Characterization of Klima (DECK) and MIPs science questions. The CMIP essential infrastructure is currently delivered by volunteer efforts by the WGCM members, the CMIP Panel, the WIP (WGCM Infrastructure panel) and individual scientists in often partly/un-funded efforts. A recently approved WMO Congress Resolution calls for institutionalizing critical components of the CMIP enterprise.

3 WMO Products

3.a Update on Five-year Climate Summary Report 2015-2019

Global temperatures continue to exhibit a warming trend. The five-year period 2015–2019 is likely to be the warmest of any equivalent period on record globally, with all five years the five warmest on record. The year 2016 remains the warmest year on record due to an additional heating associated with the strong El Niño 2015/2016. A provisional annual statement on the State of the global Climate in 2019 will be released in late November 2019.

Averaged over the five-year period 2015-2019, the global temperature anomaly has been estimated to be +1.1°C ± 0.1°C above the 1850-1900 baseline. This is consistent with the finding of IPCC special report on global warming of 1.5, which states that human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of between 0.8°C and 1.2°C.



Continuing and/or accelerated trends have also predominated among other key climate indicators, including rising sea levels, a continued decline in the Arctic sea-ice extent, an abrupt decrease in Antarctic sea ice, continued ice mass loss in the glaciers and the Greenland and Antarctic ice sheets, and the clear downward trend in the northern hemisphere spring snow cover.

Heatwaves were the deadliest meteorological hazard in the 2015–2019 period, affecting all continents and resulting in new temperature records in many countries accompanied by unprecedented wildfires that occurred in particular in Europe, North America and other regions. The 2019 northern summer saw record-breaking wildfires that expanded to the Arctic regions, setting new records, and wide-spread fires in the Amazon rainforest. Among all weather-related hazards, tropical cyclones were associated with the largest economic losses, with floods, landslides and associated loss and damage. The costliest hazard event was Hurricane Harvey in 2017, which led to an estimated economic loss of more than US$ 125 billion.

3.b The WMO Greenhouse Gas (GHG) Bulletin

The latest analysis of observations from WMO Global Atmosphere Watch shows that globally averaged surface concentrations calculated from this in-situ network for carbon dioxide (CO2), methane (CH4) and nitrous Oxide (N2O) reached new highs. The growth rates of the CO2, CH4 and N2O concentrations in the atmosphere averaged over the 2015–2017 period for which data have been completed and processed are each about 20% higher than those over 2011–2015. The WMO Greenhouse Gas Bulletin released on 25 November showed that globally averaged concentrations of CO2 reached 407.8 ppm in 2018, up from 405.5 ppm in 2017. The increase in CO2 from 2017 to 2018 was very close to that observed from 2016 to 2017 and just above the average over the last decade.

	Concentration			*Growth rate*		
	2015-2017	*2011-2015*	*2015-2017 % to pre-industrial*	*2015-2017*	*2011-2015*	*% change*
CO_2	403	395.5	145	2.6	2.2	+18%
CH_4	1851.7	1826.4	256	8.7	7.2	+21%
N_2O	329.1	326.2	122	0.87	0.73	+19%

3.c State of Climate Services

In response to Decision 11 adopted by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (11/CMA.1) WMO, through the Global Framework for Climate Services (GFCS), has prepared a "State of Climate Services" report documenting the current status of climate information and associated services in relation to Parties' priorities identified in their NDCs and NAPs. The first "State of Climate Services" report, focused on services for adaptation in the agriculture and food security sector, will be launched at COP25.

4 WMO and GFCS Initiatives

4.a Climate science basis for climate action

Through an agreement with the Green Climate Fund (GCF), WMO is organizing a series of workshops in five countries – Saint Lucia, Democratic Republic of Congo, Cabo Verde, Cambodia and Paraguay – to articulate the climate science basis of NAPS and GCF and other funded projects and activities. This project has provided an opportunity to test the methodologies for articulating the climate science basis for climate action and enhancing the confidence at national level concerning the use of climate information in project planning. These workshops also provide expert input from the WMO expert bodies, NMHSs, and regional and global centres that compile climate information based on high quality data sources, identify key vulnerability, and assist to co-produce solutions. An online platform for climate information developed by the Swedish Meteorological and Hydrological Institute (SMHI) is made available to national stakeholders in each country. The climate science basis initiative has further contributed to Decision 11/CMA.1 and Decision 8/CP24 through capacity development at the country and local level(s) to support the application of methodology, data, tools, and knowledge for enhancing the climate science basis of climate action. The overall outcomes of this initiative will be reported to COP 25 and shared in a policy document.

In collaboration with United Nations Institute for Training and Research (UNITAR), GFCS also has developed an E-course on "Integrating climate risk information into NAPs". Launching on 30 October 2019, the course is designed to respond to the learning needs of both climate services providers (National Hydro-meteorological Services, research/academic and international organizations), and users (e.g. decision makers, private investors, non-governmental organizations, etc.), as well as of those working at the science-policy interface for outreach or communication purposes. In particular, the e-course shows how to strengthen NAPs through appropriate climate information and coordinated policy action, enabling different types of institutions and actors to work together in a collaborative framework, drawing on the resources of the global hydro-meteorological community at large.

4.b National Frameworks for Climate Services

In support of promoting the routine use of climate information services to guide and inform adaptation planning at the national level, sectoral, and local level, the GFCS has been supporting countries to develop National Frameworks for Climate Services (NFCS). The national frameworks serve as a key institutional mechanism to coordinate, facilitate and strengthen collaboration among national institutions to improve the co-production, tailoring, delivery and use of science-based climate prediction and services. NFCSs support the Paris Agreement by ensuring the availability of science-based research and systematic observations for decision-making. NFCSs also support NAPs by providing climate services that help in assessing climate vulnerabilities, identifying adaptation options, developing products that help improve the understanding of climate and its impacts, and enhancing the adaptation planning and implementing capacity of climate-sensitive sectors. As of August 2019, 46 WMO Members had established or were in the process of establishing National Frameworks for Climate Services (NFCSs).[7] Of these, four were fully established, 15 had completed the steps and were

[7] https://gfcs.wmo.int/NFCS_status

moving into operation, four had started the process of NFCS establishment, 14 were in the process of initiating the first steps, and nine were in the planning phase.

4.c WMO Country Support Initiative

The Eighteenth World Meteorological Congress approved the WMO Country Support Initiative (CSI) through Resolution 74 (Cg-18). The CSI will provide advisory services to developing countries and development partners to increase effectiveness of investments in weather, climate, and hydrological services. Through the CSI, developing countries and development partners will have access to one-stop-shop advice on WMO requirements, regulatory material, standards and good practices to ensure that investments are integrated within WMO regional and global systems.

4.d Alliance for Hydromet Development

The Alliance for Hydromet Development, also approved in Resolution 74 (Cg-18), aims at scaling up the efforts of major development and climate finance partners to close the capacity gap on high-quality weather forecasts, early warning systems, and climate information through collective action. The Alliance members commit to specific actions, including on improving systematic observations for better data, and the need for innovative ways to finance developing country surface-based observations. The Alliance is expected to be launched at COP25.

_____