WORLD METEOROLOGICAL ORGANIZATION

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

TECHNICAL WORKSHOP

Enhancing ocean observations and research, and the free exchange of data, to foster services for the safety of life and property

(Ocean-Safe)

A contribution to the planning phase (2019–2020) of the United Nations Decade of Ocean Science for Sustainable Development (2021–2030)

Geneva, Switzerland, 5 to 6 February 2019

FINAL REPORT

(Rev. 2)

WORLD METEOROLOGICAL ORGANIZATION

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

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EXECUTIVE SUMMARY

The workshop on enhancing ocean observations and research, and the free exchange of data, to foster services for the safety of life and property was held at the WMO Headquarters in Geneva, Switzerland, from 5 to 6 February 2019. More than 50 participants from 16 Countries, 10 international Organizations, 1 Non-Governmental Organization, and from all WMO Regional Associations attended the Workshop.

The workshop was organized in conjunction with the 2019 face-to-face meeting of UN-Oceans, the UN interagency coordination mechanism on ocean affairs, which was hosted by WMO at the Headquarters.

The safety and wellbeing of people throughout the world and the economic benefits to all nations are at the centre of the WMO mandate and action. To address meteorological hazards, strengthen resilience in the face of climate change and variability, and build the scientific knowledge base for sustainable development, sustained oceanographic and marine meteorological (ocean/met.), observations and their free and unrestricted exchange are critical.

While the oceans cover more than 70% of the Earth surface, the natural system is fully coupled between the atmosphere and ocean and the delivery of effective and improved marine and weather services depends on both atmospheric and oceanic information. The growth of seamless forecasting systems means that meteorological services need an increasing amount of quality information about the ocean and the atmosphere above the ocean surface in order to be able to deliver the weather, marine and climate services derived from the use of such prediction systems. Ocean and marine-focused services particularly need both ocean and atmospheric information. Examples of products and services and the required data are provided in table 1.

This workshop was organized by WMO with the support of its technical commissions and co-sponsored programmes[1].

The workshop considered the evolving requirements for ocean observation and research in support of WMO Application Areas with focus on marine meteorological services, which particularly rely on global and high resolution numerical weather prediction. The following Applications, which also rely on ocean observations, were also addressed: tropical cyclone, storm surge and high impact weather forecasting, sub-seasonal to longer range prediction, climate monitoring, climate modelling, climate impact analysis and climate services.

To address such requirements, ocean/met observations are made in the framework of WMO initiatives such as the WMO Integrated Global Observing System (WIGOS), the World Weather Watch (WWW), and the Global Atmosphere Watch (GAW). Different collection means are used, such as ships of opportunity, data buoys and installations, profiling floats, remote sensing by satellites, and cabled observatories, to support critical services relying heavily on free and unrestricted exchange of the collected data.

The Workshop made recommendations with relevant standards and a workable list of marine meteorological and oceanographic variables, including from exclusive economic zones, indispensable for the issue of timely and accurate storm warnings for the safety of life at sea and the protection of life and property in coastal and offshore areas.

The workshop achieved following outcome:

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[1] The Joint WMO-IOC Technical Commission on Oceanography and Marine Meteorology (JCOMM), the Commission for Basic Systems (CBS) and the Commission for Instruments and Methods of Observation (CIMO) and its co-sponsored WMO-IOC-ISC World Climate Research Programme (WCRP), IOC-WMO-UN Environment-ISC Global Ocean Observing System (GOOS) and WMO-IOC-UN Environment-ISC Global Climate Observing System (GCOS).

- The Workshop highlighted the relevance of WMO activities and applications to address socio-economic benefits, incl. in support of safeguarding life and property at sea as outlined in Session 1;
- Key elements for a draft Congress Resolution with Critical variables and observations gaps was agreed upon and recommended, and corresponding draft Resolution on Ensuring Adequate Marine Meteorological and Oceanographic Observations and Data Coverage for the Safety of Navigation and the Protection of Life and Property in Coastal and Offshore Areas was drafted (see ***Annex 6***);
- For data to have full benefit (e.g. for hazards, cyclones etc.), the Workshop recommended to have broader use of ocean data, e.g. using JCOMM Ocean Open GTS project, in particular those produced by the research community, shared in real-time using fit for purpose format and fir for purpose interoperability with WMO Information System (WIS) and other relevant data systems;
- The workshop promoted partnership with the private sector to integrate data from them for delivery of Earth system approaches/climate services, and proposed initiating a pilot project with the World Ocean Council (WOC);
- The workshop agreed on way forward for future collaboration between WMO and IOC regarding facilitating the making of oceanographic observations in coastal regions in support of Earth System Prediction and climate services, and proposed draft congress Resolution in this regard (see ***Annex 7***);
- The workshop helped clarifying the legal framework, in the view to facilitate the making of observations in coastal regions in support of WMO applications (see ***Annex 3***).
- The workshop recognized the importance of Observing System Simulation Experiments (OSSEs) and sensitivity analyses to be used to investigate the importance of data collected within EEZs. The workshop proposed conducting a pilot activity in this regard.

This outcome will be submitted to the World Meteorological Congress for consideration in the updating of Resolution 9 (Cg-IX), and is offered as a contribution to the United Nations Decade of Ocean Science for Sustainable Development and its objectives I (Knowledge of the ocean system), III (Ocean-related hazards) and IV (Cooperation in observation, data and other infrastructure).

GENERAL SUMMARY

OPENING

The workshop was opened by WMO Secretary General, **Dr Petteri Taalas**, who welcomed all participants and thanked the Organizing Committee for their hard work to prepare the workshop:

- **Mr Tom Cuff**, NOAA National Weather Service, USA, Chair of the Services and Forecasting Systems Coordination Group of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM);
- **Mr Jon Turton**, UK Met Office, vice-Chair of the Observations Coordination Group (OCG) of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM);
- **Dr Erik Andersson**, Deputy Director of Forecasts, European Centre for Medium Range Weather Forecast (ECMWF), Chair of the Inter Programme Expert Team on Observing System Design and Evolution (IPET-OSDE) of the WMO Commission for Basic Systems /CBS);
- **Dr Glenn Nolan**, Secretary General of the European Global Ocean Observing System (EuroGOOS);
- **Dr Martin Visbeck**, GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany, member of the WCRP Joint Scientific Committee, Executive Planning Group for the UN Ocean Science Decade, Expert in Ocean Circulation and Climate Dynamics
- **Mr Johan Stander**, South Africa Weather Service, Co-President, Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM)
- **Dr Emma Heslop**, Intergovernmental Oceanographic Commission (IOC) of UNESCO, Programme Specialist for the Global Ocean Observing System (GOOS) and the Observations Coordination Group (OCG) of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM)
- **Prof. Tullio Scovazzi**, Professor of International Law, University of Milano-Bicocca, Milan;

Dr Taalas highlighted that the workshop is part of a week of ocean meetings at WMO; a meeting of UN Oceans follows on Thursday and Friday. Dr Taalas referred to the WMO reform, and that the Oceans will be a central focus. The Oceans are important, covering 70% planet surface; but he noted that there were limitations in the Ocean Observing System. WMO needs to ensure observations such as those from Voluntary Observing Ships are carried out. Dr Taalas also highlighted WMO's role in the UN Framework Convention on Climate Change, and the importance of the ocean to understanding and tracking climate, with 93% extra heat going into oceans with consequences for sea level rise. An emerging priority for WMO is to be able to track the Carbon Budget, and notes the need to enhance the observing system. Disaster risk reduction and early warning systems are also an important priority for WMO, with many disasters such as cyclones and floods, having an ocean component. Floods in particular point to the need for more integrated observing systems across weather, oceans and hydrology.

Lastly, Dr Taalas informed the meeting the WMO and IOC would be signing a joint agreement on greater cooperation this week which highlights WMOs recognition of the importance of Ocean information for WMO, and the partnerships required to deliver ocean information to WMO members.

The Secretariat then provided information on working arrangements for the workshop.

SESSION 1 (SOCIO-ECONOMIC BENEFITS)

SOCIO-ECONOMIC BENEFITS OF WMO APPLICATIONS USING MARINE METEOROLOGICAL AND OCEANOGRAPHIC OBSERVATIONS

Session Chair, Dr Sarah Jones, Head Research and Development, Deutscher WetterDienst (DWD, Germany), and Chair of the Scientific Steering Committee of the WMO World Weather Research Programme (WWRP) introduced the session by outlining some overall societal drivers for the free exchange of data, in the context of a UN Organization and particularly noting Least Developed States, Landlocked Developing States, Small Island Developing States are disproportionately impacted by weather and climate events.

Tropical cyclones present a major threat to these countries, requiring accurate weather forecasts and warnings to mitigate their impacts. At the recent WMO International Workshop on Tropical Cyclones the need for improving forecasts of intensity and structure in order to provide actionable information about Tropical Cyclone impacts was emphasized strongly.

The IPCC report highlighted how a slower rate of Global Mean Sea Level Rise in a 1.5°C warmer world compared to a 2°C warmer world could mean up to 10.4 million fewer people exposed to impacts globally in 2100 and enable greater opportunities for adaption. Increasing the confidence in and the utility of the information from climate projections of GMSLR will allow better and more effective decisions on adaptation to be taken.

For both of these examples there is a clear need for improved marine meteorological and oceanographic observations from multiple platforms in open ocean and coastal regions, from tropical and polar oceans, providing input to coupled Earth System models and research into how to obtain and use them. The socio-economic benefits depend on utilizing these observations in data assimilation , for process understanding leading to improved uncoupled and coupled prediction systems, for evaluation and verification, for quantifying uncertainty, and for communicating the resulting information to decision makers and policy makers.

Dr Jones recalled the two goals of this meeting, focused on:

(1) Short term approach with focus on facilitating the making of surface marine meteorological observations in support of safety of life and property at sea;

(2) Longer term approach, and future collaboration with the IOC of UNESCO with regard to ocean observations requirements, including in coastal regions, in particular in support of Earth System Prediction and hydro-climate services.

The 2030 Agenda for sustainable development and the UN Decade of Ocean Science for Sustainable Development (Martin Visbeck, GEOMAR).

Dr Martin Visbeck, GEOMAR Helmholtz Centre for Ocean Research Kiel (Germany), member of the WCRP Joint Scientific Committee, of the Executive Planning Group for the UN Ocean Science Decade, and Expert in Ocean Circulation and Climate Dynamics, began the meeting in earnest by outlining how ocean information is needed to support the 2030 Agenda for Sustainable Development, and the UN Decade of Ocean Science for Sustainable Development.

To set the context, Dr Visbeck highlighted that more than 40% of population live within 100km from the shore.

Driven largely by the fact that if people communities are to participate in global economy, you need to ship goods (90% of transport by sea). Moreover, 16 out of 23 megacities are coastal megacities. Dr Visbeck notes that the world’s population doubled in his lifetime, this has significant consequences for resources. The Sustainable Development Goals (SDGs) come in, which were motivated by the question, what is the safe and just operating space for humanity?

One of the SDGs is focused on the ocean (SDG14). However, ocean information will support a number of the other SDGs, including SDG13 (Climate), as well as others on food security, sustainable cities, etc.

The SDGs motivated the development of a UN Decade of Ocean Science for Sustainable development. There is currently a UN Decade for Biodiversity. Unfortunately it isn't visible in the global community. This highlights that having a UN Decade is no guarantee of success; and it is down to the Ocean community and partners to ensure the UN Ocean Decade delivers to its aspirations.

The UN Ocean Decade will be mission oriented, with key foci of significant relevance to WMO interests, e.g.

- A Safe ocean
- A Sustainable and productive ocean
- A Transparent and accessible ocean.

The UN Ocean Decade aims to be a cooperation framework for ocean science, and this meeting is very timely in shaping the decade.

Another key initiative in the run up to the UN Ocean Decade is the OceanObs'19 Community conference (recognizing that ocean observing is a major volunteer community collaborative effort), to set the agenda for the next decade of ocean observing. Many of the outcomes will feed into the UN Ocean Decade. IOC and WMO are expected to engage. The conference this year will focus on the users perspective, with outcomes anticipated including strengthened governance for ocean observing; hence, WMO's perspective would be very valuable.

Lastly Dr Visbeck welcomed news that WMO is thinking about arranging WMO's ocean portfolio, and strengthening the partnerships in this space.

In the discussion, it was asked what would be success for a Decade of Ocean Science? Dr Visbeck noted that this is under discussion within the Executive Planning Group for the Ocean Decade; an important legacy would be for the community to be better organized in gathering information about the ocean. Efforts are being fostered working across communities and agencies, but could be approved. Stronger partnerships will be essential. Specific outcomes could be:

- Under the auspices of UN Oceans, a more joined up Ocean Observing System, Ocean Information System, and Assessment procedure.
- More education regarding the importance of ocean for society; Ocean Literacy.
- We need to articulate the future we want for the ocean for the next 50-100 years. Climate, Environmental Stressors. Need joined up vision for the how we want the ocean to look in the future.

Copernicus Marine Service: Ocean Monitoring and reporting

Dr Karina Von Schuckmann, Copernicus Marine Services, and Oceanographer at Mercator Ocean, France reported on the Copernicus Marine Service, and particularly on monitoring and reporting. COPERNICUS is the European Earth observation and monitoring program based on space-based and in situ observation, and operates six environmental monitoring services.

Mercator Ocean International has been entrusted by the EU to implement the Copernicus Marine Environment Monitoring Service (CMEMS) which provides an open and free access to regular and systematic marine information. The CMEMS ocean reporting provides a unique reference of value-added expert information at a regular frequency and is achieved through two principal tools, i.e. the CMEMS Ocean State Report and the CMEMS Ocean Monitoring Indicators. Today, we have the opportunity to improve the end-to-end product development (added value chain) for ocean information. Earth observations from remote sensing techniques, the international Argo program together with other ocean observing system components, and operational data dissemination through marine and climate services have all tremendously increased our capabilities for ocean monitoring and reporting, particularly over the past two decades. The UN 2030 sustainable development framework delivers a clear guidance on urgent goals to be achieved by 2030 for a path into a sustainable future for society. The key ingredient is to establish an ongoing dialogue between decision makers, the private sector and the information providers (experts) on the marine environment in order to establish valuable decision supporting tools based on the combination of Earth observations and ocean in-situ data for e.g. Essential Ocean/Climate Variables and GCOS Global Climate Indicators.

During the discussion, the future of the Copernicus was discussed, particularly whether the focus could be expanded, and what WMO and others could to do to articulate development priorities, such as observing the deep ocean. A second phase of Copernicus is under discussion, and signals are currently good. For the deep ocean, observing approaches are already being trialed, such as the Deep Argo float pilot deployments.

The Socio Economic benefits of medium and long range weather forecasting (Erik Andersson, ECMWF)

Dr Erik Andersson, Deputy Director of Forecasts at the European Centre for Medium Range Weather Forecast (ECMWF), and Chair of the Inter Programme Expert Team on Observing System Design and Evolution (IPET-OSDE) of the WMO Commission for Basic Systems /CBS) highlighted how integrated the ocean has become in numerical weather forecasting. Fully integrated system (beyond simply a boundary condition). Gradual improvements have been made with forecast skill. The next challenge is to stretch out the forecast skill onto longer timescales (e.g. beyond 5 days). There is significant societal impact in medium-range and longer-range forecasting with respect to 1) the Protection of life and property, 2) Agriculture, 3) Floods, 4) Forest fires, 5) Energy production and consumption; renewables, 6) Transport and 7) Retail.

Improved coupling of the atmosphere with the ocean is a key component of the development strategy for Numerical Weather Prediction (NWP) in the next several years. The ocean surface, the deep ocean and arctic sea/ice conditions are relevant to forecasting at all time ranges, contributing to the ability to forecast tropical cyclone intensity, heat waves, cold spells and seasonal temperature anomalies. Model development is now focusing on improving the physical description of atmosphere— ocean— sea-ice— land interactions and data assimilation.

Coastal application and other marine meteorological services

Mr Nick Ashton, Marine Services expert at the UK Metoffice, and Vice-Chair of the Services Coordination Group (SCG) of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) reported on Coastal application and other marine meteorological services. He explained that meteorological services, in particular forecasting services, are developed and coordinated through the Services & Forecast Systems Program Area of JCOMM. This Program Area has a mandate which includes ensuring the provision of safety-related weather information and forecasts, including the provision of information in support of

Emergency Response activities such as incidents of pollution and search & rescue. It also has a mandate to attempt to reduce the risk of natural disasters and their effect on coastal communities, and to develop and establish appropriate ocean forecasting services. Forecasting services, in particular, are provided under the auspices of the UN Convention on the Safety of Life at Sea (SOLAS), which principally covers the operation of larger vessels and operating in deeper waters. In addition, there are a number of emerging requirements which need consideration, for example, the marine impacts of volcanic ash deposition, communication and navigation implications of solar magnetic storms, and the development of graphical information compatible with ships onboard systems (such as ECDIS). In the field of Emergency Response, there is a need to enhance and refresh systems in support this activity, including the development of some specific tools such as tracking systems for radioactive material releases.

In the discussion, the challenges posed by gaps in observations required for value added services was discussed. It is important that these observation requirements are articulated and advocated for by those developing value added services. Mr Ashton noted that he would discuss these aspects in more detail as part of his talk in session 2. The workshop also discussed the need for training on the use of observations and products.

Kerala Flood 2018: A wake up call for increasing resilience to high impact weather.

Dr Paruthummootil Jacob Philip, Institute for Sustainable Development and Research (Mumbai, India), and Representative of WMO Disaster Risk Reduction gave a presentation on the factors which affected the impact of the Floods in Kerala last year.

Dr Philip introduced the characteristics of India as context for his talk. India is the 7th largest country in the world and the 2nd most populous with a population of 1.3 billion people. Providing for such a population is a challenge for the Indian government. India also has the 4th largest economy in the world, and is growing. India's relationship with the Ocean is particularly important. The country is mostly a peninsula; and is the second largest peninsula in the world (after Arabian peninsula). Hence, the country has a very long coastline, and relies on the ocean for marine resources, and monsoon rains. India has a large coastal population, which considers the ocean as the provider. However, it also brings hazards, as demonstrated by the 2004 Indian Ocean Tsunami.

More recently, there were major floods in the Kerala region in the south of India. Following a period of torrential rains, there were floods and landslides which caused 400 deaths and 100 billion dollars of damage. In the aftermath, the post mortem started as to whether more could have been done to prevent these losses. Controversy followed about lapses in forecasts versus responsibilities of damn managers.

Dr Philip noted substantial improvements in recent years with regard to weather forecasting. However, extreme weather events, like the Kerala flood, point to the fact that we have miles to go. Dr Philip also Welcomed Erik's presentation regarding improved forecasting of high impact events.

The discussion focused on the specifics of how to improve the delivery of information, regarding longer timescales, additional variables, perhaps better regional downscaling, and whether perhaps different information is needed after the event verses before. Whether we need better forecasts or improved communication of actionable information from the forecasts, such as communicating the severity/potential unprecedented nature of an event, potential impact. The discussions also highlighted the need to work towards improved integrated hydrological and meteorological forecasting.

PANEL DISCUSSION, SESSION 1

Panelists:

- **Dr Martin Visbeck,** GEOMAR Helmholtz Centre for Ocean Research Kiel (Germany), member of the WCRP Joint Scientific Committee, of the Executive Planning Group for the UN Ocean Science Decade, and Expert in Ocean Circulation and Climate Dynamics;
- **Dr Karina Von Schuckmann,** Copernicus Marine Services, and Oceanographer at Mercator Ocean, France;
- **Dr Erik Andersson,** Deputy Director of Forecasts at the European Centre for Medium Range Weather Forecast (ECMWF), and Chair of the Inter Programme Expert Team on Observing System Design and Evolution (IPET-OSDE) of the WMO Commission for Basic Systems /CBS);
- **Mr Johan Stander,** South Africa Weather Service, and Co-President, Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM); and
- **Dr John Wilkin,** Professor, Marine and Coastal Sciences, Rutgers University, USA, and Co-Chair of the Physics and Climate Panel (OOPC) of the Global Ocean Observing System (GOOS).

The Panel, interacting with the workshop addressed the following questions:

1. How SDGs are relevant to protection of life and property at sea ?
2. How critical are WMO Applications to protection of life and property at sea ?
3. How do we make sure that ocean observations contribute through the Global Data Processing and Forecasting System (GDPFS) for earth system monitoring, prediction and delivery of hydro-climate services relevant for sustainable resource management and adaptation to climate change?

The broader drivers for ocean observations, partnership building and data sharing

The panel discussed the synergies across the SDG agenda, and highlighted a study from the International Science council to see how the ocean connects across the SDG Agenda.

It highlighted the need for joined up interventions and actions. There are potential conflicts and impacts so by trying to address one issue, you might have a negative impact on another. For example, ocean fertilization could have a positive impact on climate, but a negative impact on the ecosystems. Hence a 'systems' approach is needed. Other examples requiring aggregated information included the World Ocean Assessment, and the IPCC Special Report on Ocean and Cryosphere.

The new WMO strategy was highlighted and the emphasis on 'Earth System Approaches' which will require significant partnership building with communities external to WMO's core constituency. For instance, for early warning systems; some warnings are related to weather events, e.g. storm surges; some have little to do with weather such as tsunamis, and some partly to do with weather such as harmful algal blooms.

We measure the ocean for many reasons, including for weather and climate; and there are many 'actors' (funders, implementers, and users) of the observing system. How do we collect and disseminate ocean information to meet this broad range of needs from a global point of view, that is equitable? We need to ensure there is a joined up agenda for information gathering.

The panel then discussed how research contributes to the assessment and planning of prediction systems. For instance, with the example of the Year of Polar Prediction the panel discussed its legacy, and key factors for success for future similar efforts. A legacy of long term observing systems is seen as a key outcome of such projects, as well as the research based observations being widely available for use and reuse following the project, to ensure maximum intellectual value for investment. Other examples include The Year of Tropical Convection, and the Year of the Maritime Continent. The potential for a future project focused on the Air Sea interactions in the Indian Ocean region was discussed, motivated by the talk on the Kerala Floods.

The WMO is focused on members (the countries), which are generally represented by National Meteorological and Hydrological Services. The potential role and contributions of regional efforts such as the European programme, Copernicus Marine Environmental Monitoring Service was discussed. Copernicus can contribute in terms of providing input on user requirements, services delivery, and expertise capacity, and is also keen to collaborate to identify priorities and requirements from the WMO perspective.

The panel also discussed the broader motivations for ocean observations and data sharing and the partnerships that need to be developed to have maximum impact for society. Particular motivations for enhanced observations and data sharing include the move towards seamless prediction systems, coupling between the ocean and atmosphere on shorter timescales, and higher resolution forecast systems, and the inclusion of ocean biogeochemistry in models. In addition, we are seeing rapid developments in observing technologies to take higher resolution observations, measure remote parts of the ocean, measure more variables, and the development of cheaper, easier to use observing equipment.

The panel highlighted that the most vulnerable regions are significantly impacted by severe weather events, and we need to ensure that vulnerable regions benefit particularly from data sharing and enhanced information availability, including local capability development for forecast systems and downscaling.

The gap from forecasting to services was particularly highlighted, and the need to ensure people understand the forecast, and consequences; Hence WMO needs to go further to impact based forecasts, and this will require partnerships, and this was recognized in the formation of GFCS. WMO has technical expertise, then sector knowledge insights are needed to talk about priorities and impact.

Ocean Observations and data sharing, the value of WMO engagement.

Moving into how WMO can help to improve Ocean Observations, noting it is a collaborative arrangement with mostly research funding; and particularly how we connect ocean and terrestrial observations to support in the coastal zone. Ocean Observing is much more of a multi-stakeholder arrangement. More collaboration on data sharing, standards, joined up initiatives are key to advancing the observing system. The OceanObs'19 will look at Governance of ocean observing to see if we can work towards more stringent commitments.

While Weather Forecasting and Safety and Coastal protection are major drivers of observations and services in ocean, there are other drivers also. For example, the Copernicus Marine Environmental Monitoring Service (CMEMS) connects weather biodiversity, climate, coastal issues in one service. This is an example of a partnership arrangement that couldn't be achieved by one met service. For productive partnerships, we need to play to the strengths of our partners and see what the solution space would be.

While much of the data collected in the ocean is research funded, increasing amounts of data are available in real-time through the GTS or web-services. Aligned with the Joint WMO-IOC Strategy for Ocean Data Management, WMO will support the broader use of these data by working with the research community to expand support for distributing data in real time. For data to have full benefit (e.g. for hazards, cyclones etc.), we need this data shared in real-time using fit for purpose format and interoperability with WMO Information System (WIS) and other relevant data systems (***recommendation***). Under the JCOMM Observations Coordination Group, efforts are being trialed to improve how non met services can participate in providing data to, and using data from the GTS, through an Ocean Open GTS[2]. In real-time and delayed mode, middleware tools such as ERDDAP are being used to improve how we bring diverse datasets and data sources into a single environment, enhancing their usability. Open GTS is to be included in the WIS framework for the benefit of oceanographic and other communities.

Addressing risks of data sharing.

The benefits of data sharing have been discussed in depth in this session and can be useful in communications with coastal states, but the concerns and risks also need addressing; largely focused on security and protecting natural resources. For instance, if another nation or organization is able to survey marine living resources, there are concerns groups better able to use that information will exploit those resources. Alternatively, as we are increasingly able to measure ocean chemistry, there is a risk that potentially polluting, damaging industrial sites might be made public. It is important to demonstrate the benefit of sharing data for the things people care about, and also work towards ensuring that the benefits of data sharing are equitable. Additionally, negotiations are underway through the Convention on Biodiversity (CBD) regarding protecting Biodiversity Beyond National Jurisdictions, BBNJ. Coastal states are particularly engaging in the process to advocate for benefit sharing arrangements; for instance in line with the Nagoya Protocol on access to genetic to genetic resources and the fair and equitable sharing of benefits arising from their utilization to the Convention on Biodiversity. Many states are supportive of the ocean observations for scientific and operational applications, but they but they also see the dual use of these observations for applications over which they are much more protective. For example, identifying lucrative drugs.

Communication of benefits, particularly with an emphasis on engagement and participation is key, to demonstrate the benefits of data already available. Risk alert maps, based on hindcast products, climate projections to inform adaptation, mitigation; perhaps linked to WMO's multi-hazard warning system. Information needs to be communicated on how and where observations will make a positive impact on the forecasts and warning systems.

An Organization for Economic Co-operation and Development (OECD) study is underway to estimate the economic value of sustained observing globally, including coastal regions, which could be helpful in demonstrating the value of data sharing.

Private Sector Data Collection.

Private sector organizations are increasingly involved in ocean observing; either through the collection of data for their own needs, or through the development and operation of ocean observing technologies.

Wind energy providers measure wind. In the Netherlands, the government gives subsidies to the offshore wind parks, but their data isn't made available. This data would be particularly useful for a range of applications. The aviation industry sets the precedent for private sector legislation of sharing data. Oil platforms also collect a significant amount of data, but the legislation of data sharing is patchy. In the North Sea, it is shared as the companies are

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[2] WMO is working on lowering the barriers to put and get data from GTS. WIS Data Collection and Production Centre (DCPC) is to be established for the "Ocean Open GTS" promoted by JCOMM to be part of WIS. WMO is also starting an initiative to work on the data formats used by the ocean community to make them fit for operational purposes and allow their exchange in GTS alongside the WMO BUFR and GRIB formats. Moreover the GTS will evolve to include more technologies that are part of the WIS 2.0 implementation plan.

convinced of the benefits of data sharing for improved forecasting; whereas for the Gulf of Mexico, it isn’t.

A number of private companies are involved in the development of satellites and autonomous platforms. A business model whereby the platforms are not sold; but the platforms are operated by the company and data is sold to the user. This presents issues around transparency, best practice and data sharing.

A potential approach would be to develop public trusted databases, with provisions real-time versus delayed mode data; given the commercial value of data diminishes with time. By developing a demonstrating project with private partners there is potential to prove enhanced value through better forecasts. Such efforts are needed also to build an environment of mutual trust.

Another major private sector contributor is the shipping industry, who are already involved in the observing system through Voluntary Observing Ship (for meteorological observations) and Ship of Opportunity (for subsurface ocean observations) Programmes. The shipping industry in particular value corporate social interaction. We need to ensure that companies are on safe legal ground when collecting and sharing data (one of the goals of this workshop); we need to advocate that participation in ocean observing is good industry behavior so it becomes industry standard; we need to work with the shipping industry regarding real-time data sharing benefits and risks (e.g. being targeted by pirates); and we need to work with the industry to encourage the inclusion of observation packages as part of the ship build specification, rather than retrofitting.

The range of observation activities in the coastal zone were highlighted and the many partners and orgs who make observations. NHMSs need high quality forecasting, need high quality observation. WMO has regulations and guidance material, but partnerships will be needed to ensure that guidance and support can be provided to non-meteorological service partners. As an example, GOOS Regional Alliances focus on building capacity, interchange of standards and best practices and coastal observing to global observing.

In fostering data sharing at all levels, the need to build trust, and demonstrate mutual benefit was emphasized.

Summary: Key messages from session 1.

- The session highlighted the increasing demand for integrated information across sectors, disciplines; particularly in support of the Sustainable Development Goals. The role of ocean observations in support of a broad range of applications was highlighted.
- WMO recognizes the need to integrate atmosphere, ocean, hydrological observations
- While the broad benefits of data sharing have been comprehensively covered, increased focus is needed on identifying risks and meeting concerns. Some initial steps were suggested, but it will be a steady process of building trust.
- In strengthening the value cycle across observations, research and services delivery; we need to identify observation needs but also improve communication of outcomes and benefits of research and other applications to a broad audience, to demonstrate value of data sharing for all and articulate needs, advocate for improved observations. Improved products and forecasts need to be translated into useful information and communicated appropriately. We need to ensure the benefits and applications are also shared equitably and this demonstrated.
- There is an important role for WMO working with on the improved management and dissemination of data in real time beyond.

- In working on data sharing and utility with the broader community (research agencies, local government, the private sector, academia), alternative approaches might be needed to ensuring quality, through demonstration projects, building trust.
- Engaging at the regional level to understand opportunities, challenges, and improve use and usability of observations within the region will be important. Regional constructs such as WMO Regional Associations, GOOS regional alliances could assist in this.
- Given the move towards earth system approaches and demands for increasingly integrated information, diverse partnerships will be needed across communities, sectors and disciplines. In building partnerships, we need to build trust, highlight mutual interests and benefits and the strengths the partners bring to the table.

SESSION 2 (DATA NEEDS AND GAPS)

THE NEED FOR OBSERVATIONS, ASSESSED GAPS AND THE EVOLVING CAPABILITIES FOR THE COLLECTION AND DISTRIBUTION OF OCEANOGRAPHIC AND MARINE METEOROLOGICAL DATA IN SUPPORT OF WMO ACTIVITIES RELATED TO SAFETY OF LIFE AND PROPERTY AT SEA

Session 2 was chaired by Mr Stefan Klink, Deutscher Wetterdienst (DWD), and vice-chairperson of the Inter Programme Expert Team on Observing System Design and Evolution (IPET-OSDE) of the WMO Commission for Basic Systems (CBS).

SESSION 2 LECTURES

1. How protection of life and property at sea relies on WMO Application Areas (e.g. NWP) and observations

Presentation was delivered by **Mr Nick Ashton**, UK Met Office, Vice-Chair of the Services and Forecasting Systems Coordination Group (SCG) of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM).

Mr Ashton explained that for the Services & Forecast Systems Program Area of JCOMM, the highest priority is the Safety of Life. This relies on both forecasting, at a variety of resolutions, and the availability of real time observations where possible. In the provision of forecasts, whilst the requirements of the International Convention for the Safety of Life at Sea (SOLAS) emphasize the need for modelling of deeper waters for larger vessels, there is a need for accurate modelling of waters nearer shore where both a large amount of Search & Rescue resource is employed and where coastal issues may be resolved to help protect coastal communities from inundation. In addition, where possible, a selection of real time information should be made available as mariners have a very high regard for this. Whilst this may, primarily, relate to *in situ* observations from ships and buoys, there are other data which would be of value in this respect, such as information from buoys nearer shore, output from systems such as HF radar and even satellite data if it can be easily interpreted and communicated.

2. Tropical Cyclone forecasting requirements

Presentation was delivered via teleconference by **Mr Daniel Brown**, WMO Regional Specialized Meteorological Center (RSMC) - Hurricane Center / US NOAA National Hurricane Center (NHC), Senior Hurricane Specialist and representative of WMO Tropical Cyclone Programme.

He reported on observational requirements for tropical cyclone (TC) analysis and forecasting. Mr Brown discussed the importance of *in situ* observations from reconnaissance aircraft, ships, and buoys. He also discussed the importance of remotely sensed data such as microwave imagery, AMSU sounder information, scatterometer data and geostationary satellite imagery. Information from these sources provide estimates of tropical cyclone location, intensity, structure, and size for TC analysis, which is very important for the development of accurate, life-saving TC track and intensity forecasts. Mr. Brown also discussed the importance of satellite and radiosonde observations for use in numerical modeling. He also mentioned the need for accurate sea surface temperature and ocean heat content information for use in tropical cyclone modeling and intensity forecasting. Lastly, he mentioned the importance of sea surface height measurements and bathymetry data for use in storm surge modeling and validation of storm surge forecasting for the protection of life and property near coastlines. He concluded by showing a table of tropical cyclone observational requirements that was developed at the recent Ninth session of the WMO Technical Coordination Meeting (TCM-9) of the Tropical Cyclone - Regional Specialized Meteorological Centers (TC-RSMCs) and Tropical Cyclone Warning Centers (TCWCs). See ***Annex 5*** for details.

3. WIGOS Framework and outcome of the International Workshop on the Impact of Various Observing Systems on NWP

Presentation was delivered by **Dr Erik Anderssо**n (ECMWF) who recalled that the WIGOS Rolling Requirements Review (RRR) process is managed by the WMO Commission for Basic Systems (CBS) Expert Team on Observing System Design and Evolution (IPET-OSDE). The RRR process helps ensure that the WIGOS meets the requirements of WMO programmes, and evolves according to user needs. Requirements are systematically gathered and stored in OSCAR/Requirements. Gaps with respect to the actual capabilities of WIGOS are analyzed and discussed in "Statements of Guidance" documents. The gap analysis feeds into the Implementation plan towards realizing the Vision for WIGOS in 2040.

Once every four year, the CBS organizes a WMO workshop on the impact of various observing systems on Numerical Weather Prediction (NWP). The seventh workshop in this series will take place in Korea in May 2020. In preparation for this workshop, specific science questions have been formulated to encourage impact assessment of marine observing systems in the context of NWP, longer-range forecasting and climate monitoring.

It was noted that moored buoy observations are very important as they provide many useful parameters (for atmosphere and ocean) and continuous reporting which is important to monitor changes in the ocean conditions, and model development. They are very useful for long term monitoring of the climate. Improved coverage is important. Argo data are important due to their excellent sampling of the ocean (horizontally and vertically). *In situ* observations required for calibration of SST and SCAT winds.

The workshop also noted the importance of the following issues: (i) data availability where observations exist but are not being shared with WMO, (ii) improving data latency to allow their timely assimilation in the models, and (iii) assuring required coverage of ocean observing networks (e.g. tropical moored buoys).

The workshop recognized the importance of Observing System Simulation Experiments (OSSEs) and sensitivity analyses to be used to investigate the importance of data collected within EEZs. The workshop proposed conducting a pilot activity in this regard (***recommendation***).

4. Use of ocean observations (requirements and gaps)

Two presentations were delivered under this item.

First presentation, focusing on "Coastal observations requirements and gaps – satellite, in situ, data access and broadcast; model downscaling; observing system design", was delivered by **Dr John Wilkin**, Professor, Marine and Coastal Sciences, Rutgers University, USA, and co-Chair of the Physics and Climate Panel (OOPC) of the Global Ocean Observing System (GOOS).

Strong vertical temperature gradients in coastal waters, frequently as much as 15C in less than 30 m on many broad continental shelves, represents a highly variable thermal potential environment that can strongly affect the ocean's response to storms. Improving the local and global prediction of weather and oceanic conditions in coastal waters requires in situ observations throughout the water column into depths beyond the view of space borne instruments. An explosion in new technological capabilities to make such observations using autonomous vehicles and the tagging of large marine fauna is opening up new possibilities for widespread and sustained observing of the coastal ocean. This lecture demonstrated some of these capabilities and the experience of research networks in achieving high density long duration data sets via these methods. While there remain technical challenges to building, operating and funding networks of such sensors, the trajectory toward solving these is positive. Challenges to realizing this potential for operational marine monitoring lie in securing routine access to coastal waters within national EEZ for piloted autonomous vehicles, and in developing robust real-time data streams for data acquired by networks that are operated, increasingly, by entities other than national oceanic or meteorological services; e.g. research programs engaged in systematic sampling for climate time series (but by the nature of these platforms data are delivered in real-time), commercial companies operating fleets of vehicles with data as a service, and animal tagging networks for which physical ocean conditions are secondary to their mission. The JCOMM Open Access to GTS/WIS Pilot Project is one approach to developing these data management systems.

Second presentation, focusing on "the Copernicus Marine Service and its use and priorities for ocean observations and the supported maritime safety applications (JCOMM and MONGOOS)", was delivered by **Dr Giovanni Coppini**, Copernicus Marine Service, Euro-Mediterranean Centre on Climate Change, Italy, and Chair of the JCOMM Expert Team on Marine Environmental Emergency Response (ETMEER).

Dr Coppini briefly introduced the Copernicus Marine Environment Marine Service (CMEMS) consisting of and Operational and scientifically assessed service providing Observations (satellite, in-situ) and models (analyses/forecasts) both for Physics and Biogeochemistry. CMEMS is generic enough to serve a wide range of downstream applications and there are more than 12 000 subscribers.

Dr Coppini presented the essential role of in-situ and satellite upstream observations for CMEMS. CMEMS offer is highly dependent on the satellite and in-situ observing capabilities (validation, assimilation). Dr Coppini presented the importance of the observation impact studies which are performed in CMEMS.

Dr Coppini showed the case studies of the Mediterranean and Black Sea CMEMS analysis and forecasting system presenting their capacity of assimilating the data, assessing the error and showing the importance and impacts of observations for modelling activities.

Dr Coppini introduced to the maritime safety activities carried out by the JCOMM Expert Team on Marine Environmental Emergency Response (ET-MEER) and showed the importance of observations in applications like oil spill and marine pollution.

Finally conclusions were drawn related to the Requirements for the long term evolution of the Copernicus Satellite Component the Requirements – in-situ observations and the need of supporting the development of added value applications such as the ones related to maritime safety (JCOMM; MONGOOS) and improve the knowledge on how uncertainty propagates and perform OSE/OSSE simulations also for the added value products.

More details about Dr Coppini's presentation with requirements for the long term evolution of the Copernicus Satellite Component, requirements for in-situ observations, and general conclusions are provided in ***Annex 3***.

5. Implementation of Ocean Observing Networks and trends with focus on coastal aspects (e.g. innovations, new technology)

Presentation was delivered by **Mr Jon Turton**, UK Metoffice, and vice-chairperson of the JCOMM Observations Coordination Group (OCG).

He outlined the role of the JCOMM Observations Coordination Group (OCG) that works to coordinate and integrate a comprehensive and sustained in-situ global ocean observing system, and the critical role of JCOMMOPS in this. OCG provides guidance for established networks and to 'emerging' networks aspiring to become a JCOMM Observations Programme Area (OPA) network. We rely on multiple networks to collect and deliver the full range of essential variables needed for climate monitoring, operational NWP and ocean forecasting, where delivery in real-time (<1hr) is critical for NWP and near-real-time (<1day) for ocean forecasting. He then introduced the various networks that form the JCOMM OPA and their present status, these being: SOT (not discussed in detail as described by Henry Kleta in the next presentation), Data Buoy Cooperation Panel (DBCP, including the global drifter array noting the new development of wave drifters, and moored buoy networks), sea level (GLOSS), OceanSITES, Argo (noting the Argo2020 vision) and ship-based hydrography (GO-SHIP). In addition sub-surface gliders, animal-borne instruments, high frequency (HF) radar and surface water CO_2 are 'emerging' networks that OCG is engaging and Unmanned Surface Vehicles (USV) is an emerging technology of interest. In summary he noted that the ocean observing system includes meteorological, physical oceanographic and bio-geochemical variables, and serves a wide range of user applications including operational weather and ocean forecasting, climate and ocean science. There is a mix of operational and research funded platforms and networks, with partnerships between NMSs and research institutes internationally within JCOMM, the GOOS RAs (GRAs) and nationally. Specifically for coastal observations moored met buoys, waverider buoys and ship-borne AWS are important, where sub-surface gliders and USV are newer technologies well suited for coastal observations.

6. Ship Observations Team (SOT) implementation and issues

Presentation was delivered by **Mr Henry Kleta**, Deutscher WetterDienst (DWD), Germany, and chair of the JCOMM Voluntary Observing Ship scheme Panel (VOSP). He presented on behalf of the chair of the JCOMM Ship Observations Team (SOT).

Mr Kleta provided information on the implementation status of the networks within the SOT, i.e. the Voluntary Observing Ship scheme (VOS), the Ship of Opportunity Programme (SOOP) and the Automated Shipboard Aerological Programme (ASAP). The acquired variables and the status of the networks in 2018 were displayed together with the amount of data reported (into the Global Telecommunication System –GTS) inside and outside of high seas. He explained about arising issues concerning data acquisition outside high seas.

VOS scheme provides for the following observations:

- Atmospheric pressure (and tendency)
- Sea Surface Temperature
- Air Temperature and rel. Humidity (or Dewpoint)
- Wind (Speed and Direction, relative and true)
- Visual observations:
- Clouds (Cl, Cm, Ch, cover + height)
- Waves (Wind Waves and Swell)
- Visibility
- Weather (past and present)
- Sea Ice
- Phenomena (animals, aurora, corona, rain/fog/cloud-bow, meteorite,…)

The ASAP provides for profiles of the Atmosphere (Radiosondes), including height (as reference derived via pressure or GPS), air temperature and rel. Humidity, and wind (derived from GPS data).

The SOOP Provides for the following observations:

- Surface to depth temperature profiles using eXpendable Bathy-Thermograph (XBTs)
- pCO2, pressure and temperature measurements using flowthrough system
- Sea Surface Temperature, conductivity and salinity observations using Thermosalinographs (TSG)
- Phytoplankton and other bio-geo-chemical observations using pulled probe at variable Depth

The workshop also noted that the SOCONET (flowthrough system, Surface) provides for Sea Surface Temperature, Salinity, Oxygen, CO2, Methane, Chlorophyll, and Turbidity observations.

With regard to relevant regulations, the workshop noted the following:

SOLAS, Chapter V, Regulation 5 – Meteorological Services and warning, has the following clauses:

> In particular, Contracting Governments undertake to carry out, in cooperation, the following meteorological arrangements:
>
> […]
>
> to arrange for a selection of ships to be equipped with tested marine meteorological instruments (such as a barometer, a barograph, a psychrometer, and suitable apparatus for measuring sea temperature) for use in this service, and to take, record and transmit meteorological observations at the main standard times for surface synoptic observations (i.e. at least four times daily, whenever circumstances permit) and to encourage other ships to take, record and transmit observations in a modified form, particularly when in areas where shipping is sparse.

IMO Maritime Safety Committee Circular 1293/Rev. 1 dated 25 May 2018 also encourages participation of ships in the VOS scheme.

WMO Resolution 9 (Cg-19), realizing that, at present, WMO plans and coordinates two types of activities over the ocean (a) Activities of an operational nature and (b) Marine scientific research activities, it urges Members to continue to promote marine meteorological and related oceanographic observational programmes over the ocean, for both operational and research purposes.

The workshop noted the following: Drifting buoys are often deployed from ships for monitoring purposes. Although the drifters are consumable and are not recovered nor refurbished, it is understood that such deployments do not fall under the International Dumping Convention

(London Protocol, where there are explicit exclusions) – there is no issue concerning pollution under international law.

7. Monitoring of Ocean Observing Networks and support for addressing the regional gaps

Presentation was delivered by **Mr Mathieu Belbéoch**, Lead of the JCOMM *in situ* Observations Programme Support Centre (JCOMMOPS).

He started to recall how vast the ocean was, and that the representation of 10 000 observing platform dots on a single map was misleading, providing the impression – due to the size of the dots on the map – that the entire ocean was covered by instruments.

As a general statement on the status of the observing system the workshop noted the unprecedented communication effort required to promote the existing and anticipate benefits of a global and multidisciplinary system.

After a brief presentation of JCOMMOPS infrastructure, Mr Belbéoch introduced the benefits of a good monitoring to optimize network performance, and ensure a transparent implementation.

He insisted on three major gaps including:

i) the need for a clear observing network design with implementation targets,
ii) the logistical challenge to maintain the global network through use of academic, industry, or even NGOs ship time, and
iii) the political challenge to facilitate access to the Exclusive Economic Zones. While a program such as Argo has some guidelines with regard to UNCLOS interpretation (IOC Res. XX-6 and XLI-4) for deployments in high seas, the need to facilitate deployments directly into EEZ remains.

The workshop noted that due to administrative burden and estimated risks of not receiving authorization, some Argo float operators were hesitant to take steps for requesting clearance for deployments of instruments into some EEZs, and for that reason that so some ocean areas remained un-sampled or under-sampled. For the other networks, without specific guidelines, there was a clear apprehension in the implementer community.

Regarding ocean observing network implementation, Mr Belbéoch invited to explore solutions at different levels, through international organizations (IOC and WMO), through direct contacts with political deciders, but also through creative solutions (e.g. buoys donations to UN) and international cooperation.

The warning system for float approaching some Member States EEZ was implemented at JCOMMOPS, and the workshop acknowledged that a similar centralized notification system could be set up for other GOOS/WIGOS components.

Mr Belbéoch outlined the JCOMMOPS medium run strategy with regard to the regional expansion of ocean observing networks, in line with IOC and WMO regional strategies. As a first step, a "Glider/Regional coordinator" is about to be recruited, who will particularly develop and promote a pilot project on the integrated Mediterranean Sea monitoring. The workshop recommended JCOMMOPS to connect to WMO and WIGOS regional strategy. For example, the Regional WIGOS Centres (RWCs) could play a role and assist JCOMMOPS with regard to regional coordination (starting with monitoring/metadata and move toward implementation, data flow issues resolution). The workshop also noted that the GOOS Regional Alliances (GRAs) are active analyzing gaps and requirements and regional capacity. It invited JCOMMOPS to connect more directly with the GRAs for regional assessment.

Presentation was concluded with the following remarks:

- Observing network monitoring is the key to an optimized, integrated and transparent observing system and
- The current law of the sea guidelines were not compatible, in practice, with a sustained GOOS/WIGOS, requiring the deployment of thousands of elements each year, and ideally a fast track and centralized procedure for MSR clearances could help.

Note: Lunch break side event was organized where Mr Belbéoch introduced the JCOMMOPS website to the audience. Through a live demonstration, he explained how one could have a look on the ocean observing systems through different perspectives: international, national, regional, instrumental, etc. He demonstrated in particular how Members and Member States could monitor in real-time the observing systems operating in their Exclusive Economic Zones.

8. Global Atmosphere Watch requirements and the making of atmospheric measurements from ships

Presentation was delivered via teleconference by **Dr Chris Fairall**, Expert on studies of coupled air-sea interaction processes and chief of Weather and Climate Physics Branch, in Earth Systems Research Laboratory, Physical Science Division of NOAA.

He reported on several aspects about meteorological, radiative flux, and aerosols observations made from ships. The content follows from ongoing PSD work research air-sea interaction and improving the ocean observing system. He considered so-called bulk meteorological variable (wind speed, SST, air temperature, and relative humidity) needed to compute estimates of turbulent fluxes. He explained that radiative fluxes are straightforwardly measured with commercial radiometers (pyranometer for solar and pyrgeometer for IR), with due consideration given to placement and stabilization. Aerosol observations are principally done in research programs but some important variables (total optical depth, optically relevant size spectra) are feasible for unattended operation. Accuracy and some practical issues (sensor placement, contamination) are also discussed.

PANEL DISCUSSION, SESSION 2

Panelists:

- **Panel Chair: Mr Stefan Klink**, Deutscher Wetterdienst (DWD), and vice-Chair of the Inter Programme Expert Team on Observing System Design and Evolution (IPET-OSDE) of the WMO Commission for Basic Systems /CBS)
- **Dr Karina von Schuckmann**, Oceanographer at Mercator Ocean, France, Copernicus Marine Services
- **Dr John Wilkin**, Professor, Marine and Coastal Sciences, Rutgers University, USA, and co-Chair of the Physics and Climate Panel (OOPC) of the Global Ocean Observing System (GOOS)
- **Mr Nick Ashton**, UK Metoffice, and vice-Chair of the Services Coordination Group (SCG) of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM)
- **Mr Jon Turton**, UK Metoffice, and vice-Chair of the Observations Coordination Group (OCG) of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM)
- **Mr Henry Kelta**, Deutscher Wetterdienst (DWD), Germany, and chair of the Voluntary Observing Ship scheme Panel (VOSP) of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM)

Questions for Panel Discussion, Session 2:

The Panel, interacting with the workshop addressed the following questions, with following outcome:

1. **What are the most critical applications areas requiring marine meteorological and oceanographic observations to allow WMO to address its mandate to protect life and property, in particular in coastal regions ?**

The safety and wellbeing of people throughout the world and the economic benefits to all nations are at the centre of the WMO mandate and action. To address meteorological hazards, strengthen resilience in the face of climate change and variability, and build the scientific knowledge base for sustainable development, sustained oceanographic and marine meteorological (ocean/met.), observations and their free and unrestricted exchange are critical.

While the oceans cover more than 70% of the Earth surface, the natural system is fully coupled between the atmosphere and ocean and the delivery of effective and improved marine and weather services depends on both atmospheric and oceanic information. The growth of seamless forecasting systems means that meteorological services need an increasing amount of quality information about the ocean and the atmosphere above the ocean surface in order to be able to deliver the weather, marine and climate services derived from the use of such prediction systems. Ocean and marine-focused services particularly need both ocean and atmospheric information.

Numerical Weather Prediction (NWP) is regarded as foundational Application Area for WMO, since many other Applications Areas depend on it. NWP is increasingly relying on marine meteorological and oceanographic observations, including because of the coupling of atmospheric and ocean models.

Marine Services including maritime safety and support to maritime transportation and pollution prevention and mitigation is critical when it comes to protecting life and property at sea and in coastal regions. Table 1 below summarizes the types of services covered under Marine Services.

Requirements	***Products and services***
Maritime distress *Reduce risks of pollution* *Emergency response to pollution* *Search and rescue operations* *Fleet management & ship routing planning*	*Warnings, bulletins* *Maritime Safety Information* *Forecasts of* o *Weather (tropical cyclones, storms, wind, precipitation, temperature, snow & frost),* o *Sea-state (waves, currents)* o *Sea-ice &. Icebergs* *Climate outlook information (future)* *Climatological information (history)*
Coastal Inundation[3] *Costal erosion and management*	

Table 1: Examples of products and services for Marine Services.

Other critical Applications areas depending on ocean observations include the following ones:

- High impact weather, storm surges in particular linked to Tropical Cyclone prediction, and coastal inundation.
- Climate monitoring under the Global Climate Observing System (GCOS);
- Sub-seasonal to longer range prediction,
- Climate modelling,

[3] e.g. Inform port and harbor authorities when inundation may cease so that they can decide on when to resume normal operations

- Climate impact analysis and climate services, and particularly Coastal adaptation. Wave models and wave climatology are important for such applications.
- Global Atmosphere Watch (GAW);
- Ocean Acidification: biogeochemistry and ecosystems, to inform ocean health and ocean acidification.

2. What are the most critically needed atmospheric, marine meteorological and ocean observations variables to address the needs of these applications ?

As part of the Rolling Review of Requirements, the Global and High Resolution NWP Statements of Guidance have identified the following critical atmospheric variables that are not adequately measured by current or planned systems are (in order of priority):

Global NWP[4]:

- Wind profiles at all levels outside the main populated areas, particularly in the tropics and in the stratosphere;
- Temperature and humidity profiles of adequate vertical resolution in cloudy areas, particularly over the poles and sparsely populated land areas;
- Satellite based rainfall estimates;
- Snow equivalent water content.

High Resolution NWP[5]:

- Wind profiles at all levels;
- Temperature and humidity profiles of adequate vertical resolution in cloudy and rainy areas;
- Precipitation;
- Snow equivalent water content;
- Soil moisture.

All variables above can be taken above the ocean.

Statement of Guidance for High Resolution NWP, also recommends that focus should particularly be made on boundary layer observations, as this is where the NWP vertical resolution is highest and so the vertical resolution gap (especially compared to satellite data) is largest.

Statement of Guidance for Ocean Applications[6] (including marine services) lists the following variables that can be observed over the ocean as important:

- Sea Surface temperature (Ships and moored and drifting buoys provide in situ observations with acceptable accuracy, but coverage and frequency are poor or marginal over large areas of the Earth)
- Ocean wind stress
- Sub-surface temperature
- Salinity
- Ocean Topography
- Surface heat, radiative and freshwater fluxes
- Ocean current data
- Sea ice
- Deep sea observations
- Aerosol and greenhouse gases
- Solar irradiance

The workshop noted that for providing Maritime Safety Information, the following variables are particularly critical: visibility and fog. Prediction of such variable also relies on other types of observations.

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[4] https://www.wmo.int/pages/prog/www/OSY/SOG/SoG-Global-NWP.pdf
[5] https://www.wmo.int/pages/prog/www/OSY/SOG/SoG-HighRes-NWP.pdf
[6] https://www.wmo.int/pages/prog/www/OSY/SOG/SoG-SSLP.pdf

Storm surges and coastal inundation prediction rely on altimetry, good elevation data, and tide gauges for verification.

Wave models rely on good winds, which are provided by Satellites. Direct observations of directional wave data is lacking, in particular to validate models. Model downscaling makes observational user requirements more stringent.

Requirements for Tropical Cyclone forecasting, including table of required critical variables, are provided in ***Annex 5***.

Climate services and particularly coastal adaptation rely on the use of wave and sea state data, sea level.

GOOS has worked on defining Essential Ocean Variables (EOVs, and related derived variables), with related requirements for observations (see GOOS Strategic Mapping[7]). Summary is provided in Table 2 below.

PHYSICS	BIOGEO-CHEMISTRY	BIOLOGY AND ECOSYSTEMS
Sea state	Oxygen	Phytoplankton biomass and diversity
Ocean surface stress	Nutrients	Zooplankton biomass and diversity
Sea ice	Inorganic carbon	Fish abundance and distribution
Sea surface height	Transient tracers	Marine turtles, birds, mammals abundance and distribution
Sea surface temperature	Particulate matter	Hard coral cover and composition
Subsurface temperature	Nitrous oxide	Seagrass cover and composition
Surface currents	Stable carbon isotopes	Macroalgal canopy cover and composition
Subsurface currents	Dissolved organic carbon	Mangrove cover and composition
Sea surface salinity	Ocean colour	Ocean Sound
Subsurface salinity		Microbe biomass and diversity (*emerging)
Ocean surface heat flux		Benthic invertebrate abundance and distribution (*emerging)

Table 2: Summary of Essential Ocean Variables (click on link for details)

3. What are the most critical observational gaps in coastal areas to address the needs of these applications ?

The Workshop noted that gaps can be of the following nature: (i) geographic gaps, (ii) latency of data reaching data assimilation schemes, and (iii) observations taken but not exchanged. It is the purpose of the WMO Rolling Review of Requirements to address such gaps, and resulting

[7] http://www.goosocean.org/index.php?option=com_content&view=article&id=120&Itemid=277

recommended actions are reflected in the Implementation Plan for the Evolution of Global Observing System (EGOS-IP[8]).

The workshop also identified that observations of a number of marine meteorological variables, including from within exclusive economic zones, are used operationally by WMO Applications and are most critical for those Applications, in particular to allow WMO to deliver the services in support of the safety of navigation and the protection of life and property in coastal and offshore areas. Such observations include for example:

- Sea level pressure,
- Surface wind speed and direction,
- Surface air temperature,
- Surface relative humidity,
- Precipitation at the surface,
- Sea surface temperature,
- Sea surface salinity,
- Sea surface currents,
- Directional and non-directional wave observations,
- Visibility,
- Sea-ice,
- Ice accretion,
- Sub-surface temperature and salinity,
- Sea level,
- Atmospheric composition,
- Atmospheric temperature, humidity and wind profiles,
- All other ocean surface and atmospheric observations that are needed to derive fluxes between the ocean and the atmosphere.

Other identified gaps are listed below:

- Wave rider buoys exist, especially in developed Countries: addressing long term changes has been a motivation for collecting such data, in particular to validate wave and storm surge models. Offshore moored buoys can provide warnings. In future wave drifters will be providing significant wave height data at the global level.
- Typical gaps exist in the in mid Atlantic. There are also gaps in the Arctic where the Year of Polar Prediction (YOPP[9]) Project has demonstrated the impact of observations.
- Issue of data availability where observations are taken but not available remains an issue to be addressed.
- In some remote areas, and particularly in the oceans, satellite data telecommunication is used, and can be costly. Through the Satcom Forum[10], WMO is looking at assessing capabilities of Satcom systems, and promoting Satcom for Developing Countries.
- Bathymetry is important for Tropical Cyclone prediction (see also ***Annex 5***).

4. What are the main obstacles when it comes to filling these gaps ?

The workshop identified the following obstacles when it comes to filling the gaps:

- For some types of VOS measurements such as visibility and waves, these are typically made manually and require an observer on-board the ship. Automatic Weather Stations

[8] http://www.wmo.int/pages/prog/www/OSY/gos-vision.html#egos-ip

[9] https://www.polarprediction.net/

[10] https://wiswiki.wmo.int/tiki-index.php?page=SATCOM

(AWS) installed onboard ships allow for more dated to be collected thanks to higher temporal resolution data although for less number of variables.
- There are areas where there are no ship sailing, and the volatility of ship recruitment due to ships changing route or owner is an issue.
- Sometimes, there are administrative and political obstacles to the making of marine meteorological and oceanographic observations, incl. for ship recruitment. These can be driven by economical (e.g. exploitation of natural resources), or national security concerns. In other cases, the official process to get permission to take data in EEZ is not always practicable as it is lengthy and authorization may come the day before the cruise or not at all. When an observing network is operational, official process to seek authorization can be cumbersome and may not always be suitable for routine/monitoring activities.
- With the development of new networks, such the glider network, there are arising needs for fleet management whereby the necessary workforce capability is not entirely funded.
- Low or poor level of communication with policy makers, sometimes reduces reference of observational needs in relevant policy documents. It was noted that the UN Oceans initiative can help in this regard, e.g. by making sure that ocean observations are mentioned in the sustainable Development Goals (SDGs).
- It is difficult to fund observing systems in Developing Countries, and Capacity Development efforts are needed.
- Not all observations that are made, in particular by the maritime industry and the private sector are made available to WMO. Public Private Engagement is important from that perspective.

SESSION 3 (LEGAL REGIME AND PRACTICE)

THE INTERNATIONAL REGIME AND THE PRACTICE FOR THE COLLECTION OF SHIP-BASED OBSERVATIONS AND OTHER TYPE OF MOBILE MARINE METEOROLOGICAL PLATFORM DATA IN COASTAL AREAS AND THE ROLE OF WMO

Session 3 was chaired by **Prof. Tullio Scovazzi**, Professor of International Law, University of Milano-Bicocca, Milan.

1. Review of considerations on the legal status of routine meteorological observations and data collection from voluntary observing ships (VOS) in exclusive economic zones

Presentation was delivered by **Dr Stefano Belfiore**, Executive Assistant to the WMO Secretary-General Cabinet and External Relations Department. He reviewed the position of WMO governing bodies since 1979 on the possible influence of provisions of Part XIII of the United Nations Convention on the Law of the Sea concerning marine scientific research on the routine meteorological and oceanographic observations taken at sea, in particular those collected through the Voluntary Observing Ships Scheme. He recalled that the Chairperson of the Third Committee of the Third United Nations Conference on the Law of the Sea (1973-1982) expressed to WMO Secretary-General the opinion, not objected during the negotiations, that those provisions would not create any difficulties and obstacles hindering adequate meteorological coverage from the ocean areas including areas within the exclusive economic zone carried out both in the framework of existing international programmes and by all vessels since such activities had already been recognized as routine observation and data collecting which was not covered by Part XIII and that they were in the common interest of all countries and had undoubted universal significance.

2. Operational activities and marine scientific research under UNCLOS

Presentation was delivered by **Ms. Alice Hicuburundi**, Senior Legal Officer, Division for Ocean Affairs and the Law of the Sea, Office of Legal Affairs, United Nations.

The presentation focused on the legal regime for the conduct of marine scientific research under the 1982 United Nations Convention on the Law of the Sea.

In her introduction, the presenter highlighted the importance of marine science and its supporting technologies, which through improving knowledge and applying it to management and decision-making, can make a major contribution to eliminating poverty; ensuring food security; supporting human economic activity; conserving the world's marine environment; helping to predict, mitigate the effects of and respond to natural events and disasters; and generally promoting the use of the oceans and their resources for the objective of sustainable development.

Noting that operational meteorology and or "marine meteorological observations" or even "operational oceanography" are terms that are not included in UNCLOS, the presenter highlighted that Part XIII of UNCLOS on the conduct of marine scientific research lays down a comprehensive global regime under which States are required to promote and cooperate in the undertaking of marine scientific research and reflect a balance between rights and interests of coastal and other States.

The presentation ended with some food for thoughts suggesting that the general principles applicable to marine scientific research may provide guidance on how to address issues that may arise with regard to the conduct of meteorological observations.

Following her presentation and related discussion, Mr Elie Jarmache proposed as possible way forward, giving consideration to the convening of an advisory body composed of States representatives with expertise in the law of the sea, modelled on the IOC ABELOS, and with a mandate to develop guidelines concerning operational marine meteorological measurements such as under the VOS scheme, in the same manner as was done for the Argo Guidelines.

Further details about Ms Hicuburundi's presentation are provided in ***Annex 8***.

3. Open legal questions on operational meteorological observations in marine waters within national jurisdiction

Presentation was delivered by **Prof Tullio Scovazzi**.

He recalled that the main legal question addressed by the Workshop is whether operational meteorological observations in the exclusive economic zone fall under the regime of marine scientific research, as set forth in the UNCLOS. This can be considered as a question of interpretation of the words "marine scientific research", which are not defined in the UNCLOS. Two meanings are admissible, one broader and one stricter.

After having considered the rules on treaty interpretation (Arts. 31 and 32 of the Vienna Convention on the Law of Treaties), he explained that the conclusion can be reached that operational meteorological observations in the exclusive economic zone do not fall under the regime of marine scientific research. This conclusion is consistent with the ordinary meaning of the word "research", the UNCLOS preparatory work, the subsequent practice in the UNCLOS application, and other relevant rules of international law applicable in the relations between UNCLOS parties, in particular the SOLAS Convention and the Climate Change instruments.

Summary of Prof. Scovazzi's presentation is provided in ***Annex 4***.

4. Polar code requirements

Presentation was delivered by **Mr David Jackson**, Former Director of the Canadian Ice Service, and representative of the International Ice-Charting Working Group (IICWG).

Mr Jackson explained that the International code for ships operating in Polar waters, commonly called "The Polar Code) (PC), centered into force on January 1, 2018. It is to be adopted as national legislation by each individual country. The PC is also promulgated through amendments to SOLAS and MARPOL. It specifies certain requirements of ships such as the application of a certificate identifying the ice regime in which it is allowed to operate, the development of a POLAR WATERS OPERATIONS MANUAL. As well, each chapter covers other requirements such as, inter-alia, ship construction, communications requirements, stability and water tight integrity as well as fire and safety protection and lifesaving equipment. In order to collect information and distribute its meteorological products, the WMO relies on a number of methods, including satellites. It behoves the WMO to ensure it maintains the continuum of data availability, data evaluation, data continuity and data innovation. By paying attention to the challenges of polar operations as well as its clients' needs, not to say its own, there are a number of steps the WMO can take to ensure it supplies the correct information in the correct user preferred formats that will satisfy the requirements of the PC and the needs of mariners operating in ice-infested polar waters.

The ensuing discussion underlined that polar regions are data sparse (atmosphere, ice, ocean) and recommended to ensure that ships can implement the Polar Code using WMO products. It was also recommended to make use of the Arctic Shipping Best Practices Forum[11].

5. Ocean Observing in Exclusive Economic Zones - IOC Work in coordination with GOOS, JCOMM OCG and WMO

Presentation was delivered by **Ms Emma Heslop**, Intergovernmental Oceanographic Commission (IOC) of UNESCO, and Programme Specialist for the Global Ocean Observing System (GOOS) and the JCOMM Observations Coordination Group (OCG).

A number of legal uncertainties are linked to ocean observing the Exclusive Economic Zones (EEZs) of coastal states, provision was made within UNCLOS for the conduct of « marine scientific research » for peaceful purposes, however there was no definition marine scientific research or which measurements fall under this scope. IOC has a 20 years history of work in developing a cooperative framework for the sharing of ocean data in EEZs. Through the work of IOC/ABE-LOS (Advisory Body of Experts on the Law Of the Sea) a global mechanism, working within the existing legal frameworks, was agreed at IOC (IOC Resolution EC-XLI.4 - 2008) to enable bi-lateral notification of Argo programme floats that drift into coastal states EEZs. The IOC member States recently passed a resolution to extended this Argo Notification Scheme to include six new biogeochemical variables (Decision IOC/EC-LI/4.8 - 2018). Several JCOMM Observations Coordination Group (OCG) 'global' networks have experienced difficulties when conducting their activities in countries EEZs, from deployment of instruments (like floats, buoys or gliders) to sampling. These difficulties were also brought to the Global Ocean Observing System (GOOS) Steering Committee and a joint JCOMM OCG/GOOS Project was created to address these issues. As a first step a survey was undertaken of the OCG 'global' and 'emerging' networks to help assess the ocean observing community needs. The results of the survey highlighted the several key benefits of measuring within the EEZ, from weather forecasting to climate change assessment and monitoring, and the sustainable use of natural resources. The respondents also related their experiences regarding clearance requests which indicated that it was impractical for most sustained ocean observing applications, and impossible for some. One early conclusion is that IOC/WMO could do more to promote making the clearance process more consistent, easier and shorter, for sustained observations – EEZ clearance best practice - or find a mechanism that processes requests more efficiently, whilst respecting legal frameworks and sovereignty. The survey also allowed to highlight the network's priority variables as well some possible solutions. The GOOS and JCOMM OCG community, with support from WMO particularly in expressing value of observations to weather, hazard warnings and climate, will continue and consider with IOC potential practical solution spaces that could exist within the existing legal framework to support ocean observing within EEZs–this will be reported to the IOC Assembly in 2019.

6. National experience regarding current regime

Presentation was delivered by **Mr Henry Kleta,** Deutscher Wetterdienst (DWD), Germany, chair of the Voluntary Observing Ship scheme Panel (VOSP) of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM), and Chair of the VOS Expert Team in E-SURFMAR (the surface marine observation programme of EUMETNET).

He reported on behalf of the Deutscher Wetterdienst (DWD) and the E-SURFMAR on the experience regarding the current regime concerning data acquisition outside high seas. Part of the report was dedicated to actual questions that arose during the last years while operating stations and platform on the world oceans.

The ensuing **discussion** focused on the need to provide a reasonable interpretation of UNCLOS to create more favorable conditions for operational oceanography and MSR; in particular:

- Identify some useful elements to be included in Draft Resolution of the World Meteorological Congress that can be recognized/endorsed by the annual omnibus Resolution on Oceans and the Law of the Sea adopted by the UN General Assembly;

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[11] https://www.pame.is/index.php/projects/arctic-marine-shipping/the-arctic-shipping-best-practices-information-forum

- Leverage the support already provided by GOOS to deliver operational services to ocean health and climate services, focusing on socioeconomic benefits and consultations with Members/Member States (e.g. Ocean Dialogue at Congress).
- Adapt to changes in shipping: with the routes changing on average every 2 years compared to 10 years in the past.
- Explore evolutionary practical guidelines for UAVs in conformity with UNCLOS.
- Recognize that most of operational oceanography and MSR is carried out by the research communities rather than by NMHSs.
- Decouple essential purpose from the technology used to address this purpose
- Make use of awareness raising opportunities, such as the UN Decade of Ocean Science, for advancing the agenda, including dedicated events for specific constituencies (e.g. Ocean Dialogue at Congress).

PANEL DISCUSSION, SESSION 3

Panelists:

- **Prof. Tullio Scovazzi** (Italy), panel chair
- **Dr Emma Heslop** (IOC)
- **Ms Alice Hicuburundi** (DOALOS)
- **Prof. Fred Soons** (Netherlands)
- **Mr Elie Jarmache** (France)
- **Mr David Jackson** (Canada, IICWG)

Questions for Panel discussion:

The Panel, interacting with the workshop addressed the following questions:

1. What is the regime for operational activities, such as meteorological observations, under the Law of the Sea Convention? How can "operational" activities be distinguished from "marine scientific research"?
2. A country such as the USA has clearly identified the collection of marine meteorological data and other routine ocean observations - used for monitoring and forecasting of ocean state, natural hazard warnings and weather forecasts, and climate prediction - not to be marine scientific research. What is the position of other countries?
3. What principles can be used to facilitate the conduct of operational meteorological observations at sea (not aimed to the exploitation of marine resources) with the necessary freedom and timeliness to serve the purpose of the protection of life and property?
4. The Convention for the Safety of Life at Sea (Chapter 5, Safety of Navigation; Regulation 5, Meteorological services and warnings) requests Contracting Governments undertake to encourage the collection of meteorological data by ships at sea and to arrange for their examination, dissemination and exchange in the manner most suitable for the purpose of aiding navigation (this data includes atmospheric pressure, wind, air temperature, sea surface temperature, wave height and sea ice extent). What is the legal regime of such observations on surface compared to those in the water column?
5. Based on the legal regime and the established practice of States, as well as the opinion formulated by the President of the Third Committee of UNCLOS III, what can be inferred about the legal status of routine meteorological observations at sea, including in exclusive economic zones?

Prof. Soons underlined the importance for legal experts and lawyers to be aware of the scientific and technological aspects of operational and research activities. In the last 45 years, MSR saw tremendous changes due to technological developments, in particular the use of

Unmanned Autonomous Vehicles (UAVs); therefore, the law should change and adapt to reflect those developments.

He recalled that the VOS Scheme is participated in by both merchant ships and research vessels. Those vessels collect multiple types of data for different purposes, some of which are for operational purposes and not for MSR. However, the concerns of coastal states on the possible utilization of data should be addressed; hence the request by the Permanent Representative of Germany to the Secretary-General of WMO to clarify the legal status of VOS and other meteorological observations taken in the EEZ.

The very concept of operational oceanography was introduced by the USA some 15 years ago to distinguish it from MSR, pointing to the routine collection of ocean variables transmitted in real time and publicly available, although there remains lack of clarity about the use of data. This notion was advocated also by other States (UK, Netherlands, Belgium and others), although yet other were of a different opinion (Argentina, India, Morocco, Egypt). The notion of operational oceanography will remain vague until there is a generally agreed definition.

It is generally understood that the collection of meteorological data under VOS are not MSR, but it is not clear if this applies to other data collection schemes. Within IOC/ABE-LOS there was no agreement on the approach and the Argo Guidelines do not clarify the notion of operational oceanography in relation to Part XIII UNCLOS. However, the practice shows gradual acceptance of some operations through practical arrangements, without formal discussions and changes to the legal regime.

As the procedures of UNCLOS – with 6-month advance request for permits – are outdated, the question arises about the applicability or non-applicability of Part XIII in relation to operational oceanography. An implementing agreement to UNCLOS would in principle appear the right solution were it not that formal negotiations may not deliver the right outcome. For this reason, it would be wise to continue and expand the practice.

The first step to achieve this is understanding what to achieve, then clarifying the procedures to achieve it. In this regard, the JCOMM/GOOS survey on the EEZ issue provided a useful contribution. In addition, there must be a political risk assessment. If the Parties to UNCLOS and the USA were willing to find a solution, then it would be worthwhile to proceed with an intergovernmental discussion involving lawyers, policy-makers, diplomats, scientists.

IOC ABE-LOS worked on three issues: (a) transfer of marine technology, (b) procedures for the implementation of art. 247 (Marine scientific research projects undertaken by or under the auspices of international organizations); and (c) Argo. The procedures adopted by IOC for the implementation of art. 247 did not result in a useful outcome; on the other hand, the case of the Argo Guidelines was a more positive compromise: practical arrangements can indeed modify things in a better way than formal agreements, avoiding clashes of principles.

Dr Jarmache noted that Germany adopted a consistent approach in requesting clarifications to both WMO and IOC on aspects related to operational oceanography. From the practice and the discussion, it appears clear that shipmasters can be reassured that VOS activities are not MSR; yet, there is a paradox: UNCLOS provides to definition of MSR, therefore it is not possible to say what activities fall or not under MSR. In this sense, it may be difficult to demonstrate that operational oceanography and observations are not covered by Part XIII of UNCLOS and achieving a formal agreement on this may be politically difficult as the times are not mature yet.

An alternative way to look at the issue would be using the flexibility embedded in UNCLOS and building on already consensus practice as in the case of Argo. Art. 246 (Marine scientific research in the exclusive economic zone and on the continental shelf) establishes that under normal circumstances the coastal states shall grant consent for MSR. On the other hand, art. 247 did not appear to work reasonably.

The operational and scientific communities are mostly from developed countries and appeal to the freedom of science. In conclusion, even existing procedures under UNCLOS (art. 246) may be adequate to achieve results if interpreted in a flexible way. What was achieved by ABE-LOS for Argo is a good practical arrangement that could be replicated.

The **meeting participants** commented on these positions noting the possible use of different approaches to mature internationally the pragmatic recognition of operational oceanography in conformity with UNCLOS:

- Raise awareness of coastal states about the benefits of operational oceanography and share data (example of the Tropical Cyclone Programme)
- Focus the discussion on a critical and acceptable set of meteorological variables rather than on the platforms and related technology, including aspects related to environmental impact assessment
- Associate capacity building for coastal states to data collection activities
- Promote informal consultations on the subject on the occasion of international meetings (e.g. Informal Consultative Process on the Law of the Sea)
- Involve NGOs in the process to communicate issues, including explaining benefits of data collection for resource conservation
- Establish agreements on the use of UAVs with the shipping industry (large vessels) and with the support of IMO
- Use strategically the provisions of UNCLOS avoiding the introduction of new terminology; in this sense, MSR could be defined as "research and data collection involving operational oceanography and shipborne observation and using many other modern tools"
- Strengthen the contribution of WMO to the Polar Code, including regarding the collection of meteorological data

The Session **Chair** summarized the discussion concluding that there could be a possibility to proceed with guidelines within WMO and the involvement of other UN and international organizations (IOC, IMO, IHO, IPCC), avoiding clash of principles on whether activities apply to MSR or other areas.

He then illustrated key elements for a Draft Resolution to be submitted to the eighteenth World Meteorological Congress. The workshop reviewed these elements and concurred with it with some additions. Draft proposed Congress Resolution on *Ensuring Adequate Marine Meteorological and Oceanographic Observations and Data Coverage for the Safety of Navigation and the Protection of Life and Property in Coastal and Offshore Areas* was drafted accordingly and is provided in ***Annex 6***.

SESSION 4 (CONCLUSION)

WAY FORWARD AND RECOMMENDATIONS OF THE WORKSHOP

Session 4 was chaired by **Mr Johan Stander**, South Africa Weather Service, and co-president of JCOMM.

Engaging shipping and other ocean industries in ocean observations

Presentation was delivered by **Mr Paul Holthus**, founding president and CEO of the World Ocean Council (WOC).

He outlined that the global ocean is used by many economic sectors, including: shipping, fishing, offshore oil and gas, seabed mining, offshore wind energy, cruise tourism, submarine cables. The WOC is an International, cross-sectoral business leadership alliance with 75+ members and a global network of 35,000 ocean industry stakeholders. The goal of the WOC - as the Global "Blue Economy" Business Organization - is a healthy, productive global ocean and its sustainable use and stewardship by responsible ocean business community.

Major cross cutting framework areas of WOC include work on Sustainable Development Goals (SDGs), especially Improving Ocean Knowledge (SDG 14.a), and an Ocean Investment

Platform. The theme areas of WOC include the SMART Ocean - SMART Industries program which is working to scale up the collection and sharing of data from industry vessels/platforms of opportunity, e.g. through the installation of sensors or deploying of instruments.

Through the SMART Ocean - SMART Industries program, the WOC engages scientific institutions and organizations to identify, priority data collection needs, areas, and parameters, and appropriate cost-effective technology. WOC identifies and recruits companies with vessels/platforms operating in the priority areas which are interested and capable of hosting or deploying instruments. It also instigates supports and facilitates working relationship between the companies and scientific institutions. WOC ensures industry data collection efforts are efficient, cost effective and contribute to national and international public science programs.

The WOC 7th Sustainable Ocean Summit (SOS) will take place from 20 to 22 November 2019 in Paris, France.

The Workshop welcomed the steps taken by WOC and WMO to sign Memorandum of Understanding (MoU), in particular in the context of WMO's Public Private Engagement, and the draft WMO Strategic Plan 2020-2023. The workshop agreed that future collaboration between WMO and WOC under the MoU will offer opportunities to enhance mutual benefits and better demonstrate the value of the services delivered by WMO Members to the maritime industry as well as facilitate the provision of more observational data the industry to WMO.

In order to achieve tangible collaboration, the workshop agreed that a plot project with specific focus e.g. on European shipping companies with roadmap could be initiated.

The workshop also invited WOC to engage with EMODNET with regard to uploading data collected by WOC members in to the EMODNET data portal.

The workshop invited WOC to make contact with the Chairs of the JCOMM Observations Coordination Group (OCG), and the Ship Observations Team (SOT), and consider participating at their respective meetings this year.

PANEL DISCUSSION, SESSION 4

Panelists:

- **Mr Johan Stander** (JCOMM co-President, South Africa), panel chair
- **Mr Stefan Klink** (DWD), chair session 2 panel
- **Prof. Tullio Scovazzi** (Italy), chair session 3 panel
- **Dr Emma Heslop** (IOC)
- **Dr Karina von Schuckmann** (Copernicus Marine Service), on behalf of chair Session 1 panel
- **Mr Jon Turton** (JCOMM OCG, UK)
- **Mr Paul Holthus** (World Ocean Council - WOC)

The Panel addressed the short term and longer term approaches to facilitate the making of ocean observations in coastal regions.

In doing so, the Panel consolidated the views of the workshop during previous Sessions discussions, and identified a number of principles and technical elements to be brought to WMO Congress.

The workshop noted the following:

- The importance of observations for applications was highlighted, and Global and High Resolution NWP underpins most other WMO Application Areas. The workshop also concurred with the importance of observations for Nowcasting and very short range forecasting, and the need to collect higher frequency observations. For example, it was recommended that data buoys ought to be reporting sub-hourly data. WIGOS and its future Global Basic Observing Network (GBON) will also provide a mechanism to address the gaps.
- The legal framework (UNCLOS) cannot realistically be amended, but this is not an insurmountable obstacle if there is political will to improve things. We can have approach that is consistent with UNCLOS, e.g. drafting guidelines avoiding addressing the principles, but addressing common concerns such as safety at sea and climate change. Coastal states need to be involved as they are primary concerned. communication is also important.
- Future collaboration with IOC: The issues discussed during the workshop, and particularly MSR, operational oceanography, communication and legal aspects, are complex, and IOC is willing to collaborate with WMO partner. WMO will play a key role in understanding the benefits in these areas. The Workshop has been useful to create relationship between WMO and IOC on such matters. Step by step process is now needed, as IOC will have to consult with its Member States, to create political will and to move forward for addressing IOC and WMO common requirements.
- Integrating data for climate services: while there is the need to assure sustainability of observing system to deliver short term data, services are key elements of the value chain and should also be sustained. It will require establishing partnerships with policy science, the private sector, and the academic community. The existing framework will have to be extended, not only for climate, marine services, maritime security, but also to other application areas such as ocean health. Mapping of related requirements with ECVs, EOVs will be useful.

CONCLUSION:

Johan Stander (South Africa) summarized the outcome of the workshop as follows:

- The Workshop highlighted the relevance of WMO activities and applications to address socio-economic benefits, incl. in support of safeguarding life and property at sea as outlined in Session 1;
- Key elements for a draft Congress Resolution with Critical variables and observations gaps was agreed upon and recommended, and corresponding draft Resolution on Ensuring Adequate Marine Meteorological and Oceanographic Observations and Data Coverage for the Safety of Navigation and the Protection of Life and Property in Coastal and Offshore Areas was drafted (see ***Annex 6***);
- For data to have full benefit (e.g. for hazards, cyclones etc.), the Workshop recommended to have broader use of ocean data, e.g. using JCOMM Ocean Open GTS project, in particular those produced by the research community, shared in real-time using fit for purpose format and fir for purpose interoperability with WMO Information System (WIS) and other relevant data systems;
- The workshop promoted partnership with the private sector to integrate data from them for delivery of Earth system approaches/climate services, and proposed initiating a pilot project with the World Ocean Council (WOC);
- The workshop agreed on way forward for future collaboration between WMO and IOC regarding facilitating the making of oceanographic observations in coastal regions in support of Earth System Prediction and climate services, and proposed draft congress Resolution in this regard (see ***Annex 7***);

- The workshop helped clarifying the legal framework, in the view to facilitate the making of observations in coastal regions in support of WMO applications (see ***Annex 3***);
- The workshop recognized the importance of Observing System Simulation Experiments (OSSEs) and sensitivity analyses to be used to investigate the importance of data collected within EEZs. The workshop proposed conducting a pilot activity in this regard.

Before closing the workshop, Assistant Secretary General, **Dr Wenjian Zhang**, delivered a presentation, where he recalled the new draft WMO Strategic Plan 2020-2030 including WMO Vision 2030[12], overarching priorities[13] and long term goals[14]. He then highlighted the following points aligned with WMO strategy for Earth System approach:

- Draft Strategic Plan Long Term Goal 2 calls for an integrated Earth system observational network increasingly automated and optimized to ensure effective global coverage. High quality fit-for-purpose measurements feeding a continuous global data exchange underpinned by data management and data processing mechanisms. Global Earth System observations will provide a basis for meeting the demand for increasing seamless prediction capability from weather to climate scales based on a unified modeling approach;
- Draft Strategic Plan Long Term Goal 3 calls for leveraged global research community resulting in fundamental advances in the understanding of the Earth system, leading to improved policy-relevant advice and predictive skill at all time scales in a seamless context. This will result in the strengthened forecast and warning performance of all Members as research and operations coalesce to apply the best science to all components of the service value chain.
- For an Earth System approach perspective, the Ocean is playing a critical role, as it is one important component of the Earth System interacting with the Atmosphere and the World Climate. WMO is therefore taking steps to engage more strongly with the Ocean community, and the co-sponsored IOC-WMO-UN Environment-ICS Global Ocean Observing System (GOOS). Substantial improvements in 10 day weather forecasts, Tropical Cyclone Prediction, Marine Services, sub-seasonal to longer range prediction, climate monitoring, and climate services can be expected from improved ocean observing system. This will lead to better services provided by WMO in particular in Coastal Regions, and in megacities located near the coasts.

Dr Zhang, closed the workshop by thanking all participants, lecturers, panelists and the organizing committee. He expressed special thanks to the chair of the Organizing Committee, Mr Tom Cuff (NOAA, USA).

The workshop closed at 18:00 on Wednesday 7 February 2019.

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[12] *We envision a world in 2030 where all WMO Members, especially the most vulnerable, are more resilient to the socioeconomic consequences of extreme weather, water, climate and other environmental events; and support their sustainable development through the best possible services, whether over land, at sea or in the air.*

[13] (1) Reducing losses of life and property from hydrometeorological hazards, (2) Supporting climate action to build resilience and adaptation to climate risk, and (3) Enhancing socioeconomic value from hydrometeorological and climate services.

[14] (1) Better serve societal needs: Delivering actionable, authoritative, accessible, user-oriented and fit-for-purpose services, (2) Enhance Earth system observations and predictions: Strengthening the technical foundation for the future, (3) Advance targeted research: Leveraging leadership in science, (4) Close the gap on services: Enhancing and leveraging existing capabilities among all WMO Members to bring capability to all, and (5) Work smarter: Supporting effective policy- and decision-making and implementation in WMO.

ANNEX 1

WORKSHOP PROGRAMME

Tuesday 5 February 2019

9:00 – 9:30	**Opening** – WMO Secretary General (SG), Petteri Taalas **Working Arrangements** – Secretariat **Introduction to session 1** – Sarah Jones (DWD, Germany)
9:30 – 10:30	**Session 1 (socio-economic benefits): Socio-economic benefits of WMO Applications using marine meteorological and oceanographic observations** **Chair:** Sarah Jones (DWD, Germany) **Lectures (10 min each):** • Sustainable Development Goals (SDGs) and the United Nations Decade of Ocean Science for Sustainable Development (2021-2030) – Martin Visbeck (WCRP, GEOMAR, Germany) • Medium to long range forecasting – Erik Andersson (ECMWF) • Copernicus Marine Service: Ocean monitoring and reporting - Karina von Schuckmann (Mercator Ocean) • Coastal application and other marine meteorological services – Nick Ashton (JCOMM, UK) • Severe weather – The Kerala flood example – P.J.Philip (Institute For Sustainable Development and Research, ISDR, India)
10:30 – 11:00	**Break**
11:00 – 12:30	**Panel discussion (90 min) – Panelists:** • Sarah Jones (DWD, Germany), panel chair • Martin Visbeck (WCRP, Germany) • Erik Andersson (ECMWF) • Karina von Schuckmann (Copernicus Marine Service) • Johan Stander (GFCS & JCOMM, South Africa) • John Wilkin (USA, OOPC) **Questions for Panel Discussion:** 1. How SDGs are relevant to protection of life and property at sea ? 2. How critical are WMO Applications to protection of life and property at sea ? 3. How do we make sure that ocean observations contribute through the Global Data Processing and Forecasting System (GDPFS) for earth system monitoring, prediction and delivery of hydro-climate services relevant for sustainable resource management and adaptation to climate change
12.30 – 13.30	**Lunch**
13:30 – 14:00	**Live demonstration of JCOMMOPS tools**

14:00 – 15:30	**Session 2 (data needs and gaps): The need for observations, assessed gaps and the evolving capabilities for the collection and distribution of oceanographic and marine meteorological data in support of WMO Activities related to safety of life and property at sea,** **Chair:** Stefan Klink (CBS IPET-OSDE vice-Chair, DWD, Germany) **Introduction to session 2** – Erik Andersson (ECMWF) (5 min) **Lectures (15 min each):** • How protection of life and property at sea relies on WMO Application Areas (e.g. NWP) and observations - Nick Ashton (JCOMM, UK) (15 min) • Tropical Cyclone forecasting requirements - Daniel Brown (NHC, USA) (15 min) • WIGOS Framework and outcome of the International Workshop on the Impact of Various Observing Systems on NWP – Erik Andersson (ECMWF) (15 min) - Note: the presentation will bring focus on the need for marine meteorological and ocean observations, incl. in polar regions • Use of ocean observations (requirements and gaps) - John Wilkin (OOPC, USA) and Giovanni Coppini (Italy) (15 min) • Implementation of Ocean Observing Networks and trends with focus on coastal aspects (e.g. innovations, new technology) – Jon Turton (JCOMM, UK) (15 min) • Ship Observations Team (SOT) implementation and issues – Henry Kleta (SOT, Germany), Voluntary Observing Ship Scheme (VOS) Panel (VOSP) Chair on behalf of SOT (15 min)
15:30 – 16:00	**Break**
16:00 – 17:30	**Session 2 (continued)** **Lectures (15 min each):** • Monitoring of Ocean Observing Networks and support for addressing the gaps in particular in coastal regions – Mathieu Belbéoch (JCOMMOPS) – 15 min • Global Atmosphere Watch requirements and the making of atmospheric measurements from ships – Chris Fairall (USA) – by teleconference – 15 min **Panel discussion (60 min) – Panelists:** • Stefan Klink (Panel chair, CBS IPET-OSDE vice-Chair, DWD, Germany) • Karina von Schuckmann (Copernicus Marine Service) • John Wilkin (OOPC, USA) • Nick Ashton (JCOMM, UK) • Jon Turton (JCOMM OCG vice-Chair, UK) • Henry Kelta (VOSP Chair, on behalf of SOT, Germany) **Questions for Panel Discussion:** 1. What are the most critical applications areas requiring marine meteorological and oceanographic observations to allow WMO to address its mandate to protect life and property, in particular in coastal regions ? 2. What are the most critically needed atmospheric, marine meteorological and ocean observations variables to address the needs of these applications ? 3. What are the emerging required atmospheric, marine meteorological and ocean observations variables to address the needs of these applications ? 4. What are the most critical observational gaps in coastal areas to address the needs of these applications ? 5. What are the main obstacles when it comes to filling these gaps ?

Wednesday 6 February 2019

9:00 – 10:30	**Recap of day 1 (30 min)** **Session 3 (Legal regime and practice): The international regime and the practice for the collection of Ship-based observations and other type of mobile marine meteorological platform data in coastal areas and the role of WMO** **Chair:** Tullio Scovazzi (Italy) **Introduction to session 3** – Tullio Scovazzi (Italy) **Lectures:** • Review of considerations on the legal status of routine meteorological observations and data collection from voluntary observing ships (VOS) in exclusive economic zones - Stefano Belfiore (WMO) (15 min) • Operational activities and marine scientific research under UNCLOS - Ms. Alice Hicuburundi (Senior Legal Officer, UN/DOALOS) (25 min) • Open legal questions on operational meteorological observations in marine waters within national jurisdiction - Tullio Scovazzi (Italy) (25 min)
10:30 – 11:00	**Break**
11:00 – 12:30	**Session 3 (continued)** **Lectures:** • Polar code requirements - David Jackson (Canada, IICWG) (25 min) • IOC requirements and approach with regard to EEZ issue - Emma Heslop (IOC) (25 min) • National experience regarding current regime – Henry Kleta (Germany) (25 min)
12.30 – 13.30	**Lunch**
13:30 – 15:30	**Panel discussion (120 min) – Panelists:** • Prof. Tullio Scovazzi (Italy), panel chair • Emma Heslop (IOC) • Alice Hicuburundi (DOALOS) • Prof. Fred Soons (Netherlands) • Elie Jarmache (France) • David Jackson (Canada, IICWG) **Questions for Panel discussion:** 1. What is the regime for operational activities, such as meteorological observations, under the Law of the Sea Convention? How can "operational" activities be distinguished from "marine scientific research"? 2. A country such as the USA has clearly identified the collection of marine meteorological data and other routine ocean observations - used for monitoring and forecasting of ocean state, natural hazard warnings and weather forecasts, and climate prediction - not to be marine scientific research. What is the position of other countries? *3.* What principles can be used to facilitate the conduct of operational meteorological observations at sea (not aimed to the exploitation of

<table>
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marine resources) with the necessary freedom and timeliness to serve the purpose of the protection of life and property?
4. The Convention for the Safety of Life at Sea (Chapter 5, Safety of Navigation; Regulation 5, Meteorological services and warnings) requests Contracting Governments undertake to encourage the collection of meteorological data by ships at sea and to arrange for their examination, dissemination and exchange in the manner most suitable for the purpose of aiding navigation (this data includes atmospheric pressure, wind, air temperature, sea surface temperature, wave height and sea ice extent). What is the legal regime of such observations on surface compared to those in the water column?
5. Based on the legal regime and the established practice of States, as well as the opinion formulated by the President of the Third Committee of UNCLOS III, what can be inferred about the legal status of routine meteorological observations at sea, including in exclusive economic zones?
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<tr><td>15:30 – 16:00</td><td>Break</td></tr>
<tr><td>16:00 – 17:30</td><td>
Session 4 (Conclusion): Way forward and recommendations of the workshop
Chair: Johan Stander (JCOMM co-President, South Africa)
Introduction to sessions 4 – Johan Stander (JCOMM co-President, South Africa)
Lectures (15 min each)
• Engaging shipping and other ocean industries in ocean observations (Paul Holthus, World Ocean Council - WOC)
Panel Discussion (30 min) – Panelists:
• Johan Stander (JCOMM co-President, South Africa), panel chair
• Karina von Schuckmann (Copernicus Marine Service), on behalf of chair Session 1
• Stefan Klink (DWD, Germany, chair session 2
• Tullio Scovazzi (Italy), chair session 3
• Emma Heslop (IOC)
• Jon Turton (JCOMM OCG, UK)
• Paul Holthus (World Ocean Council - WOC)
Guidance for Panel Discussion:
The workshop will address the short term and longer term approaches to facilitate the making of ocean observations in coastal regions.

In doing so, panel discussion will seek to consolidate the views of the workshop during previous Sessions discussions, in particular to identify a number of principles and technical elements to be brought to WMO Congress. This may include for examples:

• Relevance of WMO activities and applications to address socio-economic benefits, incl. in support of safeguarding life and property at sea;
• Critical variables and observations gaps;
• Roadmap forward to integrate data from partners for delivery of Earth system approaches/climate services;
• Future collaboration between WMO and IOC regarding facilitating the making of oceanographic observations in coastal regions in support of Earth System Prediction and climate services;
• How legal framework could be clarified, updated in such a way to facilitate the making of observations in coastal regions in support of WMO
</td></tr>
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	applications; etc. **Conclusion (30 min)** – Johan Stander (South Africa) and Wenjian Zhang (WMO Assistant Secretary General): Key principles and technical elements (e.g. list of critical variables to be observed and reported; list of emerging variables increasingly required) for a WMO 18-Cg resolution (or WMO-IOC), which may be transmitted to UN processes (UNGA and/or ICP).

ANNEX 2

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ANNEX 3

DETAILED SUMMARY OF DR GIOVANNI COPPINI'S PRESENTATION ON THE COPERNICUS MARINE ENVIRONMENT SERVICE AND ITS USE AND PRIORITIES FOR OCEAN OBSERVATIONS AND THE SUPPORTED MARITIME SAFETY APPLICATIONS (JCOMM AND MONGOOS).

Dr Coppini briefly introduced the Copernicus Marine Environment Monitoring Service (CMEMS) consisting of and Operational and scientifically assessed service providing Observations (satellite, in-situ) and models (analyses/forecasts) both for Physics and Biogeochemistry. CMEMS today is a network of European producers and deliver a single catalogue (Worldwide and European-wide coverage). CMEMS consists of a central information system to search, view, download products and monitor the system. CMEMS service desk supports users who relies on a network of technical & marine experts. CMEMS is generic enough to serve a wide range of downstream applications and there are more than 12 000 subscribers.

Dr Coppini presented the essential role of in-situ and satellite upstream observations for CMEMS. CMEMS offer is highly dependent on the satellite and in-situ observing capabilities (validation, assimilation). CMEMS has defined its present/future requirements both for in-situ and satellite observations. Service and Service evolution require: 1) continuity and 2) significant improvements of ocean observing capabilities.

CMEMS Thematic Assembly Centers provide remote sensing data on Sea Level, SST, Sea Ice, Ocean Colour, Wave, Wind which are available and essential for users and fro the analysis forecasting systems of CMEMS. Major contribution are from Sentinel missions (S1, S3, Jason-3/S6 and S2) + contributing missions (e.g. Metop, MSG, Alti-Ka, SMOS, Cryosat-2, VIIRS, AMSR-2, etc).

User requirements do not directly translate into observation requirements; there is a need to take into account the added value chain that goes from observations to information and assessment.

Observation impact studies are performed in CMEMS to:

- verify that observation information is « optimally » used in the analysis step and improve the assimilation components
- quantify the impact of the present observation network in ocean analysis and forecasts,
- demonstrate the value of an observation network for operational ocean analysis and forecasts,
- help defining and testing future observing systems from an integrated system perspective involving satellite and in-situ observations and numerical models.

Dr Coppini showed the case studies of the Mediterranean and Black Sea CMEMS analysis and forecasting system presenting their capacity of assimilating the data, assessing the error and showing the importance and impacts of observations for modelling activities.

Dr Coppini introduced to the maritime safety activities carried out by the JCOMM Expert Team on Marine Environmental Emergency Response (ETMEER) and showed the importance of observations in applications like oil spill and marine pollution.

Finally conclusions were presented.

Requirements for the long term evolution of the Copernicus Satellite Component

- Based on user requirements and the evolution of the CMEMS for the next decade, the main CMEMS recommendations for the evolution of the Copernicus Satellite Component are as follows:
- Ensure a continuity of the present capability of the Sentinel missions (S1, S3, S6) (+ S2)
- Develop new capabilities for wide swath altimetry

- Fly a geostationary ocean colour mission over Europe to strongly improve the time resolution of ocean colour observations over European seas.
- Fly a European microwave mission for high spatial resolution ocean surface temperature and sea ice concentration.
- Ensure continuity (with improvements) of the Cryosat-2 mission for sea ice thickness monitoring and sea level monitoring in polar regions.
- R&D actions should be developed, in parallel, to advance our capabilities to observe sea surface salinities and ocean currents (e.g. SKIM) from space.

Requirements – in-situ observations

- Critical sustainability gaps, sampling gaps and major gaps for biogeochemical observations (e.g. carbon, oxygen, nutrients, Chl-a).
- Sustaining the Argo global array, consolidating its regional components and implementing its major extension (Biogeochemical Argo and Deep Argo) are strong priorities to CMEMS.
- Improving EuroGOOS ROOSes (Regional Ocean Observing Systems) and key observing systems such as FerryBoxes, gliders, tide gauges and HF Radars are also strong priorities for regional CMEMS products.
- Mercator Ocean is working with the European Environment Agency and EuroGOOS in the framework of a future European Ocean Observing System (EOOS) to address these gaps and consolidate / improve global and regional in-situ observing systems.

General conclusions

- ARGO assimilation: quality control and programming of floats to be discussed with assimilators. Need to have some ARGO mission to be fixed by MFC
- Assimilation of gliders require major thinning of the data (too frequent in space and time), need to concentrate gliders in Straits with strong currents
- Need major improvement of models with tides, wave mixing and hydrology coupling
- Target in 2023: decrease by 50% the RMSE and bias of upper water T,S and current fields and assimilate waves to improve momentum flux (winds) and currents
- Train the new “data assimilators”, build tools on DA, Research to operation software environments;
- Devise more specific products for intermediate and end users; Keep together and evolve with multiple solutions, intercompare (e.g. GODAE)
- Support the development of added value applications such as the ones related to maritime safety (JCOMM; MONGOOS) and improve the knowledge on how uncertainty propagates and perform OSE/OSSE simulations also for the added value products.

ANNEX 4

OPEN LEGAL QUESTIONS ON OPERATIONAL METEOROLOGICAL OBSERVATIONS IN MARINE WATERS WITHIN NATIONAL JURISDICTION

- We are addressing a question:

Do operational meteorological observations in the exclusive economic zone fall under the regime of marine scientific research, as set forth in the UNCLOS?

- This is a question of interpretation of a treaty, that is to identify one meaning of the words "marine scientific research", where two meanings are admissible, one broader and one stricter.

Vienna Convention on the Law of Treaties

(Vienna, 1969)

Article 31

General rule of interpretation

1. A treaty shall be interpreted in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in their context and in the light of its object and purpose. (…)

3. There shall be taken into account, together with the context: (…)

(*b*) any subsequent practice in the application of the treaty which establishes the agreement of the parties regarding its interpretation;

(*c*) any relevant rules of international law applicable in the relations between the parties.

"The importance of such subsequent practice in the application of the treaty, as an element of interpretation, is obvious; for it constitutes objective evidence of the understanding of the parties as to the meaning of the treaty" (International Law Commission, *Commentary to the Draft Articles on the Law of Treaties*).

Article 32

Supplementary means of interpretation

Recourse may be had to supplementary means of interpretation, including the preparatory work of the treaty and the circumstances of its conclusion, in order to confirm the meaning resulting from the application of article 31, or to determine the meaning when the interpretation according to article 31:

(a) leaves the meaning ambiguous or obscure; (…)

1) Ordinary meaning of the word "research";

2) Preparatory work;

3) Subsequent practice in the application;

4) Any relevant rules of international law applicable in the relations between parties.

1) Research = A detailed study of a subject, especially in order to discover new information or reach a new understanding.

Art. 246 UNCLOS:

a) research which is of direct significance for the exploration and exploitation of natural resources, whether living or non-living; [I do not know if there is oil, start prospecting with air guns] or

b) research carried out to increase scientific knowledge of the marine environment for the benefit of all mankind [nobody knows from where whales found in summer in my exclusive economic zone come and where do they go in their periodical migrations]

[Routine meteorological] observation = To watch more carefully something that I already know. I am not looking for something new, but I am observing a phenomenon that I already know in its existence and range (temperature of water), just to collect data referred to a particular moment and to repeat my collection later.

2) Preparatory work:

a) Resolution 16 (Cg-VIII) of WMO Congress 1979, expressing a concern;

b) Yankov statement of 20 August 1980. He made a statement, clearly expressing the view that "routine observations and data collecting are not covered by Part XIII of the draft UNCLOS. The statement was included in the summary records of III Committee. No State reacted and no State objected.

c) On 25 August 1980 he referred to his statement in the plenary. Again no State reacted and no State objected.

3) Subsequent practice in the UNCLOS application:

a) Letter of 12 August 1994 by which the WMO Secretary-General, in view of the forthcoming UNCLOS entry into force, informed Member States represented at the Commission for Marine Meteorology, that routine marine meteorological and oceanographic observations voluntarily made by ships are indispensable for the provision of services in support of the safety of life and property at sea.

b) Repeated by the WMO Commission for Marine Meteorology in 1997-

c) Recommendation 14 (EC-70) by the WMO Executive Council restating the indispensable character of meteorological and oceanographic observations voluntarily made by ships that cannot be replaced by data collected from satellites.

d) I am not aware of objections.

e) This is confirmed by State legislation: ???

4) Any relevant rules of international law applicable in the relations between parties.

There are a number of instruments that bind States parties to co-operate in the collection and dissemination meteorological and oceanographic observations voluntarily made by ships. They confirm that this activity, which is carried out without any economic interest, is needed to ensure safety of life and property at sea.

International Convention for the Safety of Life at Sea (1974)

"The Contracting Governments,

being desirous of promoting safety of life at sea by establishing in common agreement uniform principles and rules directed thereto, (…)

Regulation 5

Meteorological Services and Warnings

1. Contracting Governments undertake to encourage the collection of meteorological data by ships at sea and to arrange for their examination, dissemination and exchange in the manner most suitable for the purpose of aiding navigation. (…)

2. In particular, Contracting Governments undertake to carry out, in co-operation the following meteorological arrangements:

2.1. to warn ships of gales, storms and tropical cyclones by the use of information in text and, as far as practicable, graphic form, using the appropriate shore-based facilities for terrestrial and space telecommunications services; (…)

2.4. **to arrange for a selection of ships to be equipped with tested marine meteorological instruments (such as a barometer, a barograph, a psychrometer, and suitable apparatus for measuring sea temperature) for use in this service,** and to take, record and transmit meteorological observations at the main standard time for surface synoptic observation (i.e. at least four times daily, whenever circumstances permit) and to encourage other ships to take, record and transmit observations in a modified form, particularly when in areas where shipping is sparse;

2.5. **to encourage companies to involve as many of their ships as practicable in the making and recording of weather observations; these observations to be transmitted using the ships terrestrial or space radiocommunications facilities for the benefit of the various national meteorological services; (…)**".

As early as 1853, the first maritime conference for devising a uniform system of meteorological observation (through uniform and reliable thermometers and barometers) was convened in Brussels. It was attended by the delegates, mostly naval officers, of ten States.

Memorable statement by the American representative, Mr Maury:

"Heretofore, when naval officers of different nations met in such numbers, it was to deliberate at the cannons' mouths upon the most effective means of destroying the human species. To day, on the contrary, we see assembled the delegates of almost every maritime nation, for the noble purpose of serving humanity by seeking to render navigation more and more secure. I think, Gentlemen, we may congratulate ourselves with pride upon the opening of this new æra".

This spirit, which was transmitted to the WMO, established in 1873, must be kept also today.

After the sinking of the "unsinkable" liner *Titanic* (1912) the first SOLAS was concluded in 1914 and the United States established patrol vessels charged to provide ice information at any time at any ship with which the patrol vessels can communicate.

United Nations Framework Convention on Climate Change

(New York, 1992; 197 parties)

"***Noting* that there are many uncertainties in predictions of climate change, particularly with regard to the timing, magnitude and regional patterns thereof, (…)**

***Conscious* of the valuable analytical work being conducted by many States on climate change and of the important contributions of the World Meteorological Organization**, the United Nations Environment Programme and other organs, organizations and bodies of the United Nations system, as well as other international and intergovernmental bodies, to the exchange of results of scientific research and the coordination of research,

***Recognizing* that steps required to understand and address climate change will be environmentally, socially and economically most effective if they are based on relevant scientific, technical and economic considerations and continually re-evaluated in the light of new findings in these areas,**

Article 4

Commitments

1. All Parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall: (…)

(g) **Promote and cooperate in scientific, technological, technical, socio-economic and other research, systematic observation and development of data archives related to the climate system** and intended to further the understanding and to reduce or eliminate the remaining uncertainties regarding the causes, effects, magnitude and timing of climate change and the economic and social consequences of various response strategies; (…)

Article 5

Research and systematic observation

In carrying out their commitments under Article 4, paragraph 1 (g), the Parties shall:

(a) Support and further develop, as appropriate, international and intergovernmental programmes and networks or organizations aimed at defining, conducting, assessing and financing research, data collection and systematic observation, taking into account the need to minimize duplication of effort;

(b) Support international and intergovernmental efforts to strengthen systematic observation and national scientific and technical research capacities and capabilities, particularly in developing countries, and to promote access to, and the exchange of, data and analyses thereof obtained from areas beyond national jurisdiction; (…).

Paris Agreement (Paris, 2015; 184 parties)

Article 7

(…) 7. **Parties should strengthen their cooperation on enhancing action on adaptation, taking into account the Cancun Adaptation Framework, including with regard to: (…)**

(c) Strengthening scientific knowledge on climate, including research, systematic observation of the climate system and early warning systems, in a manner that informs climate services and supports decision-making; (…)

8. United Nations specialized organizations and agencies are encouraged to support the efforts of Parties to implement the actions referred to in paragraph 7 of this Article, taking into account the provisions of paragraph 5 of this Article.

Article 8

1. Parties recognize the importance of averting, minimizing and addressing loss and damage associated with the adverse effects of climate change, including extreme weather events and slow onset events, and the role of sustainable development in reducing the risk of loss and damage.

ANNEX 5

CRITICAL NEED OF MARINE METEOROLOGICAL OBSERVATIONS IN SUPPORT OF THE TROPICAL CYCLONE FORECASTING

1. Background

At the ninth session of the Tropical Cyclone-Regional Specialized Meteorological Centers (TC-RSMCs) and Tropical Cyclone Warning Centers (TCWCs) Technical Coordination Meeting (TCM - 9, Honolulu, Hawaii, USA, 9-12 December 2018), experts discussed about the critical needs of marine meteorological data for the tropical cyclone community. They provided a recommendation and completed a table which summarizes the TC needs and what they are needed for.

2. Recommendation

The primary mission of the Tropical Cyclone-Regional Specialized Meteorological Centers (TC-RSMCs) and Tropical Cyclone Warning Centers (TCWCs) is to provide appropriate TC guidance information (analysis, forecasting, prognostic reasoning, etc.) to the Members of the five Tropical Cyclone Programme regional bodies[15] for every TC, including the marine-related hazards such as heavy rains, strong winds, cyclonic swell, waves and storm surges, occurring within their respective area of responsibility.

The TC community recommends that observations of the following marine meteorological variables, including from within Exclusive Economic Zones, which are used operationally by TC Centers and NMHSs and are critical to deliver the services in support of the safety of navigation and the protection of life and property in coastal and offshore areas be carried out:

[15] Regional Association I Tropical Cyclone Committee (RA I TCC), RA IV Hurricane Committee, RA V TCC, ESCAP/WMO Typhoon Committee, WMO/ESCAP Panel on Tropical Cyclones

	Analysis / Forecasting	**Verification**[16]	**Assimilation**[17]	**Purposes**	**Most impactful Variables**	**Comments**
Wind speed and direction	X	X	X	TC analysis[18] (intensity, structure, position) Model verification	Crucial	
Wind gust	X	X	X	TC analysis Model verification	Crucial	
Atmospheric Pressure	X	X	X	TC analysis Model verification	Crucial	
Sea state	X	X	X	Model verification Mariner bulletin	Crucial	
Wave height	X	X	X	Model verification Mariner bulletin	Crucial	
• *Dominant wave period (pic period)*	X	X	X	Model verification Mariner bulletin		
• *Average period*	X	X	X	Model verification Mariner bulletin		
• *Mean wave direction*	X	X	X	Model verification Mariner bulletin		
Temperature - surface	X		X	Intensity forecasting[19]	Crucial	
Temperature - subsurface	X		X	Intensity forecasting	Crucial	
Ocean heat content	X		X	Intensity forecasting	Crucial - 60 to 100m	

[16] The observations are needed for the operational forecasters to check whether their TC intensity analysis is relevant, to assess whether the models are appropriately calibrated and to deliver to their users (mariners, public, emergency managers, etc.) the most accurate advisories and/or warnings.

[17] Data are used for assimilation in the atmospheric and ocean models which are coupled to constitute a comprehensive TC forecasting model.

[18] TC analysis: assessment of the intensity, structure, position. To define the intensity of a TC, the operational forecaster relies on the measurement or assessment of the maximum winds and of the sea level minimal pressure.

[19] The intensification of tropical cyclones involves a combination of different atmospheric and at the surface conditions. The upper ocean provides heat energy to the overlying atmospheric boundary layer and for the deepening process. The upper ocean thermal structure is a key element in the study of TC-ocean interactions and resulting TC intensification.

					deep	
Ocean surface heat flux			X			
Currents- surface			X			
Currents - subsurface			X			
Essential Ocean Variable[20] "Sea surface height" / Essential Climate Variable "sea level"		X	X	Storm surge/coastal inundation	Crucial	Sea level: gauges needed for "storm surge and coastal flooding forecasting and warning systems, for assimilation of in situ sea level data into ocean circulation models, and for calibration/validation of the satellite altimeter and models"[21]
Bathymetry			x	Storm surge modelling		
Submergence %	X		x	TC analysis Model verification		The evolution of this parameter showed that the buoy entered into the eye leading to the validation of the observed pressure by the buoy as the minimal pressure [22]
~~Precipitation~~						With contamination by water sprays from waves especially in TC conditions, the reliability of the data will be constantly questioned

[20] http://www.goosocean.org/index.php?option=com_content&view=article&id=14&Itemid=114
[21] http://www.wmo.int/pages/prog/www/OSY/SOG/SoG-Ocean.pdf
[22] The importance of the "submergence" parameter was emphasized. Submergence is provided by the drifting buoys but not received by the operational met community as not being a recognized parameter in the current met messages circulating through the GTS. This parameter indicates the percentage of time passed by the buoy underwater. This parameter is helpful to the TC community, since whenever a buoy by chance finds itself within the eye (or inside the radius of maximum wind when an eye is not yet visible) there is a clear signature of the transition of the crossing of the radius of maximum winds with a quite significant reduction of the percentage of submergence after entering inside the eye (or eye-like feature). It is then a powerful parameter and way to certify that the buoy has penetrated inside the radius of maximum wind (or not) and if so therefore to validate the minimum sea level pressure observed by the buoy as an eye pressure measurement (and incidentally to better spot the location of the LLCC if no eye is visible on sat imagery). There was such a case in 2003 of a weakening TC (called HAPE) with no eye visible anymore on the InfraRed imagery (Central Dense Overcast (CDO) pattern) passing right over a drifting buoy which helped us assess the intensity of the storm (Caroff and Fontan 2003).

ANNEX 6

PROPOSED DRAFT WORLD METEOROLOGICAL CONGRESS RESOLUTION ON ENSURING ADEQUATE MARINE METEOROLOGICAL AND OCEANOGRAPHIC OBSERVATIONS AND DATA COVERAGE FOR THE SAFETY OF NAVIGATION AND THE PROTECTION OF LIFE AND PROPERTY IN COASTAL AND OFFSHORE AREAS

Draft Resolution 6.1(2)/5 (Cg-18)

Ensuring adequate marine meteorological and oceanographic observations and data coverage for the safety of navigation and the protection of life and property in coastal and offshore areas

THE WORLD METEOROLOGICAL CONGRESS,

Noting Recommendation 14 (EC-70), and subsequent work of JCOMM and its Observations Coordination Group (OCG) in liaison with the IOC-WMO-UN Environment-ICS Global Ocean Observing System (GOOS) Steering Committee,

Recalling:

(1) Article 2 of the Convention of the World Meteorological Organization, committing Members: "(a) To facilitate worldwide cooperation in the establishment of networks of stations for the making of meteorological observations as well as hydrological and other geophysical observations related to meteorology … ", and (b) "To promote the establishment and maintenance of systems for the rapid exchange of meteorological and related information",

(2) The United Nations Convention on the Law of the Sea of 10 December 1982 (UNCLOS), in particular the provisions of Part XIII on marine scientific research, which require States and competent international organizations to promote and facilitate marine scientific research, including through cooperation, in order to increase scientific knowledge of the marine environment as a critical underpinning of effective measures to preserve the marine environment and ensure the sustainable use of ocean resources for the benefit of all mankind,

(3) The report of the Third Committee of the Third United Nations Conference on the Law of the Sea (1973–1982), which included the letter sent on 25 August 1980 to the Secretary-General of WMO by the Chair of the Committee expressing that in his opinion the provisions of Part XIII of UNCLOS on marine scientific research would not create any difficulties and obstacles hindering adequate meteorological coverage from the ocean areas, including areas within the exclusive economic zones, carried out both in the framework of existing international programmes and by all vessels, since such activities had already been recognized as routine observation and data collecting which was not covered by Part XIII and that they were in the common interest of all countries and had undoubted universal significance, as they are indispensable for the issue of timely and accurate storm warnings for the safety of navigation as well as for the protection of life and property in coastal and offshore areas,

(4) the present Marine Meteorology and Oceanography Programme and Tropical Cyclone Programme, which use both vessels, under and the Voluntary Observing Ship (VOS) Scheme, and operational surface marine meteorological observing platforms (e.g. drifting buoys, unmanned surface vehicles), and strive to provide adequate meteorological coverage from the ocean areas, including areas within the exclusive economic zones, falling therefore under the content and the spirit of the letter mentioned in paragraph (3) above,

(5) Resolution 9 (Cg-IX) – United Nations Conference on the Law of the Sea, which requested the Executive Council and the Secretary-General: (a) To arrange, in close consultation with the president of the Commission for Marine Meteorology (now Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology), for a continuing review of the implications of the legal provisions of the Convention on the

ocean-related activities of WMO with a view to informing the United Nations and Members of WMO, as appropriate; and (b) To take action, as necessary, to ensure that the ocean-related activities of WMO, both operational and scientific, are undertaken under the most favorable conditions,

(6) Resolution 40 (Cg-XII) – WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities, which recognizes marine meteorological observations as essential data, and which are thereby freely exchanged in real-time among all countries for the general benefit to all countries,

(7) The International Convention for the Safety of Life at Sea (SOLAS, 1974) as amended,

Further noting:

(1) The *Technical Regulations* (WMO-No. 49), Volume I, Part I,

(2) The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160),

(3) The *Manual on Marine Meteorological Services* (WMO-No. 558), Volume I, Part I, defining WMO Members' responsibility for issuing warnings for high seas and coastal waters according to internationally agreed procedure,

Welcoming the outcome and recommendations of the WMO Technical Workshop on enhancing ocean observations and research, and the free exchange of data, to foster services for the safety of life and property (Ocean Safe, Geneva, 5-6 February 2019), which was organized as a contribution to the planning phase (2019–2020) of the United Nations Decade of Ocean Science for Sustainable Development (2021–2030),

Considering:

(1) That adequate marine meteorological data coverage from ocean areas, including those from the exclusive economic zones (EEZs), is indispensable for the issue of timely and accurate storm warnings for the safety of life at sea and the protection of life and property in coastal and offshore areas,

(2) That the SOLAS Convention, Chapter V, Safety of Navigation, Regulation 5, specifies that the contracting governments undertake, inter alia, to encourage the collection of meteorological data by ships at sea and to issue warnings of gales, storms and tropical storms,

(3) That VOS Scheme, which has undergone technological developments, is even more important today, not only to ensure safety of navigation and protection of life and property in coastal and offshore areas, but also to face other concerns, in particular the consequences of climate change,

(4) That Members of WMO have undertaken the responsibility of issuing warnings for the high seas and coastal waters according to internationally agreed procedures, including those based on advisories by Regional Specialized Meteorological Centres and Tropical Cyclone Warning Centres,

(5) That WMO-coordinated research programmes require extensive marine meteorological and oceanographic data sets from the world ocean, including EEZs,

(6) That meteorological observations from satellites over the oceans, including over EEZs, are routinely made available for operational purposes,

(7) That i*n situ* observations over the oceans, from surface marine meteorological networks (e.g. VOS, data buoys), are indispensable for the generation of forecasts and services, as some of the marine meteorological and oceanographic observations, such as sea-level pressure, sub-surface temperature and salinity profiles, cannot currently be adequately measured from space,

(8) That *in situ* observations, for example sea surface temperature, wind and waves are also essential for calibration and validation of satellite data,

(9) That marine meteorological and oceanographic observations included in numerical models contribute to improving prediction skills at all time scales,

(10) That marine observing platforms, such as voluntary observing ships, data buoys, uncrewed surface vehicles, Argo profiling floats and sub-surface gliders are providing meteorological observations primarily from data sparse areas of the ocean,

Recognizing:

(1) That since Resolution 9 (Cg-IX) was adopted, the observational user requirements of operational WMO applications, including global and high-resolution numerical weather prediction and sub-seasonal to longer-range prediction, and climate services have substantially evolved, and are now increasingly relying on marine meteorological and oceanographic observations,

(2) The future direction of WMO, as part of the Strategic Plan, in support of Earth system prediction, which coupled with ocean models will be relying greatly on marine meteorological and oceanographic data made routinely available to WMO,

(3) That technological advances can now provide *in situ* observational data of the requisite enhanced quality and spatial and temporal resolution, from the world oceans, including from EEZs,

(4) That there is no regulation in place for the collection of marine meteorological and oceanographic measurements within EEZs in support of operational applications of WMO, while the IOC Guidelines for the Implementation of Resolution XX-6 of the IOC Assembly Regarding the Deployment of Profiling Floats in the High Seas within the Framework of the Argo Programme (IOC Resolution EC-XLI.4) are operated effectively and fully consistently with UNCLOS,

Reaffirms:

(1) The indispensable and critical nature of routine marine meteorological and oceanographic observations used operationally by WMO Application Areas, through the variables listed in the Annex to this Resolution, including from EEZs, to the provision of services in support of safety of navigation and the protection of life and property in coastal and offshore areas;

(2) The critical importance of the VOS Scheme and operational surface marine meteorological observing platforms (e.g. drifting buoys, unmanned surface vehicles), hereinafter called surface observing platforms, for ensuring the provision on routine basis of adequate marine meteorological observations and data coverage, noting that:

(a) Voluntary observations from ships have been at the core of WMO and its predecessor activities since the 1853 Maritime Conference held at Brussels for devising a uniform system of meteorological observations at sea and have been regulated by WMO according to 1974 SOLAS Convention and previous SOLAS Conventions,

(b) The VOS Scheme and surface observing platforms are not covered by UNCLOS Part XIII on marine scientific research and can consequently be freely operated in the EEZs,

(c) The VOS Scheme and surface observing platforms are supported by consistent practices of Members according to WMO Technical Regulations,

(d) While not covered by UNCLOS Part XIII, the operation of the VOS Scheme and surface observing platforms fully complies with UNCLOS general principles, such as peaceful use of the sea, protection of human life at sea, dissemination of information;

(3) The need to further strengthen existing co-operation and activities under surface observing platforms;

(4) The fact that observations from the VOS Scheme and surface observing platforms are made in the context of agreed, long-standing operational systems and that they are freely exchanged among, and are of general benefit to, all countries;

(5) The fact that VOS observations are made, on a voluntary basis under the VOS Scheme, by merchant vessels engaged in normal trading activities, whose officers should be

reassured, where necessary, of the continuing legality and importance of their work in this regard;

Requests the Joint WMO-IOC Board, in close consultation with the technical commissions and the Research Board to keep reviewing the implications of the legal provisions under ocean-related instruments (e.g. UNCLOS, SOLAS, Polar Code) on the ocean-related activities of WMO with a view to informing the Members of WMO and interested United Nations organizations, as appropriate;

Requests the Executive Council to include a reference to UNCLOS and other relevant ocean-related legal instruments in Part 3 (Impacts of international agreements) of the WMO Statement on the Role and Functions of National Meteorological and Hydrological Services;

Urges Members:

(1) To facilitate and promote marine meteorological and related oceanographic observational and research programmes over the ocean for operational purposes, in particular from within EEZs;

(2) To take, as necessary, action to ensure that the ocean-related activities of WMO, both operational and scientific, are undertaken under the most favorable conditions;

(3) To adopt legislation encouraging the collection of marine meteorological and oceanographic data, as listed in the Annex to this Resolution, by surface observing platforms and to arrange for their dissemination and exchange in real-time;

(4) Where Marine meteorological observations are generally made on a voluntary basis under the VOS Scheme by vessels engaged in their normal activities, to reassure their officers, where necessary, of the continuing legality and importance of their work in this regard;

(5) To support the referring of this Resolution in the Resolution on Oceans and the Law of the Sea to be adopted by the seventy-fourth session of the United Nations General Assembly.

This Resolution replaces Resolution 9 (Cg-IX), which is no longer in force.

Annex to Draft Resolution 6.1(2)/5 (Cg-18)

Marine meteorological and oceanographic variables, which observations are critical for the safety of navigation and the protection of life and property in coastal and offshore areas

Observations of the following marine meteorological and oceanographic variables, including from within exclusive economic zones, are used operationally by WMO Applications and are critical for those Applications to allow WMO to deliver the services in support of the safety of navigation and the protection of life and property in coastal and offshore areas:

- Sea level pressure,
- Surface wind speed and direction,
- Surface air temperature,
- Surface relative humidity,
- Precipitation at the surface,
- Sea surface temperature,
- Sea surface salinity,
- Sea surface currents,
- Directional and non-directional wave observations,
- Visibility,
- Sea-ice,

- Ice accretion,
- Sub-surface temperature and salinity,
- Sea level,
- Atmospheric composition,
- Atmospheric temperature, humidity and wind profiles,
- All other ocean surface and atmospheric observations that are needed to derive fluxes between the ocean and the atmosphere.

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ANNEX 7

PROPOSED DRAFT WORLD METEOROLOGICAL CONGRESS RESOLUTION ON FUTURE COLLABORATION BETWEEN WMO AND IOC REGARDING FACILITATING THE MAKING OF OCEANOGRAPHIC OBSERVATIONS IN COASTAL REGIONS IN SUPPORT OF EARTH SYSTEM PREDICTION AND CLIMATE SERVICES

Draft Resolution 6.1(2)/6 (Cg-18)

FUTURE COLLABORATION BETWEEN WMO AND IOC REGARDING FACILITATING THE MAKING OF OCEANOGRAPHIC OBSERVATIONS IN COASTAL REGIONS IN SUPPORT OF EARTH SYSTEM PREDICTION AND CLIMATE SERVICES

THE WORLD METEOROLOGICAL CONGRESS,

Recalling draft Resolution 6.1(2)/5 (Cg-18),

Noting a 20-year history of work by the Intergovernmental Oceanographic Commission of UNESCO (IOC) to develop a cooperative framework regarding the sharing of ocean data in Exclusive Economic Zones (EEZs), in particular:

(1) IOC Resolution XX-6 (1999, "The Argo Project"), defining the Argo profiling float network and its implementation "fully consistent with the UNCLOS [United Nations Convention on the Law of the Sea]," as a part of the Global Ocean Observing System and the Global Climate Observing System,

(2) IOC Resolution EC-XLI.4 (2008, "Guidelines for the Implementation of Resolution XX-6 of the IOC Assembly Regarding the Deployment of Profiling Floats in the High Seas within the Framework of the Argo Programme"), defining a framework for notification of coastal IOC Member States of Argo profiling floats likely to enter their EEZ,

(3) Decision IOC/EC-LI/4.8 (2018, "Evolving Capabilities of the Argo Global Array of Profiling Floats"), agreeing to the continued use of the guidelines defined in IOC Resolution EC-XLI.4 for six new biogeochemical parameters, and to a framework for approval of additional new parameters,

Noting further that the Argo Information Centre at the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology *in situ* Observations Programme Support Centre (JCOMMOPS) plays an important role in ensuring the above guidelines are implemented,

Acknowledging that the IOC-WMO-UN Environment-ICS Global Ocean Observing System (GOOS) and the JCOMM Observations Coordination Group (OCG) are presently undertaking work to identify issues related to the implementation of sustained ocean observing in EEZs, under the provisions of UNCLOS,

Noting with satisfaction Argo's pioneering free and open data policy, in compliance with the IOC Oceanographic Data Exchange Policy (IOC Resolution XXII-6),

Recognizing that:

(1) National Meteorological and Hydrographic Service operational forecast models and services increasingly rely on sustained global data streams of subsurface ocean observations, to improve the skill of their forecasts, and to provide services that save lives and protect property, and support the blue economy,

(2) WMO and IOC research, notably on climate and its impacts, depends on the availability of global sustained ocean observation data streams,

(3) The UN Framework Convention on Climate Change call on Parties to strengthen systematic observation of climate (Article 5),

(4) The increasing need to develop 'ecological' early warning systems, providing alerts for stakeholders and managers and combining ocean model and in situ observations, for example for harmful algal blooms and coral bleaching events,

Further recognizing that:

(1) many of these oceanographic data streams are implemented and funded by national oceanographic research agencies and organizations working outside the operational framework of National Meteorological and Hydrographic Services,

(2) many oceanic processes move across EEZ boundaries, and

(3) the interrelated nature of the ocean, signifying that oceans and seas present a special case as regards to the need for international coordination and cooperation;

Confirms the importance of:

(1) Respecting the relevant legal frameworks for the taking and sharing of ocean data in waters under national jurisdiction,

(2) Full consultation and exchange of views with WMO Members,

(3) Informing all WMO Members and IOC Member States of these activities through the UN General Assembly Resolution on Oceans and Law of the Sea;

Decides that:

(1) WMO work through its forecasting systems and services activities to identify the requirements for subsurface ocean variables to improve the quality of these forecasts and services,

(2) WMO work closely with the IOC in order to explore mechanisms that make the highest-impact subsurface ocean data freely available,

(3) WMO work to build the capacity of all Members to use the resulting forecast systems and services for societal benefit;

Requests Technical Commissions and Research Board to include the above Decision in their work programme;

Urges Members to extend bilateral and multilateral cooperation in research, observations, forecasting, services and capacity development, in order to make ocean data more freely available.

ANNEX 8

OPERATIONAL ACTIVITIES AND MARINE SCIENTIFIC RESEARCH UNDER UNCLOS

(Summary of presentation delivered by Ms. Alice Hicuburundi, Senior Legal Officer, Division for Ocean Affairs and the Law of the Sea, Office of Legal Affairs, United Nations)

I. Operational activities at UNCLOS III

The background documents for this meeting note that at the Third United Nations Conference on the Law of the Sea, during the negotiations of the Convention, in reply to the concerns expressed by WMO that operational meteorological observations and related oceanographic observational activities could be affected by the legal provisions on marine scientific research contained in the Informal Composite Negotiation Text then under negotiation, the Chairman of the Third Committee wrote a letter to the Secretary-General of WMO stating that in his report to the Committee, he expressed the opinion that: "The pertinent provisions of ICNT/Rev.2 on marine scientific research would not create any difficulties and obstacles hindering adequate meteorological coverage from the ocean areas including areas within the exclusive economic zone carried out both in the framework of existing international programmes and by all vessels since such activities had already been recognized as routine observation and data collecting which was not covered by Part XIII of the ICNT and that they were in the common interest of all countries and had undoubted universal significance."

It is worth noting that this statement appears to be more of a reflection of the personal views of the Chairman and not of the Conference. Therefore, Ms. Hicuburundi suggested that relying exclusively on the statement of the Chairman to the Third Committee as an unequivocal legal basis to exclude these activities from the UNCLOS MSR regime may not be advisable.

Moreover, the practice, including a brief analysis of national legislation, which is also reflective of how a State interprets certain provisions of the Convention, shows that some States include the collection of meteorological and oceanographic data in their MSR regulation – while others do not.

II. Other efforts

Years after the conclusion of the Third United Nations Conference on the Law of the Sea, and more recently, with the growing large-scale deployment at sea of new means of data collection, including floats and gliders equipped to collect data on a near continuous basis and make them available in near-real time, the Assembly of the IOC of UNESCO, on the basis of work undertaken by the IOC Advisory Body of Experts on the Law of the Sea, adopted, in 2008, the Guidelines for the Implementation of Resolution XX-6 of the IOC Assembly Regarding the Deployment of Profiling Floats in the High Seas within the Framework of the Argo Programme (contained in document . The discussions leading to the adoption of these Guidelines have shown that different views continue to be held on the applicability of Part XIII of UNCLOS to such means of collecting data at sea.

In light of the differences of views concerning the nature and applicable framework for various methods of data collection at sea, the body had agreed to first address only the deployment of Argo floats and to postpone for future consideration the collection of oceanographic data by other instruments. Following the adoption of the Argo Guidelines, work on other means of collecting data has not been undertaken.

III. A way forward?

UNCLOS is generally recognized, including consistently by the General Assembly of the United Nations, as setting out the legal framework within which all activities in the oceans and seas must be carried out. As a result, we can begin to address this issue by looking at UNCLOS.

In particular, the general principles applicable to marine scientific research (MSR), contained in Part XIII, may provide guidance on how such activities may be conducted.

The purpose of both MSR activities and those considered as operational is to discover and provide scientific information for peaceful purposes and for the benefit of mankind. Because both can involve the acquisition of basic scientific data, it appears that operational oceanography includes some activities that are similar to marine scientific research. However, there are significant differences. While both are scientific activities, the type of scientific research envisaged in Part XIII of UNCLOS is that of a specific project conducted by specific scientists from a specific research vessel on one (or perhaps a few) voyage(s).

In contrast, operational oceanography involves continuous, routine monitoring of the state of the marine environment over large areas, with unmanned equipment, or by vessels of opportunity (or voluntary observing ships) over long periods of time. If the equipment is floating buoys, then these may drift in or out of several States' maritime zones almost every day. If the monitoring is done by vessels of opportunity (or voluntary observing ships), they may conduct continuous measurements throughout a long voyage in numerous maritime zones.

In view of the similarities between the objectives of operational oceanography and MSR, one could consider that the general principles in sections 1 (general provisions) and 2 (international cooperation) of Part XIII of UNCLOS are applicable, *mutatis mutandis,* to operational oceanography. These rules and principles reaffirm that States and competent international organizations have the right to conduct MSR; that such research shall be conducted exclusively for peaceful purposes; that researchers should comply with regulations for the protection of the marine environment; and that States have the duty to cooperate in MSR, including with regard to publication and dissemination of information and knowledge. This general duty to cooperate carries with it other responsibilities such as the duty to (a) promote and facilitate MSR; (b) cooperate for the promotion and development of MSR for peaceful purposes; and (c) cooperate to create favourable conditions for the conduct of scientific research. Capacity-building and technical assistance to developing countries, including with regard to the transfer of marine technology (Part XIV) is also critical.

In addition, sections 4 (Scientific research installations or equipment in the marine environment), 5 (responsibility and liability) and 6 (settlement of disputes and interim measures) would also provide guidance.

However, it would appear that the long standing practice of using voluntary observing ships does not provide for the application of the consent regime in accordance with section 3 of part XIII. It must also be noted that the use of other means than vessels renders the implementation of the consent regime difficult. Hence the efforts of the IOC ABELOS, in the past, aimed at clarifying the legal framework applicable to the collection of oceanographic data with specific means within the context of UNCLOS and which eventually led to the adoption of the Argo Guidelines.

Ms Hicuburundi ended her presentation by looking forward to the exchange on key points to be addressed by the Session Chair for a possible way forward in addressing in particular the concerns about the VOS scheme.