World Meteorological Organization	Intergovernmental Oceanographic Commission (of UNESCO)

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ASSESS SCIENTIFIC AND OPERATIONAL REQUIREMENTS

BACKGROUND MATERIAL

SUMMARY

Reference: **JCOMM-III/Doc. 5**

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Appendix:

- Background Material

BACKGROUND MATERIAL

1. THE WMO/CBS ROLLING REVIEW OF REQUIREMENTS (RRR)

1.1 The WMO/CBS Rolling Review of Requirements process has documented the user requirements for observations for all application areas within WMO Programmes (global NWP, regional NWP, synoptic meteorology, nowcasting and very short-range forecasting, seasonal and inter-annual forecasting (SIAF), atmospheric chemistry, aeronautical meteorology, climate monitoring, marine meteorology and oceanography, hydrology and agricultural meteorology) and has developed *Statements of Guidance* (SoGs) on the extent to which these requirements are or will be met by present, planned and proposed observing systems.

1.2 The process periodically reviews users' evolving requirements for observations, together with the capabilities of observing systems to meet them. It consists of four stages:

- A review of users' requirements for observations, within an application area;
- A review of the observing capabilities of existing, planned and proposed observing systems;
- A *Critical Review* of the extent to which the capabilities meet the requirements; and
- A *Statement of Guidance* (SoG), based on the output of the *Critical Review*.

1.3 The SoG is essentially a *gap analysis*. It informs WMO Members on the extent to which their requirements are met by present systems, will be met by planned systems, or would be met by proposed systems. Further information on the RRR process and the SoGs for the applications areas listed above, including their covered activities, is available at http://www.wmo.int/pages/prog/sat/RRR-and-SOG.html.

User requirements for observations

1.4 Within the RRR process, observational requirements for each application area are captured within the WMO/CEOS database, which is available at http://www.wmo.int/pages/prog/sat/Databases.html. For each application, user requirements are stated for each geophysical variable of interest in a "technology-free" way, in terms of spatial and temporal resolution, accuracy and timeliness. Each requirement is quantified in terms of three values:

- The "*goal*" is a maximum requirement. The cost of improving the observations beyond the goal is unlikely to be matched by a corresponding benefit;
- The "*threshold*" is the minimum requirement below which data are not useful;
- The "*breakthrough*" is an intermediate level between "*threshold*" and "*goal*", which, if achieved, would result in a significant improvement for the targeted application.

Observing capabilities and user requirements - a gap analysis

1.5 The observing capabilities of present and planned observing systems are quantified using the same criteria as for the user requirements and also stored in the WMO/CEOS database. This facilitates the comparison with user requirements, which constitutes the *Critical Review*, and the subsequent documentation of the key compliances and gaps in the SoG. Impact studies, such as the Observing System Experiments (OSEs) and the Observing System Simulation Experiment (OSSEs), as well as workshops, are key elements in this review. The full SoGs (*gap analyses*) for each application area can be found at http://www.wmo.int/pages/prog/sat/RRR-and-SOG.html.

2. ASSESS SCIENTIFIC AND OPERATIONAL REQUIREMENTS

2.0.1 Although the baseline global ocean observing system developed under GOOS and implemented by JCOMM is designed to meet climate requirements, marine services in general and NWP will be improved by the implementation of the systematic global observations called for by the GCOS-92 plan. The system supports global and regional weather prediction, global and coastal ocean prediction, marine hazard warning, marine environmental monitoring, naval applications, weather forecasts and many other non-climate uses. In items 2.1 and 2.3 of this report are presented only those variables not adequately covered by the GCOS-92, which are required for met-ocean applications, global and regional NWP, and synoptic meteorology. Progress has been made to include those variables in the *OPA implmentation goals* [see agenda items 6.1 and 6.3] and in the *Implementation Plan for the Evolution of the Global Observing System (GOS)* [see item 3 of this report].

2.1 Met-ocean applications

2.1.1 The full set of observational requirements for met-ocean applications for geophysical variables within the ocean or at the ocean/atmosphere interface is given in the WMO/CEOS database, which is available at http://www.wmo.int/pages/prog/sat/Databases.html. During the intersessional period, the SPA developed a *User Requirement Document*, which describes the observational requirements for met-ocean applications (see http://www.jcomm.info/SPA). These include marine forecasting and warning services, and ocean mesoscale forecasting. The WMO/CEOS database and the *Statement of Guidance (SoG) for Ocean Applications* have been updated accordingly. CBS, at its fourteen session (Dubrovnik, March 2009), requested JCOMM to address tsunami monitoring in both the WMO/CEOS database and the *SoG for Ocean Applications*.

2.1.2 Those critical issues relevant to observations of the ocean and the ocean/atmosphere interface for met-ocean applications are presented below [full SoG for Ocean Applications available at http://www.wmo.int/pages/prog/sat/RRR-and-SOG.html]. Variables, such as sea surface temperature, sea ice and snow over sea ice, waves, ocean sub-surface variables, ocean topography, and ocean currents, also required for GNWP, RNWP, SIAF or synoptic meteorology are addressed under this item.

Waves

2.1.3 Requirements for wave observations include: (i) assimilation into wave forecast models; (ii) validation of wave forecast models; (iii) calibration/validation of satellite wave sensors; (iv) ocean wave climate and its variability on seasonal to decadal time scales; and, (v) role of waves in coupling. Marine forecasters use wave model outputs as guidance to issue forecasts and warnings of wave variables (such as significant wave height and period, and dominant wave direction) for their area of responsibility and interest, in support of several marine operations. Satellite altimeters provide information on significant wave height with global coverage and good accuracy but marginal horizontal/temporal coverage. Information on the 2-D frequency-direction spectral wave energy density is provided by SAR instruments with good accuracy but marginal horizontal/temporal resolution. HF radars are also being used for costal models. *In situ* observations are used for the validation of models and satellite products with requirements of 1000km spacing requiring a network of around 400 buoys with minimum 10%/25cm accuracy for wave height and 1 second for wave period.

Sea Level

2.1.4 Sea level observations are needed for tsunamis, storm surges and coastal flooding forecasting and warning systems, as well as for tide and mean sea level applications. While altimeters are primarily being used for sea level and provide for good global coverage and accuracy, the horizontal/temporal coverage is marginal. *In situ* observations are used for assimilation in ocean circulation models, and for calibration/validation of the satellite altimeter and models. The aim of any tide gauge recording should be to operate a gauge which is accurate to better than 1cm at all times; i.e., in all conditions of tide, waves, currents, weather; and provide for high frequency data (6 to 15 min) with accurate timing (1 min.); measurements must be made relative to a fixed and permanent local tide gauge bench mark (TGBM).

Sea surface temperature

2.1.5 Ships and buoys provide observations of sea surface temperature of good temporal frequency and accuracy. Coverage is marginal or absent over some areas of the Earth, but recent improvements in the *in situ* network have enhanced coverage considerably. Infra-red instruments on polar satellites provide information with global coverage, good horizontal resolution and accuracy, except in areas that are persistently cloud-covered. Here, data from passive microwave instruments on research satellites has been shown to be complementary. Temporal coverage is adequate for met-ocean applications, GNWP and RNWP but, for SIAF, observation of the diurnal cycle is required, for which present/planned geostationary satellites offer a capability. In general, higher accuracy would be useful in support of met-ocean applications and SIAF.

Sea-ice and snow over sea-ice

2.1.6 Sea-ice cover and type are observed by microwave instruments on polar satellite with good horizontal and temporal resolution and acceptable accuracy. Data interpretation can be difficult when ice is partially covered by melt ponds. Operational ice thickness monitoring is required, particularly in support of met-ocean applications and SIAF, but it is not currently planned. Satellite imagery (visible/infra-red and microwave) provide information on snow cover and snow water content over land, but interpretation is very difficult over sea-ice resulting in an observational gap.

Ocean sub-surface variables

2.1.7 For met-ocean applications, and in the latter part of the medium-range for GNWP (~7-15 days) and for SIAF, the role of the sub-surface layers of the ocean becomes increasingly important, and hence observations of these variables, particularly temperature and salinity, become relevant. Argo is the major source of sub-surface temperature and salinity observations, providing global coverage to ~2000 m, mostly with acceptable-to-good spatial resolution, but only marginal temporal resolution in the tropics. The Tropical Atmosphere Ocean (TAO)/TRITON moored buoy network provides data of good frequency and accuracy, and acceptable spatial resolution, of sub-surface temperature for the tropical Pacific. The tropical moored networks in the Atlantic (PIRATA) and the Indian (RAMA) Oceans are better than marginal but do not yet have long-term commitment. The Ships-of-Opportunity Programme (SOOP) provides data of acceptable spatial resolution over some regions of the globe but temporal resolution is marginal. SOOP is evolving to provide enhanced temporal resolution along some specific lines. Surface salinity will be measured by satellite instruments on forthcoming research missions. There will be a need for continuity of those measurements.

Ocean topography and ocean currents

2.1.8 Ocean altimetry provides a measure of the sea surface topography. Research satellites are providing a mix of data with acceptable accuracy and resolution, and with good spatial resolution (along the satellite tracks) but marginal accuracy and frequency. Geodetic data from satellites such as GRACE, CHAMP and GOCE will improve knowledge of the geoid and hence the utility of altimeter data. Satellite altimetry is also being used to infer the distribution of ocean currents, for which moored buoys provide observations which are good in temporal coverage and accuracy but marginal otherwise.

Visibility

2.1.9 Poor visibility is a major hazard to all vessels because of the increased danger of collision. Surface visibility observations are made primarily by ships, and at the coastal stations (mainly at harbours, where the VTS (Vessel Track System) is usually available). This parameter can vary substantially over short distances. Accuracy is acceptable in coastal areas and marginal in open ocean. Horizontal/temporal resolution is poor over the most of the global ocean. Visibility is deduced from the output of regional atmospheric models [see SoG for regional NWP, available at http://www.wmo.int/pages/prog/sat/RRR-and-SOG.html].

2.2 GOOS and GCOS

2.2.1 The Global Climate Observing System (GCOS) cooperates closely with the Global Ocean Observing System (GOOS), which is led by the UNESCO/IOC and co-sponsored by the WMO, the United Nations Environment Programme (UNEP) and the International Council for Science (ICSU). The Ocean Observation Panel for Climate (OOPC), sponsored by GOOS, GCOS and the World Climate Research Programme (WCRP) has the lead responsibility in planning of the open ocean climate module of GOOS. The Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) takes responsibility for the implementation of the ocean component of GCOS. GCOS and GOOS together will work on an integrated framework for coastal and arctic systems.

OceanObs'09 Conference

2.2.2 Almost a decade has passed since the *OceanObs'09 Conference* (Venice, September 2009) played a major role in consolidating the plans for a comprehensive ocean observing system able to deliver systematic global information about the physical environment of the oceans. Now, the world's oceans are being observed routinely and systematically by means of satellite and *in situ* techniques. The availability of these observations has led to rapid progress in ocean analysis and forecasting as well as new scientific understanding of oceanic variability and the role of the oceans in weather and climate. This information and knowledge supports a wide range of societal and business benefits. It is now critically important to ensure sustainability and further development of the present system and to realize the full extent of the benefits across all stakeholders and for all participating nations. It is equally important to define a clear path to plan for extending the present system to include comprehensive observation, analysis and forecasting of the biogeochemical state of the ocean and the status of marine ecosystems. The OceanObs'09 conference will celebrate a decade of progress and make a major contribution to chart the way forward for the coming decade. Detailed information, including the Community White Papers and the Conference Statement that outlines consensus outcomes from the OceanObs'09 conference, is available at http://www.oceanobs09.net/.

Integration of Marine Meteorological and Oceanographic Observing Systems

2.2.3 The Argo profiling float network has reached completion with 3000 floats operational in November 2007. All operational floats report their data in real time onto the Global Telecommunication System (in TESAC and BUFR format) via the two Global Data Assembly Centres (GDAC) of US and France. Argo has revolutionized understanding and monitoring of the world's oceans by providing unique insight into temperature, salinity and currents in the ice-free oceans. It has been recognized that continued operation of the array is crucial for GOOS and the ocean component of GCOS. Maintenance of the Argo array faces challenges, as the floats have a nominal 4 year lifetime. Most Argo national programmes continue to be supported by research funding, which poses difficulties for sustaining the observations over decadal timescales. Support from operational agencies and users are needed to justify the long-term funding. The Prediction and Research Moored Array in the Tropical Atlantic (PIRATA) has completed its pilot phase (reflected in a redefinition of the acronym) and continued in a 17 surface mooring and one subsurface ADCP mooring configuration in 2008.

2.2.4 The status of the all over *in-situ* global ocean observing system reached 62% of its initial goals and, despite of the impression of a dense network and that a significantly amount of observations are made by satellites, there are still significant gaps. The percentage of implementation per year needs to be increased urgently.

2.2.5 The WCRP Climate Variability and Predictability (CLIVAR) project has continued the development of pilot observing systems in all oceans of the world. The novel feature of most of these systems is that they include requirements for future climate prediction and the scope of observations goes beyond the physical variables. These developments require cooperation with similar initiatives by other programmes. A hydrography advisory group, the “Global Ocean Shipbased Hydrographic Investigations Panel (GO-SHIP)” has been formed, co-sponsored by the CLIVAR’s Global Synthesis and Observations Panel (GSOP), the IOC International Ocean Carbon Coordination Project (IOCCP) and the IGBP SOLAS-IMBER carbon group. It brings together interests from physical hydrography, carbon, and biogeochemistry to develop guidelines and advice for the development of a globally coordinated network of sustained ship-based hydrographic sections that will become an integral component of the ocean observing system post-CLIVAR.

2004-2008 Progress Report on the Implementation of the Global Observing System for Climate

2.2.6 GCOS published a “*Progress Report on the Implementation of the Global Observing System for Climate in Support of the UNFCCC 2004-2008*” in response to a request by the United Nations Framework Convention on Climate Change (UNFCCC) Subsidiary Body for Scientific and Technological Advice (SBSTA), at its 23rd session in December 2005. The Progress Report was prepared by a broadly-based group of experts with strong support from the GCOS Panel Chairs, GCOS Secretariat and the Secretariats of the three main component observing systems (WMO, GOOS and GTOS). It describes progress against 131 actions set forth in the 2004 GCOS Implementation Plan to ensure the availability of observations for climate information, services, and assessment purposes. The Progress Report was submitted, at the 30th session of the SBSTA, which took place in June 2009, in Bonn, Germany. The assessment was mainly based on: (i) performance reports from GCOS component systems; (ii) national reports on systematic observation of climate submitted to the UNFCCC in 2008; and (iii) additional information by experts of all three domains and in-situ and space measurement systems. The Progress Report showed significant progress against 76% of the 131 Actions. The implementation of GCOS has progressed but still does not meet all UNFCCC needs, particularly in the areas of systematic and sustained observations of the oceans and the terrestrial domain, and of regional-scale observations in developing countries. Developed countries have generally improved their observational capacity, but have made only limited progress in assuring long-term continuity of measurements. Space agencies have actively incorporated GCOS requirements, as defined in the Satellite Supplement to the GCOS Implementation Plan, into mission planning and strategies for data exploitation, including reprocessing and generation of satellite-derived, user-tailored products. In the Report, key priorities for the next five year have been identified as:

2.2.7 General Conclusions of the Progress Report:

(a) Developed Countries have improved their climate observation capabilities, but limited progress in resolving financial issues related to long-term continuity;

(b) Developing Countries have only made limited (*in-situ*) progress, with decline in some regions, and capacity building support remains small in relation to needs;

(c) Operational and Research Networks show increasing regard to climate needs;

(d) Satellite agencies have improved both mission continuity and capability and are increasingly meeting the needs for reprocessing, data access, and product generation.

2.2.8 Main conclusions for the *Atmospheric Domain*:

(a) Good progress with availability, quality and exploitation of data from satellites for climate purposes across the range of Essential Climate Variables (ECVs) – from basic meteorological variables to radiation and atmospheric composition;

(b) Good progress in general with *in-situ* meteorological networks; support through the system improvement programme has helped maintaining a baseline; however, overall progress in developing countries has been limited;

(c) Some specific issues persist (e.g., measurement of precipitation, clouds, snow depth; precipitation data exchange; sunshine duration; metadata);

(d) Good progress in advancing climate reference networks;

(e) Improved planning and progress with implementation of atmospheric composition networks meeting climate needs.

2.2.9 Main conclusions for the *Ocean Domain*:

(a) Useful progress in almost every action called for in the Implementation Plan of 2004, but many actions remain incomplete;

(b) The ice-free upper 1500 m of the ocean are being observed systematically for temperature and salinity for the first time in history;

(c) Most in-situ networks have made progress (e.g., tide gauges, moored reference sites, tropical moored arrays, full ocean depth observations);

(d) Most in-situ observing activities continue to be carried out under research agency support and on research programme time limits;

(e) Important progress in provision of critical ocean satellite data of sea surface ECVs has been made, but not for all variables, and data access remains to be ensured;

(f) Important progress in development of historical ocean reanalysis and in high resolution ocean forecasting capabilities;

(g) Promising developments in improved methods and standards will allow wider measurement of biological and chemical ECVs and consideration of new ECVs in the years ahead;

(h) Data sharing remains incomplete, particularly for tide gauges and biogeochemical ECVs. Data archaeology needs to continue.

Up-Date of the GCOS Implementation Plan

2.2.10 The SBSTA-30 invited the GCOS Secretariat to prepare an update of the GCOS Implementation Plan for its 33rd session in November 2010. The update of the GCOS Implementation Plan will take into account developments over the past five years such as adaptation plans and mitigation measures, and will revise the needed actions and the list of Essential Climate Variables (ECVs). The SBSTA invited the GCOS Secretariat to include, in this updated GCOS Implementation Plan, a breakdown of costs involved. The costs should be broken down by region, observing system and between developed and developing countries. The SBSTA invited the GCOS Secretariat to provide a provisional updated Implementation Plan in conjunction with a provisional estimation of costs, for the 15th session of the Conference of the Parties (COP-15), 7–18 December 2009, in Copenhagen.

National Committees and Coordinators

2.2.11 GCOS is promoting the establishment of National GCOS Coordinators and encourages national ocean services to participate in national GCOS committees. A letter signed by all heads of the four sponsoring organizations has been sent on 19th June 2009 to the respective representatives asking for support for improved coordination of GCOS at the national level.

Standardization

2.2.12 The list of marine and ocean stations, including VOS (WMO Pub. 47, the International List of Selected, Supplementary and Auxiliary Ships) is updated quarterly.

2.2.13 WIGOS is addressing standardization issues from a multi-disciplinary perspective, dealing with requirements from all WMO Programmes and co-sponsor programmes [see agenda item 10.2].

2.2.14 JCOMM and UNESCO/IOC-IODE prepared a *Catalogue of Best Practices and Standards under JCOMM and IODE of UNESCO/IOC*, which had been published on the web at http://bestpractice.iode.org/ [see agenda item 11.2].

2.2.15 The GCOS/WCRP Atmospheric Observation Panel for Climate at its thirteenth session (Geneva, April 2007) had recognized that monthly CLIMAT TEMP/CLIMAT TEMP SHIP reports had very limited value for ongoing climate research purposes, taking into account improvements in collection and exchange of the daily TEMP messages and improved real-time quality control at operational weather prediction centres. The Panel conclued that CLIMAT TEMP was no longer required for GCOS purposes and that the Hadley GUAN Monitoring Centre had ceased its CLIMAT TEMP monitoring activities in 2007. CCl has been requested to assess the impacts of a possible discontinuation of CLIMAT TEMP on other domains, such as applied climatology, research and aviation.

Observing Systems under GAW addressing climate

2.2.16 The WMO/GAW Global Atmospheric CO_2/CH_4 Monitoring Network was formally recognized by CAS and GCOS as a major component of the GCOS comprehensive network in 2006. In 2007, an agreement was reached between GCOS and GAW, which specified the terms under which the GAW ozone and contributing networks were designated as the GCOS Global Baseline Total Ozone Network and the GCOS Global Baseline Profile Ozone Network. The agreement further specified terms under which selected NDACC stations could contribute to a GCOS Reference Upper-Air Network. The agreement has been approved by the WMO/GAW Scientific Advisory Group for Ozone, the Chair of the OPAG EPAC, and the GCOS Steering Committee, and thus added another component to the set of GCOS baseline networks in addressing the Essential Climate Variables. Implementation of GCOS networks continues, with additional networks being formally added as appropriate; in the upcoming years aerosols will be the focus.

GCOS Global Terrestrial Network for River Discharge (GTN-R)

2.2.17 The Pilot Project *"Initiation of Global Hydrological Network addressing a GCOS Requirement*" is largely based on the "*Hydrological Applications and Run-Off Network (HARON)*" project proposal. The proposal for HARON, jointly developed by WMO and GEO, is intended to improve and support the closure of the global water budget, in line with requirements of GCOS and the Global Water Cycle Experiment (GEWEX). In a phased approach, HARON foresees integration of dedicated river gauging networks of existing hydrological stations on a global scale into a global runoff observation network, including the 380 global river discharge stations in the GCOS Global Terrestrial Network for River Discharge (GTN-R). Technical upgrade and sustained maintenance of these stations will be addressed by HARON.

2.3 Global and regional NWP, and synoptic meteorology

2.3.1 The full set of observational requirements for global NWP (GNWP), regional NWP (RNWP), seasonal and inter-annual forecasting (SIAF) and synoptic meteorology, for geophysical variables within the ocean or at the ocean/atmosphere interface is given in the WMO/CEOS database, which is available at http://www.wmo.int/pages/prog/sat/Databases.html.

2.3.2 RNWP has observational requirements very similar to those of GNWP. Where they differ they are more demanding in terms of horizontal and temporal resolution, and timeliness. Observational requirements for SIAF take, as their starting point, those for GNWP, and then add requirements for additional variables (e.g. ocean currents and ocean colour) or more demanding requirements of the same variables (e.g. for SST, and for sub-surface temperature and salinity). Those issues relevant to observations of the ocean and the ocean/atmosphere interface, principally for GNWP but with comments on differences for RNWP and SIAF where necessary, are presented below [see the full SoGs, available at http://www.wmo.int/pages/prog/sat/RRR-and-SOG.html, for more details]. Variables, such as sea surface temperature, sea ice and snow over sea ice, waves, ocean sub-surface variables, ocean topography, and ocean currents required for GNWP, RNWP, SIAF or synoptic meteorology are addressed in item 2.1 of this report.

Surface pressure and surface wind

2.3.3 Over ocean, ships and buoys provide observations of acceptable frequency. Accuracy is good for pressure and acceptable/marginal for wind. Coverage is marginal or absent over large areas of the Earth. Polar satellites provide information on surface wind – with global coverage, good horizontal resolution, and acceptable accuracy – in two ways. Scatterometers give information on wind speed and direction, whereas passive microwave imagers provide information on wind speed (only). Passive polarimetric radiometers have recently been demonstrated; in addition to wind speed, they offer directional information but of inferior quality to scatterometers at low wind speed. Temporal coverage is acceptable for GNWP and SIAF but marginal for RNWP. Surface pressure is not observed by present or planned satellite systems except for: some contribution from radio occultation data, and measurements of atmospheric optical depth for a gas of known composition such as oxygen (e.g. as planned with NASA's OCO mission). Surface pressure observations at relatively low spatial density are important as a complement to high-density satellite surface winds, in order to anchor the NWP surface pressure field. Such observations would be useful at high temporal resolution (e.g. hourly).

Surface air temperature and humidity

2.3.4 Over oceans, ships and buoys provide observations of acceptable frequency and acceptable accuracy (except ship temperatures during the daytime, which currently have poor accuracy). Coverage is marginal or absent over large areas of the Earth. Satellite instruments do not observe these variables, or do so only to the extent that they are correlated with geophysical variables that significantly affect the measured radiation (i.e. skin temperature and atmospheric layer-mean temperature and humidity). Observations of surface humidity over ocean are of lower priority for NWP than many other variables.

Precipitation

2.3.5 Surface stations measure accumulated precipitation with a temporal resolution and accuracy that is acceptable but a horizontal resolution that is missing over most of the Earth. Ground-based radars measure instantaneous precipitation with good horizontal and temporal resolution and acceptable accuracy, but over a few coastal areas only. Microwave imagers and sounders offer information on precipitation of marginal horizontal and temporal resolution, and acceptable/marginal accuracy (though validation is difficult). Geostationary infra-red imagers offer some information at much higher temporal resolution through the correlation of surface precipitation with properties of the cloud top, but accuracy is marginal due to the indirect nature of this relationship. Satellite-borne rain radars, together with plans for constellations of microwave imagers, offer the potential for improved observations. For RNWP, satellite estimates of precipitation are marginal at best but, away from coastal areas, they are virtually the only source of precipitation information over oceans.

2.4 Other

2.4.1 The requirements for the operational collection and exchange of data for coastal GOOS, including physical and non-physical variables (biogeochemical and socio-economic) have been just emerging. Such requirements had been compiled Design and Implementation Strategies for the Coastal Module of GOOS, which are available at http://www.ioc-goos.org/content/view/14/ 28/. All three requirements, physical, biological and chemical, together with a range of complementary meteorological observations, are needed to obtain a comprehensive view of the behaviour of coastal seas and their responses to natural and anthropogenic forcing, in support of sustainable development. IODE of UNESCO has been dealing with the data management issues of all kinds of data, including management and exchange of non-physical observations.

3. The Vision for the Global Observing System (GOS) in 2025

The vision for the GOS in 2025 – the ocean component

3.1 In 2009, WMO/CBS adopted a new Vision for the GOS, in response to the evolving needs of WMO Programmes for observations and to the opportunities offered by recent developments in technology and in planned/proposed observing systems. This new *Vision for the GOS in 2025* in available at http://www.wmo.int/pages/prog/www/OSY/WorkingStructure/documents/CBS-2009_Vision-GOS-2025.pdf .

3.2 The new Vision provides high-level goals to guide the evolution of the GOS in the coming decades. These goals are intended to be challenging but achievable. The new Vision addresses general trends and issues facing the evolution of the GOS: response to user needs, integration, expansion, automation, consistency and homogeneity. It contains high-level guidance to observing system providers for the task of developing an interoperable and co-ordinated “system of systems”: a system of space-based and surface-based observing systems to meet a comprehensive range of user requirements for observations in a coordinated manner.

3.3 Those elements of the Vision relevant to the implementation of ocean observing systems are extracted below [see the full Plan for more details]:

3.3.1 The *space-based component of the GOS* will provide information on:

Sea surface temperature	High-resolution multi-spectral visible/IR imagers and IR spectral sounders on operational geostationary and polar-orbiting satellites; microwave imagers on polar-orbiting satellites; dual-view IR imagers
Sea ice cover	microwave and visible/infra-red imagers, and scatterometers
Sea surface wind speed and direction	scatterometers and polarimetric microwave imagers
Ocean surface topography, sea level, wave heights and sea ice topography	Altimeter constellation including a reference mission in a precise orbit and polar-orbiting altimeters for global coverage
Precipitation	microwave imagers and sounders and from precipitation radars
Ocean colour	narrow-band and hyperspectral visible / near-IR imagers

Wave heights, directions and spectra; sea ice leads; ice shelfs; ice bergs	synthetic aperture radars

3.3.2 The *surface-based component of the GOS* will include:

Ocean – upper air	
Automated Shipboard Aerological Platform (ASAP) ships	Wind, temperature, humidity, pressure
Ocean – surface	
HF Coastal Radars	Surface currents, waves
Synoptic sea stations (ocean, island, coastal and fixed platform)	Surface pressure, temperature, humidity, wind; visibility; cloud amount, type and base-height; precipitation; weather; sea-surface temperature; wave direction, period and height; sea ice
Ships	Surface pressure, temperature, humidity, wind; visibility; cloud amount, type and base-height; precipitation; weather; sea-surface temperature; wave direction, period and height; sea ice
Buoys – moored and drifting	Surface pressure, temperature, humidity, wind; visibility; sea-surface temperature; 3D & 2D wave spectrum, wave direction, period and height
Ice buoys	Surface pressure, temperature, wind, ice thickness
Tide stations	Sea water height, surface air pressure, wind, salinity, water temperature
Ocean – sub-surface	
Profiling floats	Temperature, salinity, current, dissolved oxygen, CO_2 concentration
Ice tethered platforms	Temperature, salinity, current
Ships of opportunity	Temperature
R&D and Operational pathfinders – examples	
Instrumented marine animals	Temperature
Ocean gliders	Temperature, salinity, current, dissolved oxygen, CO_2 concentration

Implementation strategy and key issues for ocean observing systems

3.4 The WMO/CBS has developed an *Implementation Plan for the Evolution of the GOS* (EGOS-IP), in response to the *Vision for the GOS* and the gaps identified by the SoGs. The current version of EGOS-IP, which includes comments on implementation status and issues, is available at http://www.wmo.int/pages/prog/www/OSY/WorkingStructure/index.html. EGOS-IP includes the following sections relevant to ocean observing systems [with EGOS-IP section numbers shown in parentheses – see the full Plan for more details]:

- Data dissemination: higher temporal frequency and more widespread exchange (G1);
- Documentation: improved metadata (G2);
- Timeliness: more timely availability of observations from ocean systems (G3);
- Improved dissemination of atmospheric vertical profile information from radiosondes, including ASAPs (G8);
- More atmospheric profiles over the oceans, including ASAPs (G14);
- Improvements in marine observation telecommunications (G15);

- Tropical moorings: develop RAMA in Indian Ocean and sustain both RAMA and the Atlantic Ocean arrays (G16);
- Drifting buoys: improved coverage of surface pressure observations, particularly in the Southern Oceans (G17);
- XBT and Argo: improved timely delivery of observations (G18);
- Ice buoys: increased coverage (G19);
- New observing systems, including ocean gliders and deep ocean reference stations (G22);
- In-situ wave observations capability (GN1);
- Increased temporal resolution of SST data (GN2);
- Develop and consolidate VOSClim fleet (GN3);
- Sea-surface wind from low Earth orbiting (LEO) satellites (S7);
- LEO altimeters: develop ocean topography missions to operational status (S8);
- LEO ocean salinity: develop operational capability (S14);
- LEO synthetic aperture radar (SAR): make data available for operational use (S15).

3.5 The EGOS-IP will be reviewed in November/December 2009, to take into account elements from *Vision for the GOS in 2025*.