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IOC Group of Experts on the Global Sea Level Observing System (GLOSS)

Twelfth Session
Paris, France
9–11 November 2011

GOOS Report No. 198
GCOS Report No. 150
JCOMM Report No. 98

UNESCO

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ABSTRACT

The Group of Experts on the Global Sea Level Observing System (GLOSS-GE), at its Twelfth session, evaluated the status of the various GLOSS station networks including data reporting for delayed mode, high frequency, real-time data streams as well as reviewing the status of continuous measurements of vertical land movement near stations in the GLOSS Core Network.

The Group reviewed recent studies based on tide gauge observations, sample sea level products and technical developments pertaining to radar gauge calibrations.

The draft *GLOSS Implementation Plan* was reviewed and adopted by the Group.

Several regional and national reports were presented and reviewed. Finally the Group reviewed present links between GLOSS and other relevant programmes, and identified its own intersessional activities for 2011–2013.

Note*: this report is published in electronic copy only and is available on UNESDOC, the documents database of UNESCO (http://unesdoc.unesco.org/ulis/)*

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1. ORGANIZATION OF THE SESSION

1.1 OPENING OF THE SESSION

The Technical Secretary of the IOC Group of Experts on the Global Sea Level Observing System, Thorkild Aarup, opened the Group's Twelfth Session at 14:00 on Wednesday 9 November 2011 in UNESCO, Paris, on behalf of the Executive Secretary IOC, Wendy Watson-Wright, who was unable to welcome the participants personally, owing to her obligations vis-à-vis the 36th General Conference of UNESCO.

The Executive Secretary had offered consolidated welcoming remarks for both the workshops and the GLOSS GE meeting on Monday 7 November 2011 at the start of the workshops on: (i) Storm Surge Monitoring and Extreme Sea Levels and the Need for High Quality Real-Time Sea Level Data; and (ii) Space-based methods for vertical tide gauge control. She highlighted the importance of the workshops as they provide input for updating and finalising the "GLOSS Implementation Plan" at the GLOSS-GE-XII. She also highlighted what the GLOSS community had done in order to respond to the need for more real time sea level stations following the 2004 Indian Ocean Tsunami and increase in the number of continuous GPS stations co-located with GLOSS sea level stations that had taken place over the last 10 years.

The Executive Secretary emphasised that that there is a clear increasing societal demand for sea level monitoring (locally and globally) with a diverse group of user needs to address from long term sea level studies for climate monitoring and impact, climate adaptation and coastal planning, over to tsunami and sea level hazard monitoring. The international community relies on GLOSS to provide the main sea level data streams and to provide advice/best practice/training to help societies to close remaining gaps in the observing network.

The Executive Secretary recalled that GLOSS was established more than 25 years ago by the IOC and IOC has supported it over the years with secretariat and funding. She informed the meeting that UNESCO is going through some financially challenging times as some countries will withhold their assessed contributions to UNESCO (and hence IOC) regular programme budget as a consequence of the vote to admit Palestine as a full member of UNESCO. The Executive Secretary stated that IOC is committed to continue to support GLOSS as a core programme of IOC.

The Executive Secretary then spoke about the workshop on Storm Surge Monitoring and Extreme Sea Levels and the Need for High Quality Real-Time Sea Level Data, and recalled that the first session is a tribute to Dr David Pugh's contribution to GLOSS and how he was one of the founders of the GLOSS programme together with Prof. Klaus Wyrtki of the University of Hawaii. She highlighted some of David Pugh's achievements, i.e. Chair of the GLOSS-GE (1987–1995); UK Delegate to IOC Assembly and Executive Council meetings (1985–2003) and Head of the UK Delegation (1990–2003); IOC Vice-Chairman (1999–2003); Chairman of IOC (2003–2007). In addition David Pugh served on the Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS) (2001–2003) and the UN Group of Experts on a Global Marine Assessment (March 2004).

The Executive Secretary concluded by expressing her deep thanks to David Pugh for his work on GLOSS and the IOC.

1.2 PRACTICAL ARRANGEMENTS

The Technical Secretary announced the practical arrangements for this session of the Group of Experts. He reminded participants that all relevant documents for the present session were available, or would be in due course, once ready, on the GLOSS website (http://www.ioc-goos.org/glossge12).

1.3 ADOPTION OF THE AGENDA

No changes were proposed to the provisional agenda and the Group of Experts adopted the Agenda for its Twelfth Session (Annex I to the present report).

2. REVIEW OF GLOSS ACTIVITIES AND STATUS OF ACTIONS FROM LAST SESSION

The Chair of the Group of Experts, Mark Merrifield, briefly reviewed the state of implementation of the Group's intersessional activities for 2009–2010, agreed at its Eleventh Session (UNESCO, Paris, 13–15 June 2009). He informed the participants that a first complete draft of the "GLOSS-GE Implementation Plan 2012" had been prepared, but it would need to be finalized in the light of the deliberations of the present session. The GLOSS Manual on data-quality control has been completed. GLOSS has continued to provide technical advice to operators of tsunami warning systems.

The Technical Secretary stressed the importance of harmonizing as far as possible the procedures of the four IOC regional International Coordination Groups on Tsunami Early Warning and Mitigation Systems (for: the Pacific Ocean; the Indian Ocean; the North-eastern Atlantic, the Mediterranean and Connected Seas; and the Caribbean), as recommended by the Inter-ICG Task Team on Sea Level for Tsunami and endorsed by the Working Group on Tsunami and Other Hazards Related to Sea Level Warning and Mitigation Systems [see also agenda item 8].

The Chair stressed the need, under the present difficult financial circumstances, for the Group of Experts to do more for less; this would require the practical contributions of more of the Group's members during the forthcoming intersessional period and beyond in the implementation of GLOSS activities. He also emphasized the continuing efforts to establish a joint web-portal for access to sea-level observations (both research quality and real-time data) and vertical land motion archived at (i) the Permanent Service for Mean Sea Level/British Oceanographic Data Centre (BODC); (ii) the University of Hawaii Sea Level Center (UHSLC); (iii) the IOC Sea Level Station Monitoring Facility; and (iv) SONEL (the data assembly centre for GLOSS concerning observations from GNSS stations co-located with tide gauges [centre hosted at University of La Rochelle, France]). The four centres and TIGA are working on a joint station metadata catalogue. A meeting between the four centres was held in Honolulu, Hawaii, 15–18 March 2010 to address this matter.

The Chair acknowledged that the GLOSS-GE-XI actions pertaining to development of sea-level data products were not advanced as much as could be desired. The Chair encouraged the development of sea-level indices to be included in the "state of the ocean" website (http://ioc-goos-oopc.org/state_of_the_ocean/) maintained under the auspices of the Ocean Observations Panel for Climate (OOPC). The Chair also encouraged a more systematic compilation of regional sea-level products and including these on the GLOSS website.

Discussion

There were no comments by the Group of Experts.

3. GLOSS CORE NETWORK

3.1 REVIEW OF GLOSS CORE NETWORK STATUS (LOW FREQUENCY AND HIGH FREQUENCY, DELAYED AND FAST MODE)

Lesley Rickards (Permanent Service for Mean Sea Level) presented a report on the work of the PSMSL (available at the http://www.ioc-goos.org/glossge12), with particular reference to the

GLOSS Core Network (GCN). The GCN contributes to the Global Ocean Observing System (GOOS) and to the Global Climate Observing System (GCOS). Sea level is one of the essential climate variables and the completeness of the GCOS observing network is measured by a metric of core observation components, including the GCN. The PSMSL deals primarily with the delayed-mode, quality-controlled, low-frequency data stream. In 2009–2011, it has acquired an additional 6,250 station-years of data. Where feasible, data for each station are reduced to a common datum, the Revised Local Reference (RLR), which ensures the data's suitability for research-quality time-series analyses. However, PSMSL also cooperates with the British Oceanographic Data Centre (BODC) to maintain an archive of delayed-mode, higher-frequency sea-level data from the GLOSS Core Network.

Geographical coverage remains uneven. Most data are from North America and Europe, but large data sets have recently been received from Asia, Australasia and southern Africa. Major data gaps remain for South America and parts of Africa; for the latter, the data gaps are being addressed partly through the efforts to re-establish/upgrade some sea-level stations in Africa. This effort was funded by the third phase of the Ocean Data and Information in Africa (ODINAFRICA) project under the International Oceanographic Data and Information Exchange (IOC/IODE) programme. PSMSL is giving particular attention also to polar region data, and received data from four new stations in the Russian Arctic.

The GLOSS Handbook updating is nearly complete; it will be published later this year (2011).

The new PSMSL website was launched in April 2010.

PSMSL has also continued to play an active role in GLOSS training and technical assistance activities and participates actively in major international scientific and technical conferences and publications on sea-level observation and research.

Mark Merrifield (University of Hawaii Sea Level Center – UHSLC) gave a presentation on the GCN quality-controlled, high-frequency data stream handled by UHSLC. The Centre has recently set up a new data server which allows the breakdown of the data in terms of tide-gauge station identification and sensor content, country or area, and cooperating programmes (e.g. GLOSS, GCOS, NOAA). Mark Merrifield demonstrated the new website of the UHSLC and the typical metadata associated with each station.

Discussion

The question was raised about stations equipped with more than one sea-level sensor. Mark Merrifield explained that, so far, only the data from the primary sensor were being used.

Patrick Caldwell (Joint Archive on Sea Level) gave a presentation on the JASL. The Archive is maintained with the collaboration of the University of Hawaii Sea Level Center and the NOAA National Oceanographic Data Center. JASL is science-driven and depends on the implementation of an open-data policy; in this respect, it is supported by some 100 agencies in 90 countries. The data are quality-controlled and therefore constitute a data product. Nevertheless, the original data are also archived. JASL is not concerned with real-time or near-real-time data archiving, nor with data on extreme events. For research purposes, JASL selects the "best" station data. Its outreach is through software support (SLPR2), training, and provision of guidance via e-mail. JASL submits data more or less annually to the World Data Centre for Oceanography (Silver Spring, USA) and to the Permanent Service for Mean Sea Level/British Oceanographic Data Centre.

JASL cooperates with the UHSLC by providing JASL data to update fast-delivery (FD) data management, but is not itself involved in FD management; nevertheless JASL strives to include all FD sites in its database.

The ICSU Committee on Data for Science and Technology (CODATA)'s Data at Risk Task Group is conducting an enquiry with a view to establishing an inventory of data holdings world-wide (Phase I) and to rescue, as far as possible, all "sleeping" data. In this it is seeking support from GLOSS members in building the inventory, which should include: reports on holdings; names of stations; length of time-series; what is recorded (e.g. marigram) and how (e.g. tabulated); ancillary data (e.g. tide-staff readings, levelling); recording media (e.g. paper, microfiche), the state of such media (e.g. risk of loss) and their volume (e.g. how many pages, boxes?); location of holdings (e.g. your agency, elsewhere); and plans restoration to electronic media. Patrick Caldwell invited interested members of the Group of Experts to send their information on sea-level data in need of rescue to him (Patrick.Caldwell@noaa.gov) by 1 April 2012.

Discussion

The question of techniques for digitization of historic data was raised. The main one used is photography of the paper records, with subsequent scanning for conversion to the data format; there is also an ongoing effort at automation. In the decision as to which station data are selected for inclusion in the Joint Archive, the Group of Experts felt that some form of scientific approval was desirable, with particular importance being given to the measurement of oceanic sea-level signals and the length of the time-series. Data should also be assembled for specific purposes. The question was raised as to whether the recommendation of a regional ICG on tsunami warning systems would be considered an acceptable criterion in the selection of data from sea-level stations for inclusion in the JASL. This was thought to be a matter for consideration by the Group of Experts.

It was noted that the peak in data delivery had occurred about twenty years ago, and this was reflected similarly in the PSMSL and the JASL records. This peak was not considered to be particularly linked to the completion of the World Ocean Circulation Experiment (1990–2002) and Tropical Ocean Global Atmosphere programme (1985–1995). The Group of Experts decided to seek an explanation for this drop in data delivery.

Also, data loss has been detected particularly with respect to the European Arctic region and to South America. And there is still not much data relevant to tsunami warning.

The Group of Experts decided to advertise these problems on the GLOSS website.

Mark Merrifield indicated that these problems needed to be addressed in the forthcoming intersessional period.

3.2 REVIEW OF COLLOCATED AND NEARLY COLLOCATED CONTINUOUS GPS STATIONS

Guy Wöppelmann (CNRS, Université de La Rochelle, France) gave a presentation on "Sea-level estimation with GPS-corrected tide-gauge records" (available on http://www.ioc-goos.org/glossge12; further details about the inventory of tide gauges collocated with continuous Global Navigation Satellite System (GNSS) stations is available at www.sonel.org). In the GLOSS Core Network the number of collocated stations has increased (since 2009) from 147 to 181. Of these there are presently 112 active sea-level stations that are co-located with GNSS stations, 6 are inactive, 27 have not transmitted any data for the last 30 days, and 36 GNSS stations do not allow for any data exchange with the international GNSS processing centres (i.e. IGS or the GNSS processing centre at the Université de La Rochelle).

Vertical land movements (VLM) have been shown to be an important source of spatial sea-level variability. Based on some reference stations, the horizontal position accuracy is <7 mm, and <15 mm for the vertical position accuracy, with velocity accuracies of <1.5 mm per year and <3 mm per year, respectively. In areas that are not seismically active and where post glacial rebound dominate land movement, it is generally assumed that the land movement trend is linear over the period of the tide-gauge records, and that the vertical movement of a GNSS antenna is the same as that of the tide gauge itself. In the monitoring of local land movement, a good geodetic link between the GNSS antenna and the tide-gauge benchmark is required, but is often not assured; a separation distance of <500 m is desirable; otherwise, differential GNSS campaigns are needed to determine the geodetic link. Regarding the data processing, a GLOSS-dedicated GNSS data assembly centre is highly desirable; a high accuracy in the data processing is important for sea-level applications.

Tilo Schöne (GeoForschungsZentrum Potsdam, Germany) gave a complementary presentation on the progress of the TIGA pilot project (PP). The objectives of the PP are: to provide a dedicated GNSS product (coordinates, time-series of coordinates, vertical rates) for sea-level research purposes; interact with GLOSS, particularly with respect to defining the scope of TIGA and identifying the users of TIGA results; promote the establishment of links to other geodetic techniques (especially DORIS, and absolute gravity measurements) which may contribute to the determination of vertical motion.

Regarding vertical positioning, the PP recommended the connection of each tide-gauge benchmark to the International Terrestrial Reference Frame (ITRF) and monitoring it by GPS. It is important to separate land motion from climate-related sea-level change; this is required for calibration of satellite altimeters and for determining absolute ocean current transport, thus to establish the relationship between the height determination system and the sea level, as a reference for local mapping. It is also considered important to reconstruct sea level from historical records in order to develop a sound basis for coastal-zone protection and as a reference of long-term consistency for Law of the Sea purposes (e.g. coastal and harbour navigation, continental shelf claims). The Global Climate Observing System (GCOS) also requires implementation of the GCN based on geocentrically located, high-accuracy tide gauges with assured continuous acquisition, real-time exchange and archiving of high-frequency data. It is also important to put all regional and local tide-gauge measurements within the same global geodetic reference system, and to promote the recovery and exchange of historical sea-level records. These initiatives need to be backed by including sea-level objectives in all relevant capacity-building programmes (GOOS, JCOMM, WMO, etc.). The TIGA Pilot Project has also achieved the reprocessing of a large GPS@TGs data set previously not known to the International GNSS Service (IGS) and supported many scientific applications (altimetry calibration, sea-level reconstruction and change analyses, and height system development).

The PP has made a number of recommendations with respect to the GNSS capability: if possible each long-term and reliable tide gauge should be equipped with continuous GNSS, and if (for practical or budgetary reasons) this is not possible, a pillar should be set up for regularly repeated GNSS campaigns; the single/dual receiver concept should be implemented, based on a primary GNSS + a GNSS pillar within less than 10 to 50 m, best if situated on top of the tide-gauge system (even if obstructions are present), with a secondary GNSS on stable ground, both operating continuously.

Regarding the siting of primary GNSS stations, it is important to avoid sites subject to: (i) naturally unstable terrain; (ii) significant changes to the surroundings, foreseen or likely, or to excessive radio frequency interference; (iii) excessive radio-frequency reflective surfaces (fences, walls, etc.) and other sources of signal multipath; (iv) excessive natural or man-made surface vibrations (e.g. from ocean waves or heavy vehicular traffic). If possible, geodetic receivers and choke-ring antennas, capable of receiving all GNSS signals, should be used, with a 30-second sampling rate (1 Hz, if in a hazardous area), a short latency for data transmission, and a levelling benchmark at the GNSS pillar supported by regular levelling to other benchmarks.

It was also considered important to supply metadata (tide-gauge data, meteorological data, equipment changes, unusual impacts, reconstruction works, IGS logs) and, in particular, to provide levelling between benchmarks on a regular (repeated) basis, without, however, abandoning first-order levelling capability.

Discussion

The question was raised as to whether the measurement of absolute sea level is the objective; and whether it is practical to combine absolute and relative sea-level data in relevant sea-level databases. Guy Wöppelmann explained that an important objective is to be able to compare mean sea level at different locations (calibration and unification of datums). Determining benchmark geocentric positions is therefore essential. However, at present, many GLOSS stations are still not collocated with GNSS installations, so the GLOSS-GE could help to improve this situation. He also stressed the need for further effort to enable existing sea-level stations to have multipurpose monitoring capabilities, particularly for warning systems for tsunamis, storm surges and other ocean-related hazards. To this end, the Working Group on GNSS Tide Gauge Benchmark Monitoring (TIGA-WG) will carry out a complete review of the GNSS capabilities in GLOSS, including the data processing. This will include a new analytical strategy comparing three independent geodetic calculations for each station.

In the Caribbean region, Christa von Hillebrandt-Andrade highlighted the development of the Continuously Operating Caribbean GPS Observational Network (COCONet—see http://www.unavco.org/science/snapshots/atmosphere/2012/coconet.html) and the potential there is for collaboration with GLOSS to develop a regional GPS/sea-level network, particularly in support of the Tsunami and Other Coastal Hazards Warning System for the Caribbean Sea and Adjacent Regions (CARIBE-EWS); see also section 4.3, here below.

4. REGIONAL SEA-LEVEL NETWORKS IN SUPPORT OF TSUNAMI WARNING SYSTEMS

The Indian Ocean tsunami of 26 December 2004 led the IOC Assembly to decide to establish (in addition to the existing Pacific Tsunami Warning System—PTWS) tsunami warning systems for the Indian Ocean (IOTWS), the Caribbean (CARIBE-EWS), and the North-East Atlantic, Mediterranean and Connected Seas (NEAMTWS) and called on GLOSS to assist with the development of these systems.

4.1 INDIAN OCEAN

No status report was provided on the sea-level network in the Indian Ocean Tsunami Warning System. However, the Technical Secretary informed the Group of two developments: (i) India is now contributing high-frequency sea-level data in real time to the Indian Ocean Tsunami Warning System; and (ii) Oman is developing a national sea-level network as part of their effort to develop a National Multi-Hazard Early Warning System.

Discussion

The Group of Experts welcomed the contribution from India and the planned development in Oman.

4.2 PACIFIC OCEAN

Mark Merrifield, on behalf of Stuart Weinstein (Deputy Director of NOAA Pacific Tsunami Warning Centre, Honolulu, Hawaii), gave a presentation on the improvements over the past six years in the detection capabilities in the Pacific Tsunami Warning System.

The WMO Global Telecommunication System (GTS) is a network of surface and satellite-based telecommunications links and centres for the global exchange of meteorological, climatic, seismic and other data to support multipurpose early warning and forecast systems. Tsunami Warning Centres (TWCs) rely heavily on the GTS to supply sea-level data in near real time from about 400 sea-level stations world-wide and to transmit Tsunami Bulletins. Presently there are 12 or so basic formats, with a number of variations, in use for transmitting sea-level data on the GTS.

For a TWC to use sea-level data transmitted via the GTS, the centre needs at least to have: (i) access to GTS data; (ii) decoder software to translate sea-level messages into sea-level data; and (iii) a metadata database (used by the decoder). High-frequency transmissions allow a TWC to confirm the existence or non-existence of a destructive tsunami more quickly. This is important because, for every hour a tsunami warning remains in effect, 500–1000 km of additional coastline are placed in a warning status, depending upon where the earthquake occurred.

The increase in the number of sea-level stations and in the frequency of data transmissions over the last six years has decreased the wait time for getting confirmation from three sea-level stations to report evidence of a tsunami, to the extent that now, in 2011, the wait time in many cases is shorter than the wait time was for getting confirmation from just one station in 2005.

Over the past six years there has been a move to more frequent data transmission from many sea-level stations in the Pacific sea-level network. Continuous data transmission (every 5–15 min or better) is clearly preferred because: (i) a tsunami may occur at any time; (ii) a sea-level station may be destroyed before it can transmit evidence of a tsunami. Observations of tsunami wave amplitude decay may be used to forecast when it is safe to cancel a warning. Also, a small tsunami might not trigger a warning. Continuous data are also desirable in multi-hazard (storm surges, seiches, etc.) warning systems.

NOAA/NESDIS has made 5-minute transmission slots available on the GOES-W and GOES-E satellites for sea-level stations in support of the tsunami warning systems (PTWS and CARIBE-EWS). Recommendations to NOAA/NESDIS for the allocation of these high-frequency transmission slots in the Pacific and Caribbean are made by PTWS in consultation with GLOSS. In the consideration of which stations should be recommended for high-frequency transmission a few requirements were highlighted: (i) proximity to seismic zones; (ii) present gaps in detection network including new sites in regions of low station density to lower the latency in detection (sites situated in estuaries, fjords, etc., that are not facing the open ocean, have greater detection latency and may be sheltered from a tsunami).

The Tohoku Earthquake and Tsunami of 11 March 2011 was used to exemplify the principles exposed.

Discussion

It was pointed out that the various formats used for transmitting sea level data via the Global Telecommunications System (of WMO) may also reflect the different requirements for transmission, data compression, capabilities and limitations (including that of relative cost to the station operator, which is usually a principal consideration in the establishment of a new sea-level station).

4.3 CARIBBEAN

Christa von Hillebrandt-Andrade (NOAA/NWS Caribbean Tsunami Warning Program, Puerto Rico) reported on developments in the Tsunami and Other Coastal Hazards Warning System for the Caribbean Sea and Adjacent Regions (CARIBE-EWS).

There are 17 sea-level stations in operation in the Caribbean. The CARIBE-EWS system needs to have at least 100 fully operational stations. The existing stations are at various levels of operation and the help of the IOC Sea Level Station Monitoring Facility in raising operating standards is proving a great resource.

It is widely recognized in the Caribbean that a successful sea-level network for tsunami applications depends on its multi-purpose applications (e.g. climate change, hydrometeorology, navigation and tsunami detection). It is also necessary to broaden the stakeholder group, to include as far as possible: tsunami warning centres; marine meteorological services; climate centres; the maritime shipping community; hydrographic services; tourist and hotel associations; emergency management agencies; and the science and technology community.

The United States Government has provided funding to install/upgrade 11 new sea-level stations in the Caribbean: in Barbuda (installed and operated by the National Ocean Service) and, installed by UHSLC and the Puerto Rico Seismic Network (PRSN) with US National Weather Service Tsunami Program funds, in Costa Rica, Curaçao, Grenada, Dominica, and Puerto Plata and Punta Cana (Dominican Republic). Still awaiting installation are two stations in Colombia, as well as a station in the Turks and Caicos Islands, and in Panama.

Other national installations are planned (e.g. France).

The Caribbean Institute of Meteorology and Hydrology is maintaining a few sea-level stations for the Caribbean Community Center for Climate Change (CCCCC). However, these stations only transmit observations every hour and they would need to be upgraded to more frequent transmission if they are to contribute to the tsunami sea-level network.

The NOAA National Weather Service established (on 1 February 2010) the Caribbean Tsunami Warning Program, jointly with the Puerto Rico Seismic Network, at the University of Puerto Rico, Mayagüez, as a first US step towards the establishment of a Caribbean Tsunami Warning Center (CTWC). The ICG/CARIBE-EWS, at its Sixth Session, endorsed the establishment of a Caribbean Tsunami Warning Centre in Puerto Rico and requested the US to provide an implementation plan towards full tsunami warning capabilities for the consideration of the ICG/CARIBE-EWS at its next session (April, 2012).

The US National Science Foundation/University has announced that it will fund the Continuously Operating Caribbean GPS Observational Network (COCONet) project. The aim of the COCONet project is to develop a large-scale geodetic and atmospheric infrastructure in the Caribbean that can form the backbone of a continuous GPS network in support of geoscience and atmospheric investigations and to enable research on process-oriented science questions with direct relevance to geohazards. Under this project it is envisioned that 50 new continuous GPS stations will be established in the region. The ICG/CARIBE-EWS has been advocating where possible to co-locate the new GPS stations with existing tide gauges.

A tsunami detection capability study has been carried out in the region. One hundred and eighty-four earthquake sources were evaluated. Tsunami travel times were calculated; the sources were as determined for NOAA forecast studies.

The Second Caribbean GLOSS–CARIBE-EWS Sea Level Network Operators Short Course was held in Grenada in January 2011. It comprised: the basics of sea-level measurement; the best practices for the installation and operation of sea-level stations; and the quality control and analysis of sea-level data. A third such training course is proposed to be held in Merida, Mexico, in March 2012.

The principal needs with respect to sea-level measurement in the Caribbean region are: a broader user base (currently, the sea-level data are ingested by the TWC, but are mostly underutilized for other applications); additional training for sea-level network operators; to explore alternatives for robust real-time high-rate (1-minute) transmission; quality control of data for many of the stations; to determine the predicted tides for many stations; the establishment of a Caribbean Sea Level Data Centre as a data repository and for data quality control and analysis; the timely publication of Caribbean sea-level data (and data products); and to strengthen levelling practices.

Discussion

It was agreed that there is a real need to re-evaluate the GLOSS Core Network in the Caribbean and align it with existing operational stations. It was also agreed that the cost of station operation was one of the main factors in developing and maintaining the Caribbean and the other tsunami warning systems. There is particular difficulty for stations on small islands, most of which require ship time to ensure servicing of installations. New funding mechanisms will become necessary as the current support for UHSLC/PRSN for installations and maintenance will run out in 2014. More generally, it was recognized that the Caribbean sea-level data could be further explored for research and other operational applications thereby also broadening the user base.

The Group of Experts recommended that COCONet/UNAVCO be encouraged to supply the continuous GPS data to the TIGA data centres (for state-of-the-art reanalyses by at least three processing centres).

4.4 NORTH-EAST ATLANTIC AND MEDITERRANEAN

Dov Rosen (Israel Oceanographic and Limnological Research Ltd., Haifa) gave a presentation on the state of NEAMTWS, with particular emphasis on MedGLOSS. In terms of tsunami frequency, historically, the Mediterranean is the second most affected sea area, so a lot of importance is attached to the sea-level networks in this region. Forty-seven new stations were added in 2011.

Discussion

It was pointed out that still only a few of the stations in NEAMTWS transmit data via the GTS (for instance via a satellite data transmitter using the Meteosat satellites). The Internet still is preferred by tide gauge agencies in the NEAMTWS Member States – perhaps due to ease of initial installation and initial investment cost.

5. REPORT OF THE SEA LEVEL STATION MONITORING FACILITY

Francisco Hernández and Bart Vanhoorne (both of the Flanders Marine Institute [VLIZ], Ostend, Belgium) presented a report on the work of the IOC Sea Level Station Monitoring Facility (www.ioc-sealevelmonitoring.org).

The Sea Level Station Monitoring Facility receives data through three data transmission systems: WMO's Global Telecommunications System; Internet; and BGAN (Broadband Global Area Network). The data in all three systems are emitted by the tide-gauge stations.

They provided an overview of the data transmission and processing for the three types of communication systems. The benefits and drawbacks of each of the three transmissions systems are summarized in Table 1.

The Facility now tracks about 470 stations, up from about 300 stations since the GLOSS-GE-XI meeting (May 2009). During the 27 February 2010 Chile earthquake and tsunami and the 11 March 2011 Great East Japan earthquake and tsunami the web service was used extensively (i.e. 2,901,945 hits, which is about 65 times the normal daily traffic).

Table 1. Performance comparison for different data transmission options.

	GTS	**Internet (FTP/Webservice)**	**BGAN**
Transmit interval (min.)	5..15 (or +)	1..60	5
AVG delay (min.)	11	11-12	1-5
Ratio expected/arrived (%)	~100%	<< 80%	~100%
Access	Restricted/WMO	Easy	Transmission = expensive
Format standardization	some	none	good
(Dis)advantages	- format decoding?	lots of communication errors HTTP/FTP/timeout/..	+ trigger (no batch script)

Over the past two years the Facility and the web service have been enhanced in a few areas, including simplifying the plots of the data, tick-box options for exclusion of outliers and removal of spikes and outliers with respect to plotting, and the option of more direct read out of data

Each station transmission system has advantages and disadvantages. Access to the GTS comes via the national meteorological institute and agreed practices; there is some format standardization and format decoding may be necessary. Access to the Internet is easy, but suffers from communication error; there is no format standardization; and the “expected data”/“arrived data” ratio is significantly below 100%. BGAN data transmission is notably more expensive than the other two systems but appears to be more reliable.

6. SUMMARY OF RECENT RESEARCH BASED ON TIDE-GAUGE OBSERVATIONS

Svetlana Jevrejeva (Permanent Service for Mean Sea Level, Liverpool, UK) summarized some of the difficulties facing sea-level research, with particular reference to the work being carried out at PSMSL. The tide-gauge data have a historical interest, but it is important to account for tectonic movements in the Earth’s crust relative to the determination of absolute sea level. This factor is being taken into account by means of satellite monitoring of tide-gauge benchmarks. Sea-level data are currently being widely used in oceanographic, geographical and geophysical research, with particular emphasis on long-term trends and extreme events. However, some regions are better represented in the database than others. Also, in a comparison of the periods 1985–1989 and 2005–2009, a number of weaknesses can be seen. The sea-level stations are constantly changing, in terms of number, of location, of data submission, and of data loss. High accuracy satellite altimeter data are only available for the last 20 years and there is no coverage for the polar regions; and the southern hemisphere has been chronically under-represented in the PSMSL database, with the danger that the global view of sea-level change is biased dangerously towards the northern hemisphere. Svetlana Jevrejeva noted that global sea level had risen during the 20th century by 1.8±0.5 mm per year, increasing to over 3.1±0.7 mm per year in the 1990s.

Svetlana Jevrejeva drew attention to a few scientific studies that had come out since the last GLOSS-GE meeting, in particular: (i) an update of the globally reconstructed sea level (Church & White 2011, Sea-Level Rise from the Late 19th to the Early 21st Century, Surveys of Geophysics, DOI 10.1007/s10712-011-9119-1); (ii) an estimate of long term sea-level rise determined at Port Arthur (Falkland Islands) based on a benchmark left by Captain James Clark Ross in 1842 (Woodworth et al. 2010, Journal of Geophysical Research, Vol. 115, C09025, doi:10.1029/2010JC006113); (iii) analysis of Arctic sea-level records, Henry et al. Sea-Level Variations since 1950 along the Coasts of the Arctic Ocean, Journal of Geophysical Research, 117, 2012. doi:10.1029/2011JC007706; and (iv) extension of the sea-level record at Brest back to 1711 (Wöppelmann et al., 2008, Geophysical Research Letters, 35, L22605, doi:10.1029/2008GL035783).

Svetlana Jevrejeva informed the GLOSS Working Group about the IPCC's 5th Assessment Report (AR5). Sea level will be addressed in Working Group 1 (WG1). Chapter 3 of the WG1 report will cover ocean observations including sea-level change, ocean waves and storm surges; and Chapter 13 will include: a synthesis of past sea-level change and its components (models for sea-level change; projections of globally averaged sea-level rise, and of the regional distribution of sea-level change); and extreme sea-level events (potential ice-sheet instability and its implications; and multi-century projections).

Svetlana Jevrejeva also mentioned the time line for the AR5. By 31 July 2012 papers must be submitted for publication to be eligible for assessment by the WG1. By 15 March 2013 papers cited in WG1 must be published or accepted for publication. The WG1 report will be published in September 2013. Svetlana Jevrejeva encouraged the GLOSS community to make WG1 aware of studies relevant to the WG1 assessment. She also encouraged the GLOSS community to serve as reviewers for the AR5 report.

Finally she highlighted two issues that continue to be central in sea-level science: (i) What is the rate of global/regional sea-level rise? (ii) What are possible changes in extreme events in a warming climate?

In that regard she also emphasized the importance for recovery of historical data.

7. ACTIONS AND REQUIREMENTS FROM WORKSHOPS (7–9 NOVEMBER 2011)

7.1 WORKSHOP ON STORM-SURGE MONITORING AND EXTREME SEA LEVELS AND THE NEED FOR HIGH-QUALITY REAL-TIME SEA-LEVEL DATA (7–8 NOVEMBER 2011)

Kevin Horsburgh (National Oceanography Centre, Liverpool, UK) reported on the main results of this Workshop (Agenda, Abstracts and Presentations from this Workshop are available at HTTP://IOC-GOOS.ORG/GLOSSGE12). He summarized the main requirements coming out of the Workshop for GLOSS and the GLOSS Core Network:

- Observations should be made available in real time
- High-frequency data are needed not only for operational purposes but also to advance science

He also highlighted areas where GLOSS can assist and should advance development:

- While there is a move towards radar gauges – calibration issues and best practices are still to mature
- Automated QC/QA procedures

- Availability of products needed by society: i.e. extremes and return periods, generalized extreme value (GEV) products

Finally Kevin Horsburgh highlighted the need for linkage to the JCOMM Storm Surges and Wave community.

7.2 WORKSHOP ON SPACE-BASED METHODS FOR VERTICAL TIDE-GAUGE CONTROL (9 NOVEMBER 2011)

Tilo Schöne reported on the main results of this Workshop (Agenda, Abstracts and Presentations from this Workshop are available at HTTP://IOC-GOOS.ORG/GLOSSGE12). Tilo Schöne emphasized the view that the main requirement for GLOSS is to achieve a more uniform geographical distribution of continuous GNSS stations co-located with GLOSS Core Network stations. He also mentioned that the TIGA Working Group had agreed to reprocess GNSS/GPS and he encouraged GLOSS station operators with access or ability to facilitate access to collocated GNSS data to provide their datasets. In that respect Matt King and Gary Mitchum volunteered to identify high-priority sites.

8. WORKING GROUP ON TSUNAMI AND OTHER HAZARDS RELATED TO SEA LEVEL WARNING AND MITIGATION SYSTEMS (TOWS-4): REPORT AND REQUIREMENTS TO GLOSS FROM THE TOWS INTER-ICG TASK TEAM ON SEA LEVEL FOR TSUNAMI

Allison Allen (NOAA, Silver Spring, Md., USA) summarized the main outcomes of the first meeting of the TOWS-WG's Inter-ICG Task Team on Sea Level for Tsunami (Seattle, Wash., USA, 29 November–1 December 2010, http://unesdoc.unesco.org/images/0019/001939/193911e.pdf).

Tsunami warning systems based mainly on earthquake magnitude and tsunami travel-time (TTT) maps require a complete tsunami wavelength to be recorded at a monitoring site to be able to verify tsunami generation. This can use up valuable warning time during an event. In contrast, tsunami warning systems based on a forecast model only require a preliminary indication of a sea-level anomaly for the sea-level observations to verify the generation of a tsunami as forecast by the models. A measure of the full wavelength can subsequently be utilized by data assimilation or visual comparison to validate or modify the initial tsunami threat forecast. Given the forecast model requirements, the physical nature of tsunami waves, the different scales of tsunami effects, the timing and the practical requirements for issuing warnings, the Inter-ICG Task Team developed the following basic requirements for sea-level observations in tsunami warning systems:

Core Data Requirements:

- Sampling – for a coastal tide gauge <1 minute; for a deep-ocean tsunameter 15 seconds. Accuracy – for a coastal tide gauge ±10 cm (±1 cm for multipurpose monitoring); for a deep ocean tsunameter ±1 mm.
- Transmission frequency (relative to distance/travel time from source) – <1 minute (local tsunami) for a TTT of <15 minutes; <5 minutes for a TTT of <1 hour or 100 km distance from tsunami source; <15 minutes for a TTT of >1 hour or 100 km distance from tsunami source.
- Internal latency – <2–3 minutes.
- Principles governing the design and implementation of sea-level monitoring networks in support of tsunami warning systems:
- Scientific aspects – design to minimize tsunami verification time and to maximize warning time and resource utilization; a network must be ocean-basin specific, recognizing the different tsunami sources and warning-time imperatives.

- Combined coastal and deep-ocean monitoring – Coastal tide gauges can be used to: verify generation of a tsunami; provide information on the local response to a tsunami generated by a nearby or far-field source; monitor after the tsunami threat has passed. The local response signal from coastal tide gauges is difficult to use to verify offshore tsunami wave characteristics required for tsunami forecast verification. Deep-ocean tsunami detection buoys ("tsunameters") provide best information on open-ocean tsunami wave characteristics (signal conditioning by shallow-water bathymetry); this tsunameter information is therefore the most appropriate for comparison with, or assimilation into, numerical tsunami models to forecast wave heights and basin-wide propagation characteristics.
- Verification of tsunami generation near the source – warning-time requirements dictate a need for sea-level measurement sites to be located as close to the source of the seismic event as possible.
- Delays in monitoring the progress of the wave due to the wave travelling over shallow depths or through harbour choke points should also be avoided; but the siting should not be so close to the source that the station could be destroyed by the initiating quake.
- Tsunami propagation across an ocean basin – the progress of the tsunami wave must be followed by the tsunami warning service to allow refinement of the warnings and to provide the most accurate predictions of impacts. Sea-level data are important for data assimilation into and verification of forecast models. Inverse modelling of the sea-level data can also be used to verify calculations of the seismic source.
- Verification of tsunami impacts – the tsunami warning service also requires sites for verification of the impact of a tsunami and post-analysis of the event. Tsunami forecast models are very accurate, but still lack detailed bathymetric data at the coastline, so coastal observations are required to facilitate correlation of deep-water observations with onshore impacts.
- Continuity of observations – prompt availability of data is necessary, hence a requirement for accessibility to communications systems and for easy access for station maintenance; if the location is very remote, the likelihood of a rapid return to service after a failure is reduced. Built-in redundancy in monitoring stations can help allow for possible station downtime; otherwise the warning service capability (warning imperative) may be compromised, especially in the case of deep-ocean tsunameters.
- Free and timely data access – warning services require a constant flow of reliable and timely data; the data must be available and in good order whenever required, which places a high demand on the data-collection platforms and communications to ensure a near-100 per cent data availability.
- Warning services also require high-frequency data, ideally at 1-second intervals, which in turn demands reliable data transmission, hence reliable and economic communications at sensor locations.

The Task Team also considered the specific requirements for each major ocean basin and for each major component of tsunami warning system operations: criteria for siting stations; instrumentation; data exchange and archiving; real-time monitoring; quality assurance; and performance monitoring.

Discussion

On the question of whether deep pressure recorders were used in warning systems, the response was yes, but the TOWS-WG is not strongly prescriptive in this respect.

9. OVERVIEW OF THE GLOSS IMPLEMENTATION PLAN

Mark Merrifield briefly reviewed the present draft of the updated GLOSS Implementation Plan (GIP 2012). GLOSS has been operating on the Implementation Plan from 1997 [IOC Technical Series, 50]. The update of this plan was started at the GLOSS-GE-X and continued at the GLOSS-GE-XI. The Plan was originally drawn up in 1997. Since the 1997 plan was developed there has been much progress in the area of tide gauge and co-location with GNSS stations, and the use of tide gauges for calibration of satellite altimeters. Following the 2004 Indian Ocean tsunami GLOSS has also engaged in collaboration with the regional tsunami warning systems and worked on upgrading many stations to high-frequency sampling and real-time data transmission. Taking into account the results of the present session of GLOSS, the GLOSS Implementation Plan will be finalized at the beginning of 2012 as IOC Technical Series, 100.

Discussion

The Group of Experts recognized that the upgrading of sea-level stations to allow monitoring for tsunami, storm-surge and other hazard warning systems, and particularly for stations to become eligible for the GLOSS Core Network, was placing a heavy burden on station operators in terms of repair, maintenance, technical updating and data management, as well as cost. High-frequency data were a particular problem and help in this respect was needed. The NOAA National Geophysical Data Center (NGDC) (Paula Dunbar) could help, although the NGDC is specialized in specific real-time events.

The Group of Experts agreed that GLOSS could provide help to operators and data centres, and that a particular effort should be made to automate certain procedures, whether at the monitoring end or the data-transmission end.

Regarding data management, the Group of Experts recognized that the real problem is not the archiving, but the use to which the data and data products are put. It considered that the promotion of GLOSS data products is important as a means of raising the awareness of governments and of the general public of the importance of sea-level measurement, hence of the need to maintain stations in as full an operational state as possible. One way of doing this is to exploit extreme events (like major tsunamis) and the associated warning function of the media. It also considered it necessary to maintain key maps, especially of sea-level station networks, constantly up to date as stations change their status (e.g. fully operational or non-operational; data communication breakdown; removal, replacement or relocation).

The NGDC could also help in terms of GLOSS data products. It is necessary to identify more clearly who are the key stakeholders in the exploitation of GLOSS data and data products. The possibility and feasibility of charging users for data and data products was raised, but the Group of Experts believed that this would probably raise the need to modify the IOC data exchange policy, which went beyond the Group’s remit.

The Group of Experts concluded that there is a need to increase budgetary sources for station operation. The users of the GLOSS networks should press for long-term funding. Nevertheless, it agreed that the problem also needs to be addressed at the level of the UN system itself.

GLOSS could make a stronger case to the IOC Member States, though differing needs in different Member States should be kept in mind. National commitments to GLOSS need to be sustained and the role of national contacts for GLOSS needs to be clarified.

The question of internal GLOSS organization was also raised. The Group of Experts recognized that its members could continue to help to bridge gaps, reduce loss of data. It also considered it important to follow the evolution of station networks more closely and to address the related problems more quickly. The Group agreed that the Chairperson was now being expected to do far more intersessional work than in the past and that such work should be wider spread to include other members of the Group of Experts who would volunteer to undertake specific agreed tasks intersessionally and report to the Group of Experts at its next session. The Group of Experts agreed to study the question of defining more precisely the role of the Chairperson, particularly in terms of his/her co-operation with the Technical Secretary. It recognized the need for ensuring better GLOSS representation at major, relevant scientific meetings, for better communications amongst the members and officers of the Group themselves and with national contacts, as appropriate.

To the suggestion that the Group could designate two Vice-Chairpersons to share the intersessional work with the Chairperson, the Group of Experts agreed that this would complicate arrangements and possibly introduce considerations other than purely scientific and technical ones.

The Group of Experts regretted the fact that the Technical Secretary was no longer assisted in the IOC secretariat, following the return of Belén Martín Miguez to Spain after completion of her temporary employment at the Secretariat, and expressed the hope that another Member State would offer to second a suitably qualified professional to the Secretariat to assist the Technical Secretary responsible for GLOSS.

The Group of Experts also opposed a suggestion to revive the GLOSS Bulletin, mainly because it involved too much intersessional work relative to its usefulness.

10. NATIONAL AND REGIONAL SEA-LEVEL ACTIVITIES

Several regional and national reports were presented and are available on the GLOSS-GE-XII meeting website.

10.1 EUROPE

Philip Woodworth provided a review of the situation concerning coordination of sea-level observation in Europe. This review was provided in light of the fact that the former European Sea Level Service (ESEAS) has ceased.

The last few years have not been easy for European sea-level work, with the demise of the ESEAS activities and the moribund state of MedGLOSS. However, there continues to be a clear societal demand for monitoring, understanding and predicting sea-level changes and therefore a need for the best possible European sea-level data. There is also scientific research interest, as demonstrated by the steady stream of publications on European sea level in spite of all the difficulties, and by the high attendance at the recent Workshop on Unresolved Issues in Mediterranean Sea Level Research, at the University of the Balearic Islands, Palma de Mallorca, 30 May–1June 2011
http://imedea.uib-csic.es/proyecto/sealevel/finalreport_archivos/final_report_v2.pdf.

So what is the best way forward in these organizationally and economically difficult times?

The elements of European sea-level infrastructure are, as before:

1. A mechanism for the exchange of real-time sea-level information from national agencies.
2. A mechanism for the exchange of delayed-mode information for science and other off-line analyses.
3. A mechanism for the exchange of GPS data at tide gauges.
4. A community mechanism by which interested people could meet to exchange ideas on new

science and technology, decide on standards and data provision and, most importantly, represent the region in GLOSS. This community can be considered both institutional (e.g. a ‘club’ of tide-gauge agencies rather like the EOSS Cost Action was) and scientific, with a mixture of both at different times.

Concerning International Real Time and Delayed-Mode Sea-Level Data Exchange then the real time sea level data exchange is relatively well established in Europe and several services are in place as it will be evident from this GLOSS meeting. There have been a number of models for implementing delayed-mode data exchange in Europe. However, the best one (as was clear by the time of the end of ESEAS) is when those data which national agencies wish to make available are placed on an accessible server and ‘pulled’ by a central server to a database.

A prototype web portal server for European delayed-mode data has operated at BODC for a couple of years using data from the UK and a small number of other countries (notably Spain) and the mechanism now needs to be expanded. Each national agency would make its data available in a specified format (similar to the ESEAS format), together with metadata, that would be pulled into the BODC portal.

Such a mechanism is relatively efficient in terms of staff effort, as most of the QC of the data is done at the national agency (BODC will define QC standards and formats following experience in ESEAS). The portal is then able to handle automatically the user registrations, monitor downloads and report back regularly to the national agencies on how much their data are being used. However, it is not feasible to have any kind of system without some staff effort; e.g. to send regular reminders to agencies to update their data directories or resolve queries about data or metadata. BODC could provide that minimum staff resource.

The portal should be able to generate MSL values from the submitted data, with those values being transmitted to the PSMSL. However, in the medium term, it would be more realistic to expect continued separate submissions of MSL data from agencies to the PSMSL.

Concerning international exchange of GNSS data then mechanisms for GNSS data exchange exist for high-accuracy positioning applications like the geodetic monitoring of tide gauges. These have been built on and around the International GNSS Service (http://igs.org) since 1994. Most agencies having networks of GNSS stations have followed its standards for collecting and archiving the measurements in a receiver-independent exchange format (RINEX) at local, regional and global scales. The IGS provides a well tried international infrastructure for exchanging, archiving and analysing GNSS data that a specific community may take advantage of, setting up dedicated pilot projects, working groups, and using the IGS pre-existing network infrastructure (data fluxes, analyses expertise, etc.). However, whereas a community may benefit from the expertise and infrastructure of the IGS, it should be highlighted that the installation of GNSS stations and provision of the data and metadata are the responsibility of that (motivated) community, as well as the definition of the relevant outcome products of the GNSS analyses and of their standards which may be based on the IGS solution independent exchange format (SINEX) or a derivation. The latter being said, the IGS pilot project TIGA concerned with GNSS tide-gauge benchmark monitoring has developed into being an IGS working group since 2011. In addition to a certain lack of motivation or resources from the tide-gauge agencies to install GNSS stations at tide gauges and to make them freely available to everyone, as requested by WMO, IOC or IPCC for climate and environmental research activities, and to some general everlasting issues of GNSS metadata file format or GNSS log-files, a dedicated GNSS at tide gauge data assembly centre is lacking. This centre would fulfil what the IGS will certainly not do: i.e. to supplant the tide-gauge community, its interests, motivations and duties, providing the data and metadata at tide-gauge stations, as well as making the sea-level community aware of these geodetic issues; defining the products, formats, etc. A prototype web portal server of such a data assembly centre has been set up (i.e. the SONEL http://www.sonel.org) in an attempt to bridge the PSMSL and IGS services. PSMSL and SONEL have started working together. SONEL also participates in the consultations with the three other GLOSS data centres (PSMSL, UHSLC and the Sea Level Station Monitoring Facility). However, the resources of SONEL should be developed and assessed. France has agreed to provide these for a 4 year period starting in 2011.

Concerning community activities then the Workshop on “Unresolved issues in Mediterranean Sea Level” (Palma de Mallorca, 30th May – 1st June 2011; http://imedea.uib-csic.es/proyecto/sealevel/index.html), was successful in demonstrating the interest and need in meetings of interested European sea-level people. The organization of regular meetings is a key to the creation of a European forum for sea-level researchers of many different but complementary disciplines, together with users and agencies. The meetings serve to enhance communication, to exchange the latest scientific information or to facilitate the participation of agencies and countries that have traditionally been outside the community (e.g. those along the North African coast). Ideally, a series of meetings should have its own regular calendar.

Many models for meetings could be followed; e.g. they could take place alongside the regular (2 yearly) GLOSS Group of Experts meetings or the (annual) European Geosciences Union meetings in Vienna. On the other hand, many people will recall the days of EOSS when meetings were held in a different institution each time with the host responsible for the agenda etc. and the baton passed to the next host. Although this way of working is perhaps more suitable for researchers than for service agency people, it has worked well in other programmes (e.g. MedCLIVAR).

Philip Woodworth concluded that there is not at the moment any best model for how the European sea-level community might be in the future. It is also clear that there is no central source of funding for travel and no central bureau to do the organizing. Even if no central bureau exists, it may be desirable to have some kind of central steering committee. Finally he suggested that the GLOSS-GE should discuss sea level observation and science for the European region as a whole, including the European Arctic and the Atlantic islands, and logical extensions to, for example, North Africa, without the programmatic boundaries that have plagued the Group in the past. For the moment the Group of Experts could build on 1–4 above and see how it goes.

Discussion

The Group of Experts acknowledged the fact that EuroGOOS is considering a mechanism for European sea-level network and science coordination. A report on this matter is in preparation by EuroGOOS so it would appear appropriate to also consider such a mechanism before proceeding.

Linked to the presentation of Philip Woodworth, Elizabeth Bradshaw (PSMSL, Liverpool, UK) gave a presentation on the prototype European delayed-mode database at BODC. She stressed the fact that the delayed-mode database did not conflict with the database held at the Flanders Marine Institute (VLIZ), which was concerned with real-time data. She described the mode of access to the European delayed-mode database and reminded the Group of Experts that the quality control of the data in the database remains with the authority providing the data.

Discussion

There was no discussion on this point.

10.2 MEDGLOSS

Dov Rosen gave an update on MedGLOSS since the Eleventh Session of the Group of Experts.

All MedGLOSS stations provide data according to GLOSS standards, as will RT (real-time) data stations. Minimum requirements for old data were: hourly averaged sea-level and atmospheric-pressure values. All NRT (near-real-time) stations are required to have their bench marks monitored by GPS, preferably by Continuous GPS stations. NRT stations usually have a low-latency sea-level data-gathering capacity. Five stations were upgraded to RT mode using new RT logging software and transmission equipment, developed by the MedGLOSS focal centre (http://medgloss.ocean.org.il/) with ICSEM (International Commission for the Exploration of the Mediterranean Sea) and IOLR (Israel Oceanographic and Limnological Research Ltd.) funds.

The MedGLOSS website is being upgraded, to be able to hold data, tools and software. RT data will be provided, including preliminary quality control.

The MedGLOSS focal centre has developed a WINDOWS user-friendly interface based on the POL (now NOC Liverpool) tidal package TASK 2000 and called Tide Tasks for Windows (TT4W) to aid tidal analysis and forecasting; however, it only supports hourly data. TT4W version 2, working under WINDOWS 7 and MS EXCEL 2010, was developed, enabling analysis of up to a one-year cycle of sea-level data of unlimited length, at up to 3-minute data intervals. It is now undergoing debugging in preparation for its dissemination to qualified users of the sea-level monitoring community and for educational purposes, under an agreement between the UK Natural Environment Research Council and IOLR.

The IOLR hosted a training workshop in January 2010 on the operation of the upgraded equipment and software for the operators of the upgraded stations. RT data transmission of four 15-second averaged samples per minute started at the Portomaso and Paphos stations in summer 2010, followed by the Kacively and Constanta stations in 2011. At the same time, the MedGLOSS focal centre upgraded the Hadera and Ashdod stations, starting RT transmission at Hadera in spring 2010 and at Ashdod in spring 2011. The IOLR station at Elat in the Gulf of Aqaba (Red Sea), though not formally a MedGLOSS station, was also upgraded recently and will start RT transmission in late November 2011. By late 2011, a new RT transmission sea-level station will start to operate at Ashkelon port; it is presently under construction by IOLR. In addition to the RT stations upgrade, an additional software package is being developed by the focal centre for quick in situ detection of various sea-level-based hazards and alert via the Internet. The software is expected to become operational in 2012, depending on funding availability.

The approach used for detection of hazards from sea-level signals consists of: monitoring, in parallel to sea level, additional parameters – atmospheric pressure, wind gusts, short and long waves; monitoring long-term mean conditions to be able to distinguish fast or significant changes from the background state, after removal of astronomic tide; using five sliding windows on the monitored data, to be able to detect early changes over the whole range of tsunami periods: 5-minute, 10-minute, 20-minute, 60-minute, and 3-hour windows; and routine spectral, cross-spectral and trend analyses of the data, as well as comparison of the changes every few minutes against the mean values of the five sliding windows.

Discussion

To the question as to what sea-level sensors were being used in this particular sea-level network, Dov Rosen explained that a full range of sensors was being used, with the exception of laser devices, which had not proved successful. All instruments/sensors are checked and calibrated once a year. In the event of a tide-gauge replacement, an accuracy of 1 millimetre was being achieved. Besides sea level itself and the usual parameters associated with sea-level measurement, atmospheric pressure is now routinely recorded at MedGLOSS stations.

10.3 RED SEA

Yasser Abualnaja (Red Sea Science & Engineering Research Centre, King Abdullah University of Science & Technology—KAUST) reviewed the situation in the Red Sea and in particular for the Saudi Arabian network. (Reference was also made to the technical visit report by Chérif Sammari (Tunisia), in 2004 (http://www.gloss-sealevel.org/publications/documents/red_sea_visit_report_december_2004.pdf).

At present, only the Aramco Oil company maintains regular monitoring of mean sea level in the Red Sea. After 1993, the float tide gauges were replaced by acoustic tide gauges to GLOSS standards. Since 1998, five Aramco tide gauges (Sonar Research Ltd) in the Red Sea (Jeddah, Rabigh, Yanbo, Jazan and Duba) transmit data in real time to the Ras Tannura office (Saudi Arabia), where they are archived and processed.

PERSGA (Regional Organization for the Conservation of the Environment of the Red Sea and the Gulf of Aden) and ROPME (Regional Organization for the Protection of the Marine Environment) both cooperate with Aramco in this endeavour and have plans to develop a framework for the conservation and management of the coastal and marine resources of the Arabian (Persian) Gulf and the Red Sea, though with little or no interest in sea-level monitoring.

Saudi Arabian tide gauges at Jeddah and Alwajh have problems due to inadequate maintenance, and those at Jazan and Haql are, apparently, not currently working.

The Saudi Arabian General Commission of Survey (GCS) has developed a broad plan to establish a tide-gauge network to monitor the sea level in the Red Sea and the Arabian (Persian) Gulf and is proposing to conform to GLOSS standards; six stations will be deployed along the Red Sea and one in the Gulf of Aqaba. Data collections held by the GCS are in accordance with the standards set by the International Council for the Exploration of the Sea (ICES).

Nevertheless, at present, tide-gauge benchmarks are not connected to a geodetic datum, but calibration and levelling are carried out regularly. Also, at present, tide-gauge data are being used exclusively for purposes of safe navigation. Saudi Arabian universities are also planning to establish tide-gauge networks.

Discussion

Yasser Abualnaja reassured the Group of Experts that Aramco support for the maintenance of its tide-gauge station was long-term. The Aramco data have been carefully assessed using IOLR software. Egyptian scientists have also studied sea-level fluctuations in the Red Sea from one end to the other, using satellite altimetric data. Regarding the development of the Red Sea tide-gauge network, KAUST is intending to set up a station in the Red Sea and to promote cooperation with Egypt and Sudan in the monitoring of sea level there.

10.4 AFRICA

Angora Aman (University of Cocody, Côte d'Ivoire) reviewed the status of tide-gauge stations in Africa (except the Mediterranean), which he and Charles Magori (Kenya Marine and Fisheries Research Institute) had prepared.

Numerous African coastal cities are at risk due to sea-level rise; the principal danger being coastal zone erosion. Africa has about 40 GLOSS sea-level stations, and as many others that do not yet meet GLOSS criteria.

Regarding collocation of tide-gauge stations with GNSS capability, selected stations in Takoradi (Ghana), Inhambane and Pemba (Mozambique) are collaborating with the Instituto

Geofísico do Infante D. Luís, Lisbon, Portugal, in the installation of a Global Navigation Satellite System (GPS, GLONASS and GALILEO) receivers, with a view to: determining the connection between the horizontal and the vertical datum; monitoring in situ crustal motion; deriving absolute or climate-related signals in mean sea level from the tide records; and determining whether the tide gauge is sinking into the harbour or the mean sea level is rising.

In closing Angora Aman emphasized that there are considerable challenges and that environmental monitoring is, at present, failing, owing to a lack of resources for station maintenance. Unfortunately, the mistakes made in the other parts of the world in sea-level station operation are being repeated in Africa. The lack of maintenance of the tide-gauge network represents a great danger for GLOSS in Africa.

Discussion

The Group of Experts agreed that there is a need to increase the number of tide-gauge stations in Africa, but to do this a significant amount of technical support would be necessary, the more so if these stations were, in due course, to become multi-purpose for general hazard-warning and were to be considered for eventual participation in the GLOSS Core Network. The Group acknowledged that station failure was common and widespread and, wherever feasible, the Group's members and their institutions should provide as much technical help as possible to maintain stations in full operation. The Group welcomed the establishment of the stations that had been established under the IOC's ODINAfrica-III project. The Group questioned the establishment of a tide-gauge station at Lagos, Nigeria, which is strongly influenced by a major river discharge, but accepted the explanation that its purpose included concern for the busy maritime shipping in and out of Lagos Harbour.

Concerning African sea level monitoring also see agenda item 11.3 on the WMO project on strengthening marine meteorology observations in NW Africa.

10.5 NATIONAL REPORTS

Twenty-two national reports were made available (see list in Annex IV and http://www.ioc-goos.org/glossge12); 11 were presented during the session and are briefly summarized here in alphabetical order (of UNESCO country names in English).

Chile

Juan Fierro presented the Chilean national report. On 27 February 2010, a devastating earthquake (M 8.8) struck Chile, triggering a tsunami which crossed the Pacific Ocean. Chilean experience with earthquakes has shown that sea-level stations are also strong tsunami detection systems, providing a potential warning time of minutes to hours, depending on proximity of source. The following lessons have been drawn from this experience: sea-level stations should have stronger mounting structures, to be able to resist catastrophic tsunami waves; the data logger cabinet and data transmission antennas should be installed as high as possible and not near to existing buildings; submerged sensors should be fixed deep enough to provide sea-level data during recession of the sea; a backup sea-level sensor and an independent source of energy should be available; a secondary telemetry system should be deployed; and higher transmission frequency through a satellite link should be used.

Following the 27 February earthquake, seven new sea-level stations were established and 12 others were upgraded. Thirty-three new stations are being planned, with near-real-time data transmission, a sampling interval of 1 minute and telex transmission at intervals of 1, 5, 10, 15, and 60 minutes. The standard sensor configuration will cover sea level, water temperature, combined air temperature and humidity and atmospheric pressure. Three self-contained platforms will be established: at San Pedro, Puerto Soberanía (1 year backup), and Rada Covadonga.

The preferred water-level sensors are: the submersible PR-36XW for measuring hydrostatic level; and a QHR 102 radar water-level sensor (contact-free), insensitive to mud, driftwood, leaves, etc. and to fog and air temperature fluctuation, with low power consumption.

The preferred telemetry options comprise spread-spectrum radio (local), a mobile phone link (GPRS, for long distance) and mobile satellite links (GOES/BGAN, for remote areas). A direct readout ground station allows direct reception of data from GOES satellites without dependence on secondary links.

Thus, alternative systems for real-time data transmission using several telemetry options (GOES, BGAN, GPRS and a Wide Area Network) provide powerful support to the National Tsunami Warning System. The higher-frequency GOES transmission slots allow tsunamis to be followed in real time. The radar water-level sensor has demonstrated high reliability in several sea conditions as a back-up sea-level sensor (and as a potential primary sensor). The Servicio Hidrográfico y Oceanográfico de la Armada is recognized as a leader in the use of remote-data-collection systems. Densification has improved the Chilean sea-level data collecting network for operational and scientific purposes.

Discussion

On the question of calibration, Juan Fierro indicated the use of Vega radars, as well as comparison of the two kinds of sensors. Some participants remarked the huge investment required in the development of the Chilean tide-gauge network and questioned whether it was being matched by the scientific sea-level research, so as to take advantage of the current development. Juan Fierro believed it was. As part of the Chilean scientific response, the Universidad de Concepción will send data to PSMSL and UHSLC for scientific purposes.

Denmark

Per Knudsen (Danish National Space Institute – DTU Space) presented the Danish national report. The Danish Marine Institute (DMI), the Danish Marine Science Association (DaMSA), the Coast Directorate and some harbour authorities run about 87 tide gauges. The instantaneous sea levels, together with time-series for 8 days (2-day prognoses) are shown on the DMI web site (http://www.dmi.dk/dmi/index/danmark/vandstand.htm). Four stations are equipped with CGPS. Ten new stations will be installed by 2012, taking the total number to 97. Fourteen DMI stations are included in PSMSL network.

Land uplift is being assessed by precision levelling (relative to mean sea level) and permanent GPS stations. At present the mean uplift is 1.8 mm per year.

In Greenland, DTU Space is running tide gauges at: Pituffik/Thule; Ittoqqortoormiit/Scoresbysund; Qaqortoq/Julianehåb. All three stations are delivering data to NEAMTWS, via the IOC Sea Level Station Monitoring Facility (5 minutes), to UHSLC, and to PSMSL (GCN). GCN stations at Nuuk (225) and Ammassalik (228) closed down in 2002 and 2004, respectively.

In the Faroe Islands, the GCN at Torshavn (237), run by the DMI, broke down in 2006; a new station at the same location is being planned, to be operated by the Torshavn Harbour Authority. There is some delay, however, since this proposal is part of a wider political negotiation on meteorological information. Moreover, with the breakdown of the new government, the DaMSA was closed. The other partners concerned are: the Danish Maritime Authority; DMI – Oceanography (tide gauges, Palle Bo Nielsen); National Survey and Cadastre (KMS) – Hydrographic Survey; and the Danish Navy – Coast Guard, the Navy Centre for Operational Oceanography.

Discussion

It was remarked that Denmark was currently subject to a vertical tectonic rise of over a millimetre per year, which could compromise the establishment of an absolute sea-level. Per Knudsen explained that this uplift is in a roughly N–S direction and is being monitored closely. Otherwise, Denmark is satisfied with the performance of its GLOSS stations, especially those in Greenland.

France

Guillaume Voineson presented the French national report. There are GLOSS stations (and their numbers) at: Brest (242) and Marseille (205), in Metropolitan France; at Fort de France (204), Martinique, in the Caribbean; at Îles du Salut (202), Guyana, in the South Atlantic; at Dzaoudzi (96), Comoros, and at Pointe des Galets (17), La Réunion, both in the Indian Ocean; at Noumea (123), New Caledonia; at Papeete (140), Rikitea (138) (all in French Polynesia); Clipperton Island (165) in the eastern Pacific; Niku Hiva (142), in the Marquesas; at the Kerguelen Islands (23), the Crozet Islands (21), Saint-Paul Island (24), all in the southern Indian Ocean; and Dumont d'Urville, in the Antarctic. A new radar and pressure-gauge station, collocated with GPS, was installed at Leava, Futuna Island, Wallis and Futuna, in the Pacific in October 2011. And a new GCN station has been proposed for Toamasina, Madagascar.

The Service Hydrographique et Océanographique de la Marine is the French national sea-level coordinator since 2010, through the Réseau de référence des observations marégraphiques (REFMAR). The Système d'Observation du Niveau des Eaux Littorales (SONEL) is the French contact for PSMSL. It provides daily, monthly and annual mean sea level and follows their trends; it also monitors benchmark stability by collocated GPS and conducts data archaeology to build longer time-series.

Discussion

Regarding the data management, the question was raised as to whether the REFMAR (Réseau de référence des observations marégraphiques) and the GLOSS databases overlapped significantly. REFMAR exports sea-level data to PSMSL and UHSLC, but there is no duplication of products.

As to plans to develop two stations in Madagascar (at Nosy Bé and at Toamasina), it was found that the antennae were too close to the ground or to the GPS receiver, resulting in too high a level of interference, hence presenting a risk for data transmission.

Much interest was expressed in gaining access to the Djibouti station. This should be possible, since it was installed by the IOC and the French Service Hydrographique et Océanographique de la Marine (SHOM) is currently helping to level it.

Germany

Christoph Blasi (German Federal Institute of Hydrology) presented the national report of Germany. The responsibilities for national waters are divided between federal and state (Länder) governments. For coastal waters, two federal agencies are involved in water and environmental issues: the Bundesamt für Seeschifffahrt und Hydrographie (BSH; Federal Maritime and Hydrographic Agency); and the Bundesanstalt für Gewässerkunde (BfG; Federal Institute of Hydrology). The BSH is mainly concerned with: prediction of tides, water levels and storm surges; monitoring of the marine environment; prosecution of environmental offences; and improving knowledge of the oceans. The BfG is responsible for the German waterways in federal ownership; it advises federal ministries (e.g. the Federal Ministry of Transport, Building and Urban Affairs) and, among other national entities, the Federal Waterways and Shipping Administration (WSV) regarding the utilization and management of the German federal waterways. The WSV operates a network of gauging stations in coastal and inland waters. Some Länder and some harbour authorities operate their own tide gauges.

At present, all tide gauges measure the water level with a float-system in a stilling well. The mechanical signal of the float is transformed by an angle encoder into electrical signals to make them ready for data transmission. Sea-level data from seven tide gauges (Borkum, Helgoland, Hörnum, Cuxhaven, Kiel Holtenau, Warnemünde, and Sassnitz) go via Web Services to the Sea Level Station Monitoring Facility; four North Sea gauges (Borkum, Helgoland, Hörnum, and Cuxhaven) serve the ICG/NEAMTWS. BSH is the German national Tsunami Warning Focal Point

To improve the quality of data, a quality-management scheme is being developed and will be introduced in Germany. The following principles will be applied: the statistical estimation of the uncertainty and the maximum systematic error of every measured parameter should be quoted; the quality of the collected data should be checked in the light of the measurement method applied and over the whole procedure of data collection; the essential parametric data, including the corresponding statistical uncertainties should be safely stored for future generations; and, if official data and parameter values are stored in digital databases, it must be ensured that they cannot be modified or manipulated.

On-going research is mainly concerned with: sea-level increase; exploitation of tidal and wave energy; changes in coastal and offshore currents; changes in coastal and estuarine morphology; changes in sea chemistry, and relocation of environmentally protected areas.

Investigation of historical trends in sea level has shown that they are non-linear and with no significant acceleration in the period 1908–2008. However, there was a short-lived decline around 1970 and, in the last 20 years, a relatively strong acceleration. Study of the interaction of wind-waves and currents in estuaries, with a focus on climate change, is ongoing.

Discussion

To the question of how to remove the effect (on sea-level measurement) of river flow, Christoph Blasi indicated that it depended on the primary use of the tide-gauge information; in certain cases the main interest was in river navigability rather than region-wide mean sea level as such. So not all German tide gauges were useful for GLOSS.

Indonesia

Khafid (Center for Geodesy and Geodynamics) presented the Indonesian national report. Ten tide gauges are being operated in cooperation with Germany; and another 10 in cooperation with IOC/UHSLC. The operation of 93 other tide gauges is financed by the Indonesian Government.

The Indonesian Sea Level Monitoring Network prior to the 2004 Sumatra tsunami consisted of 53 stations, of which 28 stations were using analogue graphical chart recorders and 25 stations were using digital recorders with a Public Switch Telephone Node (PSTN) data connection.

Twenty-three new tide gauges are being installed; the purpose is to: complete the grand design for the Indonesia Tsunami Early Warning System (InaTEWS); monitor the effects of global climate change on Indonesian waters; provide fundamental data for the development of the National Spatial Data Infrastructure. Mean sea level, the lowest astronomical tide and the highest water levels are determined for survey and mapping purposes.

Discussion

To question of whether the Indonesian tide gauges were working well or were subject to hysteresis, Khafid informed the Group of Experts that hysteresis was not a problem; nevertheless, only 80% of the original stations in the Indonesian network were still operational and of these, 50% have some mechanical problems, mostly attributable to flooding damage to the gauges. Regarding data transmission, Indonesia was cooperating with Germany to improve such transmission; the PECAN and Ariane satellite systems were being used at present.

Japan

Yohko Igarashi (Japan Meteorological Agency) presented the Japanese national report. Tide-gauge stations are being operated by the Japan Meteorological Agency, the Japan Coast Guard, the Geographical Survey Institute, the Ports and Harbours Bureau, the Water and Disaster Management Bureau (WDMB), and some other organizations. There are 16 radar tide-gauge stations, 28 acoustic tide-gauge stations, 30 float tide-gauge stations, and a hydraulic pressure tide gauge on Marcus Island. Fourteen Japanese tide-gauge stations are in the GLOSS Core Network.

JMA stations collect raw data, record hourly sea levels and deviations, high/low tide levels. JMA computes monthly and annual means and extreme values. Hourly data are sent to the GLOSS fast-delivery data centre (UHSLC), and monthly mean data are sent to PSMSL.

Data from other stations are used for disaster prevention and various analyses: real-time sea-level monitoring; calculation of tidal harmonic constants and astronomical tides; storm surges, tsunamis, unusual tides; and long-term sea-level change (with GPS data). The latter is monitored by the GPS Earth Observation Network System (GEONET). The Geographical Survey Institute has established about 1,200 GPS-based control stations throughout the country. Land movement in Japan is monitored daily by GEONET. GPS stations near GCN stations in Japan are part of GEONET.

Observational data thus obtained are made available for current survey work and for the study of earthquakes and volcanic activity. Real-time data from the Ofunato and Naha tide-gauge stations are available via GTS. The Ofunato station is being rebuilt and reinstalled in a slightly different place.

Discussion

In response to a query on data transmission, Yohko Igarashi informed the Group of Experts that the JMA was considering sending its sea-level data to the GLOSS Data Centres. Japan's interest was directed not only to the monitoring of sea level, but also to the determination of tsunami wave heights. To this end, the JMA would set up a new sea-level monitoring system, starting next year; station sensors would include pressure gauges. The GPS tide gauges were maintained by other organizations than the JMA, in Japan.

Mexico

Jorge Zavala Hidalgo (Universidad Nacional Autónoma de México – UNAM) presented the Mexico national report. The national institutions engaged in sea-level monitoring in Mexico are: the Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California (CICESE); the Mexican Navy (Secretaría de la Marina—SEMAR); and UNAM. CICESE operates stations mainly in the northwest part of the country, including Baja California and the Mexican Pacific islands. SEMAR operates stations in most parts of the Mexican coastline. UNAM operates stations in most of the country except the northwest.

An effort is being made to rehabilitate the network (at least 18 sites, currently 22), organize the data base and the web site, digitize archived marigrams, and enhance collaboration with relevant national and international institutions. Data processing is still too slow, but efforts are now being made to speed it up.

Discussion

There was no subsequent discussion.

Portugal

Joana Reis (Portugal Hydrographic Institute—IHPT) presented the Portuguese national report. The IHPT serves as the Portuguese Navy's ocean science laboratory. Established in 1960, its main responsibility is the installation and maintenance of tide-gauge stations, as well as acquisition, processing, archiving and dissemination of sea-level data. It also publishes the official Portuguese Tide Tables. The IHPT sea-level database was upgraded in 2010–2011 to be able to receive data in real time.

GLOSS stations have been established in: Cascais, Lisbon; Funchal, Madeira; Santa Cruz das Flores, Lajes das Flores, and Ponta Delgada, all in the Azores.

The Portuguese Geographic Institute operates the Cascais station; a float gauge installed around 1881 is still working and an acoustic tide gauge was installed in 2003, 250 m away from the float gauge. The sampling interval is 3 minutes (for tide) and 5 seconds (for NEAMTWS). A permanent GPS station is installed near the two tide gauges. Data are available in near real time at http://www.vliz.be/gauges/map.php and ftp://www.igeo.pt/Cascais/maregrafo.

One analog and one digital float tide gauges are installed at Funchal; the digital gauge has a sampling interval of 6 minutes, with a mobile phone connection every 2 days to download data. A radar sensor will be installed by the end of 2011, recording one-minute averages and sending them in real time through a GPRS connection. An acoustic tide gauge was installed in Caniçal, near Funchal, in December 2007, with a sampling interval of 1 minute. It is awaiting levelling work between the Funchal and Caniçal stations.

The station at Santa Cruz das Flores was destroyed by a heavy storm in December 2010. The float gauge station at Lajes das Flores is now the only station on Flores Island. It has a sampling interval of 6 minutes. The IHPT will start sending sea-level data to GLOSS and PSMSL from Lajes das Flores from 2006 to the present. IHPT plans to upgrade this station (radar gauge and one-minute averages in real time).

The Ponta Delgada station has radar, pressure and float gauges installed by the UHSLC, with a sampling interval of 1 minute for the radar and pressure sensors, 5 minutes for the float gauge. This station is part of NEAMTWS and has a permanent GPS station 1550 m away. Data are available in near real time at:
http://www.vliz.be/gauges/map.php and http://ilikai.soest.hawaii.edu/RSL1/index.html.

Elsewhere, one station has been deactivated, due to harbour construction, and six others have been upgraded with radar sensors with 1-minute sampling. Real-time sea-level data are sent directly to IHPT through GPRS.

Portugal will continue upgrading its sea-level network through the installation of radar sensors, 1-minute sampling interval and real-time connections to the stations. Besides Funchal, sea-level stations at Leixões, Figueira da Foz, Vila Real de Santo António and Lajes das Flores will be established by early 2012. More stations will be incorporated into the NEAMTWS. Automatic

QC procedures will be introduced and cooperation with the Portuguese-speaking countries of Africa will be pursued.

Discussion

Questions on the state of specific stations were raised and specifically answered.

Russian Federation

Oleg Nikitin presented the national report of the Russian Federation. The Russian Federation currently operates 12 GLOSS coastal stations reporting delayed-mode data (Barentsburg, Spitzbergen; Dikson, Kara Sea; Kaliningrad, Baltic Sea; Mirny, Antarctica; Murmansk, Barents Sea; Nagaevo Bay, Sea of Okhotsk; Petropavlovsk-Kamchatsky, Bering Sea; Port Tuapse, Black Sea; Providenya, Barents Sea; Russkaya Gavan, Kara Sea; Tiksi, Laptev Sea; and Yuzhno Kurilsk, Sea of Okhotsk). At present, no Russian sea-level gauge has an associated GPS receiver, but short-term vertical and horizontal benchmark coordinates are determined near points of sea-level observation in the Baltic Sea using GPS/GLONASS receivers.

Recently, a network of sea-level gauge stations of the Russian Tsunami Warning System was established along the Russian coasts of the Far Eastern Seas. They produce real-time data at a 1-minute interval. Though this network targets tsunami warning, some of these stations could be also included in the GLOSS real-time network. This possibility is under consideration.

Regarding real-time sea-level data, two Russian stations in the Baltic Sea (Kronstadt and Saint-Petersburg) were reporting such data to the Baltic Operational Oceanographic System (BOOS). Another BOOS station on Hogland Island, Gulf of Finland, was added to BOOS in 2010; it is operated by the St. Petersburg Centre for Hydrometeorology and Environmental Monitoring. The gauge is a Russian-manufactured (GMU-2) wave, sea-level, atmospheric pressure and temperature recorder with a quartz hydrostatic pressure sensor. The Hogland data show a good coherence with those from the nearest Estonian station. Real-time data from seven Russian stations in the Far Eastern Seas are accessible through the IOC SLSMF: http://www.ioc-sealevelmonitoring.org/map.php.

Once per year, the Russian Responsible National Oceanographic Data Centre (RNODC) in Obninsk (Kaluga region) provides the monthly mean sea-level values from the active stations to the PSMSL. The RNODC also sends monthly mean sea-level values from the Petropavlovsk-Kamchatsky station to the UHSLC, monthly.

Sea-level observations have been made at Russian coastal hydrometeorological stations over many tens and even hundreds of years. A rich collection of historical data has been accumulated, but most of them were collected before computers were in wide use and are therefore stored in a paper format; sea-level data from Russian seas have been available (in the RNODC) in electronic form only since 1977. A sustained effort is being made by the Russian Federal Hydrometeorology and Environmental Monitoring Service to convert the earlier data into an electronic format. A lot of historical monthly mean sea-level data from 113 Russia stations were delivered to the PSMSL.

It is planned to review the list of the national GLOSS stations reporting delayed-mode (climatic) sea-level data.

The Federation's National Contact Points for sea-level observations and GLOSS are: Oleg Nikitin, State Oceanographic Institute (SOI), for sea-level observations in the European part of Russia (Baltic, White, Azov, Black and Caspian Seas); Igor Ashik, Arctic and Antarctic Research Institute (AARI), for sea-level observations in the Arctic (Barents, Kara, Laptev, East-Siberian and Chukchi Seas); Youri Volkov, Director, Far-Eastern Hydrometeorological Research Institute

(FEHRI), for sea-level observations in the Far-Eastern Seas (Bering and Okhotsk Seas and the Sea of Japan) and the Pacific Ocean; Nicolay N. Mikhailov, Head, Oceanographic Data Centre, All-Russia Research Institute of Hydrometeorological Information – World Data Centre (WDC), for international sea-level data and information exchange. The SOI, AARI and FEHRI are responsible for periodical inspections and quality control of sea-level measurements made by regional and local subdivisions of the Russian Hydromet Service in the above-listed seas.

Discussion

Great interest was expressed in the status of the Hogland Island station and in the availability of real-time data from it. Oleg Nikitin reassured the Group of Experts that, in spite of a brief interruption, this station's data are now on-line. He reminded the Group that the station was in a remote location on an island and that storms and heavy ice hindered regular servicing; otherwise, this station is autonomous. Regarding the important question of how GLOSS might help to bring the Federation's Arctic stations back on-line, Oleg Nikitin indicated that these stations were being managed by Dr Igor Ashik, Arctic and Antarctic Research Institute (St Petersburg, Russia), and GLOSS should feel free to approach him for information.

Sweden

Thomas Hammarklint (Swedish Meteorological and Hydrological Institute—SMHI) presented the Swedish national report. The national sea-level system was modernized in 2005. A stilling well is the preferred technique, with steel wires and floats. Levelling is done once a year. And paper charts are used as a backup. The data logger stores 1-minute values on a flash memory card. Real-time data are validated weekly by an inspector on site; the data (10-minute values + hourly maxima and minima) are transferred to the SMHI hourly. The real-time data are quality-controlled and human quality control of data is performed continuously.

The two GLOSS stations are Stockholm, Baltic Sea, Göteborg-Torshammen, Kattegat. In addition to the two GLOSS stations, Smögen, Skagerrak, also contributes to the NEAMTWS sea-level network. All three have an associated CGPS. Land uplift is monitored continuously, so as to allow glacial isostatic adjustment. Sea-level records, corrected for land uplift, for 14 stations since 1886 were analysed.

Data are transmitted to PSMSL (yearly); European Sea Level Data portal (monthly); IFREMER/MYOCEAN (daily); GLOSS/VLIZ (hourly); BOOS (hourly); NOOS (hourly); SEPRISE (hourly). (See also www.smhi.se; www.boos.org).

The Swedish sea-level network has on at least two occasions (July 1959, May 1979) observed "sea jumps", the cause of which may have been meteorological and/or tsunami. Two factors seem necessary for these sea-level anomalies to occur: a frontal passage with the same speed as the long-wave velocity; and a uniform, moderate depth and a smooth bottom profile.

Discussion

A question on specific technical details was posed and answered.

USA

Richard Edwing presented the US national report. NOAA is responsible for the US National Water Level Observing Network (NWLON). The number of stations has increased from 200 to 210. Stations are multi-mission, for coastal and environmental planning and assessment, wetland restoration and monitoring, maritime navigation and safety, and marine forecasting. Hardened stations and single-pile platform design have been installed in areas of high vulnerability to coastal storms (e.g. Gulf of Mexico). NOAA maintains a tide gauge offshore (Oil Platform Harvest, Santa Barbara Channel, California) in support of altimeter calibration.

Stations transmit real-time data every 6 minutes, with 6-minute average water-level values, six 1-minute average water-level values. The six-minute average includes back-up water level and associated meteorological data. Stations also store 15-second water-level data.

NOAA sea-level stations also support a tsunami warning function; currently, 169 tsunami-capable NWLON stations are operational along all US coasts. NOAA's tsunami website (www.tsunami.noaa.gov) provides real-time high-frequency data to the public. NOAA also monitors sea level for storm-surge warning purposes, using microwave water-level sensors, since emergency managers, forecasters, first responders, and decision-makers rely on real-time sea-level data during surge events; real-time data and tidal datums are integrated into NOAA's SLOSH (Sea, Lake and Overland Surges from Hurricanes) model.

There are currently 43 NOAA-operated long-term sea-level stations in the USA within five kilometres of a Continuously Operating Reference Station (CORS), with a view to reducing uncertainty in altimeter drift estimation. Efforts are underway to increase this number, focusing on GLOSS stations as a priority.

NOAA now publishes long-term sea-level trends for 166 global stations in 59 countries. Additional products include: annual seasonal cycle; interannual variation; and variation of the 50-year mean-sea-level trend.

Regarding new capabilities, NOAA has developed a methodology to obtain long-term measurements in the Arctic. The NOAA Center for Operational Oceanographic Products and Services (CO-OPS) has developed a new exceedance probability tool to allow determination of extreme events. University of South Florida has made progress in unifying procedures for comparing any altimeter data set with tide-gauge records.

The UHSLC collaborates in the operation of 64 tide-gauge stations; it maintains three high-frequency data sets: the Joint Archive for Sea Level (JASL); a GLOSS fast-delivery database; and near-real-time data. UHSLC researchers completed a study of the spatial pattern of Pacific sea-level rise during 1993–2009 from satellite altimetry compared to previous time periods as sampled by the tide-gauge network; an analysis of extreme sea-level events, using the global array of tide-gauge data, is near completion.

The Puerto Rico Seismic Network (PRSN), University of Puerto Rico at Mayagüez (UPRM), operates 6 sea-level stations in Puerto Rico. In the Caribbean region, CO-OPS has installed a multipurpose tide station at Barbuda, and NOAA has established a Caribbean Tsunami Warning Program, as a first step in a phased approach to the establishment of a Caribbean Tsunami Warning Center; NOAA also supports a Caribbean Tsunami Program Manager and maintains an inventory of sea-level stations in the region.

Discussion

The question was raised as to whether the US sea-level observations can be related to benchmarks, especially at offshore stations. For this, standard methods, including statistical approaches, are being used. At the Joint Archive for Sea Level (JASL), which operates in a delayed mode, progress is being made in digitizing sea-level data, but much remains to be done; relevant research is currently budget-limited.

Regarding the question of how the US sea-level stations are powered and maintained, each station operates on batteries recharged by associated solar panels, and is serviced once a year, as far as possible. A high level of redundancy is being built into new stations to ensure continuity of monitoring between servicing.

11. LINKAGES BETWEEN GLOSS AND OTHER PROGRAMMES

11.1 JCOMM OPA REPORT

Candyce Clark (NOAA Climate Program Office) presented a report on JCOMM's Observations Programme Area (OPA). She briefly described JCOMM's operating framework; besides OPA, there is a Data Management Programme Area (DMPA) and a Services Programme Area (SPA). The OPA covers six in situ observing programmes co-ordinated by JCOMM through a Technical Co-ordination Group. They are: the IOC–WMO Data Buoy Co-operation Panel (DBCP); the JCOMM Ship Observations Team; GLOSS; IOC–WMO/CLIVAR–GODAE Array for Real-time Geostrophic Oceanography (ARGO); OceanSITES; and the International Ocean Carbon Coordination Project. These six global programmes are linked via the JCOMM Observations Coordination Group. The JCOMM Observations Programme Support Centre (JCOMMOPS) provides technical coordination and supports the development of an integrated global ocean observing system.

JCOMM products and services include: a density map for any data set; a scoring system for instrument-deployment planning; a bilateral EEZ warning system. The metrics are designed, and gradually finalized, according to the requirements of each component of JCOMMOPS.

NOAA's Observing System Monitoring Center (OSMC, www.osmc.noaa.gov), building on recognized data standards, ensures visualization and evaluation overviews as, for example, all platforms reporting the past three days, reporting SST the past three days, drifters reporting SST the past three days, Canadian drifters reporting SST, or all platforms reporting SST, with Reynolds SST error estimate as an underlay.

JCOMM continues to build on the legacy of the OceanObs'09 Conference though a post-OceanObs'09 Working Group to promote a common vision for ocean observations, with a view to ensuring the provision of routine and sustained global information on the marine environment sufficient to meet society's needs for describing, understanding and forecasting marine environmental variability (including living marine resources), weather, seasonal to decadal climate variability, climate change, sustainable management of living marine resources, and assessment of longer-term trends.

The Korean Meteorological Administration and the IOC signed an agreement on support for the JCOMM-IV session (May 2012) on 17 October 2011.

Discussion

Mark Merrifield informed the Group of Experts that the UHSLC was partly funded by NOAA through the CC programme. It was also recognized that GLOSS should take the use of ocean gliders more seriously as an ocean monitoring mechanism.

11.2 IHO

Juan Fierro reported on IHO's current involvement in sea-level measurement; this interest is pursued mainly through its Tide and Water-level Working Group (TWLWG). Its current tasks include: preparation of a standard for digital tide tables and for the transmission of real-time tidal data; the dynamic application of tides in Electronic Chart Display and Information Systems (ECDIS); maintenance of a standard tidal constituent list & inventory of tide gauges used by States; the study of long-term data sets for the determination of global sea-level rise; and the comparison of tidal predictions generated by different analytical software using a common data set.

IHO is preparing a Manual on Tides to be made available in French and English.

Liaison between IHO and GLOSS is in good shape, with regular communication between the IHO and GLOSS secretariats; mutual attendance at IHO and GLOSS meetings is assured, and common membership is increasing. The Director of the International Hydrographic Bureau, Steve Shipman, who will leave the IHB on 31 May 2012, expressed (in absentia) his best wishes for the GLOSS Group of Experts.

IHO documentation is available at www.iho.int.

Discussion

No particular questions were raised.

11.3 WMO

Edgar Cabrera (World Meteorological Organization) gave a presentation on WMO's activities in the field of sea-level measurement. WMO has been active in establishing sea-level stations on a global basis and with a meteorological capability for measuring some key meteorological parameters.

Discussion

It was pointed out that two planned tide-gauge stations in Africa were close to two UHSLC gauges. If the WMO stations were going to be maintained in the long term, Mark Merrifield informed the Group of Experts that the two UHSLC gauges could be dismantled, and thus avoid duplication of effort. Edgar Cabrera explained that WMO stations were adapted more to WMO's needs (meteorological, navigational) than to GLOSS needs (long-term trends, notably in response to the effects of climate change, and sea-level research).

As to the quality control of WMO station data, initially, the Spanish Puertos del Estado (Ports Authority) was assuming responsibility.

12. PRODUCTS AND TECHNICAL DEVELOPMENTS

12.1 GLOSS MANUAL ON QUALITY CONTROL OF SEA-LEVEL DATA

Lesley Rickards reported on the updating of the GLOSS Quality Control Manual. The objective of data-quality control is to ensure the data consistency within a single data set and within a collection of data sets and to ensure that the quality and errors of the data are apparent to the user who has sufficient information to assess its suitability for a task. (IOC/CEC Manual, 1993). Quality control, if done well, has three key advantages: maintaining standards; ensuring consistency; and ensuring reliability.

Information relating to quality control of tide-gauge data has been included in the IOC Manuals on Sea Level Measurement and Interpretation (IOC Manual and Guides 14, Volumes I–IV), but this is the first time that detailed information on quality-control procedures has been assembled into one document. Data from many countries are contributed to GLOSS and, in particular, to the GLOSS Data Centres and the PSMSL. It is considered beneficial to publish the current good practice and distribute the information widely, even if a more standardized approach can be realized.

The objective of the Handbook is to derive a set of recommended standards for quality control of tide-gauge data. This would result in sea-level data sets that have been acquired and processed to agreed standards and promote acceptance of a GLOSS quality endorsement. The Handbook should also be reviewed and updated at regular intervals.

Its contents include: an introduction; the elements of quality control (quality-control flags, automatic quality-control procedures, delayed-mode or 'scientific' quality control, on-site quality control and the Van de Casteele test); the further quality control and processing of historical data; metadata; site history and documentation; and software packages for the quality control and processing of sea-level data.

The first step will be to publish version 1.0, followed by: a request for feedback and comments from users; preparation of a review and revision for the next session of the GLOSS Group of Experts; the addition of new quality-control checks and of more information on benchmarks and datums; the inclusion of more examples; and recommendations on data formats.

Discussion

In response to a question on the language versions of this manual, Lesley Rickards informed the Group of Experts that the English version was available on the website dedicated to the present meeting, but French, Russian and Spanish versions could also be made available if there are any volunteers that will arrange for translation.

12.2 RADAR GAUGE INTERCOMPARISON

Bob Heitsenrether (NOAA, National Ocean Service) reported on the results of recent intercomparisons of radar water-level sensors (available from NOAA's Center for Operational Oceanographic Products and Services –CO-OPS– www.tidesandcurrents.noaa.gov); see also section 12.3, here below. The results of the tests have been very useful in promoting the water-level gauge stations from a transitional trial status to a fully operational status.

CO-OPS monitors and assesses the U.S. coastal environment; it also distributes real-time ocean/meteorological observations and various forecasts and turns operational oceanographic data into meaningful information. The USA has two major real-time coastal observatory systems: the National Water Level Observation Network (NWLON); and the Physical Oceanographic Real-Time Systems (PORTS). They are backed by an Ocean System Test and Evaluation Program (OSTEP).

Many throughout the sea-level community have identified the benefits of radar water-level sensors. The CO-OPS water-level data are expansive in space and time, and the network has multiple applications. When introducing new technology to an expansive observatory, it is critical to establish a case for continuity. To this end, CO-OPS has been conducting a series of laboratory and field tests over the past three years. A long-term test plan and preliminary results were presented at the Eleventh Session of the GLOSS Group of Experts (Paris, 13–15 May 2009). Since 2009, based on field test results, CO-OPS started a transition to operations.

The Design Analysis Associates WaterLog H-3611i Radar was the sensor selected for testing. The test plan included a series of laboratory (flat metal target tests, wave tank, environmental chamber) and long-term field tests (collection of long-term measurements in multiple locations near NWLON reference stations, so as to capture a broad range of environmental variability). Testing was conducted at five sites in the USA, and Bob Heitsenrether presented these results. He explained that, when introducing new technology into a pre-existing observing system, it is critical to conduct rigorous testing to fully understand sensor functions and performance. The test plan is driven by NWLON's multiple applications and stringent requirements, but previous testing throughout the sea-level community was also taken into account.

Regarding the transition from testing to operational status, the field test results showed that radar water-level sensors clearly meet functional requirements in semi-enclosed, fetch-limited, small-wave environments (significant wave height <1 m; dominant period <10 s). CO-OPS effort to transition radar water-level sensors from a test to an operational status involves three different categories of applications: existing long-term NWLON stations; temporary stations supporting hydrographic survey applications; and newly constructed stations. A Pre-deployment Laboratory Test Procedure and Facility was developed comprising: sensor offset derivation; dynamic liquid target test; and verification of fixed-target resolution, time response, and range accuracy. In the comparison of NWLON and radar data, monthly root mean square deviations differed by <1 cm and monthly mean differences are within ±5 mm. New laboratory facilities and sensor mounting hardware are being designed and developed.

Discussion

It was recognized that large waves (in terms of length and period) were easier to measure by a radar sensor than were small waves which tended to become lost in the “noise” of the system, mainly owing to the presence of more water droplets in the sensor’s field of view. It was also pointed out that there is an important difference between an experimental or test situation and a field situation. It was agreed that careful calibration was needed to account for the possible differences.

12.3 CO-OPS AND PACIFIC SEA-LEVEL PRODUCTS

Allison Allen (NOAA, National Ocean Service) informed the participants of the development of sea-level products in NOAA’s Center for Operational Oceanographic Products and Services (CO-OPS) and sea-level products in the Pacific Ocean region. CO-OPS oversees two observations systems: the National Water Level Observation Network (NWLON), which monitors: water level, wind speed/direction, barometric pressure, air and water temperature, and conductivity, as well as operating short-term water-level station deployments; and the National Current Observations, with short-term current meter deployments at some 70 sites a year.

The data products of CO-OPS comprise: sea-level trends at 55 Pacific basin NWLON stations, nearly 40 global stations, including seasonal and interannual variation; tidal datums and prediction at every station; and extreme water levels (e.g. tsunami) and storm events, for which, an exceedance probability tool has been developed.

Data delivery is via a website (www.tsunami.noaa.gov) and Web Services, with real-time access for coastal hazard mitigation.

The Pacific Storms programme is focused on improving understanding of patterns and trends of storm frequency and intensity “storminess” in the Pacific region. It is exploring how the climate-related processes that govern extreme storm events are expressed within and between three thematic areas: heavy rains, strong winds, and high seas, and is developing a suite of extreme-events climatology-related data and information products.

Pacific Storms derived data products include: Foundational Products (time-series, cumulative distribution function); Inter-Annual Products (frequency counts, exceedance probabilities, long-term trends and epochal change); Annual Products (daily time-series, monthly polar plots and monthly frequency counts); and Climate Indices (paired extremes and indices time-series – individual).

The Pacific Climate Information System (PACIS) is a mechanism to identify, produce, and deliver authoritative and timely information about climate variations and trends and their impacts on built, social-human, and natural systems on regional, national, and global scales to support decision-making. It provides a programmatic framework to bring together ongoing and future climate observations, operational forecasting services and climate projections, research, assessment, data management, outreach, and education —an integrated system of climate services— to address the needs of the Pacific Islands. It also provides a forum for sharing the expertise, experience and perspective needed to guide integrated programme planning and product development. The focus areas are: preserving freshwater resources and minimizing the impacts of drought; fostering community resilience to the impacts of sea-level rise, coastal inundation, and extreme weather; and sustaining marine, freshwater, and terrestrial ecosystems.

In the Pacific, IOC/GLOSS, UHSLC, US NOAA, and the Australian Bureau of Meteorology (ABOM), among others, are involved in an effort to create a fully integrated 'end-to end' system of climate-related water-level services. However, at present, numerous programmes, projects and activities are in place, but, overall, they are not well connected: there are gaps and overlaps. A lack of uniformity in the distribution mechanisms, content and format makes information generated through these efforts difficult to access and use. It is therefore necessary to align the multi-organizational structures and functions needed to support effective and efficient delivery of climate-related water-level products and services at the regional level.

At present, the Australian Baseline Sea Level Monitoring Project and South Pacific Sea Level and Climate Monitoring Project produce monthly and yearly data reports. The NOAA National Climatic Data Center (NCDC) produces an integrated suite of extremes climatology products, including hindcasts, on its Pacific Storms Climatology Products website (http://www.pacificstormsclimatology.org).

Regarding product outlooks, the Australia Climate Change Science and Adaptation Planning Program (PACCSAP) will create experimental seasonal forecasts of sea-level anomalies in the western Pacific; the NOAA/NWS Pacific ENSO Applications Climate (PEAC) Center will produce Seasonal Sea Level Outlook experimental consensus forecasts; and NOAA/NCDC's Pacific Storms Climatology Products website will continue to offer new data products.

A Regional Climate-related Sub-system Demonstration Project will: catalogue products and services that already exist, their content, format, and timing; classify products and services, effectively a product metadata schema; develop synthesis and guidance materials; and collaborate in areas of mutual interest, including: climatological extremes/hindcasts; 1–3-month seasonal forecasts); and multi-decadal scenarios/projections. The project will also develop data interoperability and associated 'backend' IT systems, and information portals and associated 'front-end' IT systems. Research and assessment will include: correlation between extreme water levels and regional climate indices/teleconnections; inundation modelling, particularly along reef-fronted shorelines; and consolidated needs analyses in support of join programme planning and product development. For outreach, education, training and capacity-building, the project will pursue the shared development of curricula and delivery of training, and develop shared information portals and associated content.

The proposed Integrated Water Level Service (IWLS) could be based on, for example: the Sea Level Station Monitoring Facility website developed and maintained by VLIZ for UNESCO/IOC (http://www.ioc-sealevelmonitoring.org/map.php); the NOAA CO-OPS systems metadata and real-time observations for stations within the NWLON via websites and web services (http://tidesonline.noaa.gov/ and http://opendap.co-ops.nos.noaa.gov/content/); the NOAA CO-OPS website tide and current predictions, including storm warnings (http://tidesandcurrents.noaa.gov/index.shtml); and the ABOM tide predictions and wave forecasts through the Australian National Tidal Centre (http://www.bom.gov.au/oceanography/projects/ntc/ntc.shtml).

Discussion

The Group of Experts took note of the NOAA initiatives. It also recognized the importance of making available sea-level products for use in coastal-zone engineering and welcomed the possibility of discussion of this issue at the forthcoming International Conference on Coastal Engineering (Santander, Spain, 1–6 July 2012). The importance of other relevant data studies in the field of coastal-zone engineering was also recognized, as it was also for the scientific community and for governments. The US Army Corps of Engineers was considered to be a potential primary user of relevant data products.

13. ACTIONS FOR JCOMM-IV

No particular actions from GLOSS-GE were envisioned for JCOMM-IV. GLOSS will provide input for the JCOMM-OPA report.

14. INTERSESSIONAL ACTIONS FOR GLOSS-GE 2011–2013

Mark Merrifield presented a list of actions to be carried out intersessionally by the Group of Experts and invited comments from the participants.

Discussion

The Group of Experts accepted the list presented, but it recognized that a lot depended on the resources available at the institutional level. For the US institutions concerned, the problem was in large part due to the withdrawal by the USA of its financial contribution to UNESCO following the recognition of Palestine as a fully-fledged Member State of the organization. Nevertheless, it was pointed out that experience had shown that a reduction in available funding was not necessarily fatal. Every effort has to be made to do more and/or better with less. The important objectives were to improve GLOSS and promote greater awareness of its functions, objectives and achievements. To this end, as far as possible, it was necessary to aim GLOSS training courses at the points of greatest need. The list of intersessional actions for GLOSS-GE 2011–2013 is in Annex III hereto.

15. DESIGNATION OF A NEW CHAIRPERSON FOR GLOSS-GE

The Technical Secretary informed the Group of Experts that Mark Merrifield had announced his interest to retire from the post of Chairperson of the Group. He informed the Group that he had received only the candidature of Gary Mitchum (South Florida University, St. Petersburg, Florida) and that this candidature had the endorsement of the USA focal point for the IOC.

There being no other candidate for the post of Chairperson of the IOC Group of Experts on the Global Sea Level Observing System, Gary Mitchum was designated Chairperson, by acclamation, for the forthcoming intersessional period and the Group's Thirteenth Session.

16. ANY OTHER BUSINESS

Mark Merrifield invited participants to announce any other item of business that they wished to be addressed by the Group of Experts at the present session.

No other item of business was proposed.

17. DATE AND PLACE OF NEXT SESSION

Mark Merrifield invited proposals for the dates and place of the Thirteenth Session of the Group of Experts.

There being no proposal tabled, Mark Merrifield informed the participants that he would invite the new Chairperson, in consultation with the Technical Secretary, to decide the dates and place of the Group of Experts' next session.

18. CLOSURE

Mark Merrifield invited the Technical Secretary to close the present session. Thorkild Aarup thanked the outgoing Chairperson for his excellent work on behalf of the Group of Experts over the past six years, which had resulted in a substantial expansion of the Group and in the development of a new "GLOSS Implementation Plan" for the coming several years. It had also resulted in a reorientation back to a prevalence of science over technology in the field of sea-level measurement and research. The outgoing Chairperson had also notably increased the involvement of the Group's members in its intersessional work which had also grown during the outgoing Chairperson's time.

The Technical Secretary also thanked the outgoing Chairperson for his close collaboration with him.

Mark Merrifield expressed his great pleasure at having had the opportunity to develop GLOSS; he said it was also quite remarkable that he could identify among the participants three or four previous Chairpersons, which testified to the Group's solidarity and longevity as a useful IOC subsidiary body. It had also been a great pleasure to work with Thorkild Aarup as the Group's Technical Secretary.

The outgoing Chairperson assured the Group of Experts that the incoming Chairperson, Gary Mitchum, was greatly committed to pursuing the goals of GLOSS.

At the invitation of the outgoing Chairperson, the Technical Secretary closed the Twelfth Session of the Group of Experts for the Global Sea Level Observing System at 15:45 on 11 November 2011.

ANNEX I

AGENDA

1. ORGANIZATION OF THE SESSION

1.1 OPENING OF THE SESSION
1.2 PRACTICAL ARRANGEMENTS
1.3 ADOPTION OF THE AGENDA

2. REVIEW OF GLOSS ACTIVITIES AND STATUS OF ACTIONS FROM GE-XI

3. GLOSS CORE NETWORK

3.1 REVIEW OF GLOSS CORE NETWORK STATUS (LOW FREQUENCY AND HIGH FREQUENCY, DELAYED MODE AND FAST MODE)
3.2 REVIEW OF COLLOCATED AND NEARLY COLLOCATED CONTINUOUS GPS STATIONS

4. REGIONAL SEA-LEVEL NETWORKS IN SUPPORT OF TSUNAMI WARNING SYSTEMS

4.1 INDIAN OCEAN
4.2 PACIFIC OCEAN
4.3 CARIBBEAN
4.4 NORTH-EAST ATLANTIC AND MEDITERRANEAN

5. REPORT OF THE SEA LEVEL STATION MONITORING FACILITY

6. SUMMARY OF RECENT RESEARCH BASED ON TIDE-GAUGE OBSERVATIONS

7. ACTIONS/REQUIREMENTS FROM WORKSHOPS (7-9 NOVEMBER 2011)

7.1 WORKSHOP ON STORM SURGE MONITORING AND EXTREME SEA LEVELS AND THE NEED FOR HIGH-QUALITY REAL-TIME SEA-LEVEL DATA, 7-8 NOVEMBER 2011
7.2 SPACE-BASED METHODS FOR VERTICAL TIDE-GAUGE CONTROL (9 NOVEMBER 2011)

8. WORKING GROUP ON TSUNAMIS AND OTHER HAZARDS RELATED TO SEA-LEVEL WARNING AND MITIGATION SYSTEMS (TOWS-4): REPORT AND REQUIREMENTS TO GLOSS FROM THE TOWS INTER-ICG TASK TEAM ON SEA LEVEL FOR TSUNAMI

9. OVERVIEW OF THE GLOSS IMPLEMENTATION PLAN

10. NATIONAL AND REGIONAL SEA LEVEL ACTIVITIES

10.1 EUROPE
10.2 MEDGLOSS
10.3 RED SEA
10.4 AFRICA
10.5 NATIONAL REPORTS

11. LINKAGES BETWEEN GLOSS AND OTHER PROGRAMMES

11.1 JCOMM OPA REPORT
11.2 IHO

11.3 WMO

12. PRODUCTS AND TECHNICAL DEVELOPMENTS

12.1 GLOSS MANUAL ON QUALITY CONTROL OF SEA-LEVEL DATA
12.2 RADAR GAUGE INTERCOMPARISON
12.3 CO-OPS AND PACIFIC SEA-LEVEL PRODUCTS

13. ACTIONS FOR JCOMM-IV

14. INTERSESSIONAL ACTIONS FOR GLOSS-GE 2011–2013

15. DESIGNATION OF NEW CHAIR FOR GLOSS-GE

16. ANY OTHER BUSINESS

17. DATE AND PLACE OF THE NEXT SESSION

18. CLOSURE

ANNEX II

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ANNEX III

INTERSESSIONAL ACTIVITIES 2011–2013

Action	**Responsible members**
Propose strategies for improving the GLOSS networks in the Arctic Ocean	GLOSS GE Chair, GE reps from USA, Russia, Canada, Northern Europe
Investigate and clarify the peak and decline in data delivery to PSMSL and JASL	Lesley Rickards and Pat Caldwell
Re-evaluate the GLOSS Core Network and align it (where relevant and possible) with existing operational stations	GLOSS GE Chair, Mark Merrifield, Lesley Rickards, Christa von Hillebrandt
Identify funding opportunities for historic data recovery projects	GLOSS GE Chair, Technical Secretary
Identify automated techniques for the digitization of archived mareograms	Elizabeth Bradshaw (Chair), Thomas Hammarklint, Jorge Zavala-Hidalgo, Pat Caldwell, Stefan Talke
Recommend sea-level product suite that highlights GLOSS datasets, including implementation strategies	Allison Allen(Chair), to be formed
Continue development of the GLOSS website, including the connectivity of all GLOSS Data Centre websites	GLOSS data centre directors
Finalize the GLOSS Implementation Plan 2012	Mark Merrifield, GLOSS GE Chair, and Technical Secretary
Reconsider: the structure and the modus operandi of GLOSS and, in particular, of the GE; the specific responsibilities of the FW Chair, and of the GLOSS National Focal Points; the methods of communication in the GLOSS community	GLOSS GE Chair, Technical Secretary, past GE Chair,
Establish sea-level indices for OOPC list of indices	GLOSS GE Chair
GLOSS to provide report for JCOMM-IV	GLOSS GE Chair
Consider ways and means of increasing GLOSS's financial operating basis via, for example: publicity campaigns; raising the awareness of Member States with respect to the high value of sea-level monitoring; exploitation of the GLOSS warning functions and extreme sea-level events; and data-product sales	Working group assigned by GE Chair and Technical Secretary:
Make GLOSS Status Maps (~12 maps from PSMSL + UH) available on GLOSS web-site	Lesley Rickards, Elizabeth Bradshaw, Mark Merrifield
Establish station metadata master catalogue	Francisco Hernandez , Bart van Hoorne, Guy Wöppelmann, Simon Holgate, Mark Merrifield
Explore/arrange for archival (and possible QC) of high-frequency data from VLIZ	GLOSS GE Chair, GLOSS data centre directors
Encourage submission of cGPS data to TIGA in	Tilo Schöne, Guy Wöppelmann,

Action	**Responsible members**
advance of reprocessing deadline of April 2012	relevant GLOSS contacts, Technical Secretary
Encourage CoCONET project to submit Caribbean cGPS data to TIGA	Tilo Schöne, Christa von Hillebrandt, Guy Wöppelmann
Identify high-priority cGPS@TG sites	GLOSS GE Chair, Matt King
Arrange to translate GLOSS Data Quality Manual	Lesley Rickards, Christa von Hillebrandt
Consider list of tsunami water-level stations that GLOSS may want to incorporate into a tsunami focused database	Christa von Hildebrandt (chair), Yohko Igarashi, Begoña Perez Gomez, Khafid
Implement netCDF outputs and serve Fast Delivery and Delayed Mode datasets with an OPeNDAP server	Simon Holgate, Mark Merrifield
Evaluate and recast the GCOS network	Philip Woodworth (chair), Gary Mitchum, Mark Merrifield, Simon Holgate
Maintain links between GLOSS and JCOMM Waves Group	GLOSS-GE Chair and Kevin Horsburgh
Update GLOSS manuals	GLOSS-GE, Technical Secretary

ANNEX IV

LIST OF DOCUMENTS

(Documents and presentations from the GLOSS-GE-XII meeting and the associated workshops are available from http://www.ioc-goos.org/glossge12)

Agenda Item

1.	Provisional Annotated Agenda - 12th Session of the Group of Experts for GLOSS
1.2	Provisional Timetable - GLOSS GE-XII 2011 and Associated Workshops
3.1	PSMSL Report GLOSS GE XII 2011
8.	Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOW-WG), Inter-ICG Task Team 1 on Sea Level Monitoring for Tsunami, First Meeting, Seattle, USA, 29 November-1 December 2010
9.	GLOSS Implementation Plan 2012 (Draft)
10.4	US Report GLOSS GE-XII 2011
10.4	Spain Report GLOSS GE XII 2011
10.4	Saudi Arabia Report GLOSS GE XII 2011
10.4	Chile Report GLOSS GE XII 2011
10.4	Russia Report GLOSS GE XII 2011
10.4	Indonesia Report GLOSS GE XII 2011
10.4	Mexico Report GLOSS GE XII 2011
10.4	Denmark Report GLOSS GE 2011
10.4	Portugal Report GLOSS GE XII 2011
10.4	France Report GLOSS GE XII 2011
10.4	Côte d'Ivoire Report GLOSS GE XII 2011
10.4	Germany Report GLOSS GE-XII 2011
10.4	New Zealand Report GLOSS GE XII 2011
10.4	Japan Report GLOSS GE XII 2011
10.4	China Report GLOSS GE-XII 2011
10.4	Italy Report GLOSS GE XII
10.4	South Africa Report GLOSS GE XII 2011
10.4	Sweden Report GLOSS GE XII 2011
10.4	Norway Report GLOSS GE XII 2011
10.4	UK Report GLOSS GE XII 2011
10.4	Brazil Report GLOSS GE XII 2011
10.4	Denmark Report GLOSS GE 2011
12.1	Manual on Quality Control of Sea Level Observations, Version 1.0, November 2011

12.2 Test and Evaluation Report - Limited Acceptance of the Design Analysis WaterLog H-3611i Microwave Radar Water Level Sensor, Silver Spring, Maryland, March 2011

15. Nomination letter for Dr Gary Mitchum of 23 September 2011

Other Documents

Provisional Timetable - GLOSS GE-XII 2011 and Associated Workshops

ANNEX V

LIST OF ACRONYMS

AARI	Arctic and Antarctic Research Institute (Russian Federation)
ABOM	Australian Bureau of Meteorology
ARGO	Array for Real-Time Geostrophic Oceanography
BfG	Bundesanstalt für Gewässerkunde (Federal Institute of Hydrology, Germany)
BGAN	Broadband Global Area Network (INMARSAT)
BODC	British Oceanographic Data Centre (UK)
BOOS	Baltic Operational Oceanographic System
BSH	Bundesamts für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency, Germany)
CARIBE-EWS	Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions
CCCCC	Caribbean Community Center for Climate Change
CGPS	Continuous Global Positioning System
CICESE	Centro de Investigación Científica y de Educación Superior de Ensenada
CLIVAR	Climate Variability and Prediction (WCRP)
CNRS	Centre national de la recherche scientifique (France)
COCONet	Continuously Operating Caribbean GPS Observational Network
CODATA	Committee on Data For Science and Technology (ICSU)
CO-OPS	Center for Operational Oceanographic Products and Services (NOAA)
CORS	Continuously Operating Reference Station (NOAA)
CTWC	Caribbean Tsunami Warning Centre
DaMSA	Danish Marine Science Association
DBCP	Drifting Buoy Cooperation Panel (WMO–IOC)
DMI	Danish Marine Institute
DMPA	Data Management Program Area (JCOMM)
DORIS	Doppler Orbitography and Radiopositioning Integrated by Satellite
DTU Space	Danish National Space Institute (Danish Technical University)
ECDIS	Electronic Chart Display and Information Systems (IHO)
EGU	European Geosciences Union
EOSS	European Sea-level Observing System
ESEAS	European Sea Level Service
EuroGOOS	European Global Ocean Observing System
FD	Fast Delivery
FEHRI	Far-Eastern Hydrometeorological Research Institute (Russia)
GALILEO	European global navigation satellite system

GCN	GLOSS Core Network
GCOS	Global Climate Observing System (WMO–ICSU–IOC–UNEP)
GCS	General Commission of Survey (Saudi Arabia)
GE	Group of Experts
GEONET	GPS Earth Observation Network System
GFZ	GeoForschungsZentrum (Germany)
GLONASS	Globalnaya Navigatsionnaya Sputnikovaya Sistema (Russian navigation system)
GLOSS	Global Sea Level Observing System (JCOMM)
GNSS	Global Navigation Satellite System
GODAE	Global Ocean Data Assimilation Experiment
GOES	Geostationary Operational Environmental Satellite
GOOS	Global Ocean Observing System (WMO–ICSU–IOC–UNEP)
GPRS	General Packet Radio Service
GPS	Global Positioning System
GPS@TG	GPS at Tide Gauge
GTS	Global Telecommunication System (WMO)
ICES	International Council for the Exploration of the Sea
ICG	Intergovernmental Coordination Group
ICG/NEAMTWS	International Coordination Group for the North-East Atlantic, Mediterranean and Connected Seas Tsunami Warning System
ICG/PTWS	International Coordination Group for the Pacific Tsunami Warning System
ICSEM	International Commission for the Scientific Exploration of the Mediterranean Sea
ICSU	International Council for Science
IFREMER	Institut français de recherche pour l'exploitation de la mer (France)
IGS	International GNSS Service
IHO	International Hydrographic Organization
IHPT	Instituto Hidrográfico (Portugal)
InaTEWS	Indonesia Tsunami Early Warning System
IOC	Intergovernmental Oceanographic Commission (UNESCO)
IODE	International Oceanographic Data and Information Exchange
IOLR	Israel Oceanographic and Limnological Research, Ltd.
IOTWS	Indian Ocean Tsunami Warning System
IPCC	Intergovernmental Panel on Climate Change (UN)
ITRF	International Terrestrial Reference Frame
IWLS	Integrated Water Level Service
JASL	Joint Archive for Sea Level
JCOMM	Joint Commission for Oceanography and Marine Meteorology (WMO–IOC)

JCOMMOPS	JCOMM Observations Programme Support Centre
JMA	Japan Meteorological Agency
KAUST	King Abdullah University of Science & Technology (Saudi Arabia)
KMS	Kort og Matrikkelstyrelsen (National Survey and Cadastre, Denmark)
LTT	Long-term trend
MedCLIVAR	Mediterranean Programme on Climate Variability and Prediction (WCRP)
MedGLOSS	Mediterranean Programme for the Global Sea-Level Observing System
MSL	Mean sea level
NCDC	National Climatic Data Center (NOAA)
NEAMTWS	North-East Atlantic, Mediterranean and Connected Seas Tsunami Warning System
NESDIS	National Environmental Satellite, Data, and Information Service (NOAA)
NGDC	National Geophysical Data Center (NOAA)
NOAA	National Oceanic and Atmospheric Administration (USA)
NOC	National Oceanography Centre (UK)
NOOS	North-West Shelf Operational Oceanographic System
NRT	Near real time
NTWC	National Tsunami Warning Centre
NWLON	National Water Level Observing Network (NOAA)
NWS	National Weather Service (NOAA)
ODINAfrica	Oceanographic Data and Information Network for Africa (IODE)
OOPC	Ocean Observations Panel for Climate (GOOS)
OPA	Observations Programme Area (JCOMM)
OSMC	Observing System Monitoring Center (NOAA)
OSTEP	Ocean System Test and Evaluation Program (NOAA)
PACCSAP	Climate Change Science and Adaptation Planning Program (Australia)
PACIS	Pacific Climate Information System
PEAC	Pacific ENSO Applications Climate Center (NOAA)
PERSGA	Regional Organization for the Conservation of the Environment of the Red Sea and the Gulf of Aden
POL	Proudman Oceanography Laboratory (UK)
PORTS	Physical Oceanographic Real-Time Systems (NOAA)
PP	Pilot Project
PRSN	Puerto Rico Seismic Network
PSMSL	Permanent Service for Mean Sea Level (UK)
PSTN	Public Switch Telephone Node
PTWS	Pacific Tsunami Warning System
QA	Quality assurance

QC	Quality control
REFMAR	Réseaux de référence des observations marégraphiques (SHOM)
RLR	Revised Local Reference
RNODC	Responsible National Oceanographic Data Centre (IODE)
ROPME	Regional Organization for the Protection of the Marine Environment (UNEP)
RT	Real time
SEMAR	Secretaría de la Marina (Mexico)
SEPRISE	Sustained, Efficient Production of Required Information Services (EU FP6 project)
SHOM	Service Hydrographique et Océanographique de la Marine (France)
SINEX	Solution independent exchange (IGS format)
SLOSH	Sea, Lake and Overland Surges from Hurricanes (NOAA)
SLSMF	Sea Level Station Monitoring Facility
SMHI	Swedish Meteorological and Hydrological Institute
SOI	State Oceanographic Institute (Russia)
SONEL	Système d'Observation du Niveau des Eaux Littorales (France)
SPA	Services Program Area (JCOMM)
SST	Sea Surface Temperature
TIGA	IGS Tide Gauge Benchmark Monitoring Project
TOWS	Tsunamis and Other Hazards Related to Sea Level Warning and Mitigation Systems
TWC	Tsunami Warning Centre
TWLWG	Tidal and Water Level Working Group (IHO)
UHSLC	University of Hawaii Sea Level Center
UN	United Nations
UNAM	Universidad Nacional Autónoma de México
UNAVCO	University NAVSTAR Consortium (USA)
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPRM	University of Puerto Rico at Mayagüez (USA)
VLIZ	Vlaams Instituut voor de Zee/Flanders Marine Institute (Belgium)
VLM	Vertical land movements
WCRP	World Climate Research Programme (WMO–ICSU–IOC)
WDC	World Data Centre (ICSU)
WG	Working Group
WMO	World Meteorological Organization
WSV	Wasser- und Schifffahrtsverwaltung des Bundes/Federal Waterways and Shipping Administration (Germany)

In this Series, entitled

Reports of Meetings of Experts and Equivalent Bodies, which was initiated in 1984 and which is published in English only, unless otherwise specified, the reports of the following meetings have already been issued:

1. Third Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans
2. Fourth Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans S. Fourth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño' ***(Also printed in Spanish)***
4. First Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in Relation to Living Resources
5. First Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources
6. First Session of the Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
7. First Session of the Joint CCOP(SOPAC)-IOC Working Group on South Pacific Tectonics and Resources
8. First Session of the IODE Group of Experts on Marine Information Management
9. Tenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies in East Asian Tectonics and Resources
10. Sixth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
11. First Session of the IOC Consultative Group on Ocean Mapping ***(Also printed in French and Spanish)***
12. Joint 100-WMO Meeting for Implementation of IGOSS XBT Ships-of-Opportunity Programmes
13. Second Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
14. Third Session of the Group of Experts on Format Development
15. Eleventh Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
16. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
17. Seventh Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
18. Second Session of the IOC Group of Experts on Effects of Pollutants
19. Primera Reunión del Comité Editorial de la COI para la Carta Batimétrica Internacional del Mar Caribe y Parte del Océano Pacífico frente a Centroamérica ***(Spanish only)***
20. Third Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
21. Twelfth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
22. Second Session of the IODE Group of Experts on Marine Information Management
23. First Session of the IOC Group of Experts on Marine Geology and Geophysics in the Western Pacific
24. Second Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources ***(Also printed in French and Spanish)***
25. Third Session of the IOC Group of Experts on Effects of Pollutants
26. Eighth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
27. Eleventh Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans ***(Also printed in French)***
28. Second Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in Relation to Living Resources
29. First Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
30. First Session of the IOCARIBE Group of Experts on Recruitment in Tropical Coastal Demersal Communities ***(Also printed in Spanish)***
31. Second IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
32. Thirteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asia Tectonics and Resources
33. Second Session of the IOC Task Team on the Global Sea-Level Observing System
34. Third Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
35. Fourth Session of the IOC-UNEP-IMO Group of Experts on Effects of Pollutants
36. First Consultative Meeting on RNODCs and Climate Data Services
37. Second Joint IOC-WMO Meeting of Experts on IGOSS-IODE Data Flow
38. Fourth Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
39. Fourth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
40. Fourteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asian Tectonics and Resources
41. Third Session of the IOC Consultative Group on Ocean Mapping
42. Sixth Session of the Joint IOC-WMO-CCPS Working Group on the Investigations of 'El Niño' (***Also printed in Spanish)***
43. First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
44. Third Session of the IOC-UN(OALOS) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources
45. Ninth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
46. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico
47. Cancelled
48. Twelfth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans
49. Fifteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asian Tectonics and Resources
50. Third Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
51. First Session of the IOC Group of Experts on the Global Sea-Level Observing System
52. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean
53. First Session of the IOC Editorial Board for the International Chart of the Central Eastern Atlantic ***(Also printed in French)***
54. Third Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico ***(Also printed in Spanish)***
55. Fifth Session of the IOC-UNEP-IMO Group of Experts on Effects of Pollutants
56. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
57. First Meeting of the IOC *ad hoc* Group of Experts on Ocean Mapping in the WESTPAC Area
58. Fourth Session of the IOC Consultative Group on Ocean Mapping
59. Second Session of the IOC-WMO/IGOSS Group of Experts on Operations and Technical Applications

60. Second Session of the IOC Group of Experts on the Global Sea-Level Observing System
61. UNEP-IOC-WMO Meeting of Experts on Long-Term Global Monitoring System of Coastal and Near-Shore Phenomena Related to Climate Change
62. Third Session of the IOC-FAO Group of Experts on the Programme of Ocean Science in Relation to Living Resources
63. Second Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
64. Joint Meeting of the Group of Experts on Pollutants and the Group of Experts on Methods, Standards and Intercalibration
65. First Meeting of the Working Group on Oceanographic Co-operation in the ROPME Sea Area
66. Fifth Session of the Editorial Board for the International Bathymetric and its Geological/Geophysical Series
67. Thirteenth Session of the IOC-IHO Joint Guiding Committee for the General Bathymetric Chart of the Oceans ***(Also printed in French)***
68. International Meeting of Scientific and Technical Experts on Climate Change and Oceans
69. UNEP-IOC-WMO-IUCN Meeting of Experts on a Long-Term Global Monitoring System
70. Fourth Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
71. ROPME-IOC Meeting of the Steering Committee on Oceanographic Co-operation in the ROPME Sea Area
72. Seventh Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño' ***(Spanish only)***
73. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico ***(Also printed in Spanish)***
74. UNEP-IOC-ASPEI Global Task Team on the Implications of Climate Change on Coral Reefs
75. Third Session of the IODE Group of Experts on Marine Information Management
76. Fifth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
77. ROPME-IOC Meeting of the Steering Committee for the Integrated Project Plan for the Coastal and Marine Environment of the ROPME Sea Area
78. Third Session of the IOC Group of Experts on the Global Sea-level Observing System
79. Third Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
80. Fourteenth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans
81. Fifth Joint IOG-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
82. Second Meeting of the UNEP-IOC-ASPEI Global Task Team on the Implications of climate Change on Coral Reefs
83. Seventh Session of the JSC Ocean Observing System Development Panel
84. Fourth Session of the IODE Group of Experts on Marine Information Management
85. Sixth Session of the IOC Editorial Board for the International Bathymetric chart of the Mediterranean and its Geological/Geophysical Series
86. Fourth Session of the Joint IOC-JGOFS Panel on Carbon Dioxide
87. First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Pacific
88. Eighth Session of the JSC Ocean Observing System Development Panel
89. Ninth Session of the JSC Ocean Observing System Development Panel
90. Sixth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
91. First Session of the IOC-FAO Group of Experts on OSLR for the IOCINCWIO Region
92. Fifth Session of the Joint IOC-JGOFS CO, Advisory Panel Meeting
93. Tenth Session of the JSC Ocean Observing System Development Panel
94. First Session of the Joint CMM-IGOSS-IODE Sub-group on Ocean Satellites and Remote Sensing
95. Third Session of the IOC Editorial Board for the International Chart of the Western Indian Ocean
96. Fourth Session of the IOC Group of Experts on the Global Sea Level Observing System
97. Joint Meeting of GEMSI and GEEP Core Groups
98. First Session of the Joint Scientific and Technical Committee for Global Ocean Observing System
99. Second International Meeting of Scientific and Technical Experts on Climate Change and the Oceans
100. First Meeting of the Officers of the Editorial Board for the International Bathymetric Chart of the Western Pacific
101. Fifth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico
102. Second Session of the Joint Scientific and Technical Committee for Global Ocean Observing System
103. Fifteenth Session of the Joint IOC-IHO Committee for the General Bathymetric Chart of the Oceans
104. Fifth Session of the IOC Consultative Group on Ocean Mapping
105. Fifth Session of the IODE Group of Experts on Marine Information Management
106. IOC-NOAA *Ad hoc* Consultation on Marine Biodiversity
107. Sixth Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
108. Third Session of the Health of the Oceans (HOTO) Panel of the Joint Scientific and Technical Committee for GLOSS
109. Second Session of the Strategy Subcommittee (SSC) of the IOC-WMO-UNEP Intergovernmental Committee for the Global Ocean Observing System
110. Third Session of the Joint Scientific and Technical Committee for Global Ocean Observing System
111. First Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate
112. Sixth Session of the Joint IOC-JGOFS C02 Advisory Panel Meeting
113. First Meeting of the IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional - Global Ocean Observing System (NEAR-GOOS)
114. Eighth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of "El Niño" ***(Spanish only)***
115. Second Session of the IOC Editorial Board of the International Bathymetric Chart of the Central Eastern Atlantic ***(Also printed in French)***
116. Tenth Session of the Officers Committee for the Joint IOC-IHO General Bathymetric Chart of the Oceans (GEBCO), USA, 1996
117. IOC Group of Experts on the Global Sea Level Observing System (GLOSS), Fifth Session, USA, 1997
118. Joint Scientific Technical Committee for Global Ocean Observing System (J-GOOS), Fourth Session, USA, 1997
199 First Session of the Joint 100-WMO IGOSS Ship-of-Opportunity Programme Implementation Panel, South Africa, 1997
120. Report of Ocean Climate Time-Series Workshop, Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate, USA, 1997
121. IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional Global Ocean Observing System (NEAR-GOOS), Second Session, Thailand, 1997

122. First Session of the IOC-IUCN-NOAA *Ad hoc* Consultative Meeting on Large Marine Ecosystems (LME), France, 1997

123. Second Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), South Africa, 1997

124. Sixth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico, Colombia, 1996 ***(also printed in Spanish)***

125. Seventh Session of the IODE Group of Experts on Technical Aspects of Data Exchange, Ireland, 1997

126. IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), First Session, France, 1997

127. Second Session of the IOC-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LME), France, 1998

128. Sixth Session of the IOC Consultative Group on Ocean Mapping (CGOM), Monaco, 1997

129. Sixth Session of the Tropical Atmosphere - Ocean Array (TAO) Implementation Panel, United Kingdom, 1997

130. First Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System (GOOS), France, 1998

131. Fourth Session of the Health of the Oceans (HOTO) Panel of the Global Ocean Observing System (GOOS), Singapore, 1997

132. Sixteenth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans (GEBCO), United Kingdom, 1997

133. First Session of the IOC-WMO-UNEP-ICSU-FAO Living Marine Resources Panel of the Global Ocean Observing System (GOOS), France, 1998

134. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean (IOC/EB-IBCWIO-IW3), South Africa, 1997

135. Third Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), France, 1998

136. Seventh Session of the Joint IOC-JGOFS C02 Advisory Panel Meeting, Germany, 1997

137. Implementation of Global Ocean Observations for GOOS/GCOS, First Session, Australia, 1998

138. Implementation of Global Ocean Observations for GOOS/GCOS, Second Session, France, 1998

139. Second Session of the IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), Brazil, 1998

140. Third Session of IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional - Global Ocean Observing System (NEAR-GOOS), China, 1998

141. Ninth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño', Ecuador, 1998 ***(Spanish only)***

142. Seventh Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and its Geological/Geophysical Series, Croatia, 1998

143. Seventh Session of the Tropical Atmosphere-Ocean Array (TAO) Implementation Panel, Abidjan, Côte d'Ivoire, 1998

144. Sixth Session of the IODE Group of Experts on Marine Information Management (GEMIM), USA, 1999

145. Second Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System (GOOS), China, 1999

146. Third Session of the IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), Ghana, 1999

147. Fourth Session of the GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC); Fourth Session of the WCRP CLIVAR Upper Ocean Panel (UOP); Special Joint Session of OOPC and UOP, USA, 1999

148. Second Session of the IOC-WMO-UNEP-ICSU-FAO Living Marine Resources Panel of the Global Ocean Observing System (GOOS), France, 1999

149. Eighth Session of the Joint IOC-JGOFS CO2 Advisory Panel Meeting, Japan, 1999

150. Fourth Session of the IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional – Global Ocean Observing System (NEAR-GOOS), Japan, 1999

151. Seventh Session of the IOC Consultative Group on Ocean Mapping (CGOM), Monaco, 1999

152. Sixth Session of the IOC Group of Experts on the Global Sea level Observing System (GLOSS), France, 1999

153. Seventeenth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans (GEBCO), Canada, 1999

154. Comité Editorial de la COI para la Carta Batimétrica Internacional del Mar Caribe y el Golfo de Mexico (IBCCA), Septima Reunión, Mexico, 1998
IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico (IBCCA), Seventh Session, Mexico, 1998

155. Initial Global Ocean Observing System (GOOS) Commitments Meeting, IOC-WMO-UNEP-ICSU/Impl-III/3, France, 1999

156. First Session of the *ad hoc* Advisory Group for IOCARIBE-GOOS, Venezuela, 1999 ***(also printed in Spanish and French)***

157. Fourth Session of the IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), China, 1999

158. Eighth Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and its Geological/Geophysical Series, Russian Federation, 1999

159. Third Session of the IOC-WMO-UNEP-ICSU-FAO Living Marine Resources Panel of the Global Ocean Observing System (GOOS), Chile, 1999

160. Fourth Session of the IOC-WMO-UNEP-ICSU-FAO Living Marine Resources Panel of the Global Ocean Observing System (GOOS). Hawaii, 2000

161. Eighth Session of the IODE Group of Experts on Technical Aspects of Data Exchange, USA, 2000

162. Third Session of the IOC-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LME), France, 2000

163. Fifth Session of the IOC-WMO-UNEP-ICSU Coastal Panel of the Global Ocean Observing System (GOOS), Poland, 2000

164. Third Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System (GOOS), France, 2000

165. Second Session of the *ad hoc* Advisory Group for IOCARIBE-GOOS, Cuba, 2000 ***(also printed in Spanish and French)***

166. First Session of the Coastal Ocean Observations Panel, Costa Rica, 2000

167. First GOOS Users' Forum, 2000

168. Seventh Session of the Group of Experts on the Global Sea Level Observing System, Honolulu, 2001

169. First Session of the Advisory Body of Experts on the Law of the Sea (ABE-LOS), France, 2001 ***(also printed in French)***

170. Fourth Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System, Chile, 2001

171. First Session of the IOC-SCOR Ocean CO_2 Advisory Panel, France, 2000

172. Fifth Session of the GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), Norway, 2000 ***(electronic copy only)***

173. Third Session of the *ad hoc* Advisory Group for IOCARIBE-GOOS, USA, 2001 ***(also printed in Spanish and French)***

174. Second Session of the Coastal Ocean Observations Panel and GOOS Users' Forum, Italy, 2001

175. Second Session of the Black Sea GOOS Workshop, Georgia, 2001

176. Fifth Session of the IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional – Global Ocean Observing System (NEAR-GOOS), Republic of Korea, 2000

177. Second Session of the Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Morocco, 2002 ***(also printed in French)***

178. Sixth Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), Australia, 2001 ***(electronic copy only)***

179. *Cancelled*

180. Second Session of the IOC-SCOR Ocean CO_2 Advisory Panel, Honolulu, Hawaii, U.S.A, 2002 ***(electronic copy only)***

181. IOC Workshop on the Establishment of SEAGOOS in the Wider Southeast Asian Region, Seoul, Republic of Korea, 2001 (SEAGOOS preparatory workshop) ***(electronic copy only)***

182. First Session of the IODE Steering Group for the Resource Kit, USA, 19–21 March 2001

183. Fourth Session of the IOC-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LMEs), France, 2002

184. Seventh Session of the IODE Group of Experts on Marine Information Management (GEMIM), France, 2002 ***(electronic copy only)***

185. Sixth Session of IOC/WESTPAC Coordinating Committee for the North-East Asian Regional - Global Ocean Observing System (NEAR-GOOS), Republic of Korea, 2001 ***(electronic copy only)***

186. First Session of the Global Ocean Observing System (GOOS) Capacity Building Panel, Switzerland, 2002 ***(electronic copy only)***

187. Fourth Session of the ad hoc Advisory Group for IOCARIBE-GOOS, 2002, Mexico ***(also printed in French and Spanish)***

188. Fifth Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean (IBCWIO), Mauritius, 2000

189. Third session of the Editorial Board for the International Bathymetric Chart of the Western Pacific, Chine, 2000

190. Third Session of the Coastal Ocean Observations Panel and GOOS Users' Forum, Vietnam, 2002

191. Eighth Session of the IOC Consultative Group on Ocean Mapping, Russian Federation, 2001

192. Third Session of the Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Lisbon, 2003 ***(also printed in French)***

193. Extraordinary Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño', Chile, 1999 ***(Spanish only; electronic copy only)***

194. Fifth Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System, France, 2002

195. Sixth Session of the IOC-WMO-UNEP-ICSU Steering Committee of the Global Ocean Observing System, South Africa, 2003

196. Fourth Session of the Coastal Ocean Observations Panel, South Africa, 2002 ***(electronic copy only)***

197. First Session of the JCOMM/IODE Expert Team On Data Management Practices, Belgium, 2003 *(also JCOMM Meeting Report No. 25)*

198. Fifth Session of the IOC-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LMEs), Paris, 2003

199. Ninth Session of the IOC Consultative Group on Ocean Mapping, Monaco, 2003 ***(Recommendations in English, French, Russian and Spanish included)***

200. Eighth Session of the IOC Group of Experts on the Global Sea level Observing System (GLOSS), France, 2003 ***(electronic copy only)***

201. Fourth Session of the Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Greece, 2004 ***(also printed in French)***

202. Sixth Session of the IOC-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LMEs), Paris, 2004 ***(electronic copy only)***

203. Fifth Session of the Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Argentina, 2005 ***(also printed in French)***

204. Ninth Session of the IOC Group of Experts on the Global Sea level Observing System (GLOSS), France, 2005 ***(electronic copy only)***

205. Eighth Session of the IOC/WESTPAC Co-ordinating Committee for the North-East Asian Regional – Global Ocean Observing System (NEAR-GOOS), China, 2003 ***(electronic copy only)***

206. Sixth Meeting of the Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Spain, 2006 ***(also printed in French)***

207. Third Session of the Regional Forum of the Global Ocean Observing System, South Africa, 2006 ***(electronic copy only)***

208. Seventh Session of the IOC-UNEP-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LMEs), Paris, 2005 ***(electronic copy only)***

209. Eighth Session of the IOC-UNEP-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LMEs), Paris, 2006 ***(electronic copy only)***

210. Seventh Meeting of the IOC Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Gabon, 2007 ***(bilingual English/French)***

211. First Meeting of the IOC Working Group on the Future of IOC, Paris, 2008 ***(Executive Summary in English, French, Russian and Spanish included)***

212. First meeting of the Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG), Paris, 3–4 April 2008 ***(Executive Summary in English, French, Russian and Spanish included)***

213. First Session of the Panel for Integrated Coastal Observation (PICO-I), Paris, 10–11 April 2008 ***(electronic copy only)***

214. Tenth Session of the IOC Group of Experts on the Global Sea level Observing System (GLOSS), Paris, 6–8 June 2007 ***(electronic copy only)***

215. Eighth Meeting of the IOC Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Paris, 21–25 April 2008 ***(bilingual English/French)***

216. Fourth Session of the Global Ocean Observing System (GOOS) Regional Alliances Forum (GRF), Guayaquil, Ecuador, 25–27 November 2008 ***(electronic copy only)***

217. Second Session of the Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG), Paris, 27 March 2009 ***(Executive Summary in English, French, Russian and Spanish included)***

218. Ninth Meeting of the IOC Advisory Body of Experts on the Law of the Sea (IOC/ABE-LOS), Paris, 30 March–3 April 2009 ***(bilingual English/French)***

219. First Session of the IOC-SCOR International Ocean Carbon Coordination Project (IOCCP) Scientific Steering Group (also IOCCP Reports, 3), Broomfield, Colorado, U.S.A., 1 October 2005 ***(electronic copy only)***

220. Second Session of the IOC-SCOR International Ocean Carbon Coordination Project (IOCCP) Scientific Steering Group (also IOCCP Reports, 6), Paris, France, 20 April 2007 ***(electronic copy only)***

221. Third Session of the IOC-SCOR International Ocean Carbon Coordination Project (IOCCP) Scientific Steering Group (also IOCCP Reports, 10), Villefranche-sur-mer, France, 3–4 October 2008 ***(electronic copy only)***

222. Fourth Session of the IOC-SCOR International Ocean Carbon Coordination Project (IOCCP) Scientific Steering Group (also IOCCP Reports, 15), Jena, Germany, 14 September 2009 ***(electronic copy only)***

223. First Meeting of the joint IOC-ICES Study Group on Nutrient Standards (SGONS) (also IOCCP Reports, 20), Paris, France, 23–24 March 2010 *(Executive Summary in E, F, R, S included)*

224. Third Session of the Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG), Lisbon, Portugal, 5–6 May 2010 ***(Executive Summary in English, French, Russian and Spanish included)***

225. Eleventh Session of the IOC Group of Experts on the Global Sea level Observing System (GLOSS), Paris, 13–15 May 2009 ***(electronic copy only)***

226. Second Session of the Panel for Integrated Coastal Observation (PICO-II), Paris, 24–26 February 2009 ***(electronic copy only)***

227. First meeting of the Task Team on Seismic Data Exchange in the South West Pacific of the ICG/PTWS Regional Working Group for the Southwest Pacific, Port Vila, Vanuatu, 19–20 October 2009 ***(electronic copy only)***

228. Fourth Session of the Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG), Paris, France, 20–21 March 2011 ***(Executive Summary in English, French, Russian and Spanish included)***

229. Second Session of the IODE Steering Group for Ocean Teacher (SG-OT), Miami, Florida, 11–15 April 2011

230. First Meeting of the Inter-ICG Task Team 1 on Sea Level Monitoring for Tsunami (Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG), Seattle, USA, 29 November–1 December 2010

231. First Meeting of the Inter-ICG Task Team 2 on Disaster Management and Preparedness (Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG), Seattle, USA, 29 November–1 December 2010

232. First Meeting of the Inter-ICG Task Team 3 on Tsunami Watch Operations (Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG), Seattle, USA, 29 November–1 December 2010

233. Primera Reunión del Grupo de Trabajo Regional para América Central del Grupo Intergubernamental de Coordinación del Sistema de Alerta contra los Tsunamis y Atenuación de sus Efectos en el Pacífico (ICG/PTWS), Managua (Nicaragua) del 4 al 6 de noviembre de 2009 ***(Resumen dispositivo en español e inglés)***

234. Segunda Reunión del Grupo de Trabajo Regional para América Central del Grupo Intergubernamental de Coordinación del Sistema de Alerta contra los Tsunamis y Atenuación de sus Efectos en el Pacífico (ICG/PTWS), San Salvador (El Salvador) del 28 al 30 de septiembre de 2011 ***(Resumen dispositivo en español e inglés)***

235. First Session of the Joint IODE-JCOMM Steering Group for the Global Temperature-Salinity Profile Programme (SG-GTSPP), 16–20 April 2012, Ostend, Belgium

236. Ad hoc Session of the Joint JCOMM-IODE Steering Group for the Ocean Data Standards Pilot Project (SG-ODSPP), 23–25 April 2012, Ostend, Belgium

237. First Meeting of the Regional Working Group on Tsunami Warning and Mitigation System for the South China Sea Region (SCS-WG), Sanya, China, 12–14 December 2011

238. First Meeting of the IODE Steering Group for OceanDocs (SG-OceanDocs), 24–27 January 2012, Ostend, Belgium

239. Fifth Session of the Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG), Tokyo, Japan, 15 February 2012 ***(Executive Summary in English, French, Russian and Spanish included)***

240. Ad hoc Session of the IODE Group of Experts on Biological and Chemical Data Management and Exchange Practices (GE-BICH), Ostend, Belgium, 25 October 2012

241. Twelfth Session of the IODE Group of Experts on Marine Information Management (GE-MIM), Miami, USA, 22–25 January 2013

242. Twelfth Session of the IOC Group of Experts on the Global Sea level Observing System (GLOSS), Paris, 9–11 November 2011 ***(electronic copy only)***