JCOMM EXPERT TEAM ON WIND WAVES AND STORM SURGES (ETWS) SECOND SESSION

Geneva, Switzerland, 20-24 March 2007

FINAL REPORT

JCOMM Meeting Report No. 49

WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (OF UNESCO)

JCOMM EXPERT TEAM ON WIND WAVES AND STORM SURGES (ETWS) SECOND SESSION

Geneva, Switzerland, 20-24 March 2007

FINAL REPORT

JCOMM Meeting Report No. 49

N O T E

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariats of the Intergovernmental Oceanographic Commission (of UNESCO), and the World Meteorological Organization concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

C O N T E N T S

General Summary of the Work of the Session 1

Annex I – List of Participants 16

Annex II – Agenda 18

Annex III – SPA Top Level Objectives 20

Annex IV – JCOMM Wind Wave and Storm Surge Programme Elements and Activities for 2005-2009 21

Annex V – Wave Model Verification Data Exchange Report Outline / Web Page on the SPA Website 30

Annex VI – Proposal for a JCOMM Extreme Waves Data Base 31

Annex VII – Concept, Structure and Content of the Dynamic Guides 33

Annex VIII – Surface Wave Observation Requirement Document 34

Annex IX – JCOMM Scientific and Technical Symposium on Storm Surges – Invited Speakers . 42

Annex X – Terms of Reference and General Membership of the Task Team to Consider Improved Baseline Sea State Maritime Safety Information using Modern Techniques 43

Annex XI – Terms of Reference of an Expert on Met-ocean Information in Graphical Form 44

Annex XII – List of Actions 45

Annex XIII – Acronyms and Other Abbreviations 49

GENERAL SUMMARY OF THE WORK OF THE SESSION

1. OPENING OF THE SESSION

1.1 Opening

1.1.1 The second session of the JCOMM Expert Team on Wind Waves and Storm Surges (ETWS) was opened by the Services Programme Area (SPA) Coordinator, Dr Craig Donlon, on behalf of the ETWS chairperson, Mr Val Swail (Canada), at 0930 hrs on Tuesday, 20 March 2007, in salle 7Lake at the WMO Headquarters, Geneva, Switzerland.

1.1.2 Dr Donlon welcomed participants to the session and expressed his considerable appreciation to WMO for hosting the meeting. On behalf of the Team, Dr Donlon expressed his sincere wish that Mr Val Swail, chairperson of the ETWS, recovers from his illness soon. It was truly regrettable that he was not able to attend the session physically, as his wealth of knowledge on the subject is vast and his real-time contributions were truly missed. Moreover, he expressed his appreciation to Mr Val Swail for all the comments and contributions he provided to the meeting during the teleconferences and for the excellent work in the preparation of the meeting. He then introduced Professor Hong Yan, the Deputy Secretary-General, to address the session.

1.1.3 On behalf of the Secretary-General of the WMO, Mr Michel Jarraud, and of the Executive Secretary the IOC, Dr Patricio Bernal, Professor Hong Yan welcomed participants to the session, to Geneva in general and to the WMO in particular. Professor Hong Yan recalled that the National Meteorological Services of a large number of maritime countries, for many years have been engaged in the provision of ocean wave forecast and hindcast services in support of the requirements of users in the whole range of maritime activities. In recognition of this, both requirements of National Meteorological Services of ocean-related services and the rapid developments which were occurring in wave measurement, analysis and forecasting techniques, the WMO Commission for Marine Meteorology (CMM), that preceded JCOMM, established in 1984 a WMO Wave Programme. Consequently, at the first session of the JCOMM (Akureyri, Iceland, June 2001) the Commission agreed that it would be logical to transform the WMO Wave Programme into the JCOMM Wind Waves and Storm Surge Programme. Its Terms of Reference now include storm surge prediction support that cut across various WMO Programmes, in particular the WMO Tropical Cyclone Programme and the WMO Disaster Prevention and Mitigation Programme. Professor Hong Yan pointed out that the continuing provision of safety-related met-ocean products and services is a fundamental priority of JCOMM.

1.1.4 Professor Hong Yan also recalled that during the present mandate, the Secretary-General of WMO attempted to introduce substantial reforms as a continuing process in internal management while enhancing the Secretariat's support to Members and the Technical Commissions, particularly by strengthening all the cross-cutting issues in support of Disaster Risk Management. To this end, JCOMM, and in particular the Expert Team on Wind Waves and Storm Surges, play a critical role for enhancement of capacities by monitoring, detecting, and forecasting of ocean-related hazards (such as severe storms, extreme waves, storm surges, tropical cyclones and ocean-associated phenomena), to further improve coastal management through its own activities and initiation of a new Inter-Commission collaborations in relevant areas. In this context, Professor Hong Yan pointed out some areas/activities from the Work Plan of this Expert Team that were identified as having a potentially high interest for the proposed mechanism on strengthening relationships between inter-commission activities. These include:

a) To develop guidelines for storm surge prediction, followed by the development of a demonstrated project for storm surge warnings. Through the WMO DPM Programme a number of EWS projects were being initiated and these present an opportunity to include storm surge warnings;

b) To enhance storm surges statistics in collaboration with the JCOMM Expert Team on Marine Climatology. This would involve guidelines for storm surges historical databases and statistical techniques to enable Members/Members States carry out statistical analysis in their countries. There is a clear need for enhanced global and regional statistics on Storm and Surges;

c) Concerning capacity development for storm surge warnings, it is necessary to strengthen relationships with the CBS, OPAG on PWS for enhancement of public storm surge warnings, and with CHy for interfacing storm surge and coastal flood models.

1.1.5 Professor Hong Yan finally expressed his sincere appreciation for the work undertaken by this Team in the preparation of the *Guide to Storm Surge Forecasting* to be published by the end of 2007 as a WMO Guide Series and convening of the First International Scientific and Technical Symposium on Storm Surges in Seoul, Republic of Korea, from 2 to 6 October 2007, at the kind invitation of the Government of the Republic of Korea. Professor Hong Yan assured participants of the full support of his staff and concluded by wishing everyone a successful meeting and an enjoyable stay in Geneva.

1.1.6 Dr Georgi Kortchev, Director of the Applications Programme Department of the WMO, welcomed the participants to the session and to Geneva. Dr Kortchev recalled that at the Second Session of the JCOMM (JCOMM-II, Halifax, Canada, September 2005), the Commission urged the ETWS to complete the preparations of the *Guide to Storm Surge Forecasting* during the intersessional period and adopted Recommendation 1 (JCOMM-II) on this topic. Responding to this recommendation, and in order to develop the contents and the implementation plan for the preparation of the *JCOMM Guide to Storm Surge Forecasting*, the WMO hosted an Expert Meeting in Geneva, Switzerland, in February 2006. The Team noted that by the end of June 2007 the *Guide* will be edited linguistically, the final layout and format will be prepared and reviewed by Mr Val Swail, Dr Tad Murty, Professor Igor Lavrenov and the Secretariat. Dr Kortchev also recalled that this Meeting agreed the *Guide* should raise attention to the need for addressing the vulnerability of coastal areas exposed to storm surges, and forecasting not only hazards but risks, which result from a combination of a hazard with a vulnerability. This is provided in Chapter 9 of the *Guide,* "Surge Disaster Preparedness", and take advantage of the existing knowledge and expertise amongst the WMO and IOC Programmes. This is done in accordance with the increasing practice of NMHSs to use and deliver warning and risk hazard maps. Dr Kortchev pointed out the need to further strengthen collaboration with the Expert Team on Marine Climatology and the Expert Team on Maritime Safety Services by defining a joint work plans. Dr Kortchev finally wished everyone an enjoyable stay in Geneva.

1.1.7 The list of participants in the session is given in Annex I.

1.2 Adoption of the agenda

1.2.1 The Team adopted its agenda for the session based on the provisional agenda given in Annex II.

1.3 Working arrangements

1.3.1 The Team agreed its hours of work and other practical arrangements for the session. The Secretariat introduced the documentation, and participants briefly introduced themselves, to facilitate future interactions.

2. Reports

2.1 Report of the Services Programme Area coordinator

2.1.1 The Team noted with interest and appreciation the report of the Services Programme Area (SPA) Coordinator, Dr Craig Donlon. This report covered the structure of the SPA, a brief

description of the new Expert Team on Marine Accident Emergency Support (ETMAES), the terms of reference for the newly appointed Rapporteur for Operational Ocean Forecasting Systems (OFS), the work plan developed by the Coordinator for the current intersessional period and concluded with a series of key issues for the Expert Team on Wind Waves and Storm Surges (ETWS) to consider during the remainder of the meeting.

2.1.2 At the SCG-III (Exeter, United Kingdom, 7-10 November 2006), the SPA coordinator proposed a new structure for the SPA which focus all current ETs on a common theme of Met-ocean Services in support of Maritime Safety Systems. In addition, noting the importance of pulling through the successes of the Ocean Forecasting systems (such as those within the Global Ocean Data Assimilation Experiment (GODAE) Project) into JCOMM as GODAE transitions from pilot project to operations and, the increasing role of integrating ocean forecast systems, a new Rapporteur for Operational Ocean Forecasting Systems (in particular ocean meso-scale forecasting) has been appointed to facilitate this transition. The Team was informed that the newly appointed Rapporteur, Dr Adrian Hines (Met Office, United Kingdom) is attending the ETWS meeting and will also replace Dr Martin Holt on the ETWS membership.

2.1.3 Dr Donlon introduced the agreed Top Level Objectives (TLOs) for the SPA work-plan, which are applicable to all activities of ETWS, and other ETs within the SPA specified in Annex III. An electronic version of the SPA work plan is available at http://www.jcomm-services.org. Dr. Donlon discussed the role of the SPA within JCOMM and noted that a key challenge for the programme is the integration of science and standards into operational services supporting maritime safety, emergency response, disaster risk reduction and maritime hazards with full users' support and interaction. The main deliverables from the work plan are a series of standards specification documents and services including the following:

- A New JCOMM SPA web site for general discussion, promotion and information on the activities of the SPA at http://www.jcomm-services.org;
- A JCOMM Services User Requirement Document (URD);
- Observation Requirements for JCOMM Services including in situ and satellite observations;
- A JCOMM Catalogue of Operational Ocean Products and Services;
- Standard Data and Metadata Formats for Ocean Products (including satellite, climatology, model, combined);
- A Guide to Ocean Product Presentation, Symbology and Nomenclature.

The SPA Coordinator and ET Chairpersons will develop these documents with inputs from ETs themselves rather than by a dedicated Task Team for Ocean Products Development. A Guide to Ocean Product Presentation, Symbology and Nomenclature will be presented to the Commission during JCOMM-III for approval.

2.1.4 The Team noted with appreciation that the SPA is planning an International Maritime Met-ocean Services Conference (IMMSC) 2008 (Exeter, UK, 5-9 October 2008), with the aim of establishing and agreeing on international Met-ocean Services requirements, identifying shortcomings of the present systems and reviewing long and short-term solutions. The Conference will bring together private and public maritime application industries, system and service providers, marine scientists and engineers to improve communication and mutual understanding. A Scientific Coordination Group will be established to develop the format and content of the Conference in the next six months. Dr. Donlon requested that the ETWS provides delegates to represent the Team on the IMMSC Scientific Steering Team **(Action: ETWS members and Secretariat)**. The ETWS contributions to this Conference are further discussed under item 7.6.

2.1.5 The SPA Coordinator, Dr Craig Donlon, presented the SPA website (www.jcomm-services.org), including a revised JCOMM Electronic Product Bulletin (J-EPB) for ocean services. Dr Donlon demonstrated the functionality of the website, which has been developed so that ET Chairpersons and Team members can directly access and edit web pages from anywhere in the

world by simply using a web browser. Dr Donlon explained that basic template pages had been prepared for each of the ETs within the SPA, and that the SPA Coordinator would maintain all web management services and tools. Dr Donlon acknowledged the support of the Met Office (United Kingdom), who had paid $10K USD for the JCOMM web system. Dr Donlon reminded the ETWS that the task to populate the JCOMM SPA web space with useful content was now the responsibility of the ETs themselves, using the web-tool provided by the coordinator. The system is easy to use, providing an interface similar to Microsoft Word, so that no knowledge of HTML is required to develop and edit pages.

2.1.6 The Group agreed that the web is now an important and necessary communication tool and should therefore contain useful information to its potential audiences. It agreed that content should be added as a matter of urgency by the Team. Dr Donlon therefore encouraged the ET Members to take action and provided them with a username and password to have access to include content into the SPA website **(Action: ETWS members)**.

2.1.7 The SPA Coordinator noted the following as key areas for ETWS to consider during the discussions:

a) Production of the *Guide to Storm Surge Forecasting*;
b) Continuation and expansion of the operational wave forecast verification project;
c) Development and updating the dynamic part of the *Guide to Wave Analysis and Forecasting*;
d) Completion of Technical Reports on wave climate effects on design criteria and review of boundary layer wind fields;
e) Development (in collaboration with the ETMC) of an archive of extreme wave events;
f) Development of a statement of requirements for wave observations;
g) Contribution to the organization of the First JCOMM Scientific and Technical Symposium on Storm Surges (Seoul, Republic of Korea, from 2 to 6 October 2007);
h) Co-organize the 10th International Workshop on Wind Waves and Storm Surges (Hawaii, USA, from 11 to 16 November 2007);
i) Participation in the development of the Cross-JCOMM Pilot Project on Extreme Water Level (JEWL), in collaboration with WMO DPM Programme and other Technical Commission (e.g., CHy, CAS and CBS/WIS);
j) Respond to a requirement of the ETMSS for forecasting rogue waves and dangerous seas;
k) Contribute to the JCOMM user requirements document;
l) Develop one or more capacity building modules for OceanTeacher and/or Bilko lessons on storm surge and waves;
m) Enhance storm surge statistics (with the collaboration of the ETMC);
n) Contribute and participate in the October 2008 IMMSC Conference.

2.2 Report of the chairperson

2.2.1 The Team noted with appreciation the report by the chairperson, Mr Val Swail, on the activities and plans of the Team presented by the SPA Coordinator, Dr Craig Donlon. He first noted the background of the establishment and the Terms of Reference of this Team. JCOMM-I agreed that it would be logical to transform the WMO Wave Programme into the JCOMM Wind Wave and Storm Surge Programme. The most important considerations were that (a) storm surge prediction support was included in the new expanded terms of reference of JCOMM; and (b) there were many commonalties between systems providing wind wave and storm surge prediction.

2.2.2 Mr Val Swail in his report described the activities and accomplishments of the ETWS in the period since JCOMM-II, noting in particular: (i) the publication of JCOMM Technical Reports on the wave forecast verification project, satellite data assimilation and the Eighth Waves Workshop, (ii) the Expert Meeting on the development of the JCOMM Guide to Storm Surge Forecasting and subsequent content developed for the Guide, (iii) the 9th International Workshop on Wave Hindcasting and Forecasting (Victoria, Canada, September 2006) where the JCOMM Waves

Programme was presented, and (iv) presentations made to the 22nd Session of the Data Buoy Cooperation Panel and the First Joint SAMOS/GOSUD workshop on the requirements for enhanced wave measurements. In response to significant interest expressed at 9th Waves Workshop, a questionnaire was developed (by the SPA Coordinator and the Secretariat) and distributed to the participants on their wave data requirements. The Team noted that the Secretariat had received fifteen answers so far and urged the Secretariat to compile this information in order to include this information in the *Wave Observations Requirements Document* to be transferred to the OCG as soon as possible **(Action: Secretariat)**.

2.2.3 The key elements for the ETWS during the 2005-2009 intersessional period were presented in detailed, including: (a) production of the *Guide to Storm Surge Forecasting*; (b) continuation and expansion of the operational wave forecast verification project; (c) development and updating the dynamic part of the *Guide to Wave Analysis and Forecasting*; (d) completion of Technical Reports on wave climate effects on design criteria and review of boundary layer wind fields; (e) development, with the ETMC, of an archive of extreme wave events; (f) development of a statement of requirements for wave observations; (g) contribution to the organization of the First JCOMM Scientific and Technical Symposium on Storm Surges (Seoul, Republic of Korea, 2-6 October 2007); (h) co-organize the 10th International Workshop on Wind Waves and Storm Surges (Hawaii, USA, 11-16 November 2007).

2.2.4 During the ensuing discussion of the report, the Team stressed that it is a very ambitious work plan, which would require substantial efforts by the Team during the current intersessional period, and it agreed to prioritize these activities. The work plan was thoroughly reviewed under relevant agenda items during the session. The background document for the ETWS activities is provided in Annex IV.

2.3 Report of the Secretariat

2.3.1 The Team recalled that the second session of the JCOMM took place in Halifax, Canada, in September 2005. Bearing in mind that the best way to activate and motivate the main JCOMM subsidiary bodies is to have them meet early in the intersessional period, to prepare work strategies, address priority issues identified by JCOMM-II and allocate specific tasks, a work programme was prepared which allowed for the Management Committee and SPA Coordination Group to meet in 2006 and to develop a specific work plan.

2.3.2 The Team noted with appreciation the summary reports on: (i) the results of JCOMM-II; (ii) the fifth session of the Management Committee; (iii) the third session of the SPA Coordination Group; (iv) the second session of the Expert Team on Maritime Safety Services; and (v) the first session of the Expert Team on Marine Accident Emergency Support. The meeting was briefed on these meetings. Details of actions proposed to the ETWS by Coordination Groups and other Teams were discussed under appropriate agenda items.

3. Activities

3.1 Operational wave forecast verification project

3.1.1 The Rapporteur for Operational Ocean Forecasting Systems, Dr Adrian Hines, presented the operational wave forecast verification project. His presentation covered the background to the verification exchange, and the status of the exchange and issues raised at previous meetings.

3.1.2 The Team noted that the routine intercomparison of wave model forecast verification data has been in place since 1995 and now includes 10 participants contributing data on a routine basis (ECMWF, Met Office, FNMOC, NCEP, Meteorological Service of Canada, Météo-France, DWD, BOM, SHOM and JMA). The Team recalled that the aim of this exchange is to provide a mechanism for benchmarking and assuring the quality of wave forecast model products that contribute to applications such as safety of life at sea, ship routing and the Global Maritime Distress and Safety System (GMDSS). The Team noted with appreciation that Republic of Korea

is prepared to take part of the wave intercomparison project. The Team also noted the interest expressed by China to participate in this project and urged the ETWS chairperson and the Secretariat to make the necessary arrangements **(Action: ETWS chairperson and Secretariat)**.

3.1.3 Dr Hines pointed out that data are collated and statistics are produced on a monthly basis at ECMWF, including a range of statistics (bias, RMSE, correlation coefficient, scatter index, symmetric slope) for a number of parameters (significant wave height, peak period, and wind speed). Plots of statistics together with the verification data are made available to the participants via FTP.

3.1.4 The Team noted that the intercomparison is based upon a set of buoy observations at which data is provided from all of the available systems. Whilst the number of available buoy observations that could potentially be used in the exchange has grown over recent years, including these additional observations is not straightforward for all participants. In consequence, the common set of observations is not optimal to this task. A number of recommendations made during the ETWS-I for development of the verification exchange have been forwarded, most notably the continued expansion of the exchange to take in new contributors. A technical report on the verification activity, requested by the JCOMM SCG-I meeting, was published in 2006.

3.1.5 Other recommendations made at ETWS-I require further action, most notably the proposal for a routine summary report for wider dissemination (an issue also raised at the JCOMM-I meeting), the use of additional observation types (spectral observations and altimeter wave height observations), and changes to the content of the verification (forecasts of extreme sea state, verification against model analyses, and standardization of the peak period computation).

3.1.6 Dr Hines proposed a number of recommendations for consideration by ETWS-II, which formed the basis for the subsequent discussion. Following the initial discussion, a Working Group on Wave Intercomparison Project **(Action: WG-WIP – Mr Val Swail, Dr Adrian Hines, Dr Jean Bidlot, Dr Hendrik Tolman, Dr Thomas Bruns, Dr Jang Won Seo, Mr Jean-Michel Lefèvre and Mr Graham Warren)** was established for further detailed exploration of the way forward. The Working Group agreed to develop a report for inclusion on the SPA website that sets out the rationale for the validation exchange, together with plans for further expansion, including technical details of the methodologies to be employed. Dr Hendrik Tolman agreed to lead the preparation of an outline for the report (given in the Annex V) **(Action: Dr Hendrik Tolman)**. Dr Jean Bidlot agreed to be the focal point for the developing of the content of this report on the SPA website **(Action: Dr Jean Bidlot)**.

3.1.7 The WG-WIP discussed a number of technical issues related to the expansion of the exchange, most notably use of additional data types, data formats, and data policy issues. Lead responsibility for contribution of detailed information for the main areas of expansion of the exchange, based on the outcomes of the discussion and further investigation, was divided as follows:

- Description and expansion of existing work **(Action: Dr Jean Bidlot and Dr Hendrik Tolman)**;
- Validation against altimeter wave height data **(Action: Dr Hendrik Tolman and Mr Jean-Michel Lefèvre)**;
- Validation against spectral buoy data **(Action: Dr Jean Bidlot and Dr Hendrik Tolman)**;
- Validation of spatial data **(Action: Dr Adrian Hines and Mr Jean-Michel Lefèvre)**.

3.1.8 In each area, the person responsible will contribute with detailed specification for the practical implementation of the extensions to the validation exchange, in consultation with other WG-WIP members as required. Dr Hines suggested that each WG-WIP member should provide examples of utilization of these data to be presented on the SPA website **(Action: WG-WIP)**.

3.1.9 The WG-WIP recommended that the wave intercomparison work should be presented in a dedicated session at the upcoming 10th Wave Workshop and the ETWS chairperson, Mr Val Swail agreed to arrange to make it happen **(Action: ETWS chairperson)**. It was agreed this is an excellent opportunity to publicize the work undertaken within the exchange project. In addition, Dr Jean Bidlot agreed to investigate the possibility of making results from the existing validation exchange available via the SPA web pages **(Action: Dr Jean Bidlot)**. The Team recalled that the presentation of the wave intercomparison work at the 10th Wave Workshop will happen ten years after the first presentation of the project at the Waves 97 Workshop.

3.2 Extreme wave database

3.2.1 The Team noted the proposal (provided in Annex VI) that has been developed between the chairpersons of both the Expert Team on Wind Waves and Storm Surges (ETWS) and the Expert Team on Marine Climatology (ETMC), and the JCOMM Data Management Programme Area (DMPA) Coordinator, for the establishment of a JCOMM Extreme Wave Database for use in model validation and validation of remotely sensed waves, where such models and algorithms suffer from lack of sufficient data.

3.2.2 In discussion, concerns were raised about the need to associate adequate disclaimers with the planned database, since the extracted *in situ* data would necessarily be very sparse and incomplete. It was also suggested that altimeter data be included as an integrated component of the system. The Team agreed to establish this database **(Action: ETWS chairperson (leader), ETWS members, ETMC Chairperson and DMPA Coordinator)**, through the solicitation of additional contributions of *in situ* data (e.g., beyond the Canadian and US data that have been scanned in preliminary fashion), with the likelihood that some complications would also need to be sorted out on open re-distribution and other national or organizational data policies; and with Dr Hendrik Tolman kindly agreeing to arrange for the provision of a selection of appropriate altimeter data **(Action: Dr Hendrik Tolman)**. Dr Jean Bidlot agreed to inform the Team regularly on the buoys data that would become available on the GTS **(Action: Dr Jean Bidlot)**.

3.3 Wind, Wave and Surge Climatologies

3.3.1 The Team noted that following the ETWS-I (Halifax, Canada, June 2003), questionnaires were developed and distributed to Members/Member States to supply information on measured and hindcast wave and surge databases (following the example of the present Tables 9.2, 9.3 in the *Guide to Wave Analysis and Forecasting (WMO-No. 702))*. The Team noted with appreciation that Dr María Paula Etala has analyzed the results from the storm surge questionnaire. The Team noted that the wave questionnaires have not yet been analyzed so far and urged the ETWS chairperson and the Secretariat to make this analysis as soon as possible **(Action: ETWS chairperson and Secretariat)**. It noted that the Global Data Processing and Forecasting Systems (GDPFS) of the WMO World Weather Watch (WWW) has been maintaining a continuously updated catalogue of data and products stored in the system, including wave models description. The Team therefore urged the Secretariat to compile the information available under this catalogue on wave models **(Action: Secretariat)** and recommended that this information would be combined with the analysis of the results from the wave questionnaire **(Action: Mr Val Swail, Dr Jean Bidlot, Mr Jean-Michel Lefèvre and Secretariat)**. The Team agreed that the analysis of the results from both questionnaires would be placed online as section of the dynamic parts of the wave and surge Guides **(Action: Mr Val Swail, Dr María Paula Etala and Secretariat)**.

3.3.2 The Team suggested a continuation of ongoing work including in the areas of completing analyses of existing questionnaires, and updating inventories of climatological products. Products from the US Corps of Engineers in this area were emphasized as an important potential resource and recommended to establish a liaison with them on these matters **(Action: Mr Val Swail, Dr Hendrik Tolman and Secretariat)**.

3.4 JCOMM Extreme Water Level (JEWL) project

3.4.1 The Team was informed that at the Third Session of the Services Programme Area (SPA) Coordination Group (November 2006) a decision was taken to develop a Cross-JCOMM Pilot Project on Extreme Water Level (JEWL = JCOMM Extreme Water Level) (near-shore waves, surges and tides) in coastal/shelf zones (including assessment of current activities plus requirements, and defining a cross-JCOMM framework for develop the pilot project). Noting in particular, the existing experience and expertise of the Bureau of Meteorology, amongst others, Mr Phillip Parker was appointed Leader of the project. Dr María Paula Etala was appointed Leader of the Working Group on JEWL project (WG-JEWL). She would closely work with Mr Phillip Parker to delineate a concrete scope, structure and content of the project. This would include appropriate liaisons with WMO Disaster Prevention and Mitigation Programme, WMO Tropical Cyclone Programme, WMO Hydrology and Water Resources Programme and the WMO Commission for Hydrology **(Action: WG-JEWL – Dr María Paula Etala (leader), Dr Hans de Vries, Dr Jang Won Seo, Dr Hendrik Tolman, Dr Kevin Horsburgh and Mr Masakazu Higaki)**. The Team noted with interest that the National Hurricane Center's (NHC) Storm Surge Group developed the Maximum Envelope of Water (MEOW) and urged Dr Hendrik Tolman to provide information on this issue and the contact details of this Group **(Action: Dr Hendrik Tolman)**. Noting the need to provide input to the development of effected-oriented products in the coastal zone, such as inundation maps, as well as waves and storm surges combined products; the Team was urged to provide to the Secretariat the best practices on met-ocean products provision in support of disaster risk reduction **(Action: ETWS members)**.

4. Guides and relevant publications

4.1 Guides

4.1.1 Guide to Wave Analysis and Forecasting

4.1.1.1 The Team noted that the *Guide to Wave Analysis and Forecasting* (WMO-No. 702) was first published in 1988 and its second edition was published in 1998. The guide is designed to enhance the provision of up-to-date information and guidance material on all aspects of ocean-related activities of National Meteorological Services (NMSs).

4.1.1.2 The Team recalled that the Secretariat made available a .pdf version of the *Guide to Wave Analysis and Forecasting* on the SPA web site. The Team noted that much of the material in the Guide was written based on knowledge and information available up to about 1996, and that since then, a significant amount of research had been carried out by a number of national/international agencies, which had contributed much valuable information on wave forecasting. The Team also recalled that in view of on-going developments of practices in numerical wind wave forecasting, JCOMM-I had stressed the need for relatively regular updating of the Guide. It agreed on the necessity of such an update and agreed to adopt the following approach: firstly, to use the existing static part of the Guide content as the backbone framework for constructing the dynamic part of the Guide. For the latter, it was recommended that a set of web pages with this information should be created, and urged the Secretariat to produce them **(Action: Secretariat)**. The content of these web pages would be regularly reviewed by the Working Group on Wave Guide **(Action: WG-WG – Dr Thomas Bruns (leader), Mr Val Swail, Dr Jean Bidlot, Dr Jong-Won Seo, Mr Jean-Michel Lefèvre and Mr Graham Warren)**; Secondly, to develop a more dynamic part covering matters relating to new technologies and emerging issues, which could be made available in digital form on the web, which links to operational systems, models outputs, and training modules **(Action: all ETWS members)**. The Team recommended to establish a similar procedure to the Guide to Storm Surge Forecasting **(Action: WG-JEWL)**.

4.1.2 Guide to Storm Surge Forecasting

4.1.2.1 The WG-JEWL reviewed in detail the first draft of the *Guide to Storm Surge Forecasting*, and a list of suggestions and comments was prepared to be transmitted to Dr Tad Murty that would

be editing the Guide **(Action: Dr Tad Murty and Secretariat)**. The Team noted, some parts of the Guide would be re-written,edited linguistically by end of June 2007, with the final layout and format prepared and reviewed by Mr Val Swail, Dr Tad Murty, Professor Igor Lavrenov and the Secretariat **(Action: Mr Val Swail, Dr Tad Murty, Professor Igor Lavrenov and the Secretariat)**.

4.1.3 Dynamic parts of the Guides

4.1.3.1 The Team noted and agreed with the structure and initial content for the dynamic part of the wave and surge Guides proposed by the ETWS chairperson. Based on the discussions under the agenda item 4.1.1, the Team also recommended using the WMO-No. 702 as the backbone framework to create the background web pages for the dynamic part of the Guide **(Action: WG-WG)**. In addition, the Team recommended to include in item E of the *Concept, Structure and Content of the Dynamic Guides*, links to documents and products hosted elsewhere, including the work undertaken by other communities such as the US Corps of Engineers (revised version given in Annex VII). The Team also emphasized that the First JCOMM Scientific and Technical Symposium on Storm Surges (Seoul, Republic of Korea, 2-6 October 2007) should provide appropriate input for the dynamic part of the Guide, emphasizing new developments.

4.2 Technical Reports

4.2.1 The Team recalled that since JCOMM-II, two JCOMM Technical Reports "Verification of Operational Global and Regional Wave Forecasting Systems Against Measurements from Buoys" (2006) (WMO/TD-No. 1333, Marine Meteorology and Related Oceanographic Activities Report No. 30) and "Techniques and Benefits of Satellite Data in Wind and Wave Models" (2006) (WMO/TD-No.1357, JCOMM Technical Report No. 33) had been published in accordance with the identified interest during the ETWS-I.

4.2.2 The Team was informed that Mr Val Swail, in collaboration of Dr Sofia Caires, has been presently developing the "Climate Change Effects on Design Criteria" Technical Report. The Team recommended, it would be appropriated to develop and publish (prior JCOMM-III) a Technical Report on downscaling techniques for wind field and its use in high resolution wave and storm surge models which is important for models **(Action: Dr Hans de Vries (leader – to identify an expert from KNMI to contribute to the development of this Technical Report), Mr Val Swail, Dr Jean Bidlot, Dr Adrian Hines, Dr Hendrik Tolman and Mr Jean-Michel Lefèvre)** in addition to the proposed theme “Review of boundary layer wind fields”.

5. Observations Requirements

5.1 The Rapporteur for Operational Ocean Forecasting Systems, Dr Adrian Hines, presented a draft requirement for surface wave observations for wave forecast modelling and related activities. The requirements document is expected to include both the current requirement, and the foreseen requirement in the medium to long-term (next 5-10 years). Dr Hines emphasised that this document should present the requirements for observations, without addressing the availability or otherwise of suitable technical solutions to deliver those observations.

5.2 The Team agreed that the requirements document consists of a brief description of the applications for which the data are required followed by the table of requirements that specifies requirements for temporal and spatial sampling, accuracy and timeliness. For each of these, a minimum (the value below which the observation does not yield any significant benefit for the application in question) and a maximum (the value above which no further significant benefits would be obtained) requirement would be specified. Dr Hines emphasised the need for the ETWS to provide input into the requirements document.

5.3 Dr Hines presented a summary of the priorities and issues for five application areas: (i) assimilation into offshore wave forecast models; (ii) validation of wave forecast models; (iii) calibration / validation of satellite wave sensors; (iv) ocean wave climate and variability; and (v) the role of waves in coupling. The different nature of the final application area was noted, and it was

proposed to separate this requirement from the others as these all require routine monitoring activities.

5.4 The draft table of requirements was then presented and discussed. During the discussion the following points were agreed:

- At the request of the Secretariat, there was agreement to add a further table to the observations requirements to set out their implications in terms of *in situ* network and satellite sampling;

- Due to the large number of entries in the table of observations requirements; this table should be completed and included as an Annex to this report, as well as, placed on the SPA website.

- WG-WIP agreed to provide their input to the document to Dr Hines prior the SOT-IV meeting, in April 2007;

- The need to flag additional observations requirements, for example for spatial data (e.g. through wide swath wave height data or coastal HF radar) and for coastal observations, was noted;

- Noting the need to harmonize the Buoy Data Network, Dr Jean Bidlot kindly offered to report to the Group on the differences between Buoy Systems **(Action: Dr Jean Bidlot)**.

5.5 The updated Surface Wave Observation Requirement document with the above revisions incorporated is provided in Annex VIII. This document should be transmitted to the SOT and OCG prior to their meetings, preferentially before 13 April 2007 **(Action: WG-WIP)**.

6. Workshops and Capacity Building

6.1 Technology transfer

6.1.1 Storm Surge Symposium (SSS)

6.1.1.1 The Team recalled the second session of JCOMM addressed the importance of enhancing storm surge forecasting capabilities, and the need to complement other international efforts including the series of capacity building workshops on storm surge and wave forecasting (organized by JCOMM and the WMO Tropical Cyclone Programme) and JCOMM efforts in assisting the development of marine-related hazards warning systems. To this end, the 1st JCOMM Scientific and Technical Symposium on Storm Surges would take place at the Convention & Exhibition Center (COEX), in Seoul, Republic of Korea, from 2 to 6 October 2007. The focus of the Symposium would be similar to the very successful JCOMM scientific and technical workshops in other related fields, including the International Workshop on Wave Hindcasting and Forecasting and the CLIMAR Workshop on Advances in Marine Climatology.

6.1.1.2 Dr Jang Won Seo, the representative of the Local Organizing Committee for the Symposium (LOC), presented the overall progress in preparation of the Symposium. The local host had developed a Symposium website: http://www.jcomm2007sss.org comprising the overall information on the Symposium as well as the online submission system for abstracts and full papers. The Organizing Committee, comprised by key JCOMM members, WMO and IOC, finalized the second announcement of the Symposium. The Team was contributing to the scientific programme, planning through the Programme Committee, and finalized the list of the invited speakers (provided in Annex IX). Dr. Seo informed that the LOC – led by Korea Meteorological Administration (KMA) in collaboration with Ministry of Maritime Affairs and Fisheries (MOMAF) and Korea Ocean Research and Development Institute (KORDI) – was actively working on the overall preparation including designing a poster on the Symposium. The LOC was keen for cooperation

with the GEO noting that the results of this Symposium are an important input to GEOSS implementation in the Societal Benefit Area of Disasters. The Team agreed that GEO and JCOMM would both benefit to enhanced collaboration noting that the SSS provide an excellent opportunity in this respect. The Team requested the Secretariat and Organizing Committee to coordinate with the GEO Secretariat for further collaboration in preparing of this Symposium **(Action: Secretariat and Organizing Committee)**.

6.1.1.3 The Team also noted the importance of the Storm Surge Symposium to the WMO DPM Programme and to the JEWL Pilot Project, and requested the Secretariat to further enhance the coordination with DPM and other relevant programmes for appropriate scientific and technical input to the Symposium **(Action: Secretariat)**.

6.1.1.4 The Team noted that at the time of this meeting no invited speaker for the inundation modeling and mapping topic was identified. Dr Hendrik Tolman kindly offered to provide some names to the Programme Committee Chairperson, Mr Val Swail, soon **(Action: Dr Hendrik Tolman)**. The Team suggested that an additional topic on "Disaster Prevention and Mitigation Strategies and Societal Impacts" should be included, and urged the Symposium's Programme Committee to consider this proposal and to identify an expert to be an Invited Speaker for this topic **(Action: Symposium's Programme Committee)**.

6.1.1.5 The Team expressed its sincere appreciation to the Local Host and the Local Organizing Committee for their excellent work in preparing the Symposium as well as their significant contribution to this important event to implement the requirements derived from the JCOMM-II. It also expressed its satisfaction on the efficient work by the Organizing Committee and the Programme Committee encouraging them to work proactively for a successful event.

6.1.2 JCOMM Training workshops

6.1.2.1 The Team noted that WMO, jointly with the Cooperative Programme for Operational Meteorology Education and Training (COMET) (UCAR/United States), had conducted two training workshops on numerical wave analysis and forecasting, in 1995 and 1997. The meeting noted with appreciation and satisfaction that all the Team members who participated in the ETWS-I have contributed to a workshop on wind wave and storm surge analysis and forecasting for Caribbean countries (Dartmouth, Canada, June 2003). The Team recommended that a partnership with the COMET should be explored **(Action: ETWS Chairperson and Secretariat)**. The Team suggested that an inventory of Training materials should be developed and this information should be make available on the SPA website **(Action: ETWS members and Secretariat)**.

6.1.2.2 The meeting was informed that the US National Weather Service (NWS) had been annually organizing such internal workshops and that it was well recognized that such workshops were high return activities. Other workshops have been organizing in collaboration with the WMO Tropical Cyclone Programme that is further discussed under the agenda item 7.4. The Team agreed that the ETWS should continue to provide support to such training events where appropriate and possible.

6.1.2.3 The Team noted that several training materials produced by some of the Team members are already available and recommended that during the current intersessional period the Team should focus its work producing of e-learning modules to support training workshops.

6.1.3 Development of e-learning modules (OceanTeacher, Bilko)

6.1.3.1 The SPA Coordinator, Dr Craig Donlon, presented the report on possible alternatives for training within the ETWS. He recalled that the Services Programme Area (SPA) Coordination Group (SCG), during its Third Session, agreed that capacity needs to be developed appropriately for each Member in a manner that eventually results a fully functioning suite of met-ocean services satisfying national, regional and international needs. The Team noted that the SCG defined four stages of development for which the capacity building needs are very different:

a) **Stage 0:** Countries/Regions with very little or no services, very limited resources, who does not recognize their needs;

b) **Stage I:** Countries/Regions with little or no services, limited resources, who recognize their needs;

c) **Stage II:** Countries/Regions with some infrastructure, resources and good knowledge of met-ocean requirements and limitations. These Countries/Regions are capable of implementing SPA systems;

d) **Stage III:** Countries/Regions that have high-level infrastructures, resources and research and development activities and capable of developing the next generation of JCOMM services and products through innovations (e.g., graphic products, ecosystem models, etc.)

6.1.3.2 The Team also noted that for each stage, the most appropriate specialised training and regional cooperative projects would be different. For example, Stage III countries may require advanced training workshops, such as the Storm Surge Symposium. In contrast, it may be more appropriate to develop an initial capacity to use apply met-ocean products and services provided by other Member in countries that do not yet have operational services in place (Stage 0 and I). In this context, the SCG supported initiatives at all four stages of development, and agreed that should be developed e-learning tools (such as OceanTeacher and/or Bilko lessons) on the activities of each ET, covering the different stages.

6.1.3.3 The Team noted that the IOC/UNESCO Bilko Programme (see: http://www.bilko.org) is a complete system for learning and teaching remote sensing image analysis skills. Its primary goal is to make remote sensing training materials accessible to those without specialist resources at their disposal as well as to promote good teaching practices by tapping the diverse skills and expertise of an expert community. The Team also noted that Bilko system could be used to demonstrate more than just remote sensing data. Recently developed set of Bilko lessons and resources focusing on the use of ocean forecast output systems proved extremely successful with graduate and post-graduate students. The SPA Coordinator, Dr Craig Donlon, provided background information on IOC/UNESCO Bilko Programme (http://www.bilko.org). The Team also noted that GODAE and ESA are developing Bilko lessons (see, e.g. http://earth.esa.int/dragon/oceantraining2007.html). Based on the discussions, the Team recommended that should be developed one Bilko lesson on wind waves **(Action: Dr Jean Bidlot)** and another on storm surges **(Action: Mr Masakazu Higaki)**.

6.2 Other workshops and conferences

6.2.1 The Team noted the list of potential workshops and conferences that the Team should consider its participation. It recommended that this list should be available on the SPA website **(Action: Secretariat)** and encouraged the Team members to participate **(Action: ETWS members)**.

7. Cooperation with other bodies

7.1 Expert Team on Maritime Safety Services (ETMSS)

7.1.1 The Team was informed that the Second Session of the ETMSS (ETMSS-II, Angra dos Reis, Brazil, January 2007) has discussed elements for a stronger collaboration between the ETWS and the ETMSS, especially with a view to improve guidelines and regulations for the provision of complex sea states or extreme waves in Maritime Safety Information (MSI). Recognizing that sea state products and services to Mariners can be improved (e.g., by providing % chance of Rogue Waves, etc.), the ETMSS agreed on the Terms of Reference (ToR) and General Membership of a Task Team to consider improved baseline sea state MSI using modern techniques. The Team

nominated experts to represent the ETWS in this Task Team; the updated membership is provided in Annex X **(Action: Dr Hans de Vries and Dr Hendrik Tolman – to identify experts from Netherlands and USA, respectively, to represent the ETWS in the Task Team to consider improved baseline sea state MSI using modern techniques)**.

7.1.2 The Team was informed that according to the constraints related to the dissemination at sea of MSI, both for the SOLAS and non-SOLAS vessels, the provision of additional parameters or information in text or vocal form could be difficult and/or limited. The ETMSS has invited ETWS members to participate in the project for the provision of met-ocean MSI in graphical form, especially regarding the definition of symbols and potential thresholds for sea-state parameters or indicators and symbology (e.g., significant wave height above X meters, cross sea/steepness indexes, etc.). In this context, at its Second Session, the Expert Team on Maritime Safety Services (ETMSS-II, Angra dos Reis, Brazil, January 2007), agreed on the Terms of Reference (ToR) for an appointed expert, that could be founded by the Swiss Government, and the list of ETs experts to conduct this work. The Team nominated experts to represent the ETWS in this Task Team; the updated membership is provided in Annex XI **(Action: Dr Hans de Vries and Mr Masakazu Higaki – to identify experts from Netherlands and Japan, respectively, to represent the ETWS in the Task Team on met-ocean information in graphical form)**.

7.1.3 The Team was informed that the ETMSS-II discussed the content of the new Marine Meteorological Services Monitoring Programme questionnaire, adapted for the SOLAS and non-SOLAS vessels, that would be disseminate at the beginning of 2008 through appropriate channels, after final discussion during the SOT-IV Session (Geneva, Switzerland, 16-21 April 2007). The Team reviewed this questionnaire and suggested that an additional items similar to items 3 and 4 should be included for Marine Bulletins and urged the Secretariat to make the appropriate changes to this questionnaire and circulate to the Team for review and comments before 13 April 2007 **(Action: Secretariat)**.

7.2 Expert Team on Marine Climatology (ETMC)

7.2.1 The chairperson of the Expert Team on Marine Climatology (ETMC), Mr Scott Woodruff, presented a report on existing and proposed interactions between the ETWS and the ETMC. The Team agreed in principle with developing new linkages with ETMC, including a definite role at CLIMAR-III and potential joint work towards the development of wave climate summaries for ICOADS based on the historical in situ record **(Action: ETMC and ETWS Chairpersons)**. However, the ETWS Chairperson was felt to be in a better position than the other Team members, present at the meeting to carry these areas forward. The Team noted the need to support ICOADS and the inclusion of waves by developing new international ICOADS staff at different institutions coordinated by the ETMC and ETWS chairpersons **(Action: ETMC and ETWS chairpersons)**.

7.2.2 Two additional areas of suggested linkage: (i) enhanced storm surge statistics; and (ii) potential impacts of climate change on future OGP design criteria; seemed less obviously linked at this stage to ETMC. Moreover, in referring to “climatologies” of storm surge inundation zones, “risk areas” and “maximum envelope of water” were suggested as alternative terminologies.

7.3 Expert Team on Climate Change Detection and Indices (ETCCDI)

7.3.1 The chairperson of the Expert Team on Marine Climatology (ETMC), Mr Scott Woodruff, presented the report of the second meeting of the Joint CCl/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices (ETCCDI, Niagara-on-the-Lake, Canada, 14-16 November 2006), specifically those aspects pertaining to potential marine indices. This was set as a less immediate priority for the Team, in view of the absence of any lengthy in situ records from buoys (earliest starting around the 1970s), and questions about the homogeneity and usability for this purpose of Voluntary Observing Ship observations (e.g., since the mid 20th century). However, again the ETWS Chairperson was felt to be in a better position than other Team members present at the meeting to carry this area forward **(Action: ETWS Chairperson)**.

7.4 WMO Tropical Cyclone Programme (TCP)

7.4.1 The Team noted that the WMO Tropical Cyclone Programme has been organizing a series of workshops on storm surges, waves and ocean circulation forecasting in the South China Sea and expanded Asia and South pacific region in cooperation with JCOMM (mainly through its Capacity Building Rapporteur for SPA). Mr Koji Kuroima, Chief of the WMO Tropical Cyclone Programme, presented the summary report of the "Fourth Regional Workshop on Storm Surge and Wave Forecasting - A Hands-on Forecast Training Laboratory" that was hosted by PAGASA (Philippine Atmospheric, Geophysical and Astronomical Services Administration) in Manila, Philippines in September 2006. The meeting agreed that the ETWS should continue to contribute to and support these events as appropriate and nominated a focal point from this Team to strengthen the link between the WMO TCP and the ETWS **(Action: Mr Jean-Michel Lefèvre)**.

7.4.2 The Team recommended the use of open source codes in these workshops and Dr Hendrik Tolman kindly offered to support the Secretariat and WMO TCP in identifying possible open source codes that can be used in TCP workshops **(Action: Dr Hendrik Tolman)**. The Team also recommended that Bilko lessons should be used in these workshops (see item 6.1.3).

7.5 WMO Disaster Prevention and Mitigation Programme (DPM)

7.5.1 The Team was presented with a report on the outcomes of the First DPM Coordination Meeting (Geneva, Switzerland, 4-6 December 2006) related and/or requesting the involvement of the Team. The Team recalled the WMO's present and future strategy of enhancing the Secretariat's support to Members particularly by strengthening all the cross-cutting issues in support of Disaster Risk Management. The Team noted that per request of the WMO EC-LVIII (June 2006), as a benchmark four fact-finding surveys were submitted to the DPM Focal Points and Working Groups, including: (i) Country-level DPM survey; (ii) Regional-level DPM survey; (iii) Programme and (iv) Technical-Commission DPM surveys. Analysis of key hazards has revealed that there are a number of hazards posing a risk to all Members that responded to these surveys. These include, severe storms, droughts, floods (river flooding and flash floods), earthquakes and forest and wild land fires. In addition to these hazards, others also pose major risks on the regional basis. Specifically, in **RA I**, aviation hazards, smoke, dust or haze, and locust swarms; **RA II**, heat wave, sandstorm, landslide or mudslide, tropical cyclones, coastal flooding and storm surge, hailstorm; **RA III**, landslide or mudslide; **RA IV**, tropical cyclones, landslides or mudslides, coastal flooding, and storm surge; **RA V**, tropical cyclone, coastal flooding, storm surge, tsunami, landslide or mudslide; and, **RA VI**, heavy snow, heat and cold waves, hailstorm and freezing rain.

7.5.2 The Team also noted that the WMO Programme-level and Technical Commission-level DPM Surveys identified 42 projects and activities. A number of synergistic opportunities were identified across several projects. Cross-cutting project planning and implementation could result in better outcomes and more optimal utilization of the WMO resources in achieving those outcomes. In this context, WMO is developing a DPM-related Project related to Tropical Cyclones and associated phenomena, such as high waves, storm surges, and coastal management, including coastal flooding and impacts in coastal agriculture. The Team recommended that the ETWS contribution to this project should be through JEWL **(Action: WG-JEWL)** (see item 3.4).

7.6 Users' community

7.6.1 The Team noted that a key activity for the SPA is to draft and publish a proper user community specification of needs within a well-articulated JCOMM Services *User Requirement Document* (URD) typically based on an assessment of the current capability. The Team agreed that URD can be used to prioritize specific developments and actions within the SPA by identification of gaps in current service provision. In this context, the Team agreed to provide individual assessments of users' requirements for Storm Surge and Wind Waves **(Action: ETWS members)** and urged the Secretariat to compile all these contributions and include them in a core portfolio on users/applications across SPA ETs **(Action: Secretariat and SPA Coordinator)**.

7.6.2 The Team nominated Dr Jean Bidlot and Dr Jang Won Seo to represent both wind waves and storm surges components of the ETWS, respectively, in the IMMSC Scientific Steering Committee **(Action: Dr Jean Bidlot and Dr Jang Won Seo)**. The Team suggested that participation of NOAA´s Ocean Prediction Center in the steering team would be beneficial and requested Dr Hendrik Tolman to collaborate with the Secretariat in making the necessary arrangements **(Action: Dr Hendrik Tolman and Secretariat)**.

8. AOB

8.1 The Team agreed that there were no additional formal issues to consider under this agenda item.

9. Review of ETWS-II session report and action items

9.1 The meeting reviewed, revised and adopted the final report of the session, including action items provided in Annex XII.

10. Closure of the session

10.1 In closing the meeting, the SPA coordinator, Dr Craig Donlon, thanked all participants for their valuable input to what had been a very productive meeting, and looked forward to working with all the members of the Team on the many ongoing action items. He noted that the Team had an ambitious work plan and that the meeting had made positive steps towards its implementation. On behalf of all participants, he expressed his appreciation to the ETWS chairperson, Mr Val Swail, for being available to participate in the meeting by teleconference, for all the comments and contributions he provided to the meeting, and for the excellent work in the preparation of the meeting.

10.2 The ETWS chairperson, Mr Val Swail, expressed his appreciation to all participants for their very positive and valuable input to the discussions, to what had been a very successful meeing, and looked forward to working with all participants on the many ongoing action items. He expressed his deeply sadness for not attending the meeting personally and showed his especial gratitude to the Secretariat, particularly Ms Alice Soares, for the excellent work in the preparation of the current ETWS session and for the ongoing support.

10.3 On behalf of the Secretariat, Mr Edgard Cabrera expressed his sincere appreciation and thanks to all participants, especially to the ETWS chairperson, Mr Val Swail, who provided a very important and valuable input to the meeting, being far away from the place of the meeting. He concluded by expressing his appreciation to the Scientific Officer in charge of the meeting, Ms Alice Soares, for the preparation of the documents and for the meeting itself.

10.4 The Second Session of the JCOMM Expert Team on Wind Waves and Storm Surges closed at 11.25 hours on Saturday, 24 March 2007.

_____

Annex I

LIST OF PARTICIPANTS

Dr Jean Bidlot
European Centre for Medium-Range
Weather Forecasts
Shinfield Park
Reading, Berkshire RG2 9AX
United Kingdom
Telephone: +44-118 9499708
Telefax: +44-118 9869450
E-mail: jean.bidlot@ecmwf.int

Dr Thomas Bruns
Deutscher Wetterdienst
Bernhard-Nocht-Strasse 76
D-20359 HAMBURG
Germany
Telephone: +49-40 6690 1818
Telefax: +49-40 6690 1947
E-mail: thomas.bruns@dwd.de

Dr Hans de Vries
Royal Netherlands Meteorological
Institute (KNMI)
Wilhelminalaan 10
P.O. Box 201
3730 AE DE BILT
Netherlands
Telephone: +31-30 2206615
Telefax: +31-30 2210407
E-mail: Hans.de.Vries@knmi.nl

Dr Craig Donlon
Coordinator, JCOMM Services PA
Chairperson, JCOMM Services Coordination
Group
Director
International GODAE SST Pilot Project Office
National Centre for Ocean Forecasting
Met Office, Fitzroy Road
Exeter EX1 3PB
United Kingdom
Telephone: +44-1392 886 622
Telefax: +44-1392 885 681
E-mail: craig.donlon@metoffice.gov.uk

Dr María Paula Etala de Aso
Servicio Meteorolǵico de la Armada
Av. Comodoro Py 2055, piso 15
1104 Ciudad Autnoma de
BUENOS AIRES
Argentina
Telephone: +54-11 4317 2000 ext. 3152
Telefax: +54-11 4317 2309
E-mail: etala@ara.mil.ar

Mr Masakazu Higaki
Office of Marine Prediction
Marine Division
Global Environment and Marine Department
Japan Meteorological Agency
1-3-4 Otemachi, Chiyoda-ku
TOKYO 100-8122
Japan
Telephone: +81-3 3212 8341 ext. 5125
Telefax: +81-3 3211 3047
E-mail: m-higaki@naps.kishou.go.jp

Dr Adrian Hines
Manager of FOAM
Met Office
FitzRoy Road
EXETER Devon EX1 3PB
United Kingdom
Telephone: +44-1392 886509
Telefax: +44-870 900 5050
E-mail: adrian.hines@metoffice.gov.uk

Dr Kevin Horsburgh
Proudman Oceanographic Laboratory
Joseph Proudman Building
6 Brownlow Street
LIVERPOOL L3 5DA
United Kingdom
Telephone: +44-151 795 4835
Telefax: +44-151 795 4801
E-mail: Kevinh@pol.ac.uk

Mr Jean-Michel Lefèvre
Division Marine et Oceanographie
Direction de la Prévision
Météo-France
Météopole
42, avenue Coriolis
31057 TOULOUSE Cedex
France
Telephone: +33-5 61 07 82 95
Telefax: +33-5 61 07 82 09
E-mail: jean-michel.lefevre@meteo.fr

Dr Jang Won Seo
National Institute of Meteorological Research
Korea Meteorological Administration (KMA)
Global Environment System Research Lab.
460-18, Shindaebang-dong, Dongjak-gu
Seoul 156-720

Republic of Korea
Telephone: +82-2 849 0665 ext. 712
Telefax: +82-2 847 2496
E-mail: jwseo@metri.re.kr
jwseo@kma.go.kr

Mr Val R. Swail
Chairperson, JCOMM Expert Team on
Wind Waves and Storm Surges
Climate Research Division
Environmental Canada
4905 Dufferin Street
TORONTO, ON M3H 5T4
Canada
Telephone: +1-416 739 4347
Telefax: +1-416 739 5700
E-mail: val.swail@ec.gc.ca

Dr Hendrik L. Tolman
SAIC-GSO at NOAA/NCEP
Environmental Modeling Center
5200 Auth Road, Room 209
CAMP SPRING, MD 20746-4304
USA
Telephone: +1-301 763 8000 ext. 7253
Telefax: +1-301 763 8545
E-mail: Hendrik.Tolman@NOAA.gov

Mr Graham R. Warren
Supervisor
Oceanographic Systems Development
Bureau of Meteorology
G.P.O. Box 1289
MELBOURNE, Vic. 3001
Australia
Telephone: +61-3 9669 4041
Telefax: +61-3 9662 1223
E-mail: g.warren@bom.gov.au

Mr Scott D. Woodruff
Chairperson, JCOMM Expert Team on
Marine
Climatology
NOAA
Earth System Research Laboratory (R/PSD3)
325 Broadway
BOULDER, CO 80305
USA
Telephone: +1-303 497 6747
Telefax: +1-303 497 7013
E-mail: scott.d.woodruff@noaa.gov

SECRETARIAT

Mr Edgard Cabrera
WMO Secretariat
Chief, Ocean Affairs Division
Applications Programme Department
World Meteorological Organization
7 bis, Avenue de la Paix
Case postale No 2300
CH-1211 GENEVE 2
Switzerland
Telephone: +41-22 730 82 37
Telefax: +41-22 730 81 28
E-mail: ecabrera@wmo.int

Ms Boram Lee
Ocean Observations and Services
Intergovernmental Oceanographic
Commission (IOC)
UNESCO
1, rue Miollis
75732 PARIS Cédex 15
France
Telephone: +33-1 45 68 39 88
Telefax: +33-1 45 68 58 12
E-mail: b.lee@unesco.org

Ms Alice Soares
WMO Secretariat
Scientific Officer, Ocean Affairs Division
Applications Programme Department
World Meteorological Organization
7 bis, Avenue de la Paix
Case postale No 2300
CH-1211 GENEVE 2
Switzerland
Telephone: +41-22 730 84 49
Telefax: +41-22 730 81 28
E-mail: asoares@wmo.int

Annex II

AGENDA

1. Opening of the session

1.1. Opening
1.2. Adoption of the agenda
1.3. Working arrangements

2. Reports

2.1 Report of the Services Programme Area Coordinator
2.2 Report of the Chairperson of the Team
2.3 Report of the Secretariat

3. Activities

3.1 Operational wave forecast verification project
3.2 Extreme wave database
3.3 Wind, Wave and Surge Climatologies
3.4 JCOMM Extreme Water Level (JEWL) project

4. Guides and relevant publications

4.1 Guides

- 4.1.1 Guide to Wave Analysis and Forecasting
- 4.1.2 Guide to Storm Surge Forecasting
- 4.1.3 Dynamic parts of the Guides

4.2 Technical Reports

5. Observations Requirements

6. Workshops and Capacity Building

6.1 Technology transfer

- 6.1.1 Storm Surge Symposium
- 6.1.2 JCOMM Training workshops
- 6.1.3 Development of e-learning modules (OceanTeacher, Bilko)

6.2 Other workshops and conferences

7. Cooperation with other bodies

7.1 Expert Team on Maritime Safety Services (ETMSS)
7.2 Expert Team on Marine Climatology (ETMC)
7.3 Expert Team on Climate Change Detection and Indices (ETCCDI)
7.4 WMO Tropical Cyclone Programme (TCP)
7.5 WMO Disaster Prevention and Mitigation Programme (DPM)
7.6 Users' community

8. AOB

9. Review of ETWS-II session report and action items

10. Closure of the session

Annex III

SPA TOP LEVEL OBJECTIVES (TLOs)

Top Level Objectives (TLOs) for the SPA work plan which are applicable to all activities of ETWS and other ETs within the SPA:

a) TLO-1: Support to maritime safety, hazard warning and disaster mitigation systems. The objective is to monitor and develop modifications to maritime safety, hazard warning and disaster mitigation systems as necessary and to assist Members/Member States as required. Systems include: the WMO marine broadcast system for the GMDSS, as well as MPERSS; storm surges; tropical cyclones; Tsunami; search and rescue; marine pollution; ice and iceberg warnings; rogue waves and dangerous sea state.

b) TLO-2: The Importance of a User Focused Programme. The Objective is to understand and respond to present and future needs of the maritime service industry and ensure that the services provided to users meet these requirements, including content, delivery timeliness and quality. A key priority for the JCOMM SPA is to provide mechanisms and services that engage the user community in JCOMM discussions, plans and activities and to manage user feedback on all aspects of JCOMM.

c) TLO-3: Working Effectively with Members/Member States. The Objective is to keep under review and to respond to the requirements of Members/Member States for guidance in the implementation of their duties and obligations with regard to marine services, in particular those specified in the WMO *Manual on Marine Meteorological Services* (WMO-No. 558);

d) TLO-4: Pulling through scientific and technical expertise to operational systems. The Objective is to build on international scientific and technical excellence to better meet the needs of the international maritime service industry by developing the preparation and dissemination of ocean products and services;

e) TLO-5: Communications and ‘joining up’ the SPA. The Objective is to integrate the internal cross-programme area activities of JCOMM, with international regional/global efforts and with that of others to increase efficiency and capability including the relevant programmes of WMO and IOC (e.g., DPM, WWW, WCP, GOOS, GCOS), as well as with other organizations such as IMO, IHO, IMSO and ICS in the provision of marine services and information;

f) TLO-6: Maintaining and monitoring international standards. The Objective is to ensure that the JCOMM SPA acts as a flexible, streamlined organization capable of coordinating international maritime services;

g) TLO-7: Building appropriate capacity within JCOMM. The Objective is to build appropriate capacity within JCOMM to make the most of international collaboration (e.g., GOOS, GEO/GEOSS) to share marine meteorological and oceanographic knowledge, infrastructure and services for the benefit of the Maritime community.

Annex IV

JCOMM WIND WAVE AND STORM SURGE PROGRAMME
ELEMENTS AND ACTIVITIES FOR 2005-2009

A. OBSERVATIONS AND DATA

1. Further development of wind wave, storm surge, and ocean wind observations

Further development of the observations of wind waves, variations of sea level associated with storm surges, and of near-surface wind over the ocean is necessary for better initialization of predictive models, hindcast and forecast verification and other related uses. There is a certain potential for improving meteorological objective analysis quality on account of marine variables in an analysis scheme. Assimilation of satellite data on significant wave height and directional spectrum is an important factor for gaining additional skill of numerical wave forecasts, particularly for areas with open boundaries. At the same time, financial resources available for the development of these observing systems are limited, and so is payload of future satellites. Therefore, corresponding research and planning is essential for the optimal further development of the ocean observing system. Some relatively new types of ocean surface observations, such as coastal radar, offer considerable advances in provision of real-time maritime services.

Recommended actions/activities:

(a) Continue studying the impact of various types of satellite sensors, such as scatterometers and altimeters on quality of wind wave, storm surge and wind forecasting;

(b) Maintain a constant liaison of the JCOMM with the bodies involved in planning of the other observations in the Global Ocean Observing System in matters related to observations of wind waves and storm surges;

(c) Promote and facilitate generation of more data on directional wave spectrum from any sensors, including satellites;

(d) Continue development and facilitate enhancement in the use of coastal radar observations for servicing port and harbour operations.

2. Increased access to observations and other types of wind wave, sea level height, and related data

Measurement and modelling of waves and storm surges provides data which are of great interest to a large community of marine forecasters, climatologists, offshore and coastal operators, etc. Large and increasing volumes of data from satellite sensors, wind wave models (including data on directional wave spectra), and hydrodynamic models (including data on sea level in a variety of time scales) make it necessary to provide an effective means of communicating and storing of information. This is also true for other marine meteorological variables that are derived from atmospheric boundary layer wind data, or are produced by satellite sensors. Processing of data for the objective analysis, in marine climatological applications requires metadata.

Recommended actions/activities

(a) Support and facilitate putting all types of wind wave, storm surge sea level, and wind data on the WMO GTS and/or the Internet for their open and expeditious exchange;

(b) Promote standards, identify needs for special codes, and develop the code amendments if necessary, including standards for presentation of the JCOMM Wind Wave and Storm Surge Programme related variables on the Internet;

(c) Promote active generation, use, and efficient storage of metadata.

3. Ship wave observations

Much of the wave information used in climatological studies and in operational forecasting is acquired as visual observations from shipping (especially from vessels in the VOS system). The use of such data requires caution as they exhibit considerable variability in quality. Seeking more uniform observing practices through training, and providing guidance material can enhance quality of these data sets. Guidance material is reviewed in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) and the *Guide to Wave Analysis and Forecasting* (WMO-No. 702). Automation of wave observations from merchant shipping remains a distant goal; however, this possibility should not be abandoned.

Recommended actions/activities

(a) Include material on wave observation practices in relevant WMO training seminars, particularly for PMOs;

(b) Extend the Help component of the Turbowin software by putting in place a corresponding description of wave observation practices from the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) and the *Guide to Wave Analysis and Forecasting* (WMO-No. 702);

(c) Consider the feasibility of automated wave observations from shipping (e.g. though the use of ship bow-mounted sensors) in cooperation with the OOPC.

4. Rescue of wave and storm surge data and facilitating access to it

Further development of wind wave and storm surge modelling and prediction, studies of ocean - atmosphere interaction and climate change, as well as some other applications require access to historic wave and storm surge data. Not all sources of such data are yet known and the data storage is not always reliable enough to guarantee that a future user will be able to access the data. To some extent, this is also related to the lack of corresponding metadata. Therefore, the JCOMM should continue attempts to identify existing public and private sources of surface wind, wave, and storm surge measurement data with the objective to ensure its safe storage and, if possible, open access to the data and metadata and its incorporation into an international data exchange system. Further, the JCOMM should assist the Members in making the best use of such data.

Recommended actions/activities

(a) Continue activities identifying marine surface wind, wind wave, and storm surge data sets, including data already existing on the Internet (both real-time and historic);

(b) Facilitate production of metadata in conjunction with the primary data set;

(c) Promote the cataloguing of all known sources of data and metadata through the Responsible National Oceanographic Data Centre for Waves (RNODC-Waves) of the IOC;

(d) Ensure that the Members receive summaries of such catalogued data as a stimulus for their participation;

(e) Ensure that the practice of open access to all data stored at the RNODC-Waves for all data contributors is *strictly followed and known by potential data contributors.*

B. BASIC SERVICES

5. Monitoring of wind wave service availability and nomenclature of products

Wind wave analysis and prediction is required at several spatial scales, from the ocean basin dimensions and downscaling to local areas. It is imperative for the JCOMM Wind Wave and Storm Surge Programme to monitor the availability and nomenclature of the services. In particular, it is essential to guarantee that the Marine Weather Bulletins broadcast through the GMDSS contain necessary warnings, information, and forecasts on wind waves. In general, because the predictability of wind wave field is deteriorating in time slower than the predictability of the wind field, it is highly desirable to extend the range of weather forecasting up to the edge of practically useful weather forecast.

Recommended actions/activities

(a) Continue monitoring the availability of wind wave forecast services, to the extent that these meet corresponding requirements of marine safety;

(b) Encourage the extension of wind wave forecast range up to the duration of practically useful weather forecast.

6. Monitoring of storm surge service availability

Storm surges are one of the main factors leading to loss of life and property in low-lying coastal areas. At present, the forecasting services cover only a portion of the areas, which are prone to storm surges. Monitoring of available services, of models and other technical means to predict storm surges is a matter of priority.

Recommended actions/activities

(a) Continue surveying present surge forecasting services and disseminate information to Members;

(b) Identify areas of the world, which are prone to significant storm surges but are not covered by corresponding forecasting services.

7. Further improvement of forcing for wind wave and storm surge numerical forecasting

Access to appropriate surface wind and atmospheric pressure fields remains one of the most limiting factors to wind wave and storm surge nowcasting and forecasting. It is important to assess specific requirements for boundary-layer fields to be used in various types of models used in wind wave and storm surge nowcasting and forecasting. This is particularly pertinent, as surface winds derived from satellite data become incorporated into the data assimilation.

Recommended actions/activities

Complete and publish a review on boundary layer wind fields.

8. Extended use of data assimilation in wind wave forecasting

Very often, wave observations are not used in wave analysis and forecasting. Waves are diagnosed from wind information. The application of observed data (both wave and wind) in operational forecasting has to be promoted and existing techniques for observation assimilation in predictive models to be reviewed. Of particular importance at present, is the progress in assimilation of remotely-sensed wave and marine surface wind data.

Recommended actions/activities

To prepare a review of techniques and benefits on the use of satellite-derived data in wave and marine surface wind models and on assimilation of observations (especially remotely-sensed waves and near surface wind) in wave forecasting.

9. Better estimation of operational analysis/hindcast/forecast skill

Lack of sufficient volume of high quality continuing observations for a long time was a limiting factor in verification of operational wave hindcasts and forecasts. Hence, it has slowed down the development of wave modelling and forecasting considerably. Recognizing this fact, a group of wave modelers initiated a project on real-time verification of large-scale wave models and operational exchange of skill scores. The WMO CMM gave its full support to the project. At present, the estimation of wave nowcast/forecast is well-established between five participating centres. If extended, this activity can be instrumental in the evaluation of operational wave analysis and forecast skill of many other national centres, and therefore can facilitate further development of wave prediction techniques through elimination of persistent biases and identification of areas of potential improvement. In addition, estimates of characteristic wave analysis and forecast errors may be used in some applications and in development of data assimilation techniques. Well developed in the numerical meteorological forecasting and sufficiently well developed in the wind wave forecasting, the forecast verification practices can help to initiate more objective estimation of storm surge prediction quality.

Recommended actions/activities

(a) Disseminate the results of verification of operational wind/wave analyses and forecasts;

(b) Promote exchange of verification data and analysis between the operational centres involved in wind wave forecasting, and try to increase the number of centres participating in such exchange;

(c) Consider the sufficiency of currently used skill scores for an adequate representation of spectral wind wave forecast quality, and to establish a standard set of exchanged statistical scores;

(d) Promote more data for verification in the tropics and southern ocean to receive better geographical coverage and representative statistics;

(e) Elicit through national reports on the work regarding experiments on instrumental and model intercomparisons and verifications of wind wave and storm surge models, including relevant bibliographies.

C. SPECIALIZED SERVICES

10. Application of wave, sea level, and surface wind data to inter-disciplinary problems

The application of wind wave and sea level information to inter-disciplinary problems is an important motivation for its acquisition and processing. Integrated coastal zone management is inefficient without the adequate provision of real-time and specialized, user-tailored information on waves, storm surges, and winds. The JCOMM Wind Wave and Storm Surge Programme should ensure that the requirements for wave information and its applications in areas of national and international concern (such as marine pollution, coastal erosion, etc.) and other specialty services (ship routing, fisheries, aquaculture, etc.) are understood and facilitated. In particular, the requirements of various modules of the GOOS in wind wave and storm surge data have to be clearly identified. Considerable economic potential of weather routing of ships, and assistance in provision of weather and wind wave related services for complex, weather sensitive operations is noteworthy.

Recommended actions/activities

(a) Continue establishing requirements for wind wave and storm surge information, its application, and its relationship to other elements in a range of environmental problems, especially those connected to the modules of the GOOS, especially the COOP;

(b) Continue support for the development of specialized marine meteorological services related to storm surge and wind wave data, including ship routing and support of marine weather sensitive operations.

11. Wind wave and storm surge hindcast studies, numerical generation of climate data sets

With the increasing use of numerical models to generate wave and storm surge climatologies by hindcasting, a wealth of synthetic data is accumulating. These data extend knowledge of the wind wave and storm surge conditions from areas in the vicinity of measuring devices to regions where no such instruments have ever been deployed. An inventory of known hindcast and measured wave climatologies are provided in the Second Edition of the *Guide to Wave Analysis and Forecasting*. Considerable advances in the recent studies were associated with the use of meteorological re-analysis project data. They made it possible to generate a long series of data along with global coverage and to derive statistically reliable estimates of trends and long return period parameters.

Recommended actions/activities

Continue monitoring studies on surface wind wave, storm surge, and surface wind climatologies and continually maintain and update the inventory of hindcast climatologies.

12. Prediction of the individual highest or rogue wind wave

Wind wave nowcasting and forecasting concentrate on the evolution of parameters of the wave spectrum or on statistically averaged parameters, such as significant wave height. Even if the users are well prepared for facing typical conditions expected during the storm, many of them may be perturbed by a single or rogue wave. Efforts have been allocated to develop new methods and review existing methods of predicting the range of wave heights in a single storm. The proposed techniques, which are applicable to rare but physically regular wind waves, have to be assessed and more widely implemented into a day-to-day practice. At the same time, the nature, generating conditions, and predictability of rogue waves need to be further studied with the aim to develop methods of prediction of their probability.

Recommended actions/activities

(a) Facilitate efforts aimed at the prediction of expected range of wave heights during a storm;

(b) Support studies of unusual and rogue waves and incorporation of their outcome into forecasting practices.

13. Extreme wind waves and storm surges, objective interpretation of forecast uncertainty and its use in provision of specialized services

Continuing the development of offshore activities, various aspects of coastal zone management such as design of protective constructions, and many other applications require knowledge of rare events. These events are unlikely, but not impossible. *The Guide to Wave Analysis and Forecasting* (WMO-No. 702) and other recent publications, provide a review of this subject with respect to wind waves. There is a constant need to review and modernize methods

and techniques of estimating long return period values of wind waves, storm surges, and distribution of other variables accompanying values of low probability. A serious problem is connected to possible changes in estimates of long return values corresponding to variability of climate. In addition, it is very important to assess potential impact of long return period storm surges occurring in conditions of mean sea level rise. Statistical interpretation of forecasts needs to be more firmly incorporated into service practices. For example, ensemble wave forecasting is a developing area, which provides a range of forecasts, which in a statistical sense can be a representation of possible wave development scenarios. This information can be an adequate basis for estimating uncertainty of the forecast, which in turn facilitates the developing of a range of specialized services such as weather routing of ships, etc.

Recommended actions/activities

(a) Review the subject focusing on variations of long return period parameter caused by long-term trends in climatic mean values;

(b) Promote activities aimed at better objective interpretation of wind wave and storm surge forecasting and its use in provision of specialized user-tailored services;

(c) Encourage the development of total water level (tide, surge and wave) prediction services.

D. GUIDANCE MATERIAL AND ASSISTANCE

14. Guides

The Second Edition of the *Guide to Wave Analysis and Forecasting* (WMO-No. 702) is now available. Updating the existing guide should be an ongoing effort. Translation of the revised guide from English into other WMO languages is essential. In view of the limited number of copies available, it may be desirable to make the guide accessible on the Internet from the WMO website.

Recommended actions/activities

(a) Place the *Guide to Wave Analysis and Forecasting* on the WMO website under the JCOMM homepage;

(b) Develop a plan and Implementation Plan for the preparation of a *Guide to Storm Surge Forecasting*.

15. Training and other types of assistance

The establishment and improvement of the provision of marine meteorological services can only be achieved by adequate training of staff. Every opportunity should be taken to incorporate wind wave and storm surge analysis and forecasting material in training workshops and seminars on marine meteorology. Member State(s), which run professional meteorology courses, should be encouraged to include specific course material on wind wave and storm surge analysis and forecasting.

Recommended actions/activities

(a) Encourage Members/Member States to include specific material on wind wave and storm surge analysis and forecasting in training courses;

(b) Organize training courses and workshops to include wind wave and storm surge analysis and forecasting, such as a workshop on wind wave and storm surge analysis and forecasting for Caribbean counties (June 2003), and to promote the inclusion of such material in an advanced physical oceanography and marine meteorology courses.

16. Regional projects/campaigns

Development of the wind wave and storm surge forecasting services is efficient on a regional basis. Common geographic conditions, joint interests, concerns, and similar experiences create a solid foundation for mutual assistance and support. Very often, neighbouring countries are affected by the the same weather systems, and therefore, their cooperation in marine forecasting is very fruitful. This is particularly true for the prediction of storm surges and wind waves associated with tropical cyclones. The JCOMM Wind Wave and Storm Surge Programme should encourage the development of regional forecasting systems and provide assistance in these activities. Many areas of the world are affected by storm surges; the northern Indian Ocean and South China Sea are good examples of this problem, which have been the subject of particular attention. The JCOMM should provide assistance in the creation of new national and international wind wave and storm surge programmes, providing guidance and assistance to Members in establishing wind wave and storm surge related services and in implementing corresponding models. The cooperation of the JCOMM with GOOS and the WMO Tropical Cyclone Programme in these matters must be strengthened. Other examples, where regional projects would be beneficial, include the joint wind wave and sea ice forecasting.

Recommended actions/activities

(a) Provide assistance to Members/Member States in establishing wind wave and storm surge related services, as appropriate;

(b) Provide guidance and technical assistance for development of regional projects, such as the proposed storm surge forecasting project in the northern part of the Indian Ocean, as requested and appropriate.

E. DEVELOPMENT

17. Wave modelling/data assimilation/retrieval of wave spectrum

Rapid development in wave modelling makes it necessary to monitor the state-of-the-art and make such information available to its Members/Member States. Much of the effort is now focusing on specialized and local applications. There are a number of factors needing detailed attention, such as effects of complicated topography, shallow water, strong tides and currents, wind modification near land-sea interface, dependence on wind-wave interactions on the stage of the wave spectrum development, etc. Implementation of spectral wave models continues to deserve special attention. Other important areas of activity are development of data assimilation techniques and retrieval of directional wave spectrum from remotely-sensed and *in situ* observations. Continuing reviews of practices adopted by various groups involved in these activities is desirable.

Recommended actions/activities

(a) Monitor the state-of-the-art in wave modelling and wave models numerical implementation;

(b) Encourage the preparation of information on the application of wave models in areas affected by strong local influences, such as complicated topography, currents, shallow water, tides, etc., to be presented at various relevant conferences;

(c) Maintain contacts with other research communities developing wind wave models and extend international cooperation in scientific and technical aspects of wave modelling and related areas;

(d) Encourage making codes of wind wave models available including on the Internet;

(e) Encourage the development of methods to retrieve full spectral information from remotely-sensed, *in situ* and other wave data.

18. Storm surge modelling

State-of-the-art storm surge prediction models have been developed and implemented for many parts of the world. Factors determining the efficiency and success of such prediction systems are an adequate representation of the dynamic processes, good quality forcing, conditions of the model open boundaries incorporating basic tidal harmonics, and efficient numerical implementation. It is essential to develop joint predictive systems, including a hydrological component. Flooding of coastal areas may depend on not only the pure drift of seawater, but on the river transport, current and previously accumulated precipitation, and the saturation of the soil. Adequate prediction of coastal flooding also often requires a very good quality data on on-land topography. Integration of many separate highly sophisticated components into a consolidated prediction and decision-making support system remains a challenge.

Through the JCOMM Wind Wave and Storm Surge Programme, expert advice on meteorological and oceanographic component of such predictive systems can be provided.

Recommended actions/activities

(a) Monitor the state-of-the-art in storm surge modelling;

(b) Encourage the development of associated activities in hydrological sciences;

(c) Establish and maintain contacts with other relevant research communities involved in prediction of coastal flooding;

(d) Encourage that the codes of models suitable for storm surge prediction are made available, to include the Internet.

19. Combined ocean-wave-atmosphere sea-ice modelling

Recently, several aspects of coupled modelling have found their way into operational forecasting. Notable examples include wave-induced surface stress in atmospheric circulation models, and coupling of ocean and atmosphere models in both hurricane and climate applications. Although many scientific issues regarding coupling are still unresolved, it is expected that coupling will become more prevalent in the near future.

Recommended actions/activities

Continuously review developments in this field.

20. New types of data, techniques and experiments for measurement of waves and surface wind

Preparing Members for the introduction of new kinds of data is a part of a continuing campaign to share the benefits of new technology. Members/Member States should be made aware of the expected impact of new data streams, and how to use such data. By making information available to Members/Member States, they are in a better position to take advantage of opportunities for exploiting new technology and participating in national and international initiatives. National reports of known works are elicited through the national focal points in conjunction with the survey of wave models. These reports keep Members/Member States informed on progress in developing methods and techniques. Cooperation with international and national research projects depends on local involvement of personnel who are associated with National Meteorological Services (NMSs). Such involvement is to be encouraged through national focal points. Publicity should be given to future plans and to network experiments to facilitate cooperation of parties with

potential interests. This includes large-scale international efforts, which have some elements of interest to the JCOMM Wind Wave and Storm Surge Programme.

Recommended actions/activities

(a) Consider procedures and techniques for the operational application of new types of satellite-derived data by National Meteorological Services;

(b) Continue to update and publish information on new techniques for measurement of waves and surface wind;

(c) Provide Members with information on major wave/marine wind experimental campaigns.

21. Cataloguing of programme related activities

The cataloguing of operational and experimental wave models has become an established activity, and regular updates are a useful means of disseminating information regarding the nature and status of models currently in use to Members/Member States.

Recommended actions/activities

Prepare regular updates (two-yearly) of the catalogue of operational and experimental wind wave and storm surge models, along with their products, and disseminate these alongside other information in WMO publications.

Annex V

WAVE MODEL VERIFICATION DATA EXCHANGE REPORT OUTLINE
WEB PAGE ON THE SPA WEBSITE
(limited distribution during the development of this web page)

1. Overview and justification.
    a. Historical success of program
    b. Development of validation techniques.
    c. Making data available is essential and therefore,
    d. Setting up of formats is essential.
    e. Other things like validation techniques can and should more dynamic.

2. Review of validation data
    a. Inventory of wave observations.
    b. Gridded model field comparisons with or without data.
    c. Note on wave analyses.
    d. Wave model runs without data assimilation.

3. Data dissemination policies.
    a. Existing local policies
    b. Preferred policies for the data base access.

4. Requirements for data formats.
    a. Flexibility.
    b. Backward compatible.

5. How to make use of a validation data set
    a. Describe existing work
    b. Suggestions for spectral validation
    c. Suggestions for spatial validation
    d. Suggestions for using altimeter data.

Appendices:
    Data formats.
    Centres participating in this project

Annex VI

PROPOSAL FOR A JCOMM EXTREME WAVES DATA BASE

Purpose:

Phase 1: To provide a source of instrumented wave observations of extreme wave events for model development, forecast verification and satellite validation.

Phase 2: To provide a comprehensive source of all instrumented wave measurements (in-situ and remote-sensing) for known extreme wave events (both recent historical events and ongoing).

Data qualification:

- Data will be captured for those storms in which a SWH ≥ 14m;
- Storms will be defined as commencing when the SWH first exceeds 5 m and ending when the SWH first falls below 5m;
- Areas of interest will include all wave observations within a 500 km radius of the buoy (or other platforms) registering the extreme event;
- Appropriate information regarding the type of instrument, sampling characteristics, data processing carried out, etc., will be included with the data;
- Appropriate attribution of contributors will be maintained.

Phase 1: The database will hold all instrumented observations that are available from the storm period and area, including:

- *In-situ* surface elevation time series;
- *In-situ* wave spectra from surface-following instruments (e.g., wave buoys, Tucker);
- Other environmental observations collected *in situ* in the storm period and area will be included.

Phase 2: The database will hold all instrumented observations that are available from the storm period and area, including:

- *In-situ* surface elevation time series;
- *In-situ* wave spectra from surface-following instruments (e.g., wave buoys, Tucker);
- *In-situ* wave spectra from surface radars (e.g., MIROS);
- Satellite derived wind fields;
- Satellite derived wave estimates.

Data Assembly and Delivery Services:

- Contributors will be organized under the auspices of the ETWS;
- Administration of the assembly and maintenance of the database (db) will be under the Chairperson of the ETMC.

The archive centre will provide services that include:

- Receive data from contributors;
- Ensure data pass agreed QC before inclusion;
- Load data into the db;
- Provide the db in a convenient format mutually agreed between the ETWS and ETMC;
- Provide a convenient download service for the db contents.

Yet to clarify:

- Exactly what data and metadata fields need to be included (see Phase 1 then Phase 2);

- Is the definition of a storm and area adequate?
- How we will solicit an archive:
    - NCAR might be interested;
    - Proposal will be presented to the IODE.
- Who will run the database?
- What are the “agreed” QC and delivery formats?
    - We will need to be flexible when accepting different data formats. On output, one could build something in the netCDF or use the IMMA format. Several output formats should probably be considered.
- Are the services enough?

Annex VII

CONCEPT, STRUCTURE AND CONTENT OF THE DYNAMIC GUIDES

A. Content available or expected in 2007 on CD-ROM or DVD:
   a. Proceedings of the 8th to 10th International Workshops on Wave Hindcasting and Forecasting;
   b. Proceedings of the 1st JCOMM Scientific and Technical Symposium on Storm Surges;
   c. Workshop on Wind Wave and Storm Surge Analysis and Forecasting for Caribbean Countries.

B. JCOMM Technical Reports available or expected in 2007 online at: www.jcomm-services.org:
   a. *Verification of Operational Global and Regional Wave Forecasting Systems Against Measurements from Moored Buoys* - JCOMM/TR-No. 30; WMO/TD-No. 1333;
   b. *Techniques and Benefits of Satellite Data in Wind and Wave Models* - JCOMM/TR-No. 35; WMO/TD-No. 1357;
   c. Climate Change Impacts on Offshore Design Criteria.

C. Results of Analysis of Questionnaires expected in 2007 online at: www.jcomm-services.org:
   a. Operational and pre-operational storm surge models (analysis by Dr María Paula Etala of questionnaire results for review and comment);
   b. Catalogue of measured and hindcast storm surge data bases (analysis by Dr María Paula Etala of questionnaire results for review and comment);
   c. Operational and pre-operational wave models;
   d. Catalogue of measured and hindcast wave data bases.

D. Other reports produced by or for the Expert Team:
   a. *The web-based KNMI/ERA-40 global wave climatology atlas* - WMO Bulletin 53(2), 142-146;
   b. Special issue of journal with selected papers from the 2007 Storm Surge Symposium;
   c. Reports resulting from work on waves and surges by the ETCCDI.

E. Links to documents and products hosted elsewhere:
   a. Proceedings of the 1st to 10th International Workshop on Wave Hindcasting and Forecasting at: www.waveworkshop.org;
   b. ERA-40 Global Wave Climate Atlas at: www.knmi.nl/waveatlas;
   c. MSC50 North Atlantic Wave Atlas at: www.oceanweather.com/MSC50WaveAtlas.

Annex VIII

SURFACE WAVE OBSERVATION REQUIREMENT DOCUMENT

Introduction

The purpose of this document is to specify the requirements for surface wave observations that arise from offshore wave forecast modelling and related activities. The document aims to present the foreseen requirement for the medium to long term (present out to c. 10 years ahead). The requirement has been prepared in consultation with the JCOMM Expert Team on Wind Waves and Storm Surges.

It should be noted that this document presents the requirements for observations, without addressing the availability or otherwise of suitable technical solutions to deliver those observations. The technical solution best able to meet the requirements will depend upon the variety of observing platforms available with consideration of practicalities and costs.

The observation requirements are presented as follows: firstly, a brief description of the applications for which the data are required is given, including indications of any particular issues or priorities relating to the application. Secondly, the table of requirements is specified (Table 1). Within the table the requirements for temporal and spatial sampling, accuracy and timeliness are specified. In each case two values are given:

- Min: the value below which the observation does not yield any significant benefit for the application in question
- Max: the value above which no further significant benefits would be obtained.

Spatial sampling and temporal frequency entries are based upon point data at the specified spacing, reporting with the specified frequency. Thus a requirement of 100km and 24 hours is taken to mean point observations spaced 100km apart each reporting once every 24 hours. In practice, however, it should be noted that the actual representativeness of the observations will vary between platforms, and the requirement for representativeness of the observations will depend upon model resolution. More specifically, for maximum benefit observations with a footprint smaller than a model grid box and with temporal averaging smaller than a model timestep will deliver the maximum benefit.

For applications with other quantitative requirements of particular importance, these additional requirements are noted in the table.

Finally, the implications of these requirements in terms of particular observing platforms are presented (Table 2). This table is intended to provide guidance as to how best to meet the requirements given the current observing technology.

Applications

The applications included within the scope of this document are those related to offshore wave forecast modelling. Particular applications are:

1. Assimilation into offshore wave forecast models

This application includes assimilation into both global and regional scale offshore wave models, and the requirements can be sub-divided accordingly. Assimilation is currently largely based around use of satellite observations. Altimeter wave height observations provide the most straightforward data set to use, and would generally be used alongside associated wind speed observations. SAR derived wave spectra can also be used, but present more technical challenges. In situ measurements are currently too sparse in the open ocean to be of particular value, but could potentially provide higher accuracy observations to complement (and correct for biases in) the satellite observations. In general, the availability of observations with some spatial coverage

(e.g. HF radar data, swath data) would offer significant benefits for assimilation though the ability to fully initialise features on a range of scales.

The requirements for observations for assimilation are dependent upon the resolution of the models employed, with a need to constrain model evolution across the model grid, and in particular a need for sufficient resolution to capture the synoptic scales. Current global model resolutions are typically of the order of 30-100km, with regional model resolutions down to 3-4km (with a natural progression to higher resolution expected). Coastal models require different observing methods to those used for the open ocean due not only to their high resolution, but also due to limitations of the satellite data close to land, hence for these models systems such as coastal HF radar are of particular importance. The real-time nature of the assimilation application together with the rapid response time of sea state parameters to changes in winds makes timeliness a priority.

2. Validation of wave forecast models

The requirements for validation are driven by two main activities: real-time validation, with requirements very closely related to those for assimilation; and delayed mode validation, with requirements that place greater emphasis on accuracy, and more relaxed timeliness requirements. Requirements for the former, which is generally focussed on rapid validation of performance for particular events, are therefore included with those for data assimilation. Requirements for the latter, which is typically concerned with statistical measures of performance, are presented as a distinct category.

In situ buoy data are currently the key data source for validation due to their accuracy and the availability of spectral data, particularly for delayed mode validation. Due to the dependence of the wave forecasts on surface winds, there is also significant value from use of collocated surface wind data in validation activities. However, spatial sampling of buoy data does not currently meet the requirement for validation of offshore wave models, and in consequence altimeter data are also widely used for validation of point data. As with the assimilation application, availability of observations with some spatial coverage would provide significant benefits through provision of a more spatially homogeneous validation.

Again, requirements are dependent upon model resolution, though the required sampling is less dense than is required for assimilation. The key requirement, however, is to ensure that the sampling is sufficient to include a representative sample of different physical regimes globally. There is a strong requirement for improved coverage of high quality spectral observations, especially to improve representation of swell in wave forecast models.

3. Calibration / validation of satellite wave sensors

Whilst the satellite instruments clearly have the potential to provide observations with synoptic global coverage, the quality and usability of these observations is dependent upon good calibration of the satellite sensors. This can only be achieved through use of a sufficiently dense network of accurate in situ measurements. Point data are required for validation of altimeter wave measurements, whilst spectral data are required for use with SAR derived wave spectra.

Sampling requirements are similar to those for validation of forecast models, with the additional consideration that buoy observations located along satellite ground tracks would be of particular value. Accuracy is of greater importance than timeliness for this application.

4. Ocean wave climate and variability

Determination of ocean wave climate requires a long timeseries of stable data, with sufficient sampling to capture the physical regimes of the global ocean. This application therefore involves additional requirements: stability and sustainability of the observing platform. In situ measurements provide the natural source for such a time series of data, though the open ocean in situ sampling is currently inadequate for this purpose. Satellite observations can provide complementary

information, but cannot be used in isolation without the in situ observations. Timeliness is not a consideration for this application.

5. Role of waves in coupling

Investigation of the role of waves in coupling requires collocated observations of a wider range of parameters than is required for the other observations, most notably air-sea flux measurements. Spatial sampling could be restricted to a small number of open ocean locations to allow processes to be studied in detail. Again, timeliness is not a consideration for this application.

This application differs from the other applications in that the work in this area is generally focussed around dedicated process studies, rather than routine monitoring. Hence the requirements are more specific to particular studies, and in general are not likely to be addressed by the same platforms as the routine observation requirements.

Table 1: Observations requirements

Application	Parameter	Unit	Area	Horizontal Resolution (km)		Temporal frequency (hours)		Accuracy			Delay of Availability (hours)		Decadal Stability	Remarks
				Min	Max	Min	Max	Min	Max	Units	Min	Max		
(a) Assimilation into / real-time validation of global wave forecast models	(1) Significant wave height	m	Global	60	5	24	0.1	10% 0.25m	2% 0.1m	% / m	6	No delay		Data with spatial coverage would be advantageous. Collocated surface wind data advantageous for real-time validation
	(2) Dominant wave direction	degrees	Global	60	5	24	0.1	22.5	5	degrees	6	No delay		
	(3) Wave period	s	Global	60	5	24	0.1	1	0.1	s	6	No delay		
	(4) 1D frequency spectral wave energy density	m^2 / Hz	Global	300	25	24	0.1	20%	10%		6	No delay		
	(5) 2D frequency direction spectral wave energy density	m^2 / Hz	Global	300	25	24	0.1	20%	10%		6	No delay		Directional accuracy requirements for 2D spectra as for wave direction data.
(b) Assimilation into / real-time validation of regional wave forecast models	(1) Significant wave height	m	Regional	20	0.1	24	0.1	10% 0.25m	2% 0.1m	% / m	6	No delay		Strong requirement for data with spatial coverage. Collocated surface wind data advantageous for real-time validation.
	(2) Dominant wave direction	degrees	Regional	20	0.1	24	0.1	22.5	5	degrees	6	No delay		
	(3) Wave period	s	Regional	20	0.1	24	0.1	1	0.1	s	6	No delay		
	(4) 1D frequency spectral wave energy density	m^2 / Hz	Regional	100	1	24	0.1	20%	10%		6	No delay		
	(5) 2D frequency direction spectral wave energy density	m^2 / Hz	Regional	100	1	24	0.1	20%	10%		6	No delay		

(c) Delayed mode validation of wave forecast models	(1) Significant wave height	m	Global	1000	50	240	6	10% 0.25m	1% 0.05m	% / m	720	24		Priority is increased coverage of high quality spectral observations. Additional parameters of use for delayed mode validation (e.g. surface wind data, full time series of sea surface elevation)
	(2) Dominant wave direction	degrees	Global	1000	50	240	6	22.5	1	degrees	720	24		
	(3) Wave period	s	Global	1000	50	240	6	1	0.1	s	720	24		
	(4) 1D frequency spectral wave energy density	m^2 / Hz	Global	1000	50	240	6	20%	10%		720	24		
	(5) 2D frequency direction spectral wave energy density	m^2 / Hz	Global	1000	50	240	6	20%	10%		720	24		
(d) Calibration / validation of satellite wave sensors	(1) Significant wave height	m	Global	1000	10	24	1	10% 0.25m	1% 0.05m	% / m	720	24		Collocation with satellite ground tracks advantageous
	(2) Dominant wave direction	degrees	Global	1000	10	24	1	5	1	degrees	720	24		
	(3) Wave period	s	Global	1000	10	24	1	1	0.1	s	720	24		
	(4) 1D frequency spectral wave energy density	m^2 / Hz	Global	1000	100	24	1	20%	10%		720	24		
	(5) 2D frequency direction spectral wave energy density	m^2 / Hz	Global	1000	100	24	1	20%	10%		720	24		
(e) Ocean wave climate and variability	(1) Significant wave height	m	Global	1000	100	24	6	10% 0.25m	1% 0.05m	% / m	720	24	0.01m	Wave climate applications may rely on nearshore wave modelling. Hence validation data for use in nearshore wave models is an additional requirement for climate applications.
	(2) Dominant wave direction	degrees	Global	1000	100	24	6	22.5	1	degrees	720	24	1.0 degrees	
	(3) Wave period	s	Global	1000	100	24	6	1	0.1	s	720	24	0.05s	
	(4) 1D frequency spectral wave energy density	m^2 / Hz	Global	1000	100	24	6	20%	10%		720	24		
	(5) 2D frequency direction spectral wave energy density	m^2 / Hz	Global	1000	100	24	6	20%	10%		720	24		

(f) Role of waves in coupling	(1) Significant wave height	m	Global	1000	10	6	0.5	10% 0.25m	1% 0.05m	% / m	720	24	Additional collocated measurements required. Process studies likely to require dedicated dense sampling in small regions, and sampling to higher frequency than routine monitoring. Wave observations should be included routinely in studies of air-sea interaction.
	(2) Dominant wave direction	degrees	Global	1000	10	6	0.5	22.5	1	degrees	720	24	
	(3) Wave period	s	Global	1000	10	6	0.5	1	0.1	s	720	24	
	(4) 1D frequency spectral wave energy density	m^2 / Hz	Global	1000	10	6	0.5	20%	10%		720	24	
	(5) 2D frequency direction spectral wave energy density	m^2 / Hz	Global	1000	10	6	0.5	20%	10%		720	24	

Table 2: Implications for particular observing platforms

Platform	Relevant requirements	Required network	Comments
In situ (non-spectral) buoys	a1, c1, d1, e1, f1 a3, c3, d3, e3, f3 c4, d4, e4, f4	Validation requirement is for average 10º spacing requiring a network of around 400 buoys with minimum 10% / 25cm accuracy for wave height and 1 second for wave period. Higher density would be advantageous for data assimilation. Standardised measurements and meta data are essential to ensure consistency between different stations. Provision of 1D spectra from buoys with suitable instrumentation is valuable.	Primary requirement is for high quality observations for validation and calibration of altimeter data. Secondary requirement for use in assimilation. Lack of open ocean buoy observations currently makes assimilation on a global scale unfeasible. Improvement to the network would make this viable, and a potential primary requirement. An (approximately) uniform distribution of buoy observations is desirable. Collocated surface wind observations are advantageous for validation activities. Further additional parameters are of value for use in delayed mode validation. Current in situ reports are not standardised resulting in impaired utility.
In situ spectral buoys	c5, d5, e5, f5	Validation requirement is for average 10º spacing requiring a network of around 400 buoys. Higher density would be advantageous for assimilation.	Primary requirement is for high quality observations of 2D spectra for use in validation and in calibration of SAR data. At present this type of data are not widely available, and in consequence validation and calibration activities of this type are not common. Secondary requirement for use in assimilation.
Satellite altimeter	a1, b1, c1, e1 a3, b3, c3, e3	Minimum 20km resolution required for use in regional models. Along track spacing is likely to be adequate to meet this requirement; cross-track spacing is not. Multiple altimeters are therefore required to provide adequate cross track sampling. Fast delivery (within 6 hours at most) required with accuracy of 10% / 25cm for wave height, and 1 second for wave period. Long-term, stable time series of repeat observations required for climate applications.	Primary requirements arise from data assimilation. Secondary requirement for use in validation. Swath data would be advantageous. Precise specification of wave period products is required.

Synthetic aperture radar / Real aperture radar	a5, b5, c5	100km resolution required for use in regional models, with fast delivery required (within 6 hours)	Primary requirements arise from data assimilation. Secondary requirement for use in validation. Real aperture radar capability expected to be available within 5 years.
Coastal radars	b1, b2, b3 c1, c2, c3	High resolution observations (up to 100m resolution) required over coastal model areas.	Requirement for use in assimilation into, and validation of high resolution coastal wave models.
Other technologies: (e.g. Navigation radar, Other radar, Shipborne sensors such as WAVEX)	all	Potential contribution of these platforms should be developed where they can contribute to meeting the specified requirements.	

Annex IX

JCOMM SCIENTIFIC AND TECHNICAL SYMPOSIUM ON STORM SURGES
(2-6 October 2007, Seoul, Republic of Korea)

Invited Speakers
(as confirmed by 15 March 2007)

At the time of writing the following invited speakers have confirmed their participation in the Symposium, with tentative titles shown in italics. Discussions are continuing with several additional invited speakers.

1. Dr. Tad Murty (Canada) - The JCOMM Guide to Storm Surge Forecasting - this would provide a discussion of the Guide, which should be completed by then and in press, and would also incorporate the topic "status and review of numerical storm surge modelling".

2. Dr. Kevin Horsburgh (United Kingdom) - The future of operational tide-surge modelling systems.

3. Prof. Shishir Dube (India) - Storm surges in the Bay of Bengal.

4. Dr. Jang-Won Seo (Republic of Korea) - Forecast technique using KMA operational storm surge model in the East Asia.

5. Dr. Isaac Ginis (United States) - Warm ocean influence on intensification of hurricanes.

6. Dr. Øyvind Saetra (Norway) - North Sea - ensemble techniques.

7. Dr. María Paula Etala (Argentina) - Argentina storm surge -estuary model.

8. Dr. Vince Cardone (United States) - Review on achievements and limitations of meteorological forcing.

9. Dr. Bruce Harper (Australia) - Developments in storm tide modelling and risk assessment in the Australian region.

10. Dr. Don Resio (United States) - Estimation of hurricane surge risk in the Gulf of Mexico.

Annex X

TERMS OF REFERENCE AND GENERAL MEMBERSHIP OF THE TASK TEAM TO CONSIDER IMPROVED BASELINE SEA STATE MSI USING MODERN TECHNIQUES

The Task Team shall:

1. Survey of the main marine users of sea state information based on feedback of Port Meteorological Officers (PMOs) and other channels used by the NMHSs;

2. Review the quality and content of sea state information provided by MSI services (e.g., what are the differences in representativeness (hourly/daily, instantaneous/time average));

3. Develop definitions and generic product specifications for Crossing seas, Rogue waves, steep/short seas, and other sea state parameters as suggested by user community (ref. to (1.));

4. Integrate negative surge (low water level) information into the guidelines for warnings/bulletins with existing MSI;

5. Review the mandate to improve basic MSI with appropriate authorities;

6. Update the VOS questionnaire to include feedback on sea state.

General Membership:

- Representative from Mauritius (Mr Mohamudally Beebeejaun – Chairperson)
- Representative from the United Kingdom (Mr Nick Ashton)
- Representative from the USA (Mr Timothy Rulon)
- OPS Rapporteur (Dr Adrian Hines)
- Experts from ETWS (Mr Graham Warren (Australia), Mr Jean-Michel Lefevre (France), Dr Jang Won Seo (Republic of Korea), Dr María Paula Etala (Argentina), representative from Netherlands (to be appointed **(Action: Dr Hans de Vries)**) and representative from USA (to be appointed **(Action: Dr Hendrik Tolman)**))
- One expert from ETMAES (Lieutenant-Commander Rodrigo Obino)

Annex XI

TERMS OF REFERENCE OF AN EXPERT ON MET-OCEAN INFORMATION IN GRAPHICAL FORM

The Expert, jointly with ETs Experts (membership), shall:

- With the ETMSS and SCG, specify the need for a basic set off graphical and digital information for MSI;
- Keep under review existing and planned projects/works on formats for coding and displaying met-ocean information on graphical form (especially objects), within the respective WMO bodies, including CBS, at both the international and regional levels;
- Keep under review existing and planned project(s)/work(s) on navigational system(s) for marine users, including formats, developed or approved by the IMO or IHO (i.e., Marine Information Objects (MIOs)), in particular, the work undertaken by the HGMIO and other agencies/companies, especially for meteorology and oceanography aspects;
- Liaise with the WMO Secretariat, IMO, IHO or other agencies/companies to facilitate consistency between the existing or planned WMO standards and WMO Information System (WIS);
- Report the status of the project to the ETMSS Chairperson, SCG and the WMO Secretariat, as appropriate;
- Prepare a first version of a detailed report to the SCG-IV, planned for the beginning of 2009, as well as a final version to the JCOMM-III, including proposals on the formats contents and symbology and dissemination, to be used in future, including within the GMDSS.

The report by the Expert will be reviewed by members of the ETMSS, as appropriate, and be submitted to SCG-IV. After review by the SCG, the proposals will be submitted for approval to JCOMM-III, if appropriate.

General Membership:

- Representative from Argentina (Commander Negri)
- Representative from France (Mr Henri Savina)
- Representative from the United Kingdom (Mr Nick Ashton)
- Representative from the USA (Mr Timothy Rulon)
- Representative from Russian Federation (Mr Valery Martyschenko)
- Two experts from the ETSI (to be appointed during the ETSI-III)
- Experts from ETWS (Mr Graham Warren (Australia), representative from Japan (to be appointed **(Action: Mr Masakazu Higaki)**), and representative from Netherlands (to be appointed **(Action: Dr Hans de Vries)**))
- One expert from ETMAES (Mr David Feit (USA))
- OFS Rapporteur (Dr Adrian Hines)

Annex XII

LIST OF ACTIONS

Para	Action	By whom	When/target
2.1.6	Include content into the SPA website	ETWS members	ASAP
2.2.2	Compile the information received based on the questionnaire developed on the 9th Waves Workshop and transfer to the OCG	Secretariat	ASAP
3.1.2	Make the necessary arrangements to include China in the Waves Intercomparison Project	ETWS Chairperson and Secretariat	ASAP
3.1.6	Further detailed exploration of the way forward with the Waves Intercomparison Project	WG-WIP	ASAP
3.1.6	Prepare an outline for the report on the Waves Intercomparison Project to be developed on the SPA website	Dr Hendrik Tolman	Done
3.1.6	Develop the report on the Waves Intercomparison Project on the SPA website	Dr Jean Bidlot	JCOMM-III
3.1.7	Waves Intercomparison Project – description and expansion of existing work	Dr Jean Bidlot and Dr Hendrik Tolman	JCOMM-III
3.1.7	Waves Intercomparison Project – validation against altimeter wave height data	Dr Hendrik Tolman and Mr Jean-Michel Lefevre	JCOMM-III
3.1.7	Waves Intercomparison Project – validation against spectral buoy data	Dr Jean Bidlot and Dr Hendrik Tolman	JCOMM-III
3.1.7	Waves Intercomparison Project – validation of spatial data	Dr Adrian Hines and Mr Jean-Michel Lefevre	JCOMM-III
3.1.8	Provide examples of the Waves Intercomparison Project on the SPA website	WG-WIP	JCOMM-III
3.1.9	Make the necessary arrangements to present the Waves Intercomparison Project in the 10th Waves Workshop	ETWS chairperson	ASAP
3.1.9	Investigate the possibility of making results from the existing validation exchange available on the SPA website	Dr Jean Bidlot	ASAP
3.2.2	Develop the Extreme Waves Database	ETWS chairperson (leader), ETWS members, ETMC chairperson and DMPA coordinator	JCOMM-III
3.2.2	Arrange for the provision of a selection of appropriate altimeter data to the Extreme Waves Database	Dr Hendrik Tolman	Ongoing

Para	Action	By whom	When/target
3.2.2	Regularly inform the Team on the buoys data that would become available on the GTS	Dr Jean Bidlot	Continuing
3.3.1	Analyze the waves questionnaire	ETWS chairperson and Secretariat	ASAP
3.3.1	Compile the wave models information available on the GDPFS of the WWW	Secretariat	End 2007
3.3.1	Combine the information provided from the questionnaires and from the GDPFS	Mr Val Swail, Dr Jean Bidlot, Mr Jean-Michel Lefevre and Secretariat	Mid-2008
3.3.1	Place the results of the waves and storm surges questionnaires on the SPA website	Mr val Swail, Dr María Paula Etala and Secretariat	Mid-2008
3.3.2	Establish a liaison with the US Corps of Engineers for completing the inventory of models and climatological products	Mr Val Swail, Dr Hendrik Tolman and Secretariat	ASAP
3.4.1	Delineate a concrete scope, structure and content of the JEWL pilot project	WG-JEWL	End 2007
3.4.1	Provide information on MEOW and the contact details of the NHC Storm Surge Group	Dr Hendrik Tolman	ASAP
3.4.1	Provide to the Secretariat the best practices on met-ocean products provision in support of disaster risk reduction	ETWS members	ASAP
4.1.1.2	Create web pages with the WMO-No.702 content	Secretariat	ASAP
4.1.1.2 and 4.1.3.1	Regularly review of the WMO-No.702 content	WG-WG	Ongoing
4.1.1.2	Provide links to operational wave systems, models outputs, and training modules on the SPA website	ETWS members	Ongoing
4.1.1.2	Provide links to operational storm surge systems, models outputs, and training modules on the SPA website	WG-JEWL	Ongoing
4.1.2.1	Edit the Guide to Storm Surge Forecasting	Dr Tad Murty and Secretariat	Mid-2007
4.1.2.1	Final revision of the Guide to Storm Surge Forecasting	Mr Val Swail, Dr Tad Murty, Professor Igor Lavrenov and Secretariat	End 2007
4.2.2	Identify an expert from KNMI to contribute to the development of the Technical Report on downscaling techniques for wind field and its use in the high resolution wave and storm surge models	Dr Hans de Vries	ASAP
4.2.2	Develop the Technical Report on downscaling techniques for wind field and its use in the high resolution wave and storm surge models	Expert to be appointed from KNMI, Mr Val Swail,	JCOMM-III

Para	Action	By whom	When/target
		Dr Jean Bidlot, Dr Adrian Hines, Dr Hendrik Tolman and Mr Jean-Michel Lefevre	
5.4	Report to the Team on the differences between Buoy systems available on the GTS	Dr Jean Bidlot	Continuing
5.5	Develop the Surface Wave Observation Requirement Document	WG-WIP	Prior SOT-IV
6.1.1.2	Coordinate with the GEO Secretariat for further collaboration in preparing the SSS	Secretariat and Organizing Committee	ASAP
6.1.1.3	Further enhance collaboration with DPM and other relevant programmes for appropriate scientific and technical input to the Symposium	Secretariat	ASAP
6.1.1.4	Provide some names to the Programme Committee for an Invited Speaker on inundation modeling and mapping topic	Dr Hendrik Tolman	ASAP
6.1.1.4	Identify an expert to be an Invited Speaker for the topic “Disaster Prevention and Mitigation Strategies and Societal Impacts”	SSS Programme Committee	ASAP
6.1.2.1	Establish a partnership with COMET	ETWS chairperson and Secretariat	End 2007
6.1.2.1	Develop an inventory on training materials and make them available on the SPA website	ETWS members and Secretariat	JCOMM-III
6.1.3.3	Develop a Bilko lesson on waves	Dr Jean Bidlot	JCOMM-III
6.1.3.3	Develop a Bilko lesson on storm surges	Mr Masakazu Higaki	JCOMM-III
6.2.1	List all potential workshops and conferences of interest for the Team on the SPA website	Secretariat	Continuing
6.2.1	Participate in workshops and conferences of the interest for the Team	ETWS members	Continuing
7.1.1	Identify experts from Netherlands and USA to represent ETWS in the Task Team to consider improved baseline sea state MSI using modern techniques	Dr Hans de Vries and Dr Hendrik Tolman	ASAP
7.1.2	Identify experts from Netherlands and Japan to represent ETWS in the Task Team for the provision of met-ocean information in graphical form	Dr Hans de Vries and Mr Masakazu Higaki	ASAP
7.1.3	Review the Marine Meteorological Services Monitoring Programme Questionnaire and present to the SOT-IV	Secretariat	Prior SOT-IV
7.2.1	Develop wave climate summaries for ICOADS based on the historical in situ records	ETWS and ETMC chairpersons	JCOMM-III
7.2.1	Develop new international ICOADS staff at different institutions	ETWS and ETMC chairpersons	JCOMM-III

Para	Action	By whom	When/target
7.3.1	Represent ETWS in the ETCCDI	ETWS chairperson	Continuing
7.4.1	Strengthen the link between the WMO TCP and the ETWS	Mr Jean-Michel Lefevre	Ongoing
7.4.2	Identify possible codes to be used in the TCP workshops	Dr Hendrik Tolman	Ongoing
7.5.2	Provide contribution to the WMO DPM through JEWL	WG-JEWL	Ongoing
7.6.1	(a) Provide individual assessments of users' requirements for storm surge and wind waves; (b) compile this information	(a) ETWS members; (b) Secretariat and SPA coordinator	Prior SCG-IV
7.6.2	Represent (a) waves and (b) storm surge components in the IMMSC Scientific Steering Committee	(a) Dr Jean Bidlot and (b) Dr Jang Won Seo	Ongoing
7.6.2	Make the necessary arrangements to include the NOAA's Ocean Prediction Center in the IMMSC Scientific Steering Committee	Dr Hendrik Tolman and Secretariat	ASAP

WG-JEWL – Working Group on JEWL
WG-WG – Working Group on Wave Guide
WG-WIP – Working Group on Waves Intercomparison Project

Annex XIII

ACRONYMS AND OTHER ABBREVIATIONS

BOM	Bureau of Meteorology (Australia)
CAS	Commission for Atmosphere Sciences (WMO)
CBS	Commission for Basic Systems (WMO)
CHy	Commission for Hydrology (WMO)
CLIMAR	International Workshop on Advances in Marine Climatology
CMM	Commission for Marine Meteorology (WMO)
COEX	Convention &Exhibition Center (Seoul, Republic of Korea)
COMET	Cooperative Programme for Operational Meteorology Education and Training (UCAR/USA)
COOP	Coastal Ocean Observing Panel (GOOS)
DB	Data Base
DMCG	Data Management Programme Area (DMPA) Coordination Group (JCOMM)
DMPA	Data Management Programme Area (JCOMM)
DPM	Disaster Prevention and Mitigation Programme (WMO)
DWD	Deutscher Wetterdienst
ECMWF	European Centre for Medium-range Weather Forecasts
ERA	ECMWF Re-Analysis
ESA	European Space Agency
ET	Expert Team
ETCCDI	Joint CCl/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices
ETMAES	Expert Team on Marine Accident Emergency Support (JCOMM)
ETMC	Expert Team on Marine Climatology (JCOMM)
ETMSS	Expert Team on Maritime Safety Services (JCOMM)
ETSI	Expert Team on Sea Ice (JCOMM)
ETWS	Expert Team on Wind Waves and Storm Surges (JCOMM)
FNMOC	Fleet Numerical Meteorology and Oceanography Center (US Navy)
GCOS	Global Climate Observing System
GDPFS	Global Data Processing and Forecasting System (WWW)
GEO	Group on Earth Observation
GEOSS	Global Earth Observation System of Systems
GMDSS	Global Maritime Distress and Safety System
GODAE	Global Ocean Data Assimilation Experiment
GOOS	Global Ocean Observing System
GOSUD	Global Ocean Surface Underway Data Project
GTS	Global Telecommunication System (WWW)
HGMIO	Harmonizing Group on Marine Information Objects
ICOADS	International Comprehensive Ocean-Atmosphere Data Sets
ICS	International Chamber of Shipping
IHO	International Hydrographic Organization
IMMA	International Maritime Meteorological Archive
IMMSC	International Maritime Met-ocean Services Conference
IMO	International Maritime Organization
IMSO	International Mobile Satellite Organization
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IODE	International Oceanographic Data and Information Exchange (IOC)
J-EPB	JCOMM Electronic Product Bulletin
JEWL	JCOMM Extreme Water Level Pilot Project
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
JMA	Japan Meteorological Agency
KMA	Korea Meteorological Administration
KNMI	Royal Meteorological Institute of Netherlands

KORDI	Korea Ocean Research and Development Institute
LOC	Local Organizing Committee for the Storm Surge Symposium
MEOW	Maximum Envelope of Water
MIO	Marine Information Objects
MOMAF	Ministry of Maritime Affairs and Fisheries
MSC	Meteorological Service of Canada
MSI	Maritime Safety Information
NASA	National Aeronautics and Space Administration (USA)
NCAR	National Center for Atmospheric Research (USA)
NCEP	National Centers for Environmental Prediction (USA, NOAA)
netCDF	Network Common Data Form
NHS	National Hurricane Center
NMHS	National Meteorological and Hydrological Service
NMS	National Meteorological Service
NOAA	National Oceanic and Atmospheric Administration (USA)
NWS	National Weather Service (USA, NOAA)
OCG	Observations Programme Area (OPA) Coordination Group (JCOMM)
OFS	Ocean Forecasting System
OGP	International Association of Oil & Gas Producers
OOPC	Ocean Observations Panel for Climate (of GOOS, GCOS, WCRP)
OPA	Observations Programme Area (JCOMM)
OPAG	Open Programme Area Groups
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PMO	Port Meteorological Officer
PWS	Public Weather Service
QC	Quality Control
RA	Regional Association (WMO)
RMSE	Root Mean Square Error
RNODC-Waves	Responsible National Oceanographic Data Centre for Waves (IOC)
SAMOS	Shipboard Automated Meteorological and Oceanographic System
SAR	Synthetic Aperture Radar
SCG	Services Programme Area (SPA) Coordination Group (JCOMM)
SHOM	Service Hydrographique et Océanographique de la Marine
SOLAS	International Convention for the Safety of Life at Sea
SOT	Ship Observations Team (JCOMM)
SPA	Services Programme Area
SSS	Storm Surge Symposium
SWH	Significant Wave Height
TCP	Tropical Cyclone Programme (WMO)
TOL	Top Level Objectives
TOR	Terms of Reference
URD	User Requirement Document
VOS	Voluntary Observing Ship
WIS	WMO Information System (WMO)
WCP	World Climate Programme (WMO)
WCRP	World Climate Research Programme
WG-JEWL	Working Group on JEWL
WG-WIP	Working Group on Wave Intercomparison Project
WMO	World Meteorological Organization
WWW	World Weather Watch (WMO)