

**EXPERT TEAM ON
WIND WAVES AND STORM SURGES (ETWS)
FIRST SESSION**

Halifax, Canada, 11-14 June 2003

FINAL REPORT

JCOMM Meeting Report No. 22

**EXPERT TEAM ON
WIND WAVES AND STORM SURGES (ETWS)
FIRST SESSION**

Halifax, Canada, 11-14 June 2003

FINAL REPORT

JCOMM Meeting Report No. 22

NOTE

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.

CONTENTS

Report	1
Annex I - List of Participants	13
Annex II - Agenda	15
Annex III - JCOMM ETWS Intersessional Work Plan 2001-05	16
Annex IV - Draft Table of Contents of "Guide to Storm Surge Forecasting"	18
Annex V - Outline of a JCOMM Technical Report "Use of Satellite Data in Wave Models"	19
Annex VI - MAXWAVE Project.....	20
Annex VII - JCOMM Wind Wave and Storm Surge Programme, Elements and Activities for 2001 -2005	24
Annex VIII - Proposed Revision of Terms of Reference of the ETWS	35
Annex IX - List of Action Items	36
Annex X - List of Acronyms and Other Abbreviations	38

GENERAL SUMMARY OF THE WORK OF THE SESSION

1. OPENING OF THE SESSION

1.1 Opening

1.1.1 The first session of the JCOMM Expert Team on Wind Waves and Storm Surges (ETWS) was opened by its chairman, Mr Val Swail (Canada), at 0930 hours on Wednesday, 11 June 2003, in Cambridge Suite Hotel, Halifax, Canada.

1.1.2 On behalf of the Meteorological Service of Canada (MSC) and in particular its Assistant Deputy Minister, Dr Marc Denis Everell, Mr Swail welcomed participants to the session, and to Halifax. He noted that this is the first meeting not only for the Team but also of the former CMM Subgroup in this field. He noted that the WMO Wave Programme was transformed into the JCOMM Wind Wave and Storm Surge Programme and that storm surge prediction support was included in the new expanded terms of reference of the ETWS. He looked forward to lively discussion during the meeting. He concluded by wishing participants an enjoyable stay in Halifax.

1.1.3 On behalf of the Secretary-General of WMO, Professor G.O.P. Obasi, and the Executive Secretary IOC, Dr P. Bernal, the Secretariat representative also welcomed participants to the first session of the ETWS. In doing so, she expressed the very sincere appreciation of both Organizations to the Government of Canada, to the Meteorological Service of Canada and its Assistant Deputy Minister, Dr Marc Denis Everell, and especially to the local organizer and the chairman of the Team, Mr Val Swail and his staff, for the excellent facilities provided as well as for the tremendous organizational effort already put into preparations for the meeting. She noted that the WMO Wave Programme was first proposed at CMM-VII in 1981, came into existence in 1984 and had been transformed into the JCOMM Wind Wave and Storm Surge Programme at JCOMM-I. The original general objective of the programme was to help WMO Members in the provision of high quality data well as wave analysis and forecast services to a large variety of applications including maritime safety services. She also noted that a Workshop on Wind Wave and Storm Surge Analysis and Forecasting for Caribbean countries would take place in Dartmouth in the following week. She expressed her sincere appreciation to the Team members who were contributing to the workshop. She assured participants of the full support of the Secretariat, both during the meeting and throughout the implementation of the work programme of the Team, and she concluded by wishing all participants a very successful meeting and an enjoyable stay in Halifax.

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

1.2 Adoption of the agenda

1.2.1 The meeting adopted its agenda for the session on the basis of the provisional agenda. This agenda is given in *Annex II*.

1.3 Working arrangements

1.3.1 The meeting agreed its hours of work and other practical arrangements for the session. The documentation was introduced by the Secretariat, and participants made short introductions of themselves, to facilitate future interactions.

2. REPORT OF THE CHAIRMAN AND THE SECRETARIAT

2.1 Report of the chairman of the Team

2.1.1 The meeting noted with appreciation the report by the chairman on the activities and plans of the Team. 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. Most important considerations were that storm

surge prediction support was included in the new expanded terms of reference of JCOMM and that there were many commonalities between systems providing wind wave and storm surge prediction. He stressed that the Commission clearly recognized that it was a very ambitious programme, which would require substantial efforts by JCOMM members, other experts and Members/Member States during the coming four years.

2.1.2 He reported his activities as the chairman of the Team, including his participation in the first session of the Services Coordination Group (SCG-I) (Geneva, April 2002), and submission of his reports to the first and second session of the Management Committee through the Services Programme Area Coordinator. He stressed that the Management Committee well recognized the importance of the JCOMM Wind Wave and Storm Surge Programme.

Work Plan

2.1.3 The meeting was presented with the work plan, which was reviewed by SCG-I and at the second session of the Management Committee (MAN-II) (Paris, February 2003).

2.1.4 The work plan was thoroughly reviewed under relevant agenda items during the session. The revised work plan is in *Annex III*.

2.2 Report of the Secretariat

2.2.1 The meeting recalled that JCOMM was formally established in 1999 and that its first session (JCOMM-I) took place in Akureyri, Iceland, in June 2001. 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-I and allocate specific tasks, a work programme was prepared which allowed for the Management Committee and all PA Coordination Groups to meet in the first half of 2002. In addition to these meetings, the programme includes other subsidiary bodies and related meetings, in particular those of a regular nature (e.g. the present session of the Expert Team on Wind Waves and Storm Surges) or planned prior to JCOMM-I, as well as some training events directly under JCOMM.

2.2.2 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. (3.2, 5, 6.1.1, 7.1, and 7.2)

3 ACTIVITIES OF MEMBERS/MEMBER STATES

3.1 Catalogue of operational wind waves and storm surge models and products

3.1.1 The meeting noted that the Guide to Wave Analysis and Forecasting, second edition (WMO-No. 702) (1998), included catalogues of performance of operational wave models and of numerical wave models operated by National Meteorological Services (Tables 6.1 and 6.2). It recognized that preparing a catalogue of operational and experimental wave models and its regular updates were useful means of disseminating information to Members/Member States on the nature and status of models currently in use. It recognized that generic information, including relevant web sites on which further description and/or even data themselves are available, should also be included in the catalogue. The meeting agreed that the catalogue should not be for commercial models and that it should be basically for operational/national models. It also noted that information on pre-operational (semi-operational) models would also be useful. It agreed that decision on the inclusion of such pre-operational models in the catalogue should be left for Members. Verification activities were discussed under agenda item 3.2.

3.1.2 The meeting therefore agreed that a questionnaire should be distributed to Members to collect information on operational/pre-operational wind wave models and their products, following the example of the present Tables in the Guide to Wave Analysis and Forecasting, every two years. It agreed that the questionnaire should be basically in the form of the existing Table 6.2 and that the following

columns should be added: contact (organization, web site, etc.) updated and/or reviewed date(s), and comments. The meeting agreed that the same type of table should also be proposed for storm surge models.

3.1.3 The meeting also agreed that a separate table should be developed to show the availability of codes for both wind wave models and storm surge models, indicating any restrictions. Questionnaires for this table should be developed in a similar form.

3.1.4 The meeting agreed that a formal letter should be distributed from the WMO Secretariat to Permanent Representatives (PRs) of Members and that copies should be sent to IOC action addressees and JCOMM focal points to make sure that information was provided from Members/Member States. (**Action:** Secretariat) It was agreed that Val Swail would develop a questionnaire and collect and assemble information provided by Members/Member States regarding wave models and that Paula Etala (Argentina) would be responsible regarding storm surge models. (**Action:** Val Swail and Paula Etala) The meeting further agreed that updated information should be sent to the Secretariat, but that the Team should be responsible for assembling the information provided to produce the final version of the tables. (**Action:** ETWS members)

3.1.5 The meeting agreed that once tables were prepared by Mr Swail and Ms Etala, the tables should be sent to the WMO Secretariat so that they should be placed on the JCOMM web site. (**Action:** Val Swail, Paula Etala, Secretariat)

3.1.6 The meeting further agreed that for the purpose of further distribution of the information, the content should be placed on the WMO web site as part of the dynamic part of the Guide to Wave Analysis and Forecasting (WMO-No. 702) (see agenda item 4.1.1).

3.1.7 With regard to "performance of operational model" (Table 6.1 in the Guide), the meeting noted that information on verification activities (see agenda item 3.2) would provide even better information. It agreed that Table 6.1 would not be updated.

3.2 Verification activities

3.2.1 Martin Holt (United Kingdom) described numerical wave model forecasting verification activities. Since 1995, five centres (European Centre for Medium-range Weather Forecast (ECMWF), Met Office (UK), Fleet Numerical Meteorology and Oceanography Center (FNMOC) (USA), Canadian Meteorological Centre (CMC) and National Centers for Environmental Prediction (NCEP) (USA)) running global wave models have routinely exchanged model forecast data at an agreed list of moored buoy sites at which instrumented observations of significant wave height, wave period and wind speed are available from the WMO Global Telecommunication System (GTS). The meeting noted that Météo-France had joined the activities in 2001. The verification exchange provides a mechanism for quality assurance of the national wave forecast models contributing to safety of life at sea, ship routing, Global Maritime Distress and Safety System (GMDSS), etc.

3.2.2 The meeting recognized the importance of the verification activities and expressed its sincere appreciation to the six centres. The meeting recalled that SCG-I recommended to the ETWS that a JCOMM Technical Report should be prepared on the wave model verification project, giving some details of the conduct of the project as well as results. With regard to the details of the conduct of wave model verification activity, the meeting agreed that it would be appropriate to prepare a JCOMM Technical report.

3.2.3 The meeting considered the information presented by Martin Holt on behalf of the six centres and reached the following decisions:

- i. The verification activity should continue as a tool for research and development of operational wave model systems, and does not need to be formalized. (The principal users of the results from the exchange are the participants themselves)

- ii. The exchange activity should be extended
 - a. By including additional participants and models.
 - b. By including, where appropriate, regional wave models
 - c. By including additional observation locations with data as provided by participants (not necessarily relying solely on the GTS, though it is noted that such data needs to be provided from sustainable long term monitoring sites)
- iii. A description of the exchange will be prepared for the JCOMM webpage, to encourage wider participation. This will include summary results (subject to agreement from participants) (see vi)
- iv. Whilst it is desirable to publicize the activity, this should be at the participants discretion, rather than as a routine summary report. It is noted that the present exchange is designed as one requiring minimal effort, for maximum benefit to the participants.
- v. Additional verification criteria, (e.g. hit rate for exceedence of threshold values of significant wave height) should be developed where appropriate
- vi. A JCOMM Technical Report should be prepared, with input from the participants, to document the present operation of the exchange, along with a summary of the outcomes. The meeting accepted with appreciation that Martin Holt would take a leading role in preparing the Report. (**Action:** Martin Holt)
- vii. The possibility of basing a wave model certification scheme on the outcome of the verification exchange was discussed This was felt to be inappropriate, since the verification activity is intended to guide model development, rather than select between available models.

3.2.4 The meeting also agreed that the following technical topics may be taken forward independently at individual centres, rather than as a part of the exchange activities:

- i. Where possible, intercomparison of spectral model data with available spectral observations, for instance those at moored buoys, ERS-2 SAR data after retrieval, and Envisat level-2 ASAR wave spectra.
- ii. Consideration is given to validation against altimeter wave height and wind speed observations. As these data become more widely and freely available consideration should be given to including this validation in the exchange activity.
- iii. Consider verification of model forecast fields against wave model analysis, for bias, standard deviation of error, and anomaly correlation of significant wave height. This requires a large amount of data.
- iv. Consider standardizing the computation of model peak period (or establish best practice in this computation)

3.3 Climatologies

3.3.1 With the increasing use of numerical wave 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 is given 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 (ERA-15, ERA-40, MSC40, NCEP/NCAR). They made it

possible to generate long series of data with global coverage and to derive statistically reliable estimates of trends and long return period parameters.

3.3.2 The meeting agreed that it would be valuable to continue monitoring studies of wind wave, storm surge and surface wind climatologies, and to prepare an update of the inventory of hindcast wind wave climatologies and measured wind wave and storm surge data bases. The meeting agreed that it was necessary to develop targeted questionnaires for distribution to Members/Member States to supply information on hindcast data and on long-term records of measurements, following the example of the present Tables 9.2, 9.3 in the Guide to Wave Analysis and Forecasting. It further agreed that questionnaire(s) should be basically in the form of the existing tables, that new columns such as contact and availability should be added and that the column for verification should be deleted. It agreed that it was premature to prepare a hindcast storm surge database.

3.3.3 The meeting agreed that a formal letter should be distributed from the WMO Secretariat to PRs of Members and that copies should be sent to IOC action addressees and JCOMM focal points to make sure that information be provided from Members/Member States. (**Action:** Secretariat) It was agreed that Val Swail would collect and assemble information provided by Members/Member States regarding wind waves and that Paula Etala would be responsible for storm surges. (**Action:** Val Swail, Paula Etala)

3.3.4 The meeting agreed that once tables were prepared by Mr Swail and Ms Etala, the tables should be sent to the WMO Secretariat so that they should be placed on the JCOMM web site. (**Action:** Val Swail, Paula Etala, and Secretariat)

3.3.5 The meeting further agreed that for the purpose of further distribution of the information, the content should be placed on the WMO web site as part of the dynamic part of the Guide to Wave Analysis and Forecasting (WMO-No. 702) (see agenda item 4.1.1).

4. GUIDES AND RELEVANT PUBLICATIONS

4.1 Guides

4.1.1 Guide to Wave Analysis and Forecasting

4.1.1.1 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.

4.1.1.2 The meeting recalled that although JCOMM-I requested the Secretariat to make available the Guide to Wave Analysis and Forecasting on the WMO web site, this has not yet been realized because the Guide was among the WMO mandatory (sale) publications. However, it noted with satisfaction the likelihood that a .pdf version of the Guide would shortly be made available in this way.

4.1.1.3 The meeting 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 and climatology. The meeting 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 basic approach now being implemented for the Guide to the Applications of Marine Climatology (WMO-No. 781), namely that it would comprise two parts: (1) a static part which would be expected to remain valid over a relatively long time frame, and which could be maintained as a hard-copy publication; (2) a second, more dynamic part covering matters relating to new technologies and emerging issues, which could be made available in digital form on the World Wide Web.

4.1.1.4 The meeting recognized that it would be necessary to identify topics to be published as a dynamic part of the Guide. It further agreed that the most effective way to provide up-to-date information for the dynamic part of the Guide would be publication of appropriate JCOMM Technical Reports on the identified topics. The meeting recalled that publication of four JCOMM Technical Reports was being planned (see agenda item 4.2) It agreed that these publications and catalogues planned to be prepared (see agenda items 3.1 and 3.3) should form the dynamic part of the Guide.

4.1.1.5 The meeting also noted that the International Workshops on Wave Hindcasting and Forecasting, most recently the 7th Workshop, had contributed significantly to the topics relevant to the Guide. It agreed this type of workshop would provide a good opportunity to identify topics for which future Technical Reports should be prepared. In addition, individual papers, or groups of papers on specific topics, could be selected to produce a JCOMM Technical Report which would then form a part of the dynamic part of the Guide.

4.1.2 Guide to Storm Surge Forecasting

4.1.2.1 The meeting recalled that JCOMM-I noted that, in addition to the Guide to Wave Analysis and Forecasting, guidance on storm surge prediction was required. The meeting noted with appreciation a draft table of contents of the new Guide proposed by Shishir Dube (India). The meeting reviewed the proposal and agreed with the table of contents, given in *Annex IV*.

4.1.2.2 The meeting further agreed that Shishir Dube and Graham Warren(Australia) would take leading roles to develop draft content for peer review. (**Action:** Shishir Dube and Graham Warren) The meeting agreed that an English final draft should be ready by JCOMM-II.

4.2 Technical Reports

4.2.1 The meeting recalled that in the previous intersessional period, two JCOMM Technical Reports "Evaluation of the Highest Wave in a Storm" (1998) (WMO/TD-No. 858, Marine Meteorology and Related Oceanographic Activities Report No. 38) and "Estimation of Extreme Wind Wave Height" (2000) (WMO/TD-No.1041, JCOMM Technical Report No. 9) had been published in accordance with the identified interest of wave forecasters in the prediction and evaluation of highest waves. It also recalled that JCOMM-I and SCG-I had expressed the need for technical reports to be prepared in support of three key areas (1) forcing for wind wave and storm surge numerical models; (2) data assimilation in wind and wave forecasting; (3) long-term trends in long return period estimates of winds and waves. The meeting agreed that three JCOMM Technical Reports, in addition to the one for the verification activities (see agenda item 3.2) should be published in this intersessional period.

Extended use of data assimilation in wind wave forecasting

4.2.2 The meeting noted the importance of the progress in assimilation of remotely sensed wave and marine surface data and agreed to publish a technical report on this issue. The meeting noted with appreciation an outline of the technical report proposed by Jean-Michel Lefèvre (France). The meeting suggested some modification, and the modified outline was agreed as *Annex V*. The meeting recognized that a questionnaire should be prepared to collect necessary information to be included in the Technical Report. The Team accepted with appreciation that Mr Lefèvre would take a leading role to prepare for this publication. (**Action:** Jean-Michel Lefèvre) Mr Lefèvre will also prepare a draft questionnaire which will be circulated to the members of the Team by September 2003. (**Action:** Jean-Michel Lefèvre)

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

4.2.3 The meeting recognized that access to appropriate surface wind fields still remained one of the most limiting factors to wind wave and storm surge nowcasting and forecasting. The meeting agreed that this report should be composed of 1) catalogue of operational wind fields, 2) hindcast reanalysis wind fields and 3) some description/limitation regarding wind fields. The meeting noted that it was necessary to clearly show what kind of data were assimilated to produce each wind field.

4.2.4 The meeting accepted with appreciation that Val Swail would develop a draft questionnaire to collect appropriate information and a draft outline of the report for circulation among the members of the Team by September 2003. (**Action:** Val Swail)

Long-term trends in long return period estimates of winds and waves

4.2.5 The meeting agreed that there was a constant need to review and modernize methods and techniques of estimating long return period values of wind waves, storm surge and distribution of other variables accompanying values of low probability.

4.2.6 The meeting accepted with appreciation that Val Swail would take a leading role to prepare a Technical Report on this topic. This report would be produced using Chapter 12 of "Estimation of Extreme Wind Wave Height" (JCOMM Technical Report No. 9) as a starting point. (**Action:** Val Swail)

4.2.7 All the three Technical Reports as well as one on verification activities (see para 3.2.3) were planned to be published by the end of 2004.

Global Atlas by ERA-40

4.2.8 The meeting was informed that Sofia Caires (KNMI) was presently developing a "Global Wave Climatology Atlas" based on the results of the ERA-40 reanalysis project. The meeting recognized the importance of a global wave atlas in general. It also recognized that at the moment this was the only such global atlas based on hindcast data and that such information would be very useful for Members/Member States. At the same time, it recognized that it would not be appropriate to publish a JCOMM Technical Report dedicated to a single model/organization, etc. It agreed that a short summary would be prepared by the Team to be placed on the JCOMM web site which would link to this information on the KNMI web site so that Members/Member States could get such information through a JCOMM window. (**Action:** Val Swail and ETWS) It further agreed that the summary should be updated to include other such information in the future by the Team as appropriate.

5. OBSERVATIONS

5.1 The meeting noted that the JCOMM Observations Coordination Group, at its first session (OCG-I) (La Jolla, USA, April 2002) had requested the Team to consider the possibility of designating a global network of in situ wave buoys, to provide the ground calibration segment for both satellites (altimeter) and wave models.

5.2 The meeting recognized the importance of designation of such a subset. However, the meeting noted that the ETWS was not in a position to actually designate such a network. Recalling the establishment of the Global Surface Network (GSN) and the Global Upper Air Network (GUAN), the meeting further noted that the Team was prepared to provide support/suggestion when such selection was made within the context of the Global Ocean Observing System (GOOS). The meeting noted the importance of discussion between the Team and the GOOS/GCOS/WCRP Ocean Observations Panel for Climate (OOPC) in this regard (see agenda item 7.3).

5.3 Noting the discussion at OCG-I, the meeting agreed that the Team would provide technical advice, as requested, in terms of enhancement of the shipboard report compilation and transmission software regarding wave observation practices, and calibration regarding automated wave observations from ships. (**Action:** ETWS members)

6. SEMINARS, TRAINING COURSES AND WORKSHOPS

6.1 Technology transfer

6.1.1 JCOMM Training workshop

6.1.1.1 The meeting 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. It also recalled that JCOMM-I (Akureyri, June 2001) agreed that workshops on wave modeling, analysis and forecasting were highly valuable in assisting countries to improve their capabilities in this important field and that the Commission strongly urged WMO and IOC to ensure that they be continued on a regular basis in the future.

6.1.1.2 The meeting noted with appreciation and satisfaction that all the Team members who participated in the ETWS-I would contribute to a workshop on wind wave and storm surge analysis and forecasting for Caribbean countries to be held in Dartmouth in the following week. The meeting expressed its sincere appreciation to the Meteorological Service of Canada, especially Mr Val Swail for their enormous efforts and substantial contribution to the organization of the workshop.

6.1.1.3 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. The meeting noted that another workshop in this field was planned to be held in the next WMO financial period (2004-2007). It strongly recommended that this type of workshop should be organized on a regular basis. The meeting agreed that the ETWS should continue to provide such support to training events where appropriate and possible. The meeting noted that the number of participants would be an important factor regarding the effectiveness of organization of such events.

6.1.1.4 The meeting recalled that the JCOMM Task Team on Resources had developed questionnaires to obtain reaction from participants and lecturers on the usefulness and effectiveness of training events for the purpose of further improvements of such events. It noted that the coming workshop would be the first opportunity to use the questionnaires, with comments on the questionnaires themselves to be conveyed to the Secretariat. (**Action:** lecturers at the Caribbean workshop) The meeting agreed that the results of the questionnaire survey should be returned to the Capacity Building Coordination Group (CBCG) for their consideration to improve future JCOMM activities under the Capacity Building Programme Area. ((**Action:** Secretariat))

6.1.2 Consulting services

6.1.2.1 Since 1994, the former CMM Subgroup on Wind Waves had been offering consulting services on matters pertinent to wave modelling and forecasting services to all WMO Members. The meeting recognized the usefulness of such services and expressed the view that the broad mandate of JCOMM might require a similar opportunity for the development of storm surge prediction services, thus that such services should also be provided as appropriate.

6.1.2.2 The meeting recalled that the JCOMM Capacity Building Coordination Group (CBCG), at its first session (CBCG-I), particularly emphasized the value of making available as freeware, software packages for use on PCs and workstations for modelling and forecasting ocean elements such as waves, surges, oil spill trajectories/dispersion, ocean thermal structure, etc. Such software should be easily adaptable to local institutional and environmental conditions, and software delivery should also include training in adaptation and use. It was further recognized that the quality and value of the modelling depended on the amount and quality of the input data available locally. In this context, any project delivering models should also consider linkages to relevant satellite and in situ data.

6.1.2.3 The meeting recalled that JCOMM-I was informed of a project for the development of a storm surge prediction system implemented by the Governments of Norway and Viet Nam. The meeting agreed that members of the Team could participate in such projects as technical advisors.

6.1.2.4 The meeting recalled that Japan had expressed an offer at JCOMM-I to provide technical support to other countries in storm surge modelling. The meeting noted with appreciation that several organizations including NCEP, Office of Naval Research (ONR) (USA) and Rijkswaterstaat (Netherlands) had been material in making free software available for wind wave models, and that the Indian Institute of Technology had provided a surge model to neighbouring countries for their use.

6.1.2.5 The meeting noted that Members/Member States as well as the members of the Team should continue the role of consulting services as requested and appropriate. (**Action:** ETWS members)

6.2 Other workshops and conferences

6.2.1 JCOMM-I and SCG-I agreed that 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. Members/Member States, which run professional meteorology courses, should be encouraged to include specific course material on wind wave and storm surge analysis and forecasting.

6.2.2 The meeting agreed with the importance of conferences, workshops, seminars and training courses in the coordination of wind wave and storm surge activities globally, for exchange of information on data bases, methodologies and techniques, and sharing of expertise among developed as well as developing countries.

6.2.3 The meeting agreed to participate in other upcoming conferences and workshops planned for the next two years, in either a scientific, organizational or coordination role (**Action:** ETWS members):

- i. JCOMM Ship Observations Team, Second session (London, 28 July - 1 August 2003)
Graham Warren will contact the SOT chair
- ii. OOPC VIII (Ottawa, Canada, September 2003)
Val Swail may attend
- iii. Training Workshop on Storm Surge (Kuantan, Malaysia, 15-19 September 2003)
Shishir Dube will attend
- iv. MAXWAVE Project Final Meeting (Geneva, 8-10 October 2003)
Val Swail, J-M Lefèvre and Martin Holt will attend
- v. Data Buoy Cooperation Panel Meeting (Brazil, 20-29 October 2003)
Graham Warren will contact the DBCP chair
- vi. CLIMAR-II (Brussels, 17-22 November 2003)
Val Swail is in the Organizing Committee
- vii. Toulouse workshop May 2004
Some members of the Team may attend
- viii. JCOMM Expert Team on Marine Climatology (Gdynia, Poland, mid-2004)
- ix. WISE workshop (St Petersburg, June/July 2004)
Igor Lavrenov is organizing, J-M Lefèvre, Martin Holt and Hendrik Tolman will attend
- x. JCOMM Data Buoy Cooperation Panel Meeting (Chennai, India, October 2004)
- xi. 8th International Workshop on Wave Hindcasting and Forecasting, late 2004, TBD
Val Swail and Hendrik Tolman are organizing, most members of ETWS will attend

6.2.4 The meeting noted that the International Workshops on Wave Hindcasting and Forecasting, most recently the 7th Workshop, had contributed significantly to topics relevant to the JCOMM Wind Wave and Storm Surge Programme. It agreed that the ETWS would lead the organization of the 8th International Workshop on Wave Hindcasting and Forecasting, tentatively scheduled for late 2004, and subsequent editions of this two-yearly meeting. (**Action:** Team members) It recommended that JCOMM should be a co-sponsor of the workshop, without any financial implication. (**Action:** Secretariat)

7. COOPERATION WITH OTHER BODIES

7.1 WMO Tropical Cyclone Programme (TCP)

7.1.1 The meeting 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 region in

cooperation with JCOMM (mainly through its co-president). It noted with appreciation that Shishir Dube contributed to these workshop as a lecturer. The meeting agreed that the ETWS should continue to contribute to and support these events as appropriate. (**Action:** ETWS members)

7.2 MAXWAVE Project

7.2.1 The meeting noted with interest and appreciation the report on the MAXWAVE Project given by Martin Holt and Jean-Michel Lefèvre. The MAXWAVE project (<http://w3g.gkss.de/projects/maxwave/>) is a research project supported by the European Commission under the Fifth Framework Programme contributing to the implementation of the Key Action 3: Sustainable Marine Ecosystems within the Energy, Environment and Sustainable Development. Three NMSs are involved in the project, among other partners. A summary of this presentation is in *Annex VI*.

7.2.2 The meeting noted that two members of the ETWS, Martin Holt and Jean-Michel Lefèvre are involved in the MAXWAVE project and recognized that it was important to maintain the liaison with this project, primarily through them.

7.2.3 The meeting noted that MAXWAVE meetings, the 5th consortium meeting (11-12 September 2002) and the 2nd Senior Advisory Panel (12-13 September 2002), had been held in parallel to the first session of the JCOMM Expert Team on Maritime Safety Services (ETMSS-I) (Lisbon, 11-14 September 2002) and a presentation of this project for ETMSS-I participants had been given. The meeting was pleased to note that the chairman of the ETWS was invited to the 10th MAXWAVE meeting

7.2.4 The meeting recalled that the ETMSS-I noted that sea state forecasting was complicated, including a variety of factors, that graphical information would be most appropriate for the provision of sea state information to mariners, and that further development of wave models could also affect this issue. It noted that the ETMSS-I had recommended a revision of the Manual on Marine Meteorological Services (WMO-No. 558) so that warnings for severe sea states (swell, risk of abnormal waves) should also be issued and that phenomena like breaking seas, cross seas and risk of abnormal/rogue waves shall also be included in warnings if feasible. The meeting agreed that ETMSS and ETWS should maintain communication on this issue. In this connection, the meeting was pleased to note that Météo-France, as a partner in the MAXWAVE project, planned to implement a warning system related to sea-state on a pre-operational basis from the end of 2003, and to submit, before JCOMM-II, a detailed proposal for warning criteria (including if feasible threshold) and formats for complex seas (breaking, cross sea, abnormal/rogue waves) for high seas forecasts, for eventual inclusion in the Manual on Marine Meteorological Services (WMO-No. 558). The meeting agreed that support to the improvement of Maritime Safety Services for Mariners should be a high priority task for the ETWS and it further agreed that once proposals (both for forecasting methods and vocabulary) were drafted, the draft should be circulated to the ETWS members to seek their comments. (**Action:** ETWS and Secretariat) The meeting was pleased to note that research orientated projects such as the MAXWAVE would eventually contribute to operational services.

7.3 GOOS

7.3.1 The meeting agreed that the Team would be pleased to provide suggestions, as requested, to OOPC and/or GOOS Coastal Ocean Observing Panel (COOP) when an observational network, such as selection of a subset of in situ wave buoys for ground calibration for satellite and/or wave models, was designated within the GOOS context.

7.3.2 The meeting urged that the network of in situ wave observations from moored buoys be enhanced, particularly for offshore locations and in the tropics and southern ocean, in order to provide more balanced geographical coverage and therefore more representative statistics in the validation of wave model output and calibration of satellite sensors.

7.3.3 The meeting agreed that the Team should maintain and enhance liaison with major international programmes and their individual components, such as GOOS, OOPC, COOP, Global

Ocean Data Assimilation Experiment (GODAE), by participating in organizational or technical meetings on an opportunistic basis or on request.

7.3.4 The meeting recalled that the former CMM Subgroup on Wind Waves had an invited presentation at the OceanObs99 (St Raphael, France, October 1999), a major achievement of the OOPC. The meeting agreed that the Team should make a similar contribution to the follow-on to OceanObs99, whenever this might occur. (**Action:** ETWS members)

7.4 User community

7.4.1 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 adequate provision of real time and specialized, user-tailored, information on waves, storm surges, and winds. The meeting agreed that 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 special services (ship routing, fisheries, aquaculture, etc.) are understood and facilitated. In particular, the requirements of various modules of GOOS for wind wave and storm surge data have to be clearly identified. The considerable economic potential of weather routing of ships and assistance in the provision of weather and wind wave related services for complex, weather sensitive operations, is noteworthy.

7.4.2 The meeting recalled that the Team should provide technical advice to NMSs and relevant oceanographic organizations who provide services to end users such as ship routing, oil and gas industry, fisheries, aquaculture, etc. The meeting noted that the workshops/conferences such as the 7th International Wave Workshop which were attended by important end-user groups for wind wave and storm surge information could provide a good opportunity to consider user requirements.

7.4.3 The meeting noted that the International Standards Organization (ISO) standard should be investigated regarding requirements for wind and wave parameters and formats. It agreed that Igor Lavrenov would prepare an information document on this issue for the consideration of the ETWS. (Action: Igor Lavrenov)

8. REVIEW OF JCOMM WIND WAVE AND STORM SURGE PROGRAMME

8.1 The JCOMM Expert Team on Wind Waves and Storm Surges was established at JCOMM-I, based on transformation of the WMO Wave Programme into the JCOMM Wind Wave and Storm Surge Programme. A draft Programme was presented at JCOMM-I. The Team thoroughly reviewed the Programme and the revised programme with annotations is in *Annex VII*.

8.2 The meeting reviewed the Terms of Reference of the Team and recommended modifications as in *Annex VIII*.

9. REVIEW OF ETWS-I SESSION REPORT AND ACTION ITEMS

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

10. CLOSURE OF THE SESSION

10.1 In closing the meeting, the chairman, Mr Val Swail, 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 the Meteorological Service of Canada, he expressed his pleasure at having had the opportunity to host the meeting in Halifax. He wished all participants an enjoyable stay and a safe return journey.

10.2 On behalf of all participants, the Secretariat representative expressed her thanks once again to MSC, its Assistant Deputy Minister, Dr Everell, and to Mr Val Swail, for hosting the meeting and for providing such impressive facilities, support and hospitality. She also expressed her appreciation to the chairman for his excellent chairing of the session and for his substantial support and work. She further thanked Val Swail for his kind and substantial support to the workshop to be held in Dartmouth in the following week.

10.3 The first session of the JCOMM Expert Team on Wind Waves and Storm Surges closed at 1145 hours on Saturday, 14 June 2003.

LIST OF PARTICIPANTS

ARGENTINA

Dr María Paula Etala de Aso
Servicio Meteorológico de la Armada
Av. Comodoro Py 2055, piso 15
1104 Ciudad Autónoma de
BUENOS AIRES
Argentina
Telephone: +54-11 4317 2000 ext. 3152
Telefax: +54-11 4316 2309
E-mail: etala@ara.mil.ar

AUSTRALIA

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

CANADA

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

FRANCE

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

INDIA

Professor Shishir K. Dube
Director
Indian Institute of Technology
KHARAGPUR 721 302
India
Telephone: +91-3222 282002
Telefax: +91-3222 282000
E-mail: skdube@iitkgp.ernet.in

RUSSIAN FEDERATION

Prof. Igor V. Lavrenov
Arctic and Antarctic Research Institute (AARI)
State Scientific Centre of Russia
38, Bering Str.
St Petersburg 199397
Russian Federation
Telephone: +7-812 352 36 04
Telefax: +7-812 352 26 88
E-mail: lavren@aari.nw.ru

UNITED KINGDOM

Dr Martin Holt
Met Office
London Road
BRACKNELL, Berkshire RG12 2SZ
United Kingdom
Telephone: +44-1344 856241
Telefax: +44-1344 854499
E-mail: martin.holt@metoffice.com

USA

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

SECRETARIAT

Ms Teruko Manabe
Ocean Affairs Division
World Weather Watch-Applications
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 80 21
E-mail: manabe_t@gateway.wmo.ch

Ms Boram Lee
UNESCO/Intergovernmental Oceanographic
Commission
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

Mr Yves Tréglos
GOOS Project Office
UNESCO/Intergovernmental Oceanographic
Commission
1, rue Miollis
75732 PARIS Cédex 15
France
Telephone: +33-1 45 68 39 76
Telefax: +33-1 45 68 58 12/3
E-mail: y.treglos@unesco.org

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 chairman of the Team
 - 2.2 Report of the Secretariat
- 3 Activities of Members/Member States
 - 3.1 Catalogue of operational wind waves and storm surge models and products
 - 3.2 Verification activities
 - 3.3 Climatologies
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
 - 4.2 Technical Reports
5. Observations
6. Seminars, training courses and workshops
 - 6.1 Technology transfer
 - 6.1.1 JCOMM Training workshop
 - 6.1.2 Consulting services
 - 6.2 Other workshops and conferences
7. Cooperation with other bodies
 - 7.1 WMO Tropical Cyclone Programme (TCP)
 - 7.2 Max wave Project
 - 7.3 GOOS
 - 7.4 User community
8. Review of JCOMM Wind Wave and Storm Surge Programme
9. Review of ETWS-I session report and action items
10. Closure of the session

**JCOMM ETWS INTERSESSIONAL WORK PLAN 2001-05:
SUMMARY OF PROPOSED ACTIONS**

N°	Action Title	Expected result	Members Participating
1.	Revise and update Guide to Wave Analysis and Forecasting	a. Place Guide on WMO web site by end 2003† (4.1.1)	Secretariat
		b. Develop plan for dynamic part of Guide by June 2003; initial content online by end 2003 (4.1.1)	Val Swail* and all ETWS members
2.	Develop plan for Guide to Storm Surge Forecasting	a. Develop a proposed Table of Contents by June 2003 (4.1.2)	Shishir Dube*
		b. Develop draft content for peer review by end 2004 (4.1.2)	Shishir Dube* , Graham Warren
3.	Develop technical advice and provide support to Members on wave and storm surge modelling, forecasting and service provision	a. Technical report on review of boundary layer wind fields by end 2004; questionnaire developed for Members by fall 2003, responses by March 2004 (4.2)	Val Swail*
		b. Technical report on techniques and benefits of satellite data in wind and wave models and assimilation of observations in wave forecasting by end 2004; questionnaire developed for Members by late 2003, responses by March 2004 (4.2)	Jean-Michel Lefèvre*, Martin Holt, Graham Warren, Hendrik Tolman, Igor Lavrenov
		c. Review report on variations of long return period caused by long-term climate trends by end 2004 (4.2)	Val Swail*
		d. Organize training courses and technical workshops to include wind wave and storm surge analysis and forecasting, specifically WWSS_CAR June 2003 (6.1.1) and 8th Waves Workshop Fall 2004 (6.2)	Val Swail*, Hendrik Tolman, and all ETWS members as opportunities arise to organize, and to participate when possible
		e. Prepare two-yearly updates of catalogue of operational wind wave and storm surge models and products, initially by end 2004; questionnaires developed by fall 2003, responses by March 2004 (3.1)	Val Swail*, Paula Etala*, Martin Holt, Cem Dalgun, Igor Lavrenov, Shishir Dube
		f. Update inventory of hindcast wind wave climatologies, and measured wind wave and storm surge data bases, initially by end 2004, two-yearly thereafter; questionnaires developed by fall 2003, responses by March 2004 (3.3)	Val Swail*, Paula Etala*

N°	Action Title	Expected result	Members Participating
		g. Consultation service to WMO Members developing their wave and storm surge forecasting services – continuous (6.1.2)	All ETWS members
4.	Monitor projects for verifying operational wind wave model output and develop procedures to distribute information on the wave forecast verification scheme	Continue exchange of wave verification data and analysis between operational centres, and encourage other centres to participate; publish a JCOMM Technical Report by end 2004 (3.2)	Martin Holt*, Igor Lavrenov, Jean-Michel Lefèvre, Graham Warren, Hendrik Tolman
5.	Cooperate with the WMO Tropical Cyclone Programme and provide expert assistance as required	Provide expert assistance to the IOC/IHO/WMO Project on storm surge disaster reduction in the northern Indian Ocean area on request (7.1)	All ETWS members on request <i>(stalled at present)</i>
6.	Report to JCOMM Services Coordination Group – two-yearly and JCOMM Management Committee - yearly	Text of the report detailing ETWS Workplan and progress (2.1, 2.2)	Chairman* in consultation with WMO Secretariat and ETWS members

Agenda item number in parentheses

* activity leader

† Concept initially rejected by Publications Section WMO, but will be requested again

DRAFT TABLE OF CONTENTS
GUIDE TO STORM SURGE FORECASTING

- 1. Introduction and General Considerations**
 - 1.1 Oceanographical Aspects of Storm Surges
 - 1.2 Meteorological Aspects of Storm Surges
 - 1.3 Factors contributing to disastrous surges

- 2. Methods of Storm Surge Prediction**
 - 2.1 Empirical Methods
 - 2.2 Numerical Methods

- 3. Data Input required for surge forecasting**
 - 3.1 Meteorological Input
 - 3.1.1 *Accuracy of meteorological input required*
 - 3.1.2 *Strength and weakness of existing wind models*
 - 3.2 Oceanographic Inputs
 - 3.3 Location specific inputs
 - 3.4 Hydrological Input

- 4. The Basic Storm Surge Equations and Methods of Solutions**
 - 4.1 Formulation of the Storm Surge Equations
 - 4.2 Computational Stability
 - 4.3 Staggered and Nonstaggered Grid Schemes
 - 4.4 Finite Differencing of Time Derivative
 - 4.5 Treatment of Open Boundaries
 - 4.6 Treatment of complex coastal boundaries
 - 4.7 Treatment of the Nonlinear Advective Terms
 - 4.8 Moving Boundary Models and Inclusion of Tidal Flats
 - 4.9 Tide-Surge Interaction
 - 4.10 Surge-River Interaction
 - 4.11 Surge-Wind Wave Interaction
 - 4.12 Coastal inundation

- 5. Finite Element Models**
 - 5.1 Introduction
 - 5.2 Finite-Element Models for Tides and Storm Surges
 - 5.3 Development in the late 1970s and early 1980s
 - 5.4 The Corps of Engineers Models
 - 5.5 Other f-e Models

- 6. Operational Storm Surge Prediction Models**
 - 6.1 Evaluation of Models
 - 6.2 Merits and Limitations

- 7. Guidelines for real-time forecasting in an operational office**
 - 7.1 Multiple Forecast Scenario
 - 7.2 Ensemble Forecast

- 8. Surge Disaster Preparedness**

OUTLINE OF A JCOMM TECHNICAL REPORT ON THE USE OF SATELLITE DATA IN WAVE MODELS

Background

During the last decade, the number of reliable wave observations has improved drastically with the advent of earth-observing satellites. Most important for the meteorological and oceanographic community have been the European Remote Sensing satellites ERS-1 and ERS-2, Launched by the European Space Agency (ESA). Since 1991, these satellites have provided global wave observations on a near-real time basis. Recently, JASON and ENVISAT successors of TOPEX and ERS-2 respectively will provide wind/wave data in quasi-real time with a higher accuracy.

1. Overview

How the satellite data influence what NMSs are using for forecasts.

2. List of Satellites and Instruments, their status

The name of the missions, dates of launches, expected duration, type of data, data availability, contact for ERS-1, ERS-2, TOPEX/Poseidon, ENVISAT, GFO, etc. (A questionnaire survey should be conducted)

3. Description of the data

The main limitations and advantages of each type of data will be described in comparison with conventional in situ data.

4. Distribution of the data

Some data are archived in some centres, or/and are distributed on the Global Transmission System (GTS). It would be useful to indicate the main satellite archive centres from where data can be asked.

5. Satellite data requirements

In order to prepare and define future satellite missions, it is relevant and important to provide information to Space agencies such as: type of data, spatial coverage, spatial resolution, temporal resolution. In addition to this, suggestions about the type of studies to be carried out in order to estimate the possible impact of some data for wave forecasting, with a description of the methodology, would be very useful.

6. Short review of the existing wave data assimilation methods

Though the experience with data assimilation has much longer history in meteorology than it has in wave modeling, a number of studies has been carried out during the last 10 years in the field of wave data assimilation. Methods have been developed in order to assimilate wave data in operational wave models.

7. List of MET Centres that assimilate satellite wave data

An increasing number of meteorological centres such as ECMWF, The Met Office, Météo-France, NCEP, KNMI, etc. assimilate wave satellite data in their operational wave models. (A questionnaire survey should be conducted)

8. Future opportunity

MAXWAVE PROJECT

Martin Holt (United Kingdom) and Jean-Michel Lefèvre (France)

1. Introduction

Following meetings and discussion between the International Maritime Organisation, naval architects, and wave modelling scientists during 1998-99, the requirement for a project such as MAXWAVE was identified. The project aims to better understand the likelihood of occurrence of extreme damaging waves, and to better understand the effect of such a wave on a ship, deriving new design criteria. The opportunity was taken during year 2000 to submit a project proposal for European Commission funding under Framework Programme 5.

2. MAXWAVE Project description and organization

The particular objectives of the MAXWAVE project are:

1. To confirm the existence of rogue waves and their risk of encounter. Existing measurements and hindcast modeling will be used to better understand the shape and impacts of extreme waves in relation with ship/offshore accidents. Modern measurement techniques will be exploited towards the recognition of extreme individual waves and their regional probability of occurrence;
2. To implement the improved knowledge of freak waves to modern ship design, by having involved the two marine communities;
3. To develop forecast criteria for rogue waves with the aid of physical, mathematical statistical and deterministic wave model tests and by that to improve security for human life;
4. To disseminate and exploit the project results by the project members, covering the marine design/operation side, the wave science community, system providers and certifying institutions.

The partners in the MAXWAVE project are: GKSS-Forschungszentrum Geesthacht GmbH, Det Norske Meteorologiske Institut, Deutsches Zentrum für Luft und Raumfahrt e.V., Met Office (UK), Instituto Superior Tecnico, Unit of Marine Technol. & Engin., Météo-France, Ocean SensWare, Katholieke Universiteit Leuven, Technische Universität Berlin, Det Norske Veritas, and the Polish Institute of Hydro-engineering PAS Gdansk joined the project during 2002.

The project is coordinated by Wolfgang Rosenthal of GKSS, and runs for 36 months, starting from December 2000. The work of the project is arranged into ten work packages: WP1 Investigation on extreme single waves; WP2 Extreme wave statistics from buoy records; WP3 Extreme wave statistics from radar data sets; WP4 Analysis ship accidents – data bases and hindcast; WP5 Regional distribution of extreme waves; WP6 Wave conditions for design; WP7 Wave criteria for offshore structures; WP8 Definition of 'warning criteria'; WP9 Dissemination & Exploitation and WP10 Socio-economic assessment of the end product.

The work plan of the project contains three blocks. The first and second block treat oceanographic issues and marine design problems respectively, whereas the third block is devoted to forecasting of extreme events and cross disciplinary work.

The first block aims to improve the knowledge about abnormal waves with respect to identifying suitable forecasting parameters. Statistics of abnormal waves are documented by in situ measurements with conventional wave sensors and with new remote sensing techniques. New algorithms for the estimation of single wave events will be developed for ship based radar. Space born synthetic aperture radar with new analysis techniques for global ocean investigations will be exploited with respect to the recognition of extreme wave event development.

The second block of the project addresses issues of ship design and offshore design. Constructions have become larger and more complicated in recent years and experience has grown with conventional design prescriptions. The input parameters still come from the state-of-the-art description of ocean sea state in terms of significant wave height, peak period and mean direction. Impact of additional sea state parameters and impact on more recent design strategy on possible future design regulations will be considered.

In the third block a number of weather events with observations of unusual sea state, mostly connected with accidents, will be reconstructed to reconsider sea state and its impact to structures. This cross-disciplinary block deals both with the economic and socio-economic issues related to the increase of safety for offshore activities.

The name "rogue wave" is given to individual waves of exceptional wave height or of abnormal shape. Such waves deviate strongly in shape or in height from the average sea state, described by the usual integral parameters of significant wave height and peak period, and are transient phenomena on the ocean surface. Neither the occurrence of these waves nor their physical structure is well understood by conventional wave science. Primary generation mechanisms for these waves can include; wave-current interaction, refraction around shoals, diffraction around islands and nonlinear superposition and phasing of many wave component frequencies.

The next generation of ocean-going vessels will be designed to withstand events which, in a general sense, are known to occur as atmospheric and sea state conditions, including extreme storm conditions. One significant and crucial gap remains: the occurrence of unexpectedly steep and violent waves in certain sea areas, without forewarning, at times with only a moderate sea state. This phenomenon has caused accidents not only for smaller and medium size ships, but also, to an astonishing degree, for modern, larger bulk carriers and crude oil tankers. Due to its nature, the exact conditions surrounding the incident are often inadequately recorded. The prevailing conditions may be interpreted from weather maps and can be analyzed in hindcast studies. However there is not a unique relationship between the hindcast average sea state and the momentary, individual cause of an accident. This follows from the fact, that the output from a numerical wave prediction model is usually presented as the significant wave height, a parameter that describes the average sea state, whereas the assumed direct cause of a ship accident, the occurrence of an individual extreme wave, can not at present be predicted from the wave energy spectrum. The accidents described above seem to be concentrated in certain areas of the world ocean, and there exists a comprehensive documentation on accidents that have been investigated around the world.

For the present, when harbours have to become more secure and when ships are getting larger and demand to be more operationally efficient, we propose to develop an information product for the benefit of improved safety on the ocean. This serves marine designers and operators and other marine applications, and will be a contribution to the UN programme Global Maritime Distress Safety System. This product will describe the geographical occurrence, the statistical nature and the predictability of large or steep waves, and if possible provide a warning service.

3. Some results from WP4 hindcasts and WP8 definition of warning criteria

One aim of WP4 is to investigate the possibility of deriving diagnostics from the wave energy spectrum and local wind conditions that might indicate increased likelihood of occurrence of an extreme wave. If successful, such diagnostics could be produced routinely and form part of an enhanced warning service contribution to GMDSS.

Where possible the wave model hindcast has been run for an event for which instrumented wave crest records were available. A particular example of this was the "Stenfjell" storm in the North Sea, where radar sea surface elevation 2Hz time series at the Ekofisk platform are available through met.no. Several possible criteria are under consideration, including calculation of the JONSWAP parameter gamma from the wave spectrum. An example of this is shown in Figure 1, with overlaid contours of windsea height, taken from the Met Office global wave model. Here this diagnostic identifies in the storm west of Spain an area of high waves that are still actively growing. Other parts of this storm also have high waves, but values of gamma closer to 1. Work to relate this parameter to likelihood of occurrence of an extreme wave is ongoing. Another spectral diagnostic, proportional to wave power ($H_s^2 * T_z$ for windsea) also serves to identify areas of extreme sea state. Figure 2 shows an example from a case study in the North Sea in which the ship Stjenfjell was damaged by an extreme wave.

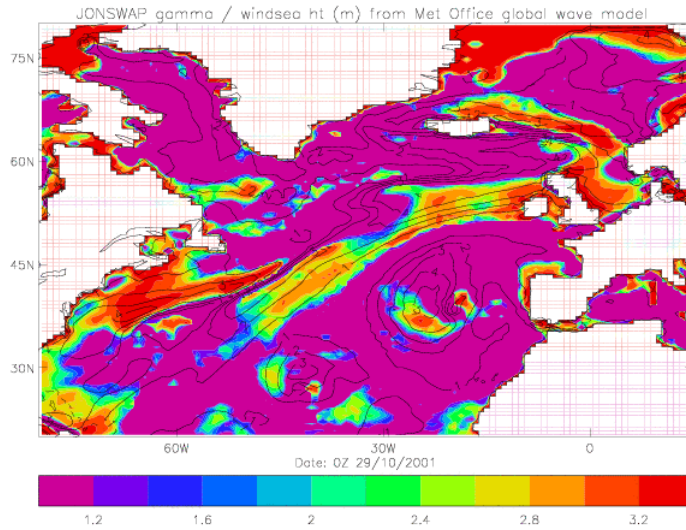


Figure 1 JONSWAP spectral parameter gamma (colour) and contours of “windsea” wave height, from Met Office global wave model

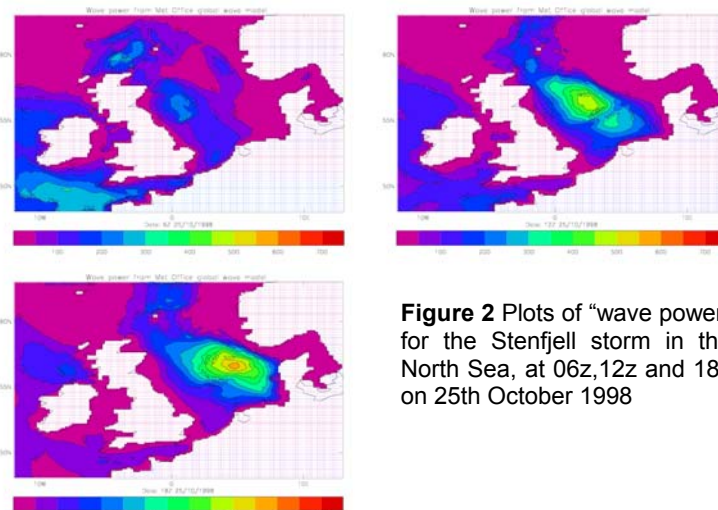


Figure 2 Plots of “wave power” for the Stenfjell storm in the North Sea, at 06z, 12z and 18z on 25th October 1998

**JCOMM WIND WAVE AND STORM SURGE PROGRAMME
ELEMENTS AND ACTIVITIES FOR 2001-2005**

A. OBSERVATIONS AND DATA

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

Further development of observations of wind waves, variations of sea level associated with storm surges, and of near-surface wind over the ocean is needed for better initialization of predictive models, for hindcast and forecast verification and other uses. There is certain potential for improving meteorological objective analysis quality on account of marine variables in a multi-variate analysis scheme. Assimilation of satellite data on significant wave height and directional spectrum is an important factor of gaining additional skill of numerical wave forecasts, particularly for areas with open boundaries. At the same time financial resources available for 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;

This is an area where the ETWS has an active involvement at the present time. During the intersessional period a report will be produced detailing the impacts of assimilating various types of wave data (as well as wind data, e.g. from scatterometers), particularly from satellites, but also in situ measurements.

- (b) Maintain constant liaison of 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;

The ETWS had a significant involvement in the OceanObs99 meeting in St. Raphael in 1999, developing a theme paper on the requirements for wind wave observations in GOOS. The ETWS is committed to a continuation of this type of activity during the intersessional period, on an opportunistic, or as requested (e.g. by OOPC), basis.

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

The ETWS will continue to promote increased capability for more directional spectrum data from satellite, in situ and other data, as important input to data assimilation schemes and verification in operational numerical wave prediction efforts.

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

The ETWS is not at present actively involved in the use of coastal radar observations of waves. However, this group encourages the OCG to pursue the continued development of this method

of wave observation, for the provision of real-time wave information, the ETWS will work towards the facilitation of the use of these data as the technology becomes routinely available in support of 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 efficient and effective means of communicating and storing this 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;

The OCG should ensure that when observation systems are put in place, that the communications capability is in place so that all types of wind wave and storm surge data are transmitted via the GTS and/or internet. ETWS noted that submission of data on a monthly basis was also useful for verification studies.

- (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;

The development of new observational requirements for waves and surges resides with the ETWS. The responsibility for developing special codes or code amendments to address these new requirements rests with the OCG.

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

This activity is the joint responsibility of the SCG, OCG and DMCG.

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. 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 but this possibility should not be abandoned.

Recommended actions/activities

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

This should be the primary responsibility of the OCG. ETWS will provide technical advice as requested and appropriate.

- (b) Extend the Help component of the Turbowin software by putting there 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);

This should be the primary responsibility of the OCG. ETWS will provide technical advice as requested.

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

Improved wave measurements from VOS would be of great benefit in wave analysis and forecasting, for assimilation into models, and verification of forecast output. The ETWS requests that the OCG document existing automated wave measurements from ships, and consider the implementation of appropriate systems in the VOSClm programme. The ETWS will participate in the evaluation of present and future automated wave measurement systems.

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 not always is the data storage 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 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, JCOMM should assist 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 ones existing on the Internet (both real-time and historic);
- (b) Facilitate production of metadata along 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 IOC;
- (d) Ensure that Members receive summaries of catalogued data as a stimulus for their participation;
- (e) Ensure that the practice of open access to all data stored at RNODC-Waves for all data contributors is *strictly followed and known by potential data contributors*.

The ETWS will continue with the above activities, in cooperation with the Data Management Coordination Group (DMCG). No direct involvement of the OCG is expected, since this task

deals with rescue of historical data sets, rather than the generation of new data. Item (e) is seen to be primarily a DMCG activity.

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. Because in general 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 of availability of wind wave forecast services, and to the extent 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.

Support for GMDSS is the primary responsibility of the ETMSS. ETWS will keep communication with and provide support for the ETMSS as requested. (Action 3.e)

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 part 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;

ETWS will prepare a catalogue on this issue (Action 3.e)

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

The areas will be identified based on the questionnaires planned to be prepared.

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

Access to appropriate surface wind and atmospheric pressure fields still 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

ETWS will publish a Technical Report on this issue (Action 3.a)

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 be reviewed. Of particular importance at present is the progress in assimilation of remotely-sensed wave and marine surface wind data.

Recommended actions/activities

Prepare a review on techniques and benefits of 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.

ETWS will publish a Technical Report on this issue (Action 3.b)

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. In its turn it slowed down considerably the development of wave modelling and forecasting. Recognizing this fact a group of wave modellers 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 for the project. At present the estimation of wave nowcast/forecast is well established between five participating centres. If extended, this activity can be very instrumental in 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 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 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 get better geographical coverage and representative statistics,

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

ETWS discussed the verification activities (see agenda item 3.2) in details. ETWS will publish a Technical Report on this issue (Action 4). It should be stressed that the intention of the verification activities is to develop operational wind wave forecasting systems, and that it is not to serve as a certification of such systems.

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 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 special services (ship routing, fisheries, aquaculture, etc.) are understood and facilitated. In particular, the requirements of various modules of 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 GOOS, especially COOP;
- (b) Continue support for development of specialized marine meteorological services related to storm surge and wind wave data including ship routing and support of marine weather sensitive operations.

ETWS will maintain dialogues with relevant groups.

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 is given 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 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 update the inventory of hindcast climatologies.

ETWS will prepare a catalogue on this issue (Action 3.f)

12. Prediction of the individual highest or rogue wind wave

Wind wave nowcasting and forecasting concentrate on 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. Some efforts have been allocated to develop new 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 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 prediction of expected range of wave heights during a storm;

It should be noted that a Technical Report related to this issue was published in the last intersessional period. ETWS noted the necessity of the education of users on the interpretation of the forecasts and the importance of clarification of forecast. ETWS will also investigate alternative forecast measures.

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

ETWS will continue to liaise with and support relevant projects such as the MAXWAVE project.

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

Continuing 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 are the events that 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. Also 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;

ETWS will publish a Technical Report on this issue (Action 3.c)

- (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, wave) prediction services;

Additional research on ensemble forecasts will be promoted.

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 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 web-site.

Recommended actions/activities

- (a) Place the Guide to Wave Analysis and Forecasting on the WMO web-site under the JCOMM home page;

English version will shortly be made available (Action 1.a) on the JCOMM web site. ETWS will develop a dynamic part of this Guide (Action 1.b)

- (b) Develop a plan and implementation plan for the preparation of a Guide to Storm Surge Forecasting.

ETWS will develop this Guide. (Action 2)

15. Training and other types of assistance

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 States, 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 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 countries (June 2003) and promote the inclusion of such material in an advanced physical oceanography and marine meteorology courses.

ETWS contributed to the workshop for the Caribbean countries and will continue to support such events (Action 3.d).

16. Regional projects/campaigns

Development of wind wave and storm surge forecasting services is efficient on a regional basis. Common geographic conditions, joint interests, concerns, and similar experiences create a good foundation for mutual assistance and support. Very frequently, neighbouring countries are affected by the same weather systems, and therefore their cooperation in marine forecasting is very fruitful. This is particularly true for prediction of storm surges and wind waves associated with tropical cyclones. JCOMM Wind Wave and Storm Surge Programme should encourage 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. 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. Cooperation of JCOMM with GOOS and the WMO Tropical Cyclone Programme in these matters must be strengthened. Other examples where regional projects would be beneficial include joint wind wave and sea ice forecasting.

Recommended actions/activities

- (a) Provide assistance as required to Members/Member States in establishing wind wave and storm surge related services;
- (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 Members. Much of the effort is now focusing on specialized and local applications. There are a number of factors needing more 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;

ETWS will prepare a catalogue (Action 3.e)

- (b) Encourage preparing 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 conference;

JCOMM would be a co-sponsor of the 8th International Wave Workshop where such information would be presented and published in the proceedings.

- (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; (see para 3.1.3, 6.1.2.4)
- (e) Encourage 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 adequate representation of 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 not only on the pure drift of seawater but on the river transport, current and previously accumulated precipitation, and 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 still 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;

ETWS will prepare a catalogue on this issue (Action 3.e)

- (b) Encourage the development associated activities in hydrological sciences;
- (c) Establish and maintain contacts with other research communities involved in prediction of coastal flooding;
- (d) Encourage that codes of models suitable for storm surge prediction are made available including on the Internet.

It should be noted that storm surge models have more regional aspects than wave models and cannot be as easily adopted to specific locations.

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

Recently several aspects of coupled modelling have found their way into operational forecasting. Notable examples are including 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 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 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 better positioned to take opportunities for exploiting new technology and participating in national and international initiatives. National reports of known work are elicited through the national focal points in conjunction with the survey of wave models. These keep Members/Member States informed on progress in developing techniques. Cooperation with international and national research projects depends on local involvement of personnel who are associated with National Meteorological Services. 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 a potential interest. 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;

ETWS will publish a technical report on satellite data assimilation (Action 3.b)

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

This activity is a shared responsibility with OCG. ETWS will provide such information through workshops and conferences (Action 3.d).

- (c) Provide members information on major wave/marine wind experimental campaigns. *(Action 3.d)*

21. Cataloguing of programme related activities

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

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.

ETWS will prepare catalogues (Action 3.e)

**PROPOSED REVISION OF TERMS OF REFERENCE
OF THE EXPERT TEAM ON WIND WAVES AND STORM SURGES**

Terms of Reference

The Expert Team on Wind Waves and Storm Surges shall:

- (a) Review and advise on the implementation of wind wave and storm surge activities within JCOMM, and as required propose amendments, ~~as required~~;
- (b) Develop technical advice on wave and storm surge modelling, forecasting and service provision, and as required provide assistance and support to Member States ~~as required~~;
- (c) Monitor projects for verification of operational wind wave and storm surge model outputs, and as required assist in their implementation ~~as required~~;
- (d) Ensure effective coordination and cooperation with appropriate GOOS bodies on requirements for, and implementation of, wind wave and storm surge products and services;
- (e) Provide advice to the Services Coordination Group and other JCOMM groups, as required, on issues related to wind waves and storm surges.

LIST OF ACTION ITEMS

para	action	By whom	when
3.1.4	Distribute questionnaires Members to collect information on operational/pre-operational wind wave models and their products to PRs (copy to IOC action addressees and JCOMM focal points)	Secretariat	Late 2003
3.1.4	Develop a questionnaire, and collect and assemble information provided by Members/Member States regarding wave models	Val Swail	Late 2003 March 2004
3.1.4	Develop a questionnaire, and collect and assemble information provided by Members/Member States regarding storm surge models	Paula Etala	Late 2003 March 2004
3.1.4	Assemble the updated information provided to produce the final version of the tables and send them to the Secretariat	ETWS members	
3.1.5	Post the tables sent by Val Swail and Paula Etala on the JCOMM web site	Val Swail Paula Etala Secretariat	When the tables are received
3.2.3	Prepare a JCOMM Technical report on verification activities	Martin Holt	By end 2004
3.3.3	Distribute questionnaires to PRs to collect information on hindcast wind wave climatologies and measured wind wave data (copy to IOC action addressees and JCOMM focal points)	Secretariat	Late 2003
3.3.3	Develop a questionnaire, and collect and assemble information provided by Members/Member States regarding hindcast wind wave climatologies and measured wind wave data base	Val Swail	Late 2003 March 2004
3.3.3	Develop a questionnaire, and collect and assemble information provided by Members/Member States regarding measured storm surge data base	Paula Etala	Late 2003 March 2004
3.3.4	Post the tables sent by Val Swail and Paula Etala on the JCOMM web site	Val Swail Paula Etala Secretariat	When the tables are received
4.1.2.2	Take leading roles to develop draft content of the Guide to Storm Surge Forecasting for peer review	Shisir Dube Graham Warren	By end 2004
4.2.2	Prepare a questionnaire to collect information on satellite use to be included in the Technical Report.	Jean-Michel Lefèvre	September 2003
4.2.2	Take a leading role to prepare a JCOMM Technical Report on the use of satellite data in wave models	Jean-Michel Lefèvre	By end 2004
4.2.4	Develop a draft questionnaire to collect appropriate information and a draft outline of a JCOMM Technical Report on wind filed for circulation among the members of the Team	Val Swail	September 2003
4.2.6	Take a leading role to prepare a JCOMM	Val Swail	By end 2004

	Technical Report on variations of long return period		
4.2.8	Prepare a short summary on “Global Wave Climatology Atlas” based on the results of the ERA-40 reanalysis project to be posted on the JCOMM web site.	Val Swail and ETWS	
5.3	Provide technical advice as requested, in terms of enhancement of the shipboard report compilation and transmission software regarding wave observation practices, and calibration regarding automated wave observations from ships	ETWS members	Continuous
6.1.1.4	Send comments on the questionnaires to be used at training workshops to the Secretariat.	lecturers at the Caribbean workshop	After the Caribbean workshop
6.1.1.4	Send the results of the questionnaire survey should be returned to the Capacity Building Coordination Group (CBCG) for their consideration to improve future JCOMM activities under the Capacity Building Programme Area	Secretariat	After the Caribbean workshop
6.1.2.5	Continue the role of consulting services as requested and appropriate.	ETWS members	Continuous
6.2.3	Participate in other upcoming conference and workshops in either a scientific, organizational or coordination role	ETWS members	As specified
6.2.4	Lead the organization of the 8 th International Workshop on Wave Hindcasting and Forecasting, tentatively scheduled for late 2004, and subsequent editions of this two-yearly meeting	ETWS members	
6.1.1.4	Take necessary actions so that JCOMM should be a co-sponsor of the wind workshop	Secretariat	At MAN-III
7.1.1	Continue to contribute support TCP events as appropriate	ETWS members	Continuous
7.2.4	Once proposals (both for forecasting methods and vocabulary) regarding a revision of the Manual on Marine Meteorological Services (WMO-No.558) were drafted, circulate the draft to the ETWS members to seek their comments	Météo-France Secretariat	
7.3.4	Make a contribution to the follow-on to OceanObs99, whenever this might occur	ETWS members	
7.4.3	Prepare an information document on ISO requirements for wind and wave parameters and formats for the consideration of the ETWS.	Igor Lavrenov	

LIST OF ACRONYMS AND OTHER ABBREVIATIONS

ASAR	Advanced Synthetic Aperture Radar
CBCG	Capacity Building Coordination Group (JCOMM)
CBS	Commission for Basic Systems (WMO)
CMC	Canadian Meteorological Centre (Meteorological Service of Canada)
COMET	Cooperative Programme for Operational Meteorology Education and Training (UCAR/USA)
CMM	Commission for Marine Meteorology (WMO)
COOP	Coastal Ocean Observing Panel (GOOS)
DBCP	Data Buoy Cooperation Panel (WMO-IOC)
DMCG	Data Management Coordination Group (JCOMM)
ECMWF	European Centre for Medium-range Weather Forecasts
ERA	ECMWF Re-Analysis
ETMSS	Expert Team on Maritime Safety Services (JCOMM)
ETWS	Expert Team on Wind Waves and Storm Surges (JCOMM)
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
FNMOCC	Fleet Numerical Meteorology and Oceanography Center (US Navy)
GCOS	Global Climate Observing System
GMDSS	Global Maritime Distress and Safety System
GODAE	Global Ocean Data Assimilation Experiment
GOOS	Global Ocean Observing System
GSN	GCOS Surface Network
GTS	Global Telecommunication System (WWW)
GUAN	GCOS Upper Air Network
IGOS	Integrated Global Observing Strategy
IGOSS	Integrated Global Ocean Services System
IHO	International Hydrographic Organization
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
ISO	International Standards Organization
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
JCOMMOPS	JCOMM in situ Observing Platform Support Centre
KNMI	Royal Meteorological Institute of Netherlands
MAN	Management Committee (JCOMM)
MPERSS	Marine Pollution Emergency Response Support System
MSC	Meteorological Service of Canada
NASA	National Aeronautics and Space Administration (USA)
NCAR	National Center for Atmospheric Research (USA)
NCEP	National Centers for Environmental Prediction (USA, NOAA)
NMS	National Meteorological Service
NOAA	National Oceanic and Atmospheric Administration (USA)
NWP	Numerical Weather Prediction
NWS	National Weather Service (USA, NOAA)
OceanObs99	The first International Conference for the Ocean Observing System for Climate
OCG	Observations Coordination Group (JCOMM)
OGP	Office of Global Programmes (NOAA)
ONR	Office of Naval Research (US Navy)
OOPC	Ocean Observations Panel for Climate (of GOOS, GCOS, WCRP)
RNODC-Waves	Responsible National Oceanographic Data Centre for Waves (IOC)
SAR	Synthetic Aperture Radar
SCG	Services Coordination Group (JCOMM)
SOT	Ship Observations Team (JCOMM)
TCP	Tropical Cyclone Programme (WMO)

WCRP	World Climate Research Programme
WISE	Waves in Shallow Water Environment
WWW	World Weather Watch (WMO)