WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (OF UNESCO)

JOINT WMO/IOC TECHNICAL COMMISSION FOR OCEANOGRAPHY AND MARINE METEOROLOGY (JCOMM)
EXPERT TEAM ON MARINE CLIMATOLOGY

ETMC-II/Doc. 4.3
(15.II.2007)

SECOND SESSION

ITEM 4.3

GENEVA, SWITZERLAND, 26 TO 27 MARCH 2007

Original: ENGLISH

DATA ARCHIVAL

Archival of wave and storm surge data, extreme wave archive

(Submitted by Mr Val Swail, Chairperson of the Expert Team on Wind Waves and Storm Surges (ETWS), Mr Scott Woodruff, Chairperson of the Expert Team on Marine Climatology (ETMC), and Mr Robert Keeley, Chairperson of the Data Management Programme Area (DMPA))

Summary and purpose of document

This document contains a description for a proposal to establish a relatively small and manageable data base of extreme storm sea states for comparison with wave forecast and hindcast products, model development and evaluation and satellite sensor calibration and validation.

(Note: This document being submitted in parallel as ETWS-II/Doc. 3.2)

ACTION PROPOSED

The Expert Team on Marine Climatology is invited to:

(a) Note and comment on the report and project proposal, as appropriate;

(b) Contribute, and/or solicit contributions to the Extreme Wave Data Base;

(c) Consider whether a similar extreme database is feasible for storm surges.

Appendices: A. Proposal for a JCOMM Extreme Waves Data Base
B. Extreme (≥14m) Wave Height Reports in the NDBC Archive (S. Woodruff, 31 January 2007)

DISCUSSION

1. Introduction

A recent paper by Holliday, et al. (2006) described a storm in the Rockall Trough west of Scotland, where significant waves of 18.5 m (max 29.1 m) were measured from a British research vessel using a Tucker wave gauge. Comparison with the best available model hindcast data showed a value of 14.0 m, raising again the issue put forth by Cardone, et al. (1996) and Resio, et al. (1999) regarding the ability of present day numerical models to capture so-called "Extreme Storm Seas (ESS)", with SWH above about 12 m. Subsequent to the Holliday event, other large historical storms have been noted, including a 15.7 m storm described by Draper in December 1972, and a February 1962 storm at a nearby Ocean Weather Station of 16.7 m. In the former case, the models performed reasonably well, but not so well in the latter. Why? This leaves some doubt about the true performance of the models. The possible deficiencies in the models, especially at these extreme wave heights, could have a major impact on present wave climatologies (such as the ERA40 and MSC50), and resulting impacts on the computed design criteria for offshore structures.

If the data from these events were assembled together and one added to the mix the recent large hurricane events (Ivan Katrina) in the Gulf of Mexico, the January 2006 storm off Norway, and historical events such as the Draper 1972 storm, one have the beginnings of an invaluable data set of high quality measurements which could be used (together with other environmental observations collected *in situ* in the storm period and area) to validate wind wave models and also satellite altimeter wave estimates which have largely unknown characteristics at these heights.

2. Action Required

A proposal has been developed (see Appendix A) between the Expert Team on Wind Waves and Storm Surges (ETWS) and the Expert Team on Marine Climatology (ETMC) of the JCOMM Data Management Programme Area (DMPA) for the establishment of a JCOMM Extreme Wave Database for use in model validation and validation of remotely sensed waves, where such models and algorithms suffer from lack of sufficient data. This database would be populated with **measured** wave data where the significant wave height exceeds 14 metres, with appropriate accompanying metadata.

Mr Robert Keeley and Mr Scott Woodruff have run initial searches on selected archived wave data bases. For the Canadian archive, Twenty one separate events were identified from 1985 to 2006, all but two occurring in the fall-winter-spring months. Some appeared to persist for number of hours. For the abbreviated NDBC data set (all buoys and C-MAN data for 1970-2005), fifty-four reports were identified that met the first primary qualification. Two of the values look rather extreme, and there are sixteen near-duplicates which seems suspicious. The NDBC scan results are summarized in Appendix B.

The Ninth International Workshop on Wave Hindcasting and Forecasting, Victoria, Canada, 24 to 29 September 2006, expressed a strong interest in expanding the scope of the extreme wave data archive, to include satellite estimates as well as data from wave radars such as the WaMoS or MIROS.

The rationale for the database is to have a relatively small and manageable set of extreme storm sea states for comparison with wave forecast and hindcast products, model development and evaluation and satellite sensor calibration and validation. The database should carry a JCOMM label, and be referenced from various locations in the JCOMM web pages, including the Dynamic Part of the *Guide to Wave Analysis and Forecasting* presently under development. Development of this database should be undertaken jointly by the ETWS, ETMC and others, including possibly the IODE, SOT and DBCP.

It has been further suggested that an archive of storm surge events for similar purposes should also be considered.

3. References:

Holliday, N. P., M. J. Yelland, R. Pascal, V. R. Swail, P. K. Taylor, C. R. Griffiths, and E. Kent (2006), Were extreme waves in the Rockall Trough the largest ever recorded?, *Geophys. Res. Lett.*, *33*, L05613, doi:10.1029/2005GL025238

Resio, Donald T., Swail, V.R., Jensen, R.E., and Cardone, V.J: 1999 “Wind Speed Scaling in Fully Developed Seas,” *Journal of Physical Oceanography*. 29, 1801-1811.

Cardone, V.J., R.E. Jensen, D.T. Resio, V.R. Swail and A.T. Cox, 1996. Evaluation of contemporary ocean wave models in rare extreme events: "Halloween storm” of October, 1991; "storm of the century" of March, 1993. *J. Atmos. and Oceanic Tech*., Vol. 13, No. 1, p. 198-230.

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Appendices: 2

APPENDIX A

PROPOSAL FOR A JCOMM EXTREME WAVES DATA BASE

Purpose:

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

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

Data qualification:

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

Phase 1:

- The data base will hold all instrumented observations that are available from the storm period and area including:
- *In-situ* surface elevation time series;
- *In-situ* wave spectra from surface-following instruments (e.g., wave buoys, Tucker);
- Other environmental observations collected in situ in the storm period and area will also be included.

Phase 2:

- The data base will hold all instrumented observations that are available from the storm period and area including:
- *In-situ* surface elevation time series;
- *In-situ* wave spectra from surface-following instruments (e.g., wave buoys, Tucker);
- *In-situ* wave spectra from surface radars (e.g., MIROS);
- Satellite derived wind fields;
- Satellite derived wave estimates.

Data Assembly and Delivery Services:

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

The archive centre will provide services that include:

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

- Provide a convenient download service for the database contents.

Yet to clarify:

- Exactly what data and metadata fields to include (Phase 1 then Phase 2);
- Is the definition of a storm and area adequate?
- How we will solicit an archive?
  - NCAR might be interested;
  - Proposal will be presented to IODE.
- Who will run the data base?
- What is the "agreed" QC and delivery formats?
  - We will need to be flexible in accepting different data formats. On output, we could build something in netCDF or use the IMMA format. We probably should consider a few output formats.

Are the services enough?

APPENDIX B

EXTREME (≥14M) WAVE HEIGHT REPORTS IN THE NDBC ARCHIVE
S. WOODRUFF, 31 JANUARY 2007

Following were the draft "data qualification" criteria for the Archive:

(a.) Data will be captured for those storms in which a SWH ≥ 14m;
(b.) Storms will be defined as commencing when the SWH first exceeds 5 m and ending when the SWH first falls below 5m;
(c.) Area of interest will include all wave observations within a 500 km radius of the buoy registering the extreme event.

This preliminary experiment was limited to the first criterion, i.e., all (i.e., 54) reports in this NDBC archive with significant wave height (SWH) ≥ 14m (Table 1). The specific archive used was a TD-1171 format (NCDC, 2003) version obtained from NCDC 6 June 2005 covering 1970-2005. Figure 1 illustrates the location of the 54 reports.

Table 1. Reports in the NDBC 1970-2005 archive with WH ≥ 14m. The selected fields are: year, month, significant wave height (m), latitude, longitude (°E), platform type (PT) and ID (WMO or earlier "EB" buoy number). For EB10, there was a total of 16 hourly near-duplicate reports with identical data values.

YR	*MO*	*SWH*	*LAT*	*LON*	*ID*	*Hourly near dups*
1975	9	19.5	27.5	272	EB10	15
1979	6	37	26	270	42001	
1979	11	15	56	212	46001	
1980	10	39.5	34.9	239.1	46011	
1981	3	19	52	204	46003	
1981	3	19.5	52	204	46003	
1985	9	14.5	32.3	284.7	41002	
1986	11	14	50.9	224.1	46004	
1986	11	14.5	48.3	226.1	46036	
1990	1	15	42.5	229.6	46002	
1991	1	14.5	51.9	204.1	46003	
1991	1	14.5	51.9	204.1	46003	
1991	1	15	51.9	204.1	46003	
1991	1	15.5	51.9	204.1	46003	
1991	1	16	51.9	204.1	46003	
1991	1	17	51.9	204.1	46003	
1993	3	14	32.3	284.8	41002	
1993	3	14.5	32.3	284.8	41002	
1993	3	14.5	32.3	284.8	41002	
1993	3	15.5	32.3	284.8	41002	
1996	11	14.5	56.9	182.2	46035	
1996	11	15.5	56.9	182.2	46035	
1997	11	15.5	56.9	182.2	46035	
1999	3	14	44.6	235.5	46050	
1999	10	14	40.8	222.5	46006	
1999	10	14	40.8	222.5	46006	
1999	10	14.5	40.8	222.5	46006	
1999	10	15.5	40.8	222.5	46006	
1999	10	15.5	40.8	222.5	46006	
1999	10	16.5	40.8	222.5	46006	

2000	12	14.5	40.8	222.5	46006
2001	1	14	38	230	46059
2001	2	15	56.9	182.2	46035
2002	11	14	40.8	222.5	46006
2002	11	14	40.8	222.5	46006
2004	3	14	56.6	223.8	46084
2004	9	16	29.2	271.6	42040
2005	1	15	51.2	179	46071
2005	1	15.5	51.2	179	46071

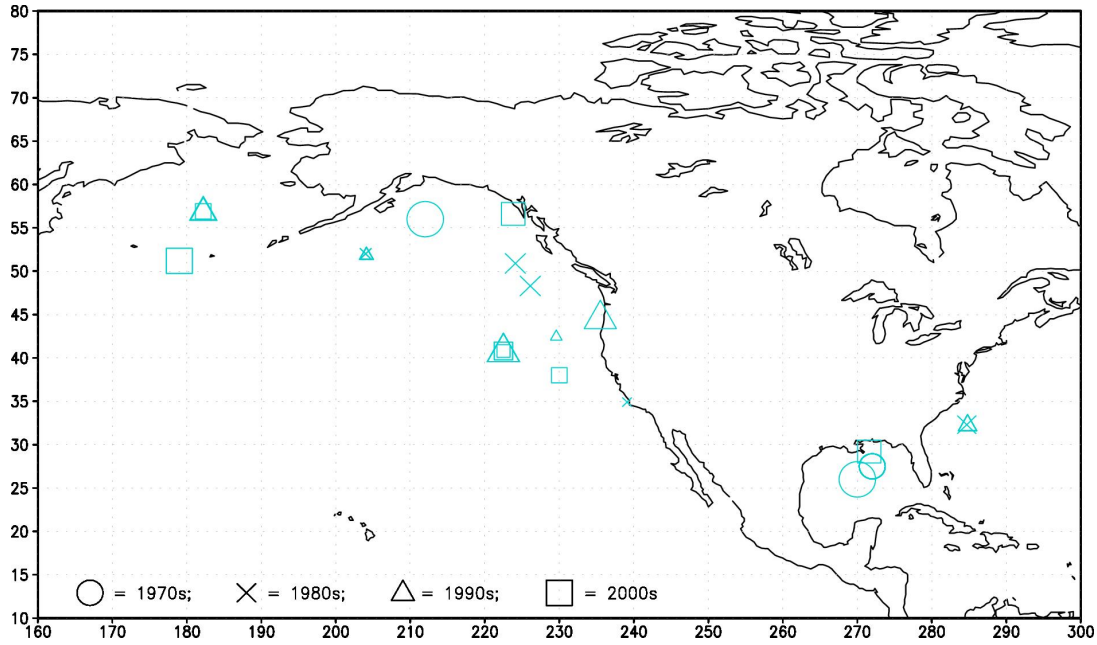

Figure 1. Locations of extreme SWH reports (from Table 1) in the NDBC archive. The indicated symbols are used to differentiate reports from the different decades, and larger symbols indicate reports from later within each decade.

Reference

NCDC, 2003: Data Documentation for Data Set 1171 (DSI-1171) National Data Buoy Center (NDBC) Data Users Reference (20 March 2003) [http://www1.ncdc.noaa.gov/pub/data/documentlibrary/tddoc/td1171.pdf].