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NEW PRODUCT

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This bulletin, prepared by Y. Y. Chao, L. D. Burroughs, and H. L. Tolman of the Marine Modeling and Analysis Branch (MMAB), Environmental Modeling Center (EMC), National Centers for Environmental Prediction (NCEP), describes automated wave guidance for Eastern North Pacific and adjacent waters in alphanumeric, and Gridded Binary (GRIB) formats. This guidance was implemented operationally in May 2002.

The Eastern North Pacific and Adjacent Waters regional wave model (ENP) was developed to provide wind wave forecast guidance for the U.S. West coast and Hawaiian waters. The ENP is based on the NOAA WAVEWATCH-III (NWW3) which is described in detail in Technical Procedures Bulletin (TPB) 494 (Chen, Burroughs, and Tolman 2003) and Tolman (2002). The NWW3 provides the boundary conditions to the ENP. The domain extends from 170.25^{o}W to 76.75^{o}W and from 4.75^{o}N to 62.25^{o}N with a grid resolution of 0.25^{o} by 0.25^{o} in latitudinal and longitudinal directions.

Various graphics and text products for the ENP are available at http://polar.ncep.noaa.gov/waves, and available for anonymous ftp at ftp://polar.ncep.noaa.gov/pub/waves.

The following wind and wave parameters are available in GRIB format at the web site above and will be on AWIPS as GRIB bulletins when AWIPS Build OB2 is distributed to the field: H_s, D_m, T_m, peak wave period and direction, wind sea peak period and direction, wind speed and direction, and u- and v-wind components.

Spectral text bulletins for the ENP are available at the web site above. These files are in ASCII and are available by anonymous ftp from the directory given above. These bulletins became available on the Satellite Broadcast Network (SBN) in May 2003.

The ENP wave guidance is generated four times daily from the 0000, 0600, 1200 and 1800 UTC cycles of the Global Forecast System (GFS).

WAVE FORECASTING FOR THE EASTERN NORTH PACIFIC

and

ADJACENT WATERS

(1)

By

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1. Introduction

In order to predict wave conditions adequately over the continental shelf and near land boundaries, a regional model which has higher resolution in grid space and possibly in spectral components is required. The regional model also must calculate rigorously the effects of submarine bottom conditions and any currents which may exist on wave growth, transformation and dissipation. A global-scale wave model usually is designed only to provide the general wave pattern over the deep ocean. It does not provide information accurate enough to describe small-scale, complex wave patterns near the coastal areas.

The Eastern North Pacific (ENP) regional wave model is designed to fill the needs of the Western and Pacific Regions, Tropical Prediction Center, and the Ocean Prediction Center (OPC). The model structure is essentially the same as the Western North Atlantic (WNA) regional model which is described in detail in Technical Procedures Bulletin (TPB) 495 (Chao, Burroughs and Tolman, 2003). The NWW3 provides the boundary conditions to the ENP. More specifically, the ENP accounts for wave dispersion within discrete spectral bins by adding in diffusion terms to the propagation equation (Booij and Holthuijsen 1987); it uses the Chalikov and Belevich (1993) formulation for wave generation and the Tolman and Chalikov (1996) formulation for wave dissipation; it employs a third order finite differencing method by utilizing a split-mode scheme with a Total Variance Diminishing limiter to solve wave propagation; its computer code has been optimized to fully utilize the MPP structure of the IBM computer; the domain extends from 170.25^{o}W to 76.75^{o}W and from 4.75^{o}N to 62.25^{o}N with a grid resolution of 0.25^{o} by 0.25^{o} in latitudinal and longitudinal directions.

The following wind and wave parameters are available in GRIB format at the web site above and will be on AWIPS as GRIB bulletins, when software build OB2 is distributed to the field: H_s, D_m, T_m, peak wave period and direction, wind sea peak period and direction, wind speed and direction, and u- and v-wind components.

Spectral text bulletins for the ENP are available at the web site above. These files are in ASCII and are available by anonymous ftp from the directory ftp://polar.ncep.noaa.gov/pub/waves. These bulletins will be available on the SBN in May 2003, but with a condensed format necessitated by the capabilities of the communications gateway and display capabilities of AWIPS. See fig. 1 for a sample bulletin and Table 1 for the list of points having spectral wave bulletins, their locations, and their bulletin headers. The ENP wave guidance is generated four times daily out to 168 hours based on the 0000, 0600, 1200 and 1800 UTC cycles of the of the Global Forecast System (GFS).

The ENP model has been run continuously on the IBM computers since September 2001. In the succeeding sections, the established forecasting system along with the model structure will be described, followed by a comparison of predicted results with buoy data and NWW3 model output for identical locations. Finally, the strength of the new model (ENP) and the available products and dissemination is presented.

2. Model Description

Regional wave forecasts for Eastern North Pacific and Hawaiian waters are generated at NCEP by using the ENP model. Fields of directional frequency spectra in 24 directions and 25 frequencies are generated at one hour intervals up to 168 hours. The 24 directions begin at 90 degrees to the east and have a directional resolution of 15 degrees. The 25 frequencies used by the ENP are given by bin in Table 2.

Figure 2 shows the domain of interest and the depth field which is derived from bathymetric data available from the National Geophysical Data Center. Required input wave spectral data for the boundary grid points of the ENP are obtained by linearly interpolating the output of neighboring grids of the NWW3. The wind fields driving the model are obtained from the output of NCEP's operational GFS (Kanamitsu *et al.* 1991 and Caplan *et al.* 1997). The wind fields are constructed directly from spectral coefficients of the lowest sigma level at 0.5^{o} x 0.5^{o} longitude and latitude resolution, and are interpolated to the resolution of the wave model grid. They are converted to 10 m winds by using a logarithmic profile corrected for stability with air-sea temperature differences. Air and sea temperature data are obtained from the lowest sigma level air temperatures of the GFS and from the SST analysis available in the model. Finally, the wave model incorporates a dynamically updated ice coverage field in the region. These data are obtained from NCEP's operational automated passive microwave sea ice concentration analysis (Grumbine 1996; updated daily). Ocean currents are not considered in the model at the present.

The model runs four times daily for the 0000, 0600, 1200 and 1800 UTC cycles. Global Data Assimilation System (GDAS) wind fields from the previous 12 hours at 3-h intervals (analyses and 3-h forecasts) are used for a 12-h wave hindcast. Winds from the AVN at 3-h intervals out to 168 hours are used to produce wave forecasts up to 168 hours at hourly intervals.

3. Performance Evaluation

The ENP has run on the IBM mainframe computer continuously since September 2001. The adequacy of the model has been evaluated by comparing model output of the ENP with observed data at NDBC buoys. Figure 3 shows the locations of buoy measurements used for verifying model output in the vicinity of Hawaiian Islands. The model data at the buoy station are obtained based on interpolating gridded data surrounding the buoy station. Figure 4 shows the scatter plot of the hindcast significant wave height NWW3 and ENP for December 2001 through January 2002 . Also shown are the following statistical indices: the mean bias error (bias), standard deviation(std),root mean square error (rms), scatter index (SI), the slope of best fit line and correlation coefficient (c.c). The total number of data points (4116) used in the analysis combines the results from the measurement of four buoys located in deep water. It can be seen from the figure that the ENP provides comparable or slightly better statistical results than NWW3. An important aspect of the island effect on waves, which can only be detected by using a high grid resolution model, is shown in Fig. 5. In Fig. 5, the wave height time series of measurements (+ marks), NWW3 (red lines) and ENP (green lines) at buoy locations 51001 and 51004 are presented. During this period of time, the dominant wave direction was from north-west to south-east, closely parallel to the alignment of the group of Hawaiian islands . At Buoys 51001, which is located north-westward from the islands, the wave height of NWW3 and ENP are essentially the same. At buoy 51004 which was located south-eastward from the islands, however, over-predictions of the wave height by the NWW3 model are clearly indicated. In contrast, the ENP model predictions are very close to buoy measurements.

Figure 6 shows available buoy measurements off and along the coastal line of West Coast. The NWW3 and ENP model predictions at those deep water buoys are virtually the same. The statistical evaluation of ENP hindcast against the buoy measurements in the shelf is shown in Fig. 7. The performance evaluation of NWW3 model against these shelf buoys cannot be made because of coarse grid mesh so that an adequate interpolation is not possible. The overall performance of the ENP model over the shelf during the five month period (September 2001 through January 2001) is very satisfying.

4. Available Products and Dissemination

The following wind and wave parameters are available in GRIB format at http://polar.ncep.noaa.gov/waves and on AWIPS as GRIB bulletins: H_s, D_m, T_m, peak wave period and direction, wind sea peak period and direction, wind speed and direction, and u- and v-wind components. Spectral text bulletins are also available on the web at the site above and will be on AWIPS as soon AWIPS software build OB2 is distributed to the field.

a. GRIB bulletins

GRIB bulletins will be available for use in AWIPS when software build OB2 is distributed to the field later this year. Table 3 gives the bulletin headers and their meaning. Bulletins are available at 6-h intervals from 00- through 72-h and at 12-h intervals from 72- through 168-h. Available parameters are H_s, D_m, T_m, peak wave period and direction, wind sea peak wave period and direction, and u and v components of the wind velocity. A 0.25 x 0.25 degree lon./lat. grid is used with a domain of 170.25^{o}W - 76.75^{o}W by 4.75^{o}N - 50.25^{o}N.

b. Web Based Alphanumeric Spectral Messages

Spectral text bulletins are presented for numerous points of the ENP. These bulletins are in ASCII and are available on the INTERNET, and became available to the field on the SBN in May 2003. The line length of the web table is 130 characters by 100 lines. The header of the table identifies the output location, the generating model and the run date and cycle of the data presented. At the bottom of the table, a legend is printed. The table consists of 8 columns. The first column gives the time of the model results with a day and hour (the corresponding month and year can be deduced from the header information. The second column presents the overall significant wave height (H_s), the number of individual wave fields with a wave height over 0.15 m that could not be tracked in the table (x). Individual wave fields in the spectrum are identified by using a partitioning scheme similar to that of Gerling (1992). In the remaining six columns individual wave fields identified with their wave height (H_s), peak wave period (T_p) and mean wave direction (dir, direction in which waves travel relative to North). Generally, each separate wave field is tracked in its own column. Such tracking, however is not guaranteed to work all the time. An asterisk (*) in a column identifies that the wave field is at least partially under the influence of the local wind, and, therefore, most likely part of the local wind sea. All other wave fields are pure swell.

b. Spectral text bulletins for AWIPS

The format for the spectral text bulletins sent to AWIPS is generally the same as that for the web, except that the period is to the nearest second, the wave heights are to the nearest foot, the direction is from (meteorological, rather than oceanographic), the number of fields that couldn't be tracked is not given, and the asterisk indicating when a wave field is, at least, partially under the influence of the local wind is not shown. The bulletin width is 69 characters, which is a legacy of the teletype era and the display capability of AWIPS. A sample bulletin is shown in fig. 1, and the list of points for the NWW3 is given in Table 1.

5. References

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