

U. S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Centers for Environmental Prediction
5200 Auth Road Room 207
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Technical Note

Example of WAVEWATCH III for the NE Pacific [†].

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13 March 2008

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1 Introduction

A sample case of the nested-grid full-spectral third-generation wind-wave model WAVEWATCH III was tested in the Pacific Ocean for the Wave Information Study (WIS) of the Engineer Research and Development Center (ERDC) of the US Army Corps of Engineers (USACE). A set of three nested grids was developed to match the coarse and intermediate resolution wind fields from Oceanweather Inc. (OWI), with a high resolution grid along the western coast of the United States. This report details how the model was set up to run using these grids and wind fields, and includes examples of all the input files. Model results are expected to be validated using data from the National Data Buoy Center (NDBC) wave buoys, so a version of the model requesting point output at the specific buoy locations is also presented.

The WAVEWATCH III model is described in the user manual and system documentation (Tolman, H. L. 2002e). The manual describes the governing equations, numerical approaches, installation, compilation, and running of the model. The nested-grid driver is described in Tolman (2007a), and the grid generation product used is described in Chawla and Tolman (2007a). This report will not repeat all of that information, but instead focuses on showing a detailed example of how to set up the individual input files and run the model. However, having a copy of the manual available when using this report will be useful, as the manual contains more information about the various flags that can be set in the input files (many of which are not used here).

2 Nested Grids

A set of three nested grids (Figure 2.1 and Table 2.1) was produced for the Pacific Ocean according to specifications given by USACE ERDC Coastal and Hydraulics Laboratory (CHL). The full resolution ETOPO2 bathymetry was used as the reference grid, with the Puget Sound, Columbia River Estuary, and San Francisco Harbor excluded. The two lowest resolution grids were chosen to match the spatial area and resolution of a 3-year dataset of Pacific wind fields from OWI, which will be used as input in the model. A third, highest resolution grid was designed to cover the shelf break, and include all of the mainland USA west coast.

Table 2.1: Grid range and resolution.

Name	Latitude	Longitude	Resolution
PAC	64°S : 64°N	110°E : 60°W	1/2 deg
PAC_int	30°N : 50°N	140°W : 110°W	1/4 deg
PAC_cos	30°N : 50°N	130°W : 115°W	1/12 deg

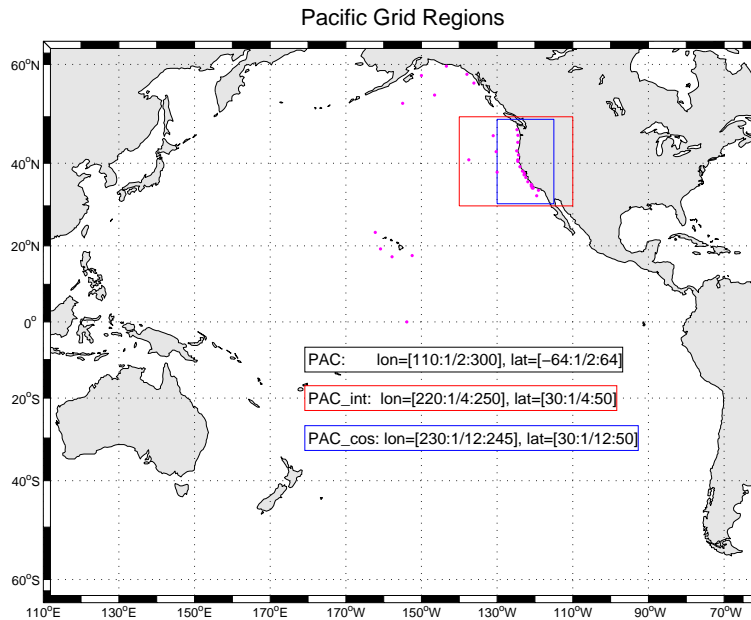


Fig. 2.1 : Set of nested grids for the Pacific Ocean. The magenta points correspond to the NDBC location of the validation buoys.

Three files were created for each grid: a bathymetry, a mask, and an obstruction grid which accounts for wave attenuation by unresolved islands. The ocean depth off the Pacific coast of the United States increases rapidly over a very short distance from shore (Figure 2.2). Water depth is approximately 2000 meters just one degree of longitude west of the coast. This results in differences in the NDBC reported depths at the buoy locations, and the corresponding depth in the model grid. This issue will be addressed in more detail in Section 5.

Because of the bathymetry, even at 1/12 degree resolution there are very few grid points that are in depths less than 20 meters. Figure 2.3 shows a close up of the coastline from $45^{\circ}N$ to $50^{\circ}N$, around Vancouver Island. The colored contours show the depths of up to 200 meters, and overlaid on these are the locations of the 1/12 degree resolution grid. All in all, there are only 116 grid points that are in waters of up to 20 meters depth.

3 Input Wind Fields

Sample OWI wind fields were obtained for January 2000, for both the 1/2 degree grid and the 1/4 degree grid at three hourly temporal resolution. These winds are derived by analyzing model data from NCEP, the US Navy, ECMWF, plus in-situ data from buoys, ships, coastal stations, TOPEX altimeter winds, NSCAT scatterometer winds, and NOAA reconnaissance winds (Cox and Cardone, 2002).

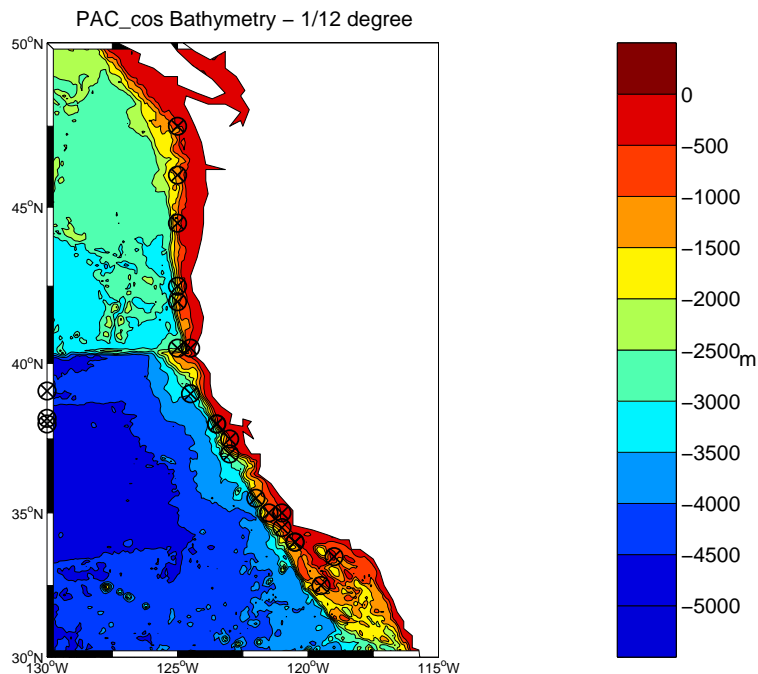


Fig. 2.2 : Bathymetry of the coastal grid. NDBC buoy locations are marked with circled X.

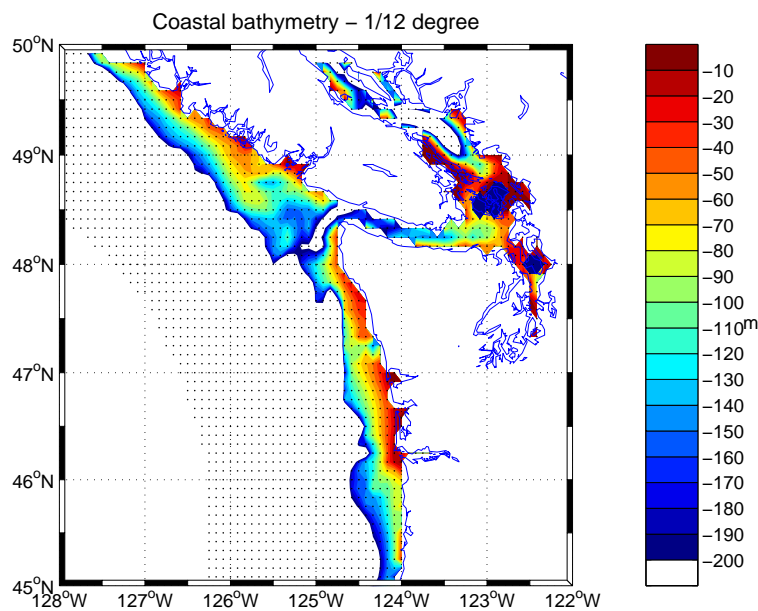


Fig. 2.3 : Depths up to 200 meters along Vancouver island and the Straits of Juan de Fuca, showing the location of the 1/12 resolution grid.

The wind fields are reported in WIN format (ascii files). The first step is to re-format this data into the style that WAVEWATCH III expects: a time-stamp followed by the u and v components. An example fortran code is attached in the Appendix A, but the relevant section is this:

```
C Write ascii wind file for WAVEWATCH III
10      format (a8,1x,a6)
        write (FILEUNIT,10) ymd,hms
14      format (8f10.4)
        write (FILEUNIT,14) ((uu(i,j),i=1,iLon),j=1,iLat)
        write (FILEUNIT,14) ((vv(i,j),i=1,iLon),j=1,iLat)
```

Once the wind data has been re-formatted, the script running WAVEWATCH III can be adjusted to read these files (see the example shell script in Appendix B on how to generate the wind files for WAVEWATCH III). It is important to note that the wind files must be read “bottom to top”, so the 3rd line in the wind preprocessor input file should read:

```
‘NAME’ 2 2 ‘(I8,I7)’ ‘(8F10.4)’
```

To verify that the wind fields are being processed correctly, the model output wind speed can be compared with independent wind speed data for the same area. For example, the DMSP Special Sensor Microwave/Imager (SSM/I) derived ocean surface wind speed for January 18, 2000 (Figure 3.1) shows the same structure as the wind speed output by the test run (Figure 3.2). Note that the colorbars are different between the figures, but similarities are still discernable. For example, there are three systems in the north of the basin with wind-speeds between 15–20 m/s. There is also a feature off the south-west coast of Australia with wind-speeds between 10–15 m/s, and a feature off the south-west coast of South America with wind-speeds between 15–20 m/s.

4 Running the wave model

The model was started from calm conditions ($H_s = 0$), run for the month of January 2000, and output requested every three hours. Since it takes approximately two weeks for the model ocean to spin up from calm, only the data from the 15th to 31st of January was requested and will be shown in the final section.

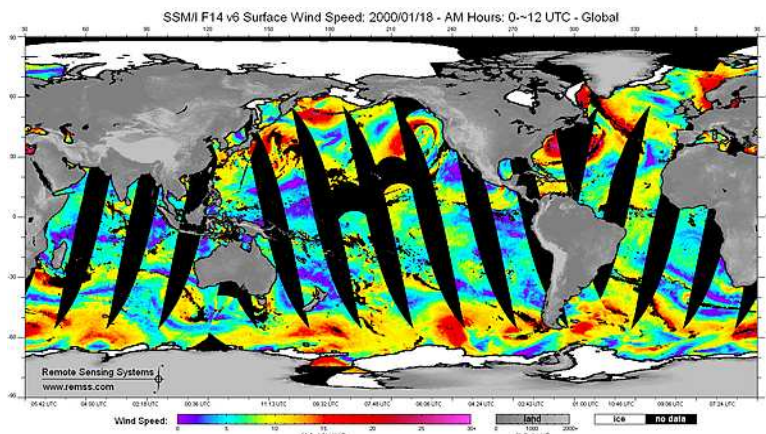


Fig. 3.1 : SSM/I surface wind speed for January 18, 2000 (taken from the website http://www.ssmi.com/ssmi/ssmi_data_daily.html).

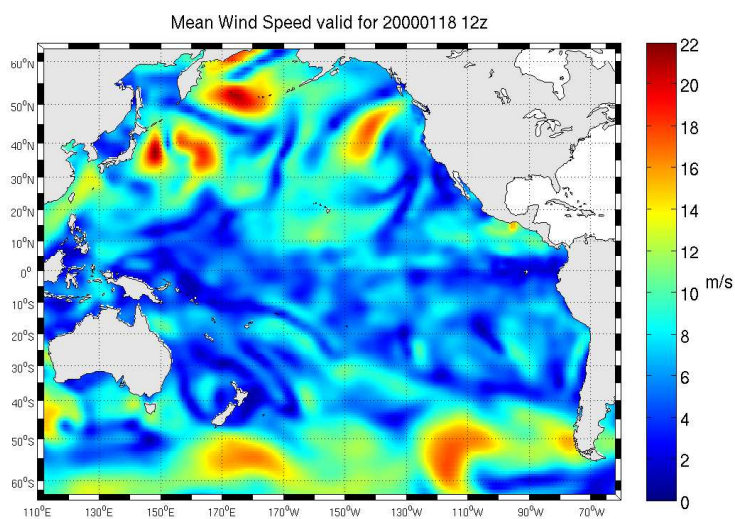


Fig. 3.2 : WAVEWATCH III output surface wind speed for January 18, 2000.

4.1 Grid Preprocessor

The model's grid preprocessor requires input files corresponding to the individual grids (see Appendix C.1 for an example, where `ww3_grid.inp.grd1` corresponds to the lowest resolution grid), input data (wind fields in this case, see Appendix B), and output points (Appendix C.2) if requested. The grid preprocessor takes information from the specific grid's input file and writes a model definition file. While most of the grid input file concerns only the grid resolution and starting points, there are two lines that are important to set up correctly: the line with spectral information and the line that defines the model's time steps.

The spectral information line will determine the frequencies that will be considered in the model: frequency increment factor, first frequency (Hz), number of frequencies (wavenumbers), and directions, and the relative offset of the directional increment. In this case,

1.1 0.035 29 24 0.5

Here the model is intended to study wind waves with a period of no more than 29 seconds. Therefore the first frequency in the grid input files is 0.035 Hz. For generating the point output definition file, this line is the only line that matters in the grid input file - the rest is just dummy data and will be ignored.

The time steps line contains the global time step, the spatial time step, the directional time step, and the source term time step, all in seconds. The first of these time steps that should be determined is the spatial time step Δt_{xy} . This is the time step for spatial propagation, and as such must satisfy the Courant-Friedrichs-Levy (CFL) criterion: the speed of fastest waves in the model must be less than or equal to the grid spacing divided by the time step. Therefore each grid is going to have its own Δt_{xy} determined by the grid's resolution, the maximum latitude in the grid, and the first frequency (this last will be the same for all grids):

$$\Delta t_{xy} = \frac{\Delta x}{C_g} \quad (4.1)$$

$$: = \frac{\frac{40 \cdot 10^6}{360} * \Delta x * \text{cosd}(\text{maxlat})}{\frac{1.15 * g}{4\pi} * \frac{1}{f}} \quad (4.2)$$

$$: = \frac{40 * 10^6 * \Delta x * \text{cosd}(\text{maxlat}) * 4\pi * f}{360 * 1.15 * g} \quad (4.3)$$

$$: = 123766 * \Delta x * \text{cosd}(\text{maxlat}) * f \quad (4.4)$$

Note that Δx is in degrees (1/2, 1/4, and 1/12 here), $\text{cosd}(\text{maxlat})$ is the cosine of the maximum latitude in degrees, and f is the first frequency. This gives a maximum allowable time step for spatial propagation. In general, choose an integer close to this number (no fraction of seconds). For example, in the

Table 4.1: Time steps for each grid.

Grid	Δt_g	Δt_{xy}	Δt_k	Δt_S
1/2 deg	1800	940	900	15
1/4 deg	900	690	450	15
1/12 deg	450	225	225	15

lowest resolution grid $\Delta x = 1/2$ and $maxlat = 64$, so $\Delta t_{xy} = 949.4$ seconds — therefore choose $\Delta t_{xy} = 940$ seconds. The global time step Δt_g , by which the entire solution is propagated in time, can be set to approximately 2 or 3 times the Δt_{xy} . Note that although there is a different Δt_g for each grid, it is at these time steps that the grids will exchange information. Therefore it is advisable to choose Δt_g for each grid in such a way that they intersect at given times. For an example, see Table 4.1.

Once Δt_g has been determined, then the directional time step is set to $\Delta t_k = 1/2\Delta t_g$. The source time step is adjusted internally and $\Delta t_S = 15$ seconds is the minimum allowed value.

4.2 Multi-grid wave model

The nested grid module takes information generated by the grid preprocessor, interpolates the winds and currents, updates ice concentrations (if any, none are used in this case) and water levels, propagates the wave field, and applies the selected source terms for a number of time steps. The multi-grid input file contains information about each input data field (two different resolution wind fields in this case), which grids will be used and how they relate to each other, starting and ending times of the run, whether or not to mask the areas of the nested grids (here the areas are masked), and six sections that request output starting at a specified time (`$t_beg`), ending at a set time (`$t_end`), and produced at a time interval (`$dt`):

1. Fields of mean wave parameters.
2. Point output.
3. Output along track.
4. Restart files.
5. Boundary data.
6. Separated wave field data.

These six lines must always appear in the multi-grid input file. However, if an output is not required, then a $\$dt=0$ suppresses the output. In the cases presented in this report, only three of these output sections are activated. The first (Appendix D.1) is an example with a string requesting field output (in this case the flags for depth, mean current, wind speed, wave height, wave length, wave period, and wave direction are set), but no point output is requested. The second example (Appendix D.2) shows the input file with the same field request, but also with point output requested for five buoy locations. Both examples request a restart file for the ending date of the run. Requesting point output basically asks the model to interpolate the wave spectra at the specified buoy locations and from that construct the wave parameters, which is different than interpolating the field output to those locations.

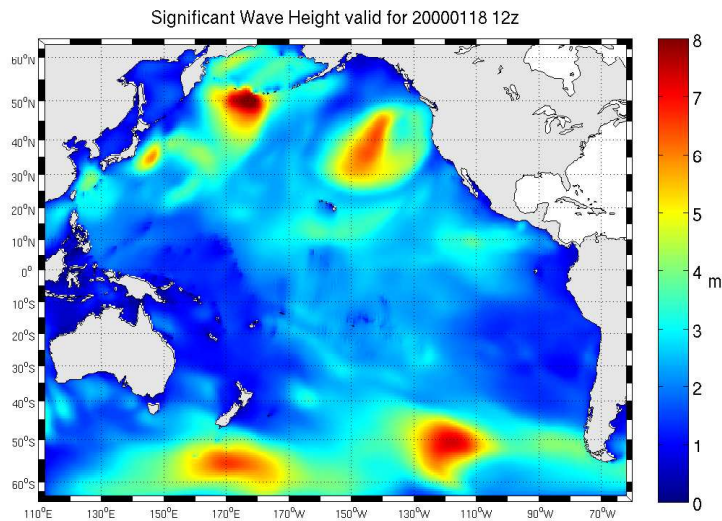


Fig. 4.1 : Model output significant wave height in meters. Note that all three grids are shown, with the coarsest resolution to the left of the figure, and the highest resolution along the western coast of the USA.

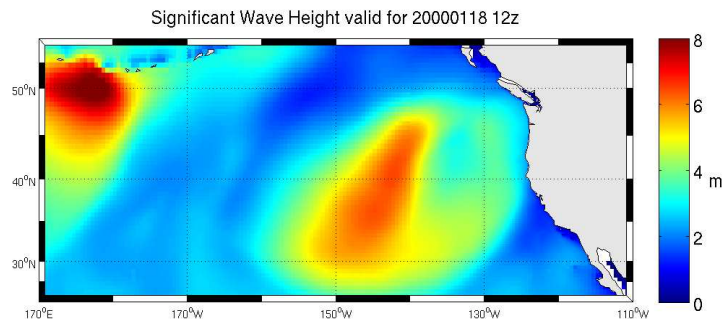


Fig. 4.2 : Close-up of model output significant wave height in meters.

As an example of the output produced by the model, the significant wave heights are presented in Figure 4.1. Note the effect of small islands on wave propagation. For example, the Hawaiian and Aleutian islands are in the 1/2 degree grid, and show how the wave energy is blocked by the islands. The same effect is seen in the center of the basin, between $30^{\circ}S$ to $10^{\circ}N$ and $170^{\circ}W$ to $140^{\circ}W$. Here the islands are too small to be resolved at 1/2 degree, but the obstruction grid still accounts for their presence.

Figure 4.2 is a close up to show how well the nested grids line up. First the output wave height for the lowest resolution grid is plotted for the entire basin, with the intermediate and coastal grid areas masked out. Then the intermediate grid wave height is plotted, and then the coastal wave height. Note that the 1/2 degree resolution patchiness is visible to the left of the figure, but that close to the shore where the resolution is 1/12 degree the image is very smooth.

5 Point output versus nearest grid point

Model results are expected to be validated against buoy data, and a list of buoys along the Pacific coast of the US was provided by the ERDC. The latitude, longitude, and depth of their positions was compiled from the National Data Buoy Center (NDBC) website. In order to see if point output would be necessary (versus using the nearest grid point from field output), the position of the buoys was plotted against the grid points. Which spatial grid is used depends on the location of the buoys. For example, coastal buoys are plotted on the 1/12 degree resolution grid, but the Hawaiian buoys are plotted on the 1/2 degree grid. Figure 5.1 shows the best and worst case for the coastal NE Pacific buoys. In some cases the distance between the buoy locations and the nearest grid point is greater than 5 kilometers.

Ocean depth is a very important variable when dealing with wave heights, especially in shallow water (say less than 200 meters depth). Most of the buoys considered here are in very deep waters. Only eleven are in depths less than 200 meters, and of these only three in less than 100 meters. Figure 5.2 shows the difference between the NDBC depth for the buoy, the model bathymetry interpolated for the buoy location (point output), and the model bathymetry for the nearest grid point (field output) for a sample of five buoys. These buoys were chosen so that there would be one from each grid (buoy 51001 is in the 1/2 degree grid, buoy 46005 in the 1/4 degree grid, and buoy 46023 in the 1/12 degree grid), one at the boundary of the coastal and intermediate grid (buoy 46059), and one in shallow water (buoy 46027).

Because of the range of differences in buoy locations and depths, results of wind speed and wave height were compared with historical NDBC data using both point output and nearest grid point for the five buoys. Figure 5.3 shows the timeseries for the shallow water buoy 46027. Overall the model performs very

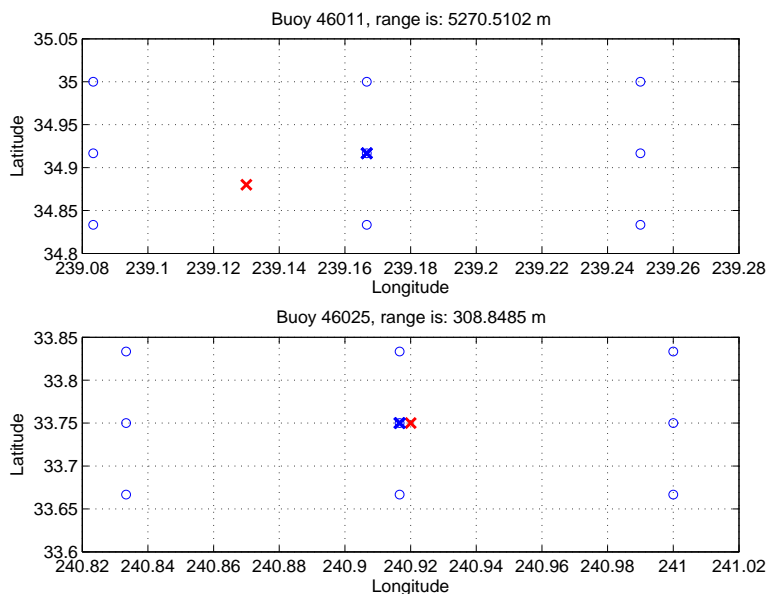


Fig. 5.1 : Model grid points, with NDBC buoy location in red and nearest model grid point in blue.

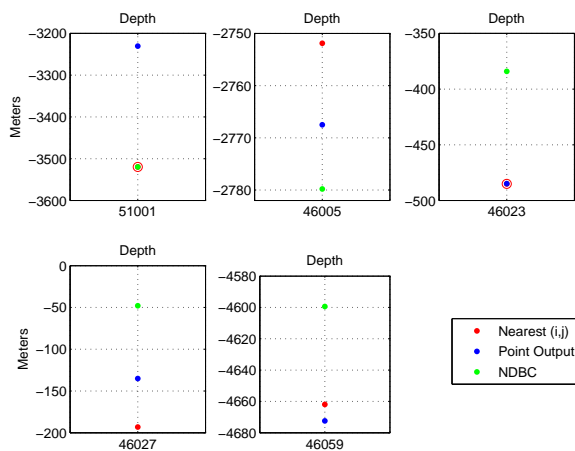


Fig. 5.2 : Reported depth of the NDBC buoy location (green), depth of the nearest model grid point (red), and depth of the point output from the model (blue).

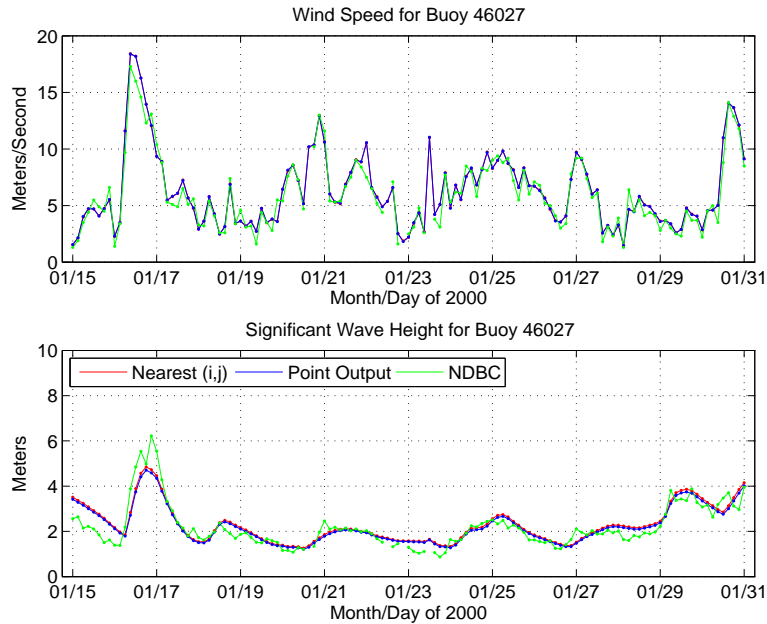


Fig. 5.3 : Difference between the model output wind speed (m/s) and wave height (m) for shallow water buoy 46027.

well, with the wind speed and the wave height tracking the historical data closely.

In general, differences in the wind speed at point output and nearest grid point are small, with most around 0.05 m/s (Figure 5.4), which ranges from 2% to 5% of the total wind speed for these buoys. The differences in wave height are even smaller (Figure 5.5), with most less than three centimeters in wave heights of around 3 meters. The biggest difference occurs in buoy 46027, which is in the shallowest water, and is about 7% of the total wave height. NDBC has this buoy listed as being in 47.9 meters of depth, but the model returns a depth of 135.1 meters for the point output, and 193.1 meters for the nearest grid point in the field output.

6 Conclusions

Besides defining the spatial grids and reading the input fields correctly, there are a few parameters that must be defined carefully when setting up the WAVEWATCH III model. Making sure that the time steps satisfy the CFL criterion is essential, and a simple formula to do this has been provided. Examples have been attached in the Appendices which show how the various model input files might look, and hopefully explain some of the finer details.

It is always important to validate model output, but when comparing wave data from shallow water buoys to the model careful consideration must be given

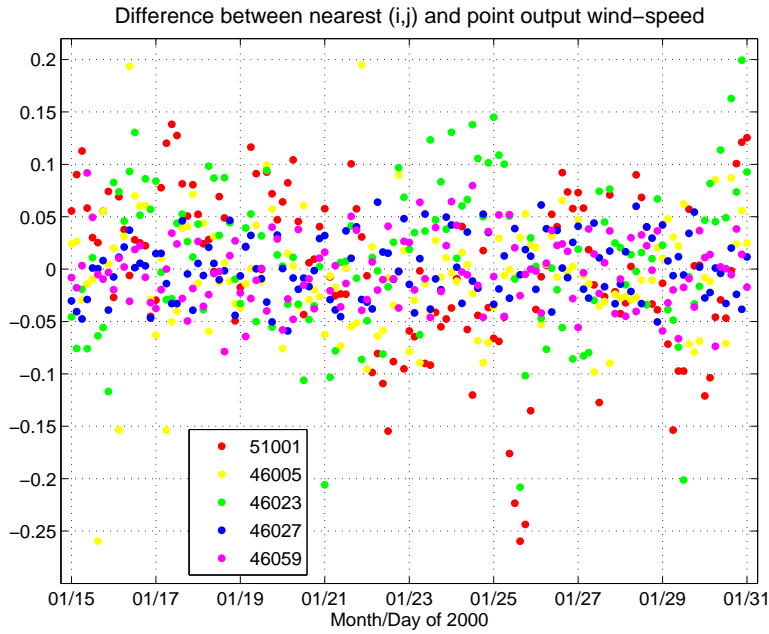


Fig. 5.4 : Difference between the model output wind speed in m/s at the buoy locations (point output) versus the nearest grid point (field output).

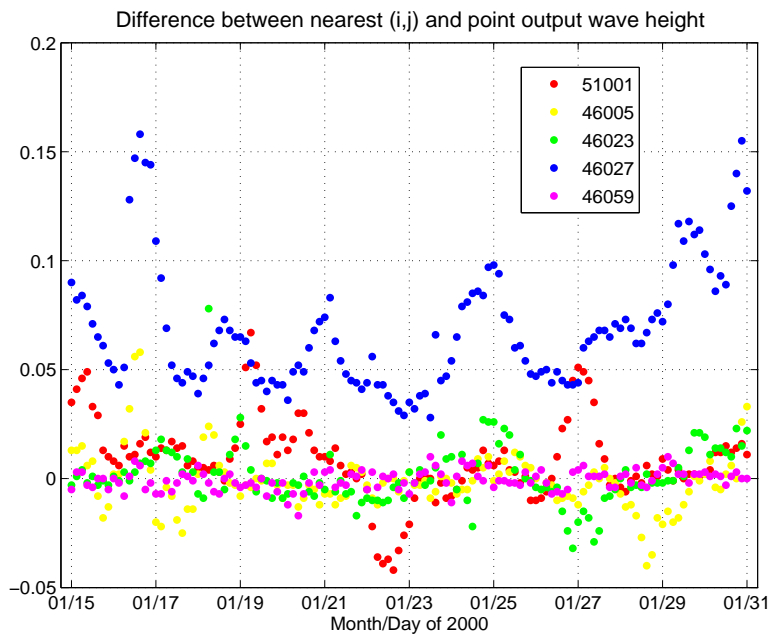


Fig. 5.5 : Difference between the model output average wave height in meters at the buoy locations (point output) versus the nearest grid point (field output).

to the depth at which both occur. As a general rule, it is better to request point output for the specific buoy locations and let the model interpolate the spectral energy to those points.

References

Chawla, A. and H.L.Tolman, 2007a: Automated grid generation for WAVEWATCH III. Tech Note 254, NOAA/NWS/NCEP/MMAB, 71 pp.

Cox, A.T. and V.J. Cardone, 2002: Operational System for the Prediction of Tropical Cyclone Generated Winds and Waves. 6th International Workshop on Wave Hindcasting and Forecasting November 6-10, 2000, Monterey, California.

Tolman, H.L., 2002e: User manual and system documentation of WAVEWATCH III version 2.22. Tech Note 222, NOAA/NWS/NCEP/MMAB, 133 pp.

Tolman, H.L., 2007a: Development of a multi-grid version of WAVEWATCH III. Tech Note 256, NOAA/NWS/NCEP/MMAB, 88 pp + Appendices.

APPENDICES

A Example wind re-formatting code

```

C-----
C Read in the data in WIN format and output ascii file
C ready for WAVEWATCH III.
C run as: pgf95 -o format_winds format_winds.f
C output file is: YYYYMM_winds.asc
C           with time-stamp, uu and vv (wind components)
C-----
      program format_winds
      implicit none

      integer grid, error, mon
      parameter (grid=2)
C grid=1 => basin winds. Anything else for intermediate grid winds.
      character*4 YYYY
      parameter (YYYY='2000')
      integer FILEUNIT1, FILEUNIT2
      parameter (FILEUNIT1=20, FILEUNIT2=40)
      character*38 DATAFILE
      character*23 OUTFILE
      character*2 month

      integer startdate, enddate
      character*10 yymmddhh
      character*8 ymd
      character*6 hms
      character*2 mm
      integer iLat, iLon, YMDH, iMin
      real dx, dy, SWlat, SWlon
      real, allocatable :: uu(:, :), vv(:, :)

      integer icnt, jcnt, i, j
      real, allocatable :: slat(:), slon(:)

C Filenames for regional winds (match PAC_int grid) are:
C           YYYYMM_HiResWISPac.win
C and for basin winds (match PAC grid):
C           YYYYMM_WIS_Pacific_HalfDeg_LevelIII.WIN

      do mon=1,1
         write(month, '(i2.2)') mon

```

```

if (grid .eq. 1) then
  DATAFILE = YYYY//month//'_WIS_Pacific_HalfDeg_LevelIII.WIN'
  OUTFILE = 'WIS'//YYYY//month//'_halfdeg.wind'
else
  DATAFILE = YYYY//month//'_HiResWISPac.win'
  OUTFILE = 'WIS'//YYYY//month//'_quartdeg.wind'
endif

write(*,*)'datafile is ',DATAFILE,' and outfile is ',OUTFILE
open(unit=FILEUNIT1,file=DATAFILE(1:len_trim(DATAFILE)),
&   form='FORMATTED',status='OLD',iostat=error)

if (error .ne. 0) then
  write(*,*) 'Error ',error,' opening .win data file'
  write(*,*) 'Exiting now'
  stop
end if

C Read in begining/ending dates of wind file
10   format (t56,i10,t71,i10)
    read (FILEUNIT1,10) startdate,enddate
    write(*,*)'start and end dates are: ',startdate,' and ',enddate

    YMDH = startdate
C Loop until YMDH is same as enddate

    do while (YMDH .le. enddate)

C Read Grid Specifications/Date
11   format (t6,i4,t16,i4,t23,f6.0,t32,f6.0,
&     t44,f8.0,t58,f8.0,t69,i10,i2)
    read (FILEUNIT1,11) iLat,iLon,dx,dy,SWlat,SWlon,YMDH,iMin

C Allocate uu and vv:
    allocate (uu(iLon,iLat), vv(iLon,iLat))
    allocate (slat(iLat), slon(iLon))

C Read u,v components of the wind
12   format (8f10.4)
    read (FILEUNIT1,12) ((uu(i,j),i=1,iLon),j=1,iLat)
    read (FILEUNIT1,12) ((vv(i,j),i=1,iLon),j=1,iLat)

```

C Latitude and longitude for each point can be calculated as follows:

```
C
C      do icnt = 1,iLat
C          slat(icnt) = SWlat + (icnt - 1) * dx
C      enddo
```

```
C      do jcnt = 1,iLon
C          slon(jcnt) = SWlon + (jcnt - 1) * dy
C      enddo
```

C Wind Speed and Meteorological Wind Direction can be
C computed from the u and v components as follows:

```
C
C      WS = sqrt(uu(iLon,iLat)**2 + vv(iLon,iLat)**2)
C      WDIR = mod(180.+atan2d(uu(iLon,iLat),vv(iLon,iLat)),360.)
```

```
      open(unit=FILEUNIT2,file=OUTFILE(1:len_trim(OUTFILE)),
&         form='FORMATTED',iostat=error)
      if (error .ne. 0) then
          write(*,*) 'Error ',error,' opening output ascii file'
          write(*,*) 'Exiting now'
          stop
      end if
```

C Get time-stamp: YYYYMMDD HHMMSS

```
      write(yymmddhh,'(i10.10)') YMDH
      ymd = yymmddhh(1:8)
      write(*,*) 'ymd is: ',ymd
      write(mm,'(i2.2)') iMin
      hms = yymmddhh(9:10)//mm//'00'
      write(*,*) 'hms is: ',hms
```

C Write ascii wind file for WAVEWATCH III

```
13      format (a8,1x,a6)
          write (FILEUNIT2,13) ymd,hms
```

```
14      format (8f10.4)
          write (FILEUNIT2,14) ((uu(i,j),i=1,iLon),j=1,iLat)
          write (FILEUNIT2,14) ((vv(i,j),i=1,iLon),j=1,iLat)
```

C Add one so that the while loop finishes properly

```
        if (YMDH .eq. enddate) then
            YMDH = YMDH + 1
        end if
        deallocate (uu, vv)
        deallocate (slat, slon)
    end do

    close(FILEUNIT1)
    close(FILEUNIT2)

    end do
    stop
end
```

C-----

B Example wind input shell script

```

#-----
# use wind fields as input
#-----
#
# 3. Input fields -----

echo ' '
echo '+-----+'
echo '| Input data      |'
echo '+-----+'
echo ' '

NRI='0'

windfield='halfdeg quartdeg'
ln -s mod_def.grd1 mod_def.halfdeg
ln -s mod_def.grd2 mod_def.quartdeg

for wind in $windfield
do
  if [ '$wind' != 'no' ]
  then
    NRI=expr $NRI + 1
    if [ -f $path_d/wind.$wind ]
    then
      echo '   Wind file $path_i/wind.$wind'
      ln -sf $path_d/wind.$wind .
    else
      echo '   Copy
raw wind files {\ldots} '
      cp $path_d/WIS200001_$wind.wind.gz $wind.raw.gz
      gunzip -f $wind.raw.gz
cat > ww3_prep.inp.$wind << EOF
$ WAVEWATCH III Field preprocessor input file
$ -----
'WND' 'LL' T
$
EOF

    if [ '$wind' = 'halfdeg' ] ; then
      echo '   110. 300. 381 -64. 64. 257' >> ww3_prep.inp.$wind ; fi

```

```
    if [ "$wind" = 'quartdeg' ] ; then
        echo " 220. 250. 121 30. 50. 81" >> ww3_prep.inp.$wind ; fi
    echo " 'NAME' 2 2 '(I8,I7)' '(8F10.4)' " >> ww3_prep.inp.$wind
# 2 => read wind file bottom to top
    echo " 20 $wind.raw " >> ww3_prep.inp.$wind
    echo "$ End of input file " >> ww3_prep.inp.$wind

    rm -f mod_def.ww3
    ln -s mod_def.$wind mod_def.ww3

    cp ww3_prep.inp.$wind ww3_prep.inp
    echo " Screen output routed to $path_o/ww3_prep.$wind.out"
    $path_e/ww3_prep > $path_o/ww3_prep.$wind.out
    mv wind.ww3 wind.$wind
    echo " Copy wind.$wind to $path_i"
    cp wind.$wind $path_i/.

    rm -f $wind.raw ww3_prep.inp.$wind ww3_prep.inp mod_def.ww3
    echo " "
    fi
    fi
done
```

```
#-----
```


C Grid preprocessor input files

C.1 Example grid input file

```

$ ----- $
$ WAVEWATCH III Grid preprocessor input file $
$ ----- $
$
$   'Pacific 1/2 degree grid           '
$
$   1.1  0.035  29  24  0.5
$
$   F T T T F T
$
$   1800. 940. 900. 15.
$
$   &MISC FLAGTR = 2 /
END OF NAMELISTS
$
$   381    257
$   30.    30.    60.
$   110.  -64.    1.
$   -0.1  2.50  20  0.001  1  1  '({\ldots} .)' 'NAME' 'PAC.bot'
$                                     21  0.010  1  1  '({\ldots} .)' 'NAME' 'PAC.obs'
$                                     22          1  1  '({\ldots} .)' 'NAME' 'PAC.mask'
$
$   0.    0.    0.    0.    0
$
$ ----- $
$ End of grid preprocessor input file $
$ ----- $

```

C.2 Example grid input file for output points

```

$ ----- $
$ WAVEWATCH III Grid preprocessor input file for point output $
$ ----- $
$
$   'Spectral resolution for points'
$
$   1.1  0.035  29  24  0.5
$
$   F T T T F T
$
$   450.  225.  225.  15.
$
$ END OF NAMELISTS
$
$   3      3
$   1.    1.    1.
$  -1.   -1.    1.
$ -0.1  2.50  10  -1000.  2 1 '(...)' 'UNIT' 'dummy'
$
$  9*1
$
$  10 3 1 '(...)' 'PART' 'dummy'
$
$   0  0  F
$   0  0  F
$   0  0
$   0. 0. 0. 0. 0
$
$ ----- $
$ End of grid preprocessor input file for point ouput $
$ ----- $

```

D Example multi-grid input file

D.1 No point output

```

$ ----- $
$ WAVEWATCH III multi-grid input file (no point output) $
$ ----- $
  3 2 F 1 T T
$
  'halfdeg'  F F T F F F F
  'quartdeg' F F T F F F F
  'grd1'  'no' 'no' 'halfdeg' 'no' 'no' 'no' 'no'  1 1  0.00 1.00  F
  'grd2'  'no' 'no' 'quartdeg' 'no' 'no' 'no' 'no'  2 1  0.00 1.00  F
  'grd3'  'no' 'no' 'quartdeg' 'no' 'no' 'no' 'no'  3 1  0.00 1.00  F
$
20000101 000000  20000107 000000
$
T  T
$
20000101 000000  10800  20000107 000000
$
T T T F F T T T T F F F F F F F F F F F F F F F F F F F F F F F
$
20000101 000000      0 20000107 000000
20000101 000000      0 20000107 000000
20000107 000000      1 20000107 000000
20000101 000000      0 20000107 000000
20000101 000000      0 20000107 000000
$
  'the_end'  0
$
  'STP'
$ ----- $
$ End of multi grid input file $
$ ----- $

```

D.2 With point output

```

$ ----- $
$ WAVEWATCH III multi-grid input file (with point output) $
$ ----- $

  3 2 T 1 T T
$
  'halfdeg'  F F T F F F F
  'quartdeg' F F T F F F F
  'points'
  'grd1' 'no' 'no' 'halfdeg' 'no' 'no' 'no' 'no' 1 1 0.00 1.00 F
  'grd2' 'no' 'no' 'quartdeg' 'no' 'no' 'no' 'no' 2 1 0.00 1.00 F
  'grd3' 'no' 'no' 'quartdeg' 'no' 'no' 'no' 'no' 3 1 0.00 1.00 F
$
20000122 000000 20000131 000000
$
T T
$
20000122 000000 10800 20000131 000000
T T T F F T T T T F F F F F F F F F F F F F F F F F F F F F F F
20000122 000000 10800 20000131 000000
197.79 23.43 51001
228.98 46.05 46005
239.03 34.71 46023
235.62 41.85 46027
230.00 37.98 46059
0.E3 0.E3 'STOPSTRING'
$
20000122 000000 0 20000131 000000
20000131 000000 1 20000131 000000
20000122 000000 0 20000131 000000
20000122 000000 0 20000131 000000
$
  'the_end' 0
$
  'STP'
$ ----- $
$ End of multi grid input file (with point output) $
$ ----- $

```