National Weather Service
Office of Meteorology

Technical Procedures Bulletin

Subject: Ocean Surface Waves

Series No. 494

June 12, 2003 **Science Division, Silver Spring, MD 20910**

This bulletin, prepared by H. S. Chen, 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 global ocean wave guidance provided in alphanumeric and GRIB formats.

The NOAA WAVEWATCH III (NWW3) was implemented in March 2000. It is a third generation model which accounts for wave dispersion within discrete spectral bins by adding 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 difference 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 mainframe computer and all the power of FORTRAN 90; it uses a spatial resolution of 1.25° x 1.00° on a lon./lat. grid, a domain from 78°N to 78°S, and a directional resolution of 24 directions.

The bulletins and graphics of the new guidance follow the same formats shown in TPB No. 453 (Chen *et al.*, 2000), except for changes to the spectral text bulletins now being sent to AWIPS and the following model improvements :

(1) The model has been re-coded in FORTRAN 90 to utilize modular concepts and allocatable data structures. No noticeable changes have resulted in the guidance.

(2) Improved source term integration schemes have been used with no perceptible changes to the guidance.

(3) A new propagation scheme to eliminate the Garden Sprinkler Effect more efficiently and to account for unresolved islands and sea ice.

(4) Re-tuning to eliminate model biases induced by changes above.

(5) Spectral text bulletins for the NWW3 are available at

http://polar.wwb.noaa.gov/waves.

These files are in ASCII and are available by anonymous at

ftp://polar.wwb.noaa.gov/pub/waves/date.cycle,

where date represents the date in yyyymmdd format and cycle represents the run cycle identifier (t00z or t12z, respectively). These bulletins have been implemented on AWIPS, but with a condensed format necessitated by the capabilities of the communications gateway and display capabilities of AWIPS.

The ocean wave guidance is generated four times daily out to 168 hours based on the 0000, 0600, 1200 and 1800 UTC cycles of the Global Forecast System.

Technical Procedures Bulletin No. 453 is now operationally obsolete.

LeRoy Spayd
Chief, Training and Professional
Development Core

OCEAN SURFACE WAVES[1]

by H. S. Chen, L. D. Burroughs, and H. L. Tolman[2]

1. INTRODUCTION

During the last five decades, wind wave forecasts have improved significantly from the empirical approaches based on Sverdrup and Munk (1947) and Bretschneider (1958) to the spectral approaches based on the radiative transport equation (*e.g.* SWAMP Group 1985). At present, the most advanced spectral model for research and forecast is the so-called third generation wave[3] model (WAMDI Group 1988) of which the NWW3 is an example (Tolman 2002). The Marine Modeling and Analysis Branch (MMAB) has made systematic efforts to test and develop models based on prediction accuracy, computational efficiency and sound wave dynamics and to employ them to produce operational forecasts.

The NWW3, as noted above, is a third generation model; it accounts for wave dispersion within a discrete spectral bin by adding 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 difference 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 Massively Parallel Processing (MPP) structure of the IBM mainframe computer; it uses a spacial resolution of 1.25^o x 1.00^o lon./lat. grid, a domain north-south from 78^{o}N to 78^{o}S, and a directional resolution of 24 directions.

This TPB briefly describes the NWW3 and the wave guidance products which are being disseminated. This guidance consists of significant wave height (H_s), which combines sea and swell; mean wave direction (D_m); mean wave period (T_m); and directional wave spectra at selected grid points. Guidance is available in alphanumeric and GRIB formats. Note that other wave and wind parameters are also available in GRIB format, *i.e.,* peak wave period and direction, wind sea peak wave period and direction, wind speed and direction, and u and v wind components, and are posted at http://polar.wwb.noaa.gov/waves on the web. The reader is referred to *World Meteorological Organization (WMO) Report No.702* (second edition; 1998) for wave definitions, measurements and modeling.

The bulletins and graphics of the new guidance follow the same formats shown in TPB No. 453(Chen *et al.*, 2000), except for changes to the spectral text bulletins now being sent to AWIPS and the following model improvements :

(1) The model was originally coded in FORTRAN 77 to assure portability in the early 1990s. It has been re-coded in FORTRAN 90 to utilize modular concepts and allocatable data structures. The conversion greatly simplifies the maintenance of the NWW3 family of wave models at NCEP. To simplify the code further, some minor changes of operations were adopted. No noticeable changes have resulted in the guidance.

(2) The source term integration scheme has been changed to forward in time since the time scales are comparable to the time step (Hargreaves and Annan 2001). This results in a smoother spectra with little impact on guidance. The parameters of dynamic time stepping have been reset to get slightly faster initial growth again with no noticeable changes in the guidance.

(3) A new cheaper propagation scheme has been included in the model to eliminate the Garden Sprinkler Effect (see figs. 1 - 5). A new way to account for unresolved islands and sea ice has also been included in the model (see figs. 6-8). Dramatic improvements in model guidance have occurred in the vicinity of island groups world wide (see figs. 9 - 12)

(4) Re-tuning to eliminate model biases induced by changes above has also been done.

(5) Spectral text bulletins for the NWW3 are available at

http://polar.wwb.noaa.gov/waves.

These files are in ASCII and are available by anonymous ftp at

ftp://polar.wwb.noaa.gov/pub/waves/date.cycle,

where date represents the date in yyyymmdd format and cycle represents the run cycle identifier (t00z, t06z, t12z or t18z, respectively). These bulletins have been implemented on AWIPS, but with a condensed format necessitated by the capabilities of the communications gateway and display capabilities of AWIPS. See fig. 13 for a sample bulletin and Table 1 for the list of points having spectral wave bulletins, their locations, and their bulletin headers.

The ocean wave guidance is generated four times daily out to 168 hours based on the 0000, 0600, 1200 and 1800 UTC cycles of the Global Spectral Forecast System (GFS; Kanamitsu *et al.* 1991; Caplan *et al.* 1997).

2. NOAA WAVEWATCH III (NWW3) OCEAN WAVE FORECAST MODEL

Global ocean wave forecasts are operationally generated at the NCEP by using the NWW3 model. Fields of directional frequency spectra in 24 directions and 25 frequencies are generated at hourly 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 NWW3 are given by bin in Table 2.

Wave spectral data are computed on a 1.25 by 1.00 degree longitude/latitude grid for ocean points between latitude 78.0 degrees North to 78.0 degrees South. Wind fields are the only driving force used in the model. They are constructed from spectral coefficients of the lowest sigma layer winds from the NCEP analysis and forecasts of the GFS with no interpolation to the model grid required. The winds are then adjusted to a height of 10 m by using a logarithmic profile corrected for stability with air-sea temperature differences. Analyzed wind fields from the previous 12 hours at 3-h intervals are used for a 12-h wave hindcast. Winds from the GFS at 3-h intervals out to 168 hours are used to produce hourly wave forecasts out to 168-h which are produced four times daily from the 0000, 0600, 1200 and 1800 UTC cycles.

3. AVAILABLE PRODUCTS AND DISSEMINATION

The ocean surface waves are calculated for grid points covering the whole globe, excluding land, the North and South pole areas, and inland water bodies, such as Great Lakes, Chesapeake Bay, Mediterranean Sea, *etc*. The calculated waves are disseminated in alphanumeric format via AWIPS in GRIB format via AWIPS.

a. Spectral text bulletins on the web

Spectral text bulletins are presented for numerous points of NWW3. These bulletins are in ASCII and are available on the INTERNET at present. The line length of the table is 130 characters by 160 lines (see Fig. 14). 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 identified with a wave height greater that 0.05 m (n), and the number of such fields with a wave height over 0.15 m that could not be tracked in the remainder of the table (x). Individual wave fields in the spectrum are identified using a partitioning scheme similar to that of Gerling (1992). In the remaining six columns individual wave fields are tracked with their 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 individual 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. 13, and the list of points for the NWW3 is given in Table 1.

d. GRIB bulletins

GRIB bulletins are available for use in AWIPS. 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, $_m$, T_m, peak wave direction and period, wind sea peak wave direction and period, and u and v components of the wind velocity. A 1.25 ^{o} x 1.00^o lon./lat. grid is used with a domain from 0 ^{o} - 360^{o}E and 78^{o}N to 78^{o}S.

4. EVALUATION

Extensive evaluation of the NWW3 model has been carried out by comparing with buoy data and ERS2 altimeter data. These results are available at http://polar.wwb.noaa.gov/waves/.

5. REFERENCES

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1. [1] OMB Contribution No. 217

2. [2] H. L. Tolman is a contractor with SAIC.

3. [3]A third generation wave model solves the radiative transfer equation by direct integration of all its components without pre-assumed constraints to the spectral shape. Previous models rely (partially) on assumed spectral shapes and parameterizations of the integral effects of the physics of wave growth and decay.

Table 1. Name, location, and header information for spectral text bulletins associated with the NWW3 global wave model.

Station Name	Position (N and W, except where indicated)		AWIPS and WMO Header
	Latitude	Longitude	
Points for Wave Spectra from the NOAA WAVEWATCH III (NWW3) Global Wave Model			
Northwest Atlantic Points			
44004	38.50	70.70	AGNT41 KWBJ OSBN01
44008	40.50	69.40	AGNT41 KWBJ OSBN02
44011	41.10	66.60	AGNT41 KWBJ OSBN03
44138	44.23	53.63	AGNT41 KWBJ OSBN04
44141	42.06	56.15	AGNT41 KWBJ OSBN05
44142	42.47	62.25	AGNT41 KWBJ OSBN06
Southwest Atlantic Points			
41001	34.70N	72.60W	AGNT42 KWBJ OSBN01
41002	32.30	75.20	AGNT42 KWBJ OSBN02
Gulf of Mexico Points			
42001	25.92	89.68	AGGX44 KWBJ OSBN01
42002	25.17	94.42	AGGX44 KWBJ OSBN02
42003	25.95	85.88	AGGX44 KWBJ OSBN03
Eastern Pacific Points			
46002	42.50	130.30	AGPZ46 KWBJ OSBN01
46005	46.10	131.00	AGPZ46 KWBJ OSBN02
46006	40.90	137.50	AGPZ46 KWBJ OSBN03
46059	38.00	130.00	AGPZ46 KWBJ OSBN04
Canadian Points			
46036	48.35	133.92	AGPZ47 KWBJ OSBN01
Eastern Gulf of Alaska Points			
46184	53.90	138.87	AGGA47 KWBJ OSBN02
46004	50.97	135.80	AGGA47 KWBJ OSBN03
Western Gulf of Alaska and Bering Sea Points			
46001	56.30	148.30	AGGA48 KWBJ OSBN01
46066	52.65	155.00	AGGA48 KWBJ OSBN02
Bering Sea Points			
46035	57.00	177.70	AGPN48 KWBJ OSBN01

South Pacific Points			
TPC01	15.00 S	85.00	AGPS40 KWBJ OSBN01
TPC02	15.00 S	110.00	AGPS40 KWBJ 0SBN02
TPC03	15.00 S	135.00	AGPS40 KWBJ OSBN03
Pago_Pago	15.00S	168.75	AGPS40 KWBJ OSBN07
Papeete	19.00S	149.60	AGPS40 KWBJ OSBN08
Rarotonga	21.20S	159.80	AGPS40 KWBJ OSBN09
Niue	19.10S	169.90	AGPS40 KWBJ OSBN10
Nukunono	9.20S	171.90	AGPS40 KWBJ OSBN11
Tongatapu	22.00S	175.00	AGPS40 KWBJ OSBN12
Funafuti	8.50S	179.20E	AGPS40 KWBJ OSBN13
maintain Nadi	18.00S	176.25E	AGPS40 KWBJ OSBN14
Port_Vila	18.00S	167.50E	AGPS40 KWBJ OSBN15
Noumea	24.00S	167.50E	AGPS40 KWBJ OSBN16
Nauru	00.50S	167.00E	AGPS40 KWBJ OSBN17
Equatorial Points			
TPC04	00.00	93.75	AGXT40 KWBJ OSBN01
51028	00.00	153.88	AGXT40 KWBJ OSBN02
Hawaiian Points			
51001	23.40	162.30	AGHW40 KWBJ OSBN01
51002	17.20	157.80	AGHW40 KWBJ OSBN02
51003	19.10	160.80	AGHW40 KWBJ OSBN03
51004	17.40	152.50	AGHW40 KWBJ OSBN04
Midway	28.20	177.4	AGHW40 KWBJ OSBN06
FF_Shoals	23.90	166.30	AGHW40 KWBJ OSBN07
Johnston	16.70	169.50	AGHW40 KWBJ OSBN08
Western Pacific Points			
Saipan	16.00	147.50E	AGPW40 KWBJ OSBN01
Guam	12.00	143.75E	AGPW40 KWBJ OSBN02
Wake	19.50	166.50E	AGPW40 KWBJ OSBN03

Palau	9.00	136.25E	AGPW40 KWBJ OSBN04
Yap	9.60	138.00E	AGPW40 KWBJ OSBN05
Chuuk	8.00	152.50E	AGPW40 KWBJ OSBN06
Pohnpei	7.00	157.50E	AGPW40 KWBJ OSBN07
Kosrae	5.10	163.00E	AGPW40 KWBJ OSBN08
Majuro	8.00	171.25E	AGPW40 KWBJ OSBN09
Enewetak	13.00	163.75E	AGPW40 KWBJ OSBN10
Tarawa	1.00	174.00E	AGPW40 KWBJ OSBN11

Notes:

1. The WMO/AWIPS headers follow the form given for oceanographic data, *i.e.*, $AGA_1A_2i_1i_2$, where i_1 is 4 and always means spectral wave data.

2. i_2 is the geographic location, where:
   0 - means Pacific Ocean, particularly in proximity to U.S. held islands (Hawaii and Guam's areas of responsibility)
   1 - means proximity to NE Atlantic States from Virginia northward
   2 - means proximity to SE Atlantic States from North Carolina southward and Puerto Rico
   4 - means proximity to southern Gulf of Mexico states
   6 - means proximity to Pacific States and southern British Columbia
   7 - means proximity to Panhandle of Alaska and northern British Columbia (Juneau's areas of responsibility)
   8 - means proximity to southern and southwestern Alaska (Anchorage's areas of responsibility)

3. A_1A_2 is used by the originating office (NCEP/NCO) to identify the oceanic area of the point, where:
   NT - Western Atlantic
   GX - Gulf of Mexico
   CA - Caribbean Sea
   PZ - Eastern Pacific
   GA - Gulf of Alaska
   PN - North Pacific including Bering Sea
   AC - Arctic Ocean
   HW - Hawaiian Waters
   PW - Western Pacific
   XT - Tropical Belt
   PS - South Pacific

4. The AWIPS identifier form is NNNxxx: where NNN is OSB - Oceanographic Spectral Bulletin, and xxx takes the form: mnn - where m is the wave model and nn is the number of the point in a given geographic location according to note 2 above. nn can range from 01 - 99.

5. m is the wave model where:
   N is the NOAA WAVEWATCH III global wave model
   A is the Alaska Waters regional wave model
   W is the Western North Atlantic regional wave model
   H is the North Atlantic Hurricane regional wave model
   E is the Eastern North Pacific regional wave model
   P is the North Pacific Hurricane regional wave model
   X is the Western North Pacific regional wave model
   T is the Western Pacific Typhoon regional wave model

Table 2. The center frequencies and corresponding band widths with center period by frequency bin.

bin number	center frequency (Hz)	frequency band width (Hz)	center period (s)
1	.0418	.00399	23.94
2	.0459	.00439	21.76
3	.0505	.00482	19.79
4	.0556	.00531	17.99
5	.0612	.00584	16.35
6	.0673	.00642	14.87
7	.0740	.00706	13.51
8	.0814	.00777	12.29
9	.0895	.00855	11.17
10	.0985	.00940	10.15
11	.1083	.01034	9.23
12	.1192	.01138	8.39
13	.1311	.01251	7.63
14	.1442	.01376	6.93
15	.1586	.01514	6.30
16	.1745	.01666	5.73
17	.1919	.01832	5.21
18	.2111	.02015	4.74
19	.2322	.02217	4.31
20	.2555	.02438	3.91
21	.2810	.02682	3.56
22	.3091	.02951	3.24
23	.3400	.03246	2.94
24	.3740	.03570	2.67
25	.4114	.03927	2.43

Table 3. WMO GRIB bulletin header descriptors.

T_1	T_2[1]	A_1[2]	A_2	dd	Station id
O	A B C J K M N P Y	J	A C E G I J K L M X N Y O P Q Z R S T U	88	KWBJ

Where:

T_1 is the bulletin type descriptor: O - oceanographic.
T_2 is the parameter descriptor, see notes below.
A_1 is the grid and domain descriptor: J - 1.25° x 1.00° lon/lat grid over domain from 0 - 360E and 78N - 78S.
A_2 is the forecast hour descriptor, see notes below.
dd is the surface descriptor: 88 - ocean surface.

Notes:

1. Parameter descriptors

A - u-wind component
B - v-wind component
C - Total significant wave height
J - Peak wave period
K - Peak wave direction
M - Peak wind sea period
N - peak wind sea direction
P - D_m
Y - T_m

2. Forecast hour descriptors at 6-h intervals from 0- to 72-h and at 12-h intervals from 72- to 120-h.

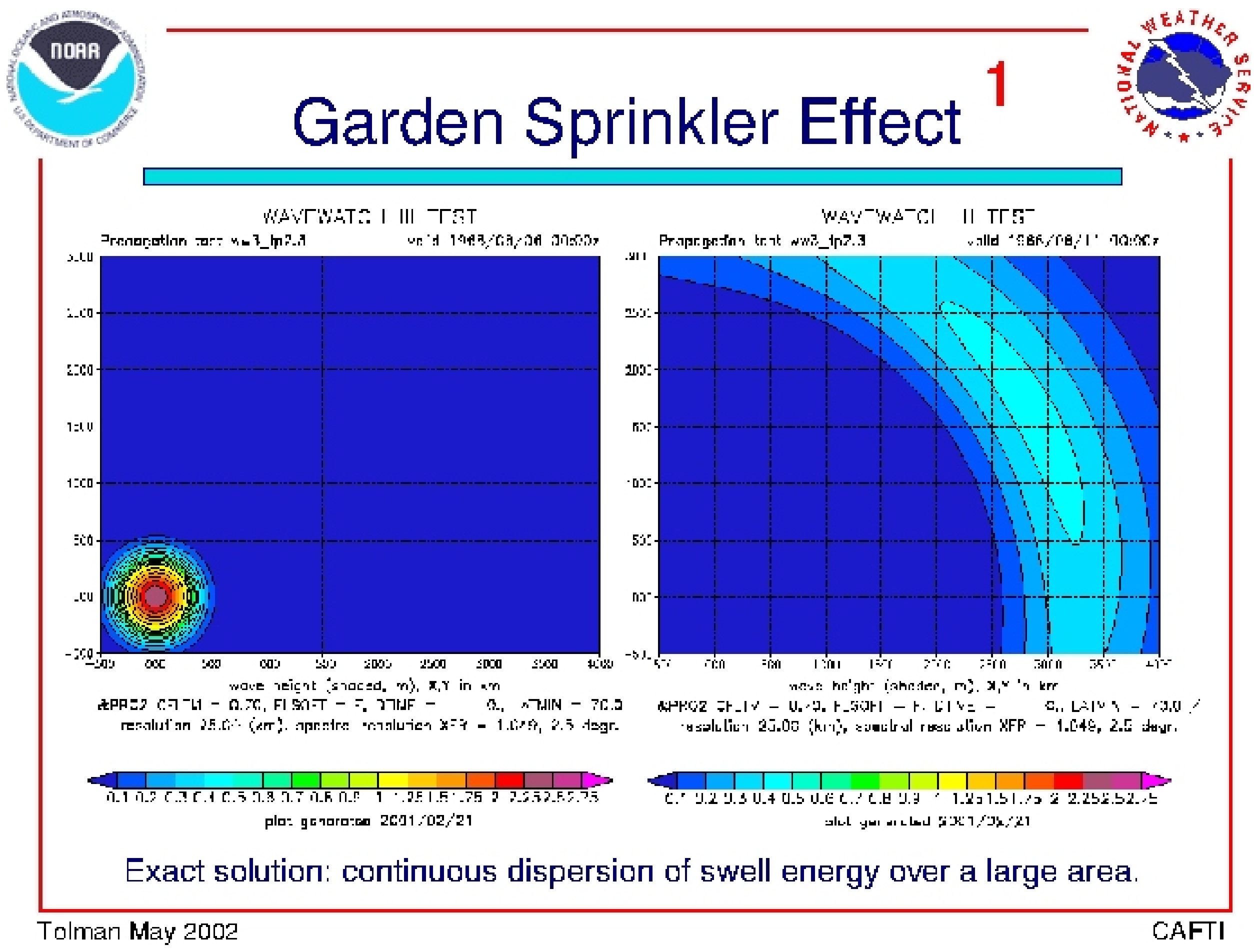

Figure 1. Exact solution of dispersion of swell energy over a large area.

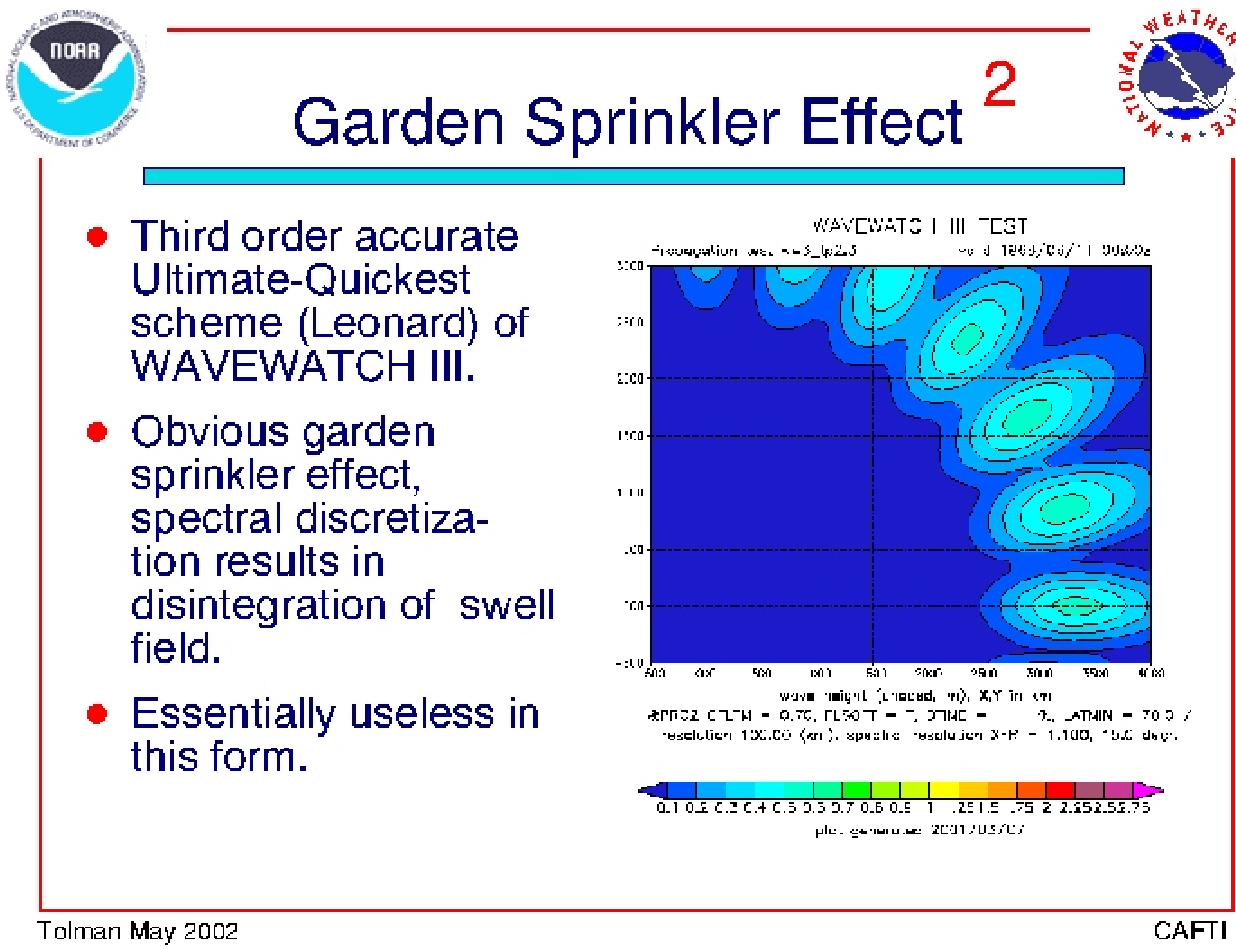

Figure 2. Disintegration of swell field due to spectral discretization of wave energy - the ‘ garden sprinkler’ effect.

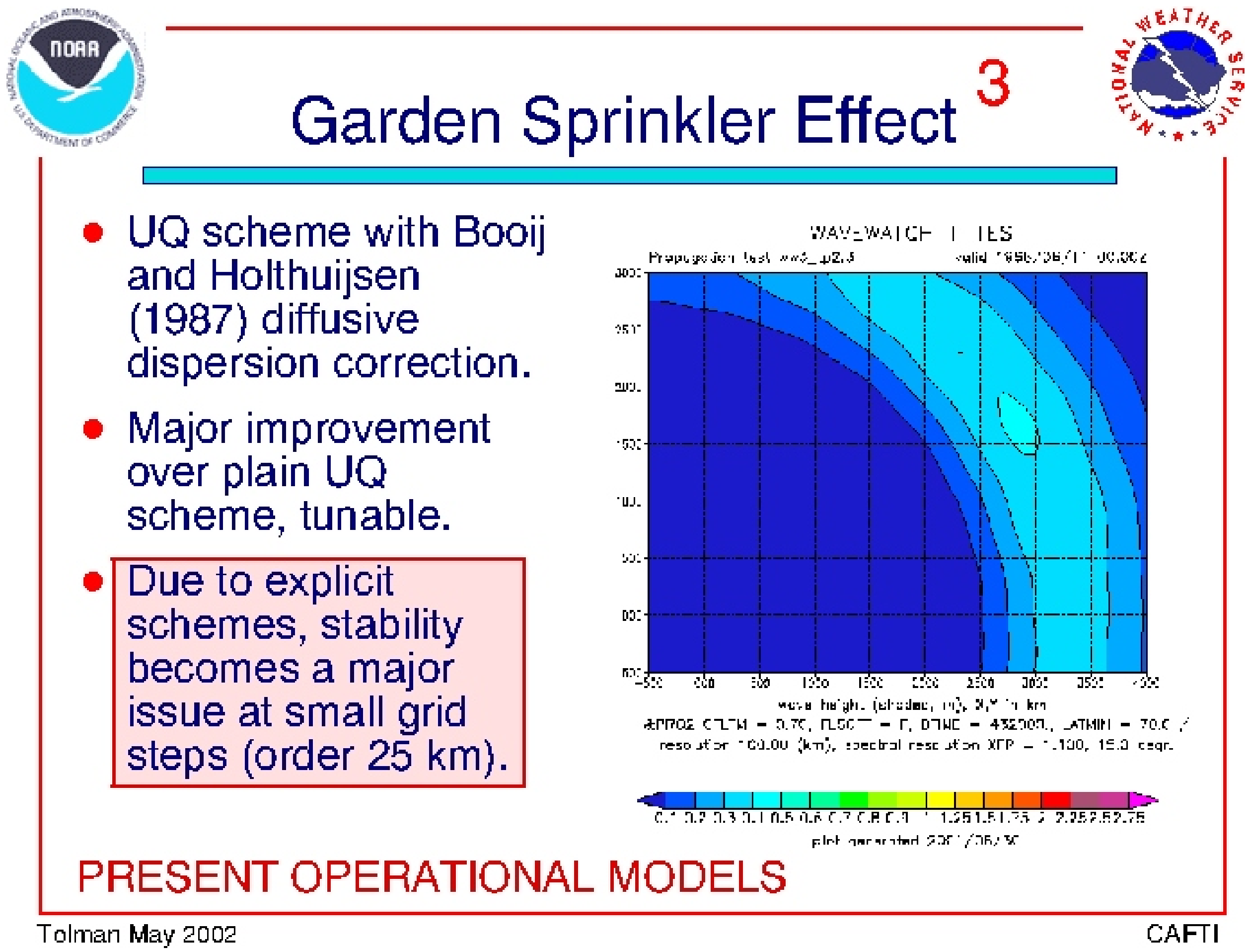

Figure 3. The Booij and Holthuijsen (1987) solution to the ‘garden sprinkler’ effect.

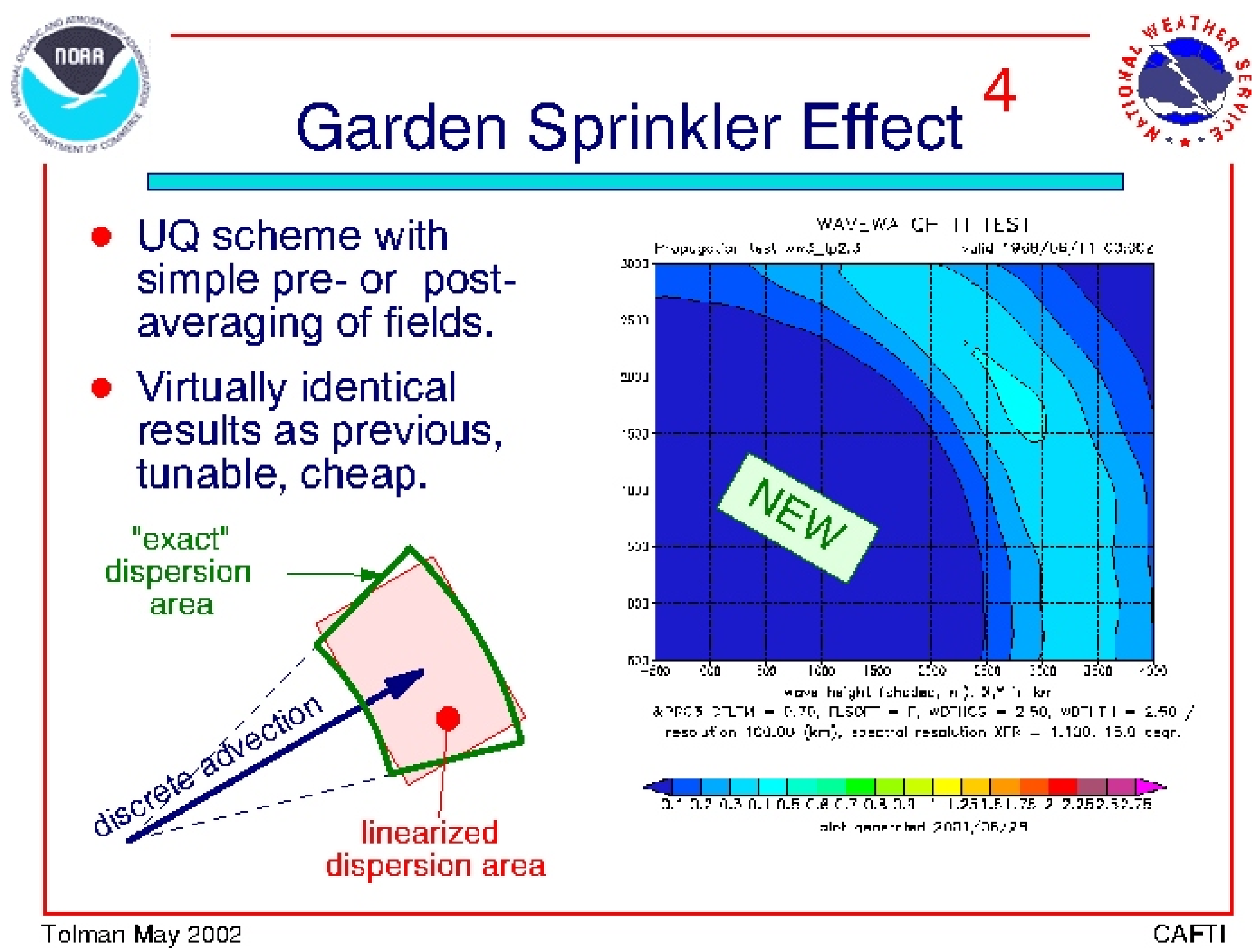

Figure 4. New method for handling the ‘garden sprinkler’ effect.

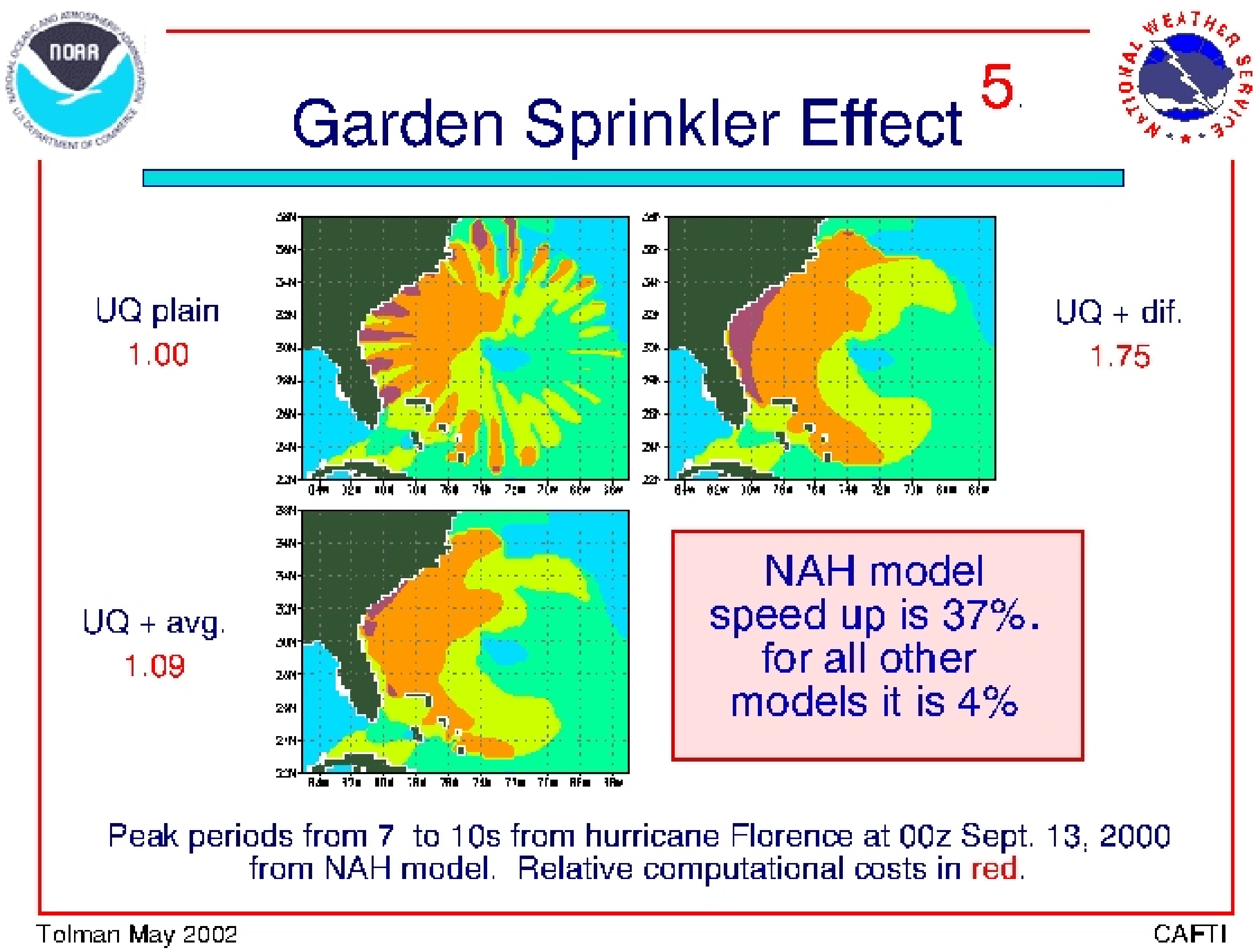

Figure 5. Comparison of methods to deal with the 'garden sprinkler' effect and the relative computational costs of each.

1

Islands

- Scatter index for Hs (rms error / avg obs) against ERS-2 altimeter data clearly shows where unresolved islands result in highly increased model errors. (NWW3, March - May 1998).

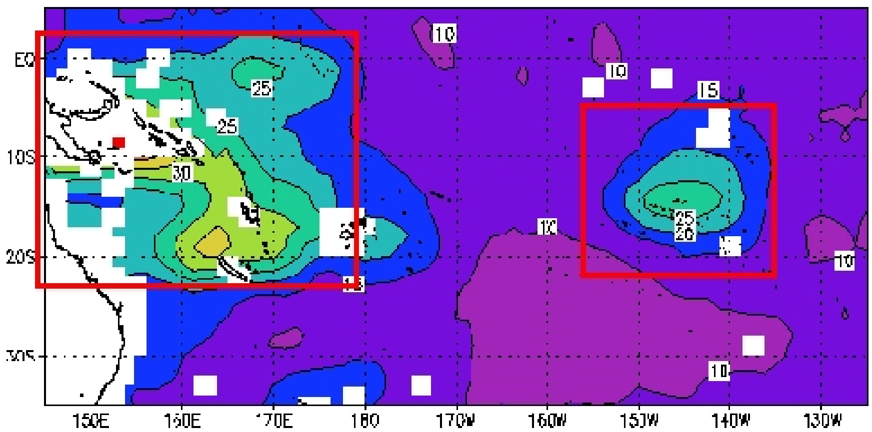

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Figure 6. Model errors induced by unresolved islands.

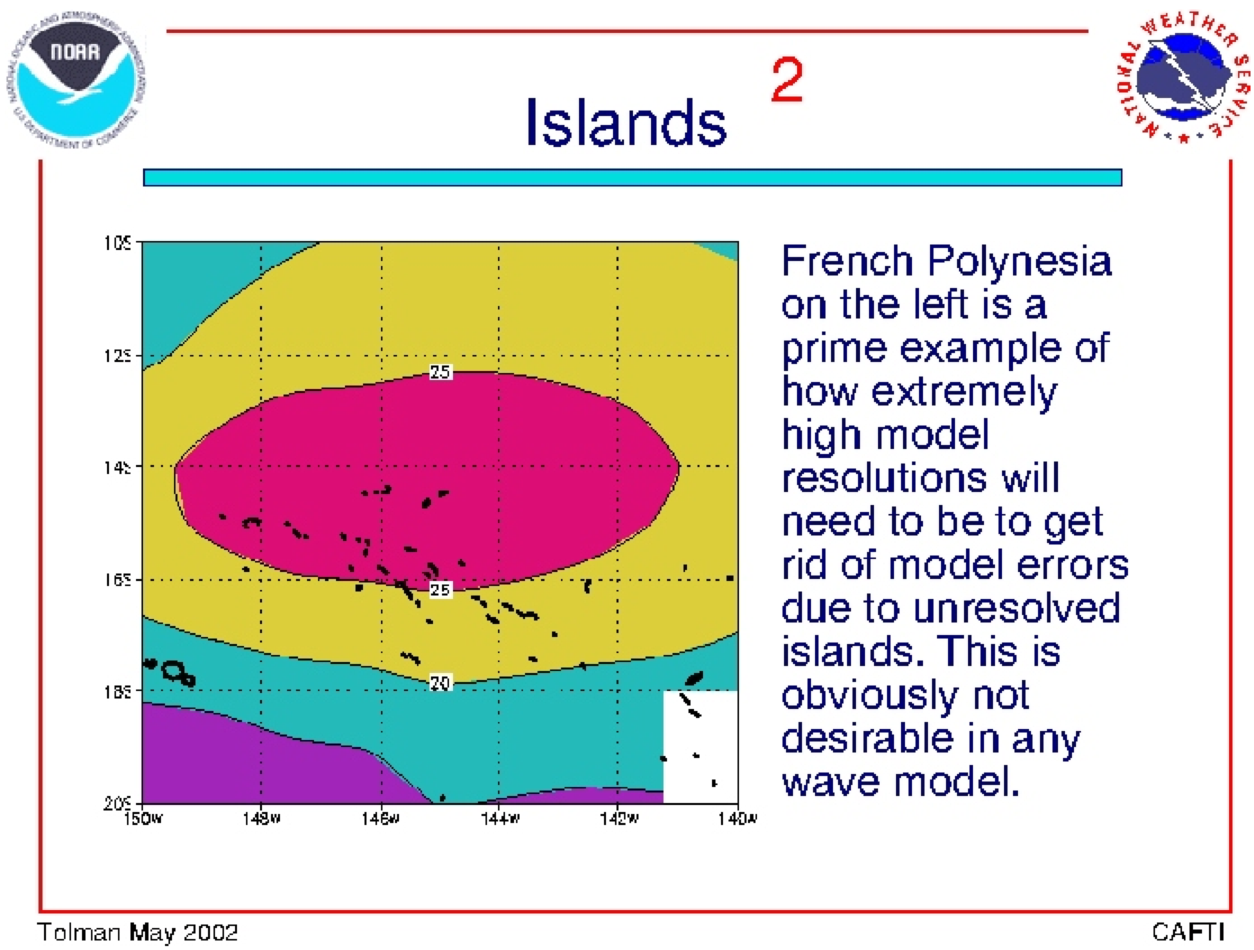


Figure 7. To resolve this island group would be unrealistically expensive, computationally.

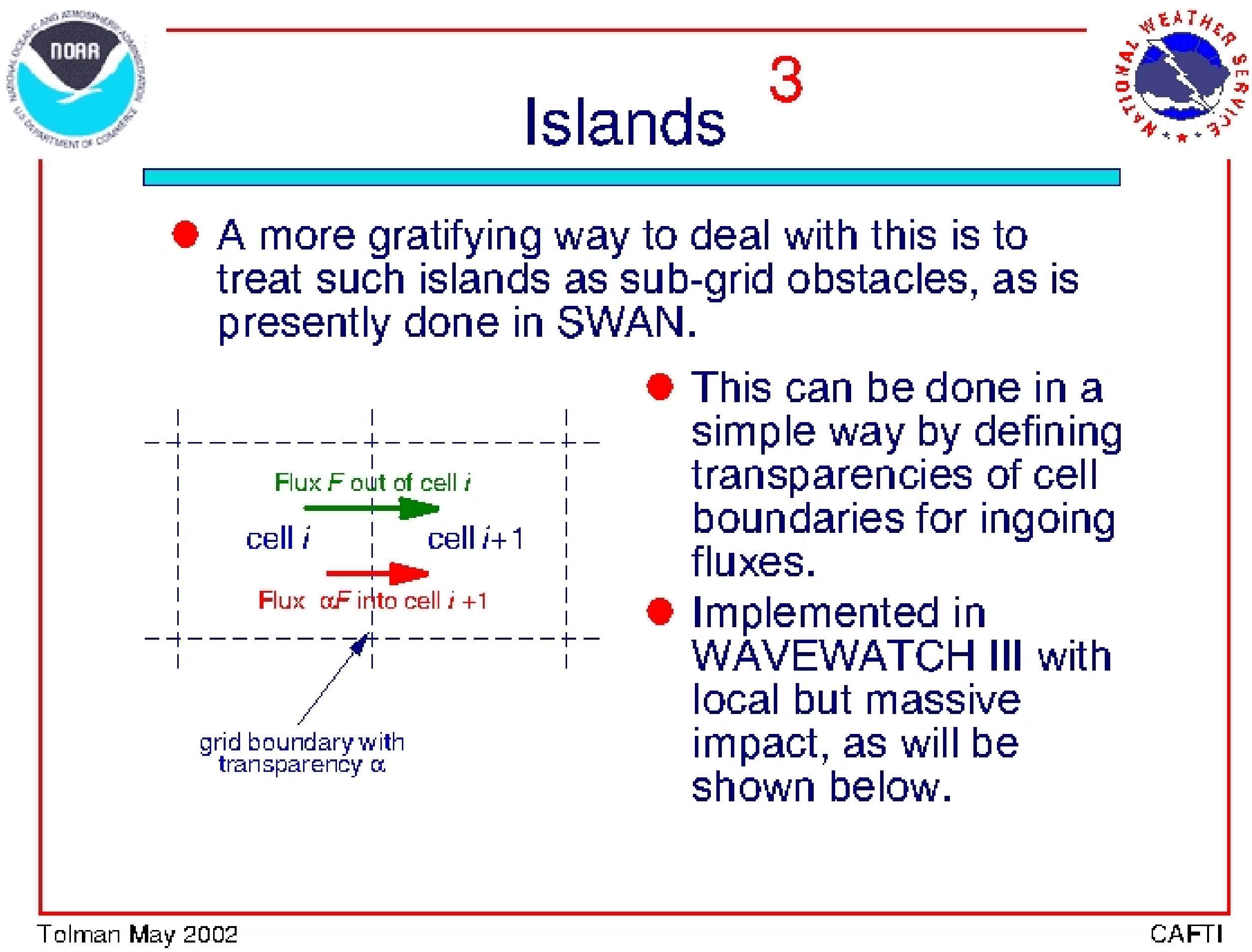
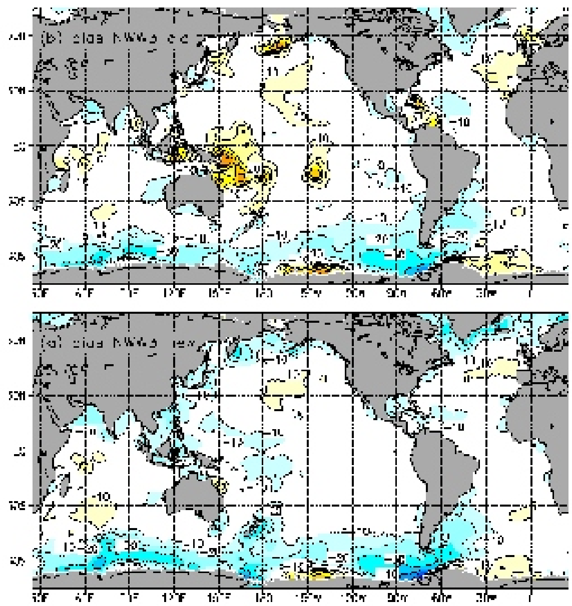


Figure 8. The sub grid obstacle approach to unresolved islands.

Final Results 1



Bias for NWW3 model wave height against ERS-2 in cm
without (top), and with (bottom) sub-grid islands

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Figure 9. Bias changes due to addition of sub grid islands.

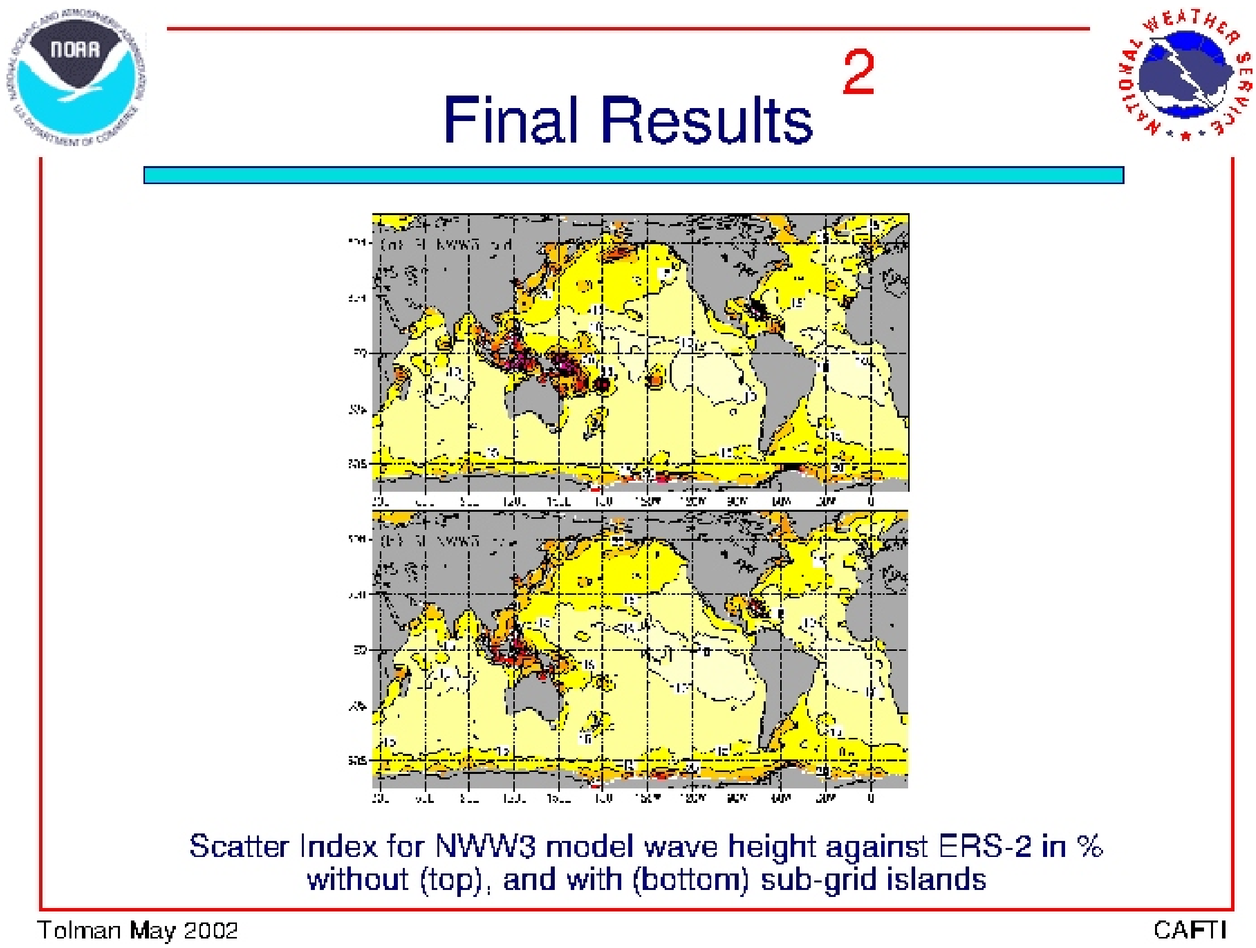
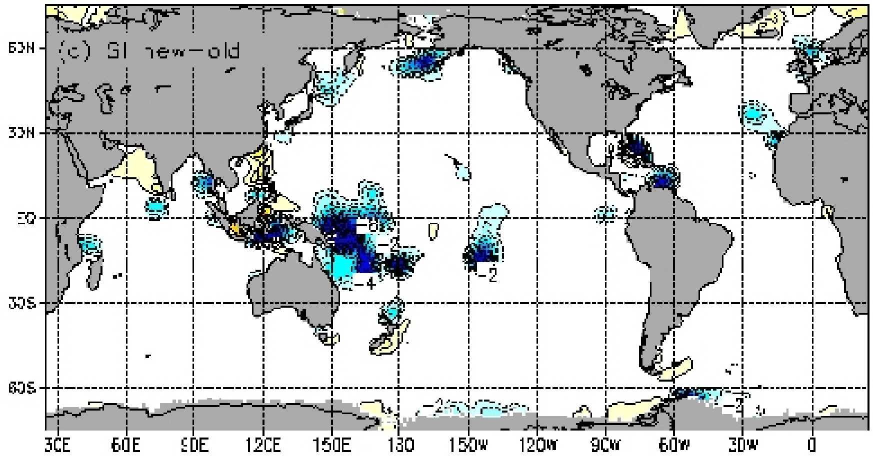


Figure 10. Scatter index plots without and with sub grid islands.

Final Results 3



Corresponding Scatter index differences, blues are improvements, contours at 2% intervals.

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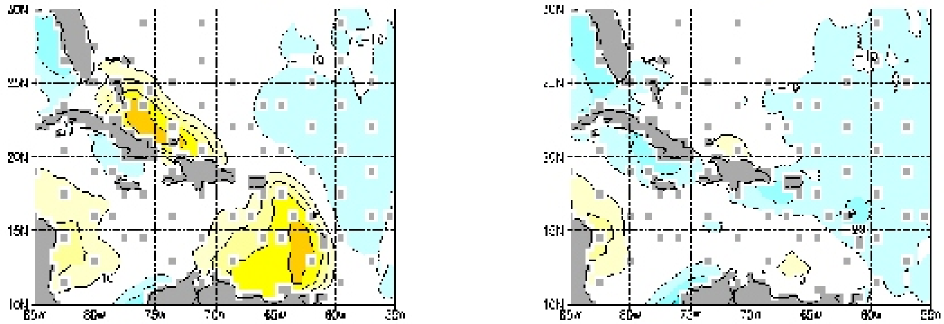
Figure 11. Differences in Scatter Index due to sub grid islands.

Final Results 4

bias without sub-grid islands

bias with sub-grid islands



WNA model has similarly massive local impact, as does AKW. Effects for most buoys (due to location) and against bulk altimeter data (due to local impact) generally negligible, and therefore not shown.

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Figure 12. Impact of sub grid islands on higher resolution models.

```
AGNT42 KWBJ 080418
OSBN02
LOCATION : 41002      (32.30N  75.20W)
MODEL    : NWW3 GLOBAL 1X1.25 DEGR.
CYCLE    : 20020508 T00Z
<
DDHH HS SS PP DDD SS PP DDD SS PP DDD SS PP DDD SS PP DDD SS PP DDD
-------------------------------------------------------------------
0712  4  4 07 061  1 08 133  1 03 175
0713  4  4 07 062  1 08 133  1 03 177
0714  4  4 07 063  1 08 133  1 03 178
0715  4  4 07 063  1 08 133  1 03 180
0716  4  4 07 064  1 08 133  1 03 181
0717  4  4 07 065  1 08 133            1 03 200  1 03 165
0718  4  4 07 066  1 08 133  1 03 185
0719  4  3 07 066  1 08 133  1 03 187
0720  4  3 07 067  1 08 133  1 03 189
0721  4  3 07 068  1 08 133  1 03 191
0722  4  3 07 069  1 08 132  1 03 193
0723  4  3 07 069  1 08 132  1 03 194
0800  3  3 07 070  1 08 132  1 03 196
0801  3  3 07 070  1 08 132  1 03 186  1 03 227
0802  3  3 07 071  1 08 132  1 03 185  1 03 229
0803  3  3 07 071  1 08 131  1 03 198
0804  3  3 07 072  1 08 131  1 02 209
0805  3  3 07 072  1 08 131  1 02 209
0806  3  3 07 073  1 08 131  2 04 209
0807  3  3 07 073  1 08 130  2 04 212
0808  3  2 07 075  1 08 132  2 04 215
0809  3  2 07 075  1 08 132  2 04 218
0810  3  3 08 088            2 04 221
0811  3  3 08 089            2 04 224
...................................................................
...................................................................
...................................................................
1413  3  1 09 089  2 06 019  1 09 064  1 02 221  2 06 137
1414  3  1 09 080  2 06 019            1 02 218  2 06 137
1415  3  1 09 080  2 06 019            1 02 222  2 06 137
1416  3  1 09 080  2 06 019            1 03 223  2 06 136
1417  3  1 09 081  2 06 019            1 03 220  2 06 135
1418  3  1 09 081  2 06 019            1 02 215  2 06 135
1419  3  1 09 082  1 06 019            1 02 213  2 06 136
1420  3  1 09 082  1 06 019            1 02 213  2 06 135
1421  3  1 09 082  1 06 019            1 02 214  2 06 135
1422  3  1 09 083  1 06 018            1 03 219  2 06 135
1423  3  1 09 083  1 06 018            1 04 220  2 06 135
1500  3  1 09 083  1 06 018            1 03 232  2 06 134
-------------------------------------------------------------------
DD  = DAY OF MONTH
HH  = HOUR OF DAY
HS  = TOTAL SIGNIFICANT WAVE HEIGHT (FEET)
SS  = SIGNIFICANT WAVE HEIGHT OF SEPARATE SYSTEM (FEET)
PP  = PEAK PERIOD OF SEPARATE SYSTEM (WHOLE SECONDS)
DDD = MEAN DIRECTION OF SEPARATE SYSTEM (DEGREES/"FROM")
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Figure 13. Sample wave spectra from the NWW3. These bulletins give a 12-h hindcast as well as a 168-h forecast at 1-h intervals. Only a portion of the bulletin is shown here.

Location : 51001 (23.40N 162.30W)
Model : NWW3 global 1x1.25 degr.
Cycle : 19990120 t12z

day & hour	Hst (m)	n x - -	Hs Tp dir (m) (s) (d)	Hs Tp dir (m) (s) (d)	Hs Tp dir (m) (s) (d)	Hs Tp dir (m) (s) (d)	Hs Tp dir (m) (s) (d)	Hs Tp dir (m) (s) (d)
20 0	2.8	5	2.5 12.9 130	1.1 8.4 287	.2 11.1 359	.2 11.8 194		
20 1	2.8	5	2.5 12.7 130	1.1 8.4 287	.2 11.1 359	.2 11.8 195		
20 2	2.7	5	2.5 12.6 129	1.1 8.4 287	.2 11.1 359	.2 11.7 195		
20 3	2.7	5	2.5 12.5 129	1.1 8.4 287	.2 11.1 359	.2 11.7 196		
20 4	2.7	6	2.5 12.4 129	1.1 8.3 287	.2 11.0 359	.2 11.6 196		
20 5	2.7	6	2.4 12.3 128	1.1 8.3 287	.2 11.0 359	.2 11.5 194		
20 6	2.7	6	2.4 12.3 128	1.1 8.3 287	.2 11.0 359	.2 11.4 195		
20 7	2.7	6	2.4 12.2 128	1.1 8.3 287	.2 11.0 359	.2 11.4 195		
20 8	2.7	6	2.5 12.2 128	1.1 8.3 287	.2 11.0 359	.2 11.3 196		
20 9	2.7	5	2.5 12.2 128	1.0 8.3 287	.2 11.0 358	.2 11.3 196		
20 10	2.8	5	2.6 12.2 128	1.0 8.3 287	.2 10.9 358	.2 11.3 196		
20 11	2.9	5	2.6 12.2 129	1.0 8.3 287	.2 10.9 358	.2 11.3 197		
20 12	3.0	6	2.5 12.2 128	1.0 8.2 287	.2 10.9 3	.2 11.3 197	1.2 16.2 133	
20 13	3.1	6	2.3 12.0 128	1.0 8.2 287	.2 10.9 3	.2 11.3 197	1.7 15.5 132	
20 14	3.2	6	2.3 12.0 128	1.0 8.2 287	.2 10.8 3	.2 11.3 198	1.9 15.6 132	
20 15	3.4	6	2.4 12.1 128	1.0 8.2 287	.2 10.6 3	.2 11.3 198	2.1 15.7 132	
20 16	3.5	6	2.4 12.1 128	1.0 8.2 287	.2 10.5 3	.2 11.3 198	2.3 15.7 132	
20 17	3.6	6		1.0 8.1 287		.2 11.3 199	3.5 15.7 130	
20 18	3.8	6		1.0 8.1 287		.2 11.3 199	3.6 15.7 130	
20 19	3.9	6		1.0 8.1 287		.2 11.3 199	3.8 15.7 130	
20 20	4.0	6		1.0 8.1 287		.2 11.3 200	3.9 15.6 130	
20 21	4.1	6		1.0 8.0 287		.2 11.3 200	4.0 15.4 130	
20 22	4.1	6		1.0 8.0 288		.2 11.3 200	4.0 15.3 130	
20 23	4.2	6		.9 8.0 288		.2 11.3 200	4.1 15.1 130	
21 0	4.2	6		.9 7.9 288		.2 11.3 200	4.1 15.0 129	
21 1	4.3	7		.9 7.9 288		.2 11.2 200	4.2 14.9 129	
21 2	4.3	7		.9 7.8 288		.2 11.2 201	4.2 14.8 129	
21 3	4.3	7		.9 7.8 288		.2 11.2 201	4.2 14.8 129	
21 4	4.3	7		.9 7.8 288		.2 11.2 201	4.2 14.7 128	
21 5	4.3	6	.2 15.2 11	.9 7.7 288		.2 11.2 200	4.2 14.7 128	
21 6	4.3	6	.2 15.2 11	.9 7.7 288		.2 11.2 200	4.2 14.6 128	
21 7	4.2	6	.2 15.2 11	.9 7.7 288		.2 11.1 200	4.1 14.6 128	
21 8	4.2	6	.2 15.2 11	.9 7.7 288		.2 11.1 199	4.1 14.6 128	
21 9	4.2	6	.2 15.2 11	.9 7.6 288		.2 11.1 199	4.1 14.5 128	
21 10	4.1	6	.2 15.3 11	.8 7.6 288		.2 11.1 199	4.0 14.5 128	
21 11	4.1	6	.2 15.3 11	.8 7.6 288		.2 11.0 198	4.0 14.5 128	
21 12	4.0	7	.2 15.3 11	.8 7.6 288	* .4 3.3 245	.2 11.0 197	3.9 14.4 128	
21 13	4.0	7	.2 15.4 11	.8 7.6 289	* .5 3.4 248	.2 11.0 197	3.9 14.4 129	
21 14	3.9	7	.2 15.4 11	.8 7.6 290	* .6 3.8 250		3.8 14.4 129	
21 15	3.9	7	.2 15.4 11	.8 7.6 289	* .7 4.0 253	.6 4.0 201	3.7 14.3 128	
21 16	3.9	7	.2 15.5 11	.8 7.6 289	* .8 4.2 255	.7 4.2 203	3.6 14.3 128	
21 17	3.8	7	.2 15.5 11	.7 7.6 290	* .9 4.4 257	.7 4.5 205	3.6 14.3 129	
21 18	3.8	7	.2 15.5 11	.7 7.5 289	* .9 4.6 266	* .9 4.9 214	3.5 14.3 129	
21 19	3.8	6	.2 15.5 11	.7 7.5 290	* 1.0 4.8 267	* 1.0 5.1 214	3.4 14.2 129	
21 20	3.7	5	.2 15.5 8	.7 7.5 289	* 1.1 5.0 268	* 1.1 5.5 214	3.3 14.2 130	
21 21	3.7	5	.2 15.4 8	.7 7.4 288	* 1.1 5.2 268	1.2 5.8 211	3.2 14.1 129	
21 22	3.7	5	.2 15.4 8	.7 7.4 289	* 1.2 5.5 268	* 1.2 5.9 215	3.2 14.1 131	

21 23	3.7 3	.2 15.3 8				3.1 14.0 130	* 2.0 6.1 242
22 0	3.7 5	.2 15.3 9	* 1.5 5.8 274	1.5 6.4 210		3.0 14.0 130	
22 1	3.7 4	.2 15.2 9			* 2.2 6.5 240	3.0 13.9 131	
22 2	3.7 5	.2 15.2 9	.9 8.2 165		* 2.3 6.7 239	2.7 13.8 128	
22 3	3.7 5	.2 15.1 9	1.0 8.4 164		* 2.4 6.8 237	2.6 13.8 127	
22 4	3.7 4	.2 15.1 9			* 2.7 7.1 226	2.6 13.7 127	
22 5	3.8 4	.2 15.0 9			* 2.8 7.2 227	2.5 13.6 128	
22 6	3.8 5	.2 15.0 11			* 3.0 7.3 228	2.4 13.6 128	
22 7	3.8 5	.2 14.9 11			* 3.1 7.4 229	2.3 13.5 128	
22 8	3.9 4	.2 14.9 11			* 3.2 7.5 229	2.2 13.5 128	
22 9	3.9 4	.2 14.9 11			* 3.3 7.6 230	2.1 13.4 129	
22 10	4.0 5	.2 14.5 7			* 3.4 7.7 231	2.1 13.4 129	
22 11	4.0 5	.2 14.5 7			* 3.5 7.7 232	2.0 13.3 129	
22 12	4.1 5	.2 14.5 8			* 3.6 7.7 234	1.9 13.3 129	
22 13	4.1 5	.2 14.5 8			* 3.7 7.8 235	1.9 13.3 130	
22 14	4.2 5	.2 14.5 8			* 3.8 7.9 236	1.8 13.2 130	
22 15	4.2 5	.2 14.5 8			* 3.8 8.0 237	1.7 13.2 130	
22 16	4.2 5	.2 14.5 8			* 3.9 8.2 238	1.7 13.2 131	
22 17	4.3 5	.2 14.5 9			* 3.9 8.3 239	1.6 13.1 131	
22 18	4.3 5				* 4.0 8.3 240	1.5 13.1 132	
22 19	4.3 4				* 4.0 8.3 241	1.5 13.1 132	
22 20	4.3 4				* 4.0 8.4 242	1.4 13.0 132	
22 21	4.3 4				* 4.1 8.4 243	1.4 12.9 133	
22 22	4.3 4				* 4.1 8.4 245	1.3 12.9 133	
22 23	4.3 4				* 4.1 8.4 246	1.3 12.7 134	
23 0	4.4 4				* 4.2 8.4 247	1.2 12.6 134	
23 1	4.4 4				* 4.2 8.5 248	1.1 12.5 134	
23 2	4.4 4				* 4.3 8.5 250	1.1 12.4 135	
23 3	4.5 5				* 4.4 8.5 251	1.0 12.4 135	
23 4	4.5 5				* 4.4 8.6 252	1.0 12.3 136	
23 5	4.6 5				* 4.5 8.6 252	1.0 12.3 137	
23 6	4.6 5				* 4.5 8.7 253	.9 12.2 137	
23 7	4.6 5				* 4.6 8.8 253	.9 12.2 138	
23 8	4.7 5	.2 15.0 31			* 4.6 8.9 254	.9 12.1 142	
23 9	4.7 5	.2 15.0 31			* 4.6 9.0 255	.8 12.1 143	
23 10	4.8 4	.2 14.9 31			* 4.7 9.1 255	.8 12.1 143	
23 11	4.8 4	.2 14.9 31			* 4.7 9.1 255	.8 12.0 144	
23 12	4.8 4	.2 14.9 31			* 4.7 9.2 256	.7 12.0 145	

Hst : Total significant wave height.
n : Number of fields with Hs > .05 in 2-D spectrum.
x : Number of fields with Hs > .15 not in table.
Hs : Significant wave height of separate wave field.
Tp : Peak period of separate wave field.
dir : Mean direction of separate wave field.
* : Wave generation due to local wind probable.

Figure 14. Sample spectral text bulletin as it is found on the INTERNET.