NOAA WAVEWATCH III

NCEP's operational ocean wave model

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Outline

- ✔ What is a wave model ...
  (excerpts from the web page primer)
- ✔ NCEP ocean wave guidance
  - ➤ past
  - ➤ present
  - ➤ future
- ✔ Strong and weak point of new models
- ✔ Products
  - ➤ what
  - ➤ how to get

Wind waves 1

- Wind waves are the waves at sea that are generated by local or distant winds. Waves generated locally are usually referred to as wind sea. Waves generated at distant locations in the past are referred to as swell.
- Wind waves range in wave height from negligible to 30m (100ft) and more, and in length (distance between consecutive waves) from centimeters to 1 km.
- Corresponding wave periods (i.e., the time it takes for two consecutive waves to pass a given location) range from less than 1 second to about 25s.

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

Wind waves 2

- Although wind wave conditions generally change slowly, no two consecutive waves are identical. Furthermore, individual waves are so small that it would be practically impossible to predict every individual wave. Instead the wave field is described with average measures for wave heights.
- The commonly used wave height to describe the wave field is the significant wave height H_s, which is usually defined as the average wave height of the highest 33% of all individual waves. Because smaller waves are generally not seen against the background of the larger ones, this corresponds closely to the visually observed mean wave height.

primer

Wind waves 3

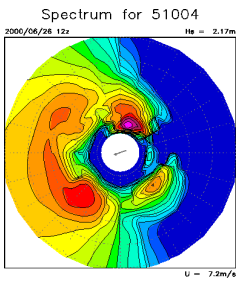
- Generally, it is assumed that individual wave heights can be described using a Rayleigh distribution. This implies that for a significant wave height H_s = 10m (33ft), one can expect :
  - ➢ 1 in 10 waves to be larger than 10.7m (36ft).
  - ➢ 1 in 100 waves to be larger than 15.1m (51ft).
  - ➢ 1 in 1000 waves to be larger than 18.6m (62ft).
- This implies that the largest individual wave that one might encounter in a storm is roughly twice as high as the significant wave height !
- In rapidly changing conditions the disparity between the significant wave height and the largest individual waves might even be larger.

primer

Wave spectra 1

In advanced wave observations and inside wave models, the wave field is not described with a single wave height, but with a so-called wave spectrum, which describes the distribution of wave energy over wave directions and frequencies at a fixed location.

A graphical representation of such a spectrum as can be found on the web page is shown here (buoy location 51004, SE of Hawaii).



primer

Wave spectra 4

The spectral plots from the wave model mostly give qualitative information. The corresponding quantitative information can be found in the bulletins.

A piece of such a bulletin is presented below. The first column gives date and hour, the second the overall wave height and number of identified individual wave fields. The next six columns (only two shown here) identify wave fields by height, period and direction.

```
Location : 51004      (17.40N 152.50W)
 Model    : NWW3 global 1x1.25 degr.
 Cycle    : 20000626 t00z
+-------+----------+-----------------+-----------------+
| day &  | Hst  n x |     Hs   Tp dir |     Hs   Tp dir |
|  hour  |  (m)  - - |    (m)  (s) (d) |    (m)  (s) (d) |
+-------+----------+-----------------+-----------------+
| 25 12  |  1.9  7  |    1.0 17.5  19 |    1.0  7.0 292 |
| 25 13  |  1.9  7  |    1.0 17.6  19 |    1.0  7.0 292 |
| 25 14  |  1.9  6  |    1.1 17.6  19 |    0.9  7.1 292 |
```

primer

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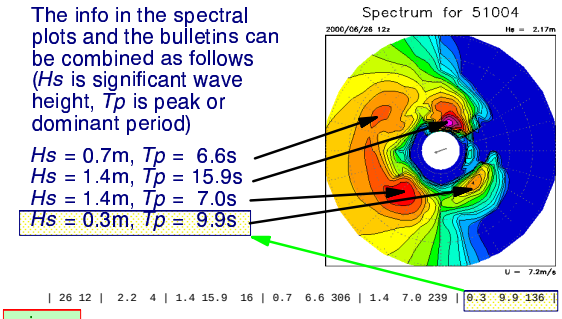
Wave spectra 5

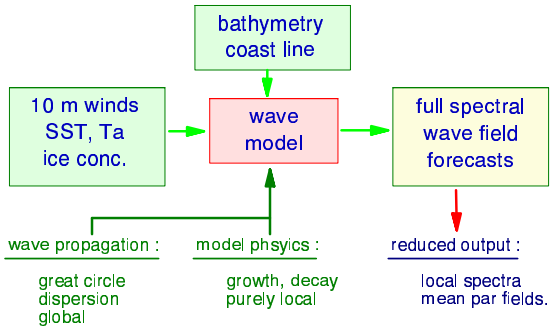
The info in the spectral plots and the bulletins can be combined as follows (*Hs* is significant wave height, *Tp* is peak or dominant period)

Hs = 0.7m, *Tp* = 6.6s
Hs = 1.4m, *Tp* = 15.9s
Hs = 1.4m, *Tp* = 7.0s
Hs = 0.3m, *Tp* = 9.9s



primer

Numerical wave models



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NCEP Guidance (past)

Up to March 9, 2000, the operational wave forecast suite of NCEP consisted of :

- Global WAM implementation at 2.5 x 2.5 degree resolution.
- Regional east coast WAM implementation at 0.25 x 0.25 degree resolution nested in a 1x1 degree basin model.
- Regional Gulf of Alaska model at 30 nm resolution (second generation model).

No longer availble in any form

NCEP Guidance (now) 1

- 1993-now, development of new wave model WAVEWATCH III (based on WAM) :
  - ✔ New governing equations :
    - ➤ Model ready for coupling to current models (Gulf Stream).
  - ✔ New physics parameterizations :
    - ➤ Chalikov and Belevich input.
    - ➤ Tolman and Chalikov dissipation.
  - ✔ New numerics :
    - ➤ Third order propagation.
    - ➤ Dynamically adjusted time steps.
  - ✔ MPI version.

http://polar.wwb.noaa.gov/waves[/wavewatch]

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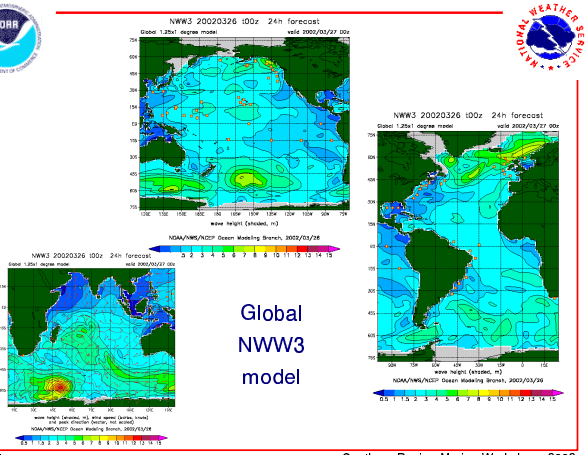
NCEP Guidance (now) 2

- NOAA WAVEWATCH III has replaced all previous operational wave models at NCEP by March 2000.
  - Global 1.25x1 degree NWW3 model (126 h forecast).
  - Regional Alaskan Waters model (AKW, 0.5x0.25 degree, 126 h forecast).
  - Regional Western North Atlantic model (WNA, 0.25 x 0.25 degree, 126 h forecast), with seasonal Hurricane version (78 h forecast).
  - All models use 24 directions, 25 frequencies, GDAS / AVN winds, 00z and 12z cycle runs, 12 hour hindcasts for continuity.

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



Tolman Southern Region Marine Workshops 2002

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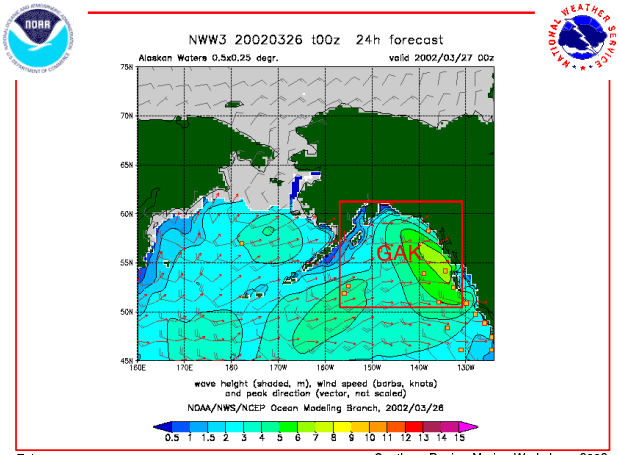

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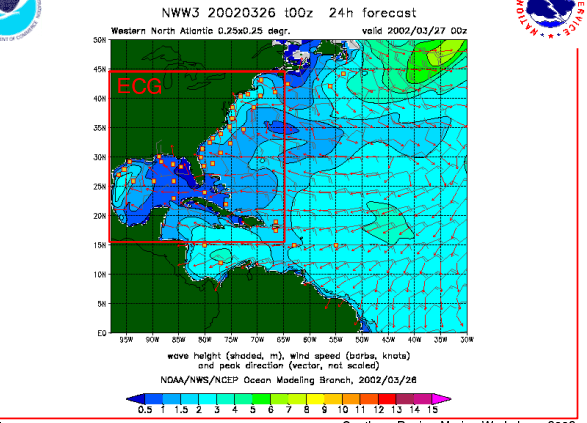

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NCEP Guidance (now) 3

- Why do we need a special Hurricane version (NAH) of the Western North Atlantic model (WNA).
  - Wave model can only be as good as the winds that drive it.
  - Hurricane winds are not done particularly well by the AVN due to resolution problems and due to limitations of the model physics.
  - Better results expected when higher resolution models are used such as the GFDL model.
  - Need for blended AVN/GFDL winds.

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

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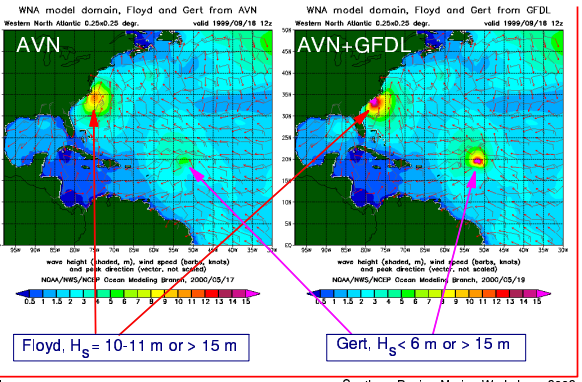
Hurricanes Floyd and Gert (Chao & Tolman)



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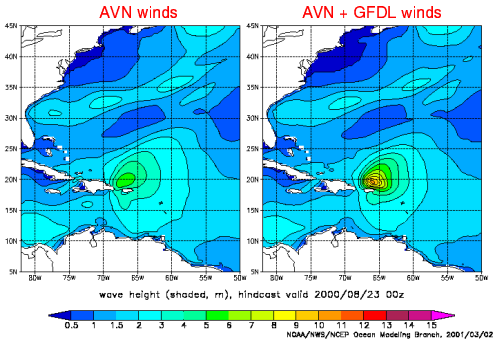
Debby significant wave height (m) 2000/08/22 00z



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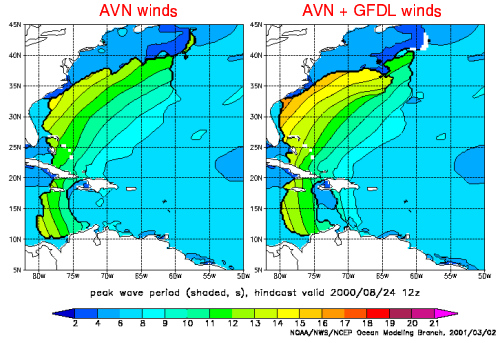
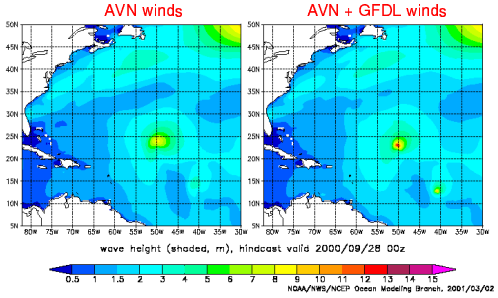
Debby peak wave period (s)
2000/08/23 12z (+ 36 h)

AVN winds | AVN + GFDL winds



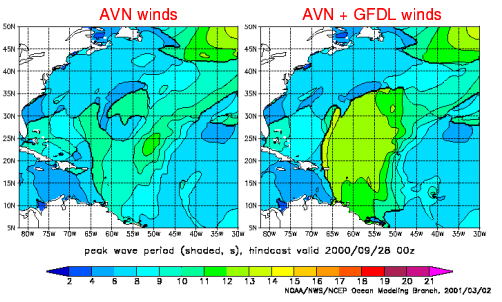
Isaac /Joyce significant wave height (m)
2000/09/28 00z

AVN winds | AVN + GFDL winds



Isaac / Joyce peak wave period (s)
2000/09/28 00z

AVN winds | AVN + GFDL winds



NCEP Guidance (future) 1

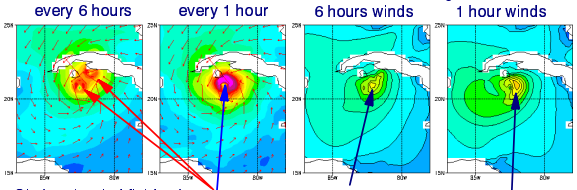
- The following changes and expansions of the model suite are expected :
  - Upgrade of blending scheme for NAH winds and upgrade time resolution of NAH wind fields to 1 hour (before June 1).
  - Eastern North Pacific (ENP) regional model. AVN version summer 2002, Hurricane version 2003.
  - Second release of WAVEWATCH III code..

http://polar.wwb.noaa.gov/waves/changes.html
http://polar.wwb.noaa.gov/NEW.waves

NCEP Guidance (future) 2

Michelle at 11/04/2001 15z

wind speeds: every 6 hours | every 1 hour
wave heights: 6 hours winds | 1 hour winds



Six hourly wind fields show two centers at off hour. These are in fact the centers at 12z and 18z, respectively. Unrealistic wind fields are caused by necessary interpolation, and do not occur with hourly winds..

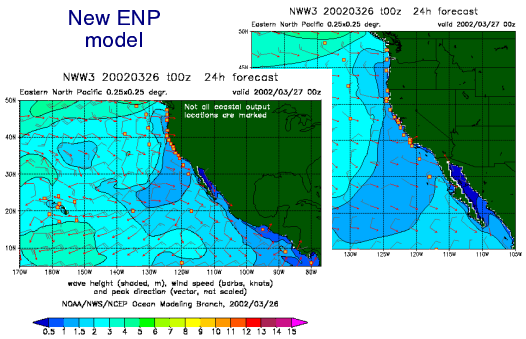
8-9 m

10 m

Wave heights from hourly winds are noisy and low. Wave heights from hourly fields are more consistent and higher.

NCEP Guidance (future) 3

New ENP model

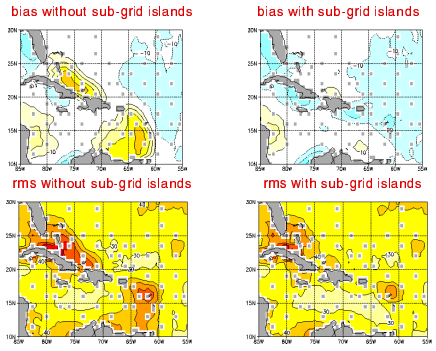


NCEP Guidance (future) 4

- The model itself is also subject to continuous development and tuning :
  - ✔ Fully allocatable FORTRAN 90 version.
  - ✔ Improved source term integration.
  - ✔ New propagation scheme, GSE, unresolved islands.
  - 5 Yr ✘ New phsysics.
  - ✓ ✘ Bug fixes, retuning.
- New version operational summer / fall 2002 ?

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

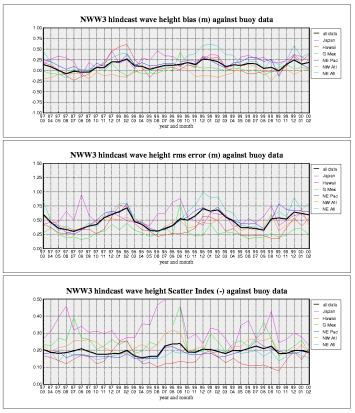
NCEP Guidance (future) 5



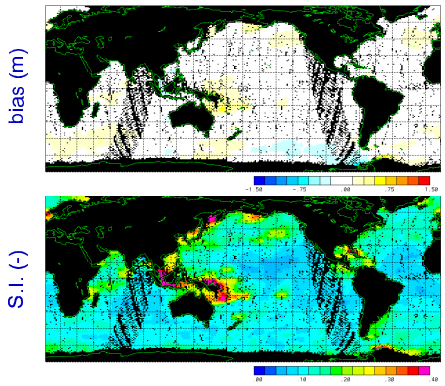
Quality of Guidance

- There is a large amount of validation data available at the web. :
  - ➤ Several statistics per month / season against buoys or satellite observations. Starting Feb 1997 for global model, Aug. 2000 for regionals.
  - ➤ Results of a six-month comparison with old operational global model including a large number of time series plots.

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



Model hindcast against altimeter

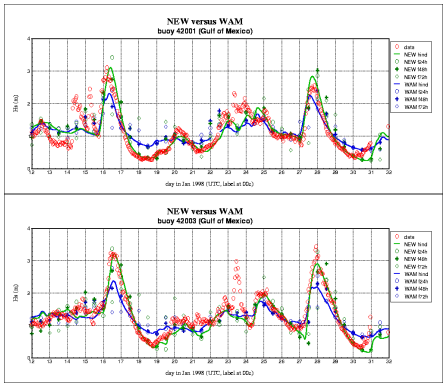


NEW vs. WAM

- Operational wave model comparison for nearly six months (1/12/98 - 6/30/98).
- Model differences :
  - ✘ Wave model (WAM - WAVEWATCH).
  - ✘ Resolutions (spatial, directions).
  - ✘ Data assimilation (all data assimilated in WAM starting 2/9/98).
- Here some Atlantic and Gulf of Mexico examples only.

http://polar.wwb.noaa.gov/waves/NEW-WAM.html

Gulf of Mexico



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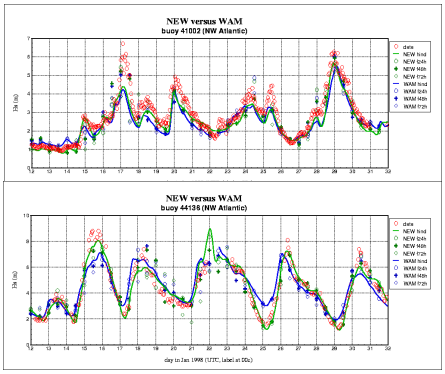
Atlantic Ocean



Quality of Guidance

- Strong points :
  - Very similar to WAM in wind seas, better in swells.
- Weak points :
  - No shadowing of unresolved islands (Hawaii, Aleutian Islands). SOLVED
  - Small scale systems not always sufficiently resolved (near-coast resolution). T254L64
  - Initial growth (East Coast).
- It is only a model, and can be only as good as its driving forces, i.e., the wind.

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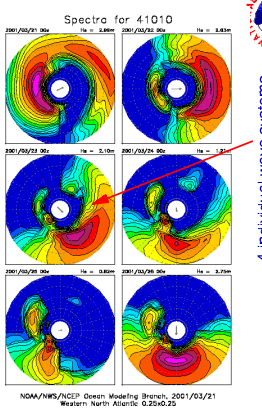
Products (what)

- Mean wave parameters in GRIB format
  - Overall significant wave height.
  - Mean direction and period.
  - Peak direction and period.
  - Wind sea direction and period.
  - NOT AVAILABLE : swell height and direction
- Text bulletins with different wave systems for output locations.

There is rarely just one swell field. What is the meaning of "the" swell height and the mean swell period and direction?

Question : for the nowcast, (upper left panel) which wave field is the wind sea ?



4 individual wave systems

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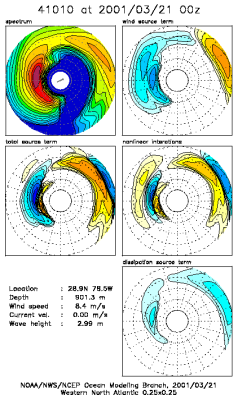
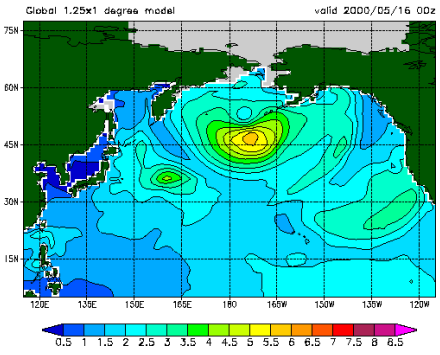
The upper left panel is the regular spectrum. The panels on the right represent the rate of change of the spectrum due to wind, nonlinearities and dissipation. The left center panel is the sum of the right panels.

Red : increase
Blue : decrease



significant wave height (m)



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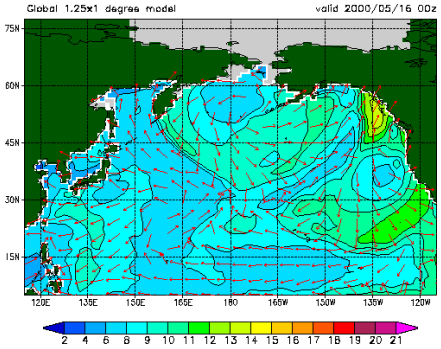
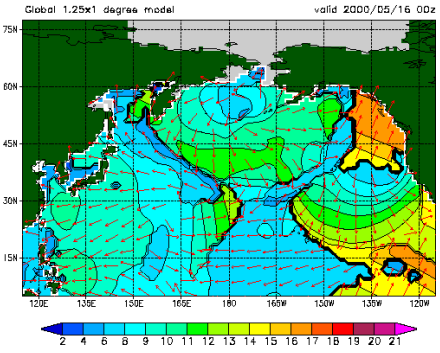
mean wave period (s) and direction



peak period (s) and direction



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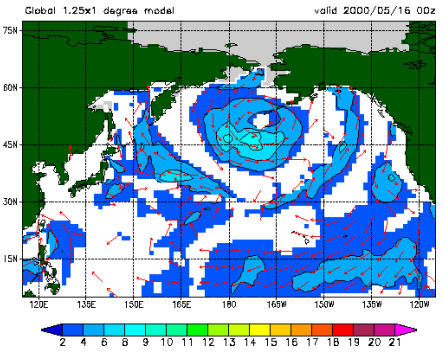
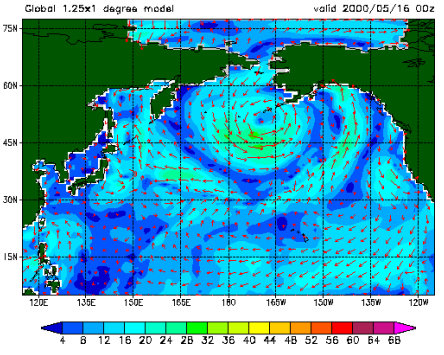
wind sea period (s) and direction



wind speed (kn) and direction



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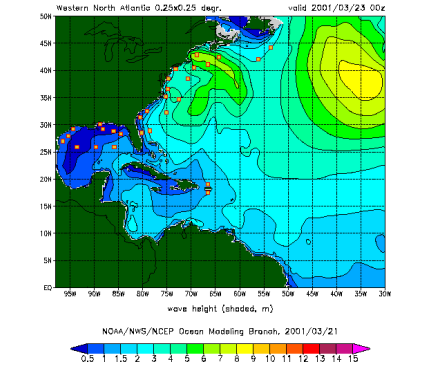
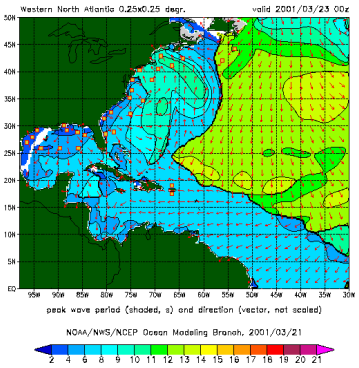
significant wave height (m)



peak period (s) and direction



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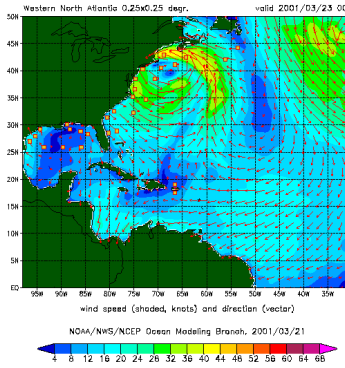
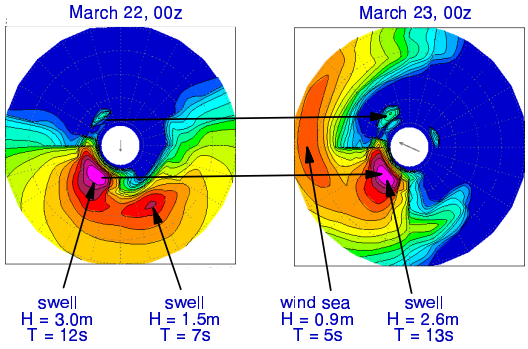
wind speed (kn) and direction



location 44141 (Nova Scotia)



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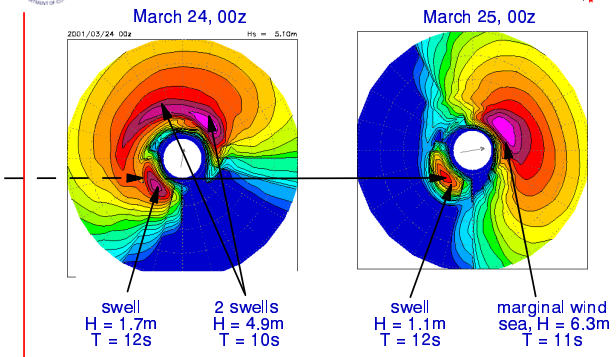
location 44141 (Nova Scotia)



Products (where) 1

- The present model has limited distribution of products through DIFAX and AFOS. These products can be viewed using AWIPS and will be maintained as long as needed.
- Global model fields are available in AWIPS 4.3.1. Errors in AWIPS graphics near coast. Presently only up to 72 hour forecast.
- The regional model fields will are presently transmitted, but will not be availble in AWIPS until build 5.0 (or later).

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Products (where) 2

- Text bulletins in condensed and modified format on AWIPS.
- ALL model data availble on the web, usually within 30 min. of the model run.
- Historical hindcast data available on web.
- We will work with any WFO or region to get products out as needed,

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

Finally ....

For questions, remarks, requests etc., contact us at

waves@ncep.noaa.gov

This E-mail will be distributed automatically among our entire wave staff, and therefore will give you the fastest response. or try

Hendrik.Tolman@NOAA.gov