Multi-grid WAVEWATCH III

Implementation of a new wave forecast model at NCEP

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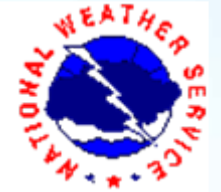
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Wave modeling at NCEP

- Guidance forecasts at NCEP provided using WAVEWATCH III v2.22
  - Global (NWW3) model
  - Regional Alaskan (AKW), Pacific (ENP) and Atlantic (WNA) models
  - Ensemble forecast model using NWW3
  - Data assimilation forecast using NWW3
  - Great Lakes (GRL) model
- Users
  - WFOS, Ocean Prediction Center and Tropical Prediction Center
  - Recreational and other external users
  - Boundary conditions for coastal waters

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Why a new forecast model?

- A new version of the WAVEWATCH III wind wave model that features
    - full two-way interactions between an arbitrary number of grids with an arbitrary range of resolutions.
    - Option to set nodes inactive (useful in designing optimal models)
    - An elegant algorithm for proper partitioning of spectral energy (ctsy: Jeff Hanson et al, USACE)
- Our Aim
    - Providing consistent guidance for NDFD grids for deep-ocean, offshore and coastal grids with a single model (present implementation).
    - Provide wave guidance directly on GFDL and HWRF grids for coupled system (still under development).
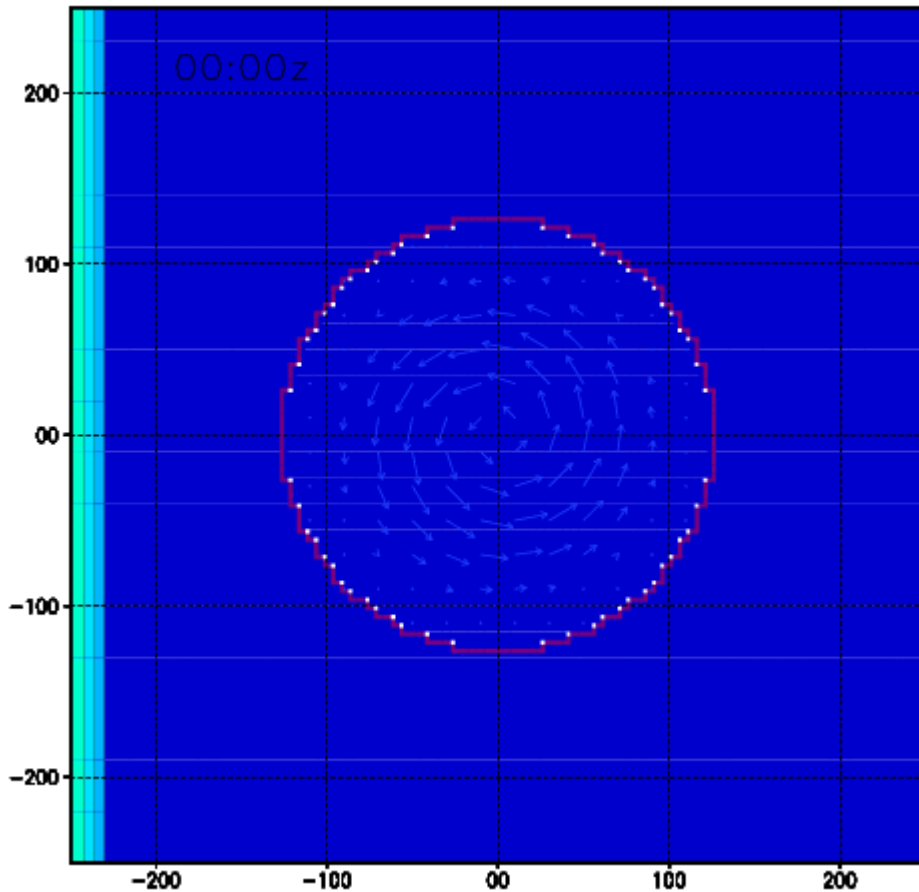
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The mosaic approach

- An unlimited number of grids that are run as separate wave models with full interaction between grids.

- Grids identified with rank number with lower rank identifying lower resolution, and same rank identifying similar, but not necessarily equal resolution.

- Basic interaction approaches:

  - Higher resolution grids get boundary data from lower resolution grids.

  - Lower resolution grid points covered by higher resolution grids obtain spatially averaged data.

  - Similar resolution grids are reconciled in their overlap.

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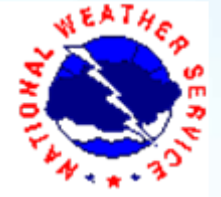
Example – Two – way nesting

Current ring with circular inner domain. Input wave height is 2.50m, contours at 0.20m, including 2.40 and 2.60. Third order UQ scheme.
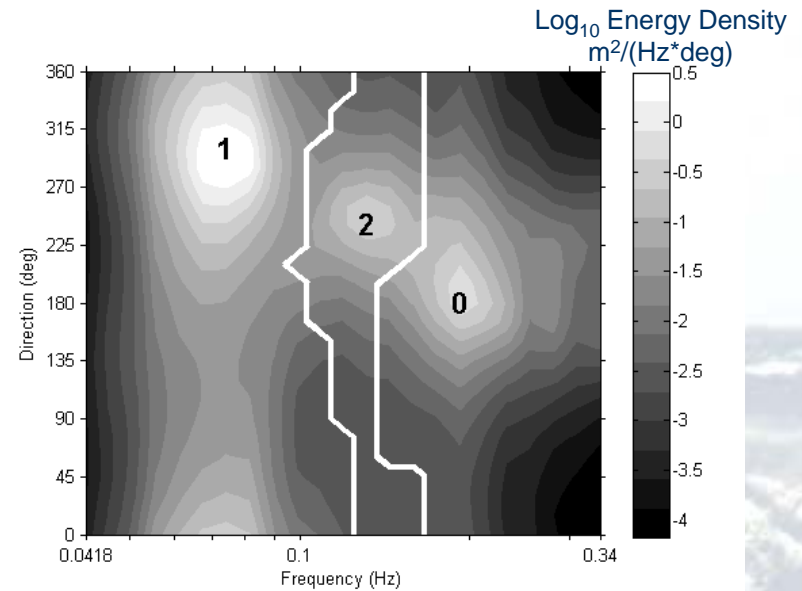
One-way nesting
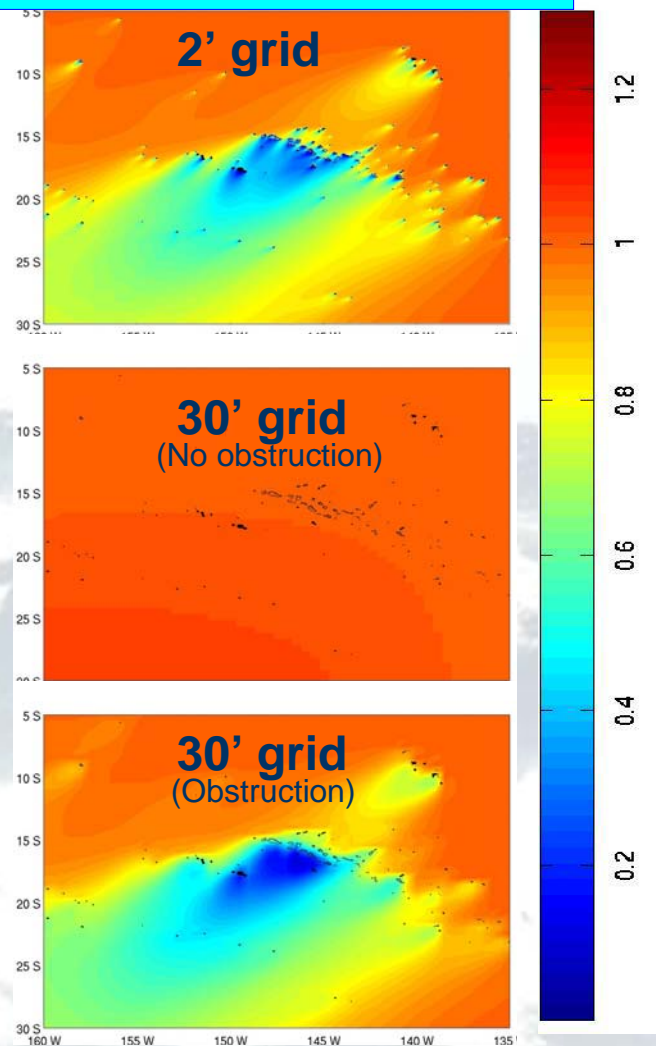
Two-way nesting

Movie loop.

Wave field separation

- Partitioning provides for each wave field:
  - H_s, T_p, L_p, θ_m, σ_m.
  - Fraction of energy that is wind-driven.
- Conventional field output for
  - Wind sea, primary and secondary swell (all 6 parameters).
  - Overall wind sea fraction.
  - Local number of wave fields.

Log$_{10}$ Energy Density m^2/(Hz*deg)

Example of partitioned spectrum, courtesy of Jeff Hanson.

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WAVEWATCH III Upgrades

Obstruction grids

- Obstruction grids simulate sub-grid blocking

- Obstruction grids for NWW3 developed manually

- An algorithm developed for generating obstruction grids using a global shoreline database

  - Database consists of over 188000 shorelines (ranging from small atolls to continents)

  - Consistent obstruction grids across grids of different resolution

2' grid

30' grid
(No obstruction)

30' grid
(Obstruction)

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Operational forecast model suites at NCEP

- Present state:
  - Global NWW3 (GFS)
    - Regional AKW, WNA and ENP (GFS).
  - After GFDL winds are available
    - Regional NAH and NPH models (GFS+GFDL).
  - Great Lakes Waves model (NAM).

- Will become:
  - Early multi-grid ocean waves (GFS).   2007
  - Late multi-grid ocean waves (GFS + HWRF + other ?).   2008
  - Early Great Lakes Waves (NAM).   2006
  - Late Great Lakes Waves (NDFD).   2008

- Ensembles and data assimilation will be ported.
- HWRF including waves.

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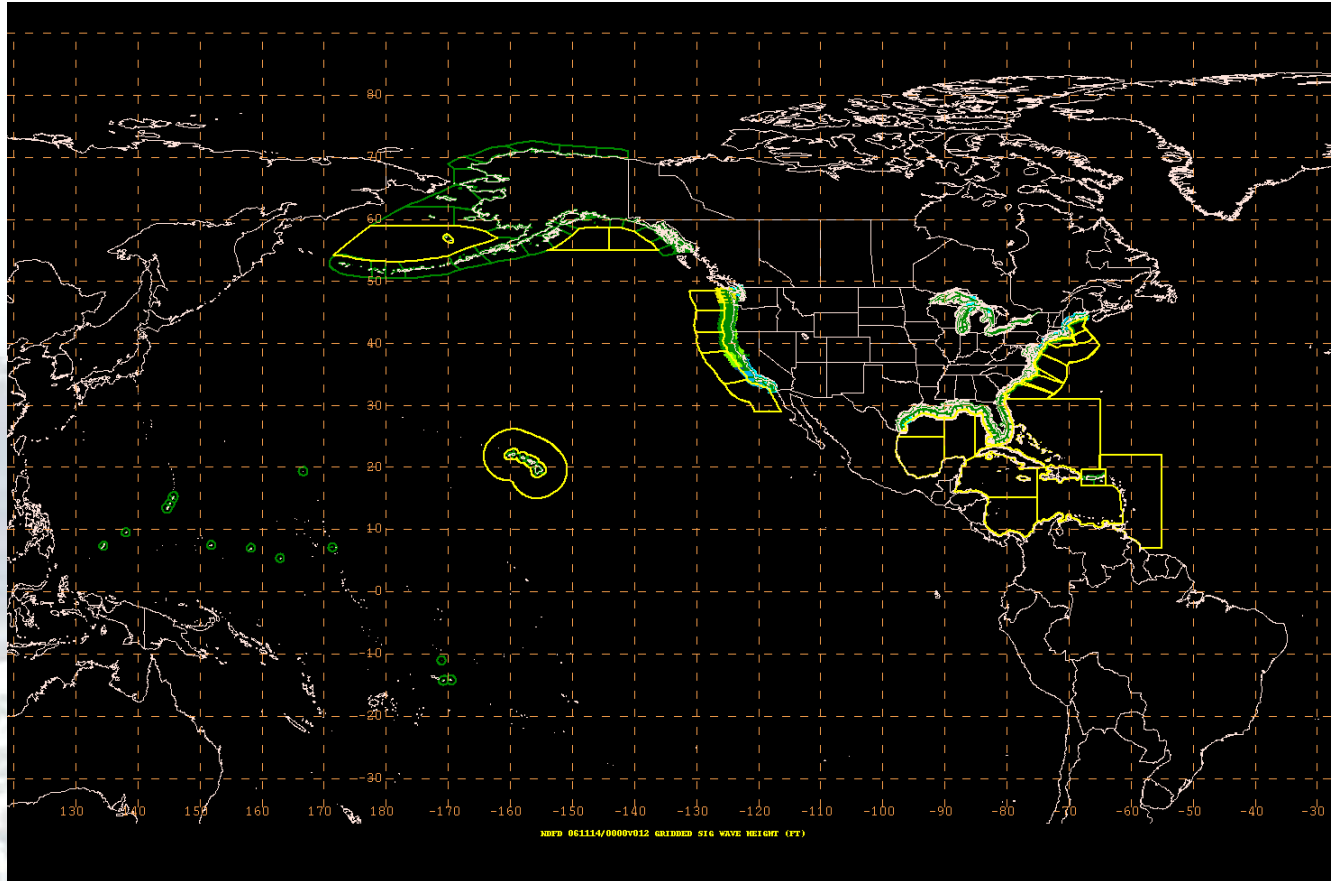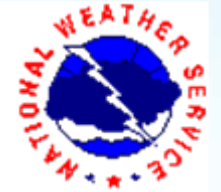
NMWW3

NWS areas of responsibilities and NDFD grids

Courtesy Joe Sienkiewicz

NMWW3 [2]

- To provide consistent guidance for all these areas, the new operational NCEP model will consist of a mosaic of 8 grids:

  - A global 30' grid.
  - An offshore Atlantic 10' grid.
  - An offshore West Coast 10' grid.
  - An east Pacific 10' grid.
  - An Alaskan 10'x15' grid.
  - A coastal Atlantic 4' grid.
  - A coastal West Coast 4' grid.
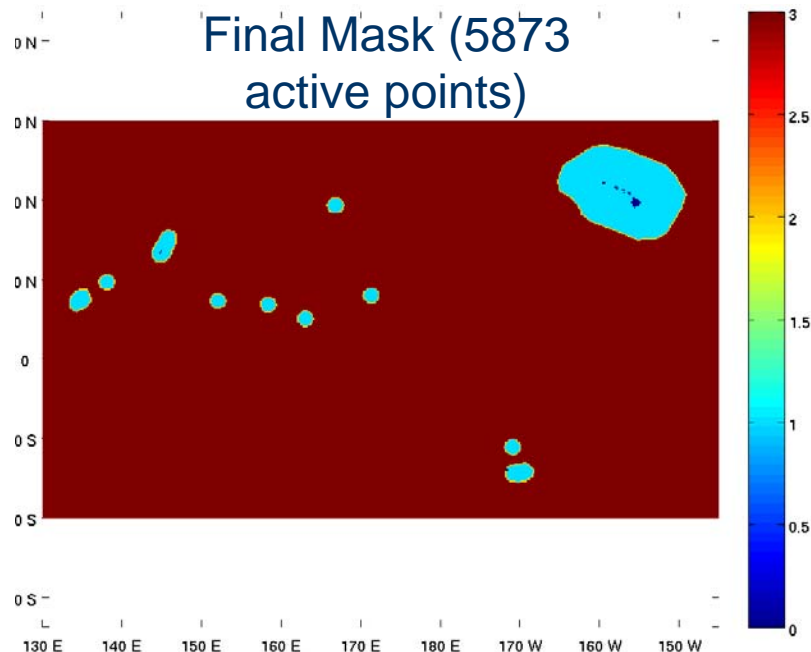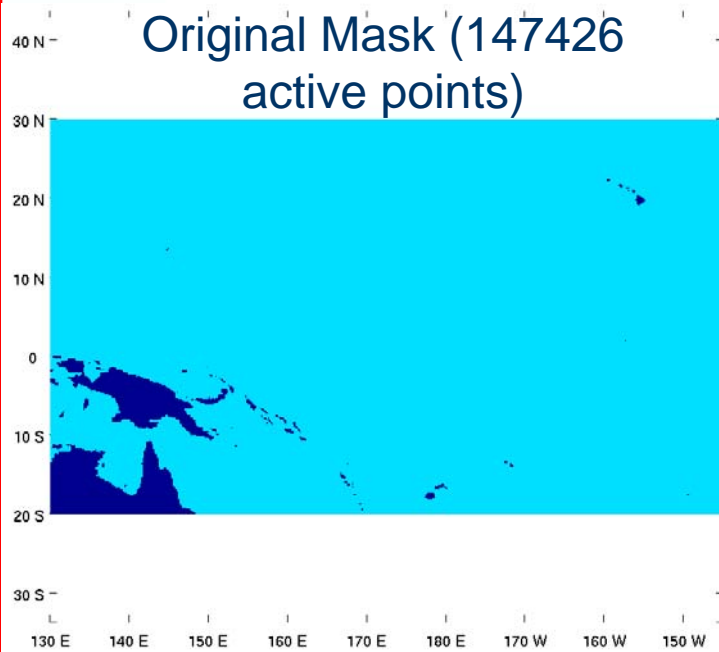 - A coastal Alaskan 4'x8' grid.

- Note: previous highest model resolution was 15'.

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NMWW3[3]

Resolution in minutes of the 8 grids making up the multi-grid model

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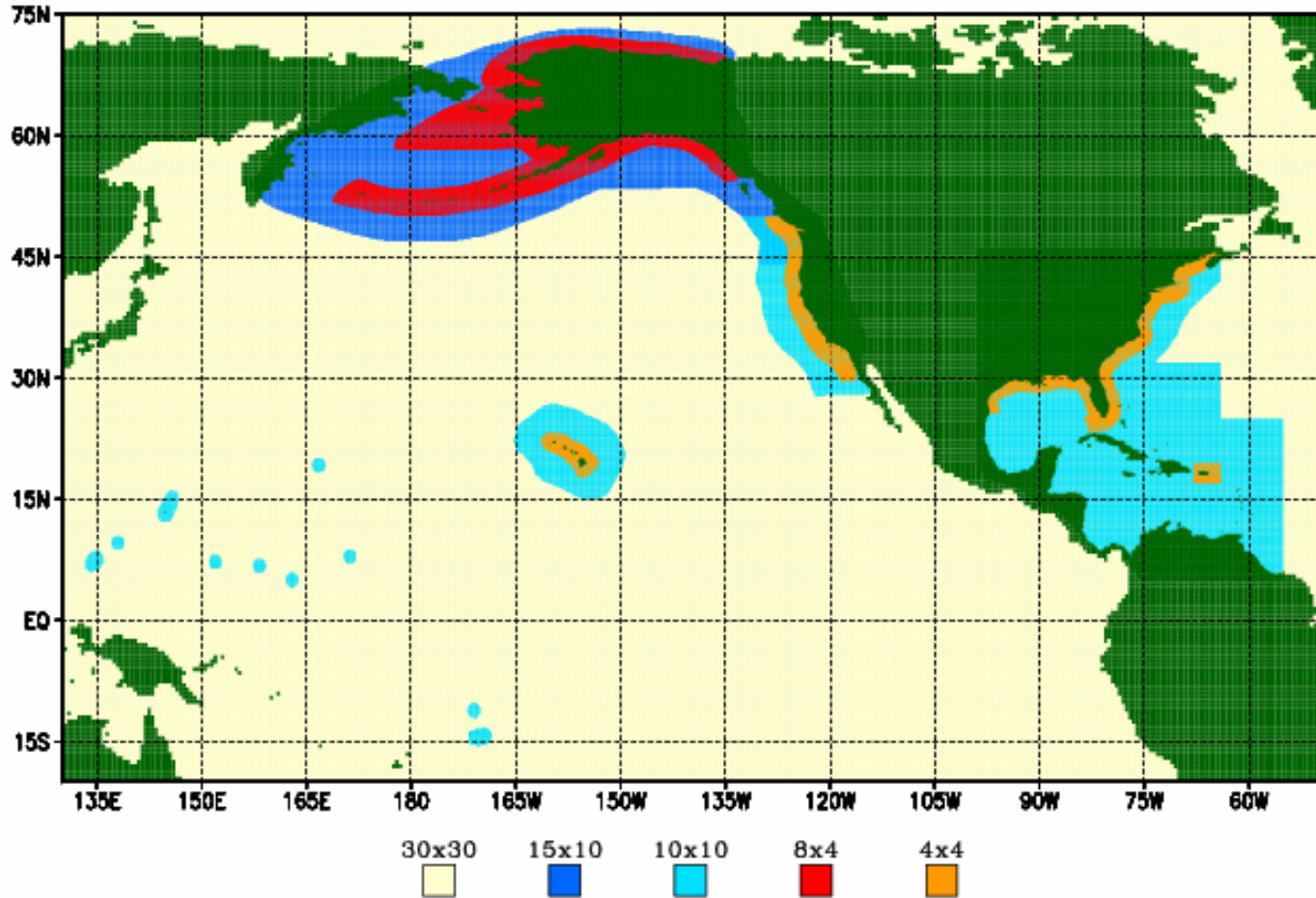
NMWW3[4]

Boundary points can be defined inside the grid

Original Mask (147426 active points)

Final Mask (5873 active points)

Computational domain for the Eastern Pacific regional grid (10')

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NMWW3[5]

multi-grid WAVEWATCH III — 2006/01/16 12:00z
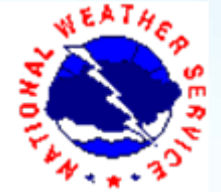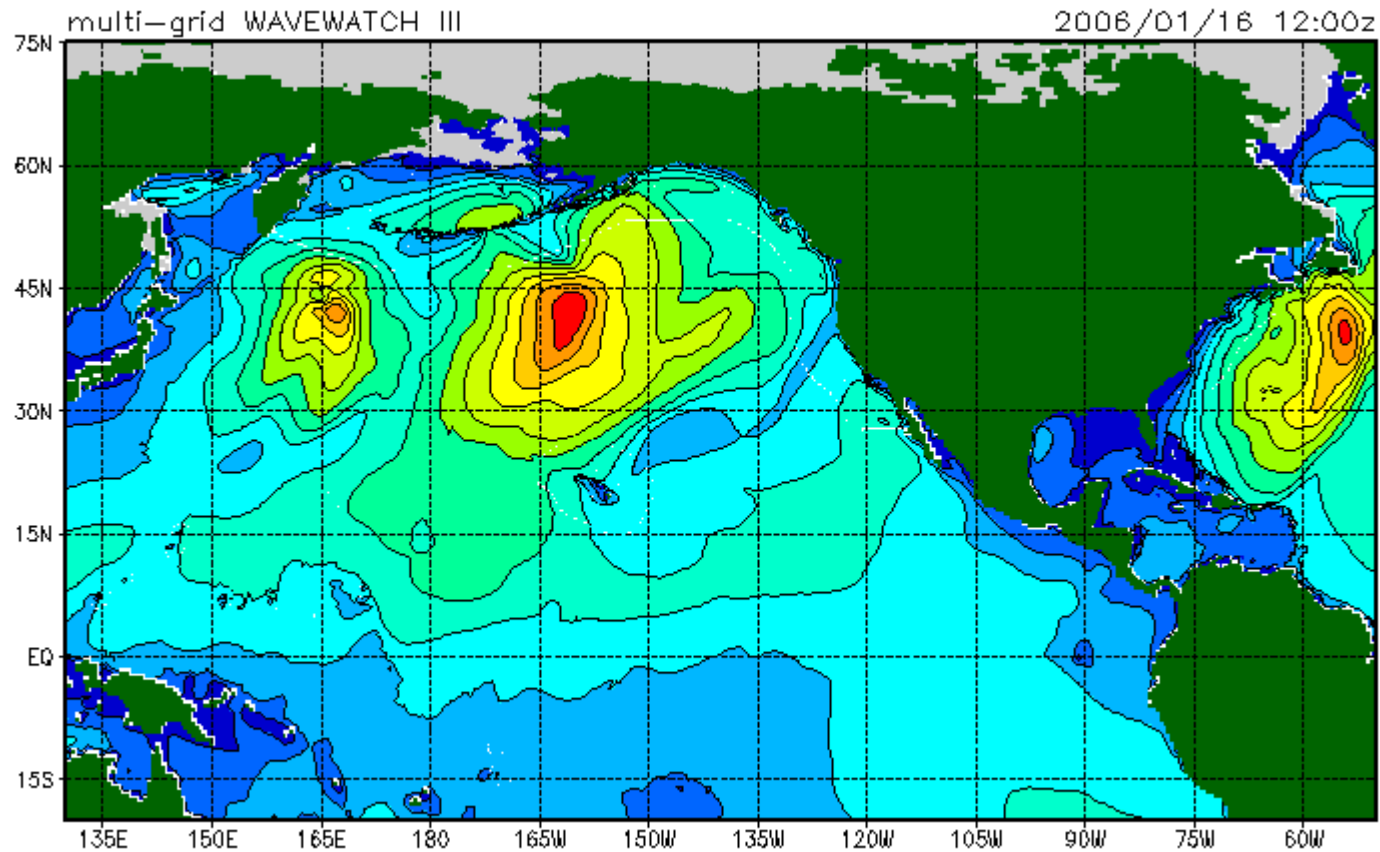
Example of consistency between grids

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NMWW3 Particulars [1]

- Cycles
  - 4 cycles a day – 0z, 6z, 12z and 18z
  - Each cycle is a 189 h simulation (9 h hindcast and 180 h forecast)
- Forcings
  - Wind (Hindcast data from GDAS, Forecast data from GFS)
  - Ice (Microwave data)
  - SST (Reynolds analysis)
- Output
  - All output fields in GRIB2 format
  - Unified point output (extracted from the highest resolution grid)
  - Additional outputs due to energy partitioning algorithm

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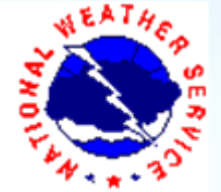
NMWW3 Particulars[2]

- **Operations**
  - Wave model run side by side with GFS to improve computational efficiency
- **New MMAB web site available for multi-grid model (Todd Spindler)**
  - http://polar.ncep.noaa.gov/waves
  - Maps available for 15 different regions (trivial to add a new region)
  - Clickable maps for point data
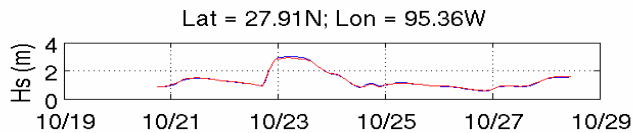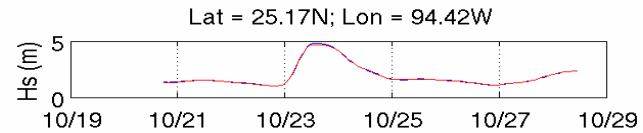 - Data access available up to 6 cycles back (including latest run)

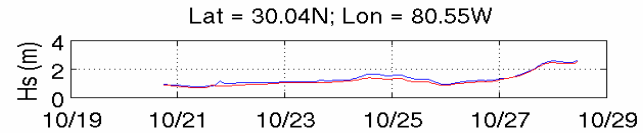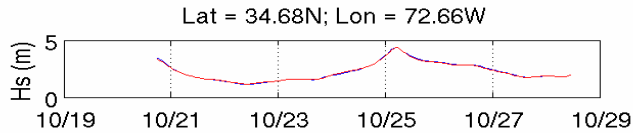Chawla etal, Nov 12, 2007

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NMWW3 Regional displays

WAVEWATCH III Regional Grids
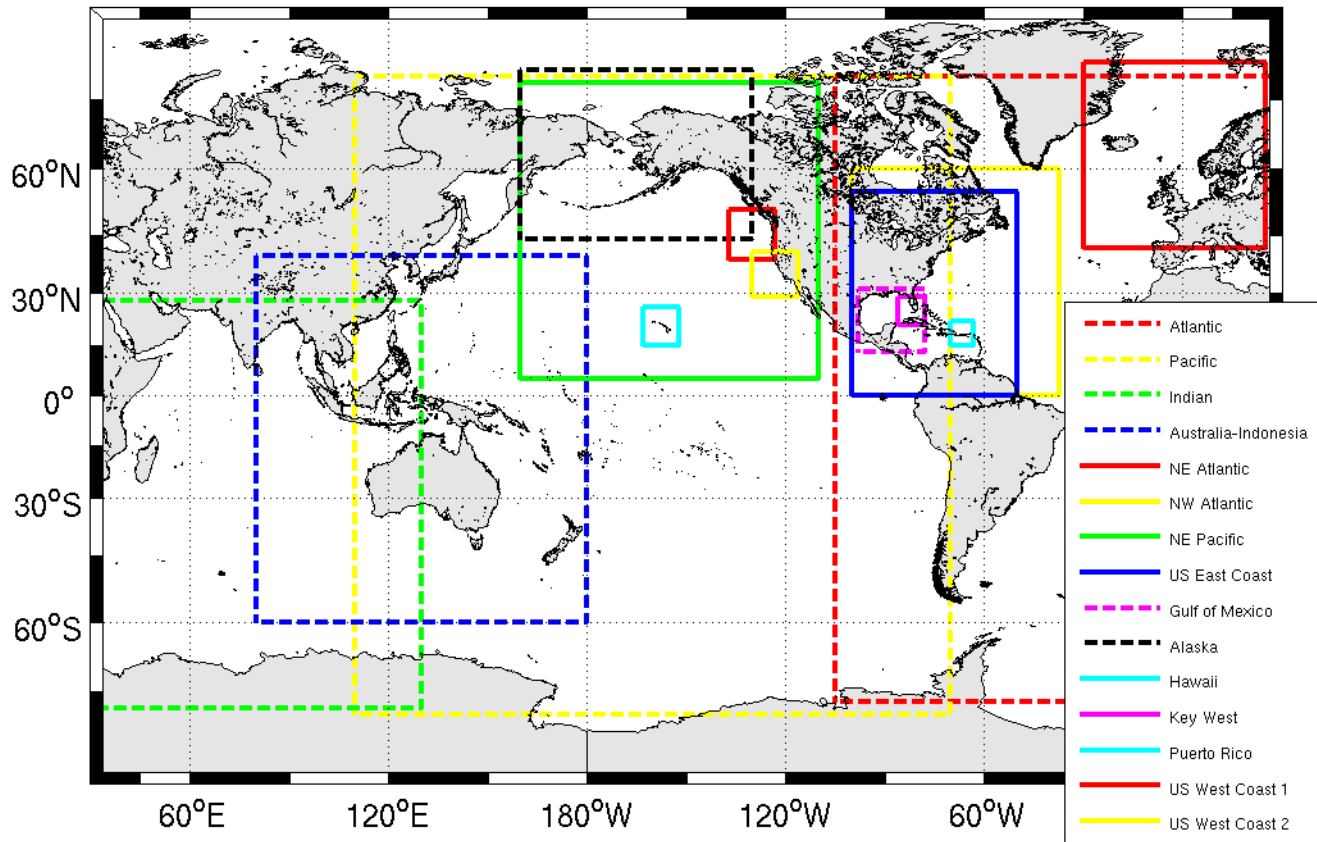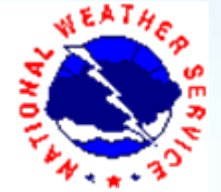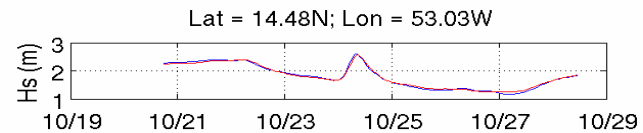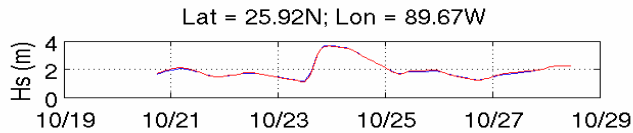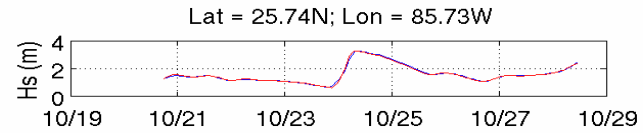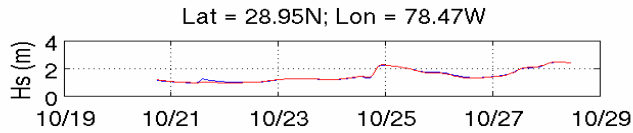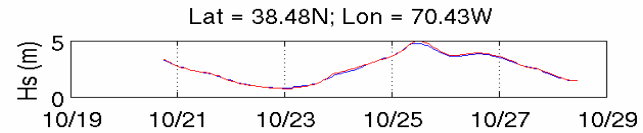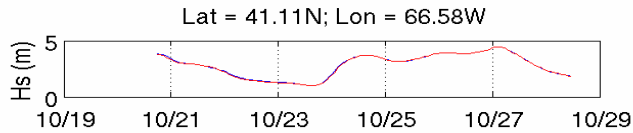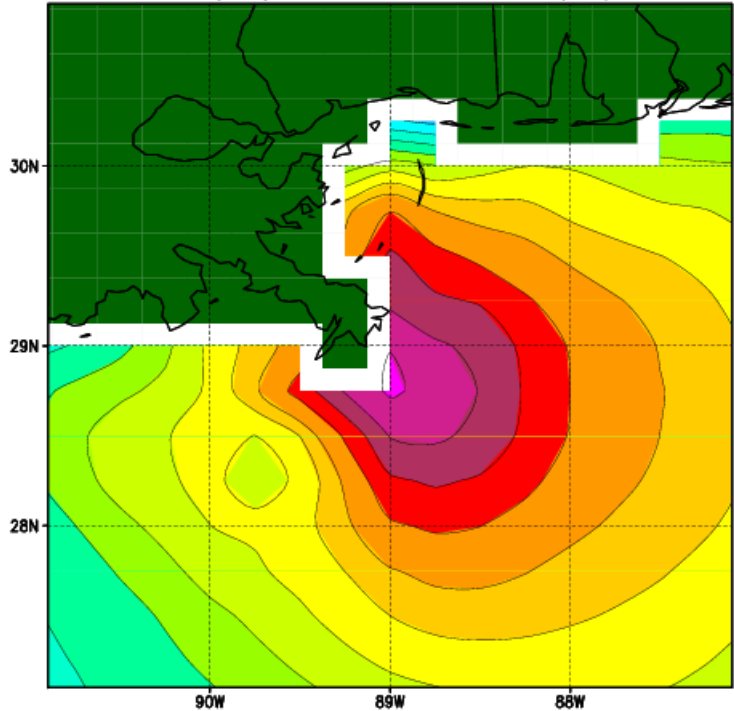
Legend:
- Atlantic (red dashed)
- Pacific (yellow dashed)
- Indian (green dashed)
- Australia-Indonesia (blue dashed)
- NE Atlantic (red solid)
- NW Atlantic (yellow solid)
- NE Pacific (green solid)
- US East Coast (blue solid)
- Gulf of Mexico (magenta dashed)
- Alaska (black dashed)
- Hawaii (cyan solid)
- Key West (magenta solid)
- Puerto Rico (cyan solid)
- US West Coast 1 (red solid)
- US West Coast 2 (yellow solid)

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Forecast Comparisons

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old WNA model

new multi-grid model
including surf zone physics

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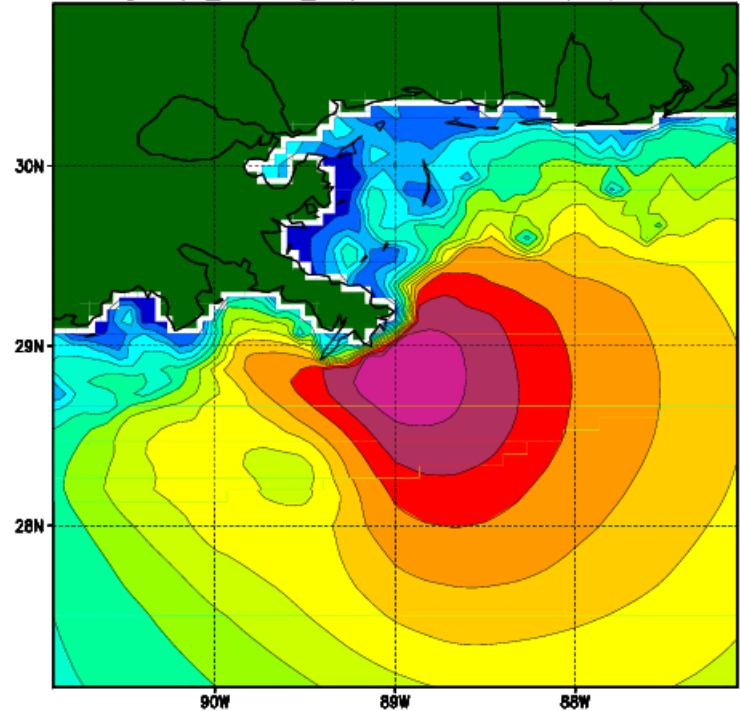
Katrina [2]
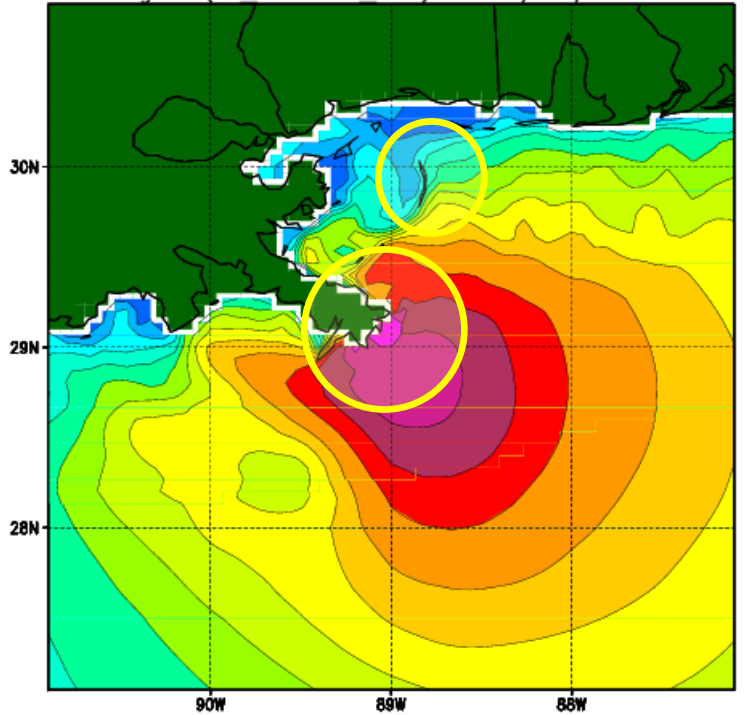
new multi-grid model
without surf zone physics

new multi-grid model
including surf zone physics

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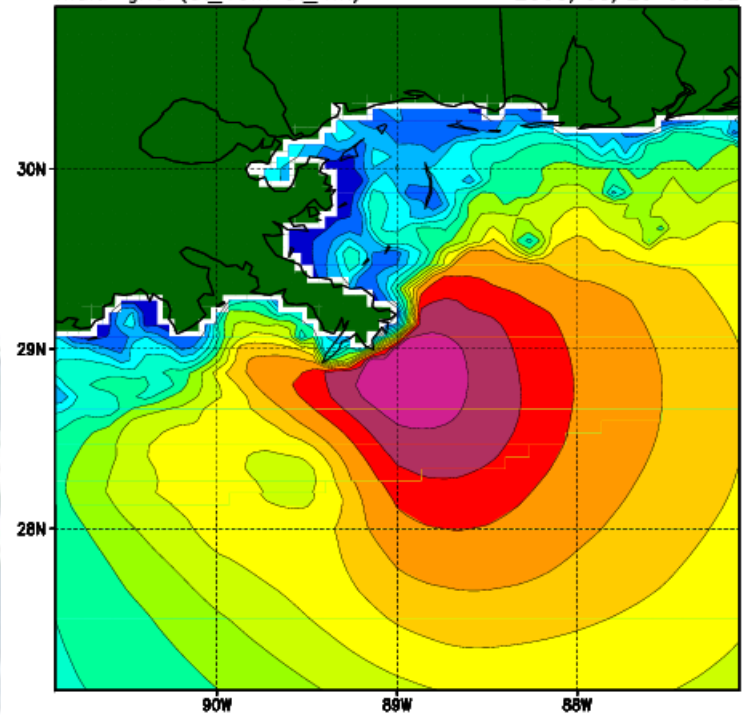
Summary

- A new operational forecast model developed for NCEP with

  - Increased coastal resolution
  - Additional products for the partitioned spectra
  - Depth limited breaking

- Near – term outlook

  - Relocatable grids for hurricane modeling
  - Develop a seamless approach for wave modeling from deep ocean to coastal inundation
  - Coupled forecast systems (specially wave – hurricane models)

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