Global wave model upgrade

EMC CCB – 7/8/2015

Global Wave Model Grids Upgrade

Project Status as of 03/11/15

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Project Information and Highlights

Lead: Arun Chawla, EMC and Becky Cosgrove, NCO

Scope:

1. Replace existing regular lat-lon Arctic Grid with a curvilinear grid that will extend the computational domain to the North Pole
2. Switch atmospheric winds input from sigma files to grib files

Introduce in next upgrade

Expected Benefits:

1. Extend the domain to the North Pole that will increase the Fetch domain to match the domain that is consistently being observed in the Arctic region due to the reduction of ice coverage, particularly in the summer months.
2. Switching to using grib files will lead to less memory use as the files are much smaller without any loss in accuracy.

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Issues/Risks

Issues:.
Risks:
Mitigation:

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Scheduling

Milestone (NCEP)	Date	Status
Initial EE setup (NCO Support)	1/31/2015	Completed
EMC testing complete/ EMC CCB approval	3/2/2015 →5/2	
Code delivered to NCO	3/6/2015 →5/6 7/6/2015	
Technical Information Notice Issued	4/01/2015 →6/01	
SPA begins prep work for 30 day test	3/9/2015 → 05/07	
30-day evaluation begins	4/6/2015 → 06/08	
30-day evaluation ends	5/5/2015 → 07/07	
IT testing ends	4/3/2015 → 07/01	
Management Briefing	5/22/2015 → 07/10	
Operational Implementation	5/26/2015 → 07/14	

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Finances

Associated Costs:

Funding Sources: NCO Base: 1.5 man months for implementation, .5 man-months annually for maintenance

Motivation for changing Arctic domain

- The original Arctic domain grid is a ½ deg regular lat – lon grid
- Due to numerical limitations (CFL criterion) this grid has to stop at 82 N
- Recent summers have seen an ice free polar arctic region
  - Larger portions of the Arctic polar region exposed to wave action
  - Concerns raised about wave induced erosion on the Northern Slopes of Alaska
  - Wave action related to increased fetch
- New upgrades in WAVEWATCH III now include irregular grids (curvilinear or unstructured)
  - Allows us to have varying grid cells to circumvent CFL limitations of regular grids

CFL limitation

Stability criteria for explicit Finite Difference schemes

$$\Delta t \leq C_g \Delta s$$

Time step

Group velocity -- F(f)

Spatial increment

For spherical coordinates

Highest latitude

$$\Delta s = min(Rcos\theta_m \Delta\phi, R\Delta\theta)$$

Radius of Earth

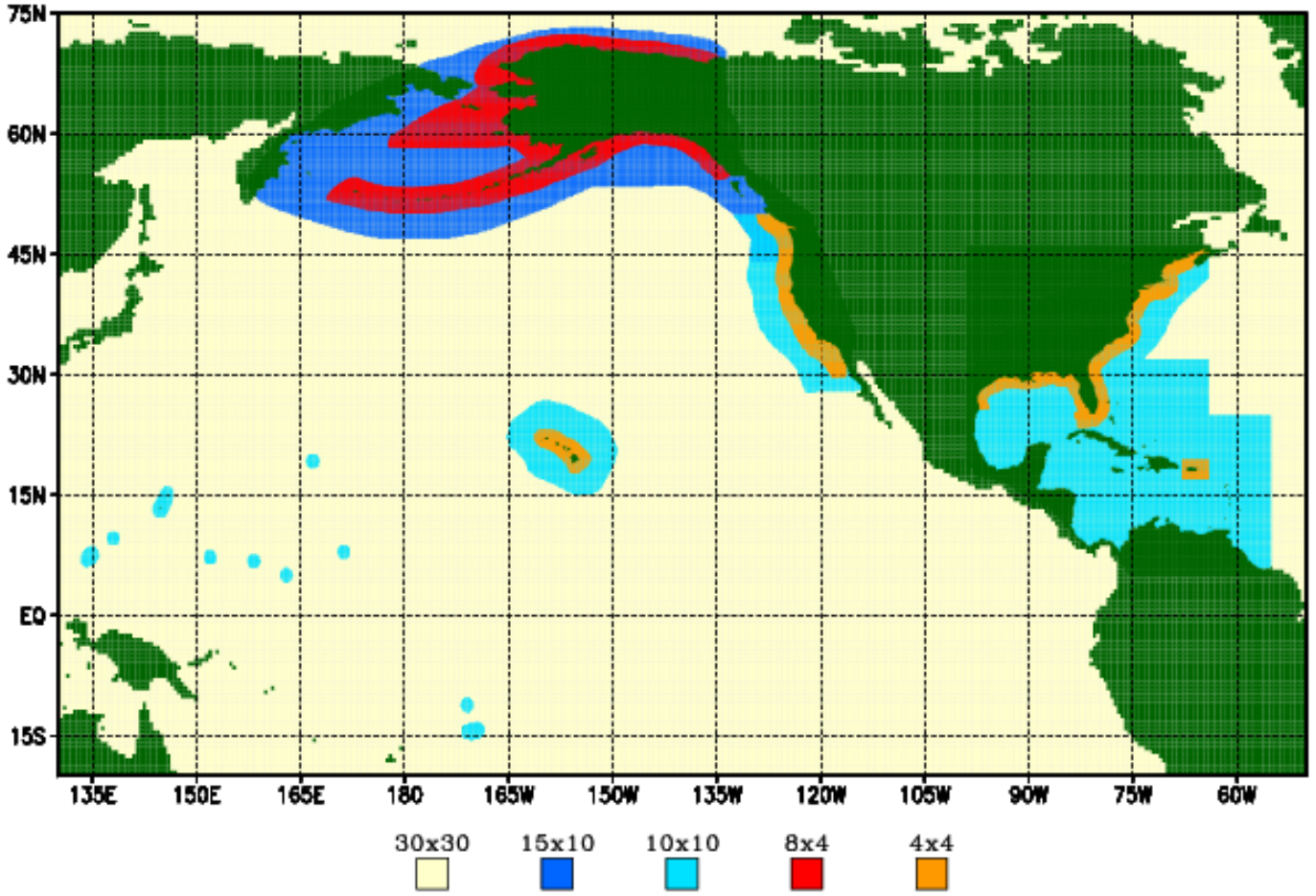
Grid resolutions in space (lon,lat)

Current Global Wave Mosaic

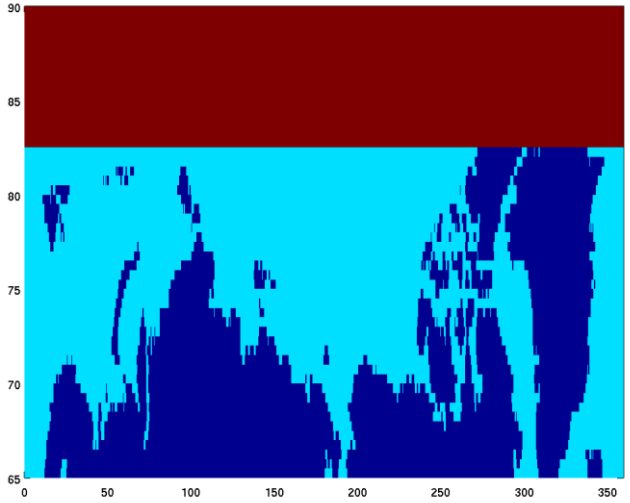
Global domain consists of a mosaic of 9 two way nested grids

- 1 global ½ deg grid (till 77.5 N)
- 1 arctic ½ deg grid (till 82 N)
- 4 regional 1/6 deg grids
- 3 coastal 1/6 deg grids

Data from the global and arctic grid interpolated on a single global domain (till 90 N) for dissemination

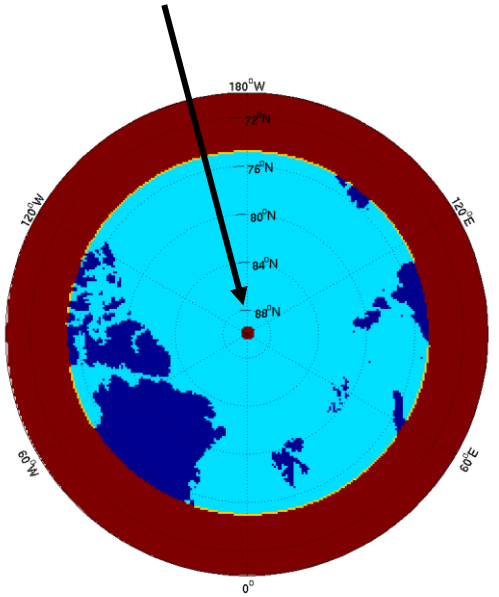


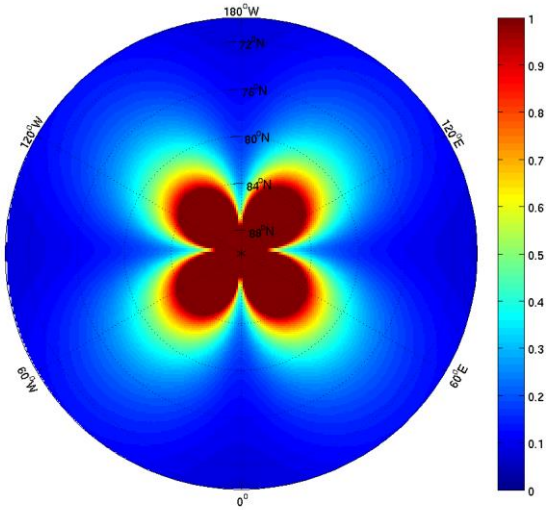
Proposed Upgrade



Replace regular Arctic grid with a polar stereographic curvilinear grid

North Pole still masked out due to singularity



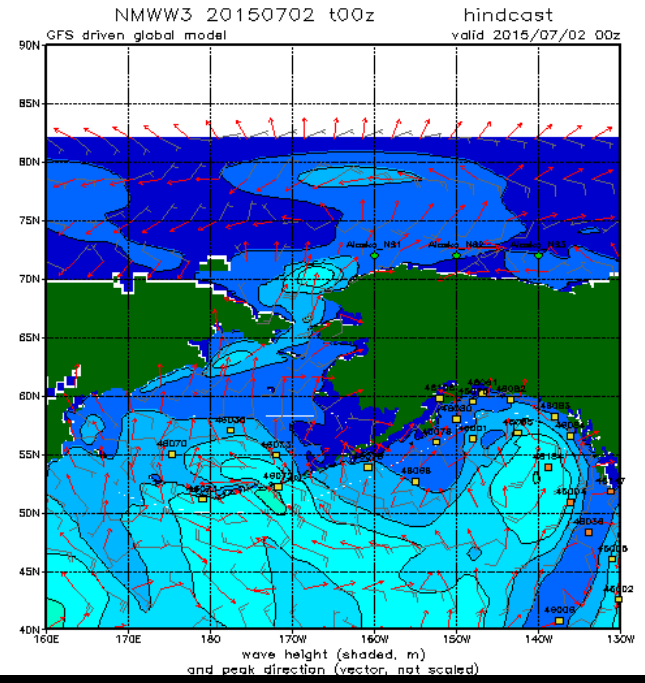


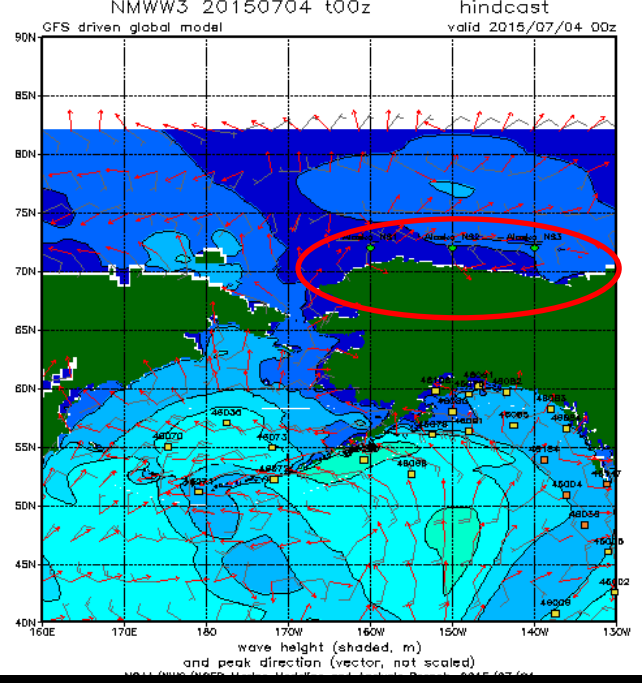
Grid cells (in spherical domain) get larger towards the pole

Grid spacings ~ 18km (in rectilinear space)

Curvilinear domain

- In the new version of WAVEWATCH III 2 – way nested between the regular and irregular grids is fairly seamless
- The varying grid cell size (with latitude) allows for a constant resolution (in rectilinear space) and consequently a significantly larger time step
- Curvilinear grid is used as an internal computational grid only
  - Data interpolated to a regular lat – lon grid for dissemination
- No change in output products (except that the global AWIPS grid will now contain values between 82 – 89.5 N)
- Modeling system tested with ice free Arctic runs


NMWW3 20150702 t00z
hindcast
GFS driven global model
valid 2015/07/02 00z
wave height (shaded, m)
and peak direction (vector, not scaled)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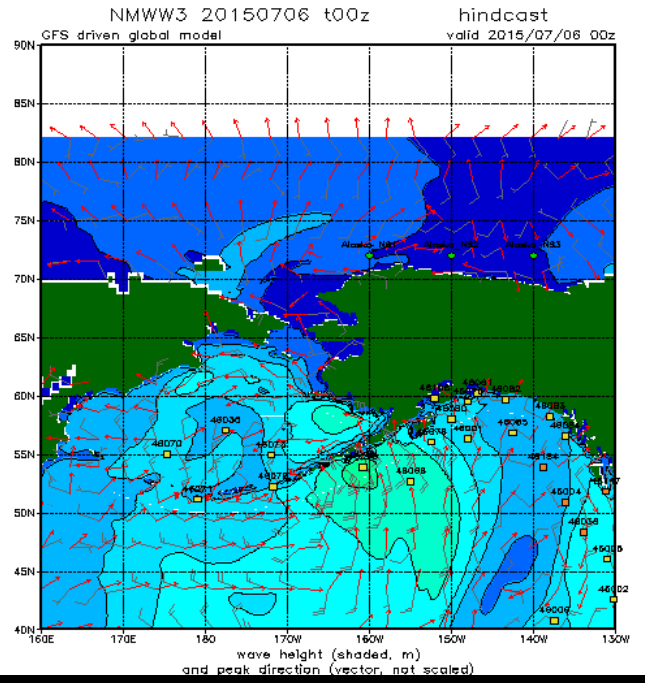
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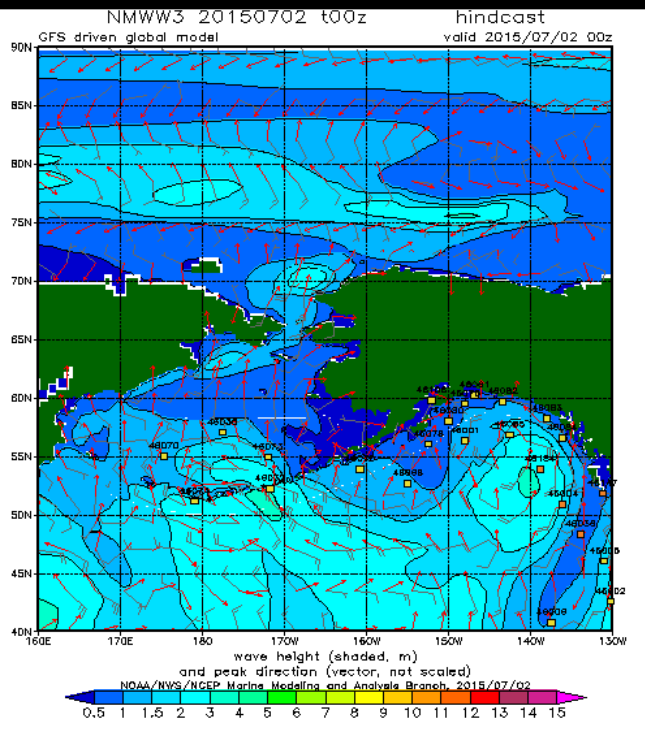
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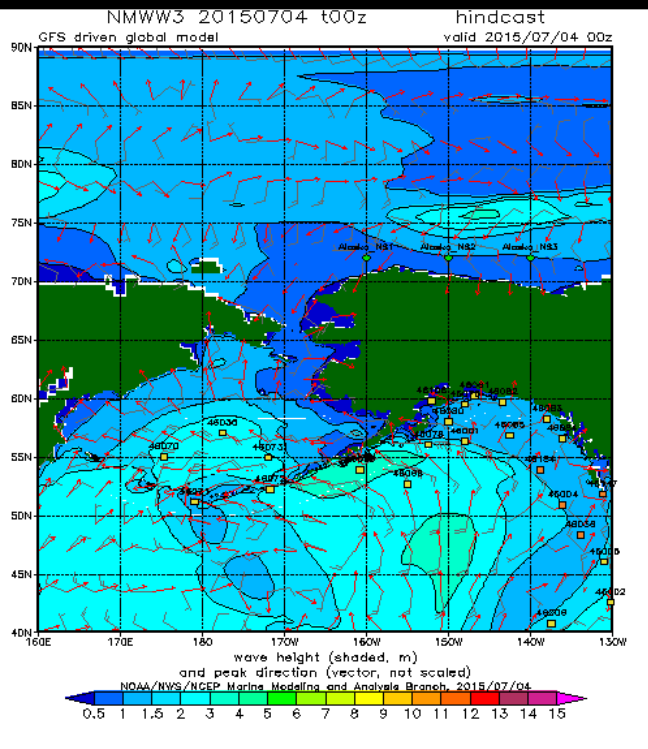
and peak direction (vector, not scaled)
NOAA/NWS/NCEP Marine Modeling and Analysis Branch, 2015/07/02
0.5 1 1.5 2 3 4 5 6 7 8 9 10 11 12 13 14 15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NOAA/NWS/NCEP Marine Modeling and Analysis Branch, 2015/07/04
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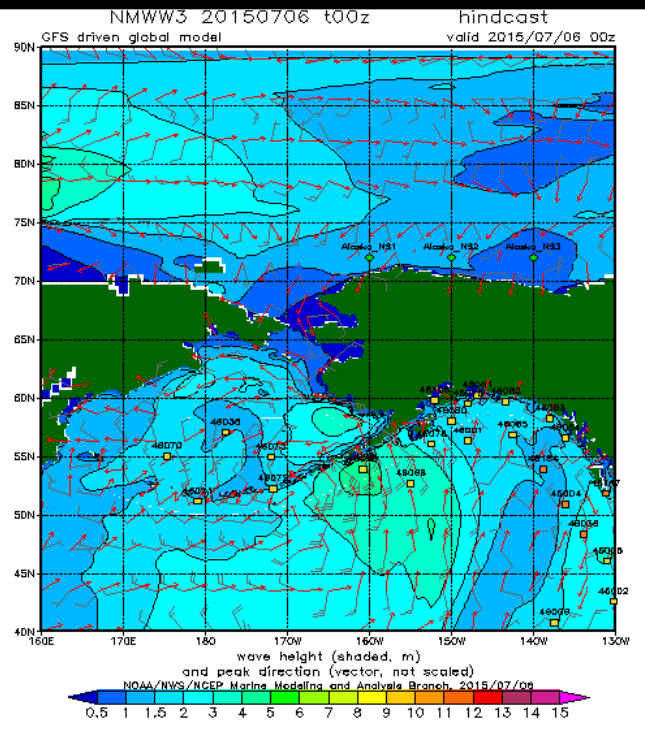
NMWW3 20150706 t00z
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GFS driven global model
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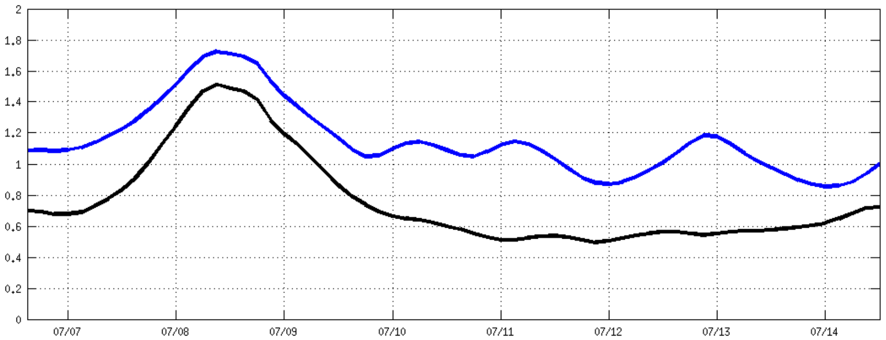
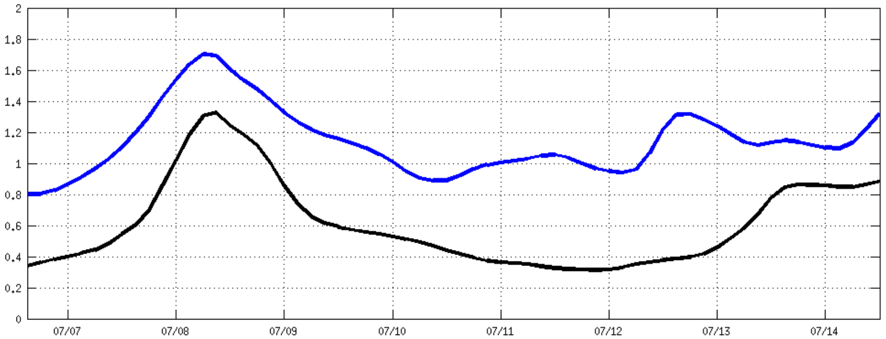
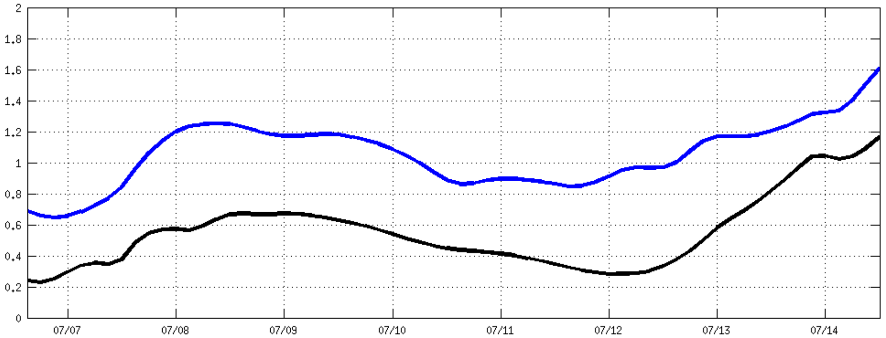
wave height (shaded, m)
and peak direction (vector, not scaled)
NOAA/NWS/NCEP Marine Modeling and Analysis Branch, 2015/07/06
0.5 1 1.5 2 3 4 5 6 7 8 9 10 11 12 13 14 15

On average Hs increases 35% - 50% near the North Slopes







NCO specific information

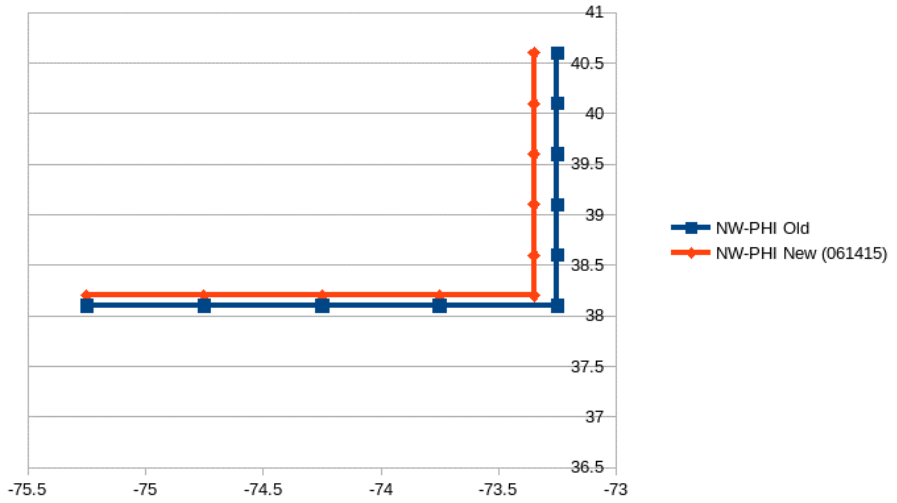
- The output in COM increases from ~57 GB to ~68 GB (per run)
- The forecast step takes ~ 5 minutes longer to run
  - Only way to confirm this is to run side by side with NCO spas
  - Speed up option : Use pre-computed interpolation weights (requires NETCDF)
- No changes to output deliverables
  - This is specially true for output to AWIPS
  - Caveat : If the regular Arctic Ocean domain grid is being erroneously delivered to the outside community then this data will no longer be available
  - Solution : Trivial to generate output on regular Arctic Ocean grids from the internal curvilinear grids
- Code delivery will include source code package that handles curvilinear grids for wave_code.v4.15.3

Summary

- New features in WAVEWATCH III allow us to extend the domain of the wave model all the way to the North Pole (from the current 82 N limit)
- When the Arctic region is ice free this upgrade leads to ~ 35% - 50% higher waves along the North Slopes of Alaska
  - Lower estimates of wave heights (from model guidance) along this region has long been identified as an issue
  - In the presence of significant ice coverage the upgrade will have minimal impact
- The new upgrade does not add any significant cost to computation times and minimal change to products (with the exception of providing wave information all the way to the North Pole)
- Solution still incomplete as waves still not allowed to cross the North Pole

Auxiliary : Changes to Point output

<u>Requested by Philadelphia Weather Forecast Office</u>
Move output boundary points for their local model domain (NWPS) to new location



<u>Requested by Guam Forecast Office</u>

Current point output from model – 558 buoy + virtual points / 2213 boundary points
Output points delivered by AWIPS – 373 buoy + virtual points
(all other data accessed from ftpprd)

Expand output points delivered by AWIPS – 558 points
(data delivered as a single file parm file. Size will increase from ~3.8 MB to ~5.68 MB)