



# NCEP Global Wave Model Upgrade 2017 wave\_multi\_1.v3.3.0

Science Evaluation OD Briefing, 25 Aug 2017

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# wave\_multi\_1.v3.3.0 Upgrade 2017

## Scope

- Addition of North Polar Stereographic Grid extending to near the north pole,

## Motivation

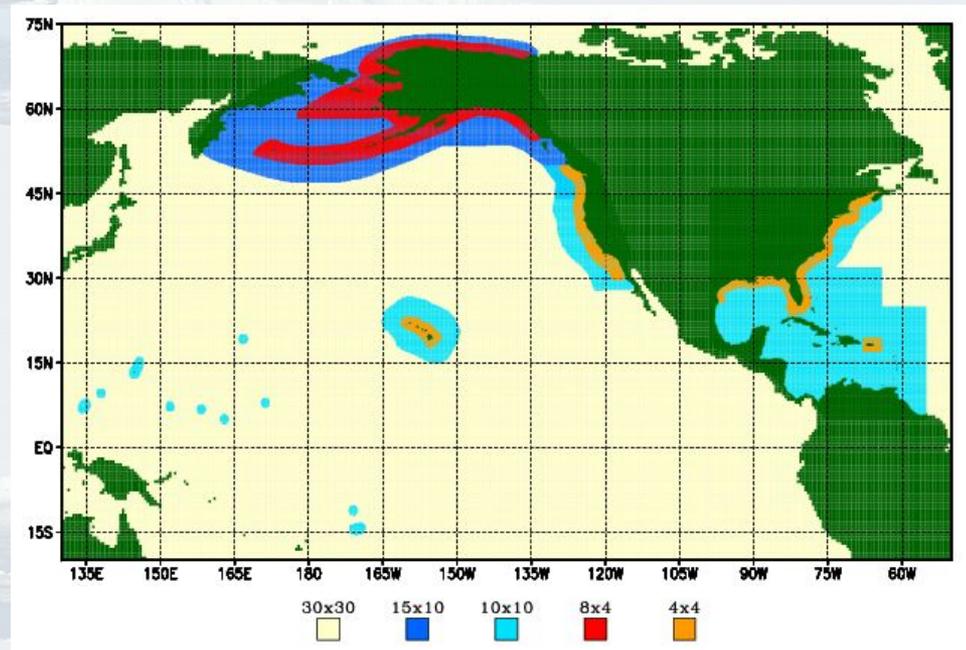
- Alaska Region identified long-lasting, consistent low-wave bias in current operational guidance,
- Receding Arctic ice extent above 82N requires extending guidance beyond current grid N limit.

## Other changes in this upgrade:

- Hourly grib2 output out to 120h,
  - consistent with GFS output stride,
  - support RTMA/URMA wave analysis product.

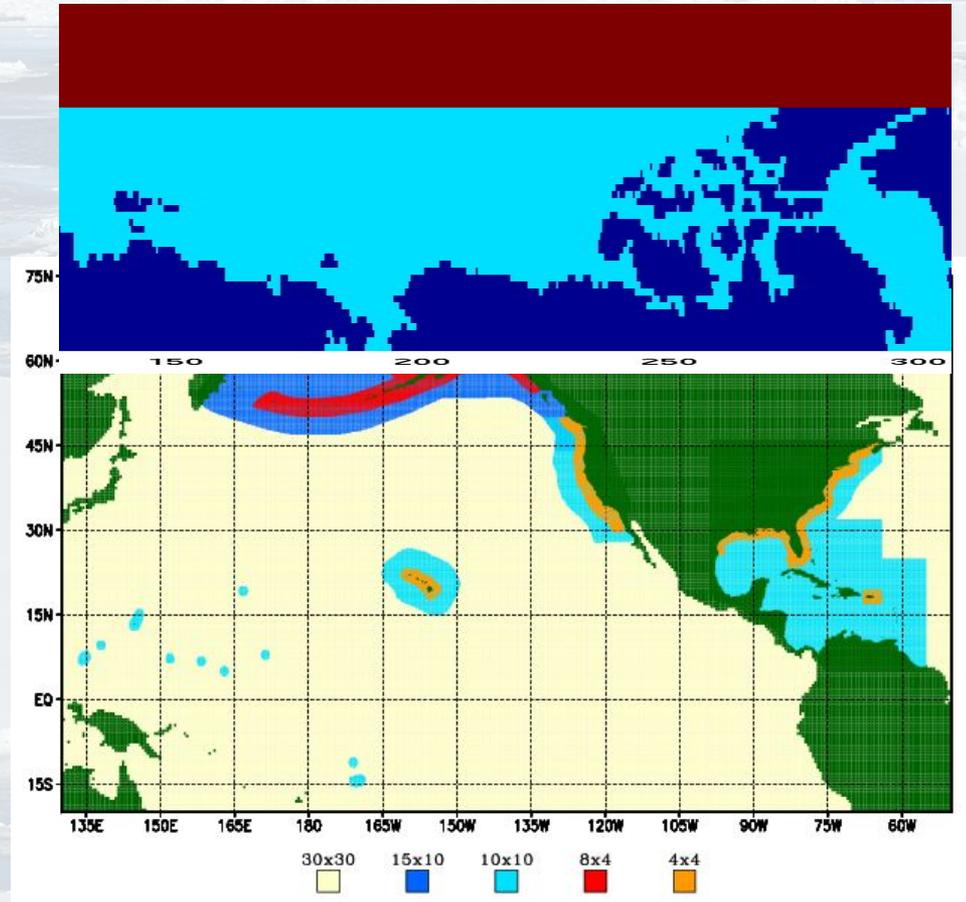
# Global Wave Deterministic (wave\_multi\_1)

- Global wave model with a mosaic of two-way nested regular spherical grids
  - ranging in resolution from  $\frac{1}{2}$  to  $1/12$  degree
  - Driven by GFS winds, runs side by side with GFS,
  - 4 cycles a day: 9 h hindcasts, 180 h forecast.
- Uses WAVEWATCH III model



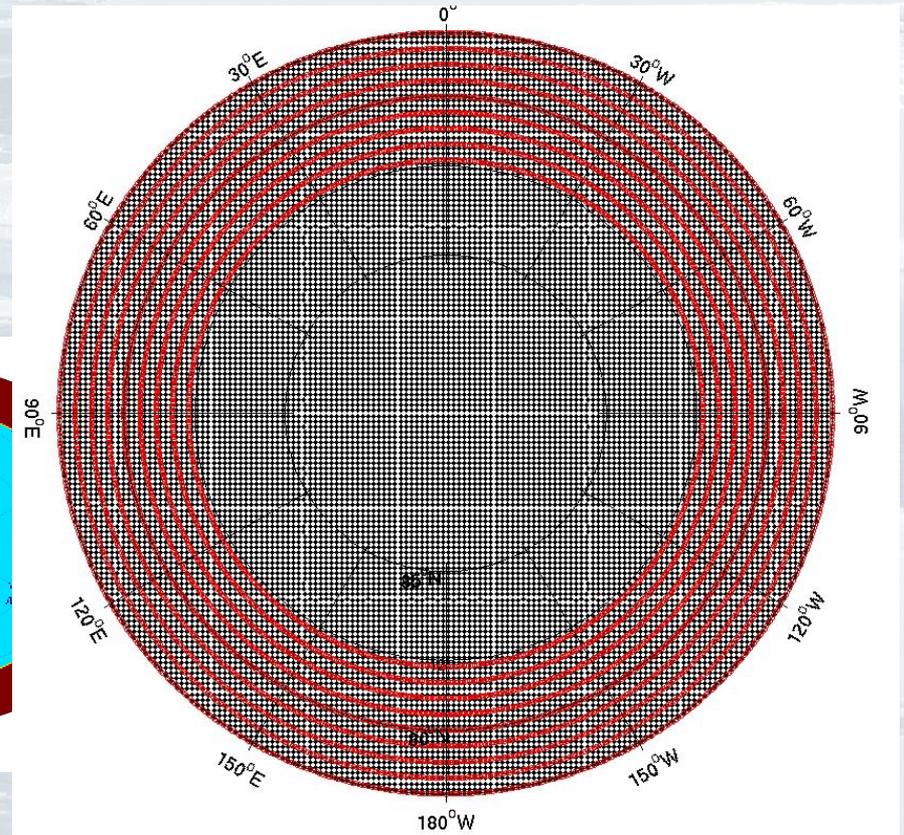
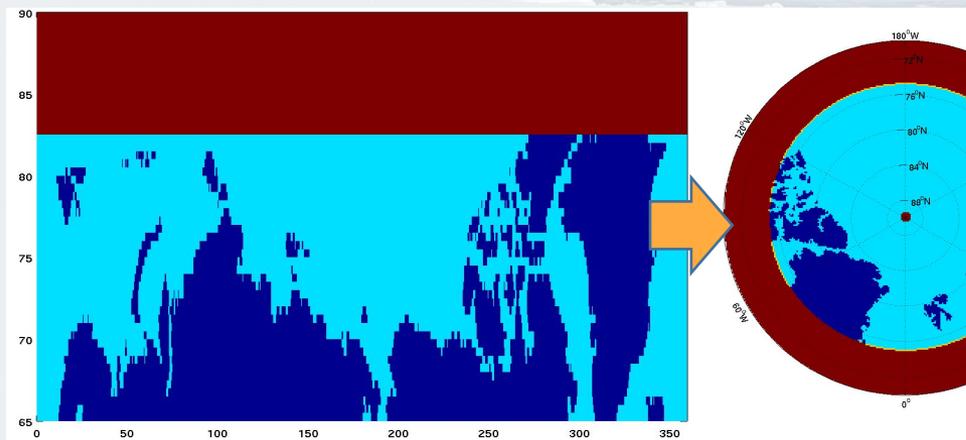
# Global Wave Deterministic (wave\_multi\_1)

- Arctic grid: ½ degree, limited at 82N → numerical constraints, small time steps.
- Receding ice extent in Arctic:
  - requirement for wave guidance within Arctic basin, needs grid > 82N,



## Proposed Spatial Grid Upgrade

Replace regular grid, limited to 82N, with polar stereographic grid resolving near pole.  
→ improved guidance under receding Arctic ice.



# Evaluation of Upgrade

Changes that need validation,

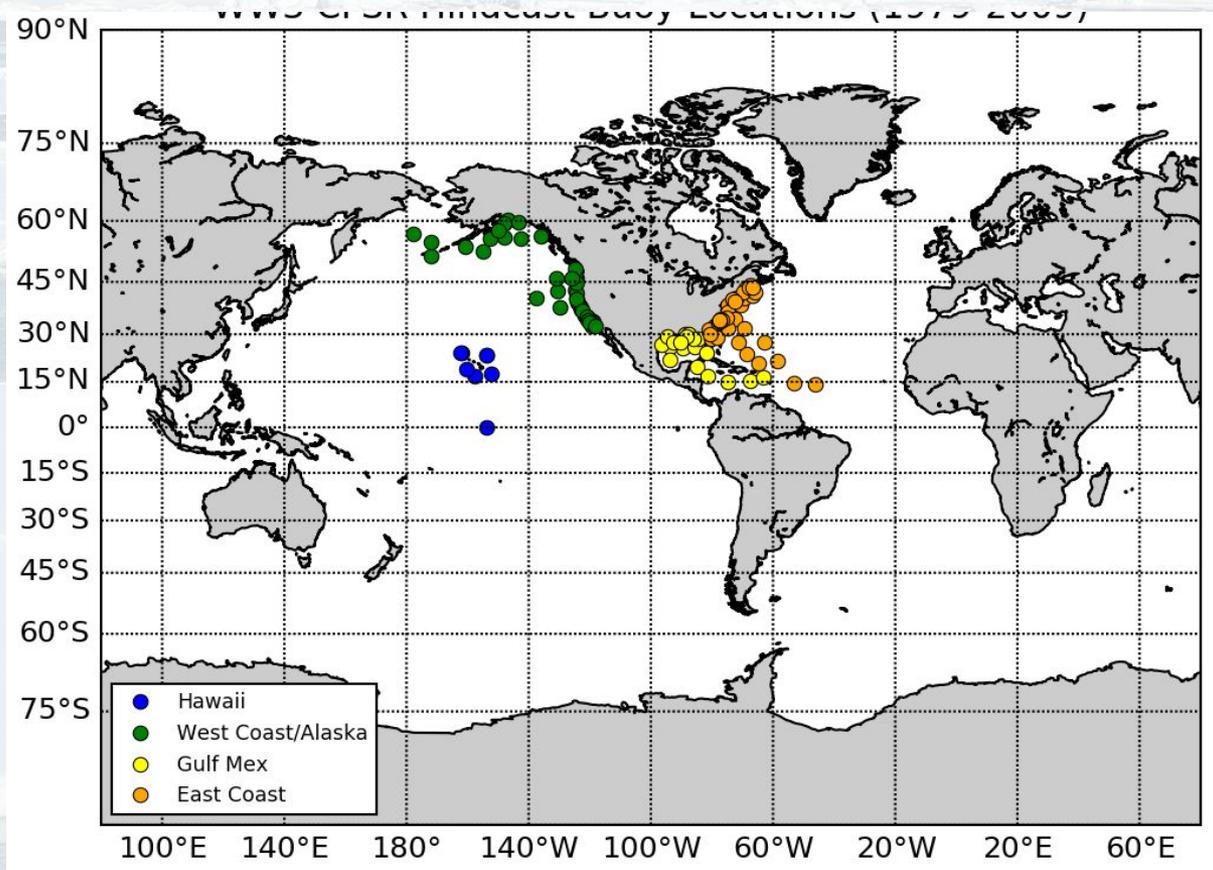
- Grid type was changed and resolution affected,
  - Current cell size  $\sim 25\text{km} \times \sim 15 \rightarrow 8\text{km}$ ,
  - Upgrade cell size  $\sim 18\text{km} \times \sim 18\text{km}$ ,
  - Does this degrade wave guidance of system within and outside the Arctic region?
- Grid was effectively extended from 82N  $\rightarrow$   $\sim 90\text{N}$ ,
  - What is the impact to wave guidance in the Arctic?
  - What is the performance within the extended area?

Validation: running Operational system and Proposed Upgrade for a multiple-year hindcast, comparing results.

# Impact to Model Skill Outside Arctic

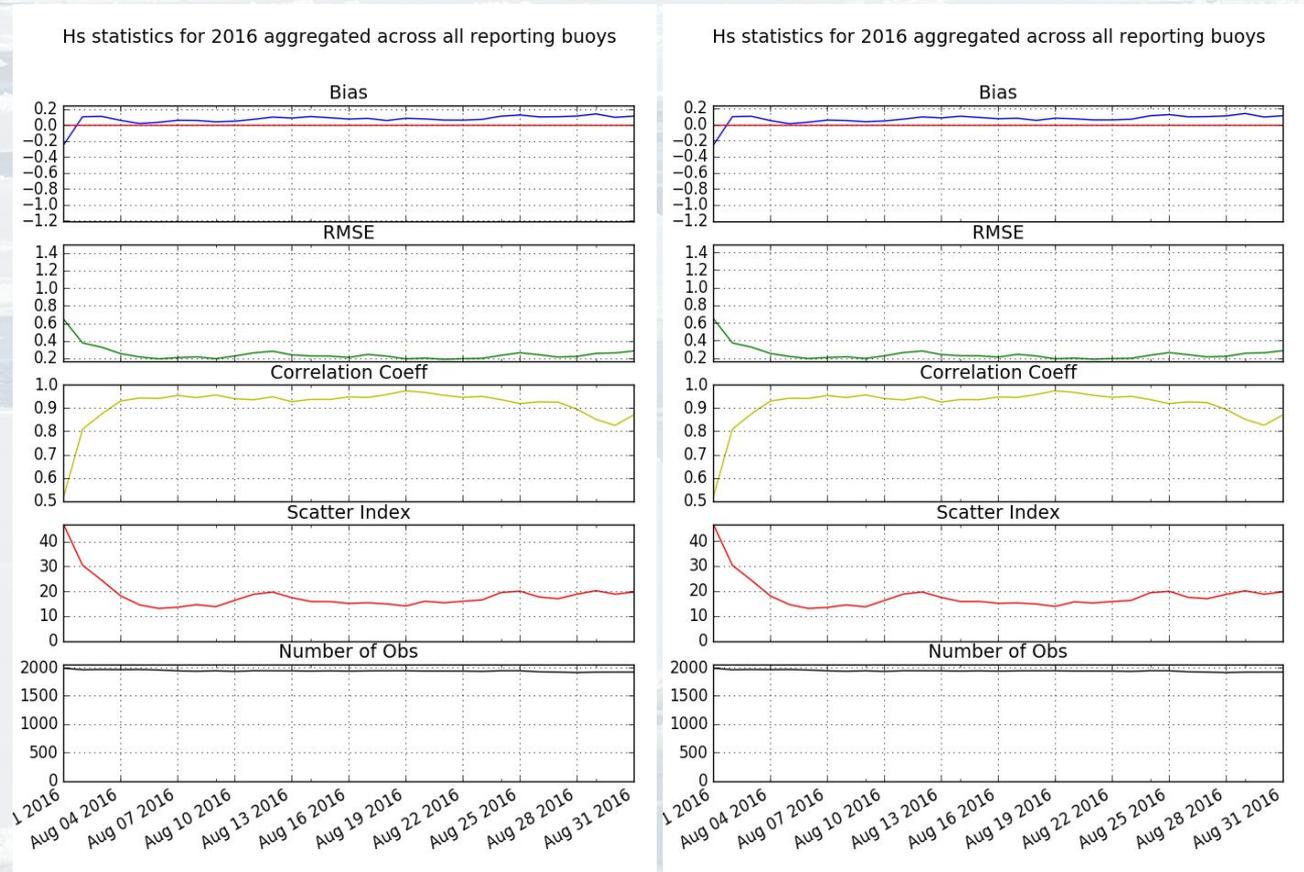
Simulations were made by running WAVEWATCH III for 2012, 2014, 2015 and 2016.

Impact outside Arctic:  
 - Model wave-heights were compared to data from buoys in several areas in the Atlantic and Pacific.



## Impact to Model Skill Outside Arctic

Impact of grid change to regions outside the Arctic, negligible,  
 - Results virtually identical at all Atlantic and Pacific buoys for all years.



Does upgrade degrade wave guidance of the system as whole? **NO**

# Impact to Wave Model Skill in the Arctic Region

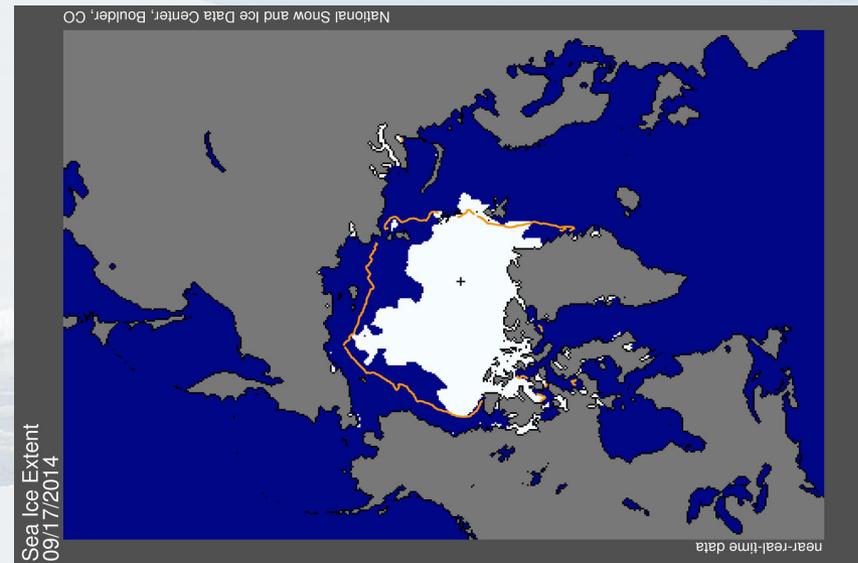
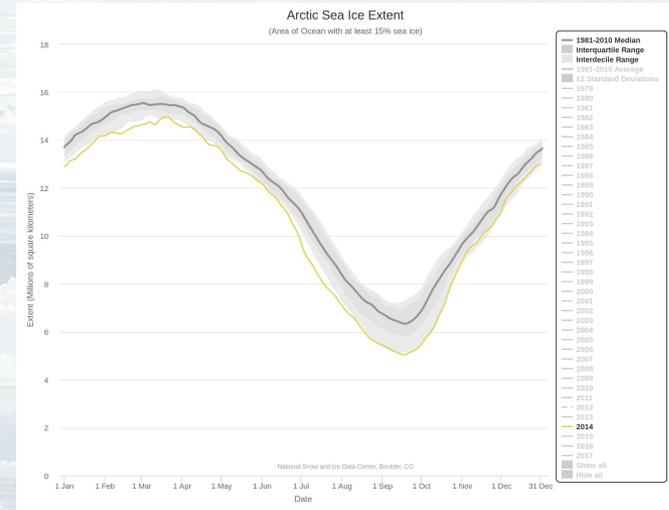
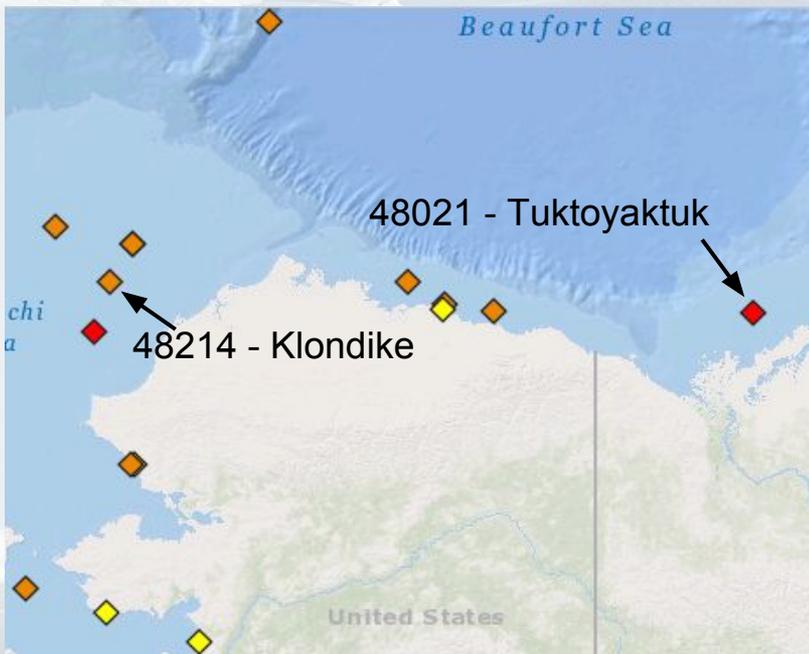
- Grid was effectively extended from 82N  $\rightarrow$   $\sim$ 90N,
  - Does this degrade wave guidance in the Arctic near the Alaskan coast?
  - What is the impact to wave guidance in the Arctic as a whole?
  - What is the performance in the extended area ( $>$  82N)?

## Impact to Skill Offshore the Alaskan Coast

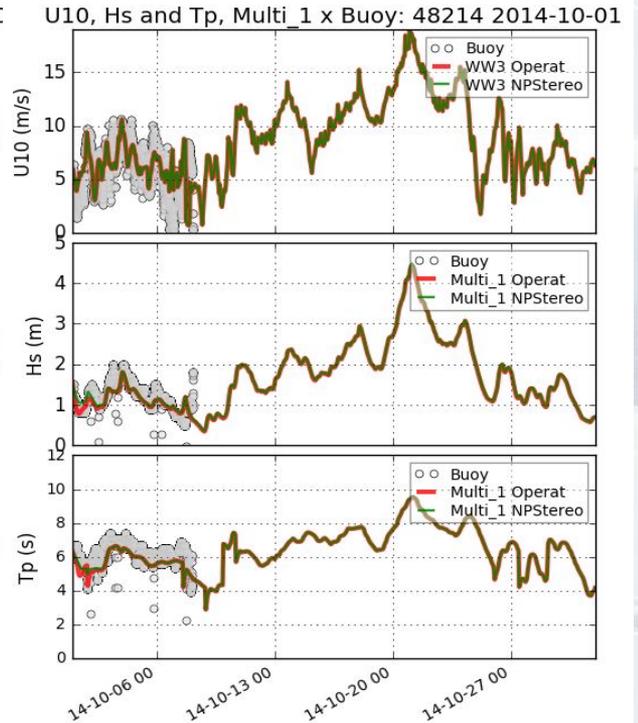
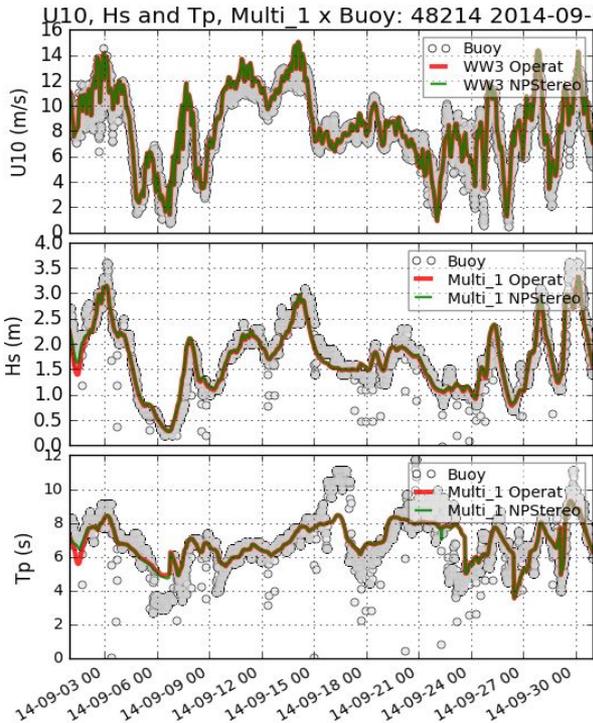
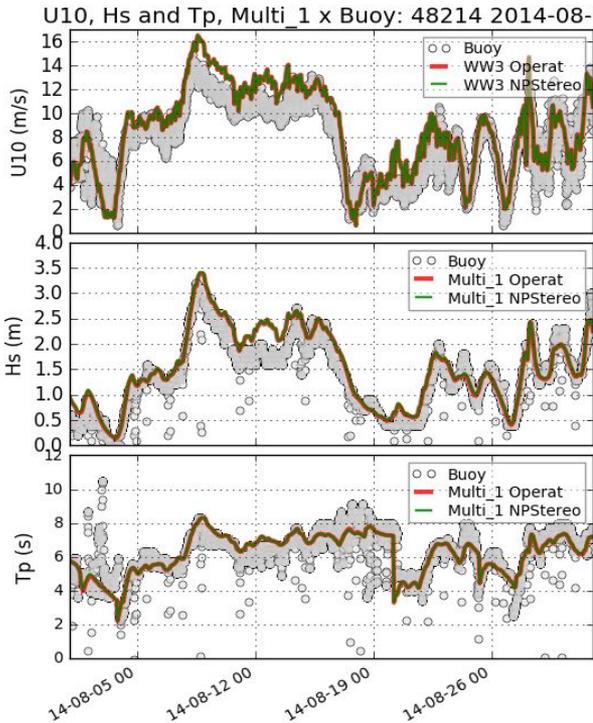
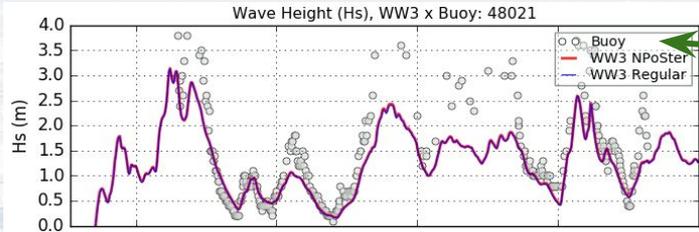
Only in situ wave data found was 2014, two buoys,

- limited to Sep at Tuktoyaktuk,
- Aug-Oct at Klondike,
- too far south (~70N), where ice pack extends under 82N (little influence of extended grid),

**Allows us to check if new grid degrades guidance relative to operational system near Alaska.**



## Time Series from *in situ* Arctic Wave Data



Does upgrade degrade guidance in the Arctic near the Alaskan coast? **NO**

# Arctic-Wide Skill - Altimeter Wave-Height Data

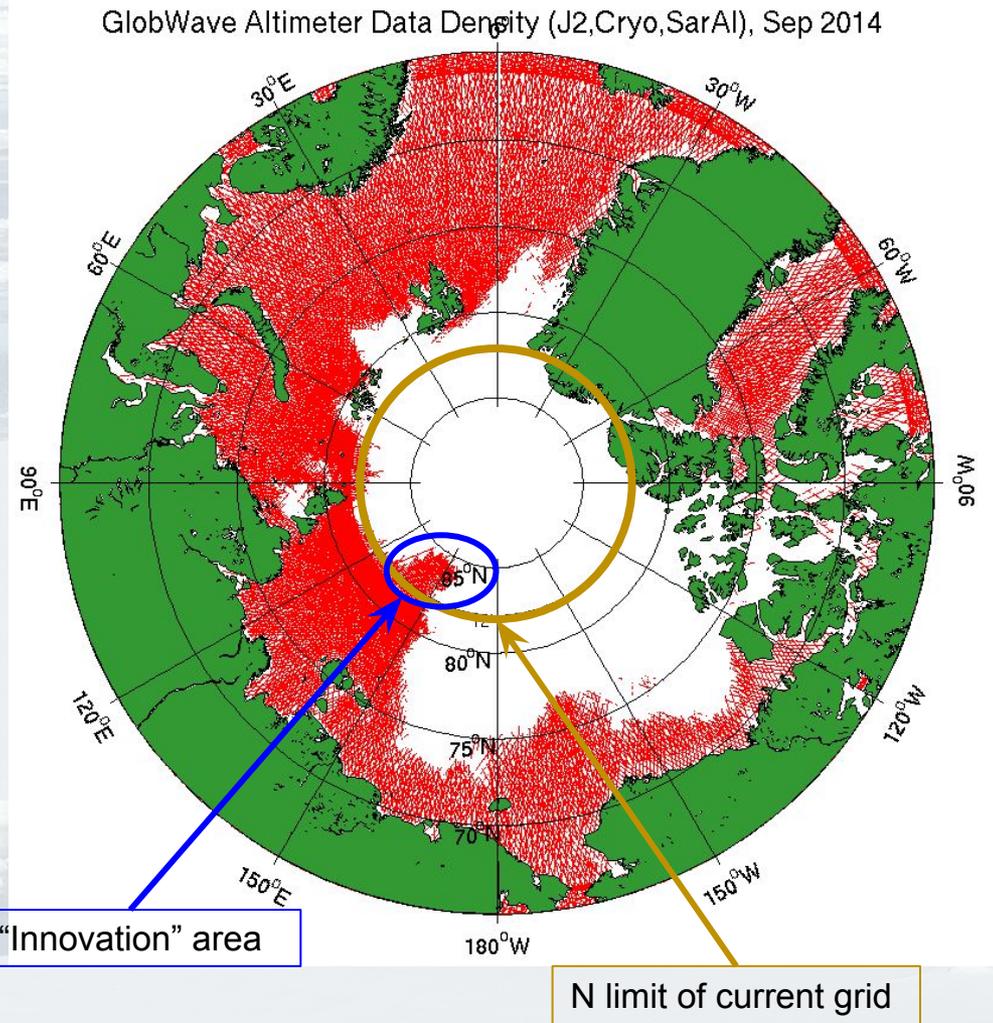
Altimeter data for validation obtained from GlobWave, QC Hs from three altimeters in 2014:

- Jason-2, Cryosat, Saral/Altika

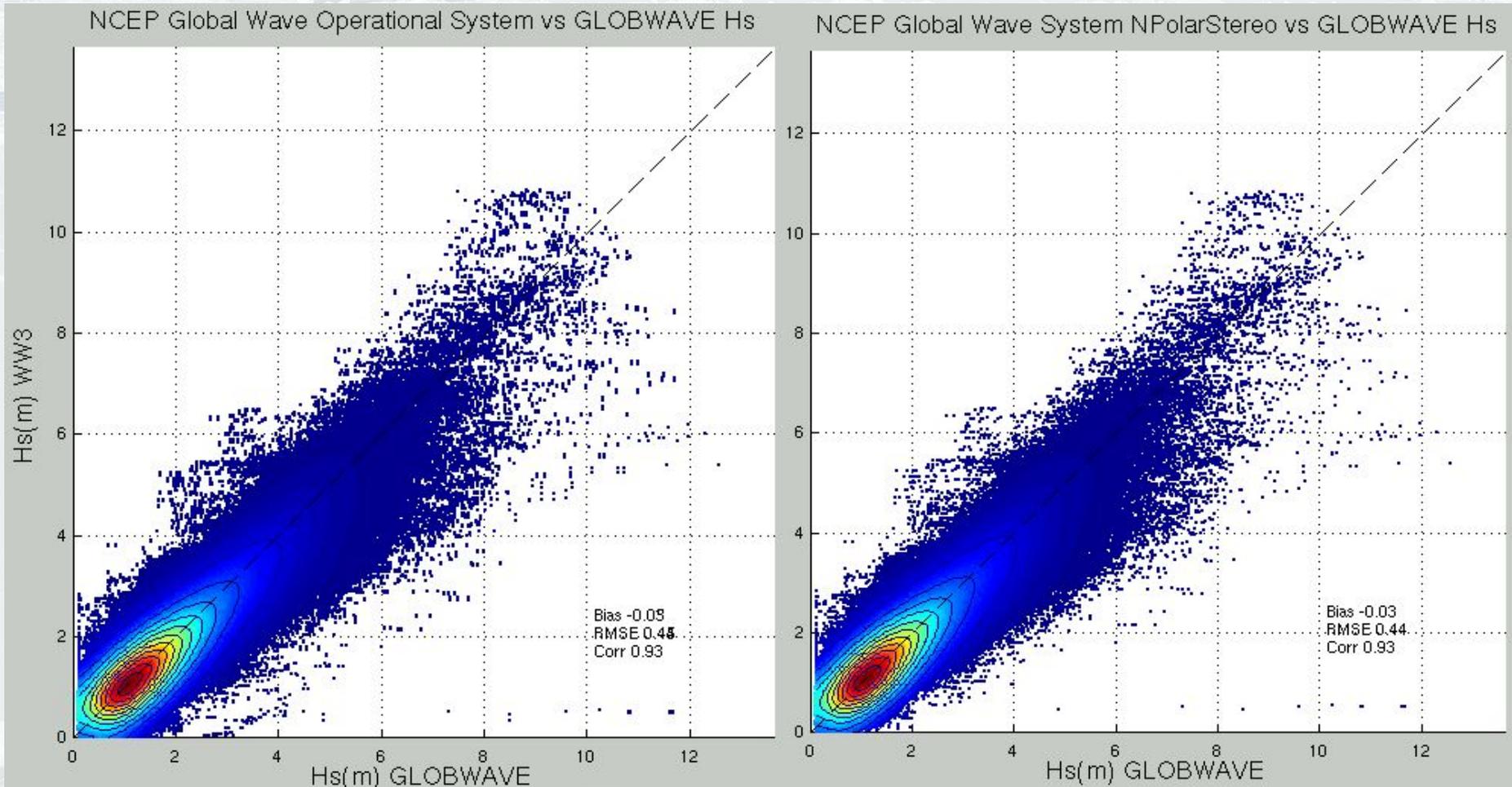
Model data bi-linear interpol to altimeter track → co-located Hs,

Allows assessment:

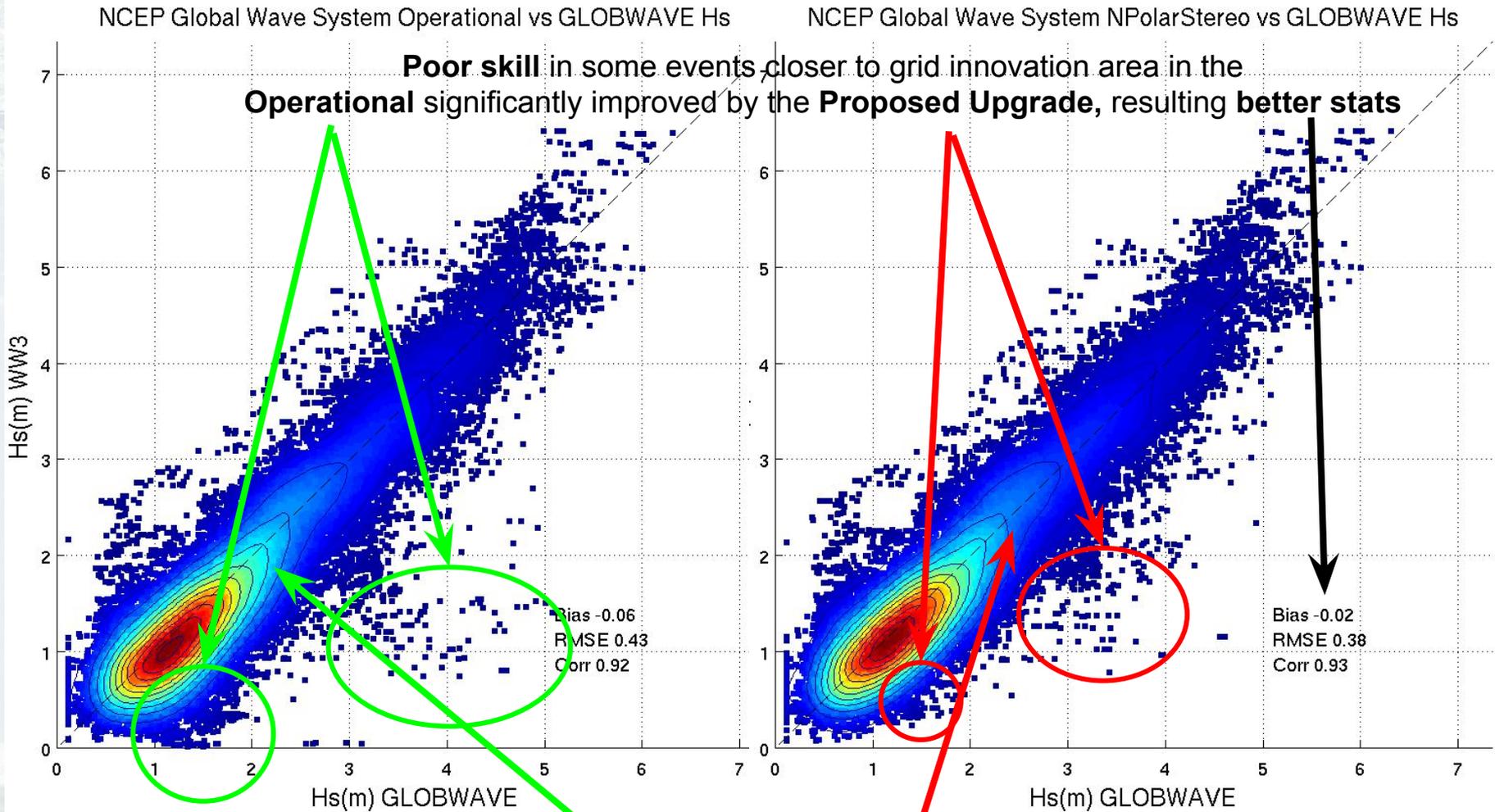
1. Arctic-wide skill:
  - **Bulk:** over area > 60N.
2. Impact of NPS grid to areas covered by current system:
  - **Case studies,** support → all-basin analysis of NPS-OPR.
3. Skill of wave model within the “innovation area” (>82N cap).



# Arctic-Wide Skill - Bulk Validation Jun-Nov 2014



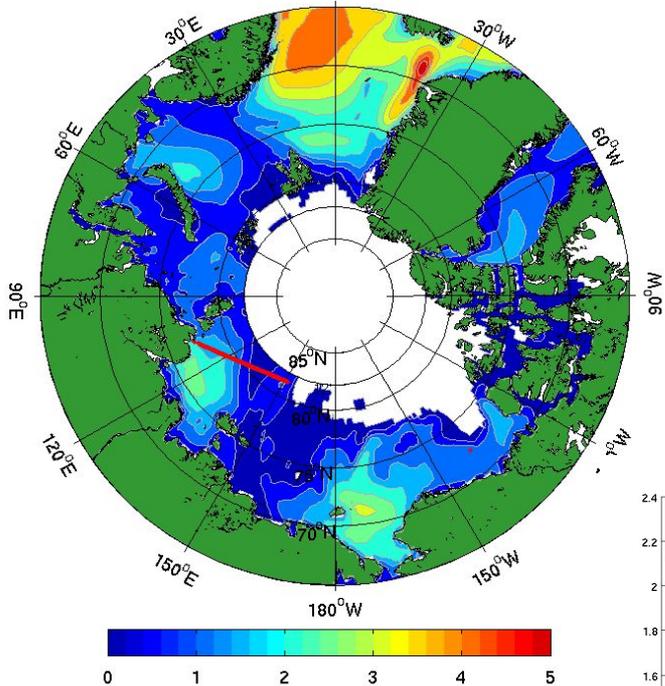
## Arctic-Wide Skill - Bulk Validation Oct 2014



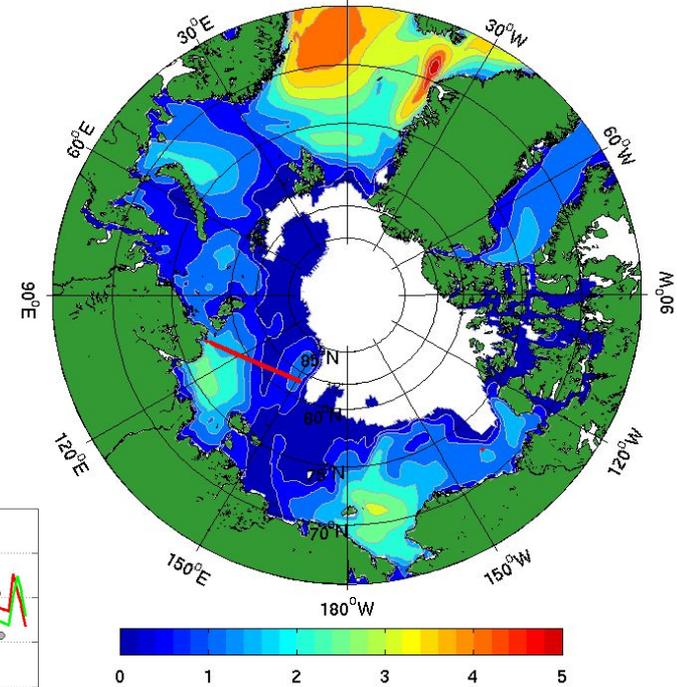
**Operational and Proposed Upgrade skills are mostly consistent for all co-locations (eg, no degradation)**

## Skill Improved: Joint Areas Near Grid Innovation

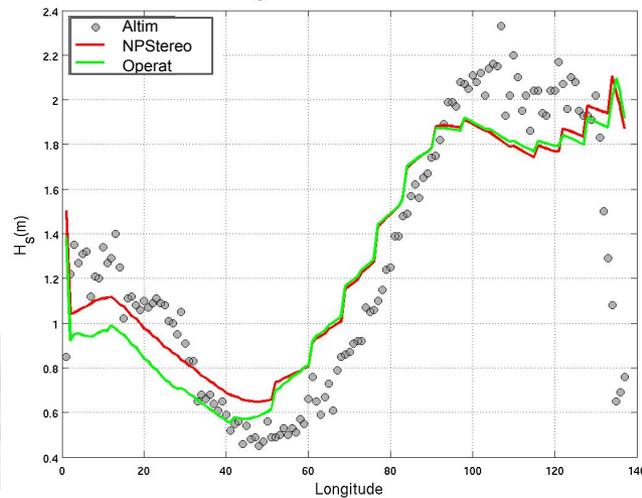
H<sub>s</sub> Map Operational Grid 2014/9/2 13h



H<sub>s</sub> Map NPSTereo Grid 2014/9/2 13h

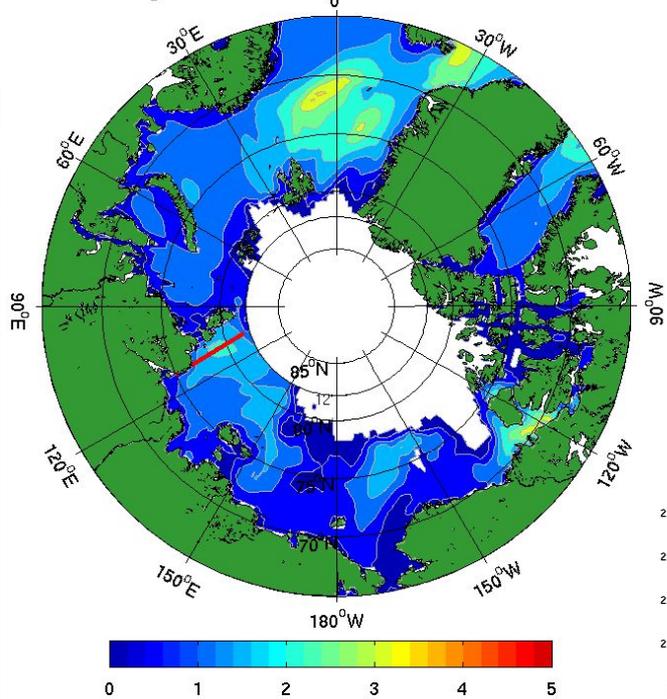


H<sub>s</sub> Along track on 2014/9/2 13h

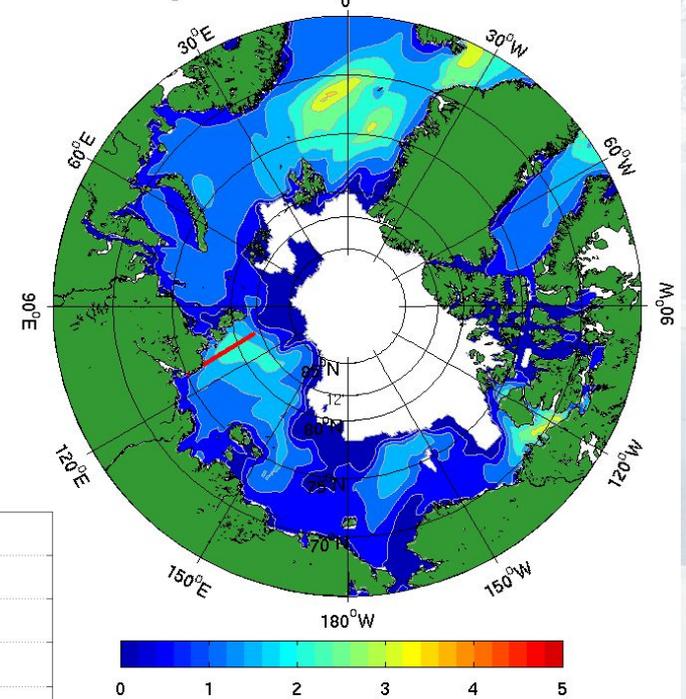


## Comparison to Altimeter Data, Cases

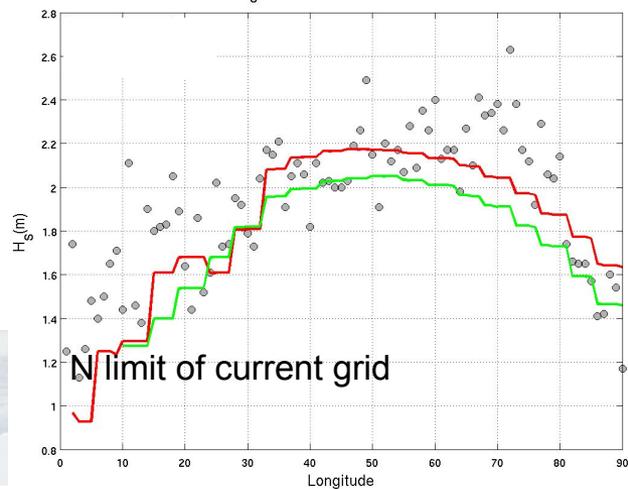
$H_s$  Map Operational Grid 2014/9/6 14h



$H_s$  Map NP Stereo Grid 2014/9/6 14h



$H_s$  Along track on 2014/9/6 14h



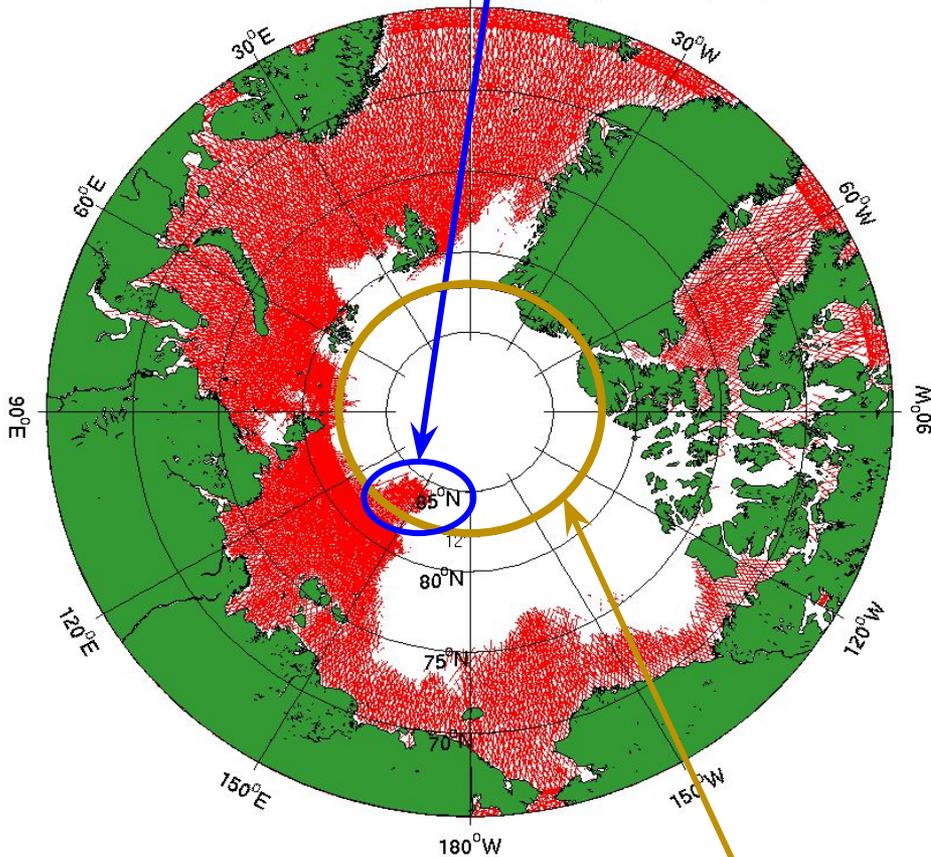
# Impact of Upgrade to Wave Model Skill

- Based on in situ and altimeter data, proposed upgrade:
  - Degrades wave guidance in the Arctic ( $> 60N$ )? **NO**
    - Buoy data: results are identical where ice extends below 82N,
  - Impact to wave guidance in the Arctic? **Positive**
    - Altimeter data: new grid brings improvement in terms of bias, RMS error and correlation.

## Performance in Extended Arctic Domain

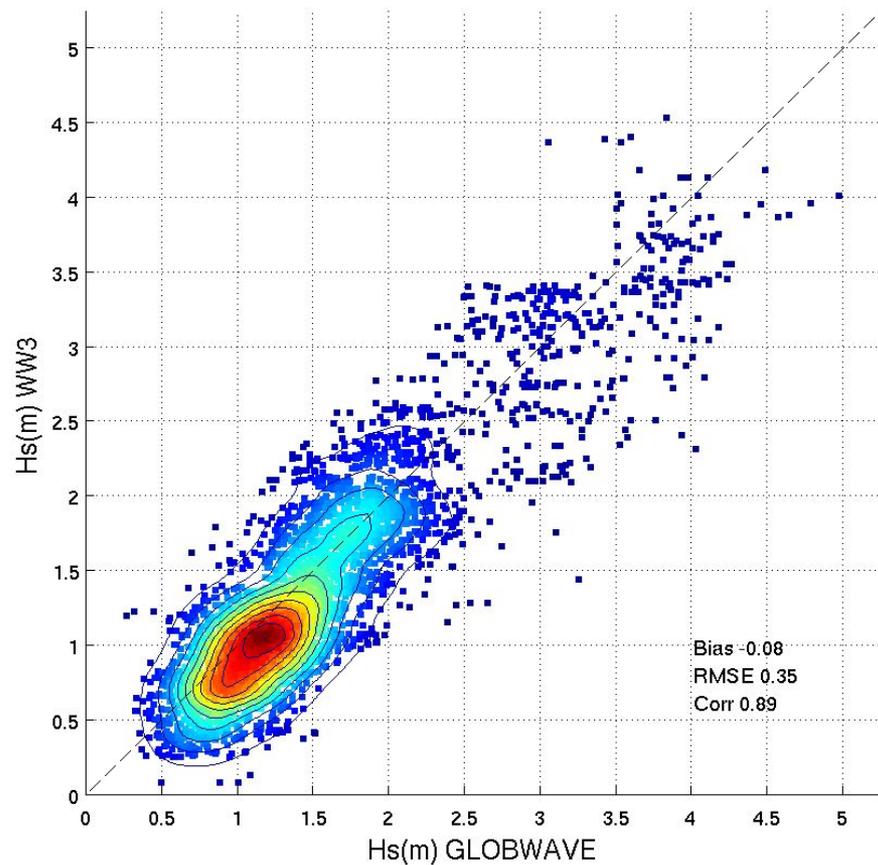
“Innovation” area

GlobWave Altimeter Data Density (J2,Cryo,SarAI), Sep 2014



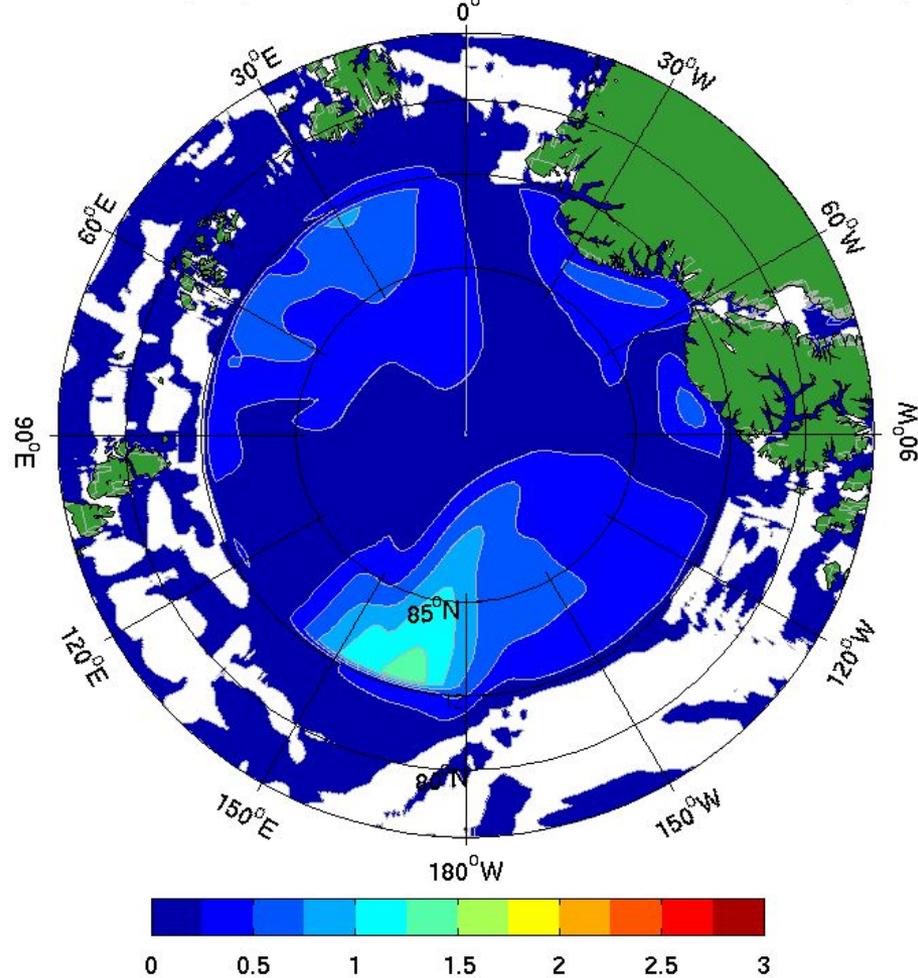
N limit of current grid

Multi<sub>1</sub> NPS grid, Data > 82N vs GLOBWAVE Hs



# Differences in Hypothetical Ice-Free Arctic Sep 2014

$H_s$  Difference Map Operational Grid NPS-OPR Ice-Free Arctic, Sep 2014



# Addition of hourly grib2 output

- Provides consistency with output stride of upstream model GFS → consistent with transition to coupled system,
- Attends requirements of supporting RTMA/URMA new wave analysis product,
- Currently grib2 files generated every 3h,
- New 1h stride will increase disk space requirement in 11Gb/day
  - No effect on compute resource usage or total runtime,
  - Request will be made to HPCRAC on code delivery.

# Impacts to WCOSS/NCO Resources

- No changes in usage of compute nodes,
- Increase in disk space requirements due to higher grib2 output stride of ~6-7Gb/day,
  - Subject to HPCRAC approval,
- No immediate changes in SBN dissemination requirements.

# External Evaluations

- Eugene Petrescu, Alaska Region
- David Mills, OPC
- Brian Miretzki, Eastern Region



# External Evaluations

- David Mills, OPC
  - Brian Miretzki, Eastern Region
  - Eugene Petrescu, Alaska Region
1. Does the extension of the global wave model grids to the Arctic basin increase the skill of wave model guidance in higher northern hemisphere latitudes?
  2. Does the extension of the global wave model grids to the Arctic basin provide added value to your use of the wave\_multi\_1 products?
  3. Is the addition of hourly wave\_multi\_1 grib2 products beneficial to your work?

# External Evaluations

Does the extension of the global wave model grids to the Arctic basin increase the skill of wave model guidance in higher northern hemisphere latitudes?

- **David:** It likely **does improve the skill** of the model as one would assume.
- **Brian:** Everything looked fine from a cursory check.
- **Gene:** The data from the extended domain appeared to be **as good as or better** than the operational and other available guidance ... [it] forecasted **higher wave heights in the Chukchi Sea closer to the coast** than the operational model during as a couple of lows ... [on] the 2<sup>nd</sup> week in August.

# External Evaluations

Does the extension of the global wave model grids to the Arctic basin provide added value to your use of the wave\_multi\_1 products?

- **Gene: Yes**, ... the data was found **quite valuable in providing improved forecasts for marine activity** occurring in the ice free waters north of 76N.
- **David: Yes**, as we currently produce graphic products in the Arctic basin at the 24-48-96 hour time step.

# External Evaluations

Is the addition of hourly wave\_multi\_1 grib2 products beneficial?

- **David:** Yes, as OPC expands our wave height grids ... [it] incorporates the hourly wave data to accompany the hourly wind data used in producing these grids.
- **Brian:** As far as hourly data that will only benefit us if EMC/NCO work to get this on AWIPS/SBN.

# External Evaluations

## Recommendations

- **David:** Implement as proposed.
- **Brian:** Implement as proposed.
- **Gene:** Implement as proposed.

# Global Wave Model Multi\_1 Upgrade 2017

The Global Wave Systems team requests approval from the NCEP Director for implementing the **wave\_multi\_1.v3.3.0** system, with the following added features:

- A Curvilinear Arctic Grid,
- Hourly grib2 output out to 120h.