The Application of Learned Wind Corrections to Wave Forecasts

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Motivation

- Bureau has recently replaced both its atmospheric models and wave models
- Validation of these systems
- Explore methods of statistical wind correction

Method

- Spatial wave biases determined from altimeter comparisons
- Spatial wind biases determined from scatterometer comparisons
- Adaptive spatially and temporally varying wind corrections developed based on scatterometer data
- Effects on the wave biases examined

Conclusions

- The wave model H_s is negatively biased over most of the globe
- This bias is due primarily to forcing winds
- These wind biases can be effectively removed in real time by learned corrections based on scatterometer data
- Wind corrections produce mixed H_s results.
  - Significant improvements in the Northern Hemisphere
  - Degradation in the Southern Hemisphere
- In general, removes some uncertainty in wind/wave error attribution, allowing more confident isolation of wave model error
- Wave model tuning can't be avoided!

Models

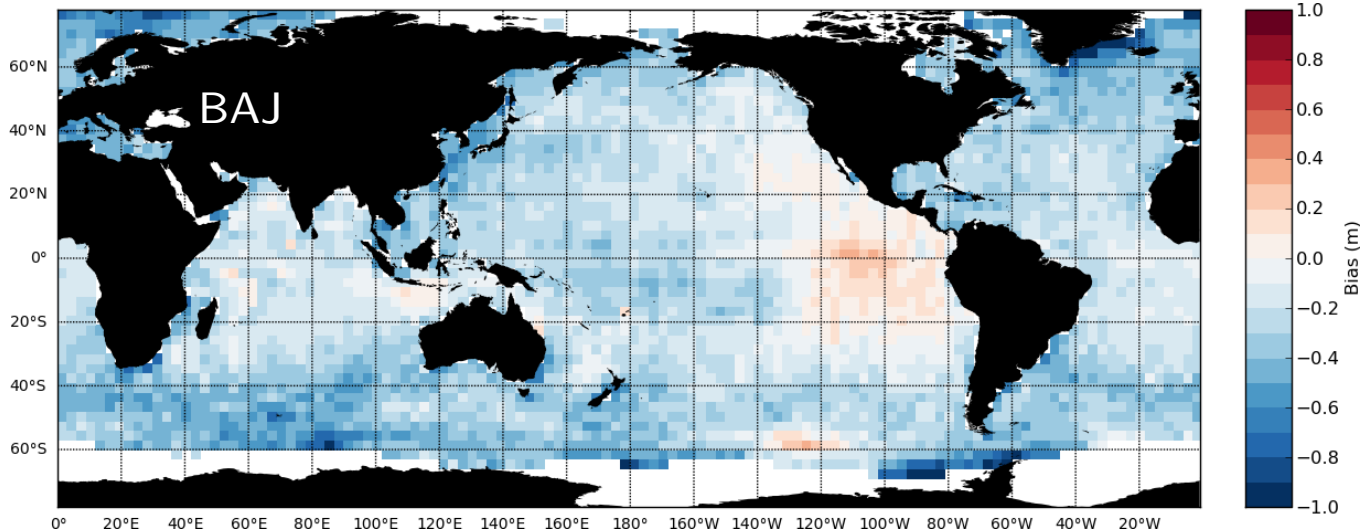
- Bureau has recently replaced its operational atmospheric models
  - GASP $\rightarrow$ ACCESS, based on The MetOffice Unified Model
- Also replaced the operational wave model
  - WAM $\rightarrow$ WAVEWATCH III®, WAM4 source terms (Bidlot and Janssen 2007)

Initial Verifications

WAVEWATCH III®

H_s bias against Jason-1 and Envisat Altimeters

July-October 2008



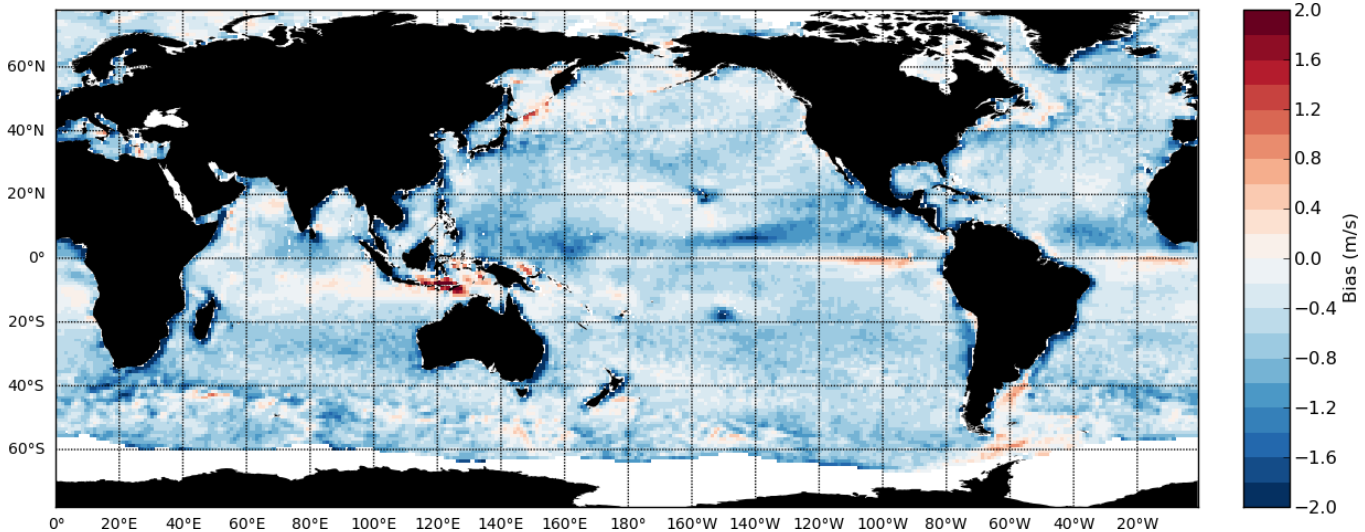
Bias ≈ -30 cm

Initial Verifications

ACCESS forcing winds

U_{10} bias against QuikSCAT scatterometer

July-October 2008



Bias $\approx$ -0.5 ms^{-1}

Error Sources

- Negative H_s bias caused primarily by the ACCESS winds

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- Tune the wave model?

Error Sources

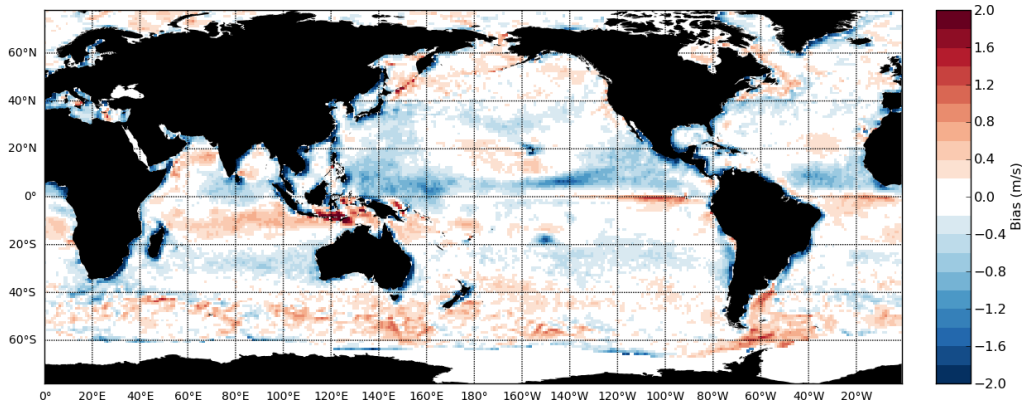
- Negative H_s bias caused primarily by the ACCESS winds
- Tune the wave model?
- Correct the winds!

Wind Corrections

Method

Simple, homogeneous corrections

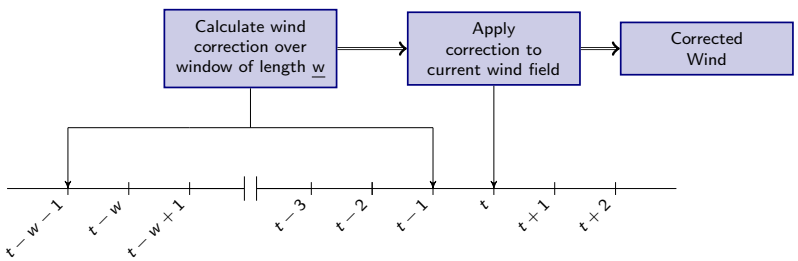
- Pros:
  - Simple
    $U_{corrected} = 1.06U \rightarrow$ Overall bias ≈ 0
- Cons:
  - Fixed in time, manual maintenance
  - Can't account for spatial variation



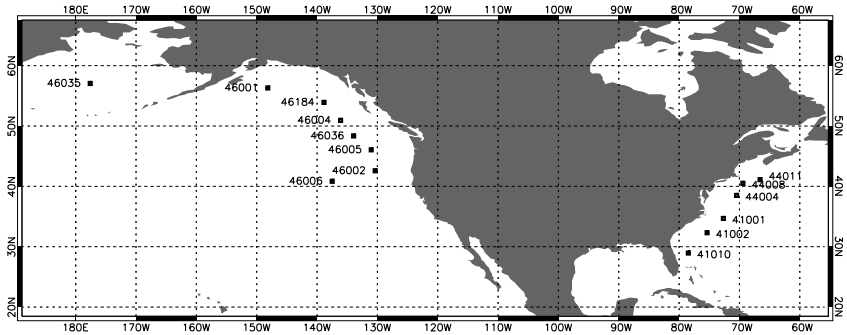
U_{10} Bias after 6% increase

Learned Corrections

- Correction based on comparison between previous model results and observations
  - Requires repeatable observations
  - Previously only applied to site based locations

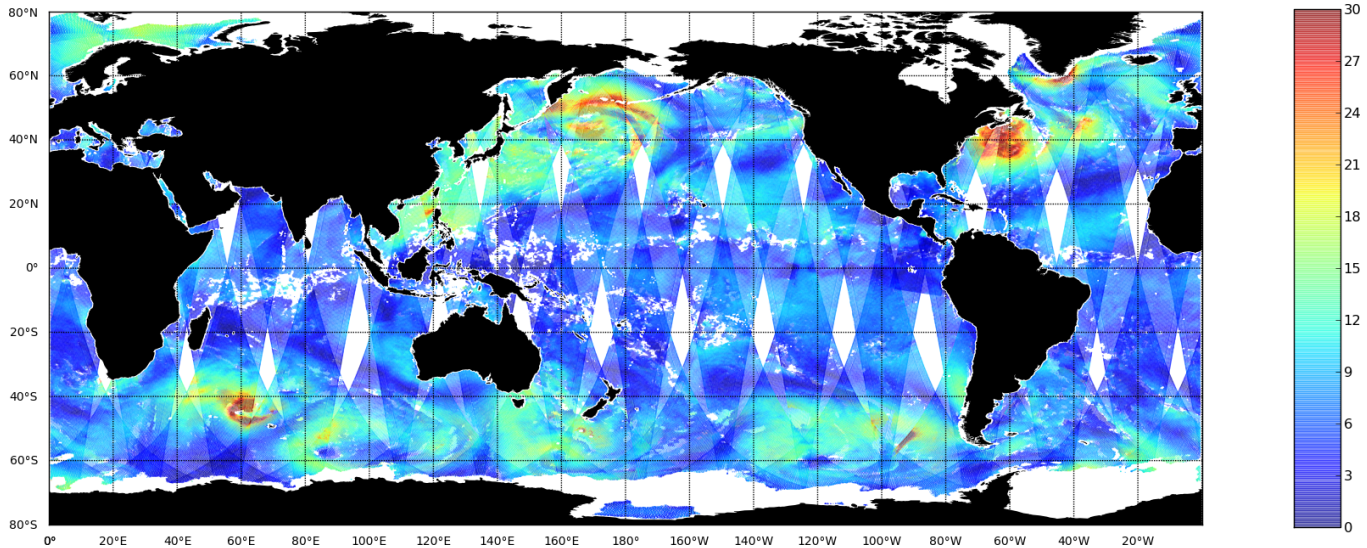


w = length of learning window



e.g. Woodcock and Greenslade 2007,
Durrant et. al. 2009

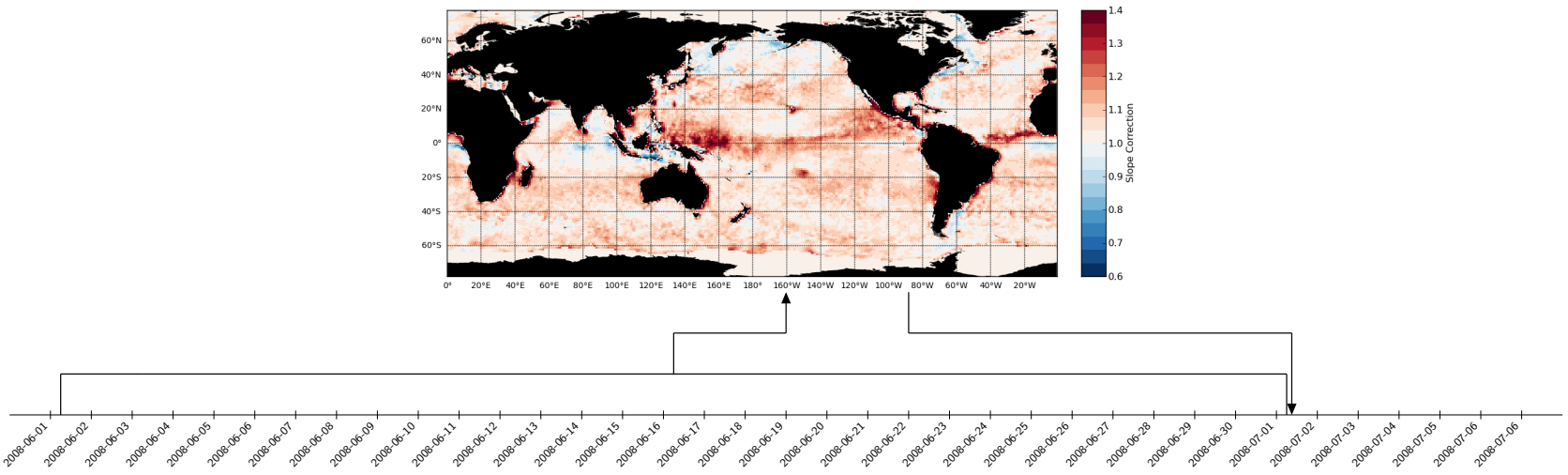
Gridded Learned Corrections?



One day of QuikSCAT data

Gridded Learned Corrections

Percentage increase at each grid point from QuikSCAT comparisons
Calculated every 3 hours, from previous 30 days

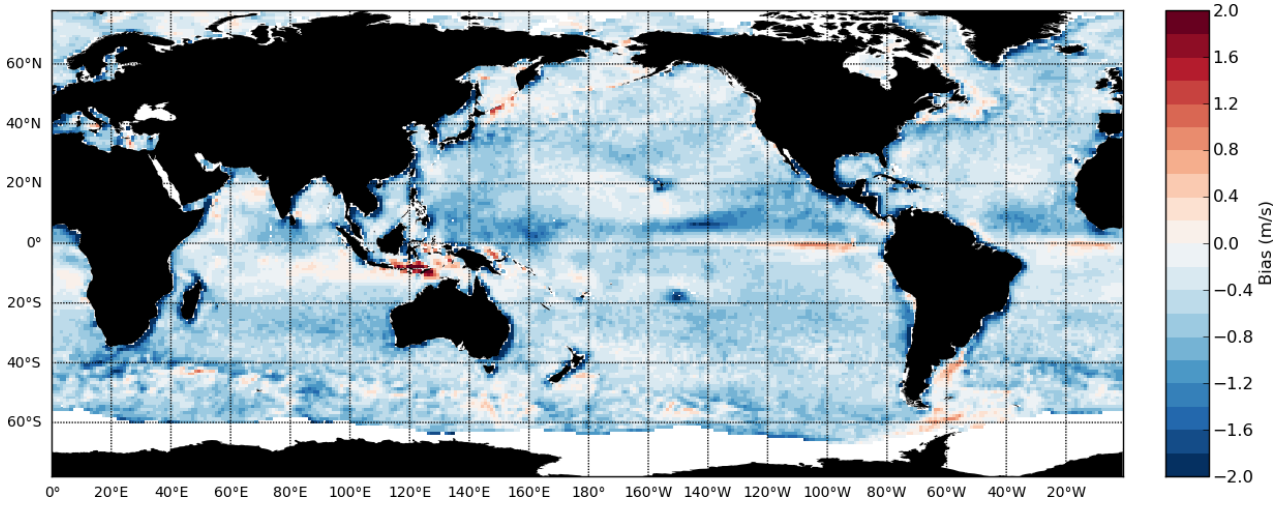


- Automatically adapts to recent bias of the atmospheric model
  - Seasonal changes
  - Large scale atmospheric modes of variability, e.g. ENSO
  - Physical changes to the model

Corrected Wind Bias

July-October 2008

Uncorrected Wind Bias



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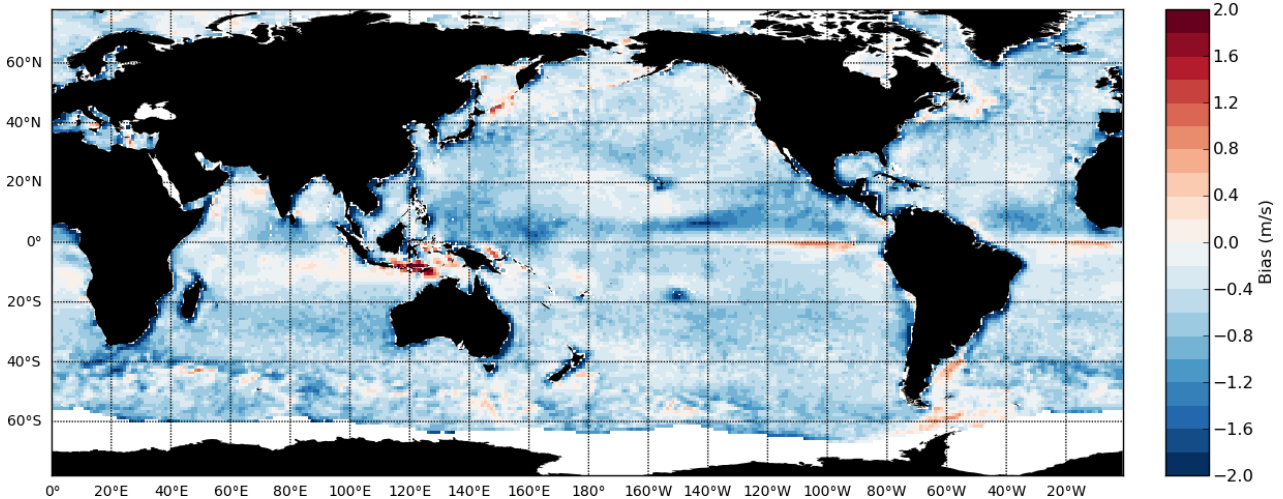

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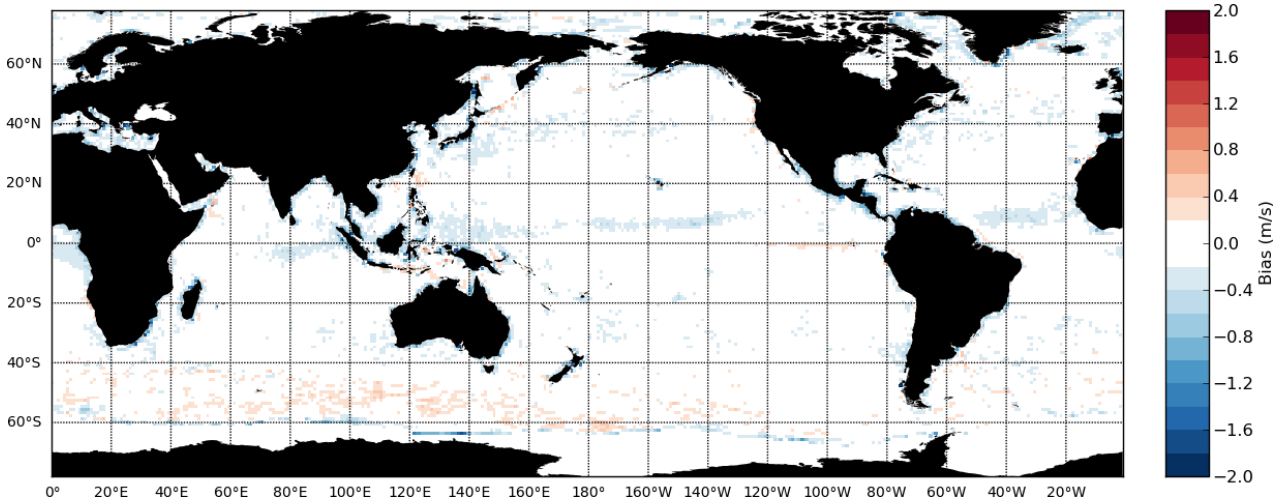
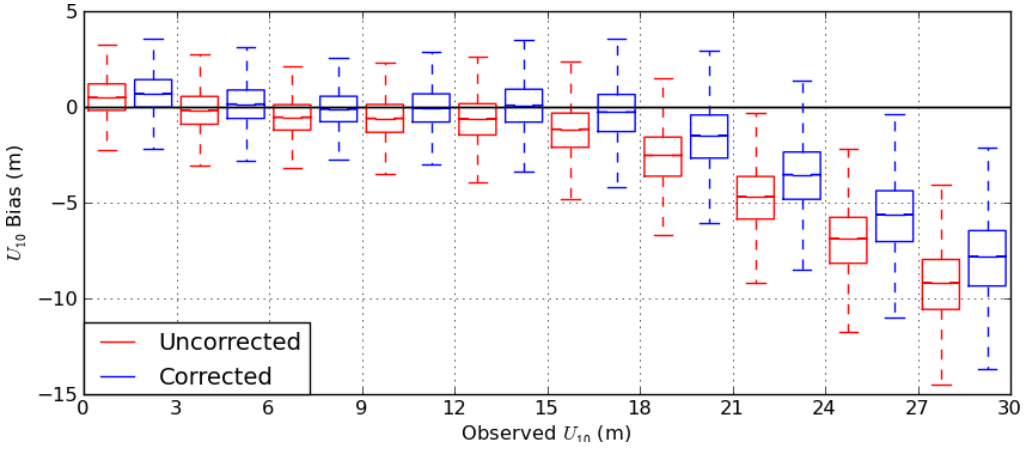
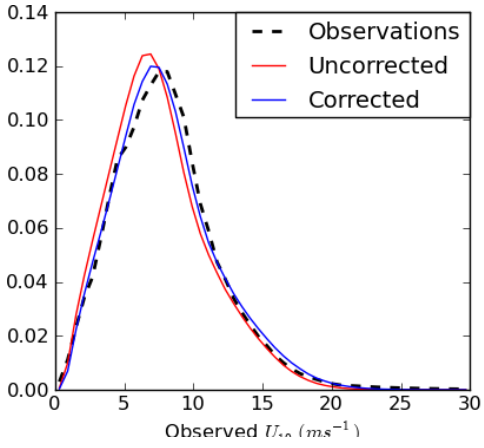


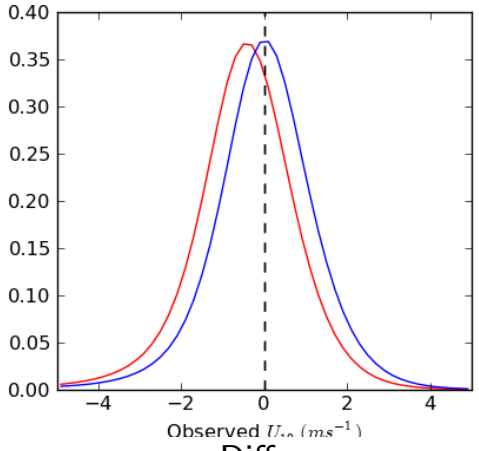
Corrected Winds

July-October 2008





PDF



Difference PDF

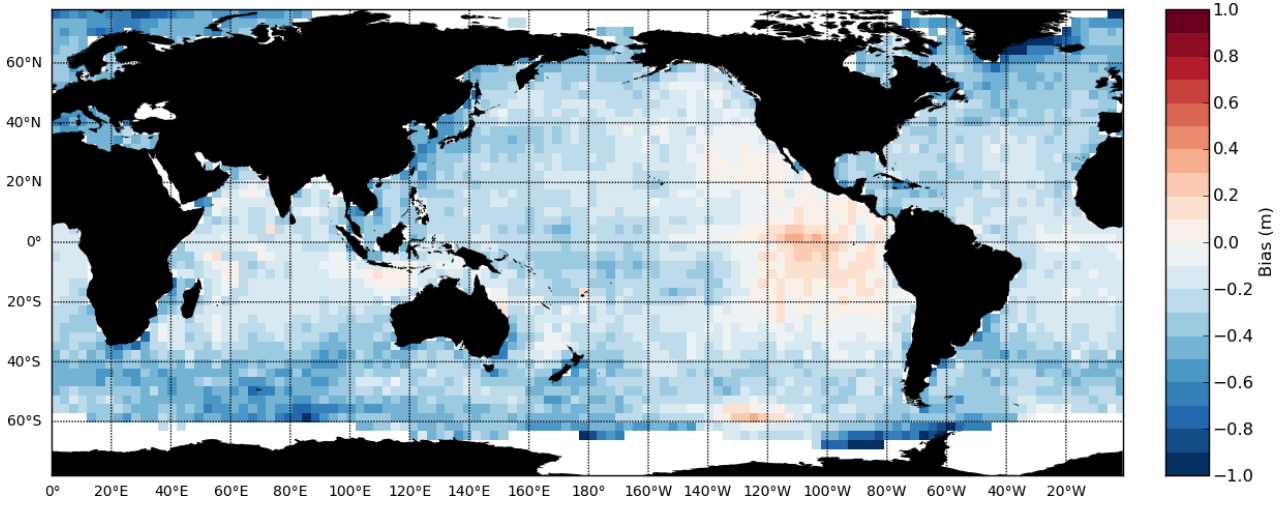
Overall RMSE reduced by 8%

High wind speeds still under-predicted

Effect on the Waves

July-October 2008

H_s Bias
Uncorrected Wind
Forcing



Effect on the Waves

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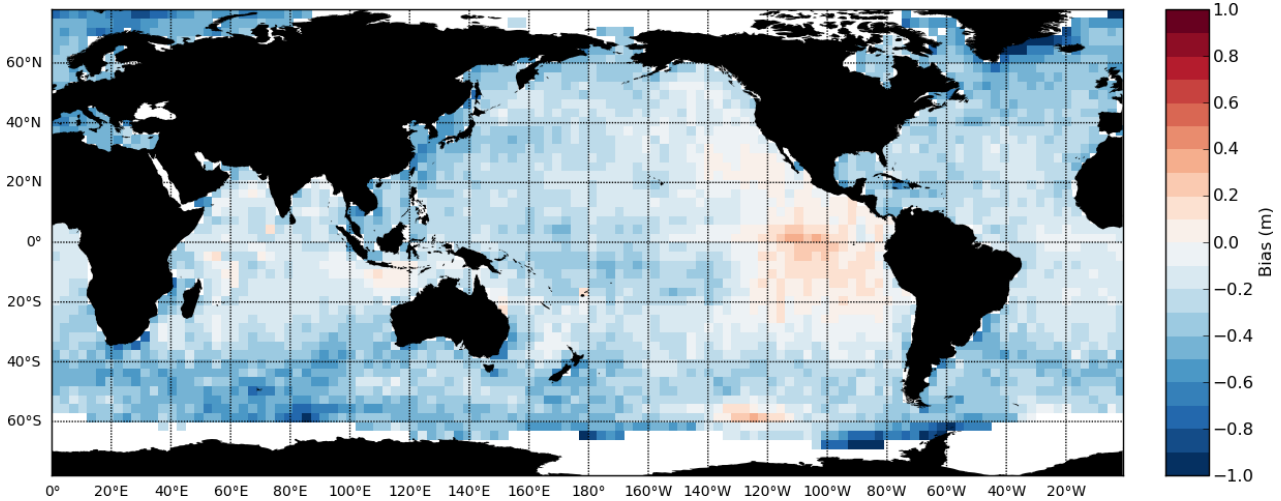

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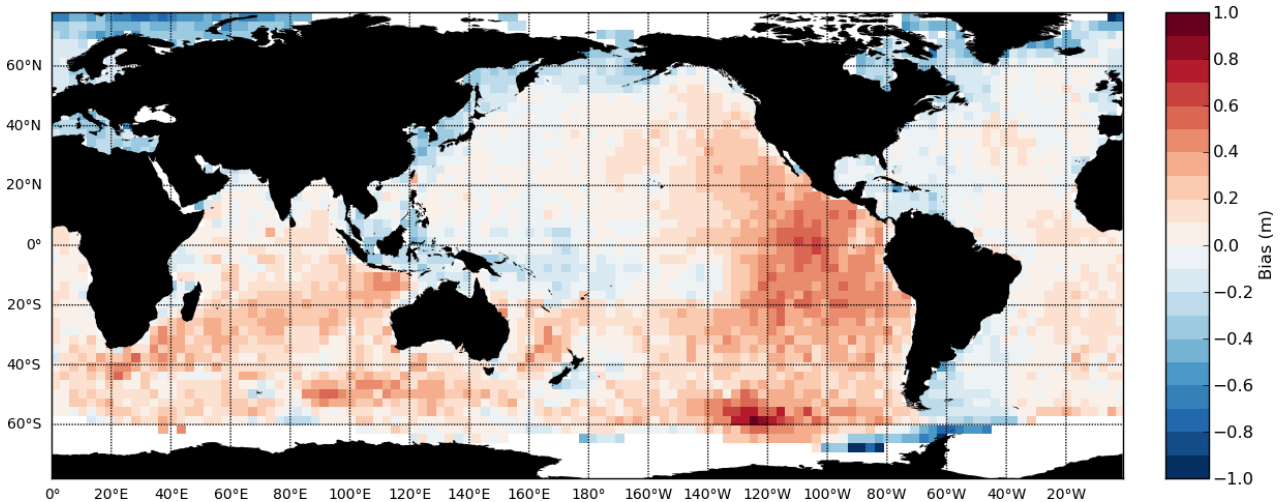

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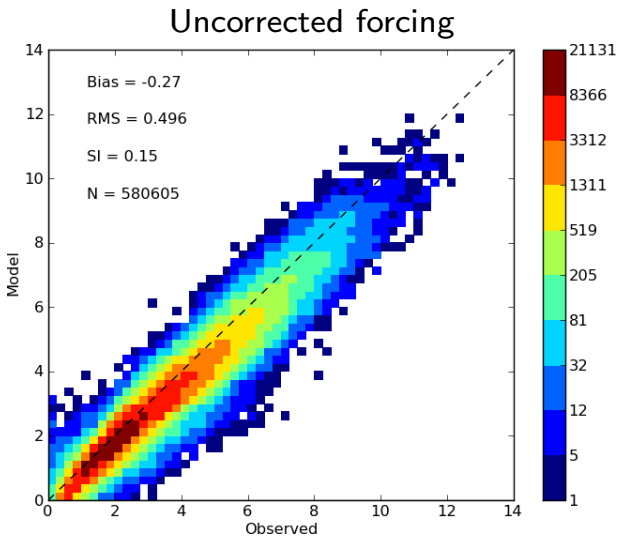
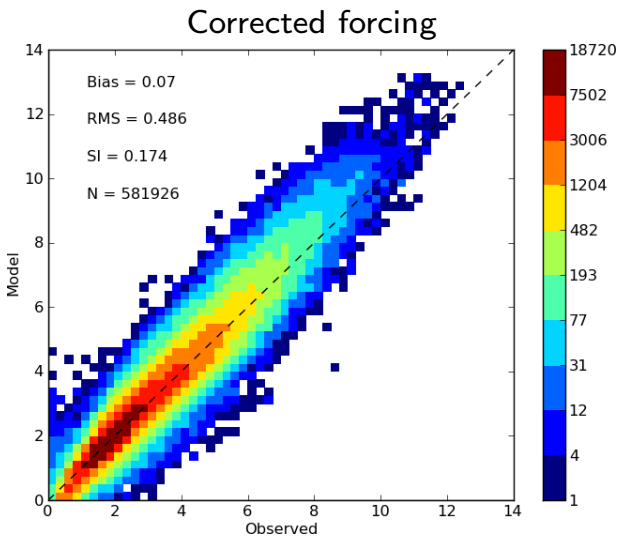
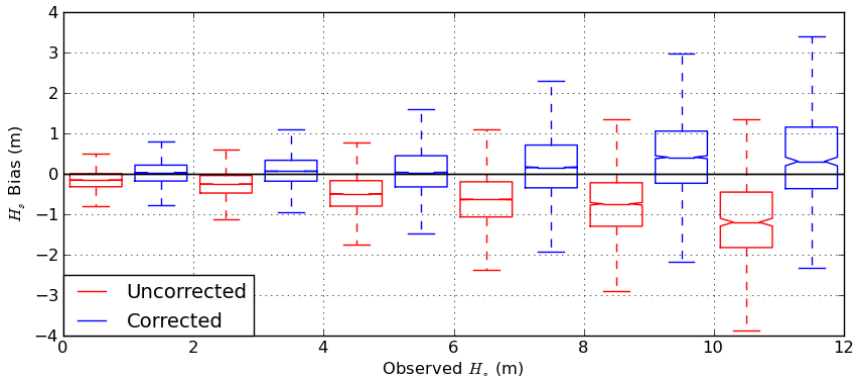


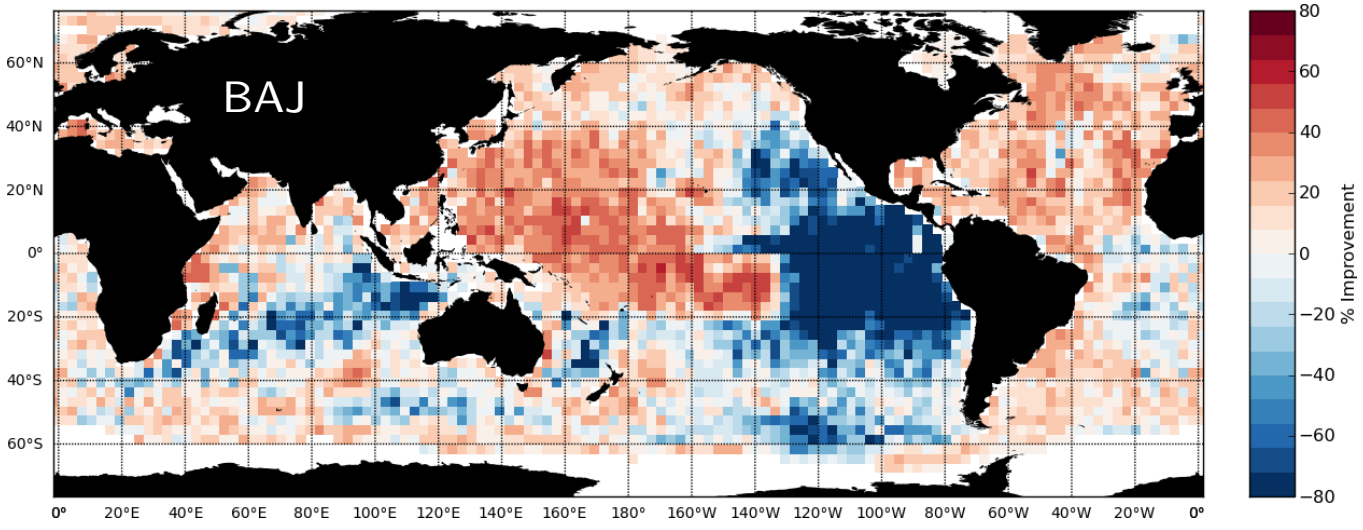




Over-predicted high H_s

Improvements in H_s RMSE

July-October 2008



+17% NH

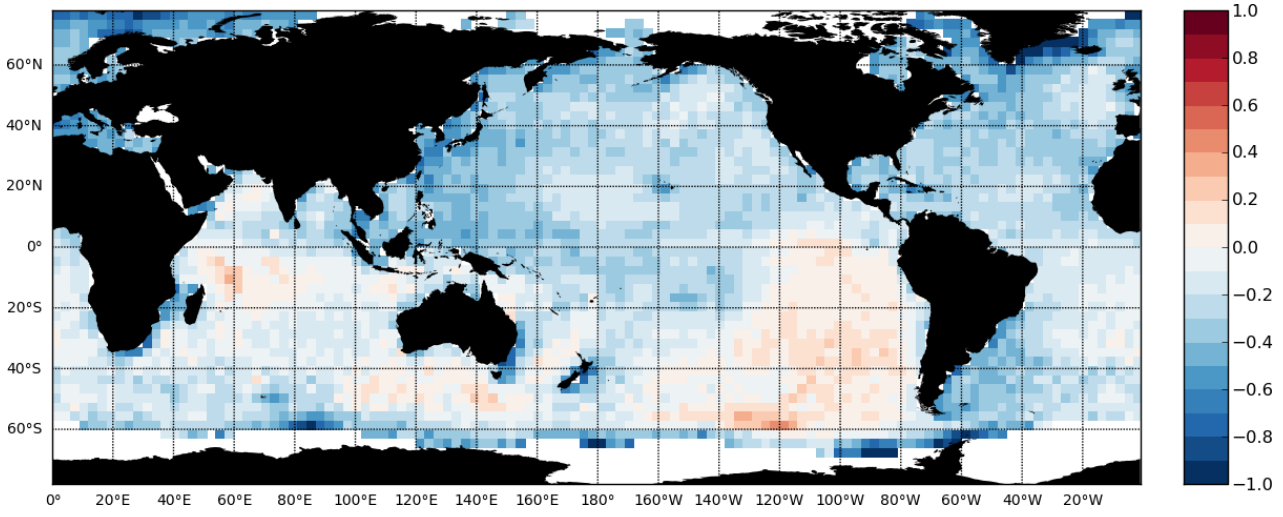
−6% Tropics

−4% SH

Comparison to TC96 Source Terms

July-October 2008

H_s Bias
Uncorrected Wind
Forcing



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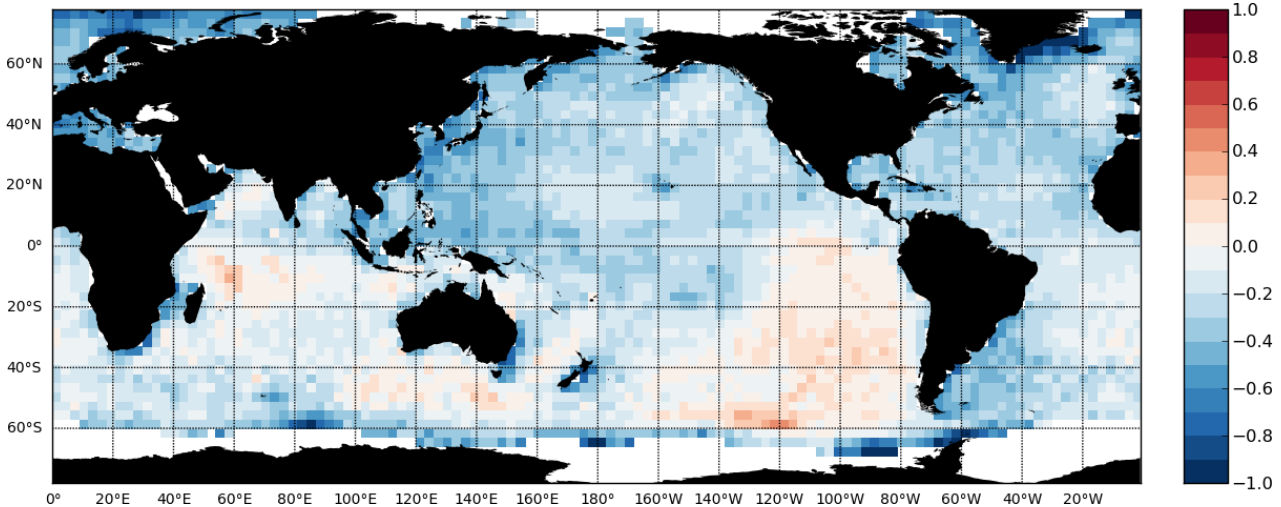

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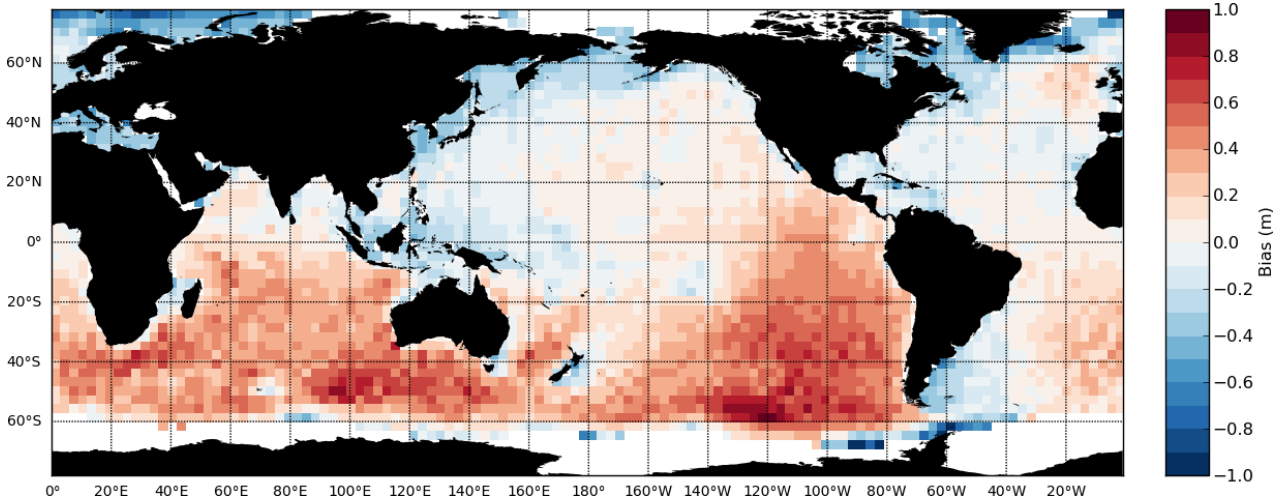

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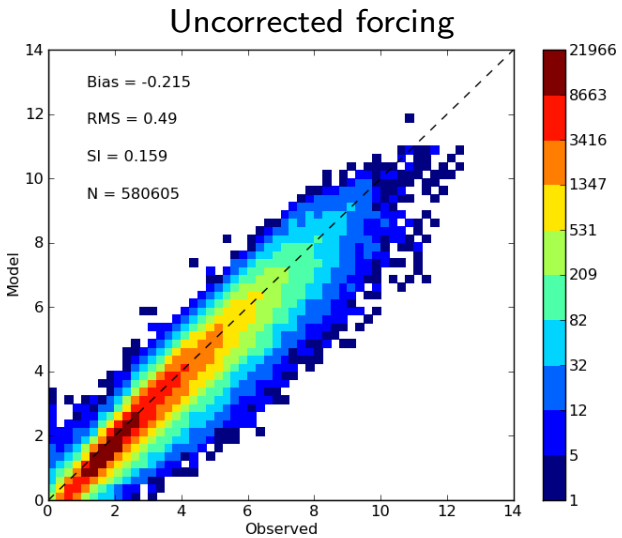
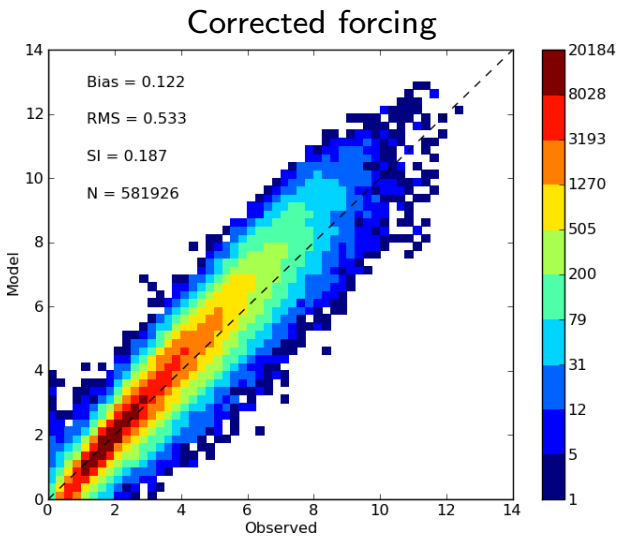
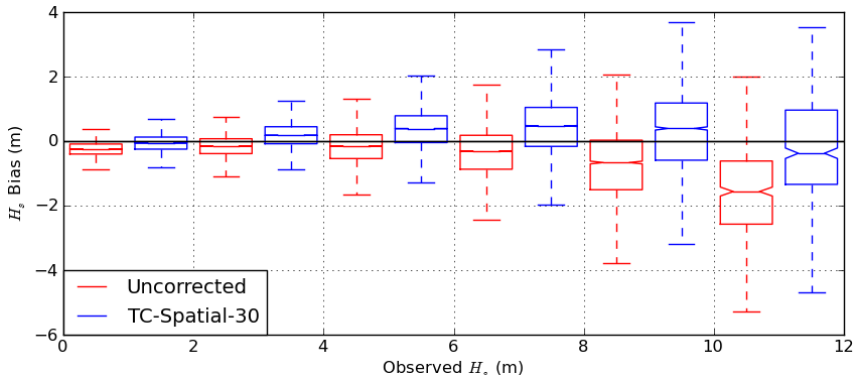
TC96

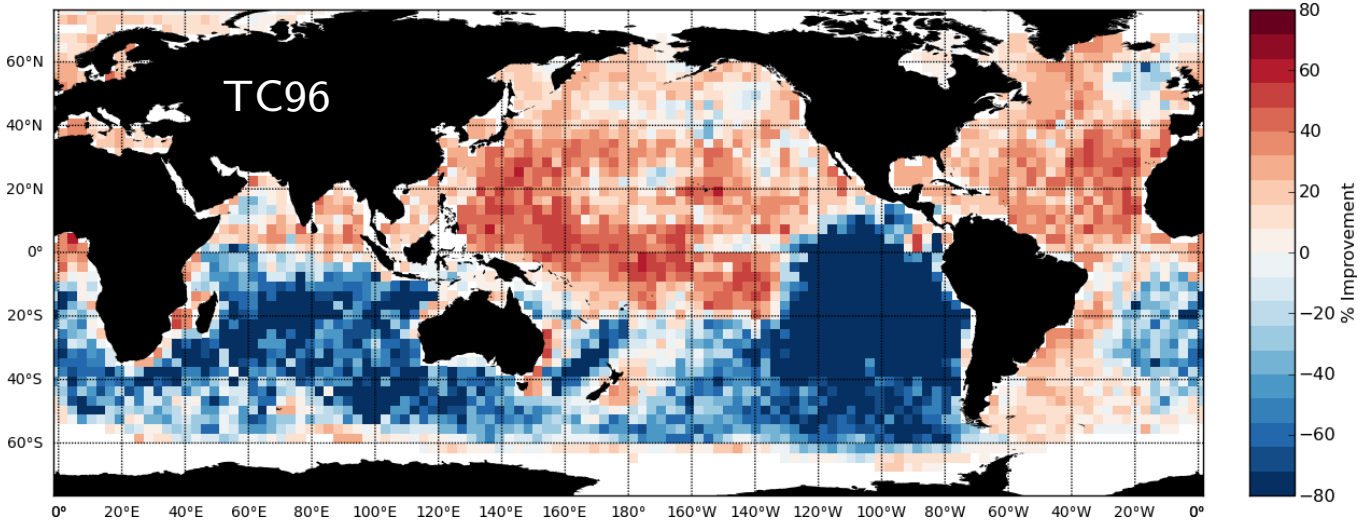






Over-predicted mid-range, high H_s ok

Improvements in H_s RMSE



+20% NH

+1% Tropics

−23% SH

Conclusions

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- This bias is due primarily to forcing winds
- These wind biases can be effectively removed in real time by learned corrections based on scatterometer data
- Wind corrections produce mixed H_s results.
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