WAVEWATCH III® validation

Present and future

Arun Chawla
SAIC @ Marine Modeling and Analysis Branch
NOAA / NWS / NCEP / EMC

Arun.Chawla@NOAA.gov

History of WAVEWATCH III® Validation Studies

- WAVEWATCH III has gone through multiple validation studies since its development (mid 1990s). Some of the notable ones are mentioned here

  Tolman, H. L., 1998b: Validation of a new global wave forecast system at NCEP. In: *Ocean Wave Measurements and Analysis*, B.L. Edge and J.M. Helmsley, Eds., ASCE, 777-786

  Tolman, H. L., 2002e: Testing of WAVEWATCH III version 2.22 in NCEP's NWW3 ocean wave model suite. NOAA / NWS / NCEP / OMB Technical Note Nr. **214**, 99 pp.

  Tolman, H. L., 2002b: Validation of WAVEWATCH III version 1.15 for a global domain. NOAA / NWS / NCEP / OMB Technical Note Nr. **213**, 33 pp.

- More validation plots for WAVEWATCH III v 2.22 can be found at

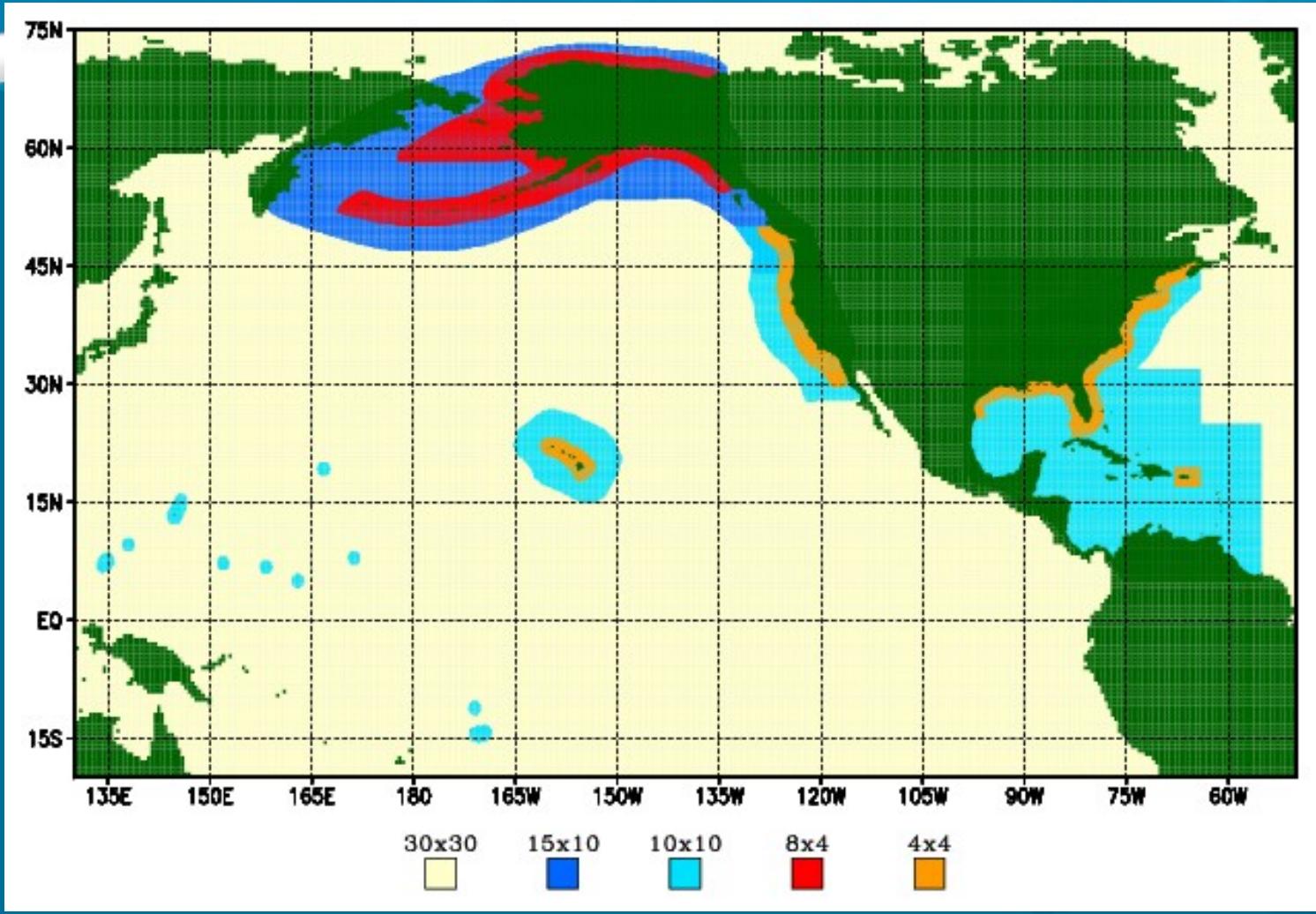
  http://polar.ncep.noaa.gov/waves/validation.html

- Here we shall concentrate on validation studies for the multi-grid version of WAVEWATCH III (v 3.14)

MODEL – DATA comparisons

- Modeling System
  - 8 grid global system using the two-way coupled multi-grid WAVEWATCH III™ model
  - Model forced with GFS winds and sea ice derived from daily passive microwave analysis
- Analysis
  - Analysis includes regular forecasts (4 cycles a data) and a 5 year hindcast (2005-2009)
  - Collocated model – altimeter comparisons with Jason-1 satellite data
  - Comparison of bulk spectral parameters with a global network of buoys
  - Spectral analysis (at select buoy locations) with IMEDS (Interactive Model Evaluation and Diagnostics System)

MODEL GRIDS



Grid resolution in minutes

Error Metrics

$$b = \frac{1}{N}\sum\left(H_m - H_o\right)$$

Bias

$$SI = \frac{\sqrt{\frac{1}{N}\sum\left(H_m - H_o - b\right)^2}}{\frac{1}{N}\sum H_0} \times 100$$

Scatter Index

$$RMS = \sqrt{\frac{1}{N}\sum\left(H_m - H_o\right)^2}$$

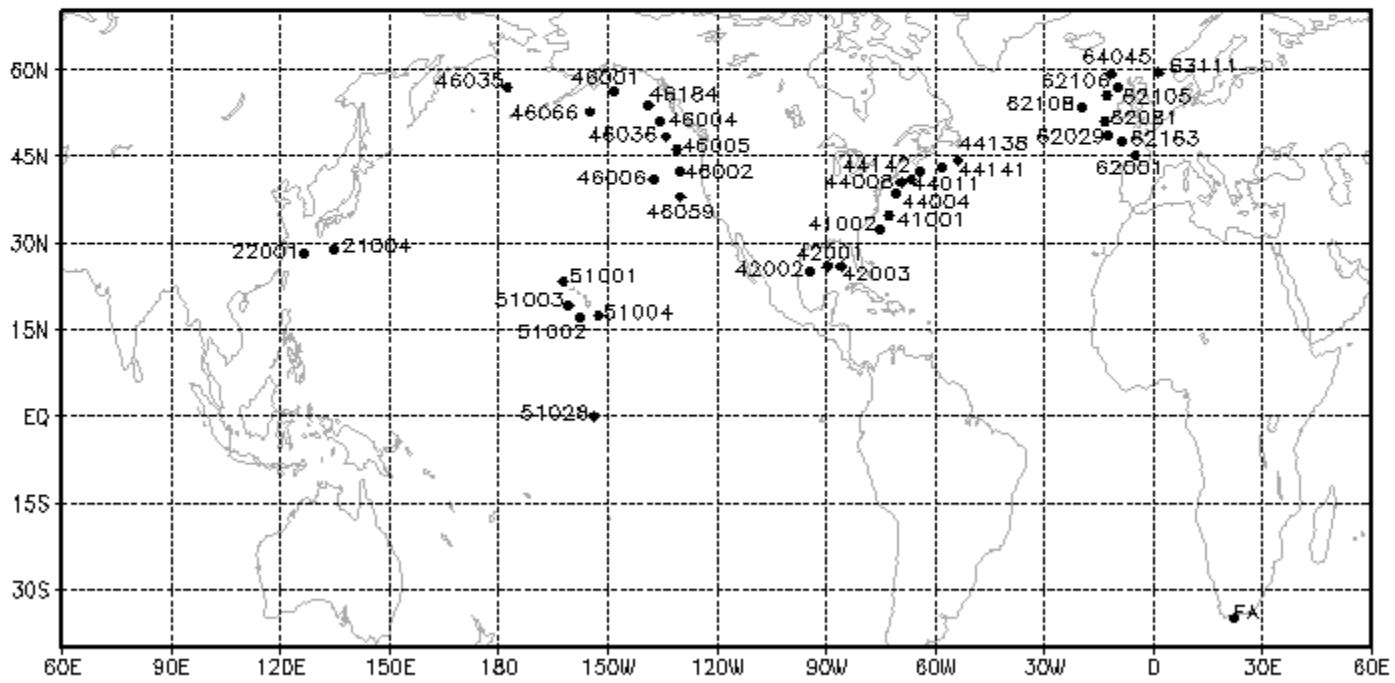
Root Mean Square error

Using Altimeter data for validation

- Advantages
  - Altimeters measure the significant wave height from back scatter observations
  - Altimeter measurements are valuable because altimeter tracks traverse the complete ocean domain
  - Satellite tracks are fast enough to provide a spatial map of observations
- Disadvantages
  - It is not a direct measurement of the wave heights and requires calibration
  - Altimeters can only provide estimates of the overall significant wave height
  - Tracks do not repeat for several days
  - Signal can be noisy

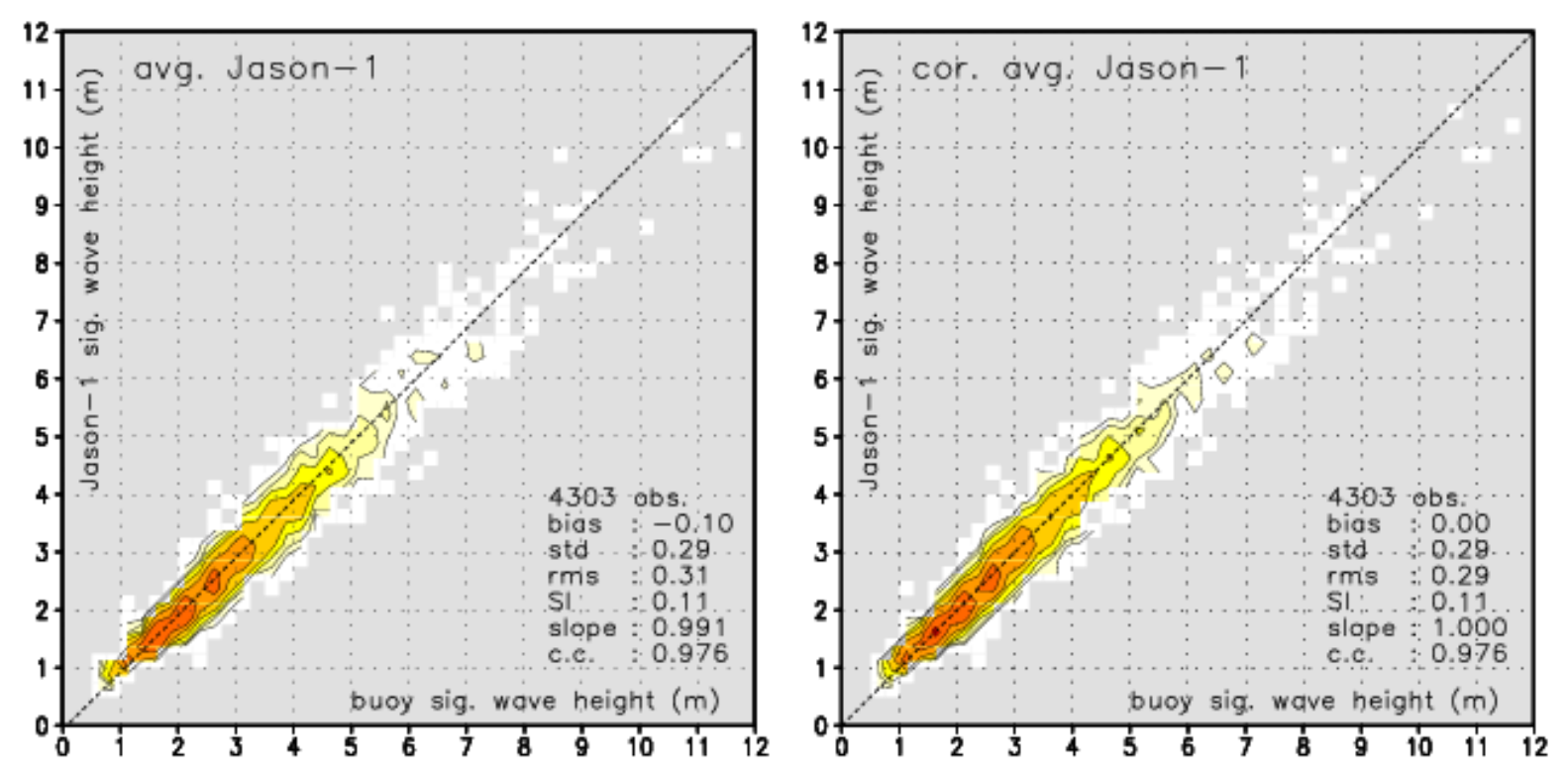
Calibrating altimeter data with buoys

Buoys used in the calibration



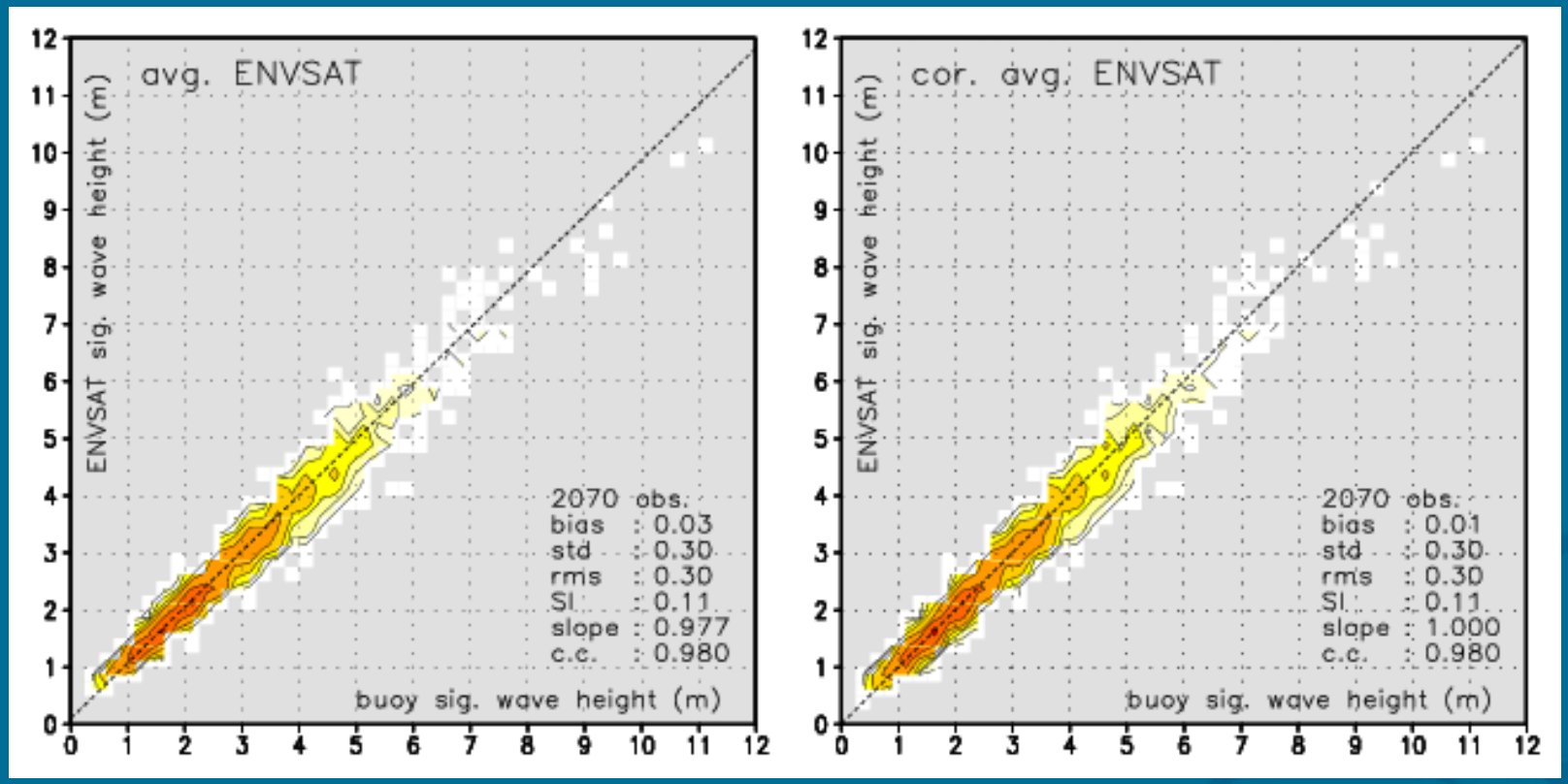
Calibrating altimeter data with buoys

JASON 1 Satellite data



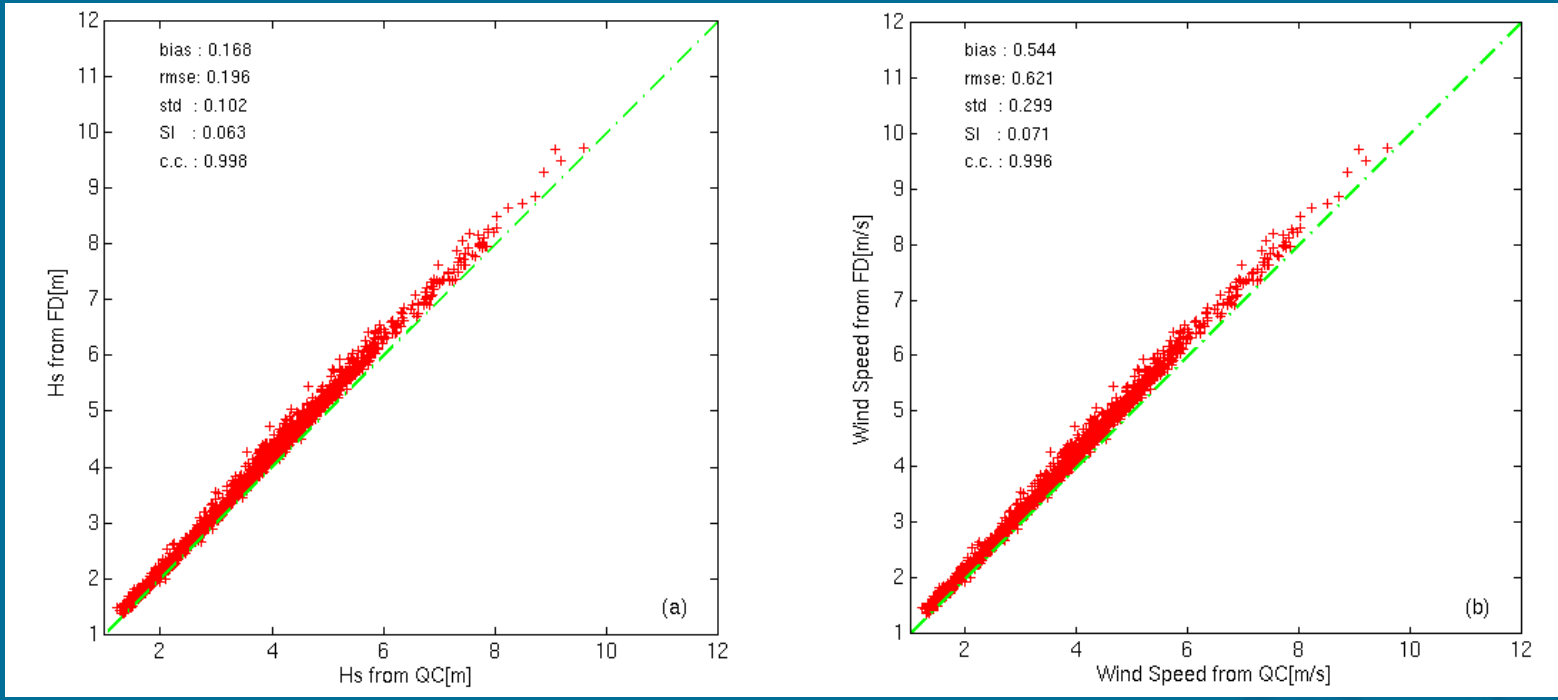
Calibrating altimeter data with buoys

ENVISAT Satellite data



Calibrating altimeter data with buoys

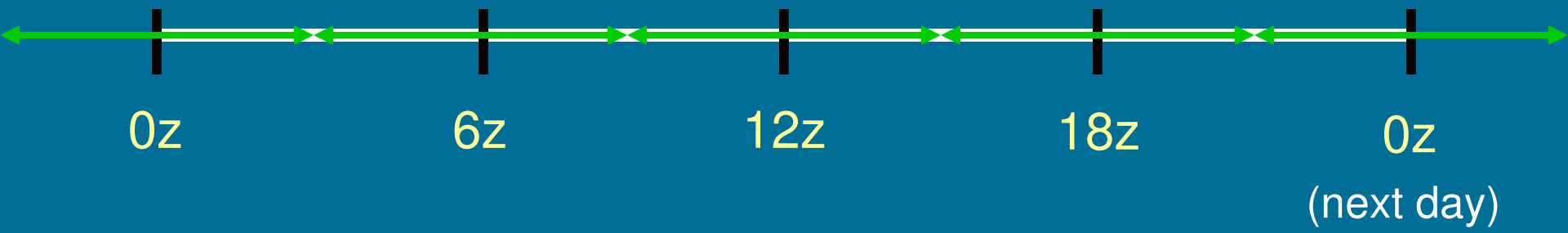
Fast Delivery altimeter data vs Quality Controlled altimeter data



MODEL – ALTIMETER COMPARISONS

- For model data comparisons
  - Model results are interpolated on to altimeter tracks
  - Collocation done for 9 periods (hindcast nowcast and 1 – 7 day forecast)
  - Collocated points on land are ignored
  - Collocated model files archived for later analysis
- Altimeter data is
  - De-spiked to remove erroneous spikes (also gets rid of small islands that cannot be resolved by the models)
  - Remove outliers
  - Filter the data using a running average (optional)
- Error estimates developed using month long archives
- Error maps developed using 3 month archives

Example of building a collocated model – data altimeter file from the different forecast cycles



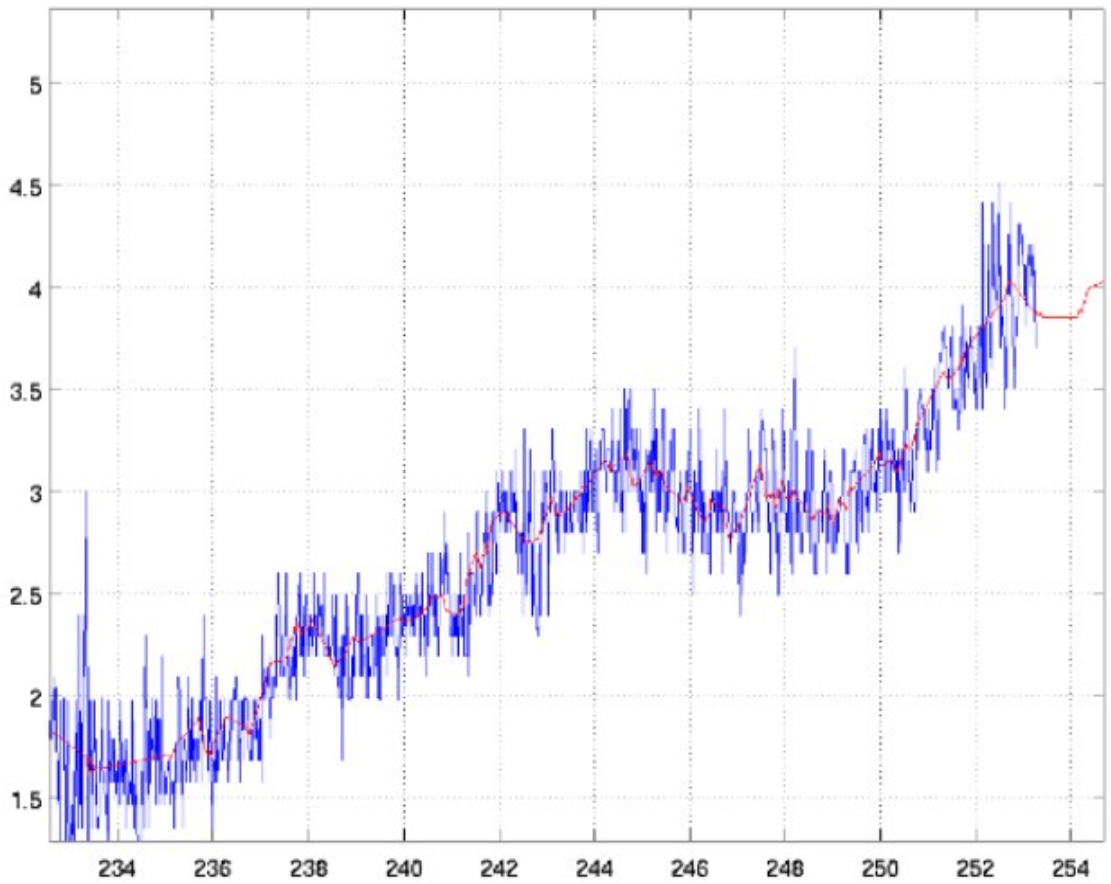
For building the "nowcast" collocated file we collect model data from -3 hours to 3 hours from each cycle

For building the "24 hour" collocated file we follow the same principle except collect data from 21 hours to 27 hours of forecast from the previous day's forecast cycles

and so on ….

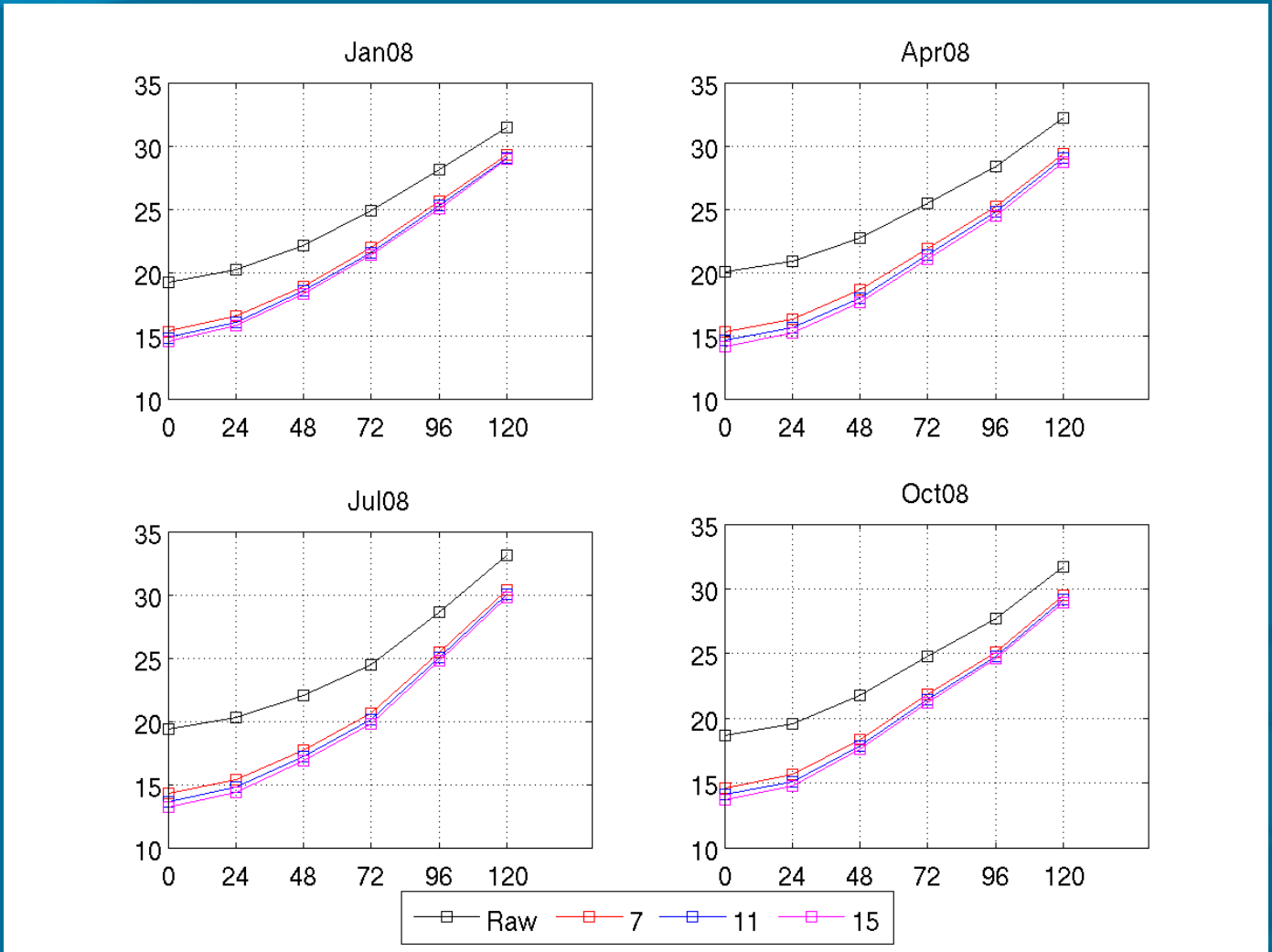
Model Altimeter Comparisons

Raw (blue) vs filtered (red) altimeter data



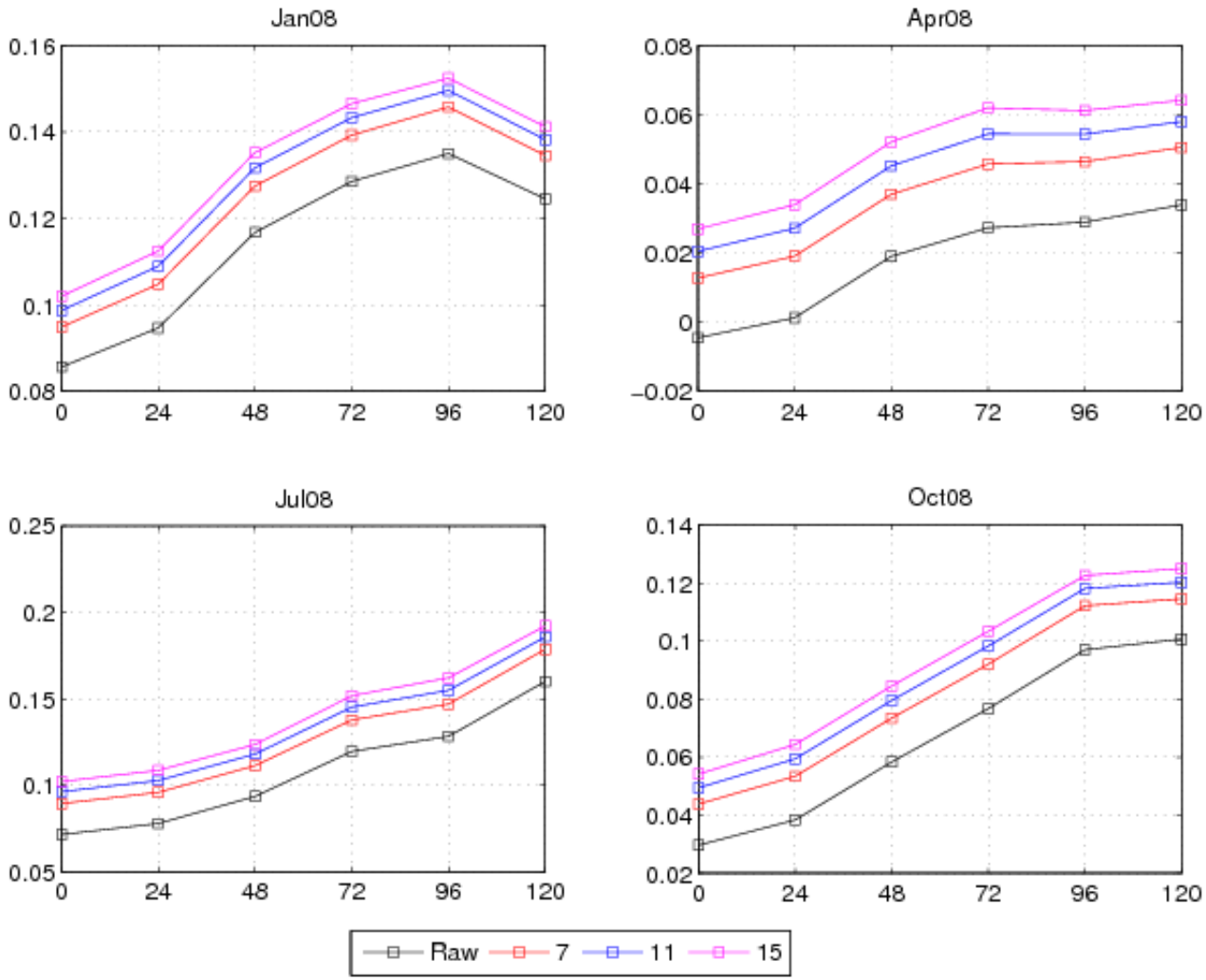
Model Altimeter Comparisons

Scatter Index (global domain)



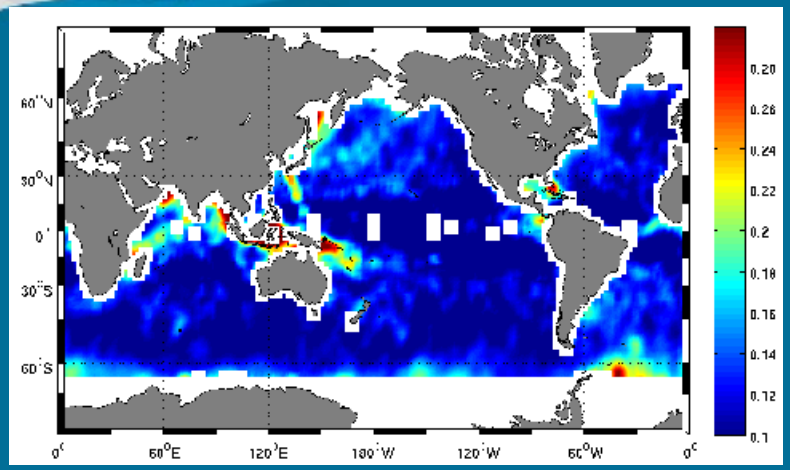
Model Altimeter Comparisons

Bias (global domain)

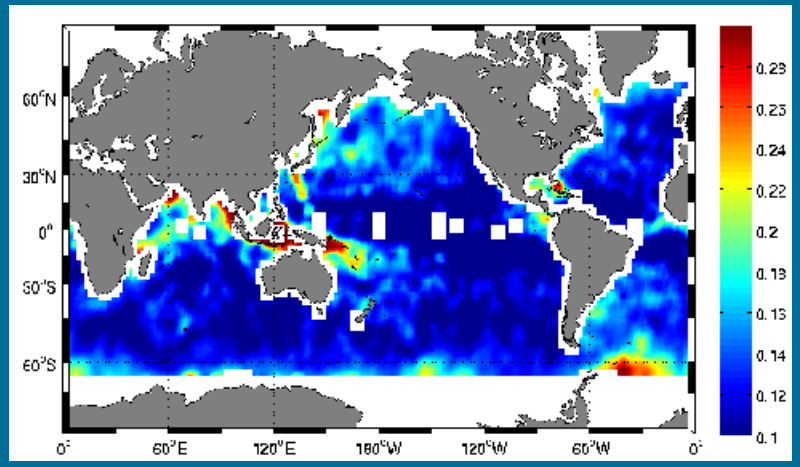


Model Altimeter Comparisons

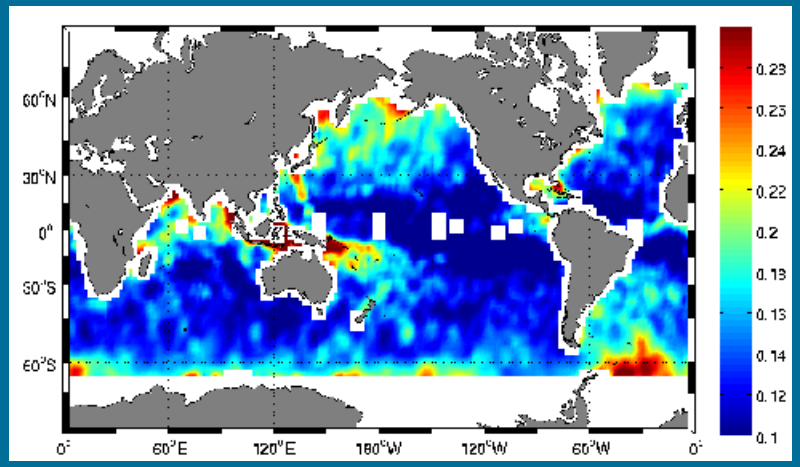
Scatter Index maps



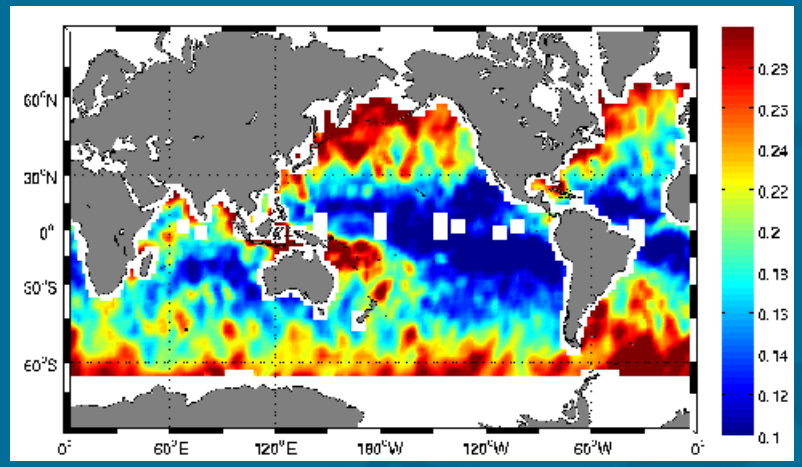
Hindcast



24 Hr Forecast



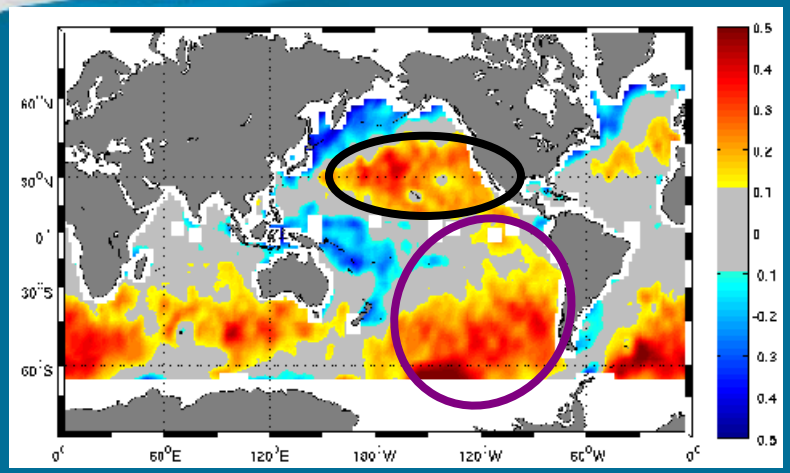
48 Hr Forecast



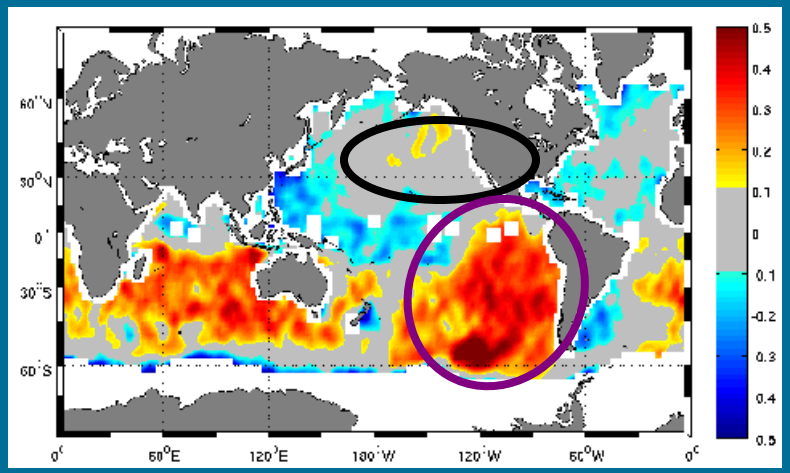
96 Hr Forecast

Model Altimeter Comparisons

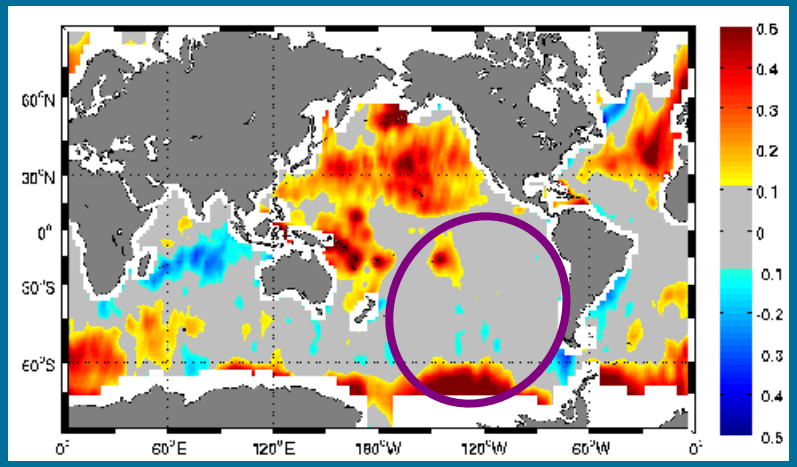
Hindcast Bias Maps



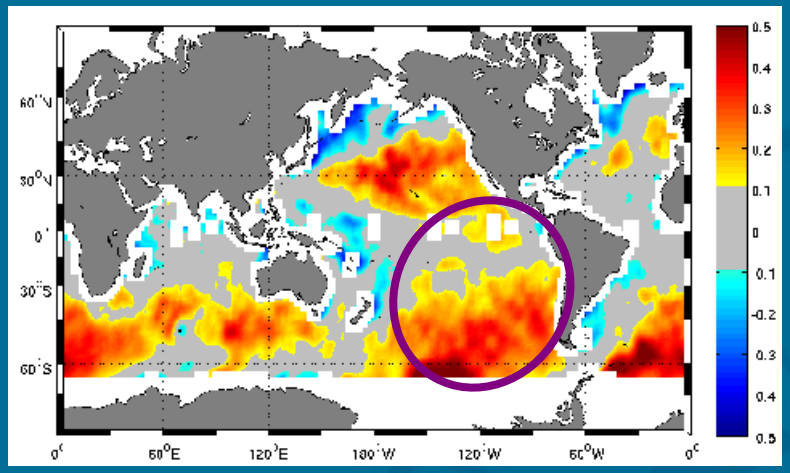
Jan – Mar, 2008



Jul – Sep, 2008



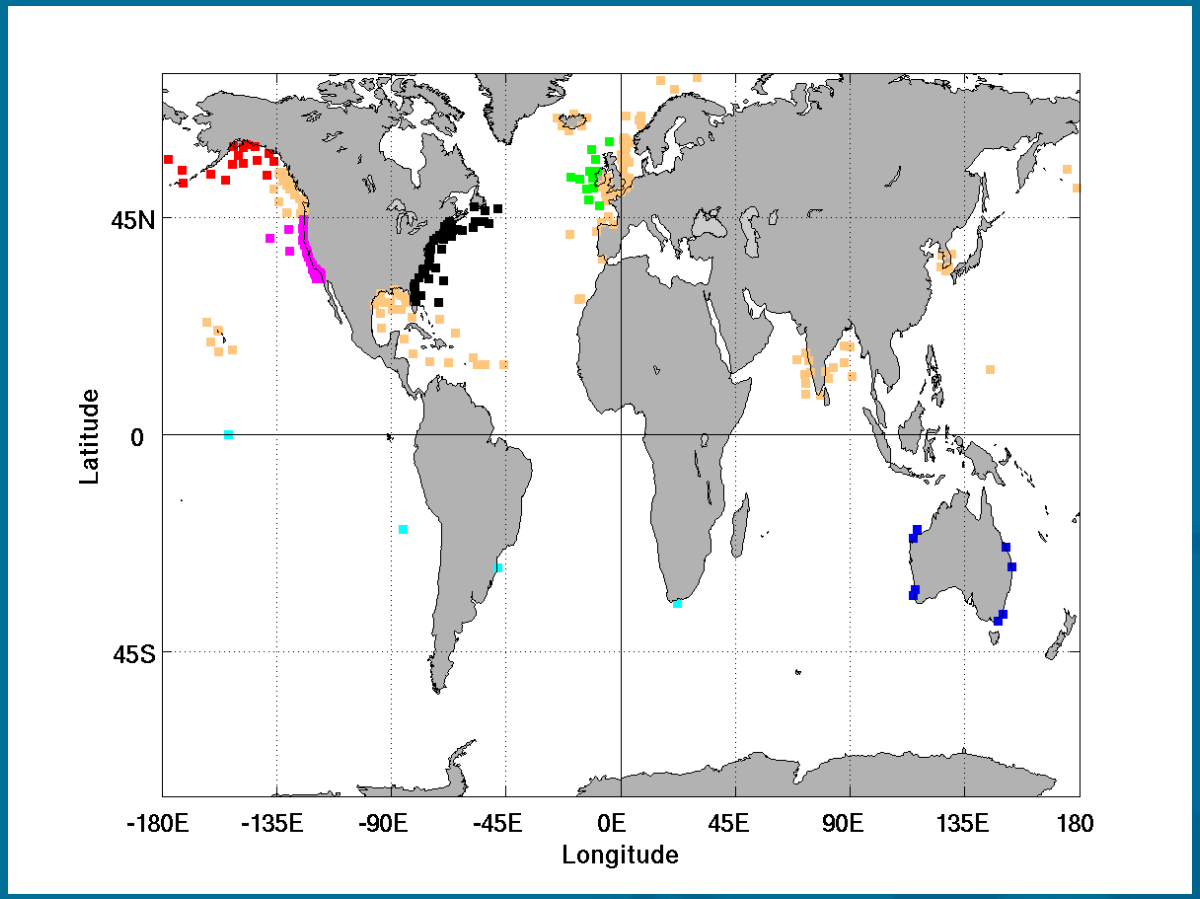
Jan – Mar, 2002 (old model)

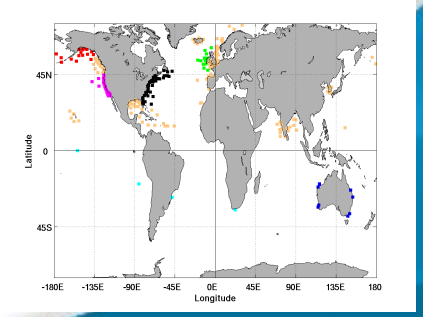


Jan – Mar, 2008 (old model)

Buoy Data

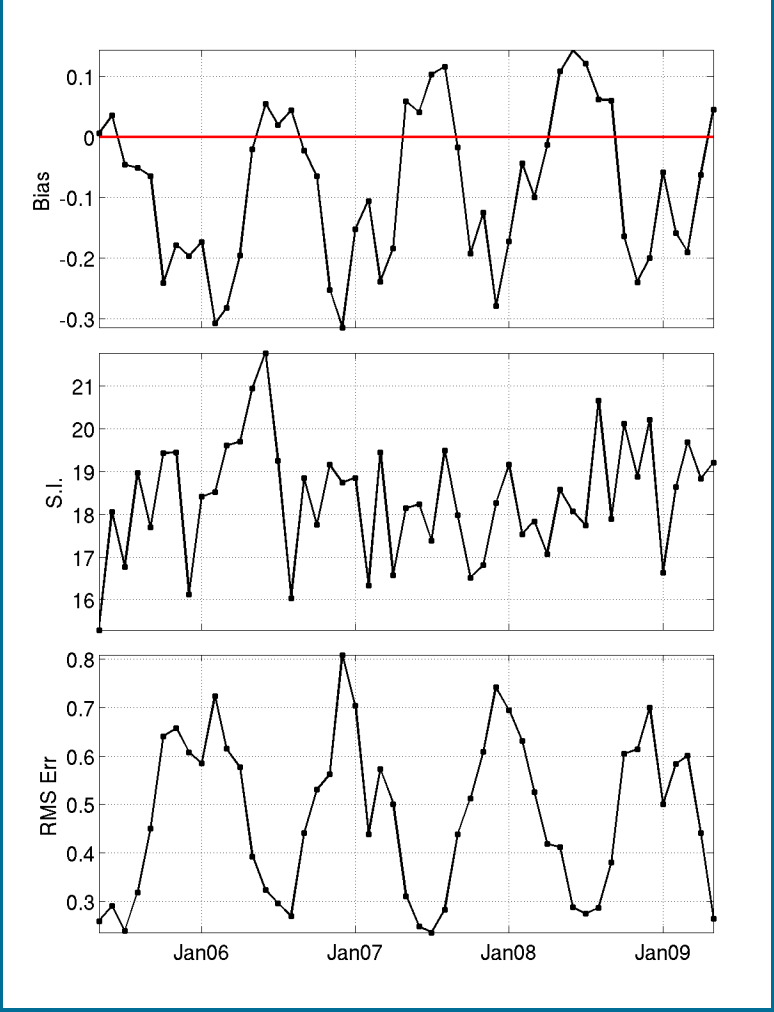
- Global network of buoy data, quality controlled and archived at ECMWF as part of inter-agency model comparison project.
- Hourly buoy data averaged over 4 hr interval, centered at the 4 synoptic time cycles of wave forecasts (0,6,12 and 18)



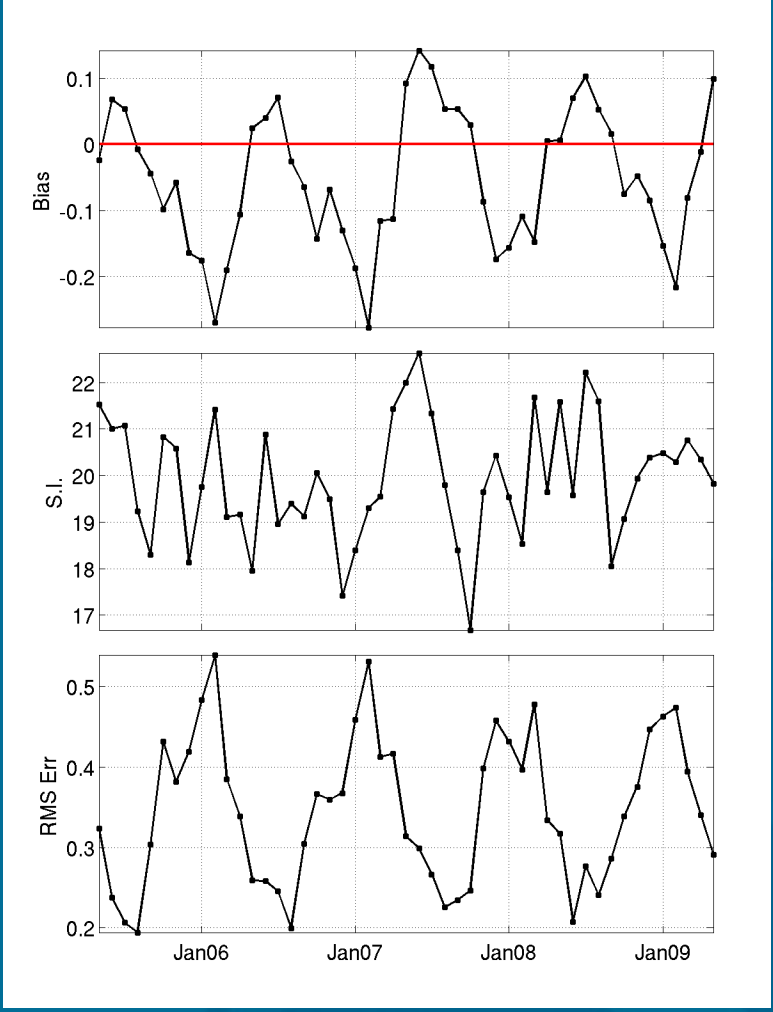


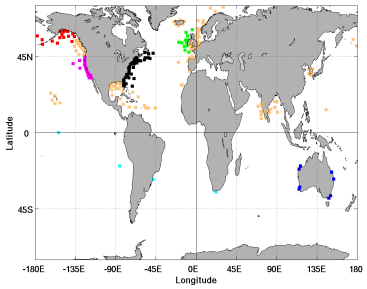
BUOY COMPARISONS (contd.)

ALASKA Buoys



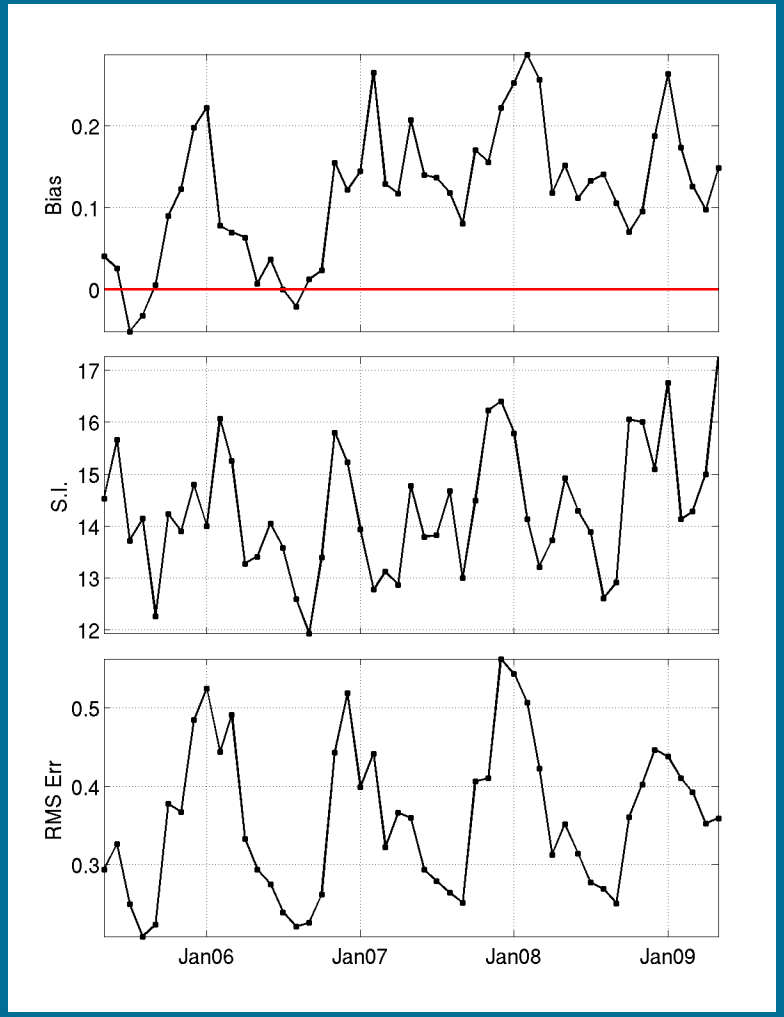
US East Coast Buoys



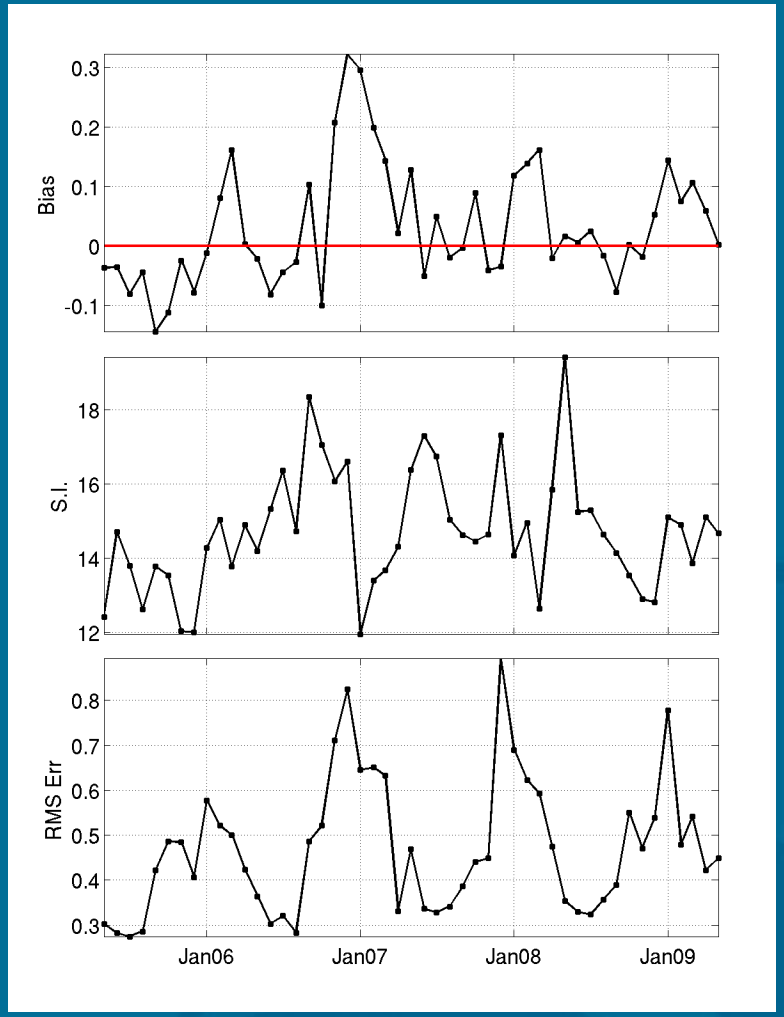


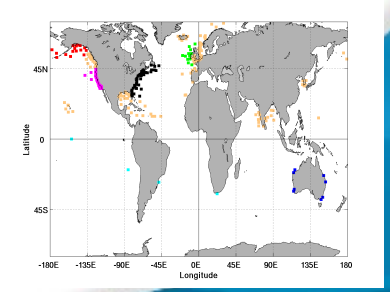
BUOY COMPARISONS (contd.)

US West Coast Buoys



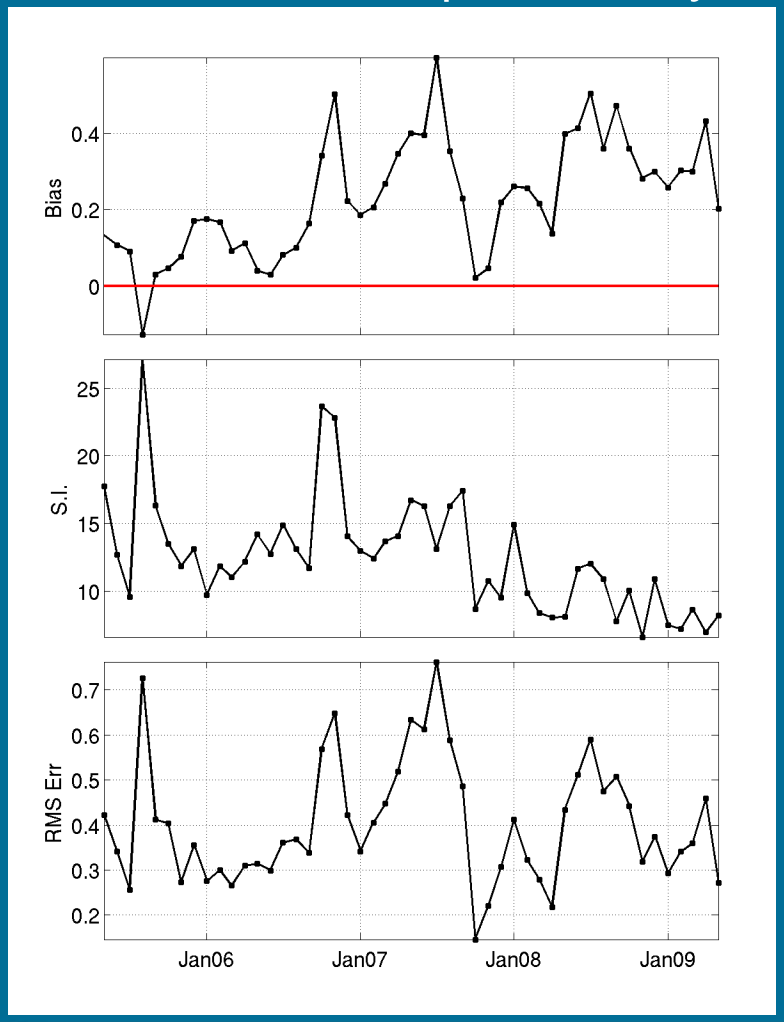
European Buoys



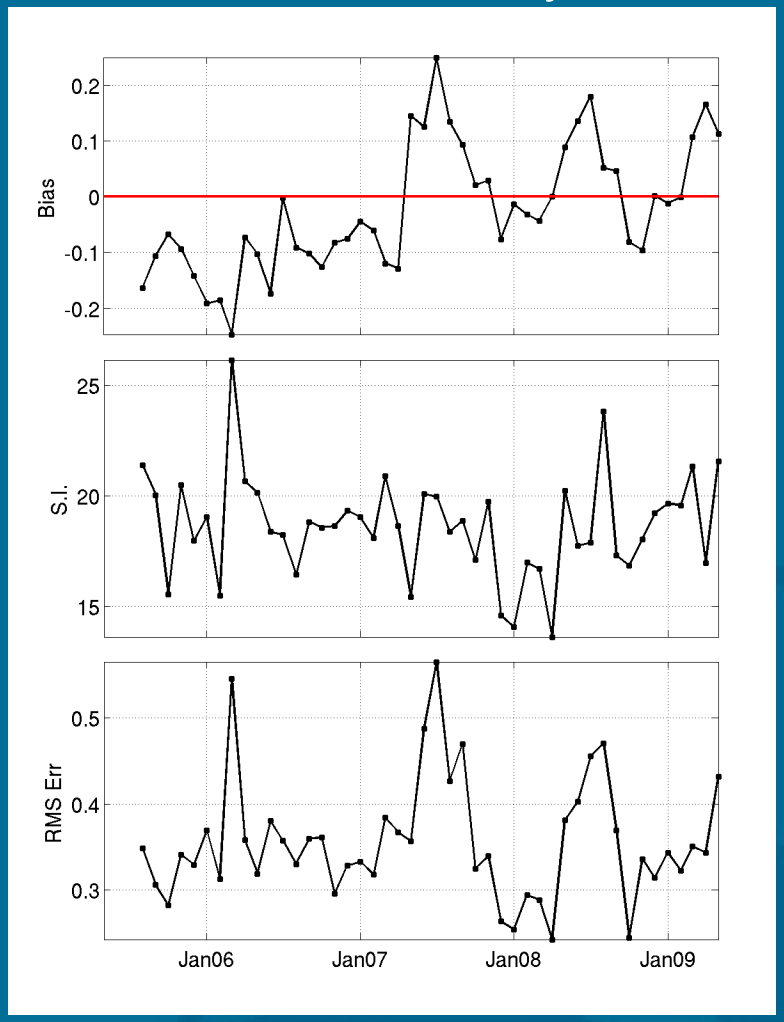


BUOY COMPARISONS (contd.)

Southern Hemisphere Buoys

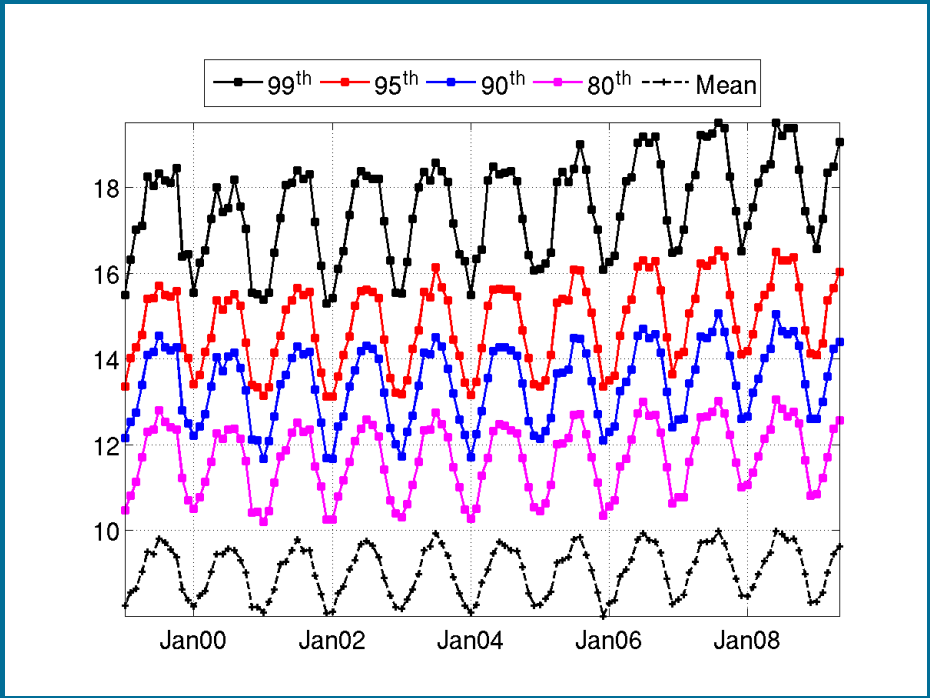


Australia Buoys

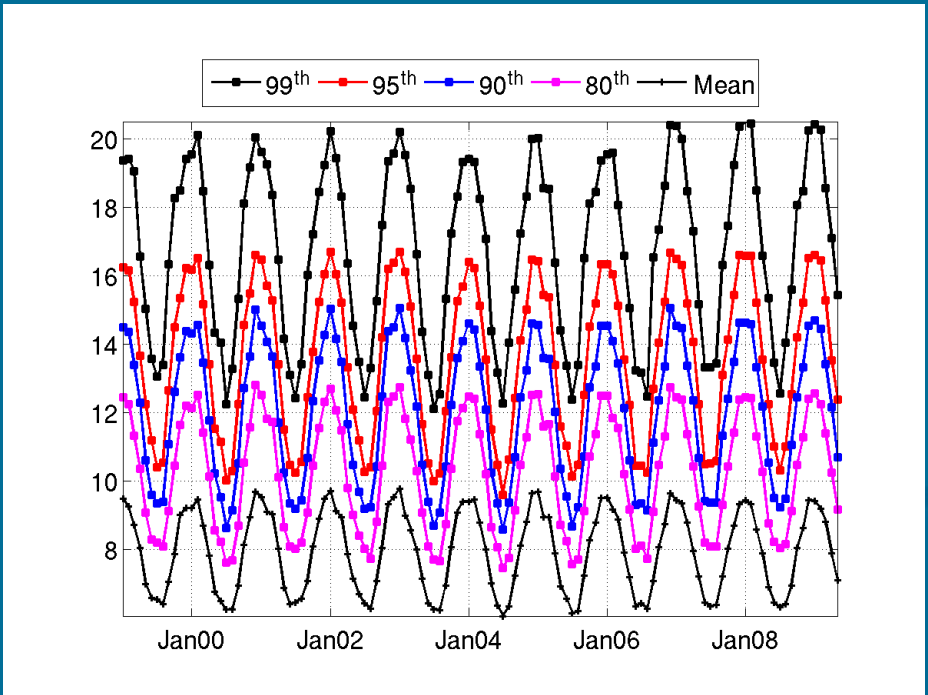


BUOY COMPARISONS (contd.)

GFS wind speed statistics (over water)



Southern Hemisphere
(60°S to 25°S)

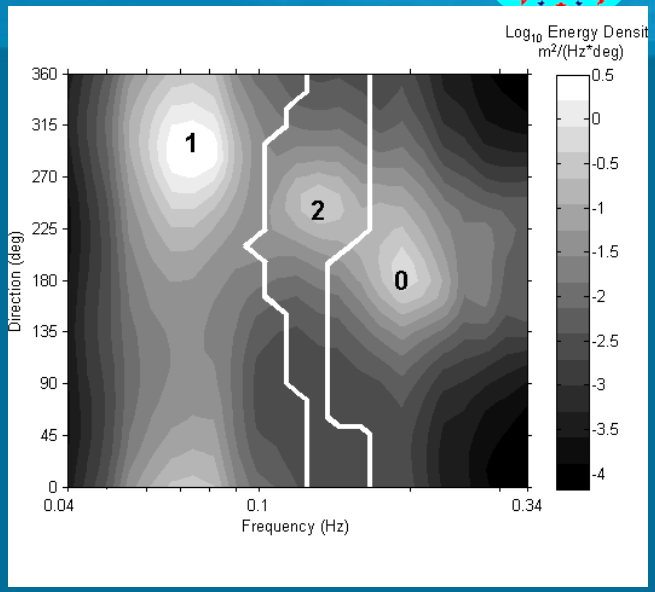


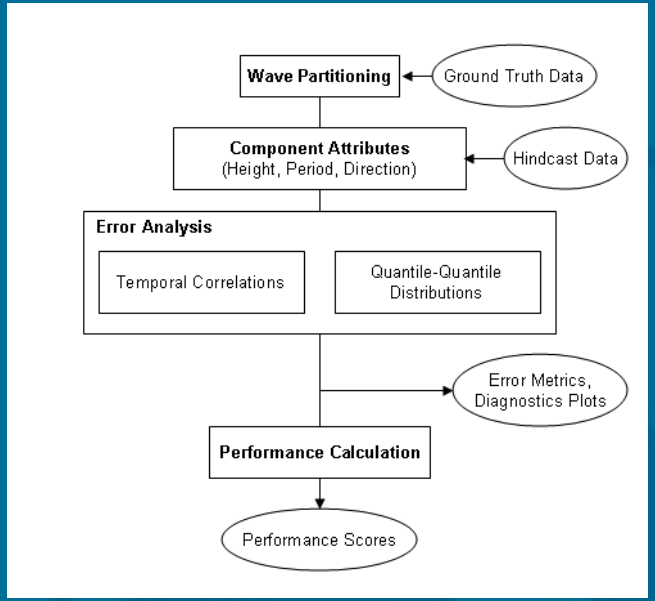
Northern Hemisphere
(25°N to 60°N)

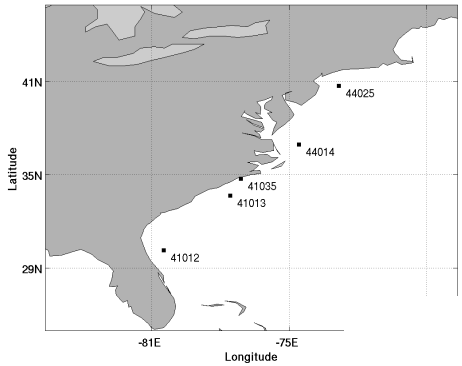
Interactive Model Evaluation and Diagnostics System (IMEDS)

Methodology

- A diagnostic analysis tool for wind wave models developed by USACE (Hanson et al 2009)
- IMEDS provides additional information on model skill by
  - Using a partitioning algorithm to separate individual peaks in the spectrum of the data
  - Use partition boundaries to identify model and data component attributes
  - Do error analysis over individual components and develop error metrics and skill scores
- IMEDS separates spectral peaks into 3 types – wind waves, young and mature swells
- Directional age criterion to separate wind waves from swells
- Frequency cut-off to separate young and mature swells

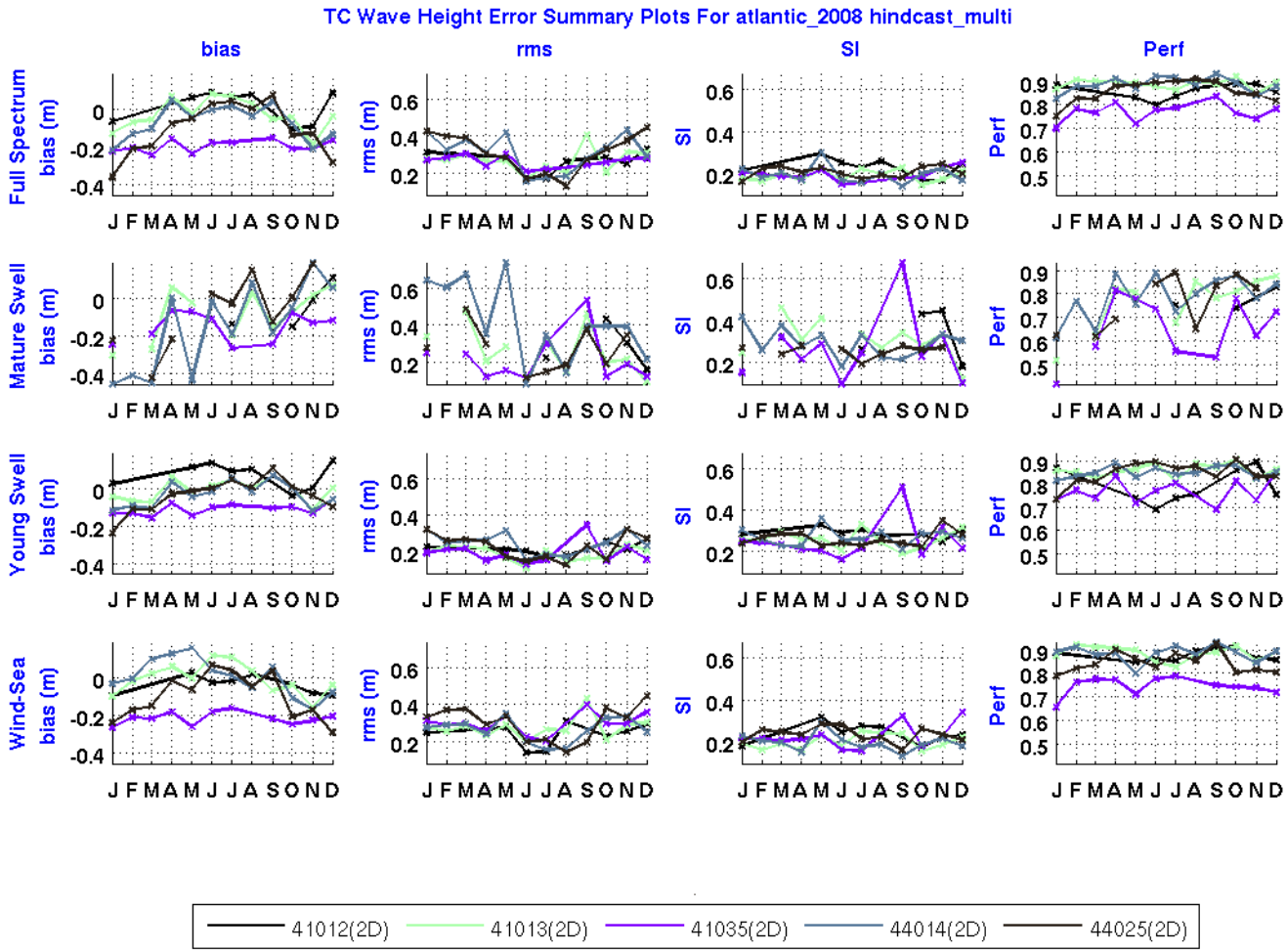


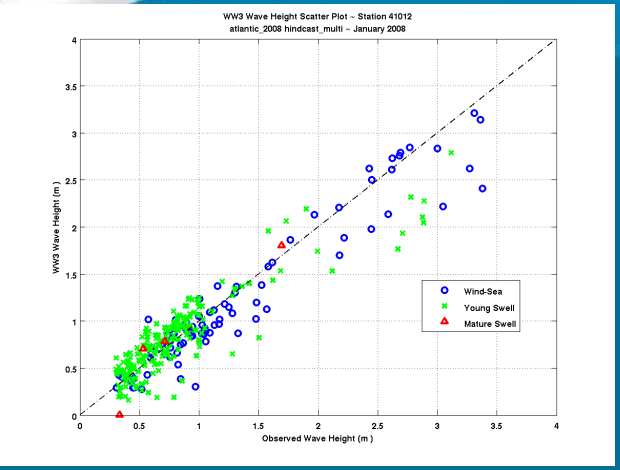




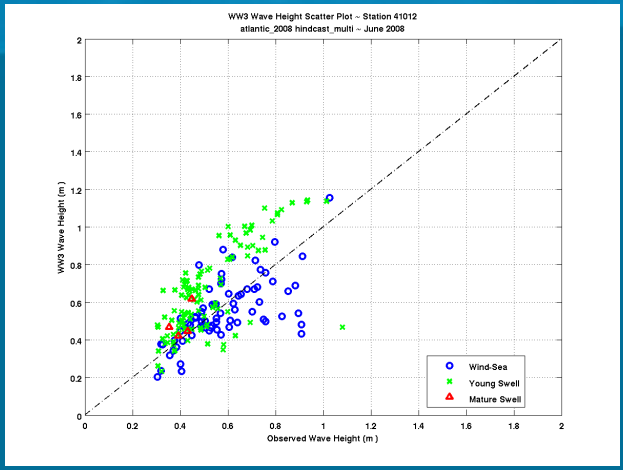
IMEDS (contd.)

Atlantic buoys

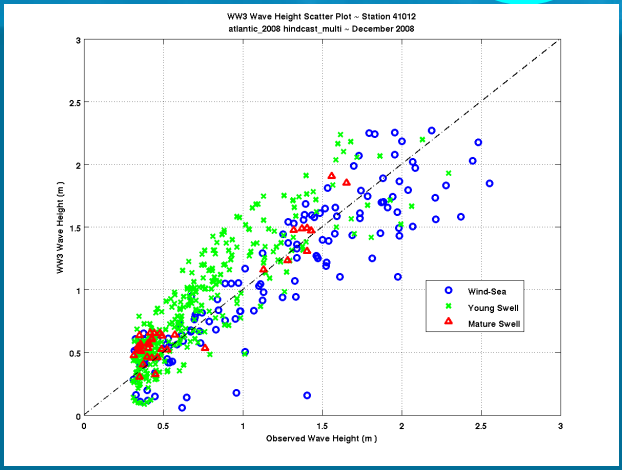




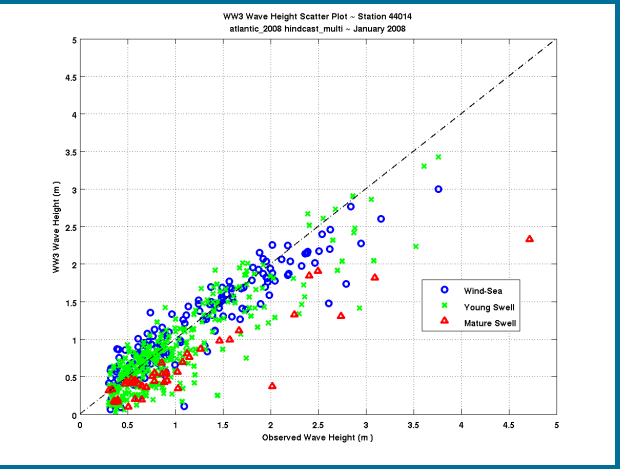
41012 – Jan,2008

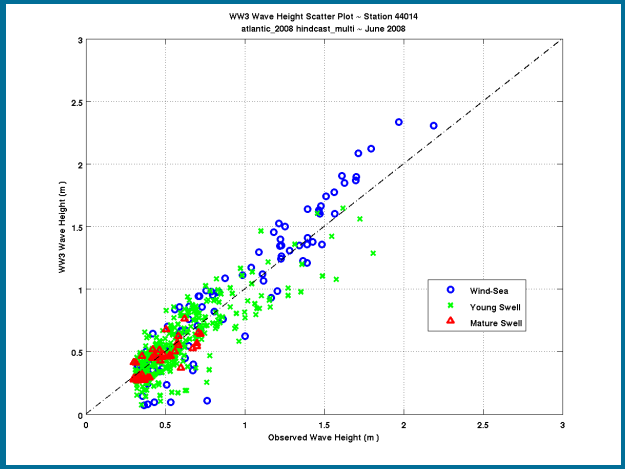


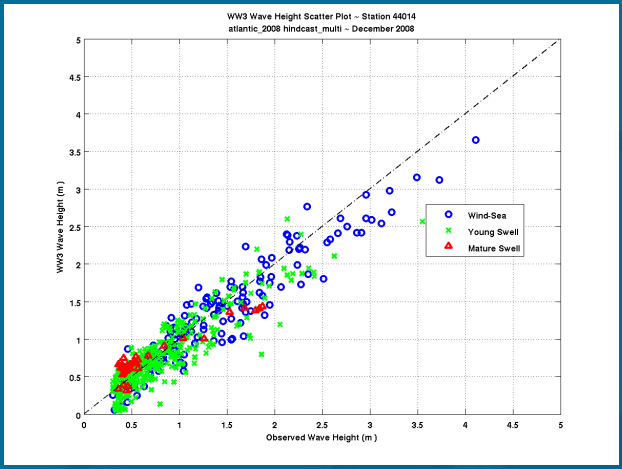
41012 – Jun,2008



41012 – Dec,2008

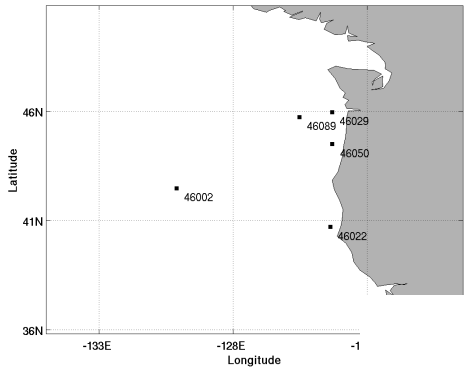


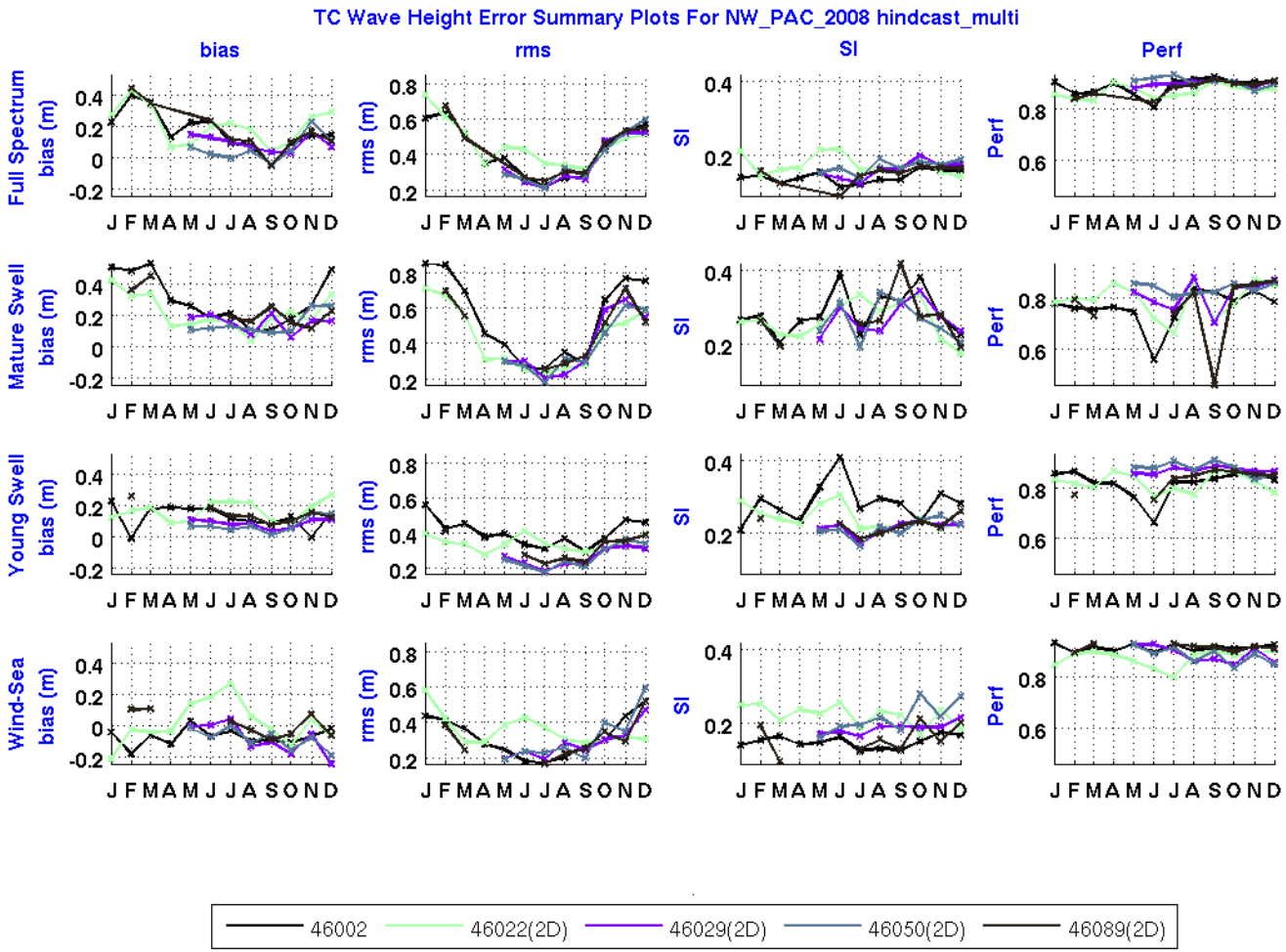


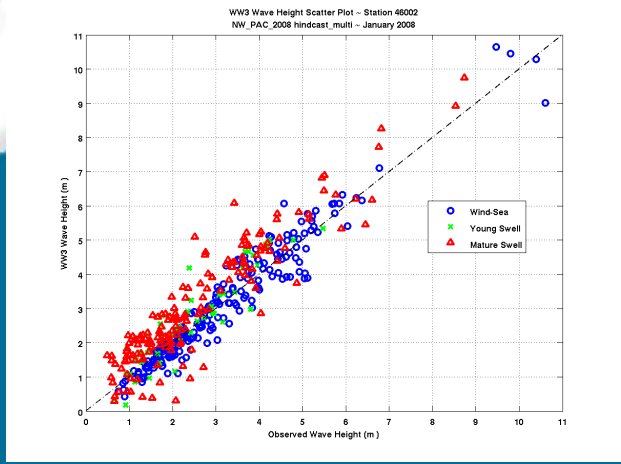


IMEDS (contd.)

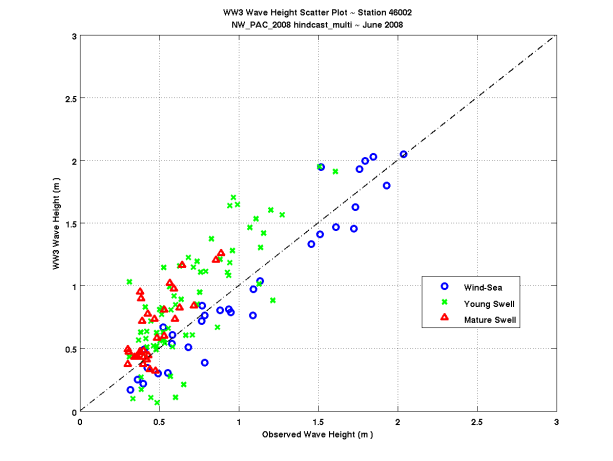
Pacific Buoys



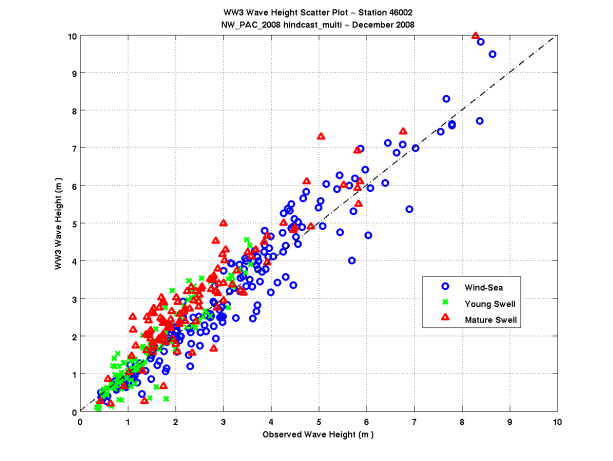




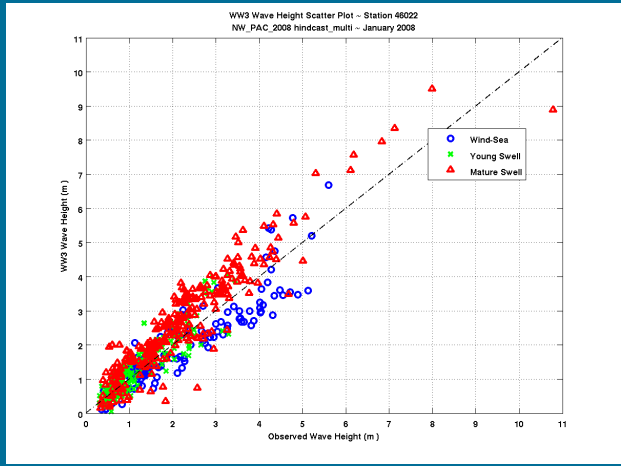
46002 – Jan,2008



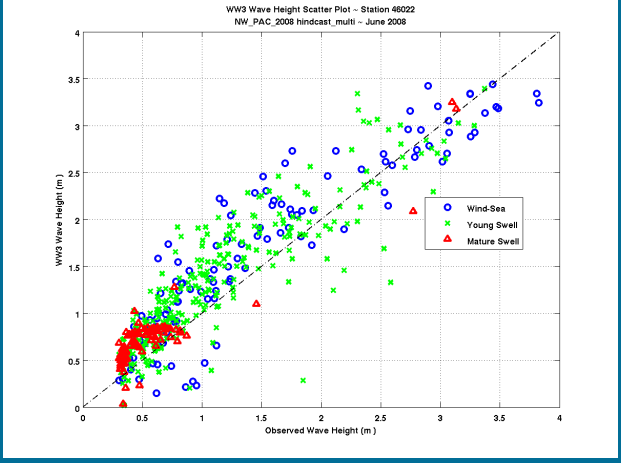
46002 – Jun,2008



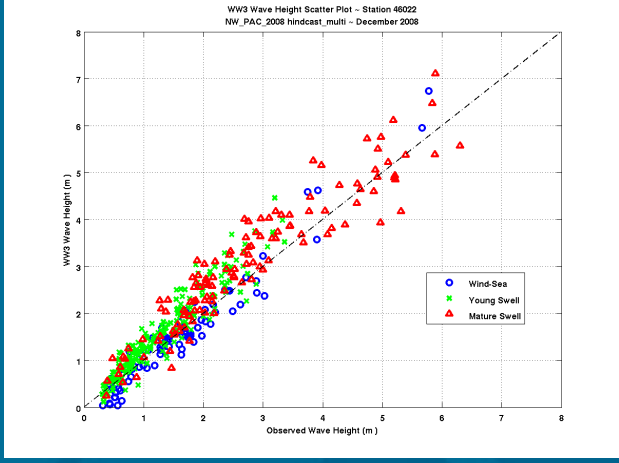
46002 – Dec,2008



46022 – Jan,2008



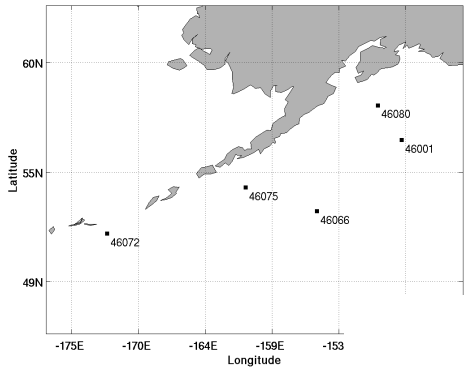
46022 – Jun,2008

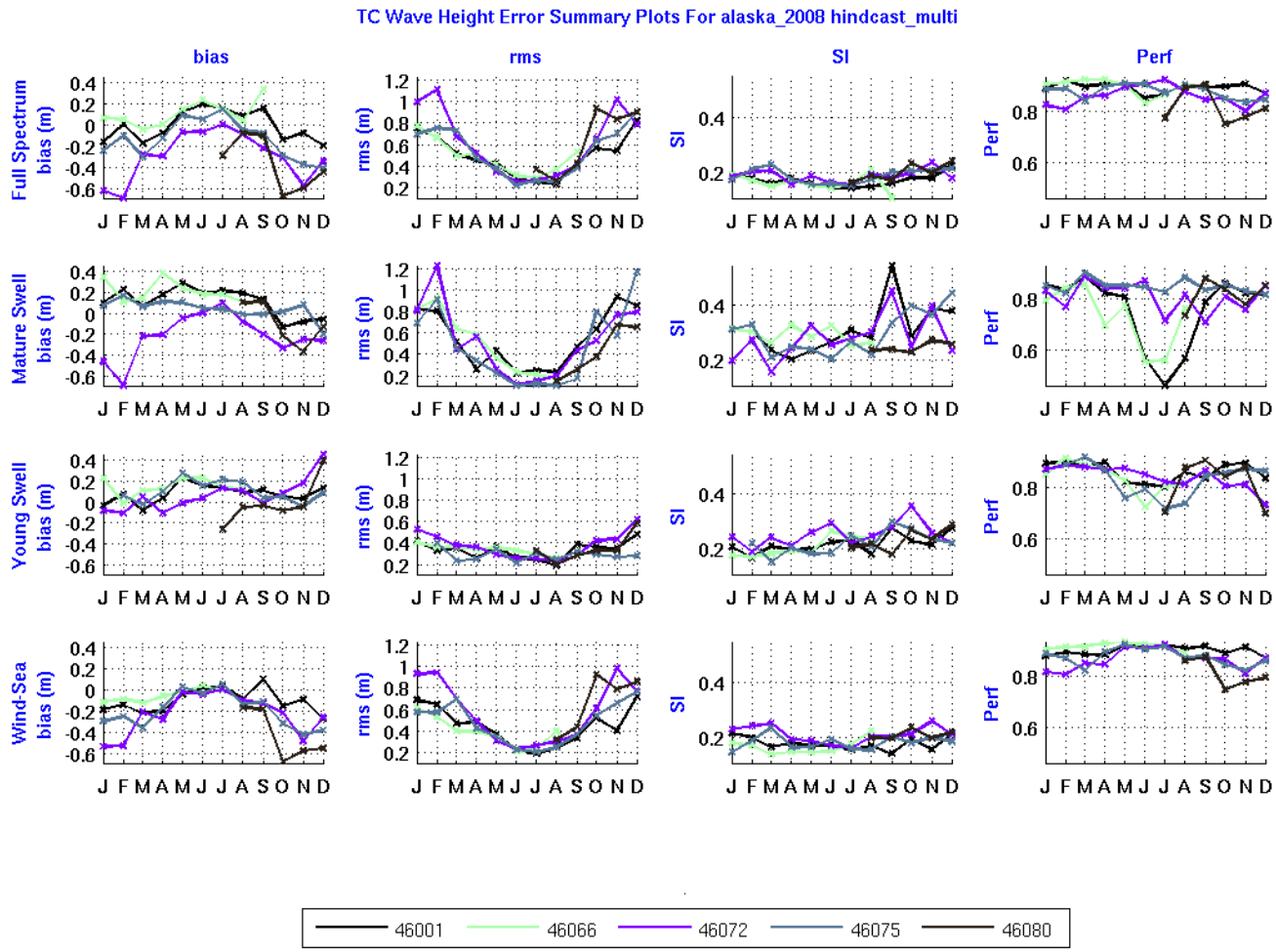


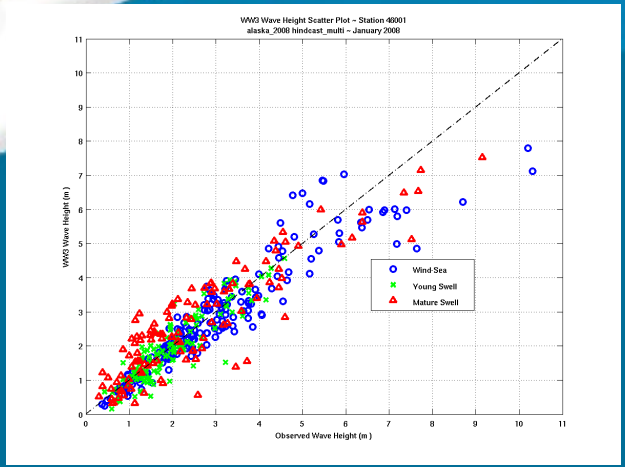
46022 – Dec,2008

IMEDS (contd.)

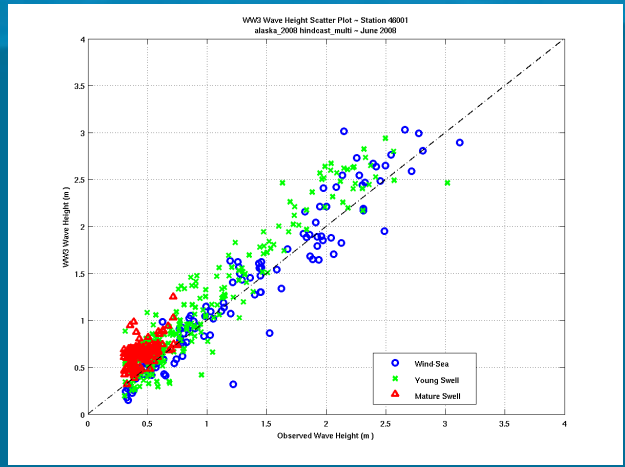
Alaska buoys



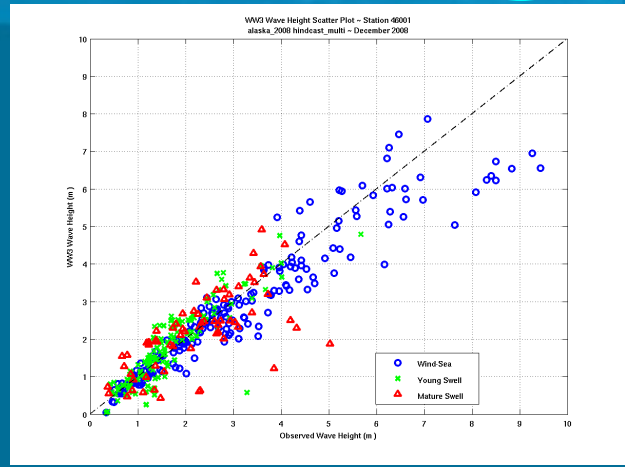




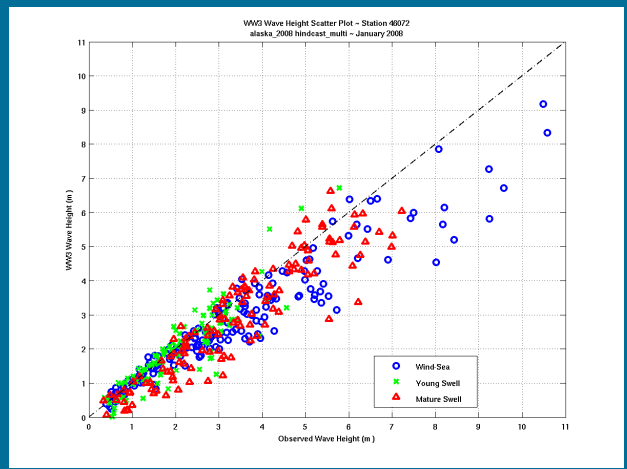
46001– Jan,2008



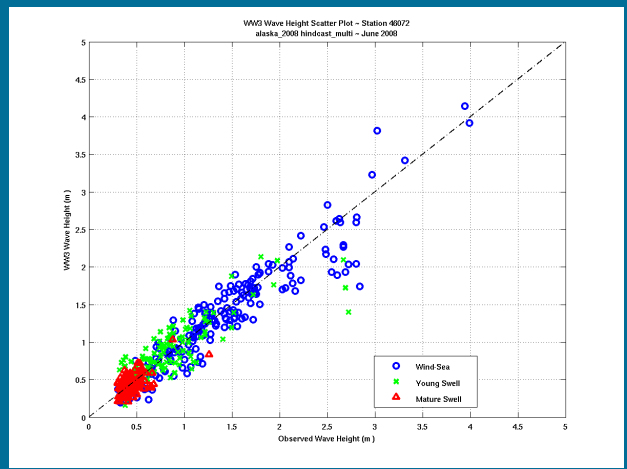
46001 – Jun,2008



46001 – Dec,2008



46072 – Jan,2008



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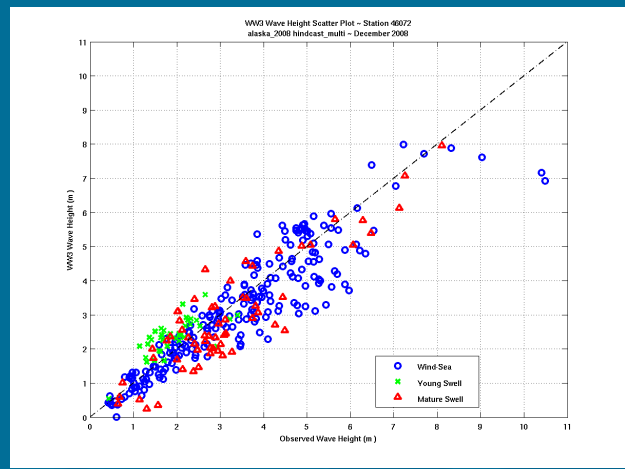

46072 – Dec,2008

CONCLUSIONS

- A small but persistent positive bias (wave heights) in the Southern Hemisphere.
  - Development of bias coincides with the GFS winds becoming more energetic in this region
- Seasonal bias patterns in the Northern Hemisphere
  - Positive biases in the swell dominated eastern parts of the basin
  - Negative biases in the wind wave dominated western parts of the basin
- Bias patterns show room for improvement in the physics packages in WAVEWATCH III
- A new NOPP initiative currently underway to improve wave physics

The End

End of lecture 3.1