On the Use of the Climate Forecast System Reanalysis Wind Forcing In Ocean Response Modeling

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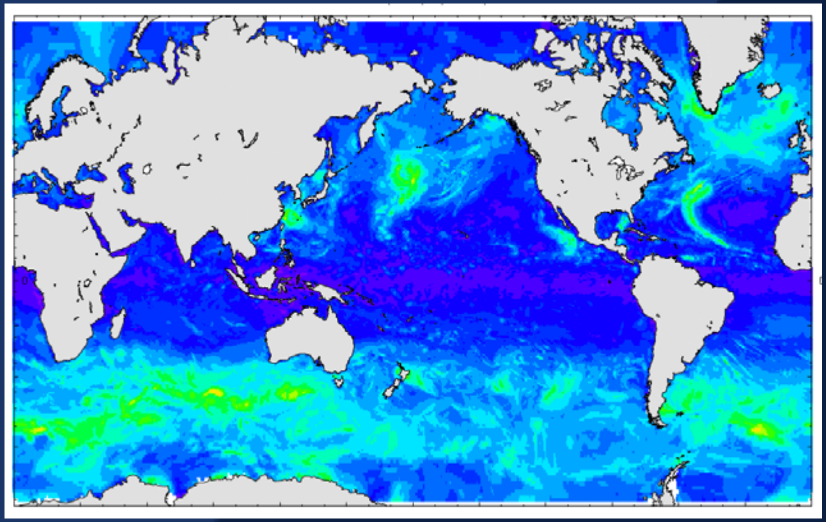
Motivation

The Climate Forecast System Reanalysis (CFSR) provides a new dataset for use in ocean response modeling. The data has already been applied in Global and regional hindcasting projects using a 3rd Generation wave model. This presentation is intended to highlight some of the features of the wind fields and provide guidance for other researchers looking to apply the data.



Methodology

- *CFSR: What is it and how do I get it?*
- *Brief summary of the wave model and altimeter data sets applied in the study*
- *Global Wave Assessment*
- *Use in WIS Pacific Hindcast*
- *Tropical Systems*
- *Extra-Tropical VESS storms*
- *Case Study in a Monsoonal Flow*

Conclusions/Recommendations

•CFSR wind fields provide an increased level of skill over R1/R2 and are comparable in overall bias/scatter to dedicated hindcasts

•Direct use of CFSR in tropical forcing is not recommended

•CFSR shows remarkable skill in some VESS storms, but suffers in continuity of peak winds in other storms leading to negative bias in modeled wave heights

•Regional use of CFSR requires careful analysis of the major wind forcing – ITWS still applies

•Inclusion of satellite data within the CFSR displays some issues in storms – questions remain about step change effects caused by changes in assimilated data

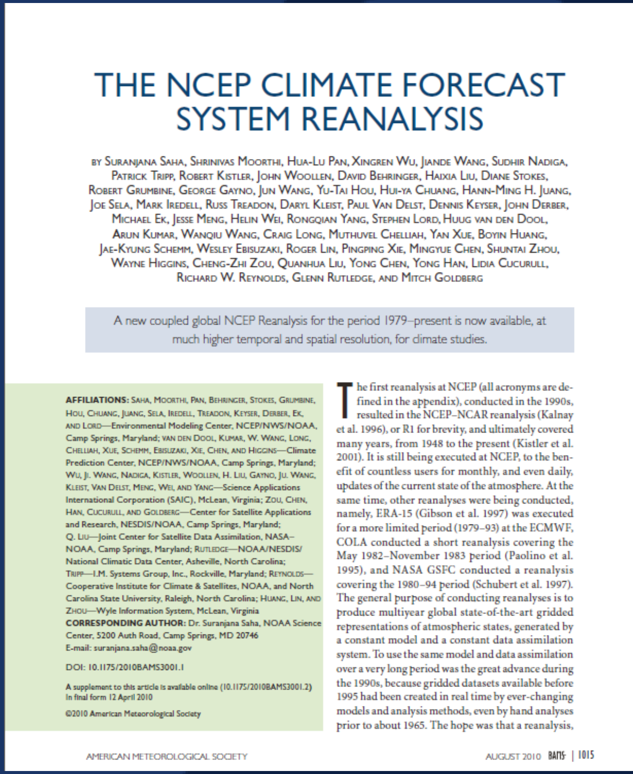
CFSR

A new global reanalysis of the period 1979 to March 2010.

Includes coupled modeling of atmosphere, ocean, and sea ice.

Horizontal resolution ~38 km with hourly data available

Full details available in August 2010 BAMS



THE NCEP CLIMATE FORECAST SYSTEM REANALYSIS

BY SURANJANA SAHA, SHRINIVAS MOORTHI, HUA-LU PAN, XINGREN WU, JIANDE WANG, SUDHIR NADIGA, PATRICK TRIPP, ROBERT KISTLER, JOHN WOOLLEN, DAVID BEHRINGER, HAIXIA LIU, DIANE STOKES, ROBERT GRUMBINE, GEORGE GAYNO, JUN WANG, YU-TAI HOU, HUI-YA CHUANG, HANN-MING H. JUANG, JOE SELA, MARK IREDELL, RUSS TREADON, DARYL KLEIST, PAUL VAN DELST, DENNIS KEYSER, JOHN DERBER, MICHAEL EK, JESSE MENG, HELIN WEI, RONGQIAN YANG, STEPHEN LORD, HUUG VAN DEN DOOL, ARUN KUMAR, WANQIU WANG, CRAIG LONG, MUTHUVEL CHELLIAH, YAN XUE, BOYIN HUANG, JAE-KYUNG SCHEMM, WESLEY EBISUZAKI, ROGER LIN, PINGPING XIE, MINGYUE CHEN, SHUNTAI ZHOU, WAYNE HIGGINS, CHENG-ZHI ZOU, QUANHUA LIU, YONG CHEN, YONG HAN, LIDIA CUCURULL, RICHARD W. REYNOLDS, GLENN RUTLEDGE, AND MITCH GOLDBERG

A new coupled global NCEP Reanalysis for the period 1979–present is now available, at much higher temporal and spatial resolution, for climate studies.

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The first reanalysis at NCEP (all acronyms are defined in the appendix), conducted in the 1990s, resulted in the NCEP–NCAR reanalysis (Kalnay et al. 1996), or R1 for brevity, and ultimately covered many years, from 1948 to the present (Kistler et al. 2001). It is still being executed at NCEP, to the benefit of countless users for monthly, and even daily, updates of the current state of the atmosphere. At the same time, other reanalyses were being conducted, namely, ERA-15 (Gibson et al. 1997) was executed for a more limited period (1979–93) at the ECMWF, COLA conducted a short reanalysis covering the May 1982–November 1983 period (Paolino et al. 1995), and NASA GSFC conducted a reanalysis covering the 1980–94 period (Schubert et al. 1997). The general purpose of conducting reanalyses is to produce multiyear global state-of-the-art gridded representations of atmospheric states, generated by a constant model and a constant data assimilation system. To use the same model and data assimilation over a very long period was the great advance during the 1990s, because gridded datasets available before 1995 had been created in real time by ever-changing models and analysis methods, even by hand analyses prior to about 1965. The hope was that a reanalysis,

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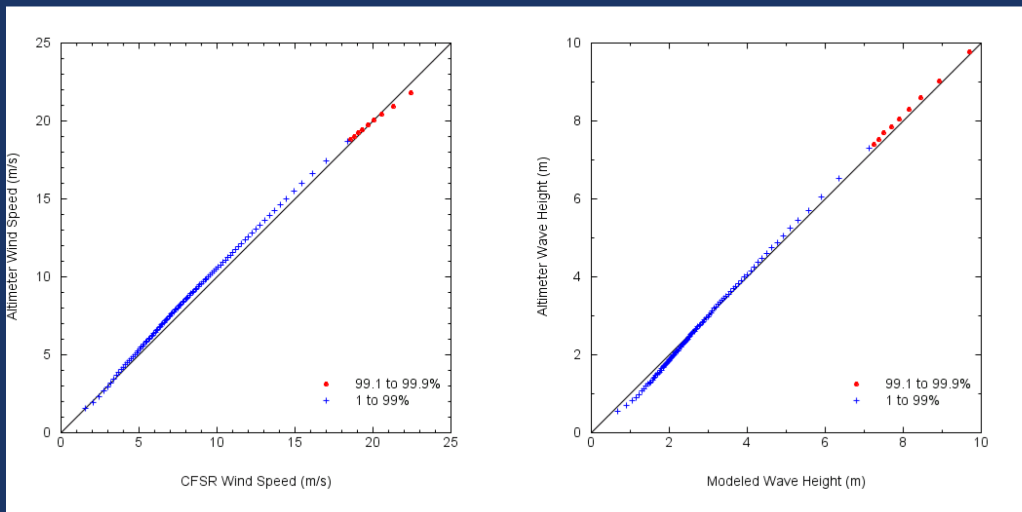
CFSR vs. R1/R2

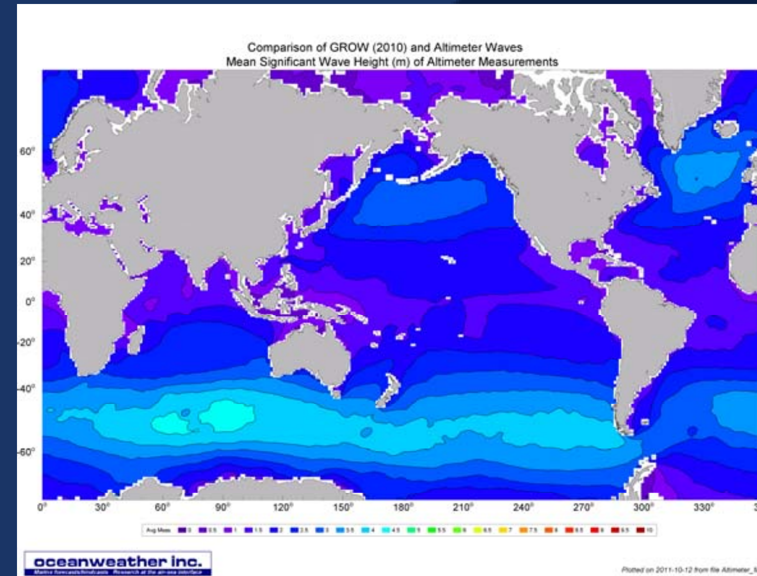
The CFSR includes numerous model improvements and advances over the 1997 R1/R2 NCEP Reanalysis.

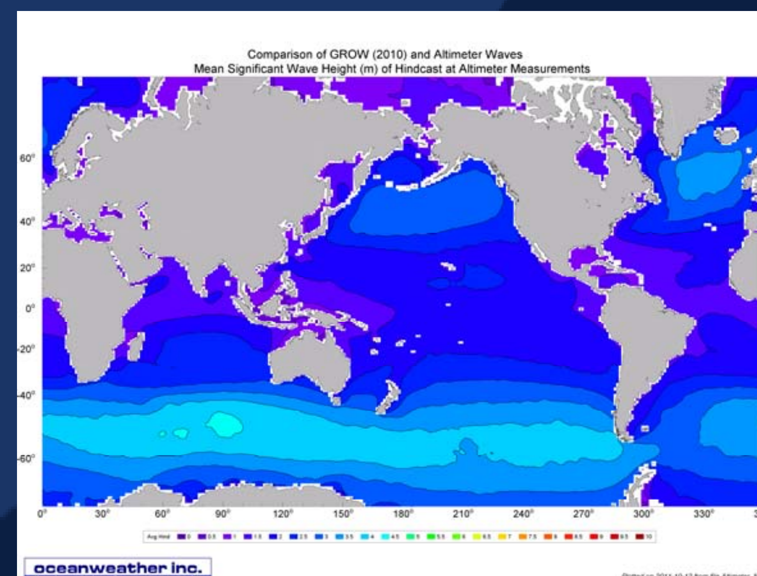
A few important changes for marine forcing highlighted here are:

- *Increased time and spatial resolution*
- *Inclusion of satellite observations of marine winds including ERS ½, NSCAT, QUIKSCAT and WINDSAT scatterometer and SSM/I winds*
- *Application the NCEP tropical storm relocation package*
- *Fixes for known S. Hemisphere problems detected in R1/R2*

Global Wave Assessment





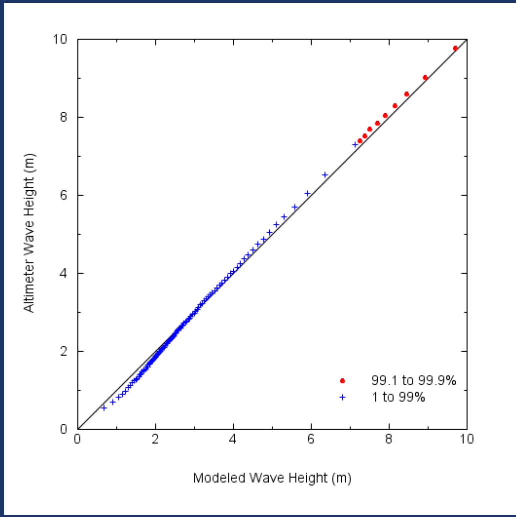


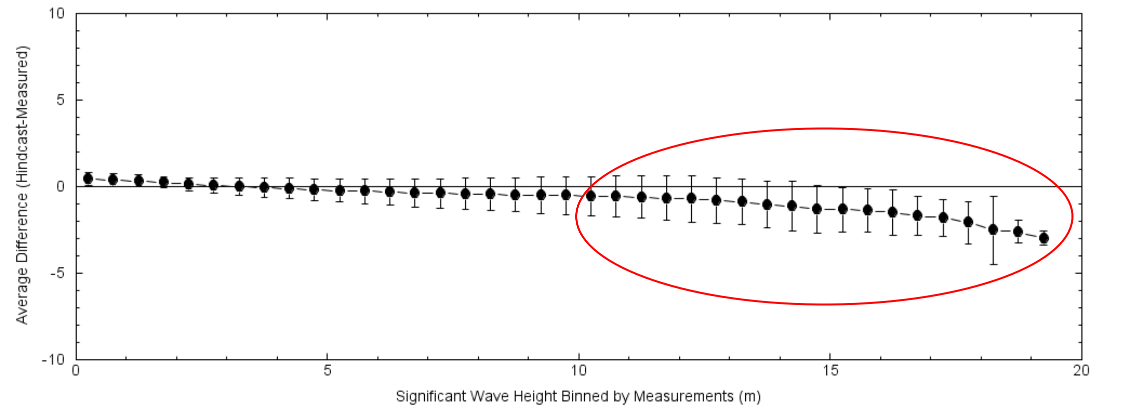
Over 600 million matched altimeter-hindcast pairs

Winds: -0.38 m/s bias, 20% SI

Waves: +0.08 m bias, 18% SI

Global Wave Assessment

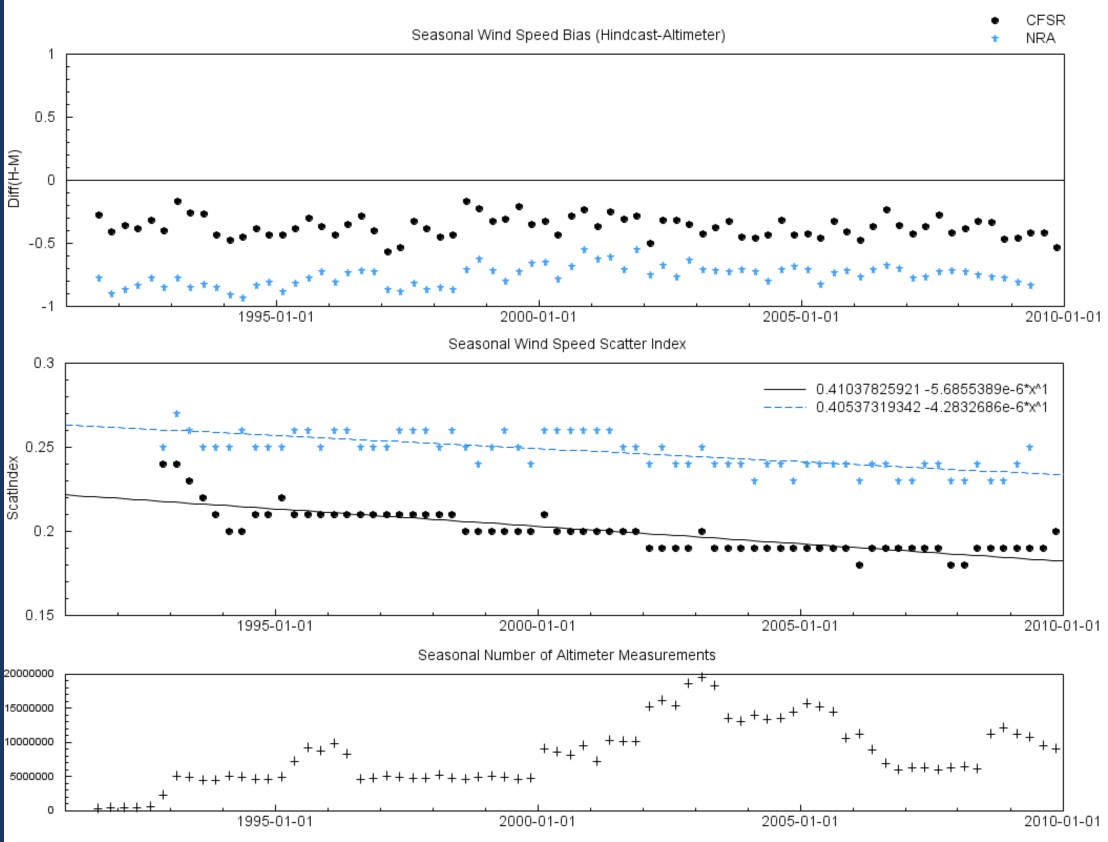




While the 1-99.9% wave height comparisons are quite good, wave hindcasts above the 99.9%/10 meter significant wave height threshold begin to show increasing negative bias.

More on this in the VESS section…

Global Wave Assessment



The CFSR forced global hindcast (blue) shows an overall decrease in bias (top) and scatter index (middle) compared to a NRA forced global hindcast.

Similar trend in decreasing scatter index over time, but as yet unexplained high scatter index in CFSR prior to 1994 (SSM/I ??)

Future work: RHTest to detect step-changes due to inclusion of satellite based measurements

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Basin Assessment in WISPAC

Wave Informational System Pacific Wave Hindcast – USCOE

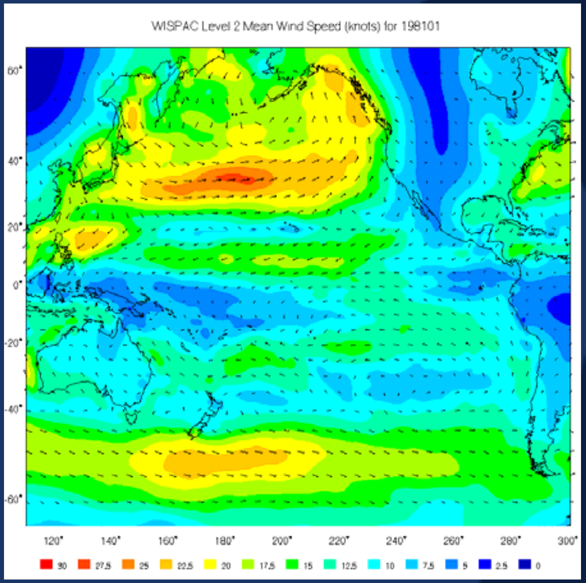
0.5 degree Pacific basin wind fields based on NRA winds with regional statistical corrections

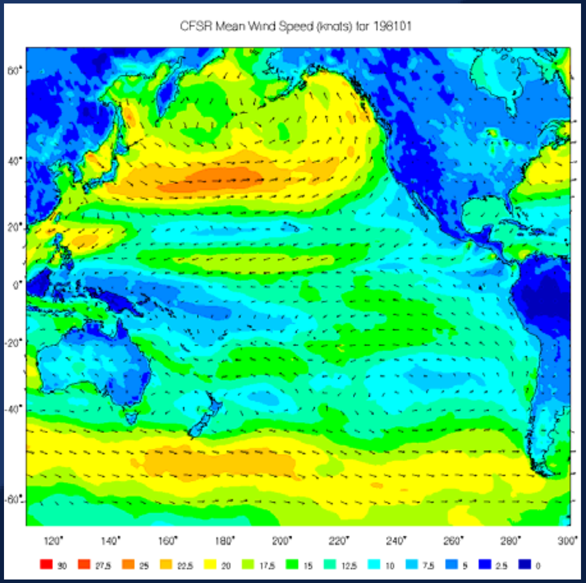
Altimeter Winds 1991-2005

WISPAC -0.49 m/s bias, 29% SI

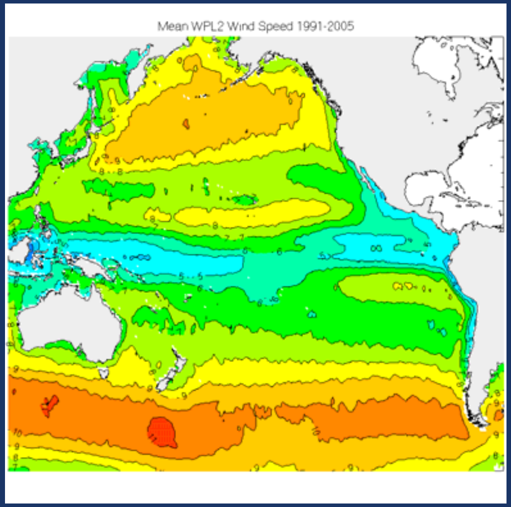
CFSR -0.22 m/s bias, 24% SI

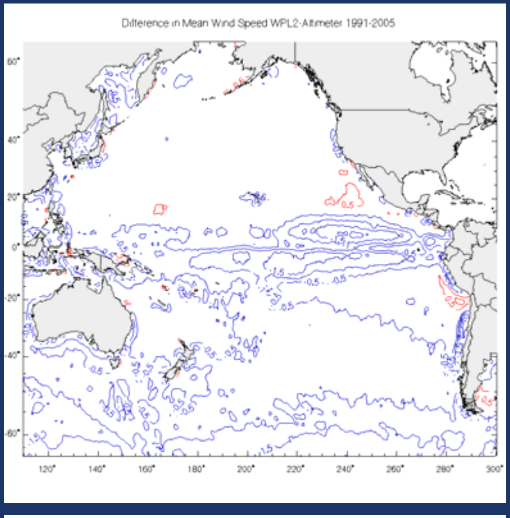
2000/2005 wave runs show similar improvement in SI

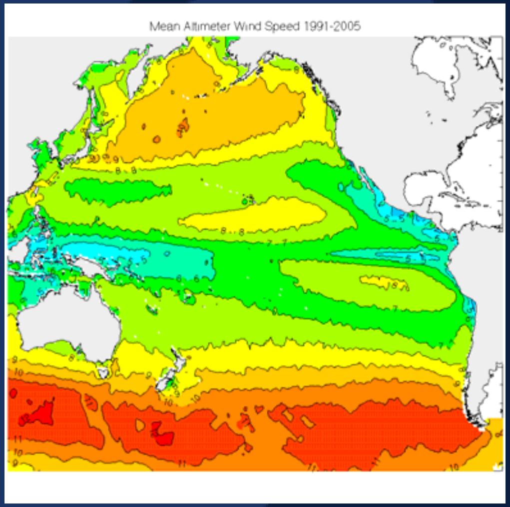


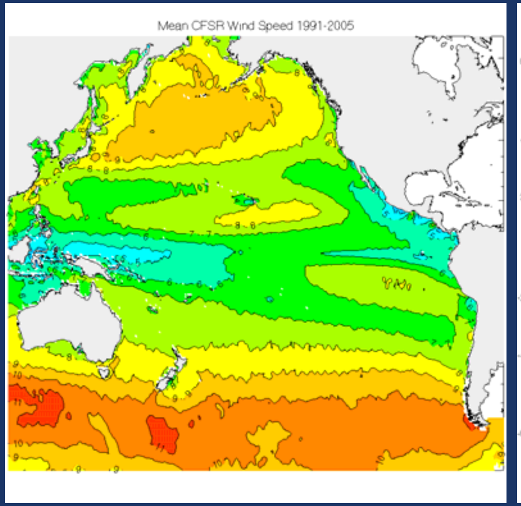


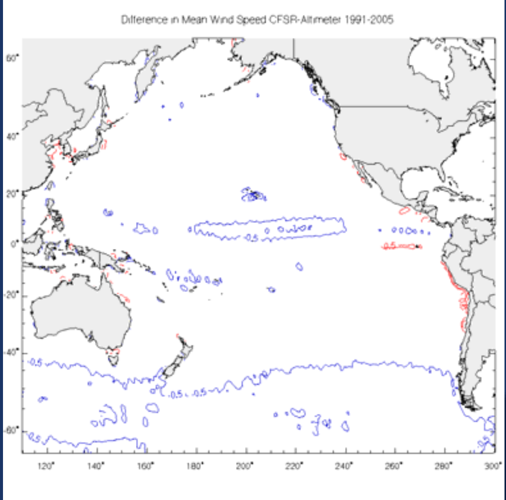
Basin Assessment in WISPAC









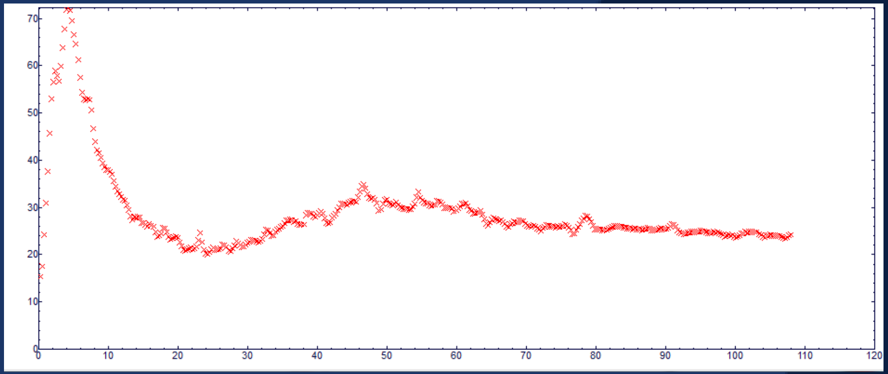


Most of the WISPAC bias in the SH, statistics between WISPAC and CFSR in NH comparable

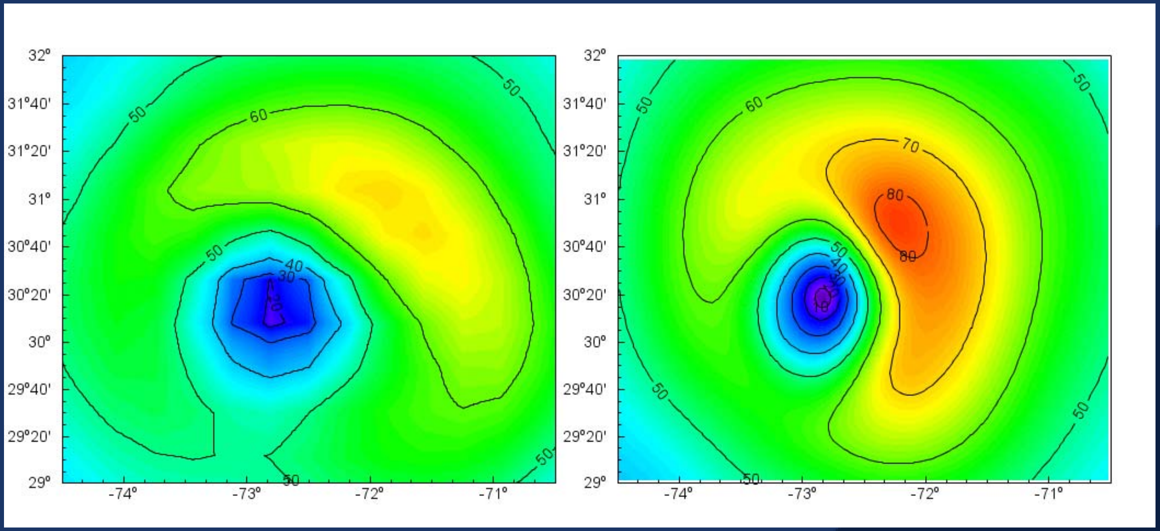
Coherent region of bias in CFSR SH may lend itself to regional corrections

Winds in Tropical Systems

CFSR includes a vortex track repositioning scheme, but even moderate tropical systems typically contain radius of maximum winds tighter than the ~38 km CFSR grid and thus are sub-scale.



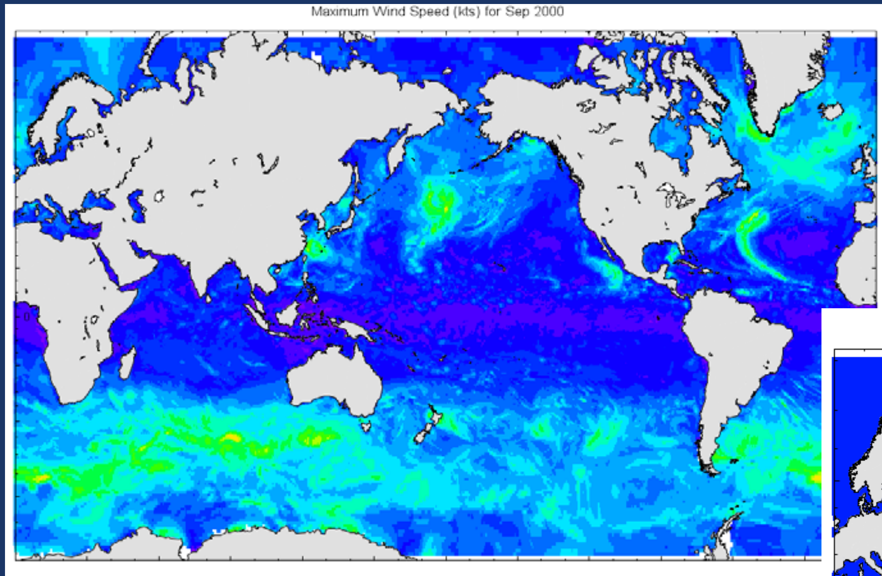
Measured wind profile in Wilma 2005 Oct-19th 892 mb, radius of maximum winds ~7 km which is 5 times smaller than the CFSR grid spacing



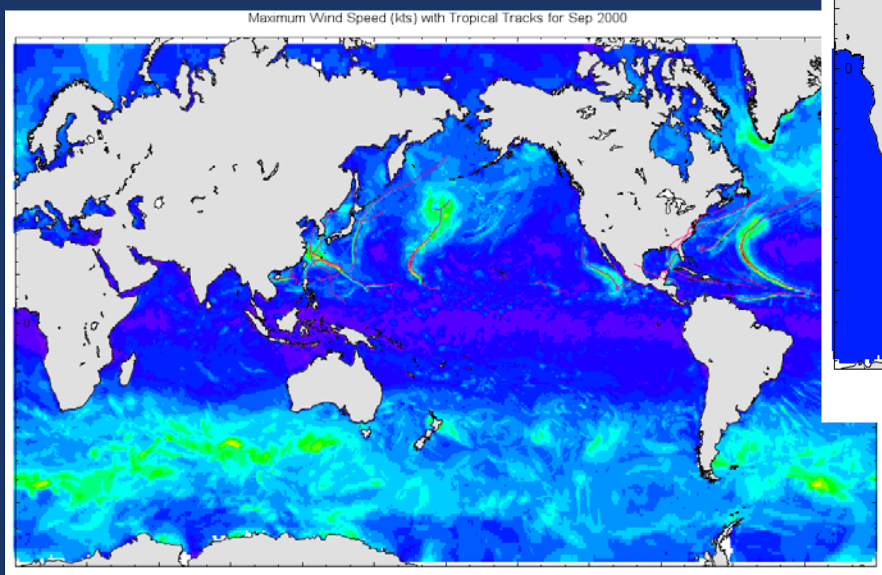
Comparison of CFSR (left) and HWind (right) wind speeds (knots, 30-min)

Valid 17-Sep-2003 16:30 UTC during Isabel – RMW ~ 95km

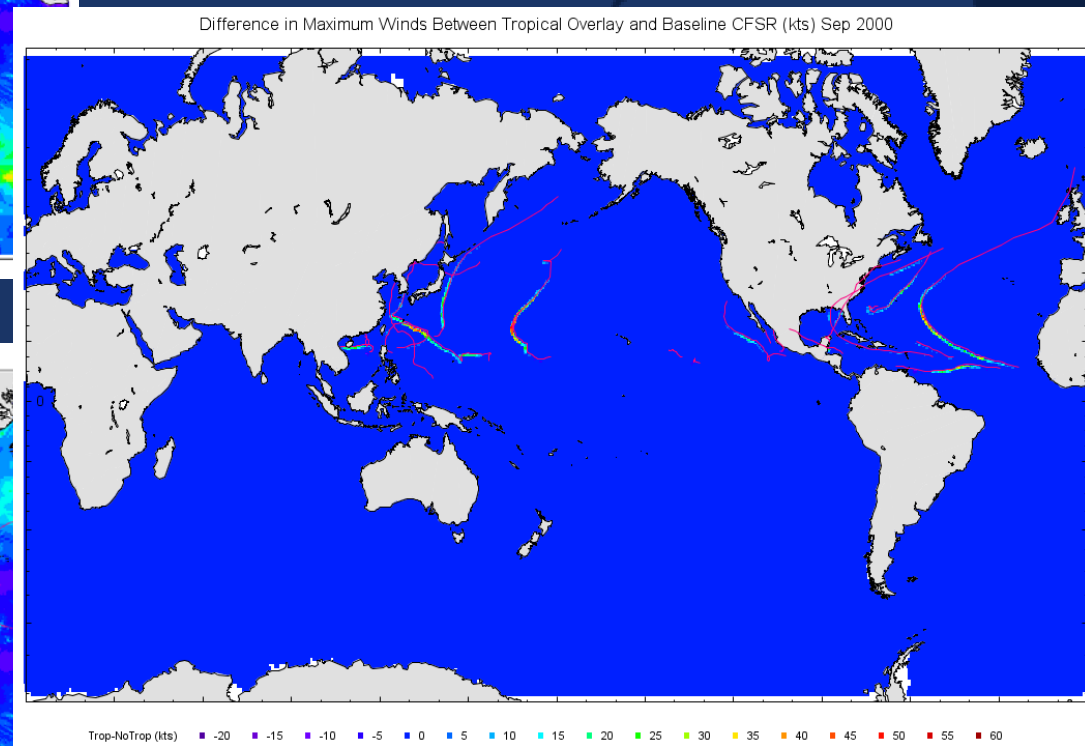
Example of imbedding mesoscale tropical winds within the CFSR



Max Monthly CFSR



Max Monthly CFSR with Tropical Overlay



Difference in maximum wind speed for Sep-2000 due to tropical overlay

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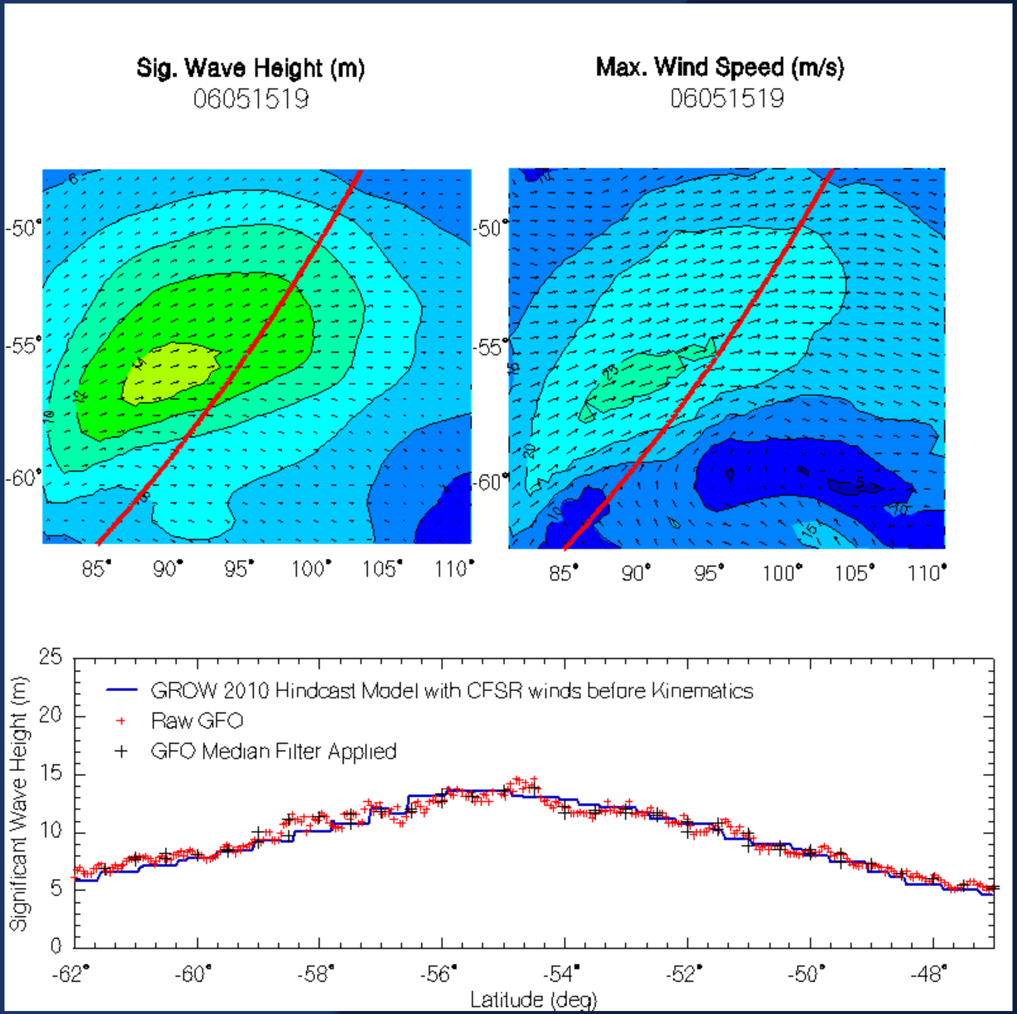
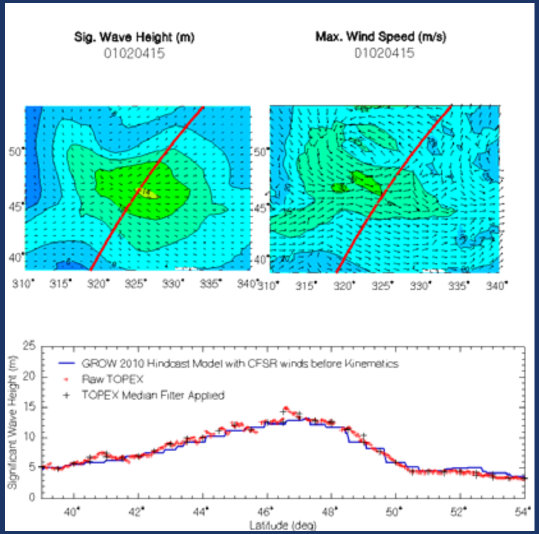
Performance in VESS

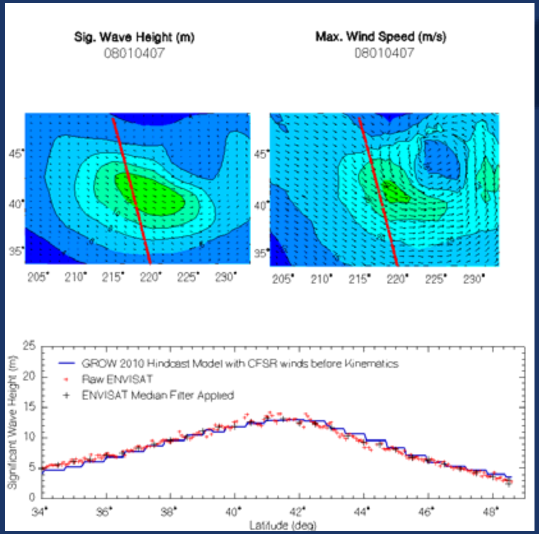
The database of Very Extreme Sea State (VESS) provides over 5000 individual altimeter segments for storm conditions over 12 meters.

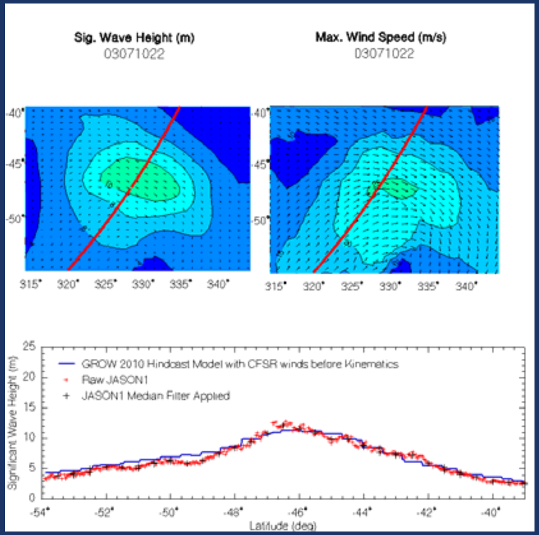
Comparisons extracted for storm events from the Global wave hindcast forced by CFSR winds

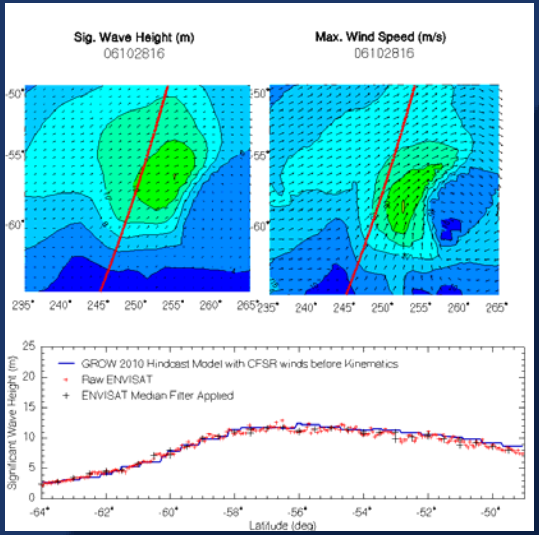


Performance in VESS: More examples of great comparisons in storm events









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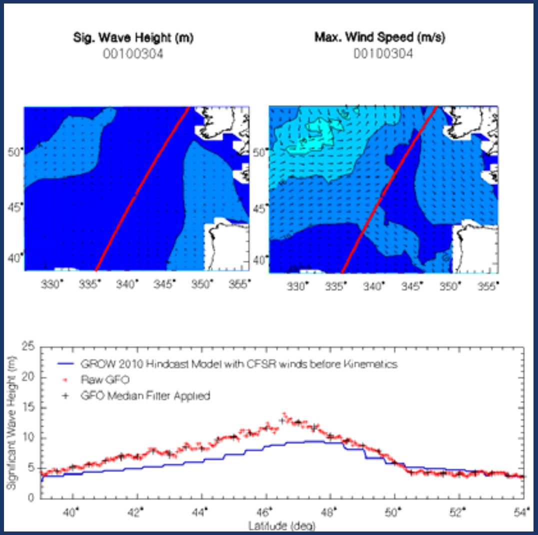
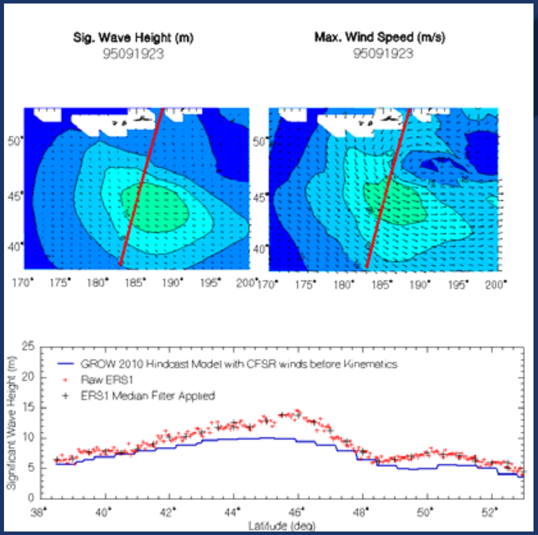
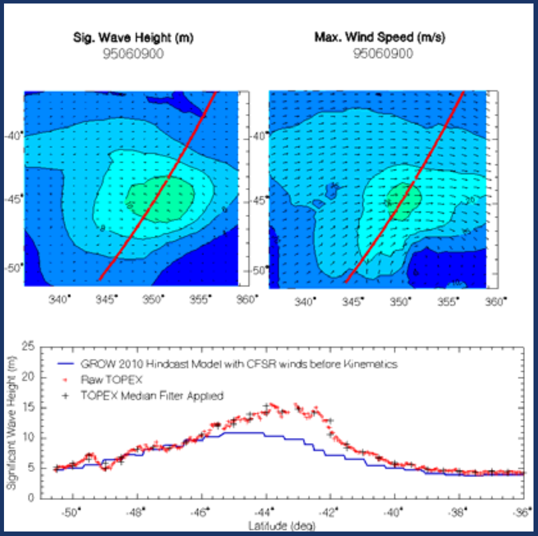
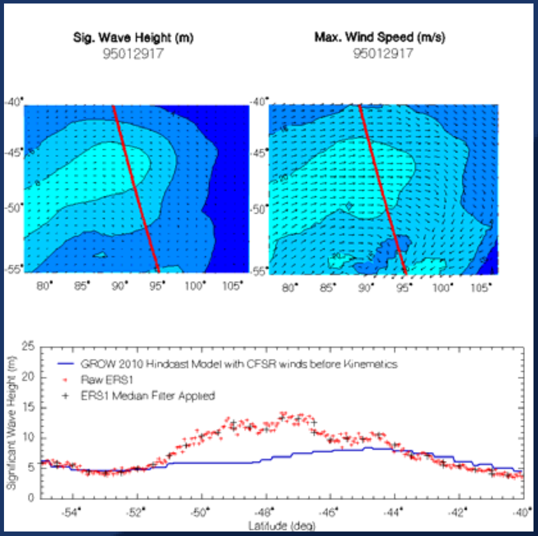
Performance in VESS: Examples of poor comparisons in storm events





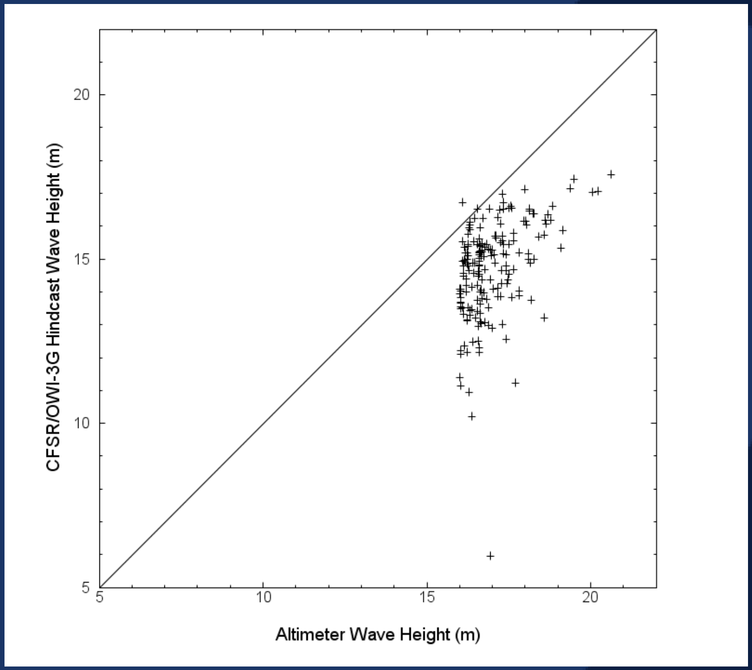




Performance in VESS

Comparisons in storms 12-14 meters show some good, some poor.

Storms > 16m show a systematic underestimation of the hindcast waves

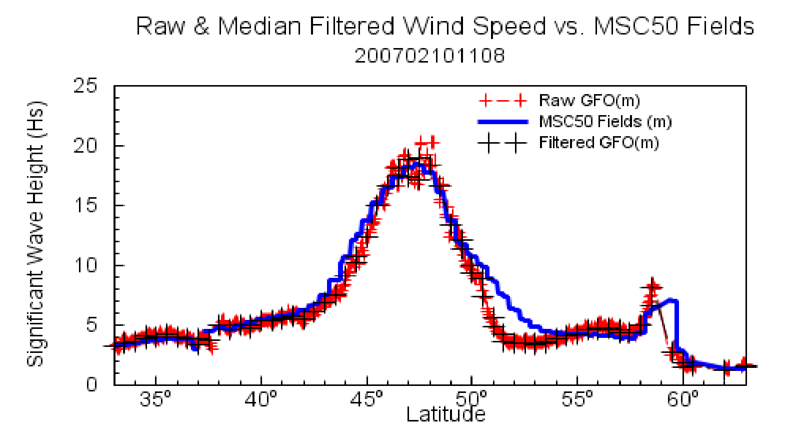


Scatter plot for VESS storms > 16 meters

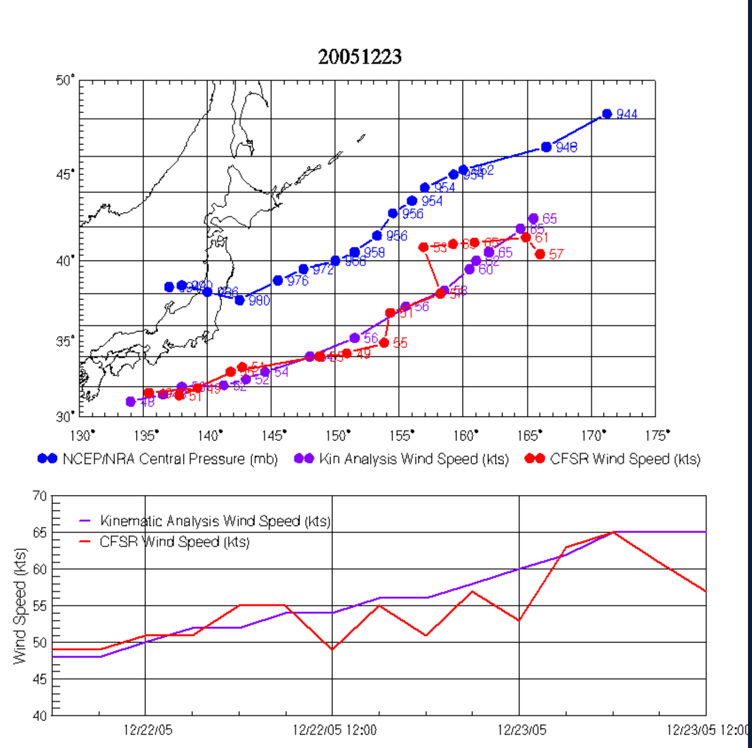
Performance in VESS

When winds in individual storms are reanalyzed using kinematic analysis peak wave conditions can be hindcast.

Storms analyzed to date show CFSR losing peak energy between scatterometer passes



Example of peak conditions hindcast with kinematic reanalysis



Continuity analysis of peak wind maxima in a North Pacific 2005 storm

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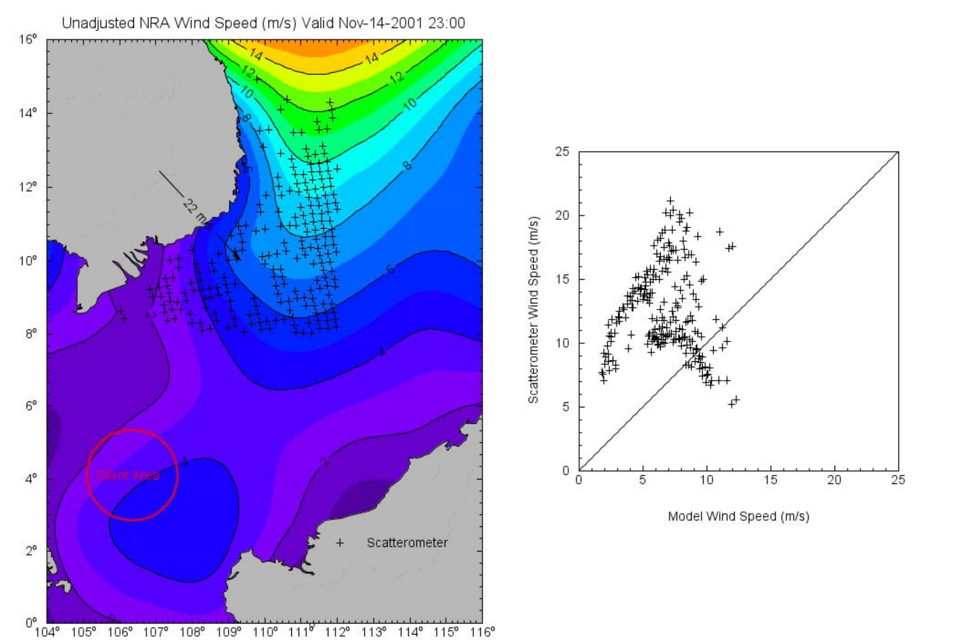
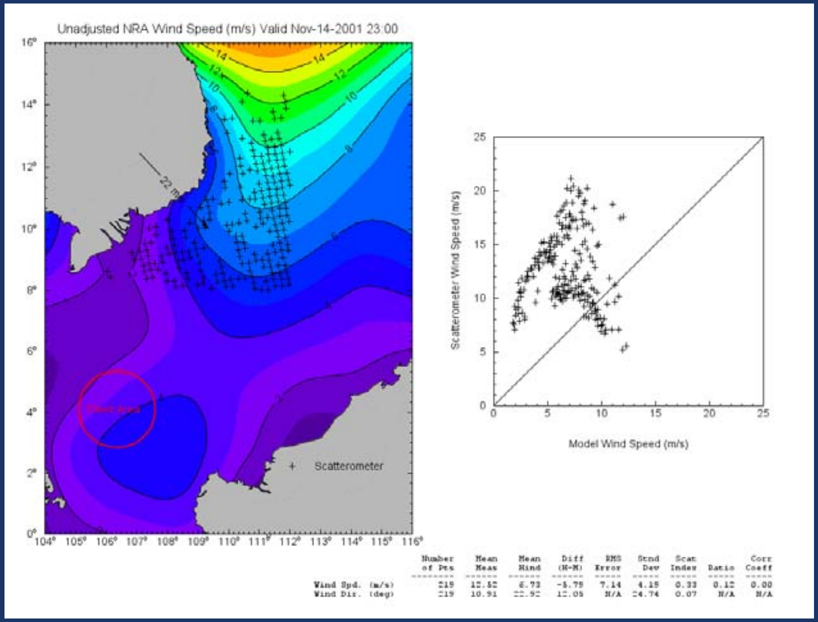
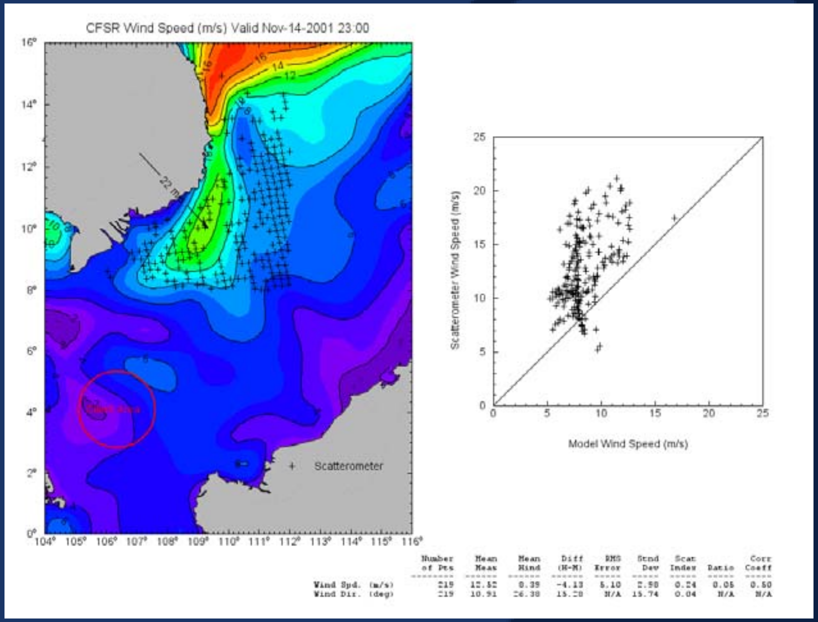
Case Study: Monsoon Flow off Vietnam

Client measurements at ~ 4N/106E show more swell energy than in hindcast. Back traced swell to generation zone offshore Vietnam

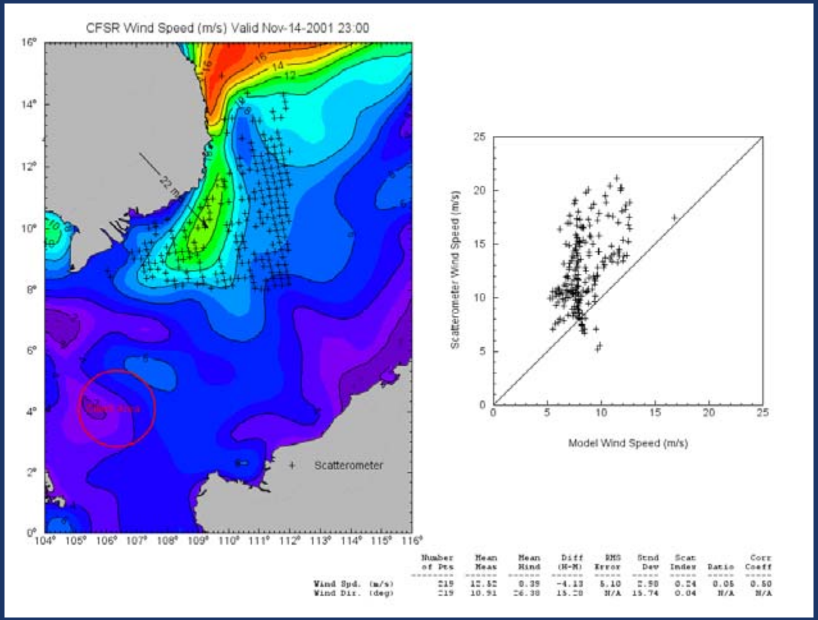


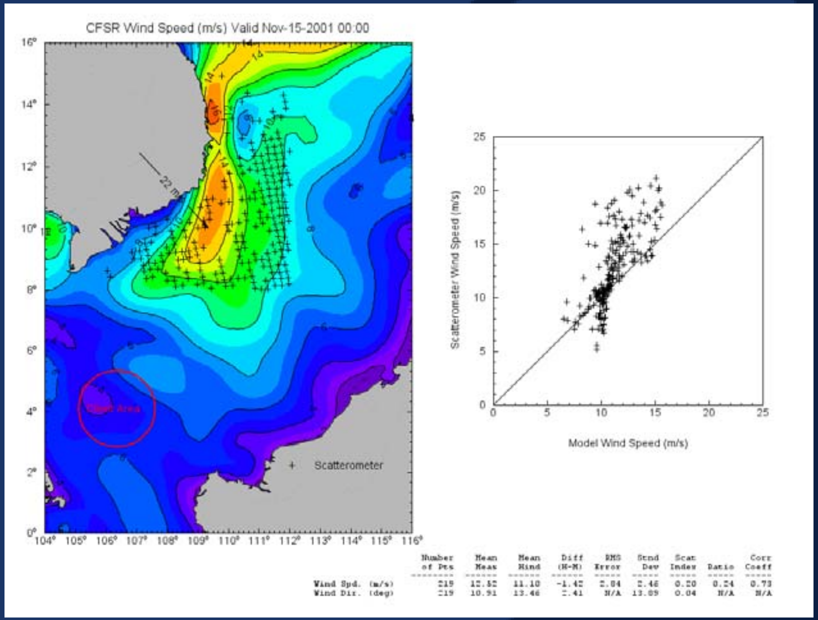
	Number of Pts	Mean Meas	Mean Hind	Diff (H-M)	RMS Error	Stnd Dev	Scat Index	Ratio	Corr Coeff
Wind Spd. (m/s)	219	12.52	6.73	-5.79	7.14	4.19	0.33	0.12	0.00
Wind Dir. (deg)	219	10.91	22.92	12.05	N/A	24.74	0.07	N/A	N/A





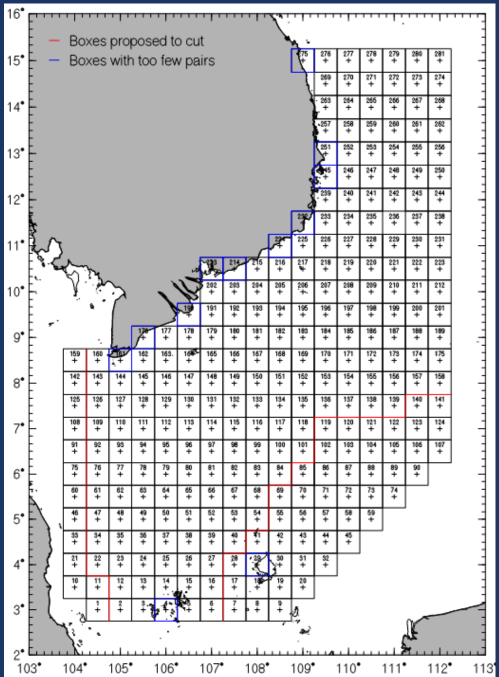
CFSR shows more structure to the core of the monsoonal flow, but still under the measured peak of 20+ m/s



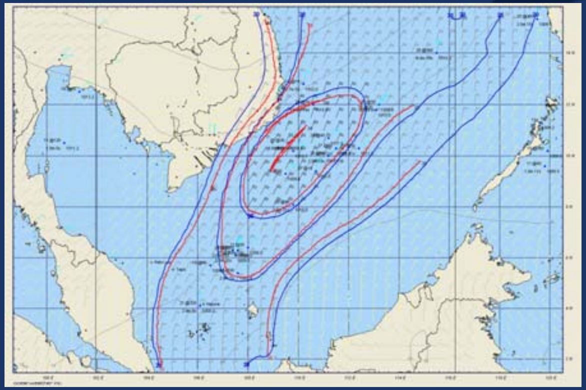


Change in CFSR over 1-hour due to inclusion of QUIKSCAT pass. Peak conditions are still under predicted at pass time and decay in the between passes. Result: while an improvement over unadjusted NRA, CFSR driven wave hindcast still significantly under predicts the swell arriving at the client site.

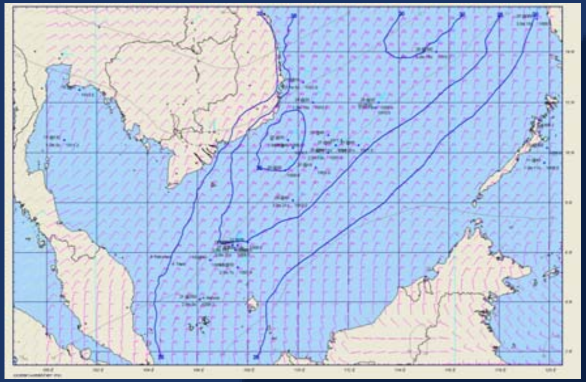
The Solution? Kinematic analysis of cold season monsoon in a training set of storms to serve as the basis of a statistical correction to the base NRA wind set



Region of monsoon corrections



Analysis of wind speeds in event



Resulting corrected wind field

oceanweather inc.

Conclusions/Recommendations

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- *CFSR shows remarkable skill in some VESS storms, but suffers in continuity of peak winds in other storms leading to negative bias in modeled wave heights*
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- *Inclusion of satellite data within the CFSR displays some issues in storms – questions remain about step change effects caused by changes in data*