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Comparison of Gulf of Mexico Wave Information Studies 2-G Hindcast with 3-G Hindcasting

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Wave Information Studies (WIS)
Hindcast Wave Data for U.S. Coasts

WIS Gulf Hindcast

- *1980-1999 Gulf wave information*
- *Hourly parameters available on website:*

  frf.usace.army.mil.wis
- *Output stations near coast in 10-20m of water*
- *Hindcast used 2-G modeling technology (WISWAVE)*

Goal of Study

- *Website has had over 10,000 hits since June 03*

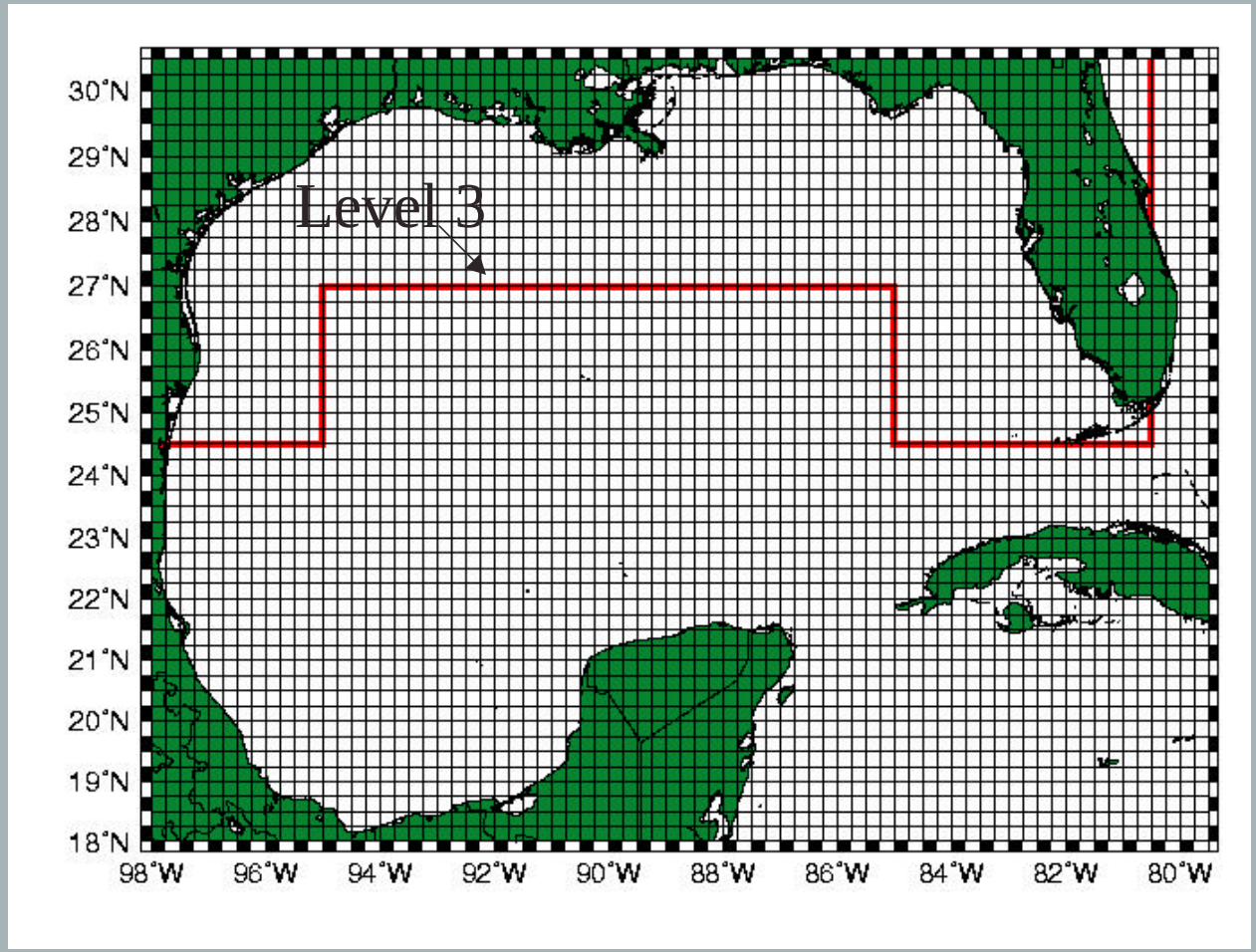
WIS wave information is being used by Corps of Engineers, other government agencies, and private consulting firms.

Comparison of 2-G hindcast results with the newer 3-G hindcasting results is important for WIS credibility and valuable for future hindcasting regimes.

Hindcast Details

- *1995 chosen for test year in Gulf of Mexico*
- *Two 3-G models (WAM and WW3) were used in test*
- *All grids and input wind fields were the same for all hindcasts*
- *Comparison of results consists of comparison statistics including circular direction statistics*

Gulf Level 2 (1/4 deg) and Level 3 (1/12 deg) Grid



Hindcast Levels

- *Level 1 – Includes both Atlantic and Gulf in 1 – deg hindcast*
- *Boundary energy enters Level 2 south of Florida*
- *Level 2 – Includes entire Gulf of Mexico with ¼ deg spacing*
- *Level 3 – Includes coastal area of Gulf – energy enters grid from central Gulf*

Wave Models

$$\frac{\partial N}{\partial t} + C_g \cdot \nabla N = \sum_{i=1}^{n} S_i$$

N is action density

C_g is group velocity

S_i are source functions (wind input, dissipation, nl-wave-wave interactions, bottom effects

2-G versus 3-G Models

- *2-G Models - parameterization of nl term*
- *3-G Models use a calculation of nl term*
- *All simulate directional energy matrices (freq and dir)*
- *All models strive to reproduce the physics of wave growth, development, dissipation, and nl interactions*

3-G Model WAM

- *WAM Cycle 4.5*
  - *Update of WAM Cycle 4 using Fortran 90*
  - *Komen et al., 1994; Guenther et al., 1992*
  - *Klaus Hasselmann's DIA for nl interactions*
  - *Wave spectra are not tied to a specific spectral shape*
  - *Same physics used in all applications*
  - *Sea ice and nesting options*
  - *Used in USACE Alaska hindcasts (Jensen et al., 2002)*

3-G Model WW3

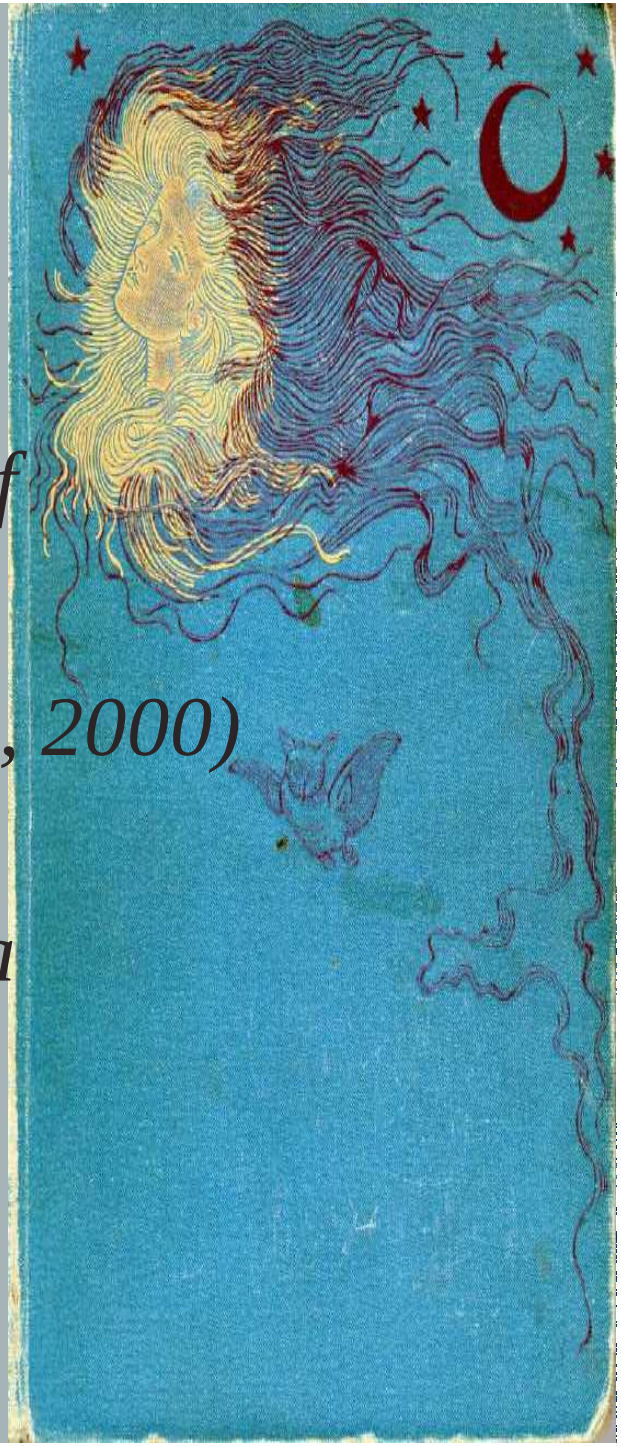
- *Wavewatch III Version 2.22*
- *Includes most recent advances in wave modeling technology*
- *Tolman (2002) user manual*
- *Marine Modeling and Analysis branch of Environmental Modeling Center at NCEP*
- *Dr. Tolman's Delft Univ. work*
- *Uses DIA for nl source term*
- *Default set-ups (Tolman and Chalikov, 1996)were used for test*
- *Different source terms available*
- *Options for sea ice, currents, and nesting*
- *Used as operational model at NOAA/NCEP*

2-G Model WISWAVE

- *Army Corps of Engineers model developed by Don Resio*
- *Uses equilibrium Jonswap and Kitaigorodskii spectral functions*
- *Wave theory in Resio,1981 and 1989; Resio and Perrie, 1991; Resio et al., 2001*
- *WISWAVE manual (Hubertz, 1992)*
- *Nested boundary conditions available*
- *Used for WIS 1980-1999 Atlantic and Gulf hindcasts for Wave Information Studies*

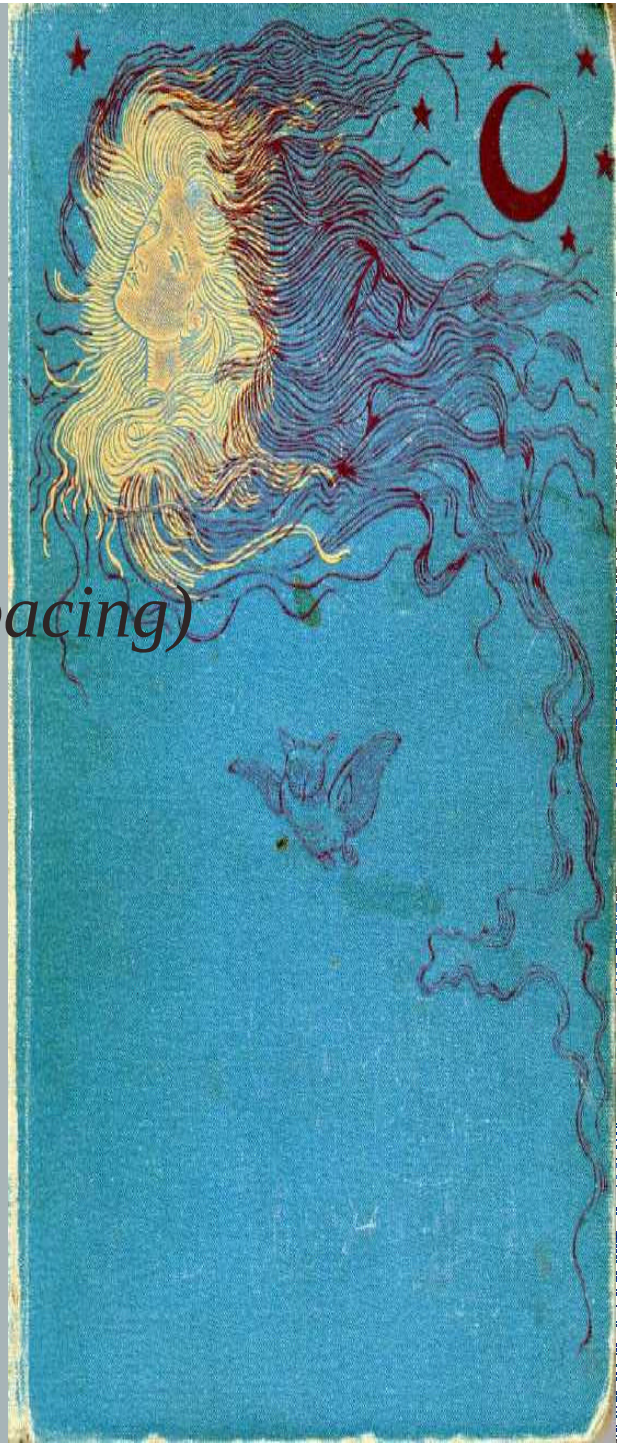
Level 1 Wind Fields

- *Includes Atlantic and eastern Gulf*
- *1 deg spacing*
- *AES40 wind product (Swail, et al., 2000)*
- *Developed by Oceanweather for Meteorological Service of Canada*
- *Derived from 6-hr NCEP/NCAR reanalysis fields*



Gulf Wind Fields (Level 2 and Level 3)

- *Oceanweather ¼ deg wind fields*
  - *NCEP 6-hr wind fields (1.9 deg spacing)*
  - *Interpolation to 1-hr*
  - *NCEP corrections by grid point*
  - *Assimilation of measured wind info*
  - *Tropical storm wind assimilation*



Measurement sites

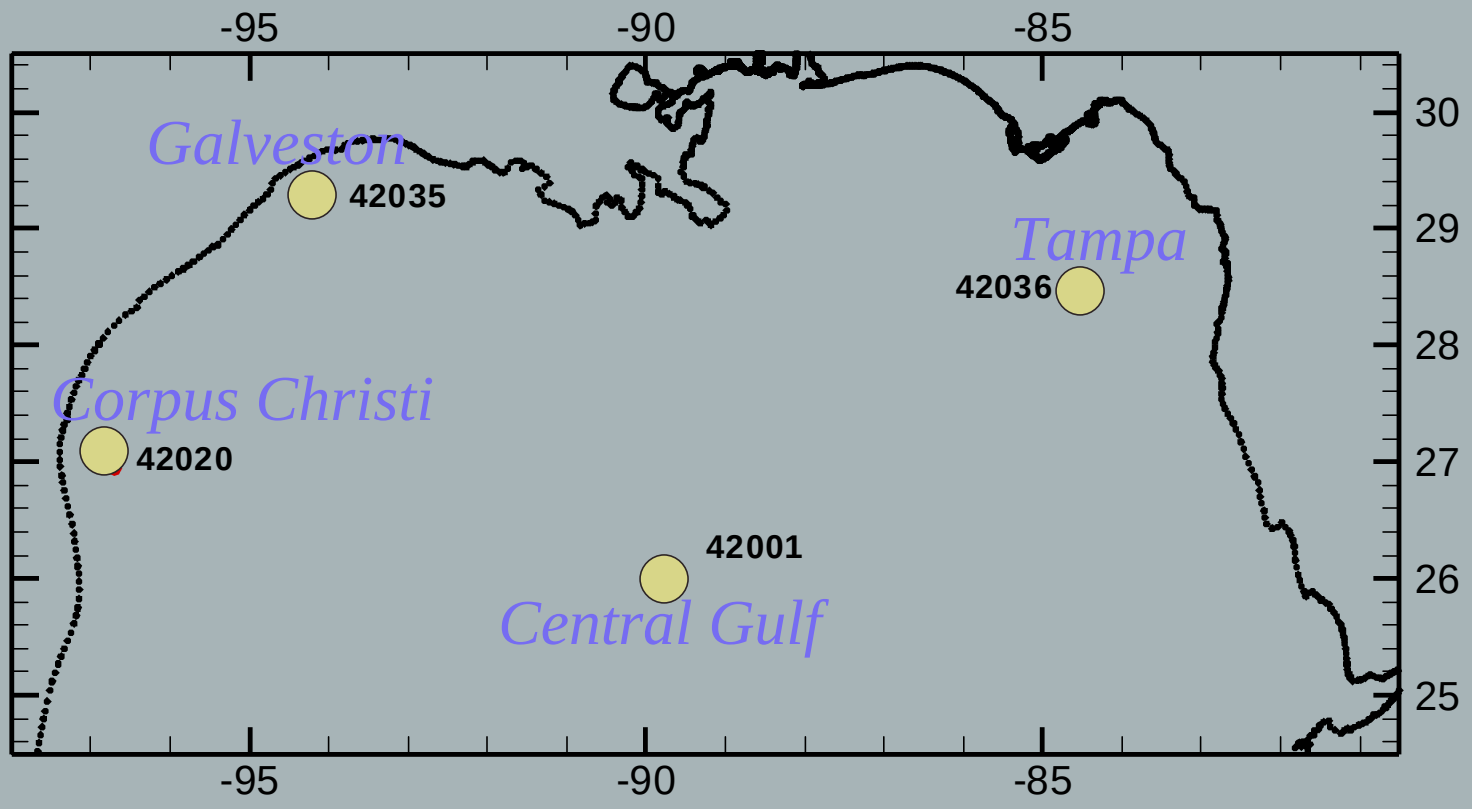
Table 1. Level 3 Measurement Sites

NDBC	Lon.	Lat.	Dep.(m)	Months
42019	-95.00	27.92	100	Jul-Dec
42020	-96.50	27.00	120	Jan-Dec
42040	-88.25	29.17	170	Dec
42035	-94.42	29.25	15	Jan-Dec
42016	-88.17	30.08	19	May
42039	-86.00	28.75	300	Dec
42036	-84.50	28.50	51	Jan-Dec

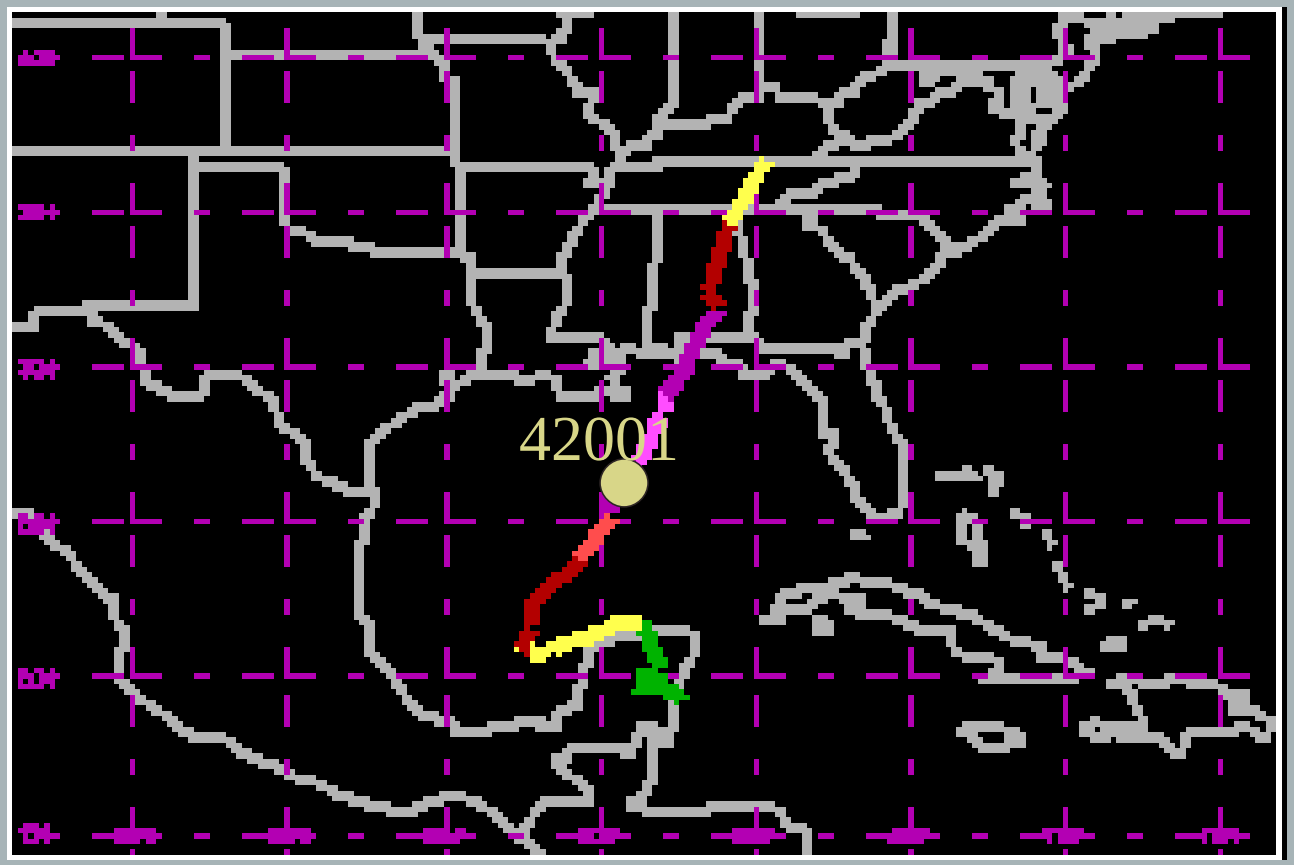
Table 2. Level 2 Measurement Sites

NDBC	Lon.	Lat.	Dep.(m)	Months
42001	-89.75	26.00	3165	Jan-Dec
42002	-93.50	26.00	3123	Jan-Dec
42003	-86.00	26.00	3206	Jan-Dec

Gulf of Mexico with Comparison NDBC Locations



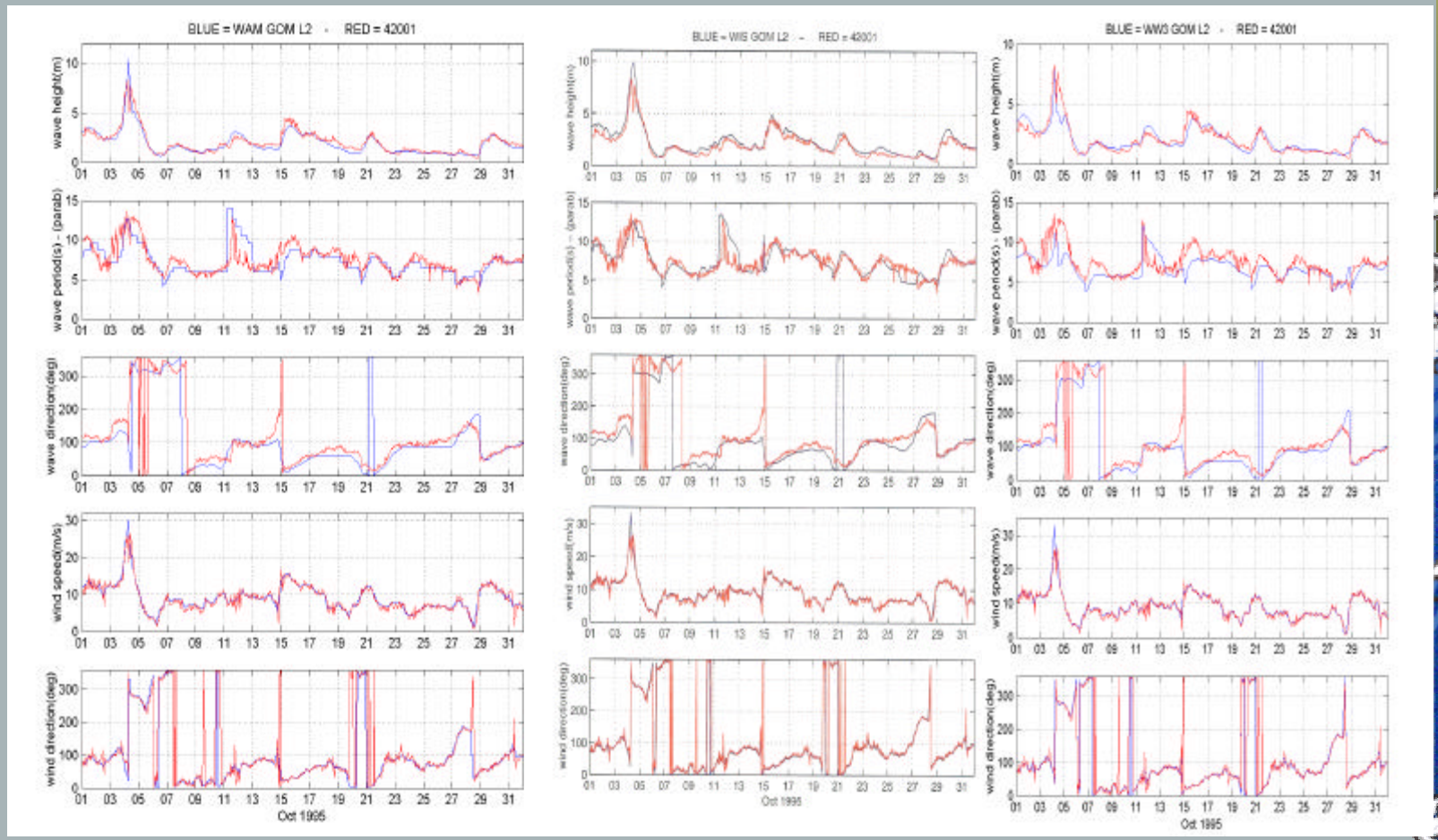
Hurricane Opal
Sept. 27- Oct. 6, 1995



*Track picture from Unisys website

Opal Level 2 Comparisons

WAM WIS WW3



October 1995 Statistics at 42001

HS Statistics at 42001 for October 1995					
	Bias (m)	RMS (m)	SI	SS	COR
WAM	-0.12	0.42	21	0.98	0.94
WIS	0.32	0.41	20	0.97	0.95
WW3	0.00	0.52	25	0.98	0.90

TM Statistics at 42001 for October 1995					
	Bias (sec)	RMS (sec)	SI	SS	COR
WAM	-0.11	0.67	10	0.99	0.85
WIS	0.24	0.61	9	0.99	0.89
WW3	0.56	0.77	12	0.99	0.78

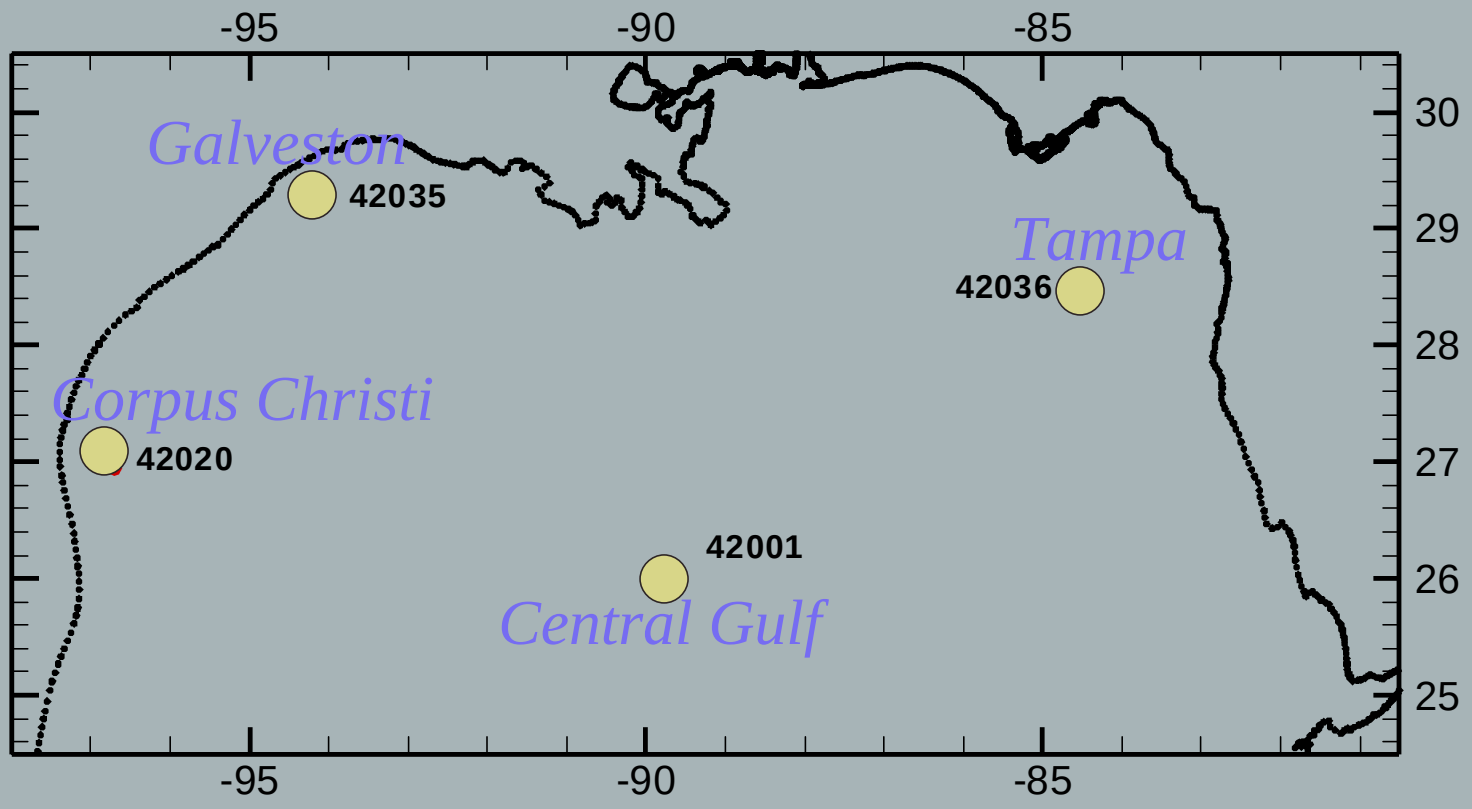
TP Statistics at 42001 for October 1995					
	Bias (sec)	RMS (sec)	SI	SS	COR
WAM	-0.18	1.40	19	0.98	0.68
WIS	0.01	1.22	16	0.99	0.76
WW3	-0. 74	1.36	18	0.98	0.63

October 1995 42001 (Directional statistics*)

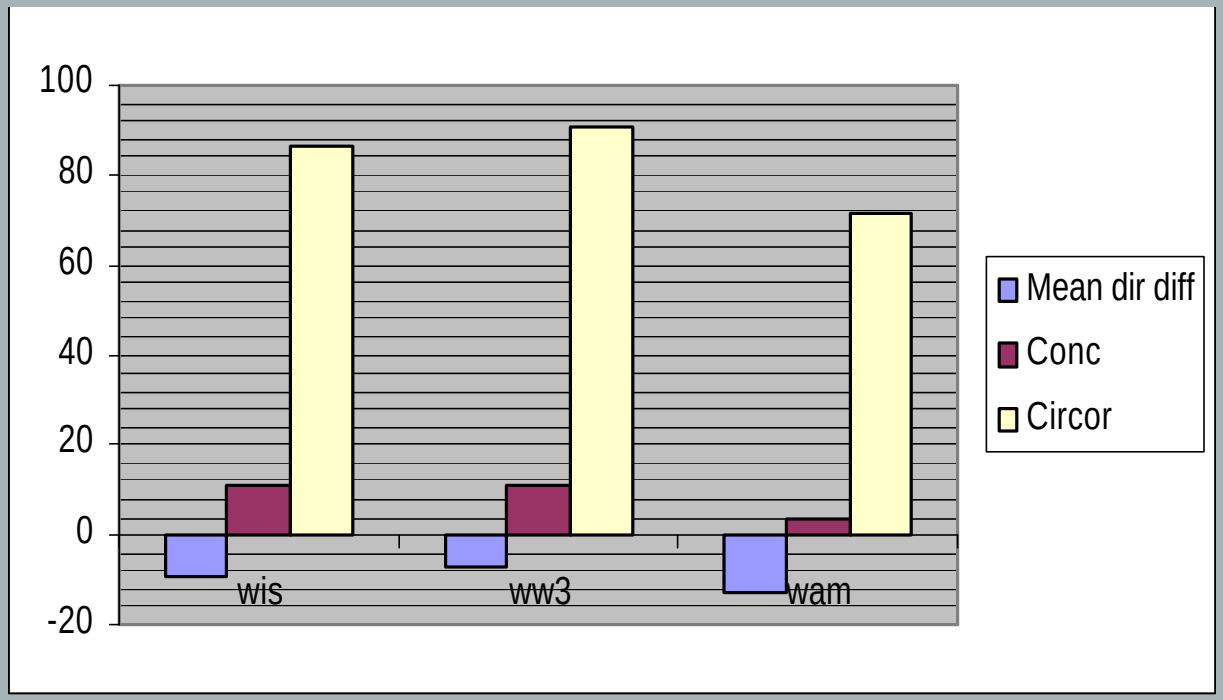
Mean Wave Direction Statistics for Gulf Level 2 October 1995 at NDBC 42001				
Model	Mean dir diff $\bar{x}$ (deg)	$\hat{k}$	Circor	Number
WIS	14.69	6.6	.85	668
WW3	12.52	7.4	.86	668
WAM	11.38	8.6	.88	668

* Tracy(2002) and Bowers et al.(2000)

Gulf of Mexico with Comparison NDBC Locations

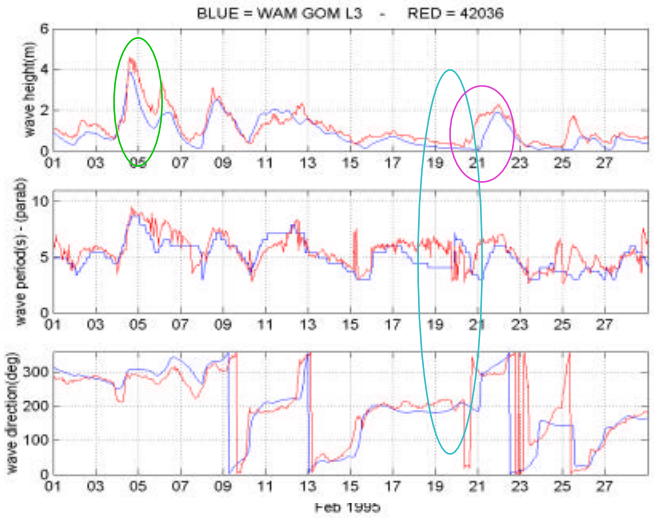


Direction Statistics at 42036 for February 1995

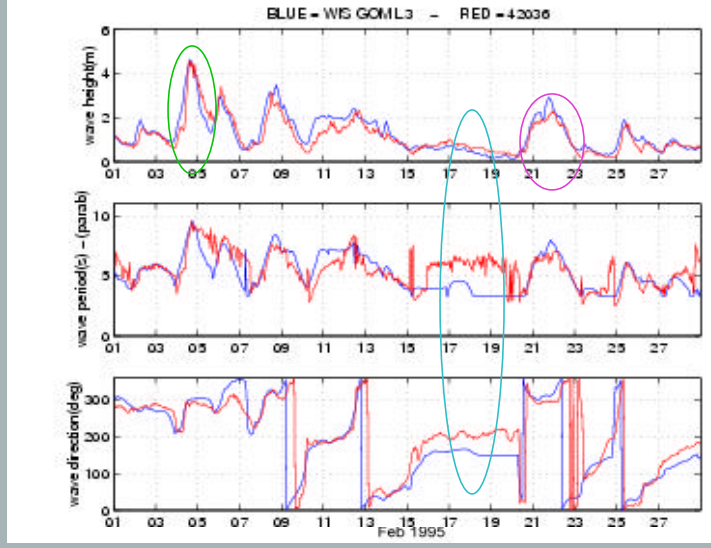


February 1995 at 42036

WAM



WIS

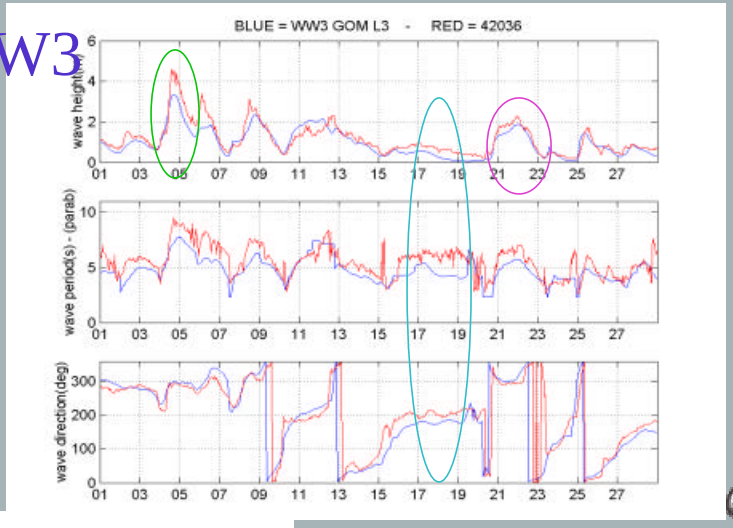


Feb 4-front (winds on back side of low)

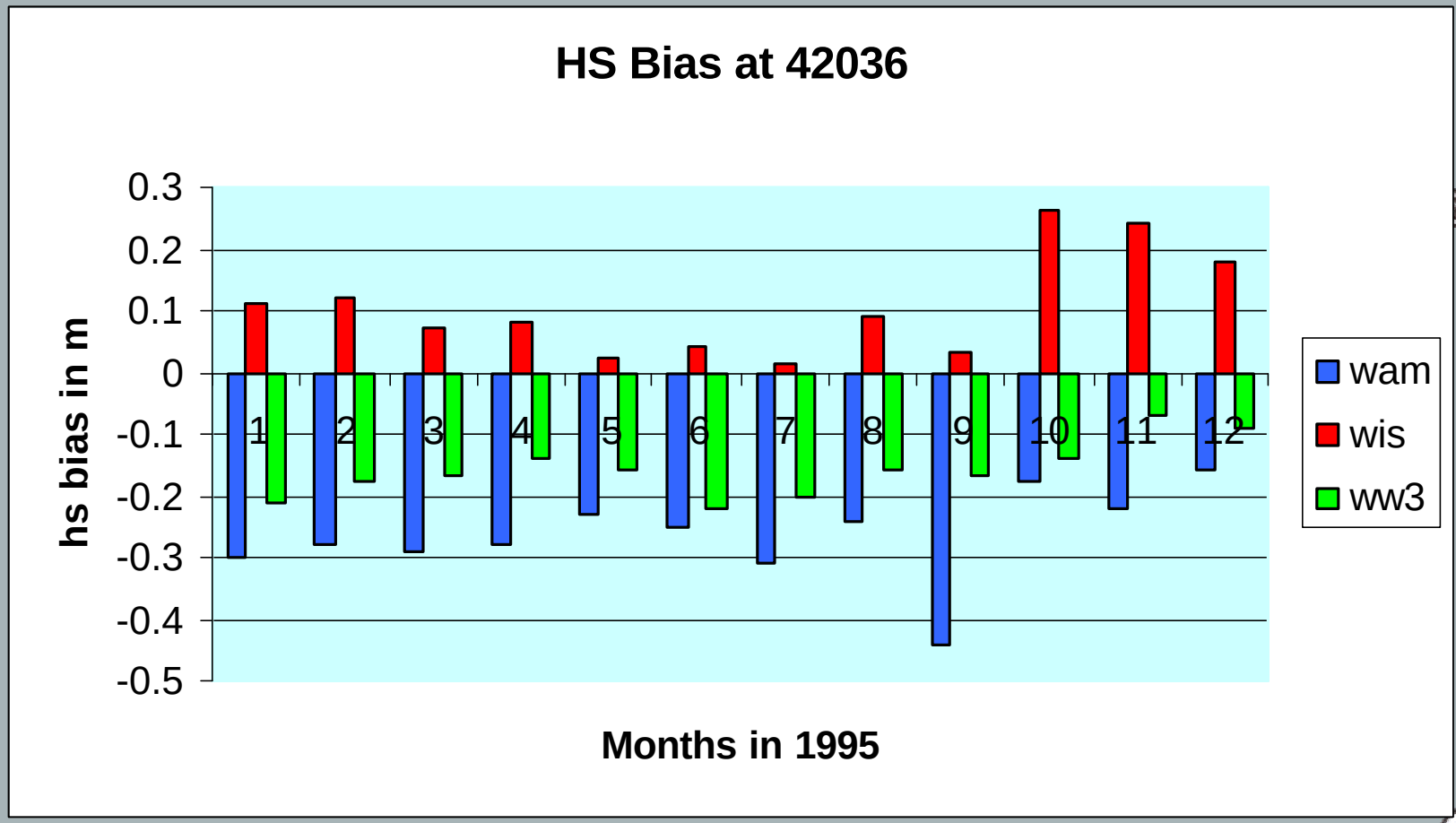
Feb 17-19-low wave ht

Feb 21-low in SE Gulf-dir change

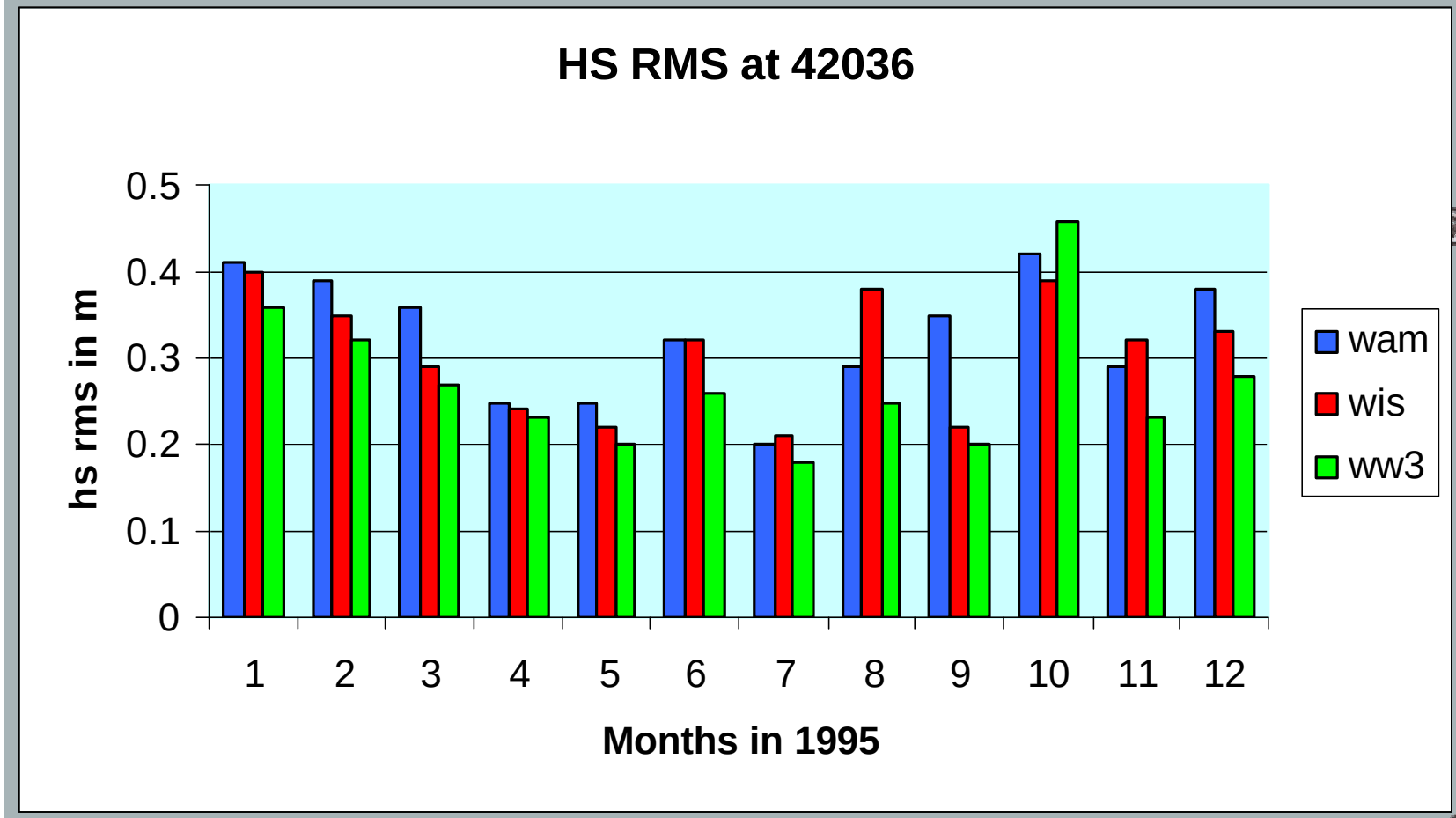
WW3



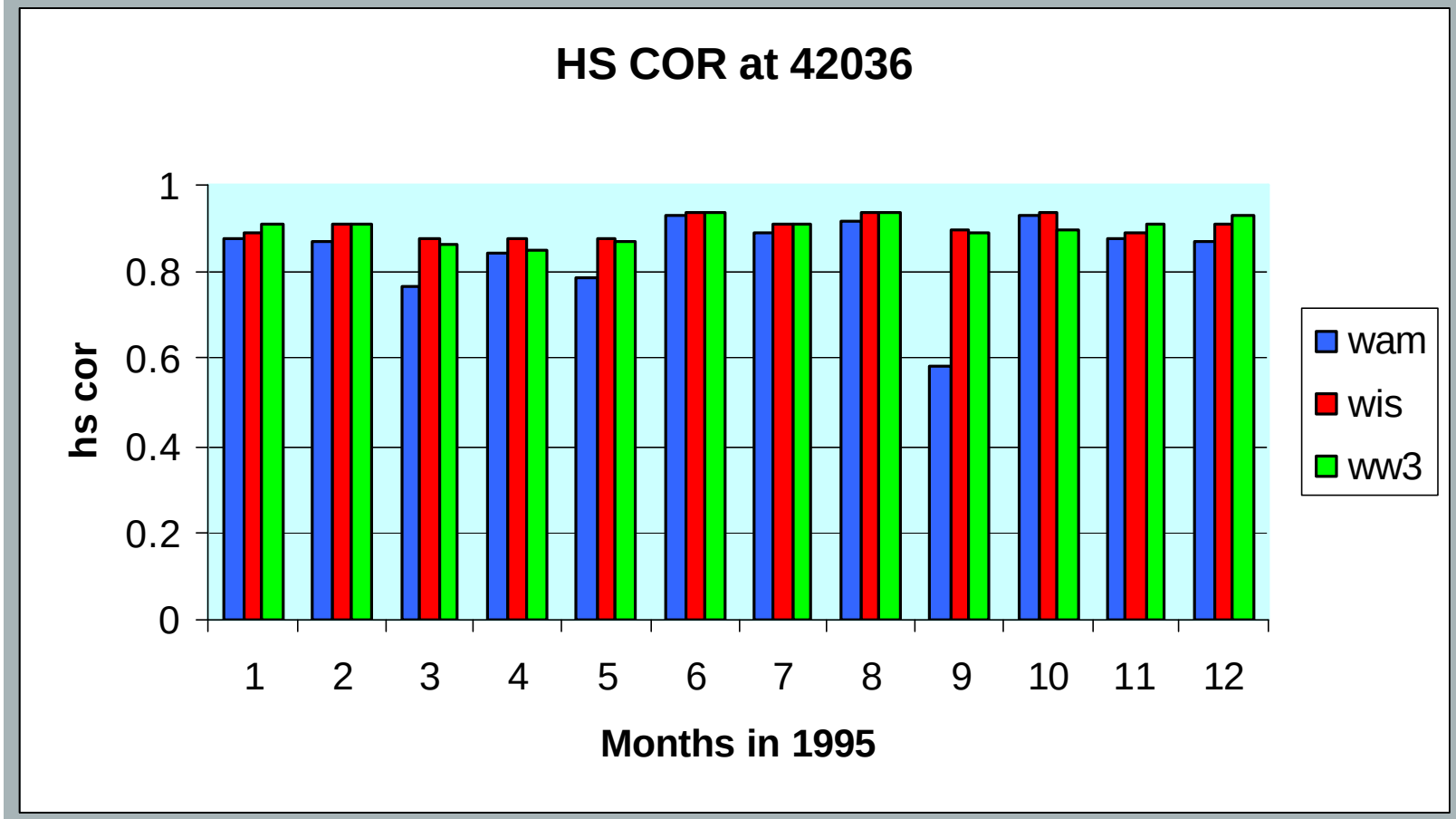
HS Bias 42036



HS RMS at 42036



HS Correlation at 42036



1995 HS Statistical Summary for Level 3 Sites

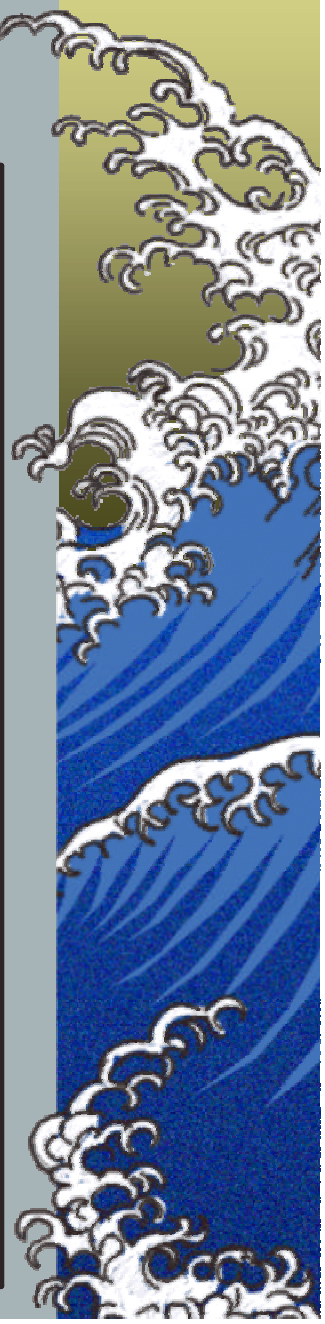
Buoy	Model	Mean Bias (m)	Mean RMS(m)	SI	SS	COR
42020	WIS	0.08	0.35	25	0.96	0.85
	WAM	-0.27	0.38	28	0.96	0.80
	WW3	-0.23	0.37	26	0.97	0. 83
42035	WIS	0.17	0.23	26.3	0.93	0.87
	WAM	-0.20	0.21	24.2	0.96	0.86
	WW3	-0.14	0.20	22.5	0.97	0.88
42036	WIS	0.10	0.30	32.4	0.95	0.90
	WAM	-0.26	0.32	34.3	0.94	0.84
	WW3	-0.16	0.27	27.5	0.97	0.90

1995 TP Statistical Summary

Buoy	Model	Mean Bias (m)	Mean RMS(m)	SI	SS	COR
42020	WIS	-0.36	1.17	18.3	0.98	0.61
	WAM	-0.19	1.31	20.6	0.97	0.54
	WW3	-0.90	1.08	16.8	0.98	0.64
42035	WIS	-0.02	1.54	28.3	0.95	0.53
	WAM	-0.01	1.54	28.4	0.94	0.47
	WW3	-1.05	1.23	22.0	0.97	0.58
42036	WIS	-0.45	1.34	24.8	0.96	0.49
	WAM	-0.02	1.53	29.3	0.97	0.56
	WW3	-0.90	1.21	22.3	0.97	0. 54

1995 TM Statistical Summary

Buoy	Model	Mean Bias (m)	Mean RMS(m)	SI	SS	COR
42020	WIS	-0.00	0.60	10.8	0.99	0.76
	WAM	-0.07	0.72	13.2	0.98	0.66
	WW3	-0.88	0.57	11.4	0.98	0.72
42035	WIS	0.25	0.73	15.3	0.98	0.69
	WAM	-0.06	0.80	16.3	0.98	0.56
	WW3	-0.88	0.57	11.4	0.98	0.72
42036	WIS	-0.05	0.77	16.0	0.98	0.61
	WAM	0.00	1.01	12.5	0.91	0.64
	WW3	-0.70	0.57	11.8	0.99	0.75



Summary

- *All 3 models are excellent hindcasting tools*
- *2G WIS results are consistent with 3G results*
- *3G has slightly better directional results*
- *WIS over-predicts HS; 3G under-predict*
- *WIS captures storms and quick frontal changes in Gulf*
- *All models need work on wave period*

Future Work

- *Similar study for Atlantic*
- *Spectral comparisons*
- *New wave system diagnostics for WIS Pacific forensics (Presentation by Jeff Hanson later in conference)*