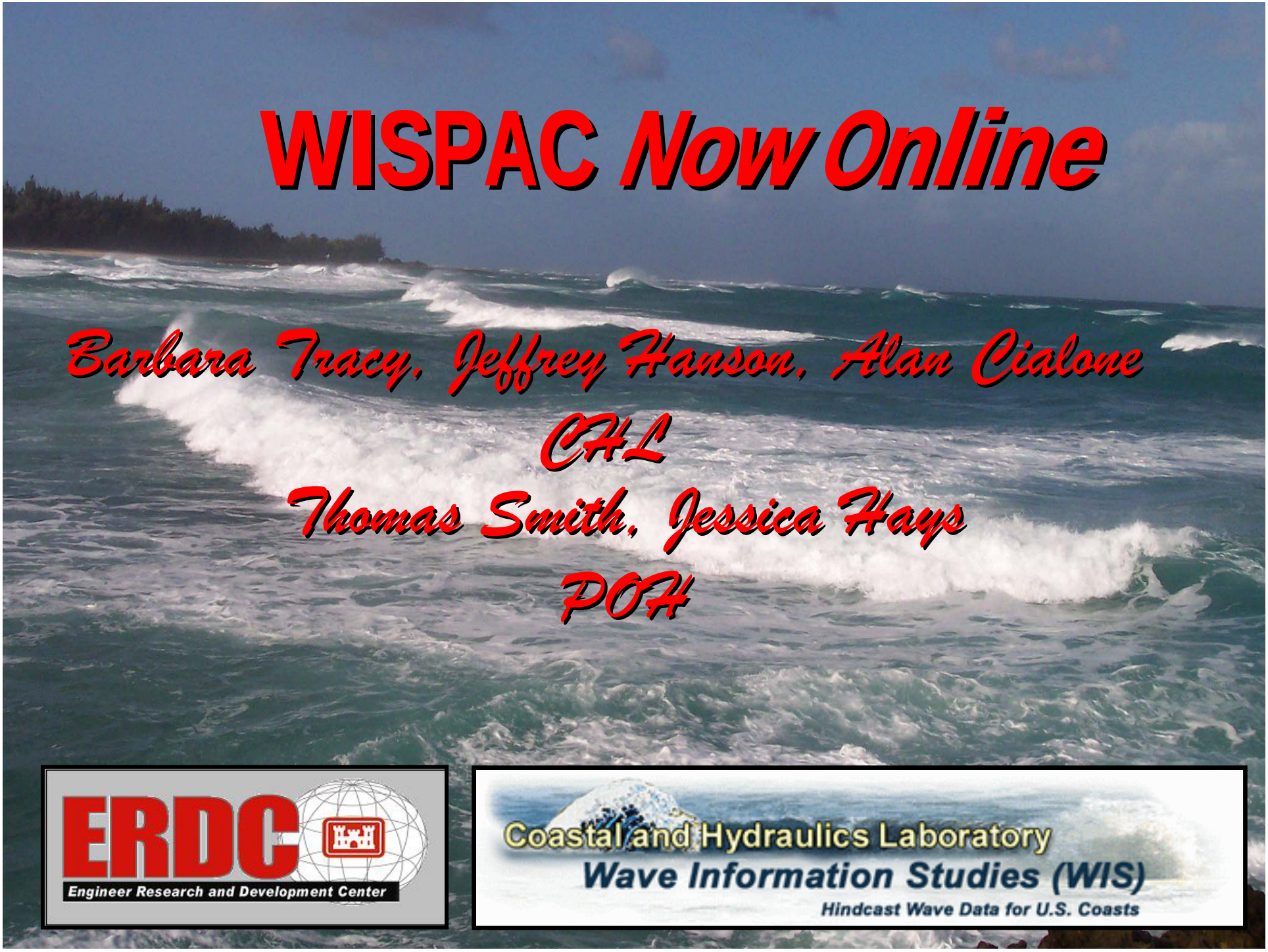
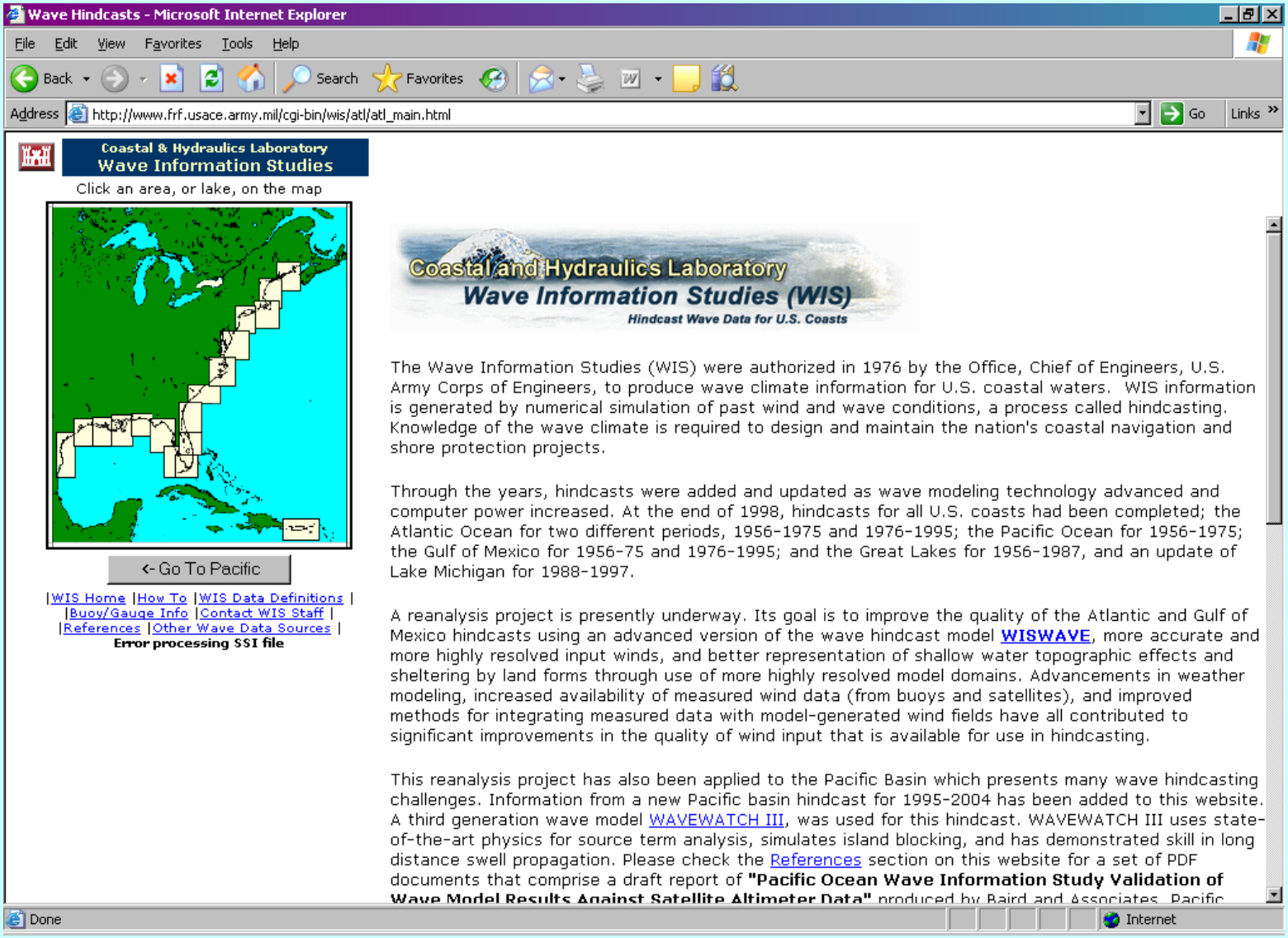

WISPAC Now Online
Barbara Tracy, Jeffrey Hanson, Alan Cialone
CHL
Thomas Smith, Jessica Hays
POH
ERDC
Engineer Research and Development Center
Coastal and Hydraulics Laboratory
Wave Information Studies (WIS)
Hindcast Wave Data for U.S. Coasts

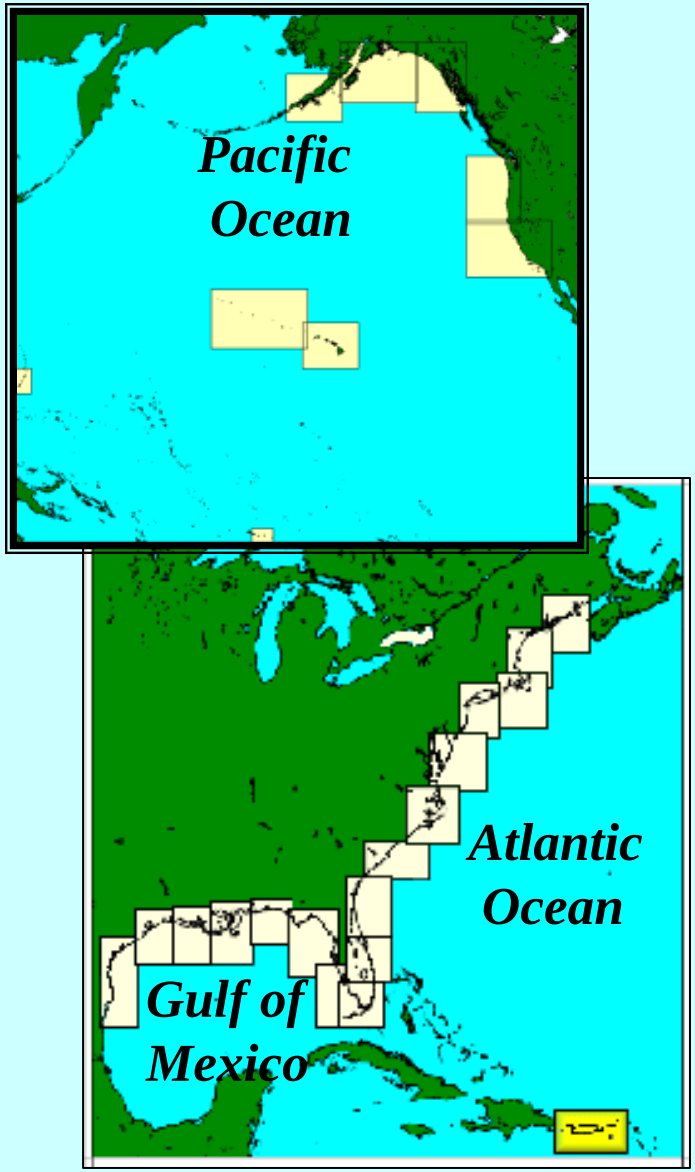
Outline

- Overview of WIS website and products
- Pacific 10-year Basin Level Hindcast
  - Wave Model Comparisons
  - Validation with Wave MEDS
- District applications of PACWIS

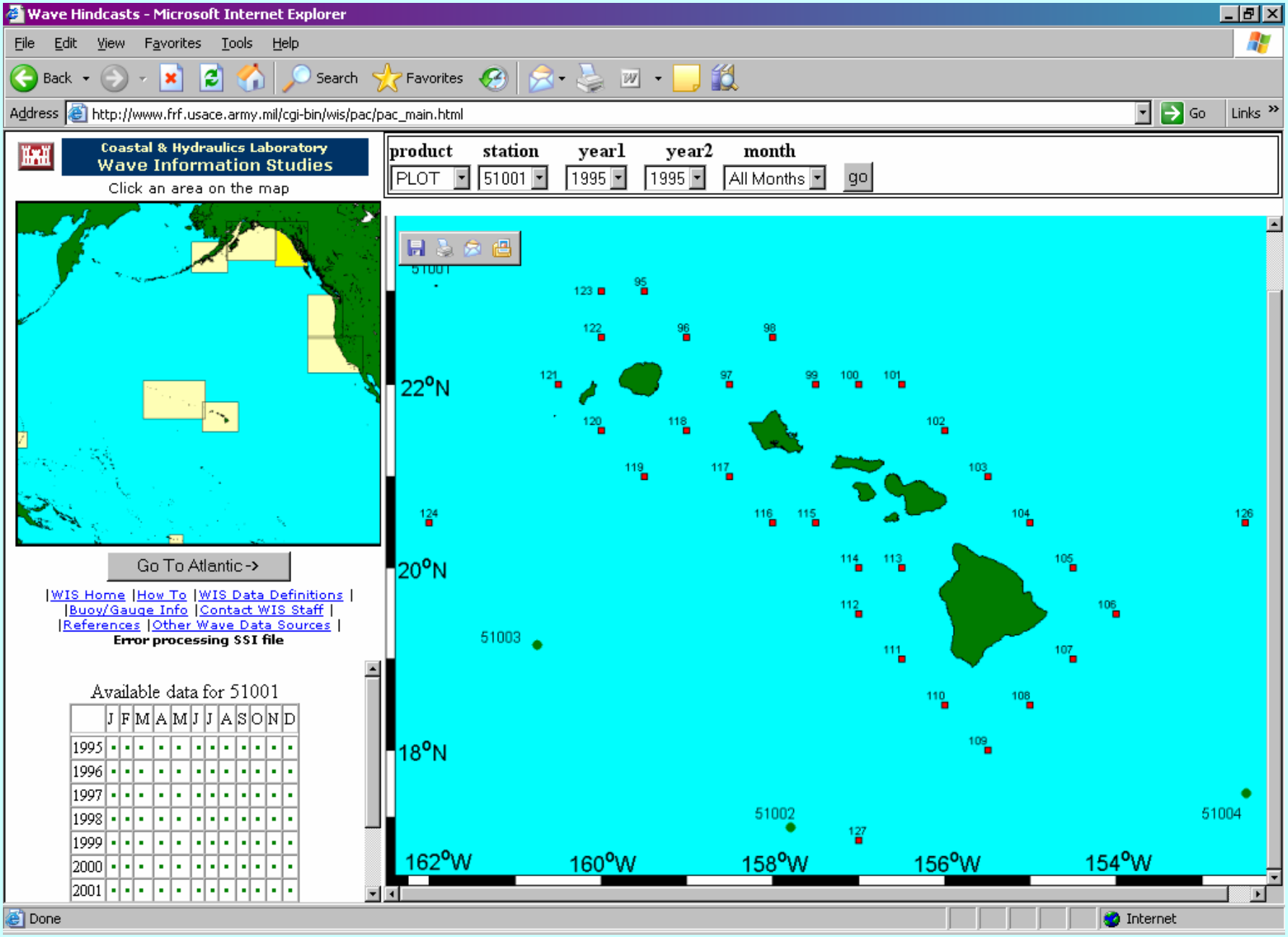


http://www.frf.usace.army.mil/cgi-bin/wis/atl/atl_main.html

WIS Wave Information



- Hourly wave parameters,
  Hs, Per, Dir, Ws, Wdir
- Stations in 10-20m depth, also deep stations
- 500+ stations in Atlantic 1980-1999
- 300+ stations in Gulf 1980-1999
- 12 stations Puerto Rico 1980-1999
- *177 Pacific Basin stations 1995-2004*
- *300+ Lake Ontario stations 1961-2000*
- Info available via WEB
- Plot, table and data list tools
- Spectra at 3-hr available from WIS staff


Wave Hindcasts - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://www.frf.usace.army.mil/cgi-bin/wis/pac/pac_main.html
Go Links
Coastal & Hydraulics Laboratory
Wave Information Studies
Click an area on the map
product station year1 year2 month
PLOT 51001 1995 1995 All Months go
Go To Atlantic->
WIS Home	How To	WIS Data Definitions
Buoy/Gauge Info	Contact WIS Staff
References	Other Wave Data Sources
Error processing SSI file
Available data for 51001
J F M A M J J A S O N D
1995
1996
1997
1998
1999
2000
2001
51001
51003
51002
51004
22°N
20°N
18°N
162°W
160°W
158°W
156°W
154°W
Done
Internet

Wave Hindcasts - Microsoft Internet Explorer

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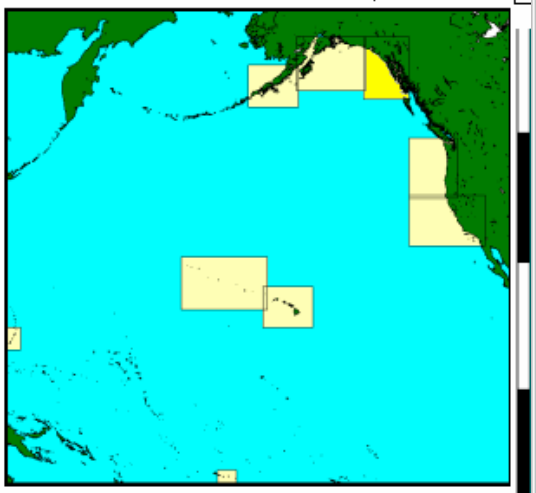
Back Search Favorites

Address http://www.frf.usace.army.mil/cgi-bin/wis/pac/pac_main.html Go Links

Coastal & Hydraulics Laboratory
Wave Information Studies

Click an area on the map



Go To Atlantic->

WIS Home	How To	WIS Data Definitions
Buoy/Gauge Info	Contact WIS Staff
References	Other Wave Data Sources

Error processing SSI file

Available data for 51001

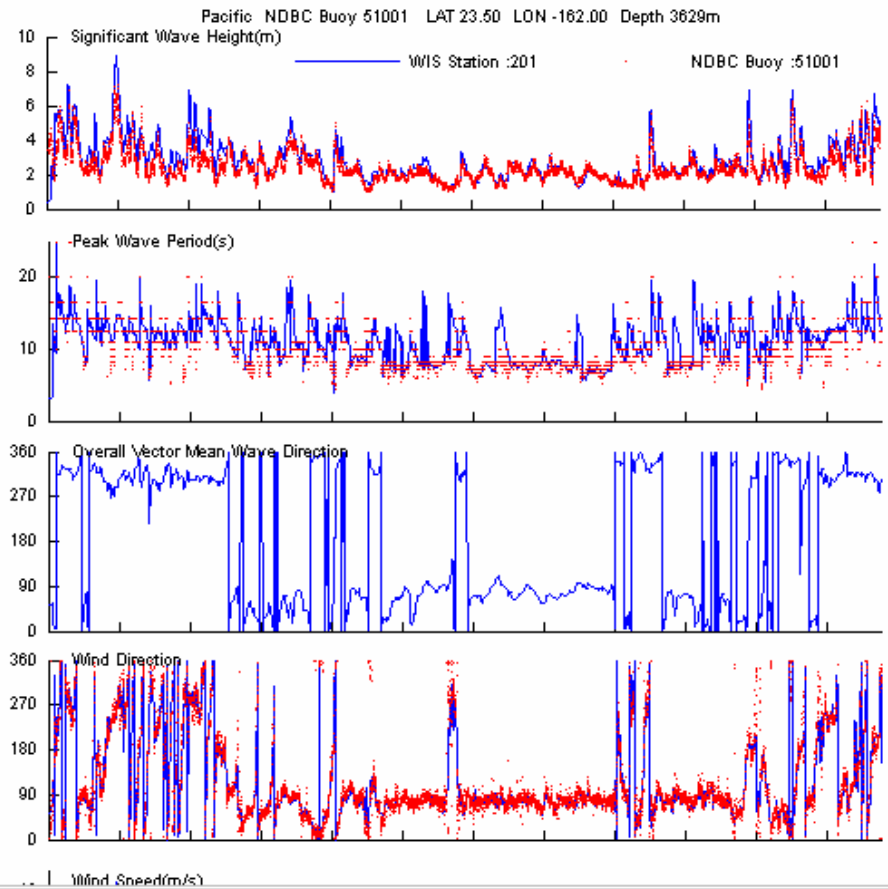
	J	F	M	A	M	J	J	A	S	O	N	D
1995	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
1996	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
1997	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
1998	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
1999	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
2000	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
2001	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪

Done

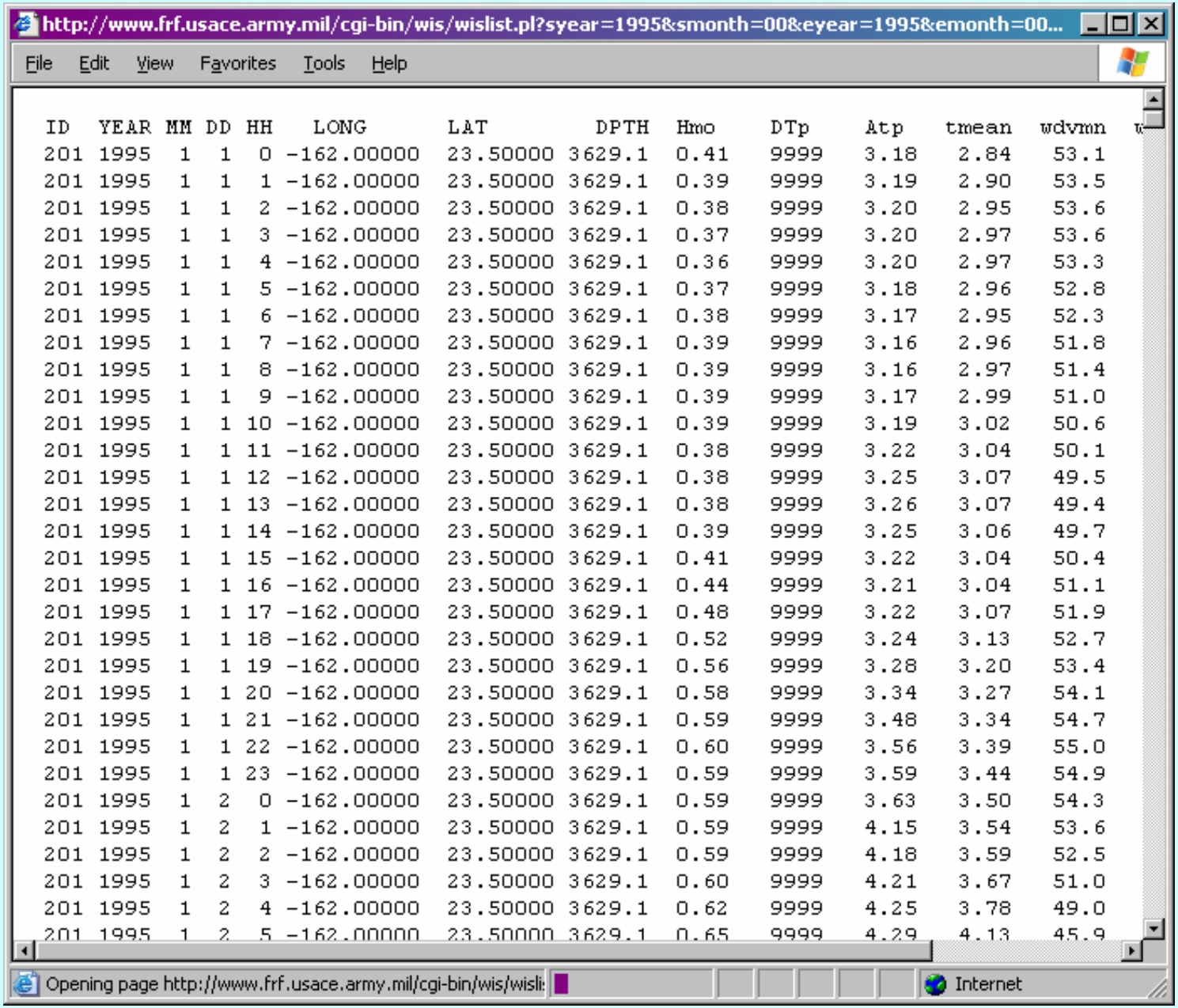
product	station	year1	year2	month	
PLOT	51001	1995	1995	All Months	go

http://www.frf.usace.army.mil/cgi-bin/wis/wisplot.pl?syear=1995&smonth=00&station=_L1.51001&sec - ...

File Edit View Favorites Tools Help



copwism... webhom... Pacificwk... Coastal ... Wave Hi... http://... 1:32 P



ID	YEAR	MM	DD	HH	LONG	LAT	DPTH	Hmo	DTp	Atp	tmean	wdvmn	w
201	1995	1	1	0	-162.00000	23.50000	3629.1	0.41	9999	3.18	2.84	53.1	
201	1995	1	1	1	-162.00000	23.50000	3629.1	0.39	9999	3.19	2.90	53.5	
201	1995	1	1	2	-162.00000	23.50000	3629.1	0.38	9999	3.20	2.95	53.6	
201	1995	1	1	3	-162.00000	23.50000	3629.1	0.37	9999	3.20	2.97	53.6	
201	1995	1	1	4	-162.00000	23.50000	3629.1	0.36	9999	3.20	2.97	53.3	
201	1995	1	1	5	-162.00000	23.50000	3629.1	0.37	9999	3.18	2.96	52.8	
201	1995	1	1	6	-162.00000	23.50000	3629.1	0.38	9999	3.17	2.95	52.3	
201	1995	1	1	7	-162.00000	23.50000	3629.1	0.39	9999	3.16	2.96	51.8	
201	1995	1	1	8	-162.00000	23.50000	3629.1	0.39	9999	3.16	2.97	51.4	
201	1995	1	1	9	-162.00000	23.50000	3629.1	0.39	9999	3.17	2.99	51.0	
201	1995	1	1	10	-162.00000	23.50000	3629.1	0.39	9999	3.19	3.02	50.6	
201	1995	1	1	11	-162.00000	23.50000	3629.1	0.38	9999	3.22	3.04	50.1	
201	1995	1	1	12	-162.00000	23.50000	3629.1	0.38	9999	3.25	3.07	49.5	
201	1995	1	1	13	-162.00000	23.50000	3629.1	0.38	9999	3.26	3.07	49.4	
201	1995	1	1	14	-162.00000	23.50000	3629.1	0.39	9999	3.25	3.06	49.7	
201	1995	1	1	15	-162.00000	23.50000	3629.1	0.41	9999	3.22	3.04	50.4	
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201	1995	1	1	18	-162.00000	23.50000	3629.1	0.52	9999	3.24	3.13	52.7	
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201	1995	1	2	2	-162.00000	23.50000	3629.1	0.59	9999	4.18	3.59	52.5	
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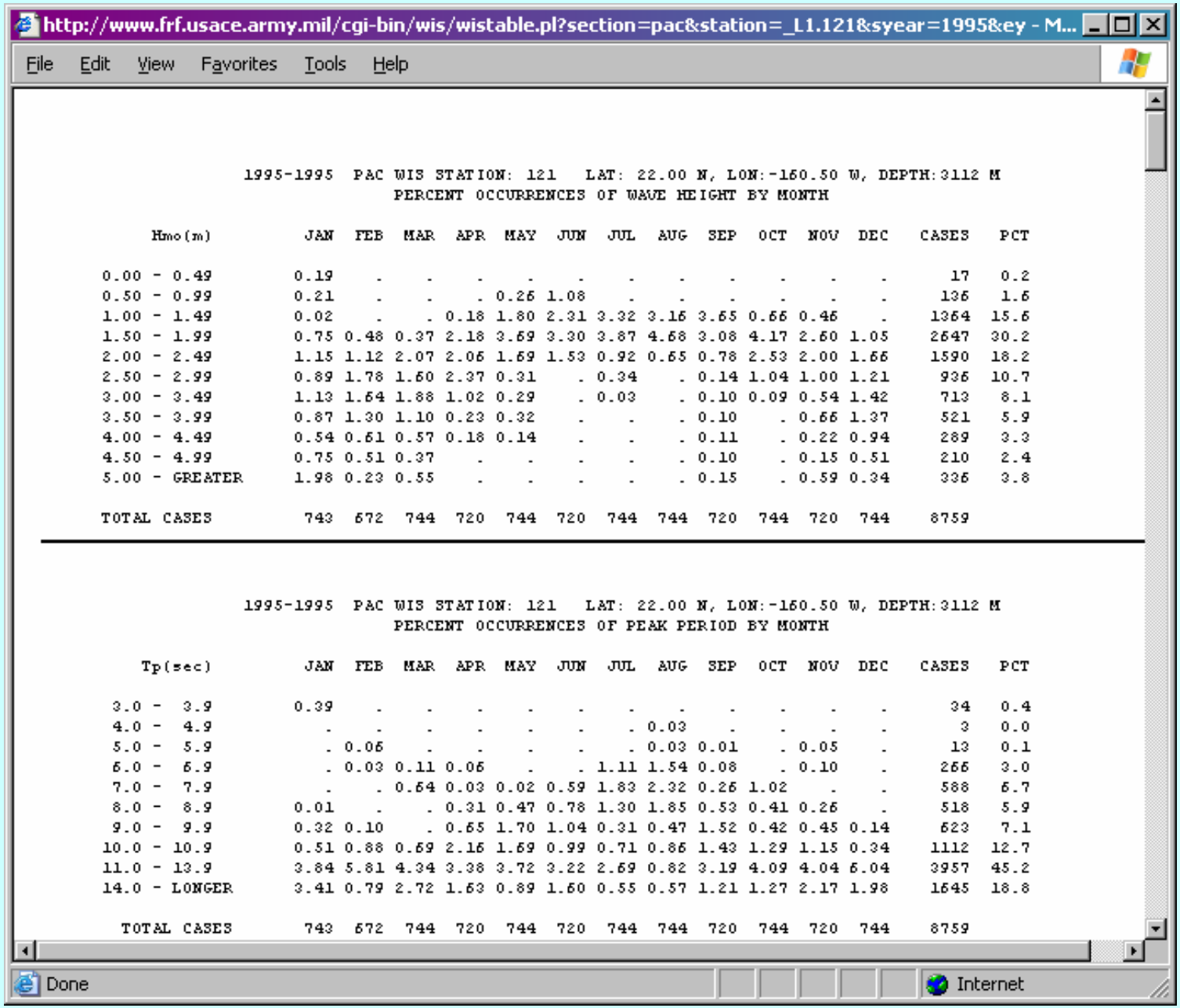
201	1995	1	2	4	-162.00000	23.50000	3629.1	0.62	9999	4.25	3.78	49.0	
201	1995	1	2	5	-162.00000	23.50000	3629.1	0.65	9999	4.29	4.13	45.9	



1995-1995 PAC WIS STATION: 121 LAT: 22.00 N, LON:-160.50 W, DEPTH:3112 M
PERCENT OCCURRENCES OF WAVE HEIGHT BY MONTH

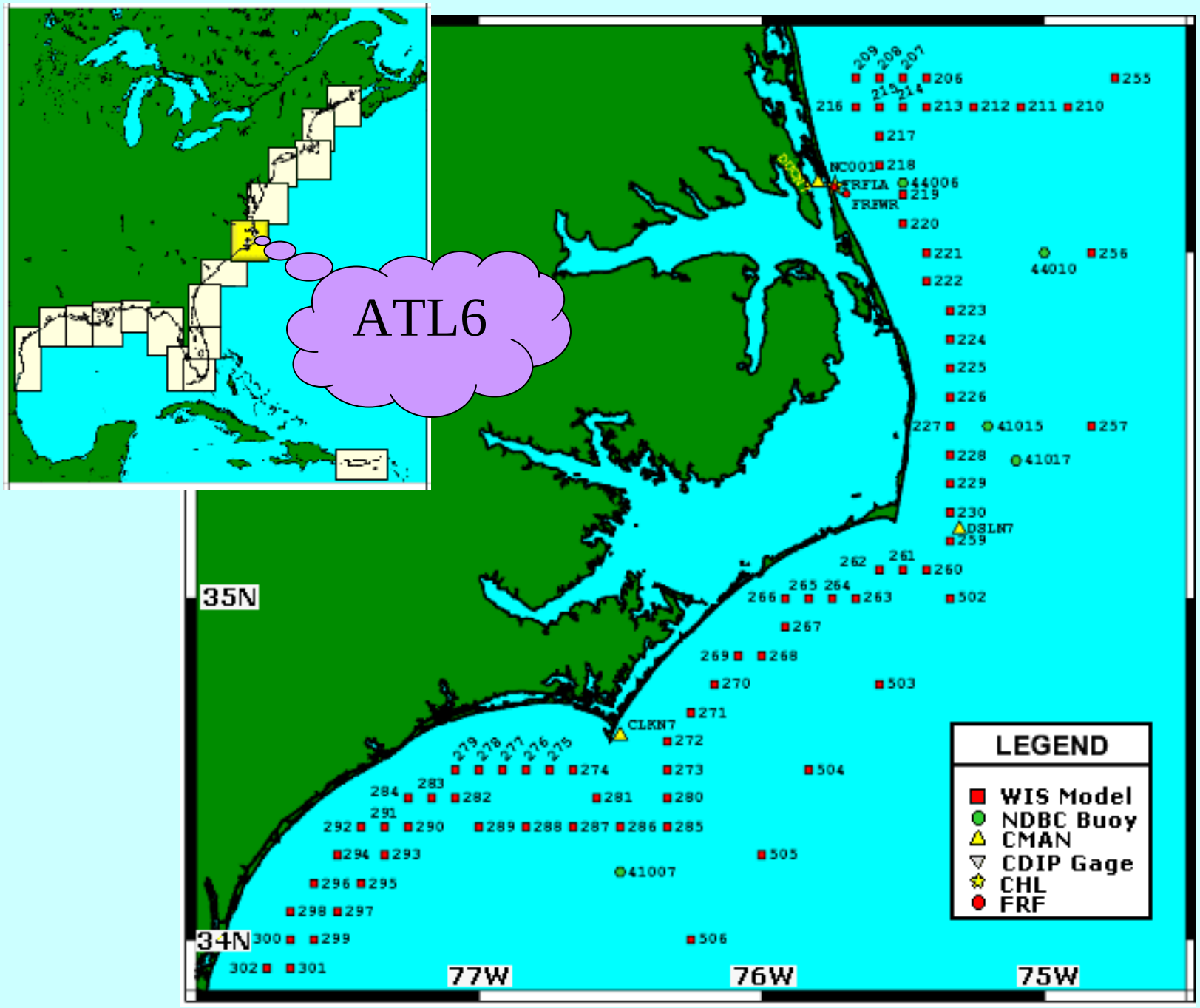
Hmo(m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	CASES	PCT
0.00 - 0.49	0.19	.	.	.	.	.	.	.	.	.	.	.	17	0.2
0.50 - 0.99	0.21	.	.	.	0.26	1.08	.	.	.	.	.	.	136	1.6
1.00 - 1.49	0.02	.	.	0.18	1.80	2.31	3.32	3.16	3.65	0.66	0.46	.	1364	15.6
1.50 - 1.99	0.75	0.48	0.37	2.18	3.69	3.30	3.87	4.68	3.08	4.17	2.60	1.05	2647	30.2
2.00 - 2.49	1.15	1.12	2.07	2.06	1.69	1.53	0.92	0.65	0.78	2.53	2.00	1.66	1590	18.2
2.50 - 2.99	0.89	1.78	1.60	2.37	0.31	.	0.34	.	0.14	1.04	1.00	1.21	936	10.7
3.00 - 3.49	1.13	1.64	1.88	1.02	0.29	.	0.03	.	0.10	0.09	0.54	1.42	713	8.1
3.50 - 3.99	0.87	1.30	1.10	0.23	0.32	.	.	.	0.10	.	0.66	1.37	521	5.9
4.00 - 4.49	0.54	0.61	0.57	0.18	0.14	.	.	.	0.11	.	0.22	0.94	289	3.3
4.50 - 4.99	0.75	0.51	0.37	.	.	.	.	.	0.10	.	0.15	0.51	210	2.4
5.00 - GREATER	1.98	0.23	0.55	.	.	.	.	.	0.15	.	0.59	0.34	336	3.8
TOTAL CASES	743	672	744	720	744	720	744	744	720	744	720	744	8759	

1995-1995 PAC WIS STATION: 121 LAT: 22.00 N, LON:-160.50 W, DEPTH:3112 M
PERCENT OCCURRENCES OF PEAK PERIOD BY MONTH

Tp(sec)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	CASES	PCT
3.0 - 3.9	0.39	.	.	.	.	.	.	.	.	.	.	.	34	0.4
4.0 - 4.9	.	.	.	.	.	.	.	0.03	.	.	.	.	3	0.0
5.0 - 5.9	.	0.06	.	.	.	.	.	0.03	0.01	.	0.05	.	13	0.1
6.0 - 6.9	.	0.03	0.11	0.06	.	.	1.11	1.54	0.08	.	0.10	.	266	3.0
7.0 - 7.9	.	.	0.64	0.03	0.02	0.59	1.83	2.32	0.26	1.02	.	.	588	6.7
8.0 - 8.9	0.01	.	.	0.31	0.47	0.78	1.30	1.85	0.53	0.41	0.26	.	518	5.9
9.0 - 9.9	0.32	0.10	.	0.65	1.70	1.04	0.31	0.47	1.52	0.42	0.45	0.14	623	7.1
10.0 - 10.9	0.51	0.88	0.69	2.16	1.69	0.99	0.71	0.86	1.43	1.29	1.15	0.34	1112	12.7
11.0 - 13.9	3.84	5.81	4.34	3.38	3.72	3.22	2.69	0.82	3.19	4.09	4.04	5.04	3957	45.2
14.0 - LONGER	3.41	0.79	2.72	1.63	0.89	1.60	0.55	0.57	1.21	1.27	2.17	1.98	1645	18.8
TOTAL CASES	743	672	744	720	744	720	744	744	720	744	720	744	8759	

Table Product on Website

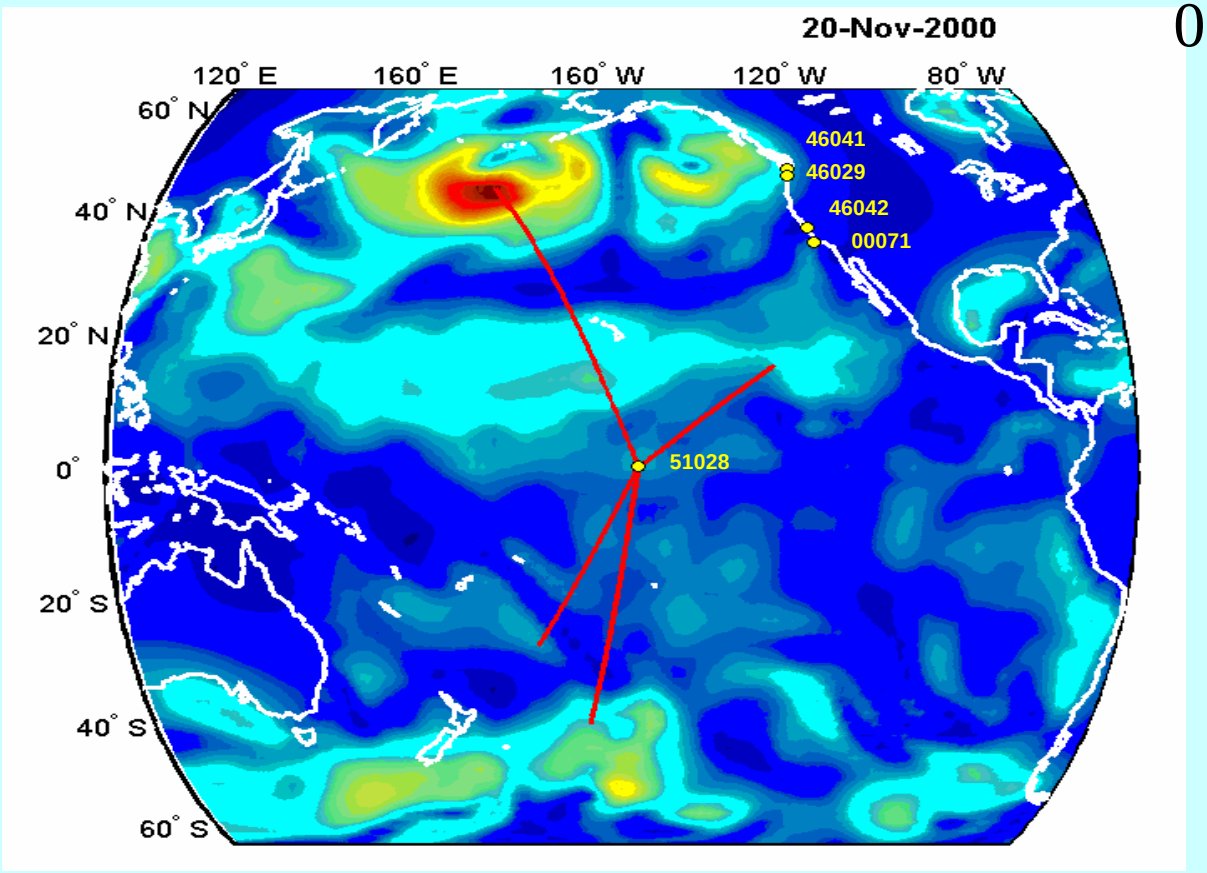
- % occurrences of Hmo by month
- % occurrences of TP by month
- % occurrences of mean DIR by month
- % occurrences of Hmo and Tp by Dir Bands
- % occurrences of WS by month
- % occurrences of WDIR by month
- Summary of mean Hmo by month and year
- Max Hmo with associated TP and Dir by month/year
- Overall Max values and means


ATL6
35N
34N
77W
76W
75W
LEGEND
WIS Model
NDBC Buoy
CMAN
CDIP Gage
CHL
FRF
NC001
FRFLA
FREWR
DSLN7
CLKN7
44006
44010
41015
41017
41007

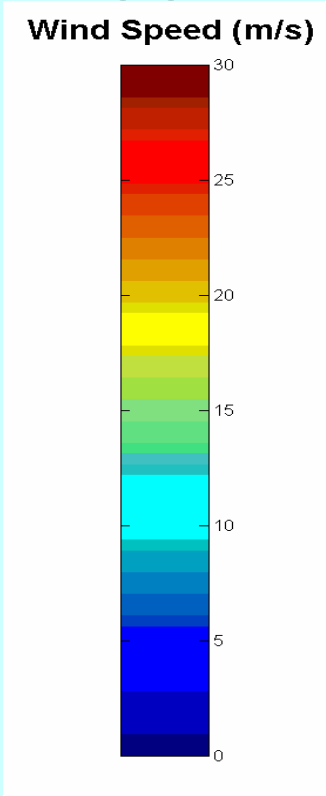
WIS 10-year Pacific Hindcast

WIS takes aim at the Pacific…

OWI Wind Field



0.5-deg grid spacing



From Wave Hindcast Workshop Paper by Hanson and Jensen(2004)

OWI Wind Fields

- Begin with NCEP/NCAR reanalysis wind fields
- Adjust using QuikSCAT scatterometer winds for full Pacific
- Convert to neutral stability
- Interpolate to grid using IOKA
- Tropical cyclones blended in over full domain at IOKA step
- Winds on 0.5-deg grid at 3 hour time interval

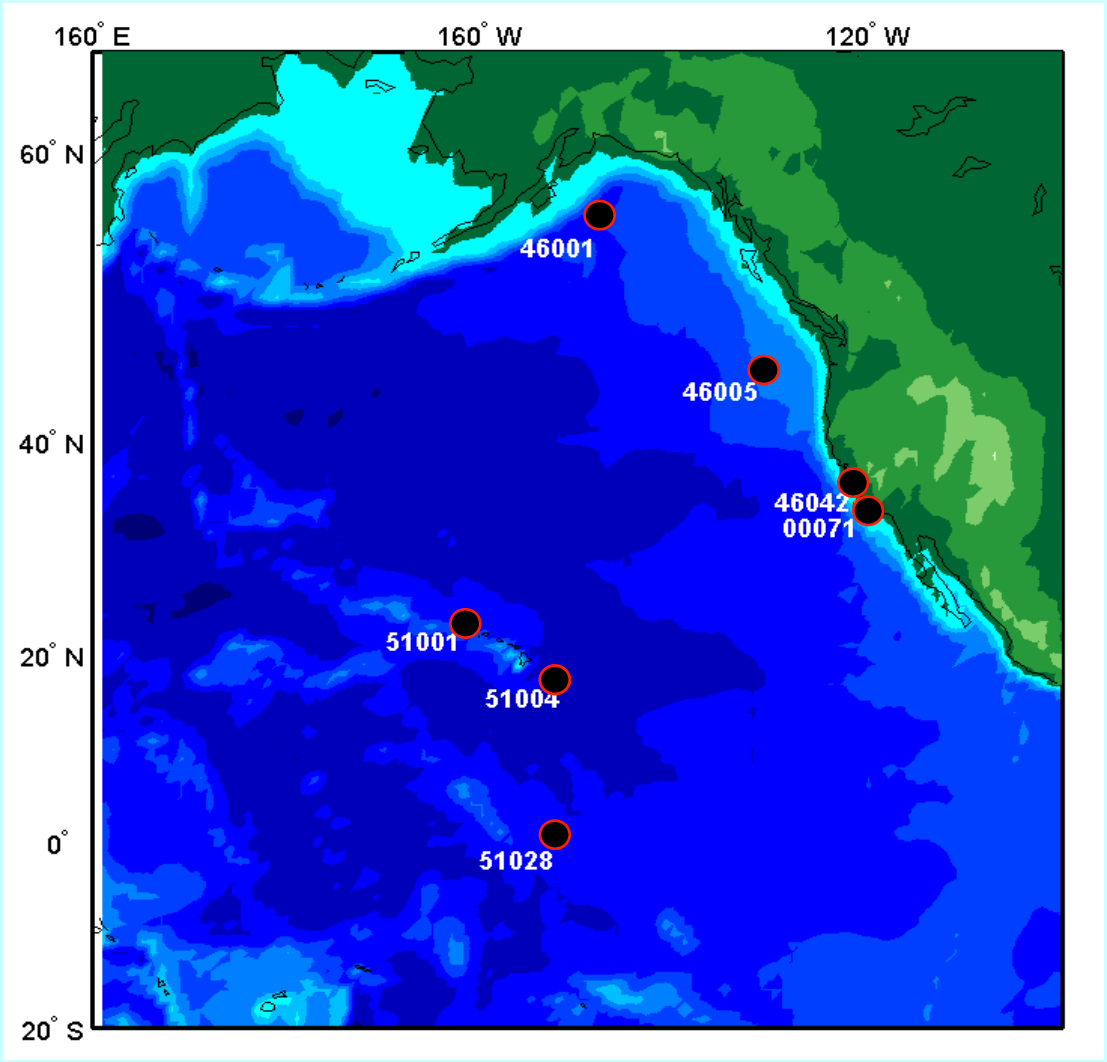
PLAN: Wave Model Collaboration to choose model that does the best job in the Pacific

From Reuters

Wave Model Contenders

- WAM Cycle 4.5 – Bob Jensen
- Wavewatch III
  - Collaboration with Hendrik Tolman
  - Use NCEP Pacific grid and obstruction information to simulate island blocking
- WAVAD (version of 2-G WISWAVE)
  - Collaboration with Baird and Assoc. (Doug Scott)
  - Use NCEP Pacific grid and obstruction information to simulate island blocking

Pacific Hindcast Validation Stations



Atlantic and Gulf Validation

- Comparisons made to all available measured data
- Monthly line comparison plots and scatter plots for all bulk parameters
- Statistics calculated
- 10-year contour plots showing results for various wave height categories
- Energy flux comparisons with measured energy flux
- Review committee

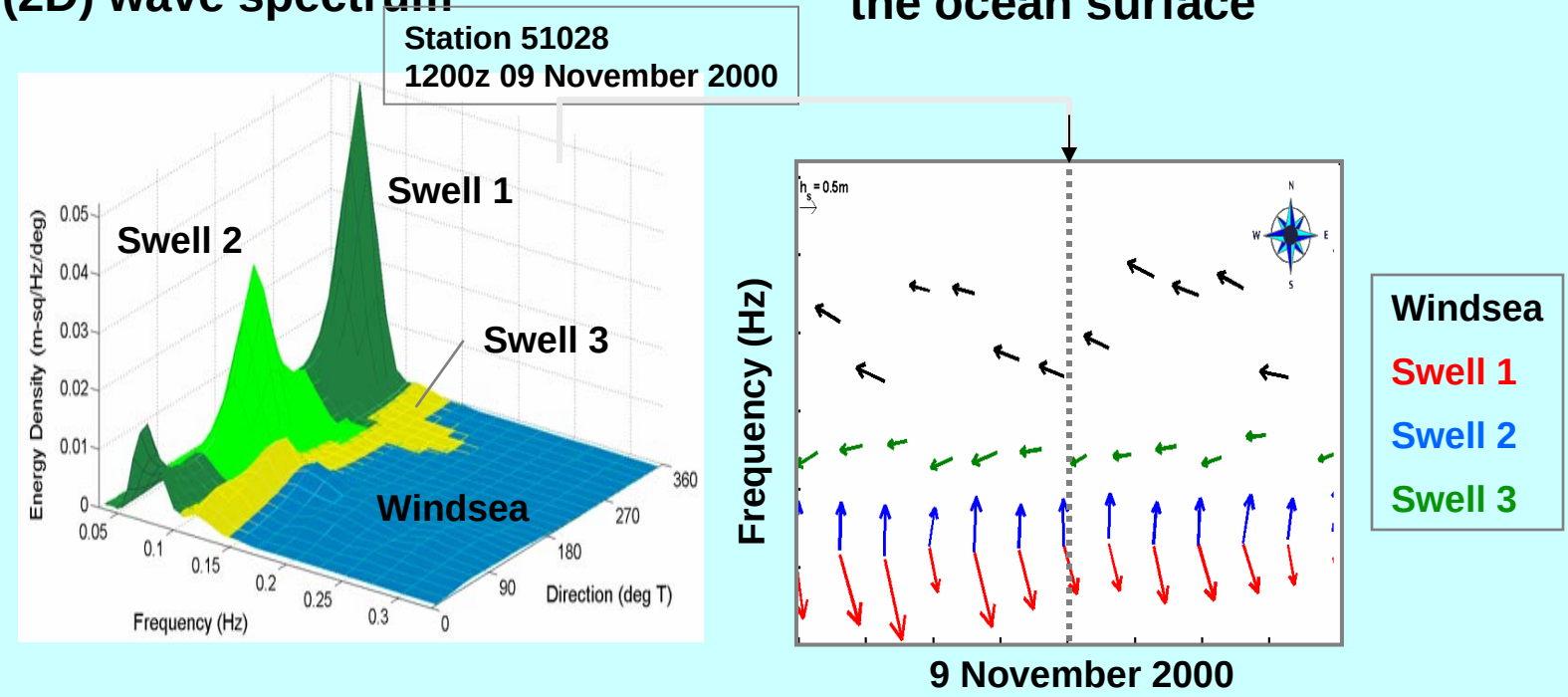
Definitions

Wave Component

A specific wind sea or swell that is attributed to a region of enhanced energy in a directional (2D) wave spectrum

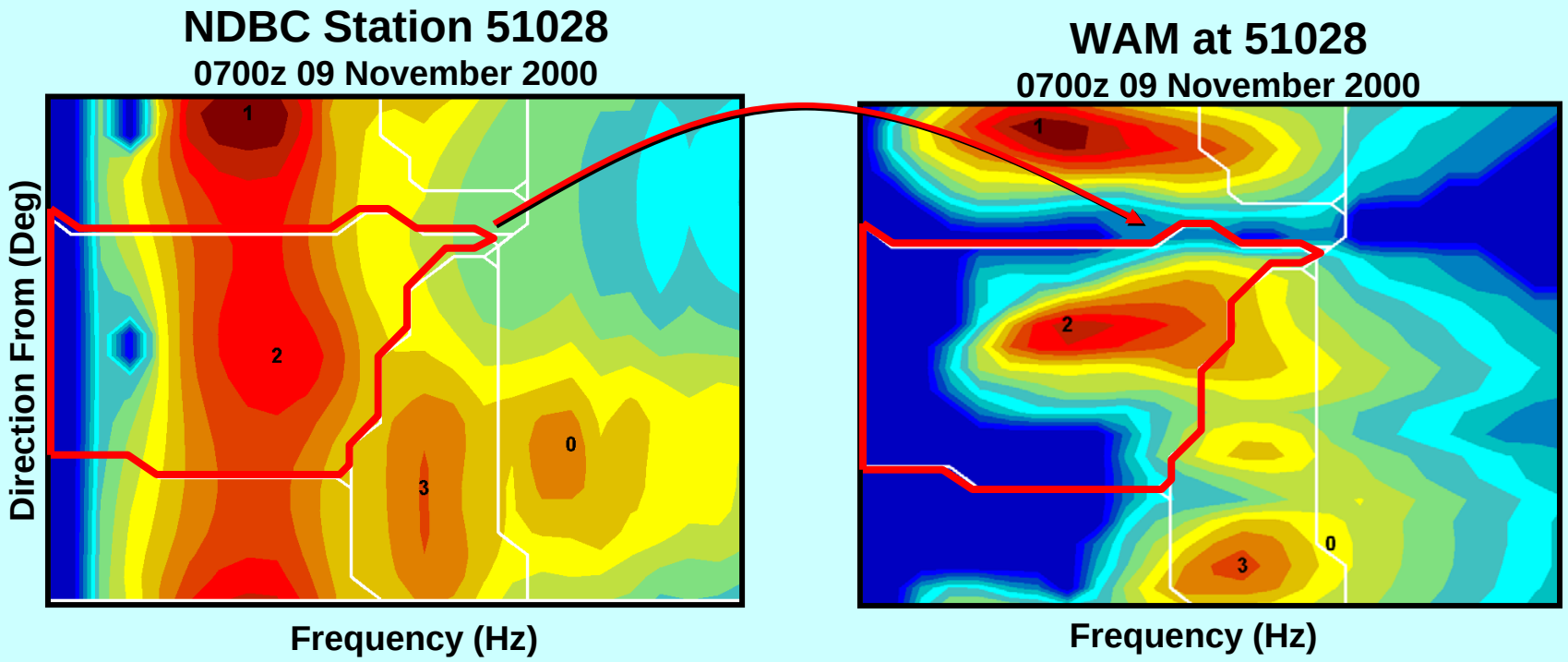
Wave System

An evolving series of wave components that can be traced to a specific wind generation event on the ocean surface



Wave Component Analysis

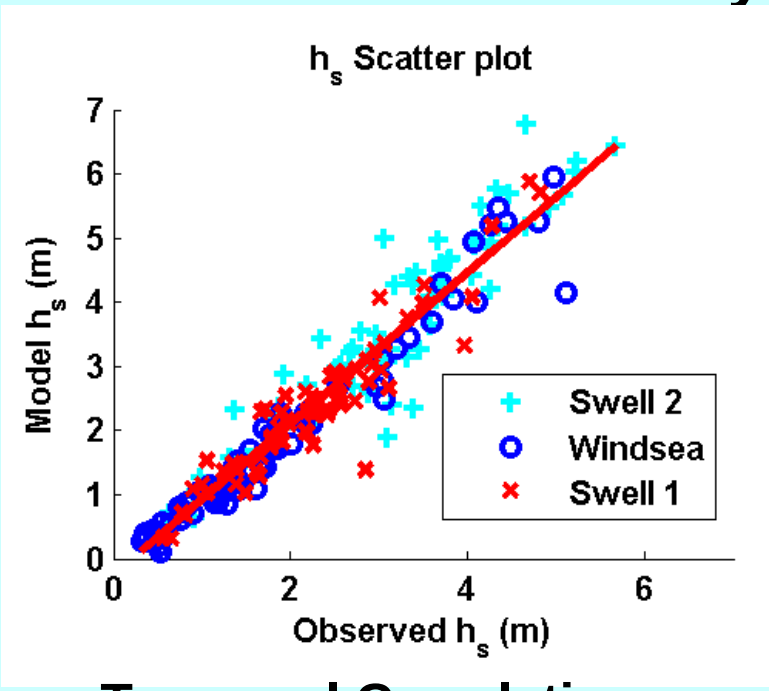
1. **Partition Buoy Spectrum**
2. **Overlay Buoy Partition Template on Hindcast Spectrum**
3. **Compute Integral Parameters in each Partition Domain: H_{m0}, T_p, θ_m, P_{xy}**



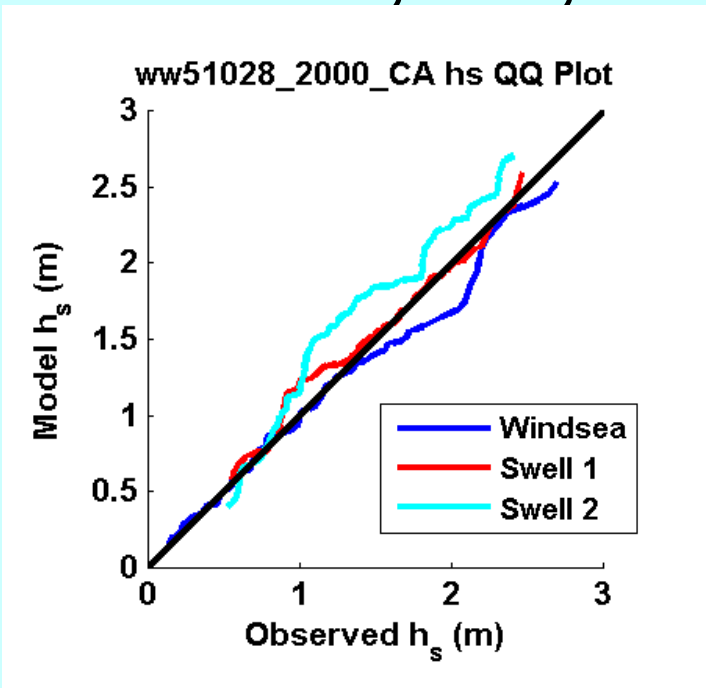
Reference: Hanson and Jensen, 8TH International Workshop on Wave Hindcasting and Forecasting, November 2004

Wave Component Analysis

1. **Partition Buoy Spectrum**
2. **Overlay Buoy Partition Template on Hindcast Spectrum**
3. **Compute Integral Parameters in each Partition Domain: H_{m0}, T_p, θ_m, P_{xy}**
4. **Perform Statistical Analyses: RMS Error, Bias, Scatter**

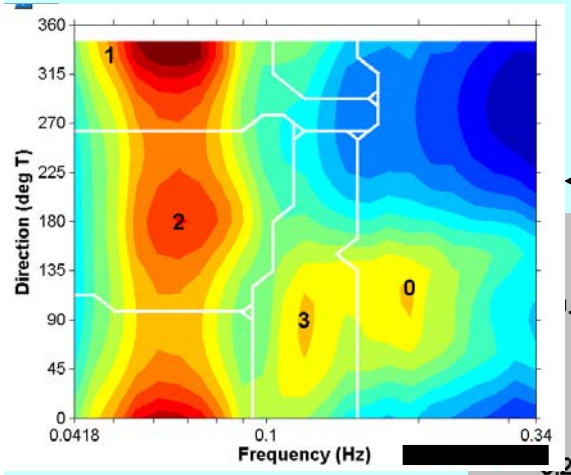


Temporal Correlations

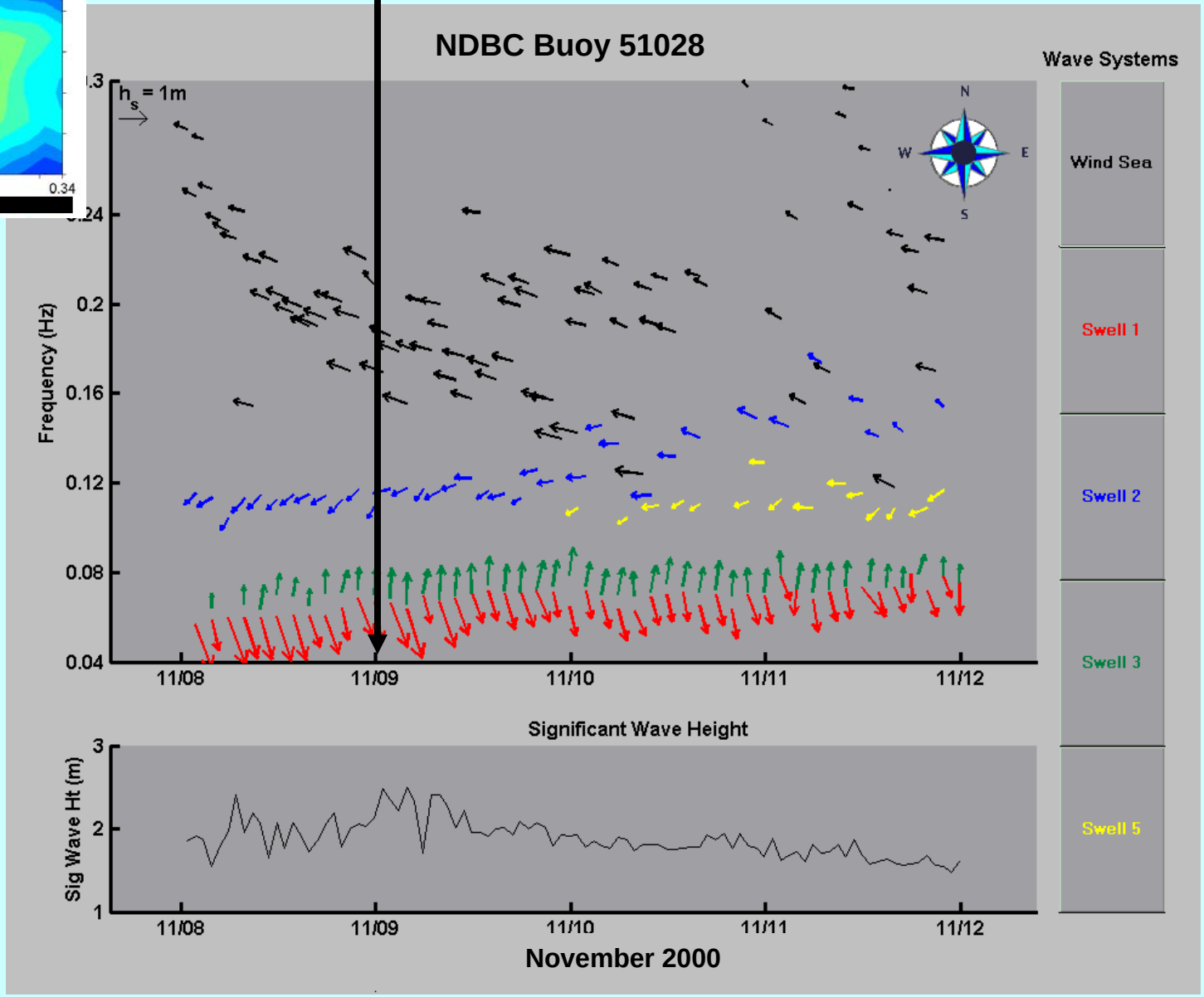


Quantile-Quantile Analysis

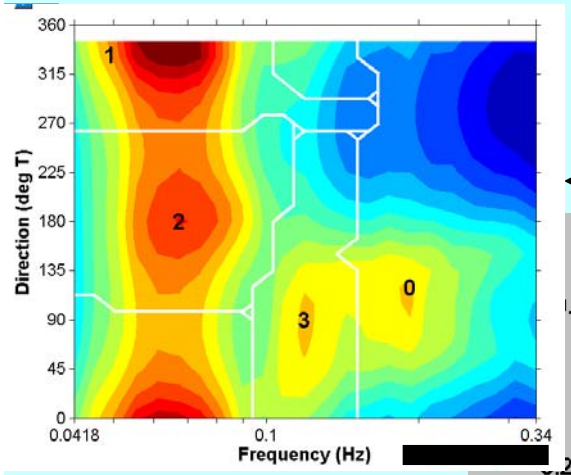
Wave System Analysis



Time-Evolving Wave Components

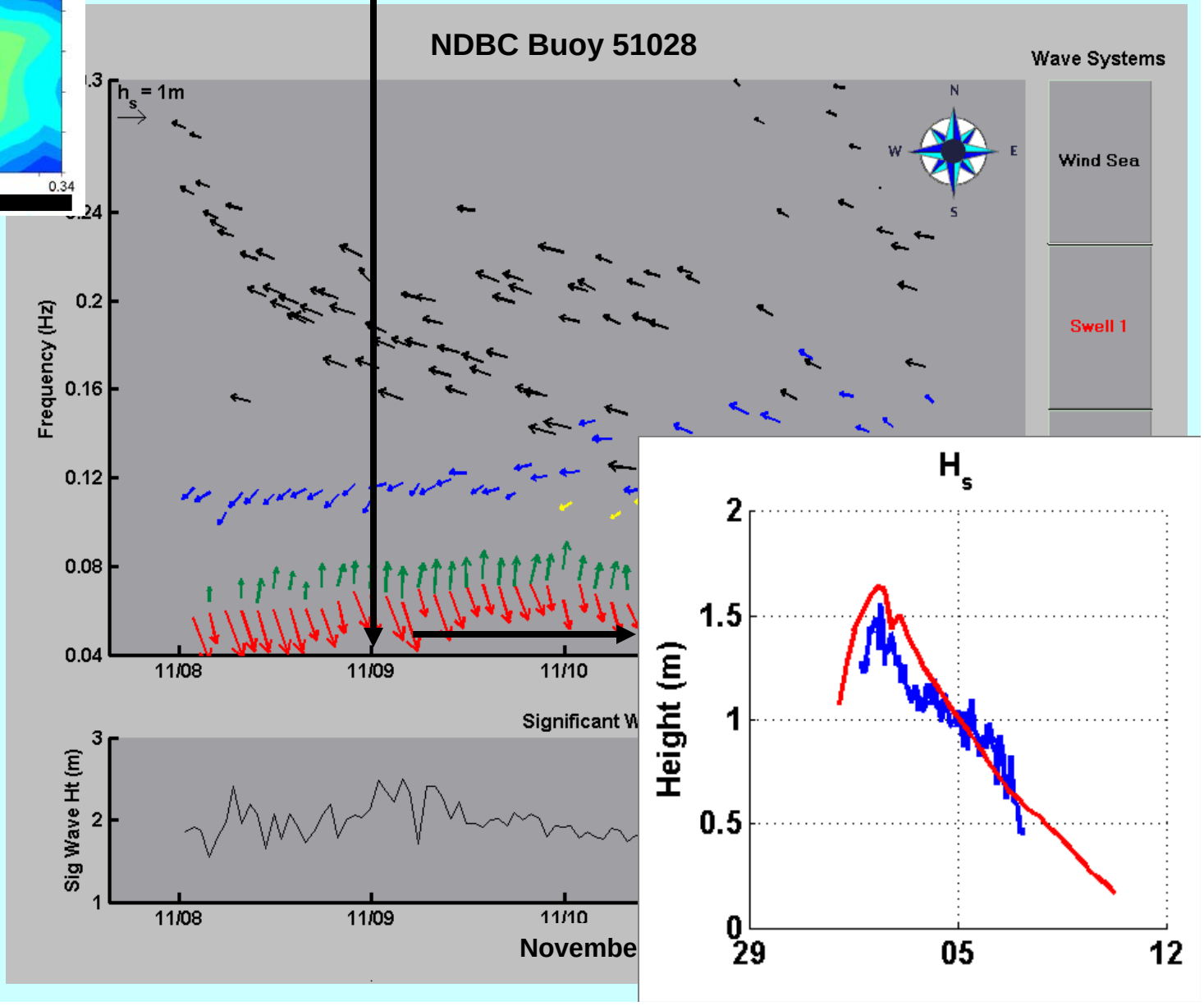


Wave System Analysis



Time-Evolving Wave Components

Compare Buoy Observations With Hindcast



Significant Wave Height
Annual Performance Summary

	Temporal Correlations			Quantile-Quantile		
Component	**WAVAD**	**WAM**	**WW3**	**WAVAD**	**WAM**	**WW3**
Windsea	**0.83**	**0.79**	**0.88**	**0.88**	**0.82**	**0.92**
Young Swell	**0.79**	**0.84**	**0.85**	**0.86**	**0.90**	**0.89**
Mature Swell	**0.73**	**0.72**	**0.78**	**0.81**	**0.78**	**0.83**
Combined	**0.78**	**0.79**	**0.84**	**0.85**	**0.83**	**0.88**

Peak Wave Period

Annual Performance Summary

	Temporal Correlations			Quantile-Quantile		
Component	**WAVAD**	**WAM**	**WW3**	**WAVAD**	**WAM**	**WW3**
Windsea	**0.89**	**0.87**	**0.92**	**0.94**	**0.91**	**0.96**
Young Swell	**0.86**	**0.86**	**0.92**	**0.89**	**0.89**	**0.96**
Mature Swell	**0.91**	**0.90**	**0.94**	**0.94**	**0.94**	**0.97**
Combined	**0.88**	**0.88**	**0.93**	**0.92**	**0.91**	**0.96**

Significant Wave Height
Annual Performance Summary

	Temporal Correlations			Quantile-Quantile		
Component	**WAVAD**	**WAM**	**WW3**	**WAVAD**	**WAM**	**WW3**
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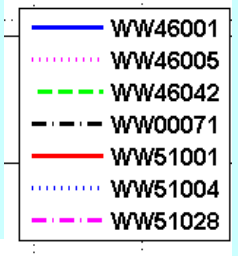
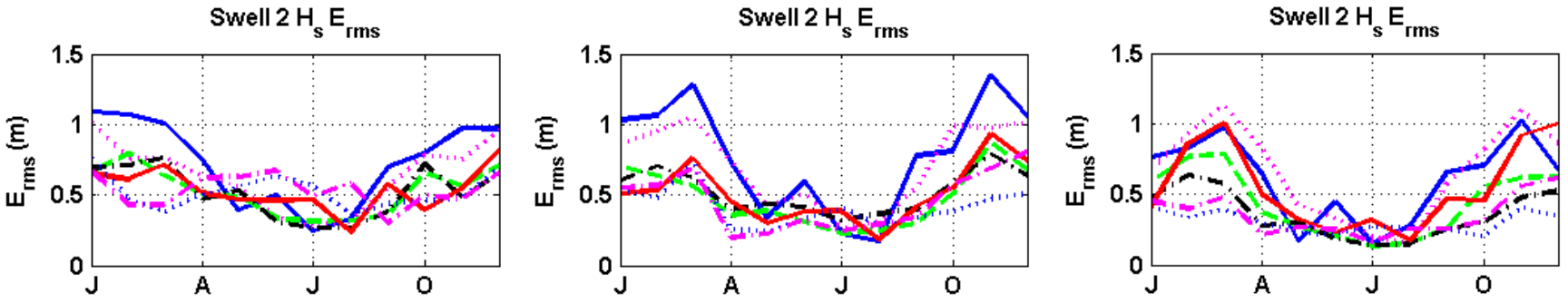
Combined	**0.78**	**0.79**	**0.84**	**0.85**	**0.83**	**0.88**

Monthly Mature Swell Height Metrics



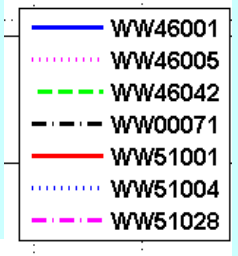
WAVAD **WAM** **WW3**

RMS Error



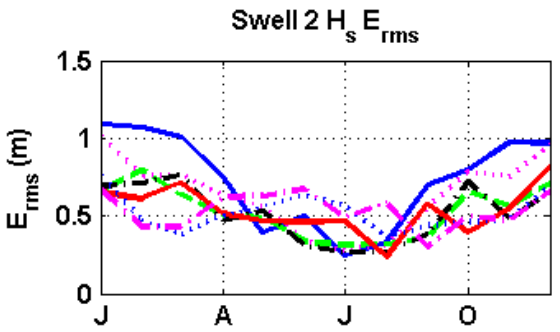
Month (2000)

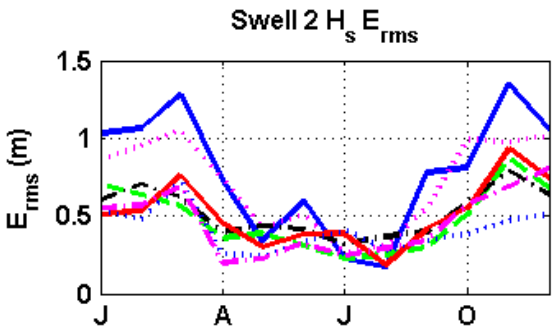
Monthly Mature Swell Height Metrics

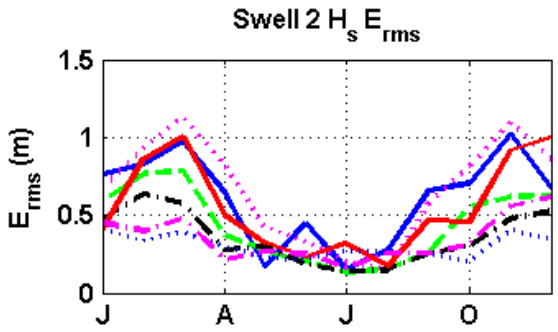


WAVAD **WAM** **WW3**

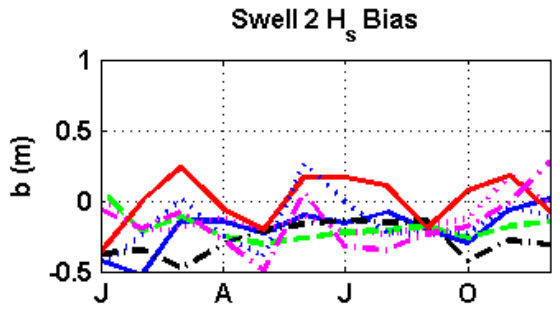
RMS Error

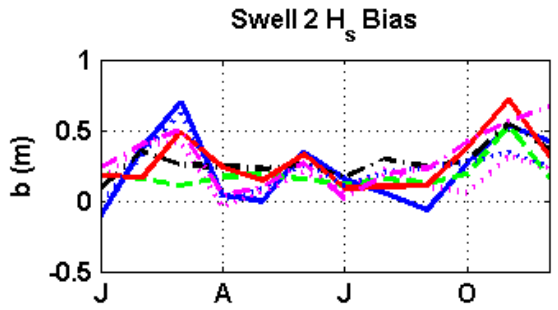


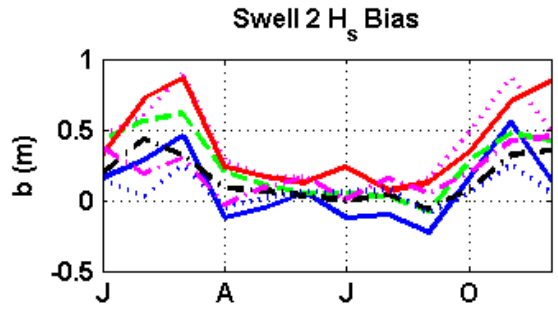




Bias

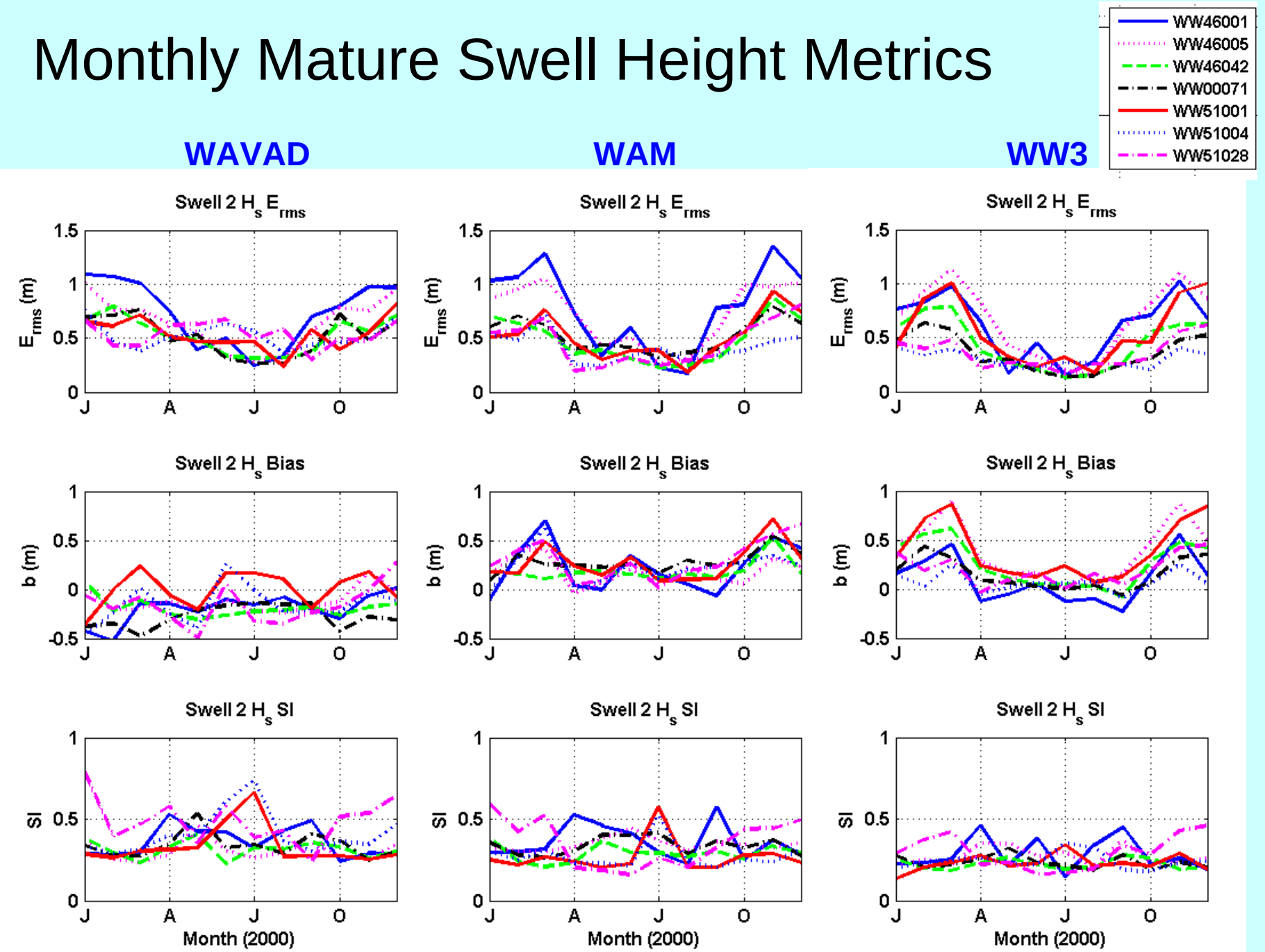




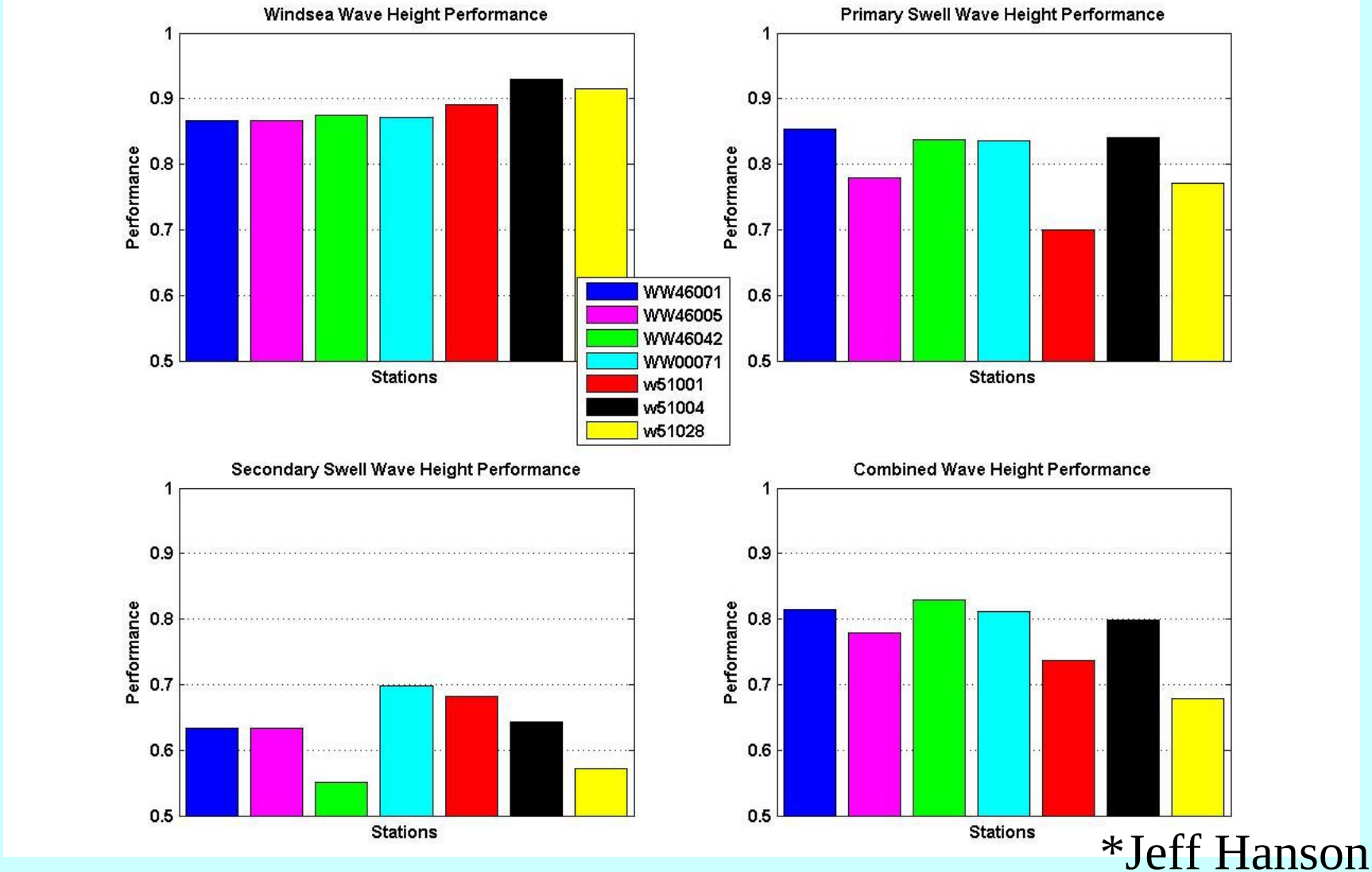


Month (2000)

Monthly Mature Swell Height Metrics



Station Significant Wave Height Performance* March 2000 (NRAQ+ winds)

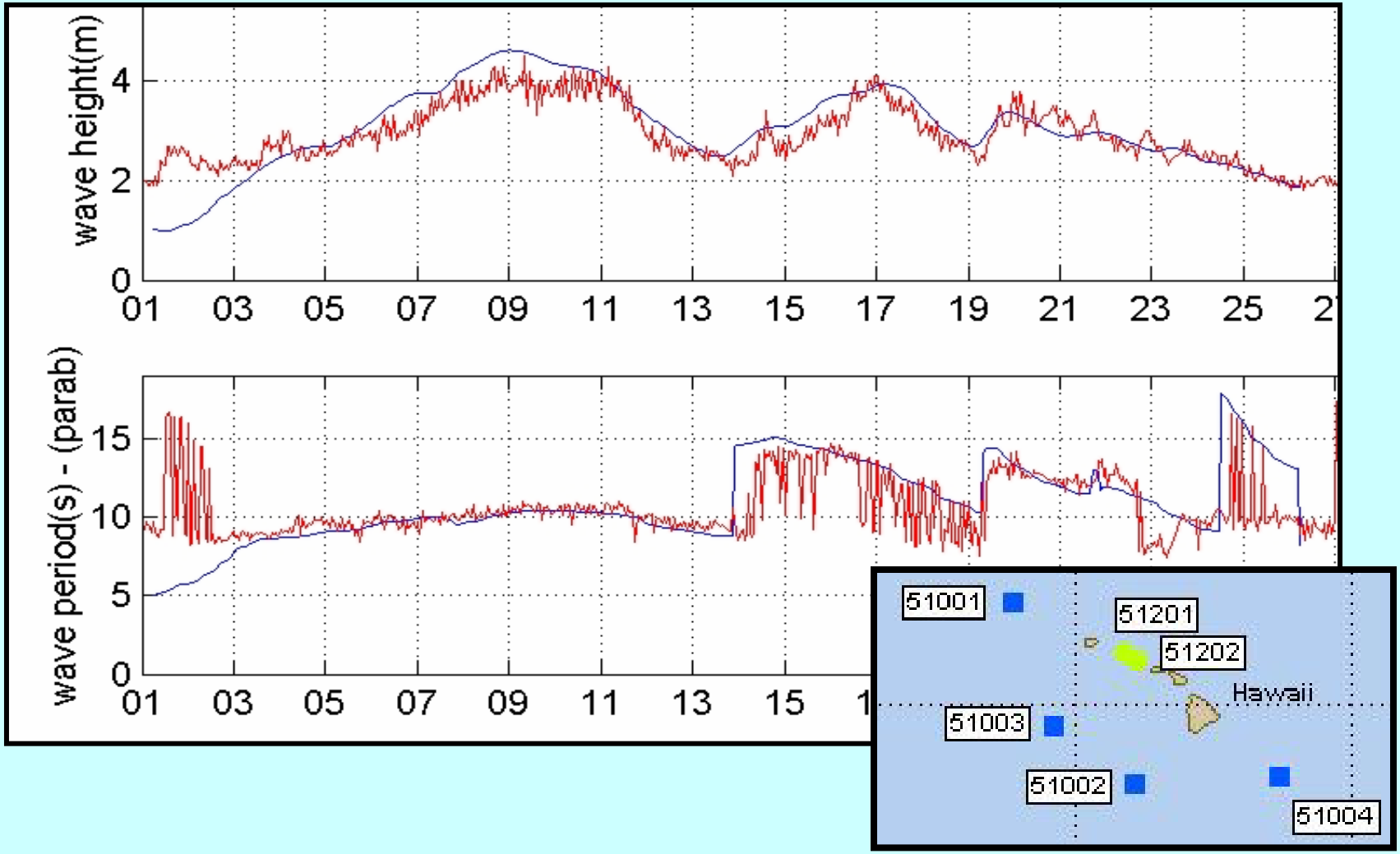


*Jeff Hanson

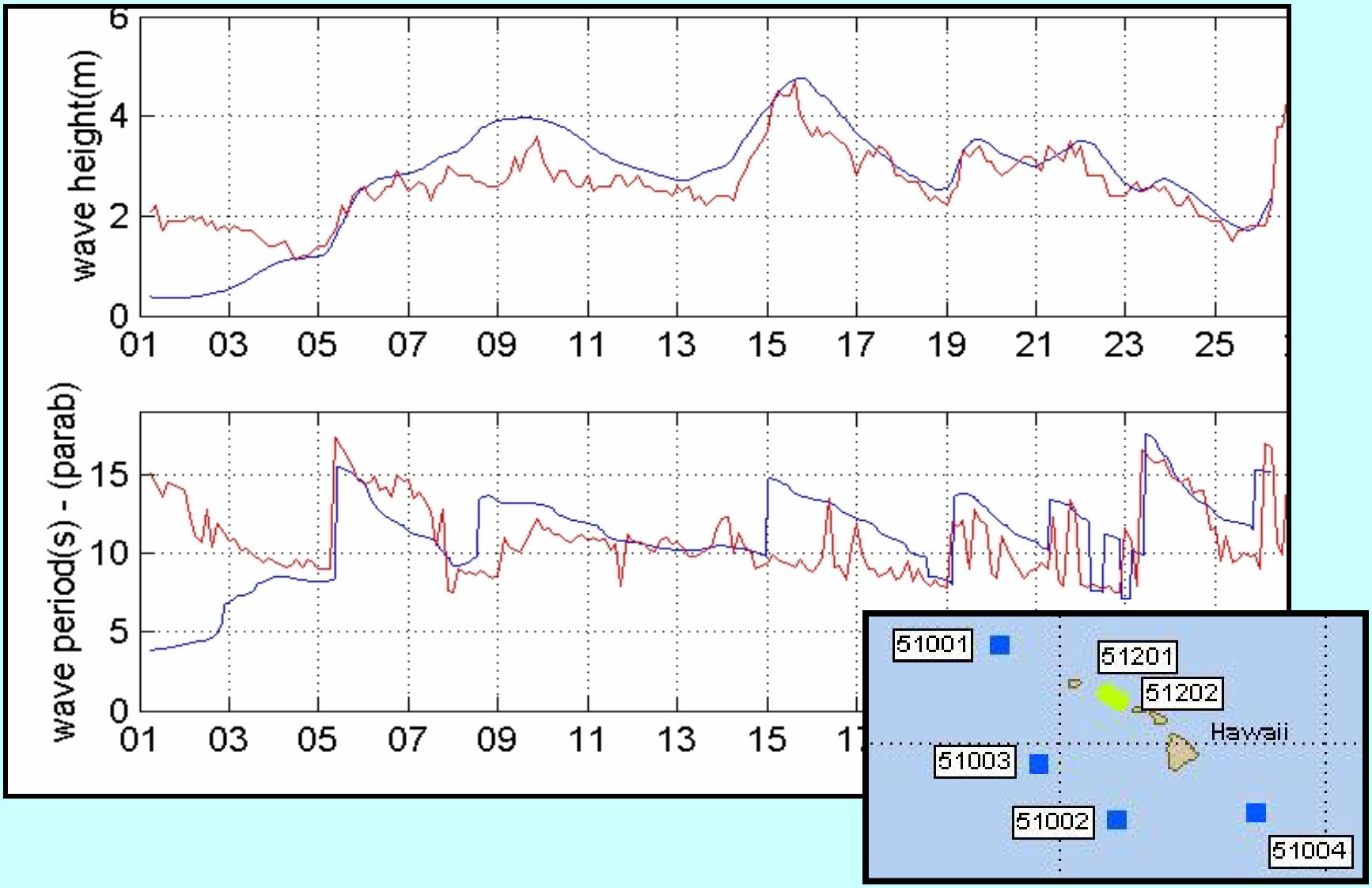
Wavewatch III Chosen for Pacific Hindcast

- All models did well
- WW3 statistics were best
- WW3 obstruction grid to represent islands was effective
- WW3 MPI implementation on HPC computers allowed parallel processing for fast computation

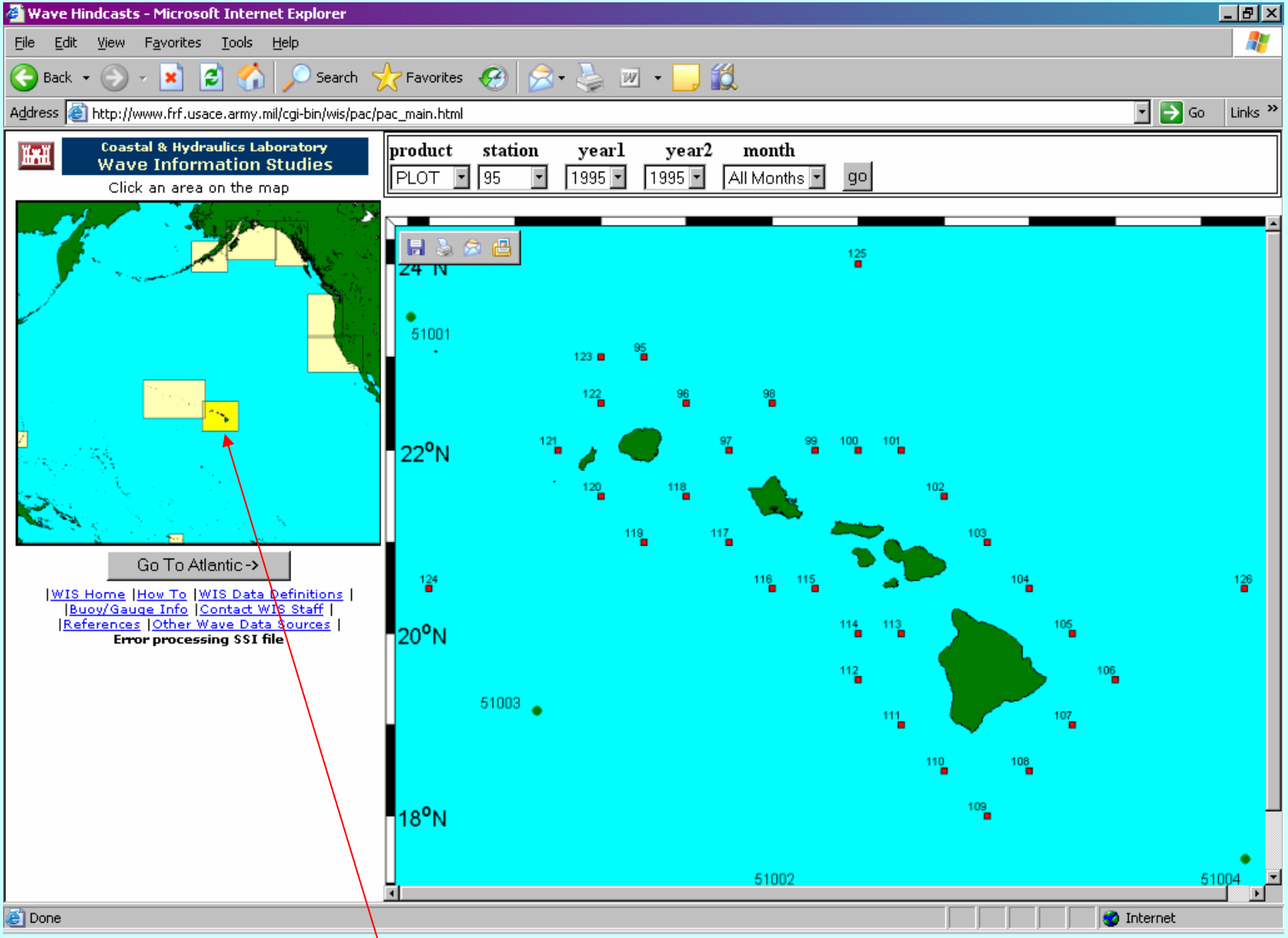
WW3 results for Hawaii Buoy-January 2000 51004 (NRAQ winds)



WW3 results for Hawaii Buoys-January 2000
51001 (NRAQ winds)



How is WISPAC being used?


Wave Hindcasts - Microsoft Internet Explorer
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Coastal & Hydraulics Laboratory
Wave Information Studies
Click an area on the map
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WIS Home	How To	WIS Data Definitions
Buoy/Gauge Info	Contact WIS Staff
References	Other Wave Data Sources
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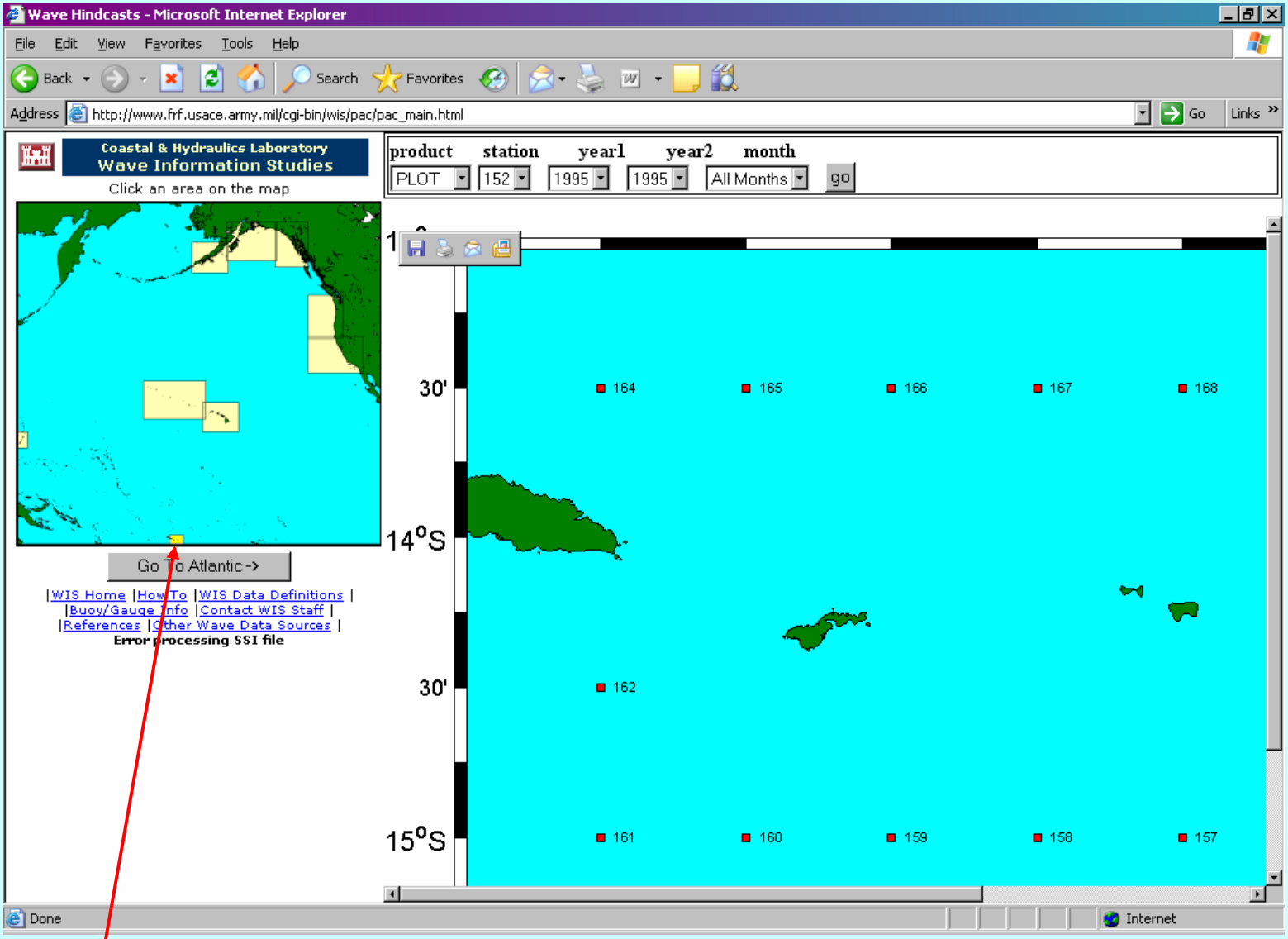
WIS HAWAII

Hawaii Projects using PACWIS

- Maui Shoreline Change Analysis
  - Delft-3D application to model seasonal swing in shoreline width at Kaanapali embayment
  - No directional measurements available
  - 10 years of WIS directional waves meet their needs
- Southeast Oahu RSM Project
  - ADCIRC and STWAVE application for circulation and wave transformation in area
  - Significant wave events to drive models are determined from PACWIS
  - PACWIS determines wave climate of typical events

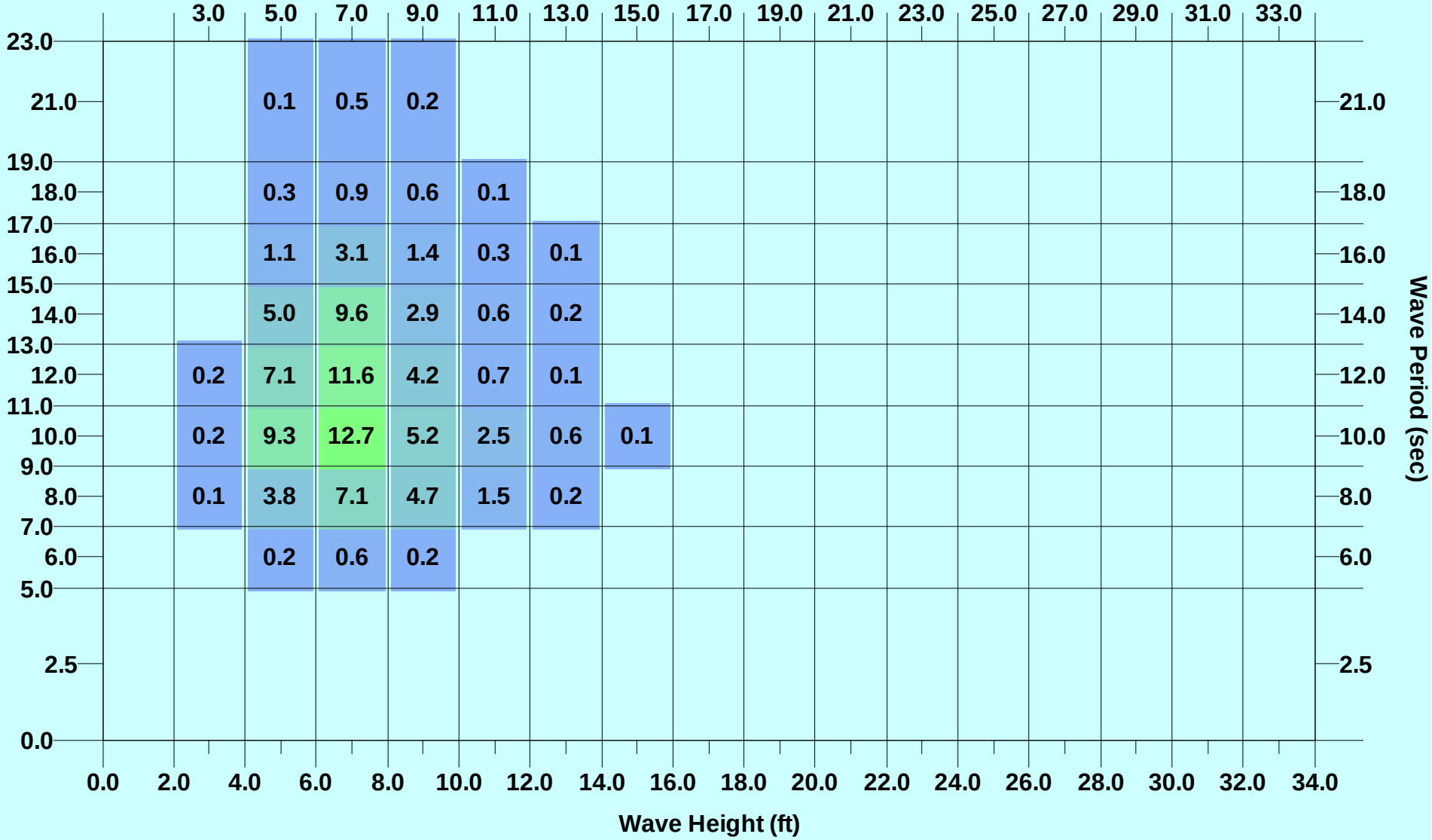


WIS American SAMOA

American Samoa

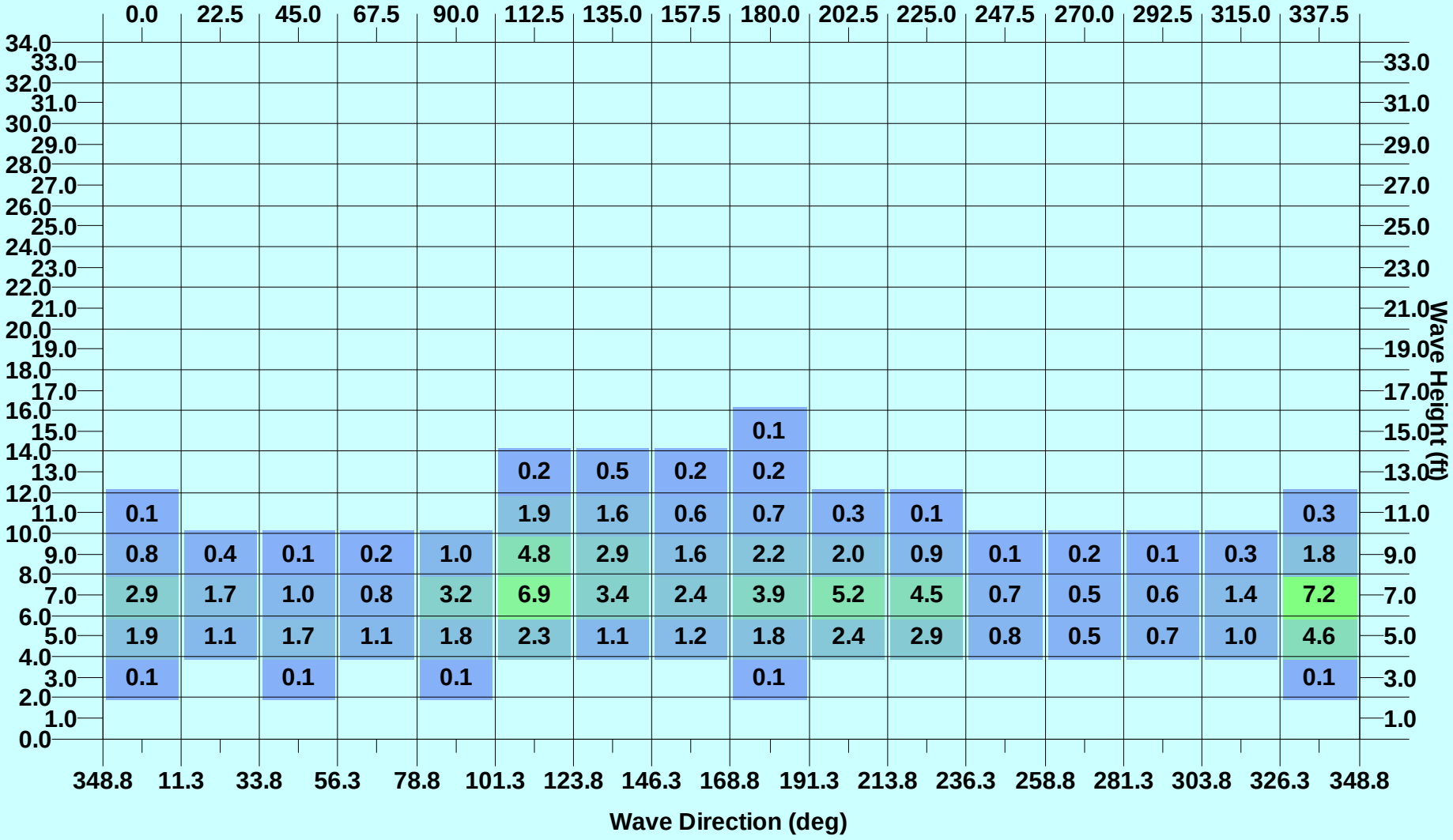
- Leloaloa shore protection project (north shore of Pago Pago Harbor)
  - **Storm waves have eroded shoreline making a road and utilities vulnerable**
  - **Previous info was from a database of ship obs for 1970-77 (not reliable for storms)**
  - **PACWIS has a reliable 10 years of information**
- Pago Pago Harbor improvements
  - **A second harbor on Tutuila is being considered because of congestion at existing facility**
  - **PACWIS is being used for this study**

WIS American Samoa Station 159
Percent Occurrence



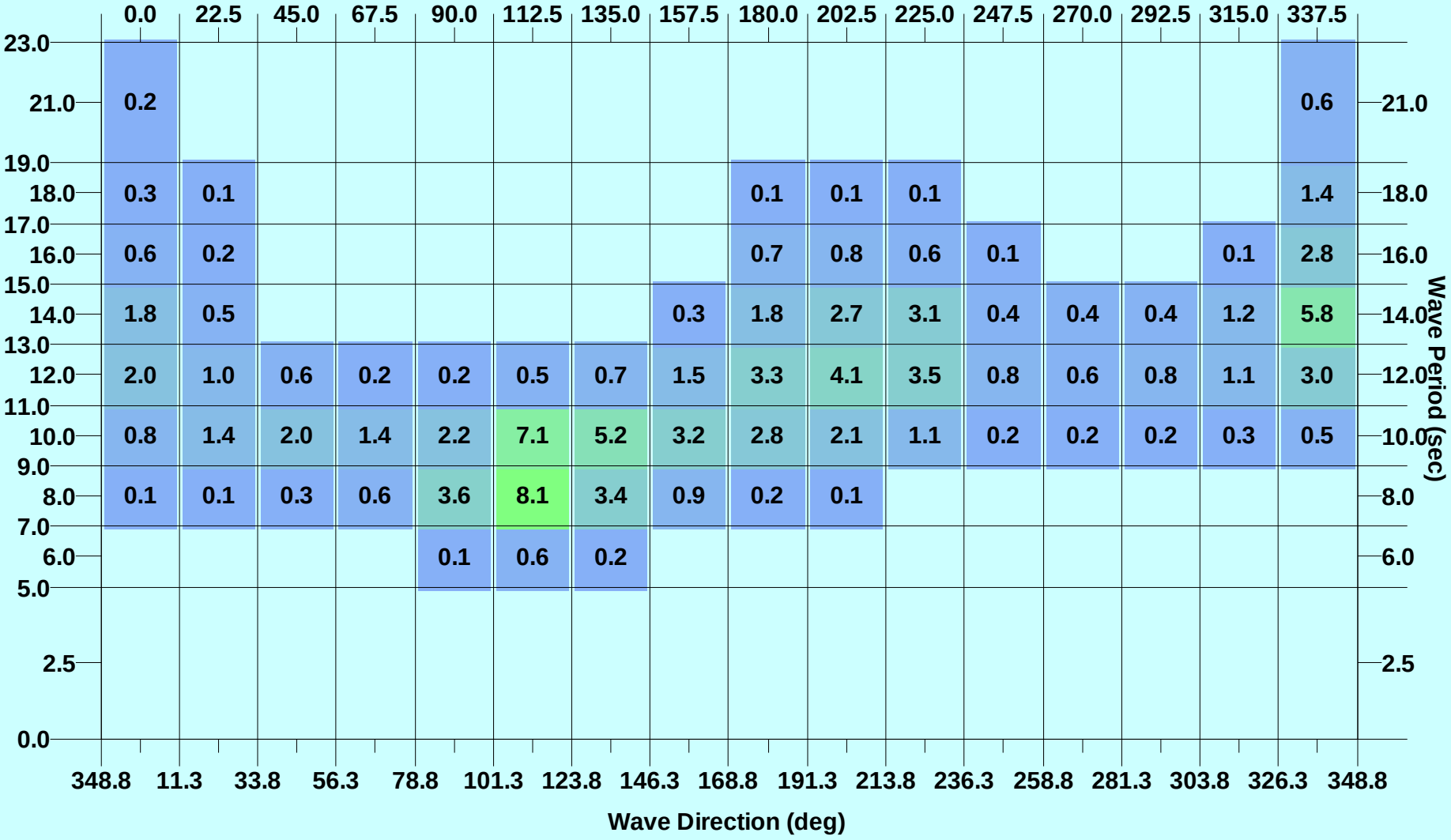
WIS American Samoa Station 159

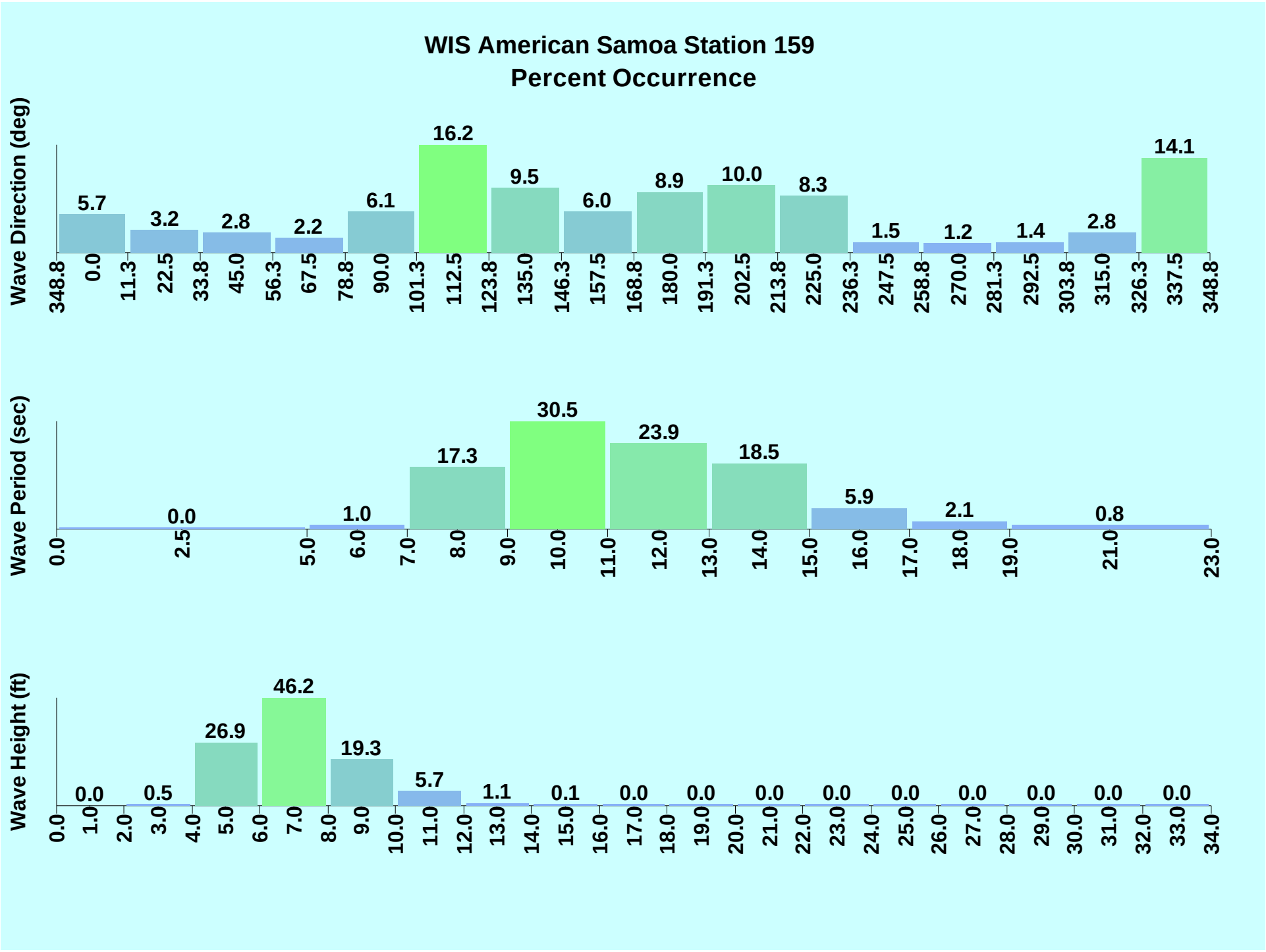
Percent Occurrence



WIS American Samoa Station 159

Percent Occurrence



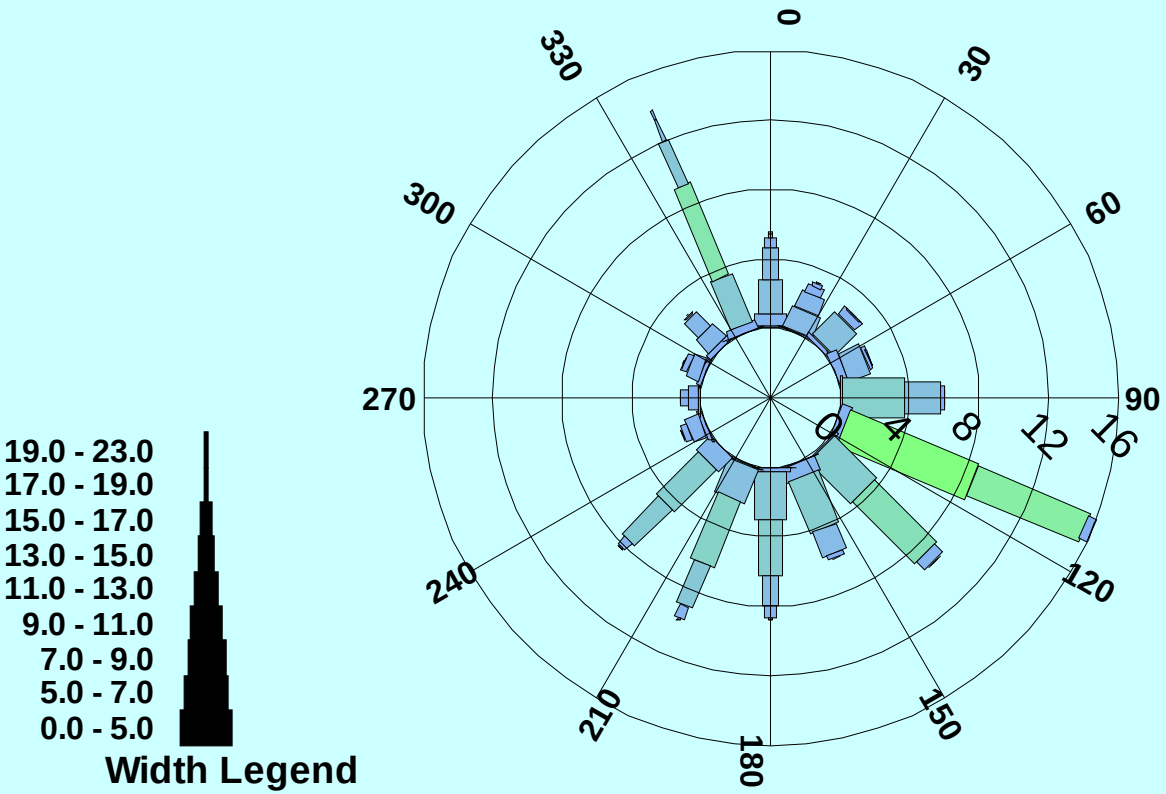

WIS American Samoa Station 159
Percent Occurrence
Wave Direction (deg)
5.7
3.2
2.8
2.2
6.1
16.2
9.5
6.0
8.9
10.0
8.3
1.5
1.2
1.4
2.8
14.1
348.8 0.0 11.3 22.5 33.8 45.0 56.3 67.5 78.8 90.0 101.3 112.5 123.8 135.0 146.3 157.5 168.8 180.0 191.3 202.5 213.8 225.0 236.3 247.5 258.8 270.0 281.3 292.5 303.8 315.0 326.3 337.5 348.8
Wave Period (sec)
0.0
1.0
17.3
30.5
23.9
18.5
5.9
2.1
0.8
0.0 2.5 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 19.0 21.0 23.0
Wave Height (ft)
0.0
0.5
26.9
46.2
19.3
5.7
1.1
0.1
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 19.0 20.0 21.0 22.0 23.0 24.0 25.0 26.0 27.0 28.0 29.0 30.0 31.0 32.0 33.0 34.0

Percent Occurrence

Wave Direction (deg)

vs.

Wave Period (sec)



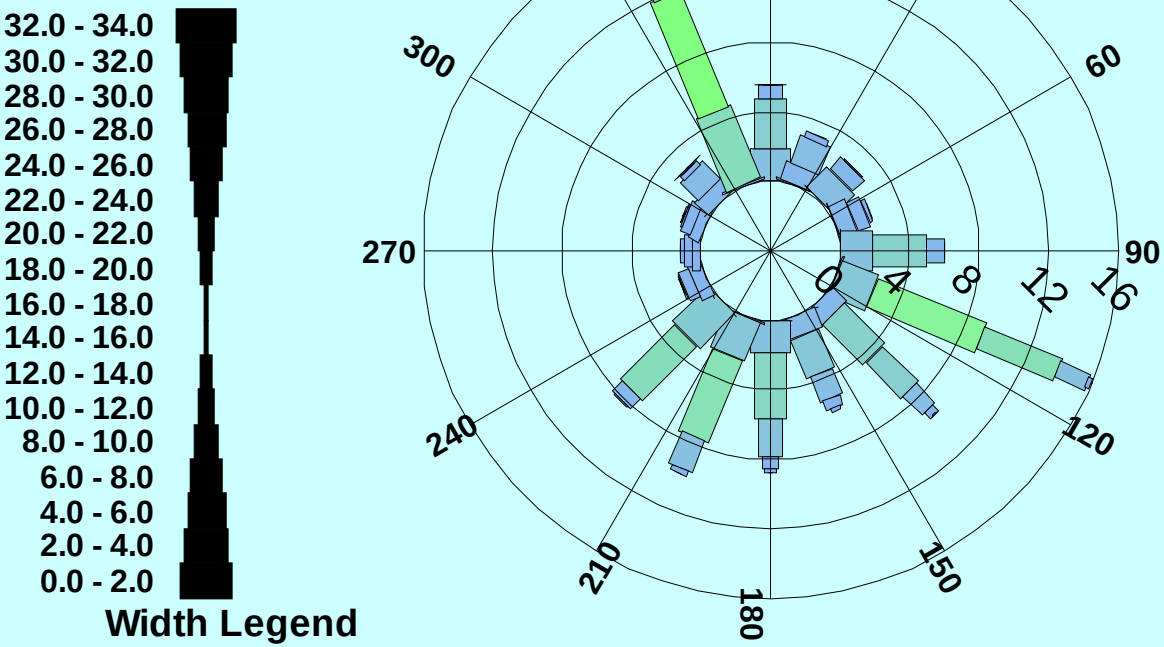
WIS American Samoa Station 159

Percent Occurrence

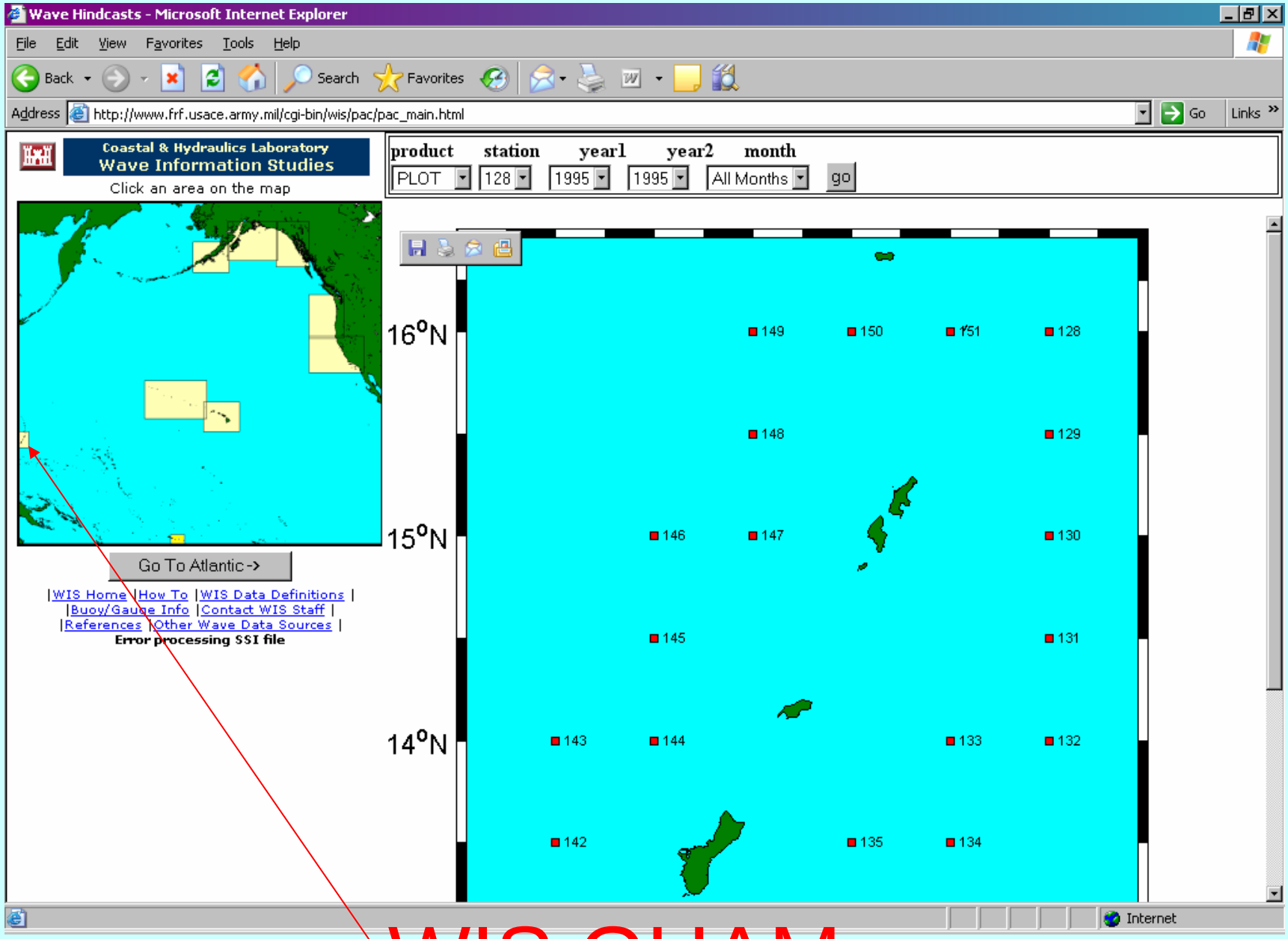
Wave Direction (deg)

vs.

Wave Height (ft)



WIS American Samoa Station 159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16°N
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14°N
149 150 151 128
148 129
146 147 130
145 131
143 144 133 132
142 135 134
Go To Atlantic ->
WIS Home How To WIS Data Definitions
Buoy/Gauge Info Contact WIS Staff
References Other Wave Data Sources
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Internet

WIS GUAM

WIS Plans for this FY:

- 10 additional years for Pacific Basin Hindcast
- One year Pacific regional forensics