Synthesizing Offshore Wave Records & Water Level Data to Characterize Nearshore Storm Wave Climate

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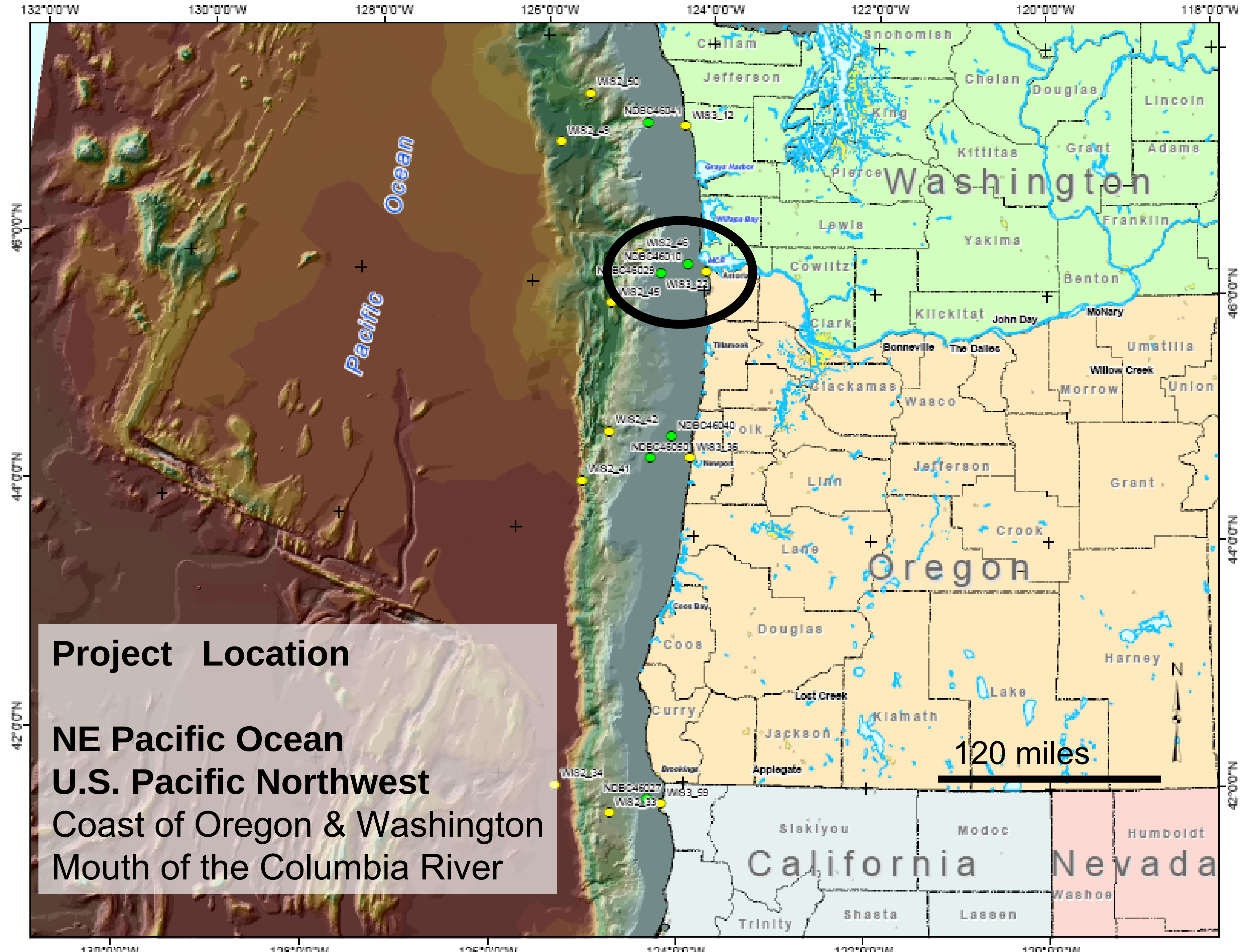
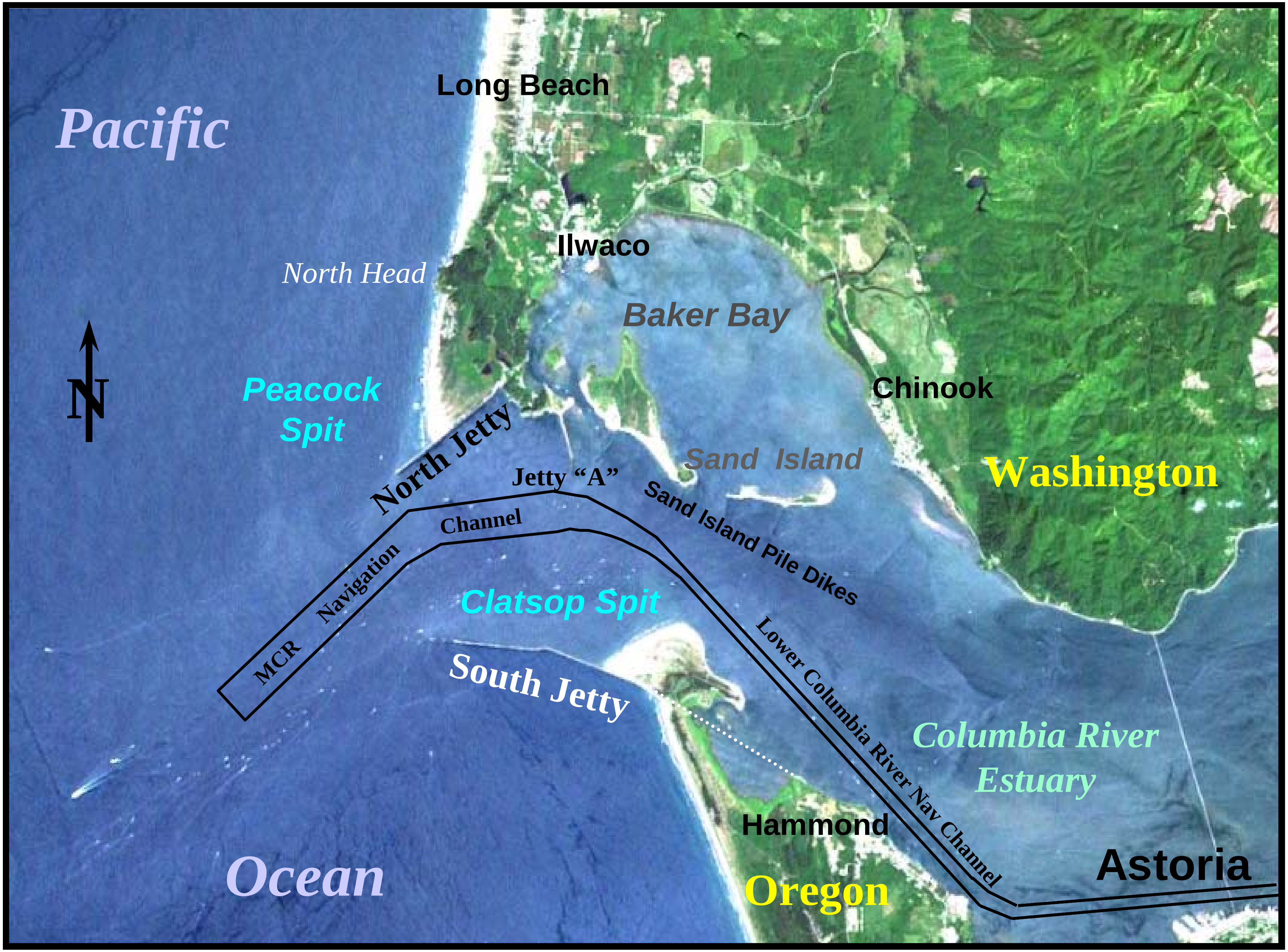
Portland, Oregon USA

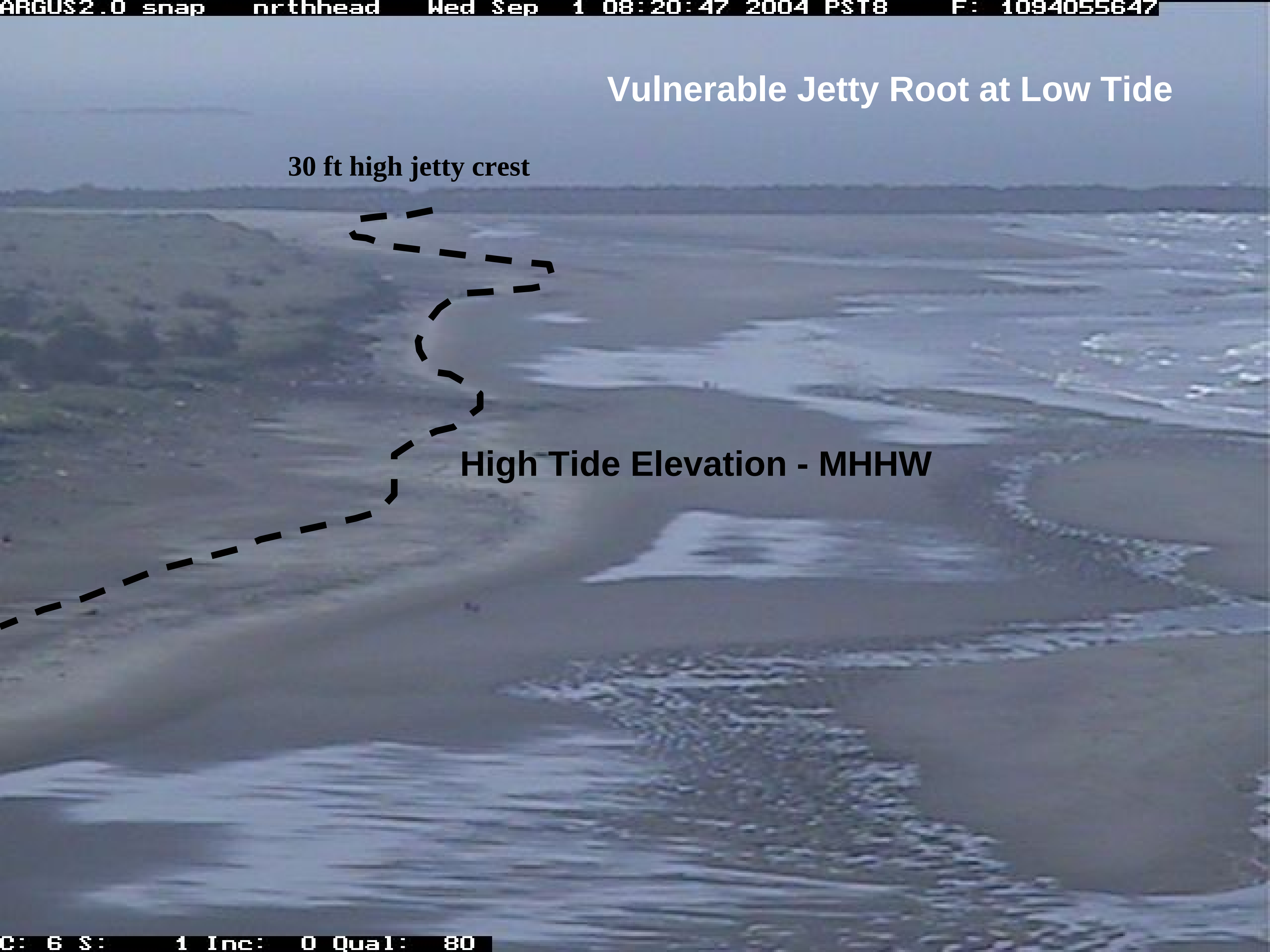
12th International Workshop on Wave Hindcasting and Forecasting & 3rd Coastal Hazard Symposium

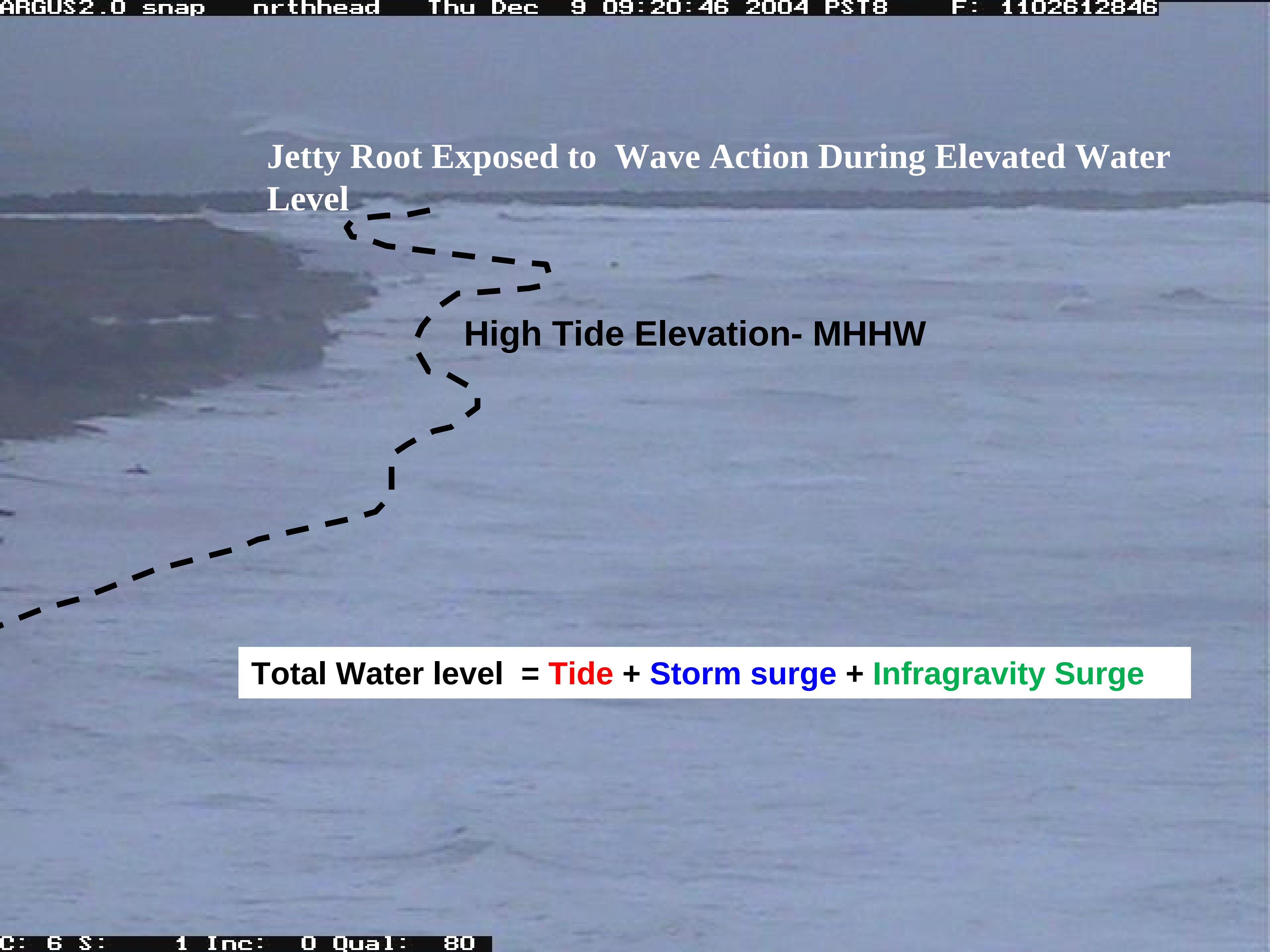

Project Location
NE Pacific Ocean
U.S. Pacific Northwest
Coast of Oregon & Washington
Mouth of the Columbia River
Pacific
Ocean
Washington
Oregon
California
Nevada
Clallam
Jefferson
Snohomish
Chelan
Douglas
Lincoln
King
Kittitas
Grant
Adams
Pierce
Lewis
Yakima
Franklin
Cowlitz
Benton
Clark
Klickitat
Umatilla
Clackamas
Wasco
Morrow
Union
Jefferson
Linn
Grant
Crook
Lane
Douglas
Coos
Harney
Lake
Curry
Jackson
Klamath
Siskiyou
Modoc
Humboldt
Washoe
Shasta
Lassen
Trinity
John Day
McNary
Bonneville
The Dalles
Willow Creek
Lost Creek
Applegate
WIS2_50
NDBC46041
WIS3_12
WIS2_48
WIS2_46
NDBC46010
NDBC46029
WIS3_22
WIS2_45
WIS2_42
NDBC46040
NDBC46050
WIS3_36
WIS2_41
WIS2_34
NDBC46027
WIS3_59
WIS2_33
120 miles
N
132°0'0"W
130°0'0"W
128°0'0"W
126°0'0"W
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
46°0'0"N
44°0'0"N
42°0'0"N

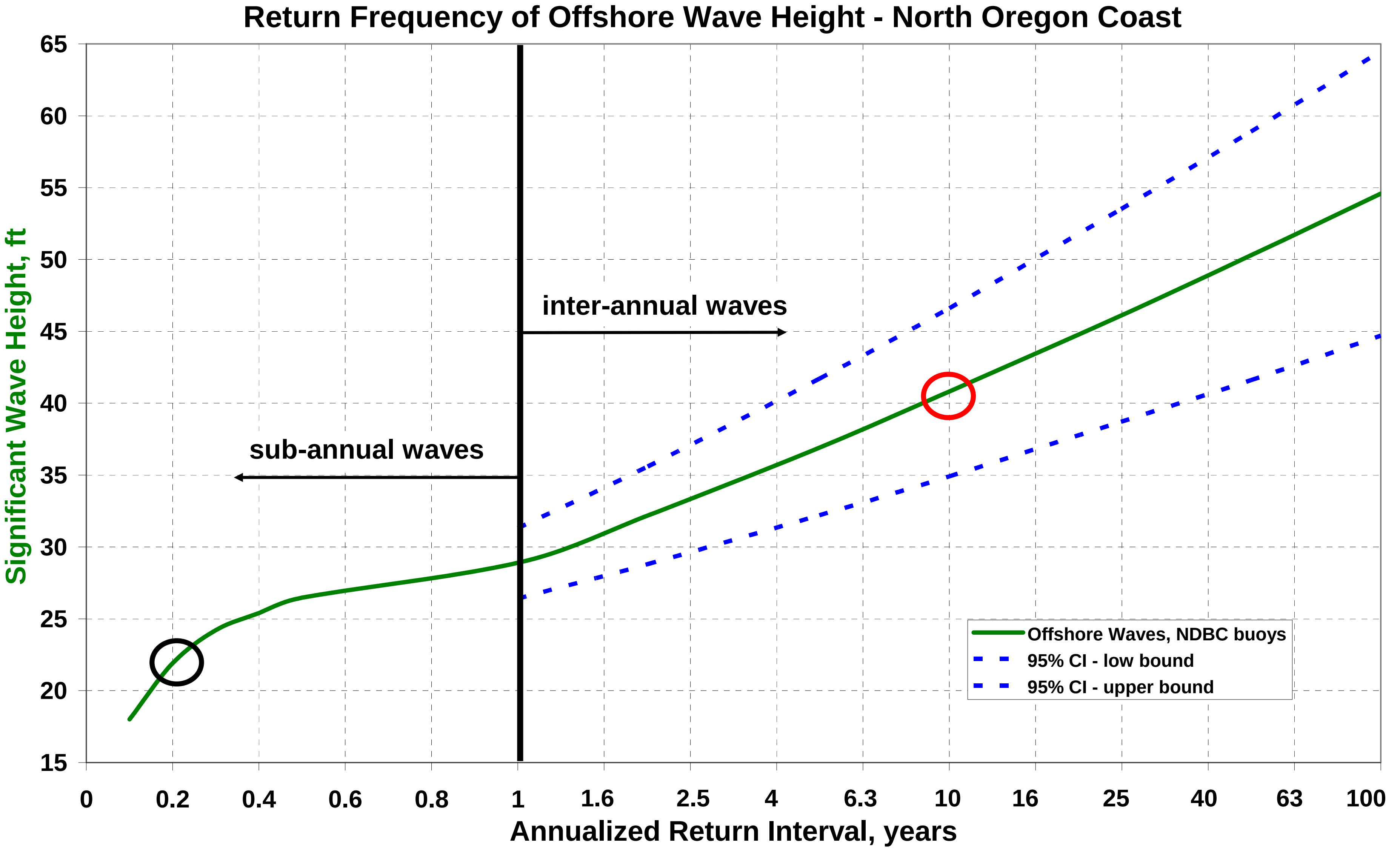


Pacific
Ocean
Long Beach
Ilwaco
North Head
Baker Bay
Peacock
Spit
Chinook
North Jetty
Sand Island
Washington
Jetty "A"
Sand Island Pile Dikes
Channel
Navigation
MCR
Clatsop Spit
South Jetty
Lower Columbia River Nav Channel
Columbia River
Estuary
Hammond
Astoria
Oregon
N

Depth-Limited Wave Breaking on Jetty Head


ARGUS2.0 snap nrthhead Wed Sep 1 08:20:47 2004 PST8 F: 1094055647
Vulnerable Jetty Root at Low Tide
30 ft high jetty crest
High Tide Elevation - MHHW
C: 6 S: 1 Inc: 0 Qual: 80


ARGUS2.0 snap nrthhead Thu Dec 9 09:20:46 2004 PST8 F: 1102612846
Jetty Root Exposed to Wave Action During Elevated Water Level
High Tide Elevation- MHHW
Total Water level = Tide + Storm surge + Infragravity Surge
C: 6 S: 1 Inc: 0 Qual: 80



Results are based on a partial-duration frequency analysis for a 20-yr period of record using data that was recorded at 1-hour intervals. Results were extrapolated to a 100-yr frequency of occurrence using a fitted Wiebull distribution (k-0.75).

Expected value for 10-year wave height = 41 ± 6 ft.

Wave height expected to be exceeded 4 times within a given year (RI = 0.2) is 22 ft

Motivation

Evaluate Life-cycle Performance of Coastal Navigation Infrastructure
Using Monte Carlo Approach

TASK: Reproduce the Annual Loading Environment – Nearshore Wave Action

SOLUTION: Stochastically Simulate Annual Nearshore Wave Environment over XX-year Life-Cycle

Must account for:

Frequency of Offshore Wave Events (dependent on H-threshold)

Water level variation

"Character" of offshore waves

Transformation of Offshore Waves to the Nearshore

Conclusions

Nearshore Wave Environment is Modulated by Water Level --- Due to Depth Limitation

Depth Limitation Based on **H**sig / **D**epth = ~ 0.4 to 0.7

Depth Limitation is Affected by "character" of waves & bathymetry

Fully define "Character" of Offshore Waves to Simulate Nearshore Conditions

Use Observed Directional Wave spectra for Model Boundary Conditions

Transform Offshore Waves (2D spectra) to the Nearshore ---

Requires Accurate Rendition of Bathymetry & Acceptable Wave Model

For a Given Water Level:

100-yr Offshore Wave Event ≠ 100-yr Nearshore Wave Event

1–yr Offshore Event produces Nearshore Waves > 30-yr Offshore Event

Approach

Select a finite number of offshore wave observations to describe the storm wave environment (1987 – 2008). 52 Discrete Events Evaluated at 3 Water Levels.

Offshore storm wave events are represented by ***observed directional spectra*** -
Wave height & period are consolidated: Features complex (real) sea states

Transform Observed Offshore Events (52) to Nearshore using STWAVE
For 3 Different Nearshore Water Levels

Produce a Data Base of Storm Events…..Sample, Assign, Interpolate

---

Deconstruct Observed Offshore Storm Wave Environment into sub-Populations
Define each Sub-Population using ***dependent*** PDFs
Direction
Wave Height

Sample Offshore Event Data Base – Best match Offshore Event

Deconstruct Observed Storm Water Levels into “Components”
Define each Water Level Component using ***conditional independent*** PDFs
Astronomical Tide
Storm Surge
Infragravity Transient

- Construct total WSE for a given Event
- Use WSE to Select STWAVE solution from Ensemble Results

Other Considerations

Threshold for Offshore Storm Events:

Hsig $\geq$ 7 meters (can occur 1 – 11 times per year)

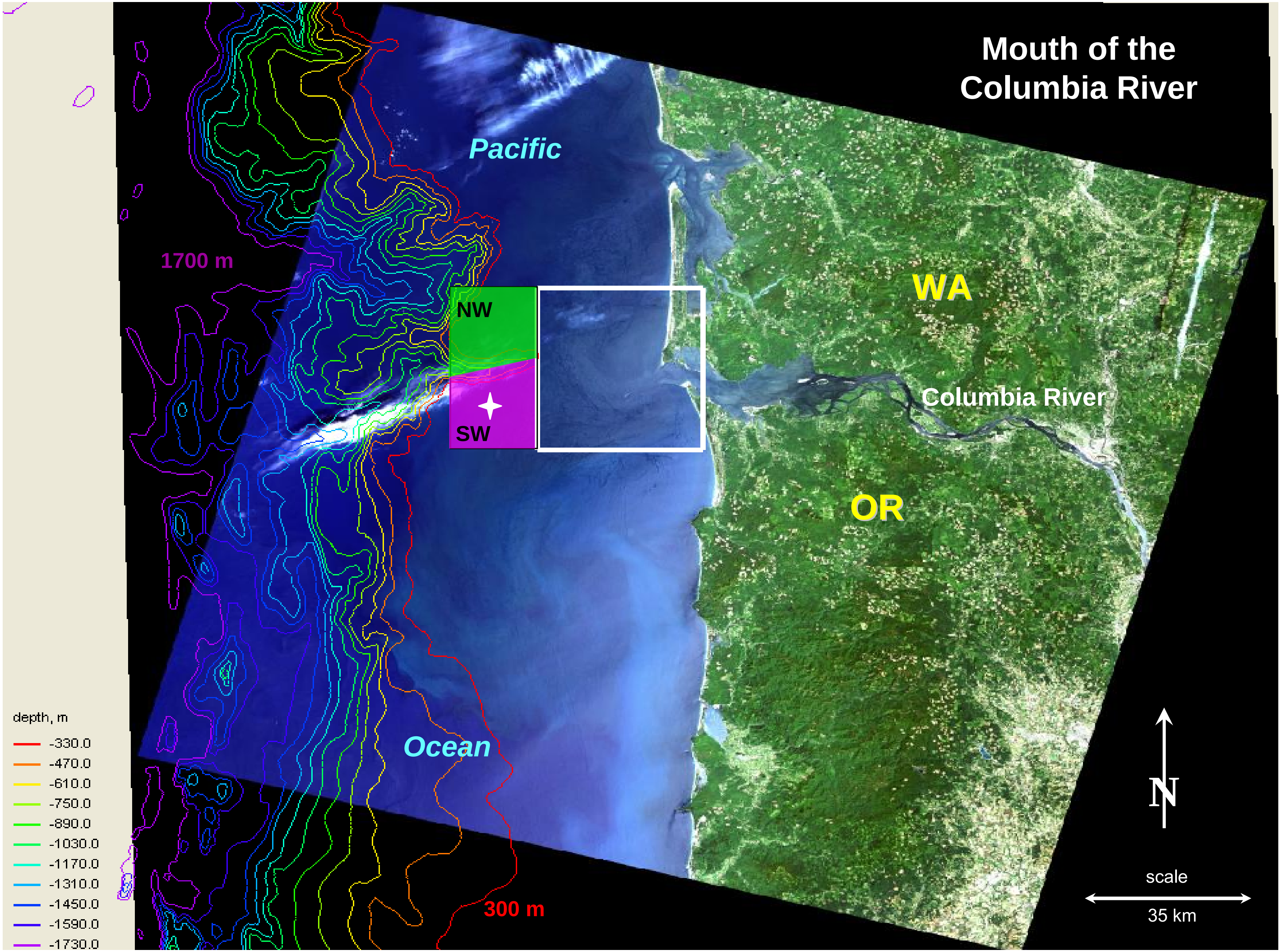
Wave Current Interaction Not Considered: Modal Wave Period = 11 – 20 sec

Non-Stationary Processes:

Water level - affected by potential sea level rise scenarios

Offshore Waves – affected by changes in environment (storminess)

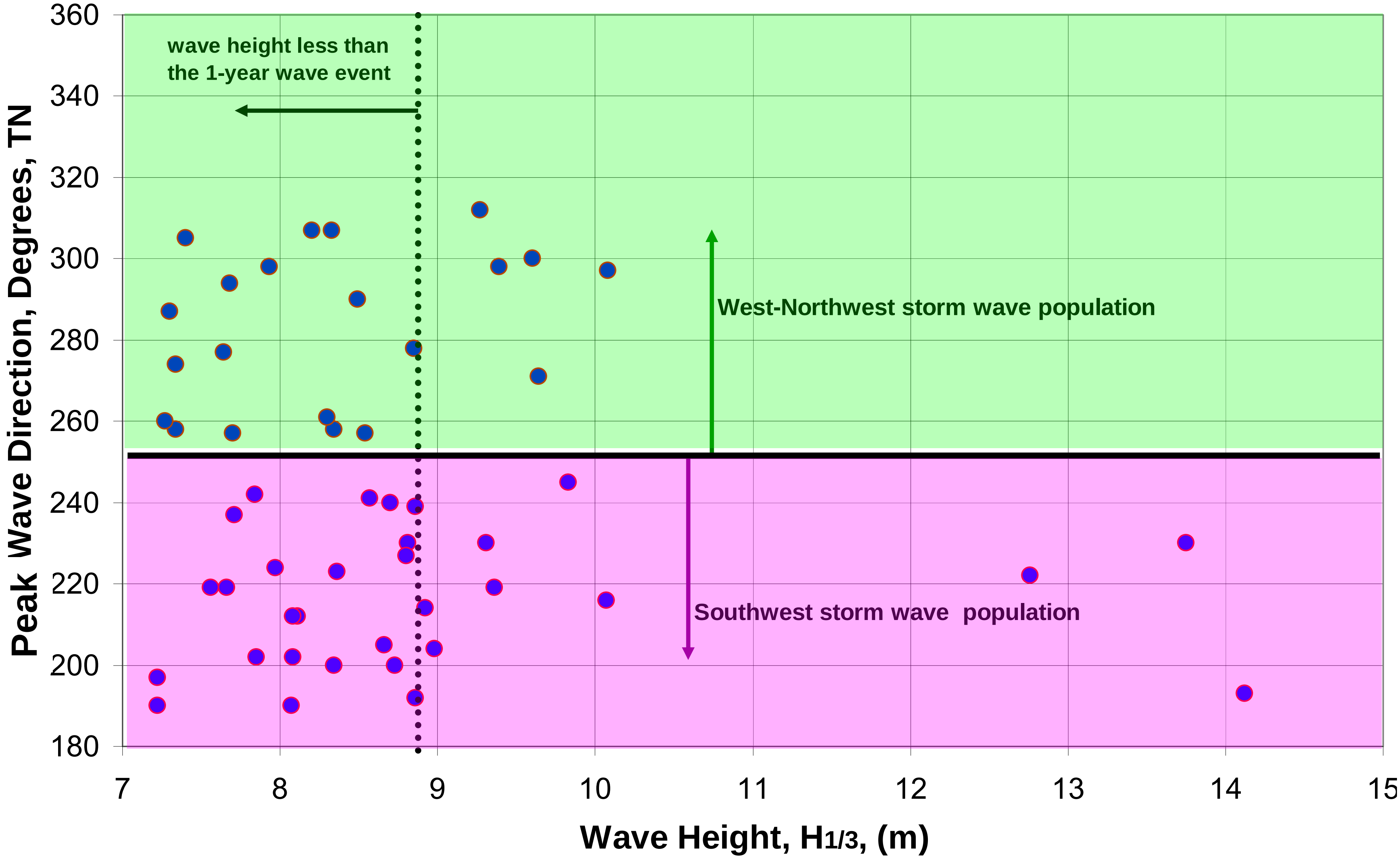
Nearshore Waves – affected by changes in morphology



Mouth of the Columbia River
Pacific
1700 m
NW
SW
WA
Columbia River
OR
Ocean
300 m
depth, m
-330.0
-470.0
-610.0
-750.0
-890.0
-1030.0
-1170.0
-1310.0
-1450.0
-1590.0
-1730.0
N
scale
35 km

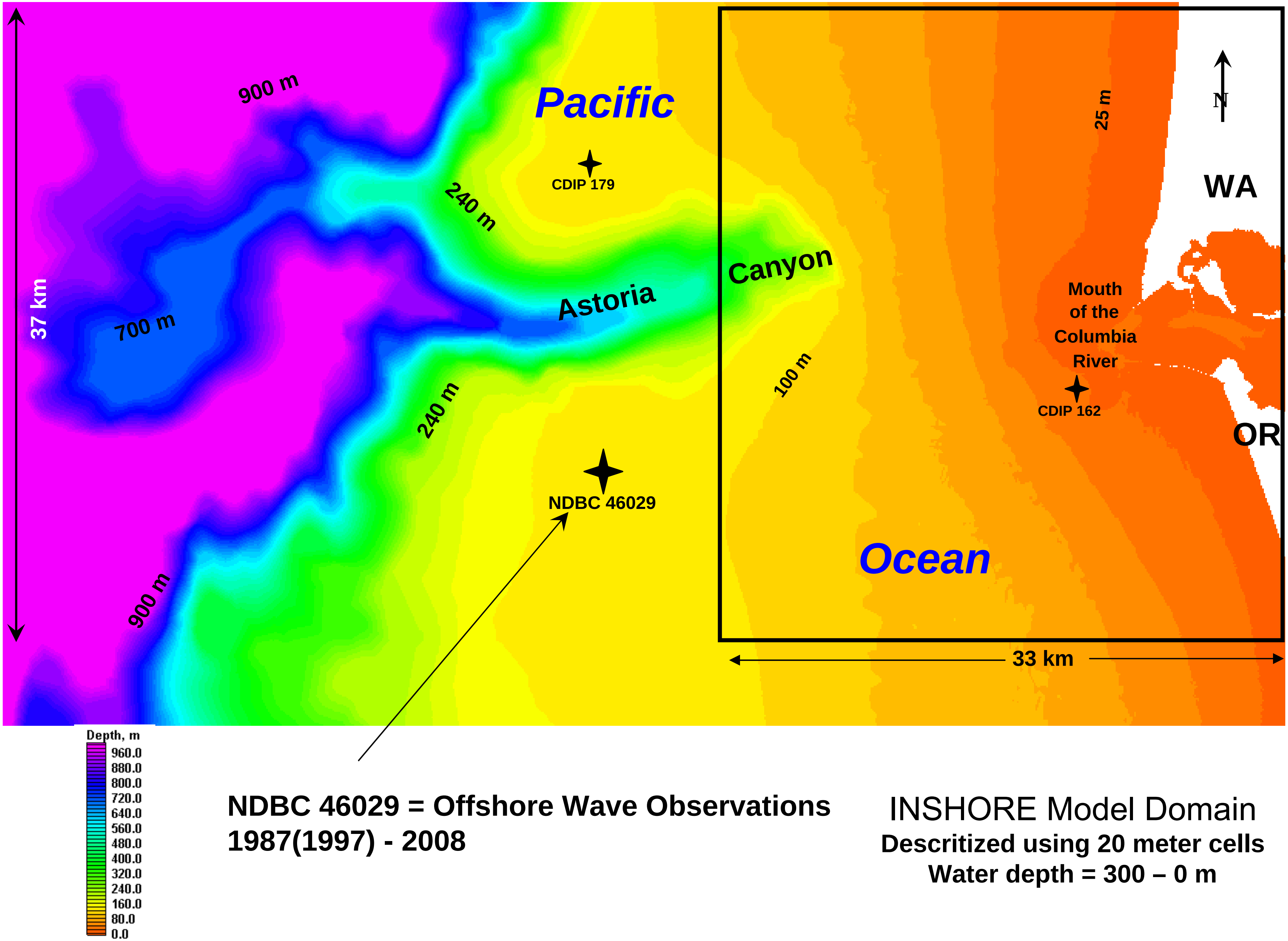
Candidate Offshore Storm Wave Events - North Oregon Coast

52 observed events used to emulate storm wave environment 18 miles offshore MCR



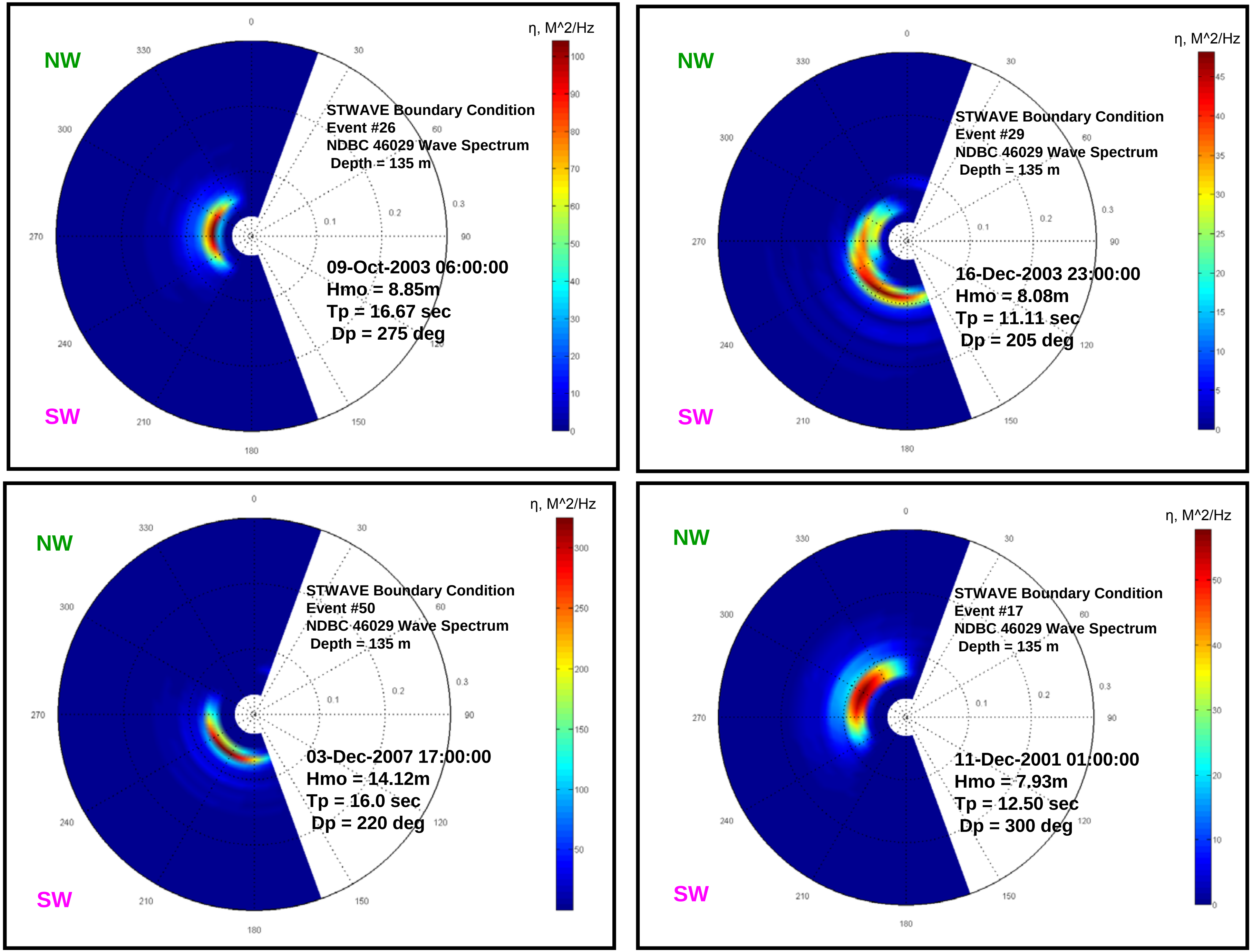
Offshore Hs = 7 m can occur 1-11 times per year; mean occurrence rate = 4.5 times per year (1987-2008)

STORM EVENT DATE					Offshore Hsig, m	OFFSHORE STORM WAVE CHARACTERISTICS					RANK (1-52)
StormID	YEAR	MONTH	DAY	HOUR UTM		Dominant Wave Period, sec	Average Wave Period, sec	Mean Wave Direction, deg AZ	Wind Direction deg AZ	Wind Speed	Offshore OBSERVATION
19981203	1998	12	3	22	8.49	16.67	12.37	290	277	3.6	25
19990116	1999	1	16	22	7.34	14.29	10.11	258	228	11.6	47
19990205	1999	2	5	22	8.92	11.11	8.9	214	172	21.9	14
19990212	1999	2	12	16	7.97	14.29	10.61	224	157	10.8	36
19990216	1999	2	16	18	9.83	20	12.51	245	167	11.4	6
19990224	1999	2	24	14	8.73	12.5	9.48	200	175	16.1	20
19990303	1999	3	3	8	12.8	16.67	11.96	222	182	20	3
19990330	1999	3	30	1	7.7	16.67	10.54	257	233	10	41
19991028	1999	10	28	11	8.81	14.29	10.51	230	183	12.7	18
20001028	2000	10	28	19	8.54	16.67	9.74	257	152	25.4	19
20001028	2000	10	28	20	8.8	14.29	10.01	227	159	14.8	24
20010302	2001	3	2	18	7.3	16.67	11.68	287	230	7.9	49
20011023	2001	10	23	13	9.39	14.29	11.23	298	275	11	9
20011120	2001	11	20	7	8.34	12.5	9.29	200	199	14.9	27
20011128	2001	11	28	17	8.86	12.5	9.47	192	210	12.5	15
20011202	2001	12	2	1	8.57	14.29	9.49	241	240	15.7	23
20011211	2001	12	11	1	7.93	12.5	9.6	298	302	10.2	37
20011214	2001	12	14	12	10.0	14.29	10.43	297	187	12.6	4
20020107	2002	1	7	22	8.34	16.67	9.8	258	192	14.2	28
20020312	2002	3	12	18	7.64	16.67	10.17	277	217	10.1	44
20021108	2002	11	8	7	7.27	16.67	10.22	260	176	12.2	51
20021215	2002	12	15	23	9.31	12.5	9.43	230	174	22.3	11
20021227	2002	12	27	15	8.07	11.11	8.94	190	205	18.9	35
20030102	2003	1	2	3	8.11	11.11	8.86	212	186	17.1	32
20030313	2003	3	13	16	8.98	12.5	9.77	204	204	16.6	13
20031009	2003	10	9	6	8.85	16.67	11.42	278	248	8.7	17
20031012	2003	10	12	10	9.64	16.67	11.62	271	232	12.1	7
20031117	2003	11	17	11	9.27	16.67	10.64	312	279	10.8	12
20031216	2003	12	16	23	8.08	11.11	9.94	212	266	8	33
20031225	2003	12	25	13	7.34	14.29	11.46	274	276	8.4	48
20040217	2004	2	17	10	7.84	16.67	11.5	242	157	6	39
20051221	2005	12	21	6	7.66	14.29	10.7	219	168	8.3	43
20051230	2005	12	30	9	7.85	12.5	9.07	202	197	11	38
20060102	2006	1	2	1	7.56	12.5	9.19	219	199	10.3	45
20060105	2006	1	5	21	8.86	16.67	12.52	239	170	7.6	16
20060130	2006	1	30	9	8.08	11.11	9.08	202	198	17.4	34
20060204	2006	2	4	13	13.8	16.67	11.56	230	205	20.1	2
20060302	2006	3	2	16	7.22	11.11	8.65	197	195	12.9	52
20060309	2006	3	9	7	7.68	12.5	9.43	294	278	11.5	42
20061024	2006	10	24	23	7.4	16.7	11.7	305	308	8.8	46
20061113	2006	11	13	8	8.7	12.5	9.3	240	276	18.3	21
20061116	2006	11	16	3	8.7	12.5	9.7	205	291	10.2	22
20061212	2006	12	12	0	8.4	12.5	9.2	223	213	12.1	26
20061215	2006	12	15	6	10.1	12.5	9.8	216	225	20.9	5
20061221	2006	12	21	13	8.3	14.3	10.7	261	211	9.9	30
20061227	2006	12	27	16	8.3	11.1	8.9	307	319	18.6	29
20070106	2007	1	6	15	7.3	14.3	9.9	287	289	9.3	50
20071009	2007	10	9	20	7.71	16	9.6	237	161	13.8	40
20071112	2007	11	12	14	9.36	10.81	9.17	219	176	20.6	10
20071203	2007	12	3	17	14.2	16	12.21	193	180	22.1	1
20081213	2008	12	13	8	9.6	14	10.9	300	290	17	8
20081225	2008	12	25	19	8.2	16	11	307	340	12	31

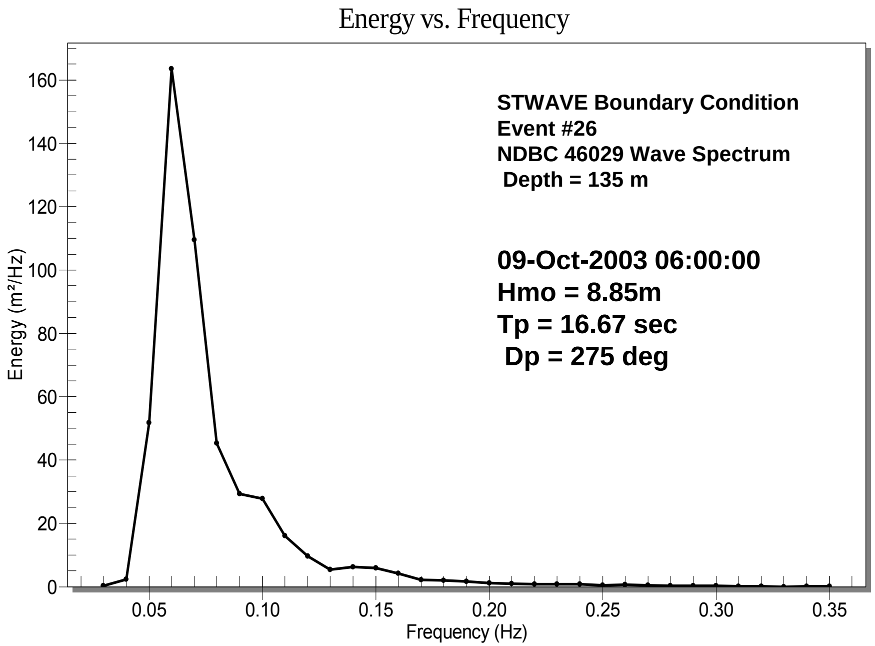


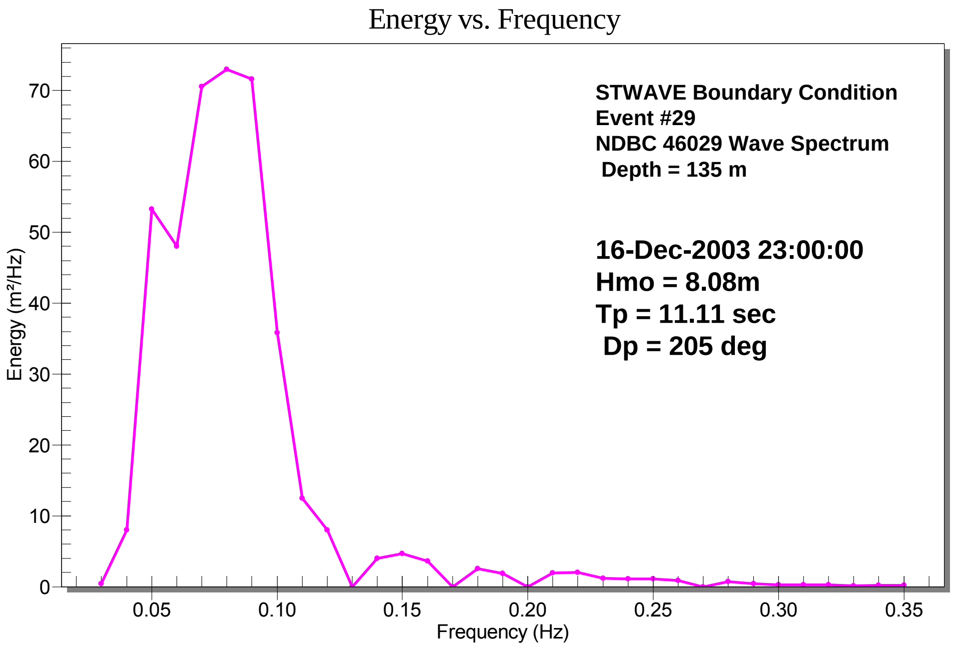
NDBC 46029 = Offshore Wave Observations
1987(1997) - 2008

INSHORE Model Domain
Descritized using 20 meter cells
Water depth = 300 – 0 m



η, M^2/Hz
NW
SW
STWAVE Boundary Condition
Event #26
NDBC 46029 Wave Spectrum
Depth = 135 m
09-Oct-2003 06:00:00
Hmo = 8.85m
Tp = 16.67 sec
Dp = 275 deg
η, M^2/Hz
NW
SW
STWAVE Boundary Condition
Event #29
NDBC 46029 Wave Spectrum
Depth = 135 m
16-Dec-2003 23:00:00
Hmo = 8.08m
Tp = 11.11 sec
Dp = 205 deg
η, M^2/Hz
NW
SW
STWAVE Boundary Condition
Event #50
NDBC 46029 Wave Spectrum
Depth = 135 m
03-Dec-2007 17:00:00
Hmo = 14.12m
Tp = 16.0 sec
Dp = 220 deg
η, M^2/Hz
NW
SW
STWAVE Boundary Condition
Event #17
NDBC 46029 Wave Spectrum
Depth = 135 m
11-Dec-2001 01:00:00
Hmo = 7.93m
Tp = 12.50 sec
Dp = 300 deg


Energy vs. Frequency
STWAVE Boundary Condition
Event #26
NDBC 46029 Wave Spectrum
Depth = 135 m
09-Oct-2003 06:00:00
Hmo = 8.85m
Tp = 16.67 sec
Dp = 275 deg
Energy (m²/Hz)
Frequency (Hz)


Energy vs. Frequency
STWAVE Boundary Condition
Event #29
NDBC 46029 Wave Spectrum
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Energy (m²/Hz)
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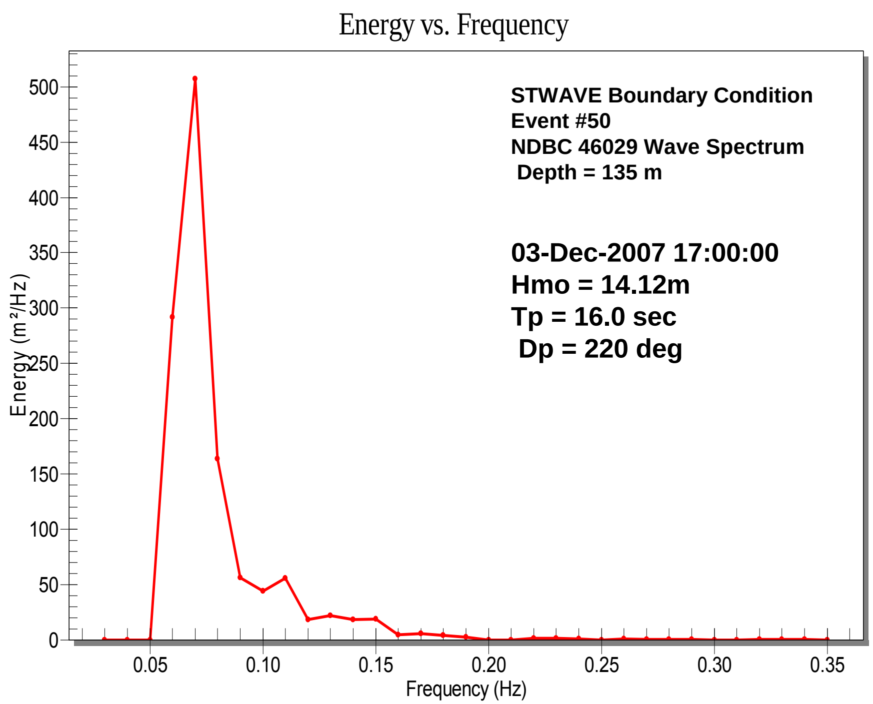
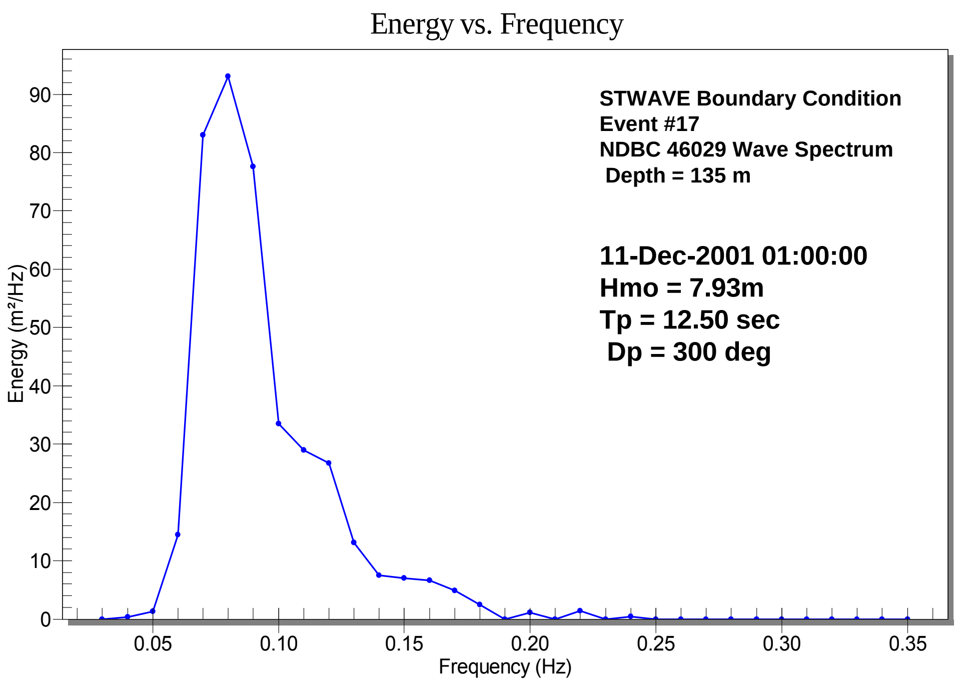
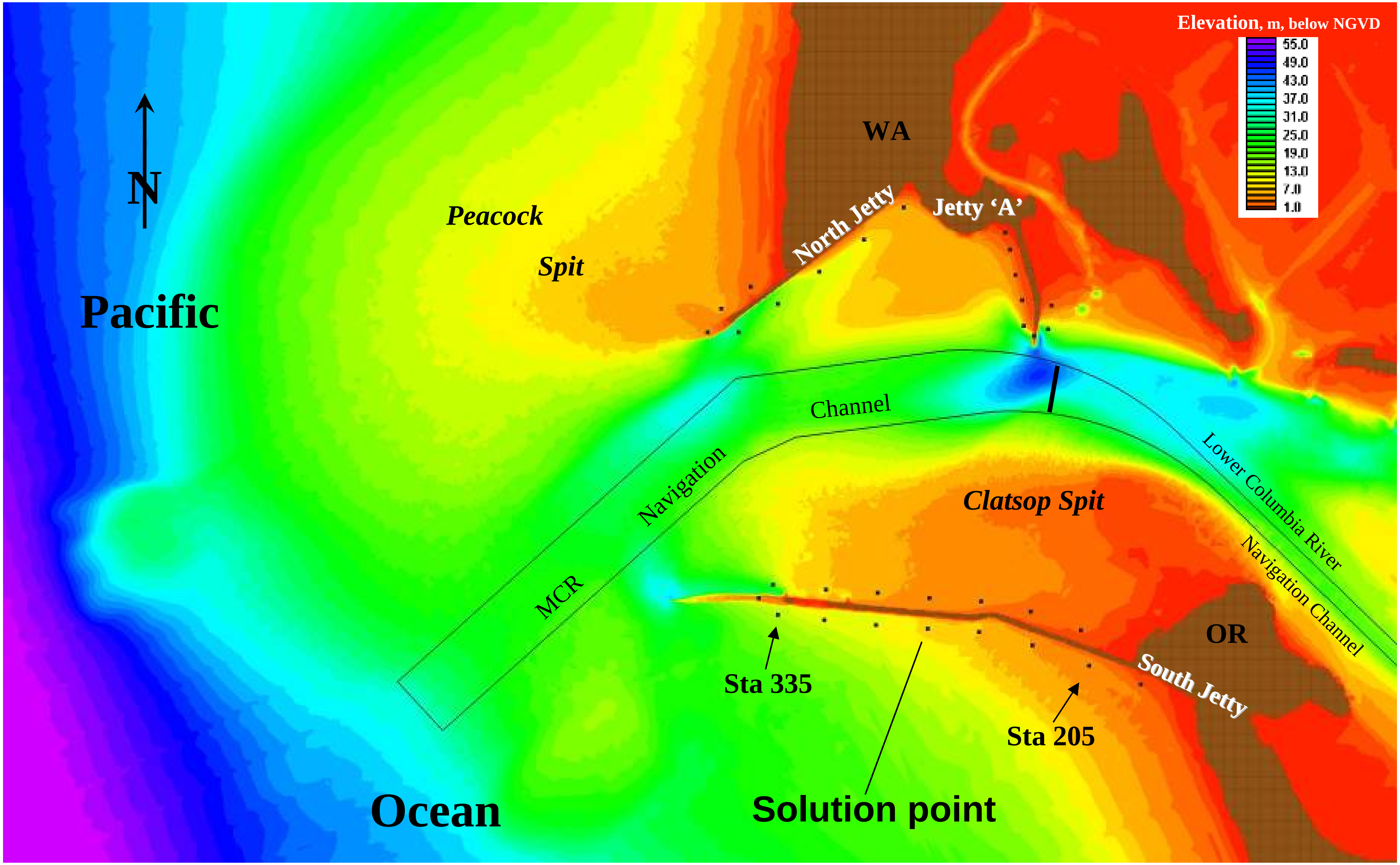
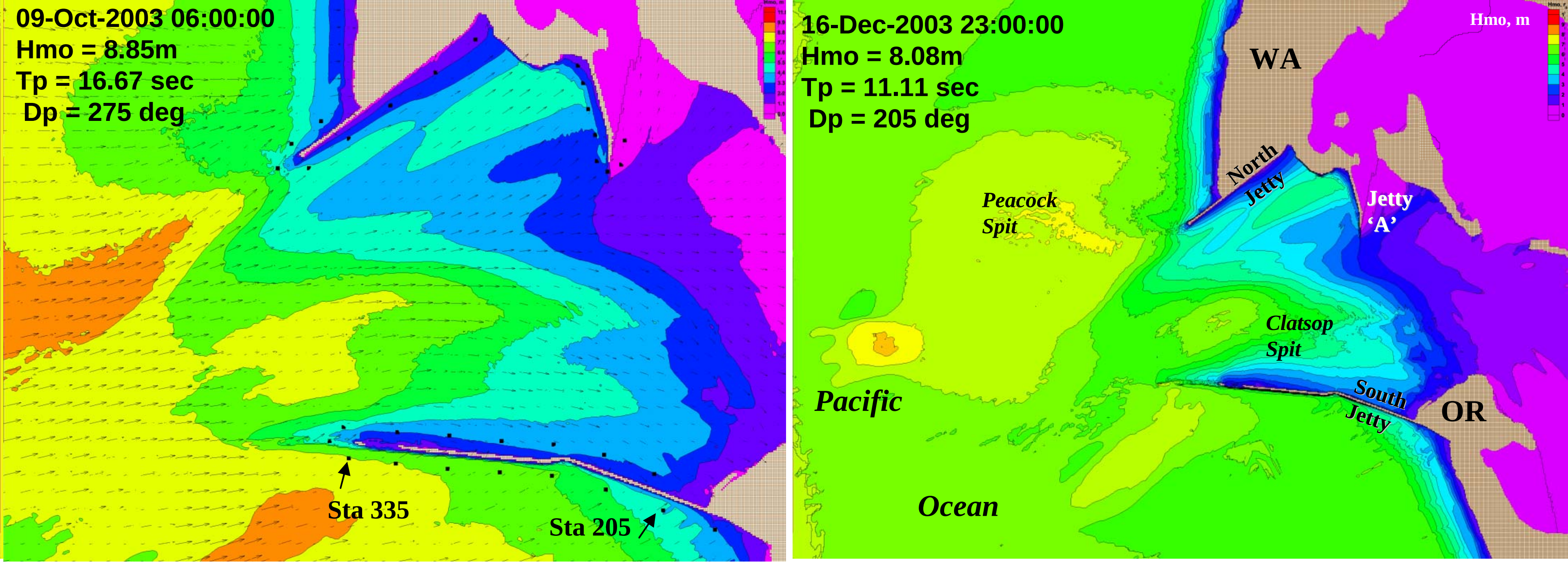

Energy vs. Frequency
STWAVE Boundary Condition
Event #50
NDBC 46029 Wave Spectrum
Depth = 135 m
03-Dec-2007 17:00:00
Hmo = 14.12m
Tp = 16.0 sec
Dp = 220 deg
Energy (m²/Hz)
Frequency (Hz)

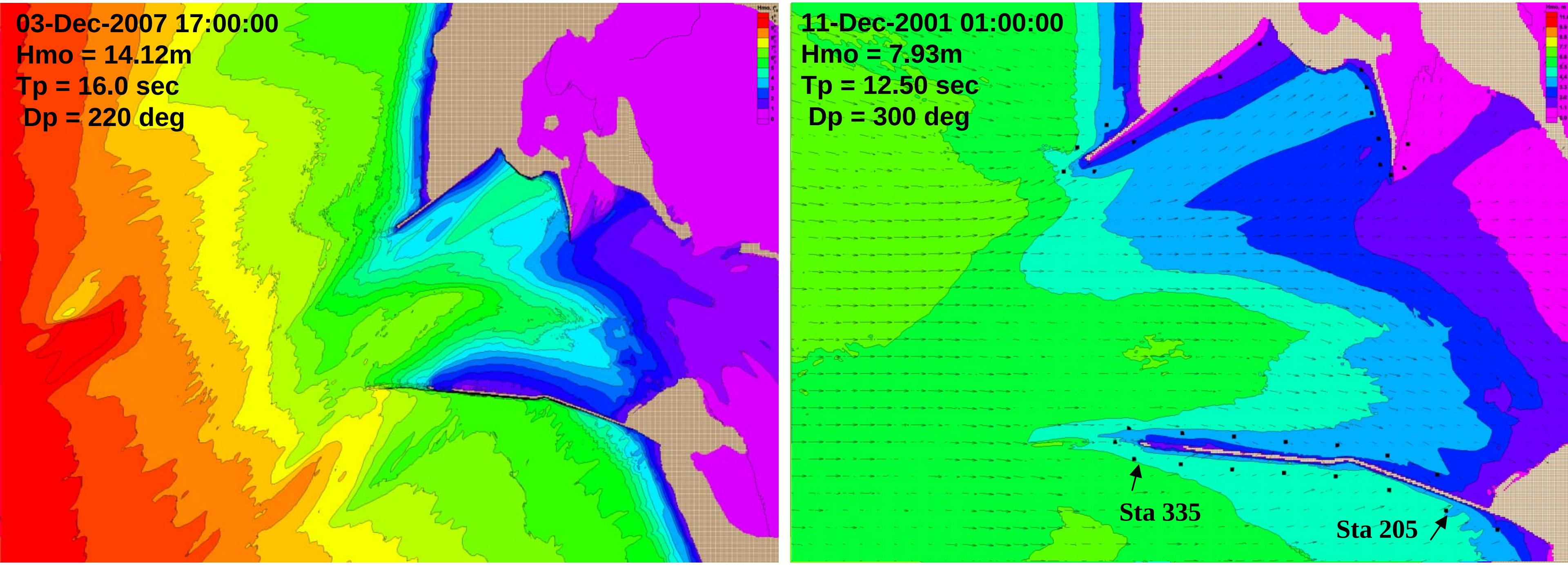

Energy vs. Frequency
STWAVE Boundary Condition
Event #17
NDBC 46029 Wave Spectrum
Depth = 135 m
11-Dec-2001 01:00:00
Hmo = 7.93m
Tp = 12.50 sec
Dp = 300 deg
Energy (m²/Hz)
Frequency (Hz)



Close-up view of MCR ***BATHYMETRY*** , a sub-area of the over all model domain as described in STWAVE. Area shown is 10 km (north-south) x 15 km (east-west). Distance between north and south jetties is 3 km. Survey data is a composite from 2003-2007. Following figures feature STWAVE results obtained for each of the 52 wave conditions at STA 335 and STA 205, for HIGH, MEDIAN, LOW storm water level conditions. "Points" along each jetty indicate "interpolation points" for continuously applying STWAVE output along each jetty.



These Nearshore Wave Simulations based on **Median** Water level



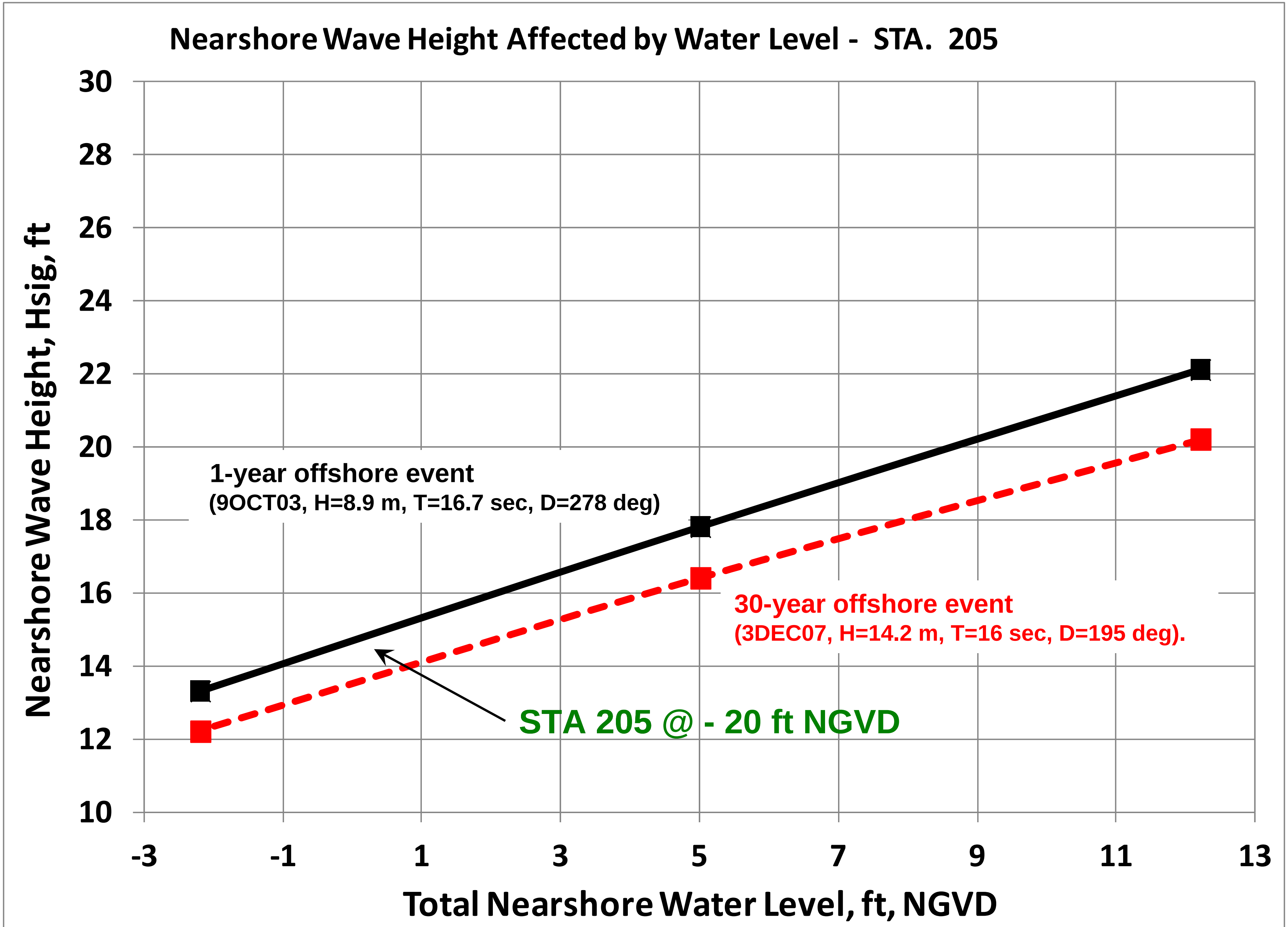
Simulated Nearshore Wave Conditions Based on MEDIAN Storm Water Level

STORM EVENT DATE					OFFSHORE STORM WAVE CHARACTERISTICS							RANK of STORM EVENT BASED ON WAVE HEIGHT AT VARIOUS LOCATIONS *				
StormID	YEAR	MONTH	DAY	HOUR UTM	Sig. Wave Height, m	Dominant Wave Period, sec	Average Wave Period, sec	Mean Wave Direction, deg AZ	Wind Direction deg AZ	Wind Speed	Offshore OBSERVATION	@ North Jetty Mid-Span CHAN Side	@ North Jetty Outer-Span OCEAN Side	@ South Jetty Mid-Span OCEAN Side	@ South Jetty Outer-Span OCEAN Side	@ Jetty "A" Mid-Span OCEAN Side
19981203	1998	12	3	22	8.49	16.67	12.37	290	277	3.6	25	37	8	3	13	16
19990116	1999	1	16	22	7.34	14.29	10.11	258	228	11.6	47	35	27	24	26	30
19990205	1999	2	5	22	8.92	11.11	8.9	214	172	21.9	14	32	51	49	48	49
19990212	1999	2	12	16	7.97	14.29	10.61	224	157	10.8	36	15	33	25	19	27
19990216	1999	2	16	18	9.83	20	12.51	245	167	11.4	6	3	18	1	1	1
19990224	1999	2	24	14	8.73	12.5	9.48	200	175	16.1	20	10	47	37	33	37
19990303	1999	3	3	8	12.76	16.67	11.96	222	182	20	3	2	44	4	2	4
19990330	1999	3	30	1	7.7	16.67	10.54	257	233	10	41	18	22	5	11	5
19991028	1999	10	28	11	8.81	14.29	10.51	230	183	12.7	18	4	31	6	7	6
20001028	2000	10	28	19	8.54	16.67	9.74	257	152	25.4	19	8	15	7	12	14
20001028	2000	10	28	20	8.8	14.29	10.01	227	159	14.8	24	12	16	8	14	17
20010302	2001	3	2	18	7.3	16.67	11.68	287	230	7.9	49	42	7	9	24	21
20011023	2001	10	23	13	9.39	14.29	11.23	298	275	11	9	38	4	10	22	19
20011120	2001	11	20	7	8.34	12.5	9.29	200	199	14.9	27	6	34	26	20	25
20011128	2001	11	28	17	8.86	12.5	9.47	192	210	12.5	15	16	41	38	31	39
20011202	2001	12	2	1	8.57	14.29	9.49	241	240	15.7	23	22	30	27	21	26
20011211	2001	12	11	1	7.93	12.5	9.6	298	302	10.2	37	51	9	46	47	41
20011214	2001	12	14	12	10.08	14.29	10.43	297	187	12.6	4	45	17	28	27	29
20020107	2002	1	7	22	8.34	16.67	9.8	258	192	14.2	28	5	25	11	6	7
20020312	2002	3	12	18	7.64	16.67	10.17	277	217	10.1	44	27	11	12	16	18
20021108	2002	11	8	7	7.27	16.67	10.22	260	176	12.2	51	11	6	2	9	2
20021215	2002	12	15	23	9.31	12.5	9.43	230	174	22.3	11	28	43	44	43	44
20021227	2002	12	27	15	8.07	11.11	8.94	190	205	18.9	35	39	52	50	50	50
20030102	2003	1	2	3	8.11	11.11	8.86	212	186	17.1	32	20	39	39	35	38
20030313	2003	3	13	16	8.98	12.5	9.77	204	204	16.6	13	14	42	29	25	33
20031009	2003	10	9	6	8.85	16.67	11.42	278	248	8.7	17	29	14	13	8	8
20031012	2003	10	12	10	9.64	16.67	11.62	271	232	12.1	7	21	20	14	3	9
20031117	2003	11	17	11	9.27	16.67	10.64	312	279	10.8	12	41	3	15	29	15
20031216	2003	12	16	23	8.08	11.11	9.94	212	266	8	33	34	1	30	32	3
20031225	2003	12	25	13	7.34	14.29	11.46	274	276	8.4	48	40	10	16	23	24
20040217	2004	2	17	10	7.84	16.67	11.5	242	157	6	39	19	26	17	10	10
20051221	2005	12	21	6	7.66	14.29	10.7	219	168	8.3	43	23	28	18	18	23
20051230	2005	12	30	9	7.85	12.5	9.07	202	197	11	38	24	36	40	38	42
20060102	2006	1	2	1	7.56	12.5	9.19	219	199	10.3	45	30	35	41	40	43
20060105	2006	1	5	21	8.86	16.67	12.52	239	170	7.6	16	7	21	19	4	11
20060130	2006	1	30	9	8.08	11.11	9.08	202	198	17.4	34	43	50	51	51	51
20060204	2006	2	4	13	13.75	16.67	11.56	230	205	20.1	2	1	37	20	5	12
20060302	2006	3	2	16	7.22	11.11	8.65	197	195	12.9	52	33	46	45	45	47
20060309	2006	3	9	7	7.68	12.5	9.43	294	278	11.5	42	50	24	43	46	45
20061024	2006	10	24	23	7.4	16.7	11.7	305	308	8.8	46	48	2	21	41	22
20061113	2006	11	13	8	8.7	12.5	9.3	240	276	18.3	21	36	29	36	39	36
20061116	2006	11	16	3	8.7	12.5	9.7	205	291	10.2	22	31	40	42	36	40
20061212	2006	12	12	0	8.4	12.5	9.2	223	213	12.1	26	17	32	31	30	35
20061215	2006	12	15	6	10.1	12.5	9.8	216	225	20.9	5	26	49	47	44	46
20061221	2006	12	21	13	8.3	14.3	10.7	261	211	9.9	30	25	19	22	17	20
20061227	2006	12	27	16	8.3	11.1	8.9	307	319	18.6	29	52	38	52	52	52
20070106	2007	1	6	15	7.3	14.3	9.9	287	289	9.3	50	49	5	32	42	28
20071009	2007	10	9	20	7.71	16	9.6	237	161	13.8	40	9	23	23	15	13
20071112	2007	11	12	14	9.36	10.81	9.17	219	176	20.6	10	44	48	48	49	48
20071203	2007	12	3	17	14.12	16	12.21	193	180	22.1	1	13	45	33	28	34
20081213	2008	12	13	8	9.6	14	10.9	300	290	17	8	46	12	34	34	31
20081225	2008	12	25	19	8.2	16	11	307	340	12	31	47	13	35	37	32

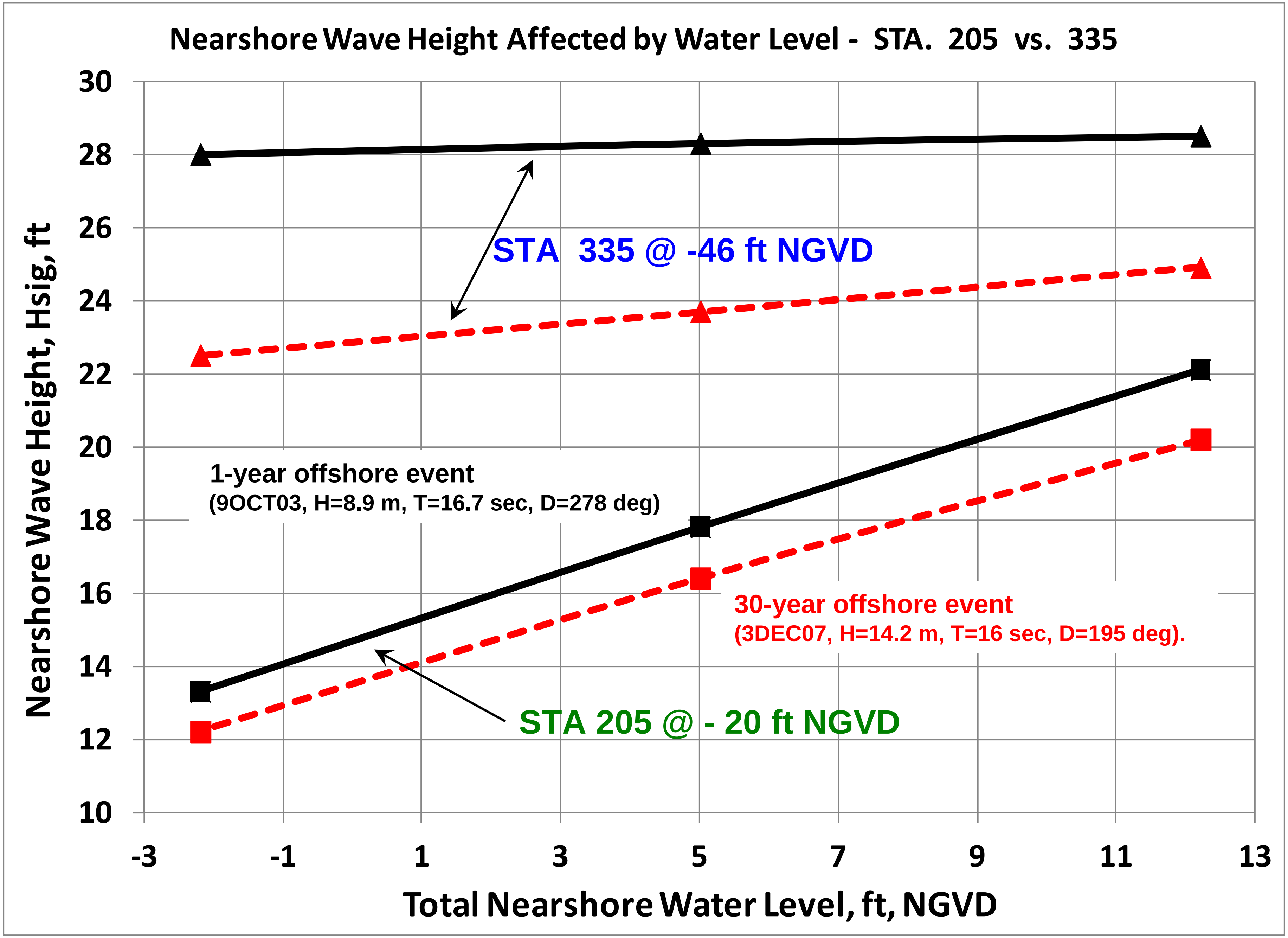
* Offshore wave conditions are ordered according to observation date and time (storm ID). Ranking of wave events is performed seperatly for the observed offshore condition and for several areas along the MCR jetties.
Note that event ranking is different depending upon location (offshore vs. nearshore), due to the interaction of the wave field with bathymetry. Ranking results for the nearhore areas are based on STWAVE simul

Offshore

STA 205 **STA 335**

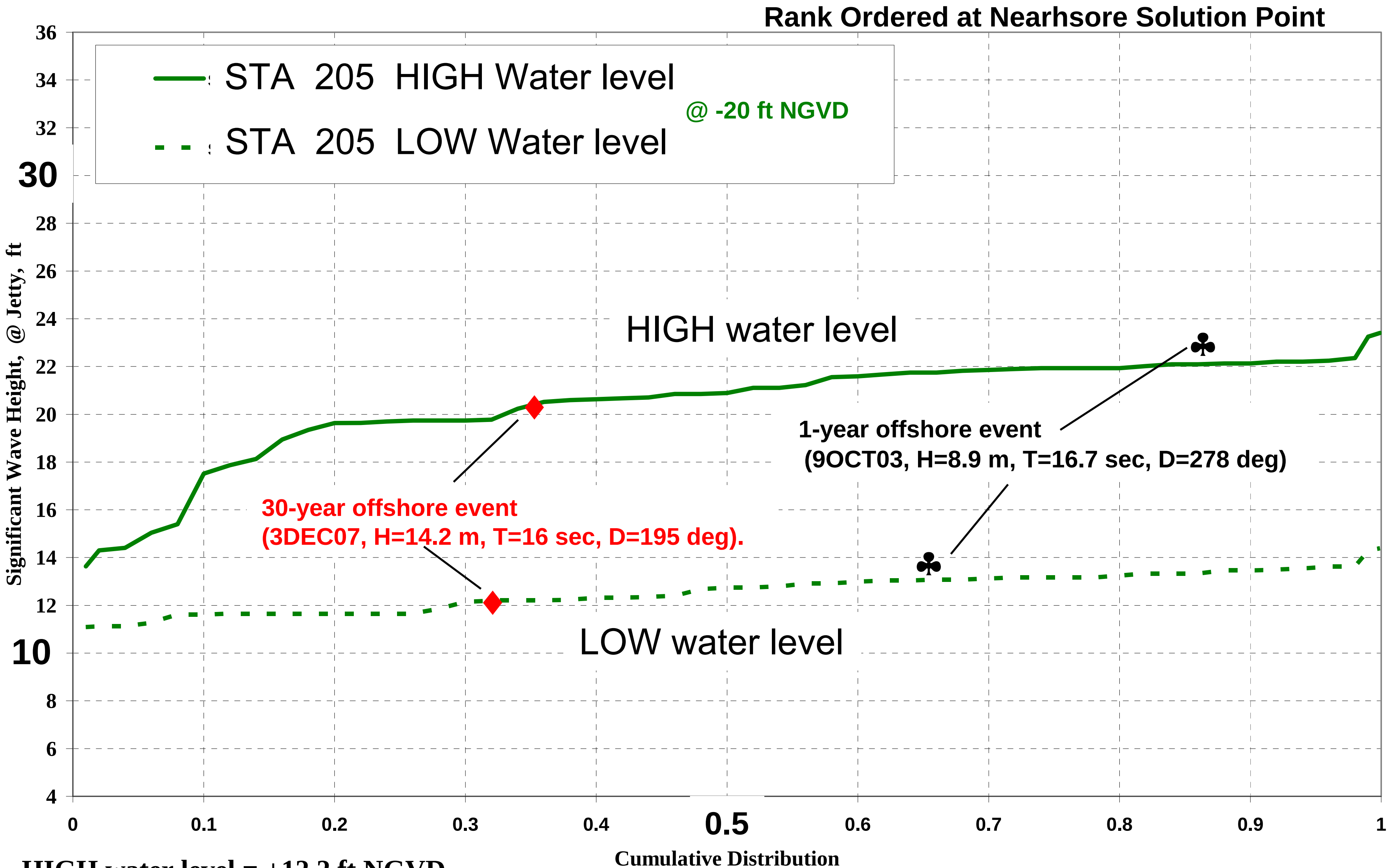


Nearshore Wave Height Affected by Water Level - STA. 205
Nearshore Wave Height, Hsig, ft
30
28
26
24
22
20
18
16
14
12
10
-3
-1
1
3
5
7
9
11
13
Total Nearshore Water Level, ft, NGVD
1-year offshore event
(9OCT03, H=8.9 m, T=16.7 sec, D=278 deg)
30-year offshore event
(3DEC07, H=14.2 m, T=16 sec, D=195 deg).
STA 205 @ - 20 ft NGVD



Nearshore Wave Height Affected by Water Level - STA. 205 vs. 335
Nearshore Wave Height, Hsig, ft
30
28
26
24
22
20
18
16
14
12
10
-3
-1
1
3
5
7
9
11
13
Total Nearshore Water Level, ft, NGVD
STA 335 @ -46 ft NGVD
1-year offshore event
(9OCT03, H=8.9 m, T=16.7 sec, D=278 deg)
30-year offshore event
(3DEC07, H=14.2 m, T=16 sec, D=195 deg).
STA 205 @ - 20 ft NGVD

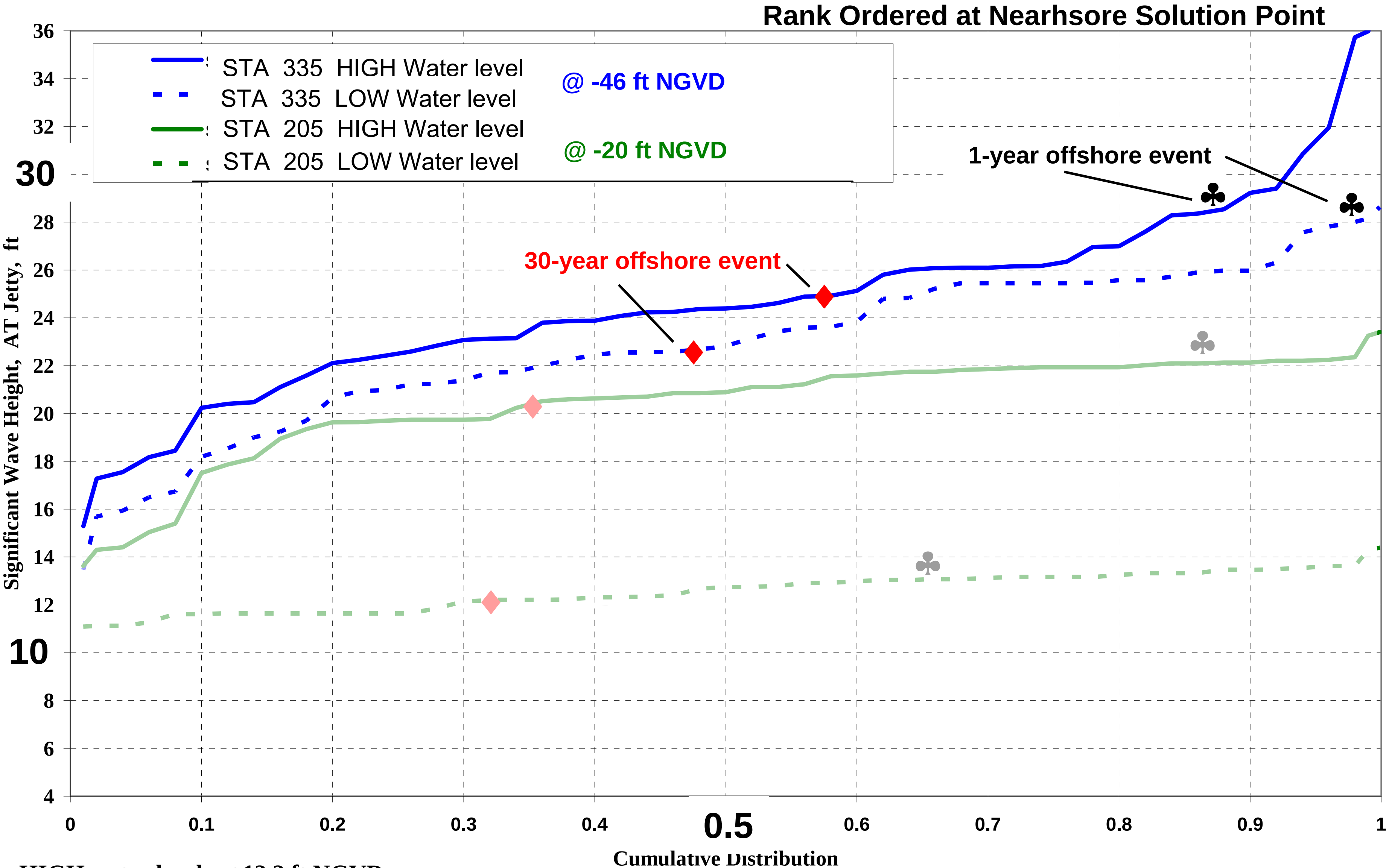
ALL 52 Offshore Wave Events Transformed to Nearshore Solution Point



HIGH water level = +12.2 ft NGVD,
= tide level of 3.4 ft NGVD + a 10-year static storm surge of 4.8 ft + a 2-year infragravity transient of +4.0 ft.

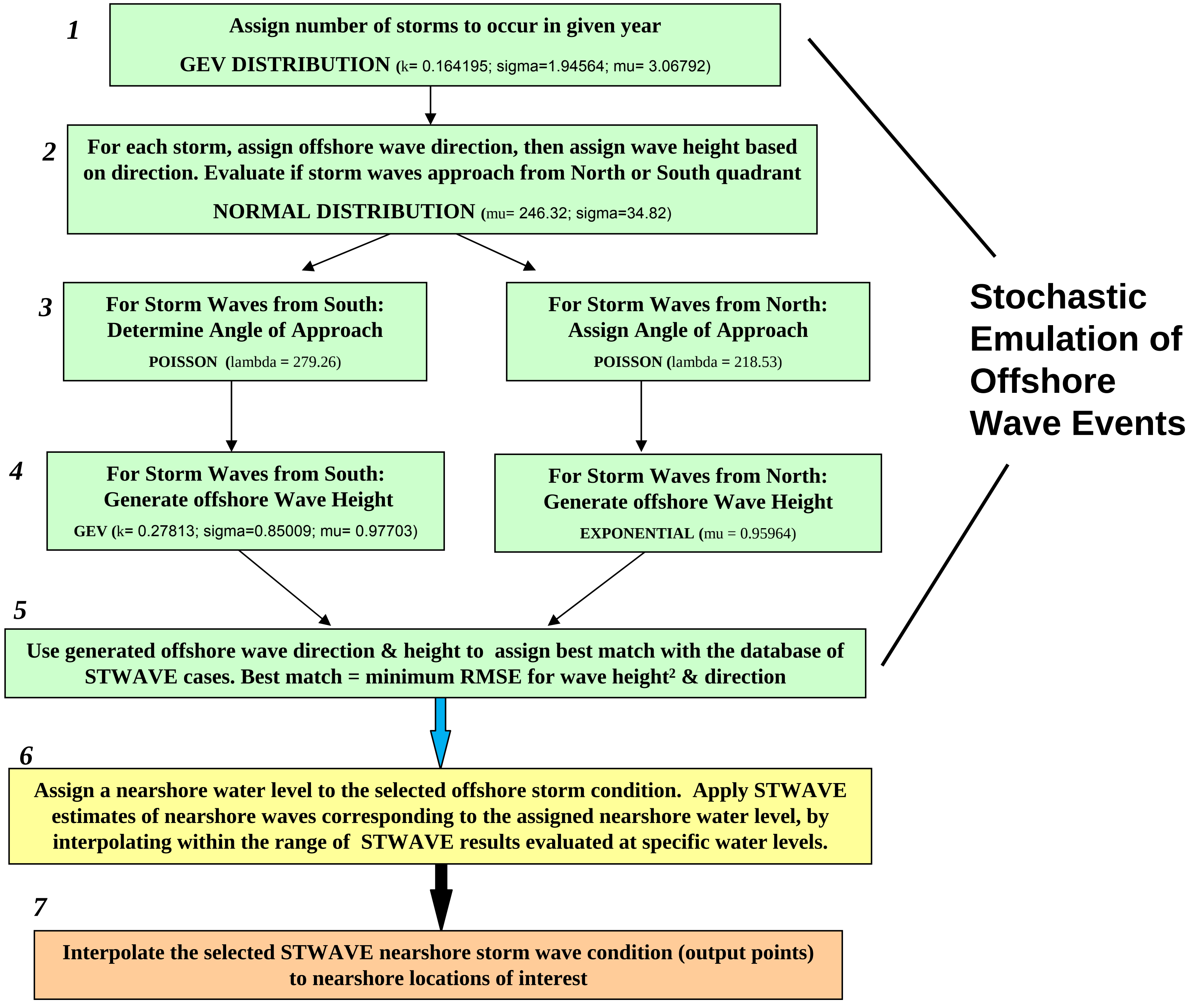
LOW water level = -2.2 ft NGVD,
= tide level of -2.7 ft NGVD + a static storm surge of 0.0 ft + a infragravity transient of +0.5 ft.

ALL 52 Offshore Wave Events Transformed to Nearshore Solution Point

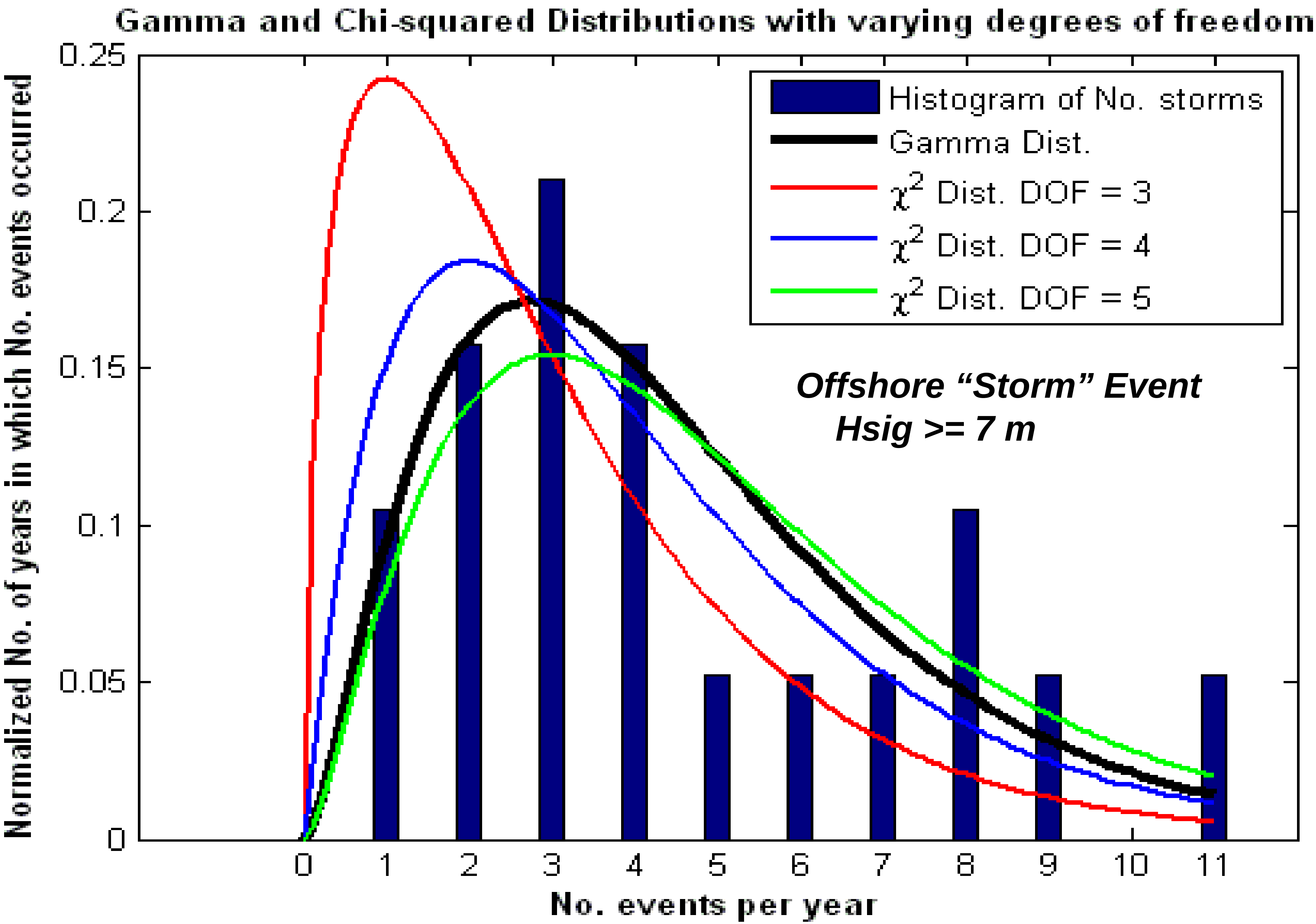


HIGH water level = +12.2 ft NGVD,
= tide level of 3.4 ft NGVD + a 10-year static storm surge of 4.8 ft + a 2-year infragravity transient of +4.0 ft.

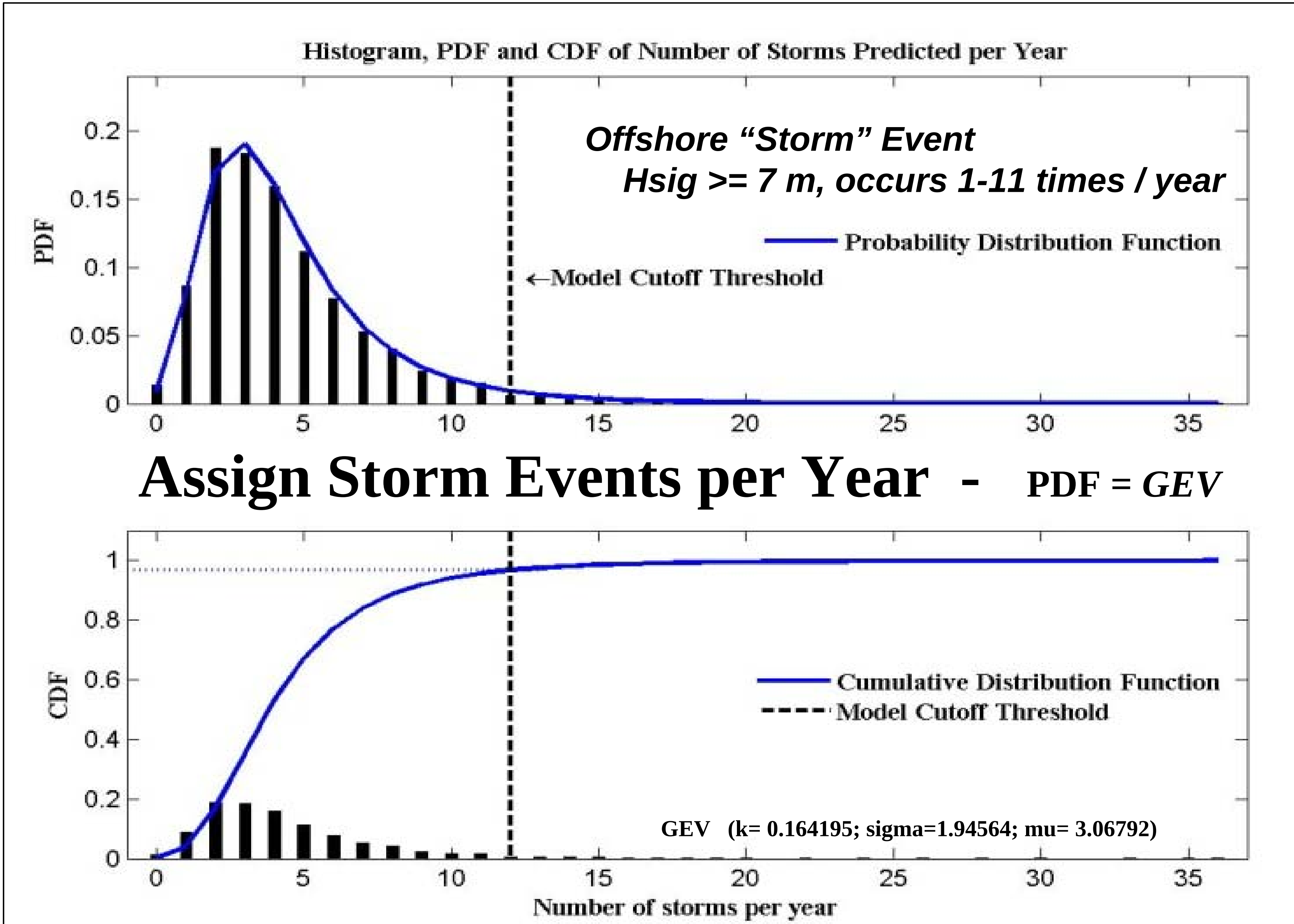
LOW water level = -2.2 ft NGVD,
= tide level of -2.7 ft NGVD + a static storm surge of 0.0 ft + a infragravity transient of +0.5 ft.

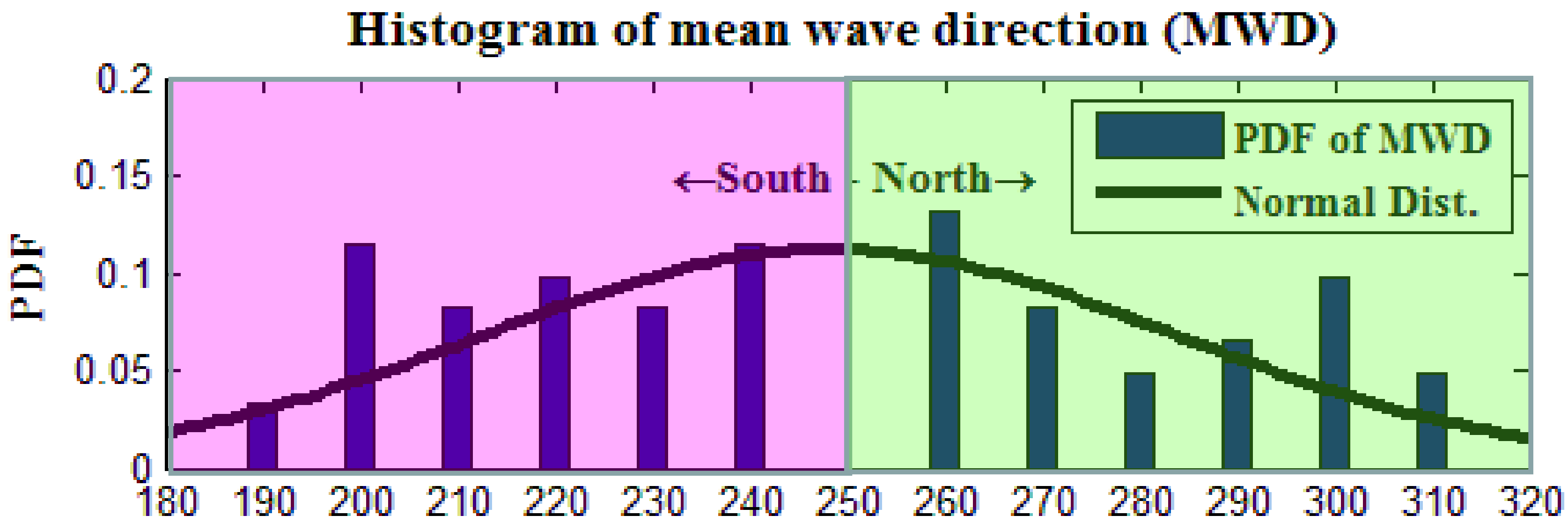

1
Assign number of storms to occur in given year
GEV DISTRIBUTION (k= 0.164195; sigma=1.94564; mu= 3.06792)
2
For each storm, assign offshore wave direction, then assign wave height based on direction. Evaluate if storm waves approach from North or South quadrant
NORMAL DISTRIBUTION (mu= 246.32; sigma=34.82)
3
For Storm Waves from South: Determine Angle of Approach
POISSON (lambda = 279.26)
For Storm Waves from North: Assign Angle of Approach
POISSON (lambda = 218.53)
4
For Storm Waves from South: Generate offshore Wave Height
GEV (k= 0.27813; sigma=0.85009; mu= 0.97703)
For Storm Waves from North: Generate offshore Wave Height
EXPONENTIAL (mu = 0.95964)
5
Use generated offshore wave direction & height to assign best match with the database of STWAVE cases. Best match = minimum RMSE for wave height² & direction
6
Assign a nearshore water level to the selected offshore storm condition. Apply STWAVE estimates of nearshore waves corresponding to the assigned nearshore water level, by interpolating within the range of STWAVE results evaluated at specific water levels.
7
Interpolate the selected STWAVE nearshore storm wave condition (output points) to nearshore locations of interest
Stochastic Emulation of Offshore Wave Events

“Finding” the Best Fit PDF: Storm Events per Year

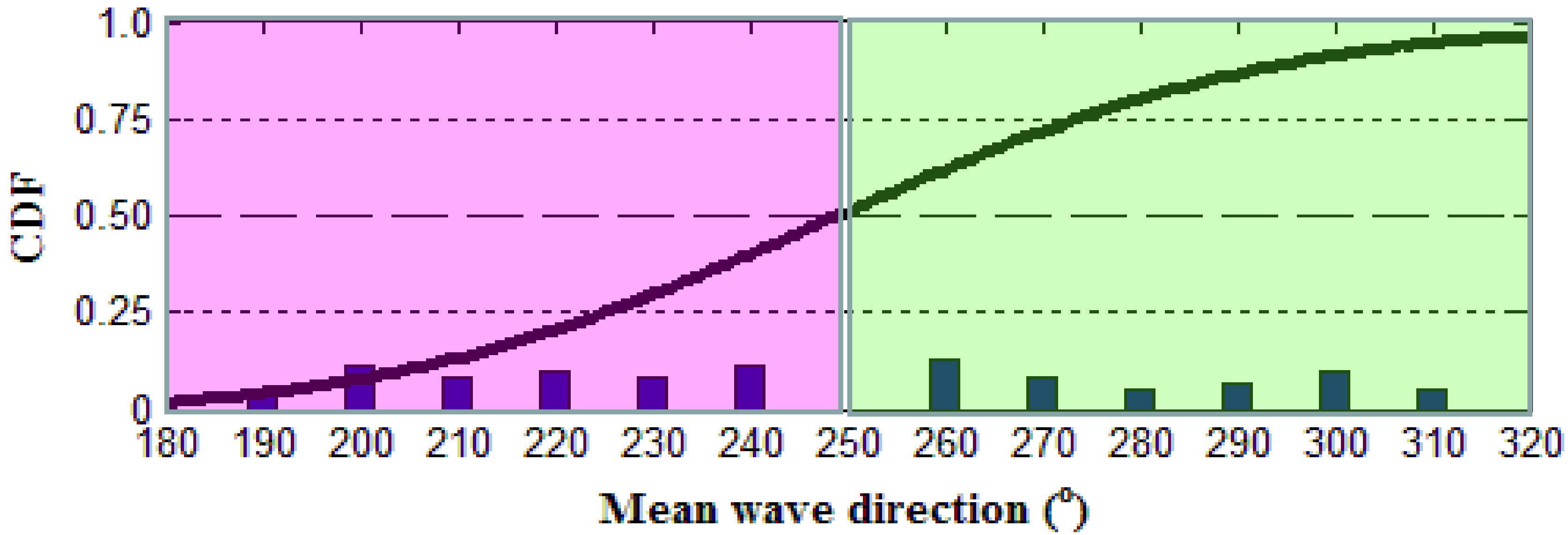


Best Fit PDF for “Storm Events per Year” = GEV

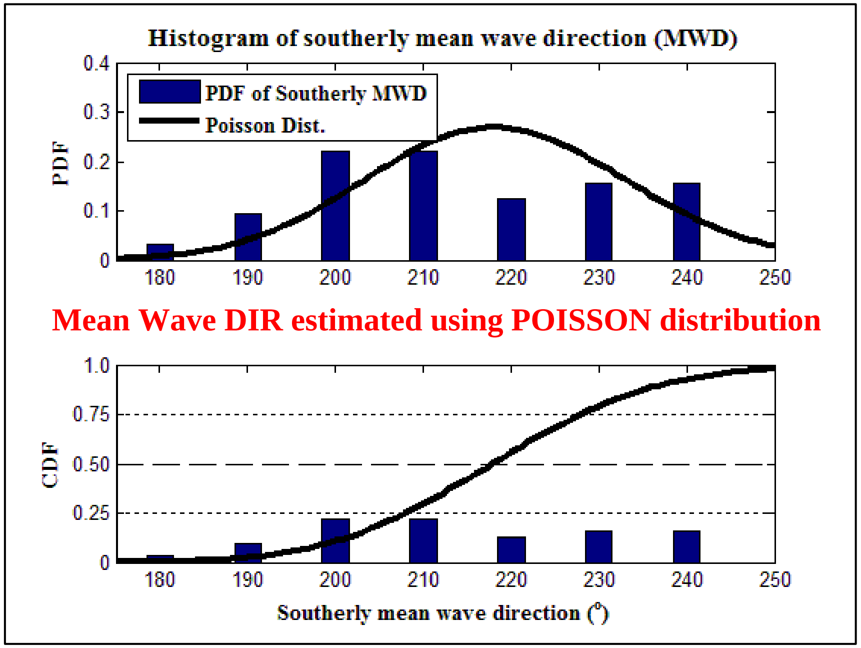


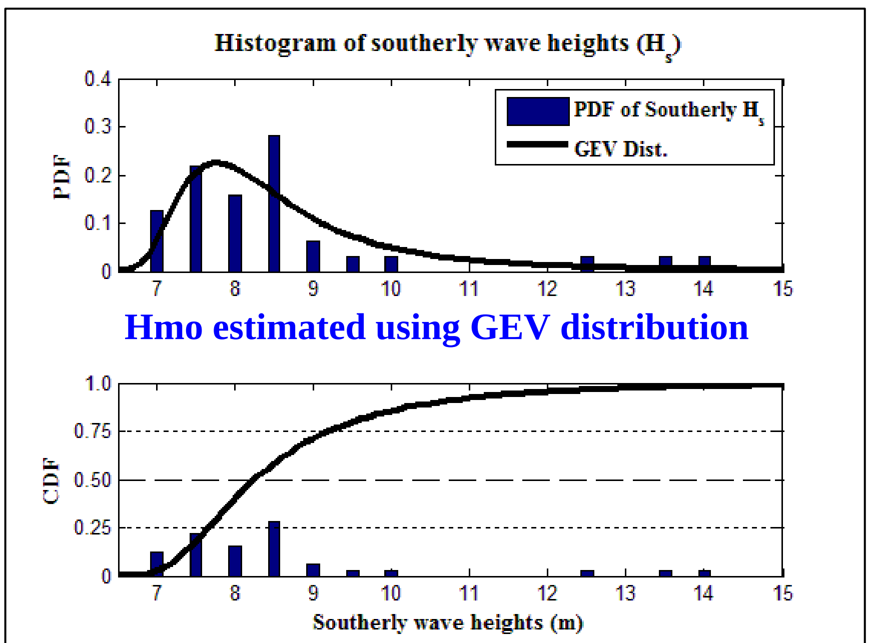


For each Storm Event --- Assign Offshore Direction - PDF = *Normal*

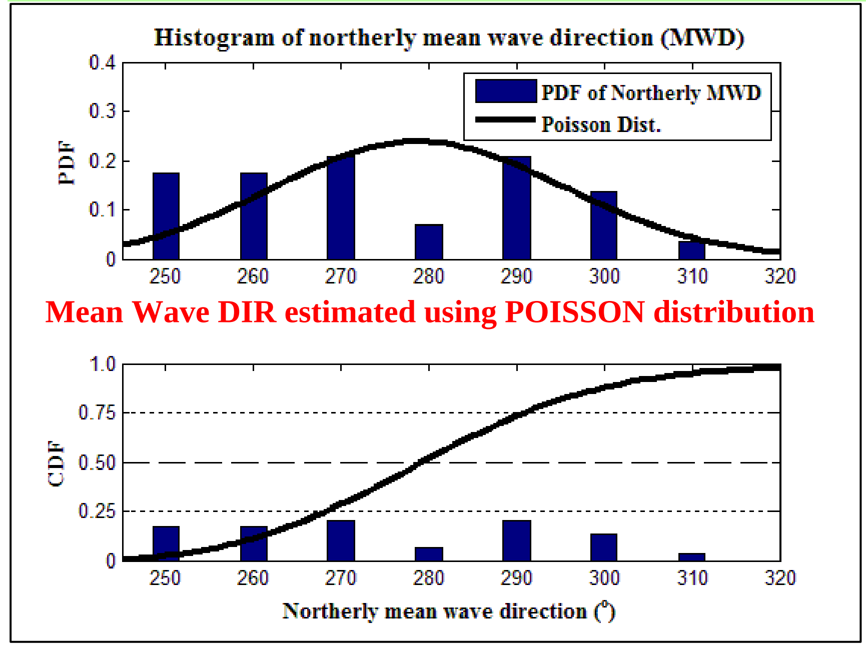


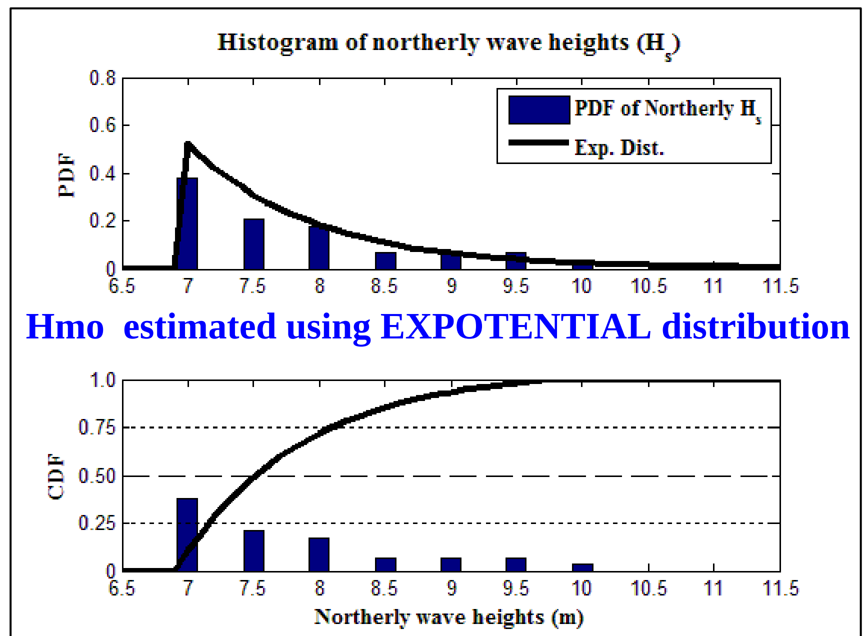
Offshore Waves from SOUTH of 250 DEG

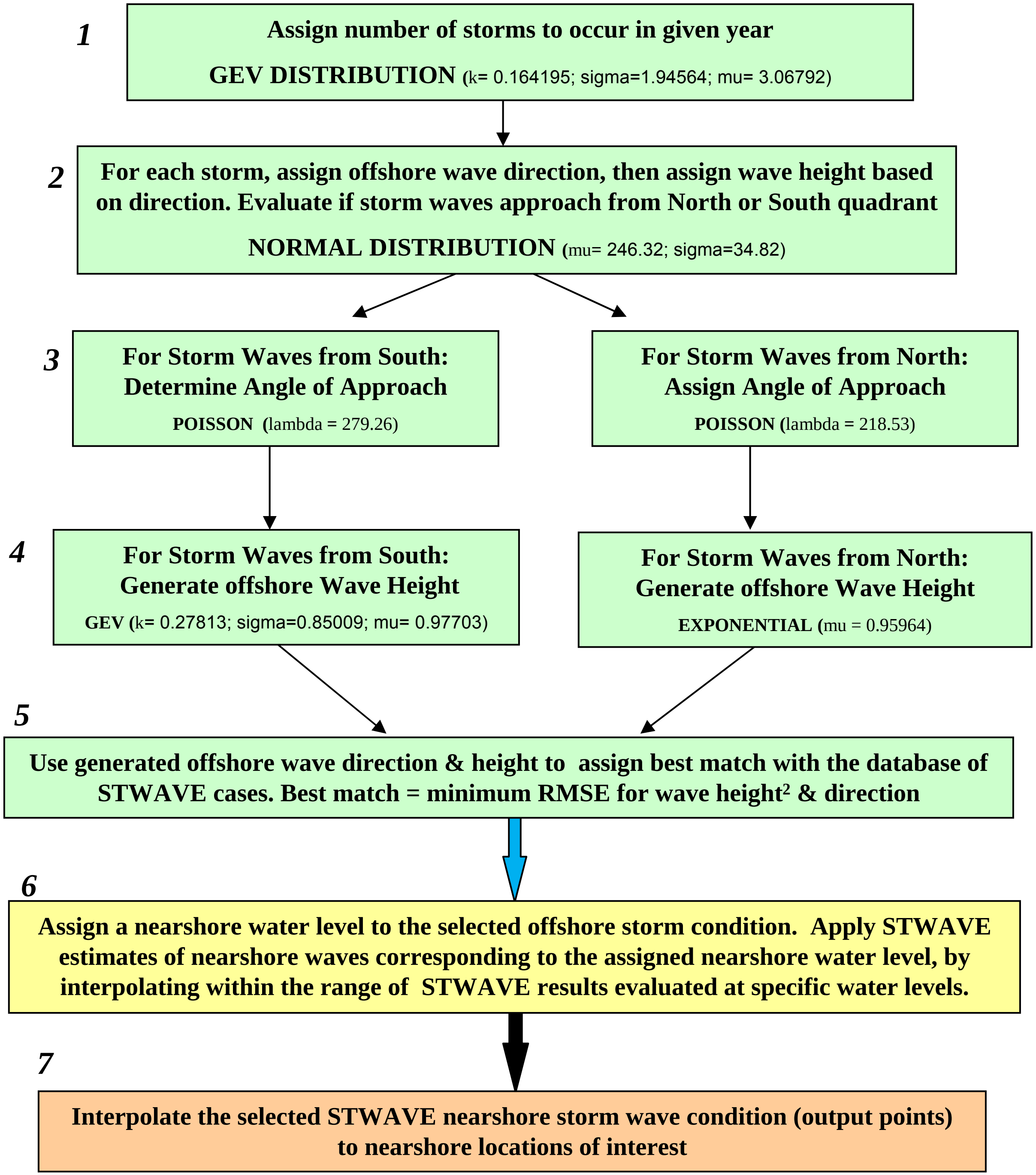




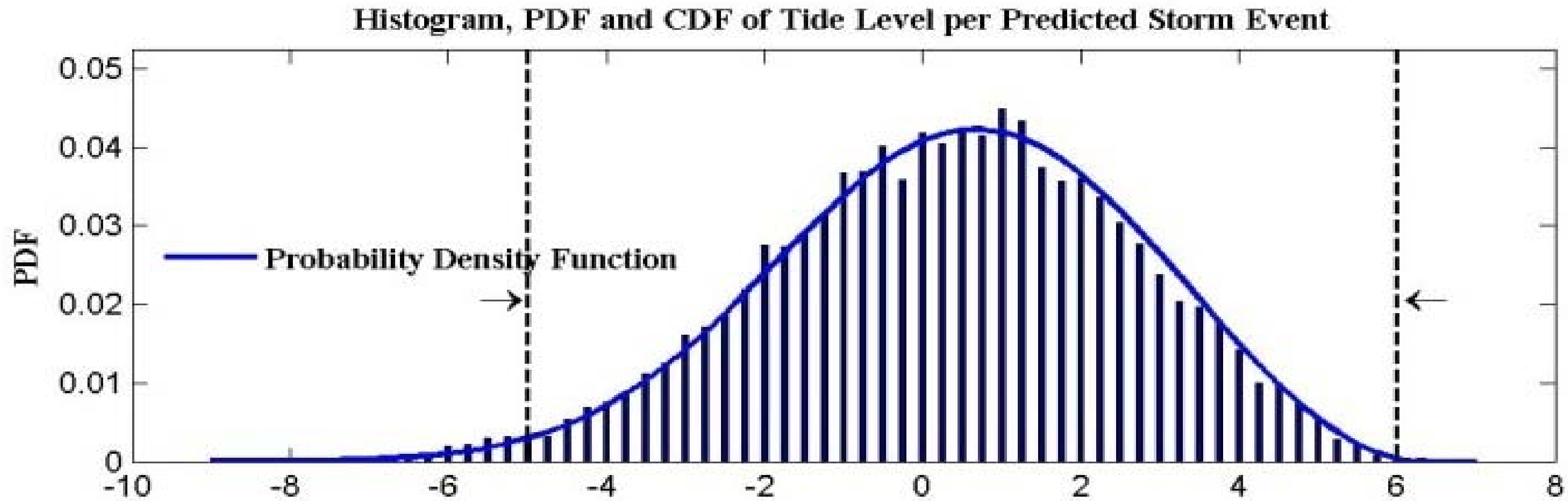
Offshore Waves from NORTH of 250 DEG



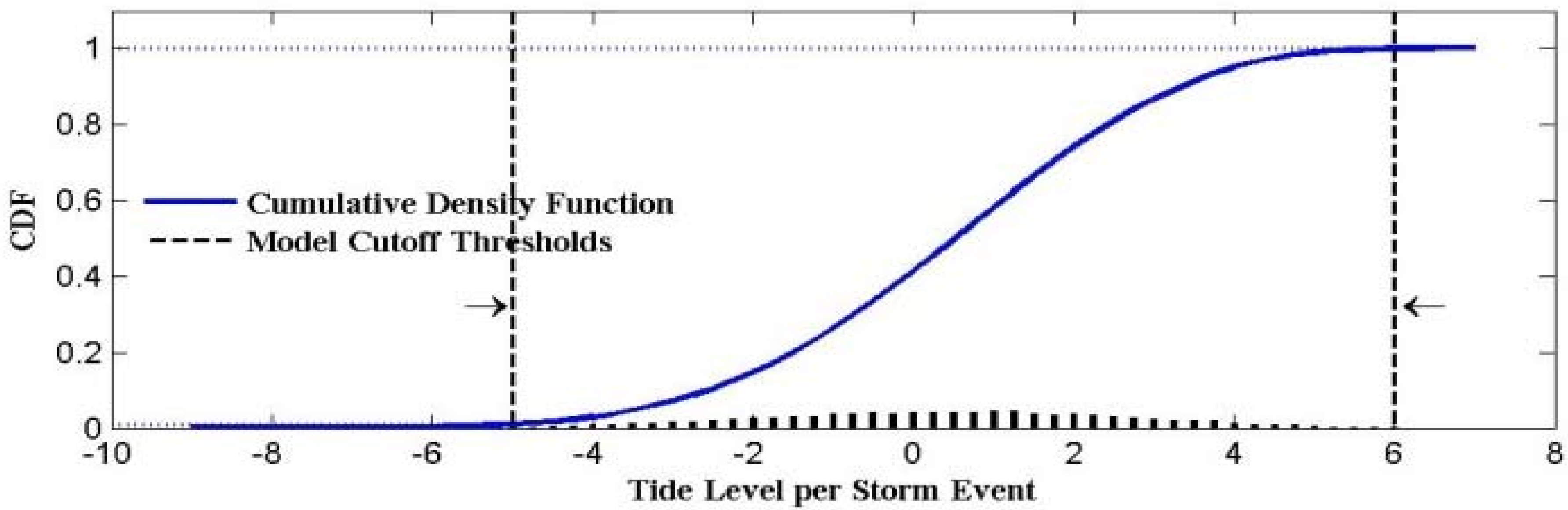




Stochastic Emulation of Nearshore Water level for Each Wave Event



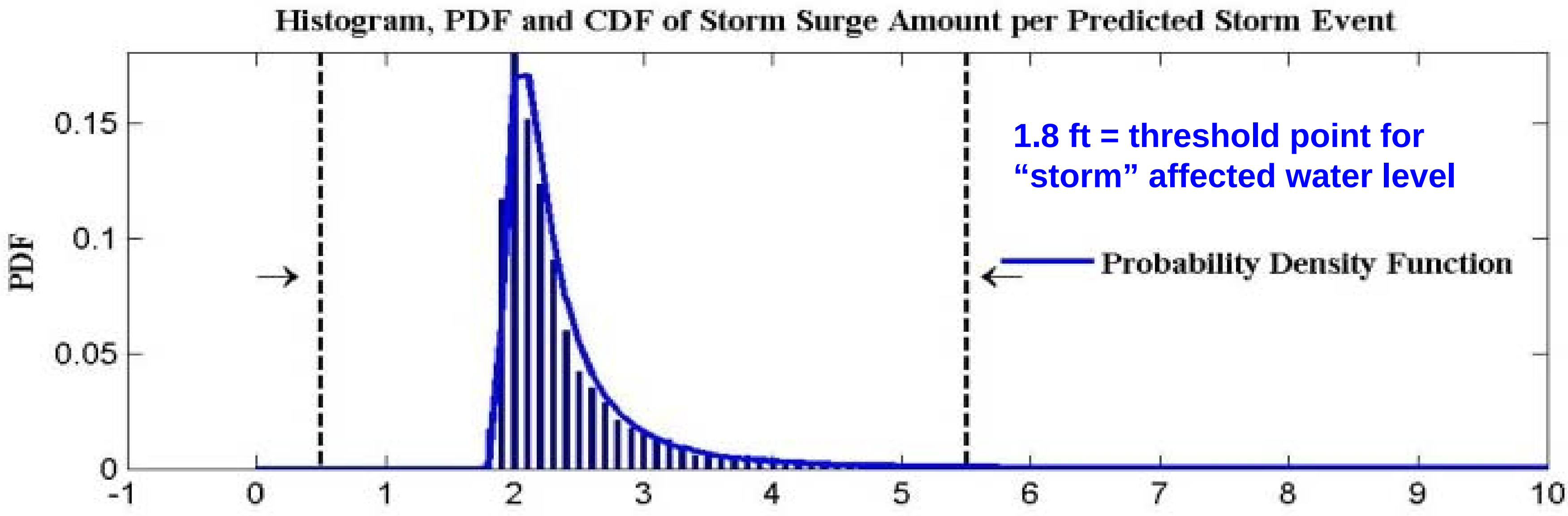
Assign Astronomical Tide, ft, NGVD - **PDF = *GEV***



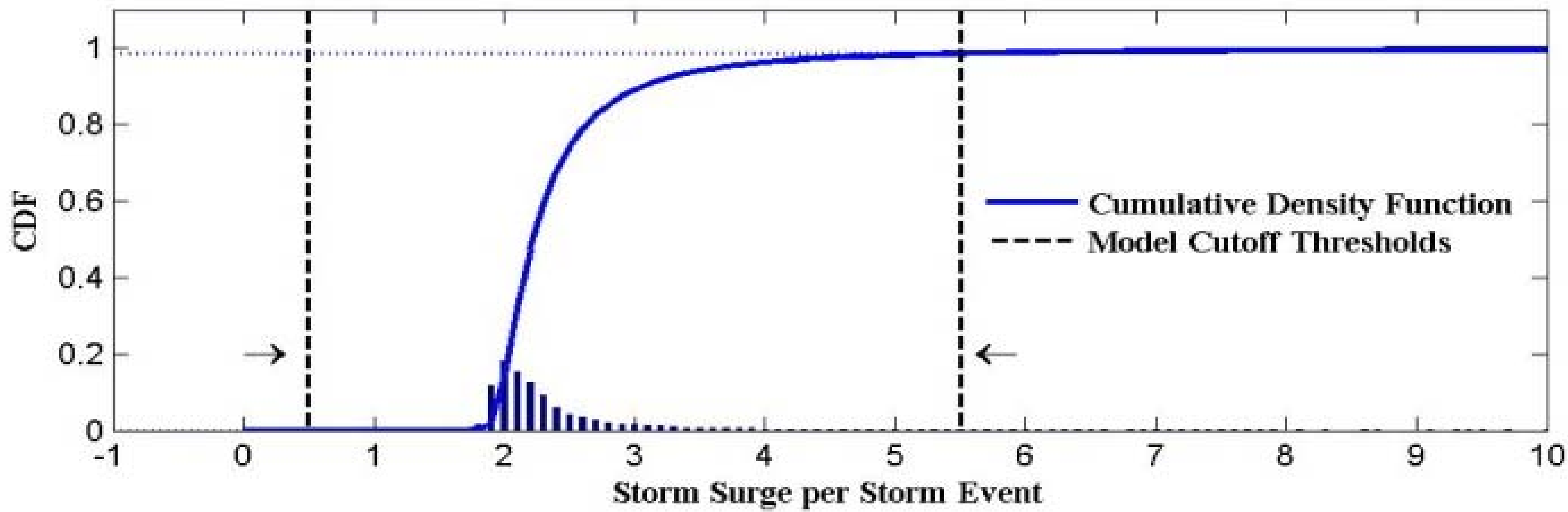
0 ft NGVD = 3.5 ft MLLW

ft NGVD

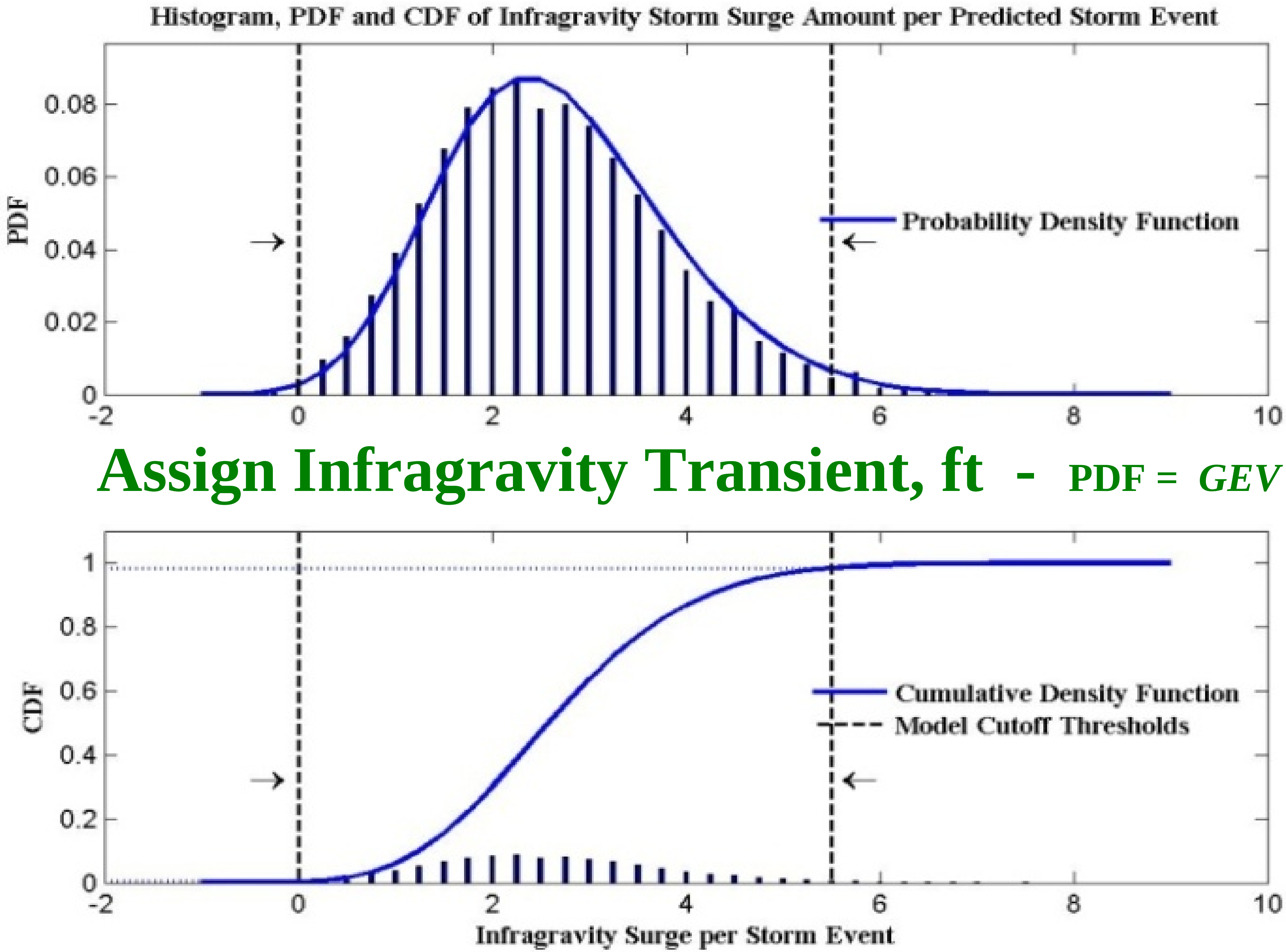
GEV (k= -0.356828; sigma=2.33657 mu= -0.285679)



Assign Static Storm Surge, ft - PDF = *GEV*



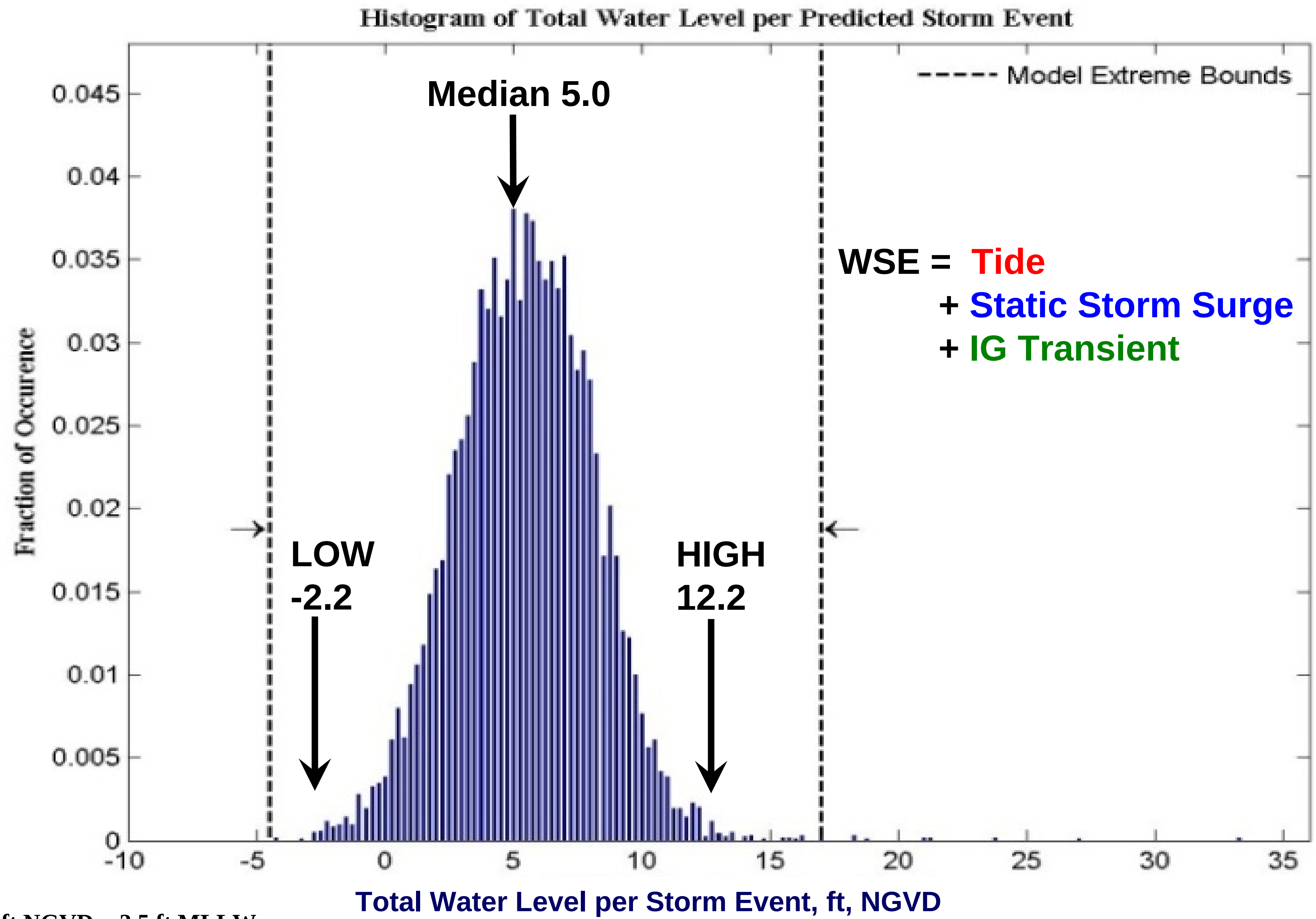
GEV (k= 0.490974; sigma=0.2278759 mu= 2.12916)



Assign Infragravity Transient, ft - PDF = *GEV*

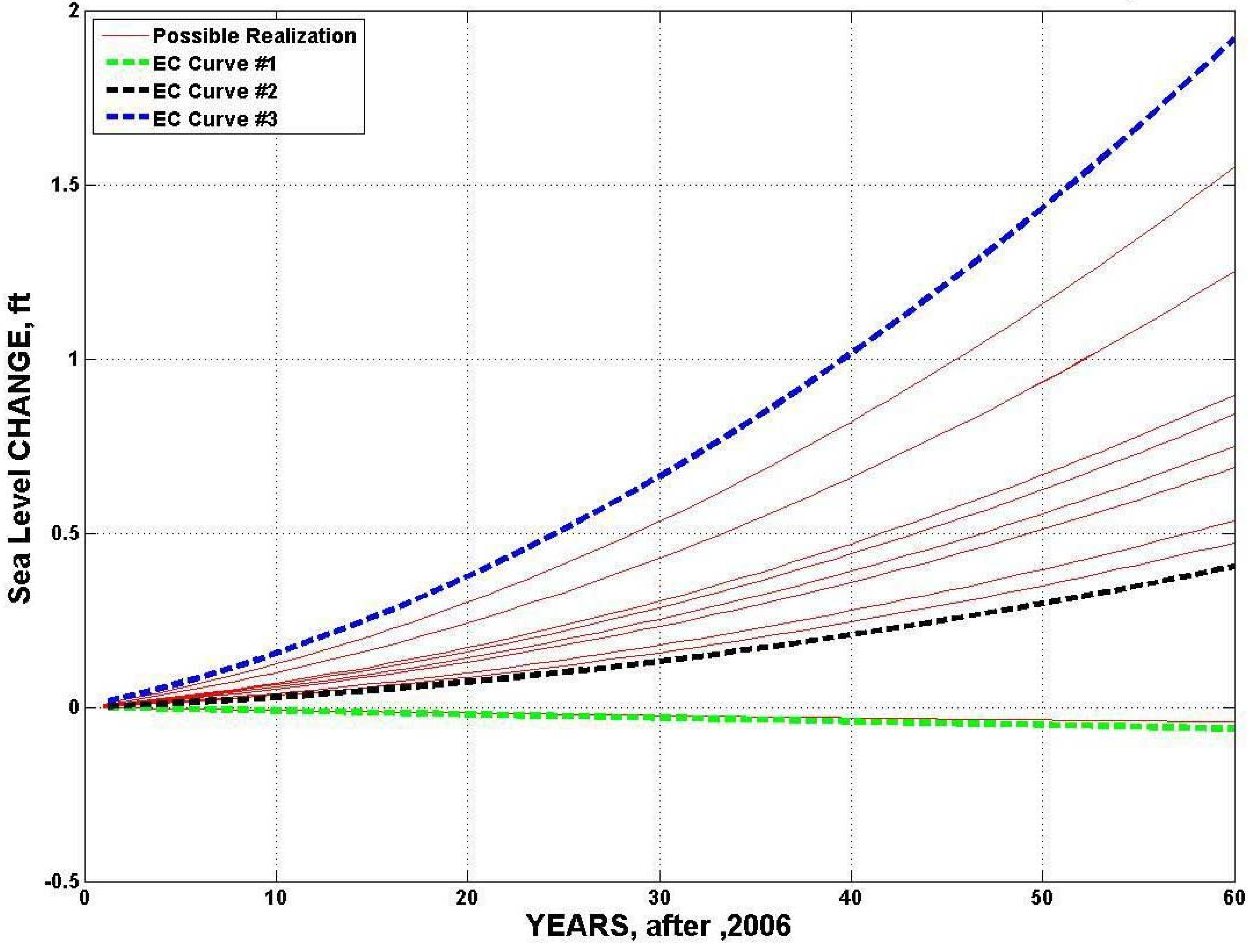
GEV (k= -0.15388; sigma=1.0674 mu= 2.200

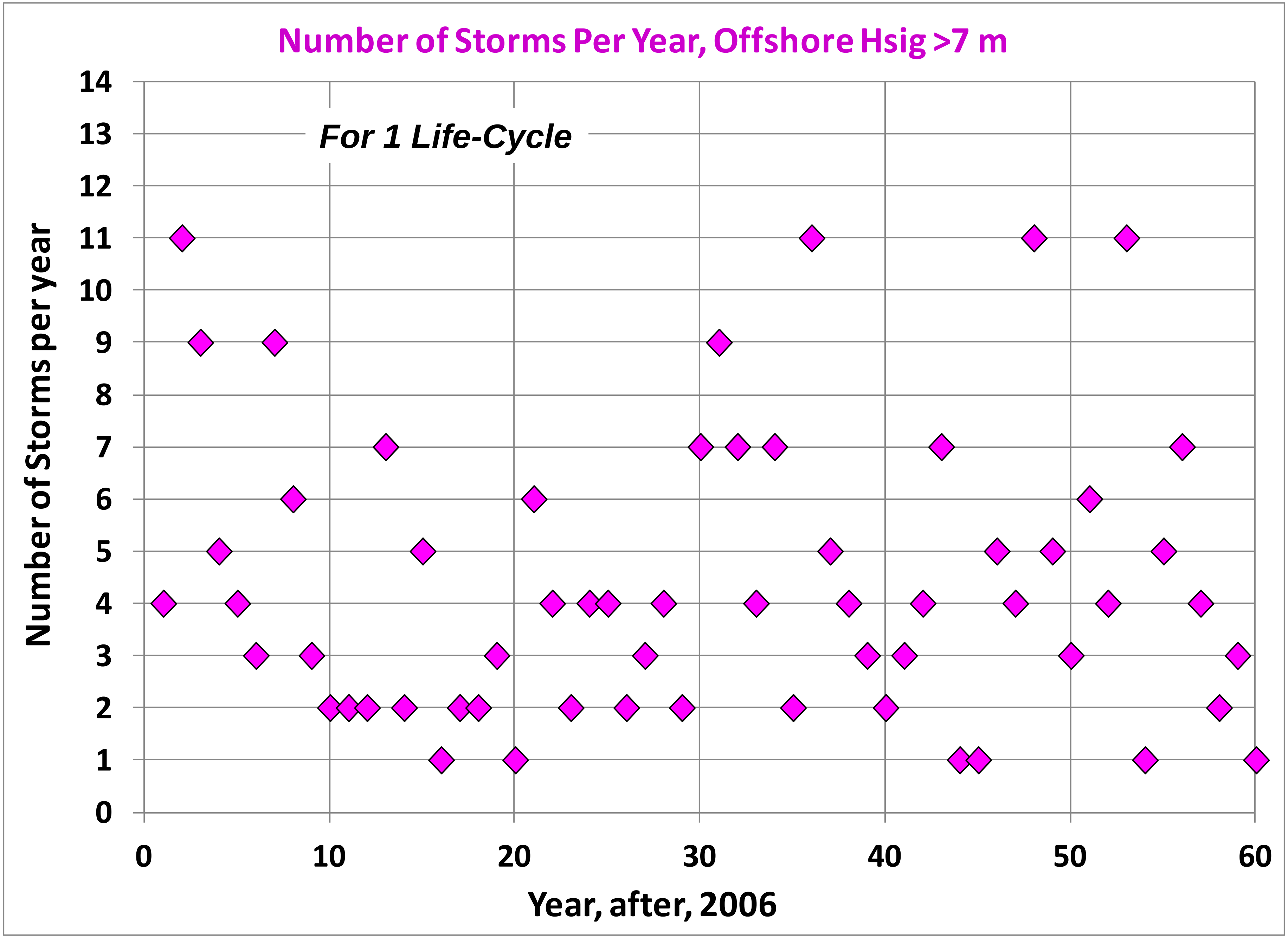
Total Water Level (WSE) Realized per Storm Event

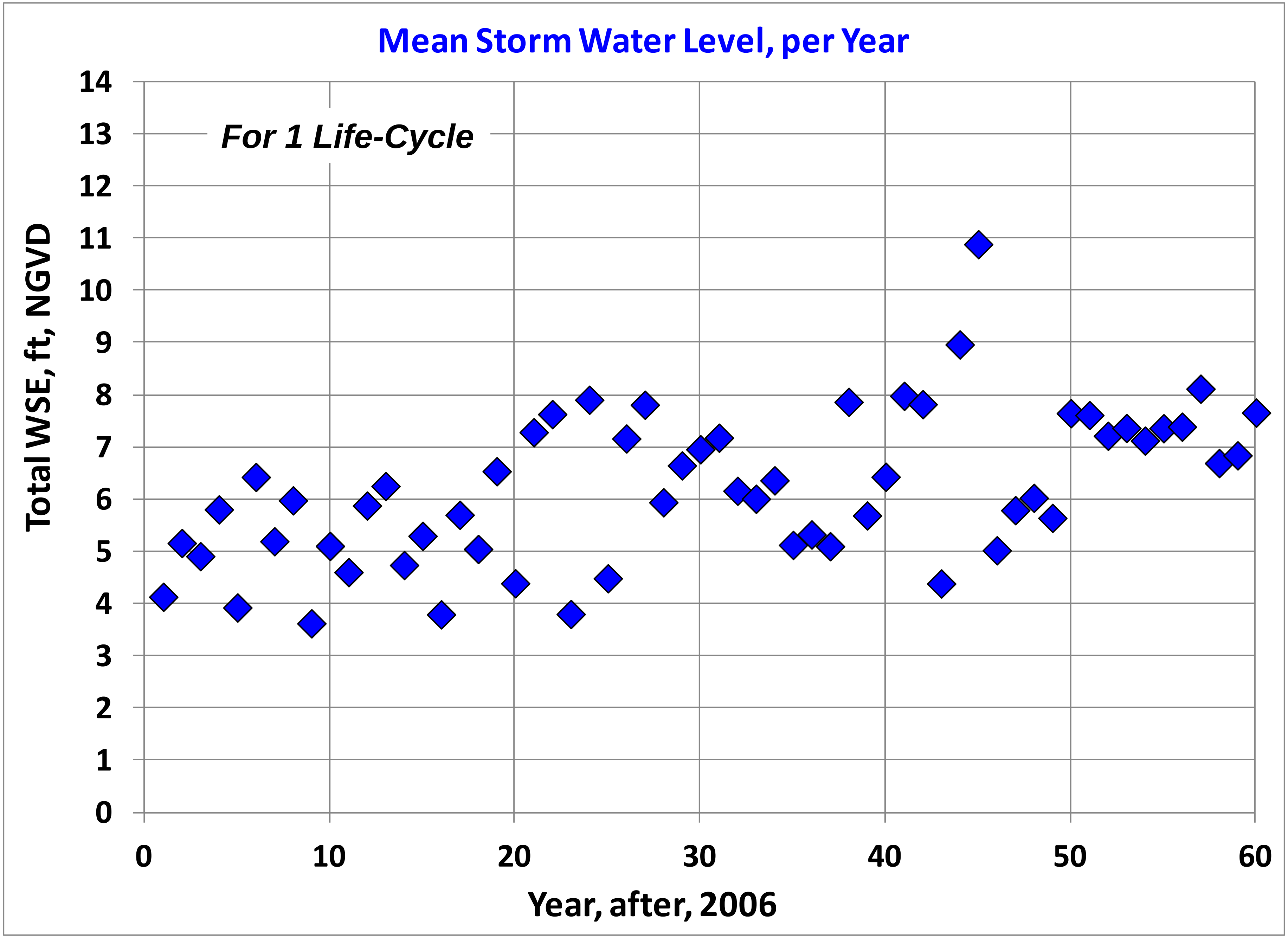


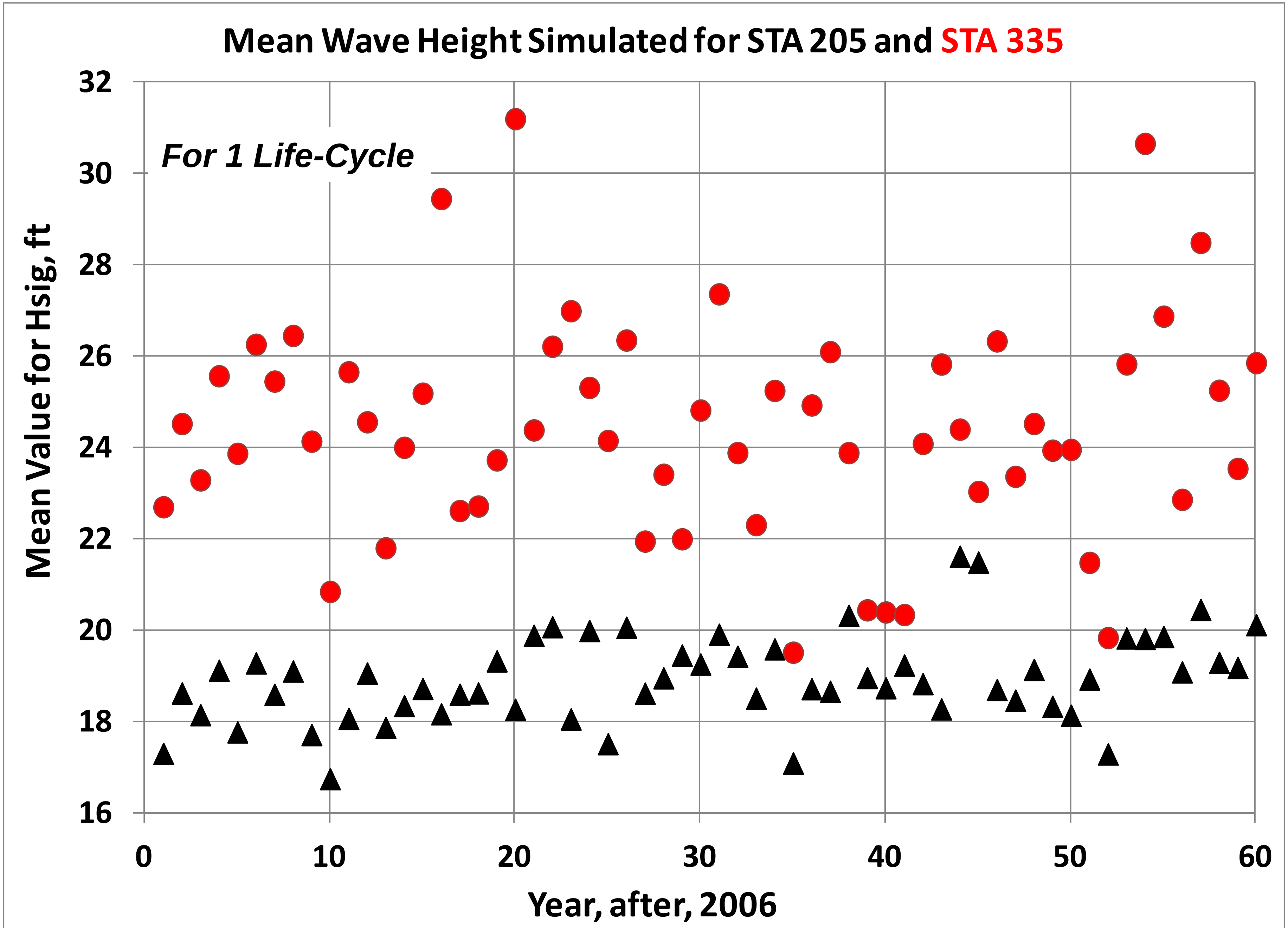
0 ft NGVD = 3.5 ft MLLW

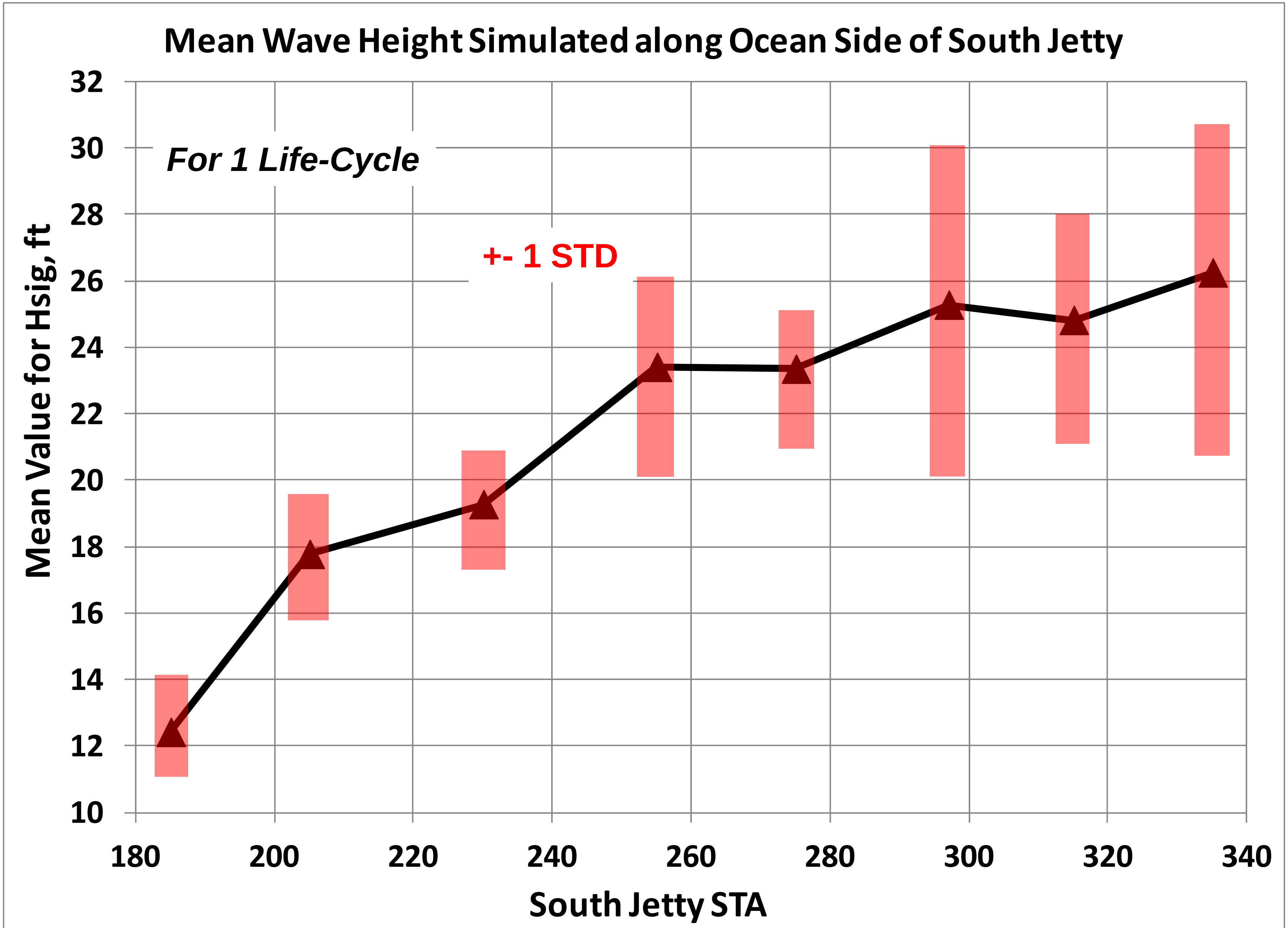
USACE - EC 1165-2-211 Sea Level Rise Forecast Estimate, Astoria,OR




Number of Storms Per Year, Offshore Hsig >7 m
For 1 Life-Cycle
Number of Storms per year
Year, after, 2006
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
0
10
20
30
40
50
60


Mean Storm Water Level, per Year
For 1 Life-Cycle
Total WSE, ft, NGVD
Year, after, 2006
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
0
10
20
30
40
50
60


Mean Wave Height Simulated for STA 205 and STA 335
For 1 Life-Cycle
Mean Value for Hsig, ft
Year, after, 2006
32
30
28
26
24
22
20
18
16
0
10
20
30
40
50
60



Mean Wave Height Simulated along Ocean Side of South Jetty
For 1 Life-Cycle
+- 1 STD
Mean Value for Hsig, ft
South Jetty STA
32
30
28
26
24
22
20
18
16
14
12
10
180
200
220
240
260
280
300
320
340

Conclusions

Nearshore Wave Environment is Modulated by Water Level

Depth Limitation: **H**sig / **D**epth = ~ 0.4 to 0.7

Depth Limitation Affected by “character” of waves (spectra) & bathymetry

Fully define the “Character” of Offshore Waves to Simulate Nearshore Conditions

Use Observed Directional Wave spectra for Model Boundary Conditions

Transform Offshore Waves to the Nearshore ---

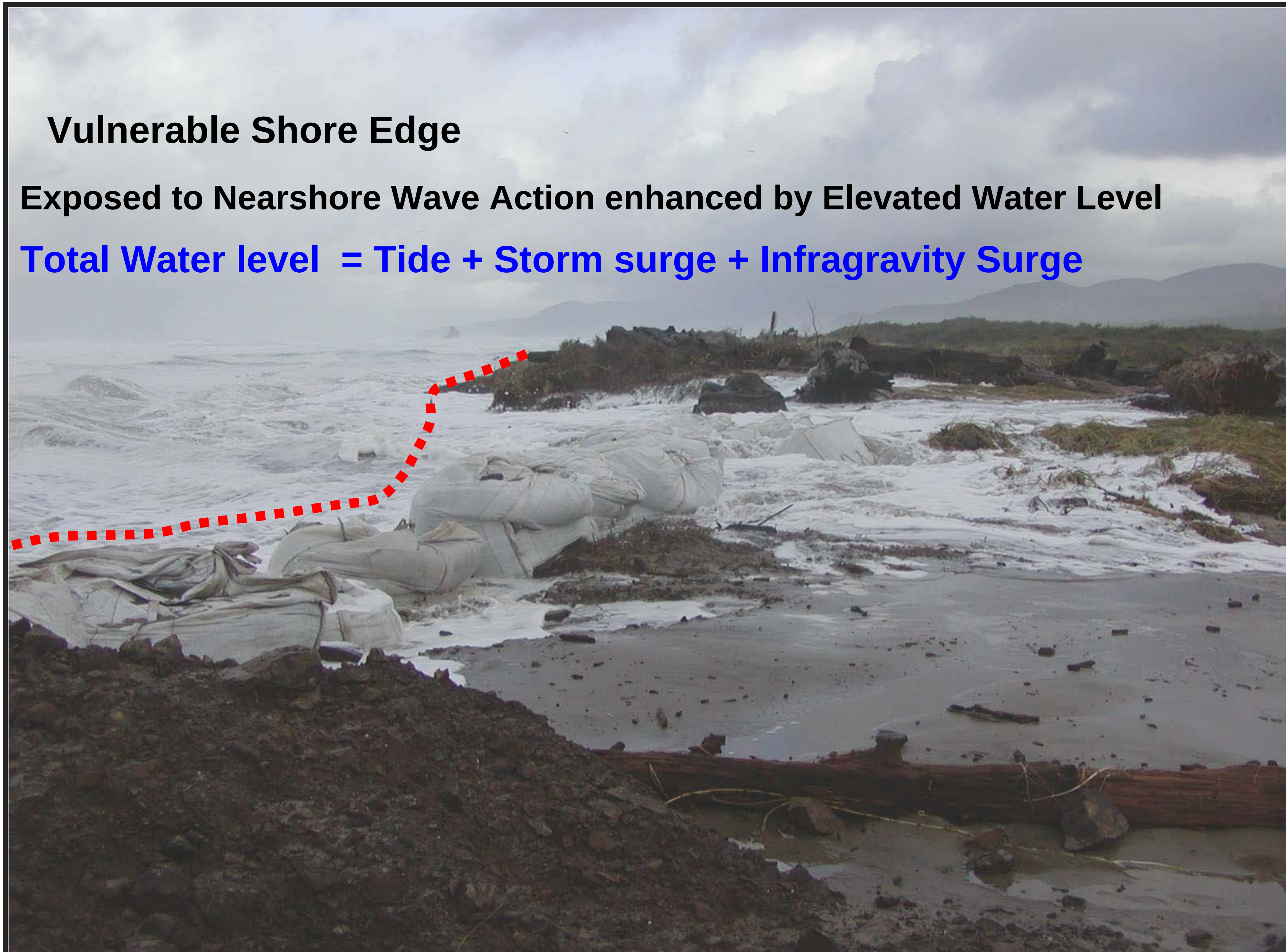
Requires Accurate Rendition of Bathymetry & Acceptable Wave Model

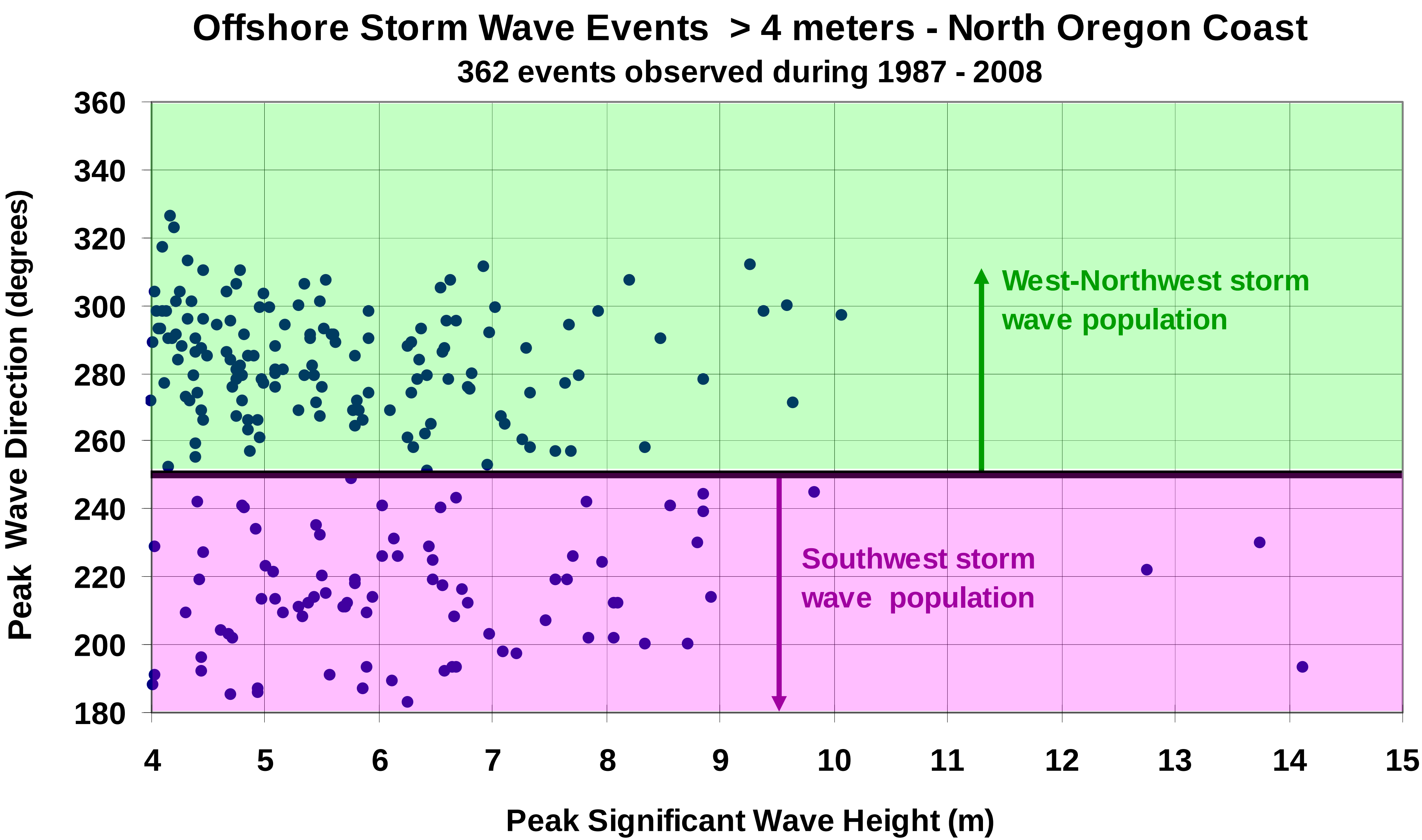
For a Given Water Level:

100-yr Offshore Wave Event ≠ 100-yr Nearshore Wave Event

1–yr Offshore Event produces Nearshore Waves > 30-yr Offshore Event


Vulnerable Shore Edge at Low Tide


Vulnerable Shore Edge
Exposed to Nearshore Wave Action enhanced by Elevated Water Level
Total Water level = Tide + Storm surge + Infragravity Surge



Offshore Storm Wave Events > 4 meters - North Oregon Coast
362 events observed during 1987 - 2008
Peak Wave Direction (degrees)
360
340
320
300
280
260
240
220
200
180
4
5
6
7
8
9
10
11
12
13
14
15
Peak Significant Wave Height (m)
West-Northwest storm wave population
Southwest storm wave population