CDIP:
Wave Observations
and Coastal Inundation Forecasting

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2nd INTERNATIONAL WORKSHOP ON WAVES,
STORM SURGES AND COASTAL HAZARDS
Melbourne, Australia

UC San Diego | SCRIPPS INSTITUTION OF OCEANOGRAPHY

- CDIP Overview
- Buoy Co-location
- Hurricane wave data
- Coastal inundation
- Wave power

COASTAL DATA INFORMATION PROGRAM

The Coastal Data Information Program
measures, analyzes,
archives and disseminates
coastal environment data
for use by coastal engineers, planners,
managers, scientists and mariners.

COASTAL DATA INFORMATION PROGRAM

- Established 1975
- ~ 70 wave buoy stations worldwide
- 13-person CDIP Waves operations team
- Major Fuding from:
  - US Army Corps or Engineers
  - California State Parks
  - Navy
- Partners:
  - NOAA IOOS
  - DOE National Renewable Energy Laboratory
  - NASA
  - Industry: Chevron, Marathon, PG&E

Primary Sponsor: US Army Corps of Engineers ®

ALASKA
241-Nome
204-Lower Cook Inlet
236-Kodiak
166 - Ocean Station Papa
205-Betton Island Ketchikan

MARSHALL ISLANDS
163-Kalo, Majuro

Northern Mariana Islands
197-Tanapag, Saipan
GUAM
196-Ritidian Point
121-Ipan

HAWAII
202 - Hanalei, Kauai
106 - Waimea Bay
198 - Kaneohe Bay
098 - Mokapu Point
165- Barbers Point
233- Pearl Harbor Entrance
187 - Pauwela, Mau
146 - Kaumalapau, Southwest Lanai
188 - Hilo

CANADA
WASHINGTON
036 - Grays Harbor
162 - Clatsop Spit
179 - Astoria Canyon
OREGON
139 - Umpqua Offshore
168 - Humboldt Bay North Spit
094 - Cape Mendocino
CALIFORNIA
029 - Point Reyes
142 - San Francisco Bar
185 - Monterey Bay West
158 - Cabrillo Point Nearshore
157 - Point Sur
076 - Diablo Canyon
222 - Santa Lucia Escarpment
071 - Harvest
111 - Anacapa Passage
028 - Santa Monica Bay
215 - Long Beach Channel
203- Santa Cruz Basin
092 - San Pedro
234 - Santa Barbara Island North
043 - Camp Pendleton Nearshore
067 - San Nicolas Island
Pedro South
045 - Oceanside Offshore
201 - Scripps Nearshore
100 - Torrey Pines Outer
220 - Mission Bay West
191 - Point Loma South
MEXICO

NEW HAMPSHIRE
160 - Jeffreys Ledge
MASSACHUSETTS
221 - Cape Cod Bay
CONNECTICUT
RHODE ISLAND
154 - Block Island
PENNSYLVANIA
NEW JERSEY
209 - Barnaget Bay Inlet
MARYLAND
DISTRICT OF COLUMBIA
DELAWARE
224 - Wallops Island
VIRGINIA
240 - Thimble Shoal
147 - Cape Henry
430 - Duck FRF
433 - Duck FRF
243 - Nags Head
192- Oregon Inlet
NORTH CAROLINA
217 - Onslow Bay Outer
150 - Masonboro Inlet
200 - Wilmington Harbor
SOUTH CAROLINA
CDIP buoys- Active
GEORGIA
132 - Fernandina Beach
194 - St. Augustine
FLORIDA
214 - Egmont Channel Entrance
143 - Cape Canaveral Nearshore
134 - Fort Pierce
144 - St. Petersburg Offshore
226 - Pulley Ridge
244 - Satan Shoal
LOUISIANA
246 - Grand Isle
181 - Rincon
PUERTO RICO

University of New Hampshire
COLUMBIA RIVER BAR PILOTS ESTABLISHED 1846
MARINE EXCHANGE SOUTHERN CALIFORNIA VTS
MARATHON
Chevron

Datawell BV
oceanographic instruments

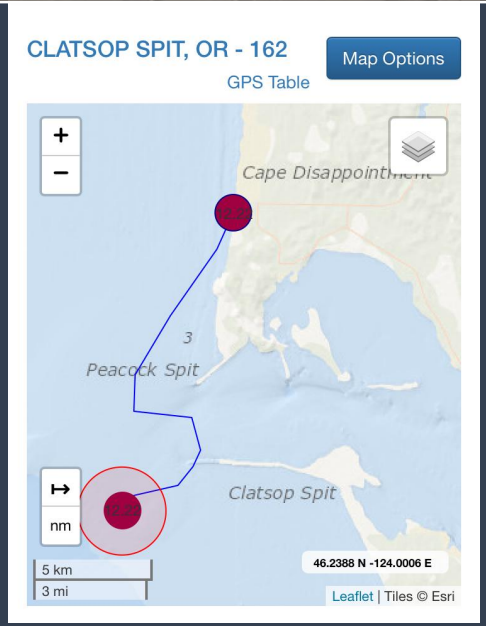
Waverider buoys

- Wave Energy Spectrum
- Directional Spectrum
- XYZ (E,N,V) Displacements
- Sea Surface Temperature
- *Sea Surface Currents*
- *Air Temperature*

OPERATIONS AND MAINTENANCE

- Batteries
- Moorings
- Anchors
- Acoustic Releases
- Service & Repairs

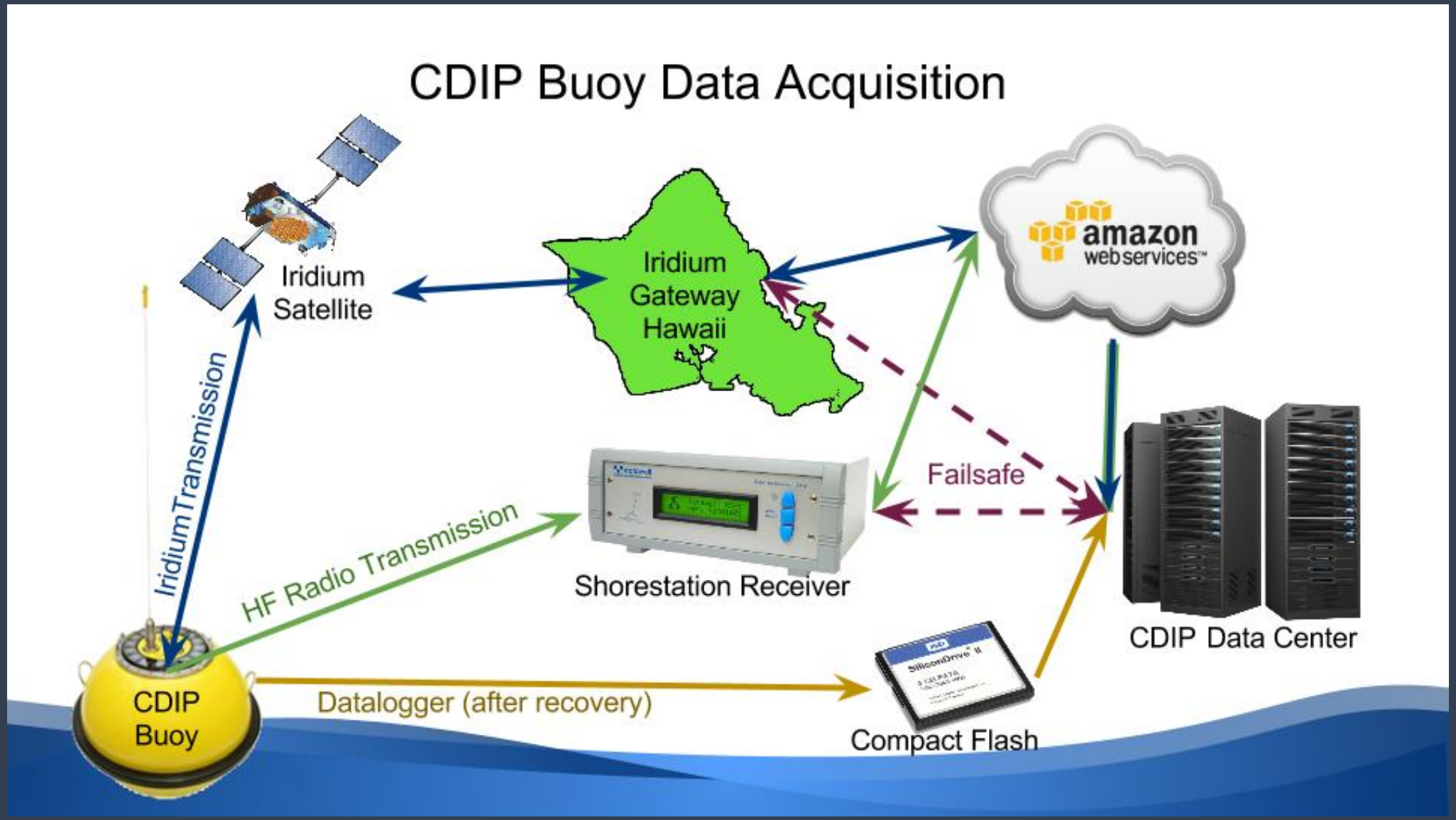
RAPID RECOVERY & RE-DEPLOYMENT

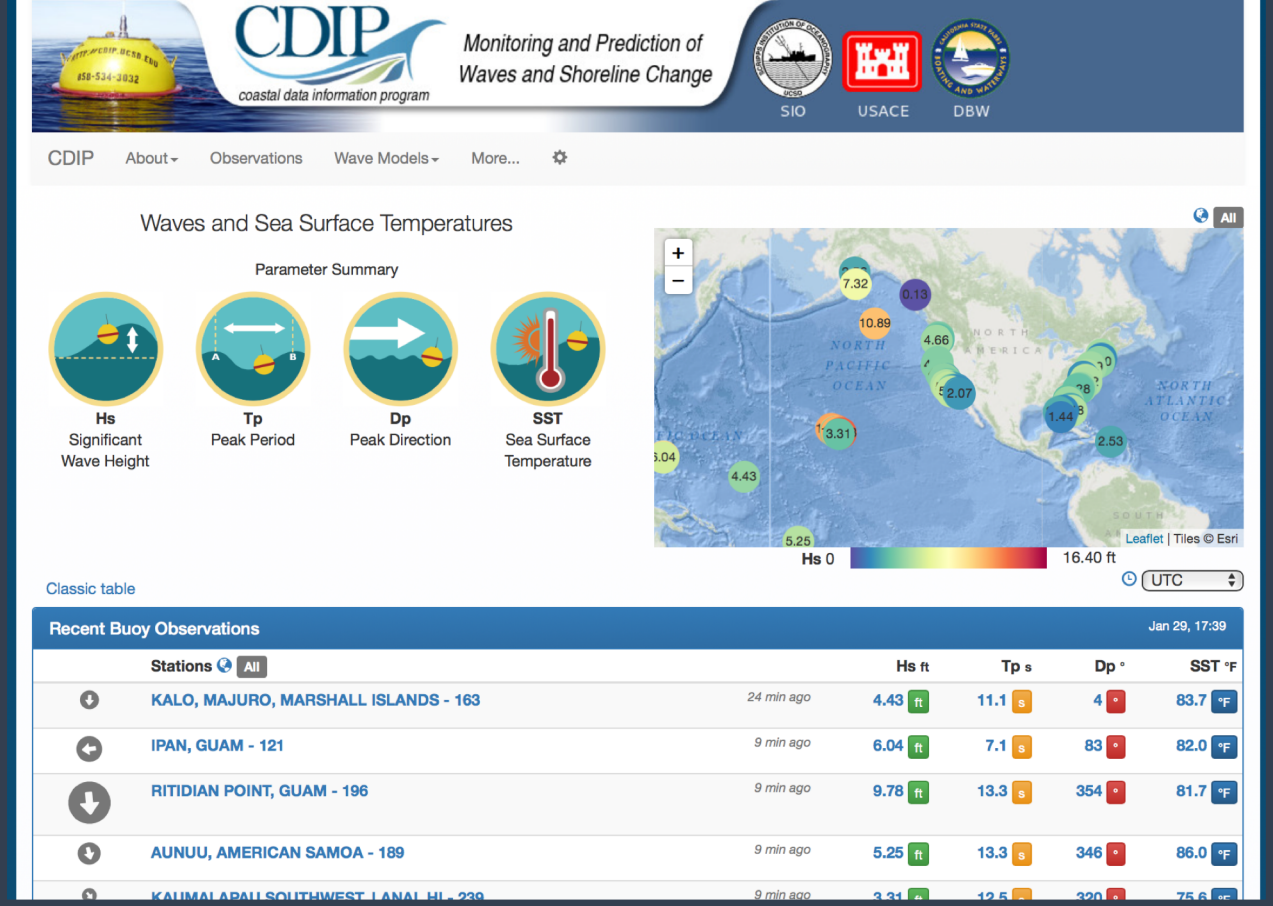


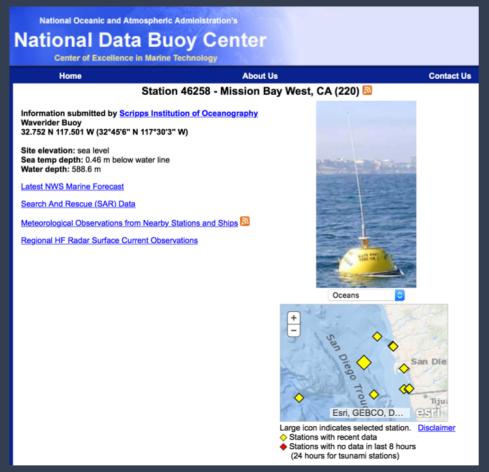
22 offsites in 2018

Minimize station downtime to measure extreme events

CDIP Buoy Data Acquisition

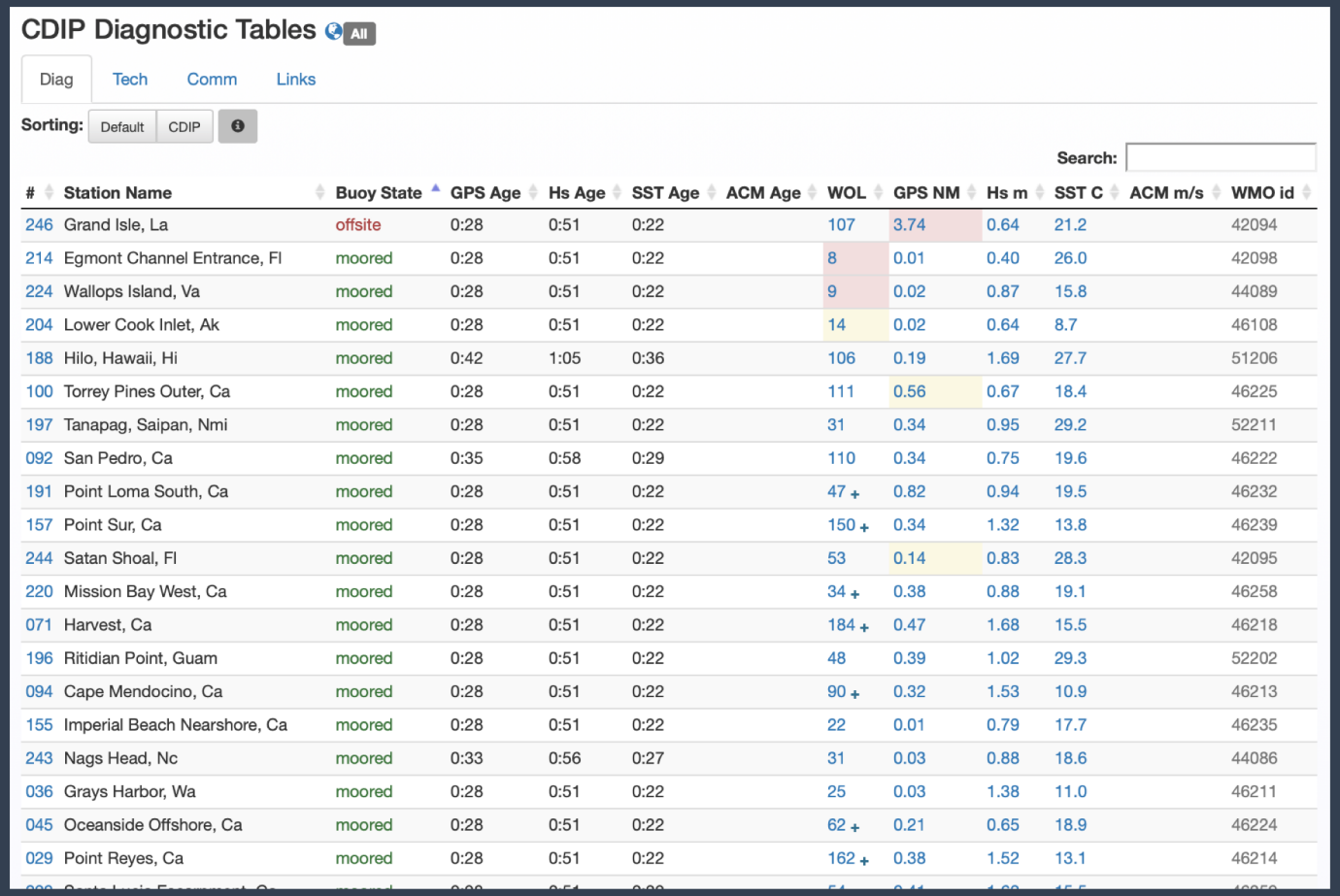






Data Dissemination

- Updates every 30 minutes (> 99% reliable)
- Spectra, parameters, displacement path
- CDIP Website (~17,000 unique visitors/day)
- National Data Buoy Center / NOAA (NWS)
- National Centers for Environmental Information archive
- Physical Oceanographic Real-Time System (PORTS®): Humboldt Bay, San Francisco, LA/LB



CDIP Diagnostic Tables All

Diag | Tech | Comm | Links

Sorting: Default | CDIP

Search:

#	Station Name	Buoy State	GPS Age	Hs Age	SST Age	ACM Age	WOL	GPS NM	Hs m	SST C	ACM m/s	WMO id
246	Grand Isle, La	offsite	0:28	0:51	0:22		107	3.74	0.64	21.2		42094
214	Egmont Channel Entrance, Fl	moored	0:28	0:51	0:22		8	0.01	0.40	26.0		42098
224	Wallops Island, Va	moored	0:28	0:51	0:22		9	0.02	0.87	15.8		44089
204	Lower Cook Inlet, Ak	moored	0:28	0:51	0:22		14	0.02	0.64	8.7		46108
188	Hilo, Hawaii, Hi	moored	0:42	1:05	0:36		106	0.19	1.69	27.7		51206
100	Torrey Pines Outer, Ca	moored	0:28	0:51	0:22		111	0.56	0.67	18.4		46225
197	Tanapag, Saipan, Nmi	moored	0:28	0:51	0:22		31	0.34	0.95	29.2		52211
092	San Pedro, Ca	moored	0:35	0:58	0:29		110	0.34	0.75	19.6		46222
191	Point Loma South, Ca	moored	0:28	0:51	0:22		47 +	0.82	0.94	19.5		46232
157	Point Sur, Ca	moored	0:28	0:51	0:22		150 +	0.34	1.32	13.8		46239
244	Satan Shoal, Fl	moored	0:28	0:51	0:22		53	0.14	0.83	28.3		42095
220	Mission Bay West, Ca	moored	0:28	0:51	0:22		34 +	0.38	0.88	19.1		46258
071	Harvest, Ca	moored	0:28	0:51	0:22		184 +	0.47	1.68	15.5		46218
196	Ritidian Point, Guam	moored	0:28	0:51	0:22		48	0.39	1.02	29.3		52202
094	Cape Mendocino, Ca	moored	0:28	0:51	0:22		90 +	0.32	1.53	10.9		46213
155	Imperial Beach Nearshore, Ca	moored	0:28	0:51	0:22		22	0.01	0.79	17.7		46235
243	Nags Head, Nc	moored	0:33	0:56	0:27		31	0.03	0.88	18.6		44086
036	Grays Harbor, Wa	moored	0:28	0:51	0:22		25	0.03	1.38	11.0		46211
045	Oceanside Offshore, Ca	moored	0:28	0:51	0:22		62 +	0.21	0.65	18.9		46224
029	Point Reyes, Ca	moored	0:28	0:51	0:22		162 +	0.38	1.52	13.1		46214

Quality Control

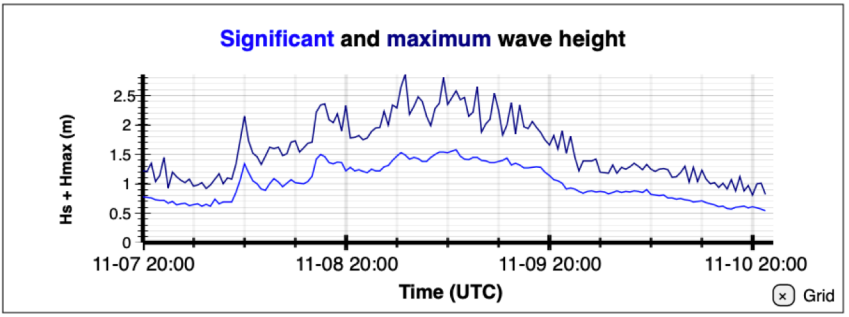
- QARTOD
- Watchkeeping team with decades of wave observing experience
- Real time QC warnings
- Data archives with complete time series and additional QC
- Exhaustive metadata
- Legacy of R&D collaboration between Datawell and CDIP

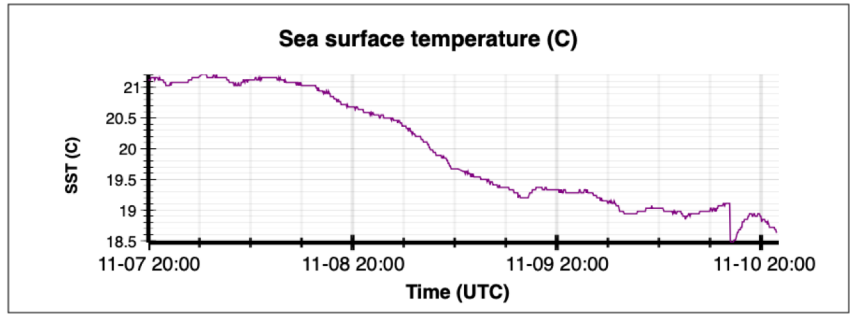
WILMINGTON HARBOR, NC BUOY - 200p1

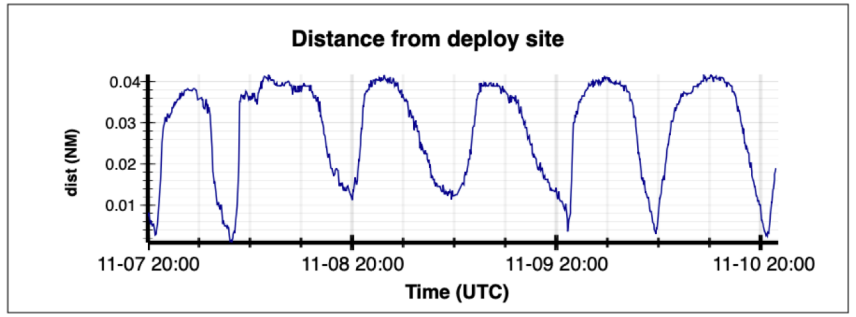
View flag plots CDIP dataset, last 7 days; QC flags not applied. 14 days 30 days

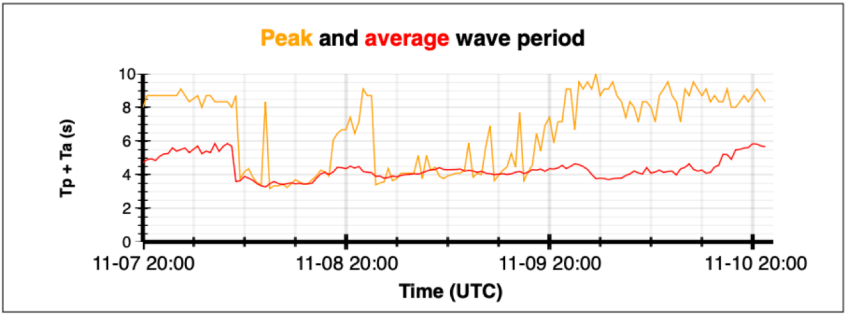
Diag table Stn page WNC browser GPS plot Data tables

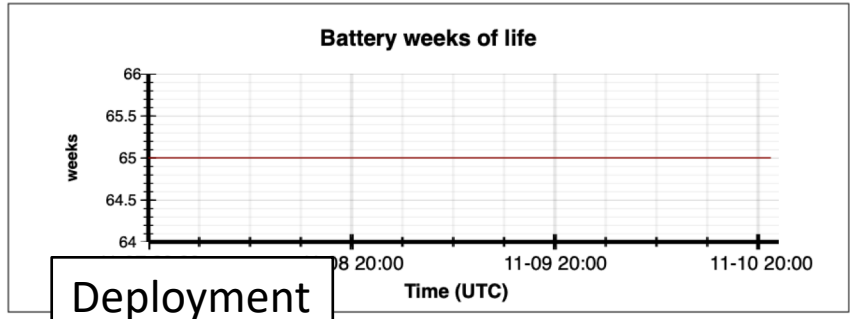
WAVES age: 00:55:58 SST age: 00:10:58 GPS age: 00:14:27 ACM age: 00:15:58

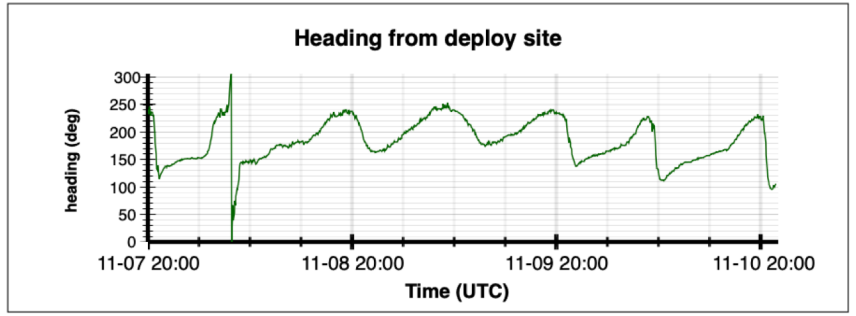


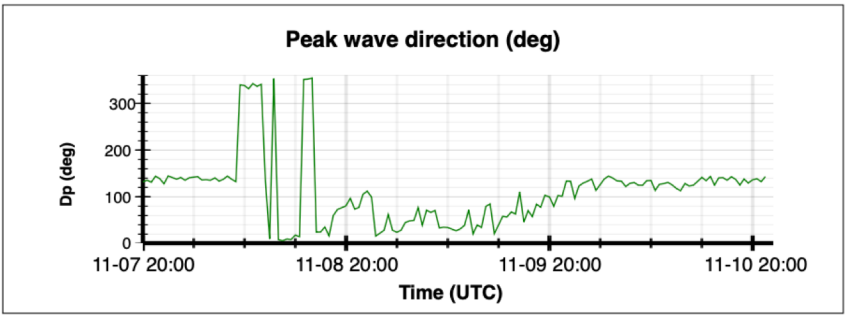


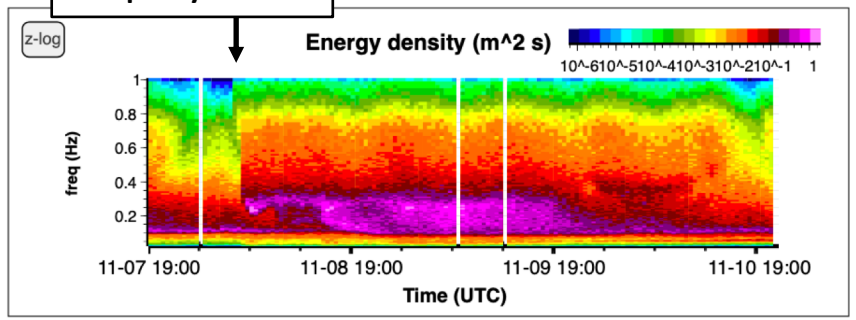


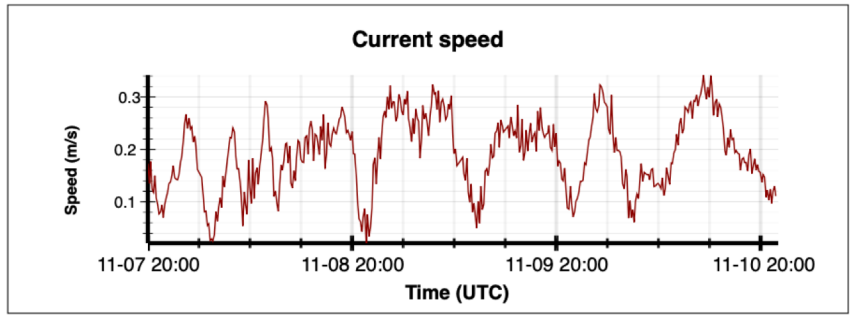


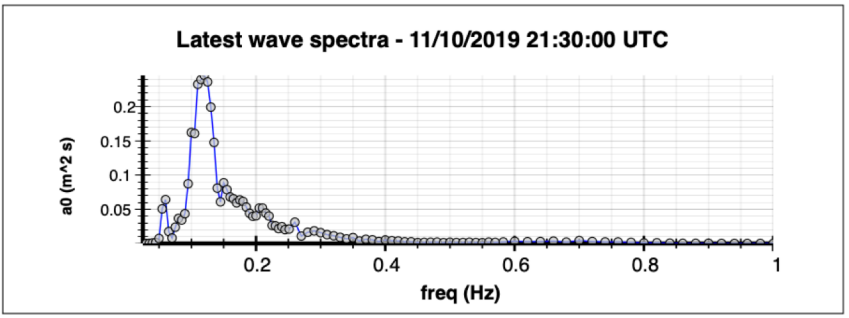


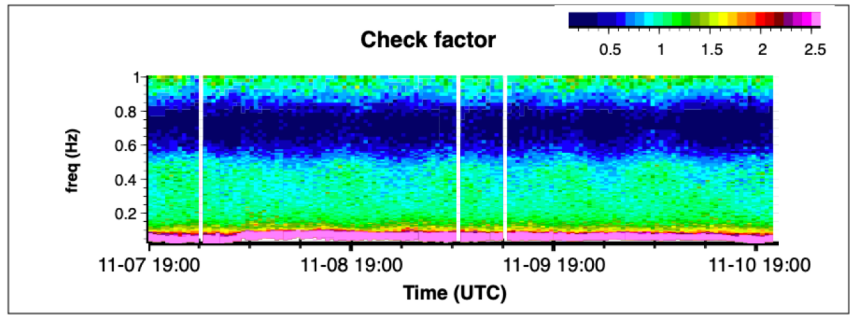


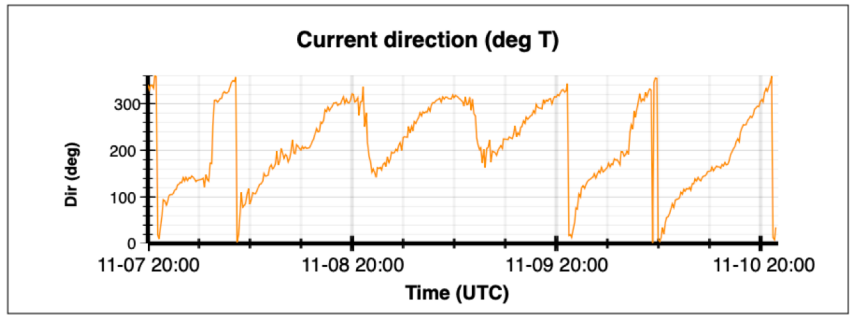












Quality Control

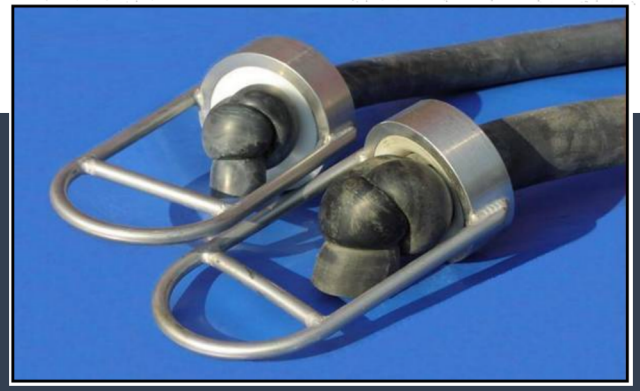
Calibration verification

Test at 6, 12, and 20 seconds period

Heave within 2%
Direction within 2 degrees

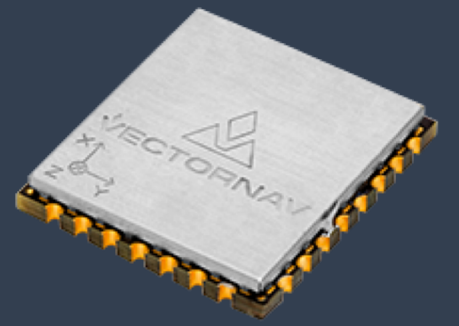
- CDIP Overview
- Buoy Co-location
- Hurricane wave data
- Coastal inundation
- Wave power

CDIP Waverider vs NDBC

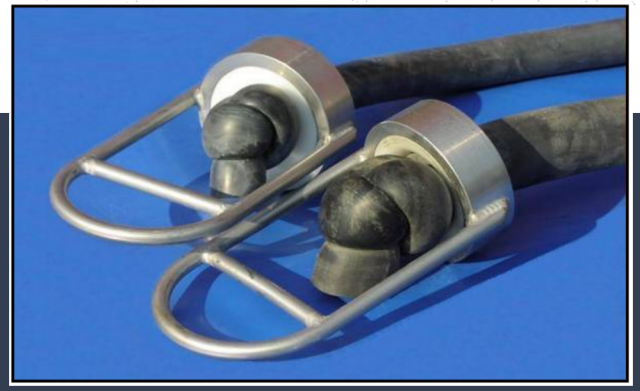


- Small
- Round
- Slack Mooring
- Rubber cord
- Standardized
- Motion path data
- HIPPY sensor

- Large
- Disc or boat shaped
- Chain Mooring
- Nonstandard size
- Nonstandard shape
- Nonstandard material
- Nonstandard sensor location
- MEMS accelerometer

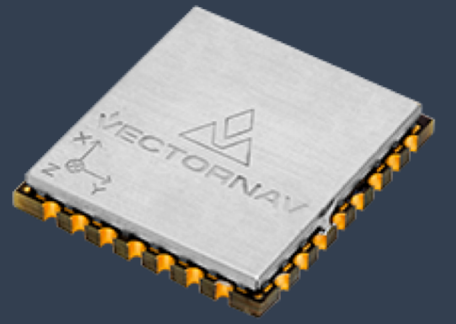


CDIP Waverider vs NDBC

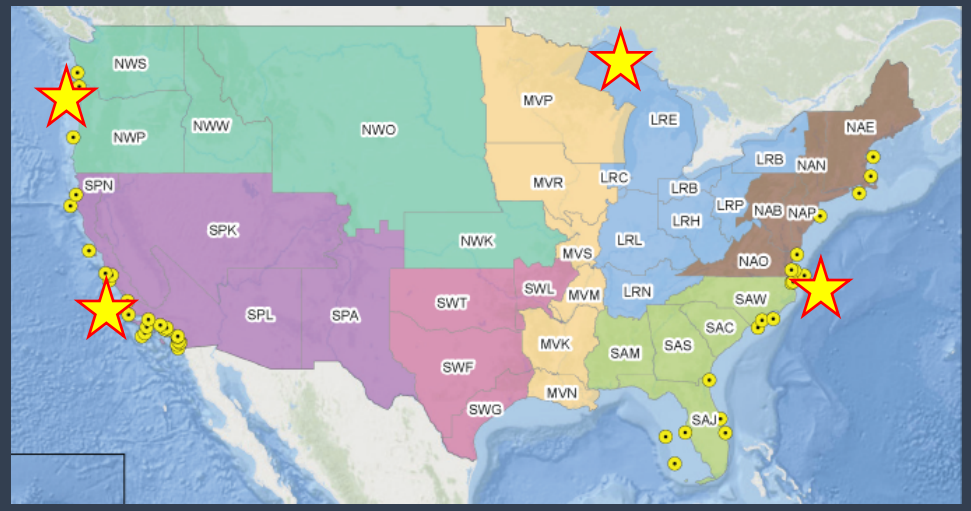


- Small
- Round
- Slack Mooring
- Rubber cord
- Standardized
- Motion path data
- HIPPY sensor
- **No met data**

- Large
- Disc or boat shaped
- Chain Mooring
- Nonstandard size
- Nonstandard shape
- Nonstandard material
- Nonstandard sensor location
- MEMS accelerometer
- **Met data + waves**



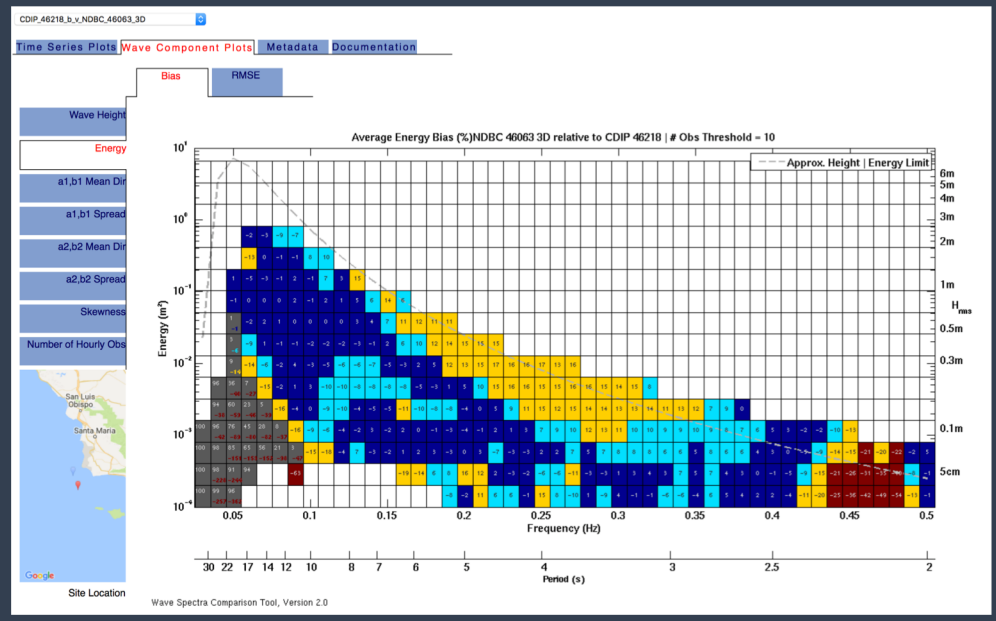
Buoy Co-Location Experiments



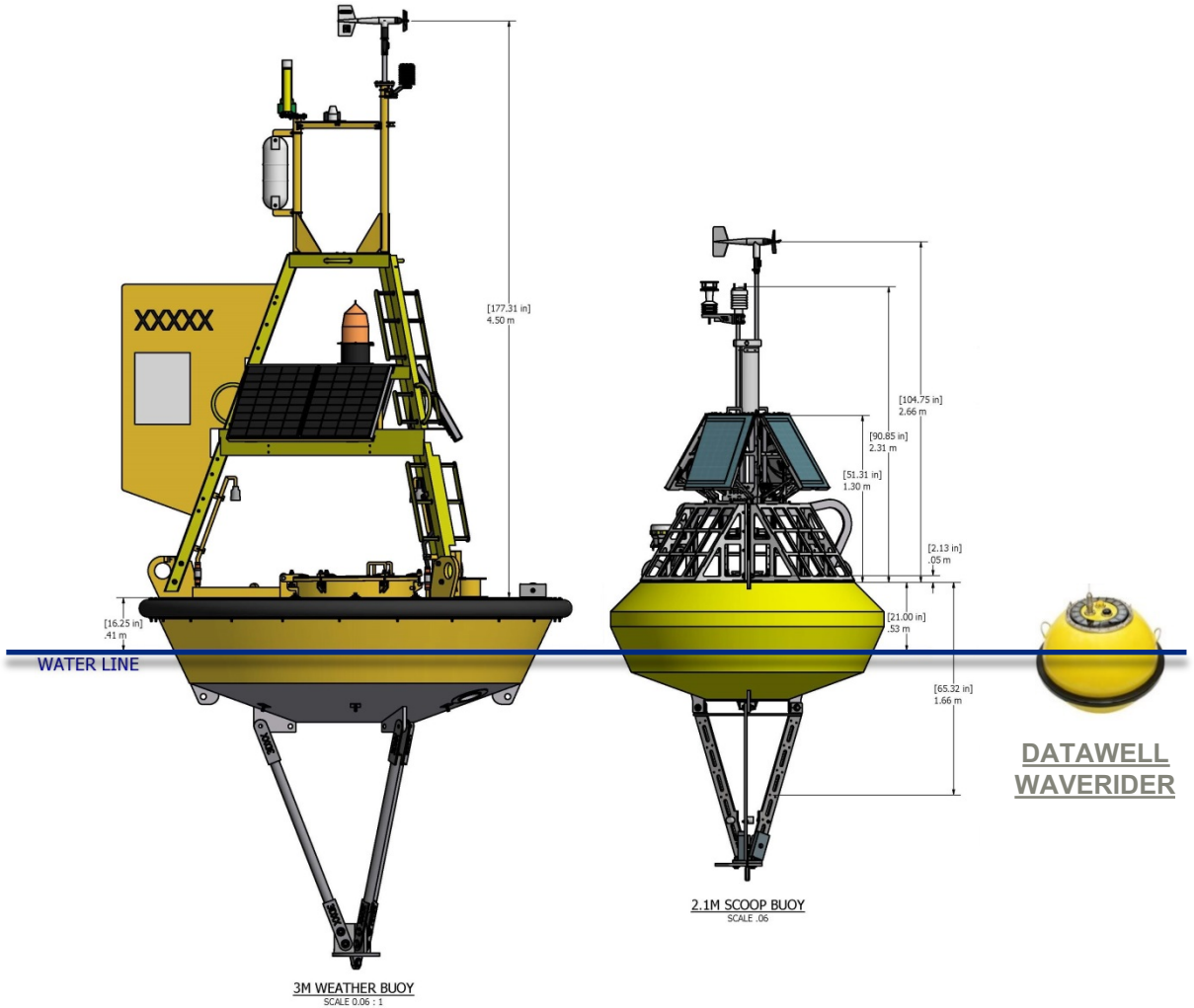
NOAA / NDBC Discus & SCOOP

USACE / CDIP Waverider

CDIP / JCOMM wave eval tool



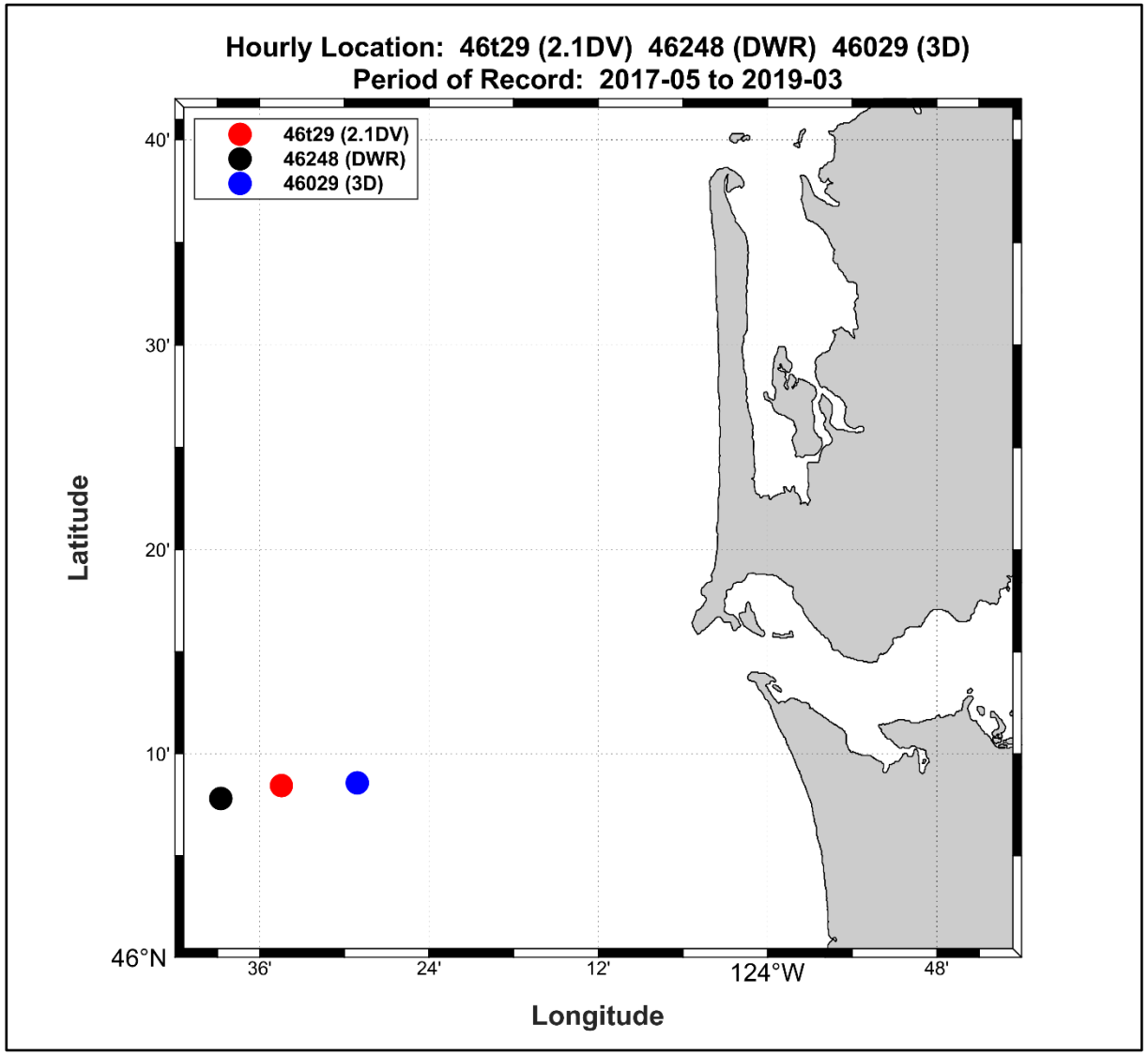
INTRODUCTION – SCOOP SYSTEM



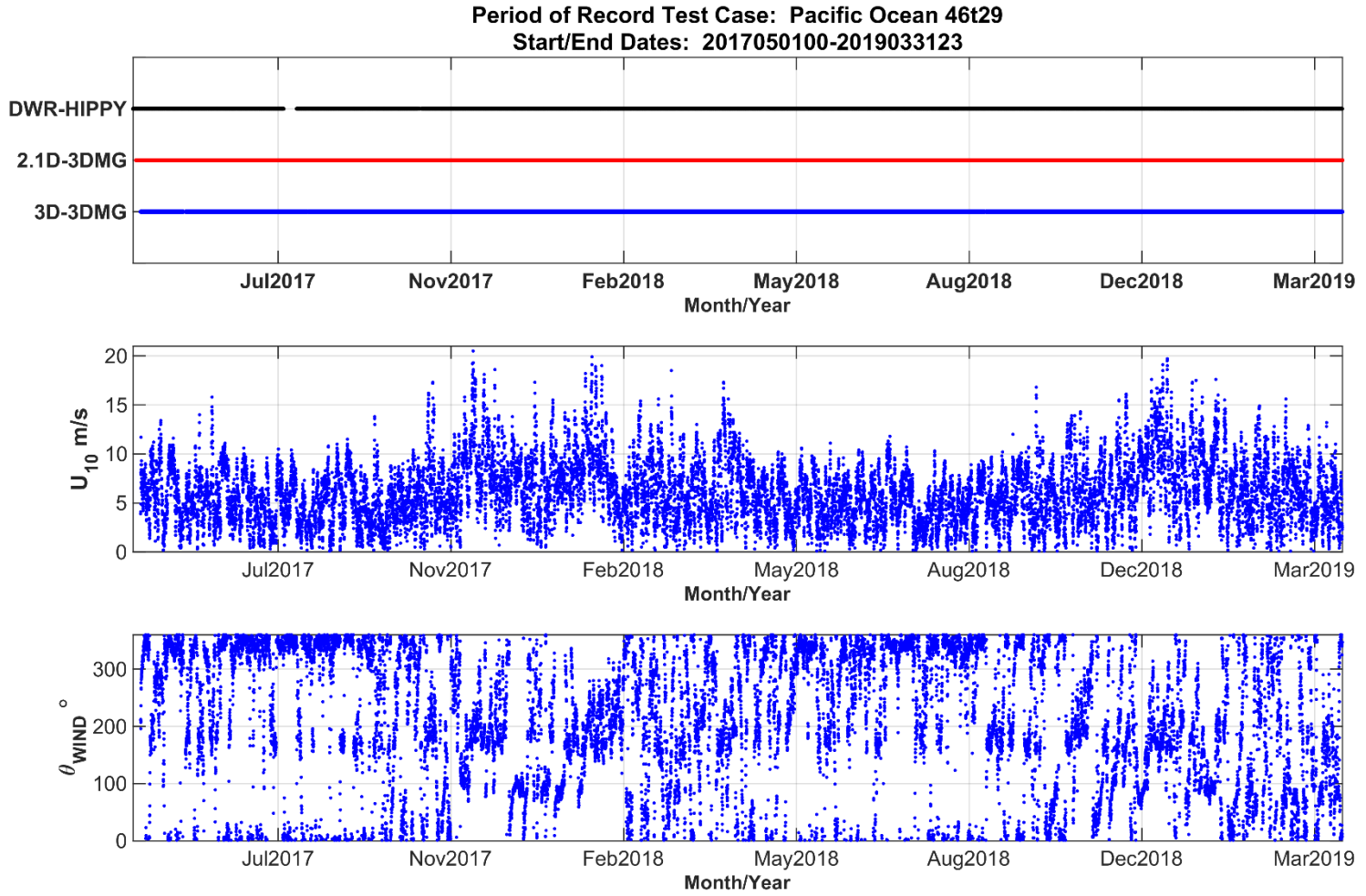
NDBC Schematic Credit: Eric Gay,NDBC

- **Legacy 3-m diameter aluminum hulls: ~1724 kg, +5 m height**
- **2.1-m diameter foam hulls: 492 kg, +3.2 m height**
- **Datawell Waverider: 0.9-m diameter, 225 kg, +0.5 m height**

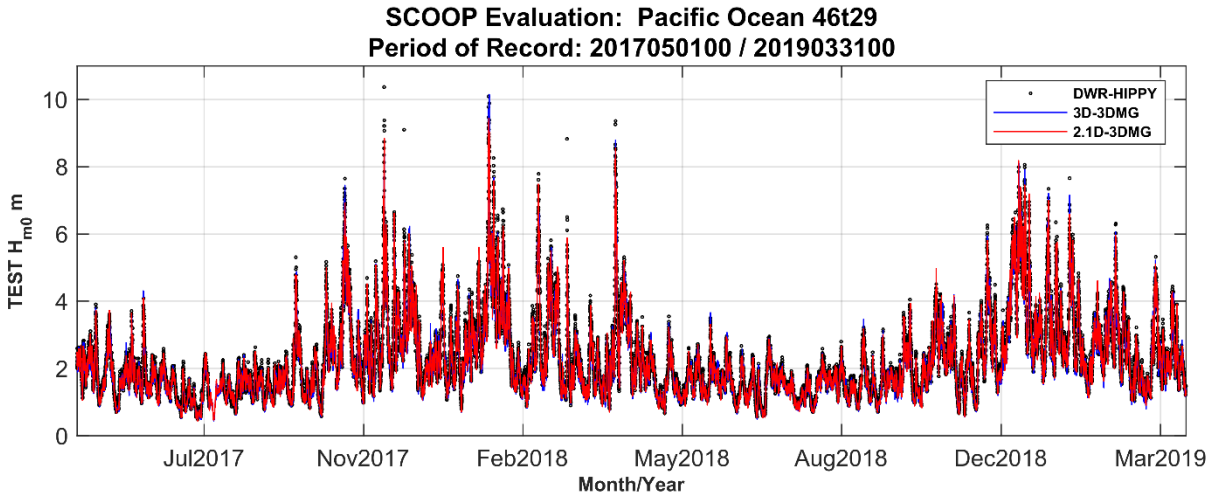
INTRODUCTION – TEST SITES

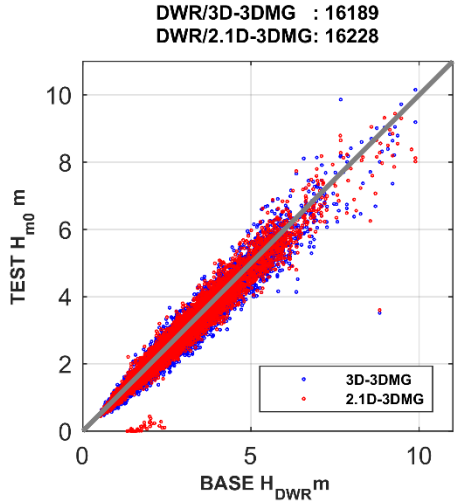


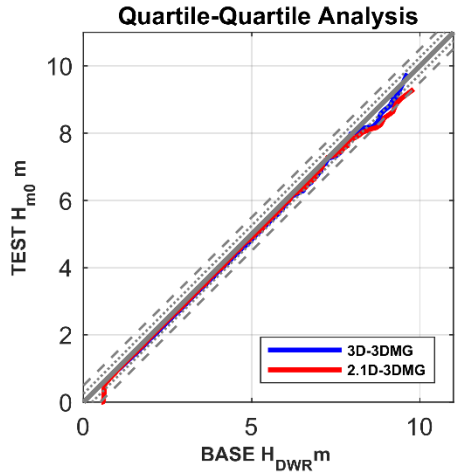
ANALYSIS-RESULTS: MET OBS



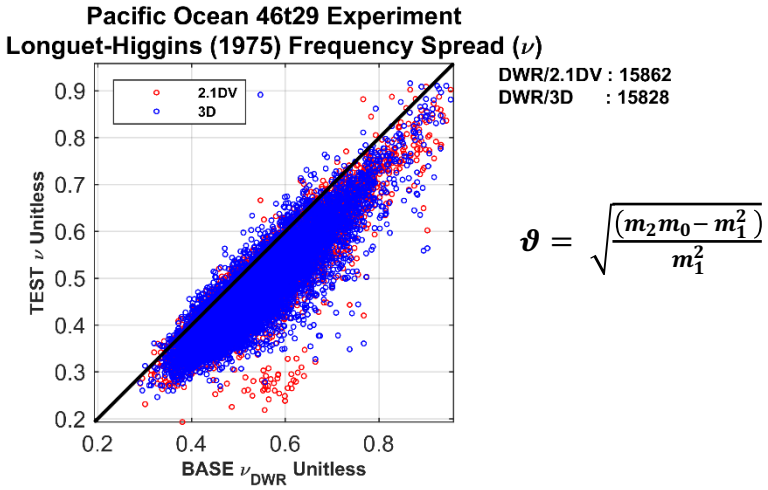
ANALYSIS-RESULTS: H_{m0}



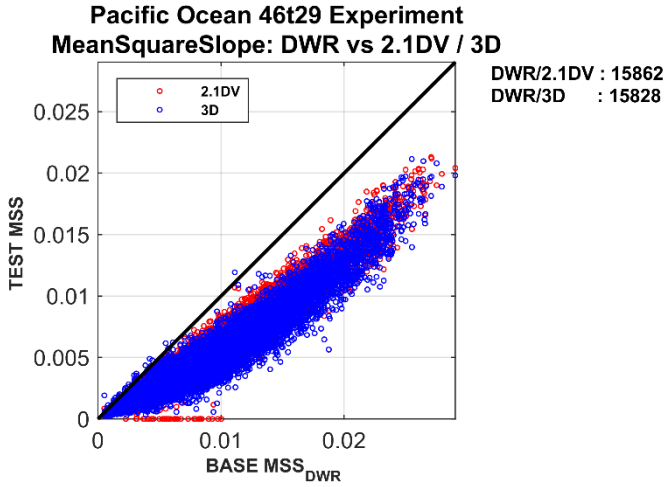


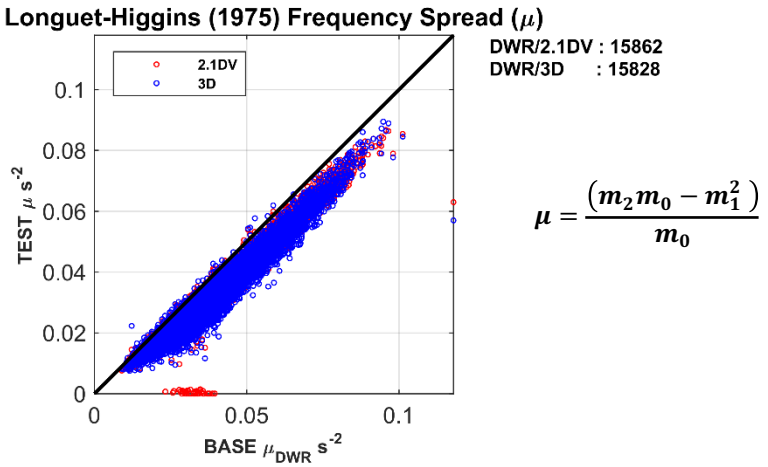


ANALYSIS-RESULTS: FREQUENCY SPECTRAL ANALYSIS

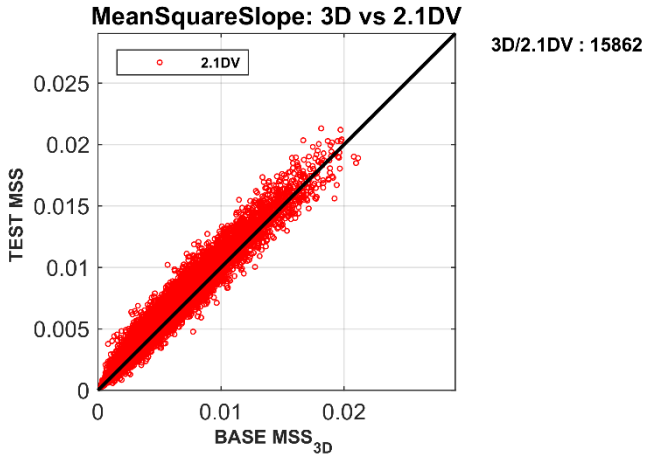


$$\vartheta = \sqrt{\frac{(m_2 m_0 - m_1^2)}{m_1^2}}$$



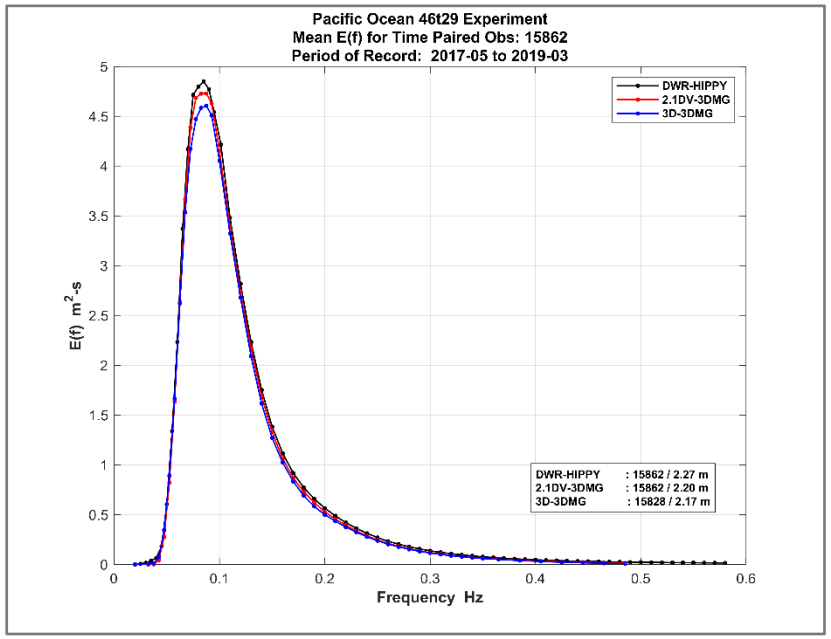


$$\mu = \frac{(m_2 m_0 - m_1^2)}{m_0}$$

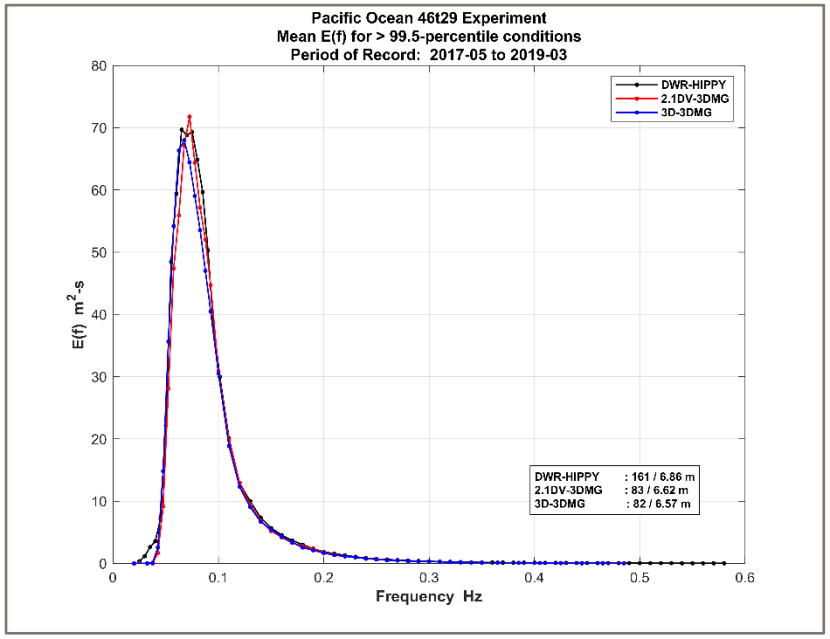


ANALYSIS-RESULTS: FREQUENCY SPECTRAL ANALYSIS

Pacific Ocean: 46t29



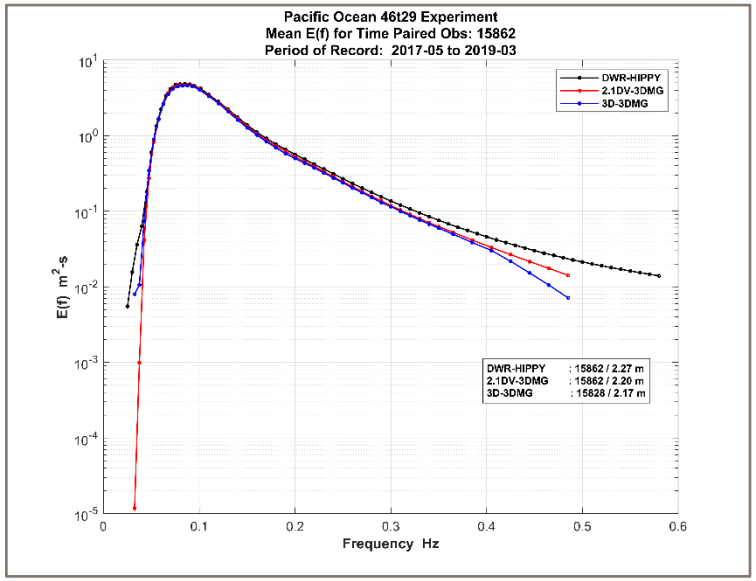
All Observations



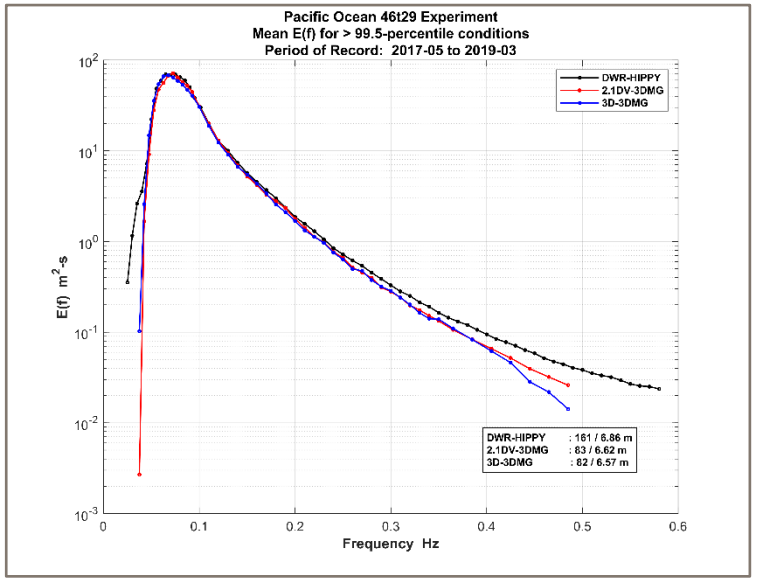
99.5-percentile

ANALYSIS-RESULTS: FREQUENCY SPECTRAL ANALYSIS

Pacific Ocean: 46t29



All Observations



99.5-percentile

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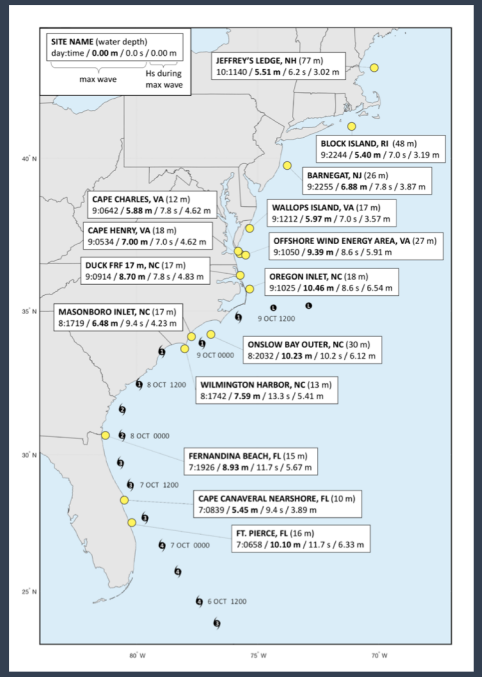
- Wave power



COASTAL OBSERVATIONS:

CDIP wave observations during Hurricanes Irma, Jose, and Maria, and a nor'easter

By

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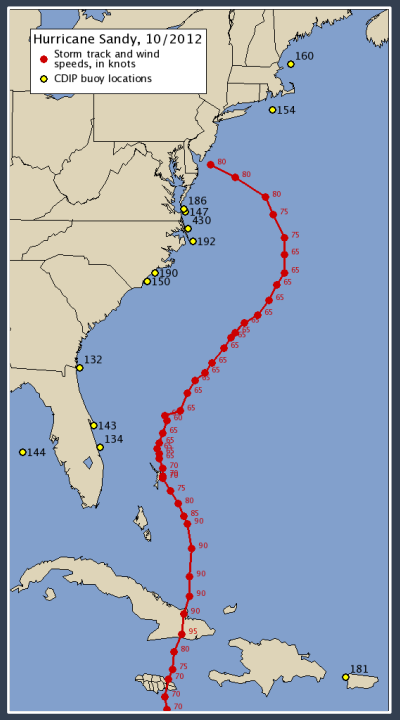
Robert E. Jensen
U.S. Army Corps of Engineers

> $140 billion

Shore & Beach ■ Vol. 86, No. 3 ■ Summer 2018



COASTAL OBSERVATIONS:

CDIP wave observations during Hurricane Matthew

By

James Behrens, Eric Terrill, Julianna Thomas, David Castel, and Richard Seymour
Scripps Institution of Oceanography,
University of California, San Diego, La Jolla, CA 92093
jb@cdip.ucsd.edu

Robert E. Jensen
U.S. Army Corps of Engineers

$11 billion

Shore & Beach ■ Vol. 86, No. 1 ■ Winter 2018

TECHNICAL NOTE:

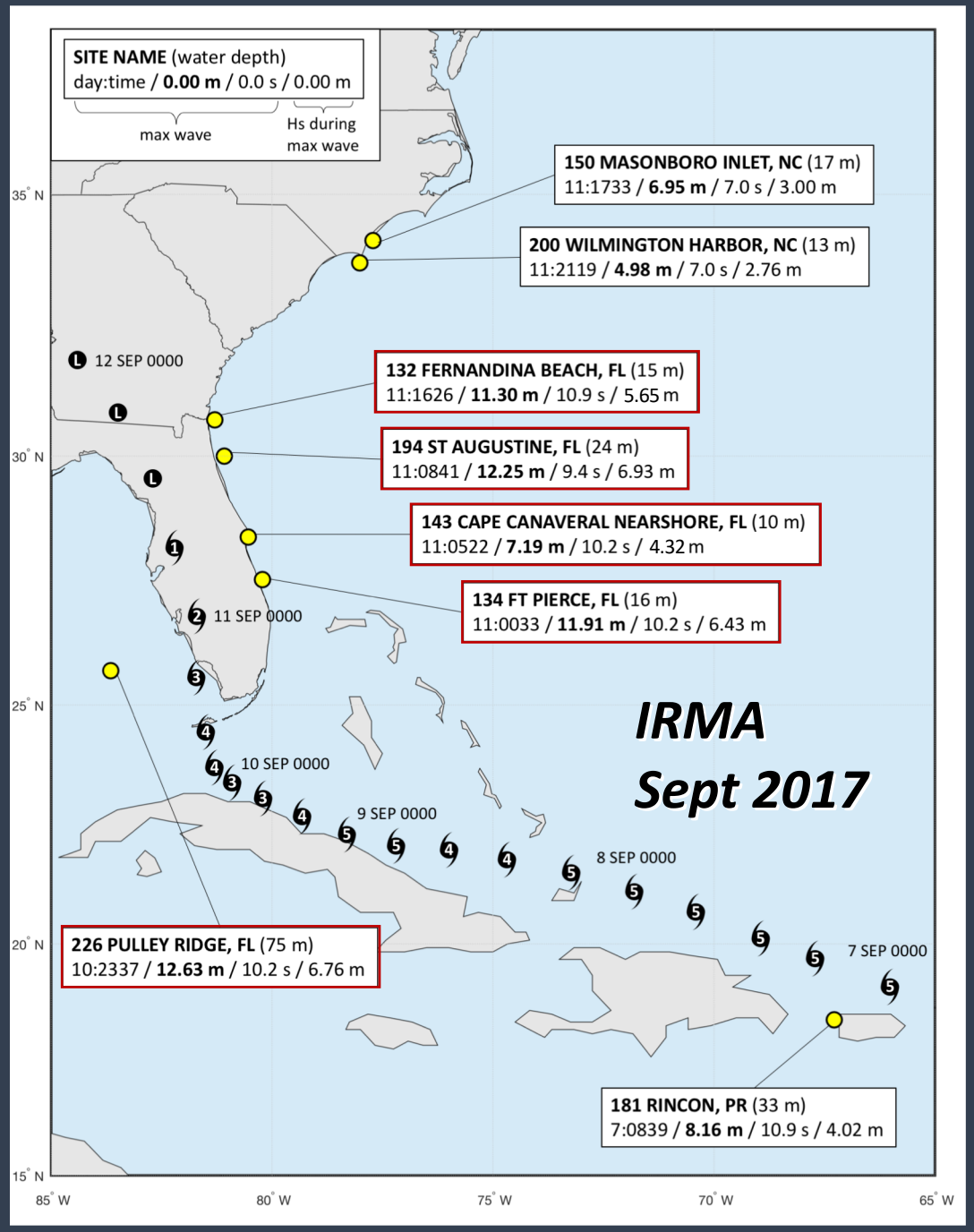
CDIP wave observations in Superstorm Sandy

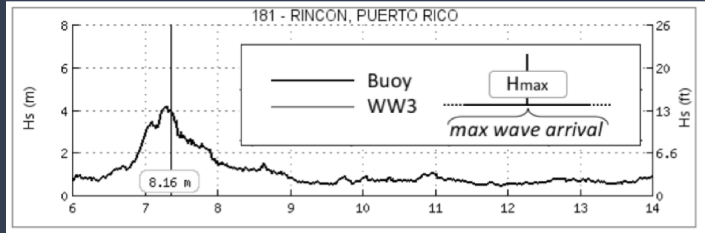
By

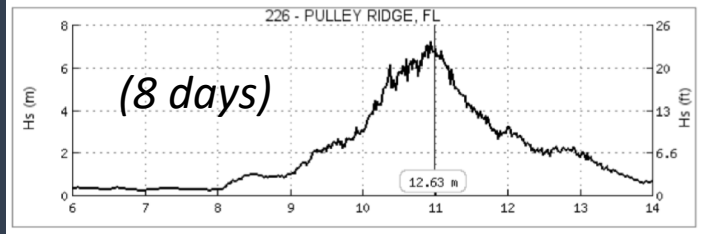
Richard J. Seymour, Corey B. Olfe, and Juliana O. Thomas
Scripps Institution of Oceanography,
University of California, San Diego, La Jolla, CA 92093

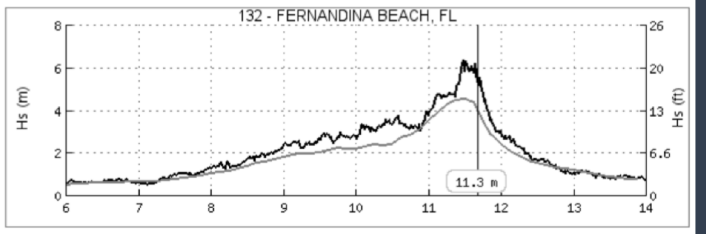
$70 billion

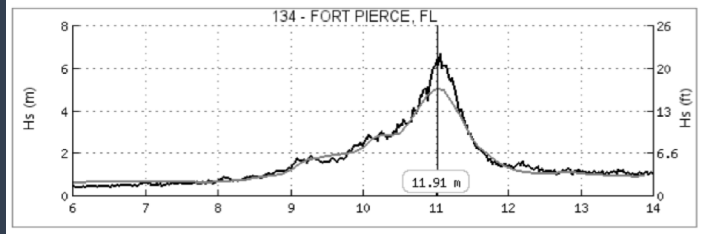
Shore & Beach ■ Vol. 80, No. 4 ■ Fall 2012

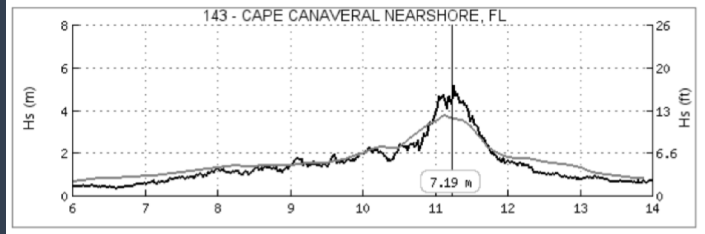


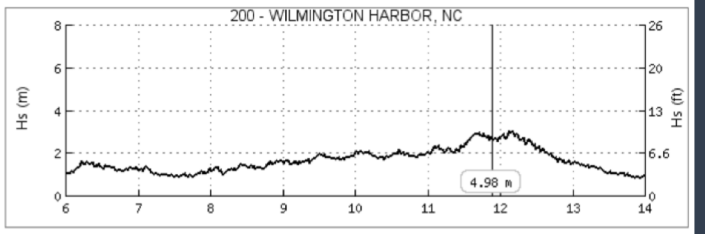








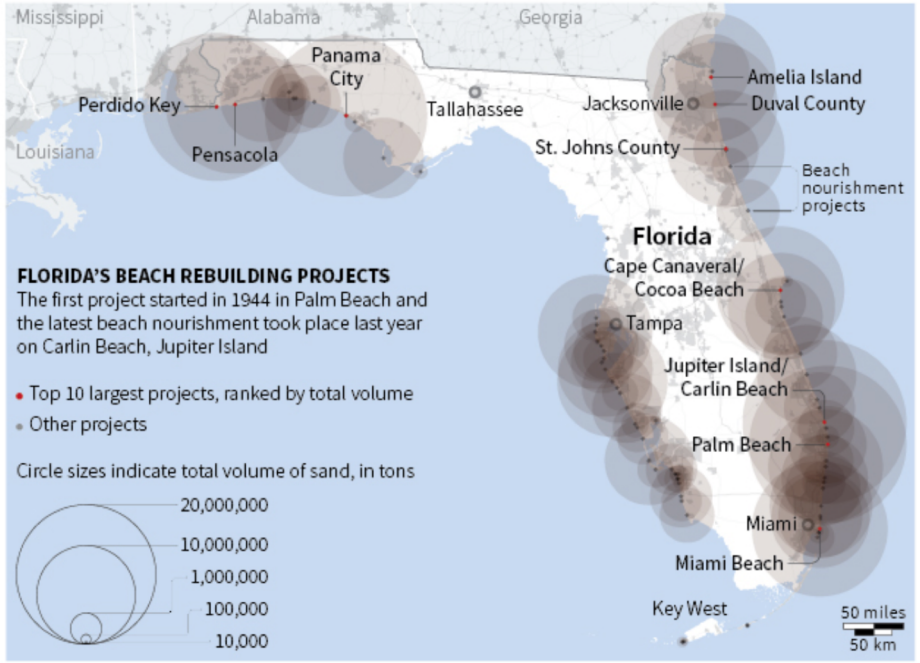




		Hmax (m)	(s)	Hs (m)	Tp (s)	Dp (°)	Hmax/Hs	Hmax/depth
181	Rincon, PR	**8.16**	10.9	**4.02**	9.88	337	**2.03**	**0.25**
226	Pulley Ridge, FL	**12.63**	10.2	**6.76**	10.53	007	**1.87**	**0.17**
134	Ft Pierce, FL	**11.91**	10.2	**6.43**	9.88	107	**1.85**	**0.74**
143	Cape Canaveral, FL	**7.19**	10.2	**4.32**	11.76	125	**1.66**	**0.72**
194	St. Augustine, FL	**12.25**	9.4	**6.93**	11.76	092	**1.77**	**0.51**
132	Fernandina Beach, FL	**11.30**	10.9	**5.65**	13.33	116	**2.00**	**0.75**
200	Wilmington Harbor NC	**4.98**	7.0	**2.76**	10.53	149	**1.80**	**0.38**
150	Masonboro Inlet, NC	**6.95**	7.0	**3.00**	7.69	098	**2.32**	**0.41**

Shifting sand

More money is spent restocking Florida's beaches with sand than anywhere else in the United States. Beach rebuilding, often called nourishments, is used to guard the Sunshine State's tourist-driven economy and protect developed communities from the sea. While nourishments happen most often in Florida, every U.S. coastal and Great Lakes state has restocked their beaches with sand at some point in the past 95 years.



LARGEST VOLUME
Ranked by total volume of sand, in million tons

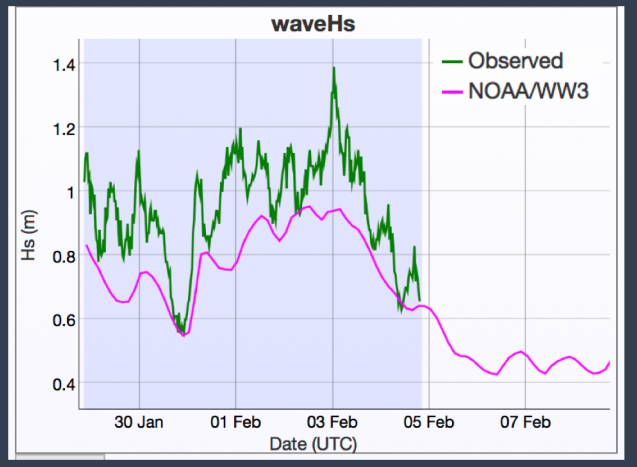
		Earliest-latest project year
California	591.2	1927-2016
Florida	452.3	1944-2017
New Jersey	257.4	1936-2015
New York	237.8	1923-2016
North Carolina	206.2	1939-2017
Louisiana	128.5	1955-2017
South Carolina	81.0	1954-2018
Mississippi	56.5	1952-2017
Delaware	52.9	1953-2017
Virginia	51.6	1951-2015

MOST SPENT
Ranked by known total cost, in millions of dollars

		Earliest-latest project year
Florida	1,340.4	1944-2017
New Jersey	1,032.3	1936-2015
North Carolina	737.7	1939-2017
Louisiana	602.8	1955-2017
New York	550.5	1923-2016
South Carolina	356.3	1954-2018
Mississippi	328.1	1952-2017
Delaware	180.8	1953-2017
Virginia	174.2	1951-2015
Texas	134.4	1956-2017

Source: National Beach Nourishment Database, American Shore & Beach Preservation Association (ASBPA)

W. Foo, 07/02/2018 REUTERS



CDIP 132 Fernandina Beach, FL

"CDIP wave buoy data enhances our modeling efforts. It is used to drive the offshore model boundary"
– Kevin Hodgens, Chief, Coastal Engineering Design Section, USACE Jacksonville District

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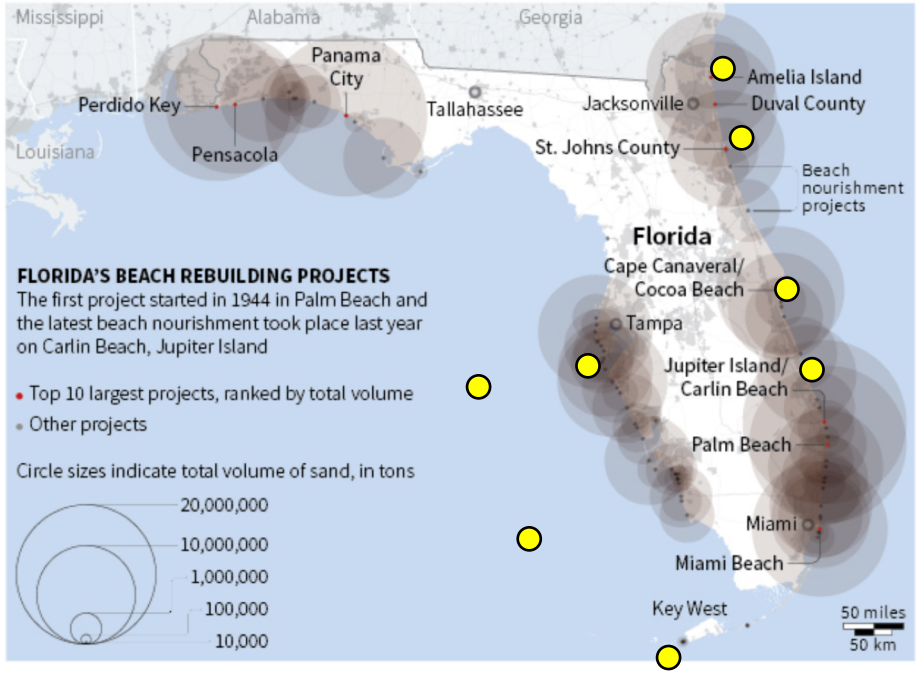

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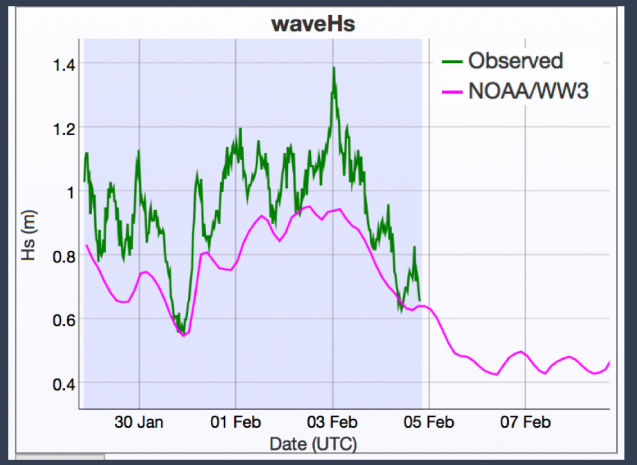

CDIP 132 Fernandina Beach, FL

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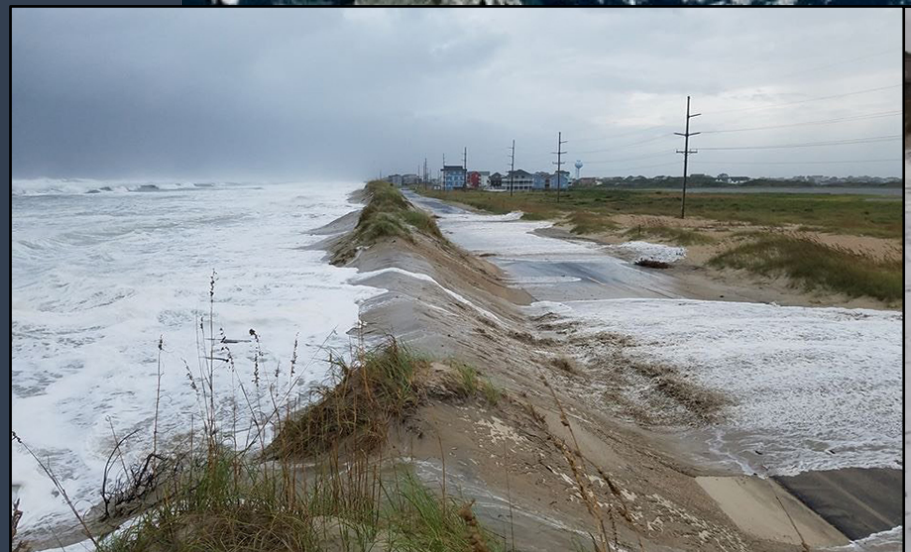
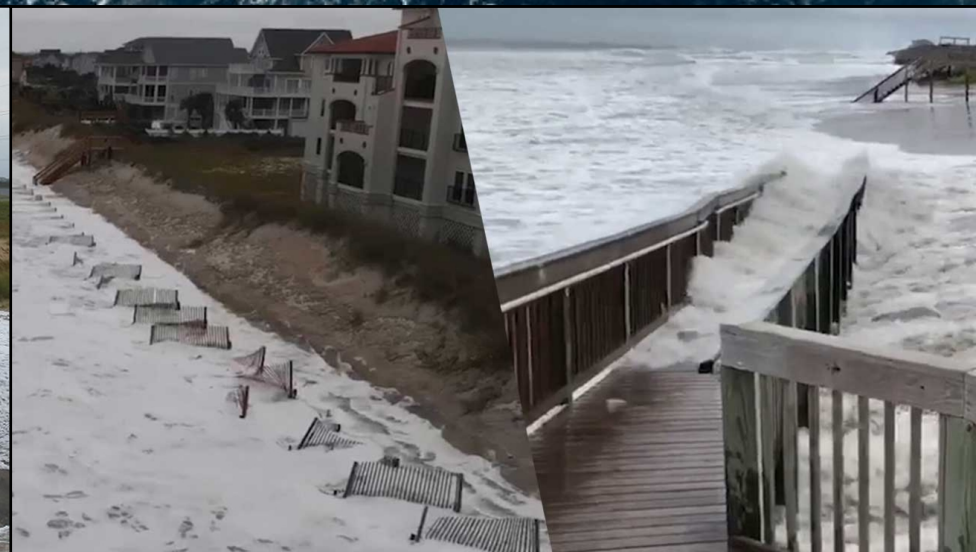
Hurricane Florence

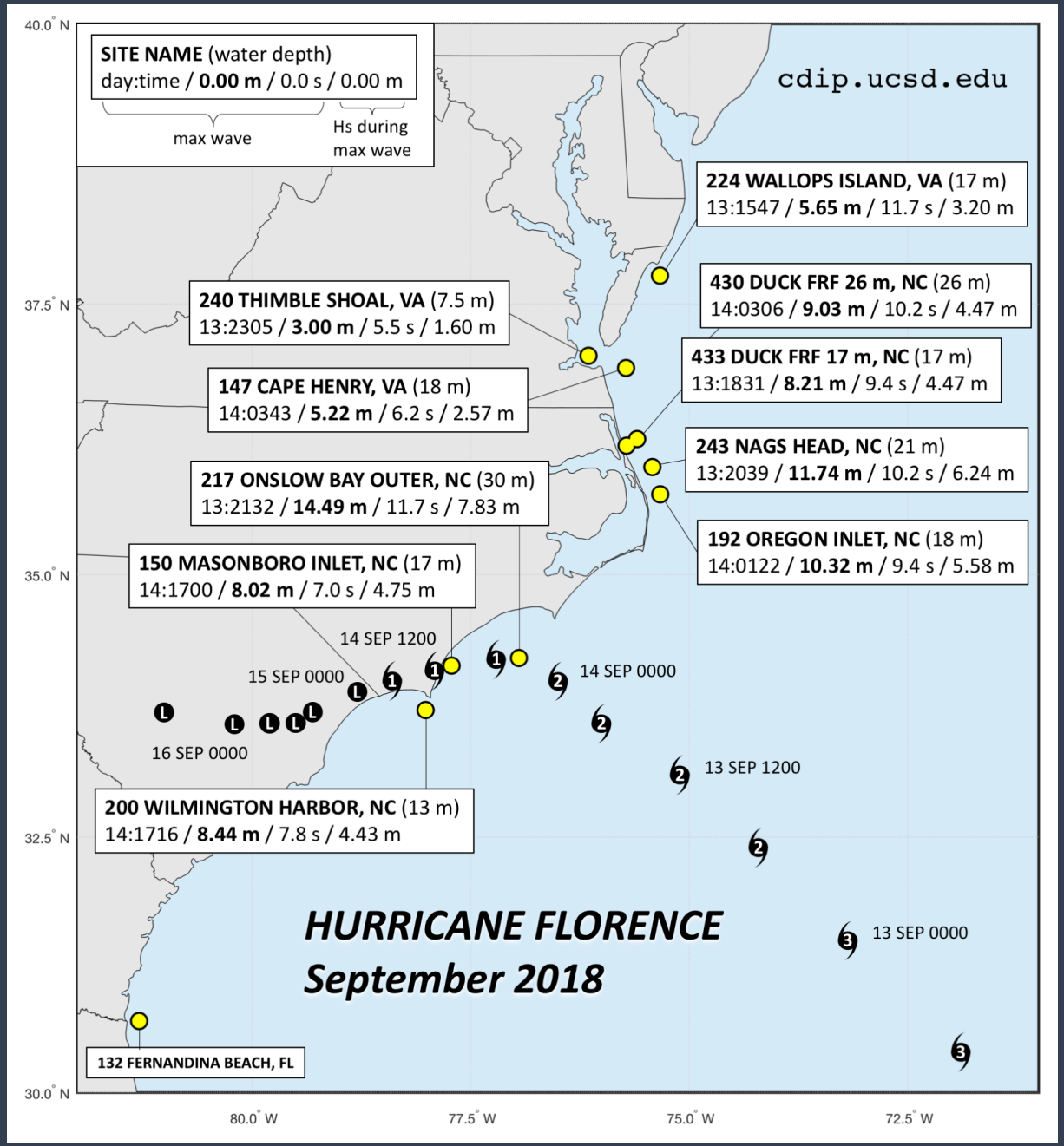
September 2018

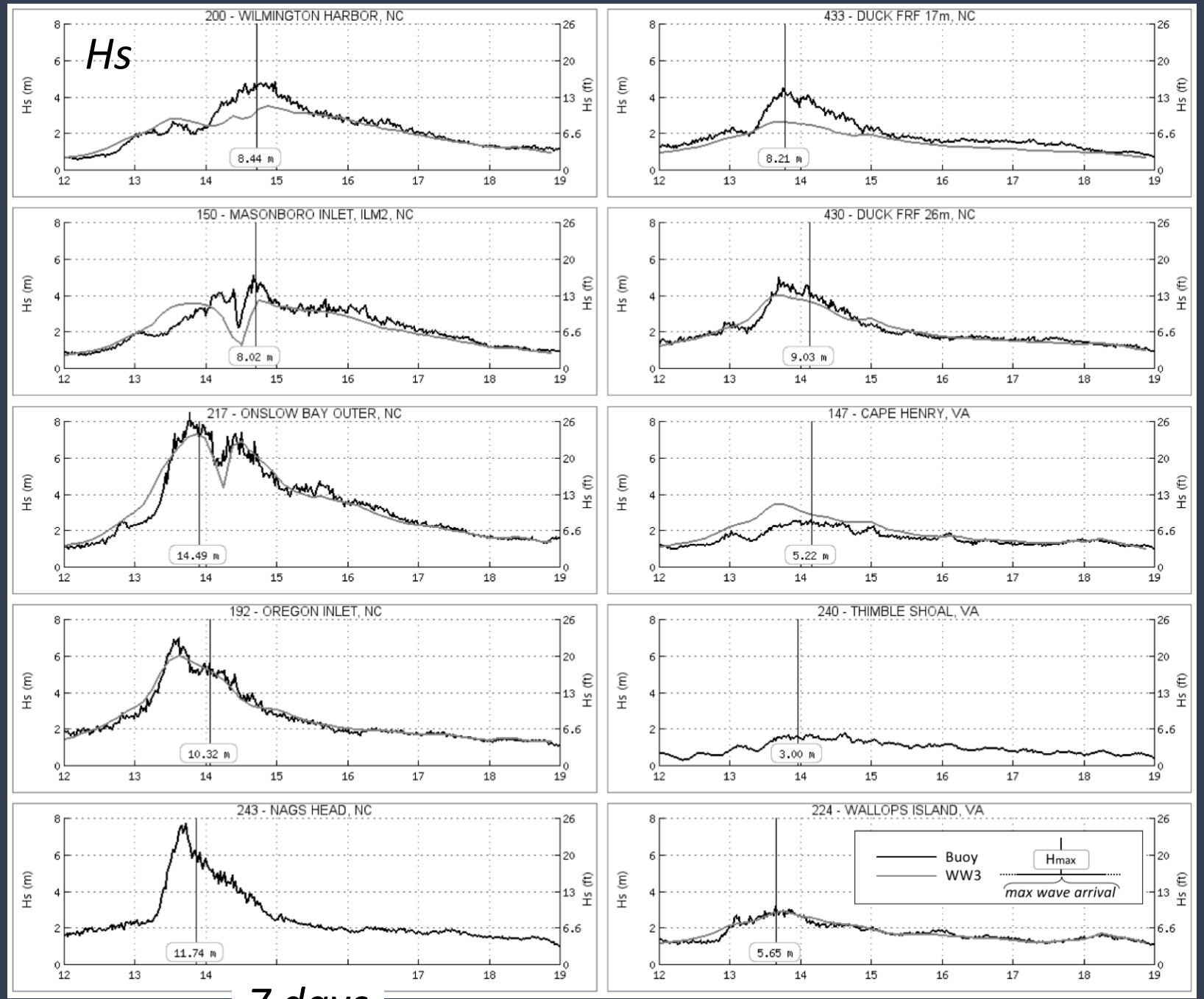
$17-22 billion in damage

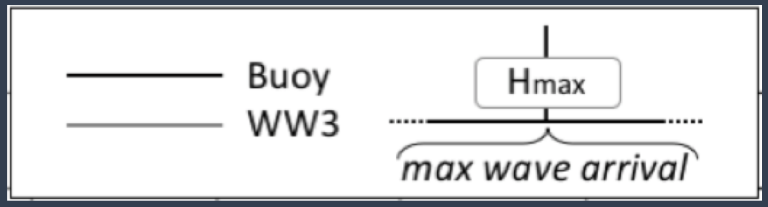


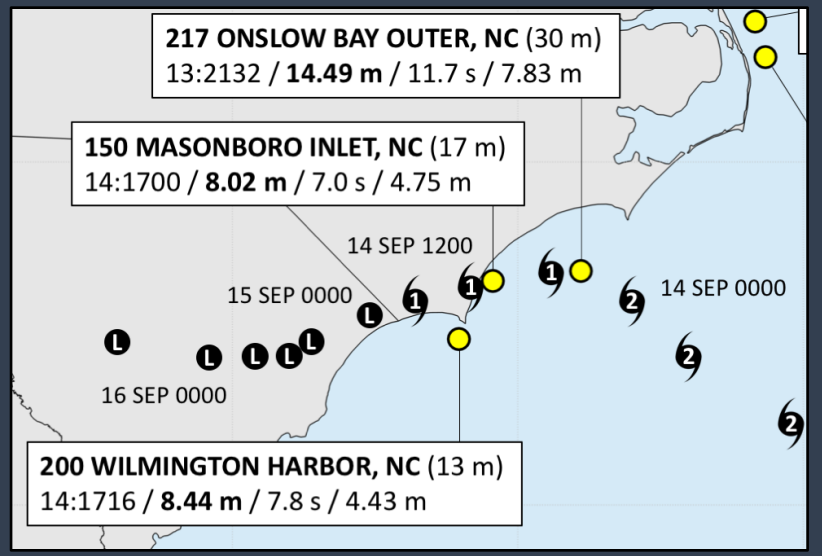


Hurricane Florence
September 2018




Hs
200 - WILMINGTON HARBOR, NC
8.44 m
433 - DUCK FRF 17m, NC
8.21 m
150 - MASONBORO INLET, ILM2, NC
8.02 m
430 - DUCK FRF 26m, NC
9.03 m
217 - ONSLOW BAY OUTER, NC
14.49 m
147 - CAPE HENRY, VA
5.22 m
192 - OREGON INLET, NC
10.32 m
240 - THIMBLE SHOAL, VA
3.00 m
243 - NAGS HEAD, NC
11.74 m
224 - WALLOPS ISLAND, VA
5.65 m
Hs (m)
Hs (ft)
Buoy
WW3
Hmax
max wave arrival
7 days


Buoy
WW3
Hmax
max wave arrival


217 ONSLOW BAY OUTER, NC (30 m)
13:2132 / 14.49 m / 11.7 s / 7.83 m
150 MASONBORO INLET, NC (17 m)
14:1700 / 8.02 m / 7.0 s / 4.75 m
14 SEP 1200
15 SEP 0000
14 SEP 0000
16 SEP 0000
200 WILMINGTON HARBOR, NC (13 m)
14:1716 / 8.44 m / 7.8 s / 4.43 m

Hurricane Dorian

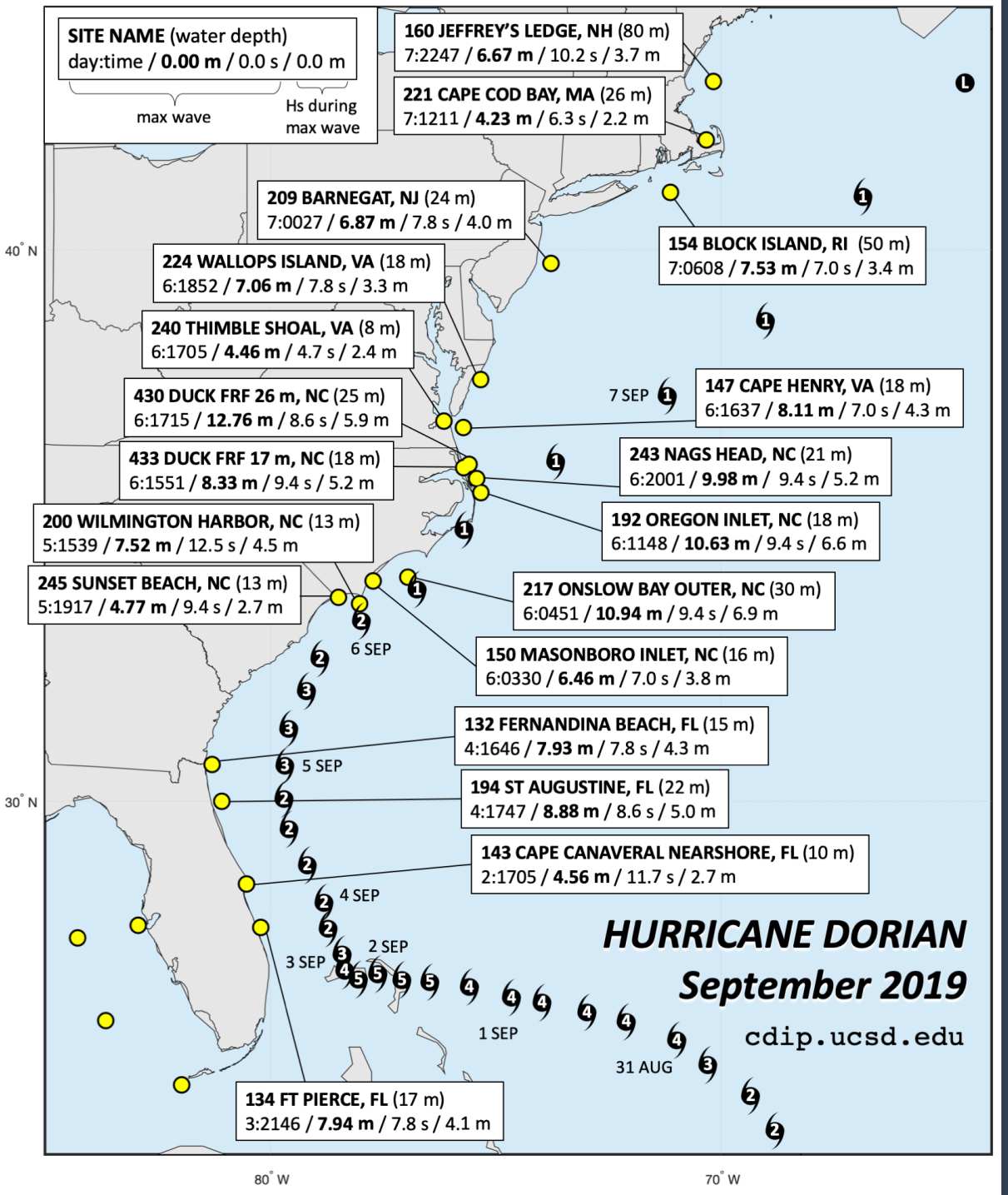
September 2019

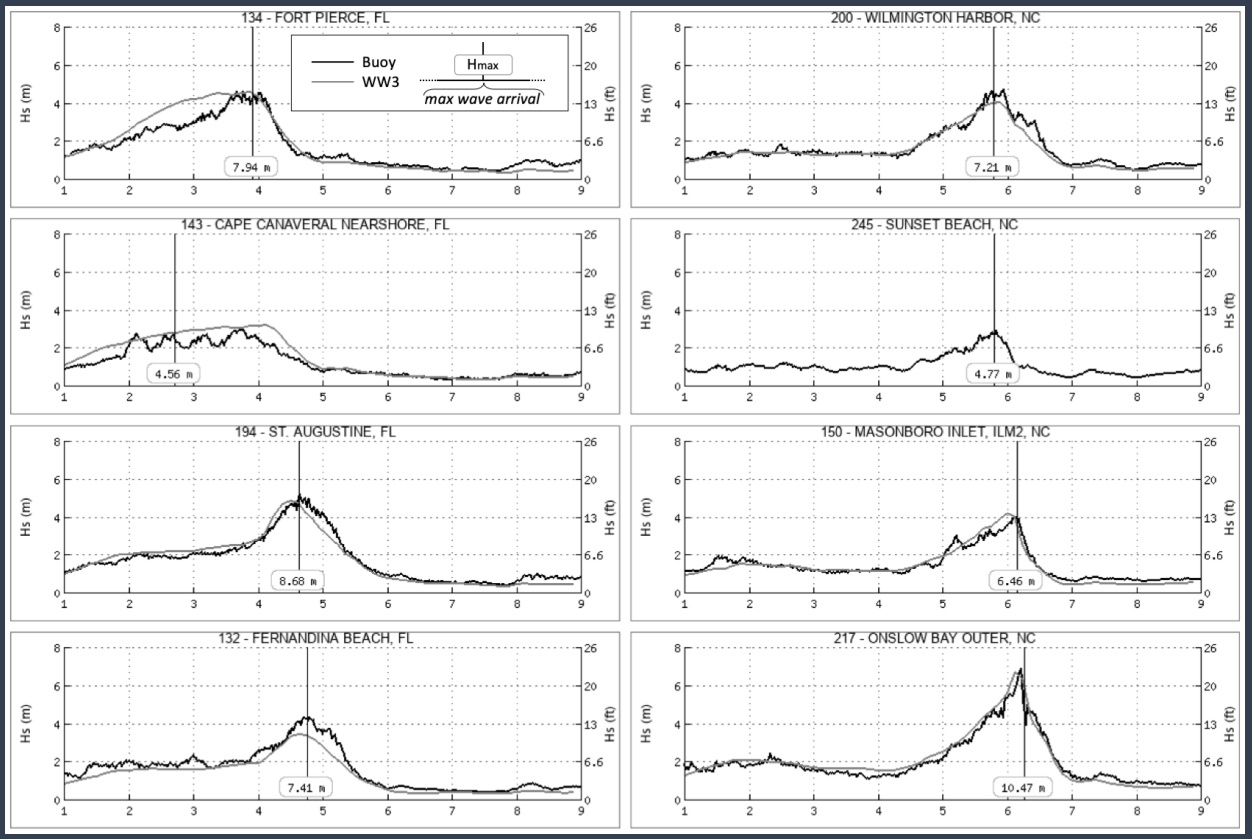
Virginia

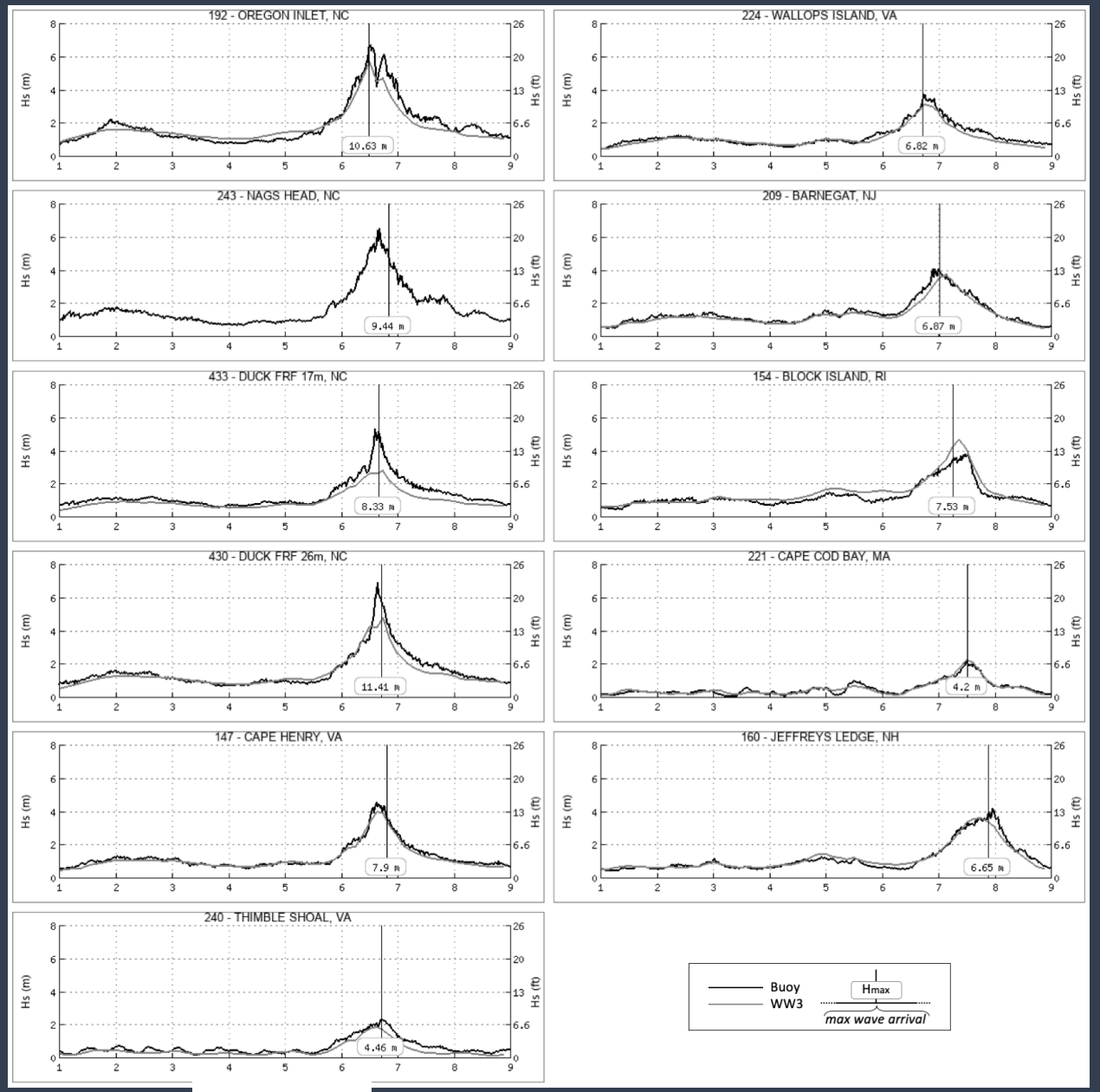
North Carolina

Hurricane Dorian

September 2019







Hurricane Dorian

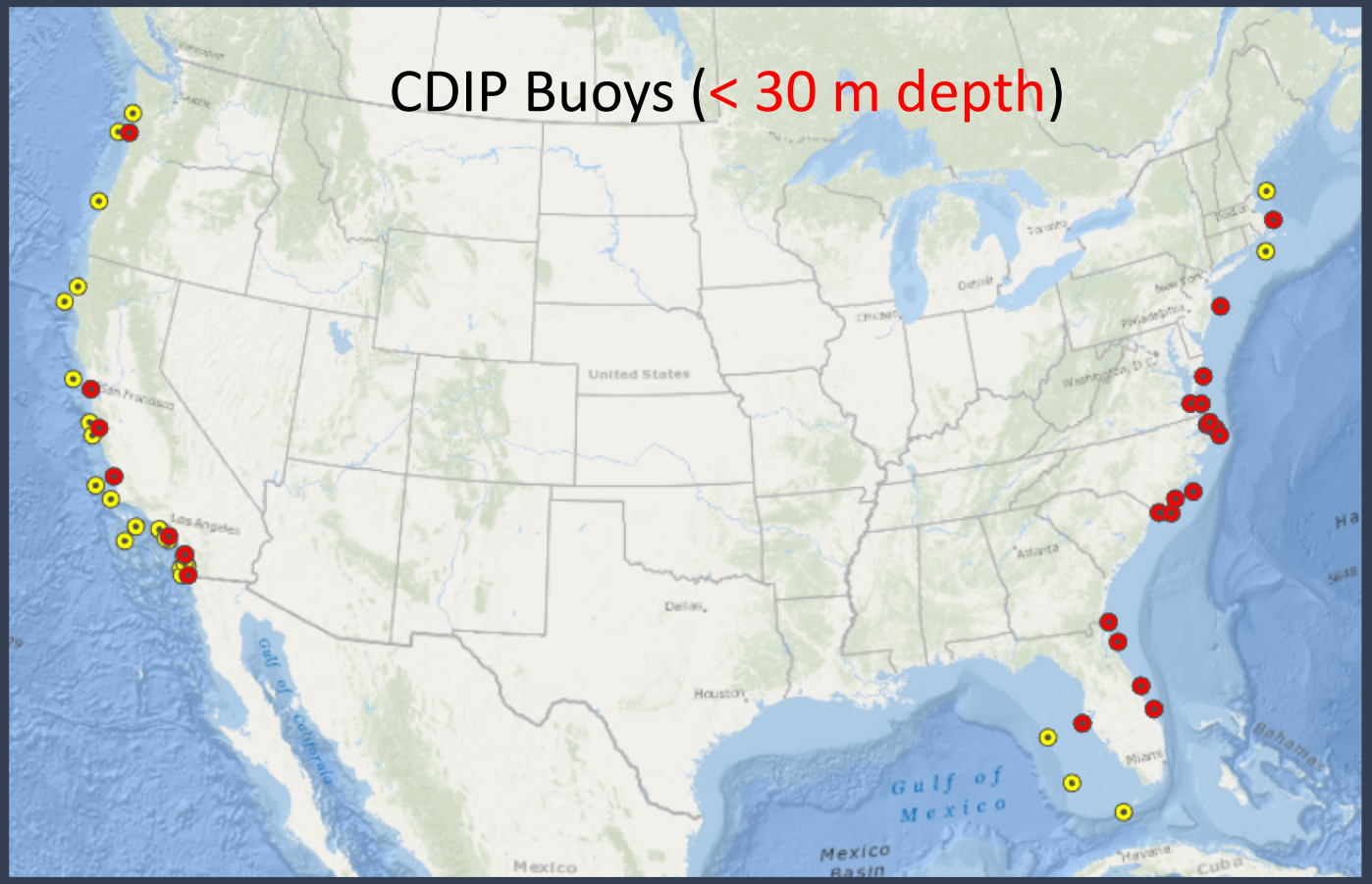
September 2019

8 days

Wave Radiation Stress

$$S_{xy} = \int_0^{\infty} \int_{-\pi}^{\pi} E(f,\theta) \frac{c_g(f)}{c(f)} \sin(\theta)\cos(\theta)\, d\theta df$$

- Sxy = alongshore momentum flux
  - Drives alongshore currents in surf zone, and thus sediment transport
  - Wave setup
- Relevance limited to shallow water depths (< 30 m)
- Planar coastlines



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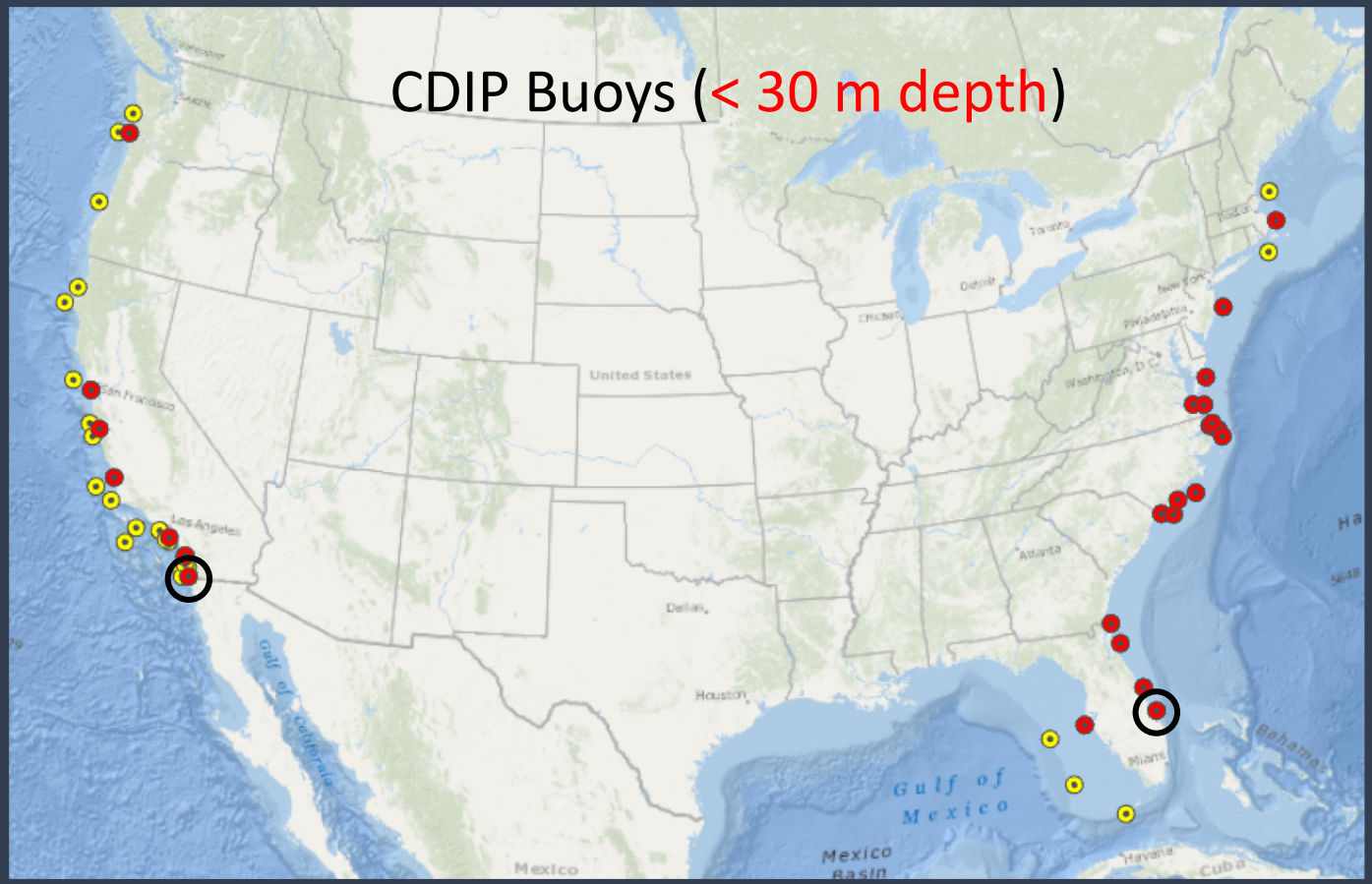
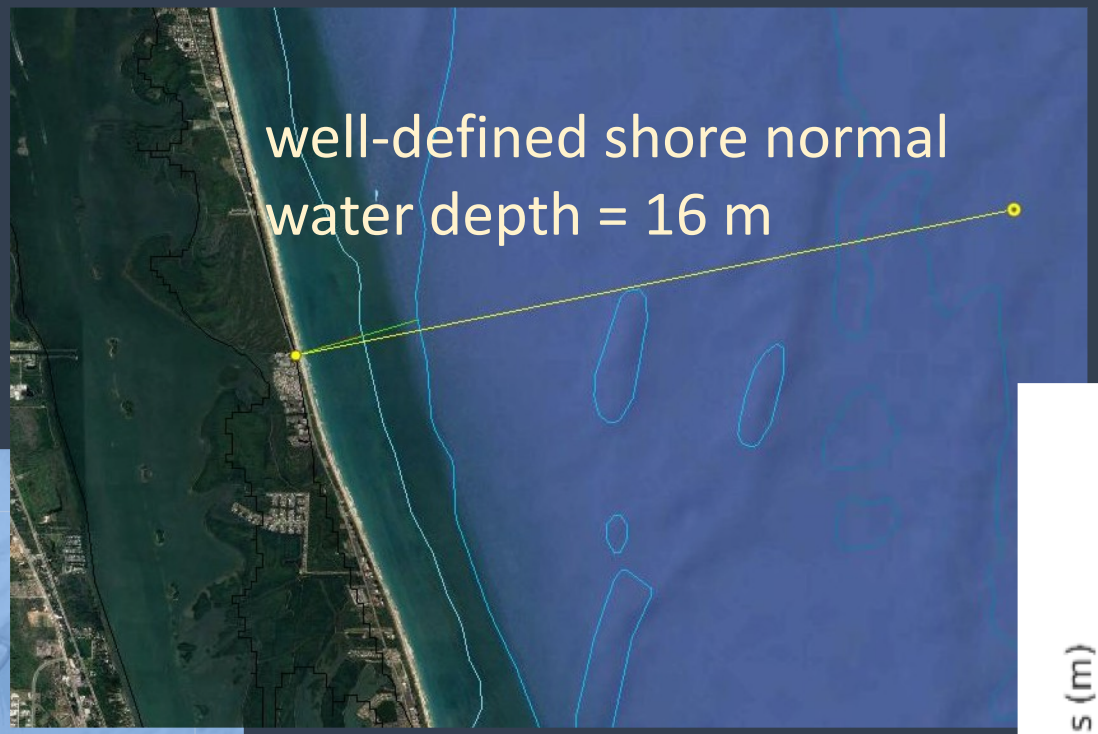
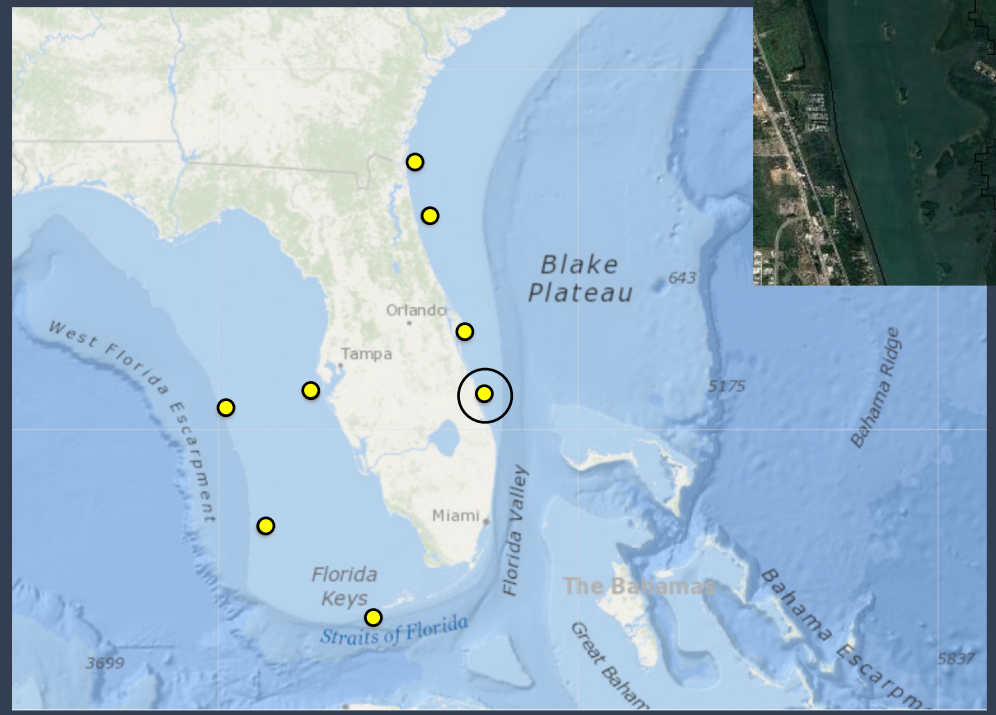
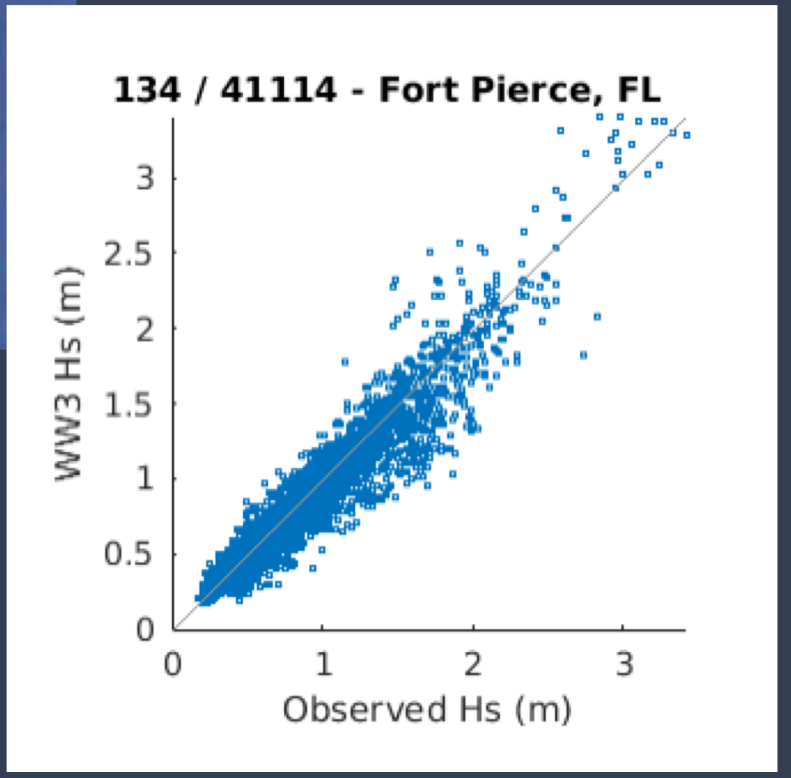


CDIP 134 (NDBC 41114) - Fort Pierce, Florida





WW3 vs Buoy: 2018 Hs



134p1_ns, 41114_ns

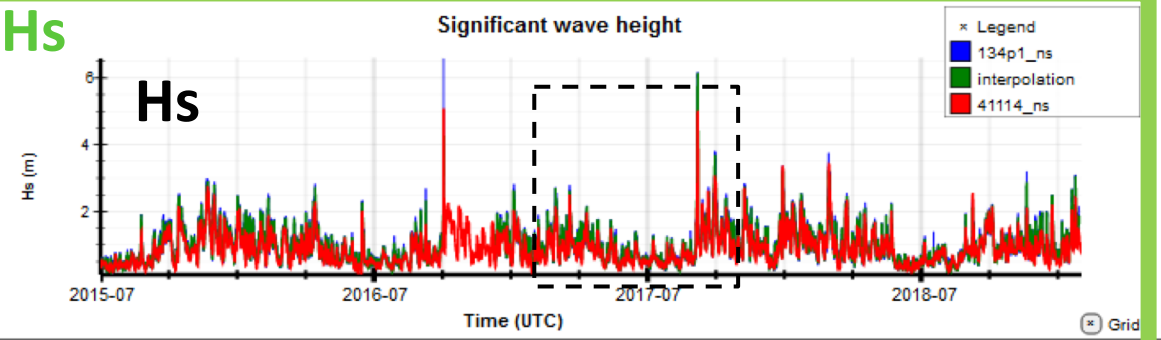
View: Complete | Yearly | Monthly

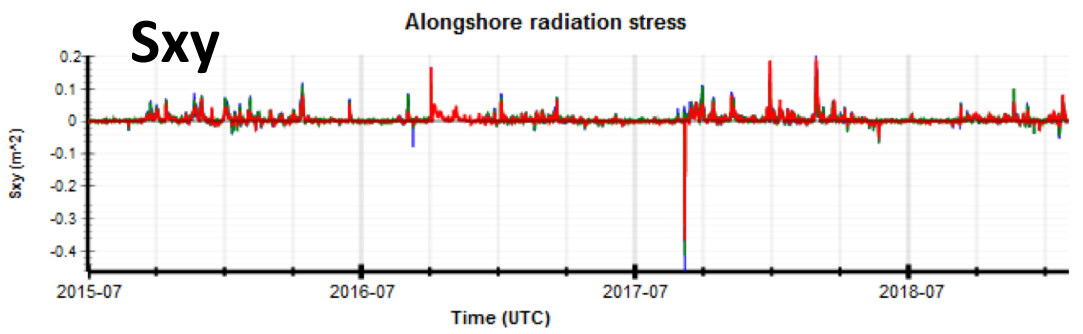
Complete dataset

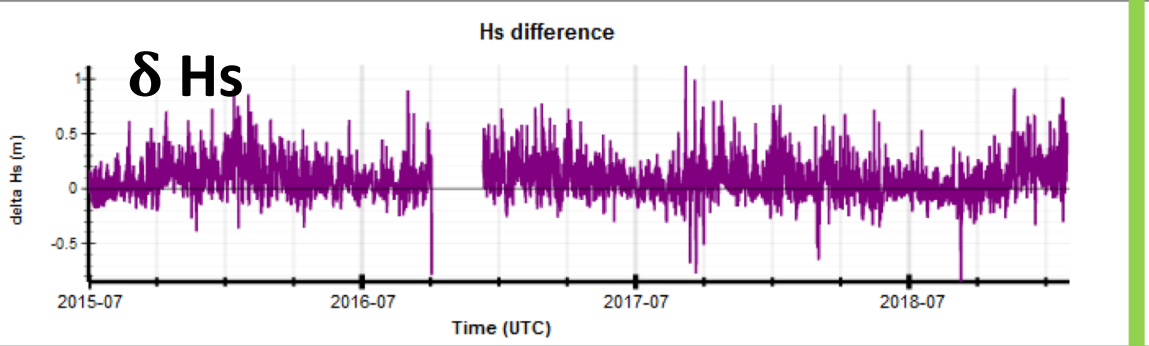
Total records: 59390, 10475
Count, stride: 9900, 2

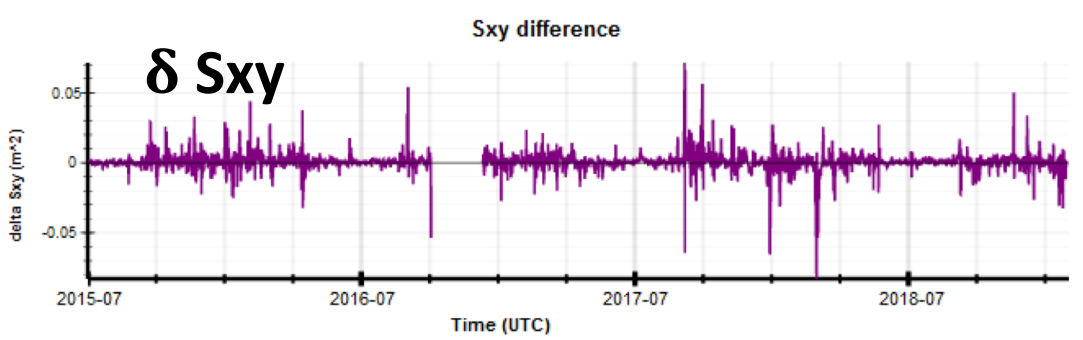
Recs per day (calculated): 8.0

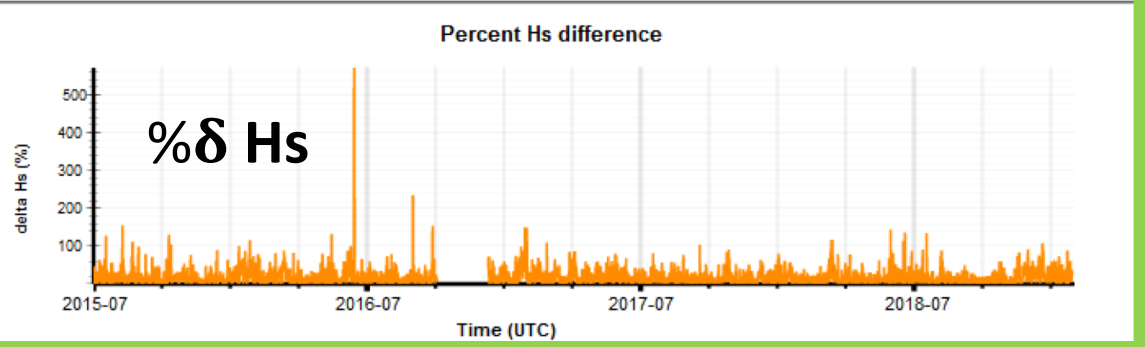
Hs

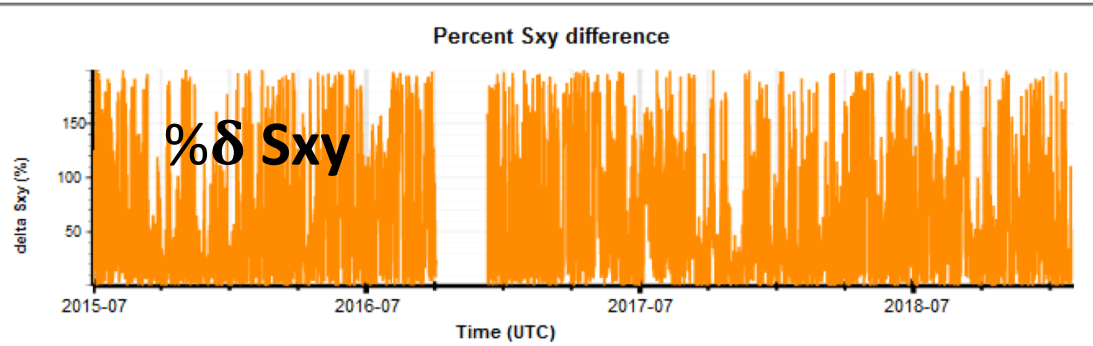


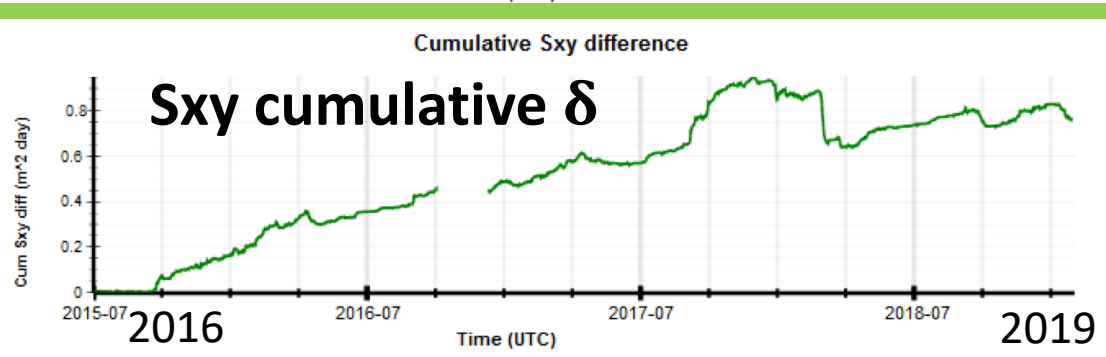


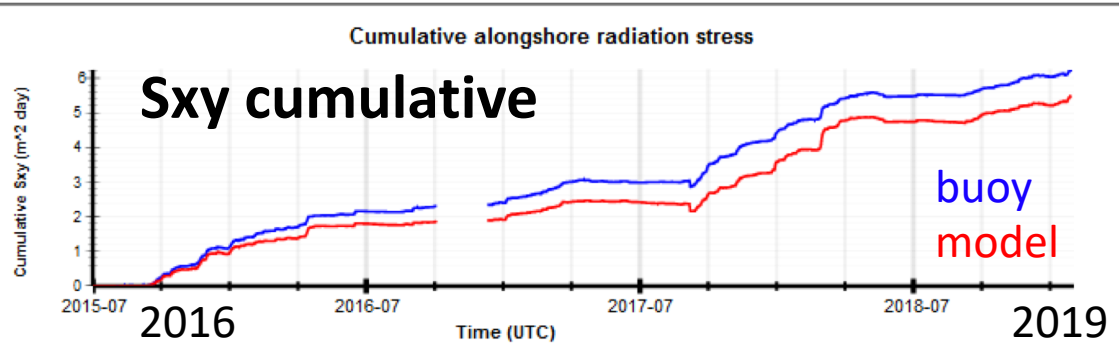












134p1_ns, 41114_ns

View: Complete | Yearly | Monthly

Complete dataset

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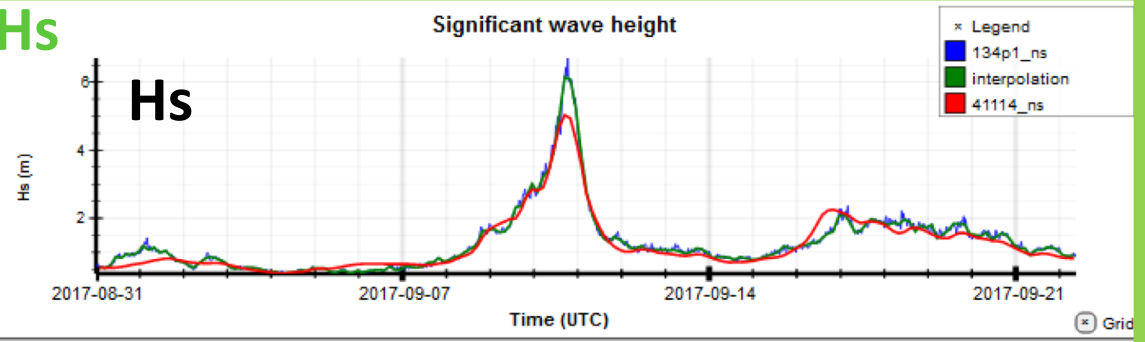
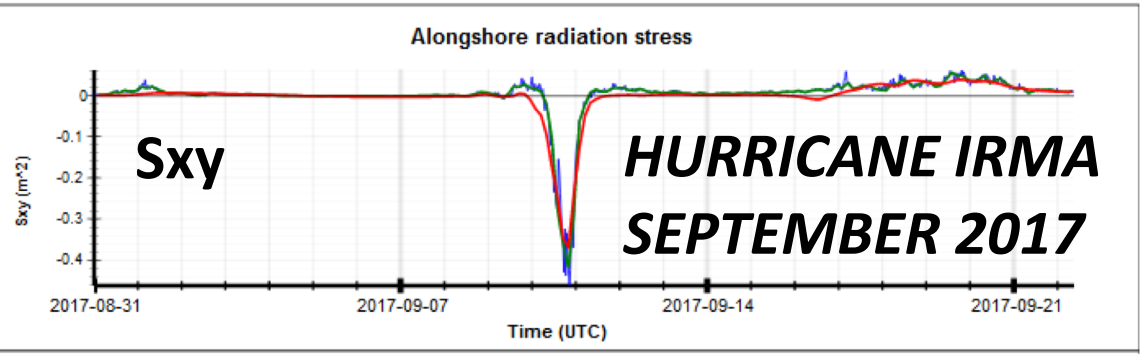
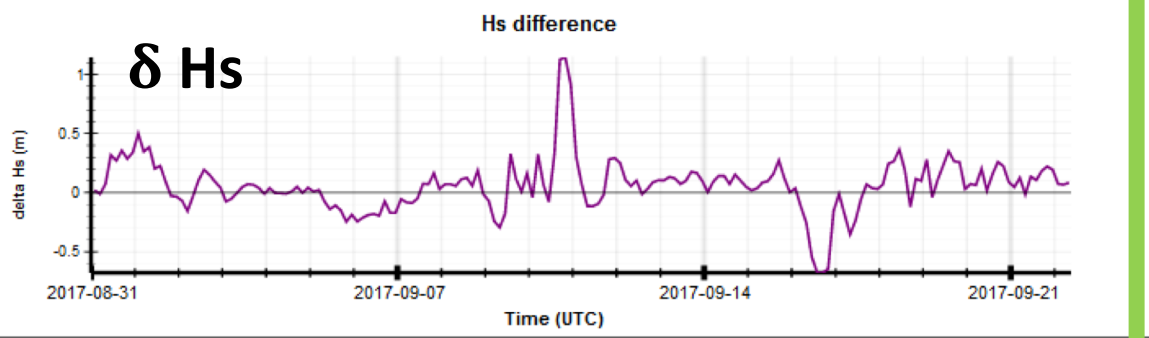
Count, stride: 179, 1

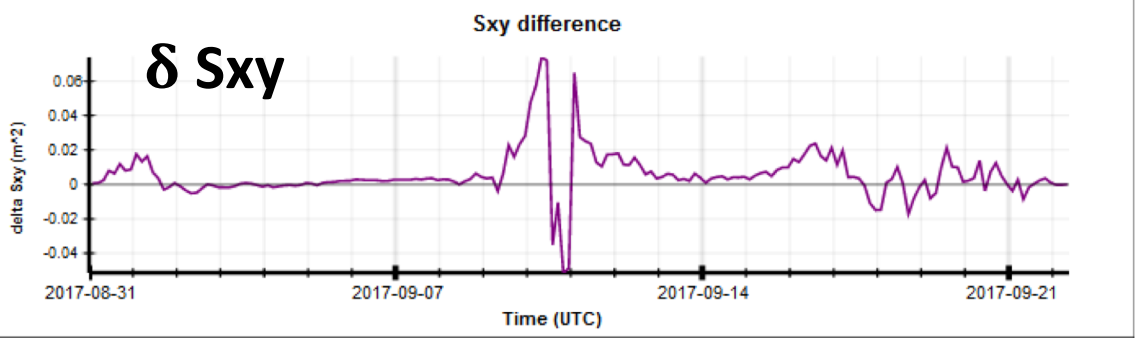
Recs per day (calculated): 8.0

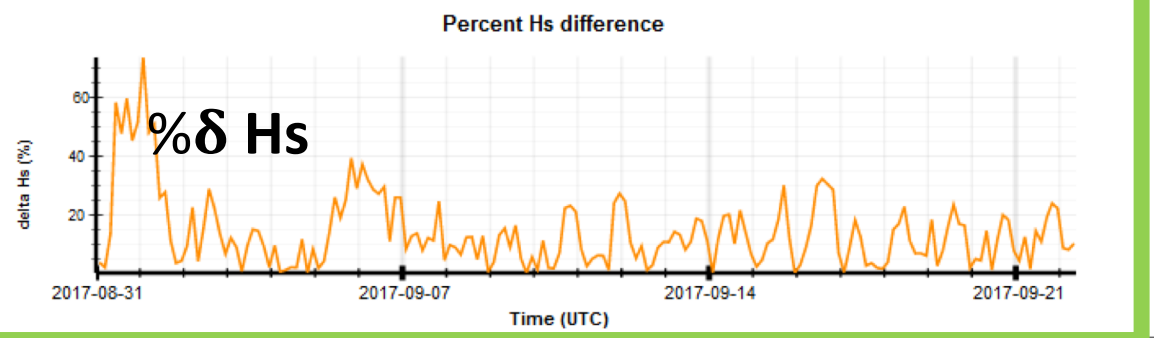
Hs

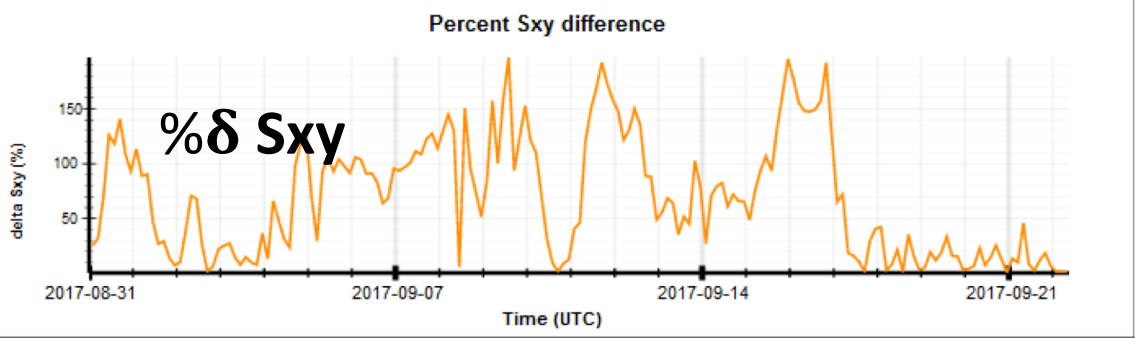


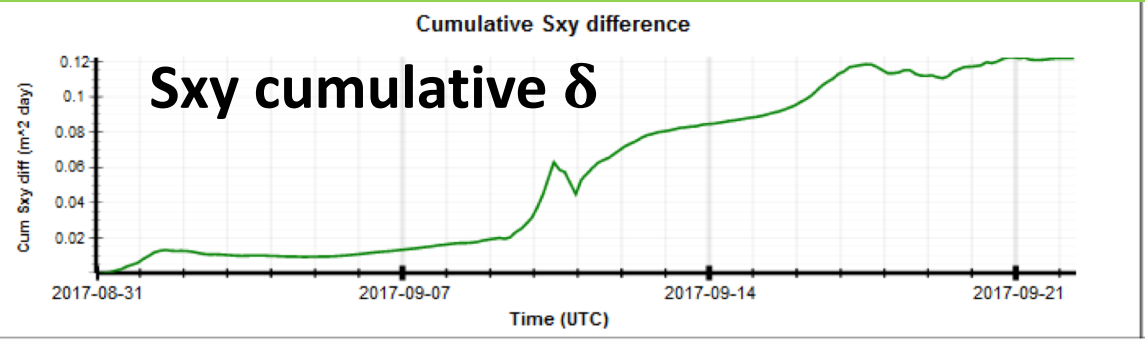


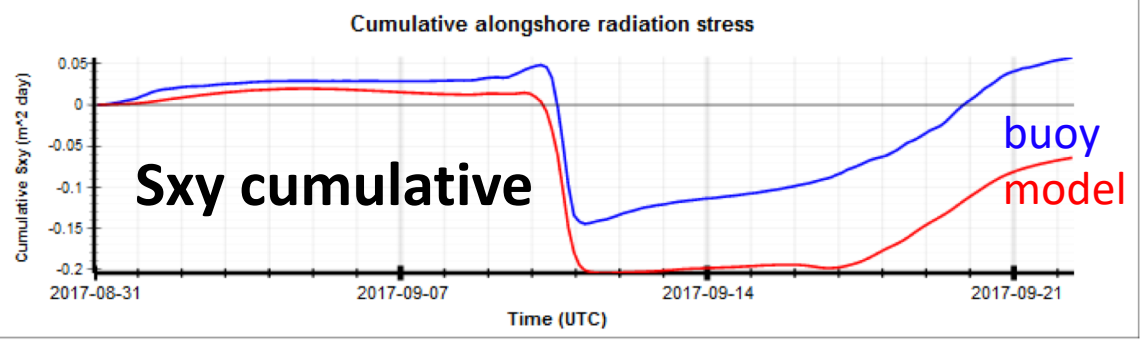




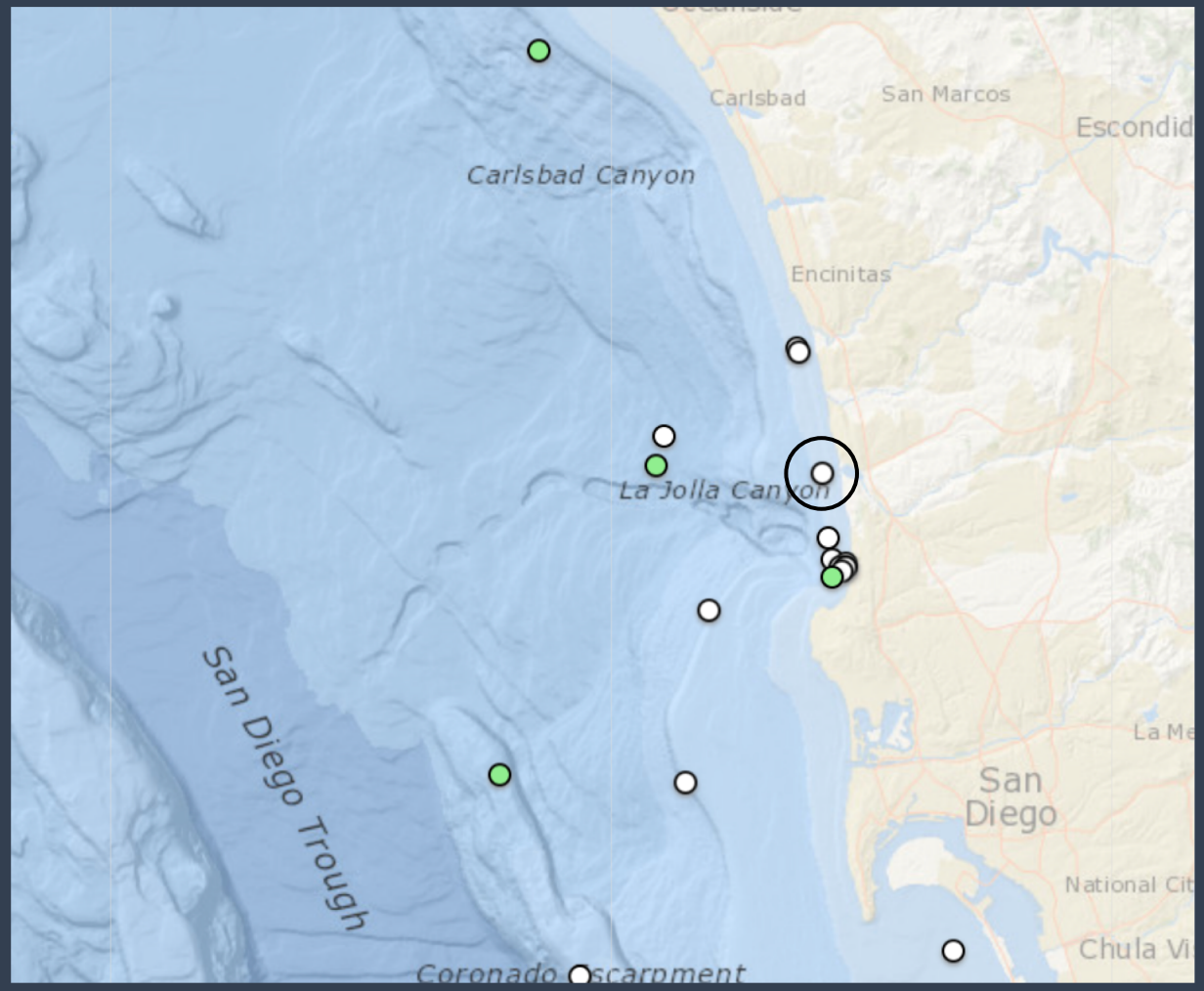


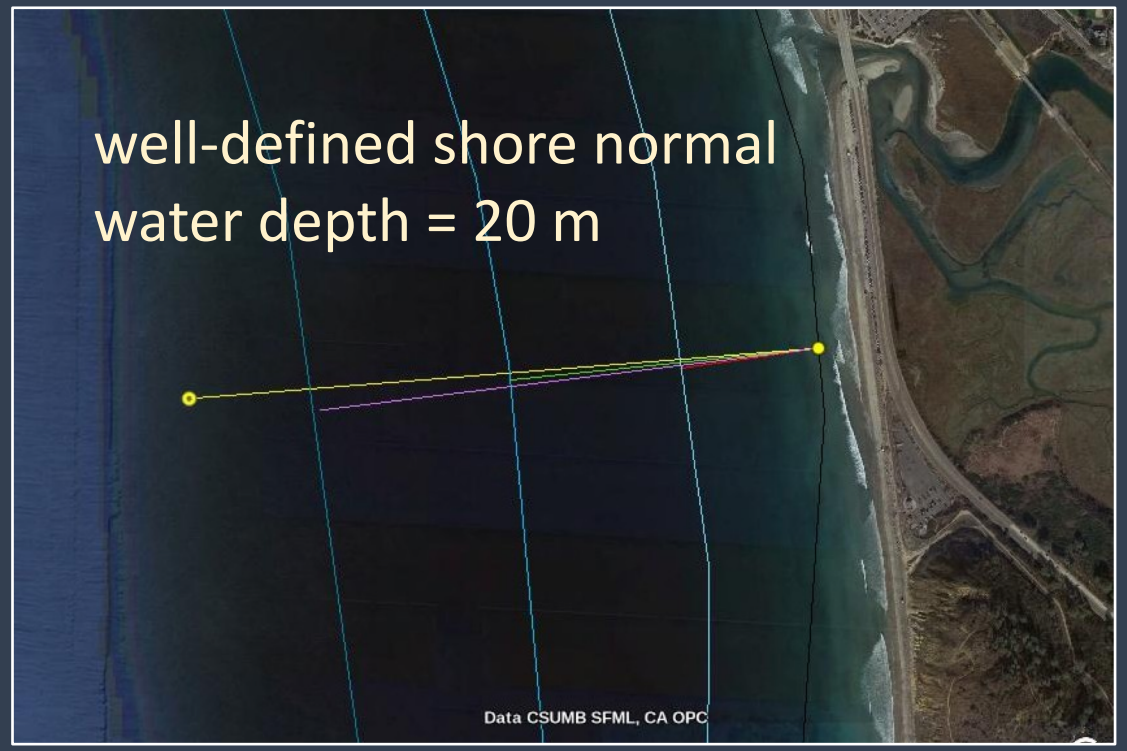






CDIP 101 Torrey Pines Inner, California





101p1_ns, BP101_ns

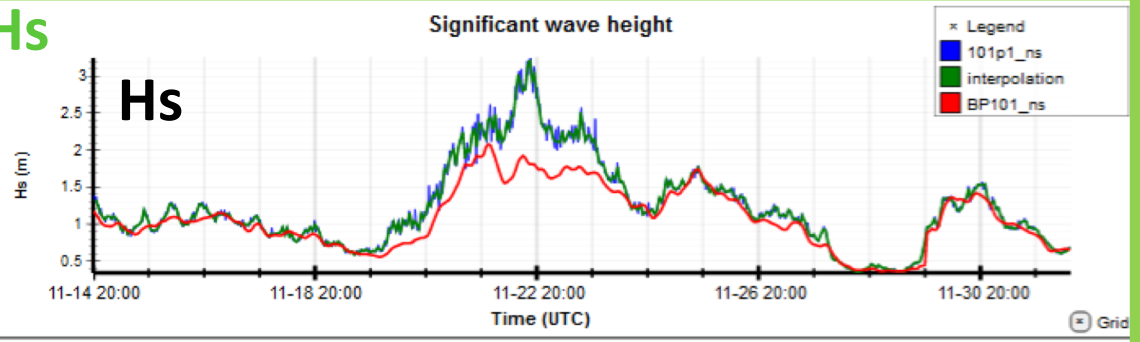
View: Complete | Yearly | Monthly

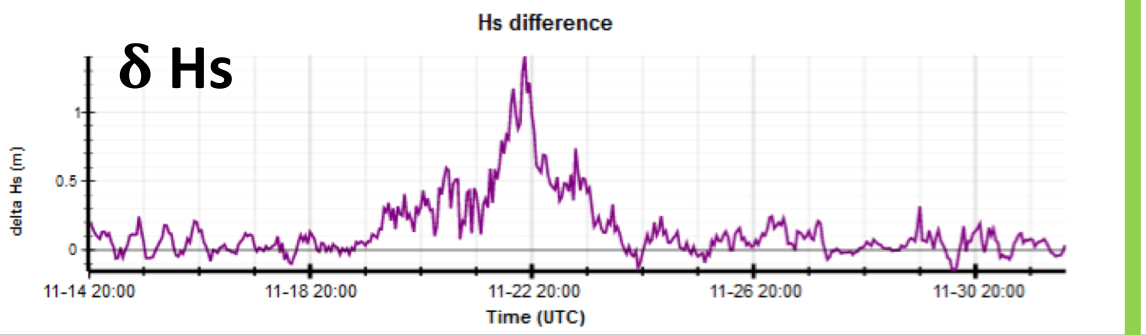
Complete dataset

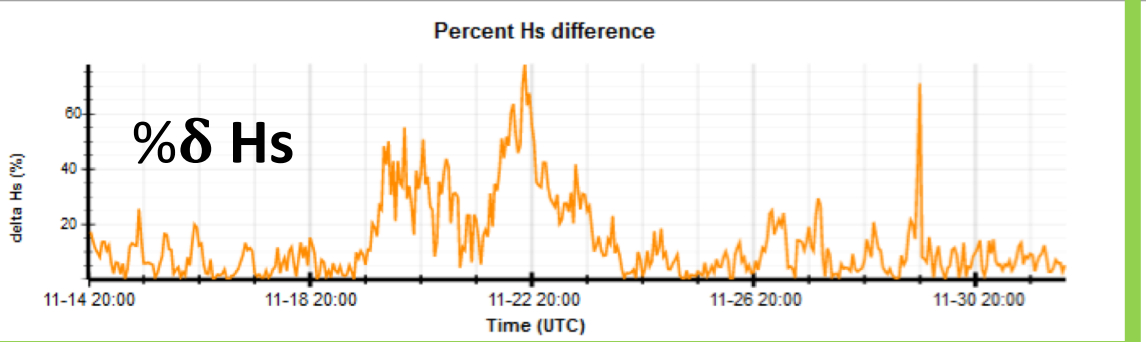
Total records: 847, 424
Count, stride: 423, 1

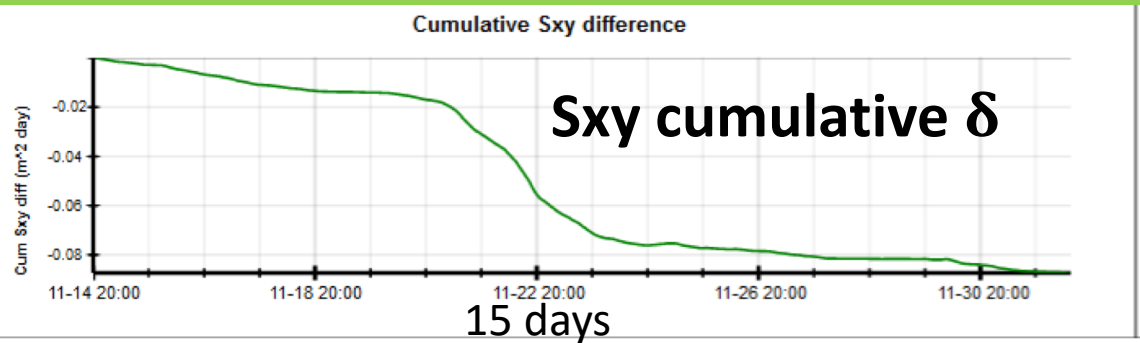
Recs per day (calculated): 24.1

Hs

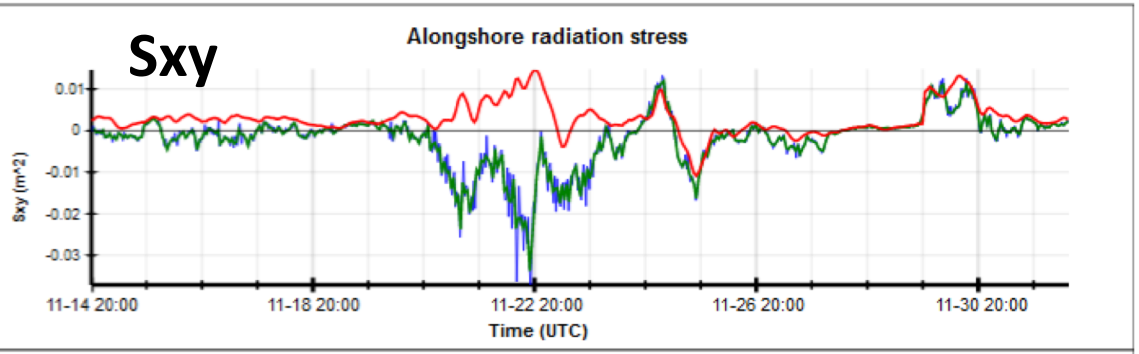


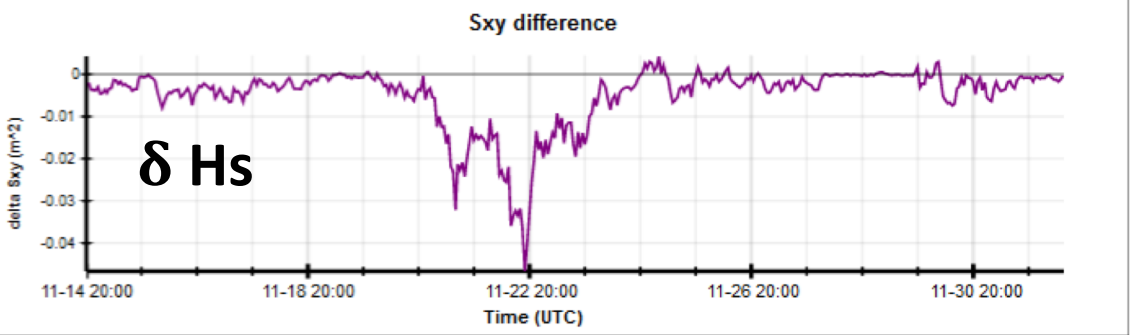


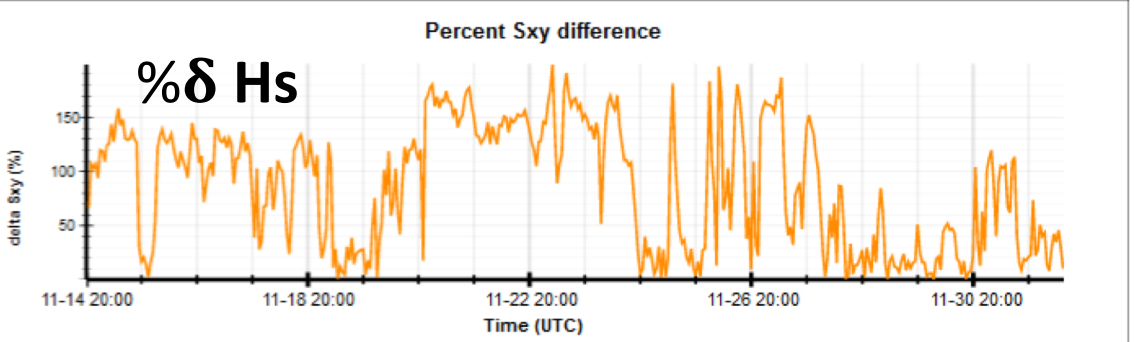


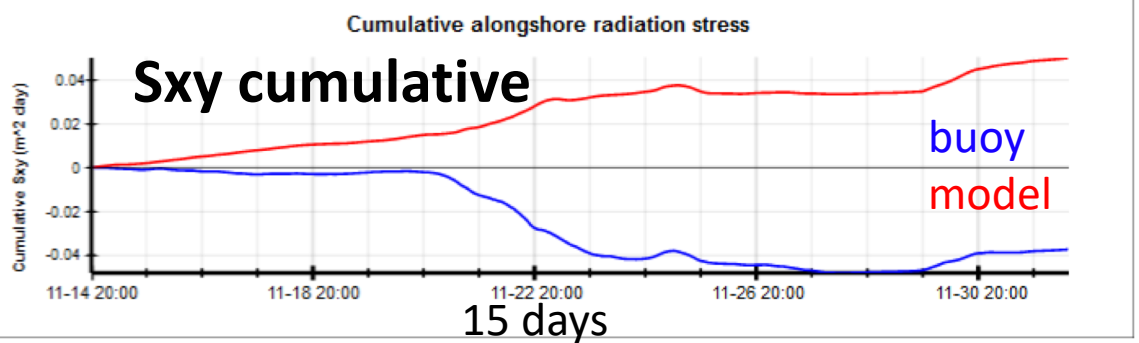


15 days









15 days

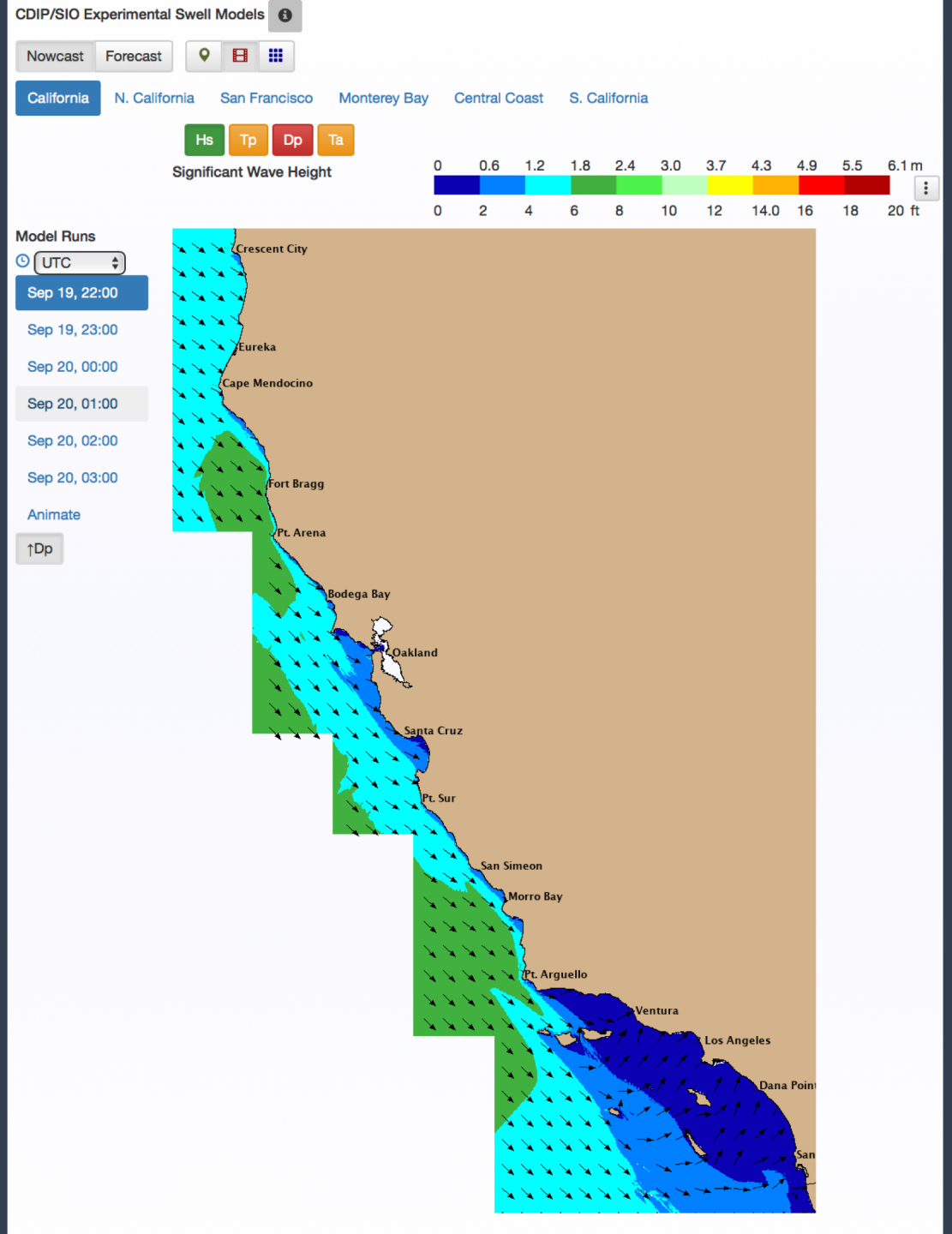
- CDIP Overview
- Buoy Co-location
- Hurricane wave data
- Coastal inundation
- Wave power

CDIP California Wave Model

"Nowcast" and hindcast (back to 2000) model driven by **buoy data** + bathymetry + physics

Output points every 100 - 200 m along the coast

T ≥ 8 sec. Does not include locally generated waves



CDIP California Wave Model

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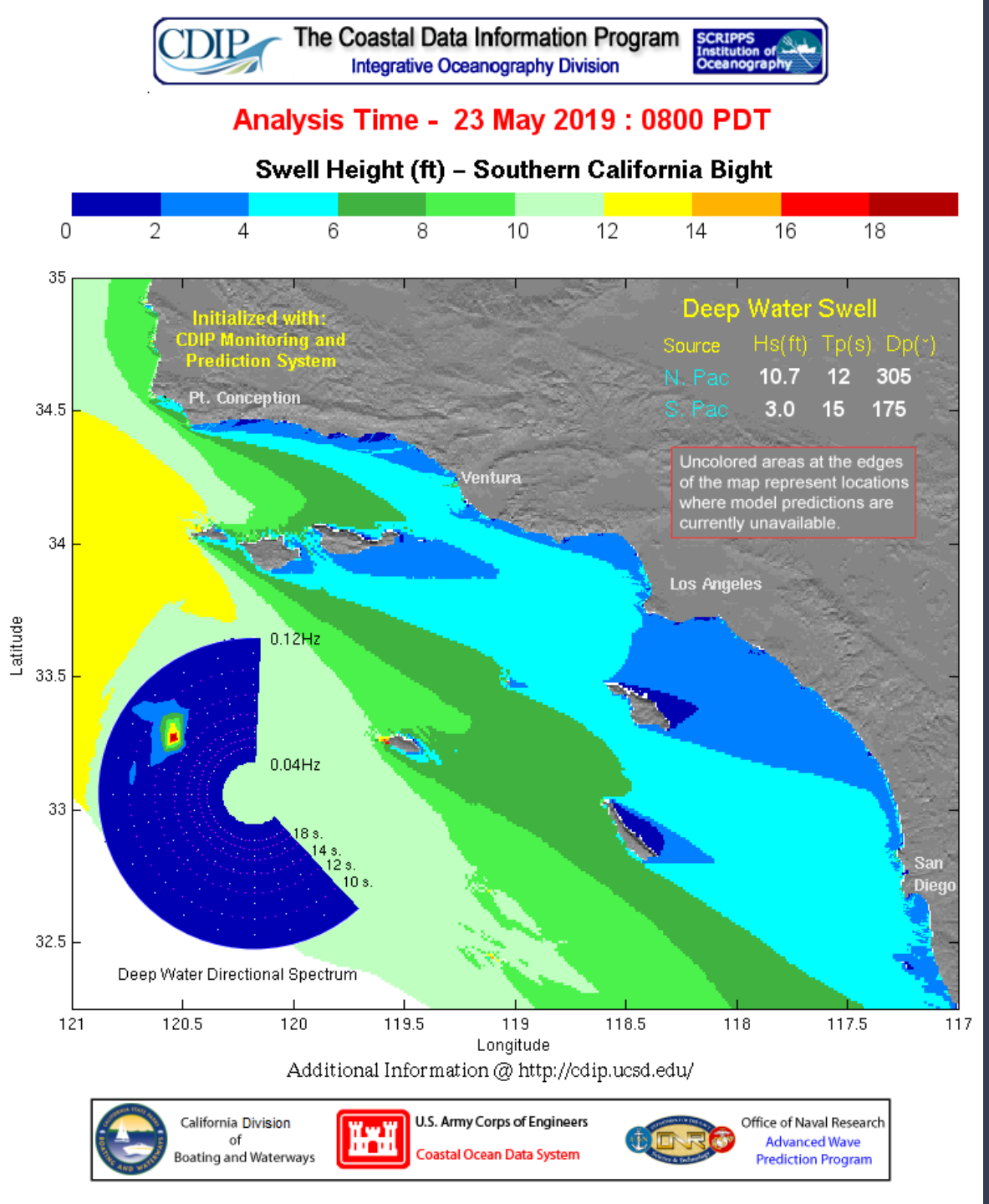
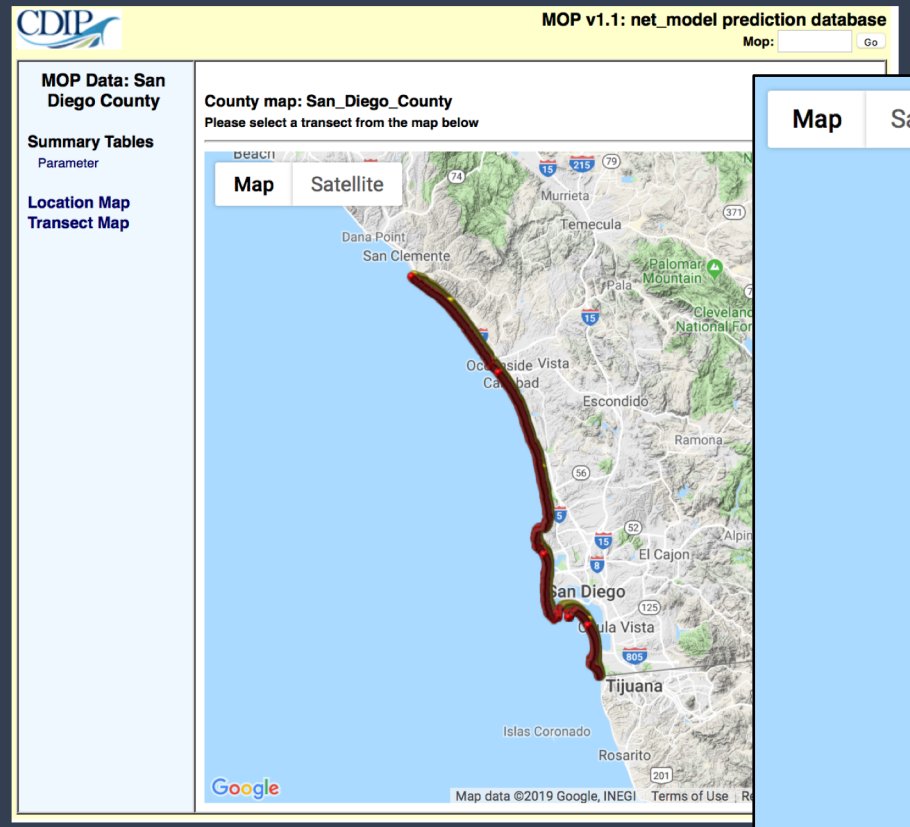
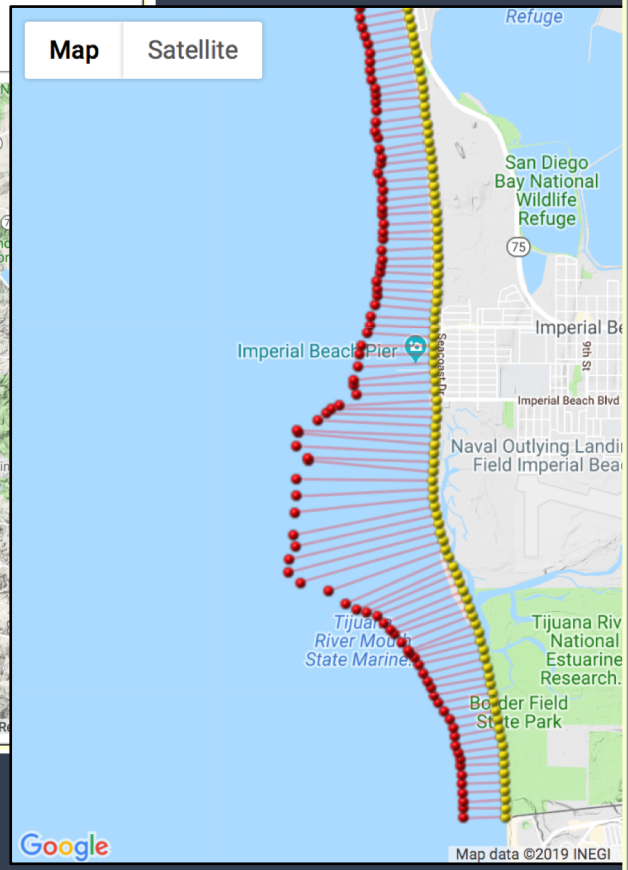
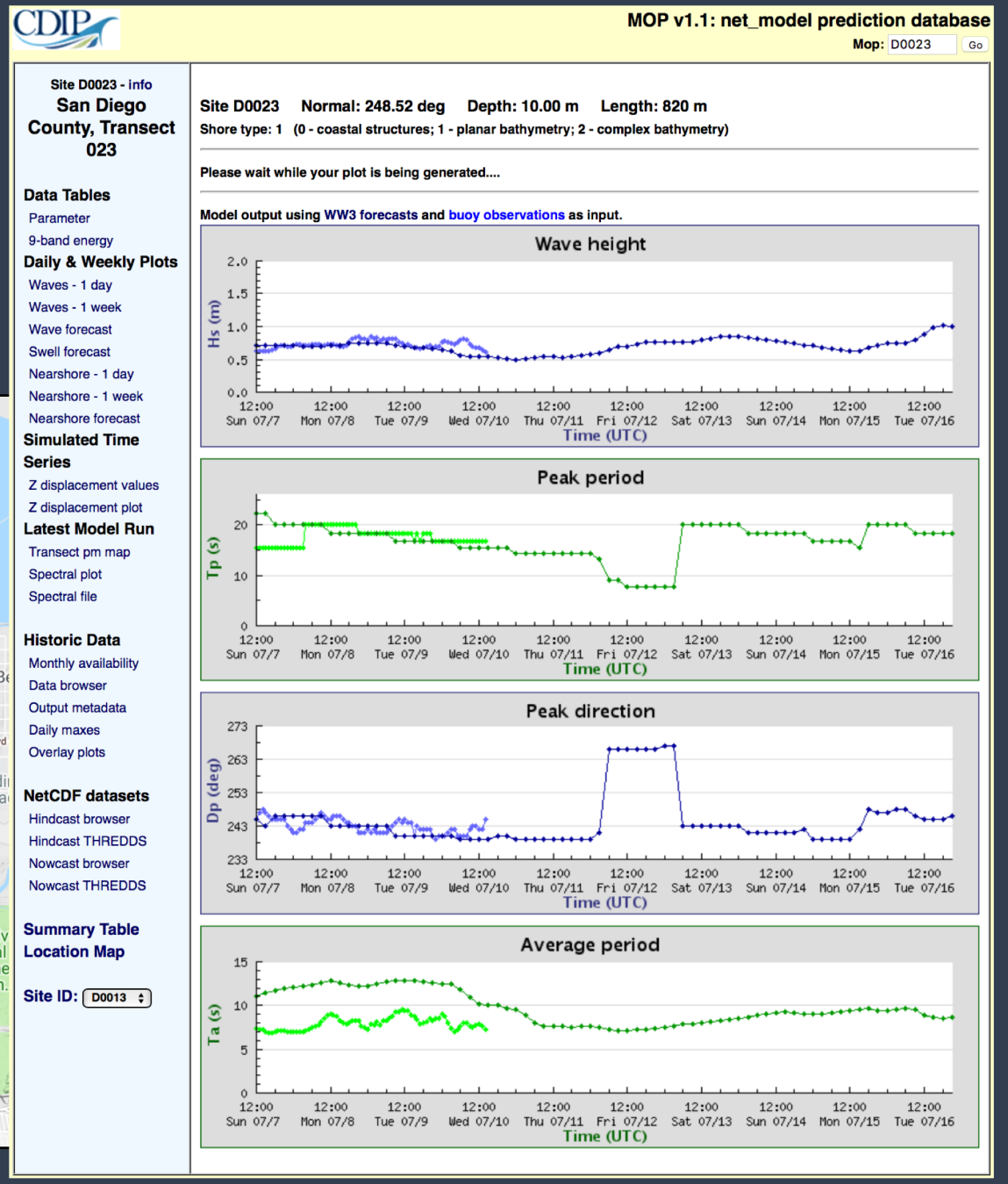


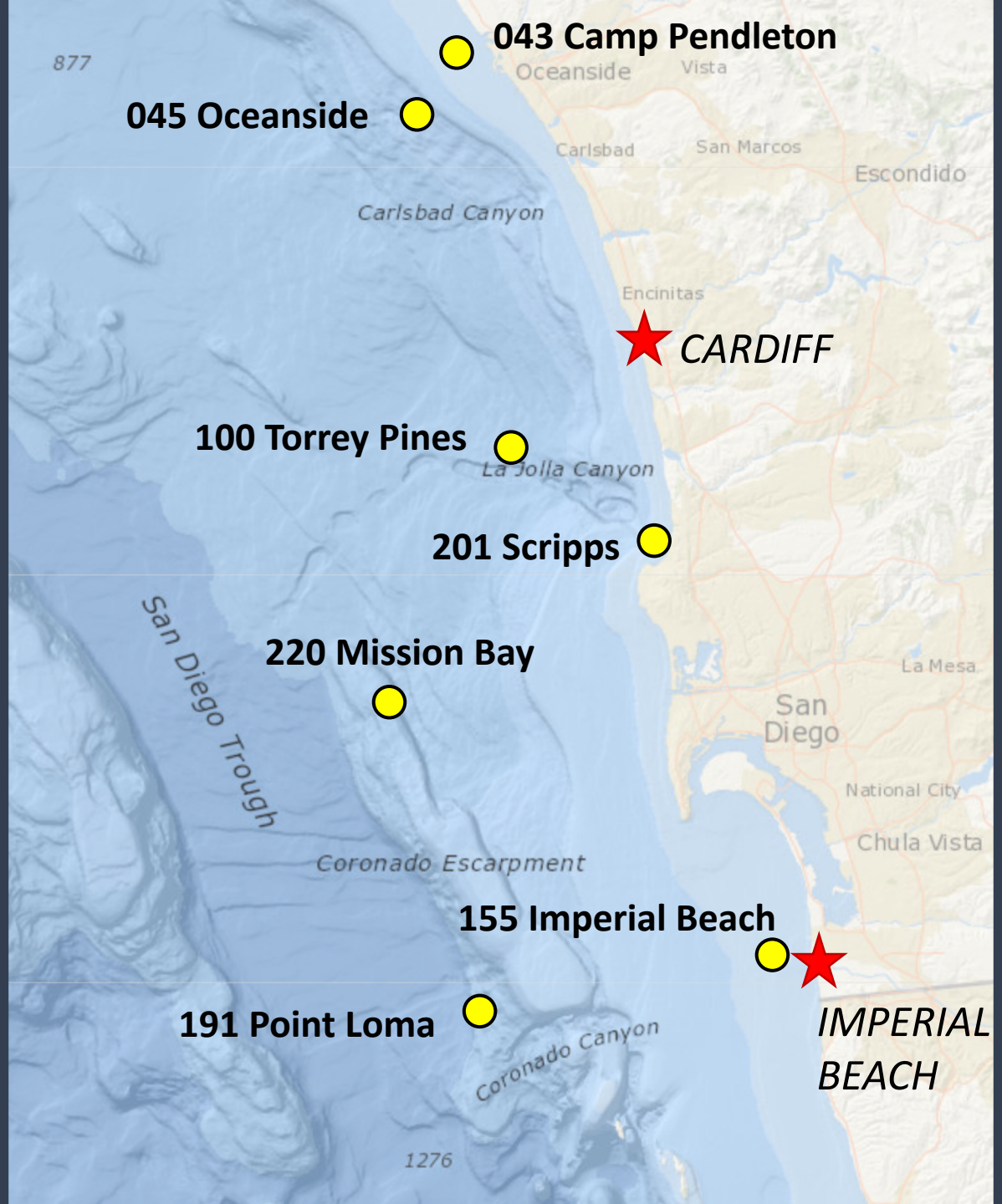
CDIP California Wave Model

Coastal wave conditions at 10 m depth

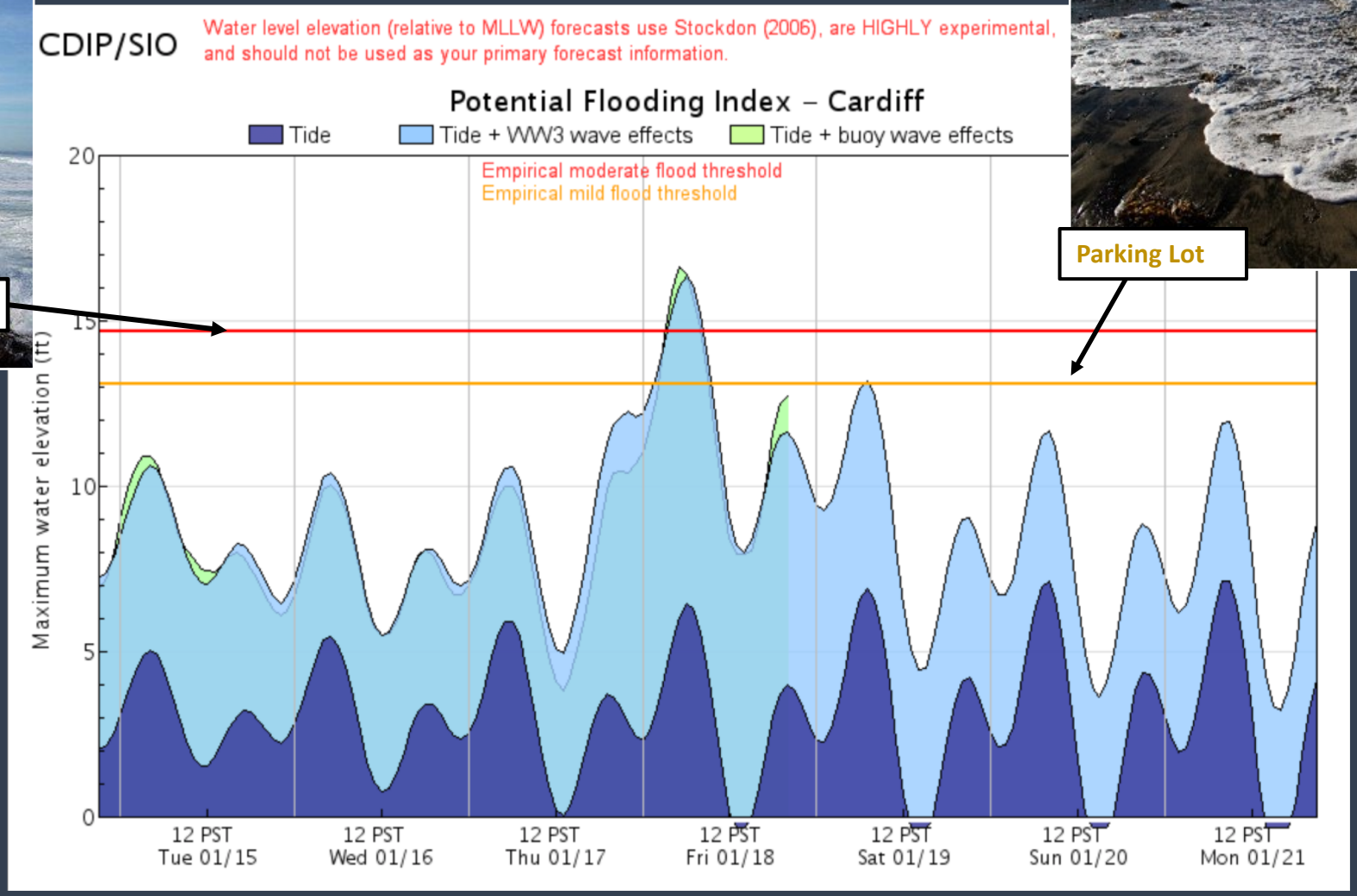







043 Camp Pendleton
045 Oceanside
CARDIFF
100 Torrey Pines
201 Scripps
220 Mission Bay
155 Imperial Beach
191 Point Loma
IMPERIAL BEACH
877
Oceanside
Vista
Carlsbad
San Marcos
Escondido
Carlsbad Canyon
Encinitas
La Jolla Canyon
San Diego Trough
La Mesa
San Diego
National City
Chula Vista
Coronado Escarpment
Coronado Canyon
1276

Flood Warnings: Cardiff, CA



Collaboration with city governments, lifeguards, California State Parks, National Weather Service, waterfront businesses

Stockdon et al (2006): Water Level = $\alpha (H_0 L_0)^{1/2}$

IMPERIAL BEACH

Resilient Futures Project

- Developed local wave and bathymetry climatology with >10 years of data
- ~1750 model runs on an idealized eroded profile
- Model is well-established in field studies

Model input:

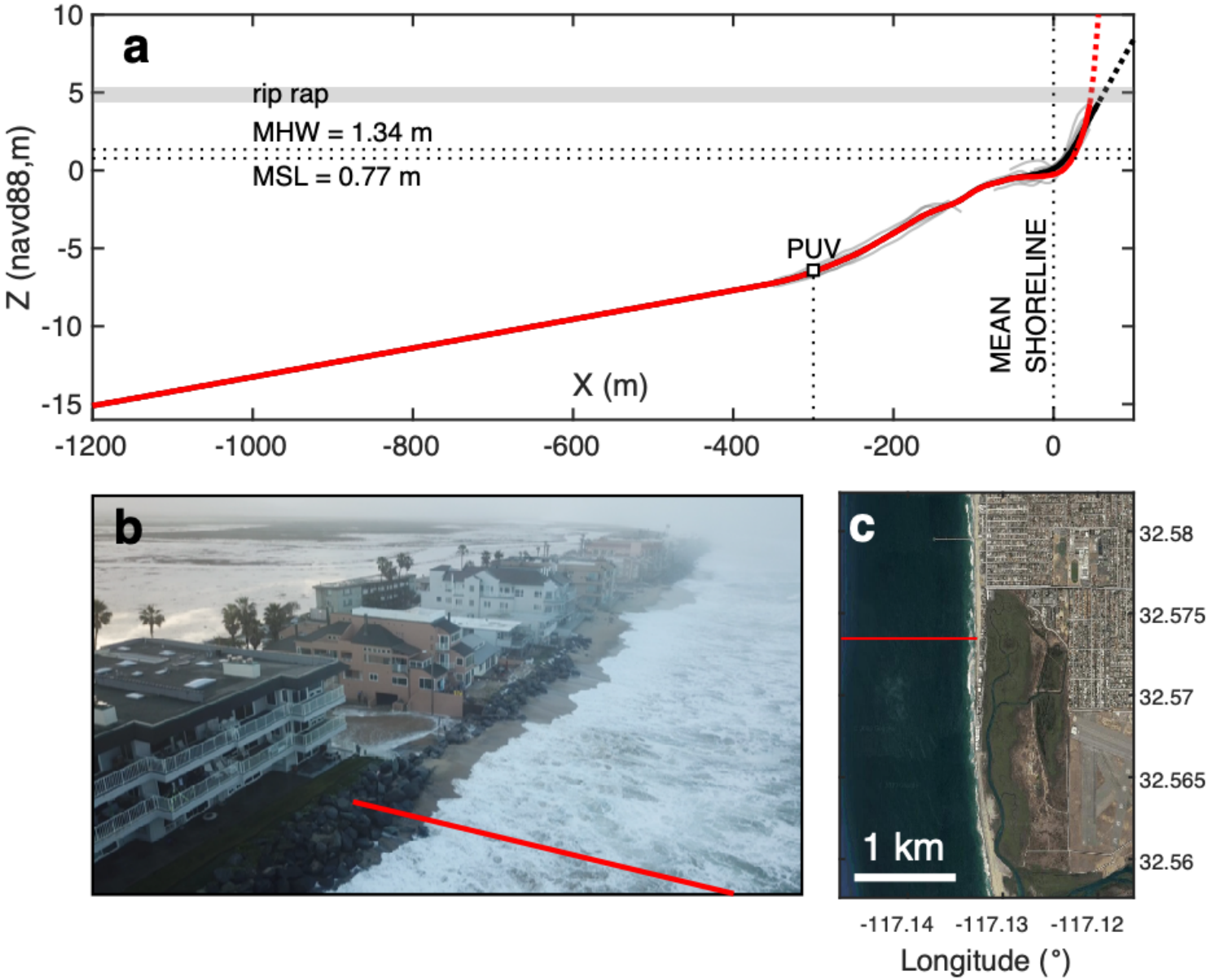
- Offshore waves
- Bathymetry

Validation:

- Lidar dataset of runup

Error sources:

- Bathymetry uncertainty
- Wave phasing
- IG component offshore



Credit: Julia Fiedler, SIO / UCSD

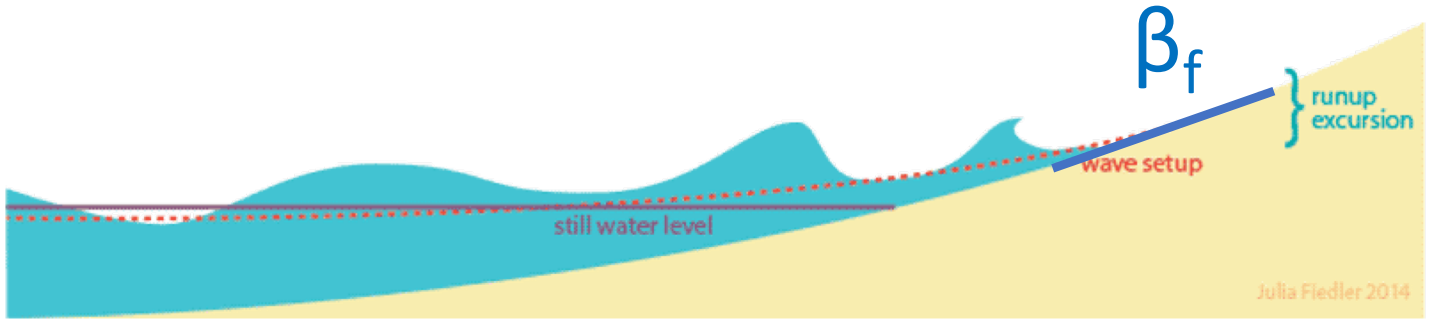
How can we reduce the error in runup prediction?

THE APPROACH:

More data!

- Accurate bathymetry (or beach slope) estimates
- Use spectral wave info instead of bulk parameters
- Understand the low-frequency waves in the model

$$R_{2\%} \sim \beta_f, (H_0 L_0)^{1/2}$$

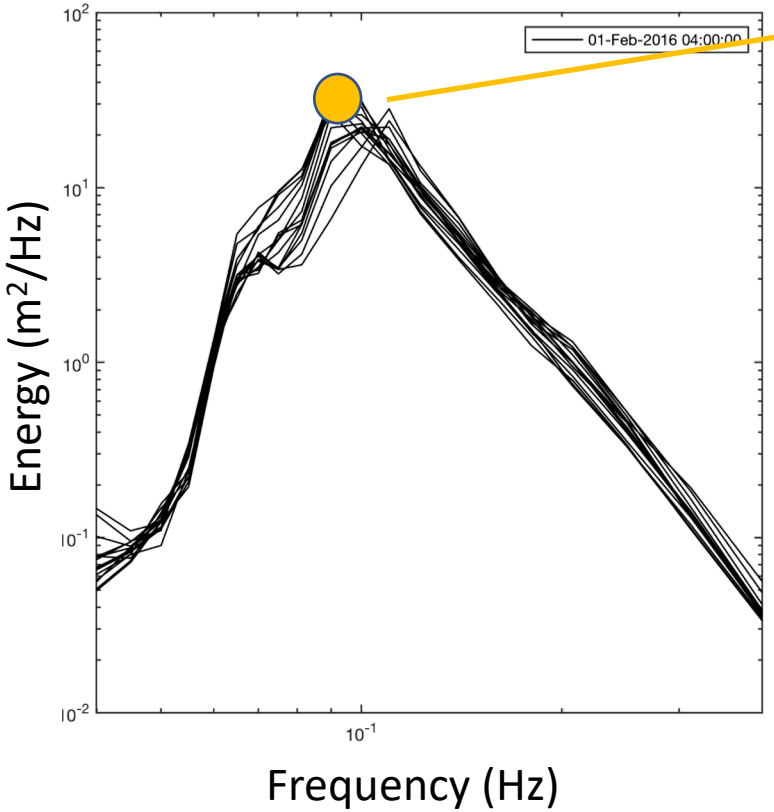


Credit: Julia Fiedler, SIO / UCSD

How can we reduce the error in runup prediction?

THE APPROACH: More data! Accommodate broad and multi-peaked spectra with a frequency-weighted integral

Wave information (MOPS model)



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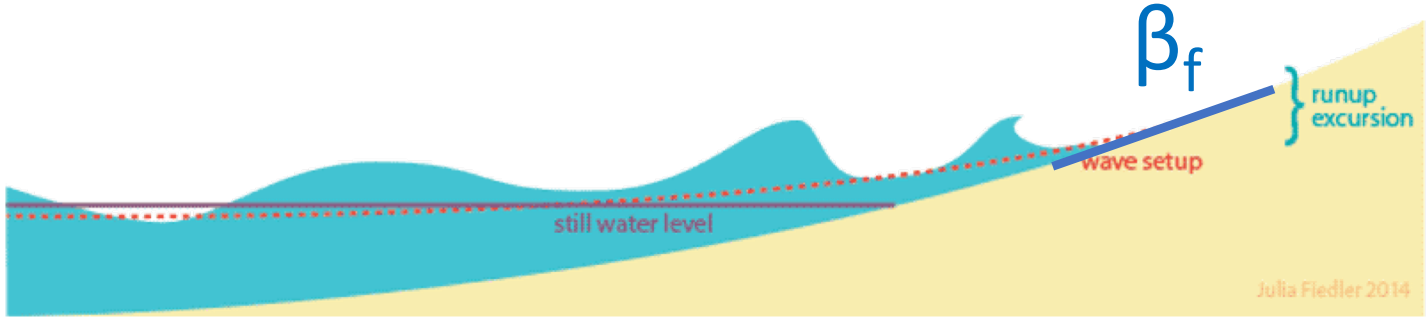

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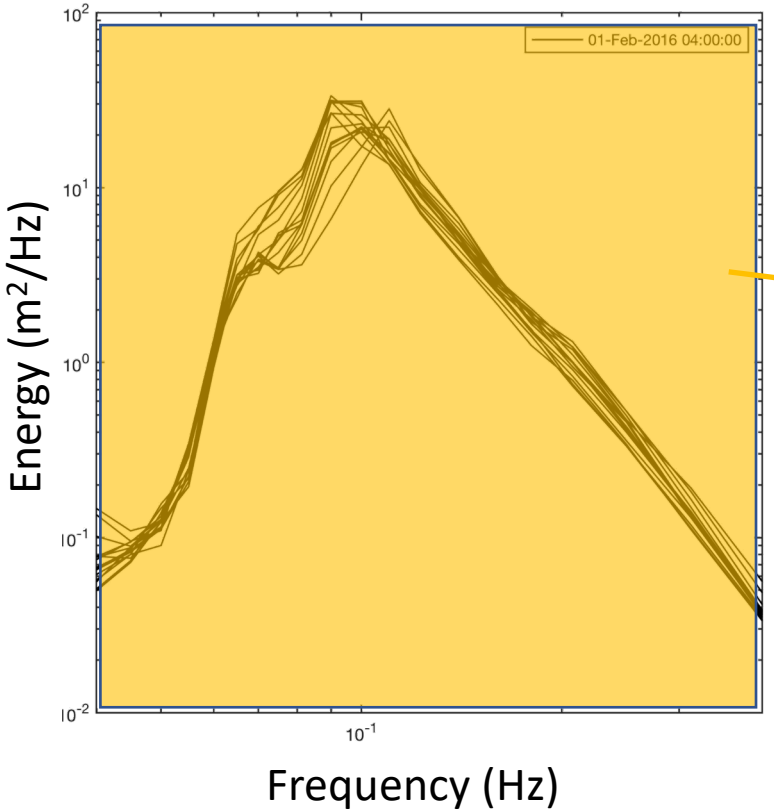
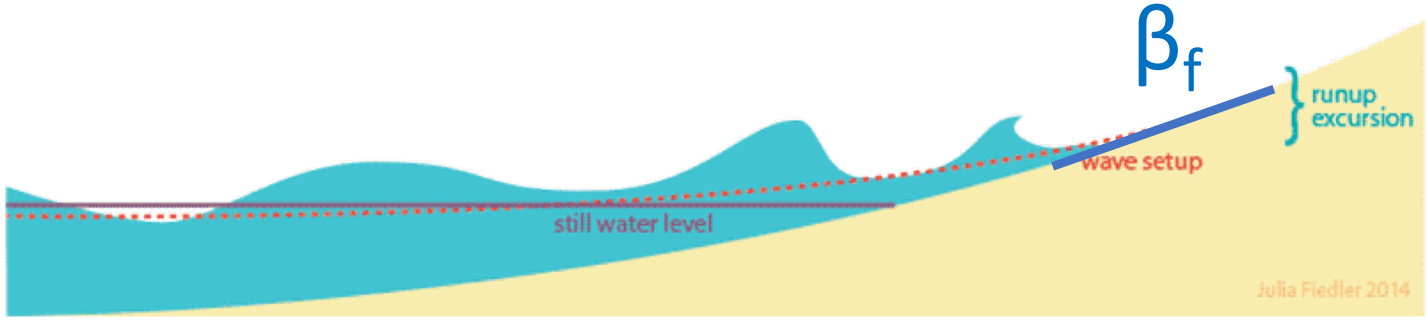


$$R_{2\%} \sim \beta_f, (H_0 L_0)^{1/2}$$

$$R_{2\%} \sim \beta_f, \int_{inc} E^m f^n df$$



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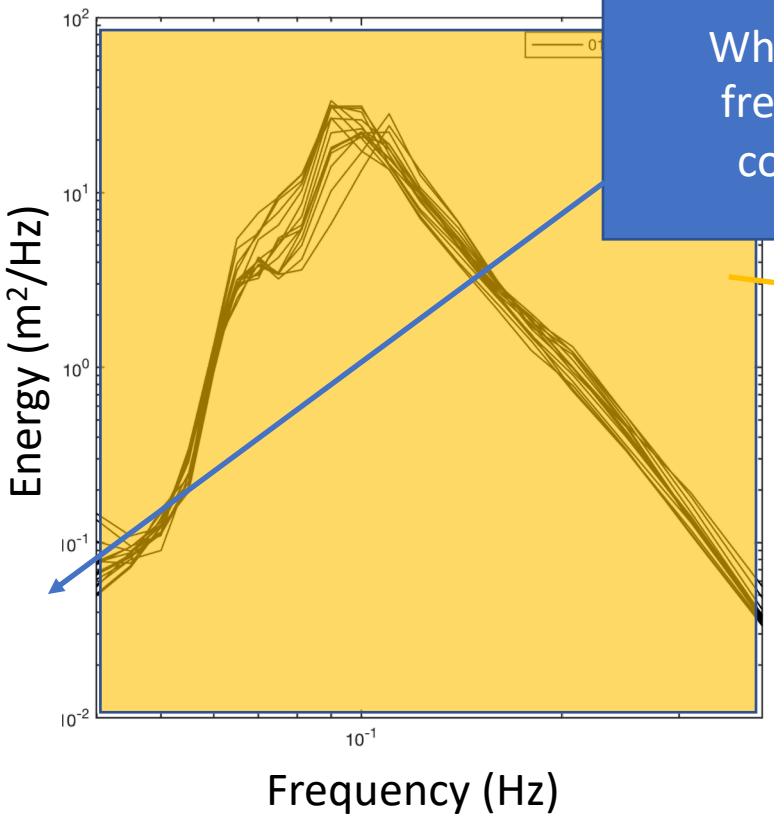
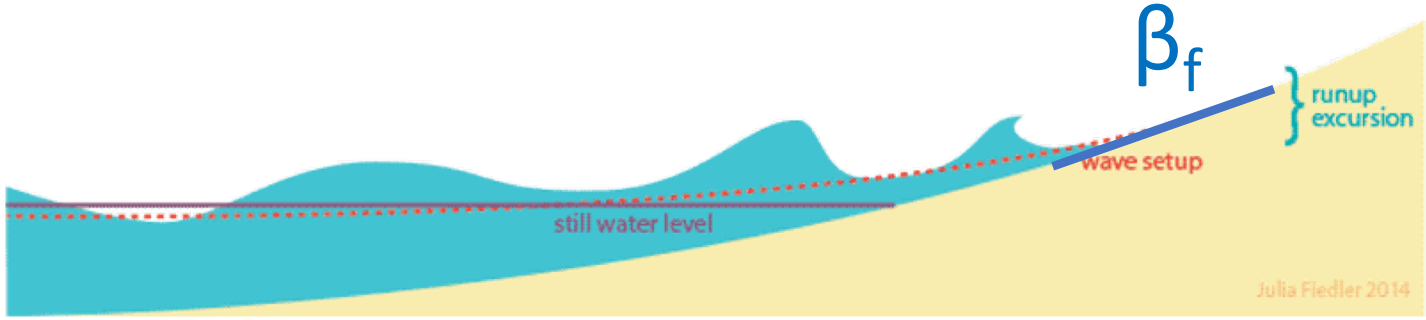


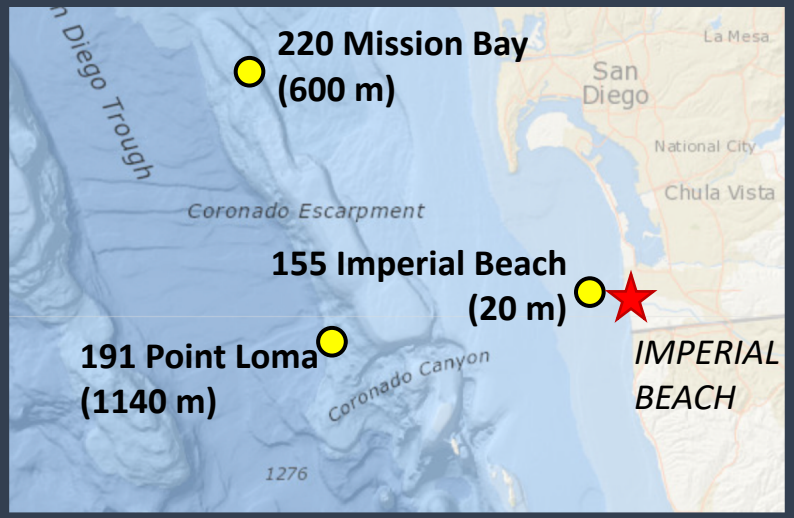
What is the low frequency (IG) component?

$$R_{2\%} \sim \beta_f, (H_0 L_0)^{1/2}$$

$$R_{2\%} \sim \beta_f, \int_{inc} E^m f^n df$$



Credit: Julia Fiedler, SIO / UCSD



Dataset comparison: 155 and BP155

Parameter: Hs | Ta | Dp | Tp

Frequency range:

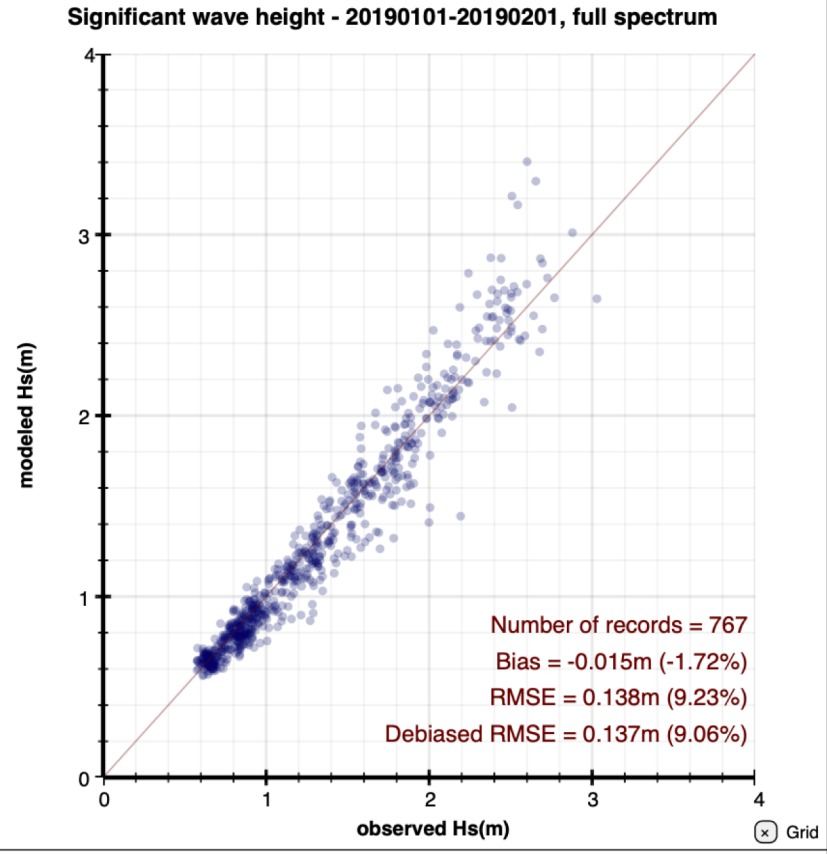
- Full spectrum
- Forerunners, below 0.05 Hz
- Long swell, 0.05 to 0.08 Hz
- Short swell, 0.08 to 0.12 Hz
- Long seas, 0.12 to 0.25 Hz
- Short seas, 0.25 to 0.40 Hz
- Wind chop, over 0.40 Hz

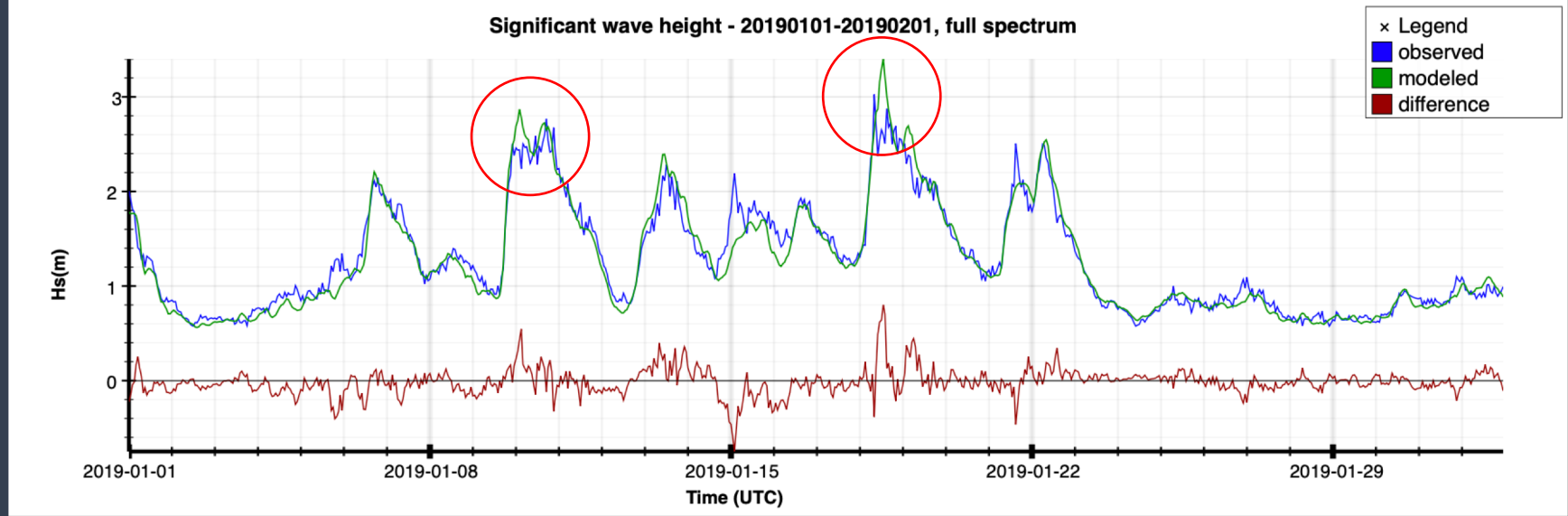
FULL SPECTRUM

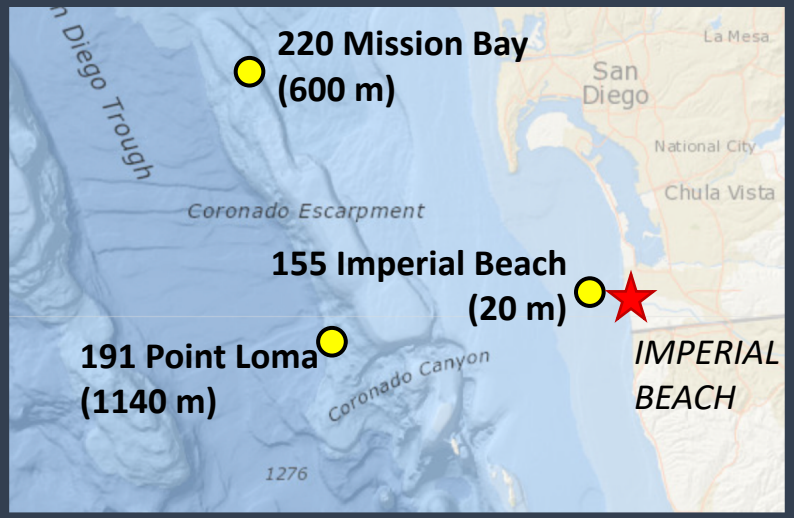
Year: 2006 | 2007 | 2008 | 2009 | 2010 | 2018 | 2019

Month: 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11

Click and drag horizontally to zoom in the plot below.







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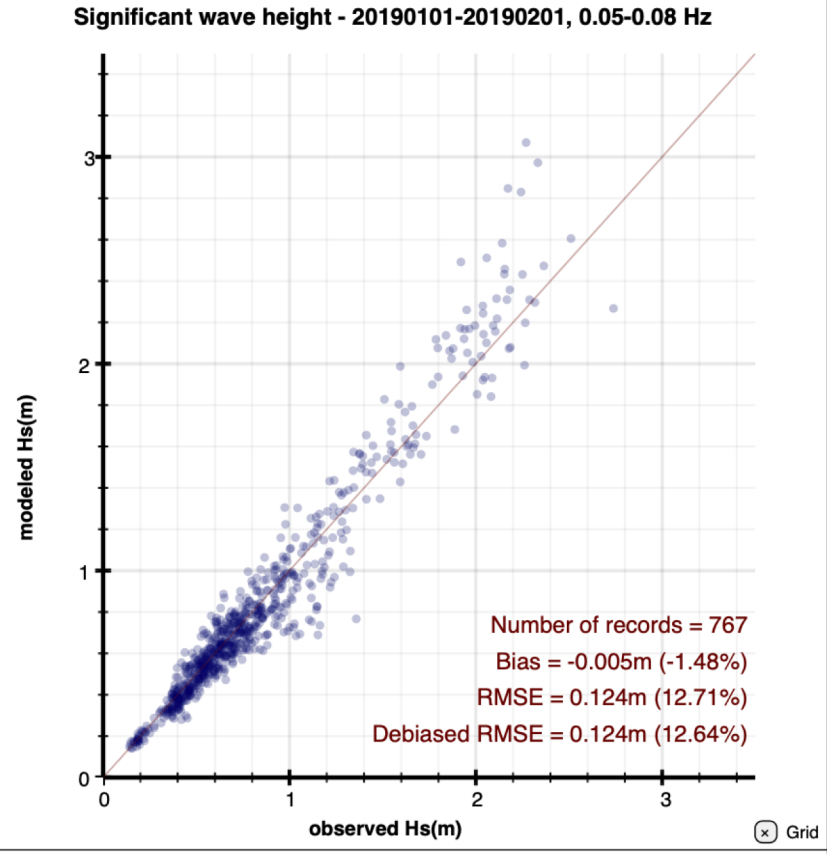
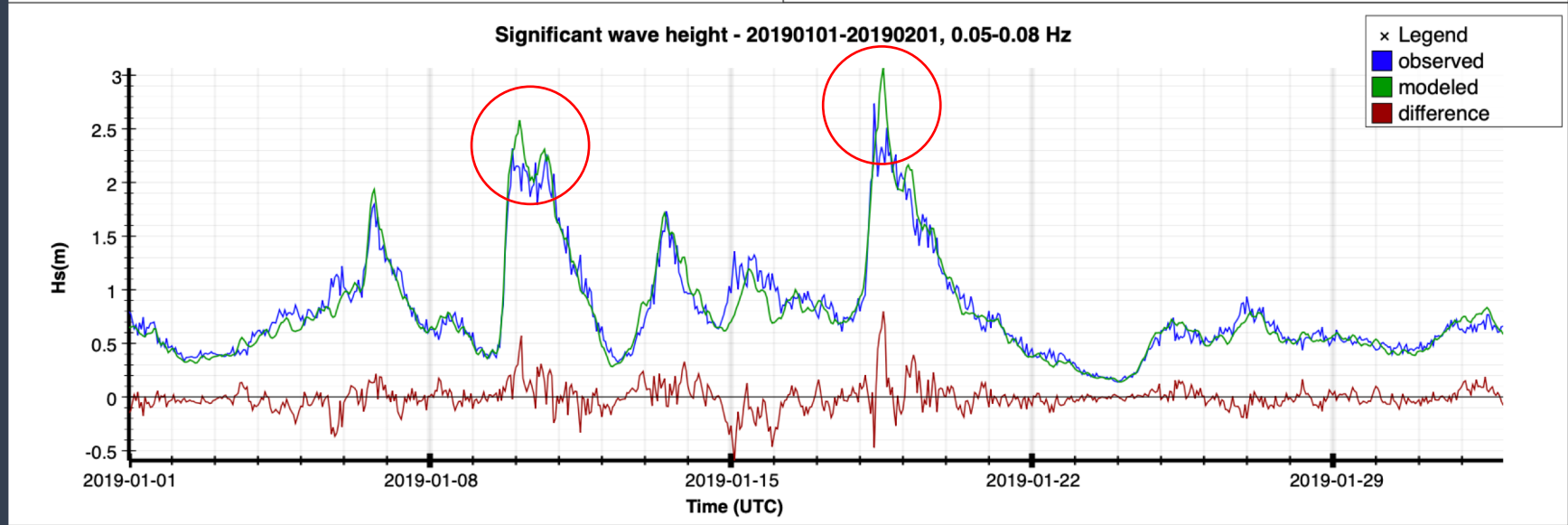
LONG SWELL

Year: 2006 | 2007 | 2008 | 2009 | 2010 | 2018 | 2019

Month: 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11

Click and drag horizontally to zoom in the plot below.





California State Parks Coastal Inundation Forecast Project

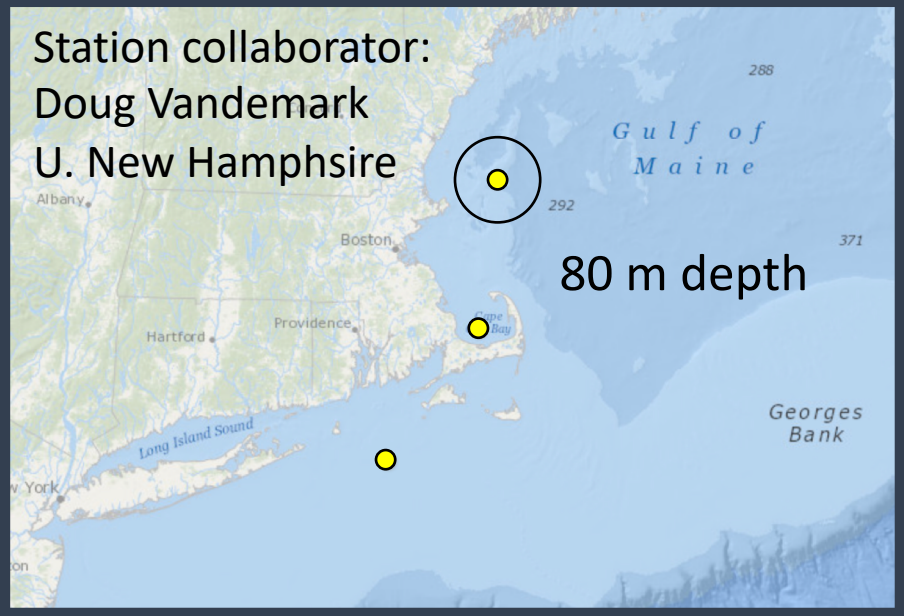
- CDIP Overview
- Buoy Co-location
- Hurricane wave data
- Coastal inundation
- Wave power

CDIP 160 / NDBC 44098
Jeffrey's Ledge, NH
Established 2008

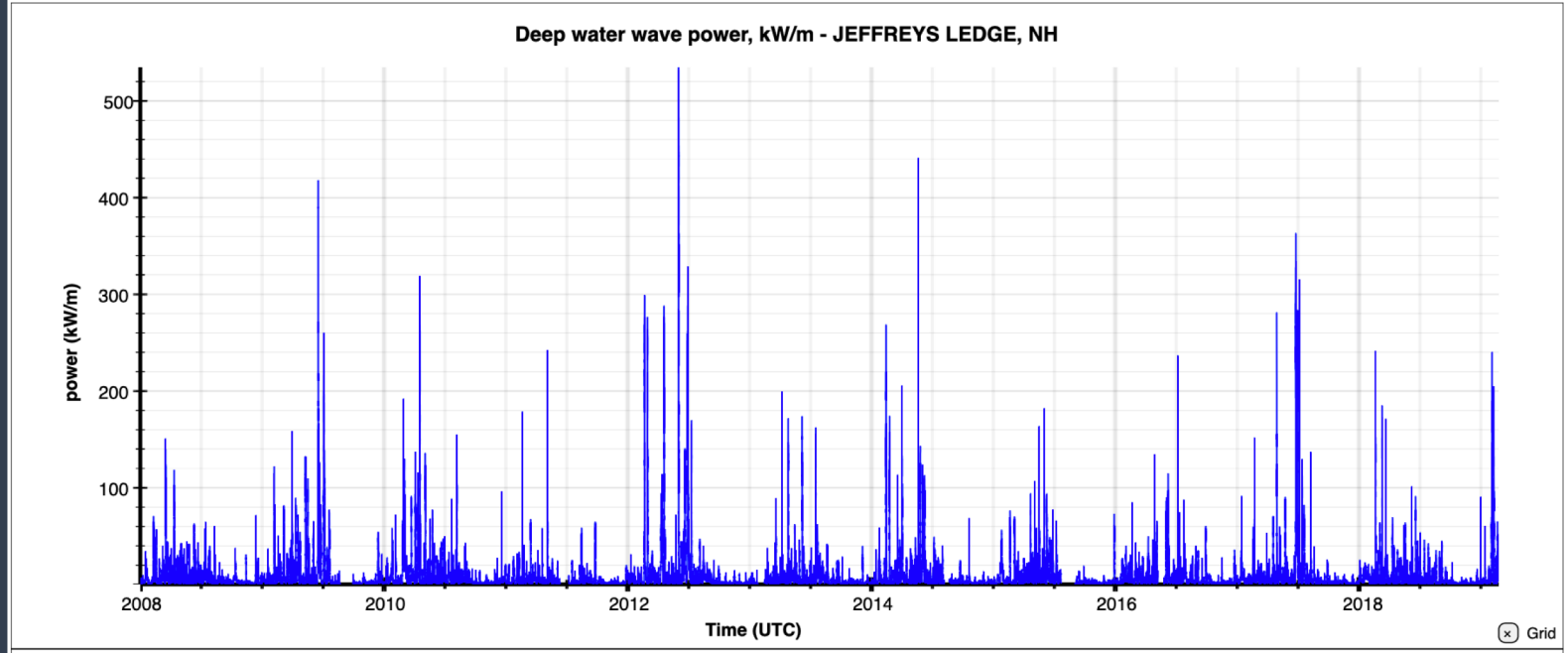
WAVE POWER FLUX

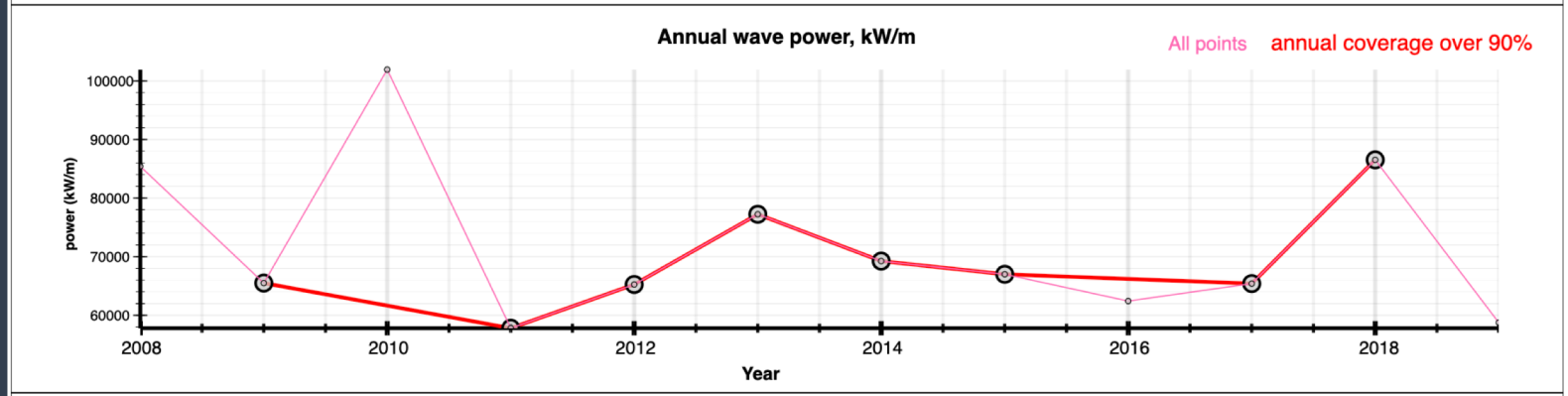
$$P = \frac{\rho g^2}{64\pi} H_{m0}^2 T_e$$

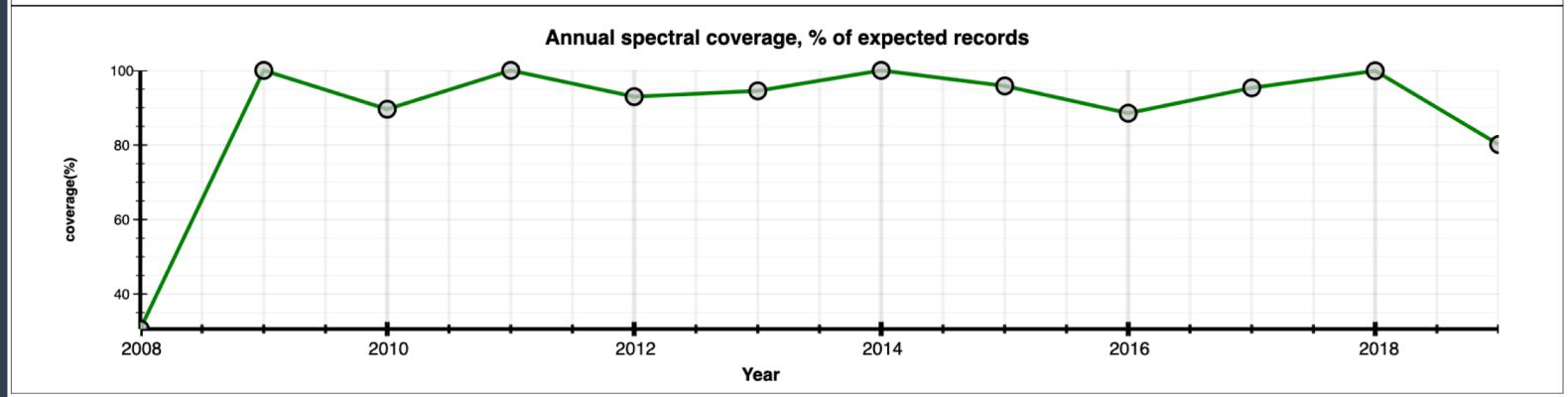
Station collaborator:
Doug Vandemark
U. New Hamphsire



80 m depth



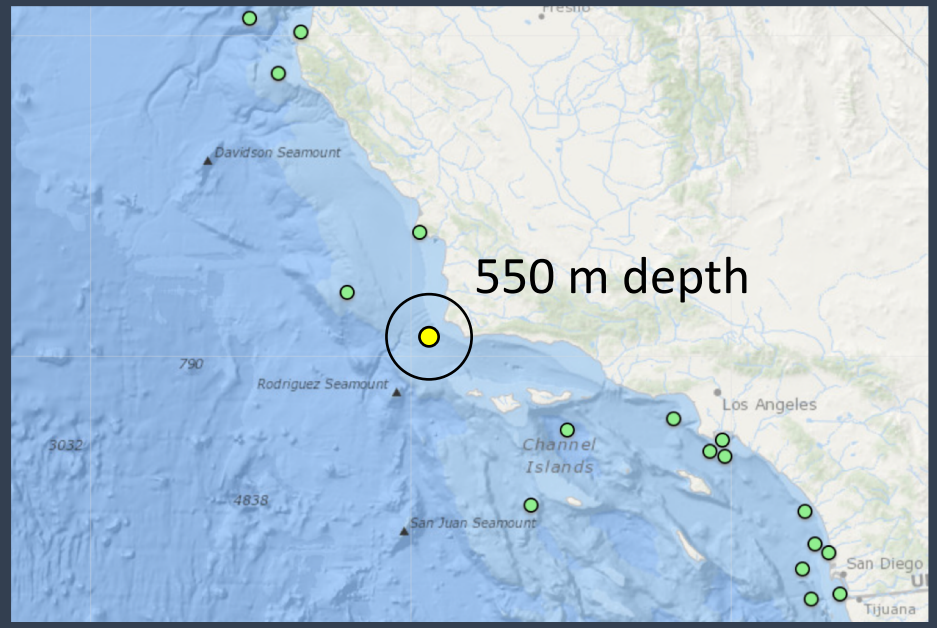


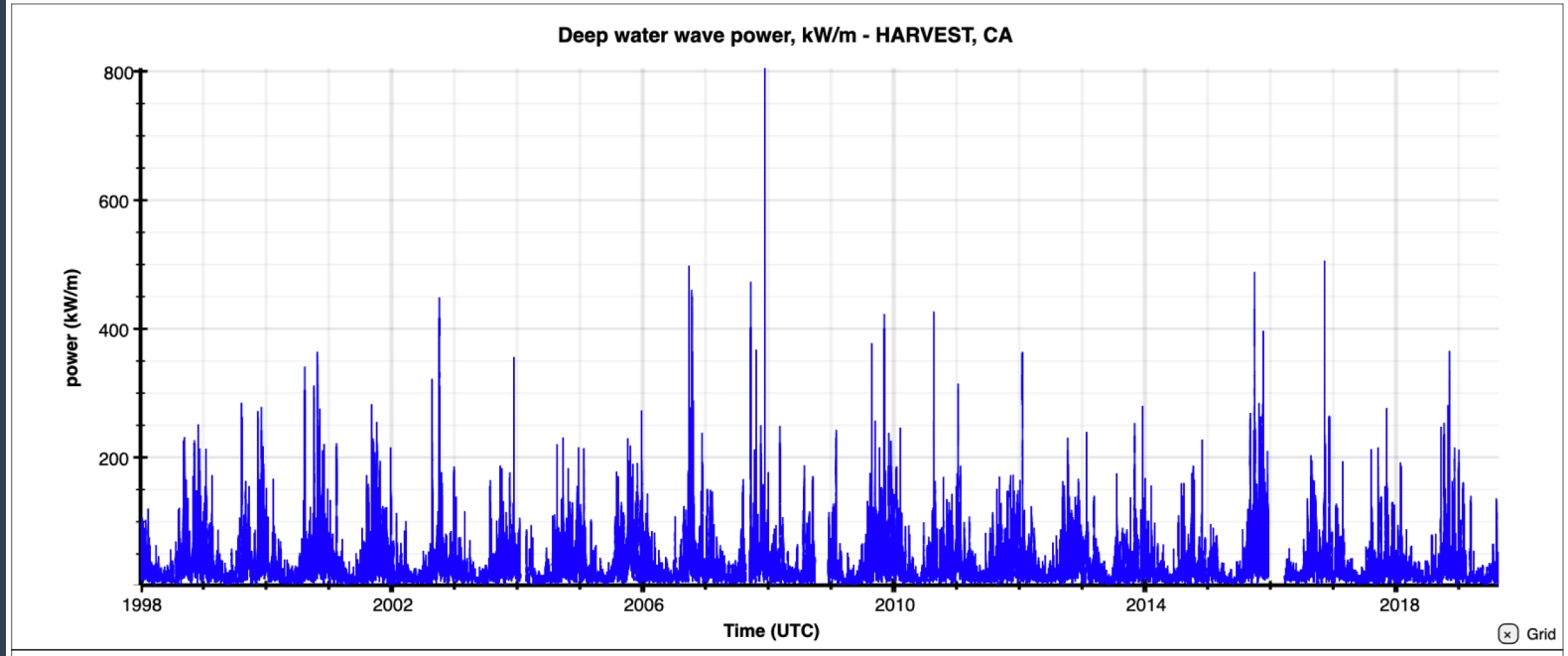


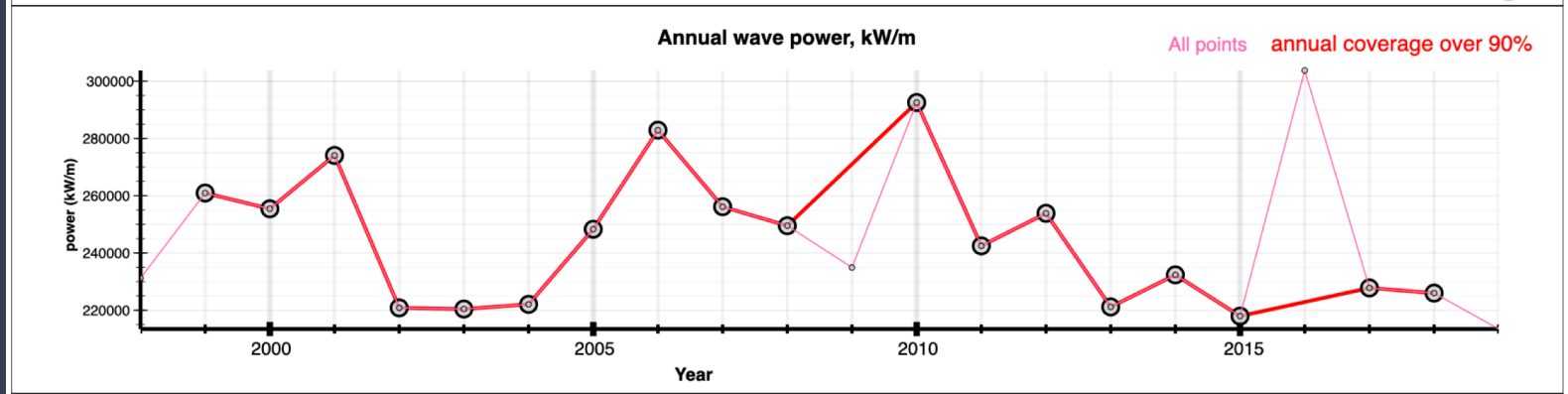
CDIP 071 / NDBC 46218
Harvest, CA
Established 1998

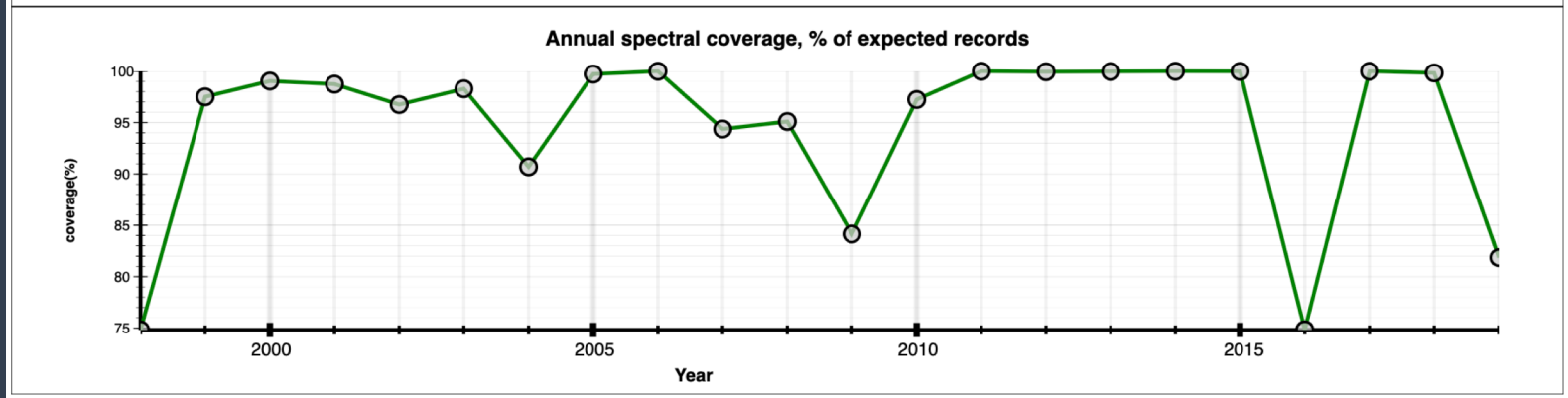
WAVE POWER FLUX

$$P = \frac{\rho g^2}{64\pi} H_{m0}^2 T_e$$



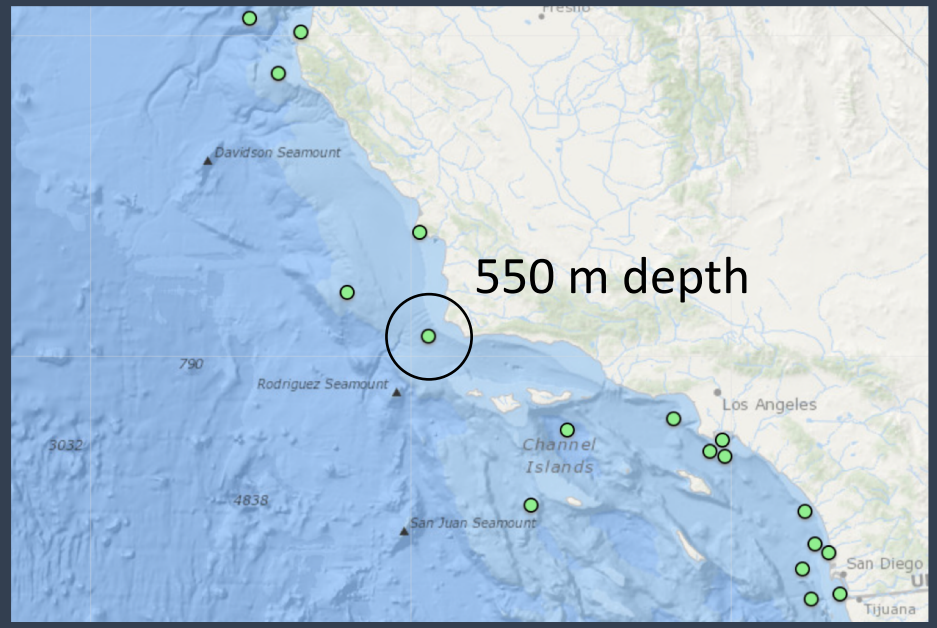


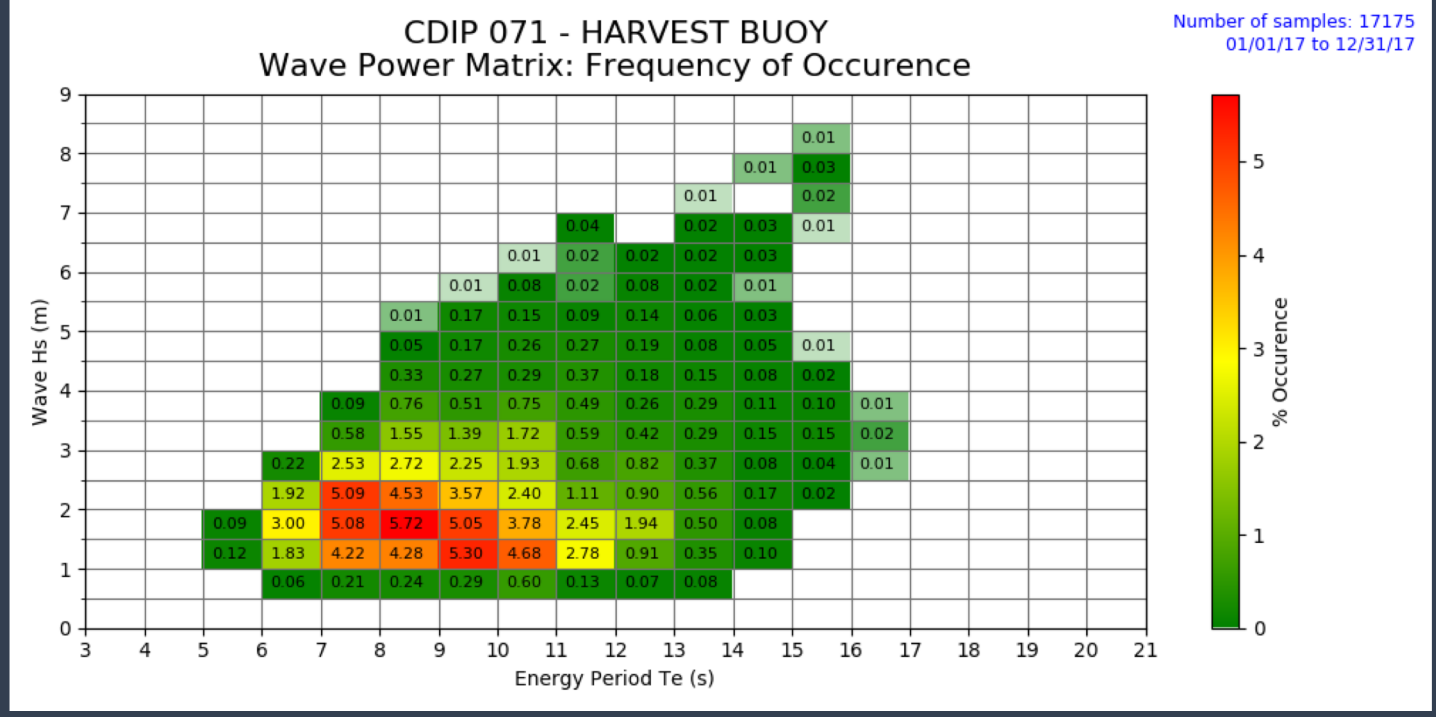


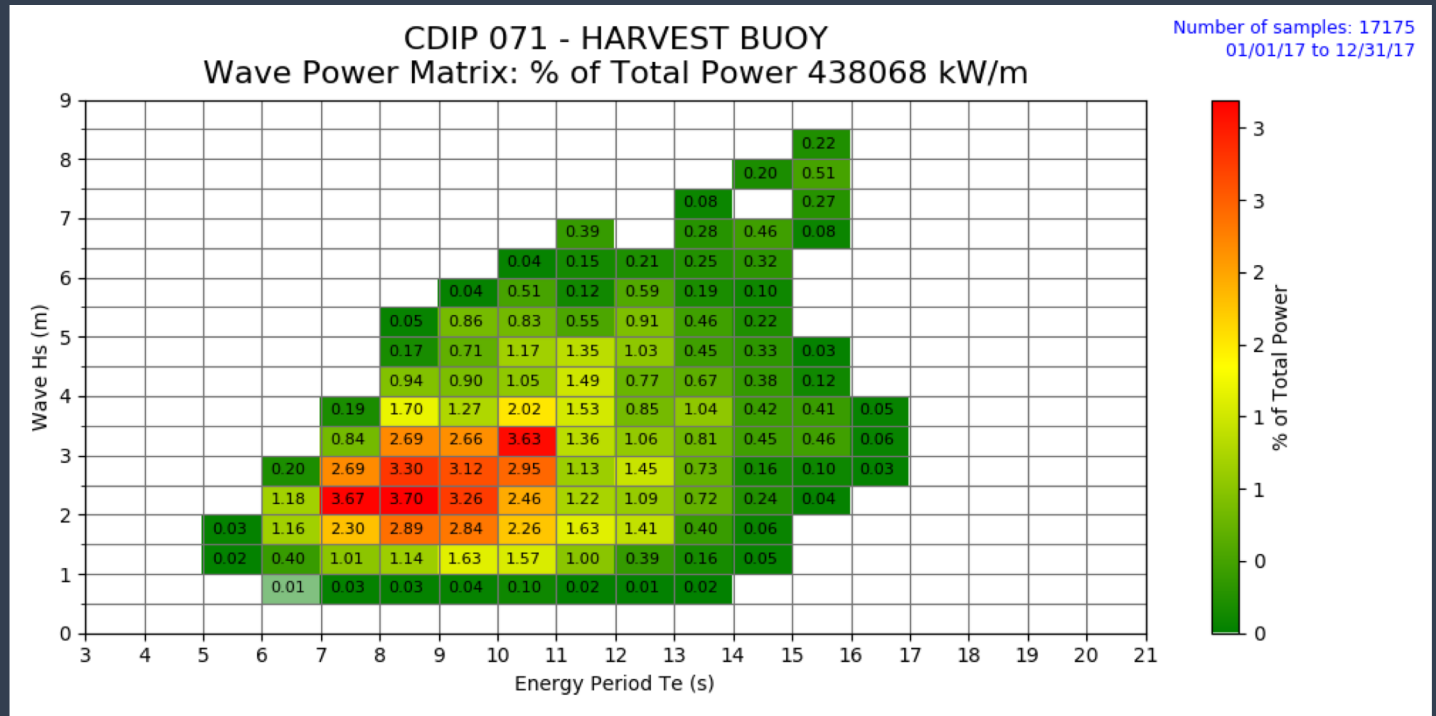


CDIP 071 / NDBC 46218
Harvest, CA

Wave Power Matrix
(“Hagerman” plots)







James Behrens
Program Manager
Coastal Data Information Program

858 534 3032

jb@cdip.ucsd.edu

cdip.ucsd.edu