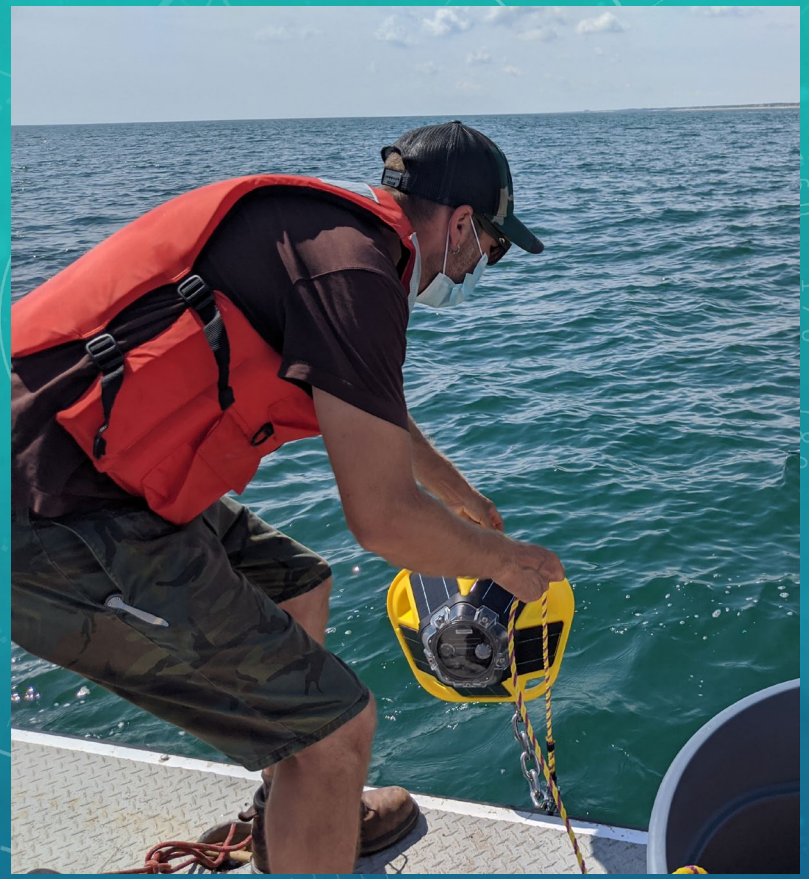
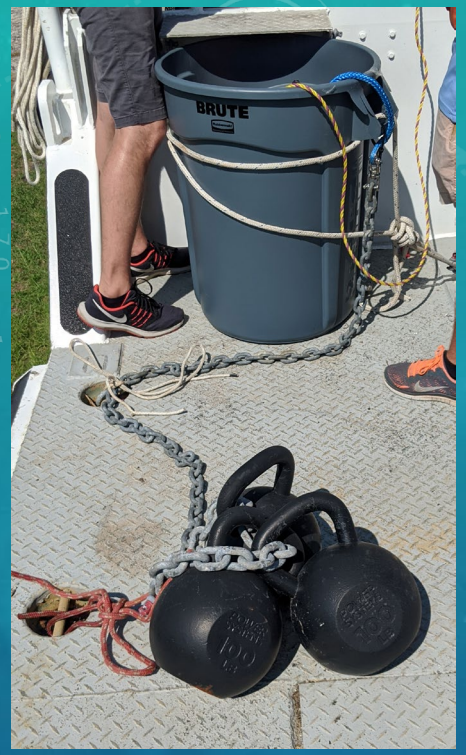




FIELD TESTING MOORED GPS WAVE BUOYS

CODS IPR 11/02/2022
C.O. "TRIPP" COLLINS III,
CLARENCE.O.COLLINS@USACE.ARMY.MIL

PLANNING AND EXECUTION: C. COLLINS, P. DICKHUDT, J. PIPES

FRF FIELD TEAM: J. PIPES, C. THOBURN, R. MITCHELL, M. GASKELL, N. DISAMONE, W. LEDFORD, N. SPORE, P. DURKIN

SIO-CORDC: T. DE PAOLO, E. TERRILL, S. MERRIFIELD, P. ROGOWSKII ET AL.

SIO-LDL: M. SCHONAU, L. CENTURIONI, T. PALUSZKIEWICZ ET AL.

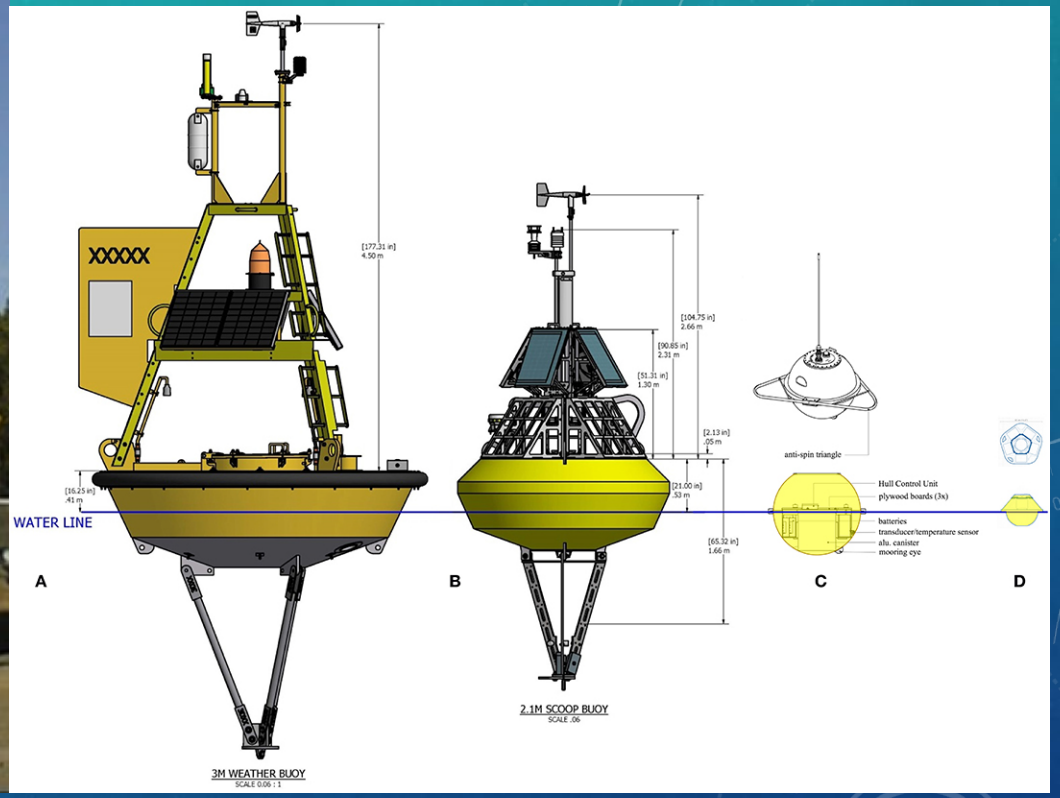
UW-APL: J. THOMSON ET AL.

SOFAR: P. SMIT ET AL.

FUNDING: USACE CIVIL WORKS CODS (J. WATTERS, S. BAK, J. ROSATI) AND K. BRODIE

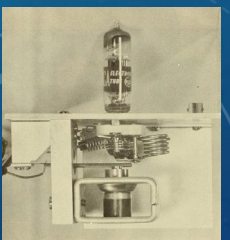
GREAT AMERICAN WAVE BUOY BAKE OFF

THE MINI-BUOY RODEO



time

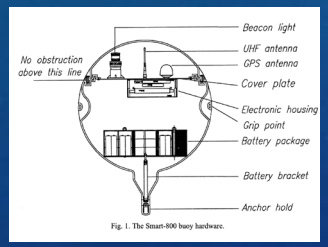
1975



Splashnik (Marks & Tuckerman, 1960)

1980

1990



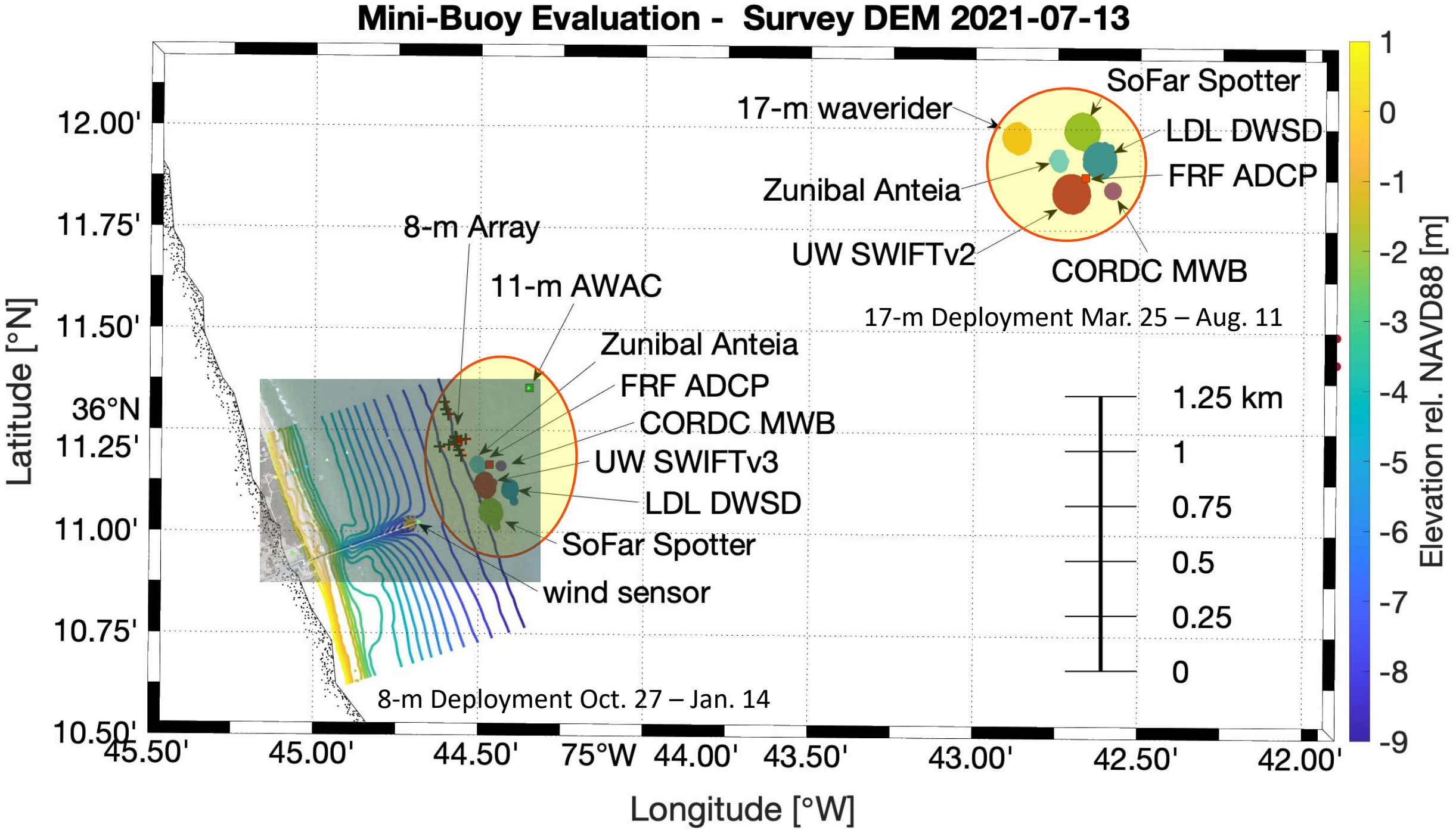
2000

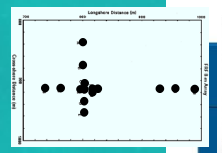
Smart 800 buoy (Krogstad et al., 1999)

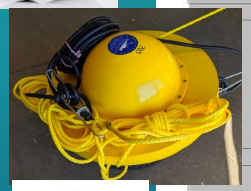
2010

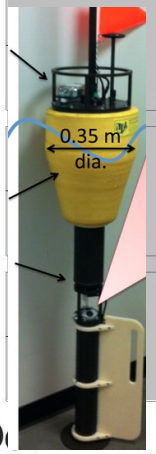
SBAS GPS (Herbers et al., 2012)

2020


Mini-Buoy Evaluation - Survey DEM 2021-07-13
SoFar Spotter
17-m waverider
LDL DWSD
FRF ADCP
Zunibal Anteia
UW SWIFTv2
CORDC MWB
17-m Deployment Mar. 25 – Aug. 11
8-m Array
11-m AWAC
Zunibal Anteia
FRF ADCP
CORDC MWB
UW SWIFTv3
LDL DWSD
SoFar Spotter
wind sensor
8-m Deployment Oct. 27 – Jan. 14
1.25 km
1
0.75
0.5
0.25
0
12.00'
11.75'
11.50'
36°N
11.25'
11.00'
10.75'
10.50'
Latitude [°N]
45.50'
45.00'
44.50'
75°W
44.00'
43.50'
43.00'
42.50'
42.00'
Longitude [°W]
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
Elevation rel. NAVD88 [m]







8-m Deployment

17-m Deployment

Oct 27

Jan 14

Mar 25

Aug 11

8-m Array

11-m AWAC

17-m Waverider

FRF ADCP

CORDC MWB

SoFar Spotter

Zunibal Anteia

UW SWIFT
v4

v3

LDL DWSD

Oct
2020

Nov

Dec

Jan
2021

Feb

Mar

Apr

May

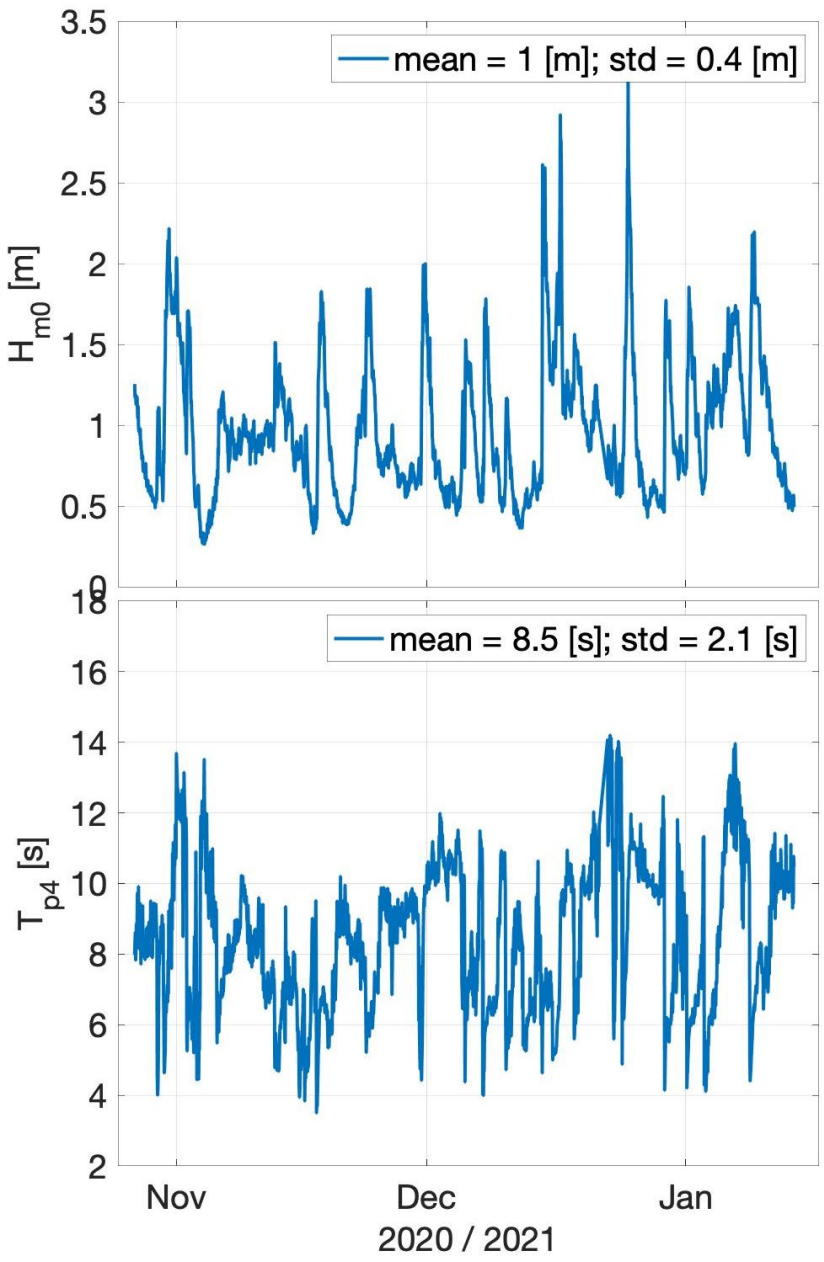
Jun

Jul

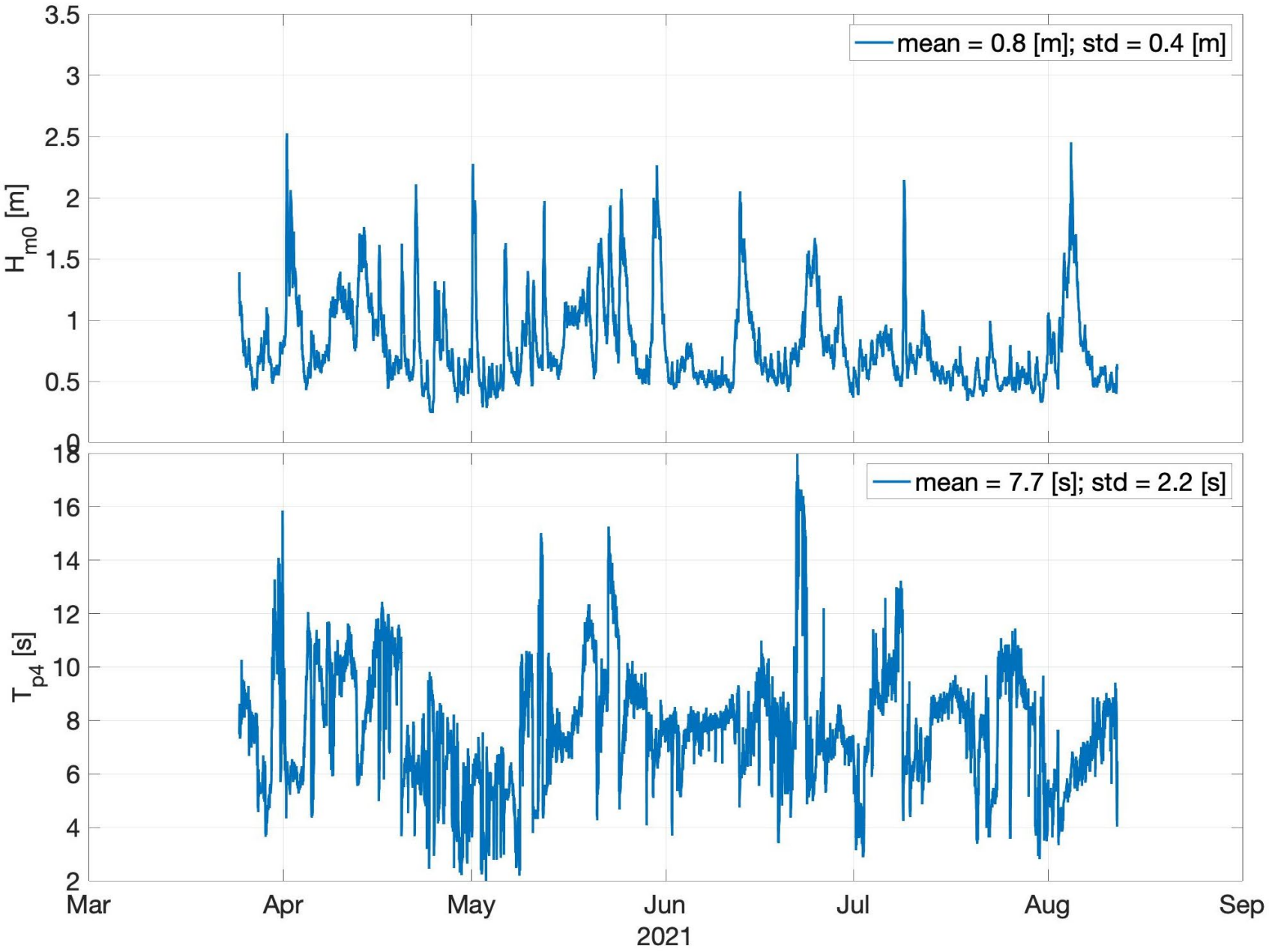
Aug

Sep

8-m Deployment (11-m AWAC)



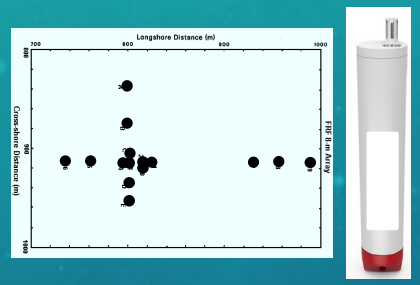
17-m Deployment (17-m Waverider)



COMPARISON STATEGY

Step 1: Establish a benchmark

8-m Deployment Benchmark



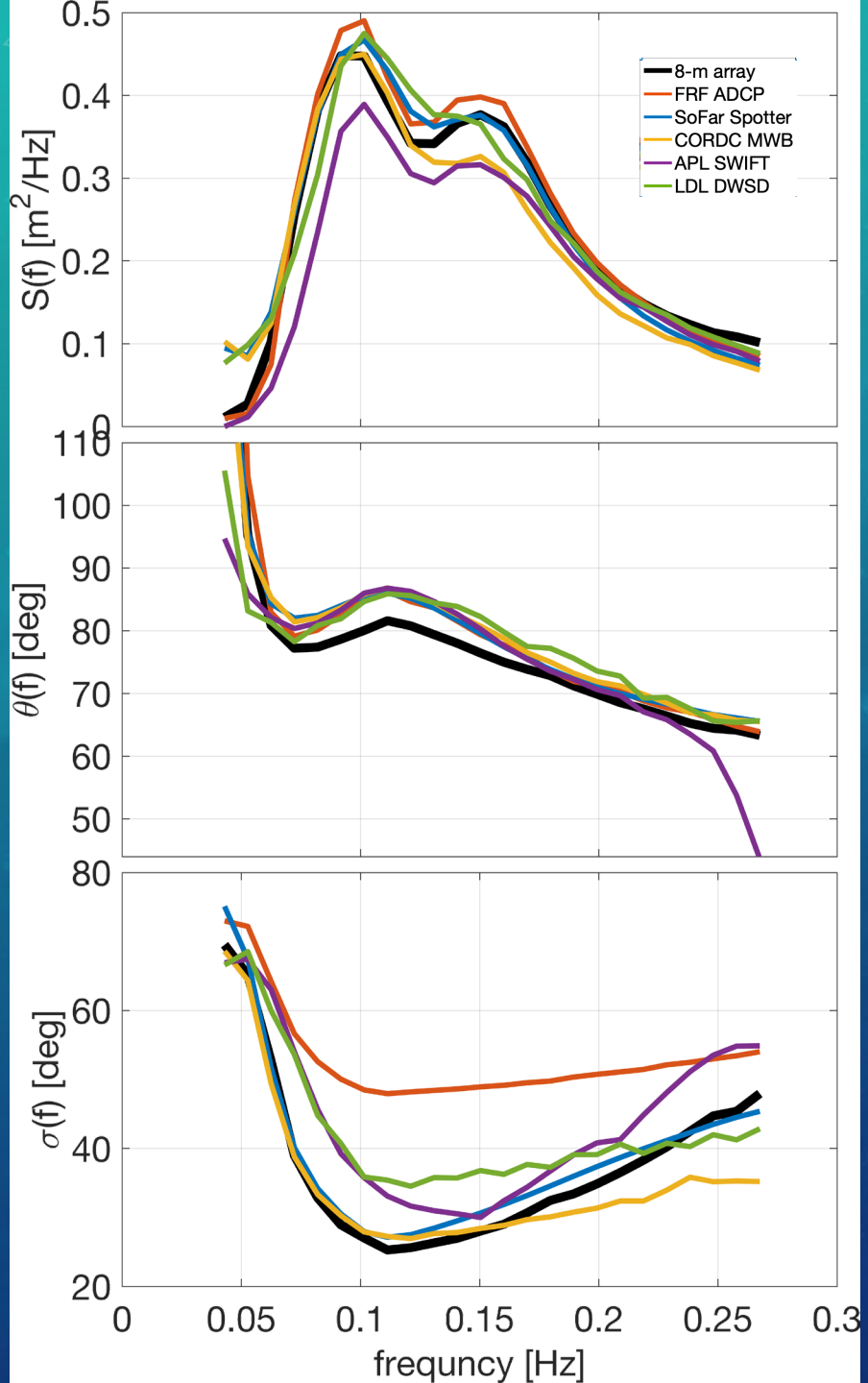
VS

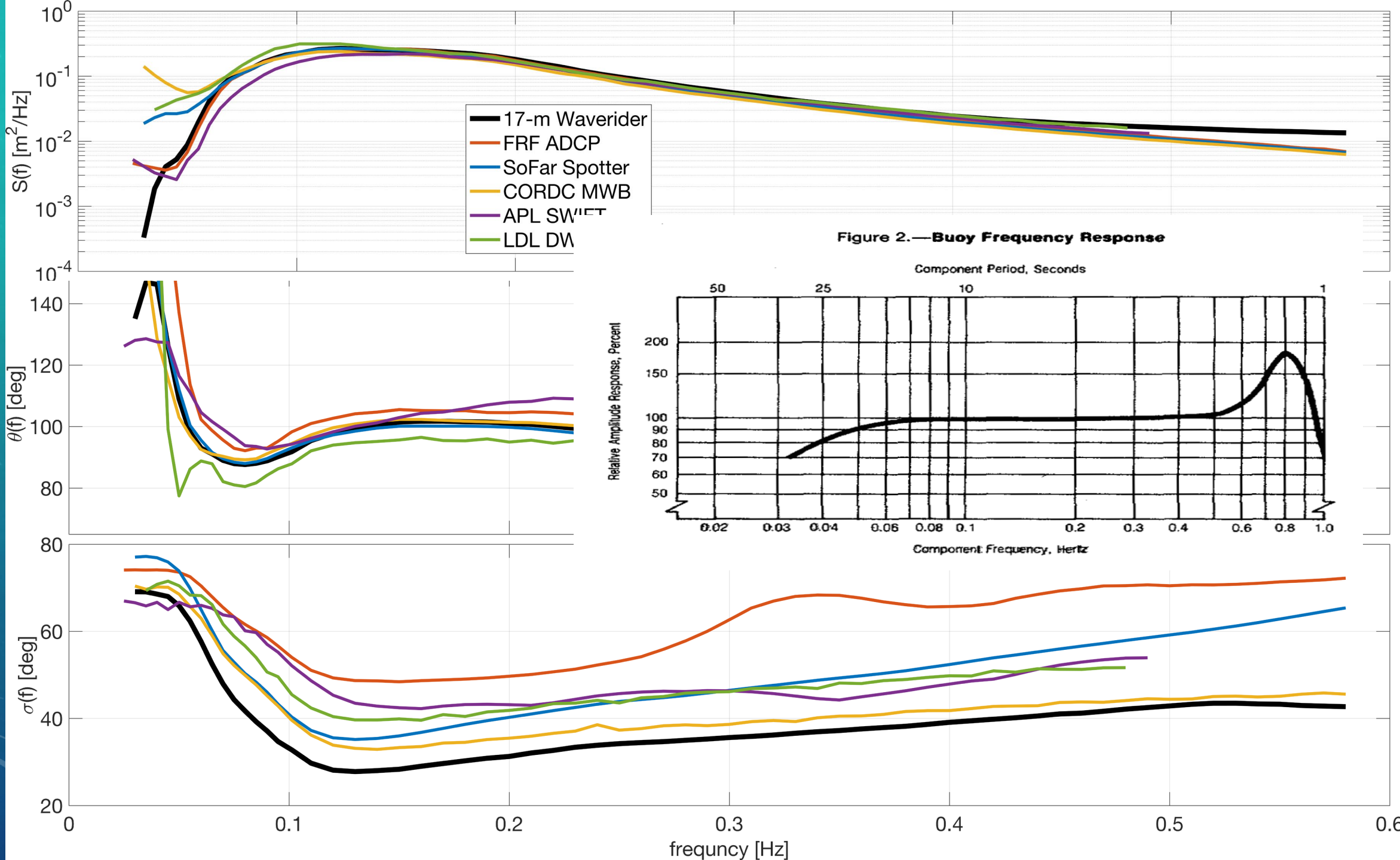
17-m Deployment Benchmark

VS

Step 2: Interpolate in time and frequency to the standard

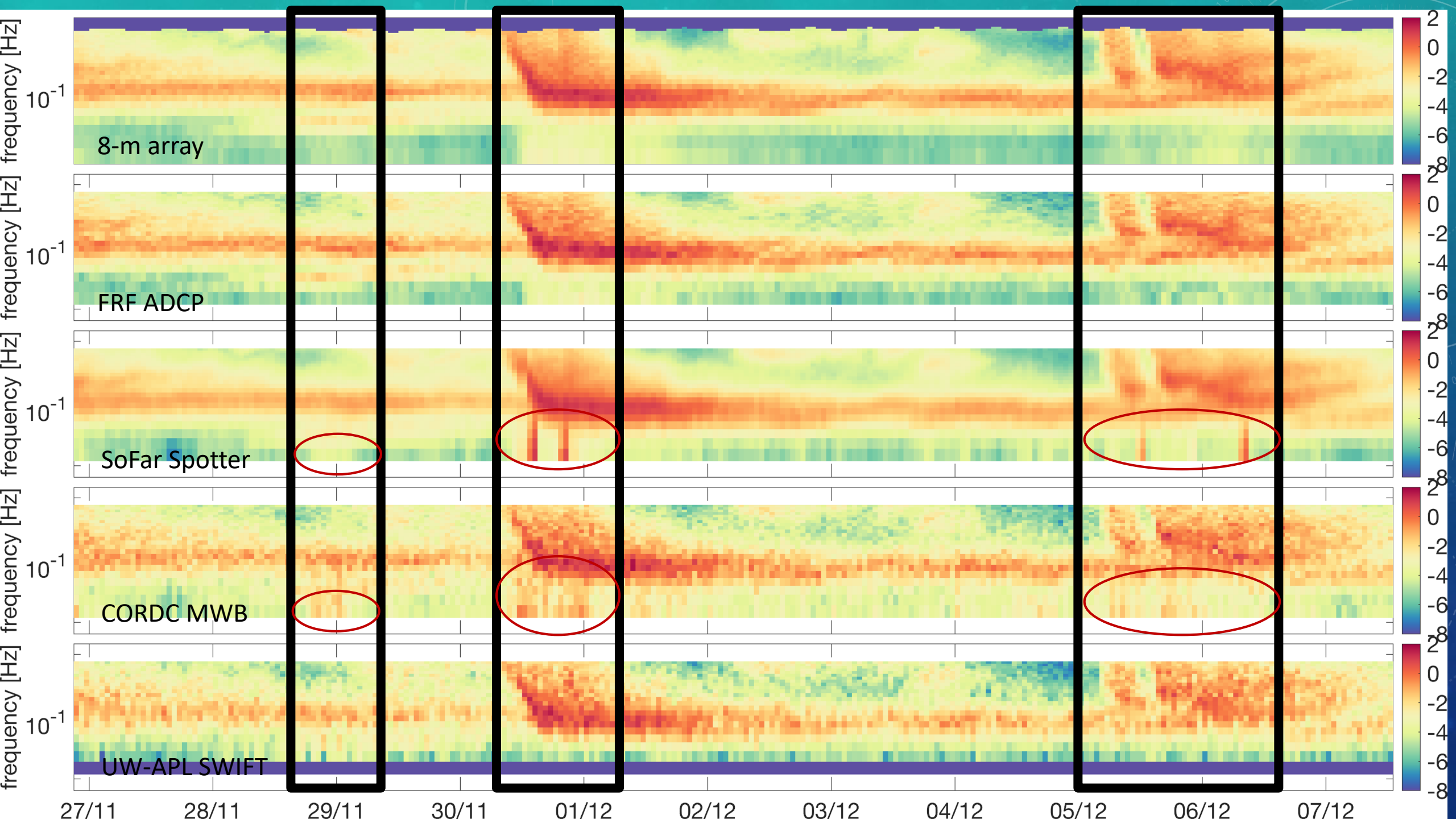
Step 3: Compare $S(f)$, $\theta(f)$, and $\sigma(f)$ and their common parameters

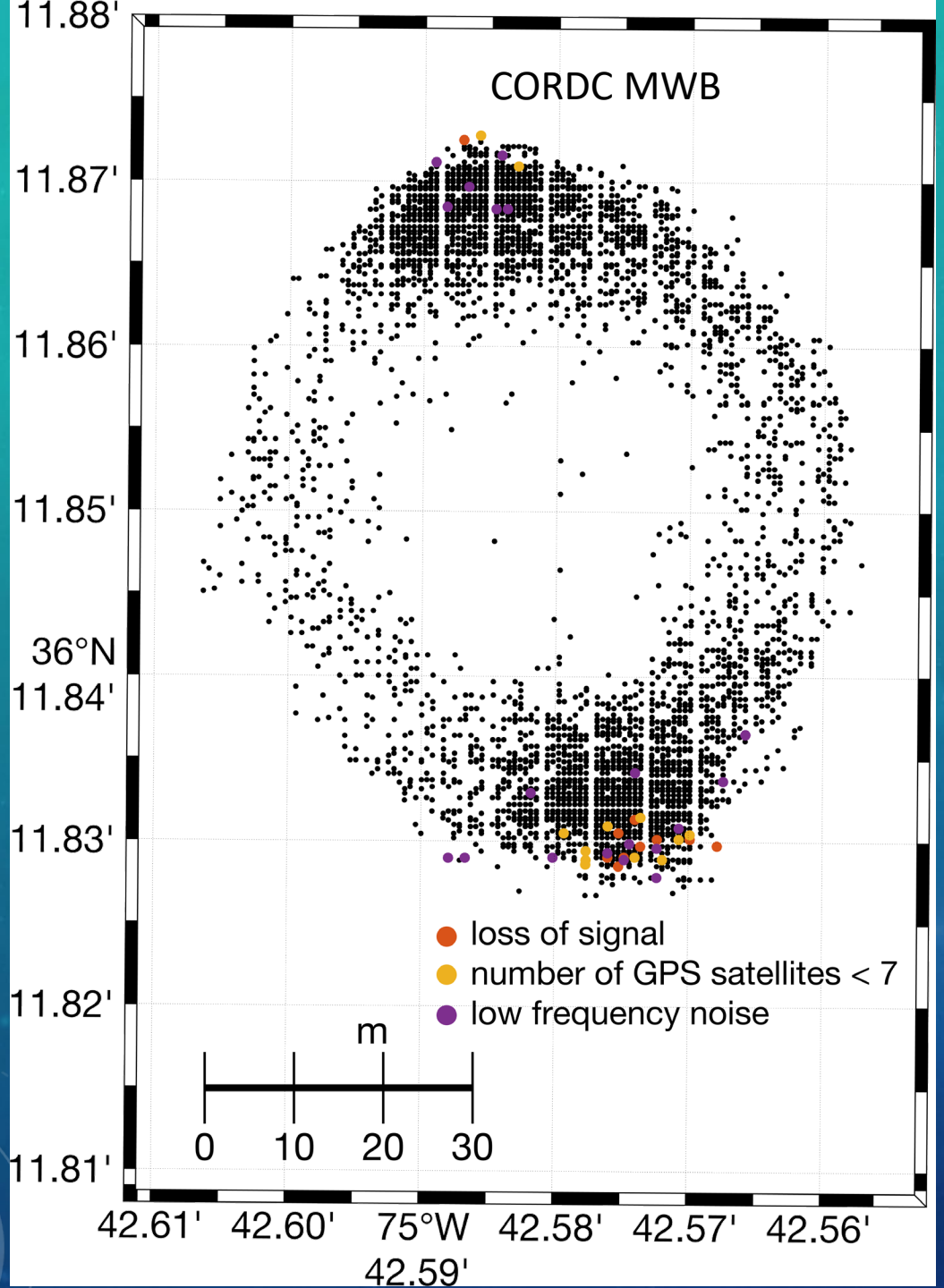

8-m array
FRF ADCP
SoFar Spotter
CORDC MWB
APL SWIFT
LDL DWSD
S(f) [m²/Hz]
θ(f) [deg]
σ(f) [deg]
frequncy [Hz]

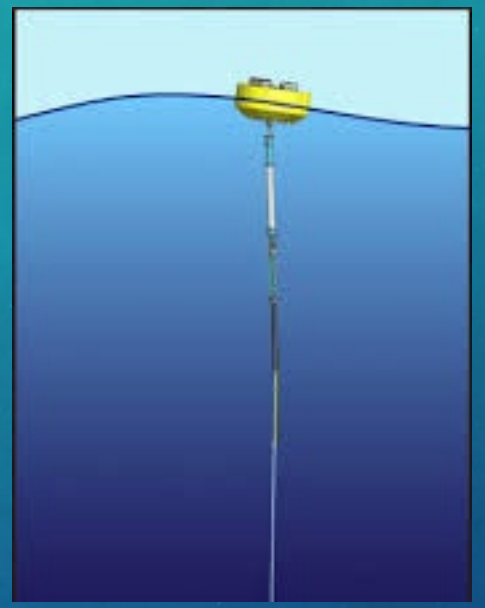

S(f) [m²/Hz]
17-m Waverider
FRF ADCP
SoFar Spotter
CORDC MWB
APL SWIFT
LDL DW
θ(f) [deg]
σ(f) [deg]
frequncy [Hz]
Figure 2.—Buoy Frequency Response
Component Period, Seconds
Relative Amplitude Response, Percent
Component Frequency, Hertz

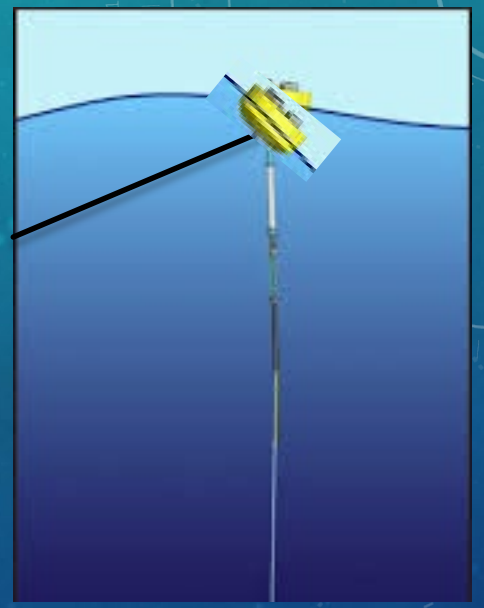
QUICK SUMMARY OF PERFORMANCE

- Significant WAVE HEIGHT
  R > 0.94, bias < ± 2 cm, rmse 5-10 cm
- Mean direction very good, typically within 5 degrees
- Some disagreement on directional spread but much better than FRF ADCP
- SWIFT buoy underestimated low frequencies, traced back to an over aggressive filter both could be reprocessed to get excellent results
- Overall assessment: GPS-based mini-wave buoys give high quality data
- Given that, let’s explore some edge cases

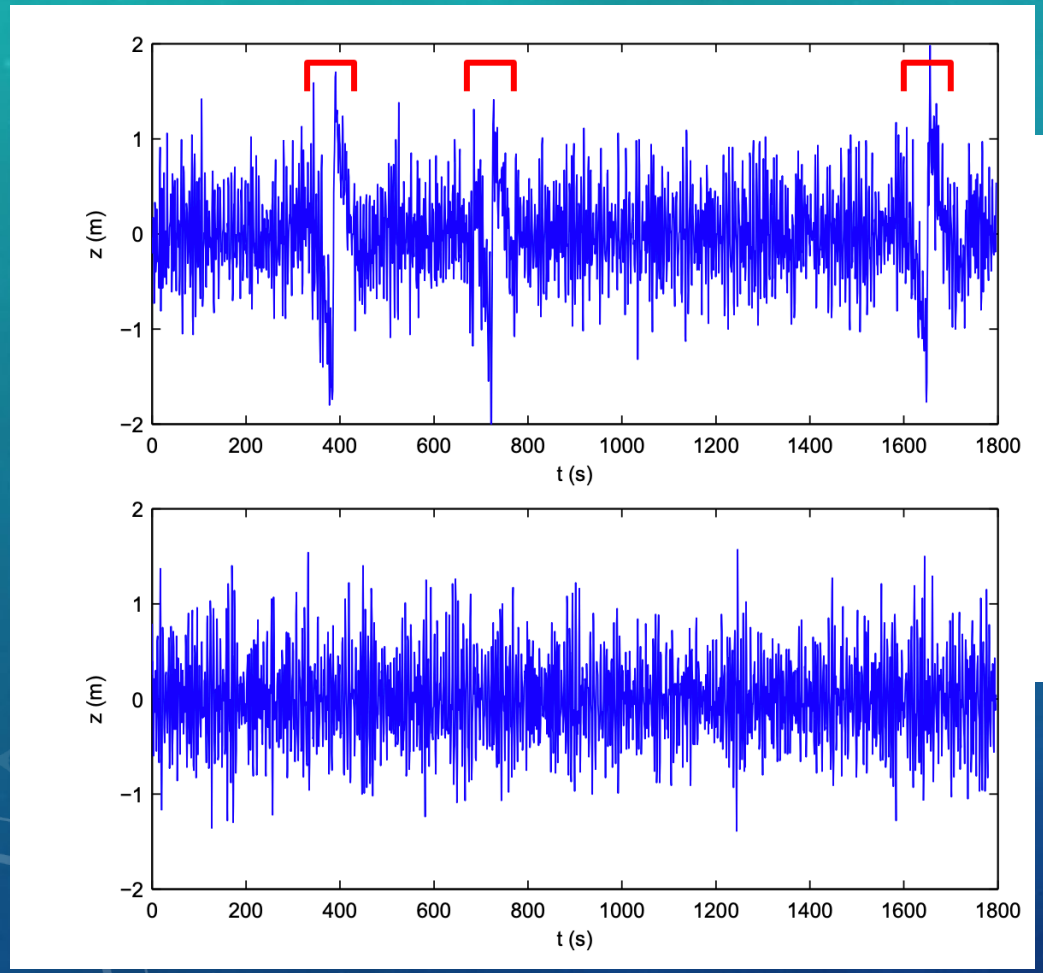

frequency [Hz]
10^{-1}
8-m array
FRF ADCP
SoFar Spotter
CORDC MWB
UW-APL SWIFT
2
0
-2
-4
-6
-8
27/11
28/11
29/11
30/11
01/12
02/12
03/12
04/12
05/12
06/12
07/12

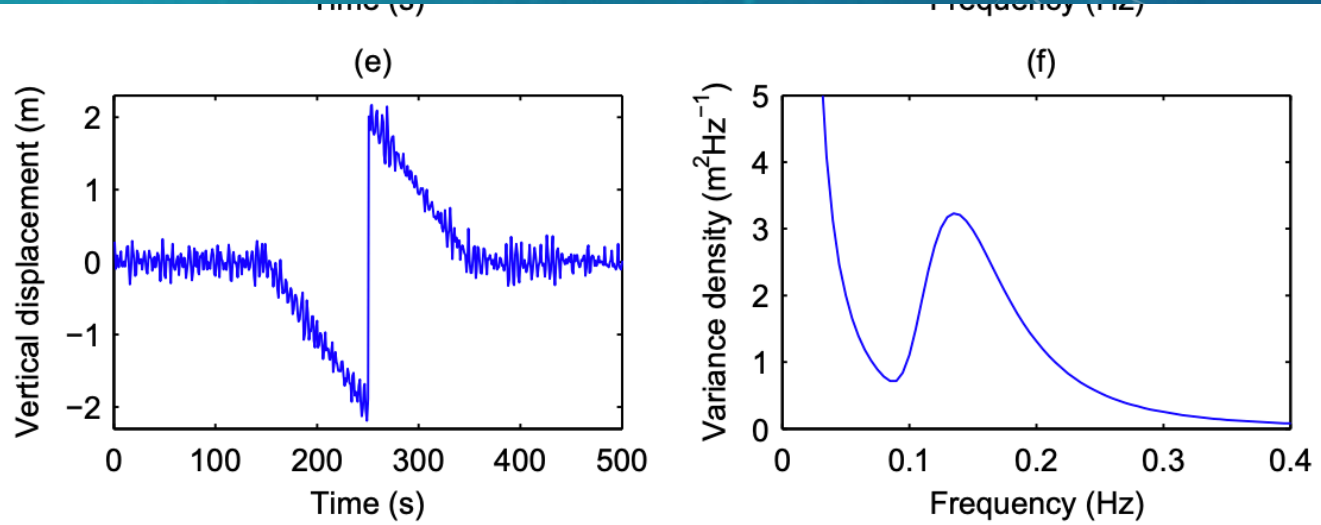

CORDC MWB
11.88'
11.87'
11.86'
11.85'
36°N
11.84'
11.83'
11.82'
11.81'
42.61'
42.60'
75°W
42.59'
42.58'
42.57'
42.56'
loss of signal
number of GPS satellites < 7
low frequency noise
m
0
10
20
30





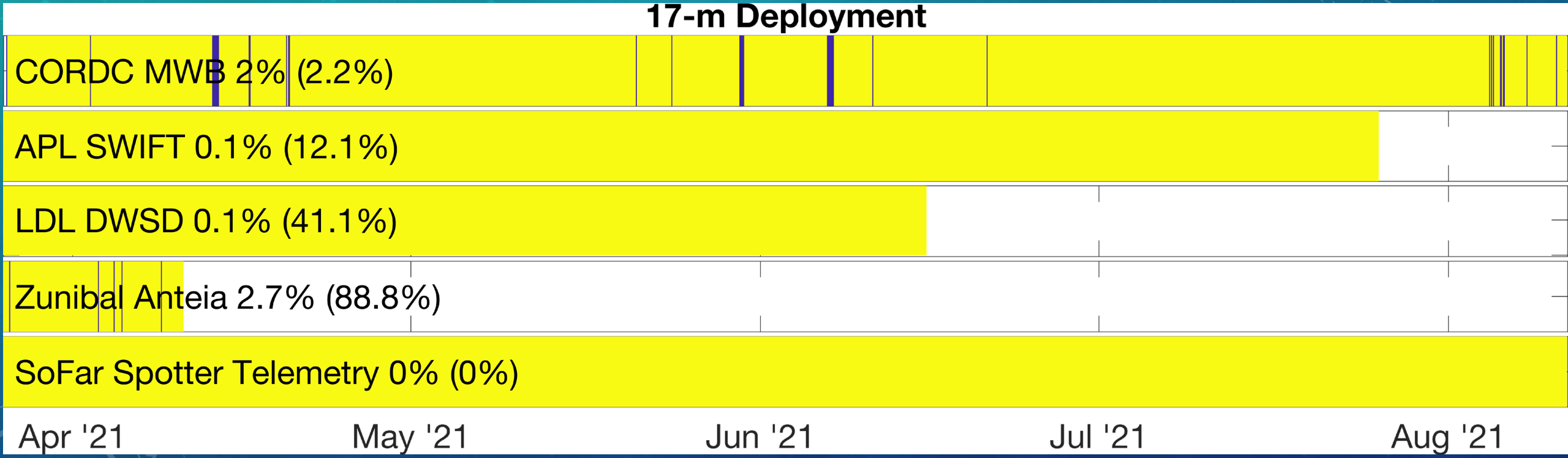
BJORKQVIST ET AL. 2016





WHAT YOU SHOULD BE AWARE OF:

- Intermittency (% of missing telemetered data)



SUMMARY:

- Field experiments testing 5 mini-buoys over 2 deployments lasting 8 months
- Established benchmark comparison with FRF ADCP and operational sensor
- Wave data from mini-buoys are on par or better than benchmarks
- Potential issues: intermittency and spurious low-frequency energy
- Rare for most buoys, can potentially be mitigated if identified, but probably will not be able to measure infra-gravity waves without further refinement (e.g. RTK or PPK)

DELIVERABLES:

- 3 presentations – WISE, MTS, DBCP WMW
- 1 article (in progress) - Performance of Moored GPS Buoys
- 1 CHTN (in progress) - Engineers Guide to Mini-Buoys
- 1 data repository (in progress)

FINAL THOUGHTS:

- RTK - GPS buoy in the nearshore for water level, infra-gravity, and waves (6.1 / 6.2)

Deliverable	Title	Status
1 journal article	Performance of Moored GPS Wave Buoys, Collins et al., (in progress) CEJ special issue	90%
1 CHTN	Engineers Guide to Miniature Wave Buoys, Collins et al., (in progress) CHTN	75%
1 presentation	Field Testing Miniature Wave Buoys, Collins et al., WISE (May /June 2022)	100%
1 Data Repository	Data to Accompany “Performance of Moored GPS Wave Buoys”, Collins et al., (in progress)	90%
Bonus journal article	Progress in Ocean Wave Measurements, Collins et al., (in progress) CEJ – review	10%
Bonus Presentation	Field Testing GPS Wave Buoys, Collins et al., MTS (September 2022)	100%
Bonus Presentation	Field Testing Moored GPS Wave Buoys, Collins et al. DBCP WMW (October 2022), invited	100%
Budget	68k	100%