Taller de Técnicas de Medición en Hidrología e Hidráulica

Módulo: Hidráulica de ambientes costeros

Clase 2: Boya GPS

UNIVERSIDAD
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FACULTAD DE INGENIERIA

Oleaje. Mediciones in-situ

Instrumento

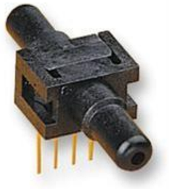
Nivel

Wave gauge

Waverider

Boya GPS

Presión



Pressure gauge

Velocidad

Ultrasound Velocity Profiling

Acoustic Doppler Velocimeter

Acoustic **D**oppler **C**urrent **P**rofiler (ADCP)

Boya GPS DWR-G4

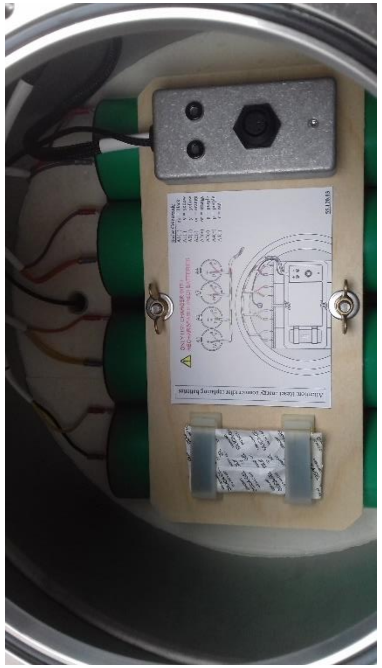
Desarrollada por Datawell BV

La boya de menor tamaño que ofrecen
40 cm de diámetro y **17 kg**

Ventaja: La operativa se resuelve con una embarcación de pequeño porte.

Menor costo que otras boyas.

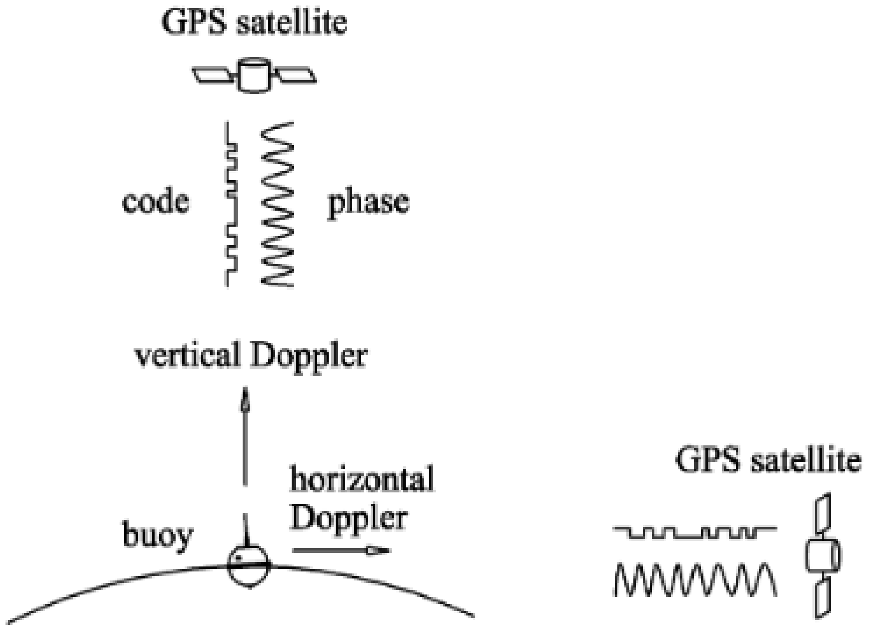
Desventaja: Menos autonomía y robustez que boyas más grandes



Promocionada para apoyo a dragados, construcción de obras marítimas, etc.

EPA (Australia) las ha usado en modalidad “caza tormentas”

Boya GPS DWR-G4



¿Qué mide? Desplazamientos en vertical y horizontal

¿Cómo mide? Doppler a la señal de GPS.

Precisión : ~1cm

Frecuencia de muestreo: 1.28 Hz

Hipótesis detrás: La boya sigue el movimiento del volumen de agua que desplaza.
Los desplazamientos medidos son los desplazamientos de la superficie libre del mar.

Análisis espectral a la serie de desplazamientos → Espectro de oleaje

Espectros: Cubre todas las direcciones con una resolución de 1.5 ° y abarca las frecuencias entre 0.025 Hz y 0.6 Hz con una resolución de 0.005 Hz si f<0.1Hz y 0.01 Hz para f >=0.1Hz.
Se almacenan en memoria interna cada 30 minutos.

5.5.1 Wave measurement principle

The GPS principle of wave measurement is explained by analogy. Apart from distance measurements between satellite and receiver, the so called GPS code phase, some GPS receivers also provide Doppler measurements. The former are used in GPS positioning, whereas the latter are indicative of satellite and receiver velocities. We exploit the analogy of Doppler frequency shifts for sound waves from moving sources. As for a passing car blowing its horn, it is in principle possible to track the motion of the car by listening to the sound of the horn. The more the frequency differs from the original frequency of the horn source, the higher the speed of the car. Integrating over time then yields the motion of the car.

5.5.2 GPS motion sensor

A GPS motion sensor consists of a GPS antenna and a GPS receiver. A patented algorithm will calculate the motion of the antenna centre.

The procedure of testing the GPS motion sensor is rather simple. Just leave the DWR-G buoy in a place where it has a clear view of the sky (no buildings or trees) and set it running. If the resulting north, west and vertical signals remain within a few centimetres approximately the sensor is alright. It may seem paradoxical to test a motion sensor by leaving it motionless. The way out of this paradox is that GPS satellites orbit the earth with velocities of 4 Km/s and any motion of the GPS receiver only forms a minor contribution. So if a motionless GPS motion sensor correctly produces a no-motion result in a highly dynamic situation then it works fine.

5.5.3 GPS and atmospheric or marine conditions

In line with the military and strategic intentions of the GPS system, GPS receivers and therefore the GPS buoy, will continue functioning during rain, snow or hail storms. The only problematic meteorological situation is when the GPS antenna is covered with a continuous layer of ice.

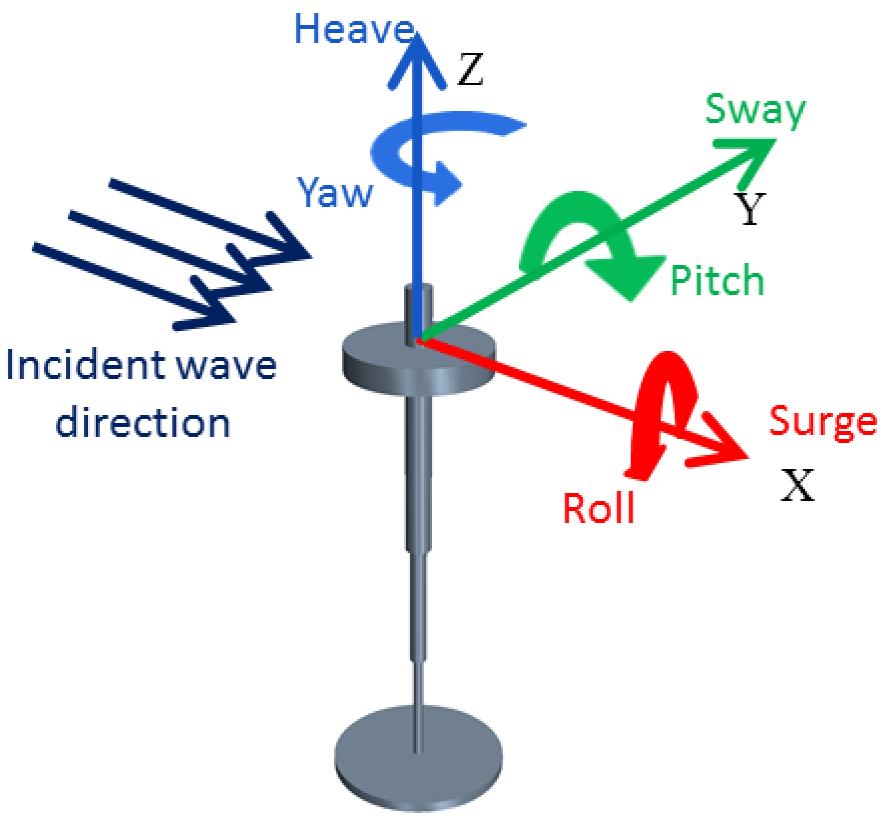
As for marine conditions, spray will also not impede the normal operation of the buoy. However, GPS signals do not penetrate through a continuous layer of salt or fresh water. A breaking wave washing over the GPS antenna will result in data missing.

Apart from meteorological and marine influences, also dirt, paint or metal constructions added by the user may block the GPS signal. If the GPS antenna has become dirty, clean it with water and soap and a soft piece of cloth.

5.5.4 GPS antenna and pseudo-motion

To be precise the three-dimensional motion of the GPS antenna is measured and not that of the centre of the buoy. This implies that pitching and rolling of the buoy will result in measured (GPS antenna) 'wave' motion, even on a perfectly smooth sea surface. This false motion is addressed as pseudo-motion. Experiments where pitch and roll have been logged, have demonstrated that the Fourier spectrum of the pseudo-vertical always remains far below the wave spectrum. In the case of pseudo-horizontal motion, only on the high frequency side, above 0.5 Hz, the pseudo-spectrum may be comparable to the true wave motion. This is consistent with the fact that pitch and roll will exert a larger effect on the horizontal than on the vertical pseudo-motion component. Furthermore, the frequency given is consistent with the typical pitch and roll behaviour displayed when the floating buoy is tilted by hand and is released.

Repaso: Modos de movimiento de un rígido



1) Surge (avance y retroceso)
2) Sway (ronza o abatimiento)
3) Heave (ascenso descenso)
4) Roll (Rolado)
5) Pitch (Cabeceo)
6) Yaw (Virada)

5.5.5 Limit on buoy velocity

The processing cannot keep up with position changes over 100 m in less than 100 s and measurements will start to fail. E.g. when a buoy is used free floating or is towed at constant velocities above 1 m/s. This will appear as sudden large oscillations in the displacement data.

5.5.6 Signal loss and flag

In the example of the passing car, one will lose track of the car if one temporarily closes one's ears. Likewise if the GPS receiver temporarily loses signal, due to waves washing over or a momentarily extreme tilt, the buoy velocity is temporarily unknown. As a result the buoy motion may contain discontinuities. However the GPS receiver knows when signal loss occurs and will inform the user of this through setting a flag: the least significant bit of the north.

In practice, breaking waves in the surf zone and areas of strong current must be avoided. Wave height by itself is not a problem. In other locations signal loss occurs less than 0.1% of the time.

5.5.7 Selective availability

As mentioned the GPS system originally was and still is a military system, maintained by the United States Department of Defence. As such a few features are incorporated to restrict the use of precise GPS to selected users. This is known as Selective Availability (SA). When SA is active a dither is added to the satellite GPS time thereby deteriorating the GPS position accuracy from 10 m to 100 m. Furthermore the precision of the satellite orbit information may be reduced. The information to correct for dithering is encrypted in the GPS signal. Unless one has the encryption key one cannot restore the intrinsic GPS accuracy.

On May 1, 2000 SA was officially discontinued, see www.navcen.uscg.gov/gps/selective_availability.htm. If, in the unlikely event, SA would be temporarily switched on for strategic reasons, the current GPS wave buoy will not work anymore! However, it will continue measuring waves immediately after SA is switched off again.

Boya GPS DWR-G4

Transmisión de datos en tiempo real:

Mediante alta frecuencia (29.825 MHz).

Desplazamientos de forma continua y espectros cada 5 minutos.

Calibración: No necesita. Testeo con boya quieta.

Fuentes de error: 1) La boya se aparta del movimiento de la ola. Resonancia o, Restricciones debido al anclaje

2) Cortes en la comunicación GPS-satélites. e.g. La antena GPS es cubierta por agua.

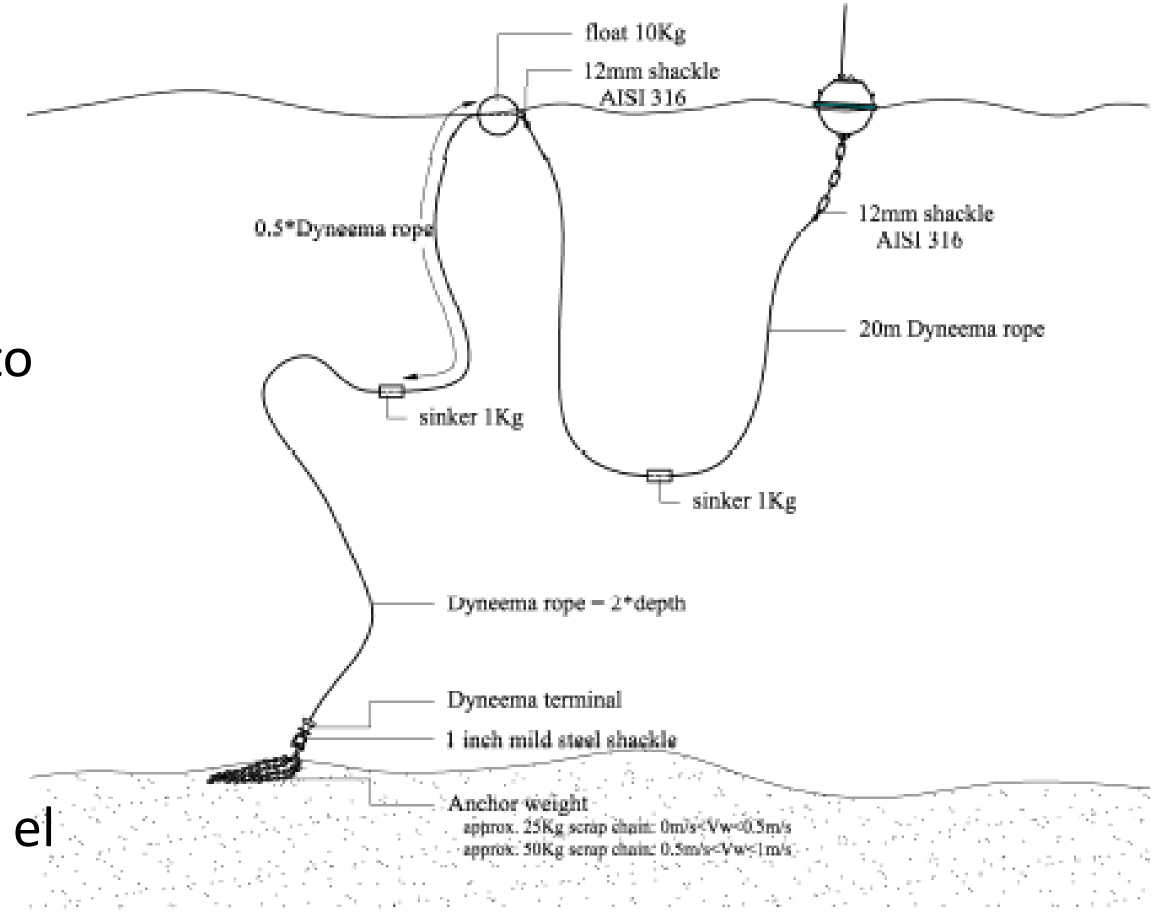
Boya GPS DWR-G4

MITIGACIÓN DE LA RESONANCIA

Defensa de goma. Mata resonancia en el movimiento vertical

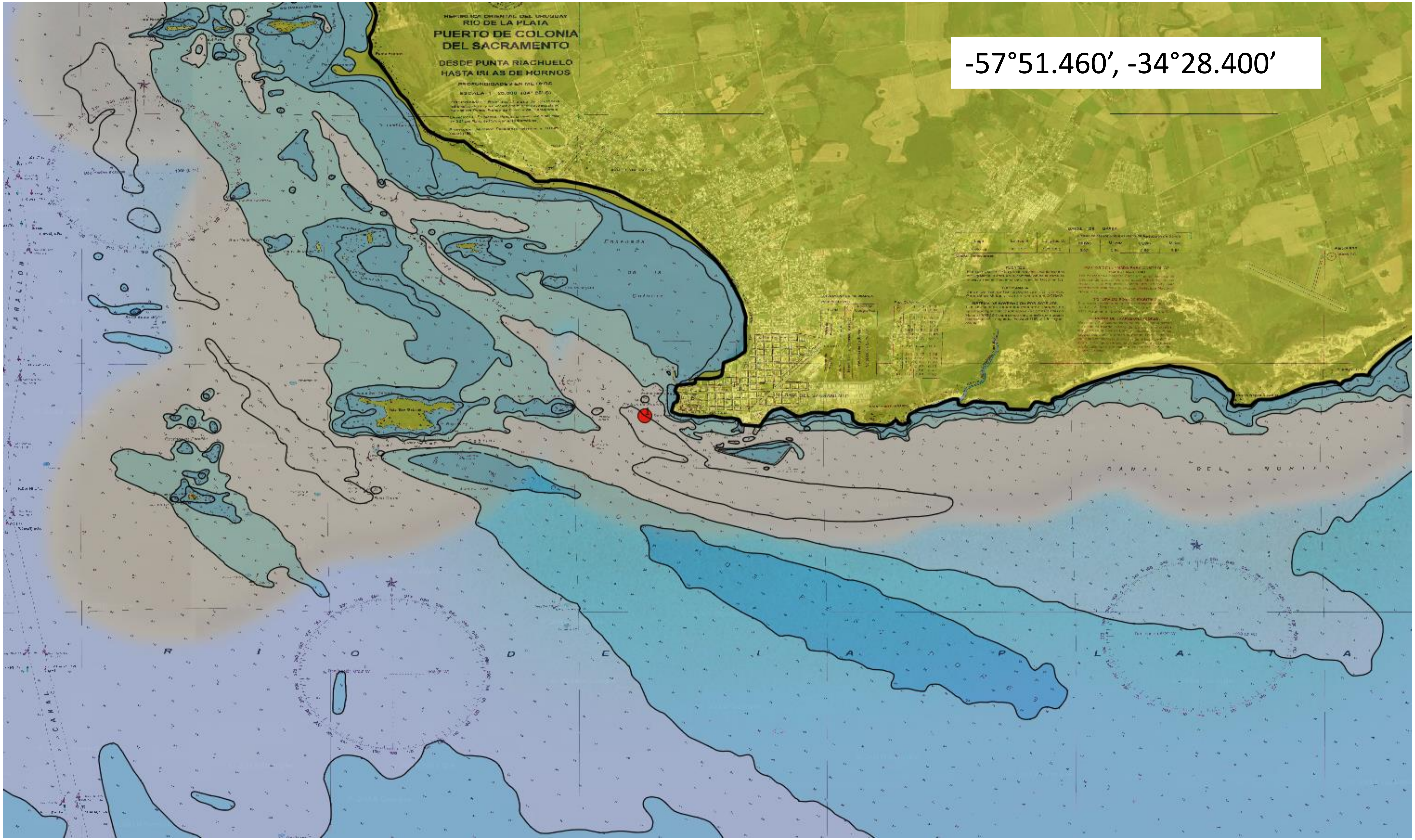
Cadena. Mata resonancia en el movimiento de "cabeceo"

CONFIGURACIÓN DEL ANCLAJE



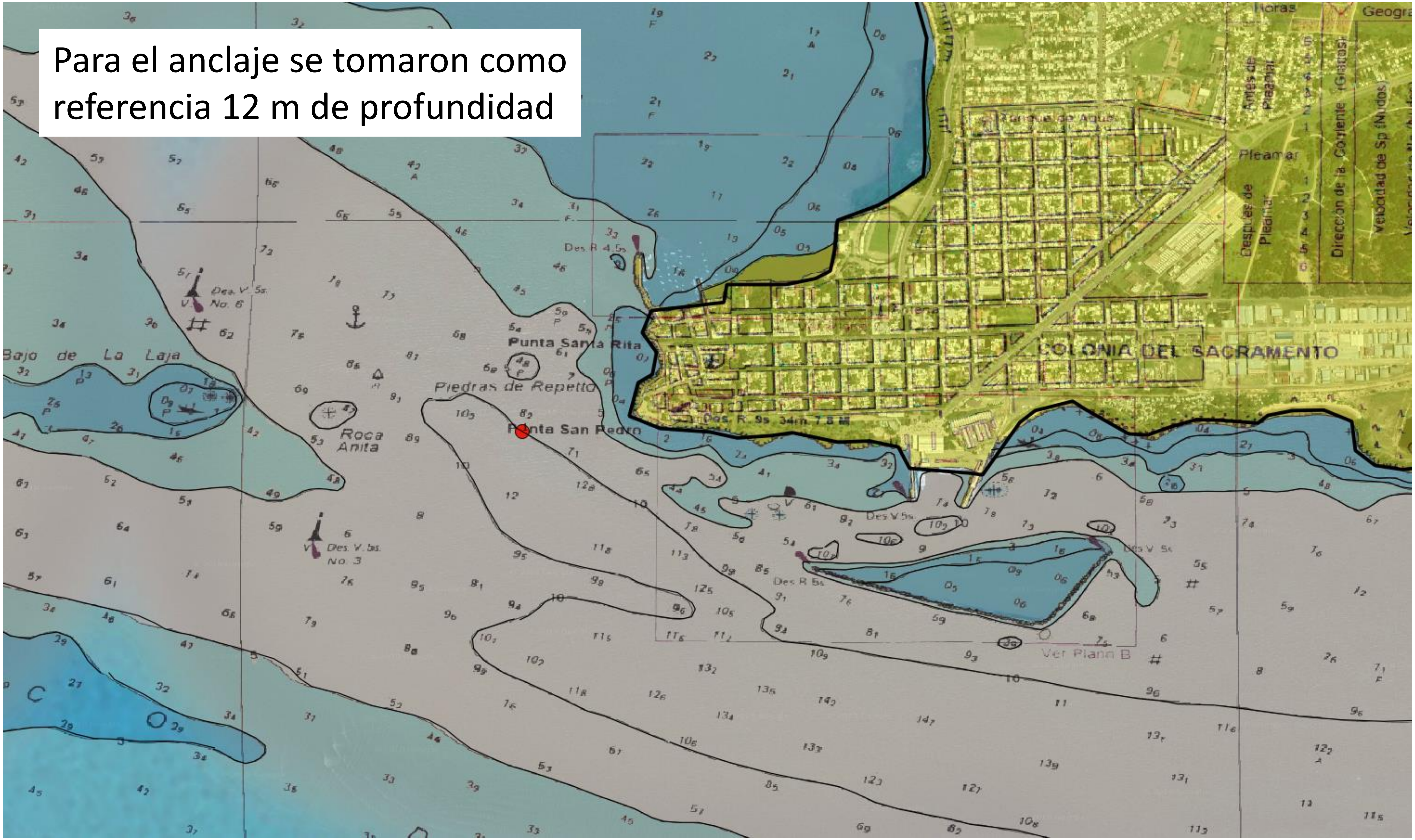
V < 1 m/s

Campaña de medición en Colonia.



Campaña de medición en Colonia.

Para el anclaje se tomaron como referencia 12 m de profundidad



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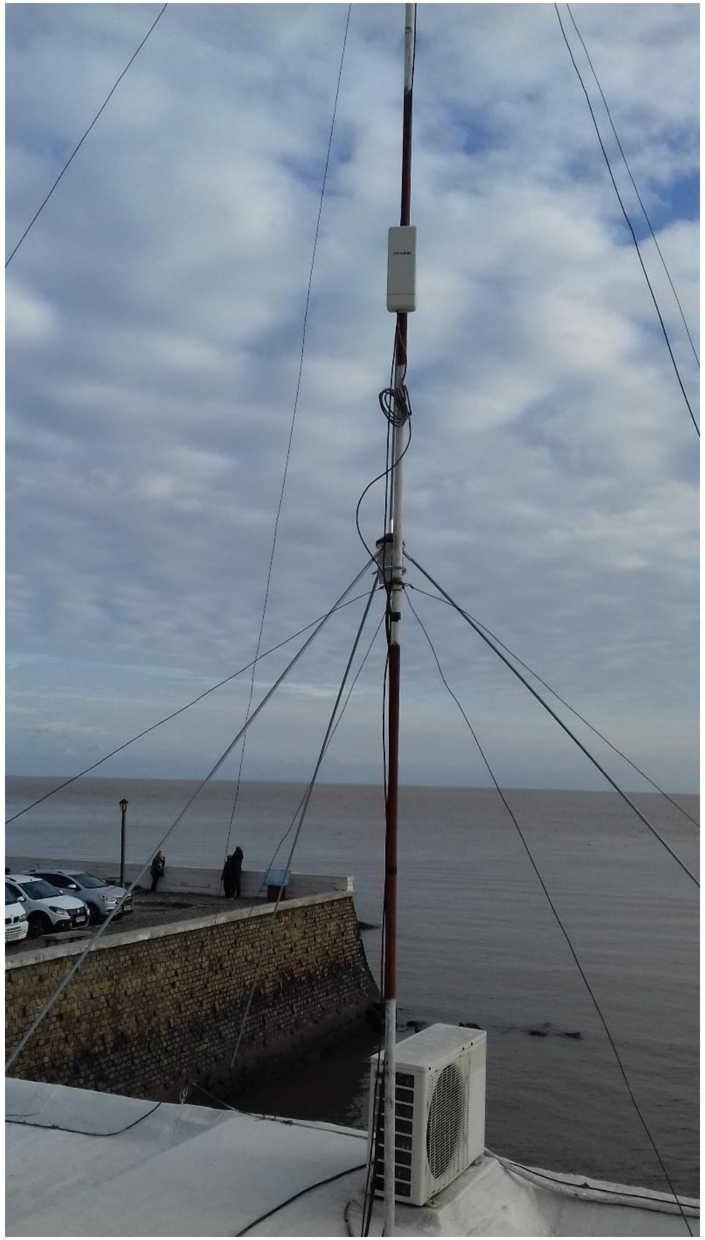

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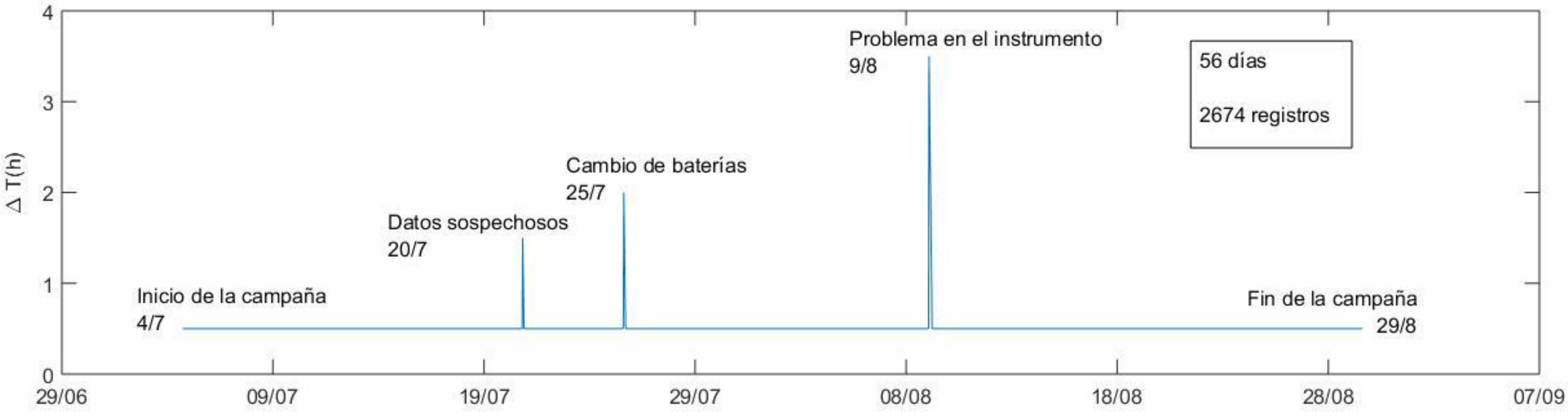


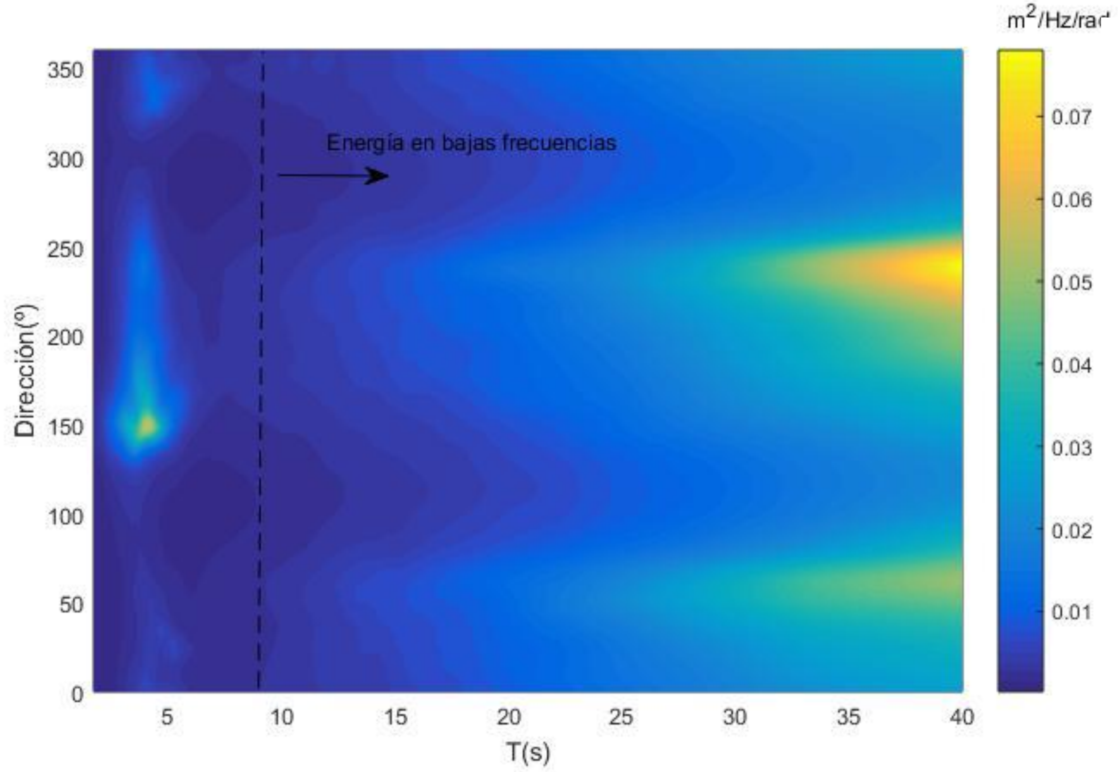
Además se dispone de:

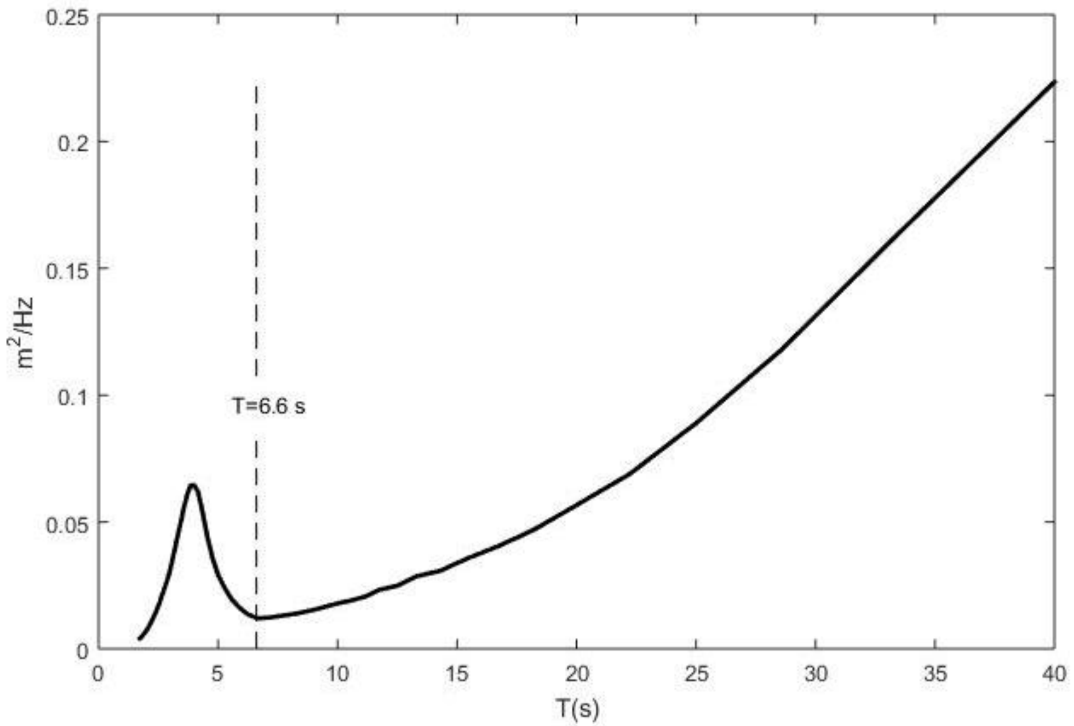
Mediciones de viento en la estación meterológica de Colonia (INUMET).

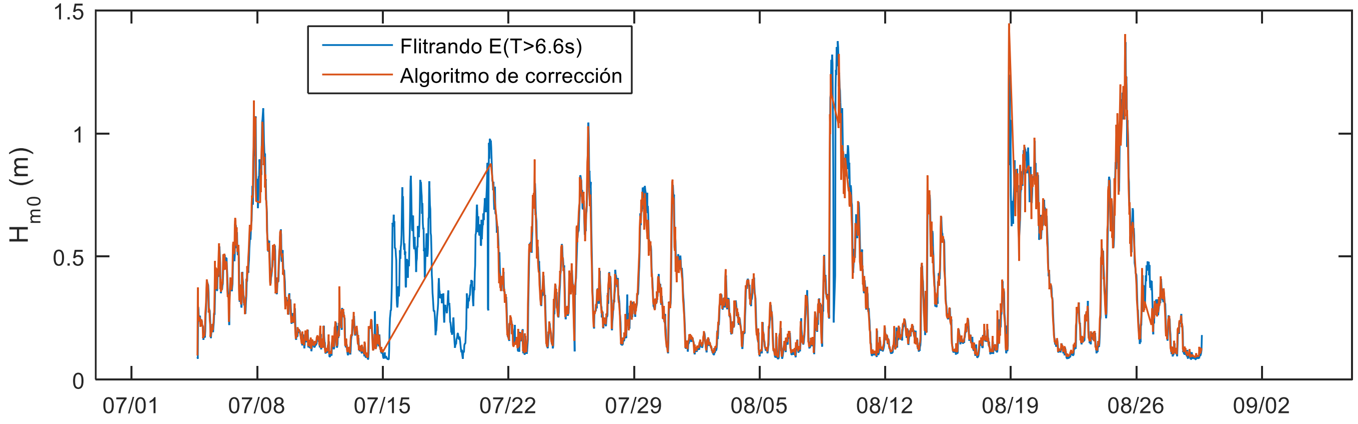
Mediciones de nivel en el puerto deportivo de Colonia.

Presentación de los datos.

Energía espuria en bajas frecuencias

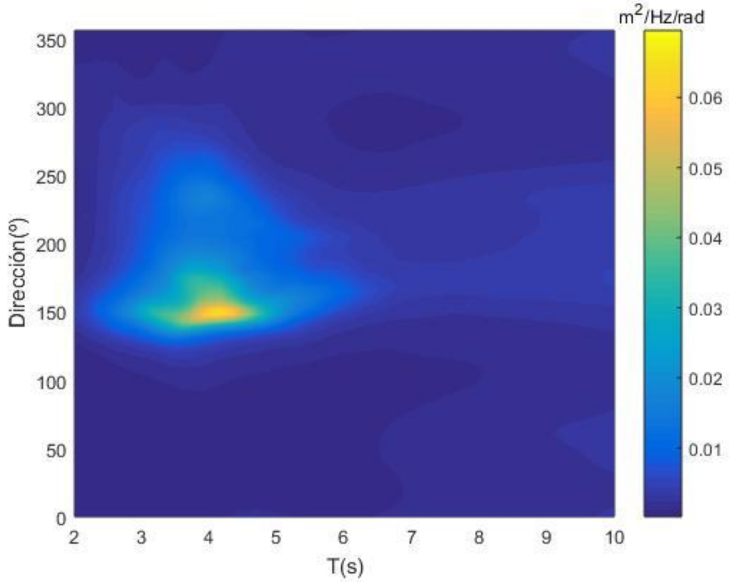


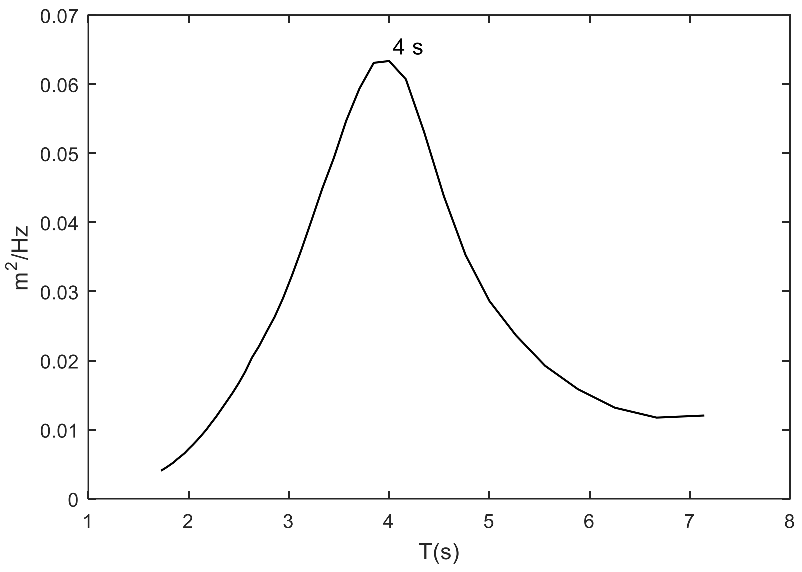


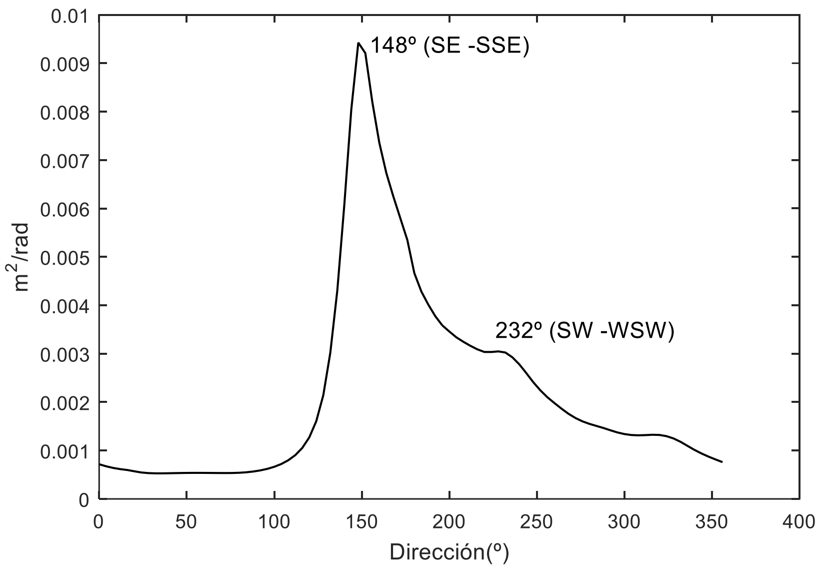


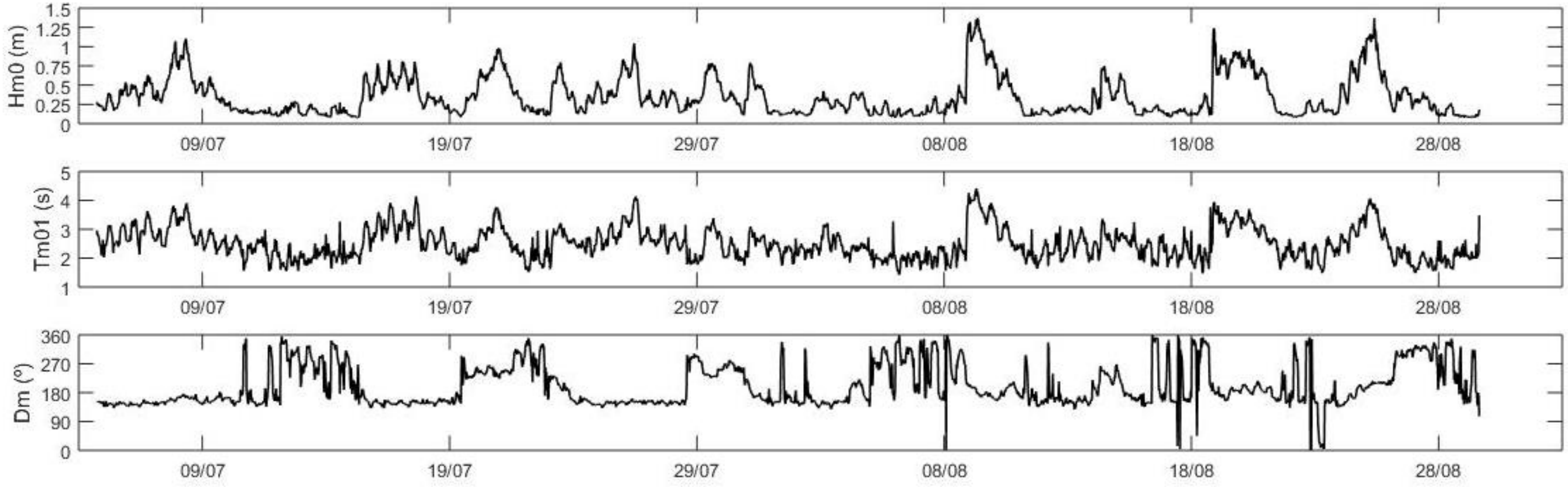
Presentación de los datos.

Espectros promedios



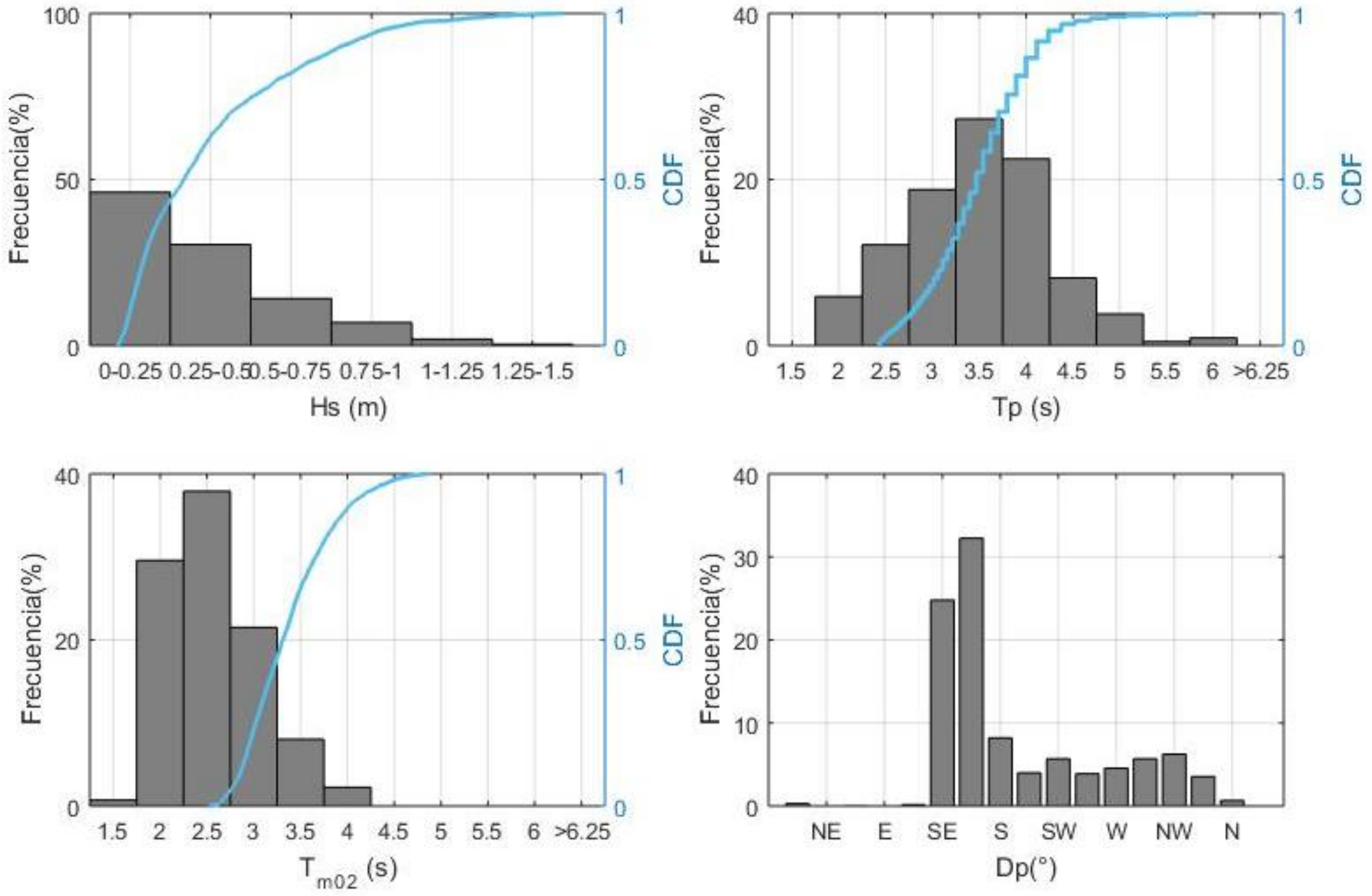






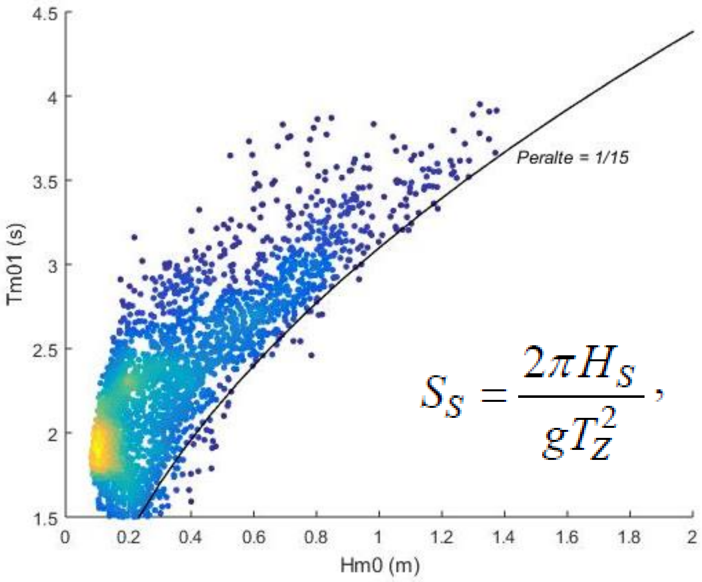
Presentación de los datos.

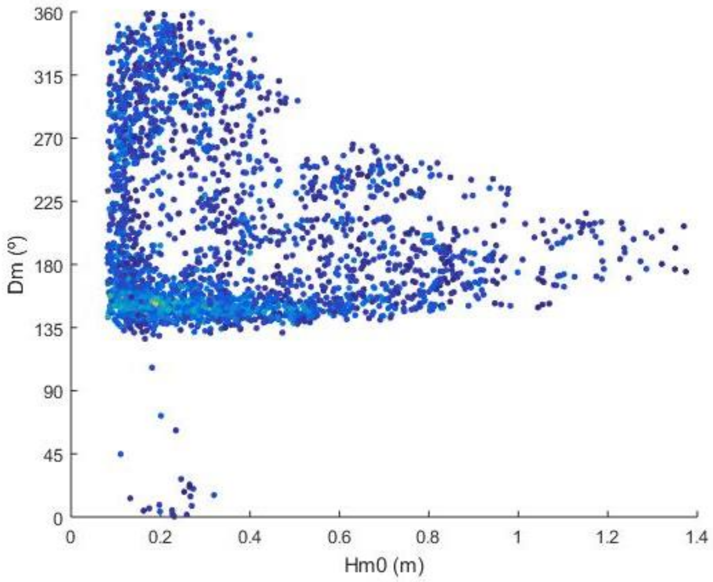
Estadística de los parámetros de oleaje

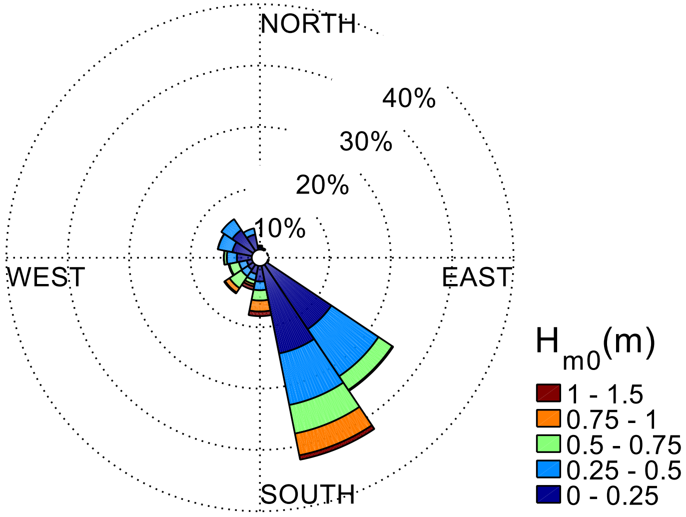


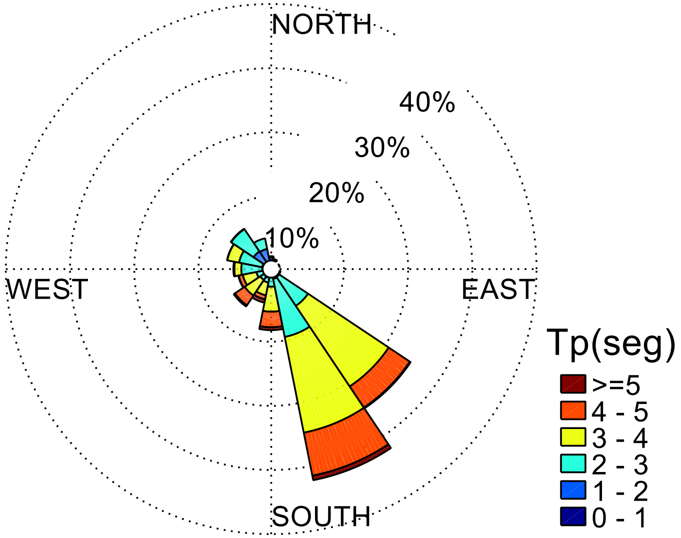
Presentación de los datos.

Estadística de los parámetros de oleaje



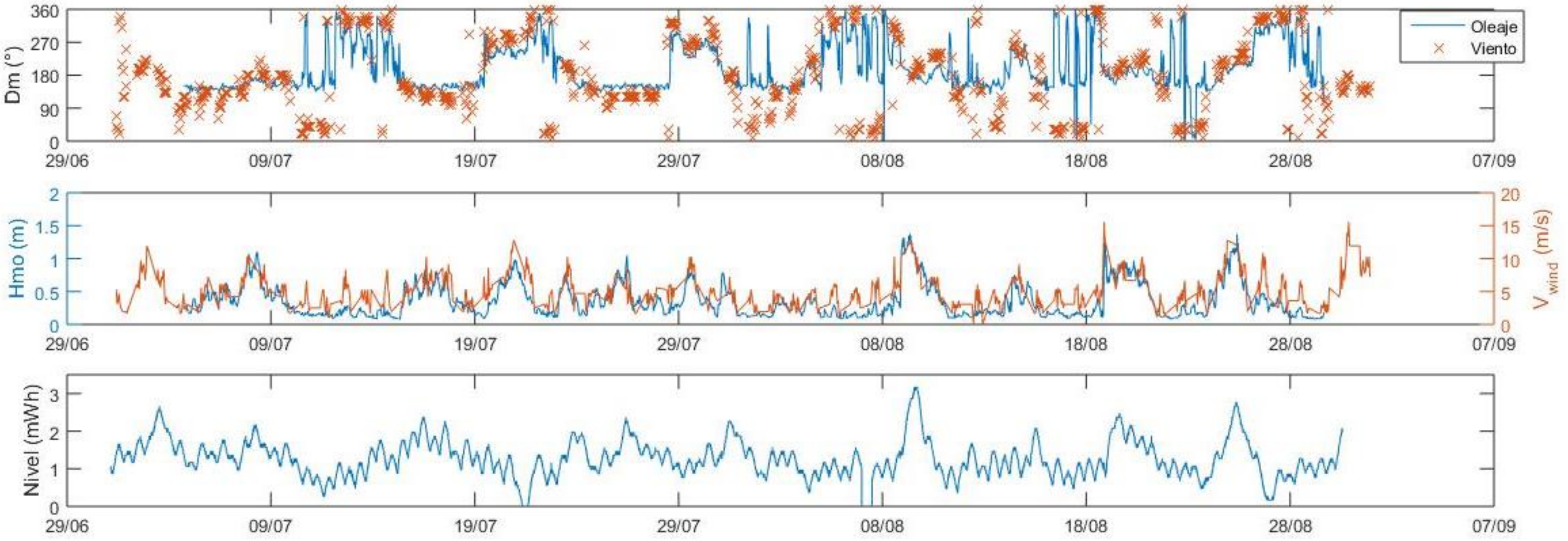






Presentación de los datos.

Oleaje – Viento - Nivel



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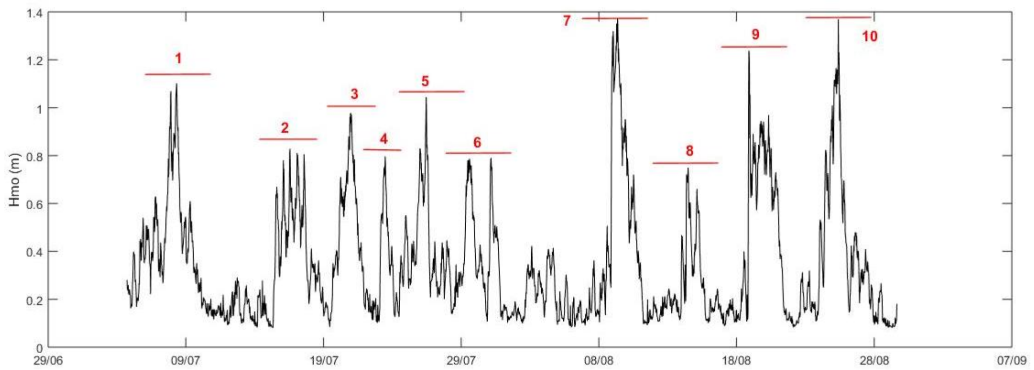

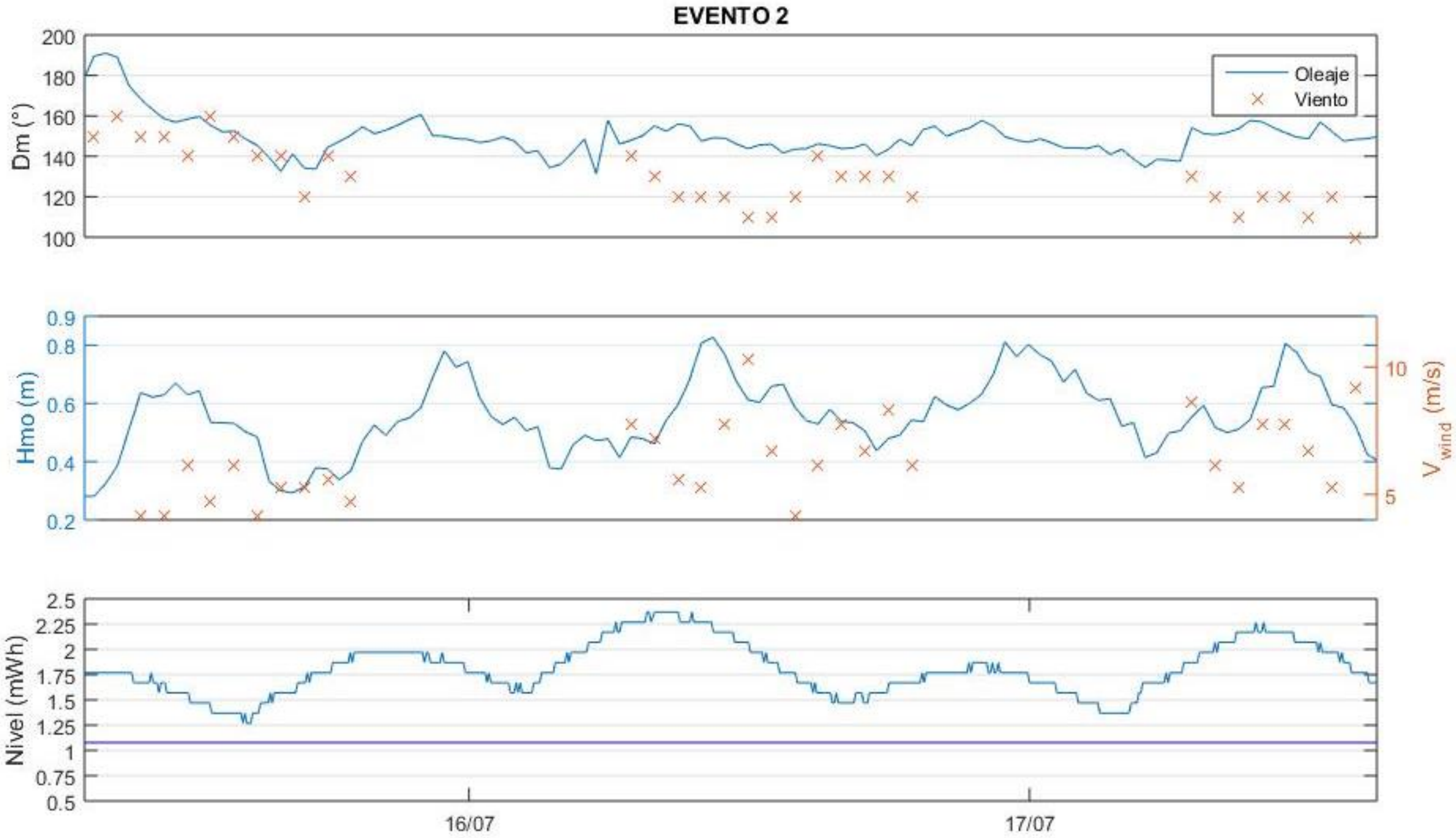

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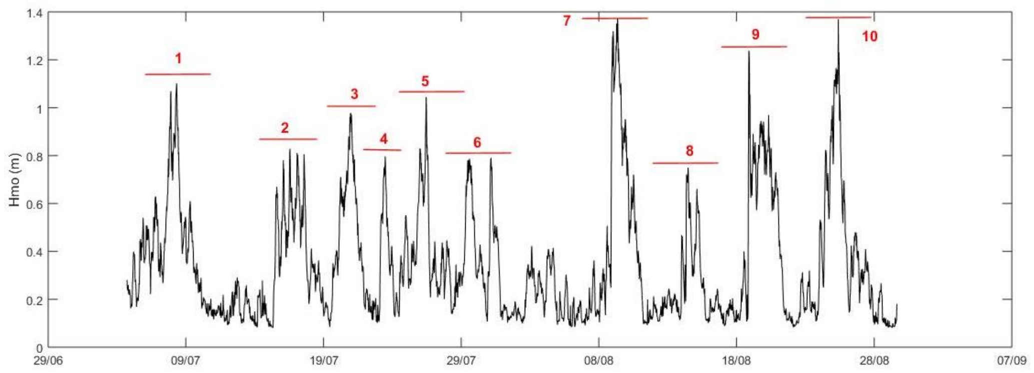

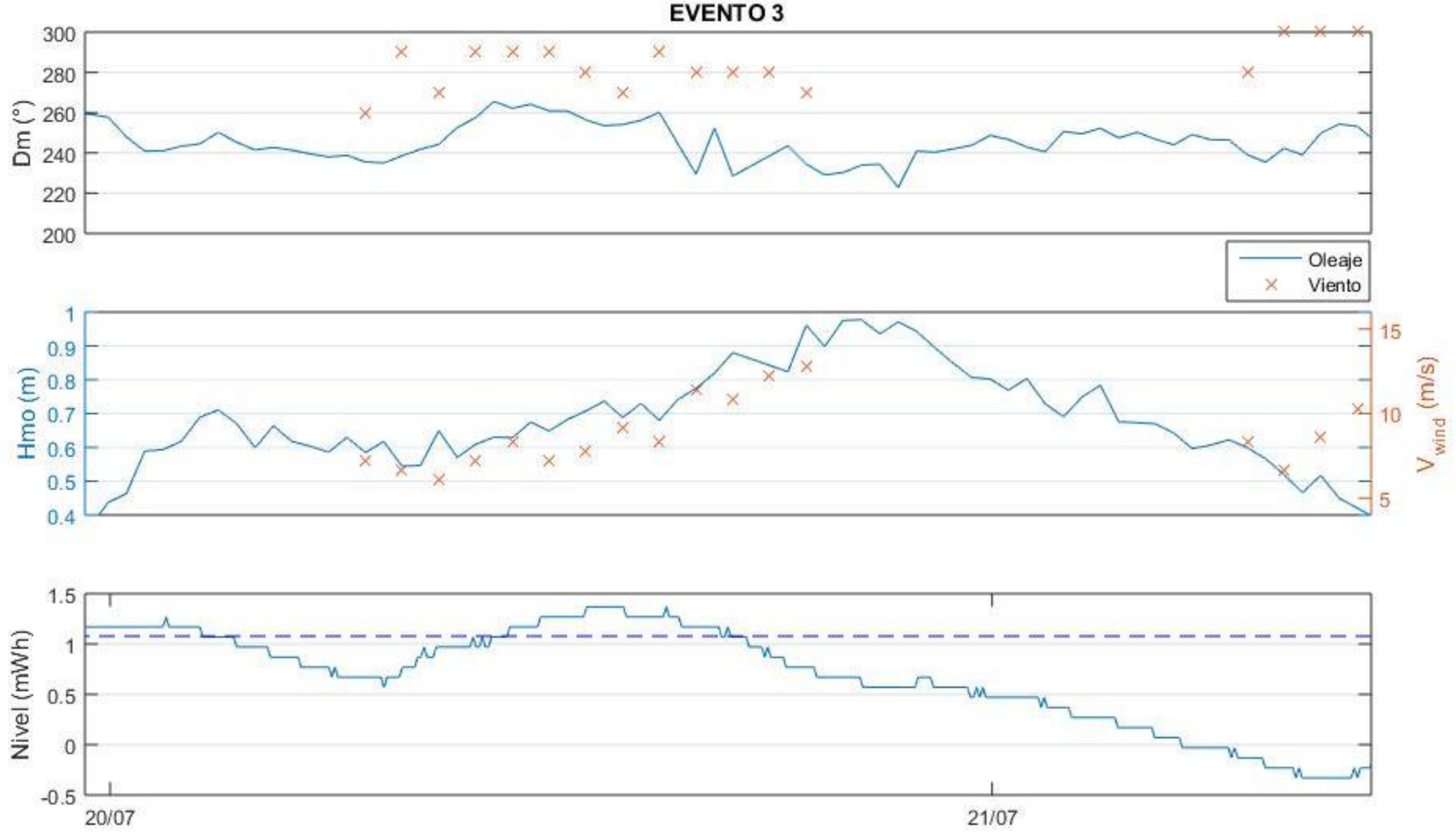

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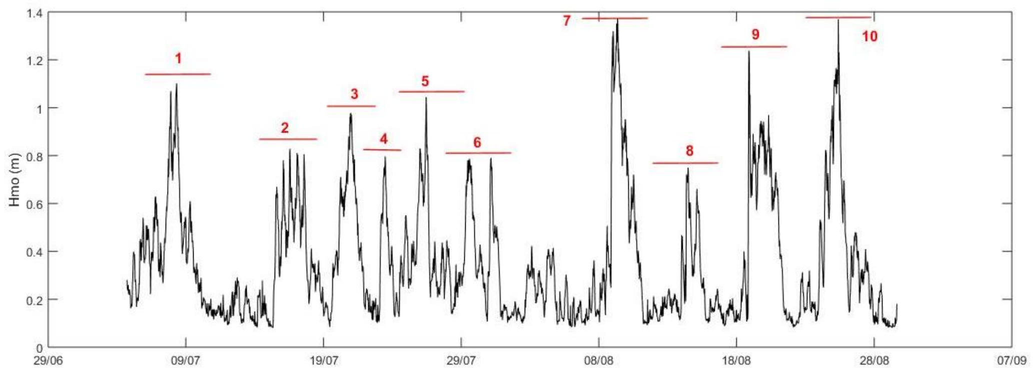
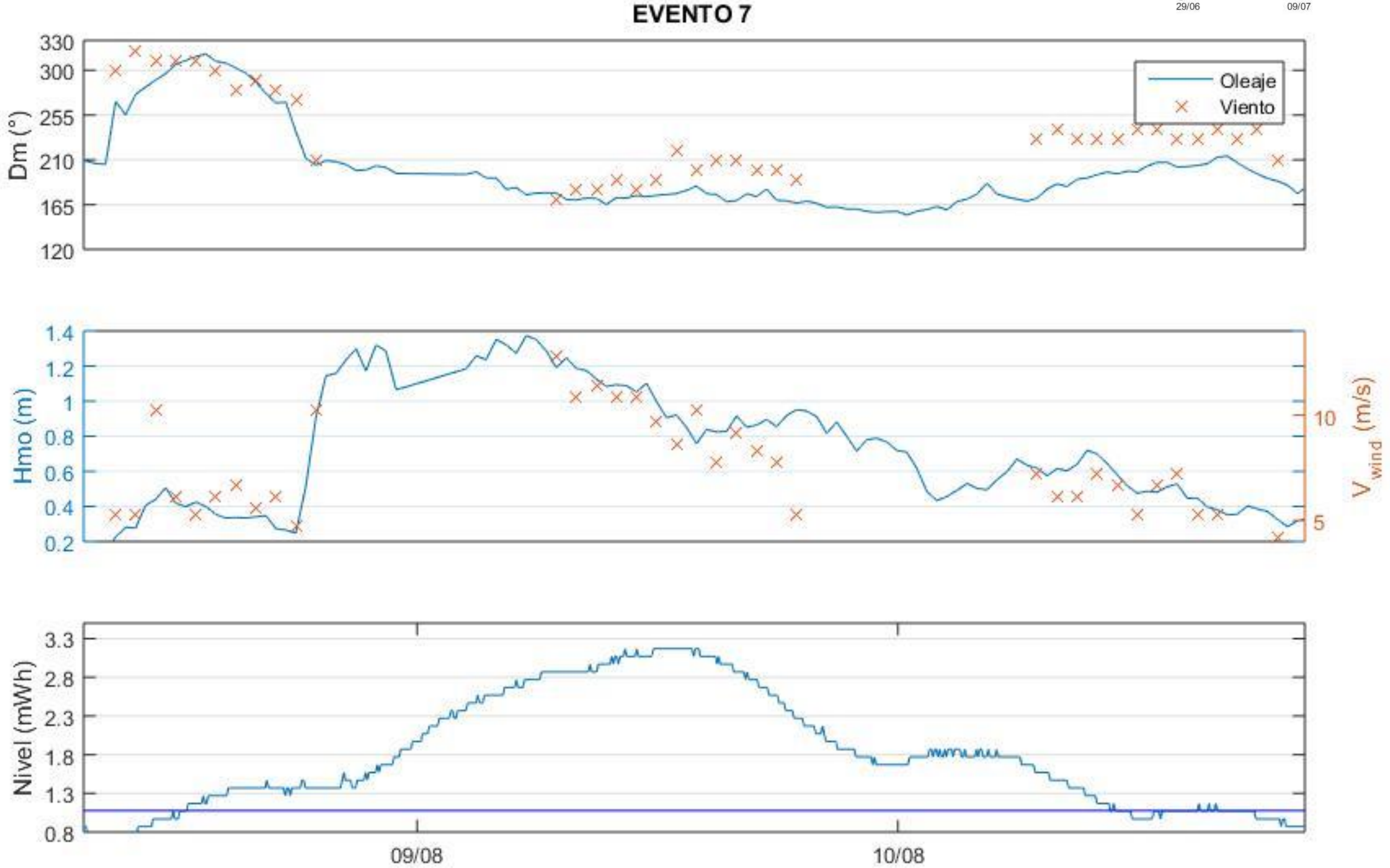
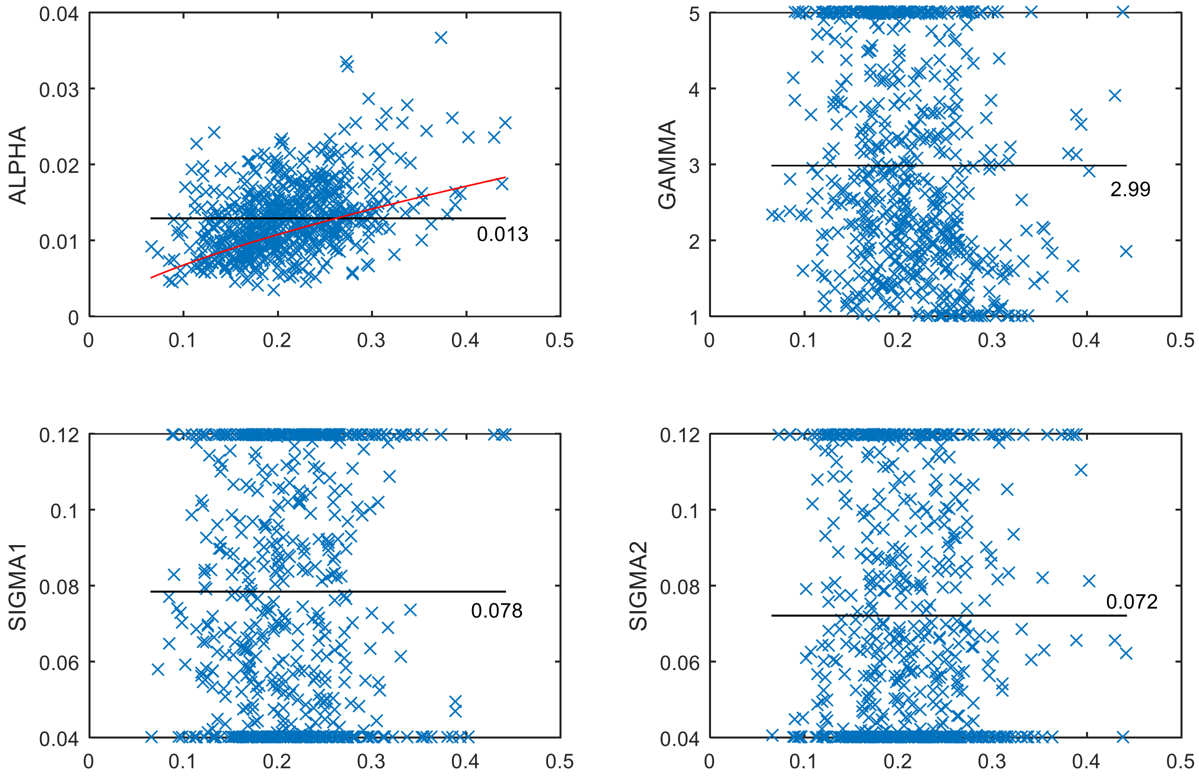




Presentación de los datos.

Comparación con formas espectrales para condiciones idealizadas

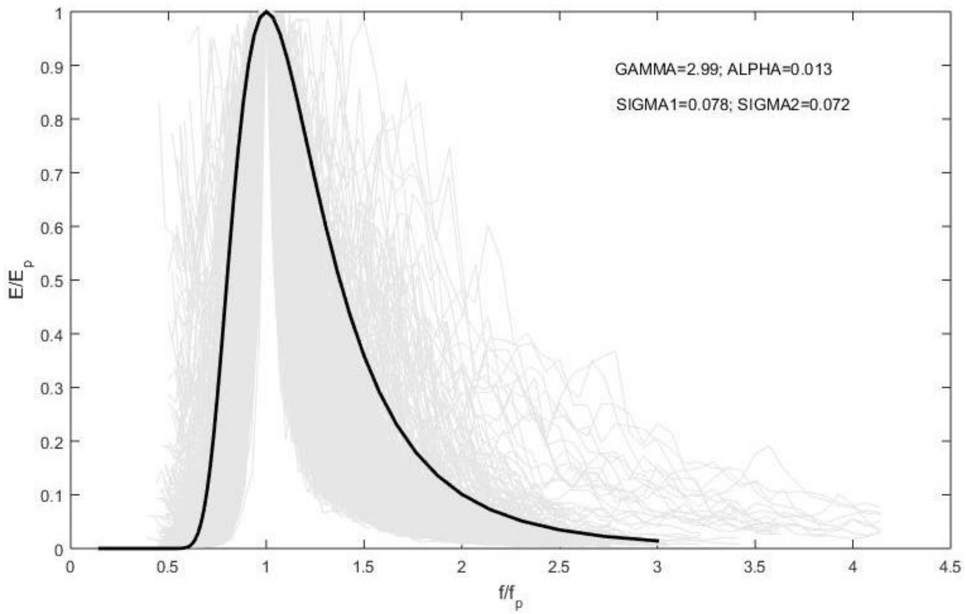


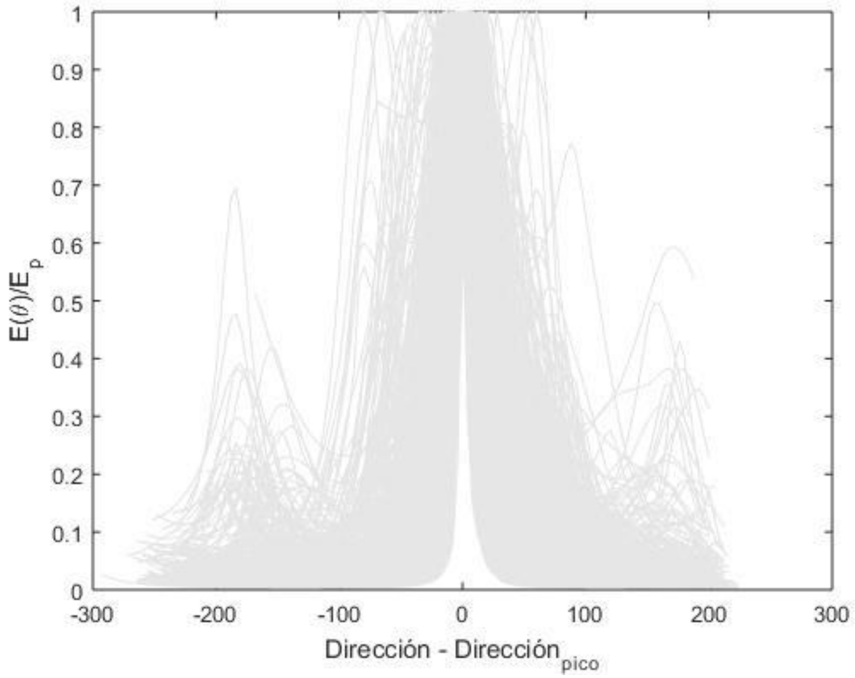
$$E_{JONSWAP}(f) = \alpha g^2 (2\pi)^{-4} f^{-5} \exp\left[-\frac{5}{4}\left(\frac{f}{f_{peak}}\right)^{-4}\right]\gamma^{\exp\left[-\frac{1}{2}\left(\frac{f/f_{peak}-1}{\sigma}\right)^2\right]}$$

Pierson–Moskowitz *shape*

JONSWAP

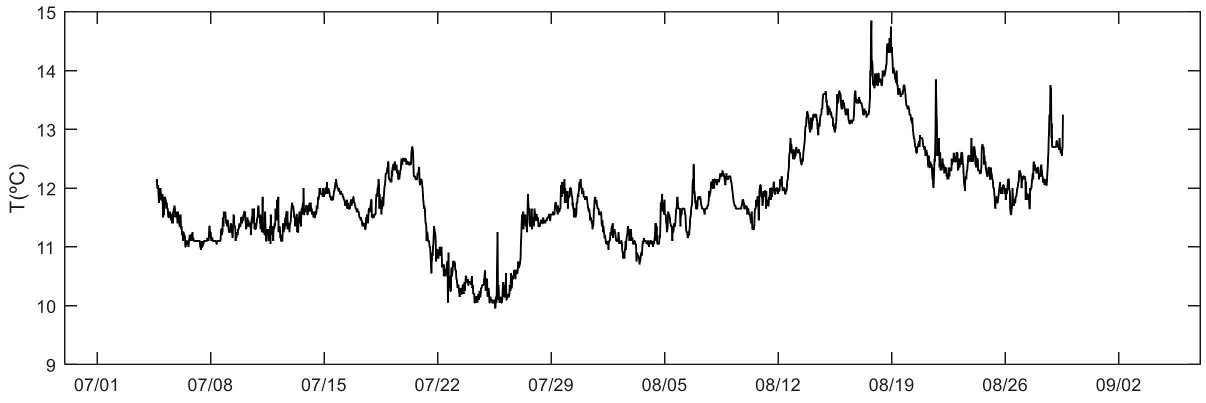
fetch-limited in deep water (6.3.15)

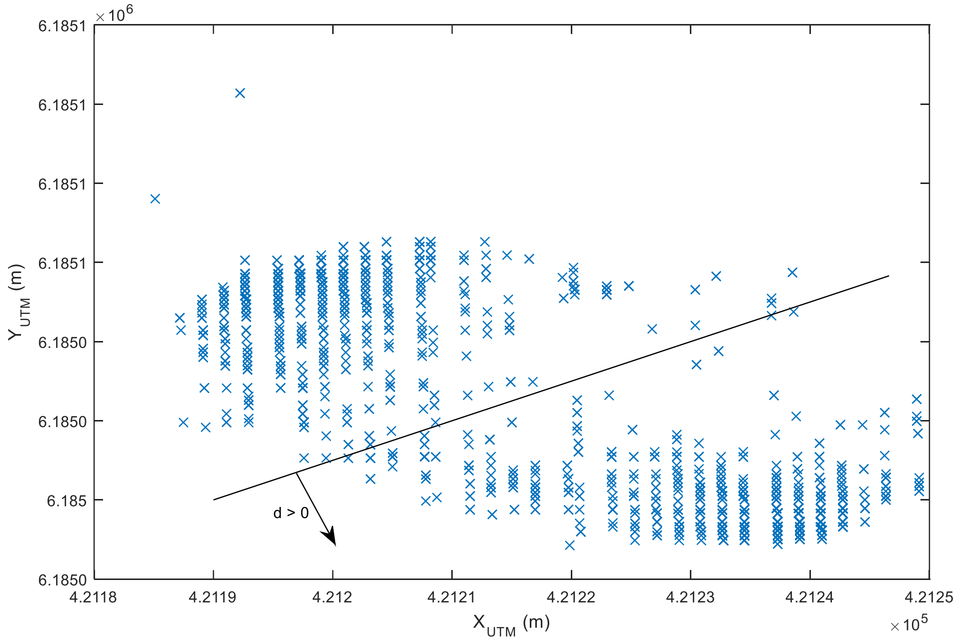


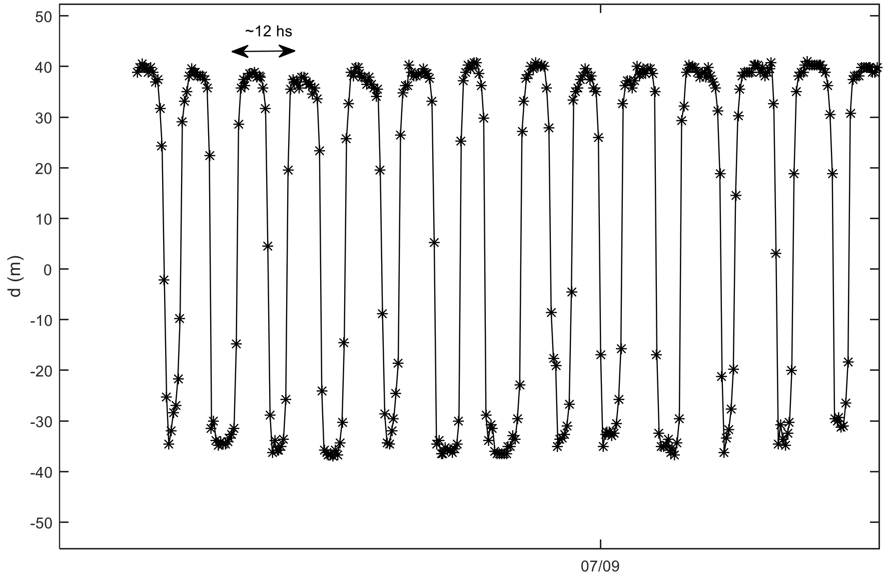


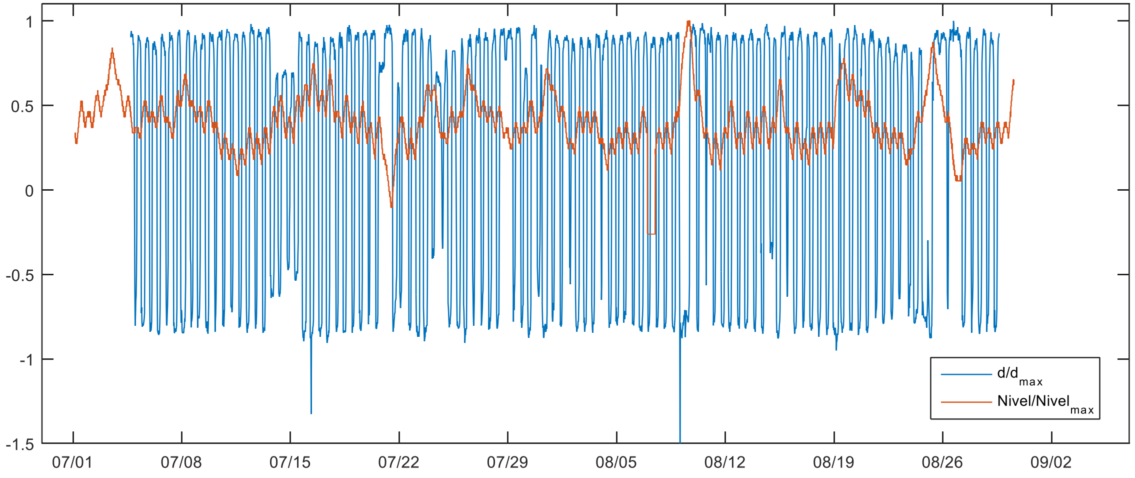
Presentación de los datos.

Datos adicionales: Temperatura y sentido de la corriente









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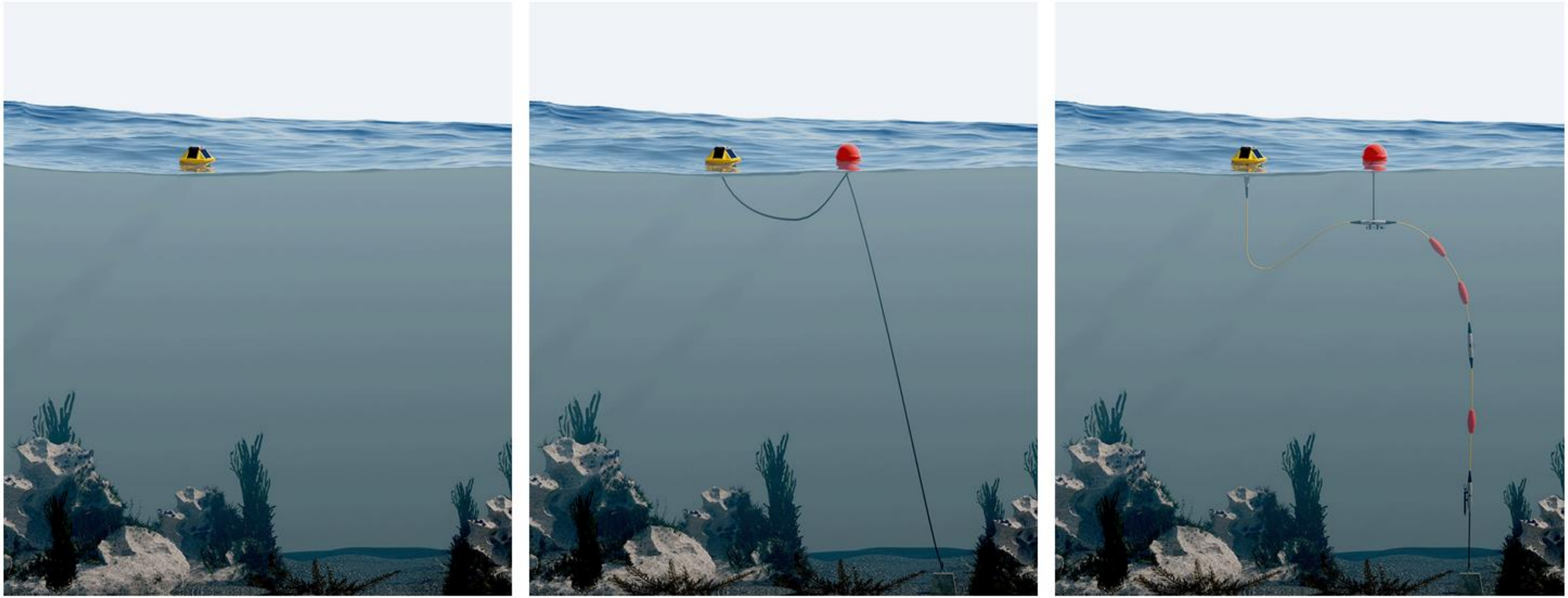
Select a Base Product Configuration*

Spotter: $5,950.00

Spotter

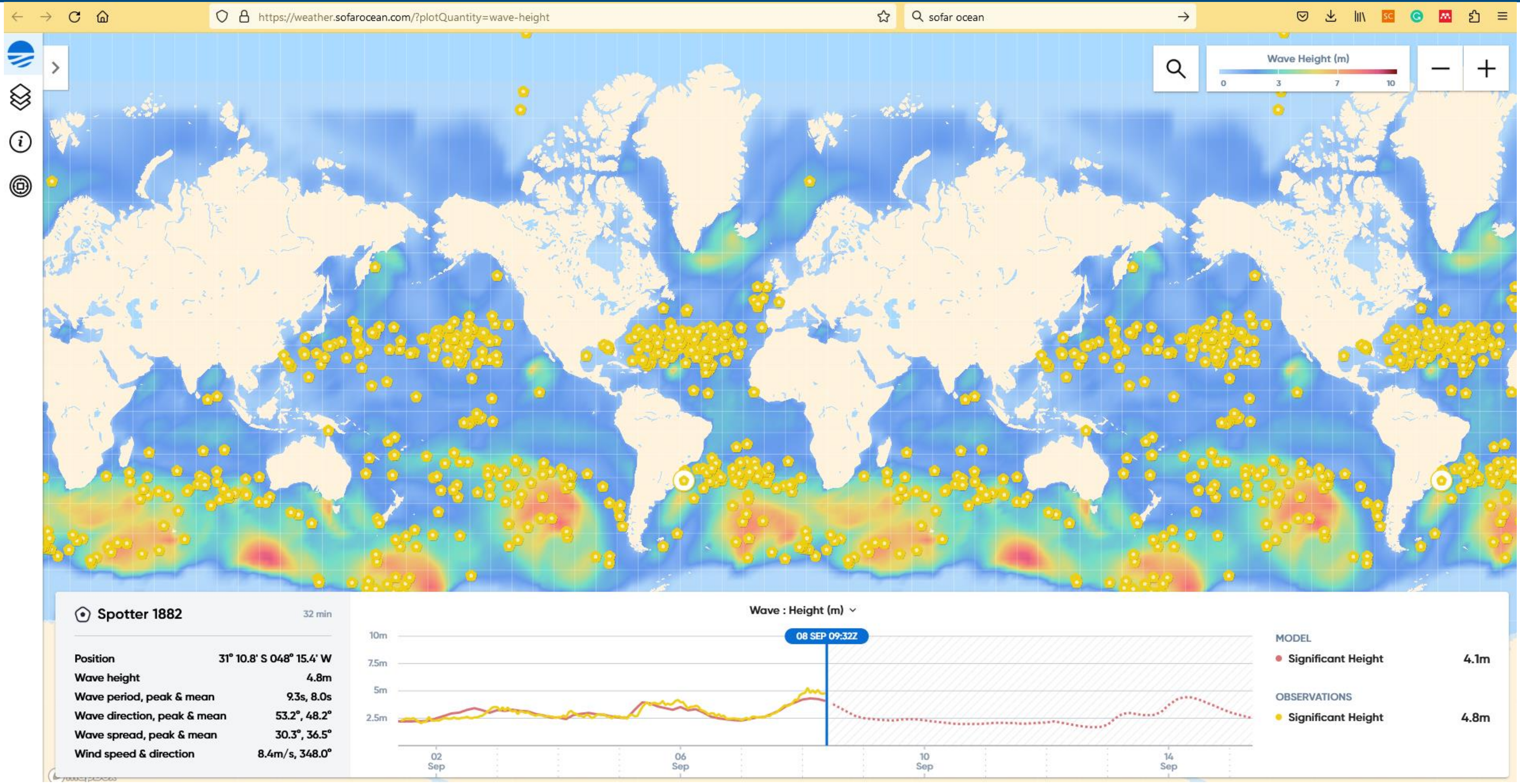
Spotter + Smart Mooring

Spotter + Smart Mooring Bristlemouth DevKit



Free Floating | Conventional Mooring | Smart Mooring

TTMHH: Hidráulica de ambientes costeros. Clase 2: Boya GPS



Bibliografía:

"Datawell waverider reference manual" Datawell BV. (2017). Capítulo 5.5

SOFAR SPOTTER Documentation:
https://www.sofarocean.com/posts/spotter-product-documentation