



PIANC French Section



# PIANC Mediterranean Days and Conference «Port of the future» by Cerema 25 to 27 october 2023 in Sete France

## Developing a wave prediction module for sustainable port operations and energy harvesting

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Delia Regueira Muñiz - **IHCantabria**

Alejandro Gonzlalez Valle - **IHCantabria**

Beatriz Rodríguez Fernández - **IHCantabria**

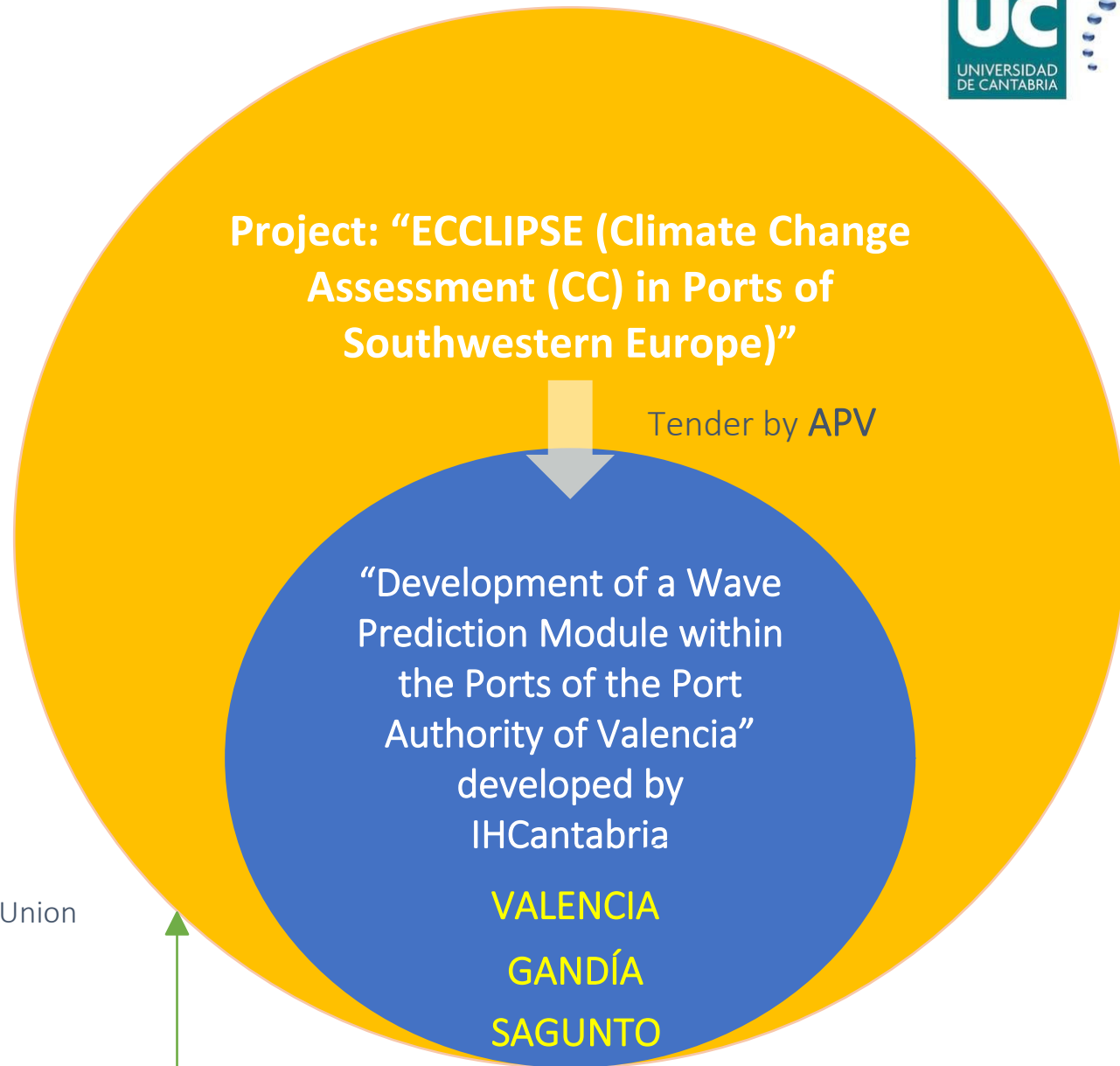
Eva Romano - **IHCantabria**

Antonio Tomás - **IHCantabria**



# Background

<https://www.interreg-sudoe.eu/gbr/home>



Funding by European Union

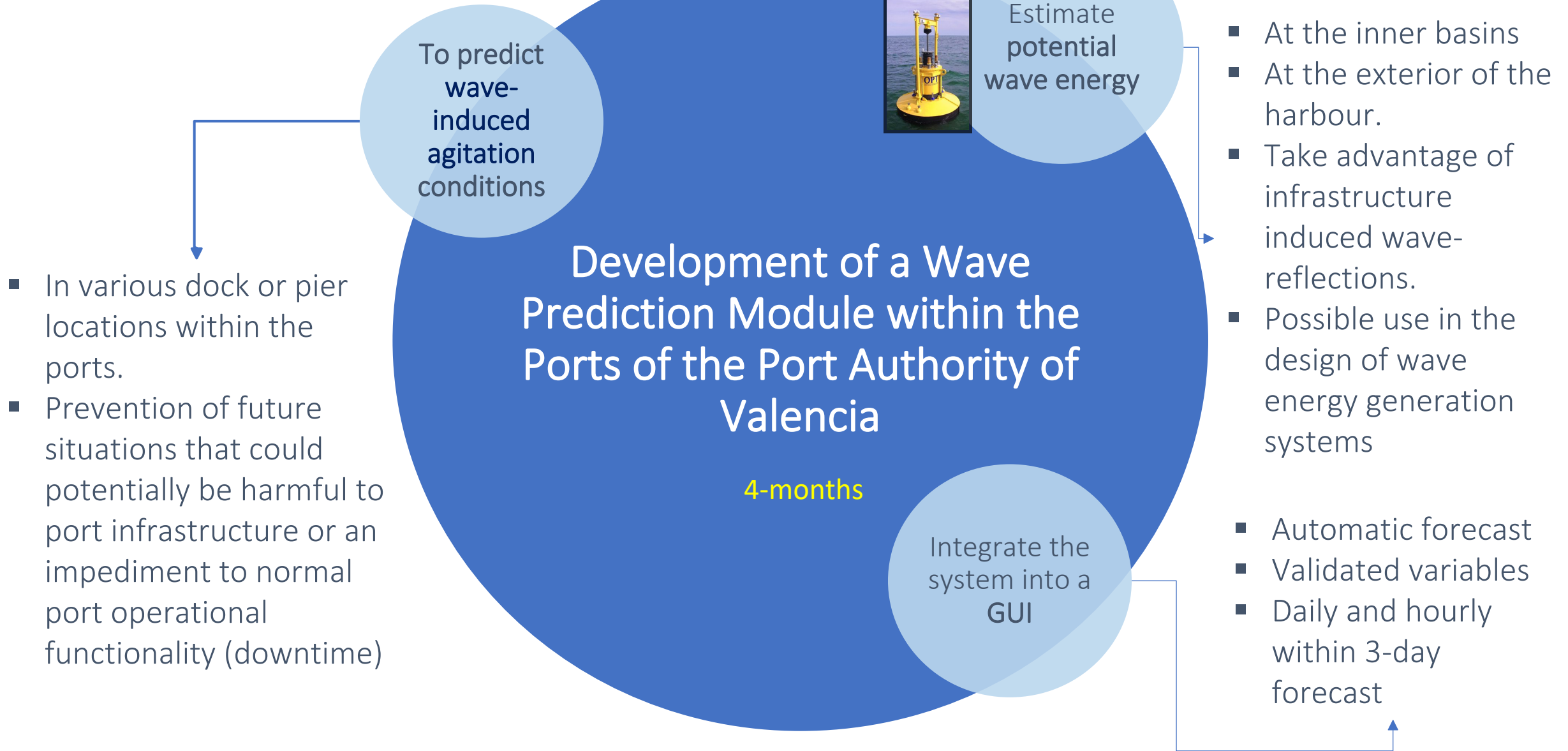


-  Research and innovation
-  Competitiveness of SMEs
-  Low-carbon economy
-  Combating climate change
-  Environment and resource efficiency



**Objective 5B1:** Improving the coordination and effectiveness of prevention, disasters management and rehabilitation tools of damaged areas.

# Project objectives



# Methodology – part A

Coastal Engineering 170 (2021) 104011

Contents lists available at ScienceDirect

**Coastal Engineering**

journal homepage: [www.elsevier.com/locate/coastaleng](http://www.elsevier.com/locate/coastaleng)

**An improved model for fast and reliable harbour wave agitation assessment**  
 Gabriel Diaz-Hernandez, Beatriz Rodríguez Fernández, Eva Romano-Moreno, Javier L. Lara

*IHCantabria - Instituto de Hidráulica Ambiental de la Universidad de Cantabria, Spain*

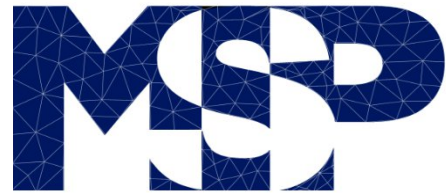
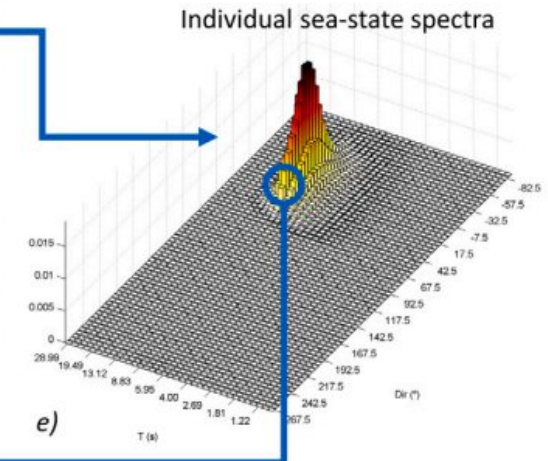
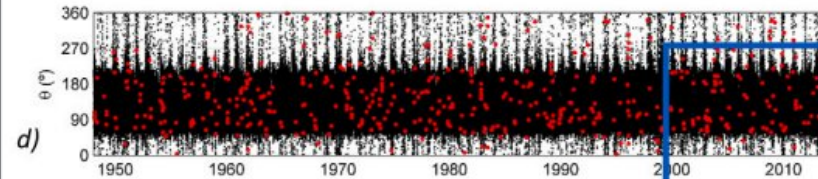
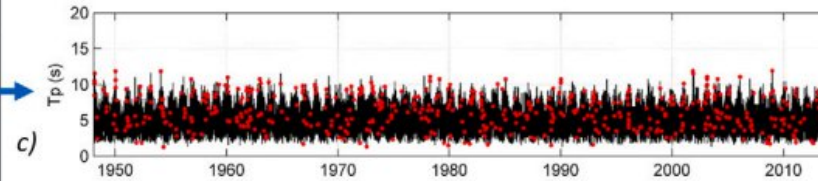
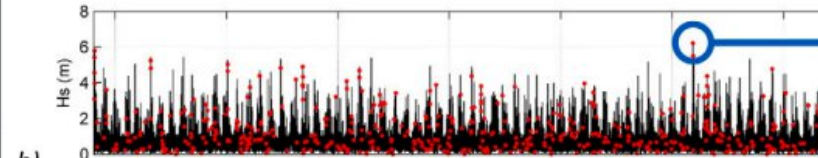
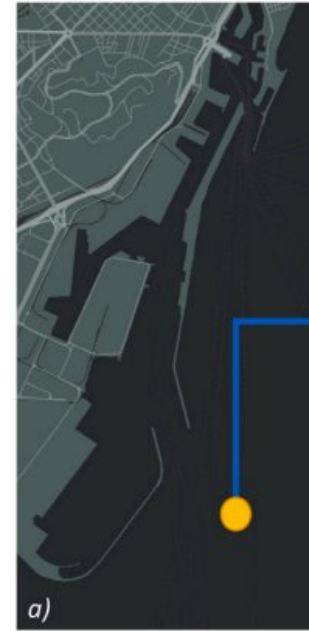
**ARTICLE INFO**      **ABSTRACT**

**Keywords:** Port/Harbour agitation; Wave penetration; Mild slope; Downscaling; Hindcast; Forecast; Short-term prediction

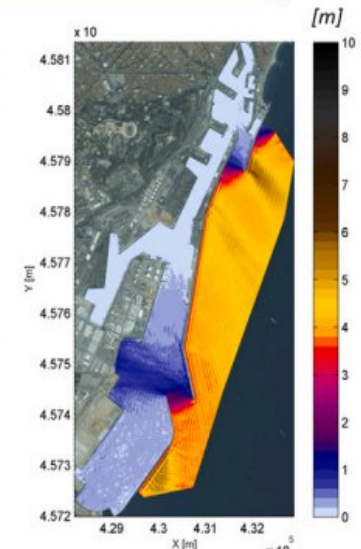
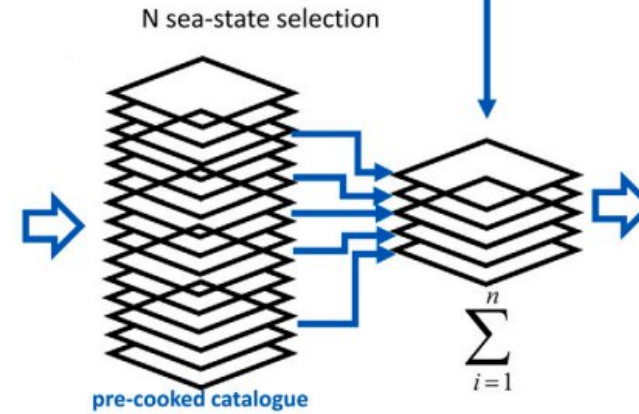
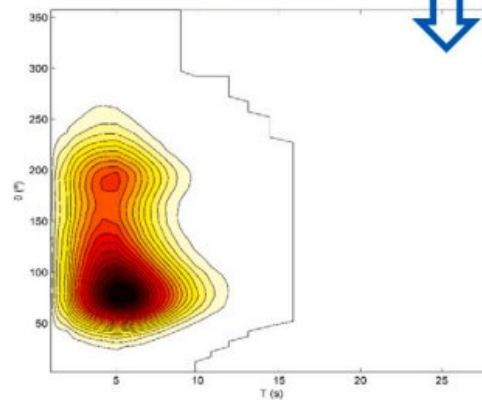
**1. Introduction**

Traditionally, the estimation of wave climate within harbours has been solved through the use of numerical tools calibrated, adapted and...

through the complete wave-agitation database reconstruction (i.e. from 30 to 60 years hourly wave database), based in the outer hindcast databases already available today (Cox and Swail, 2001; Gaires and Sterl, 2005; Reguero et al., 2012). This is considered crucial to de...



*Elliptic Mild-slope equations (linear model)*



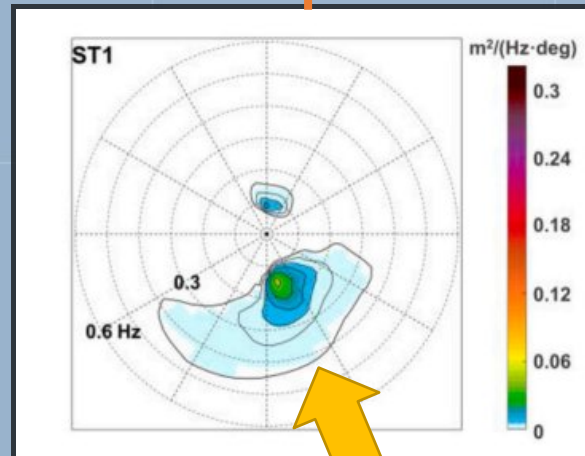
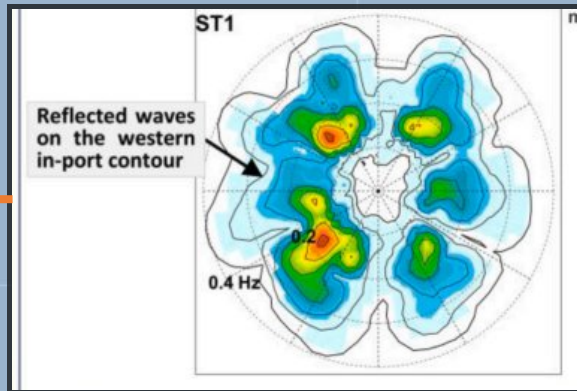
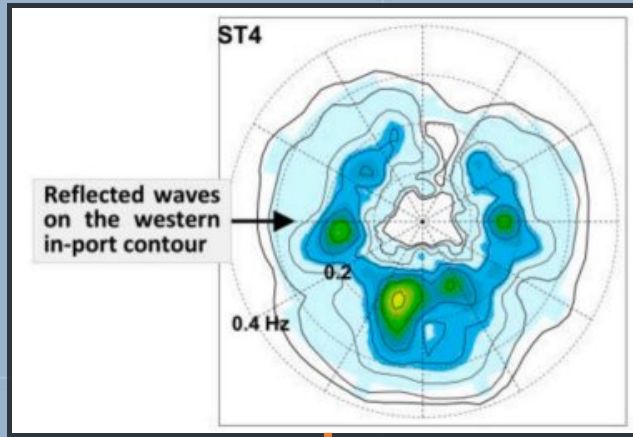
f) N spectra integration matrix (T vs.  $\Theta$ )

g) M regular waves

h) Linear sum

i) Hs agitation map

# Methodology – part B



Coastal Engineering 180 (2023) 104271

Contents lists available at ScienceDirect

Coastal Engineering

ELSEVIER journal homepage: [www.elsevier.com/locate/coastaleng](http://www.elsevier.com/locate/coastaleng)

Multimodal harbor wave climate characterization based on wave agitation spectral types

Eva Romano-Moreno, Gabriel Diaz-Hernandez, Antonio Tomás, Javier L. Lara

IHCantabria - Instituto de Hidráulica Ambiental de la Universidad de Cantabria, Santander, Spain

**ARTICLE INFO**

**ABSTRACT**

**Keywords:** Harbor wave climate, Harbor wave agitation, Multimodal waves, Directional wave spectra, Wave spectral types

A new numerical methodology reaching an improved characterization of the historical harbor wave agitation climate is presented in this work. A detailed frequency-direction wave spectrum definition of wave agitation patterns within harbor basins is achieved, providing an in-depth description of the whole multidirectional and multireflective wave patterns occurring as a natural harbor response. This constitutes an advance from the monoparametric/aggregated wave height parameter-based approaches, traditionally used for wave agitation characterization, to a multivariate and disaggregated representation of in-port waves and the multiple wave transformation processes within harbor basins. In addition, the wave agitation spectral type concept is proposed, whereby the wave agitation spectral shapes are classified into representative clusters of the historical wave agitation response in a harbor. A detailed multiannual analysis of the wave agitation response, based on the different in-port spectral wave components, their relation with the outer-harbor forcing waves, and their interactions with the harbor structures, can be achieved with the proposed methodology. This improved harbor wave climate characterization can be especially relevant for port operability and downtime analyses. The methodology is applied and validated in Africa basin (Las Palmas Port, Spain).

**1. Introduction**

A suitable characterization of harbor wave climate is the basis for variations that can occur at different in-port locations. These complex effects are translated into an equally complex definition of the wave energy distribution within the harbor basin. Because of this spatial, multicon-

Directional wave energy potential (Pw)

$$Pw = \rho g \int_0^{2\pi} \int_0^{\infty} c_g(\omega, z) S(\omega, \theta) d\omega d\theta$$

$$c_g = \frac{c}{2} \left( 1 + \frac{2kz}{\sinh(2kz)} \right)$$

# Numerical setup: computational domain & bathymetry

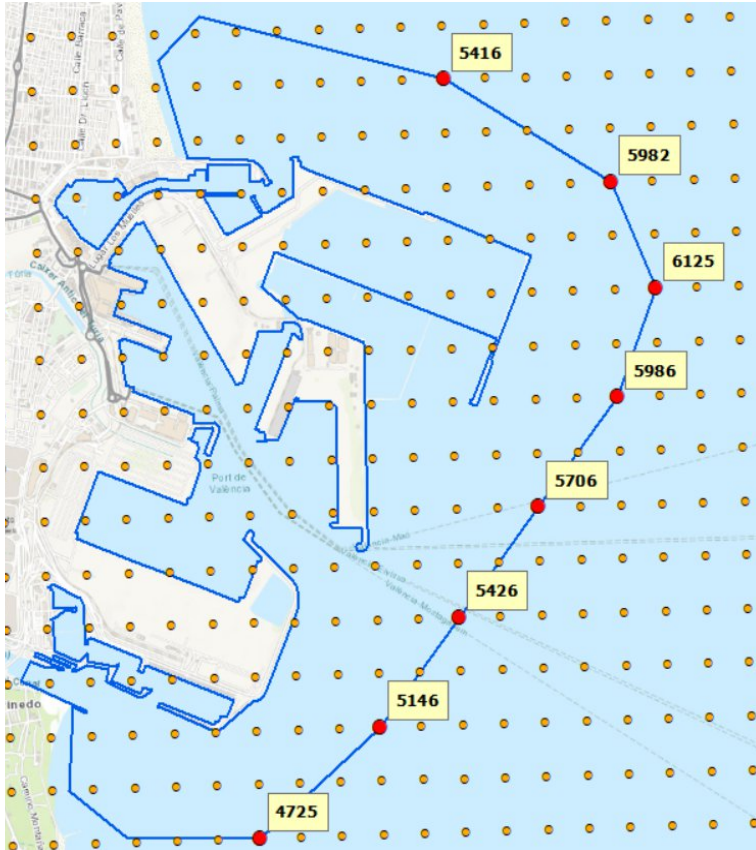
Valencia Port

Sea-levels  
Min NMT = -0.6 m  
Max NMT = 0.6 m

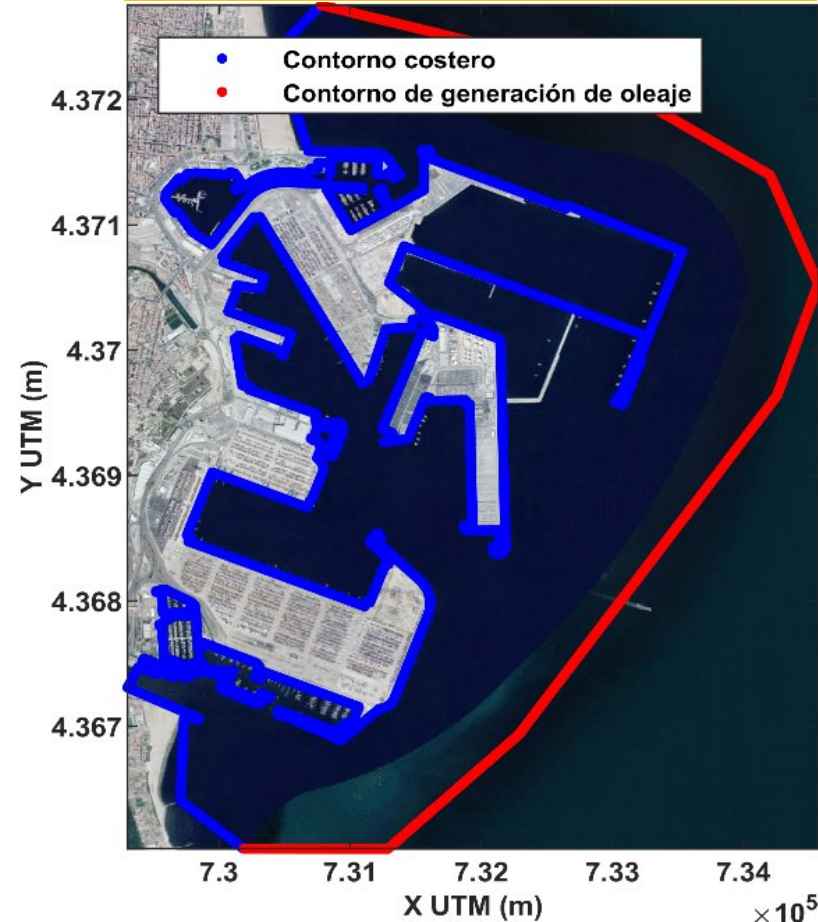
$T_{min}=2$  s  
15 nxL

nodes = 1,499,300  
elements = 3,985,638

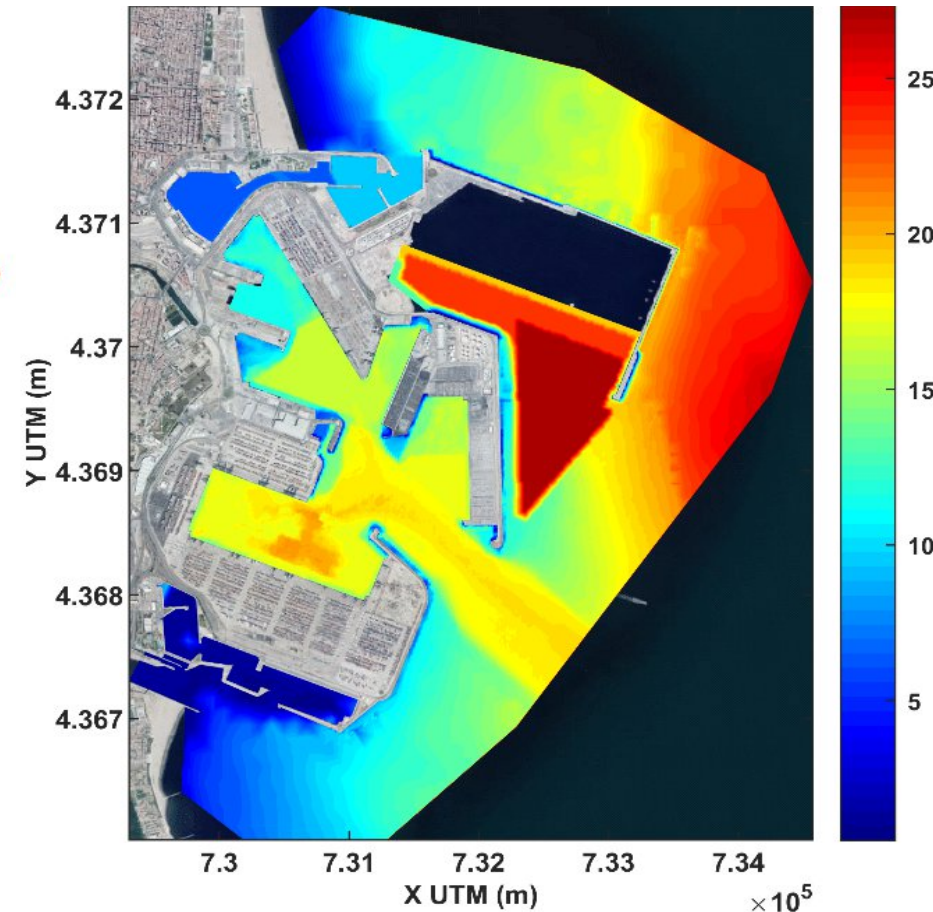
Outer forcing (SWAN model)



Numerical domain



FEM



698 Monocromatic runs

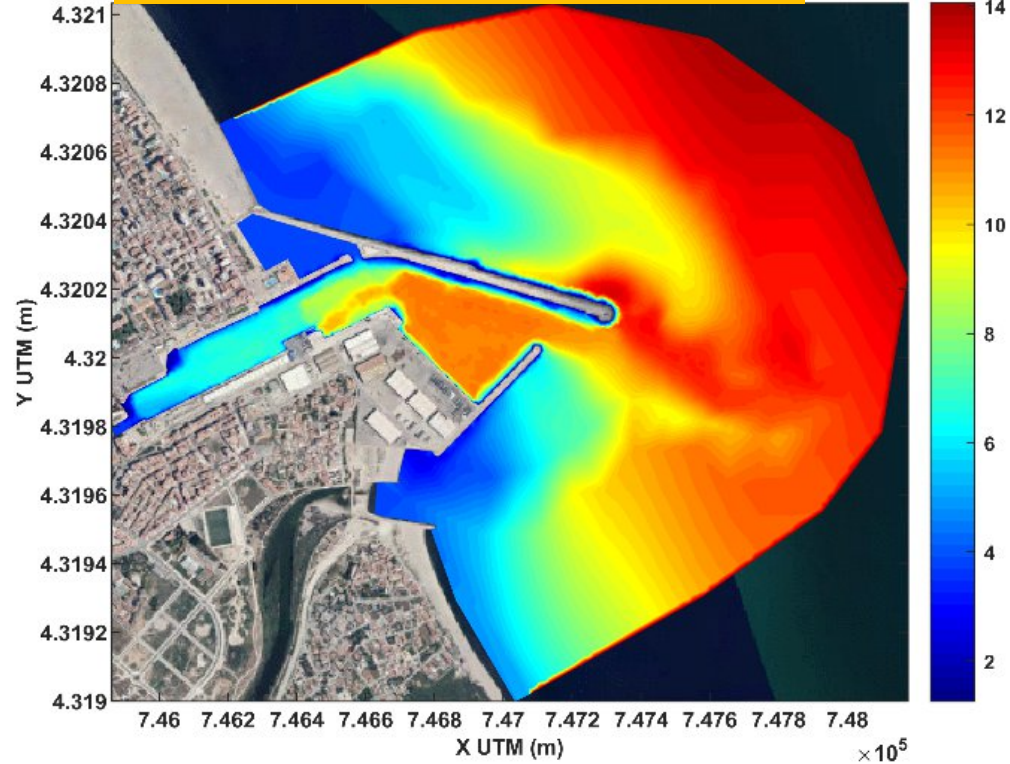
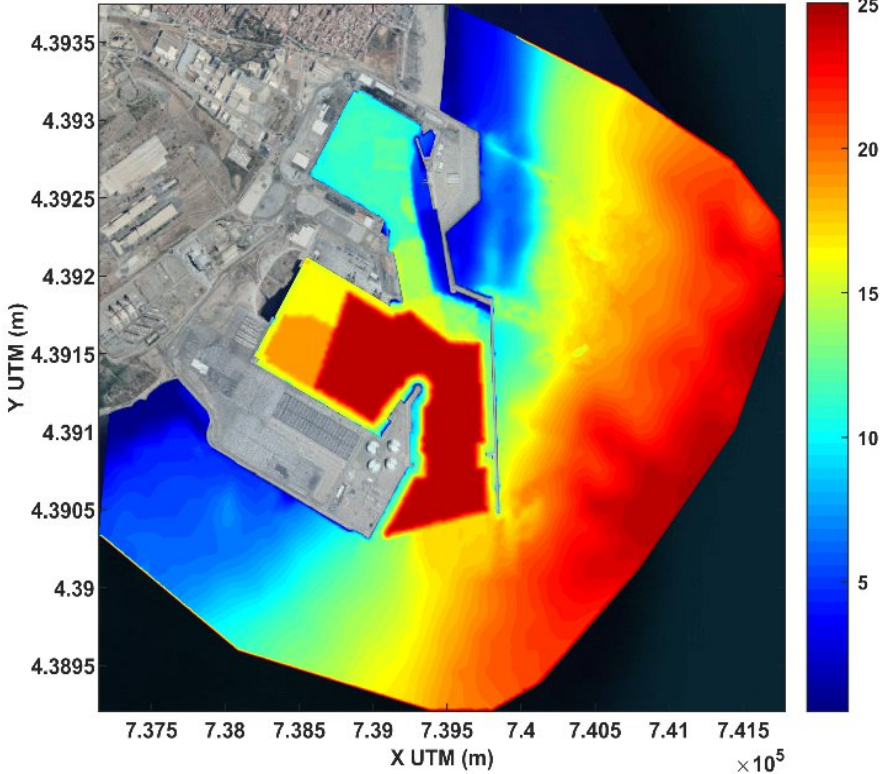
# Numerical setup: computational domain & bathymetry

Sagunto Port

Gandía Port

FEM

FEM



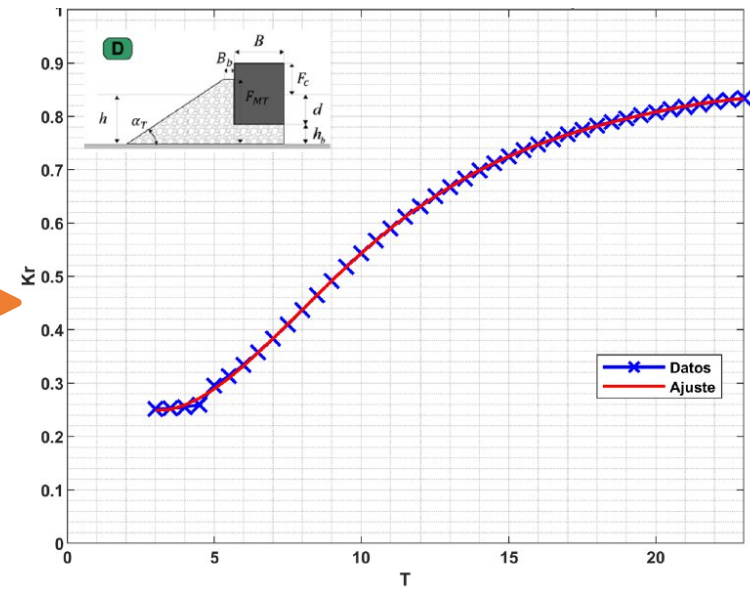
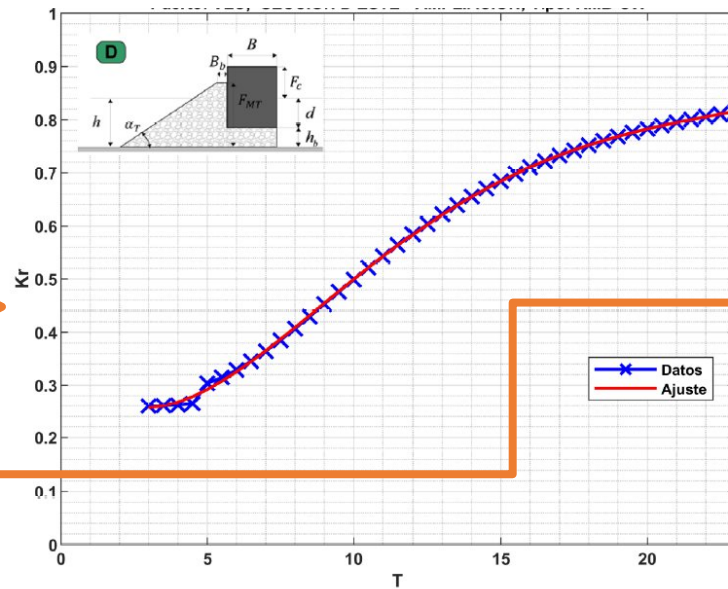
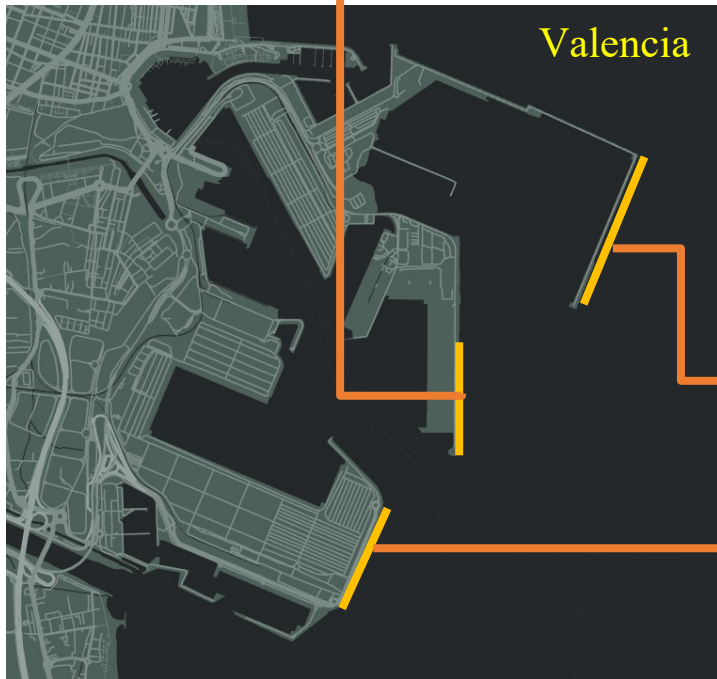
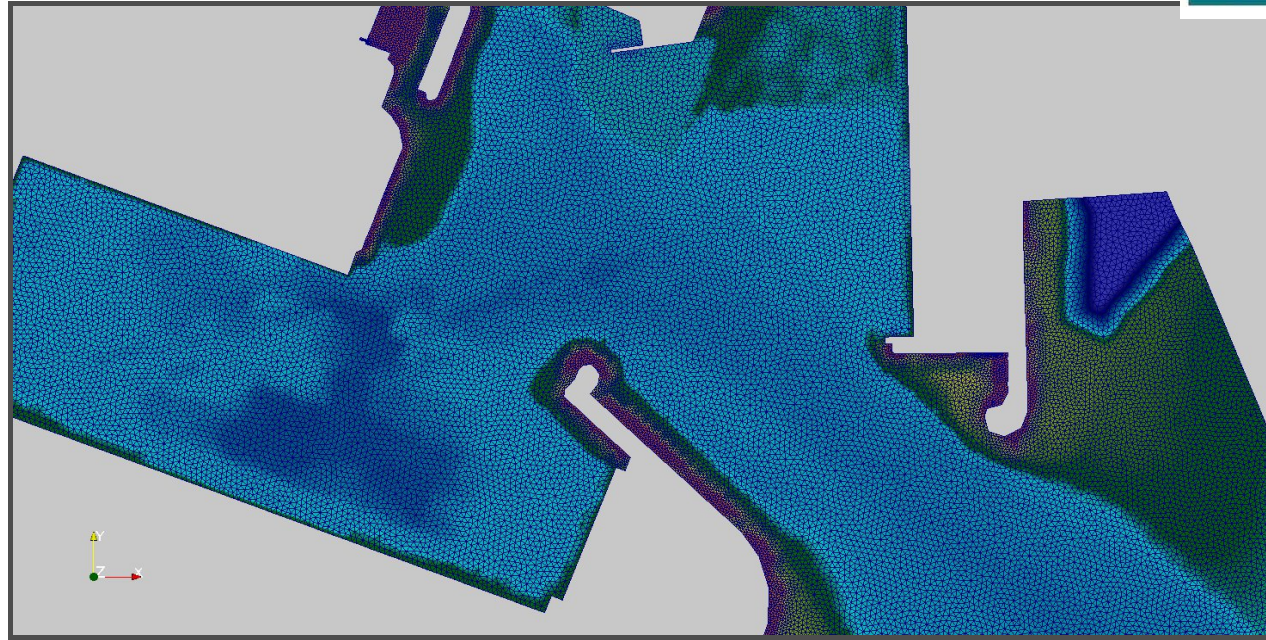
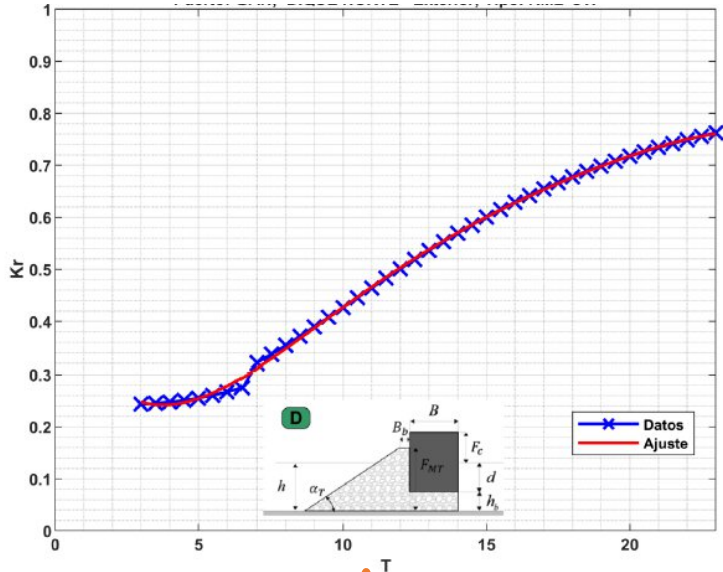
884 monocromatic  
runs

nodes= 593.756  
elements= 1.181.080

754 monocromatic  
runs

nodes= 605.218  
elements= 1.204.184

# Numerical setup: computational domain & bathymetry



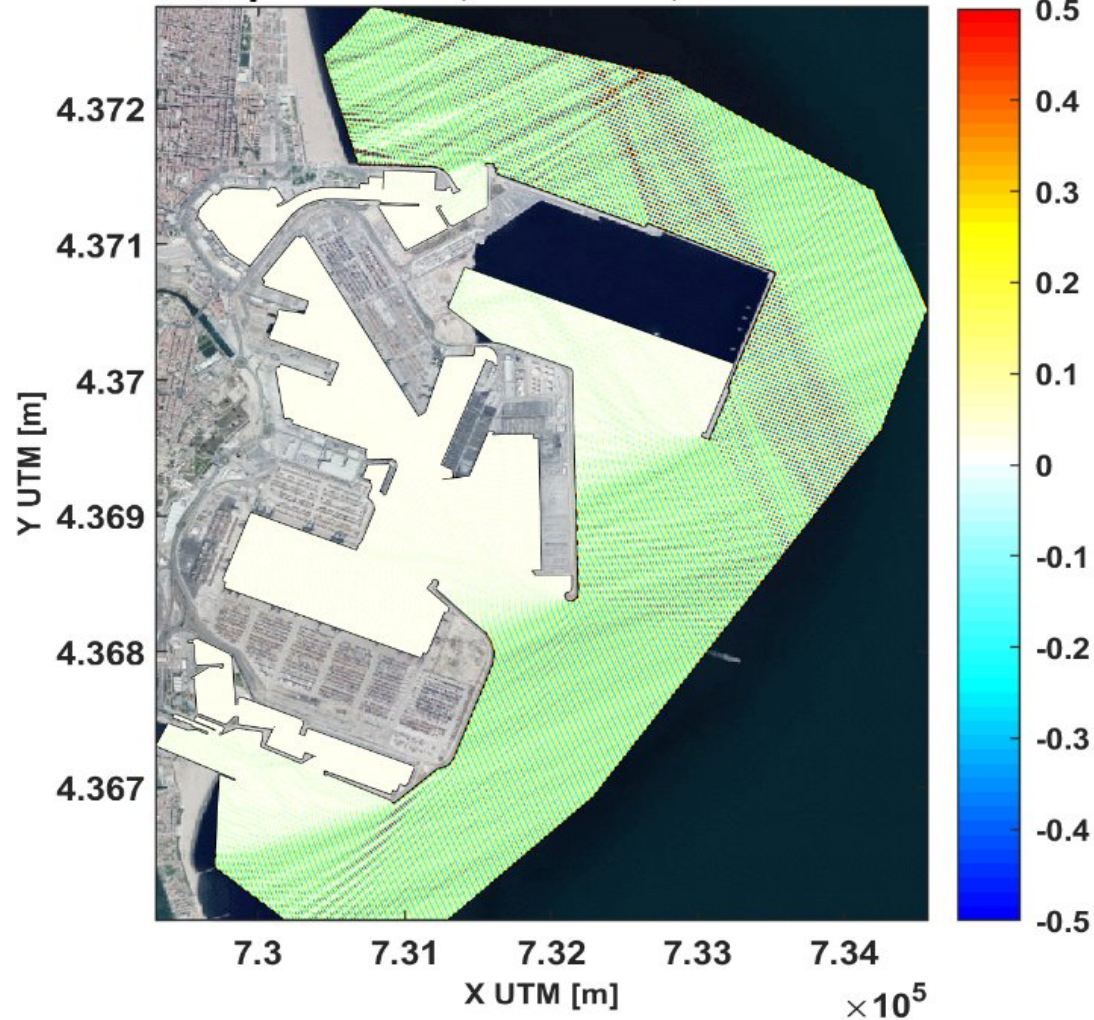


# Results – monocromatic catalogue (wave reflections)

## Valencia Port

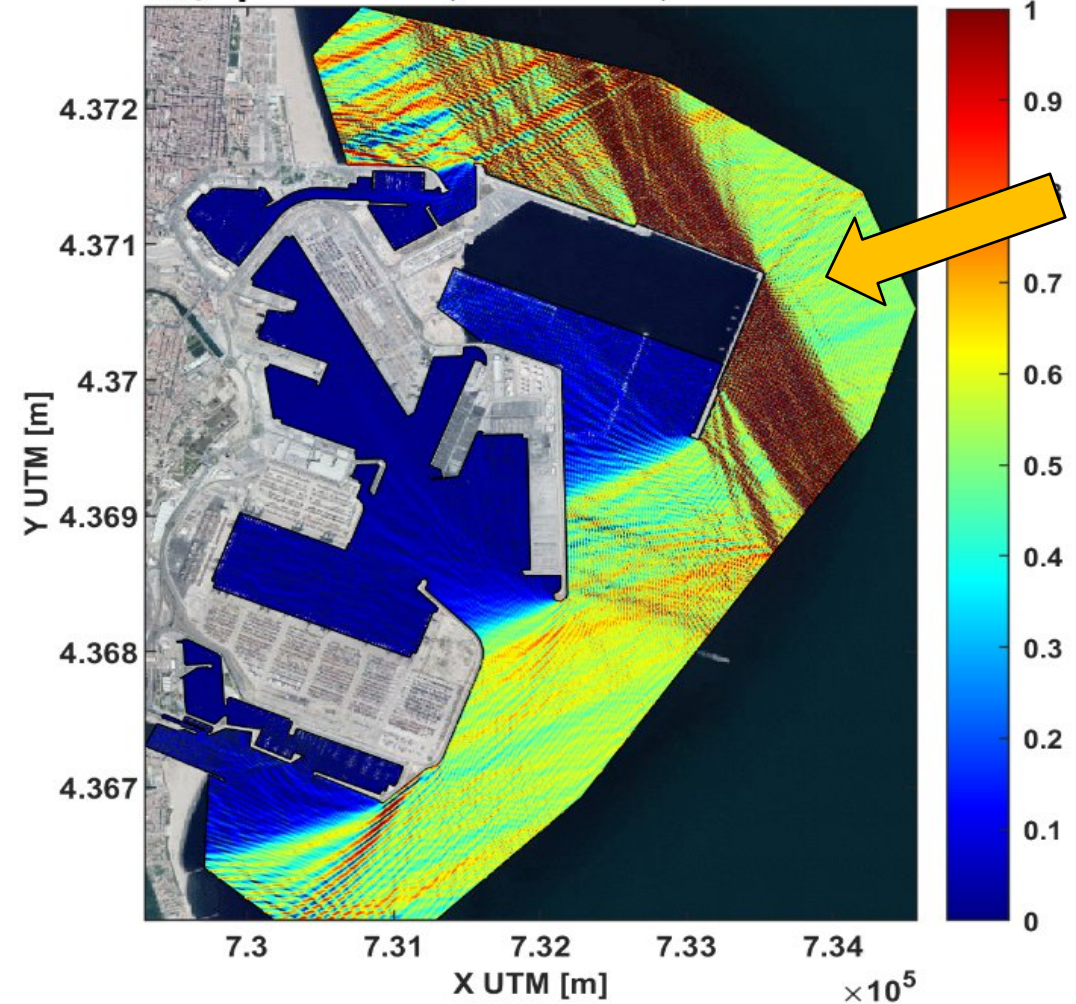
### Mapa de superficie libre VLC

$A_{wp} = 0.25 \text{ m}; T = 5.0 \text{ s}; \text{Dir} = 70.0^\circ$



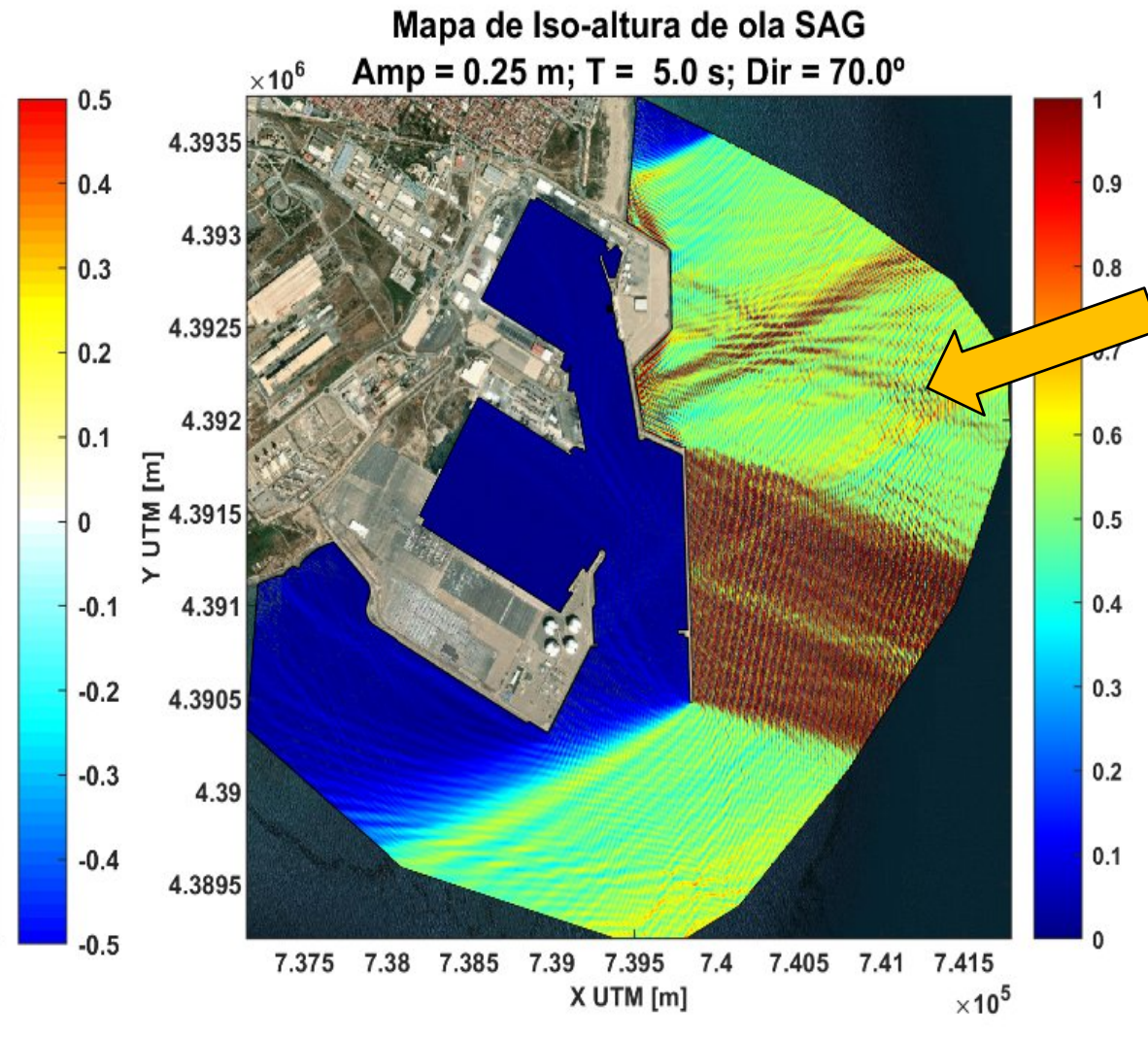
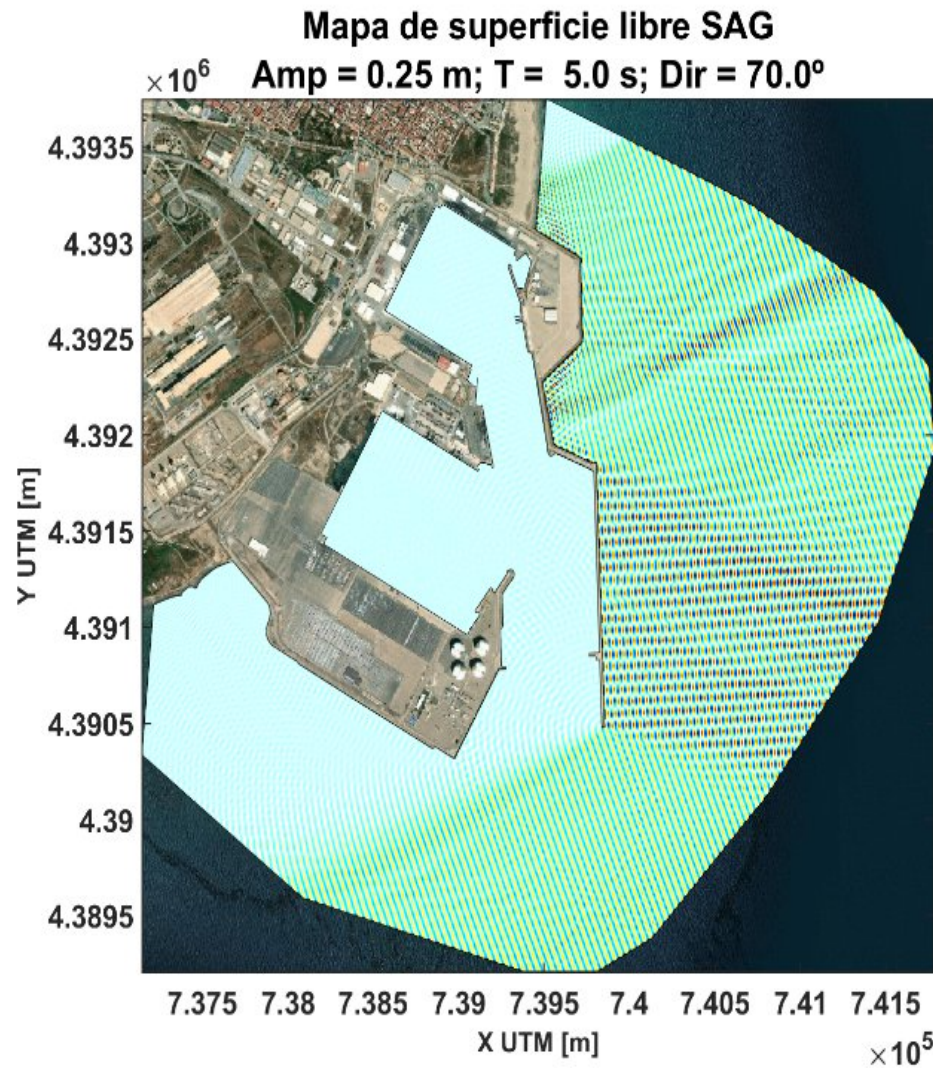
### Mapa de Iso-altura de ola VLC

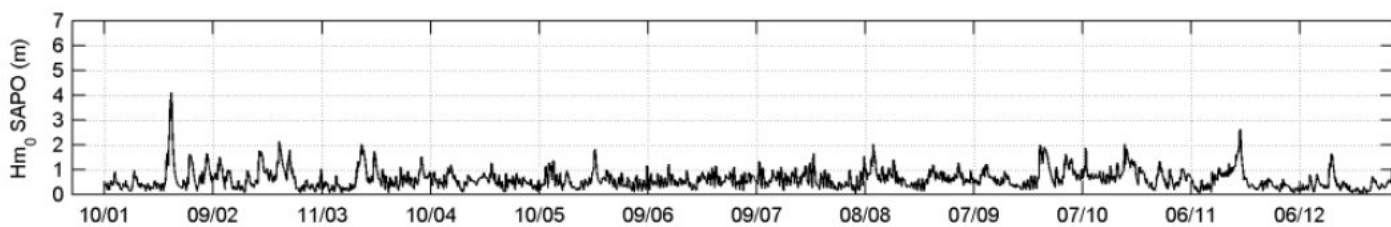
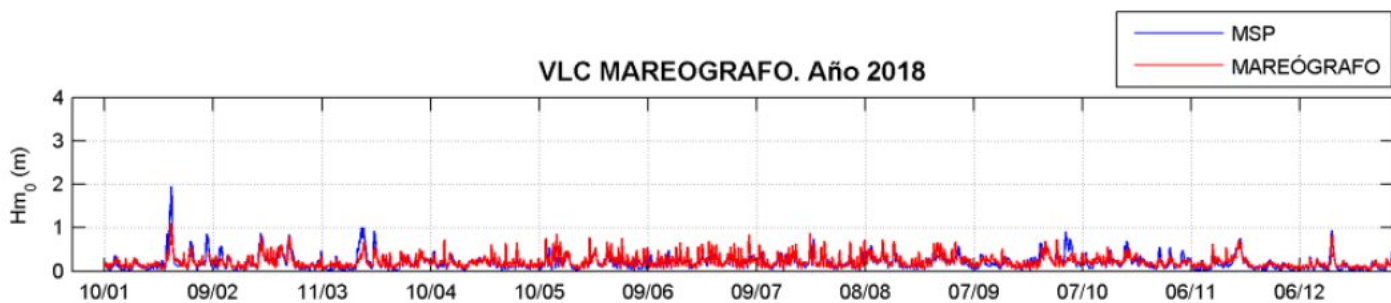
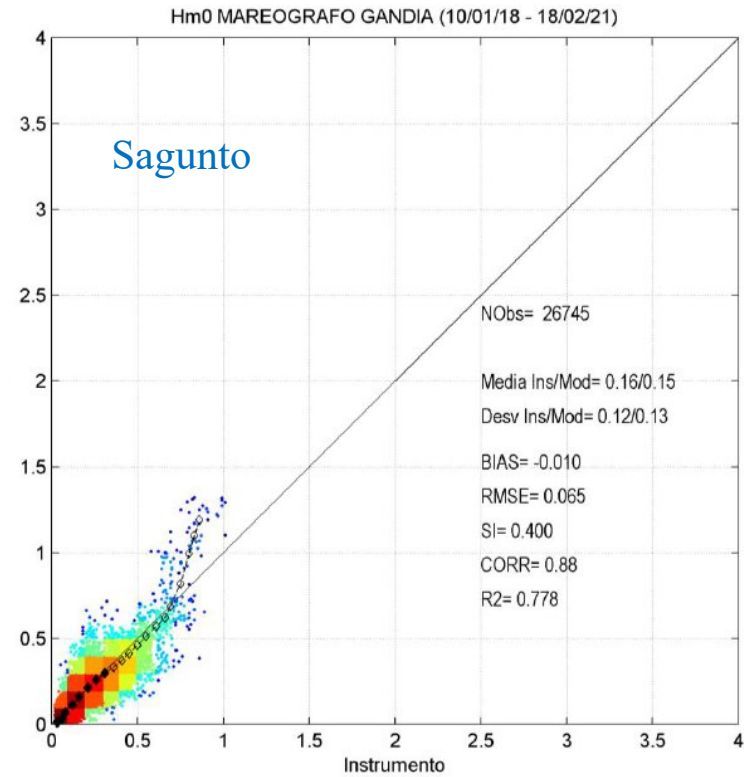
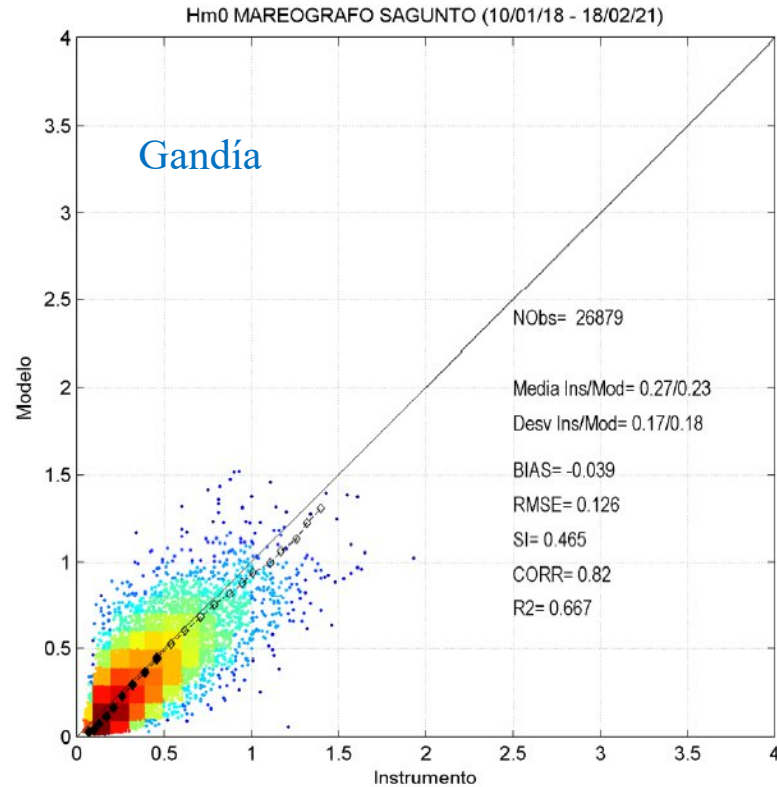
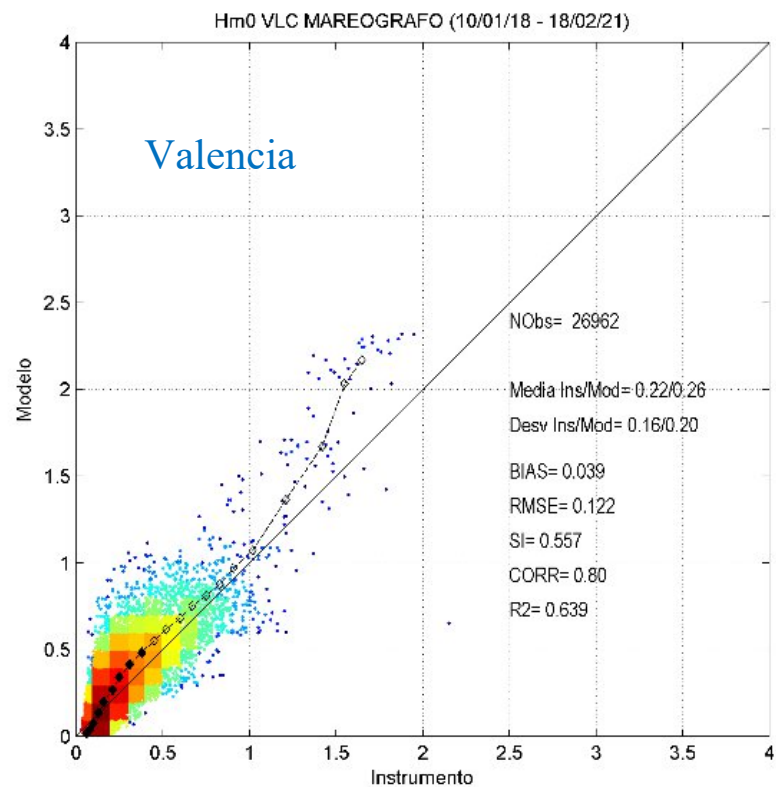
$A_{wp} = 0.25 \text{ m}; T = 5.0 \text{ s}; \text{Dir} = 70.0^\circ$



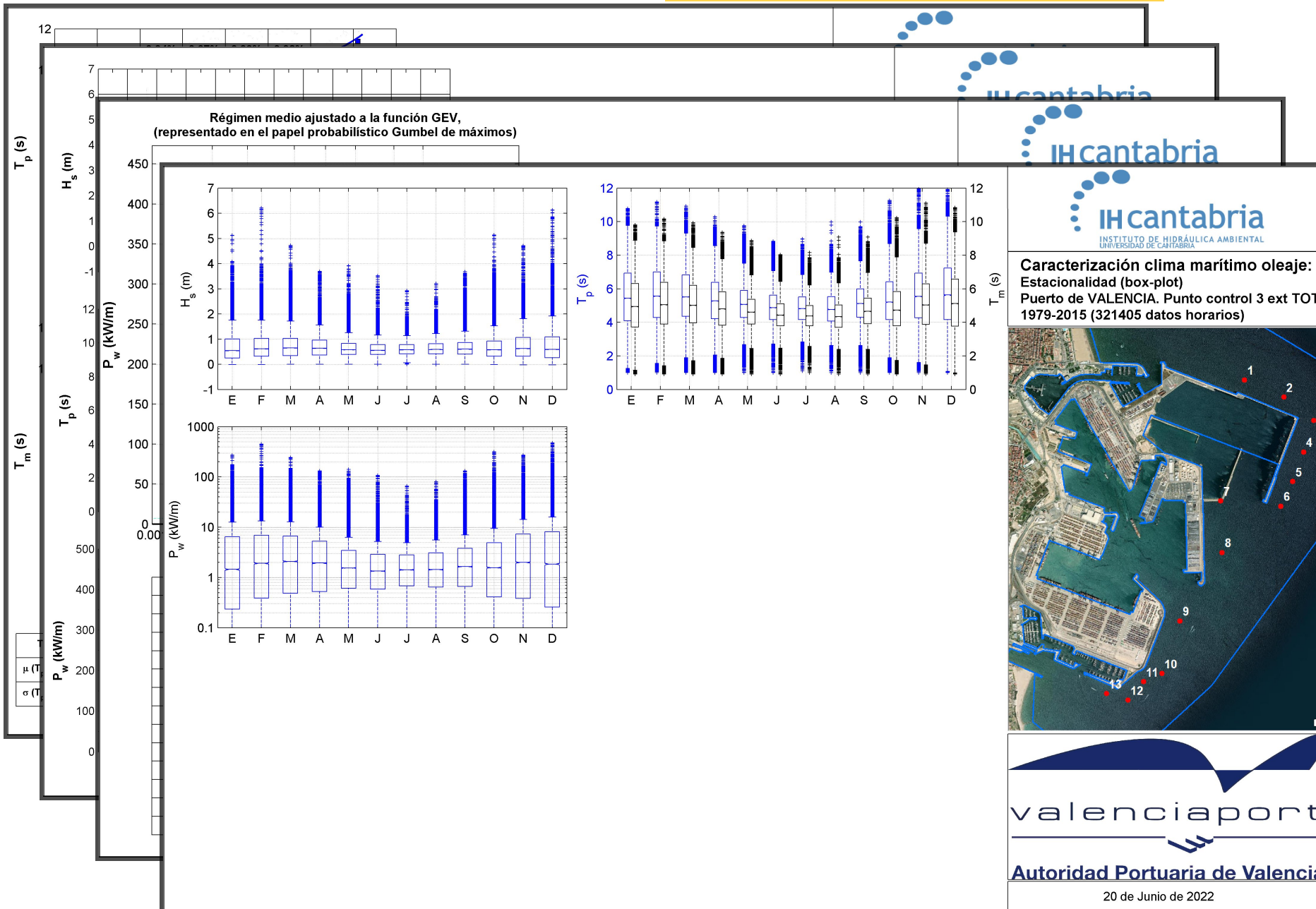
# Results – monocromatic catalogue (wave reflections)

## Sagunto Port



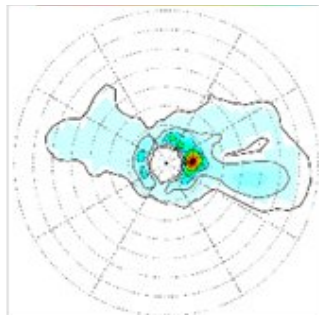


# Validation

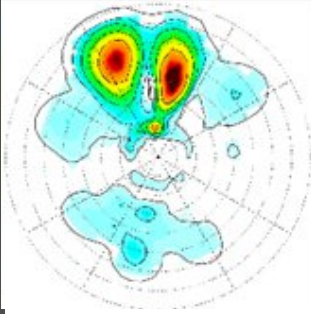




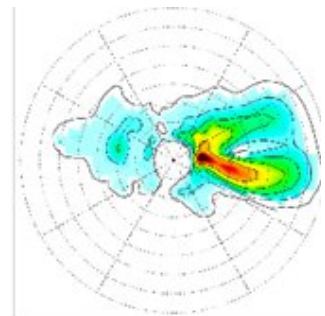
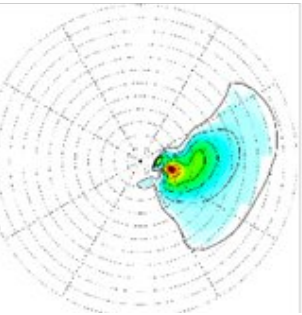
*\*construction*



Take advantage of infrastructure induced wave-reflections.



Use in the design (hindcast) and management (forecast) of wave energy generation systems



# Climate (forecast) products

3-day and hourly predictions of Wave & Energy data





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*Thank You*

