RISK ASSESSMENT OF COASTAL FLOOD

Applied to Boca Barranco beach, island of Gran Canaria, Spain

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Tutors

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2012/2014

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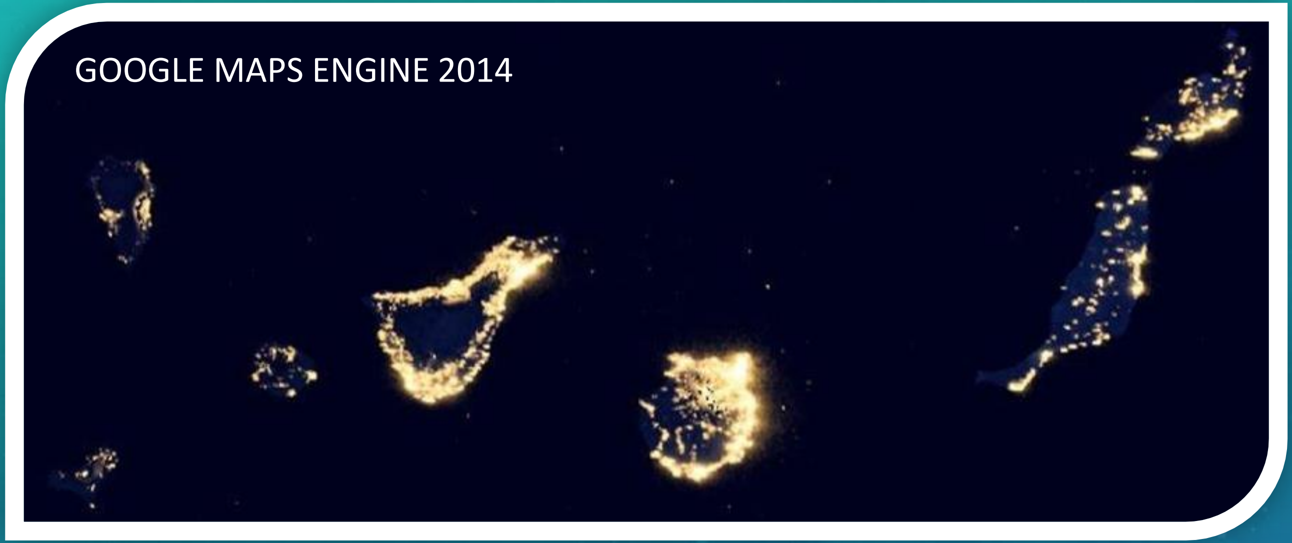
1.INTRODUCTION



Humans have preferentially established their settlements on the coast. This has undergone a dramatic acceleration in a few decades.

It is obvious that

Establishing settlements in coastal areas provides greater ease of access to many natural resources and opportunities for socio-economic improvement.

It is estimated that

¼ of the world's population lives within 100 km away from the sea and in areas of lower elevation to 100 meters.

This results in

Greater exposure of people and property to various natural hazards related to the dynamic behavior of the sea.

COASTAL FLOODING...... What is it?

Can be defined as the temporary occupation by water areas that are usually free.(NOAA,2011)

In this context

The present study aims to evaluate the level of risk associated with coastal flooding on beaches as well as coastal structures existing in Boca Barranco Beach.

HOW?

2.METHODOLOGY

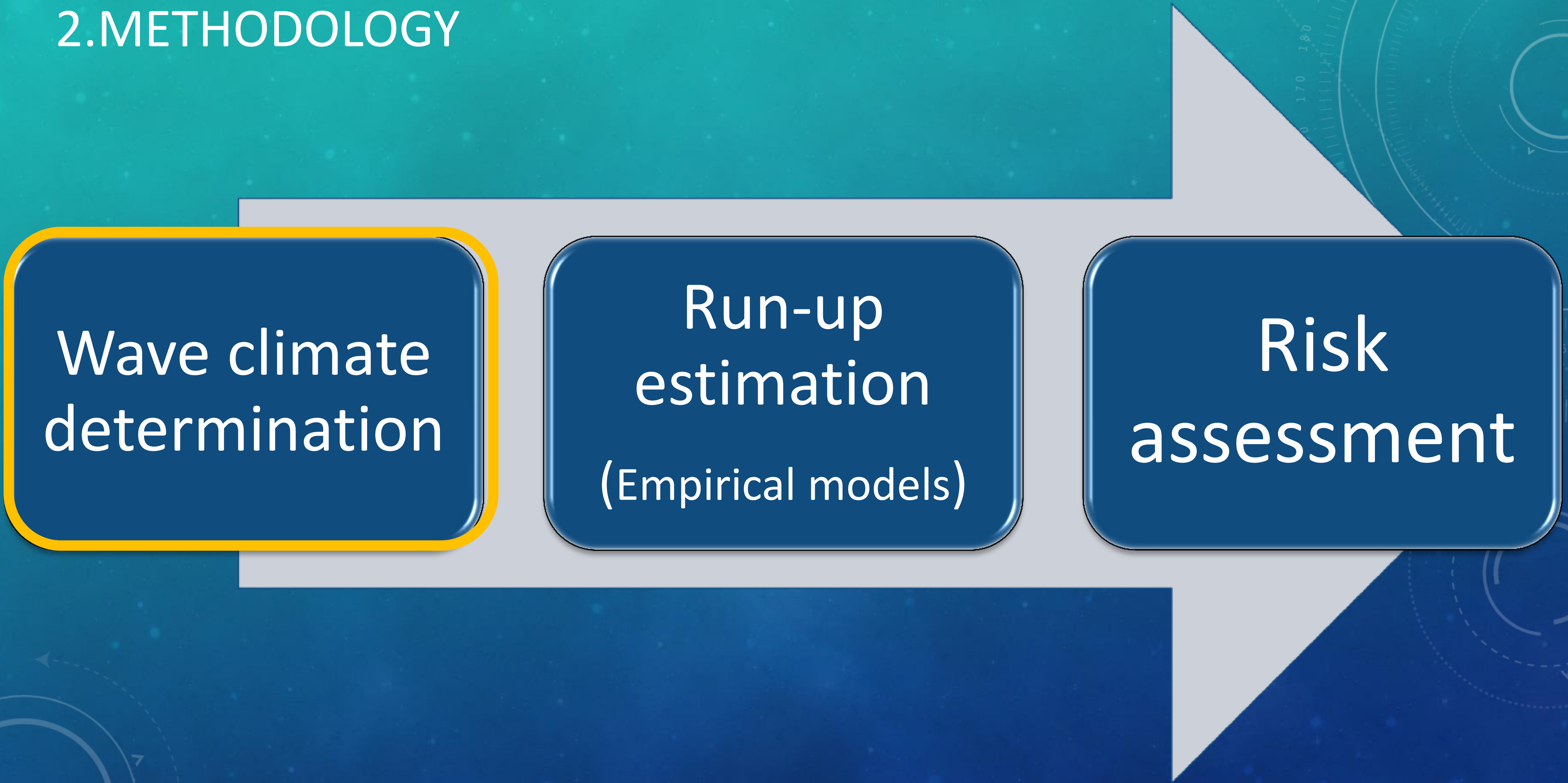
LNEC - National Laboratory of Civil Engineering
DHA - Department of Hydraulics and Environments
Lisbon, Portugal

This work is linked to **HIDRALERTA Project**
Prediction System and Alert Floods in Coastal and Port.

(Neves et al., 2010, Santos et al., 2011, Silva et al., 2011, Reis et al., 2011, Neves et al., 2012 Rocha et al., 2013; Poseiro et al., 2013).

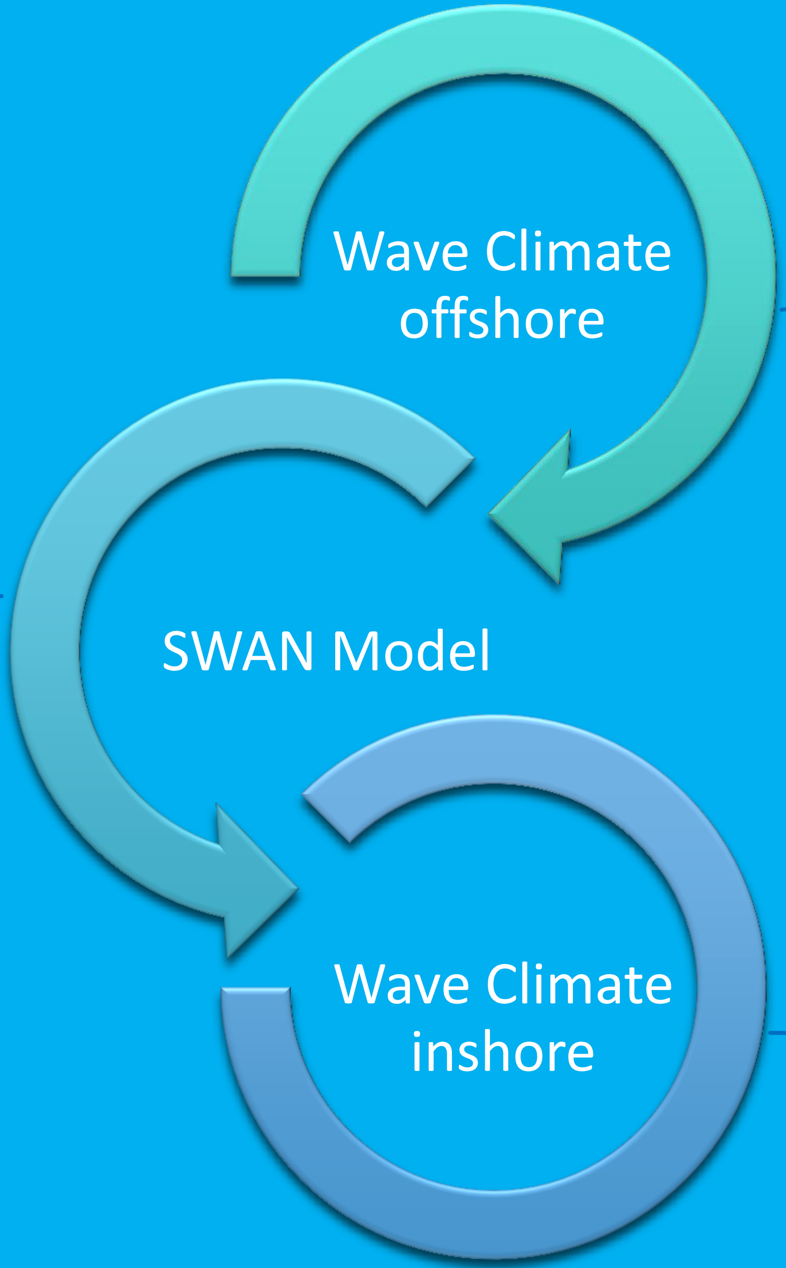
LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL

2.METHODOLOGY



Wave climate determination

Spectral model of wave climate propagation (Booij et al. 1999)



HINDCAST DATA
(22 YEARS)

Hs - significant height
Tp – peak period
Dm – mean direction

- Hs_p
- Tp_p
- Dm_p

Wave climate determination

Run-up estimation

(Empirical models)

Risk assessment

The main objective of the application of the models is to estimate :

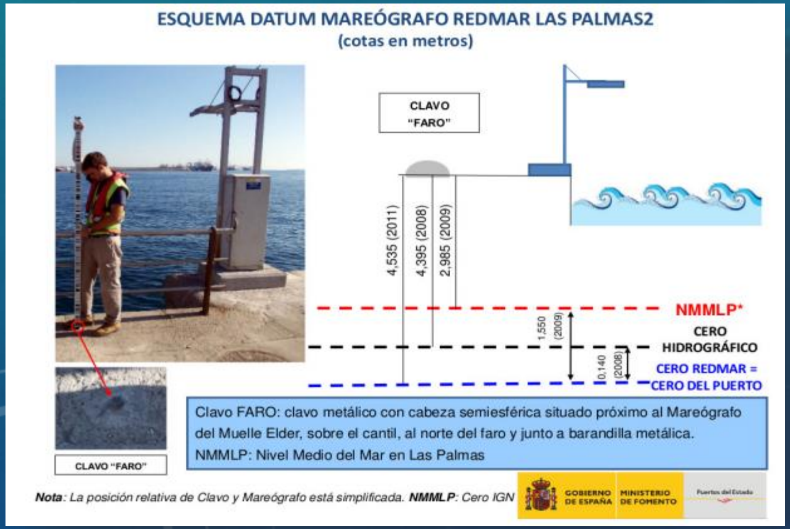
Flood level (referred to the hydrographic zero)

FL = AT + SS + Rmax

Astronomical Tides + Storm Surge + Run-up

Tide-gauge "Puertos del Estado"

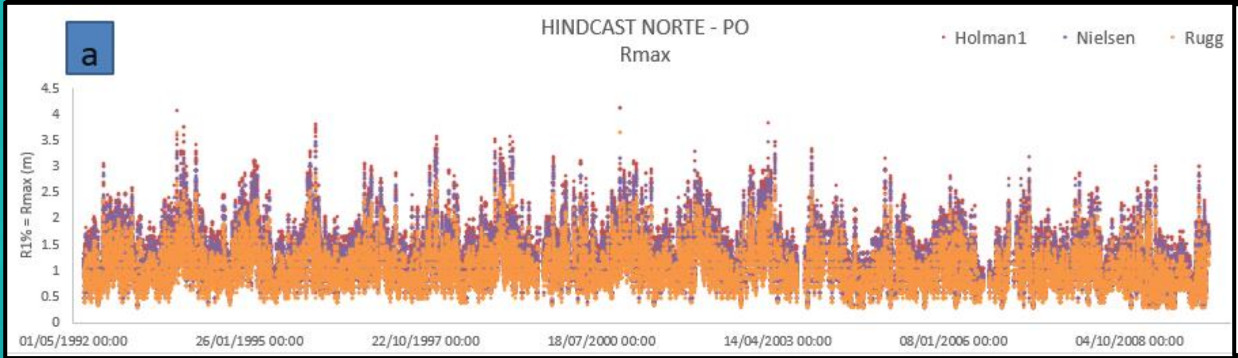
Results of models

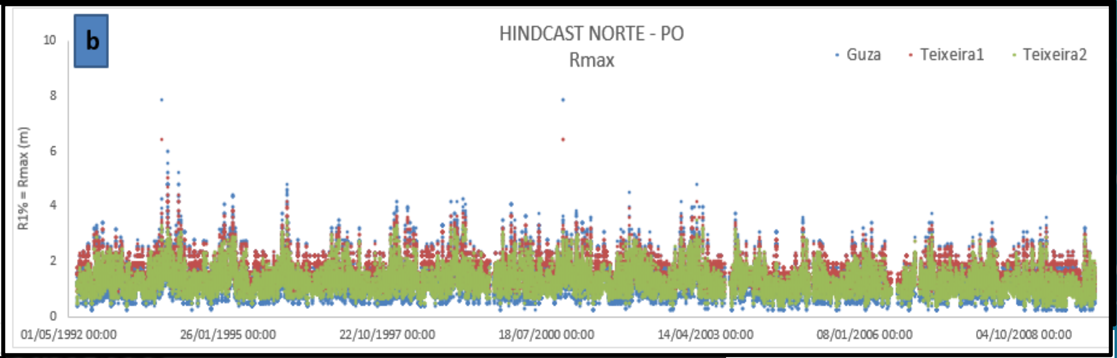


what does that mean?

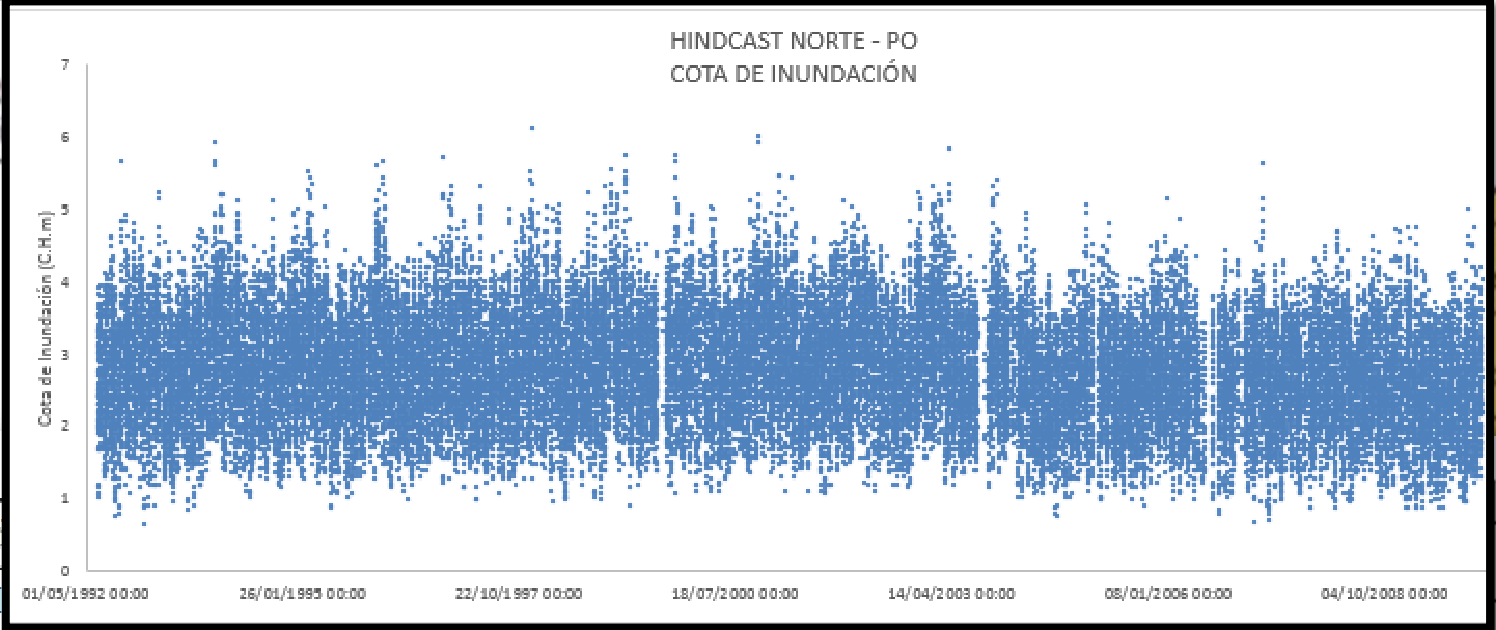
EMPIRICAL MODELS RUN-UP

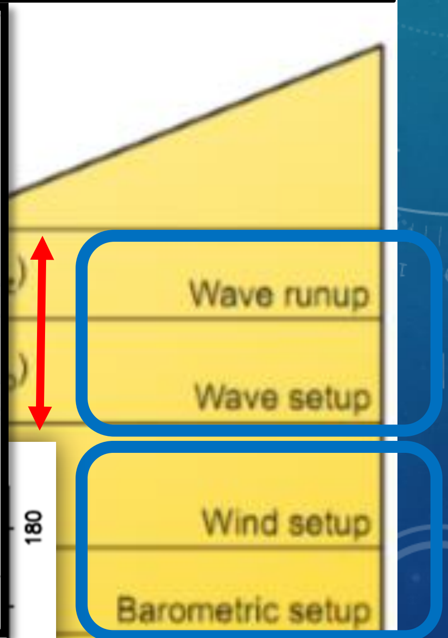
Hunt (1959)	$R = H\xi = H\left(\frac{\tan\beta}{\sqrt{\frac{H_0}{L_0}}}\right)$
Guza & Thornton (1982)	$R_S = 0.71H_S + 0.035$
Holman (1986)	$\xi_{storm} = 6.3\beta$ $R_{2\%} = (5.2\beta + 0.20)H_S$
Nielsen & Hanslow (1991)	$R_{2\%} = 1.98 * L_{RU}$ $L_{RU} = 0.6 * \tan\beta * (H_{orms} L_0)^{0.5}$ para $\tan\beta \geq 0.10$ $L_{RU} = 0.05 * (H_{orms} * L_0)^{0.5}$ para $\tan\beta \leq 0.10$
Ruggiero *et al.* (2001)	$R_{2\%} = 0.27(\tan\beta\ H_0 L_0)^{1/2}$
Stockdon *et al.* (2006)	$R_{2\%} = 0.043 * (H_0 L_0)^{0.5}$ para $\xi_0 < 0.3$
Teixeira (2009)	$R_{máx.} = 0.80 * H_s + 0.62$ $R_{máx.} = 1.08 * H_s * \xi_0$



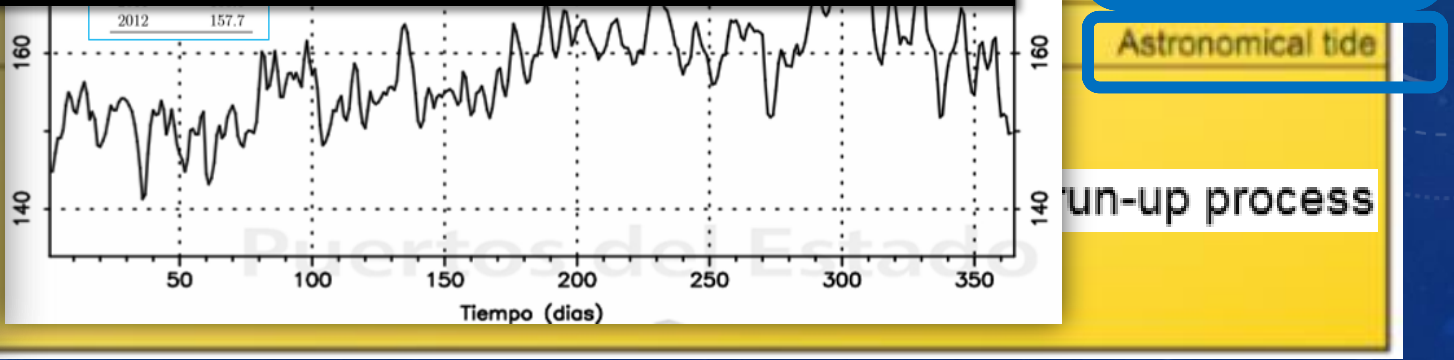


Waves increase in height
towards breaker zone (shoal

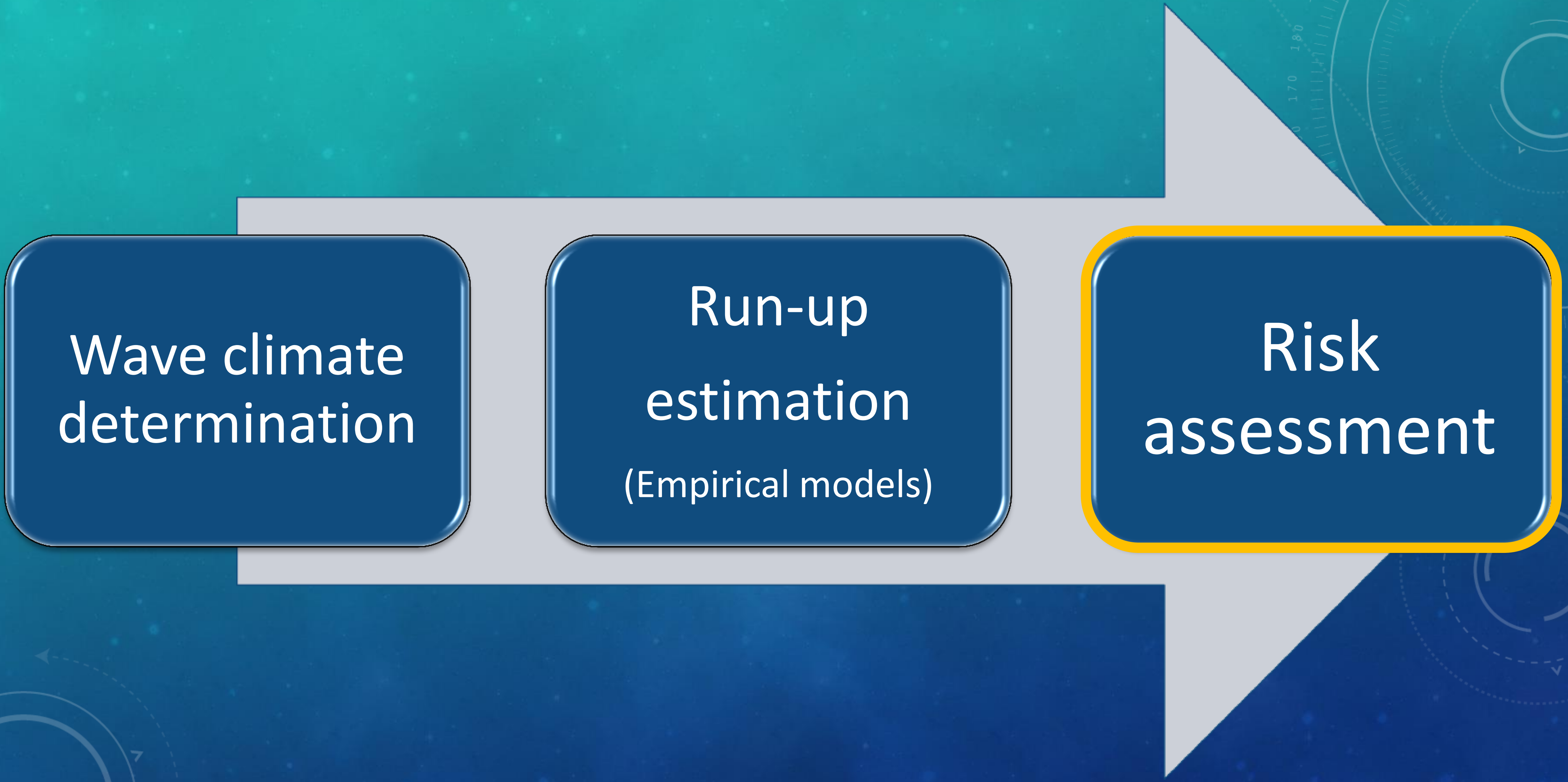




	Observac							
	Máx	Mín	M					
Pleamar	319	169	239	27	311	172	238	26
Bajamar	146	0	76	26	140	13	78	25
Pleamar viva	319	244	278	16	311	246	276	15
Bajamar viva	112	0	43	18	73	13	44	14
Pleamar muerta	258	169	199	12	223	172	198	11
Bajamar muerta	146	82	116	12	140	94	116	10



Shand et al 2011


Wave climate determination
Run-up estimation
(Empirical models)
Risk assessment

Risk Assessmet

Description	Consequence (Indicative script)	Degree
INSIGNIFICANT	Stable geological, natural sand beach, busy casual leisure premises and reduced ecological value.	1
CONSIDERABLE	Weak geological features, or possessing any shrub vegetation, areas of frequent leisure type.	2
VERY SERIOUS	Coastal protection infrastructure; relevant economic activities; very weak and unstable geological vegetation.	5
SEVERE	Permanent human occupation (urban areas); natural elements of great ecological value that are difficult to recover.	10
CATASTROPHIC	Permanent human occupation; absolutely unique areas with a great historical / natural value where the loss is irretrievable; beach-dune system.	25

Raposeiro & Ferreira, 2011

3.STUDY AREA


Boca Barranco Beach
Length – 422m
242m
159m
262m
Coastal Estructures
Image © 2014 GRAFCAN
Image © 2014 DigitalGlobe
120 m
Google earth


UTM coodinates
461090.00 X - 3100840.99 Y
Boca Barranco Beach


31/12/2000
Image © 2014 GRAFCAN
Google earth
2000

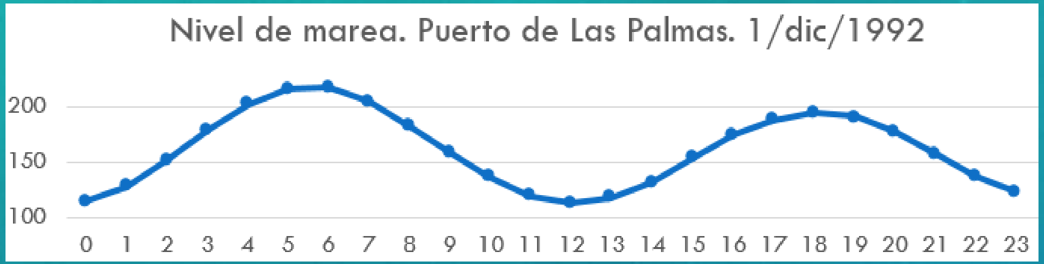

31/12/2004
Image © 2014 GRAFCAN
Google earth
2004

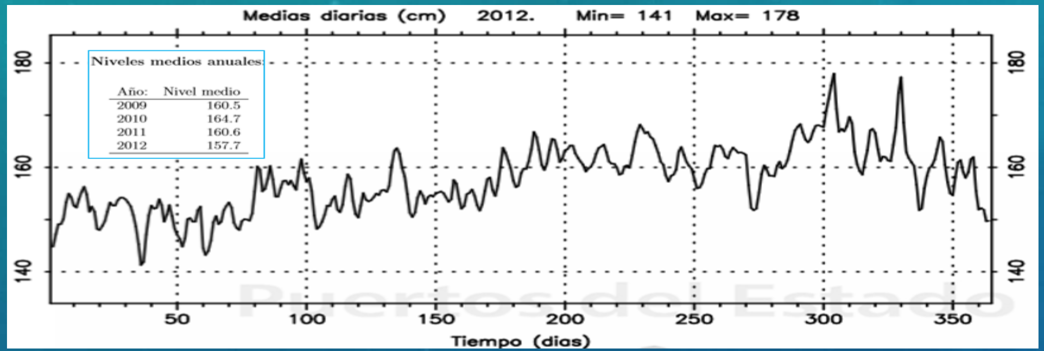

15/5/2012
Image © 2014 DigitalGlobe
Google earth
2013

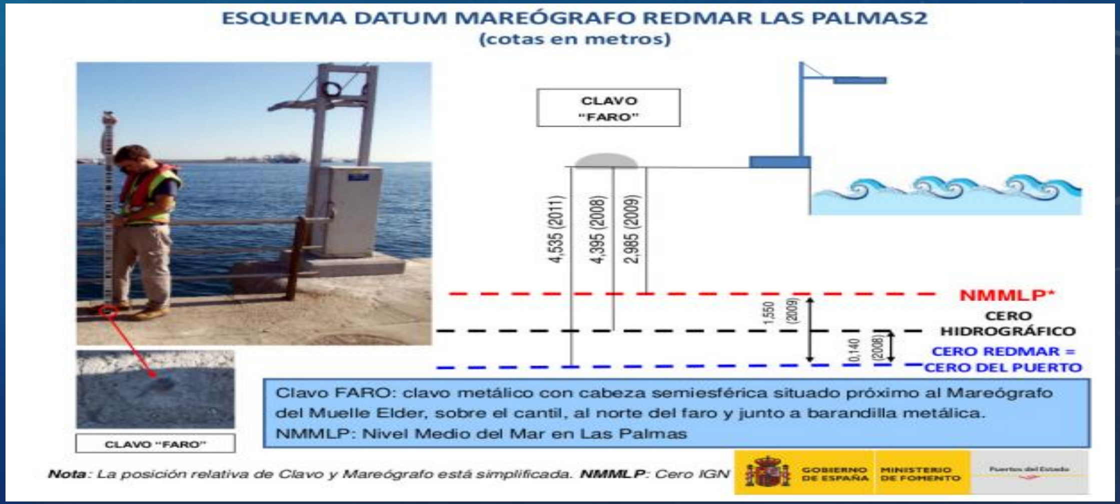

Actualidad

3.1 Data

Tide records



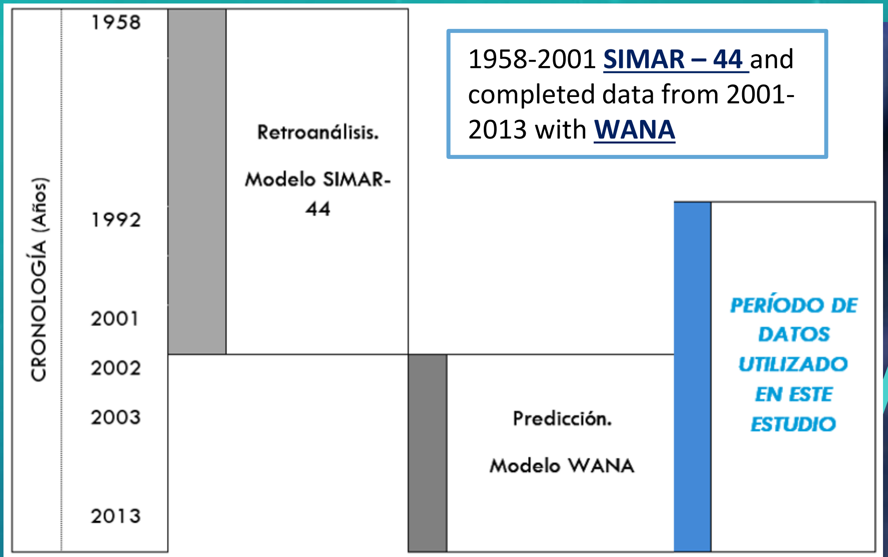


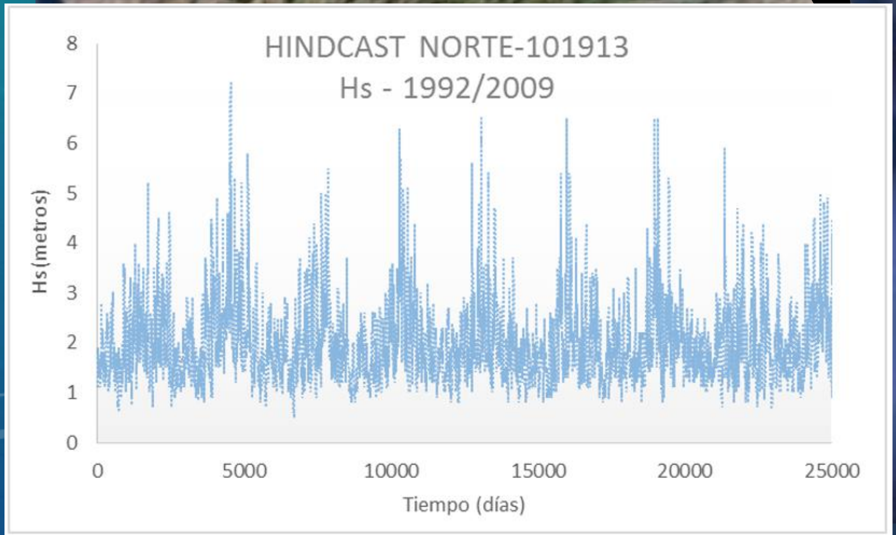


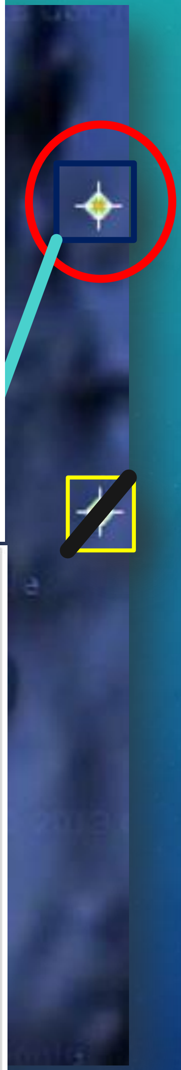
The values are relative to zero the gauge, which does not match the hydrographic zero. *<u>All the values supplied by the State Ports were applied a correction -0.14 m. to refer them to the hydrographic zero</u>*, as indicated in the protocols and data files in the gauge.

Wave Records

1958-2001 **SIMAR – 44** and completed data from 2001-2013 with **WANA**





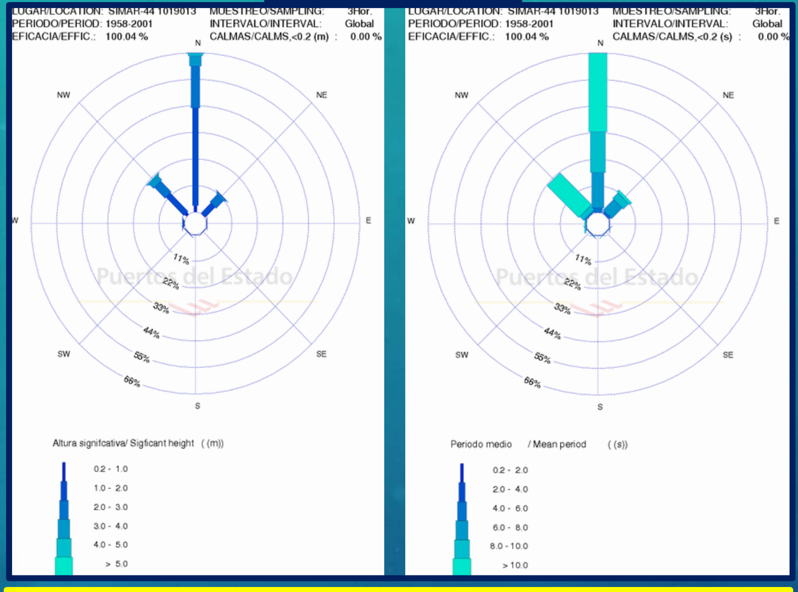


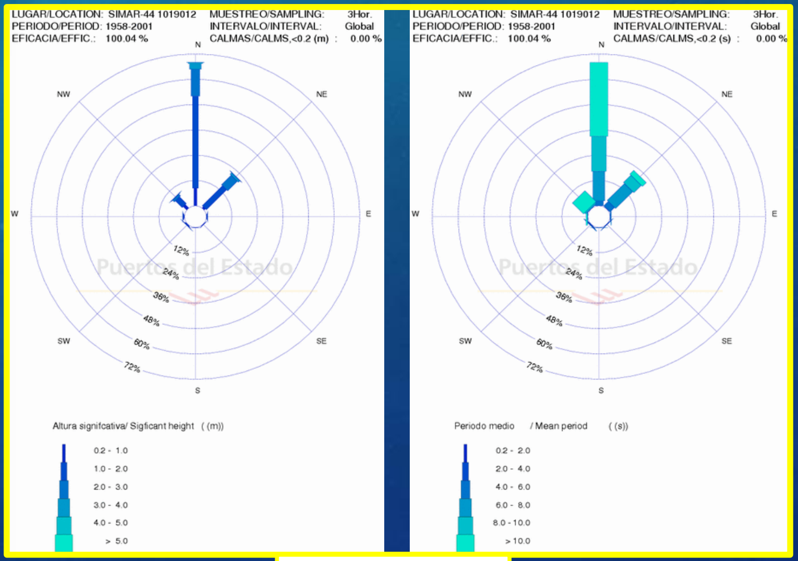
Hs
Significant height

Climatology Analysis

Tp
Peak period

HINDCAST NORTE





HINDCAST SUR

Información Histórica

- Punto SIMAR-44 (1019013)
- Punto WANA (1019013)

Punto WANA - 1019013

Longitud:	15.25° W
Latitud:	28.25° N
Cadencia:	1 Hor
Inicio de medidas:	22-10-1995
Fin de medidas:	05-05-2014
Tipo de sensor:	Dato de modelo
Modelo:	Analisis
Comentarios:	Anterior a 15/12/2011 datos cada tres horas
Conjunto de Datos:	WANA

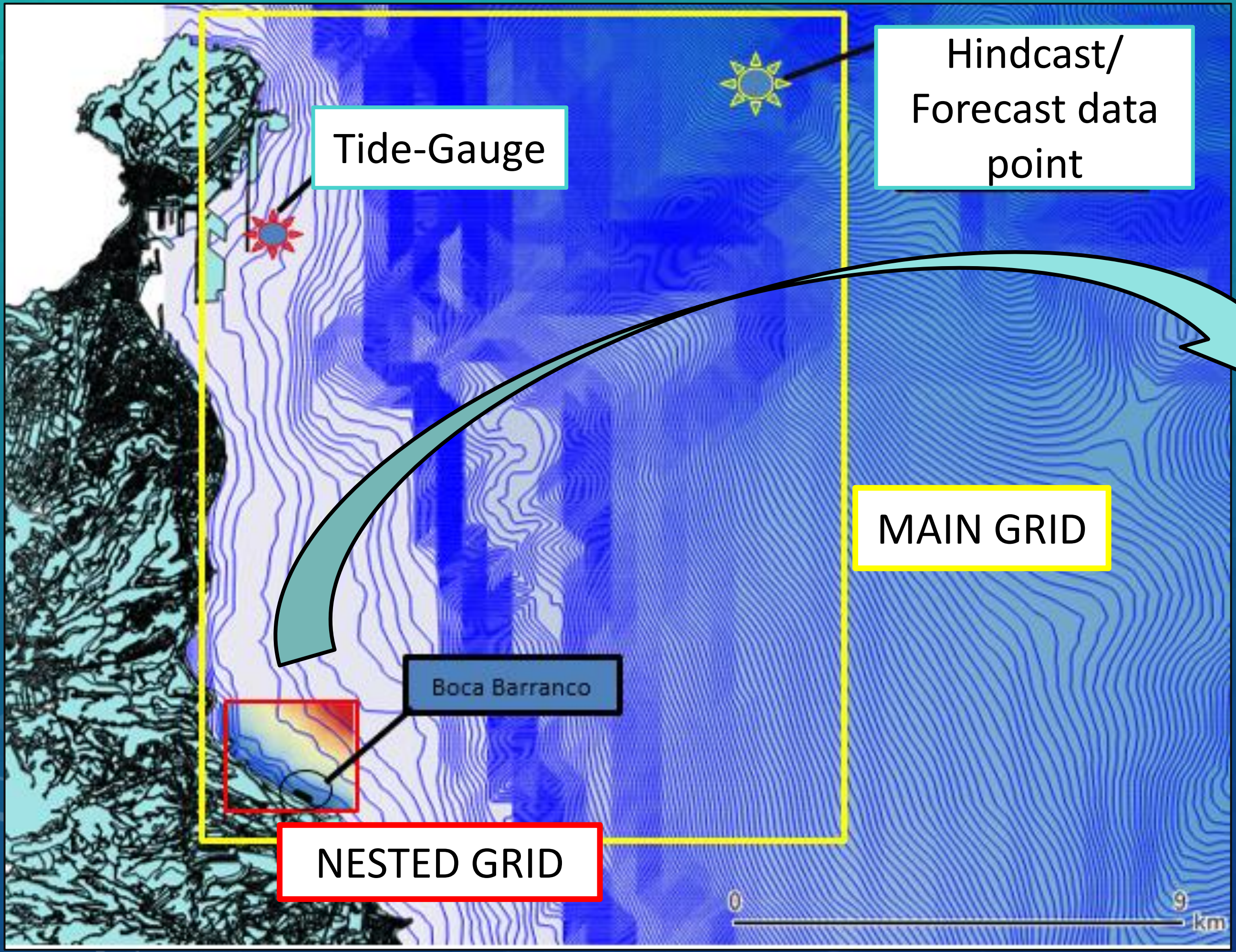
Punto SIMAR-44 - 1019013

Longitud:	15.25° W
Latitud:	28.25° N
Cadencia:	3 Hor
Inicio de medidas:	01-01-1958
Fin de medidas:	31-12-2001
Tipo de sensor:	Dato modelado
Modelo:	Hindcast
Conjunto de Datos:	SIMAR-44

GOBIERNO DE ESPAÑA MINISTERIO DE FOMENTO Puertos del Estado

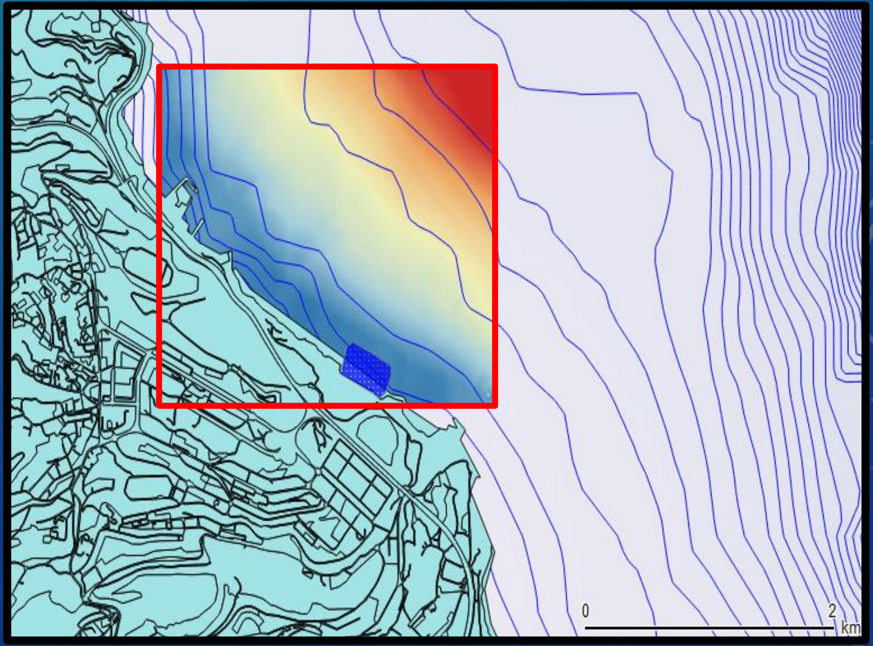
Bathymetry

The bathymetry which includes the location of the sources of wave data, provided by the **British Oceanographic Data Centre (BODC),** GRID with a resolution of 30 arcseconds.

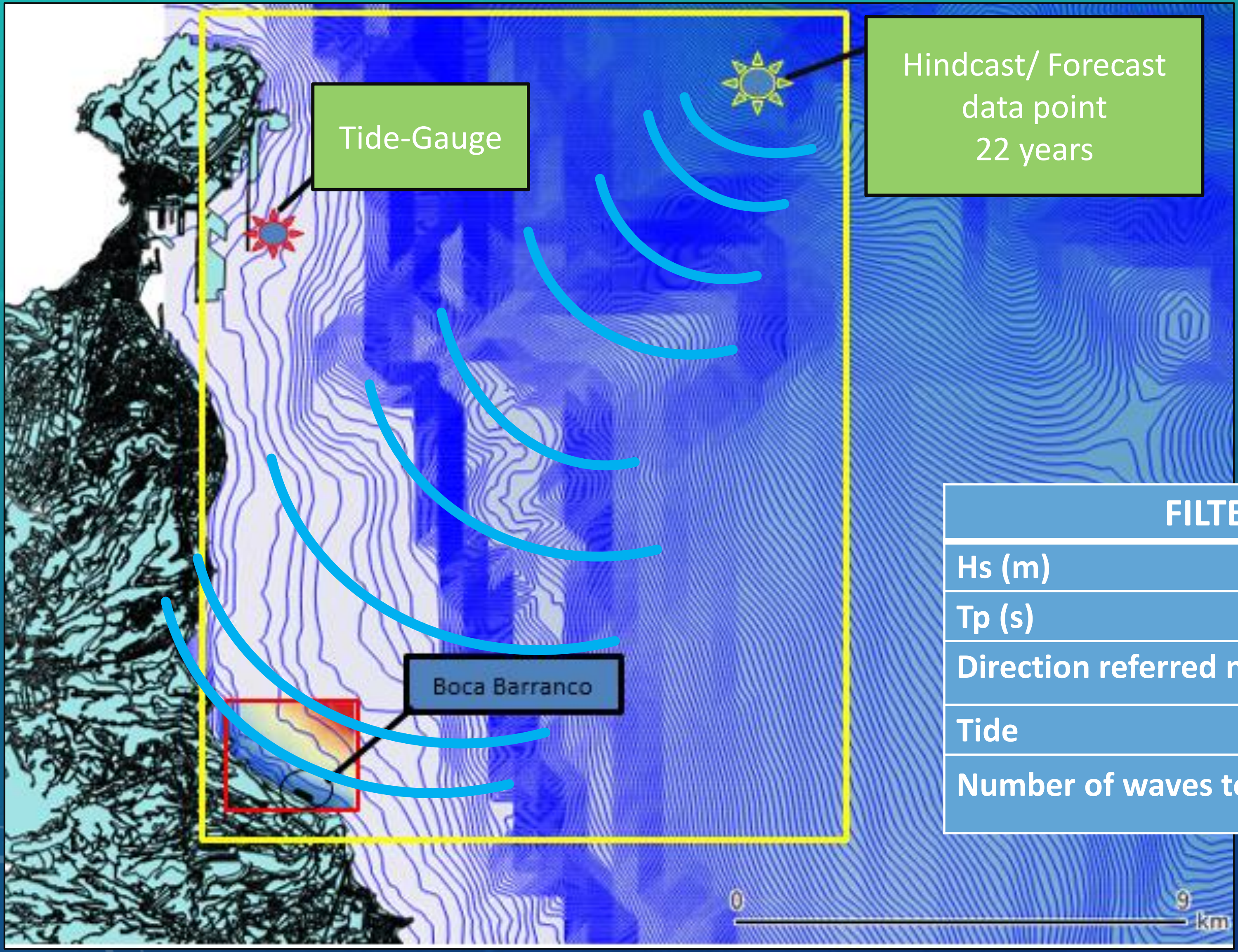


Homogenized bathymetric data bases

This step is to interpolate the bathymetry data to obtain a regular grid, as required by the SWAN model – GIS tools » Contour , kriging, fishnet



3.2 Wave Climate



Wave propagation

Features of simulations

≈ 150.000 sea state to propagate

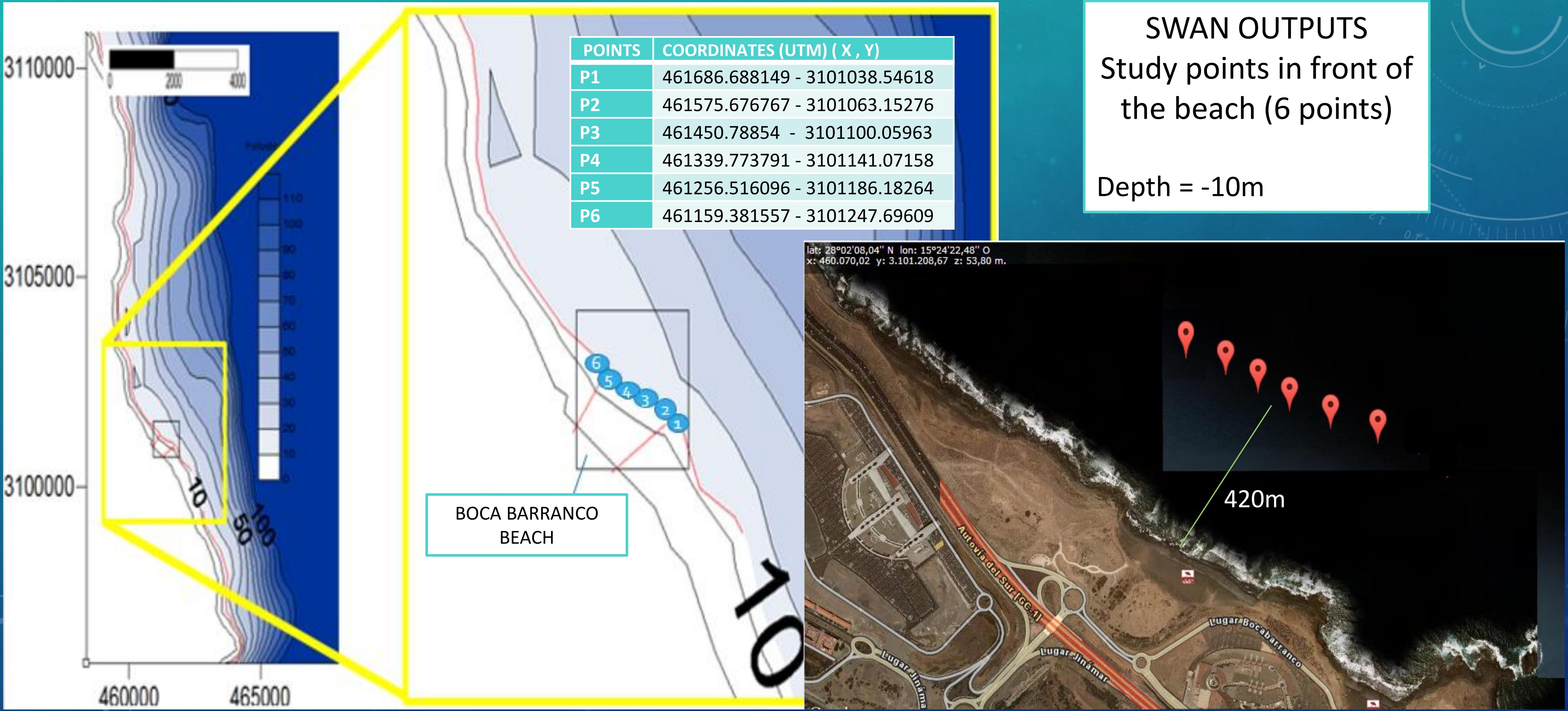
1 sea state = 3 minuts in computational calculation, all sea states = 10 mounths

We decided propagate the sea states in equivalent groups.

FILTER PROCESS	Mín	Máx	Interval
Hs (m)	0,5	7,5	0,5
Tp (s)	6	22	2
Direction referred north (sexagesimal degrees)	0	180	20
Tide	0	3	0,5
Number of waves to propagate			47.452

25 days by computer / 5 computer »» **5 days**

3.2 Wave Climate

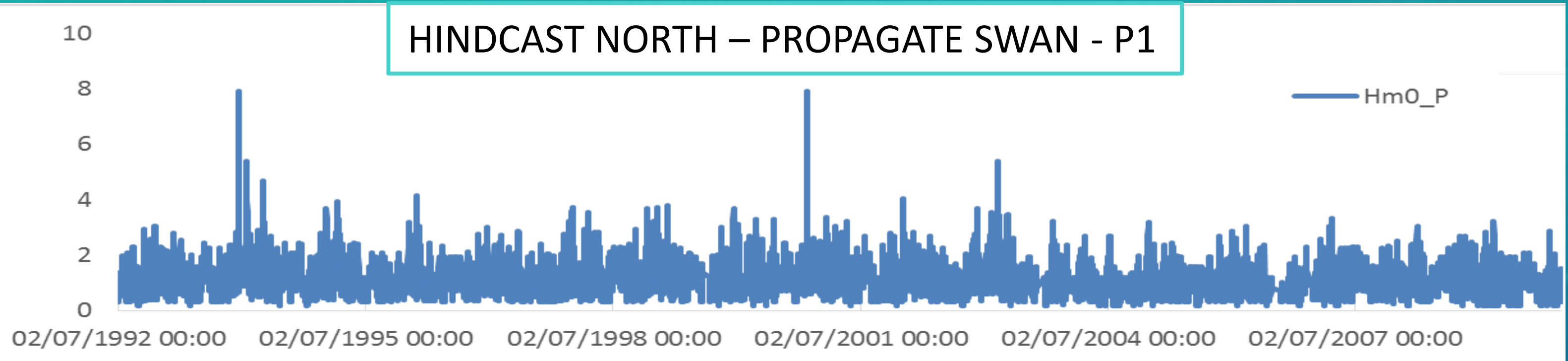


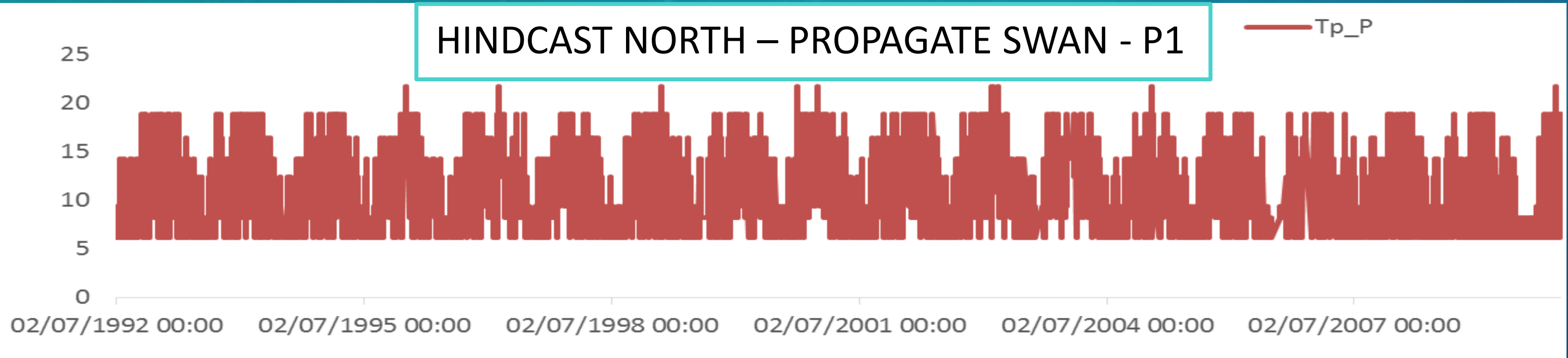
POINTS	COORDINATES (UTM) (X , Y)
P1	461686.688149 - 3101038.54618
P2	461575.676767 - 3101063.15276
P3	461450.78854 - 3101100.05963
P4	461339.773791 - 3101141.07158
P5	461256.516096 - 3101186.18264
P6	461159.381557 - 3101247.69609

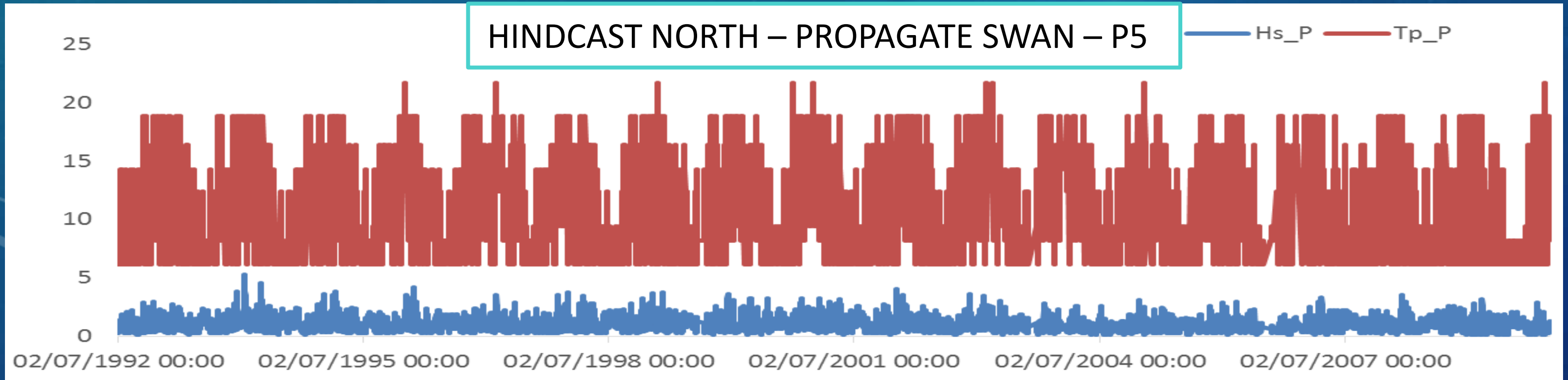
SWAN OUTPUTS
Study points in front of the beach (6 points)

Depth = -10m

3.2 Wave Climate





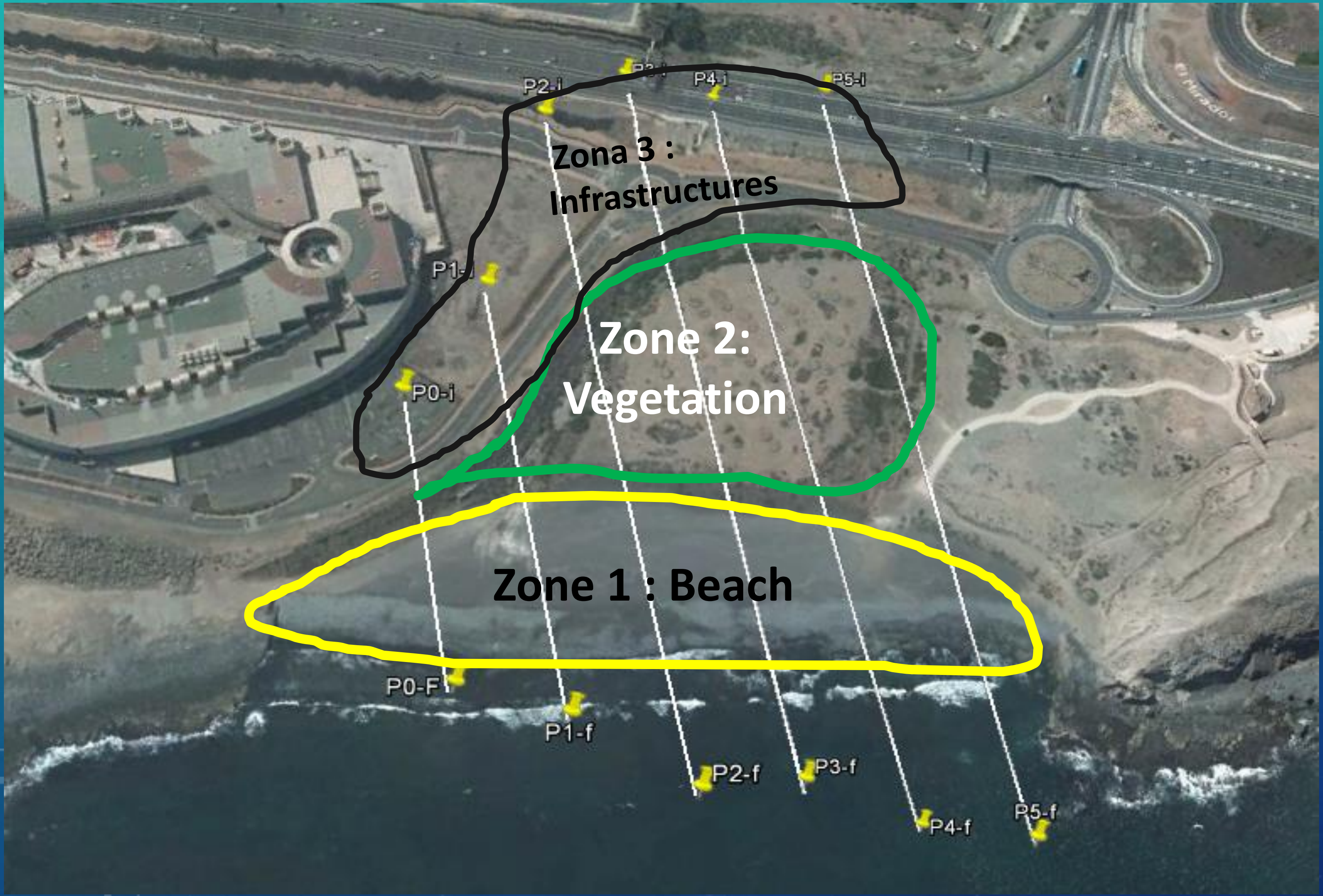


Results of the Propagation

to output points

P5	Mean	Max	Min
HS_P (m)	1.1	7.1	0.15
TP_P (s)	10.6	21	6.1

3.3 EMPIRICAL MODELS



Run up Estimation

6 PROFILES

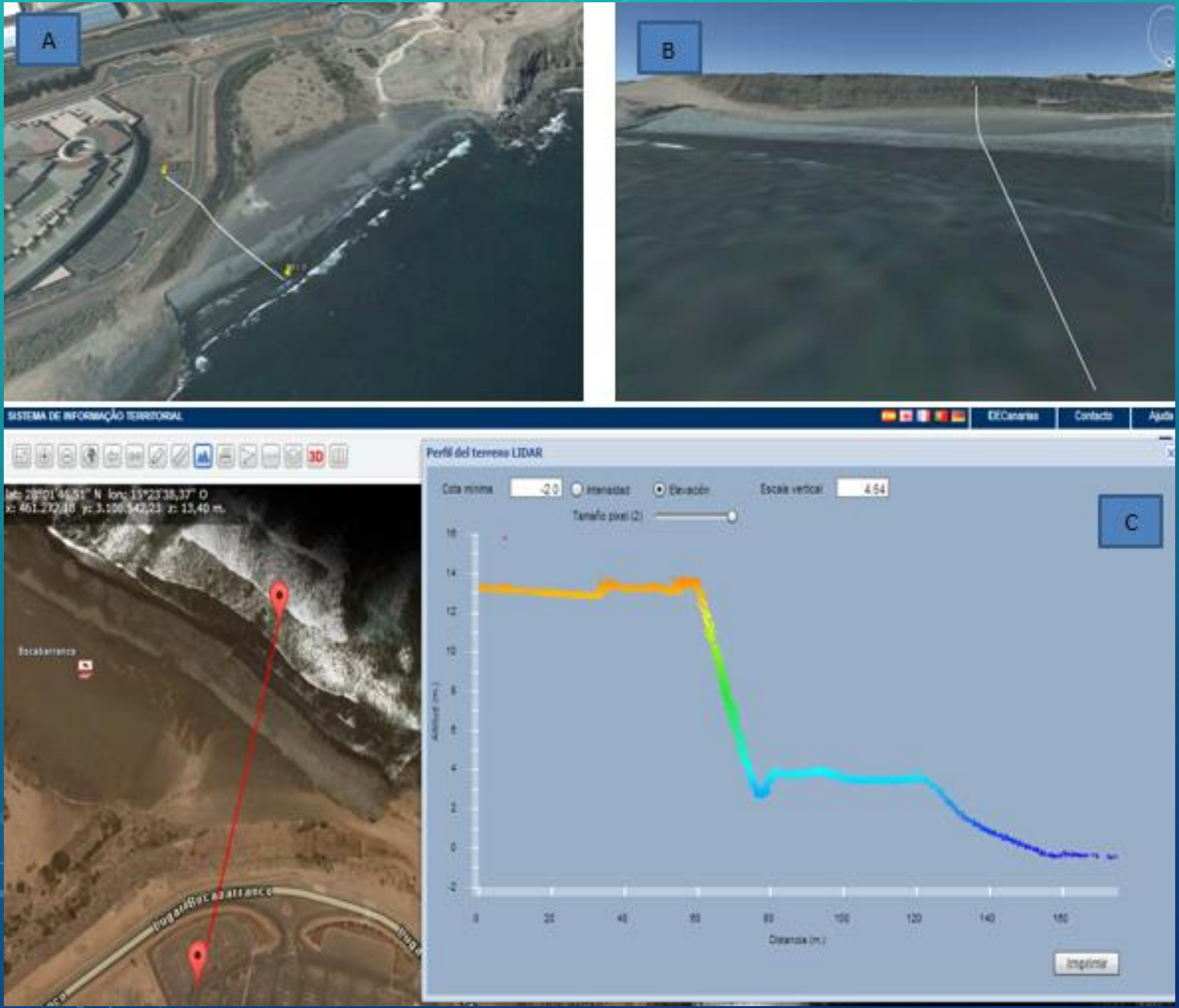
Crossing 3 case studies

EMPIRICAL MODELS

for *RUN-UP*

- The significant wave height = Hs
- Wave length = Lo
- Wave climate in offshore zone = Hm0, Pk, Dm
- The slope of the beach face (profile) = β

Authors	Run- up, R
Hunt (1959)	$R_{2\%} = \tan\beta * (H * L_0)^{0.5}$
	$R_{2\%} = 3 * H$
Holman (1986)	$R_{2\%} = H_0 * (0.83 * \xi_0 + 0.20)$
	$R_{2\%} = H_s * (0.78 * \xi_s + 0.20)$
Nielsen & Hanslow (1991)	$R_{2\%} = L_{RU} (-\ln(0.02))^{0.5}$
	$L_{RU} = 0.6 * \tan\beta * (H_{orms} L_0)^{0.5}$
	$L_{RU} = 0.05 * (H_{orms} * L_0)^{0.5}$
Stockdon et al. (2006)	$R_{2\%} = 0.043 * (H_0 L_0)^{0.5}$
	$R_{2\%} = 1.1 * (0.35 * \tan\beta * (H_0 L_0)^{0.5} + [(H_0 L_0 (0.563 * (\tan\beta)^{0.5} + 0.004))^{0.5}] / 2)$
Teixeira (2009)	$R_{máx} = 0.80 * H_s + 0.62$
	$R_{máx} = 1.08 * H_s * \xi_0$
Ruggiero et al. (2001)	$R_{2\%}\ 0.27 * (\tan\beta * H_0 L_0)^{0.5}$
	$R_{2\%} = 0.5 * H_0 - 0.22$
Guza & Thornton (1982)	$R_s = 0.71 * H_0 + 0.035$



FLOOD LEVEL CALCULATION IN THE BEACH

PROFILE 0 TO EXAMPLE

3.3 EMPIRICAL MODELS

Results

R_{max} P0	Mean	Maximum	Minimum
Hunt (1959)	~~2.205~~	12.61	0.5
Holman (1986)	1.162	[illegible]	[illegible]
Stockdon et al. (2006)	~~3.258~~	[illegible]	[illegible]
Nielsen et al. (1991)	1.180	3.465	0.313
Ruggiero et al. (2001)	1.001	3.643	0.271
Guza et al. (1982)	1.246	7.771	0.219
Teixeira 1 (2009)	1.504	6.341	0.743
Teixeira 2 (2009)	1.220	3.434	0.33

The developing empirical formulas take into account the type of beach. However, the beach does not meet the conditions of application.

These authors were excluded to calculate the flood level.

5 authors used to calculate flood level.

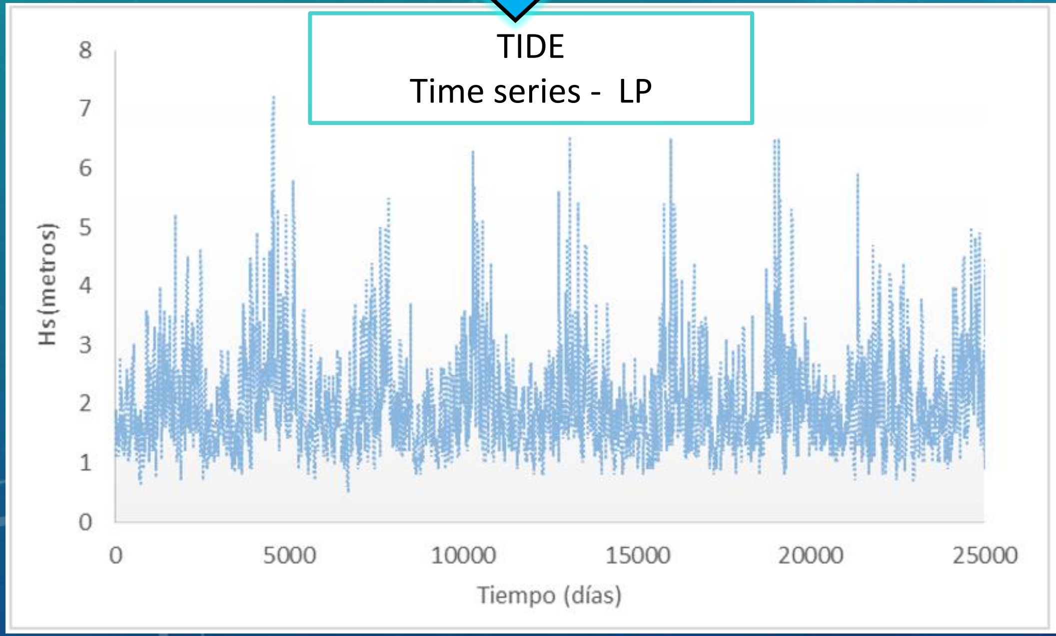
3.3 EMPIRICAL MODELS

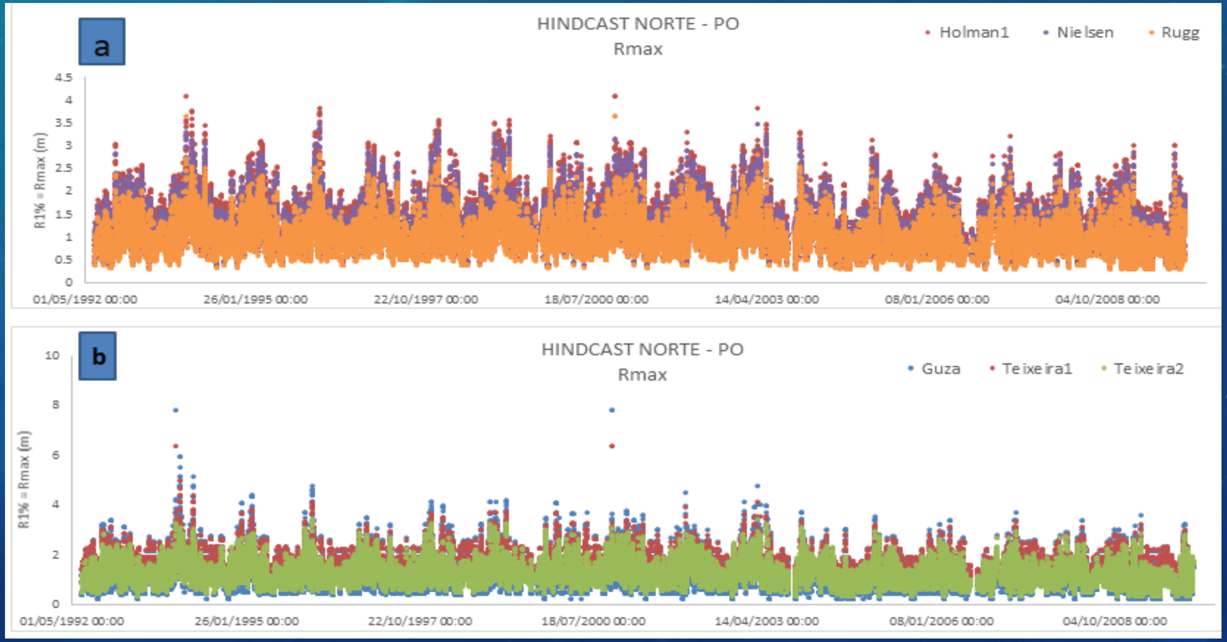
Results

Flood level (referred to the hydrographic zero)

FL = ST + SS + Rmax

Astronomical Tides + Storm Surge + Results of models



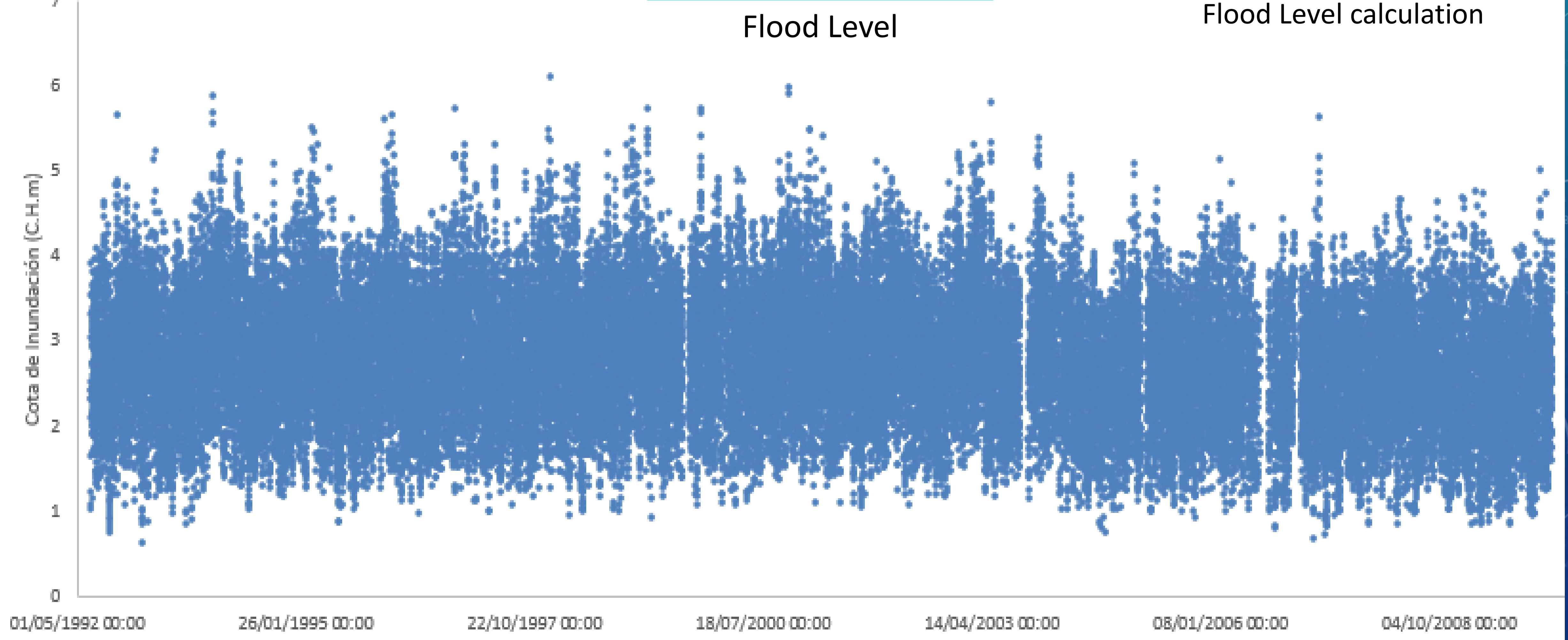


3.3 EMPIRICAL MODELS

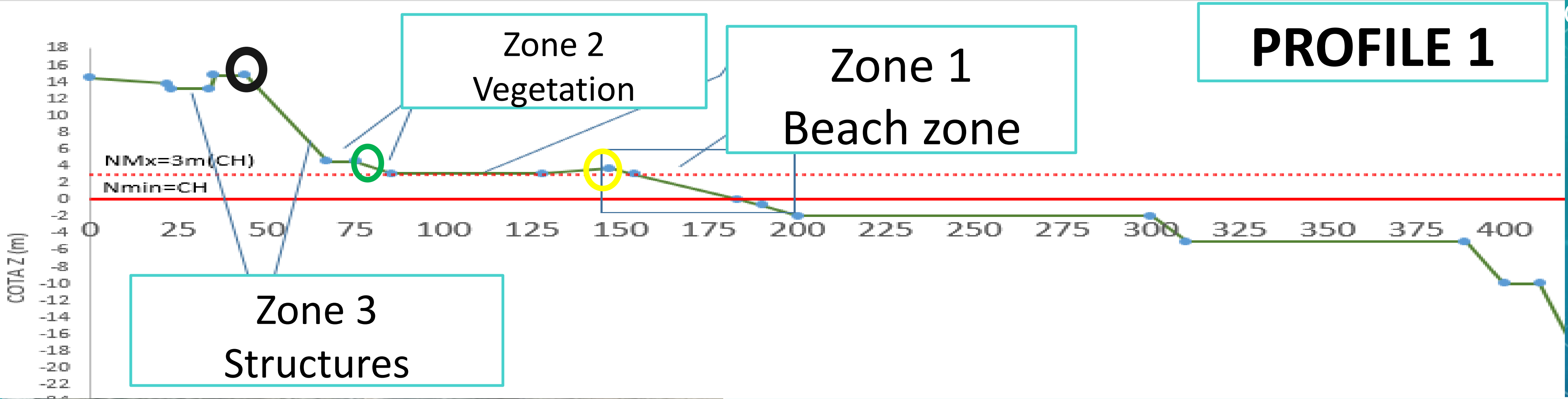
Results

HINDCAST NORTH – P0

Flood Level calculation



PROFILE 1



Definition of flood level values (m)			
Profile	***Zone 1 Beach***	***Zone 2 Vegetation***	***Zone 3 Structures***
P0	3.5	-	14
P1	3	3.4	14.8
P2	3	3.8	15
P3	3	4	15.3
P4	3	5.8	14.8
P5	3	5.1	9

P1	C.I
Número de eventos	47452
Número de eventos que ultrapassam - 3m (zona ocio) - caso 1	16374
Número de eventos que ultrapassam - 3.4m – (Poca Vegetación) - caso 2	8258
Número de eventos que ultrapassam - 14.8 (Infra-estructuras) - caso 3	0
Probabilidad de ocurrencia (%) - caso 1	34.51
Probabilidad de ocurrencia (%) - caso 2	17.40
Probabilidad de ocurrencia (%) - caso 3	0
Grado de probabilidad de ocurrencia - caso 1	3
Grado de probabilidad de ocurrencia - caso 2	3
Grado de probabilidad de ocurrencia - caso 3	1

Number of events

Exceeding values

Probability of occurrence

Probability of occurrence degree

Description	Probability of Occurrence (22 years)	Degree
UNLIKELY	0 – 3%	1
RARE	3 – 15%	2
OCCASIONAL	15 – 35%	3
PROBABLE	35 – 60%	4
FREQUENT	> 60%	5

Results

3.4 RISK ASSESSMENT

Ocurrence

Descripción	Consequence (Indicative script)	Degree
INSIGNIFICANT	Stable geological, natural sand beach, busy for casual leisure premises and reduced ecological value.	1
CONSIDERABLE	Weak geological features, or possessing any shrub vegetation, areas of frequent leisure type.	2
VERY SERIOUS	Coastal protection infrastructure; relevant economic activities; very weak and unstable geological system and important vegetation.	5
SEVERE	Permanent human occupation (urban areas); natural elements of great ecological value that is difficult to recover.	10
CATASTROPHIC	Permanent human occupation; absolutely unique areas with a great historical / natural value where the loss is irretrievable; beach-dune system.	25

Raposeiro, P. D., & Ferreira, J. C. (2011)

Results

P1	C.I
Número de eventos	47452
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Probabilidad de ocurrencia (%) - caso 1	34.51
Probabilidad de ocurrencia (%) - caso 2	17.40
Probabilidad de ocurrencia (%) - caso 3	0
Grado de consecuencia - caso 1	1
Grado de consecuencia - caso 2	5
Grado de consecuencia - caso 3	5
Aceptabilidad - caso 1	Insignificante
Aceptabilidad - caso 2	Indeseable
Aceptabilidad - caso 3	Reducido

INSIGNIFICANT	**Stable geological, natural sand beach, busy casual leisure premises and reduced ecological value.**
VERY SERIOUS	**Coastal protection infrastructure; relevant economic activities; very weak and unstable geological system and important vegetation.**

3.4 RISK ASSESSMENT

Results

P1	C.I
Número de eventos	47452
Número de eventos que ultrapassam - 3m (zona ocio) - caso 1	16374
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Probabilidad de ocurrencia (%) - caso 2	17.40
Probabilidad de ocurrencia (%) - caso 3	0
Grado de probabilidad de ocurrencia - caso 1	3
Grado de probabilidad de ocurrencia - caso 2	3
Grado de probabilidad de ocurrencia - caso 3	1
Grado de consecuencia - caso 1	1
Grado de consecuencia - caso 2	5
Grado de consecuencia - caso 3	5
Grado de Riesgo - caso 1 (Grado de la Probabilidad x Grado de Consecuencia)	3
Grado de Riesgo - caso 2 (Grado de la Probabilidad x Grado de Consecuencia)	15
Grado de Riesgo - caso 3 (Grado de la Probabilidad x Grado de Consecuencia)	5
Aceptabilidad - caso 1	Insignificante
Aceptabilidad - caso 2	Indeseable
Aceptabilidad - caso 3	Reducido

Risk Degree		Consequences				
		1	2	5	10	25
Probability of occurrence	1	1	2	5	10	25
	2	2	4	10	20	50
	3	3	6	15	30	75
	4	4	8	20	40	100
	5	5	10	25	50	125

Intersection matrix

Risk Degree = Probability of occurrence X Consequences

¿?

Acceptability

3.4 RISK ASSESSMENT

Acceptability

Results

Degree	Description	Risk Control
1-3	Insignificant	Negligible risk; not necessary to carry out risk control measures.
4-10	Reduced	Risk can be considered acceptable / tolerable if you select a set of measures to control the possible damage in a small zone.
15-30	Undesirable	Risk to be avoided if reasonably practical; requires detailed research and cost-benefit analysis; monitoring is essential.
40-125	Unacceptable	Intolerable risk; control of risk required (eg Remove the source of risks, alter the probability of occurrence or consequences, risk transfer, etc.).

3.4 RISK ASSESSMENT

Results

Prepare risk maps
to improve management

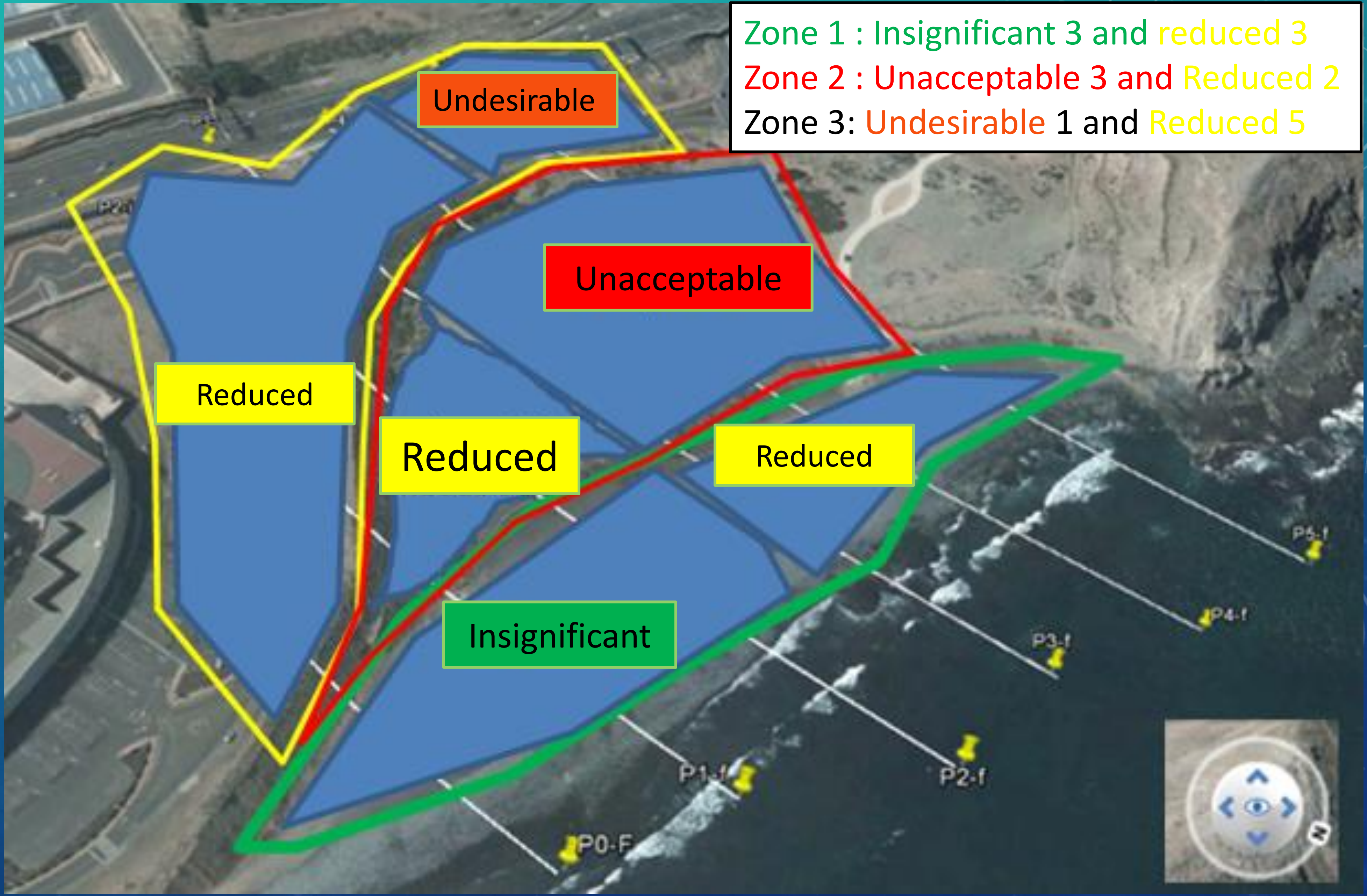
Zone 1 : Insignificant 3 and reduced 3
Zone 2 : Unacceptable 3 and Reduced 2
Zone 3: Undesirable 1 and Reduced 5

Profiles	*Zone*	*Risk Dregree*	*Acceptability*
P0	1	3	insignificant
			-
	3	5	reduced
P1	1	3	insignificant
	2	30	undesirable
	3	5	reduced
P2	1	3	insignificant
	2	10	reduced
	3	5	reduced
P3	1	4	reduced
	2	50	unacceptable
	3	5	reduced
P4	1	5	reduced
	2	50	unacceptable
	3	5	reduced
P5	1	5	reduced
	2	50	unacceptable
	3	25	undesirable

3.4 RISK ASSESSMENT

Results

Risk Maps



CONCLUSIONS

Based on large data sets and a reliable methodology:

- The study identified some potentially dangerous areas »» in zone 2 vegetation
- Other zones (1 and 3) are areas of occasional low-risk flooding.
- The most frequently flooded area is the beach zone (1), which does not present any risk.
- As expected, the area with the lower risk is zone 3, where the structures are located in a high topographic level above sea-level.
- As a result of this, overtopping is not observed in zones with infrastructures.

Thank you very much