INTEGRATION OF SENTINEL DATA INTO A WAVE FLOOD FORECASTING AND WARNING SYSTEM FOR PORTS AND COASTAL ZONES - HIDRALERTA

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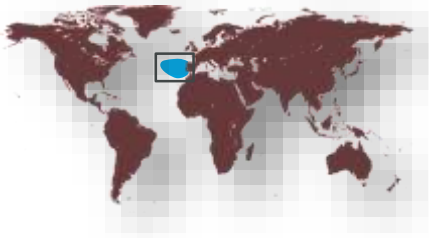
2 – LNEC - Laboratório Nacional De Engenharia Civil;
3 - ISEL – Instituto Superior de Engenharia de Lisboa,

MOTIVATION

- The **length** of Portuguese coast
- The **importance** of the coastal zone in **socio-economic activities**
- The **severity** of the **sea conditions**
- **Safety** of **people** and **goods**



Justify studying
wave-induced risks

ASSESS THE WAVE
OVERTOPPING RISK

SYSTEM

To **predict** flooding and overtopping
in port and coastal areas

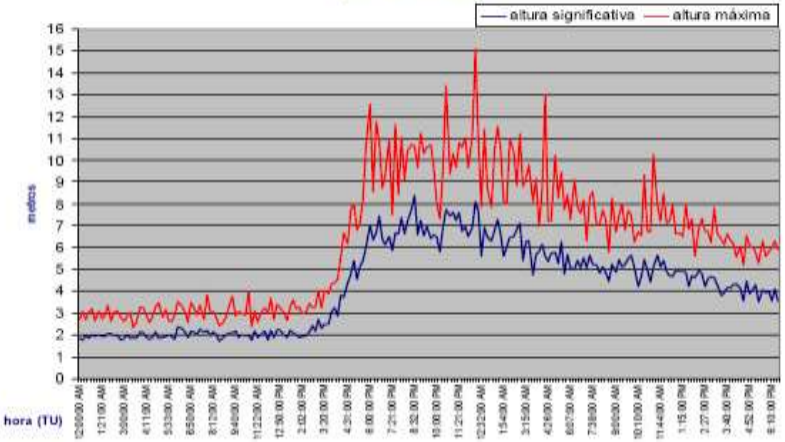
CLIMAAT

Projecto CLIMAAT (SIMMETOCEAN)

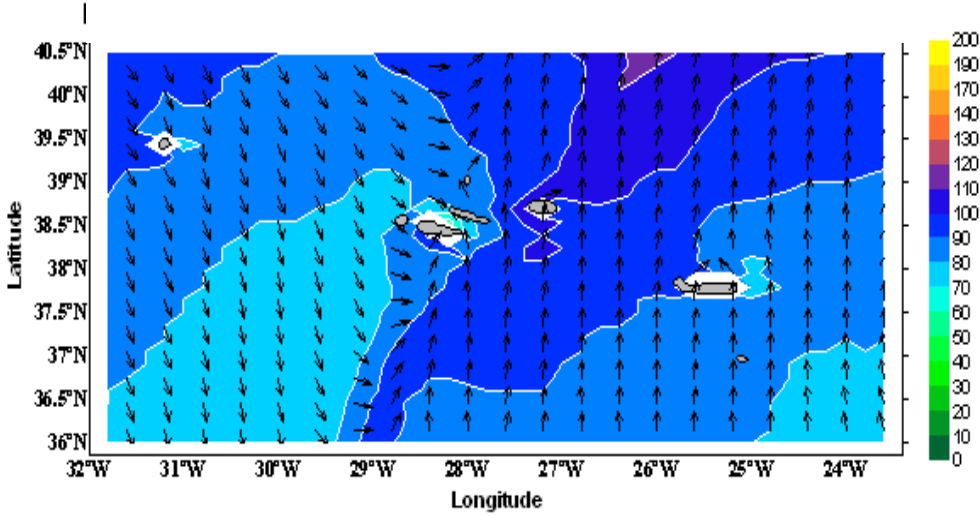
Bóia da Praia da Vitória "CLIMAAT-BOND 1"

Ondulação 26/27 de Fevereiro de 2005

(blocos de 10 minutos)




Lajes das Flores
Graciosa
Praia da Vitória
Faial / Pico
Ponta Delgada
Vila do Porto


40.5°N
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Latitude
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31°W
30°W
29°W
28°W
27°W
26°W
25°W
24°W
Longitude
200
190
170
140
130
120
110
100
90
80
70
60
50
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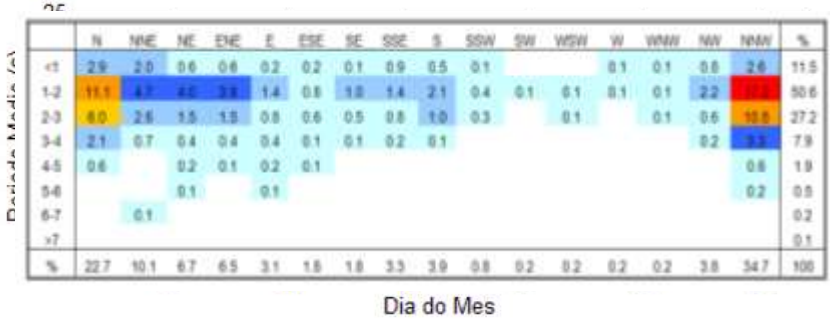
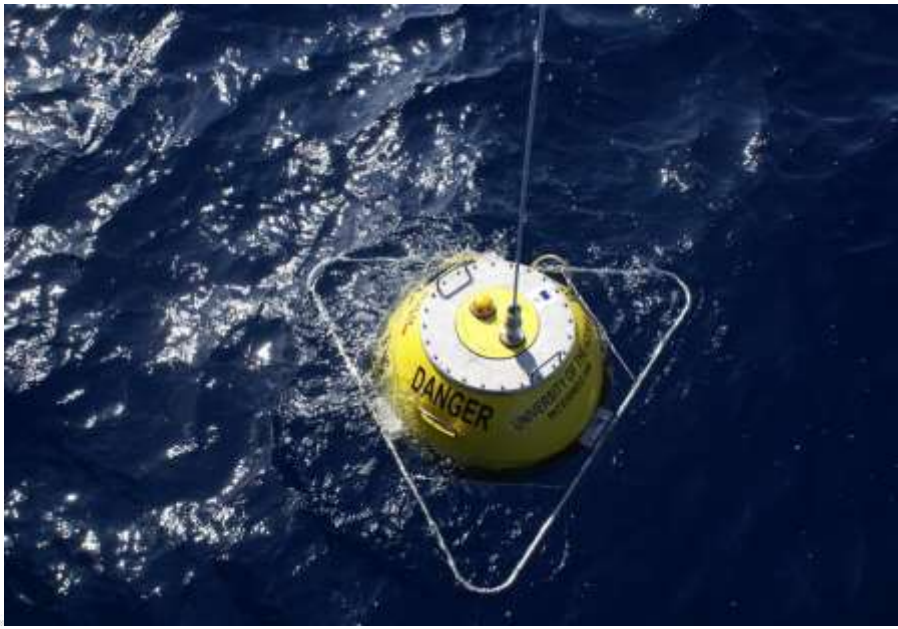
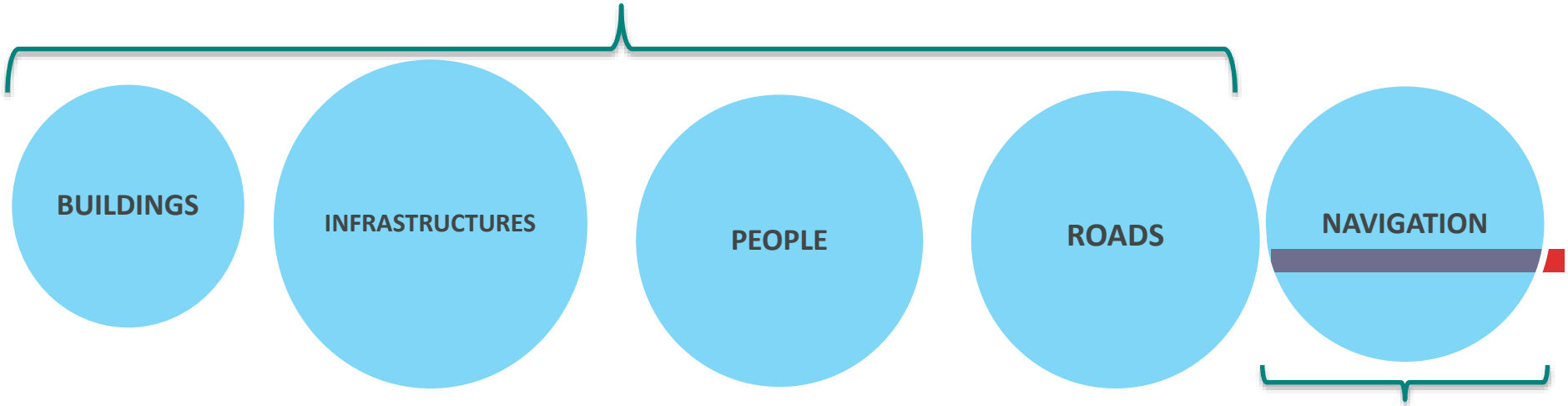
PRAIA DA VITORIA - Fevereiro 2005
Boia
Modelo
Modelo
Altura Significativa (m)
Dia do Mes


Dia do Mes


DANGER

MOTIVATION

- Consequences of wave overtopping and flooding

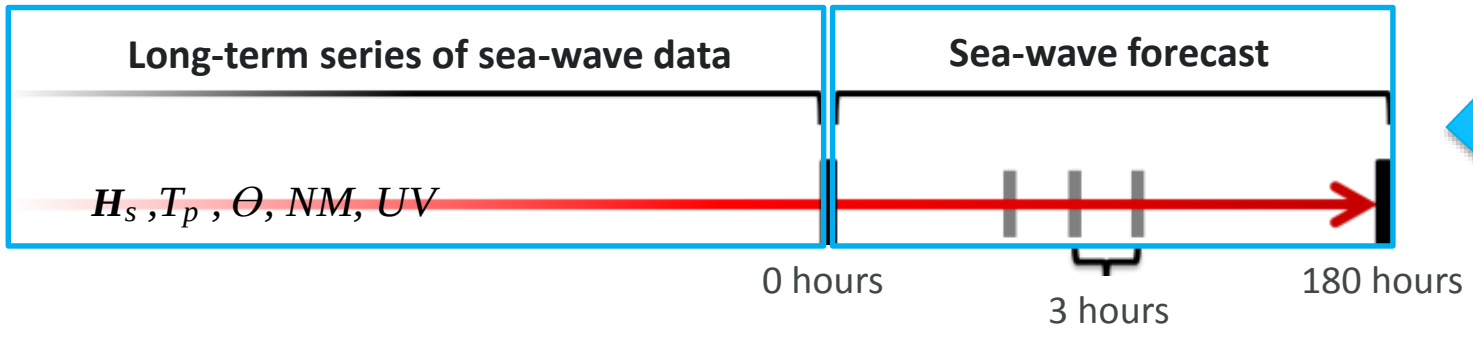


- The entry and departure in port
- Moored ships behavior

OBJECTIVES OF HIDRALERTA SYSTEM

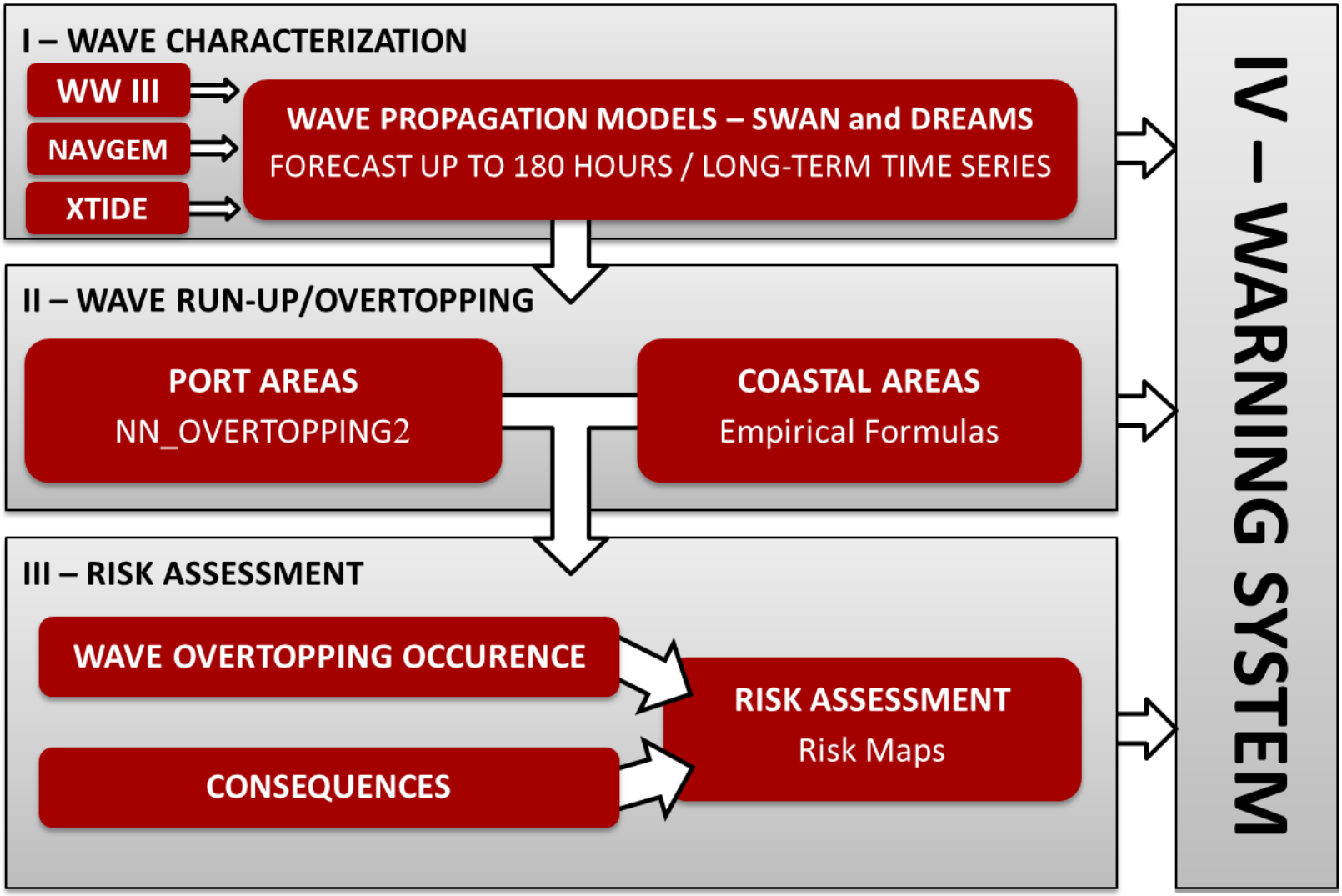
Create a user-friendly tool, that allows:

- **Real-time** and **Forecast** overtopping/flooding emergencies, issuing warning messages to the authorities when the safety of people, goods or activities in these areas is likely to be at stake; It considers sea-wave forecast up to 180 hours;
- **Construction of risk maps** that are decision-support tools for the authorities. These maps are constructed by considering either **long-term series** of sea-wave characteristics or predefined scenarios associated with climate change and/or extreme events;



METHODOLOGY

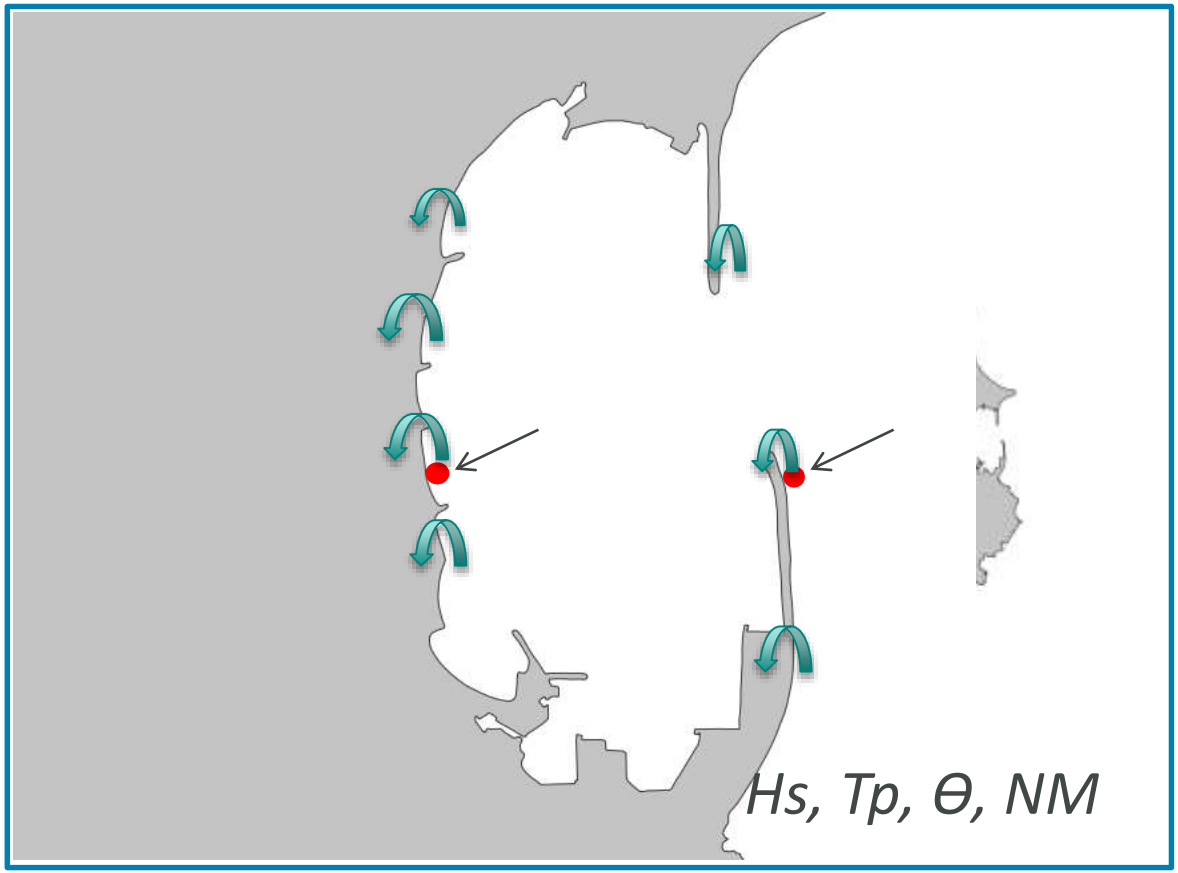
The system is developed in Python language and it is implemented in a WebGIS platform.



WARNING SYSTEM

HIDRALERTA SYSTEM

WWIII → SWAN → DREAMS → NN OVERTOPPING → EARLY WARNING



OFFSHORE WAVE PREDICTIONS

WAVE OVERTOPPING CALCULATION

INSHORE WAVE PREDICTIONS

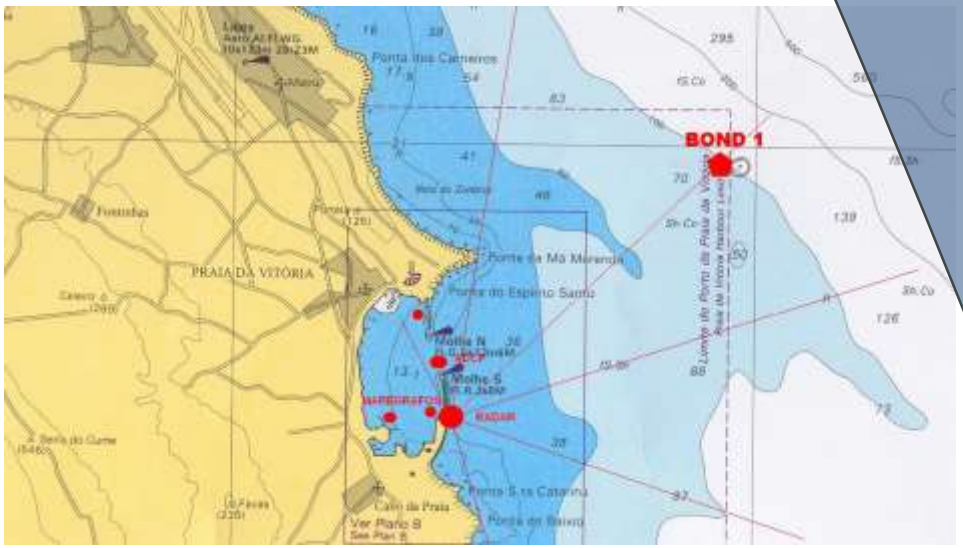
WAVE CONDITIONS INSIDE THE PORT

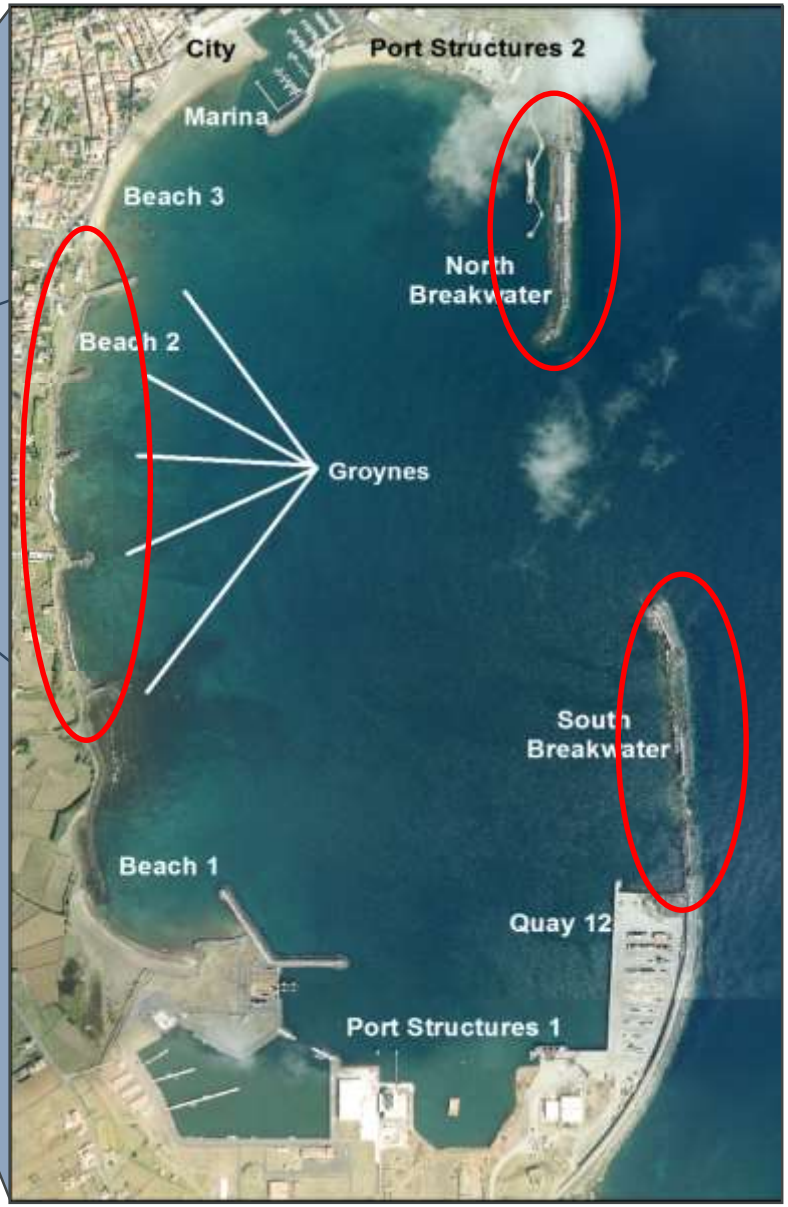
EARLY WARNING WHEN WAVE OVERTOPPING THRESHOLDS ARE EXCEEDED

WAVE PREDICTIONS NEAR STRUCTURES

WARNING SYSTEM

STUDY CASE: PRAIA DA VITÓRIA BAY

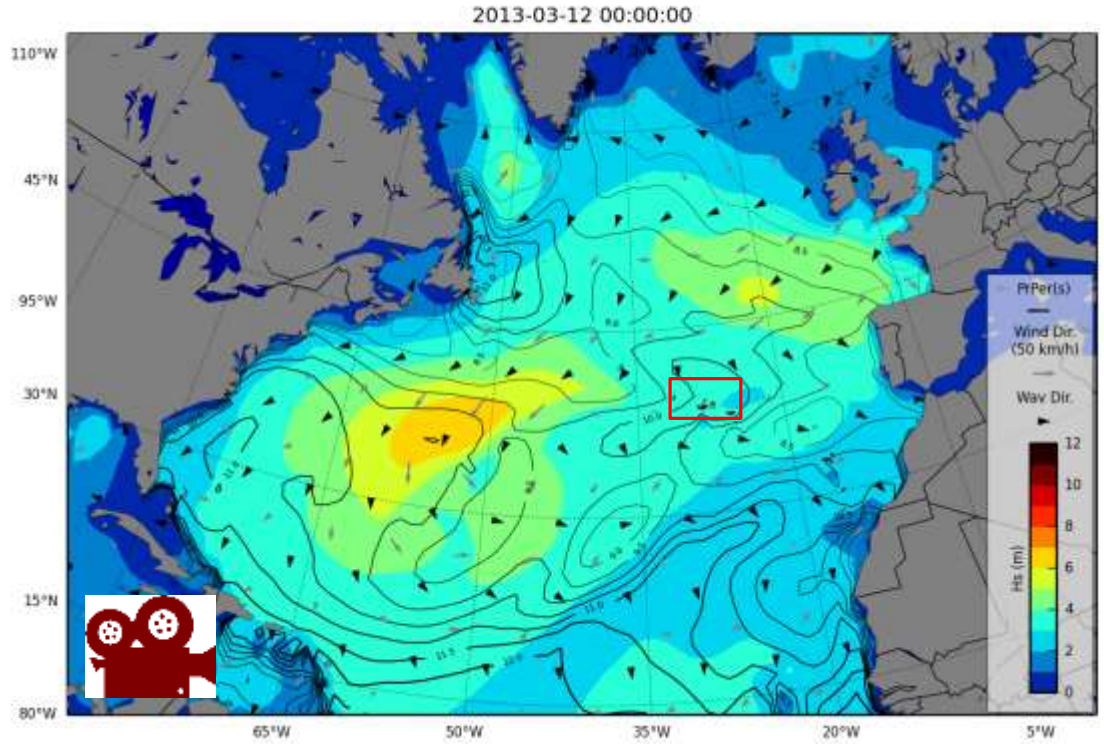




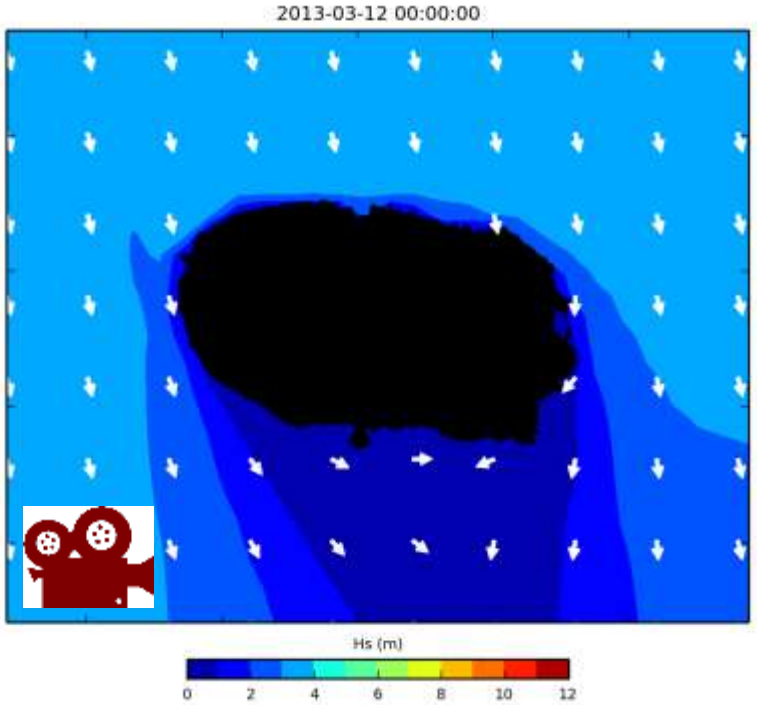
WARNING SYSTEM

APPLICATION TO PRAIA DA VITÓRIA

WWIII



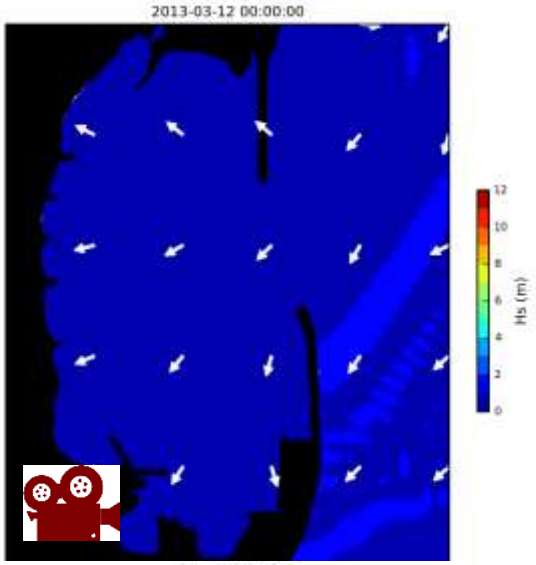
SWAN



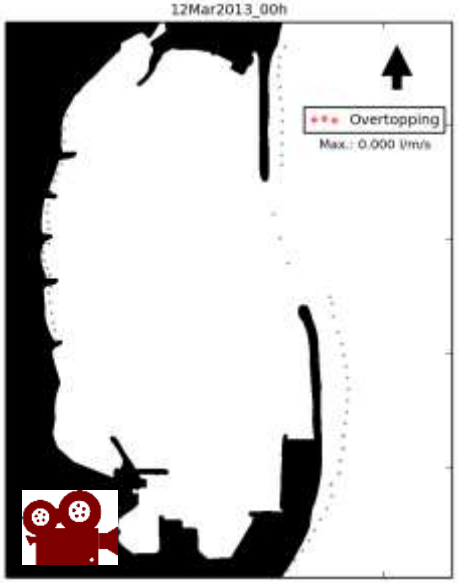
WARNING SYSTEM

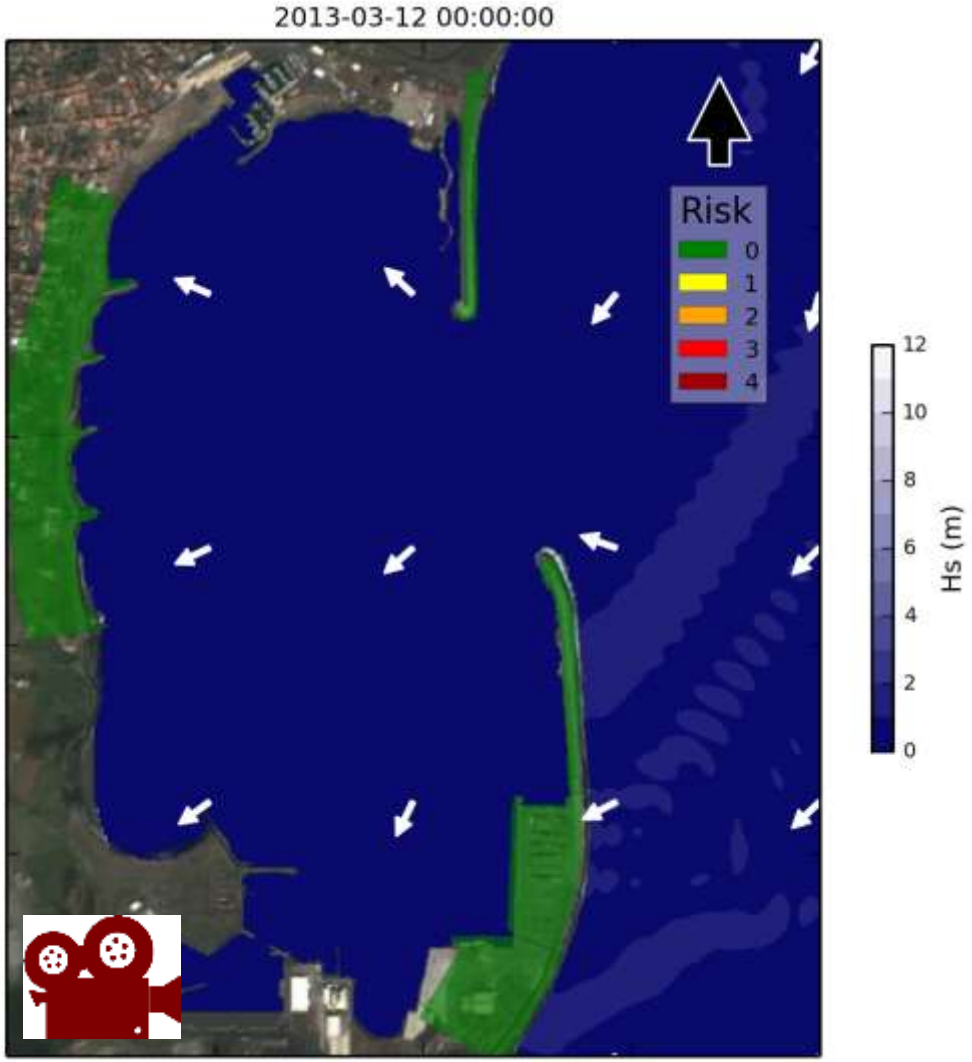
APPLICATION TO PRAIA DA VITÓRIA

DREAMS



SWAN

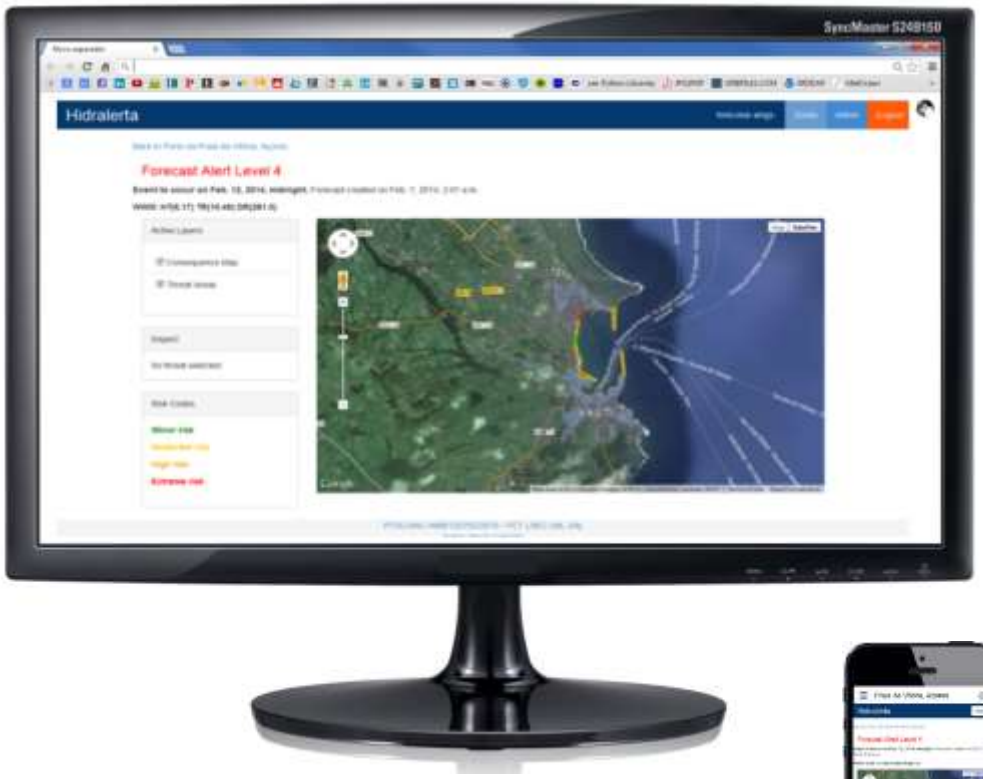




EARLY WARNING MAP

WARNING SYSTEM

ISSUE EARLY WARNING / PLATFORM

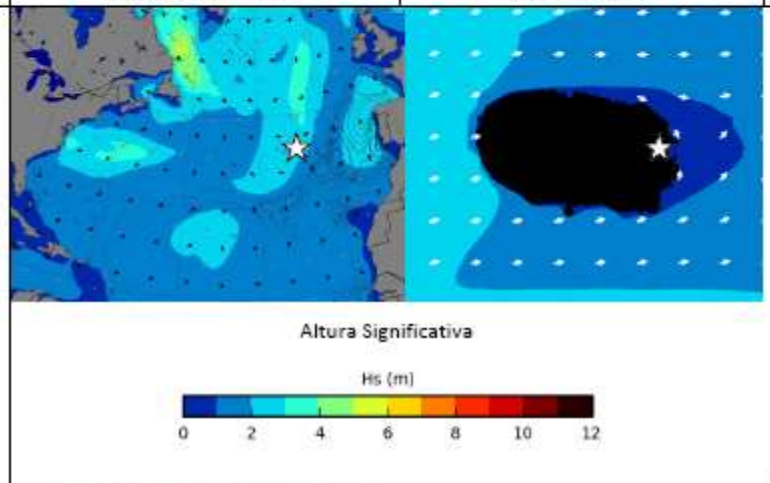
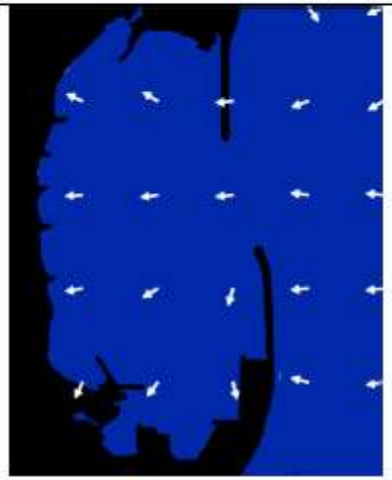
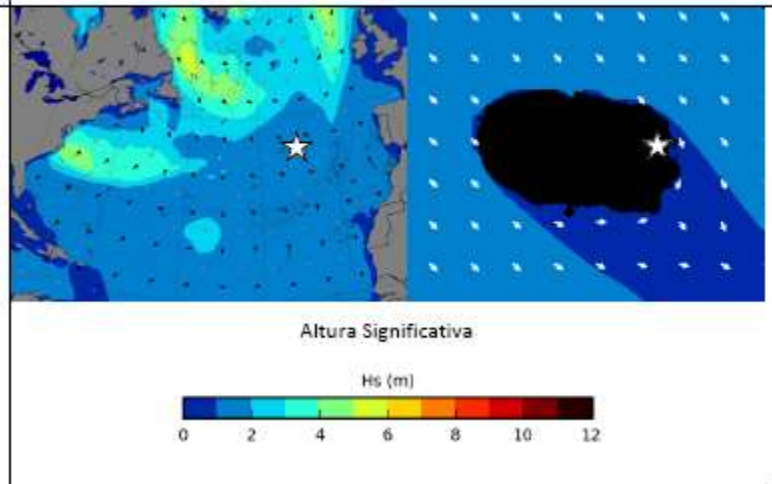
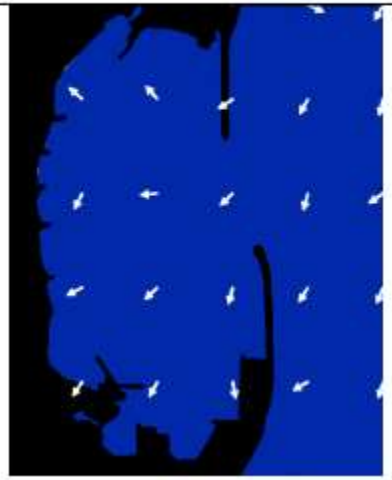


- **SYSTEM DEVELOPED IN *PYTHON***
  - COUPLING MODELS
  - SYSTEM AUTOMATIZATION
  - WEB COMPONENT
- **VISUALIZATION OF THE FORECAST RESULTS AND HISTORICAL DATA**
- **SEVERAL LAYERS OF INFORMATION (WebGIS)**

LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL

PROJECTO HIDRALERTA
PRAIA DA VITÓRIA, TERCEIRA, AÇORES
PREVISÃO DE AGITAÇÃO MARÍTIMA

Sexta-feira, 25 de Setembro de 2015, 00h00 GMT

	ATLÂNTICO NORTE	ILHA TERCEIRA	PRAIA DA VITÓRIA
24 h			
48 h			

LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL

PROJECTO HIDRALERTA
PRAIA DA VITÓRIA, TERCEIRA, AÇORES
ALERTA AO GALGAMENTO OCEÂNICO

Todas as zonas:

- **Nível de Alerta**: 0 – Sem alerta
- **Possíveis Consequências**: Sem ferimentos em pessoas; ausência de impacte ambiental; sem alterações nas actividades portuárias; sem danos em edifícios, em equipamentos, estruturas marítimas ou veículos.
- **Observações:** Prevê-se a formação, a partir de Sábado, 26 de Outubro, de um temporal no Atlântico Norte, que pode originar agitação marítima com Hs superior a 12 m, em mar aberto. Prevê-se que este sistema atinja os Açores a partir de Terça-Feira, 29 de Setembro, com agitação marítima com Hs de 4 a 5 m de NNW ao largo da Terceira e com Hs de 3 a 4 m de NE junto ao Porto da Praia da Vitória. Esta previsão poderá sofrer alterações significativas nos próximos dias, dado que este temporal ainda nem se formou.

CONSEQUÊNCIAS	PESSOAS	AMBIENTE	GESTÃO PORTUÁRIA	EDIFÍCIOS	EQUIPAMENTOS	ESTRUTURA MARÍTIMA	VEÍCULOS
SEM CONSEQUÊNCIAS	Sem ferimentos	Sem impacte ambiental	Sem alterações nas actividades portuárias	Sem danos exteriores	Sem danos	Sem danos	Sem danos
INSIGNIFICANTES	Possibilidade de ferimentos muito ligeiros	Impacto ambiental desprezável	Alterações ligeiras nas actividades portuárias	Danos exteriores quase inexistentes	Danos quase inexistentes	Dano na zona activa da estrutura não necessitando reparação	Danos quase inexistentes
REDUZIDAS	Algumas lesões ligeiras	Pequenos derrames (por exemplo de combustível)	Algumas alterações nas actividades portuárias; má publicidade para o	Danos interiores e exteriores insignificantes	Danos ligeiros que não implicam a paragem do equipamento; resolução de	Ocorrência de movimentos e quedas de blocos sem exposição de filtros; reparação	Danos insignificantes que não afectam a sua utilização

RISK ASSESSMENT SYSTEM

RISK ASSESSMENT SYSTEM

Thresholds for wave overtopping ***q***
(Pullen *et al.*, 2007)

- ***People*** – <0.1
- ***Vehicles*** – <10
- ***Buildings*** – <1
- ***Equipment*** – <0.4

Units: l/s/m

Count threshold exceedance

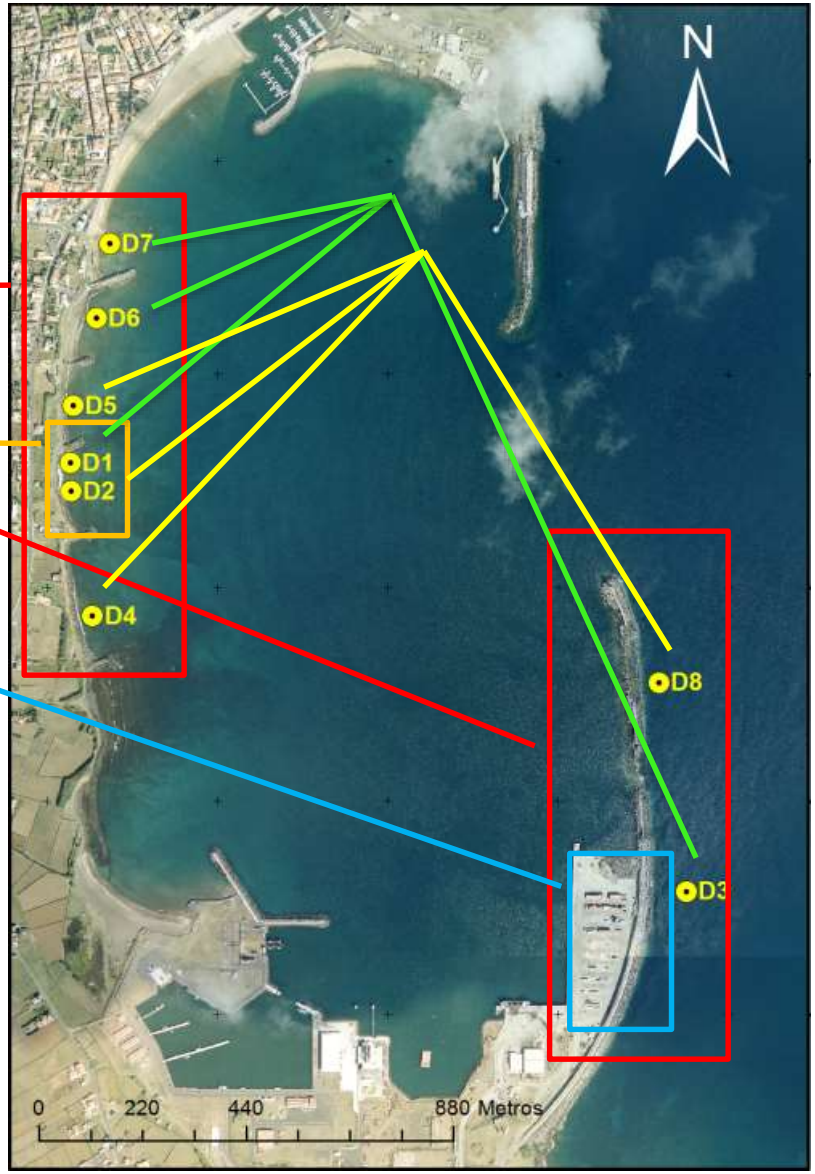
↓

Probability

↓

Probability level

1. Improbable (<1%)
2. Remote (1 – 10%)
3. Occasional (10 – 25%)
4. Probable (25 – 50%)
5. Frequent (>50%)



RISK ASSESSMENT SYSTEM

Description	CONSEQUENCES (Guidelines)						Level
	People	Environment	Port Management	Property			
				Buildings	Equipment[1]	Maritime Structure	
Insignificant	Almost no injuries (bruises at most)	Almost no environmental impact	Small changes to port activities	Almost no exterior damage	Almost no damage	Damage in the active area of the structure requiring no intervention	1
Marginal	Single slight injury				Minor damage requiring no stopping; almost immediate problem resolution	Occurrence of block movements and falls without filter exposure; immediate intervention not required	2
Relevant	Multiple slight injuries or single major injury	Some areas are restricted due to pollution caused by cargo spills	Restrictions on loading and unloading; possible partial shutdown; bad widespread publicity	Moderate interior damage	Damage requiring temporary equipment downtime for repair	Occurrence of block movements and falls with filter exposure; superstructure affected but with no significant movements	5
Serious	Multiple major injuries or single fatality	Pollution episodes in and	Loading and		Major damage; prolonged equipment downtime	Filter layer affected; substantial movements of the superstructure	10
Catastrophic	Multiple fatalities	Widespread cargo spills; serious contamination; irrecoverable losses to the environment; international aid needed	Very serious constraints to loading and unloading over a long period; very serious and long term loss of trade; bad international publicity	Very serious interior damage; building structure seriously damaged; imminent danger of collapse	Equipment loss (no recovery possibility)	Collapse of the structure	25

Reflect the importance of dangeours events

The consequences level for each cross-section

[1] "Equipment" is intended to include machinery, containers and vessels.

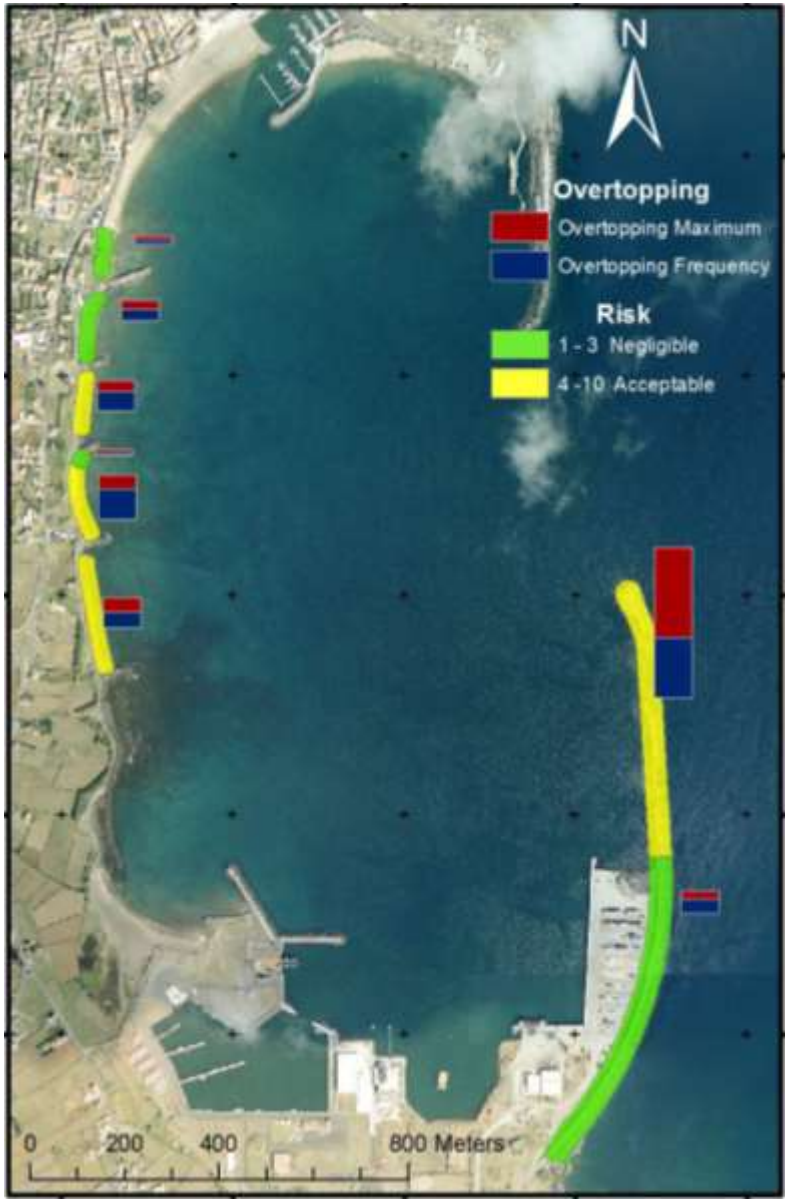
RISK ASSESSMENT SYSTEM

Level	Description	Risk Treatment (Guidelines)
1 – 3	Negligible	Insignificant risk; no further consideration needed.
4 – 10	Acceptable	Risk can be considered acceptable / tolerable provided the risk is managed.
15 – 30	Undesirable	Risk should be avoided if reasonably practicable; detailed investigation and cost/programme benefit justification required; top level approval needed; monitoring essential.
40 – 125	Unacceptable	Intolerable risk; it is mandatory to undertake risk treatment (e.g. eliminate the source of risk, change the probability and/or consequences, transfer risk).

For people (e.g.):

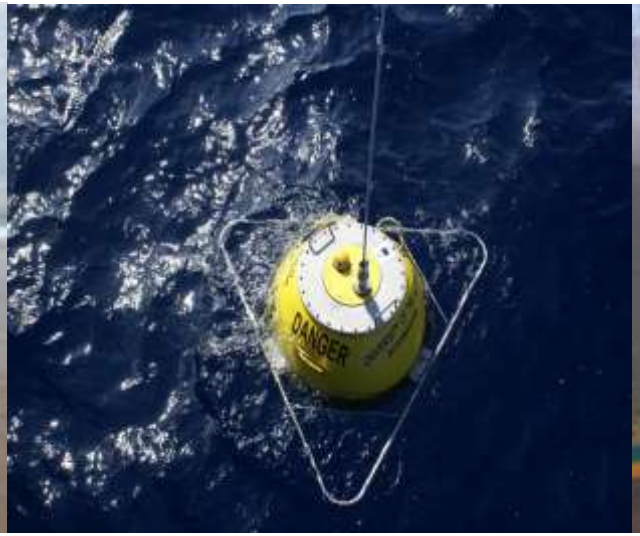
Cross section	Probab. Level	Conseq. Level	Risk Level
D1	1	1	1
D2	2	2	4
D3	1	2	2
D4	2	2	4
D5	2	2	4
D6	1	2	2
D7	1	2	2
D8	2	2	4

PEOPLE RISK MAP



HIDRALERTA VALIDATION

- HIDRALERTA system need to be validate, both as a whole and for each component.
- This validation can be made through several methodologies (in situ measurements, physical modelling, and others).



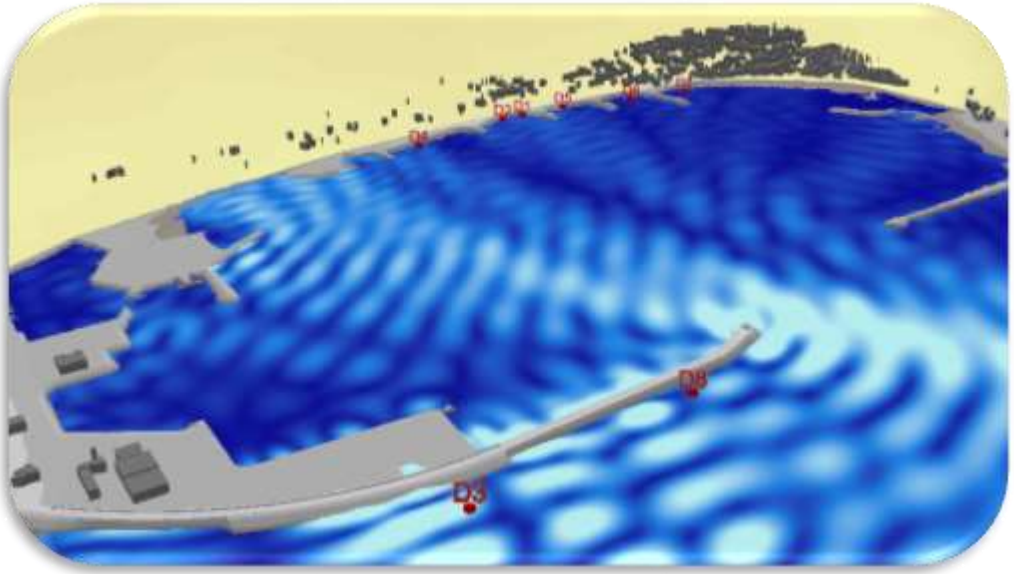
In situ measurements

Physical modelling

THE USE OF SENTINEL DATA

- The use of Sentinel data can help on this validation, namely
- Sea wave conditions
  - High accuracy radar altimeter systems for sea-level measurements will validate the DREAMS and SWAN results (wave heights , periods and directions
  - Sentinel-3's innovative altimeter will allow further advancements for monitoring water levels and sea and land surface temperature.

Wave heights, periods and directions



THE USE OF SENTINEL DATA

- Flooded areas
  - Extraction of large scale geographical information from high resolution satellite images with high temporal frequency is an efficient source of updated land use/land cover to feed environmental models
  - The use of Sentinel data will permit to identify flooded areas

CONCLUSIONS

- HIDRALERTA system has the potential to become a useful tool for the management of coastal and port areas, due to its fast and efficient capacity to effectively issue warning and to evaluate risks

- The early warning system is running permanently for Praia da Vitória

- The use of Sentinel data will be useful for the validation of HIDRALERTA
  - Sea wave characterization
  - Flooded areas

ACKNOWLEDGMENTS

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FCT
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MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

PORTOS DOS AÇORES

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UNIVERSIDADE DE LISBOA

azorina
Sociedade de Gestão Ambiental e Conservação da Natureza, S.A

Porto de Lisboa

UNIVERSIDADE DOS AÇORES

praia ambiente
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