ICCE 2018

36TH INTERNATIONAL CONFERENCE ON COASTAL ENGINEERING 2018

Baltimore, Maryland | July 30 – August 3, 2018

The State of the Art and Science of Coastal Engineering

PROBABILISTIC ASSESSMENT OF PORT OPERABILITY UNDER CLIMATE CHANGE

Paula Camus, Antonio Tomás, Cristina Izaguirre, Beatriz Rodríguez, Gabriel Díaz-Hernández, Iñigo Losada

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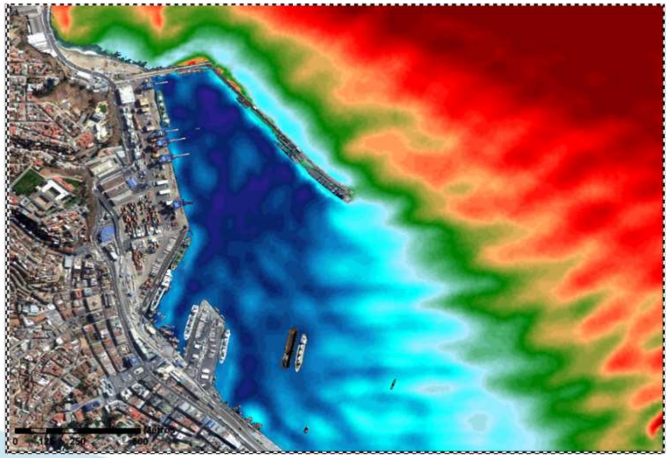
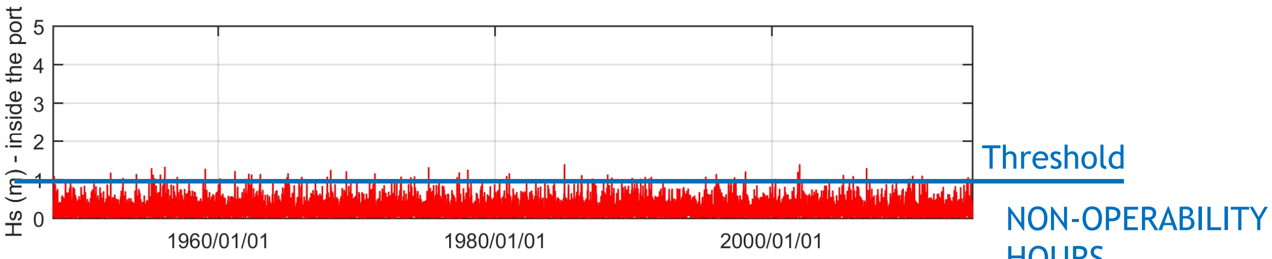
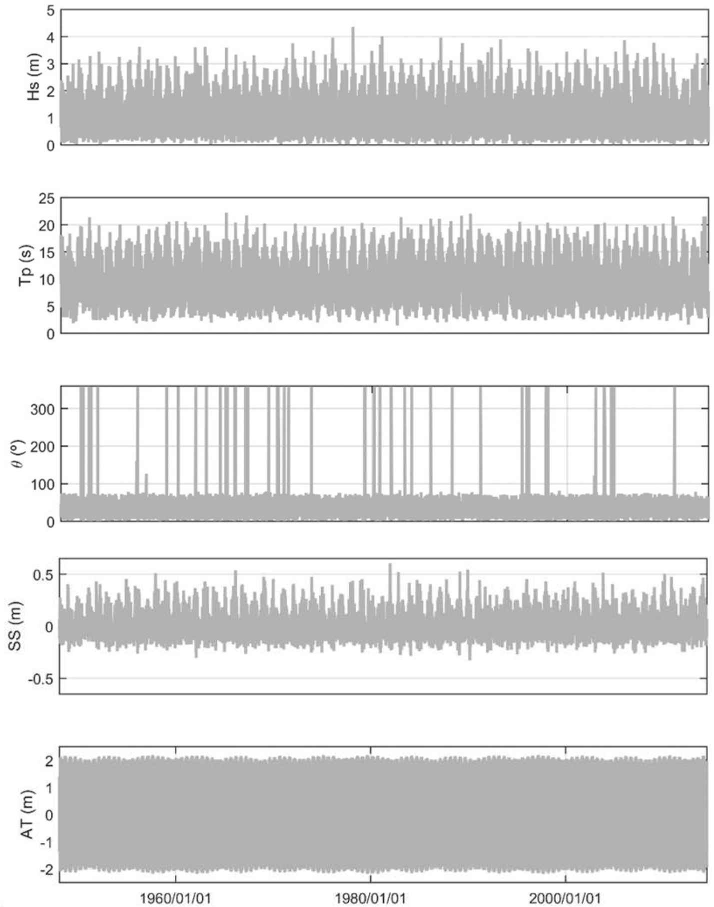


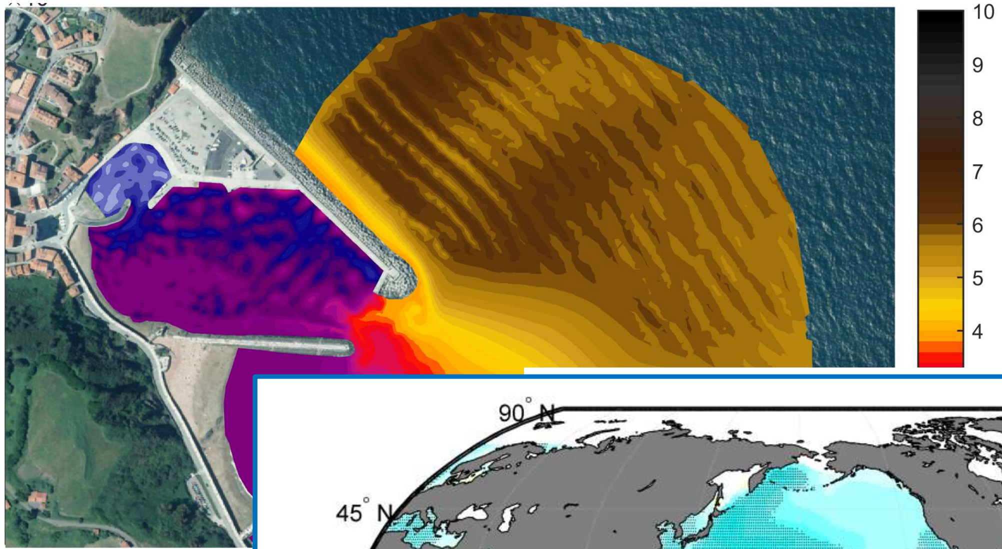
Assessment of Port Operation Downtimes

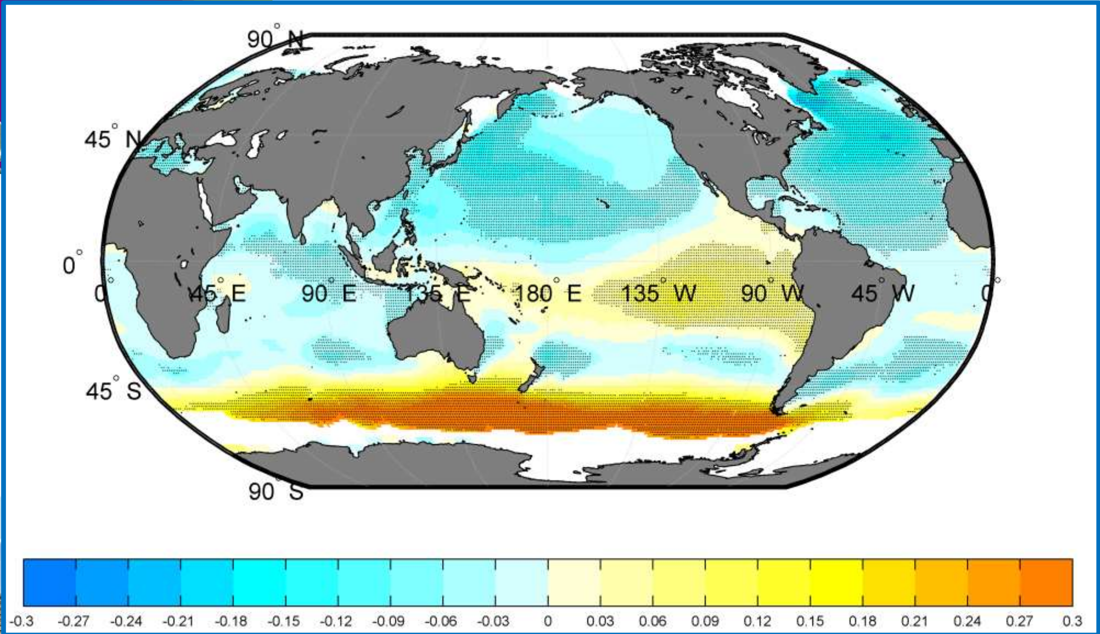


Historical Forcing Conditions

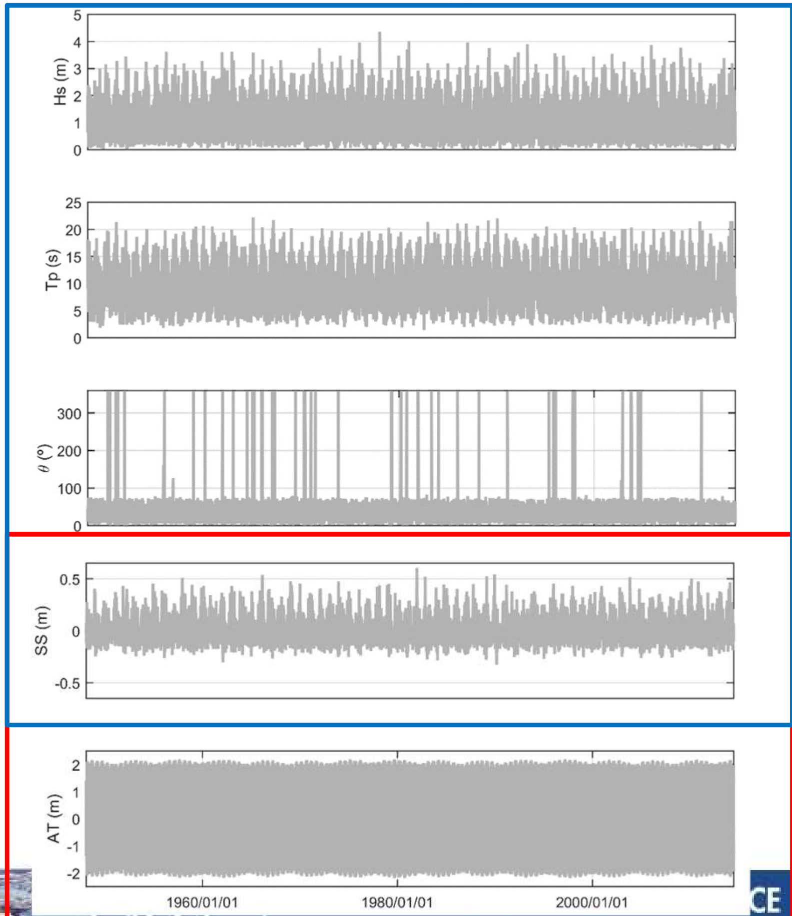


Assessment of Port Operation Downtimes Under Climate Change

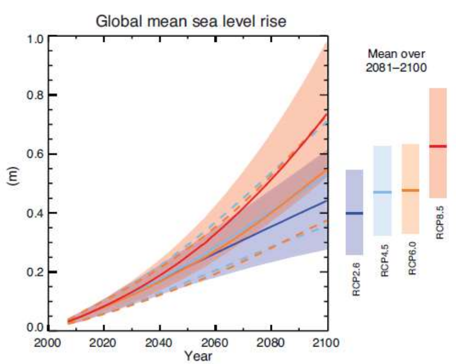




Historical Forcing Conditions



Climate Change

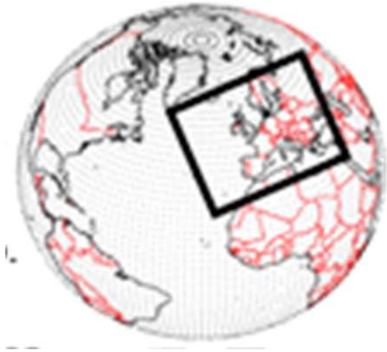


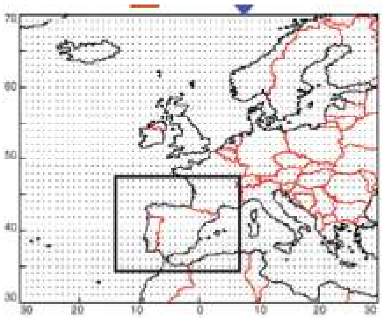
RCP Scenarios

Uncertainty

Ensemble Global Circulation Models

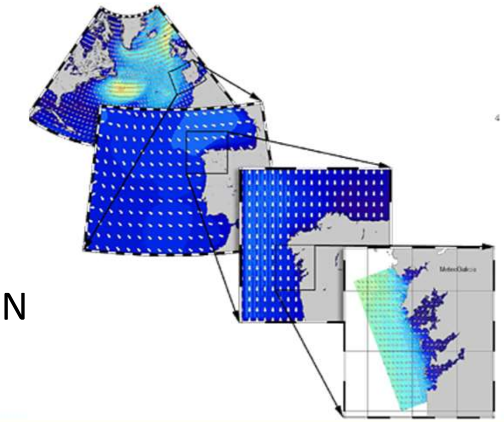
Uncertainty





Ensemble Regional Circulation Models

Uncertainty



Coastal forcing models

BIAS CORRECTION

Adapted from Ranasinghe et al. (2013)

Assessment of Port Operability
METAMODEL

Historical Forcing Conditions
Waves: Hs, Tm, Dir
Sea Level: SS, AT

↓

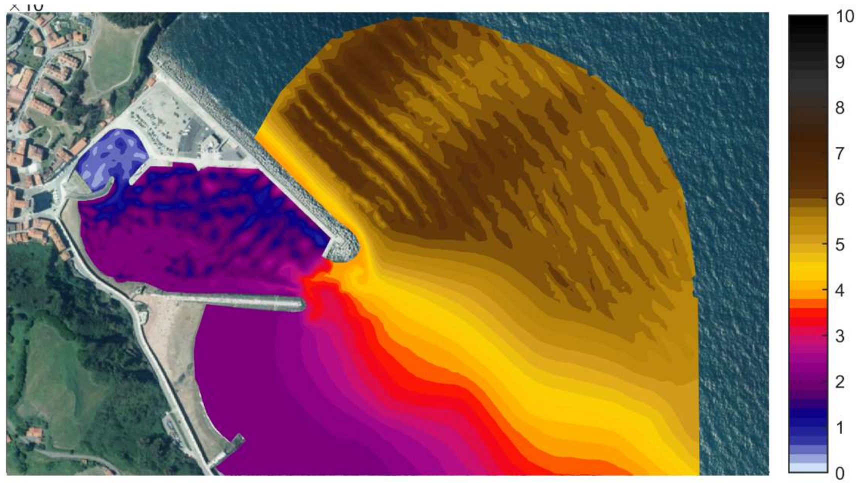
Representative Cases
(Hs, Tm, Dir, Sea Level)

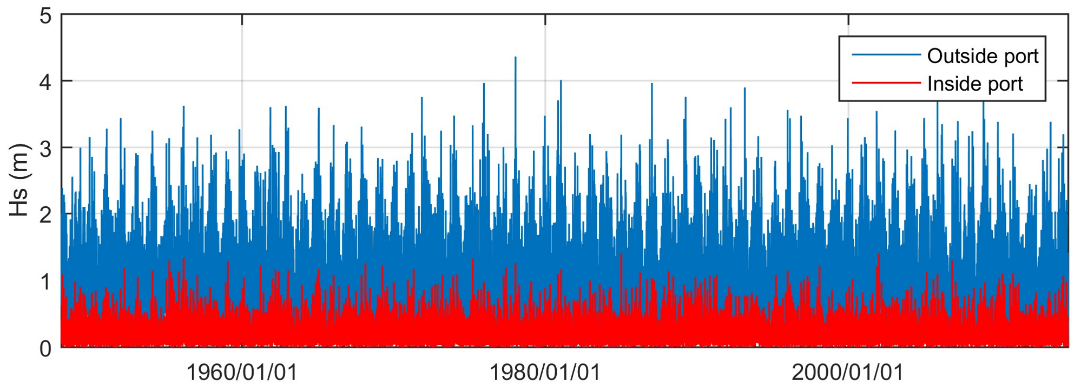
↓

Harbour Agitation Modelling
(Hs inside the harbour)

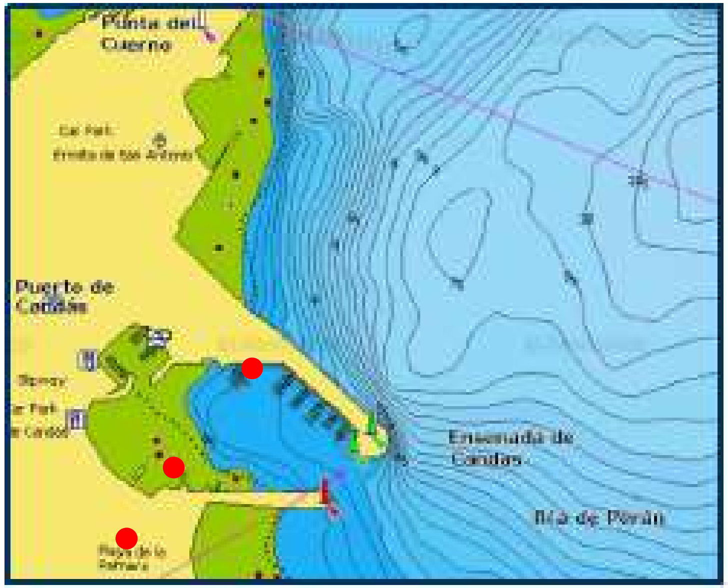
↓

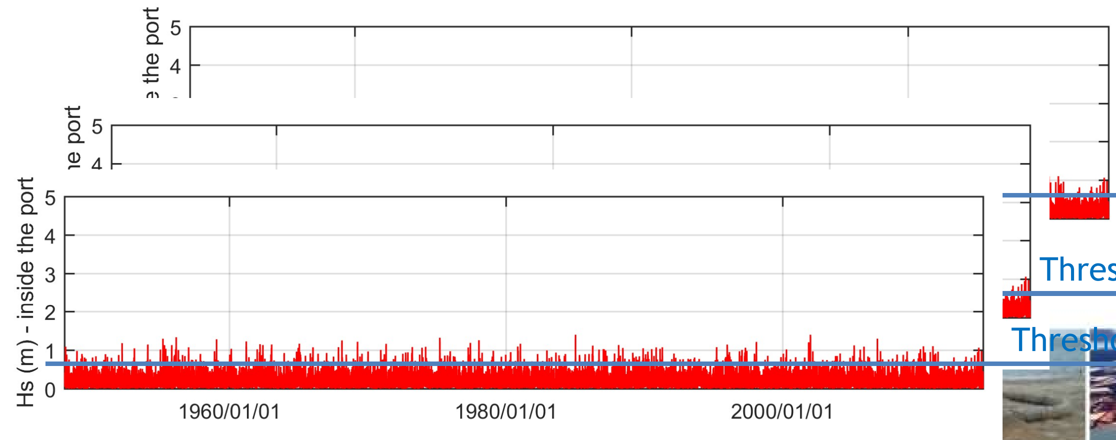
Reconstruction of Hs inside the port



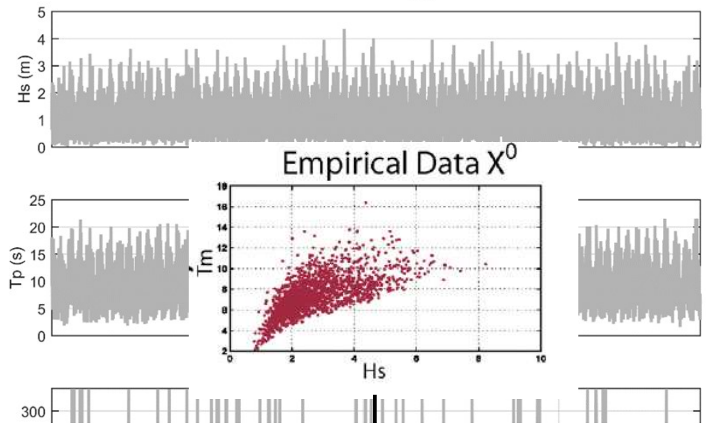


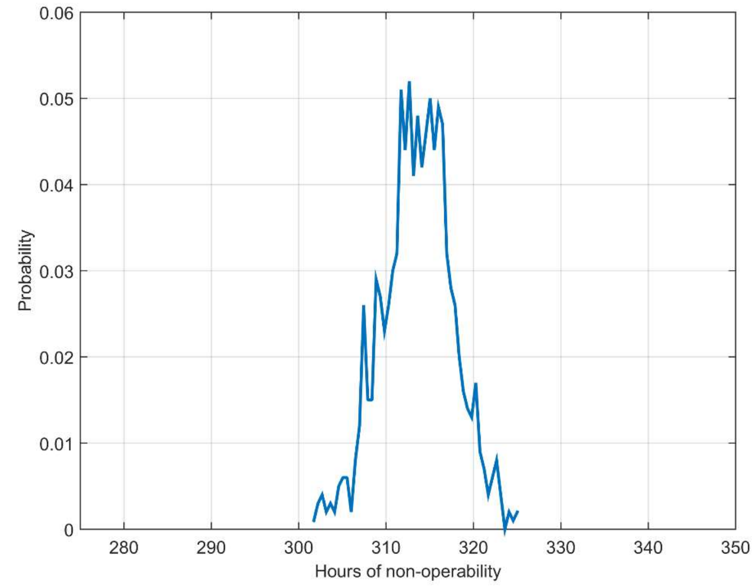
Probabilistic Assessment





Historical Forcing Conditions





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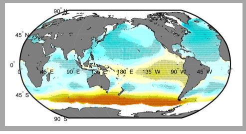
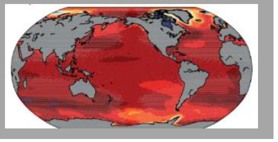
HISTORICAL CLIMATE CONDITIONS
Waves: Hs, Tm, Dir
Sea Level: SS, AT

CLIMATE CHANGE

GCM Projections
RCP Scenarios

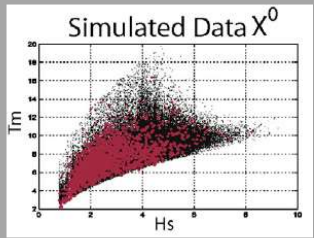


Regional SLR
RCP Scenarios



WEATHER GENERATOR

SYNTHETIC FORCING CONDITIONS
(Hs, Tm, Dir, Sea Level)



METAMODEL

SELECTION
(Hs, Tm, Dir, Sea Level)

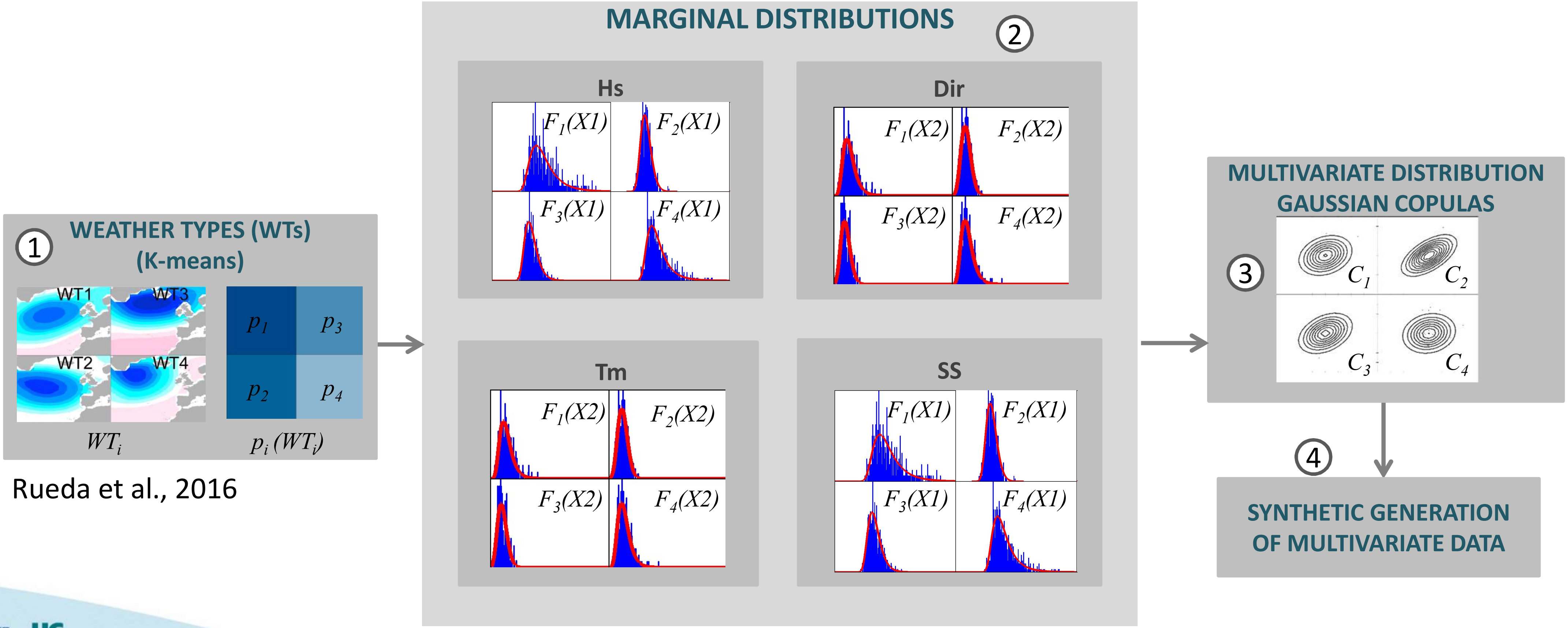
Harbour Agitation MODELLING
(Hs inside the harbour)

Multidimensional
INTERPOLATION Function

PROBABILISTIC ASSESSMENT OF PORT AGITATION
Reconstruction of Hs inside the port
for present climate

PROBABILISTIC ASSESSMENT OF CLIMATE CHANGE IMPACT ON PORT AGITATION
Reconstruction of Hs inside the port
for future climate

Probabilistic Assessment of Port Operability
WEATHER GENERATOR



Rueda et al., 2016

Probabilistic Assessment of Port Operability
METAMODEL

Synthetic Forcing Conditions
Waves: Hs, Tm, Dir
Sea Level: SS, AT

↓

SELECTION
(Hs, Tm, Dir, Sea Level)

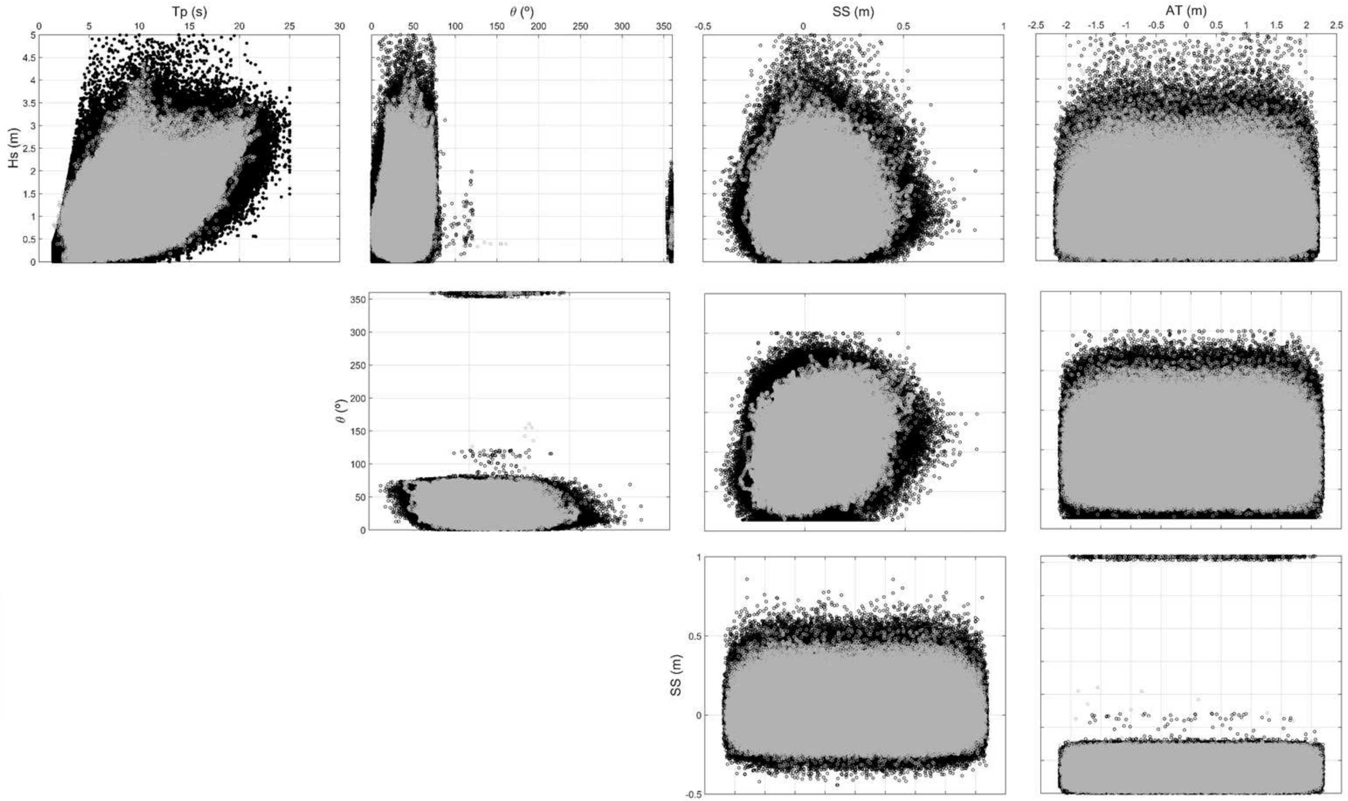
↓

Harbour Agitation Model
(Hs inside the harbour)

↓

Reconstruction of Hs inside the port
Probabilistic Assessment of Port Agitation

Camus et al., 2011



Probabilistic Assessment of Port Operability
METAMODEL

Synthetic Forcing Conditions
Waves: Hs, Tm, Dir
Sea Level: SS, AT

↓

SELECTION
(Hs, Tm, Dir, Sea Level)

↓

Harbour Agitation Model
(Hs inside the harbour)

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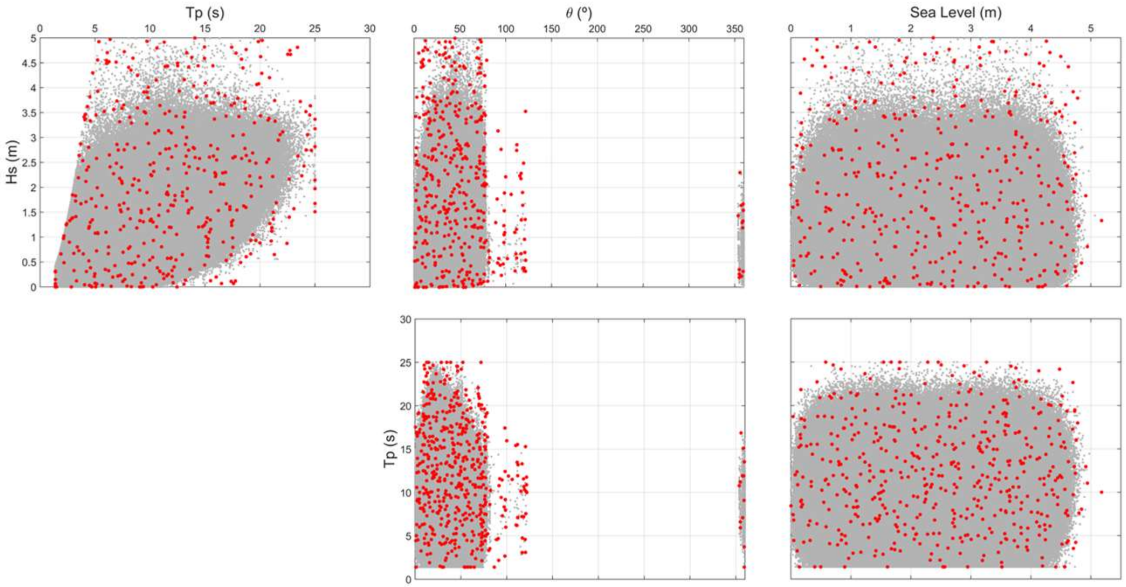
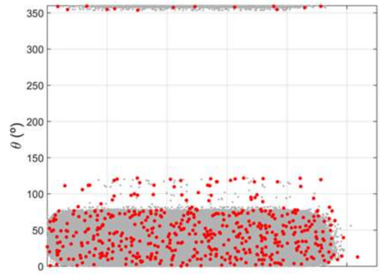
Reconstruction of Hs inside the port
Probabilistic Assessment of Port Agitation





MAXDISS algorithm

Camus et al., 2011

Probabilistic Assessment of Port Operability
METAMODEL

Synthetic Forcing Conditions
Waves: Hs, Tm, Dir
Sea Level: SS, AT

↓

SELECTION
(Hs, Tm, Dir, Sea Level)

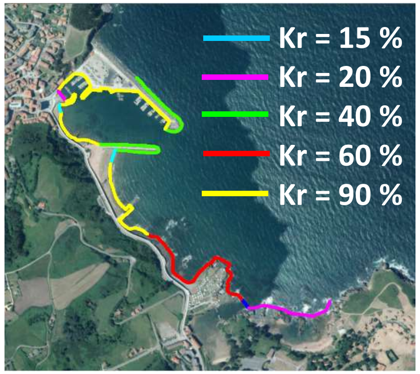
↓

Harbour Agitation Model
(Hs inside the harbour)

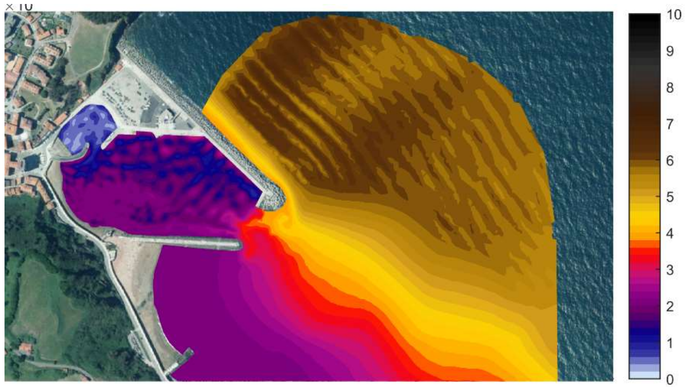
↓

Reconstruction of Hs inside the port
Probabilistic Assessment of Port Agitation

Low and mean tide



High tide



MSP: Díaz-Hernández et al., 2015

Probabilistic Assessment of Port Operability
METAMODEL

Synthetic Forcing Conditions
Waves: Hs, Tm, Dir
Sea Level: SS, AT

↓

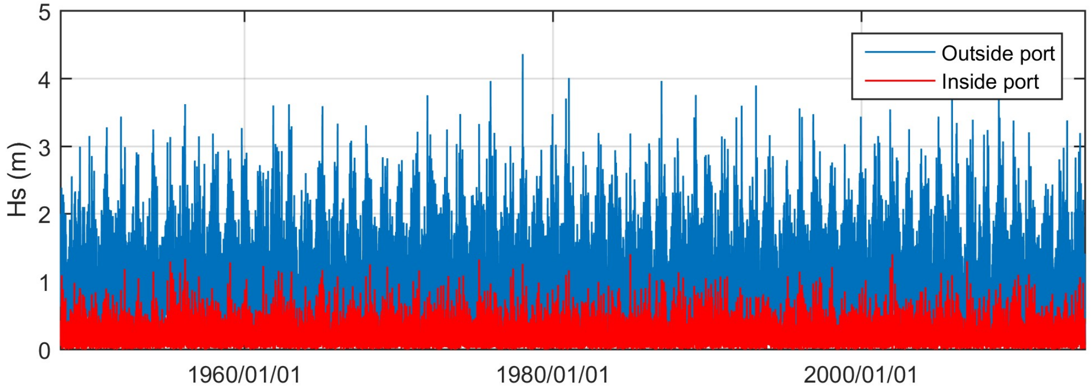
SELECTION
(Hs, Tm, Dir, Sea Level)

↓

Harbour Agitation Model
(Hs inside the harbour)

↓

Reconstruction of Hs inside the port
Probabilistic Assessment of Port Agitation



Radial Basic Functions

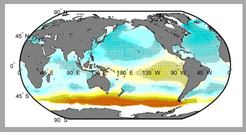
Camus et al., 2011

Climate Change

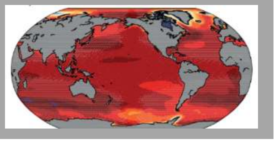
HISTORICAL FORCING CONDITIONS
Waves: Hs, Tm, Dir
Sea Level: SS, AT

CLIMATE CHANGE

GCM Projections
RCP Scenarios

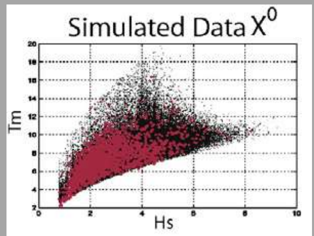


Regional SLR
RCP Scenarios



WEATHER GENERATOR

STOCHASTIC GENERATOR
Synthetic Forcing Conditions
(Hs, Tm, Dir, Sea Level)



METAMODEL

SELECTION
(Hs, Tm, Dir, Sea Level)

Harbour Agitation MODELLING
(Hs inside the harbour)

Multidimensional
INTERPOLATION Function

PROBABILISTIC ASSESSMENT OF PORT AGITATION
Reconstruction of Hs inside the port
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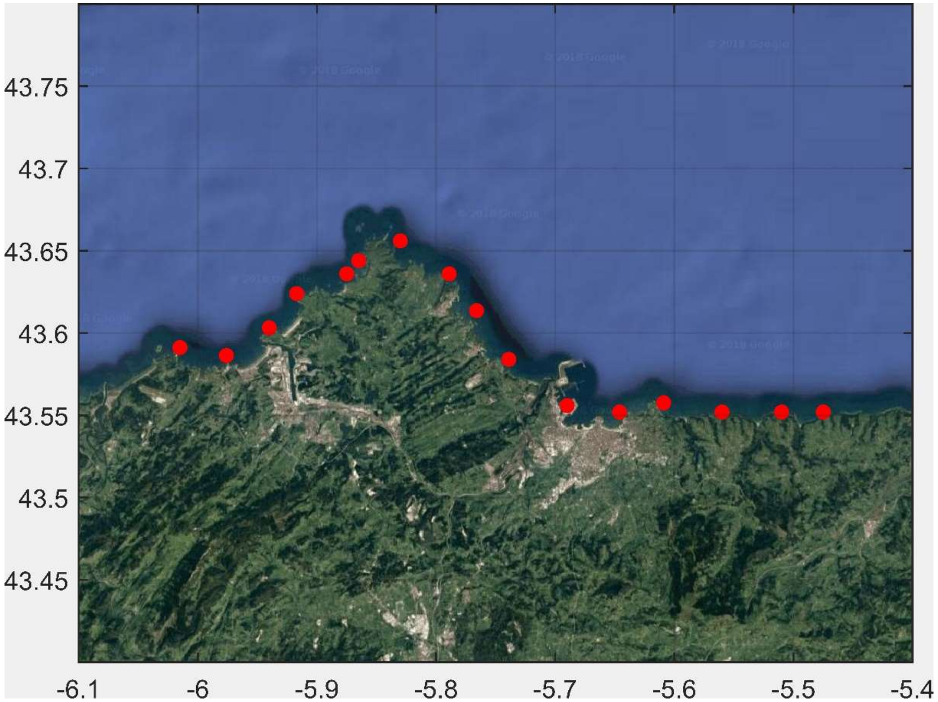
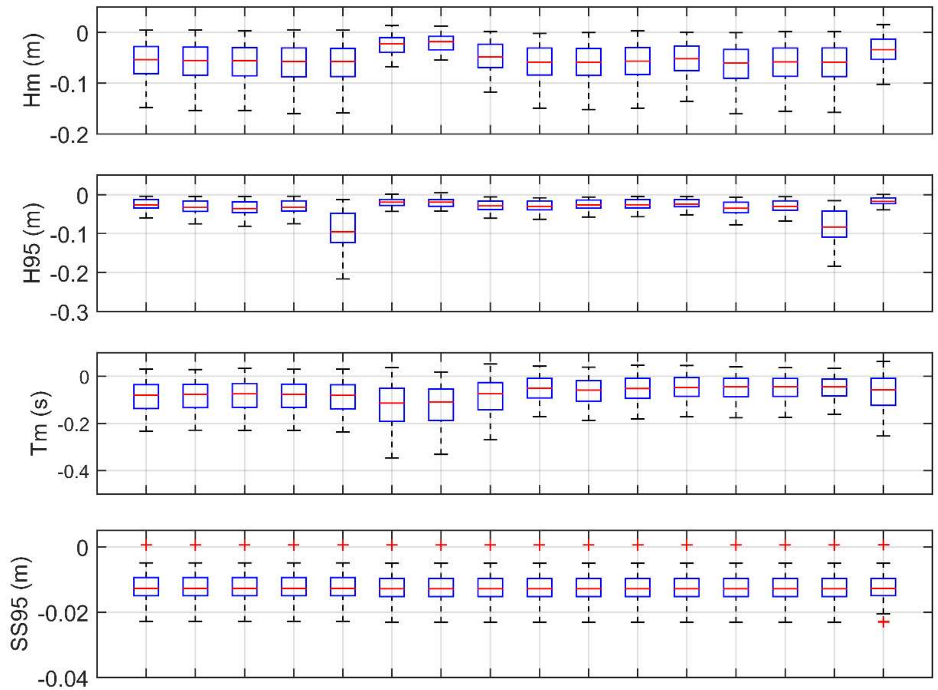
PROBABILISTIC ASSESSMENT OF CLIMATE CHANGE IMPACT ON PORT AGITATION
Reconstruction of Hs inside the port
for future climate

Climate Change
MARINE CLIMATE PROJECTIONS

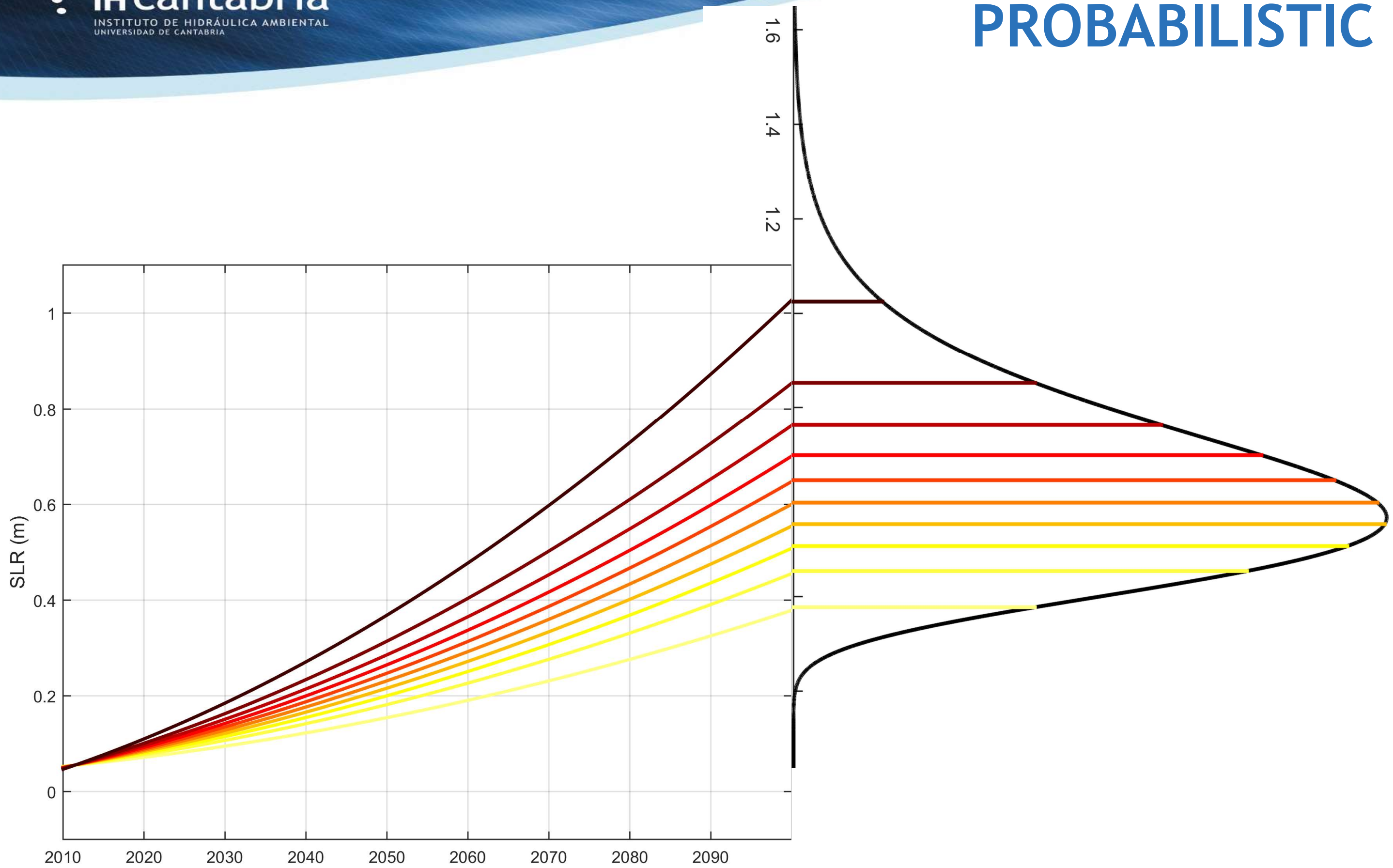
Projected wave and storm surge statistics at high resolution for RCP8.5 scenario using 40 GCMs
2071-2099 with respect to 1979-2010





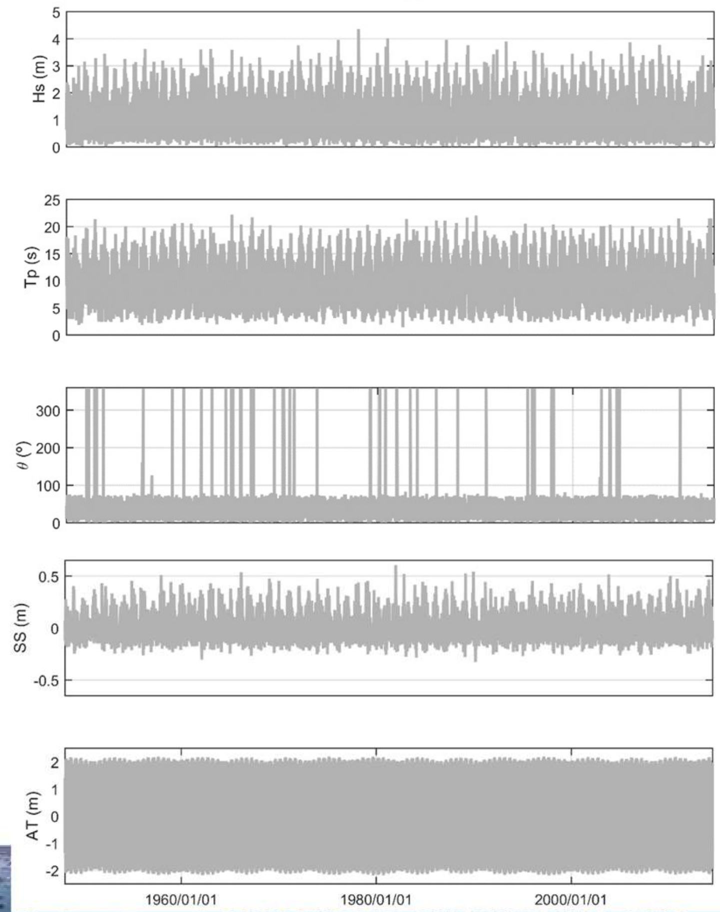
Camus et al., 2014; Pérez et al., 2015; Camus et al., 2017; Toimil et al., 2017

Climate Change
PROBABILISTIC SEA LEVEL RISE SCENARIOS



Slangen et al., 2014
RCP 8.5

Future Forcing Conditions



Probabilistic Assessment of Port Operability
METAMODEL

Synthetic Forcing Conditions
Waves: Hs, Tm, Dir
Sea Level: SS, AT

↓

SELECTION
(Hs, Tm, Dir, Sea Level)

↓

Harbour Agitation Model
(Hs inside the harbour)

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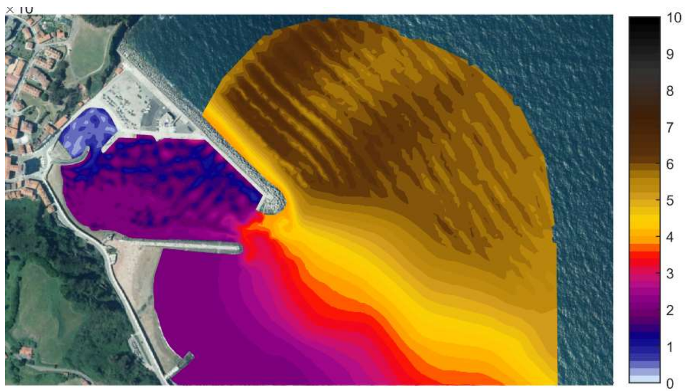
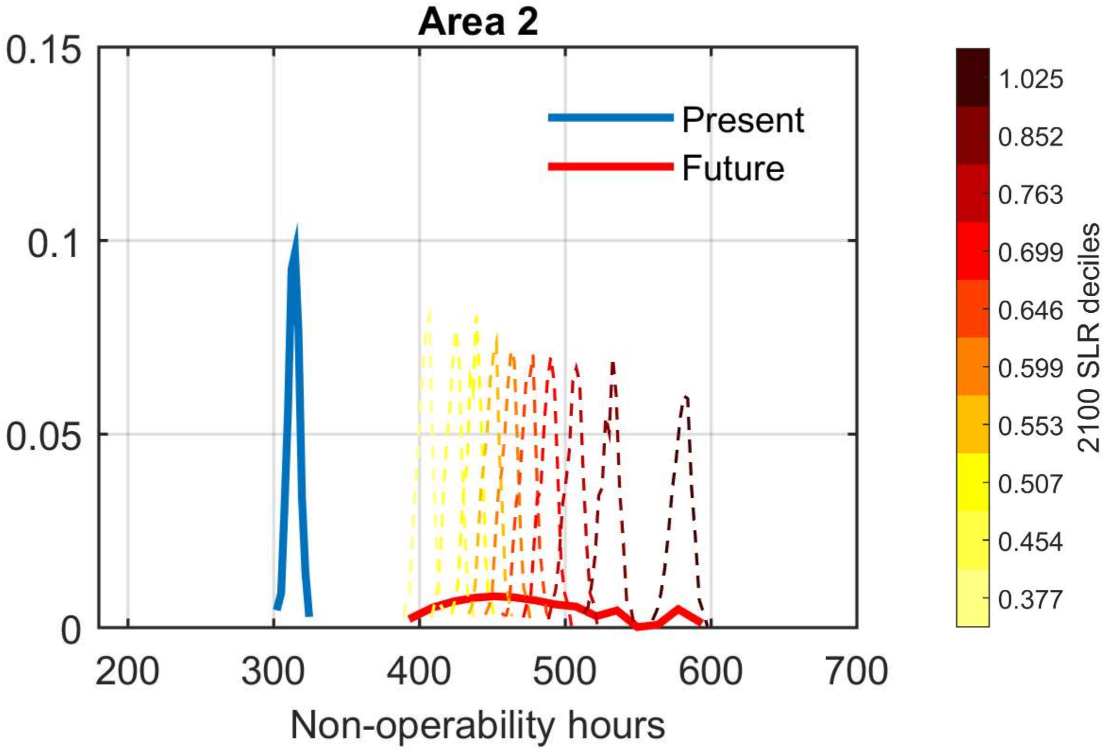
Reconstruction of Hs inside the port
Probabilistic Assessment of Port Agitation

Low and mean tide | High tide | High tide + SLR



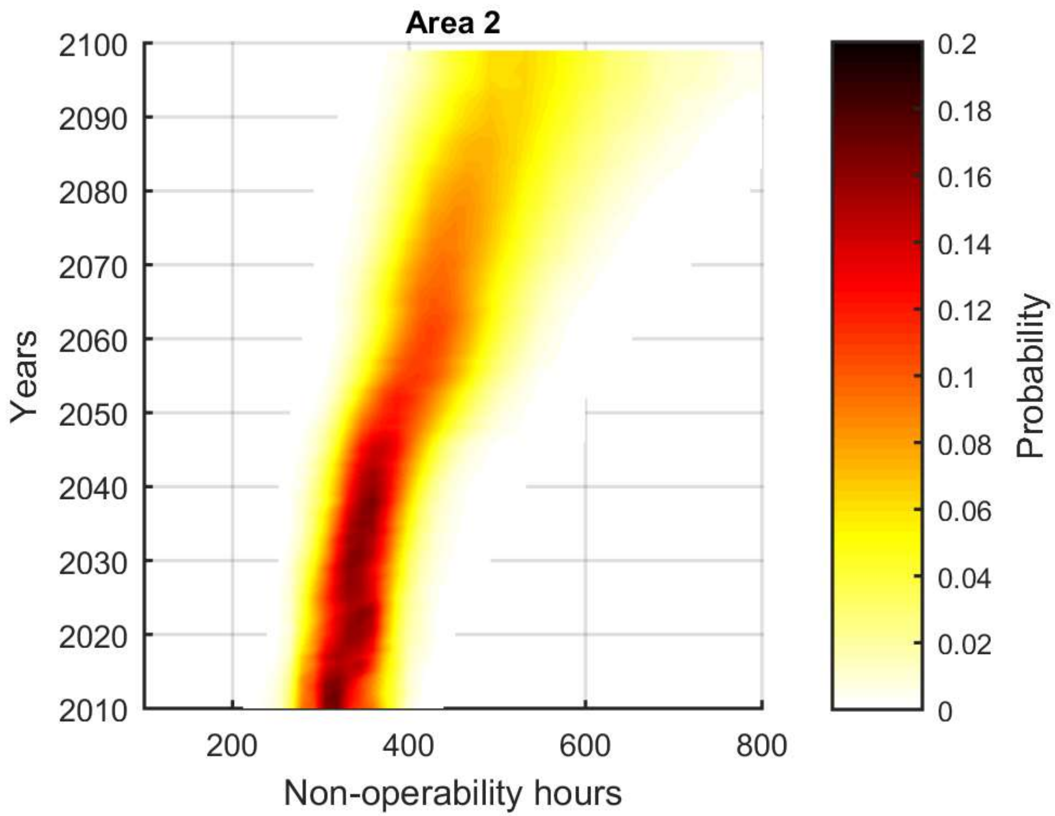
MSP: Díaz-Hernández et al., 2015

Assessment of Port Operation Downtimes Under Climate Change



Present Climate: 1960-2010
Future Climate: 2050-2100

Assessment of Port Operation Downtimes Under Climate Change



Conclusions

- A **hybrid statistical-dynamical framework** is developed to provide a **probabilistic evaluation of port operability under climate change**
- The methodology is composed of: 1) A **weather generator** which models the dependence between multivariate forcing conditions including the climate variability; 2) A **metamodel** based on a catalog of wave propagations and a multidimensional non-linear interpolation.
- **Hourly sea conditions** are transformed from the harbor entrance to **inside the port** considering the **interactions between tides, surges, waves and SLR**. **Changes in the reflection coefficient** inside the port due to SLR have been implemented in the simulation of wave agitation.
- The probabilistic assessment of port operability is expressed as the **probability distribution of non-operability hours**, including **uncertainties** associated with **marine forcing conditions** outside the port and SLR (**probabilistic scenarios**).
- Climate change induced in storminess are disregarded due to **negligible changes in waves and storm surge** in the study area.

Acknowledgments:

Project PORTIO (BIA2015-70644-R, MINECO/FEDER, UE)

Unión Europea
Fondo Europeo de Desarrollo Regional
"Una manera de hacer Europa"

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