Future changes in joint waves and storm surge events in the Mediterranean Sea

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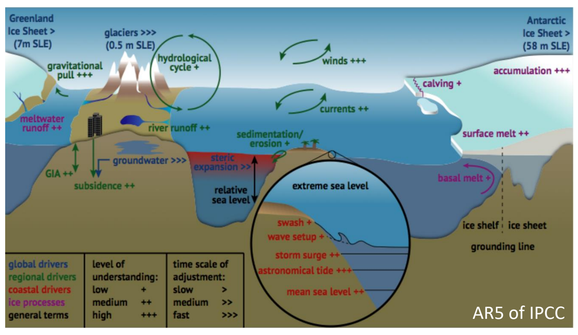
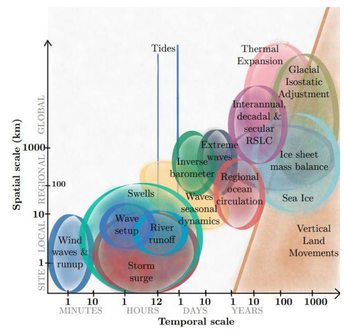
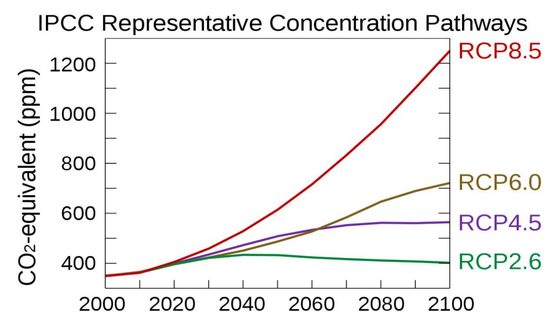
Introduction

The aim of the work is to investigate the Extreme Sea Levels along the entire Mediterranean coastline and make a comparison between past conditions and future projections caused by the climate change. Extreme Sea Levels are the result of several components: tidal excursion, wind waves and storm surge, the latter two strongly influenced by the changing atmospheric conditions.
The future projections here considered, have been obtained assuming the «Business as usual scenario» (RCP8.5) proposed by the AR5 of the IPCC (2014).







Locations, datasets and projections

Four analysed location in the Mediterranean basin for which both hindcast and future datasets of wind waves and storm surge are available.

- ***Hindcast***

H_S (10 km | 1-hour)
Mentaschi et al., 2013, 2015; Cassola et al., 2016; Besio et al., 2016
- U, V - DICCA downscaling (≃10 km)

Ss (unstructured | 6-hour)
Vousdoukas et al.,2018
- CFSR (Climate Forecast System Reanalysis model – 50km)
- EI (ERA-Interim model - 50km)

- ***Future RCP8.5***

H_S (10 km | 3-hour)
De Leo et al., 2021 ; Lira-Loarca et al., 2021a, 2021b, 2022a, 2022b
- EURO-CORDEX (≃10 km)

Ss (unstructured| 3-hour)
Vousdoukas et al.,2018
- EC-EARTH GCM (≃ 100 km)

Hs projections (10 km – 3 hours)

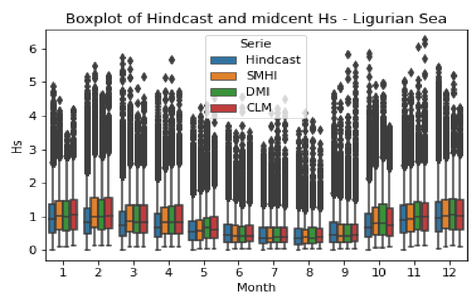
GCM	RCM
CCCma-CanESM2	CCLM4-8-18
MIROC-MIROC5	CCLM4-8-18
CNRM-CERFACS-CNRM-CM5	RCA4
IPSL-IPSL-CM5A	RCA4
MOHC-HadGEM2-ES	RCA4
MPI-M-MPI-ESM-LR	RCA4
NCC-NorESM1-M	RCA4
ICHEC-EC-EARTH	RCA4
ICHEC-EC-EARTH	HIRHAM5
NCC-NorESM1-M	HIRHAM5
MOHC-HadGEM2-ES	HIRHAM5
MPI-M-MPI-ESM-LR	HIRHAM5
IPSL-IPSL-CM5A	HIRHAM5
ICHEC-EC-EARTH	COSMO-crCLIM
NCC-NorESM1-M	COSMO-crCLIM
MOHC-HadGEM2-ES	COSMO-crCLIM

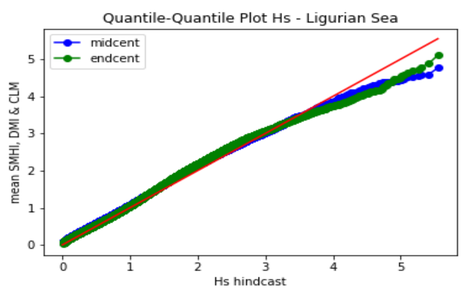
Ss projections (100 km – 3 hours)

GCM
ACCESS1-0
ACCESS1-3
CSIRO-Mk3-6-0
GFDL-ESM2M
GFDL-ESM2G
EC-EARTH

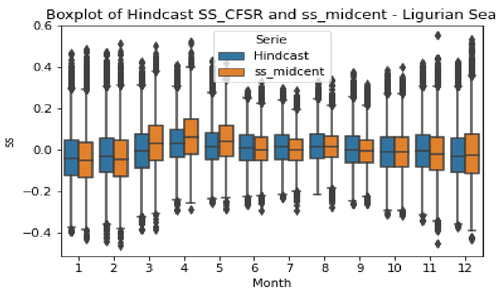
Univariate analysis

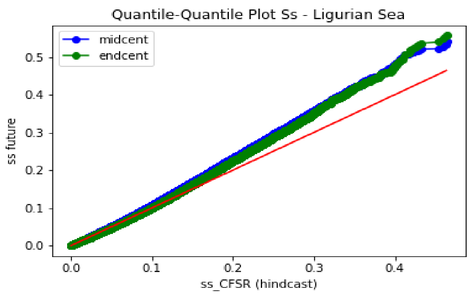
Hs





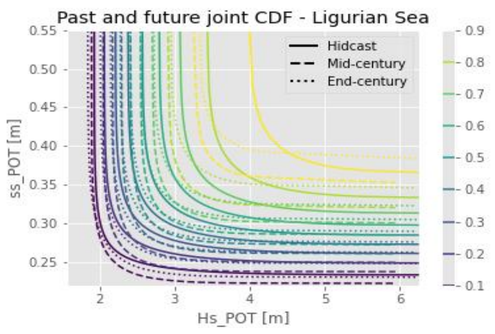
Storm Surge

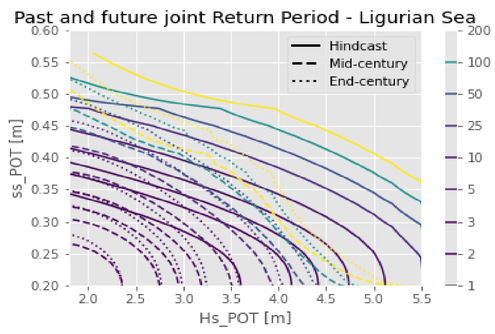




Joint analysis

The impact an extreme event has on the coast can be increased by the presence of another simultaneous extreme phenomenon: the joint analysis is therefore carried out to estimate the greatest level of hazard for the coastal environment.





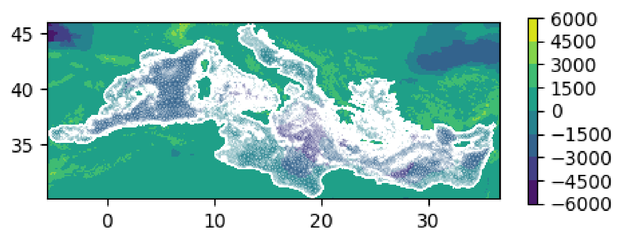
The two figures show the joint Cumulative Distribution Function CDF and the joint Return Period RT respectively of extreme events of wind waves and storm surge in one of the studied locations. For each pair of simultaneous extreme events, it is possible to estimate the probability of occurrence and the return time.

Main results

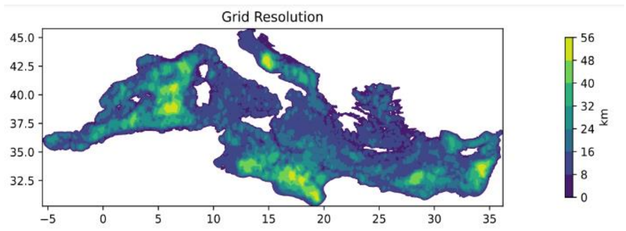
- Average values of waves are expected to grow in the future, but extreme events should become less frequent.
- Average values of storm surge are expected to decrease in the future, but extreme events should become more frequent and more intense.
- Each couple of joint Hs-ss events is associated with a higher return period in the future than in the past.
- Different modelling chains and different atmospheric inputs and resolutions strongly affect the obtained results, so the analysis can be improved using datasets obtained by the same atmospheric input with the same resolution.

Future developments

- Obtain a high-resolution storm Surge model using Delft3D Flexible Mesh. The spatial resolution is from 50 km in the open sea to 300m along the coastline, for a total of 253275 grid points.



- Develop storm surge projections for the same GCM-RCM couples of the wind waves datasets and according to the different scenarios proposed by the sixth Assessment Report of the IPCC (2022).



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