Comments for Reviewer

Dear Reviewer

Thanks again for your constrictive comments to make easier the reading of the work and clearer the different steps implemented.

Your comments suggested in the first and the second revision were very useful to put this work clearer and easy to understand. Thank you for the time spent and the interest.

As suggested in previously, the work presents preliminary results which are very promising. This approach will be strengthened and more investigated in the framework of a current PhD project related to extreme dynamics and also other european collaborations/projects

Comment 3.

Indeed, the methodology is hard to follow since we have mentioned all techniques used which is very confusing.

The idea suggested in your third comment is really excellent to make the methodological approach easier to understand.: flowchart summarizing the steps.

A figure 2 has been prepared and added in the manuscript to summarize the different steps implemented and the methods used (answer to comment 3).

Also, a detailed description related to the methodology has been added in the section 3.4

Lines 272- 312 in the new version of the manuscript (the yellow part).

3. 4 Determination of the most appropriate climate oscillation connected to each timescale extreme surges for GEV models

As suggested previously, the main hypothesis presented in this research is that effects of the physical mechanisms on the extreme surges vary according to the timescale and each scale should be related to a given climate oscillation.

This hypothesis has been investigated by two approaches:

(1) a spectral approach based on the use of wavelet techniques (wavelet multiresolution and wavelet coherence as detailed in section 3.2) for optimizing the physical relationship between the climate index and the extreme surges at each timescale.

The Bootstrap is a resampling technique used to estimate the sampling distribution of an estimator of sample statistics by drawing randomly with replacement from a set of data points.

Here, a bootstrap approach has been applied to assess the statistical significance of the correlation between the spectral component of the extreme surges and the climate oscillation at each timescale. By resampling the timeseries 10.000 times, the extreme surges have been simulated and compared to the original records; the 95% confidence intervals have been considered to extract the best climate information fitting the extreme surges (Villarini et al., 2009).

(2) a Bayesian estimation has been used to make inferences from the Likelihood function. The reason behind the choice of this approach is overcoming the limitation of short time-series with small size, the case of Weymouth station where the measurements covers the period from 1991 and 2018. A technique of Markov Chain Monte Carlo (MCMC), implemented in the evbayes package within R software, has been used basing on multiple simulations (the number of simulations is varying as a function of the length of the timeseries).

For each spectral component, a sample of 100.000 simulations has been modelled by GEV using a given climate index. The upper and lower quantiles of the posterior probability distribution for the parameters of the MCMC sample are taken. The goodness of fit has been taken as a function of the values of the upper and the lower quantiles; best results have been considered when these values are higher than 92.5% and lower than 5.2%, respectively.

Both approaches have been used to select the most appropriate atmospheric physical mechanism to each timescale of extreme surges. Then and at each timescale (i.e. spectral component), the selected mechanism (i.e. the climate oscillation in this case) has been used as covariate for modelling the extreme surge by nonstationary the implemented GEV models. The best use of the covariate into the different GEV parameters (location, scale and shape) have been investigated by means of AIC criterion.

Once the best GEV models defined for each time scale, a series of simulations have been carried out to compare modelled and observed surges.

This Bayesian inference has been also used to calculate: (1) the return levels of the nonstationary simulated surges which were compared to those of the observed ones; (2) the confidence interval (CI) assessing the goodness of this comparison.

Figure 2 summarizes the methodological approach proposed in the present research and the different steps implemented. The statistical methods used to resolve each step are also synthetized in this figure.

Figure 2. A summary of the methodological approach implemented in this research.

HYPOTHESES:

1. Effects of the atmospheric physical mechanisms on the extreme surges vary according to a given timescale.

2. Each timescale should be related to a given climate oscillation.

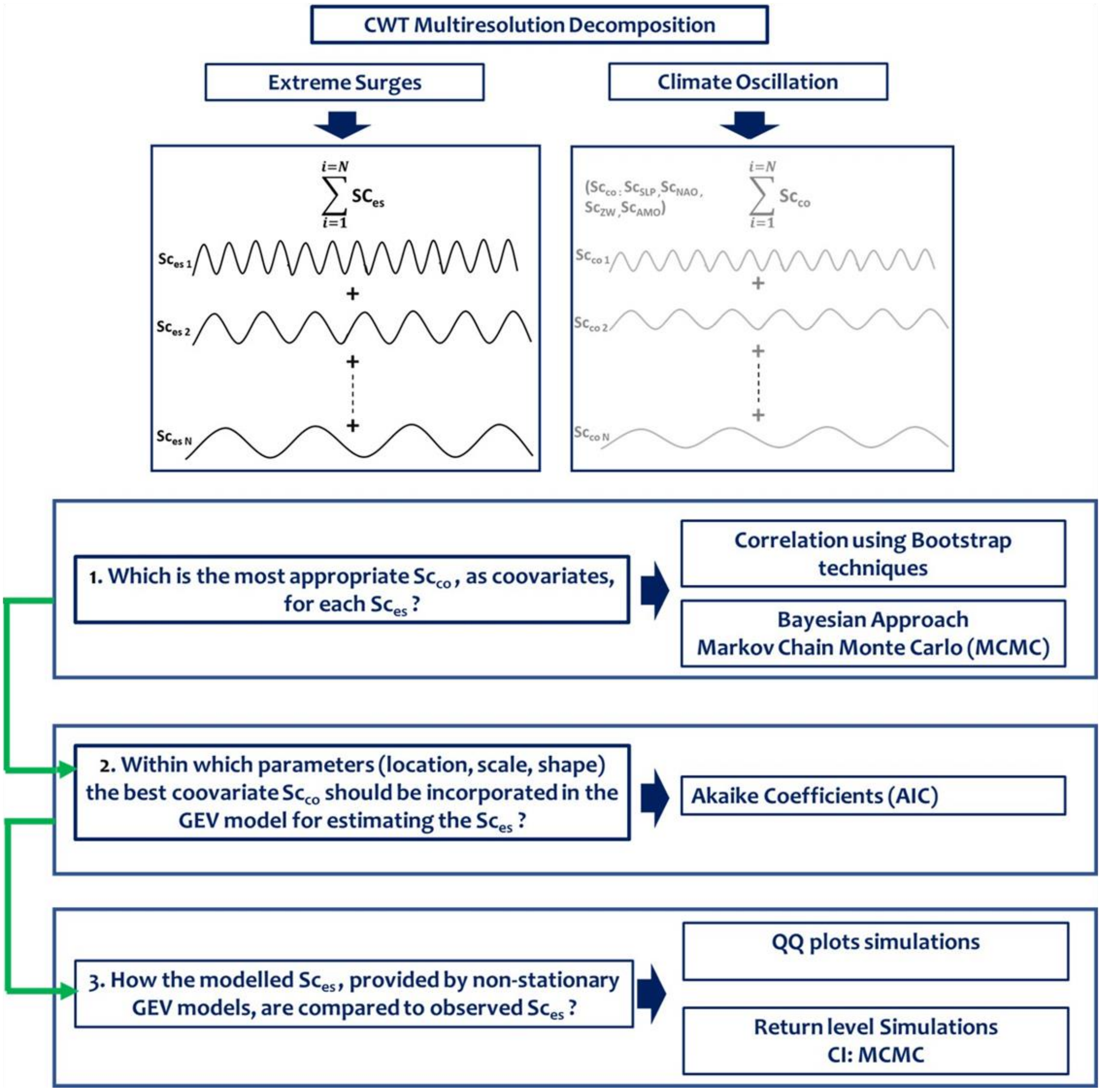

Figure 2. A summary of the methodological approach implemented in this research.

Comment 2.

The values extracted from the bootstrap technique have been double checked. We are very sorry for the inversion of the upper and lower interval for Weymouth (error when we have imported the values to the table). The corrected results are shown in Table 3.

Table 3 Analysis of the statistical significance of the correlation between the spectral component of the extreme surges and the climate oscillation at each timescale for the different stations. The 95% Confidence Intervals of the maximum values from Bootstrap technique in Square Brackets. The most significant correlations, shown by the most limited (smaller) 95% CI between the lower and the upper bounds, are illustrated by the grey columns.

~ 1.5-yr	**SLP**	**ZW**	**NAO**	**AMO**
Brest	**[0.152, 0.174]**	**[0.140, 0.182]**	**[0.141, 0.178]**	**[0.128, 0.189]**
Cherbourg	**[0.154, 0.170]**	**[0.142, 0.179]**	**[0.142, 0.186]**	**[0.115, 0.180]**
Dunkirk	**[0.151, 0.168]**	**[0.150, 0.185]**	**[0.145, 0.178]**	**[0.115, 0.183]**
Dover	**[0.155, 0.175]**	**[0.141, 0.180]**	**[0.145, 0.180]**	**[0.110, 0.180]**
Weymouth	**[0.411, 0.432]**	**[0.400, 0.445]**	**[0.299, 0.341]**	**[0.281, 0.375]**
~ 2-4-yr				
Brest	**[0.144, 0.175]**	**[0.149, 0.167]**	**[0.141, 0.179]**	**[0.138, 0.183]**
Cherbourg	**[0.163, 0.197]**	**[0.177, 0.196]**	**[0.146, 0.179]**	**[0.148, 0.195]**
Dunkirk	**[0.161, 0.185]**	**[0.168, 0.185]**	**[0.145, 0.179]**	**[0.140, 0.188]**
Dover	**[0.165, 0.195]**	**[0.175, 0.198]**	**[0.145, 0.168]**	**[0.143, 0.185]**
Weymouth	**[0.412, 0.437]**	**[0.417, 0.432]**	**[0.410, 0.439]**	**[0.405, 0.445]**
~ 5-8-yr				
Brest	**[0.075, 0.091]**	**[0.073, 0.092]**	**[0.080, 0.089]**	**[0.070, 0.091]**
Cherbourg	**[0.176, 0.198]**	**[0.185, 0.198]**	**[0.190, 0.196]**	**[0.179, 0.198]**
Dunkirk	**[0.175, 0.198]**	**[0.175, 0.185]**	**[0.181, 0.188]**	**[0.175, 0.197]**
Dover	**[0.178, 0.195]**	**[0.180, 0.192]**	**[0.180, 0.188]**	**[0.176, 0.199]**
Weymouth	**[0.210, 0.225]**	**[0.215, 0.225]**	**[0.220, 0.226]**	**[0.210, 0.232]**
~ 12-16-yr				
Brest	**[0.037, 0.046]**	**[0.034, 0.045]**	**[0.035, 0.045]**	**[0.037, 0.042]**
Cherbourg	**[0.089, 0,099]**	**[0.090, 0,099]**	**[0.090, 0,098]**	**[0.092, 0,096]**
Dunkirk	**[0.087, 0.099]**	**[0.089, 0.098]**	**[0.090, 0.098]**	**[0.092, 0.096]**
Dover	**[0.078, 0.089]**	**[0.080, 0.089]**	**[0.079, 0.087]**	**[0.083, 0.087]**
Weymouth				

As suggested in the title, the 95% CI of the maximum values, provided by this technique, have been calculated. We present the lower and the upper bounds.
The width of 95% CI (difference between lower and upper bound) varies according the timescale and its connection with the climate oscillation.
As suggested by the reviewer, detailed descriptions and interpretations have been added

Lines 472-502 in the new version of the manuscript (yellow part)

For each timescale, a bootstrap approach has been applied to assess the statistical significance of the correlation between the spectral component of the extreme surges and the climate oscillation. By resampling the timeseries 10.000 times, 95% confidence intervals (CI) have been considered to extract the best climate information fitting the extreme surges (Villarini et al., 2009).

Results of 95% CI, applied to the maximum values and provided by the bootstrap technique, for the different possible connections between a given scale of extreme surges and a climate oscillation, extracted at the scale timescale of extreme surges, are illustrated in Table 3. For each connection, the lower and the upper bounds of the 95% CI, calculated for the maximum values, are calculated (values in the square brackets in Table 3). The width of CI between both bounds reveals the statistical significance of the simulations and the goodness of the correlations. According to these results, the width of CI is important for the small timescales (high frequencies of ~ 1.5-yr and ~ 2-4 yr) with a mean of 0.05 and a maximum of 0.09. It decreases for the large timescales (low frequencies of ~ 5-8-yr and ~ 12-16-yr) to 0.012 and 0.022 of mean and maximum values, respectively.

The smallest widths are observed for the connection between ~ 1.5 -yr extreme surges and SLP; ~ 2-4 -yr extreme surges and ZW; ~ 5-8 -yr extreme surges and NAO; ~ 12-16 -yr extreme surges and AMO (grey columns in Table 3). For the large timescales (low frequencies), small widths (lower than the mean value 0.012) are also observed with other climate oscillations, different from the most appropriate one showing the most significant correlation with extreme surges. For these scales, the variability of extreme surges is mainly controlled by a given physical mechanism, related a climate oscillation, and partly affected by the contribution of other oscillations which could interact with the different large driven forces. Such interaction between the different climate oscillations has been also pointed from Table 2.

Table 3 Analysis of the statistical significance of the correlation between the spectral component of the extreme surges and the climate oscillation at each timescale for the different stations. The 95% Confidence Intervals (applied for the maximum values) from Bootstrap technique in Square Brackets. The most significant correlations, shown by the most limited (smaller) 95% CI between the lower and the upper bounds, are illustrated by the grey columns. The lowest frequency of ~ 12-16-yr is not observed in Weymouth.

Comment 3.

Thank you for this comment. Effectively many implementations for applying the same approach is very confusing.

This part has been clarified in the new version of the manuscript.

We focus only on the use of the Bayesian approach for defining the best climate covariate of each time scale and also for calculating the return levels.

Lines 306-308 of the new version:

This Bayesian inference has been also used to calculate: (1) the return levels of the nonstationary simulated surges which were compared to those of the observed ones; (2) the confidence interval (CI) assessing the goodness of this comparison.

This point has been also illustrated in the Figure 2.