Multi-scale Sea Level Dynamics of English Channel Coasts

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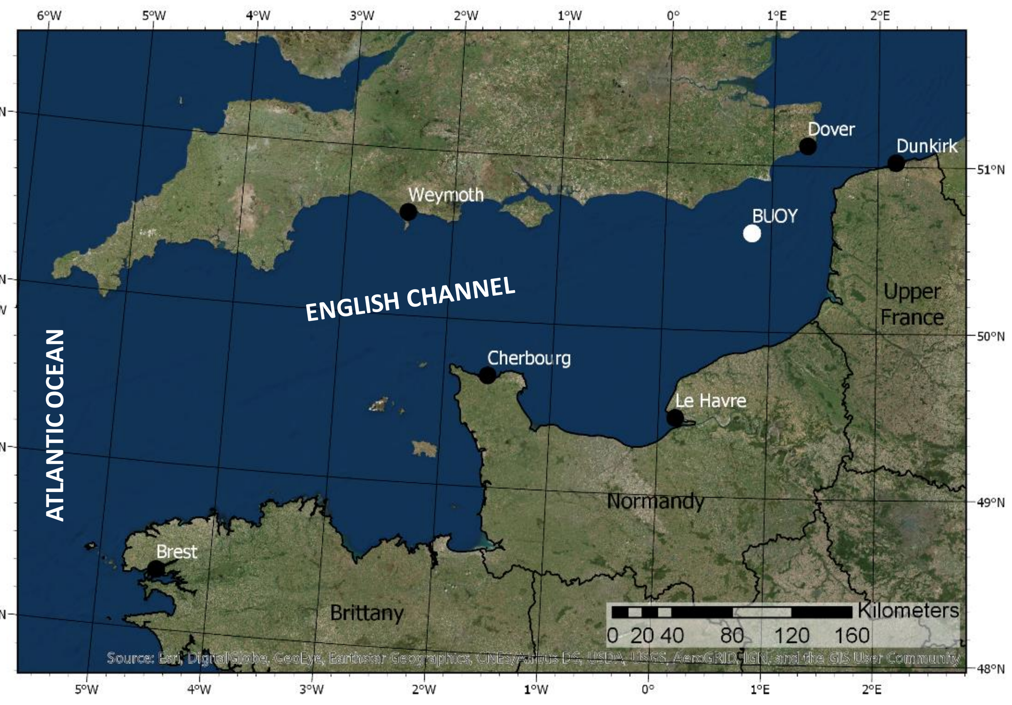
Motivations

Sea level and storm dynamics are considered the main cause for changes of coastal systems. In the context of increased coastal hazards due to variability in storminess patterns, the danger of coastal damages and/or morphological changes is related mainly to the sea level conditions and storm surges.

Investigate the nonstationary behavior of the sea level within the English Channel , from French to Britannic coasts, and seek to make its connection to the climate patterns at different time scales represent the main purposes of this work.

English Channel (Fig. 1) represents a sleeve-like shallow sea between Northern France and South England, connecting Atlantic Ocean to North Sea. A megaflood due to melting of retreating glaciers in the southern North Sea geographically separated Britain from Europe and formed English Channel at the last Quarternary Period (Collier et al. 2015).



Methodological Approach

Sea level signal has been filtered from the tidal modulation and surges have been obtained once the mean sea level trend and the harmonic components were removed.

Envelope technique has been applied to the signal of surges (non-tidal timeseries). The envelope identification depends on extrema detection followed by a low-pass filter. The envelopes of real signals are obtained using a spline interpolation from extrema sequences, as used for instance in the empirical mode decomposition (Turki et al., 2019).

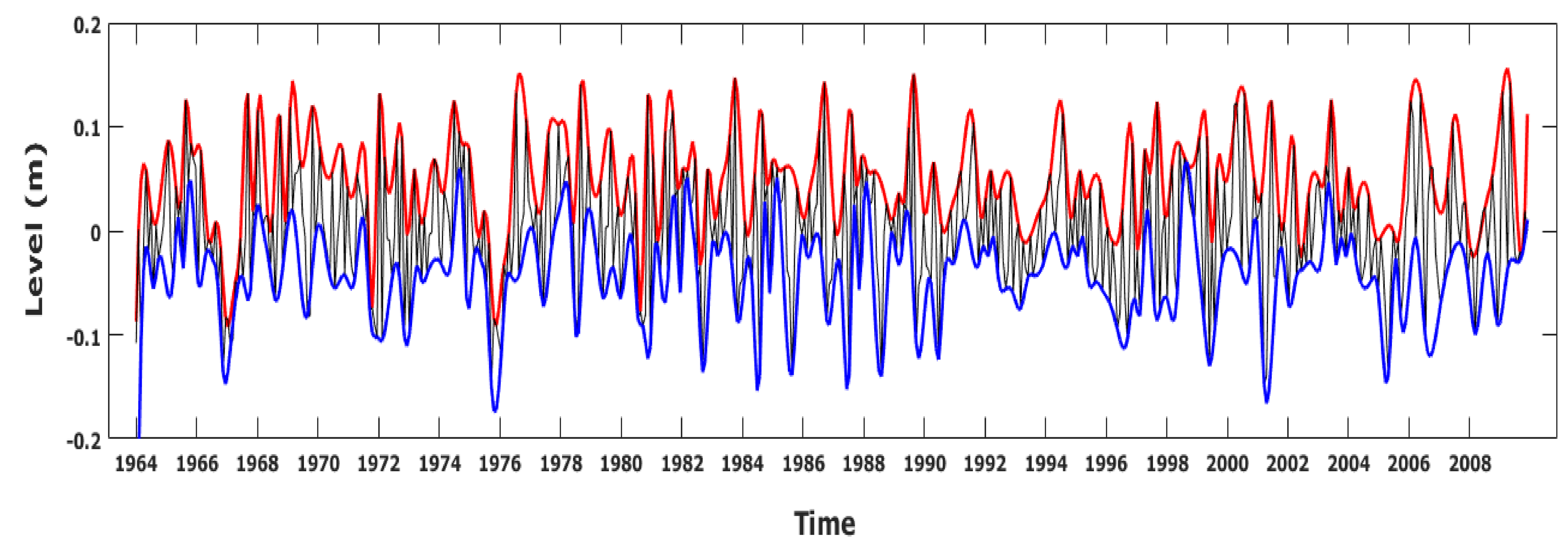


Fig 2. Envelope technique to calculate the ***demodulated signal****: the maxima (red line) and the minima (blue line) envelopes of the mean monthly surges (black line) .*

Spectral approach has been applied to the demodulated signals by the use of the continuous wavelet transform (CWT), with the aim to explore the spectral content of the oceanographic signals. Typical scales of variability of each time series were thus detected and a first comparison of time-scale patterns identified in each variable was undertaken. **CWT** produces a time-scale contour diagram on which time is indicated on the x-axis, period or scale on the y-axis and amplitude (or variance) on the z-axis.

Multiresolution analysis into different internal components of surges corresponding to different time-scales has been used with the aim to separate into a relatively small number of wavelet components from high to low frequencies that altogether explain the variability of the signal, as this will be illustrated later using sea level time series. Similar techniques have been used by Massei et al.,(2017) and Turki et al., (2019).

Nonstationary Sea Level Dynamics

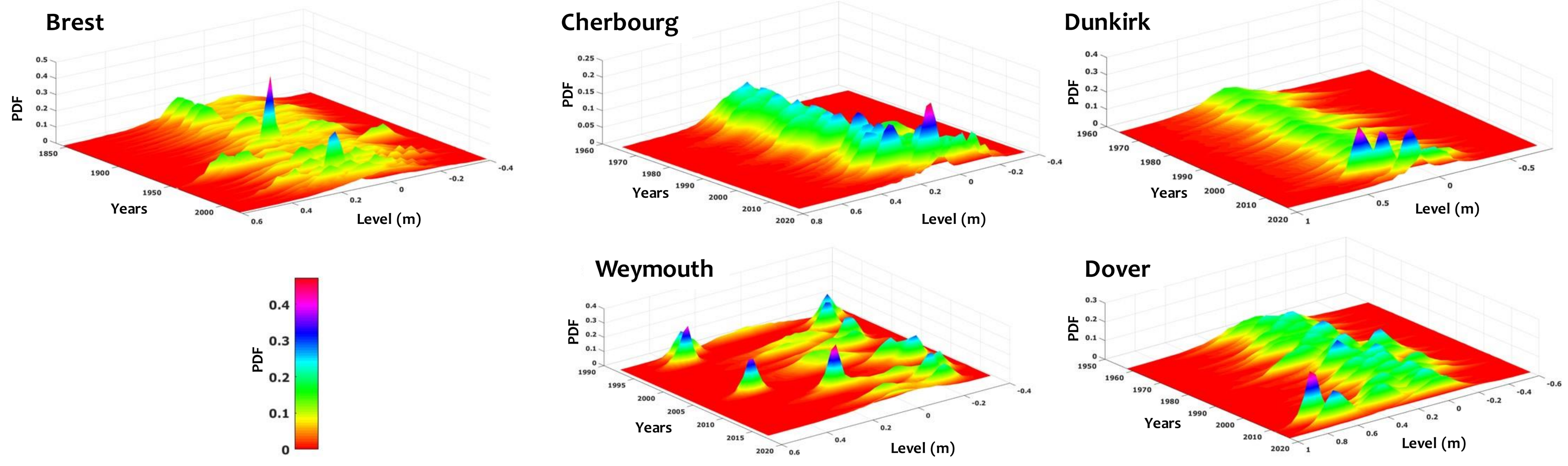


Fig 3. Annual Distribution of the probability density function (PDF) of surges. The distribution domain of changes varies between years and stations. Surges show a non-uniform multi-scale variability significantly in time. This behavior proves a non-stationary dynamics of sea level depending on the time scales

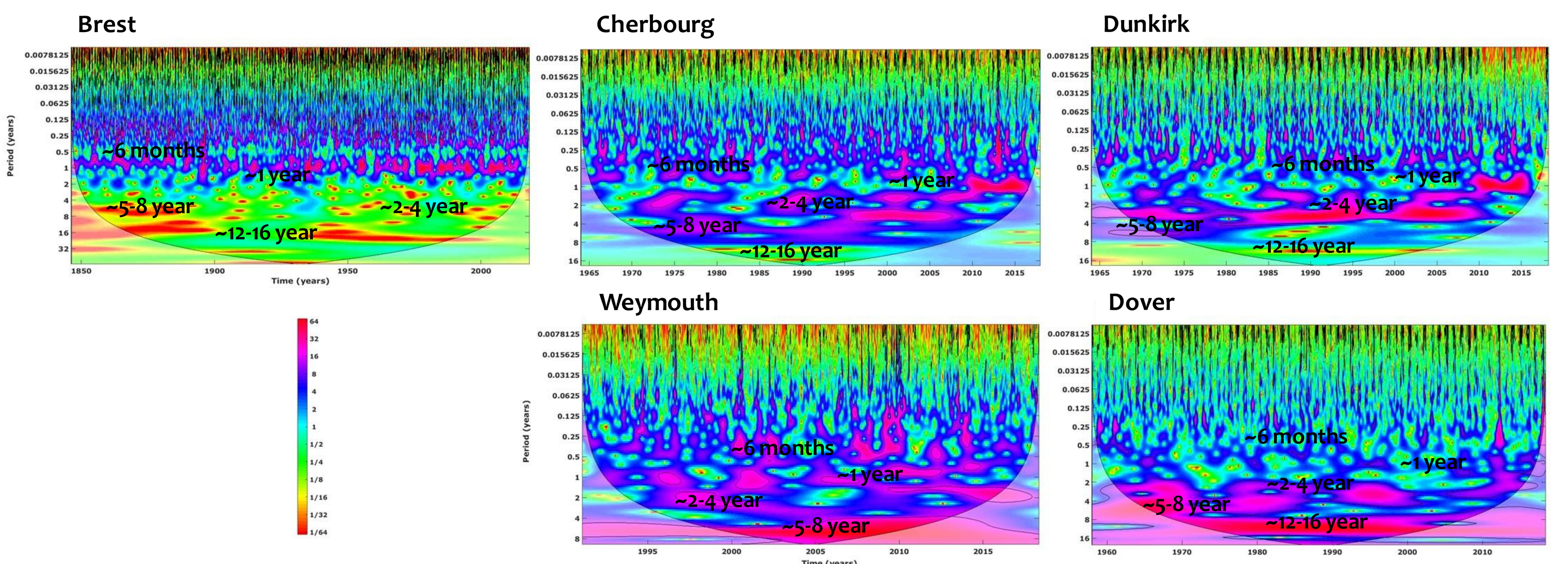


Fig 4. CWT of surges showing the changes of the different spectral variance at intermonthly (~3-6 months), interannual (~1-y; ~2-4-y; ~5-8-y) and interdecadal (~ 12-16-y) time scales. The behaviour changes depending on the frequency component and the station.

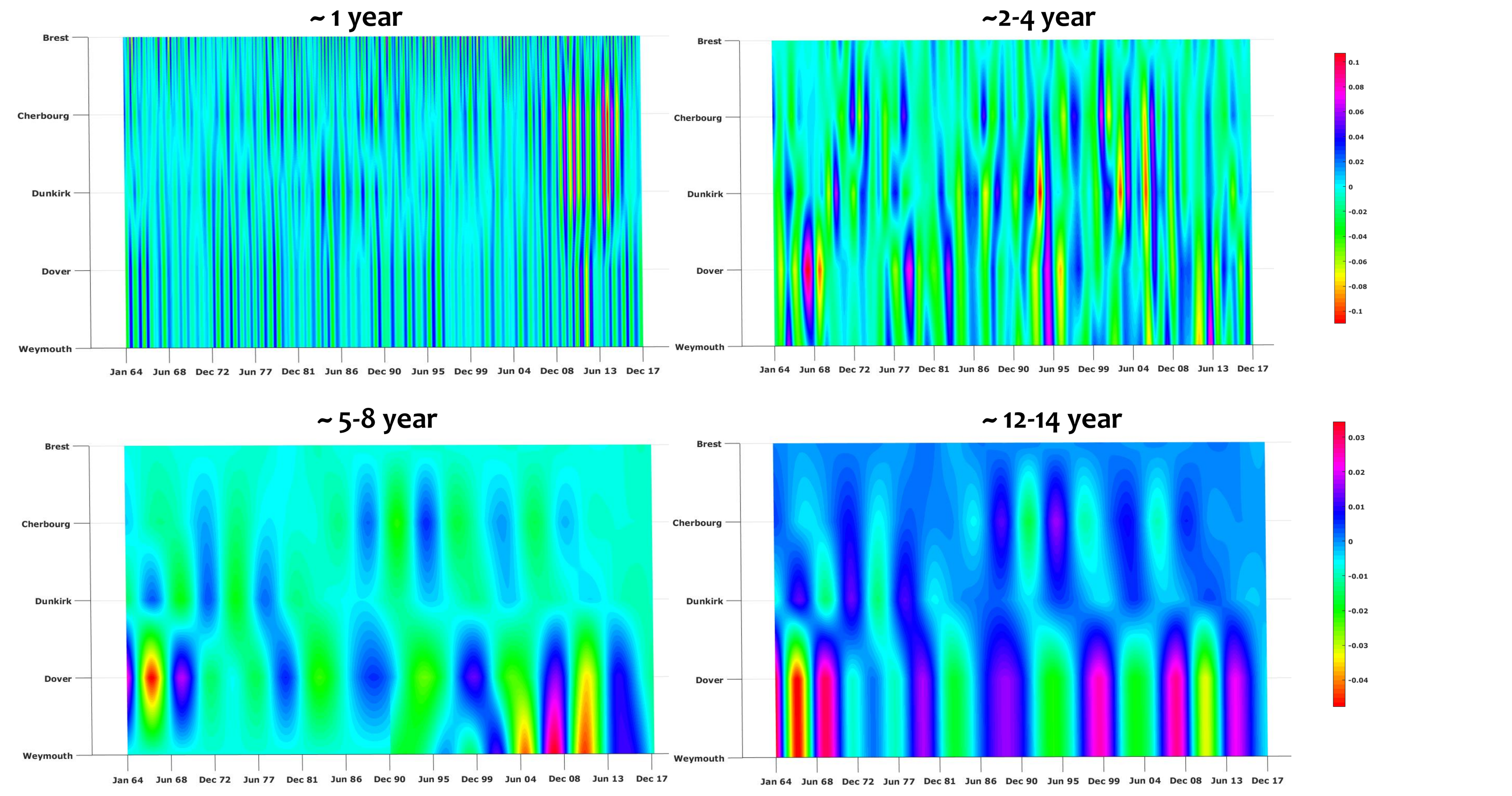


Fig 4. Multiresolution decomposition of surges showing the multi-scale variability from the interannual to the multidecadal scales.

Multi-scale sea level dynamics with Climate patterns

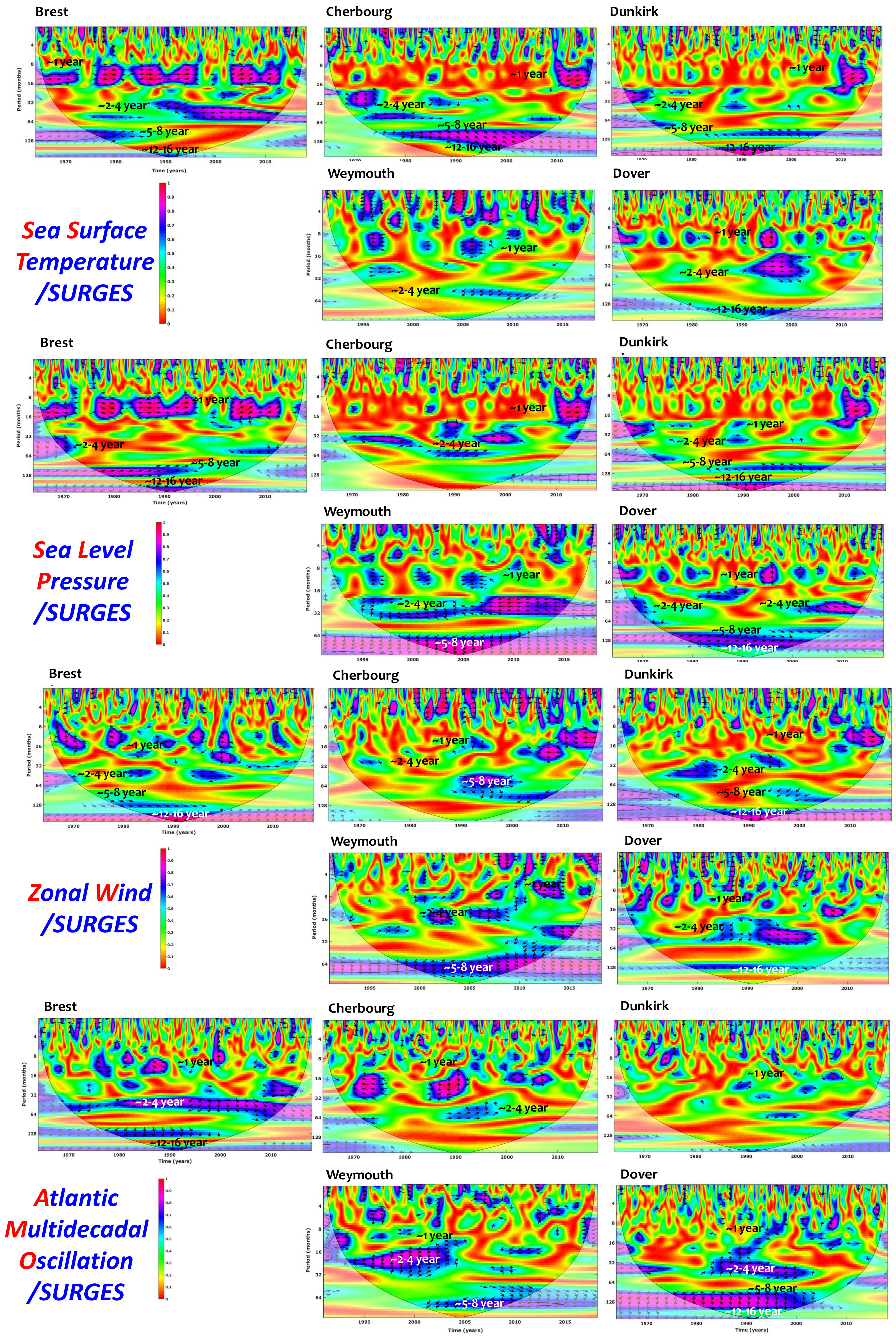


Fig 5. Cross-correlation wavelet diagrams between surges and climate patterns.

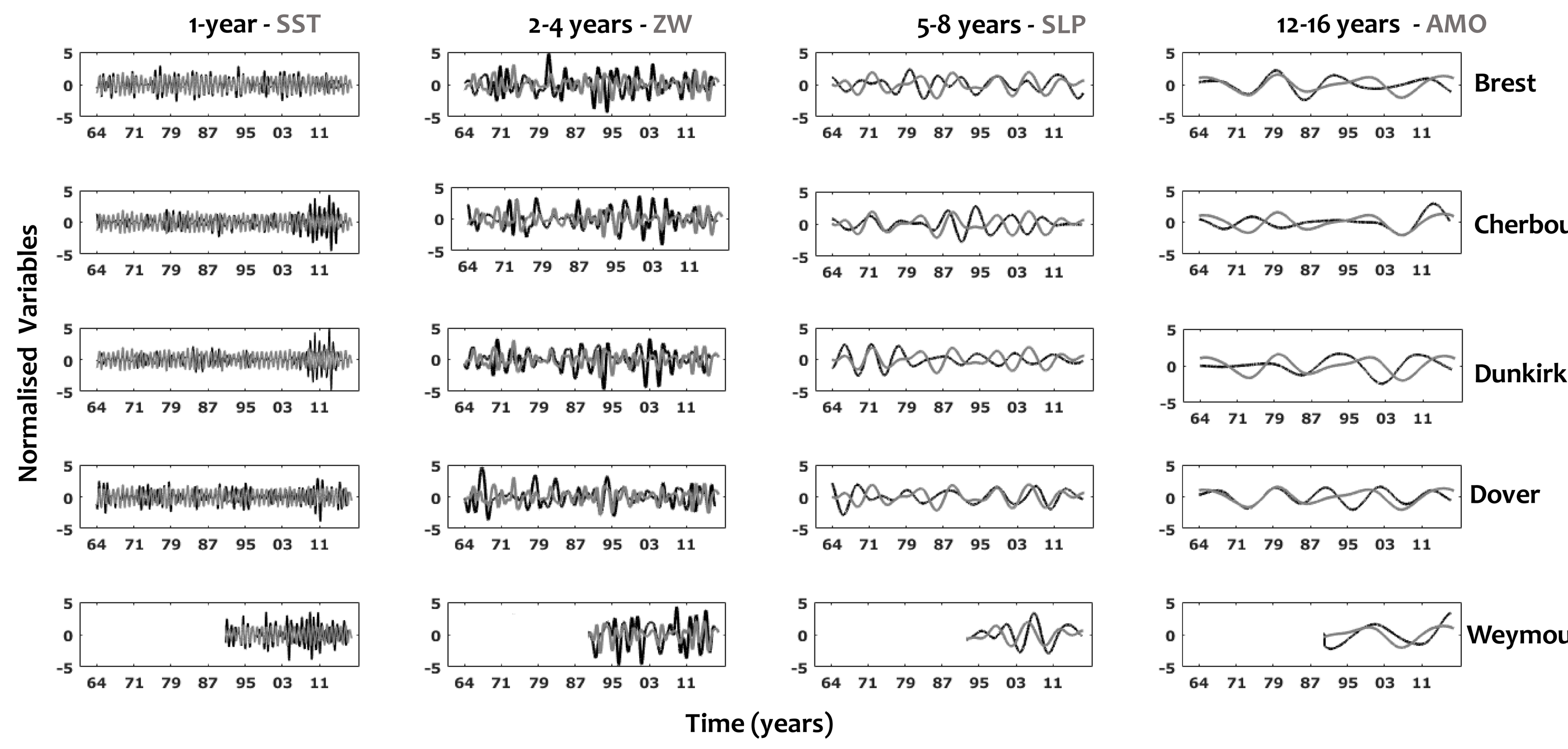


Fig 6. Correlation between the spectral components of surges and climate patterns by the use of the multi-scale components of the wavelet details at different time scales: 3 months, ~ 6 months, ~1-y, ~2-4-y, ~5-8-y, ~ 12-16-y. The effect of driving forces induced by the climate connections has proved to be significantly different at all scales.

Acknowledgments

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