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Statistical approaches for studying the wave climate of crossing-sea states

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Surface waves are an important feature of the world's oceans and seas. Their role in the air-sea exchanges is well recognized, together with their effects on the upper ocean and lower atmosphere dynamics. Physical processes involving surface waves contribute in driving the Earth's climate that, while experiencing changes at global and regional scales, in turn affects the surface waves climate over the oceans. The assessment of the wave climate at specific locations of the ocean is fruitful for many research fields in marine and atmospheric sciences and also for the human activities in the marine environment. Very often, wind generated waves (wind-sea) and one or more swell systems occur simultaneously, depending on the complexity of the atmospheric conditions that force the waves. Therefore, a wave climate assessed from the statistical analysis of long time series of integral wave parameters, can hardly say something about the frequency of occurrence of the so-called crossing-seas, as well as of their features. Directional wave spectra carry such information but proper statistical methods to analyze them are needed.
In this respect, in order to identify the crossing sea states within the spectral time series and to assess their frequency of occurrence we exploit two advanced statistical techniques. First, we apply the Spectral Partitioning, a well-established method based on a two-step partitioning of the spectrum that allows to identify the individual wave systems and to compute their probability of occurrence in the frequency/direction space. Then, we use the Self-Organizing Maps, an unsupervised neural network algorithm that quantize the time series by autonomously identifying an arbitrary (small) number of wave spectra representing the whole wave climate, each with its frequency of occurrence. This method has been previously applied to time series of wave parameters and for the first time is applied to directional wave spectra. We analyze the wave climate of one of the most severe regions of the Mediterranean Sea, between north-west Sardinia and the Gulf of Lion, where quite often wave systems coming from different directions superpose. Time series for the analysis is taken from the ERA-Interim Reanalysis dataset, which provides global directional wave spectra at 1° resolution, starting from 1979 up to the present. Results from the two techniques are shown to be consistent, and their comparison points out the contribution that each technique can provide for a more detailed interpretation of the wave climate.