Geophysical Research Abstracts
Vol. 16, EGU2014-15851-1, 2014
EGU General Assembly 2014

Mediterranean space-time extremes of wind wave sea states

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Traditionally, wind wave sea states during storms have been observed, modeled, and predicted mostly in the time domain, i.e. at a fixed point. In fact, the standard statistical models used in ocean waves analysis rely on the implicit assumption of long-crested waves. Nevertheless, waves in storms are mainly short-crested. Hence, spatio-temporal features of the wave field are crucial to accurately model the sea state characteristics and to provide reliable predictions, particurly of wave extremes. Indeed, the experimental evidence provided by novel instrumentations, e.g. WASS (Wave Acquisition Stereo System), showed that the maximum sea surface elevation gathered in time over an area, i.e. the space-time extreme, is larger than that one measured in time at a point, i.e. the time extreme. Recently, stochastic models used to estimate maxima of multidimensional Gaussian random fields have been applied to ocean waves statistics. These models are based either on Piterbarg's theorem or Adler and Taylor's Euler Characteristics approach. Besides a probability of exceedance of a certain threshold, they can provide the expected space-time extreme of a sea state, as long as space-time wave features (i.e. some parameters of the directional variance density spectrum) are known. These models have been recently validated against WASS observation from fixed and moving platforms.
In this context, our focus was modeling and predicting extremes of wind waves during storms. Thus, to intensively gather space-time extremes data over the Mediterranean region, we used directional spectra provided by the numerical wave model SWAN (Simulating WAves Nearshore). Therefore, we set up a 6x6 km2 resolution grid entailing most of the Mediterranean Sea and we forced it with COSMO-I7 high resolution (7x7 km2) hourly wind fields, within 2007-2013 period. To obtain the space-time features, i.e. the spectral parameters, at each grid node and over the 6 simulated years, we developed a modified version of the SWAN model, the SWAN Space-Time (SWAN-ST). SWAN-ST results were post-processed to obtain the expected space-time extremes over the model domain. To this end, we applied the stochastic model of Fedele, developed starting from Adler and Taylor's approach, which we found to be more accurate and versatile with respect to Piterbarg's theorem. Results we obtained provide an alternative sight on Mediterranean extreme wave climate, which could represent the first step towards operationl forecasting of space-time wave extremes, on the one hand, and the basis for a novel statistical standard wave model, on the other. These results may benefit marine designers, seafarers and other subjects operating at sea and exposed to the frequent and severe hazard represented by extreme wave conditions.