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Higher-order statistical analysis of short wind wave fields

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Today, satellite remote sensing opens the possibility of characterizing the ocean surface both at global scale and at fine resolution. Following the recent improvements in techniques and theories, links have been established between the backscattered radar cross-section of the sea surface and a large number of oceanic parameters, such as wind speed and direction, wave heights and slopes, wave spectrum, surface current, temperature and salinity, etc. However, the success of the inversion procedure relies crucially on an accurate phase resolving statistical description of the sea surface topography. In this respect, non-Gaussian characteristics of short wind waves are of primary importance, as they have a strong influence on the microwave radar return.
Observations of alongwind surface wave profiles were made in the large Luminy wind wave tank for a broad range of wind (3-10 m/s) and fetch (2-26 m) conditions. The processing of high resolution camera snapshots enables us to carry on a thorough statistical analysis of short wind wave geometrical properties. We consider distinctively four different wind wave fields characterized by a comprehensive image analysis in the range of capillary-gravity to gravity scales. This set of data makes it possible to describe and discuss the behavior of the distribution of wave heights, longitudinal wave slopes and curvatures in terms of their second- and higher-order moments as well as a function of the dominant wave scale. We calculate the autocorrelation and related functions and evidence the self-similar nature of wind wave fields. We also derive a simple and universal expression for the structure functions of third (skewness) and fourth (kurtosis) order which are needed for the simulation of sea radar return in the microwave regime.