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Freak waves in the coastal zone of the Baltic Sea

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The properties of extreme sea surface waves (freak waves) in shallow water and, particularly, their shape are analysed based on the high-resolution records of sea surface elevation in Tallinn Bay, the Baltic Sea, measured at the water depth 2.7 m from 21 June to 20 July 2008. The data set contains 97 freak waves, which occur in both calm and relatively rough weather conditions. It is shown that typical shapes of freak waves in the nearshore differ from those which are known for the deep sea. No groups of subsequent extreme waves, like the famous "Three sisters" usually reported by eyewitnesses and measured instrumentally in the open sea, are found for the coastal zone. All freak waves in the records are single waves: 63 % of them have positive, 19.5 % sign-variable and 17.5 % negative shape. It is shown that both the frequency of occurrence and the wave height of positive freak waves are correlated with the significant wave height. The height of sign-variable freak waves, which are observed only in relatively calm weather conditions, also changes in accordance with the significant wave height, while the height of negative freak waves shows no explicit dependence on the background wave height. It is suggested that the freak waves can be divided into two groups. Members of the first group, which includes 92% of the freak waves, have amplification factor (ratio of freak wave height to significant wave height) which does not vary with significant wave height and has values largely within the range from 2.0 to 2.4; while for the second group, which contains the most extreme freak waves, amplification factors depend strongly on significant wave height and can reach 3.1. Analysis based on the Generalized Pareto distribution is used to describe the waves of the first group, and lends weight to the identification of two groups. It is suggested that the probable mechanism of the generation of freak waves of the second group is dispersive focussing. The time-frequency spectra of the freak waves are studied, and dispersive tracks which can be interpreted as dispersive focussing, are demonstrated.