Geophysical Research Abstracts
Vol. 19, EGU2017-19210, 2017
EGU General Assembly 2017

Crossing seas and occurrence of rogue waves

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The study is addressing crossing wave systems which may lead to formation of rogue waves. Onorato et al. (2006, 2010) have shown using the Nonlinear Schr¨dringer (NLS) equations that the modulational instability and rogue waves can be triggered by a peculiar form of directional sea state, where two identical, crossing, narrow-banded random wave systems interact with each other. Such results have been underpinned by numerical simulations of the Euler equations solved with a Higher Order Spectral Method (HOSM) and experimental observations (Toffoli et al., 2011). They substantiate a dependence of the angle between the mean directions of propagation of the two crossing wave systems, with a maximum rogue wave probability for angles of approximately 40 degrees. Such an unusual sea state of two almost identical wave systems (approximately the same significant wave height and mean frequency) with high steepness and different directions was observed during the accident to the cruise ship Louis Majesty (Cavaleri et al. 2012).

Occurrence of wind sea and swell having almost the same spectral period and significant wave height and crossing at the angle $40^o < \beta < 60^o$ has been investigated recently by Bitner-Gregersen and Toffoli (2014). The numerical simulations carried out by HOSM have shown that although directionality has an effect on the occurrence of extreme waves in crossing seas, rogue waves can occur not only for narrow-banded wave directional spreading but also broader spectral conditions. It seems that the most critical condition for occurrence of rogue waves in crossing seas is associated with energy and frequency of two wave systems while the angle between the wave systems and directional spreading will decide how large extreme waves will grow. The 40 degree angle and narrow-banded directional spreading seem to be generating the largest waves. The study shows that occurrence of rogue-prone crossing sea states is location specific, depending strongly on local characteristics of wave climate in a particular ocean region. These sea states have been observed in the North Atlantic as well as in the North and Norwegian Seas but only in low and intermediate wave conditions. They have not been found in a location off coast of Australia and Nigeria. There are some indications that in the future climate we may expect an increase number of occurrence of rogue-prone crossing sea states in some ocean regions An adopted partitioning procedure of a wave spectrum will impact the results.

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