Some cases of observed rogue waves and attempts to characterize their occurrence conditions

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There is no consensus at present as to whether extreme waves are "normal" extremes in an homogeneous population of waves, or the results of totally different generation mechanisms, such as for instance non linear interaction and phase locking of wave trains.

In a first stage, the present paper analyses a few selected extreme waves measured in the North Sea, and verifies, according to several criteria, that these waves can be classified as *Rogue Waves* according to the criteria commonly accepted. These waves exhibit $\frac{H_{max}}{H_S}$ ratios well above 2. The measurements were carried out with radar wavemeter from a fixed platform, so it is also possible to estimate crest heights with reasonable accuracy. The corresponding ratios $\frac{C_{max}}{H_S}$ are also above 1.25. In addition, the occurrence of a very deep trough in front of the wave is verifed by examination of the reconstructed instantaneous space profiles of the water surface at several time-steps before the maximum crest. It is observed in particular that much deeper troughs may be seen from such space profiles, between the approaching wave and the observation location, than they are measured on the time-history at the sensor's location.

Many shipmasters' reports of rogue waves mention a very deep trough ahead of the wave, whereas measurements from fixed platforms often insist on a very asymetrical wave, with a normal trough and a very high crest. One might have infered then that these were two different kinds of waves, but the present study shows that they might be the same. Also, it points at the swiftness of changes in the wave shape, and leads to believe that the kinematics in a rogue wave should be computed by a method that would allow such fast changes, rather than assume a "frozen" shape.

In a second stage, the sea states where the selected extreme waves occurred are studied and characterized in terms of spectral bandwidth and multiple peakedness, of steepness, of non linearity, of wind conditions, and of the characteristics of the storm that contains them. These sea states are then compared

with the other sea states of similar H_S where no rogue wave could be observed, with the intent to find some differences or trends that could then be used as forewarning signs of an increased risk of occurrence of rogue waves.

Unfortunately, most of the differences are not significant enough to make a decisive step forward in the forecast of risks of rogue waves. Yet, the following conditions or a combination of several of them, but not necessarily all, seem to lead to an increase in the probability of encountering rogue waves:

- High significant steepness ($\frac{H_S}{1.56T_Z^2}$)
- Single peaked spectrum
- Strong winds
- Worsening sea conditions, coming to their apex

Lastly, the individual rogue waves that were identified are analysed, both in the time domain, and from the reconstructed shape that can be calculated in space. Special attention is given to the individual wave steepness and to its vertical and horizontal asymetry. These parameters are compared to the same ones for "normal" maximum waves in other sea states.