

Brief communication

“What do we know about freak waves in the ocean and lakes and how do we know it?”

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Abstract. We made an objective examination of our present state of knowledge on freak waves in the ocean and lakes from three separate perspectives:

- testimonial – from eyewitness account of actual encounters;
- empirical – from available in-situ wave measurements;
- conjectural – from academic theoretical formulations;

and led to a subjective answer to the posted title question of this paper: we do not know very much about freak waves in the ocean and lakes! There are really no interconnections among the three perspectives we examined. Put them together however, persuades us to think that freak waves are really an integral part of the ocean and lakes, they happen not infrequently but we still basically do not know when, where, how, what, and why they will happen. We do not even have as yet a viable definition on the phenomenon. So in order to expect tangible progress in our knowledge to the understanding of freak waves in the ocean and lakes, we propose to strengthen a key ingredient by further invigorate the empirical aspect of the perspective, specifically making more in-situ spatial wave measurement for freak wave studies, which is practically non-existence at the present.

1 Introduction

There are always freak wave encounters being reported in the news all around the world. However, regardless of when or where it was reported as taking place, the question posed by the title of this paper is really predicated by another rather more fundamental question: Do we really know what kind of freak wave was encountered?

Frankly, the answer must be no! We know that something happened, but no one really knows what, why, or how it happened.

Encounters are reported quite frequently nowadays. Freak (a portmanteau word for freak or rogue) waves have become somewhat of a standard nomenclature being used in news reports to describe any kind of wave-related incident. So generally, we know something happened, but most likely we have no way of knowing what kind of wave condition it was, why, or how it was encountered.

For instance, in the case of the Cruise Ship MS Louis Majesty (Fig. 1) that encountered freak waves in the northern Mediterranean near Marseille, France in early March 2010. As was reported in news reports worldwide, two passengers were swept to their death, and as many as 14 were injured when freak waves crashed into a vessel that was carrying 1350 passengers and 580 crew members. According to a Louis Cruise Lines spokesman the ship was hit by three “abnormally high” waves up to 26 feet high that broke glass windshields in the forward section. The waves hit as high as deck 5 on the 10-deck ship.

All kinds of news reports and commentaries on this case have been published online or in print since then. At one time, Google Search indicated that there were about 1300 articles available. Unfortunately, despite all of those reports, some complete with eye witness interviews and



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Fig. 1. Cruise ship *MS Louis Majesty*.



Fig. 2. Simulated image of a fictional freak wave.

“expert” opinions and analysis, there was no clear information regarding wave conditions beyond the cruise ship spokesman’s announcement of three 26 feet high waves.

So in this case, as in many other cases, we know freak waves were probably encountered, but we do not know the details of how, what, and why!

2 Perceiving perceptions

We can gather information about freak waves from three different perspectives:

- testimonial – from eyewitness accounts of actual encounters;
- empirical – from available in-situ wave measurements;
- conjectural – from academic theoretical formulation.

The responses from the three different perspectives will undoubtedly be different and have very few similarities between them.

2.1 Testimonial accounts

Testimonial accounts are probably the most widely known and, at the same time, the most uncertain. Draper (1964), who was the first one to use the word “freak” in connection with this phenomenon, provides a most succinct summarization:

“Stories abound of monstrous waves; every sailor has his tale of how a great wave arose from nowhere and hit his ship leaving a trail of damaged lifeboats and shattered crockery. Estimates of the heights of the highest waves which can be encountered at sea vary widely.”

He cited Cornish’s personal observation of a freak wave 70 feet from crest to trough that was seen in the North Pacific in 1921, and waves of 80 feet “and probably higher” in the

North Atlantic in 1923. Draper also mentioned the French scientist Captain Dumont d’Urville’s report of an encounter with waves of 80 to 100 feet high in 1826 with this anecdote “The poor fellow was openly ridiculed for making such an outrageous report even though three of his colleagues supported his estimate.”

Encountering freak waves is really nothing new. It has happened throughout the ages. Eyewitness accounts are not limited to seafarers’ tales or legends. One record describes Columbus’ encounter with one in 1498 near Trinidad on his third voyage. There was also this rather poetic report 100 years ago in the magazine *Scientific American*:

“Was it a last despairing protest of Old Ocean, when he lifted his giant hand in the blackness of night on 10 January, and smote the Cunard liner “*Lusitania*” a blow which racked and splintered her lofty bridge and pilot house, 75 feet above the sea, and crushed down her fore-castle deck and decks beneath, giving them a permanent depression of several inches? When the mass of the wave struck the breastworks and pilot house, every one of the stout wooden storm windows was burst in, the woodwork being stripped clean to the sashes – and this, be it remembered, at an elevation of 75 feet above the normal sea level.”

So that was a 75–80 feet freak wave they encountered. The *SS Lusitania* survived the early 1910 freak wave attack, but sadly she was torpedoed by a German U-boat and sunk 5 years later.

We are all familiar with the two famous characterizations of freak waves in general: a wall of water, and a hole in the sea. The 2006 movie *Poseidon* began with a simulated wall of water (Fig. 2) that capsized the huge cruise ship in the story – which can hardly be regarded as realistic.

Recently however, a young sailor, Mike Perham, described his real life close encounter with a freak wave on 29 March 2009 near the western tip of Australia during his solo sail around the world:

“It was a freak wave – and it came thundering through the black from the port side. I was in the cabin so didn’t see it coming but I had a one-second warning – its deafening roar.”

The “thundering through . . . deafening roar” is a new, never previously mentioned characterization of a freak wave. It may be that it was just taken for granted, but no one has ever mentioned the sound effect before. However, the sound of a freak wave must be enormous, and it should be readily recorded for further exploration. Exploring the connection between sound and wave heights could be an interesting approach for new wave studies. Perhaps we may also ask a similar philosophical question, not the falling tree in the forest, but a freak wave in the deep ocean . . . if no one is there to hear it, does it make a sound?

While it is of interest to recount boundless freak wave stories from those who encountered and luckily survived the ordeal, showing that freak waves have existed throughout the ages, let us also pause and remember the tragic losses of the people onboard the following vessels in the 20th Century, all presumed to have been caused by freak waves, however with no survivors or witnesses to substantiate:

- SS *Waratah*, 1909, South Indian Ocean
- SS *Ellan Vannin*, 1909, near Liverpool, North Atlantic Ocean
- SS *Edmund Fitzgerald*, 1975, Lake Superior
- MV *Derbyshire*, 1980, Western Pacific Ocean
- *Ocean Ranger Platform*, 1982, North Atlantic Ocean
- *FV Andrea Gail*, 1991, North Atlantic Ocean

2.2 Empirical recordings

Empirical recordings are the weakest link in general freak wave studies. There is no wave measurement equipment that was ever implemented for the specific purpose of recording and studying freak waves. So, it was fortuitous, or serendipitous, that Statoil installed wave measurement equipment on their Draupner platforms in the North Sea that recorded wave conditions that did some minor damage to their platform, and revealed a portrait of an unexpected wave form that everybody now recognizes as a form of freak wave. Figure 3 shows the time series plot of the widely recognized freak wave case recorded at the Statoil Draupner platform in the North Sea on New Year’s Day 1995 (Haver, 2004).

Two relevant questions that can be conveniently raised here but don’t seem to generate immediate answers are:

- How often this kind of freak wave occurs?

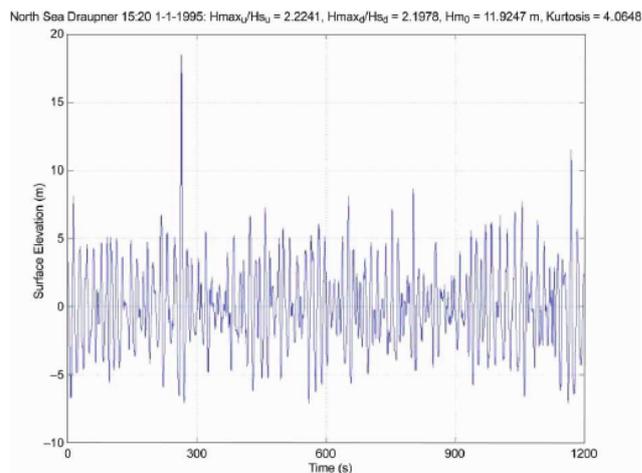


Fig. 3. Draupner wave.

- How would a recorded freak wave measurement compare with a human-reported freak wave encounter in the open ocean?

The reason to raise the second question is the interesting, unpublicized, fact that people onboard a neighboring Draupner platform did not even notice the wave event as it happened. The first question remains unanswered because Statoil’s wave measurement equipment was not in place for the long term. And, as we indicated previously, there have been no long-term wave measurements dedicated for the study of freak waves. On the other hand, a similar Draupner-type wave form has been readily found in many other parts of the World’s oceans and lakes, retrieved from existing wave recordings. Some examples are shown in the following figures from the Black Sea, the Sea of Japan, the Campos Basin in the South Atlantic Ocean, and the east coast of Taiwan in the Western Pacific Ocean (Figs. 4–8).

It is evident that Draupner-type freak waves can be easily found wherever wave measurements are made. So it is by no means a rare occurrence or confined to any specific region.

However, we cannot ascertain at the present time if freak wave encounters, wherever or whenever they may occur, will be similar to Draupner-type freak waves. So any implication or expectation of linkage between them would be a giant leap of faith without any realistic or factual basis to justify it. As we have alluded to earlier, empirical recordings are the weakest link of general freak wave studies. But at the same time, available empirical data is the only reliable source for a realistic understanding of freak wave occurrences. Therefore to strengthen this weakness, a concerted wave measurement program is the only practical, rational, and sensible approach toward a comprehensive freak wave study.

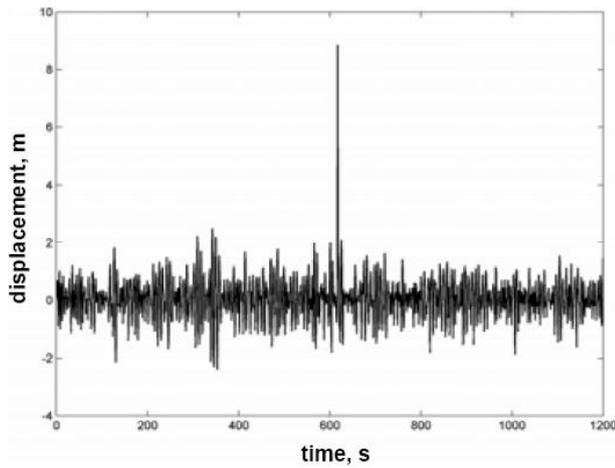


Fig. 4. A freaque wave case recorded in the Black Sea.

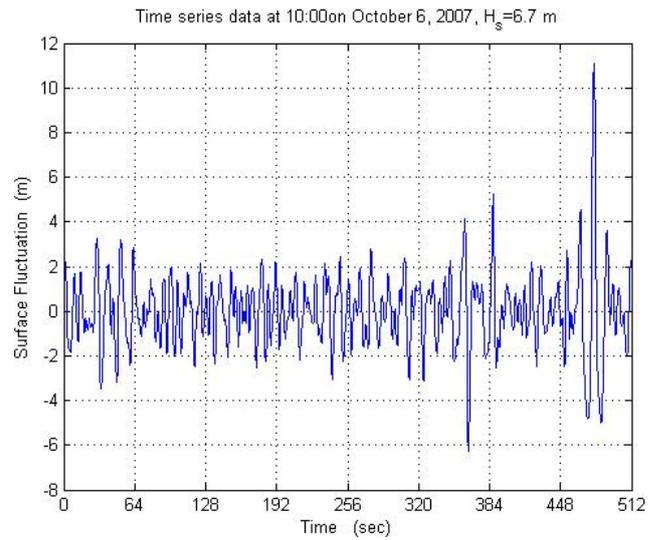


Fig. 7. A freaque wave case recorded in the east coast of Taiwan in Western Pacific.

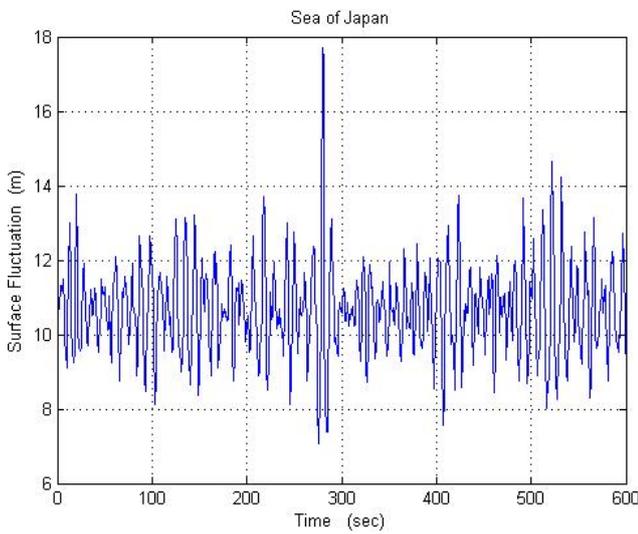


Fig. 5. A freaque wave case recorded in the Sea of Japan.

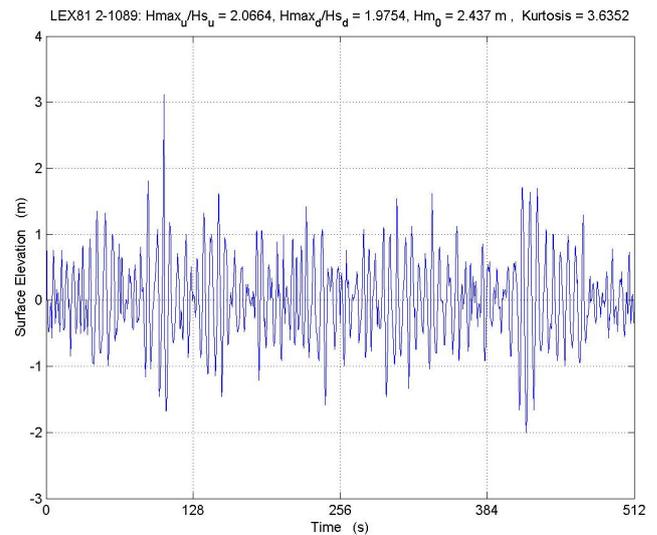


Fig. 8. A freaque wave case recorded in Lake Erie.

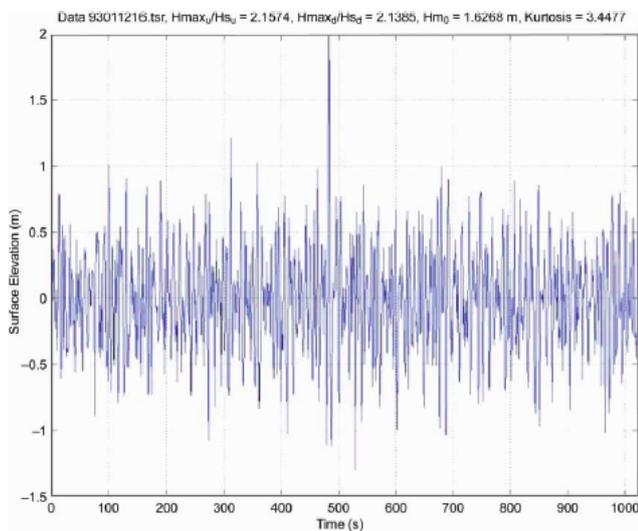


Fig. 6. A freaque wave case recorded in Campos Basin, the South Atlantic.

2.3 Theoretical conjectures

Academic theoretical studies are presently the strongest component, and perhaps the most credible aspect, of current freaque wave studies. The presently available theories on freaque waves are mainly stemmed from the linear and nonlinear wave studies of the classical hydrodynamics. Aside from the popular explanation of linear superposition of individual spectral components from all directions in the ocean that can possibly leads to a large amplitude, nonlinear mechanisms consists those governed by different enactments of NLS equation, modulation instability, Benjamin-Feir instability, focusing through wave-current interaction, focusing through inverse dispersion, among others. A good

reference for this is the recent book by Kharif et al. (2009) “Rogue Waves in the Ocean” where complete details of the presently available theoretical mechanisms and references can be found. The latest book by Osborne (2010) provides an encyclopedic presentation of nonlinear ocean wave studies including freak waves. The theoretical attainments in freak wave studies represent an ever expanding field of academic undertakings directed at establishing theoretical interpretations to what we have empirically observed. As the interesting recent issue of “The European Physical Journal Special Topics” (Akhmediev and Pelinovsky, 2010), which was devoted to the “Discussion and Debate: Rogue Waves – Towards a Unifying Concept?”, shows that there is no unifying concept in the theoretical aspect of freak wave studies yet.

As we have discussed earlier, there is very little intersection between the three independent perspectives for perceiving freak waves. There is however a small distinctive intersection that does exist between the theoretical conjectures and the empirical recordings: that of the Draupner platform’s 1995 New Year’s Day freak wave form. Most of the theoretical efforts have been targeted at establishing or reproducing the Draupner-type freak wave condition. Understanding the likely mechanism that can lead to Draupner-type waves is certainly a most desirable first step toward further understanding. But translating the theoretical mechanisms into practical procedures for helping field operations would not be easily done. The theoretical knowledge of the physics involved in developing/simulating presumed freak wave forms CANNOT substitute for practical knowledge of how freak waves occur in the ocean and lakes. One is fact, whereas the other is just an expectation. The fact is that freak waves have occurred in the ocean and lakes. The expectation, on the other hand, is a subjective personal viewpoint to regard freak wave occurrence according to the theoretical simulation process. In general, the essence of the theoretical conjectures is hinged at a Draupner-type wave form that is the result of wave measurement at a single point location. The vast ocean wave processes are by no means single point processes. So in the end, one is still confronted with the nagging question regarding what exactly we are striving to achieve in the first place.

One aspect we did not mention in our discussion so far is the laboratory experiment of freak waves, which is also a very active branch of freak wave studies. While to some extent laboratory experiments can be regarded it as an ancillary aspect of theoretical studies, they nevertheless provided rational basis on possible generic effects and engineering impacts of freak waves processes. Here we call attention to some representative references in the vast literature on laboratory experiments, e.g. Tulin and Waseda (1999), Giovanangeli et al. (2004), Onorato et al. (2006), Wu and Yao (2004), among others. Indeed, the Chapter 29 in Osborne (2010)’s new book has efficiently provided a latest masterful review and summary of laboratory experiments on freak waves.

The Proceedings of quadrennial Rogue Waves Workshops (Ifremer, 2000, 2004, and 2008) at Brest, France clearly demonstrated vital researches on freak wave studies in the recent decade have been vibrant and energetic in all perspectives.

3 What is next?

What is next is another rather fleeting question that defies a clear cut answer. Not everyone may agree with our contention that we do not know much about freak waves beyond conjectures. Similarly not everyone may agree that the study of freak waves is presently in a stagnation stage at best. Whenever or wherever a freak wave encounter is being reported, it can be expected that opinions fly while facts are sketchy. Basically we just do not know what, why, or how did it happen.

So asking what is next will likely leads to different answers for different incentives. For the purpose of furthering understanding of freak waves in the oceans and lakes, we wish to make the following suggestions as next steps to move away from our current state of stagnation:

- *Developing spatial wave measurements*, e.g., automated trinocular stereo imaging system, the ATISIS (Warnek and Wu, 2006) which provides detailed three-dimensional ocean surface pictures with respective to time. This will certainly confer true ocean wave pictures rather than the single-point wave measurement we have accustomed to and expecting it to manifestly represent the true ocean wave processes.
- *Making long-term wave measurements*, preferably at most of the available platforms and more in the world’s oceans and lakes to collect realistic long term fixed station wave data for truly systematic and comprehensive freak wave studies – locally as well as globally.
- *Equipping all large sea-going vessels with wave measuring devices* hopefully to record wave conditions at all times while the vessel is en route in the open ocean. This will supplement the fixed station wave measurements to form a comprehensive ocean wave picture. Only then can we expect to see where freak waves are truly rendered.

Granted that these are more inspirational than realistic at the present. But there has never been a freak wave measurement program and freak waves certainly deserves to be studied for its own worth. If these wishful steps we proposed can be implemented, there will be an exciting new world of ocean wave studies in store for us. Comprehensive studies will be based on facts rather than conjecture or probability. When unknowns become known, all are expected, and nothing is unexpected. So in the brave new world, all waves will likely be integral parts of the oceans and lakes, none will be banished as “freak” anymore!

4 Concluding remarks

As Akhmediev and Pelinovsky (2010) have pertinently stated in their Editorial that “The phenomenon is still mysterious and so complicated that any oversimplified definition is not adequate to illuminate all the issues”. Our presentation here is certainly no exception. We are not intended to make any generalized definitive conclusions. Rather what we have presented here are primarily our personal views and opinions on the freak wave phenomenon as we see it. While we feel strongly that there should be comprehensive freak wave measurement program implemented in order to further strengthen the general freak waves study, we do share the optimism of Osborne (2010a) that “Stay tuned, the next few years are going to be very exciting!”

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