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COMMITTEE I.1
ENVIRONMENT

COMMITTEE MANDATE

Concern for descriptions of the ocean environment, especially with respect to wave, current and wind, in deep and shallow waters, and ice, as a basis for the determination of environmental loads for structural design. Attention shall be given to statistical description of these and other related phenomena relevant to the safe design and operation of ships and offshore structures. The committee is encouraged to cooperate with the corresponding ITTC committee.

CONTRIBUTORS

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Alexander Babanin, *Australia*
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1. OFFICIAL DISCUSSION BY KEVIN EWANS AND REPLY BY COMMITTEE

1.1 Introduction

This Discussion is based on reviewing the Draft Report (dated February 2018) from the 20th ISSC Environment Committee. A brief overview is given, followed by comments, which are given for each major section of the report. The Comments section starts with General comments.

1.2 Report overview

The Report is a 100-page document authored by the 20th ISSC I.1 Committee, with its members:

Chairman: Thomas Fu, *USA*
Alexander Babanin, *Australia*
Abderrahim Bentamy, *France*
Ricardo Campos, *Portugal*
Sheng Dong, *China*
Odin Gramstad, *Norway*
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Alan John Murphy, *UK*
Fredhi Prasetyo, *Indonesia*
Wei Qiu, *Canada*
Luis Sagrillo, *Brazil*

Four Committee members, including the Chairman, remain from the 19th ISSC Committee.

The Report is organized with the following 10 Main Chapters plus References:
1. Introduction
2. Long term statistics and extreme value analysis
3. Waves & swell
4. Currents
5. Wind
6. Ice/icebergs
7. Coupled phenomena
8. Uncertainty
9. Special topics
10. Conclusions

Only one subject – Big Data - was included in the “Special topics” Chapter.

Around 400 journal and conference papers are listed in the References

1.3 Comments

- *General*
The report documents an impressive number of publications and will serve as a useful source of recent work on topics relevant to the ISSC community, and I would like to commend the Environment Committee for their effort in producing it.

In some parts, the material appears as a list of recent publications on a given topic with little to no discussion on how it contributes to existing knowledge or its relevance to current practice. In other parts, a very comprehensive overview is given of the topic and recent publications reviewed

are put into the perspective of existing understanding. It is understood that the report represents contributions from different authors, but it could be improved if the latter was a common objective for all sections.

There are several editorial issues that need attention. The report is in need of a careful proof read to correct typographical errors, and improve the English here and there, to help understanding. Many of the citations are inaccurate and some are not included in the References. All authors should be included for each publication in the References list.

REPLY BY COMMITTEE:

> *The discusser did a very thorough job in reviewing the report and provided numerous editorial comments noting that the text would benefit from reformatting, reordering or merging the sections, and suggested additional extra references. The committee believes that the editorial improvements suggested improved the report and incorporated them when possible.*

- Report Structure
The organisation of the report is significantly different to that from the previous committee. The previous report contained more general headings, with specific topics addressed as subsections. For example, the main sections on data and models each contained sections on wind, waves, and currents. The report of the present committee has main headings based on specific phenomena, such as winds, waves, and currents, with for example data and models now occurring as subsections. The result is that discussion on a specific phenomenon can be found in one location in the report, which is useful, but it is more difficult to determine the progress since the previous committee.

- Introduction
The Introduction needs substantial change. It starts well with the first two paragraphs describing the background regarding the objective of the committee and its activities, but what follows – the Sections on applications, waves, and wind need to be shifted into following main sections; perhaps a new chapter on Applications is needed to accommodate that section. As it stands, these sections are more like incomplete summaries of parts of the rest of the report rather than an introduction to the rest of the report.

The Waves section appears focussed on measurements and should be integrated into Section 3.1. The Wind section would provide a useful supplement to Section 5. The material in the Climate section focusses on the changing climate and would be better shifted to Chapter 2.
The Introduction needs to provide an overview of what the report contains and discussion on why the Committee chose the specific subjects and their relevance to the industry.
Many citations are inaccurately made, with some not included in the Reference list.

REPLY BY COMMITTEE:

> *The committee understands the suggested changes and incorporated them when possible in the report. The summaries were presented to insure inclusion, when a full chapter could not be incorporated.*

- Long Term Statistics and Extreme Value Analysis
Based on the material in this section, the section might be better called *Climate Variability and Extremes*, and the Climate section in the Introduction would fit well into this section. The section *More measurement in extreme conditions* provides good background on the importance of, but current lack of, knowledge of conditions at wind speeds above 40 ms^{-1}; but can it be concluded

that the lack of citations to publications in the recent years since the previous report reflects the fact that there hasn't been any? Also, it seems that Sections 2.1 and 2.4 could be combined in a single section on Measurements.

Overall, the section provides a good summary of various papers, but it is difficult to obtain an overview on how knowledge has progressed since the previous report. It appears there are papers that contribute to knowledge on regional climate, some on climate variability and the ability to predict trends, and some on the evaluation of various statistical techniques; perhaps the papers could be discussed accordingly and put into perspective. Also, the references to the Campos and Guedes Soares papers are confusing, as there are several for 2016.

Additional references that the Committee might consider are:

Vanem, E., 2017. A comparison study on the estimation of extreme structural response from different environmental contour methods. Marine Structures, 56, 137-162.

Ross, E., Randell, D., Ewans, K., Feld, F., Jonathan, P., 2017. Efficient estimation of return value distributions from non-stationary marginal extreme value models using Bayesian inference. Ocean Engineering, 142, 315-328.

Ross, E., Kereszturi, M., van Nee, M., Randell, D., Jonathan, E., 2017. On the spatial dependence of extreme ocean storm seas. Ocean Engineering, 145, 1-14.

Towe, R., Eastoe, E., Tawn, J., Jonathan, J., 2017. Statistical downscaling for future extreme wave heights in the North Sea. Ann. Appl. Stat., 11, 2375-2403.

- *Waves & Swell*

This section provides a clear overview of current knowledge of the physics of ocean waves, including a summary of recent papers.

The section *Measurements/Data* focusses on the measurement of waves in the laboratory, which has received a lot of attention in recent years. Notable however, is the lack of attention given to field measurement of waves in the report. Accurate and reliable field measurements are paramount to our understanding of ocean wave phenomena and human activities in the ocean. For example, in-situ measurements are often considered "ground-truth" for validation of wave models and satellite measurements, and they are important for operational activities in the offshore industry; but in-situ measurements have inherent uncertainties that remain to be understood (e.g. Ewans et al, 2014. On wave radar measurement. Ocean Dynamics. DOI 10.1007/s10236-014-0742-5). The committee might consider adding a section on ocean wave field measurements. Some references that would be relevant follow.

Section 3.1.4 *Remote Sensing* is empty.

REPLY BY COMMITTEE:

> *The sparse nature of the section on Measurements/Data is mostly due to the lack of the committee's expertise in the area of field measurements. One of the committee's recommendations is to include an expert on field measurements of waves and winds on the committee.*

- *Currents*

This section could be improved by relocating the material before Section 4.1, which appears to be a somewhat arbitrary collection of brief summaries of papers on currents, into the subsections that follow. Section 4.1 could then be preceded with an overview of the recent developments. For example, it would have been interesting to learn about the Committee's view on whether there has been any development of ocean current 3D modelling, which has shown to have generally poor agreement with in-situ measurements (certainly by comparison with wave models); some discussion on this was included in the previous report.

REPLY BY COMMITTEE:

Topics of measurements of currents and winds are very old, and the logical story for them has long since been written. In the last 3 years it didn't change, and all that can be mentioned in this regard is how different people tried to address fine details which still exist in measurements of currents and winds.

- Wind

As for the *Currents* section, this section launches into a somewhat arbitrary collection of brief summaries of papers on wind. These would better be relocated to the following subsections and replaced by some of Section 5.1 that provides an overview, with additional discussion on the more significant developments documented in the following sections. A substantial part of the material would be better relocated to *Measurements/Data* section, which could be further subdivided into in-situ and remote measurements. Currently, there appears to be two discussions on remote sensing that would be better integrated into a remote measurements section.

- Ice/Icebergs

This is a large section, by comparison with the treatment of this topic in the previous report, but it appears well organized into specific subsections. Nevertheless, it would be useful, particularly for readers not well versed in these topics, to start the section with an overview, outlining areas where development is needed and where and how these have been addressed in the recent research, with perhaps some commentary on the relevance of the choice of subsections.

- Coupled phenomena

This section provides a very interesting perspective of the interactions between atmosphere and ocean and highlights the shortcomings of not considering various phenomena in isolation, particularly those at the air-sea interface.

Reference is made to Section 5A, which doesn't exist in the report.

- Uncertainties

It is good to see a section dedicated to uncertainties, particularly in view of the ISSC/ITTC committee's initiatives to better understand and quantify these. Uncertainties with measurements in both the laboratory and field are often overlooked; based on the small number of recent publications included in the report, it appears that more needs to be done on promoting awareness and focusing attention to the problems. In this respect, the comment "A variety of reliable in situ methods and instrumentations are available these days, …" appears to overlook the uncertainties known to exist in in-situ wave measurements – see for example the JCOMM Wave Measurement Evaluation and Test project.

- Special topics

It was interesting to see Big Data being selected as a special topic. The term Big Data is relatively new and most often used to refer to the commercial use or exploitation of massive amounts of human data being collected continuously. The need to store and analyse large data sets is not new to science. The real focus of this section appears to be data analysis techniques that can collectively be called soft computing techniques, which themselves have application to data sets of all sizes. It would be good to have some discussion on examples of Environment Big Data and the challenges and opportunities associated with exploiting these data, underpinning the section title. Perhaps a second section on Soft Computing would, containing most of the current material would then be appropriate.

- Conclusions

This section consists of subsections Summary, Recommendations, and Advances, each consisting of a number of concise bullet points, some of which are well-supported by the material in the body of the report, and some of which are not. The Summary section is actually a list of concerns that the Committee have.

Improved understanding and quantification of uncertainties, climate change effects, and extremes are clear priorities for the future.

2. WRITTEN DISCUSSION

2.1 Tingyao Zhu, Research Institute of Nippon Kaiji Kyokai (ClassNK), Japan

2.1.1 Why isn't there any content in the committee reports about reviewing the research on the actually encountered environment (such as waves) by ships and offshore structures in their voyages or lifetime? It is considered that the actually encountered waves are more important for the design/operation of ships/offshore structures for safety point of view?

REPLY BY COMMITTEE:

> *To the ISSC community encountered environment is certainly the focus, but the mandate to the committee is "for descriptions of the ocean environment, especially with respect to wave, current and wind, in deep and shallow waters, and ice, as a basis for the determination of environmental loads for structural design," and not the operational context of wave encounters or offshore structure/ship operational profiles.*

2.1.2 If the answer for the question above is that there are few concerned research results at present, it is greatly appreciated that the next Committee be tasked to do this work.

REPLY BY COMMITTEE:

> *If the ISSC wishes to change the mandate of the committee to include the type of information described in the written discussion it certainly can, but this type researcher would need to be added to the committee, as most of the committee is typically composed of environmental researchers.*

2.1.3 It is well understood that the research on the mechanisms or occurrence of rogue waves is very important, but to clarify the probability of ships encountering rogue waves is more important for shipbuilding/maritime industries. It is not realistic and economic to request that all merchant ships such as bulk carriers, oil tankers and container ships can resist harsh rogue waves. Therefore, the committee should encourage researchers to carry out such kind of research. Unfortunately, there is no concerned recommendation in the conclusions of the committee report.

REPLY BY COMMITTEE:

> *Similar to the previous questions, the mandate of the committee has been to focus on the statistical descriptions of the environment, not the likelihood of encounter with a structure or ship. It might be more appropriate for one of the other*

committees to recommend the Environment committee look at this topic if it affected their topic area.

2.1.4 It is noted that the committee recommended in the conclusions that "Other ISSC committees should start to consider the effect of climate change on their areas.", but it is not so clear, how or what should be considered.

REPLY BY COMMITTEE:

The committee felt that climate change may increase the frequency and severity of storms, as well as increase the likelihood of polar operations. These changes may result in more encounters with higher waves (loads and the need for higher platform heights) and increased fatigue.

2.2 Robert Sielski, USA

Now that the presence of rogue or freak waves have been mathematically predicted and produced in a wave tank, they should no longer be considered as salty dog sea stories.
Because of the potential devastation that these waves can produce, does the committee believe that they should be included in structural and stability design criteria? Note that Committee I.2 also reviewed the paper by Klein et al. (2016) that suggested such an approach.

REPLY BY COMMITTEE:

The committee acknowledges that there are rogue waves. Freak waves are not just sea stories anymore. How to incorporate in the design criteria is something where work is needed. It is appropriate in the design criteria in the margins that are provided. Better understanding would allow for decreased margins. Generating those kind of criteria would require better modeling. We don't know much about the probability of this rogue wave (as in the OD presentation), although we understand them and reproduce them with models. Until we have a real idea what the probability we are not in the position to deal appropriately with this in the design.

2.3 Sören Ehlers, Hamburg University of Technology, Germany

The committee made a very nice effort to include and discuss Arctic concerns, which is a very nice addition to the arctic committee report. The need to measure and identify ice conditions is clearly apparent. It would be appreciated if the committee mentions that we are however still lacking the fundamental link between ice conditions and the ice loads. Therefore, the current method of choice to determine loads would be full-scale load measurements. In other words, the analogy to a response calculation in a measured wave state is not possible yet. Therefore, the ice-structure interaction section may appear to contain readily available tools for load and design simulations, which is not the case. Further, I would like to point out additional simulations tools and limitations to be found in the Arctic committee report.

REPLY BY COMMITTEE:

Agree, I think that we are challenged by the uncertainty we are trying to measure and stay away from here. It is difficult to separate between committees. The difficulty is in the environmental measurement and turning it into loads for

purpose of ice scales. It is an area where work can be found. Ice loads need to be measured and we need more work to get there.

2.4 Sanne van Essen, MARIN, The Netherlands

2.4.1 Questions regarding the rogue wave.

- Section 3.2 gives four different possible causes of rogue waves: 1) modulational instabilities (breathers), 2) temporal/ spatial variations in linear / second-order waves, 3) crossing seas or 4) changes in equilibrium state such as bathymetry changes. What is the most probable cause according to the committee?
- How do these four causes relate to the formation of rogue / freak waves by tropical cyclones (section 3.4) or the generation by waves in an opposing current (section 7.2)?
- What does the committee recommend for the performance of model testing of structural impacts in rogue waves, focused ('linear') waves or using breathers (I gather from the document that these can also be generated deterministically in a basin)? Does the generation mechanism influence the resulting impact forces as far as they are aware?

2.4.2 Section 3.1.2 page 26: What statistical variable do the wave probe accuracy confidence intervals of U95 refer to? I assume it is based on dynamic measurements in waves. Do the presented figures refer to each point on the wave profile, to the RMS, to the Hs, to the crest heights? (we did similar unpublished studies for the acoustic & resistance probes and this makes a huge difference)

2.4.3 Section 3.3.3 page 41: The publication of Amrutha and Kumar (2015) apparently gives strange wave crest distributions based on waverider measurements. I miss some comments about the influence of the measurement equipment here. The Lagrangian motion of a buoy in ocean waves leads to underestimation of the crests height (e.g. Prevosto et al., 2000). How accurate are the measurements?

2.4.4 Section 3.1.2 page 27: The camera system of Gomit et al. (2013) 'can only be used to measure a stationary wave field'. What is meant by stationary in this case, a standing wave pattern? Figure 2 does not seem to support this. I also really like that there is a discussion of the uncertainties in section 8. However, I miss some discussion of the inherent statistical uncertainties in a measurement of a finite duration. This is an important source of uncertainty in model tests (usually max 3 hours duration is available), but also for the duration of stationary conditions during trials (the ship has to keep the same heading & speed, the bathymetry cannot change etc.)

REPLY BY COMMITTEE:

Generally, the main causes for rogue waves in open ocean is motion stability and superposition. They lead to different consequences in terms of the impact. Both have to be considered. When we go to specifics of currents there are no recommendations. I wouldn't talk about rogue waves in tropical sections. The waves are on average very high. From my experience, I do not expect rogue waves in tropical areas. Rogue waves are two times higher than the mean wave height. In fact, if your wave height is in twenty minutes in average I didn't see rogue waves ever. Probably these don't happen on this planet. Tropical area is different environment with different challenges. You don't have to deal with a single large wave, but with a strong continuous impact.

3. FLOOR DISCUSSION

3.1 Sanne van Essen

You paid attention to uncertainties. As someone who actually does this experiment, I have some detailed questions about this. First one; I missed a bit the attention for the statistical uncertainty of the finite (16:15) duration test. You always have to stop your tests at some moment. It is always

not more than an hour of testing. I miss a bit the attention about that because that leads to quite some uncertainties in your wave results normally. Especially in extreme conditions. I saw a list of accuracies of certain wave probes in the basin. I really miss some more detailed information about it. It is just a number. If it is not related to a quest height or the whole profile or steepness or mean or whatever, it does not say something. Could you say something about this?

REPLY BY COMMITTEE:

Answer to this question has two parts. In space, the uncertainty is defined by footprint of a wave gauge, which are different, for instance, for a capacitance wire, or an acoustic probe, or a buoy. Obviously, a buoy, for example, cannot measure waves shorter than the buoy, but in fact the footprint is usually several times larger than the physical size of the probe, and wave measurements are averaged over the area of the footprint.

The uncertainties in frequency domain are defined by the duration of the record. In principle, longer records improve the frequency resolution, but infinite records are only possible in controlled conditions such as wave flume. In the field, the wind is hardly ever stationary, and that limits the realistic durations of records, which are typically chosen 20 to 30 minutes.

3.2 Enrico Rizzuto

I have a similar question as the one was raised about rogue waves with regards to breaking waves. Is it possible to give a summary of what we know about breaking waves? Carlos made a summary of what we know about rogue waves. We still have some problems with the statistics. We don't have a final outcome on design. Some definite criteria for the design, please. What should the equation for breaking waves look like?

REPLY BY COMMITTEE:

Wave breaking is a very large topic, people write books about wave breaking (e.g. Babanin, 2011). Their genesis is similar to that of rogue waves – for some reason, some waves become much higher than the others, and then, if a wave is too steep, it will break. The reasons can be broadly classified in two groups: linear and nonlinear. The former mostly refers to superposition of two or more waves due to their different propagation speed or direction: obviously, any superposition creates a wave steeper than the mean. The nonlinear evolution of waves, in this context, usually refers to the modulational instability of nonlinear wave trains or two-dimensional fields. In short, both reasons are physically possible, so this is a question of their relative significance (i.e. frequency of occurrence).

3.3 Elzbieta Maria Bitner-Gregersen

Rogue waves have been included already by DNV GL in the calculation of loads and responses of ship and offshore structures. We have linked the nonlinear wave programs with our software. We can now calculate the behaviour of structures in nonlinear waves and rogue waves. The whole process towards design is not completed but it is a first step towards concluding on rogue waves in design.

REPLY BY COMMITTEE:

No response needed.

3.4 Mirek Kaminski

I would like to leave rogue waves and go to the area of climate change. I would like to raise a question on the effect of climate change on design of ship and offshore structures. What does the committee think is the best way at this moment to investigate this effect, and how to include human induced climate change in this analysis?

REPLY BY COMMITTEE:

The recommendation from the committee was to start to work with the other committees to figure out those kind of questions. As Kevin pointed out, we didn't say a whole lot about climate change in our report. I think our recommendation was that we needed the research to look at how things are now changing concerning environmental aspects and how to integrate that in the design requirements and specifications. I think maybe things are changing faster than research is pointing out, we need to figure out how to handle things due to climate change. I think that is something for the next committee.

3.5 Sören Ehler

I think the references should be more valued (not just et al.) It would be nice to have a list for decent quality control of data.

REPLY BY COMMITTEE:

No response needed.

3.6 Sanne van Essen

I was wondering in certain places in the report, I saw some conclusion about buoy measurements that were taken as the truth. Could you spend more time on accuracy of the measurements? What are the properties of the different kind of measurements?

REPLY BY COMMITTEE:

It is hard because you don't know what the truth is. You are in little time domain measuring. We need multiple sets of measurements. There is no perfect instrument, there is always inaccuracies. All you can do is compare them.

3.7 Elzbieta Maria Bitner-Gregersen

I have some comments regarding the climate change. We do have tools to take care of climate change, we have made homework, we have looked how much the impact of climate change is on the design. But today there are too many uncertainties related to climate change projection so we are waiting for the next Coupled Model Intercomparison Project, CMIP6, to project waves and to see whether we can conclude that we are dealing with this subject. And I should also mention that NORSOK standards in some way account for climate change already. It's a Norwegian offshore standard. Because it's recommended, not required, to increase significant wave height and wind speed four percent on the probability level to account for climate change to be on the safe side. Significant wave height and wave speed we take 4 percent on the probability (37:30) to account for the climate change and to be on the safe side.

REPLY BY COMMITTEE:

No response needed.

3.8 Enrico Rizzuto

Do we have statistics of the loads in the breaking waves which can go from 0 to 100 percent? Do we have statistics about that? So statistics about breaking severity.

REPLY BY COMMITTEE:

This research topic is still in progress. It can be said that we have a reasonable ability to predict the breaking probability, but not the breaking severity, i.e. the energy lost by a wave in the course of breaking. Such loss can range from 0 to 100%, i.e. a wave which was breaking can disappear completely, and the energy and momentum lost can be passed on to a structure in the way. However, we do not have parameterizations for wave breaking severity.

REFERENCES

Klein et al. (2016)
Babanin, A.V., 2011: Breaking and Dissipation of Ocean Surface Waves. *Book*, Cambridge University Press, 480p