Referee comments on revised version.

1-st Referee comments
Page 1 – Abstract. Please add citation to “Chalikov and Bulgakov (2017)” (if this is the method the authors are describing and using). Please specify that long-term data are model data. Please add that you are applying the method to calculate the estimation of height of extreme waves of any given probability. Please add a short summary of your results and highlight their relevance.

Authors’ change in manuscript (highlight in yellow)

Abstract. A method of calculation of wind wave height probability based on the significant wave height probability is described (Chalikov and Bulgakov, 2017). The method can be also used for estimation of height of extreme waves of any given cumulative probability. The application of the method on the basis of long-term model data is presented. Examples of averaged annual and seasonal fields of extreme wave heights obtained by the above method are given. Areas where extreme wave can appear are shown.

2-nd Referee comments
Page 1 – Line 39 to Page 2 – Line 34: Probably this can be shorter, while it should be added what is(are) the state-of-art method(s) to estimate extreme waves? i.e. if this study is important for designing of engineering constructions or offshore activities in general, what is the method usually used to have an estimate of extreme waves nowadays? Max/average significant wave height or nothing? It would be good to compare with state-of-the-art estimates and to add at least a sentence in the conclusions to highlight why the proposed method is better.

The next text was added.

Estimation of probability of freak waves currently is based on data on significant wave height and different statistical model on probability of elevation. (Jiangxia Li at al, 2018) analyzed long-term data considered than freak wave exceeds two significant wave heights. (Larsen at all, 2015) suggested to take into account the unresolved part of wave spectrum in wave forecast model (frequencies more then 2.5 10-5 Hz) and developed the spectral correction method to fill in the missing variability of the modeled variable at high frequencies. In (Lanli Guo and Jinyu Sheng 2015) the peaks-over-threshold method was used to estimate the extreme significant wave heights from 30-year wave simulations. In (Samayam S. at al 2017) estimation of extreme wave was made by using of the extreme value theory. The main advantage of the method (Chalikov and Bulgakov, 2017) to compare with methods mentioned above and others that the method is based on results of direct modeling of wave fields.

3-rd Referee comments
Page 1 – Line 37: “M” change to “m”

Done

4-th Referee comments
Page 1 - Lines 37-38: “data are not enough to evaluate” change to “does not give information about”

Done

[Editor comment. I think it would be better to change line 34 “does not provide any information on” to “is not enough to evaluate”]
Done

5-th Referee comments
Page 2 – Line 19: “no nonlinear” change to “linear”
Done

6-th Referee comments
Page 2 – Line 40: Please move here Page 3 Line 29-33
Done

7-th Referee comments
Page 2 – Line 48: “Each” change to “each”
Done
8-th Referee comments
Page 3 – Line 29: “data” change to “model data”
Done
9-th Referee comments
Page 3 – Line 33: reference needed, are the results of the validation good?
Authors’ change in manuscript (highlight in yellow)

The model Hs data used for $P(H_s)$ were calculated with the latest version of WAVEWATCH III model (Tolman 2014) and GFS-2 wind analysis 2 (Sasha et al. 2014). The hindcasts cover the period from August 1999 to July 2015. The spatial resolution of the dataset fields is 0.5 × 0.5 degree. Calibration of the model and its validation are carried out using a great number of wave buoys. The data and results of its validation are described in (Chawla et al., 2013).

10-th Referee comments

Page 3 – Line 35-36: “method 2-3” change to “Chalikov and Bulgakov (2017) method”, if this is correct. If the application of method 2-3 “for the estimation of height of extreme waves of any given cumulative probability” is the addition of this paper to the state-of-the-art, then it needs a bit more emphasis.

Done

11-th Referee comments
Page 4 – Figure 2: Would it be possible to add a panel with the maximum annual significant wave height? How does it compare with the probability distribution?

Authors’ response

It's possible, but from the authors point of view comparing field of the maximum annual significant wave height with field of wave heights with cumulative probability 10^{-7} is not representative, because cumulative probability of maximum value of significant wave height is unknown.

12-th Referee comments
Page 4 – Line 11 & Page5 Lines 7-8: “calculated by data” change to “provided by the model”.

Done

13-th Referee comments
Page 5 – Line 8: remove].

Done

14-th Referee comments
Page 7 – Line 19-20: If 10^{-9} corresponds to P(1.85), then to what does 10-7 correspond? Maybe this can help to explain why 10^{-7} has certain practical importance, otherwise a reference should be added to support the “practical importance”.

The next text was removed
Mapping of wave heights with the cumulative probability exceeding 10 -7 may have a certain practical importance (ensuring of safety cargo shipments for instance).

Additional Editor comments.
1-st Editor comments
Line 34. “does not provide any information” is too strong.

Authors’ change in manuscript (highlight in yellow)

It is evident that significant wave height is not enough to evaluate real wave height for a given wave field.

2-nd Editor comments
Lines 35-37. The point you want to make (lines 34, 37-8) is that the same H_s can give different extreme values. So you need two examples with the same Hs but different extreme wave height.

The next text was added

Or there can be waves with height 15 meters and 17 meter in wave field characterized by H_s 10 meters.

3-rd Editor comments
Page 1 line 39 to page 2 line 10. This is quite a lot of discussion which is not much related to what you do in this manuscript. Could be less? (c.f. referee comment)

These lines were deleted.

4-th Editor comments
Page 2 lines 11-23. Since in the end your manuscript is about wave height above mean sea level, there could be less here about trough-to-crest height. However, you might have more discussion somewhere about what applications want wave height above mean sea level (e.g. fixed platforms?) and which want trough-to-crest height (e.g. ships and tethered platforms?).

The next was added

From the practical point of view the data on the probability of wave height above mean level are important for a fixed construction type of offshore platforms. For floating objects the data on full height (trough-to-crest) of wave are more important.

5-th Editor comments
Page 2 lines 24-32. Please make clear whether this paragraph is about wave height above mean sea level or about trough-to-crest height; which?

Authors' change in manuscript (highlight in yellow)

The theoretical probability distribution for wave crest height (or wave height above mean level) was suggested by Weibull (1951). Later it was studied on a basis of observational data in nature and wave channels (see review by Kharif et al., 2009). Extended data for estimation of probability of wave height can be obtained with integration of nonlinear modes based on full potential equations (Touboul and Kharif, 2010; Chalikov et al, 2009). Methods of probability calculations were considered in many papers (see, for example Bitner-Gregersen and Toffoli, 2012; Dyachenko at all, 2016).

6-th Editor comments
Section 2. I think this needs re-writing and suggest you start with equation (3) including definition of the terms in (3) to give an overview of the calculations. Then you need to say how P~ and P(Hs) are obtained. Please also specify what is not already done in Chalikov and Bulgakov, 2017.

In paper (Chalikov and Bulgakov, 2017) an algorithm for estimation of cumulative probability of waves exceeding a specific value of wave height above mean level (*P(h)* and *h* below) was developed using long-term data on H_s. The description of the method is given below.

The probability of wave exceeding specific height *h*, if significant wave height is in a small range dH_s around H_s, equals $\tilde{P}(\tilde{H})$ for specific $\tilde{H} = h/H_s$ multiplied by probability of H_s in this range $(\tilde{P}(\tilde{H}) \cdot P(H_s))$, by the standard definition of conditional probability. Consequently, $P(h)$ can be determined as integral of $\tilde{P}(\tilde{H}) \cdot P(H_s)$: over all possible value of H_s:

$$P(h) = \int_0^{H_{smax}} \tilde{P}(\tilde{H})\, P(H_s) dH_s, \qquad (2)$$

where $P(H_s)$ is probability distribution of H_s for a specific point, while H_{smax} is the maximum value of H_s in the dataset for a specific point.

The model Hs data used for $P(H_s)$ were calculated with the latest version of WAVEWATCH III model (Tolman 2014) and GFS-2 wind analysis 2 (Sasha et al. 2014). The hindcasts cover the period from August 1999 to July 2015. The spatial resolution of the dataset fields is 0.5 × 0.5 degree. Calibration of the model and its validation are carried out using a great number of wave buoys. The data and results of its validation are described in (Chawla et al., 2013).

The approximation of $\tilde{P}(\tilde{H})$ was based on results of 3-D model of potential fluid (the curl of the velocity field is zero).The model used spectral definitions of fields, finite differences for vertical derivatives calculation, fourth-order Runge–Kutta scheme for time integration. Fourier resolution is 256X64 wave number, resolution in physical space is 1024*256 (more detail in (Chalikov et al., 2014)). The calculations were done for 350 units of nondimensional time, i.e., for 70,000 time steps. The initial conditions were generated on basic JONSWAP spectrum. Model runs were calculated under condition when input energy from wind to waves equals wave energy dissipation. This condition corresponds fully developed wind waves. Totally 50 experiments were made (more detail in (Chalikov and Bulgakov, 2017)). The results of the series of experiments were processed in the following way: each wave field of surface height above mean level (η) reproduced by numerical model was normalized by the value of significant wave height corresponding to this field. ($\widetilde{H} = \eta / H_s$). (Note that η is variable of 3-D model of potential waves. It should be distinguished from h despites the fact that both (η and h) have the same physical sense.)

Then, a nondimensional wave field was used for calculation of cumulative probability of nondimensional wave height $\tilde{P}(\widetilde{H})$. The distribution obtained was approximated by the following function:

$$\tilde{P}(\widetilde{H}) = \exp\left(-3.97\widetilde{H} - 4.02\widetilde{H}^2\right) \qquad (3)$$

Note, that $\tilde{P}(\widetilde{H})$ is cumulative probability of the height of free surface above mean level. This probability for $\widetilde{H} = 1$ (the height of free surface equals significant wave height) is quite small (0.0003).

The above expression can be used for the interval $0 \leq \widetilde{H} \leq 1.85$. The probability of wave higher than 1.85 (it's maximal value of $\widetilde{H}$ in data) can be considered as extremely low and therefore - neglected. It should be noted that approximation (3) was obtained with use of the precise 3-D model based on full nonlinear equations. The volume of data used for approximation (3) includes more than 4.5 billion values of η (number point in single field multiplied by number of record in experiment multiplied by number of experiments). Currently, this approximation is considered as universal for wind wave fields where cases of freak waves are most likely. Waves of other types of spectrum (swells) have a small steepness and don't influence on extreme wave generation except rare cases when long-wave currents can steepen shorter waves.

The examples of the calculations using the method (Chalikov and Bulgakov, 2017) where space distribution of the extreme wave probability was investigated.

In these paper results of another approach of this method are considered. The global fields of wave height with cumulative probability 10^{-7} were calculated with using data Chawla et al., 2013).

7-th Editor comments
Page 2 line 41. Please explain "potential" waves.

Authors' change in manuscript (highlight in yellow)

The algorithm was based on results of 3-D model of potential fluid (the curl of the velocity field is zero).

8-th Editor comments
Page 2 line 46. Does the initial JONSWAP spectrum affect the results? This is relevant to the other referee's question about the limitations of formula (2).

Authors' response

It's generally believed that this spectrum describes field of wind waves. We can consider that eq. 3 is universal for cases of wind waves.

9-th Editor comments
Page 3 line 14. Does this mean that the maximum H~ anywhere in all 50 model runs was 1.85? "data" is too vague.

Authors' response

Yes, It does. For examples in (Bitner-Gregersen and Toffoli, 2012) extreme value of crest factor (crest divide significant wave height or the same as H~) beings from 1.3.

10-th Editor comments
Page 3 line 19 refers to wind wave fields. But was wind applied in the model runs giving (2)? If "yes", what wind? If "no", how relevant is (2) for wind-forced conditions? This is relevant to the other referee's question about the limitations of formula (2).

The next text was added

Model runs were calculated under condition when input energy from wind to waves equals wave energy dissipation. This condition corresponds fully developed wind waves.

11-th Editor comments
Page 3 line 20. ". . (swells) . . don't influence extreme wave generation." I disagree. Convergent long-wave currents can steepen shorter waves.

Authors' change in manuscript (highlight in yellow)

Waves of other types of spectrum (swells) have a small steepness and don't influence on extreme wave generation except rare cases when long-wave currents can steepen shorter waves.

12-th Editor comments
Page 3 line 29. I guess this should read "The model Hs data (Chawla et al., 2013) used for P(Hs) were calculated . ." The reader should not have to guess what you are referring to. I think the referee is saying that lines 29-33 here should be joined up with page 2 line 40.

The model Hs data used for $P(H_s)$ were calculated with the latest version of WAVEWATCH III model (Tolman 2014) and GFS-2 wind analysis 2 (Sasha et al. 2014). The hindcasts cover the period from August 1999 to July 2015. The spatial resolution of the dataset fields is 0.5 × 0.5 degree. Calibration of the model and its validation are carried out using a great number of wave buoys. The data and results of its validation are described in (Chawla et al., 2013).

13-th Editor comments
Page 4 lines 13-14. To correspond to figure 2 this should read ". . As seen, the mean value . . does not exceed 5 m anywhere, while . .". [You do not show any "maximum" Hs or even Hs when and where wave heights are extreme (cumulative probability 10**-7).]

Authors' change in manuscript (highlight in yellow)

Distribution of annual average significant wave height provided by model is shown in Fig. 2. As seen, the maximum value of field of annual average significant wave height does not exceed 5 m (southern area of Indian and Pacific oceans), while the height of real extreme wave can reach 16 m there.

14-th Editor comments Page 5 lines 7-8. Data do not calculate wave height nor do Chawla et al. 2013 according to section 2. Do you mean the field of wave height calculated as in section 2 via equation (3)?

Authors' change in manuscript (highlight in yellow)

In Fig. 3 the field of wave height with probability 10^{-7} averaged for December-February, is shown.

15-th Editor comments
Page 5 line 13. Better ". . less in the Northern Hemisphere winter, compared . ."

Done

16-th Editor comments
Page 7 lines 17-22. This could be part of a "Discussion" section.

Authors' response

There is no "Discussion" section in the paper. And from authors point of view 5 lines is no enough to form "Discussion" section.

17-th Editor comments
"Conclusions" The first and last sentences are summary very much like the abstract. Only the middle sentence is a conclusion.

Authors' change in manuscript (highlight in yellow)

The paper describes a method of calculation of extreme wave probability, based on long-term wave hindcast data on significant wave height developed in (Chalikov and Bulgakov 2017). Such method can be used for estimation of probability of extreme waves, which is important for designing of engineering constructions. Another approach of the methods is presented in the paper; algorithm (Chalikov and Bulgakov 2017) was used to evaluate height of waves of any given cumulative probability. The maps of global distribution of wave heights of certain probability for main seasons illustrate the approach of the method.