Referee Comments #1

Comment	**Authors response and changes in manuscript**
Major points	
1. In page 9, it is written: "The exponential function was fitted to sea levels with a frequency of exceedance of 5 events/year or less." Why? The frequency of exceedance of the observed data in Figure 4 is from 1/46 to about 8000 events/year. It is thought that only the data of low frequency of exceedance are used in the curve fitting because we are interested in the events of high sea level. The reason why the data of low frequency of exceedance are used should be explained.	The exponential function was applied to the sea level distribution in order to estimate the frequencies of rare/high sea levels. The limit of 5 events/year was chosen because only the tail part of the distribution follows the exponential shape, not the entire distribution. In this way, the fit is also only done on sea level representing rare events, which may behave differently from the more frequent sea levels. Above mentioned explanations will be added to the manuscript as follows: "We extrapolated the ccdf with an exponential function fitted to the tail of the ccdf (Fig. 4). The exponential function was fitted to sea levels with a frequency of exceedance less than $5.7x10^{-4}$, which corresponds to 5 hours/year. This limit was selected because only the tail part of the distribution follows the exponential shape, while more frequent sea levels behave differently."
2. In Figure 4, the maximum frequency of exceedance occurs at the sea level of -50 cm, indicating that negative storm surges frequently occur in the study area. The reason for this should be explained in the paper.	We explain in Chapter 2 (Components contributing to the sea surface level) that short-term sea level varies from -1.3 m to +2.0 m around the long-term mean sea level on the Finnish coast, and that these changes are mainly due to wind and air pressure variations. Thus -50 cm (in Figure 4) fits inside this range and is normal behaviour in the study area.
3. In page 10-11, it is written: "The wave run-up can be calculated for different percentages, e.g. as the water level exceeded 2% of the time. We set out to seek a conservative estimate for the level exceeded once during the one hour time period." In the design of coastal defense structures, it is common to use the 2% run-up height to determine the crest freeboard. If the mean wave period is 8 s, the wave run-up exceeding 2% run-up height occurs 9 times during one hour, whereas the run-up height exceeded only once during one hour is exceeded 0.22% of the time. Therefore, taking the run-up height exceeded once during the one hour time period is too conservative from the engineering point of view.	We aim at estimating maximum total water level exceeded during one hour period. Thus we defined the wave run-up using the highest single wave during an hour, since this corresponds to one well defined event when the wave data and hourly water level data are combined statistically. See also our response to the comment [11] from Reviewer #2.
4. In page 11, the relationship $H_{max} = 2H_s$ is used. Longuet-Higgins (1952, J. Marine Res. 11, 246-266) presented the relationship $H_{max} = 0.707\sqrt{lnN}H_s$ for a storm with a relatively large number of waves N.	We used Longuet-Higgins (1952) to check our results. However, we didn't find that exact relationship in the paper, but interpolated the values of the Rayleigh distribution by using the values given in the Tables.

Again, if the mean wave period is 8 s, the number of waves during one hour is 450, which gives H_{max} = 1.75H_s. Therefore, the relationship $H_{max} = 2H_s$ may be too conservative.	The waves at the study sites are typically short. The mean zero-upcrossing period (Tz, calculated as Tm02 from the spectral moments) is around 3 seconds (3.2 s at Länsikari and 2.8 s at Jätkäsaari). This means about 1200-1300 waves during an hour, which results in Hmax being between 1.9Hs and 2Hs. We calculated this relation for the entire time series to provide an even better overview (see Figure RC_A). We agree that this was not presented properly in the manuscript. A more rigorous justification for choosing the relationship Hmax=2Hs will therefore be added.
5. The assumption of complete wave reflection from a coastal structure (i.e. H_{runup}= H_{max}) may also be a too conservative assumption. This assumption, however, could be justified if we take into account the effect of wave nonlinearity in shallow water (i.e. peaked crest and flat trough), which was not considered in this study.	The water at the study sites is relatively deep when considering the short waves generated by the local fetches (around 3 s at Länsikari). At Länsikari the depth is around 10 m and at Jätkäsaari it is around 13 m. Even for the longest waves the water depth is intermediate. Shallow water nonlinearities are therefore not expected to be significant. We want to stress that the study we cited with respect to the wave reflection was made exactly at the location of Jätkäsaari. It is therefore highly representative for this study. In Björkqvist et al. (2017) the short waves were damped by the wave damping chambers. However, the longer waves were fully reflected. Since the wave damping chambers only cover a short part of the shoreline, we have to consider conditions without the presence of them. We have no reason to believe, that all the waves wouldn't be fully reflected at a pure steep wall, since we have direct measurements of full reflection of waves that were too long for the wave damping chamber to be effective.
6. Sorensen (2006, Basic Coastal Engineering, 3rd ed., Springer, p. 237) presented the relationship $R_p = R_s\sqrt{\ln(1/p)/2}$ where R_p is the wave run-up height of the exceedance probability p and R_s is the run-up height of the incident significant wave height as if it were a monochromatic wave. If we use p = 0.02 and $R_s = H_s$ (i.e. complete wave reflection), $H_{runup} = R_{2\%}$ = 1.4H_s which is 70% of the value used in this study. On the other hand, if we use p = 0.0022, which is the exceedance probability of the wave height exceeded only once during one hour (when the mean wave period is 8 s), $H_{runup} = R_{0.22\%}$ = 1.75H_s. This changes to $H_{runup} = H_{max}$ (using the relationship H_{max} =	A lot of this has already been addressed, but in conclusion: 1) The choice of Hmax instead of e.g. 2% exceedance value is not a matter of being conservative. It is a choice done to get the results to correspond to "one event". It would be possible to choose a lower value that is exceeded e.g. 25 times. However, when combined with the sea level data the values would not be events, but "25 events", and the probability of 0.4% would not correspond to one event in 250 years, but to 25 events in 250 years and would inevitably lead to some inference challenges.

$0.707\sqrt{lnN}H_s$), which is the same as the run-up height used in this study except that H_{max} is not calculated as $2H_s$ but as $1.75H_s$. In conclusion, to avoid too conservative estimate for wave run-up height, either $H_{runup} = 1.4H_s$ (general design standard) or $H_{runup} = 1.75H_s$ (run-up height exceeded once during one hour as taken in this study) should be used.	2) The relation Hmax=2*Hs is not really conservative assumption. It has its bases in the measurements and theory (Rayleigh distribution). This will be clarified in the manuscript also. 3) The assumption of full reflection is the main conservative assumption. However, we feel it has a valid base, since we have observed fully reflected waves even when wave damping chambers are present. Since the damping chambers are not present everywhere, it is reasonable to assume that the short waves – that were damped by the chambers in the measurements – will be reflected in the same way as the longer waves. This might not be true, but since we have no evidence of the contrary, we feel that this is a valid assumption, albeit a conservative one.
7. In addition to Table 1, it may be worthwhile to show the curves of F_{SL} for 2017, 2050, and 2100.	The curve for the still water level in 2017 as well as for the years 2050 and 2100 at the Helsinki tide gauge are presented in Figure 8 in the manuscript.
8. Two-parameter Weibull distributions are used for the sensitivity analysis. It may be better to add the fitted Weibull distributions (along with the shape and scale parameters) in Figure 5 to show that the Weibull distribution fits well the observation.	See our response to comment [16] from #2 Reviewer. To provide a better comparison possibility between case study wave run-up distributions (Figure 5) and the theoretical wave run-up distributions, we plotted the theoretical wave run-up distributions also in a form of complementary cumulative distribution (see Figure RC_B) and this redrawn figure will be added to the manuscript.
Minor points	
1. 1st line below Eq. (1): wave height >> wave run-up height	This terminological mistake will be corrected to the text where the terms of equation (1) are explained i.e. “wave height” will be changed to “wave run-up”. See also our response to comment [12.2] from #2 Reviewer.

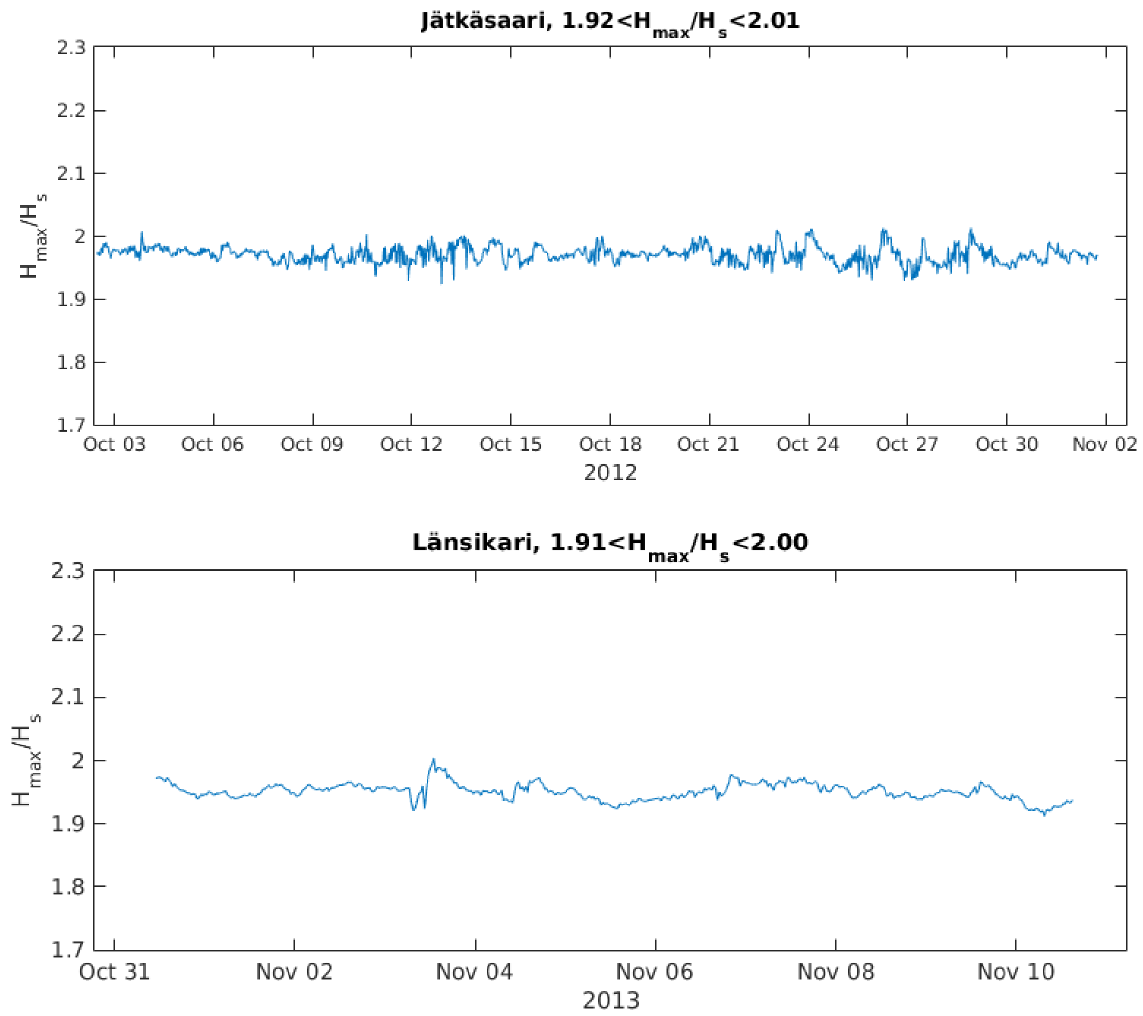

Figure RC_A. The ratio between the highest single wave and the significant wave height estimated from the Rayleigh distribution at Jätkäsaari and Länsikari.

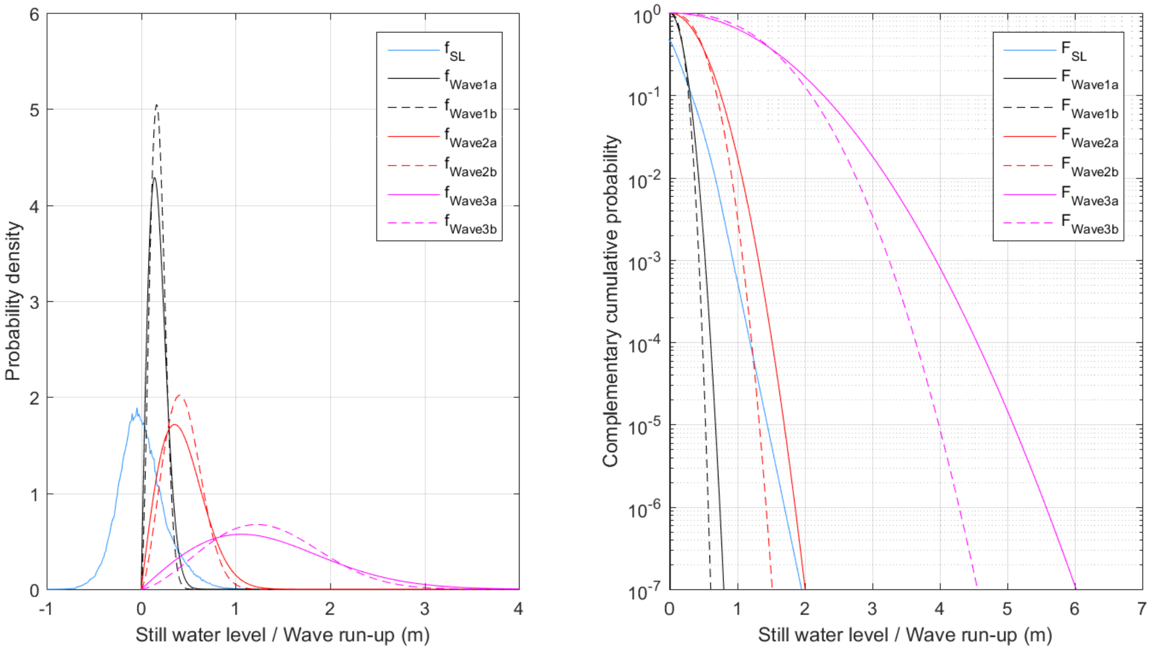

Figure RC_B. Pdfs (on the left) and ccdfs (on the right) for the still water level and the six theoretical wave run-up distributions.

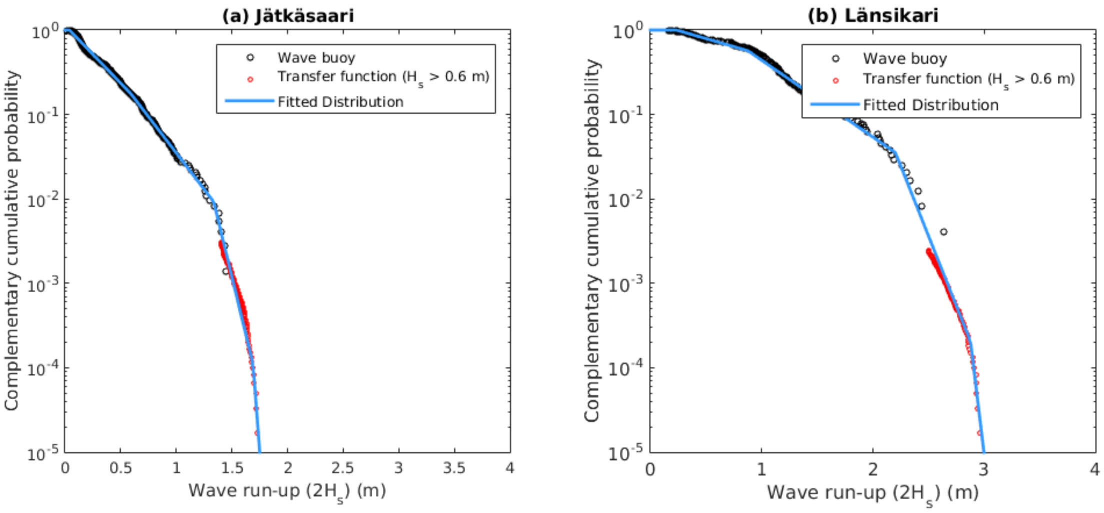

Figure RC_C. Wave run-up distributions for the two locations in the Helsinki archipelago: Jätkäsaari and Länsikari.

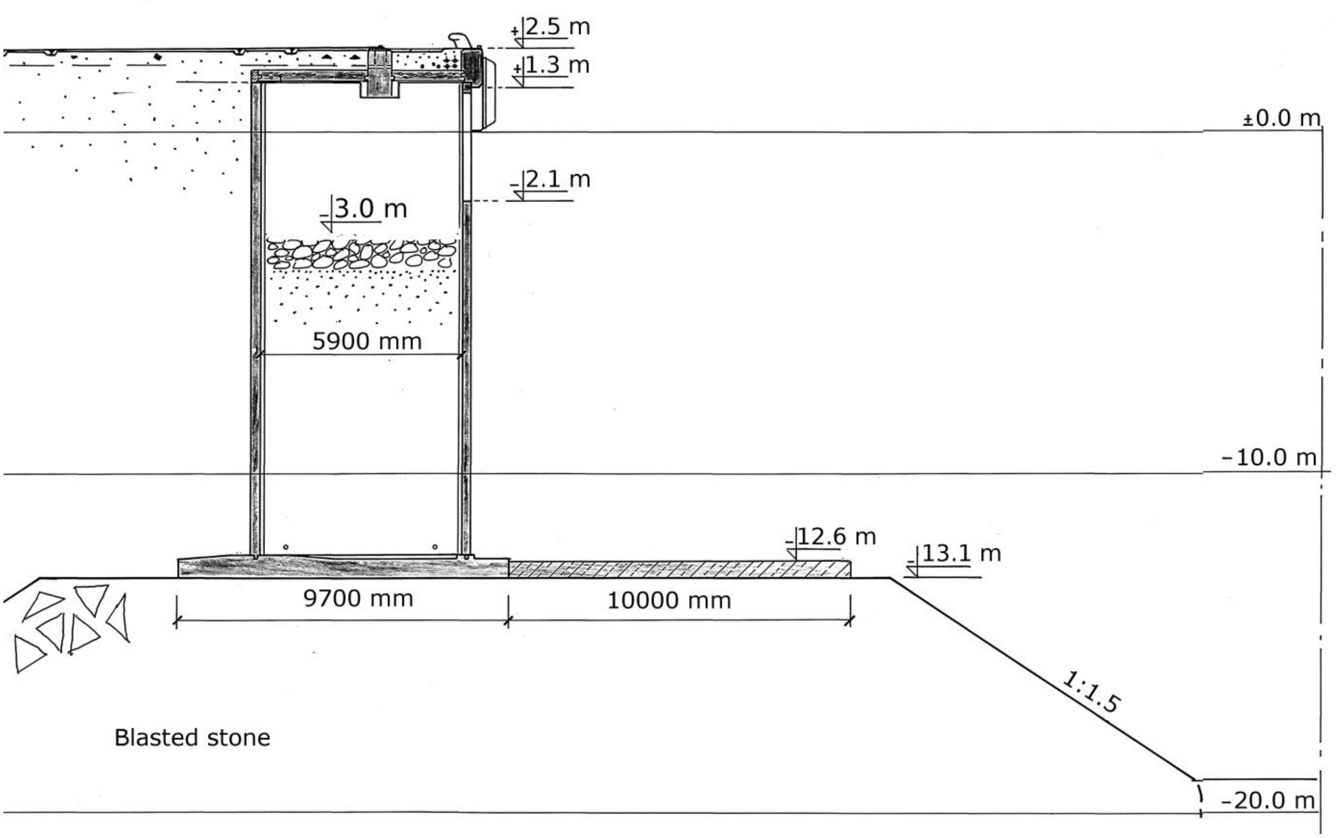

Figure RC_D. The shoreline at Jätkäsaari (from Björkqvist et al., 2017). Other parts of the shoreline are of similar shape (vertical walls), but are not equipped with wave damping chambers.

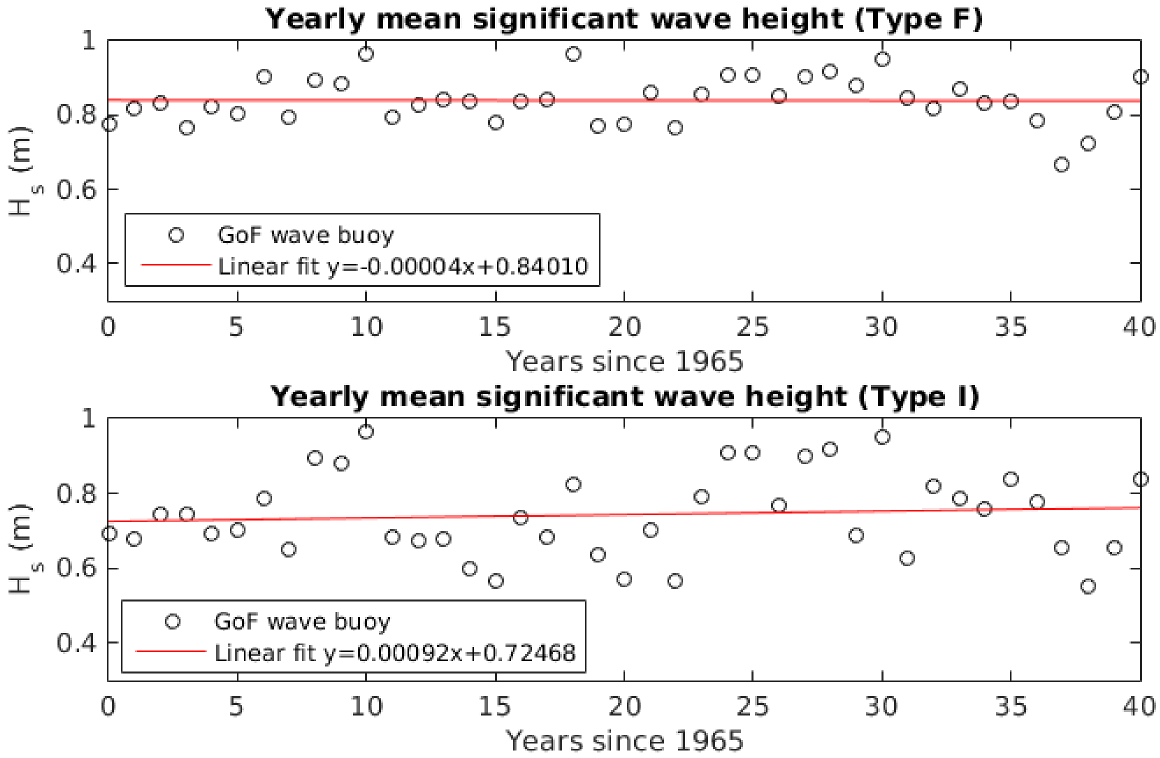

Figure RC_E. The yearly significant wave height at the Gulf of Finland wave buoy taken from the wave hindcast of Björkqvist et al. (2018). Trends were calculated for both the ice-free statistics and the ice-included statistics. Neither was statistically significant.

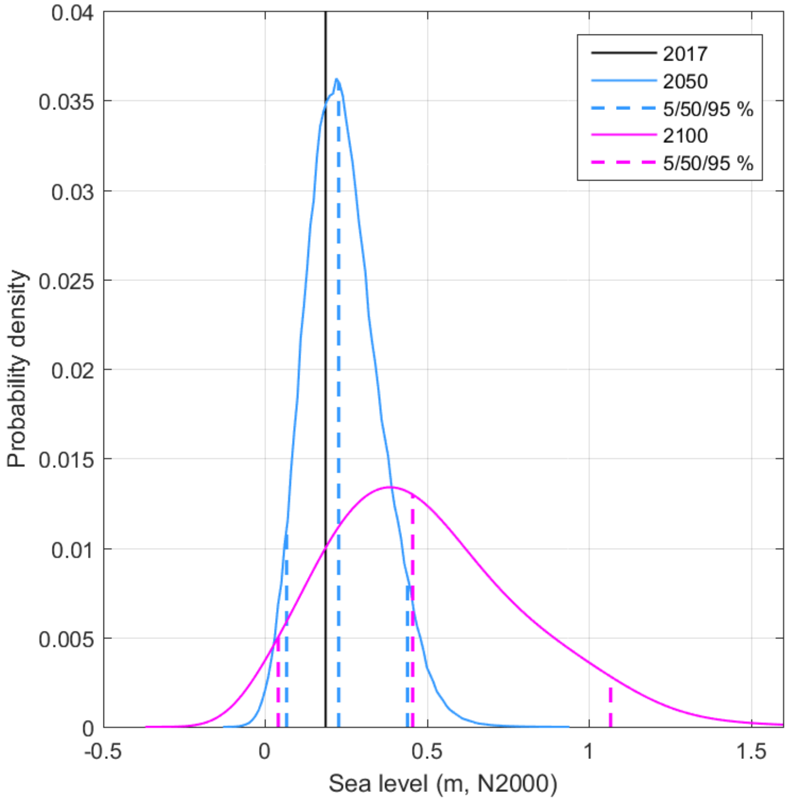

Figure RC_F. Probability density functions of future mean sea level at the Helsinki tide gauge for years 2050 and 2100 and the long-term mean sea level estimate of 0.19 m for year 2017. The 5th, 50th and 95th percentiles are shown for 2050 and 2100. The data in the Figure is from the results of Pellikka et al. (2018).