Response to Comment by Reviewer #1

1 General Comments

1. eqn (20) and previous 3 paragraphs: I believe that my comment about using the formula

$$a_i^2 = 2 \int_{\lambda_1}^{\lambda_2} S(\lambda) d\lambda \approx 2S(\lambda_i)\Delta\lambda \tag{1}$$

   to determine the breaking probability of a single frequency has not been fully understood. To me it only makes sense to use (1) when there are physical reasons to choose the limits of integration λ_0 and λ_1, or when the actual values of the amplitude are not so important. Collins et al. (2015) would fall into the former category, when they filtered high frequencies out of Hs to compare to measurements. Meylan et al. (2014) who the authors cite in support of their approach, falls into the latter category, where the authors grouped the amplitudes into bins of different magnitudes, finding higher amplitudes were attenuated more strongly than lower ones (for this conclusion to be reached only relative magnitudes are important). In contrast the authors are trying to find absolute values of the amplitudes and then using them to determine if break-up occurs on a frequency-by-frequency level. Their doing so relates to my fellow reviewers question about convergence. If they halve $\Delta\lambda$, they halve a_i^2 so in the limit as $\Delta\lambda \to 0$, the breaking probability also tends to 0 for all frequencies, and consequently there will be no breaking at all.

   We thank the reviewer for persisting until this issue is resolved and clarified. Our initial treatment of the wave spectrum was founded on a finite Fourier series representation based on the power spectrum. As the wavelength bin size $d\lambda$ is decreased to zero, the amplitudes in the Fourier series decrease too, but their number increases such that the total energy is conserved. However, given that the wave fracturing depends on these amplitudes, we agree with the reviewer that this approach is not satisfactory. We have accordingly altered the calculation of the distribution of floes formed by fracture due to surface waves as follows,

   (a) The continuous spectrum is used to get realizations of the sea surface height.

   (b) These realizations are used to calculate the strain applied to the ice floes by the sea surface height.

   (c) A statistical distribution of resulting floe size is calculated from the sea surface height plus a critical strain condition.

   The revised method is discussed in section 2.3 of the paper and demonstrated with an explicit calculation in the supplementary material section S3. This approach does not suffer the difficulty with the wave amplitudes going to zero, it is also more physically based than previously, and we thank the reviewer again for leading us toward this improvement in the model formulation.

2. Equation (20) (this is possibly redundant given my previous comment): $\varepsilon_{crit} > \varepsilon_{max} \rightarrow \varepsilon_{crit} < \varepsilon_{max}$
Thanks for pointing out this typo, this sentence was eliminated as part of the reformulation following the reviewer's first comment.

3. I am also still of the opinion that using a Rayleigh distribution for individual frequencies instead of the spectrum as a whole is suspicious.
As the response to the first comment explains, we now revised the approach completely, also addressing this issue and not using individual amplitudes at specific frequencies to determine floe fracture.

References

Collins, C. O., Rogers, W. E., Marchenko, A., and Babanin, A. V.: In situ measurements of an energetic wave event in the Arctic marginal ice zone, Geophys. Res. Lett., 42, 1863–1870, doi:10.1002/2015GL063063, 2015.

Meylan, M. H., Bennetts, L. G., and a. L. Kohout: In situ measurements and analysis of ocean waves in the Antarctic marginal ice zone, Geophys. Res. Lett., 41, 1–6, doi: 10.1002/2014GL060809.In, 2014.