Response to Reviewer 1

Question 1: Line 126 (Page 6):

Clarify the phrase "only two relatively weak ship clutter showed ambiguity" slightly. Perhaps specify whether ambiguity relates to visibility, annotation consistency, or radar signal characteristics.

Agree. The ambiguity here primarily refers to the fact that the initial and secondary annotations could not reach a definitive agreement on the identification of these two relatively weak ship clutter cases.

We revised the original sentence "Specifically, 170 ship clutter from 10 scans were re-labeled, and only two relatively weak ship clutter showed ambiguity." to "Specifically, 170 ship clutter from 10 scans were re-labeled, and differences in labeling were observed only in two relatively weak cases between the initial and secondary annotations."

Question 2: Line 343 (Page 17):

"mainlobe identification employed the same random forest model as that used for the LFM waveform; however, the relative power relationship between the mainlobe and sidelobes was re-estimated based on observations under the NLFM waveform."

Suggest clarifying briefly why re-estimating sidelobe power relationships was necessary for the NLFM case. Was this driven by waveform differences that significantly impact sidelobe structure?

Agree. As correctly understood by the reviewer, the LFM and NLFM waveforms of the Kumpula radar exhibit different sidelobe structures (the relative power relationship between the mainlobe and sidelobes of the NLFM waveform is illustrated in the figure below). Accordingly, the revised manuscript includes the following clarification: "It is worth noting that the mainlobe identification employed the same random forest model as that used for the LFM waveform. However, the relative power relationship between the mainlobe and sidelobes was re-estimated based on observations under the NLFM waveform, primarily due to the different sidelobe structures of the two waveforms."

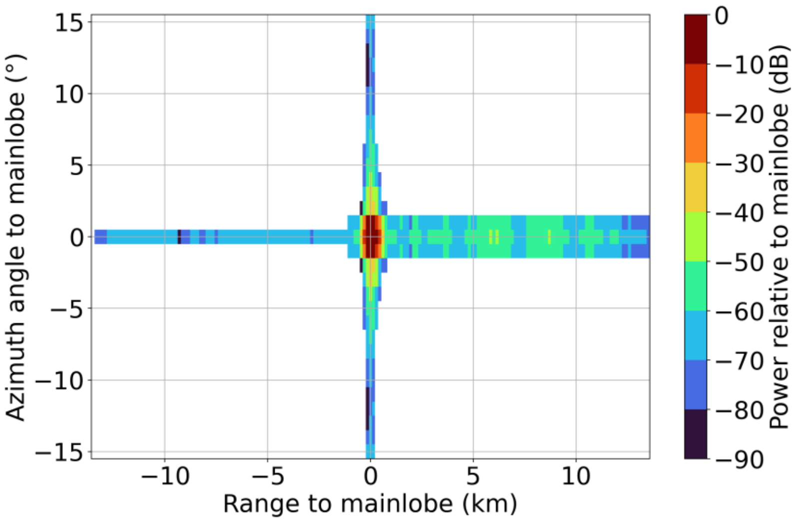

Figure xxx: Statistical result of the relative power between the mainlobe and sidelobe for eight ship clutter events with high SNR.

Question 3: Figure 11 (Page 17):

Recommend increasing the contrast or changing the color of the circles identifying the clutter mainlobes, as they are not easily distinguishable on some background echoes.

We attempted to replace the circle color with other options, but none proved to be more distinguishable against the light-colored background. Although black offers good contrast, it is already used in the figure to draw the range rings and radial lines for spatial reference. Therefore, we chose to thicken the red circles and submitted the high-resolution figure as an attachment, allowing readers to zoom in for better visibility while maintaining sufficient clarity.

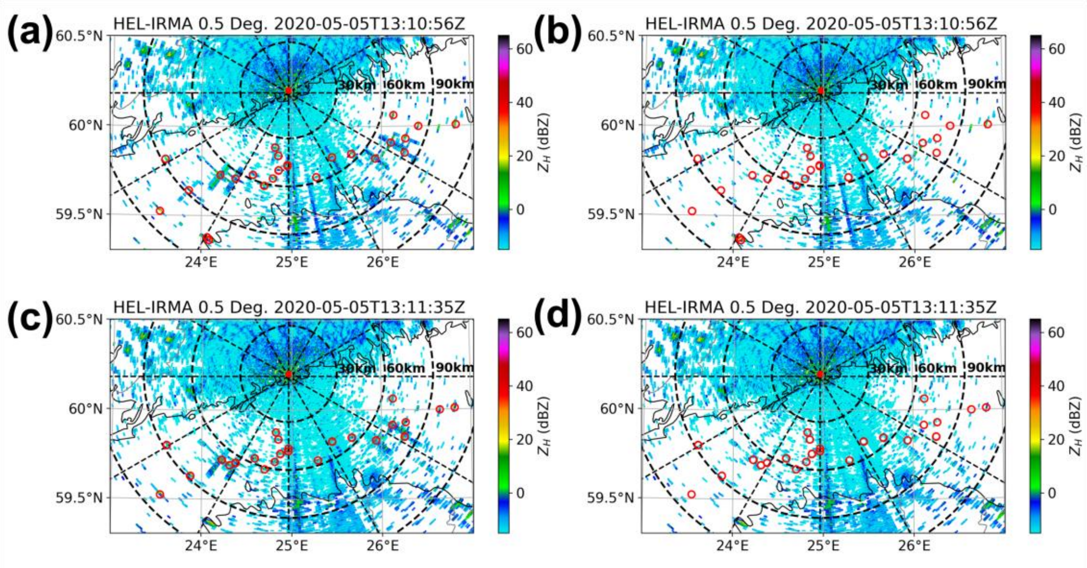

Figure xxx. Reflectivity on 0.5° elevation of Kumpula radar using LFM (1310 UTC) and NLFM (1311 UTC) waveforms on 5 May 2020. (a) Before ship clutter filtering using LFM waveform; (b) After ship clutter filtering using LFM waveform; (c) Before ship clutter filtering using NLFM waveform; (d) After ship clutter filtering using NLFM waveform. The mainlobe identification results are highlighted by red circles.

Question 4: Line 370 (Page 18):

"although the presence of ship clutter can be inferred from polarimetric variables such as the ρhv (Fig. 12d), its impact on Zh (Fig. 12a) is so minimal that it is virtually undetectable."

Consider briefly discussing implications or recommendations for operational radar usage, given this minimal clutter scenario. Should these marginal cases be explicitly filtered operationally?

Agree. In the revised manuscript, we have added the following clarification: During the evaluation of the HSCI algorithm (Section 4.1), we observed that weak ship clutter affects overlapping precipitation echoes differently in reflectivity and polarimetric variables, with the latter being more susceptible to contamination. In such cases, a general-purpose non-meteorological echo filter based on a correlation coefficient threshold could be used as an optional supplement to the HSCI algorithm in operational settings, helping to mitigate the potential impact of residual weak ship clutter on meteorological applications.

Question 5: Table 5 (Page 22):

Suggest adding a brief note about the implications of the false alarm rate (31 gates mistakenly identified as ship clutter) for operational scenarios. Though limited, operational impacts or recommendations would enhance practical context.

Agree. In the revised manuscript, we have added the following clarification: In addition, the evaluation revealed that the HSCI algorithm has a tendency to over-identify ship clutter. However, since the algorithm employs velocity and SNR filters in the sidelobe identification, even when precipitation echoes are mistakenly identified as ship clutter, the resulting precipitation loss can be kept to a minimum. For these limited range gates that are incorrectly removed, interpolation techniques or speckle filters can effectively restore the missing information.

Question 6: Line 455 (Page 22):

"to move the stage of ship clutter identification and filtering from 'data processing' to 'signal processing'" – briefly clarify the expected improvement or practical benefits of this suggested future modification.

The primary advantage of moving ship clutter identification and filtering from the data processing stage to the signal processing stage lies in handling scenarios where ship clutter overlaps with precipitation. For example, in situations like that shown in Fig. 12, even if the ship clutter is accurately identified and properly removed, some precipitation echoes overlapping with the ship clutter may still be lost. In contrast, suppressing ship clutter at the signal processing stage allows the overlapping precipitation signals to be preserved.

In the revised manuscript, we have added the following clarification: In this study, the method used to suppress the negative impact of ship clutter is to mask radar variables at the range gates where ship clutter is identified. However, when precipitation echoes overlap with ship clutter (as shown in Fig. 12), this inevitably leads to the loss of precipitation data.

Question 7: Appendix (Page 24):

The estimation method for SNR based on reflectivity could benefit from a brief comment about the accuracy or reliability of this approach compared to directly measured SNR. Would inaccuracies here significantly affect the performance of the PSD identification?

The estimation of radar reflectivity typically involves two steps: first, estimating the signal power (or SNR—the difference lies in whether the noise power is normalized) from IQ data; and second, estimating the reflectivity factor from the signal power (or SNR). In terms of radar signal processing, the SNR is obtained prior to the reflectivity factor. Unfortunately, the Kumpula radar does not output the SNR as an intermediate product.

To address this, this paper proposes an SNR estimation method. As shown in the equations listed in the appendix, this method essentially reverses the second step of the reflectivity estimation process. Strictly speaking, the term “estimation” may not be entirely accurate—“derivation” would be more appropriate. Therefore, the precision of the derived SNR is the same as that of the SNR estimated from IQ data, without introducing any additional error.

In the revised manuscript, we have added further clarification on this issue: “It is worth emphasizing that the proposed SNR estimation method can be viewed as the inverse of the reflectivity estimation. As such, the derived SNR maintains the same level of accuracy as that obtained directly from the raw time series data, without introducing any additional errors”.