Thank you for the valuable comments – responses to the comments are included below.

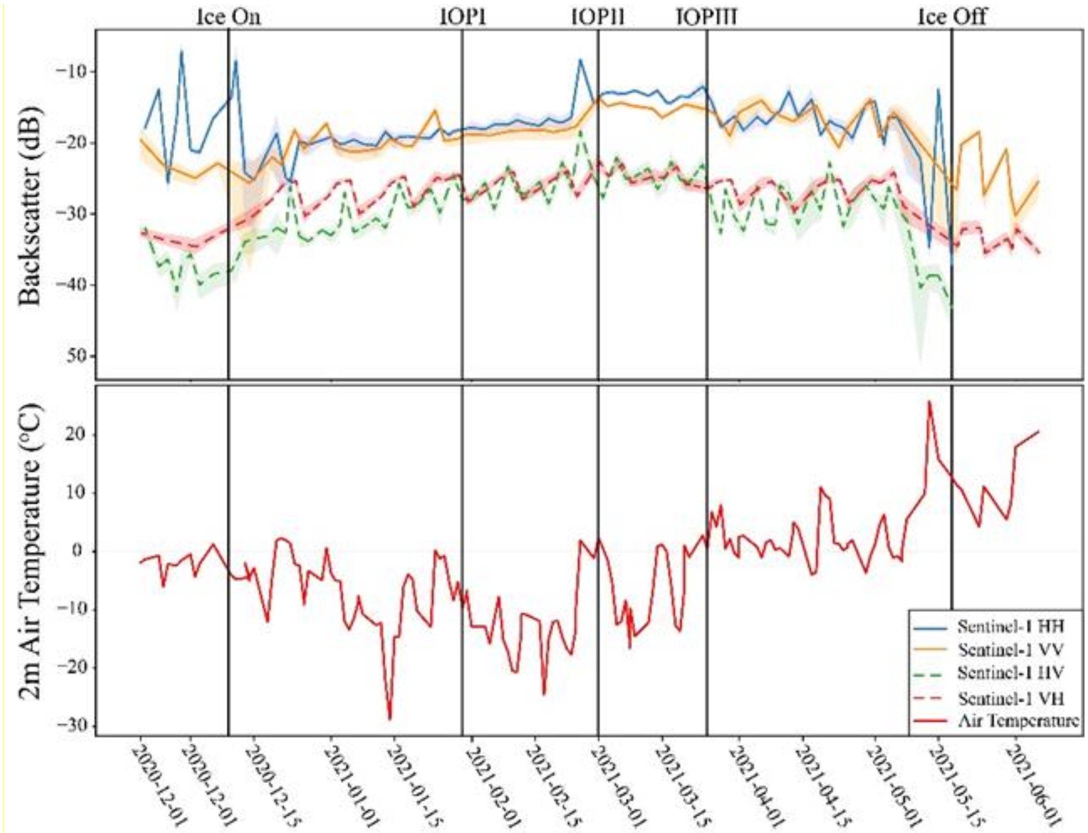
1. In Figure 2, the time series plot of backscattering reveals higher HH values compared to VV values for IOP I and IOP III. This indicates that volume scattering dominates in these periods. If surface scattering were dominant, higher VV values would be expected, as demonstrated in the modeling work shown in Figure 5. Another approach to verify this is by examining the cross-polarization (cross-pol) of the Sentinel data. In the case of volume scattering, cross-pol values are significantly higher than those of surface scattering. Therefore, during the dry snow period, solely considering the surface effect is insufficient; additional factors such as volume scattering need to be taken into account.

   Under dry conditions, the contribution of volume scattering is likely very minimal from the dry snow layer. There may be some minor contributions from the lake ice layer. However, past research (e.g., Gunn et al., 2018) has illustrated using polarimetric decomposition that when thin layers of bubbled ice are present the contribution of volume scattering is negligible.

   To address the missing cross-pol data and linkages to volume scattering, a short statement was added to the discussion on the patterns observed using Sentinel-1 cross-pol data. Figure 2 was updated to also included these values, "Additionally, while SMRT underestimates cross-pol backscatter, the observed HV and VH backscatter from Sentinel-1 also supports the dominance of the surface scattering regime under dry snow conditions. As shown in Figure 2, between January 1 and February 25, the average HV and VH backscatter was -27.84 and -25.44 dB, respectively. The low cross-pol backscatter values observed indicate that snow ice, or ice likely to depolarize signals, is limited, indicating less volume scattering during these dry conditions (Gunn et al., 2017). This is in agreement with past polarimetric decomposition experiments, which show that volume scattering contributes less compared to surface scattering when these ice types are less present (Gunn et al., 2018)."

2. On page 4, line 123, it is mentioned that the current SMRT model does not implement cross-polarization calculation. However, despite this limitation, including the measurement Sentinel data of cross-pol would still be valuable in enhancing our understanding of the scattering mechanism. Therefore, I recommend adding cross-pol information to Figure 2. Additionally, to provide a comprehensive reference for backscattering levels, it would be beneficial to include data from the entire season, including the ice-off period, pre-season, and post-season. This would offer a more complete perspective.

   Figure 2 has been modified to include cross-pol data. Additional images were added to provide a complete picture of the backscatter from before and after the ice season/during melt.



3. On page 4, line 128, the paragraph is somewhat confusing. The initial sentences address the dry snow condition, where the snow is considered a two-mixture random medium consisting of ice grains and air. To provide clarity, the sentences need to be rephrased. Subsequently, the paragraph transitions to discussing the wet snow condition. However, it then reintroduces the SHS model and exponential model, which are specifically applied to the dry snow condition. I recommend reorganizing this paragraph to separate the discussion of the dry and wet snow conditions and clearly specify the models chosen for each layer. Additionally, it should be noted that all the assumptions and models described in the original Picard's paper for the wet snow condition pertain to the passive microwave remote sensing regime, which calculates brightness temperature. Applying them directly to backscattering may not yield accurate results.

This paragraph was split into two separate paragraphs to clarify the statements, one addressing the electromagnetic model (IBA for dry snow and the addition of MEMLS for wet snow conditions). The other paragraph outlines the microstructure models. We also clarified that sticky hard spheres was used only for ice mediums, while the exponential microstructure model was used for snow mediums. We also added a sentence identifying the limitation of Picard et al. (2022) in the application to the experiments conducted here, "It should be noted that Picard et al. (2022a) specifically evaluate the models for passive microwave analysis, and these models have not been fully verified for active microwave."

4. On page 9, line 243, it should be noted that the remote sensing data utilized in this paper is backscattering. The temperature of each layer has minimal impact on backscattering and should be clarified from the outset. Consequently, it is not necessary to consider temperature as a factor in the tables and in-situ measurements. Furthermore, I suggest using the term "snow media correlation length" instead of "Pex" in the sentence to maintain consistency and clarity.

   Temperature does have a minimal impact on the dielectrics and the resulting backscatter, but it is needed to generate the most realistic representation of the mediums observed in the field. Two sentences have been added to address this comment, "It is important to note that the temperature of the layers has a minimal impact on the dielectric values and the resulting backscatter but does provide a more realistic representation of the different mediums within the model. Therefore, the temperature data from the field campaigns and CLIMo are included."

5. Figure 3 illustrates the modeling approach for a multi-layer structure during three IOP periods. To enhance clarity, it would be beneficial to consolidate the information regarding the selected model and input parameters for each layer in a single location. Currently, this information is dispersed across sections 2.1 and 2.5, making it challenging to piece together. It would be helpful to provide a clear explanation of the distinctions between dry snow, snow ice, and pure ice. It seems that all three conditions involve a mixture of ice and snow, differentiated by varying volume fractions. Please provide further elaboration on this matter.

   The same electromagnetic and microstructure models were used for all snow and ice layers; there was no change between wet snow/dry snow or clear ice/snow ice. Additionally, all the necessary input information (layer thickness, temperature, density, etc.) can be found in Tables 2 and 3, Figure 3, and Section 2.5.1 – 2.5.3. An additional table was added which summarizes the microstructure and electromagnetic model information from section 2.1 at the start of section 2.5.

Table 2. SMRT microstructure and electromagnetic model settings used for dry and wet snow layers.

Physical Layer	Microstructure Model	Electromagnetic Model
Dry Snow	Exponential model	IBA
Wet Snow	Exponential model	MEMLS V3
Snow Ice	Sticky Hard Spheres	IBA
Clear Ice	Sticky Hard Spheres	IBA

6. As previously mentioned, the temperature of each layer has a minimal effect on the backscattering calculation compared to the brightness temperature. Therefore, the introduction of the CLIMo model on page 9, line 250 does not appear necessary for this purpose.

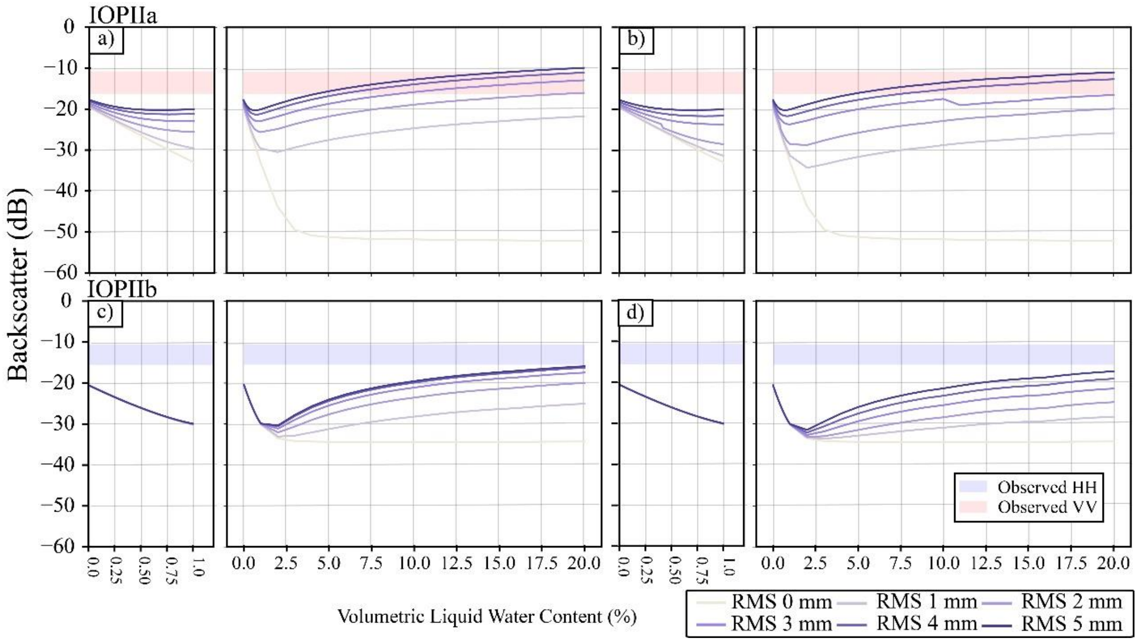
Similar to the comment above, this is to provide the most realistic representation of the medium conditions for the conducted experiment, "It is important to note that while the temperature of the layers has a minimal impact on the dielectric values and the resulting backscatter, it is still needed to run SMRT and provide a realistic representation of the different mediums within the model. Therefore, the temperature data from the field campaigns and CLIMo is essential."

7. Kindly provide further elaboration on the snow ice porosity. Does a 10% snow ice porosity mean that 10% of the volume consists of air and 90% consists of pure ice? To enhance clarity, I recommend color coding each number to clearly indicate which parameters are derived from in-situ measurements and which ones are based on ad-hoc best fit parameters. This would help differentiate between the two sources of data and improve the overall understanding of the parameter selection process.

   An additional statement was added to clarify the definition of porosity in relation to snow ice: "Additionally, the porosity of snow ice relates to the ratio of air and ice within the medium; for example, a porosity of 10% indicates that 10% of the medium is air and 90% is ice.". As suggested, n Table 2, values that are not from field measurements were bolded.

8. Figure 8 requires additional description to improve clarity. Is (a)(c) referring to IOPIIa, and (b)(d) referring to IOPIIb? It would be helpful to provide clarification regarding the color blocks. Does red represent VV, while blue represents HH? Furthermore, when comparing Figure 8 (c) and (d): despite varying VWC values from 0 to 1%, the backscattering remains almost identical and shows no sensitivity to RMSH or correlation length. This suggests that surface scattering is not the dominant factor in the overall backscattering for that particular case.

   Additional labels were added to Figure 8 in order to clarify the components of the figure.



While the backscatter does not increase when VWC is on a small scale, it does as VWC increases. A short statement was added addressing this difference: "Additionally when the wet snow interface is within the snowpack (IOPIIb), the RMSH of the interface does not result in a difference in the magnitude of backscatter (Figure 8c and 8d)."

Minor comments:

1. Please keep the color consistent through out the figures. Eg. Figure 2/5/10 using blue for HH and orange for VV. But figure 4 use orange for HH and blue for VV

   Figure 4 has been corrected to match the other figures.

2. For figure 5,6,8,9, the color block of the observed HH/VV. Is the max-min range of the HH/VV or the standard

   The coloured areas represent the minimum/maximum range for the respective polarizations; this has been clarified in the figure captions.