SUPPLEMENTARY MATERIAL: Assimilation of synthetic radar backscatters at Ku-band improves SWE estimates

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S1 Additional figures

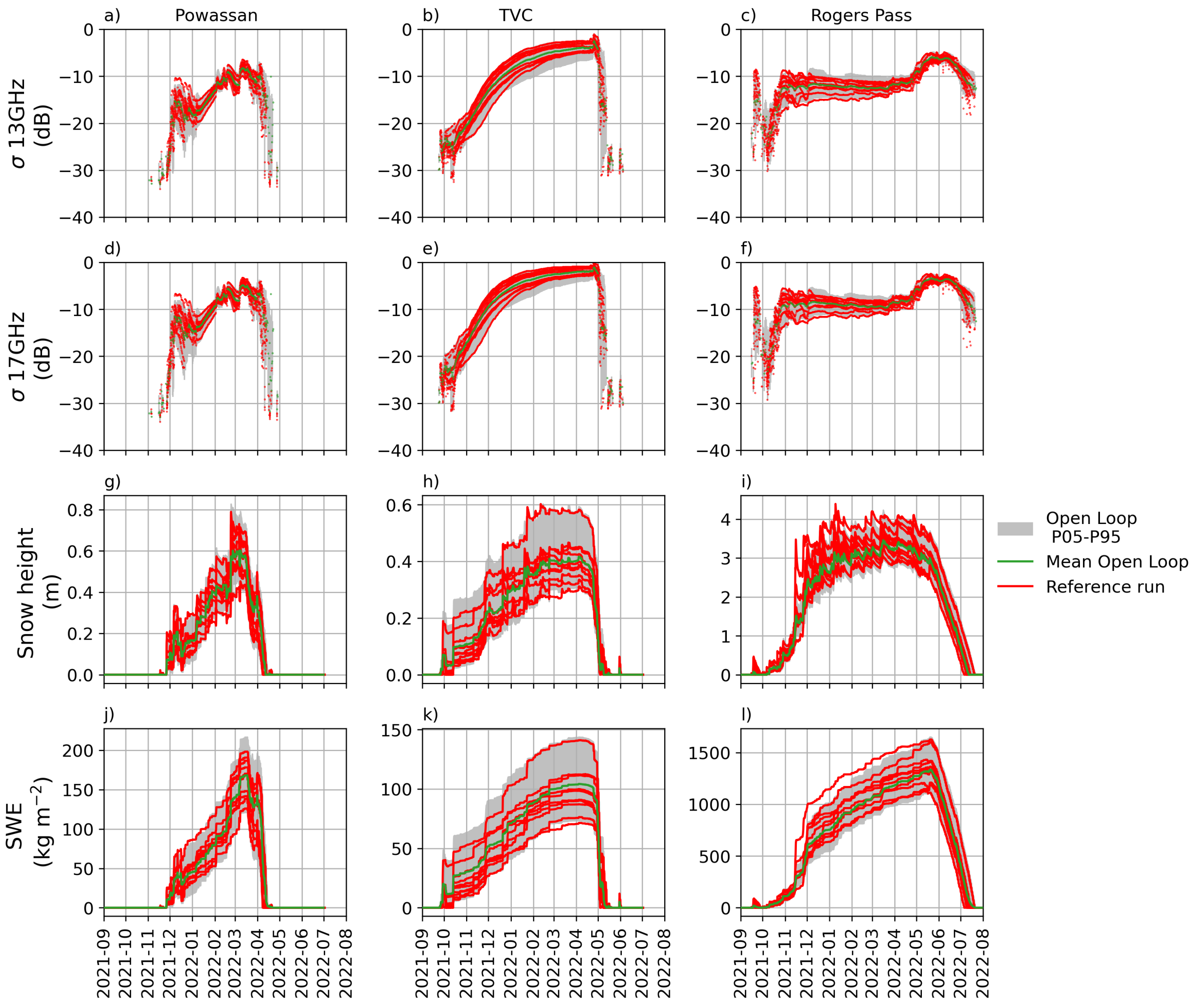

Figure S1. Spread of the open loop (OL) ensemble (between 5th and 95th percentiles) and the 10 reference runs at Powassan (a, d, g, j), TVC (b, e, h, k), and Rogers Pass (c, f, i, l) for the backscatter at 13.5 GHz (a, b, c), for the backscatter at 17.25 GHz (d, e, f), for snow height (g, h, i), and for SWE (j, k, l) for the winter 2021-2022.

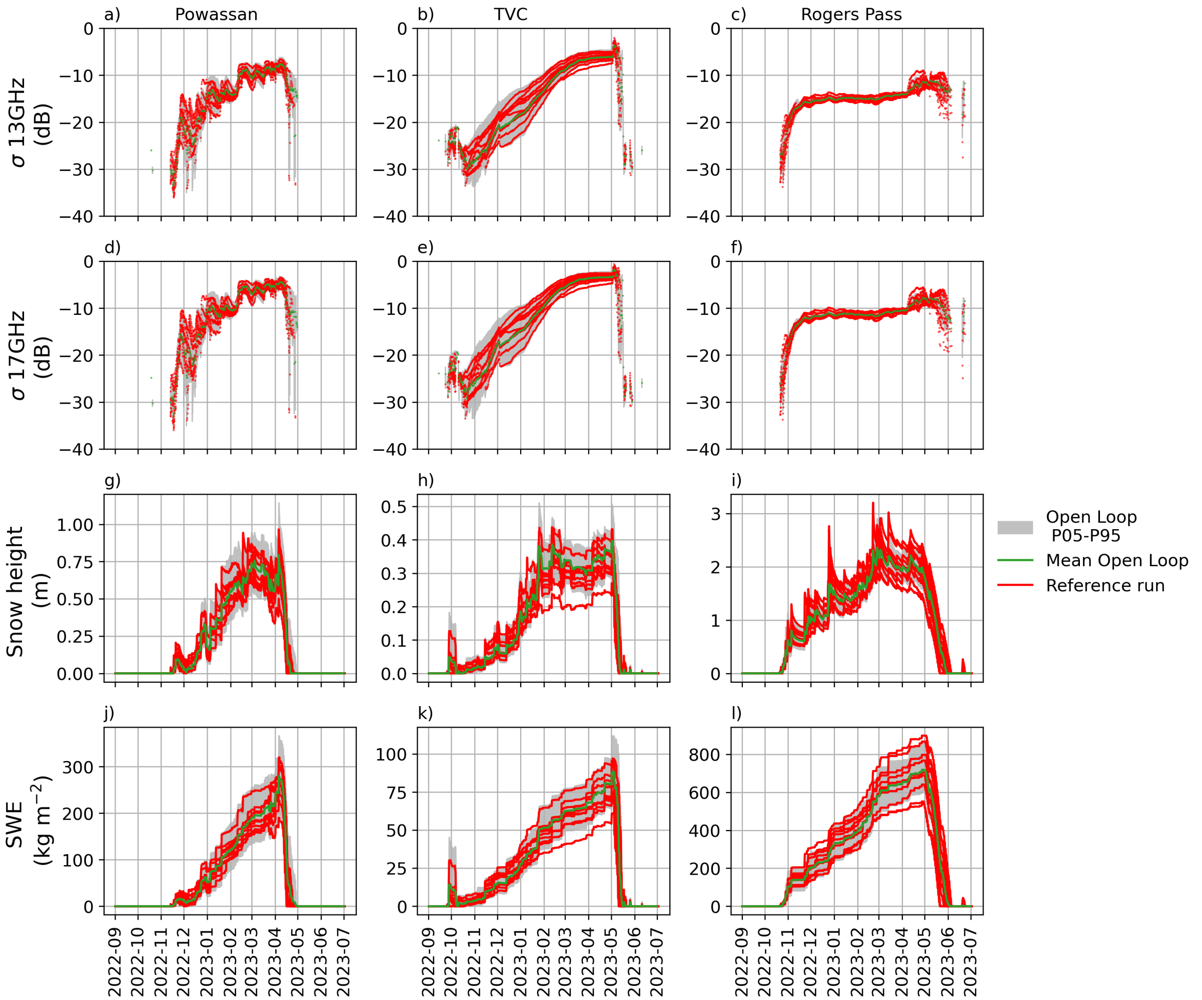

Figure S2. Spread of the open loop (OL) ensemble (between 5th and 95th percentiles) and the 10 reference runs at Powassan (a, d, g, j), TVC (b, e, h, k), and Rogers Pass (c, f, i, l) for the backscatter at 13.5 GHz (a, b, c), for the backscatter at 17.25 GHz (d, e, f), for snow height (g, h, i), and for SWE (j, k, l) for the winter 2022-2023.

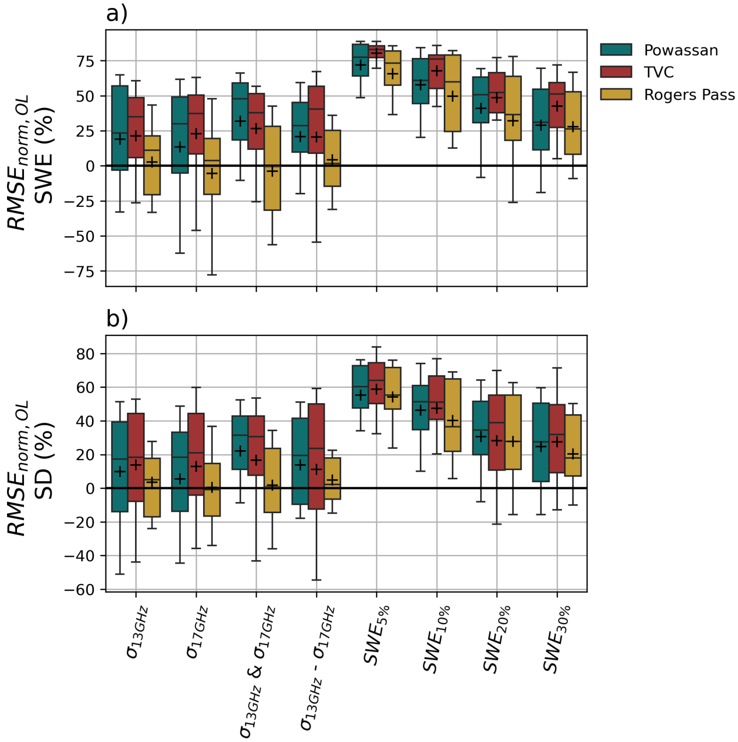

Figure S3. Normalized $RMSE$ against the open loop at all the observation times over all the different runs for the three winter seasons (a) for SWE prediction (b) and snow depth prediction at the three sites based on different inputs being assimilated. Box plots show median (center line), interquartile range (box), 10th–90th percentiles (whiskers), and mean (+). No outliers are shown for clarity.

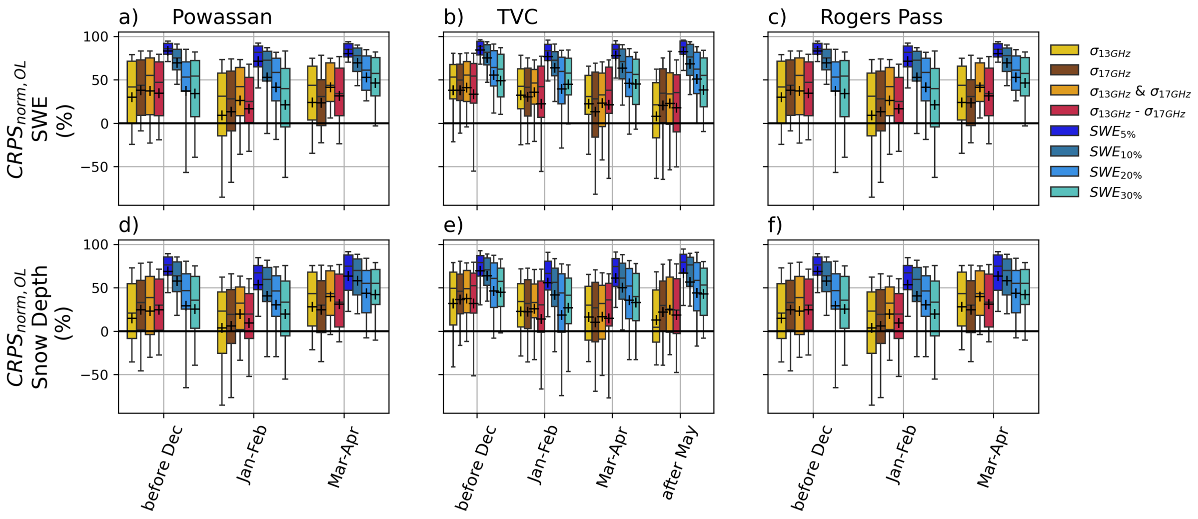

Figure S4. Normalized $CRPS$ against the open loop (OL) for all the different runs and the three winter seasons for (a,b,c) SWE prediction and (d,e,f) snow depth prediction for (a,d) Powassan, (b,e) TVC, and (c,f) Rogers Pass based on the month of the observations. Box plots show median (center line), interquartile range (box), 10th–90th percentiles (whiskers), and mean (+). No outliers are shown for clarity.

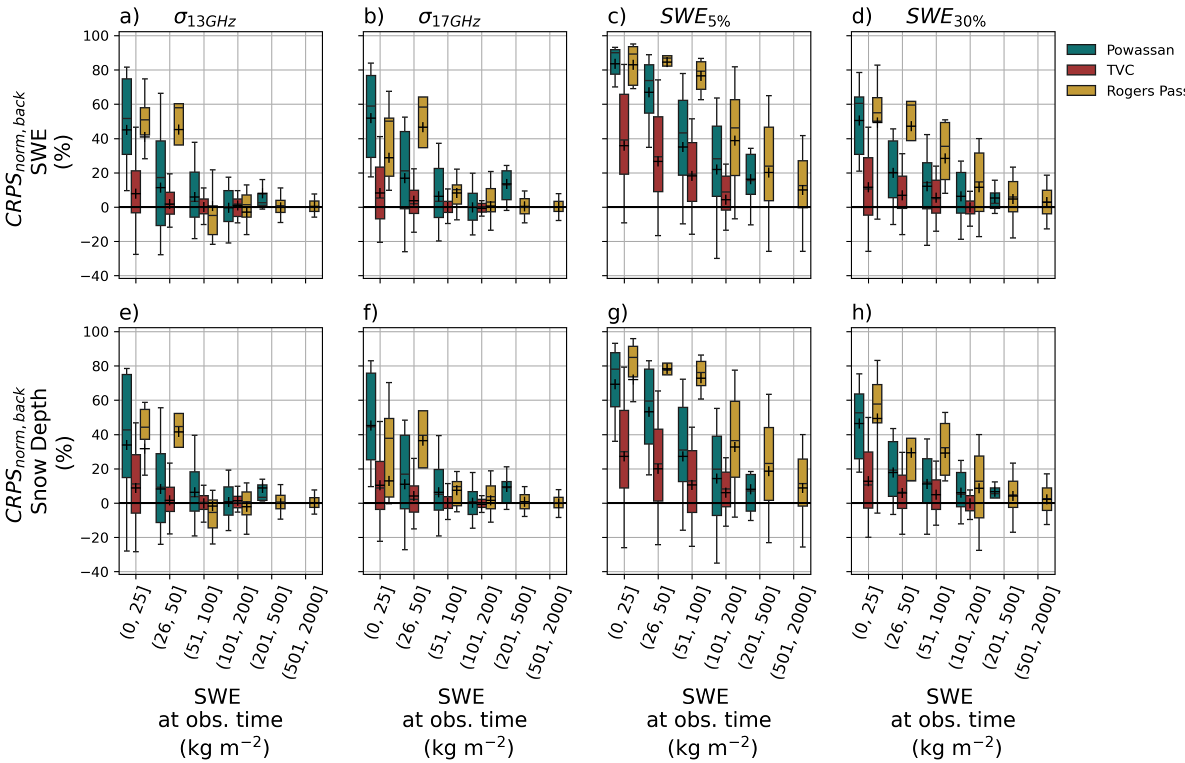

Figure S5. Normalized $CRPS$ against the background particles for all the different runs and the three winter seasons for (a,b,c,d) SWE prediction and (e,f,g,h) snow depth prediction for the assimilation experiments with (a,e) backscatter observations at 13.25 GHz, (b,f) with backscatter observations at 17.5 GHz, (c,g) with SWE observations with an uncertainty of 5 % and (d,h) with SWE observations with an uncertainty of 30 %. The results are not shown for all the assimilation experiments for conciseness. As an example, the interval (26,50] signifies that 26 is excluded and 50 included in the interval. Box plots show median (center line), interquartile range (box), 10th–90th percentiles (whiskers), and mean (+). No outliers are shown for clarity..

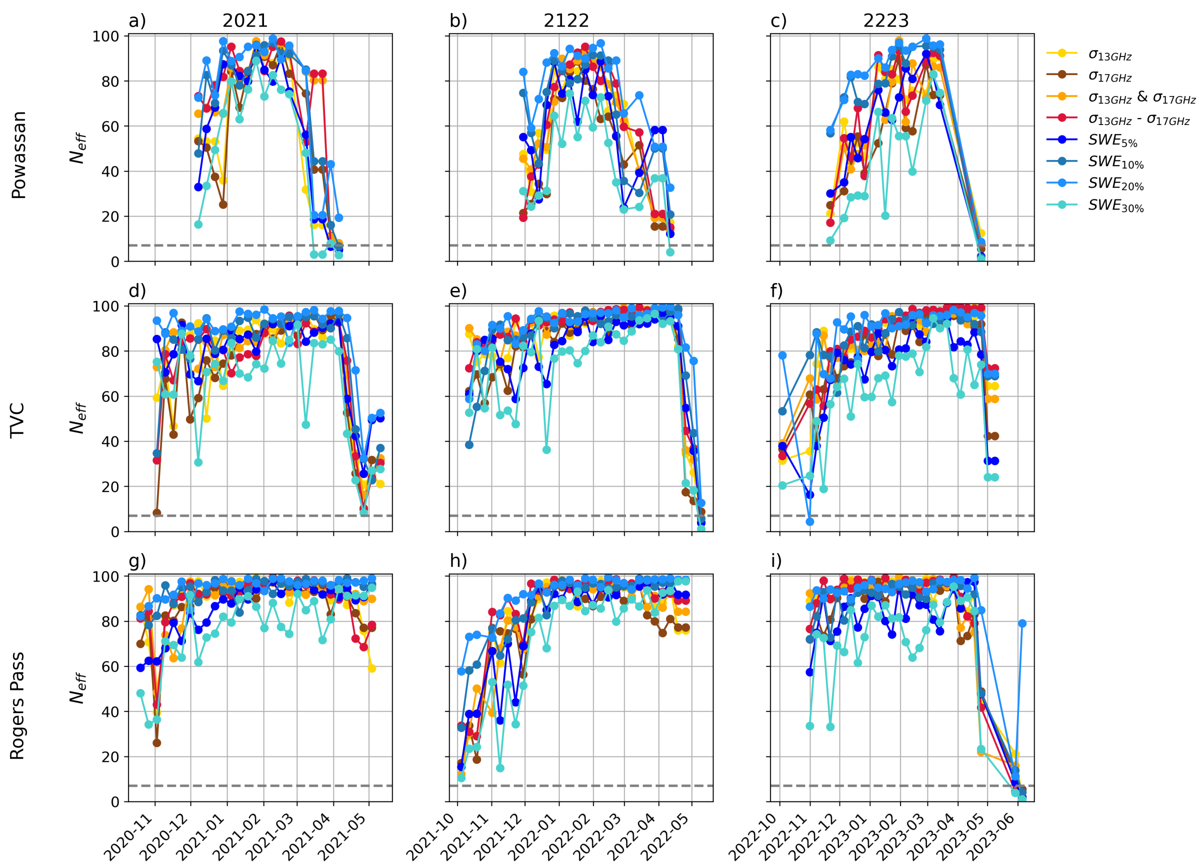

Figure S6. Evolution over time of the effective sample size (N_{eff}, Eq. 3 of the main manuscript) averaged over the 10 iterations for each winter season and for each site. The horizontal dashed line represents the 7 % threshold below which degeneracy is assumed to occur.