Further response to reviewers: A possible illustration to better show that we no longer need an accurate prior to retrieve SWE

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August 25, 2023

1 Introduction

In our manuscript, we demonstrate an algorithm that does not need accurate a priori information on either SWE or grain size to accomplish an accurate retrieval. We do this by leveraging the timeseries of radar observations: many retrieval studies try to retrieve each observation independently, which makes the problem more challenging. We use the weighted average of the retrieval from the previous day and an independent model (ERA5 in this study) as the prior.

We have already addressed the reviewers comments in the online discussion in the manuscript: https://egusphere.copernicus.org/preprints/2023/egusphere-2023-1653/ However, we did note in the discussion that we were exploring a possible figure to add that was not explicitly requested by the reviewers, but might help to clear up confusion that they expressed.

In reviewing our manuscript, both reviewers flagged that the fact that the ERA5 modeled SWE is so accurate to begin with may obscure our result. This is a communication issue: in fact our experiments are designed to address this very issue. By varying the bias systematically starting from an accurate prior, we explore in depth the effect of bias on the result, and show that we are not very sensitive to prior bias for the algorithm that takes its prior from a weighted average of the previous retrieval and the model. We propose adding Figure 1 and Figure 2, below. Figure 1 picks two of the many bias scenarios explored in the manuscript and plots them as timeseries. Figure 1 shows visually what 25% bias in the ERA5 SWE looks like. Second, the figure how the SWE retrieval using only ERA5 (triangle markers) is also quite sensitive to prior bias: the biased vs unbiased results are quite different from each other, visually. Finally, the SWE retrieval using the weighted average of the previous retrieval and ERA5 (circle markers) is much less sensitive to the prior: the two retrieval timeseries are not that much different from each other.

To better highlight these differences, we have computed SWE error for the prior and the retrieval results for these two scenarios: unbiased ERA5 and ERA5 with 25% bias artificially added, which is shown in Figure 2. The error

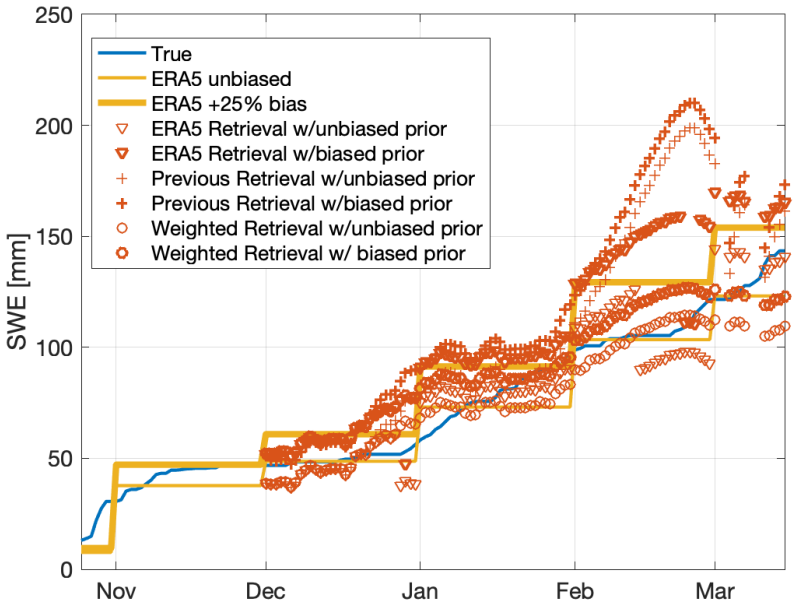

Figure 1: SWE timeseries for 2011 at Sodankyla, showing the "true" SWE computed in the manuscript (blue), the model (ERA5) priors (gold), and the retrievals (red), for two of the bias scenarios studied in the manuscript: no bias, and +25% bias artificially added to the ERA5 model estimates: thicker lines are used to distinguish the results that include bias from those that do not.

values are the difference between the SWE estimate and the "true" SWE at each time. Note that in the retrieval using ERA5 prior (red markers), the retrieval with biased prior (large markers) has much higher error than the retrieval with unbiased prior (small markers). However, in the retrieval using the weighted average (purple markers) the retrieval with biased prior is similar in error to that using the unbiased. Thus, the retrieval using the weighted average prior is much less sensitive to bias in the prior. We attribute this reduced sensitivity to simply using the previous retrieval as the prior: information about the retrieved SWE is thus transmitted from one time to the next, lessening the importance of having an accurate prior input.

In summary, we've presented here a retrieval algorithm that does not require accurate a priori information to accomplish SWE retrievals from radar. We accomplish this by leveraging the timeseries of observations. We believe this has important implications for a long-standing issue in this field: how to retrieve SWE from satellite without having accurate information to start with.

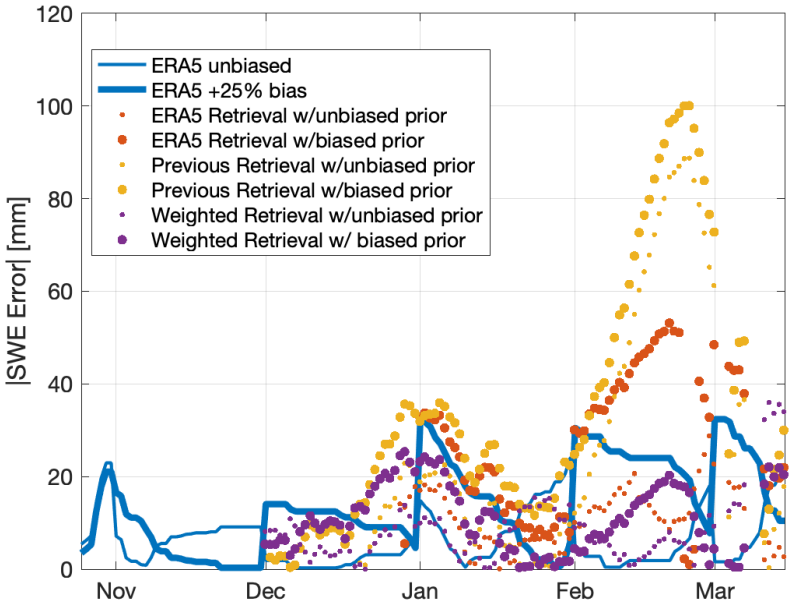

Figure 2: Absolute value of SWE error for the ERA5 model prior (blue , and three retrieval algorithm configurations (red, gold, and purple) for the unbiased (thin line and small markers) and scenario with artificial bias added (thick line and large markers) shown in Figure 1.