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Data assimilation in glacier mass balance modeling

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The accurate quantification of glacier mass balance is of vital importance for the evaluation of climate change impact and the management of hydrological resources. However, traditional modeling methodologies on a regional scale are frequently plagued by uncertainties in forcing data, model structure, and parameters. Data assimilation emerges as an effective technique to incorporate observations into modeling, thereby reducing the uncertainty of results. In this study, we evaluate the performance of different ensemble-based schemes, including the Ensemble Smoother (ES) and the Ensemble Smoother-Multiple Data Assimilation (ES-MDA), to incorporate albedo derived from MODIS satellite observations and in-situ mass-balance measurements vis stakes into the full energy balance model CryoGrid applied to Svalbard glaciers. Our primary aim is to enhance the accuracy of both the reconstruction and prediction of glacier mass balance in the Svalbard region through the synergistic use of observational data and model. In a range of experiments, we analyze the performance of different assimilation methods and different observation products. The implementation of ES-MDA has demonstrated marked improvements, while the variations in parameter dynamics have varied effects on the results. We compare the prior and posterior states to help disentangle which process or forcing has the most impact on the uncertainty of the model's results.