Supplementary Information for "Advancing snow data assimilation with a dynamic observation uncertainty"

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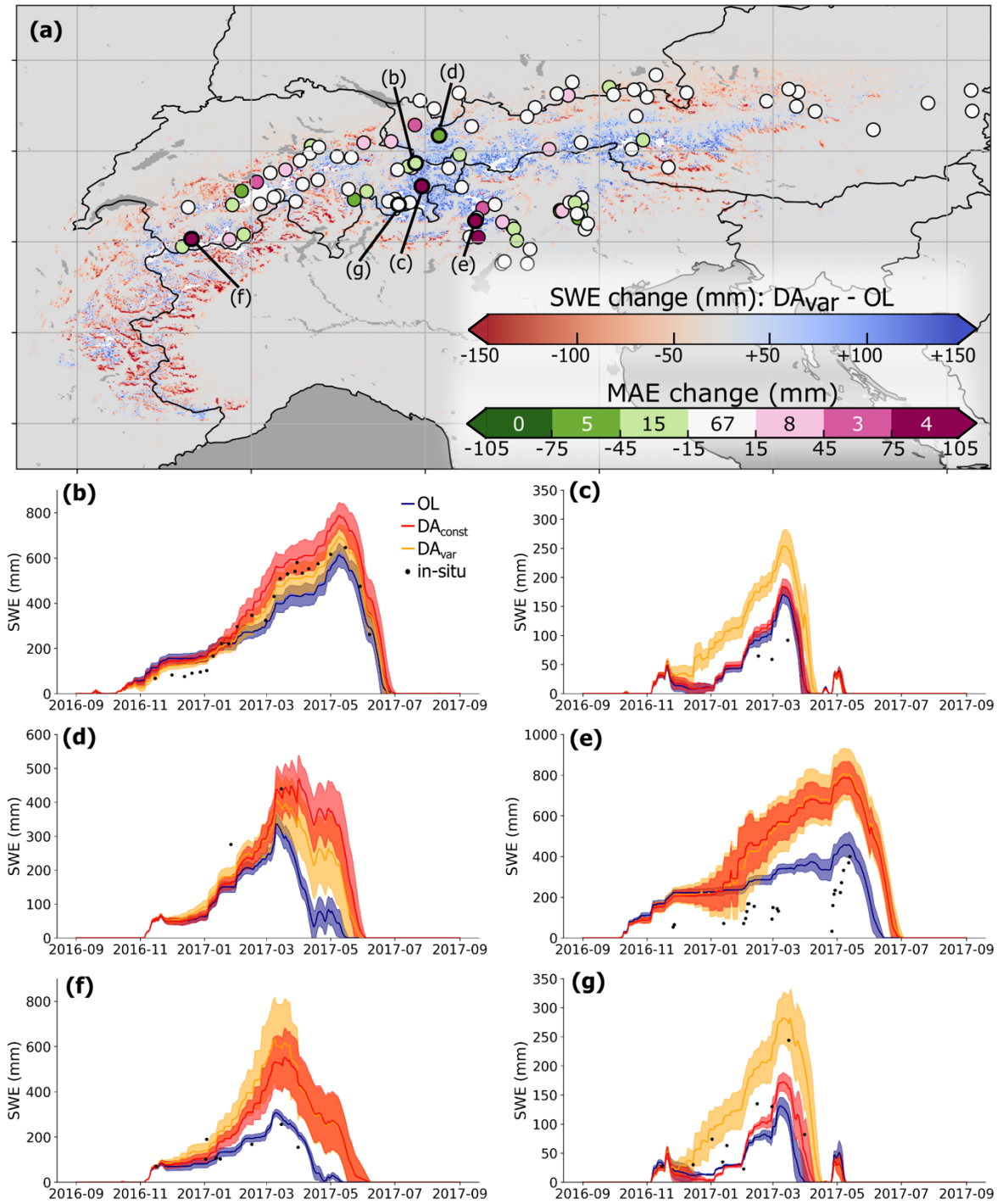
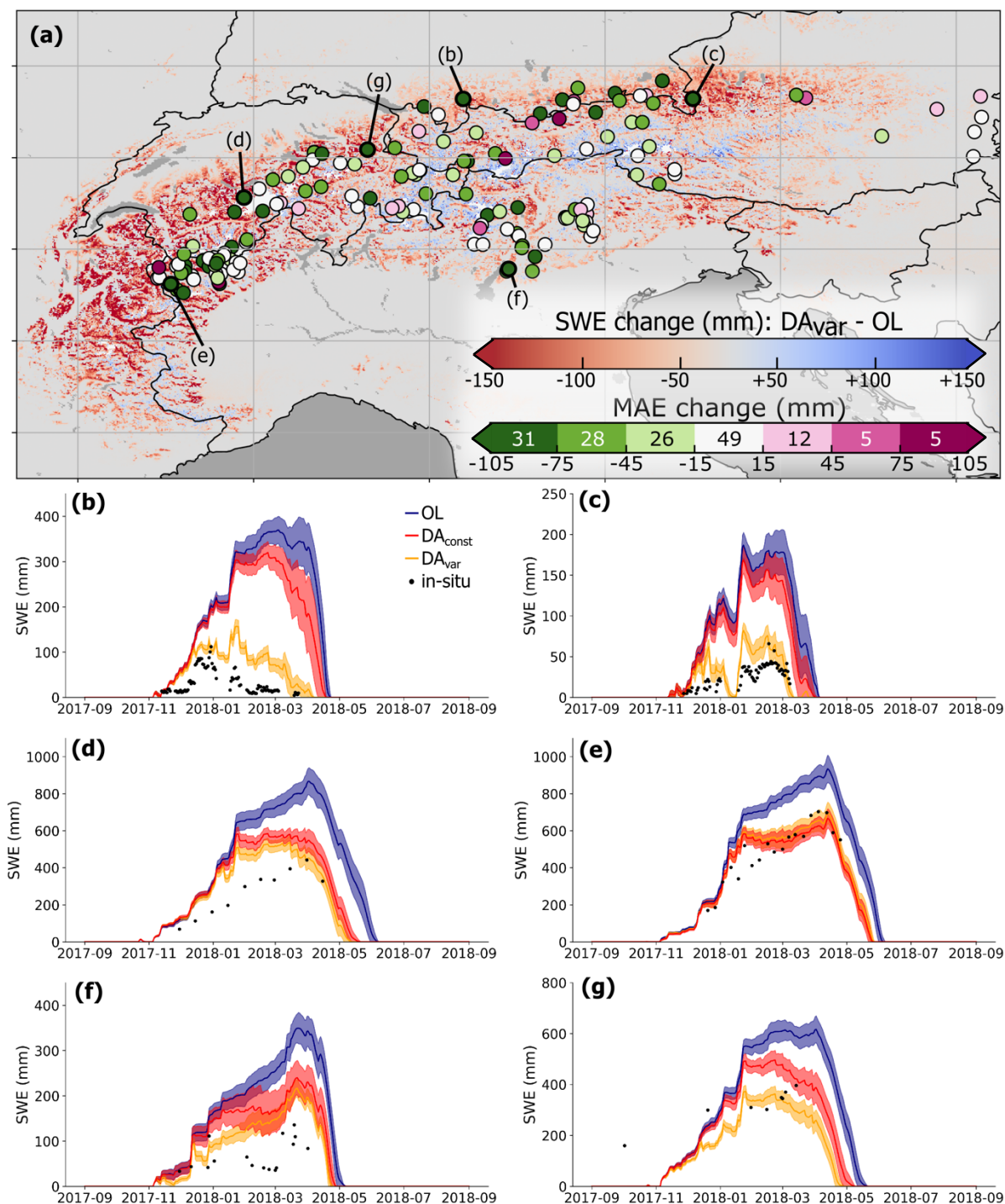
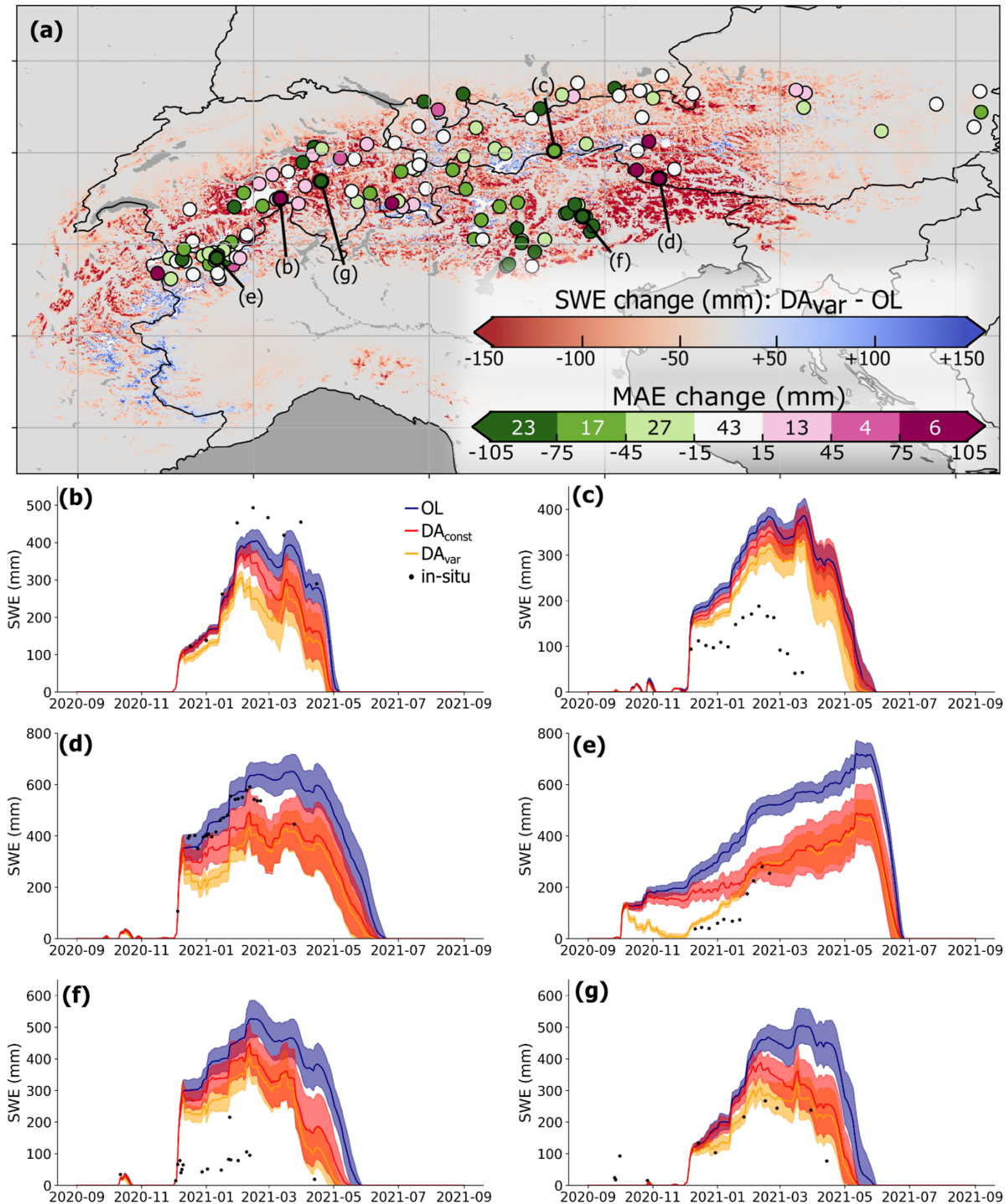
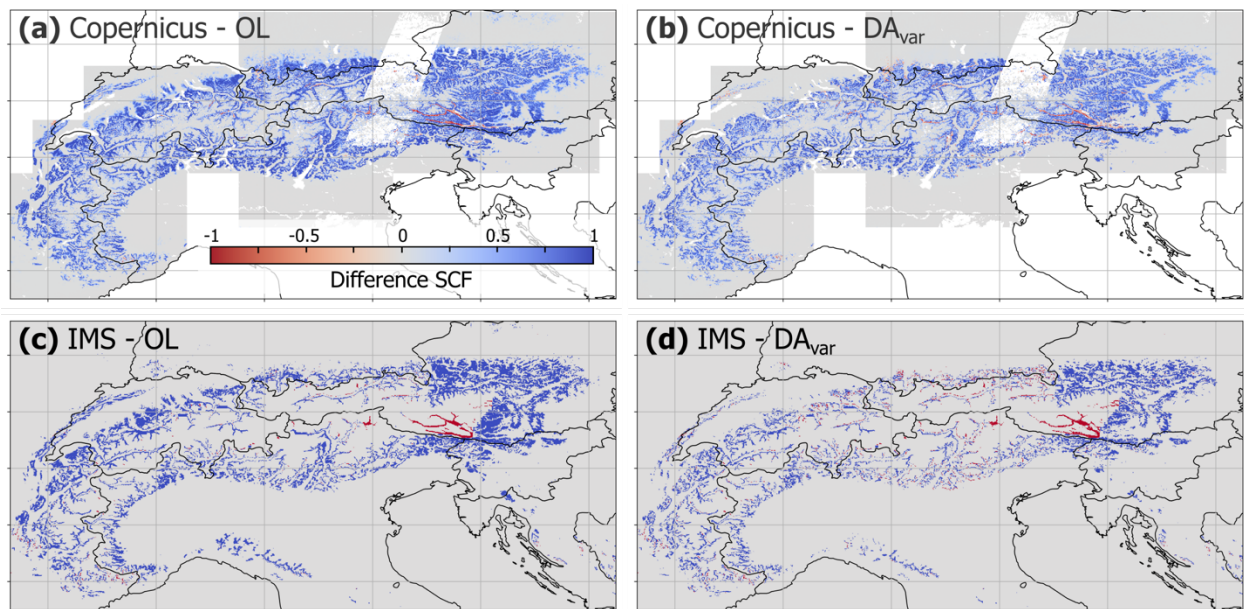
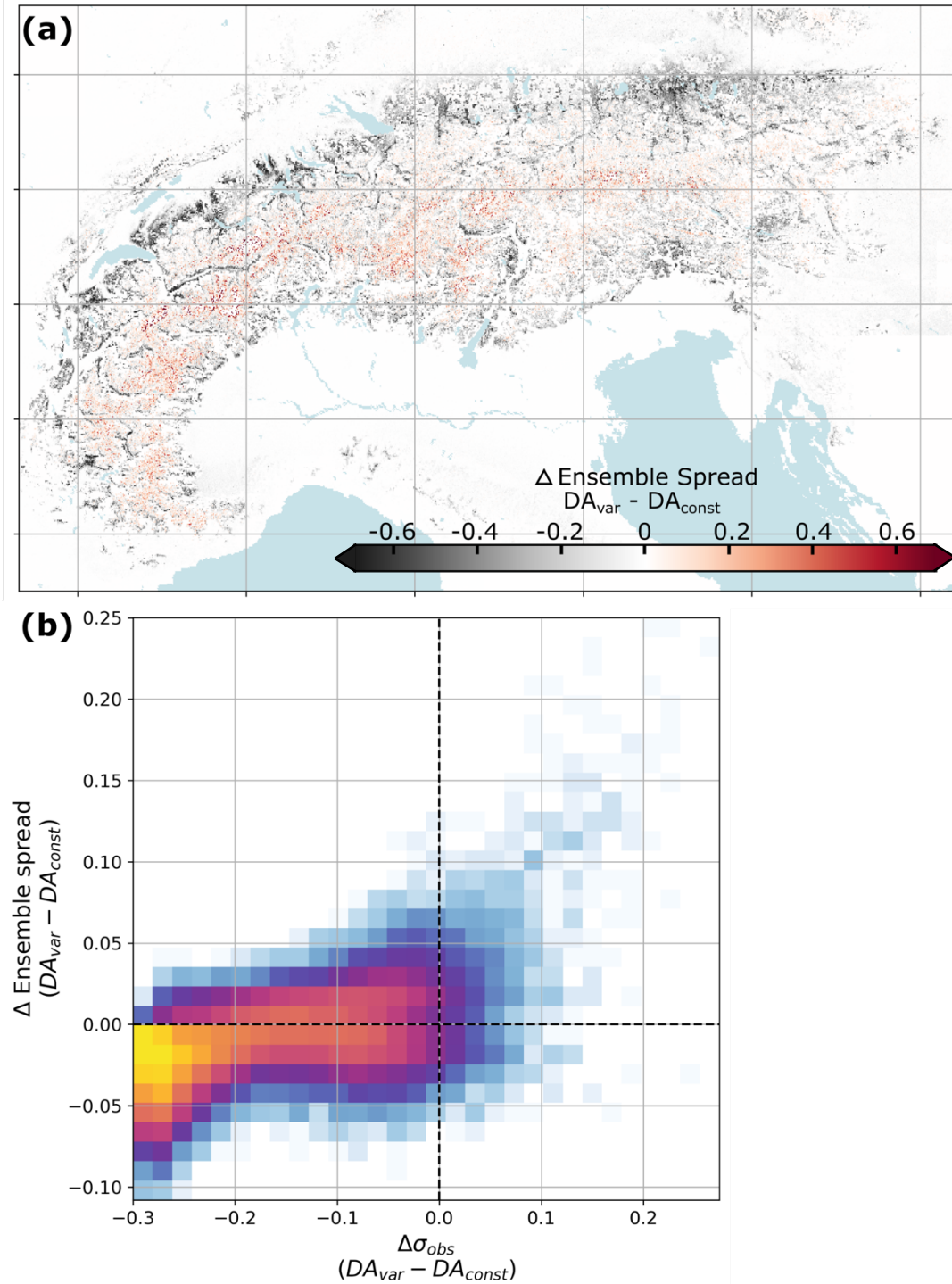
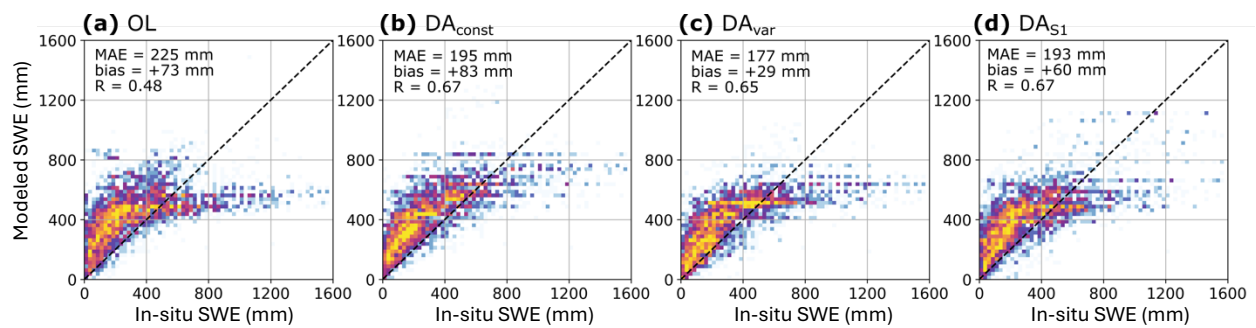
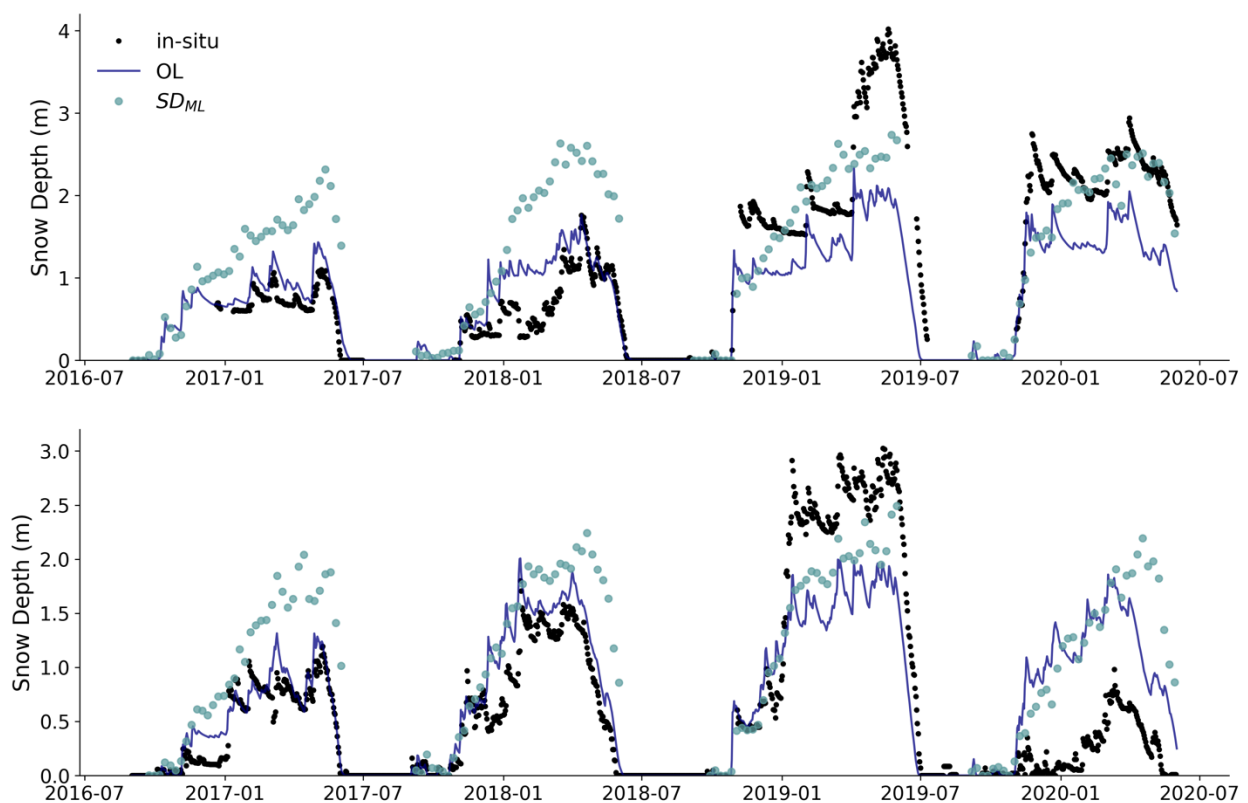
Supplemental file contains:
- Supplemental Figure S1-S7

Supplemental Figure S1 2017 SWE comparison. (a) Map of SWE changes (DA_var – OL), averaged during the period March 1 – 7, 2017. Sites with manual SWE measurements from the 2016/2017 snow season are plotted, colored according to the change in MAE between the DA_var and OL experiments. MAE changes are computed over the entire snow season. On the MAE change color bar, the number of sites that fall within each color range is indicated. (b-g) SWE timeseries from the three model experiments, compared with manual measurements (black dots) for in-situ measurement sites which are indicated in (a).

Supplemental Figure S2 2018 SWE comparison. (a) Map of SWE changes (DA$_{var}$ – OL), averaged during the period March 1 – 7, 2018. Sites with manual SWE measurements from the 2017/2018 snow season are plotted, colored according to the change in MAE between the DA$_{var}$ and OL experiments. MAE changes are computed over the entire snow season. On the MAE change color bar, the number of sites that fall within each color range is indicated. (b-g) SWE timeseries from the three model experiments, compared with manual measurements (black dots) for in-situ measurement sites which are indicated in (a).

Supplemental Figure S3 2021 SWE comparison. (a) Map of SWE changes (DA$_{var}$ – OL), averaged during the period March 1 – 7, 2021. Sites with manual SWE measurements from the 2020/2021 snow season are plotted, colored according to the change in MAE between the DA$_{var}$ and OL experiments. MAE changes are computed over the entire snow season. On the MAE change color bar, the number of sites that fall within each color range is indicated. (b-g) SWE timeseries from the three model experiments, compared with manual measurements (black dots) for in-situ measurement sites which are indicated in (a).

Supplemental Figure S4 Comparison in modeled snow cover fraction (SCF) with two snow cover products on March 1, 2021. (a) SCF difference between Copernicus Fractional Snow Cover and OL experiment. White indicates data gaps. (b) SCF difference between Copernicus Fractional Snow Cover and DA$_{var}$ experiment. (c) SC difference between IMS and OL experiment. (d) SC difference between IMS and DA$_{var}$ experiment.

Supplemental Figure S5 Impact of DA experiment on model ensemble spread. (a) Change in ensemble spread ($DA_{var} - DA_{const}$), averaged over the first week of March each year (March 1 - 7). (b) 2D histogram showing the change in ensemble spread with the change in observation uncertainty (σ_{obs}). Change in ensemble spread is taken over the first week of March (typically when SWE peaks) and change in observation uncertainty is taken over the full accumulation period leading up to the first week in March.

Supplemental Figure 6 2D histograms comparing modeled SWE to in-situ SWE observations for (a) OL, (b) DA$_{const}$, (c) DA$_{var}$, and (d) DA$_{S1}$. The MAE, average bias, and R are provided for each approach.

Supplemental Figure S7 Snow depth timeseries at two example in-situ measurement locations, demonstrating interannual inconsistencies in model and assimilated observation (SD$_{ML}$) biases.