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Impacts of snow assimilation on seasonal snow and meteorological forecasts for the Tibetan Plateau

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Figure S1 presents the spatial differences in snow density between the two ensemble reforecasts. In either the spring or the whole period, the snow density of the DA reforecasts is smaller than that of the control reforecasts for most places of the TP, especially for the ETP and around the boundary of the WTP and ETP in the southern TP, while the results are reversed in the southwestern TP. The spatial differences in snow density between the two reforecasts are statistically significant at the 5% significance level for regions where the absolute differences are larger than 25 kg/m^3. In summer, the snow density of the DA reforecasts is larger than that of the control reforecasts in the eastern and southwestern TP and the differences between the two reforecasts are smaller than 25 kg/m^3.

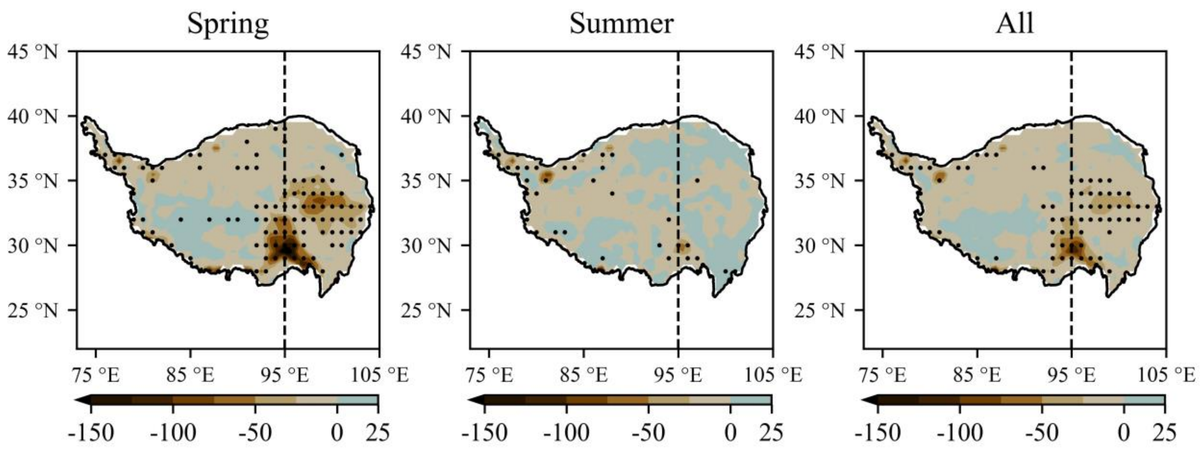

Figure S1: The spatial differences in snow density (kg/m3) between the two ensemble reforecasts (with – without snow assimilation). The stippled regions show the statistical significance of the differences identified by the t-test at a 5% significance level.

In Fig. S2, the daily temperature of the two ensemble reforecasts is compared with that of the CN05.1 data. In general, the temperature reforecasts are lower than the CN05.1 temperature. However, the temperature of the DA reforecasts is closer to the CN05.1 temperature, consistent with the high snow bias reduction.

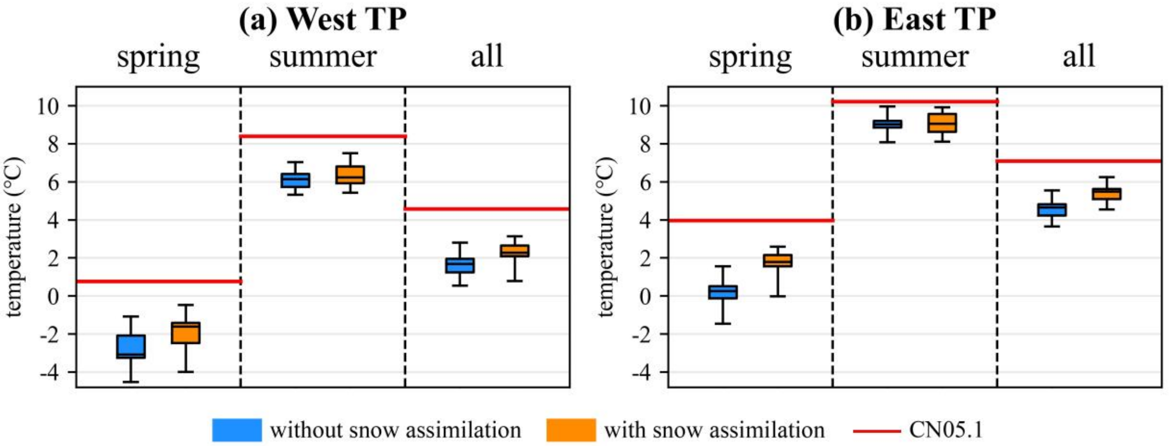

Figure S2. The daily averaged temperature of the two ensemble reforecasts and CN05.1 data in the (a) west Tibetan Plateau and (b) east Tibetan Plateau.

The spatial correlations and mean error between the temperature reforecasts and in-situ observations are displayed in Fig. S3. The temperature reforecasts are interpolated to stations using the bilinear interpolation method. The results show that with no snow assimilation, the spatial correlations between the temperature reforecasts and in-situ observations are 0.64 and 0.66 for spring and the whole period, respectively, while with snow assimilation the spatial correlations are 0.68 for both spring and the whole period. Moreover, the mean error is 7.26 ℃ in spring, 4.99 ℃ in summer and 6.12 ℃ in the whole period before snow assimilation, while the mean error is 5.71 ℃ in spring, 4.88 ℃ in summer and 5.30 in the whole period after snow assimilation. In general, the spatial correlations are higher, and the mean error is smaller when performing snow assimilation.

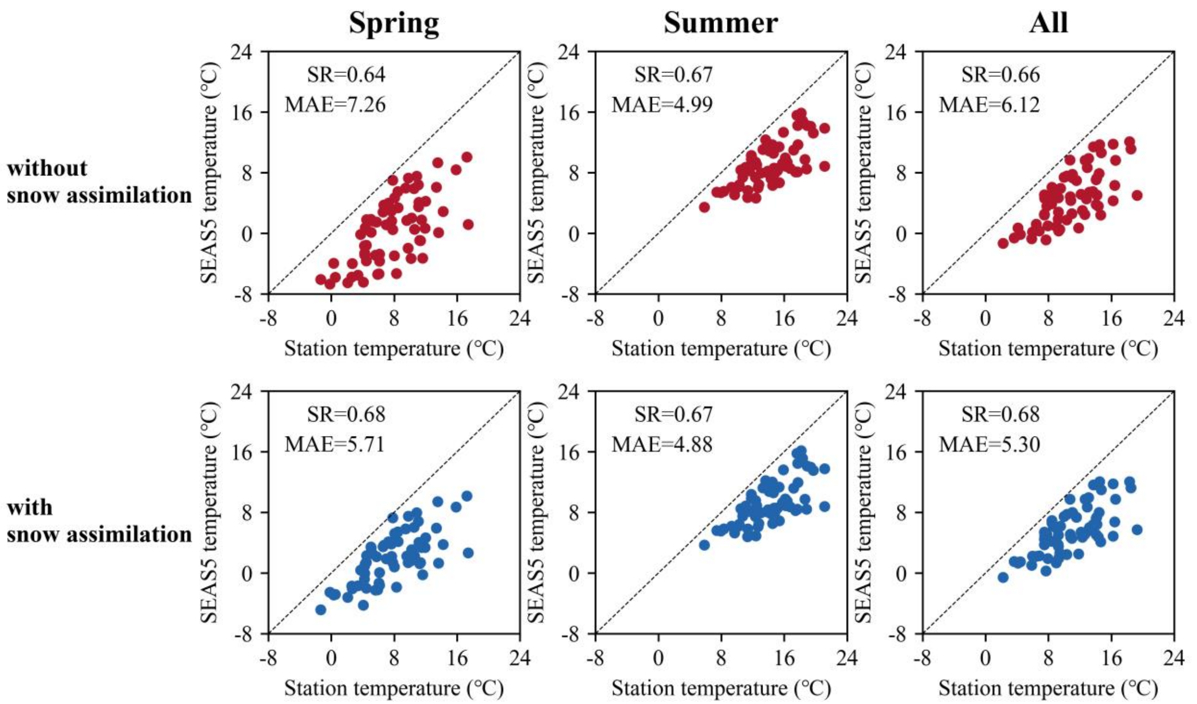

Figure S3. The spatial correlations and mean error between the temperature reforecasts and in-situ observations.

Figure S4 shows the daily precipitation of the two ensemble reforecasts and GPM data. Generally, the results are quite different in the WTP and ETP. In the WTP, the daily precipitation is slightly more than the GPM data in spring for more than half members of the reforecasts. In summer and the whole period, the daily precipitation of the two reforecasts is less than that of the GPM data. Overall, the precipitation of the DA reforecasts is closer to the GPM precipitation in the WTP. In the ETP, the daily precipitation of the two reforecasts is obviously more than the GPM data, except for some members with snow assimilation in summer. The precipitation of the control reforecasts is closer to the GPM in the ETP which is different for the situation in the WTP. In addition, the median values of the daily precipitation for the reforecasts become larger after snow assimilation.

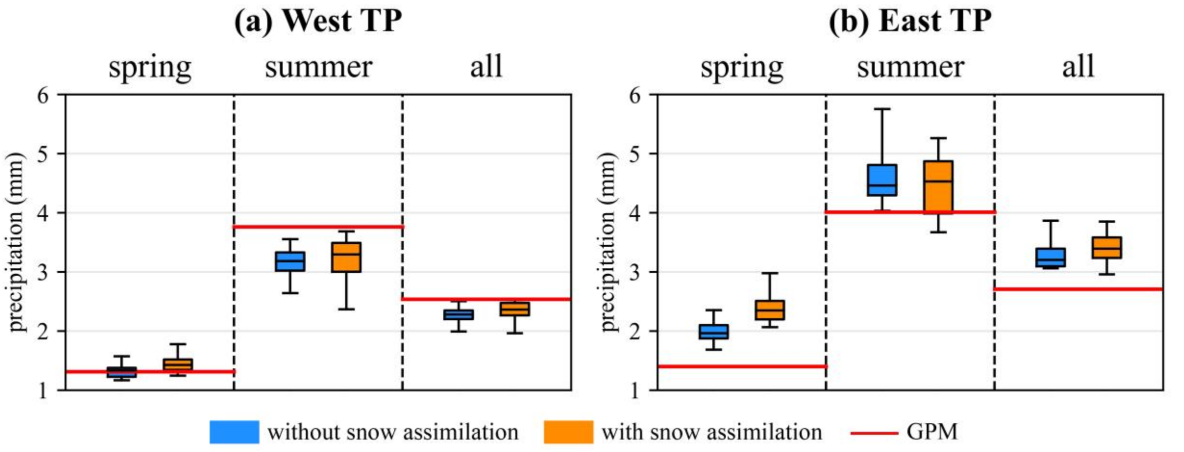

Figure S4. The daily averaged precipitation of the two ensemble reforecasts and GPM data in the (a) west Tibetan Plateau and (b) east Tibetan Plateau.

Figure S5 presents the precipitation diurnal cycles for the two ensemble reforecasts and GPM data. In the WTP, the two reforecasts perform well in forecasting the occurrence time of peak values and the precipitation amount in spring (Fig. S5a). In summer and the whole period, the precipitation diurnal cycles for two reforecasts are quite similar and the envelope of reforecasts can only cover the GPM precipitation amount at 0600 and 1200 UTC and they miss the 1800 UTC peak in summer precipitation. In the ETP, the ensemble means of the DA reforecasts are larger than those of the control reforecasts and the ensemble-mean precipitation of both reforecasts is more than the GPM data in spring (Fig. S5d). Only the envelope of the control reforecasts can cover the GPM precipitation amount at 0000 and 1800 UTC. In summer and the whole period, the precipitation diurnal cycles of the reforecasts are considerably biased compared with the diurnal cycles for GPM precipitation. For most members of the reforecasts, the precipitation reforecasts show a sharp peak at 1200 UTC and exceed the GPM precipitation at 0600 and 1200 UTC while lower at 0000 and 1800 UTC. In other words, the forecast model tends to systematically have a sharp summertime precipitation peak in late afternoon, which is not matched by GPM satellite observations.

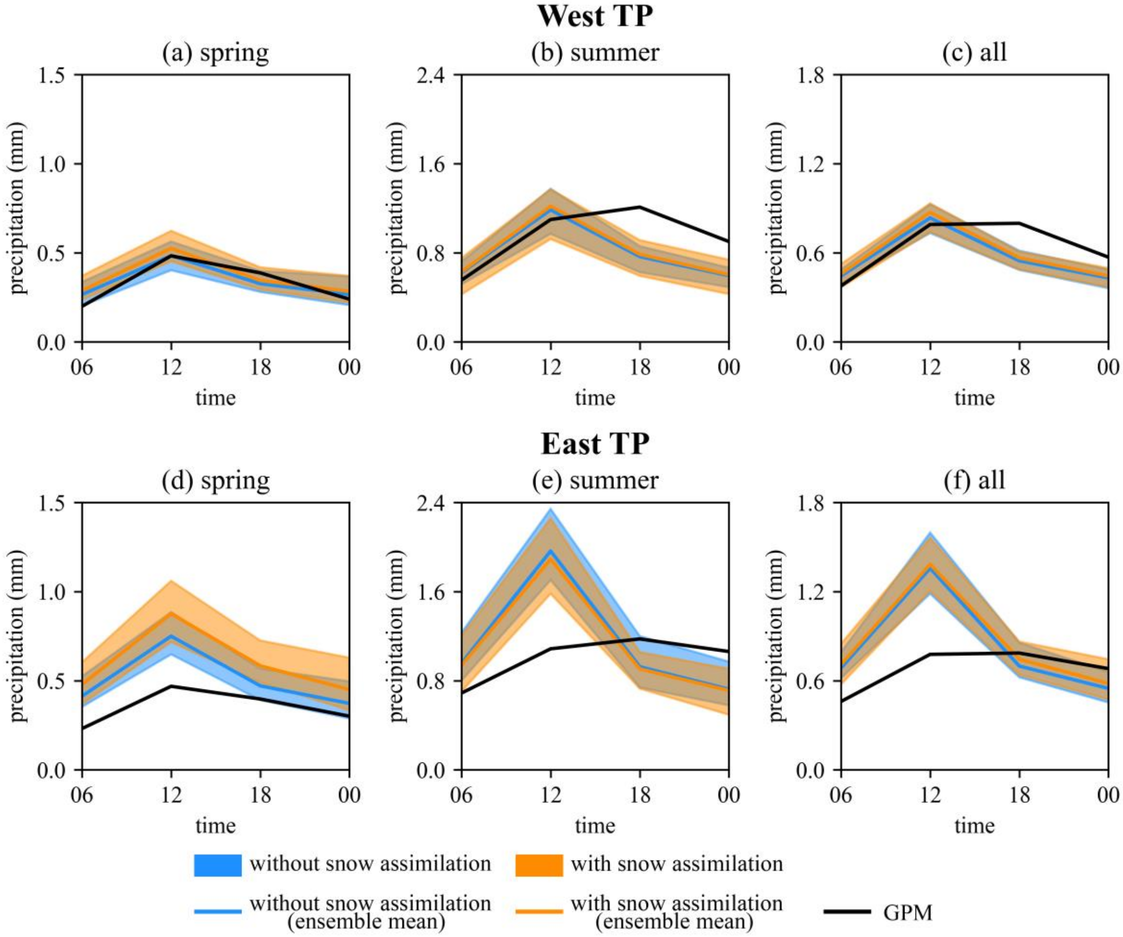

Figure S5. The precipitation diurnal cycles for the two ensemble reforecasts and GPM data.

The spatial correlations and mean error between the precipitation reforecasts and in-situ observations are also presented to evaluate the ability of two reforecasts (Fig. S6). The gridded reforecasts are interpolated to stations for this evaluation using the bilinear interpolation method. In general, the mean error between the reforecasts and observations is larger for the snow assimilation experiments. The spatial correlations between the reforecasts and observations become larger in spring while keeping almost unchanged for other periods after snow assimilation.

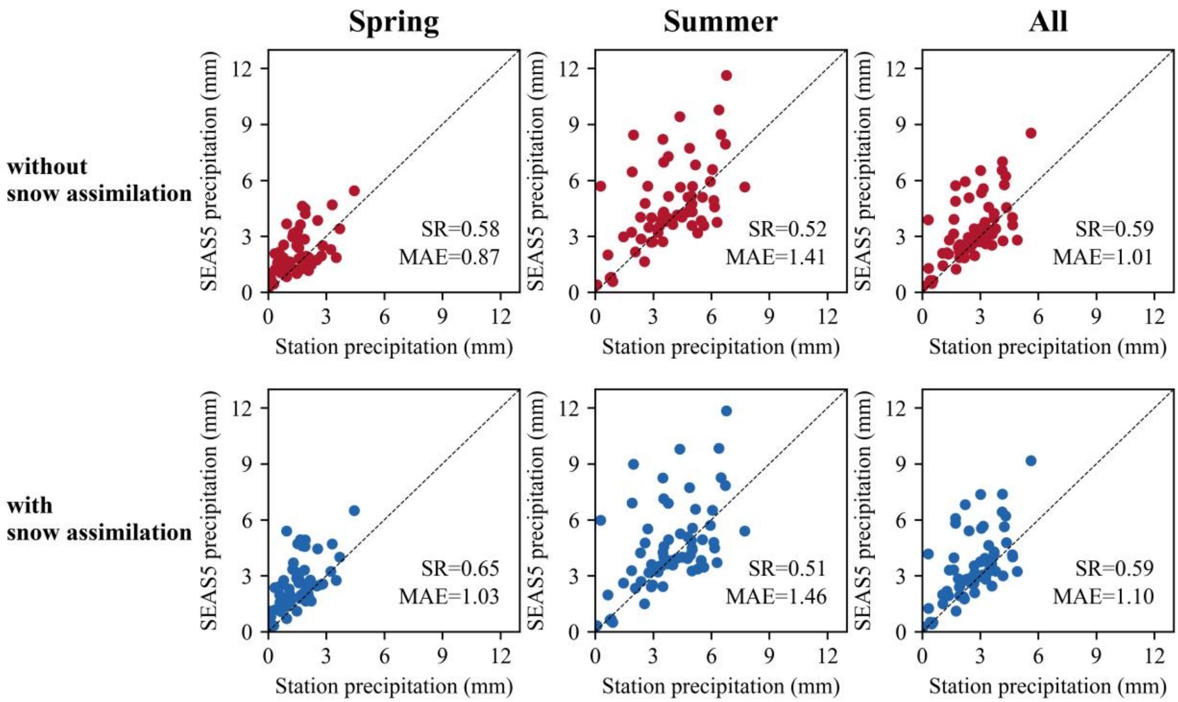

Figure S6. The spatial correlations and mean error between the precipitation reforecasts and in-situ observations.