Quantifying Spatiotemporal and Elevational Precipitation Gauge Network Uncertainty in the Canadian Rockies

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***Note that authors responses are in blue.**

RC2 Comments

I thank the authors for a very thorough response to my initial comments. I would like to re-emphasize one point: it is problematic to perform variographic analysis and interpolation in geographic coordinates (latitude and longitudes in degrees), because at mid-latitude, a degree of longitude is much shorter (in km) than a degree of latitude. Furthermore, the study domain is very elongated, covering around 8 degrees of latitude. Hence, the ratio of the length (in km) of a degree of longitude to the length of a degree of latitude varies significantly from the north to the south of the domain. Because, as I understand, the variographic analysis and interpolation were performed in geographic coordinates, I believe this choice has introduced an unwanted anisotropic effect on the variographic analysis (including potentially both on the choice of the variogram model and on the variogram parameter values), on the interpolated precipitation field and on the assessment of the uncertainty associated with the precipitation analysis. If it is indeed the case, the impact of this modelling choice on the paper results, findings and conclusions needs to be thoroughly assessed.

Thank you for the comment and suggestion. We have performed a similar leave-one-out validation presented in Section 3.2, but with a modification that ensures variographic analysis and kriging interpolation are performed using great-circle distances in kilometres – these distances should be the same no matter the latitude. The leave-one-out validation with distances in kilometres revealed a mean correlation of 0.52, bias of -1.00 mm/day, and RMSE of 4.96 mm/day for the 2020 year. These results present a slight degradation compared to the results computed in degrees for the year 2020 shown in Section 3.2; therefore, showing that in this case there was not a large difference between computing the estimates using geographic or projected (in kilometres) distances. However, the removal of one particular high-elevation gauge (Fisera Ridge) during the validation using kilometric distances made the interpolation less robust for the reference elevation surface $z_0^{i,j}$, which required that more variogram models were used as options. Additionally, to the Linear and Spherical models previously used, Penta-spherical, Gaussian, and Exponential models were also allowed. Still for 9 days of the 2020 year, $z_0^{i,j}$ could not be fitted and precipitation was set zero. We included the following paragraph to report these results and their implications in Lines 345-355: "Because geographic coordinates were used in this study to calculate the variograms and perform kriging interpolation, a separate leave-one-out validation using great-circle distances in kilometres for the 2020 WY was conducted to rule out any major anisotropic effects that this choice could have introduced in the results. The leave-one-out validation using kilometric distances presented the following mean statistics: correlation = 0.52, bias = -1.00 mm/day, and RMSE = 4.96 mm/day. These statistics reveal a slight degradation of using distances in kilometres over using them in degrees. In addition, there were difficulties of fitting the reference elevation surface $z_0^{i,j}$ for one particular high-elevation gauge (Fisera Ridge at 2325 m), which required the use of additional variogram models. Still, $z_0^{i,j}$ was not fitted for nine days of the 2020 WY for this particular gauge and precipitation was set to zero. Therefore, it is concluded that using distances in degrees did not have any major influences on the precipitation estimates for the conditions of this study and the alternative approach introduced uncertainties into the analysis. Future studies should assess whether degrees or kilometric distances are the better choice for their domain conditions."