Supplement of The Cryosphere, 18, 5619–5639, 2024
https://doi.org/10.5194/tc-18-5619-2024-supplement

The Cryosphere
Open Access

Supplement of

Use of multiple reference data sources to cross-validate gridded snow water equivalent products over North America

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S0. Data aggregation methodology

The following describes how we performed the data aggregation generalized in Section 3.1. As outlined in Section 3.1, we averaged all reference-product pairs within the same product grid at its native resolution and then averaged these reference-product pairs within a larger area. Because the product grids do not overlay perfectly, we did the following:

Starting with a single reference site all reference sites within 100 km of this site were identified. If, within a given pool of matched reference sites, there were multiple reference-product data pairs within the same native product grid, these pairs were averaged. Then, mean product and reference SWE within each pool of data was calculated. This process was repeated sequentially, starting with site ALE-05AA805 and ALE-05FA802 for snow course mountain and non-mountain, respectively, and AK101 and AB101 for gamma mountain and non-mountain, respectively. Sites included in a search pool were dropped from the list and the window moved to the next site on the list. Snow course and gamma SWE were considered separately, and mountain measurements were separated from non-mountain. Due to the nature of the aggregation method, the result will differ slightly if starting with a site other than that specified above.

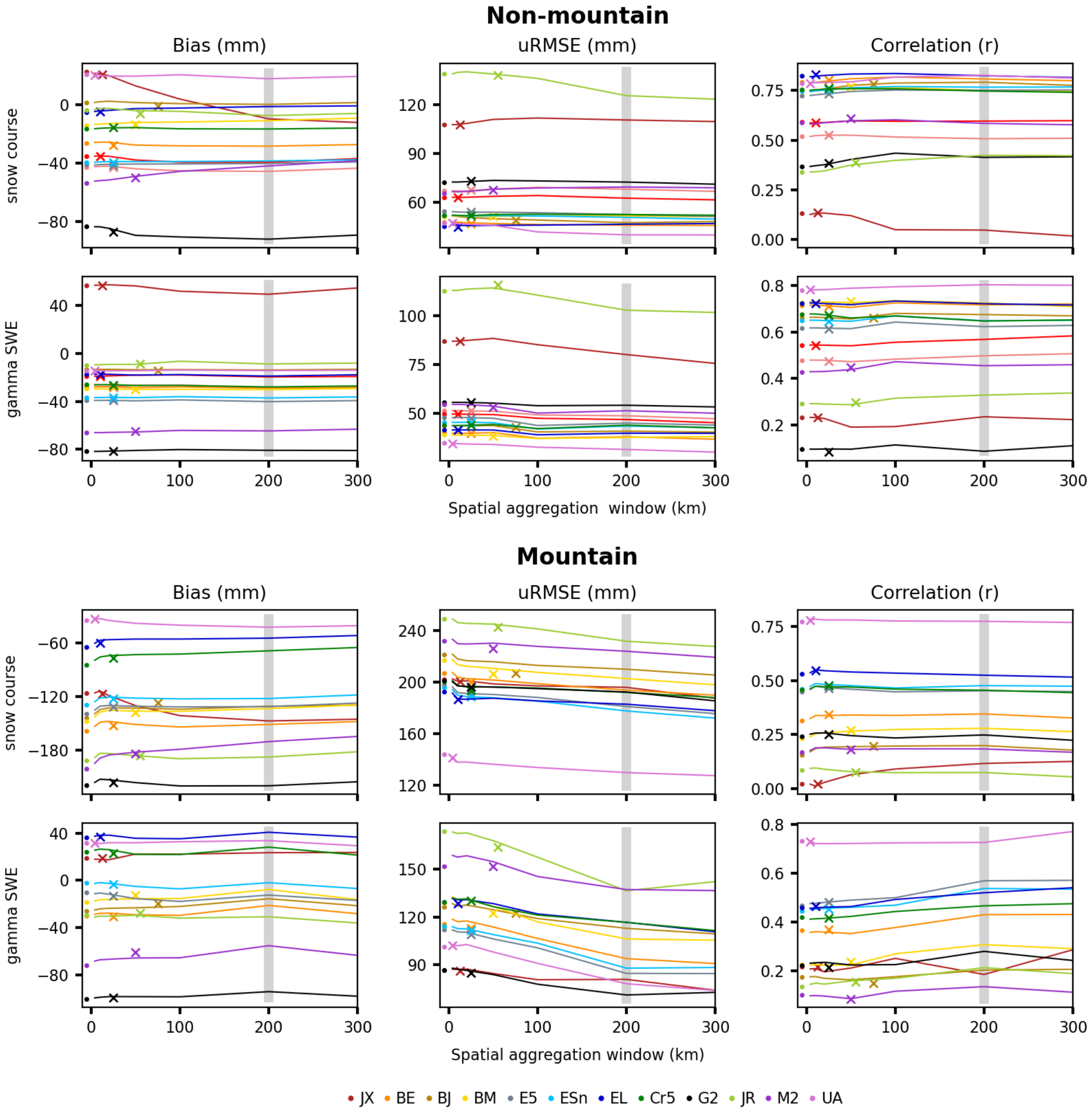

Figure S1: Product metrics calculated for various aggregation windows (see Sections 3.1 and S0). Crosses show the product metrics calculated at their native grid (i.e. all in situ observations on a given date within a product grid cell are averaged together). The circles to the left of zero show the product metrics calculated for all reference-product pairs (no averaging or aggregation). The grey vertical shading at 200 km highlights the metrics presented in the manuscript.

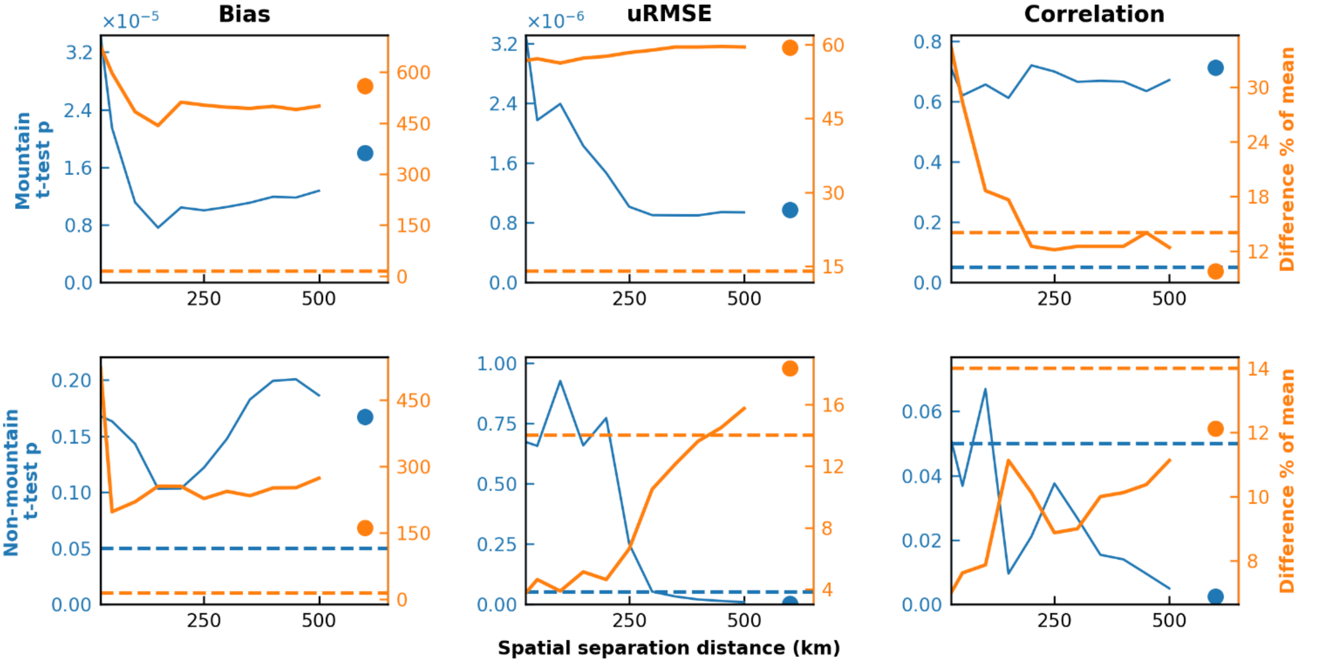

Figure S2: Difference of mean validation statistics for suite of gridded products Crocus-ERA5, Brown-ERA5, Brown-MERRA2, Brown-JRA55, ERA5, ERA5-Land, ERA5-Snow and U. Arizona calculated with snow course versus airborne gamma reference datasets. Blue: difference of means test (2-sided student t-test, Sect. 3.2) p-value for validation metrics calculated with snow courses versus airborne gamma. Orange: difference (absolute value) in product metrics computed with either reference dataset expressed as a percentage of the average snow course and airborne gamma derived value. Circles: full domain. Solid lines: values for spatial subsets consisting of reference sites within 25 km to 500 km of each other (Sect. 3.2.2). Dashed blue line: 95% significance level (p = 0.05). Dashed orange line: measurement uncertainty envelope (14%) (Sect. 3.2.1). Top row: non-mountain. Bottom row: mountain.

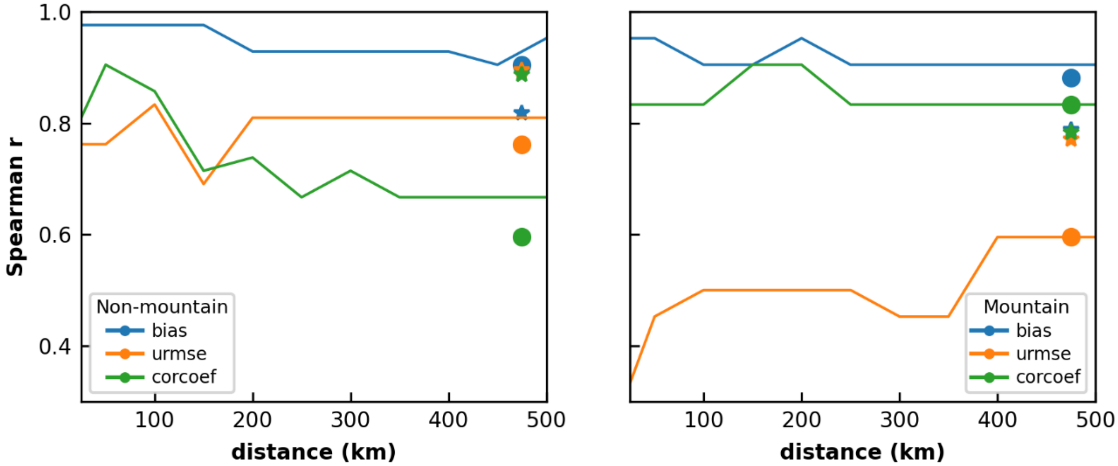

Figure S3: Spearman correlation coefficient for the products Crocus-ERA5, Brown-ERA5, Brown-MERRA2, Brown-JRA55, ERA5, ERA5-Land, ERA5-Snow and U. Arizona evaluated using snow courses versus airborne gamma over the full spatial and temporal domain (solid circle) and for various spatial subsets consisting of reference sites within 25 km to 500 km of each other (lines). Star: same as circles but for all products in Table 1.

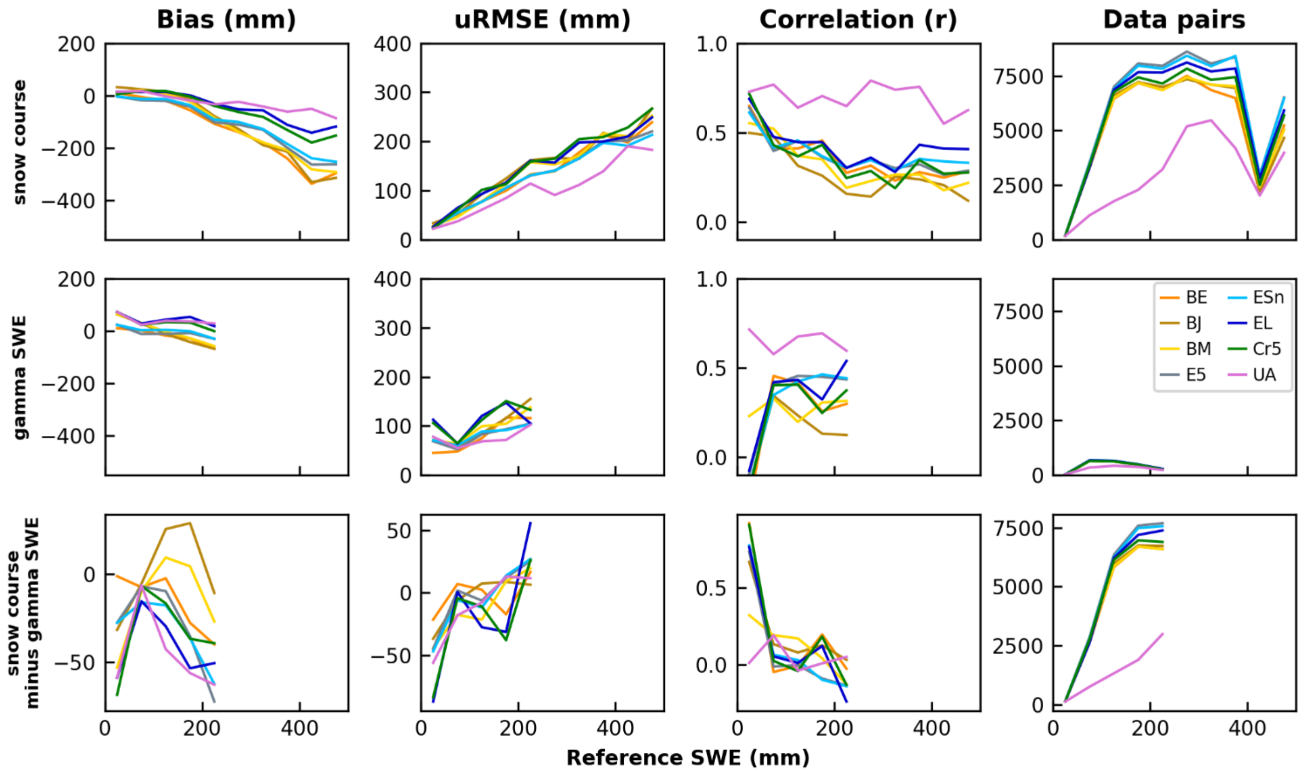

Figure S4. Same as Fig. 8 but for the full spatial and temporal domain. Product performance in mountain regions for sequential 50 mm SWE bins (x-axis location is bin midpoint). Bottom row shows the difference between snow course and airborne gamma derived metrics for each product and bin. Product metrics shown are limited to ≤ 250 mm and ≤ 500 mm and below for airborne gamma and snow course, respectively, due to limited number of data pairs above these thresholds.

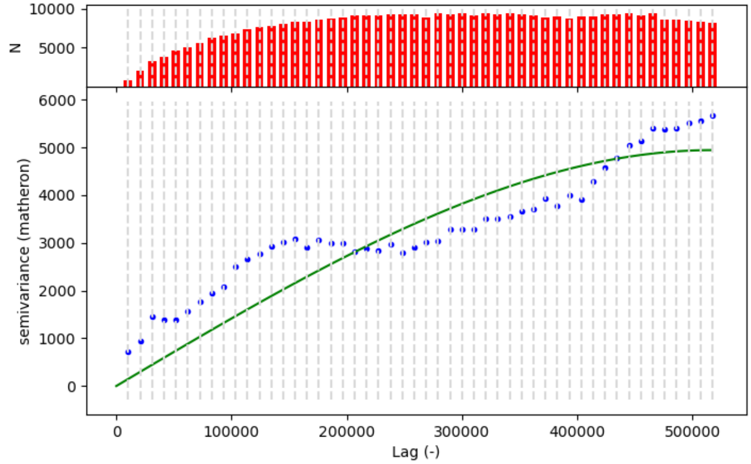

Figure S5. Semi-variogram of mean March SWE from snow courses for the period 1990–2019 for the domain 40°N–55°N, 65°W–95°W suggests two scales of variability: one around ~150 km and another around 450 km. Lag is in metres.

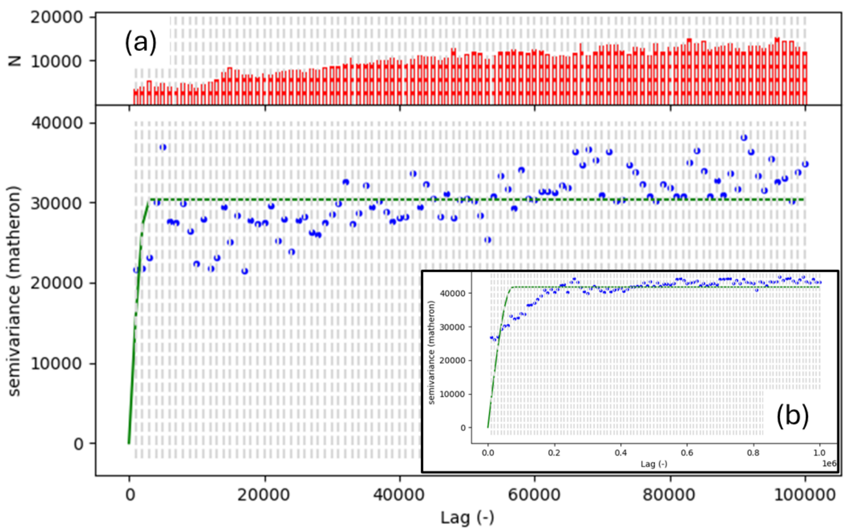

Figure S6. Semi-variogram of mean March SWE from snow courses for the period 1990–2019 for mountain regions west of 103°W excluding Alaska for max lag (a) 100,000 m (100 km) and (b) 500,000 m (500 km). Lag is in metres. Result suggests a small-scale range of < 5 km (a) and a second large-scale range around ~200 km (b).