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Spatiotemporal snow water storage uncertainty in the midlatitude American Cordillera

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S1. **Climatological SWE over different study periods**

In the WUS, GLDAS products are only available over Water Years (WYs) 2001 to 2021, and SNODAS is only available over WYs 2004 to 2021, while all other products span the 37-year record (WYs 1985 to 2021). In the Andes, the GLDAS products are only available over WYs 2001 to 2015, while all other products span the 31-year record (WYs 1985 to 2015).

The climatological SWE over the longer study periods agrees well with climatological SWE over the shorter periods (Figure S1). In WUS, climatological SWE from SNODAS, UA and ERA5-Land are comparable with WUS-SR in either time period used whereas other products underestimate SWE volumes in both cases. In the Andes, over both time periods, ERA5-Land overestimates SWE, ERA5 generates comparable SWE, and the other products underestimates SWE compared to the Andes-SR.

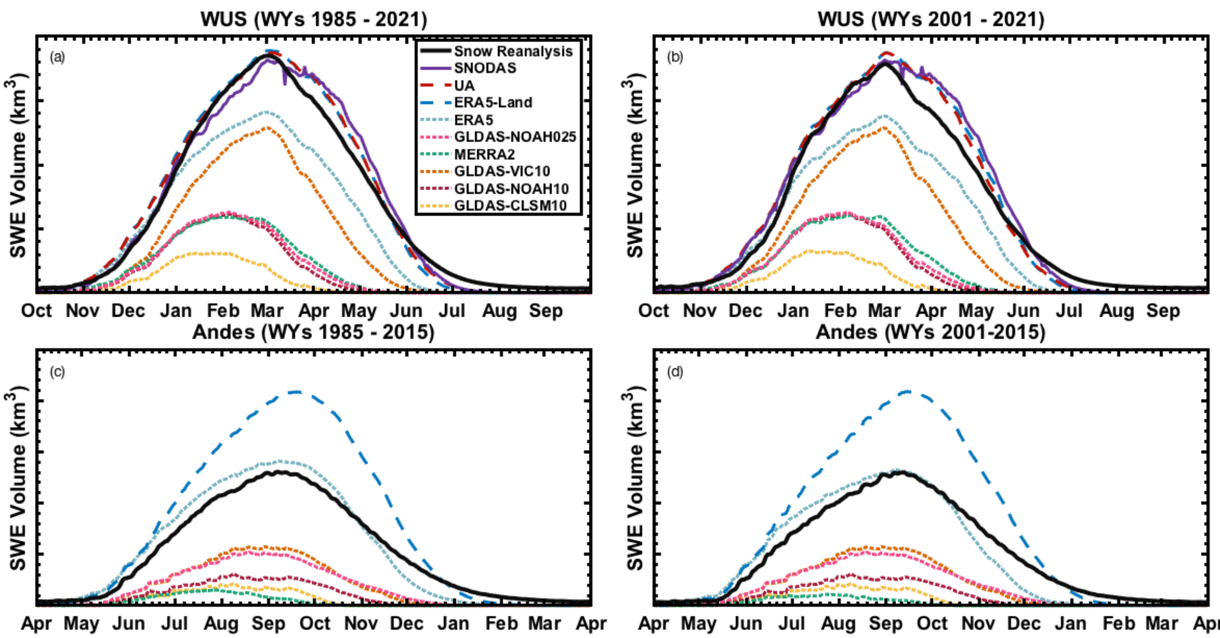

Figure S1. Climatology of seasonal cycle of SWE volume in the WUS over WYs 1985 – 2021 (a) and WYs 2001 – 2021 (b), and Andes over WYs (c) and WYs 2001 – 2015 (d). Solid lines represent high-resolution (HR) datasets and products, dashed lines represent moderate-resolution (MR) products, and dotted lines represent low-resolution (LR) products.

S2. **Domain masks, and persistent snow and ice masks**

The domain masks (Fig. S2 and S3, gray area) are derived based on the reference datasets (WUS-SR and Andes-SR) using an approach similar to Liu et al. (2022). Domain masks at reference resolutions are aggregated to the resolution used in each product.

The persistent snow and ice mask for WUS-SR is derived using the same method from Liu et al. (2021). If the annual minimum SWE of a pixel is greater than 10% of its annual maximum SWE more than once over the data period, the pixel is classified as a persistent snow and ice pixel. The persistent snow and ice for Andes-SR is from Landsat (Cortés and Margulis, 2017). The persistent snow and ice masks from reference datasets are then aggregated to the native resolution of each product (Fig. S2 and S3, red area).

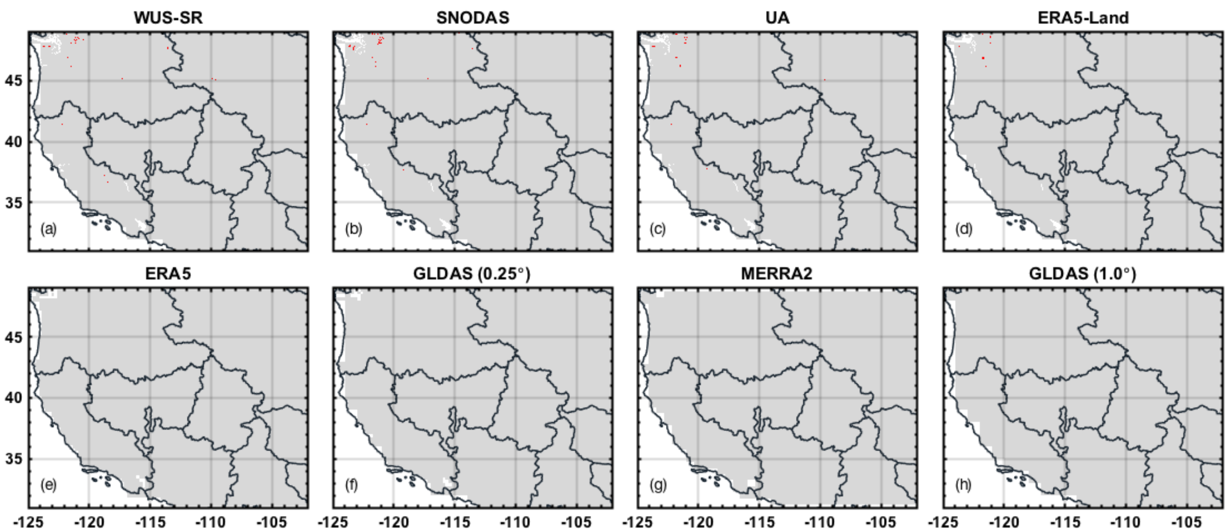

Figure S2. WUS domain masks (gray) and glacier masks (red) for each product.

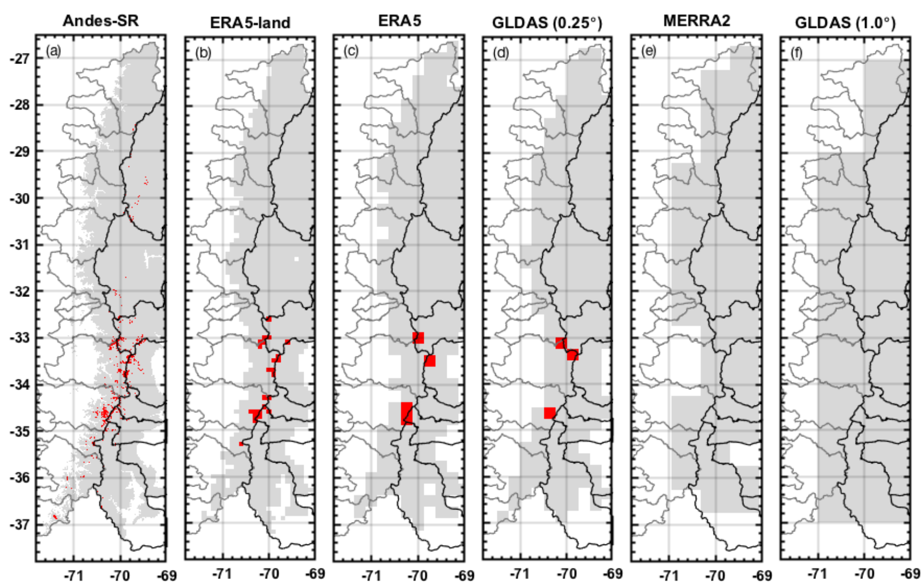

Figure S3. Andes domain masks (gray) and glacier masks (red) for each product. For the Andes-SR, SWE was only estimated for locations above 1500 m.

S3. **Windward and leeward watersheds**

For analysis related to windward-leeward SWE storage gradients, the analysis is applied at the relevant watershed scale. For moderate and coarse resolution products, a single pixel may be partially inside two different watersheds. To account for this, windward and leeward watershed masks are derived by intersecting the watersheds and product grids. For high resolution products (Andes-SR, WUS-SR and SNODAS), the centered coordinates of a pixel are used to determine if the pixel is inside a windward or leeward watershed. The fractional areas of pixel within the windward or leeward watersheds are shown in Figure S4 and S5.

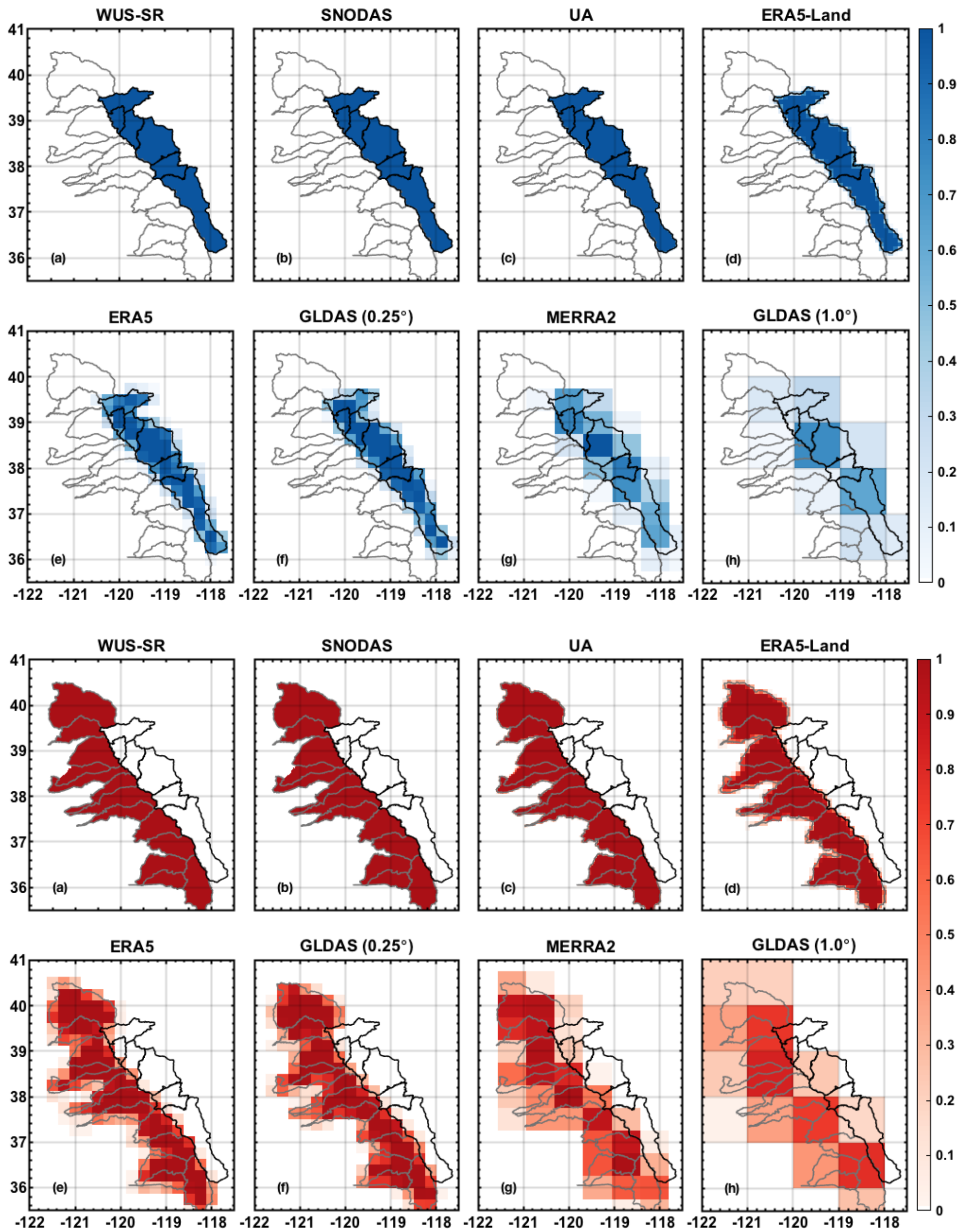

Figure S4. Fractional areas of each native pixel covering windward (red) and leeward (blue) watersheds in the Sierra Nevada.

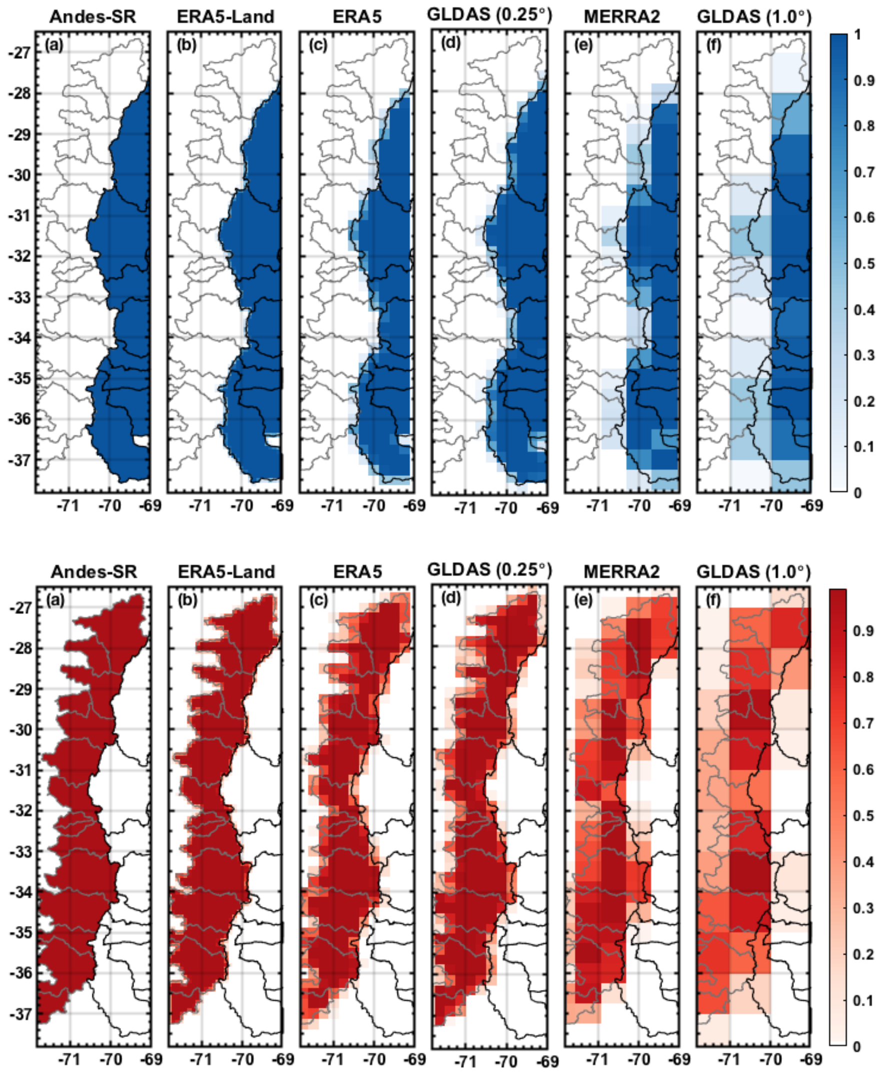

Figure S5. Fractional areas of each native pixel covering windward (red) and leeward (blue) watersheds in the Andes.

S4. Climatological March 1st SWE and April 1st SWE

Overall, the relative uncertainties of climatological SWE_{peak} over the WUS (Figure 3k) and Andes (Figure 4i) are consistent with uncertainties of March 1st and April 1st SWE across different products (Figure S6). In the WUS, HR and MR products generally agree with the WUS-SR, whereas LR products underestimate SWE. The WUS-SR average SWE_{peak}, March 1st and April 1st SWE values are 269, 185 and 150 km^3, respectively. In comparison, the average SWE_{peak}, March 1st and April 1st SWE values from HR and MR products are 284, 185 and 168 km^3, respectively. Thus, for HR and MR products, March 1st SWE has the lowest bias (0%) followed by SWE_{peak} (overestimated by 6%), and April 1st SWE (12%). For LR products, the average SWE_{peak}, March 1st and April 1st SWE values are 127, 75 and 43 km^3, respectively. The lowest bias is from SWE_{peak} (underestimated by 53%), followed by March 1st (59%) and April 1st SWE (71%).

In the Andes, Andes-SR shows that SWE_{peak} is 29 km^3, March 1st SWE is 26 km^3 and April 1st SWE is 24 km^3. The average values for MR and LR are 19, 14 and 13 km^3, respectively. SWE_{peak} has the lowest bias (34%), followed by March 1st and April 1st SWE with the same level of bias (46%).

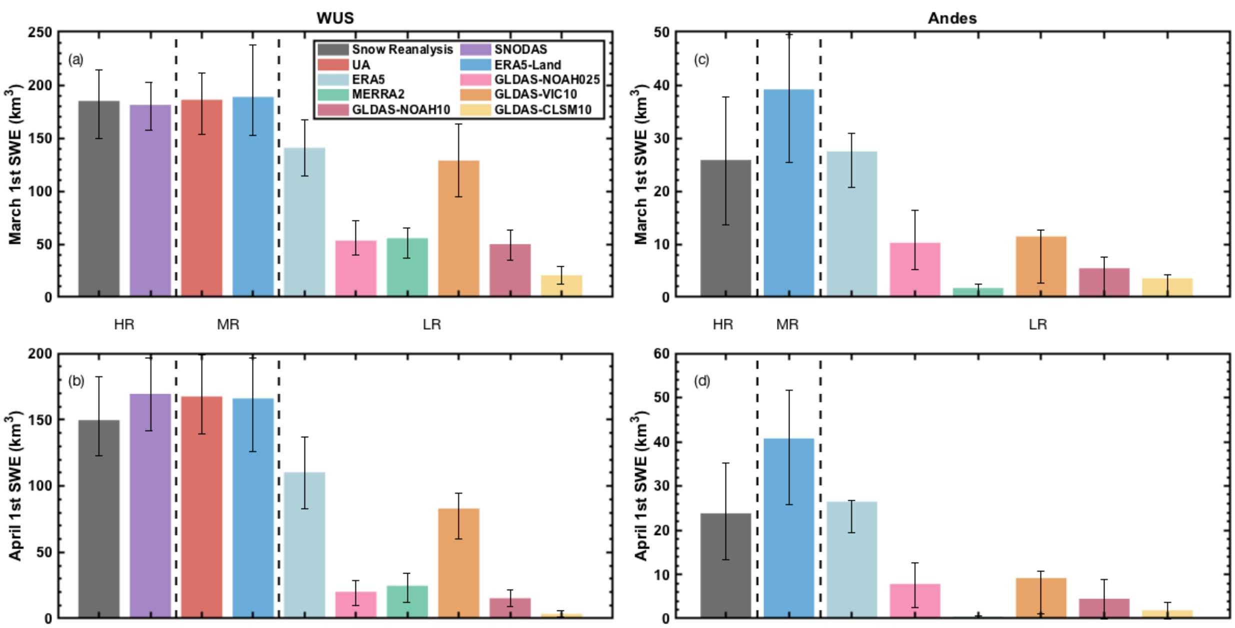

Figure S6. Climatological March 1st SWE (top panels) and April 1st SWE (bottom panels) over the WUS (left panels) and Andes (right panels). Black error bars represent the interannual inter-quartile range (IQR)."

S5. Lapse rates of swe_{peak} in the Sierra Nevada and Andes

The lapse rates were determined based on linear regressions across elevational bins in the Sierra Nevada and Andes based on the swe_{peak} distribution from the snow reanalysis datasets (Table S1). Specifically, swe_{peak} increases with elevation on both the windward and leeward side of the Sierra Nevada from 1 – 3 km. In the Andes, swe_{peak} increases with elevation over 1.5 – 3 km on both sides of the Andes, whereas it decreases with elevation over 3 – 6 km. Figure S7 and S8 shows that GLDAS products at 1° do not have enough data points to compute the lapse rates and therefore are excluded in the analysis.

Table S1. Derived swe_{peak} lapse rates over the Sierra Nevada and Andes across different elevational bands. The unit of lapse rate is m (SWE)/km (elevation) with a positive value representing an increase of swe_{peak} in meters per increase of elevation in kilometer.

Domain	Sierra Nevada		Andes			
	Windward	Leeward	Windward	Leeward	Windward	Leeward
Elevation	1 – 3 km		1. 5 – 3 km		3 – 6 km	
WUS-SR/ Andes-SR	0.34	0.21	0.30	0.22	-0.08	-0.02
SNODAS	0.29	0.20	-	-	-	-
UA	0.32	0.25	-	-	-	-
ERA5-Land	0.16	0.14	0.26	0.38	-0.09	-0.10
ERA5	0.09	0.11	0.19	0.31	-0.03	-0.05
GLDAS-NOAH025	0.03	0.04	0.17	0.16	-0.01	0.01
MERRA2	0.05	0.06	0.02	0.02	-0.02	0.01

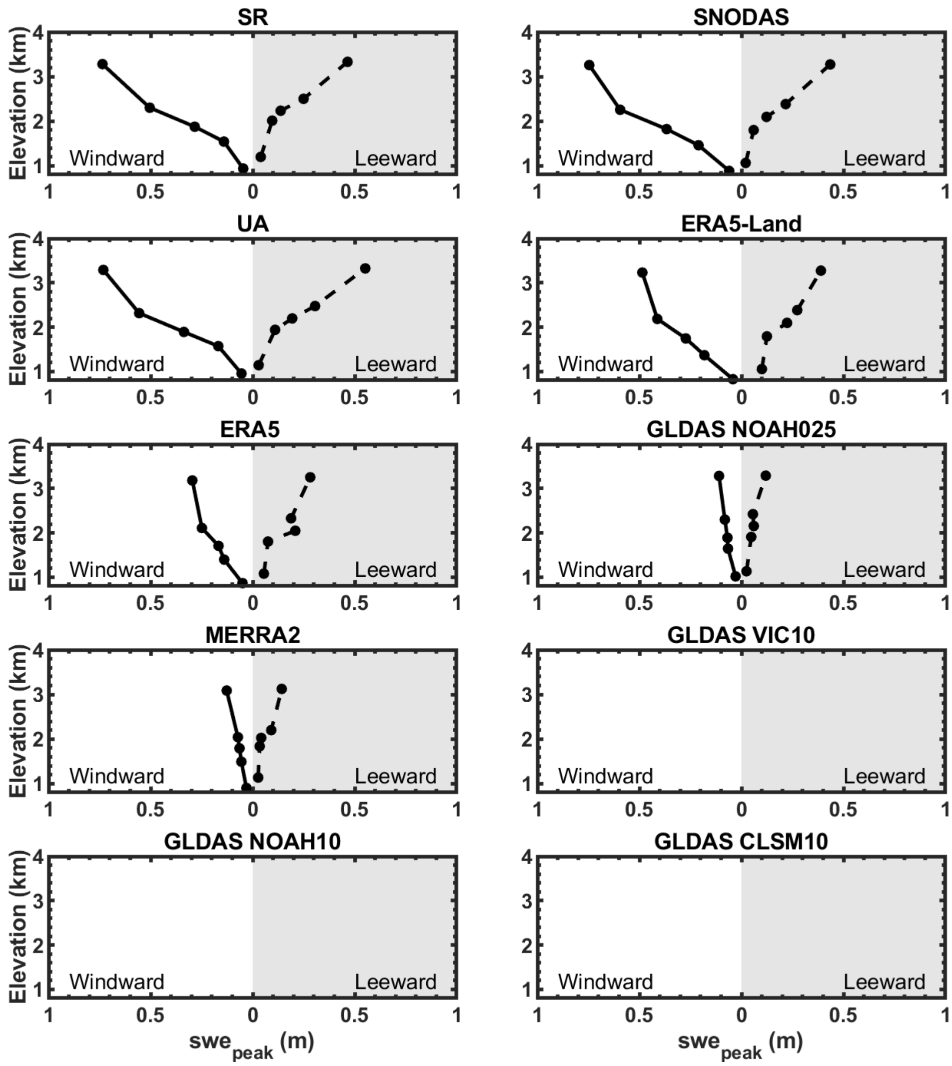

Figure S7. Elevational distribution of windward and leeward swe$_{peak}$ across the Sierra Nevada. The black dots are bin-averaged swe$_{peak}$ values.

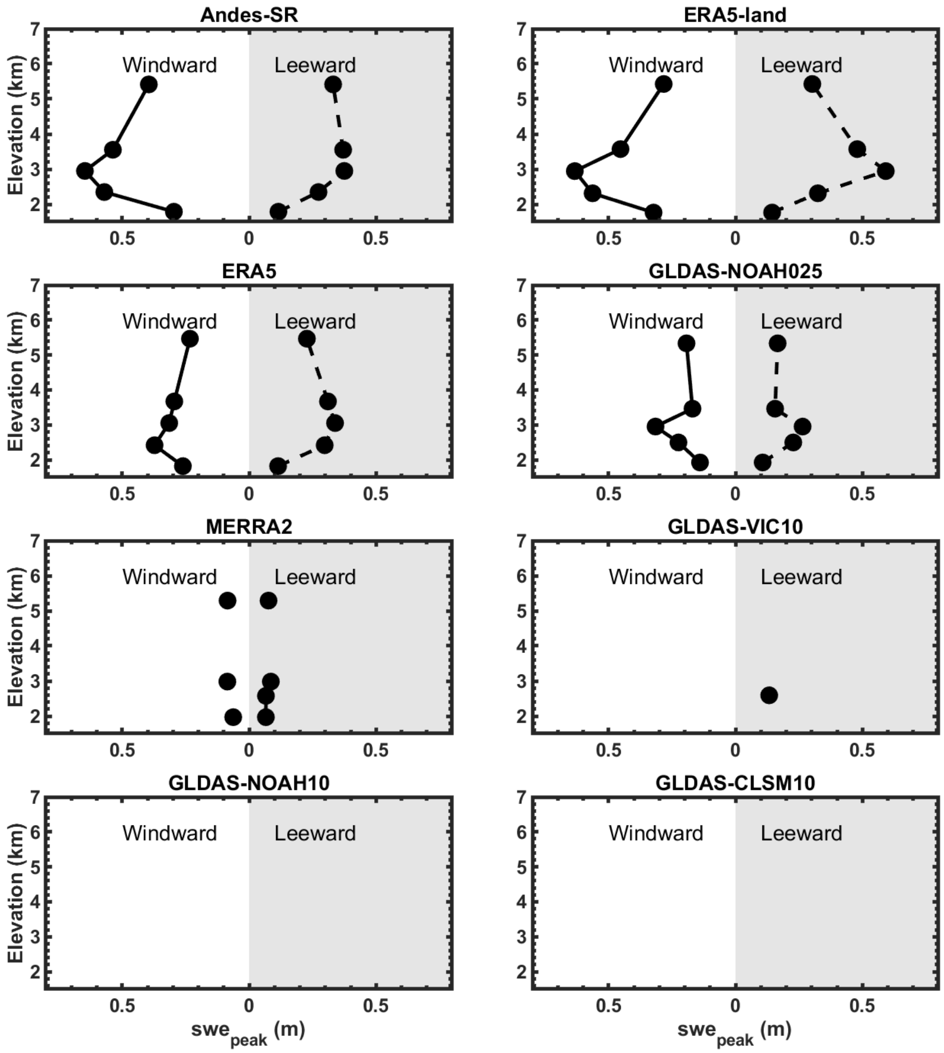

Figure S8. Elevational distribution of windward and leeward swe_{peak} across the Andes. The black dots are bin-averaged swe_{peak} values.