Table S1. Multiple regression coefficients and fit statistics for models describing the spatial variations in sine parameters that capture seasonal precipitation isotope cycles (amount-weighted fitted $\delta^{18}O$, robust-fitted $\delta^{2}H$, and amount-weighted fitted $\delta^{2}H$; see Table 2 for robust-fitted $\delta^{18}O$). Dashes mark predictors that were excluded by the stepwise-regression model selection.

	|Latitude| (° from equator)	Elevation (m asl)	Dist. from coast (km)	Temp. range (°C)	Mean Annual Temp. (°C)	Mean Annual Precip. (mm yr^{-1})	Intercept	RMSE	R^2
Amplitude (‰ $\delta^{18}O$)*	-0.07	0.0002	0.0013	0.07	-0.1	—	5.2	1.2	0.56
Phase (days)*[a]	0.39	0.0091	—	—	—	—	-1.2	13.5	0.24
Phase (days)*[b]	-1.15	—	—	—	—	—	-92.2	35.1	0.23
Offset (‰ $\delta^{18}O$)*	0.10	—	—	-0.11	0.5	-0.0006	-15.5	1.9	0.79
Amplitude (‰ $\delta^{2}H$)	-0.48	0.0024	0.0105	0.55	-1.1	—	39.1	9.5	0.61
Phase (days)[a]	0.31	0.0089	-0.0044	—	—	—	9.3	13.9	0.19
Phase (days)[b]	-1.07	—	—	0.74	—	—	-105.6	24.7	0.19
Offset (‰ $\delta^{2}H$)	0.87	0.0027	—	-0.90	4.7	-0.0054	-123.5	17.6	0.81
Amplitude (‰ $\delta^{2}H$)*	-0.56	0.0013	0.0099	0.49	-1.1	—	43.2	9.8	0.53
Phase (days)*[a]	—	0.0072	—	—	-0.4	—	-21.1	15.5	0.23
Phase (days)*[b]	—	—	—	—	—	0.0454	-130.8	151.9	0.06
Offset (‰ $\delta^{2}H$)*	0.68	—	—	-0.80	4.0	-0.0052	-110.8	17.0	0.78

*** referring to amount-weighted sine curve fits**
[a] referring to sites in latitudes > 30° (N or S)
[b] referring to sites in latitudes < 30° (N or S)

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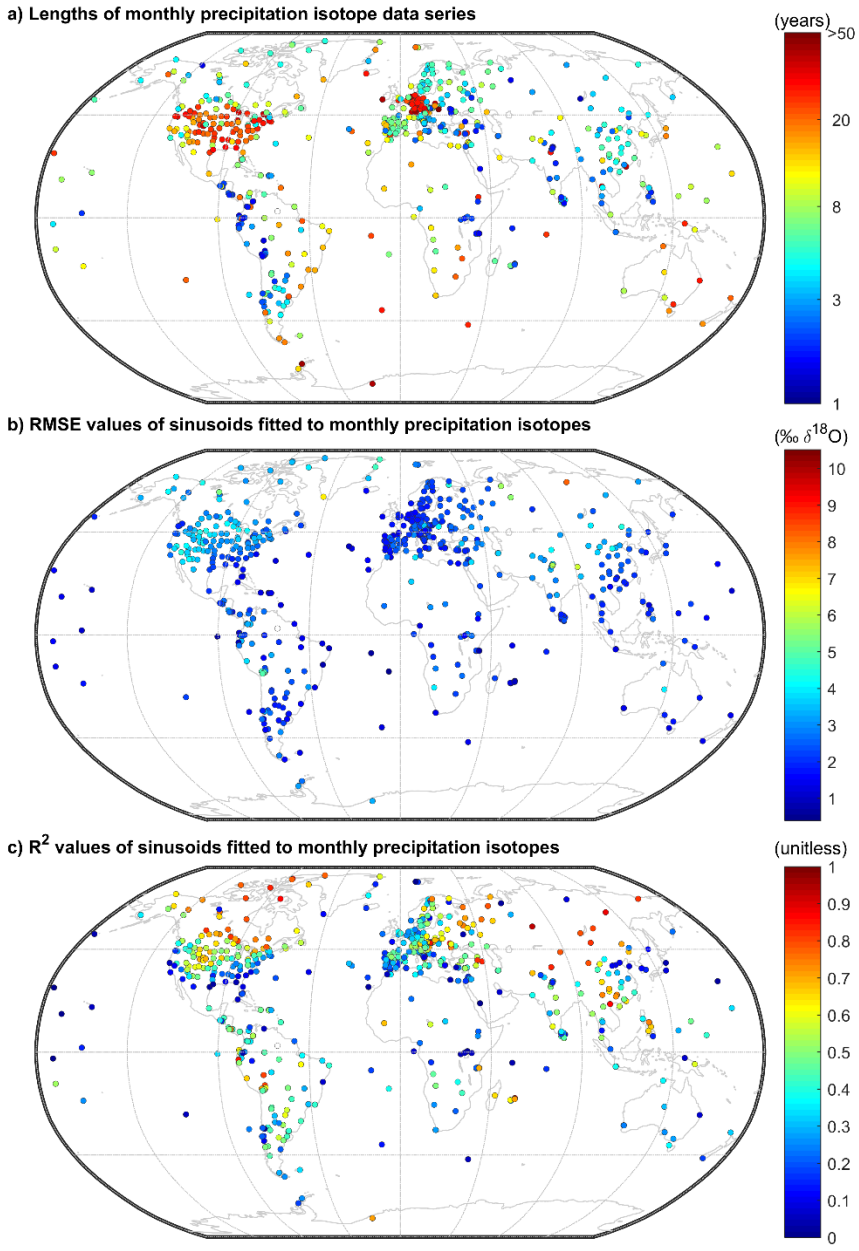

Figure S1. Maps of precipitation isotope measurement stations with colours indicating a) the length of measurements at each site, and goodness-of-fit statistics b) root mean square errors (RMSE) and c) coefficients of variations (R^2) of the fitting of sine curves to monthly, empirical time series from each station. We show the robust-fitted $\delta^{18}O$ statistics; the amount-weighted $\delta^{18}O$ fit statistics, and the $\delta^{2}H$ statistics (robust-fitted and amount-weighted) are provided in the Supporting Information 2 data file.

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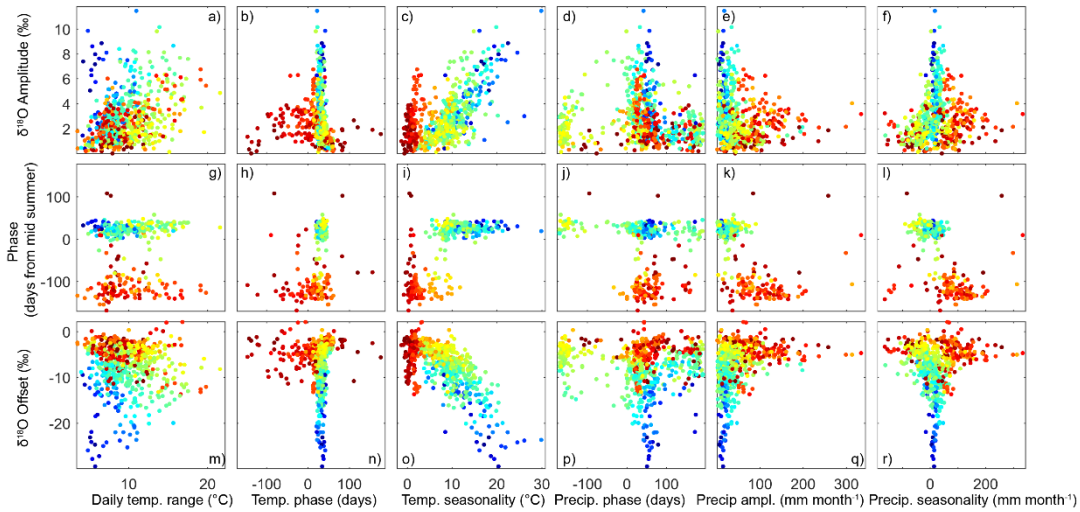

Figure S2. Scatter plots of fitted sine parameters describing precipitation $\delta^{18}O$ seasonal cycles – a-f) amplitude, g-l) phase, m-r) offset – versus site characteristics. Phase refers to day of peak temperature or precipitation amount, relative to the summer solstice. Precip ampl. refers to seasonal amplitude of precipitation amount. Seasonality metrics are calculated as the temperature or precipitation amplitude multiplied by 1.0 if they peak in the summer, and -1.0 if they peak in winter. Colours indicate absolute latitude (high latitudes in blue, low latitudes in red) as shown in Figure 2.

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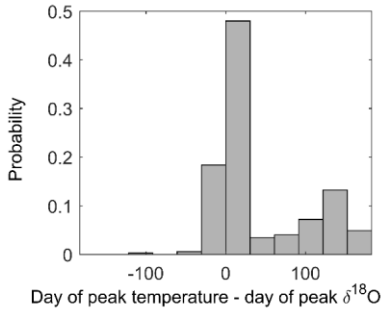

Figure S3. Histogram of phase differences between seasonal isotope cycles and seasonal temperature cycles, with height of bars showing probability. At 49% of the precipitation measurement stations, peak isotope values preceded peak temperatures by less than one month; peak isotope values lagged peak temperatures by less than one month at another 18% of the sites.

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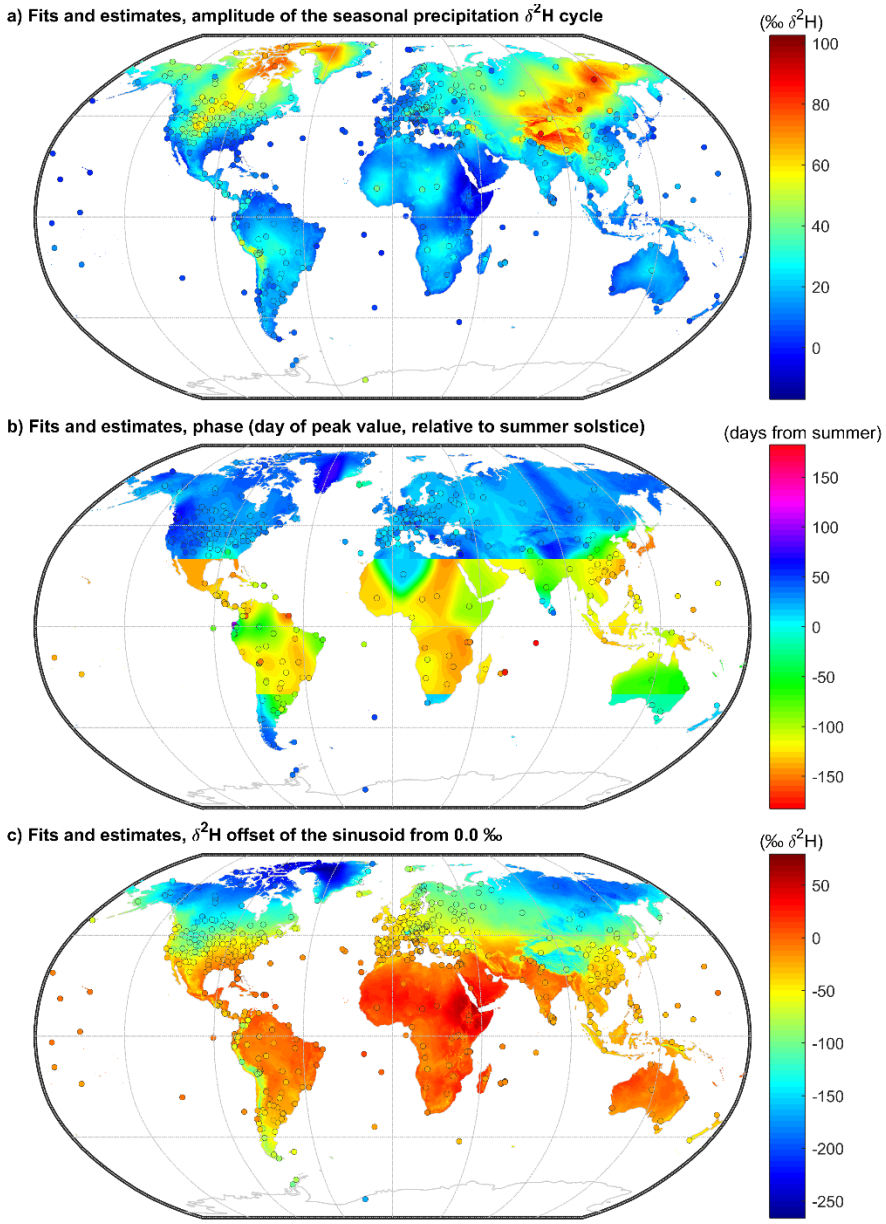

Figure S4. Maps of fitted station values (markers) and the residual-adjusted maps of sine-curve parameters (shaded) that describe the seasonal cycles in precipitation δ^2H a) amplitude, b) phase, and c) offset. The interpolated surface is the sum of the infilled surfaces in Figures 3 and 4 (see methods).

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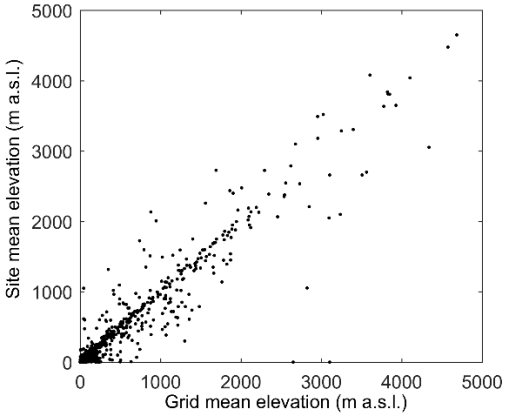

Figure S5. Elevations reported for sites regressed against gridded predictions of elevations of pixels containing those sites. Mismatches likely occur because grid-averaged values poorly capture small-scale variations in elevation.

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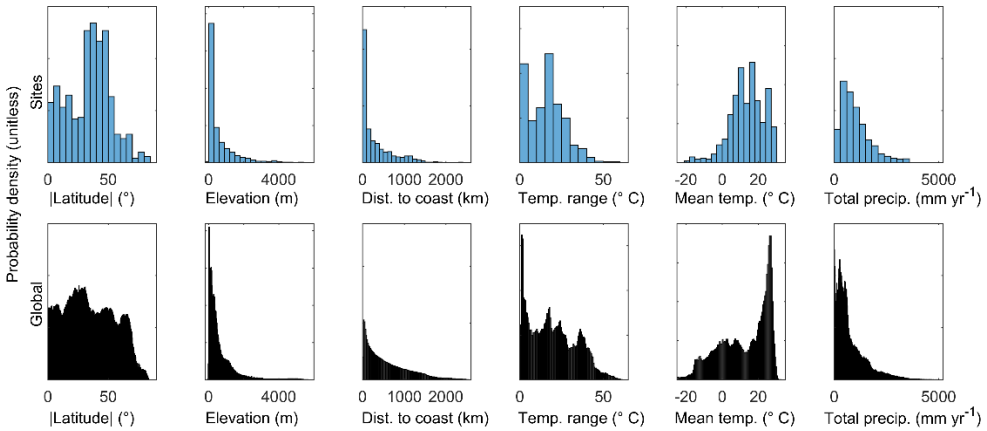

Figure S6. Probability density functions of the site characteristics used to predict seasonal precipitation isotope cycles, where the top row shows the distribution of values at precipitation isotope monitoring stations, and the bottom row shows the global distribution of values on land.

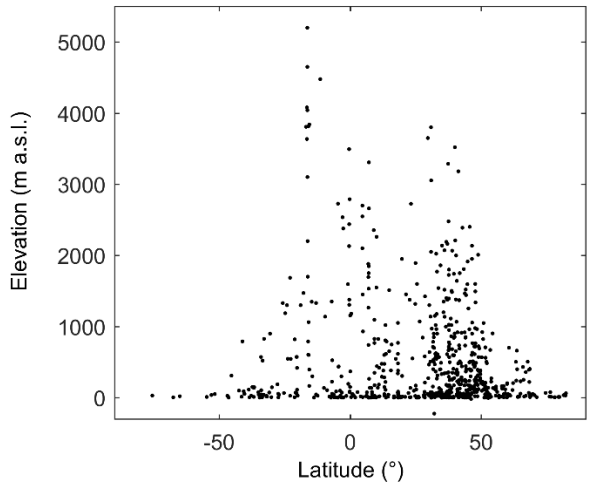

Figure S7. Elevation versus latitude of precipitation isotope monitoring sites. Very high elevation precipitation isotope monitoring sites are almost exclusively located in the intra-tropical zone (specifically, in the Andes mountains). High latitude sites are mostly in low elevation regions.