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Supporting Information for

Concentration-Discharge Patterns Across the Gulf of Alaska Reveal Geomorphological and Glacierization Controls on Stream Water Solute Generation and Export

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Additional Supporting Information (Files uploaded separately)

Introduction

This supplemental information contains a more complete description of methods, spatial data and tabulated results of statistical analysis and spatial analysis. We also show additional figures mentioned in the main text and two figures which show the regional data of the TDS vs. TSS and HCO_3^- vs. SiO_2. Text S1 explains in more detail the methods used to derive the watershed

characteristic. Text S2 explains the methods and results of the Bayesian Information Criterion (BIC) analysis and multiple linear regression.

Text S1.

The physical and climate-based watershed characteristics were calculated in QGIS 3.16.5 and with custom Python scripts. For watershed characteristics derived from raster datasets (elevation statistics, landcover, precipitation, and temperature) we used the Zonal statistics tool within the QGIS Raster analysis toolbox. To calculate watershed characteristics derived from vector data (geology and glacier coverage) a custom Python script was used to clip the input data with each watershed and calculate the percent area each parameter covers within the given watershed. Landcover, geology, and glacier coverage are reported in Table S2 as percent coverage. Climate parameters, mean precipitation and mean temperature, are averages within each watershed calculated from 1981 to 2010 using the DAYMET dataset (Thornton et al., 2020) accessed using Google Earth Engine.

Text S2.

Results of the BIC and multiple linear regression are shown in Table S2. The BIC analysis provides a list of the minimum number of parameters (watershed characteristics) that explain the variation of the given variable (*b*-values and solute yields). The resulting list of parameters are then given to a multiple linear regression (MLR) model. In Table S2 the column "Parameters Chosen" show the parameters used in the MLR along with the sign of the relationship with the given variable in parentheses. For each solute *b*-value and solute yield we provide the R^2 value for the MLR model. We also show what parameters have statistically significant ($p>0.05$) relationships in the final column.

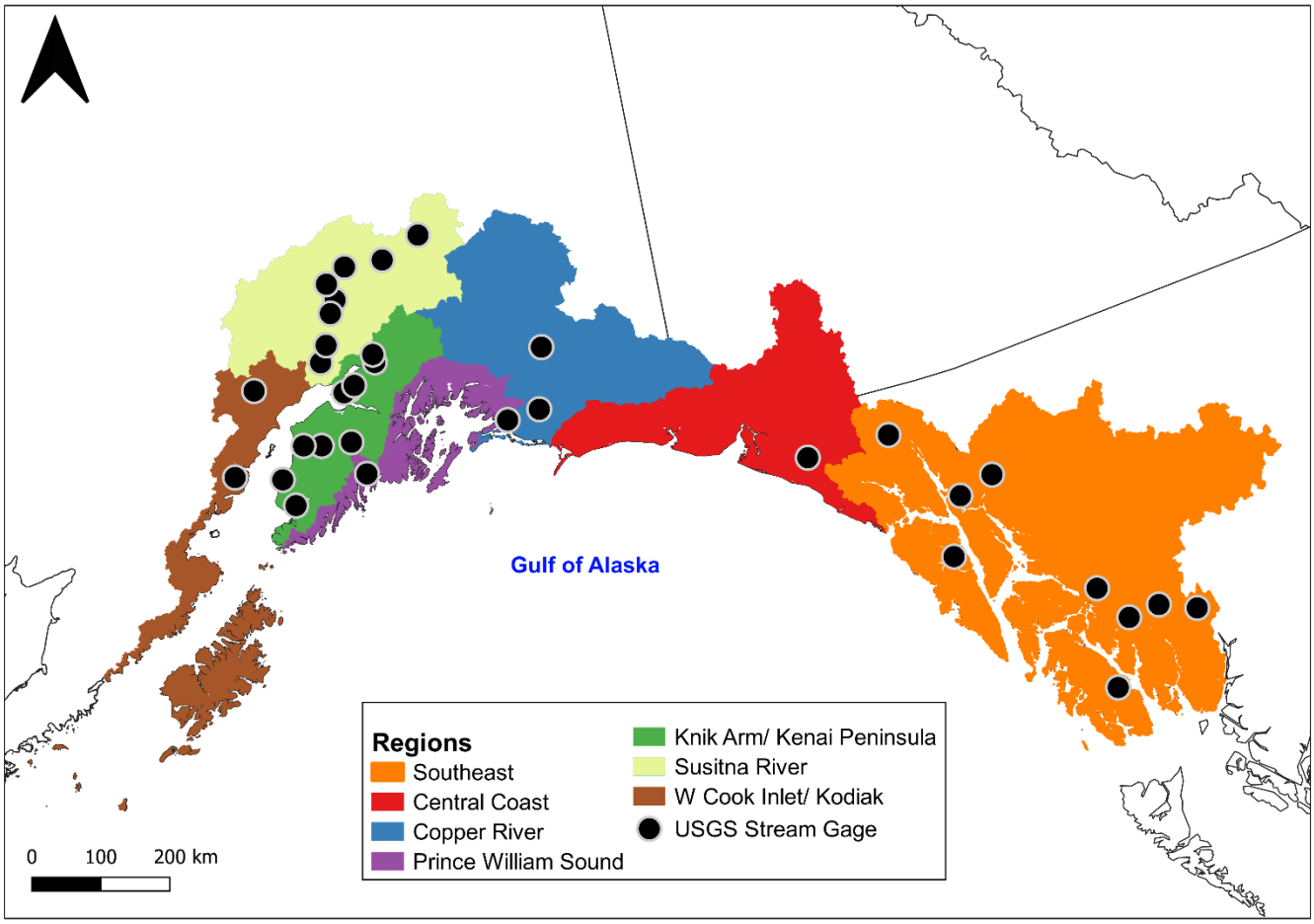

Figure S1. Locations of USGS stream gage sites used for this study. Stream sites were chosen if concentration-discharge measurements equal or exceeded 12 paired measurements. There is a notable lack of stream gages locations within the Central Coast region, likely due to the rugged terrain and abundance of tidewater glaciers.

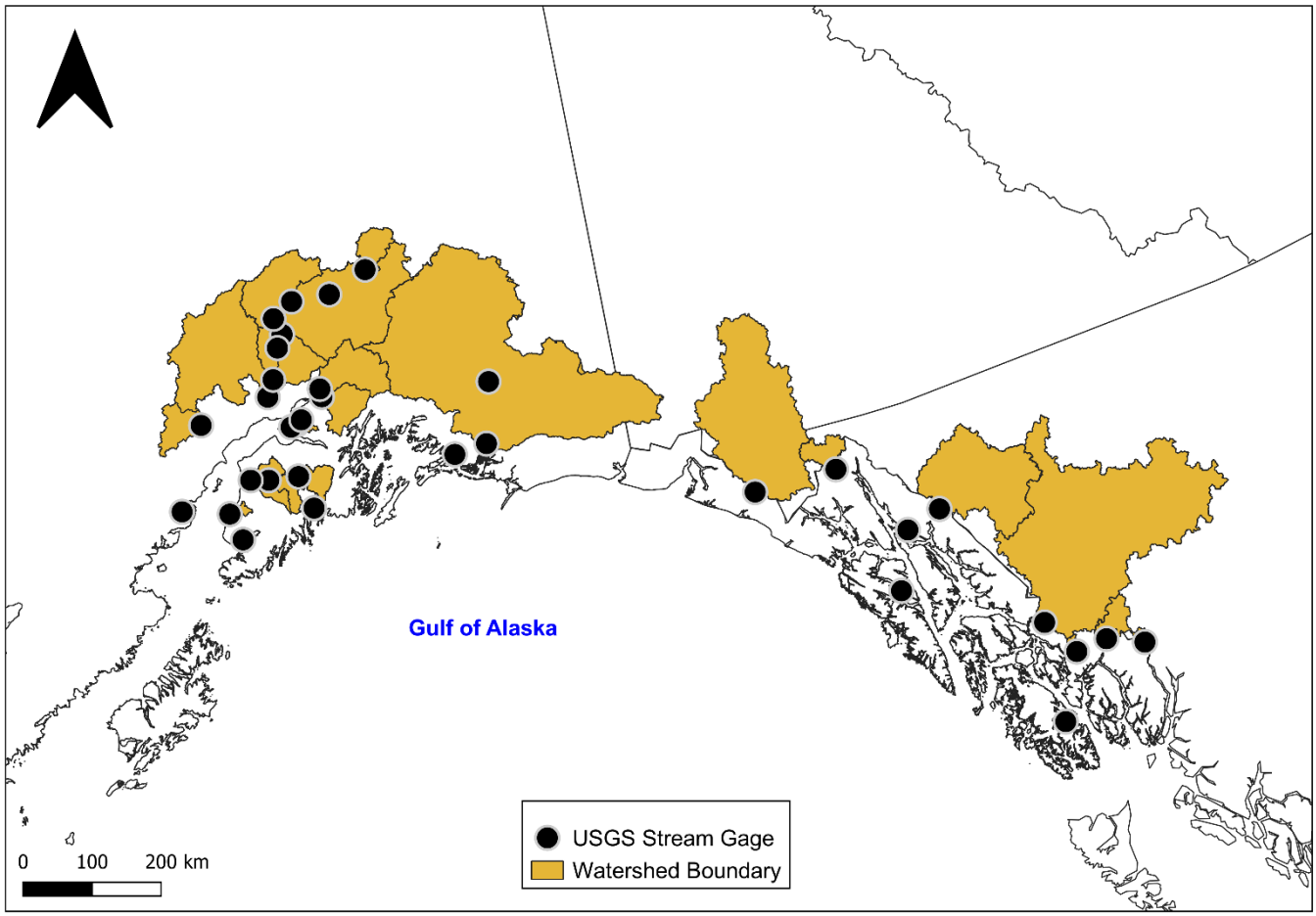

Figure S2. Watershed boundaries used in this study to calculate watershed characteristics along with USGS stream gage sites. Several watersheds within the Susitna River region are nested within each other and do not appear within this map.

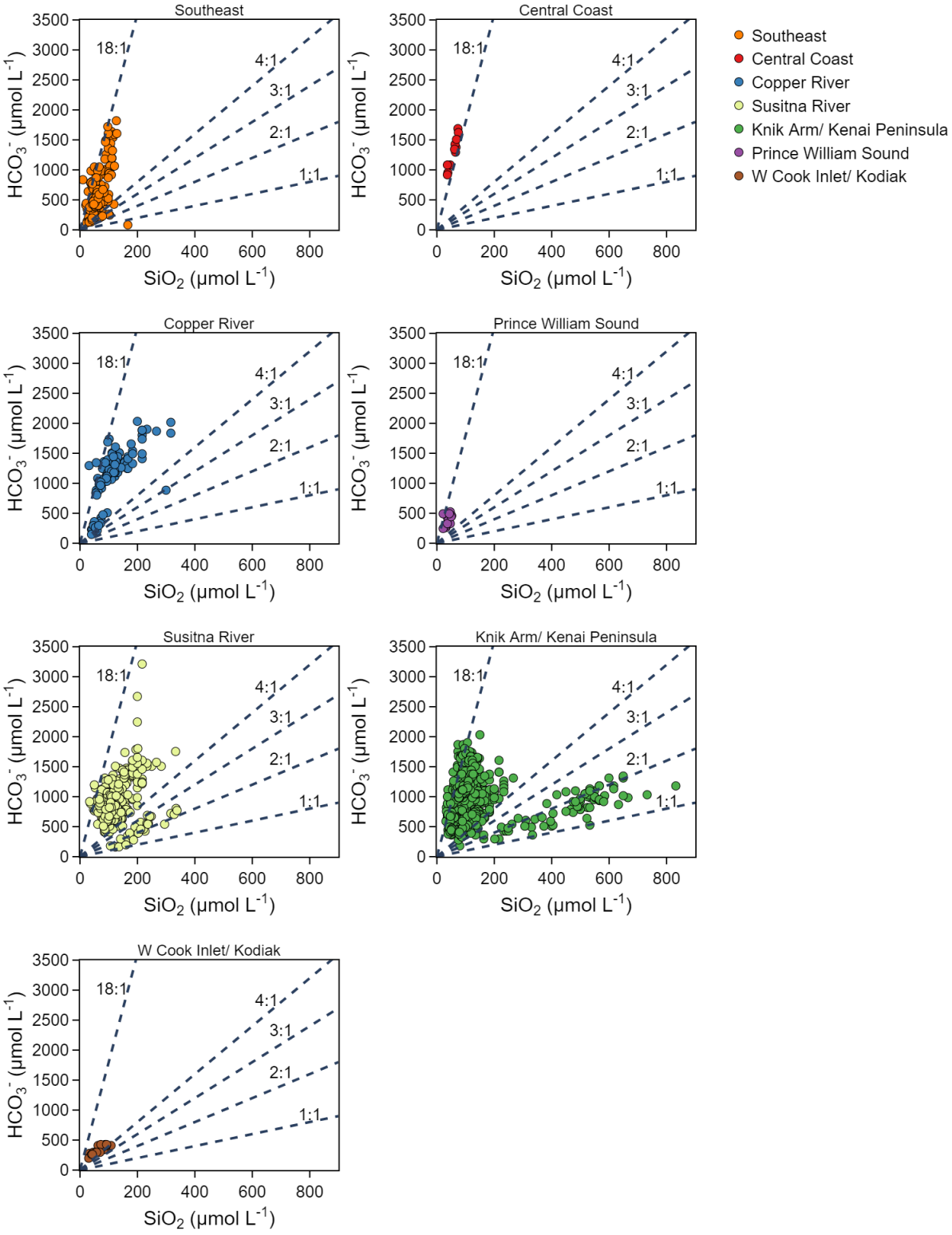

Figure S3. Concentration of HCO_3^- vs. SiO_2 for GoA stream sites plotted by region. Across the various regions of the GoA carbonate dissolution appears to be the primary weathering regime compared to silicate weathering.

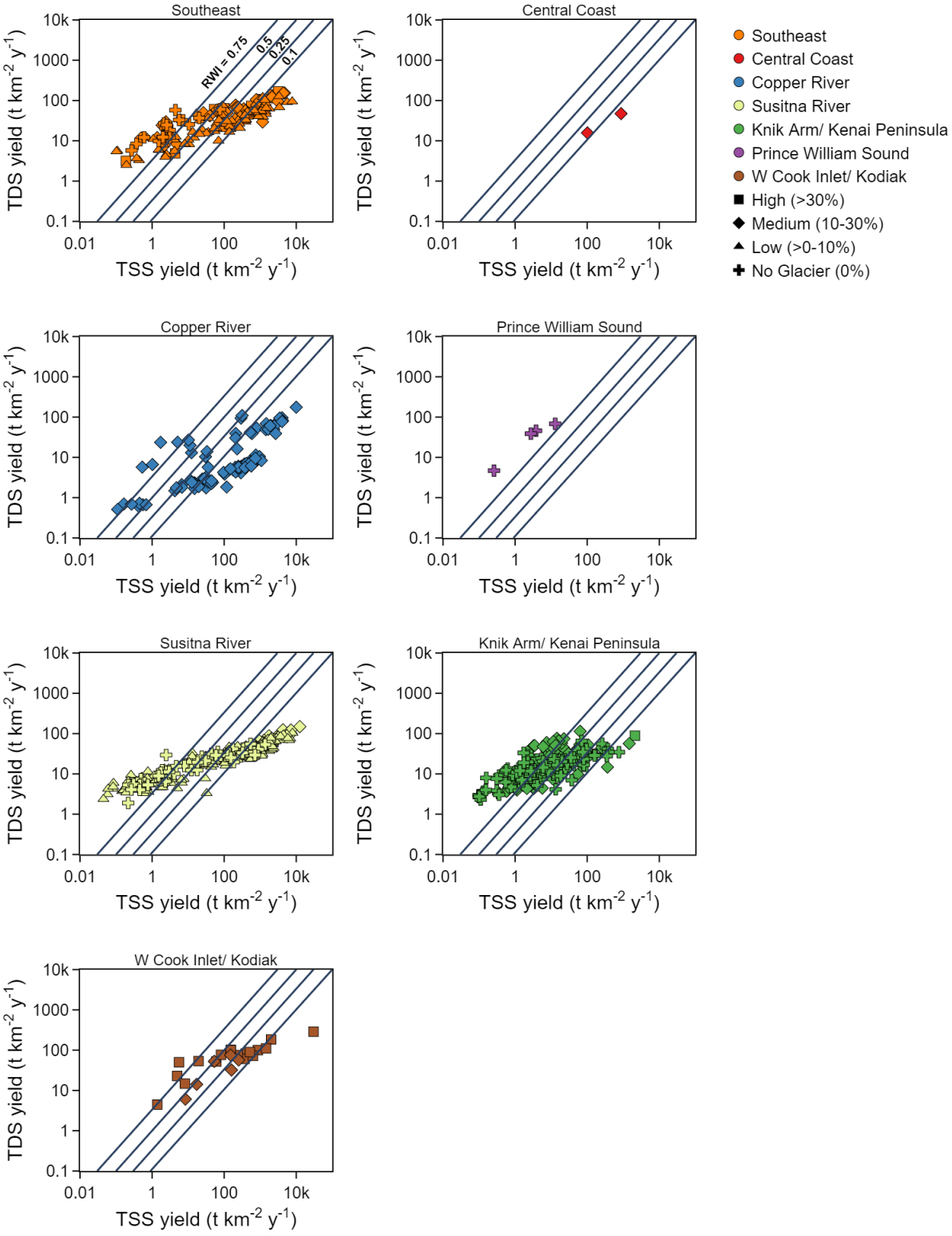

Figure S4. Cross plots of TDS yield vs. TSS yield plotted separately by region. Streams within watersheds with medium to high glacier coverage generally have lower rates of chemical weathering compared to physical weathering. Streams with low to no glacier coverage have higher rates of chemical weathering compared to physical weathering.

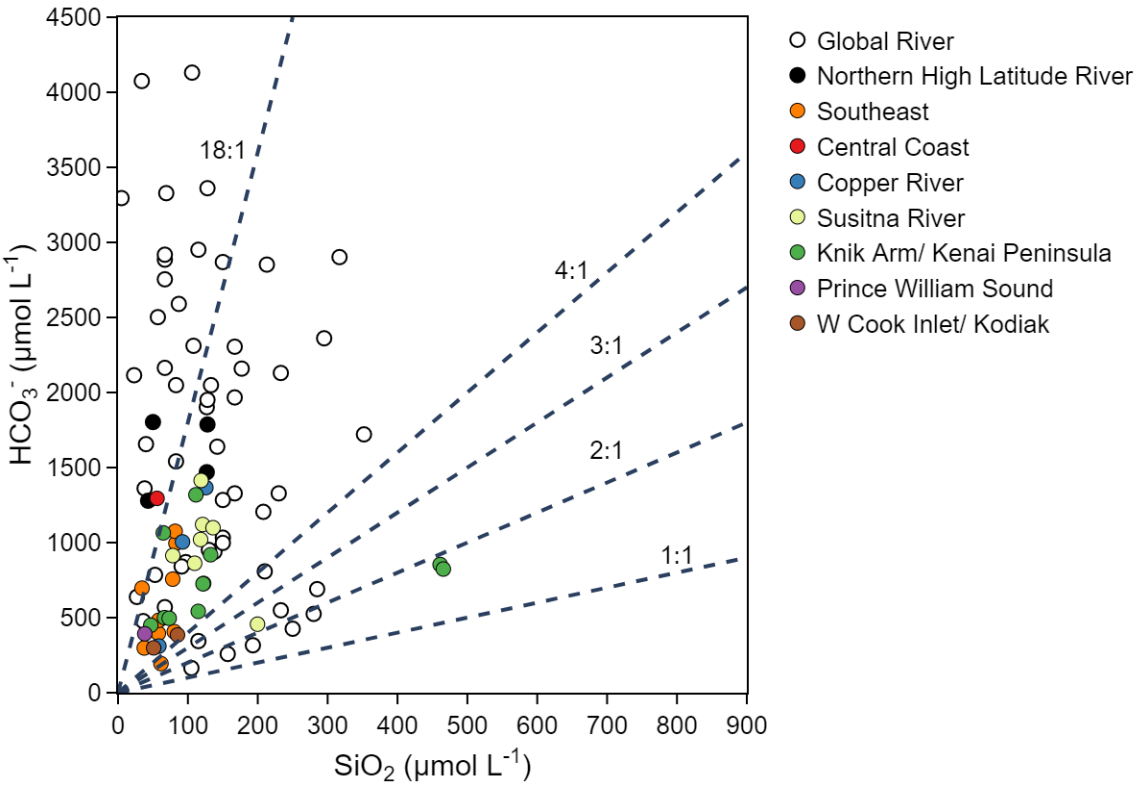

Figure S5. Mean concentration HCO_3^- vs. SiO_2 for GoA streams along with mean global and northern latitude streams. On average GoA streams have lower values compared to the global rivers. Across both datasets carbonate dissolution is the dominate weathering regimes in most basins.

$$CaCO_3(s) + H_2CO_3(aq) \rightleftharpoons Ca^{2+}(aq) + 2HCO_3^-(aq)$$

Equation S1. Carbonation of calcite resulting in 1:0.5 molar ratio of HCO_3^-: Ca^{2+}.

Solute b-value	Parameters for min. BIC	R^2	Parameters Chosen	p<0.05
HCO_3^-	4	0.2375	Relief (+), Wetland (-)	Wetland
Ca^{2+}	3	0.3488	Mean Aspect (+), Mean Slope (+), Relief (+)	All but Relief
Mg^{2+}	2	0.3423	Mean Aspect(+), Mean Slope (+)	All
Na^+	2	0.2825	Mean Aspect (+), Relief (+)	Only Relief
SiO_2	5	0.6153	Glacier Coverage (+), Mean Slope (+), Mean Elevation (-), Barren lands(+), Putonic (-), Mean q ($m^3/s/km^2$) (-)	All
TSS	8	0.9296	Mean Precip. (+), Mean Temp(+), Metamorphic (-), Volcanic (+), Mean Elevation (+), Shrubland (+), Wetland (+), Mean q ($m^3/s/km^2$) (+)	All but Mean Precip.
Solute Yield	**Parameters for min. BIC**	**R^2**	**Parameters Chosen**	**p<0.05**
HCO_3^-	2	0.4784	Glacier Coverage (+), Plutonic (-)	All
Ca^{2+}	2	0.5198	Glacier Coverage (+), Plutonic (-)	All
Mg^{2+}	2	0.4995	Glacier Coverage (+), Plutonic (-)	All
Na^+	3	0.4700	Glacier Coverage (+), Plutonic (-), Grassland (-)	All but Plutonic
SiO_2	3	0.4848	Basin Area (km^2) (-), Glacier Coverage (+), Plutonic (-)	All
TSS	4	0.5860	Glacier Coverage (+), Plutonic (+), Volcanic (+), Barren Lands (-),	Glacier Coverage and Barren Lands

Table S1. Results of the BIC analysis and multiple linear regression. The variation of the *b*-values is primarily explained by mean aspect, slope and relief. The solute yields are mainly controlled by glacier coverage. The signs within the parentheses indicate if the given variable has a positive or negative relationship with the given parameter.

Table S2. The table provides all the input data for the BIC and multiple linear regression analysis. This includes the used watershed characteristics and mean temperature and

precipitation. Also included are the calculated *b*-values and yields for each solute used in the analysis.

Dataset S1. Includes three shapefiles for the USGS watershed boundaries and USGS stream sites used in this study, and the regional boundaries of the GoA.