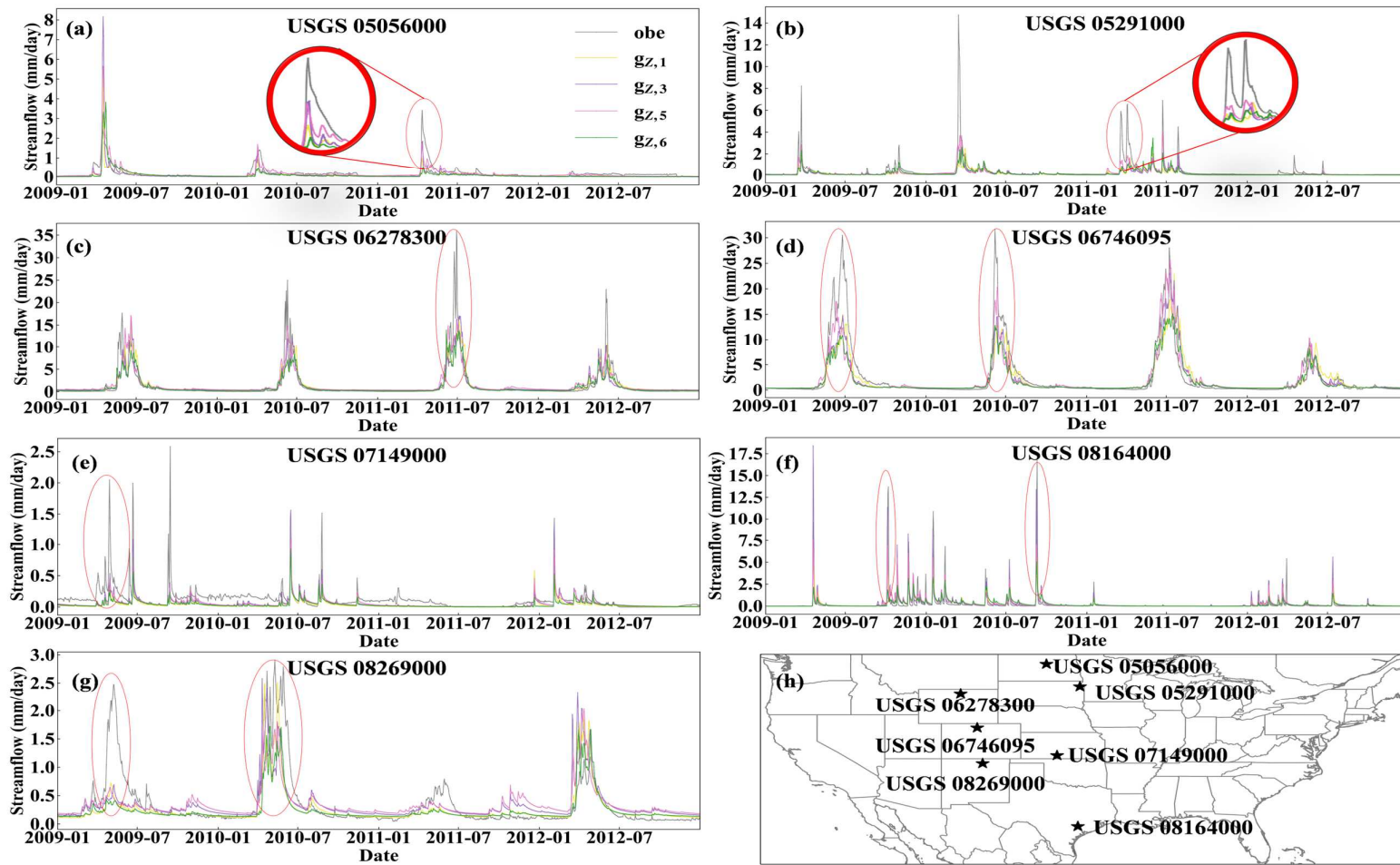**Figure S1.** The spatial variation characteristics of PET (a), P (b), T (c), SM (d), NDVI (e) and silt fraction (f) and slope (g).

.**Figure S2.** Streamflow estimation accuracy for $g_{z,1}$, $g_{z,3}$, $g_{z,5}$ and $g_{z,6}$ at selected stations (a-g) in arid catchments. (h) The locations of these selected stations.
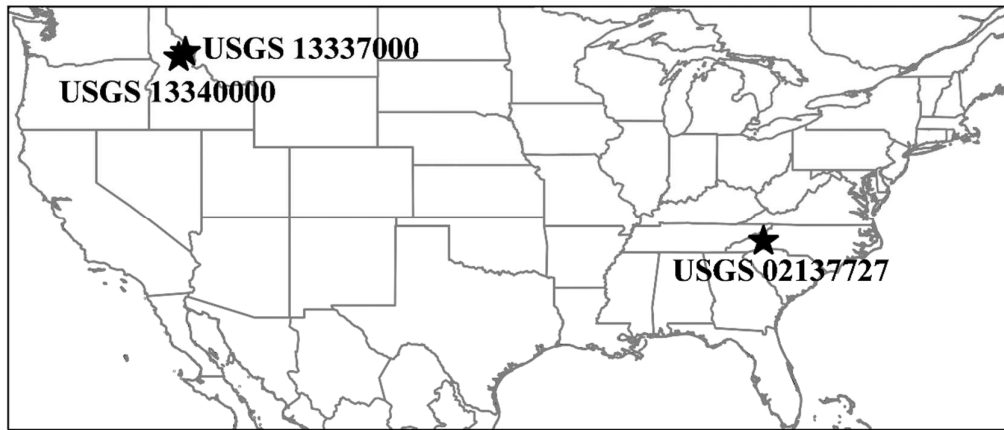
Figure S3. Location of catchments.

Table S1. The catchment attribute data.

Type	Variables	Definition
Climate	p_mean	Average daily rainfall (mm/day)
	pet_mean	Average daily potential evapotranspiration (mm/day)
	p_seasonality	The seasonality and timing of precipitation distribution
	frac_snow	The fraction of rainfall falling as snow
	Aridity	The ratio of mean potential evapotranspiration to mean rainfall
	high_prec_freq	The frequency of days with high precipitation (days/year)
	high_prec_dur	Mean duration of high precipitation events (days)
	low_prec_freq	The frequency of days with low precipitation (days/year)
	low_prec_dur	Mean duration of periods with low precipitation (days)
Topography	elev_mean	The mean elevation of the catchment (m)
	slope_mean	The mean slope of the catchment (m/km)
	area_gages2	Catchment area (km^2)
Landuse	forest_frac	Fraction of forest cover
	lai_max	Maximum monthly average of the leaf area index
	lai_diff	Difference between the maximum and minimum monthly average of the leaf area index
	gvf_max	Maximum monthly average of the green vegetation
	gvf_diff	Difference between the maximum and minimum monthly average of the green vegetation fraction
	dom_land_cover	The dominant land use type
	dom_land_cover_frac	Fraction of the catchment area occupied by the dominant land cover
	root_depth_xx	Root depth (m)
Soil	soil_depth_pelletier	Depth to bedrock (m)
	soil_depth_statsgo	Soil depth (m)

	soil_porosity	Volumetric porosity
	soil_conductivity	Saturated hydraulic conductivity (cm/hr)
	max_water_content	Maximum water content (m)
	sand_frac	Sand fraction (%)
	silt_frac	Silt fraction (%)
	clay_frac	Clay fraction (%)
Geology	geol_1st_class	The most common geologic classification
	glim_1st_class_frac	Fraction of the catchment area characterized by the most common geologic class
	geol_2nd_class	The secondary geological classification
	glim_2nd_class_frac	Fraction of the catchment area characterized by the second most prevalent geological class
	carbonate_rocks_frac	Fraction of the catchment area covered by carbonate sedimentary rocks
	geol_porostiy	Subsurface porosity
	geol_permeability	Subsurface permeability (m²)