

Hyperdroughts in central Chile: Drivers, Impacts and Projections

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Supplementary material

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Supplementary Table 1. Main hydrometeorological stations used in this work

Name	Variables	Latitude (S)	Longitude (W)	Elevation (m ASL)	Period	Source
Santiago, Quinta Normal	Precipitation	33°27'	70°42'	525	1900-2023	DMC
Maipo en el Mazano	Streamflow	33°36'	70°23'	890	1946-2023	DGA
Aconcagua en Chacabucuto	Streamflow	32°51'	70°31'	1030	1913-2023	DGA
Tinguiririca Bajo lo Briones	Streamflow	34°43'	70°49'	518	1942-2023	DGA
Choapa en Cuncumen	Streamflow	31°58'	70°35'	955	1941-203	DGA
Colorado en Raquil	Streamflow	37°05'	69°44'	850	1940-2023	DGA
San Juan Km, 47	Streamflow	31°32'	68°53'	945	1909-2023	SSRH
Mendoza en Guido	Streamflow	32°51'	69°16'	1550	1909-2023	SSRH
Tunuyán en Valle de Uco	Streamflow	33°47'	69°15'	1200	1954-2023	SSRH
Diamante en La Jaula	Streamflow	34°40'	69°19'	1500	1938-2023	SSRH
Maipo en La Obra	Turbidity	33°36'	70°24'	870	1990-2023	AA
Portillo	SWE	32°50'	70°07 W	3000	1951-2023	DGA
Laguna Negra	SWE	33°40'	70°08 W	2768	1965-2023	DGA
Laguna del Diamante	SWE	34°15'	69°42 W	3310	1956-2023	DGI
Valle Hermoso	SWE	35°09'	70°12 W	2275	1952-2023	DGA
Volcán Chillán	SWE	36°50'	71°25 W	2400	1966-2023	DGA

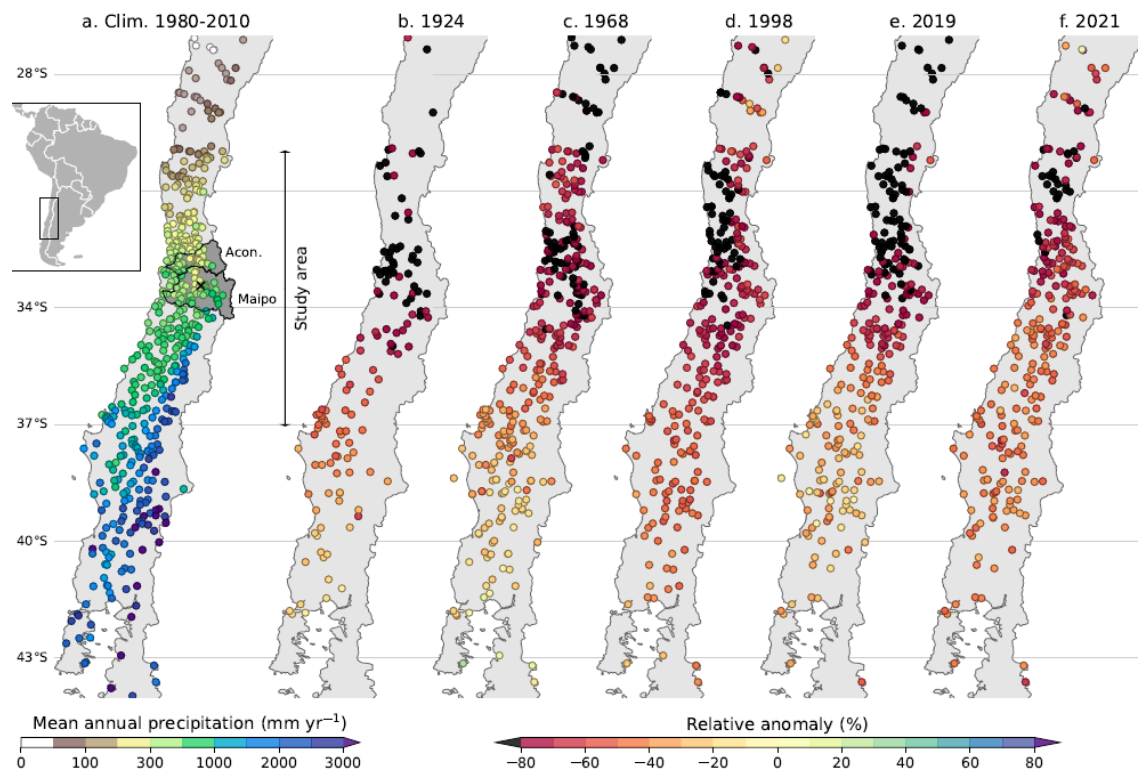
Sources: DMC = Dirección Meteorológica de Chile; DGA: Dirección General de Aguas, Chile; AA: Aguas Andinas, Chile; SSRH = Subsecretaría de Recursos Hídricos, Argentina; DGI = Departamento General de Irrigación, Argentina.

SWE: Snow Water Equivalent measurements from snow courses.

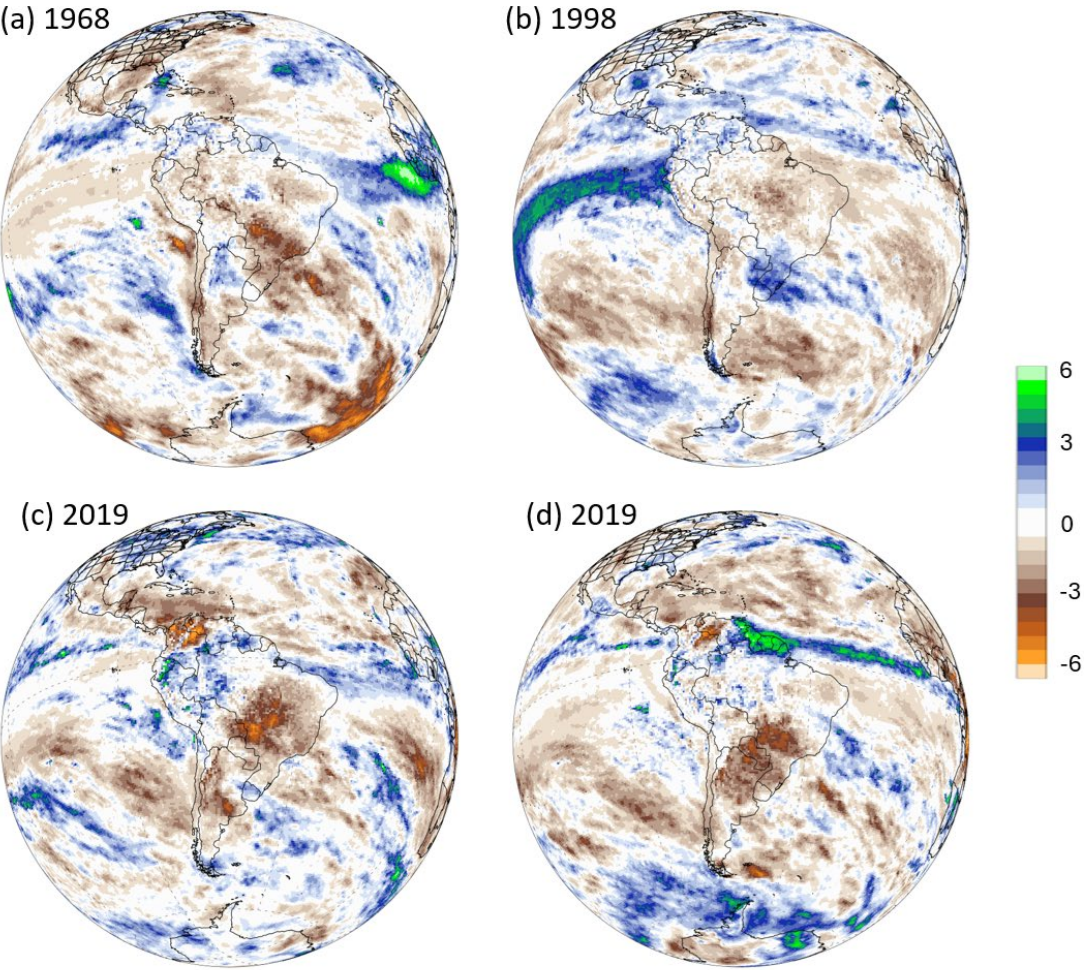
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Supplementary Table 2. Social impact’s Interview summaries

Interview Code	Age range	Gender	Institution name	Institution type
E1PR	30-59	Male	Junta de Vigilancia de la Primera Sección del río Aconcagua	Private - Agriculture
E2PR	30-59	Male	Asociación Nacional Empresas Servicios Sanitarios (ANDESS)	Private - Sanitation
E3PR	30-59	Male	Sociedad del Canal de Maipo (SCM)	Private - Agriculture
E4PR	30-59	Female	Federación de Juntas de Vigilancias de Ríos y Esteros VI región	Private - Agriculture
E5PR	30-59	Male	Aguas Andinas	Private - Sanitation
E6PR	60-	Male	Junta de Vigilancia Río Limarí	Private - Agriculture
E7GB	30-59	Male	Superintendencia de Servicios Sanitarios (SISS)	Government
E8PR	30-59	Female	Federación Nacional de Agua Potable Rural (FENAPRU)	Private - Agriculture
E9GB	30-59	Male	Superintendencia de Servicios Sanitarios (SISS)	Government
E10GB	30-59	Male	Superintendencia de Servicios Sanitarios (SISS)	Government
E11PR	30-59	Male	Esval S.A. y Aguas del Valle	Private - Sanitation
E12GB	60-	Male	Dirección General de Aguas (DGA)	Government
E13GB	30-59	Male	Dirección General de Aguas (DGA)	Government
E14PR	30-59	Male	Federación Nacional de Agua Potable Rural (FENAPRU)	Private - Agriculture
E15GB	60-	Male	Oficina Nacional de Emergencia (ONEMI)	Government
E16GB	60-	Male	Oficina Nacional de Emergencia (ONEMI)	Government
E17GB	30-59	Female	Instituto de Desarrollo Agropecuario (INDAP)	Government
E18GB	30-59	Male	Dirección de Obras Hidráulicas (DOH)	Government
E19PR	30-59	Male	Generadoras Chile	Private - Hydropower
E20GB	30-59	Male	Dirección de Obras Hidráulicas (DOH)	Government
E21PR	30-59	Male	Sociedad del Canal de Maipo (SCM)	Private - Agriculture



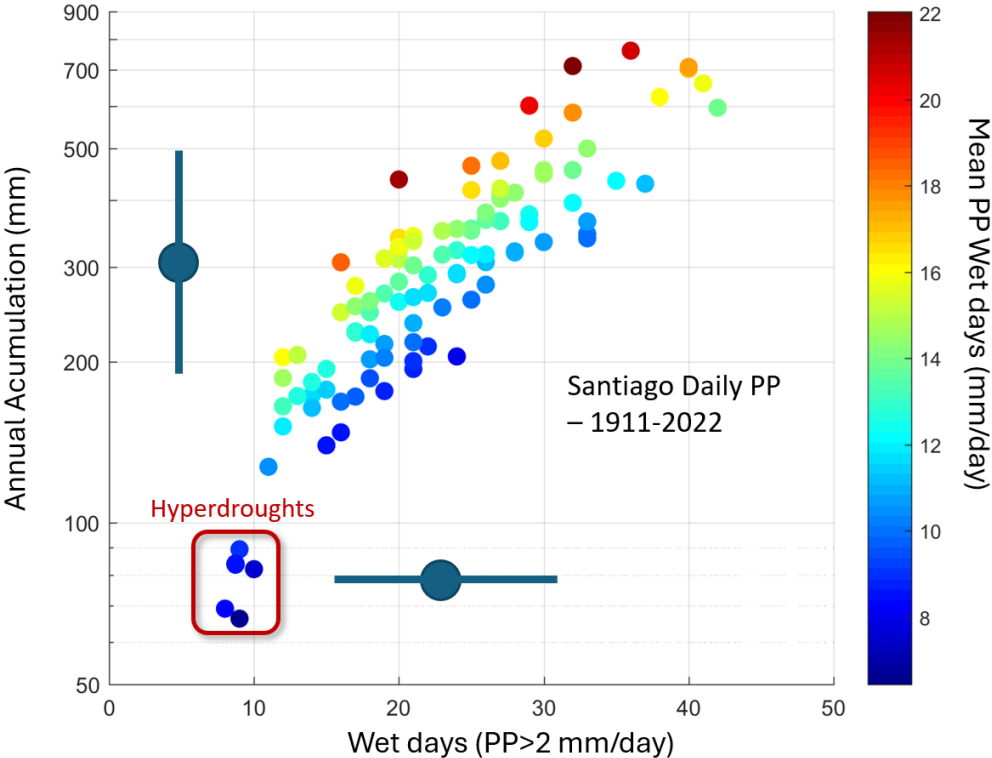
Sup. Figure 1. Panel (a) shows the climatological annual mean precipitation in stations along Chile. The study area and the outlines of the Aconcagua and Maipo basins are also indicated. The rest of the panels (b-f) show the precipitation anomalies (percentage of long-term mean values) during the HD years of 1924, 1968, 1998, 2019, and 2021.



Sup. Figure 2. Annual precipitation standardized anomalies (s.d.) for the last four hyperdroughts. Maps generated from the Climate Reanalyzer using ERA5 data.

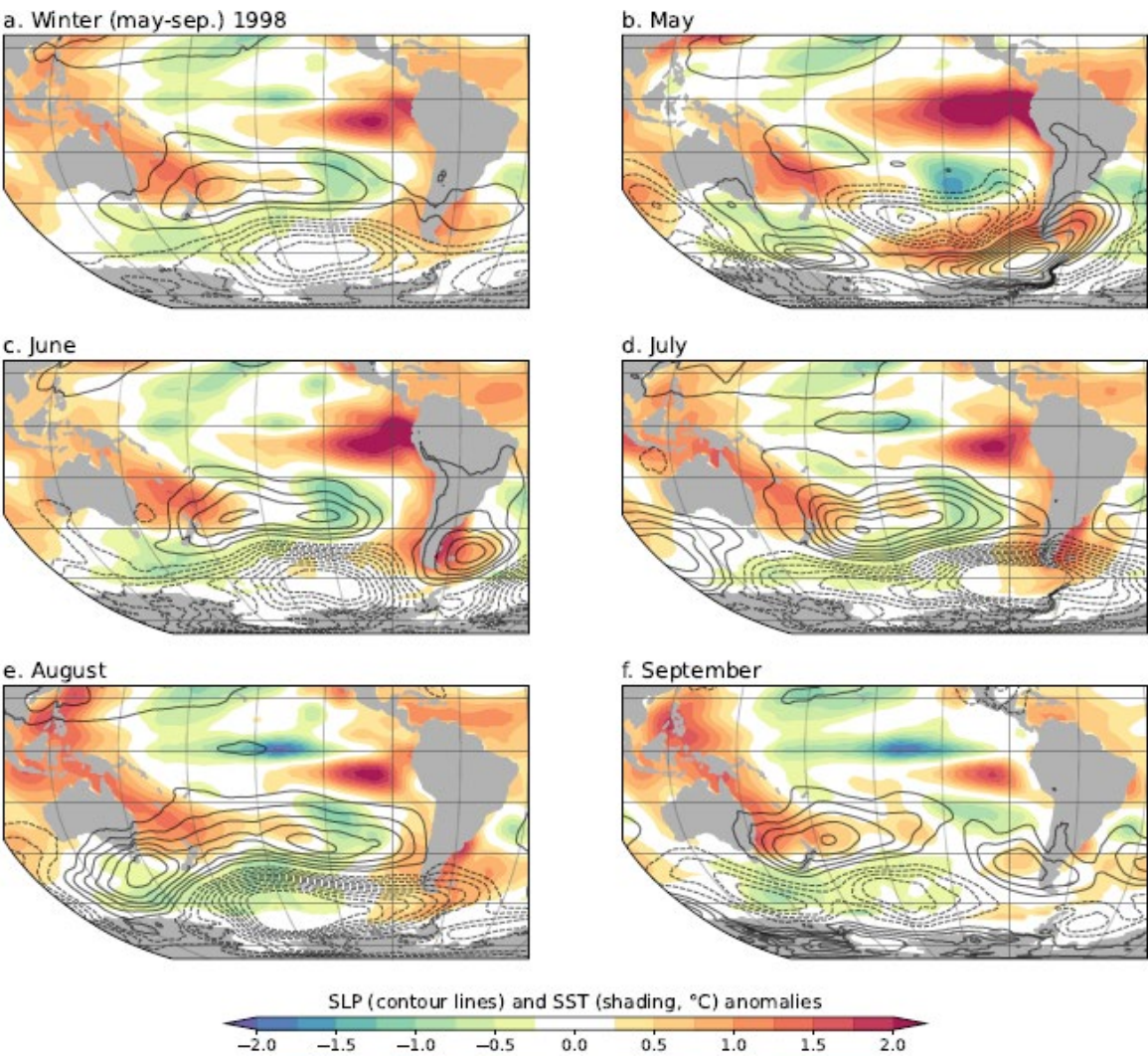
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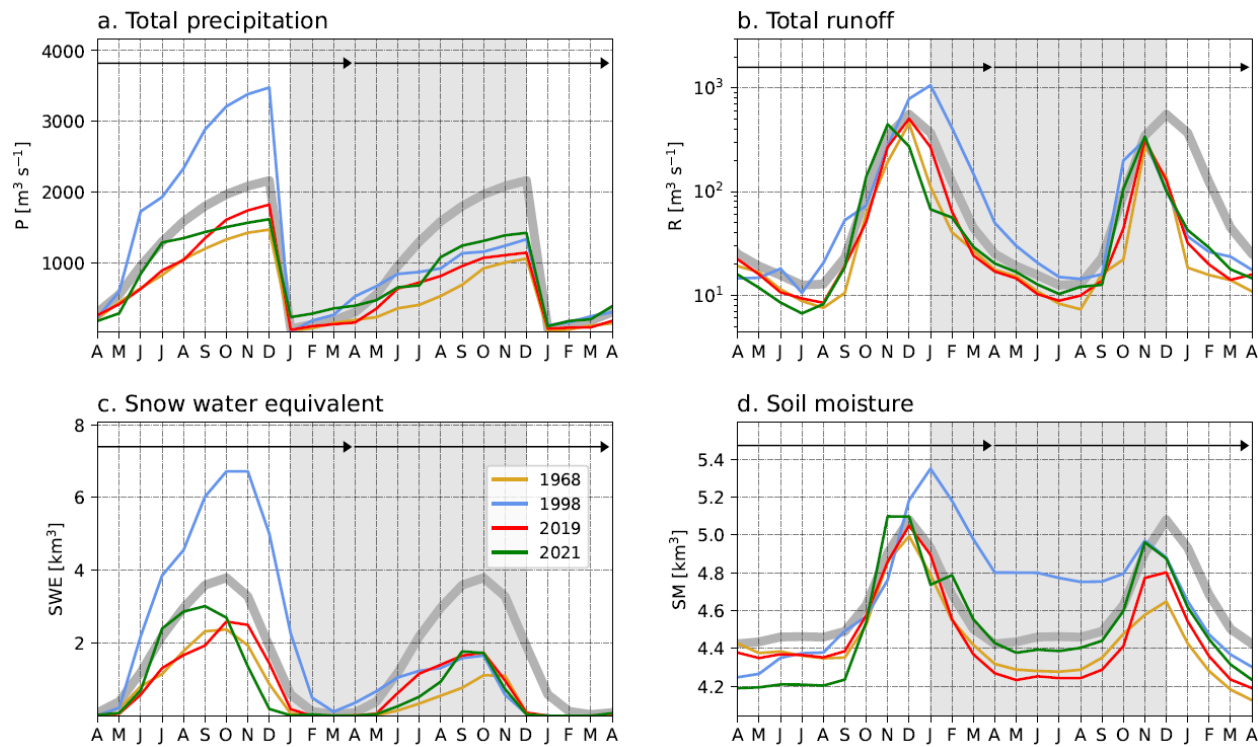


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Sup. Figure 3. Scatter plot between the number of wet days (daily accumulation larger than 2 mm) and annual precipitation, using Santiago (Quinta Normal) data from 1911 to 2022. The circles are colored according to the mean precipitation during the wet days (mm/day, scale at the right). The five hyperdrought are identified in the red rectangle. The large circles indicate the median values and the thick lines span the interquartile range of the number of wet days (horizontal line) and annual accumulation (vertical line).



Sup. Figure 4. (a) Sea surface temperature (SST) and sea level pressure (SLP) anomalies for the extended winter (May-September) of 1998. Panels (b-f) indicate the individual monthly mean SST and SLP anomalies of that winter. Positive and negative SLP anomalies are shown by solid and dashed contour lines, respectively, draw every 1.5 hPa.



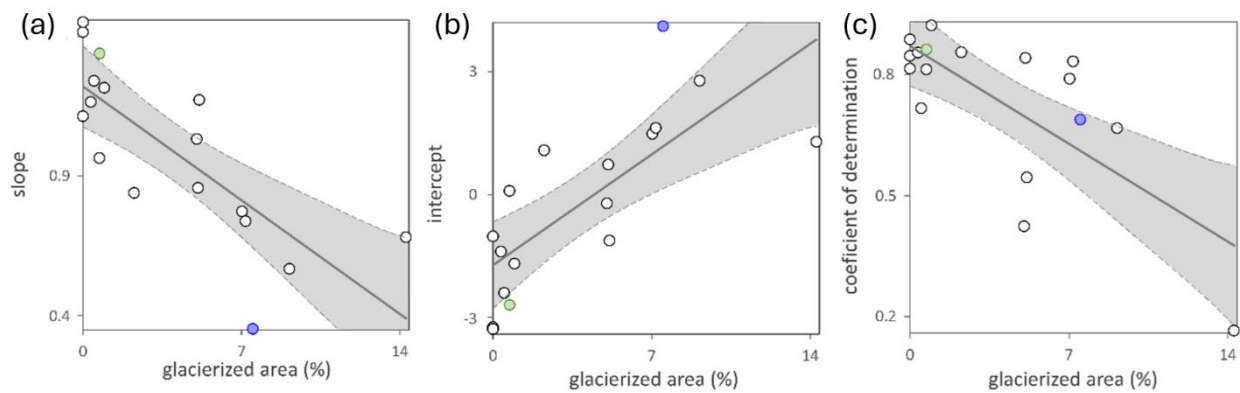
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Sup. Figure 5. Monthly series of selected variables averaged over the Maipo River upper basin for each hyperdrought (except 1924). The long term mean values are also indicated by the thick grey line. The series begin in April of the year before the HD and end in April of the year after the HD. The variables are (a) precipitation, (b) total runoff, (c) snow water equivalent, and (d) soil moisture (2-200 cm). Data from ERA5-Land. The basin outline is shown in Figure 1 and Sup. Figure 1.

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Sup. Figure 6. (a) Slope, (b) Intercept and (c) Coefficient of determination from the linear regression established between the runoff (mean discharge divided by the basin area, April-March) and glacierized area of 15 basins in the Andes of central Chile (30-37°S). The blue circle is Maipo en El Manzano and the green circle is Mapocho en los Almendros. Data from 1980-2021.

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