Comparing the impacts of climate modes of variability on coastal aquifers of California and Portugal

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Introduction and Study Area

Coastal aquifers in Mediterranean regions are particularly sensitive to inter-annual and seasonal water storage fluctuations linked to climate forcing. This comparative study examines the implications of climate variability modes on groundwater levels in coastal aquifers of California and Portugal.

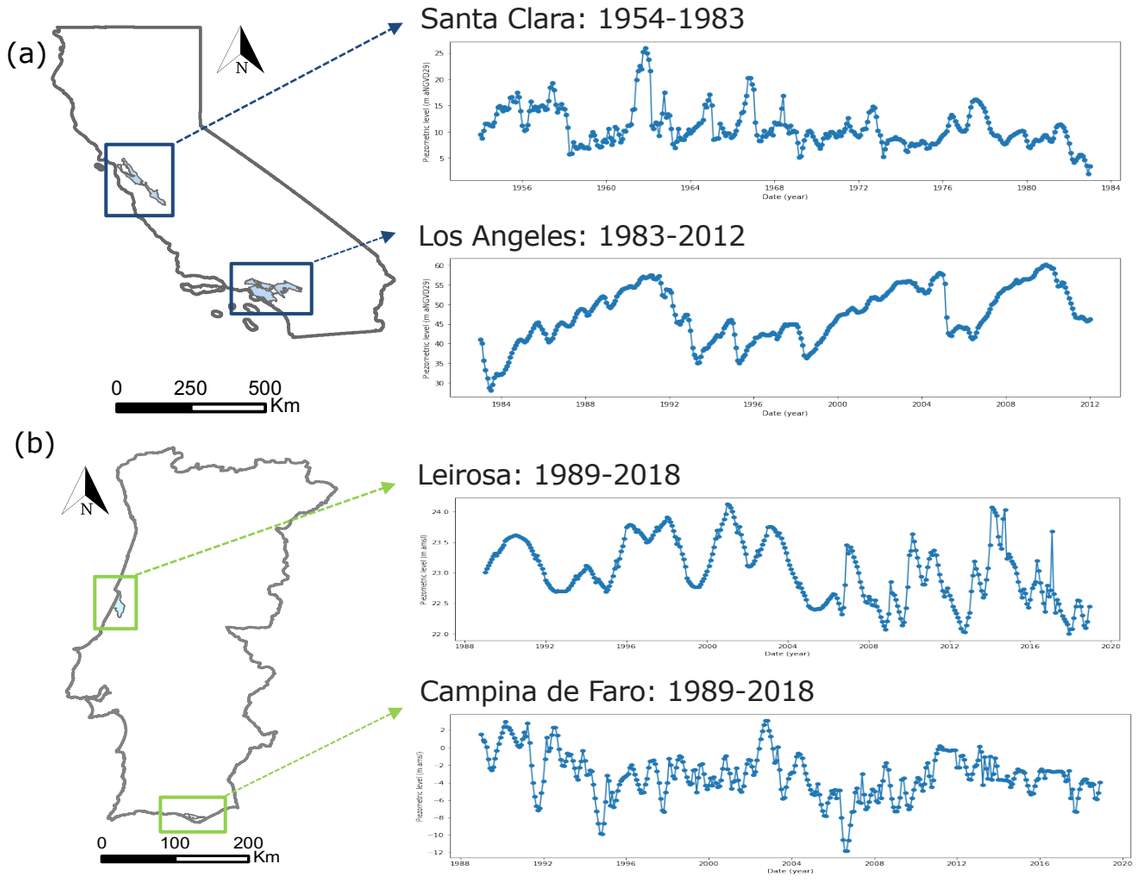

Figure 1: Map showing the location of select aquifers in (a) California and (b) Portugal with monthly interpolated groundwater levels at four piezometers from the northern and southern sectors in each region.

Climate Variability

Climate variability is a natural phenomenon which occurs on sundry spatiotemporal scales. In this study, the Pacific Decadal Oscillation (PDO), El Niño Southern Oscillation (ENSO), Pacific/North American (PNA) in California and the North Atlantic Oscillation (NAO), East Atlantic (EA), and Scandinavia pattern (SCAND) in Portugal are examined.

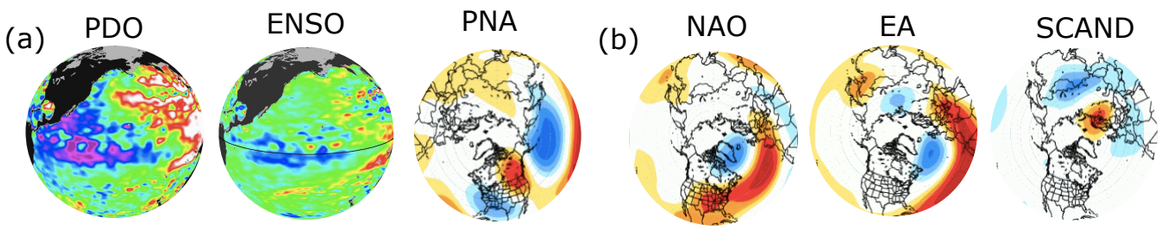

Figure 2: Pressure fields of dominant climate variability patterns of (a) coastal California and the (b) Iberian Peninsula adapted from NOAA (2012) and NASA (2012).

Methodology

Piezometric levels of the selected aquifers are analyzed using Singular Spectrum Analysis (SSA), continuous wavelet transform and wavelet coherence.

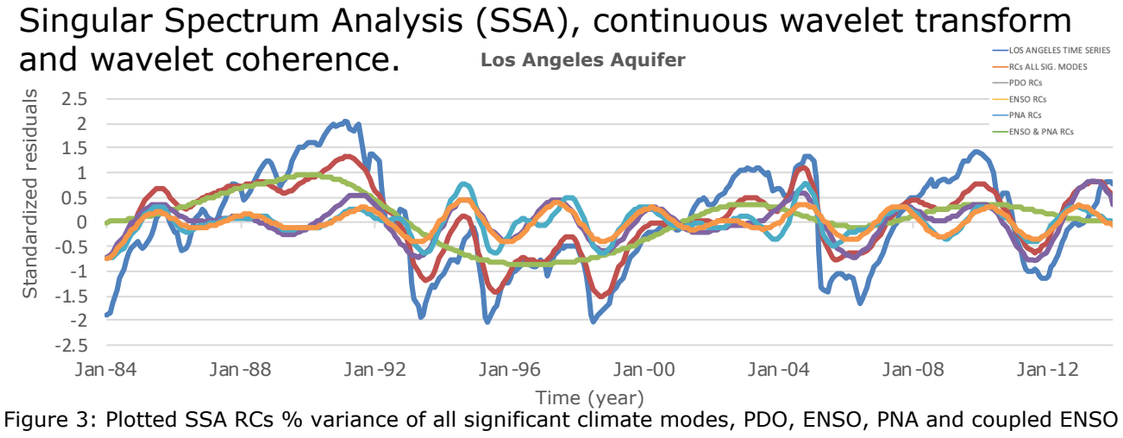

Figure 3: Plotted SSA RCs % variance of all significant climate modes, PDO, ENSO, PNA and coupled ENSO & PNA.

	PDO % VAR	ENSO % VAR	PNA % VAR	ENSO & PNA % VAR
Period (yr.)	15-30	2-7	<1-4	
Santa Clara	5%	65%	34%	24%
Los Angeles	41%	18%	11%	8%

	NAO % VAR	EA/SCAND % VAR	NAO & EA/SCAND % VAR
Period (yr.)	6-10	2-6	
Leirosa	22%	61%	22%
Campina	45%	19%	N/A

Table 1: Composite SSA RCs % variance of PDO, ENSO, PNA, NAO, EA and/or SCAND and coupled modes.

Results

Together, the climate modes are responsible for most of the inter-annual variability in groundwater storage in both coastal aquifer systems. However, the most important result is the recognition that transitive couplings greatly affect the hydrological responses in both California and Portugal.

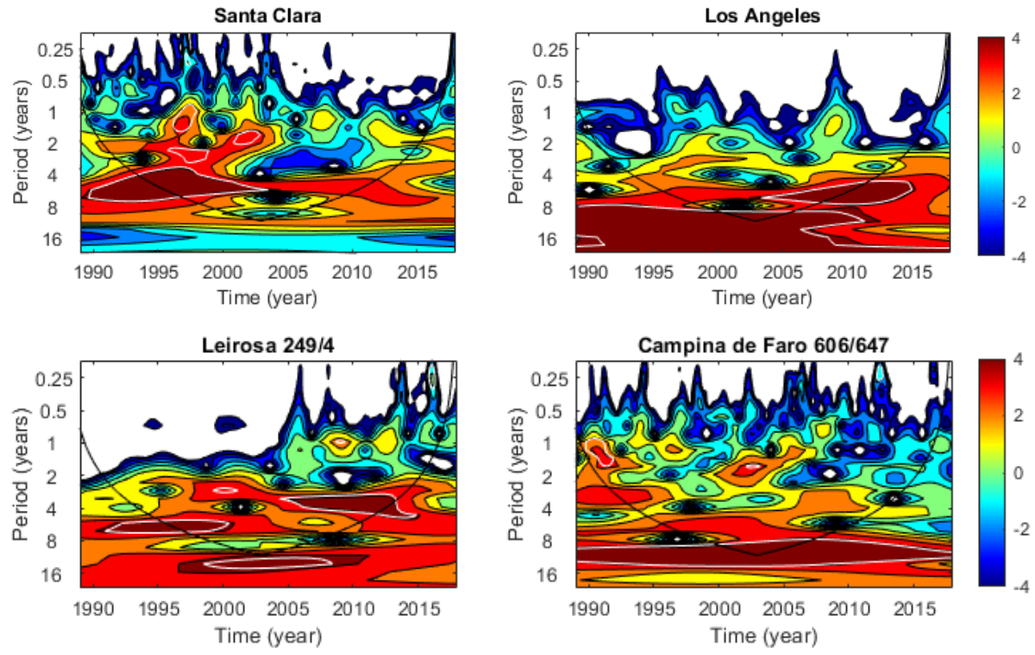

Figure 4: Wavelet power spectra of groundwater level records at Santa Clara, Los Angeles (California) and Leirosa and Campina de Faro (Portugal) aquifers. The white contours enclose regions of greater than 95% confidence levels. The black lines delimit the cone of influence.

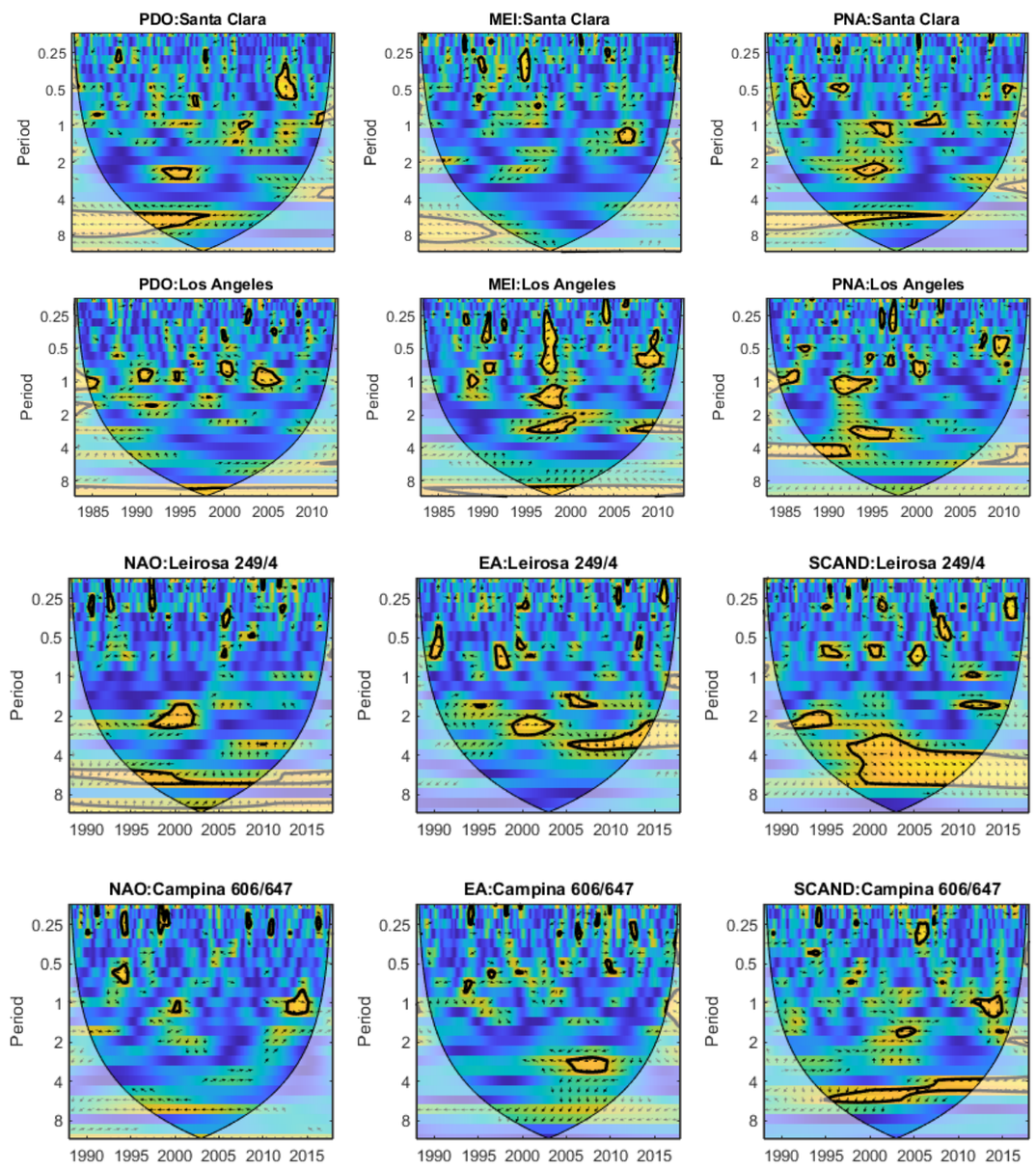

Figure 5: Wavelet coherence of hydrological time series and climate indices in Santa Clara, Los Angeles (California) and Leirosa and Campina de Faro (Portugal) aquifers.

Conclusion

Coupled phases of climate variability modes are linked to extreme piezometric levels and are associated with shifts in mode-interaction patterns. Understanding the linkages between piezometric response to climate variability modes through transitive coupling could provide useful insight for future groundwater management and security.

References

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