Patrones espacio-temporales del peligro de sequía compuesta en el norte de África: un enfoque de tipologías basado en múltiples índices

Spatio-temporal patterns of compound drought hazard in Northern Africa: a multi-index typology approach

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RESUMEN

Northern Africa (NA) encompasses diverse climate types, from Mediterranean woodlands to arid deserts, making it one of the most water-stressed regions globally. Water availability in the soil is crucial for the socioeconomic activities and ecosystem resilience of this region. This study utilizes soil water content (SWVL) datasets from the European Space Agency (ESA) and the ERA5-Land reanalysis (1980–2023) to investigate the response of three soil layers: 0–7 cm, 7–28 cm, and 28–100 cm, to changes in dry conditions considering precipitation and atmospheric evaporative demand. By integrating 3-month standardized indices for precipitation (SPI3), evapotranspiration (SPEI3), and soil moisture (SSMI3), we build a comprehensive drought typology and map monthly compound-drought hazards.Typologies are defined using mutually exclusive logical rules and strict thresholds (< -0.84) to identify four distinct categories: Compound (simultaneous SPI, SPEI, and SSMI deficits), Hydrological, Evapotranspiration-driven, and Soil-anomaly hydrology. Validation results show that ESA and ERA5-Land soil moisture data are strongly correlated in the first layer, with maximum coherence in the northwestern region for deeper layers. Trend analysis also reveals a significant decrease in soil water content, particularly in the top and intermediate layers of the Maghreb belt. Multiple regression attribution analysis demonstrates that trends in the first layer are dominated by SPI evolution, confirming NA as a primarily water-limited region. The results identify pronounced compound drought hotspots over Morocco, northern Algeria, and Tunisia. While the hydrological type is spatially dominant along the Mediterranean margin, evapotranspiration-driven and soil-anomaly types are more episodic, consistent with localized heat-demand effects and soil–land-use controls. A coherent hazard belt is observed across all seasons, with peak intensity during winter and spring in Northwestern Africa. By distinguishing physical drought manifestations (typology) from multivariate co-occurrence frequency (hazard) and their underlying drivers (attribution), this framework delivers a diagnostics to support risk-informed decision-making in water allocation, rain-fed agriculture, and the stewardship of Mediterranean forests.