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Attribution with Multivariate Analogues: a heat waves scenario

Cosmin M. Marina[1], Eugenio Lorente-Ramos[1], Laura Cornejo-Bueno[1], David Barriopedro[2], Ricardo García-Herrera[2], Matteo Giuliani[3], Enrico Scoccimarro[4], Eduardo Zorita[5], Andrea Castelletti[3], and Sancho Salcedo-Sanz[1]

[1]University of Alcalá, Department of Signal Theory and Comunications, Alcalá de Henares, Spain (cosmin.marina@uah.es)
[2]Instituto de Geociencias (IGEO), Consejo Superior de Investigaciones Científicas-Universidad Complutense de Madrid, Madrid, Spain
[3]Department of Electronics, Information, and Bioengineering, Politecnico di Milano, Milano, Italy
[4]CMCC Foundation - Euro-Mediterranean Center on Climate Change, Italy
[5]Helmholtz-Zentrum Geesthacht, Hamburg, Germany

This study introduces an innovative preprocessing technique utilizing an Autoencoder (AE) as an alternative to the traditional multivariate Analogue Method (AM). The newly proposed method, MvAE-AM, is employed to reconstruct historical heat wave events: France in 2003, the Balkans in 2007, Russia in 2010, and Spain in 1995. The AE effectively extracts critical information from variables such as soil moisture (SM), potential evaporation (PEva), mean sea level pressure (MSL), and geopotential height at 500 hPa (Z500) into a more compact univariate latent space. Subsequently, the conventional univariate AM is utilized to identify analogous past situations within this latent space, focusing on minimizing the distance to the analyzed heat wave. This analysis is extended to comparing factual and contrafactual scenarios, where the attribution of the anthropogenic impact can be studied. Our evaluation of the proposed MvAE-AM method against the standard multivariate AM (MvAM) reveals that it not only simplifies the complexity of the problem but also enhances accuracy. Furthermore, a significant advantage of the AE-based approach over classical statistical methods is its capacity for detailed explainability analysis, facilitated by explainable artificial intelligence (XAI) techniques such as SHAP. This analysis elucidates the temporal, spatial, and variable-specific factors that most significantly influence heat wave occurrences, with notable patterns of Ridges and Blocking observed across several heat wave events.