Índices de peligrosidad de incendios forestales en Castilla y León: integración de técnicas de Machine Learning

Wildfire Hazard Indices in Castile and León: Integrating Machine Learning Techniques

A. Corbea-Pérez, A. Merino, A. Navarro, J.L. Sánchez, E. García-Ortega

GFA. IMARENA. Universidad de León

RESUMEN

The Mediterranean region has emerged as a critical focal point in the context of climate change, where rising temperatures and prolonged water deficits substantially increase vulnerability to wildfires [1]. The 2025 season in Castile and León provided a stark reminder of this reality, with unprecedented destruction, including the burning of more than 150,000 hectares in August alone, underscoring the need for more advanced spatial tools for hazard estimation [2]. This research establishes an operational system to assess ignition potential at a daily 1 km resolution, specifically tailored to the heterogeneous landscapes of north-central Spain. Using a comprehensive dataset spanning 2007–2022, we compare a tabular machine learning approach, XGBoost [3], with a deep-learning architecture, ConvLSTM [4], capable of processing both temporal sequences and spatial neighbourhoods. The analysis shows that both frameworks achieve exceptional discriminatory skill, with AUC values of 0.96 or higher. Interpretable AI techniques such as SHAP and Integrated Gradients (IG) indicate that land surface temperature (LST) and relative humidity (RH) act as the primary physical drivers of hazard. Notably, the ConvLSTM model proved superior in minimising false alerts, whereas XGBoost exhibited greater sensitivity in identifying actual ignition events. These findings provide a technical cornerstone for modernising early-warning infrastructures and refining resource allocation during crises. The integration of these high-resolution models supports a transition towards proactive land-use planning and enhanced socio-ecological resilience in the face of extreme climate events.

References:

[1] Fernández-Guisuraga, J.M., Martins, S., Fernandes, P.M. (2023). Characterization of biophysical contexts leading to severe wildfires in Portugal and their environmental controls. Sci.Total Enviro., 875, 162575. https://doi.org/10.1016/j.scitotenv.2023.162575.

[2] ECMWF (European Centre for Medium-Range Weather Forecasts) (2025). https://atmosphere.copernicus.eu/highest-wildfire-emissions-least-23-years-europe-after-hectic-summer.

[3] Chen, T., Guestrin, C. (2016). Xgboost: A scalable tree boosting system. Proceedings of the 22nd Acm Sigkdd International Conference on Knowledge Discovery and Data Mining, 785–794.

[4] Shi, X., Chen, Z., Wang, H., Yeung, D.-Y., Wong, W.-K., & Woo, W. (2015). Convolutional LSTM network: A machine learning approach for precipitation nowcasting. Advances in Neural Information Processing Systems, 28.