¿Anticipan los avisos meteorológicos tradicionales los impactos locales?

Are traditional hazard-based weather warnings anticipating local impact?

J. Morales (1,2), X. Llort (2), A. Lapedriza (3,1), A. Kaltenbrunner (4,1)

(1) Universitat Oberta de Catalunya. (2) Hydrometeorological Innovative Solutions.
(3) Northeastern University. (4) Universitat Pompeu Fabra, Barcelona

RESUMEN

Hazard-based weather warnings are the standard tool for alerting responders and the population about meteorological risks, yet they typically do not consider data on vulnerability and exposure, relying instead on fixed or climatology-based thresholds. This raises questions on their effectiveness at higher resolutions, as weather impacts are ultimately determined by local characteristics such as infrastructure, population distribution, or land use. This work addresses this gap by providing the first quantitative and high-resolution assessment of how traditional heavy rain and wind gust warnings correlate with actual registered impacts, using 112 emergency calls as an impact proxy. We evaluate warning performance at a municipal and hourly resolution across Catalonia, in Northeastern Spain, over six years (from October 2018 to February 2025), analyzing warnings from two meteorological agencies: the national (AEMET: FMA - "Fenómenos Meteorológicos Adversos", part of the EU MeteoAlert program) and regional (SMC: SMP - "Situació Meteorològica de Perill"). The study begins by examining how the spatial distribution of issued warnings aligns with the rain and wind climatology of the region, and assesses if these geographical patterns relate to the distribution of emergency calls. Following this, overall warning performance metrics are calculated assuming a real-time setting. Furthermore, we conduct a series of experiments to examine relevant variables. These include varying the forecast lead-time to assess how anticipation capacity evolves over prediction horizons up to 48 hours, and comparing performance when warnings are evaluated at both their original zone resolution and the municipal level. We also analyze seasonal patterns in both warning activations and impacts to understand their influence on performance. Finally, we consider increasingly severe impact thresholds, defined by the number of emergency calls received per hour, to assess the performance sensitivity to this variable. Our analysis reveals that while traditional warnings can effectively identify general impact zones, they are severely limited when considered at the local scales due to a high number of false alarms, which can reduce their public use and trust, and potentially lead to warning fatigue. We discuss potential solutions to mitigate these limitations, such as integrating additional data layers on vulnerability, exposure, and historical impacts to refine and downscale from the original, broad warning zones to the local level. This work aims to provide not only a methodology for quantifying impact assessment at a high resolution, but also a solid evidence base to inform and accelerate the transition from traditional, hazard-centric systems towards more actionable and precise impact-based warning systems. By demonstrating both the potential and limitations of the systems currently in place, we highlight the necessity of collaborative frameworks to overcome the scarcity of open and varied impact data through standardized processes for its collection, sharing, and integration into operational warning pipelines.