Compound Weather Risk from a Counterfactual Perspective

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Introduction

Extreme weather is a multi-dimensional result of multiple physical systems interacting. Actual compound occurrences are historical realizations of these coupled processes that are unique to them. However, because of their inherent stochastic nature, they may have resulted in different outcomes. Historical meteorological research is more likely to concentrate on explaining what happened rather than analyzing the phase space of possible possibilities. Unlike extreme event catalogues, information about near misses and proximity to tipping thresholds is not collected in a systematic manner. As a result, stakeholder knowledge of high-risk system states is restricted. Alternative realizations provide a counterfactual perspective on compound weather risk, allowing for a better understanding of extreme weather events, particularly in terms of severe impact repercussions. This viewpoint would be a valuable addition to statistical analysis. Participants face a significant problem in assessing the social impact of climate change on any specific weather hazard, such as coastal flooding or tropical cyclones [1]. When the scope of the project is expanded to include many weather occurrences, the challenge takes on a whole new dimension. Such complex dynamic chains of meteorological hazard, engineering vulnerability, and infrastructure system failure may be linked geographically and temporally, resulting in catastrophic repercussions. Climate change has the potential to influence the probability of compound occurrences, as well as their occurrence pattern and other aspects [2]. The study of compound climatic events is extremely relevant to the present: many of these compound occurrences might potentially occur right now, contributing to the current risk of extreme weather. Some of these compound occurrences have occurred, or may have occurred, in the past. In the context of climate change, analyzing compound events has the added benefit of improving the robustness of present risk modeling.

Since the 1980s, the distinction between lack of information and randomness in expressing uncertainty in natural disasters has been crucial in seismic risk assessment [3]. The dynamics of the atmosphere are essentially more obvious and theoretically quantifiable than those of the Earth's crust. As a result, the basic notions of epistemic and aleatoric uncertainty are no longer required in weather hazard assessment teaching and practice. However, they've found use in urban flood risk modeling, and these ideas play a strong epistemological role in defining the many uncertainties linked with climate change [4]. Climate change projections are based on three factors: uncertainty in human-caused climate change forcing, uncertainty in the climate system's reaction to this forcing, and actual climate realization for a given time range. The first regulates the selection of a climate change scenario. The second is epistemic uncertainty, which is subjective and can be lessened as knowledge increases [5]. The third type of uncertainty is aleatoric, which refers to the unpredictability with which climate is realized during a certain time window. Climate change response epistemic uncertainty can be expressed by a distinct set of multiple physically coherent stories. The physical principles of thermodynamics limit the aleatoric uncertainty in global mean warming for any particular tale. This will be linked to specific regional dynamic variables, including a large aleatoric component, which is a factor in extreme weather formation [6]. In catastrophe weather risk modeling, where uncertainty Estimate is critical for sensible insurance decision-making; a detailed examination of aleatoric uncertainty is of special practical value. Consider the list of extreme regional weather occurrences that have occurred since 1900. A high-resolution global climate model could provide alternative realizations of this modern historical inventory, which is just one possibility. For probabilistic risk assessment, the historical catalogue remains the most important data source and standard. However, over fitting to a limited historical dataset of extreme values or projecting far beyond the greatest data point carries a statistical risk [7].

The unintentional nature of historical catalogues of extreme events is universal to all dangers, but thorough definition of this is uncommon. Bootstrapping historical events is occasionally done to assess catalogue uncertainty, although sampling with replacement does not allow for events outside of the historical experience range [8]. A universal problem necessitates a universal solution, and for thoroughly studying the accidental nature of historical catalogues, a general algorithm applicable to all dangers has been established. A comprehensive examination of how great events could have been even worse is rarely included in a historical catalogue's analysis of major events. This can be explained in part by cognitive bias. The term 'downward counterfactual' is used by psychologists to describe a notion about the past in which things went wrong [9]. Up to 90% of counterfactual beliefs are positive, implying that things have improved, while only 10% are negative. When a negative impact occurs, most people's thoughts move to how it could have been avoided or reduced, rather than how it could have been made worse. Due to result and availability bias, many possibilities for learning from near miss incidents have been missed. Mitigation strategies are frequently employed only in direct response to disasters [10]. To be expressed succinctly, concepts require vocabulary. In risk analysis as much as psychology, the downward counterfactual phrase should be main stream. Its absence implies a lack of systematic efforts to investigate more destructive interpretations of key historical events. Whenever a significant calamity occurs, one might wonder, "What are the downward counterfactuals?" This crucial question can be handled in a variety of ways, the simplest of which is to elicit responses in turn from a group of hazard experts, with experts stepping out if they run out of ideas. Rather than prescribing an explicit toolkit for producing downhill counterfactuals in various ways, this counterfactual approach focuses on encouraging downward counterfactual thought experiments [11].

A significant threat region of the climate change risk landscape is formed by a combination of weather hazard events. There are regional historical catalogues of extreme events for individual weather conditions. Regional historical catalogues of severe events can be produced by linking individual catalogues and collating other accessible information for the various combinations of weather hazards that give rise to compound situations. However, no historical catalogues exists that attempt to represent the complicated phase space of near misses [12], in which a compound weather calamity came dangerously close to occurring. Engineering, civic response, insurance, and climate science communities would all be involved in this multi-disciplinary project. The catastrophic extent of flood effect from Hurricane Katrina in 2005 would have been significantly less startling if such a database had existed beforehand. Extreme winds, rainfall, temperature, and other weather dangers can be estimated using meteorological and statistical studies, but not near to tipping points such as dam or levee breach, or river obstruction. A global library of counterfactual evaluations of important historical occurrences would be useful to all stakeholders as a supplement to existing research of extreme weather events. Such a database, which might be built over time through collaborative research efforts [13], would aid in dispelling misinformation about catastrophic tipping points and avoiding the sense of surprise and shock that tragedies with no historical precedent frequently cause. The creation of a database would allow for the systematic typology of complex weather and climatic occurrences to be incorporated. More than a list of dates and qualitative descriptors should be included in the web database. Impact evaluations and maps of hazard footprints related with the counterfactuals should be included. This visual information would aid stakeholders in better understanding the spectrum of potential repercussions and improve the function of counterfactual analysis as a risk horizon radar system [14]. The debris flow, prompted by heavy rains that caused a significant river blockage on the Nanya River in China's Sichuan region in July 2013 is an example of an insightful database entry. This was a close call; more severe rains, equivalent to a fifty-return period, would have resulted in a debris flow that would have totally blocked the river. A useful analogy in the broader area of natural hazards that cause debris flows is volcano risk, when times of volcanic instability have typically not been carefully preserved in volcano catalogues. In a worst-case scenario, some of these may have been eruption near-misses. The 1995 eruption of Montserrat's Soufriere Hill volcano was preceded by instability in the 1890s, 1930s, and 1960s, none of which were included in the authoritative Smithsonian Institution book on volcanoes of the world. The preceding historical eruption in 1630 was the lone entry [15]. WOVODAT, a global volcano logical database that collects data on volcanic unrest, fills this information gap.

The lack of a global database for compound weather risks makes it difficult to comprehend the marginal influence of climate change, which could result in a compound weather disaster. The hypothetical impact of future climate change on a historical weather event is a subset of the domain of conceivable counterfactual analyses: the future can be seen through the lens of the past. A library of counterfactual compound occurrences would give a broad framework for analyzing climate change scenario outcomes. This database would also be useful for climate change attribution research, which focuses on quantifying how anthropogenic and natural forcing affects the likelihood and intensity of extreme events. A database of counterfactual compound events, in general, would be a useful tool for developing future weather stories. Alternative realizations of historical events might be mapped as tales of past weather, which could be compared against tales of future weather, in addition to mapping historical events onto future climate conditions [16]. A mixture of moderate parameter values may be enough to expose a critical vulnerability in a dangerous infrastructure condition, rather than one or more extreme hazard parameters. Even if such a risky circumstance has never occurred before, it may have with another sampling of aleatoric uncertainty, and thus be revealed by exploratory counterfactual analysis.

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