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Remarks on climate attribution science for “spotlight” hearing
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Thank you all for making the time. My name is Jennifer Marlon, and I am a climate scientist, Senior Research Scientist and Lecturer at the Yale School of the Environment, and Executive Director of the Yale Center for Geospatial Solutions.

As extreme heat, wildfires, and flooding events worsen around the country, people are increasingly taking notice and asking of scientists, Was this event due to climate change? For many decades, the best scientific answer was something like "we can't say, because no single event can be linked directly to climate change." We could offer information about the relevant long-term trends and how certain events appear consistent with those trends, but we couldn’t say anything about a specific storm, in a particular district on a particular day.

Based on a new report released this July by the National Academies, of which I am a co-author, this is no longer true. The field of climate attribution has advanced substantially in the past decade, in terms of data availability, model sophistication, and causal methods, and we are now able to make cause-and-effect statements with varying degrees of confidence, for specific events that we could not have made ten years ago.

Today I’d like to provide some details about where and how we can make these causal statements..

I’ll start with extreme heat because this is where the science is the strongest. The physics for heat are straightforward: when you warm the whole distribution of temperatures from around the planet—which is what climate change is doing now—the upper end – the tail with the hottest days – move the farthest. We also have extensive, abundant, long historical temperature records and the models handle temperature well. So for heat waves, we can now make quantitative statements with strong confidence, and we can do it quickly – within days after an event. The recent back-to-back heat waves in Europe that killed several tens of thousands of people was analyzed by the World Weather Attribution group and they found that even just the July heat wave would have been *virtually impossible* in a climate without human warming – that’s the 99-100% certainty range. Scientists could not have drawn that conclusion in 2016.

The attribution of rainfall events is also strong. We know that warmer air holds more water vapor—and we even know how much: 7% more per degree C. We can also measure increases in heavy rainfall for specific storms, and attribute those to temperature change. Flooding is a bit more complicated, because it has both an atmospheric and a land component. Floods result not only from heavy rainfall, but from how this precipitation interacts with soils and infrastructure like drainage systems. Nevertheless, we know that climate change is contributing to increased and more extreme flooding across the globe. The 2021 floods in Germany, for example, would have been severe due to the heavy rainfall alone, which was accurately forecast, but the catastrophic nature of the impacts were completely unexpected because the cascading impacts

from the extreme weather was not even considered by state-of-the-art hydrologic models. Entire villages were swept away because heavy rainfall persisted and saturated soils in steep-sided valleys, which destabilized slopes and created debris dams that formed and then burst. Similar processes are what just caused the catastrophic flooding in Nepal after the glacier collapse a few weeks ago.

Wildfire is more complicated still, because in addition to heat and precipitation information, it requires data on fuel types and distributions, winds, ignitions, and infrastructure. Climate change only affects some of these factors, like heat, fuels, wind, and ignitions, but people also affect fuels and ignitions. And yet each of these varies substantially on very fine spatial and temporal scales. Nonetheless, even for these events, we can make attribution statements about fire weather conditions and how those are changing. We know, and have long known, that climate change is contributing to more frequent and more intense wildfires generally. And in some cases, with today's climate attribution science, we can go beyond generalities and draw conclusions about cause-and-effect for specific wildfires. This is true for last year's Los Angeles wildfires. Fire-weather conditions during the LA fires were about 35% more likely and 6% more intense than in a world that is 1.3°C cooler. On top of that, the dry season was about 23 days (roughly three weeks) longer than normal. And that extension of the dry season meant that it now overlapped with the Santa Ana wind season, which contributed to the extreme weather conditions and helped the catastrophic fire spread.

In sum: for decades, science has shown that climate change is increasing and exacerbating extreme weather events as a general trend. But every year, the science gets more precise. And today, in many cases, we can identify and explain when, why, and how climate change caused and exacerbated a specific event. Climate attribution is simpler and more precise with heat and precipitation, while flooding and wildfire—events which involve more factors—are more complicated. But the science of event attribution is advancing daily, and we are now pushing the frontiers of impact attribution. This increasingly allows us to make statements not only about the events themselves, but critically about how climate change is affecting economies, human health (for example through heat-related mortality, or increasing premature deaths from wildfire smoke), or ecosystems and natural resources.

To close, much of what we have built over the past century, from culverts and building codes, to cooling standards, flood zones, and reservoir rules, was designed to meet climate thresholds based on data from over 50 years ago. That climate no longer exists. Attribution science can now tell us, event by event, how much those thresholds are being surpassed and where.

Thank you.