Frequently asked questions for:
Rapid attribution of the August 2016 flood-inducing extreme precipitation in south Louisiana to climate change

How did you conduct this study?

- The World Weather Attribution is an international effort that aims to analyze and communicate in a timely manner the possible influence of climate change on extreme weather events such as the extreme rainfall over south Louisiana in August 2016.
- For the current study, scientists of WWA partnered with researchers at NOAA GFDL and Princeton University to analyze available observational data and two high-resolution models developed at NOAA GFDL.
- It was possible to conduct the analysis in an accelerated fashion because the scientific team was able to put other work on hold, high-quality observational data was available in near-real time, and there was a pre-calculated set of model simulations targeted to address these questions. These simulations had been thoroughly evaluated across a range of phenomena, including a recent analysis of extreme precipitation over the contiguous U.S. (Van der Wiel et al., J. Climate, 2016, Science Summary).
- We held calls on August 16 and 17 to discuss the layout of the project (which models and observations we would use to calculate precipitation statistics) and committed to publish the results independent of the final conclusions (i.e. whether climate change had an impact, climate change did not have an impact, or no conclusions could be made).

What are the main conclusions of your study?

- We looked at changes in the probability of extreme rainfall over the Central U.S. Gulf Coast, defined as maximum 3-day total rainfall in a year to mirror the extreme rainfall that occurred from the 12-14 of August 2016 in south Louisiana.
- We found that the probability of a rainfall event like the one that occurred in Louisiana has increased by at least 40%, most likely has doubled (100% increase), due to climate change. This change has occurred from 1900 to 2016.
- This impact of climate change translates to making what was once a 1/50 year event somewhere in the Central U.S. Gulf Coast, on average, at least 1/30 year event, likely even more common.
- This trend is expected to continue over the 21st century as past and projected future greenhouse forcing continues to warm the planet.

Did global warming cause this event?

- We cannot say if this storm was caused by climate change; extreme weather and storms such as these can happen in all climates. What our study does show is that the probability of this volume of rain falling in the area has increased due to climate change.

- Flooding is a complicated process, many weather events can lead to flooding. Climate change increases the probability of big rainfall events, but not all rainfall events lead to flooding.
- The immediate causes of this event were the weather conditions - and climate change only alters the probability of events like these occurring, though they still remain relatively unlikely events. We found that events like this one were possible without global warming, but their odds are much greater now.
- An analogy may serve to explain this better: If someone takes out the “2s” and “3s” from a deck of cards and we then get dealt an “Ace/King” in a game of Blackjack, it is not meaningful to say that removing the 2s and 3s from the deck caused the “Ace/King”. However, the odds of an “Ace/King” deal went up when the 2s and 3s were removed.

Was this a 1/1000 year event as reported in the media before?

- We calculated that the event is a 1/550 year event at a given *location* (a *fixed place* like a weather station that would fit in your driveway), with a range of 1/450 to 1/1450. 1/1000 falls within this range.
- This is different than the *regional* risk (*anywhere* in the Central U.S. Gulf Coast), found to be about 1/30 year event in 2016, with a range of 1/11 to 1/110.
- The estimates of a return period of an event are the best estimate given all available data. However, there is still uncertainty to these numbers, particularly due to our limited years of observations. (Observing systems have only been around since people have been available to monitor them and the technology has advanced: for rain gages they become widely available in the middle of the 20th century in the U.S., for satellites this begins by around 1980.)

How should someone interpret the "Expected years between events"?

- Return periods are the probability that an event will happen in a given year. While they are stated as a 1/50 year storm in the past (1900) versus a 1/30 year storm in 2016, this does not mean that an event only happens once every 30 or 50 years.
- It is possible for multiple events to happen in the same decade or even in the same year.
- The chance of a 1 in 500 year event at a location (the size of a backyard or weather station) to happen this year is 0.2%, it is small, but still possible. That chance is the same next year.
- Regionally across the Central U.S. Gulf Coast, this was a 1 in 30 year event. This translates to a 3.3% chance annually of occurrence somewhere in the region.
- Because this event occurred we now know with certainty that an event like this one is possible at the given *location* where it took place in August 2016 or in the *region*.

What is the difference between a local vs. regional risk? Why are the risks different?

- In the Central U.S. Gulf Coast there are a number of places where an event could happen, therefore the risk of an event somewhere in the Gulf (“regional risk”) is larger than the risk at any particular place in the Gulf (e.g., Baton Rouge; “local risk”).
- An analogy may serve to explain this better: the chances of getting struck by lightning for each person are one in a million per year, but every year 300 people are struck by lightning in the U.S. (source: NOAA, http://www.lightningsafety.noaa.gov/odds.shtml).

- We do calculate the local risk, as that is what has been reported in the media and is how we experience weather (we remember the extreme rain where we live, not extreme rain that occurs anywhere within a several state radius of us).
- However, the bulk of our calculations are for regional maxima over the Central U.S. Gulf Coast (from Houston to the Florida Panhandle), not single points.
- This difference in local versus regional risk is partly behind the impression one may get that “1/1000 year” events seem to be happening very regularly; if we look everywhere at all times, the odds of a “1/1000 year” event happening somewhere actually become quite large; this is one reason why we had to do thorough calculations of the change in odds and the impact of global warming.

Why aren’t you looking at floods when that is the hazard we are worried about? Why precipitation?

- Flooding is brought about by a source of water (e.g. extreme rainfall), land surface conditions, and the capacity of the river system.
- The tools and data to explore flooding itself and its interactions with the land surface are not presently available to us. It would take more time than is available to conduct a rapid attribution study to run a land surface model to produce the necessary data required to calculate return periods. We therefore chose to focus on one part of the flood question by only looking at extreme precipitation.
- We had recently completed a paper (Van der Wiel et al., J. Climate, 2016, Science Summary) on extreme U.S. precipitation, which gave us confidence that the high resolution models used here could reproduce observed precipitation statistics in the region of interest.

What do the observations show you?

- All observational analyses found clear positive trends
    - Increase in probability for the regional event of about a factor 6.3 (97.5% certain more than 2.1).
    - Increase in intensity (intensity refers to the total amount of rainfall for a 30 year event) of 25% (97.5% certain more than 12%).
- Estimates based on CPC gridded data are comparable to estimates based on GHCN-D station data but have larger ranges due to the shorter period of data availability.

What do the climate model experiments tell you?

- Precipitation extremes from both models increase in a manner consistent with the estimates from the gridded observations.
    - The lower-resolution (30-mile tile) FLOR-FA model shows slightly lower trends than the higher-resolution (16-mile tile) HiFLOR model.
- Taking into account all modeling results, the probability of an event like south Louisiana 2015 has increased at least by a factor 1.4 (40% increase) due to radiative forcing (climate change).
- Our best estimate of the change in probability, given the uncertainty, is close to a doubling (100% increase) due to climate change.

How can you calculate changes in risks in the present and future?

- We fit our data to a Generalised Extreme Value (GEV) Distribution (Coles, 2001).
    - This was previously done for a rapid attribution of 2015 storm Desmond over the UK (Van Oldenborgh et al. 2015a), the rapid attribution of the 2016 flooding in France and Germany (Van Oldenborgh et al. 2016), and attribution of flooding in Jakarta (Van Oldenborgh 2015b).
    - Using proven techniques from previous attribution studies makes conducting one possible on short order (~2 weeks) and allows us to compare our results in Louisiana to other locations and studies.
    - Our co-author, Geert Jan van Oldenborgh, is an expert in this technique.
- We use the observations and model data to create distributions in the past and present (2016) to estimate changes in the risks and intensities of precipitation extremes.

What role did the recent El Niño play in this event?

- We have not found a clear link between El Niño events and heavy precipitation on the Central U.S. Gulf Coast.

Why was the storm so strong when it wasn't a hurricane? I thought hurricanes were a major hazard.

- The heavy rain resulted from a stationary storm system. Because it didn't move, all rain fell over a small area instead of spreading over several states.
- At the moment of the storm, the atmosphere was heavily saturated with water vapor. That makes it possible for storms to create extreme rainfall in a short time frame.
- There are many ways to get heavy precipitation in this region, hurricanes are one of them.
- Hurricanes are a major hazard for flooding in the Central U.S. Gulf Coast, but they are not the only flooding hazard - this event is a tragic reminder of this fact.

Why does climate change alter the probability of these events?

- There is a growing body of scientific evidence that precipitation extremes are expected to increase due to the greater moisture content of a warmer atmosphere following Clausius-Clapeyron scaling (O'Gorman 2015, Lenderink and Attema 2015, Scherrer et al, 2016). Many past scientific studies have shown that atmospheric moisture is expected to increase when the climate warms. Storms therefore have more water available to transform into rain. Increasing rain intensity is one possible explanation for the change. Our research here quantifies the role of climate change in altering the probability of extreme events by modeling thousands of years with our global climate models to understand how the probabilities of extreme 3-day precipitation events have changed.
- Because of the allotted time frame for our study, we haven't investigated the details of the mechanisms behind the changes in the weather in the Gulf that lead to these events. We hope to see more of that analysis in the future.

How should communities rebuild to be more resilient in the future?

- That is a great question for which our work only provides part of the context.
- Our work shows that the risk of such an event like the one that occurred is increasing. We hope that this work and the ones that follow will help inform decision makers in planning for risks.

In March 2016, significant flooding in Louisiana also led to a declaration of a state of emergency. Why did we get two floods in one year in the same state?

- In our work we did not look at whether the odds of multiple events in a year had changed, or at whether the risk for an event later in the year is altered by having one event early in the year.
- While the risk of an event at a particular location is 1/550 year, the risk in the region has a higher probability of recurrence (1/30 year). It is possible to have extreme rainfall in a single state more than once in a given year.

Are there other places in the world that you have looked at?

- Rapid event attribution: our co-author, Geert Jan van Oldenborgh, has previously looked at Jakarta flooding (Van Oldenborgh 2015b) and European storms (for the December 2015 storm Desmond UK and May/June 2016 France/Germany, Van Oldenborgh 2015a, 2016).Others have conducted attribution studies on heat waves (Dole et al. 2011, Stott et al. 2005).
- Our group at NOAA/GFDL has tended to take a more measured pace, and looked at attribution of extreme tropical cyclone seasons around Hawaii (Murakami et al. 2015, 2016), winter storm seasons over the U.S. (Yang et al. 2015), heat waves (Jia et al. 2016), multi-year drought over the western U.S. (Delworth et al. 2015), seasonal rainfall over the U.S. (Yang et al. 2016); sometimes we have found a signature of global warming in extremes, in others we have failed to find a signature of climate variability, and at times the superposition of change and variability were key.
- This field has developed over the last decade. One of the first papers started in 2003 from heat waves (Stott et al. 2005).

Why did you conduct this study on this particular extreme rainfall event?

- We were in a unique position to address this event with an international team that was able to carve out time to focus on this question intensely. We had also just completed a study on the impacts of climate change on extreme rainfall in the U.S. (Van der Wiel et al., J. Climate, 2016, Science Summary).
- In addition, we had access to high-quality observational data in the region, and we had a pre-calculated set of model simulations suitable to address these questions, with a set of high-resolution models, built through years of targeted effort.

Citation and link to study:
Van der Wiel, K., Kapnick, S. B., Van Oldenborgh, G. J., Whan, K., Philip, S., Vecchi, G. A., Singh, R. K., Arrighi, J., and Cullen, H.: Rapid attribution of the August 2016 flood-inducing extreme precipitation in south Louisiana to climate change, Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2016-448, in review, 2016.
http://www.hydrol-earth-syst-sci-discuss.net/hess-2016-448/

NOAA Press Release:
http://www.noaa.gov/media-release/climate-change-increased-chances-of-record-rains-in-louisiana-by-at-least-40-percent

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