STATEMENT FOR THE RECORD of the
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

A Factual Look at the Relationship between Climate and Weather

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

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Introduction

Thank you Chairman Smith, Chairman Stewart, Ranking Member Johnson, and Ranking Member Bonamici for giving the National Oceanic and Atmospheric Administration (NOAA) the opportunity to submit a Statement for the Record on this important topic.

Few environmental factors affect our economy, ecosystems, and livelihoods more than weather and climate. Severe weather and climatic extremes pose risks to human health, safety, and property. In the scientific world, "weather" is classified at shorter time scales, which technically extends to two weeks. Any forecast timescales beyond two weeks – months, seasons, and years – are classified as "climate." Apart from the extremes, everyone understands the influence of weather on everyday life. Will it be hot or cold, windy or calm? Do I need an umbrella? Just as weather affects our daily decisions, so too does climate. How far from the Mississippi River or the Gulf Coast should houses be built? Will there be enough water to support the anticipated growth in Atlanta's suburbs 20 years from now? Information about climate conditions is essential to smart planning and to create better prepared and more resilient businesses and communities. The public is now demanding more data and increasingly complex products at scales that are relevant to them.

NOAA, in partnership with other agencies, is engaged in providing actionable environmental information ("environmental intelligence") to American citizens, businesses, and governments to enable informed decisions on a range of issues and scales local to global and short-term to long-term. NOAA provides a suite of products and services to the American people using the best available science, including the reliable and timely delivery of public weather and climate services which help to safeguard lives. During the last several years, as Americans have been hard-hit with a large number of extreme weather events, citizens are asking if climate change is the cause, and are turning to NOAA for timely and trusted answers.

Extreme events have significant impacts on societal and natural systems.

Although there is no single definition for an extreme event, they can be thought of as individual events that rarely occur at a given location. Since 1980, the U.S. has experienced 144 extreme events in which overall damages reached or exceeded $1 billion each, altogether resulting in more than $1 trillion in combined damages. In 2012, NOAA determined there were eleven weather or climate events with losses exceeding $1 billion in the U.S., all together totaling $110 billion in damages and 377 deaths.[1] The damage caused by Hurricane/Post-tropical Cyclone Sandy (Sandy) alone is estimated at over $65 billion. People and property are increasingly vulnerable to extreme events – for example, sea level rise makes many coastal communities more vulnerable to storm surge during hurricanes and coastal storms, which is particularly significant given

[1] http://www.ncdc.noaa.gov/billions/

that as of 2010, over 123 million people (39% of the U.S. population) lived in coastal shoreline counties.[2] In addition, periodic events such as droughts may be impacted by climate change in both intensity and duration. Even with no change in rainfall, higher temperatures lead to higher evapotranspiration and lower soil water content. These are major limitations on crop production, sometimes leading to widespread crop failure over large regions. Furthermore, these variables are important to aquifer recharge which influences urban development in arid and semi-arid regions of the U.S., as well as irrigation needs in the Great Plains.

As impacts from extreme events continue to rise, NOAA scientists are increasingly being asked whether and how natural climate variations and human-induced climate change may contribute to extreme events. NOAA's research to understand the causes of extreme events is essential in improving our ability to predict them in advance. This knowledge helps improve America's ability to anticipate extreme events and make climate-smart decisions that prepare our communities and businesses for the future.

Both natural variability and climate change influence extreme events.
Natural variability refers to changes in weather and climate that are not caused by human influences. For example, El Niño/La Niña is a naturally occurring oscillation that is known to affect climate on longer-term time scales (e.g., 3-7 years). Variability in the climate system can also be due to natural external factors like volcanic eruptions or solar variations. Many of the extreme events we experience today can be explained by natural variability alone. For example, atmospheric 'blocking' events (continental-scale stationary patterns in atmospheric pressure), or persistent weather patterns caused by El Niño/La Niña are often associated with extreme events like heat waves, droughts, and flooding.

However, climate change can also be a factor in influencing extreme events. Scientists are developing methods to determine whether climate change made specific events more likely or more severe. A supplement to the *Bulletin of the American Meteorological Society* published in September 2013 had 18 assessments of extreme events, of which it was determined that human-caused climate change contributed to the extreme conditions of approximately half.[3]

In addition, we can detect the influence of climate change in explaining long-term global and continental changes, like record low Arctic sea ice extent. Climate change has very likely increased the number of record warm days and nights, and likely lengthened the duration of prolonged period of excessive heat. Impacts also vary regionally and depend on the type of extreme considered. Increases in water vapor accompanying the warming have very likely contributed to more extremes in amount and intensity of rainfall in many regions. For other types of extremes, like hurricanes and tornadoes, there is low confidence in attributing human influence to observed changes. Though projections show likely increases in the intensity of tropical cyclones (i.e. maximum wind speed and precipitation rates) in the future, attribution remains a complex issue. Our observational records and scientific understanding about these complex relationships continue to improve over time.

Climate change can influence an extreme event's *intensity* and *frequency*.
While climate change is not the *sole* cause of any single extreme event, changes in the intensity or frequency of extremes may be influenced by climate change. Although establishing causes of a specific event can be difficult and requires case-specific methods, scientists can assess whether a specific event has become more or less likely (frequency) or stronger or weaker (intensity) as a consequence of climate change. Assessments of intensity and frequency are different ways of looking at an extreme event and

[2] See NOAA's State of the Coast: http://stateofthecoast.noaa.gov/population/welcome.html
[3] Bulletin of the American Meteorological Society, 2013. Explaining Extreme Events of 2012 from a Climate Perspective. Volume 94, No. 9. *See:* http://www.ametsoc.org/2012extremeeventsclimate.pdf

provide different insights on the role that climate change may have had on the event. Around the world, certain types of extreme weather events are becoming stronger and/or more frequent. These changes fit a pattern that is consistent with a warming climate. Though it is difficult to attribute a single cause to any one extreme weather event, climate change makes changes in the intensity or frequency of certain events *more likely*.

Figure 1 depicts a changing climate where average temperatures become higher and the frequency of extreme hot weather increases as shown by shifting the temperature distribution to the right. As shown in Figure 1, warming of the background weather can make typical heat waves *more intense* and can also make very intense heat waves *more likely to occur*. In general, the data record allows scientists to estimate changes in average intensity with higher confidence than they can estimate changes in the frequency of relatively rare events. In some cases only intensity or frequency, but not both, are influenced by climate change. Scientists are increasingly able to see whether human-caused climate change or natural variability has influenced an extreme event. For example, the occurrence of an extended period of high temperatures in the spring and summer of 2012 in the United States can be mainly explained by natural atmospheric dynamics; however, human-induced climate change was found to be a factor in the intensity of the heat and was found to have affected the likelihood of prolonged periods of excessive heat. In the case of Sandy, the record-setting impacts were largely attributable to the massive storm surge and resulting inundation from the onshore-directed storm path coincident with high tide. However, climate-change related increases in sea level have nearly doubled today's annual probability of a Sandy-level flood recurrence as compared to 1950. As these examples demonstrate, the challenge is similar to that of establishing the diagnosis of a disease or the causes of a car crash. In these cases, as with weather and climate events, causes can be complex and multiple factors can play contributing roles.

Limitations on scientists' physical understanding, observations, and modeling of extremes all contribute to uncertainties in estimates of contributions from various factors, whether natural or human, so that findings of individual studies should be interpreted with caution. The science in this area is in a stage of rapid development, and assessments of past events can change over time as additional information and improved techniques become available. NOAA's role is to use the best science available. As the observed record for extremes continues to grow, the climate continues to change, and the state of science of establishing causes for extreme events advances, event-specific statements will improve in the future.

Climate change is expected to exert a stronger influence on particular types of extreme events.

As the influence of climate change on the atmosphere and oceans continues to increase, some types of extreme events are expected to increase in intensity and frequency during the 21st Century. Changes are typically expected to be embedded within year-to-year natural variability in the next few decades, and will vary regionally. By the end of the 21st Century, it is virtually certain that daily heat extremes will increase, and it is very likely that increases in heavy precipitation events will occur given current emissions of greenhouse gases. Arctic sea-ice will likely continue to decline. Other types of extremes, like cold waves, are expected to decrease in intensity and frequency. Hurricane-associated storm intensity and rainfall rates are expected to increase significantly by the end of the century as the climate continues to warm. Yet, for other extremes, like tornadoes, the influence of anthropogenic climate change on the intensity and frequency remains very uncertain and further observations and research are needed.

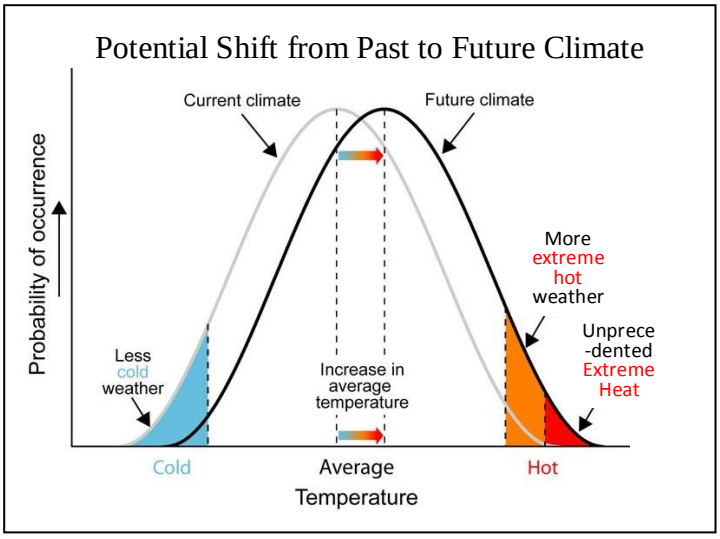
Conclusion

When assessing changes in damages caused by extreme events, it is important to recognize that Americans are already adapting when it comes to extreme events. NOAA has stepped forward to help individuals and emergency managers better cope with and prepare for impending extreme events by providing improved

forecasting of these events. For example, the accuracy of NOAA's inundation models in advance of Sandy indicated that New York City transit workers should construct an 8.5 foot barrier across a tunnel to prevent flooding. The water rose to within 3 inches of the barrier top – but held – saving millions of dollars' worth of additional damages.[4]

NOAA's work informs the nation's plans to manage the risks of extreme events in people's lives and livelihoods. NOAA is committed to advancing our forecasting capabilities by sustaining observations of the Earth system and extreme events, advancing research to understand how extremes will change in the future, and improving climate forecasts by building the next generation of forecast models to better inform decision-makers on the probabilities of a range of climate and extreme changes. To further strengthen this work, the FY 2014 President's Budget requests an increase of $9 million to improve our understanding of Earth Systems and extremes, thresholds, and marine ecosystem tipping points which are critical for the U.S. to improve its capacity for environmental and community resilience in a changing climate. In addition, a $7 million increase is requested to continue development of Earth System Models that will reduce uncertainties in sea-level rise projections, create a new modeling framework for Arctic climate change, and assess the predictability of high-impact climate extremes such as heat waves and flooding. This work will help both the private and public sectors prepare for future climate variability and play an essential role in improving the economic stability and welfare of our citizens.

Figure 1. *Illustration of a change in intensity and frequency of extreme heat waves. As the future climate warms, the distribution of temperatures will shift to the right. This causes the area under the curve for extreme hot weather to increase, indicating that events exceeding a certain threshold are more frequent. Also, the potential intensity of these events can increase resulting in more extremes of unprecedented intensity. Figure Adapted from the IPCC Special Report on Extremes.*



[4] Bulletin of the American Meteorological Society, 2013. Explaining Extreme Events of 2012 from a Climate Perspective. Volume 94, No. 9. *See:* http://www.ametsoc.org/2012extremeeventsclimate.pdf