Testimony of

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before

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on

Update on the Latest Climate Change Science

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Thank you Chairman Boxer, Ranking Member Inhofe, and members of the Committee. I am delighted to appear before you today to discuss one of the most important issues facing the nation – the serious challenge of a changing climate and especially the links between climate change and extreme events. As the US copes with the aftermath of last year's record-breaking series of 14 billion-dollar climate-related disasters and this year's massive wildfires and storms, it is critical to understand that the link between climate change and the kinds of extremes that lead to disasters is clear. Overwhelming evidence supports the conclusion in the latest report of the Intergovernmental Panel on Climate Change that "A changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events, and can result in unprecedented extreme weather and climate events." (IPCC 2012).

My name is Dr. Christopher Field. I am Director of the Department of Global Ecology of the Carnegie Institution for Science and Professor in the Departments of Biology and Environmental Earth System Science at Stanford University. Based on work over more than 35 years, I have published more than 200 peer-reviewed papers on many aspects of climate science, including field experiments, analyses of large-scale climate and agriculture databases, work with satellite observations, and studies with climate models. I am an elected member of the US National Academy of Sciences. In 2008, the Bush administration asked me to help coordinate the work of the IPCC, the Intergovernmental Panel on Climate Change. I currently co-chair Working Group II of the IPCC, which I do as an unpaid volunteer. In my testimony today, I will be presenting information from a variety of sources, including the assessments from the US National Academy of Sciences, the US National Oceanic and Atmospheric Administration, the IPCC, and papers in the technical scientific literature.

My testimony today will address the state of scientific knowledge concerning three key points.

1) Overwhelming evidence establishes that climate change is real
2) Strong evidence indicates that some kinds of climate extremes are already changing
3) Climate change leads to changes in the risk of extreme events that can lead to disasters

Thousands of scientists are carefully studying the data about climate change. Their observations are published in thousands of papers in the scientific literature. These scientists also participate in assessments of the state of knowledge, often coordinated by national academies of science or scientific societies. These assessments to evaluate the vast and rapidly growing scientific literature on climate change overwhelmingly support the conclusions that "Climate change is occurring, is very likely caused primarily by the emission of greenhouse gases from human activities, and poses significant risks for a range of human and natural systems." This comes from the 2011 Final Report of the US National Academy of Sciences, "America's Climate Choices" (National Research Council 2011). The IPCC, which provides a mechanism for all of the world's climate scientists to collaborate in assessing what is known and what is not known about the science of climate change, in its 2007 report (IPCC 2007) concluded that "Warming of the climate system is unequivocal". "The evidence is incontrovertible: Global warming is occurring." is the wording used in the statement of the American Physical Society (American Physical Society 2010).

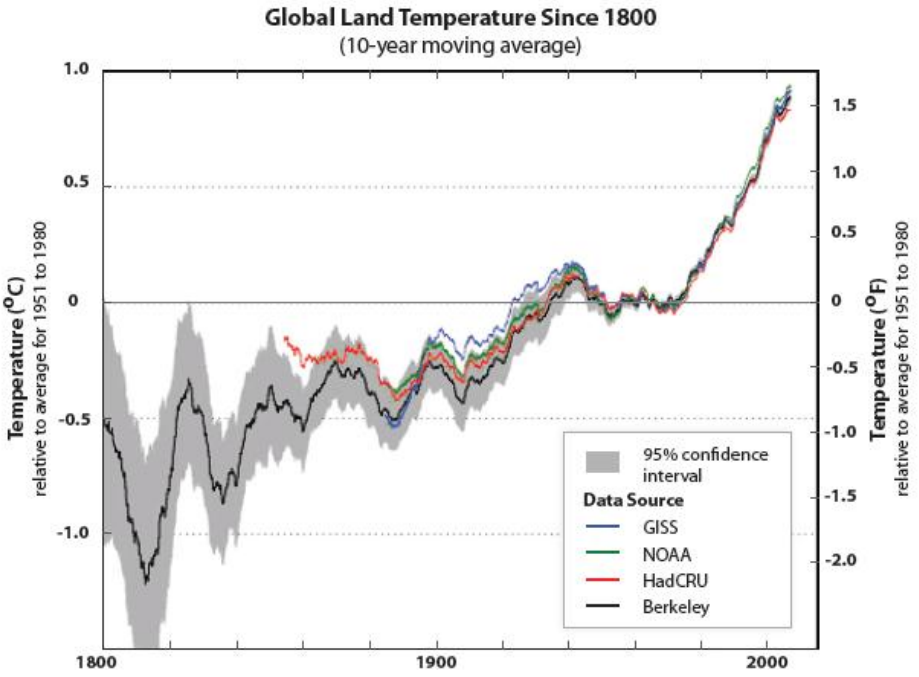

Figure 1: Global land temperature since, 1800, based on weather station data. The references for the published studies are: (Hansen et al. 2010), (Jones et al. , NOAA 2012b), (Smith and Reynolds 2005). The Berkeley data are online at: http://berkeleyearth.org/.

Several research groups have analyzed the records from weather stations, and these groups reach strikingly similar conclusions about the historical trend. Relative to 1900, the global land area has warmed by about 2°F (Figure 1). The record shows warming from 1900 to about 1940, a period of relatively constant temperatures from 1940 until about 1970, and rapid warming since 1980. In the past, there were some indications that trends from temperatures measured by satellites showed a different pattern, but several recent analyses demonstrate that, when the satellite data are analyzed carefully, the trends from the land-based weather stations and the satellites are consistent (Karl et al. 2006). We have reached the stage where the question of whether Earth is warming is not in doubt.

In its 2012 report "Managing the risks of extreme events and disasters to advance climate change adaptation", the IPCC (IPCC 2012) concluded that "A changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events, and can result in unprecedented extreme weather and climate events." Based on the analysis of historical records since 1950, the report identified trends of increasing extreme hot temperatures, intense precipitation, and extreme high sea levels. It concluded that there is evidence that human-caused climate change played a role in these changes in extremes. The report identified some areas where droughts have become longer and more intense (including southern Europe and West Africa), but others where droughts have become less frequent, less intense, or shorter.

The trend in extreme hot temperatures is striking in the proportion of record-setting daily highs versus record daily lows in station data from the US National Weather Service (Figure 2). In an unchanging climate, the expectation is that, for any given date, one should see approximately equal numbers of record high temperatures and record low temperatures. For the US, that is exactly the pattern for 1950 to 1989, but the proportion of record-setting highs has been growing and the proportion of record lows has been shrinking since then. From 1990 to 2008, 63% of the daily records were high temperatures and only 37% were lows. In 2009, 55% of the records were record highs. The numbers were 69% record highs in 2010 and 73% record highs in 2011. For the first six months of 2012, 92% of the daily temperature records in the US were record highs. Through the first 23 days of July, there were 20 record high temperatures for every record low.

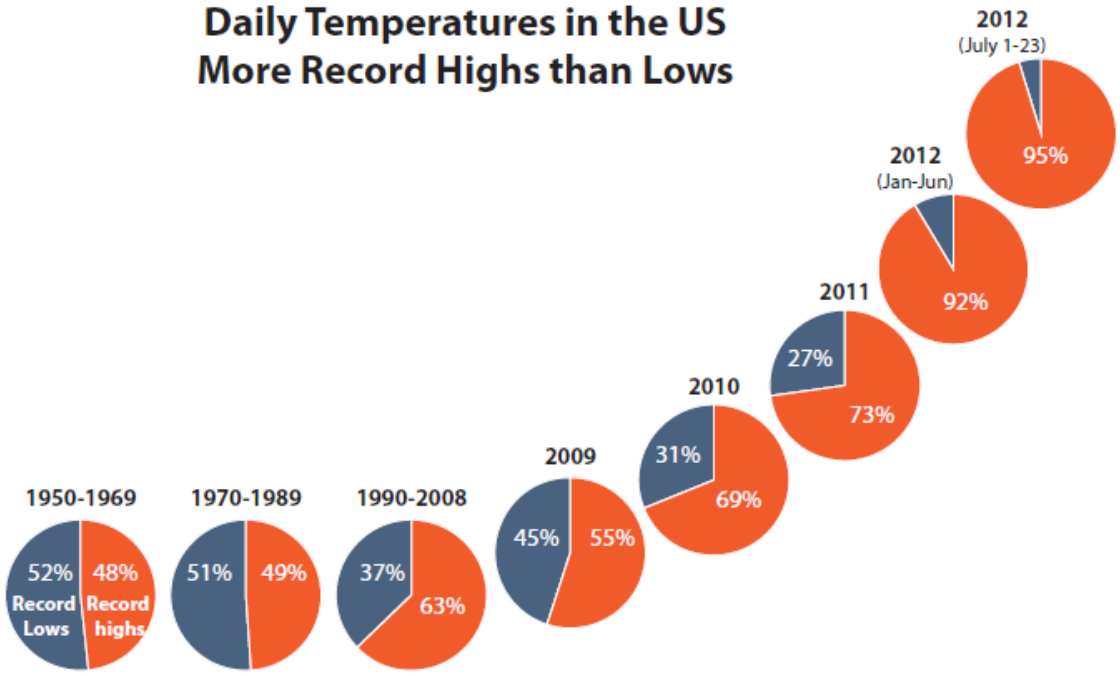

Figure 2: Changing pattern of daily temperature records in the US, based on US weather stations. If the climate is not changing, the number of record-setting high temperatures should be approximately the same as the number of record-setting low temperatures. References for the published study and the newer data are: (Meehl et al. 2009) (http://www.ncdc.noaa.gov/extremes/records/).

The US experienced 14 billion-dollar disasters in 2011, a record that far surpasses the previous maximum of 9 (NOAA 2012a). The 2011 disasters included a blizzard, tornadoes, floods, severe weather, a hurricane, a tropical storm, drought and heat wave, and wildfires. In 2012, we have already experienced horrifying wildfires, a powerful windstorm that hit Washington DC, heat waves in much of the country, and a massive drought currently affecting more of the US than any drought since 1988.

For several of these categories of disasters, the strength of any linkage to climate change, if there is one, is not known. Specifically, the IPCC (IPCC 2012) did not identify a trend or express confidence in projections concerning tornadoes and other small-area events. The evidence on hurricanes is mixed.

For other categories of climate and weather extremes, the pattern is increasingly clear. Climate change is shifting the risk of hitting an extreme. The IPCC (IPCC 2012) concludes that climate change increases the risk of heat waves (90% or greater probability), heavy precipitation (66% or greater probability), and droughts (medium confidence) for most land areas. These findings about risk do not speak directly to the role of climate change in any particular event. In this sense, the increase in risk of a weather extreme from climate change is parallel to the increasing risk of an accident from speeding in a car. The evidence pointing to the driving force behind the extra risk (either the climate change of the excess speed) can be strong, but it is still difficult to predict exactly when and where disaster might occur. And just as many factors influence the risk of a car accident, the risk of a weather-related disaster is strongly influenced by disaster preparations, early warning, and the integrity of local infrastructure like buildings, roads, and the electricity grid.

Understanding the role of climate change in the risk of extremes is one of the most active areas of climate science (Peterson et al. 2012). As a result of rapid progress over the last few years, it is now feasible to quantify the way that climate change alters the risk of certain events or series of events. For example, climate change at least doubled the risk of the European heat wave of 2003 (Stott et al. 2004), a high-impact extreme that led to tens of thousands of premature deaths, especially among the elderly or infirm (Robine et al. 2008). On the other hand, there is no evidence that climate change played a role in the serious flooding in Thailand in 2011 (Van Oldenborgh et al. 2012). The primary causal agent there was altered land management. For the 2011 Texas drought, La Niña (cold water in the eastern Pacific) played a role, but recent research by David Rupp and colleagues concludes that, in a La Niña period, extreme heat is now 20 times more likely than in the 1960s (Rupp et al. 2012).

Let me conclude with a comment about the way I see my responsibility as a scientist, particularly in the context of the 2011 Texas drought. Our nation is an agricultural superpower, and farming and ranching are among our highest callings. I hope Texans have the opportunity to maintain Texas as the nation's second largest source of agriculture income. For this hope to be realized, the farmers and ranchers of Texas need to have access to the best available information about the risks they face and their options for dealing with them. Climate change is altering those risks, and the people of Texas, indeed the people of the United States, need to know this to make good decisions about their future and their children's future.

In summary, there is no doubt that climate has changed and that changes will continue in the future, with human emissions of heat-trapping gases playing a major role. There is also no doubt that a changing climate changes the risk of extremes, including extremes that can lead to disaster. It is only by understanding those risks in the most clear-headed, objective way possible that we, as a nation, can

make good decisions about the challenges of protecting and enhancing our natural legacy, our economy, and our people.

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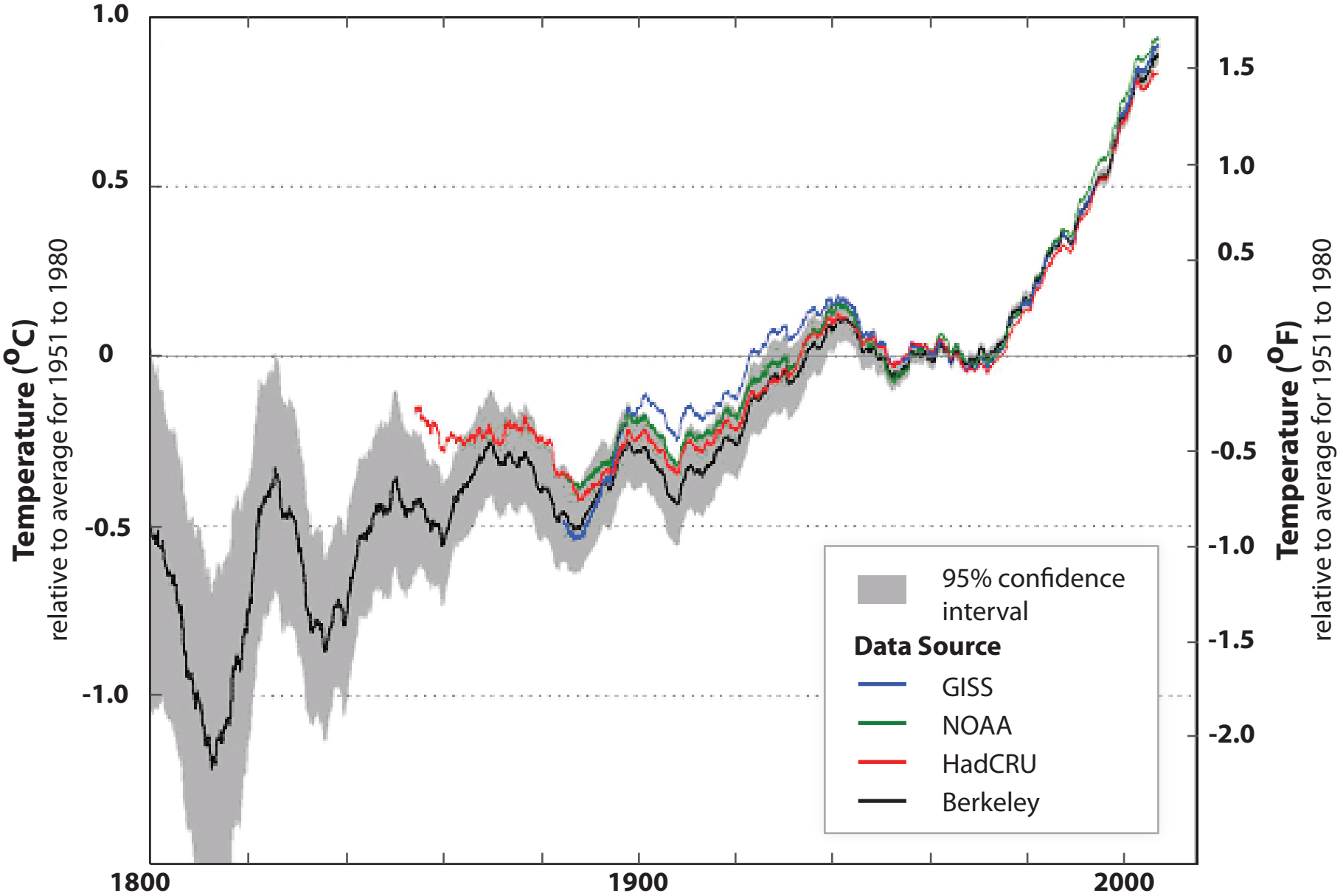
Global Land Temperature Since 1800

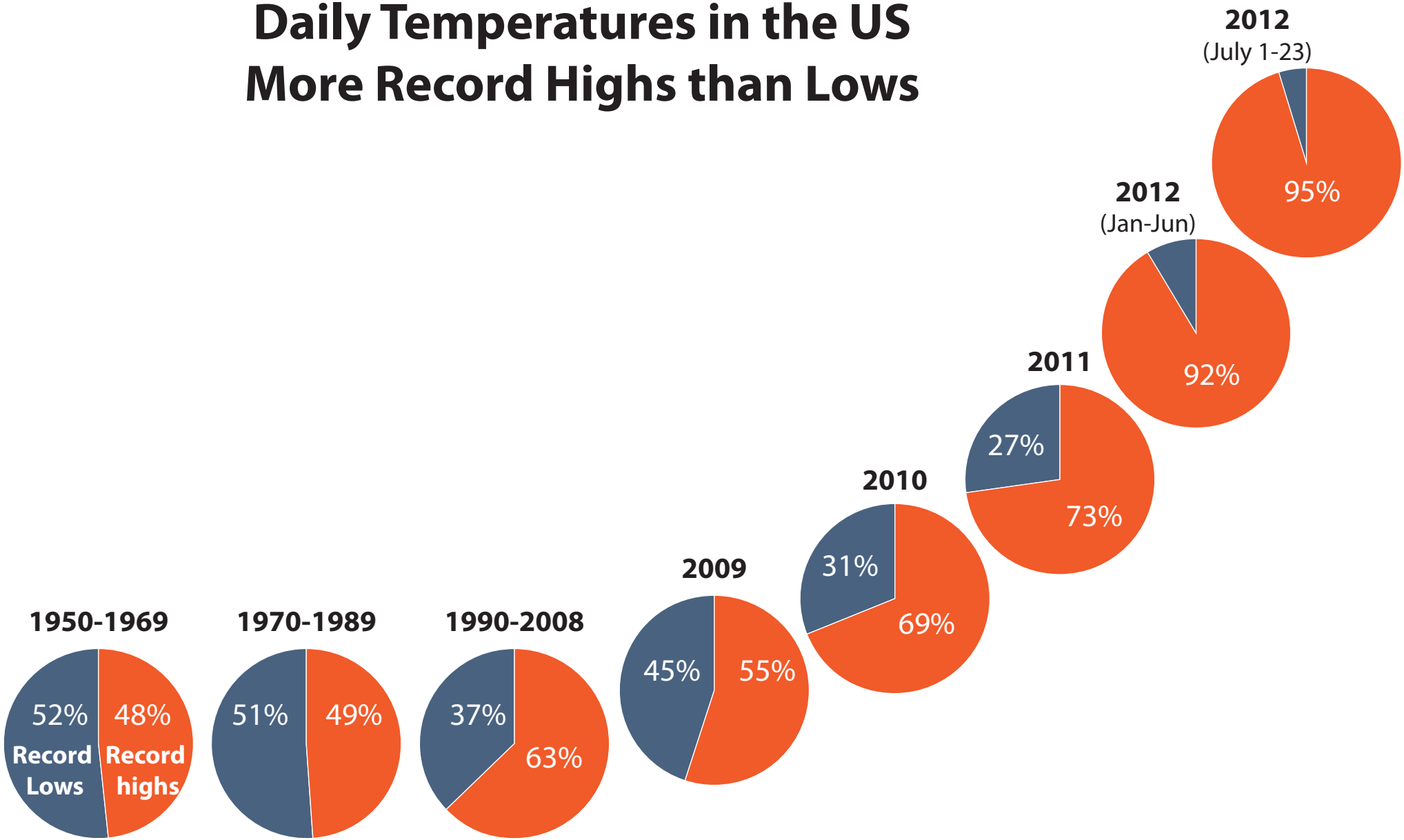
(10-year moving average)



- Warming in the climate system is unequivocal
- Four reconstructions reveal the same pattern

Summary based on figure posted at http://berkeleyearth.org/analysis/

Daily Temperatures in the US
More Record Highs than Lows



Source: Meehl et al. Geophys Res Let 2009 (for 1950-2008) and NOAA NCDC (for 2009-2012)