Statement of Dr. Michael Oppenheimer

at

Briefing before the Select Committee on Energy Independence and Global Warming
US House of Representatives

on

Extreme Weather in a Warming World

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I would like to thank Chairman Markey and the members of the committee for inviting me to participate in this briefing. My name is Michael Oppenheimer. I am an atmospheric scientist and the Albert G. Milbank Professor of Geosciences and International Affairs in the Department of Geosciences and Woodrow Wilson School of Public and International Affairs at Princeton University (details on my other affiliations may be found at http://www.princeton.edu/step/people/faculty/michael-oppenheimer/). I am a coordinating lead author of two upcoming reports of the Intergovernmental Panel on Climate Change (IPCC): a special report entitled *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*, as well as IPCC's Fifth Assessment Report. I welcome the opportunity to discuss today's topic, extreme weather in a warming world.

Earth's climate is warming due to the accumulation of human-made greenhouse gases in the atmosphere, primarily carbon dioxide emitted during fossil fuel combustion and deforestation. This climate change has altered the intensity, frequency, and geographic extent of some types of extreme events and is expected to do so increasingly in the future. From a global perspective, the findings in IPCC's Fourth Assessment Report are particularly germane to this topic.

The following table from this report[1] describes three aspects of weather extremes:

Table SPM.2. *Recent trends, assessment of human influence on the trend and projections for extreme weather events for which there is an observed late-20th century trend. {Tables 3.7, 3.8, 9.4; Sections 3.8, 5.5, 9.7, 11.2–11.9}*

Phenomenon[a] and direction of trend	Likelihood that trend occurred in late 20th century (typically post 1960)	Likelihood of a human contribution to observed trend[b]	Likelihood of future trends based on projections for 21st century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	*Very likely*[c]	*Likely*[d]	*Virtually certain*[d]
Warmer and more frequent hot days and nights over most land areas	*Very likely*[e]	*Likely (nights)*[d]	*Virtually certain*[d]
Warm spells/heat waves. Frequency increases over most land areas	*Likely*	*More likely than not*[f]	*Very likely*
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	*Likely*	*More likely than not*[f]	*Very likely*
Area affected by droughts increases	*Likely* in many regions since 1970s	*More likely than not*	*Likely*
Intense tropical cyclone activity increases	*Likely* in some regions since 1970	*More likely than not*[f]	*Likely*
Increased incidence of extreme high sea level (excludes tsunamis)[g]	*Likely*	*More likely than not*[f,h]	*Likely*[i]

Table notes:
- [a] See Table 3.7 for further details regarding definitions.
- [b] See Table TS.4, Box TS.5 and Table 9.4.
- [c] Decreased frequency of cold days and nights (coldest 10%).
- [d] Warming of the most extreme days and nights each year.
- [e] Increased frequency of hot days and nights (hottest 10%).
- [f] Magnitude of anthropogenic contributions not assessed. Attribution for these phenomena based on expert judgement rather than formal attribution studies.
- [g] Extreme high sea level depends on average sea level and on regional weather systems. It is defined here as the highest 1% of hourly values of observed sea level at a station for a given reference period.
- [h] Changes in observed extreme high sea level closely follow the changes in average sea level. {5.5} It is *very likely* that anthropogenic activity contributed to a rise in average sea level. {9.5}
- [i] In all scenarios, the projected global average sea level at 2100 is higher than in the reference period. {10.6} The effect of changes in regional weather systems on sea level extremes has not been assessed.

[1] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, Table SPM-2.

It indicates, for seven important categories of extremes, 1) the likelihood that a trend occurred during the 20th century in the characteristics of extreme behavior, 2) the likelihood that human activity contributed to the trend, and 3) the likelihood that further trends in these extremes would occur over the course of this century, assuming that greenhouse gas concentrations in the atmosphere continue to increase. I also note that research in the 3 years since the report was completed has generally strengthened these findings or left them unchanged, with the caveat that past changes in tropical cyclone activity are an area of controversy[2].

Extreme weather events have been prominent in the news in the past several months, including heat waves in the eastern US, extreme floods in the US southeast and in Pakistan, and intense heat and wildfires in Russia. An obvious question is what relation such events bear to the likelihood judgments in the table. I would like to emphasize the following points, based on these IPCC findings:

1) As has been stated many times, no individual heat wave, storm, or other short-term weather phenomenon can be uniquely tied in a cause-and-effect way to the buildup of the greenhouse gases.

2) Nevertheless, increased heat trapping due to the buildup of the greenhouse gases, and the resulting increase in evaporation from the surface have more likely than not contributed to the observed trend toward an increase in the frequency of heat waves and heavy precipitation events. In other words, there is better than an even chance that emissions of these gases are loading the dice more and more in favor of such events occurring.

3) Regardless of the causes of such individual events, they provide a useful analog for the sort of climate we face in the future. In particular, heat waves and heavy precipitation events are very likely to further increase in frequency, and intense tropical cyclone activity (e.g., intense hurricanes) is likely to increase in frequency under current expectations for future emissions. In my view, the higher are emissions, the more likely are occurrences of these extremes. As for particular weather patterns and regions, recent trends in monsoon intensity are variable from region to region, but IPCC does project a future increase in intensity of the Asian monsoon.

[2] Knutson et al, Tropical Cyclones and Climate Change, Nature Geoscience, 21 February 2010 DOI 10.1038/NGEO779

4) So-called "joint attribution"[3,4], the assignment of cause for the damaging outcomes of such extremes, such as wildfires or human mortality occurring during hot and dry spells, is a relatively new field, and it remains difficult to associate recent increases in most such impacts directly with greenhouse gas emissions, but indirect evidence is strongly suggestive of such a link in many cases. Absent a vast improvement in adaptation strategies aimed at addressing the risks entailed in the increasing frequency of climate extremes, impacts like wildfires, human mortality from extreme heat, reductions in crop yields at the low-to-mid latitudes, and major flooding events should be expected to increase, in the US and worldwide.

5) Such increases in extremes may well interact with each other, further exacerbating their consequences. For example, sea level is projected to rise by an amount ranging from about 8 inches to more than three feet (based on post-Fourth Assessment literature[5]). At the same time, intense hurricane activity is expected to increase. The combination of stronger storms pushing a higher sea would likely create unprecedented flooding, much more so than either the storms or higher sea level alone.

6) The findings above cannot be generalized to all extreme events. There is as yet insufficient evidence with regard to current or future trends for some extreme weather, e.g., tornados.

[3] Rosenzweig, C., G. Casassa, D.J. Karoly, A. Imeson, C. Liu, A. Menzel, S. Rawlins, T.L. Root, B. Seguin, P. Tryjanowski, 2007: Assessment of observed changes and responses in natural and managed systems. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, p.83.

[4] Donner et al, Model-based assessment of the role of human-induced climate change in the 2005 Caribbean coral bleaching event, Proc. Nat. Acad. Sci., www.pnas.org_cgi_doi_10.1073_pnas.0610122104 PNAS Early Edition

[5] Milne et al, Identifying the causes of sea level change, Nature Geoscience, www.nature.com/doifinder/10.1038/ngeo544 |

Finally, while extreme events are generally a physical phenomenon, circumstances where such events translate into disasters, like Hurricane Katrina or the great European heat wave of 2003, depend in large measure on individual and societal anticipation, planning, and response capacity and implementation. In other words, disaster is partly a social phenomenon. In both of these episodes, the toll was much higher than was imagined possible before the events. Unfortunately, if history is a guide, such situations may become ever more common. Even as we learn to cope better with certain extreme events, the climate may change faster than we learn about it, and faster than our ability to implement what we have learned. The only remedy for such a situation is to act to slow the climate change by slowing greenhouse gas emissions.