STATEMENT TO THE ENVIRONMENT AND PUBLIC WORKS COMMITTEE OF THE UNITED STATES SENATE

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1. Introduction

I would like to thank the Chairman and the Committee for the opportunity to provide my perspective on the subject of global warming and climate change.

I have been performing U.S. government-sponsored research for the last twenty-eight years, publishing peer reviewed papers on global temperature monitoring with satellites, on the amount of warming we might expect from greenhouse gas emissions, how to monitor hurricane strength from satellites, and quantitatively explaining ocean heat content changes.

Prior to my current position as a principal research scientist at the University of Alabama in Huntsville, I was Senior Scientist for Climate Studies at NASA's Marshall Space Flight Center. I am also the U.S. Science Team Leader for the Advanced Microwave Scanning Radiometer-E flying on NASA's Earth-observation satellite Aqua. I am a recipient of NASA's Medal for Exceptional Scientific Achievement.

In related endeavors I have authored a book on basic economics (*Fundanomics: The Free Market, Simplified*) now used in a college-level economics course; and have co-authored an Energy Law Journal article on the use of climate models under the *Daubert* standard for rules of evidence.

2. The State of Climate Science

My overall view of the influence of humans on climate is that we probably are having some influence, but it is impossible to know with any level of certainty how much influence. The difficulty in determining the human influence on climate arises from several sources: (1) weather and climate vary naturally, and by amounts that are not

currently being exceeded; (2) global warming theory is just that – based upon theory; and (3) there is no unique fingerprint of human caused global warming.

My belief that some portion of recent warming is due to humans is based upon my faith in at least some portion of the theory: that the human contribution to atmospheric greenhouse gas concentrations has resulted in an estimated 1% reduction in the Earth's ability to cool to outer space, and so some level of warming can be expected to occur from that change.

Exactly how much warming will occur, however, depends upon something we call "climate sensitivity" (Spencer & Braswell, 2010; 2011), and relatively few researchers in the world – probably not much more than a dozen – have researched how sensitive today's climate system is based upon actual measurements. This is why popular surveys of climate scientists and their beliefs regarding global warming have little meaning: very few of them have actually worked on the details involved in determining exactly how much warming might result from anthropogenic greenhouse gas emissions.

Our most recent peer-reviewed paper on this subject, Spencer & Braswell (2013), has arrived at a climate sensitivity of only 1.3 deg. C for a doubling of atmospheric carbon dioxide, based upon a variety of global measurements, including warming of the global oceans to 2,000 m depth since the 1950s. This level of warming is below the lower limit of 1.5 deg. C minimum predicted in the last (AR4) IPCC report. It is also in line with (an admitted minority of) other estimates of low climate sensitivity published in the peer review literature.

It should also be noted that the fact that I believe at least some of recent warming is human-caused places me in the 97% of researchers recently claimed to support the global warming consensus (actually, it's 97% of the published papers, Cook et al., 2013). The 97% statement is therefore rather innocuous, since it probably includes all of the global warming "skeptics" I know of who are actively working in the field. Skeptics generally are skeptical of the view that recent warming is all human-caused, and/or that it is of a sufficient magnitude to warrant immediate action given the cost of energy policies to the poor. They do not claim humans have no impact on climate whatsoever.

3. Temperature Changes in the Atmosphere and Ocean

While today's hearing is entitled "*Climate Change: It's Happening Now*", it could have been entitled, "*Climate Change: It's Happened Before*". The last 2,000 years of proxy reconstructed temperature variations for the Northern Hemisphere (Fig. 1) shows that the Modern Warm Period (today) is not significantly different from the Medieval Warm Period of ~1,000 years ago, or the Roman Warm Period of ~2,000 years ago (Ljungqvist, 2010):

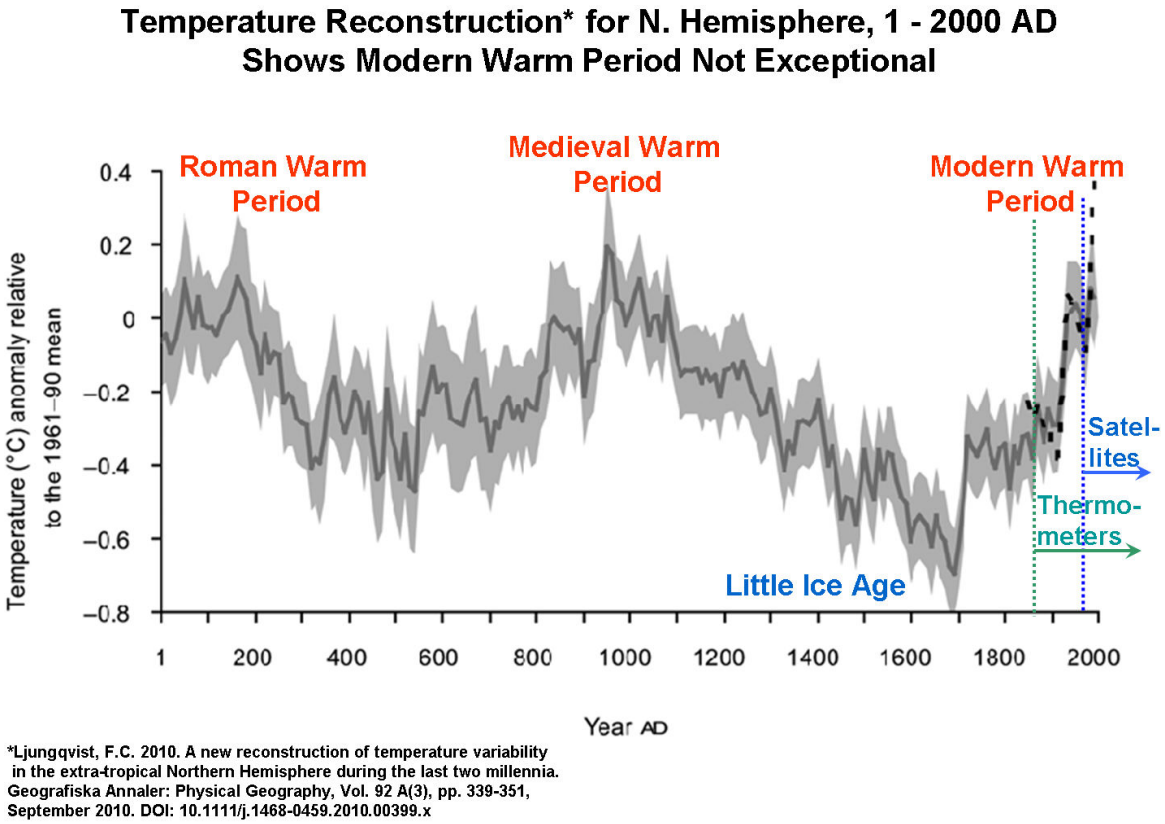

Fig. 1. Estimations of extra-tropical Northern Hemisphere (90–30°N) decadal mean temperature variations (dark grey line) AD 1–1999 relative to the 1961–1990 mean instrumental temperature from the variance adjusted CRUTEM3+HadSST2 90–30°N record (black dotted line showing decadal mean values AD 1850–1999) with 2 standard deviation error bars (light grey shading). The data are available at ftp://ftp.ncdc.noaa.gov/pub/data/paleo/contributions_by_author/ljungqvist2010/ljungqvist2010.txt.

Note in Fig. 1 that our modern observational record started during a multi-century warming trend, most of which cannot be blamed on human greenhouse gas emissions, which did not become significant until the mid-1900s. It should also be noted that, in this age of "consensus science", there are many published papers documenting the reality of the Roman Warm Period and the Medieval Warm Period. *How can we know with any level of confidence that the Modern Warm Period is caused by humans, when similar (naturally produced) warm periods also occurred during recorded history?*

While 2012 was a "record" warm year in the U.S. (again, relative to the short 150 year instrumental record), this was not true of the global average, which has not experienced statistically significant warming since about 1998. This is not surprising since the contiguous U.S. covers only about 2% of the Earth, and persistent regional weather patterns – warm or cold – are responsible for most record weather events.

The only truly global temperature measurements, unaffected by artifacts such as urban heat island effects, are for the bulk atmosphere from Earth-orbiting satellites, the methodology for which John Christy and I developed almost 25 years ago; all other measurements are at points and so are geographically incomplete. Our monitoring of the lower troposphere since the satellite record began in 1979 is shown in Fig. 2,

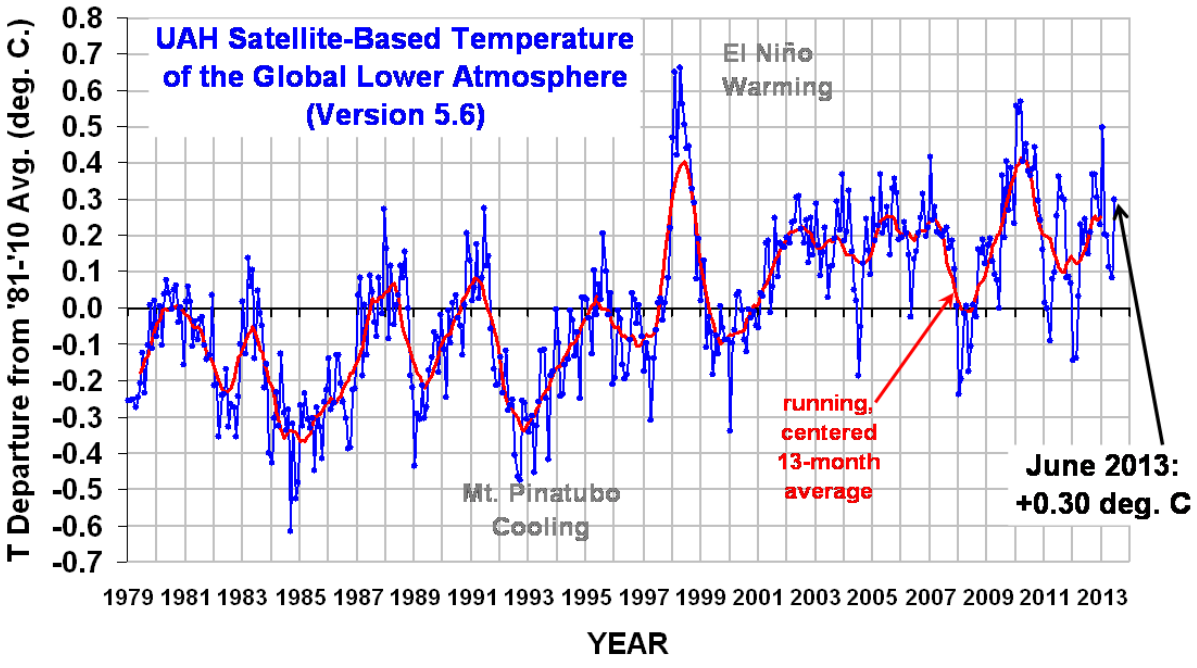

Fig. 2. UAH global lower tropospheric (LT) temperature variations between January 1979 and June 2013.

The satellite measurements reveal several significant features which are pertinent to our concern over human-induced climate change (all of the following points are also supported by the alternative version of the satellite-based temperatures from Remote Sensing Systems [RSS]):

1) The magnitude of global-average atmospheric warming between 1979 and 2012 is only about 50% that predicted by the climate models relied upon by the IPCC in their projections of global warming.
2) The level of warming in the most recent 15 year period is not significantly different from zero, despite this being the period of greatest greenhouse gas concentration. This is in stark contrast to claims that warming is "accelerating".
3) The level of observed tropical atmospheric warming since 1979 is dramatically different from that predicted by climate models; it is below all 73 models we have analyzed the output from (see Fig. 3).

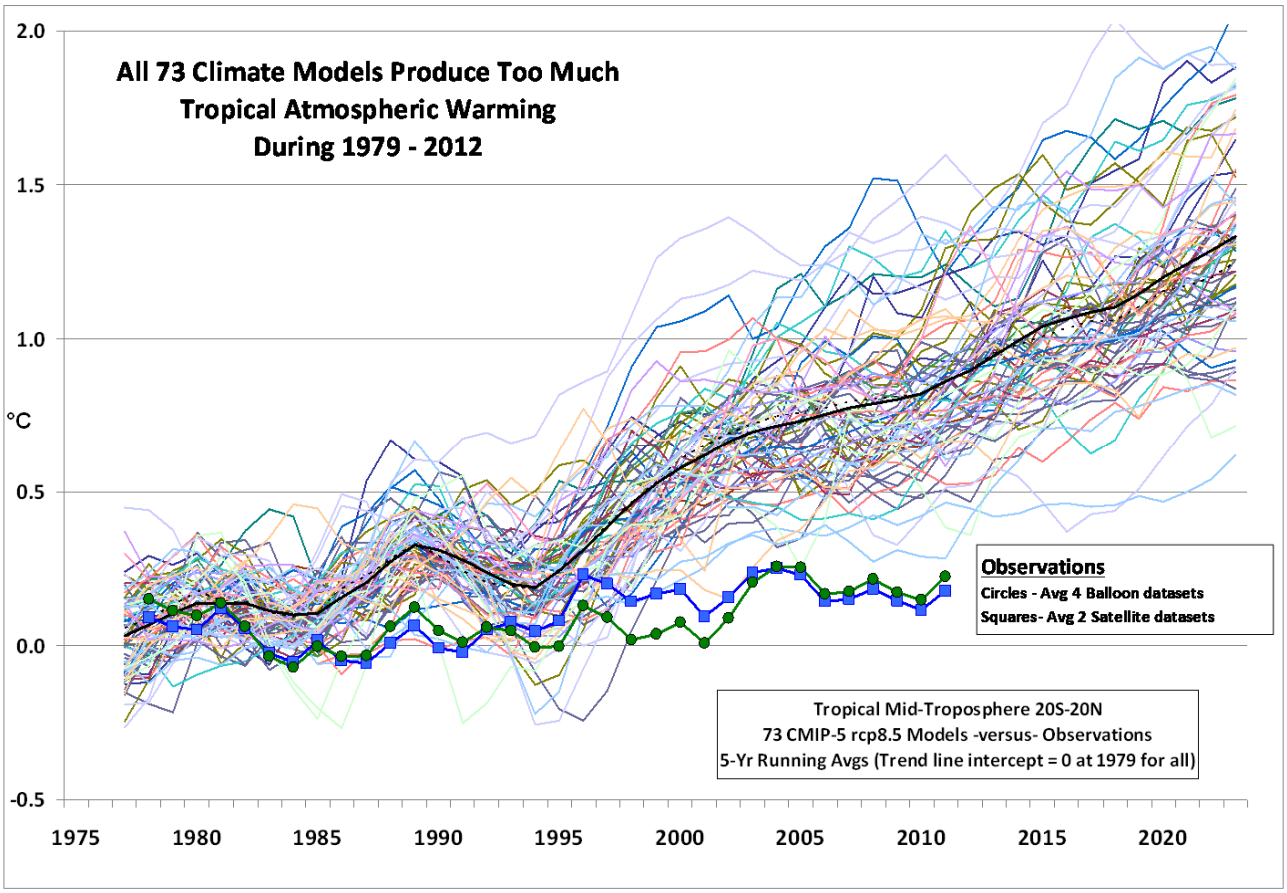

Fig.3. Mid-tropospheric (MT) temperature variations for the tropics (20°N to 20°S) in 73 current (CMIP5) climate models versus measurements from two satellite datasets and four weather balloon datasets.

On this last point, the level of disagreement between models and observations in Fig. 3 is quite striking. While one might argue that it is for a relatively restricted latitude band (20°N to 20°S), this is where almost 50% of the solar energy absorbed by the Earth enters the climate system. The discrepancy between models and observations is related to the lack of a middle- and upper-tropospheric "hotspot" in the observations, which the models produce in response to surface warming combined with positive water vapor feedback. The observations might be telling us that the global warming response to increasing CO2 (and any natural warming influence) is not being amplified by water vapor

increases, which have their greatest temperature impact in the middle and upper troposphere (Spencer & Braswell, 1997).

The lack of statistically significant warming in the last 15 years (shown in Fig. 2 above, even more striking in the RSS dataset) is sometimes glossed over with the claim that the global temperature record has a number of examples of no warming (or even cooling) over fifteen year periods. But this claim is disingenuous, because *the IPCC-presumed radiative forcing of the climate system from increasing CO2 has been at its supposed maximum value only in the last 15 years*. In other words, when the climate "stove" has been turned up the most (the last 15 years) is also when you least expect a lack of warming.

It is time for scientists to entertain the possibility that there is something wrong with the assumptions built into their climate models. *The fact that all of the models have been peer reviewed does not mean that any of them have been deemed to have any skill for predicting future temperatures.* In the parlance of the *Daubert* standard for rules of scientific evidence, the models have not been successfully *field tested* for predicting climate change, and so far their *error rate* should preclude their use for predicting future climate change (Harlow & Spencer, 2011).

The claim has been made that the extra energy from global warming has mostly bypassed the atmosphere and has been sequestered in the deep ocean, and there is some observational evidence supporting this view (e.g. Levitus *et al.*, 2012). But when we examine the actual, rather weak level of warming (measured in hundredths of a degree C) at depths of many hundreds of meters, it implies relatively low climate sensitivity (Spencer & Braswell, 2013). Part of the evidence for this result is satellite radiative budget measurements which suggest that more intense El Nino activity since the 1980s caused an apparent decrease in cloudiness, which allowed more sunlight into the climate system, which caused a natural component to recent global warming. Since the global energy imbalance leading to ocean warming since the 1950s is only about 1 part in 1,000 compared to the average rates of solar heating and infrared cooling of the Earth (Levitus *et al.*, 2012), it should not be surprising that natural climate cycles can cause such small changes in ocean temperature. Even if our ocean temperature measurements of deep warming of hundredths of a degree over the last 50 years are correct, and mostly due to

human greenhouse gas emissions, they probably do not support the IPCC's pessimistic view of future warming.

4. Has Severe Weather Increased?

The most indefensible claim regarding climate change from an observational point of view is that severe weather has increased. Meteorologists like me have long known that public perception of weather is skewed by short memories and increasing media sensationalizing of weather disasters.

During globally cool conditions in 1970 a tropical cyclone (hurricane) killed 500,000 people in Bangladesh. Records of such storms killing hundreds of thousands of people extend back to 1582. In contrast, as of this writing, it has been a record 7+ years since a major (Cat 3 or stronger) hurricane has hit the U.S. mainland. New research from northwest Florida, based upon coastal sediments, suggest that the past 600 years has been a period of weaker hurricane activity compared to the 1,000 years before that (Brandon *et al.*, 2013). All of these facts indicate the huge amount of natural variability in tropical cyclones which exists and confounds attempts to determine whether tiny global energy imbalances caused by humans have any noticeable effect.

A Hurricane Sandy class of storm is not that unusual, but it hitting a densely populated area is. Sandy's transition to a strong extratropical cyclone is what happens to virtually all poleward-moving hurricanes. The fact that it happened to merge with a separate developing extratropical cyclone during landfall is somewhat less common, but such events arguably happen every year somewhere in the world – just not where millions of people live.

There is little or no observational evidence that severe weather of any type has worsened over the last 30, 50, or 100 years, irrespective of whether any such changes could be blamed on human activities, anyway. Long-term measurements of droughts, floods, strong tornadoes, hurricanes, severe thunderstorms etc. all show no obvious trends, but do show large variability from one decade to the next, or even one year to the next. While the 2003 heat wave in France and the 2010 heat wave in Russia were exceptional, so were the heat waves of the 1930s in the U.S., which cannot be blamed on our greenhouse gas emissions.

While it is true that storm damage of manmade structures increases over time, this is due to socioeconomic reasons: there are simply more manmade targets for severe storms to hit.

5. Conclusions

The belief that global warming and associated climate change involve more severe weather cannot be supported observationally. And even if we were to observe a trend in severe weather, it would not be possible to determine with any level of confidence the extent to which the change was due to human activities versus natural variability.

While recent global warmth might well be the greatest in the last 150 years we have had thermometer records (WMO, 2013), proxy measurements (and even borehole temperatures from the Greenland ice sheet) suggest that global warmth could have been greater 1,000 years ago during the Medieval Warm Period, and 2,000 years ago during the Roman Warm Period (Loehle and McCulloch, 2008; Ljungqvist, 2010). Regarding severe weather, that same WMO report admits, "*the data do not demonstrate that the increase in observed losses is caused by an increase in the frequency and intensity of extreme events. Other factors come into play, notably the increased exposure of people and property to climate extremes and the improved and increased reporting of disasters*."

Thus, the evidence that humans are mostly responsible for either recent warmth or severe weather changes (if such changes exist at all) is equivocal, at best.

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