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Summary

The foundation of a climate science program must be a commitment to continuous and accurate observations. We must know WHAT the climate is doing before we can understand WHY it does what it does. However, we now face the loss of satellite and other observations critical to understanding the climate. The NRC Decadal Survey goals for satellite systems should be pursued vigorously as well as support for other systems.

The climate science program now has a large climate-modeling component. However, based on limited studies, too much confidence in my view is placed in model projections. These projections cannot reliably predict the climate on regional scales where we live and grow our food. The potential of billion-dollar economic impacts of proposals designed to mitigate "global warming" are based on these models and some common misunder-standings. Thus it is imperative that a "Red Team" approach be taken with climate model evaluation. Such teams, independent from those with vested interests in the modeling industry, would evaluate models with a hard-nosed methodology to inform Policymakers about model confidence from a different and scientifically defensible point of view.

The human race will adapt to whatever trajectory the climate system selects. Having a firm understanding of past variability allows society to adapt more intelligently to variations almost certain to occur in the future. Such is a benefit of a robust observing system. In 1988 I pinned a General Rule of Climate, "If it happened before, it will happen again, and probably worse." The point is that if we prepare for what has already been observed (e.g. hurricanes, droughts, floods, heat waves, blizzards) and then some, we will be much better prepared for whatever the climate does.

There is no guarantee that energy policies intended to deal with climate change will have the desired effect, either in sign or magnitude. However, policies which address the reduction of emissions as well as other important issues, one being the emphatically desirable goal of affordable energy, are worth pursuing.

Making energy more expensive by direct taxes or cap-and-trade schemes (around which business may cleverly skirt) is troublesome. First, these are regressive taxes since the poor disproportionately spend more on energy. Secondly, as a manufacturer, who employs hundreds in my state, told me last week, "If my energy costs go up according to these proposals, I'm closing down and moving offshore." Irony and tragedy are here. The irony is that higher energy costs will lead to an increase in greenhouse emissions as offshore plants have less stringent rules. The tragedy is that this will lead to further economic suffering in a part of my state where no more suffering is needed.

Observations are Foundational

A climate science program must be built on a foundation of continuous and accurate observations. In other words, it is prerequisite that we know WHAT the climate system is doing before we can understand WHY it does what it does. We know, for example, because of continuous and accurate satellite monitoring since 1979, that in 2007 the Arctic sea ice area retreated to a record minimum, and curiously, that the Antarctic sea ice area expanded to a record maximum. Even as I write this, the global sea ice extent is only about 4% lower than the long-term average:

http://arctic.atmos.uiuc.edu/cryosphere/IMAGES/global.daily.ice.area.withtrend.jpg

But why these disparate results between north and south? Blaming increasing greenhouse gases is too quick and easy an answer in my view.

While "global warming" due to extra greenhouse gases seems to be consistent with Arctic melting it is at odds with Antarctic sea ice expansion. A more reasonable explanation for at least part of the Arctic ice reduction is offered by a NASA team (Nghiem, et al. 2007) suggesting that an anomalous circulation pattern of the atmosphere over the Arctic in 2007 pushed a large part of the sea ice to lower latitudes where it melted. Higher polar temperatures, near those of the late 1930's, likely also had a role as did the thinner ice. However, more research, and more observations are necessary to understand why such events occur. The complexity of this climate system can not be overstated.

In another example, I was a co-author on a publication led by my UAHuntsville colleague Dr. Roy Spencer in which he used some terrific satellite data to discover that the greenhouse effect of clouds evidently behaves in a way that naturally mitigates warming rather than reinforcing it. We found that as the tropical atmosphere warms through heating related to rainfall, that the types of clouds that trap heat in the atmosphere shrink in coverage, allowing more heat to escape to space and cooling to ensue. This is an apparently strong negative feedback in the climate and has powerful implications because it indicates the climate might react differently to increasing greenhouse gases than current theory predicts.

Climate observations from space are indispensable for a climate program and their continuation is mandatory so that we may know WHAT the climate is doing and thus WHY. I support the recommendations of the National Research Council Decadal Survey report which insists that we add sensors and spacecraft soon to keep current measurements from disappearing. What we miss now, will be missed forever.

Ground-based observations are also critical. With the support of Congressman Cramer and Senator Shelby, Alabama has a nearly completed statewide system of the highest quality, federally-owned and operated climate stations. This type of system is needed world-wide where poor and lost measurements prevent us from having a full picture of what the climate is now doing. This is especially important because of new research in the factors that influence the historical record of surface temperatures.

Mounting observational evidence and theoretical studies are shedding light on the utility of the heretofore iconic representation of the Earth's climate change over the past 150 years - the global average surface temperature. This metric has been promoted as the key proxy to represent the impact of enhanced greenhouse gases. However, I and others have published articles which suggest that this mean surface temperature quantity is a poor metric for this task. The basic problem is that the mean surface temperature is the average of the nighttime low and the daytime high. The inclusion of the nighttime low, our research suggests, is where the problem lies.

Many studies have shown that the nighttime low has warmed more rapidly than the daytime high in most regions. The cause of this nighttime warming however is more consistent with the effects of human development of the surface and consequent influence on the near surface air (e.g. urbanization, farming, aerosol pollution) rather than greenhouse warming. The reasoning is as follows.

The nighttime temperature over land occurs generally in a shallow, cold "boundary layer", disconnected from the deep and warmer atmosphere aloft. As it so happens, the deep atmosphere does not experience large temperature changes from day to night, yet the deep atmosphere is where the impacts of greenhouse gases are thought to be most pronounced over time. The nighttime boundary layer forms in a delicate balance of physical processes (radiation, heat and moisture fluxes, turbulence, etc.) that can be disrupted by minor changes in the surface characteristics such as urbanization, farming or radiative forcing such as from clouds, aerosols or greenhouse gases (Pielke Sr. et al. 2007, Christy et al. 2006, Walters et al. 2007).

If the formation of the boundary layer is disrupted, the warmer air from above is mixed downward at night, leading to an appearance over time of an increasing temperature trend. However, this trend is not due to a warmer deep atmosphere, but to a mixing of that already-warmer air down to the surface more often than before. Global climate models, due to their coarse resolution, do not in general capture these nighttime boundary layer processes (Walters et al. 2007). Thus, while surface temperatures may show warming, these studies suggest it is not due to a global accumulation of heat (as depicted in climate models) but only to a very local redistribution of heat near the surface.

The basic point here is that it appears that a significant portion of the rising surface temperatures over land, as depicted in the mean surface temperature - most of which is due to nighttime increases - are not related to enhanced greenhouse gases but to development of the surface around locations where thermometers reside. This is another example of the type of research that requires further analysis with more detailed observations and theory, and which has the potential to alter views of the causes of some of the temperature changes now assumed to be linked to greenhouse gas increases.

Thus, from satellites above to the deepest ocean measurements and all parts in between, observations of the Earth System must have priority as the foundation of any climate science program.

Climate Model Issues

The topic of human-caused climate change is ubiquitous in the media today. As a result, people are often made to be frightened about the future and their anxiety leads to many state and federal proposals to "do something" about climate change. It is essential to point out that these scenarios are based on the projections of climate models and are often announced from media personalities whose goals are viewer ratings. However, the utility of climate models as predictive tools is highly questionable in my view. The current climate science program has a large climate modeling component, but how effective is it?

When the National Assessment chose two of the best models to describe the coming climate for the Southeastern U.S., one projected a jungle-like environment, the other a semi-arid savannah. And, none - not one - of the many models we examined were able to reproduce the actual climate of the last century in which we experienced declining temperatures and increasing rainfall in the Southeast.

Climate models will not provide reliable projections of regional climate – yet that's the scale of climate where we actually live, work and grow our food. Further, the relatively tiny impacts on global emissions of these proposals are so small relative to the large variations of local climate, that there will not be a confident, predicable outcome of legislation, nor a means to confidently detect its efficacy. No one can say for a specific region whether a policy option would increase or decrease rainfall, or whether there was even any impact at all. The climate cannot be predictably-managed.

Though regional predictions of models vary widely, the least problematic projection of models may be a single number, the global average surface temperature (problems with which were addressed earlier). Model calculations indicate that global average temperature is quite stubborn. For example, 1000 new nuclear power plants operating by 2020 would have a tiny impact of about 0.15 °C by 2100 according to the best estimate of the IPCC AR4 using the "Business and Usual" emission scenario named A1B. This is roughly equivalent to halving the U.S. carbon dioxide emissions. Thus, even on the global average scale (which has little to do with local climate variations) one must be quite circumspect as to what is possible even with dramatic changes in energy infrastructure.

Red Team Evaluations of Climate Projections

Dr. Roger Pielke, Jr. observed in commenting on Roe and Barker (2007), who themselves discussed the intrinsic uncertainties of climate modeling, "… the uncomfortable reality – for climate modelers – [is] that finite research dollars invested in ever more sophisticated climate models offer very little marginal benefit to decision makers." (*New Scientist*, 25 Oct 2007) Where could resources be invested with regard to climate model understanding if further investment in the activity itself will likely lead to little further knowledge?

In addition to continuous and accurate observations, I believe there is gap in the model evaluation program and thus this represents a productive area of research. The climate model industry should be subject to a "Red Team" analysis in which the teams take a critical look at model efficacy. If the simulations of these models are being used to drive billion dollar strategies to inhibit emissions and whose costs can have tremendous negative consequences for our economic health and welfare, they should be evaluated by the most hard-nosed program possible. Such an inexpensive program would provide policymakers with an independent point of view about the level of confidence that may be ascribed to models. This is the way science works and thus such a Red Team program would be scientifically defensible. Additionally, this evaluation would very likely lead to improvements in model formulations. If the modeling industry objects to this approach, one should ask why.

Adaptation Will Occur

Whatever trajectory the climate takes, we will of course adapt. As State Climatologist, I'm heavily involved in defining and assessing climate-related impacts to our state and the resulting viability of our economy. Parts of my state are coping with the lowest rainfall in 100 years. Sketchy records show a similar drought back in 1839-40. In general terms, changes in water supply are more important than changes in temperature, so dealing with rainfall variations is crucial for any society.

When Alabama was also dry in 1988 I pinned my General Rule of Climate: "If it happened before, it will happen again and probably worse." The point here is that by carefully examining what we know has happened in our past, add a little insurance, we will know how to reduce the negative consequences of events certain to occur in the future.

In the case of our present drought, our farmers suffered severe losses, but Senator Sessions has included in the Farm Bill a provision to offer farmers federal help in building environmentally sustainable impoundments to store our abundant winter water for use in the summer and thereby alleviate the terrible consequences. This is a perfect example of how climate observations serve as a foundation to inform us of the important variations that occur and what we can do to adapt.

The situation is more precarious in the West where the current 6-year drought pales in comparison to droughts of the past which lasted 50 years.

Make no mistake, the concentrations of some atmospheric greenhouse gases, especially carbon dioxide, are increasing. These added gases will affect the radiation budget of the atmosphere in a way that allows the earth's atmosphere and ocean to retain more heat energy. Increasing carbon dioxide, which is the basic building block of life, has other effects too, such as the invigoration of the biosphere which is manifested among other things in increased food production. But, as noted above, determining the climate impact of the total amount of the extra energy retained in the climate system due to additional greenhouse gases involves no simple or fully-understood calculation.

Energy Policy

In closing, I want to draw attention to my Op-Ed contribution to *The Wall Street Journal* (attached) which suggests that various social and environmental policy options vying for our limited resources should be understood and prioritized for effectiveness. Regarding energy policy, it is simply a fundamental fact that energy has brought uncountable benefits to human life. Thus, the demand for energy will grow given (a) the deep human desire for its benefits and (b) the enormous pent-up demand for these benefits in the developing world.

In my view, government's role is to support, as it currently does, the discovery of new sources of energy which address simultaneously several economic and geopolitical issues (e.g. energy security, balance of trade, economic resilience, air pollution (CO2 is not a pollutant)) besides the marginal and uncertain consequences of a desire to "do something" about climate change.

Making energy more expensive, whether by direct taxes (most effective in reducing energy use) or cap-and-trade schemes (around which business may cleverly skirt) is troublesome in my view. First, these represent regressive taxes as the poorest in our nation proportionally spend more on energy than the rest of us. And secondly, as a manufacturer, who employs hundreds in an economically-challenged part of my state, told me last week, "If my energy costs go up according to these proposals, I'm closing down and moving offshore." There is irony and tragedy in this path. The irony is that artificial increases in energy costs here will likely lead to an increase in greenhouse gas emissions because (a) offshore plants have less stringent requirements all around and (b) the product we need will then require transportation (and even more emissions). The tragedy is that this will lead to further economic suffering in a part of my state where no more is needed.

Please note, there is no guarantee at all that specific energy policies designed to deal with climate change will actually have the intended effect either in magnitude or sign. Will they produce more or less rain? … no one knows. However, energy policies which address other important issues mentioned above and which include the emphatically desirable goal of affordable energy, and also reduce emissions, are worth pursuing.

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My Nobel Moment

By JOHN R. CHRISTY
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I've had a lot of fun recently with my tiny (and unofficial) slice of the 2007 Nobel Peace Prize awarded to the Intergovernmental Panel on Climate Change (IPCC). But, though I was one of thousands of IPCC participants, I don't think I will add "0.0001 Nobel Laureate" to my resume.

The other half of the prize was awarded to former Vice President Al Gore, whose carbon footprint would stomp my neighborhood flat. But that's another story.

Both halves of the award honor promoting the message that Earth's temperature is rising due to human-based emissions of greenhouse gases. The Nobel committee praises Mr. Gore and the IPCC for alerting us to a potential catastrophe and for spurring us to a carbonless economy.

I'm sure the majority (but not all) of my IPCC colleagues cringe when I say this, but I see neither the developing catastrophe nor the smoking gun proving that human activity is to blame for most of the warming we see. Rather, I see a reliance on climate models (useful but never "proof") and the coincidence that changes in carbon dioxide and global temperatures have loose similarity over time.

There are some of us who remain so humbled by the task of measuring and understanding the extraordinarily complex climate system that we are skeptical of our ability to know what it is doing and why. As we build climate data sets from scratch and look into the guts of the climate system, however, we don't find the alarmist theory matching observations. (The National Oceanic and Atmospheric Administration satellite data we analyze at the University of Alabama in Huntsville does show modest warming – around 2.5 degrees Fahrenheit per century, if current warming trends of 0.25 degrees per decade continue.)

It is my turn to cringe when I hear overstated-confidence from those who describe the projected evolution of global weather patterns over the next 100 years, especially when I consider how difficult it is to accurately predict the system's behavior over the next five days.

Mother Nature simply operates at a level of complexity that is, at this point, beyond the mastery of mere mortals (such as scientists) and the tools available to us. As my high-school physics teacher admonished us in those we-shall-conquer-the-world-with-a-slide-rule days, "Begin all of your scientific pronouncements with 'At our present level of ignorance, we think we know …' "

I haven't seen that type of humility lately. Rather I see jump-to-conclusions advocates and, unfortunately, some scientists who see in every weather anomaly the specter of a global-warming apocalypse. Explaining each successive phenomenon as a result of human action gives them comfort and an easy answer.

Others of us scratch our heads and try to understand the real causes behind what we see. We discount the possibility that *everything* is caused by human actions, because everything we've seen the climate do has happened before. Sea levels rise and fall continually. The Arctic ice cap has shrunk before. One millennium there are hippos swimming in the Thames, and a geological blink later there is an ice bridge linking Asia and North America.

One of the challenges in studying global climate is keeping a global perspective, especially when much of the research focuses on data gathered from spots around the globe. Often, observations from one region get more attention than equally valid data from another.

The recent CNN report "Planet in Peril," for instance, spent considerable time discussing shrinking Arctic sea ice cover. CNN did *not* note that winter sea ice around Antarctica last month set a record maximum (yes, maximum) for coverage since aerial measurements started.

Then, there is the challenge of translating global trends to local climate. For instance, hasn't global warming led to the five-year drought and fires in the U.S. Southwest?

Not necessarily.

There has been a drought, but it would be a stretch to link this drought to carbon dioxide. If you look at the 1,000-year climate record for the western U.S. you will see not five-year but 50-year-long droughts. The 12^{th} and 13^{th} centuries were particularly dry. The inconvenient truth is that the last century has been fairly benign in the American West. A return to the region's long-term "normal" climate would present huge challenges for urban planners.

Without a doubt, atmospheric carbon dioxide is increasing due primarily to carbon-based energy production (with its undisputed benefits to humanity) and many people ardently believe we must "do something" about its alleged consequence, global warming. This might seem like a legitimate concern given the potential disasters that are announced almost daily, so I've looked at a couple of ways in which humans might reduce CO2 emissions and their impact on temperatures.

California and some Northeastern states have decided to force their residents to buy cars that average 43 miles-per-gallon within the next decade. Even if you applied this law to the entire world, the net effect would reduce projected warming by about 0.05 degrees Fahrenheit by 2100, an amount so minuscule as to be undetectable. Global temperatures vary more than that from day to day.

Suppose you were very serious about making a dent in carbon emissions and could replace about 10% of the world's energy sources with non-CO2-emitting nuclear power by 2020 – roughly equivalent to halving U.S. emissions. Based on IPCC-like projections, the required 1,000 new nuclear power plants would slow the warming by about 0.2 degrees Fahrenheit per century. It's a dent.

But what is the economic and human price, and what is it worth given the scientific uncertainty?

My experience as a missionary teacher in Africa opened my eyes to this simple fact: Without access to energy, life is brutal and short. The uncertain impacts of global warming far in the future must be weighed against disasters at our doorsteps today. Bjorn Lomborg's Copenhagen Consensus 2004, a cost-benefit analysis of health issues by leading economists (including three Nobelists), calculated that spending on health issues such as micronutrients for children, HIV/AIDS and water purification has benefits 50 to 200 times those of attempting to marginally limit "global warming."

Given the scientific uncertainty and our relative impotence regarding climate change, the moral imperative here seems clear to me.

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