Testimony of Professor Daniel P. Schrag, Harvard University
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Thank you, Mr. Chairman, and thank you to the members of the committee for inviting me to speak here today. I am Sturgis Hooper Professor of Geology at Harvard University in the Department of Earth and Planetary Sciences and Professor of Environmental Sciences and Engineering in the School of Engineering and Applied Sciences. I also serve as Director of the Harvard University Center for the Environment, which allows me to work with faculty in public health, public policy, economics, business, law and a variety of other disciplines.

One of the issues before this committee today is how global warming will contribute to national and international security. I approach this question from my work on the science of the climate system, and also from my studies of new and traditional energy technologies. As an earth scientist who studies how the climate has changed in the past, I believe there is no serious debate about whether the earth will warm as carbon dioxide levels increase over this century – it will. What is difficult to predict is exactly how much warming will occur, and exactly how that will affect human society. Unfortunately, I believe that most scientific assessments of future climate change may err on the conservative side, contrary to the claims of the few but vocal climate skeptics. This has led to a misunderstanding of the risk of adverse impacts of climate change. I will give a few examples today.

Humans are changing the amount of carbon dioxide in the atmosphere, mostly from burning of coal, oil and gas, with deforestation also playing a significant role. The current level, in excess of 380 parts per million (ppm), is higher than it has been for at least the last 650,000 years, and perhaps for tens of millions of years. To put it differently, we are experiencing higher CO_2 levels now than any human being has ever seen in the history of the earth; and over the next 100 years, without substantial changes in the trajectory of energy technology or economic development, we will see atmospheric CO_2 rise to more than 800 ppm, roughly triple the pre-industrial level. Carbon dioxide is a greenhouse gas. Its presence in planetary atmospheres causes warming of planetary surfaces; an extreme example is the CO_2-rich atmosphere of Venus, which is responsible for its surface temperature in excess of 460 °C.

The question that confronts us now is how the rise of CO_2 on this planet will affect our climate, not over millions or even thousands of years but over decades and centuries. We know that, coincident with the unprecedented rise in CO_2 over the last century, we have seen a rise in global temperatures. We know from Lonnie Thompson's work on tropical glaciers as well as many other studies that this warming is not related to any natural cycle. But this does not address the question of what will happen as CO_2 levels continue to rise. To answer this question, climate scientists have constructed models that represent the best understanding of the climate system from the last century of observations. These models tell us that climate change in this century may be dramatic, and perhaps even catastrophic. The models predict winners and losers for smaller magnitudes of change, such as mild changes in temperature or precipitation, but nearly all societies will be adversely affected by the more extreme changes that are possible including the collapse of one of the large polar ice sheets, or a large decline in mountain snowmelt. Other predictions that would pose serious challenges for societies include changes in the frequency and intensity of large storms, changes in patterns of precipitation that could lead to more severe droughts or extreme flooding, increases in peak temperatures that could drastically reduce agricultural harvests, and also ecological changes that affect ecosystems crucial to human society. In assessing future climate change for policy makers, we tend to focus on the more extreme and more adverse consequences not because we are unaware that there may be some beneficial outcomes, but simply because global warming is like an insurance problem. We need to understand the probability of the most undesirable outcomes to best gauge what steps to take to avoid them.

It is important to understand that the climate models we use to predict the future are not perfect – but this is not surprising as they are attempting to make predictions about an atmospheric state that no human being has ever seen. They remain an essential tool for exploring future scenarios, but we must also consider evidence for climate change from the geologic past. This is the major area of my research. I will not cover it today in much detail, but let me simply say that lessons from earth history are surprisingly consistent, whether from warm climates or cold, whether over millions of years or thousands. The data suggest that our real climate system is likely to be more sensitive than the models, and that there is a significant risk that future climate change will be more severe than most models now predict.

A second lesson from the study of past climates is that climate changes are not always slow and steady, but can occur in decades or even years. For example, the abrupt changes of as much as 35°F over less than a decade observed in Greenland ice cores during the last glacial period, with smaller effects throughout the Northern hemisphere, are spectacular examples of how quickly regional climate can change. The mechanisms responsible for such changes during the ice age probably required greater extent of land glaciers and sea ice than exist today, and so are unlikely to be experienced in exactly the same way over the next century. However, there are a number of possible mechanisms that can lead to abrupt and irreversible change in the climate system and may be very important over the next several decades. One is the response of glaciers on Greenland and Antarctica to enhanced polar warming over the next century. We do not know enough about glacial melting to be able to predict whether these ice sheets will decay smoothly, or whether there is the possibility for very rapid collapse. Another potential tipping point is the roughly 500 billion tons of carbon stored in permafrost in the tundra regions, particularly in Siberia. As those soils warm, microbes release the carbon as greenhouse gases – either methane or CO_2. Such a release would be a disaster if it happened quickly as it would overwhelm any emission reduction program we might implement.

Another important point in assessing the risk of catastrophic climate change is the large inertia in our climate system. CO_2 resides in the atmosphere and surface ocean for centuries, only slowly taken up by the deep ocean. If we were to reduce our emissions to zero immediately, it would take more than 200 years for terrestrial and oceanic uptake of carbon to restore the atmosphere to its pre-industrial condition. Even if we could stabilize CO_2 levels immediately, the current atmosphere with more than 380 ppm may be too warm to allow the ice sheets on Greenland or West Antarctica to survive. In addition, the oceans will continue to warm for decades even if emissions were halted. Thus, there is great inertia in the climate system, in the heat capacity of the oceans, in ice sheets, and in the residence time of carbon dioxide in the atmosphere (and in the lifetime of our energy infrastructure), all of which make substantial climate change inevitable. What this means is that we cannot wait until we actually see a disaster before we work on a solution. By the time we know whether the most extreme consequences of climate change will occur, it may well be too late to stop them.

Two examples of predictions by the climate community are particularly poignant in explaining how the scientific community tends to be conservative and also why climate surprises will often be in the adverse direction, towards more rapid and more extreme change. First, consider the sea ice distribution in the Arctic in September of 2007. Previous studies, including the Intergovernmental Panel on Climate Change (IPCC), predicted that the Arctic ice cap would disappear in the summer towards the end of the century, certainly no earlier than 2050. Then, in 2007, there was a 20 percent decline in areal extent of sea ice beyond the previous record (which was 2005). New studies predict that the Arctic may be ice free as soon as the middle of the next decade, a milestone that would drastically change the Arctic climate and enhance the melting of land ice on Greenland. Even Arctic scientists who had watched the decline in the ice cap for 20 years were amazed by such a rapid deterioration – and there are reasons why we now expect this process to accelerate.

A second example of a conservative climate prediction is the IPCC's discussion of future sea level rise. Most of the 10 to 25 inches predicted under different emissions scenarios results simply from the thermal expansion of seawater. Only two inches over the century are attributed to melting of ice on Greenland, despite the fact that the Greenland ice sheet would raise sea level by 23 feet if it melted in its entirety. This projection is equivalent to saying that the Greenland ice sheet will continue melting at exactly the same rate as it is melting today with no change as the Earth continues to warm, a highly unlikely outcome. This illustrates the basic problem with scientific assessments under such large uncertainty. When pushed, the scientific community often falls back on an answer that can be defended with confidence, even though it may not provide policy makers with an accurate picture of the risk involved.

Why do scientists tend to be conservative in their assessment of climate change? A major reason is that the scientific method teaches us to be conservative, and to state things only when we know them with high confidence, i.e., 95% confidence intervals. This is in striking contrast to another approach to risk and uncertainty in questions of national security – an approach called the "one percent doctrine", articulated by former Vice President Cheney. In Cheney's formulation, if the probability of a high consequence event such as a nuclear terrorist attack is only one percent, then we should treat it as an absolute certainty and act accordingly. To many, the Cheney doctrine is an extreme version of the precautionary principle, and yet it underscores how climate change has been treated quite differently than other matters of national and international security.

It is quite clear that climate change may have just as significant an effect on national security as many other concerns more traditionally in the spotlight of the security community. For example, one prediction of climate models – again, possibly on the conservative side – is that global warming will advance the timing of summer snow melt from mountains that serve as natural reservoirs for many parts of the world. In the western U.S., this could mean as much as 60 to 80 days earlier than today. Consider the agricultural capacity of California's central valley, which depends on rivers that drain the snowpack in the Sierra Nevada. If, by the end of this century, these rivers run dry by mid-summer, instead of lasting through the fall, then California agriculture as we know it today would be impossible. But this would be mild compared with the impacts on major river systems around the world. The great rivers that drain the Himalayas and Tibetan plateau – the Indus, the Ganges, the Mekong, the Yangtze, and the Yellow – all depend upon melting snow and ice for a large fraction of their water. Many of the three billion people who depend on these rivers are already under water stress, in part due to unsustainable practices of mining groundwater. How might the decline of the Indus affect the political stability of Pakistan and the support for Islamic terrorism? How will China and India deal with reduced water resources, especially when each is suspicious of efforts by the other to control the critical regions that represent the headwaters for their river systems? The risk of serious water stress, not just in Asia but around the world, is well above a one percent threshold for serious action, and illustrates how global warming poses an enormous challenge to peace and stability around the world.

A final point I would like to make before this committee is that many steps to mitigate climate change will also result in an increase in our national security. In addition to their impact on the climate system, fossil fuels – in particular petroleum and natural gas – represent a major cause of security concerns around the world including the geopolitics of oil, funding our enemies, and the strengthening influence that Russia has over Europe because of dependence on natural gas imports. Most new technologies that can reduce carbon emissions will also reduce our dependence on foreign sources of fossil fuels. Energy efficiency is the most important strategy, as it will likely result in significant savings to our economy. Investments in renewable energy sources in appropriate locations, as well as carbon capture and storage for coal-fired power plants and other large, stationary sources of CO_2 will reduce our need to import greater amounts of liquid natural gas in the future. And our dependence on foreign oil will only be reduced in the long run if we can develop clean, domestic alternatives such as synthetic fuels produced from biomass and coal with carbon sequestration. Through such steps, we can lead the rest of the world down a path towards greater prosperity, stability and security. If we fail in this task, we risk threatening the stability of our climate, our society, and our entire planet.