SEA LEVEL RISE IN CHARLESTON

Text of Remarks

by

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Most people have not realized that sea level has slowly been rising for at least the last 100 years. Shoreline retreat, one of its major affects, generally has been blamed on storms, the proximate cause, rather than sea level rise, the underlying reason that the erosion has been permanent. Futher obscuring the influence of sea level rise has been the fact that in some areas where local sand sediment has more than compensated for erosion the shoreline has advanced. One cannot be expected to recognize that the shoreline would have advanced even more without sea level rise.

We know, however, from tidal gauge measurements from around the world that there has been an average sea level rise of half a foot, with the east coast of the United States averaging another half foot. The information, however, does not tell us what we want to know most. Will sea level continue to rise ? Will the rise will be important? What should we do differently ?

These questions can be answered, but only by understanding the causes of of sea level rise and how those causes will operate in the future. We must be particuliarly concerned with anything that can speed or slow sea level rise. After all, a slower rise implies slower shoreline retreat, smaller increases in flooding, and less saltwater intrusion up rivers, into the groundwater, and into aquifers. A faster rise would make all these problems worse.

About half the historical rise on east coast has been due to land subsidence. That part of the rise is likely to continue in the future at historical rates. The global component of sea level rise appears equally attributable to two specific causes: the expansion of ocean waters as they warmed, and the melting of snow and ice from several alpine glaciers, from Greenland, or from the Antarctic. Both sources of sea level rise, however, have the same root cause -- the 1°F global warming experienced in the last hundred years.

Thus the future of sea level rise depends very much on future global warming. Fortunately, our ability to estimate global warming is quite advanced; the study of the earth's climate system and the determinants of its temperature having been an important focus of scientific endeavor for over 100 years. In fact, it was in the 1860's that the Irish physicist Tyndall discovered that CO_2 absorbs and then reradiates infrared radiation. Immediately he realized the importance of his discovery -- that the carbon dioxide in the earth's atmosphere acts like a greenhouse by holding energy onto the planet's surface, thus warming it considerably.

The process works like this: the sun's radiation enters the atmosphere primarily as visible light. Some percentage of sunlight is reflected back into space by clouds, snow, sea ice, or other terrestial features. The remainder warms the earth's surface. To balance that warming the surface cools off by emitting invisible infrared radiation towards space. At that point the special characteristics of CO_2, water vapor, and other the other greenhouse gases play an important role in earth's total energy budget by absorbing some percentage of this outgoing radiation. The gases warm up, balancing their heating by also reradiating infrared radiation. However, half that radiation is now emitted towards the earth's surface. The amount of energy received at the surface increases, raising the temperature. In this way the atmosphere functions as a leaky greenhouse, plugging some of the 'greenhouse's holes' that allow infrared energy to escape.

Space probes to other planets prove the importance of the greenhouse effect. Venus, for example, should be colder than earth because it receives less sunlight at its surface than Earth because of its incredible cloudiness. The satellites reveal, however, that the surface of Venus is much hotter, averaging a blazing 1450°F. The reason is clear. With an atmosphere that is 97% CO_2 and containing many other greenhouse constituents, the Venusian atmosphere is much more effective in blocking the escape of infrared radiation than Earth.

Space probes to Mars reveal the opposite situation. With an atmosphere with few greenhouse gases Mars loses almost all its infrared radiation to space and thus has a surface temperature much colder than Earth.

Earth has a moderate level of greenhouse gases, enough to warm our planet substantially. In fact the same models that accurately predict the temperature of the other planets, show that without any greenhouse gases the average temperature of earth's would fall to 0°F. The greenhouse effect is not a theory; it is a fact that makes life on earth possible

Mankind is increasing the atmospheric concentrations of greenhouse gases. As we do so we are, in effect, patching holes in our leaky greenhouse, reducing the percentage of infrared radiation that will escape and returning higher amount of energy to Earth's surface. Since 1957, when systematic measurements of atmosphere of CO_2 began, atmospheric CO_2 has risen 7%. The reasons are easy to understand. Every gallon of oil, ton of coal, and cubic meter of natural gas burnt produces CO_2, combining the weight of oxygen with that of carbon in the fuel. Thus, burning a ton of coal emits more than 2 tons of CO_2 into the atmosphere. Slash and burn agriculture produces additional CO_2, since the quantity of biomass, though more edible, is substantially smaller. Of the CO_2 that enters the atmosphere approximately half stays there, the rest being absorbed by the oceans. Thus as the world's economy grows so will the concentrations of CO_2.

Atmospheric concentrations of other greenhouse gases are increasing, although it is only in the last 10 years that these greenhouse gases have begun to be measured. In fact, we find them increasing more rapidly than CO_2. For example, chlorofluorocarbons, which were banned in the U.S. from spray cans in 1977 are still used as solvents, in foam blowing, and as refrigerants. Atmospheric concentrations are increasing more than 6% per year. Atmospheric methane, produced by a variety of agricultural and natural sources, is increasing at 1 to 1 1/2% per year. Nitrous oxide, produced by fertilizers and possibly power plants, is also growing. Finally, atmospheric chemists are predicting that tropospheric ozone will increase as a result of airplane emissions.

These less well known gases will be important to determining the rate of future warming. A study done at the Goddard Institute of Space Studies (GISS) that examined the the rise of just four of these gases (tropospheric ozone, and several fluorocarbon species were not included in the GISS calculations) showed that their increase in the 1970s was sufficient to almost double the warming attributable to CO_2 alone.

Scientific concern about the rise of CO_2 and other greenhouse gases has been growing. In 1979 the National Academy of Sciences, convened a panel of distinguished scientists to review all the evidence on this issue. The panel concluded that a doubling of CO_2 ,by the time it was fully effective, would raise 2.7° to 8.1°F. The panel indicated that because the radiation trapped by additions of greenhouse gases also has to raise the temperature of the top layers of the ocean, not just that of the atmosphere, the full temperature rise associated with each increment of greenhouse gases will be delayed by decades.

The 1979 Academy panel did not, however, try to estimate the rate at which greenhouse gases will rise or the drag on atmospheric warming that till be caused by the oceans absorbing heat. CO_2 growth depends on how fast use of fossil fuels grows, which in turn depends on the future rate of economic growth, the fuels selected for meeting energy demand, and a variety of other factors. Like the ultimate temperature rise associated with a greenhouse gas increase, there are uncertainties about this these factors. With regard to sea level rise, additional factors and uncertainties must be considered, the most important of which is the effect of global warming on the rate of ice and snow melting and runoff in places like Antarctica, Greenland, and the alpine glaciers. Additionally it is important to predict the speed with which the unstable glaciers of the West Antarctic will begin to disintegrate and add ice to the sea. While a complete collapse is hundreds of years off, increases in the rate of deglaciation could still add mass to the ocean in the next century, long before the ice could melt.

Estimate of sea level rise must make make assumptions about all the factors that will determine the course of future events. To encompass the uncertainties about which assumptions are correct, EPA used computer models capable of using different sets of assumptions to simulate the future. For example, to get our very high scenario, we used the highest estimate in the National Academy Of Science's temperature range, and a relatively high rate of economic and greenhouse gas growth. We also assumed that the oceans absorbed a lot of heat, and that the heating accelerated ice melting. It is unlikely that in the real world all the answers will in fact turn out this high, but the scenario does give us some estimate of a very high scenario. Similarly in calculating our conservative sea level rise scenario, we assumed that the lowest temperature of the National Academy scale and a low rate of economic and greenhouse gas growth. We also assumed that the oceans absorbed little heat, and that there was no acceleration in ice melting. While it is improbable that in the real world all assumptions will turn out at the low end of their ranges, this approach does give us a very conservative estimate of sea level rise. Finally, by using the mid-range or best case assumptions for each factor we developed our moderate estimate of sea level rise. For Charleston this produced about a foot and a half in the next forty years. Incidentally in 1983 the National Academy published a study of sea level rise with an almost identical estimate of global sea level rise.

With a range of sea level rise scenarios established, we have been proceeding to study how sea level rise could influence different economic activities, different parts of the environment, and different environmental protection decisions.
Our analyses are showing us that there are economic benefits associated with planning for sea level rise and accelerating scientific research to narrow the range of estimates. Among the subjects we have studied are the siting and protecting a wastewater treatment plant and the intrusion of saltwater up a river. Finally of relevance to today's conference, we studied the economic effects of sea level rise on Galveston and

Charleston.

Today we would like to tell you about the Charleston study. Before turning the floor over to Jim Titus, however, I would like to make one thing clear. Our pilot study was designed to get an approximate estimate of the effects of sea level rise, and the value of anticipating it. It was not designed to determine the best response for Charleston. Consequently many of our assumptions may be somewhat unrealistic for planning purposes. Our study may be able to assist you decide how to think about your options, but it is no substitute for making your own assessments and evaluations of the alternatives available to prepare for sea level rise.