Why Hasn't Earth Warmed as Much as Expected?

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(PhysOrg.com) -- Planet Earth has warmed much less than expected during the industrial era based on current best estimates of Earth's "climate sensitivity" -- the amount of global temperature increase expected in response to a given rise in atmospheric concentrations of carbon dioxide (CO2). In a study to be published in the *Journal of Climate*, a publication of the American Meteorological Society, Stephen Schwartz, of Brookhaven National Laboratory, and colleagues examine the reasons for this discrepancy.

According to current best estimates of climate sensitivity, the amount of CO2 and other heat-trapping gases added to Earth's atmosphere since humanity began burning fossil fuels on a significant scale during the industrial period would be expected to result in a mean global temperature rise of 3.8°F—well more than the 1.4°F increase that has been observed for this time span. Schwartz's analysis attributes the reasons for this discrepancy to a possible mix of two major factors: 1) Earth's climate may be less sensitive to rising greenhouse gases than currently assumed and/or 2) reflection of sunlight by haze particles in the atmosphere may be offsetting some of the expected warming.

"Because of present uncertainties in climate sensitivity and the enhanced reflectivity of haze particles," said Schwartz, "it is impossible to accurately assign weights to the relative contributions of these two factors. This has major implications for understanding of Earth's climate and how the world will meet its future energy needs."

A third possible reason for the lower-than-expected increase of Earth's temperature over the industrial period is the slow response of temperature to the warming influence of heat-trapping gases. "This is much like the lag time you experience when heating a pot of water on a stove," said Schwartz. Based on calculations using measurements of the increase in ocean heat content over the past fifty years, however, this present study found the role of so-called thermal lag to be minor.

A key question facing policymakers is how much additional CO_2 and other heat-trapping gases can be introduced into the atmosphere, beyond what is already present, without committing the planet to a dangerous level of human interference with the climate system. Many scientists and policymakers consider the threshold for such dangerous interference to be an increase in global temperature of 3.6°F above the preindustrial level, although no single threshold would encompass all effects.

The paper describes three scenarios: If Earth's climate sensitivity is at the low end of current estimates as given by the Intergovernmental Panel on Climate Change, then the total maximum future emissions of heat-trapping gases so as not to exceed the 3.6° threshold would correspond to about 35 years of present annual emissions of CO_2 from fossil-fuel combustion. A climate sensitivity at the present best estimate would mean that no more heat-trapping gases can be added to the atmosphere without committing the planet to exceeding the threshold. And if the sensitivity is at the high end of current estimates, present atmospheric concentrations of heat-trapping gases are such that the planet is already committed to warming that substantially exceeds the 3.6° threshold.

The authors emphasize the need to quantify the influences of haze particles to narrow the uncertainty in Earth's climate sensitivity. This is much more difficult than quantifying the influences of the heat-trapping gases. Coauthor Robert Charlson of the University of Washington likens the focus on the heat trapping gases to "looking for the lost key under the lamppost."

Schwartz observes that formulating energy policy with the present uncertainty in climate sensitivity is like navigating a large ship in perilous waters without charts. "We know we have to change the course of this ship, and we know the direction of the change, but we don't know how much we need to change the course or how soon we have to do it."

Schwartz and Charlson coauthored the paper with Ralph Kahn, NASA Goddard Space Flight Center in Maryland; John Ogren, NOAA Earth System Research Laboratory in Colorado; and Henning Rodhe, Stockholm University.

The early online release of the paper is available at AMS's journals online site.

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