THE UNCERTAINTY IN GLOBAL AND NATIONAL ESTIMATES OF CO_2 EMISSIONS FROM FOSSIL-FUEL COMBUSTION

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ABSTRACT
Both our understanding of the global carbon cycle and our ability to monitor and evaluate efforts to mitigate anthropogenic emissions of CO_2 depend on our ability to estimate the magnitude of these anthropogenic emissions. Emissions are generally estimated from data on fossil-fuel use and derive uncertainty both from the fuel-use data and from the data required to convert this to CO_2 emissions. Without independent data to verify emissions estimates, we examine some indicators of the uncertainty in emissions estimates.

INTRODUCTION
Emissions of CO_2 from fossil-fuel combustion are largely responsible for perturbing the global cycling of carbon. Estimates of the magnitude of this perturbation are required for understanding the current versus the pre-industrial cycling of carbon on the Earth and for public policy to try to mitigate further changes in the global climate system. Understanding the uncertainty in emissions estimates is important for understanding the uncertainty (including the variability) in the global carbon cycle, for better evaluating climate-change mitigation strategies, and for verifying compliance with mitigation commitments. Estimates of CO_2 emissions from fossil-fuel combustion since the beginning of the industrial era are available. But what is the uncertainty in these estimates?

UNCERTAINTY IN ESTIMATED EMISSIONS
Most estimates of fossil-fuel CO_2 emissions are based on the amount of fuel consumed, the carbon content of that fuel, and the efficiency with which fuel carbon is converted to CO_2. The largest uncertainty is introduced through data on the amount of fuel consumed and there are few independent data sources from which to evaluate uncertainty. Direct measurements of emissions from a few large point sources provide some independent data and atmospheric and satellite data may eventually provide constraints on emissions estimates. But for now we can gain some insight on uncertainty by: 1.) comparing estimates from different sources, and 2.) comparing the evolution over time of estimates from a single source. For the first comparison we can compare estimates of national emissions from various publicly available sources, including international compilations and self reported estimates from the countries themselves. For the second comparison we can look at time series data that are updated annually and examine how estimates

reported for a given country and year evolve over time through successive data revisions and updates.

Using data from international compilations and data submitted by the individual countries to the United Nations Framework Convention on Climate Change, we can show that the uncertainty is constrained but is large enough to significantly affect our understanding of the global carbon cycle and the effectiveness of our international agreements.

As an example of how data are revised and updated over time, the Figure below shows how the estimated value of global total emissions from fossil-fuel use (from the Carbon Dioxide Information Analysis Center at Oak Ridge National Laboratory) has been revised over time. Values on the graph show the % difference (absolute value) between the initially reported estimate of the global total of emissions in each year and more recent estimates of the same quantity. With a 2 to 3-year time lag required for collecting data and preparing estimates, values for 1986 emissions, for example, were first published in 1989. The global total value of emissions in 1986, as estimated in 2007, was thus about 2% different than initially estimated in 1988. Similarly, initial estimates for 2000 have subsequently been revised by nearly 6%. A significant fraction, but by no means all, of the revision of year 2000 estimates is attributable to revisions of the energy data from China. Revisions and updating of data from some individual countries result in larger fractional changes.

Both scientific and policy analyses need to consider the uncertainty of emissions estimates.