A new estimate of uncertainty associated with global carbon dioxide emissions from fossil fuel consumption

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Abstract A new evaluation of the uncertainty associated with the global total of carbon dioxide emissions from fossil fuel consumption is based upon approaching the data from a different perspective than that used by Marland and Rotty (1984, Tellus 36B: 232-261). This new evaluation is based upon quantifying the qualitative national error classes shown in Andres et al. (1996, GBC 10:419-429).

Global total emissions for the years 1950 to 2010 were calculated from the sum of emissions from individual nations plus an additional term which accounts for emissions not tabulated by each nation (e.g., bunker fuels, Andres et al., 2012, Biogeosci. (submitted)). The uncertainty on this global total was then calculated from

$\downarrow\Sigma((\text{flux}*\text{uncertainty})^2)$

where the summation is done over all nations. The result of this calculation is the mass of uncertain emissions in a given year. Repeating this calculation gives an uncertainty on global fossil fuel emissions of 2.6 to 4.8% (2 σ) for the years 1950 to 2010.

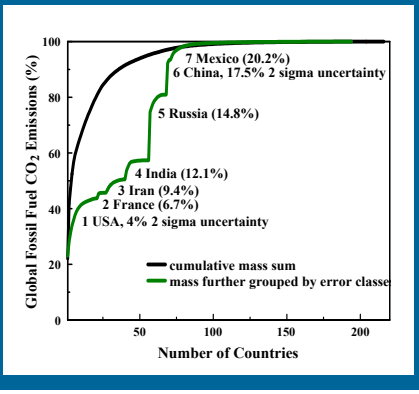
To examine an implication of this new uncertainty estimate, it is propagated into the rest of the global carbon cycle. For simplicity, this uncertainty is accommodated entirely within the terrestrial carbon sink and we conclude that the terrestrial carbon sink may be smaller than previously estimated.

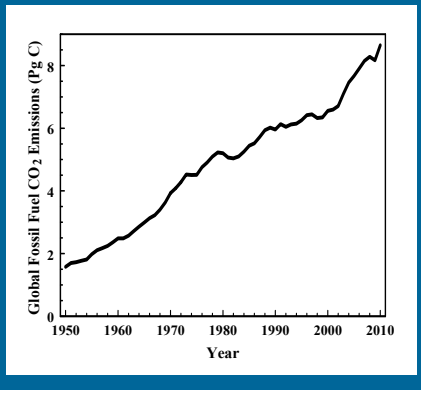
A new uncertainty estimate The left panel shows the quantification of the qualitative national error classes. Expert judgment was used to group countries into categories of similar data quality. Gregg et al. (2008, GRL 35: L08806, doi:10.1029/2007GL032887) was used to quantify two classes. A linear fit quantified the other classes. For the present analysis, class membership of individual countries has been kept constant with time.

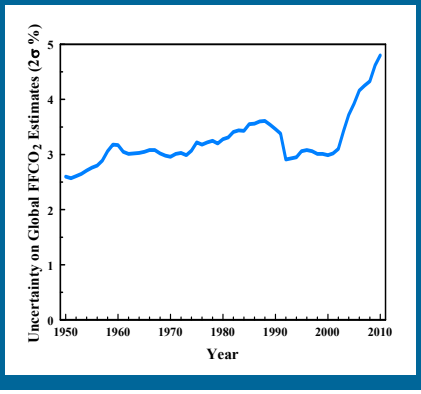
The central panel shows the mass of fossil fuel carbon dioxide emissions with time. Earlier data are based on United Nations-supplied statistics, year 2009-2010 data are based on BP-supplied statistics.

The right panel shows the resulting uncertainty estimate. The estimate is time-dependent, reflecting the changing mix of error estimates and associated mass fluxes. This approach assumes independent uncertainties. While independence is not strictly correct, dependence is also not strictly correct. Additionally, we do not possess knowledge to construct a full covariance matrix that would be required to describe the dependencies between all 160 to 216 countries in any given year.

This approach contrasts with that of Marland and Rotty (1984). They focused on the basic equation used to calculate emissions: emissions are equal to the product of three terms (i.e., fuel consumed, fraction oxidized, and carbon content). Their 6-10% range (90% confidence interval) was bounded by whether the terms are dependent or independent of each other and showed no time dependency.







Uncertainty propagation The left panel shows the two-sigma uncertainty estimate plotted with the best estimate of fossil fuel carbon dioxide emissions. The center panel shows the five-component mass-balance model of the global carbon cycle used for uncertainty propagation. The right panel shows the resulting estimate of the magnitude of the terrestrial biosphere flux with two sigma uncertainty bounds. With this simplistic approach, it is unclear whether the terrestrial biosphere is a source or sink of carbon.