Response to the Referees: Decomposing the 2010 global carbon dioxide emissions rebound

We are grateful to Dr Peters and the anonymous referee for their comments, which have greatly improved the paper. We have addressed the referees' comments as detailed below. The comments we are responding to are in bold and our responses are in plain text.

Dr Peters (Remarks to the Author):

1. It may be worth mentioning more clearly that it is an extension and not a contradiction of Peters et al. For instance, something like "We extend Peters et al. by using decomposition analysis..." or something to that effect.

We now mention that this is an extension of Peters *et al.*

2. Second paragraph or table. It would be useful to be a little bit more specific on what data is used. For example, "CO2 from Peters et al, Energy from XX for 1972 to 2008 and for 2009 and 2010, etc"

The second paragraph now includes a sentence explaining the data used. A full list of data sources is provided in Supplementary Table 1.

Our focus is emissions from energy. The use of IEA data for 1971-2009 ensures a consistent data source for all three decomposition terms, as noted in the Supplementary Methods.

We have taken the opportunity to update the data used in the analysis. We have used an updated version of the IEA data which extends to 2009 (released December 2011), and revised GDP growth data and projections (IMF, released 24 January 2012). Changes using these updated data are minor.

3. Second paragraph or table. Were there any data issues that are worth noting?

The Notes to Supplementary Table 1 now include discussion of two data issues:

* The OECD total for the BP data (used for 2010) only includes 33 of the 34 OECD countries (Estonia is not included, and there are no separate BP data for Estonia).

* BP data are for commercial energy and IEA data are for total energy, but the historical (1972-2009) growth rates of the two series are very similar.

Table 1 now also includes a listing of definitions, and a note that the data are subject to uncertainty.

4. Table: Is it possible to include the decade averages, 1972-1980, 1980-1990, 1990-2010?

Table 1 now includes decade averages.

5. Table: How did you calculate the average? In Peters et al it is (linear regression)/(mean value). Is this consistent?

We present average annual growth rates i.e. compound annual growth rates. The Note to Table 1 now includes a description of the type of average used. The formula we use to compute average growth rates is provided in the Supplementary Methods.

6. I think the sentence "Over the medium term, policy efforts...will tend to dampen emissions growth" is too strong. One easy way is to change "will" to "may".

We have changed this to "may lead to a dampening".

7. Peters et al estimated, based on decadal trends, emissions growth of 3.1+/-1.5% in 2011. It would be interesting to see an estimate based on trends in Energy/GDP and CO2/Energy.

Our approach of decomposing emissions growth into three component terms (GDP growth, energy intensity growth, and growth in carbon intensity of energy) does not allow us to form a different estimate than that which could be obtained using the two decomposition terms of Peters *et al.* (Emissions intensity growth + carbon intensity of energy growth = FFCI growth in Peters *et al.*) We are also cautious about providing an estimate for 2011 based on a decadal trend given that year-to-year fluctuations in energy intensity and the carbon intensity of energy can be sizeable (Figure 1). Rather than replicating the 2011 prediction approach of Peters *et al.*, we have instead included a discussion of the GDP growth projection for 2012 recently released by the IMF.

8. Figure. Can you label the vertical axis?

The revised Figure has labels on the vertical axes.

9. Figure. I think it would be nice to have another panel, showing the trends in CO2/Energy.

The revised Figure includes an additional panel for CO_2/energy.

10. To make this clearer, this could be mentioned more clearly in the start

We now refer to the Figure in the third paragraph.

Reviewer #1 (Remarks to the Author):

p. 1, line 2, '..faster than trend..' language not very clear and use of the term trend not precise; please improve

We changed this to "historical average annual rate".

p. 1, lines 6, 7, 8: please define the quantities more precisely: what exactly is 'ratio between energy and GDP' - later on you use the term 'Total primary energy supply' but this is still not very precise; it would possibly help if you gave the units of each quantity used;

also it would be helpful if you listed not only % changes in Table 1 but also listed the quantities themselves (i.e. GDP and change in GDP, etc.); possibly this material could be given in 'supplementary materials'. Similarly uncertainties should be added.

The ratio between energy and GDP is primary energy use divided by GDP. All numbers in Table 1 are in % units. The definitions and units for each variable are provided in the notes to Table 1. A full list of data sources and definitions is provided in Supplementary Table 1.

Total primary energy supply is the standard measure of aggregate energy use. Our definitions of energy intensity and carbon intensity of energy are consistent with earlier uses in the literature (see e.g. Raupach *et al.* 'Global and regional drivers of accelerating CO_2 emissions', *PNAS* (2007)).

Supplementary Table 2 includes quantities of the three variables and the decomposition ratios for recent years (2007-2010), as well as the years 1971 and 2000.

The IEA, BP, IMF and OECD data used in this study do not include information on uncertainties. The Note to Table 1 states: "Data are estimates reported by the data sources and are subject to uncertainty." Random data errors are likely to be averaged out in the long-run growth averages presented in Table 1, although systemic measurement errors would remain. We have also added a mention of uncertainties in the main text.

p. 1; line 12: what is special with (but common too) the years 1976, 1987 and 1990? Can you comment on this ?

The increases in global energy intensity in 1976 and 1987 were quite small (0.3% and 0.1%). Instead of focusing on these small increases, we have included an additional sentence on the 1990 increase: "The only year in which global energy intensity increased faster than it did in 2010 was 1990, during the collapse of the Soviet Union."

p. 2, line 5: ... developing world' what is the evidence ? can you give a reference ?

We removed the mention of industrialization in the developing world as existing trends would not be the cause of an above-trend rate of growth. We added a reference to IMF data on fossil fuel prices.

p. 2, line 7:'... over recent years' maybe add a graph to suppl. mat. ? also what is the reason ?

Figure 1 now includes a graph of the carbon intensity of energy for 2000-2010. The text also includes a discussion relating the changing carbon intensities of energy to the underlying energy mixes in OECD and non-OECD countries.

p. 2, line 9: 'It is likely that the 2010 emissions surge was exceptional ..' - does this not imply that the word 'rebound' in the original article was inadequate if not misleading ? if yes should this not be mentioned ?

We don't think this contradicts the Peters *et al.* article. They are saying there was a strong rebound in 2010 but after that they imply that historical trend growth rates would resume. We agree with their statement that because of the rapid growth of emissions in 2010, "the GFC has been quite different from previous global crises" (p. 4).

Table 1 '...adjusted for purchasing power parity' please give a reference ? what is the uncertainty of GDP ? how precise is the quantity defined ? Regarding 'Energy' please see above.

Supplementary Table 1 provides a full list of data sources. The notes to Table 1 also provide definitions of units of the variables used. The notes to Table 1 now state: "Data are estimates reported by the data sources and are subject to uncertainty." Information on the magnitude of uncertainties is not available. As noted above, random year-to-year errors are likely to cancel themselves out in the long-run growth averages. The inherent uncertainty in the data is also mentioned in the main text.