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Climate research outstrips CO2 emissions

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In the 1820s, the French scientist Joseph Fourier formulated the idea that some gases in the atmosphere freely let through visible and ultraviolet sunlight that heats the earth's surface but absorb and scatter the infrared radiation that is reflected back to space. As a result, heat is trapped in the atmosphere, which causes the temperature on earth to rise. This is known as the greenhouse effect.

In the late 19th century, the Swedish scientist Svante Arrhenius was the first to speculate that rising carbon dioxide (CO_2) levels in the atmosphere could change the earth's surface temperature through this greenhouse effect. He calculated that cutting CO_2 levels by half would lower the earth's temperature by 4–5°C.

His ideas were generally dismissed or simply ignored by contemporary scientists, but in 1938, Guy S. Callendar revisited his ideas and brought up more arguments in favor of Arrhenius's hypothesis. More and more scientists became convinced that atmospheric CO_2 strongly influenced the temperature on earth and that anthropogenic carbon emissions contributed significantly to atmospheric CO_2 levels. In 1960, Charles D. Keeling was the first to start measuring the carbon dioxide level in the atmosphere very precisely, and on the basis of these data was able to conclude that it was rising rapidly *(1)*.

With climate research in its infancy, Helmut E. Landsberg stressed in his 1970 *Science* paper *(2)* that very little was known about how human activity might change the climate. His article marked the establishment of modern climate change research, which continues to thrive today.

Article output and the economy

Bibliographic analysis of research articles on climate change with reference to CO_2 in peer-reviewed journals reveals that those specifically mentioning anthropogenic CO_2 form a major subset (up to half) of all articles mentioning CO_2 over the period 1996–2006 (see Figure 1). Also visible are the stagnations of growth around 1998–1999 and 2001–2002, and a plateau around 2004–2006. These periods coincide with global economic recessions.

To investigate whether there might be a relationship with the economy, the **article-output data was compared with the global gross domestic product** (GDP). And, since economic growth is driven by energy, which is predominantly generated by burning fossil fuels, another relevant **data set is the growth of anthropogenic carbon emissions** *(3)*. Putting these data together reveals a cycle whereby rising CO_2 levels drive research on CO_2-led climate change, but where funding for such research is ultimately dependent on the CO_2 emissions that drive economic growth (See Figure 2).

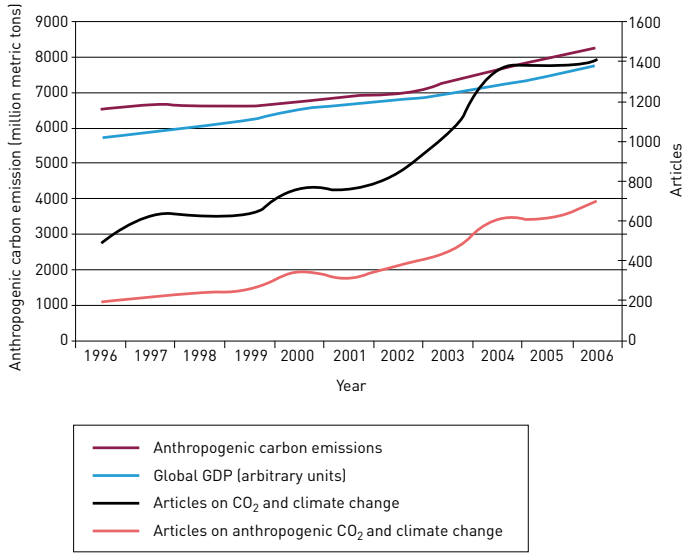

Figure 1 – Article output (articles), carbon emissions (metric tons) and GDP (arbitrary units) have all risen between 1996 and 2006, with small plateaus around major recessions. Source: Scopus

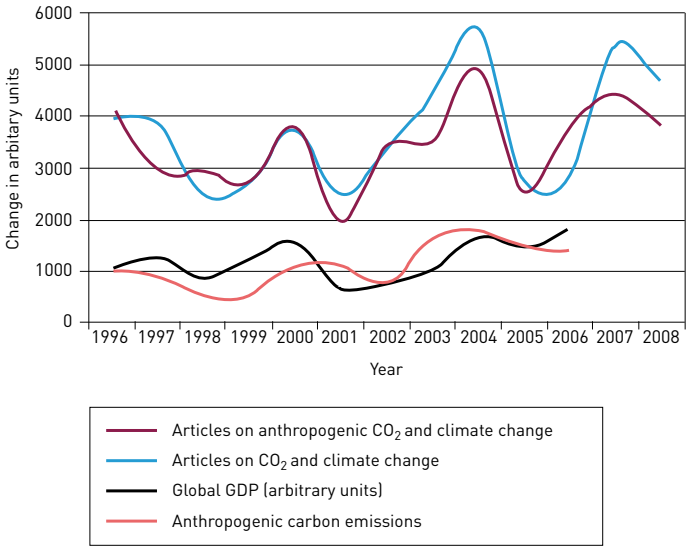

Figure 2 – Rescaling the annual variations in article output, carbon emissions and GDP in arbitrary units between 1996 and 2006 allows for direct comparison, indicating a cyclical relationship. Source: Scopus

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There is a clear relationship between both article output curves and the GDP curve. In addition, the carbon emission profile seems to either lag a year behind or jump a year ahead of the GDP curve between 1997 and 2002, but also follows the same general trend. The relationship between article output and the GDP may be explained by governmental and corporate research budgets that depend on tax revenues, and thus economically productive (CO_2-generating) activity.

Do national research outputs correlate with carbon emissions? Looking at cumulative carbon emissions and article output on CO_2 and climate change per country (see Figure 3) suggests that six of the top 10 countries publishing on this topic and also in the top 10 of carbon emitters: the US, UK, Japan, Germany, China and Canada. China appears to be a notable outlier, with research output failing to keep pace with carbon emissions, and these articles are also cited less than those of other high-emission nations.

With increasing carbon emissions and corresponding atmospheric CO_2 levels, climate change research is becoming more urgent as the potential for drastic impacts on humanity become more certain. Governments around the world are responding with a focus on research, and this is often on a par with the magnitude of each nation's carbon emissions. While it appears that the economic activity that drives CO_2 growth may also drive research on the effects of anthropogenic CO_2 on climate change, it is clear that the rate of production of scientific knowledge on anthropogenic CO_2 is outstripping growth of those emissions.

Interesting article:

Tucker, M. (1995) "Carbon dioxide emissions and global GDP", Ecological Economics, Vol. 15, Issue 3, pp. 215–223

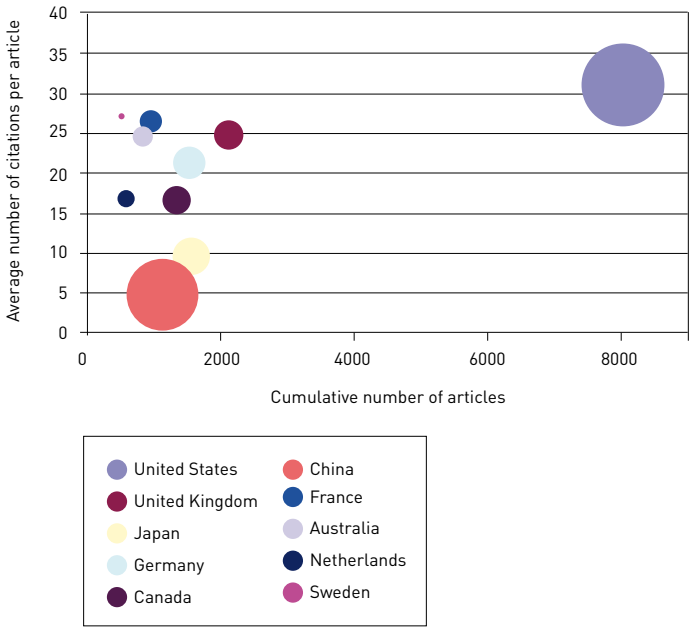

Figure 3 – Comparing the relationship between article output, average citation per article and carbon emissions (metric tons) between 1996 and 2006 indicates that countries with high CO_2 output are also among the most prolific in terms of article output.
Source: Scopus

References:
(1) Weart, S. (2009) "The Discovery of Global Warming – The Carbon Dioxide Greenhouse Effect"
(2) Landsberg, H.E. (1970) "Man-Made Climatic Changes: Man's activities have altered the climate of urbanized areas and may affect global climate in the future", *Science*, Vol. 170 (3964), p. 1265. DOI: 10.1126/science.170.3964.1265
(3) "International Carbon Dioxide Emissions and Carbon Intensity", Energy Information Administration, Official Energy Statistics from the U.S. Government