



Department
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Climate Change

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INTERNAL REVIEW OF ENVIRONMENTAL INFORMATION REQUEST 13/1591

I am writing in response to your request for an internal review of the above case. I have now reviewed the information which was provided by the Department in its response to your original request. I set out my decision below.

Your original request was made on 8th November 2013 and asked for the following information:

Do you have any experimental evidence that increasing CO2 causes an increase in atmospheric temperature?

The Department responded to your request on 5th December (the Response). The Response explained that the information you requested is available and is accessible to you, as it is already in the public domain. The Response noted that the information can be obtained from a range of sources, including for example:

- Standard reference books on climate change such as:
Global Warming The Complete Briefing by Sir John Houghton, Cambridge University Press, 4th Edition 2009;
Principles of Planetary Climate by Raymond T Pierrehumbert, Cambridge University Press, 2011.
- Reports containing information about experiments and other studies on the absorption and radiative properties of CO₂, as given for example in the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report¹.

¹ Solomon et al 2007, Chapter 1 – Historical Overview of Climate Change Science: In Climate Change 2007 WG1 contribution to the IPCC Fourth Assessment Report (section 1.4.1).



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- Websites, including The Government Office for Science webpages on the science of climate change (see <http://www.bis.gov.uk/go-science/climatescience>).

I am a Director at DECC with responsibility for the policy area within which your original request fell and, in accordance with Departmental guidelines, your request for an internal review has been referred to me.

In compliance with the Environmental Information Regulations 2004 ('the EIRs') I have conducted an internal review of the original response. In performing this review I have considered whether the original response to your request was correct.

I note that you considered that the information you requested was not publicly available from the reference sources DECC provided, because either your use of a word search of several of the cited publications on-line, using the term 'experiment', did not identify relevant information or, in one case, a publication was only accessible via a paywall.

The two cited reference books provide information on the underlying science of the 'greenhouse effect', the mechanism by which CO₂ and certain other trace gases cause a natural warming of the atmosphere and how this effect is enhanced by increasing atmospheric CO₂ concentrations due to emissions from human activity. Information on historical progress in understanding the 'greenhouse effect' is given in Chapter 1, section 1.4.1 of the IPCC's Fourth Assessment Report¹.

It is not possible to carry out experiments that would prove the 'greenhouse effect' at a whole-atmosphere scale. However, laboratory experiments have demonstrated that CO₂ and so-called greenhouse gases absorb long wave (infrared) radiation, from which it is inferred by physical arguments that the 'greenhouse effect' exists and warms the Earth as a result of the absorbed heat radiation being re-emitted. Supporting evidence for this effect are provided by satellite spectral measurements of the radiation emitted from the top of the atmosphere and by *in situ*, ground measurements of long wave radiation emitted by the atmosphere back to the ground. Specific sources of information for these lines of evidence are given below.

Laboratory measurements

In 1861, John Tyndall published experimental findings identifying CO₂ as a greenhouse gas that absorbs heat (long wave radiation)². A freely available copy is available at:

<http://www.jstor.org/stable/pdfplus/108724.pdf?acceptTC=true&acceptTC=true&jpdConfirm=t>

² Tyndall, J. 1861. On the Absorption and Radiation of Heat by Gases and Vapours, and on the Physical Connexion of Radiation, Absorption, and Conduction. *Philosophical Transactions of the Royal Society of London*, Vol. 151, pp. 1-36



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I am sorry you were unable to locate a copy of his 1863 paper³ as a non-paywalled version, however, the above (1861) paper gives more experimental detail.

Since Tyndall's papers, the absorptive qualities of CO₂ have been more precisely quantified by decades of laboratory measurements. An overview of the history of these developments is given in *The Discovery of Global Warming*, at: <http://www.aip.org/history/climate/co2.htm>

A list of papers on laboratory measurements of the absorption properties of CO₂ can be obtained at:

<http://agwobserver.wordpress.com/2009/09/25/papers-on-laboratory-measurements-of-co2-absorption-properties/>

As many of the papers listed have been published in academic journals they are, for the most part, behind a paywall. However, Information Commissioner's Office guidance indicates that information available for a fee is considered to be available to the public, i.e. in the public domain, unless there is a particularly prohibitive charge that may act as a barrier to access by the general public⁴. Nevertheless, we have identified that the following paper, for example, is freely available on-line:

Burch, Darrell E., Grynak, David A., Pembroke, John D., 1970. Investigation of the Absorption of Infrared Radiation by Atmospheric Gases. Semi-Annual Technical Report No. 1. (see <http://www.dtic.mil/dtic/tr/fulltext/u2/709894.pdf>)

Satellite and surface measurements

Such data demonstrate a direct link between CO₂ and warming: satellite measurements of infrared spectra observe less energy escaping to space at the wavelengths associated with absorption by CO₂, while surface measurements show increased downward infrared radiation that warms the Earth's surface. The result of this energy imbalance is the accumulation of heat in the atmosphere and oceans. This evidence is discussed, for example, in the following papers that are freely available on line:

John E. Harries, Helen E. Brindley, Pretty J. Sahoo & Richard J. Bantges. 2001. Increases in greenhouse forcing inferred from the outgoing longwave radiation spectra of the Earth in 1970 and 1997. *Nature*, Vol. 410, pp. 355-357. (See: <https://workspace.imperial.ac.uk/physics/Public/spat/John/Increase%20in%20greenhouse%20forcing%20inferred%20from%20the%20outgoing%20longwave%20radiation%20spectra%20of%20the%20Earth%20in%201970%20and%201997.pdf>) The paper's authors concluded that their results provided the first

³ Tyndall, J. 1863. On radiation through the Earth's atmosphere. *Philosophical Magazine*, Series 4, Volume 25, Issue 170, pp200 – 206.

⁴http://ico.org.uk/for_organisations/guidance_index/~/_media/documents/library/Freedom_of_Information/Detailed_specialist_guides/information-in-the-public-domain-foi-eir-guidance.ashx, Charges for information, p10.



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"experimental observation of changes in the Earth's outgoing longwave radiation spectrum, and therefore the greenhouse effect."

Kaicun Wang and Shunlin Liang. 2009. Global atmospheric downward longwave radiation over land surface under all-sky conditions from 1973 to 2008. *Journal of Geophysical Research*, Vol. 114, D19101, doi:10.1029/2009JD011800. (see: <http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=3&cad=rja&ved=0CEYQFjAC&url=http%3A%2F%2Fwww.researchgate.net%2Fpublication%2F232784812%2Ffile%2F9fcd509669d42fead.pdf&ei=ctfKUvDyDNKqhAesplHgDg&usq=AFQjCNHzzjhnICAct6aRje7ruOG Gme5NA>)

Having considered the information originally provided in the light of your request for an internal review, I have concluded that it did not include sufficient detail on possible sources of information available in the public domain. Further references to information sources have therefore been included in this response, in order to address your original request more fully.

If you are not content with the outcome of the internal review, you have the right to apply directly to the Information Commissioner for a decision. The Information Commissioner can be contacted at: Information Commissioner's Office, Wycliffe House, Water Lane, Wilmslow, Cheshire, SK9 5AF

Yours sincerely