

## COMMENT

**Comment on Soon et al. (2001) 'Modeling climatic effects of anthropogenic carbon dioxide emissions: unknowns and uncertainties'****David J. Karoly<sup>1,\*</sup>, John F. B. Mitchell<sup>2</sup>, Myles Allen<sup>3</sup>, Gabi Hegerl<sup>4</sup>, Jose Marengo<sup>5</sup>, Francis Zwiers<sup>6</sup>**<sup>1</sup>School of Meteorology, University of Oklahoma, 100 E Boyd St, Norman, Oklahoma 73019, USA<sup>2</sup>Hadley Centre, Met Office, London Rd, Bracknell, Berks RG 12 2SY, UK<sup>3</sup>Department of Physics, University of Oxford, Clarendon Laboratory, Parks Road, Oxford OX1 3PU, UK<sup>4</sup>Department of Earth and Ocean Sciences, Duke University, Durham, North Carolina 27708, USA<sup>5</sup>CPTEC/INPE, 12630.000, Cachoeira Paulista, SP, Brazil<sup>6</sup>Canadian Centre for Climate Modelling and Analysis, University of Victoria, PO Box 1700, Victoria, BC V8W 2Y2, Canada

Soon et al. (2001) recently presented 'a limited review of the deficiencies of climate model physics and the use of GCMs'. As they note in their conclusions, they present a biased review. It is not the purpose of this comment to address the bias in their assessment of the current state of the performance of GCMs in simulating climate variability and climate change. A more balanced and much more widely reviewed assessment is provided by the IPCC Third Assessment Report, in the chapter on evaluation of climate models by McAvaney et al. (2001). As noted by Soon et al., the IPCC reports provide 'an alternative view' and 'detailed documentation of the merits of GCMs'.

Here, we focus on several statements in the abstract of Soon et al. (2001) concerning the detection and attribution of a significant anthropogenic influence on global climate. These statements in the abstract do not appear to be closely related to material presented elsewhere in the paper. In fact, apart from in the abstract, there is very little detailed discussion by Soon et al. of the attribution of observed climate changes to one or more forcing factors, such as increasing greenhouse gases in the atmosphere, and almost no referencing of studies which have sought to quantitatively attribute some fraction of the observed climate change to different forcing factors. The IPCC Third Assessment Report also includes a detailed and widely reviewed assessment of the detection of climate change and attribution of its causes, in the chapter written by the current authors (Mitchell et al. 2001).

The specific statements of concern in the abstract of Soon et al. (2001) are:

(1) 'Given the host of uncertainties and unknowns in the difficult but important task of climate modeling, the unique attribution of observed current climate change to increased atmospheric CO<sub>2</sub> concentration, including the relatively well-observed last 20 yr, is not possible.'

(2) 'Such uncritical application of climate models has led to the commonly held but erroneous impression that modeling has proven or substantiated the hypothesis that CO<sub>2</sub> added to the air has caused ... significant global warming.'

(3) 'Our review does not disprove a significant anthropogenic influence on climate.'

Below, we briefly discuss these statements in the context of the recent assessment of the attribution of causes of climate change by Mitchell et al. (2001).

A statement similar to statement (1) above is included in the introduction of Mitchell et al. (2001): 'The unequivocal attribution of climate change to anthropogenic causes... is clearly not possible.' However, this does not mean that probabilistic statements about the attribution of climate change to anthropogenic causes cannot be made. Mitchell et al. (2001) describe the following approach: 'attribution of observed climate change to a given combination of human activity and natural influences requires... statistical analysis and careful assessment of multiple lines of evidence to demonstrate, with a pre-specified margin of error, that the observed changes are:

- unlikely to be due entirely to internal variability;
- consistent with the estimated responses to the given combination of anthropogenic and natural forcing; and
- not consistent with alternative, physically plausible explanations of recent climate change that exclude important elements of the given combination of forcings.'

Mitchell et al. (2001) discuss and assess the observed record of climate variability and change, model estimates of internal climate variability, improved model estimates of the responses to natural forcing (solar and volcanic) and anthropogenic forcing (greenhouse gases and sulphate aerosols), and a wide range of techniques used for detection and attribution of climate change. We assessed a number of attribution studies that used the approach described above and concluded '[I]n the light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase of greenhouse gas concentrations.' Consistent with the practice adopted throughout the IPCC (2001) report, the use of the word 'likely' in this statement indicates that its confidence was assessed at a level between 66 and 90%. This conclusion of the IPCC has identified, with a specified degree of confidence, a significant anthropogenic influence on climate. This is what Soon et al. in their statement (3) admit that they do not disprove. This conclusion is also not consistent with a general interpretation of their statement (2).

This IPCC conclusion, which is based primarily on observational data and careful statistical analysis, does substantiate the hypothesis that CO<sub>2</sub> added to the air is likely to have caused significant global warming over the last 50 yr. In contrast to the charge that is made in Soon et al.'s statement (2), formal detection and attribution studies critically assess climate models by determining whether they respond to changes in

external forcing during the 20th century in a manner that is consistent with the observed changes in climate. Erroneous model results will generally make the identification of anthropogenic climate change more difficult. Detection and attribution is strengthened, as in several of the studies assessed by Mitchell et al. (2001), when consideration is given to multiple external forcing factors, such as changes in the emissions of CO<sub>2</sub> and SO<sub>2</sub>, and variations in solar and volcanic forcing.

We believe that, with the word 'unique' included, statement (1) above from Soon et al. is correct but that probabilistic attribution of observed current climate change to increasing atmospheric CO<sub>2</sub> concentration is possible. Statement (2) is incorrect, as modelling studies have helped to substantiate that CO<sub>2</sub> added to the air is likely to have caused significant global warming over the last 50 yr. Statement (3) is correct.

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