DOES RECENT GLOBAL WARMING SUGGEST AN ENHANCED GREENHOUSE EFFECT?

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Abstract. Considerable controversy has been generated by the observation that the Earth's climate has warmed over the last century. Public policy decisions hinge on the question of whether this trend is natural climate variability or the result of the increase in atmospheric concentrations of greenhouse gases. The strength of the enhanced greenhouse effect depends, in large part, on the uncertain value of climate sensitivity. In this paper climate sensitivity is estimated from the global temperature record by assuming models for greenhouse forcing, climate response to forcing, and climate variability. We find optimal estimates of climate sensitivity are remarkably insensitive to assumptions, at least for forcing excluding the effect of aerosols, and these values are considerably less than most predictions arising from General Circulation Models (GCM's). It is, however, the statistical significance of these estimates that is sensitive to assumptions about climate variability. Assuming climate variability with a time scale of a decade or less, climate sensitivity is estimated to be significantly greater than zero, but also significantly lower than that predicted by GCM's. Climate variability with a century time scale is consistent with both the recent temperature record and the pre-instrumental record for the last millenium; if this type of variability is assumed, the estimate of climate sensitivity has a confidence band wide enough to encompass both zero and typical values obtained by GCM's. With century time-scale variability it will be several decades before confident estimates can be made.

1. Introduction: The Observed Trend and Greenhouse Warming

Several other authors (Barnett and Schlesinger, 1987; Tsonis and Elsner, 1989; Wigley and Raper, 1990; Houghton et al., 1990; Schönwiese and Runge, 1991; Schönwiese and Stähler, 1991) have used statistical analysis of temperature data to determine whether the recent global warming trend has been caused by an increase in atmospheric concentration of greenhouse gases. The significance of their answers, however, hinges on the assumed statistics of natural climate variability, to which the observed global warming might alternatively be ascribed. In this paper we explore quantitatively the boundaries of just what conclusions can be drawn for a wide range of assumptions on natural climate variability, but with each assumption supported by some reasonable physical process.

The global near-surface temperature, shown in Figure 1, over the time period 1856–1989 (Jones and Wigley, 1990; Parker and Folland, 1991; Houghton et al., 1990) were estimated by forming annual averages of measured land based and sea surface temperatures corrected for idiosyncrasies specific to each piece of data, as discussed by Jones and Wigley (1990). While a great effort has been extended to

Fig. 1. Estimates of global near-surface temperature from 1956–1989 reported by (a) Jones and Wigley (1990) and (b) Parker and Folland (1991). Mean of plotted temperature deviation is zero.