formation, according to the conventional folklore that emanates from Princeton; these objects cluster together to form larger and larger systems, eventually identified with galaxies. Neutrino viscosity in the very early Universe is not considered by cosmologists to be responsible for significantly smoothing out inhomogeneity, although it may play a role in isotropisation of the early Universe. The important processes that smooth out at least certain forms of inhomogeneity, leaving only galaxy- or cluster-sized fluctuations behind involve photon viscosity and diffusion, which occur at relatively late epochs.

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Climatic change

T. M. L. Wigley

The Climatic Threat: What's Wrong with our Weather? By John Gribbin. Pp. 206. (Fontana: London, 1978.) Paperback £1.

In his dialogue *The Decay of Lying* between the characters Cyril and Vivian, Oscar Wilde gave us a marvellous aphorism which can be used to describe many recent pseudoscientific works: " . . . facts are either kept in their proper subordinate position, or else entirely excluded on the general ground of dullness". It would be harsh of me to describe John Gribbin's book in this way; his work is much more subtle. Nevertheless, it might be entertaining to listen in to Cyril and Vivian for a little while. The scene is the library of a country house somewhere in England.

Cyril (coming in through the open window from the terrace): My dear Vivian, don't coop yourself up all day in the library. It is a perfectly lovely afternoon. Let us go and lie by the river and enjoy Nature.

Vivian; Enjoy Nature! My own experience is that the more we study science, the more we fear Nature. Science reveals to us Nature's love of design, the inexorable inevitability and predictability of Her changes of mood: and our vulnerability to them.

Cyril; Ah! You have been reading *The Climatic Threat* again I see. Well might you stay inside if you believe that tale. But I, for one, do not; though in truth I feel others may. Man is so eager to believe the impossible! Such plausible expositions are more tempting than apples to Eve.

. . . which gives me the opportunity to take over from Cyril and review *The Climatic Threat*. The book is a personal evaluation of some recent research into the processes of climatic change, and goes so far as to present forecasts of future climate which accord with this evaluation. At the beginning the author warns the reader that his book is subjective; that he "throws caution to the winds". The book is, however, well argued (at least superficially), and is written in an objective and authoritative manner. Unfortunately, as Cyril well realises, this style can only deceive the "average reader", who cannot possibly know how incompletely the author reviews the fields he discusses, how uncritical and selective are his references to the scientific literature, how much he has mixed sound well accepted work with controversial opinion and speculation, and how often the cautious, tentative words of others are represented as established fact. By presenting such an incomplete "subjective" (that is, "biased") survey, and by quoting uncritically the predictions of future climatic changes given by others (for example, Willett), Gribbin gives the impression that the processes of climatic change are well understood. They are not; in fact even our knowledge of how climate has changed in the past is sketchy and uncertain. For example, again contrary to the impression which Gribbin creates, climatologists do not even know how global temperature has changed over the past 100 years, let alone how it has varied over the past 1000 or more years. There are vast areas of the globe, especially in the southern hemisphere, where the observational data network is so sparse that the magnitude and direction of temperature changes in those regions are virtually unknown.

The Climatic Threat weaves its story around two main hypotheses. The first of these concerns the link between climatic variability and the general circulation of the atmosphere; the second involves the link between changes in the Sun and changes in the Earth's climate. First, Gribbin explores the hypothesis that global (or perhaps it is Arctic; Gribbin is somewhat ambiguous on this point) cooling leads to a weaker, more meridional circulation pattern, with attendant increases in the frequency of blocking situations (such as occurred during the 1976 European drought) and in the year to year variability in climate. This is an attractive hypothesis, but it is based on a number of assumptions which have yet to be tested. Furthermore, despite Gribbin's contention that the climate has become more variable recently, there has been no comprehensive statistical analysis of recent data to show whether or not significant changes in climatic variability and/or the frequency of extreme events have occurred in recent decades. Most statements made both by Gribbin and by other authors on this question lose statistical significance because the are made *a posteriori*, soon after some extreme event, and so are temporally selective. As far as changes in the frequency of blocking are concerned, available evidence (not mentioned by Gribbin) is incomplete and equivocal. Lamb has shown that the 1970–72 period was more blocked than the 1900–50 mean, and Painting has demonstrated a decrease in blocking from 1965–69 to 1970–74. The statistical significance of these results is difficult to assess, and the whole area of climatic variability is one which requires a great deal more research. Subjective evaluations are worse than useless.

Gribbin's second main point is that global climate is significantly affected by changes in solar output, and that there have been such changes in the past. This is, in part, the old sunspot–climate story, a story which is closely related to the general question of climatic cycles. As an example of Gribbin's incomplete analysis, he discusses here the Kondratyev–Nikolsky relationship between sunspots and the solar constant, and Schneider and Mass's (guarded) use of this relationship. Both items are represented as being well established, yet they are not. The Kondratyev–Nikolsky relationship has always been open to doubt and its reality has recently (1976) been rejected completely by Paltridge and Platt. The simple Schneider–Mass model itself was never meant to be interpreted as proof of a solar–terrestrial link, but only as an indication that such a link was not totally unrealistic.

With climate cycles, *The Climatic Threat* defeats itself. On p.40, I find the statement that "there are no cycles" in climate "that are accepted as proven by everyone who works on climate problems". Yet later, and in spite of this, is the irresponsible statement that "it seems quite reasonable to use the 180-year, 90-year and 22-year cycles" in solar activity "as well as the 11-year cycle, as a secure basis for climatic forecasting" (p115). If only things were so simple! In fact there is no proof that a 180-year cycle exists at all in either climate or solar activity; and the other cycles, although well established in the solar record, are uncertain and debatable in the climate record. Furthermore, even if these cycles in climate did exist, the key question, which Gribbin never asks, is how much of the variation in climate do they explain? It is fitting to close this review by returning to Cyril and Vivian.

Cyril; So you see, Vivian, how premature *The Climatic Threat* is. In climatology scientists are not so much revealing the order of Nature, as they are discovering Her complexities. They have delved successfully into many of these already, but there is much left to explore; and Nature delights in surprising those who underestimate Her.

The scene ends and Cyril and Vivian turn to exit as the first fingers of glacial ice creep under the french windows. □

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