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Book reviews

Changing Climate by the US National Research Council (National Academy Press, 1983), 496 pages, $29.50

Can We Delay a Greenhouse Warming? by S. Seidel and D. Keyes, US Environmental Protection Agency (US Government Printing Office, 1983) $6.00

In recent years, the so-called greenhouse effect of carbon dioxide (CO_2) has been widely publicised as being a particularly adverse consequence of mankind's burning of fossil fuels such as coal, gas and oil. The two reports which are the subject of this review contribute significantly to that pessimistic view of the future.

The report of the US National Research Council (NRC) is by far the most comprehensive study (496 pp.) yet produced on the topic. It is a compilation of nine major chapters and four annexes dealing with several different aspects of the CO_2 problem as perceived by a group of experts drawn from a wide spectrum of scientific disciplines. As such it is valuable for highlighting the vast complexity of the subject, but it often comes up short when attempting to make judgements about ultimate real-world consequences.

The core climate conclusion of both reports — upon which all else hinges — is that the mean near-surface air temperature of the earth will increase by 3 ± 1.5 °C for a nominal doubling of the atmospheric CO_2 concentration from 300 to 600 ppm, something which the NRC report suggests will occur by the year 2065. A secondary conclusion is that the warming in polar regions will be several times greater. From this prediction both reports conclude that vast quantities of polar and glacial ice will melt, and that great expanses of coastal lowlands will be lost to encroachments of the ocean as sea levels rise. In addition, although rainfall globally is projected to increase slightly, important food producing regions in the United States are predicted by the NRC report to suffer significant precipitation reductions, leading to streamflow reductions in the major western US watersheds ranging from 40 to 75 per cent.

As a result of these dire predictions, the US Environmental Protection Agency (EPA) concludes that, as CO_2 continues to increase in the years ahead, 'agricultural conditions will be significantly altered, environmental and economic systems potentially disrupted, and political institutions stressed.' Then, after detailed analyses of several different policies suggested as possibilities for averting these calamities, they conclude that there is very little we can do about the situation. Indeed, they find that a worldwide tax of up to 300 per cent of the cost of all fossil fuels would only delay the predicted warming by about five years and that a ban on synfuels and shale oil would have about the same meagre effect. Even a total ban on coal, they conclude, would only delay the warming by about a decade.

The reports are hard-hitting and seek to draw attention to what they perceive to be one of the greatest ecological dilemmas ever faced by mankind. However, many of their analyses are too soft to warrant the faith they put in their conclusions.

For instance, recent years have seen a number of challenges to the core climate conclusions of the reports; yet nowhere are these dissenting viewpoints discussed. Indeed, the EPA report does not even mention them, and the key climate section of the NRC report is but a rehash of previously published CO_2 reports, with over half of its pages being exact photo-reproductions of a 1982 report which merely affirms the correctness of a 1979 report! For those interested in both sides of the story, I have summarised much of missing material in the book *Carbon Dioxide: Friend or Foe?* (IBR Press, Tempe, AZ USA).

A second example of outright error is provided by the NRC report's prediction of reduced water resources in a world of enriched atmospheric CO_2. This conclusion is based upon the assumption that runoff is the simple difference between precipitation and evapotranspiration and the belief that evapotranspiration is controlled solely by temperature. In actuality, CO_2 is one of the most effective antitranspirants known to man; and A. R. Aston of the CSIRO's Division of Plant Industry has shown that, when this effect is included in a model used to investigate the ramifications of changed stomatal resistance for evapotranspiration, 'we can expect streamflow to *increase* from 40 to 90% as a consequence of doubling the atmospheric CO_2 concentration' *(J. Hydrol. 67,* 293).

Both reports also give inadequate treatment to the subject of biological benefits to be reaped from elevated concentrations of atmospheric CO_2. Whereas they foresee only minor enhancements of crop yields due to atmospheric CO_2 enrichment, a recent review of about 800 experimental observations produced by B. A. Kimball of the US Water Con-

servation Laboratory (Phoenix, AZ, USA) indicates that agricultural productivity the world over will increase by about a third for a 300 to 600 ppm doubling of the atmospheric CO_2 concentration. In addition, the reduction in plant evaporative water loss caused by CO_2's antitranspirant characteristics has been shown to lead to an actual *doubling* of plant water use efficiency (the yield produced per unit of water used) for such a CO_2 concentration doubling *(Agricultural Water Management, 7,* 55). And both of these effects have been documented to continue to increase linearly as atmospheric CO_2 increases to at least a quadrupling of its pre-industrial concentration *(Science, 220,* 428).

In conclusion, both reports can be profitably used as introductions to the CO_2 'problem', the NRC report because of the importance it attaches to the interdisciplinary nature of the topic and the EPA report because of its important analyses of energy policy. It must be remembered, however, that both reports are but *introductions* and that neither one provides anything near a final assessment of the subject. Indeed, it is very possible that they may eventually be found to be 180 degrees out of phase with reality; for there is much experimental evidence to indicate that higher concentrations of atmospheric CO_2 are *extremely* beneficial to plants and conservation of water resources, while the adverse climatic effects predicted by the theoretical models of the general circulation of the atmosphere remain completely unconfirmed.

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Large Scale Dynamical Processes in the Atmosphere eds B. J. Hoskins and R. P. Pearce (Academic Press, London, 1983) Pp XVI, 397. $54.50 ISBN 0 12 356680 0

This book is much more than an edited selection of papers presented at a conference. In reality, it is an advanced text on large-scale atmospheric dynamics based on a number of review articles by leading researchers, carefully prepared to maintain continuity and to cover recent research results.

Over the past few decades, there has been a marked impovement in the understanding of dynamical processes in the atmosphere. This has been due not only to the vast increase in detailed observations and progress in numerical modelling of atmospheric flow, but also to increased co-operation between researchers involved in observational studies and those involved in modelling and theoretical studies. This co-operation is embodied in the ideas of the 'Reading School' that the optimum situation for meteorological research is a close co-operation and interaction between observational studies of the atmosphere, simple theoretical studies and complex numerical modelling, leading to an evolving conceptual model of atmospheric processes.

An indication of the success of these ideas and a review of recent advances in atmospheric dynamics were given at the ICDM Symposium in Reading, August 1981, on 'The General Circulation of the Atmosphere I: Emphasis on the Mid-latitude Troposphere' which was held in conjuntion with the Third Scientific Assembly of IAMAP in Hamburg. This conference may become known as a landmark in meteorological research. The book is based on the invited review papers and several other major papers presented at the Symposium as well as additional review articles chosen to link the dynamics of the mid-latitude troposphere with other relevant areas.

Each chapter has a different author and addresses a different area, but they fit together remarkably well. The book is aimed at research workers and students familiar with basic texts on dynamical meteorology. Chapters on observational studies of large-scale atmospheric flow are carefully linked to relevant theoretical and numerical modelling studies, emphasising dynamical processes. Quasi-geostrophic theory is used as a basis for the analysis.

The first chapter serves as an introduction and provides background to the sections which follow by describing the typical features of the general circulation found in a diagnostic study of operational ECMWF global analyses. The importance of zonal variations of the circulation is highlighted. This is followed by a review of observational studies of the climatological mean stationary waves in the troposphere. The major features of the observed stationary wave pattern are presented and associated with orographic or thermal forcing mechanisms wherever possible. The observed low frequency variations (time-scales of about 10 days or longer) of the atmosphere are described next. They are shown to make a major contribution to the total atmospheric variance, as large as that on shorter time-scales due to baroclinic waves. These low-frequency variations have preferred geographical locations, well-defined horizontal structures resembling two-dimensional Rossby wave patterns and an equivalent barotropic vertical structure. A diagnostic study of the low frequency variability in a multi-annual experiment with a general circulation model shows very similar structures to those observed, even though there is no non-seasonal boundary forcing in the model. The internal dynamics of the GCM are able to generate realistic circulation anomalies.

These five chapters on observational and diagnostic studies are followed by two theoretical reviews. To complete the section on stationary and low frequency waves, a comprehensive review is given of the theory of stationary and quasi-stationary eddies in the mid-latitude troposphere. This uses a sequence of models of increasing complexity to describe the stationary wave patterns associated with large-scale orographic and thermal forcing. The next

chapter reviews the theory of short time-scale baroclinic eddies and their interaction with atmospheric flow on longer time-scales. The role of transient eddies in heat, momentum and vorticity transports in the general circulation is described with the possible parameterization of these transports in terms of the large-scale flow. The section on transient, baroclinic eddies is completed by a summary of observational analyses of these eddies in mid-latitudes and their interaction with the mean flow. The transient eddy heat fluxes have a dissipative effect on the time-mean flow whereas their momentum fluxes tend to enhance the time-mean flow. The net local effect appears to be dissipative.

To extend these studies of the dynamics of the mid-latitude troposphere, the next three chapters describe the three bounding regions. First, there is an observational and theoretical review of the large-scale structure of the tropical atmosphere and a discussion of possible tropical-extratropical interactions. Next, there is a review of the important features of the stratospheric circulation and their links to the troposphere. The final bounding region is the ocean and a review is given of the oceanic general circulation and its interaction with the atmosphere. This concentrates on heat transport in the oceans and inter-annual variations of sea surface temperature as the major areas of interaction with the atmosphere.

The last two chapters deal with the practical aspects and the theory of atmospheric predictability. Operational experience of medium range (up to 10 days) weather prediction with a global model at ECMWF is described. In general, three to four day forecasts for the northern hemisphere winter are good. A similar level of skill is achieved for the southern hemisphere with about one day shorter forecasts, but little skill is shown with tropical forecasts. The final chapter considers the inherent predictability of the atmosphere and the limits that this must place on extended-range numerical weather prediction.

This book is comprehensive, clear, well-presented and carefully edited. It is an essential addition to the bookshelves of any researcher interested in large-scale atmospheric circulation. However, it is not flawless. There are several editorial mistakes of minor importance. Perhaps of greater importance is the neglect of the role of 'physical' processes in the atmosphere, particularly radiation, and their interaction with large-scale dynamical processes. Also, attention in this book is focussed on several specific topics which may or may not prove to be of importance in future research and other topics may arise which prove to be of greater importance. One such possible topic is the baroclinic and barotropic instability of the time-mean zonally-varying flow, which may provide a unified description of low frequency variability and baroclinic waves.

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