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BOOK REVIEW

DYNAMICAL PALEOCLIMATOLOGY: GENERALIZED THEORY OF GLOBAL CLIMATE CHANGE, by Barry Saltzman, International Geophysics Series, vol. 80, Academic Press, San Diego, CA, 2001. No. of pages: xxix+354. Price US$69.95 (hardback). ISBN 0-12-617331-1.

This monograph uses the tools of applied mathematics to study the Earth's palaeoclimate. In this case, palaeoclimate is tightly defined as variability in the Earth-surface system with time scales between 1000 and 100 000 years. The main thrust of the work is the development and application of a box-type system model of palaeoclimate. In the process of model development, the author assesses much of the evidence for long-term variability and the theories that have previously been advanced to explain it. He also reviews, in a very readable manner, the areas of meteorology, oceanography, glaciology, biogeochemistry, geology and applied mathematics needed to build such a model. This then provides an approachable review of much of the palaeoclimate (and indeed Earth-surface processes) literature, which is constructed in a coherent, focused manner because of this emphasis on model development and extraction of the pertinent information from each field.

The book is separated into three sections. These are: an introduction, which concentrates on problem specification and outlines of the monograph's research rationale; a review of the separate disciplines that contribute to the study of long-term climate change; and, finally, the formulation and application of a 'unified dynamic' model based on the previous analysis.

The opening section of the book motivates the model development contained in the following sections. A theme introduced here, and that runs throughout the book, is the separation of climatic variability into 'climatic' and 'tectonic' averages, between which the palaeoclimate sits. The climatic average incorporates all processes of period less than 100 years (for instance, diurnal, annual and synoptic weather waves) and contains the atmosphere, upper ocean, sea ice and land surface. The tectonic average encompasses processes of period more than a million years (continental drift, tectonic activity and volcanic outgassing). This leaves the key slow-response components of the palaeoclimate system, namely the ice sheets, the deep ocean and the carbon cycle, together with its principal forcing by variation in the Earth's orbit (Milankovitch–Croll theory). The strength of this paradigm is that it is only the anomalies of the slow-response components from their tectonic averages that need to be integrated prognostically: the climatic-average processes (i.e. the atmosphere) can be diagnosed from these slow-response components. The chapter on dynamical systems analysis tailored to climate modelling is particularly useful, and helps place the analysis in the remainder of the book in context.

The middle section of the book reviews our understanding of the key components of the climate-system model. This section is impressive in its range, and covers the whole gamut of meteorology, oceanography, glaciology and biogeochemistry. All fields are considered at a good level of detail, although I would have welcomed more on the application of statistical-dynamical models of the atmosphere. The drive towards simplified box-type models is present throughout and motivates much of the discussion. This approach is justified by the argument that the net fluxes between system components that potentially drive long-term climate change (for instance, ice-sheet growth or changes in the thermohaline circulation) are far too small to be captured by the current generation of models of the three-dimensional circulation of the atmosphere, oceans and ice sheets. This is undoubtedly true and motivates the parameterization of these fluxes; however, it could be argued that this type of coupling does not preclude the use of three-dimensional circulation models.

Readers familiar with Professor Saltzman's recent work will be aware of the highly abstracted nature of the box-type models under discussion in the final section of the monograph. Without wishing to spoil the book's ending, the systems model implies that Ice Age cycles can be generated by a combination of carbon-cycle and ice-sheet feedbacks modulated by the weak forcing of orbital variations. This approach is particularly successful in explaining the contrasting nature of the Ice Age cycles (i) prior to 2.5 million years ago, (ii) between 2.5 and 0.9 million year ago, and (iii) after 0.9 million years ago. Though the implications of these findings are obviously interesting and important, I found that I had learnt more in travelling towards the goal of the unified dynamic model than in its final application.

This monograph represents a highly coherent and focused contribution to the literature on the Earth's long-term climate evolution. It offers the graduate research worker who is new to the field (with a certain level of mathematical training) an efficient introduction to its sprawling literature. It also presents a set of palaeoclimate-system models on which others will certainly build. These models would also, if programmed with the appropriate mathematical solvers and output displays, provide a very useful tool for the presentation of these concepts at an undergraduate level.

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