CLIMATE: PRESENT, PAST AND FUTURE

Volume 2

H. H. LAMB

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Climatic history and the future

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Preface

The first volume of this work was a product of the thinking about how climate is generated and, in particular, the role of the general circulation of the atmosphere and the oceans, which the writer had the opportunity to develop over fifteen years in the branches of the Meteorological Office concerned with world climatology and the development of long-range weather forecasting. Its ten main chapters were devoted to the fundamental observations and theory on the production of climate and its variability. The volume included the first publication in book form of a considerable body of forecasting rules – of British, German and Russian origin – applicable to the weather in Europe over a few months ahead, based on understanding of the seasonal development and tendencies in the atmospheric circulation and the influence of solar variation, volcanic activity, ocean surface temperature anomalies, and variations of the Arctic sea ice, and expressed in statistical terms.

The development of a capability of forecasting the prevailing weather character over the seasons ahead and the fluctuations or trend of climate over some years, and even over many decades, ahead is demanded by many practical planning needs of the age. Since Volume I was published the position has moved on in various ways.

The computer revolution in meteorology has made possible the identification of an enormous further number of statistically significant relationships connecting this, that and the other types of summer, winter, spring, autumn, January, etc., weather with various preconditions of the global atmospheric circulation, temperature and rainfall anomalies over many preceding months; but little or no improvement of the monthly and seasonal forecasts has resulted. Presumably, the explanation must lie in lack of recognition of the

physical processes and chains of causation which underlay the statistics of the past. Until these processes and the large-scale evolutions of the circulation of the atmosphere and oceans over the months involved are identified, many statistical relationships may be mistaken for independent indications of a particular forecast development (and all taken as giving added weight to the evidence for it) which are in reality only diverse features of a single process.

The successes achieved in Germany some decades ago by the pioneer of seasonal weather forecasting, Professor FRANZ BAUR, leave no doubt that the formulation of statistical rules which express real physical processes in the Earth and its fluid envelope, and in the surrounding universe (e.g. fluctuations of solar output and of tidal forces), is a valid method which has something to contribute to the solution of the problem of advising on future weather probabilities. Moreover, a probability statement is the form of advice on long-term weather prospects best adapted to planners who must assess the risks to their undertakings.

These years have also seen continued expansion of the effort, and the variety of approaches, put into mathematical modelling of the atmosphere and oceans, their dynamics and energy exchanges, etc., and the whole realm of climate. This promises great advances in our theoretical understanding and knowledge of the processes on every scale of time and space involved and of their interactions. The prospects of any specific forecast by these means is thought to be still remote, however, since there are as yet large percentage errors in many features of the present-day climatic average conditions calculated by the models. Nevertheless, the space relationships indicated are sufficiently realistic to make possible illuminating experiments on the consequences of introducing anomalies and changes at this or that place and time. The main practical contribution of such work so far has accordingly been in assessing the probable effects (and the geographical range of the effects) of various human activities and Man-made pollution, including local heat sources.

On the other side, the concern over the vulnerability of an ever increasingly overpopulated world, greedy for ever higher living standards, to climatic fluctuations affecting the total harvests and food supply increases yearly. This concern has been greatly stimulated by the droughts and floods and other weather extremes of recent years, starting with the colder winters in Europe and eastern North America in the 1960s (particularly 1962–3), and the Indian monsoon failures and droughts in the Soviet and Chinese grainlands in that decade and since. The drought which continued over many years in Africa just south of the Sahara brought a large-scale disaster in the Sahel and Ethiopia in 1972 and 1973, which caused mass migration and political upheaval, while the failures of the grain harvests in India and the Soviet Union in 1972 disrupted the world economy in foodstuffs.

The demand for sound advice on future climatic tendencies, particularly in such marginal areas (including also the Arctic fringe and the other arid regions of the Earth) is pressing. But no such advice can be given without both knowledge and understanding. There is great need therefore to pursue research aimed at (*a*) reconstructing the facts of the past

record of climate and (*b*) specifying the processes which produce climate and cause its fluctuations and changes. Without (*a*) climatology is in the position of a young science in which little laboratory work has been done to observe the facts of Nature's behaviour. The past record is also needed to test, calibrate and improve the theoretical models now being worked out in the mathematical laboratories. And those laboratories are needed to speed our progress with (*b*), without which the now growing welter of statistical results may only produce confusion.

There is also a pay-off in terms of the new light which this subject can shed on human history and on the problems of interpretation in all those sciences which are concerned with evidence of the past. It might be possible, were it not for the danger of arguing in a circle and the accusation of inventing climatic changes to explain the puzzles of history, to deduce the history of climate from the ups and downs of human affairs, the details of food prices and the like. But we can already glimpse a more satisfying outcome: so to establish the climatic record by firm physical evidence that it throws new light on causes in human history.

This is an exciting time, in which, after decades of neglect of climatology, new discoveries about the record of the past and the processes at work are being made, some of them rather easily. Most meteorologists seem hitherto to have been too readily convinced that the observations of more than about a century ago were too rough and unreliable to be worth investigating. The brilliant theorists and the advanced laboratories of meteorology today need to keep in touch with the quest for the facts of the past climatic sequence in which botanists, historians, isotope physicists and others are collaborating, in order to test and calibrate their models. If there is a danger of this being missed, it is for an honourable – but I believe insufficient – reason: a preference on the part of meteorologists for study of just those recent years in which the physical state and motion of the atmosphere in three dimensions, over the whole globe, can be most accurately and fully specified. The need remains, however, to observe the long-term processes which takes decades, centuries or millennia for their completion: they also have their sharp phases when abrupt shifts take place.

The bulk of this volume is devoted to presenting an outline of the past record of climate and the many types of evidence on which knowledge of it can now be built up. The author is acutely aware of his temerity in describing and discussing, however sketchily, the evidence and methods in such a great variety of fields of learning. It must have been impossible to do justice to them all and to the many advanced workers and work touched on. The excuse is that the subject needs such a base from which to advance. It will soon be impossible for one author or one book to survey it all. This work therefore is designed to serve as a necessary guidebook to the science of climatology and climate development at a time when it seems set for a great leap forward. The subject is fascinating for its diversity and touches nearly every aspect of our lives and environment. The need for advance to contribute to solving the pressing problems of the world-wide economy is very great.

It may be that some apology is needed, not only to various researchers whose work is inadequately presented, but also for a usage of terms that does not conform to current

practice in various branches of learning. The shock that is likely, for instance, to geologists in a different use of the words era, period, etc., and to the classicist and mathematician over different use of the word epoch, is explained by the difficulty inevitable in a work where the same stock of English words has to be used to cover intervals of time from the longest units of Earth history down to the shortest-lived atmospheric processes. The standard geological terminology is given in Table 1 in Appendix V.

The same Appendix is designed to provide an assembly of data, largely composed of some of the longest series of weather observation material and parameteorological or proxy data which appear in some way representative of the condition of global climate. These series, some of which are not yet well known and have not been readily accessible, may provide a source from which interrelationships as yet unknown may be detected.

The last two chapters and Appendix VI indicate the present position as regards understanding the effects of Man's activities and providing a forecasting capacity and some of the steps that are being taken, and should be taken, to cater better for the future.

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