CLIMATIC RECONSTRUCTION - A
SYNOPSIS OF METHODS AND DATA

by

N. A. Frazier

prepared for

Information Processing Techniques Office
Defense ADVANCED RESEARCH PROJECTS AGENCY
3701 N. Fairfax Dr.,
Arl., VA 22203

August 3, 1971

BATTELLE
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

FOREWORD

This study was supported by the Advanced Research Projects Agency under Contract No. F33657-71-C-0893, and was monitored by Mr. Rudy Black of the Nuclear Monitoring Research Office and LTC John Perry of the Information Processing Techniques Office.

TABLE OF CONTENTS

LIST OF TABLES

CLIMATIC RECONSTRUCTION - A SYNOPSIS OF METHODS AND DATA

by

N. A. Frazier

INTRODUCTION

The Advanced Research Projects Agency's NILE BLUE project is expected to provide computer capability required to improve computer models of world climate. As a complementary effort to NILE BLUE, ARPA initiated a short study whose purpose was to review existing data on and methods of determining climates which occurred less than about 15,000 years B.P. This report presents a summary of the results from that study*.

APPROACH

Data on past climates are an essential part of climatic prediction for verifying the results from computer models as well as being useful for specifying boundary conditions. As computer models become more sophisticated, testing of models over a range of climates is desirable. Several questions then arise including:

- At what times within the "reasonable" past did extremes in climate occur?
- Can one or more of these extremes be reconstructed in a sufficiently quantitative manner (climatic elements versus time versus area) to be useful to computer models of climate?
- What is meant by "sufficiently", i.e., in explicit terms what is needed for the models?
- Should attempts be made to reconstruct climates or establish climatic baselines before the advent of relatively recent weather records?

*A detailed verbal report with extensive graphic and tabular materials has been given to ARPA representatives. The decision at that meeting was to prepare this brief written summary of results.

Guided by these and other questions, work on past climates was sampled. Approximately 500 abstracts and 300 papers were assembled and make up the main information base for the study. A limited number of reports, reprints, and telephone contacts were other sources of information used. Although this sample constitutes only a small fraction of total literature available, the information base was selected during the screening of several thousand titles, cited references, and abstracts. Accordingly, the sample is believed to be representative of the types of information available, particularly with regard to the more quantitative data on past climates *vis-à-vis* NILE BLUE objectives.

Corollary subjects of climatic theories, investigations on cause-effect relations of climatic changes, certain aspects of continental drift and sea floor spreading, cyclic or pseudo-cyclic characters of climate, and climatic models, etc., were considered outside the scope of the study although some literature on these subjects was reviewed.

TERMINOLOGY

Past climates and climatic changes can be categorized in several ways. Critchfield(1)* used the following scheme:

(1) Historic time, including period of records

(2) Geochronology - several thousands of years in the past

(3) Paleoclimates - millions of years in the past.

For purposes here, the following terms and definitions apply:

(1) Climates of record (or recorded climates) - climatic data derived from weather records or other instrumentally acquired measurements

(2) Historical climates - climatic data deduced from man's writings on his activities and observations of events and phenomena (generally without the aid of instruments)

(3) Paleoclimates - climatic data on the geologic past indirectly derived from study and measurements of sediments, landforms, fossils, etc.

*References are given at the end of the report.

Evident in these terms, collectively, is a gross chronology with respective methods of investigation somewhat unique to each time period represented. Some overlap occurs because the definitions involve methods as well as gross time periods.

DESCRIPTION OF RESULTS

Characterization of Information on Past Climates

The information base was assembled in a series of iterative steps, each iteration guiding the next collection effort. Literature collected in each step was reviewed and then selectively synthesized into working sheets showing the investigator (first author), institution, key descriptors, time frame of data, area of work and methods/techniques. The working sheets resulting from the first two iterations and syntheses have been combined and given as Table A-1 (see Appendix)*.

Selected entries in Table A-1 were further reduced and rearranged to prepare Table A-2 (see Appendix)*, which grossly characterizes the areal distribution of sampled information on past climates.

Paleoclimatology

The number of sciences, disciplines, approaches, methods, etc., that are used in paleoclimatology is large. Any discussion of the subject will contain errors of omission or commission, dependent upon the eyes of the beholder. With no intent of either error, the following list is exemplary of subjects making up paleoclimatology.

Cultures/Archeology 10, 12, 54, 72**
Palynology 12, 40, 44, 54, 75, 84
Paleontology 14, 25, 26, 41, 56, 61, 64, 65, 69
Dendroclimatology 1, 23, 45, 77

*Reference numbers in Table A-1 are the same as those in Table A-2. These numbers refer to bibliographic entries in the total information base and are not to be confused with the references cited in this report.

**Numbers refer to literature examples cited in the references at the end of this report.

Dendrochronology 42, 50

Glaciology 11-13, 39-41, 43, 44, 46, 54, 62, 77

Geomorphology 8, 9, 13, 39, 40, 75

$^{18}O/^{16}O$

method 35, 66, 71

of speleothems 34, 48

of sulphates 73

of foraminiferal tests, etc., 20, 24, 27-29, 31, 33, 49, 52, 61, 64, 78

of ice cores, snow/firn 19-21, 36, 37, 47, 51

Amino acids 4, 5, 86

Insects 14

Sedimentation rates 4, 25, 31, 34, 41, 53, 65

Varves/varve chronology 3, 80, 83

Magnetic stratigraphy/chronology 15, 26, 53, 71

Isotope dating (particularly C14) 8-10, 48, 56, 72, 74, 87

Ice flow models for dating ice cores 19, 21, 37

Dendrochronological "calibration" of C14 dating 7, 18, 60, 81, 82, 85

Sea levels 8, 39, 40, 54, 68, 79

Sediments 43, 44, 65, 75

Astronomical (solar insolation) 8, 27, 28, 41

Generally speaking, the previous list is a mix of (1) methods for determining indicators of a paleoclimatic state or condition and (2) methods for determining the age or date (relative or absolute) of the indicators.

Examples of indicators are tree-ring indices, a plant community reconstructed from pollen spectra, assemblage of fossil shells (thanatocoenoses), coiling direction of foraminiferal spicas, $^{18}O/^{16}O$ of foraminiferal tests or ice core sample, red-bed sediments, glacial moraines, pluvials and strandlines, timber lines, etc. In Table I the previous listing has been rearranged to roughly demonstrate an array of types of paleoclimatic indicators versus the methods used for dating those indicators. By adapting, in one form or another, principles of uniformitarianism in combination with knowledge of relations among the indicators and modern climate, significant progress has been made in the study of paleoclimates. Truly remarkable is the extent of agreement among the various indicators of climate at global and relatively gross chronological scales.

TABLE 1. EXAMPLES OF PALEOCLIMATIC INDICATORS VERSUS DATING/AGE METHODS (RELATIVE OR ABSOLUTE)

Types of Paleo-climatic Indicators	Method for Determining Age/Date (Relative, Comparative, or Absolute) of Paleoclimatic Data										
	Isotope (Mainly C14)	Varve Chronology	Dendro-chronology	$^{18}O/^{16}O$ Variations	Ice Flow Models	Sedimentation Rates	Stratig-raphy	Amino Acids	Astrono-mical	Archeo-logical	Magnetic Stratigraphy
Palynological/ Botanical	X	X				X	X				
Paleontological	X	X				X	X	X			X
Dendroclimatological	X		X								
Glaciological	X	X					X				
Geomorphological	X	X					X				
Amino Acids (Shells)	X					X					X
$^{18}O/^{16}O$ Fossil Shells	X						X				
Speleothems	X					X					
Ice Cores				X	X						
Varves	X	X					X				
Cultures/Archeology	X						X		X	X	
Astronomical									X		
Sediments	X	X				X	X			X	X

However, the interpretations of and deductions from indicators of paleoclimates are not without the usual pitfalls that accompany drawing of conclusions from indirect evidence. Beaty[6] has most recently called attention to this point.

More definitive criteria than indicators and dates for appraising the status of paleoclimatology within the perspective of NILE BLUE are necessary. The criteria, given below, used in this study are concerned with the quantitative capability of paleoclimatic methods to perform one or more of the following functions:

(1) Determine the value of a climatic element

(2) Meet requirements of computer models for density and distribution of data on paleoclimates

(3) Determine the time interval represented by (1)

(4) Determine time interval between values of (1)

(5) Position (1) within a chronological (optimally an absolute) time scale

(6) Determine or specify a geographical area or location [represented by (1)]

(7) Apply standards to measurement methods (or be able to convert or relate data acquired by different methods)

(8) Assess errors, precision, uncertainties, accuracies and, in general, the validity of data.

A synopsis of the status of paleoclimatology with respect to these criteria is shown in Table 2.

The oxygen isotope method[35,66,71] ($^{18}O/^{16}O$) as a means for empirically determining paleotemperatures from foraminiferal tests in deep-sea cores[28,31,34] is in scientific limbo[20,24,33,49,61,64,71,78]. Variations in oxygen-18 content are at present viewed as indicators of warmer/cooler climatic changes whether from speleothems[48], ice cores[19-21,37,47,51], or foraminifera.

The capability for time resolution in variations of oxygen-18 content on younger samples from ice cores may be able to match computer model needs. The problems of converting these variations to temperature values would still remain. Also, geographical coverage would be limited to areas now covered by ice sheets.

Paleontological indicators of temperature, e.g., coiling direction and species counts, abundance, and ratios of foraminifera, involve questions of species tolerances and preferences of water temperature, salinity, and density. These indicators have been quite useful for studies of climatic warming and

TABLE 2. SYNOPSIS OF PALEOCLIMATOLOGY WITH RESPECT TO SELECTED EVALUATIVE CRITERIA

Criteria	Status of Paleoclimatology
(1) Value of climatic element	Generally qualitative, i.e., terms such as colder, warmer, dryer, wetter, more arid, etc., prevalent. Transitions from qualitative to quantitative involve uncertainties, scientific disagreements, and give results with large tolerances at present. Precise comparison of values difficult because it involves dry land, cave, ocean, and atmospheric conditions, temperatures, environments, etc.
(2) Density and distribution of data	Sparse within usual frame of reference. Areas of continental glaciation <u>relatively</u> well studied compared to other areas. Considerable work on mountain glaciation, near-surface "temperature" of oceans, etc. In general, very coarse coverage of continents, some major islands, and spotted oceanic areas.
(3) Time interval represented by values of climatic elements	Can range from near annual (tree rings, varves, variations of $^{18}O/^{16}O$ in younger parts of ice cores) through 100's into 1000's of years dependent upon sample thickness and sedimentation rates of bogs, marine sediments, etc. In general, time intervals very long compared to 5-, 10-, 20-, or even 50-year intervals of interest in climate prediction.
(4) Time interval between values of climatic elements	Can range from near annual to on the order of 10,000 years.
(5) Chronology and time scale for values of climatic elements	Depends on method. Statistical uncertainties in C14 ages often range up to ±1000 years with ±100 to 200 years common. Dendrochronological dates may be good to ±5 years. Dendrochronological calibration of C14 values limited by statistical uncertainties of C14 data. C14 dates may correspond to more than one calendar date because of variations in C14 content of atmosphere versus time.
(6) Geographical area or location represented by value of climatic element	Difficult to assess. Because of general agreement among "paleoclimatic models" over the entire globe, it can be concluded geographic area represented by values is basically global in extent or certainly very large in terms of square miles. Presumably, the very long sample-time intervals in combination with paleoclimatic methods mask the more local variations and character of climates.
(7) Standards in measurements	Standards and measurements not the limiting factor at present *vis a vis* computer models
(8) Errors, precision, accuracies, etc.	Instrumental precision and measurement statistics known in some detail. Accuracies of ages and climatic elements difficult to assess. Sources of error have been investigated.

cooling[25,26,61,64]. Palynological methods for determining temperature are subject to similar uncertainties.

The degree of racemization of amino acids in shells from sea and lake cores as a method for determining temperature is in very early research stages[5]. As a means for determining age, the method requires that paleotemperatures be known or assumed[4]. Data on total amino acids in seeds from lake sediments have been presented in much the same way as pollen spectra[86].

Statistically derived models for reconstructing paleoclimate from tree rings[45] are in an early stage of development and evaluation. The method is of great interest in that the climate reconstructed from tree-ring widths can be dated by dendrochronological methods. Application of the method could be limited to areas with trees whose growth rings meet certain requirements. Chronologically, the method would be limited to past climates whose time period is equal to or less than the age of trees that meet these requirements.

Chronology of paleoclimates poses a problem in time resolution. As a rough estimate absolute age determinations by C14 methods with dendrochronological calibration is probably between one and two orders of magnitude too gross if something representing 5-, 10-, or 20-year climatic means is needed. An exception to this is the chronology of dendroclimatic data.

Relative ages or, more precisely, differences in ages of samples from within a single deep-sea core, stratigraphic section, or bog, can be computed if sedimentation rates are known. Computation of the rates are, however, generally based on time intervals whose end ages are commonly dated by C14 or other isotope methods. Correlation of resultant climatic interpretations between widely separated areas could then present problems unique to "curve matching" because of the relatively coarse time resolution capability.

The general utility to NILE BLUE of current data on paleoclimatic elements would seem to be marginal. The prevalent characteristics of these data (e.g., qualitative descriptions and models of warmer/cooler or wetter/dryer) and the relatively gross resolution in the time scale (e.g., lengths of time such as hundreds to thousands of years represented within and between samples) would not seem to be commensurate with objectives of 5- to 20-year predictions of future climates, assuming adequate models and computer capability. Data are available on past sea levels, estimates of thickness of continental glaciers and other topics that would be of value to computer models. Final assessment of the utility of paleoclimatic data requires more precise delineation of NILE BLUE needs.

Historical Climatology

Methodologically, historical climatology was considered here as a study of climates that occurred between older paleoclimates and recent climates of instrumental record. This is, of course, an oversimplification because the climate of 800 B.P., for example, can be studied by methods of historical as well as paleoclimatology. Similarly, there is a time-scale overlap between the methods of climate of record and of historical climatology (e.g., the so-called Little Ice Age circa 400-100 B.P.) particularly before widespread use of meteorological instruments. For example, using regression equations based on data of record, Lamb, et al.[58], estimated 50-year averages (or greater) of rainfall in England and Wales back to 900 A.D., with some adjustments to fit botanical indicators. All of this serves to complicate the process of selecting the end dates of the climatic baseline(s) to be established.

Information on historical climatology would probably be the most laborious to collect. Immediately opened would be a Pandora's box of old newspapers, chronicles, personal diaries and journals, ships' logs, etc., all of which could contain information on wind direction, snow depth, appearance of first ice, date of first snowfall, clouds, floods, and on through the entire gamut of man's impressions and observations of weather phenomena. Scanning of references in Ludlum's book[63] illustrates this point quite vividly. Also involved would be phenological observations (e.g., Arakawa in Table A-I) from man's interest and activities in agriculture and horticulture. Archeological information is another important part in studies of historical climatology[10,72].

Climate of Record

The late 16th through the 17th century marks the introduction of barometers, rain gauges, and thermometers[17,57]. The date of the first known barometer/thermometer at Harvard College is 1728[63]. Lamb[57] has summarized the difficulties of using old records taken before about 1860 and calls attention to the large efforts required to convert these early data into homogeneous records. Implicit in Ludlum's[63] synthesis of information on American winters 1604-1820, a fantastically interesting book, is the laborious effort that was required to collect and use old records. Table A-I contains sources of data from early records noted in this survey. Generally, any dates after about 1700 given in Table A-2, an area summary of Table A-1, refer to instrumental records. No concerted effort was given to listing data for the 20th century. Collection and review of just the sources represented in the works of Landsberg[59], Lamb[57], Ludlum[63], and/or Mitchell[67] were soon discovered to be hopeless tasks within this study.

If, for purposes of NILE BLUE, the decision is made to establish a climatic baseline(s) using records, several issues need to be decided. These decisions are not straightforward because they involve optimization and tradeoffs among factors such as areal coverage (density and distribution of data), problems of continuity and homogeneity of data, time interval (e.g., 5, 10, or 20 years), time datums (e.g., 1780-1800, 1860-1870), and amplitudes and rates of climatic changes of most interest. People, such as Landsberg, Mitchell, and Lamb may be able to provide answers on the basis of their work. Otherwise, a considerable collection effort could be involved. In that event a computerized data base, capable of search and retrieval, for example, in Boolean combinations of the above factors as data fields would be highly desirable if not a necessity. Lack of ability to manipulate these data fields was a major drawback in this survey because of the bulk of information and the number of possible data field combinations. If established, the data base could then become the source of data to be reduced to climatic baselines.

DISCUSSION OF RESULTS

Vast amounts of information are available on past climates in myriad sources. Conclusions concerning the utility of that information to NILE BLUE cannot be drawn until the model and computer capability of NILE BLUE are transferred into a list of specific needs for data on past climates. Some interim impressions can be formulated within what are probably reasonable premises:

(1) Objectives relate to 5-, 10-, 20-, or perhaps as much as 50-year climatic predictions for areas on the order of 20,000 square miles or larger in geographical extent

(2) Computer capability to run global models to cover even the short time intervals in (1) will be marginal at best for the near future

(3) Very slow evolution in the refinement of models to permit 5- to 20-year predictions of reasonable accuracy

(4) Periods of climatic "extremes" in amplitude and/or rapidity of change are of interest; better than 50-year resolution in time interval for climatic baselines desired

(5) Evolution in computer and computer model capability will require review, revision, and updating of lists of needs for data on past climates, i.e., any list will reflect interim plateaus in capability and successive capability plateaus could cause changes in the utility of available information.

Available paleoclimatic data have served to define time periods of major paleoclimatic extremes, but the intervals of those periods are longer by 1 to 2 orders of magnitude than baseline intervals desired. Data typically indicate the direction or form of climatic change but not the scale of this change in the normal sense of climatic elements. Resolutions interpretable in terms of more local climates are the exception rather than the rule. Dependent on one's vantage point, the nature of paleoclimate data limits their present applicability to computer models, or limitations of computers and models presently preclude widespread use of available paleoclimatic data.

The status of historical climatological information is quite similar to that of paleoclimatology with the former having general superiority in time resolution and chronological accuracy by an order of magnitude. Uncertainties of converting indicators of historical climates to quantitative values are perhaps the chief technical constraint on the utility of historical climatic information relative to NILE BLUE. The impression from this study is that historical climates have not been studied in detail comparable to that of paleoclimatological studies.

Homogeneity of data is a problem for all climatic chronologies. It is perhaps more apparent in climate of record, particularly early records, perhaps because the data are quantitative and differences among data sets are relatively more discernible.

The labor involved in synthesizing existing records into a cohesive and consistent set of data is probably well reflected in some of the entries in Table A-1. Many authors who have worked with climate of record or historical climatology have limited their analyses to relatively short periods of time and limited areas geographically (on the basis of abstracts) in contrast to the hemispheric treatment over several decades.

As an example of the factors which complicate the use of relatively localized data analyses, it is probably naive to expect that the apparent occurrence of some climatic extreme in one region means that the global climate reflected the same extreme. Brief reflection on present climate suggests that a period of anomalous heat and drought in one area, for example, is accompanied by anomalous cold or excess precipitation elsewhere.

One problem is common to all climatic eras, i.e., the amount of literature and data sources. The distinct impression gained from this study is that one of the major obstacles in the study of past climates (e.g., before 1900) is the lack of a comprehensive data/information base whose data fields (area, time frame, method, etc.) can be rapidly and logically manipulated and searched in any of several needed combinations. If this impression is correct, the utility of data on past climates, whatever it might be, will not be realized by what amounts to laborious, but in reality piecemeal, collection efforts on the part of each person who sets out to study climate for a particular area and time. Some of these data could be of immediate value and others would be of marginal or no value to NILE BLUE efforts. However, their collection and study is certainly relevant to a much broader and equally important scope of research on past climates than has been treated in this study.

RECOMMENDATIONS

One definite conclusion from this study can be stated in the form of a recommendation to ARPA, viz., ARPA convene, or cause to be convened, a workshop on past climates. Invited participants, as few as possible, should represent investigators in each of the major methods used to generate data on past climates including dating and age determinations, and experts in meteorology/climatology, computers, and computer models. The chief question to be addressed by the participants should be: "Can a climatic baseline for some time interval in the past be established and, if so, what should the end dates of that time interval be?" From this question an agenda should be developed that will give rise to exchange among participants on the subjects discussed in this report, particularly the criteria listed in Table I, the premises in the previous section "Discussion of Results", and various aspects of collecting information and an information/data base.

Results to be expected from a workshop conference should be guidelines to ARPA for their decision whether to pursue climatic reconstruction for a certain period or periods in the past and designate possible research avenues, if any.

This conference would also give leaders in the methods of research on past climates an opportunity to hear what the leaders in computer models expect or need in the way of data. Conversely, the computer model people could hear what the researchers on past climates think can be achieved in the way of data on climates versus method and chronology.

ACKNOWLEDGEMENTS

The advice and counsel of H. Reiquam, P. Sticksel, E. Blosser, and R. Behn is gratefully acknowledged. Many thanks are also owed to H. Rawles and V. Holoman for their aid in collecting and screening the literature.

REFERENCE LIST

(1) Anon. 1967. *Tree rings and weather records.* NCAR Quarterly Fall 1967.

(2) Antevs, E. 1954. *Geochronology of the deglacial and neothermal ages: A reply. Telecorrelation of varves, radiocarbon chronology, and geology.* Journ. of Geol. 62: 516-521.

(3) Antevs, E. 1957. *Geological tests of the varve and radiocarbon chronologies.* Journ. of Geol. 65: 129-148.

(4) Bade, J. L., B. P. Luyendyk, and J. B. Maynard. 1970. *Marine sediments: Dating by the racemization method.* Science 170: 730-732.

(5) (a) Bade, J. L., and B. P. Luyendyk; (b) McKenna, M. C. *Route to Late Cenozoic temperature history.* Science 1971: 170:503.

(6) Beaty, C. R. 1971. *Climatic change: Some doubts.* Geol. Soc. of Am. Bull. 82(5): 1395-1404.

(7) Broecker, W. S., E. A. Olson, and J. Bird. 1959. *Radiocarbon measurements on samples of known age.* Nature 183(4675): 1582-84.

(8) Broecker, W. S. 1965. *Isotope geochemistry and the Pleistocene climatic record.* 737-753. In: The Quaternary of the United States. H. E. Wright, Jr., and D. G. Frey, Ed. Princeton University Press.

(9) Broecker, W. S., and A. Kaufman. 1965. *Radiocarbon chronology of Lake Lahontan and Lake Bonneville II, Great Basin.* Geol. Soc. of Am. Bull. 76: 537-566.

(10) Brothwell, D., and E. Higgs, Editors. 1963. *Science in archeology.* Basic Books, Inc. 595 pp.

(11) Bryson, R. A., W. M. Wendland, J. D. Ives, and J. T. Andrews. 1969. *Radiocarbon isochrones on the disintegration of Laurentide Ice Sheet.* Arctic and Alpine Research 1(1): 1-14.

(12) Bryson, R. A., D. A. Baerreis, and W. M. Wendland. 1970. *The character of late-glacial and post-glacial climatic changes 53-74.* Reprint from: Pleistocene and Recent environments of The Central Great Plains. Depart. of Geol. Univ. of Kansas Sp. Pub. 3. The University Press of Kansas.

(13) Charlesworth, J. K. 1957. *The Quaternary Era.* Vols. I & 2. Edward Arnold, Ltd. 1700 pp.

(14) Coope, G. R. 1965. *The value of Quaternary insect faunas in the interpretation of ancient ecology and climate.* Proc. 7th Cong. Internat'l. Assoc. Quat. Res. 7: 359-380.

(15) Cox, A. 1969. *Geomagnetic reversals.* Science 163: 237-245.

(16) Craig, H. 1961. *Standard for reporting concentrations of deuterium and oxygen-18 in natural waters.* Science 133: 1833-34.

(17) Critchfield, H. J. 1966. *General climatology.* Prentice Hall 2nd Edition. 420 pp.

(18) Damon, P. E., A. Long, and D. G. Grey. 1966. *Fluctuation of atmospheric C^{14} during the last six millenia.* Journ. of Geoph. Res. 71(4): 1055-63.

(19) Dansgaard, W., S. J. Johnsen, J. Møller, and C. C. Langway, Jr. 1969. *One thousand centuries of climatic record from Camp Century on the Greenland Ice Sheet.* Science 166(3903): 377-81.

(20) Dansgaard, W., and H. Tauber. 1969. *Glacier oxygen-18 content and Pleistocene ocean temperatures.* Science 166(3904): 499-502.

(21) Dansgaard, W., S. J. Johnsen, H. B. Clausen, and C. C. Langway, Jr. 1970. *Ice cores and paleoclimatology.* 337-351. In: See reference 72.

(22) Devereux, I. 1967. *Oxygen isotope paleotemperature measurements on New Zealand Tertiary fossils.* New Zealand Journ. of Sci. 10: 988-1011.

(23) Douglass, A. E. *Climate cycles and tree-growth.* Carnegie Institution of Washington Publication No. 289: Part I, 1919 127 pp; Part II, 1928 166 pp; Part III, 1936 171 pp.

(24) Duplessy, J. C., C. Lalou, and A. C. Vinot. 1970. *Differential isotopic fractionation in benthic foraminifera and paleotemperatures reassessed.* Science 168: 250-251.

(25) Ericson, D. B., M. Ewing, and G. Wollin. 1964. *The Pleistocene epoch in deep-sea sediments.* Science 146(3645): pp 723-732.

(26) Ericson, D. B., and G. Wollin. 1968. *Pleistocene climates and chronology in deep-sea sediments.* Science 162(3859): 1227-34.

(27) Eriksson, E. 1968. *Air-ocean-icecap interactions in relation to climatic fluctuations and glaciation cycles.* Meteorological Monographs 8(30): 68-92.

(28) Emiliani, C. 1955. *Pleistocene temperatures.* Journ. of Geol. 63(5): 538-578.

(29) Emiliani, C. 1963. *The significance of deep-sea cores 99-107.* In: See reference 10.

(30) Emiliani, C. 1964. *Paleotemperature analysis of the Caribbean cores A 254-BR-C and CP-28.* Geol. Soc. of Am. Bull. 75: 129-44.

(31) Emiliani, C. 1966. *Paleotemperature analysis of Caribbean cores P 6304-8 and P 6304-9 and A generalized temperature curve for the past 425,000 years.* Journ. of Geol. 74(2): 109-126.

(32) Emiliani, C. 1966. *Isotopic paleotemperatures.* Science 154(3751): 851-857.

(33) Emiliani, C. 1970. *Pleistocene paleotemperatures.* Science 168: 822-25.

(34) Emiliani, C. 1971. *The last interglacial: Paleotemperatures and chronology.* Science: 171: 571-73.

(35) Epstein, S., R. Buchsbaum, H. Lowenstam, and H. C. Urey. 1951. *Carbonate-water isotopic temperature scale.* Geol. Soc. of Am. Bull. 62: 417-25. *Revised carbonate-water isotopic temperature scale.* 1953. *Ibid.* 64: 1315-25.

(36) Epstein, S., and R. P. Sharp. 1959. *Oxygen isotope studies.* Trans. Am. Geop. Union 40(1): 81-84.

(37) Epstein, S., R. P. Sharp, and A. J. Gow. 1970. *Antarctic Ice Sheet: Stable isotope analysis of Byrd Station cores and inter-hemispheric climatic implications.* Science 168: 1570-72.

(38) Fairbridge, R. W. Editor of Conference. 1961. *Solar variations, climatic change, and related geophysical problems.* Annals of the N. Y. Acad. of Sci. 95(Art.1): 740 pp. F. N. Furness, Editor.

(39) Fairbridge, R. W. 1961. *Convergence of evidence on climatic change and ice ages.* Annals of N. Y. Acad. of Sci. 95(Art.1): 542-579.

(40) Fairbridge, R. H. 1968. *Holocene, postglacial or Recent Epoch.* 525-36. In: Encyl. of Geomorph. 1968. R. W. Fairbridge, Editor. Reinhold Book Corp. 1295 pp.

(41) Fairbridge, R. H. 1968. *Quaternary Period.* 912-931. In: Encycl. of Geomorph. R. H. Fairbridge, Editor. Reinhold Book Corp. 1295 pp.

(42) Ferguson, C. W. 1970. *Dendrochronology of bristlecone pine, Pinus aristata Establishment of a 7484-year chronology in the White Mountains of eastern-central California, U.S.A.* 237-259. In: See reference 72.

(43) Flint, R. F. 1961. *Geological evidence of cold climates.* 140-155. In: See reference 70.

(44) Flint, R. F., and F. Brandtner. 1961. *Outline of climatic fluctuation since the last interglacial age.* Annals of N. Y. Acad. of Sci. 95(Art.1): 457-460.

(45) Fritts, H. C., T. J. Blasing, B. P. Hayden, and J. E. Kutzbach. 1970. *Multivariate techniques for specifying tree-growth and climate relationships and for reconstructing anomalies in paleoclimates.* Final report to ESSA contract E-41-70(N) on project: Dendroclimatic history of the United States.

(46) Goldthwait, R. P. *Evidence from Alaskan glaciers of major climatic changes.* 40-53. In: See reference 76.

(47) Gonfiantini, R., V. Togliatti, E. Tongiori, W. De Breuck, and E. Picciotto. 1963. *Snow stratigraphy and oxygen isotope variations in the glaciological pit of King Baudouin Station, Queen Maud Land, Antarctica.* Journ. of Geoph. Res. 68(13): 3791-98.

(48) Handy, C. H. 1970. *The use of C^{14} in the study of cave processes.* 419-443. In: See reference 72.

(49) Hoefs, J., and M. Sarnthein. 1971. *$^{18}O/^{16}O$ ratios and related temperatures of recent pteropod shells (Cavolinia longirostris LEUSUER) from the Persian Gulf.* Marine Geology 10: M11-M16.

(50) Huber, B. 1970. *Dendrochronology of Central Europe.* 233-236. In: See reference 72.

(51) Johnson, S. J., W. Dansgaard, H. B. Clausen, and C. C. Langway. 1970. *Climatic oscillations 1200-2000 AD.* Nature 227(5257): 482-83.

(52) Keith, M. L., and R. H. Parker. 1965. *Local variation of ^{13}C and ^{18}O content of mollusk shells and the relatively minor temperature effect in marginal marine environments.* Marine Geology 3: 115-29.

(53) Kennett, J. P., N. D. Watkins, and P. Vella. 1971. *Paleomagnetic chronology of Pliocene-early Pleistocene climates and the Plio-Pleistocene boundary in New Zealand.* Science 171: 276-79.

(54) Klein, R. G. 1971. *The Pleistocene prehistory of Siberia.* Quaternary Research 1: 133-161.

(55) Krinsley, D. B. 1970. *A geomorphological and paleoclimatological study of the playas of Iran.* Prepared by USGS for AFCRL report AFCRL-70-0503, Part I pp 1-329; Part II pp 329-485. U. S. Gov't Printing Office.

(56) Ku, T., and W. S. Broecker. 1966. *Atlantic deep-sea stratigraphy: Extension of absolute chronology to 320,000 years.* Science 151: 448-50.

(57) Lamb, H. H. 1966. *The changing climate.* Methuen & Co., Ltd. 236 pp.

(58) Lamb, H. H., R. P. W. Lewis, and A. Woodroffe. *Atmospheric circulation and the main climatic variables between 8000 and 0 B.C.: Meteorological evidence.* 174-217. In: See reference 76.

(59) Landsberg, H. E., C. S. Yu, and L. Huang. 1968. *Preliminary reconstruction of a long time series of climatic data for the Eastern United States. Report No. 3 on a project studying climatic changes.* Univ. of Maryland, Inst. for Fluid Dynamics and Applied Mathematics Tech. Note BN-751. 30 pp.

(60) Lerman, J. C., W. G. Mook, and J. C. Vogel. 1970. *C14 in tree rings from different localities.* 275-301. In: See reference 72.

(61) Lidz, B., A. Kehrn, and H. Miller. 1968. *Depth habitats of pelagic foraminifera during the Pleistocene.* Nature 217: 245-247.

(62) Lliboutry, L. A. 1970. *Current trends in glaciology.* Earth Science Review 6(3): 141-167.

(63) Ludlum, D. M. 1966. *Early American winters 1604-1820.* American Meteorological Society. 285 pp.

(64) Lynts, G. W., and J. B. Judd. 1971. *Late Pleistocene paleotemperatures at Tongue of the Ocean, Bahamas.* Science 171: 1143-1144.

(65) Margolis, S. V., and J. B. Kennett. 1970. *Antarctic glaciation during the Tertiary recorded in sub-Antarctic deep-sea cores.* Science 170: 1085-1087.

(66) McCrea, J. M. 1950. *On the isotopic chemistry of carbonates and a paleotemperature scale.* Journ. of Chem. Physics 18(6): 849-857.

(67) Mitchell, J. M., Jr. 1961. *Recent secular changes of global temperature.* Annals of N. Y. Acad. of Sci. 95(Art.1): 235-250.

(68) Moran, J. M., and R. A. Bryson. 1969. *The contribution of Laurentide ice wastage to the eustatic rise of sea level.* Arctic and Alpine Research 1(2): 97-104.

(69) Mörner, N. 1971. *Subdivision of the late glacial and postglacial sediments of the Kattegatt Sea.* Marine Geology 10: M17-M19.

(70) Nairn, A. E. M., Editor. 1961. *Descriptive paleoclimatology.* Interscience Publishers. 380 pp.

(71) Nairn, A. E. M., and N. Thorley. 1961. *The application of geophysics to paleoclimatology.* 156-181. In: See reference 70.

(72) Olsson, I. U., Editor. 1970. *Radiocarbon variations and absolute chronology.* Nobel Symposium 12. J. Wiley and Sons. 652 pp.

(73) Rafter, T. A., and Y. Mizutani. 1967. *Oxygen isotopic composition of sulphates - part 2.* New Zealand Journ. of Sci. 10: 816-39.

(74) Ralph, E. K., and H. N. Michael. 1970. *MASCA radiocarbon dates for sequoia and bristlecone-pine samples.* 619-23. In: See reference 72.

(75) Rampton, V. 1971. *Late Quaternary vegetational and climatic history of the Snag-Klutan area, southwestern Yukon Territory, Canada.* Geol. Soc. of Am. Bull. 82: 959-978.

(76) Royal Meteorological Society, Publisher. *World climate from 8000 to 0 B.C.* Proceedings of the International Symposium held at Imperial College, London, 18 and 19 April 1966. 229 pp.

(77) Schove, D. J. 1961. *Tree rings and climatic chronology*. Annals of N. Y. Acad. of Sci. 95(Art.1): 605-622.

(78) Shackleton, N. 1967. *Oxygen isotope analyses and Pleistocene temperatures re-assessed*. Nature 215: 15-17.

(79) Shepard, F. P. 1963. *Submarine geology*. Harper and Row. 557 pp.

(80) Stuiver, M. 1970. *Long term C14 variations*. 197-213. In: See reference 72.

(81) Suess, H. E. 1965. *Secular variations of the cosmic-ray-produced carbon 14 in the atmosphere and their interpretations*. Journ. of Geoph. Res. 70(23): 5937-52.

(82) Suess, H. E. 1970. *Bristlecone-pine calibration of the radiocarbon time-scale 5800 B.C. to the present*. 303-309. In: See reference 72.

(83) Tauber, H. 1970. *The Scandinavian varve chronology and C14 dating*. 171-96. In: See reference 55.

(84) Terasmae, J. 1961. *Notes on Late-Quaternary climatic changes in Canada*. Annals of N. Y. Acad. of Sci. 95(Art.1): 658-671.

(85) Walton, A., and M. S. Baxter. 1968. *Calibration of the radiocarbon time scale*. Nature 220(5166): 475-76.

(86) Wright, H. E., Jr. *Stratigraphy of lake sediments and the precision of the paleoclimatic record*. 157-173. In: See reference 76.

(87) Zavel'skiy, F. S. 1968. *Further refinement of the radiocarbon method*. Translation: Doklady of the Academy of Sciences USSR (Earth Sciences Section) Vol. 180: 82-85. American Geological Institute.

APPENDIX

TABLES A-1 AND A-2

TABLE A-1. EXAMPLES OF INFORMATION ON PAST CLIMATES (BY INVESTIGATOR)

Reference/Name		Facility	Descriptors	Time Frame	Area	Technique/Basic Data
1	--	--	Temperature, climatic fluctuations	0-5000 B.P.	China	Instr./history
3	Addicott, W. O.	U.S.G.S.	Temperature trends/ changes	Tertiary	Marginal N.E. Pacific Ocean	Molluscan fauna
4	Alisov, B. P.	Moscow Univ.	Summer temperature	1954-1965 A.D.	Moscow environs	Instr.
7	Arakawa, H.	Met. Res. Inst., Tokyo	Climate changes	7-20th century	Japan	Phenology/records
8	Armillas, P.	State Univ. of N.Y.	Arid frontiers	5-16th century	Mexico	Agricultural/ archeology
9	Aseev, A. A.	Inst. of Geogr., U.S.S.R.	Paleotemperature of ground/air layer	?	R.S.F.S.R., Valdai Glacier	From shape of glacier shield
373	Ashbel, D.	Hebrew Univ.	Climate elements and floods	1925 and later	Israel	Instr.
10	Auer, V.	Helsinki Univ.	Climate variations	Pleist./post-Pleist.	S.A./Patagonia	?
4A	Baker, D. G.	Univ. of Minn.	Temperature trends	1819-1958 A.D.	Minnesota	Instr.
375	Barry, R. G.	Univ. of Colo.	Long-term precipitation trends	Records and history	Europe, Omaha, Sydney	Instr./history
17	Barusseau, J. P.	France ?	Paleoclimate	Quaternary	Gulf of Lion	Sea cores/micro-paleo, sediment.
20	Bean, L. H.	Virginia ?	Rainfall	1830-1961 A.D.	Nebraska	Instr.
30	Blake, I.	England	Climate	7000-3000 B.C.	Palestine	Archeology/human settlement
379	Block, M. R.	Negev Inst. for Arid Res.	Eustatic sea-level changes	0-5000 B.P.	Global ?	Historical
32	Boiarskoia, T. D.	Moscow	Climate	Pleistocene	E. and W. U.S.S.R.	Vegetation

TABLE A-1. (Continued)

Reference/Name	Facility	Descriptors	Time Frame	Area	Technique/Basic Data
381 Bolli, H. M.	?	Temperature	Pliocene and later	Caribbean sea core	Isotopic data/ foraminifera ?
36 Bonatti, E.	Inst. Mar. Sci., Italy	Climate	2000-26,000 B.P.	S. Europe/Medit.	Pollen, fauna, C14 dating
37 Borisov, A. A.	U.S.S.R.	Mean annual temperature and precipitation/climate	Paleozoic/ Cenozoic	Polar/mid/south latitudes of U.S.S.R.	?
383 Borisov, A. A.	Leningr. Univ.	Paleoclimates	Cenozoic stressed	U.S.S.R.	?
384 Borisov, A. A.	Leningr. Univ.	Temperature and floods	1700's to present	Leningrad	Instr./history (says instr. back to 1725 in U.S.S.R.)
39 Borisov, A. A.	U.S.S.R.	Mean annual temperature; radiation, circulation; climate trends; CO_2; cloud cover	Various geol. periods	U.S.S.R.	?
38 Borisov, P. M.	Inst. of Geog., U.S.S.R.	Reconstructed paleoclimates (for model prediction)	Holocene, et al.	Global ?	Paleogeographic
40 Borns, H. W., Jr.	Ohio State Univ.	Climatic changes	0-10,000 B.P.	S.W. Yukon Can.	Glaciology (some C14 dating)
385 Bowen, R. N. C.	Pittsburgh Univ.	Temperature/climate	Devonian to Holocene	?	Isotope ratio
386 Boyko, H.	Israel	Climatic features	2000 B.P.	S.W. Asia	Literary sources
42 Broecker, W. S.	Lamont Geol. Obs.	Chronology and climate	0-150,000 B.P.	?	Isotope geochemistry
43 Broecker, W. S.	Lamont Geol. Obs.	Insolation, temperature, sea level	0-150,000 B.P.	Atlantic Ocean	Astron. and isotope analysis
6A Broecker, W. S.	Lamont Geol. Obs.	Pluvial chronology	Wisconsin/post Wisconsin	Oregon and Utah	C14 dating and geological
44 Brunk, I. W.	U.S.W.B.	Climatic data	1830-1840 A.D.	E. United States	Instr. ?

TABLE A-1. (Continued)

Reference/Name		Facility	Descriptors	Time Frame	Area	Techniques/Basic Data
389	Bryson, R. A.	Univ. of Wisc.	Climatic patterns (fronts, air masses, upper-air pattern)	At intervals back to 13,000 B.P.	Central/Northern N. America	Biotic boundaries
8A	Bryson, R. A.	Univ. of Wisc.	Climate patterns; C14 isochrones of Laurentian ice retreat	At intervals back to 13,000 B.P.	Central/Northern N. America	Biotic boundaries; glaciology, C14 dating
46	Buchinskii, I. E.	Ukr.S.R. Hydromet. Inst.	Temperature, precipitation	0-150 yrs B.C.	Ukraine, U.S.S.R.	Instr.
47	Buchinskii, I. E.	Ukr.S.R. Hydromet. Inst.	Temperature, precipitation, 10-, 20-, 30-yr values	?	Ukraine, U. S.S.R.	Instr. (?)
390	Buchinskii, I. E.	Ukr.S.R. Hydromet. Inst.	5-, 10-yr, monthly temperature and precipitation	1921-1964 A.D.	Kiev, Ukraine, U.S.S.R.	Instr.
49	Budyko, M. I.	U.S.S.R., Main Geoph. Obs.	Climatic conditions/ changes	Geologic past	?	?
51	Budyko, M. I.	U.S.S.R., Main Geoph. Obs.	100-yr temperature variations, solar radiation	?	?	?
53	Budyko, M. I.	U.S.S.R., Main Geoph. Obs.	Numerical model	Various geologic ages	?	?
54	Budyko, M. I.	U.S.S.R., Main Geoph. Obs.	Climatic changes	Recent and geologic	?	Suggestions on future climate
56	Buisonjé, P. H.	Netherlands	Climatic and sea-level change	Quaternary	Netherlands Leeward Islands	Marine terraces, paleoecology, etc.
62	Butzer, K. W.	Univ. of Wisc.	Rainfall distribution	5000-2000 B.C.	Sahara	Archeology
63	Chebotarevo, N. S.	U.S.S.R.	Boundary zones of last glaciation	Pleistocene	U.S.S.R.	--
392	Cherniakova, A. P.	U.S.S.R. Hydrom. Service	Temperature	1900-1960 A.D.	Black Sea Coast	Instr.
68	Cita, M. B.	Milan Univ.	Climatic fluctuations	Würm and later ?	Adriatic Sea	Planktonic forams (sea cores)

TABLE A-1. (Continued)

Reference/Name		Facility	Descriptors	Time Frame	Area	Technique/Basic Data
69	Clark, J. A.	England	Winter climatic changes	?	Britain	Instr. (temperature), paleontology, history
72	Colinvaux, P. A.	Ohio State Univ.	Temperature change	Late glacial to present	St. Lawrence Isl., Alaska	Pollen-lacrustine core
74	Conolly, J. R.	Sydney Univ.	Temperature trends	6000-17,000 B.P.	Indian Ocean of S.W. Australia	Planktonic foram
394	Conover, J. H.	A.F.C.R.L.	Temperature trends	1820-1960 A.D.	N.E. United States	Instr.
75	Coope, G. R.	Birmingham Univ.	Climate	Sangamon to post-glacial	Britain; Scandinavia	Insect assemblages
395	Chu, P. H.	Nanking Univ.	Air circulation	1873-1960 A.D.	Far East; N.W. Pacific	Regional wind indices
81	Cushing, E. J.	Univ. of Minn.	Climate changes (temperature ?)	10,000-15,000 C14 yrs B.P.	Minnesota	Pollen stratigraphy
396	Damiean, G.	?	Rainfall	1888-1960	Belgian Congo; Africa	Instr. and lake levels
12A	Damon, P. E.	Univ. of Arizona	Atmospheric C14 variation	0-6000 B.P.	--	Dated tree rings
83	Damon, P. E.	Univ. of Arizona	C14 and climate (review)	Christian era	--	Tree rings; varves; C14
85	Dansgaard, W.	Univ. of Copenhagen	Temperature changes	0-100,000 yrs B.P.	Greenland	Ice core/oxygen isotopes
14A	Dansgaard, W.	Univ. of Copenhagen	Temperature changes	0-100,000 yrs B.P.	Greenland (global correlation)	Ice core/oxygen isotopes; dating by ice-flow model
15A	Dansgaard, W.	Univ. of Copenhagen	Questions Emiliani's paleotemperature	0-425,000 yrs B.P.	Atlantic and Caribbean Sea cores	Factors affecting oxygen isotope ratios in foraminifera
89	Davis, M. B.	Univ. of Mich.	Climate/vegetation zones	Pleistocene and later	N.E. United States	Phytogeography/ palynology

TABLE A-1. (Continued)

Reference/Name		Facility	Descriptors	Time Frame	Area	Technique/Basic Data
90	Davis, M. B.	Univ. of Mich.	Climate/vegetation zones	10,000-12,000 B.P.	N.E. United States/ Great Lakes region	Pollen assemblages
91	Davis, M. B.	Univ. of Mich.	Climate	0-12,000 B.P.	Connecticut	Pollen
92	Davis, N. E.	England	Summer weather/temperature	1880-1961	N.W. Europe and England	Indices (instr. ?)
94	Dettwiler, J.	France	Climate changes	1650-1950 A.D.	?	Instr./history
16A	Devereux, I.	New Zealand	Temperature curves	Eocene to Pliocene	New Zealand	Oxygen isotope/foram and polyzoa
16A-1	Devereux, I.	New Zealand	$^{18}O/^{16}O$ and inferred sea temperature	Pliocene-early Pleistocene	North Island, New Zealand	600-meter sediment section; oxygen isotopes/foraminifera, species counts and sinistral coiling; no dating (see Kennett, J. P.)
95	Dightman, R. A.	U.S.W.B.	Temperature and precipitation	c. 1780-1965 A.D.	Montana and Connecticut	Instr.
96	Dinies, E.	W. Germany	Severe winters - air pressure and circulation	1870-1965 A.D.	Central Europe	Instr. and solar processes
97	Dolgoshov, V. I.	U.S.S.R.	Phenology and climate variations	1906-1915; 1931-1940 A.D.	R.S.F.S.R.	Instr.?
100	Donahue, J. G.	Lamont Geol. Obs.	Climatic fluctuations	U. Pleist. to recent	S. Pacific Ocean	Diatoms in 10 sea cores
397	Dort, W., Jr.	Univ. of Kansas	Cave temperature	Late Wisconsin ?	Idaho (cave)	Limestone/thermoluminescence
17A	Duplessy, J. C.	C.N.R.S., France	Temperature (questions Emiliani work)	Quaternary	Atlantic Ocean/ Charcot Seamount	Sea core/oxygen isotope/foraminifera (questions paleotemperature results)

TABLE A-1. (Continued)

Reference/Name		Facility	Descriptors	Time Frame	Area	Technique/Basic Data
106	Duplessy, J. C.	C.N.R.S., France	Temperature variations	130,000-90,000 B.P.	France (cave)	Uranium dating; oxygen isotopes
398	Drogaitsev, D. A.	U.S.S.R.	Mean air temperature	1940-1967 A.D. (28 Januaries)	21 regions U.S.S.R.	Instr.
399	Dzerdzeevskii, V. L.	Inst. of Geog., U.S.S.R.	Air temperature, circulation, precipitation, pressure	1899-1955 A.D.	N. Hemisphere	Instr. (forecasting objectives)
107	Dzerdzeevskii, V. L.	Inst. of Geog., U.S.S.R.	Air circulation ?	1900-present A.D.	?	(Forecasts made as early as 1952)
18A	Emiliani, C.	Univ. of Chicago	Temperature vs depth from top of cores; generalized curve of temperature vs yrs B.P.	0-300,000 B.P.	North and Central Atlantic; E. Central Pacific; Caribbean (global correlations)	12 deep sea cores/ foraminifera/ oxygen isotopes (dates by sedimentation rates with C14, ionium, and uranium dating control); correlation with European and N. American glacial stages/stratigraphy
19A	Emiliani, C.	Univ. of Miami	Temperature (see above)	Extends 0-300,000 B.P. curve (see above) to 375,000 B.P.	Caribbean	2 deep sea cores/ see above + direction of coiling, species ratios correlation (C14 and Pa/Th dating control)
20A	Emiliani, C.	Univ. of Miami	Temperature	Extends 0-375,000 B.P. curve (see above) to 425,000 B.P.	Caribbean	2 deep sea cores (see above)
22A-1	Emiliani, C.	Univ. of Miami	$^{18}O/^{16}O$ and $^{13}C/^{12}C$ of 27-meter section	Pliocene-Pleistocene	S. Italy	Oxygen and carbon isotopes of 63 samples

TABLE A-1. (Continued)

Reference/Name	Facility	Descriptors	Time Frame	Area	Technique/Basic Data
22A-2 Emiliani, C.	Univ. of Miami	Generalized temperature curves	0-140,000 B.P.	Caribbean-equatorial Atlantic, N. Atlantic, Medit. cores; New Zealand and France speleothems	Sea cores and speleothems; C14 and Th/Pa dating; oxygen isotopes
400 Emiliani, C.	Univ. of Miami	Temperature	0-175,000 B.P.	See above	Review of isotope techniques to confirm previous results
23A Epstein, E.	C.I.T.	Snow and firn $^{18}O/^{16}O$ variations vs depth	--	Greenland; Antartica	Oxygen isotopes
24A Epstein, E.	C.I.T.	$^{18}O/^{16}O$	0-100,000 B.P.	Antarctic (Byrd Station)	Ice core/oxygen isotopes; age computed from ice-flow model
25A Ericson, D. B.	--	Temperature change (qualitative) vs time and depth from top of cores	0-1.5 x 10^6 yrs B.P.	Caribbean and Atlantic Ocean 23°N to 29°S	26 deep-sea cores/foraminifera-species counts, direction of coiling; dating - C14, Pa/ionium, and Pa control and sedimentation rates (correlation with European and N. American glacial/interglacial stages)
110 Ericson, D. B.	Lamont Geol. Obs.	Temperature change ? (qualitative)	0-2 x 10^6 yrs B.P.	Caribbean and Atlantic Ocean 17°N to 29°S; 9 of 10 sea cores same as 25A above	10 sea cores/foraminifera-coiling direction, ratio of species numbers to weight of 74 micrometer fraction; C14 and other radioisotope dating; magnetic polarization of cores and correlation of foram climate zones, glacial stages with dating by magnetic field reversal chronology; redefines Pliocene-Pleistocene boundary

TABLE A-1. (Continued)

Reference/Name		Facility	Descriptors	Time Frame	Area	Technique/Basic Data
111	Ericson, D. B.	Lamont Geol. Obs.	Pleistocene climate	Pleistocene	Atlantic and Pacific Oceans	Sea cores/ foraminifera
116	Fomina, T. V.	U.S.S.R.	Air temperature/ abnormal winters	c. 1910-1960 A.D.	Sea of Azov	Instr.
118	Frank, A. H. E.	Univ. of Amsterd.	Würm climate	Würm	Central Italy	Pollen stratigraphy Lake of Vico
119	Frenzel, B.	Bot. Inst., W. Germany	Climate change	Atlantic/sub-boreal	N. Hemisphere	Palynology (compilation ?)
403	Frenzel, B.	--	Climate variations	Pleistocene	Global	Review and compilation
120	Fritts, H. C.	Univ. of Ariz.	Climate change/ dendroclimatology	1500-1940 A.D.	Arizona, Colorado	Dendrochronology
121	Fritts, H. C.	Univ. of Ariz.	Climate change/ dendroclimatology	1500-1940 A.D. ?	Western N. America (Arizona, Colorado ?)	Dendrochronology
122	Fritts, H. C.	Univ. of Ariz.	Climate change/ dendroclimatology	1860-1962 A.D.	N. Arizona	Dendrochronology
123-125	Fritts, H. C.	Univ. of Ariz.	Dendrochronology	--	--	Review and analysis of technique
126-127	Frodigh, R. J.	U. S. Army/ Natick	Military implications of environmental change	Present	N. England landscapes	Time-lapse photography
129-130	Fukui, E.	Japan ?	Secular movement of climate areas	--	E. Asia and N. Pacific	Köppen classification
128	Frolov, V.	U.S.S.R.	Climatic components of 200 and 400 yrs	?	N. America	Dendroclimatology
132	Galmarini, A. G.	Argentina	Temperature/evaporation	Historical	Patagonia	Instr./pluviometric/ temperature
134	Gedeonov, A. D.	Main Geoph. Obs., U.S.S.R.	Climate fluctuations/ monthly mean temperature for January	1881-1967 A.D.	N. Hemisphere	Instr.

TABLE A-1. (Continued)

Reference/Name		Facility	Descriptors	Time Frame	Area	Technique/Basic Data
404	Giovinetto, M. B.	U.C. - Berkeley	Contains data on sea-level change	Last 100 yrs	--	--
138	Goldthwait, R. P.	Ohio State Univ.	Climate variations	7800 B.C. and later	Alaska	Glaciology/continental glaciers; some C14 dating
142	Grichuk, V. P.	Inst. of Geog., U.S.S.R.	Climate reconstruction/precipitation, temperature	5500 B.P.	N. Hemisphere	20 paleobotany profiles with C14 dating
145	Grünhagen, H.	W. Germany ?	Climate fluctuations and forecasting, temperature and precipitation	At intervals from present to late glacial	?	Beginning of instr. to present; model applied up to 365,000 B.C. and to Ice Age beginning
151	Harris, G.	Univ. of Leicaster	Temperature and precipitation	1860 and later	N. Hemisphere stations	Instr.
152	Haude, W.	W. Germany ?	Dead Sea water balance and precipitation	1800 and later	Jerusalem, Dead Sea	Instr. and historical
153	Hela, I.	Inst. Mar. Res., Finland	Climatic periodicities	1866-1965 A.D.	N. Europe	100 yrs of data
154	Hendy, C. H.	New Zealand	Temperature ?	Last glacial cycle	New Zealand	Oxygen isotopes of calcite deposited on speleothems
155	Heusser, C. J.	Am. Geog. Soc.	Climate	Pleistocene	Wash. State	Palynology with C14 dating
156-157	Heusser, C. J.	Am. Geog. Soc.	Climate and temperature trends	Pleistocene and later	W. United States, Pacific Northwest, Chile	Compilation from botanical and glacial studies
406	Hlavac, V.	Czechoslovakia	Temperature/monthly, annual 5- and 10-year means	1771-1965	Prague	Homogeneous temperature series
162	Hosking, K. J.	England	Temperature, precipitation, sunshine	1918-1968 A.D.	Isle of Wight (S. Eng.)	Instr.

TABLE A-1. (Continued)

Reference/Name		Facility	Descriptors	Time Frame	Area	Technique/Basic Data
407	Hoyanagi, M.	Tokyo Met. Univ.	Summary of climate research in Japan	--	--	--
164	Huber, B.	Germany	Periodicity of tree-ring widths	1300 ? A.D. and later	Central Europe ?	Dendrochronology
165	Hughes, G. H.	England	Poulter's index/temperature, precipitation/sunshine	Summers 1902-1966	Manchester, Eng.	Instr.
408	Hupfer, P.	Karl Marx Univ.	Days of ice, air and sea temperature	Intervals 1903-1963 A.D.	Baltic Sea	Instr.
166	Iakovleva, N. I.	Main Geoph. Obs., U.S.S.R.	Mean annual ice state, water temperature anomalies/periodicity	1890's A.D. and later	Barents Sea and N. Atlantic	Observ. and instr. ? (references to U.S. data)
29A	Johnsen, S. J.	Univ. of Copenhagen	Climatic oscillations/spectral analysis	1200-2000 A.D.	Greenland	Ice core/oxygen isotopes; ice-flow model for dating
175	Julian, P. R.	N.C.A.R.	Tree-ring chronologies	?	Colorado	Tree rings and Weather Bureau data
412	Keil, K.	W. Germany ?	Temperature fluctuations/Jan. and July means	1781-1810 A.D.; 1735-1964 A.D.	Hohenspeissenberg	Instr. ?
30A	Keith, M. L.	Penn. State Univ.	$^{18}O/^{16}O$	Present	Near-shore Gulf Coast marginal environments	Oxygen isotopes/modern mollusk shells; concludes cannot be used for paleotemperature in marginal marine environments
30A-1	Kennett, J. P.	Univ. of Rh. Isl.	$^{18}O/^{16}O$ and inferred temperature	$1.61-3.32 \times 10^6$ yrs B.P. (Pliocene/Pleist.) (Paleomagnetic chronology).	North Isl., New Zealand	Oxygen isotopes and abundance of foram; magnetic-field polarity dating and correlation ($^{18}O/^{16}O$ and microfossil data from work of Devereux, et al.); Plio-Pleistocene boundary defined; paleomagnetic dating from 3 cores at each of 61 sites

TABLE A-1. (Continued)

Reference/Name		Facility	Descriptors	Time Frame	Area	Technique/Basic Data
414	Koneck, M.	Czechoslovakia	Temperature/climate fluctuations	1851-1965 A.D.	Bratislava	Instr.
185	Kosminskii, V. V.	U.S.S.R.	Climate reconstruction/ air masses/pressure maps	Paleocene and Neocene	Kazakhstan and Central Asia	Lithochemical, mineralogical, paleontological
186	Kossowska, U.	Warsaw Univ.	Meteorological elements	17th century A.D. and later	Warsaw	Continuous observations in Warsaw since 1825
189	Kostin, S. I.	U.S.S.R.	Climatic fluctuations/ humidity variations/?	0-4000 yrs B.P.	--	Lake silt deposits/ historical/instr.? correlation with pollen, hydrological, glaciological
194	Ku, T.	Lamont Geol. Obs.	Climate chronology/warm and cold periods	0-320,000	Caribbean	Sea core/^{230}Th dating (one of same cores used by Ericson, et al., for foraminifera studies of climate and sedimentation rates); confirms sedimentation rates
196	Labeyrie, J.	France	Warm and cold periods	6500 yrs B.P. and later	Cave in France	Oxygen isotopes/ stalagmite; C14 dating; C14 content of atmosphere; growth of stalagmite
198-210 and 416, 417	Lamb, H. H.	Met. Off. England	Probably the best single source for climate reconstruction and identification of data sources for historical times and early instrumental observations; particularly strong for W. Europe; refers to Manley's work on monthly mean temperature from thermometer observations in lowlands of central England from 1680; charts of general patterns in large areas of N. Hemisphere for July 6500, 4000, 2000, and 500 B.C.; average m.s.l. pressure Jan. and July 1830-1839, and Jan. 1790-1829; decade values of indices of summer wetness/dryness and winter mildness/severity from 1100 to 1950's A.D. at 3 European longitudes (0°, 12°, 35°E); sea surface temperature deviations (N. and S. Atlantic) 1780-1820 from 1887-1899, 1921-1938 (Rennell's 1780-1820 values)			
212	Landsberg, H. E.	Univ. of Maryland	Reconstruction of climate	1738 A.D.-present	E. United States/ Philadelphia	Records; synthetic series constructed for Philadelphia

TABLE A-1. (Continued)

Reference/Name		Facility	Descriptors	Time Frame	Area	Technique/Basic Data
418	Langway, C. C., Jr.	U.S. C.R.R.E.L.	Climate changes	Back to 934 A.D. at least	Greenland	Ice-core stratigraphy oxygen isotopes
419	Lawrence, E. N.	Met. Off. England	Temperature change	1920-1968 A.D.	London, S.E. England	Instr.
420	Lee, G.	Univ. of Wisc.	Climate changes	900-1400 A.D.	Iowa	Fresh-water clams/Ca, Mg, Sr content (feasibility study)
215	Lenke, W.	Deutsch. Wett.	Historical climate	End of 16th and beginning of 17th century A.D.	Austria, Sweden, Netherlands	Observations of Tycho de Brahe
421	LeRoy, L. E.	France	Historical climates	1000 A.D. and later	N. Hemisphere	Indirect methods: climatic data for 990-1200 A.D. and 1490-1700 A.D. summarized in folded chart
422	Lidz, L.	Univ. of Miami	Temperature oscillations	Pleistocene ?	Caribbean	Foraminiferal abundances in sea core
424	Ludlum, D. M.	U.S. ?	Historical winters	1604-1820 A.D.	E. and N.W. United States	Said to be an exhaustive search of chronicles, newspapers, manuscripts, etc.; results of 15 years of searching libraries and archives
425	Mackay, J. R.	Univ. of Brit. Col.	Climatic changes	Postglacial	Mackenzie Delta, Can.	Pollen from peat deposits and their indirect methods; C14 control of dating pollen results
426	Martinov, M.	Bulgaria ?	Temperature and precipitation	1900-1966 A.D. (Jan., Feb., and Mar.)	Bulgaria	Instr.

TABLE A-1. (Continued)

Reference/Name		Facility	Descriptors	Time Frame	Area	Technique/Basic Data
429	Milankovitch, M.	Translation of Milankovtich's 1941 work titled *Canon of Insolation and the Ice Age Problem*				
236-241	Mitchell, J. M.	U.S.W.B. and E.S.S.A. (N.D.A.A.)	Papers on stochastic models, theoretical paleoclimatology, climatic periodicities, etc.			
242	Mitchell, V. L.	Univ. of Wisc.	Dendroclimatology	--	Central Canada	Tree-ring index series and factor analysis
247	Muratova, M. V.	U.S.S.R.	Contains data on allowable temperature intervals for tree species in palynological analysis			
253	Neustadt, M. I.	Inst. of Geog., U.S.S.R.	Holocene	12,000 B.P. and later	European U.S.S.R.	Peat-bog stratigraphy and C14 dating
255, 433	Nichols, H.	Univ. of Wisc.	Climate changes	6000 B.P. and later	Keewatin and Manitoba, Canada	Macrofossil and palynology evidence from peat; C14 dating
434	Olausson, E.	Oc. Inst. Sweden	Warm and cool phases (and paleotemperatures ?)	Pleistocene and later ?	North and Central Atlantic; Medit.; N. Am.-W. Europ. Basin	Sea cores/oxygen isotopes/foraminifera
272	Panov, D. G.	U.S.S.R.	Empirical equation for paleotemperatures; temperature maps and cryoisotherms for Jan. and July	Last glacial age	Europe	?
270	Pejml, K.	Czechoslovakia ?	Climatic fluctuations	16th and 17th centuries A.D.	Bohemia, Czechoslovakia	Entries in old city chronicles
279	Pinna, M.	Italy ?	Historic climate changes	0-7000 B.P.	?	Instr., historic, botanical, etc.
440	Polozova, L. G.	U.S.S.R.	Temperature trends	1901-1940 A.D.	?	Instr. ?
285	Rima, A.	Italy ?	Periodicity of winter climate	1215-1916 A.D.	W. Europe	Instr. and historical (based on C. Easton's series of winters)

TABLE A-1. (Continued)

Reference/Name		Facility	Descriptors	Time Frame	Area	Technique/Basic Data
287	Rodewald, M.	W. Germany ?	Temperature deviations	1875-1950	W. Greenland	Instr. (data from H. Rudolf's work on climate in Europe since beginning of instrumental observation in 1670)
290	Rudakov, V. E.	U.S.S.R.	Dendroclimatology/ aridity/precipitation	14th century A.D. and later	Central Asia and polar Urals	Mathematical methods for obtaining qualitative meteorological conditions and quantitative values of precipitation; history of dendro-chronology in U.S.S.R.
444	Rüge, U.	W. Germany ?	Literature survey of climate changes	17th century A.D. and later	Global	Instr. ?
445	Salteil, -	?	Precipitation	19th and 20 centuries A.D.	Israel	Instr. ?
446	Savina, S. S.	U.S.S.R.	Radiation balance and precipitation	1906-1915; 1931-1940 A.D.	W. Siberia; Eur., U.S.S.R.	Instr.
298	Schorringa, M.	Netherlands ?	Temperature and precipitation	c. 1650-1960 A.D.	Netherlands	Instr. and historical ?
299	Schorringa, M.	Netherlands ?	Temperature and precipitation	1868-1968 A.D.	De Bilt, Netherlands	Instr.
300, 301	Schönwiese, D. C.	Munich	Power spectra of temperature, pre-cipitation and pressure/climatic period	?	Germany	No apparent connection with tree-ring spectra
447	Schove, D. J.	England	Barometric anomalies	1796 A.D. and later	Indian Oc. area stations	Instr. correlations with Nile data, Java tree rings

TABLE A-1. (Continued)

Reference/Name		Facility	Descriptors	Time Frame	Area	Technique/Basic Data
448	Schwarzback, M.	Univ. of Cologne	Book on paleoclimates and paleoclimatology	?	--	Contains maps, charts, records, etc. (not described in abstract)
306	Sergin, S. Ya.	U.S.S.R.	Mathematical model of climate processes/long-term intervals	--	--	Numerical results
307	Sergin, V. Ya.	U.S.S.R.	Cybernetic theory applied to system earth's surface-atmosph.	--	--	Computer results on fluctuations
309, 43A	Shackleton, N.	Cambridge Univ.	Questions Lidz's paleo-temperature/ $^{18}O/^{16}O$ results with foraminifera	--	--	Habitat of foraminifera may be water-density dependent (water in glacial ice) rather than temperature dependent
451	Sinitsyn, V. M.	U.S.S.R.	Climatic maps/isotherms; precipitation and temperature	Paleogene and Neogene	Eurasia	Indirect methods
314	Skarzynska, K.	Poland	Reconstruction of precipitation, runoff, and evaporation	2500 ? B.P. and later	Poland	Pollen, vegetation, and other indirect methods
316	Smith, C. G.	England	Winter temperature	1816-1968 A.D.	Oxford, England	Instr.
317	Smith, L. P.	England	Temperature and precipitation	100 sample yrs	Britain	Instr.
454	Staszewski, J.	Poland	Isotherm map	1853 A.D.	Global	Instr. (consideration of R. Wiszniewski's map dated 1853)
455	Stehli, F. G.	W. Res. Univ.	Technique for ancient ocean current system	--	--	Quadric surface fitted to foraminifera data
456	Stuchlik, F.	Poland ?	Forecasting based on long period measurements	States Prague has observ. for 200 yrs	--	--

TABLE A-1. (Continued)

Reference/Name		Facility	Descriptors	Time Frame	Area	Technique/Basic Data
457	Stuiver, M.	Yale Univ.	Atm. C14 variations and extent	0-10,000 yrs B.P.	Cokes in Conn. Africa, and Formosa	Sedimentation rates dated by C14 with tree-ring corrections
45A	Suess, H. E.	U.C. - San Diego	"Calibration" of C14 time scale; C14 variations in atmosphere	0-2000 B.P.	--	C14 content of dated tree rings; empirical relationship C14 age and true age
326	Suess, H. E.	U.C. - San Diego	C14 and climate correlation	8000 B.P. and later	--	--
327	Sũkan, B.	Istanbul	Temperature and precipitation	1912-1960 A.D.	Istanbul	Instr.
336	Thomas, M. K.	Canada	Temperature and precipitation	Past century	Canadian prairies	Instr.
339	Troshkina, E. E.	Moscow State Univ.	Temperature and precipitation	c. 1850 A.D. - 1965	Mt. Elbrus and Caucasus Mts.	Instr.
461	Valnicek, B.	Czechoslovakia	Winter temperature	200 yrs of measurements	Prague	Instr.
345	Van Andel, T.	Scripps	Climates	Quaternary	Timor Sea, N.W. Australia	Sediment facies and C14 dating
346	Van Dan Heuvel, E.	Netherlands ?	Sea temperature variation	300,000 B.P. and later	?	Emiliani methods (foraminifera abundance and oxygen isotopes ?); graph showing sea temperature variations
355	Wahl, E. W.	Univ. of Wisc.	Climatic data	1830's and 1840's A.D.	E. United States	Comparison with current normals
362	Whitehead, D. R.	Univ. of Ind.	Climate and vegetation zones	Pleistocene	S.E. United States	Vegetation and C14 dating
363	Whitehead, D. R.	Williams Coll., Mass.	Climate and vegetation zones	Pleistocene	Unglaciated Eastern N. America	Palynology and phytogeography

TABLE A-1. (Continued)

Reference/Name		Facility	Descriptors	Time Frame	Area	Technique/Basic Data
468	Willet, H. C.	M.I.T.	Climate cycles	?	Western Plains, N. America	Climatic records
365	Wilson, A. T.	New Zealand	Climate change	1200 yrs ago	Lake Vanda, Antarctica	Profiles of current temperature and salinity; diffusion equations (with assumptions) used to date change
366	Wiseman, J. D. H.	Brit. Museum	Sea temperature variations (qualit.)	U. Pleist. and later	Tropical Atlantic	Sea core/foraminifera/oxygen isotopes/$CaCO_3$ sedimentation rates (questions Emiliani's results)
469	Wood, J. D.	Scotland ?	Climate analysis	1814-1816 A.D.	Dumfriesshire, Scotland	Meteorological records
369	Yamamoto, T.	Japan	Climatic variations, circulation patterns, sunspots	200 yrs of records	N. Hemisphere; Far East	200 yrs of records
471	Zerchi, M.	Germany	Winter temperature	1849 A.D. - present	--	Instr.

TABLE A-2. EXAMPLES OF INFORMATION ON PAST CLIMATES (BY AREA)

Adriatic Sea

- 68) ≥Würm

Africa

- 62) Sahara
5-2K B.C.
- 396) Belg. Congo
1888-1960
- 457) A lake
0-10K B.P.

Antarctica

- 24A) Byrd
0-100K B.P.
- 365) Lake Vanda
>1750

Asia

- 1) China
0-2000 B.P.
- 7) Japan
7-20 cent.
- 373) Israel
>1925
- 30) Palestine
7-3K B.C.
- 32) W. U.S.S.R.
Pleist.
- 37) U.S.S.R.
Paleoz.-Cenoz.
- 383) U.S.S.R.
Cenoz.
- 39) U.S.S.R.
Geolog. ?
- 386) S.W. Asia
≥2000 B.P.
- 63) U.S.S.R.
≥Pleist.
- 395) Far East
1873-1960

Asia (Cont'd.)

- 152) Israel
≥1800
- 185) Cen. Asia
Paleoc., Neoc.
- 185) Kazakh.
Paleoc., Neoc.
- 199) 0-100K B.P.
- 290) Cen. Asia
≥1400
- 445) Israel
1800's-1960's
- 446) W. Siberia
1906-1915,
1931-1940
- 447) Indian Oc.
Area
>1796
- 451) Paleog.,
Neog.
- 457) Formosa
0-10K B.P.
- 327) Istanbul
1912-1960
- 369) Far East
200 yrs of
records

Atlantic Ocean

- 43) ≥150K B.P.
- 15A) 0-450K B.P.
- 17A) W. Eur.
Basin
Quat.
- 18A) N. and Cen.
0-300K B.P.
- 400) Equator.
0-175K B.P.
- 22A-2) 0-140K B.P.
- 25A) Mid-Atl.
0-1.5M B.P.

Atlantic Ocean (Cont'd.)

- 110) Mid-Atl.
0-2M B.P.
- 111) Pleist.
- 166) N. Atl.
≥1890
- 200) ≥1780
- 434) N. Atl.
≥Pleist.
- 434) Cen. Atl.
≥Pleist.
- 434) W. Eur.
Basin
≥Pleist.
- 366) Tropical
≥U. Pleist.

Australia

- 375) Sydney
R and H

Canada

- 40) S. W. Yukon
0-10K B.P.
- 42A-1) S. W. Yukon
0-31K B.P.
- 425) Mack. Delta
>Wisc.
- 255) Keewatin
≥6000 B.P.
- 255) Manitoba
≥6000 B.P.
- 336) >1850

Caribbean Sea

- 381) ≥Pliocene
- 14A) 0-100K B.P.
- 15A) 0-450K B.P.
- 18A) 0-300K B.P.

Caribbean Sea (Cont'd.)

- 19A) 0-375K B.P.
- 20A) 0-425K B.P.
- 25A) 0-1.5M B.P.
- 110A) 0-2M B.P.
- 119A) 0-320K B.P.
- 422) Pleist. ?

Europe

- 4) Moscow
1954-1965
- 9) R.S.F.S.R.
Recent ?
- 375) R and H
- 17) France ?
Quat.
- 32) E. U.S.S.R.
Pleist.
- 36) S. Eur./Med.
2-26K B.P.
- 37) U.S.S.R.
Paleoz.-Cenoz.
- 383) U.S.S.R.
Cenoz.
- 384) Leningr.
1700-1960
- 39) U.S.S.R.
Geolog. ?
- 46) Ukraine
0-150 B.P.
- 47) Ukraine
?
- 390) Kiev, U.S.S.R.
1921-1964
- 63) U.S.S.R.
≥Pleist.
- 392) Black Sea
Coast
1900-1960

Europe (Cont'd.)

- 69) Britain
?
- 75) Britain
≥Sangamon
- 75) Scandinavia
≥Sangamon
- 14A) Netherl.
0-80K B.P.
- 92) N.W. Eur.
1880-1961
- 92) England
1870-1961
- 96) Cen. Eur.
1870-1965
- 97) R.S.F.S.R.
1906-1915;
1931-1940
- 1106) France
130-70K B.P.
- 398) U.S.S.R.
1940-1967
- 22A-2) Italy
Plio.-Pleist.
boundary
- 116) Azov Sea,
U.S.S.R.
1910-1960
- 118) Italy
Würm
- 153) N. Eur.
1866-1965
- 406) Prague
1771-1965
- 162) S. Eng.
1918-1968
- 164) Cen. Eur.
≥1300
- 165) Manch., Eng.
1902-1966
- 408) Baltic Area
1903-1963

TABLE A-2. (Continued)

Europe (Cont'd.)

- 412) Hohen. Germ. 1810-?, 1935-1964
- 414) Bratislava 1851-1965
- 186) Warsaw >1700
- 189) Karelia, U.S.S.R. 0-4K B.P.
- 196) France ≥6500 B.P.
- 199) 0-100K B.P.
- 299-1) S. W. Germ. >875
- 299-1) N. Switz. >875
- 300-01) W. Germ. Records
- 451) Paleog., Neog.
- 314) Poland >2500 B.P.
- 316) Oxford, Eng. 1816-1968
- 317) Britain 100 yrs of records
- 456) Prague 200 yrs of records
- 45A) Germ. 0-2000 B.P.
- 326) >8000 B.P.
- 339) Caucasus 1850-1965
- 461) Prague 200 yrs of records
- 469) Dumf., Scot. 1814-1816

Europe (Cont'd.)

- 471) Schwerin Dist., Germ. ≥1849
- 200) ≥6500 B. C.
- 203) England ≥1200
- 204) Britain ≥15K B.P.
- 205) England ≥10K B.P.
- 207) Cen. Eur. 1759-1959
- 208) ≥1300
- 209) Britain ≥1100
- 210) England ≥1680
- 419) S. E. Eng. 1920-1968
- 215) Austria ≥1650, <1750
- 215) Sweden >1650, <1750
- 215) Netherl. >1650, <1750
- 426) Bulgaria 1900-1966
- 253) U.S.S.R.
- 270) Bohemia >1500, <1700
- 272) Last glacial
- 285) W. Eur. 1215-1916
- 290) Polar Urals ≥1400
- 446) U.S.S.R. 1906-1915, 1931-1940
- 298) Netherl. 1740-1961

Europe (Cont'd.)

- 299) DeBilt, Netherl. 1868-1968

Global

- 379) 0-500 B.P.
- 38) Holocene
- 12A) 0-6K B.P.
- 83) ≥0 A.D.
- 403) Pleist.
- 199) 0-100K B.P.
- 203) ≥1200
- 444) ≥1700
- 454) 1853

Greenland

- 85) Camp Cent. 0-100K B.P.
- 14A) Camp Cent. 0-100K B.P.
- 29A) 1200-2000
- 418) ≥900's
- 287) W. Green. 1875-1950

Indian Ocean

- 74) Off S. W. Austr. 6-17K B.P.

Mediterranean Sea

- 22A-2) 0-13K B.P.
- 434) ≥Pleist.

Mexico

- 8) 600's-1500's

N. Zealand

- 16A) Eoc.-Plio.
- 16A-1) Plio.- Lower Pleist.
- 154) Last glacial cycle
- 30A-1) N. Isl., 1.6-3.3M B.P.

N. America

- 389) Can./N. ≥13K B.P.
- 8A) Can./N. ≥13K B.P.
- 121) Western 1500-1940 ?
- 156) Pacific N.W. ≥Pleist.
- 157) Pacific N.W. ≥Pleist.
- 346) >300K B.P.
- 468) W. Plains ?

N. Hemisphere

- 399) 1899-1955
- 119) Post-glacial
- 134) 1881-1967
- 142) 5500 B.P.
- 151) ≥1860
- 199) 0-100K B.P.
- 200) ≥1700
- 208) ≥1300
- 421) ≥1000
- 369) 200 yrs of records

Pacific Ocean

- 3) Marg. N.E. Tertiary
- 395) N.W. Pac. 1873-1960
- 100) S. Pac. Oc. ≥U. Pleist.
- 18A) E. Central 0-300K B.P.
- 111) Pleist.

S. America

- 10) Patagonia ≥Pleist.
- 132) Patagonia Historical
- 156) Chile ≥Pleist.
- 157) Chile ≥Pleist.

U. S.

- 375) Omaha R and H
- 20) Nebraska 1870-1961
- 4A) Minn. 1819-1958
- 6A) Oregon ≥Pleist.
- 6A) Utah ≥Pleist.
- 44) E. U.S. 1830's-1840's
- 72) St. Lawr. Isl., Alaska ≥Wisc.
- 394) N.E. U.S. 1820-1960
- 81) Minn. 10-15K B.P.

TABLE A-2. (Continued)

U. S. (Cont'd.)

- 89) N.E. U.S. $\geq$Pleist.
- 90) N.E. U.S. 10-12K B.P.
- 90) Grt. Lakes Reg. 10-12K B.P.
- 91) Conn. 0-12K B.P.
- 95) Montana 1780-1965
- 95) Conn. 1780-1965
- 97) Idaho Late Wisc.
- 120) Arizona 1500-1940
- 120) Colorado 1500-1940
- 122) N. Arizona 1860-1962
- 138) Alaska $\geq$7800 B.C.
- 139) Wash. St. Pleist.
- 156) Western $\geq$Pleist.
- 157) Western $\geq$Pleist.
- 175) Colorado Records ?
- 212) Philadel. 1738-1960's
- 212) E. U.S. 1738-1960's
- 420) Iowa 900-1400
- 424) E. U.S. 1604-1820
- 424) N.W. U.S. 1604-1820

U. S. (Cont'd.)

- 457) Conn. 0-10K B.P.
- 45A) W. U.S. 0-2000 B.P.
- 355) E. U.S. 1830's-1840's
- 362) S.E. U.S. Pleist.
- 363) S.E. U.S. Pleist.

Other

- 56) Netherl. Leeward Islands Quat.
- 408) Baltic Sea 1903-1963
- 166) Barents Sea $\geq$1890
- 345) Timor Sea Quat.

?

- 385) Dev.-Holo.
- 42) $\geq$150K B.P. Atl. Oc. ?
- 49) Geol. past
- 94) 1650-1950
- 107) 1900-present
- 279) 0-7K B.P.
- 440) 1901-1940

Note: M = 10^6 yrs; K = 10^3 yrs; > = after; < = before.