ARID ZONE RESEARCH

Ecological Study of the Mediterranean Zone

BIOCLIMATIC MAP OF THE MEDITERRANEAN ZONE

Explanatory Notes

UNESCO — FAO

ARID ZONE RESEARCH — XXI

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XIII. *Medicinal plants of the arid zones*
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XVI. *Plant-water relationships in arid and semi-arid conditions. Proceedings of the Madrid Symposium/Échanges hydriques des plantes en milieu aride ou semi-aride. Actes du colloque de Madrid/Intercambios hidricos de las plantas en medios áridos y semiáridos. Actas del coloquio celebrado en Madrid*
XVII. *A history of land use in arid regions*
XVIII. *The problems of the arid zone. Proceedings of the Paris Symposium*
XIX. *Nomades et nomadisme au Sahara*
XX. *Changes of climates with special reference to arid zones. Proceedings of the Unesco/WMO symposium held in Rome/Les changements de climat notamment dans la zone aride. Actes du colloque de Rome organisé par l'Unesco et l'OMM*
XXI. *Bioclimatic map of the Mediterranean zone*

The reviews of research are published with a yellow cover; the proceedings of the symposia with a grey cover.

Ecological Study of the Mediterranean Zone

BIOCLIMATIC MAP OF THE MEDITERRANEAN ZONE

Explanatory Notes

U N E S C O — F A O

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CONTENTS

INTRODUCTION

This survey of ecological situations in the Mediterranean zone, involving the preparation of a 1/5,000,000 map and explanatory notes of the bioclimates and the vegetation respectively for a belt running from Morocco to the Indus and 1/10,000,000 maps of bioclimates in other parts of the world arose out of international conversations which require recapitulating here before the method adopted is described.

At its first session (Rome, 1948), one of the main questions before the Sub-Commission for the Co-ordination of Mediterranean Forestry Problems of the Food and Agriculture Organization (FAO) was defining the countries to be included in its operations. The outcome was, firstly, realization that the countries with Mediterranean-type ecologies but located outside the Mediterranean basin should participate, and secondly, the definition of the true Mediterranean or 'eumediterranean' region and the regions of transition from Mediterranean to other types of climate and vegetation.

The Sub-Commission further examined possible methods for effecting internal subdivisions in either type of region and concluded that the best would be the ecological method which brings in the essential factors in environment, namely climate, soil and vegetation, and by presenting them in context should make it possible to see what parts of the world had environmental conditions producing analogous biological results and thus put attempts at introducing valuable new species in general and another for afforestation in particular on a scientific footing.

In the later sessions, the Sub-Commission continued with the question of making a map of the ecological situation and accumulated a quantity of information on vegetation, soils and climates, but felt that an outline map of Mediterranean climate boundaries was needed at once. Accordingly the sixth session, held in Madrid in 1958, approved a map delimiting the 'eumediterranean' and transitional regions produced by a working party under the chairmanship of Mr. de Philippis (Italy) with Mr. Gaussen (France) as rapporteur.

This showed the Secretariat of the Sub-Commission firstly that the material sent in was neither sufficient in quantity nor homogeneous enough for the full ecological mapping recommended, and secondly that an intergovernmental working party was ill-suited to discuss so technical a subject, and persuaded it that it would be preferable to commit the preparation of such a map to a small team of experts. Furthermore, it was becoming obvious that the project was not merely of interest to the forestry sector but also bore on other technical and scientific sectors. In particular it tied in with the activities of Unesco on the systematic study of arid and semi-arid parts of North Africa, the Middle East and South Asia and of FAO under its Mediterranean Development Project.

Accordingly the Secretariat of the FAO Sub-Commission contacted the Secretariat of the Unesco Advisory Committee on Arid Zone Research and after an initial exchange of views, the directors of the FAO Forest Division and of the Unesco Department of Natural Sciences agreed terms for the ecological studies suggested by the Sub-Commission to be deemed a common project of both organizations, as their collaboration was likely to facilitate the relations of the team of experts appointed by the Sub-Commission with the other scientific circles interested in the project while for the Advisory Committee on Arid Zone Research, the study of the regions of transition between the Mediterranean and desert climates was of prime importance.

Both bodies having approved the negotiations between their respective secretariats, Professor Emberger of the Faculty of Science of the University of Montpellier (France) and Mr. Kassas of the Faculty of Science of the University of Cairo (Egypt) were nominated by Unesco and Professor de Philippis, of the Faculty of Agriculture and Forestry of the University of Florence (Italy) and Professor Gaussen of the Faculty of Science of the University of Toulouse (France) by FAO to undertake the preparation of a general 'ecological map' of the Mediterranean zone. Accordingly a working party consisting of the experts named plus Messrs. Batisse and Fontaine representing Unesco and FAO respectively met at Unesco House, Paris, in January 1959 to lay down objectives to be achieved by preparing a map of this kind, define the basic criteria to be obeyed, examine the material available and determine what more needed to be collected, and to agree the symbols and manner of cartographic representation to be used.

The Working Party decided to regard its geographical frame of reference as comprising an area much greater than the Mediterranean region proper, covering all land surfaces between the twentieth and fortieth parallels of latitude approximately (but excluding detailed treatment of the mountainous regions of Western Europe) and extending from the Atlantic to the Indus. In almost the whole of this huge region the climate is indeed Mediterranean in type—i.e., with hot, dry summers, winters relatively mild with rainfall mostly in the spring and autumn and extremely sparse in summer. However the Mediterranean climate proper is found only in a relatively narrow strip along the coasts and the greater the distance from the sea the more it is a case merely of climate with a bias which is Mediterranean in contradistinction to the climates to the south and south-east where the bias is respectively desert and tropical, to the north-east where it is steppic, and to the north where it is temperate. Thus the mapping limits we have selected put the area of Mediterranean climate proper in the centre surrounded by the various zones of transition between it and the regions of unlike climates which appear on the periphery of the map. Parenthetically it should be pointed out that 'Mediterranean climate' could be deemed debatable as a term since the same type of climate is found in other parts of the world, in South Africa, in south-west Australia, in California or in Chile. Some authorities, accordingly, would have preferred a designation without geographical implications. However, 'Mediterranean climate' is very widely used and its situation here was felt to be the more justified in as much as the region surveyed has the Mediterranean as its centre.

In view of the international objects pursued and of the topographical basis and funds available, the working party settled on the scale of 1/5,000,000 which is large enough to provide a general picture of the variety of major ecological zones in the region under consideration and thus provide worth-while information towards the over-all evaluation of the countries concerned and of large-scale development planning. This scale has the further advantage, given the absence of intra-regional homogeneity in the quality and quantity of the basic data available, of making it possible to prepare the sheets fairly rapidly. Next, after examining the available cartographic material on the climatology and ecology of the Mediterranean countries, the Working Party concluded that the ecological conditions of the region could best be exhibited on the scale selected, by preparing two separate maps, one described as a bioclimatic map and the other a vegetation map, there being provision for the preparation of a pedological map on the same scale and covering the same region under another Unesco-FAO joint project. Lastly the Working Party submitted that the bioclimatic map of the Mediterranean region be supplemented by maps on a still smaller scale but using the same symbolic manner of cartographic representation, for the other regions in the world of homologous climate in South Africa, in Australia, and in North and South America.

During the succeeding meetings, held at Rome in October 1959 and Paris in May 1960, the Working Party went on to block out the two maps.

For the bioclimatic map which this brochure presents, the Working Party began by considering the various methods of representation theoretically usable. The lack of basic data for certain sectors of the map and its scale led them to try for a simple method based on the most generally available data and giving adequate results and several combinations of elements were tried. Finally, however, in view of the benefit of publishing the 1/5,000,000 map immediately and of the fact that the scale limited the possibilities of including all the data considered, it was decided to ask Mr. Gaussen to plot his original from the calculations of totals of dry days, with the isotherms for coldest month mean temperatures 0°, 15°, 20° C. surcharged. It was felt that a map on these lines would be adequate for the general ends in view. The method is described in detail on a later page and it produces a map based on climatological data which can be regarded as a bioclimatic map.

Comparison of the climatological with the soil and natural vegetation maps is of prime significance and it was decided that the vegetation map prepared in connexion with the present project should show the climax vegetation, i.e., the vegetation which would occupy land given a long period without interference by man and his animals. This map will be published shortly on the same scale and using the same cartographic bases and will also be accompanied by an explanatory brochure.

The Working Party was of course only too conscious of the limited usefulness of even the best 1/5,000,000 scale maps and accordingly recommended that FAO and Unesco consider how to institute, for the more important sectors of the area concerned, a programme of larger scale ecological mapping in conjunction with other special mapping projects, notably pedological. Such maps, say to a scale of 1/1,000,000 and using the cartographic bases of the *Carte Internationale du Monde*, appear essential for securing an accurate general picture and adequate knowledge of present and potential conditions of land use at national level.

Pending the making of larger scale maps, which, in the present state of our knowledge of the environments and of our available scientific and financial resources, will undoubtedly take a long time for many parts of the region which concerns us, FAO and Unesco hope that the present map will give useful service both to individual nations and internationally. It is addressed alike to the scientist in want of synthesized and generalized data and the university teacher as a lecture-room tool and to the administrators, the technologist, the agronomist and the forestry man who want the general picture and differing regions broadly compared.

FAO and Unesco take this opportunity of expressing their warm thanks to Messrs. Emberger, Gaussen, Kassas and de Philippis who have spared no effort to carry to success, in the finest spirit of scientific co-operation, the difficult task entrusted to them. The two Organizations wish to express their special gratitude to Messrs. Gaussen and Bagnouls for sifting the data and for their meticulous preparation of the master map carried out at the Institut de la Carte Internationale du Tapis Végétal (University of Toulouse). Finally they also wish to thank all the government services and individual scientists who were kind enough to supply the information and data requested of them and who are too numerous to be named here, save only for drawing attention to the help given by the World Meteorological Association in securing the most recent climatological data.

PREPARATION OF THE BIOCLIMATIC MAP

DEFINITION OF A BIOCLIMATIC MAP AND CHOICE OF METHOD

The purpose of a bioclimatic map is to exhibit for a particular region, a synthesis of the climatic factors of special importance for living creatures.

It is accordingly based on a particular aspect of the study of climate, but climate is an extremely complex subject in itself. Determining the action of a particular climatic factor on a particular animal or plant species is still at the stage of trial and error. The reciprocal interaction of certain climatic factors are still conjectural. Indeed there are vast areas where they are still only at the stage of organizing the dense and well instrumented meteorological networks which will give them data, adequate in quantity and reliability.

There are many meteorological elements which can be measured with fairly complete accuracy and in their paper on 'Climatological Observational Requirements in Arid Zones', M. Gilead and N. Roseman (1958)[1] list 26 items: 7 of radiation, 4 of temperature, 7 of precipitations, 2 of humidity, 4 of evaporation, 1 of surface pressure and 1 of wind.

It is desirable for all these measurements to be obtainable ultimately all over the world and their use for producing a synthesis of all climate factors is foreseeable. However this looks to be far in the future.

In practice all that can be hoped for at present from most countries' meteorological services is reasonably acceptable data on temperature and precipitations, plus some information on atmospheric humidity and more rarely some on fogs, dew, etc. Moreover the 'scrappy' information we have comes from far too few meteorological stations even for small-scale work. Fortunately however there is one fact which is firmly established: namely that of all the elements in the environment those of most importance for living entities, plants in particular, are warmth and water.

Hence, relying almost entirely on the two factors of temperature and amount of water available, it is possible, not indeed to define local climates and still less microclimates, but to sketch a small-scale picture of the major climatic complexes determining the different types of vegetation which amounts to an adequate bioclimatic map.

In certain respects such a picture will always be approximate only: to make a map the boundaries must be plotted from the points for which data are held and they are usually too few for the purpose, which makes the plot conjectural within limits. Moreover in nature, the shifts from one type of climate to another are progressive and never abrupt save in special cases such as a mountain divide. Thus the boundary plotted on a map is necessarily extremely arbitrary just like the conventional limit values of the meteorological variables used in establishing a climate classification.

However small scale bioclimatic maps serve as a preparatory step towards more detailed studies which can be made later on on a larger scale and bringing in additional factors.

There are of course several possible methods for preparing bioclimatic maps. The whole subject is difficult and can be tackled from many different angles and thus it is not surprising that the most varied methods should have been suggested. It is out of the question to discuss here all the indices, coefficients or diagrams relating to the representation of climates which have been worked out since Koppen's which is the oldest, 1918, and most widely used but remains extremely valuable. It should be noted that only a few of the methods in question adopt a biological standpoint but that almost all rely on temperature and precipitation. Many of them, mostly of merely historical interest now, were discussed in a publication by Curé in 1943. Since then still other methods have been advanced but for our present purposes the only ones of real interest are those focused on the characteristic arid climate problems and lending themselves

1. See under 'General' in the bibliography at the end of this volume.

additionally to satisfactory cartographical representation. Thus there is de Martonne's (1926) aridity index which gives good results when annual precipitations are low. Thornthwaite's (1933) method, based on potential evapotranspiration, has served towards some interesting cartographic work, in particular on bioclimatic conditions in North America. Peveril Meigs (1953) used this method as the basis for his map of the distribution of arid homoclimates, published by Unesco. Penman's (1948) method, also based on the study of evapotranspiration which he seeks to relate to exact measurements of physical factors, produces answers of great importance for agriculture particularly for determining the water requirements of plants. Lastly, there is Emberger's method using *m*, the mean of the minimum temperatures of the coldest month, and the 'pluviometric quotient' Q reached by dividing the precipitation P by the product $\left(\frac{M + m}{2}\right)$ $(M - m)$, where M is the mean of the maximum temperatures of the hottest month, correlated with a profound study of the vegetation of the Mediterranean region giving finely particularized results which have allowed of the preparation of large-scale maps.

As indicated several combinations of elements borrowed from these various methods were given practical trials for map making and in particular the Working Party tried using Gaussen's ombrothermic diagrams and number of dry days (to be defined on a later page) and Emberger's Q and *m* values in combination.

The lesson of the tests was that the limitations of a 1/5,000,000 scale, combined with the inadequacy of the data for large areas of the region dealt with, made it necessary to use only uncomplex factors for which adequate data could be secured.

It is obvious that, over and above the meteorological factors, a study of the vegetation in the ground will provide direct pointers to bioclimates. However, when it is proposed to make both vegetation and bioclimatic maps of a region to exhibit the ecological conditions as fully as possible, clearly cartographic tautology is only avoidable by basing the bioclimatic map solely on meteorological data and reasoning on the facts of the physical environment (relief, direction of winds, etc.). Naturally only those climatic factors with a definite action on plants will be taken into account and no notice will be taken, say, of variations in atmospheric pressure which do not affect plants directly. The relative importance of factors will also have to be determined in selecting those to be used since what is a major factor at one point may be a minor one elsewhere and vice versa. The final question to be determined is which are the general factors affecting the vegetation as a whole, as represented on the scale selected, since it is out of the question to take the biology of the individual species into account. Thus making a bioclimatic map is a matter first and foremost of biology and in particular of botany, for of all living entities plants are the only ones wholly of the climate of their habitat.

It was in the light of these considerations that the FAO-Unesco working party decided to plot the map's bioclimatic zones in terms of ombrothermic diagrams and xerothermic indices, following the method described below.

UTILIZATION OF CLIMATIC FACTORS

In the climate classification employed in this paper, the essential factors taken into account are: (a) temperature; (b) precipitations and number of days of rain; (c) atmopsheric humidity, mist and dew.

The data are often not used separately but balanced against each other so as to reveal whatever 'seasons' there are which have a special influence (favourable or unfavourable) on the vegetation, namely: hot seasons, cold seasons, dry seasons, humid seasons.

Obviously, as this kind of classification is necessarily relative, conventional definitions of its terms are needed.

Temperature

A *hot month* is a month in which the average temperature is above 20° C., and hence with no risk of frost.

The *hot season* is the period of consecutive hot months.

A *cold month* is a month in which the average temperature is 0° C. or below.

The *cold season* is the period of consecutive cold months.

When the mean temperature of the coldest month, *t*, is over 15° C., frost is an infrequent phenomenon, and the 15° C. coldest month mean is treated as the boundary-line between frost-free and frost-prone countries.

Climates with coldest month temperatures between — 5° C. and + 15° C. are rated as follows:

$15°\text{ C.} > t > 10°\text{ C.}$ = warm temperate [1]
$10°\text{ C.} > t > 0°\text{ C.}$ = temperate
$0°\text{ C.} > t > -5°\text{ C.}$ = cold temperate.

The curves of the coldest month mean temperatures of 20°, 15° and 0° C. are plotted on the map, the last being of great importance as it marks the divide between the warm-warm temperate and the cold-cold temperate climates, and on the boundary of our area, between the Mediterranean climates with relatively mild winters and the climates with cold winters which produce a steppic vegetation.

1. In the following pages *t* designates mean temperature of the coldest month and T any mean temperature.

Drought

A *dry month* is defined as a month in which the total of precipitations P expressed in millimetres is equal to or less than twice the mean temperature T of the month expressed in degrees Centigrade:

$$P \leqslant 2T.$$

This purely rule-of-thumb relation has been reached from perusal of works by many authorities on plant ecology in various parts of the world where there is an appreciable dry season and it works extremely well for the Mediterranean region.

The *dry season* is the series of consecutive dry months as defined above.

Ombrothermic diagrams

A graph is constructed showing: (a) on the abscissa, the months of the year (beginning with the shortest—January in the northern hemisphere, July in the southern); (b) on the ordinate: to the right of the line monthly precipitations P (in millimetres); to the left of the line average temperatures T (in °C.) to a scale double that of precipitation. The thermic curve (curve joining the levels of monthly temperature) and the ombrographic[1] curve (curve joining the monthly rainfall points) are then plotted. When the ombrographic curve sinks below the thermic curve, $P < 2T$. The space enclosed by the two curves then indicates the duration and severity of the dry season as defined above which will be used for determining the xerothermic index.

A graph of this kind is known as an ombrothermic diagram and such diagrams for stations characteristic of various climatic regions or sub-regions appear on later pages.

A point to note is that the transition from 'dry' to 'wet' is not abrupt but via an intervening 'semi-dry' month, defined as a month in which the total of precipitations is more than twice and less than three times the temperature:

$$2T < P < 3T$$

and in particular, that there are regions which have no dry season (axeric climate) but do have a season which is 'semi-dry' according to the definition above.

The map indicates the modified axeric regions adjoining the area of Mediterranean climate which have semi-dry seasons.

Xerothermic index

So far we have been considering only means of temperature and precipitation. It can however be appreciated that the intensity of drought conditions does not necessarily remain constant throughout the dry months. In the first place the feeble precipitations which determine it vary from month to month and the character of the rainfall from place to place. Secondly, in the absence of rain, atmospheric humidity is extremely important and a day without rain cannot be rated as dry, if, say, there has been mist for a good part of it.

These considerations suggested the definition of a 'xerothermic index' (i.e., index of hot weather drought) which seeks to take all these factors into account.

The monthly index x_m denotes the degree of drought of a given dry month and is defined as the number of days in the month which can be deemed dry from the biological point of view. It is calculated as follows:

1. To allow for the character of the showers, only the number of days without rain is used for calculations, so that identical monthly precipitations, P, will give a relatively high index of drought if the rain took the form of violent thunder showers of little benefit to the plants and a relatively low one for longer and steadier rain which does much more good to vegetation.
2. Days with mist and dew are reckoned as half a dry day.
3. To allow for atmospheric humidity, H, the convention is that a day when $H = 40$, and the air is dry to plants counts as a dry day, and one when $H = 100$ (saturation) counts as half of a dry day.

Between $H = 40$ and $H = 100$, the agreed values are as follows:[2]

A day when $40 < H < 60$ counts as 9/10's of a dry day;
A day when $60 < H < 80$ counts as 8/10's of a dry day;
A day when $80 < H < 90$ counts as 7/10's of a dry day;
A day when $90 < H < 100$ counts as 6/10's of a dry day.

The following is an example of the calculation of the monthly xerothermic index x_m (in month of July):

Number of days of rain: 4.
Number of days of mist and dew: 8.
Mean atmospheric humidity for the month: 65.

$$x_m = 31 - \left(4 + \frac{8}{2}\right) \times 0.8 = 18$$

The xerothermic index (x) for the dry season is the sum of the calculated monthly indices for the dry months. It thus gives the number of 'biologically' dry days during the dry season.

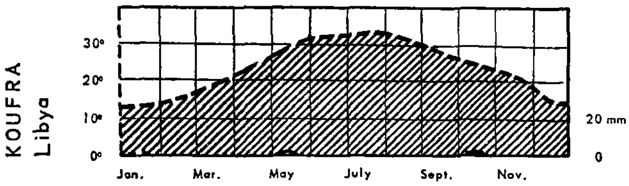
The xerothermic index values derived from the meteorological data are transferred to the map in black figures, and are determinants for the definition of bioclimates within the classification given below.

1. Ombros = rain.
2. It is also possible to arrive at the number of absolutely dry days by multiplying the number of days without rain, fog or dew by a coefficient from a table worked out in function of the values of H and ranging from 1 ($H = 40$) to 0.5 ($H = 100$). This was the method used for the map.

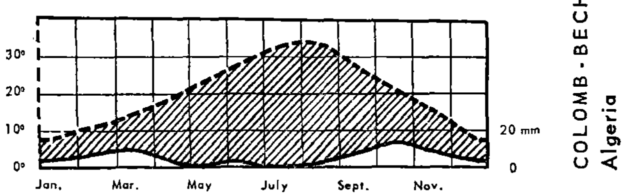
I - WARM AND WARM TEMPERATE CLIMATES

DESERT CLIMATES

True desert

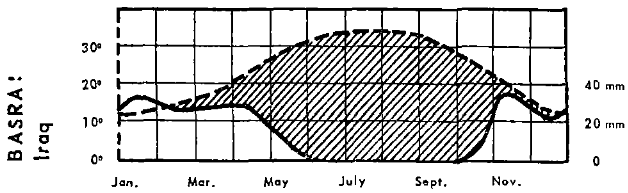


Desert

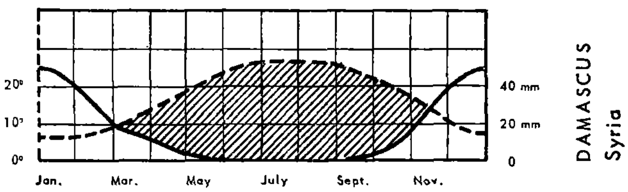


SUB-DESERT CLIMATES

Accentuated

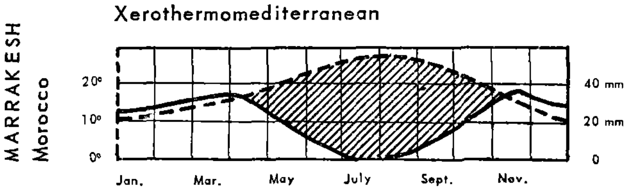


Attenuated

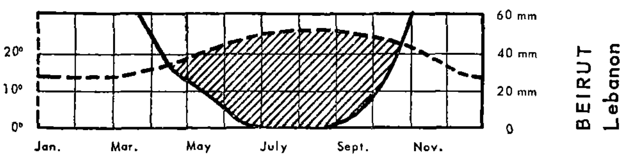


MEDITERRANEAN CLIMATES

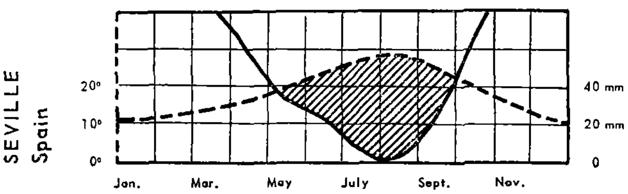
Xerothermomediterranean



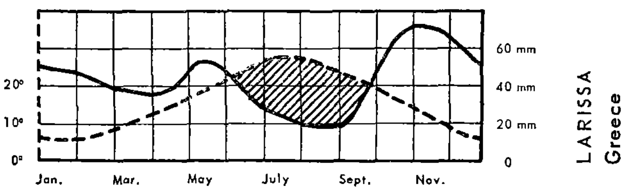
Thermomediterranean (accentuated)



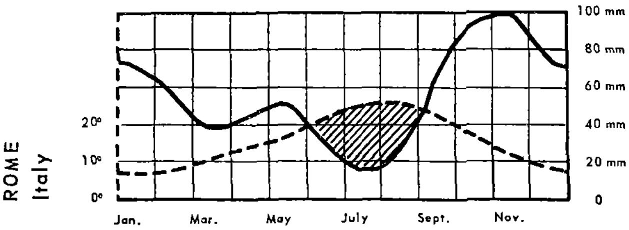
Thermomediterranean (attenuated)



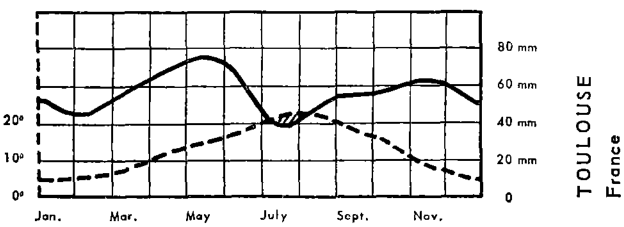
Mesomediterranean (accentuated)



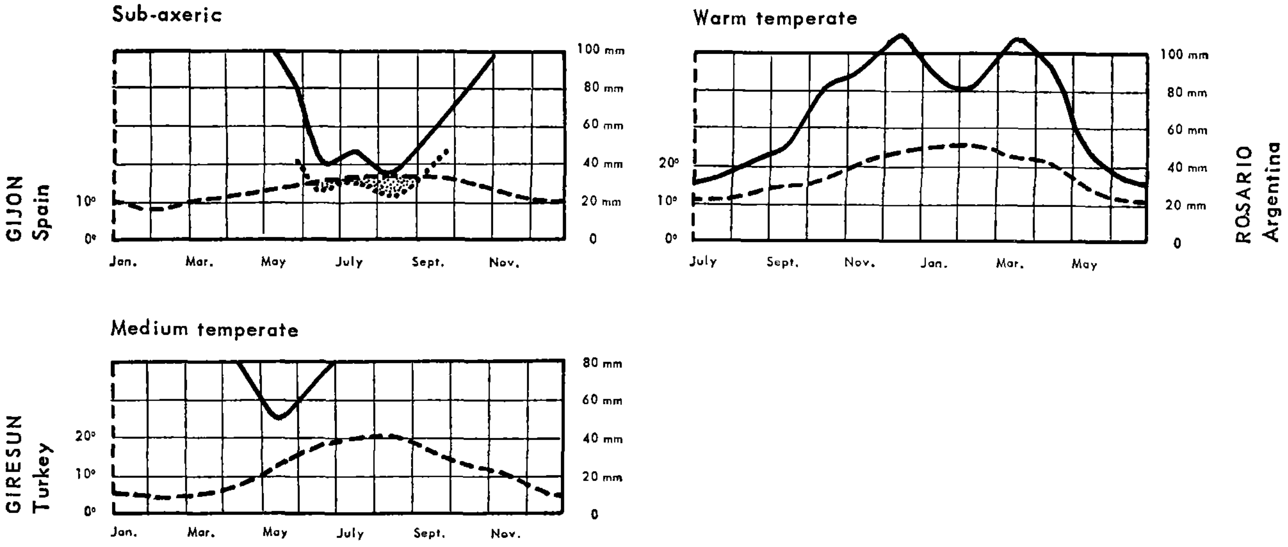
Mesomediterranean (attenuated)



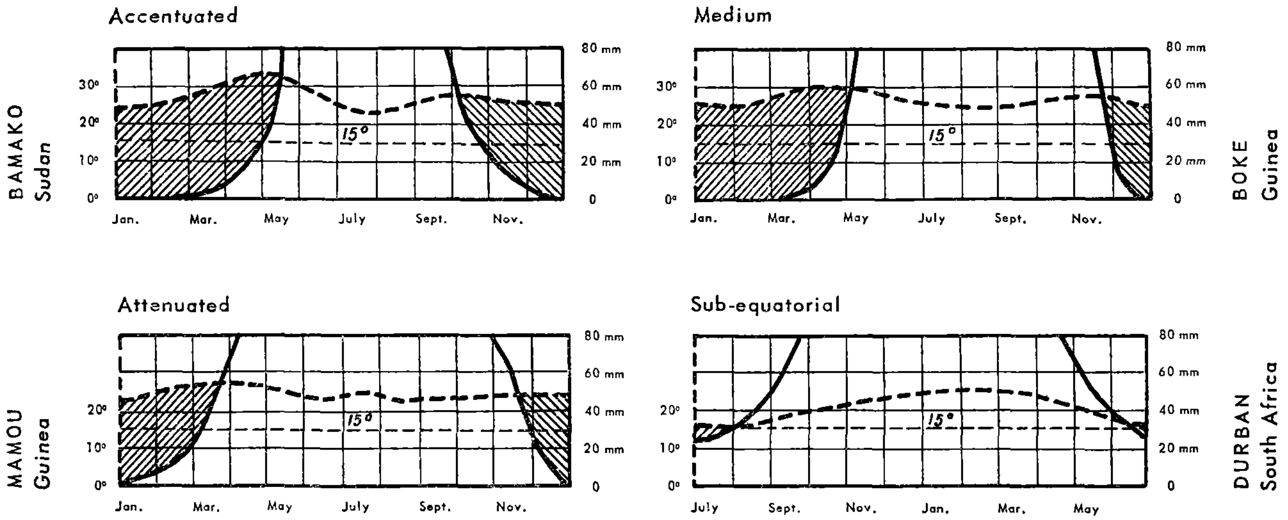
Sub-mediterranean



AXERIC CLIMATES



TROPICAL
(warm)

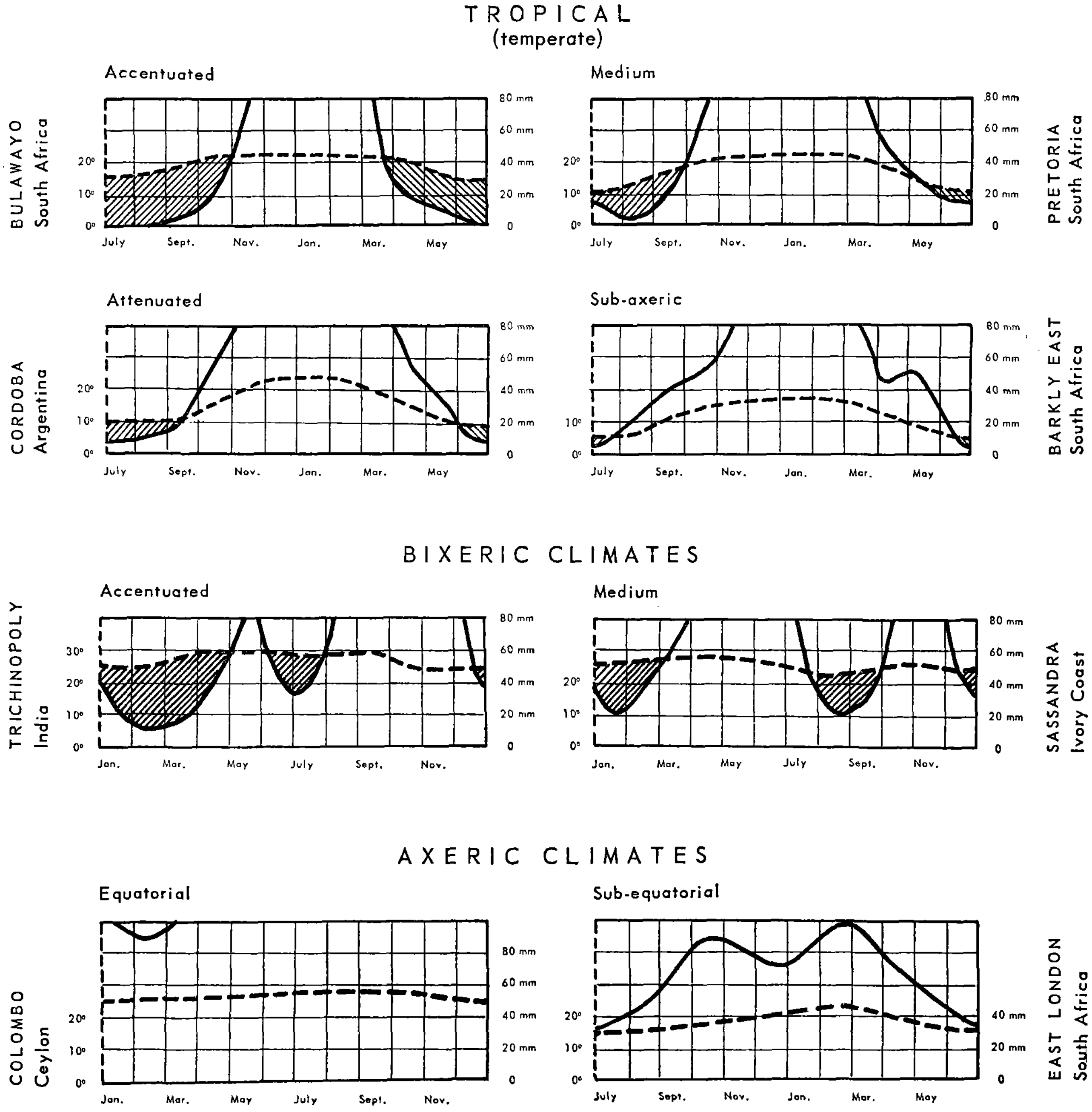


CLASSIFICATION OF BIOCLIMATES

Although the map deals primarily with the Mediterranean zone, it includes vast transitional zones and, particularly on the periphery, regions of quite different climate. It is therefore important that the classification and mode of representing bioclimates adopted for the map be of general applicability.

In the classification selected climates are divided initially on the basis of temperature, with three groups of climates distinguishable according to the average temperature of the coldest month (t):

1. Warm, warm temperate and temperate climates when $t > 0°$ C. (*constant positive temperature curve*).
2. Cold and cold temperate climates when $t < 0°$ C. (negative temperature curve at certain points in the year).
3. Glacial climate when the mean temperature, T, is less than 0° C. for all the months of the year (constant negative temperature curve).



A second division is then effected on the basis of the distribution, nature and intensity of the drier periods.

Group I. Where a climate in the first group (warm, warm temperate and temperate) has a dry season lasting the greater part of the year, the climate is *desert* when the value of the xerothermic index is over 300, or *hot sub-desert* when $200 < x < 200$ (dry period lasting from 9 to 11 months). When rainfall may not occur every year (broadly when $x > 355$) the climate is *true desert.*

Sub-desert climates can be subdivided into *accentuated* ($250 < x < 300$) and *attenuated* ($200 < x < 250$).

Climates in Group I, with dry seasons of from 1 to 8 months, are classed as *Mediterranean* if the dry season coincides with the period of longest daylight or *tropical* if it coincides with the period of shortest daylight.

Thus in our classification 'Mediterranean' is in some sort the converse of 'tropical.[1]

Climates with two separate dry seasons are called *bixeric*, and those with no dry seasons are *axeric*.

The Mediterranean climate as a whole presents subdivisions according to the values of x. We thus get:

(a) *Xerothermomediterranean*, i.e., warm and dry when $150 < x < 200$;

(b) *Thermomediterranean*, subdivided in turn into *accentuated* with a long dry season when $125 < x < 150$ and *attenuated* with a shorter dry season, when $100 < x < 125$;

(c) *Mesomediterranean* again subdivided into *accentuated* with a long dry season when $75 < x < 100$, and *attenuated* with a shorter dry season when $40 < x < 75$;[2]

(d) Finally *sub-Mediterranean*, a transitional climate when $0 < x < 40$.

This last type of climate is not regarded as Mediterranean proper or 'eumediterranean'.

The climates of tropical and bixeric patterns are subdivided initially into 'warm' and 'temperate' according as the mean temperature of the coldest month is above or below 15° C.

Each of these subdivisions is then broken down, according to the values of x, into:

Accentuated (long dry season), when $150 < x < 200$;
Intermediate, when $100 < x < 150$;
Attenuated (short dry season), when $40 < x < 100$;
Transitional (ultra-short dry season),
when $1 < x < 40$.

For bixeric climates, the xerothermic index x is calculated by adding together the indices for the two dry periods.

The final category in Group I is that of the axeric climates, i.e., climates with a xerothermic index of 0. Here, as rainfall is adequate for the vegetation, the consideration for the delimitation of the bioclimates is temperature. Here we get, on the one hand the category of warm *axeric* qualified as *equatorial* if $t > 20°$ and as *sub-equatorial* if $15° < t < 20°$ and on the other that of *temperate axeric* which may be subdivisible into *temperate axeric* with *semi-dry season* (as defined above), *warm temperate* if $10° < t < 15°$ or *temperate* if $0° < t < 10°$.

The transition from Mediterranean to temperate axeric climate is often via a zone of climate with semi-dry season. On the other hand the transition from tropical to Mediterranean climate is generally via a zone either of desert or sub-desert climate or of bixeric climate.

The first way the pure tropical climate becomes increasingly arid until we get a desert (or sub-desert) climate in which the bias is first tropical then indeterminate and finally Mediterranean. Where this happens it is useful to show the transition on the map which has here been done by overprinting small blue circles on the 1/5,000,000 map in sub-desert regions of tropical or indeterminate bias; in the desert areas, the rainfall is too sporadic for the differentiation to signify for our present purposes.

The second way, a summer rainfall minimum becomes increasingly marked until we get a summer in addition to the winter dry season making the climate bixeric. Then the winter dry season vanishes and we get a Mediterranean climate.

Obviously, in either of the latter types of transitional climate, the bias will be tropical in some years and Mediterranean in others so that precise boundaries are extremely difficult to trace and valid only as mean positions.

Group II. In the second group of climates (cold and cold temperate) the season of frosts comes into the differentiation. These climates are divisible into *cold desert* when the season of frosts and the dry season together total between 11 and 12, *cold sub-desert* (9 to 10 months), *cold steppic* (5 to 8 months), *cold sub-axeric* (2 to 4 months) and *cold axeric*, which is sub-divided solely according to the length of the frosty season.

Group III. The third group consists of one climate only, the glacial with permanent frost.

This bioclimate classification on xerothermic indices can apply anywhere in the world though a few additional subdivisions, unnecessary for our present purposes, could be introduced in the group of cold and cold temperate climates where the index is nil.

CARTOGRAPHIC REPRESENTATION OF BIOCLIMATES: COLOURS AND COLOUR PATTERNS

The convention in maps of an ecological nature is to use red for hot climates, black hachures for cold, a range of shades from red to yellow for aridity of decreasing orders, blue for humid conditions, with combinations of colours between the two ends of the spectrum to express intermediate situations.

Working on these principles, the map is coloured as follows:

Desert climates are shown in red (brick red was chosen in preference to a vivid scarlet).

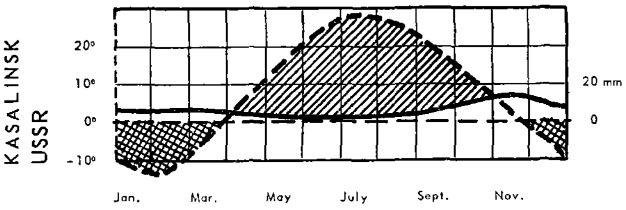
Sub-desert climates are orange overprinted with small blue circles on the 1/5,000,000 map, as mentioned earlier, when the bias is tropical.

For *Mediterranean climates* the ground is yellow surcharged with orange (long dry period) or green (short dry period). Extreme Mediterranean climates are

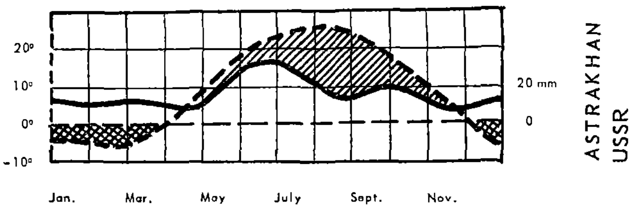
1. Cases arise where it is possible to grow plants from tropical countries in a Mediterranean climate if their particular ecology allows of it but it is desirable to make a clear-cut distinction between the two types of climates. In practice they are almost always separated geographically by desert, sub-desert or bixeric zones.
2. It so happens that the value 40 corresponds extremely satisfactorily with the limits of olive cultivation used as a handy line of demarcation of 'eumediterranean' conditions.

II - COLD AND COLD TEMPERATE CLIMATES

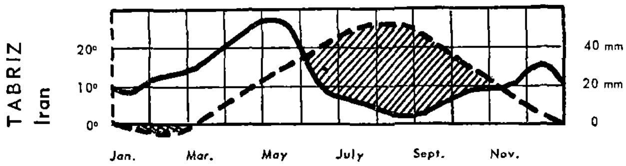
Cold desert



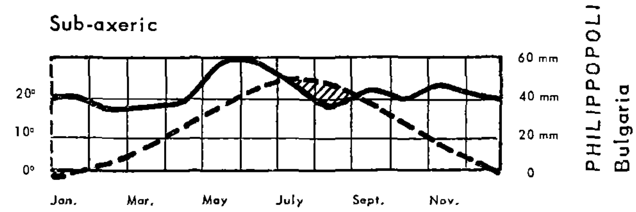
Cold sub-desert



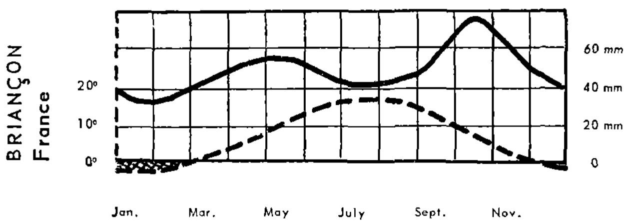
Steppic

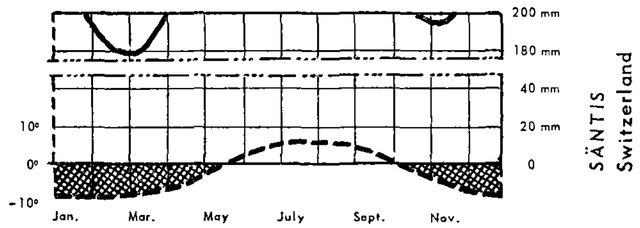


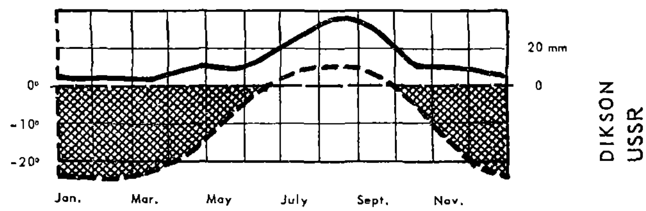
Sub-axeric



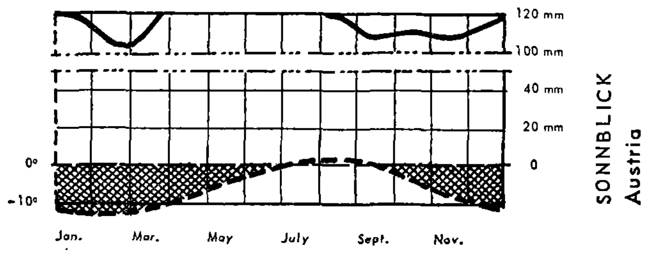
AXERIC
(cold)







III - GLACIAL CLIMATE



represented by alternate broad orange and narrow yellow bars for those with a very long dry season ($200 > x > 150$) and alternate broad green and narrow yellow where the dry season is very short ($x < 40$). When alternate bars of colour are used the pairs should be understood as representing the climate over the year, the colour and breadth of the bars corresponding to the intensity and duration of the dry and wet seasons.

Hot tropical climates are represented by alternate orange and violet vertical bars, the orange for the dry season and the violet (warmth + wet = red + blue = violet) for the wet. Here again the breadth of either bar corresponds more or less to the length of the dry and wet seasons in a year.

For *sub-tropical climates* green (yellow + blue) is used instead of violet.

For *bixeric climates* the colours and combinations used are the same as for tropical climates but the barring is diagonal. The bixeric climates are basically tropical but their two dry seasons make this a separate—usually transitional—type.

Axeric climates are shown in plain colours: violet for hot climates (equatorial); green for warm temperate climates; dark green for temperate climates; yellow-green for climates with sub-humid periods.

Cold climates with a dry season are represented according to the same rules as above but are surcharged with black hachuring. Thus the colouring clearly indicates the Mediterranean bias in cold steppic and particularly cold sub-axeric climate. Similarly all arid regions, whether hot or cold, are coloured red or orange. For some cold climate stations the totals of dry months and months of frost are indicated on the map, the latter in italics with the letter *g*.

Cold axeric climates are coloured blue-green with black hachuring if the period of frost is eight months or less, and white with black hachuring when the frost period is over eight months, as this usually means persistent snow, at least in those countries with sufficiently humid winters.

Glacial climates are coloured white with black gridding.

It is hardly necessary to add that the same cartographic conventions have been used for the 1/5,000,000 map and the 1/10,000,000 insets of climatically homologous regions in North and South America, Australia and South Africa. Therefore one legend only is given for all the maps.

SOURCES OF DOCUMENTATION AND UTILIZATION OF DATA

Meteorological documentation

The bibliography shows the list of documents and publications consulted and in particular those yielding meteorological data. The first approach made was obviously to the meteorological services of the countries interested. Most of them responded with alacrity, in some cases forwarding unpublished documents. Mr. Dubief, of the Institut de Météorologie et de Physique du Globe de l'Algérie, an expert in Saharan matters, was kind enough to supply a full set, as yet unpublished, of very recent and comprehensive data on the arid and semi-arid regions of Africa and the Middle East he had studied.

On the other hand, apart from the Services which did not respond to our requests for documentation, there are many countries in whose meteorological networks the stations are too dispersed for the purposes even of a 1/5,000,000 map. Moreover, some of the stations have been operating for too short a time for acceptable means to be calculable while in addition not all of these give the full range of information necessary and many indicate no more than temperatures and precipitations.

To remedy these innumerable lacunae to some extent, a careful scrutiny has been made of all documents, maps, etc., which might yield some meteorological information.

The fact remains, however, that the accuracy of the map as far as climate boundaries are concerned varies considerably between country and country, while higher, generally speaking, for the western than for the eastern section. In the present situation of meteorology it was difficult to be more thorough over the main map. On the other hand, for the 1/10,000,000 inset maps of climatically homologous regions, prepared solely for purposes of comparison, a less exhaustive study but adequate for the purpose in view was felt to suffice.

Utilization of meteorological data

It can be assumed—and the validity of the assumption is broadly confirmed by experience — that satisfactory means can be calculated on the basis of twenty-five years' readings of precipitation and ten years' of temperatures and these are the two periods taken in most cases for plotting the ombrothermic diagrams. When these lengths of readings are not obtainable, means based on ten years' readings of precipitations and five of temperatures will pass muster but if either 'base-period' is shorter the result must be treated with caution.

On the other hand three or four years' readings are sufficient to give a reasonable mean value of atmospheric humidity, as this is a climate factor for which more or less the same values recur yearly. The position is the same as regards mist and dew which are both atmospheric phenomena displaying appreciably more uniformity between year and year than temperature and still more precipitation. Moreover, in a given geographical region there are only slight variations in atmospheric humidity between station and station.

Valid data on atmospheric humidity have generally proved obtainable. Where they were not it has in many cases been possible to work out an approximate figure of atmospheric humidity at one station by comparison with neighbouring stations in the same geographical sector. The errors to which this can give rise are not great: 30 dry days with H = 70 give a xerothermic index of 22.5 against 21 when H = 75. A five-unit error in H gives a 1.5 error for x, which is of little importance.

There are some stations for which the numbers of days of mist and dew were not known, but in such cases it is again possible to calculate the index. Actually it can be taken that the atmospheric humidity balance very largely takes in the effects of fog and dew provided the readings are taken at dawn, noon and dusk, as is actually done in public meteorological stations. Here again the error arising is low: the coefficient for a day when H = 90 will be 0.58 if the day is rated as humid and 0.5 if it is rated as foggy, which is near enough. In this connexion it is important to stress, with reference to approximations of this kind, that the xerothermic index is only intended to indicate how serious the dry conditions are from the biological angle and accordingly an unattainable precision should not be aimed at in calculating it. Incidentally the spread of the values of x for differentiating between two varieties of climate is large enough to permit the approximations made necessary by the inadequacy of the meteorological data.

Other bioclimatic factors

While temperature and humidity are the climate factors of most importance for living entities and were the only ones it was practicable to use in making a map on this scale and for this region, there are nevertheless other factors which may be related to temperature or humidity with varying degrees of complexity, which have a fundamental role in bioclimatology. The first of them of course is solar radiation, but measuring it is an operation of some delicacy. Studies of it in our region are still too piecemeal for it to have been possible to contemplate using the results. Similarly evaporation and transpiration values have had to be disregarded: though these complex phenomena are of capital importance in plant physiology, measurements of them come from stations too widely dispersed or too idiosyncratic for them to serve towards the preparation of this map.

The study of minimum temperatures or of the mean of minimum temperatures of the coldest month (m) is of special importance in introducing exotics which are normally less resistant to exceptional cold than the indigenous species and these values, in parts of the area mapped for which they are known, have been useful for pin-pointing certain boundaries. However, the data available did not permit isotherms of mean minimum temperatures in the coldest month to be plotted. Yet they are of significant interest, particularly the $m = 0^{\circ}$ isotherm, for making additional sub-divisions of Mediterranean climate corresponding to important differences in cropping possibilities. In this connexion, however, the proximity of cold climate zones (black hachures) will often indicate that while a region tends to be Mediterranean in climate, it may have frost on cold nights.

In the mountain fringes of the Mediterranean lands a factor with a marked limiting influence on vegetation is snow; in the absence of direct information some idea of the extent to which it is operative can be got from the number of frosty months.

The factors of wind, sea fret and the exposure of slopes cannot be taken into consideration at the scale of this map, but altitude, on the other hand, is an extremely important element which has been allowed for to the utmost degree possible. In the absence of climatic data, it is perfectly legitimate to work on elevations.

Finally, advantage has been taken of what various members of the Working Party knew personally about the terrain and scattered items of information about climatic vegetation or crops in quantities of scientific publications to try to locate certain boundaries whose position on the map necessarily remains approximate.

All in all however, the use of the xerothermic index which is intended by definition for those countries where arid conditions obtain and which relies on meteorological data available in most instances has met the requirements for the region being mapped.

DISTRIBUTION OF THE MAIN BIOCLIMATES IN THE REGIONS STUDIED

The purpose of these maps being to make it possible to compare Mediterranean-type bioclimates throughout the world and to study the associated regions of transition to the other climate patterns in general and to arid conditions in particular, it is felt that the inclusion here of a succinct analysis of the points emerging from study of these maps will serve a useful purpose. In view of the general primary subject of this study, the comments which follow relate mainly to the regions of Mediterranean and sub-desert climate on the main and inset maps and not so much to the peripheral regions of quite distinct climates. By way of supplementary documentation, a proportion of ombrothermic diagrams for stations shown on the maps are included.

Political boundaries have been indicated merely for the purpose of situating the terrain mapped and thus it follows automatically that the terms used in this digest have only their connotations in physical geography. They are, incidentally, identical with those used on the topographic base and some of them may have changed since the latter was published.

1/5,000,000 MAP OF THE MEDITERRANEAN REGION

Tropical climates of Africa on the edge of the map

In order to centre the map, its southern limit is made to fall at approximately 12° north latitude. It therefore includes tropical climates but not the equatorial and sub-equatorial climates to be found further to the south.

In Africa the border-lines between types of tropical climate run more or less east-west but converge near the coasts.

An attenuated tropical climate ($40 < x < 100$) prevails in the coastal belts of Guinea and Sierra Leone. The main example of 'regular' tropical climate ($100 < x < 150$) is Guinea. The climate is accentuated tropical climate ($150 < x < 200$) over much of Senegal, Portuguese Guinea, Gambia, the Southern Sudan and the interior of the Upper Volta with two further small zones on the crests of the Ennedi and Darfour.

The climates in the 'tropical' sector of the map are mainly sub-desert.

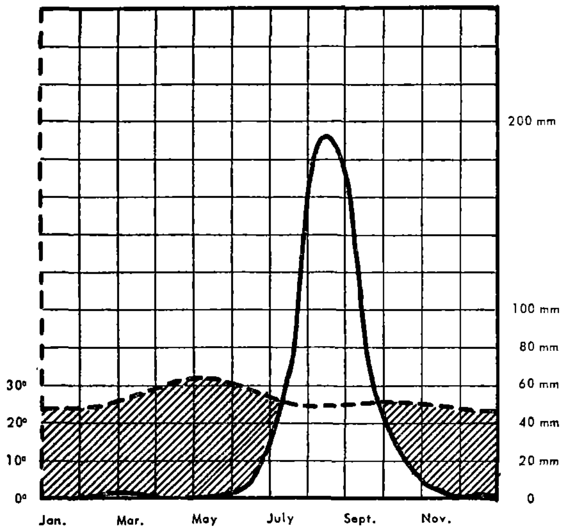
The climate is attenuated sub-desert ($200 < x < 300$) over part of Senegal, a large part of Mali, the Upper Volta, the Niger, North Nigeria and Chad and an accentuated belt ($250 < x < 300$) along the coast of Mauritania over much of the Niger, Northern Chad and the Sudan and northward along the western coast of the Red Sea.

In the Sudan the shift from the Mediterranean to the tropical type of climate follows an irregular course towards the north of the country. In Port Sudan the climate still has a Mediterranean bias with maximum precipitations in November whereas in Merowe a slight and tentative maximum is discernible in August. Khartoum is definitely tropical as are Kassala and El Fasher, with particularly high summer temperatures between Wadi Halfa and Khartoum.

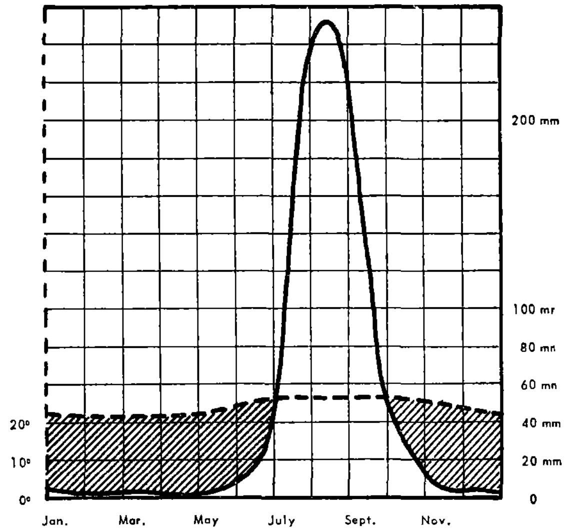
In Eritrea altitude interrupts the sub-desert régime in the coastal ranges: rainfall is more abundant and the results according to the exposure and the geographical conditions are accentuated or regular hot tropical and sub-tropical climatic zones, with an accentuated bixeric climate (two dry seasons) in the north of the massif. Bixeric climates are usually transitional between tropical and Mediterranean régimes, between which it is extremely difficult to trace a clear boundary line in countries with relatively rare and irregular rain.

Some notes on this Red Sea littoral climate in Arabia are included. For instance, at Berbera, opposite Aden, there is a sub-desert climate with an April maximum: it would thus be Mediterranean but the mean temperature for the coldest month is over 15° C. and the vegetation is spiny and deciduous scrub.

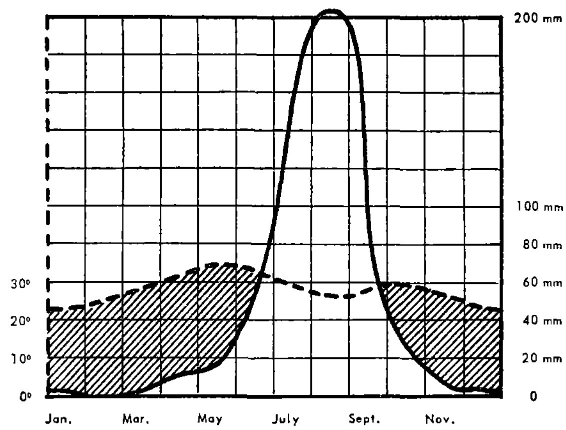
ST. LOUIS



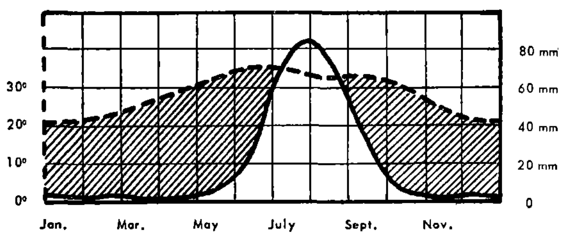
DAKAR



NIORO



TIMBUKTU



Above and facing are the ombrothermic diagrams for St. Louis and Dakar (Senegal); Timbuctu and Nioro (Mali); Bobo Dioulasso and Ouagadougou (Upper Volta); Agadès and N'Guigmi (Niger); Asmara and Macallé (Ethiopia); Abéché (Chad); Nouakchott (Mauritania); and Khartoum (Sudan).

Arid and ultra-arid regions of Northern Africa

The xerothermic index selected as the lower limit of desert conditions is 300. Obviously this is a mean value: for edaphic reasons desert conditions may begin at slightly lower indices but desert conditions undoubtedly exist above the 300 value and 355 is the lower limit of 'true' desert.

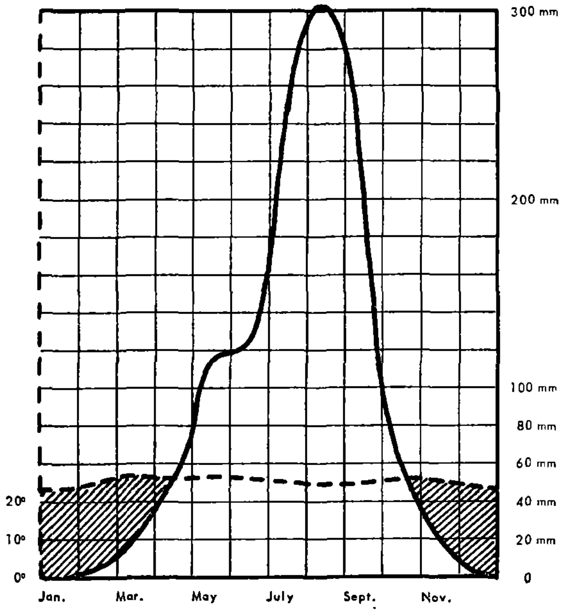
The demarcations on the map coincide to a high degree with those plotted by Saharan experts.

In particular it will be observed that the desert does not reach the coast save for a small stretch of the Red Sea western littoral. In the coastal belts, particularly on the Atlantic, the humidity is fairly high so that Port-Etienne for instance with 360 rainless days per year, has a xerothermic index of 260. These are areas where high atmospheric humidity with frequent days of mist and dew create a sub-desert, instead of a desert, vegetation. In the deserts of Egypt and the Sudan there are also some oases due to mist and atmospheric humidity rather than to the soil's water resources.

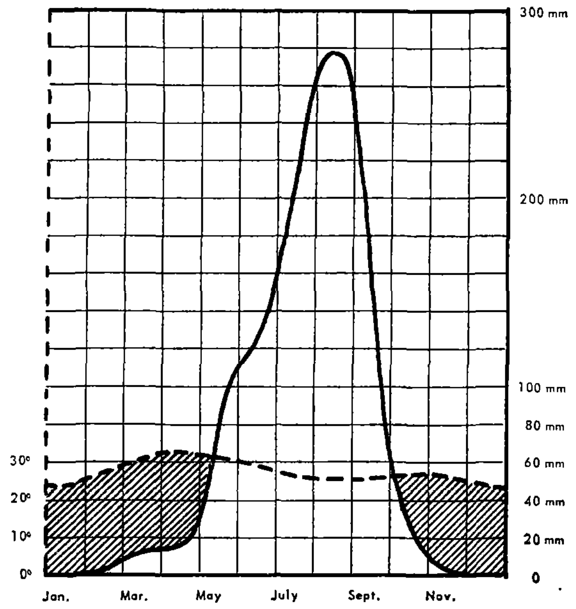
In the deserts of northern Africa, variations in climate arise from increases in altitude: the conditions on the summits of the Ahagar, Tassili-N'Ajjer, Tibesti, Aïr and Ennedi highlands and the Nubian mountains are sub-desert.

A fairly large extent of the desert regions is qualified as absolutely 'desert', i.e., country where there may be years without rain, but in fact it is far from easy to

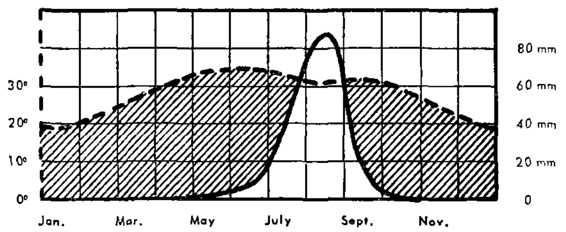
BOBO-DIOULASSO



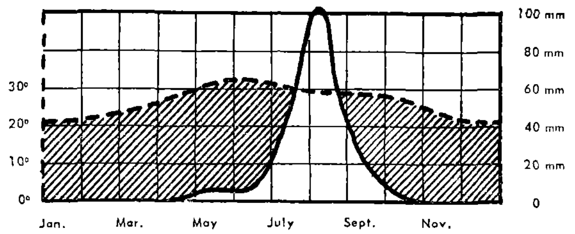
OUAGADOUGOU



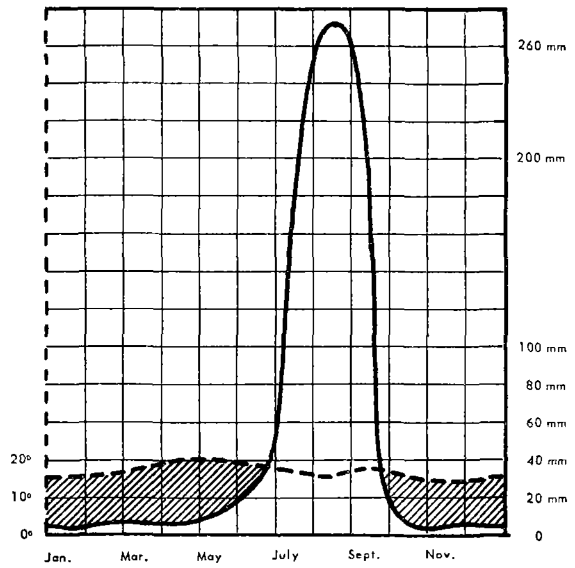
AGADÈS



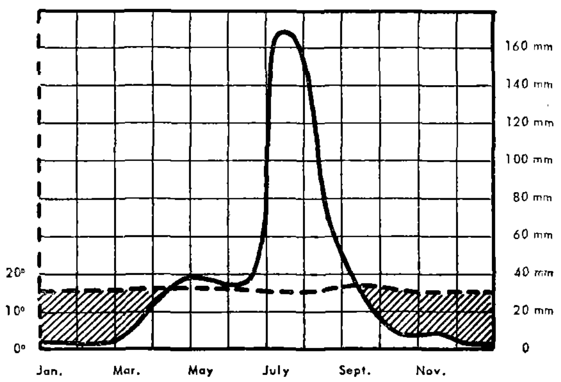
N'GUIGMI



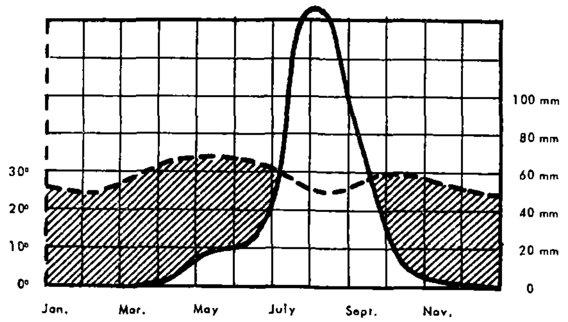
MACALLÉ



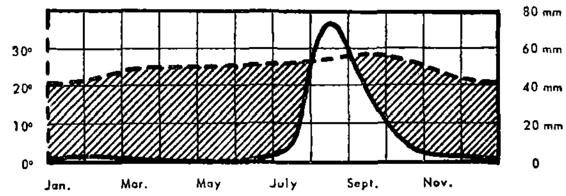
ASMARA



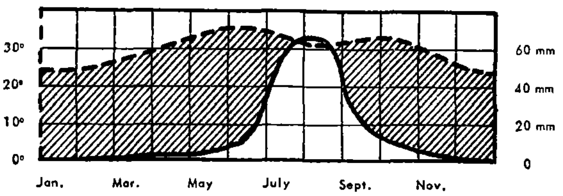
ABÉCHÉ



NOUAKCHOTT



KHARTOUM



say where the absolute desert begins for lack of adequate meteorological data. However, the areas so designated are regions of extreme aridity where rain is a very rare phenomenon.

The irregularity of the precipitations and the sparsity of long-term records makes a purely climatic study of the Sahara difficult.

There are nevertheless clues of which a number of writers have availed themselves (Dubief, Capot-Rey) and there are differences between place and place with an appreciable effect on the vegetation. These are ascribable in most cases rather to factors (humidity in depressions) which are edaphic rather than climatic even though the humidity is often a product of the climate. Either way the use of $x > 355$ as determinant works well and allows for the factor of atmospheric humidity which is of great importance in the neighbourhood of the coasts.

As regards summer temperatures it is observable that, from the neighbourhood of the Saharan Atlas on, the figures are notably high save in the mountain massifs.

The sub-desert zones are divisible into areas with a tropical bias and summer rains or with a Mediterranean bias and winter rains. In the deserts of northern Africa, the trend is towards a fairly clear-cut tropical pattern as far as the twentieth parallel; then there is an indeterminate zone northwards to the twenty-eighth parallel after which the bias becomes Mediterranean.

Facing this page are the ombrothermic diagrams for Mourzouk (Libya), In Salah (Algeria), Merowe (Sudan), Largeau (Chad), Port Etienne (Mauritania), and Gafsa (Tunisia).

Northern Africa

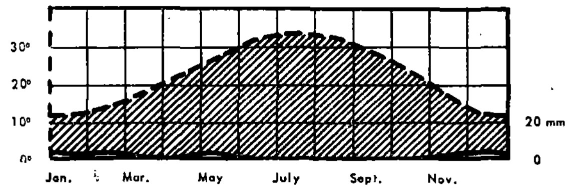
In Northern Africa the zone of Mediterranean-biased sub-desert climates begins in Morocco, in the lower valley of the Sous, and one arm is thrust along the Atlantic coast. The other skirts the anti-Atlas, extends along the eastern slope of the range, up the Moulouya Valley and over much of the central part of the Moroccan and Algerian high plateau, and thence marches with the southern slopes of the Algerian section of the Saharan Atlas to beyond Chott-el-Hodna when it swings away from the Aruès and Tébéssa mountains to reach the coast in Tunisia at approximately the level of Sfax. Thence, eastwards except on the coast and in a few 'Mediterranean' enclaves on the coastal heights of Tripolitania and Cyrenaica the sublittoral climate is essentially sub-desert right across to lower Egypt. This is the typical climate of the Nile Delta (the coast again excepted).

From the bioclimatic angle we have to remember the *khamsin* in Egypt: though of brief duration (10 to 12 days per year) this parching wind may be positively catastrophic for crops.

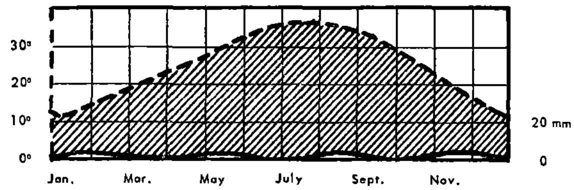
Everywhere else the climate is Mediterranean (save on the crests of the Moroccan Atlas).

Morocco. Here every variant of the basic régime is to be found. A xerothermomediterranean (hot dry) climate ($150 < x < 200$) prevails throughout the Marrakech region, enclosing a small zone of attenuated sub-desert in the neighbourhood of Chichaoua, and borders the southern and eastern foot of the anti-Atlas as far as the left bank of the Moulouya where the valley climate is arid with a desert climate enclave along the river's middle reaches.

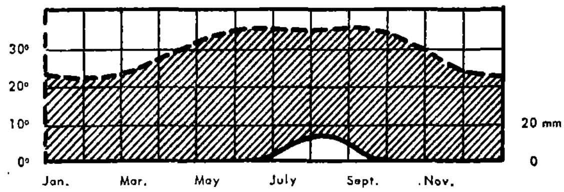
MOURZOUK



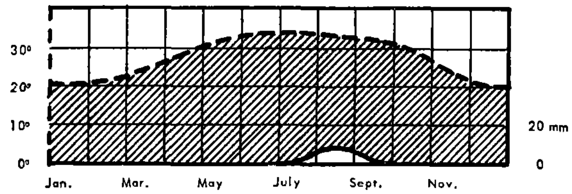
IN SALAH



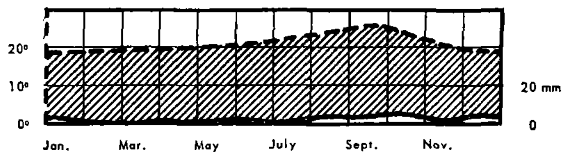
MEROWE



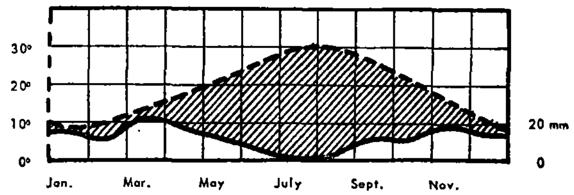
LARGEAU



PORT ÉTIENNE



GAFSA



A hot but less dry régime (thermomediterranean) (aggravated: $125 < x < 150$ and attenuated: $100 < x < 125$) is found in the lowlands of central Morocco, on the southern and eastern slopes of the Atlas ranges, on the relatively dry Mediterranean coast and also in the Djebel Sarho.

The mesomediterranean variant (aggravated: $75 < x < 100$ and attenuated: $40 < x < 75$) is found on the middle slopes of the Atlas ranges and the Riff and also characterizes the Atlantic coast from Tangier to Azemmour, where atmospheric humidity is always extremely high and obviously reduces the degree of aridity, as the xerothermic index shows. Thus Casablanca on the coast has the same number of rainless days (146) in the dry season as Berrechid 35 kilometres inland, but the former's mean atmospheric humidity (H) of 78 makes an index of 90 against 120 in Berrechid where $H = 61$.

This situation is more or less universal. Given identical conditions of precipitation—same length of dry period (approximately), same number of rainy days—the coastal regions are almost always less arid than areas inland because of a higher belt of atmospheric humidity.

The sub-Mediterranean climate ($0 < x < 40$) is a mountain climate in Morocco. In the Riff it comes next below the sub-xeric belt (axeric with a semi-dry season), whereas in the Atlas the transition to the cold climates is from mesomediterraneans. In both the great Moroccan massifs the climate at middle altitudes is cold with a summer dry season[1] but it is only in the Atlas and at the greatest heights that cold axeric climates are found with cold seasons which may be as long as eight months.

Algeria. Xerothermomediterranean conditions in Algeria are confined principally to part of the high plateau and to the lips of the Chott-el-Hodna basin. A further small enclave occurs in the Relizane region.

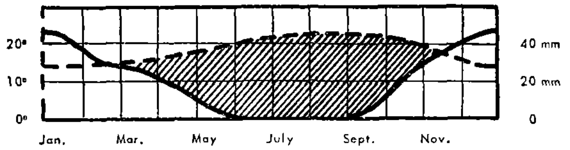
The main area of thermomediterranean climate is Oran—accentuated inland and attenuated on the coast. Other areas where it obtains are the lower Chelliff Valley where it is accentuated, parts of the high plateau, most of the Saharan Atlas, around the Aurès and on the Nementcha Mountains. Winters are relatively cold and there are wide variations of temperature between day and night.

In the fertile parts of Algeria—the Tlemcen region, the Ouarsenis, the whole Algérois coast and the Constantine area—the climate is mesomediterranean and also in the higher zones of the Saharan Atlas and the high areas of the Aurès.

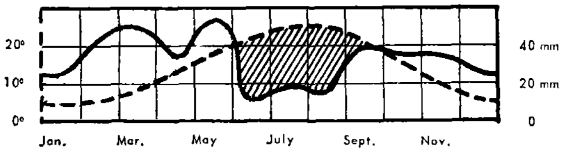
In the hill country of the Ouarsenis, Kabylia, and the South Philippeville region the climate is sub-Mediterranean and with some sub-axeric 'islands' at certain parts in the massifs with heavy rainfall.

1. Mountain climates characterized by low night temperatures can be divided into those with dry summers (oroxerotheric) and those with wet (orohygrotheric).

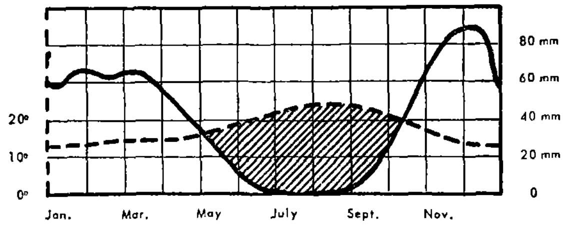
AGADIR



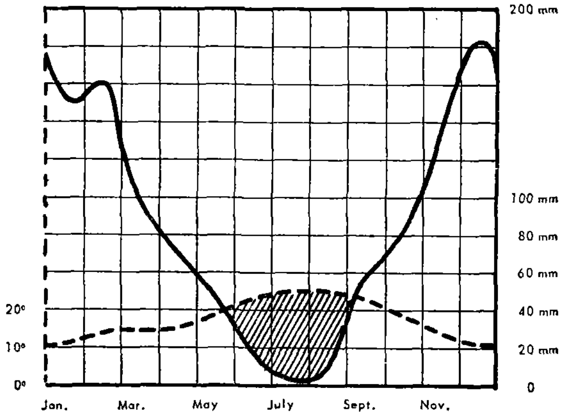
LA MESKIANA



RABAT



TABARKA



There are no areas of cold climate in Algeria except the mountain crests. On the coast, frost is an extremely rare phenomenon though heavy snow sometimes does serious damage to trees with indeciduous foliage by breaking the branches.

Tunisia. There is a broad belt of xerothermomediterranean climate inland south of the Tébessa mountains which runs west-east and peters out on the coast.

Throughout the whole of the north-east of the country, the climate is essentially thermomediterranean with a further tongue up the Medjerda valley.

North and north-west Tunisia are less arid with a mesomediterranean climate on the north of the Tébessa mountains down to the coast. Near the coast on the Medjerda mountains which are better watered than the rest of the country, the climate is sub-mediterranean. As in Algeria cold climate conditions are not found in Tunisia (i.e., no monthly average is below 0° C.).

Libya. The climate of the coastal areas of Tripolitania is xerothermomediterranean in the lowlands and thermomediterranean on the uplands where rainfall is better distributed.

The situation is exactly the same in Cyrenaica where the climate on the coast is mainly xerothermomediterranean and thermomediterranean in the Djebel Akhdar.

Tripolitania and the Cyrenaica peninsula are the only parts of Lybia with appreciable precipitations and the desert of Syrtis which separates them brings the sub-desert climate right down to the coast.

Inland the Libyan desert presents a repetition of Saharan conditions and oases are rare. In some quarters it is thought that summer temperatures are a little less high than in the south Algerian Sahara, but the data are unquestionably inadequate. To the south the Fezzan abuts on the Tibesti massifs which run as high as 3,300 metres, introducing a slightly more temperate influence revealed by outposts of Mediterranean vegetation.

Egypt. Without the Nile, Egypt would be the harshest of deserts with particularly high summer temperatures south of Luxor. Desert characteristics are a little less marked in the coastal climate of the Nile delta, but in the delta irrigation creates special microclimatological conditions which the map can hardly bring out. Flanking the valley, irrigation has also transformed the climate of the Fayoum region. Along the Red Sea coast, the hills are too low to effect any appreciable improvement in the hot desert nature of the climate.

Above and on the facing page are selected ombrothermic diagrams for the regions discussed: Agadir and Rabat (Morocco); La Meskiana (Algeria); Tabarka (Tunisia); Cyrène (Libya); and Cairo and Alexandria (Egypt).

Iberian peninsula

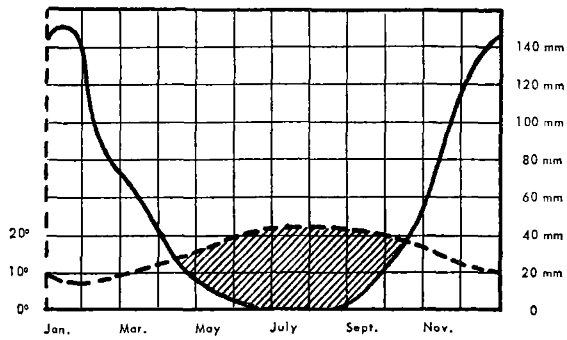
The most arid part of the peninsula is south-east Spain. The Almeria region is sub-desert and is bounded by a zone of xerothermomediterranean climate which covers the whole coast from Murcia to the west of Almeria.

In order of decreasing aridity there is an aggravated thermomediterranean zone on the coasts of the Gulf of Cadiz from Faro in Portugal to Jerez de la Frontera in Spain, while an attenuated thermomediterranean climate prevails in most of the lower valley of the Guadalquivir and over a zone which starts at the latitude of Cordoba and broadens out gradually towards the coast, where it extends eastward to just beyond Cadiz, and west and north along the coastal belt as far as the neighbourhood of Lisbon. The same fairly arid climate is found in the middle reaches of the Ebro valley (Zaragoza area), in the relatively dry sections of the Douro and Guadiana valleys (respectively the Zamora and Badajoz regions), with isolated patches along the Tagus.

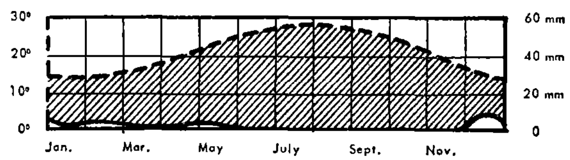
Most of the peninsula is mesomediterranean in climate, and mainly aggravated in the southern half of Spain and Portugal, the central area of the plateau of Old Castille and the Ebro valley around the more arid area centring on Zaragoza. The zone of attenuated mesomediterranean climate begins in the west near Lisbon and runs along the flanks first of the central Sierras (Sierra de Gredos and Sierra de Guadarrama) and then of the Montes Universales to reach the Mediterranean coast near Valencia, continuing thence throughout the coastal belt to the east end of the Pyrenees. This is also the climate of the slightly less elevated parts of the Castillian plain, the upland valleys of the Ebro basin and near the crests of the Sierras of southern Spain.

In these ranges a sub-Mediterranean climate is found in the better-watered parts but the real sub-Mediterranean areas are most of the Montes Universales, the Sierra de la Demanda, northern Portugal, the valleys and western part of the coast of Cantabria and the foothills of the Pyrenees. Owing to the lack of detailed information the slightly humid climate around Teruel may be rather too pronounced on the map.

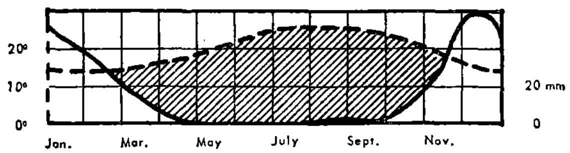
CYRÈNE



CAIRO



ALEXANDRIA

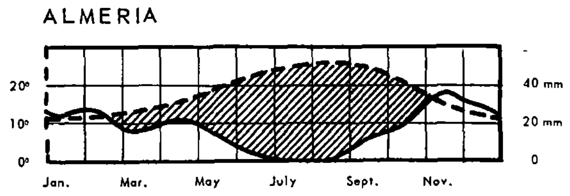


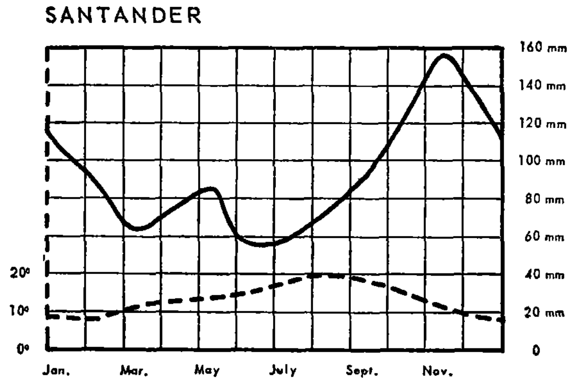
The most humid part of the peninsula consists of the rest of the Cantabrian coast and the Cantabrian Mountains. The climate is sub-axeric (with insignificant semi-dry season) at the western end of the Cordillera and in a belt which extends along the coast to the neighbourhood of Santander and runs thence along the southern foot of the Cordillera, spreads out into the Burgos area and finally marches with the Pyrenees. There are also 'islands' of the same climate at high altitude in the Southern Sierras, mainly on the very well-watered massifs north of Gibraltar.

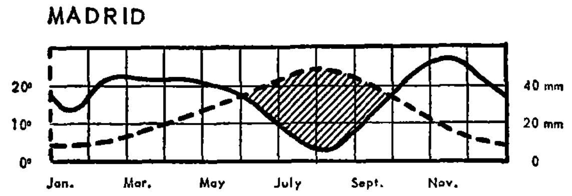
The northern slopes of the Cantabrian Cordillera and the coasts of the Gulf of Gascony from Santander northwards to the French frontier are extremely rainy and have the modified axeric climate often designated 'Atlantic'.

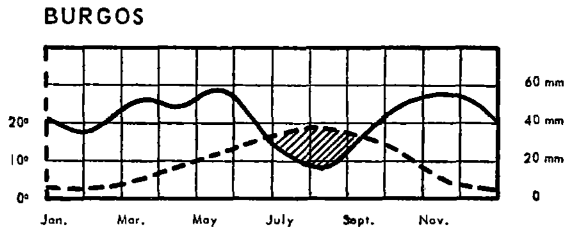
The cold climates of the peninsula—of which there are more in Portugal—are of two types—cold with summer dry season in the Southern Sierras, in the eastern part of the Montes Universales, and in the Central Sierras with their intensely severe winters and cold axeric in the Cantabrian Cordillera and the Sierra de la Demanda.

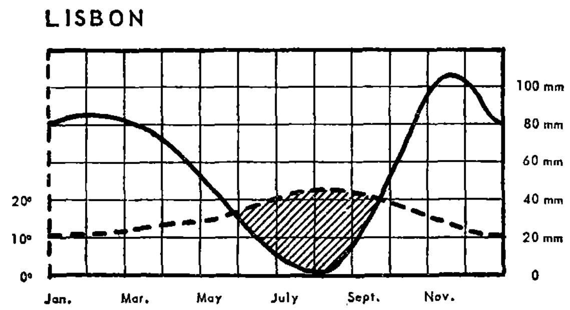
The Balearic Islands have a mesomediterranean climate with a small sub-Mediterranean zone on the north-western heights of Majorca.

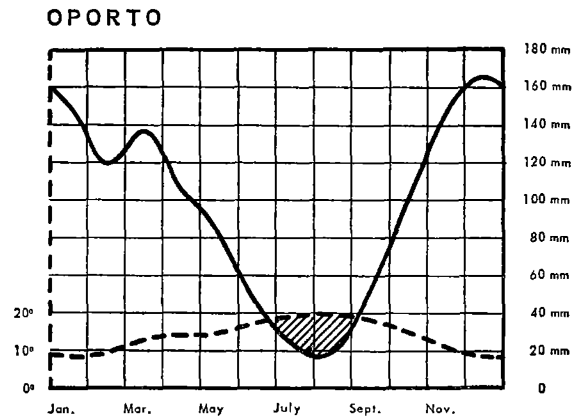












In the Canaries the climate exhibits considerable variations from Mediterranean-biased sub-desert to mesomediterranean on the heights of Grand Canary and Teneriffe where precipitations are at a very tolerable level. In mountainous islands climate contrasts are always extremely sharp.

Above are the ombrothermic diagrams for Almeria, Santander, Madrid and Burgos (Spain); and Lisbon and Oporto (Portugal).

Pyrenees

Of the Pyrenees the eastern part is of oroxerotheric climate in Cerdagne, attenuated orohygrotheric in the Ariege and Catalan sectors and strongly orohygrotheric in the west. Cold climate conditions begin at altitudes of approximately 1,500 metres at the coastal ends of the chain and at averages of about 1,000 metres inland. In most of this system the climate is axeric with one to four months of frost conditions. Cold seasons running from four to eight months are not found below the 2,000 metre level while for anything longer than eight the lower limit lies around 3,000 metres; in these last instances snow is persistent. In the valleys, as indeed in all highly accidented regions, differences in exposure and orientation produce many gradations of local variations from the region's macroclimate, which obviously cannot be shown on a map to the present scale. In particular, precipitations are minimal in valleys screened by mountain masses, a phenomenon common to all mountain areas. In France, with the moisture-laden winds coming from the west, the valleys mainly affected are those running north-south. In Catalonia, the south-easterly winds bring the rain and the Catalan ranges are extremely well-watered but under the lee of the Cadi-Canigou chain there is a dry belt from Seu d'Urgell across the Cerdagne and the valley of the Têt.

France

France's area of Mediterranean climate, exclusively of the attenuated type, is concentrated in the south-east corner facing the Mediterranean itself.

The belt is narrow at the Spanish frontier and broadens out in the Roussillon plain and the Têt valley. It then follows the line of the Aude to the west of Carcassonne, turns south of the Montagne Noire and the Cevennes to the Rhône near Orange and continues towards Italy, taking in the whole of Provence.

The sub-Mediterranean climate belt runs around the Pyrenees to the east, narrows down up the Garonne valley as far as the neighbourhood of Bordeaux and runs along the south of the Montagne Noire in the Cevennes and up the Rhône to Montelimar. Another branch follows the course of the Durance as far as Digne, goes round the pre-Alps and joins up in Italy with the north Apennine sub-Mediterranean region.

Bordering the 'Mediterranean' areas is an extensive zone of sub-axeric climate, starting from the eastern Pyrenees. South of the Garonne it extends over much of the Ariège, the Gers and the Landes while on the north bank it reaches from the Gironde right up to lower Brittany, embracing the whole of Poitou and the Charentes, thrusting up the Dordogne, Lot, and Tarn valleys, round the south of the Massif Central, up the Rhône as far as Valence and up the Durance as far as Gap and round the south of the Alps to join up with the vast sub-axeric region of Po Valley in Italy.

All the rest of France, so far as it figures on the map is axeric in climate, mitigated below 1,000 metres altitude and cold above 1,000 metres. The heart of the Massif Central is axeric with from one to four months' frost but only the high crests around the Plomb du Cantal have four to eight months' frost.

The Alps will be discussed as a single system on a later page.

In Corsica the climate is thermomediterranean in the south of the island, in the hot Bonifacio region, and Mediterranean everywhere else in the lowlands. In the central highlands the climate is sub-Mediterranean and cold with a dry season on the crests of the ranges. Below are diagrams for Perpignan and Bayonne.

Italy

The most arid parts of Italy are western Sicily and the coasts of the Gulf of Taranto and the climate is accentuated thermomediterranean.

The climate of the Taranto, Otranto region, the east coast of Calabria and most of the lowlands of Sicily is attenuated thermomediterranean.

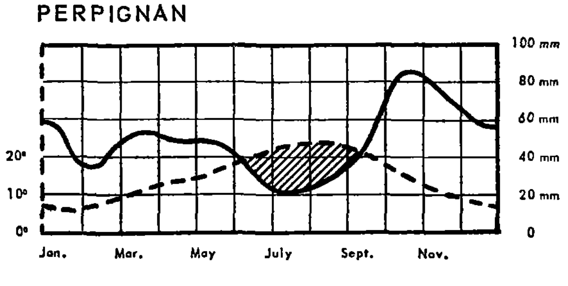
In the lowlands of central Italy the climate is mainly mesomediterranean. It is attenuated in a belt which is narrow along the Liguria coast, broadens out along the coasts of the Thyrrhenian sea down to Naples, under the southern end of the Apennines and turns north again in a narrowing belt along the Adriatic coast as far as the neighbourhood of Ravenna.

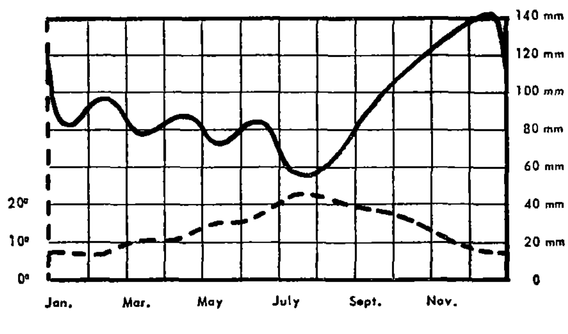
An accentuated mesomediterranean climate prevails along the coast opposite the Toscan archipelago (where the climate is identical) down to the level of Rome and again from the neighbourhood of Naples in two belts, one running towards the west coast of Calabria and the other to the Apulean plateaux. In Sicily, mesomediterranean conditions are found in the north and central middling elevations.

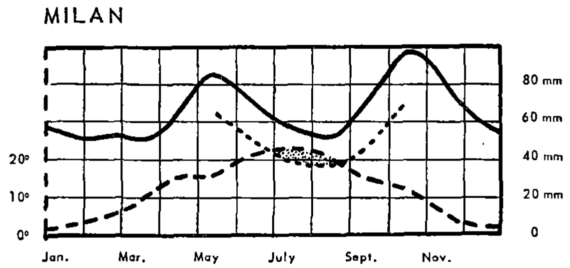
The area of sub-Mediterranean climate, which ends on the Gulf of Venice, north of the city itself, is the zone surrounding the cold-climate areas in the Apennines, plus a few small 'islands' on the uplands of Calabria and Sicily.

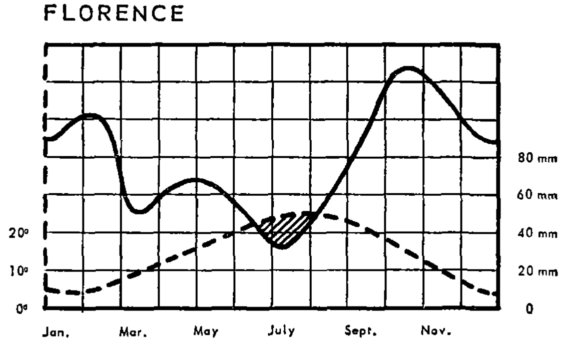
In actual fact there is an enormous range of local climates and at the limits of the Mediterranean conditions proper, exposure has a great influence; valley bottoms are colder and damper than the insolated hillsides.

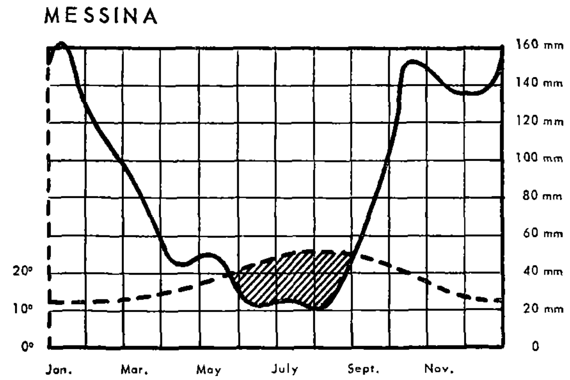
The plain of the Po constitutes a large zone of sub-axeric climate, with a semi-dry season throughout; probably too, there are parts of it with a true though

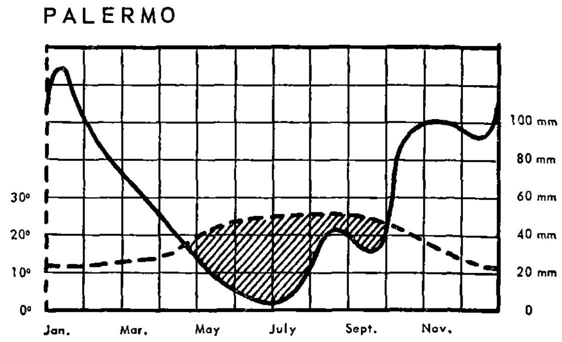












very short dry season, but this does not mean, as is often thought, that the climate there becomes Mediterranean. A narrow belt of sub-axeric climate follows the western and southern coasts of Istria to south of Trieste.

A very special type of climate, the so-called 'insubrian', is found around the Italian lakes, characterized by relatively mild winters and fairly rainy summers. It is localized and difficult to represent in detail but is essentially a low altitude temperate axeric climate on the edge of the cold Alpine climates.

The cold climates of the Apennines with cold seasons rarely over four months' long, are axeric in the north of the chain but have a dry season in the southern part.

In Sardinia the typical climate of the north-western, western and southern districts is thermomediterranean, attenuated except in the hot and dry part of the extreme south-west where it is accentuated. In the north-east and at the middle elevations in the centre of the island the climate is mesomediterranean with a sub-Mediterranean 'island' on the highest ground. Above are the diagrams for Milan, Florence, Messina and Palermo.

The Alps

In the Alps the local climates are too numerous to be dealt with individually on the scale selected and accordingly the map level shows the areas of the alpine cold climates which are all axeric. In the valley bottoms within the massifs there are dryer parts—Valais, the Aosta valley, Maurienne, Tarentaise and Upper Durance and this is universal throughout the area. They constitute a cold season zone beginning about the 1,400-metre level in the south-east of France, at the 1,000-metre level to the west of the massif (Savoie, Jura) and towards the 500-metre level in the north of Italy.

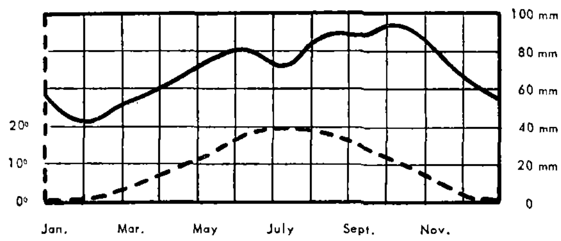
In the heart of the system there are four months of frost or over at altitudes varying, according to region, from 1,300 to 1,500 metres. At about the 2,500-metre level there are over eight months of frost, and a glacial climate (12 months' frost) starts at about 3,500 metres.

Opposite are the diagrams for Geneva and St. Moritz (Switzerland) and Graz and Innsbruck (Austria).

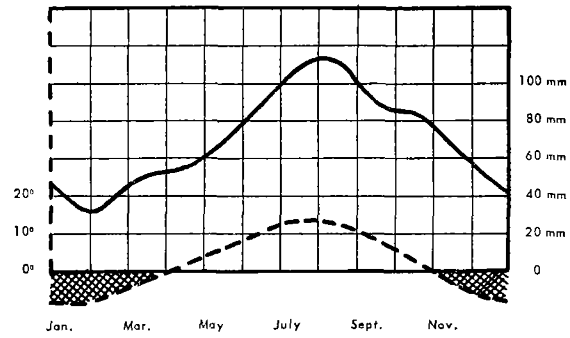
Yugoslavia, Albania

The Yugoslav islands in the Adriatic have an attenuated mesomediterranean climate but the northerly wind (Bora) lowers atmospheric temperatures and often reduces humidity. On the mainland the high plateaux of the Karst lie very near the coast and accordingly the area of sub-Mediterranean climate is very narrow, though there are small areas—which cannot be shown on the map—in valleys of appropriate orientation where mesomediterranean conditions prevail.

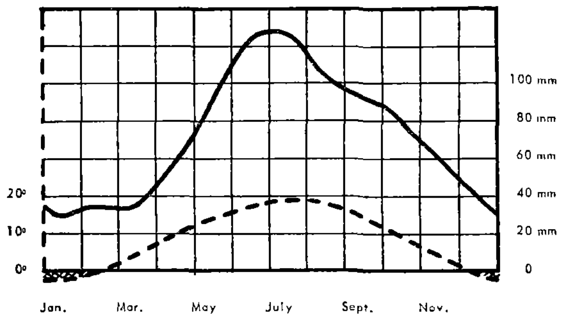
GENEVA



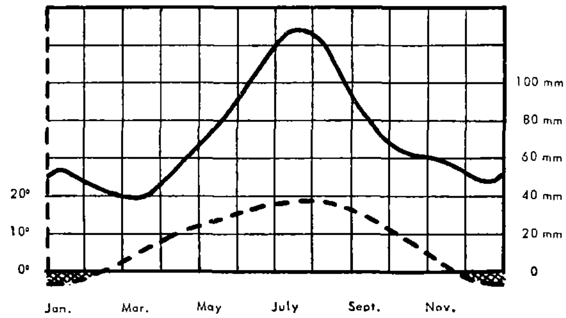
SAINT-MORITZ



GRAZ



INNSBRUCK



Between the sub-Mediterranean littoral zone and the cold climates of the interior, there is a very narrow belt of sub-axeric climate, which broadens out in Albania and a further zone in the north of Yugoslavia extending from Nouska in the Sava valley to fairly high up the valleys of the streams draining into the Sava basin. All the rest of the country has a cold axeric climate, attenuated, but only the mountain crests of Herzegovina have over four months' cold.

A point to note is that towards Montenegro rainfall is extremely violent. This lessens its effectiveness as much of the water floods off over the surface without doing anything for the vegetation.

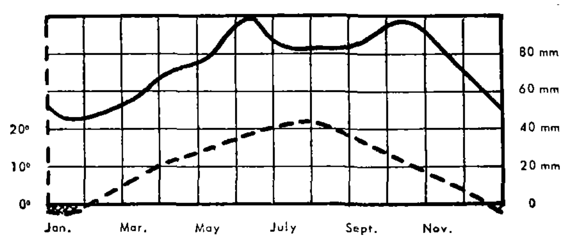
Below are the diagrams for Zagreb and Split (Yugoslavia).

Greece

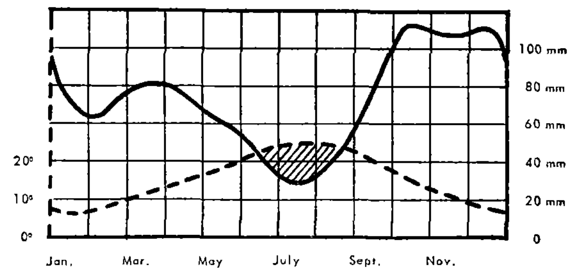
The areas of accentuated thermomediterranean climate are the Athens district, much of Euboea, the Cyclades and the Dodecanese, which are the most arid regions in Greece. The climate is attenuated thermomediterranean in the coastal belt of the Peloponnese (except in the far south) in the islands of Cephalonia and Zante (Ionian Sea) and on part of the coast near the Turkish frontier.

In most of Greece the climate is mesomediterranean, attenuated from the Albanian coast inland and over the middle altitudes of north Greece and the Peloponnese and accentuated in the lowland and coastal areas as also in the Sporades, Lemma and Tharos

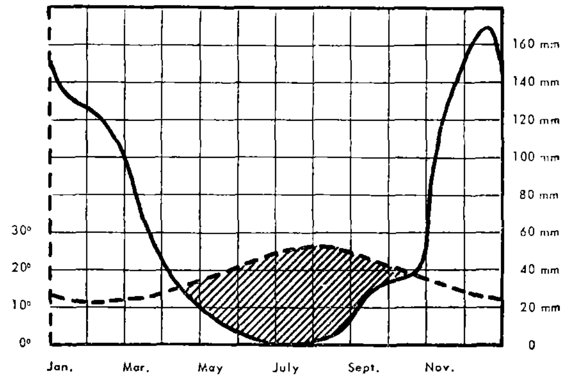
ZAGREB



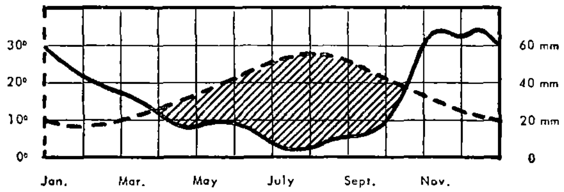
SPLIT



CANEA



ATHENS



islands. In Corfu (Ionian Sea) the prevalent climate is attenuated Mediterranean.

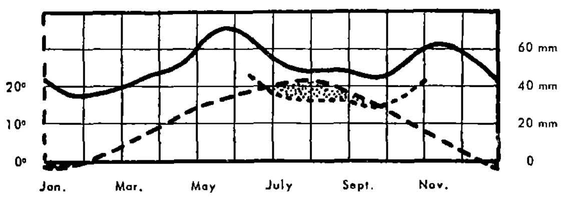
Sub-Mediterranean climates are only found in Greece at high altitudes adjoining the cold climates with a dry season found about the 1,800-metre level. Thus the mountains are of the oroxerotheric type. Towards Thrace winters are severe.

In Thessaly the winter on the plains is often severe while temperature inversion produces more clement conditions on rising ground.

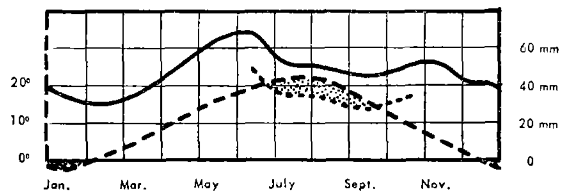
On the western coast of Chalcidice and Kavalla the climate is almost thermomediterranean. This type of climate certainly prevails are the more favourably situated places but precise data is not available. In Crete the climate is accentuated thermomediterranean throughout the northern coastal belt and attenuated in the west, but in the south greater humidity creates a mesomediterranean climate accentuated on the coast and attenuated in the highlands of the interior with a few sub-Mediterranean 'islands' at very high altitudes. Snow falls on the mountains each year.

Above are the diagrams for Athens and Canea.

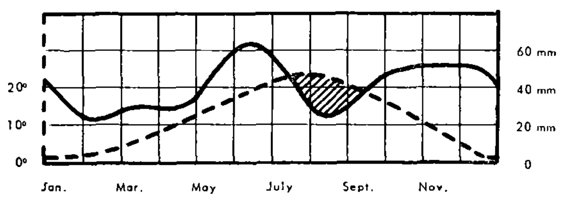
BUDAPEST



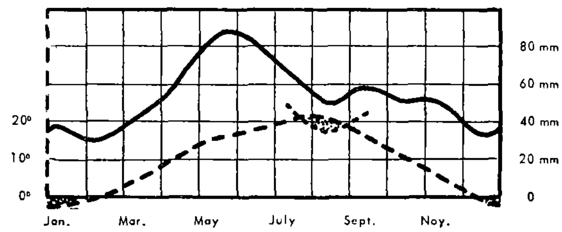
SZEGED



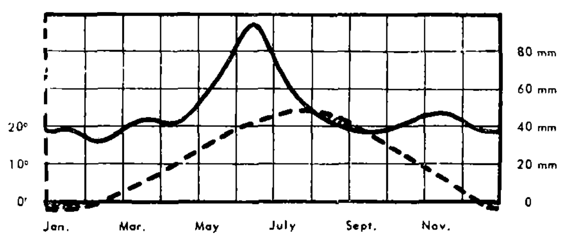
VARNA



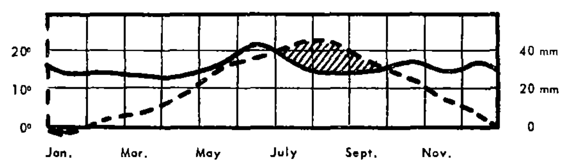
SOFIA



BUCHAREST



CONSTANTZA



Central Europe

The part of central Europe covered by the map runs from the south of the Carpathians to the Balkans and the climate throughout is cold temperate or cold save in the south where the 0° C. coldest-month curve runs across the south-east of Bulgaria and touches the Black Sea in the neighbourhood of Constantza.

On the coast of the Carpathians, the Transylvanian Alps and the Balkans, the climate, of cold axeric type, is harsh and the season of frosts lasts from five to eight months but, everywhere else, the season of frosts does not exceed four months so that the climate is cool temperate. It can be either of two types: entirely axeric or with a very short dry or fairly long semi-dry season in addition to its 'winter'; the main areas of the second type are Hungary, east of the Danube in the Tisa Basin, and a large part of the plain country in Rumania. Some authorities distinguish a 'Danubian climate' with hard winters and hot summers but with no true dry season save here and there.

Opposite are some diagrams for these regions: Budapest and Szeged (Hungary); Varna and Sofia (Bulgaria); Bucharest and Constantza (Rumania).

U.S.S.R.

Only the extreme south of the U.S.S.R. falls within the area of the map. East of the Caspian the 0° C. coldest-month curve coincides pretty much with the forty-third parallel.

North of this limit, in the desolate Oust-Ourt region, the climate is cold sub-desert and even incipient cold desert.

South of the line there is a huge zone of sub-desert climate over the arid Kara-Koum region, accentuated in the north and attenuated in the south. The severity of both climates, with their hard winters, very hot summers and violent winds, is due to the area's central position in a major land mass. Going from south to north there is a gradual change from areas with dry summers to regions with summer rains but cold winters (towards the northern boundary of the map).

Marching with these arid regions to the south, there is a belt of xerothermomediterranean climate which begins on the eastern shore of the Caspian, south of the Kara Bougaz Gulf, broadens out in the Douzlou-Alan region and then hugs the Iranian and Afghan ontiers to reach the upper valley of the Amou Dariafr further to the east.

On the western shores of the Caspian a narrow belt of similar climate starts from the north bank of the mouth of the Koura (Azerbaidjan's river) and ends on the coast towards Makhatch-Kala.

The huge Koura Basin and the Crimea are the principal areas of Mediterranean climate in the U.S.S.R.

Thermomediterranean conditions are found in the lower Koura valley accentuated near the river's mouth and attenuated in the hinterland, and again to the south-east of the Caspian contiguous with the Iranian frontier and on the west coast and part of the north-eastern sectors of the Crimea.

Mesomediterranean climates are found on all land at intermediate altitudes throughout the Koura Basin as far as Tiflis, accentuated in the relatively warm valleys and attenuated on the slopes in the southern and north-eastern coastal belts of the Crimea, in the Kerch peninsula and beyond the Kerch straits on the mainland up to west of Krasnodar.

The east coast of the Crimea is more humid with a submediterranean climate which extends beyond the Kerch country along the Black Sea littoral to Touapse.

Further along the Black Sea coast there is a small zone of sub-axeric climate in the Sotchi area, followed, in the littoral belt to the south and south-east, by the only zone of axeric temperate climate in the sector.

In all the rest of the U.S.S.R. included on the map, climates are cold, with summer dry season and four to eight months combined cold and dry seasons on the south Russian steppes and extending from the Odessa region, north-west of the Black Sea to the Petrov region, on the west coast of the Caspian, over part of the Crimea and the low plains in the extreme north of the Caucasus.

Contiguous with this harsh climate are middle zones with continued cold and dry seasons of four months or less, in Moldavia to the west, the central Crimea and the plains bounding the Caucasus on the north and east.

The cold axeric climates are found mainly in the Caucasus, Georgia and Armenia, attenuated (one to four months' frost) at low altitudes but with the frost season increasing with altitude until it lasts throughout the year on the summits of Mounts Elbrouz, Skhara and Kazpek. The cold climate of the Caucasus is exaggerated because the scale of the map would not make it possible to show the diversity of climates created by the slopes' different orientations. In some parts which are favourably orientated the climate is distinctly warmer and mediterranean crops can be grown.

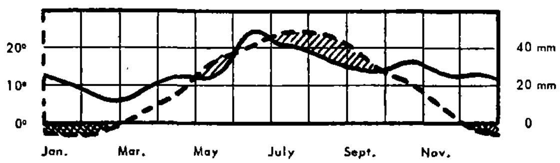
There follow diagrams for Odessa and Krasnovodsk.

Turkey

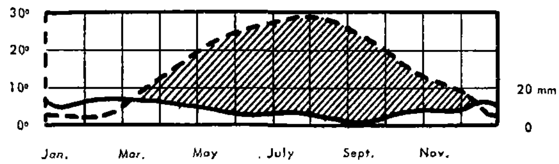
In Turkey a true Mediterranean climate is found in Turkey-in-Europe, in all the west and south of the country and on part of the Black Sea littoral, becoming xerothermomediterranean on the Syrian frontier, in the plains of the Ourfa region and inland in western Turkey in Asia, in the lake region south of Ankara.

There is an accentuated thermomediterranean climate north of the Syrian frontier throughout the hill country of Kurdistan and in the west of the relatively

ODESSA



KRASNOVODSK



arid coast facing the Dodecanese. The attenuated form of the same climate prevails in the Gallipoli peninsula, in the Aegean coastal lands, in most of the south coast and in some dry valleys inland.

In the moderately high country of west and south Turkey, the climate is mesomediterranean, accentuated in the south-west, the southern sub-littoral belt, the littoral belt west of the Gulf of Iskendaron, in the region north of the Sea of Marmora and some valleys in the north, and attenuated in the Brousse region south of the Sea of Marmora principally, with other zones on the Black Sea coast of Turkey-in-Europe, in the foothills of the Taurus and on the Gulf of Iskanderon.

Some regions of Mediterranean climate in Turkey located near regions of cold climate (black hachures) may, of course, be subject to frosts with mean minimum temperatures for the coldest month below zero; Diyarbekir is an example.

There are two fairly well watered parts of Turkey where the climate is sub-Mediterranean—on the Black Sea between Cape Indje and Unye and on the middle elevations between Unye and Trebizond and secondly, at the head of the Gulf of Iskanderon.

Temperate axeric climates occur only on the western and eastern extremities of the Black Sea coast. In the centre, there is a coastal strip of sub-axeric climate from Unye to Trebizond though with a very brief dry season.

This combination is often described as the 'Pontic climate'. In its inner border zones the rains are heavier in winter than in summer, particularly towards the east, and the same phenomenon is common to the whole periphery of the central plateaux.

Everywhere else in Turkey climates are cold and often harsh with totals of from four to eight dry and cold months combined, as is the case in the steppic regions, though on the heights overlooking the Black Sea, those west of Ankara and the southerly slopes of the Taurus and Kurdistan, the cold and dry months combined are not more than four in number.

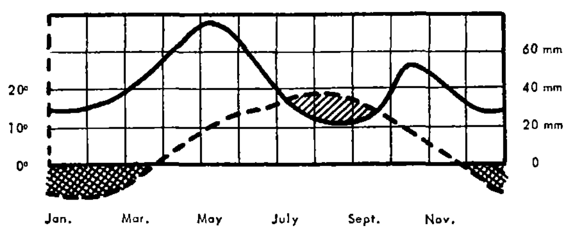
Obviously in this chaotic mountain country there are plenty of different local climates varying with the run of the valleys and other topographic factors; they would repay detailed individual study on a larger scale.

The number of months with frost reveals that east of Ankara the winter climate gradually becomes more severe in the cold steppic zone of Turkey. While there is only one month of frost in Ankara there are four in Van and Erzurum.

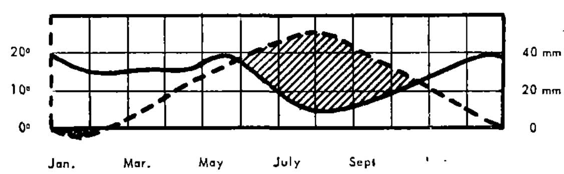
North-eastern Turkey is extremely well watered and the climate is cold temperate axeric, with neither a dry nor a sub-dry season. Similarly there are no traces of a dry season on the high crests of the interior with cold seasons of over four and in places over eight months.

There follow the diagrams for Erzurum and Ankara.

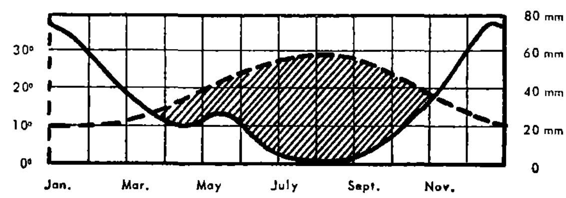
ERZURUM



ANKARA



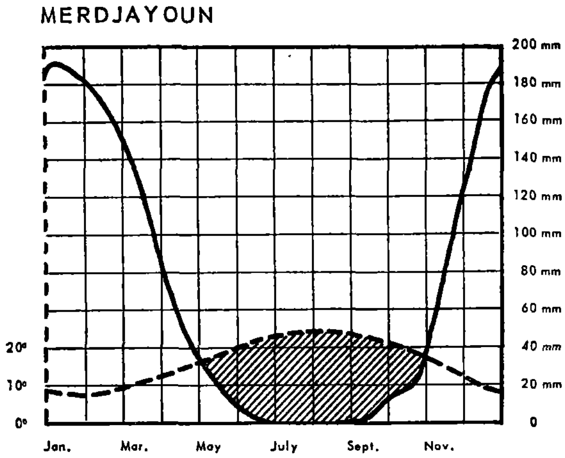
NICOSIA

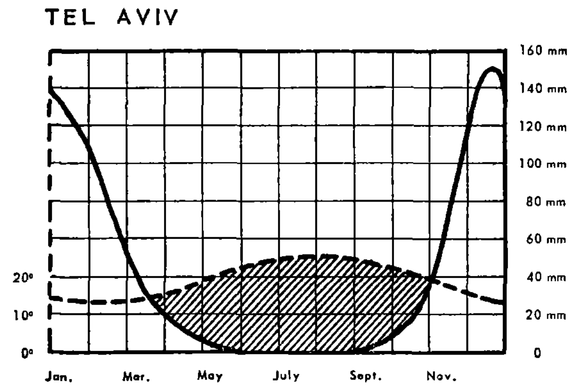


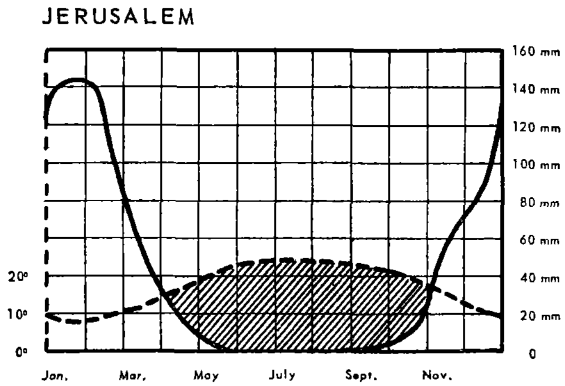
Cyprus

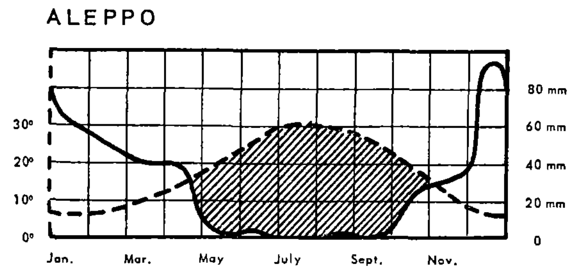
Here the climate is dry and classifiable as xerothermomediterranean almost everywhere except on the south-western heights where it is thermomediterranean, accentuated at the middle elevations and attenuated on the high crests. There are one or two points where winter snows occur.

The diagram for Nicosia is shown on the left.









Near East

The best-watered part of the Near East is around the Gulf of Iskanderon and on the Djebel Ansarieh in particular, where the climate is mesomediterranean.

Along the coastal belt from Lattakia to Jaffa, the climate is thermomediterranean, attenuated north and accentuated south of Tripoli, and the same conditions prevail in the highlands of Lebanon, with a few areas of cold climate with a short dry season at very great heights.

The whole coast north of Haifa has heavy winter rains and deep snow on the mountains of the Lebanon and Anti-Lebanon. At Jerusalem, too, at an altitude of 790 metres, winter snows are not uncommon, whereas the Dead Sea littoral, below sea level, has an exceptionally hot climate though it cannot be shown on the map.

From the Gaza area northwards, there is a belt of xerothermomediterranean climate more or less parallel with the coastline but east of the coastal ranges taking in Jerusalem, Damascus, Homs, Aleppo and Urfa regions.

The desert boundary line touches the coast on the south of the Sinai peninsula, swings near the Mediterranean littoral, and after taking in the Dead Sea and skirting the highlands of Hashemite Jordan, runs northwards to a point south of Palmyra and then more or less along the thirty-second parallel towards Iraq.

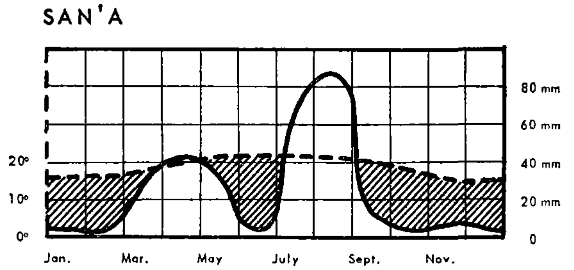
Between the boundaries of the desert and the Mediterranean climates of the coast, a sub-desert climate with Mediterranean bias is universal, extending to a sizeable area mainly in Syria, and also prevails on the highlands in the south of the Sinai peninsula.

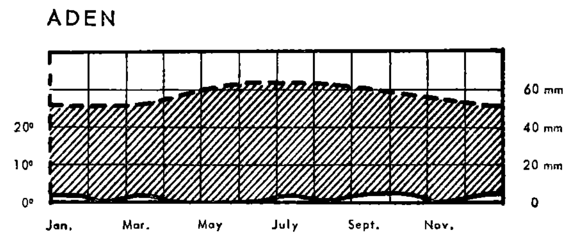
Above are some diagrams for these regions: Merdjayoun (Lebanon); Tel Aviv and Jerusalem (Israel) and Aleppo (Syria).

Arabian peninsula

The Arabian peninsula is one vast desert except for certain coastal areas and the mountain areas of the Yemen, Hadramaut and Hadjar (Oman).

On the higher ground in the Hadramaut there is a zone of accentuated bixeric climate ($150 < x < 200$),





which recurs in the Yemen mountains but becomes intermediate bixeric ($100 < x < 150$) in certain areas of rather higher rainfall notably in the relatively fertile Taiz region. A bixeric climate prevails throughout the chain from the Djebel Sabor (in the south) to the Djebel Ibrahim (in the north). Mecca can be taken as marking the boundary between climates of Mediterranean and tropical bias and the bixeric area is the zone of transition between the two.

The régime is Mediterranean in the east of the peninsula on the Hadjar uplands which have a xerothermomediterranean climate.

A belt of attenuated sub-desert climate begins on the coast of the Red Sea in the Mastura neighbourhood and then swings away from the coast to skirt the massifs of the Yemen and Hadramaut. The same pattern is found to the east of the peninsula on the Hadjar uplands.

The main coastal climate of Arabia is accentuated sub-desert save in the less arid Mecca region and in the extreme south-east, a region of greater aridity where the desert reaches to the coast. On the southern coast of Arabia the climatic bias is markedly tropical and atmospheric humidity is high but the climate nevertheless remains accentuated sub-desert.

On the slopes bordering the Red Sea the changes in the régimes are significant. On the coast itself summers are very dry while higher up dryness occurs mostly during the winter. It would be difficult to show on the map the precise boundaries of these régimes and for this the reader is referred to the studies of Troll (1941-).

The same type of climate prevails on the inland-facing slopes of all the massifs girdling the desert region.

The latter occupies almost the whole of the peninsula. It reaches down to the coast at the northern end of the Red Sea and in the south-east on the Sea of Oman. The Nefud proper, the Dahna (Dahana) desert and the central basins are so arid as to rank as true deserts.

The climatic limits shown for the central parts of Arabia are tentative in the extreme in view of the almost complete lack of records. They have desert characteristics and extremely irregular rainfall with some entirely rainless years. On the Persian Gulf, summer temperatures are extremely high.

Diagrams for San'a and Aden are given above.

Iraq

In the highlands of Kurdistan, the lower limit of the cold climate is at about 1,500 metres altitude.

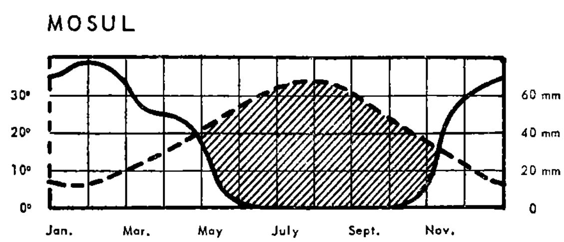
At the foot of these mountains is Iraq's least arid region, notably the upper Tigris valley and the Suleimanya area, where the climate is accentuated thermomediterranean.

Immediately flanking this zone, a belt of dryer xerothermomediterranean climate extends to a fair breadth and includes the Mosul and Kirkuk regions; thence it follows the Iranian frontier to the neighbourhood of Zorbatiya. All the rest of the country is definitely arid with particularly highs ummer temperatures down-river from Mosul.

The climate along the middle course of the Tigris is mainly attenuated sub-desert whereas the accentuated sub-desert conditions prevail in the valley of the Euphrates and continue from the junction of the two rivers (Schatt-el-Arab) down to the coast of the Persian Gulf.

The boundary-line of the desert climate cuts through lake Khammar to the east and passes between the Tigris and Euphrates valleys. At Ad Diwaniy, it crosses the Euphrates and thence runs westward roughly along the thirty-second parallel. The presence of the rivers enables the extreme aridity of the climate to be countered by irrigation.

Below is the diagram for Mosul.



Iran

Here the range of climates is very wide. Inland a desert climate prevails in three great depressions, the Dasht-i-Kavir to the north, the Dasht-i-Lut in the centre and the marshy Chil Kounar in the south.

The depressions are surrounded by regions of sub-desert climate (with Mediterranean bias) in a narrow belt in the north under the Elbourz range but broader westward predominating in the south and occupying almost all the eastern part of the country, running on into the arid regions of Afghanistan and Pakistan. On the highest ground, where winters are severe, the climate is cold sub-desert. The south coast, in contrast, is extremely hot with insignificant rainfall but the climate is accentuated sub-desert of Mediterranean bias thanks to very high atmospheric humidity.

Xerothermomediterranean climates prevail over large areas. They are found at the head of the Persian Gulf, in the country round the mountain massifs of the west, south of the Elbourz range, notably in the Teheran region, and throughout the Meched and Kariz regions of the north-east on the Afghan frontier.

Thermomediterranean climates prevail mainly in the great north-western valleys of the Kizil-Ouzoun, Shah Rud, Tara Tchai, etc., and extend high up-river; at their furthest point they approach Hamadan and Sultanabad though here severe frosts occur (mean minimum temperatures for the coldest month below zero). There is a further area of the same climate on the south-east coast of the Caspian near the Russian frontier.

On the Iranian side of the Caspian, the climates are mesomediterranean and sub-mediterranean. This is a region favoured by nature and of high fertility where, in addition, water supplies from the mountains create extremely favourable conditions for irrigation. Orange groves are cultivated in the sheltered parts.

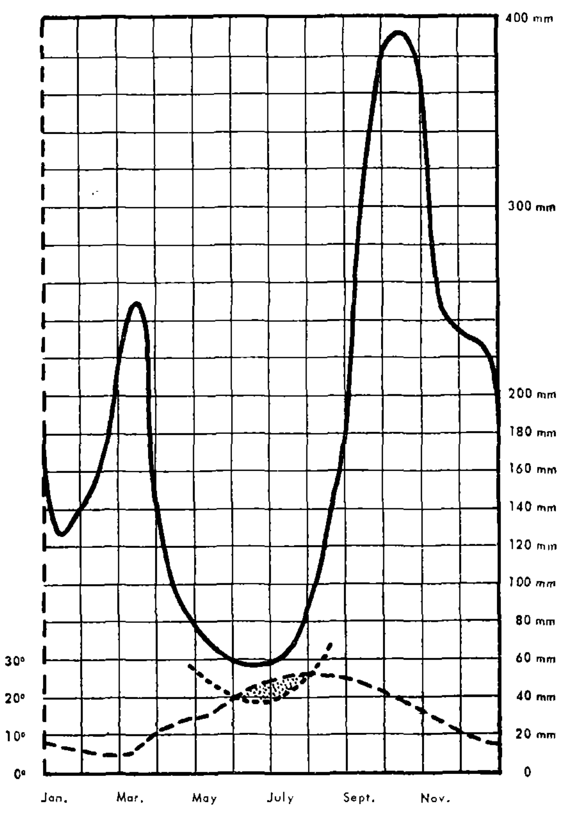
In the east and centre the climate is attenuated mesomediterranean, sub-Mediterranean in the west and in the hot and very well watered Pahlavi region subaxeric.

In the mountain massifs of Iran climates are cold but present plentiful differences. In the vast tortured massif of the west, the climate, in general, is steppic (cold with dry season) and with total cold and dry seasons combined of four to eight months. This is a harsh climate in which only pastoralism is really practicable, but in the valleys between the ranges on the moderately high ground of north-west Iran and in the foothills around the Elbourz the climate is less extreme and the period inimical to vegetation does not exceed four months.

On the Elbourz the climate is cold temperate axeric at the middle altitudes and cold axeric on the heights, with frost for over eight months on the Demavend where snow is persistent. The Caspian slope is much more humid.

Diagrams are given for Pahlavi and Teheran.

PAHLAVI



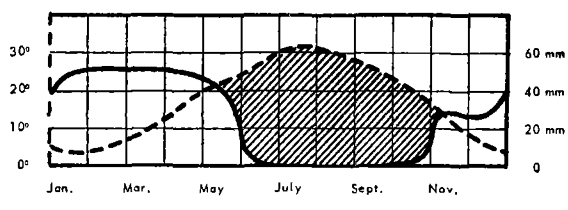
Afghanistan

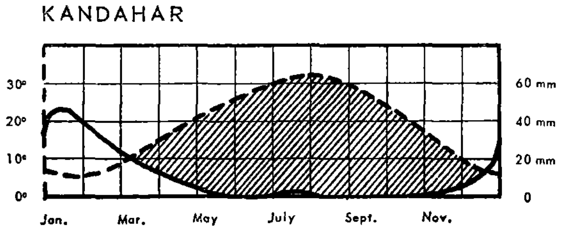
Most of Afghanistan is arid.

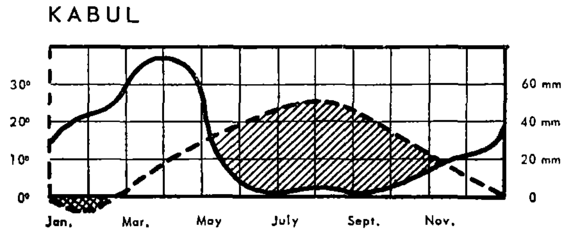
The most fertile part is in the east, on the frontier with west Pakistan. Over most of the area, the climate is xerothermomediterranean, but is thermomediterranean in some low-lying parts of the valleys of the north-east and the Kabul valley in particular, and there are even islands of mesomediterranean climate in the Matun region (east of Gardez). At high altitudes in the same eastern frontier area, there is a cold climate with summer dry season, with the cold and dry seasons together not exceeding four months.

The xerothermomediterranean climate also prevails along the frontiers with Iran and the U.S.S.R. at low altitudes. Throughout all the rest of the country, climates are arid owing to the length either of the dry season in the hot lowlands or of the cold season in the uplands or, again, the combination of severe

TEHERAN







winters and dry summers in a large part of the country.

In the Kandahar desert and the deserts on the Iranian and West Pakistan frontiers, the 'dry season' is twelve months long.

Surrounding these deserts there is a broad belt of sub-desert climate with Mediterranean bias over all the low country of the west and south. Throughout the rest of the country cold climates prevail, usually cold sub-desert with over eight months' drought and frost in all, though conditions are less severe in the areas bordering the U.S.S.R. and Pakistan with combined totals of from four to eight months.

About the 4,000-metre level the cold season is over eight months in length and between about 5,000 to 5,500 metres altitude, according to region, the climate becomes glacial.

As Afghanistan's network of weather stations is still thinly spread and a number of the stations have only recently been put into operation, observations will have to continue for many years to provide acceptable measurements for studying all the variants of climate prevailing in the complex mountain system which forms the major part of the country.

Above are the diagrams for Kandahar and Kabul.

West Pakistan and India

With the exception of the high table-lands of Baluchistan and the Indo-Gangeti plains about 150 kilometres south of the Himalayas, the parts of Western Pakistan and India included in the map are arid lands.

In western Baluchistan the climate is in the main desert with Mediterranean bias, forming one system with the deserts of Iran and Afghanistan, while a desert climate with tropical bias prevails throughout the middle basin of the Indus.

In the west, the belts of sub-desert climate surrounding the deserts are of a Mediterranean bias, attenuated in the relatively humid coastal areas and on the high table-lands and accentuated where they meet the desert climate in the low-lying warm areas of the south-west.

The Indus desert area is surrounded by a vast zone of sub-desert climate with tropical bias, which also prevails in most of the Punjab, Rajastan and the south coast. There is a decrease in aridity from west to east thanks to more abundant and, above all, better distributed rainfall.

There is a Mediterranean climate in the valleys and high table-lands in central and northern Baluchistan, the upper Indus valley, and Kashmir which does not appear on the map, while the xerothermomediterranean is the typical climate of the central ranges of Baluchistan (Kalat Plateau) and the hills on the west of the Indus basin.

Thermomediterranean conditions are found only in the middle valley of the Kabul River, and in the Parachinar region (near the Afghan frontier) there are warm humid valleys with mesomediterranean climate.

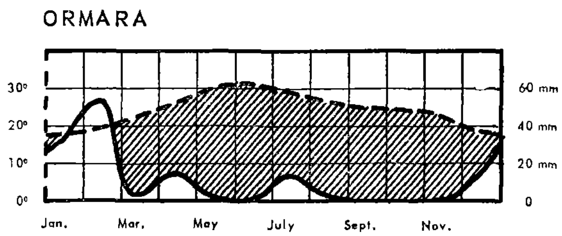
A tropical climate only prevails in the south of the parts mapped on the coasts of the Gulf of Cambay where it is of the accentuated type.

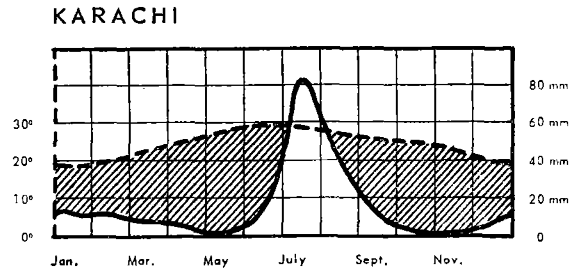
In the north the predominant climate is bixeric, accentuated in a broad belt in the Indo-Gangetic plain with its western limit in the Peshawar region and running off our map to the east, intermediate in a narrow belt at the foot of the western Himalayas and attenuated only in the foothills of the Himalayan chain between the 1,000 and 2,000-metre levels. As altitudes increase, the dry season shortens more and more until the climate is sub-axeric and at certain points temperate axeric.

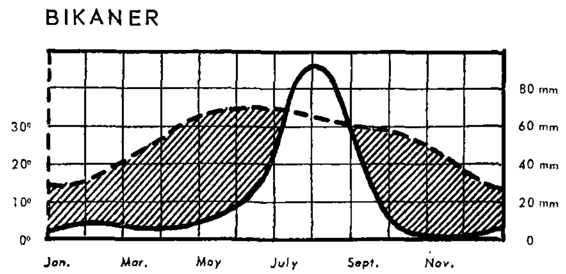
In the western Himalayas, the lower limits are at heights between 2,000 and 2,500 metres according to place for the cold climates, between 3,500 and 4,000 metres for climates with up to four months' frost, between 4,500 and 5,000 metres for those with eight months' frost and around 5,500 metres for glacial climates.

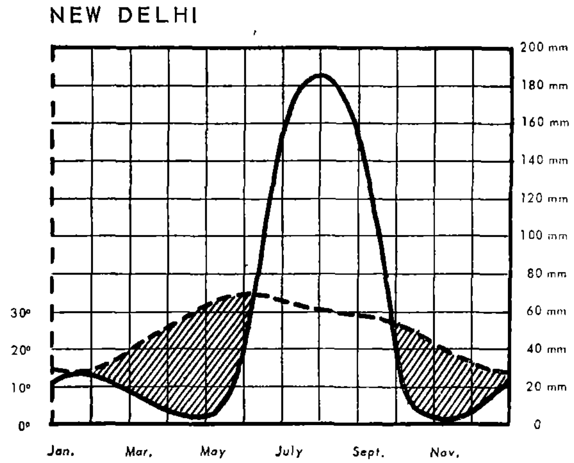
There follow the diagrams for Ormara and Karachi (Pakistan) and Bikaner and New Delhi (India).

The eastern boundary of the Old World countries with Mediterranean climates runs through Western Pakistan; it can be drawn roughly a little west of the Indus but without trying to make it too hard and fast, as there is no clear-cut divide between the climates of tropical and Mediterranean bias respectively.









1/10,000,000 MAPS OF HOMOLOGOUS REGIONS[1]

Southern Africa

In southern Africa, climates of Mediterranean pattern are confined to a small area whose boundaries can be taken roughly as the south-west coast and a line from Port Elizabeth to the mouth of the Orange River.

Within this area, the most humid regions are around Cape Hang Klip and the coastal belt between Victoria Bay and Port Elizabeth with sub-Mediterranean climates. Near Cape Seal, there is a narrow coastal band of sub-axeric climate.

The climate is mesomediterranean in the coastal belt between the Cape of Good Hope and Victoria Bay, mostly accentuated type save on the coast in the extreme south-west and on the coastwise slopes between Victoria Bay and Addo, while thermomediterranean on the coasts of the Zwartberg Heights and coastal ranges between the Cape of Good Hope and Haedjes Bay.

The northern slopes of the Zwartberg, the massif in the Worcester area, and the west coast between Haedjes Bay and Lamberts Bay have xerothermomediterranean climates.

North of the area of Mediterranean climates, are the arid regions (desert and sub-desert) of Southern Africa.

The Orange River valley and most of Great Nama Land have a desert climate.

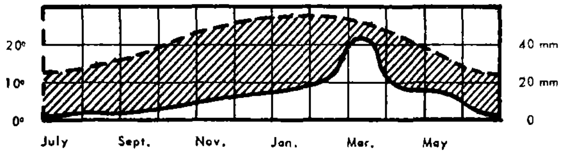
The climate is essentially accentuated sub-desert in the Kalahari, the north of Cape Province and on the coastal slopes of the great massif of South-West Africa, while a belt of attenuated sub-desert climate runs along the west coast where air humidity is extremely high, covers Nieuweld Mountains in the Cape and takes in the east and north of the Kalahari; a zone of similar climate in the Chabane region is split between Mozambique, Southern Rhodesia and the Transvaal.

In the east of the area mapped, the régime is tropical. A belt of accentuated temperate tropical climate running north-south bounds the arid regions of the west, while the intermediate type is the main climate of all the massifs in the east of the Republic of South Africa, changing to attenuated above 2,000 metres altitude, with fairly low temperatures during the period of least daylight. About the 3,000-metre level the climate becomes cold temperate axeric.

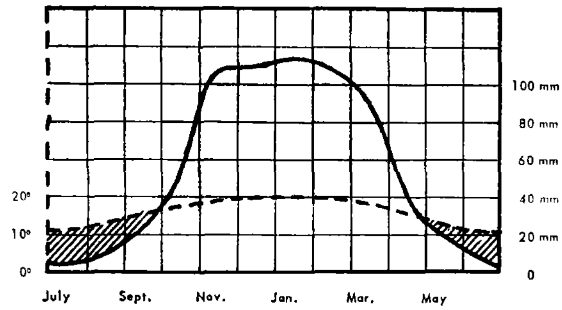
The north-eastern part of the area mapped has a warm tropical climate with mean temperatures of over 15° C. in every month, accentuated in the middle basin of the Limpopo River, intermediate in the Lundi River valley and on the coastal region of southern Mozambique and attenuated in Zululand and the Inyak peninsula.

1. In view of the smallness of the scale, only the main climatic divisions have been shown on these maps and to avoid overcrowding them, no distinction has been made between sub-desert climates of tropical and Mediterranean bias respectively.

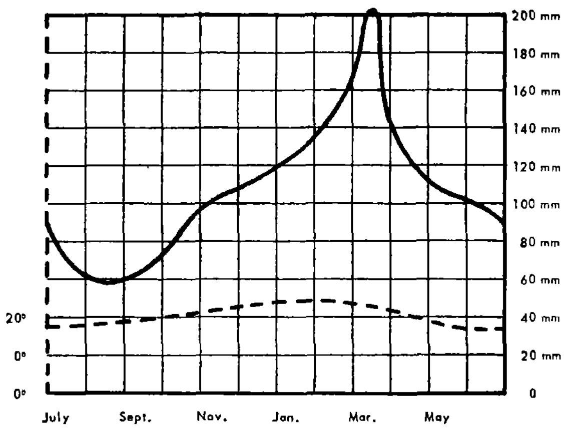
UPINGTON



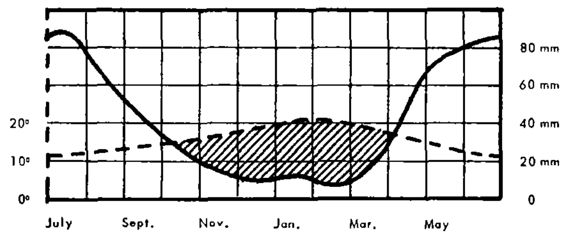
JOHANNESBURG



CAPE ST. LUCIA



CAPE TOWN



All the south-east coast, from the Inyak peninsula to Port Elizabeth, is extremely well watered, and the climate is submesaxeric ($x < 40^{o}$) in the Lake Kosi and Durban regions and everywhere else on the coast warm axeric (sub-equatorial).

Above are diagrams for Upington, Johannesburg, Cape St. Lucia and Cape Town (Republic of South Africa).

Southern Australia

The parts of Australia with climates of Mediterranean type are in the south and south-west.

While the northern coast of the Great Australian Bight is arid, there is a true Mediterranean climate on either flank of the southern part of Australia to the west and parts of South Australia, and New South Wales and almost all Victoria and the east.

West Australia has a true Mediterranean climate throughout the coastal belt from Cape Naturaliste to north of Cape Paisley, attenuated on the south coast and accentuated in the Cape Leeuwin region and the sublittoral. Between Entrecasteaux Point and Cape Howe rainfall is extremely abundant and the climate is sub-Mediterranean.

Over much of the west coast from Geralton to Cape Naturaliste the climate is thermomediterranean, as also is a fairly extensive area in the hinterland about the latitude of Perth with a narrow belt running on towards the Great Bight and reaching the coast in the neighbourhood of Point Culver. This climate follows the attenuated pattern on the coast in the Perth area and on the heights and is accentuated elsewhere.

The xerothermomediterranean prevails in a region describing an arc from the west coast (Lynton) to the Great Bight (Barramul).

In the south-east of Australia there is a narrow belt of sub-Mediterranean climate along the coast between Portland and Melbourne which then broadens and runs to the west and north of the foothills of the Australian Alps. There is a sub-axeric climate in the Melbourne region, on the coast, and on the heights west of the city and the middle altitudes north of the Australian Alps.

The main area of mesomediterranean climate is the south-west of the State of Victoria, with a zone embracing the plains north of the Australian Alps and a belt from Discovery Bay along the coast to Kingston in South Australia where there is also a small 'island' at the end of the York Peninsula.

The climate is thermomediterranean on the coasts of the Eyre and York peninsulas, in a coastal zone running from York Peninsula to Kingston and in a narrow belt running west-east as far as Narrandera in New South Wales.

In the greater part of the basins of the Murray and Murrumbidgee Rivers the climate is xerothermomediterranean, westward throughout the Bryan region at the head of the Spencer Gulf, over much of the Eyre Peninsula and along the coast of the Great Bight as far as Coymbra.

From Coymbra to Barramul the climate on the coast of the Great Bight is attenuated sub-desert, thence it continues westward, north of an arc from Barramul to the north of Lynton on the west coast of Australia, while eastward from Coymbra, its southern limit touches the head of the Spencer Gulf, runs on towards Florida in New South Wales and thence northward to the western slopes of the Queensland mountains.

The zone of accentuated sub-desert climate marches with the boundary of Australia's desert area. The line runs west of the Great Sandy Desert and Gibson's Desert, southward roughly along the hundred and twentieth meridian to its intersection with the thirtieth parallel, then east south of the Victoria desert and across the Nullarbor Plain, north of the Flinders Range along the valley of the Barcoo (Cooper's Creek) and then north-west.

Australia's arid regions have a Mediterranean bias as far as the thirtieth parallel, indeterminate thence to the midway line and tropical thereafter.

In the small area of the Australian Alps included in the map there is an area of cold climate with under four months' frost on Mount Buller, while around it, and along the coast from Port Albert, the climate is temperate axeric.

The areas of tropical climate of north and east Australia do not figure largely on the present map. However, two areas of accentuated warm tropical climate do appear in the north-east corner, in Queensland, on either side of the central range.

In the cooler country of the range itself and to the south of it the climate is accentuated temperate tropical.

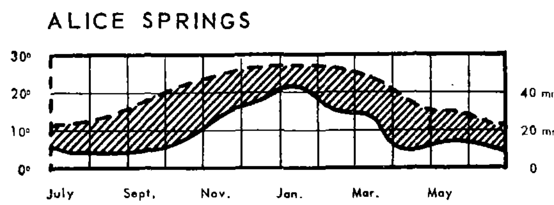
The intermediate and attenuated temperate tropical climates are represented on the map only by two small areas in New South Wales, around Condobolin and Temora respectively.

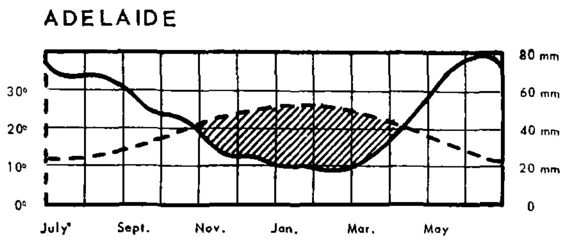
Below are the diagrams for Alice Springs (Northern Territory), Adelaide (South Australia), Albany (West Australia) and Melbourne (Victoria).

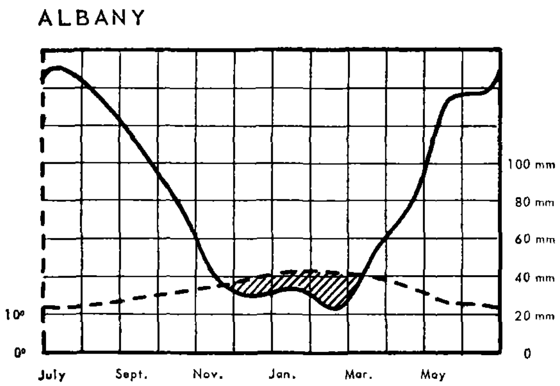
Southern part of South America

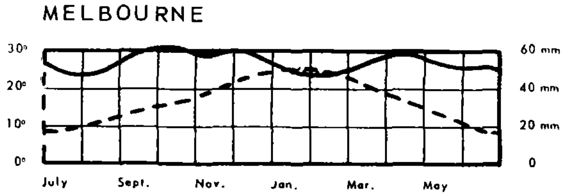
In this area, broadly speaking, the tropical elements are east and the Mediterranean west of an imaginary line drawn south-east from the Coquimbo headland in Chile to the mouth of the Rio Colorado in Argentina (Bahia Blanca). Argentina's areas of Mediterranean climate are divided from the corresponding areas in Chile by the Cordillera of the Andes.

The xerothermomediterranean climate prevails over vast areas in Argentina—on the lower course of the Rio Negro, on the hills of north and central Patagonia, on the middle and lower courses of the Deseado, Chico and Santa Cruz rivers and over the whole Atlantic









coast from Cape San Jose to El Reynard. In Chile it is the climate of the Pacific Coast, from the mouth of the Rio Choapa to San Antonio (near Valparaiso).

Thermomediterranean conditions occur in Argentina in a narrow coastal belt on either side of the mouth of the Rio Negro where they are accentuated, in southern Patagonia, on the lower courses of the Rio Gallego (attenuated) and the Rio Coyle (accentuated), and in a belt in the Andes foothills—where it is predominantly accentuated, running north from east of Lake Buenos Aires as far as Lake Alumine. In Chile the accentuated type prevails in the Rio Mataquito region and the attenuated in the valley of the Rio Maule.

Chile has the largest area of mesomediterranean climate, embracing the whole Concepcion region, the basin of the Rio Itato where it becomes accentuated and the basin of the Rio Biobio where it is attenuated. The only parts of Argentina with this climate are the middle altitudes, east of the Patagonian Andes between Lake Buenos Aires and Cushamen and in southern Patagonia, in the Cape Virgenes region.

The sub-Mediterranean climate is represented in Argentina by a few small scattered 'islands' in the humid and sheltered valleys within the Patagonian Andes. In Chile it is the climate of the Rio Cantin basin and the upper valley of the Rio Biobio.

Contiguous with this climatic area is an enclave of sub-axeric climate (with short sub-dry season) extending over the area round the mouth of the Rio Tolten, with a small tongue in a region shared by Argentina and Chile in the neighbourhood of Figueroa.

Temperate axeric climates are found in Chile from the mouth of the Rio Tolten as far as the cold lands of the far south, throughout the littoral and on the innumerable isles and islets of the south. They prevail in the Great Pampas zone of Argentina and correspond more or less to the quadrilateral Guatmozin (inland), Bahia Blanca, Mar del Plata and the head of the River Plate estuary. The line Guatmozin-Rio de la Plata roughly corresponds to the 10° isotherm for coldest month temperatures and north of this line the climate is warm temperate axeric (temperature of the coldest month between 10° and 15° C.). As in other parts of the world, the transition between the tropical and Mediterranean régimes is via arid climates in the greater part of South America.

A desert climate—of indeterminate bias—prevails in part of the Valdez Peninsula, the basin to the north of Cipolletti and—its main area—the upper valleys of the Desaguadero, the Bermejo and the Zanjon rivers.

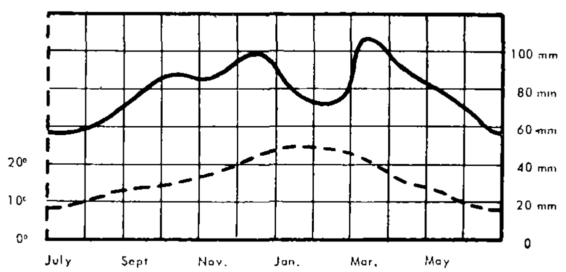
Around these three areas of desert climate a belt of sub-desert climate runs north from the Atlantic coast between Cape San Jose and the mouth of the Rio Verde to broaden out in the region south of Mendoza and still more in the Sierra de Famatine-Satinas Grandes area. Other areas are the valley of the Rio Chico and part of the Valdez peninsula.

The opposite sides of the watersheds present great contrasts. Thus the foot of the Sierra de Aconquija, west of Tucuman, is tropical to the west and sub-desert to the east, and the same difference appears in the Sierras to the east of the Andean massif.

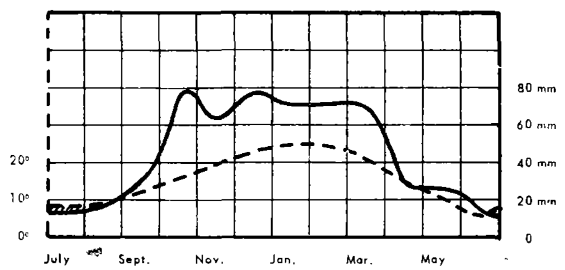
In Chile the area of sub-desert climate begins on the coast near the thirtieth parallel in the Quillaicillo region and runs north in two belts, a narrow one along the coast and another along the middle slopes of the Andes. Between the two is the start of the desert region of Atacama, where conditions of extreme aridity are attained.

Between the limits of the zones of sub-desert and temperate axeric climate respectively which run roughly north-south, Argentina has a succession of

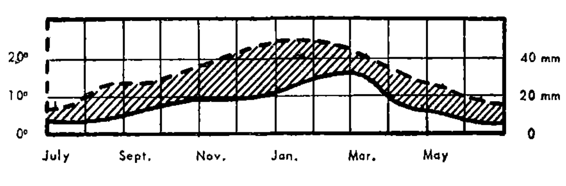
BUENOS AIRES



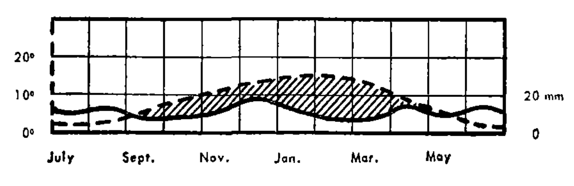
VICTORICA



MENDOZA



SANTA CRUZ



belts of climate under a tropical régime, also running north-south and increasingly arid from east to west.

In the north-east of the area on our map is a region of warm tropical climate, of intermediate type, in the central part of the south Chaco, attenuated in the east of south Chaco, and south of the Middle Chaco, and becoming transitional in a narrow belt bordering the zone of warm temperate axeric climate.

However, in the greater part of the area under the tropical régime the climate is temperate tropical.

The zone of accentuated temperate tropical climate marches with the sub-desert areas. It embraces part of the middle course of the Rio Salado, the west of the Sierra de Cordoba, the eastern sector of the Salinas Grandes and the middle altitudes on the western faces of the Sierra de Ambato and the Sierra de Aconquija.

The intermediate temperate tropical belt follows the lower course of the Rio Colorado, takes in the eastern slopes of the Sierra de Cordoba and runs up the middle valley of the Rio Pasajo towards the heights to the east of the Aconquija chain.

The attenuated temperate tropical belt starts on the Atlantic coast, south of Bahia Blanca, runs northward and spreads over the Cordoba region.

The transitional belt (sub-axeric) starts on the coast at Bahia Blanca, extends over the western part of the Pampas and runs up the west bank of the Rio Parana.

The cold climates are found in the Cordillera des los Andes and as the chain runs north-south, the altitudes at which frost conditions last one, four, eight or twelve months vary with latitude and with distance inland at identical latitudes.

On the thirtieth parallel, the cold climates start between the 2,000 and 2,500-metre levels and the zone of year-round frost conditions at altitudes about 5,000 or 5,500 metres.

On the fiftieth parallel, the cold climates start around the 500-metre level and glacial climates towards 2,000 metres. These lower altitudes rapidly decrease towards the south of the continent and it may be an exaggeration to represent a Mediterranean climate for the Rio Coyle.

Opposite and below are the diagrams for the following stations in Argentina: Buenos Aires, Victorica (west of Buenos Aires), Mendoza (eastern slope of the Andes), Santa Cruz (South Patagonia) and in Chile: Valparaiso (north coast) and Valdivia (central coastal area).

Western region of North America

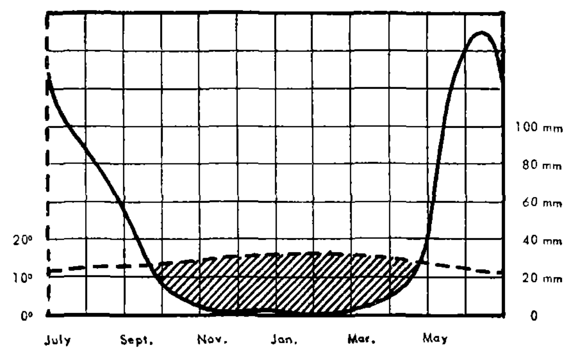
The whole coastal region of the western United States is under a Mediterranean régime.

Aridity increases from north to south, but is tempered on the coast by high atmospheric humidity and in many localities by frequent mists.

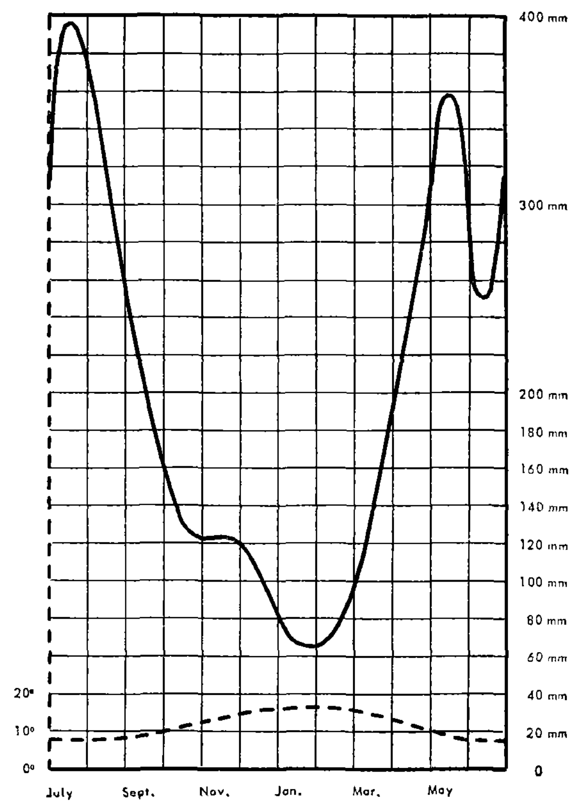
The climate already has a discernible Mediterranean bias in the extreme south-west of Canada where there is a sub-dry season and the climate is sub-axeric in part of Vancouver Island, on the coast of Georgia Strait and on the middle heights around Mount Olympus (U.S.A.).

On the eastern coasts of Vancouver Island and in the vicinity of Vancouver city we find a short dry season which marks the beginning of a zone of sub-Mediterranean climate which runs in a broad belt throughout the coastal zones of Washington and Oregon States

VALPARAISO



VALDIVIA



down to the mouth of the river Umpqua, continuing along a narrow coastal belt as far as Trinidad in the north of California. In the better-watered coastal chain west of Portland, the climate is sub-axeric.

A mesomediterranean climate prevails over large areas in the middle basin of the Columbia river, all the western face of the Cascades range and throughout the coastal region of California between Trinidad and San Francisco; it is attenuated on the coast and around the Columbia river and accentuated on the high ground and on the plain north of the Blue Mountains.

The thermomediterranean climate prevails over the whole Californian coast from San Francisco to the neighbourhood of Los Angeles. It is of the attenuated type in the San Francisco region but the accentuated type begins in Monterey Bay and extends over the coastal highlands as far as San Bernardino. The climate is again accentuated thermomediterranean in the area between the coastal range and the Sierra Nevada, throughout the whole plain north of the Sacramento and on the western slopes of the southern stretch of the Sierra Nevada.

In the plain between the coastal chain and the Sierra Nevada the attenuated sub-desert climate of the Joaquin river valley is surrounded by an area of xerothermomediterranean climate continuing southward from this dry region in a belt which skirts the heights to the north of Los Angeles and from north of Los Angeles covers a coastal strip down to Bahia San Sebastian Vizcaino (Mexico) on the west coast of lower California. The same climate prevails north of Sacramento in the fairly dry region of Colusa and Pyramid Lake.

The boundary line of the desert climate area starts from the western shore of the Gulf of California around Concepcion Point, runs up the coast in Mexican territory and then crosses the United States frontier where it passes west of Lake Salton, skirts the east of the San Bernardino heights, approaches the town of Mojave, then north via Death Valley to a point due east of Mt. White, thence east and south via Las Vegas to due east of Phoenix and ends on the east coast of the Gulf of California at Puerto Libertad.

Another relatively small region on the map is in the Rio Grande valley in Mexico, south of Ciudad Juarez. The Yuma region at the head of the Gulf of California is extremely arid and the Gran Desierto (*Grand Desert* on the map) is true desert.

In lower California there is a sub-desert climate in the south of the peninsula and on the highlands of the centre and north. In California itself there is a narrow belt of the same climate between the areas of Mediterranean and desert climate and in Nevada between the areas of cold and desert climate. It also prevails throughout the Colorado valley as far as Grand Junction, over wide areas in Arizona, where only the San Francisco plateau has an appreciable degree of humidity, in the south of New Mexico State and in the middle section of the Rio Grande basin in Mexico proper.

The bias of the arid climates on the east of the Sierra Nevada is definitely Mediterranean; for all the others it is indeterminate or tropical.

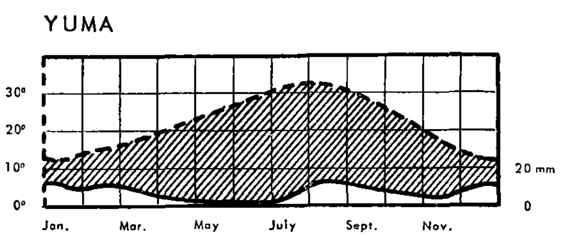
Tropical climates do not figure largely on this map. In Mexico the western Sierra Madre has a temperate tropical climate, intermediate on the fairly well watered high plateaux and accentuated at low altitudes. In the United States there is a temperate tropical climate in New Mexico east of the Rio Grande, while west of the river as far as the Green River the climate is transitional with a tropical régime at certain points but mostly bixeric.

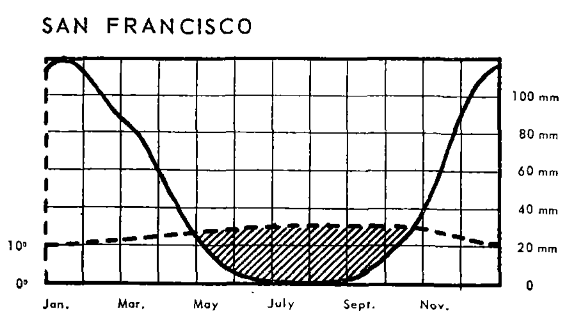
There are few areas of temperate axeric climate apart from the Vancouver region and Cape Flattery.

Much of the country covered by the map is under cold climates, mainly of the steppic or sub-desert type with a dry season.

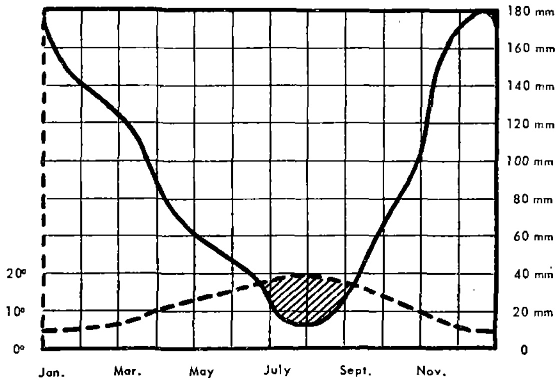
A point to note is that while rainfall distribution is Mediterranean in the western states (rain in the period of shortest daylight), in the inland states, the main rainy season is in summer. The amounts received are more in total than the winter rainfall, but the amounts delivered by each shower are small and with the extremely high summer temperatures of these inland areas, the vegetation is subjected to summers which on balance are on the arid side.

There is a sub-desert dry season cold climate on the Great Basin table-land in south-east Oregon and on both sides of the upper Colorado valley. In these areas the total of cold and dry months together is over eight. It decreases to over four and under eight in parts of

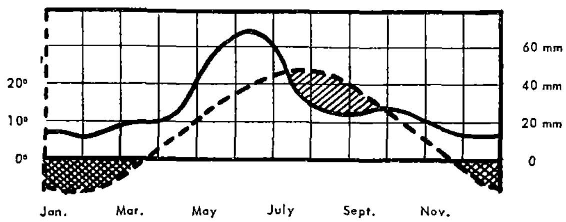




PORTLAND



MILES CITY



the Sierra Nevada, in the lake region to the south of the Cascades Range and on the Blue Mountain and the same conditions prevail in the east of Washington State, in most of Montana, Idaho, Wyoming and Utah, in western Colorado and to north-west New Mexico.

The area of cold sub-axeric climate which has cold and dry seasons combined totalling over two and under four months and hence is much milder, is found mainly along the boundary of the western region of Mediterranean climate, but also at middle latitudes in some of the better-watered inland massifs, e.g., the ranges south of the Bitter Root Mountains (Oregon), the Wahshatsch Mountains (Utah), the Park Range (Colorado), the Laramie Mountains (Wyoming) and the San Francisco table-land (Arizona).

All types of cold axeric climate are represented on the map. In mid-continent United States on the fortieth parallel the mountain regions of continental climate have four months of frost conditions around the 2,200-metre level and eight about 4,000 metres.

In northern United States and southern Canada the altitude limits of the various cold climates vary considerably with the degree to which the climate is of continental type; the coastal region in particular has remarkably mild winters and temperature differences are very small. In this type of country, on the fiftieth parallel, the cold climates only begin between 500 and 800 metres altitude; a four-month frost season is found towards the 1,200-metre level.

At the same latitude inland within the area shown on the map, a four-month frost season starts towards the 400-metre level, a season of eight months between 2,000 and 2,500 metres and twelve months of frost conditions between 3,200 and 3,800 metres.

As with the Alps, all these highly accidented areas in the United States and Canada would be worth detailed study to determine the many shades of climate created by the tortured topography. On the scale used only the over-all climates can be shown.

Opposite and above are diagrams for Yuma (Arizona), San Francisco (California), Portland (Oregon) and Miles City (Montana).

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It would be difficult to list all the publications in which climate is studied, since any work on geography or vegetation contains a chapter related to climate. Consequently, only the essential information available from meteorological services in various countries is given for each section. This is followed by a list of publications in which either statistical data or climatic maps are supplied. Well-known atlases were consulted but are not listed here. For the countries which are represented on 1/10,000,000 scale maps the bibliography is limited to essentials.

The main sources of information used for the preparation of this work are indicated by an asterisk.

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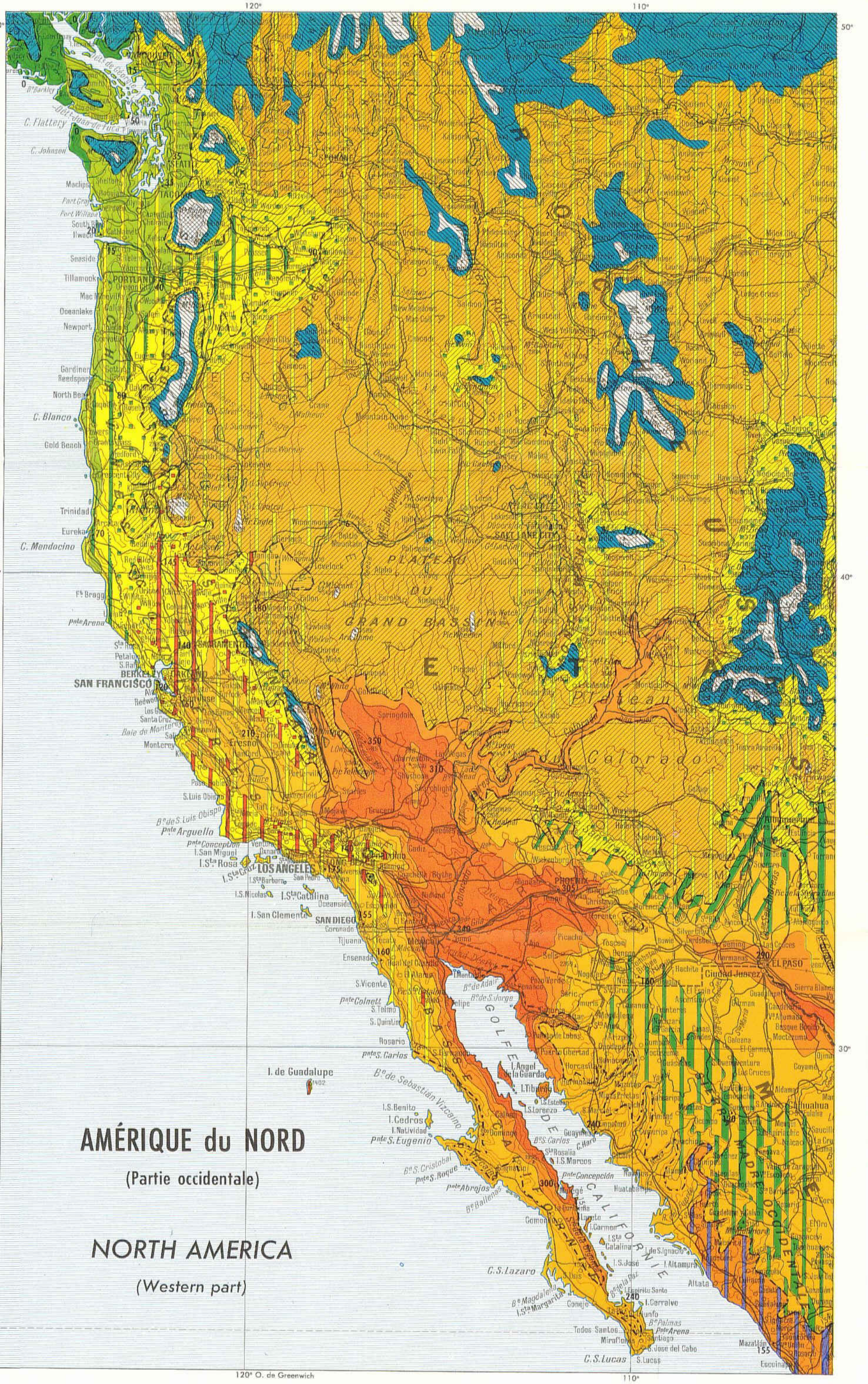
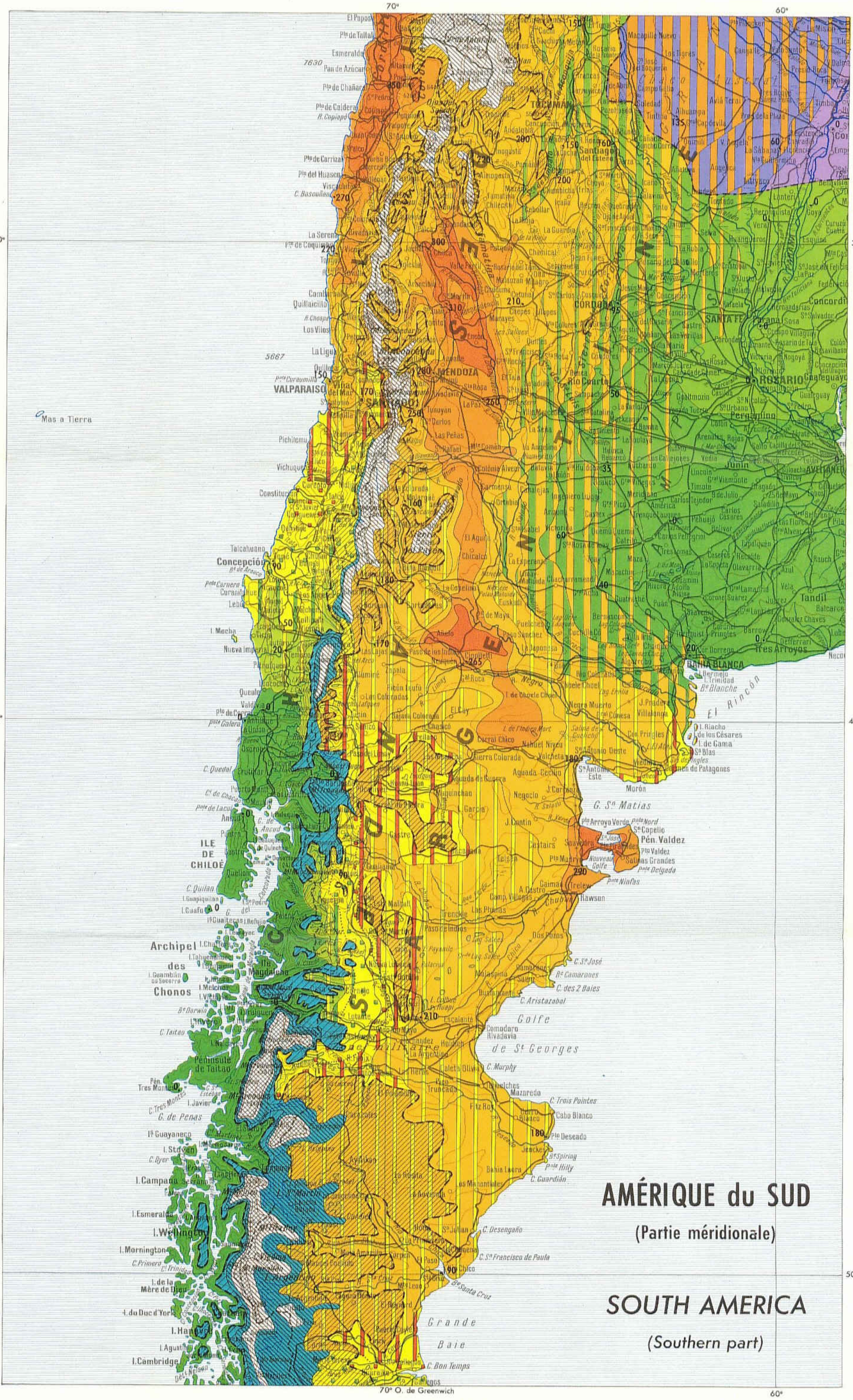


AMÉRIQUE du NORD
(Partie occidentale)

NORTH AMERICA
(Western part)


AMÉRIQUE du SUD
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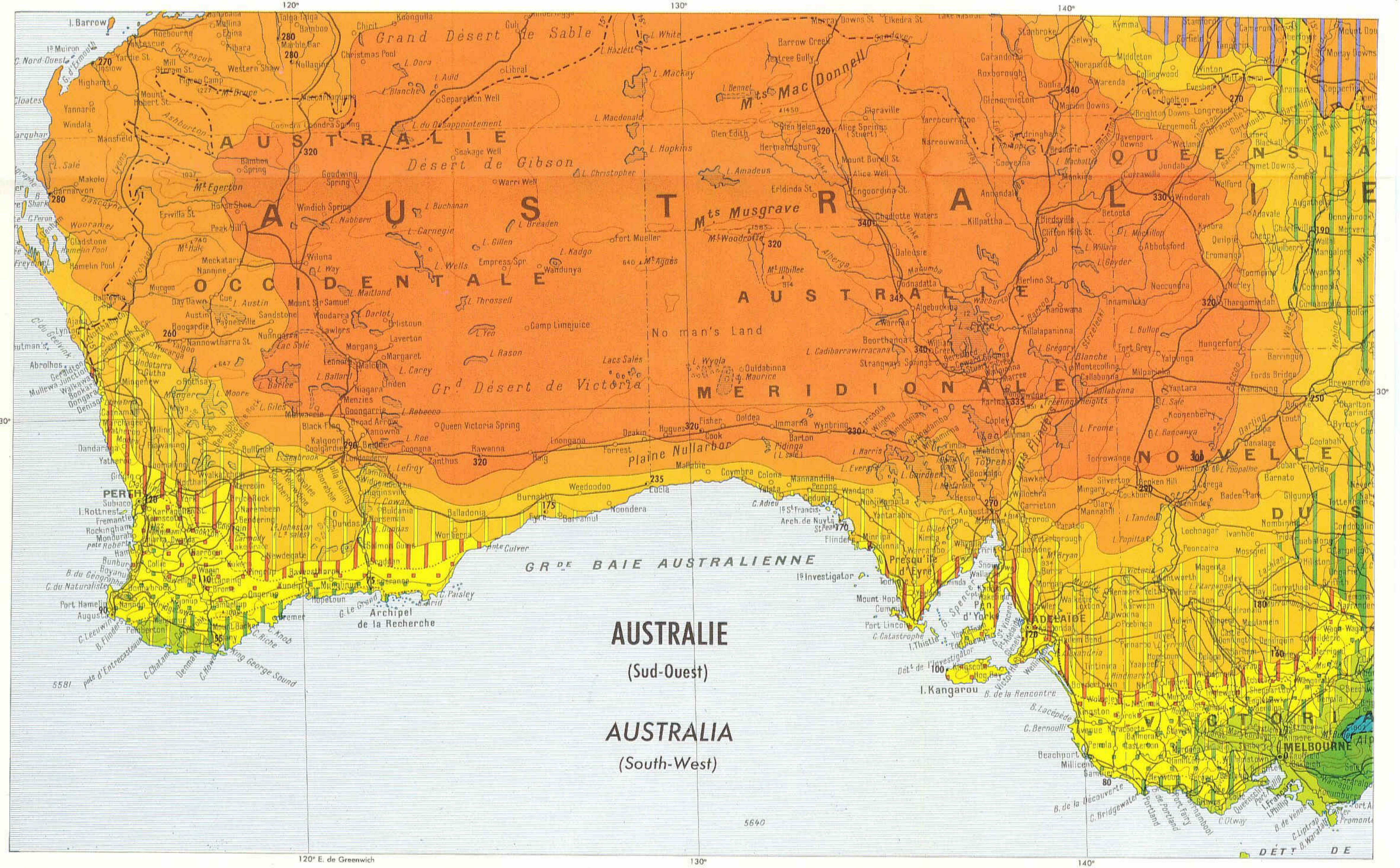

AUSTRALIE
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AUSTRALIE MÉRIDIONALE
QUEENSLAND
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VICTORIA
Grand Désert de Sable
Désert de Gibson
Grd Désert de Victoria
Plaine Nullarbor
No man's Land
Mts Mac Donnell
Mts Musgrave
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I. Kangarou
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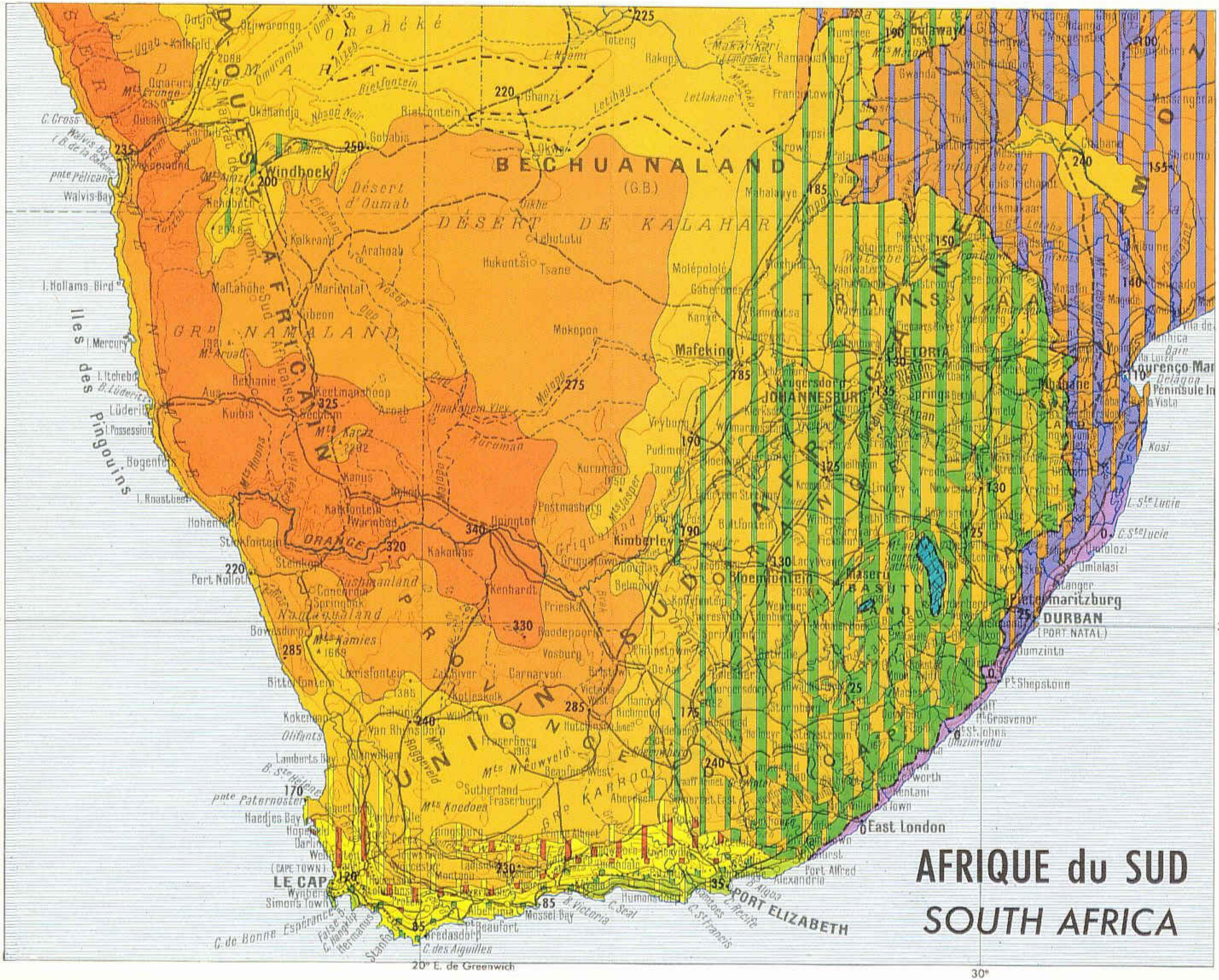
140°
30°


AFRIQUE du SUD
SOUTH AFRICA
BECHUANALAND
(G.B.)
DÉSERT DE KALAHARI
Désert d'Oumab
TRANSVAAL
Windhoek
Mafeking
PRETORIA
JOHANNESBURG
Kimberley
Bloemfontein
Maseru
BASUTOLAND
Pietermaritzburg
DURBAN
(PORT NATAL)
East London
PORT ELIZABETH
LE CAP
(CAPE TOWN)
Mossel Bay
C. des Aiguilles
C. de Bonne Espérance
Walvis Bay
Lüderitz
Iles des Pingouins
ORANGE
Namaqualand
Bushmanland
Lourenço Marques
Bulawayo
Upington
Keetmanshoop
Kuruman
Vryburg
Port Nolloth
Beaufort West
20° E. de Greenwich
30°