Review: The Climatological Atlas of India
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## The Climatological Atlas of India.

'Climatological Atlas of India.' Published by the authority of the Government of India, under the authority of Sir John Eliot, K.C.I.E., F.R.S., late Meteorological Reporter to the Government of India and Director-General of Indian Observatories, Issued by the Indian Meteorological Department, 1906, . . . through Messrs. John Bartholomew & Co., Edinburgh.

The Indian Meteorological Service is the largest and most complete system of the kind in the tropics, and its history, as outlined in the Introduction to the Atlas under review, is a record of steady improvement and progress. The history is divided into three periods: that previous to 1864 or 1865, when such observations as were made were local, and arranged upon no system; that between 1865 and 1875, when the work was organized on a provincial basis, and was still lacking in completeness and comparability; and, finally, that from 1875 to date, when the organization was imperial and directed from a central office. It was only in the last period that the observations, as a whole, reached such a general level of uniformity and accuracy as could warrant the detailed treatment necessary to turn them to account in establishing the climatology of India.

The last quarter of the nineteenth century is the period for which the various elements of climate have been worked up, and this work also falls into three parts: the elaboration of the figures of actual observations so as to yield numerical means and extremes, the results of which have been published in various volumes of the Indian Meteorological Memoirs since 1901; the Atlas now before us, giving cartographical expression to the data formerly published in Tables, and a 'Handbook of the Meteorology of India' which is promised, and in which the bearings of the whole work will be authoritatively set forth. Meanwhile, the Atlas is prefaced by a certain amount of letterpress, though not enough to make it independent of the memoirs of the past or the handbook of the future. While the meteorologist must of necessity refer back for much essential information, and summon his patience to wait for some desirable generalizations, the geographer, at least, may accept this Atlas as a single and substantial gain to his knowledge, and proceed in its light to rearrange his ideas of Indian climate.

The organization which made the Atlas possible deserves to be referred to. The commission appointed to inquire into the Orissa famine of 1866, recommended that Prof. Tyndall should be invited to come to India "and develop meteorological inquiry." This, apparently, was not done. In 1871, after considering memoranda from Mr. H. F. Blanford and Sir Richard Strachey, the Indian Government consulted the Council of the Meteorological Office in London,* which suggested a scheme for reorganization. The Indian Government accepted this scheme, and appointed Mr. H. F. Blanford as imperial reporter, entrusting to him the carrying out of the new system. Mr. Blanford continued to direct the work, extending the system of observations to the larger native states and improving details; but the record of the work of the department becomes more impersonal as it proceeds, and the date at which Sir John Eliot succeeded Mr. Blanford is not mentioned. Sir John had, however, been meteorological reporter for the province of Bengal since 1874, so that his personal labours in a responsible position in India extended over

* Presumably the body consulted was the Meteorological Committee of the Royal Society, which was responsible for the Meteorological Office from 1867 to 1877.

the whole period dealt with in the Atlas, and there is certainly no one else with such a grasp of the whole vast subject as he.

With the meteorological aspects of the work we have at present no concern. The question of the trustworthiness of native observers, the problem of the proper exposure of instruments, the methods of reduction and correction are all considered and settled in the volumes of the Indian Meteorological Memoirs, and we have only to see how these data, which are unquestionably the best that could be had, have been brought together in the form of maps, and what these maps teach regarding the climate of India.

The Atlas, which is produced by Messrs. John Bartholomew & Co., of Edinburgh, is similar in size, and in the execution of the 120 plates of maps, to the volume on Meteorology in Bartholomew's great 'Physical Atlas,' except that the binding is in plain cloth, which will doubtless prove more enduring than leather, and the paper on which the letterpress is printed is too thin for the great size of the page.

A series of general maps serves as an introduction to the special plates dealing with climatology. First come two double-page maps of the Indian Empire on the scale of 1 : 10,000,000; the first showing the configuration by a striking series of graduated tints which bring out the contrast of the Central Asian plateau, over 10,000 feet in elevation with the plains and hills of India; the second giving the larger features of the complex political geography. The physical geography of India is a fact of such supreme importance that it is very properly carried through all the climatological maps by means of contour-lines and faint black tinting, quite unobtrusive, and in no way spoiling the effect of the special colouring, but quite distinctly there when looked for. As is well known, the figures of atmospheric pressure and temperature are usually charted after reduction to their calculated values at sea-level; but the uncertainty of the correction at great heights is so considerable that Sir John Eliot has wisely refrained from utilizing, in this way, any data derived from stations at a higher elevation than 3000 feet above the sea. The practical result of this is to limit the scope of the maps to India proper, and to stop all climatological colouring on the slopes of the Himalaya short of the great Tibetan plateau. We are glad to note that for the purpose of this Atlas Ceylon is included, as it should be, in representing the distribution of atmospheric phenomena. Two plates are occupied with four maps showing subdivisions of India adopted for various statistical purposes, and then follow two double-page charts of the Indian ocean, illustrating the general distribution of pressure and the direction of the winds at two opposite seasons—January and July. These are most interesting and suggestive, for they show the climatological solidarity of the British Empire around the Indian ocean, illustrating the interdependence of the climate of India with the climates of Singapore, Hongkong, Borneo, New Guinea, and Australia on the one side, and those of Aden, Somaliland, British East Africa, Zanzibar, Mauritius, and South Africa on the other. The great annual overturning of the atmosphere which drives the air in January—the northern winter and the southern summer—from Asia southward over India, across the equator towards Africa and Australia, and draws back the air in July—the northern summer and the southern winter—from Australia and Africa, across the equator to India, really dominates the climate, not of India only, but of all the Indian ocean, and these striking plates exhibit the surge of the air in a really impressive way.

After the introductory maps, which deal with arrangement and general principles, come masses of orderly detail set out more fully than for any other country. As a rule, thirteen one-page plates are devoted to each special subject, representing the distribution for each month and for the year as a whole. The page is usually

shared by three maps, the natural scales of which are unfortunately not given; but one representing the condition at 8 a.m. is on the scale of about 225 miles to 1 inch; the other two, representing in less detail the conditions at 10 a.m. and 4 p.m., are on the scale of about 450 miles to 1 inch. The charting of mean meteorological conditions for two hours of the day, showing the full effect of the diurnal range, is quite new, and places this atlas above every other work of the kind. The number of stations yielding records and the duration of the periods from which "normals" are calculated differs somewhat for the different elements; but in every case the number of stations is relatively so small that the lines of equal value which are drawn must be viewed as only roughly approximate.

The first element dealt with is barometric pressure and wind, and while the large map enables one to follow the changes from month to month in detail, the two smaller maps remind one of the large diurnal range which is constantly at work altering the force of the wind at every hour of the day and night. Thus it appears that the average pressure over India varies as much between 8 a.m. and 4 p.m. every day in April (to take an example at random) as it does at 8 a.m. in a whole month during the gradual annual change. The next series of thirteen maps shows the average daily pressure for each month on the larger scale, and the diurnal range expressed in two different ways on the two smaller maps. Tropical meteorology differs from that of temperate countries in nothing so much as in the regularity and extent of the regular diurnal range of pressure between morning and afternoon, and this series of maps gives much new matter for study.

Temperature maps follow, the first thirteen showing the mean temperature of the day, the mean maximum and the mean minimum of each month; bringing out with quite startling vividness how the area of greatest warmth moves north-westward across India as the season advances, until the Punjab and the extreme north-west which were the coolest part of the peninsula in January, have become the hottest in June; showing, too, how in India the south or most nearly equatorial portion is the coolest part of the country in the hottest months, the influence of height above sea-level being allowed for. Thirteen maps show, in the first place, the distribution of diurnal range of temperature for every month, and, in addition, the absolute maximum and absolute minimum temperatures for the month. The range is remarkable; thus in January there are maxima exceeding 97°·5 in South India, and minima falling short of 25° in the north-west, whereas in June and July there are maxima exceeding 125° in the north-west and minima below 65° in the south.

The next set of thirteen plates deals with relative humidity, a condition which is not so frequently charted as its importance deserves. The distribution is always such that the highest percentage is found in the north-east and round the coast, the lowest in the interior and towards the north-west, but the centre of minimum relative humidity moves farther into the north-west angle of the country as summer advances. The range in relative humidity between 9 a.m. and 4 p.m. is very striking, being dependent, of course, on the great range of temperature. Unfortunately, the readings of the wet-bulb thermometer, on which the humidity observations depend, are the least satisfactory of the elements of climate observed, and there is less certainty about the results than in the case of pressure and temperature. A second series of thirteen plates deals with the absolute humidity or total amount of water-vapour present in the atmosphere irrespective of the temperature or the probability of condensation. While the relative humidity is the more important condition in its relation to practical matters of health and agriculture, the absolute humidity has a special value in meteorological discussions, and its variations from month to month show a close relation to the seasonal changes of wind.

A beautiful series of thirteen plates shows the proportion of the sky covered with cloud, on the average of the day, at 8 a.m. and at 4 p.m. The colouring shows small amounts of cloud in tints of blue, large amounts in shades of brown, forming in this way almost a picture of the state of the sky. The resemblance with the relative humidity maps is, of course, very close, although the cloud-maps represent the approach to saturation in a much higher stratum of the atmosphere than that dealt with by the wet-bulb thermometer. In the cold weather, from November to February, there are two areas of moderate cloud, one on the slopes of the Himalayas, the other in southern Madras; the country between the two is practically cloudless. In the hot weather the regions on which a strong sea-wind blows are heavily clouded, the regions most affected shifting with the seasonal changes of wind, but the north-west corner of India remains with the minimum amount of cloud all the year through.

The section devoted to rainfall maps is particularly interesting, for it is here that the influence of geographical conditions upon climate are most clearly marked. The effect of height above sea-level on atmospheric pressure and on temperature is carefully eliminated before the figures are placed on the map, but rainfall is charted as it falls. The general distribution of rain in India, depending as it does on configuration and on seasonal winds (or currents, as the Indian Meteorological Department prefers to call moving air as well as moving water *), is familiar in its broad features. The larger map for each month represents the normal rainfall in inches, the smaller maps give the number of rainy days (in India this means days with one-tenth of an inch or more) and the tracks of storm-centres crossing the country; and half a dozen additional plates present the rainfall of the various seasons. By taking account of the rainfall, it is possible to divide each of the fundamental divisions of the Indian year (those in which the north-east and the south-west monsoons respectively occur) into two parts. During the first half of the dry season, from December to February, in the cold weather rain occurs chiefly during the passage of shallow depressions across the north of India, bringing heavy snow on the northern mountains. The second part of the dry season or hot weather (March and April) has only light irregular rains due to local thunderstorms, but in Assam these rains are very important to tea-growers. From May or June to September the south-west monsoon brings a general rainfall over the whole of India except South-Eastern Madras and the extreme north-west. The remaining months of October and December have heavy rains round the Bay of Bengal as the monsoon retreats, while the greater part of India is dry.

The scale of the annual map of normal rainfall is too small to do more than indicate the broad general dependence of rainfall on configuration and wind direction, bringing out the general wetness of the coasts, especially the west coasts, and the general dryness of the interior, especially in three large areas, viz. the Indus valley in the north-west, the upper valley of the Krishna behind the Western Ghats in southern India, and the middle valley of the Irawadi in Burma. The detailed relationship between rainfall and configuration is not advanced by this work. We must confess, indeed, that the treatment of rainfall as a whole is a little disappointing. The omission of stations above 3000 feet deprives the map of much of its character, and in this department of climatology where geographical principles are

* In the text Sir John Eliot refers to "the great oceanic current of the south-west monsoon," meaning thereby the wind that blows over the land, not the water that flows in the sea. To use a technical term of oceanography without explanation or definition to describe an allied but totally different phenomenon in meteorology seems to us a mistake.

most closely concerned we miss the firm grasp which might have brought the data into a completer shape than they at present show.

With reference to the great advance now being made in our knowledge of the upper regions of the atmosphere, attention may be called to a series of small maps showing the pressure of the atmosphere at 10,000 feet elevation above India.

H. R. M.

## AFRICA.

### Rainfall in North-East Africa.

'The Rains of the Nile Basin in 1905.' By Captain H. G. Lyons, Director-General, Survey Department, Egypt. Cairo, 1906.

In 1905 several new rain-gauge stations were established in the Nile basin (making seventy-five stations in all), and returns showing the number of rainy days were also received from forty-four posts scattered over the Sudan plains. It is hoped that by collecting information from so wide an area, it may be possible to deduce the probable development of the East African monsun in its northern extension, though, as Captain Lyons says, "much study is still necessary before it can be said precisely what information is more useful, and what weight should be given to such evidence as excess or deficiency of rain in different areas."

The meteorological information given in this report is interesting and important, including a set of maps of the mean monthly rainfall over the region which show well the advance of the rains northward in early summer, and their return in the autumn across the equator. The northern edge of the equatorial rainbelt just reaches Khartum, which has its one short rainy season. The precipitation over the Nile basin in 1905 was deficient everywhere, with the exception of the Delta, which had a heavier winter rainfall than in 1904, owing to the passage of the Mediterranean cyclonic depressions nearer the African coast, and the Nile flood was only 0·65 of the average volume. This makes the tenth successive year of low floods, only two since 1895 having risen, very slightly, above the average, while the others were well below. Captain Lyons emphasizes the fact that the Nile water-supply is but little affected by the rainfall of the equatorial lake plateau, the evaporation in the marshy regions of the Bahr-el-Jebel and Bahr-el-Ghazal basins being so great that the run-off is only 0·95 per cent. of the precipitation.

## AUSTRALASIA AND PACIFIC ISLANDS.

### Plant-dispersal in the Pacific.

'Observations of a Naturalist in the Pacific between 1896 and 1899.' Vol. 2, Plant-dispersal. By H. B. Guppy, M.B., F.R.S.E. *Illustrations and Maps.* Large 8vo, pp. 627. London: Macmillan & Co. 1906. *Price* 21*s. net.*

This book figures as vol. 2 of Mr. Guppy's book on the Pacific, but it would perhaps have been as well had the two volumes appeared under distinct and differing titles. The first, it may be remembered, dealt with Vanua Levu, and was a comprehensive and most careful study of that island from a geological and physical point of view. It was, indeed, the trained geologist to whom it mainly appealed. The volume under consideration is for the botanist and the student of distribution, and though it may be as little intended for the layman as its predecessor, it has, it must be admitted, but faint connection with the latter. The place of "Vol. 2" on the back of the book is, however, taken by the customary two stars, so that the purchaser who wishes to confine himself to this latest record of Mr. Guppy's