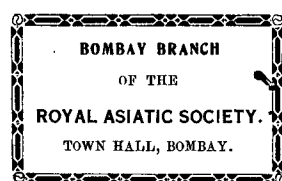




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CLIMATOLOGICAL ATLAS OF INDIA

PUBLISHED BY THE AUTHORITY OF THE GOVERNMENT OF INDIA

UNDER THE DIRECTION OF

SIR JOHN ELIOT, K.C.I.E., F.R.S.

LATE METEOROLOGICAL REPORTER TO THE GOVERNMENT OF INDIA AND DIRECTOR-GENERAL OF
INDIAN OBSERVATIONS



ISSUED BY THE INDIAN METEOROLOGICAL DEPARTMENT

1906

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PREFACE

THE Climatological Atlas of India has been prepared under the orders of the Government of India to show all the more important features of the climatology of that tropical area, as determined from the results of the observations recorded during the first twenty-five years of the operations of the Imperial Meteorological Department, initiated in the year 1875-76.

Normal or mean values were calculated chiefly from the observed data of the 25-year period 1876-1900, in anticipation of the preparation of the Atlas, and published in Vol. XVII. of the Indian Meteorological Memoirs.

A Handbook of the Meteorology of India is now in course of preparation, and will it is hoped be published shortly. In that work will be given a full statement of all the more important features of the climates and weather of India, and this volume with the Atlas will form a complete work, each part supplementing the other, and be a record of the more important results of meteorological observation and investigation in India during the period 1876-1900.

It may be stated, as some excuse for any imperfections that may be found in the Atlas, that it was prepared by the late head of the Department, amidst heavy administrative work, with the assistance of a native clerical staff.

JOHN ELIOT.

18th April 1906.

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INTRODUCTION

The introduction contains a brief history of the progress of the work of meteorological observation in India and hence of the growth of the Meteorological Department, a list of the observatories contributing observations that have been utilised in the preparation of the Atlas with their position and elevation, and a brief explanation of the charts.

The following brief history of the work of meteorological observation in India is condensed from the administration report of the Meteorological Reporter to the Government of India for the year 1901-2.

The History of Meteorological Observations in India may be divided into three periods, viz. :—

- 1st.—Previous to 1864 or 1865, or period of local observation.
- 2nd.—Period from 1864 to 1875, or period of provincial systems of meteorological observation.
- 3rd.—Period from 1875 to date, or period of the present imperial system.

History of the Work of Meteorological Observation previous to 1865 in India (i.e. during the period of unsystematised observation).—With few exceptions the work of meteorological observation in India has been from the beginning almost entirely and exclusively carried out by officials under orders from higher authorities. Previously to 1864, orders were occasionally issued by the provincial or other authorities to district officers, chiefly Collectors of districts and medical officers, to arrange for taking observations of rain and temperature and occasionally of air pressure. Sets of instruments were sent out, either from the stores of the Medical Department or of the Mathematical Instrument Department, without any comparison and usually with no instructions for the guidance of observers so as to secure uniformity of exposure or of methods of observation. The thermometers were in some cases exposed in rooms of public buildings, in others they were placed against the walls of verandahs, and in other cases they were located in some kind of open shed where they were fairly exposed to the open-air movement, and hence assumed a temperature differing only slightly from that of the air out in the open. They were, in fact, in most cases suspended in a convenient place, generally selected with a view to preserve them from unofficial curiosity. The work of observation was handed over to a sheristadar, writer, native compounder or hospital assistant, in most cases untrained or very imperfectly trained, and with very peculiar views of the requirements for accuracy or punctuality of observation. Up to the year 1865 by far the greater part of the meteorological statistics in India were obtained by these methods. No attempt was made to turn these data to account, nor even to ascertain whether they were of any scientific value. They were, as a rule, forwarded to the Boards of Revenue or Medical Boards of the Presidencies, where they were allowed to accumulate without any examination, and were practically inaccessible for the purposes of scientific enquiry. A portion of the rainfall data was obtained by Mr. Blanford and embodied in the statistics utilised in his memoir “On the Rainfall of India” published in the “Indian Meteorological Memoirs,” Vol. III. And during the years of the Sepoy Mutiny (1857 to 1860) the collection of meteorological statistics was suspended over nearly the whole of India. Hence rainfall data for that period are almost invariably wanting, even in the case of certain stations the rainfall observations of which go back to ten, twenty or thirty years before the Mutiny.

A large portion of the rainfall and meteorological registers collected by the Medical and Revenue Departments were made over to the Messrs. Von Schlagintweit in the years 1861-63. These gentlemen were sent out by the English Government in 1861 (at the instance of Prince Albert) on a scientific mission to India and High Asia. Mr. Blanford visited Munich in 1878 and examined these registers, but found that they were of little value for his meteorological investigations and for the discussion of the rainfall in India. It is hence certain that the meteorological observations taken during this period at sudder and other stations in obedience to orders from Revenue or Medical Boards, and any discussions based on them, are of little or no value from a scientific point of view, however interesting they might be historically in throwing some light upon the general meteorological conditions accompanying the droughts and famines of the years 1837-38, 1853-54 and 1866-67 in India.

Fortunately observations of great value were recorded at a few stations where scientific observatories of the first rank were, for purely scientific purposes, established chiefly by the action of the East India Company. These observatories were as follows:—

- (1) The Madras astronomical, magnetical and meteorological observatory.
- (2) The Trivandrum meteorological and magnetical observatory.
- (3) The Dodabetta meteorological observatory.
- (4) The Colaba (Bombay) meteorological and magnetical observatory.
- (5) The Calcutta meteorological observatory.
- (6) The Simla meteorological observatory.

The following gives a brief account of the establishment, progress, work and publications of these observatories:—

THE MADRAS OBSERVATORY.—The East India Company resolved in 1792 to establish an observatory at Madras for promoting the knowledge of astronomy, geography and navigation in India. Sir Charles Oakeley, President of the Council, anticipating the order from the India House, began to carry out the scheme on his own authority, so that when the actual orders arrived in 1792 the observatory was already built and partly supplied with instruments. This was rendered possible by the liberality of William Petrie, a member of the Madras Government, who in 1788 built and equipped an astronomical observatory at his own expense, which he handed over to the Government in 1789. This formed the nucleus of the observatory established by the East India Company.

Mr. John Goldingham was appointed astronomer in 1792, and held that office for thirty-eight years (until 1830). He commenced the work of meteorological observation at Madras in the year 1796, and a continuous series of observations from that date to the present time are in existence, although only a part has been published.

Hourly meteorological observations were commenced in the year 1845, and were continued until 1861, when it was decided to take the observations upon a reduced scale of three observations daily at suitable hours.

Mr. Pogson on more than one occasion urged the desirability of establishing a branch observatory at the most suitable site on the Palni or Nilgherry Hills for certain classes of astronomical work, more especially photographic and spectroscopic observations of the sun and stars. No action was taken in this matter during his lifetime.

The Government of India recently decided to erect a solar physics and meteorological observatory at Kodaikanal in the Palni Hills, and to place it under the charge of the Director of the Madras Observatory. As a preliminary measure, the control of that observatory was transferred from the local to the Imperial authority in 1899. No change was made in the work of meteorological observation.

The following is a list of the volumes of meteorological observations and discussions which have been issued by the Directors of the Madras Observatory :—

- (1) Meteorological account of the weather at Madras, from the 1st June 1787 to the 31st December 1790. By a gentleman in the East India Company's Civil Service.
- (2) Tables containing results of meteorological observations taken at the Madras Observatory in the years 1796–1825, under the superintendence of John Goldingham, Esq., F.R.S. (Published in "Madras Observatory Papers." *Inter alia* there is a discussion on the effect of the moon on the barometer.)
- (3) Meteorological register kept at the Madras Observatory by John Goldingham, Esq., F.R.S., and Thomas Glanville Taylor, Esq., F.R.S., F.R.A.S., for the years 1822–43.
- (4) Hourly meteorological observations made at the Madras Observatory by Captain S. O. E. Ludlow during the period 1841–45.
- (5) Meteorological observations made at the Madras Observatory in the years 1851–55, under the superintendence of W. S. Jacob, Esq., F.R.A.S.
- (6) Hourly meteorological observations made at the Madras Observatory from January 1856 to February 1861. (With an introduction and Tables of mean hourly variations from the monthly means for the whole period of twenty years by C. Michie Smith.)
- (7) Results of the meteorological observations made at the Government Observatory, Madras, during the years 1861–90, under the direction of the late N. R. Pogson, C.I.E., F.R.A.S., edited by C. Michie Smith, B.Sc., F.R.A.S., F.R.S.E.
- (8) Madras Observatory daily meteorological means by C. Michie Smith, B.Sc., F.R.A.S., F.R.S.E., Government Astronomer.

THE COLABA OR BOMBAY OBSERVATORY.—The East India Company, recognising the value of the scientific work carried out by the Madras Astronomical Observatory, determined in the year 1820 or 1821 to establish a similar establishment of the Colaba Observatory. The present site was selected in 1823, and buildings erected in 1826 under the superintendence of Mr. Curnin.

The work of meteorological observation appears to have commenced in 1841 and to have been continued to the present time with no interruption. The instruments at that time included three standard barometers, two or three complete sets of wet and dry bulbs, maximum and minimum thermometers, a set of solar and terrestrial radiation thermometers, five ground thermometers, a self-registering anemometer and pluviometer (by Osler) and two rain gauges.

The work of observation was apparently carried out in such an unsatisfactory manner that the Government of Bombay in 1864 found it desirable to appoint a Committee of Enquiry to ascertain, for the information of Government, the improvements which were needed, and the extension of the observatory operations which were desirable in order to place the observatory on a proper footing.

The Committee in its report pointed out a number of defects and made a series of suggestions, of which the most important were :—

- (1) The appointment of a qualified Superintendent or Director.
- (2) The improvement of the meteorological and magnetic observations by the addition of several new instruments, and more especially of a complete set of photographic self-registering instruments of the Kew pattern.
- (3) The continuous examination and discussion of the data and frequent publication of the results.

These recommendations were accepted by the Bombay Government. Mr. Charles Chambers was appointed Director, and the additional instruments required for the equipment of the observatory were ordered from England. These instruments were received, placed in position and adjusted during the years 1870–71, and have been in continuous use from the year 1871.

Mr. Chambers was furnished with a small temporary staff to tabulate and arrange the meteorological observations recorded previously at certain military stations in the Presidency. He published in the year 1881 the results of the examination of these records and of the observations recorded up to date at the Bombay Observatory in a volume entitled "The Meteorology of the Bombay Presidency."

Shortly after the death of Mr. Chambers in 1891 the observatory was transferred from the local control of Government of India. to the Imperial Government. The work of meteorological observation continues to be carried on under Mr. Moos, the present Director, exactly as it was during the preceding twenty years under Mr. Chambers.

The following is a list of the discussions of meteorological observations which have been issued by the Colaba Observatory from its establishment to the present date :—

- (1) Meteorology of the Bombay Presidency, by C. Chambers, Esq., published in 1878.
- (2) The normal winds of Bombay—Appendix I. to the Bombay magnetical and meteorological observations, 1865–70, by C. Chambers, F.R.S.
- (3) On the variation of daily range of atmospheric temperature, as recorded at the Colaba Observatory, Bombay—Proceedings of the Royal Society, No. 222, 1882, by C. Chambers, F.R.S.
- (4) Summary of fifty years' results of meteorological observations—Appendix to Bombay magnetical and meteorological observations, 1895, by N. A. F. Moos, B.Sc., F.R.S.E.
- (5) Notes on the Harmonic Analysis of Temperature and Barometric Pressure at Colaba, 1876 to 1895—Appendix B to the magnetical, meteorological and seismological observations, Bombay, 1898–99, by N. A. F. Moos, B.Sc., F.R.S.E.
- (6) Normals of meteorological elements—Appendix C to the Bombay magnetical, meteorological and seismological observations, 1898–99, by N. A. F. Moos, B.Sc., F.R.S.E.
- (7) Bombay magnetical and meteorological observations for the years 1845, 1846, 1847, 1848, 1849, 1850, 1851, 1852, 1853, 1854, 1855, 1856, 1857, 1858, 1859, 1860, 1861, 1862, 1863, 1864, 1865 to 1870, 1871 to 1878, 1879 to 1882, 1883, 1884, 1885, 1886, 1887, 1888 to 1889, 1890, 1891 to 1892, 1893, 1894, 1895, 1896, 1897, 1898 to 1899 (37 volumes).

THE DODABETTA OBSERVATORY.—In the year 1845 the East India Company suggested that a series of meteorological observations should be made at Ootacamund, and forwarded a set of instruments to Mr. Taylor, Government Astronomer, Madras, in the hope that he might be able to make the necessary arrangements. Mr. Taylor, after two visits to Ootacamund, came to the conclusion that no series of observations on the Nilgherry Hills could be considered of scientific value unless they were taken on the highest point, viz., the summit of Dodabetta Peak (elevation about 8600 feet), where the observatory would have a free exposure to the general air movements across these hills. It was arranged that a meteorological bungalow

should be erected on the summit of Dodabetta, and that one of the assistants from the Madras Observatory should be sent there to undertake the work of observation.

The work of observation was commenced on the 12th January 1847, and was continued during the period June 1847 to December 1855, when the observatory was closed, and the building allowed to go to ruin.

The observations were published by the Director of the Madras Observatory in three parts or volumes, entitled—

- (1) Meteorological observations made at the meteorological bungalow on Dodabetta (elevation 8640 feet) in the year 1847-48.
- (2) Meteorological observations made at the meteorological bungalow on Dodabetta in the years 1848-50.
- (3) Meteorological observations made at the meteorological bungalow on Dodabetta in the years 1851-55.

They were at first made twice daily with hourly observations on one day (21st-22nd) of each month, but from September 1849 to December 1855 hourly observations were recorded on three days of each month.

Sanctioned re-establishment of
Dodabetta Observatory, 1901.

The Government of India has recently sanctioned the erection of an observatory on the same site.

THE TRIVANDRUM OBSERVATORY.—The Trivandrum Observatory owed its origin in 1836 to the enlightened views of His Highness Rama Vurmah, then reigning Raja of Travancore.

The advantages which might accrue to science by the establishment of an astronomical observatory in the most southern part of the Indian Peninsula were first brought to the Raja's notice by Mr. J. Caldecott, commercial agent of the Travancore Government at the Port of Allepey. His Highness sanctioned the construction of an observatory, named Mr. Caldecott its Director, and gave him power to furnish it with the best instruments to be obtained in Europe.

Before the astronomical observatory was completed, the appeals of Humboldt and others for a combined system of observation relating to terrestrial physics, and especially to terrestrial magnetism, had resulted in the erection of several observatories for this object in Europe and in the English possessions abroad. Travancore offered special advantages in this department of scientific observation, as the magnetic equator passes across the country. Mr. Caldecott, while in Europe waiting for the construction of the astronomical instruments, received the Raja's permission to purchase additional instruments wherewith to furnish a magnetical and meteorological observatory. This observatory was built in 1841, and the work of observation dates from 1842.

Mr. Caldecott died at Trivandrum in 1849, and the observatory was then placed under the direction of Mr. John Allan Broun, F.R.S.

Mr. Broun shortly after his appointment decided that it would be necessary, for a complete examination of the questions to be solved, that observations should not be limited to a single station at Trivandrum, but that subsidiary observatories should be established at different points up to the highest elevation in the Travancore Hills. Four observatories at different heights were hence established, the most elevated on the Agustia Malley, the highest mountain in the narrow chain of the Travancore Ghats, and rising rapidly from the plains of Coromandel and Malabar, and possessing the great advantage of being free from the effects of neighbouring high table-lands.

The Travancore Durbar decided in 1865 to close its system of observatories. Mr. Broun returned to Europe in that year. Before leaving he persuaded the authorities to continue the Trivandrum Observatory for six years on a reduced scale. He also undertook to receive and discuss the observations. A further extension of the work of observation at the end of that period in 1869 was due to the recommendation of the British Resident, and meteorological observations have continued to be recorded more or less regularly up to the present time.

The books containing the meteorological observations which were taken at the Trivandrum Observatory from the year 1853 to the year 1864, during which period Mr. Broun was Director, were taken to England by him on his retirement with a view to their publication. His health broke down shortly after he returned to Europe, and the manuscript volumes of observations were made over after his death by his widow to the Edinburgh Royal Society, by whom it was suggested that the publication of the meteorological observations should be undertaken by the India Meteorological Department, and the Government of India accepted the suggestion and arranged that the work should be undertaken by that Department.

The results of the observations were published as Parts 1, 2 and 3, Vol. V., "Indian Meteorological Memoirs," arranged as follows:—

1st Part.—Hourly meteorological observations at Trivandrum during the years 1853 to 1864.

2nd Part.—Comparative observations at the stations of Kalliad, Kamala, Charetha and Agustia, situated at different elevations on the Travancore Hills.

3rd Part.—Discussion of the observations.

The observations and discussion were issued as Parts 1, 2 and 3, Vol. V. of the "Indian Meteorological Memoirs," and form a separate volume of that publication.

THE SIMLA OBSERVATORY.—The observatory was established under the superintendence of Lieutenant-Colonel Boileau, R.E., in the grounds of the "Observatory House," not far from the present position of Viceregal Lodge, in 1840, and the observations were carried out systematically from 1841 to 1845. The temperature observations are not satisfactory, as the instruments were either removed at night into a closed room or the room in which they were placed was shut up.

The observations recorded were published in two volumes without discussion. The first volume contains data of the actual observations of the several meteorological instruments, taken at intervals of two hours during the years 1841 and 1842, and of one hour during the years 1843-45. The second volume gives the results of the meteorological observations for the period 1841-45.

THE CALCUTTA OBSERVATORY.—The work of meteorological observation was commenced in Calcutta by the Survey of India Department. An observatory was erected in the compound of the Survey Office buildings in Park Street in 1853, and eye observations of the ordinary meteorological instruments were recorded from that year to the year 1875. The observations were published in a tabulated form in the proceedings of the Asiatic Society during the years 1853-76. They have never been published in a collected form. When the establishment of a central observatory of the Meteorological Department at Alipore was sanctioned, it was decided to discontinue the work of meteorological observation at the Survey Office.

Period from 1865 to 1875 of Provincial Systems of Meteorological Observation.—Before the commencement of this period, steps were being taken in various directions with a view to improve and systematise the work of meteorological observation in India, and to make it practical as well as scientific in its objects and aims. The

first steps were undoubtedly taken by the Asiatic Society of Bengal, which at that period of its history took keen interest in the progress of meteorology in India.

The action of the Society originated in 1857 in a memorandum by Colonel (now Sir Richard) Strachey, followed by the appointment of a Committee to consider the matter. Shortly after came the outbreak of the Mutiny, when men had little leisure or taste for scientific pursuits. The further consideration of the improvement of the work of meteorological observation hence remained in abeyance for five years, and it was not until 1862 that a report was drawn up by the Committee, and embodied in a letter to the Government. In reply to this letter the Society was requested to draw up a scheme for giving practical effect to its recommendations. Various delays unfortunately supervened, and it was not until the beginning of 1865 that the report was laid before Government.

This report will be found printed in the published Proceedings of the Society for December 1864.

Meanwhile an application urging the necessity for improvement came from a totally different source. Three months before the report of the Asiatic Society was submitted to Government, the memorable cyclone of October 1864 had roused the attention of the mercantile and shipping community of Calcutta to the necessity of the establishment of a meteorological system for the purpose of warning the port and shipping of the approach of cyclones. The Bengal Chamber of Commerce wrote a letter to the Government calling attention to the inefficient system under which no warning was given to the shipping of the approach of one of the most disastrous storms on record.

The Secretary of State for India, at the instance of the War Office, about the same time, urged upon the Government of India the necessity for the systematic record of meteorological phenomena, in order to furnish data for the investigation of the relations of climate and weather and disease in India, and the collection of all data that might be of value in connection with sanitary improvements and projects in India.

The Government of India appointed a Sanitary Commission, with Sir John Strachey as President, to consider the best means for giving effect to these recommendations and suggestions. It commenced operations by calling for opinions from a large number of officers and authorities in India on the subject of the extension of meteorological observation and investigation in India.

The Asiatic Society of Bengal amongst others was consulted, and drew up a scheme for the consideration of the Sanitary Commission, almost identical with the suggestions contained in the report submitted to the Government of India in 1864.

The Government of Bengal, in reply to the letter of the Bengal Chamber of Commerce, already referred to, appointed a Committee, consisting of Colonel Tennant and Messrs. Blanford and Obbard, to formulate a scheme for the establishment of meteorological observatories on an extended basis along the coast of the Bay of Bengal and at the port of Calcutta which would give effective warning of the approach of storms to that port. The report of the Committee was submitted to the Government of Bengal in April 1865.

The scheme of the Committee for the protection of the port of Calcutta was approved in May 1865 and was immediately brought into operation.

The question of the establishment of a general meteorological system was, by the instructions of the Government of India in 1865, taken up by the Sanitary Commission. They suggested the establishment of local and provincial systems of observatories, with local reporters independent of each other and not subject to any general unifying control.

Provincial systems for the North-Western Provinces and for the Punjab were sanctioned in 1865. A system for Bengal with Mr. Blanford as its head was sanctioned in 1867. A Meteorological Department was established in Madras in the year 1867 under the control of Mr. Pogson, Government Astronomer. A system of meteorological registration was initiated in the Central Provinces in 1868 by the Sanitary Commissioner. Observatories had been established some years previously by the military authorities at Belgaum, Poona, Deesa and Kurrachee. A scheme was drawn up in about 1871 for the formation of a Meteorological Department in the Bombay Presidency under the general control of the Director of the Colaba Observatory, and was submitted to the Government of India for sanction.

No attempt was made during this period to commence the work of systematic observation in Burma, or the Native States of India.

The result of the efforts of Government during this decade, 1865-74, was to establish five independent systems which only covered or dealt with about a third of the total area of India. There was no attempt to co-ordinate the systems. There was entire absence of unity of aim and object, and of unity of direction. The parochial system of dealing with the meteorology of a well-defined meteorological area like the Indian monsoon region was self-condemned from the first.

The following is the opinion of a competent authority of the value of the meteorological statistics collected during this period by the provincial systems (*vide* the "Calcutta Review," Vol. LII., for the year 1871):—

"From a review of the measures that have been carried out for the collection of meteorological statistics during the past six years, the conclusion is, we think, inevitable, that they have proved a failure. For a large part of India we have absolutely no information, the registers, which have been obtained at a considerable cost, having been kept back (for reasons which are not assigned), or sent to England to be thrust away among the records of the India House, or otherwise lost sight of. In another part, again, nothing has been done; and finally, those Provinces which have been furnished with printed returns, have for the most part given them to us with such imperfections and deficiencies that they are not comparable the one with the other, and cannot be made so without additional data which are not at present forthcoming. We do not wish to exaggerate the failure, nor to assert that such results as we have are already worthless. Nay, we believe that by judicious measures and the expenditure of a sum that would make but an insignificant addition to the present annual outlay, a large portion of the data already amassed might be rendered of service to Science; but there is but little hope of this under the present system, and therefore—and because at best its results must be partial and imperfect—it is a failure."

The summaries or results of the observations of these systems will be found in part in the following publications:—

- (1) Annual Meteorological Reports of the provinces of Bengal and Assam for the years 1867-1874.
- (2) Annual Meteorological Reports for the North-Western Provinces and Oudh for the years 1862-1874.
- (3) Annual Meteorological Reports for the Punjab for the years 1865-1874.
- (4) Weekly or monthly summaries or results of the observations published in the local Gazettes by the Sanitary Commissioner of the Central Provinces and by the Government Astronomer, Madras.

Period from 1875 to date, or Period of the Imperial System introduced in 1875.—The defects of the provincial systems, and the failure of these five isolated systems of observation to throw much light on the meteorology of India, were very generally recognised prior to the year 1871. For example, the Commission of Enquiry into the Orissa and Bengal famine of 1866 urged strongly that Professor Tyndall should be invited to come to India and develop meteorological enquiry. The question of the best manner of carrying out meteorological observation and investigation in India was shortly afterwards referred by the Government of India to various authorities.

Their opinions and suggestions were fully considered by the Government of India, and in October 1871, a despatch was sent to the Secretary of State dealing with the measures taken during the previous seven years to establish systematic registration of meteorological observations, and suggesting measures for the future organisation of the Meteorological Department. The despatch also included a memorandum drawn up by Mr. H. F. Blanford, stating the measures that had been taken to establish meteorological systems up to the year 1871, and a note by General (now Sir Richard) Strachey, in which he made suggestions for the future organisation of the Department.

The Secretary of State for India consulted meteorological and other scientific authorities in England, and more especially the Council of the Meteorological Office, which suggested a scheme for the reorganisation of the Department. The Secretary of State and the Government of India finally determined to reorganise the Department and extend the work of meteorological observation on the general lines laid down by the Council. The most important suggestion made by the Council was the appointment of an Imperial Reporter to superintend the work of meteorological observation over the whole of India. The appointment of the Imperial Reportership was offered to Mr. Blanford (who was then at home on leave) in August 1874. He came out about the end of the year, and immediately set to work to draw up a scheme for the consolidation and extension of the work of meteorological observation in India, in accordance with the general instructions he had received from the Government of India in a letter dated the 17th December 1874. His report, dated 26th July 1875, is the foundation of the present system of meteorological observation in India.

The chief object of his proposals was the systematic study of the climate and weather of India as a whole and the application of the knowledge thus acquired to the issue of storm and flood warnings and of weather forecasts. For these purposes the adoption of uniform methods of observation and of the record of observations in all parts of India was laid down as essential in order to secure a basis of accurate data for the scientific study of the meteorology of India. The following gives a summary of the more important proposals contained in his report :—

- (1) The establishment of a Central Meteorological Observatory at Calcutta, an important part of the work of which would be the verification and comparison with standard instruments of all instruments issued to meteorological observatories in India.
- (2) Increase of the number of observatories in India by the establishment of observatories in certain areas not adequately represented, and the redistribution of existing observatories in other provinces.
- (3) Arrangement of the observatories into three classes. At stations of the first and second classes, special observations to be recorded for the study of the diurnal variation of pressure, temperature and other elements of meteorological observation.
- (4) The provincial systems (with the then Meteorological Reporters) to be retained in Bengal, the North-Western Provinces, the Punjab and Madras—but to be subordinate to the Imperial Reporter. A special Reporter to be appointed for Bombay and Rajputana, in which areas the work of meteorological observation was much behind-hand.
- (5) The improvement of the storm warning system of the Calcutta and Madras Coasts.
- (6) The discussion of the meteorological data of the whole of India in annual volumes by the Reporter General for India, and the publication of special investigations of a purely scientific character in a series to be entitled "The Indian Meteorological Memoirs."

The whole of Mr. Blanford's proposals were approved and sanctioned by the Government.

The new system, including the establishment of the additional observatories, was brought into effective and complete operation in the year 1876.

The changes in the Meteorological Department during the next four or five years were mainly determined by the drought and famines of the years 1876 and 1877. Madras was visited by a very severe drought and famine in 1876-77, and the North-Western Provinces by a severe drought during the south-west monsoon of 1877. The latter was fortunately followed by good winter rains, and the scarcity hence did not intensify into famine. The monsoon rains of 1878 were very considerably delayed in North-Western India, and the authorities were apprehensive of another season of drought in Northern India, and hence anxious to have all available information of the progress of the monsoon.

An important incident of the year 1878 was the preparation of a tentative forecast of the character of the monsoon season at the request of the Government in June.

This was not the first forecast that has been attempted in India. In July 1874, the late Mr. W. G. Wilson was desired by the Government to furnish a similar opinion; and his forecast, based on less data than are now available, and relating only to the Presidency of Bengal, was justified by the result.

The most important result of the desire of Government for early information of the progress of the monsoon in 1878 was the introduction of the system of daily telegrams of the weather from all parts of India and Burma, and the publication of a Daily Weather Report of the whole of India for the information of Government.

The Commission which was appointed to enquire into the disastrous Madras famine of the year 1876-77 presented their report to Government in the year 1881. In the introductory chapter of that report a summary was given of what was then known respecting the distribution of rainfall in India, and the variations to which it is subject. The Committee also pointed out that there was sufficient evidence to indicate that there was some relation between the seasonal distribution of rain in India and the sunspot periodicity, and recommended that India should assist in the work of solar observation. They concluded that chapter with the following important remark :—

"Within the last few years a very satisfactory system of meteorological observations has been established all over British India, and, in our opinion, it is of primary importance that it shall be maintained in complete efficiency, and shall so far be strengthened and improved as to ensure the early and punctual supply of information to executive Governments, and to the officials in all departments concerned with the agriculture of the country, or the preparations required to meet famines, as to the actual progress of the periodical seasons of rain in all parts of the provinces, for which these Governments or officers are respectively responsible. So far as it may become possible, with the advance of knowledge, to form a forecast of the future, such aids should be made use of, though with due caution."

Mr. Blanford's proposals to give effect to suggestions of Famine Commission, 1881.

Mr. Blanford was shortly afterwards requested to formulate proposals in order to give effect to the chief recommendations of the Famine Commission. The following is the summary of those proposals :—

- (1) The improvement of the Daily Weather Report by increase of the number of stations from which daily telegrams are received.
- (2) The establishment of additional observatories in areas not sufficiently represented in the meteorological system.
- (3) The collection of current information of the weather in the Indian Seas from the logs of ships entering the ports of Calcutta and Bombay, and the discussion of a valuable series of selected observations taken on board vessels in the Indian Seas, which had been collected by the English Meteorological Office, by the India Meteorological Office.
- (4) The improvement of the work of solar observation in order to obtain accurate measures of the sun's heating power at the earth's surface and its periodic variations.

The proposals were sanctioned and brought into operation during the next two years (1880-82).

The reduction and discussion of the observations taken on board vessels in the Indian Seas, collected during twenty years (1856-75) by the London Meteorological Office, was carried out during the following years. The results were published in three volumes:—

- (1) Monthly Weather Charts of the Bay of Bengal and adjacent sea north of the Equator showing pressure, winds and currents.
- (2) Monthly Weather Charts of the Arabian Sea and the adjacent portion of the North Indian Ocean showing pressure, winds and currents.
- (3) Charts of the Bay of Bengal and adjacent sea north of the Equator showing the specific gravity, temperature and currents of the sea surface.

A system of télégraphic reports and storm warnings for the larger ports on the west coast of India was established in 1880. The scheme eventually adopted continued in operation with practically no change until September 1888. Storm signals, consisting of a cone for the day-time and three lamps in a triangle at night, were provided at Bombay and five other ports, viz., Kurrachee, Ratnagiri, Vengurla, Karwar and Kumta, and were hoisted on due intimation to that effect from the Bombay Meteorological Office.

A system of storm signals for warning the Port of Calcutta of cyclones approaching from the Bay, which had been in operation since 1865, was found by experience to be defective, as it was restricted to the intimation of the most dangerous type of cyclonic storms, viz., cyclones of comparatively infrequent occurrence. It was found that storms of limited extent, occasionally very violent over a small area, are frequently formed at the head of the Bay during the rainy season, and indeed may be considered as a characteristic feature of the season. They are dangerous to shipping leaving the port of Calcutta, and it was therefore desirable to have the means of issuing special warnings to the lower reaches of the river whenever such storms appear about the Sandheads. A new system of signals was hence introduced to give warning of such storms, and in certain cases to indicate the probable course the storm would take, whether to the east or west of the mouth of the Hooghly. The system also included general signals for indicating bad weather, when the actual existence of a cyclone is still in doubt. The system was brought into operation in 1882.

In connection with this extension, sanction was given to the issue of a Daily Weather Report for the Bay of Bengal giving observations, a brief descriptive summary of the weather in the Bay and adjacent coasts, and a weather chart of the Bay showing the chief features of the weather in a graphic form. This was the first Daily Weather Report with an illustrative chart issued by the Meteorological Department.

The Government of Bengal had been for some time dissatisfied with the small amount of current weather information they received. As some parts of the province were in 1882-83 threatened with drought, full and early information became essential. The Government decided that they could only obtain the current information they required by the publication of a Daily Weather Report for the province.

The Government of Bengal then instructed their Reporter to prepare a scheme for the publication of a Daily Weather Report for the Province of Bengal which should give full data and a summary that would enable the Government and public to follow the variations of the rainfall and the changes of weather during the south-west monsoon period.

The Meteorological Reporter to the Government of Bengal submitted a complete scheme, which was adopted by the Government of Bengal and forwarded to the Government of India with the intimation that the Government of Bengal were prepared to make a grant from provincial funds to meet the additional expenditure of the Meteorological Department in carrying out the scheme; and the Government of India in March 1883, at the request of the Government of Bengal, sanctioned the establishment of a large number of additional stations in Bengal and the publication of Daily Weather Reports for the Province of Bengal during the south-west monsoon, or from 15th May to 15th November, and of weekly and monthly meteorological and rainfall returns in the *Calcutta Gazette*, with short summaries giving the more important features of the weather and rainfall for the periods in question.

The scheme was sanctioned by the Government of India on terms which were accepted by the Government of Bengal.

The report thus sanctioned was the first provincial report issued regularly in India, and has been continued with slight extensions and improvements.

It was at first issued without a chart, but in 1896 sanction was given for the addition of a chart.

The necessity of obtaining meteorological data relating to the Indian Seas from vessels navigating these seas intensified with the increasing activity of the Department. This information was urgently required in order to trace the origin and tracks of storms in these seas, and to throw light on the causes of the variations of the south-west monsoon rainfall. In 1881 a system of collecting, from ships entering the port of Calcutta, copies of so much of the meteorological entries in their logs as related to their passage up the Bay of Bengal from the Equator was hence initiated, and has since been largely extended.

Another important addition to the practical work of this Department was made during the year 1885. This was due to the occurrence of very destructive floods in the lower valleys of the Nerbudda and Tapti Rivers in July 1884, of which no warning was given to the District Officers, in the absence of previous arrangements. Mr. Blanford, in consequence, proposed arrangements by which the District Officers and Political Officers of Surat, Baroda, &c., should receive early notice of any unusually heavy rainfall in the drainage basins of these rivers, in addition to information of the occurrence of conditions likely to give rise to severe floods in these rivers.

These arrangements have continued in operation up to the present time without any change, and have been found effective and satisfactory.

An attempt to estimate the prospects of the monsoon rains, based on the results of the snowfall reports and the general character of the winds, and pressure distribution in the period immediately antecedent to the rainy season, was made by Mr. Blanford in each of the years 1882-84. In 1885, the indications on which this forecast was based were of a more pronounced character than in either of the previous years, and the prediction which they seemed to justify, viz., that the influx of the monsoon rains on the West Coast and in Southern and Western India generally, would be considerably retarded, was so fully borne out by the subsequent history of the season, that confidence in the general validity of the method was much strengthened.

The forecast for the south-west monsoon rains of 1885 was the first of the series of annual forecasts which have been regularly issued and published in the *Gazette of India*.

In the year 1888 it was decided to adopt 8 A.M. instead of 10 A.M. as the hour of observation for the observations embodied in the weather telegrams transmitted daily for publication in the departmental Daily Weather Reports.

Arrangements were also made for the extension and improvement of the methods of collecting rainfall data for the information of the Government of India and the adoption of a uniform system of rainfall registration and of publication of rainfall statistics throughout India.

It was also decided to adopt 8 A.M. as the hour for the daily measurement of rain throughout India.

The latter changes were brought into operation from January 1889. They have effected a great and continuous improvement in the registration and publication of rainfall data.

A series of improvements were made in the India Daily Report during the years 1887 and 1888. The most important was the calculation of daily normals and their employment to furnish the variations of pressure and temperature of the day and of the accumulated seasonal rainfall to date from the normal in each Daily Weather Report.

Government also sanctioned the addition of a chart to the report to show the distribution of pressure and the direction of the air movement at 8 A.M., and the rainfall of the previous twenty-four hours. These changes were completed in January 1889.

Further progress was made at this time, with the sanction of Government, in the work of collecting meteorological information from the captains of vessels navigating the Arabian Sea and the Bay of Bengal. Government also sanctioned, as soon as sufficient information was forthcoming to give a fairly adequate view of the general weather conditions in the Indian Seas, the publication of a Daily Chart based on these observations in the Bay of Bengal and Arabian Sea and also at certain Indian and Extra-Indian stations, including Port Blair, Amini Devi, Aden, Perim, the Seychelles, Bushire, Baghdad, &c., and on those already published in the ordinary India Daily Weather Report.

An important extension in the work of storm warning was effected in the year 1886-87. Previously to this, warnings were given to a comparatively small number of ports. The Burma ports were not warned at all, and ports of the Madras and Bombay Coasts were very inadequately warned.

During the year 1886 Mr. Blanford took up the question of the extension of the system of warning to all Indian ports, including those in Burma. He drew up and introduced a general system of signals for the Burma and Madras ports, and instructions for their use for the guidance of Port Officers. The apparatus for hoisting the storm signals was not ready at the Madras ports until nearly the end of the year 1887, and the extension hence did not come into effective operation at these ports until the beginning of 1888.

It was shortly afterwards found that the system in force was defective and unsatisfactory for the West Coast ports, and proposals were submitted in 1888 to the Government for the adoption of a system of signals suggested by the Port Officer of Bombay as most suitable for the conditions and requirements of the West Coast. The proposals were finally approved by the Government of Bombay and introduced on and from the 15th of September 1889. The signals of this system differed to some extent from the signals employed for storm warning on the Madras, Bengal and Burma ports, an arrangement that led to some inconvenience.

The necessity for a large extension of the work of flood warning was shown by the damage caused by a remarkable series of floods during the south-west monsoon of 1889.

Heavy floods occurred in the Lower Indus Valley in the first and second weeks of July which breached the North-Western Railway in some places and suspended traffic between Lahore and Kurrachee for some time, and also breached the bunds on the right-hand bank of the river Indus near Dera Ghazi Khan. Heavy floods also occurred in August in the Quetta District and in the hills of Eastern Baluchistan. The Quetta Railway was breached in several places and traffic suspended for some days.

These floods brought under discussion the general subject of flood warnings to officers in the Public Works Department, and arrangements were made by which telegraphic information of heavy rainfall and warnings of floods were sent to all Public Works Officers who made application for them. The number of recipients of these telegrams has steadily increased, as it has been found by experience that the information and warnings received from the Department frequently enable Public Works Officers to make arrangements which minimise the destruction and loss of public property due to floods.

The commercial public in Bombay had for some years desired to have a local Daily Weather Report. Arrangements were finally completed for the publication of a suitable report and chart giving information for the chief wheat and cotton areas, on which the commerce of Bombay is largely dependent for its export trade.

Hitherto no effort had been made to interest the larger Native States in the work of meteorological observation or to secure their co-operation. The Nizam's Government, in response to a suggestion by the Government, established seven observatories to work in co-operation with the India Meteorological Department. The seven stations selected for the establishment of these observatories were Hyderabad, Gulburga, Raichur, Aurangabad, Khamamet,* Indur and Bidar.

The Mysore State also arranged about the same time to establish a local system of stations under favourable conditions. A first-class observatory (in which a continuous record of the readings of the instruments is made by photographic methods) was established at Bangalore, and smaller observatories at three other stations, viz., Mysore, Hassan and Chitaldroog. These observatories commenced work in 1891-92.

The Government of India also sanctioned the establishment of fourteen additional observatories during the year (1892-93). Two of these (Mainpuri and Bahraich) were suggested by the Government of the North-Western Provinces to give information of important areas hitherto unrepresented in our system. Four were established at the stations of Minbu, Yamethin, Fort Stedman and Lashio in Upper and Central Burma, to give additional information of that large area, previously very imperfectly represented by the four stations at Toungoo, Mandalay, Kindat and Bhamo. The remaining eight additional observatories were located at stations on the North-West Frontier and in Persia. Four of the observatories were established at Gilgit, Kabul, Chaman and Cherat, and four at Jask, Muscat, Teheran and Ispahan.

The Government of India in 1888 sanctioned the issue of a Daily Weather Report and Chart of the India monsoon area based chiefly on marine meteorological data, as soon as sufficient materials were available. As a large amount of useful information was collected at the ports of Calcutta and Bombay in the years 1890-92, it was thought that the time had arrived for the commencement of this work. The Government of India hence formally sanctioned the publication for two years of Daily Weather Charts of the whole Indian monsoon area embodying the meteorological information obtained from the logs of vessels and from the Extra-Indian stations in Persia, Arabia, &c., as well as the information given in the India Daily Weather Reports of the same period, and thus furnishing at a glance the meteorological features of the whole Indian land and sea areas on each day of the period for which the publication was sanctioned (i.e., for the years 1893 and 1894).

These reports and charts were found to be of such interest and value that the Government of India sanctioned their continuance for a further period of five years until the 31st December 1899. They were then temporarily discontinued, but will probably be resumed in an enlarged form.

The desirability of the issue of a Daily Weather Report for the information of the officials and commercial public at Madras was under consideration from the year 1888.

The unsatisfactory seasons and partial failure of the crops in portions of the Madras Presidency in the years 1892 and 1893 intensified the desire for the full and early weather information that can only be given by a local Daily Weather Report.

* Recently transferred to Hanumkonda.

Introduction.

Arrangements were made for the issue of the Madras Daily Weather Report and Chart in 1893 and for its publication from the 1st October 1893.

Proposals were submitted in the year 1895 to the Kashmir Durbar for extending in that State the work of meteorological observation which had been commenced in October 1891 by the establishment of an observatory at Srinigar. In 1896 observatories were opened at Dras, Skardu and Gulmarg, and in 1900 at Sonamarg.

The extension of the storm signal work was followed in 1886-89 by objections to the employment of two different systems of storm signals at Indian ports as confusing to seamen and possibly leading to mistakes. The Government of India accepted the principle that a uniform system of signals was desirable for the whole of India, and called upon the Imperial Reporter to prepare a suitable scheme. This was submitted for opinion to the various commercial and mercantile authorities interested and was generally approved. One important objection was made, that the system, although well adapted for the larger ports, was too extensive and complicated for small ports and fishing towns, a large number of which on the Kathiawar and Konkan coasts are warned. The Government of India referred the whole question to a small Committee consisting of the Director of the Marine Survey of India, the Port Officer, Bombay, and the Meteorological Reporter to the Government of India, and asked them to submit a revised system which should satisfy, so far as possible, all requirements.

The Committee recommended for adoption, with some slight changes, the uniform system proposed by the Imperial Reporter for use at all the larger and more important ports. They also came to the conclusion that it was "desirable the storm signals used at small ports, frequented only by country vessels or small coasting steamers, should be made as simple as possible. This could easily be done by using a selection from the uniform series of storm signals proposed for the larger ports, and it was suggested that the selection should be made so that these smaller ports should be warned only of storms likely to affect them directly. This, it was pointed out, could be done by the use of three day and three corresponding night signals selected from the larger system."

The Committee hence recommended for adoption :—

- 1st.—An extended or complete system of storm signals for the larger ports.
- 2nd.—A brief system of storm signals for use at the small ports. The Committee also suggested that the port authorities concerned should decide for their respective ports which system should be adopted.

The proposed system and recommendations of the Committee were accepted by the Government of India, and the various local authorities were consulted as to the date of the introduction of the new system, and the 1st of April 1898 was finally chosen.

The most important recent addition to the Department is due to the transfer of the Colaba (Bombay), Madras and Kodaikanal Observatories from the control of the Provincial Governments concerned to the Imperial Government. These observatories, although nominally provincial observatories, were really Imperial, as each served a special purpose for the whole of the Indian Empire. This change was effected on the 1st April 1899, when the observatories were placed under the general superintendence of the Meteorological Reporter to the Government of India (who was also appointed Director-General of Indian Observatories).

Summary of more important changes during the period 1887-1901.

The following is a very brief statement of the more important changes in, and additions to, the work of the Department during the period 1887-1901 :—

- (1) The number of observatories working under, or in connection with, the Department furnishing information for inclusion in the Daily Weather Reports and Monthly Reviews was increased from 135 on the 1st April 1887 to 230 on the 31st March 1901. The increase is hence 95 in number, or 70 per cent. of the number in 1886-87.
- (2) The number of ports warned on the Indian coast was increased from 15 in 1886-87 to 45 in 1900-1, an increase of 200 per cent. The system of storm signals was improved and additional signals introduced to meet defects shown by actual working and experience.
- (3) The number of officials and other authorities to whom flood and weather warnings are sent whenever necessary by special urgent (storm signal) messages has increased from *Nil* in 1886-87 to 77 in 1900-1. The number of these warnings issued in the former year was *Nil* and in the latter year 509.
- (4) In 1886-87 there were only three Daily Weather Reports issued for the information of Government and the public, viz., the Simla and Bay of Bengal Reports, of which only the latter was illustrated by a chart. There are now issued five Daily Weather Reports and charts of which the following give data :—

	Number of Stations, 1886-1887.	Number of Stations, 1900-1901.
India—Daily Weather Report	97	158
Bengal { Bay of Bengal Daily Weather Report	20	28
{ Bengal Daily Weather Report	41	66
Bombay Daily Weather Report	<i>Nil</i>	54
Madras Daily Weather Report	<i>Nil</i>	39

Current weather information is now placed as rapidly before the more important Governments and public as is possible under the conditions of Indian telegraphic and postal facilities.

- (5) The introduction of a uniform system of the registration of rainfall throughout India (more especially the adoption of a common type of rain gauge, common hour of registration and methods of inspection) and of the publication of the data of observation. The number of rain gauge stations has been increased to some extent, chiefly by increase in Rajputana, Central India, Baluchistan, Kashmir, and other districts in which the work was previously very imperfectly performed. An important improvement in connection with this was the introduction of weekly rainfall telegrams to Simla from District Officers for the preparation of weekly rainfall reports and of charts showing the distribution of the rainfall of each season to date for the information of the Government of India.
- (6) A large extension of the work of collecting meteorological information relating to the Indian Seas. The data now systematically collected are sufficient to enable daily weather charts to be prepared which show the character of the weather changes in the sea area almost as fully as is done for the land area by the charts in the Daily Weather Reports. Pilot charts for the Indian Seas are, as a result of this, now prepared and issued by the office.

- (7) The establishment of a Solar Physics Observatory for the systematic examination and study of the changes in progress in the sun and their correlation with the larger features of Indian meteorology, and the transfer of the Magnetic Observatory at Colaba and the Astronomical Observatory at Madras from Provincial to Imperial control.

Publications of the Department, 1876-1901.

The following is a list of the more important publications and discussions of the India Meteorological Department during the first twenty-five years of its existence, from 1876 to 1901:—

- The Indian Meteorologist's *Vade-Mecum*, Part I.
 The Indian Meteorologist's *Vade-Mecum*, Part II.
 Instructions to Observers of the India Meteorological Department.
 Tables for the reduction of Meteorological Observations in India.
 Handbook of Cyclonic storms in the Bay of Bengal for the use of sailors, Vol. I.—Text.
 Handbook of Cyclonic storms in the Bay of Bengal for the use of sailors, Vol. II.—Plates.
 Cyclone Memoirs, Part I.—Bay of Bengal Cyclone of 20th to 28th May 1887.
 Cyclone Memoirs, Part II.—Bay of Bengal Cyclone of 21st to 28th August 1888.
 Cyclone Memoirs, Part III.—Bay of Bengal Cyclones of 13th to 20th September, and 27th to 31st October 1888, and Arabian Sea Cyclone of 6th to 9th November 1888.
 Cyclone Memoirs, Part IV.—An enquiry into the nature and course of storms in the Arabian Sea, and a catalogue and brief history of all recorded storms in the Arabian Sea from 1648-1889.
 Cyclone Memoirs, Part V.—Account of three Cyclones in the Bay of Bengal and Arabian Sea during November 1891.
 Report of the Midnapore and Burdwan Cyclone of the 15th and 16th of October 1874.
 Report of the Vizagapatam and Backergunge Cyclones of October 1876.
 Report on the Madras Cyclone of May 1877.
 Reports on the Meteorology of India for the years 1875-90 (16 volumes).
 India Weather Review—Annual Summaries for the years 1891-1900 (10 parts).
 Monthly Weather Review for each month, January to December, for the years 1891-1900 (120 parts or 10 volumes).
 Indian Meteorological Memoirs, Vol. I., containing the following memoirs:—
- On the winds of Calcutta.—An analysis of ten years' hourly observations of the wind vane and four years' anemograms.
 - The meteorology and climate of Yarkand and Kashghar, being chiefly a discussion of registers kept by Dr. J. Scully in 1874-75.
 - The diurnal variation of the barometer at Simla.
 - Storms in Bengal during the year 1876, accompanied with increased atmospheric pressure and the apparent reversal of the normal diurnal oscillation of the barometer.
 - On the rainfall of Benares considered in relation to the prevailing winds.
 - On the diurnal variation of the barometer at Indian stations, Part I.: Calcutta and Hazaribagh.
 - Variation of rainfall in Northern India.
 - Meteorological and hypsometrical observations in Western Tibet, recorded by Dr. J. Scully, with a discussion.
 - The winds of Kurrachee.
 - Some results of the meteorological observations taken at Allahabad during the ten years 1870-79.
 - The diurnal variation of the barometer at Indian stations, Part II.: Goalpara, Patna, and Leh.
 - The meteorology of the North-West Himalaya.

Indian Meteorological Memoirs, Vol. II., containing the following memoirs:—

- Account of the south-west monsoon storm of the 18th to the 24th of September 1878 in the north of the Bay of Bengal.
- List of cyclones on the West Coast of India and in the Arabian Sea up to the year 1881.
- Note on the foregoing list of cyclones and on the Gujarat land-cyclone of the 11th to the 13th July 1881.
- On the temperature of North-Western India.
- Account of the south-west monsoon storms of the 8th to the 19th October 1882 in the Bay of Bengal.
- Account of south-west monsoon storms generated in the Bay of Bengal during the years 1877 to 1881.
- Observations of temperature and humidity at heights of 4 feet and 40 feet above the ground at the Alipore Observatory, Calcutta.

Indian Meteorological Memoirs, Vol. III., containing a full discussion of the rainfall of India and cognate subjects.

Indian Meteorological Memoirs, Vol. IV., containing the following memoirs:—

- Account of the south-west monsoon storm of the 12th to the 17th of May in the Bay of Bengal and at Akyab.
- On the diurnal variation of the rainfall at Calcutta.
- The meteorological features of the southern part of the Bay of Bengal.
- The False Point cyclone of 22nd September 1885.
- On the ground temperature observations made at the old observatory, Allahabad.
- List and brief account of the south-west monsoon storms generated in the Bay of Bengal during the years 1882 to 1886.
- The cyclonic storms of November and December 1886 in the Bay of Bengal.
- The cyclone of the 25th May to the 2nd June 1881 in the Arabian Sea.
- On temperature and humidity observations made at Allahabad at various heights above the ground.
- The Arabian Sea cyclone of the 4th to the 13th June 1887.
- On the meteorology and climatology of Northern Afghanistan.
- An account of the more important cold weather storms in India during the years 1876 to 1891.

Indian Meteorological Memoirs, Vol. V., containing:—

- The discussion of the hourly observations made at Sibsagar, Goalpara, Patna, Hazaribagh, Dhubri, Roorkee, Allahabad, Lucknow, Agra, Leh, Deesa, Kurrachee and Lahore and at Simla.

Indian Meteorological Memoirs, Vol. VI., containing the following memoirs:—

- The relation between sunspots and weather as shown by meteorological observations taken on board ships in the Bay of Bengal during the years 1856 to 1879.
- Investigation into the mean temperature, humidity and vapour tension conditions of the Arabian Sea and Persian Gulf.
- A preliminary discussion of certain oscillatory changes of pressure of long period and of short period in India.
- The hot winds of Northern India.
- An account of a storm developed in equatorial regions.
- Hailstorms in India during the period 1883-97 with a discussion on their distribution.
- A discussion of the anemographic observations recorded at Simla during the period September 1893 to August 1896 and at Darjeeling during the period April 1885 to December 1896, and an investigation into the general features of the air movement in the Himalayan mountain area.
- A discussion of the anemographic observations recorded at Darjeeling during the period May 1885 to May 1896 and an investigation into the general features of the air movement in the Sikkim Himalayas.
- A discussion of the thunderstorm observations recorded in 1897 at ten selected stations in India.

Indian Meteorological Memoirs, Vol. VII., containing the following memoirs:—

- Hourly observations of pressure, temperature, vapour tension, humidity, cloud, wind direction, and velocity of wind taken at Trivandrum during the years 1853 to 1864.

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Indian Meteorological Memoirs, Vol. VIII., containing the following memoirs:—

- Hourly meteorological observations recorded at the Agustia Observatory during the period from January 1856 to September 1858 and from June to December 1864.
- Hourly comparative meteorological observations taken at Trivandrum, Vannatheertham (eastern station), Kalliad (western station) and Agustia for the periods 23rd March to 20th April 1857, 20th January to 19th February 1859, 9th September to 8th October 1864 and 2nd to 28th January 1865, also at Cape Comorin from 23rd September to 13th November 1858 and at Charatha and Kamala from 20th January to 19th February 1859.

Indian Meteorological Memoirs, Vol. IX., containing the following memoirs:—

- The diurnal variation of atmospheric conditions at Chittagong, Cuttack, Jubbulpore, Pachmarhi, Nagpur, Poona, Belgaum, Bellary, Trichinopoly, Rangoon, Aden, Alipore and Jeypore.

Indian Meteorological Memoirs, Vol. X., containing the following memoirs:—

- The discussion of the hourly meteorological observations recorded at Trivandrum during the years 1853-64.
- The discussion of the hourly meteorological observations recorded at Agustia during the years 1856-58 and 1864.
- Discussion of the comparative hourly meteorological observations recorded at Trivandrum, Calliad, Vannatheertham and Agustia for the periods 23rd March to 20th April 1857, 20th January to 19th February 1859, 9th September to 8th October 1864 and 2nd to 28th January 1865, and at Charatha and Kamala from 20th January to 19th February 1859.

Indian Meteorological Memoirs, Vol. XI., containing the following memoirs:—

- Observations recorded during the solar eclipse of 22nd January 1898 at 154 meteorological stations in India.
- A discussion of the observations recorded during the solar eclipse of 22nd January 1898 at 154 meteorological stations in India.
- Report on cloud observations and measurements in the plains of the North-Western Provinces of India during the period December 1898 to March 1900.

Indian Meteorological Memoirs, Vol. XII., containing:—

- A discussion on the failure of the south-west monsoon rains in 1899.
- A discussion of the results of the hourly observations recorded at 29 stations in India given in Volumes V., IX. and X. of the Indian Meteorological Memoirs.

Indian Meteorological Memoirs, Vol. XIII., containing:—

- Daily normals of maximum and minimum temperature, 8 A.M. air pressure and rainfall and five-day means of normal cloud amount, relative humidity and aqueous vapour pressure.

Indian Meteorological Memoirs, Vol. XIV., containing:—

- “The Rainfall of India,” giving data to the end of 1900 in continuation of and including the rainfall data in Vol. III.

Monthly weather charts of the Bay of Bengal and adjacent sea area north of the Equator showing mean pressure, winds and currents.

Monthly weather charts of the Arabian Sea and the adjacent portion of the North Indian Ocean showing mean pressure, winds and currents.

Charts of the Bay of Bengal and adjacent sea area north of the Equator showing the specific gravity, temperature and currents of the sea surface.

Daily weather reports and charts of the Indian monsoon area for the years 1893 to 1899.

Normal weather or Pilot Charts of the Indian monsoon area for 8 A.M. for each month beginning with November 1900.

Also in preparation at the end of the period (1876-1901):—

- A Climatological Atlas of India.
- A Handbook of the Meteorology of India.

The following gives a list of the observatories, with their latitude and longitude, furnishing meteorological observations regularly to the India Meteorological Department, the date of establishment, the elevation of the level of the mercury in the barometer-cistern above the sea, the position of the anemometer, and approximate elevation of the cups of the anemometer above ground so far as they are known:—

STATION.	Position of Observatory.		Date of Establishment of Observatory.	Elevation of Bar-cistern above Mean Sea-level.	Date of Change of Elevation.		Position of Anemometer.	Elevation of Cups above Ground.	
	Lat.	Long.		Feet.				Ft.	In.
Mergui	12° 27' N.	98° 35' E.	1st September 1877	96	...	...	On a wooden staging set up to the west of the shed	21	6
Tavoy	14° 7' N.	98° 18' E.	20th March 1888	26	...	...	On the roof of the Court-House, a two-storied building to the west of the Telegraph Office	...	...
Moulmein	16° 30' N.	97° 38' E.	1st January 1876	94	...	...	On a wooden staging to the east of the shed	26	9
Rangoon	16° 47' N.	96° 13' E.	1st January 1876	41	...	...	On a ridge above roof of the High School	49	2
				57	1st March 1902		On a small wooden post on durwan's quarters in the Secretariat compound	about 20	0
Bassein	16° 4' N.	94° 50' E.	1st January 1877	42	...	...	On the highest part of the roof of the Hospital building	40	8
				27	13th July 1888				
Diamond Island	15° 52' N.	94° 19' E.	1st February 1878	41	...	...	On a post near the shed	6	0
Akyab	20° 7' N.	92° 57' E.	7th May 1866	20	...	...	On wooden posts about 18 yards north-west of the Telegraph Office	...	...

STATION.	Position of Observatory.		Date of Establishment of Observatory.	Elevation of Bar-cistern above Mean Sea-level.	Date of Change of Elevation.	Position of Anemometer.	Elevation of Cups above Ground.	
	Lat.	Long.		Feet.			Ft.	In.
Toungoo	18° 55' N.	96° 31' E.	1st November 1877	169	... ..	On a lofty platform near the northern end of the Hospital	48	11
				183	1st May 1884			
Thayetmyo	19° 22' N.	95° 12' E.	1st November 1877	130	... ..	On a tower of the Station Hospital	52	0
Taunggyi	17° 8' N.	96° 30' E.	9th December 1894	...	... ..	Not known	...	
Lashio	22° 55' N.	97° 50' E.	1st August 1893	2,751	... ..	On wooden posts	...	
Bhamo	24° 16' N.	97° 17' E.	1st November 1886	381	... ..	On posts on the roof of Civil Hospital	20	0
Kindat	23° 44' N.	94° 29' E.	1st July 1886	377	... ..	On a strongly built wooden staging	...	
Minbu	20° 12' N.	94° 58' E.	18th February 1893	165	... ..	Fixed on wooden posts 10 yards east of thermometer shed	...	
Yamethin	20° 27' N.	96° 9' E.	1st March 1893	645	... ..	On wooden posts	...	
				657	26th December 1897			
Mandalay	21° 59' N.	96° 8' E.	1st August 1878	250	... ..	On wooden platform	50	0
Chittagong	22° 21' N.	90° 53' E.	8th May 1866	87	... ..	On the roof of the Telegraph Office	29	9
Silchar	24° 50' N.	92° 51' E.	11th May 1869	89	... ..	On a wooden staging	24	9
				104	24th June 1880			
Barisal	20° 42' N.	90° 24' E.	2nd July 1883	13	... ..	On the top of the Registration Office	...	
Dacca	23° 43' N.	90° 26' E.	15th April 1867	35	... ..	On a post 3 feet above the staircase turret of the Telegraph Office	46	6
				22	3rd May 1884	On the roof of staircase of the Telegraph Office, a double-storied building	44	3
Narayanganj	23° 37' N.	90° 32' E.	9th March 1894	26	... ..	On the roof of the Telegraph Office building	20	0
Mymensingh	24° 46' N.	90° 27' E.	18th June 1883	59	... ..	On the roof of the Hardinge School	20	0
Saugor Island	21° 40' N.	88° 10' E.	21st August 1865	6	... ..	On the roof of the Telegraph buildings	48	10
				25	15th February 1880			
Calcutta (S. G. O.)	22° 34' N.	88° 24' E.	1st January 1853	18	... ..			
Calcutta (Alipore)	22° 32' N.	88° 24' E.	1st April 1877	21	... ..	On the north-west turret of the Observatory building	54	0
Jessore	23° 10' N.	89° 10' E.	1st August 1867	33	... ..	On the roof of the Jail Hospital	29	1
Berhampore	19° 18' N.	84° 51' E.	1st August 1867	67	... ..	On the roof of the Civil Surgeon's Office	24	9
Bogra	24° 51' N.	89° 26' E.	2nd December 1884	61	... ..	On masonry pillars about 3½ feet high upon parapet wall of the Warder's guard-room	25	0
Sibsagar	26° 59' N.	94° 41' E.	1st January 1874	333	... ..	On a masonry pillar 2 feet high on the roof of the Civil Surgeon's Office	29	6
Dhubri	26° 2' N.	90° 2' E.	1st January 1881	115	... ..	On wooden posts	16	0
Burdwan	23° 16' N.	87° 54' E.	1st September 1873	102	... ..	On a masonry pillar about 7 feet high on the roof of the Deed Registry Office	16	2
				99	11th December 1902			
Patna	20° 42' N.	83° 10' E.	1st September 1867	179	... ..	On a masonry pillar about 3 feet high above the roof of the Temple Medical School	35	0
				183	1st September 1881			
Gaya	24° 49' N.	85° 3' E.	15th April 1869	375	... ..	On the roof of the Collectorate	30	0
Benares	25° 19' N.	83° 3' E.	1st January 1863	267	... ..	On the south-west tower of the Queen's College	76	11

N.B.—Elevations in italics indicate barometrical determinations.

Introduction

STATION.	Position of Observatory.		Date of Establishment of Observatory.	Elevation of Bar-cistern above Mean Sea-level.	Date of Change of Elevation.	Position of Anemometer.	Elevation of Cups above Ground.	
	Lat.	Long.		Feet.			Ft.	In.
Darjeeling	27° 3' N.	88° 18' E.	1st July 1867	6,960	... ..	On a tower on the crest of the ridge	19	9
				6,941	April 1870			
				6,912	May 1873			
				7,421	October 1881	On a narrow ridge to the north of the thermometer shed	...	
				7,408	13th October 1897			
				7,376	March 1899			
Jalpaiguri	26° 32' N.	88° 46' E.	15th May 1883	284	... ..	On the roof of the two-storied Post Office building	...	
Dinajpur	25° 37' N.	88° 40' E.	20th May 1883	118	... ..	On a small masonry pillar above the roof of the Judge's Court	about 25	0
				123	19th April 1893			
Purnea	25° 46' N.	87° 31' E.	1st June 1874	125	... ..	On a masonry pillar above solitary cell building of the Jail	24	0
Darbhanga	26° 10' N.	85° 57' E.	1st November 1875	166	... ..	On the roof of the Raj Hospital	34	2
Gorakhpur	26° 45' N.	83° 24' E.	1st May 1866	257	... ..	On a masonry pillar above parapet wall of the roof of the Hospital	26	3
Bahraich	27° 34' N.	81° 38' E.	8th June 1892	401	... ..	On the parapet wall of the Lyall Library	about 20	0
Bareilly	28° 22' N.	79° 27' E.	1st January 1866	568	... ..	On the roof of the College . . .	48	4
Roorkee	29° 52' N.	77° 53' E.	1st January 1863	887	... ..	On an iron bracket embedded in a small pillar on the roof of the College	40	0
				899	13th March 1902			
Umballa	30° 21' N.	76° 52' E.	27th July 1892	892	... ..	On a masonry pillar, 4 feet high, on the roof of Civil Surgeon's Office	20	0
Ludhiana	30° 55' N.	75° 54' E.	1st August 1868	806	... ..	On the roof of the Dispensary	23	7
				812	28th April 1878			
Sialkot	32° 31' N.	74° 36' E.	1st June 1866	830	... ..	On the roof of the Hospital building	29	2
Rawalpindi	33° 37' N.	73° 6' E.	1st May 1866	1,652	... ..	On the Dispensary building . .	29	0
				1,674	28th April 1895	On small masonry basement on roof of the Telegraph Master's quarters	about 20	0
Ranikhet	29° 40' N.	79° 33' E.	1st April 1870	6,069	1st January 1876	On the roof of the observer's bungalow	18	6
Dehra Dun	30° 19' N.	78° 4' E.	1st January 1867	2,233	... ..	On the top of the Survey Office building	50	0
Mussooree	30° 27' N.	78° 6' E.	16th May 1866	6,705	... ..	No anemometer	...	
Chakrata	30° 43' N.	77° 54' E.	1st March 1869	7,051	... ..	On a wooden scaffolding near the Observatory	12	4
				6,977	1st February 1894			
				7,022	6th June 1897	On a wooden staging to the south of the shed	...	
				7,012				
Simla	31° 6' N.	77° 13' E.	1st January 1873	7,048	7th March 1885			
				7,073	1st March 1889			
				7,274	April 1890	On a tower of the Town Hall	about 30	0
				7,224	1st July 1892			
Murree	33° 55' N.	73° 27' E.	1st October 1870	6,344	... ..	On high wooden poles	14	8
				6,333	14th June 1897			
Srinagar	34° 6' N.	74° 51' E.	9th October 1891	5,204	... ..	On the uppermost story of the Lal Mandi Palace	about 25	0

STATION.	Position of Observatory.		Date of Establishment of Observatory.	Elevation of Bar-cistern above Mean Sea-level.	Date of Change of Elevation.		Position of Anemometer.	Elevation of Cups above Ground.	
	Lat.	Long.		Feet.				Ft.	In.
Leh	34° 10' N.	77° 40' E.	1st September 1873	11,503	...	...	...	24	6
Kailang	32° 34' N.	77° 4' E.	1st July 1883	10,087	...	...	On the top of a two-storied building	25	0
Allahabad	25° 28' N.	81° 54' E.	1st January 1866	309	...	...	On a pillar raised on the roof of the Muir College building	29	1
					1st January 1886		On a pillar at the south-east corner of the roof of the Observatory building	26	0
Lucknow	26° 55' N.	80° 59' E.	1st January 1867	369	...	...	On the roof of the Museum . .	58	0
				368	6th October 1894		On the roof of the Telegraph Office	...	
Cawnpore	26° 28' N.	80° 24' E.	1st October 1889	416	...	...	On a pillar on the roof of the Telegraph Office	about 25	0
Mainpuri	27° 14' N.	79° 3' E.	1st May 1892	516	...	...	On the roof of the combined Post and Telegraph Office building	about 20	0
Agra	27° 10' N.	78° 5' E.	1st December 1862	555	...	...	On masonry pillar about 5 feet high on the roof of the Thomson Hospital	37	6
Meerut	29° 1' N.	77° 45' E.	1st January 1867	738	...	...	On the top of a wooden post on the roof of the Civil Surgeon's house	36	6
Delhi	28° 39' N.	77° 17' E.	8th August 1874	718	...	...	On the roof of the operation room of the Civil Hospital	19	5
Lahore	31° 34' N.	74° 21' E.	1st January 1866	732	...	...	On the top of the thermometer shed	19	6
				702	7th January 1885		On the roof of the office building .	28	0
Cherat	33° 50' N.	72° 1' E.	8th December 1892	4,256	...	...	On a masonry pillar 6 feet high on a well exposed hill	6	0
Peshawar	34° 2' N.	71° 37' E.	1st July 1866	1,110	...	...	On a brick-built pillar 4 feet high on roof of Civil Hospital	21	2
Khushab	32° 18' N.	72° 24' E.	1st January 1890	612	...	...	On the roof of the barometer house	about 18	0
Dera Ismail Khan . . .	31° 51' N.	70° 56' E.	1st May 1866	591	...	...	On the Jail Office building . .	25	2
				590	25th September 1895.		On the roof of the Telegraph Office	25	4
Montgomery	30° 58' N.	73° 21' E.	1st January 1890	558	...	...	On the roof of the Civil Surgeon's Office	about 18	0
Mooltan	30° 12' N.	71° 31' E.	1st April 1866	420	...	...	On the roof of the Dispensary . .	24	5
Sirsa	29° 32' N.	75° 7' E.	1st February 1876	662	...	...	On a masonry pillar 4 feet high on the roof of the combined Post and Telegraph Office	18	0
Bikaner	28° 1' N.	73° 22' E.	1st September 1877	769	...	...	On the roof of the Hospital building	28	3
				771	14th January 1892				
Pachpadra	25° 55' N.	72° 11' E.	1st September 1879	380	...	...	On a post fixed in a masonry pillar	16	0
Kurrachee	24° 51' N.	67° 4' E.	1856	49	...	...	On a square tower on a hill near the Station Hospital	22	0
							On a tower of the Telegraph Office	30	0
				30	1st June 1897				
Hyderabad (Sind) . . .	25° 23' N.	68° 24' E.	19th May 1877	94	...	...	On one of the western bastions of the Jail	25	10
				96	27th March 1895		On a wooden post 3 feet high on the roof of the Telegraph Office	about 16	0
Jacobabad	28° 17' N.	68° 29' E.	1st February 1877	186	...	...	On a wooden post 5 yards high on the roof of the Hospital	44	2
Quetta	30° 12' N.	67° 0' E.	1st January 1879	5,503	...	...	On a masonry pillar 6½ feet high on the roof of the Police ward	23	0
Chaman	30° 55' N.	66° 28' E.	15th November 1892	4,311	...	...	On a small masonry pillar 1 foot 8 inches high on the roof of the Telegraph buildings	12	0
Colombo	6° 56' N.	79° 56' E.	1st July 1869	40	...	...	Not known	...	

Introduction

STATION.	Position of Observatory.		Date of Establishment of Observatory.	Elevation of Bar-cistern above Mean Sea-level.	Date of Change of Elevation.	Position of Anemometer.	Elevation of Cups above Ground.	
	Lat.	Long.		Feet.			Ft.	In.
Trivandrum	8° 29' N.	76° 59' E.	1st January 1853	198	...	On the roof of the Observatory building	20	0
Cochin	9° 58' N.	76° 17' E.	1st February 1868	10	...	On a wooden post close by the Port wharf	16	4
Calicut	11° 15' N.	75° 49' E.	1st August 1880	27	...	On roof of small shed at end of pier	20	1
Mangalore	12° 52' N.	74° 53' E.	1st March 1880	52				
				65	22nd August 1893	On a wooden post 20 feet high in the compound of the Collector's Office	20	0
Mercara	12° 26' N.	75° 47' E.	1st April 1880	3,721	...	On a post	18	9
				3,781	1st January 1887	On a wooden staging	...	
Karwar	14° 48' N.	74° 11' E.	24th October 1877	44	...	On a post	...	
Goa	15° 30' N.	73° 57' E.	1st May 1860	199	...	Not known	...	
Mormugao	15° 25' N.	72° 50' E.	1st August 1890	60	...	On the roof of the Palace in Fort	100	0
Ratnagiri	17° 8' N.	73° 19' E.	1st January 1877	110	...	On a tower	28	5
Bombay	18° 55' N.	72° 54' E.	1st January 1847	37	...	On the tower of the Observatory.	53	0
Surat	21° 12' N.	72° 52' E.	2nd April 1877	36				
				39	1st April 1896	On the roof of the Civil Hospital.	...	
Bhavnagar Para	21° 45' N.	72° 12' E.	1st January 1898	55	...	On the roof of the Hospital . .	...	
Veraval	20° 53' N.	72° 26' E.	1st February 1890	18	...	On the roof of a small house erected for keeping barometer	15	0
Rajkot	22° 18' N.	70° 56' E.	18th June 1877	429	...	On a stone pillar	33	6
Bhuj	23° 15' N.	69° 49' E.	1st December 1876	395	...	On a post	30	0
Ahmedabad	23° 2' N.	72° 38' E.	18th January 1893	163	...	On wooden posts about 10 feet high on the roof of the Municipal Office	25	0
Deesa	24° 14' N.	72° 13' E.	1856	474	...	On a tower	61	9
				466	1st November 1878			
Tinnevely	8° 44' N.	77° 44' E.	February 1892	168	...	On a wooden post 4 feet high fixed against the east parapet wall of the Sub-Magistrate's Cutchery	20	0
Madura	9° 55' N.	78° 10' E.	6th February 1868	447	...	On a small masonry pillar on the roof of the Lying-in Hospital	31	0
Trichinopoly	10° 50' N.	78° 46' E.	1st December 1867	272				
				255	12th June 1878	On a masonry tower to the east of the Superintending Engineer's Office	30	0
Coimbatore	11° 0' N.	77° 0' E.	15th November 1867	1,348	...	On the roof of the Superintending Engineer's Office	45	0
Salem	11° 39' N.	78° 12' E.	1st November 1867	940	...	On the roof of the upper rooms of the Collectorate	50	0
Wellington	11° 22' N.	76° 50' E.	1st March 1870	6,200	...	On the roof of soldiers' quarters in Hospital	34	9
Mysore	12° 18' N.	76° 42' E.	10th May 1893	2,518	...	Not known	...	
Bangalore	12° 58' N.	77° 37' E.	1st November 1867	2,982	...	On the Market Sergeant's quarters	32	0
				3,021	2nd August 1894	On the Observatory building . .	35	0
Hassan	13° 1' N.	76° 10' E.	20th November 1892	3,091	...	Not known	...	
Chitaldroog	14° 14' N.	76° 26' E.	2nd August 1892	2,405	...	On a masonry pedestal above the roof of the District Engineer's Office	...	
Cuddapah	14° 28' N.	78° 52' E.	1st April 1884	433	...	No anemometer	...	
Kurnool	15° 50' N.	78° 5' E.	1st January 1883	914				
				945	26th July 1902	On a wooden post embedded in the roof of the Collector's Office	...	

N.B.—Elevations in italics indicate barometrical determinations.

STATION.	Position of Observatory.		Date of Establishment of Observatory.	Elevation of Bar-cistern above Mean Sea-level.	Date of Change of Elevation.	Position of Anemometer.	Elevation of Cups above Ground.
	Lat.	Long.		Feet.			Ft. In.
Bellary	15° 9' N.	76° 57' E.	1st December 1867	1,455	...	On the roof of the Hospital building	30 2
				1,475	24th April 1885		
Raichur	16° 12' N.	77° 25' E.	5th December 1891	1,378	...	On the corner of the parapet wall of the roof of the Revenue Office	...
				1,326	22nd January 1901		
Secunderabad	17° 27' N.	78° 33' E.	1st November 1867	1,787	...	On a rock north of the Observatory	31 1
Hyderabad (Deccan)	17° 20' N.	78° 30' E.	10th November 1891	1,690	...	On a masonry pillar on the roof of the Chief Engineer's Office	about 25 0
Gulbarga	17° 19' N.	76° 54' E.	16th October 1891	1,503	...	On a masonry tower	36 0
Belgaum	15° 52' N.	74° 34' E.	1856	2,524	...	On a tower near the European Gymkhana	47 0
				2,539	12th April 1898		
Bijapur	16° 50' N.	75° 47' E.	26th December 1891	1,948	...	On a masonry pillar on the roof of an old building	about 18 0
Sholapur	17° 40' N.	75° 56' E.	2nd January 1877	1,585	...	On a post to the south-east of the Native Infantry Hospital	29 5
				1,590	10th January 1889	On a wooden post about 32 feet high	32 0
Poona	18° 31' N.	73° 55' E.	1856	1,992			
				1,840	20th June 1879	On a tower in the Jail	73 0
Ahmednagar	19° 5' N.	74° 48' E.	26th February 1890	2,152	...	On the wall of the Fort	about 25 0
Malegaon	20° 32' N.	74° 37' E.	19th May 1877	1,439	...	On a post	26 1
				1,430	16th October 1878	On a wooden post embedded in masonry basement	...
Buldana	20° 32' N.	76° 14' E.	1st January 1873	2,132	...	Is screwed on the top of the wind vane on the summit of a post above a wooden stage	24 9
Chikalda	21° 54' N.	77° 22' E.	1st February 1876	3,642	...	On a post	13 11
Akola	20° 42' N.	77° 2' E.	1st January 1870	930	...	On staging	25 1
Amraoti	20° 56' N.	77° 48' E.	1st January 1873	1,213	...	On staging	about 25 0
Khandwa	21° 50' N.	76° 23' E.	1st January 1875	1,037	...	On a post on the summit of a hill	5 7
				1,044	1st July 1883	On a pillar to the west-south-west of the shed	...
Nagpur	21° 9' N.	79° 9' E.	1st January 1869	1,025	...	On a strongly built masonry tower	36 0
Indore	22° 44' N.	75° 50' E.	25th February 1877	1,822	...	On a masonry pillar 2 feet high on the roof of the Hospital	27 2
Neemuch	24° 27' N.	74° 52' E.	3rd March 1877	1,639	...	On roof No. 2, Royal Artillery Barrack	65 0
				1,630	27th August 1888	On a wooden post 7 feet high	7 0
Mount Abu	24° 36' N.	72° 45' E.	1st May 1876	3,945	...	On a masonry pillar 5 feet 7 inches high on a rock 56 feet high from ground	61 7
Ajmer	26° 27' N.	74° 44' E.	1st April 1866	1,632	...	On a masonry pillar 3 feet high on the roof of the Commissioner's Office	43 2
				1,611	1st January 1880		
Sambhar	24° 54' N.	75° 13' E.	1st April 1880	1,254	...	On a masonry pillar 4 feet high on the roof of the Assistant Commissioner's Office	27 0
Jaipur	26° 55' N.	75° 52' E.	1st January 1879	1,431	...	On a special tower	45 6
Saugor	16° 37' N.	76° 51' E.	1st April 1870	1,769	...	On a brick pillar	10 2
				1,807	27th May 1896	On a wooden staging not far from the shed	25 3
Sutna	24° 34' N.	80° 55' E.	1st July 1876	1,040	...	On the roof of the Hospital	26 0
Nowgong	25° 3' N.	79° 30' E.	4th June 1877	757	...	On the ridge of a hut	16 6

N.B.—Elevation in italics indicates barometrical determination.

Introduction

STATION.	Position of Observatory.		Date of Establishment of Observatory.	Elevation of Bar-cistern above Mean Sea-level.	Date of Change of Elevation.	Position of Anemometer.	Elevation of Cusps above Ground.	
	Lat.	Long.		Feet.			Ft.	In.
Jhansi	25° 27' N.	78° 37' E.	December 1862	855	... ..	On a pillar of the Tahsil building	23	7
				858	14th June 1887	On a masonry pillar on the City Police Office	about 30	0
Hoshangabad	22° 46' N.	77° 45' E.	1st January 1870	1,004	... ..	On the roof of the old barometer room over the Jail gateway	31	6
				1,020	6th August 1875			
				1,006	8th October 1895			
Pachmarhi	22° 30' N.	78° 27' E.	1st May 1870	3,504	... ..	On a wooden post embedded in the roof of the Tahsildar's court	32	0
				3,528	12th May 1893			
Jubbulpore.	23° 10' N.	79° 59' E.	1st January 1869	1,337	... ..	On a wooden post fixed in a masonry pillar	10	0
				1,327	8th April 1881			
Seoni	22° 6' N.	79° 35' E.	1st January 1870	2,030	... ..	On the top of the female ward of the Hospital	32	3
Chanda	19° 56' N.	79° 21' E.	1st March 1870	634	... ..	On a masonry pillar to north-north-east of shed	17	2
Raipur	21° 15' N.	81° 41' E.	1st January 1870	970	... ..	On a wooden post of the thermometer shed	17	3
Sambalpur	21° 28' N.	84° 1' E.	1st January 1875	474	... ..	On a wooden post	18	5
				486				
Chaibassa	22° 35' N.	85° 51' E.	21st August 1883	760	... ..	On a wooden post	16	0
Ranchi	23° 23' N.	85° 23' E.	11th July 1883	2,128	... ..	On the roof of the Dāk Bungalow	...	
Hazaribagh	23° 59' N.	85° 25' E.	1st August 1867	2,014	... ..	On the top of a sentry box on the Jail wall	30	6
				2,007	22nd November 1880	On the roof of the anemograph tower	27	11
Balasore	21° 30' N.	86° 58' E.	22nd May 1883	56	... ..	On the roof of the Executive Engineer's Office	...	
				48	7th October 1891			
False Point	20° 20' N.	86° 46' E.	1st October 1865	21	... ..	On a substantial tower	25	0
Cuttack	20° 48' N.	85° 54' E.	21st March 1867	80	... ..	On the roof of the Telegraph Office building	38	0
Gopalpur	19° 16' N.	84° 57' E.	1st January 1881	21	... ..	On a small wooden post on the pier	22	0
Vizagapatam	17° 42' N.	83° 20' E.	1st January 1872	31	... ..	On the roof of the Observatory building	17	5
Waltair	17° 44' N.	83° 23' E.	1st April 1897	226	... ..	On the roof of the Observatory room	...	
Cocanada	16° 57' N.	82° 15' E.	1st April 1890	26	... ..	On a wooden post	28	8
Masulipatam	16° 9' N.	81° 12' E.	1st August 1868	15	... ..	On a small masonry pillar on the roof of the Municipal Hospital	39	0
Nellore	14° 27' N.	80° 1' E.	19th September 1888	71	... ..	On a masonry pillar on the roof of the Telegraph Office	12	0
Madras	13° 4' 6" N.	80° 17' 21" E.	1792	22	... ..	On a turret of the Observatory roof	50	0
Cuddalore	11° 43' N.	79° 49' E.	1st March 1889	12	... ..	On a wooden post 4 feet high embedded in a masonry pillar about 4 feet high on the roof of the Post and Telegraph Office	...	
Negapatam	10° 46' N.	79° 53' E.	1st June 1868	15	... ..	On the roof of the Hospital building	27	0
				31	2nd March 1891	On the roof of the Port Office	...	
Pamban	9° 17' N.	79° 15' E.	2nd January 1891	37	... ..	On a wooden post close by the thermometer shed	...	
Port Blair	11° 41' N.	92° 45' E.	1st June 1868	61	... ..	On the roof of one of the convicts' barracks	31	3
Nancowry	8° 2' N.	93° 36' E.	1st May 1873	81	... ..	On a wooden post erected on a brick platform	11	8

N.B.—Elevations in italics indicate barometrical determinations.

STATION.	Position of Observatory.		Date of Establishment of Observatory.	Elevation of Bar-cistern above Mean Sea-level.	Date of Change of Elevation.	Position of Anemometer.	Elevation of Cups above Ground.
	Lat.	Long.		Feet.			Ft. In.
Minicoy	8° 17' N.	72° 49' E.	21st January 1891	7	...	Not known	...
Amini Devi	11° 6' N.	72° 45' E.	1st September 1880	13	...	Not known	...
Perim	21° 36' N.	72° 23' E.	4th June 1891	201	...	Not known	...
Aden	12° 46' N.	45° 3' E.	15th July 1880	94	...	About 15 yards from the edge of a hill	6 10
Muscat	23° 37' N.	58° 35' E.	1st February 1893	20	...	On the roof of the Residency . .	...
Jask	25° 45' N.	57° 45' E.	1st December 1892	13	...	On the roof of the Telegraph Office, the highest building in the station	...
Bushire	29° 0' N.	49° 50' E.	1st April 1876	25	...	On the roof of another bungalow of Residency	39 0
				14	13th November 1890		
Ispahan	32° 40' N.	51° 44' E.	1st July 1893	<i>5,817</i>	...	Not known	...
Teheran	35° 41' N.	51° 25' E.	1st September 1893	<i>4,002</i>	...	Not known	...
Kalat	28° 58' N.	66° 28' E.	23rd March 1901	...	...	...	...
Kabul	34° 30' N.	69° 18' E.	1st October 1893	...	...	...	...
Kashgar	39° 24' N.	76° 7' E.	15th August 1893	...	...	Not known	...
Baghdad	33° 20' N.	44° 22' E.	1st October 1887	220	...	Not known	...
Zanzibar	6° 10' S.	39° 11' E.	17th January 1880	73	...	Not known	...

N.B.—Elevations in italics indicate barometrical determinations.

GENERAL MAPS (PLATES I. TO X.)

Plate I.—II. gives an orographical map of India showing the larger physical features of the Empire and of the neighbouring regions—more especially the mountain and plateau areas to the north and west of India, the presence of which play an important part in determining and modifying its meteorology. The colouring of the map shows at a glance the position and direction of the larger river plains (which determine the local direction of the lower air currents or movement), and the extent and elevation of the mountain and plateau areas, the directional relation of which to the prevailing air currents, more especially those of the south-west monsoon, profoundly modify and partially determine the distribution of rainfall. The chart also indicates for any district the chief features determining its local characteristics of climate and weather, as distance from the sea and the larger mountain ranges, its elevation, and the configuration of the neighbouring districts, all of which affect its temperature, humidity and rainfall.

It is necessary in order to understand some of the broader features of the climatology of India to gauge the extent and elevation of the plateau areas to the north and west. The great Thibetan plateau, about 2000 miles in length from west to east, and varying from 300 miles to 800 miles in breadth from north to south, has an area nearly as large as India, and exceeds 10,000 feet in mean elevation. It is cut off from India by the Himalayan mountain mass, the mean elevation of the central axial ranges of which probably exceeds 20,000 feet. India is thus protected from cold air currents originating in Central or Northern Asia, and its climate is hence purely tropical and sub-tropical. The plateau of Iran to the west of Northern or Extra Tropical is of much smaller extent and of less elevation (averaging about 5000 feet). The eastern edge of the plateau formed by the Suleiman and other frontier ranges is a similar but less effective barrier and protection from cold air currents than the Himalayas. Such currents do occasionally advance from Southern Russia across Persia, Baluchistan, and Afghanistan in the winter months.

It may also be pointed out that India is dependent upon currents from the Indian Ocean for its rainfall, and hence the study of the configuration and position of the Indian Seas and Ocean with respect to the neighbouring land regions is necessary for the explanation of the larger air movements over India.

Plate III.—IV. shows the present political divisions of India, and the larger and more important towns. It is given for reference mainly to indicate the position of the observing stations of the India Meteorological Department, the latitudes and longitudes of which are stated in the list, pages xvi. to xxiii.

Plates V. and VI. include four small charts, showing the four systems of meteorological divisions, which have been adopted by the Meteorological Department for the varying requirements of the Government officials to which it furnishes meteorological data and information. The first rainfall chart (Plate V.) exhibits the boundaries of the twenty-seven rainfall divisions selected by Blanford in his discussion on the rainfall of India (Vol. III. Indian Meteorological Memoirs). In that memoir data are given for about 450 representative stations where rainfall observations had been taken carefully and systematically for a sufficient number of years to furnish satisfactory average or normal values for purposes of comparison. It may be noted that Blanford estimated from these normals that the mean annual rainfall of India is 42 inches. The data of these stations continue to be employed in returns made to the India Office, as they probably afford the most accurate estimate of the larger seasonal and annual variations of the rainfall of the Empire from year to year.

The second chart of Plate V. shows the division into eleven meteorological provinces, selected by the India Medical Department in conjunction with the Meteorological Department for the tabulation of meteorological data for the comparisons and discussions of the Medical Department. These divisions represent areas which are fairly homogeneous so far as the chief prevailing diseases and climatic conditions are concerned.

The first chart of Plate VI. shows the system of divisions employed for the comparison of rainfall and crop statistics by the Meteorological Department and the Department of Commerce. The distribution of rainfall differs so largely in space and time in India as to make it necessary to employ for purposes of comparison a more elaborate and minute scheme of division than that of Blanford's. This system has been in operation from the year 1891, when the methods of rainfall registration, tabulation and publication were unified and placed under the general control and superintendence of the Meteorological Department. This division is employed for the rainfall data and comparisons of the Monthly India Weather Summaries.

The second chart of Plate VI. shows the divisions according to which stations are grouped in the India Weather Report. Previously to 1901 the stations were arranged according to the political divisions. This was, however, found to be unsatisfactory, and it was determined to group them from considerations of general similarity of meteorological conditions. The chart exhibits the arrangement or grouping adopted and at present employed in the India Daily Weather Report.

Plates VII.-VIII. and IX.-X. represent the distribution of pressure (reduced to sea-level and constant gravity) and of the direction of the air movement in the lower atmosphere in Central and Southern Asia and the Indian Seas and Ocean in the two months of January and July, most fully representative of the conditions of the north-east and south-west monsoons in India.

The January chart (Plate VII.-VIII.) indicates that broad belts of high pressure stretch across the Indian Ocean and Central Asia, with an intermediate area of lower pressure, most marked in a belt to the south of the Equator. The air movement in the sea area, and also in the lower land area, is in accordance with the general pressure scheme, except so far as it is modified locally in the land areas by the presence of mountain ranges, valleys, &c. It is, however, necessary on examining the map to bear carefully in mind the elevation of the great Thibetan Plateau, where the actual general atmospheric movement is determined, not by pressure conditions in the lower atmospheric strata near the sea-level, but by those obtaining at an elevation of from 10,000 to 30,000 feet. It has been shown by Tisserenc de Bort and others that at that elevation pressure decreases in Asia continuously from the Equator to Siberia. This, it may be noted, is indicated in Hill's chart for January, Plate CXVII.

The general air movement during the season represented by the January chart over the open Thibetan Plateau should hence be from south to north with the usual deflection to east caused by motion over the surface of the rotating earth.

The chart in Plate IX.-X. represents the pressure (reduced to sea-level) and winds over the same area for the month of July, most representative of the rainy season of India or the south-west monsoon of Southern Asia and the Indian Seas. The south of the Indian Ocean is occupied by a belt of high pressure. The pressure in that area is on the average about .15 inch higher in July than in January, due to the change from summer to winter temperature conditions. Pressure decreases more or less continuously at the sea-level northwards to a belt stretching from the Punjab to the head of the Persian Gulf. Hence there is a continuous movement from south to north from the centre of the Indian Ocean to the peninsulas of Southern Asia in the lower atmosphere. In the middle atmosphere (at 10,000 feet) pressure also decreases northwards over Southern and Central Asia. The lower air current of the south-west monsoon hence extends to an elevation considerably exceeding 10,000 feet in July. A comparison of the two maps is hence most interesting and instructive as showing the chief conditions determining and accompanying the monsoon alternations of climate and weather in India.

PRESSURE AND WIND CHARTS

PRESSURE.—This element of observation is obtained by means of Fortin Standard barometers, the tubes of which are $\frac{1}{16}$ inch in diameter. They are carefully compared before issue at the Calcutta Central Observatory, and their corrections to the Calcutta Standard (Newman No. 109) accurately determined. A number of comparisons of the Calcutta Standard with instruments sent out from England (the Kew corrections of which had been carefully determined before despatch) shows that it is .011 inch higher than the Kew Standard.

The observers are, so far as possible, trained to read the instruments correctly to .002 inch. Occasionally erroneous observations, due to hasty reading of the instruments, are recorded, but the errors are usually eliminated by comparison with the barometric data of neighbouring stations. Occasionally also the observations are more or less tainted with errors for considerable periods when an untrained observer takes over the work at an observatory from a trained observer going on leave, or transferred to another station. It is not always possible under the conditions of Indian service to arrange for the training of these temporary observers. Erroneous observations recorded under these circumstances are rejected from the data utilised for the calculation of normals. It may also be noted that the mercury in the barometer cisterns appears to be peculiarly liable to oxidation in India. This is a constant source of trouble and of small errors which it is impossible to avoid or eliminate. Every effort is, however, made to keep observatories supplied with good standard barometers, and occasional comparisons are made during inspection in order to ascertain whether the index errors of the instruments remain constant. If the short comparison practicable during inspection in any case makes it appear that the error of the barometer has changed by more than .004 inch, another instrument is supplied as soon as possible.

An examination of the data and of the means based on them in various ways shows that the observations are reliable and accurate in the great majority of cases. The data are not quite satisfactory for some of the stations recently opened in Burma, and for such stations as Katmandu, in the least accessible parts of India.

The pressure normal data from which the pressure charts were prepared are given in Tables X., XII., XIV., XVI. and XVIII., Vol. XIII. Indian Meteorological Memoirs.

Table X. gives data of the mean 8 A.M. pressure reduced to 32° F., constant gravity and sea-level of 144 stations for each month and the year.

Table XII. gives data of the mean 10 A.M. pressure reduced to 32° F., constant gravity and sea-level of 99 stations for each month and the year.

Table XIV. gives data of the mean 4 P.M. pressure reduced to 32° F., constant gravity and sea-level of 99 stations for each month and the year.

Table XVI. gives the mean pressure of day reduced to 32° F., constant gravity and sea-level of 102 stations for each month and the year.

Plates XI. to XXIII. show the mean distribution of pressure at 8 A.M., 10 A.M. and 4 P.M. for each month of the year and for the year by means of three charts. The pressure is corrected to constant gravity (Lat. 45°) and to sea-level for all stations below 3000 feet, and the charts hence afford accurate data for the comparison of pressure gradients and winds in the lower atmosphere over India.

The second series of plates numbered XXIV. to XXXVI. consist each of three charts. The large chart shows the mean daily distribution of pressure for each month and for the year, and is hence similar to the charts of the preceding

series. The small charts show the distribution of the diurnal range of pressure between 10 A.M. and 4 P.M. The diurnal oscillation is one of the most striking recurring features of the barometer in India. The left-hand charts give the actual distribution of the diurnal range as observed at all stations below 3000 feet. As the actual pressure and hence also the diurnal range decreases with elevation under the same general conditions, the right-hand charts have been prepared to show the diurnal range (not at sea-level) but reduced to the pressure of the sea-level, on the supposition that it varies with the actual pressure. This supposition does not give the exact relation, but it eliminates some of the variations or discrepancies due to elevation, and hence it is hoped gives a slightly more satisfactory view of the distribution of the diurnal range of pressure in the Indian area.

WIND DIRECTION, VELOCITY AND STEADINESS.—The results of wind observation include data of (1) mean direction of the air movement during a given period; (2) total amount of the air movement or resultant amount in the mean direction during the period; and (3) the steadiness of the movement during the period.

The direction of the air movement is determined by means of small wind vanes suitably placed, and read to sixteen points.

The mean direction for any period is determined by the application of Lambert's formula, in which equal values or weights are given to all winds, independent of their strength. Observers are instructed to note calm when the cups of the anemometer are not moving at the time of observation.

The amount of the air movement during any interval is obtained by means of readings of small Robinson cup anemometers. These instruments as ordinarily constructed are somewhat difficult to read by our native observers, and hence occasional errors due to this cause are made. It is, however, probable that this cause of error does not appreciably affect the monthly mean values based on the data. The chief sources of error are due to carelessness in the treatment of the instrument, more especially want of cleanliness, insufficient oiling and presence of dust, especially in the hot weather. The means or normals are, however, fairly accordant, taking into consideration the large differences of exposure of these instruments, and probably give an estimate of the lower air movement over India which can be used as a standard for comparison to determine the variation of the lower atmospheric movement in direction and intensity from year to year and season to season. The measure of the steadiness of the air movement is obtained by calculation. It is given as the percentage ratio of the wind resultant obtained from a series of wind direction values or observations by means of Lambert's formula, to the total number of winds. Thus if the mean of 30 daily observations in April in different directions was 15 in the direction of S. 25° W., the steadiness of the wind would be $\frac{15}{30} \times 100$ or 50.

It is an element of considerable importance in the meteorology of India. For example, it indicates the great variability of the wind at such stations as Allahabad in the trough of low pressure during the south-west monsoon. The wind directions on the pressure and wind charts are indicated by arrows, the length of which measures the steadiness according to the scale stated, and the amount or strength of the wind is given approximately by the number of feathers attached to the arrows.

The normal wind data utilised in the preparation of the pressure and wind charts will be found in Tables XIX. to XXVII. of normal data, Vol. XVII. Indian Meteorological Memoirs.

Table XIX. gives the mean 8 A.M. wind direction of 164 stations for each month and the year. The means were obtained from the observations of the period 1889–1899, and are hence strictly comparable in period.

Tables XX. and XXI. give similar data for 10 A.M. and 4 P.M. of 124 and 121 stations respectively. The means of these elements of observation were deduced from the records of the period 1879–1899.

Table XXII. gives the mean direction of wind of 126 stations for each month and the year. The means are derived from the observations recorded at 10 and 16 hours of the available period down to 1902.

Table XXIII. gives the mean steadiness of the wind direction at 8 A.M. of 164 stations, Table XXIV. at 10 A.M. of 123 stations, Table XXV. at 4 P.M. of 121 stations, and Table XXVI. the mean at 10 A.M. and 4 P.M. of 126 stations for each month and the year.

Table XXVII. gives the mean hourly velocity of the wind of 161 stations for each month and the year.

The chief features of the pressure distribution and air movement are broadly marked.

In the cold weather months of January and February, pressure is highest in the Indian region over North and North-west India. The isobars run practically parallel to the parallels of latitude. Pressure diminishes southwards to a low-pressure belt to the south of the Equator—an equatorial belt of calms or variable winds at this period of the year. The air movement is hence from north to south with the normal deflection due to the earth's rotation, giving north-east winds over the Indian Seas. In Northern India the movement is modified by the lie of the river valleys. It is from north in Burma, east in the Brahmaputra Valley, west in the Gangetic Plain and also in the Central Indian Plateau. This drift recurves in Bengal and the north of the Bay through north-west and north to north-east, and is continued as a movement from north-east to east-north-east in the centre and south of the Bay and across the Peninsula, whence it passes across the Ghats at a moderate elevation and ultimately forms part of the general movement from north-east in the Arabian Sea. Local land and sea breezes prevail during this period in the west coast districts and adjacent sea. The air movement is very feeble in North-western and Central India, averaging 1 to 2 miles per hour. It increases with its southerly advance, and in the south of the Indian Seas it ranges from 3 to 4 (Beaufort notation). It is only during this period that India shares fully in the movement known as the north-east monsoon proper—the seasonal phase in the Indian monsoon region of the north-east trades.

The period of the hot weather from March to May is characterised by rapid increase of temperature with accompanying pressure changes.

India becomes a permanently hot area with respect to the neighbouring seas. During the first half of the period it is hotter during the day hours, but slightly cooler by night. In May this variation of the diurnal relation passes away, and the interior of India is on the average hotter than the neighbouring seas during the whole twenty-four hour period. With the unequal rise of temperature over land and sea, pressure decreases more rapidly over the interior than in the neighbouring seas, and the pressure distribution is continuously and largely modified. The interior becomes a low-pressure sink with respect to the neighbouring seas. The high-pressure conditions prevailing at the beginning of March rapidly disappear, with the result that in April and May the isobars run parallel to the coast, and in the interior enclose low-pressure areas which vary considerably in position from day to day, determining and being determined by the accompanying weather. The mean positions of these low-pressure areas are clearly exhibited in the plates for April and May. In the latter month the most prominent local feature is a trough of low pressure extending from Upper Sind and the South-west Punjab to South Behar and Chota Nagpur, and frequently developed at its two extremities into shallow local depressions.

The air movement in the coast districts determined by the thermal and pressure conditions is one of indraught, increasing in intensity and in its area of extension with the advance of the season. It gives westerly winds on the west coast of India, south to south-east winds on the Madras Coast of the Bay, and south-west to south-east winds on the Bengal Coast. The indraught is most vigorous across the Bengal Coast, and the winds are hence as a rule strongest in North-eastern India in May. In the interior of Northern India the air movement is similar in direction to that of the preceding season. Winds are on the average from north-west to west in North-western and Central India and the Gangetic Plain (not including the Delta), and from east in the Assam Valley. There are hence in this season three wind

systems converging to Central and West Bengal, giving rise to the development of the shallow depression at the eastern extremity of the trough of low pressure in Northern India. The air movement arising from the indraught from the sea towards the interior heated area of India not only affects India in increasing volume and intensity but also the Indian Seas. The indraught extends further and further from the coasts seawards as well as landwards, so that by the end of May it includes nearly the whole of the Bay area and a portion of the Arabian Sea, extending to about 300 miles from the Bombay Coast. In the central and southern parts of the Arabian Sea the winds fall off in strength but continue unchanged in mean direction. The movement in the Indian land area is hence of local origin, and is a transitional type between the general circulations of the north-east and south-west monsoons. In Bengal, Assam, Tenasserim, and Malabar the sea winds give rise to frequent local thunderstorms. Over the whole of the interior of India intensely hot dry weather prevails at the end of May. These hot weather conditions are brought to an abrupt termination in June by the advance from the equatorial region of a strong steady current, the continuation of the south-east trades. During the previous two months the south trades strengthen and their northern limit advances northwards to the neighbourhood of the Equator. Usually in the last week of May or first week of June the south-east trades are impelled across the Equator in consequence of increase of strength and of diminution of resistance in front, and advance rapidly across the Indian Seas and Coasts into the interior. The current from the Bay passes partly into Burma and partly over the north of the Bay into Bengal, where it is deflected by the Himalayan range and advances up the Gangetic Plain to the East Punjab, giving southerly winds in Bengal and easterly winds in the Gangetic Plain. The current in the Arabian Sea advances directly to the west coast and gives westerly winds over the peninsula, and westerly-south-westerly winds in Central India and Rajputana.

An examination of the plates for the months of June, July, August and September shows clearly the extension of the two branches of the great air movement from the oceanic region to the south of India. It also shows one of the more remarkable features of the air movement, which is exhibited in a narrow elongated belt, extending from Upper Sind to Arssa, between the fields of the two currents. In this belt, covering nearly the same area as the hot weather trough of low pressure, the air movement is remarkably unsteady, shifting between west and east in apparently the most irregular manner, and the pressure is lower than in the districts to the north and south. This area is the south-west monsoon trough of low pressure, along which the cyclonic storms of the period pass from the coast districts into the interior. It shifts considerably in position during the season, depending chiefly upon the relative strengths of the two branches of the south-west monsoon currents.

The establishment of this movement accompanies and produces considerable changes in the pressure distribution, chiefly in the coast districts and the peninsula. The isobars in India run more or less directly east and west across the peninsula and Central India and also in the Bay. Pressure is lowest on the average in Upper Sind at the western extremity of the trough of low pressure, and increases southwards with very varying rates depending upon and related to the general strength of the monsoon currents. These conditions continue with little change from June to August. In September the current begins to show signs of decreasing activity and strength.

Usually before the end of September, pressure begins to rise rapidly in Upper India, and light dry westerly winds set in over the northern limits of the furthest extension of the humid currents of the south-west monsoon. A general increase of pressure accompanies decrease of temperature in October, with the result that during the greater part of the month both temperature and pressure are remarkably uniform. Westerly winds usually extend over the whole of Northern and Central India during the month. The Bay current is directed chiefly to Bengal and Burma in the first half of the month, and shortly afterwards recurves round a belt of slightly lower pressure in the centre of the Bay—the continuation of the south-west monsoon trough of low pressure, which has been transferred and modified in form by the general pressure changes in India. The belt of low pressure moves down the Bay in November and usually passes out of the Bay limits before the end of December, shortly after which it merges or is transformed into the equatorial low-pressure belt of the north-east monsoon. During this period pressure continues to rise in Northern India relatively to Southern India, and before the end of the period the cold weather type of pressure distribution and air movement is fully established.

The plates for the months of October, November and December show clearly the gradual withdrawal of the south-west monsoon circulation (by contraction at its northern limits) and the establishment of the land winds of the dry monsoon in the northern limits of the empire, and their gradual extension over India.

The small charts of Plates CXV. to CXVIII. were prepared by the late Mr. S. A. Hill, Meteorological Reporter to the Government of the North-western Provinces and Oudh, for a memoir he was writing before his death. The left-hand charts give the pressure at the sea-level and winds for four typical months of the year, and the right-hand charts the probable distribution of pressure at the level of 10,000 feet as determined by calculation.

TEMPERATURE MAPS

The temperature charts will be found in the plates numbered XXXVII. to LXII. Each plate includes three charts. Plates XXXVII. to XLIX. show the mean daily temperature, the mean maximum and the mean minimum for each month of the year and for the mean of the year, and Plates L. to LXII. the mean diurnal range of temperature and the highest and lowest (absolute maximum and minimum) temperatures of each month of the year and of the year in the plains of India.

The distribution of temperature is in each map indicated by colour and also by means of lines termed isotherms. As the mean temperature of India is almost exactly 80° , areas in which the temperature is above 80° are coloured red, and below 80° are coloured green (the intensity of the colouring indicating the amount of the departure from that mean value, 80° , and shown by the colour scale or scheme attached to each map).

Isotherms are lines of equal temperature, and join places having the same temperature conditions denoted by the map. They are drawn for differences of 2.5° F. in the larger maps and for 5° F. in the smaller maps of the temperature series. It may be assumed that as a rule temperature decreases regularly in passing by the nearest line from one isotherm to the next, of either increasing or decreasing value, so that they enable the temperature value indicated by the map at any intermediate position between two isotherms to be estimated by a simple rule-of-three sum.

The temperature of the air at any place depends upon many factors, of which the most important in India are the altitude of the sun, latitude, elevation, distance from the sea, and the character of the prevailing winds (hence also amount of cloud and rainfall). The variation of temperature with latitude changes in India with the season. In the cool weather period from November to February temperature decreases with increase of latitude and hence from south to north, and the isotherms run across India nearly parallel to the parallels of latitude. During the next three months, the hot weather season, the interior of India is heated above the coast districts, and the hottest area (the thermal focus, as it is termed by

Blanford) is slowly transferred northwards from the South and Central Deccan to North-western India. The isotherms during this period are hence closed curves about a central area—the area of highest temperature for the month.

During the remainder of the year from June to September, the south-west monsoon or rainy season, temperature is permanently highest in the area including Upper Sind, the South-west Punjab, and North-west Rajputana, and decreases rapidly for some distance to the east and south. It is almost uniform over the area of frequent rain, including about two-thirds of India, over which it varies only slightly throughout the period. Temperature on the whole increases with increase of latitude in India in this season. The seasonal changes of the variation of temperature with latitude are hence of great interest and importance for a comprehension of Indian meteorology.

The rapid decrease of temperature with altitude is one of the most familiar facts of meteorology, and of great importance in India from the medical standpoint. It has been ascertained that, on the average, temperature changes about 800 times more rapidly in the same distance in a vertical direction than in a horizontal direction (north or south). A comparison of data for places in temperate and tropical regions has shown that the mean temperature falls on the average 1° F. for every 330 feet of rise. This question was carefully considered by Blanford, who came to the conclusion that in India the mean temperature decreases on the average 1° for every 450 feet of elevation. It should, however, be noted that this law only holds for mean temperature. In the dry hot season of Northern India, temperature over the plains decreases at the hottest time of the day at the rate of 1° F. for every 190 to 200 feet of elevation. The rate of decrease even at the hottest time of the day varies largely with the season. It is most rapid in the hot weather and least rapid in the height of the rains, when the vertical temperature gradient (or rate of decrease) on a day of heavy general rain may be as small as 1° F. in 600 feet. The vertical gradient during the night hours is much more variable and irregular. In the dry season temperature occasionally increases at the coolest time of the night for some considerable distance with elevation. Under especially favourable conditions the minimum temperature in the dry season may be as much as 10° higher at Murree, Simla and other hill stations (at elevations of about 7000 feet) overlooking the plains, than at the plains stations some thousands of feet below, e.g. Rawalpindi, Lahore, Ludhiana, Roorkee, &c. It is hence not possible to give a law of variation for the change of the maximum day temperature or minimum night temperature with elevation as has been given for mean temperature.

For scientific purposes, and for the exact comparison of mean temperature conditions, it is usual to make an allowance or correction for elevation, and thus reduce the mean temperature observations to the same level. The level usually chosen as the standard is the sea-level. In the maps showing the distribution of mean daily temperature, Plates XXIV. to XXXVI., the isotherms are drawn to represent the mean temperature reduced to sea-level. The correction employed is based on Blanford's rule that the mean temperature decreases on the average of 1° F. per 450 feet of elevation. This rule, however, is only found to apply satisfactorily to the lowest strata of the atmosphere below 3000 feet; and hence to the plains and plateaus in India but not to the higher elevations in the Himalayas, &c. The mean temperature charts hence give the distribution of temperature over the whole of India with the exception of the hill ranges over 3000 feet.

No correction is made for elevation in the case of maximum and minimum temperature observations, and the charts for these elements represent the actual temperature conditions at the hottest and coolest periods of the day over the whole of India, with the exception of hill or mountain ranges over 3000 feet, which, however, form a very small part of the surface of the interior of the Indian peninsula.

Distance from the sea and direction and character of the prevailing winds are of great importance in India. In the cold weather or north-east monsoon period, November to February, continental or land winds prevail over the whole area, and they contribute to give the ordinary latitude variation of temperature which obtains in that season. In the hot weather season local sea winds prevail in the coast districts and dry land winds over the more distant interior. Hence temperature is hottest in the interior, and there are large contrasts of temperature between the interior and the coast districts. The temperature conditions and relations are hence chiefly determined by this local contrast between land and sea.

In the south-west monsoon period, winds of oceanic origin giving frequent rain obtain over nearly the whole area. The temperature conditions are hence remarkably uniform over the area of damp winds and heavy rainfall (including almost the whole of India with the exception of the dry area in Upper India, viz. Upper Sind, the South-west Punjab and North-west Rajputana).

It may again be noted that the monthly charts showing the mean maximum and minimum temperature of the day and the diurnal range of temperature are based on the actual data, and are hence from the medical standpoint useful for discussions of the relations between climate and disease.

The data of this element of observation employed in the preparation of the temperature charts are given in Vol. XVII. of the Indian Meteorological Memoirs. They are as follows:—

Table I. Mean maximum temperature of 171 stations for each month of the year and for the whole year (utilised for left-hand small chart in each of Plates XXXVII. to XLIX.).

Table II. Mean minimum temperature of 171 stations for each month of the year and for the whole year (utilised for the right-hand small chart in Plates XXXVII. to XLIX.).

Table III. Mean diurnal range of temperature for each month of the year and for the whole year at 170 stations (utilised for the large charts in Plates L. to LXII.).

Table VI. Absolute maximum temperature recorded in each month of the year during the period 1875–1902 at 171 stations (utilised for the left-hand small charts in Plates L. to LXII.).

Table VII. Absolute minimum temperature recorded in each month of the year during the period 1875–1902 at 171 stations (utilised for the right-hand small charts in Plates L. to LXII.).

Table V. The mean temperature of the day reduced to sea-level at 145 stations for each month of the year and for the whole year (utilised in the preparation of the large charts in Plates XXXVII. to XLIX.).

A statement of the exposure of the thermometer method of observation and of the methods to ensure accuracy of the data will be found in the "Handbook of Instructions to Observers in India" prepared and issued by the India Meteorological Department.

The maximum temperatures are generally satisfactorily recorded in India, and the data show few discrepancies.

The minimum temperature data are not quite so reliable as those of the maximum temperature, due to the imperfection of minimum thermometers. The spirit column is liable to break and give rise to a detached portion in the upper part of the tube, chiefly in the hottest and coldest months. Careless observers almost invariably fail to notice this, and send in for considerable periods readings too low by the length of the detached portion. The error is usually detected on inspection of the observatories when the length of the detached column is carefully measured and corrections applied to the previous erroneous observations. Every effort is made by frequent test observations and by the comparison of data to eliminate these sources of error, and with a few exceptions, the data are quite consistent.

The means of the maximum and minimum temperatures have been determined from the whole of the available observations recorded since 1875. In the great majority of cases the means are based on the data of the 25-year period

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1875-1899, but in the cases of the remaining stations which have been established and opened since 1875 they are for shorter periods, in all instances exceeding 10 years. No attempt has been made to correct the means for these stations in the tables to the 25-year period 1875-1899, but in preparing the charts allowance has been made for this difference of period.

The mean monthly and annual range data are obtained by taking the difference of the mean maximum and mean minimum values for each station for the corresponding period.

The absolute maximum and minimum temperatures are the highest and lowest temperatures recorded in each month from the year 1875, or from the opening of the observatory to the year 1902, and the differences of these values for each station furnish the absolute range.

The mean for each month of the mean temperature of the day is obtained by taking the mean of the maximum and minimum and applying a correction determined from the hourly observation data given in Vols. V., IX. and X. of the Indian Meteorological Memoirs. The data at once furnish the necessary corrections for the stations at which these observations were recorded. At the remaining stations the corrections were determined from the values belonging to the nearest stations of similar conditions of exposure, &c., at which the hourly or six-hourly observations had been recorded. The corrections for each station will be found in Table A (pages xv to xx) of the introduction to the tables of normal data, Vol. XVII. Indian Meteorological Memoirs.

The mean monthly and annual temperatures for each station are reduced to sea-level by adding 1° for each 450 feet of elevation. This increment value for elevation was determined by Mr. Blanford after careful consideration, and has been employed in the calculation of all sea-level tables of temperature given in the Annual Reports and Memoirs of the Department, and it has been thought most desirable to continue its use in the preparation of the data for the Atlas. The mean temperatures of all stations above 3000 feet have not been reduced by the above method, and are not utilised in the preparation of the charts of mean sea-level temperatures for the Atlas.

In each map is given the mean value for the whole of India of the element of observation represented on the map. These are the arithmetical means of the values for all stations below 3000 feet. They give estimates of some value in illustration of the seasonal changes of the temperature conditions in a large tropical area subject to monsoon variation of atmospheric movement.

Also in the mean temperature charts an additional isobar of the mean temperature of the whole Indian area is given, from which at a glance it can be seen which parts are hotter and cooler than the mean of the whole area.

HUMIDITY CHARTS

These consist of two series, the first exhibiting the distribution of the amount of aqueous vapour (as measured by its pressure) in the lowest stratum of the atmosphere, and the second the dampness or dryness of the atmosphere measured as the percentage ratio of the actual amount of vapour present to the total amount required to saturate the air space at the actual temperature of the air and aqueous vapour. The former is usually termed the "absolute humidity of the air," and the latter the "relative humidity of the air." The former is of primary importance in all scientific investigations of the atmospheric movements, and the latter for investigations of the relations between growth, health and disease.

RELATIVE HUMIDITY.—The series of charts in the plates numbered LXIII. to LXXV. show the distribution of relative humidity in each month and on the mean of the year. Each plate contains three charts. The large chart illustrates the distribution of the mean monthly relative humidity for the whole day period, and the two small charts the mean relative humidity at 8 A.M. and 4 P.M. for each month and for the mean of the year. As with a given amount of aqueous vapour in the air the relative humidity decreases as temperature increases and *vice versa*, the relative humidity is actually greatest shortly before sunrise and least in the afternoon from 2 P.M. to 3 P.M. The comparison of the 4 P.M. charts with the 8 A.M. charts hence shows approximately the change of humidity in each month due to the day change of temperature.

The actual observations recorded to furnish this element are readings of the dry bulb and wet bulb thermometers. From these readings and by the use of the tables drawn up by the Meteorological Department from the experimental results of Regnault and August, the relative humidity can be at once determined.

The actual observations are in the great majority of cases satisfactory. Accurate results depend upon the proper exposure of the instruments so that there may be a flow of air across the instruments and upon the wet bulb being kept supplied with water so that the muslin covering may be always kept damp. This is occasionally somewhat difficult to maintain during the driest and hottest months of the year in India. Careless observers hence occasionally take the readings with the muslin covering and thread of the wet bulb only imperfectly damp, or flood it with water if perfectly dry at the instant of observation and take the reading almost immediately afterwards.

These observations hence show certain discrepancies. A list of the stations for which the means are not satisfactory and do not fully represent the hygrometric conditions in the open country outside of the stations at which the observatories are situated is given in the introduction of Vol. XVII. Indian Meteorological Memoirs.

The data utilised for the preparation of the relative humidity charts are given in Tables XXXI., XXXII. and XXXIII. of Vol. XVII. Indian Meteorological Memoirs.

Table XXXI. gives data of the mean 8 A.M. humidity of 165 stations for each month and for the year. The means were derived from the observations of the period 1889-99 at all stations, and are hence strictly comparable in period.

Table XXXII. gives similar data for 4 P.M. at 117 stations for each month and for the year. The means for this element were obtained by the observations recorded at that hour during the period 1877-1902. As observations at that hour have not been taken at the majority of observatories opened in Upper and Central Burma, Rajputana, Mysore, Hyderabad (Deccan), Persia, &c., during the last twelve years, 4 P.M. data are wanting for these stations.

Table XXXIII. gives the mean daily relative humidity at 124 stations in the Indian Empire for each month of the year and for the year. The means are based on the whole of the available data for the period 1877-1902, and are obtained by taking the means of the minimum, 10 A.M. and 4 P.M. humidity, and reducing to true means by applying corrections determined from the hourly observation data given in Vols. V., IX. and X. of the Indian Meteorological Memoirs. The corrections for each station are given in the table, pages 44 to 46, Vol. XVII. Indian Meteorological Memoirs.

Lines of equal relative humidity are given in each chart. They are drawn for differences of 5 per cent.

As the air almost invariably contains more moisture in the coast than in the interior districts, and its temperature is during the greater part of the year lowest in the coast districts, the relative humidity diminishes from the coast districts into the interior in all months except November to January. The decrease of humidity in passing into the interior from

the coast districts is especially rapid in the hot weather months. During that period the air is very dry over the whole of the interior but more especially in North-western India, where the influence of the local sea winds of the period is very slight. Humidities as low as 5 per cent. are of occasional occurrence at such stations as Jacobabad, Deesa, Jaipur, Agra, Lahore, Sirsa, Montgomery, Khandwa and Ahola.

In the cold weather period, temperature as well as aqueous vapour decreases on passing from the coast districts into the interior. Hence the variations of the relative humidity over India are much smaller than in the hot weather period. The air is driest at that season in the Deccan area and North Bombay.

In the south-west monsoon period or rainy season, temperature and the amount of aqueous vapour vary slightly over by far the greater part of India. Hence in that period the air is very damp and the mean relative humidity ranges between 80 and 90 over the greater part of India.

ABSOLUTE HUMIDITY OR AQUEOUS VAPOUR PRESSURE.—The second series of Humidity Charts, numbered LXXXVI. to LXXXVIII., show the amount of aqueous vapour (as measured by its pressure) present in the lowest atmospheric stratum.

The amount or mass of the aqueous vapour per cubic foot is not strictly proportional to its pressure, as it also depends upon the temperature. The variation of the weight or mass of aqueous vapour per unit of volume is small and may generally be neglected. But if the quantity of aqueous vapour per cubic foot is as is sometimes done expressed as grains (of which 7000 make a pound avoirdupois), it is necessary to take into account not only the pressure but the temperature of the aqueous vapour.

For meteorological purposes it is found to be sufficient to follow the changes of the pressure of the aqueous vapour in exactly the same way as is done in the case of the atmosphere. Aqueous vapour pressure as air pressure is measured in terms of the length of a column of pure mercury at temperature 32° , the weight of a column of which of given section (a square inch, &c.) is exactly equal to the pressure of the gas on the same surface area. Aqueous vapour pressure of a tenth of an inch is approximately equal to a mass or weight of one grain per cubic foot. A simple rule-of-three sum will hence enable any one to estimate approximately the quantity of vapour present in the air in any case suggested by the charts of absolute humidity.

The aqueous vapour pressure is obtained from observations of the wet and dry bulb thermometers and by the use of special tables prepared for its immediate determination without special calculation in each case. It may be perhaps noted that these tables have been prepared by means of August's formula modified by Regnault. The formula is based on the relation that the difference between the temperature of the dry and wet bulbs is proportional to the difference between the actual vapour pressure and the saturation vapour pressure at the same temperature, *i.e.*

$$E - e \propto T - t, \text{ or } e = E - c(T - t)$$

T and t are the observed temperatures obtained from the dry and wet bulbs, and E and e are the saturation and actual aqueous vapour pressures at the air temperature T ; c is a factor, depending slightly on pressure and temperature, and the constant in which is determined from actual experiment. This constant in the formula actually employed has been obtained from the data of experiments in Europe, and it is certain it does not give satisfactory or accurate values for cases of high temperature and great dryness of the air, such as occur in the hot weather in the interior of India.

The data utilised for the preparation of the absolute humidity or aqueous vapour pressure charts are given in Tables XXVIII., XXIX. and XXX. of Vol. XVII. Indian Meteorological Memoirs.

Table XXVIII. gives data of the mean 8 A.M. vapour pressure of 165 stations for each month and for the year. The means were derived from the observations of the period 1888–1899 at all stations, and are hence strictly comparable in period.

Table XXIX. gives similar data for 4 P.M. of 118 stations for each month and for the year. The means for this element were obtained by the observations recorded at that hour during the period 1877–1902. As observations at that hour have not been made at the majority of observatories opened in Upper and Central Burma, Rajputana, Mysore, Hyderabad (Deccan), Persia, &c., during the last twelve years, the data for this element are wanting for the areas represented by these stations.

Table XXX. gives the mean daily vapour pressure at 124 stations in the Indian Empire for each month of the year and for the year. The means are based on the whole of the available data for the period 1877–1902, and are obtained by taking the means of the minimum, 10 A.M. and 4 P.M. vapour pressure, and reducing to true daily means by applying corrections determined from the hourly observation data given in Vols. V., IX. and X. of the Indian Meteorological Memoirs. The corrections for each station are given in Table E of the Introduction, Vol. XVII.

The distribution of the aqueous vapour pressure is indicated in each map by two different shades of colour, and by variation of tint, in accordance with the colour scale attached to each map. It is shown more fully by means of the lines of equal vapour pressure which are drawn for differences of .05 inch or .10 inch, and serve the same purpose as the isobars in the pressure charts.

It may be noted that there is one important difference between the data of the air pressure and aqueous vapour pressure charts. In the former the pressure values are reduced to sea-level and to constant gravity. No such reduction is made in the case of the aqueous vapour pressure data. The formula employed in the Russia Climatological Atlas is $p_0 = p_h(1 + .0004h)$, where p_0 is the reduced sea-level pressure corresponding to the pressure p_h at the height h (in metres). It was, however, decided after full consideration that it would be most satisfactory for the purposes for which the Atlas was prepared to use the actual data for all stations, and to draw the lines from the data of stations below 3000 feet in elevation. The charts hence give the actual distribution of aqueous vapour at the level of the plains and plateaus of India below that elevation, and hence of the whole of the interior, with the exception of some of the higher hill ranges of very limited extent. The lines near the west coast of the peninsula do not represent the actual variation in passing from the coast across the West Ghats, but a hypothetical equal spaced variation from the sea-level or coast conditions to the general level of agricultural life and activity at the eastern base of the West Ghats and on the West Deccan plateau.

The chief factors determining the amount of aqueous vapour present in the air are distance from the sea and the character of the winds. It is lowest over the whole of India in December and January, when winds of land origin prevail. It is absolutely lowest in Upper India, and increases from the interior to the sea. It begins to increase with the commencement of sea winds on the coast. These sea winds increase in intensity and in their area of extension into the interior from March to May. Hence the amount of aqueous vapour increases steadily and rapidly in the coast districts, and by smaller amounts and later in the season over the interior. It is for example not until the month of May that the increase is marked in the Punjab. The transformation of these local sea winds into the humid winds of the oceanic currents of the south-west monsoon accompanies a large and rapid increase of absolute humidity over the whole of the interior, with the result that the variation of the aqueous vapour pressure or amount of vapour present in the air varies less in July and August than in any other month, and is chiefly due to differences of elevation.

CLOUD PLATES

The plates containing the charts that illustrate the seasonal and local distribution of cloud in India are numbered LXXXIX. to CI. Each plate contains three charts. The large chart in each plate gives the mean distribution of the cloud amount of the day for each month and for the year. The small charts show the distribution of the mean cloud amount at 8 A.M. and 4 P.M. for each month and for the year. A comparison of these charts indicates the effect of the diurnal heating of the atmosphere due to solar radiation, and of the variation of the atmospheric movement in the middle or higher atmosphere in modifying the cloud amount and distribution throughout the year.

The amount of cloud is estimated in terms of the proportion of the sky covered with cloud by numbers ranging from 0 to 10. A sky free from cloud is denoted by 0, and an overcast sky by 10.

The estimates are personal only, as no instrument is used. They give the proportion of sky covered with cloud without any regard to the kind of cloud, or apparent thickness of the cloud masses.

As the measurement of cloud amount is a purely personal estimate, different observers may give different values for the same extent of clouded sky. The variation due to this personal estimate is generally small in amount in the case of the observers of the Indian Meteorological Department, and the means or normal data obtained from these observations are fairly comparable in the great majority of cases. It was, however, found necessary in preparing the charts to reject partly or entirely the means for the following stations as they disagreed to so large an extent from those at the surrounding stations as to indicate clearly that the discrepancy was due to erroneous estimate of the amount of cloud for more or less considerable periods:—

Tavoy, Balasore, Gopalpur, Jhansi, Mooltan, Surat, Mainpuri, Cuddalore, Madura and Minicoy (at all of which the cloud estimates are generally too low), and Nellore, Masulipatam, Nowgong, Sirsa, Bikanir, Delhi and Raipur (for which they are generally too high).

The data from which the cloud charts were prepared will be found in Vol. XVII. of the Indian Meteorological Memoirs, and are as follows:—

Table XXXIV. Normal or mean 8 A.M. cloud amount at 165 stations for each month of the year, and for the year.

Table XXXVI. Normal or mean 4 P.M. cloud amount at 107 stations for each month of the year, and for the year.

Table XXXVII. Average monthly and annual mean proportion of clouded sky, corrected to true diurnal means at 110 stations in India.

The 8 A.M. means were derived from the actual 8 A.M. observations of the period 1889–1899, and are hence strictly comparable so far as the period of observation is considered. They are the means of all the observations at that hour for the monthly period to which they refer, or the means of all observations at that hour for the annual chart.

The 4 P.M. means were obtained in a similar manner from the actual observations, so far as they have been recorded at the observatories at that hour, from the commencement of the work of observation, and differ to some extent in period.

The mean daily amounts of cloud for 110 stations are derived from the means of 8 A.M., 10 A.M. and 4 P.M., by applying suitable corrections for each month, determined from the results of the hourly observations given in Vols. V., IX. and X. of the Indian Meteorological Memoirs. The corrections for each station are obtained in a similar manner to the corresponding humidity corrections, *vide* page xxviii. Tables giving the corrections which were utilised for the determination of the true daily means from the actual observational data, *i.e.* of various combinations of hours, are given in Tables G and I, pages xlix to lx, of the Introduction to Vol. XVII. Indian Meteorological Memoirs.

The monthly and annual means based on twenty to twenty-five years agree very satisfactorily, with very few exceptions, showing that the means of data of twenty years or over furnish results that may be accepted as sufficiently accurate to indicate all the more important features of the distribution of cloud, and of its diurnal and seasonal variation throughout the year in India.

The mean cloud amount for the whole Indian area is given in each chart. These estimates show strikingly one of the most characteristic differences between the dry season from November to May and the wet season from June to October in India.

The chief features of the seasonal distribution of cloud are simple and evident on inspection of the charts.

In the cold weather from November or December to February there are two regions of moderate cloud. The first is in Northern India, due chiefly to the passage of cold weather storms, and hence greatest over the Himalayan region and decreasing rapidly southwards from the submontane tracts. The second area is South Madras and the Coromandel coast districts, where it is due to winds that have advanced over the Bay. The intermediate area, including the Konkan, the Deccan area and Lower Burma, is almost free from cloud continuously throughout the period.

The distribution of cloud in the hot weather is chiefly dependent upon the local sea winds which blow across the coasts during the period. The amount of cloud is large in those districts where the local sea winds are strongest and meet with ranges of hills shortly after their passage across the coast into the interior. It is hence large in Travancore, Malabar, South Madras, Tenasserim, Bengal and Assam. There is also much cloud over the Himalayan area, but it decreases to some extent during the months of March and April. In consequence of the changes of the character of the winds, the area of greatest serenity or least cloud is transferred northwards and westwards into North-west and Central India during the period.

During the south-west monsoon period cloud formation is determined by the extension of the humid currents of that monsoon, and by the various conditions which favour ascensional movement in a humid current, more especially forced ascent due to the presence of hills or to the passage of cyclonic storms due to the existence of persistent conditions which determine their movement along similar tracks for considerable periods in India. Hence the amount of cloud is greatest in the coast districts, over and near the various mountain ranges, and in and near the trough of low pressure in the Indo-Gangetic Plain, and is least in the dry and comparatively hot area in Upper India. Skies are almost continuously free from cloud during this period in Baluchistan, Persia and the Persian Gulf, which are outside of the south-west monsoon lower air movement.

RAINFALL MAPS

The distribution of rainfall is shown by a series of nineteen plates, numbered CII. to CXX.

In the thirteen plates numbered CII. to CXIV. the distribution of the rainfall, and the average number of rainy days month by month, and for the whole year, is exhibited. In the last six charts of the series the seasonal distribution of rainfall and number of rainy days is shown.

The fundamental division of the year in India, based on the most characteristic features of the air movement and the accompanying precipitation, is into the dry season or north-east monsoon, and the wet or rainy season or south-west monsoon. The former season extends from December to April or May, and the latter during the remaining seven months of the year. The local distribution of the rainfall suggests that each of these two seasons may be subdivided into two subordinate seasons or periods. During the first half of the dry season, from December to February, the precipitation occurs chiefly during the passage of shallow cyclonic storms across Northern India; and hence in the mountain regions forming the north and north-west frontier of the Empire, and in the Indo-Gangetic Plain. The snowfall is very heavy during this period in the Western Himalayas, the chief supply for the permanent maintenance of the snow and glacier accumulation in that area being in fact received during this period. The precipitation in the plains diminishes southwards from the Himalayas, and although small in amount, is of great value for the cold weather wheat and other crops in Northern and Central India. This period is usually termed the cold weather season, from the character of the temperature conditions in Northern India. The second period of the dry season is known as the hot weather season. The rainfall of this period occurs chiefly during local thunderstorms, and in those coast districts where there is much convective movement or forced ascent due to various actions, such as the obstruction of hill ranges. The rainfall of this period is as a rule very irregularly distributed, and is moderate to large in amount only in Malabar, Tenasserim, Bengal and Assam. This spring rainfall in Assam is of much importance for the early growth of the tea crop.

The precipitation of the period May to November is due to the invasion of India by the great oceanic current of the south-west monsoon. This current usually advances over the Indian Seas in the last week of May or the first fortnight of June, when it begins to give heavy rain to the Bombay coast districts (after a period of almost entire absence of rainfall lasting from November to nearly the end of May). It extends from the Bengal and Bombay coasts rapidly into the interior, and during the next three months gives more or less frequent and general rainfall in Burma, the west coast districts, the Deccan, and Northern and Central India. Occasional showers, frequently accompanying thunderstorms, are received in South and East Madras, but the rainfall in that area is small in amount compared with the precipitation in Northern India. This season of general rain over the whole area (except part of Madras and the dry area in Upper India) lasts from May or June to September, and is the period of the south-west monsoon proper.

During the remaining three months the precipitation is chiefly due to the south-west monsoon current as it withdraws from Northern India and contracts or retreats down the Bay of Bengal. Bengal and Burma receive light to moderate rain during the first part of this period. The current in its retreat down the Bay usually recurves near its northern limit of extension and is determined to the west coast of the Bay. Hence the most important precipitation of the period is received in the Madras Presidency, the Central and South Deccan and Mysore. It increases in total amount southwards, and is greatest in the South Coromandel coast districts. The precipitation of the period is hence most general in those parts of the peninsula where the rainfall of the preceding season is most scanty and irregular in its distribution. This period of frequent rainfall in the south and east of the peninsula is known as the retreating south-west monsoon.

Hence the distribution of rainfall in India suggests the following division of the year:—

Periods.	Sub-periods.
Dry season.	Cold weather season.
	Hot weather season.
Wet or rainy season.	South-west monsoon proper.
	Retreating south-west monsoon.

Plates CIII. to CXX. exhibit the distribution of rainfall and the number of rainy days in each month of the year, and for the whole year, and also for the two seasons and the four subordinate seasons as defined above. The measurement of the rainfall by means of the ordinary rain gauge is a simple matter, but requires care and regular observation. Much attention has been given in India to the collection of accurate rainfall data. Previously to the year 1889, the work of superintendence and of the collection and publication of the results of observations was carried out by the local authorities, with the result that the type of rain gauge employed, the hours of observation and methods of publication of the data differed largely in different provinces. In 1889 the registration of rainfall was systematised and uniform methods introduced by the orders of the Government of India, and the general supervision of the work was handed over to the India Imperial Meteorological Department. It was at the same time decided that although the measurement of rainfall should as hitherto be made to hundredths of an inch, as in other countries, the definition of a rainy day for statistical purposes should be a day on which the rainfall was at least a tenth of an inch. This definition was adopted for two reasons. A fall of less than a tenth of an inch is of no economic value for agriculture in a tropical country such as India. Observers under the conditions of Indian official life cannot be trusted to record small amounts of rain on the days of their occurrence. This was clearly shown by actual comparisons of the number of rainy days at neighbouring stations which exhibited very large discrepancies, due of course to neglect by many observers to record falls of a few hundredths of an inch on the days of their occurrence.

Experience has shown that the rainfall data of the meteorological stations (about 250 in number) are not sufficient to give a fairly accurate and adequate view of the distribution of rainfall in India. Rainfall statistics of more than 2200 stations for upwards of twenty-five years are available. These have been collected and tabulated by the Meteorological Department, and means computed of the rainfall and number of rainy days month by month throughout the year. These results are given in Tables XXXVIII. and XXXIX., Vol. XVII. Indian Meteorological Memoirs.

These tables give the average monthly and annual rainfall and number of rainy days respectively at 2219 stations. The normal or average monthly and annual amounts have been calculated from all available data down to 1900: they are based in the great majority of cases on data of thirty to forty years. In some cases, as Bombay and Madras, the data extend back for about eighty-three years. In calculating the average number of rainy days from the available data, a rainy day is counted when at least a tenth of an inch of rain has been measured.

The distribution of rainfall and of the number of rainy days is indicated by tints of two colours, varying in intensity with the amount according to the colour scheme given in each chart. The distribution is shown more exactly by lines of equal amounts of rain or equal number of rainy days.

The charts exhibit the precipitation for all parts of India below the elevation of 3000 feet. It would not be possible to exhibit in such maps the very large variation of rainfall with elevation on such hill ranges as the Assam Hills, the West Ghats and the Himalayas. The rainfall at such hill stations as Cherrapunji, Mahableshwar, &c., is hence not exhibited in the maps, but data for all the more important hill stations in India will be found in Vols. XIV. and XVII. of the Indian Meteorological Memoirs.

STORM TRACK CHARTS

These are given in Plates CII. to CXIV., and have been prepared from the data accumulated in the India Meteorological Office.

The storms, the tracks of which are given in the charts, belong to two classes. The first class is that of the cyclonic storms of the cold weather period of the dry season. These are shallow but extensive depressions, the majority of which form in Persia, the Persian Gulf, or Baluchistan, and the remainder chiefly in Sind or Rajputana. They all advance in directions ranging between east and east-south-east. Many of them march across India along the Indo-Gangetic Plain into Bengal and Burma. They give much cloud and light to moderate rain to the plain districts over which they pass, and are accompanied with large temperature changes, temperature in front of the storm being sometimes 20° to 30° F. higher than in the rear. Winds are cyclonic in direction, but are usually comparatively feeble on the plains of India, and rarely attain the strength of a gale except in the Punjab.

These cold weather storms occur in the months of December to March. There are three well-defined belts along which they pass. A considerable proportion advance from Upper Sind to the foot of the hills between Ludhiana and Roorkee along what may be termed the northern track belt. The majority advance along a well-defined belt from Sind through Rajputana, Behar and Bengal to Burma, which may be designated as the central cold weather storm track belt.

A small number march along tracks considerably further south, across the head of the peninsula. The tracks of each of these storms are given separately.

The charts give the track belts (and the number of storms) or the actual tracks. It will be observed that the only storms of the period January to March belong to this class of cold weather storms. No storms were reported in the Arabian Sea during this period, and only one (of doubtful character) in the Bay of Bengal.

The second class of storms only occur during the wet season, or period of south-west monsoon winds. They are as compared with the cold weather storms of much smaller extent, but the barometric depression at the centre is usually much greater, the winds are much more violent and frequently of hurricane force near the centre, and the accompanying rainfall excessive. They usually march in some westerly direction, and hence opposite to the general direction of movement of the cold weather storms. They sometimes exhibit the remarkable feature known as the calm centre, and are occasionally accompanied with storm waves causing much destruction of life and property when they strike the coast. The great majority of them form at sea, and increase in intensity as they approach the coast to which they are determined, and decrease as they advance from the east into the interior, at a rate varying very largely with the meteorological conditions obtaining at the time.

Storms of this class occur chiefly between the months of May to December. They march along fairly well-defined tracks during the strength of the monsoon from June to September. During this period the storms with very few exceptions originate in a comparatively small area in the north-west of the Bay, the position of which is also indicated in the maps, and during that period they advance as a rule along the trough of low pressure which forms an important feature of the pressure distribution.

The tracks of these storms are apparently extremely erratic in the months of May and October, and it is not possible to show any definite track belts in either month. They are somewhat less erratic in November and December, when they chiefly advance in westerly directions from the centre of the Bay to the Madras Coast.

An inspection of the charts will show at a glance the more important features of these storms, and more especially some of the characteristic differences between the storms of the south-west monsoon proper and of the retreating monsoon.

In the small right-hand charts of Plates CXIV., CXIX. and CXX. are given the tracks of the more important land-formed cyclonic storms which were generated during the months of June, July and August in areas of heavy rainfall in North-eastern India.

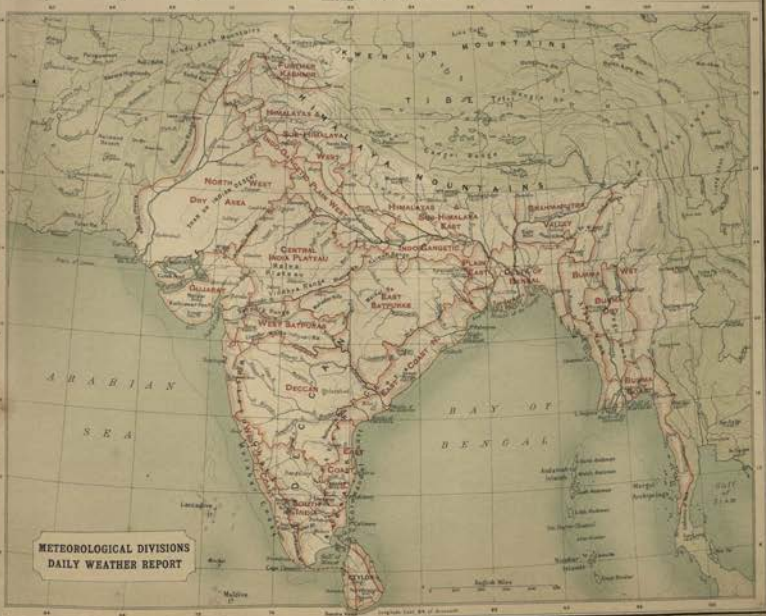
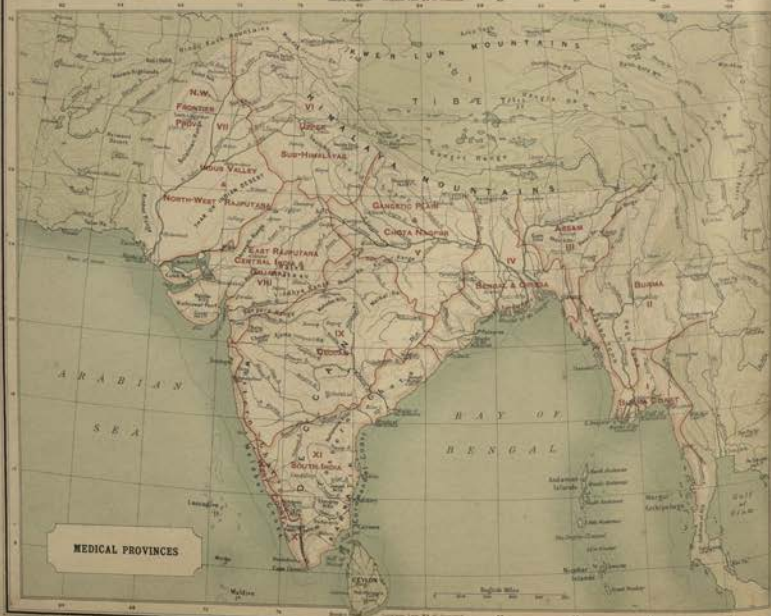
OROGRAPHICAL FEATURES OF INDIA

CLIMATOLOGICAL ATLAS OF INDIA

PLATE I







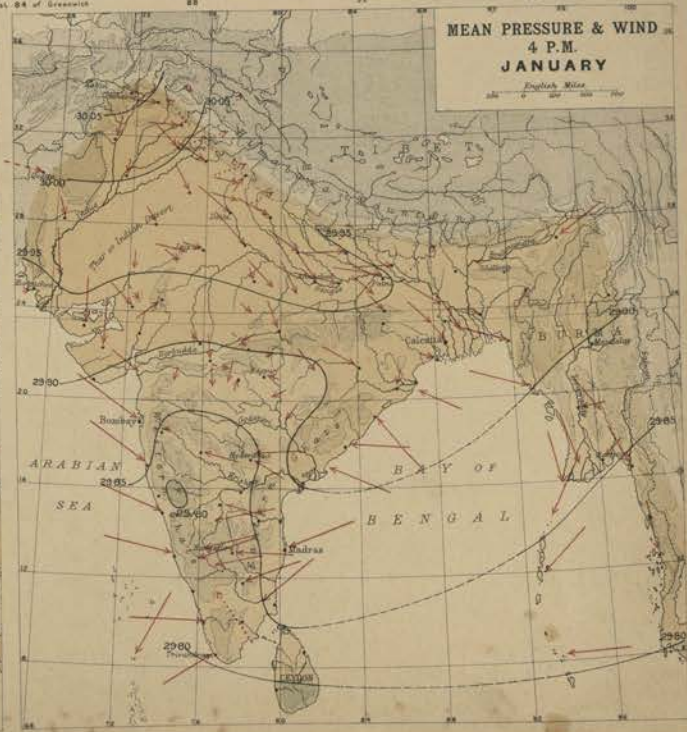
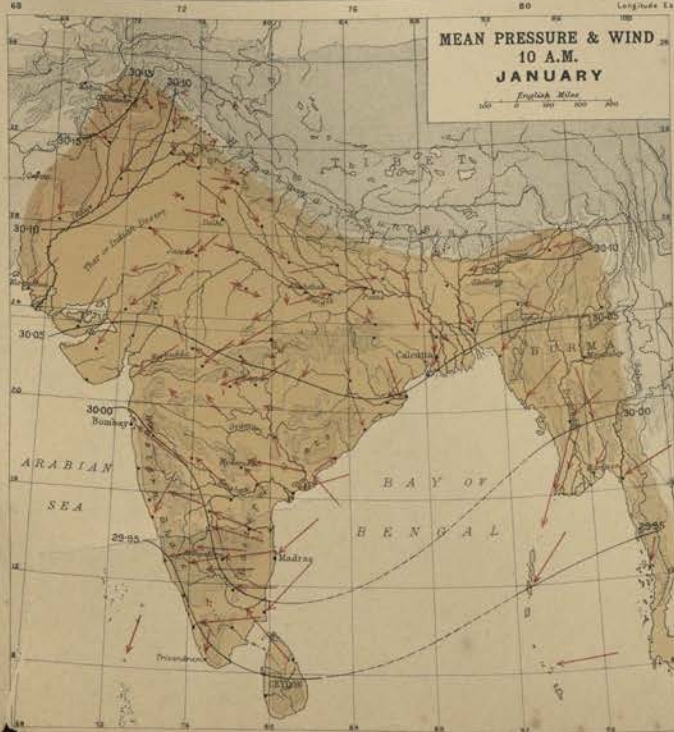


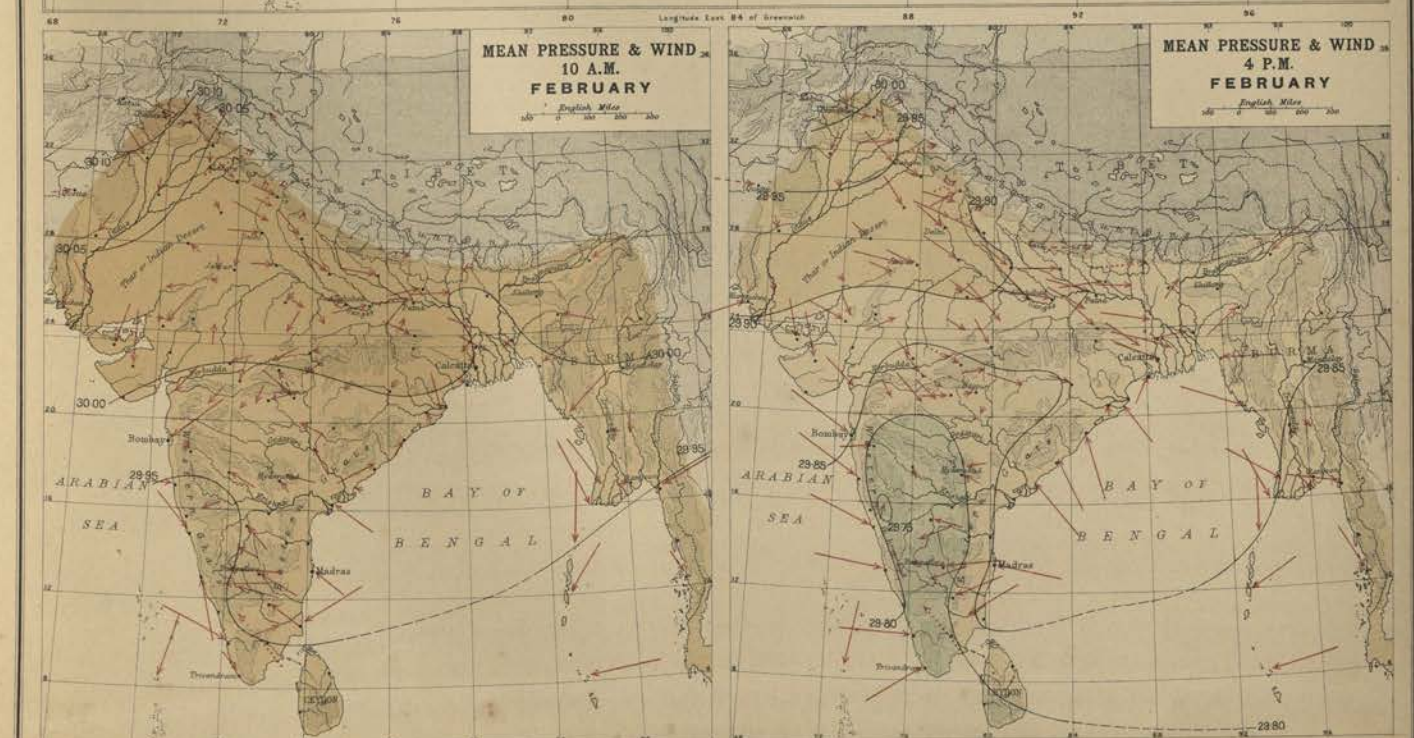
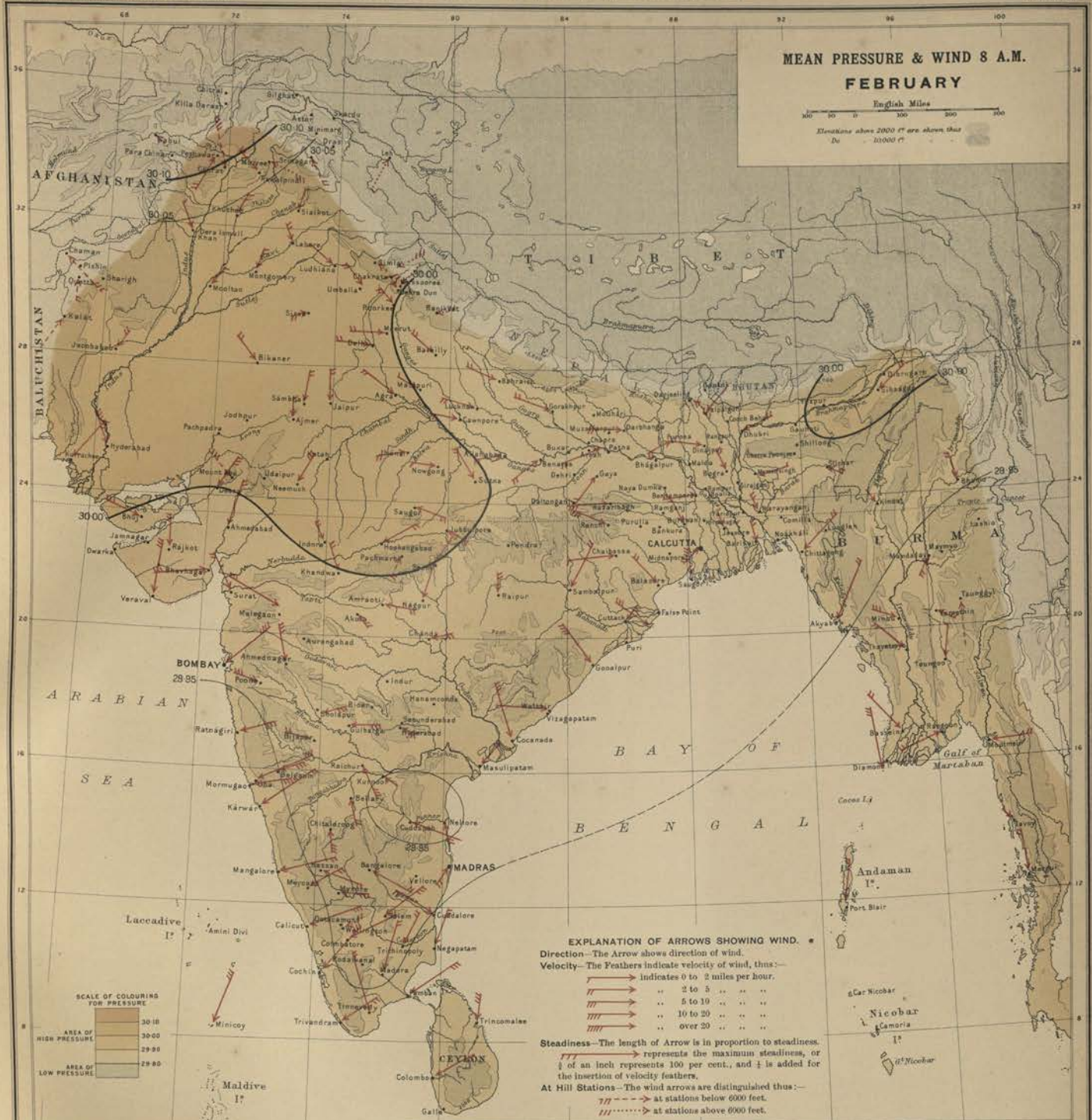
SOUTHERN ASIA & INDIAN OCEAN SHOWING ISOBARS & WINDS FOR JULY

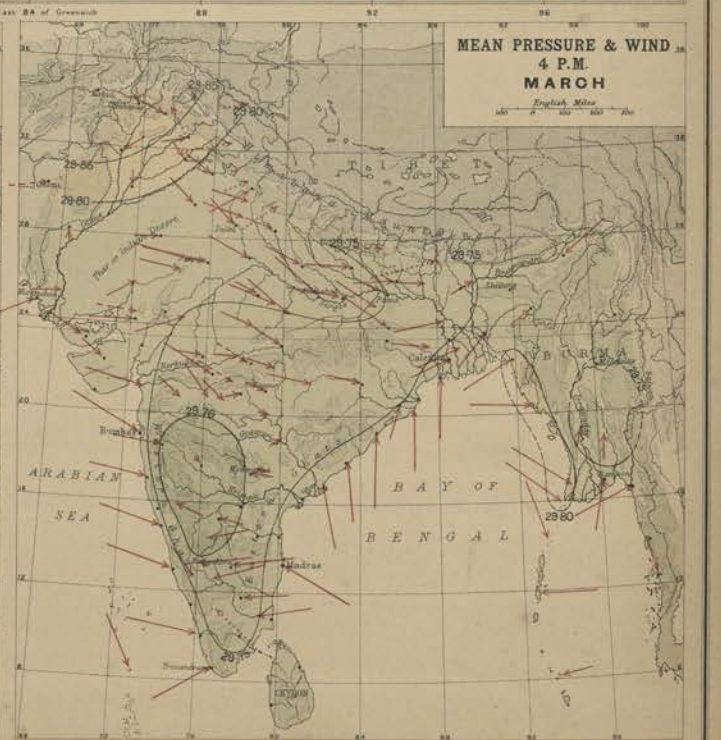
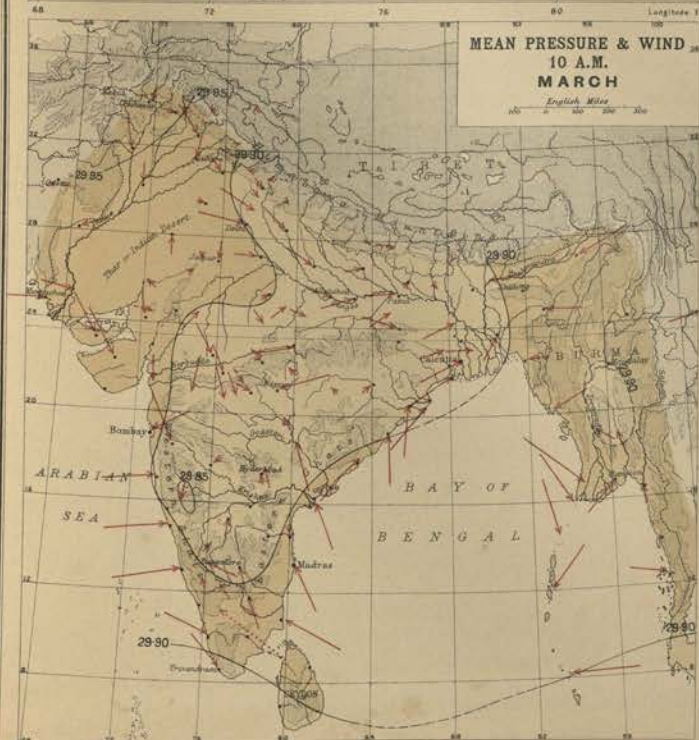
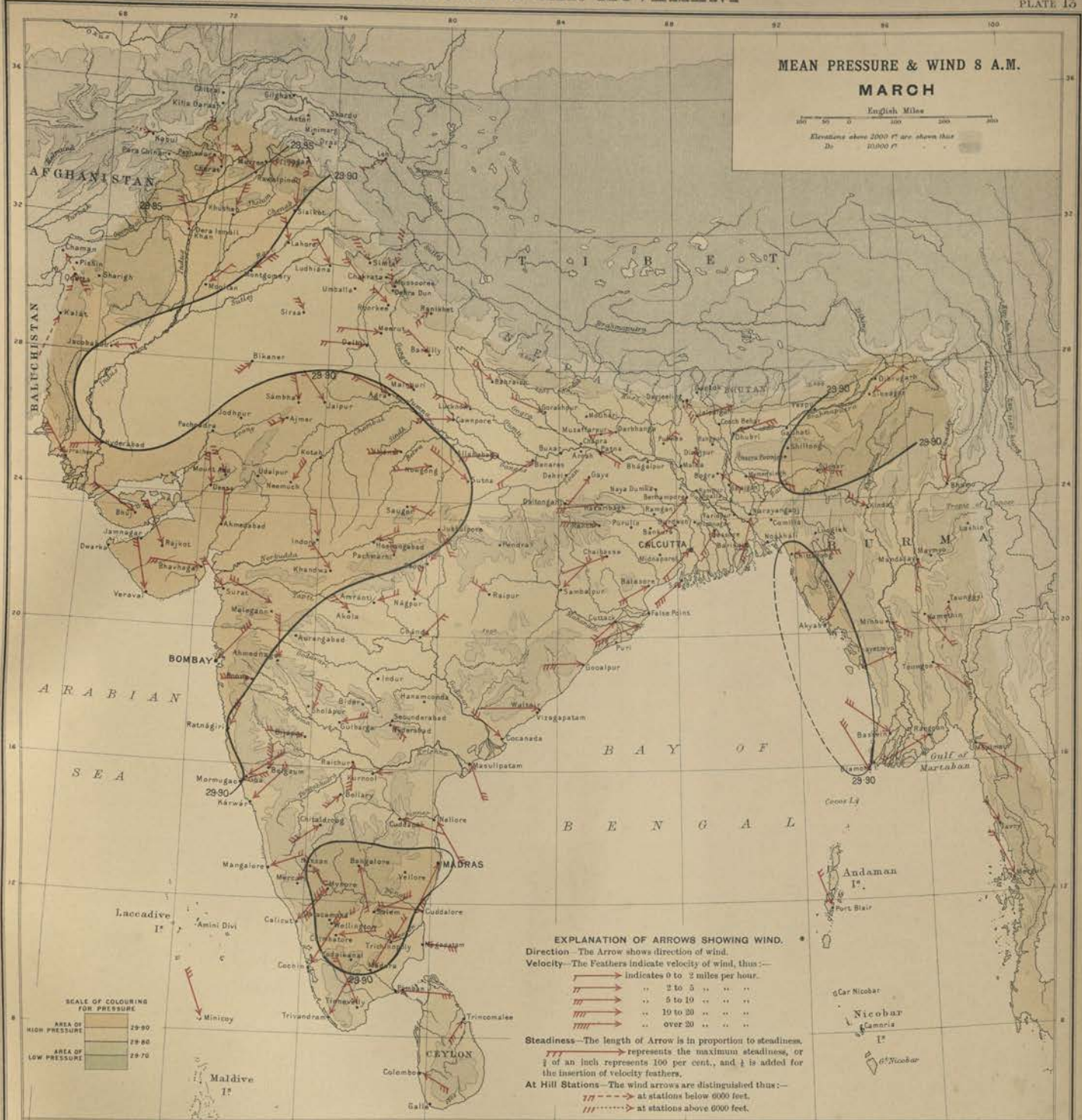
PHYSIOGRAPHICAL ATLAS OF INDIA

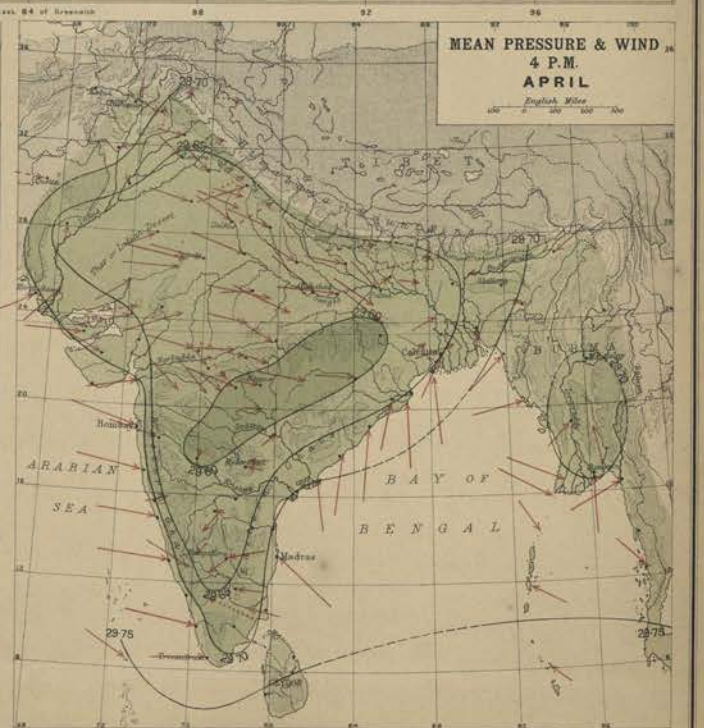
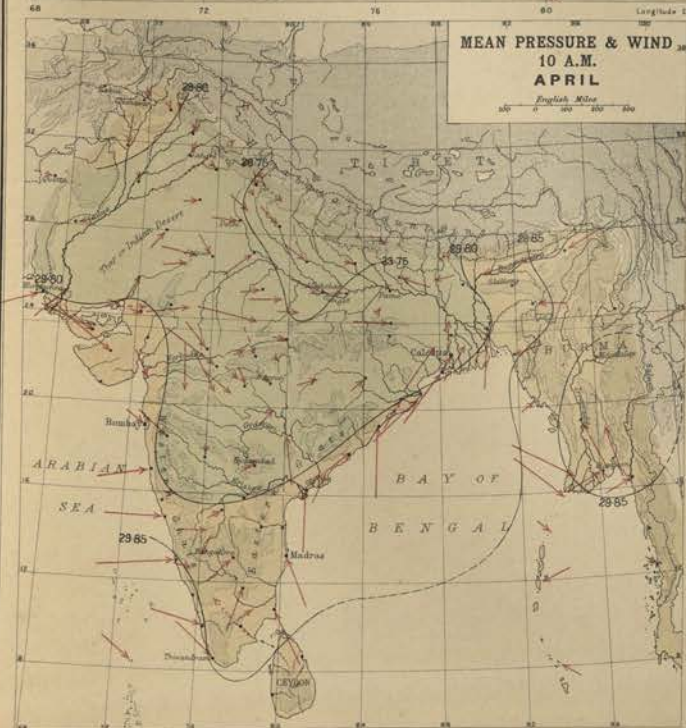
PLATE 9-10

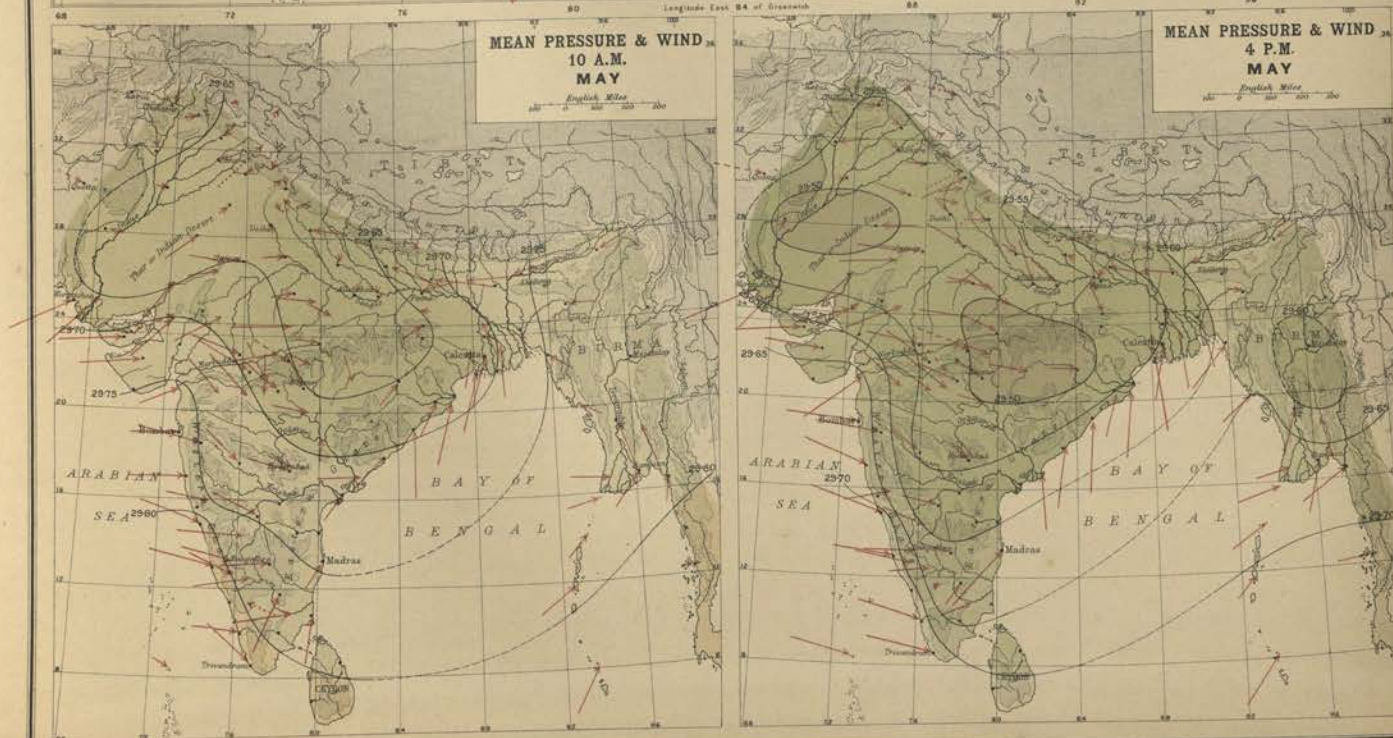
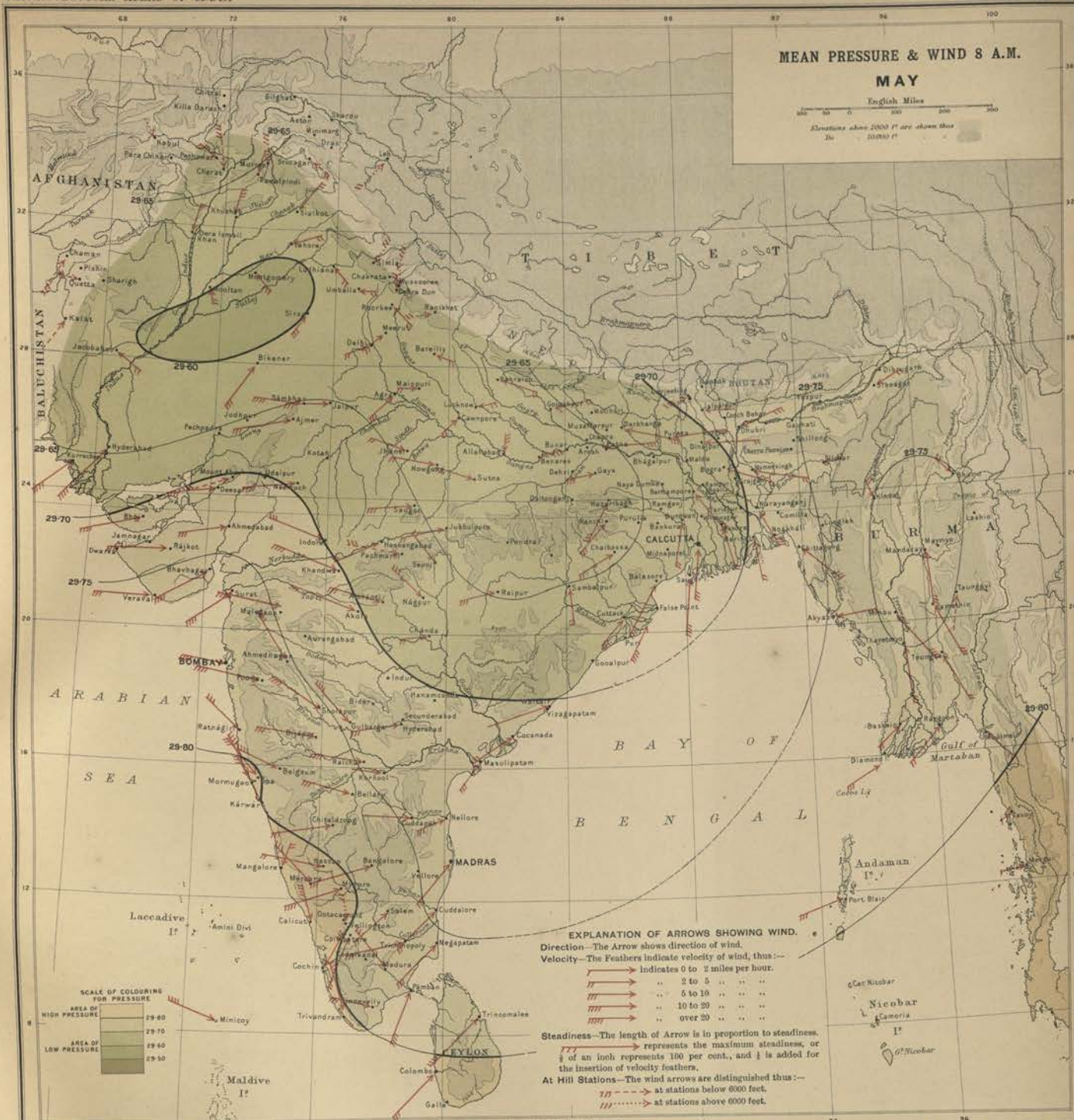


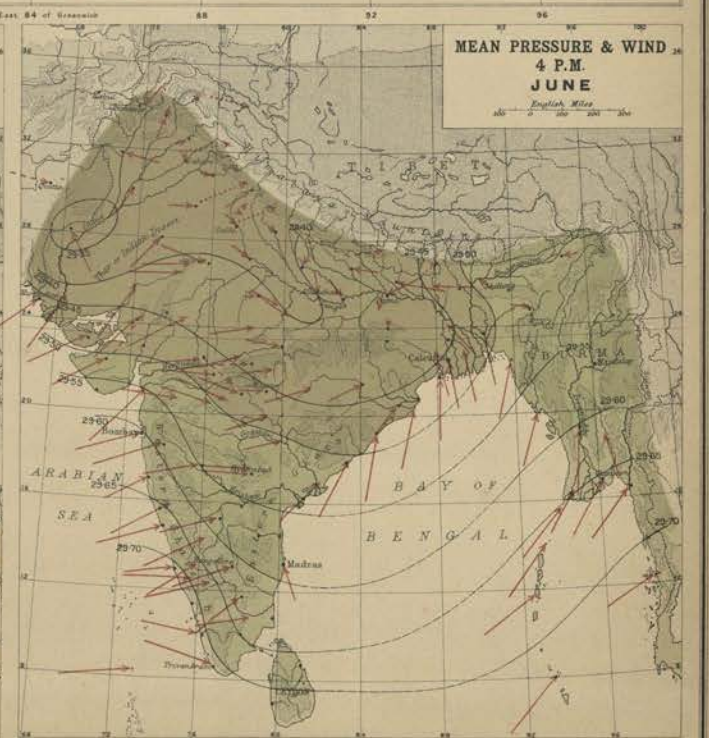
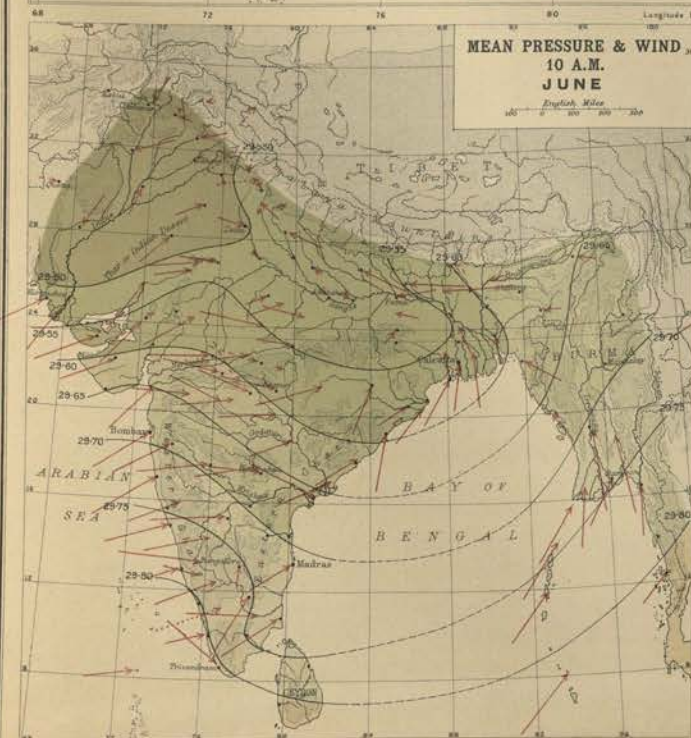






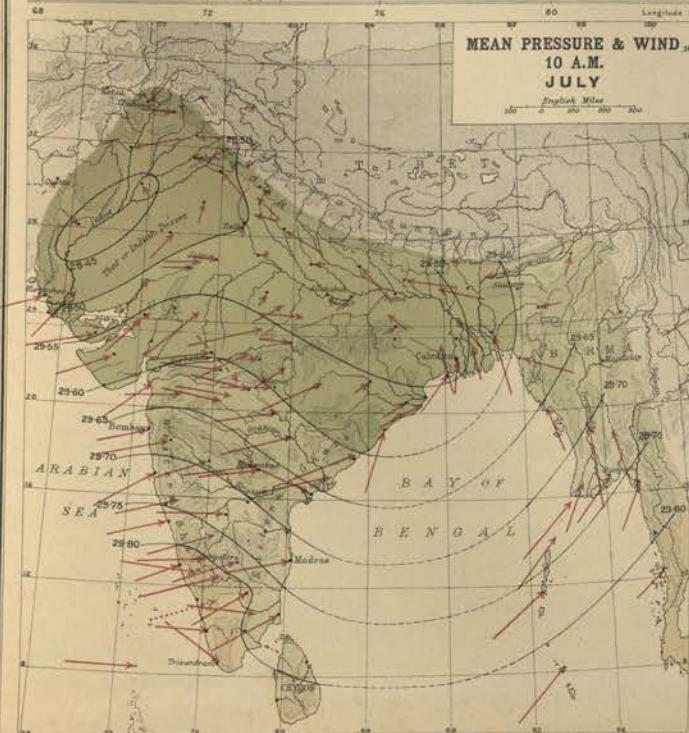
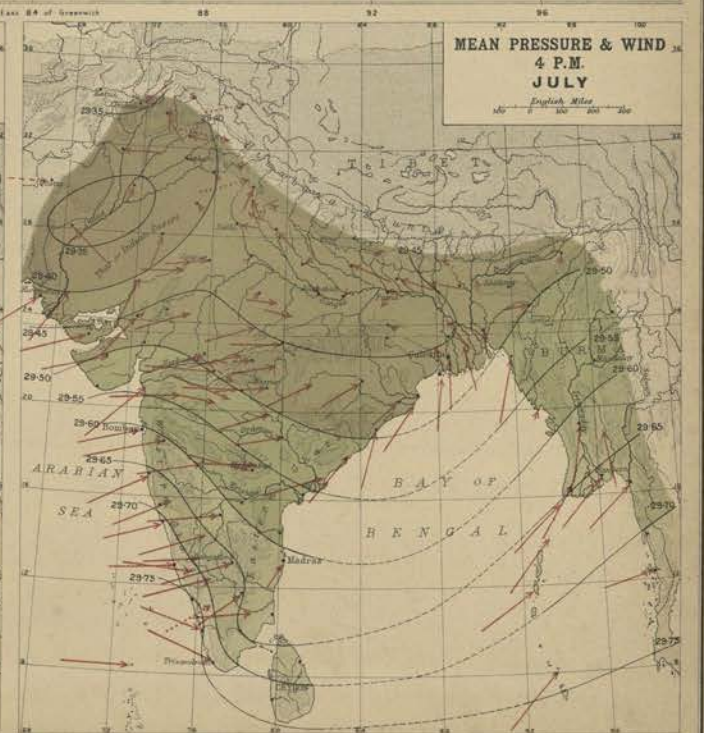


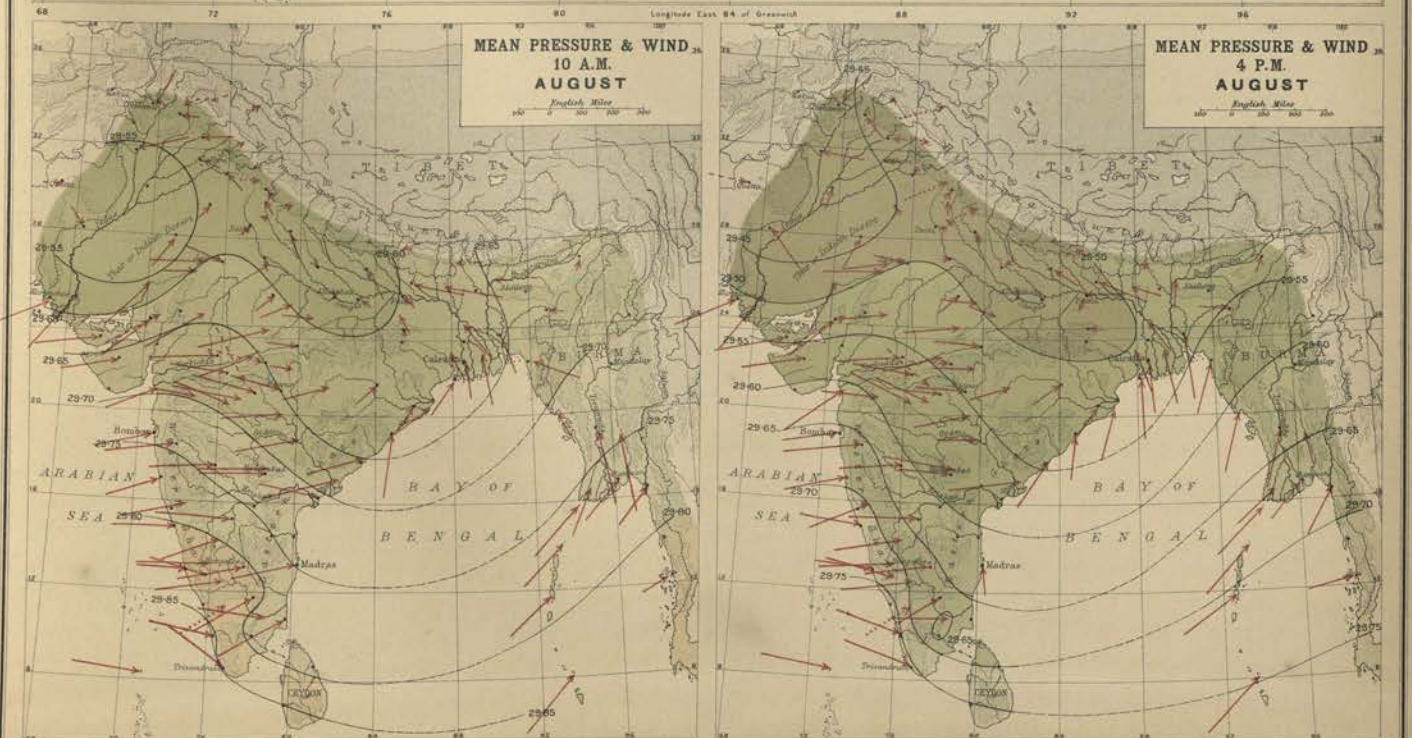


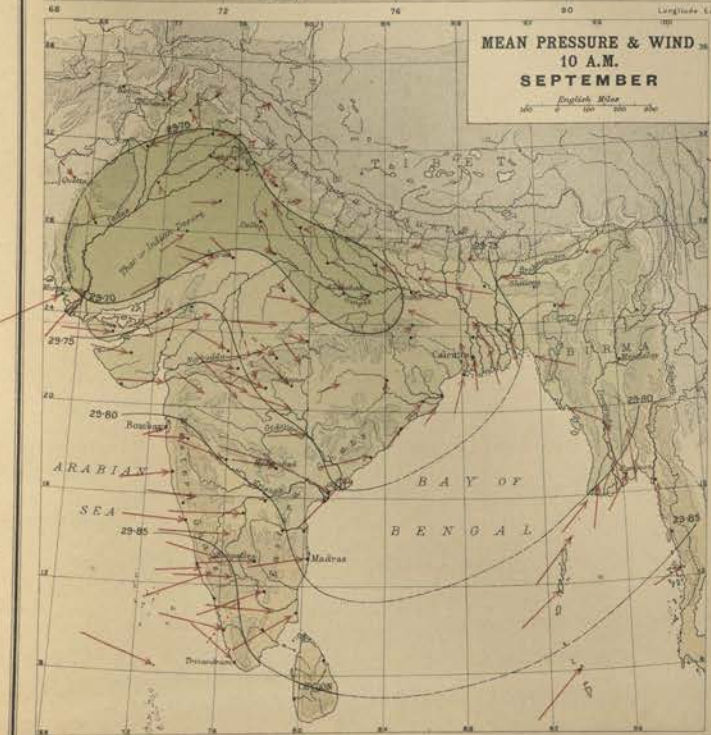


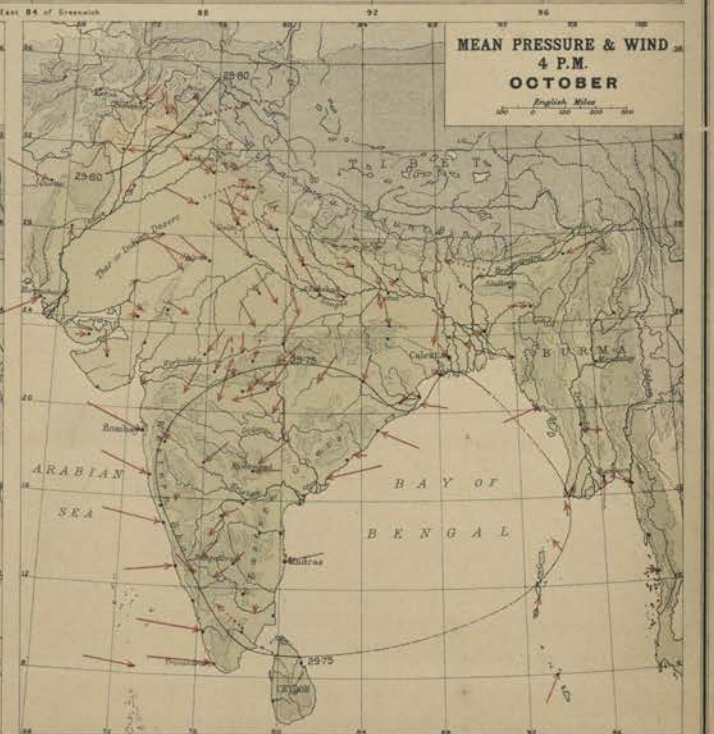
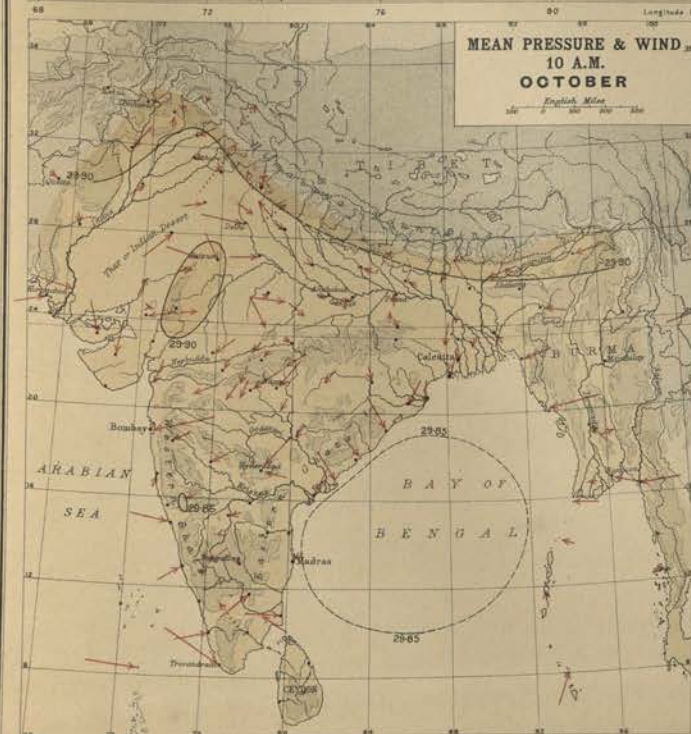
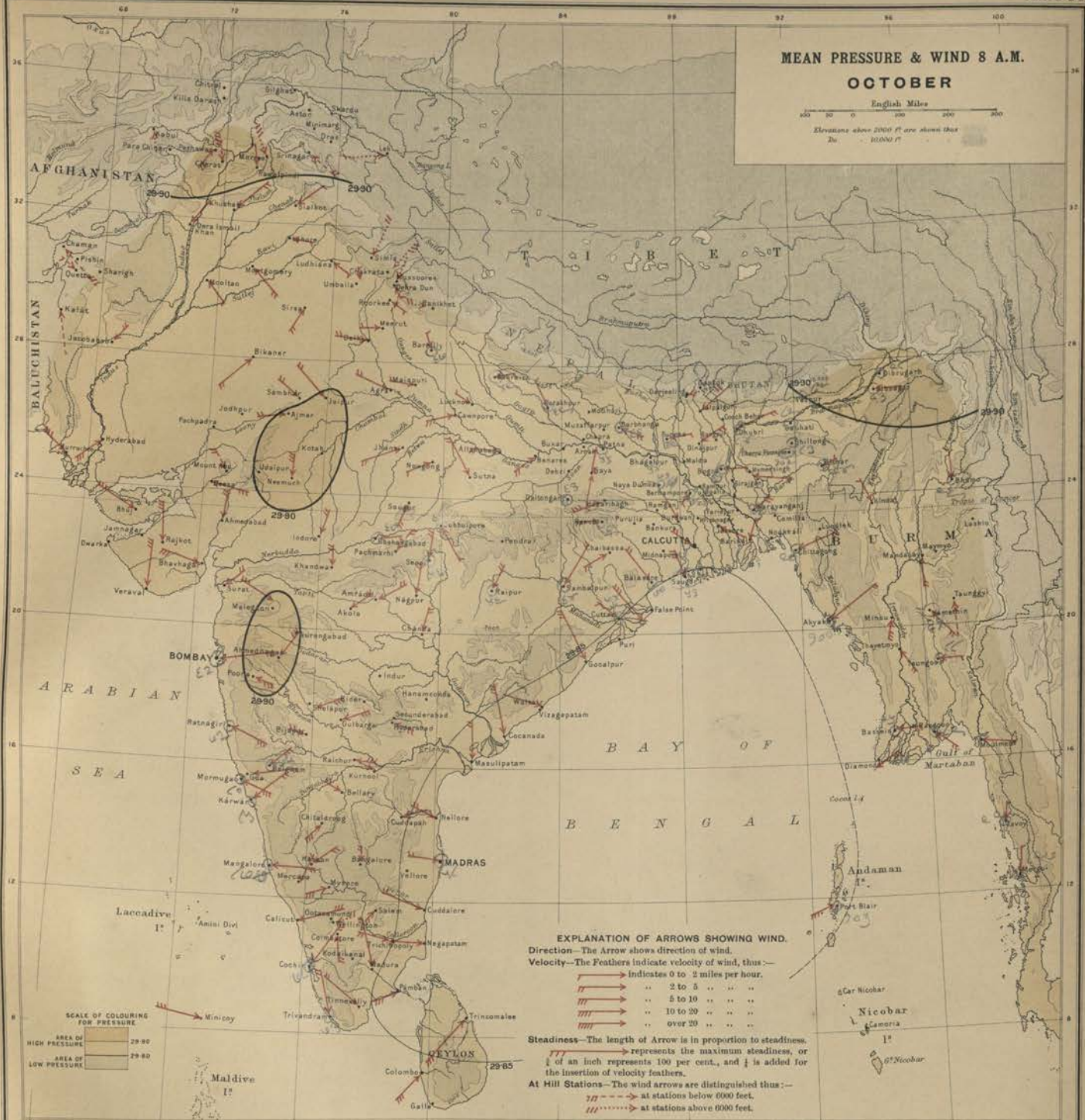
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JULY

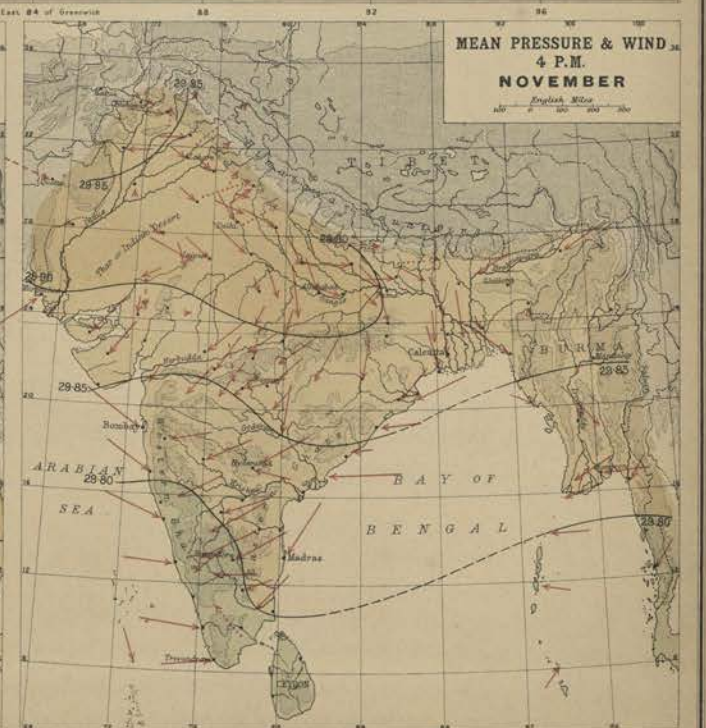
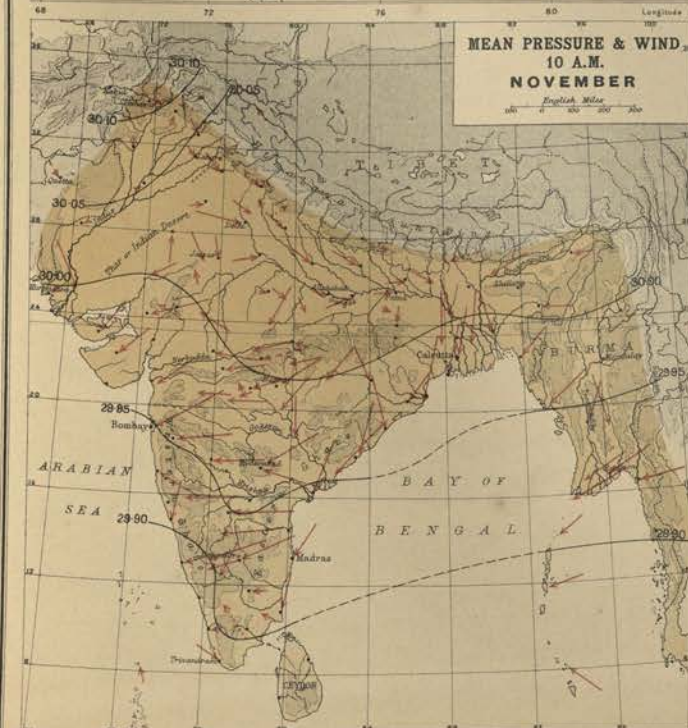
English Miles
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Elevations above 2000 ft are shown thus
Do 10000 ft

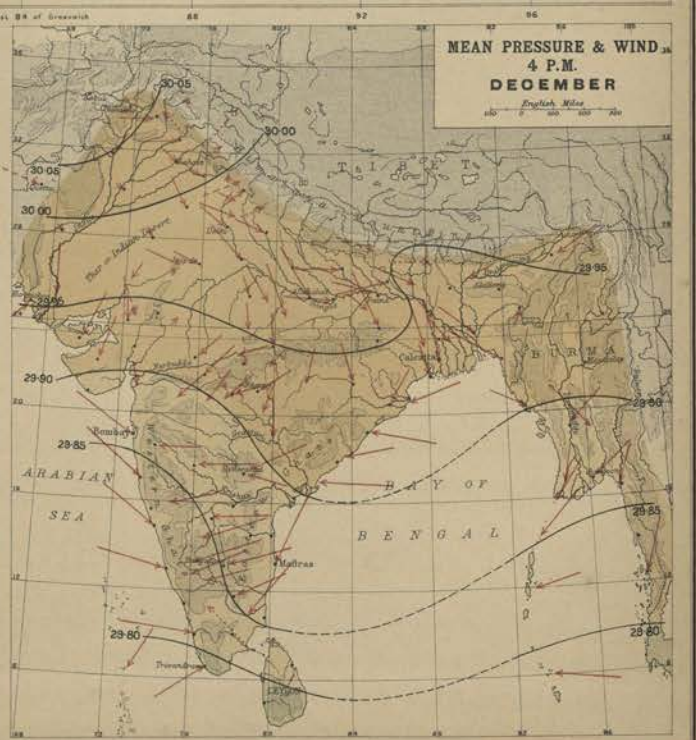
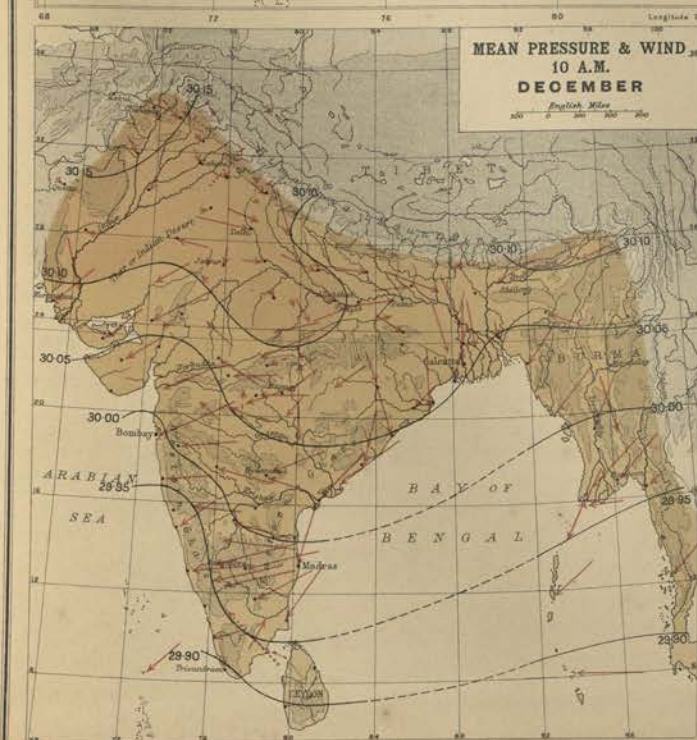
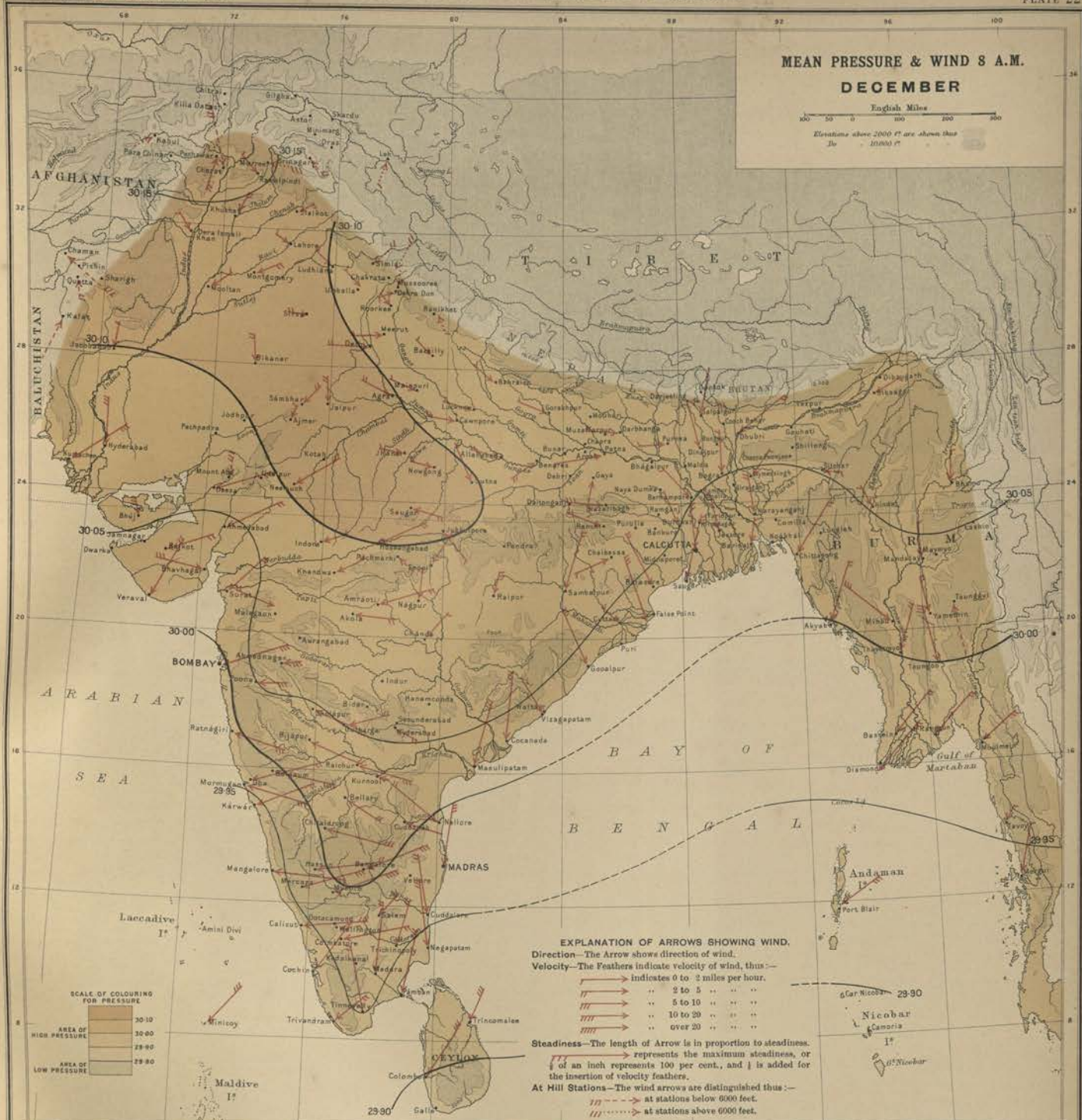
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JULYEnglish Miles
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4 P.M.
JULYEnglish Miles
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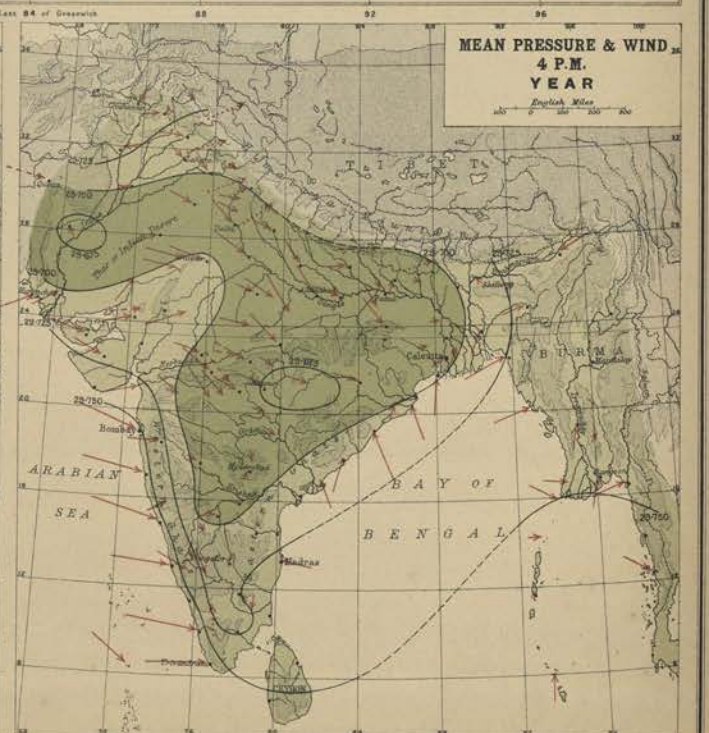
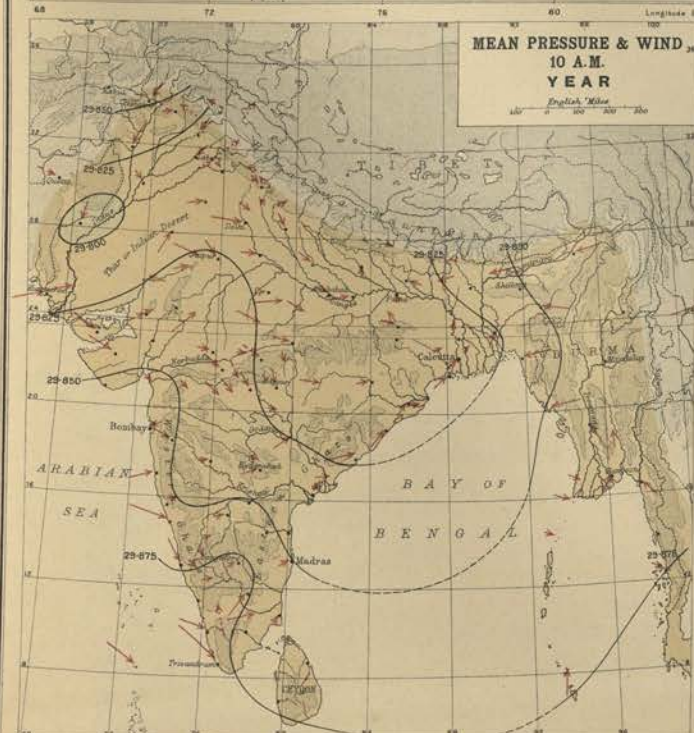


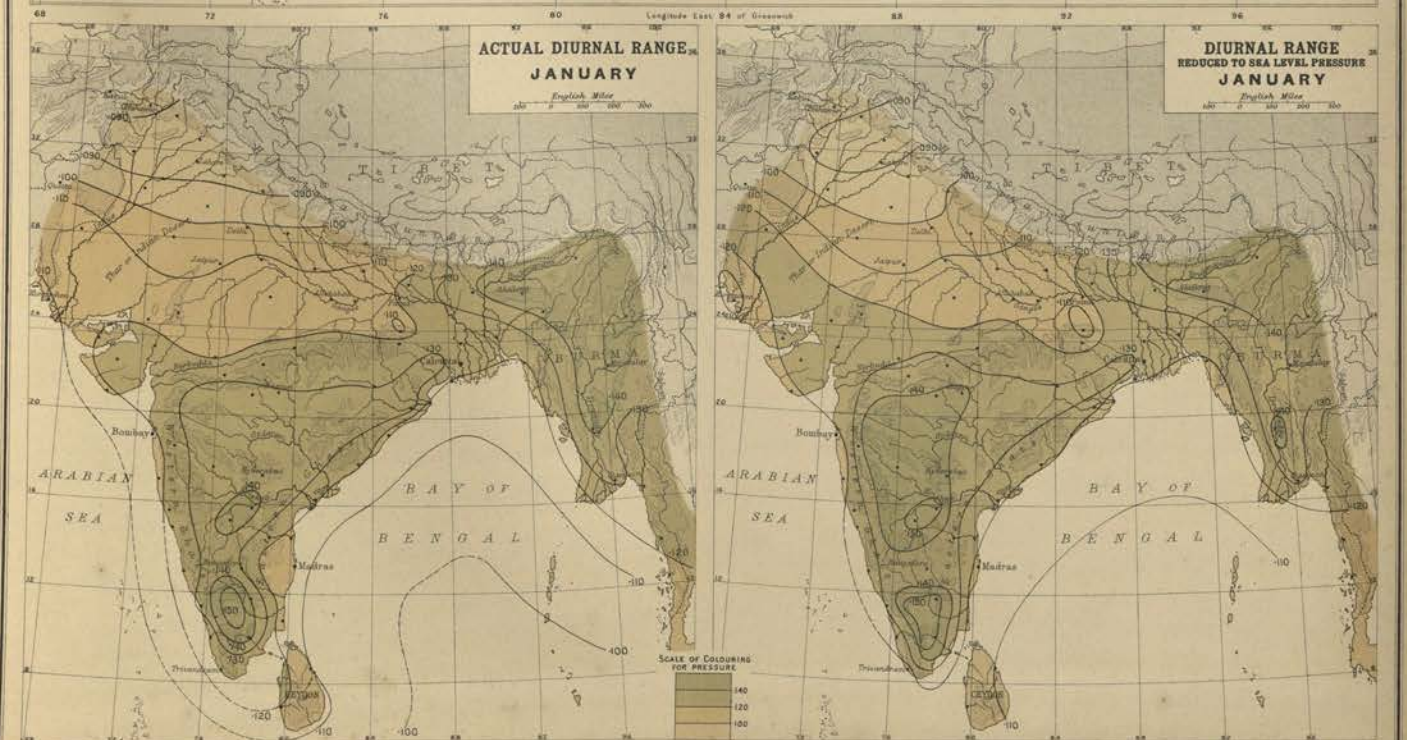
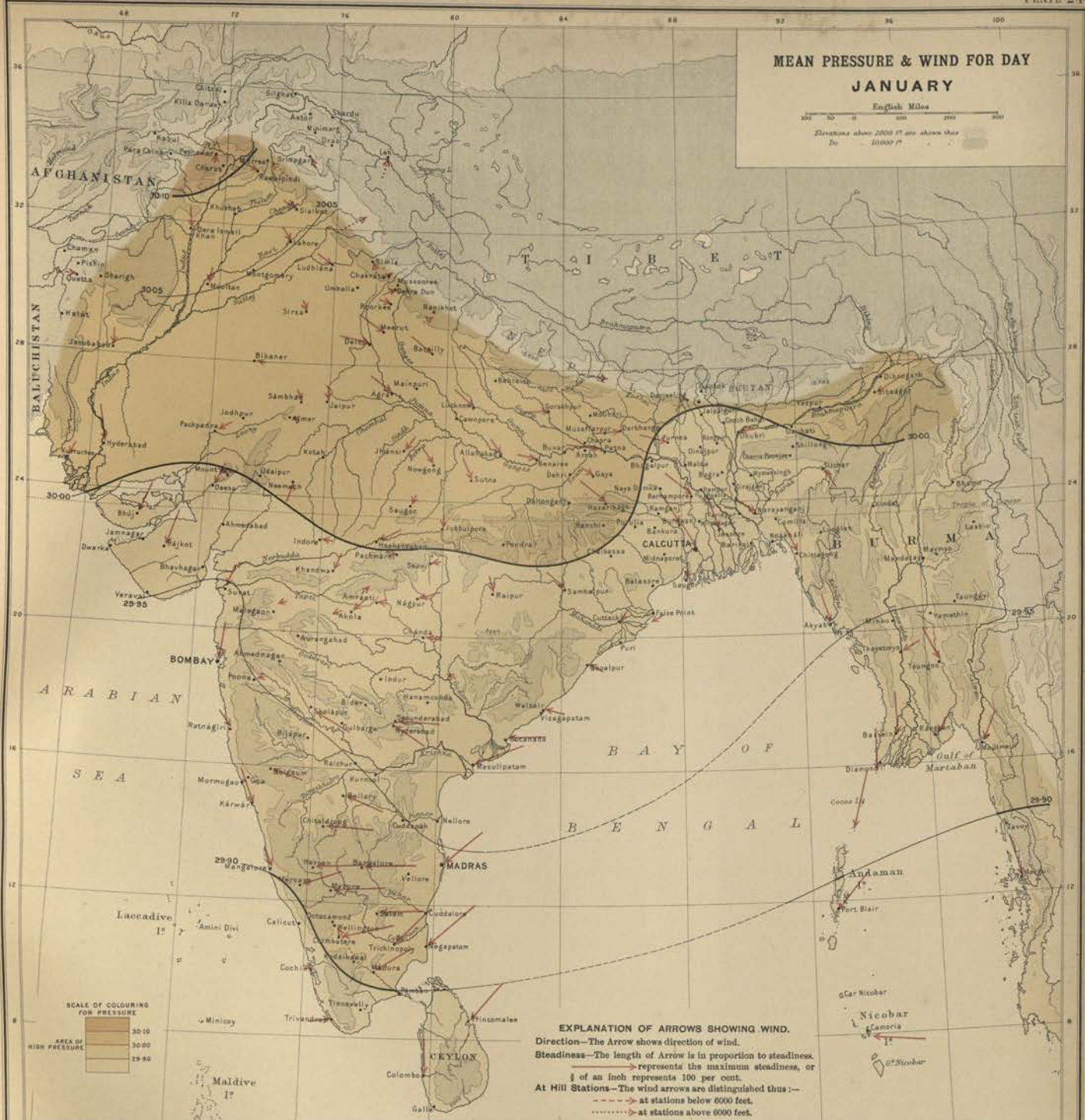


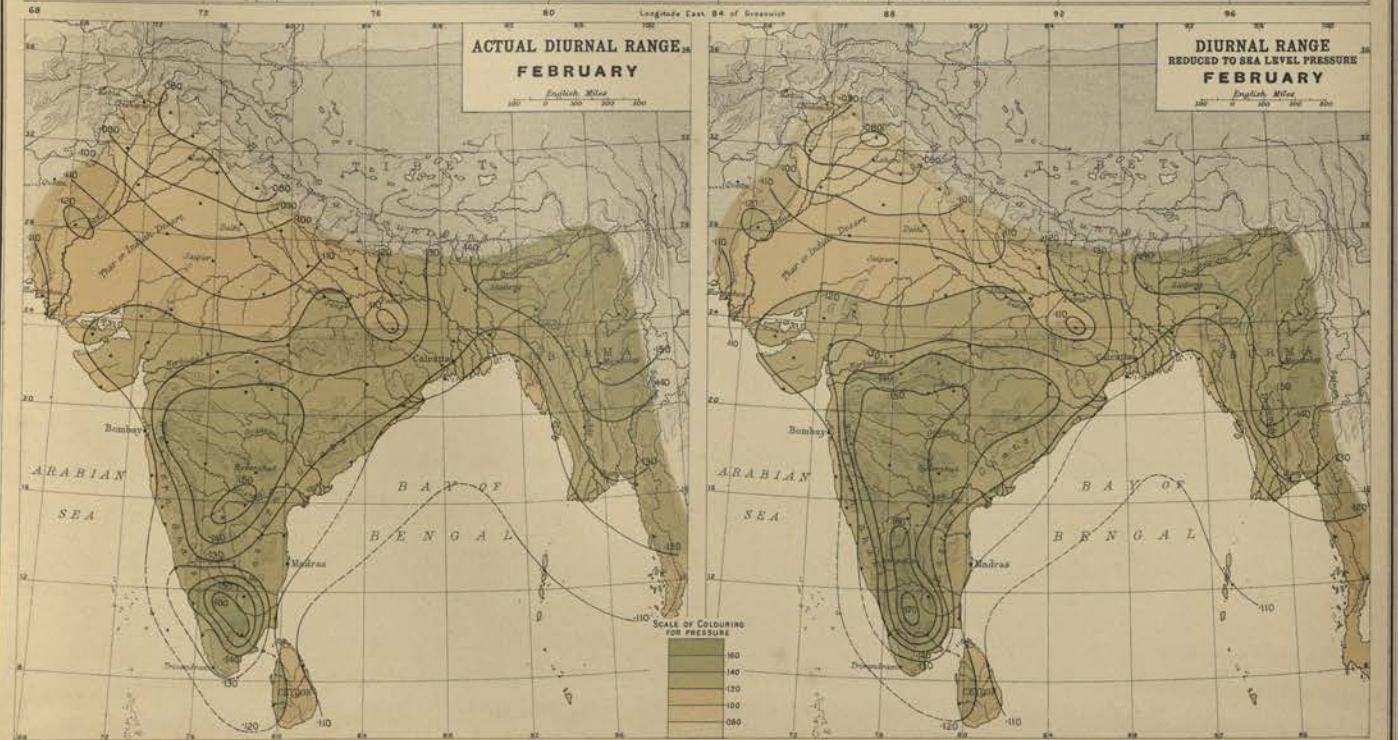


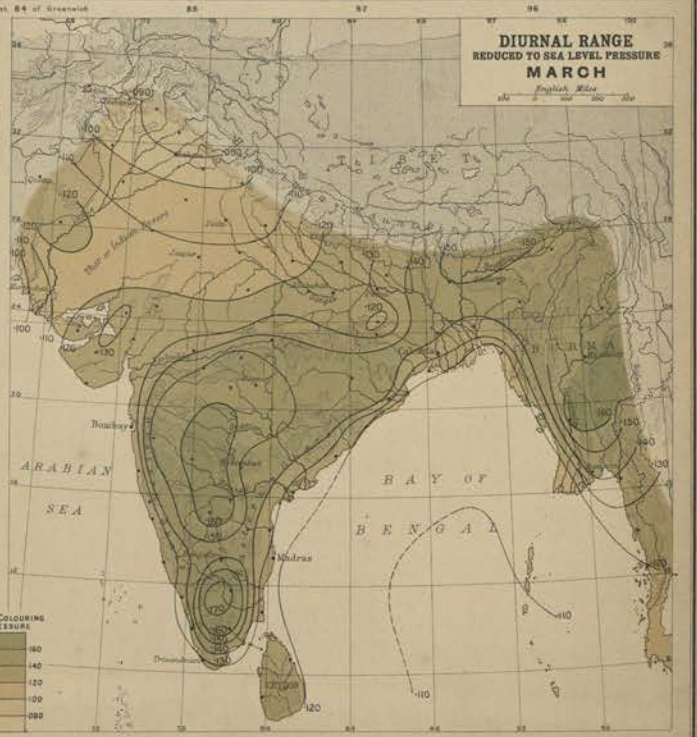
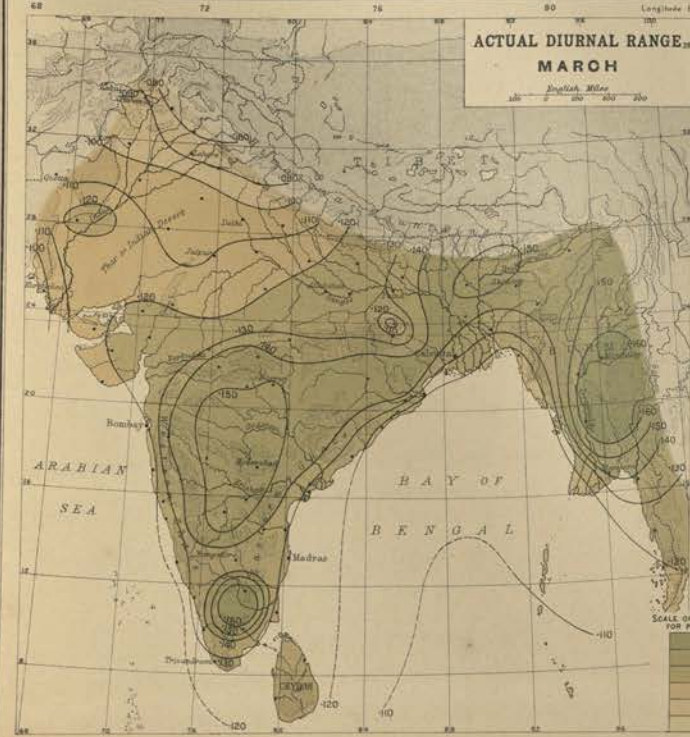
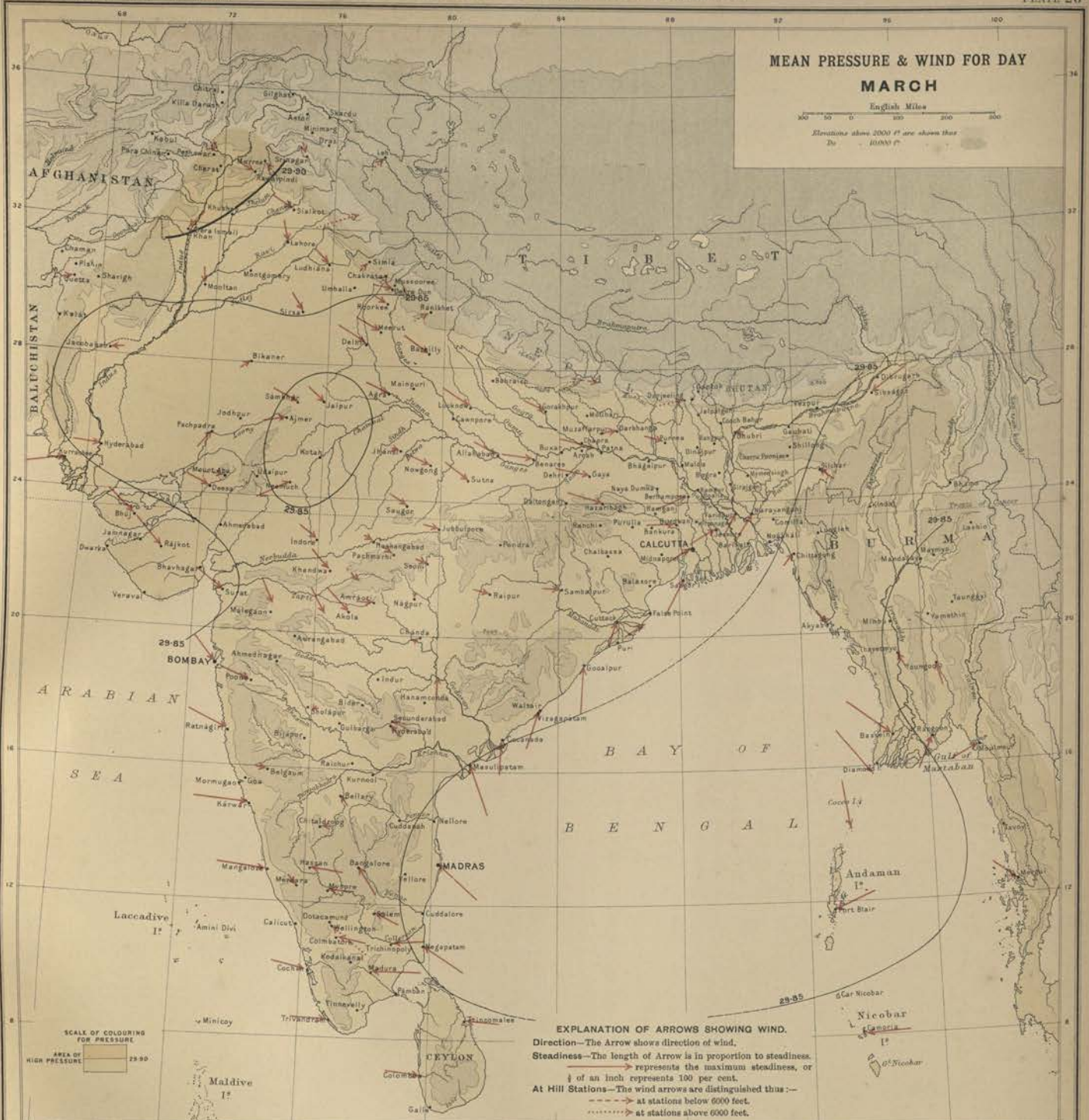


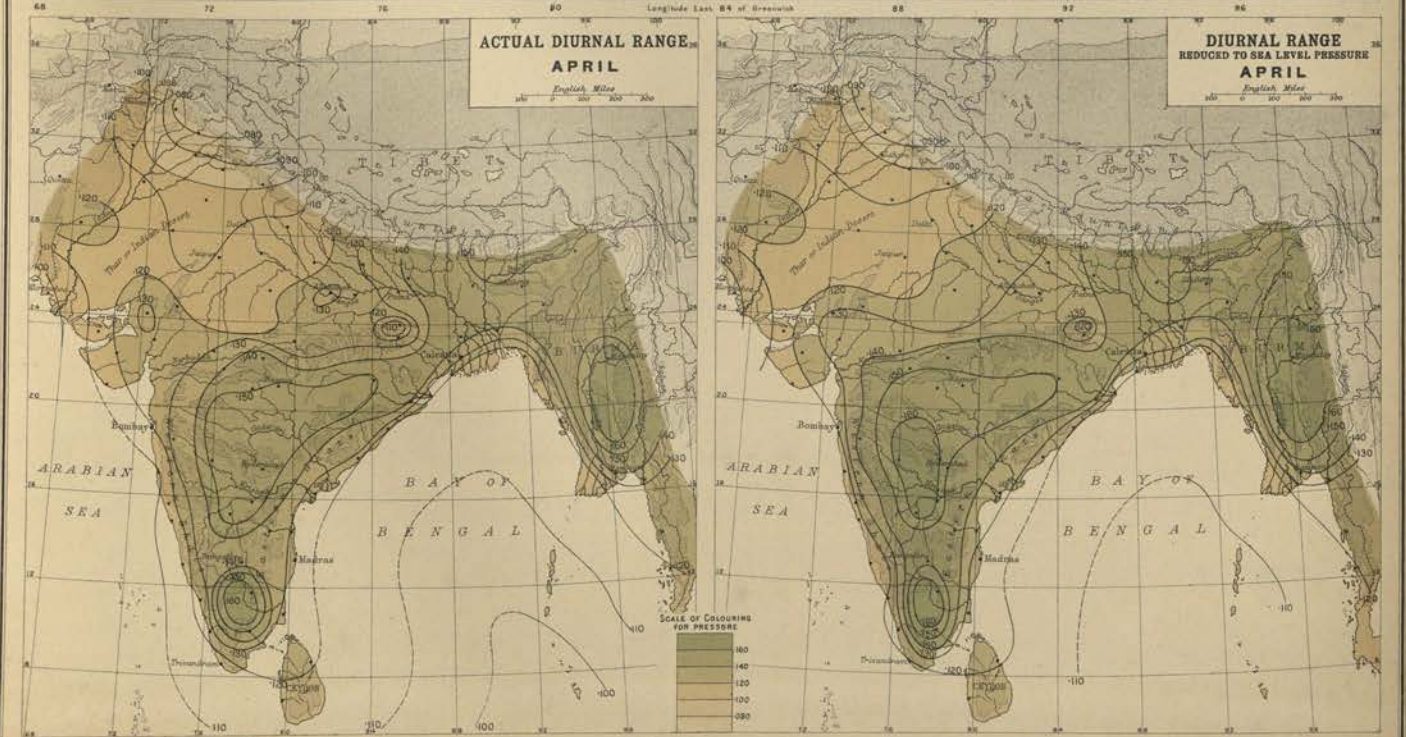


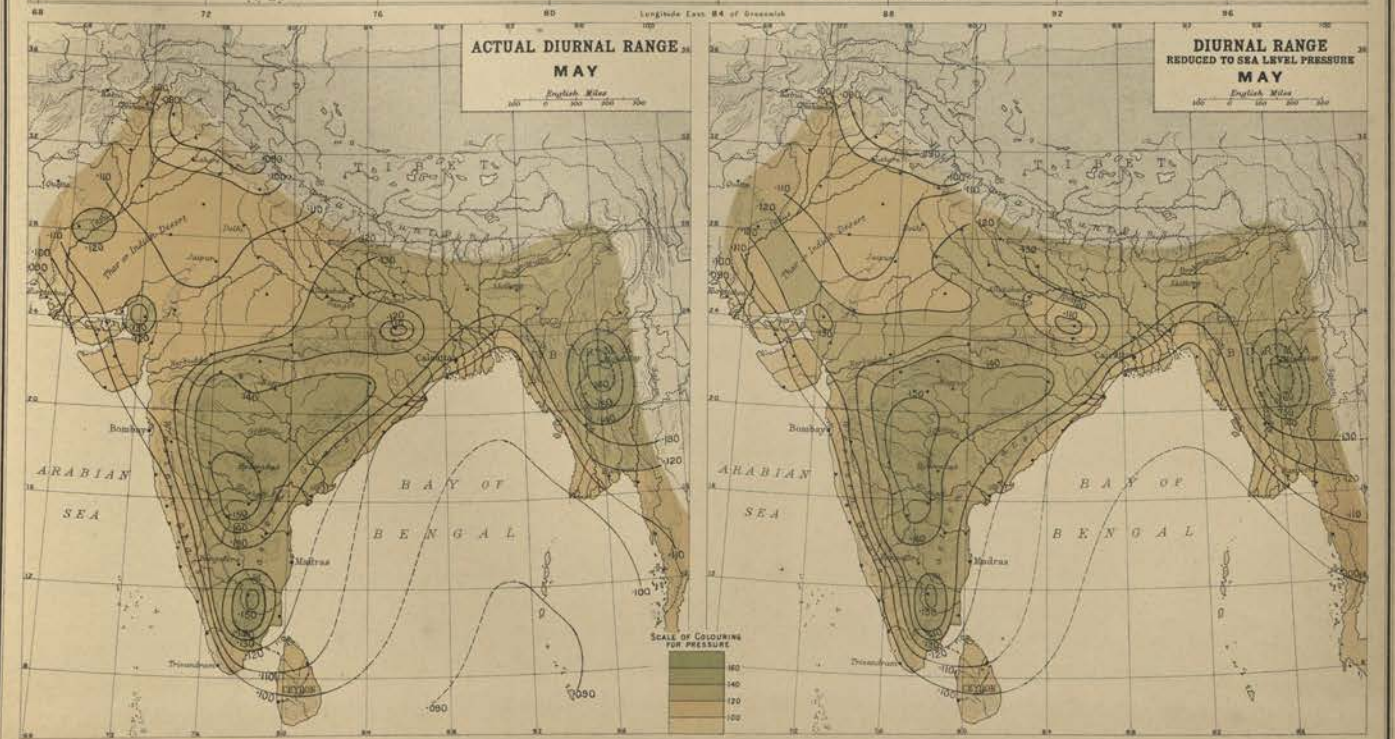
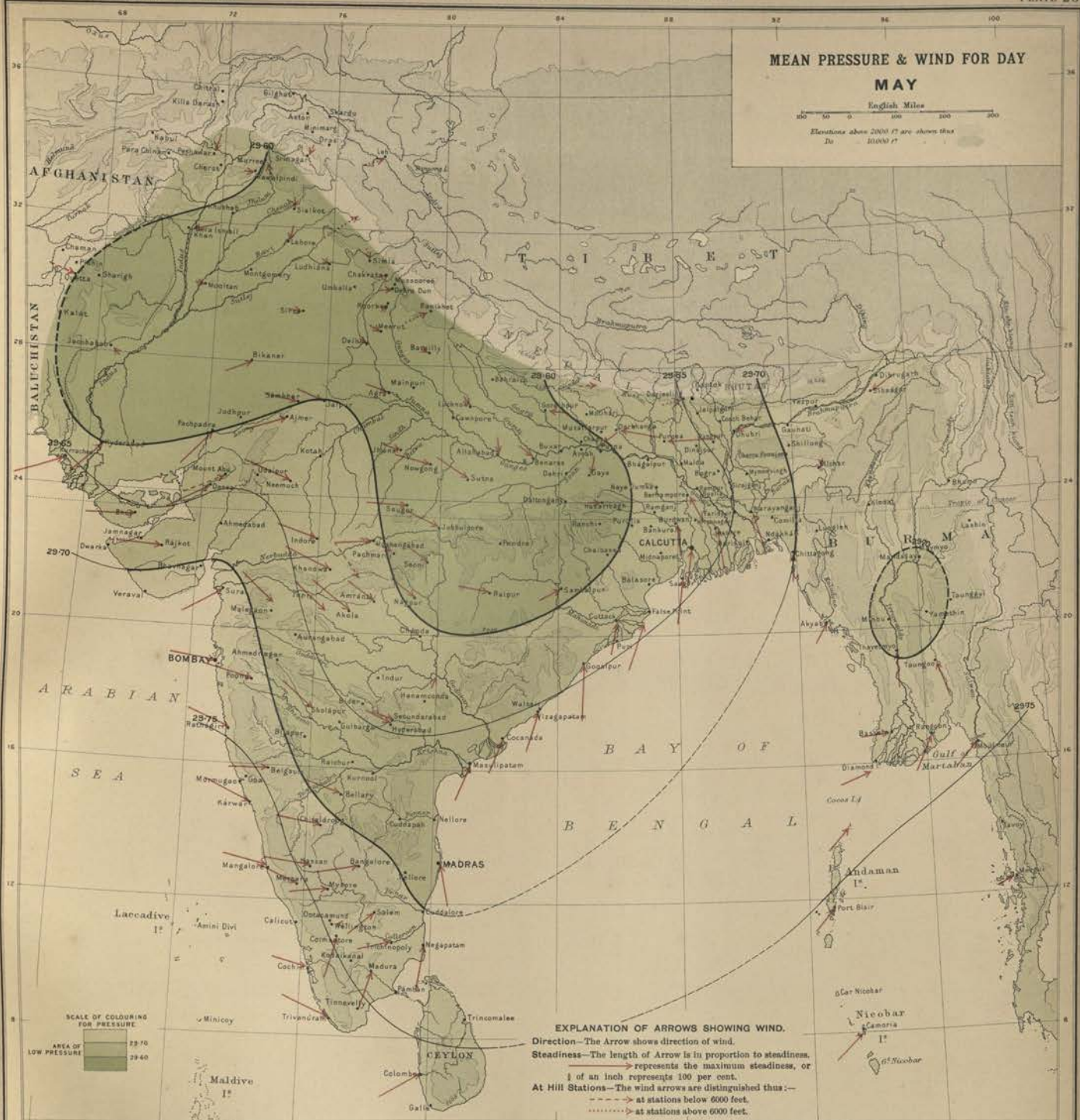


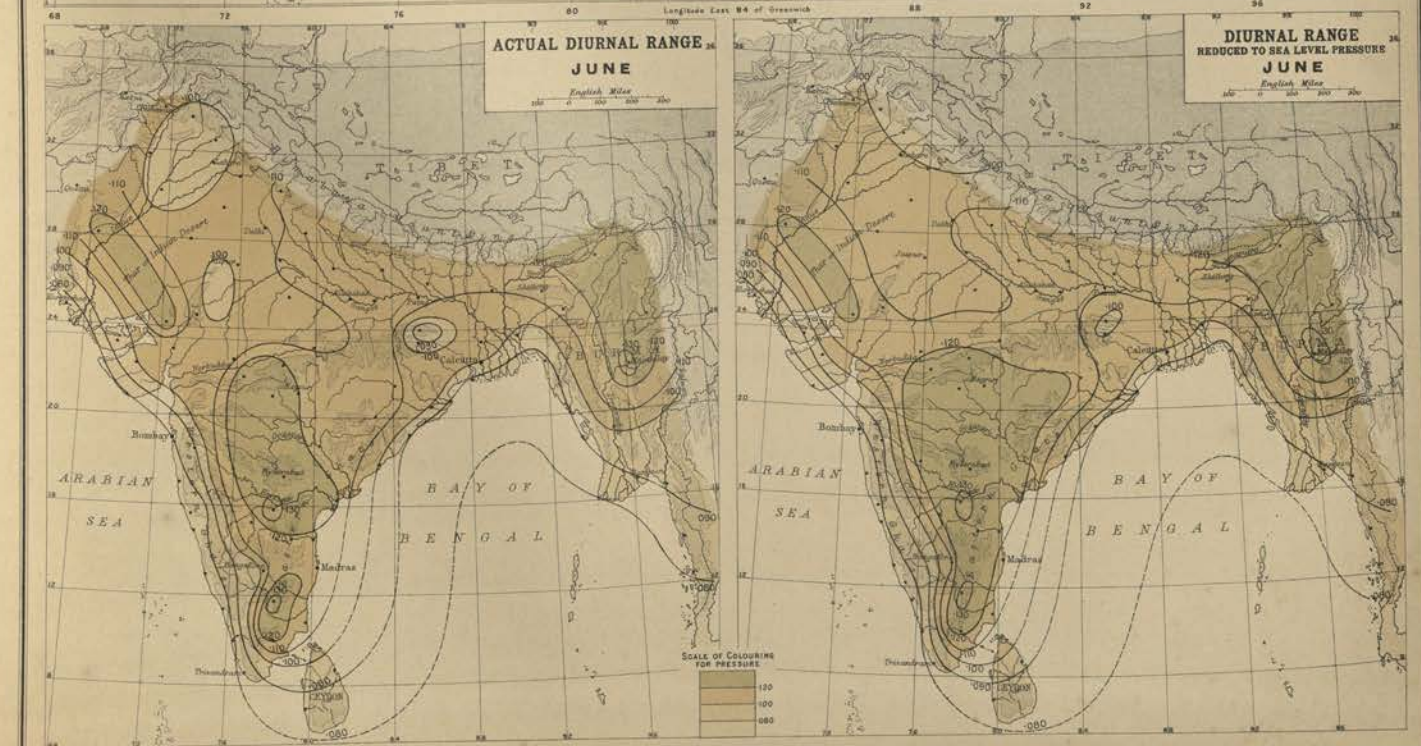


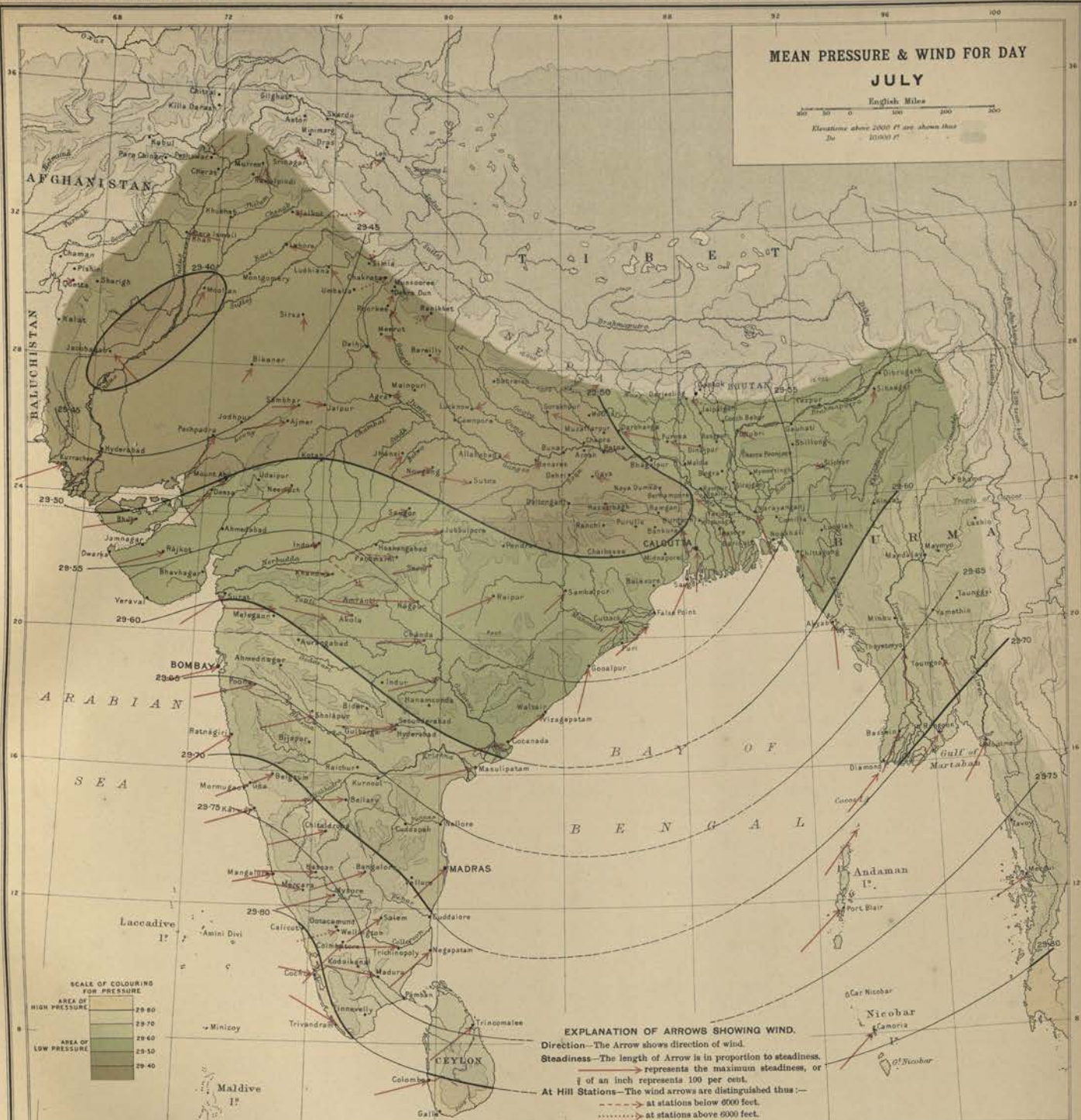




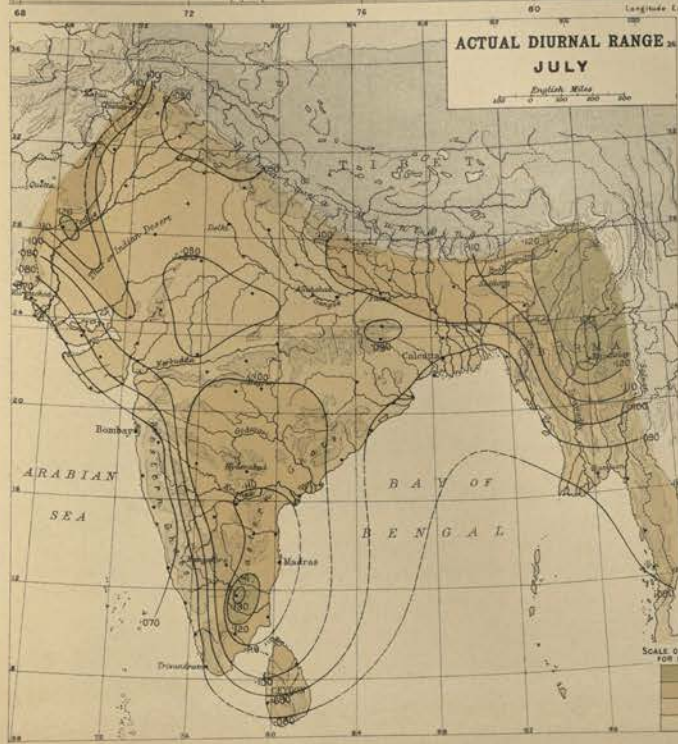




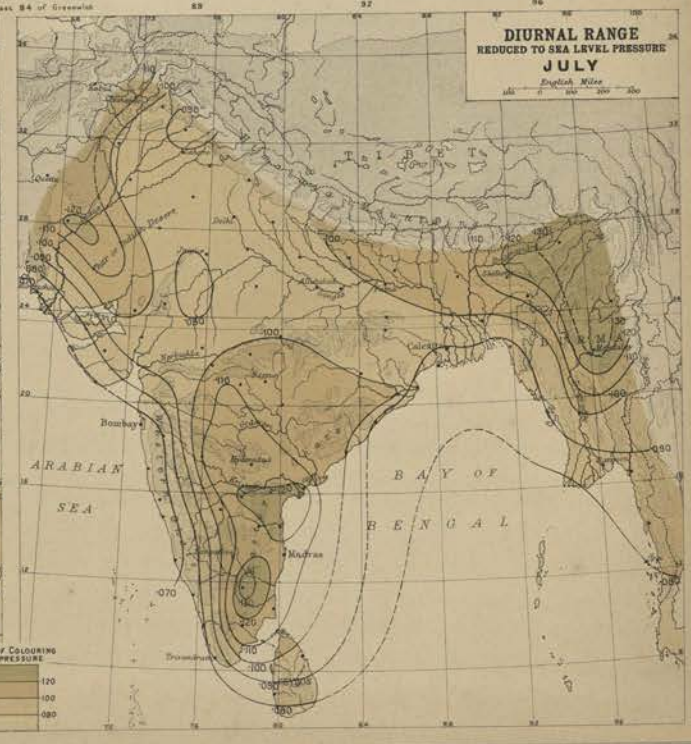


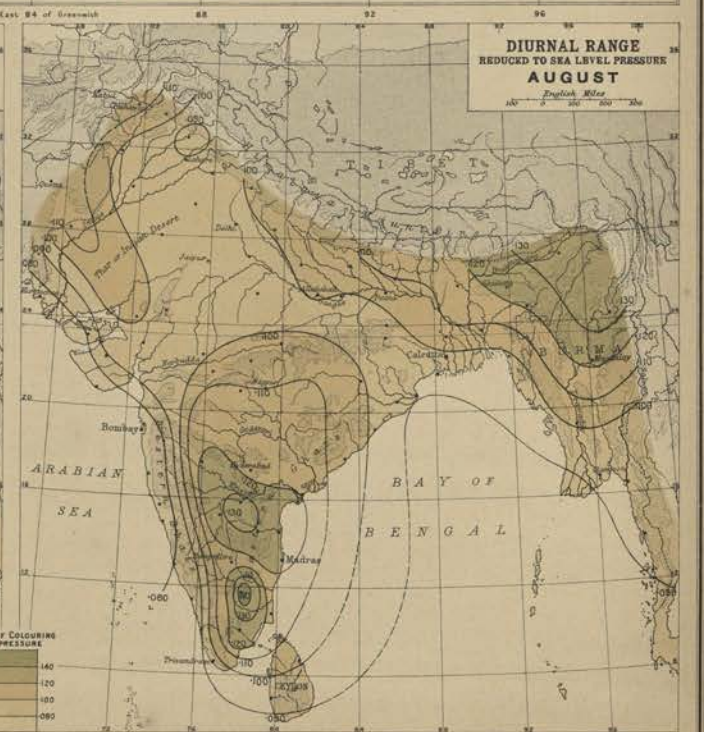
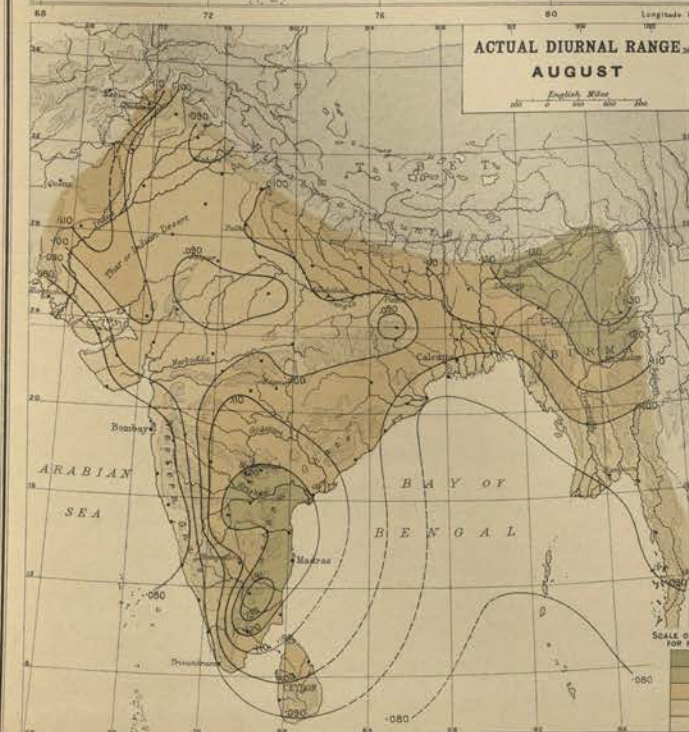
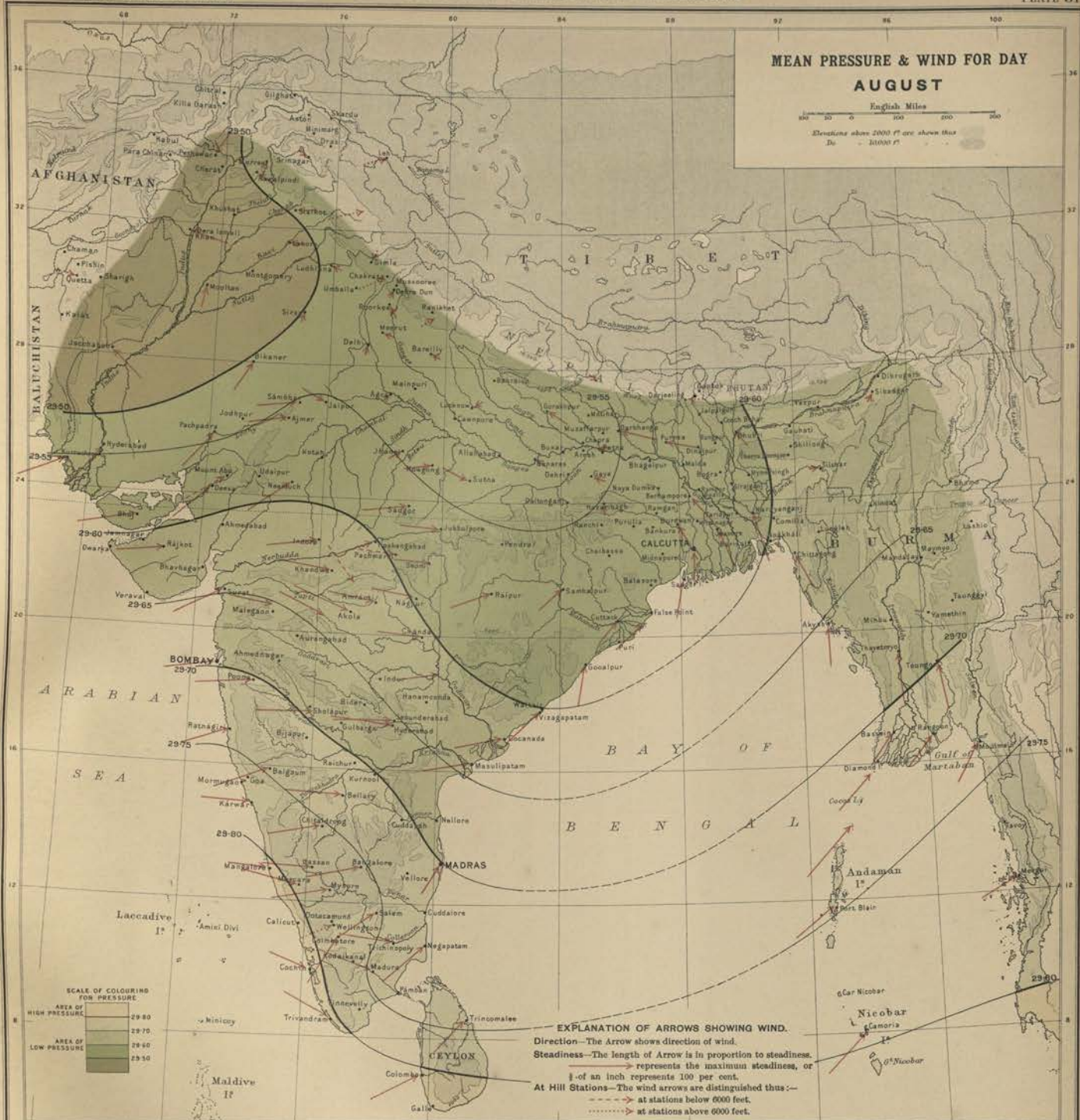


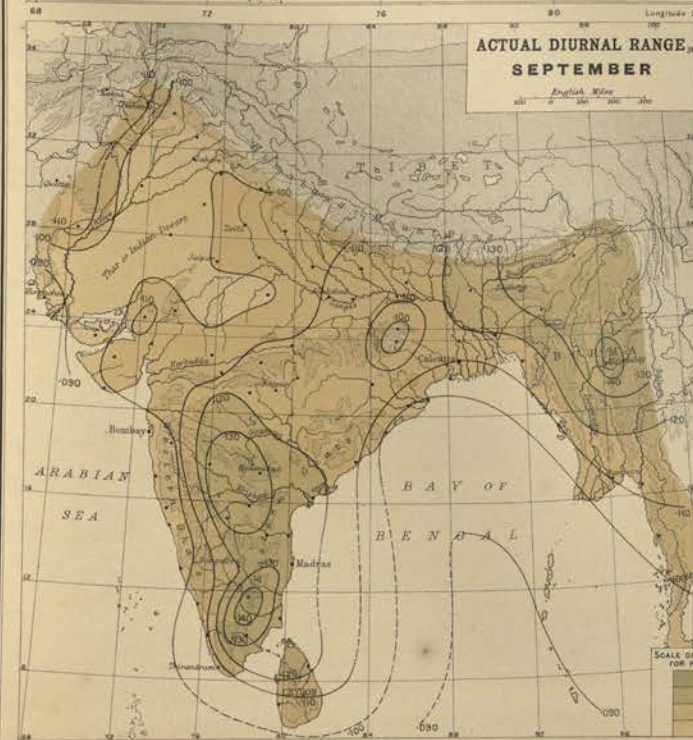
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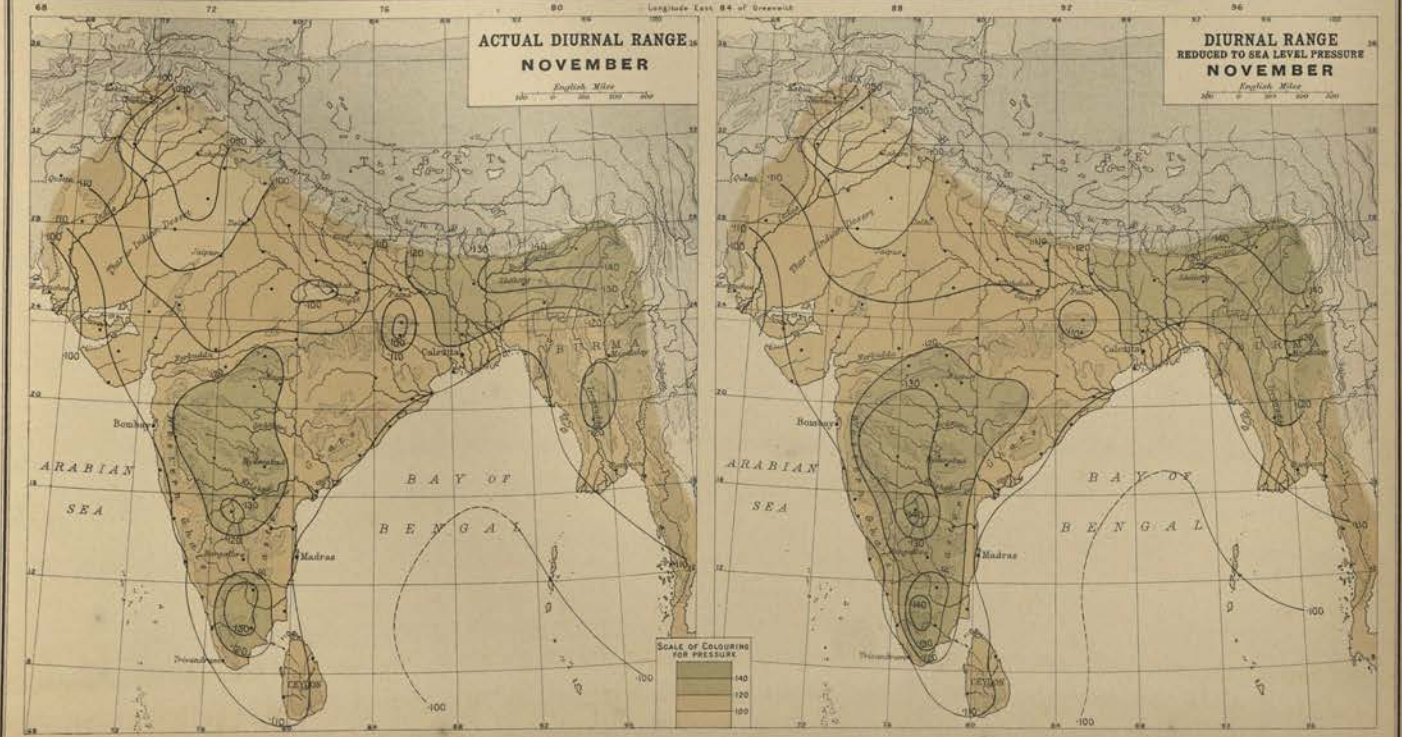
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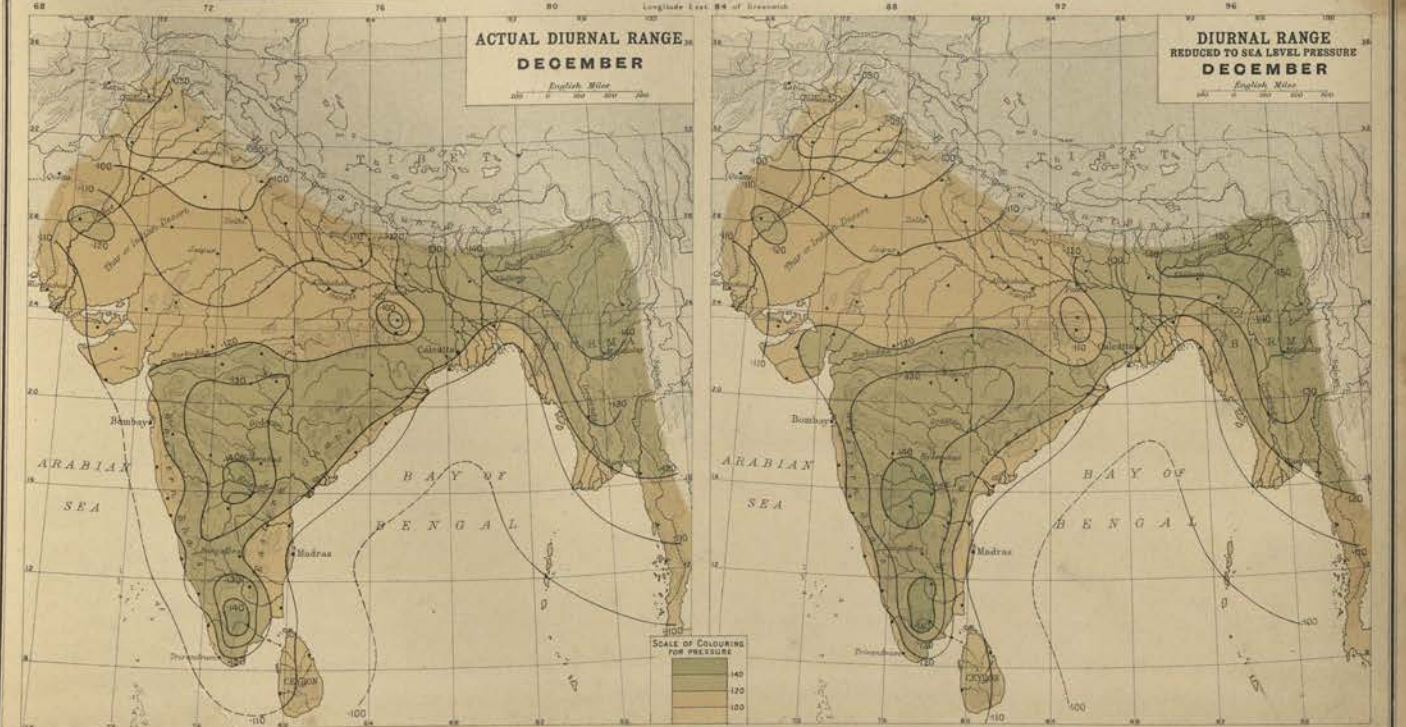
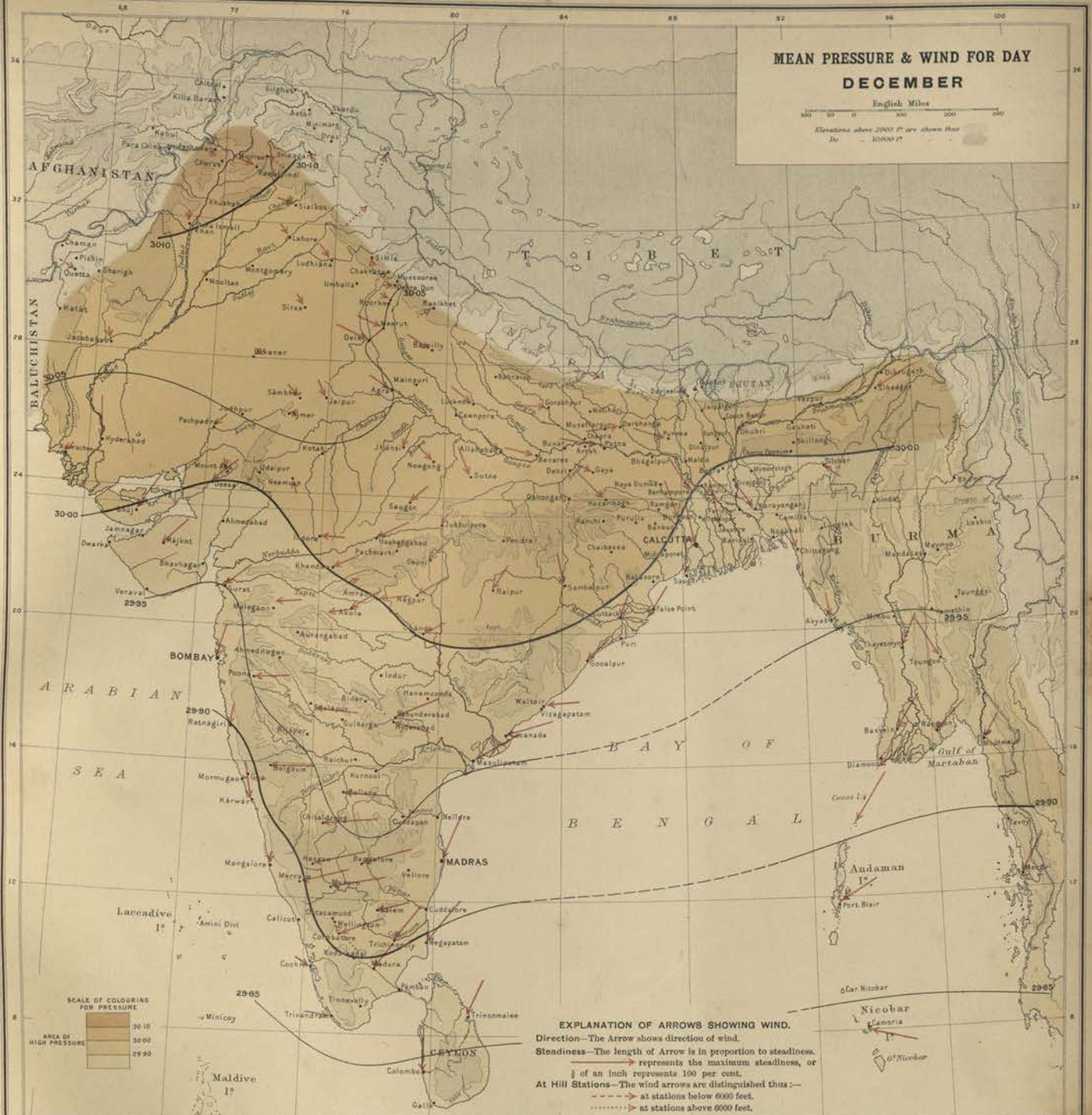


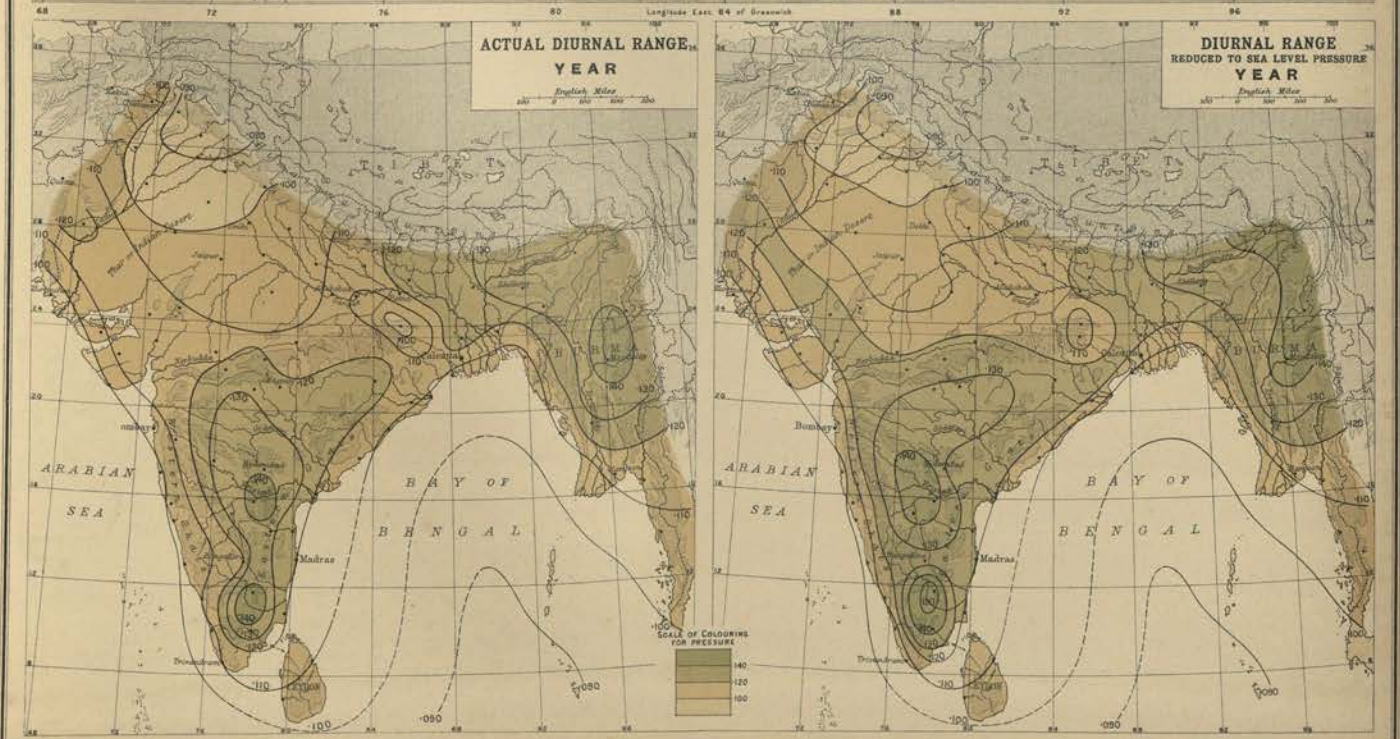
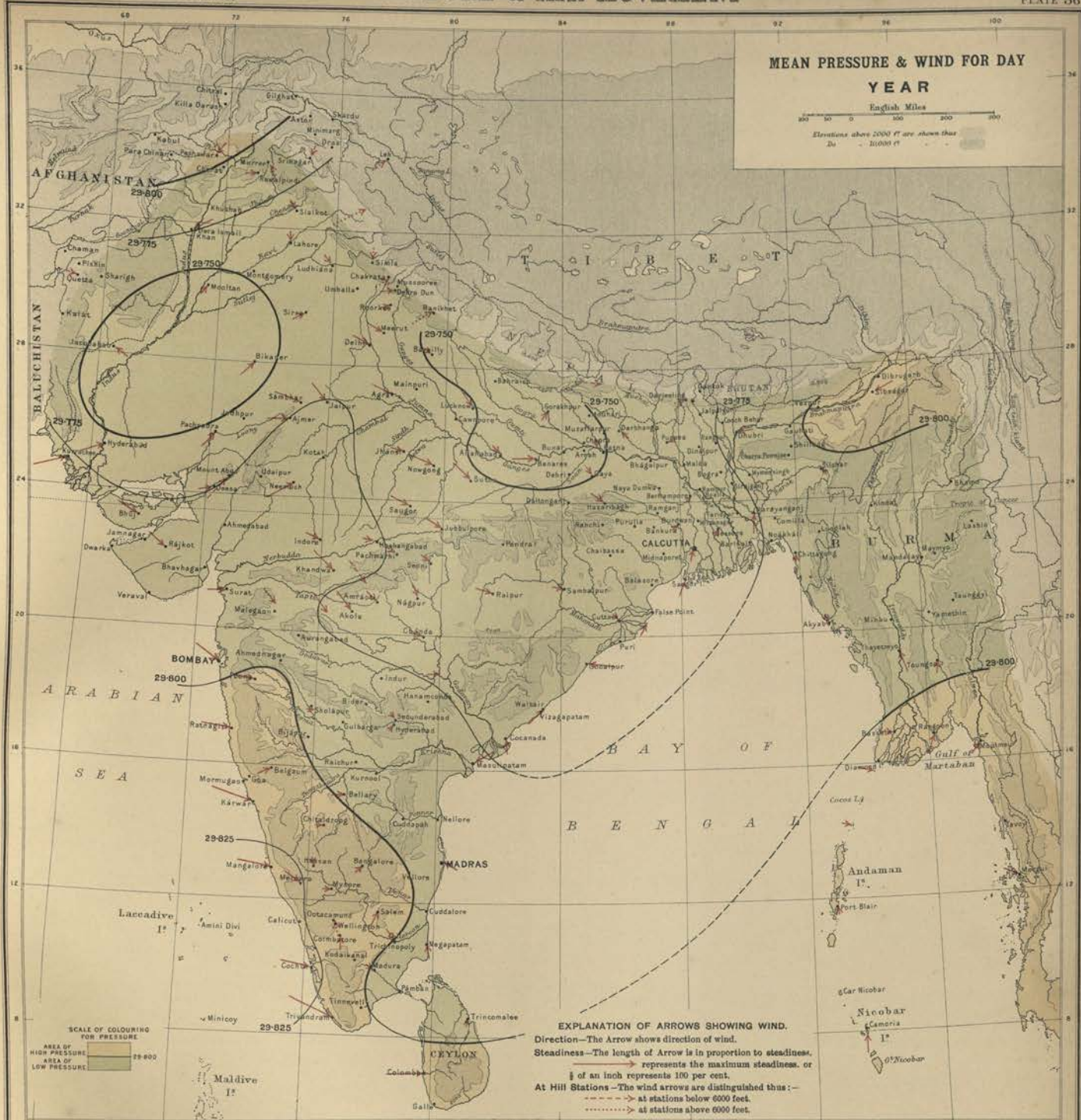


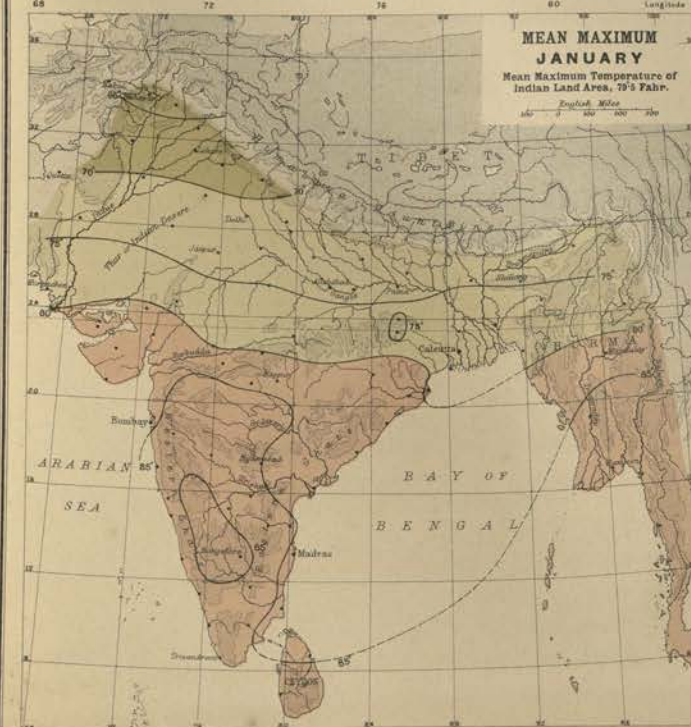
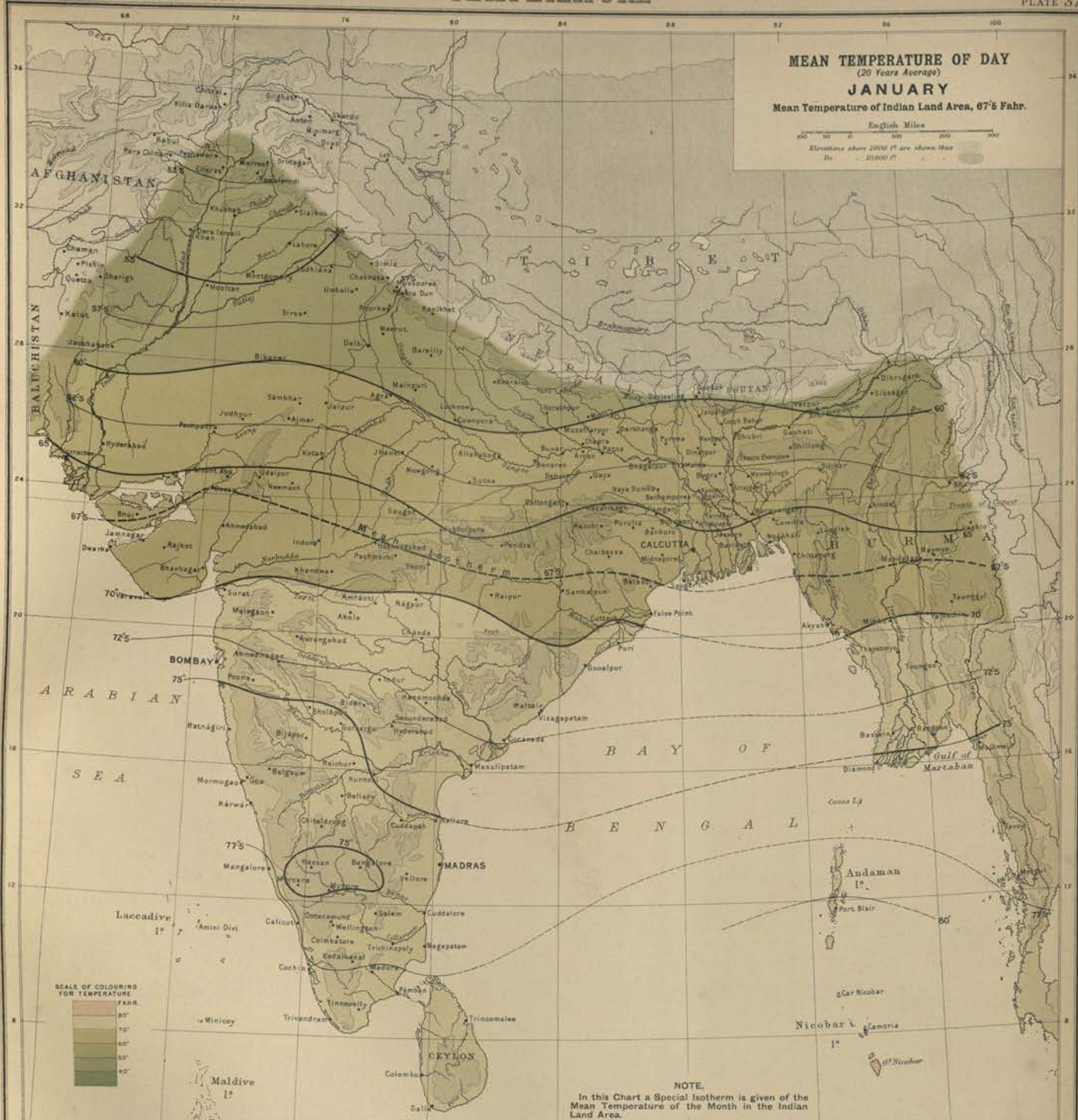






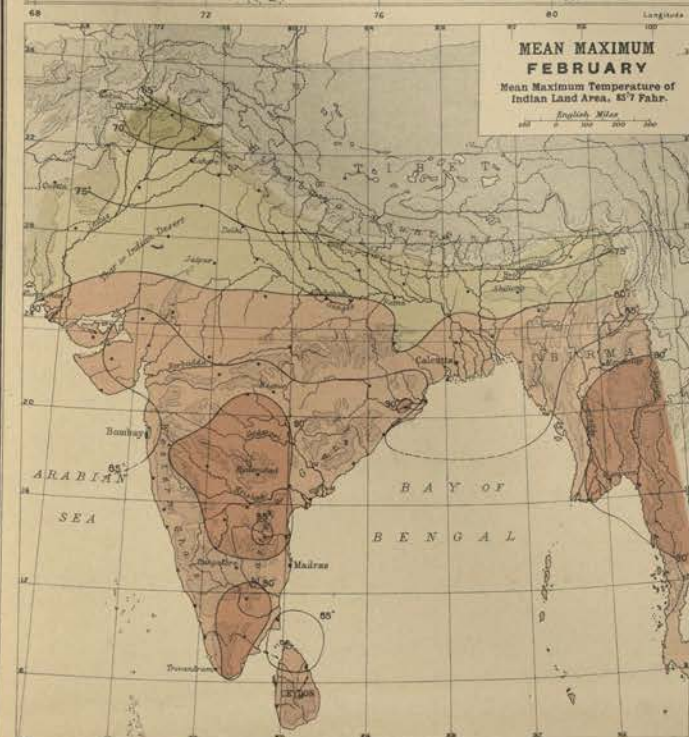
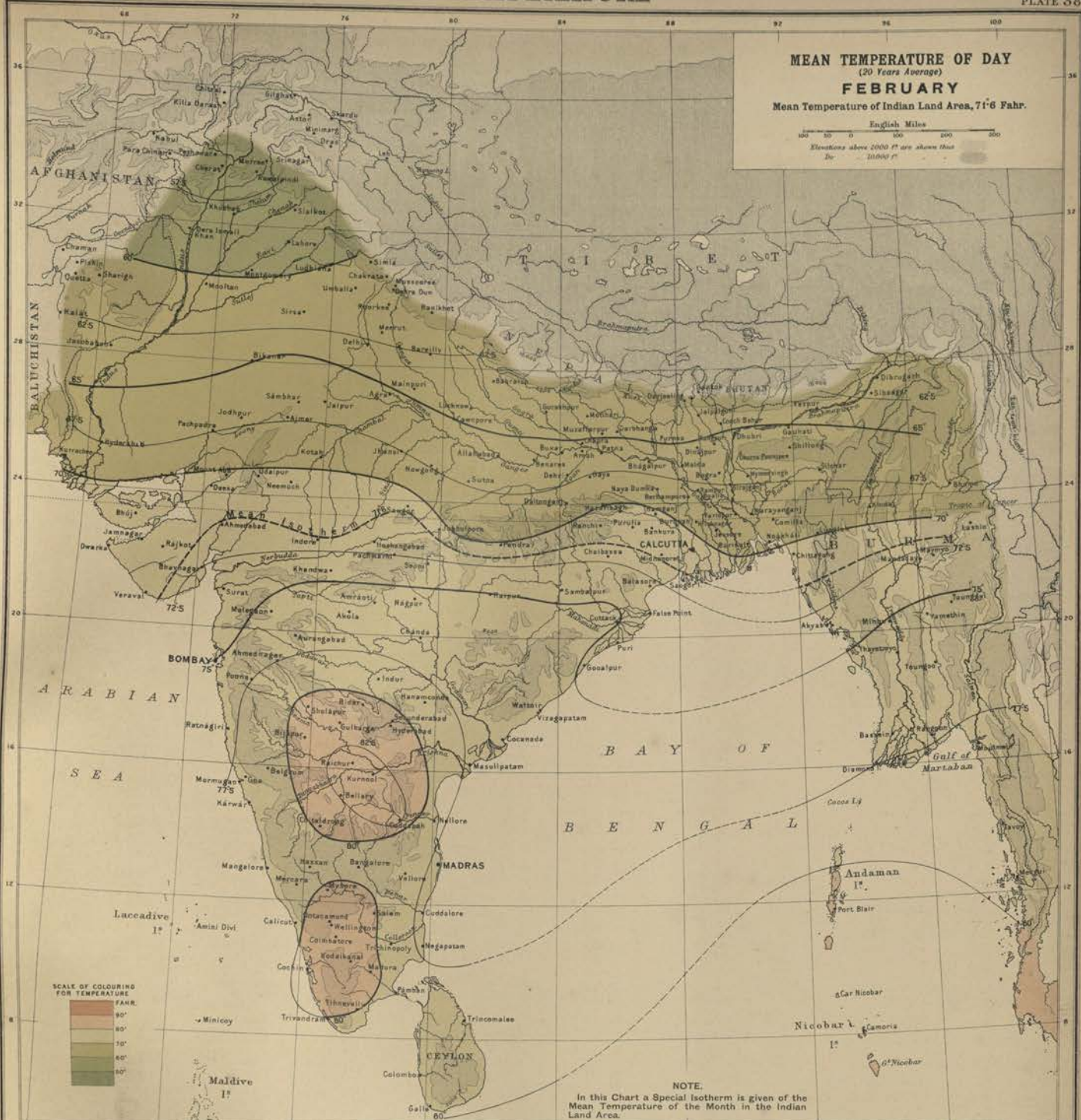






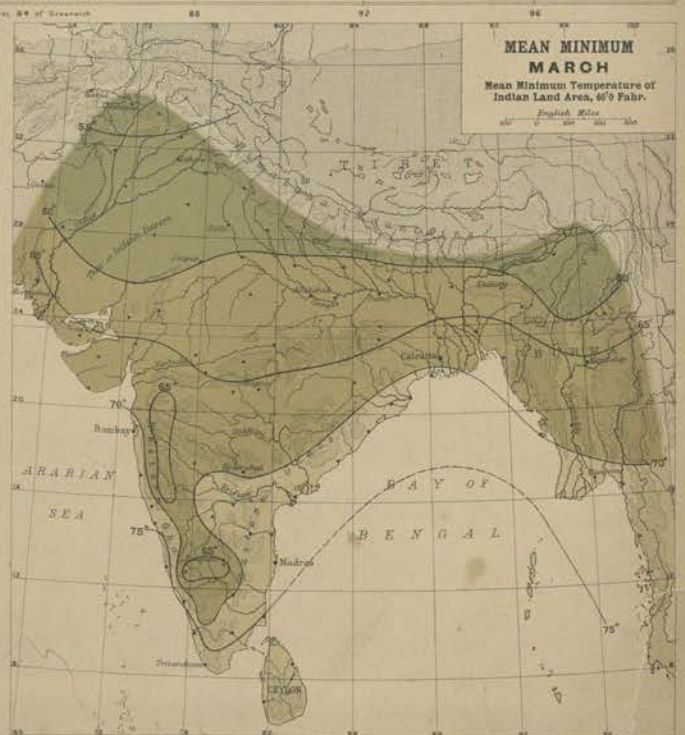
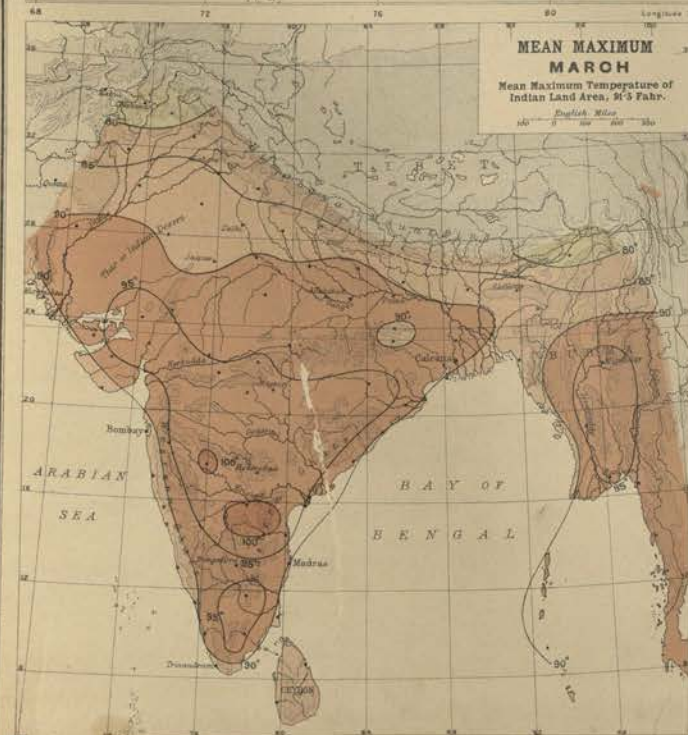
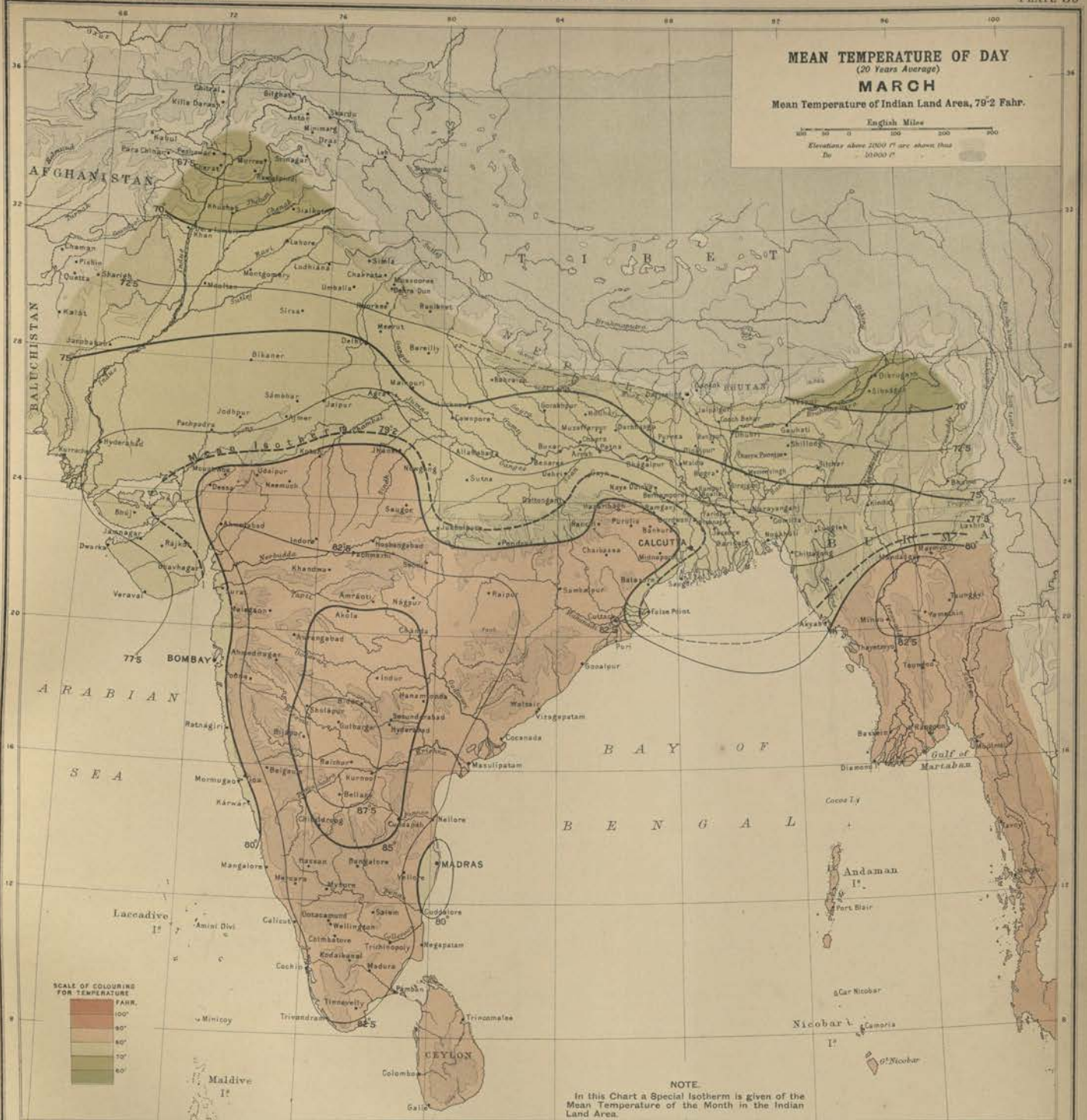
Mean Temperature is reduced to Sea Level by correction of 1° F. for every 450 feet of elevation.
The Isotherms are obtained from the data of Stations below 3000 feet in elevation.

Indian Meteorological Department.

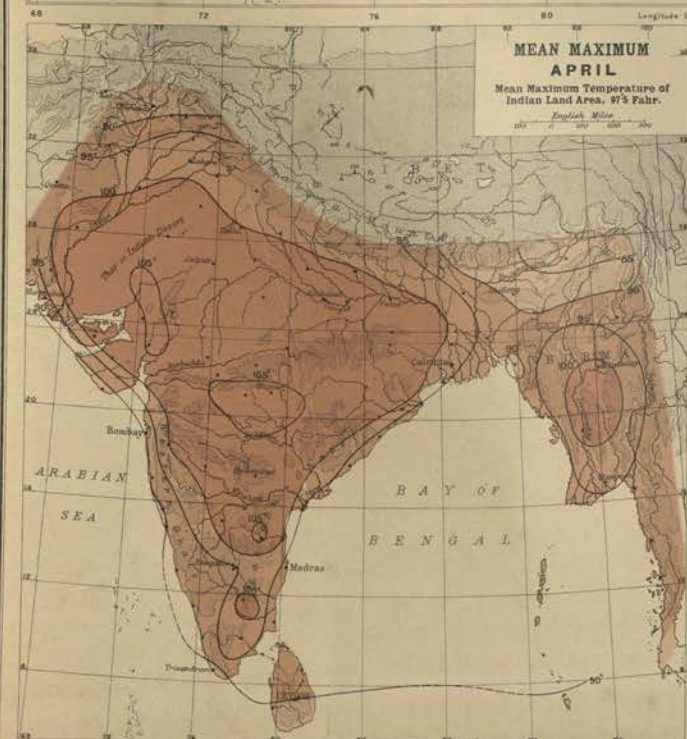
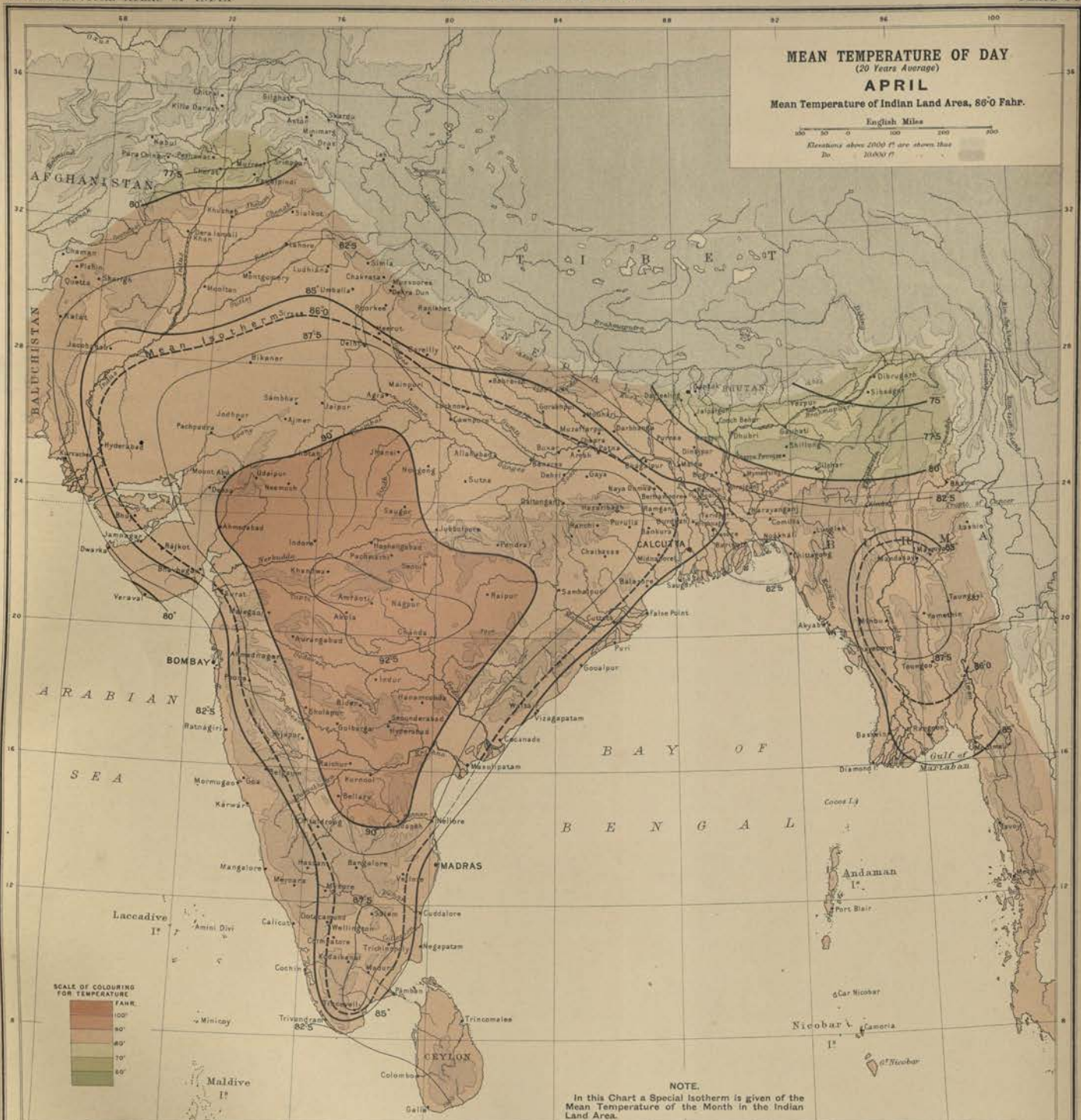


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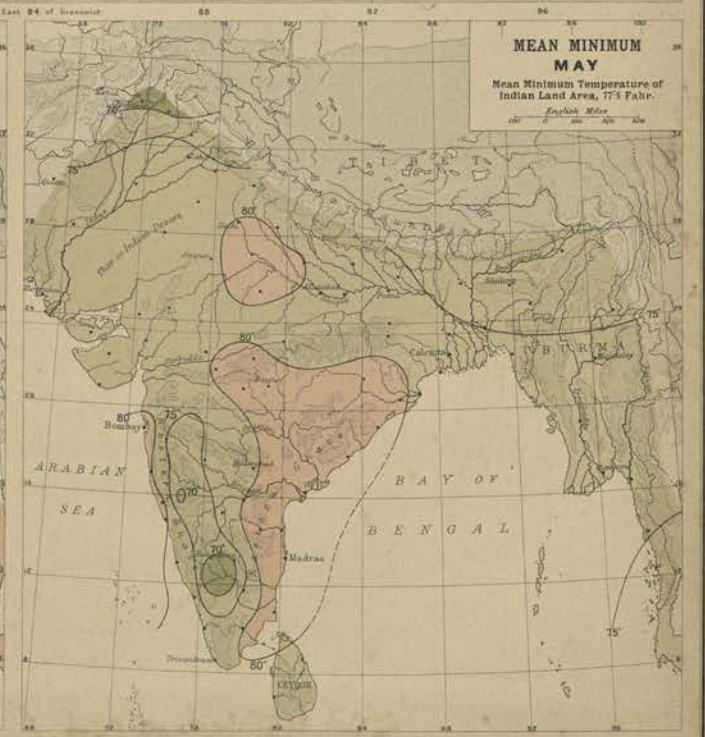
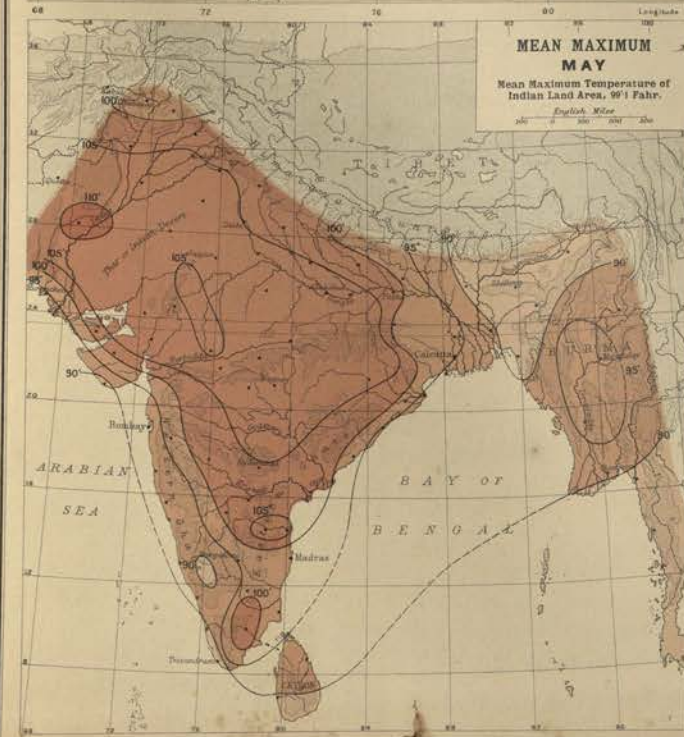
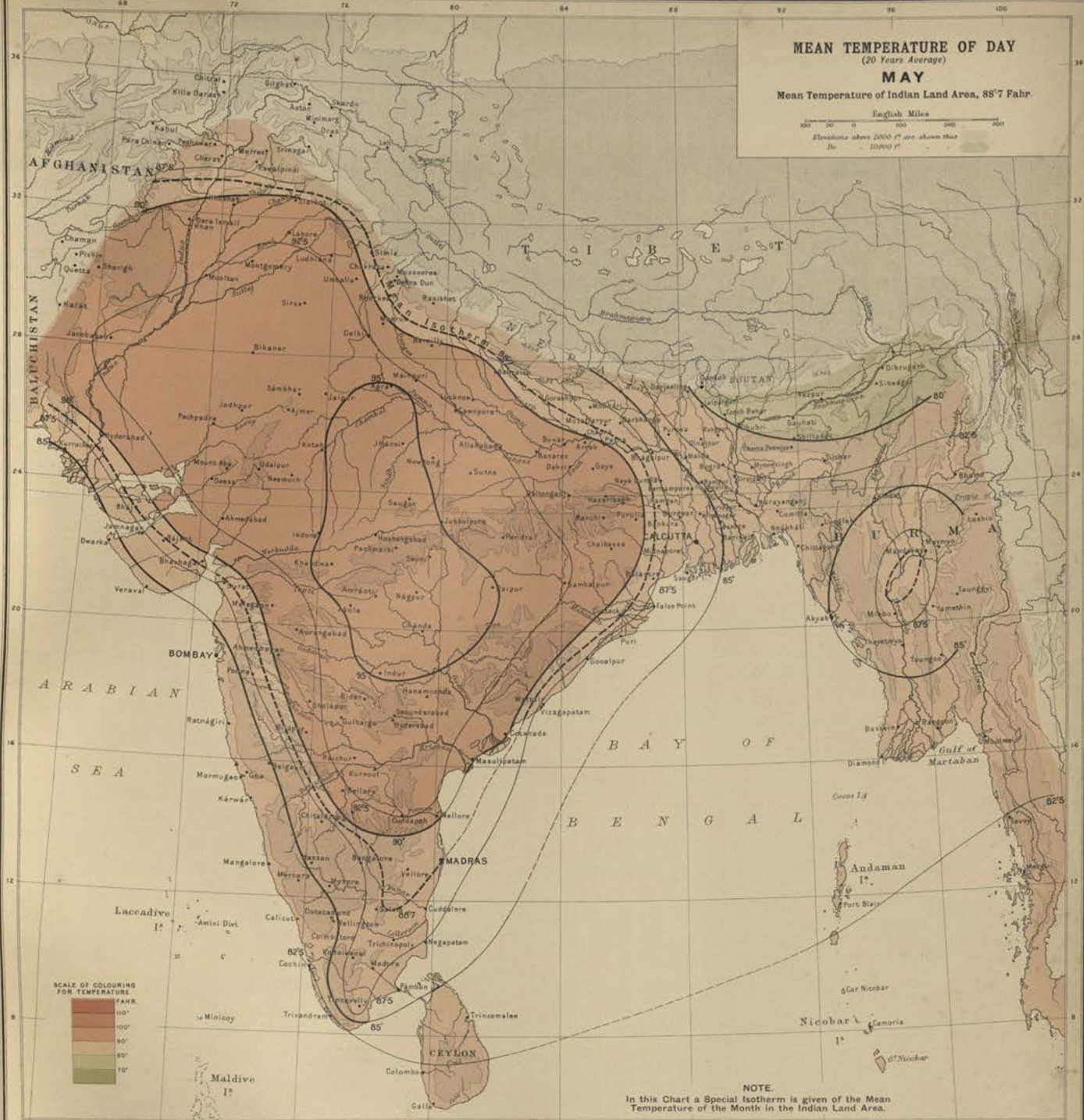
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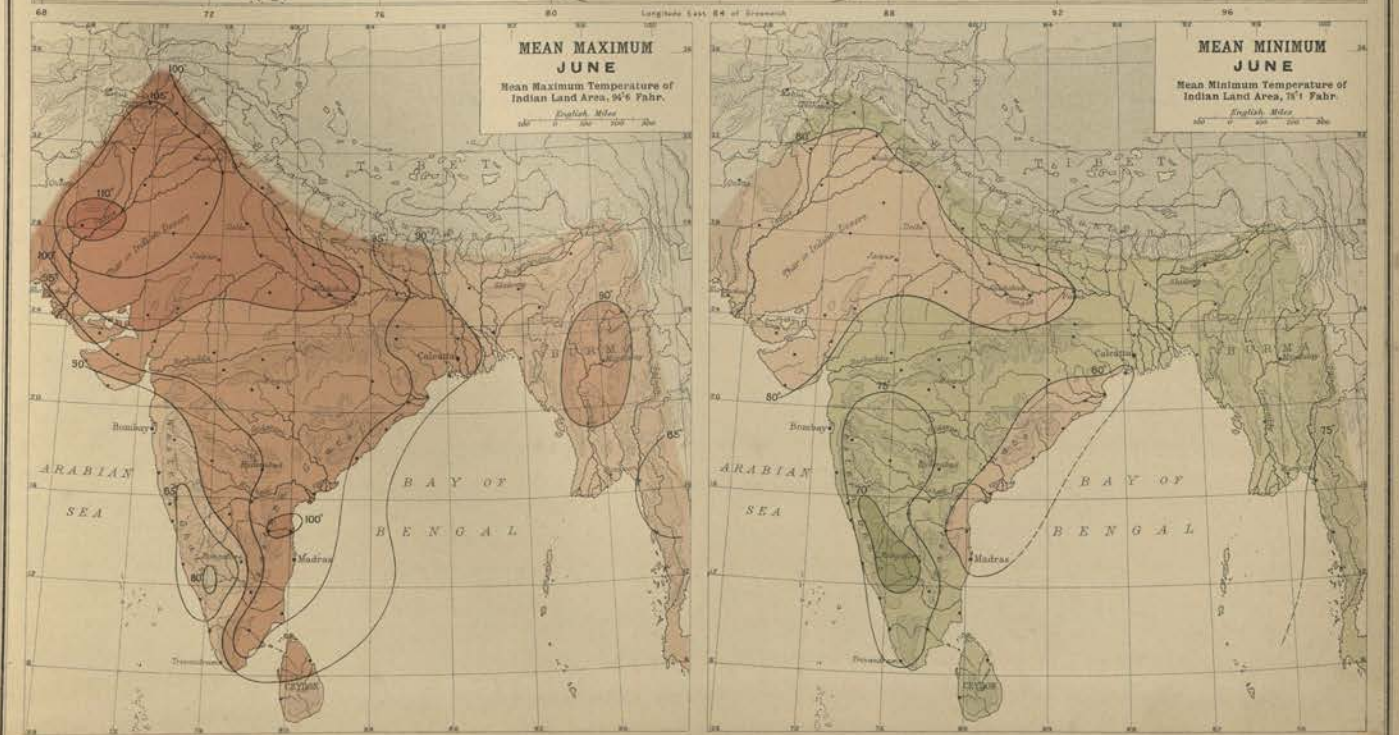
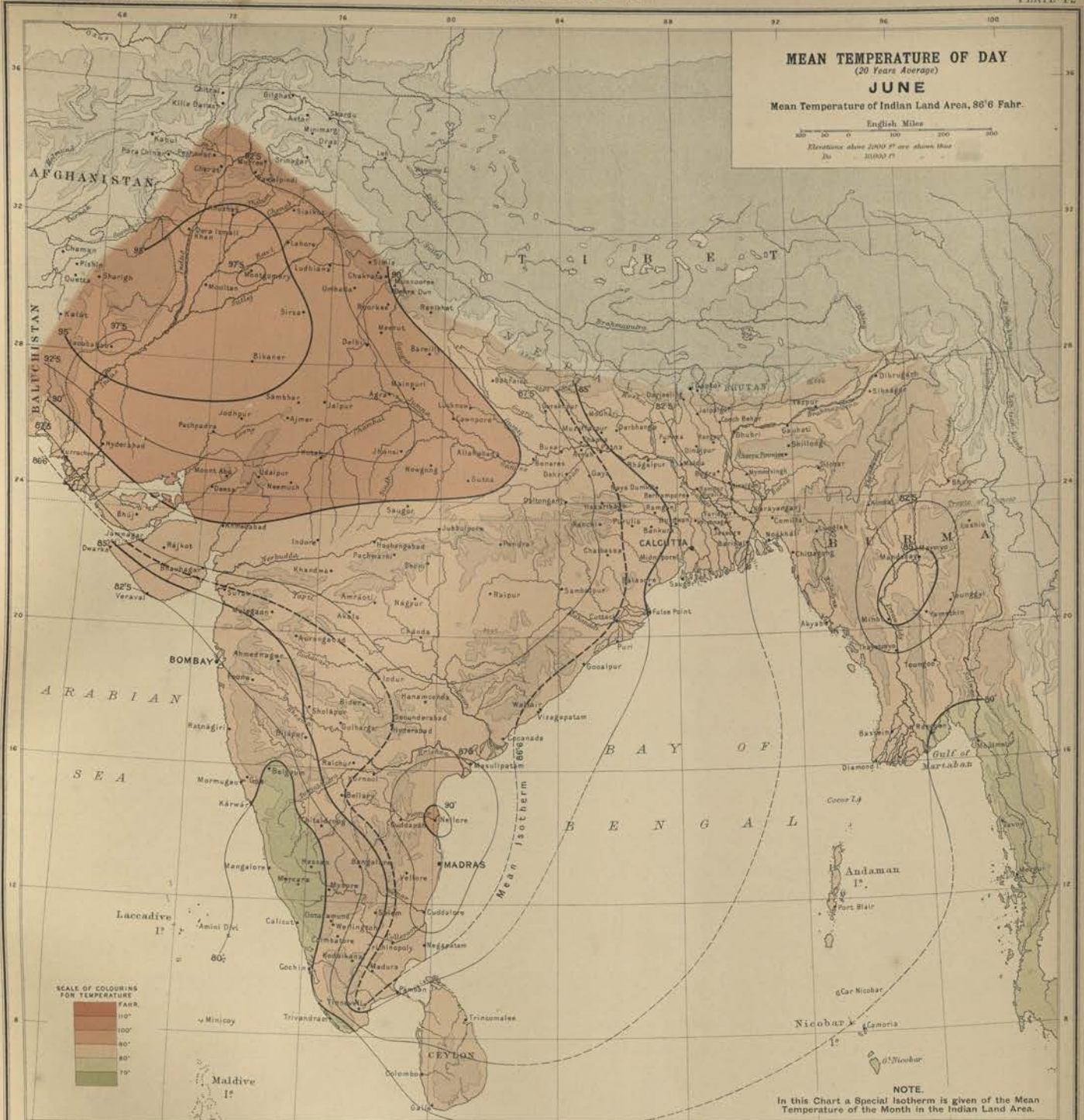


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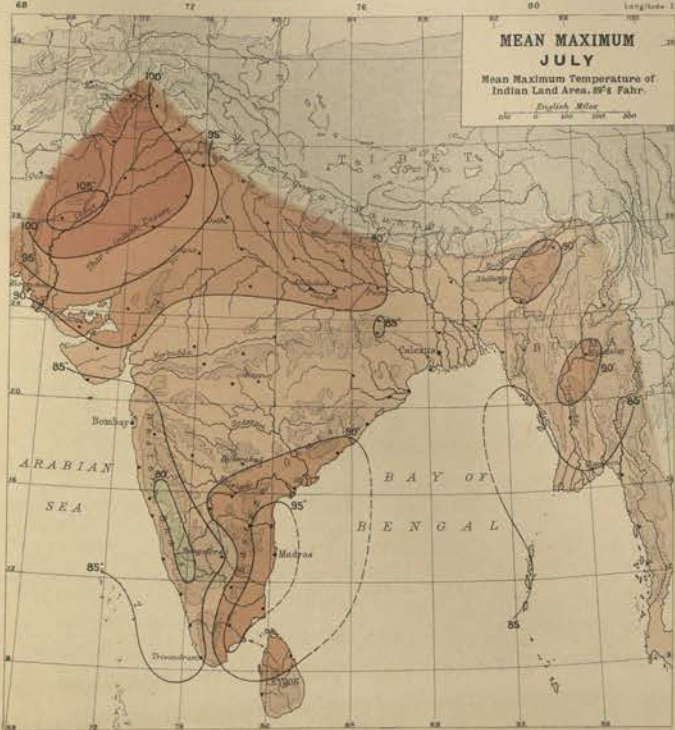
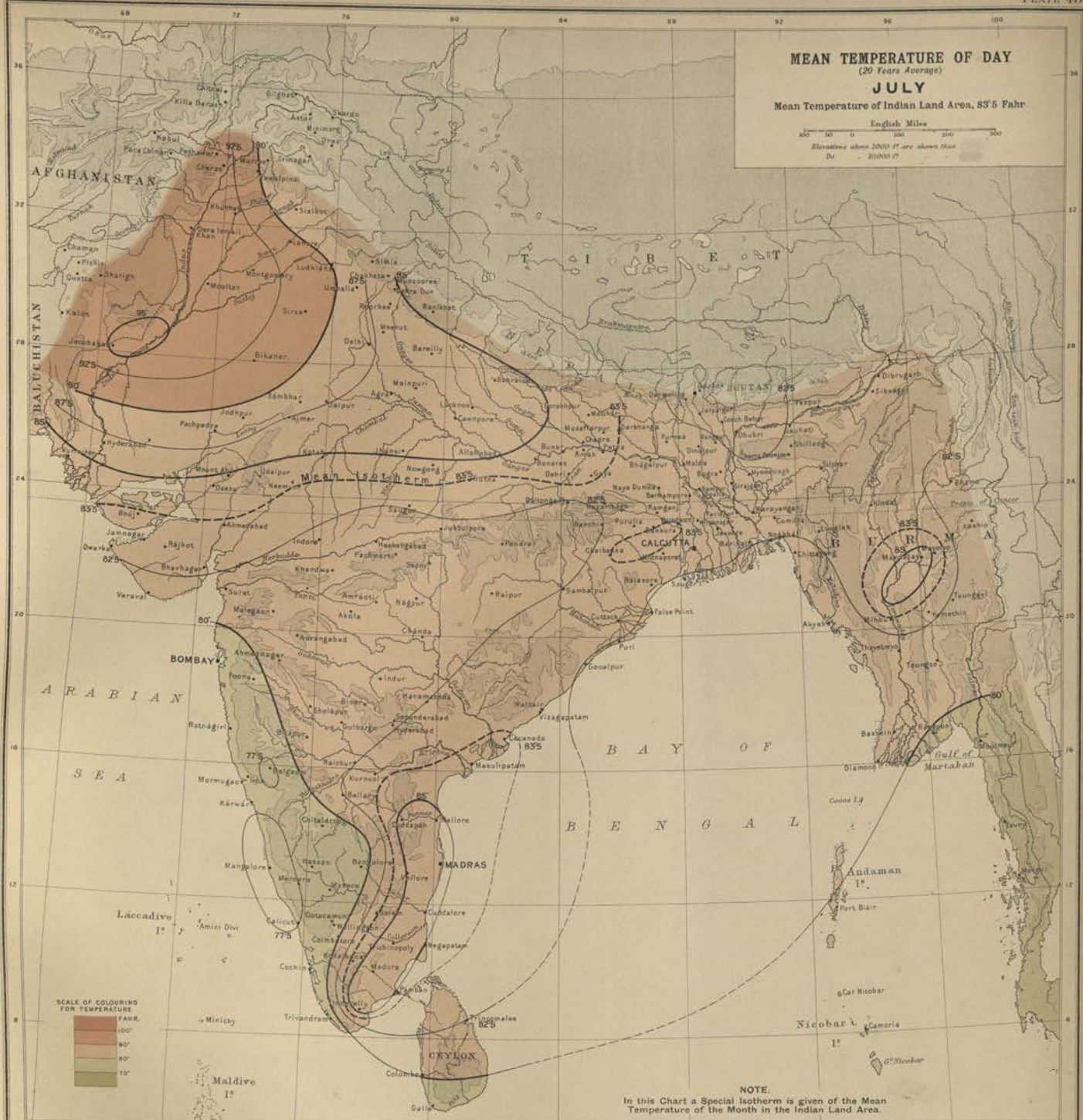




Mean Temperature is reduced to Sea Level by correction of 1° F. for every 450 feet of elevation.
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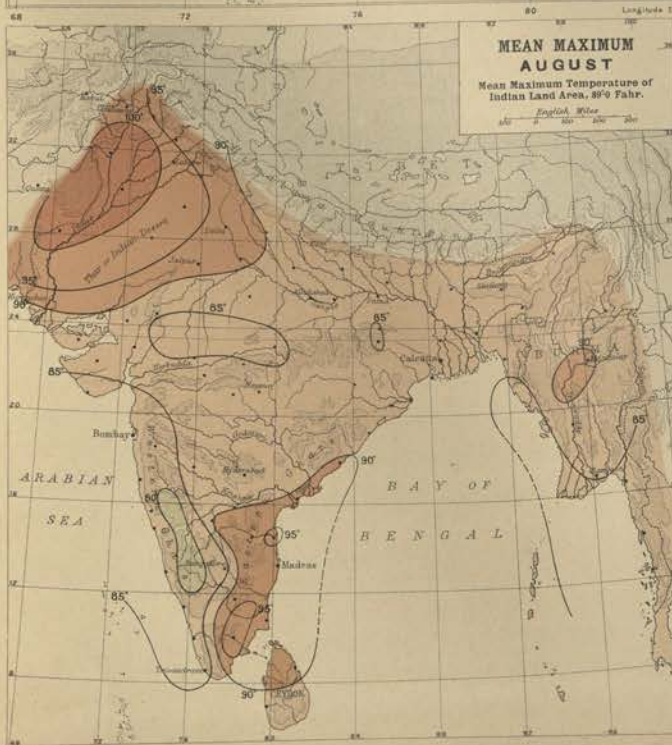
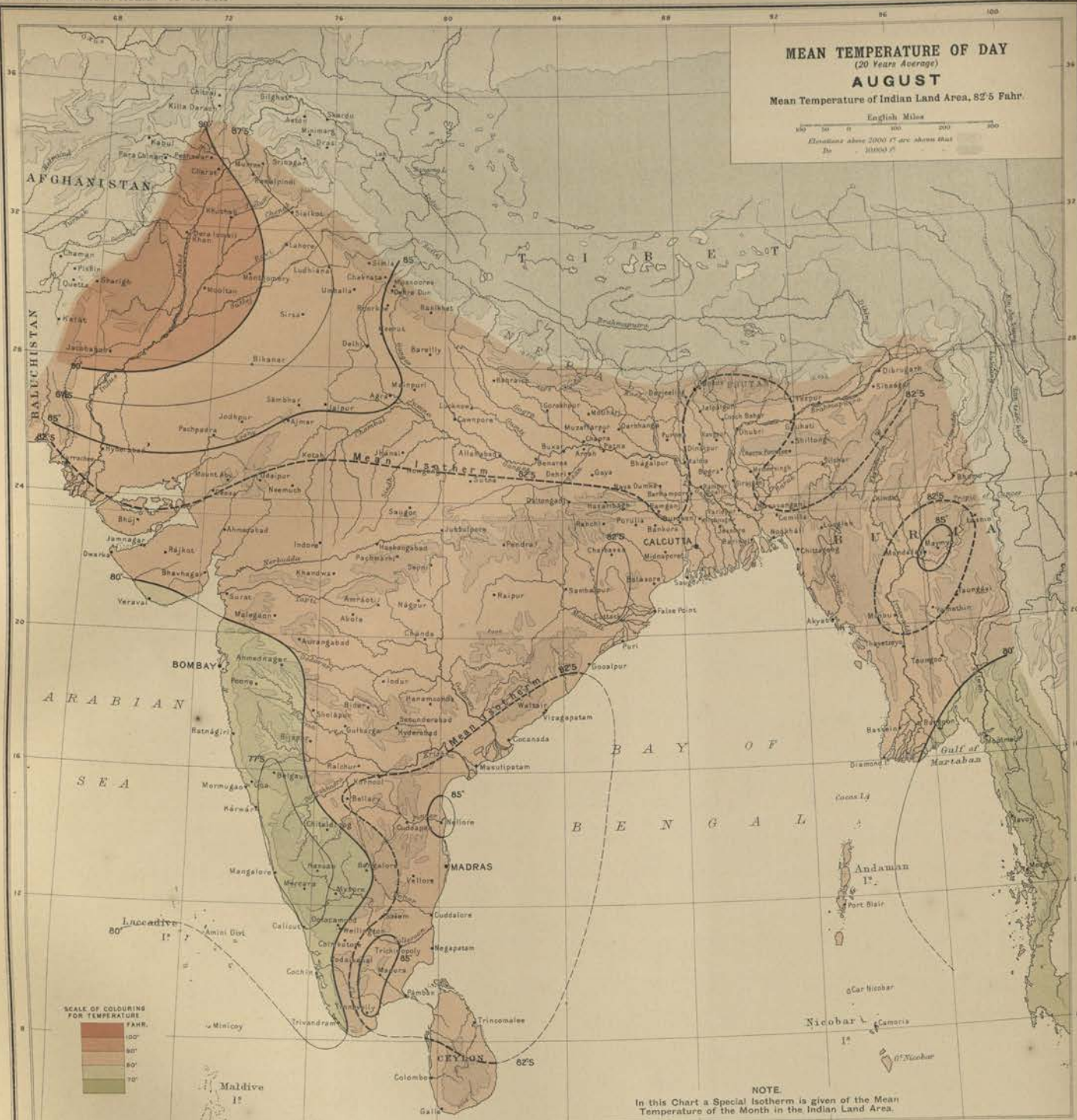
Indian Meteorological Department

J. D. Borchgrevink, Editor, Geogr. Inst.



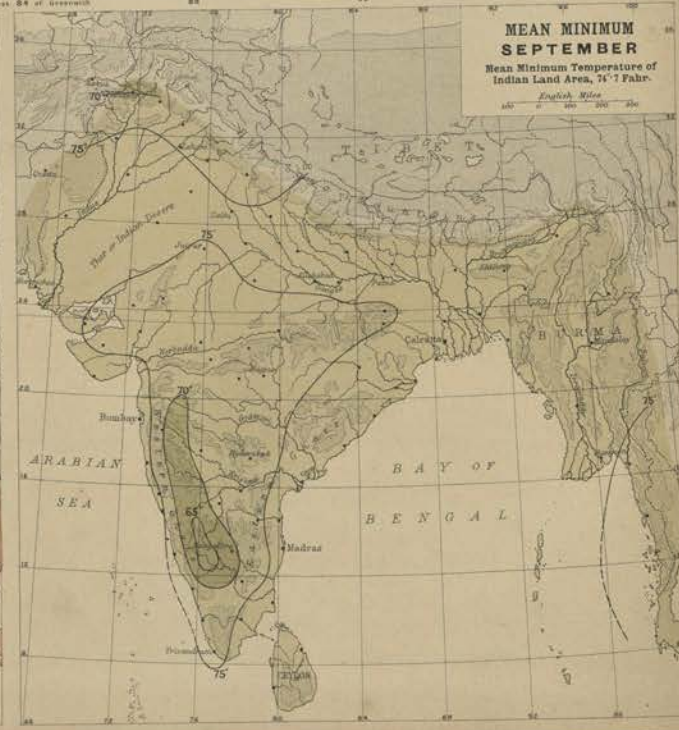
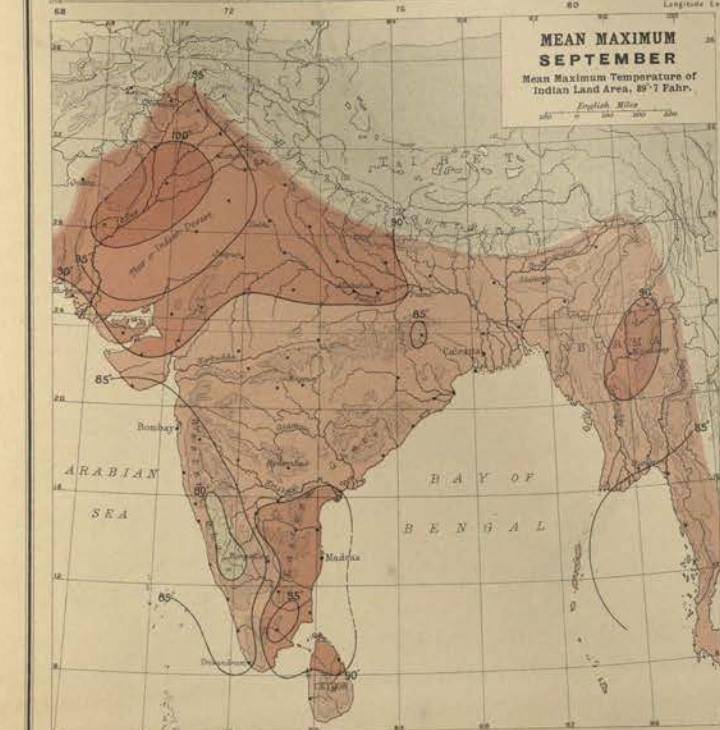
Mean Temperature is reduced to Sea Level by correction of $t^{\circ}\text{F.}$ for every 450 feet of elevation.
The isotherms are obtained from the data of Stations below 3000 feet in elevation.

Indian Meteorological Department



Mean Temperature is reduced to Sea Level by correction of 1° F. for every 450 feet of elevation.
The Isotherms are obtained from the data of Stations below 3000 feet in elevation.

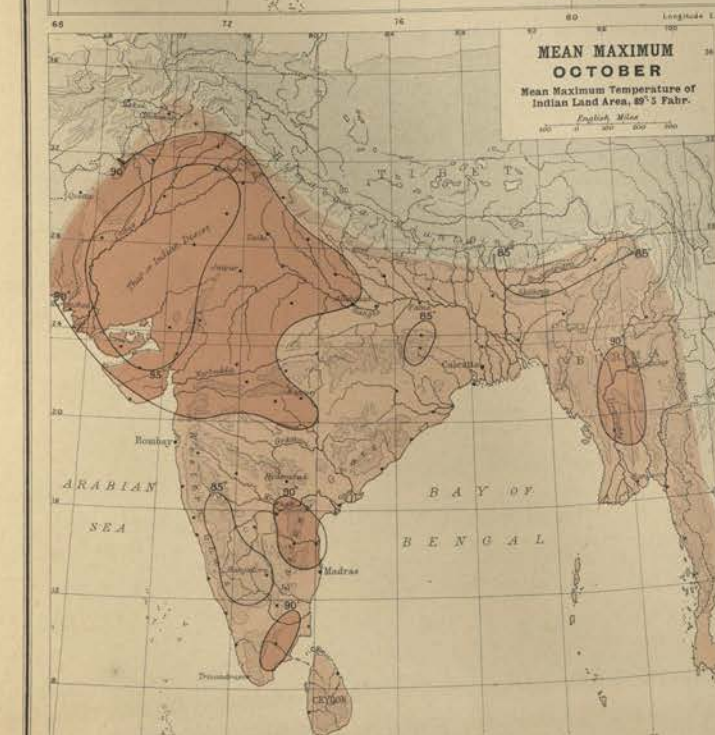
Indian Meteorological Department



Mean Temperature is reduced to Sea Level by correction of 1° F. for every 450 feet of elevation.
The Isotherms are obtained from the data of Stations below 3000 feet in elevation.

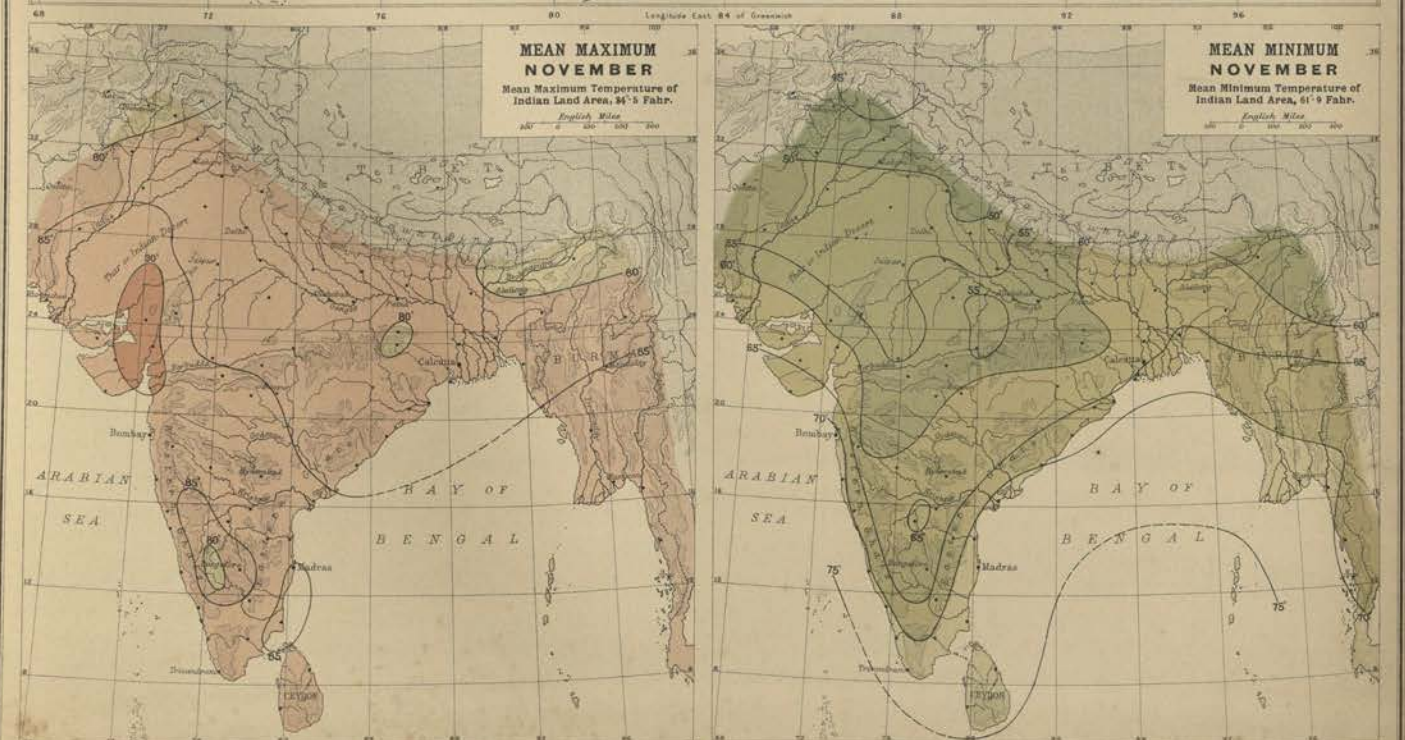
Indian Meteorological Department

J. V. Burckelove, Editor Charge 1911.

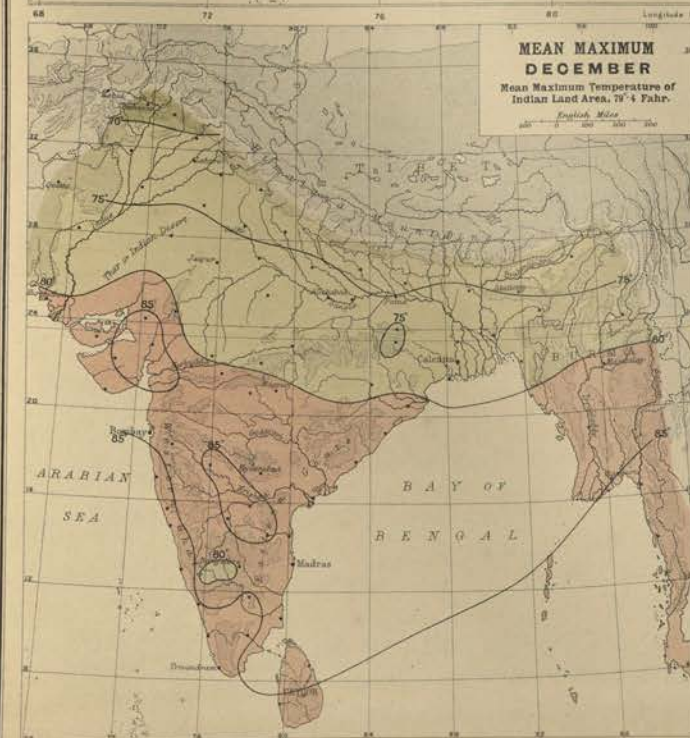


Mean Temperature is reduced to Sea Level by correction of 1° F. for every 450 feet of elevation.
The Isotherms are obtained from the data of Stations below 3000 feet in elevation.

Indian Meteorological Department



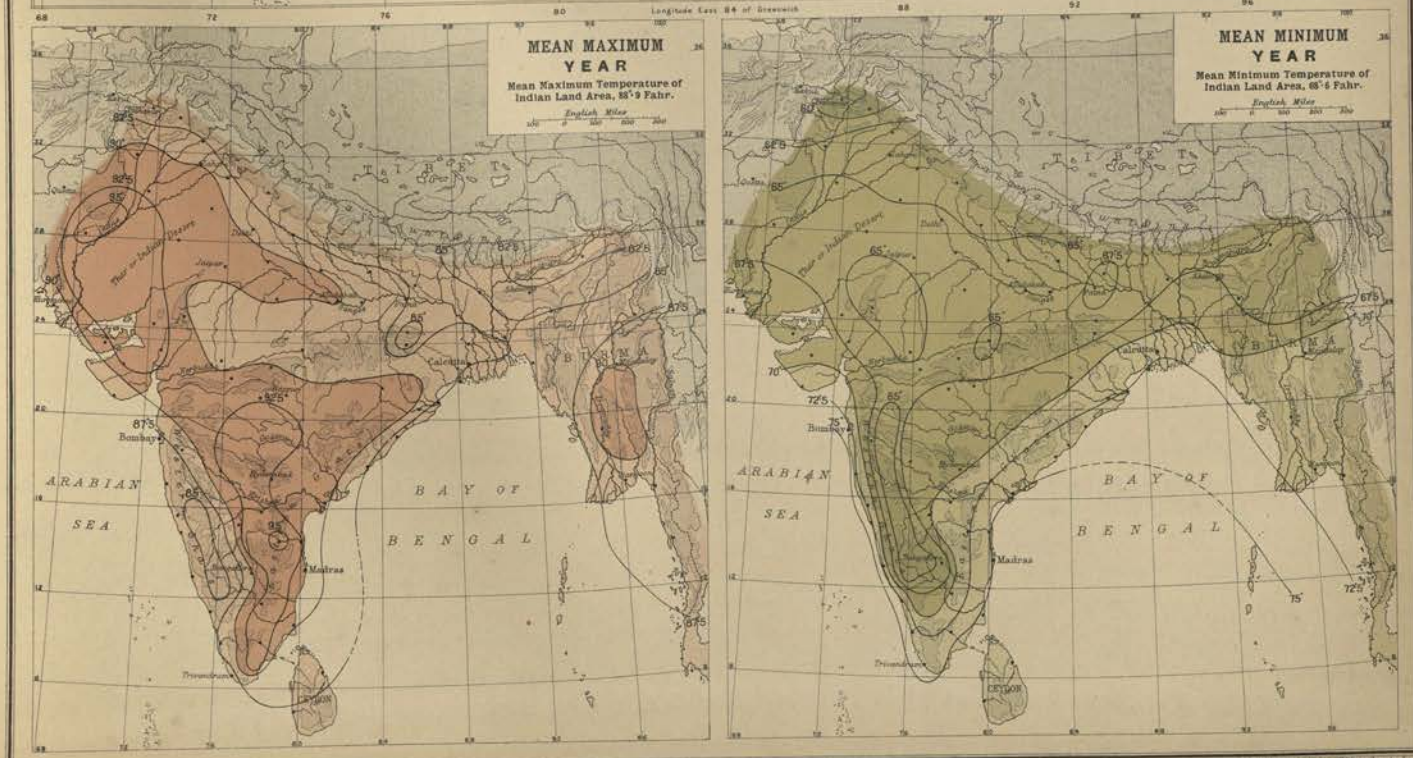
Mean Temperature is reduced to Sea Level by correction of 1° F. for every 450 feet of elevation.
The Isotherms are obtained from the data of Stations below 3000 feet in elevation.

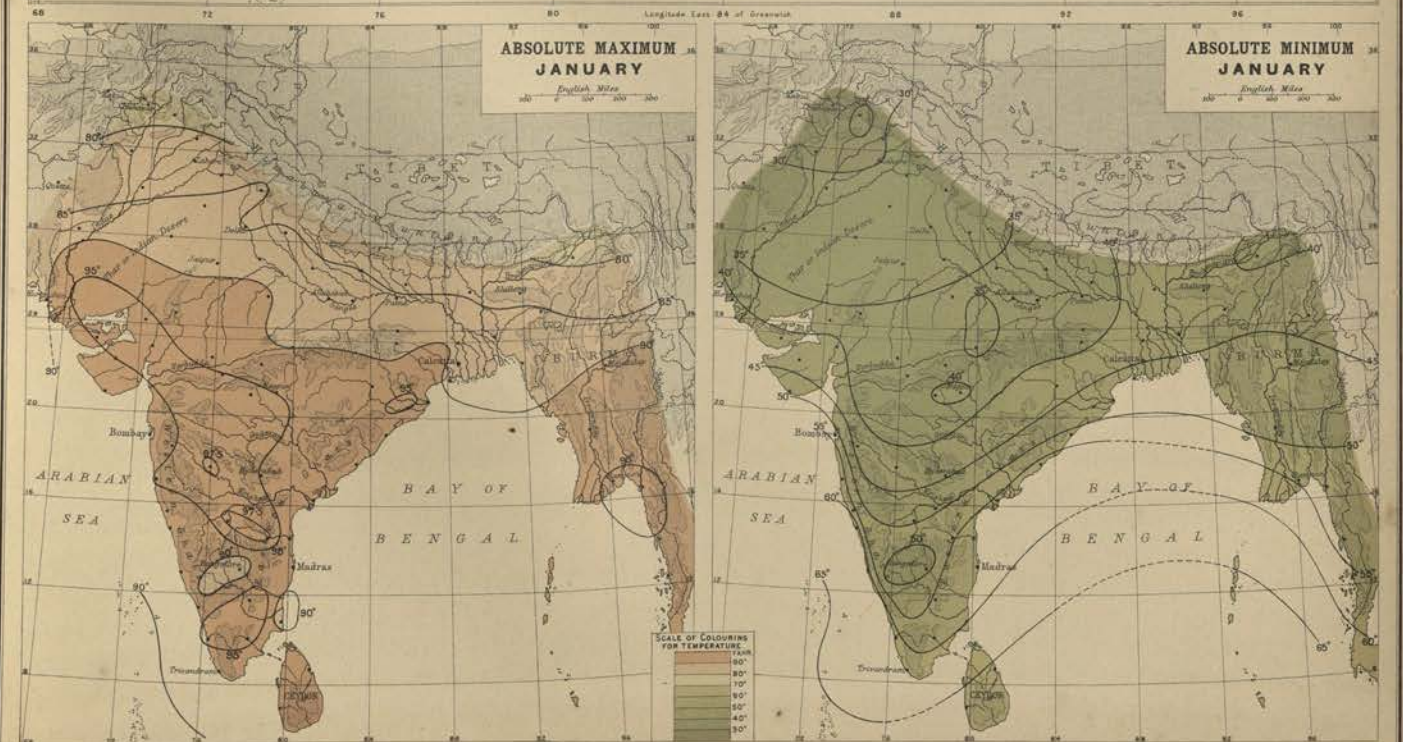
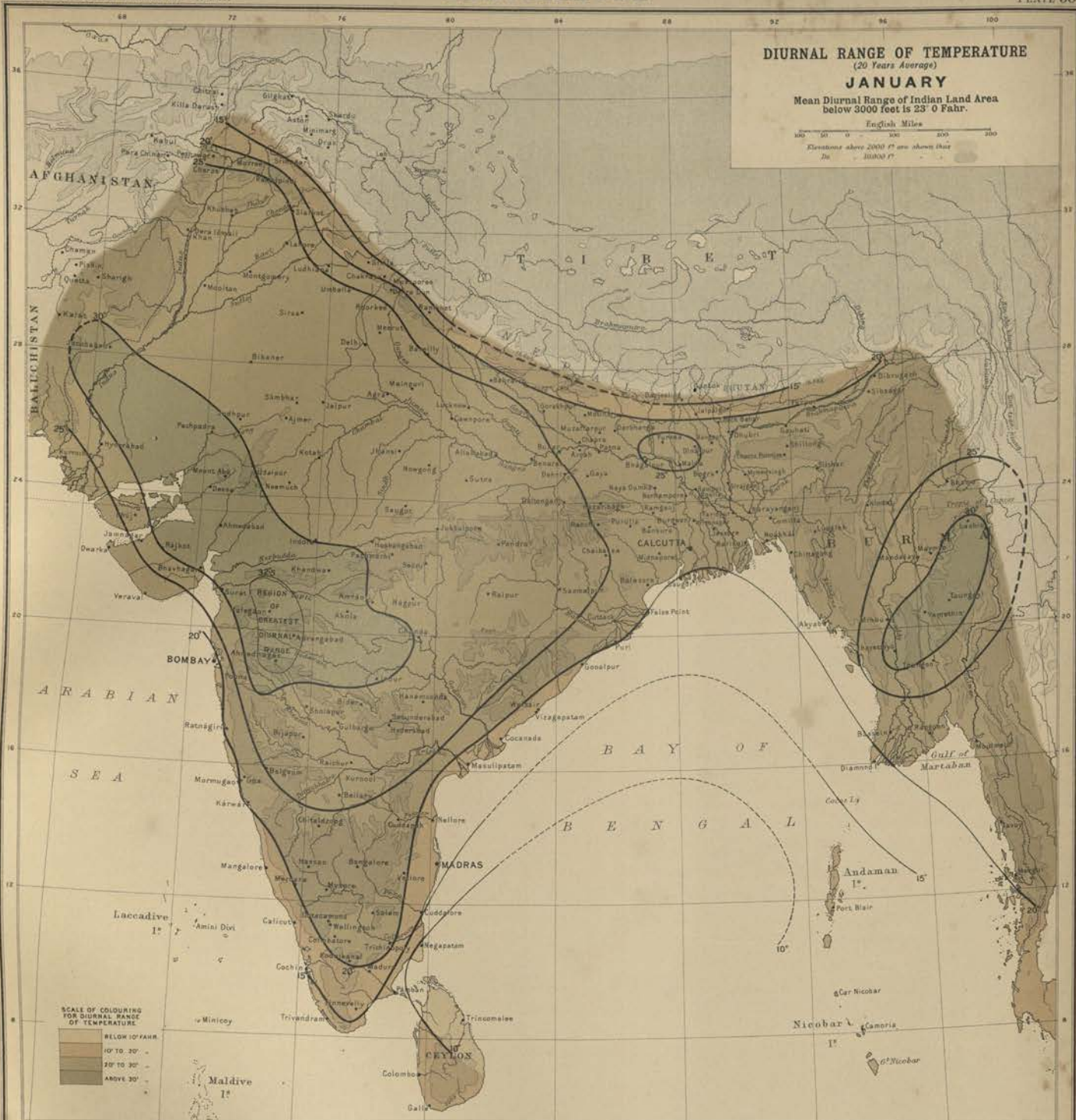


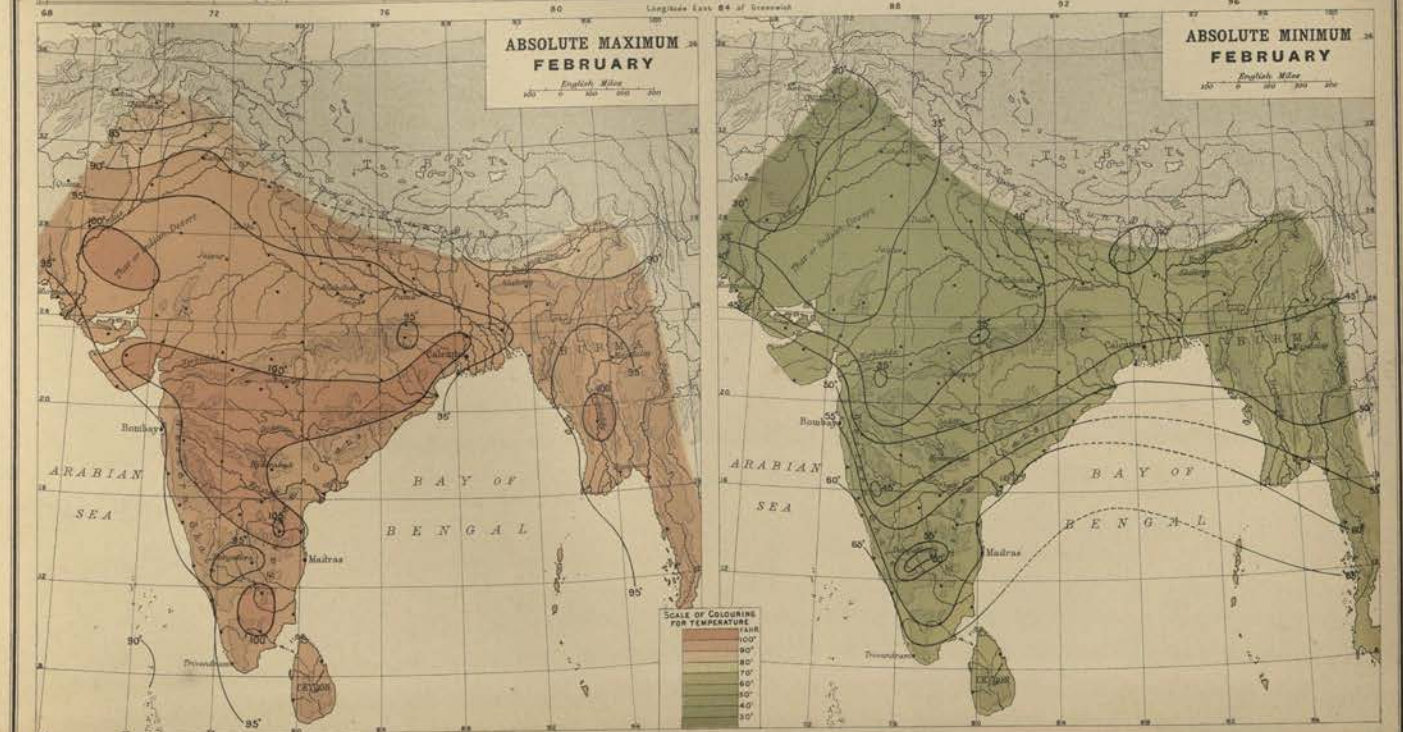
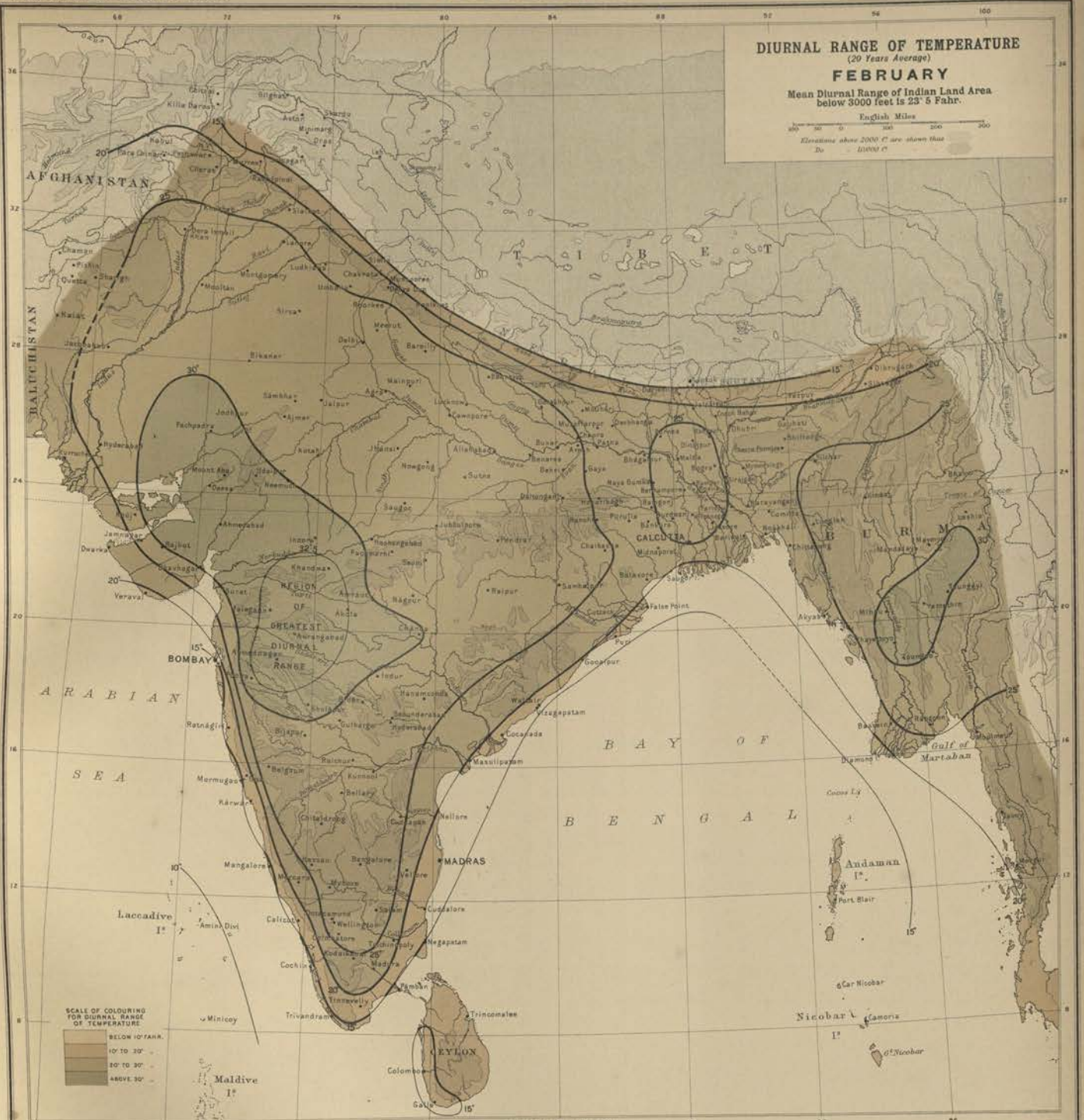
Mean Temperature is reduced to Sea Level by correction of T. F. for every 450 feet of elevation.
The Isotherms are obtained from the data of Stations below 3000 feet in elevation.

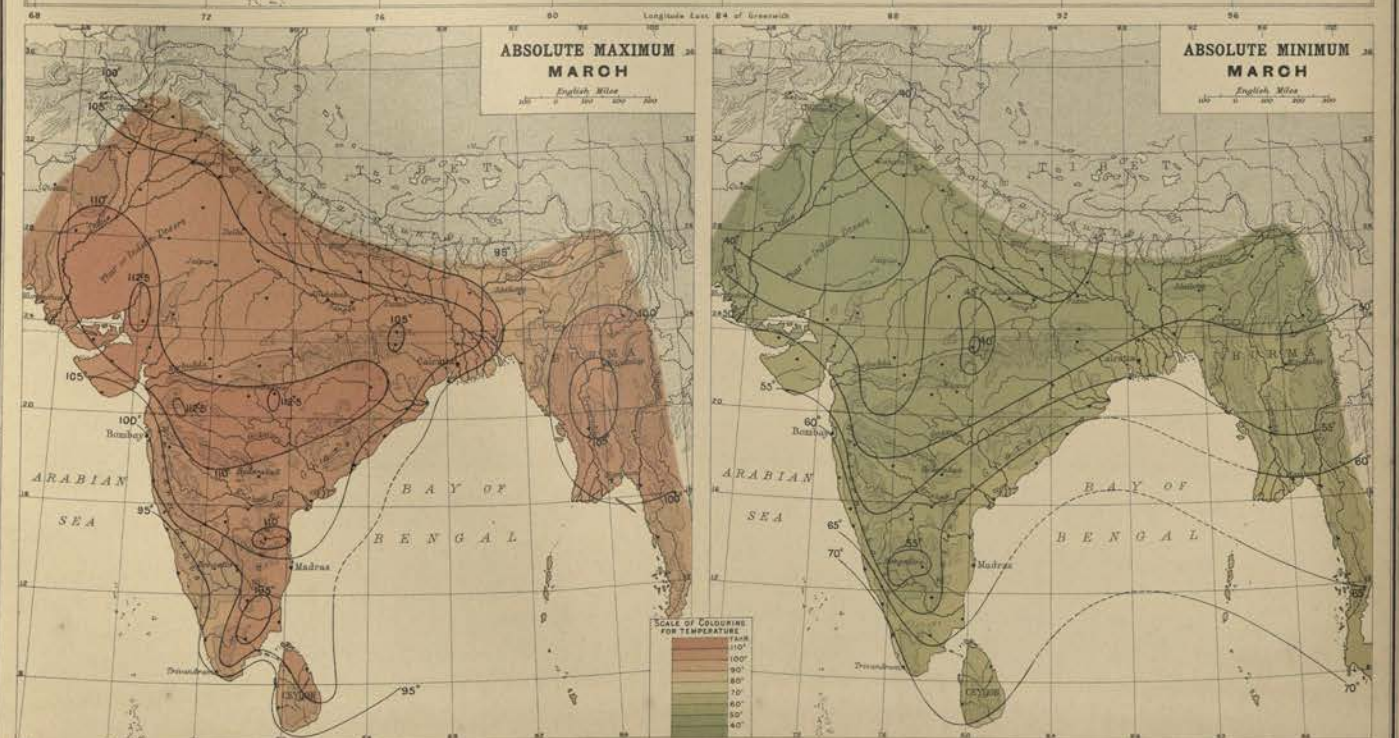
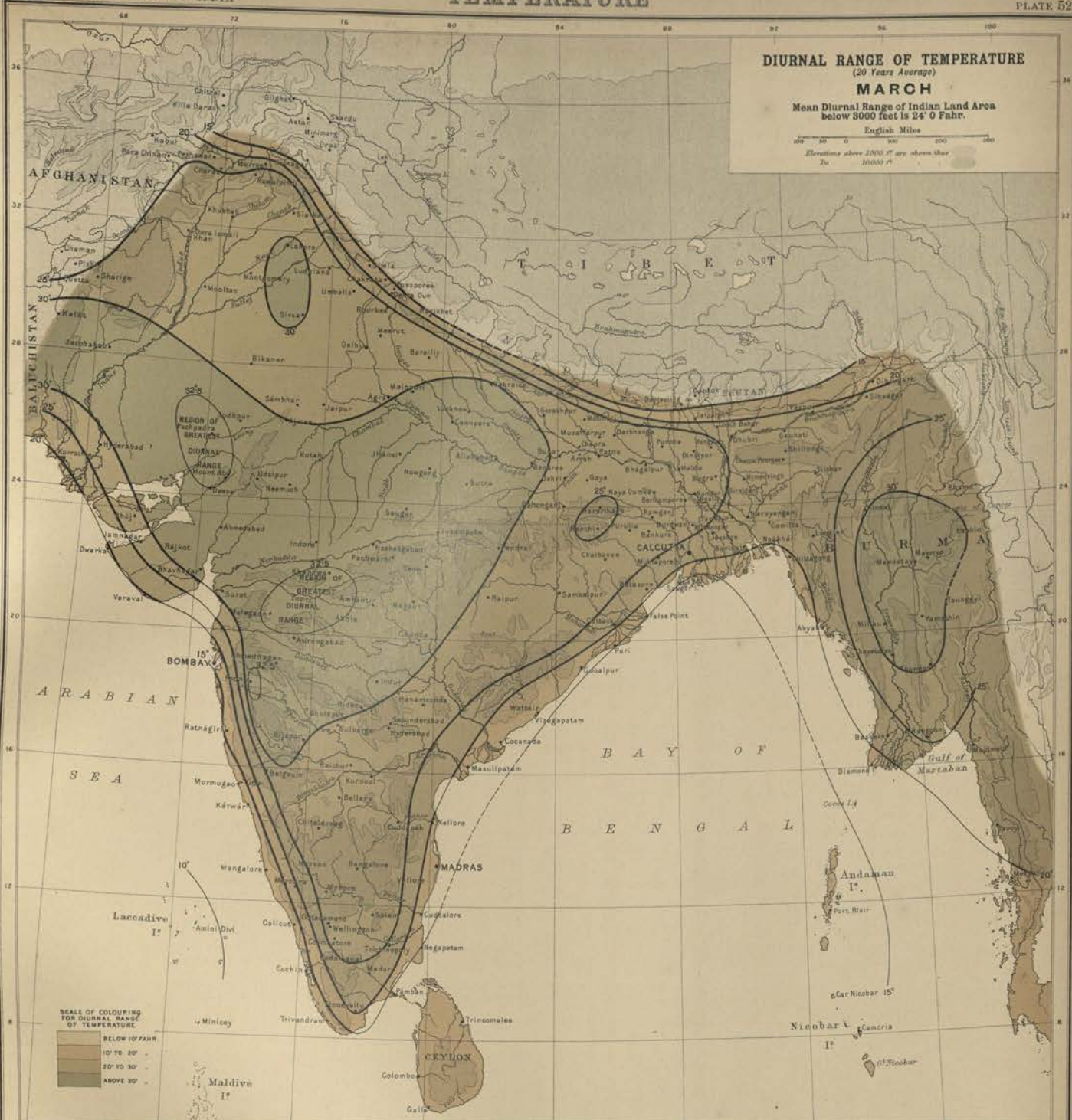
Indian Meteorological Department

J. B. Parikh, Editor, Geogr. Inst.









DIURNAL RANGE OF TEMPERATURE
(20 Years Average)

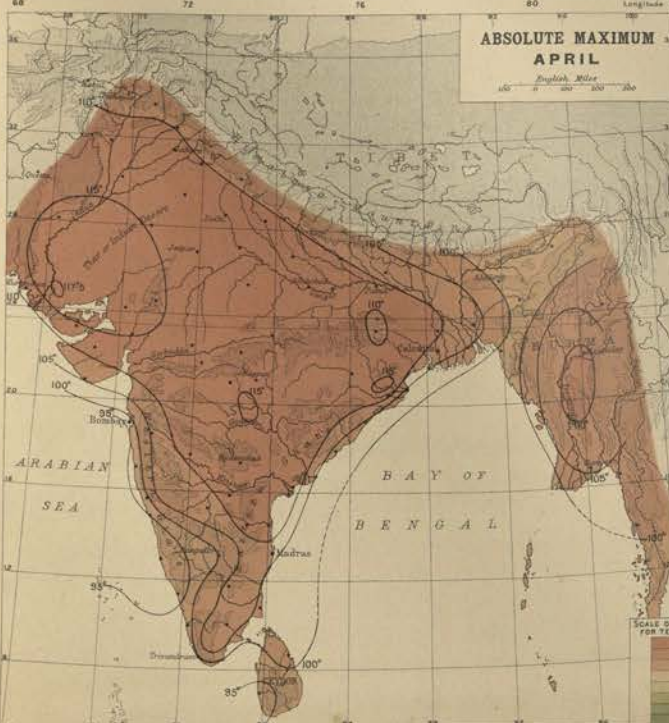
APRIL

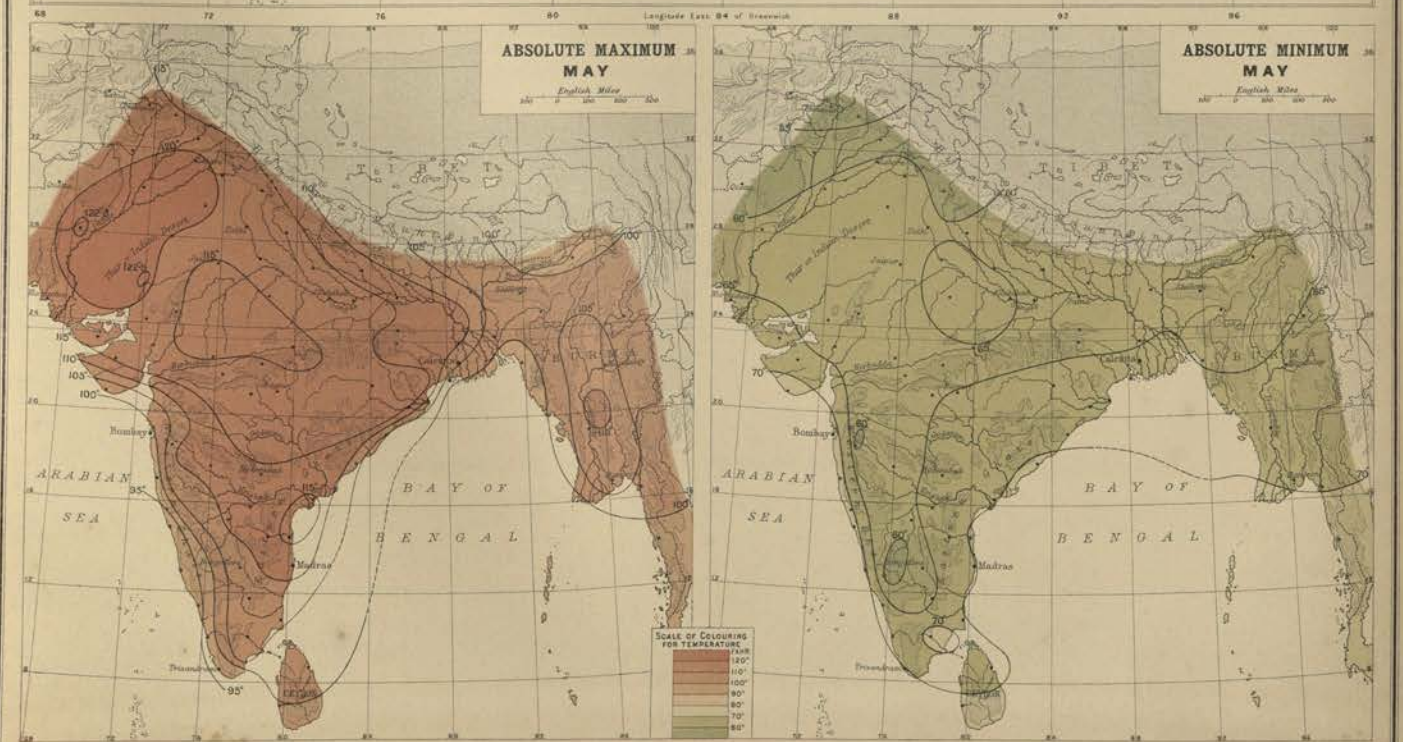
Mean Diurnal Range of Indian Land Area
below 3000 feet is 23° F.

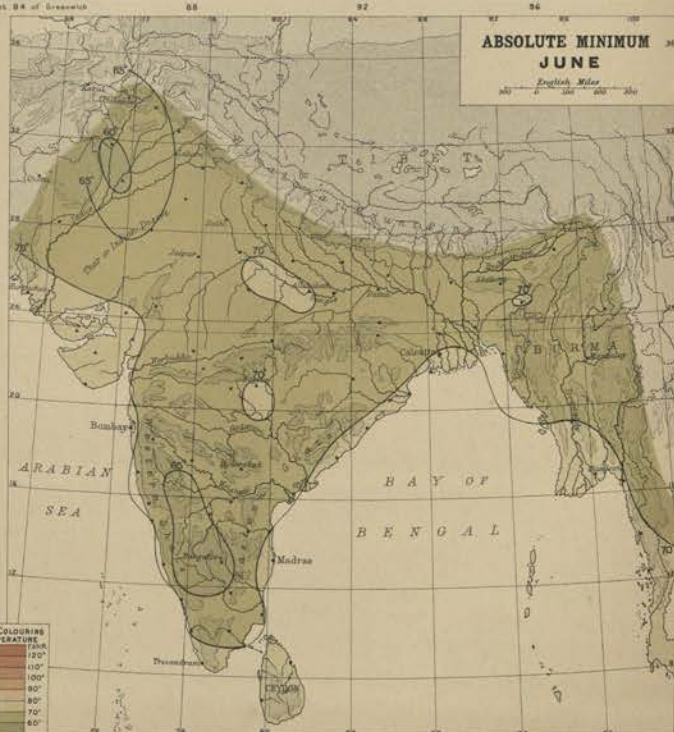
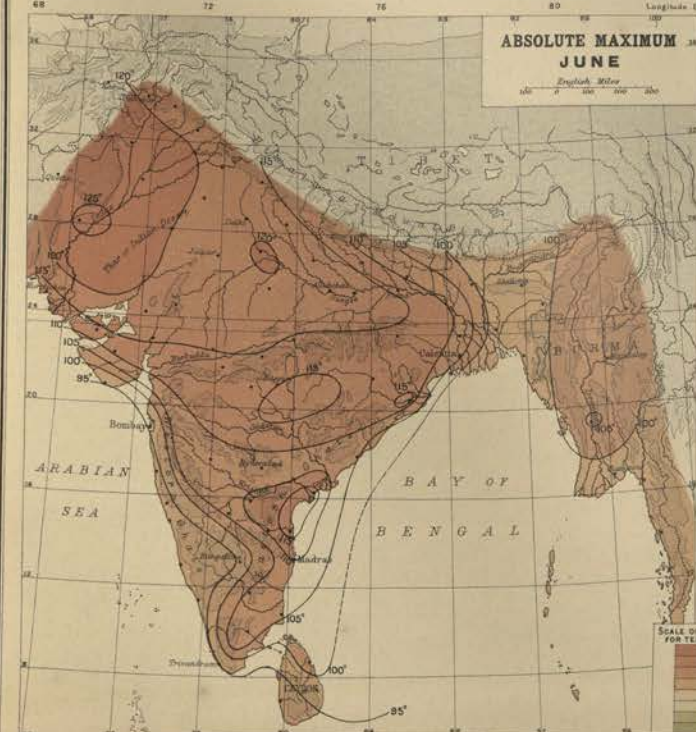
English Miles

Elevations above 3000 ft. are shown thus

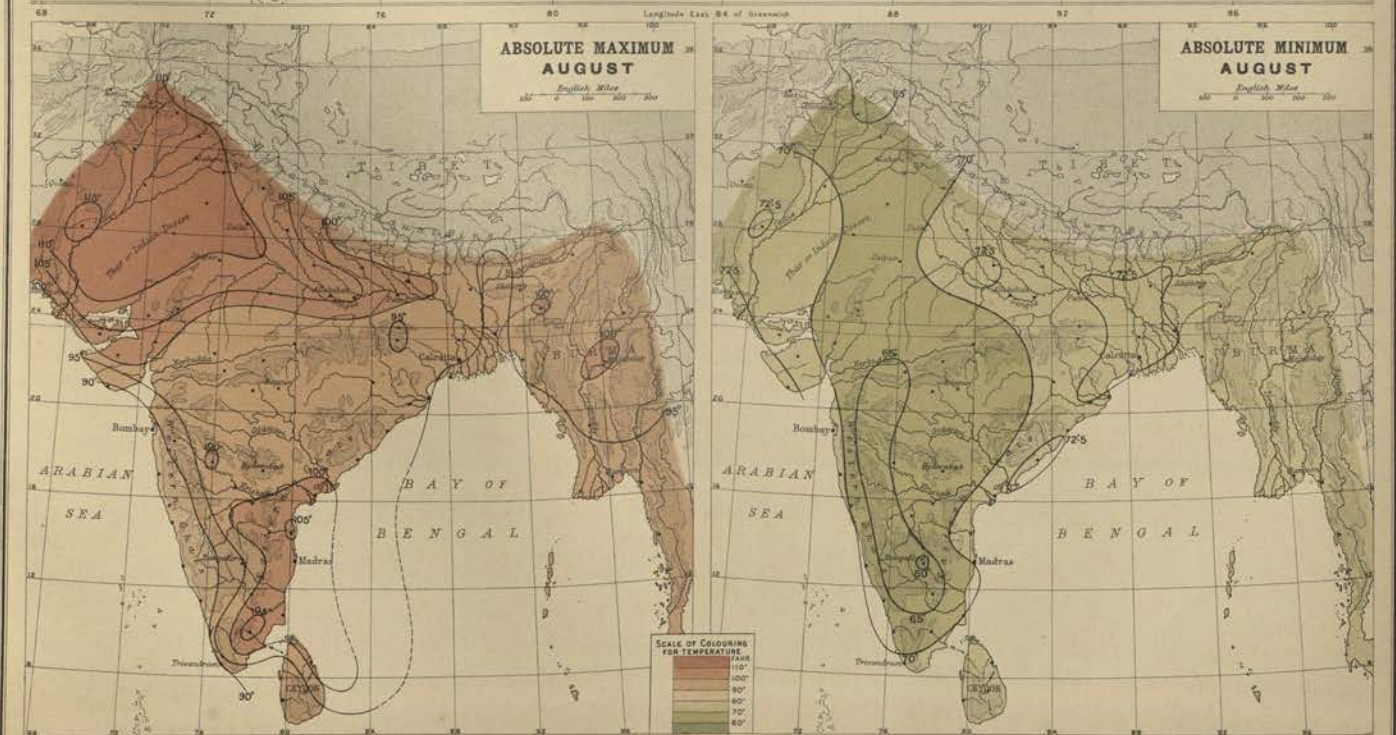
In Indian ft.

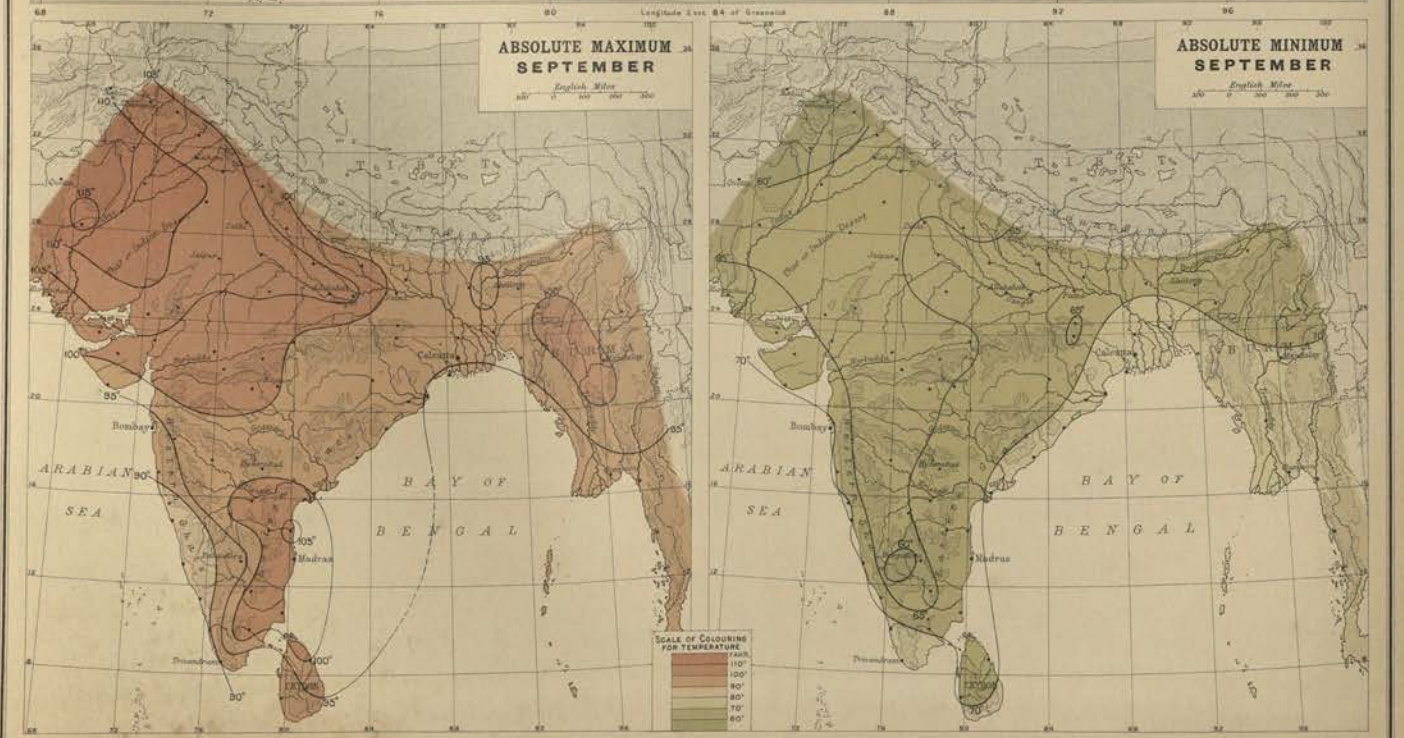
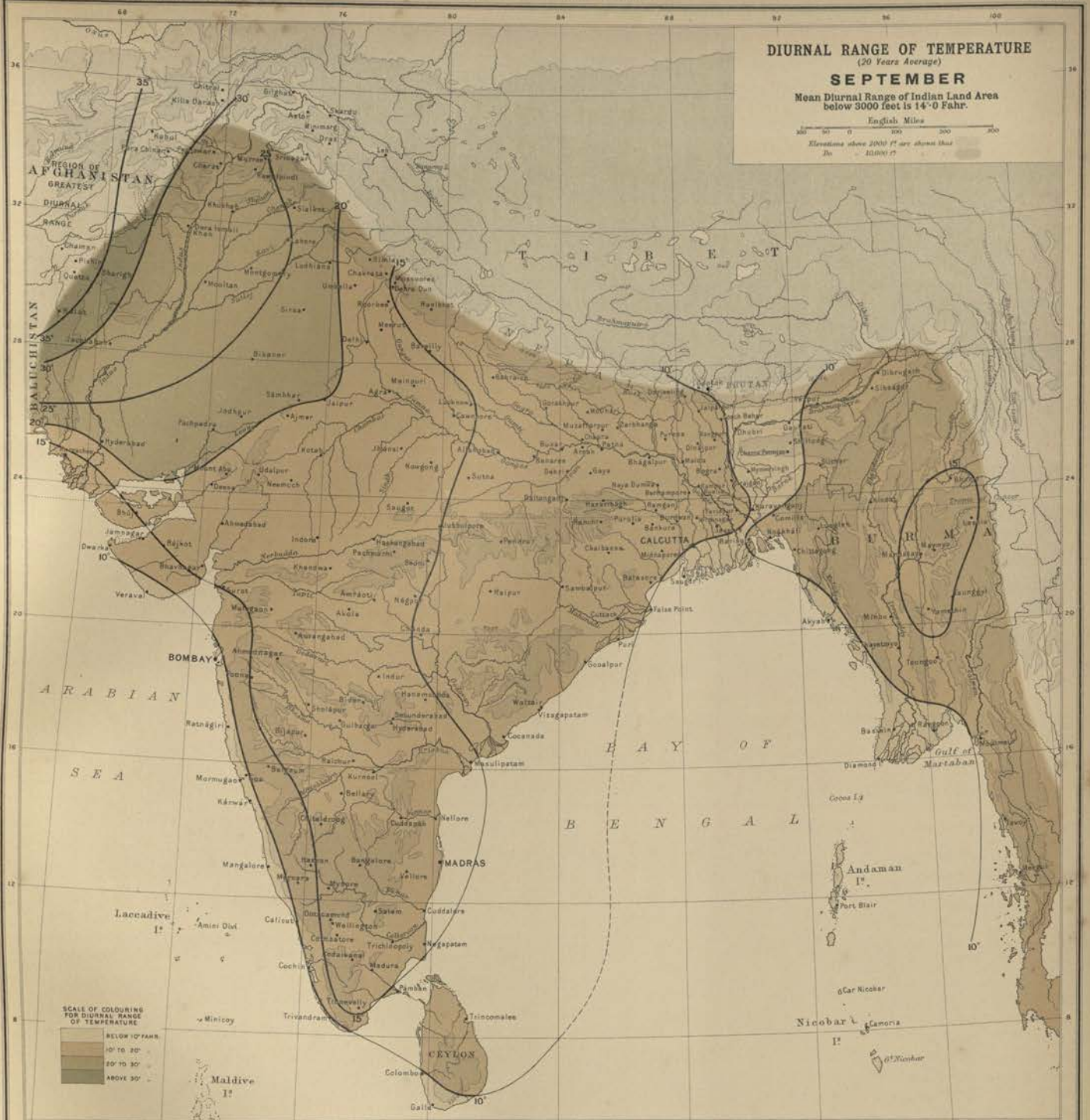


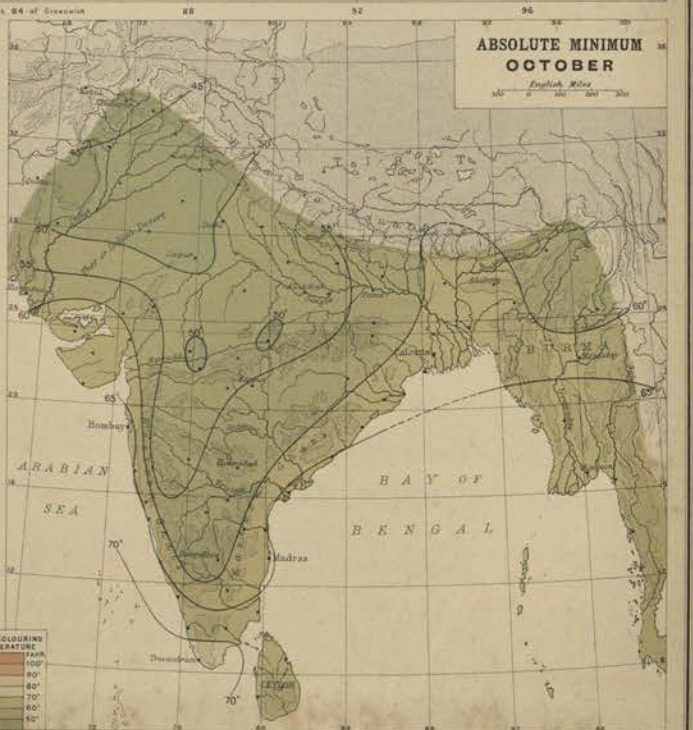
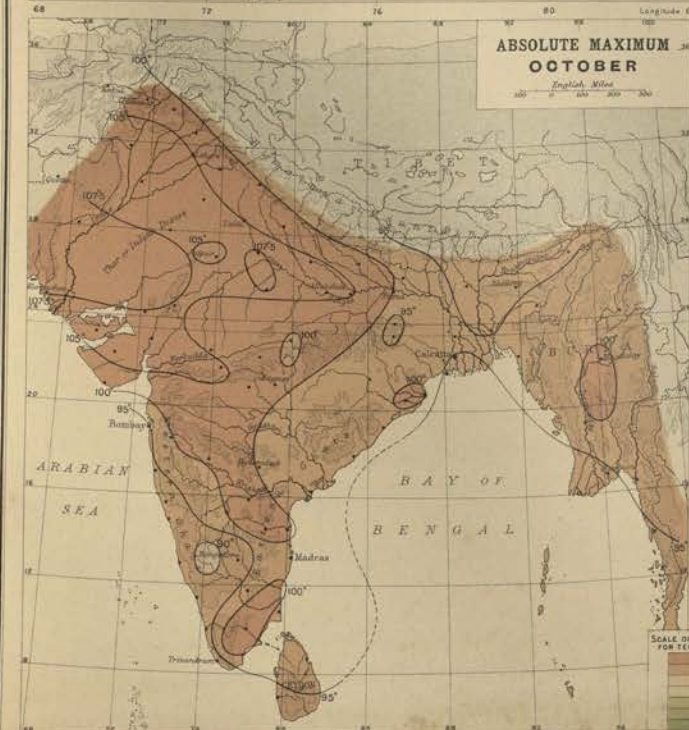
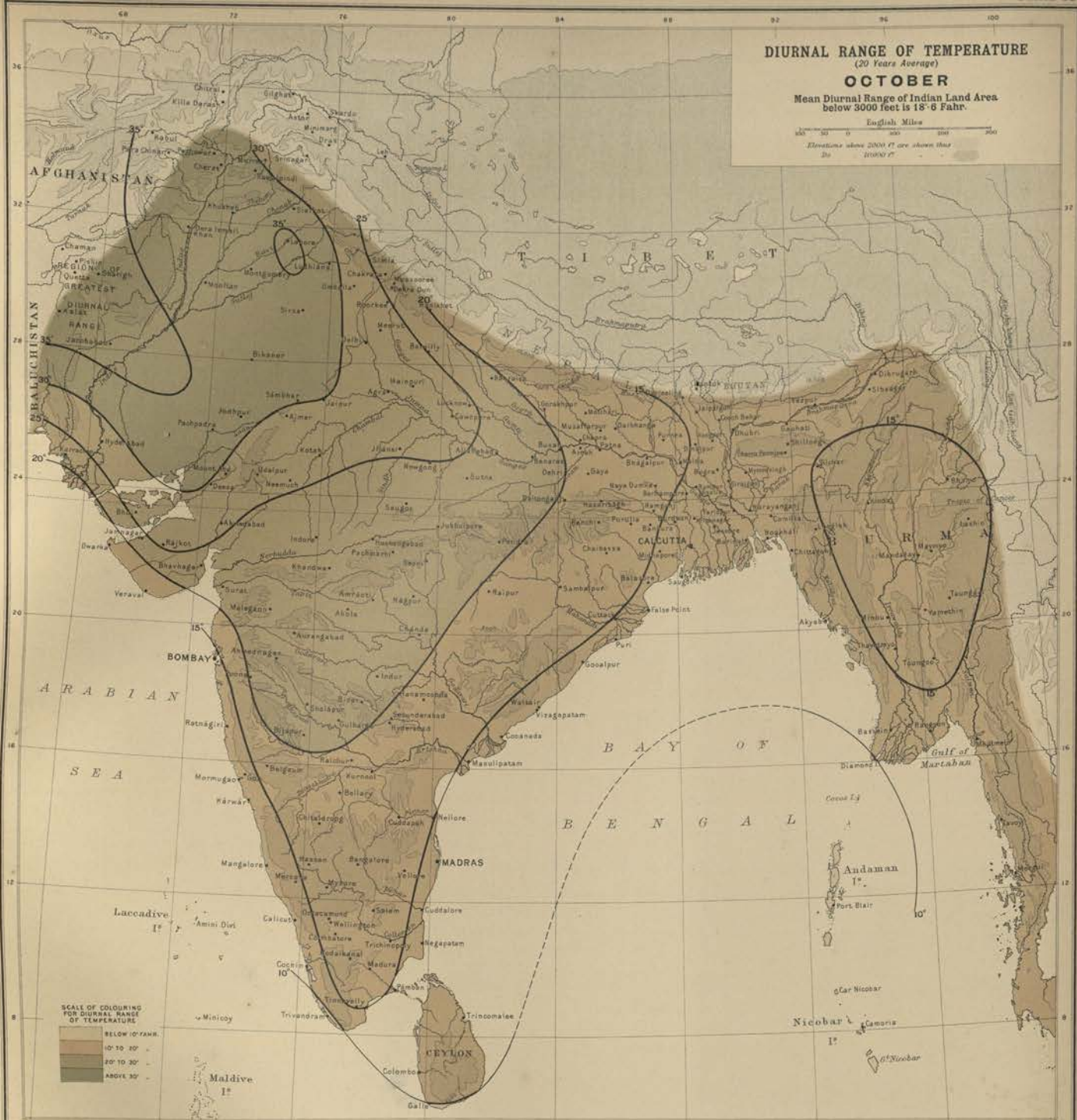


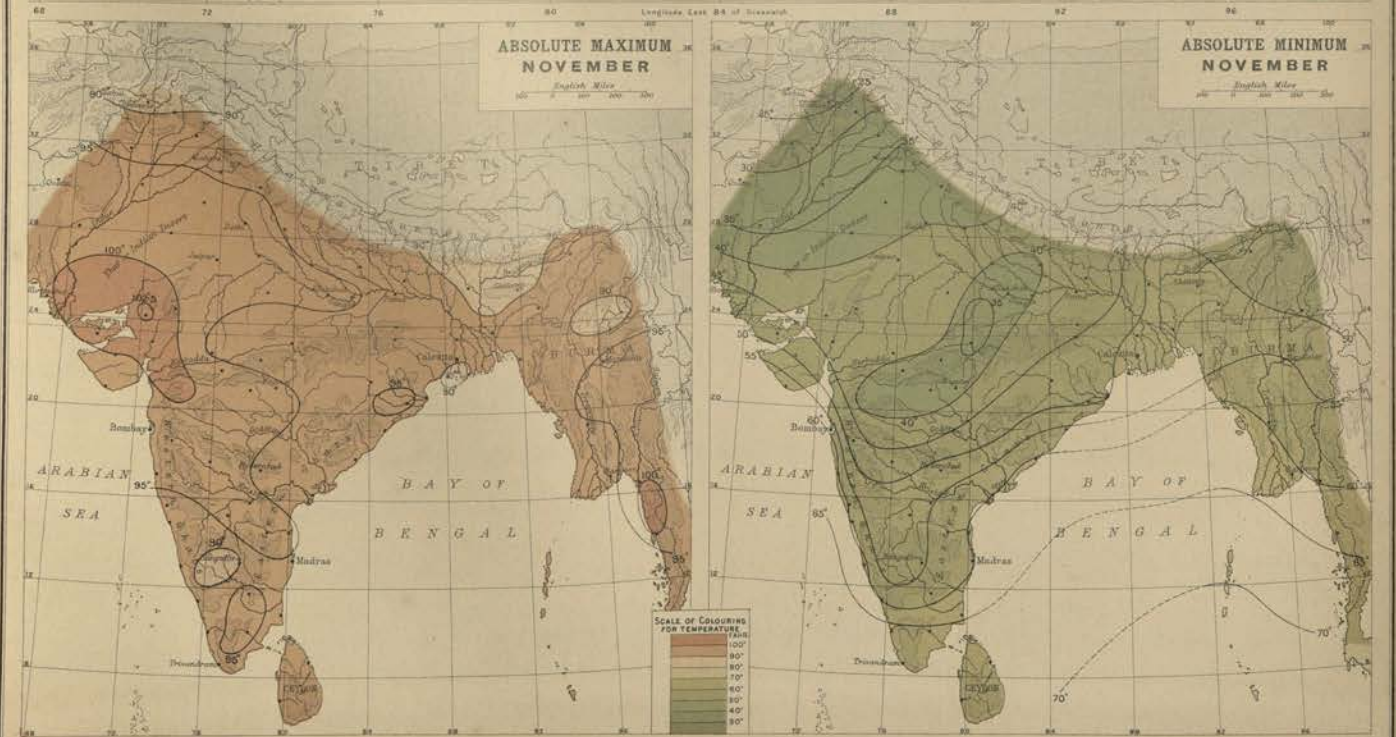


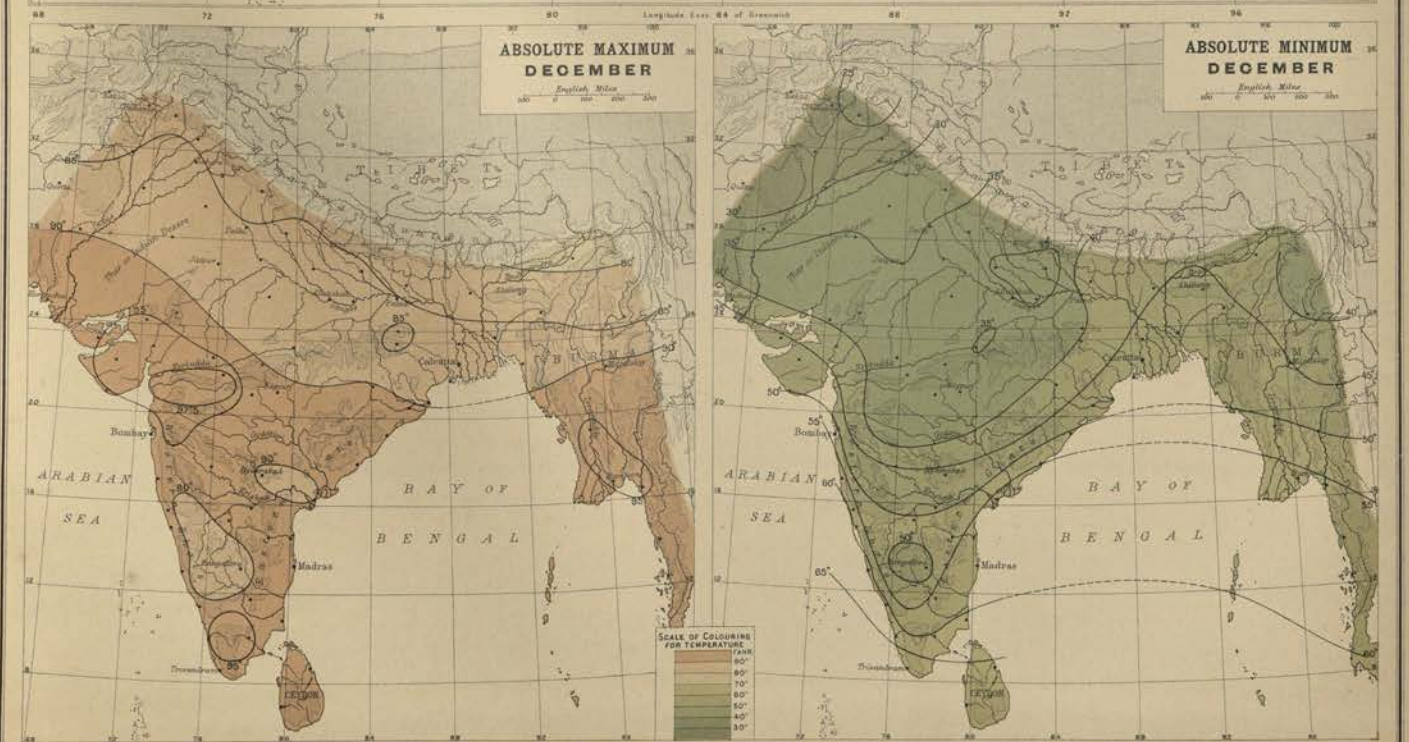
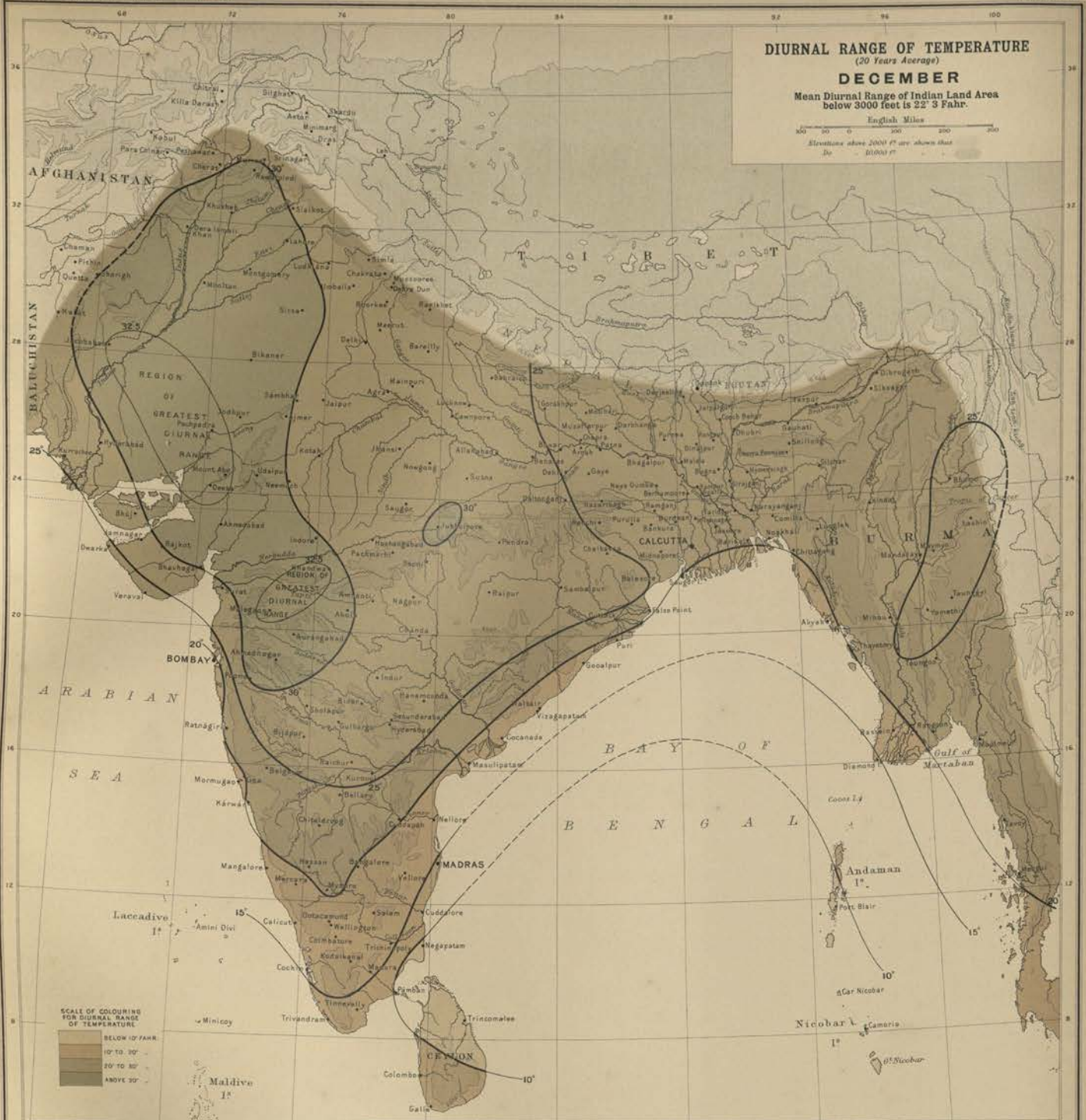


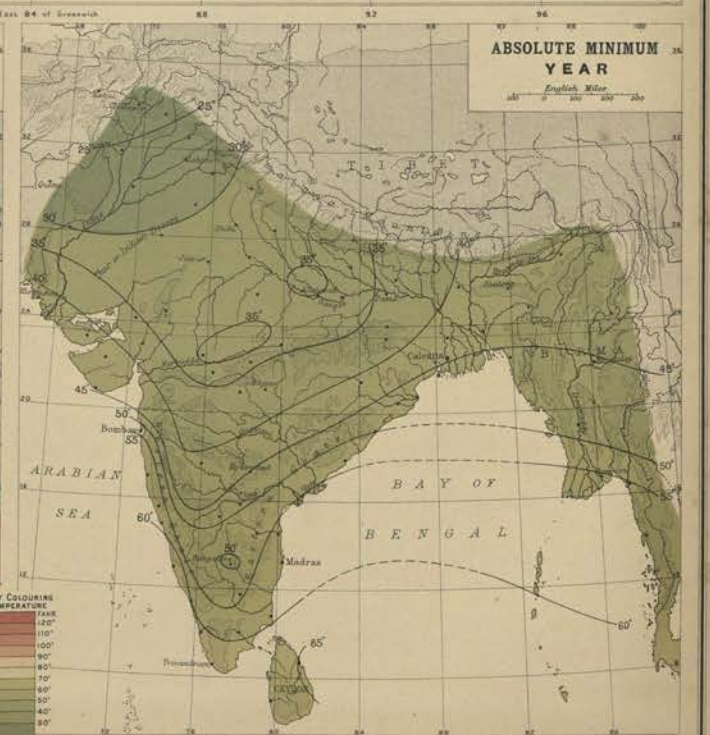
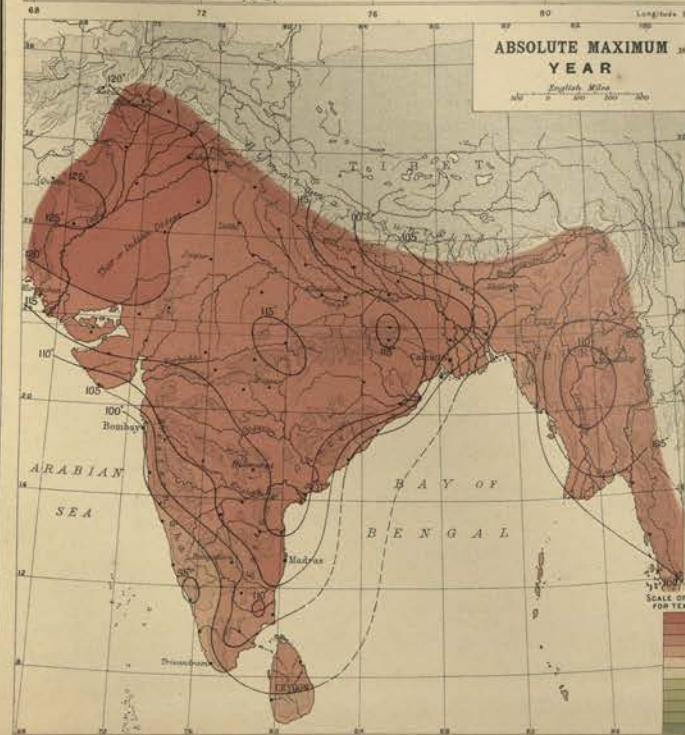
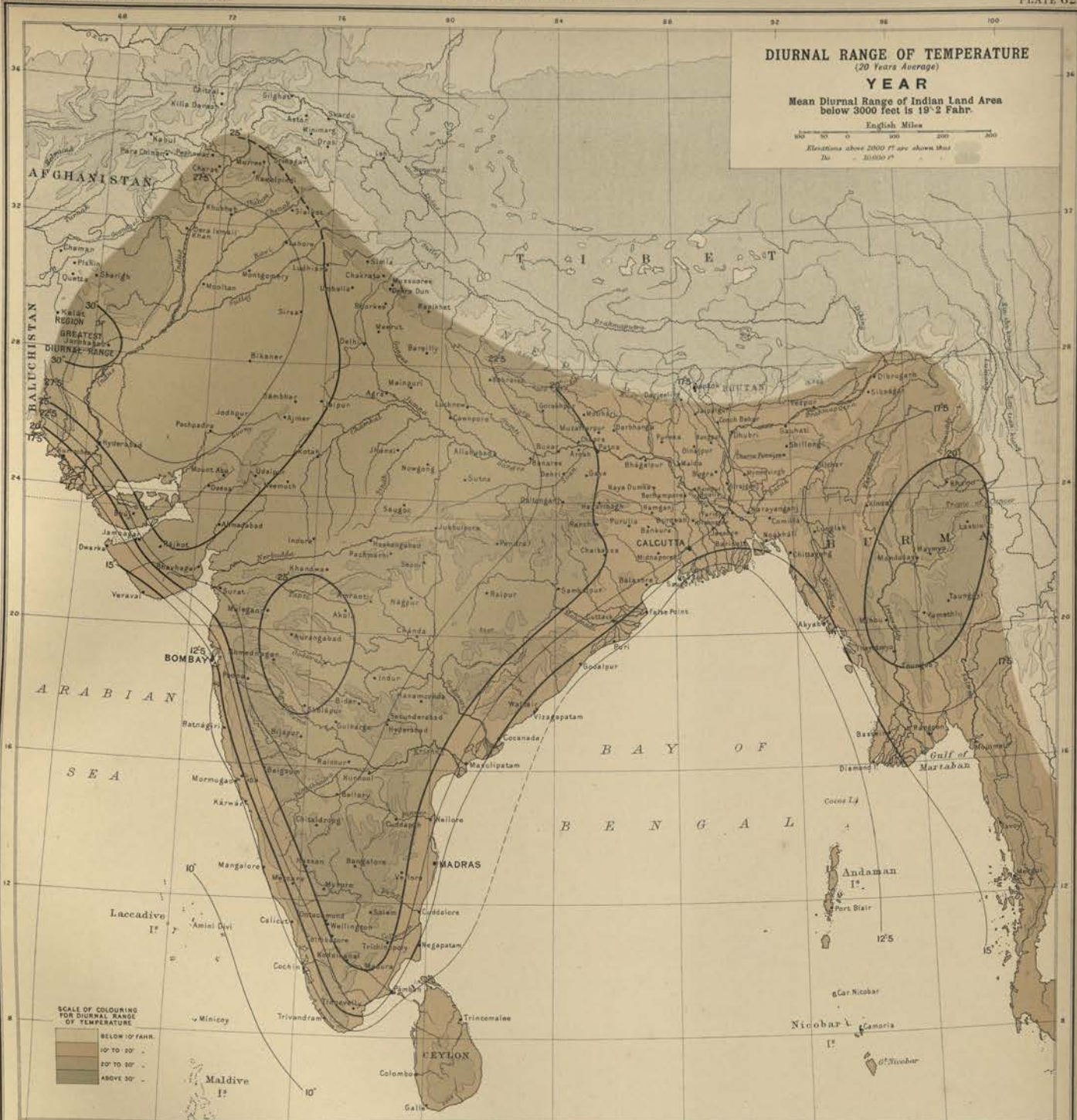


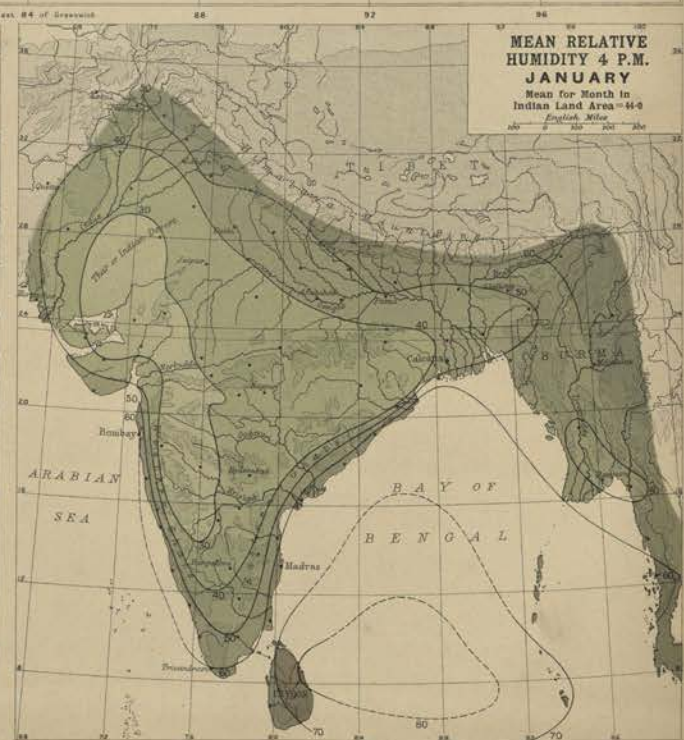
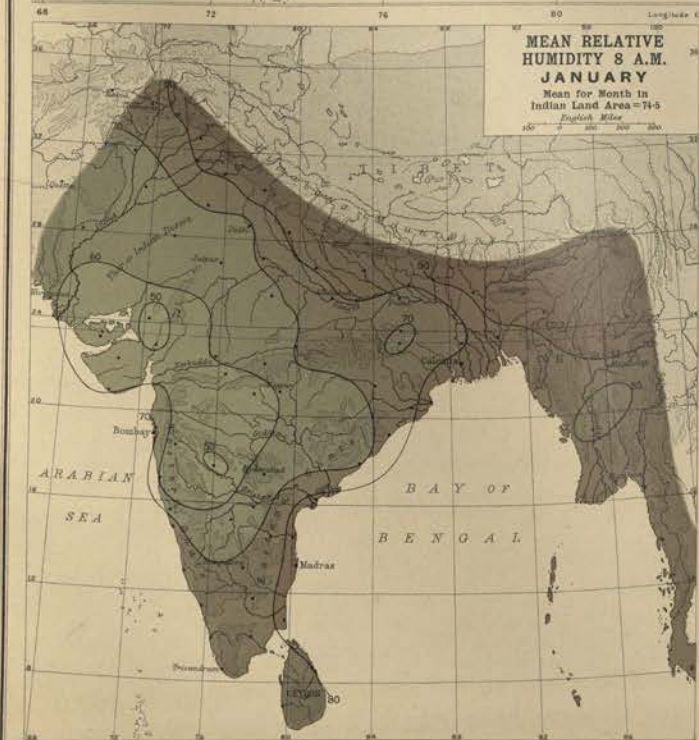
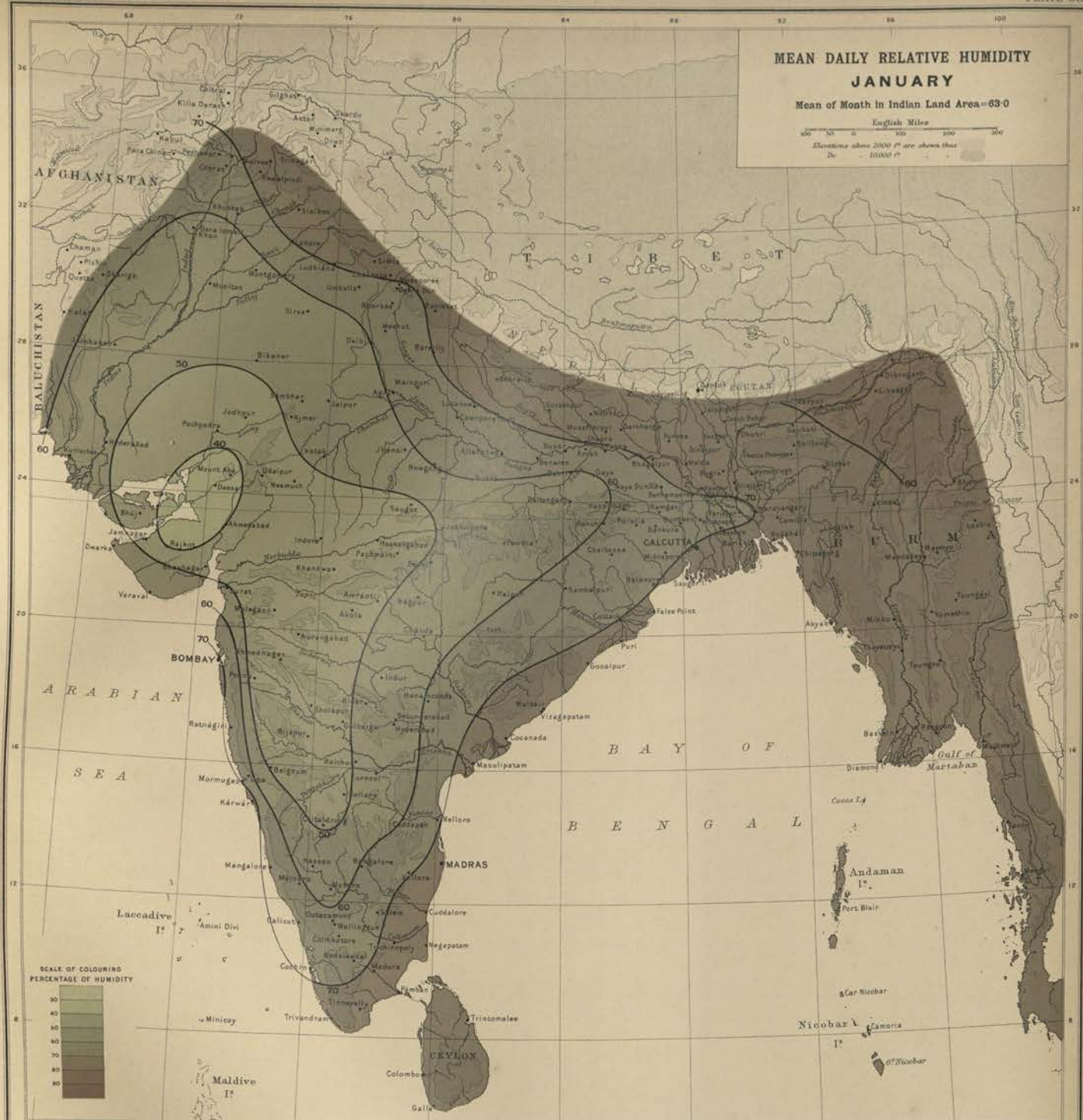


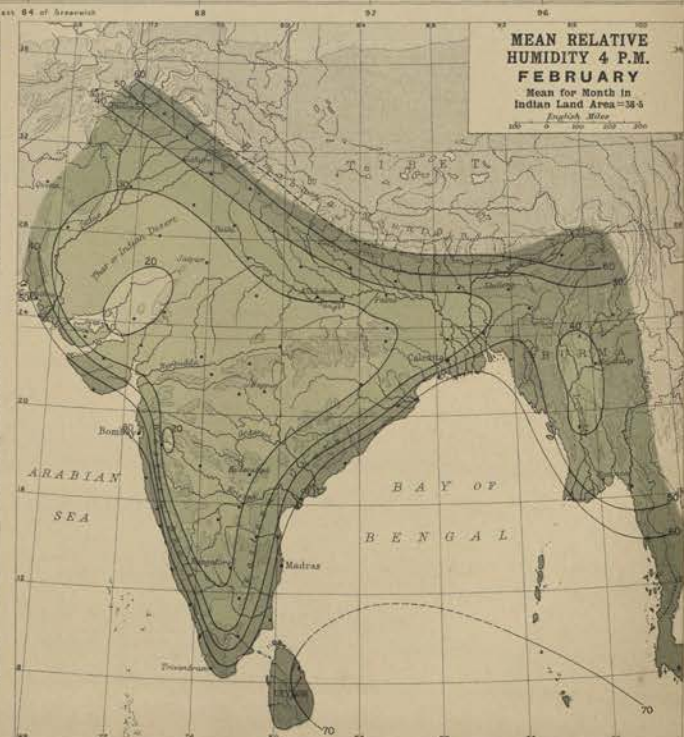
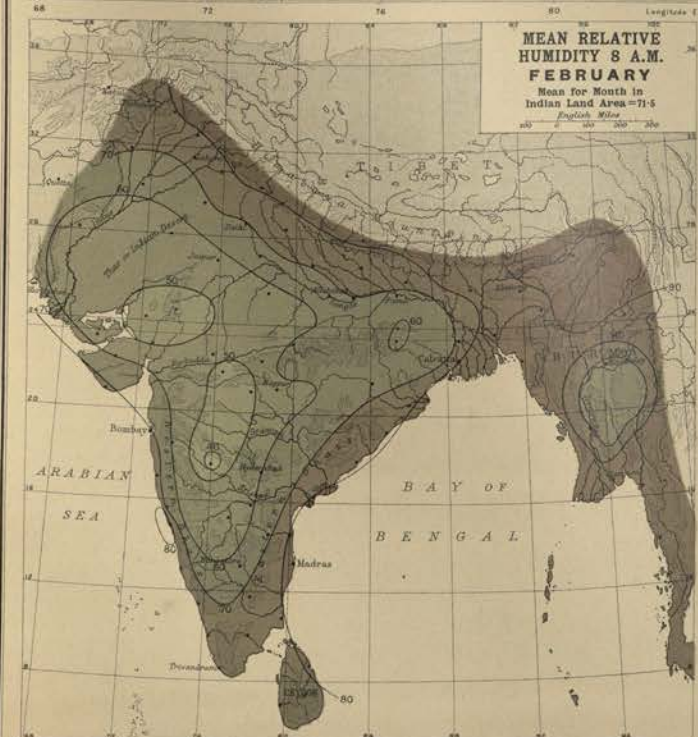
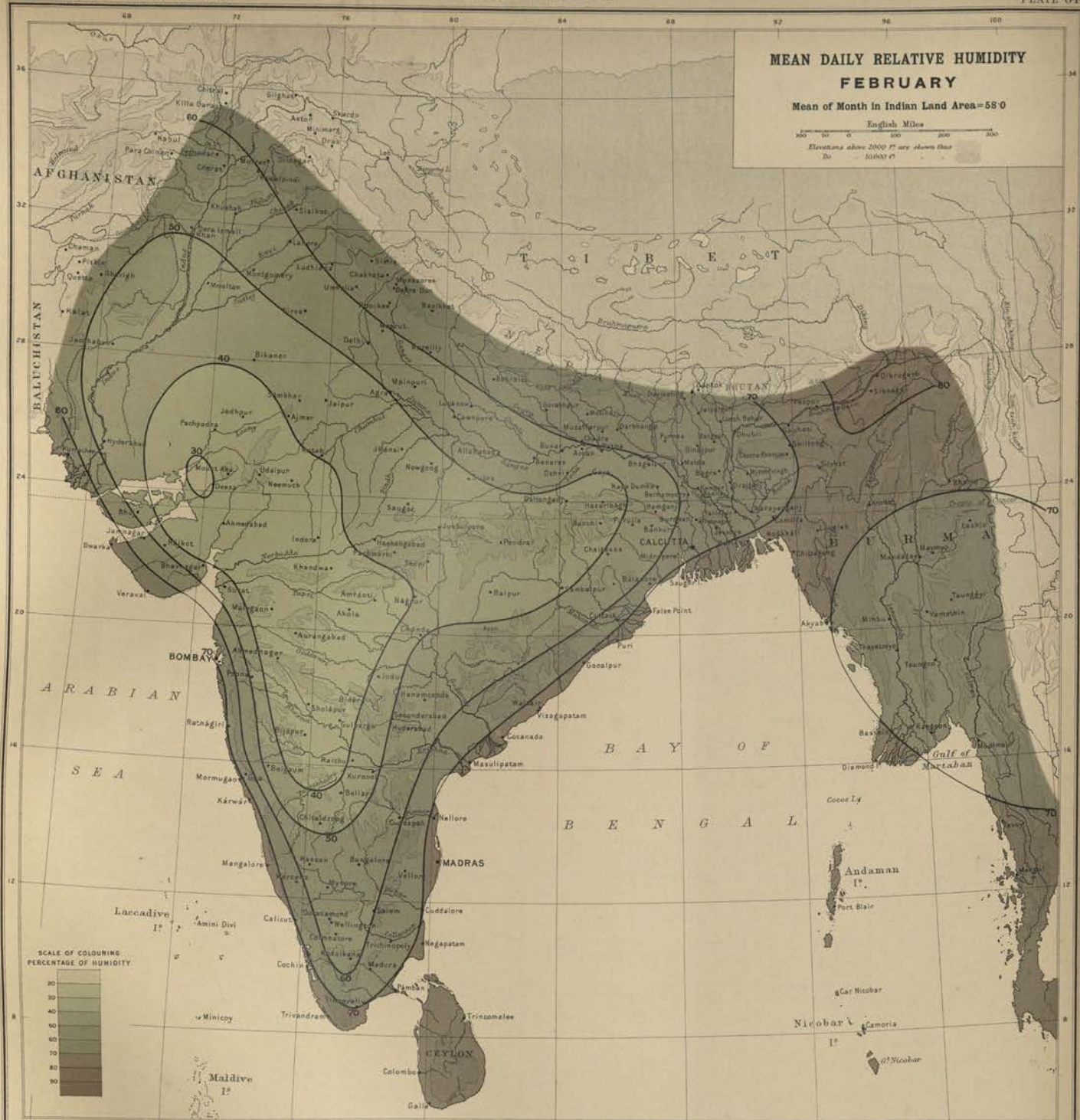


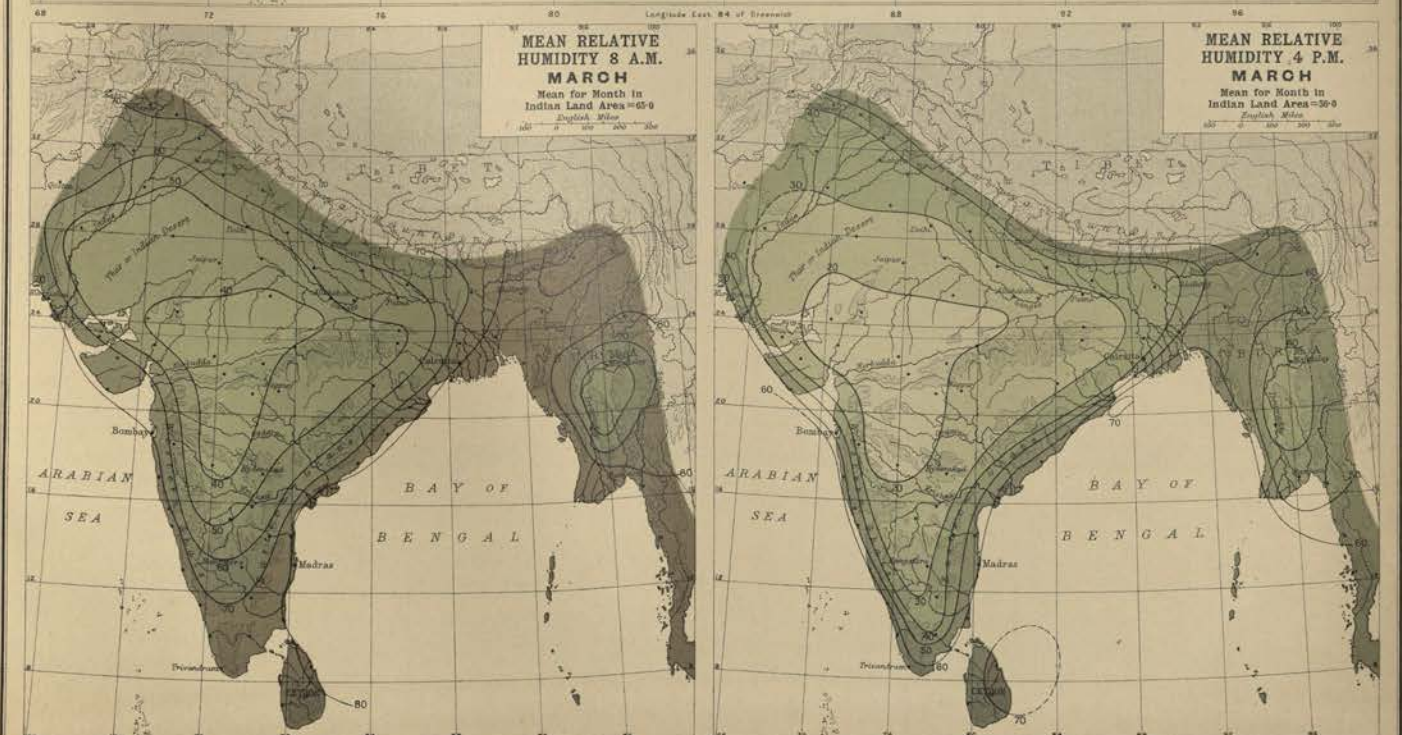
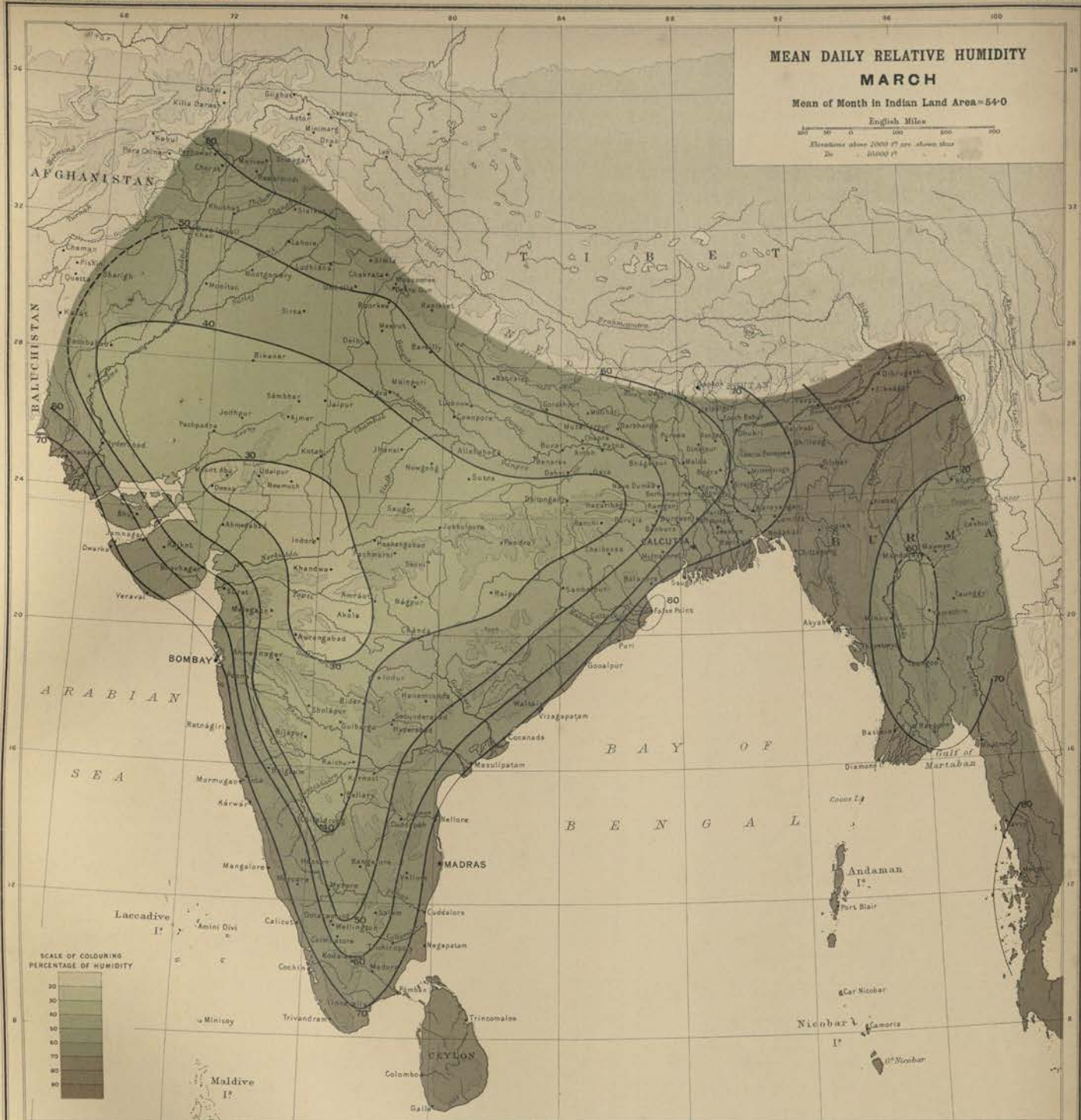


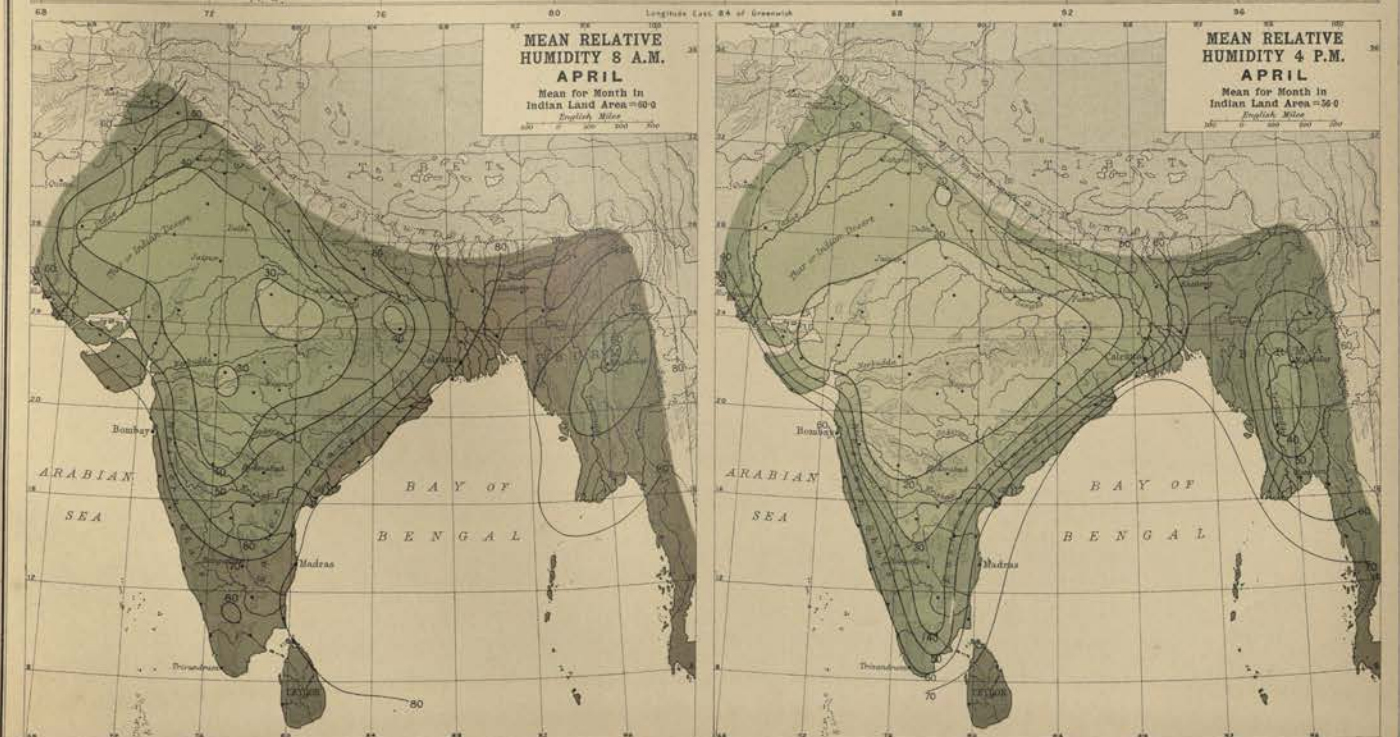
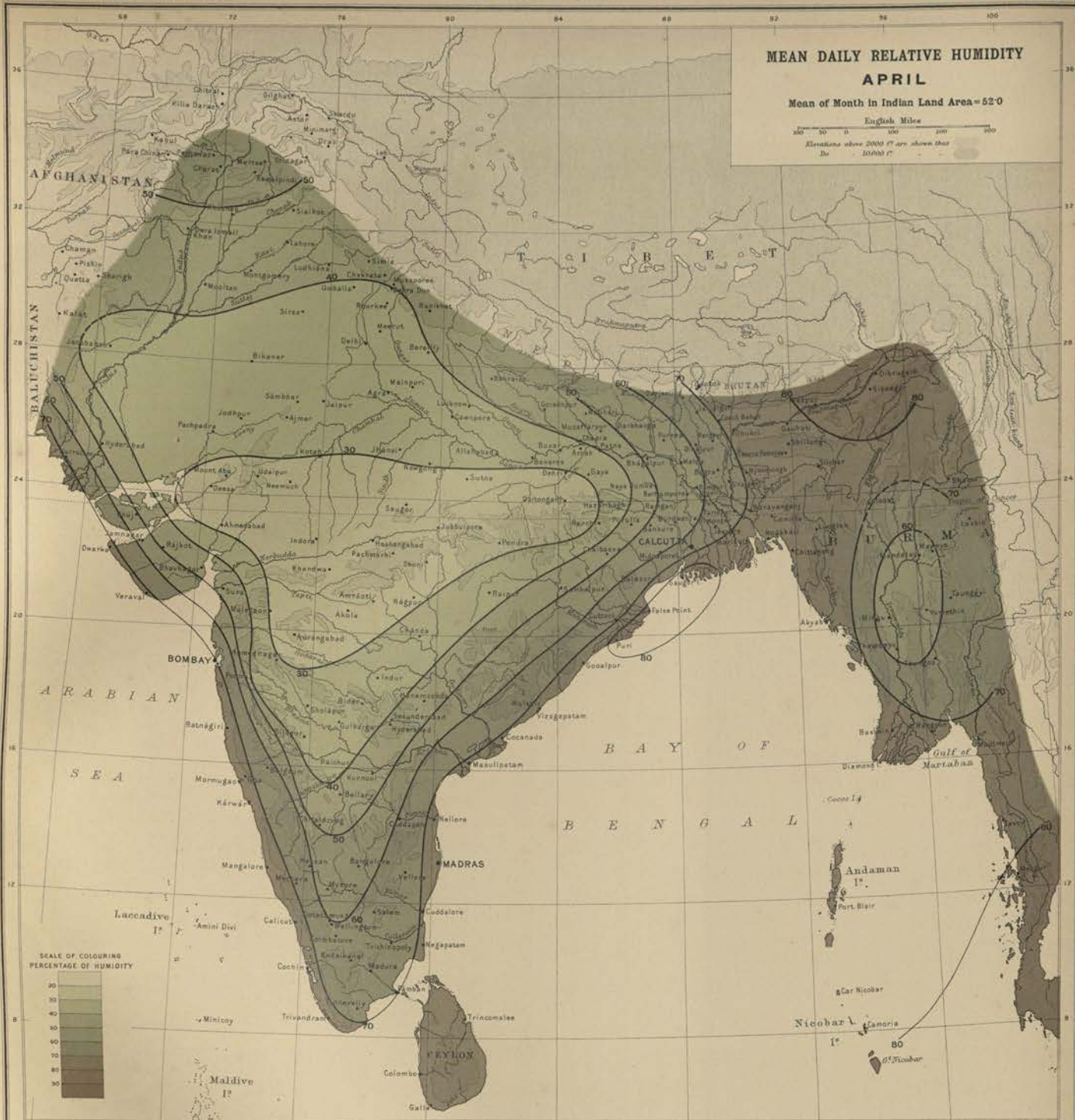


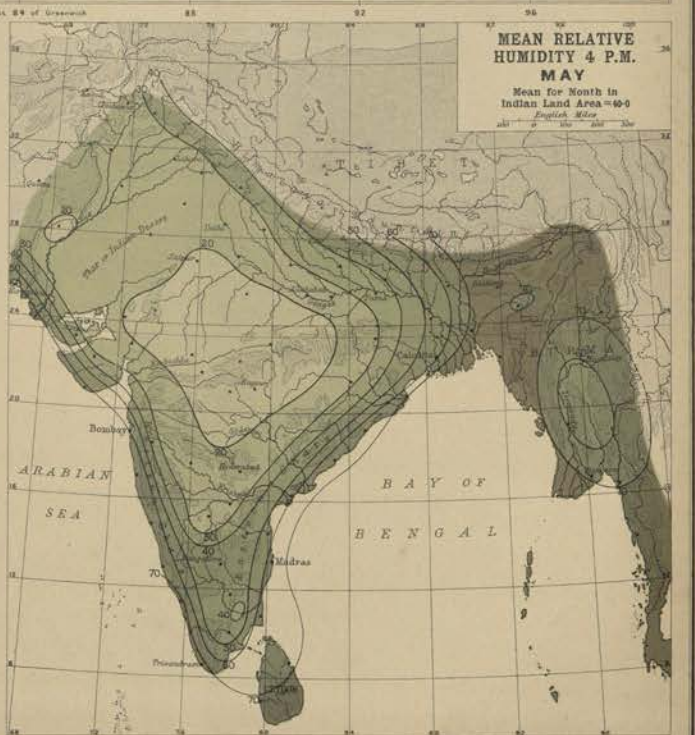
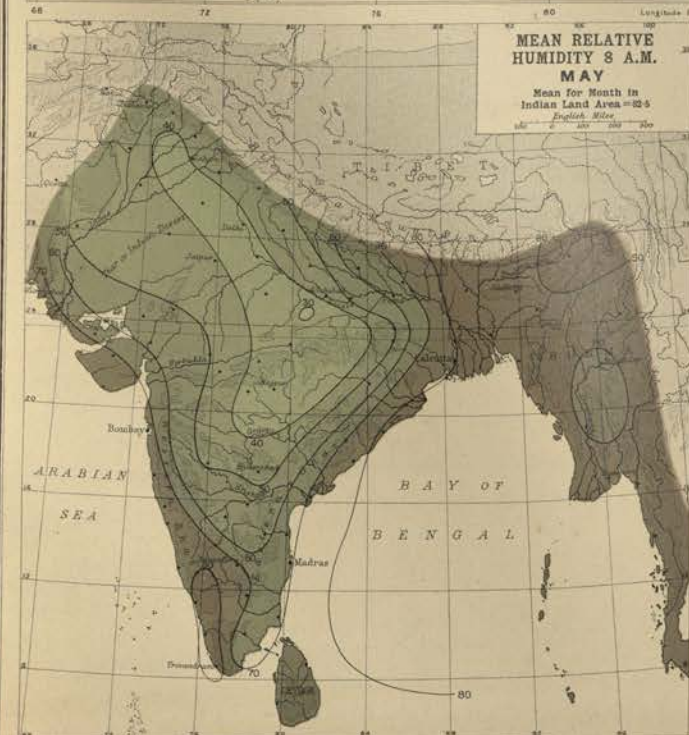
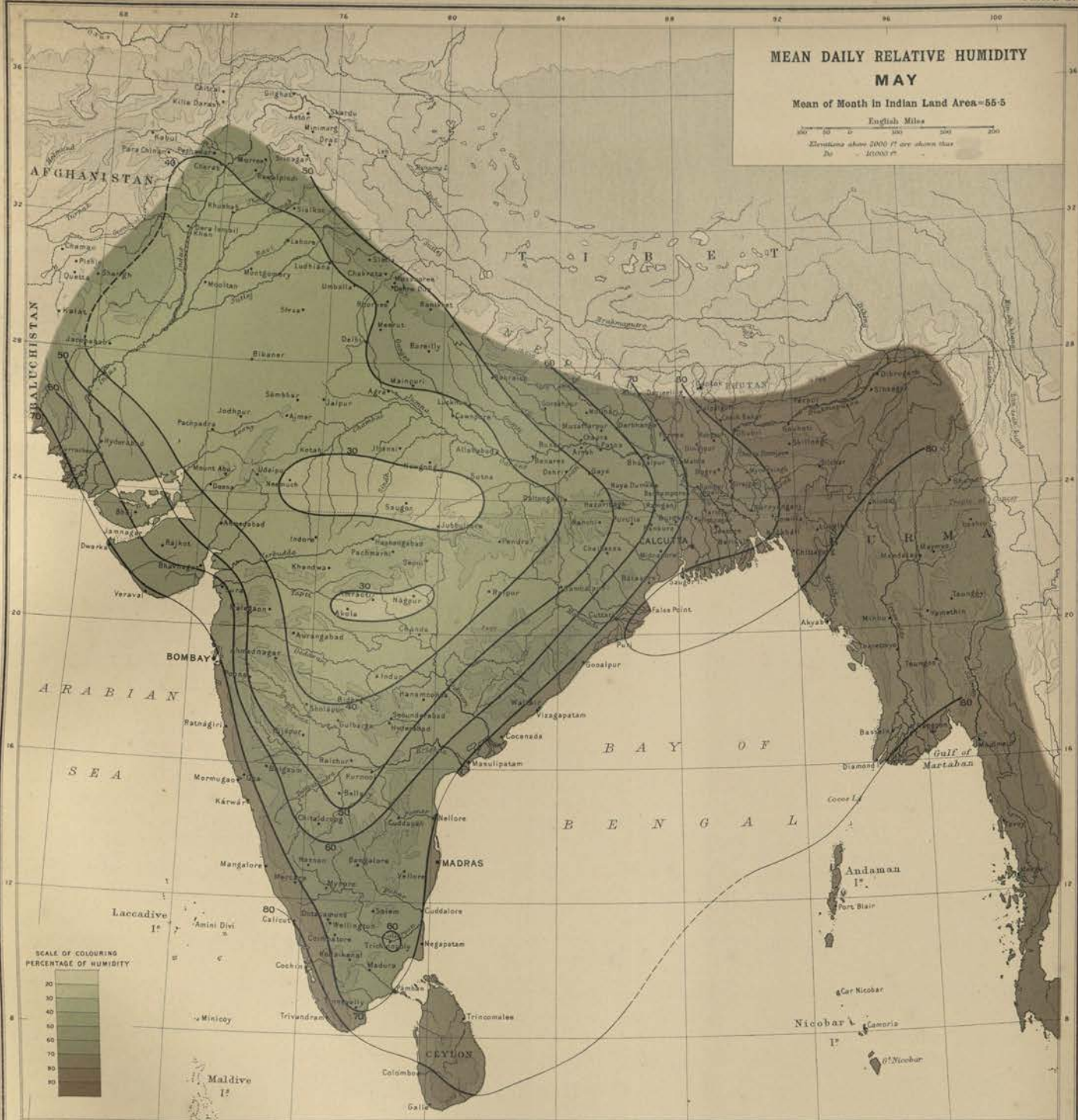


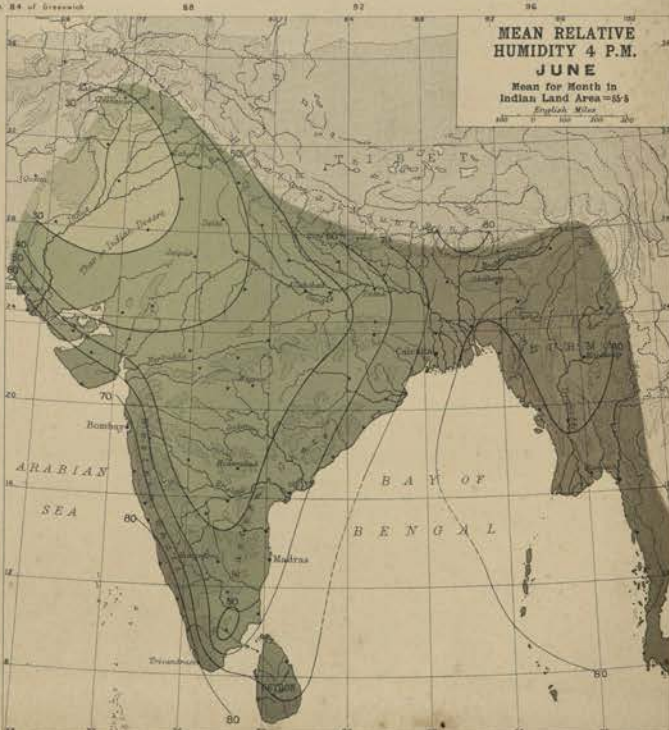
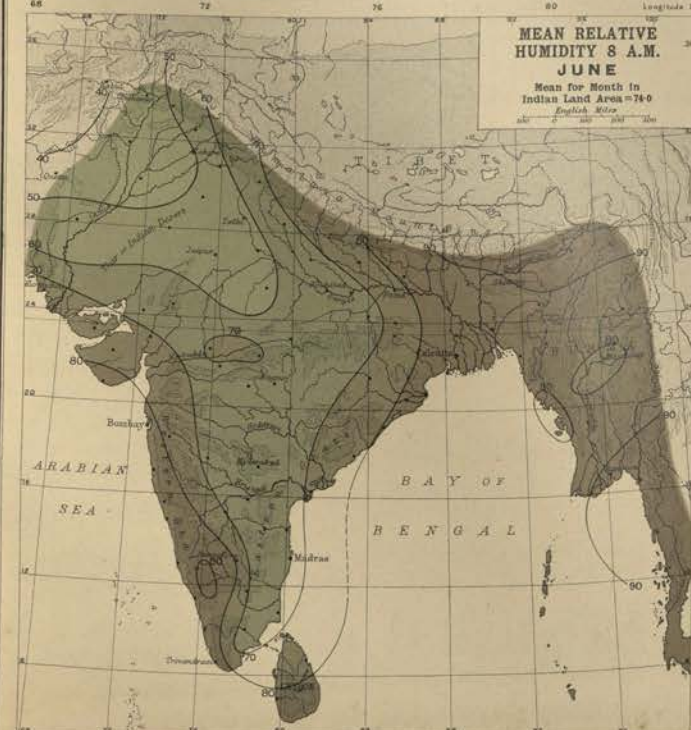
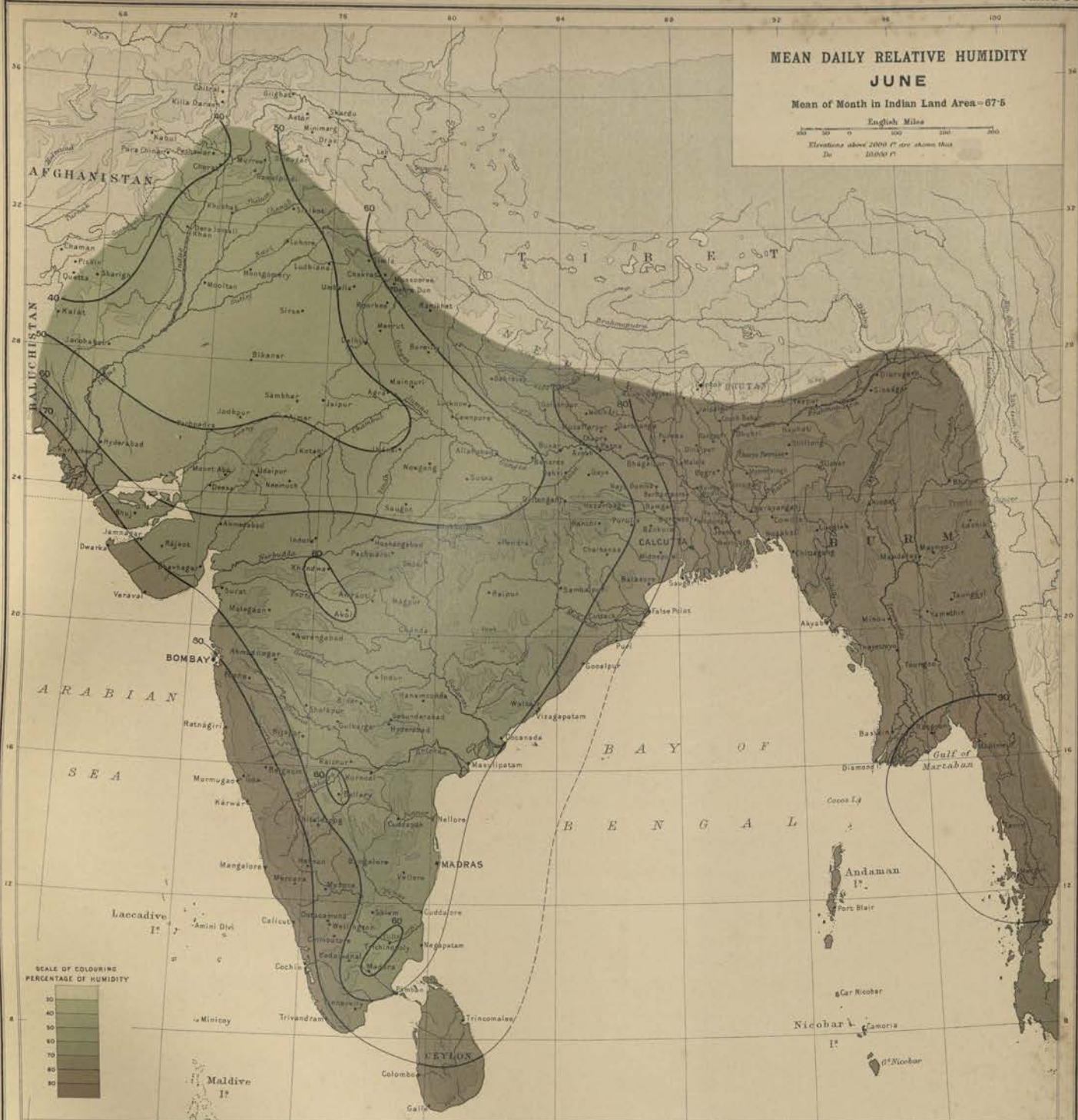


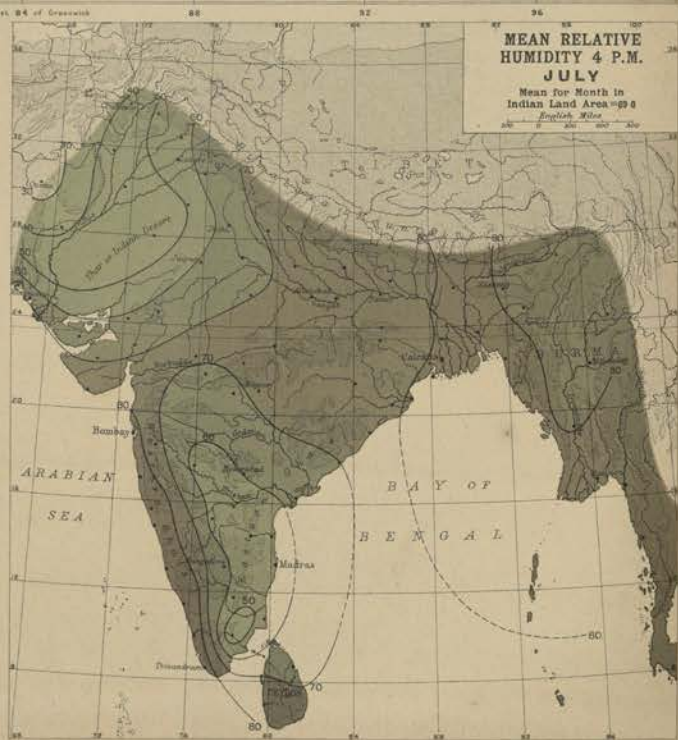
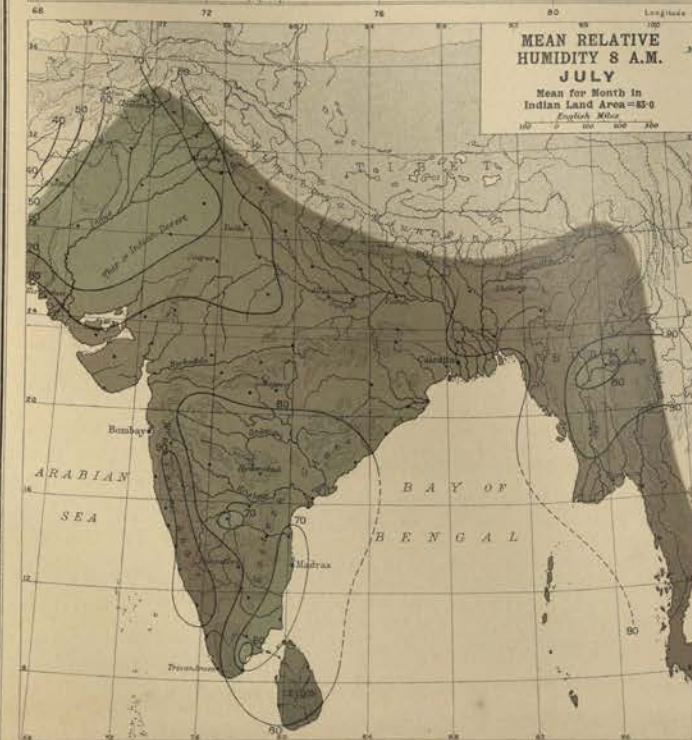
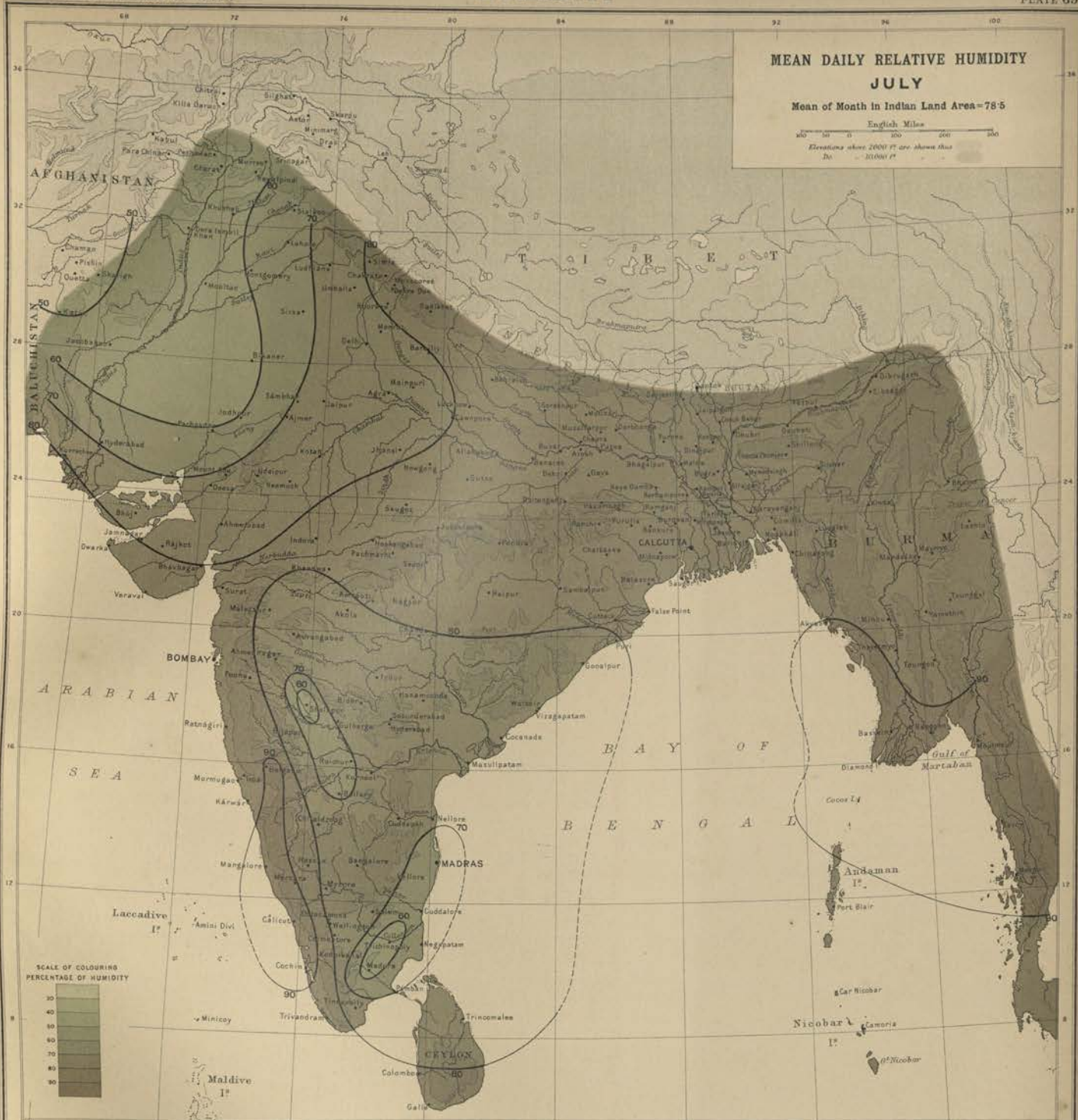


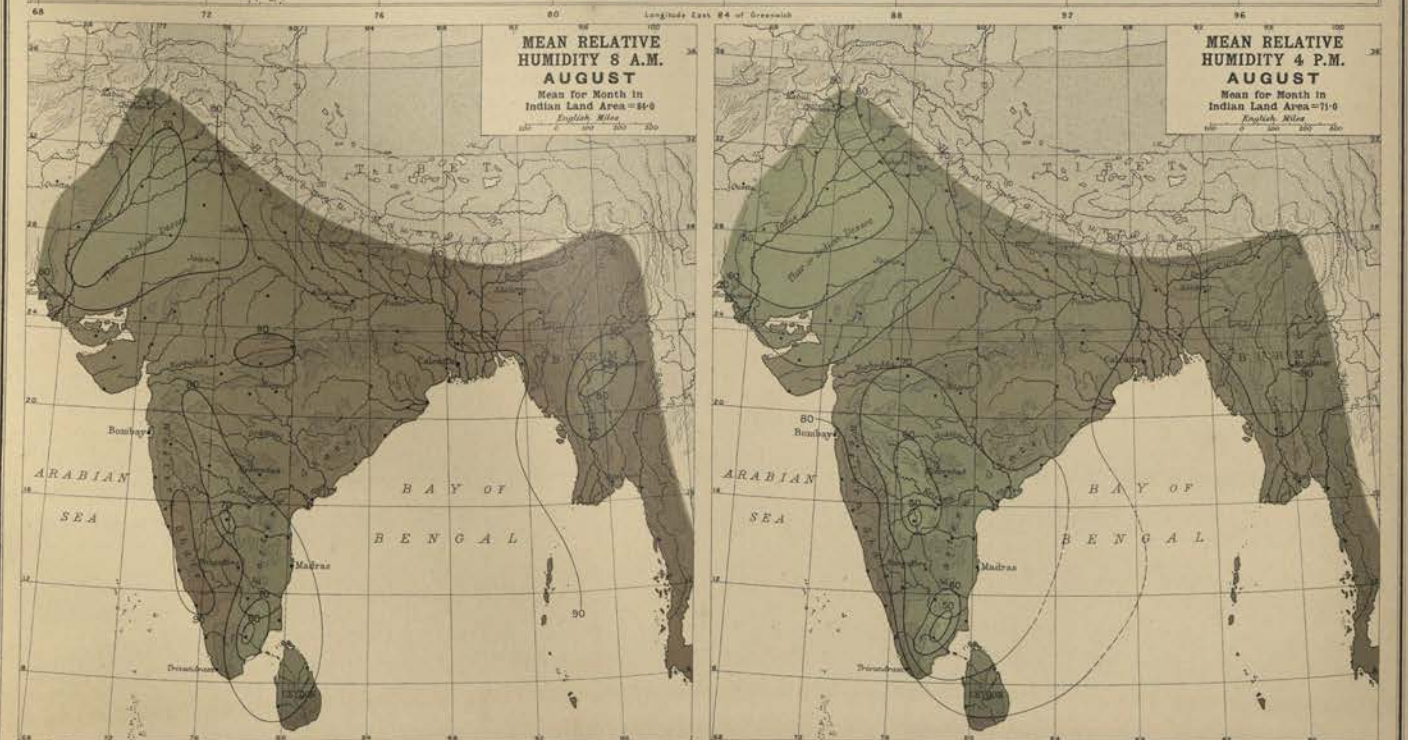


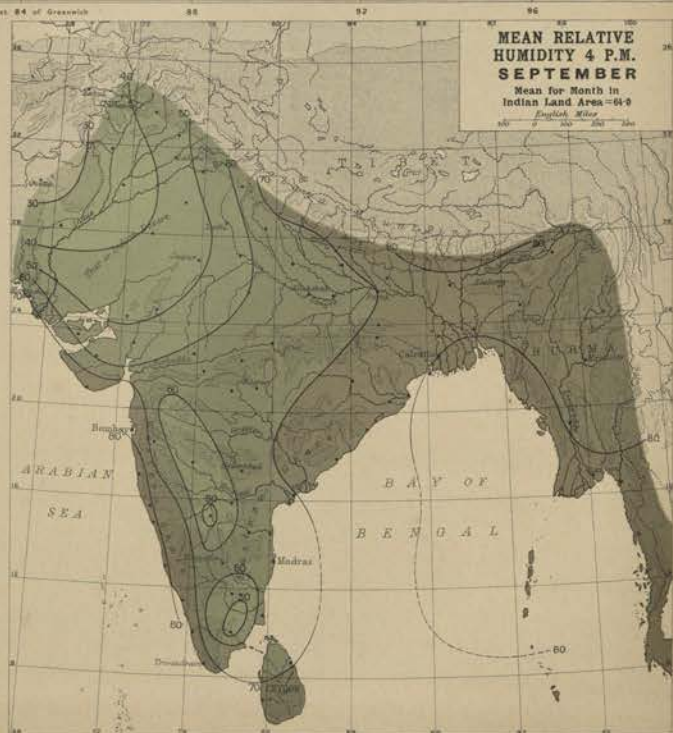
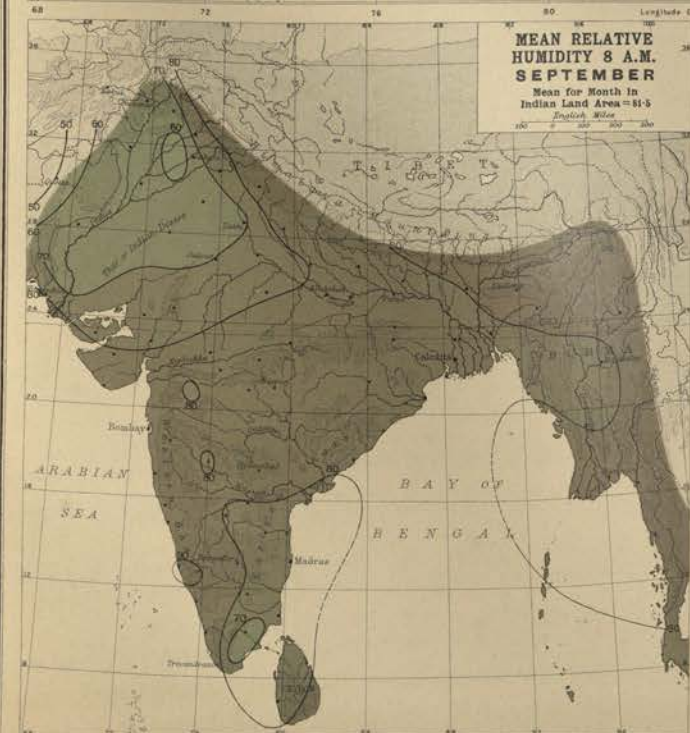
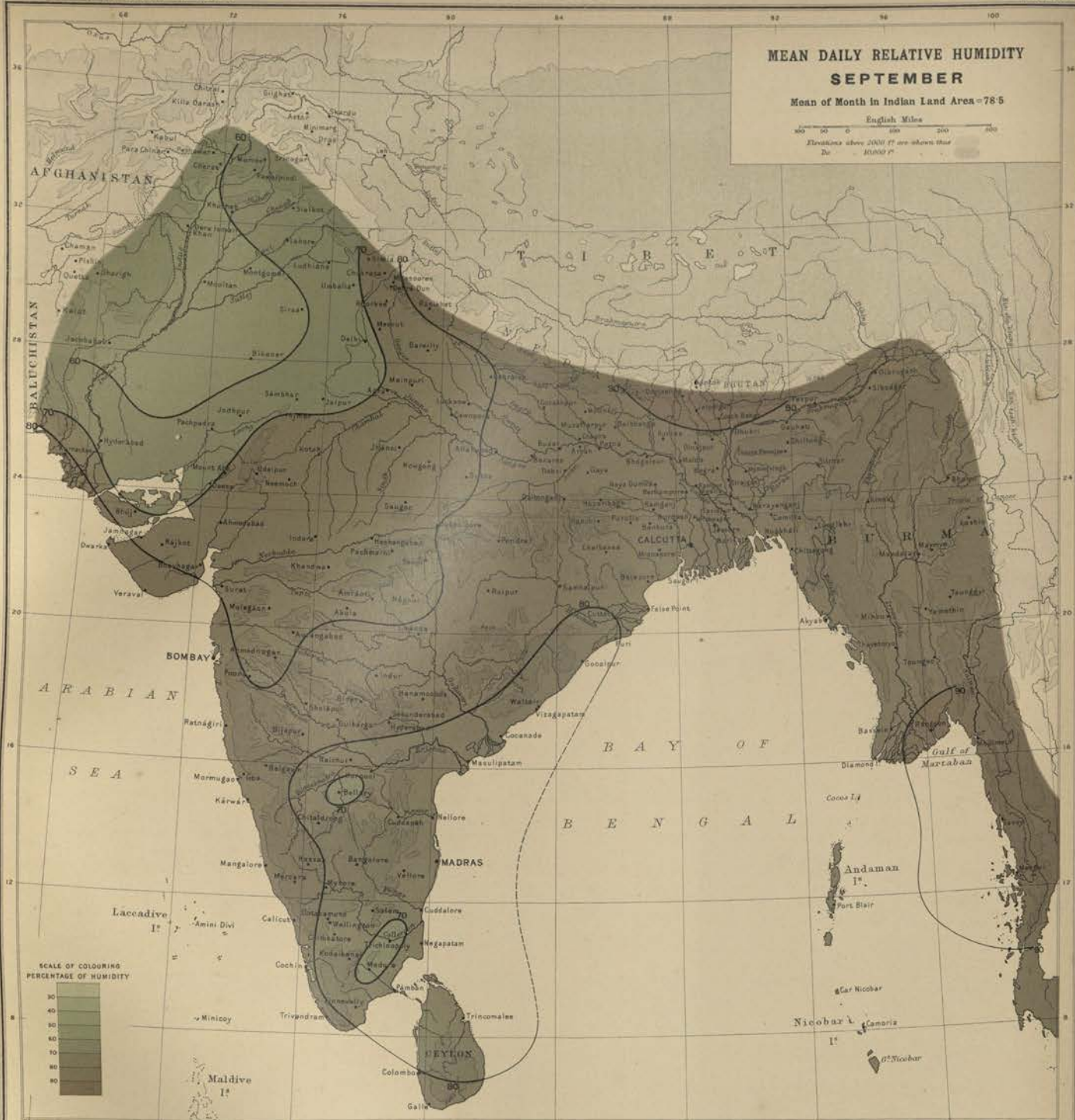


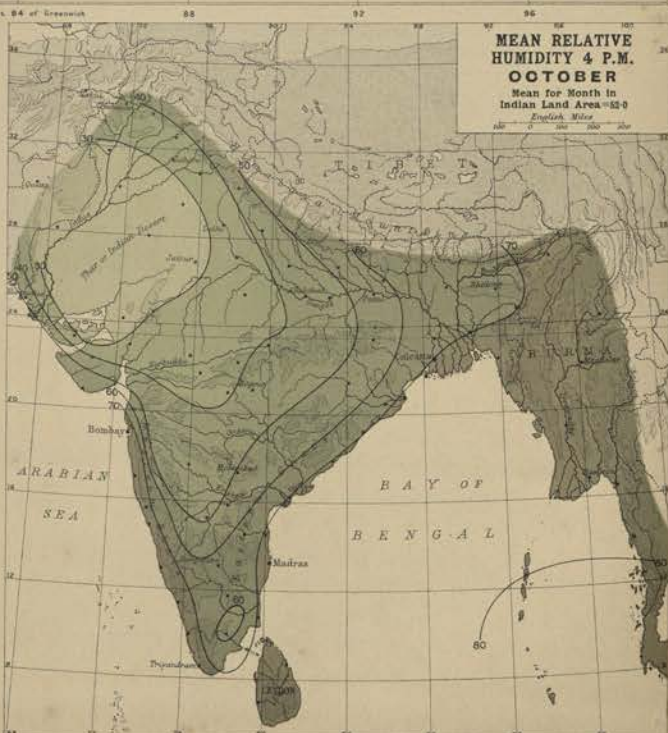
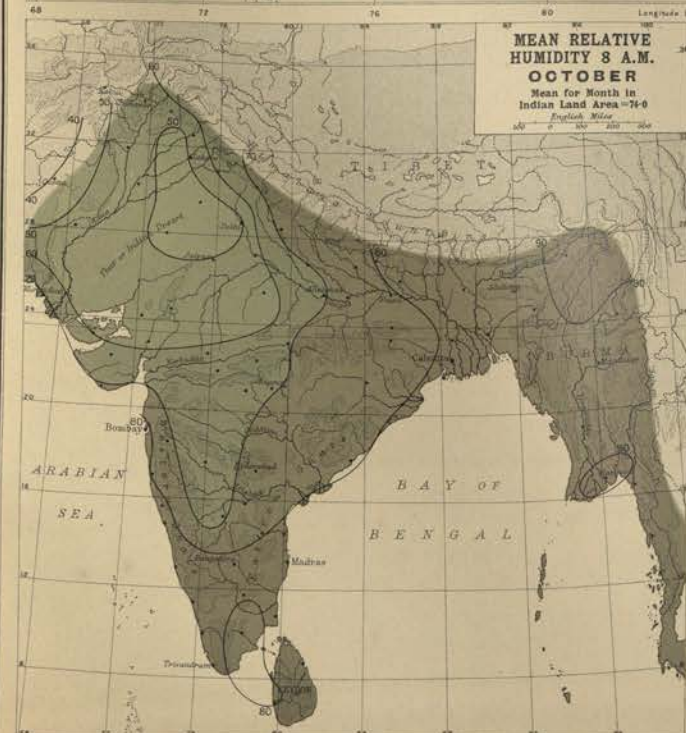
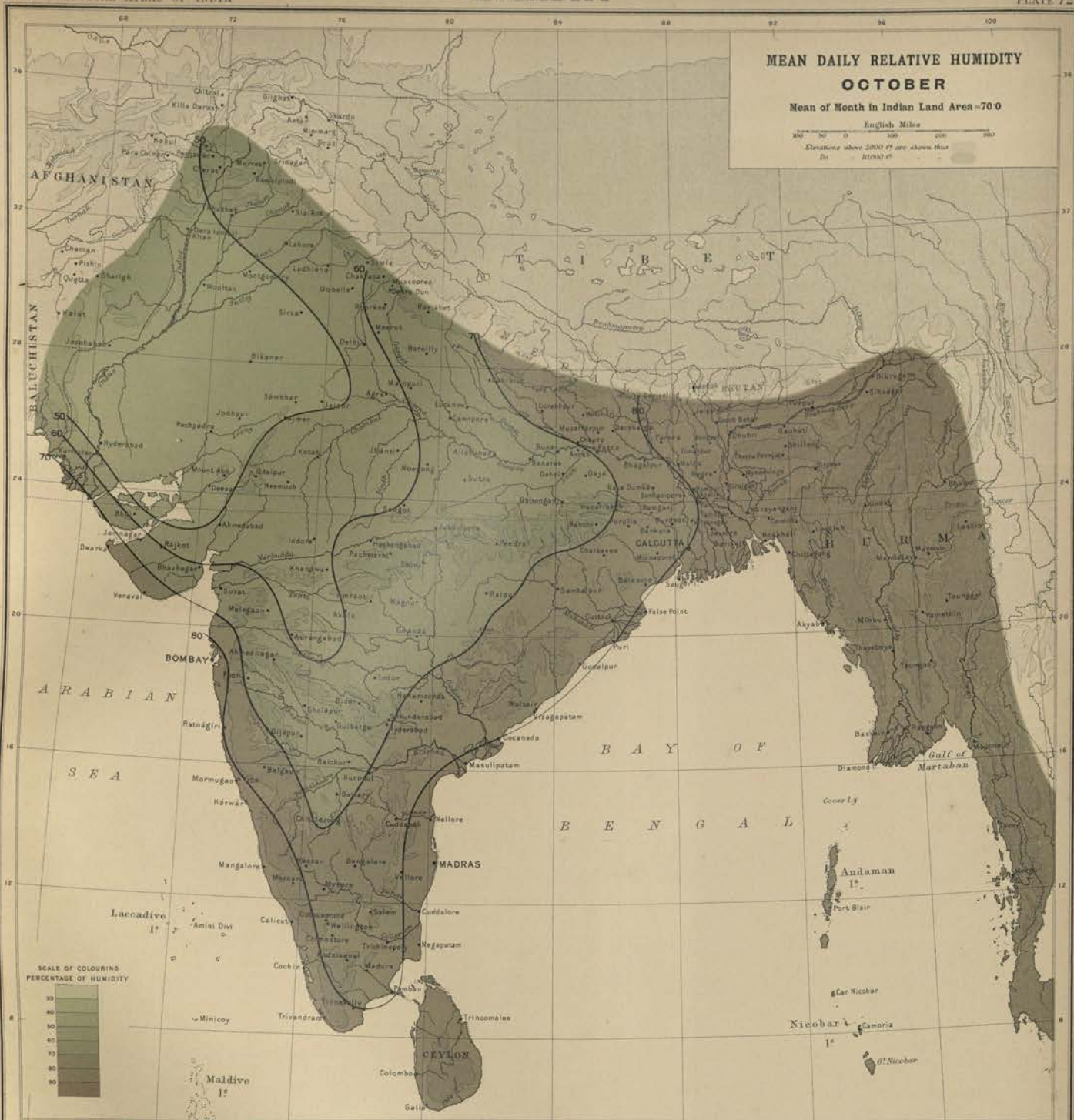


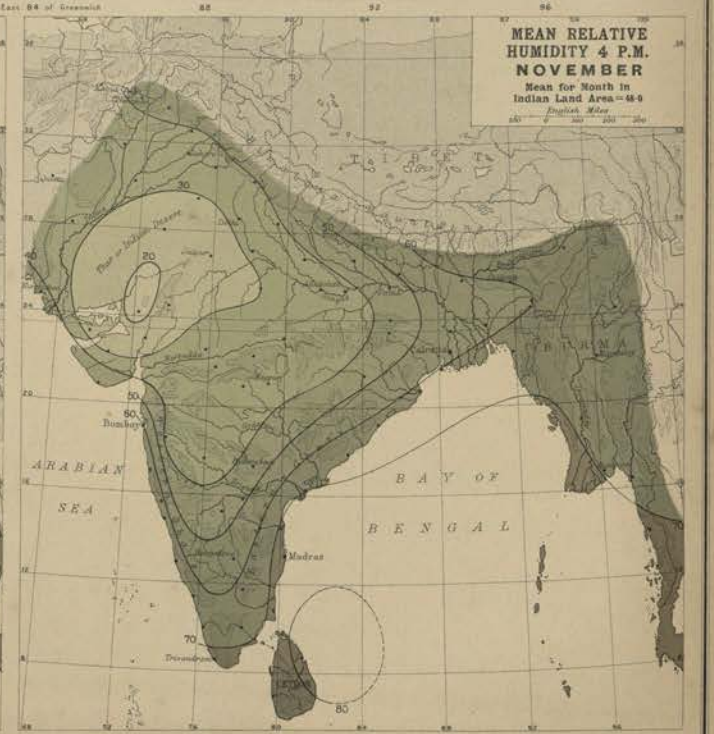
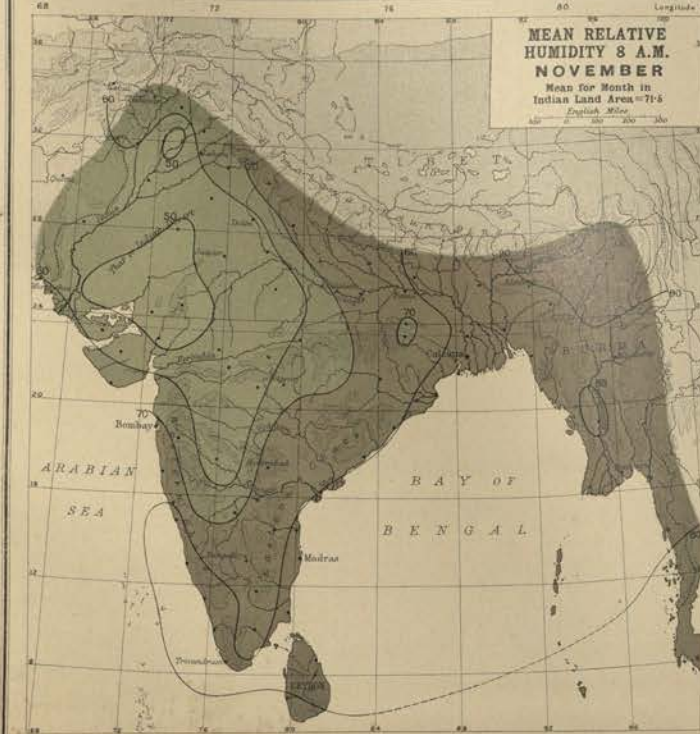
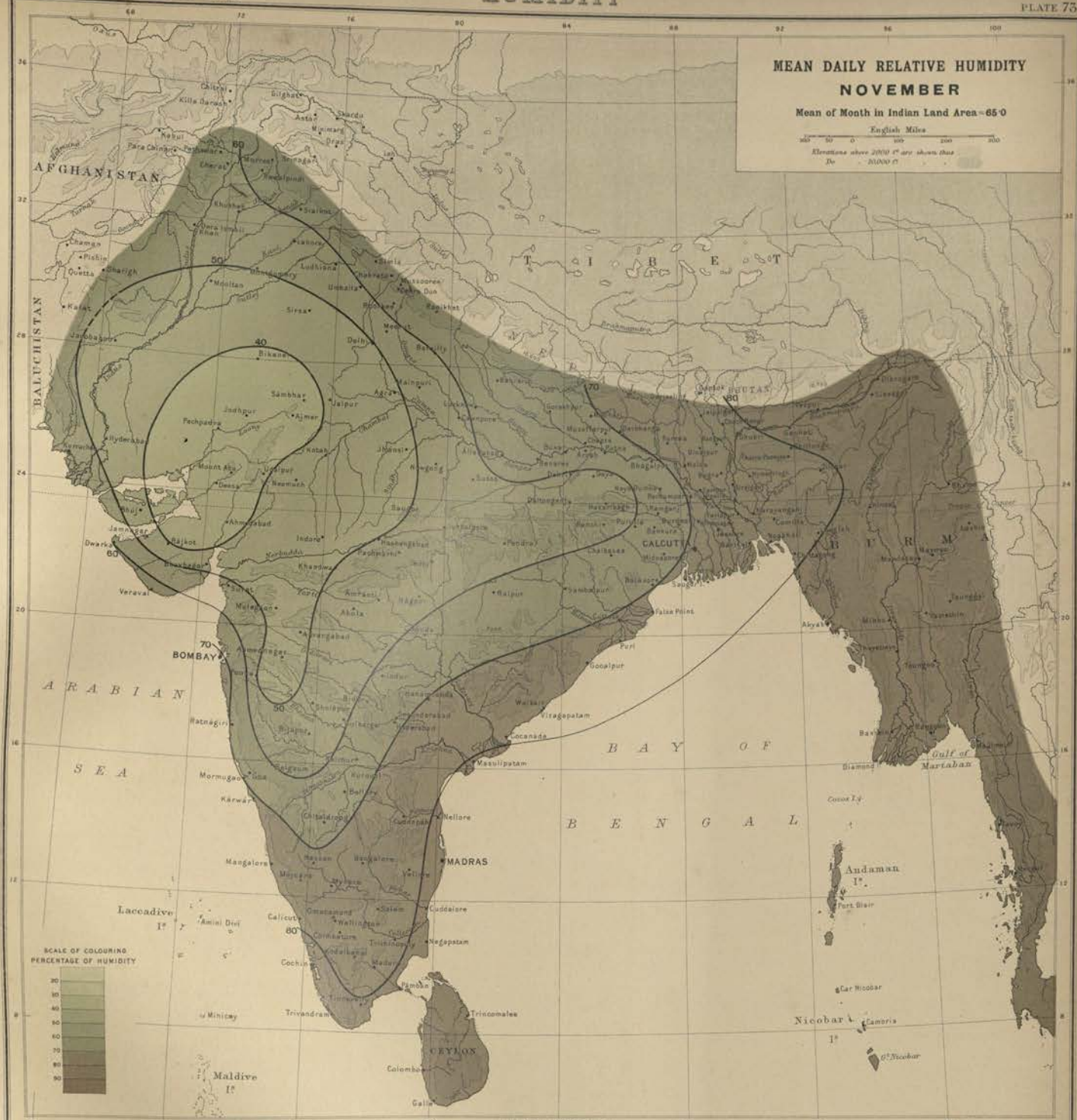


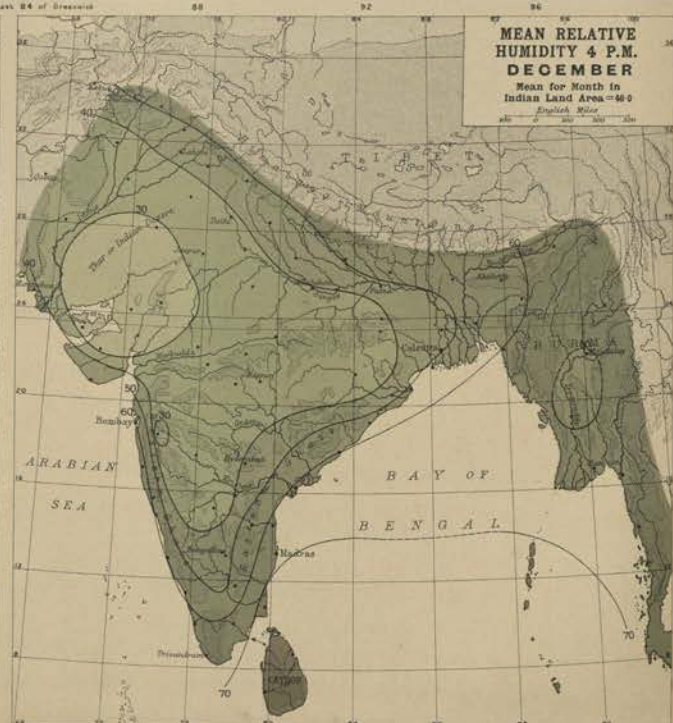
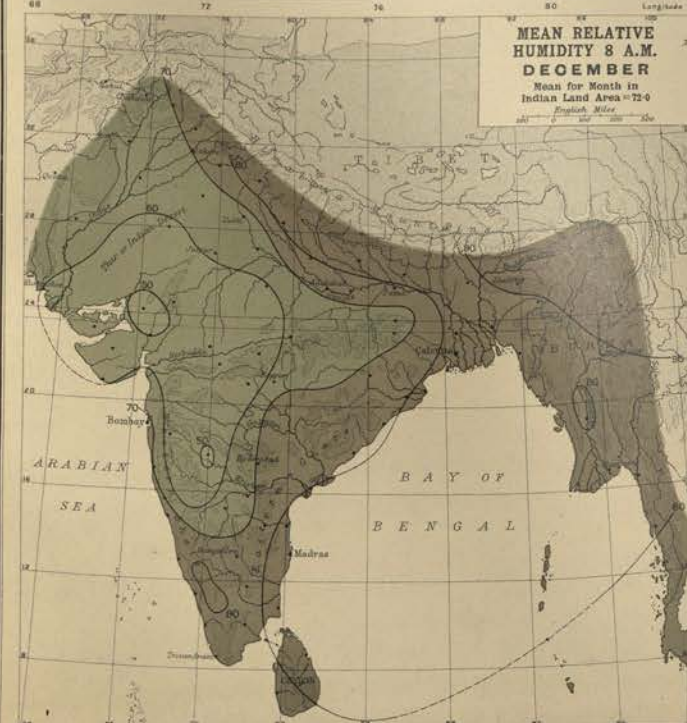
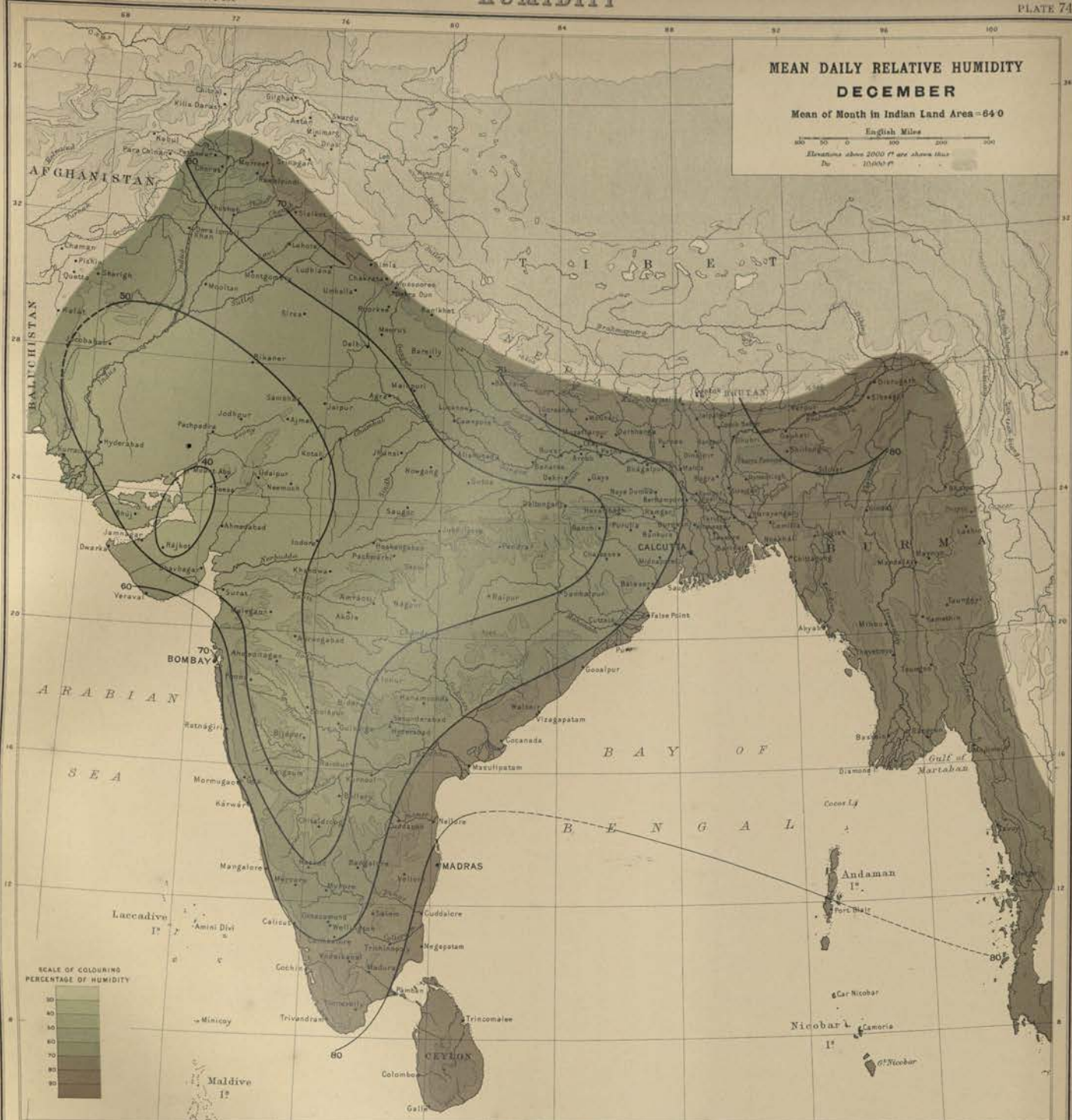


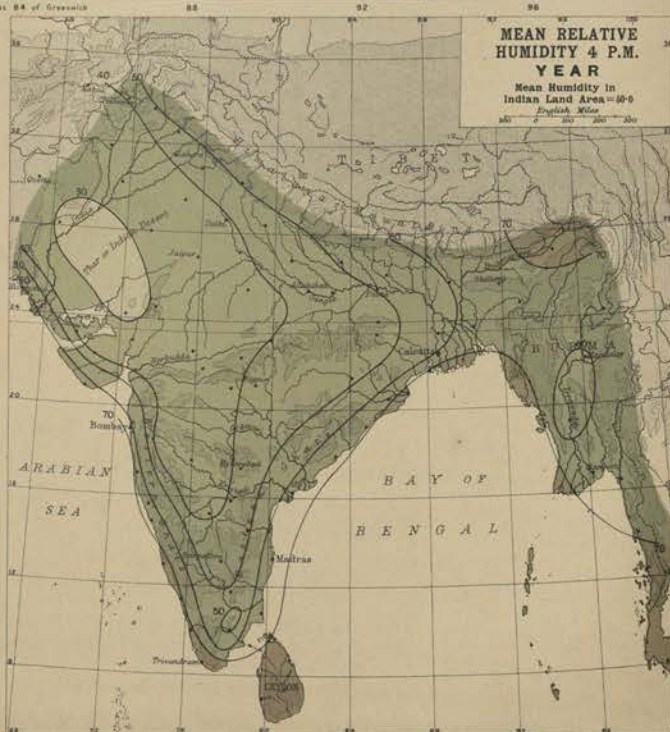
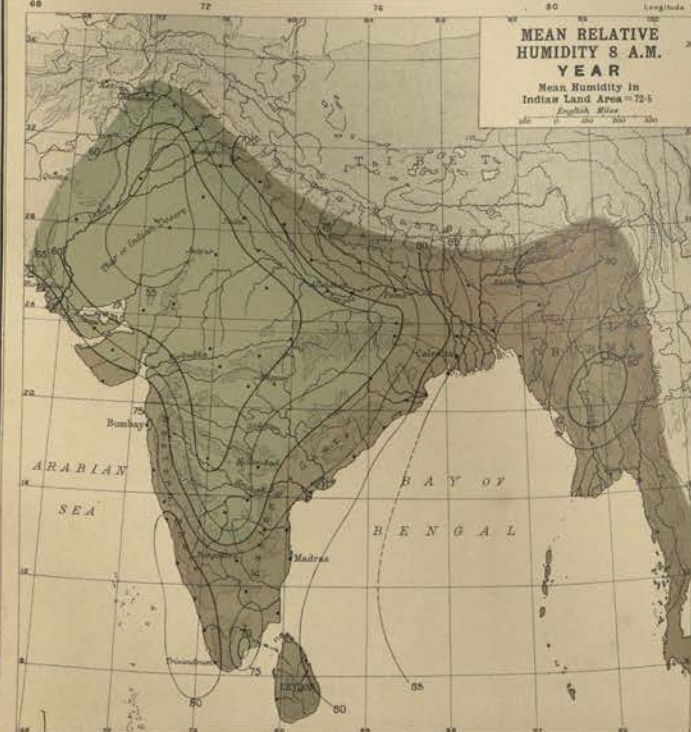
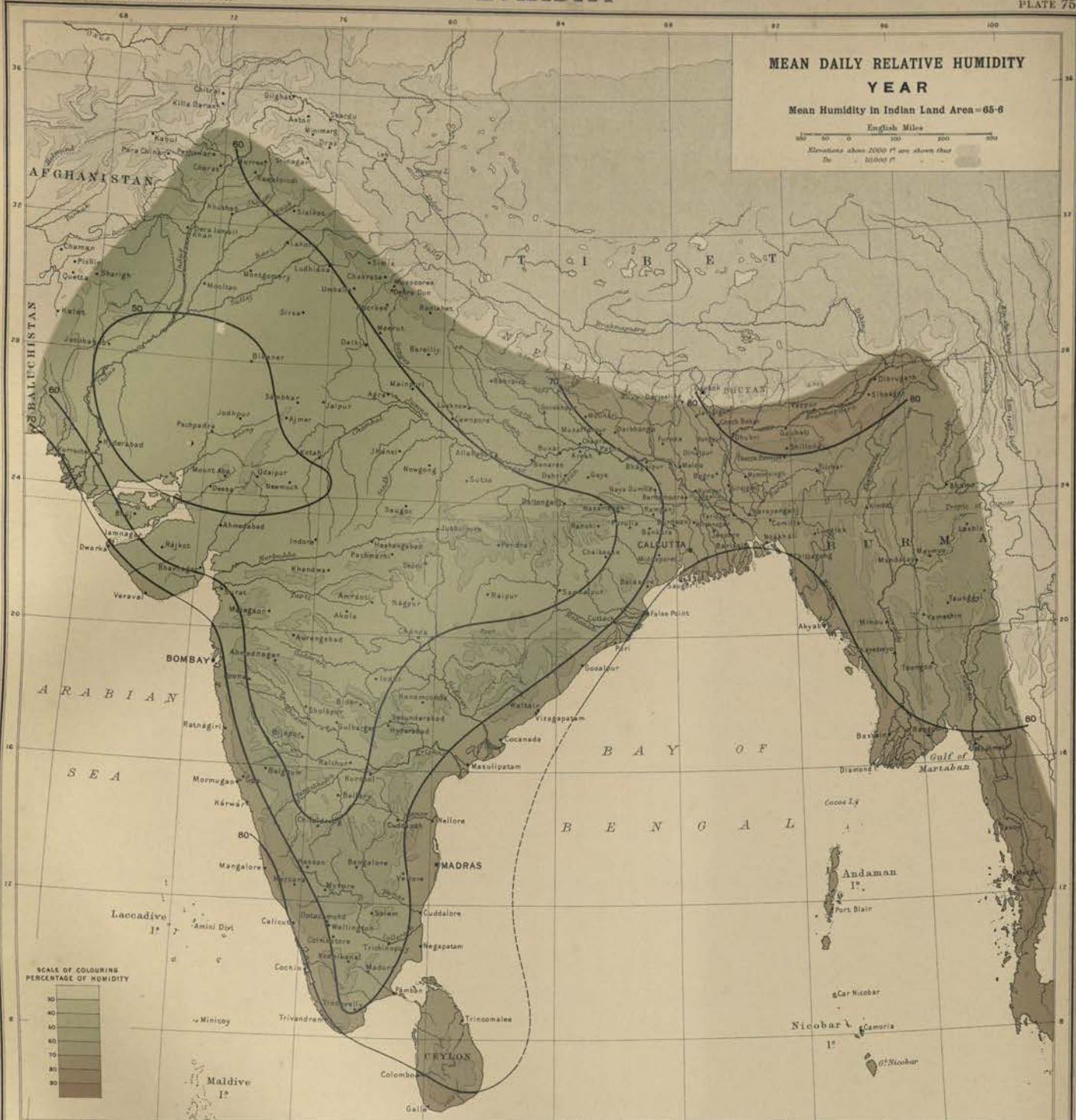


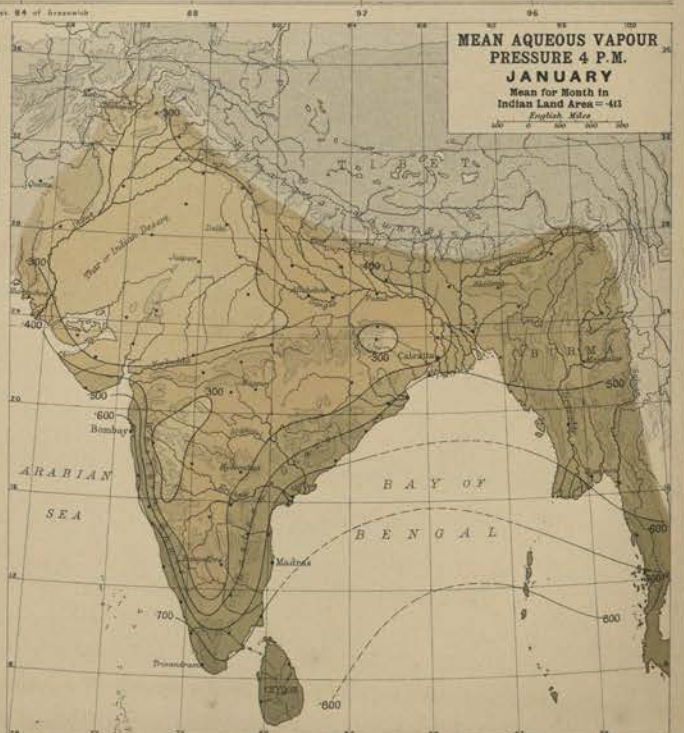
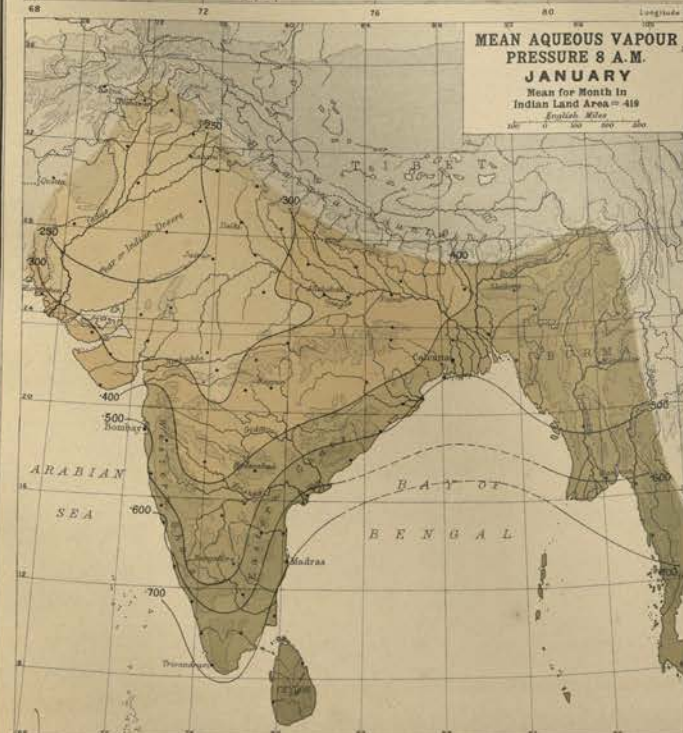
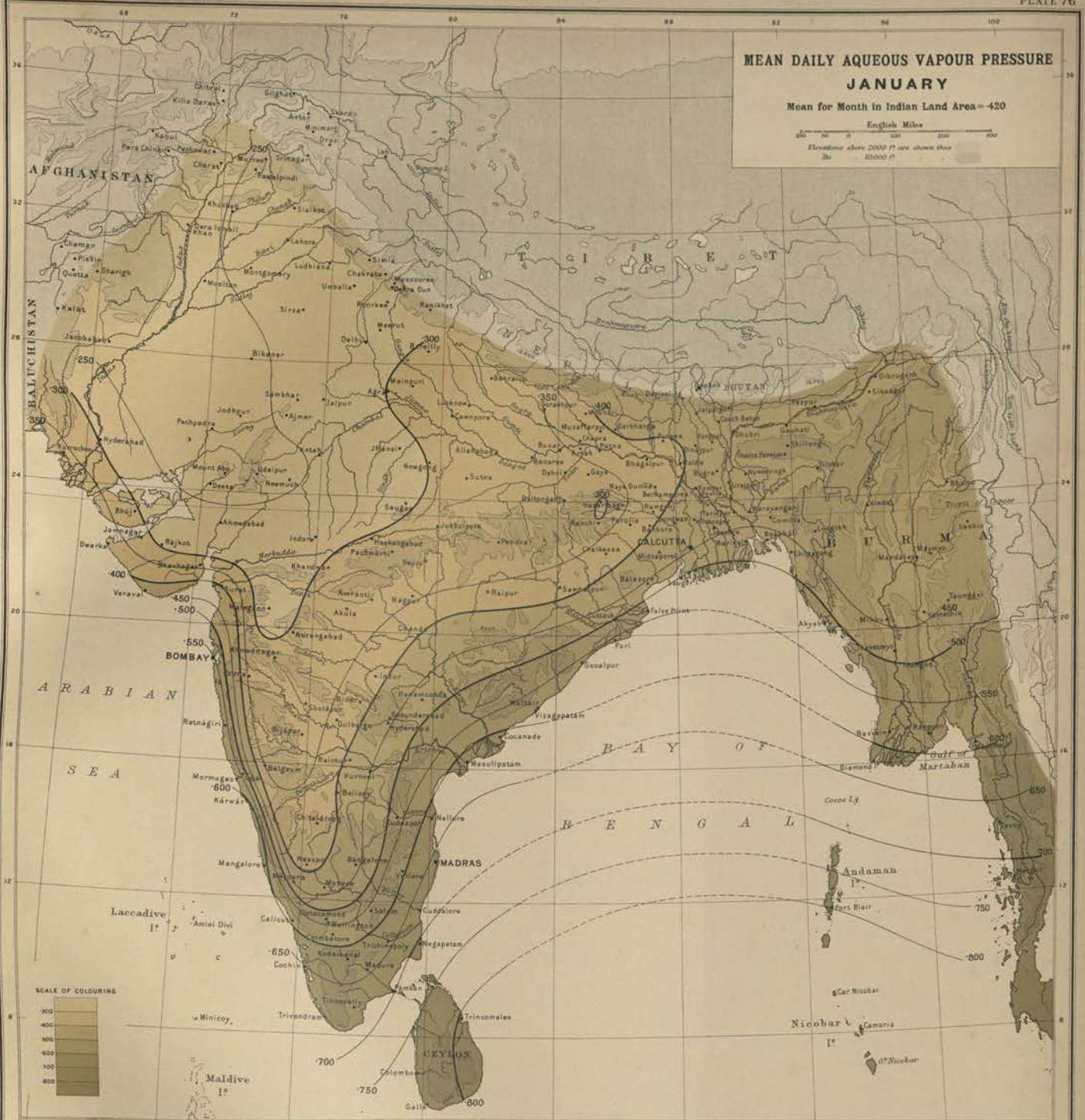








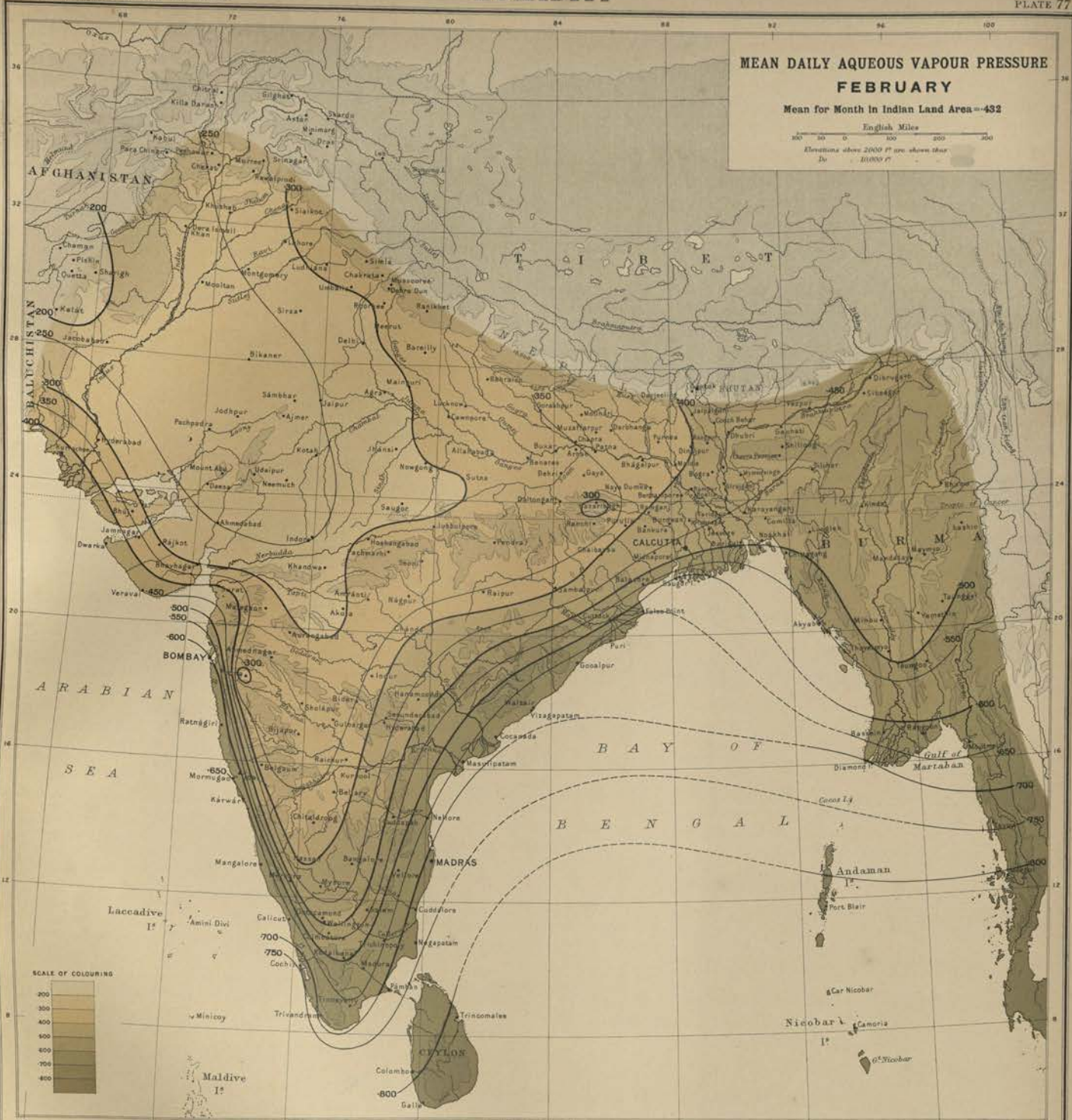




MEAN DAILY AQUEOUS VAPOUR PRESSURE FEBRUARY

Mean for Month in Indian Land Area = 432

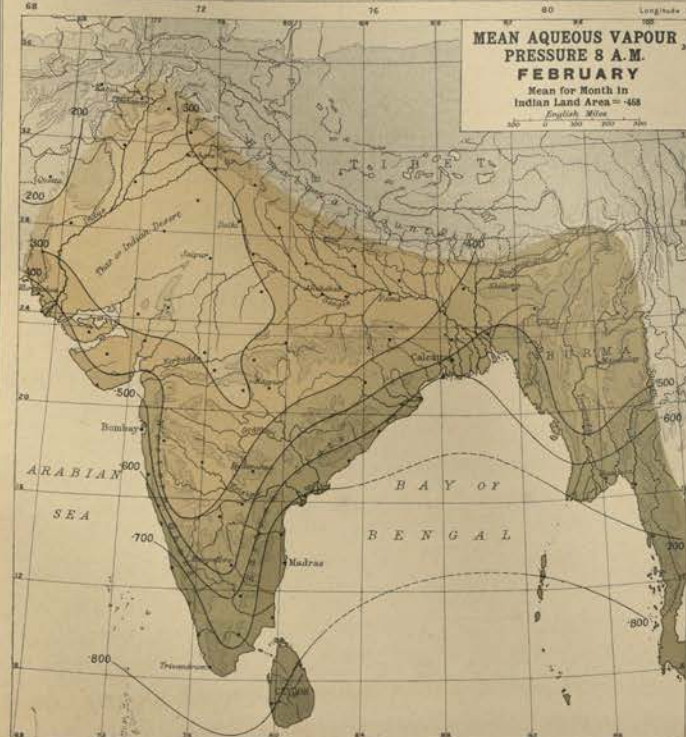
English Miles
Scale 0 100 200 300
Elevations above 2000 ft are shown thus
in 1000 ft



MEAN AQUEOUS VAPOUR PRESSURE 8 A.M. FEBRUARY

Mean for Month in
Indian Land Area = 458

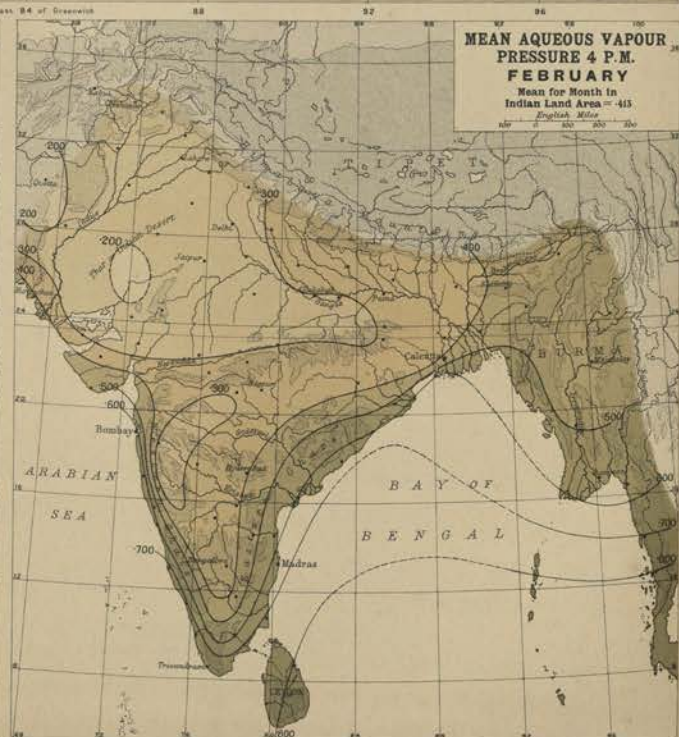
English Miles
Scale 0 100 200 300

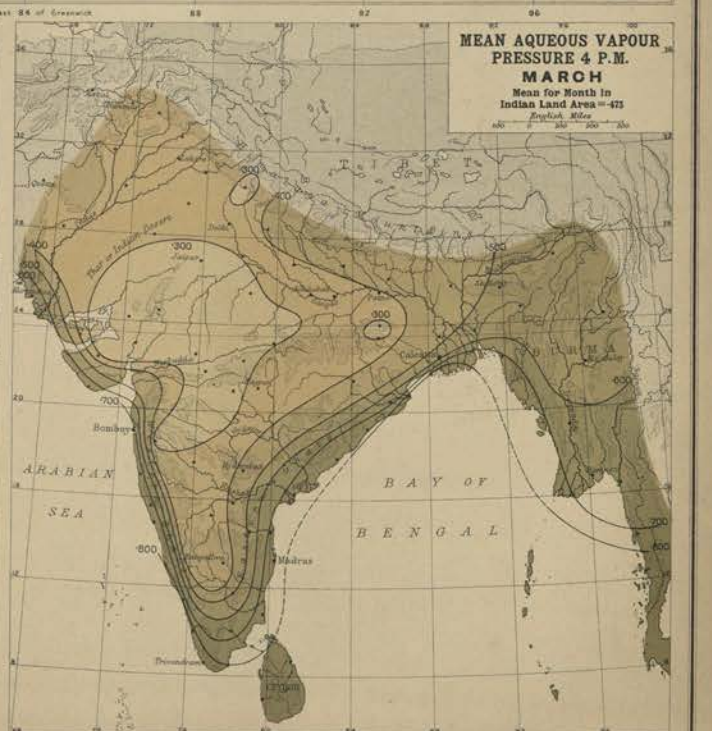
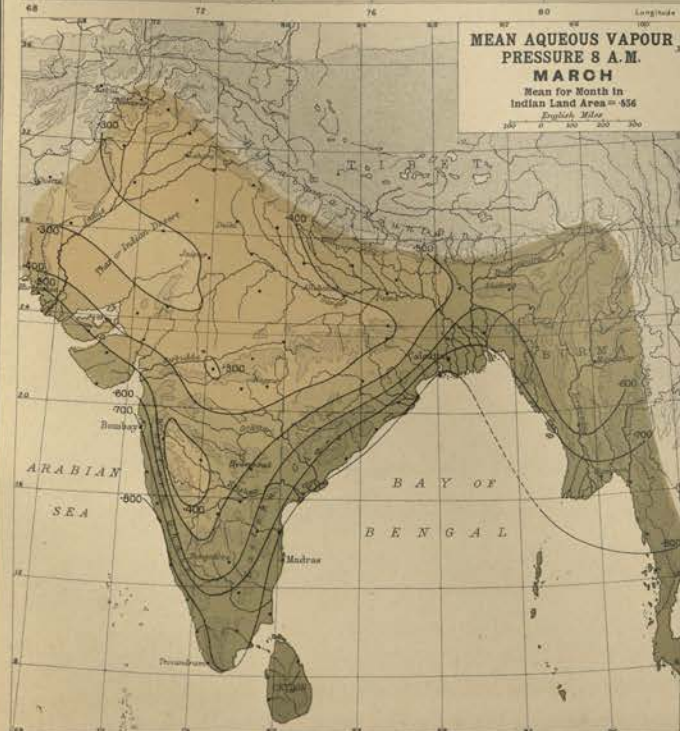
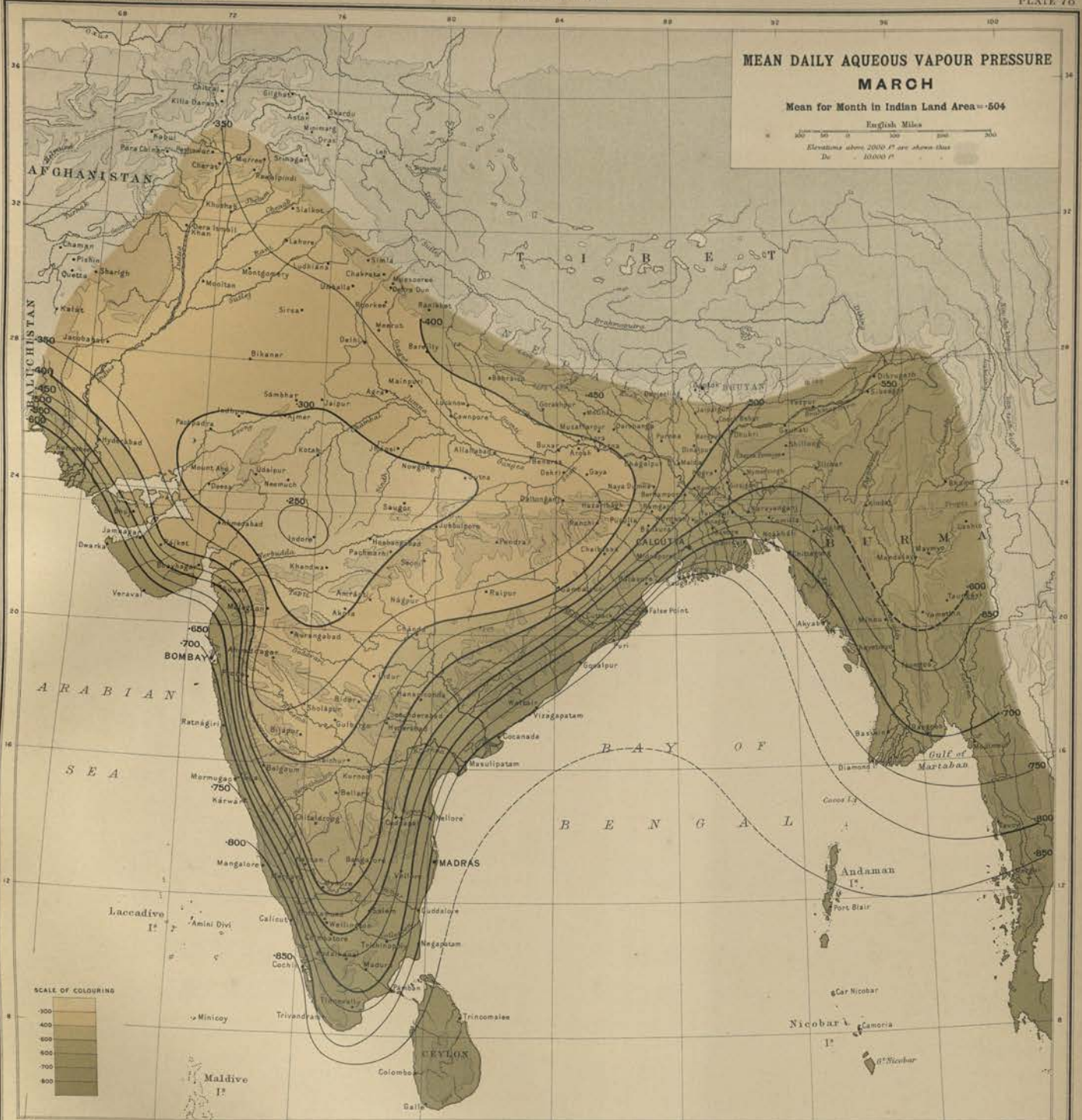


MEAN AQUEOUS VAPOUR PRESSURE 4 P.M. FEBRUARY

Mean for Month in
Indian Land Area = 415

English Miles
Scale 0 100 200 300

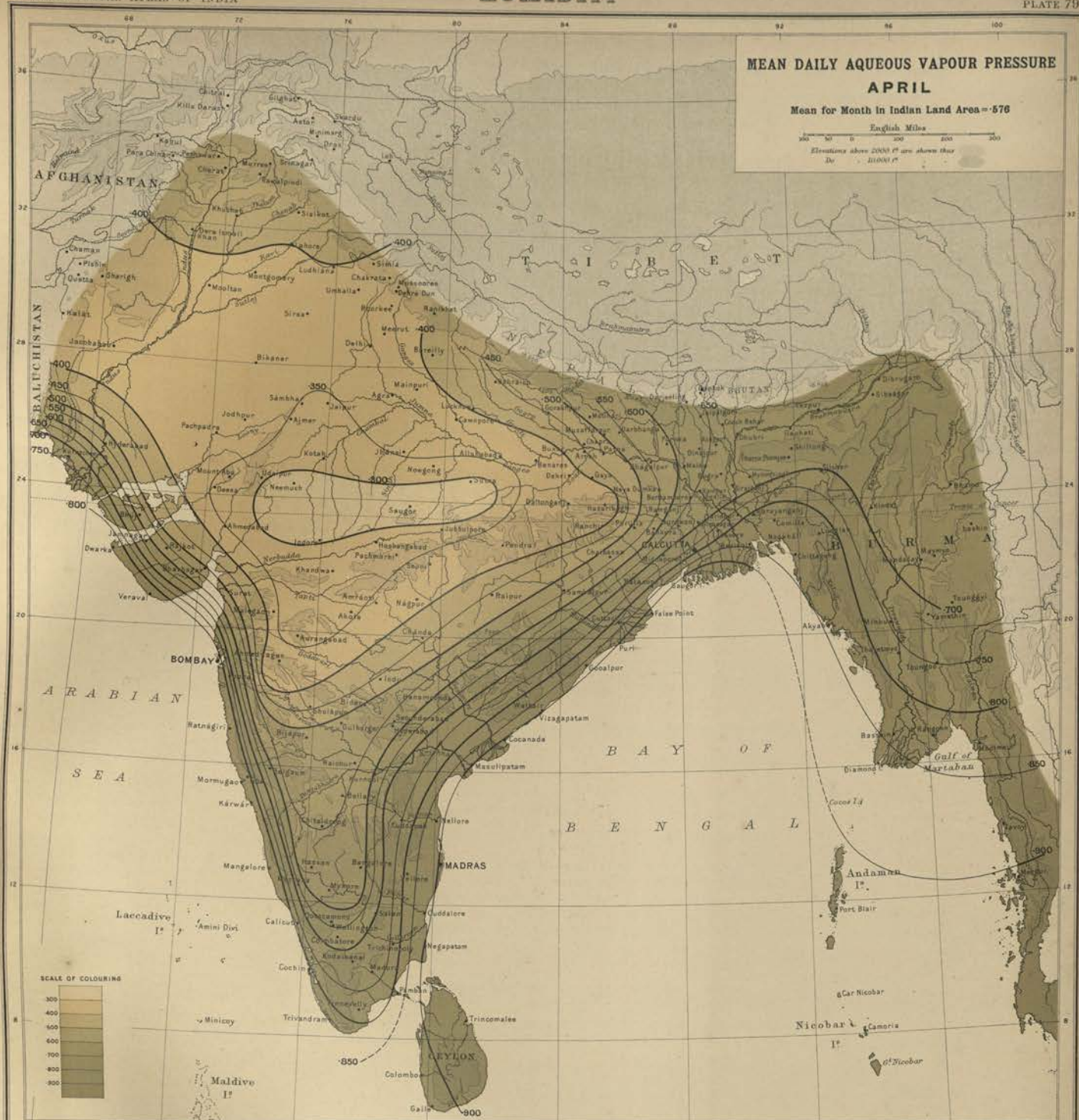




MEAN DAILY AQUEOUS VAPOUR PRESSURE APRIL

Mean for Month in Indian Land Area = 576

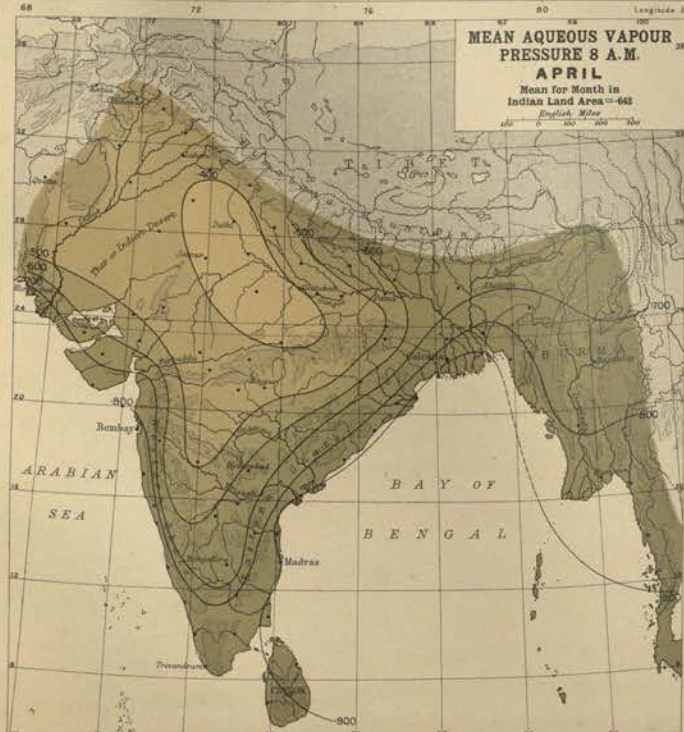
English Miles
100 0 100 200 300
Elevations above 2000 ft are shown thus
20 21000 ft



MEAN AQUEOUS VAPOUR PRESSURE 8 A.M. APRIL

Mean for Month in
Indian Land Area = 445

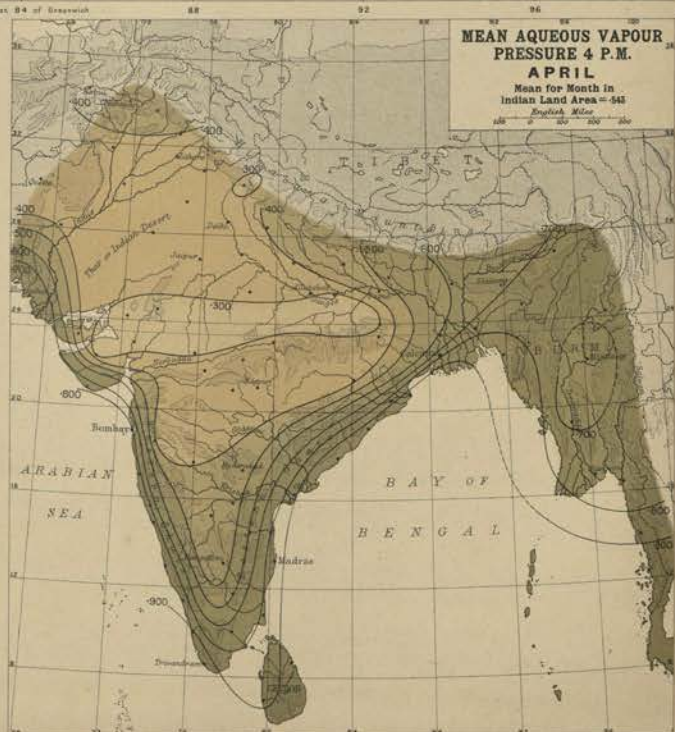
English Miles
100 0 100 200 300

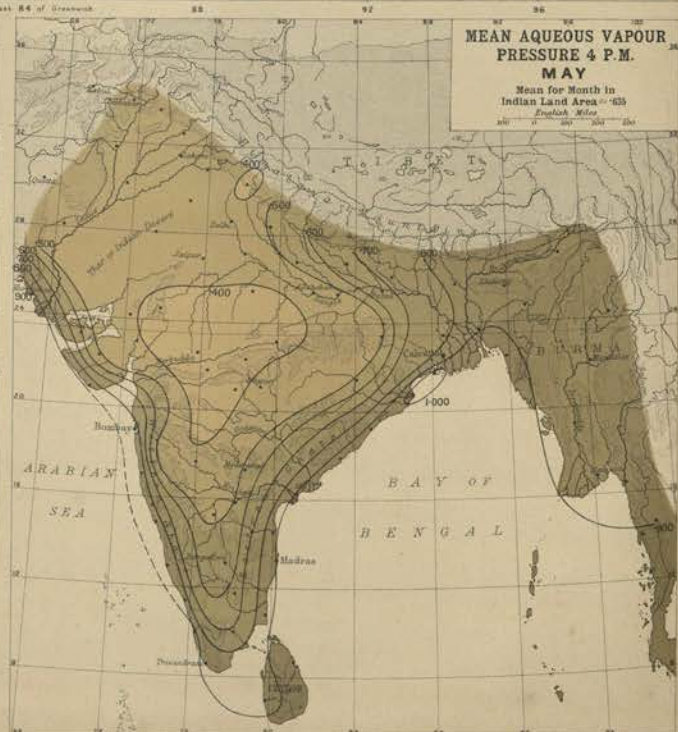
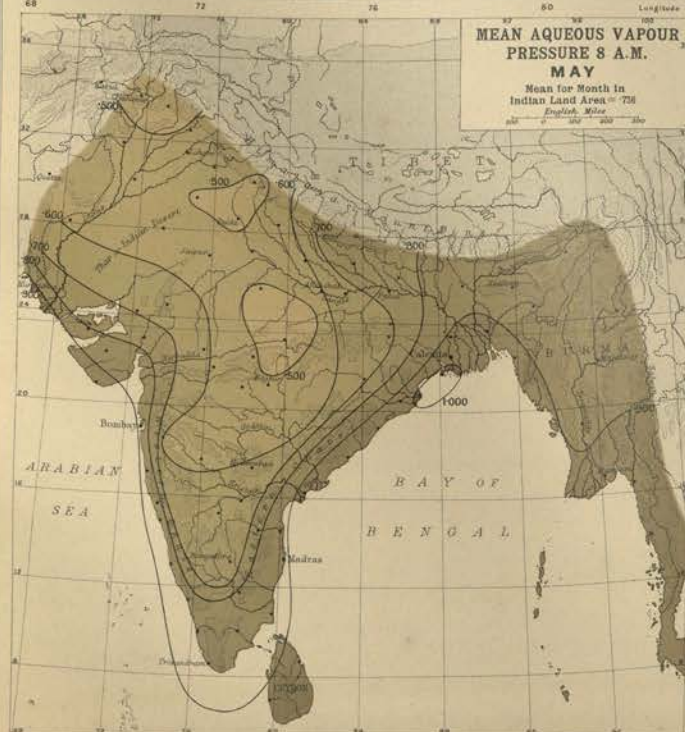
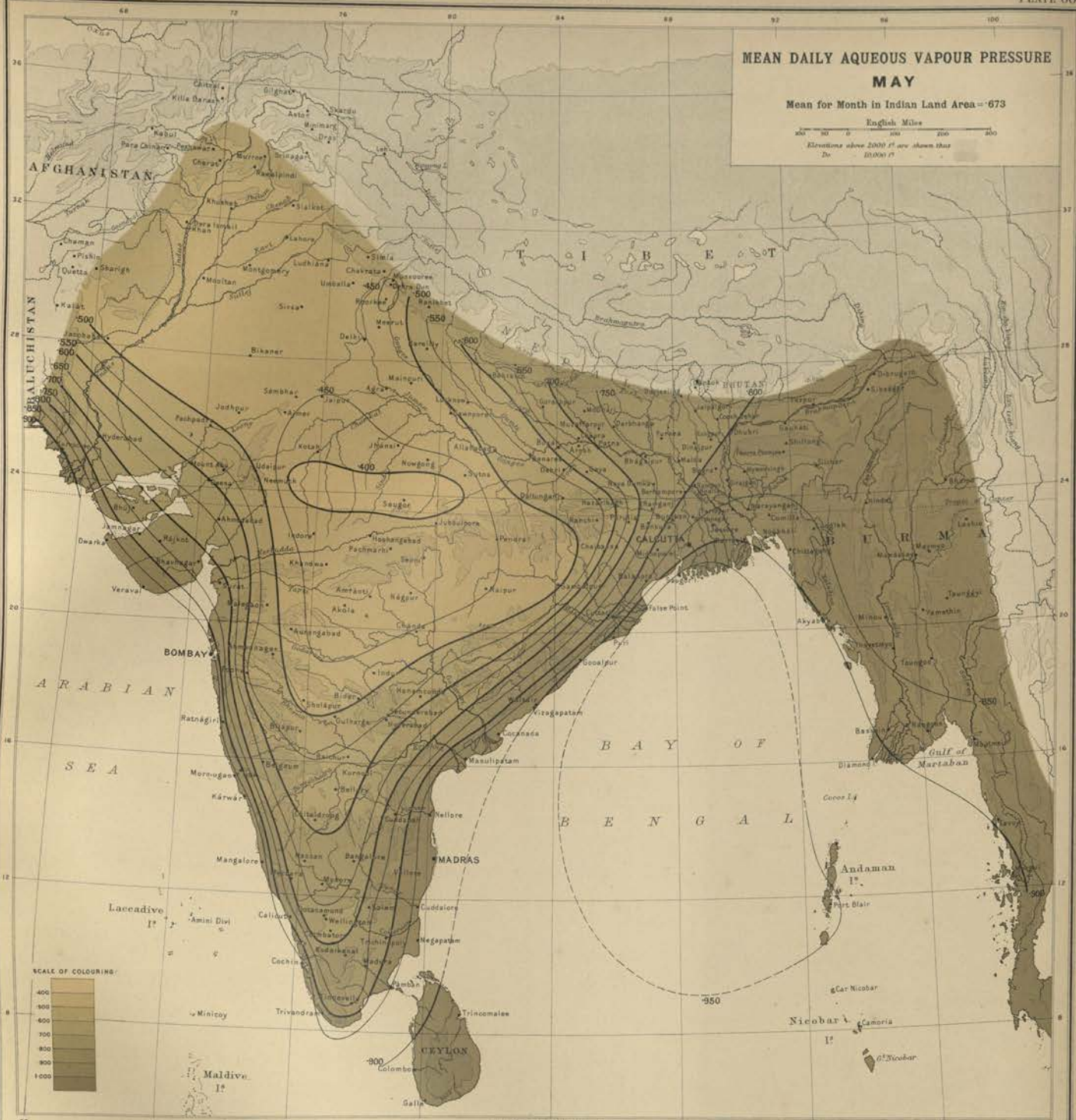


MEAN AQUEOUS VAPOUR PRESSURE 4 P.M. APRIL

Mean for Month in
Indian Land Area = 545

English Miles
100 0 100 200 300

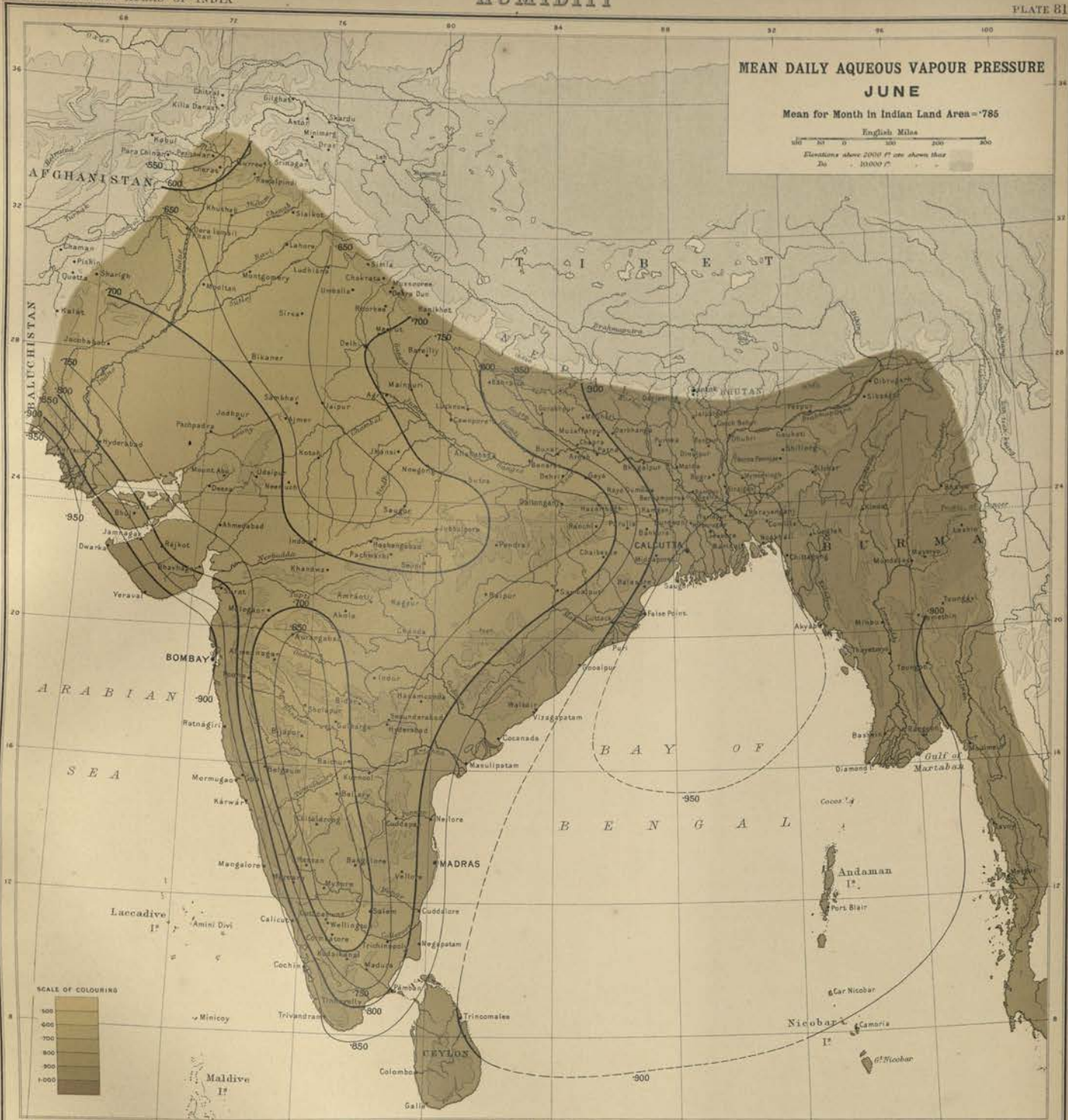




MEAN DAILY AQUEOUS VAPOUR PRESSURE JUNE

Mean for Month in Indian Land Area = 785

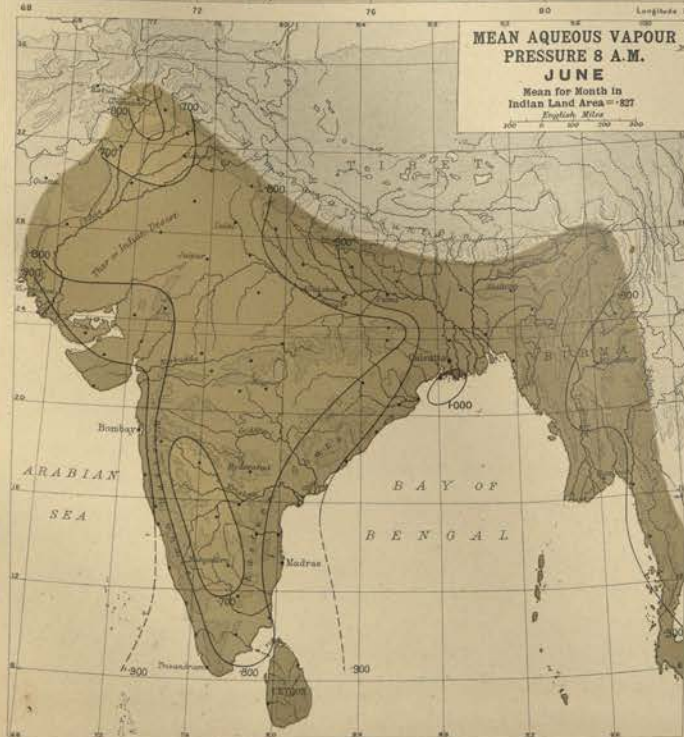
English Miles
0 50 100 200 300
Elevations above 2000 ft are shown thus
20 10000 ft



MEAN AQUEOUS VAPOUR PRESSURE 8 A.M. JUNE

Mean for Month in Indian Land Area = 827

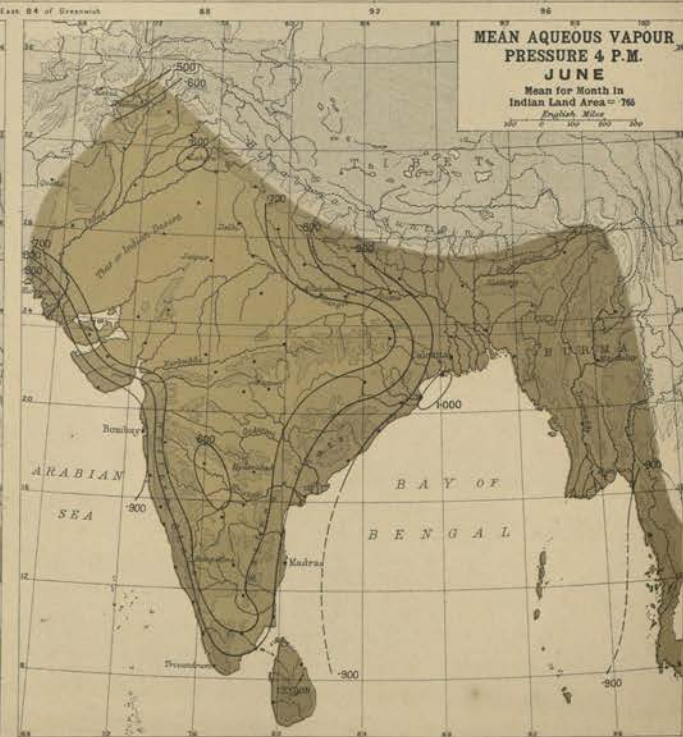
English Miles
0 50 100 200 300

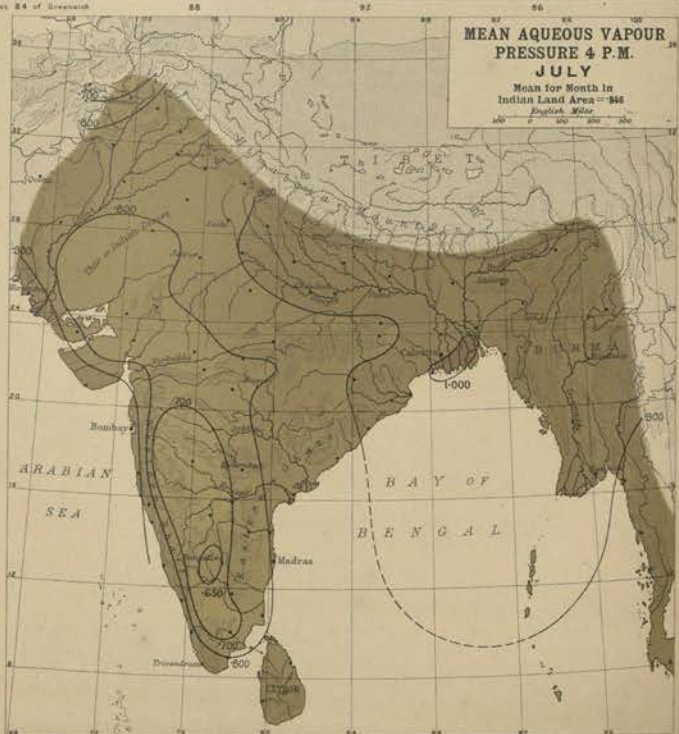
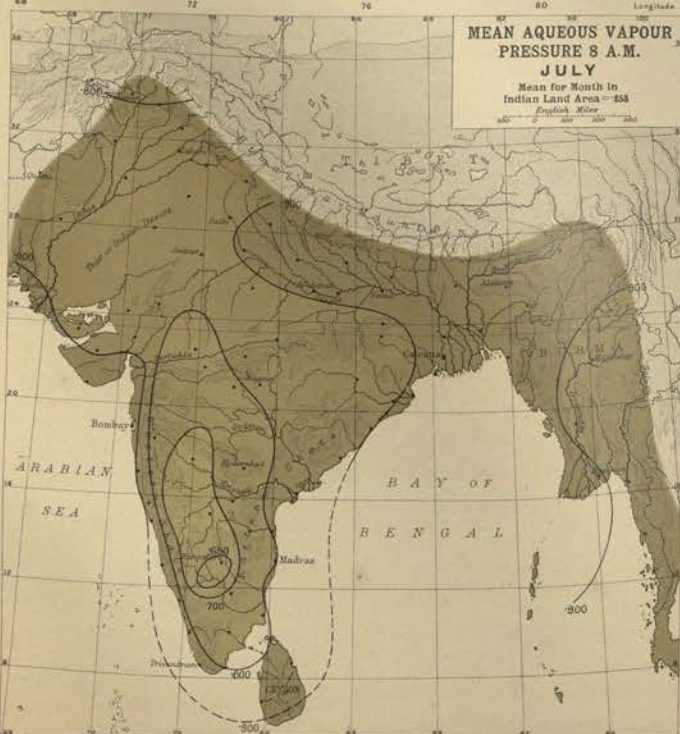
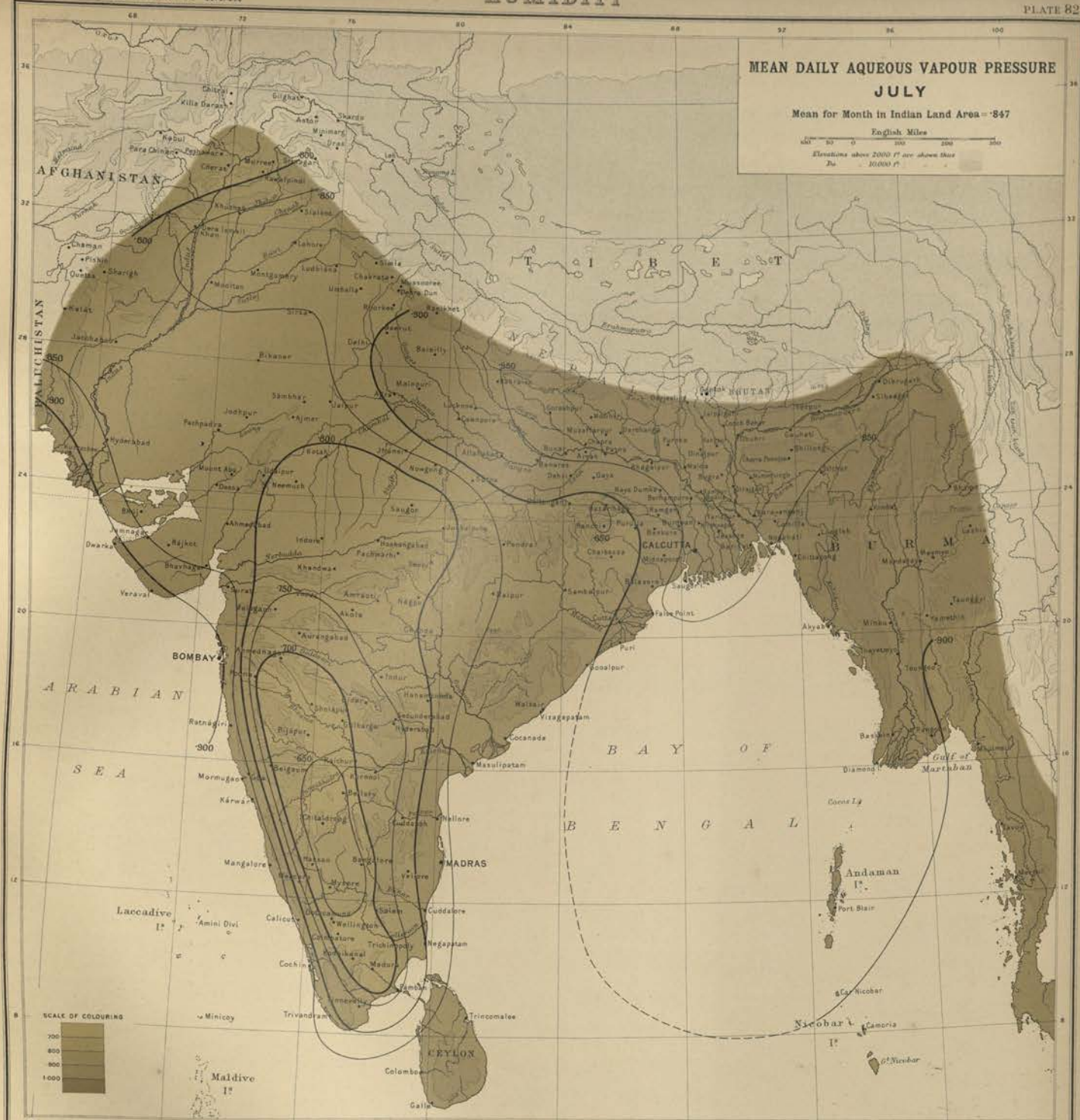


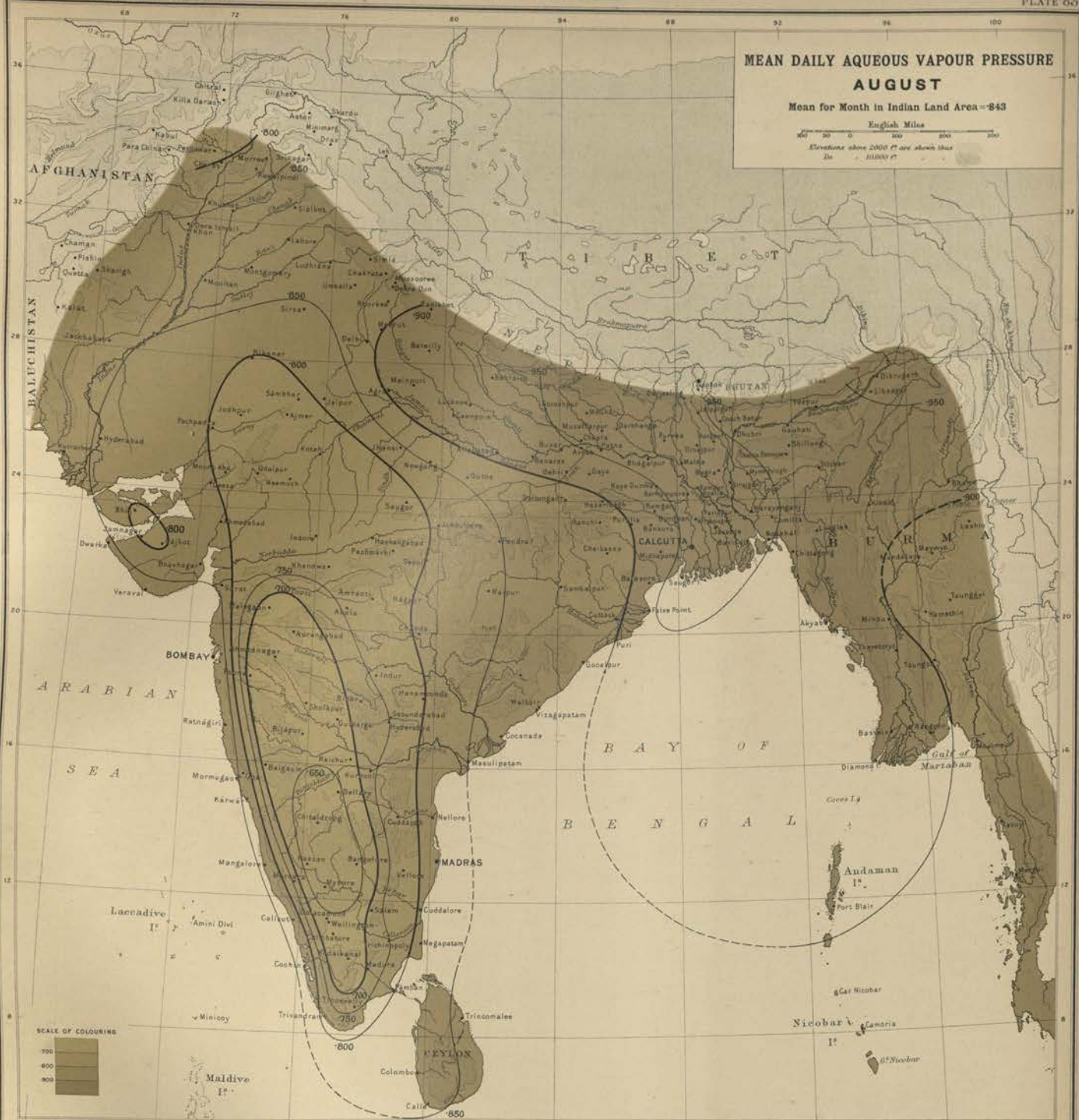
MEAN AQUEOUS VAPOUR PRESSURE 4 P.M. JUNE

Mean for Month in Indian Land Area = 766

English Miles
0 50 100 200 300







**MEAN AQUEOUS VAPOUR
PRESSURE 8 A.M.
AUGUST**

Mean for Month in
Indian Land Area = 843

English Miles
0 50 100 200 300

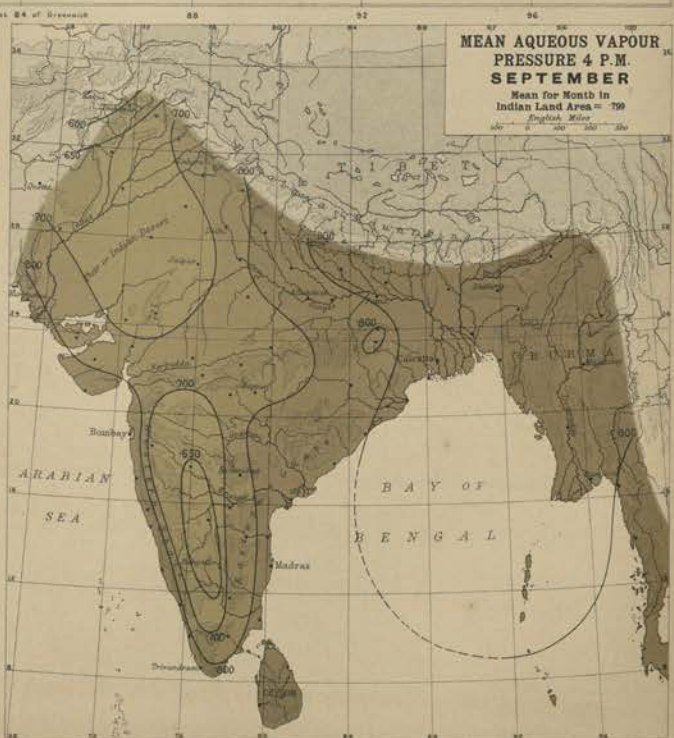
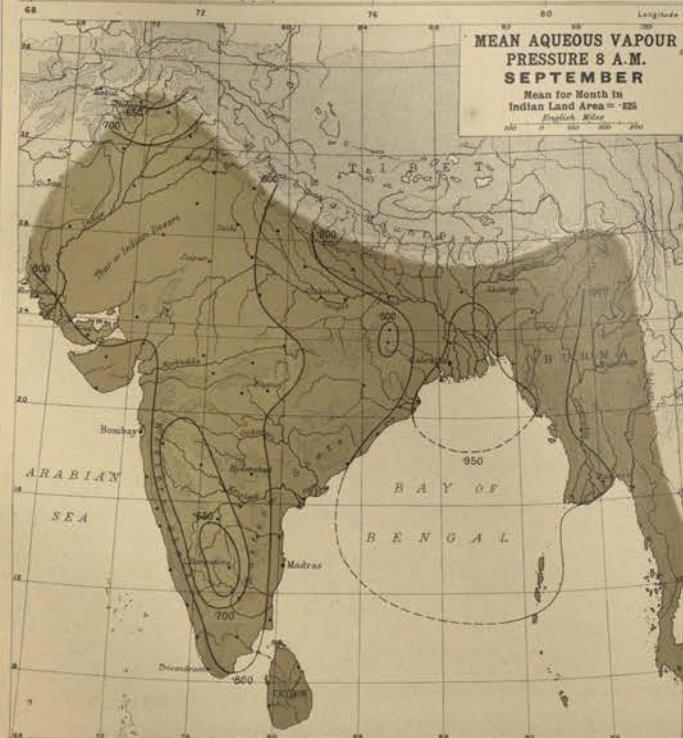
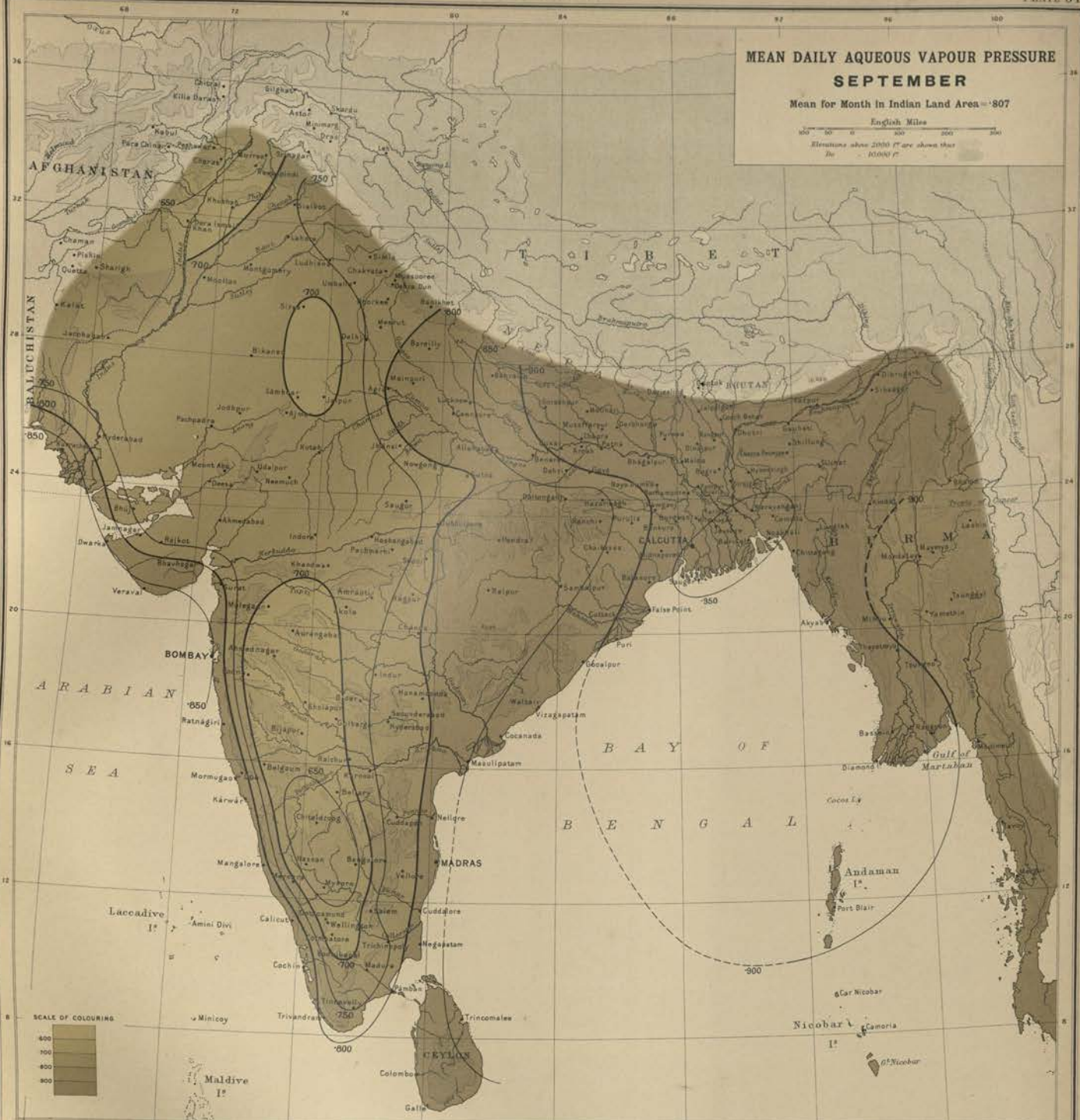
Longitude East, 84 of Greenwich

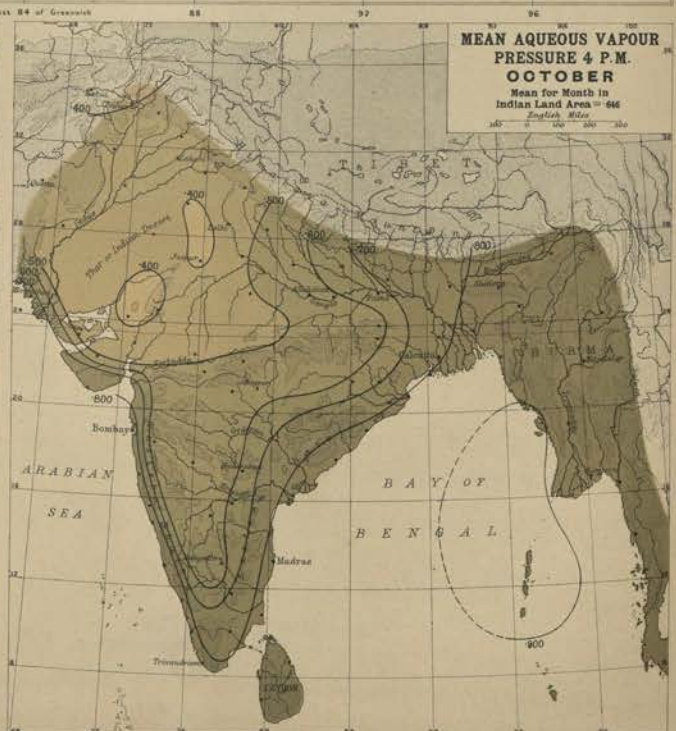
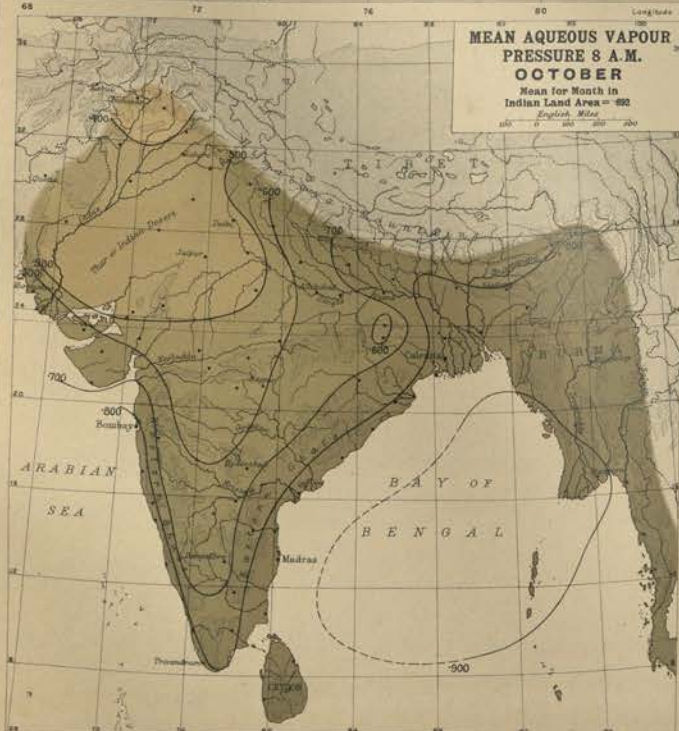
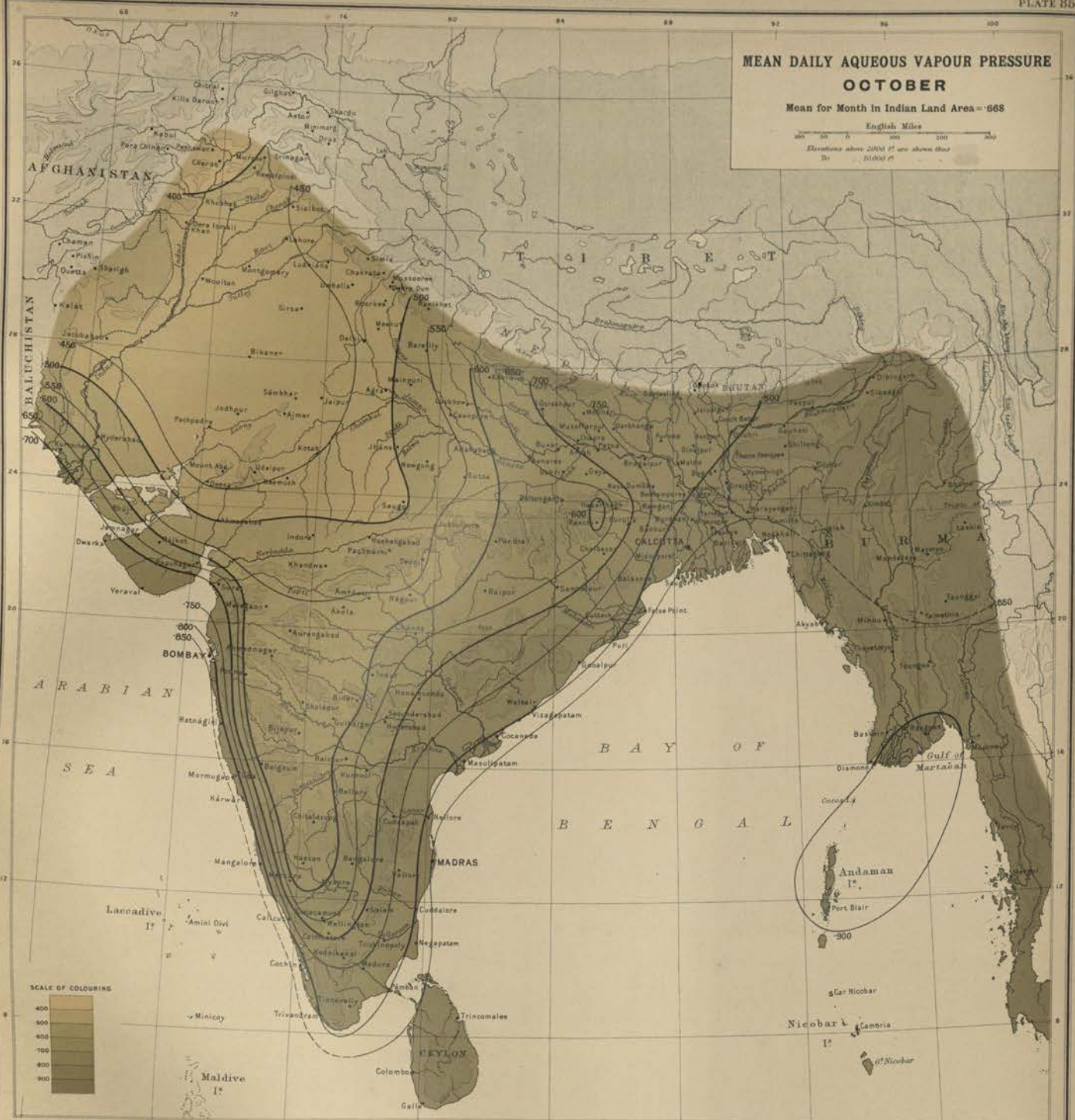
**MEAN AQUEOUS VAPOUR
PRESSURE 4 P.M.
AUGUST**

Mean for Month in
Indian Land Area = 844

English Miles
0 50 100 200 300

Longitude East, 84 of Greenwich



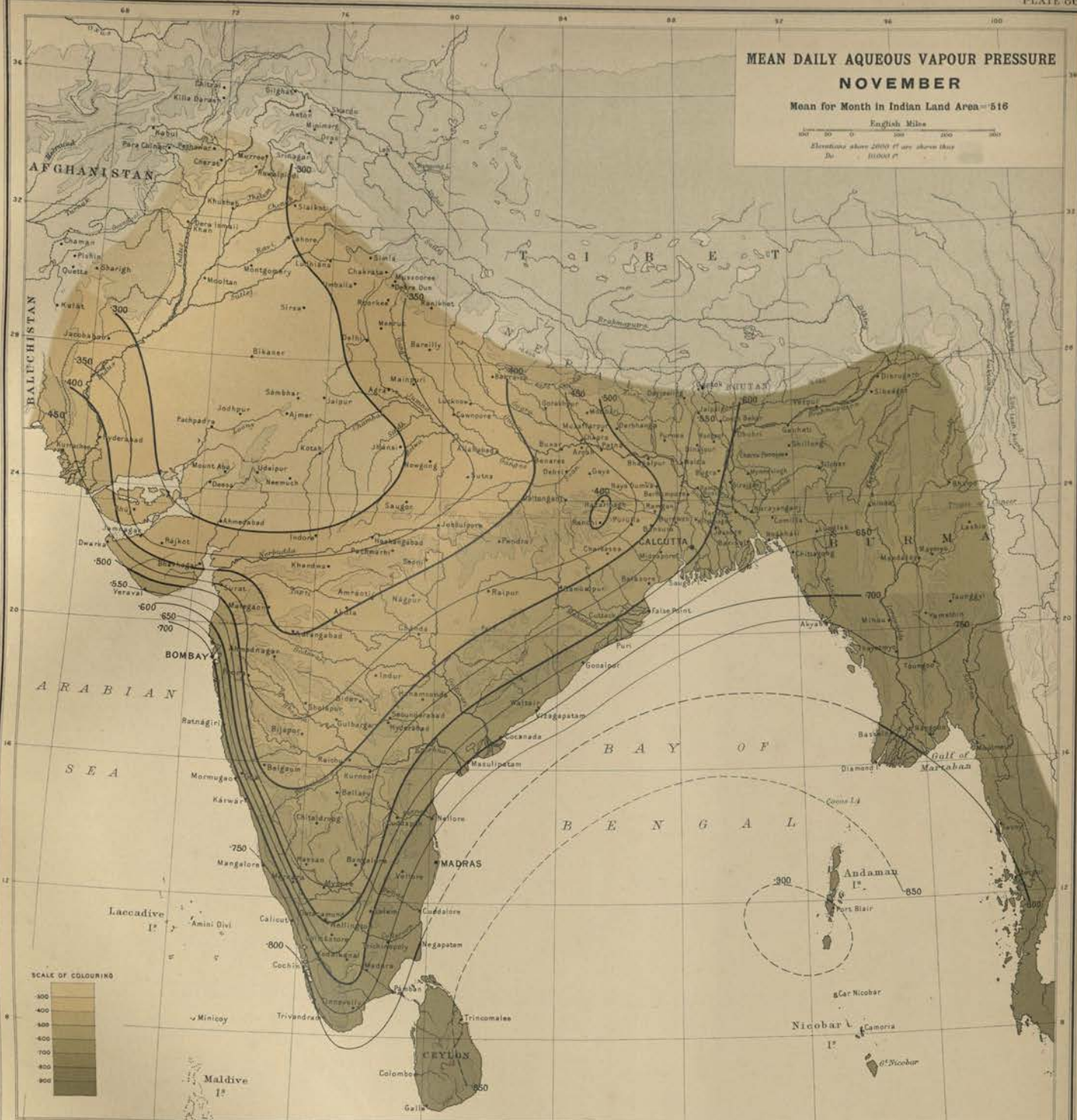


MEAN DAILY AQUEOUS VAPOUR PRESSURE

NOVEMBER

Mean for Month in Indian Land Area = 516

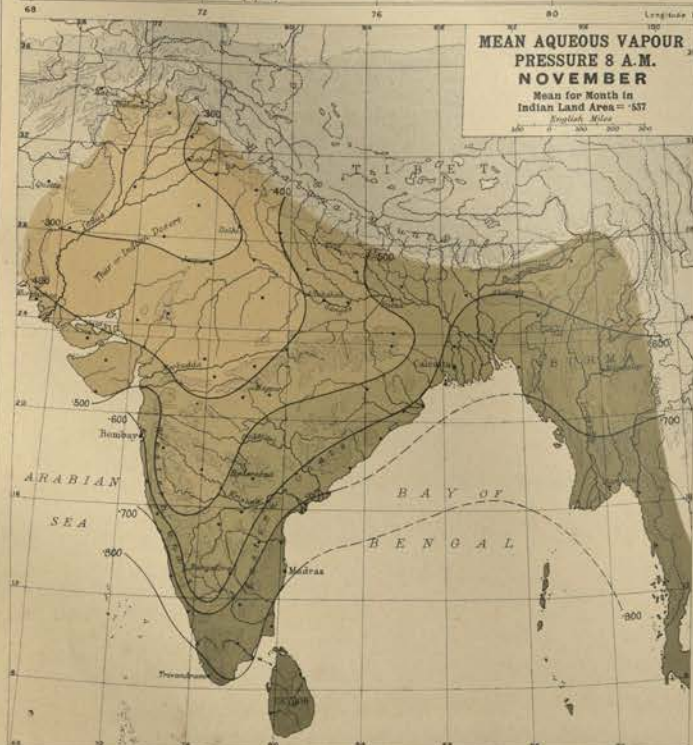
English Miles

Elevations above 2000 ft are shown thus
Do 10000 ft

MEAN AQUEOUS VAPOUR PRESSURE 8 A.M. NOVEMBER

Mean for Month in Indian Land Area = 517

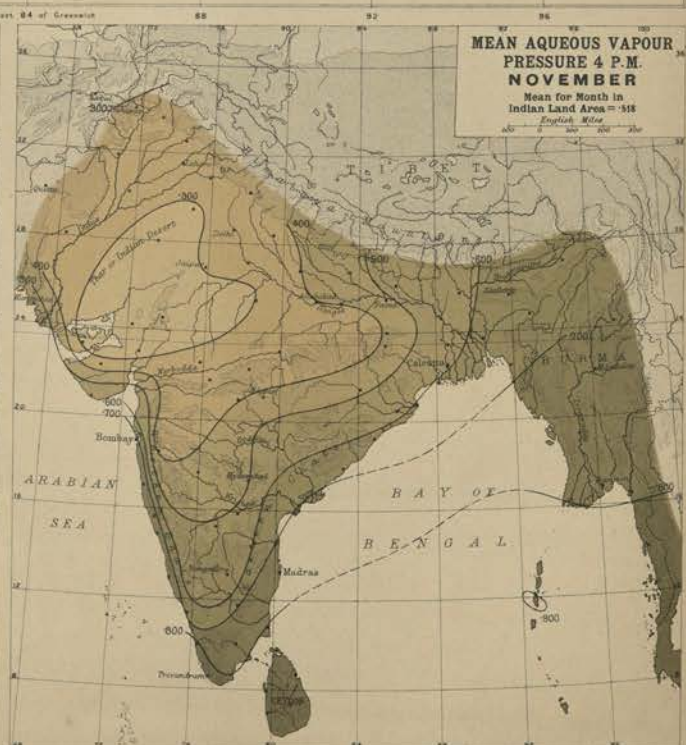
English Miles



MEAN AQUEOUS VAPOUR PRESSURE 4 P.M. NOVEMBER

Mean for Month in Indian Land Area = 518

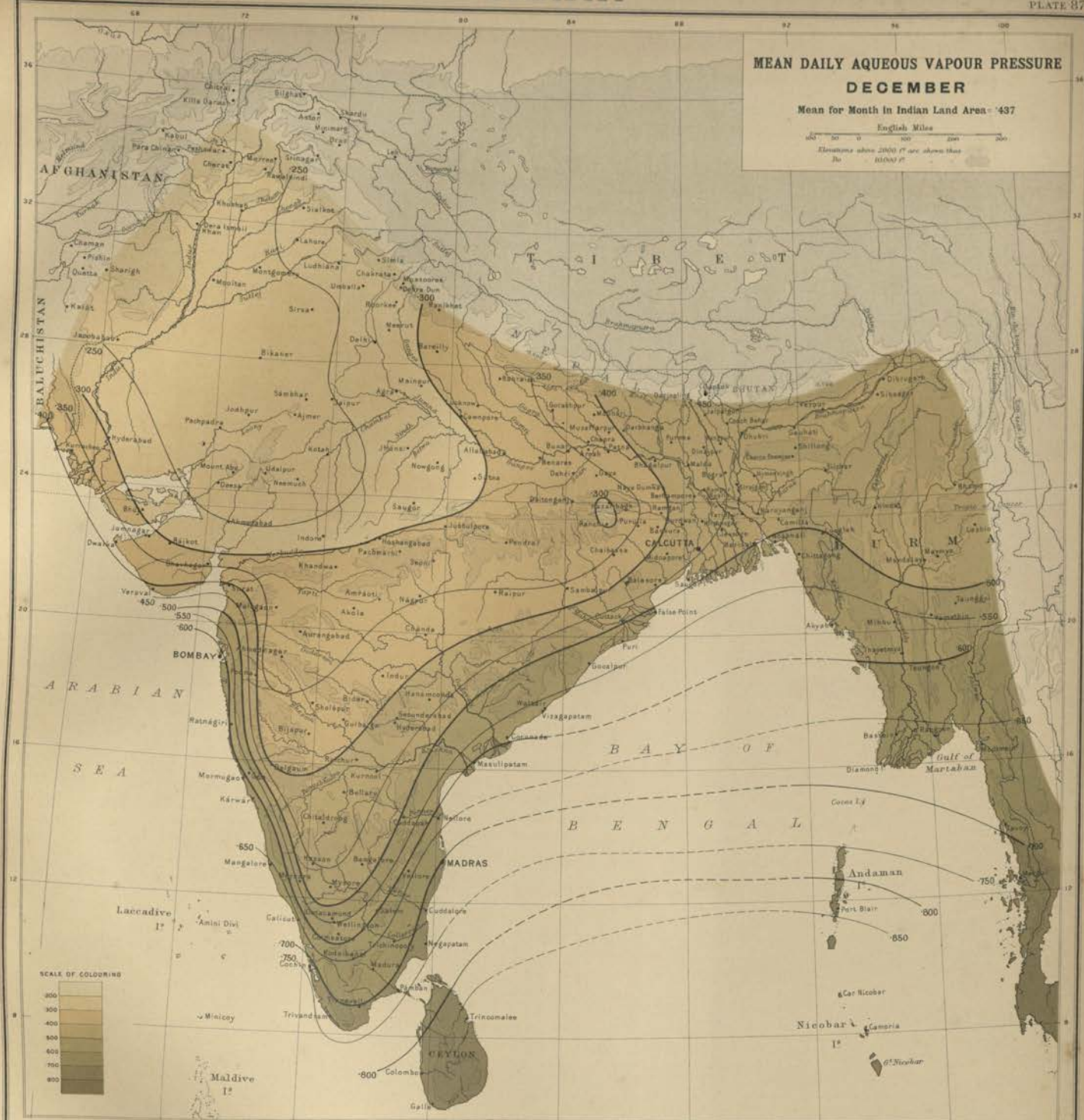
English Miles



MEAN DAILY AQUEOUS VAPOUR PRESSURE DECEMBER

Mean for Month in Indian Land Area = 437

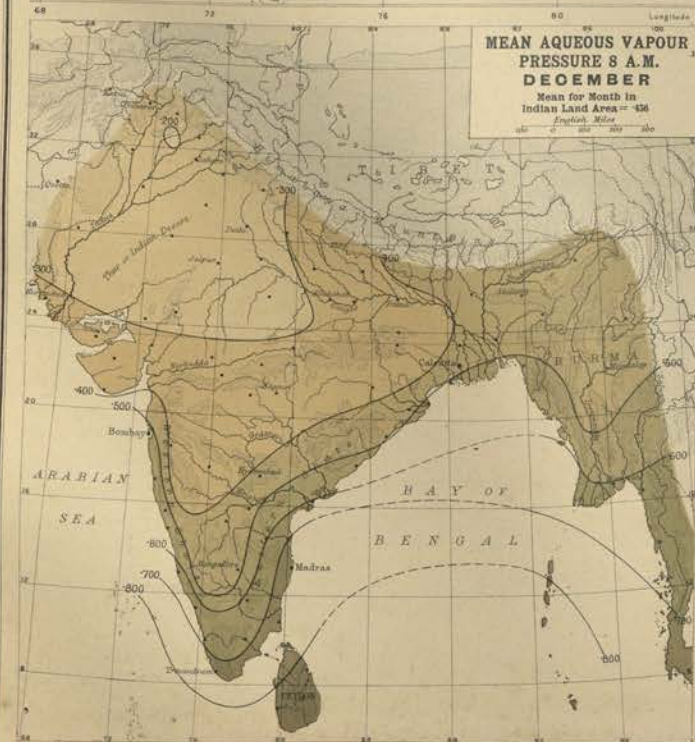
English Miles
0 50 100 150 200
Elevations above 2000 ft are shown thus
No 10000 ft



MEAN AQUEOUS VAPOUR PRESSURE 8 A.M. DECEMBER

Mean for Month in
Indian Land Area = 436

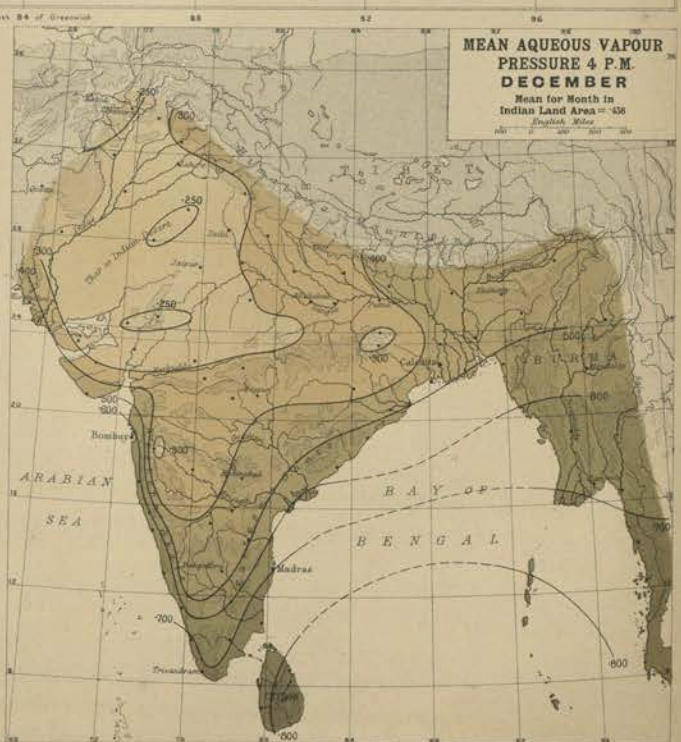
English Miles

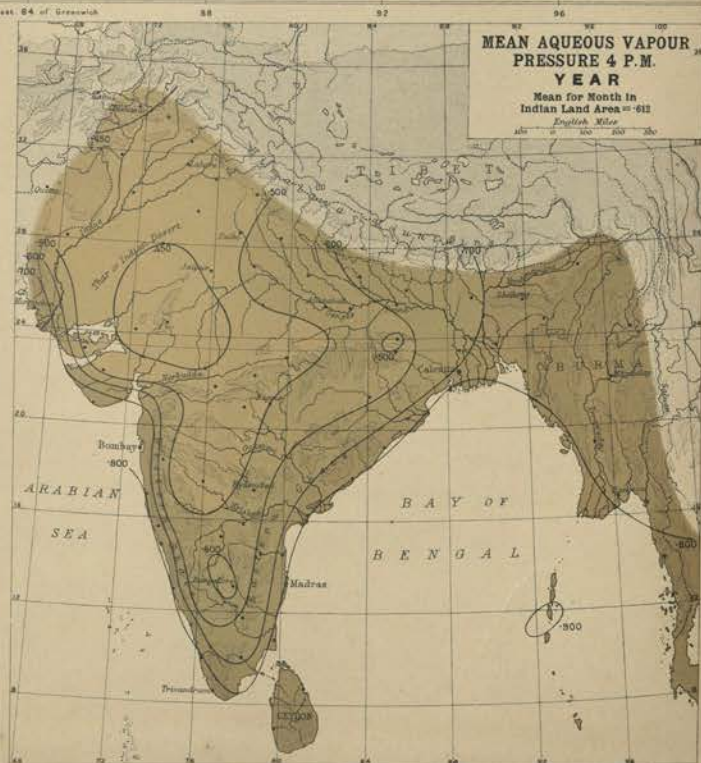
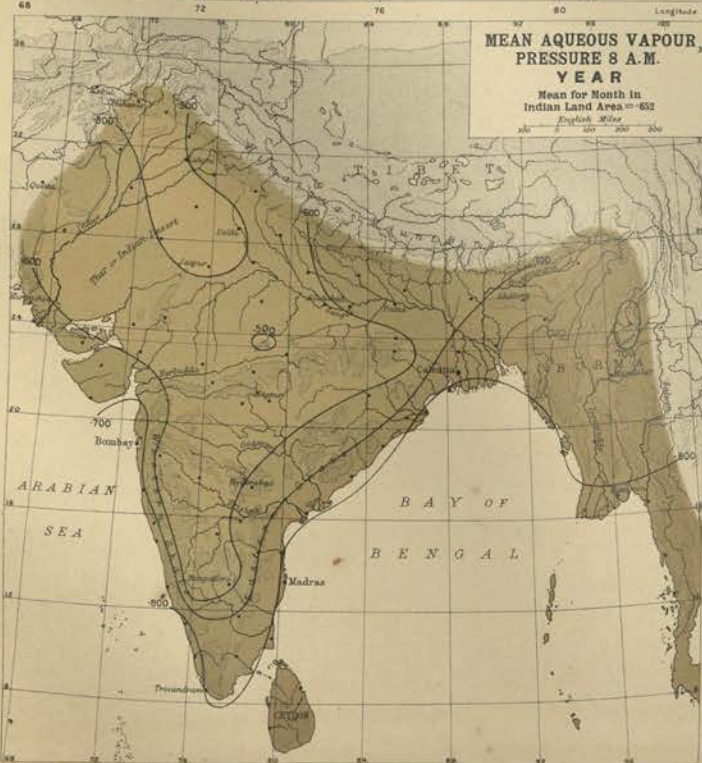
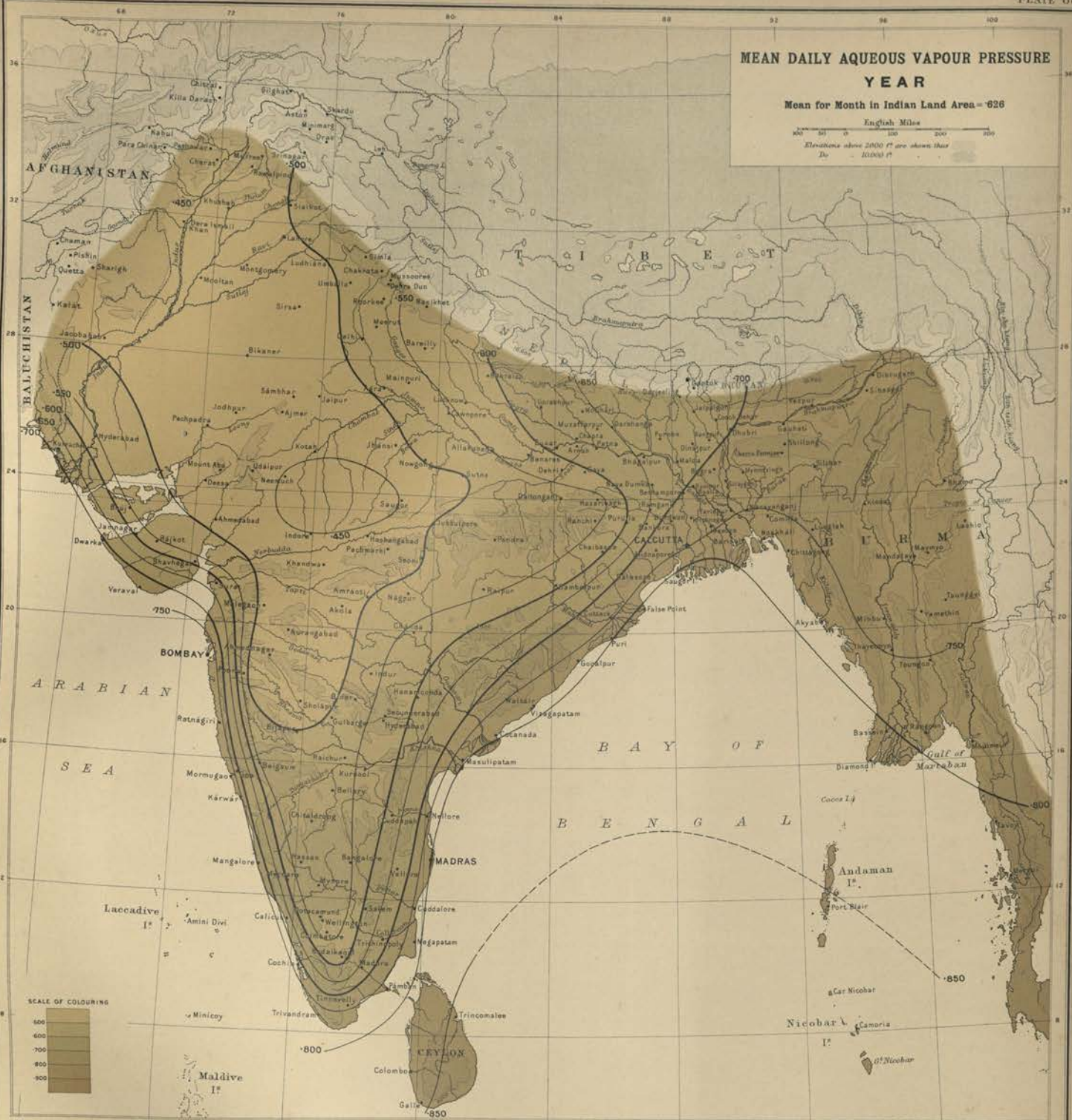


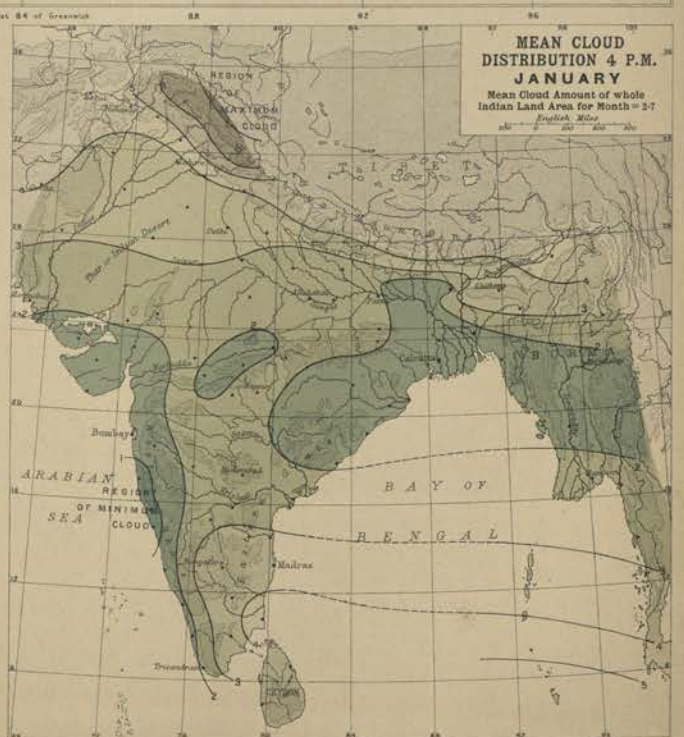
MEAN AQUEOUS VAPOUR PRESSURE 4 P.M. DECEMBER

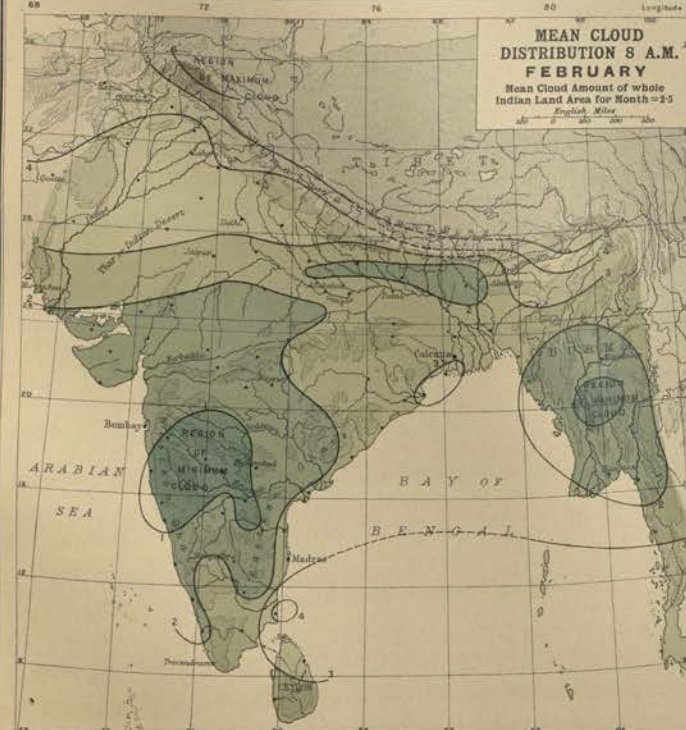
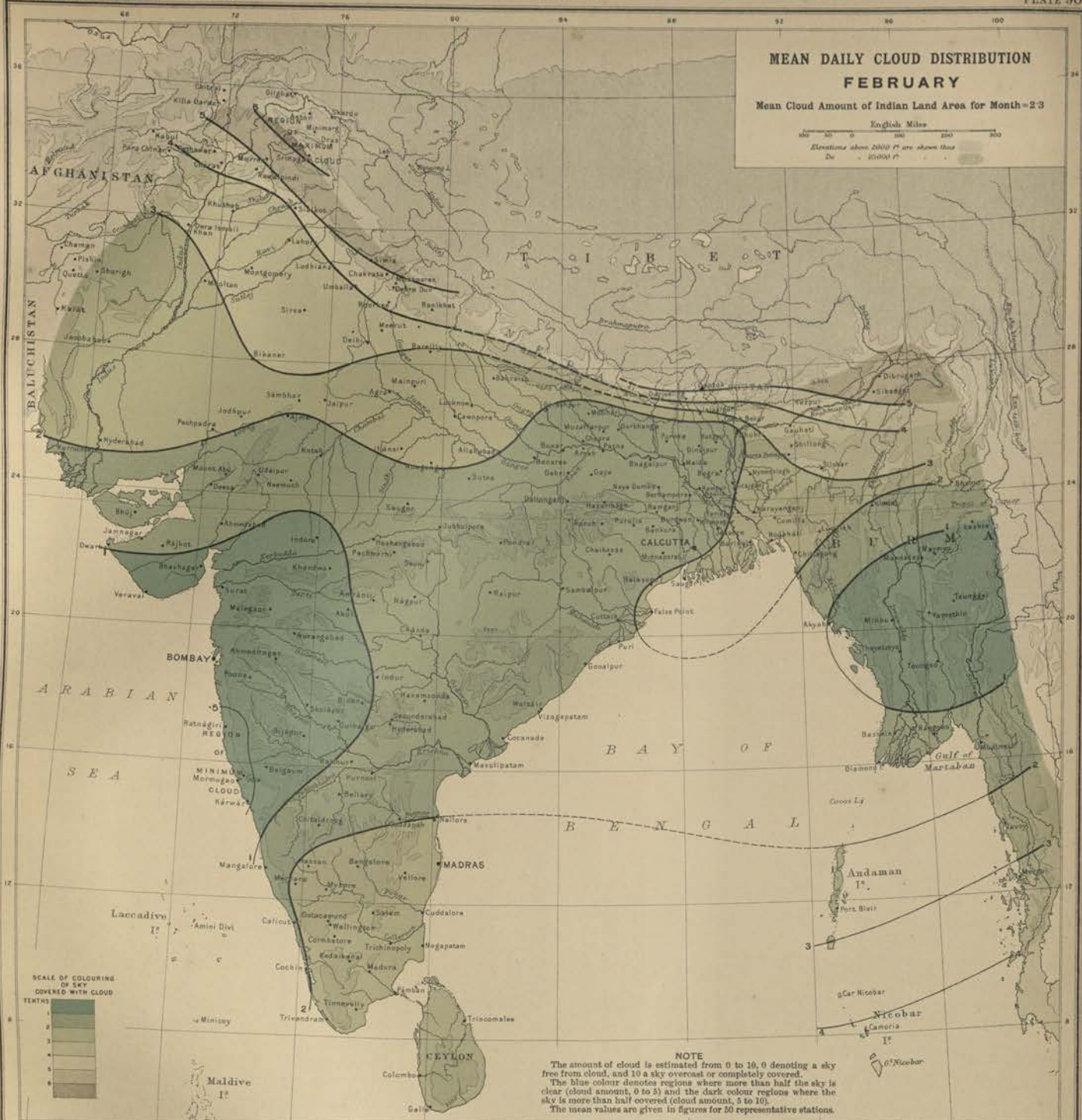
Mean for Month in
Indian Land Area = 436

English Miles

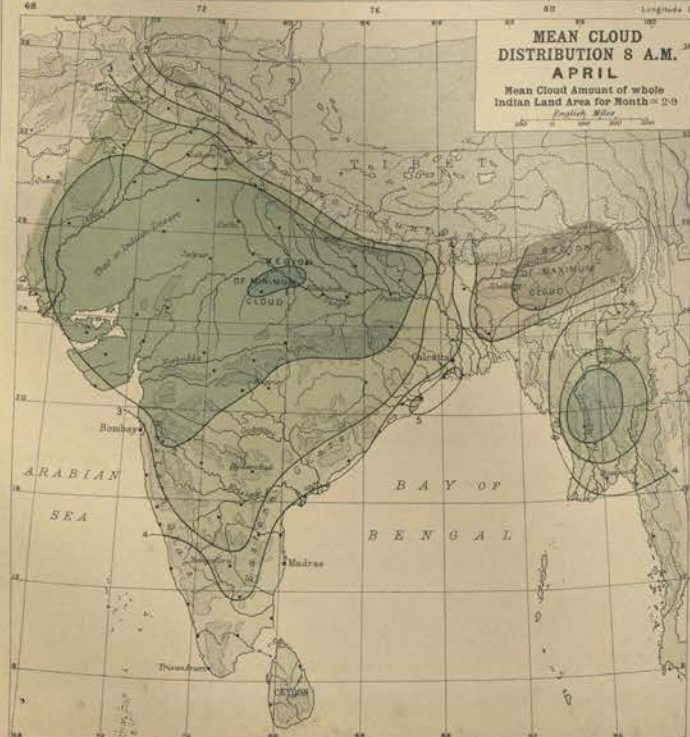
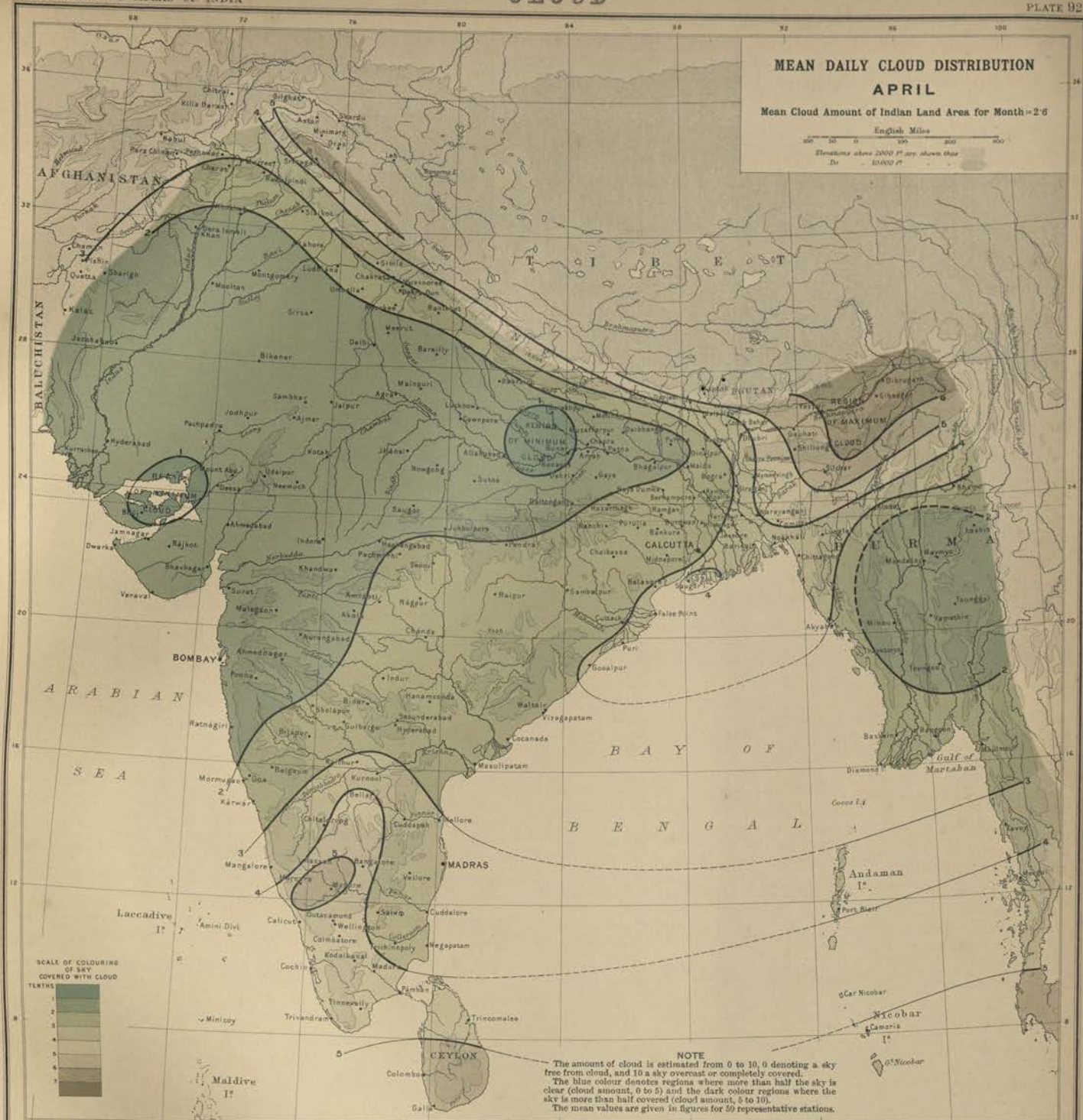


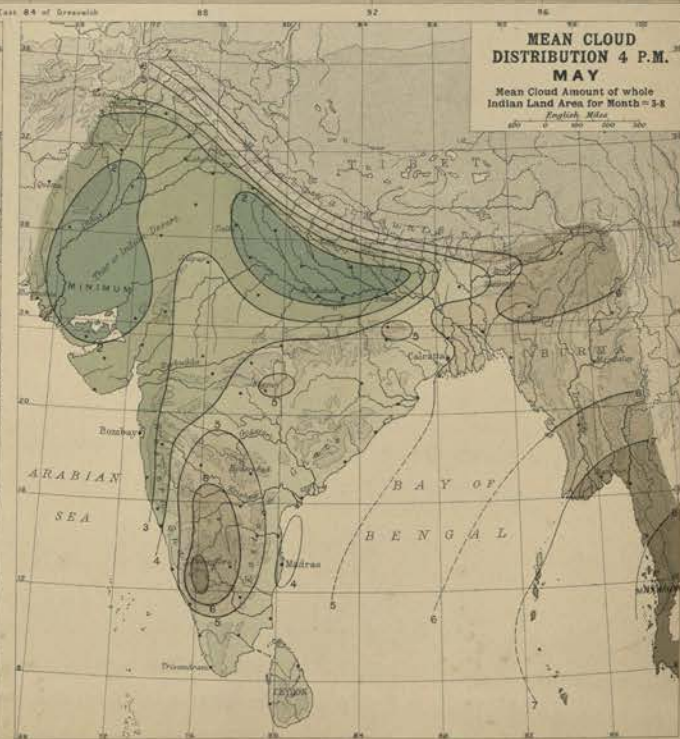
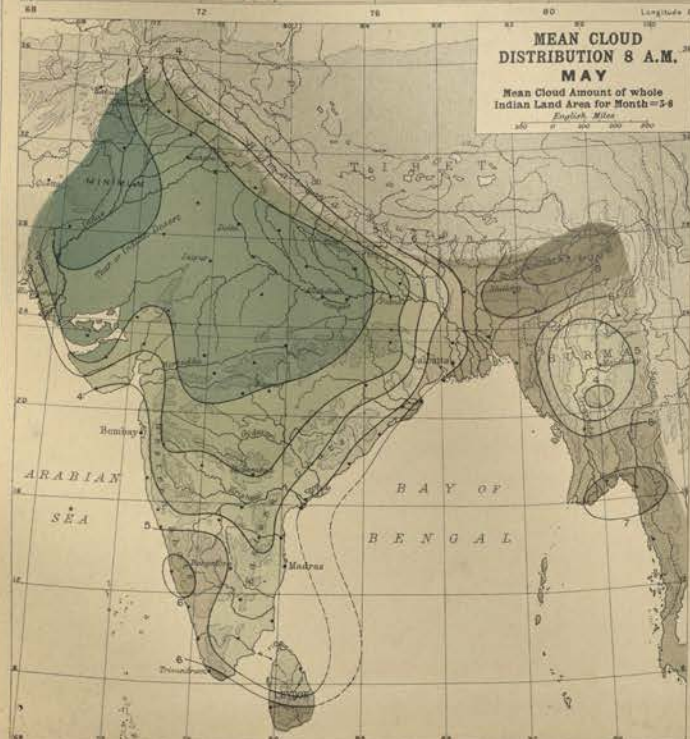
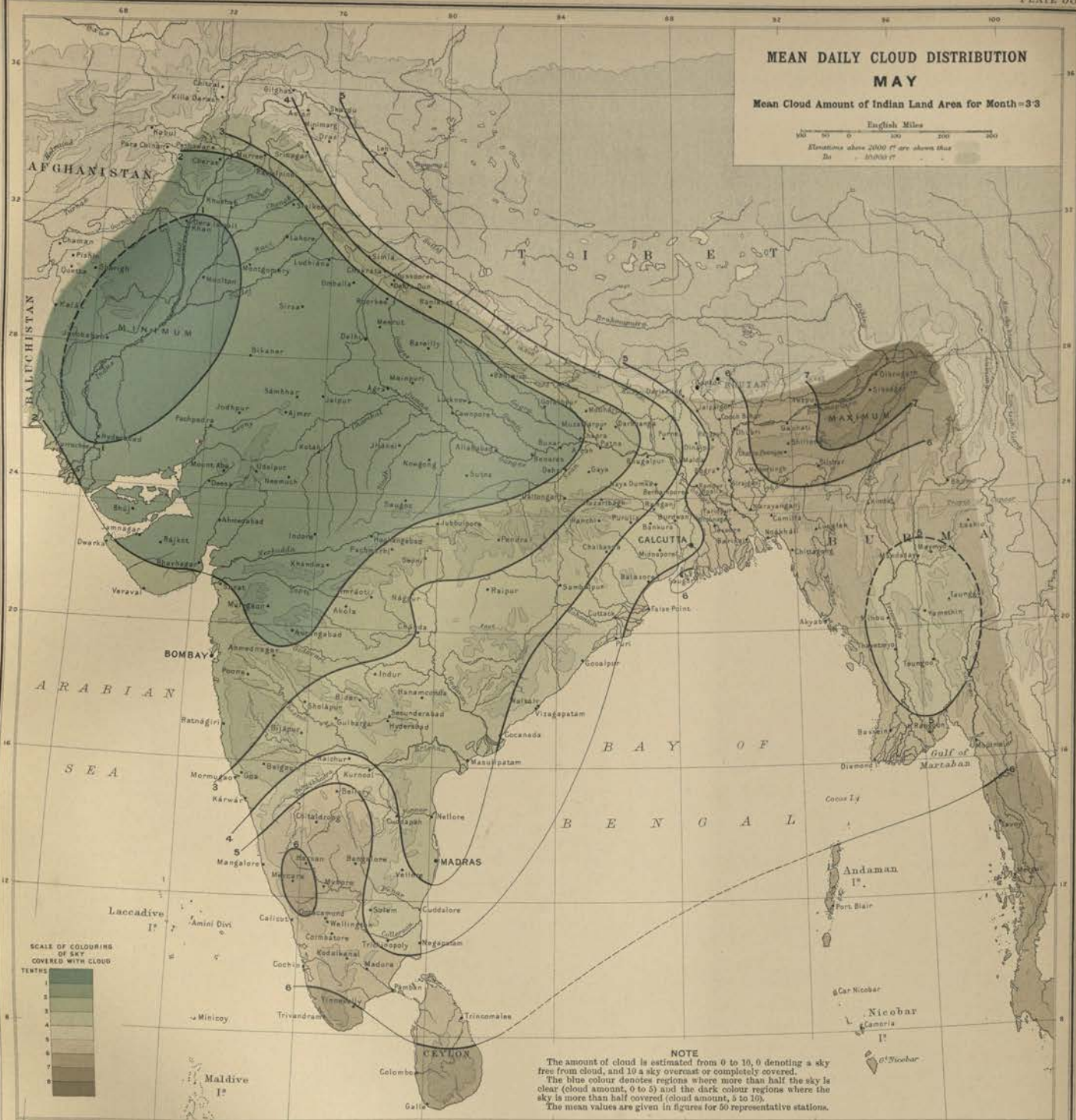


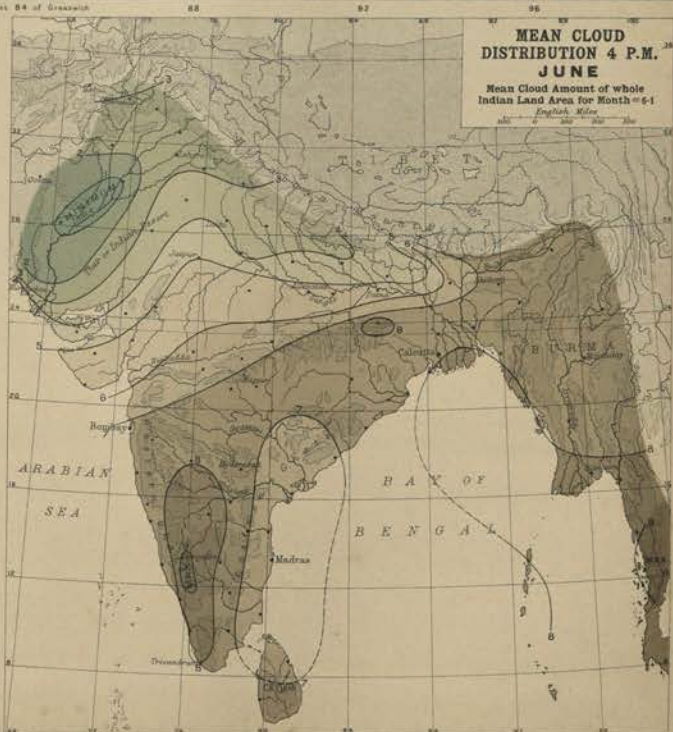
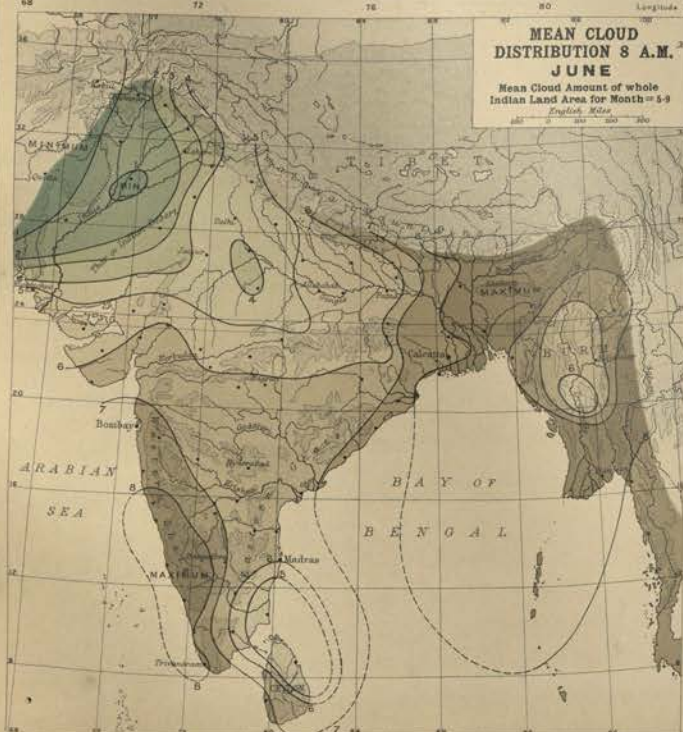
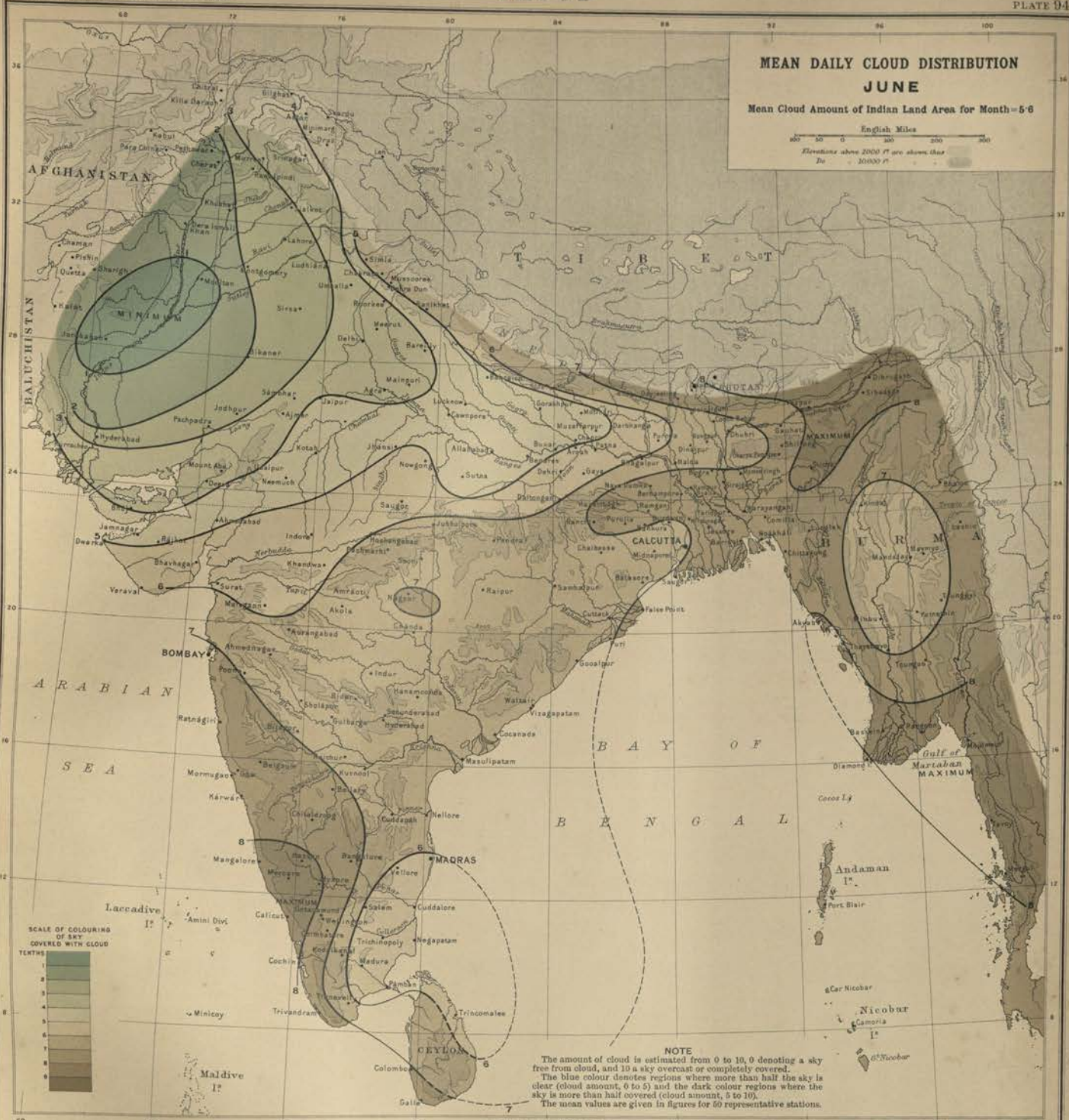


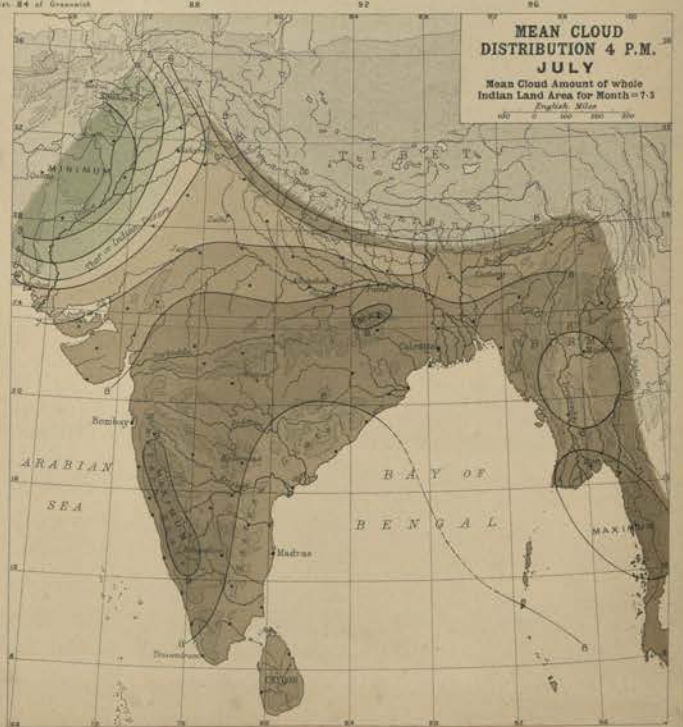
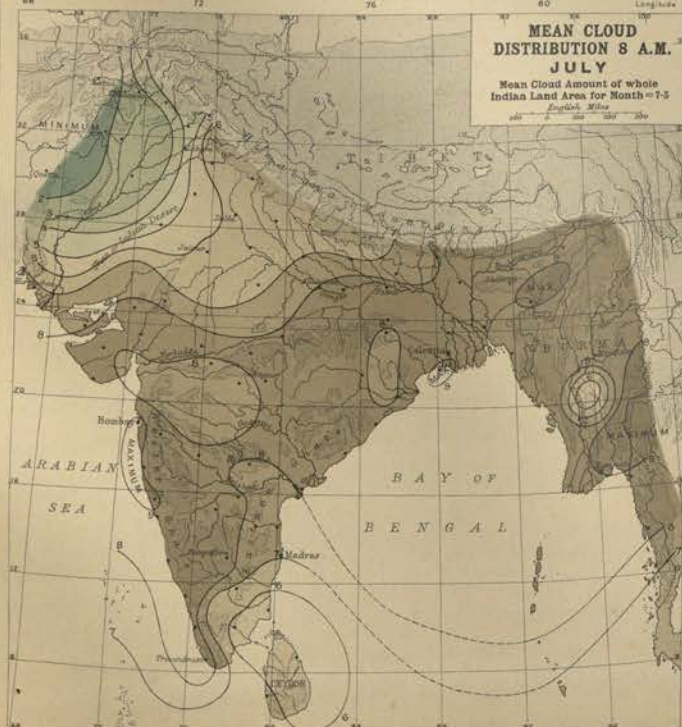
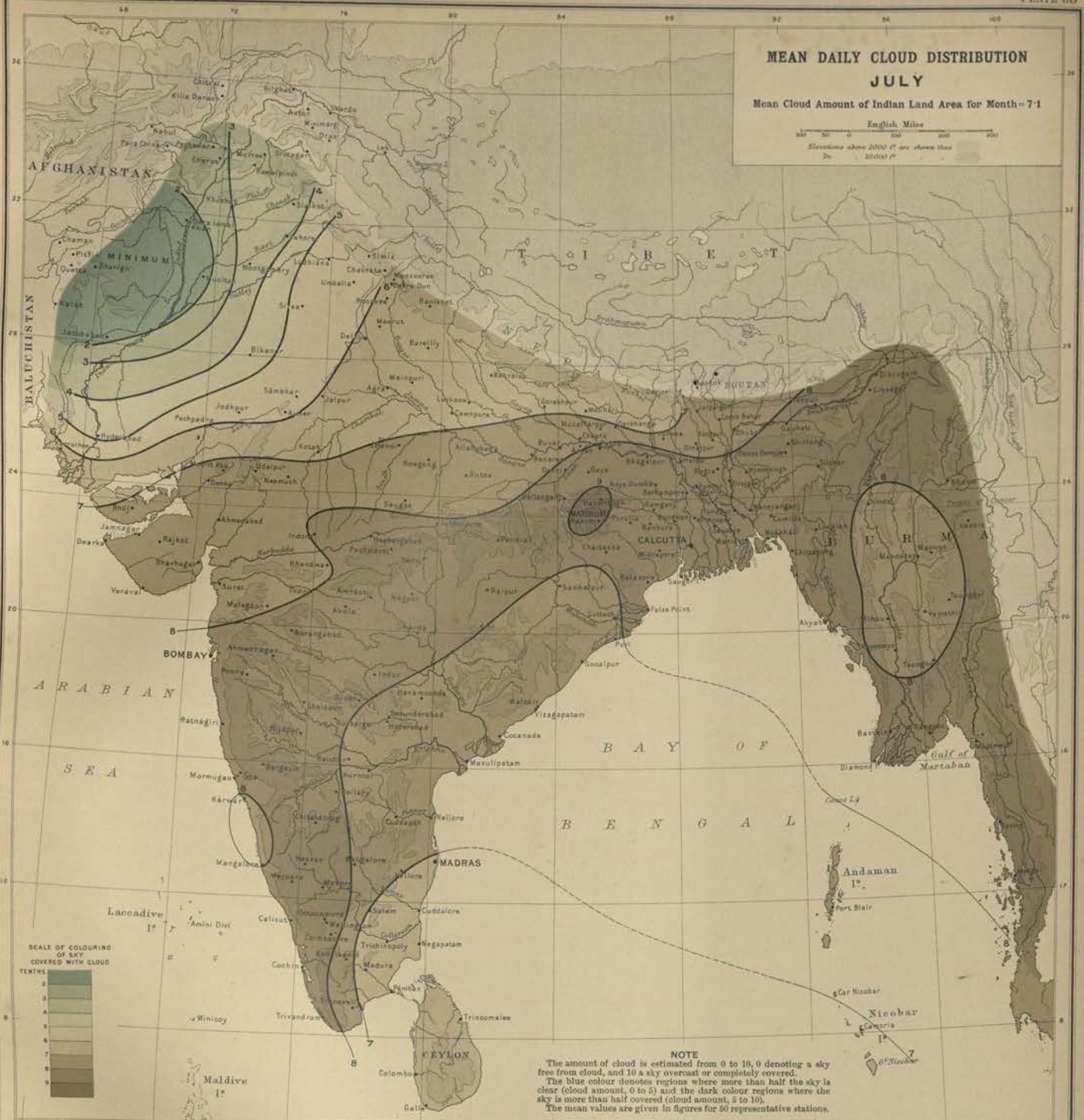


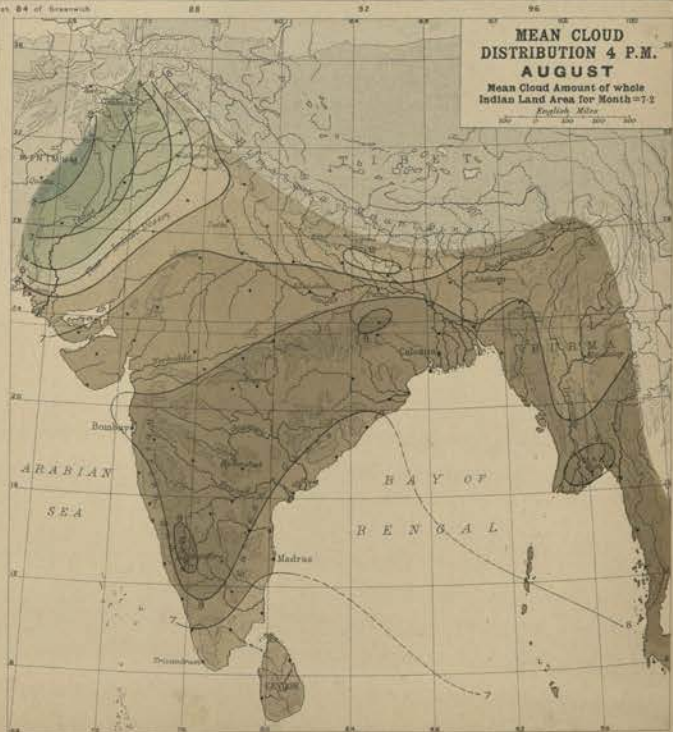
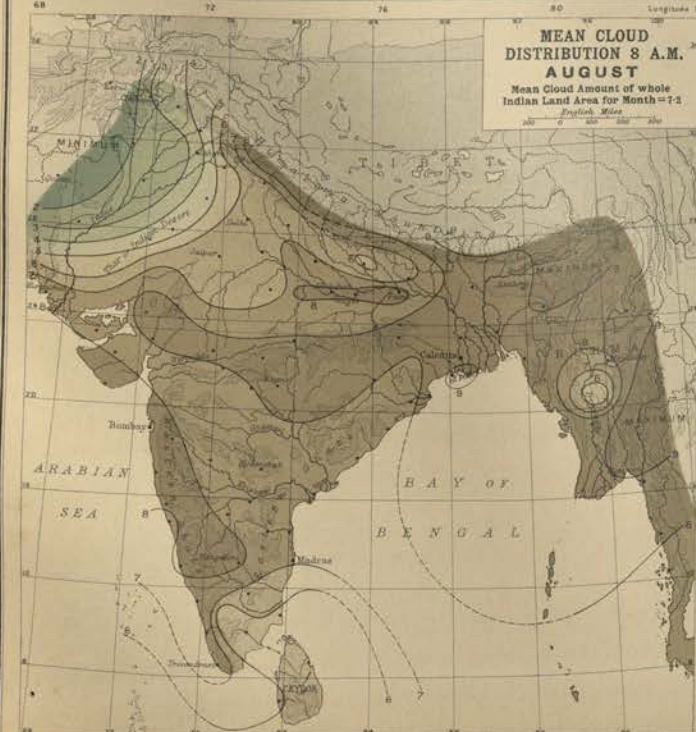
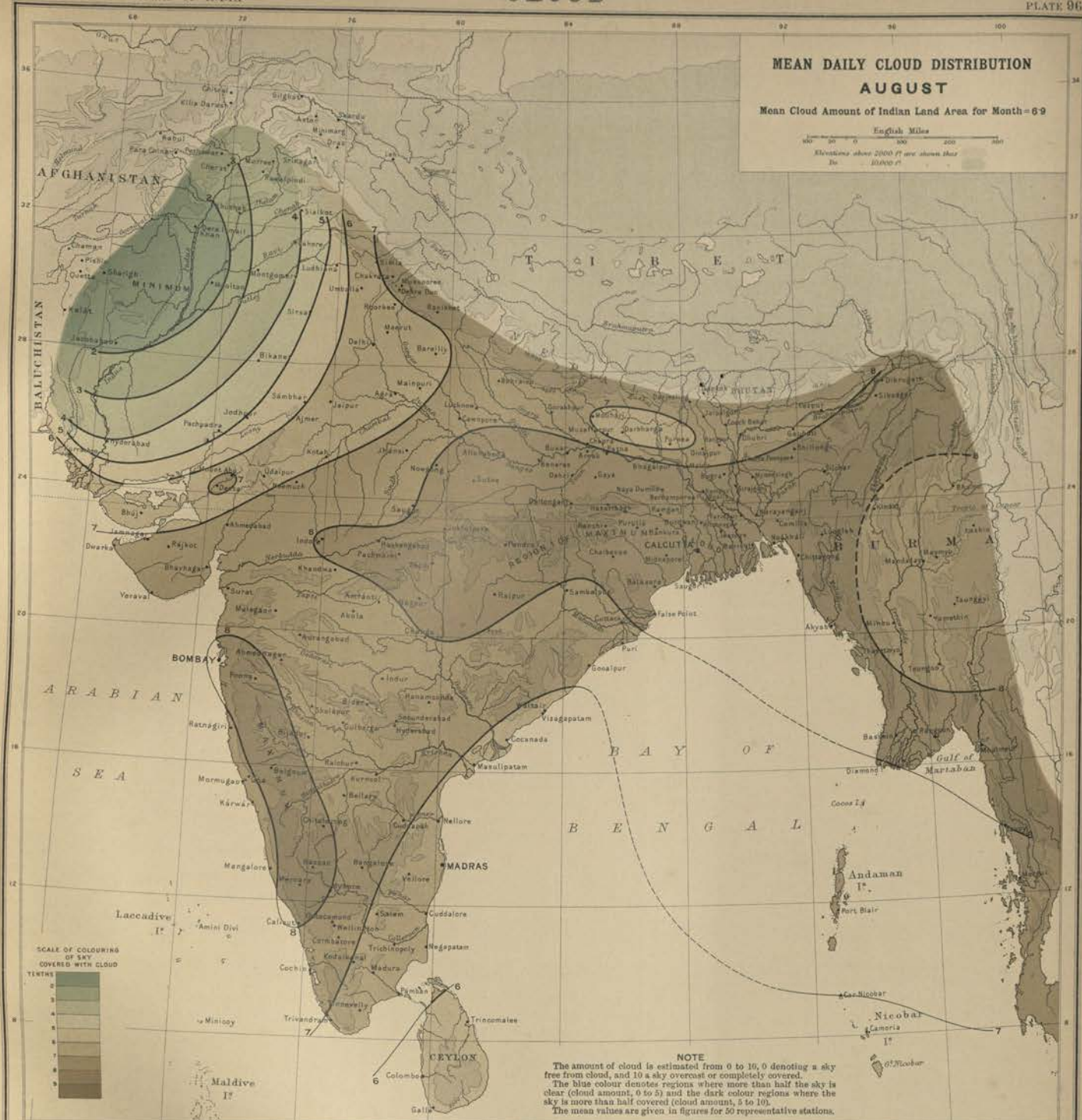


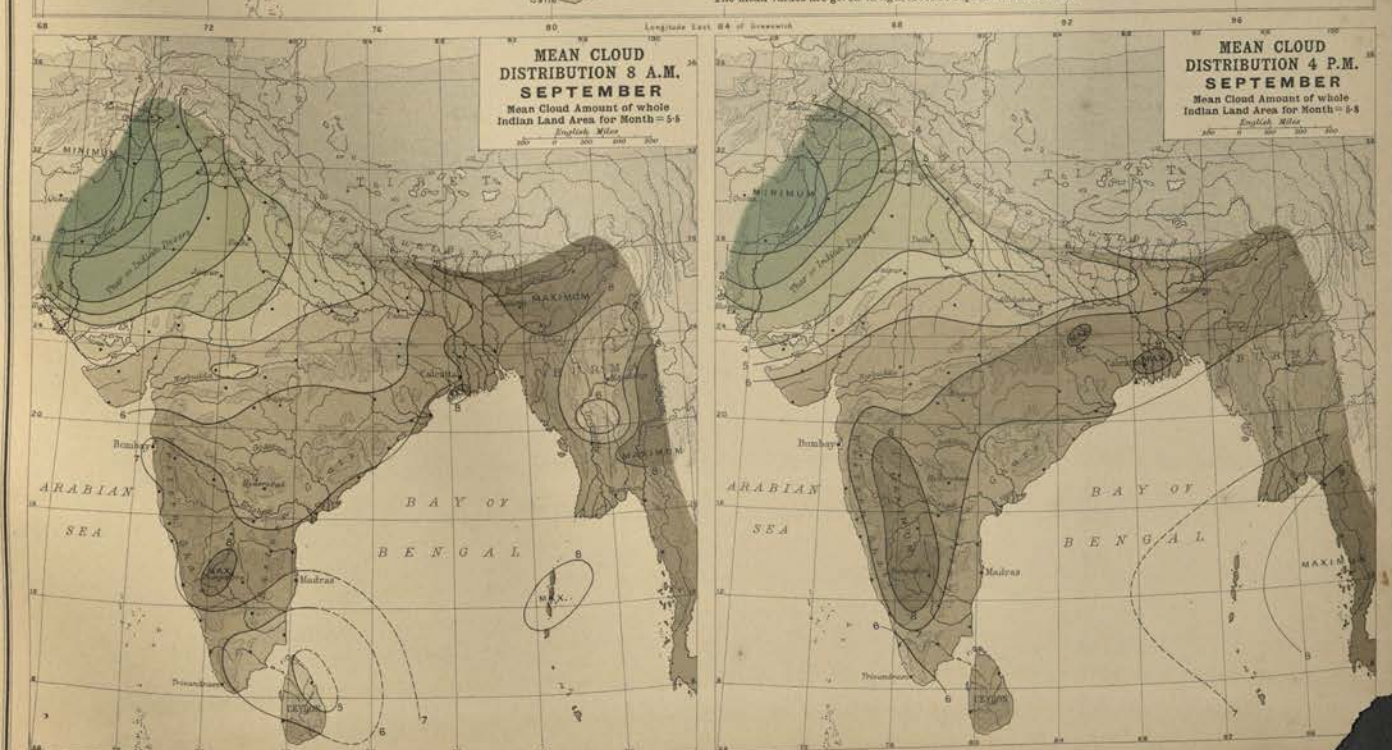
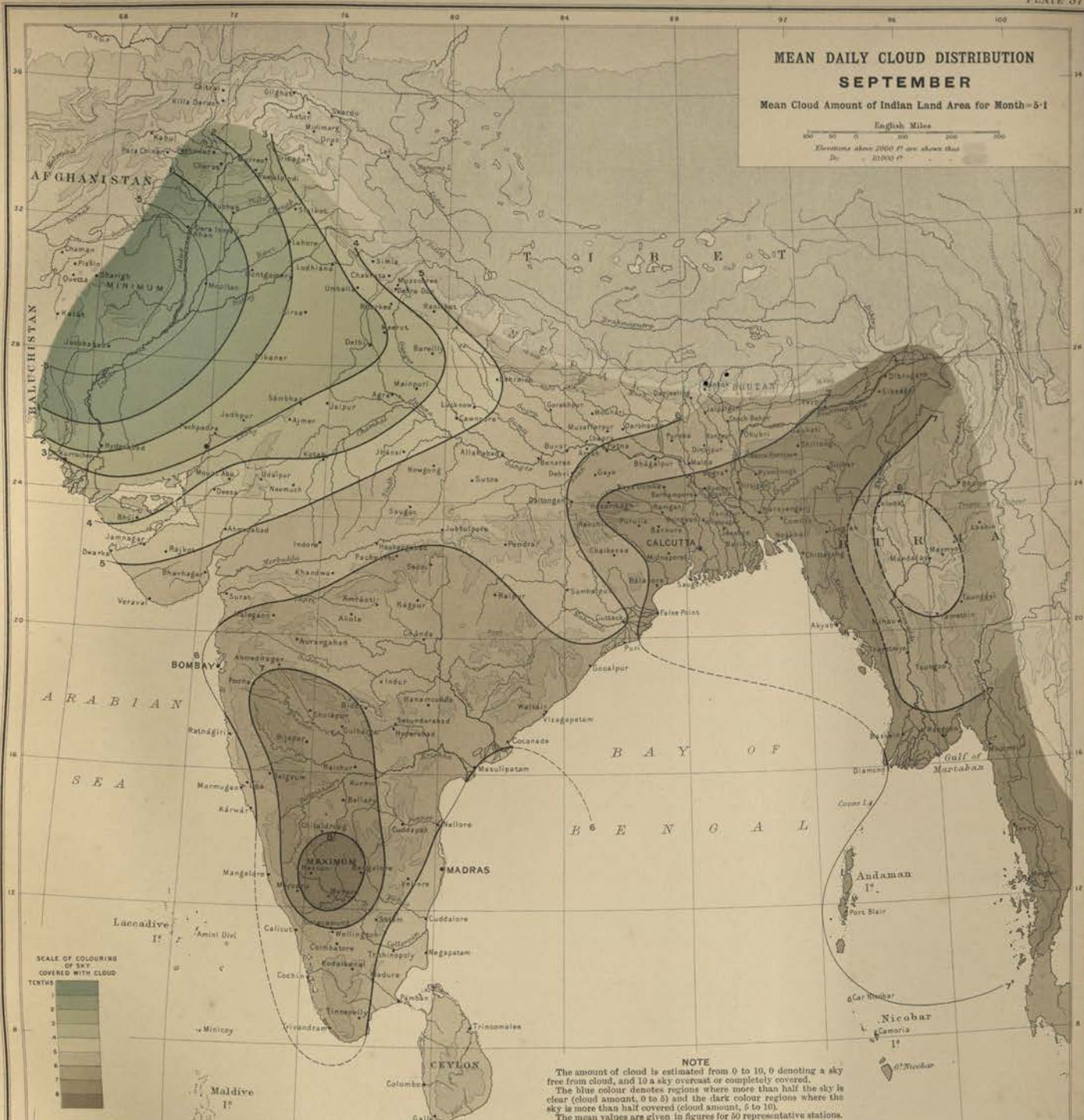


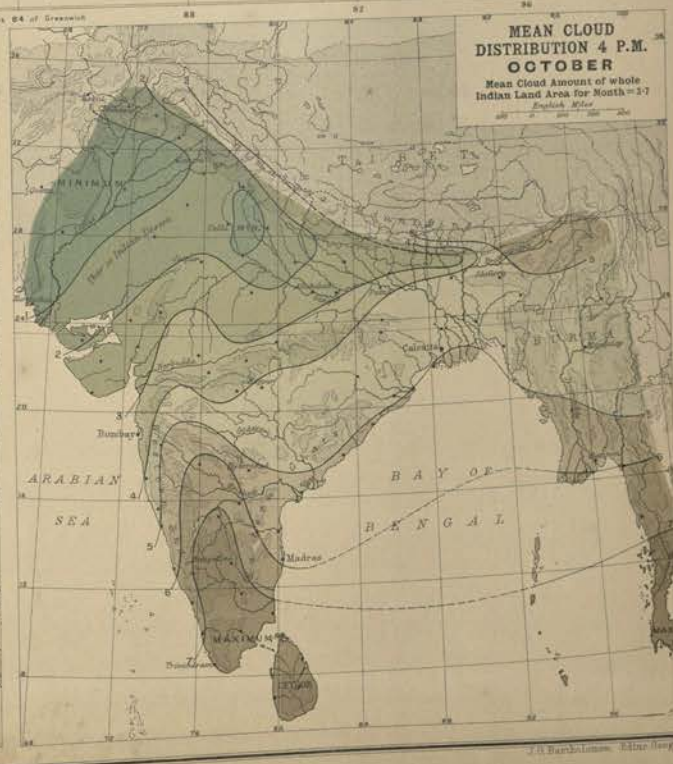
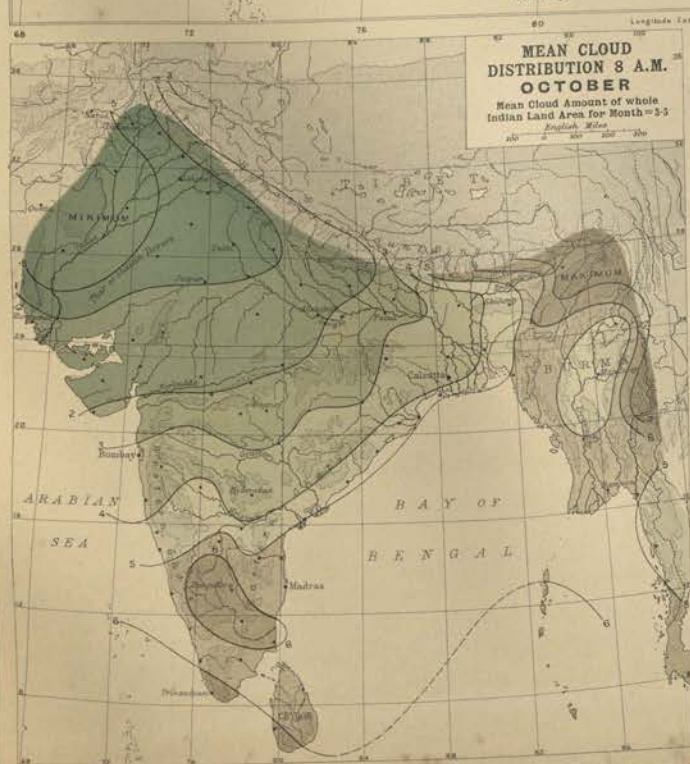
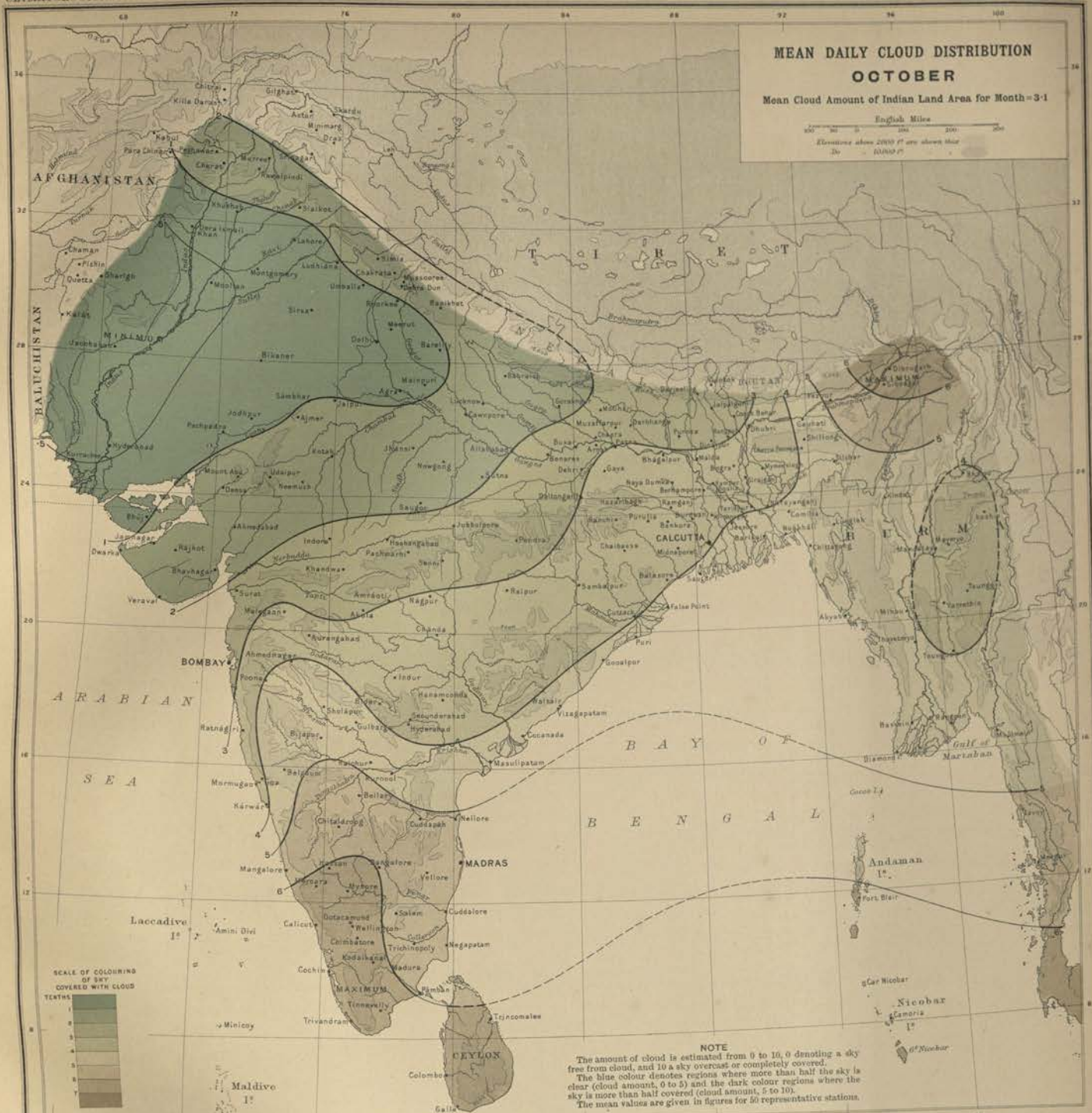


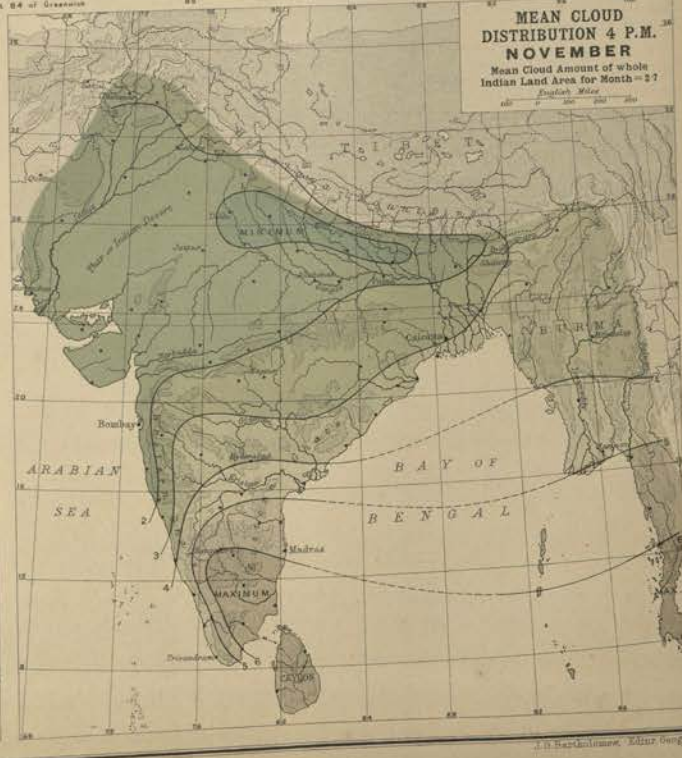
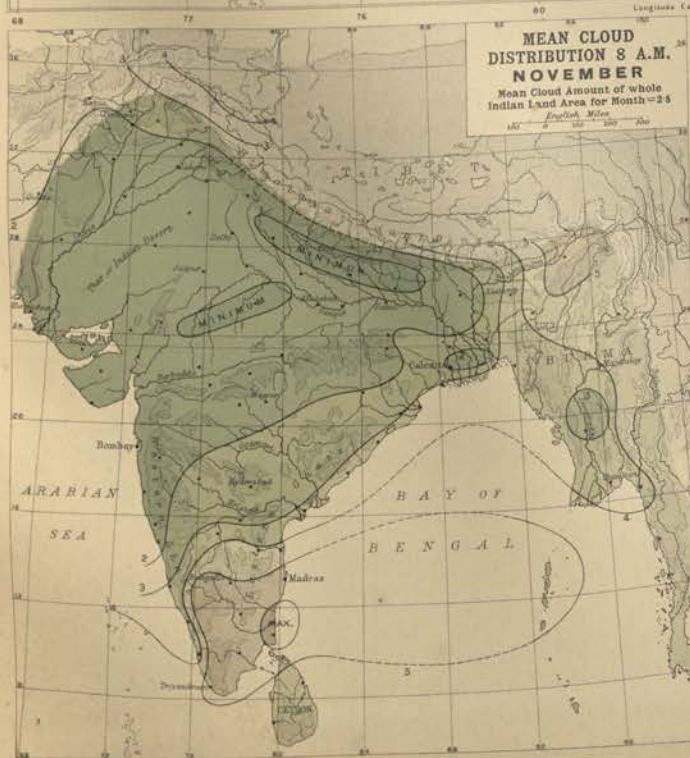
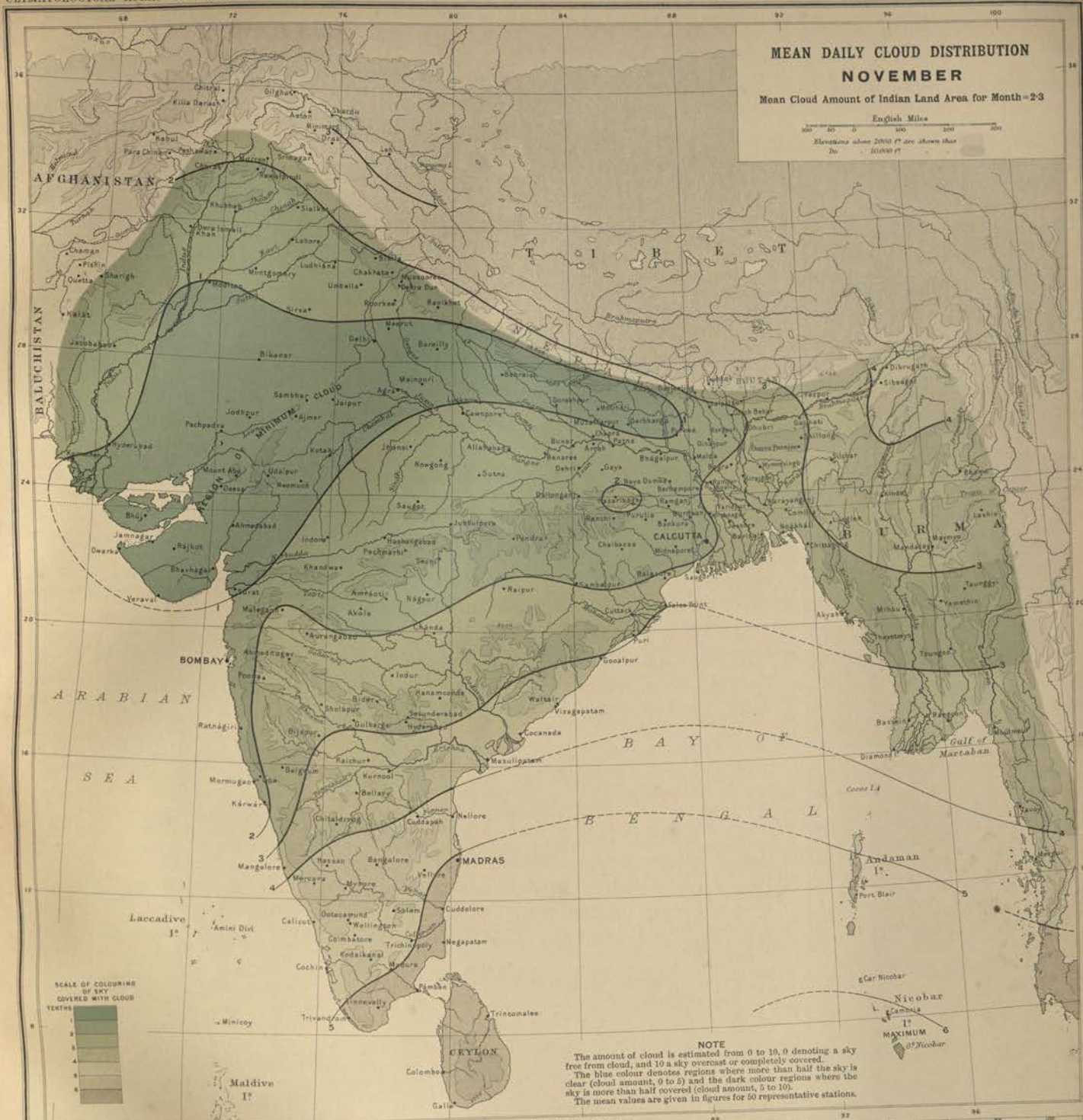


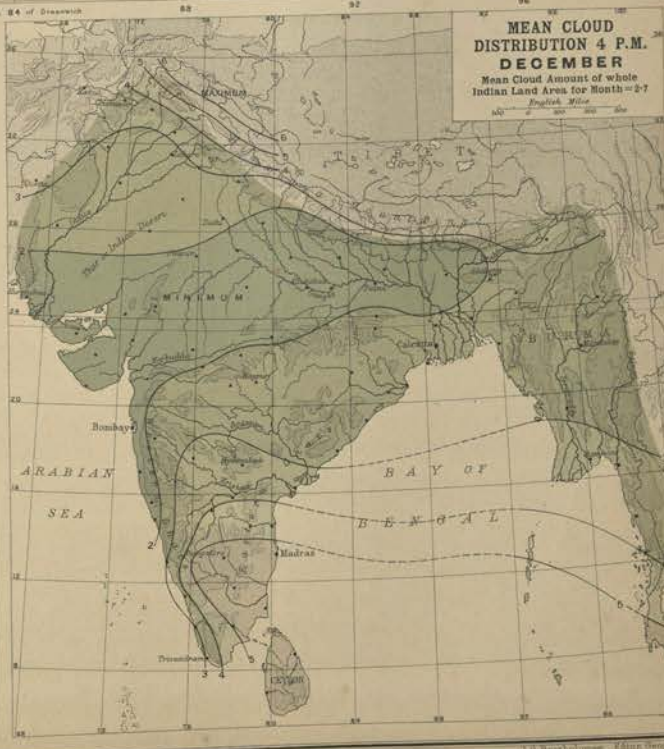
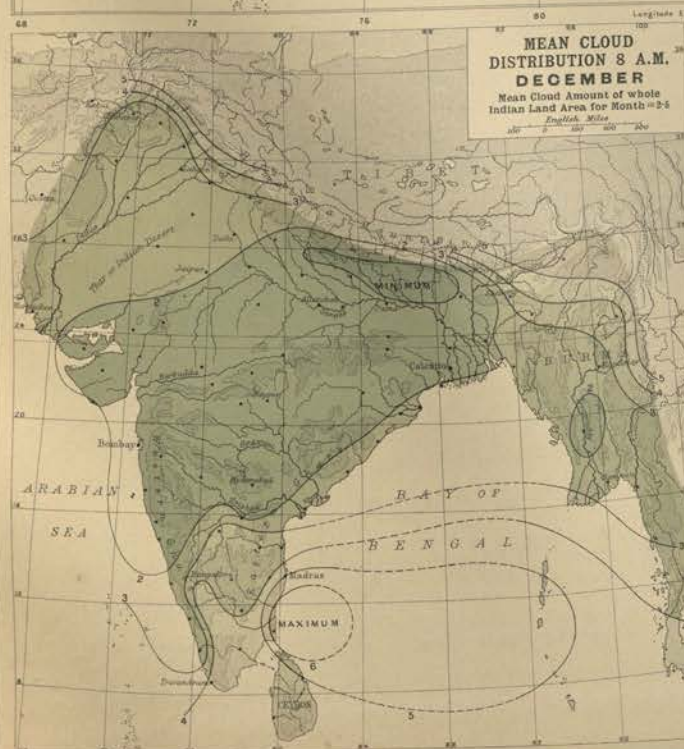
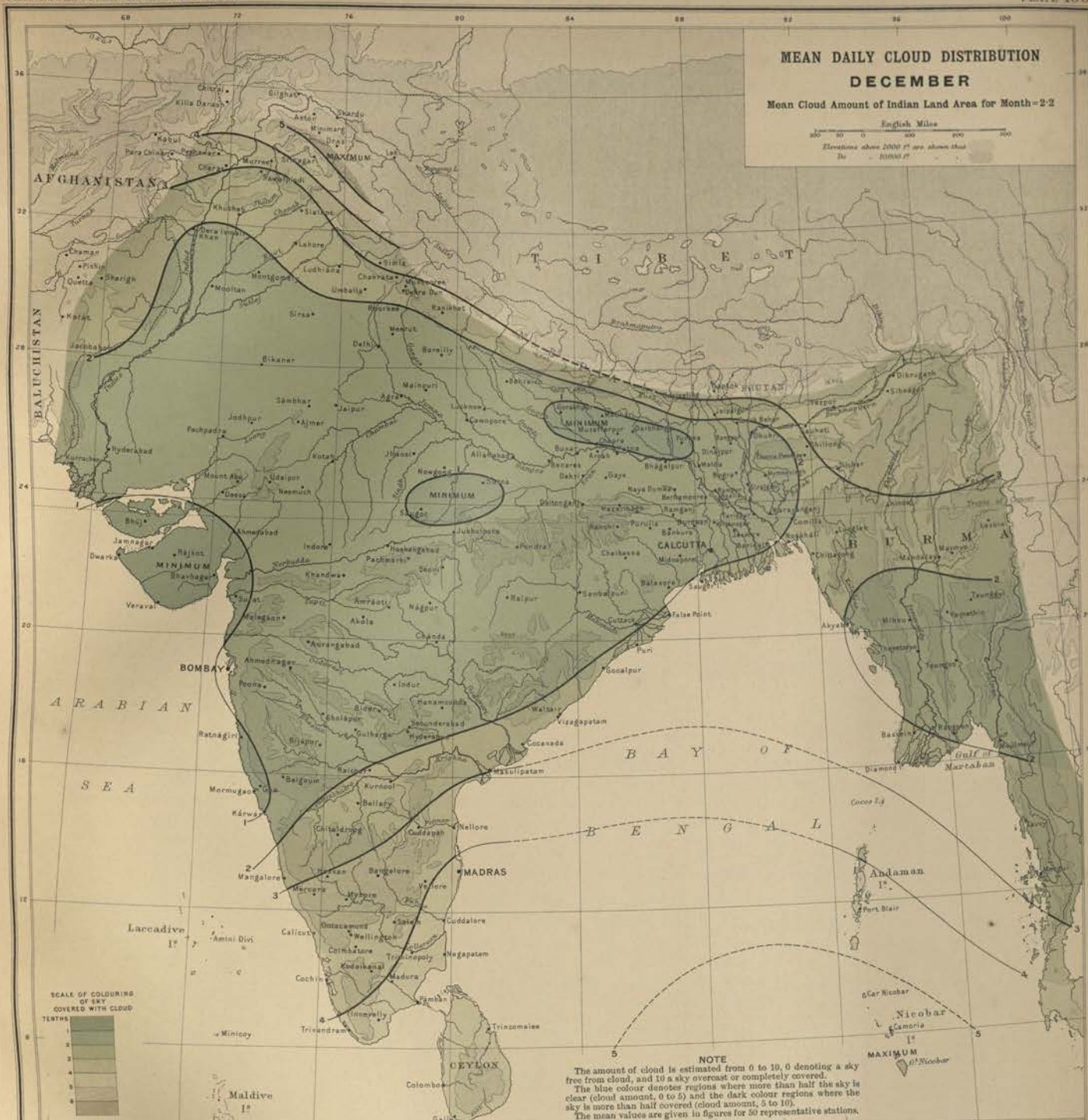


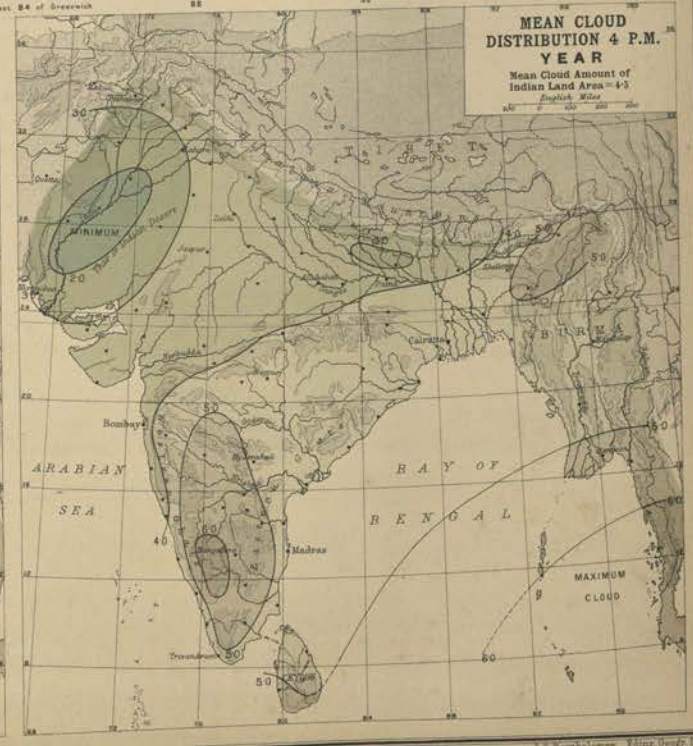
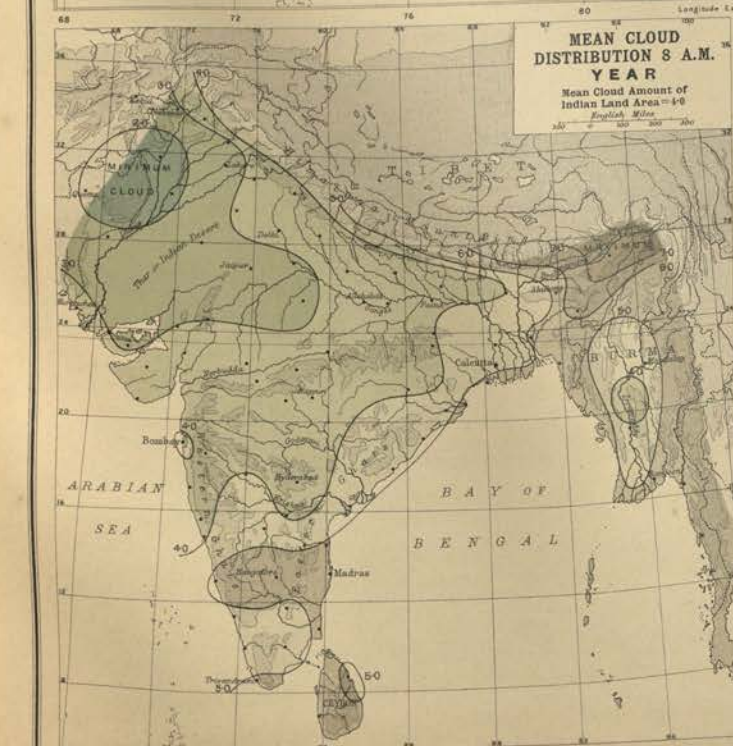
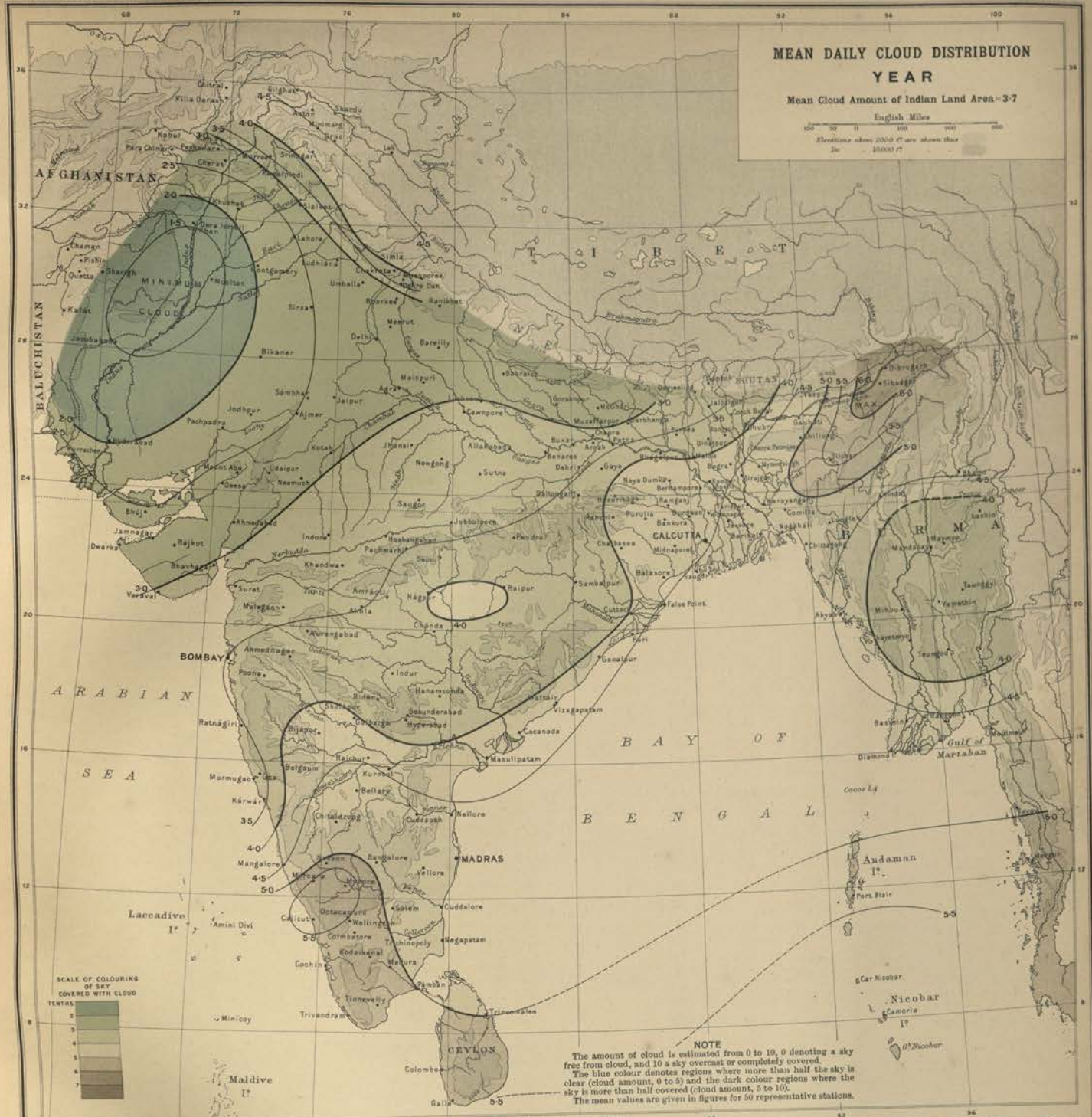


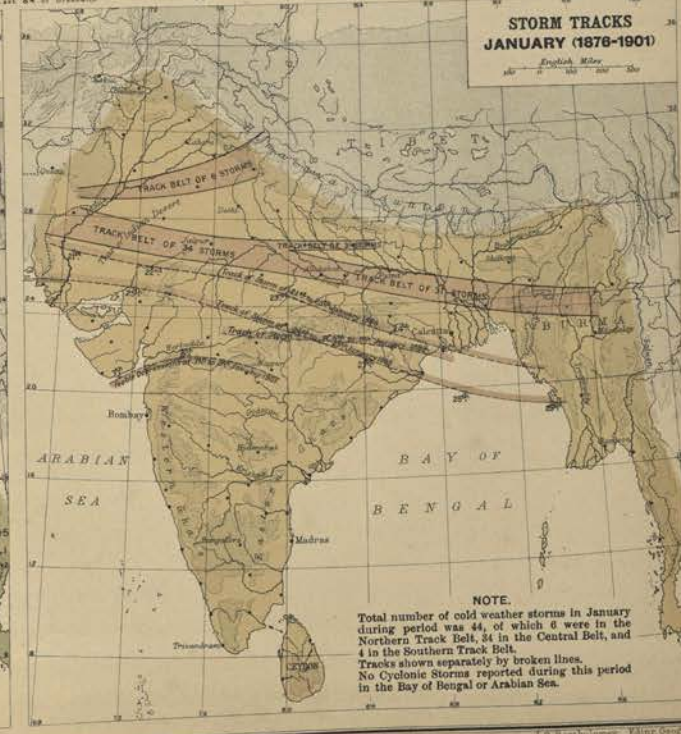
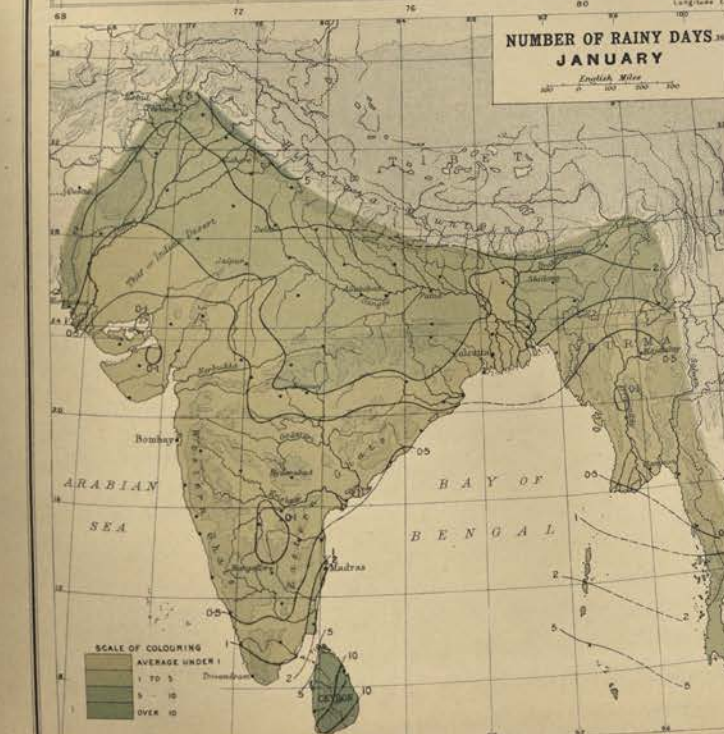
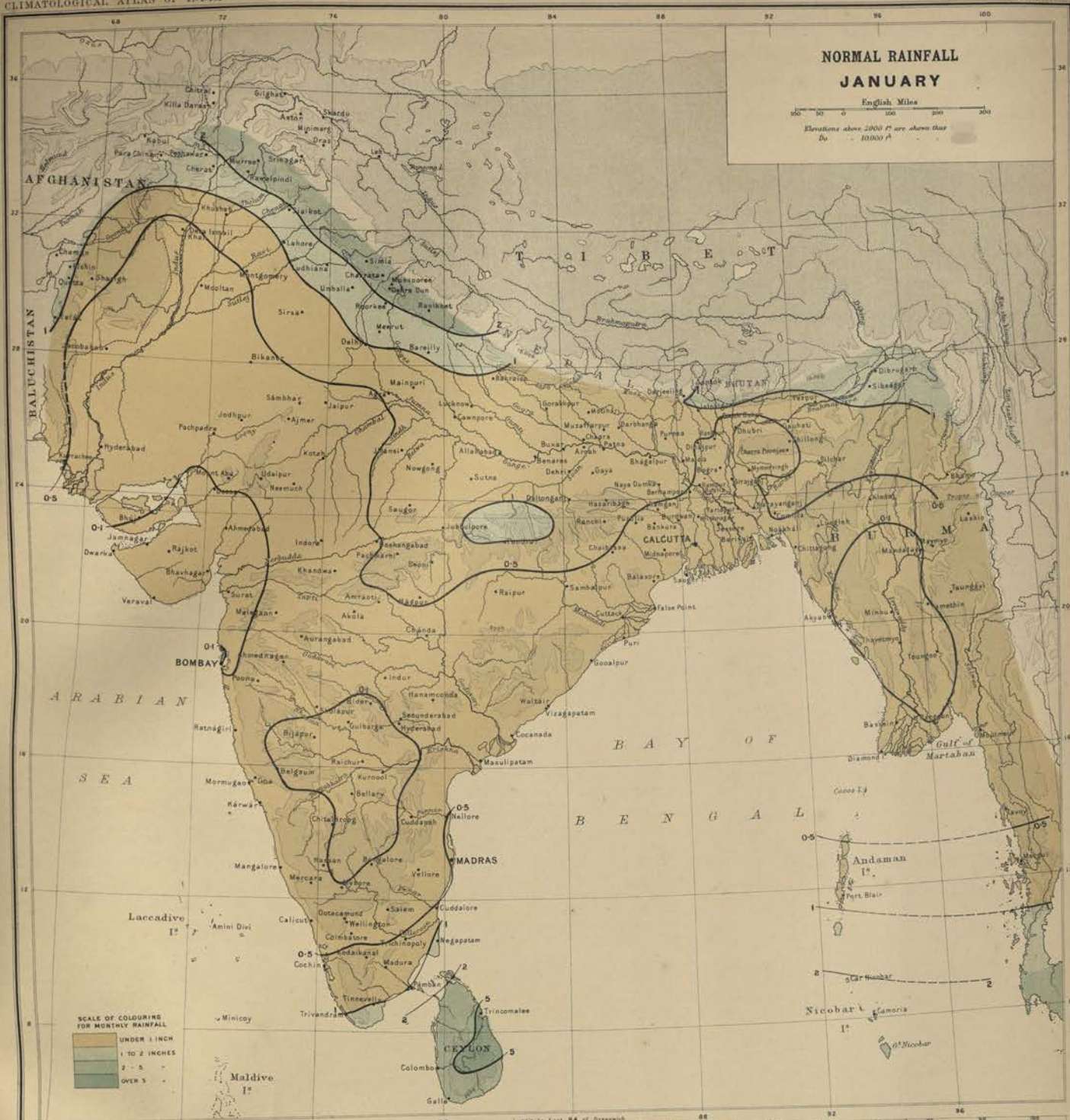


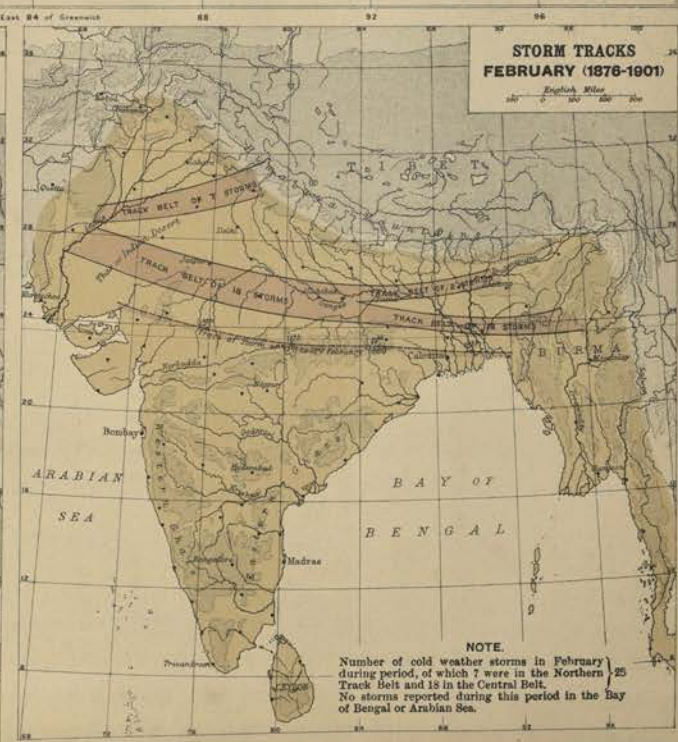
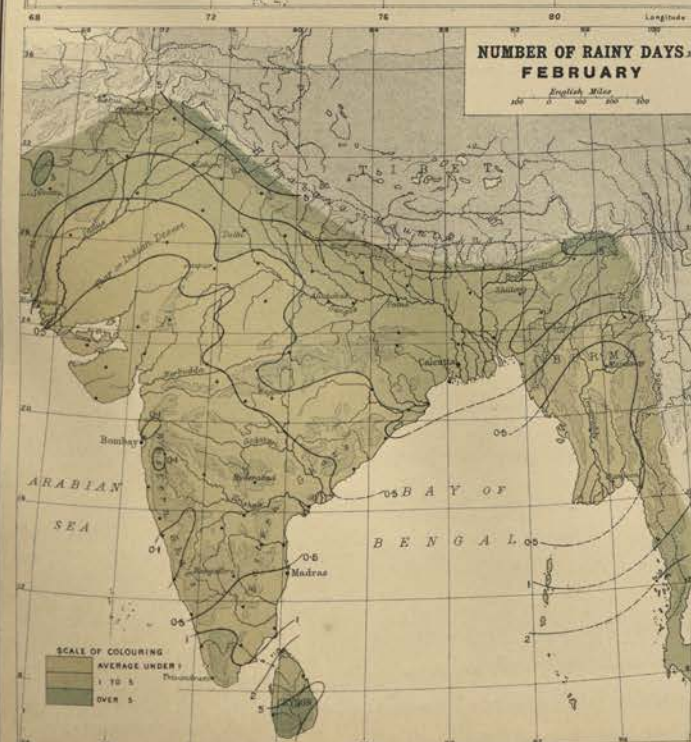


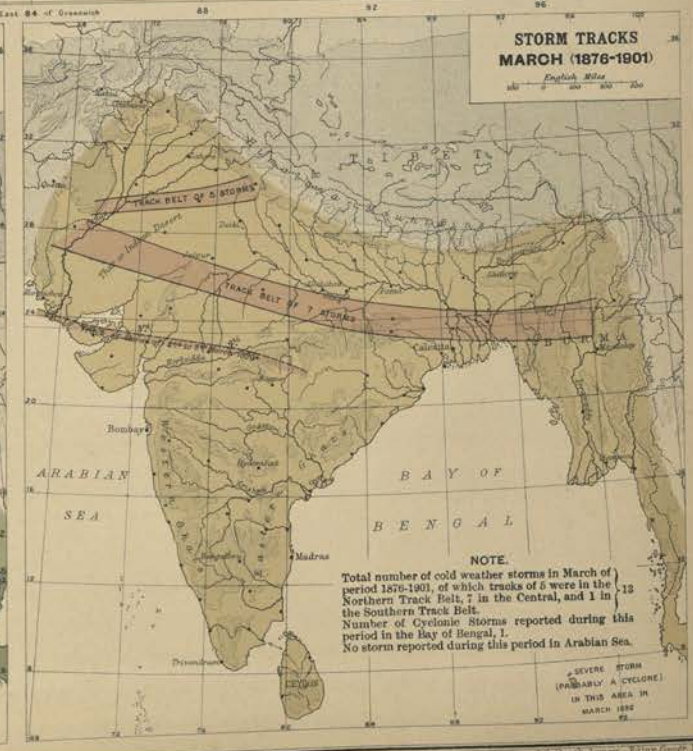
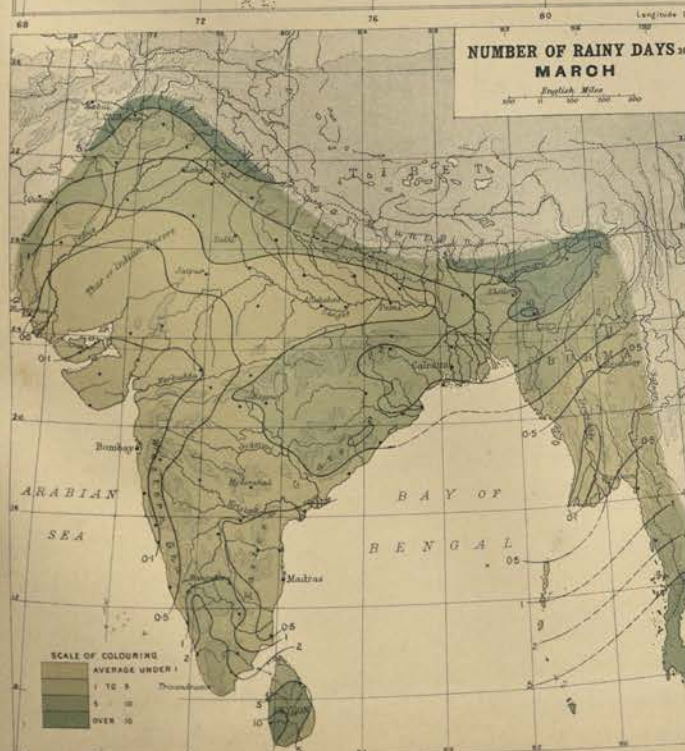


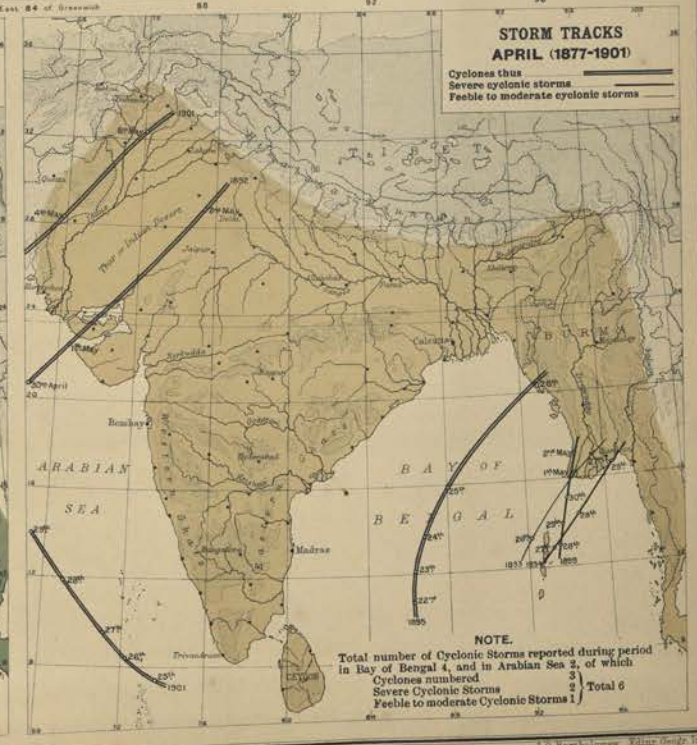
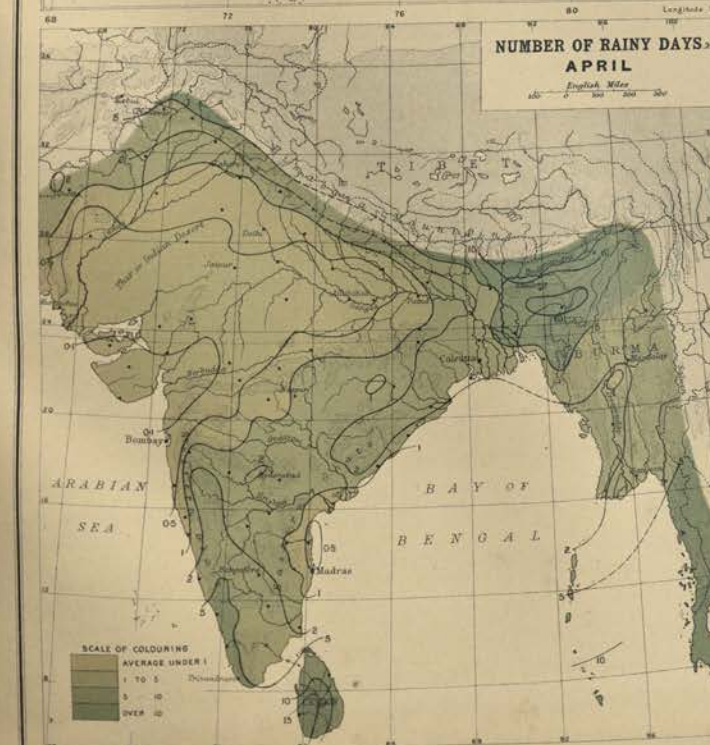
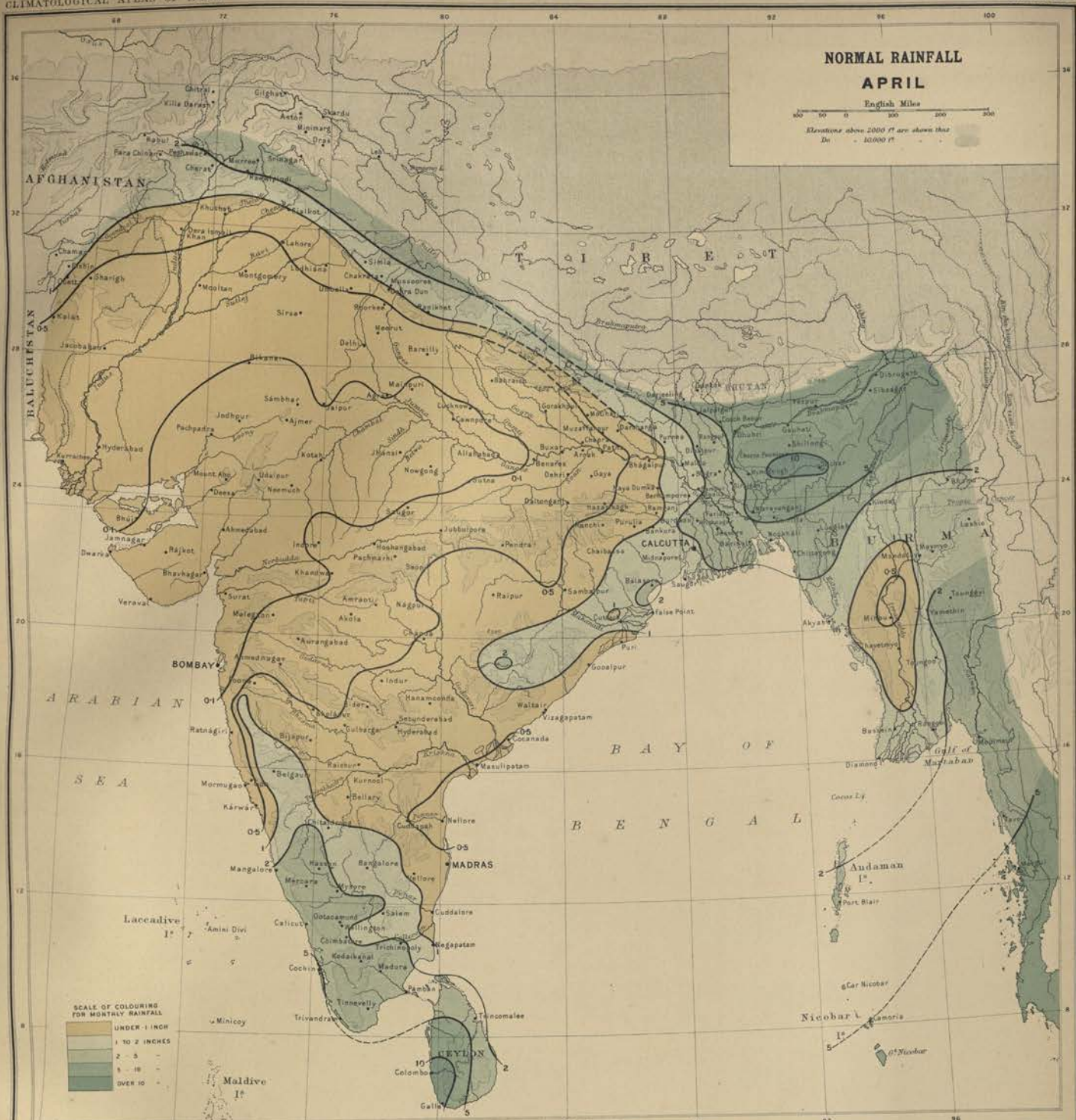


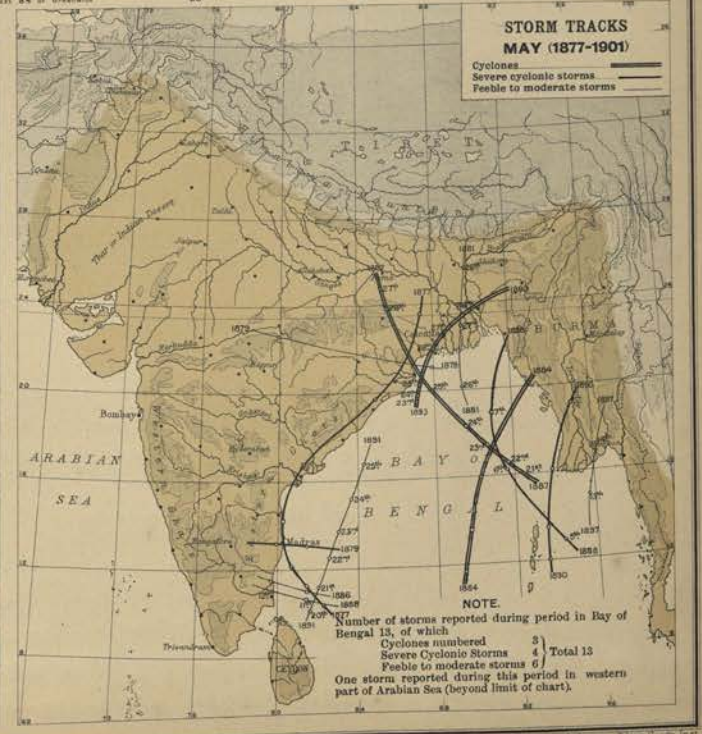
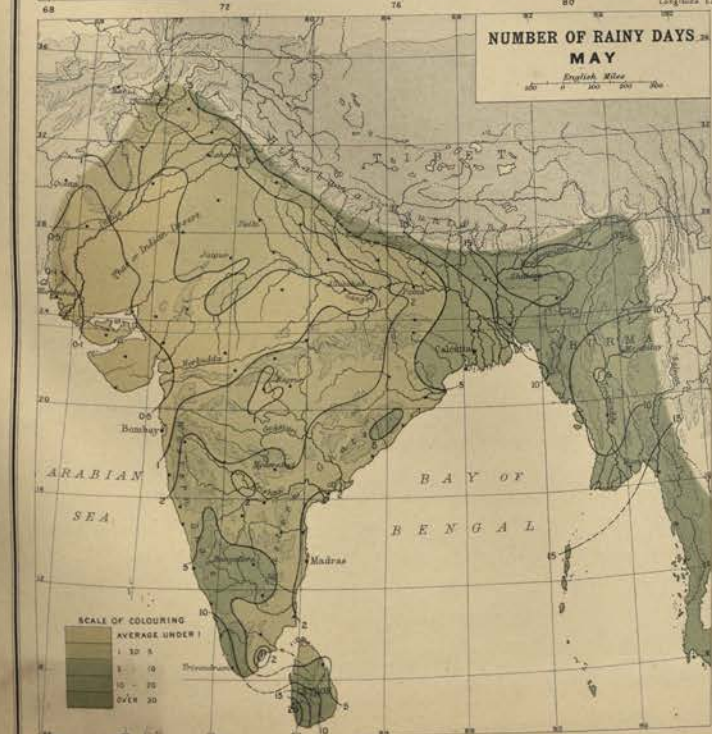
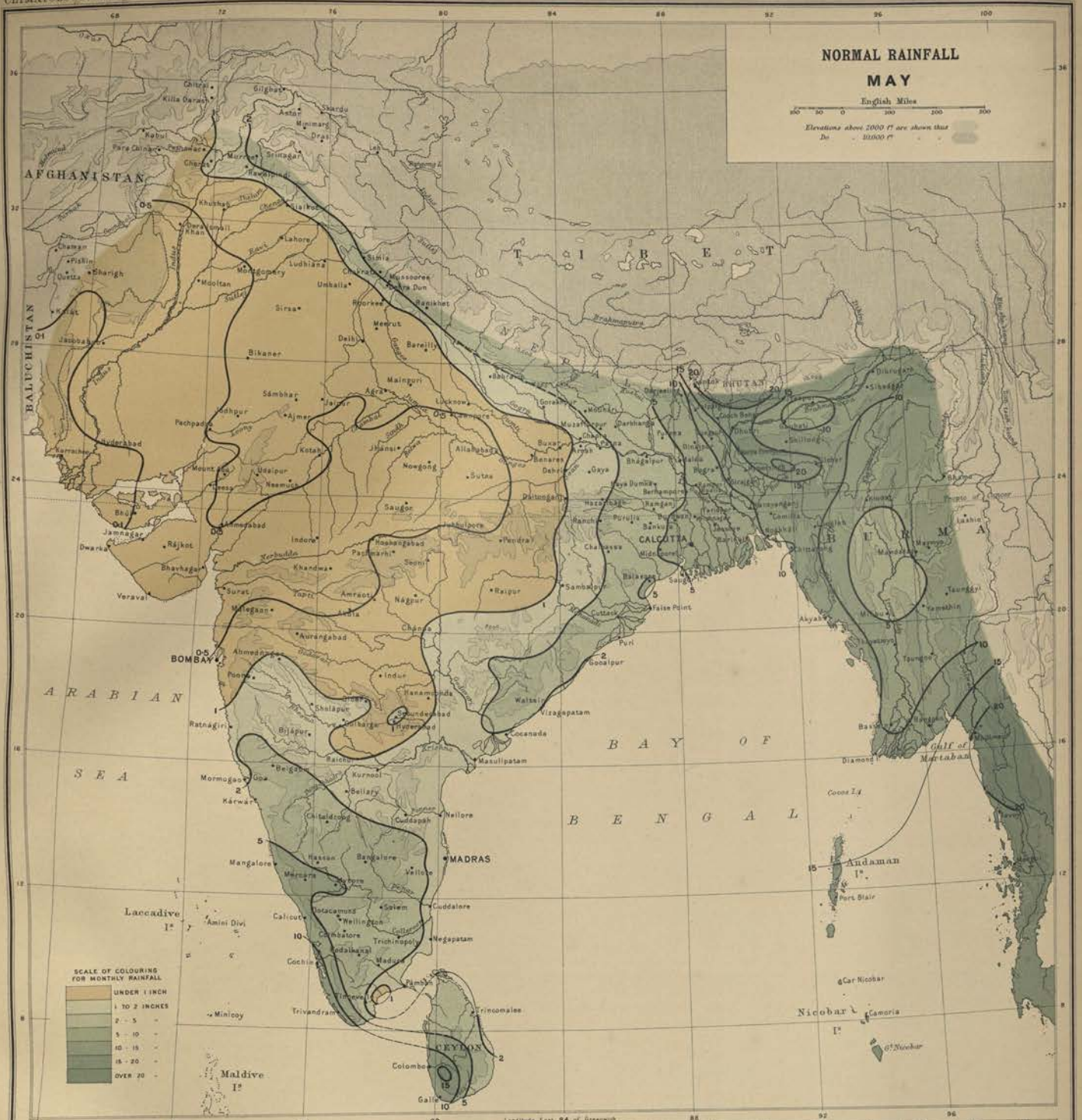


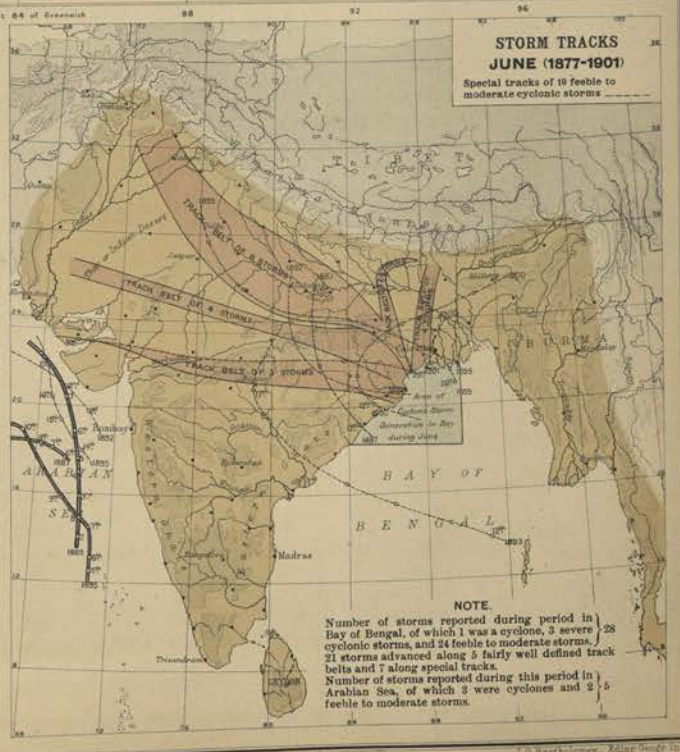
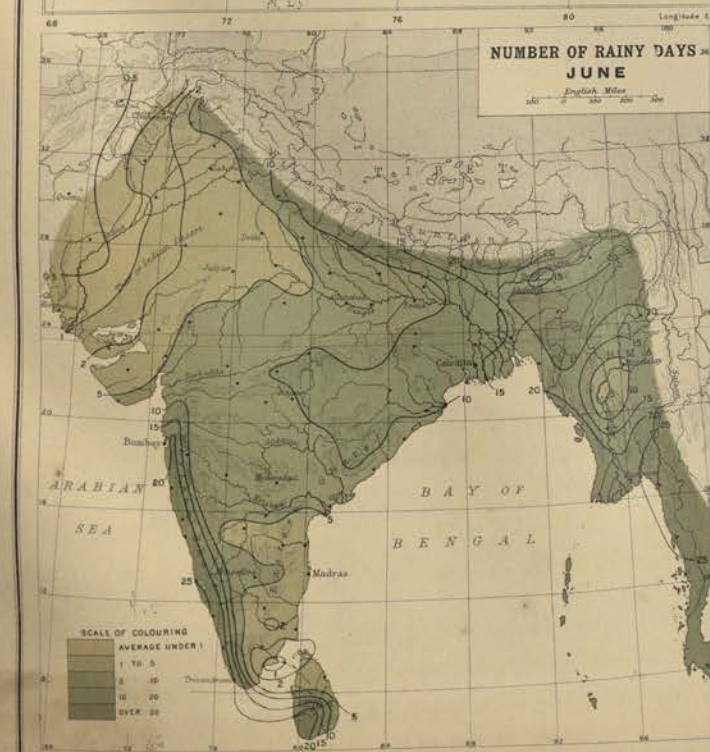
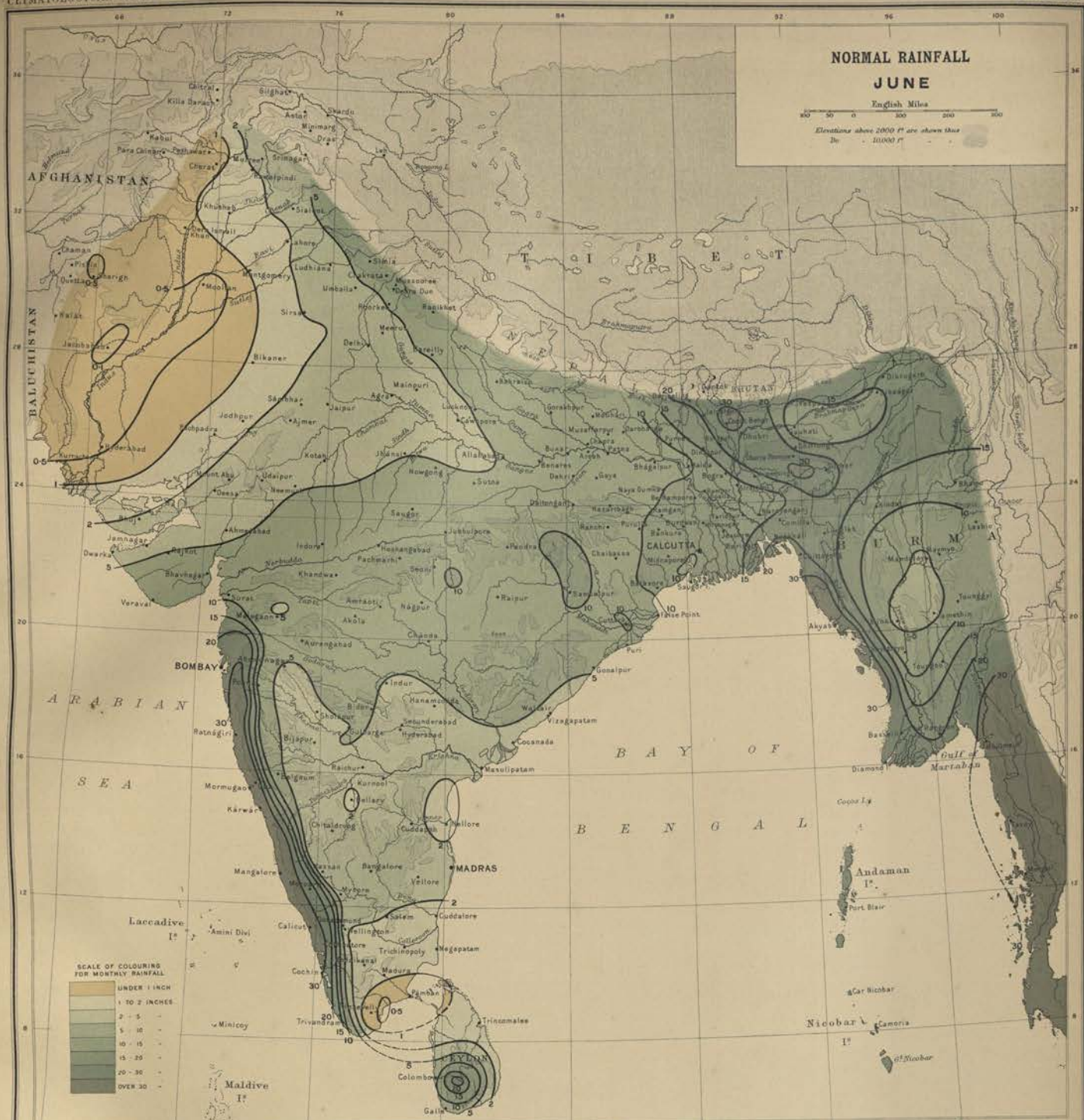


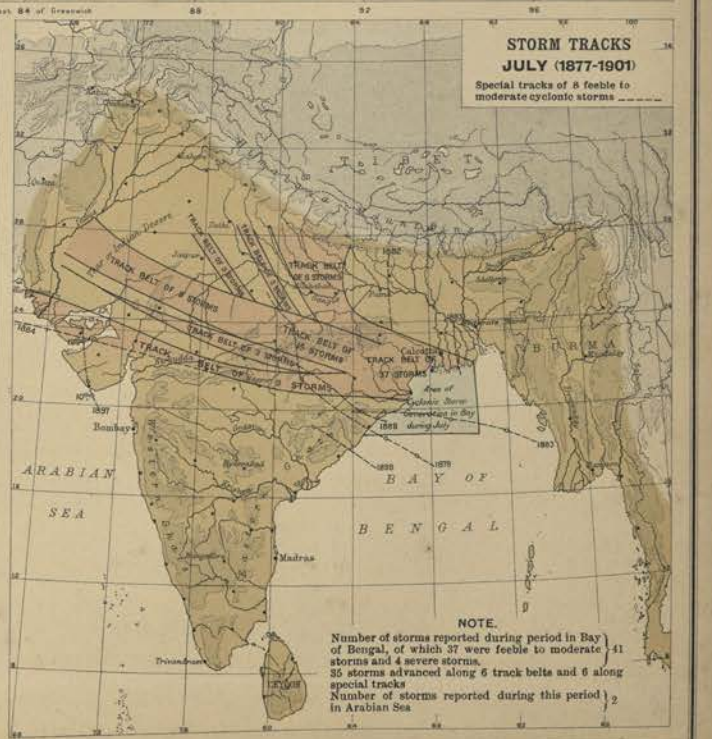
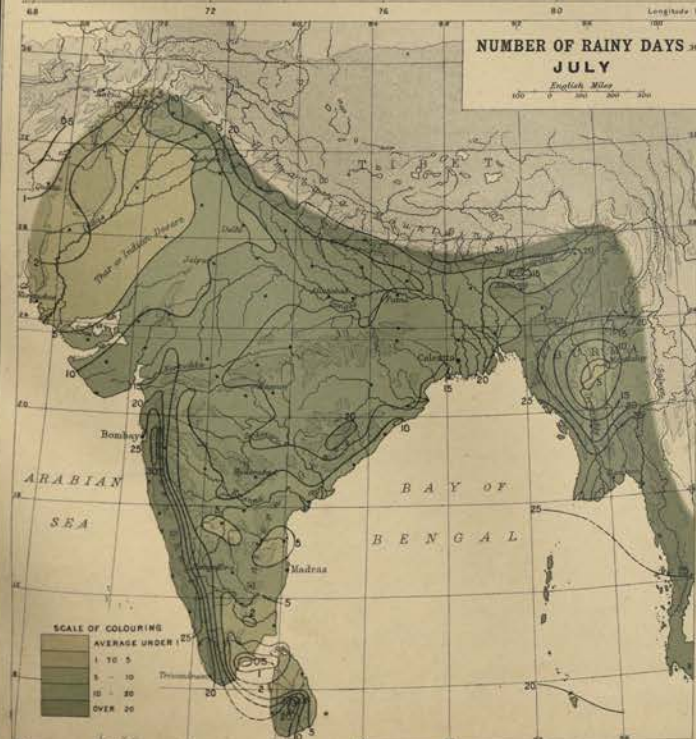
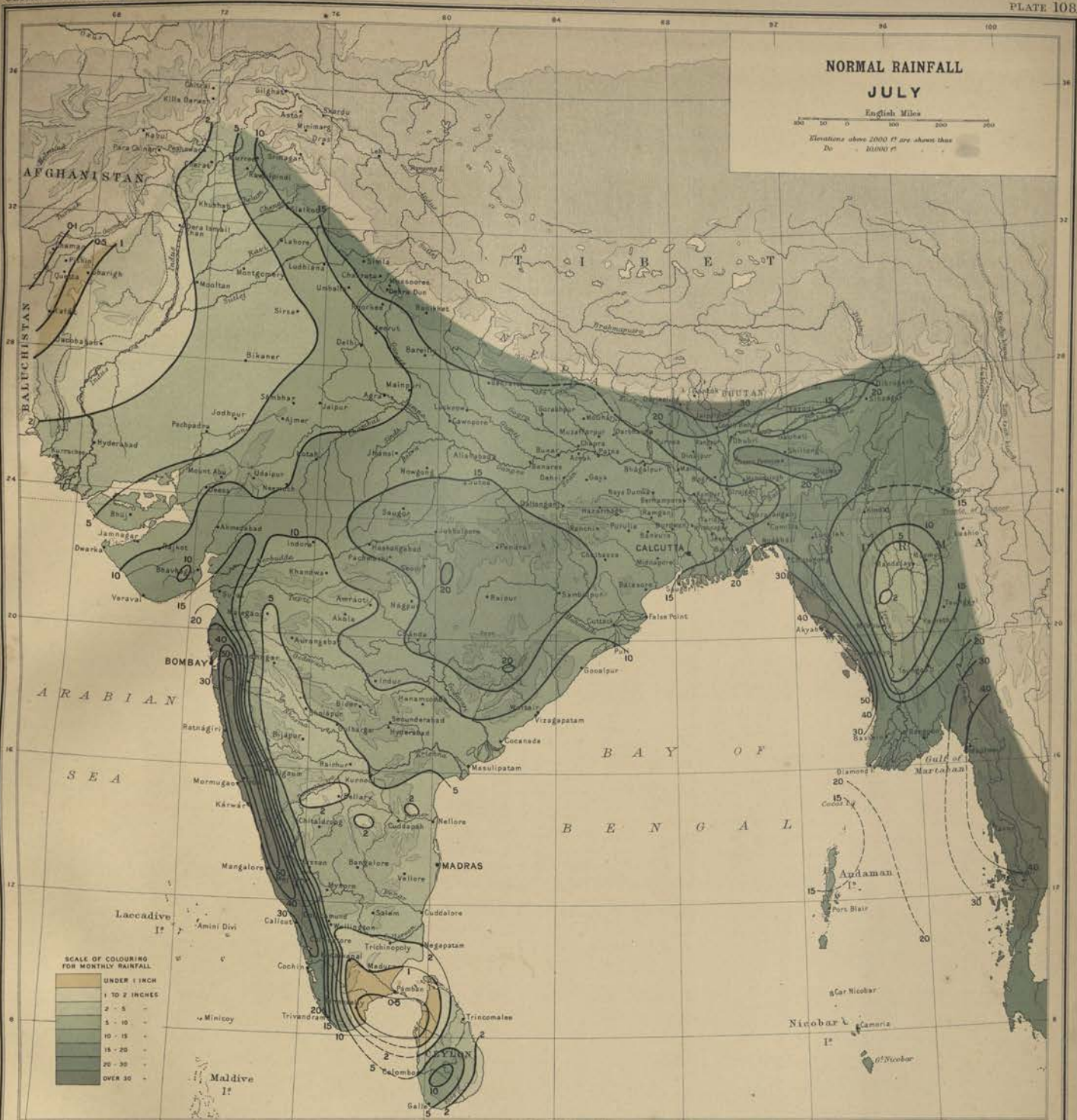














Total number of storms reported during period } 36
in Bay of Bengal, of which 34 were feeble to
moderate cyclonic storms and 2 severe storms.
31 storms advanced along 6 track belts and 5 by
special tracks. No cyclonic storms reported
during this period in Arabian Sea.

