# CLOUDLAND

W. CLEMENT LEY

7/6 net

*With Illustrations*

# CLOUDLAND

A

STUDY ON THE STRUCTURE AND CHARACTERS OF CLOUDS

BY

REV. W. CLEMENT LEY

M.A., F.R.Met.Soc.

*WITH NUMEROUS COLOURED PLATES, PHOTOGRAPHS, CHARTS, AND DIAGRAMS*

LONDON: EDWARD STANFORD

26 & 27 COCKSPUR STREET, CHARING CROSS, S.W.

1894

# CLOUDLAND

London Stanford's Geog^l Estab^t

CUMULO – NIMBUS

Thou on whose stream, 'mid the steep sky's commotion,
Loose clouds like earth's decaying leaves are shed,
Shook from the tangled boughs of heaven and ocean,

Angels of rain and lightning! there are spread
On the blue surface of thine airy surge,
Like the bright hair uplifted from the head

Of some fierce Mænad, even from the dim verge
Of the horizon to the zenith's height,
The locks of the approaching storm. Thou dirge

Of the dying year, to which this closing night
Will be the dome of a vast sepulchre,
Vaulted with all thy congregated might

Of vapours, from whose solid atmosphere
Black rain, and fire, and hail, will burst: O hear!

SHELLEY, *Ode to the West Wind.*

# PREFACE

THE task which has been attempted in the following pages is one which is beset with many difficulties. In the first place, clouds are in themselves inaccessible and intangible objects which cannot be examined by direct experimental means, so that we have to rely mainly upon theory based on careful observation. It is very difficult to treat of a vague and complicated subject in any but a vague and complicated manner; and so intricate are the causes to which clouds and winds are due, and so intimate is the connection between them, that it would not be possible to treat of one without having to deal with the other, or to pursue a study of the one without a study of the other. Secondly, the subject itself is one which has received scant attention by meteorological writers, who seem to have considered that the science of meteorology consists entirely of investigations into the variations of temperature, pressure, and wind at the earth's surface, and that the thermometer, barometer, and weather chart are the only things necessary to make a man a competent meteorologist, and who have been apt to forget that the barometer and thermometer, after all, only show the variations of pressure and temperature at the earth's surface over a very small local area, and that the weather chart is merely the result of a large number of individual observations. Lastly, in spite of the great importance of the science, especially in a country on whose fickle climate so much depends, it is very few indeed out of the number whose interests are concerned who care to study practically the cause and effect of variations in the atmosphere.

The main object, then, which has presented itself to the author has been to help and interest the individual observer, and he believes that, just as individual observation has always been the force which has built up and accelerated the growth of a rising science, so will the improvement of individual observations be the chief factor in aiding the growth of meteorology. He has therefore abstained from any description of instruments, and, as far as possible, from detailed accounts of well-known scientific phenomena, and has assumed that the reader possesses some slight ordinary knowledge of meteorology. The difficulties he has had to encounter have not only been those mentioned above. Long illness, which finally prevented him from completing the work as he had originally intended, was the greatest obstacle. But if he has in any way succeeded in rendering easier the task of observers at meteorological stations, or of adding any interest to, or throwing any light on, the subject as a whole, his task will have been fully accomplished.

The classification of clouds, the theories of their formation, and the other subjects dealt with are the outcome of lifelong observational study, but, owing to the author's ill-health, I have been obliged to arrange and set these in order, and have in one or two cases added explanations and diagrams where he had intended to do so; but this has not been done without an intimate knowledge of the author's opinions and intentions, and careful consideration of other works on the subject. The reader's pardon is craved for any errors and appearance of incompleteness which must thus necessarily occur.

Much valuable assistance has been obtained from the works of other authors; more especially may be mentioned the works of Professor William Ferrel, the greatest of modern meteorologists. References have, as far as possible, been made, and in those cases in which they have not the author's apologies are due.

The author particularly wishes to express his thanks to Mr. Arthur Clayden for a series of beautiful photographs which he has kindly given him permission to reproduce. These have been supplemented by a few reproductions of rough water-colour sketches made by the author some years ago.

C. H. LEY.

London, 30*th July* 1894.

# CONTENTS

# LIST OF ILLUSTRATIONS

## COLOURED PLATES



## PHOTOGRAPHS



## CHARTS

## DIAGRAMS

# CHAPTER I

## THE ATMOSPHERE

1. CLOUDS have been correctly defined by Dickson as "portions of the atmosphere which, from natural causes, have become temporarily visible." They are aggregates of particles floating in the air, generally, but not necessarily, particles of water or ice. It will therefore be useful, before proceeding to analyse the various forms of cloud and their bearing on weather, to try and fix in our minds some ideas of the nature of this atmosphere and of the processes taking place in it which affect the formation of cloud.

2. For the actual constitution of ordinary impure air it will be sufficient to remind the reader that it contains by volume about 78 per cent of nitrogen, 20 per cent of oxygen, a variable quantity of aqueous vapour (usually about $1\frac{1}{2}$ per cent), a little carbonic acid and other gases, and lastly, a variable but important amount of dust of various kinds.

Now the most important of these constituents, as regards the subject of which we are going to treat, are the variable ones, viz. the aqueous vapour and the dust particles. The powers which are possessed by these two factors in altering the conditions and affecting the character of weather and climate are perhaps not sufficiently realised. But before dealing with these it will be necessary to say a few words on the variation of temperatures and pressures through the atmosphere, even at the cost of repeating universally known and understood facts.

3. The pressure of the atmosphere at any point is simply the weight per unit of area of the whole column of air which rests above that point. Thus the higher we rise in the atmosphere the less the pressure will be. And if the pressure and density of the atmosphere were the same throughout as at sea-level, and the temperature were also uniform, the whole height of the atmosphere would only be about 5 miles. But these three factors all decrease rapidly with increase of altitude, and react upon one another in such a manner as to make it impossible to absolutely determine the height of the atmosphere. From other considerations we suspect that this height must be at least 100 miles or more, although, of course, we cannot say that it ends at any particular level, for it grows gradually more and more rarefied until it disappears in space. The fact that the envelope of air exerts a weight on the earth's surface of about eighty billions of tons may give us some notion of the vastness of this envelope.

4. For small altitudes and in still atmosphere we may take the pressure as decreasing at the rate

of 1 in. per 1000 feet increase in elevation, and the temperature as decreasing at the rate of ·216° Fahrenheit for every 100 feet increase. But these rules are liable to considerable variation. For instance, in the cold winter nights of the temperate zones, when the earth loses heat rapidly by radiation into space, the temperature distribution may become inverted, the base of a column of air becoming colder than the upper portion. On the other hand, during the afternoon of a hot summer's day, and in some other conditions, the decrease of temperature with elevation is much greater than that given above. The pressure distribution also varies considerably. There are extensive permanent areas in different parts of the globe in which the pressures at the earth's surface are less, and decrease at a less rapid rate with altitude, than those on either side of these areas. There are also local wandering areas of low pressure called cyclones, and local areas of high pressure called anticyclones. These will be treated of in later chapters. It will be sufficient here to state that the unequal distribution of pressure and temperature over the globe disturbs the atmospheric equilibrium to such an extent as to cause strong permanent as well as local currents.

These movements are not only horizontal, but also more or less vertical, interchange taking place between the upper and the lower layers of air. It is necessary to mention one result of this interchange which plays a conspicuous part in some of those phenomena which are the subject of the present work.

5. Whenever a gas is subject to rapid compression, whatever the nature of the force which produces the compression may be, the temperature of the gas is raised. And conversely, whenever a gas undergoes a sudden expansion, its temperature is correspondingly lowered. Consequently, if a current of dry air is ascending rapidly, its decrease of temperature is very rapid, not only on account of its increasing distance from the earth, but also on account of its expansion due to decrease of pressure. The rate of this decrease in such a current is found to be about ·54° Fahrenheit for each 100 feet of ascent (·98° C. per 100 m.). It follows from this that if the distribution of temperature with altitude in quiet air be about that mentioned in § 4, a column of ascending air will be quickly cooled down to a point below the temperature of the surrounding quiet air, and its density becoming greater than that of this air, the column will quickly fall back again. We may for convenience call such a condition one of "stable equilibrium." On the other hand, if, as in the example given above of a hot summer's day, the temperature of the still air decreases abnormally with increase of altitude, the ascending column may lose heat less rapidly than the still air around it, and consequently it will continue to ascend. To such a state we can apply the title "unstable equilibrium." It will be obvious that this state is not likely to exist at a great altitude above the earth.

It will also be seen that in the state of stable equilibrium a downward motion commencing in any layer of the atmosphere would, like an ascensional movement, be speedily arrested, while in a state of unstable equilibrium it will tend to continue downwards. It should be borne in mind that while the atmosphere is undisturbed, whatever the change of temperature dependent on altitude may be, no vertical movement of the atmosphere will take place, whether the atmosphere be in a state of stable or unstable equilibrium, until some disturbing force begins to act in one direction or another. Any approximately vertical current which tends to turn a portion of the atmosphere upside down or to effect an interchange between its lower and higher strata may be called an "inversion movement" or "current of inversion."

6. We now have to consider one of the primary causes of these disturbances in our atmosphere, viz. aqueous vapour. This vapour is a compound gas, and were it similar to the simple gases in the atmosphere, its effects would not be nearly so complicated. But in the first place, its density is only about half that of dry air, so that if it were to remain a gas, it would ascend to a height much greater than that of our atmosphere. In the second place, with decrease of temperature it does not remain a gas, but becomes condensed into water and congealed into ice.

Now the greater the temperature of any portion of air, the greater its capacity for holding water-vapour, or the amount of water-vapour which such a portion of air can hold as water-vapour depends on its temperature. Therefore, if the temperature be lowered, water-vapour will be condensed on any solid surfaces with which it comes in contact until the amount left is the maximum which can be held at the new temperature. The temperature at which any portion of air commences to deposit vapour in the above manner is termed its "dew-point." Also the pressure exerted by aqueous vapour is a measure of the amount of this aqueous vapour, and is usually but not happily termed the *tension* of aqueous vapour. The proportion between the actual vapour-tension at any particular temperature and the maximum vapour-tension possible at that temperature is called the "relative humidity."

Hence the amount of aqueous vapour which can exist in any portion of the atmosphere diminishes very rapidly with decrease of temperature, so that we have, roughly speaking, only to ascend about 6000 feet (1830 m.) to get above one half the whole amount of vapour contained in the atmosphere, while at about 25,000 feet (7620 m.) the whole amount of vapour is very trifling.

The distribution of water-vapour at the earth's surface of course depends greatly on the respective geographical position of water and land surfaces, and of damp and dry surfaces generally. Vapour is therefore most abundant over the oceans and the great lakes and the land adjacent to them. As water gives off vapour in proportion to its own temperature on the one hand, and to the capacity for additional vapour in the air on the other