Circular 5

R B Montgomery

CODES FOR CLOUD FORMS AND STATES OF THE SKY

**ACCORDING TO THE
INTERNATIONAL SYSTEM OF
CLASSIFICATION**

Woods Hole Oceanographic Institution
ATLAS-GAZETTEER COLLECTION

**U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU**

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WEATHER BUREAU

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INTERNATIONAL SYSTEM OF
CLASSIFICATION

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INTRODUCTION

At Copenhagen, Denmark, in 1929, the International Meteorological Organization adopted code specifications for clouds including lower, middle, upper, and predominating clouds. The third edition of the International Atlas of Clouds and of the States of the Sky which was published in 1932 and the abridged edition which was published in 1930, contain detailed instructions for observing and coding cloud forms in accordance with the specifications adopted at Copenhagen. The cloud codes form a part of the International figure code for synoptic messages.

Definitions, descriptions, and codes in the following pages are based on the third edition of the International Atlas and are intended for the use of observers who report clouds in synoptic messages in the International Code. This publication is not designed for public distribution. The cloud codes are of little interest to the general public. The Weather Bureau has prepared a separate publication entitled "Cloud Forms," which is especially designed for general use in the identification and study of the forms of clouds.

Observers who have access to the International Atlas should also study the illustrations, diagrams, and comments contained therein.

The observer will note the following details in which International practices differ from those heretofore in effect in the Weather Bureau:

1. The definition of cirrocumulus clouds has been restricted more than in previous editions of the International Atlas. Real cirrocumulus is now considered to be uncommon; it must have an evident connection with cirrus or cirrostratus; it must result from a change in cirrus or cirrostratus; and it must show some characteristics of ice crystal clouds.

2. The distinction between cumulus and cumulonimbus has been modified. By the new definitions, masses of cumulus clouds, however heavy they may be, and however great their vertical development, are not classed as cumulonimbus unless the whole or a part of their tops is transformed or is in process of transformation into a cirrus mass. In the species *cumulonimbus calvus*, however, no cirriform parts can be detected at first but nevertheless the freezing of the upper parts has already begun and the tops are beginning to lose their rounded outlines and clear-cut contours; the hard and "cauliflower" swellings soon become confused and melt away so that nothing can be seen in the white mass but more or less vertical fibers. Hence, the criterion for distinction in cases difficult to identify is the fibrous summit that must be present if the cloud is to be called cumulonimbus without having the clearly defined cirriform top. Precipitation may fall from cumulus clouds, though only in relatively small quantities.

3. Altocumulus clouds are now distinguished from stratocumulus by the specific criterion that the well-defined, regularly arranged elements which are observed in the layer are not altocumulus if they are greater than 10 solar diameters in their smallest diameters, i. e., the apparent width of three fingers when the arm is held extended.

4. Dense sheets of middle-level nonfibrous clouds, heretofore called altostratus, have been changed to *altocumulus opacus*. This change restricts the dense altostratus forms to the dense fibrous sheets of rain (sometimes snow) that usually succeed cirrostratus by lowering, a development that is of much importance to the forecasters. If a dense sheet of middle-level clouds shows definite relief on the lower surface it is classed as altocumulus and not altostratus.

5. The name "nimbostratus" has been introduced and the name "nimbus" has been eliminated. The observer should read the definitions carefully and note particularly that the name "nimbostratus" should not be applied to the lower parts of a cumulonimbus cloud. When precipitation falls from nimbostratus clouds it is continuous in character. Nimbostratus is evolved by lowering of a sheet of altostratus or in exceptional cases from a sheet of stratocumulus but not from cumulonimbus.

6. The hyphens in cloud names have been eliminated, e. g., cirrostratus has been changed to cirrostratus.

NAMES AND HEIGHTS OF CLOUDS

Clouds are classified according to form and appearance, but consideration is also given to the physical processes producing them. There is a general relation between the forms of clouds and their heights as shown by actual measurements. The temperature, moisture, and movements of the air differ characteristically at the various levels above the earth's surface and hence there are significant differences in the formation of clouds as well as the apparent effects of distance or height above the observer.

In the International system there are 4 families and 10 genera, and in addition certain species, varieties, and special features. The 10 genera and their heights, as given in the International Atlas, are shown in the following table, where each word preceded by a number is the name of a cloud form which constitutes a distinct genus. The mean heights are for temperate latitudes and refer not to sea level but to the general level of land in the region. There is nearly always some variation from the mean height, which serves merely as a guide to the general elevation. In certain cases there may be large departures from the mean height.

Cirrus clouds sometimes may be observed as low as 3,000 meters in temperate regions and at lower levels in higher latitudes. In the polar regions, and in extremely cold weather elsewhere, ice spicules are occasionally observed in the air at and near the surface. When ice crystals or spicules are seen floating in the air at the surface, the phenomenon is recorded as ice fog or ice crystals, depending on visibility and other criteria for identifying hydrometeors.

Clouds composed at least partially of water droplets can exist at very low temperatures; sometimes low clouds are composed of a mixture of water droplets and ice crystals or snow. The observer must be guided by the appearance of the clouds. If they have the usual appearance of cirrus forms, they should be so recorded and reported in regular synoptic messages. Clouds at very low levels which have the appearance of ordinary stratus clouds should be recorded and reported as such, even when upper air soundings show that they are made up of snow crystals, ice spicules, or a mixture of either or both with water droplets. In special cases an explanatory note should be entered in the record to show the composition of the clouds as revealed by airplane soundings. In this connection the observer is referred to the section, "Aerial views of clouds."

CLASSIFICATION ¹

Family A: High Clouds

(Mean lower level, 6,000 meters, 20,000 feet)

1. Cirrus.
2. Cirrocumulus.
3. Cirrostratus.

¹ Species, varieties, and special features are described in the sections which follow.

Family B: Middle Clouds

(Mean upper level, 6,000 meters, 20,000 feet; mean lower level, 2,000 meters, 6,500 feet)

4. *Alto cumulus*.
5. *Alto stratus*.

Family C: Low Clouds

(Mean upper level, 2,000 meters, 6,500 feet; mean lower level, close to the surface)

6. *Strato cumulus*.
7. *Stratus*.
8. *Nimbo stratus*.

Family D: Clouds With Vertical Development

(Mean upper level, that of cirrus; mean lower level, 500 meters, 1,600 feet)

9. *Cumulus*.
10. *Cumulonimbus*.

DEFINITIONS AND DESCRIPTIONS OF THE FORMS OF CLOUDS

CIRRUS

(41, 42, 43, 44, 45, 46, 51, 52)¹

A. Definition

Detached clouds of delicate and fibrous appearance, without shading,² generally white in color, often of a silky appearance.

Cirrus appears in the most varied forms, such as isolated tufts, lines drawn across a blue sky, branching feather-like plumes, curved lines ending in tufts, etc.; they are often arranged in bands which cross the sky like meridian lines, and which, owing to the effect of perspective, converge to a point on the horizon, or to two opposite points (cirrostratus and cirrocumulus often take part in the formation of these bands).

B. Explanatory Remarks

Cirrus clouds are always composed of ice crystals, and their transparent character depends upon the degree of separation of the crystals.

As a rule when these clouds cross the sun's disk they hardly diminish its brightness. But when they are exceptionally thick they may veil its light and obliterate its contour. This would also be the case with patches of altostratus, but cirrus is distinguished by the dazzling and silky whiteness of its edges.

Halos are rather rare in cirrus.

Sometimes isolated wisps of snow are seen against the blue sky, and resemble cirrus; they are of a less pure white and less silky than cirrus; wisps of rain are definitely gray, and a rainbow, should one be visible, shows their nature at once, for this cannot be produced in cirrus.

Before sunrise and after sunset, cirrus is often colored bright yellow or red. These clouds are lit up long before other clouds and fade out much later; some time after sunset they become gray. At all hours of the day cirrus near the horizon is often of a yellowish color; this is due to distance and to the great thickness of air traversed by the rays of light.

Cirrus, being in general more or less inclined to the horizontal, tends less than other clouds to become parallel to the horizon, under the effect of perspective, as the horizon is approached; often on the contrary it seems to converge to a point on the horizon.

¹ Numbers inserted in parentheses in connection with a cloud name refer to the pictures in which that cloud is illustrated.

² Dense cirrus derived from an anvil (*cirrus nothus*) may have shading.

C. Species

Among the principal forms one may note:

Cirrus filorus (42).—More or less straight or irregularly curved filaments (neither tufts nor little hooks and without any of the parts being fused together).

Cirrus uncinus (45, 52).—Cirrus in the shape of a comma, the upper part either ends in a little tuft or is pointed.

Cirrus densus (43).—Cirrus clouds with such thickness that without care an observer might mistake them for middle or low clouds.

Cirrus nothus (44).—Cirrus proceeding from a cumulonimbus and composed of the debris of the upper frozen parts of these clouds.

D. Varieties

Ordinary cirrus may appear in many very different forms. One may particularly note the forms *floccus* and *vertebratus* which are really aspects of the varieties *cumuliformis* and *undulatus radiatus*, respectively.

CIRROCUMULUS

(49, 51, 52)

A. Definition

A cirriform layer or patch composed of small white flakes or of very small globular masses, usually without shadows, which are arranged in groups or lines, or more often in ripples resembling those of the sand on the seashore.

B. Explanatory Remarks

In general cirrocumulus represents a degraded state of cirrus and cirrostratus both of which may change into it. In this case the changing patches often retain some fibrous structure in places.

Real cirrocumulus is uncommon. It must not be confused with small altocumulus on the edges of altocumulus sheets. There are in fact all states of transition between cirrocumulus and altocumulus proper; this is only to be expected as the process of formation is the same. In the absence of any other criterion the term cirrocumulus should only be used when—

1. There is evident connection with cirrus or cirrostratus.
 2. The cloud observed results from a change in cirrus or cirrostratus.
 3. The cloud observed shows some of the characteristics of ice crystal clouds which will be found enumerated under cirrus.
- Clear rifts are often seen in a sheet of cirrocumulus.

CIRROSTRATUS

(46, 47, 48, 49, 50)

A. Definition

A thin whitish veil which does not blur the outlines of the sun or moon, but usually gives rise to halos. Sometimes it is quite diffuse

and merely gives the sky a milky look; sometimes it more or less distinctly shows a fibrous structure with disordered filaments.

B. Explanatory Remarks

A sheet of cirrostratus which is very extensive, though in places it may be interrupted by rifts, nearly always ends by covering the whole sky. The border of the sheet may be straight edged and clear-cut but more often it is ragged or cut up.

During the day, when the sun is sufficiently high above the horizon, the sheet is never thick enough to prevent shadows of objects on the ground.

A milky veil of fog (or thin stratus) is distinguished from a veil of cirrostratus of a similar appearance by the halo phenomena which the sun or the moon nearly always produces in a layer of cirrostratus.

The following are the principal halo phenomena: A circle of 22° radius round the sun or moon; this is roughly the angle subtended by the hand placed at right angles to the arm when the latter is extended; this halo is sometimes, but rarely, accompanied by one of 46° radius. Parhelia, paraselenae (mock suns or mock moons), luminous patches, often showing prismatic colors, a little over 22° from the sun or moon and at the same elevation. A luminous column, e. g., sun pillar, extending vertically above and below the luminary.

Often only small fragments of these appearances are visible but they are none the less characteristic of high clouds.

What has been said above of the transparent character and colors of cirrus is true to a great extent of cirrostratus.

C. Species

Cirrostratus has two principal aspects which correspond to the two following species:

Cirrostratus nebulosus (48, 50).—A very uniform nebulous veil, sometimes very thin and hardly visible, sometimes relatively dense, but always without definite details and usually with halo phenomena.

Cirrostratus filiosus (47).—A white fibrous veil, where the strands are more or less definite, often resembling a sheet of cirrus densus from which indeed it may originate.

ALTOCUMULUS

(28 to 38, inclusive)

A. Definition

A layer (or patches) composed of laminae or rather flattened globular masses, the smallest elements of the regularly arranged layer being fairly small and thin, with or without shading.³ These elements are arranged in groups, in lines, or waves, following one or two directions, and are sometimes so close together that their edges join.

The thin and translucent edges of the elements often show irisations which are rather characteristic of this class of cloud.

From the definition it follows that altocumulus comprises the subgenera:

³ See p. IV for distinction between dense sheets of altocumulus and altostratus.

Alto cumulus translucidus (28, 29, 32).—*Alto cumulus* formed of elements whose color—from dazzling white to dark gray—and whose thickness vary much from one example to another, or even in the same layer; the elements are more or less regularly arranged and distinct. In the definition of the elements it is the variation in the transparency of the layer, variable from one point to another, that plays the essential part. There appears in the interstices either the blue of the sky, or at least a marked lightening of the layer of cloud due to a thinning out.

Alto cumulus opacus (35, 36).—An *alto cumulus* sheet which is continuous, at least over the greater part of the layer, and consisting of dark and more or less irregular elements, in the definition of which transparency does not play a great part, owing to the thickness and density of the layer; but the elements show in real relief on the lower surface of the cloud sheet.

B. Explanatory Remarks

The limits within which *alto cumulus* is met are very wide.

At the greatest heights, *alto cumulus* made up of small elements resembles *cirrocumulus*; *alto cumulus*, however, is distinguished by not possessing any of the following characters of *cirrocumulus*:

1. Connection with *cirrus* or *cirrostratus*.
2. An evolution from *cirrus* or *cirrostratus*.
3. Properties due to physical structure (ice crystals) enumerated under *cirrus*.

At lower levels, where *alto cumulus* may be derived from a spreading out of the tops of *cumulus* clouds, it may easily be mistaken for *stratocumulus*; the convention is that the cloud is *alto cumulus* if the smallest, well defined, and regularly arranged elements which are observed in the layer (leaving out the detached elements which are generally seen on the edges) are not greater than 10 solar diameters in their smallest diameters, i. e., approximately the width of three fingers when the arm is held extended.

When the edge or a thin semitransparent patch of *alto cumulus* passes in front of the sun or moon a corona appears close up to (within a few degrees of) them; this is a colored ring with red outside and blue inside; the colors may be repeated more than once. This phenomenon is infrequent in the case of *cirrocumulus* and only the higher forms of *stratocumulus* show it.

Irisation, mentioned above, is a phenomenon of the same type as the corona; it is characteristic of *alto cumulus* as distinguished from *cirrocumulus* or *stratocumulus*.

Alto cumulus clouds often appear at different levels at one and the same time. Often, too, they are associated with other types of cloud.

The atmosphere is often hazy just below *alto cumulus* clouds.

When the elements of a sheet of *alto cumulus* fuse together and make a continuous layer *altostratus* or *nimbostratus* is the result. On the other hand a sheet of *altostratus* can change into *alto cumulus*. It may happen that these two aspects of a cloud sheet may alternate with each other during the whole course of a day. It is also not rare to have a layer of *alto cumulus* coexisting with a veil resembling *altostratus* at a height very little less than the *alto cumulus*.

It is interesting to note that one may often observe filiform descending trails to which the name *virga* has been given.

C. Species

Among the principal kinds one may note:

Altocumulus cumulogenitus (33).—This is an altocumulus cloud formed by the spreading out of the tops of cumulus, the lower parts of the cumulus clouds having melted away; the layer in the first stages of its growth has the appearance of *altocumulus opacus*.

D. Varieties

An important variety of altocumulus should be noted, namely, *altocumulus cumuliformis*, which has two different aspects:

Altocumulus floccus (38).—Tufts resembling small cumulus clouds without a base and more or less ragged.

Altocumulus castellatus (37).—Cumuliform masses with more or less vertical development, arranged in a line, and resting on a common horizontal base, which gives the cloud a crenellated appearance.

The caps or hoods which form above a cumulus by the uplift of a damp layer, and which may be pierced by the tops of the cumulus are considered as a detail of cumulus, and denoted by the term *pileus* attached to the name cumulus; but in reality they are aberrant forms of *altocumulus translucidus*. Moreover, similar clouds, independent of cumulus, can be formed by the same process by the effect of a rising current caused by a mountain or any obstacle. They are then named altocumulus, and they are classed, on account of their form, with the variety *lenticularis* (30).

ALTOSTRATUS

(15, 25, 26, 27, 34)

A. Definition

Striated or fibrous veil, more or less gray or bluish in color. This cloud is like thick cirrostratus but without halo phenomena; the sun or moon shows vaguely, with a faint gleam, as though through ground glass. Sometimes the sheet is thin, with forms intermediate with cirrostratus. Sometimes it is very thick and dark, sometimes even completely hiding the sun or moon. In this case differences of thickness may cause relatively light patches between very dark parts; but the surface never shows real relief,⁴ and the striated or fibrous structure is always seen in places in the body of the cloud.

Every form is observed between high altostratus and cirrostratus on the one hand, and low altostratus and nimbostratus on the other.

Rain or snow may fall from altostratus (*altostratus precipitans*), but when the rain is heavy the cloud layer will have grown thicker and lower, becoming nimbostratus; but heavy snow may fall from a layer that is definitely altostratus.

From the definition of altostratus it follows that there are three subgenera:

1. *Altostratus translucidus* (15, 25).—A sheet of altostratus resembling thick cirrostratus; the sun and the moon show as through ground glass.

⁴ See p. IV for distinction between dense sheets of altocumulus and altostratus.

2. *Altostratus opacus* (26, 27).—An opaque layer of altostratus of variable thickness which may entirely hide the sun, at any rate, in parts, but showing a fibrous structure in some parts.

3. *Altostratus precipitans*.—A layer of opaque altostratus which has not yet lost its fibrous character, and from which there are light falls of rain or snow, either continuous or intermittent. This precipitation may not reach the ground in which case it forms virga.

B. Explanatory Remarks

The limits between which altostratus may be met with are fairly wide (about 5,000 to 2,000 meters).

A sheet of high altostratus is distinguished from a rather similar sheet of cirrostratus by the convention that halo phenomena are not seen in altostratus, nor are the shadows of objects on the ground visible.

A sheet of low altostratus may be distinguished from a somewhat similar sheet of nimbostratus by the following characters: Nimbostratus is of a much darker and more uniform gray, and shows nowhere any whitish gleam or fibrous structure; one cannot definitely see the limit of its undersurface which has a wet look, due to the rain (or snow), which may not reach the ground.

The convention is also made that nimbostratus always hides the sun and moon in every part of it, while altostratus only hides them in places behind its darker portions, but they reappear through the lighter parts.

Careful observation may often detect virga hanging from altostratus, and these may even reach the ground causing slight precipitation. If the sheet still has the character of altostratus it will then be called *altostratus precipitans*, but if not it has become nimbostratus.

A sheet of altostratus, even if it has rifts in places, has a general fibrous (or ground glass) character. A cloud layer, even a continuous one, which has no fibrous structure, and in which rounded cloud masses may be seen is classed as altocumulus or stratocumulus according to circumstances.

Altostratus may result from a transformation of a sheet of altocumulus, and on the other hand altostratus may often break up into altocumulus.

STRATOCUMULUS

(9, 10, 11, 12, 18, 19, 20, 21, 28)

A. Definitions

A layer (or patches) composed of laminae, globular masses or rolls; the smallest of the regularly arranged elements are fairly large; they are soft and gray, with darker parts.⁵

These elements are arranged in groups, in lines, or in waves, alined in one or in two directions. Very often the rolls are so close that their edges join; when they cover the whole sky they have a wavy appearance.

From the definition it follows that stratocumulus comprises two kinds:

⁵ Also, a low, continuous sheet, thick or thin, with distinct irregularities of large size. See explanatory remarks under "Stratus."

1. *Stratocumulus translucidus* (12).—A not very thick layer; in the interstices between its elements either the blue sky appears, or at any rate there are much lighter parts of the cloud sheet, which here is thinned out on its upper surface.

2. *Stratocumulus opacus* (21).—A very thick layer made up of a continuous sheet of large dark rolls or rounded masses; their shape is seen not by a difference in transparency, but they stand out in real relief from the under surface of the cloud layer.

There are transitional forms between stratocumulus and altocumulus on the one hand and between stratocumulus and stratus on the other.

B. Explanatory Remarks

The difference between stratocumulus and altocumulus is given under the latter.

It should also be noted that the cloud sheet called altocumulus by an observer at a small height might appear as stratocumulus to an observer at a greater height (12).

It often happens that stratocumulus is not associated with any clouds of the second or third families; but it fairly often coexists with clouds of the fourth family.

The elements of thick stratocumulus (*stratocumulus opacus*) often tend to fuse together completely, and the layer can, in certain cases, change into nimbostratus. The cloud is called nimbostratus when the cloud elements of stratocumulus have completely disappeared and when, owing to the trails of falling precipitation, the lower surface has no longer a clear cut boundary.

Stratocumulus can change into stratus, and vice versa. The stratus being lower, the elements appear very large and very soft, so that the structure of regularly arranged globular masses and waves disappears as far as the observer can see. The cloud will be called stratocumulus as long as the structure remains visible.

C. Species

Among the principal species may be mentioned:

1. *Stratocumulus vespertilis* (9).—This name is given to flat elongated clouds which are often seen to form about sunset as the final product of the diurnal changes of cumulus.

2. *Stratocumulus cumulogenitus* (10).—Stratocumulus formed by the spreading out of the tops of cumulus clouds, which latter have disappeared; the layer in the early stages of its formation looks like *stratocumulus opacus*.

D. Varieties

The cloud called roll cumulus in England and Germany is designated *stratocumulus undulatus* (11); its wave system is in one direction only. It must not be confused with flat cumulus clouds ranged in line. Stratocumulus often has a mammatus (festooned) character; that is to say there is a high relief on the lower surface where pendant rounded masses or corrugations are observed, and at times these look as though they would become detached from the cloud. Care must be taken not to confuse this cloud with some kinds of *altostratus opacus* whose under surface may appear to be slightly corrugated or mammillated; *altostratus opacus* is distinguished by its fibrous structure.

STRATUS

(13, 14)

A. Definition

A low uniform layer of cloud, resembling fog, but not resting on the ground.

Fractostratus.—When this very low layer is broken up into irregular shreds it is designated *fractostratus* (13, 25).

B. Explanatory Remarks

A veil of true stratus generally gives the sky a hazy appearance which is very characteristic, but which in certain cases may cause confusion with nimbostratus. When there is precipitation the difference is manifest: nimbostratus gives continuous rain (sometimes snow), precipitation composed of drops which may be small and sparse, or else large (at least some of them) and close together, while stratus only gives a drizzle, that is to say, small drops very close together.

When there is no precipitation a dark and uniform layer of stratus can easily be mistaken for nimbostratus. The lower surface of nimbostratus however has always a wet appearance (widespread trailing precipitation, “virga”); it is quite uniform and it is not possible to make out definite detail; stratus on the other hand has a drier appearance, and however uniform it may be it shows some contrasts and some lighter transparent parts, that is, places less dark where the cloud is thinner, corresponding to the interstices between the rolls and globular masses of stratocumulus, but considerably larger, while nimbostratus seems only to be feebly illuminated, as though lit up from within.

Stratus is often a local cloud, and when it breaks up the blue sky is seen.

Fractostratus sometimes originates from the breaking up of a layer of stratus, sometimes it forms independently and develops till it forms a layer below altostratus or nimbostratus, which latter may be seen in the interstices.

A layer of fractostratus may be distinguished from nimbostratus by its darker appearance, and by being broken up into cloud elements. If these elements have a cumuliform appearance in places the cloud layer is called fractocumulus and not fractostratus.

NIMBOSTRATUS

(16, 17)

A. Definition

A low, amorphous, and rainy layer, of a dark gray color, usually nearly uniform; feebly illuminated seemingly from inside. When it gives precipitation it is in the form of continuous rain or snow.

But precipitation alone is not a sufficient criterion to distinguish the cloud which should be called nimbostratus even when no rain or snow falls from it.

There is often precipitation which does not reach the ground; in this case the base of the cloud is usually diffuse and looks wet on

account of the general trailing precipitation, virga, so that it is not possible to determine the limit of its lower surface.

B. Explanatory Remarks

The usual evolution is as follows: A layer of altostratus grows thicker and lower until it becomes a layer of nimbostratus. Beneath the latter there is generally a progressive development of very low ragged clouds, isolated at first, then fusing together into an almost continuous layer, in the interstices of which, however, the nimbostratus can generally be seen. These very low clouds are called fractocumulus or fractostratus according as to whether they appear more or less cumuliform or stratiform.

Generally the rain only falls after the formation of these very low clouds, which are then hidden by the precipitation or may even melt away under its action. The vertical visibility then becomes very bad.

In certain cases the precipitation may precede the formation of fractocumulus or fractostratus, or it may happen that these clouds do not form at all.

Rather rarely a sheet of nimbostratus may form by an evolution from a stratocumulus.

CUMULUS

(1, 2, 3, 4, 18, 19, 20, 23, 33, 37, 44)

A. Definition

Dense clouds with vertical development; the upper surface is dome shaped and exhibits rounded protuberances, while the base is nearly horizontal.

When the cloud is opposite the sun the surfaces normal to the observer are brighter than the edges of the protuberances. When the light comes from the side, the clouds exhibit strong contrasts of light and shade; against the sun, on the other hand, they look dark with a bright edge.

Fractocumulus.—True cumulus is definitely limited above and below, its surface often appears hard and clear cut. But one may also observe a cloud resembling ragged cumulus in which the different parts show constant change. This cloud is designated fractocumulus (2).

B. Explanatory Remarks

Typical cumulus, over land areas, develops on days of clear skies, and is due to the currents of diurnal convection; it appears in the morning, grows, and then more or less dissolves again toward the evening.

Cumulus, whose base is generally of a gray color, has a uniform structure, that is to say it is composed of rounded parts right up to its summit, with no fibrous structure. Even when highly developed, cumulus can only produce light precipitation.

Cumulus, when it reaches the altocumulus level, is sometimes capped with a light, diffuse, and white veil of more or less lenticular shape, with a delicate striated or flaky structure on its edges; it is generally shaped like a bow which may cover several domes of the cumulus, and

finally be pierced by them. This cloud which does not constitute a species is given the name of *pileus*, a cap or hood.

The clouds which form below altostratus or nimbostratus and which can develop into a complete layer, through whose interstices the altostratus or nimbostratus is generally seen, are usually fractostratus; but if they have a cumuliform appearance they should be classed as fractocumulus. They rarely have this appearance during or soon after rain; on the other hand it is frequent at the beginning of the formation of the low cloud, and when it breaks up.

C. Species

Among the principal species one may note:

1. *Cumulus humilis* (1).—Cumulus with little vertical development, and seemingly flattened. These clouds are generally seen in fine weather.

2. *Cumulus congestus* (3, 4).—Very distended and sprouting cumulus, whose domes have a cauliflower appearance.

CUMULONIMBUS

(5, 6, 7, 8, 21, 22, 24)

A. Definition

Heavy masses of cloud, with great vertical development, whose cumuliform summits rise in the form of mountains or towers, the upper parts having a fibrous texture and often spreading out in the shape of an anvil.

The base resembles nimbostratus, and one generally notices virga. This base has often a layer of very low ragged clouds below it (fractostratus, fractocumulus).

Cumulonimbus clouds generally produce showers of rain or snow and sometimes of hail, and often thunderstorms as well.

If the whole of the cloud cannot be seen the fall of a real shower is enough to characterize the cloud as a cumulonimbus.

B. Explanatory Remarks

Even if a cumulonimbus were not distinguished by its shape from a strongly developed cumulus its essential character is evident in the difference of structure of its upper parts, when these are visible (fibrous structure and cumuliform structure). Masses of cumulus, however heavy they may be, and however great their vertical development, should never be classed as cumulonimbus unless the whole or a part of their tops is transformed or is in process of transformation into a cirrus mass.

Although the upper cirriform parts of a cumulonimbus may take on very varied shapes, yet in certain cases they spread out into the form of an anvil. To this interesting feature the name *incus* is given.

In certain types of cumulonimbus, which are especially common in spring in moderately high latitudes, the fibrous structure extends to nearly the whole cloud mass, so that the cumuliform parts almost wholly disappear; the cloud is reduced to a mass of cirrus and of virga.

The veil cloud *pileus* is seen with cumulonimbus clouds as with cumulus.

When a cumulonimbus covers nearly all the sky the base alone is visible, and resembles nimbostratus, with or without fractostratus or fractocumulus below. The difference between the base of a cumulonimbus and a nimbostratus is often rather difficult to make out. If the cloud mass does not cover all the sky, and if even small portions of the upper parts of the cumulonimbus appear, the difference is evident. If not it can only be made out if the preceding evolution of the clouds has been followed, or if precipitation occurs; its character is violent and intermittent (showers) in the case of cumulonimbus, as opposed to the relatively gentle and continuous precipitation of a nimbostratus.

The front of a thunder cloud of great extent is sometimes accompanied by a roll cloud of a dark color in the shape of an arch, of a frayed out appearance, and circumscribing a part of the sky of a lighter gray. This cloud is named *arcus* and is nothing more or less than a particular case of fractocumulus or fractostratus.

Fairly often a mammatus structure appears in cumulonimbus, either at the base, or on the lower surface of the lateral parts of the anvil.

When a layer of menacing cloud covers the sky and virga and mammatus structure are both seen it is a sure sign that the cloud is the base of a cumulonimbus, even in the absence of all other signs.

Cumulonimbus is a real factory of clouds; it is responsible in great measure for the clouds in the rear of disturbances. By the spreading out of the more or less high parts and the melting away of the underlying parts, cumulonimbus can produce more or less thick sheets of altocumulus or stratocumulus (spreading out of the cumuliform parts) and dense cirrus (spreading out of the cirriform parts).

C. Species

Among the principal species may be noted:

1. *Cumulonimbus calvus* (5, 6).—Cumulonimbus characterized by the thunderstorm or the shower that it causes, or by virga, but in which no cirriform parts can be made out. Nevertheless the freezing of the upper parts has already begun; the tops are beginning to lose their cumulus structure, that is to say, their rounded outlines and clear cut contours; the hard and “cauliflower” swellings soon become confused and melt away so that nothing can be seen in the white mass but more or less vertical fibers. The freezing, accompanied by the change into a fibrous structure, often goes on very rapidly.

2. *Cumulonimbus capillatus* (7).—Cumulonimbus which displays distinct cirriform parts, having sometimes, but not always, the shape of an anvil.

PRINCIPAL VARIETIES

The chief varieties common to different genera are as follows:

1. *Fumulus*.—At all levels, from cirrus to stratus, a very thin veil may form, so delicate that it may be almost invisible. These veils seem to be most frequent on hot days, and in low latitudes. Occasionally they may be observed to thicken rapidly, forming clouds easily visible, especially cirrus and cumulus. The clouds thus produced seem unstable however, and usually melt away soon after their formation.

Cirrus fumulus must not be confused with *cirrostratus nebulosus*. The latter is much more stable and does not show the phenomenon of the formation and subsequent rapid disappearance of cirrus clouds.

2. *Lenticularis* (30).—Clouds of an ovoid shape, with clean-cut edges, and sometimes irisations, especially common on days of strong, dry winds in rough country. This form exists at all levels from cirrostratus to stratus.

3. *Cumuliformis*.—The rounded form resembling cumulus which the upper parts of other clouds may sometimes assume. This may be seen at all levels from cirrus to stratus.

4. *Mammatus*.—This description is given to all clouds whose lower surfaces form pouches or breasts. This form is found especially in stratocumulus and in cumulonimbus, either at the base, or even more often on the lower surface of anvil projections. It is also found, though rarely, in cirrus clouds, probably when they have originated in the anvil of a dispersing cumulonimbus.

5. *Undulatus*.—This term is applied to clouds composed of elongated and parallel elements, like waves of the sea. There is sometimes an appearance of two distinct systems, as when the cloud is divided into rounded masses by undulations in two directions.

6. *Radiatus*.—This term is applied to clouds in parallel bands (polar bands), which owing to perspective seem to converge to a point on the horizon, or to two opposite points if the bands cross the whole sky. The point is called the radiant point, or vanishing point.

CHIEF CASUAL DETAILS

The chief casual varieties are the following:

1. *Virga*: Wisps or falling trails of precipitation; applied principally to altocumulus and altostratus.

2. *Pileus*: A cap or hood; applied principally to cumulus or cumulonimbus.

3. *Incus*: Anvil; upper part of cumulonimbus.

4. *Arcus*: Arch cloud; usually associated with cumulonimbus.

ENTRY OF CLOUDS ON RECORD FORMS

The proper method of entering cloud observations on record forms, including abbreviations, are described in the instructions accompanying the forms.

Abbreviations.—Abbreviations in the International Atlas are of the form shown by the following examples: Cist., Acu., Steu., and Cunb., etc. These merely constituted a simplification of the abbreviations previously used, for example, Ci.-St., A.-Cu., St.-Cu., and Cu.-Nb., etc. The International Meteorological Organization in a meeting at Warsaw in 1935 adopted shorter abbreviations which supersede those shown in the International Atlas. The Warsaw abbreviations are as follows:

Cirrus.....	Ci	Stratocumulus.....	Sc
Cirrocumulus.....	Cc	Stratus.....	St
Cirrostratus.....	Cs	Nimbostratus.....	Ns
Alto cumulus.....	Ac	Cumulus.....	Cu
Altostratus.....	As	Cumulonimbus.....	Cb

The Warsaw abbreviations and, in addition, the following four special abbreviations have been adopted by the Weather Bureau, effective January 1, 1939:

Fractostratus.....	Fs	Cumulonimbus mammatus (Mam-	
Fractocumulus.....	Fc	mato cumulus).....	Cm
Alto cumulus castellatus.....	Acc		

AMOUNT AND DIRECTION OF MOTION

An observation of the state of the sky should also contain an estimate of the cloudiness; both the total cloud amount, that is the amount of the sky in tenth parts covered by all the clouds, and the partial cloud amounts for each genus of cloud.

In estimating the cloud amount it is best to ignore the part of the sky close to the horizon, for there the clouds seem to be packed together owing to perspective, so that the cloud amount seems greater than it really is. When the amount of cloud is large it is easier to estimate the amount of the sky that is free from cloud, and from this, by subtraction, to obtain the cloud amount.

In entering cloud amounts in record forms the observer will be guided by instructions printed on the forms or special instructions accompanying them.

The direction of motion of clouds may often be easily observed by sighting on a steeple, tower, pole, or other structure in an open place. If the motion of the cloud be very slow, the head should be steadied by using a rest. This method is readily applied only to clouds that are well above the horizon, preferably near the zenith. When a nephoscope is available it should be used at or near the time of observation and if feasible, at some period prior to the observation when plenty of time is available. Whether with or without a nephoscope, the observer should take note of the kind of clouds and their direction of movement during a period of 2 or 3 hours prior to the observation whenever practicable so that the information obtained will be of assistance at the time of observation.

OBSERVATION OF CLOUDS FOR CODED MESSAGES

A careful examination of this publication, "Cloud Codes" will show the observer that the International plan of reporting clouds in synoptic messages is radically different from that employed by the Weather Bureau for many years in the word code. The principal difference is that the Weather Bureau has heretofore based its coding on the kinds or forms of clouds and their movements, whereas the International Cloud Code is arranged to give information concerning states of the sky which include cloud forms, indications of structure, and the general evolution and organization of the clouds.

In the International synoptic message one figure, 0-9, is included for each of the three principal cloud levels. In each case, "0" signifies "no clouds." Thus there are 27 cloud code classifications, 9 for each level—lower, middle, and upper—as shown in the tables on pages 19 and 20.

One form of cloud may be found in several different code classifications. For example, in the table for lower clouds, cumulus is mentioned in the specification opposite the code figures 1, 2, 4, 7, 8, and 9. These represent different stages in the evolution of the clouds or different arrangements in combination with other clouds in the sky. The same is true of clouds at the other levels—middle and upper—as will be seen in an examination of the appropriate tables.

Even if the observer is attempting to determine only the form of cloud, a more or less continuous watch of the sky is helpful because cloud forms are more easily identified when the evolution of the clouds is observed. In using the International Code, it is important that the evolution of the clouds and the states of the sky be carefully watched whenever possible because they are the basis of the classifications.

The states of the sky are classified with respect to the position of the observer relative to the center of a disturbance. Thus the cloud observations, if carefully made, should give valuable supplementary information relative to the structure and evolution of the disturbance. In order that the observer may code the cloud forms and states of the sky correctly he must study the code specifications, cloud descriptions, and illustrations so that he will have them clearly in mind when watching the evolution of clouds and making observations for coded messages. The time allotted to the observation is insufficient to permit the observer to search specifications and descriptions; he must have all of this in mind and whenever possible should also be fortified with a knowledge of the development and arrangement of clouds during an adequate interval (2 or 3 hours if practicable) preceding the observation.

In the issue of instructions for observing clouds, it is fully realized that many observations are taken in darkness without any preceding period of daylight to permit a preparatory period of observation; also, that conditions may change materially just prior to an observation

taken in darkness so that the preceding notes taken in daylight will not be appropriate for use in coding clouds for the synoptic message. However, it is intended that the observer will take every advantage of periods of daylight or visibility of the moon and stars that is practicable without undue hardship in extending his hours of duty or depriving him of needed rest. The cooperation of other employees in the office should be secured in making cloud notes during periods when the observer cannot be on watch.

It is also important that doubtful cloud observations be omitted from the coded messages. When there is serious doubt about the direction of movement, it should be coded as "unknown." When there is real doubt as to the form of scattered clouds because they are seen only near the horizon, or for other reasons the clouds cannot be accurately observed at or prior to the observation, no cloud word should be sent. However, doubt should exist only after every effort has been made to ascertain the facts. For example, a definite cloud bank on the horizon should be reported and if it is observed to be advancing slowly its direction of movement should be given. It is important to note that a bank of what appears to be cirrostratus on the horizon, definitely advancing, is coded H_5 when the high clouds do not extend 45° above the horizon. This may be the first indication in the sky of the approach of a disturbance.

It is especially desirable that care be exercised in observations of high and intermediate clouds, particularly altostratus and altocumulus clouds, because accurate data concerning clouds at these levels are of very great value to the forecasters. Preconceived ideas as to the probable direction of upper and intermediate clouds based on average conditions or past experience should not influence the observer. Intermediate and high clouds may be visible at one station when the sky is completely covered by low clouds at surrounding stations. In such cases, isolated observations of intermediate and high clouds become of critical importance.

Special instructions are necessary for observing and coding clouds at mountain stations where they may exist at levels below the observer's station.

CODE TABLES

The form of predominating cloud is the genus which is observed to cover the largest portion of the sky at the time of observation. All species or special forms of each cloud genus will be counted in determining the total amount of sky covered by that genus.

FORM OF PREDOMINATING CLOUD

Code figures	Form of cloud	Code figures	Form of cloud
1	Cirrus.	6	Stratocumulus.
2	Cirrostratus.	7	Nimbostratus.
3	Cirrocumulus.	8	Cumulus or fractocumulus.
4	Alto cumulus.	9	Cumulonimbus.
5	Altostratus.	0	Stratus or fractostratus.

Codes for the forms of clouds and states of the sky, lower, middle, and upper levels, are as follows:

I. LOWER CLOUDS C_L

0. No lower clouds.....	22
1. Cumulus of fine weather.....	22
2. Cumulus heavy and swelling, without anvil top.....	22
3. Cumulonimbus.....	23
4. Stratocumulus formed by the flattening of cumulus clouds.....	23
5. Layer of stratus or stratocumulus.....	23
6. Low broken up clouds of bad weather.....	24
7. Cumulus of fine weather and stratocumulus.....	24
8. Heavy or swelling cumulus, or cumulonimbus, and stratocumulus.....	24
9. Heavy or swelling cumulus (or cumulonimbus) and low ragged clouds of bad weather.....	24

II. MIDDLE CLOUDS C_M

0. No middle clouds.....	25
1. Typical altostratus, thin.....	25
2. Typical altostratus, thick (or nimbostratus).....	25
3. Altocumulus, or high stratocumulus, sheet at one level only.....	25
4. Altocumulus in small isolated patches; individual clouds often show signs of evaporation and are more or less lenticular in shape.....	26
5. Altocumulus arranged in more or less parallel bands, or an ordered layer advancing over the sky.....	26
6. Altocumulus formed by a spreading out of the tops of cumulus.....	27
7. Altocumulus associated with altostratus or altostratus with a partially altocumulus character.....	27
8. Altocumulus castellatus, or scattered cumuliform tufts.....	28
9. Altocumulus in several sheets at different levels, generally associated with thick fibrous veils of cloud and a chaotic appearance of the sky.....	29

III. UPPER CLOUDS C_U

0. No upper clouds.....	29
1. Cirrus, delicate, not increasing, scattered and isolated masses.....	29

2. Cirrus, delicate, not increasing, abundant but not forming a continuous layer.....	30
3. Cirrus of anvil clouds, usually dense.....	30
4. Cirrus, increasing, generally in the form of hooks ending in a point or in a small tuft.....	30
5. Cirrus (often in polar bands) or cirrostratus advancing over the sky but not more than 45° above the horizon.....	30
6. Cirrus (often in polar bands) or cirrostratus advancing over the sky and more than 45° above the horizon.....	31
7. Veil of cirrostratus covering the whole sky.....	31
8. Cirrostratus not increasing and not covering the whole sky.....	31
9. Cirrocumulus predominating, associated with a small quantity of cirrus.....	31

THE STATE OF THE SKY AND THE EVOLUTION OF THE CLOUDS

The necessity of noting the state of the sky as a whole.—It is evident from the specifications of the cloud code that to describe the sky at the station at a particular time logically and completely it is not enough to know the genera or even the species of the clouds present; for example altocumulus appears in seven specifications of the code, and cirrus in nine. In reality each specification of the code, as the explanations show, is not so much a dry enumeration of the genera or species of clouds in the sky as a general indication of the structure, the organization, and the evolution of the cloud complex which makes up the state of the sky. Some specifications only refer to the general structure; for example $C_M=9$ is a thundery sky; everyone knows that in thundery conditions degenerate cloud forms are met with which are very difficult to classify, while the thundery look of the sky is apparent immediately and without any doubt.

Each specification of the code corresponds to a state of the sky—lower, middle, or high.¹ The observer should have at his “fingers’ ends” the commentaries accompanying the definitions; he should consider as a whole the lower, middle, or high clouds there described, and try to make a considered judgment of the observed sky as a whole, so that he can directly apply the proper numbers of the code.

The detailed analysis of the individual clouds should follow and not precede this recognition of the state of the sky as a whole. If the observer becomes accustomed to this course he will find in a short time that the different states of the sky—lower, middle, and high—corresponding with the code, will seem just as “live” as the typical cloud forms, and it will be just as easy to identify a state of the sky as the form of a cloud.

Necessity of following the evolution of the sky.—The aspect of the sky is continually changing, and many transitional forms exist between the different types of cloud. It is relatively rare for the observer to see typical clouds of one genus which float past, or persist in the sky for any considerable time; in most cases he will find that he has difficulties at the time of observation if he has not taken the trouble to watch the sky since the last observation. If, however, he has taken this precaution he will often be able to refer a confusing state of the sky, or a particular cloud, to a previous state which was typical and easy to identify. Moreover, most of the specifications of the cloud code take into account the evolution of the clouds. A single isolated observation is insufficient.

As regards evolution, the recognition of the state of the sky, recommended in the previous paragraph, is better than the identification of clouds considered by themselves, for, as a matter of fact, the evolution of the state of the sky can be followed indefinitely at one station, while the evolution of a cloud, if, as is usual, it is a “migrant” can only be observed during the relatively short time that it takes to cross the sky.

¹ In the International Atlas, the term “state of the sky” has two distinct meanings. (1) The form and arrangement of the clouds in the sky at any given level—lower, middle, or high—is a “state of the sky” at that level; this is the meaning of “state of the sky” in the code specifications. (2) The combination of all clouds in the sky is also described as a “state of the sky,” for example, a “front zone sky,” an “emissary sky,” etc. In the latter sense it is used by the forecaster as an interpretation of the combination of code figures in the synoptic message.

CODE SPECIFICATIONS

LOWER CLOUDS C_L

0. No Lower Clouds.

1. Cumulus of Fine Weather (1).¹

This is observed under different aspects:

A. In a state of formation, in general in the morning.

B. Completely formed in general in the middle of the day, with definite horizontal bases, the air being more or less calm; these are (a) with rounded tops but without "cauliflower" heads, or (b) flat and "deflated."

C. Completely formed but broken up by the wind; in this case they remain separate and are white in color (2).

The cumulus clouds of fine weather usually have a marked diurnal period on the continent, growing until the middle of the afternoon, and decreasing later, both as to amount of cloud in the sky and in their vertical development.

These cumulus clouds are found only at a distance from disturbances. When the veil of cirrostratus, which fringes the front of a disturbance, begins to cover the sky, the cumulus of fine weather changes from type Ba to type Bb and finally disappears entirely.

The fractocumulus of fine weather noted above and coded as $C_L=1$, must not be confused with the fractocumulus of bad weather which is coded $C_L=6$, or $C_L=9$. The former are ($C_L=1$) detached white clouds usually in a blue sky, and remain detached; the latter are found in the central part of a disturbance or in its rear; in the first case ($C_L=6$) they form² under a gray sheet of altostratus or of nimbostratus; in the second case ($C_L=9$), in a sky crowded with clouds at all altitudes, they form under the bases of cumulonimbus or very large cumulus clouds or in the spaces between these. In both cases they are dark, receiving little light, and generally become very numerous, while the fractocumulus clouds of fine weather usually show white on a blue sky, and remain detached.

2. Cumulus, Heavy and Swelling, Without Anvil Top (3, 4).

There are two types of these:

A. In calm air and especially on hot days with a thundery tendency they form heavy masses with horizontal bases, and very great vertical development. They are sometimes in the form of towers, sometimes of complex heaps with "cauliflower" formation. They often have caps or hoods (*pileus*).

B. In strong winds in the rear of disturbances they also form towering masses, with great vertical development but tossed about and broken up.

These cumulus clouds, especially those of the second class, are often associated with thick cirrus ($C_H=3$) and with extensions of strato-

¹ Numbers in parentheses after code classifications refer to cloud pictures which illustrate the codes.

² Fractocumulus clouds of bad weather ($C_L=6$) develop under a sheet of altostratus or nimbostratus and should not be confused with fractocumulus which persist from a previous disturbance or exist independently.

cumulus and altocumulus ($C_M=6$). None of these cumulus clouds should show ice crystal clouds at their tops; this would mean that they had reached the cumulonimbus stage which would entail code $C_L=3$.

3. Cumulonimbus (5, 6, 7, 8).

Cumulus clouds of great vertical development, with the tops composed of ice crystal clouds. Sometimes the nascent ice crystal cloud is merely mingled with the "cauliflower" tops, where a fibrous structure appears and the clear-cut outlines fray out; sometimes the completely formed ice crystal clouds crown the cumulus with a definite plume of cirrus of a shape more or less like that of an anvil. Sometimes, especially in the spring and in high latitudes, the ice crystal formation involves nearly the whole cloud even to the base. At the end of the growth of a cumulonimbus the lower cumuliform part of the cloud often tends to disappear leaving only the upper or cirrus part.

When the anvil, reaching nearly to the zenith, begins to overshadow the observer, a mammatus structure will often be seen on the lower surface of the anvil projection.

Like the heavy and swelling cumulus, cumulonimbus is formed either in calms, especially on hot thundery days, or in a strong wind in the rear of disturbances.

Cumulonimbus is a regular factory of clouds. By extension at various levels it often produces either cirrus masses by an extension of the ice crystal parts, or masses of altocumulus or stratocumulus by an extension of the cumuliform parts, and these may end by becoming detached from the parent cloud. Thus cumulonimbus, $C_L=3$, may coexist with cloud sheets that should be coded $C_H=3$ or $C_M=6$.

At the end of the evolution of cumulonimbus, $C_L=3$ should only be coded when the cumuliform parts are still visible. When the cumuliform clouds have degenerated, the anvil top or the clouds derived therefrom should be coded $C_H=3$.

When cumulonimbus nears the zenith, and its base, with low dark clouds under it, often in the form of a roller or an arch, has covered all or nearly all the sky, code $C_L=3$ should be replaced by $C_L=9$.

4. Stratocumulus Formed by the Flattening of Cumulus Clouds (9, 10).

Cumulus tops may settle down and the bases may spread out; this is a frequent end to the progressive changes of the cumulus of fine weather. On the other hand, the bases may melt away and the tops may spread out; this is a common phenomenon in the rear of a disturbance after squalls or showers. Very opaque sheets or a layer of stratocumulus may be formed in this way, often showing a festooned formation (*mammatus*) in places. At the end of the process the clouds thus formed may thin out.

The first case is *stratocumulus vesperalis*, the second *stratocumulus cumulogenitus*.

5. Layer of Stratus or Stratocumulus (11, 12, 13, 14).

Clouds usually forming a single layer, fairly regular and not very dark or menacing; they have a certain stability. The stratocumulus has often semitransparent parts, or even clear spaces between the elements of the cloud.

These cloud formations are common on the continent, especially in winter, and are found outside the regions of disturbances, or on their extreme lateral edges.

The layer of stratocumulus may often be broken up; code $C_L=5$ is used only for those sheets of stratocumulus that are not formed from cumulus; otherwise they are coded $C_L=4$. The observer may be in doubt between $C_L=5$ and $C_M=3$; the code $C_L=5$ is used only when the stratocumulus is fairly low and rather like stratus (large and rather diffuse tessellations or waves); if it is clearly high up and related to altocumulus it is coded $C_M=3$.

6. Low Broken Up Clouds of Bad Weather (15, 16, 17).

The following is the ordinary course of formation of these clouds: When a veil of altostratus becomes lower, and tends to turn into nimbostratus, it usually has below it a gradually increasing layer of fractocumulus or fractostratus; these clouds are isolated at first. They ultimately fuse together into a continuous sheet; but through interstices the veil of relatively light higher cloud may be seen (16). The continuous rain does not usually occur until after the formation of the fractostratus or fractocumulus, which is then hidden by the precipitation, or may even disappear under its influence.

This type is found in the middle of a typical disturbance.

For the difference between the fractocumulus of bad weather and that of fine weather see the explanation under $C_L=2$.

7. Cumulus of Fine Weather and Stratocumulus (18, 19).

Cumulus clouds may form below an already existing sheet of stratocumulus, which they do not penetrate.

Before the formation of the cumulus, the layer of stratocumulus would have been coded $C_L=5$ or $C_M=3$ according to its height.

If the cumulus penetrates the stratocumulus layer it must be coded $C_L=8$.

8. Heavy or Swelling Cumulus, or Cumulonimbus, and Stratocumulus (20, 21).

Heavy or swelling cumulus, or cumulonimbus may form below an already existing sheet of stratocumulus, and some of the cumulus or cumulonimbus may penetrate the layer.

This is a formation analagous to $C_L=7$ except that the vertical development of the convection clouds is more marked, so that in the absence of the upper layer they would be coded $C_L=2$ or $C_L=3$.

9. Heavy or Swelling Cumulus (or Cumulonimbus) and Low Ragged Clouds of Bad Weather (22, 23, 24).

When a heavy or swelling cumulus or a cumulonimbus nears the zenith it can hide all, or nearly all the sky with its base; the latter may somewhat resemble nimbostratus, but is distinguished from it by its previous history, or by the broken character of the rain, which, in the case in question, falls to the ground in showers, or, if it does not reach the ground, is seen falling from the lower surface of the cloud in wisps of rain or snow called virga.

Generally below the base of such a great cloud there is a greater or smaller amount of lower cloud broken up in the manner of fractocumulus or fractostratus, these low clouds may sometimes be in the form of a roller, or an arch.

It may also happen that low dark clouds of the nature of fractocumulus or fractostratus may grow in amount in a sky covered with heavy or swelling cumulus or with cumulonimbus and may fill the spaces between the main cumulus clouds.

Only in these two cases should $C_L=9$ be coded:

A. When a cumulus cloud approaches the zenith and its upper parts are still visible it should be coded $C_L=2$ or $C_L=3$ according as to whether it is a heavy and swelling cumulus or a cumulonimbus.

B. In damp climates it may happen that dark fractocumulus or fractostratus forms a layer completely closing up the spaces between the masses of heavy cumulus. In such cases one cannot distinguish individual cumulonimbus clouds under their typical aspect; but their passage overhead is manifest by a temporary darkening of the sky and by showers. Their presence, thus made known, allows the code $C_L=9$ to be used and not merely $C_L=6$.

MIDDLE CLOUDS C_M

0. No Middle Clouds.

1. Typical Altostratus, Thin (15, 25).

A sheet of this cloud resembles thick cirrostratus, from which it is often derived without any break; but halo phenomena, sun pillar, etc., are not seen in altostratus, and the sun appears as though shining through ground glass and does not cast shadows.

This cloud is found in the central part of a typical disturbance.

If there were halo phenomena or if the sun cast shadows one would code $C_H=5$, $C_H=6$, $C_H=7$, or $C_H=8$ according to circumstances. If the sun were hidden, or liable to be completely hidden by a thick part of the sheet, the code $C_M=2$ should be used.

2. Typical Altostratus, Thick (or nimbostratus) (26, 27).

The sun and moon are completely hidden, at any rate by some parts of the cloud sheet. Typical thick altostratus can be formed either by a thickening of typical thin altostratus, $C_M=1$ or by the fusing together of the cloudlets in a sheet of altocumulus, $C_M=7$.

Nimbostratus is derived either by a change from typical thick altostratus, or by the fusing together of the cloudlets in a sheet of stratocumulus ($C_L=5$).

This type is found in the central parts of a typical disturbance.

In the case of a transition from altocumulus into altostratus, if it shows either in whole or part the structure of altocumulus (ripples, waves, or tessellations) it is coded $C_M=7$. In the case of a change from stratocumulus to nimbostratus, it will also be coded $C_M=7$ if the lower surface shows a real relief (waves or tessellations) instead of showing a smooth under surface. Thick typical altostratus and nimbostratus are often accompanied by underlying and very low clouds, which are ragged and dark (fractocumulus or fractostratus); in the gaps one can generally see the altostratus or the nimbostratus of a lighter gray; this case will be coded as $C_L=6$, and $C_M=2$. If the lowest clouds form a continuous sheet the observer will not assume what is above, but will code $C_L=6$.

3. Altocumulus, or High Stratocumulus, Sheet at One Level Only (28, 29).

A cloud generally forming a single layer; it is fairly regular, and of uniform thickness, the cloudlets, tessellations or waves, being always

separated by clear spaces or lighter gaps; the cloudlets are neither very large nor very dark. This layer is generally fairly stable, that is to say it changes but slowly. In tropical and subtropical regions such a layer often forms at the end of the night in calm weather, even at a high altitude, in the absence of any disturbance.

This layer of cloud is sometimes broken up but it is only coded as $C_M=3$ if the layer does not proceed from the extensions of the tops of the cumulus clouds; in the latter case it is coded as $C_M=6$. For the difference between $C_M=3$ and $C_L=5$ see the explanatory remarks on $C_L=5$. The layer of altocumulus that should be coded $C_M=3$ is distinguished from that coded $C_M=5$ by its stability with no tendency to increase, and by a greater regularity and uniformity.

4. Altocumulus in Small Isolated Patches, Individual Clouds Often Showing Signs of Evaporation and Being More or Less Lenticular in Shape (30, 31).

As regards the smallness of the cloudlets these little patches of altocumulus resemble cirrocumulus, but do not show the characters of clouds formed of ice crystals. Lenticular altocumulus clouds show the most beautiful irisations; when this is the case they are lens shaped, fairly thick, but with little or no shadows and of a pure dazzling white; they are slightly wavy at the edges.

Generally they are scattered over the sky quite irregularly and are often at different levels; they are mostly in constant change so that if one looks away from the sky for only a few minutes it is difficult afterward to identify the clouds previously seen. Individually they are often in process of dissolution, but the amount of cloud over the whole sky does not in general become greater or less.

This type of cloud is common on the extreme lateral edge of disturbances and also in mountainous districts under the influence of the foehn wind.

The characteristics mentioned above are very typical. Nevertheless in cases where the observer is doubtful between $C_M=4$ and $C_M=6$ or between $C_M=4$ and $C_M=5$ they can be discriminated in the following way: The sheets of altocumulus of $C_M=4$ are higher and more delicate than those of $C_M=6$ and they do not have the same regular structure as those of $C_M=5$. Wisps of rain or snow (virga) may sometimes be seen falling from the underside of sheets of altocumulus of class $C_M=4$.

5. Altocumulus Arranged in More or Less Parallel Bands, or an Ordered Layer Advancing Over the Sky (32).

The essential feature of this type is that the sky becomes more and more covered; the process often begins with altocumulus in large parallel bands, which often have a roughly lenticular shape. On their edges they may show signs of evaporating, but on the whole the amount of cloud and the thickness of the sheets increases.

Sometimes altocumulus appears from the beginning as a sheet, often under the form of a vast pavement with more or less rectilinear joints, and the semitransparent parts allow the blue of the sky to be seen. This layer very soon thickens in places, or has another layer, lower and darker, forming beneath it.

This cloud is met with on the lateral side of a typical disturbance or on the front of a weak disturbance.

This type of altocumulus is distinguished from that coded as $C_M=3$ by the progressive deterioration of the sky, and by the irregular thickness of the layer. Again the proportions of these sheets and their regular structure differentiate them from those coded as $C_M=4$.

6. Altocumulus Formed by a Spreading Out of the Tops of Cumulus (33).

Cumulus clouds of sufficiently great vertical development may undergo an extension of their summits while their bases may gradually melt away. These sheets of altocumulus are generally fairly thick and opaque at first with rather large elements, dark and soft; later they may thin out and finally have rifts in them, or at any rate semitransparent interstices.

The phenomenon of the extension of cumuliform masses is common in the rear of disturbances, after squalls and showers.

These extensions from the summits of cumulus clouds must not be confused with the ice crystal extensions of a cumulonimbus from which the anvil and hybrid cirrus is formed. The anvil, and even the cirrus, detached from the cumulus which produced it, may sometimes have a festooned appearance on the lower surfaces, and thus may have a certain likeness to a sheet of altocumulus. But the altocumulus does not have the whiteness, the silky appearance, nor the fibrous structure of a cirrus anvil.

To discriminate between the altocumulus coded $C_M=6$ on the one hand, and the altocumulus coded $C_M=3$, $C_M=4$, and $C_M=5$ on the other, see the explanations of $C_M=3$, $C_M=4$, and $C_M=5$.

The observer may in certain cases be in doubt between $C_M=6$ and $C_L=5$. At the end of the evolution of sheets of *altocumulus cumulogenitus* when they may have thinned out and become semitransparent one would not of course think of coding $C_L=5$; but at the beginning of the change when the cloud elements are rather large, dark, and soft there are all the transitions between stratocumulus and altocumulus. It is a question of the apparent size of the elements; the convention is that the cloud in question is altocumulus when the smallest well-defined cloud elements observed over the sheet as a whole (and ignoring the separated portions which may exist beyond the edges of the sheet) are not greater than 10 diameters of the sun, i. e., approximately the width of three fingers when the arm is held extended; in case of doubt it is best to code $C_M=6$, which allows one to note ($C_L=2$ or $C_L=3$) cumulus clouds which are visible at the same time.

7. Altocumulus Associated With Altostratus, or Altostratus With a Partially Altocumulus Character (34, 35, 36).

Different clouds are comprised in this section:

A. Typical altostratus can lie above sheets of altocumulus which are at a definitely lower level. This type including typical altostratus can only exist in the central part of a disturbance.

B. A more or less continuous layer of altocumulus can have below it a gray veil of cloud, often hardly visible, lying at a level very little lower; in places, and for short times it hides the cloudlets of the altocumulus sheet sufficiently to give it in places the appearance of altostratus. This type is found in the central part of a weak disturbance, or on the lateral edge of the central part of a typical disturbance.

C. In a layer of altocumulus which is growing thicker ($C_M=5$) the cloudlets may fuse together and the layer may become alto-

stratus; the cloud loses its tessellations, and takes on a fibrous structure; this transitional state is coded $C_M=7$, as is also the transition from stratocumulus to nimbostratus. It is observed in the same situation as the preceding cloud.

D. Again, altostratus, and even nimbostratus can change progressively into altocumulus, and in this case also the state of transition is coded $C_M=7$. This phenomenon is common after continuous rain, when the altostratus breaks up, that is to say at the passing away of the end of the central part of a typical disturbance. It is also found in the actual center when the disturbance is filling up.

E. The opaque cloud sheets with a more or less irregular corrugated structure, too dense and thick for the transparency of the ripples to afford any criterion for their classification, should be coded as $C_M=7$. The wave structure, though not visible as lighter parts, is nevertheless apparent, and gives a corrugated appearance to the under surface. These sheets were sometimes called "wrinkled" altostratus in the old classification, but they should now be called *altocumulus opacus*. They are met with in the same situation as classes B and C above.

These different types have this in common, that they denote a weakening of a disturbance, because they are related either to one which is weakened as a whole, or to a weakened, lateral part of a typical disturbance.

As regards the usually ephemeral change of altostratus, or nimbostratus to altocumulus or stratocumulus, or vice versa (class C and D above) and the differences between codes $C_M=2$ and $C_M=7$, see the notes on $C_M=2$.

Corrugated *altocumulus opacus* (class E above) has two origins; either it forms (a) like the cloud sheets of class C above, by the uniting of the cloudlets and the general thickening of a layer of altocumulus coded as $C_M=5$ (or more rarely $C_M=3$), or (b) as in class D above, it forms from thick altostratus or from nimbostratus ($C_M=2$) which is in process of dissolution; but it represents a definitely more stable type than C or D; in case of these latter there is a quick and almost direct change of the *altocumulus translucidus* into altostratus or vice versa; in the case of class 5 the intermediate stage of *altocumulus opacus* can be maintained for some time. The layer of corrugated *altocumulus opacus* ($C_M=7$) is distinguished from sheets of altocumulus coded $C_M=3$ or $C_M=5$ by its greater thickness which gives it a darker color and a menacing appearance, and by the very marked irregularity of the relief of the under surface which gives it a characteristic pendant appearance (festoon clouds, pendant corrugations).

8. *Altocumulus Castellatus*, or *Scattered Cumuliform Tufts* (37, 38).

The character common to these types of altocumulus is a domed shape, but they have very different aspects.

A. *Altocumulus castellatus* is composed of a series of small cumuliform masses with more or less vertical development, arranged in line and resting on a common horizontal base (reduced sometimes to plain gray wisps); this gives the cloud a crenellated appearance.

B. The second kind is observed in scattered tufts, white or gray, but without definite shadow, with the rounded parts very slightly domed; they resemble very small, more or less broken up cumulus clouds without a base.

These cloud forms are the precursors of thunderstorms, but the first named variety may appear a long way in advance.

9. **Alto cumulus in Several Sheets at Different Levels, Generally Associated With Thick Fibrous Veils of Cloud, and a Chaotic Appearance of the Sky** (39, 40).

This type is very difficult to analyse; it is generally complex, and patches of middle cloud, more or less fragmentary, are seen superposed; they are often badly defined and with soft outlines; there are all the transitional forms between low alto cumulus and the fibrous veil. The sky moreover is covered with clouds of different layers, but as in general there is not a continuous sheet, blue patches may be seen. Luckily, though these middle clouds are very difficult to classify individually, the state of the whole sky is very typical; it has a disordered, heavy, and stagnant appearance (calm or light wind).

These appearances are characteristic of the central parts of thundery disturbances.

The clouds of other levels which almost always exist in a thundery sky are principally *cirrus densus* ($C_H=3$) and large cumulus ($C_L=2$) or cumulonimbus ($C_L=3$).

It would be too complicated, and hardly worth while, to attempt to analyse in detail the individual characters of the alto cumulus sheets in a thundery sky. It should be carefully noted that such a sky can be identified by its general appearance as a whole, which is quite typical. There is only one other type which in this respect may be confused with a thundery sky, because it also has a more or less disordered appearance; this is the sky in the rear of a disturbance, but this latter is fairly easily distinguished by its "tossed about" and "windswept" appearance.

UPPER CLOUDS C_H

0. No Upper Clouds.

1. **Cirrus, Delicate, Not Increasing, Scattered and Isolated Masses** (41).

This type of isolated cirrus is widely scattered; its amount does not noticeably increase either in time or in any particular direction. It does not collect into sheets or bands, and there is no tendency for the elements to fuse together into masses of cirrostratus. The cirrus clouds whose strands end in an upturned hook or tuft must not be included in this class.

Cirrus clouds of this type are indications of a very distant disturbance, and are found either on its front or on its borders. The place where these clouds are observed is generally not influenced by the disturbance, at any rate for some time.

The chief characteristic of the type $C_H=1$ is the sparseness of the cirrus. It is only distinguished from the type $C_H=2$ by this fact of the cirrus being more sparse.

This type of cirrus is distinguished: From that of class $C_H=3$ in that it is delicate and does not originate in anvil clouds; from class $C_H=4$ in that it does not increase either in time or in any particular direction of the sky, and that it does not belong to the uncinus type (strands with upturned ends); from class $C_H=5$ and class $C_H=6$ in that it does not increase in time or in any particular direction, that

it does not form into sheets or bands, and that it does not show, in any part of the sky, any tendency to pass into cirrostratus.

2. Cirrus, Delicate, not Increasing, Abundant but not Forming a Continuous Layer (42).

The definition of this type is precisely the same as the preceding with the exception that in this type the cirrus is more abundant over the whole sky, but without any tendency to increase in any particular direction.

Cirrus of this type is the forerunner of a disturbance either on its front or on its borders.

3. Cirrus of Anvil Clouds, Usually Dense (43, 44).

In this type the cirrus either actually proceeds from the anvil of a cumulonimbus, in which case one sees cirriform masses attached to the remains of cumulus, or it has probably so originated, being still anvil-like in shape, or else remarkable for its density and frayed-out appearance, generally showing virga in places.

Originating in cumulonimbus, this type of cirrus is met with either in the rear of typical disturbances or else around thunderstorms.

In the first case the cloud is hybrid cirrus; in the second it is dense cirrus, in which case the cumulonimbus stage may have ended some time previously.

4. Cirrus, Increasing, Generally in the Form of Hooks Ending in a Point or in a Small Tuft (45).

This type of cirrus which is often in the form of streaks ending in a little upturned point or in a small tuft, increases in amount both in time and in a certain direction. In this direction it reaches the horizon where there is a tendency for the cloud elements to fuse together, but the clouds do not pass into cirrostratus.

This type often occurs on the front of a typical disturbance.

If the cirrus increases in time and in a certain direction tending also to pass into cirrostratus in this direction it should be coded as $C_{\mu}=6$ or $C_{\mu}=5$ according as to whether the front of the cirrus sheet, formed out of the scattered cirrus is at a greater or lesser altitude than 45° above the horizon.

5. Cirrus (Often in Polar Bands), or Cirrostratus Advancing Over the Sky, but not More Than 45° Above the Horizon (46).

A sheet of fibrous cirrus partly uniting into cirrostratus, especially toward the horizon in the direction where the cirrus strands tend to fuse together; the cirrus is often in a herring-bone formation, or is in great bands converging more or less to a point on the horizon. In this class is also included a sheet of cirrostratus without any cirrus. In either case the front of the sheet is not more than 45° above the horizon.

This type occurs in the front of a typical disturbance.

The varieties included in this definition are "herring-bone cirrus" and "polar bands." What is termed the front of the sheet means the front either of the cirrostratus sheet, if this cloud exists without cirrus, or of that part of the sky where the cirrus fibers are close enough to each other to appear welded together, instead of being discrete masses like the cirrus which precedes this sheet.

6. Cirrus (Often in Polar Bands) or Cirrostratus Advancing Over the Sky, and More Than 45° Above the Horizon (47).

The definition of this type is exactly the same as the previous one, with the sole exception that the edge of the sheet is more than 45° above the horizon.

This type is found in the front part of a typical disturbance, a little nearer the center than the former type.

The same remarks on the limits of the cloud sheet apply as for $C_H=5$.

7. Veil of Cirrostratus Covering the Whole Sky (48).

There are two cases:

A. Thin, very uniform nebulous veil sometimes hardly visible, sometimes relatively dense, always without definite detail, but always producing halo phenomena (halo, sun pillar) round the sun or moon.

B. A white fibrous sheet with more or less clearly defined fibers, often like a sheet of fibrous cirrus, from which indeed it may be derived.

This type is found in a typical disturbance immediately in front of the central area.

8. Cirrostratus not Increasing, and not Covering the Whole Sky (49, 50).

This is a case of a veil or sheet of cirrostratus reaching the horizon in one direction but leaving a segment of blue sky in the other direction; this segment of blue sky does not grow smaller. Generally the edge of this sheet is clear cut, and does not tail off into scattered cirrus.

This type is found on the north lateral edge of a disturbance, the aspect of the cloud being generally very different from that of the clouds on the south lateral edge. (The terms north and south apply to the most frequent case of a disturbance moving from west to east.)

If the segment of blue sky is diminishing the cloud must be coded as $C_H=6$ or $C_H=5$ according as to whether the elevation of the sheet of cirrostratus is greater or less than 45° .

9. Cirrocumulus Predominating, Associated With a Small Quantity of Cirrus (51, 52).

An absolutely necessary characteristic of cirrocumulus, according to the new definition of this cloud, is its relationship to cirrus or cirrostratus.

This type is found on the front or lateral edges of a weak disturbance.

If the cirrus fibers, or the sheet of cirrostratus merely becomes slightly corrugated in parts the cirrocumulus is neglected. But if the bank of cirrus or of cirrostratus degenerates wholly into cirrocumulus it is coded as $C_H=9$; this is an important sign of the weakening of a disturbance.

KEY TO IDENTIFICATION OF CLOUD CODE TYPES

Observers may find the forms and arrangement of clouds in the sky, as classified in the codes, to be rather confusing, especially in the beginning. The following key may be helpful in determining the code numbers to use. However, the observer should not depend upon the key alone. He should make a thorough study of all the definitions and classifications and have them clearly in mind, using the key only as a general guide or reminder.

The first step is to determine whether the clouds are at lower, middle, or upper levels. If clouds at more than one level are present, the observer should determine which clouds belong to each of the three principal levels. He will then determine the code number to use in each case.

The key is therefore intended merely to supply a hint to the observer who will then recall the finer distinctions of the various code types.

Although a code number is sent for clouds at each of the three principal levels, it is evident that certain combinations are rare or even impossible. For example, with an extensive sheet of dense altocumulus, M_7 ,¹ the observer may be unable to identify the upper cloud code type even if he knows that there are upper clouds.

¹ The symbol M_7 is equivalent to $C_u=7$; M_8 is equivalent to $C_u=8$; etc.

UPPER CLOUDS ¹

Detached or in groups or patches					Layer or sheet covering all or a part of the sky				
Increasing		Stable or decreasing			Increasing			Stable	
Delicate, usually with hooks or tufts	More or less dense probably derived from anvil	Delicate		Dense	Below 45°	Above 45°		Covering whole sky	Covering almost but not quite whole sky
		Scarce	Abundant	Probably derived from anvil	Sheet of cirrostratus or of fibrous cirrus merging into cirrostratus	Not covering whole sky	Has recently extended over whole sky		
H ₄	H ₃	H ₁	H ₂	H ₃	H ₅	H ₆	H ₇	H ₇	H ₈

¹ If cirrocumulus predominates, use code *II*₆.

MIDDLE CLOUDS ¹

In groups, patches or layer with openings					Continuous layer or sheet		
Spreading or advancing over the sky		With cumuli-form tufts	Stable or evaporating		Lowering or thickening		Degenerating
Derived from cumulus	In parallel bands or ordered layer	(Castellatus)	Lenticular	In single layer	Thin	Thick	Thick
					(Typical thin altostratus)	No definite relief on under surface	Alto cumulus or alto cumulus associated with altostratus, with definite relief on under surface
M ₆	M ₅	M ₈	M ₄	M ₃	M ₁	M ₂	M ₇

¹ Alto cumulus in the typical chaotic, thundery type of sky is coded *M*₆.

LOWER CLOUDS

Detached masses						Sheet or layer				
With vertical development			Without vertical development			Single layer of stratus or stratocumulus	Low clouds of bad weather fused into continuous sheet	Stratocumulus with fair weather cumulus below	Stratocumulus with towering cumulus below or with cumulus or cumulonimbus penetrating the layer	Cumulonimbus covering the sky with ragged low clouds of bad weather below
Small, with slight development (typical fair weather type)	Active vertical growth without fibrous summit	Great vertical growth with fibrous summit	Spread out from cumulus	Low bad weather clouds						
				Under altostratus or nimbostratus	Under cumulonimbus					
L ₁	L ₂	L ₃	L ₄	L ₆	L ₉	L ₅	L ₆	L ₇	L ₈	L ₉

SKY AND CLOUDS IN A TYPICAL DISTURBANCE

The accompanying diagram, taken from the International Atlas, shows the distribution of cloud and sky types in the various sectors of a typical disturbance.

In identifying cloud and sky types, observers in the United States should be guided by the photographs and not by the position of the clouds in the disturbance. The following notes are taken from the International Atlas:

1. This diagram corresponds with a typical disturbance—to be precise, the first of a family—arriving from the west in western Europe.

2. It sometimes happens that the rear zone is much more extensive and that it persists for several days over the same region.

3. Fractocumulus may occur practically anywhere in the rear zone.

4. The specifications M₈ and M₉ correspond respectively with the front or lateral sector and with the central or rear sector of a thunderstorm disturbance. They can find no place in this diagram which is that of a normal disturbance.

5. Observers should not take the form of cloud corresponding with the position in this diagram as necessarily determining the form of cloud to be reported.

PHOTOGRAPHS

Cloud photographs to illustrate the various code specifications are shown on the succeeding pages. The pictures are accompanied by descriptions which indicate briefly the reasons for the code figures assigned. Observers should not rely solely on these pictures and accompanying descriptions in coding cloud observations. All of the definitions, descriptions, and code specifications in the preceding pages must be studied and the criteria for distinguishing the various cloud forms and coding classifications must be memorized. Observers must be able to prepare coded messages quickly and without searching specifications and cloud pictures at time of observation.

Illustrations in the International Atlas should also be studied carefully by all observers who have access to it.

The cloud photographs reproduced here have been obtained from various sources. Many of them were selected from the Weather Bureau collection to which many individuals have contributed. The following persons furnished photographs especially for use in illustrating code specifications: Dr. Charles F. Brooks, Dr. W. J. Humphreys, Mr. H. T. Floreen, and the Reverend C. E. Deppermann, S. J. Photographs used for plates 61, 62, and 63 were taken by Mrs. Lois Bowen (T. W. A., Inc.) and photographs for plates 66, 69, and 70 were taken by the National Advisory Committee for Aeronautics through courtesy of Pan American Airways.

1. Cumulus of Fine Weather, L_1 .

The clouds are scattered and have definite horizontal bases and rounded upper surfaces. The diurnal period of convection is well advanced (3:30 p. m., local time) without much vertical development. The large cloud in the foreground has its shaded, horizontal base turned toward the observer. Near the horizon the horizontal bases and deflated appearance of the clouds are more clearly shown. (Photo taken at Cheyenne, Wyo., by H. T. Floreen.)

2. Fractocumulus of Fine Weather, L_1 .

The clouds are broken up by the wind. The shadows are light, indicating that the clouds are thin. This form of fractocumulus must not be confused with the fractocumulus of bad weather, L_6 (pls. 15 and 16), forming beneath altostratus or nimbostratus, and L_9 (pls. 22, 23, and 24) which appears below heavy and swelling cumulus or cumulonimbus. (Photo taken at Washington, D. C., by W. J. Humphreys.)

3. Cumulus, Heavy and Swelling, Without Anvil Top, L_2 .

The large cloud mass in the center has a horizontal, heavily shaded base and shows active vertical development, with heaps in a "cauliflower" formation. The upper surfaces look hard and are clear cut, hence the central cloud mass has not yet reached the cumulonimbus (L_3) stage. (Photo at Cheyenne, Wyo., by H. T. Floreen.)

4. Cumulus, Heavy and Swelling Without Anvil Top, L_2 .

These clouds have great vertical development in the form of towers, showing active convection on a warm afternoon. Their height and the absence of any other cloud forms indicate that they are of recent growth. However, the second cloud from the left shows signs of the formation of an anvil and is in a transition stage between L_2 and L_3 . (Photo at Manila, P. I., by C. E. Deppermann.)

5. Cumulonimbus With Anvil Top Beginning to Form, L_3 .

The main cloud mass is in process of transformation from L_2 to L_3 . The "cauliflower" summits remain but they are softening and the summit shows some horizontal spreading. There is a light shower below the central mass. Cumulus clouds, L_2 , also show to the right in the picture but the cumulonimbus would be given preference in coding. (Photo on Mount Wilson, Calif., by F. Ellerman.)

6. Cumulonimbus, L_3 .

The anvil is partially formed and the "cauliflower" swellings have dissolved in the upper portion of the cloud mass. There is a small veil cloud at the left of the summit. Heavy cumuliform masses appear in the lower part of the picture with some altocumulus and patches of dark fractocumulus. A heavy shower is visible. (Photo at Cheyenne, Wyo., by H. T. Floreen.)

7. Cumulonimbus, L_3 .

The anvil is fully developed and its edges are frayed out. Cumulus clouds of a lighter shade appear against the gray of the anvil; at the center, they are merging with the cirrus mass. Below, there is a roller of dark fractocumulus. The anvil alone, after the cumuliform parts have disappeared, would be coded H_3 (pl. 44), but in this picture the cloud is coded L_3 . (Photo at Washington, D. C., by P. A. Miller.)

8. Cumulonimbus, L_3 .

Here the cumulonimbus is shown as a regular "factory of clouds." The cirriform parts (H_3) of anvils extend overhead and beyond the limits of the photograph. The principal mass appears to be only one of several cumulonimbus clouds in the vicinity. This one has not advanced far enough to be coded L_9 . (Photo at Pensacola, Fla., by Air Service, U. S. Navy.)

9. Stratocumulus Formed by the Flattening of Cumulus Clouds, L_4 .

The tops of the cumulus clouds are subsiding and flattening and the bases have spread out at the end of the period of diurnal convection. Parts of cumulus bulges are still visible. Stratocumulus is seen in the upper part of the picture, from degeneration of another mass of cumulus. There are crepuscular rays. This type is called *stratocumulus vesperalis*. (Anonymous.)

10. Stratocumulus Forming From Cumulus, L_4 .

In this case the tops of the cumulus clouds are spreading out at the end of the diurnal period to form opaque layers of stratocumulus. The final phase in this process is the melting away of the bases of cumulus or cumulonimbus and thinning of the stratocumulus. This type is called *stratocumulus cumulogenitus*. The stratocumulus formed in this way may show a *mammatus* structure. (Photo taken on M. S. *Northern Sun* by B. A. Thompson.)

11. Layer of Stratocumulus, L_5 .

This layer is in rather irregular waves or rolls, with lighter semi-transparent parts. Occasionally stratocumulus appears in rolls which are very symmetrically arranged; usually the layer is more or less broken. These clouds are not formed from cumulus; otherwise they would be coded L_4 . (Photo at Washington, D. C., by W. J. Humphreys.)

12. Layer of Stratocumulus, L_5 .

These clouds show dark shadows but large patches of sky may be seen between them. This layer is called stratocumulus. However, the photograph was taken on Mount Wilson at a height of 1,750 meters. Had the observer been at sea level the clouds would have appeared smaller and might have been called altocumulus or high stratocumulus, requiring code M_3 . (Photo by F. Ellerman.)

13. Layer of Stratus, L_5 .

A uniform layer of stratus is like high fog and often has insufficient contrasts in its light and dark portions to make a good photograph. In this picture the stratus is very low and very uniform. The hill penetrates the cloud layer and shreds of cloud (fractostratus) are visible along the hillside. (Photo at Aberdeen, Scotland, by G. A. Clarke.)

14. Layer of Stratus (or Stratocumulus), L_5 .

Here is a fairly uniform cloud sheet, with some lighter and some darker parts, corresponding roughly to the rolls of stratocumulus but appearing somewhat larger. Stratus is often a local cloud and when it breaks up the blue sky is seen as is evident toward the horizon in this picture. Sometimes, as in this case, there are transitional forms between stratus and stratocumulus but in either case the layer is coded L_5 . (Photo at Rockland, Maine, by J. Oddin.)

15. Low Broken Up Clouds of Bad Weather, L_6 .

The picture shows patches of dark fractostratus (or fractocumulus) against a background of thin altostratus. If the low clouds here are remnants of preexisting cumulus, L_1 or L_2 , they should be so coded, but clouds of this type which develop below altostratus or nimbostratus should be coded L_6 . (Photo at Cheyenne, Wyo., by H. T. Floreen.)

16. Low Broken Up Clouds of Bad Weather, L_6 .

The low clouds show up dark against the lighter background of nimbostratus which appears in places, chiefly at the upper right. The low clouds show some relief especially where they are not badly broken up; they appear to be fractocumulus rather than fractostratus. The clouds in the background may be nimbostratus or altostratus but in either case the proper code numbers are M_2 for the middle layer and L_6 for the low clouds. (Photo at Manila, P. I., by C. E. Deppermann.)

17. Low Clouds of Bad Weather, L_6 .

The upper part of this picture shows a layer of nimbostratus clouds trailing off to dense altocumulus in the distance. Below in the foreground beyond the trees is a layer of dark fractocumulus (L_6) of bad weather with a band of brighter sky between the two layers. This photograph, which was taken at Blue Hill Observatory with a minor front approaching, should be compared with plate 27. (Photo by C. F. Brooks.)

18. Cumulus of Fine Weather and Stratocumulus, L_7 .

In this picture a layer of stratocumulus in waves is shown with openings at the right where the sky is visible. Below this layer there were cumulus clouds of fine weather. A part of a cumulus cloud is shown in the right lower margin of the picture; it looks dark against the stratocumulus. In this code type the stratocumulus is formed independently and not derived from cumulus. (Photo at Cheyenne, Wyo., by H. T. Floreen.)

19. Cumulus of Fine Weather and Stratocumulus, L_7 .

In this photograph there are stratocumulus clouds in large soft masses with cumulus clouds below; the latter by themselves would be coded L_1 . This combination is coded L_7 . If the cumulus clouds are sufficiently developed to be coded L_2 or L_3 (pls. 20 and 21), the combination of cumulus and stratocumulus should be coded L_8 . (Photo by F. W. Backer in the International Atlas.)

20. Heavy and Swelling Cumulus and Stratocumulus, L_8 .

Here is a layer of stratocumulus with cumulus clouds below. The latter are heaped up and do not penetrate the stratocumulus in this picture but often they do penetrate an existing stratocumulus layer (pl. 21). In some cases, where the layer above is higher, it may be altocumulus derived from cumulus clouds; in that case the altocumulus would be coded M_6 (pl. 33) and the cumulus L_2 or L_3 , according to circumstances. (Anonymous.)

21. Heavy Cumulus or Cumulonimbus, and Stratocumulus, L_5 .

In the upper part of the picture there is a corrugated sheet of stratocumulus which, if it were alone, would be coded L_5 . However, there are cumulus and cumulonimbus clouds below, some of which penetrate the stratocumulus. This combination of cumulus and stratocumulus clouds is coded L_5 . It should be compared with plates 19 and 20. (Photo by C. J. P. Cave in the International Atlas.)

22. Heavy or Swelling Cumulus (or Cumulonimbus) and Ragged Low Clouds of Bad Weather, L_9 .

Cumulus clouds are visible in the distance but a large cumulonimbus cloud has overspread much of the sky with dark fractocumulus clouds which occupy the upper portion of the picture. The presence of a screen of rain falling in the middle distance is shown by the rainbows, primary and secondary. The proper code number is L_9 . (Photo at Aberdeen Scotland, by G. A. Clarke.)

23. Heavy or Swelling Cumulus and Low Ragged Clouds of Bad Weather, L_9 .

A large mass of cumulus has covered much of the sky and the ragged edges of fractocumulus are seen in the direction toward which the clouds are moving. These low ragged clouds are distinguished by their association with a cumulus mass and must not be coded L_6 which is reserved for low ragged clouds below a sheet of altostratus or nimbostratus (Pls. 15, 16, and 17). (Photo at Washington, D. C., by W. J. Humphreys.)

24. Heavy or Swelling Cumulonimbus and Low Ragged Clouds of Bad Weather, L_9 .

In this picture the cumulonimbus has spread over the sky with a shower in the left half of the picture. A ragged mass of dark fractocumulus appears in the upper right corner. Whether the main cloud is cumulonimbus or a heavy and swelling cumulus, the low ragged clouds are coded L_9 . Clouds with a *mammatus* structure may appear; after they have become disassociated with the cumulonimbus, and the latter is no longer in evidence, code L_4 should be used instead of L_9 . (Anonymous.)

25. Typical Altostratus, Thin, M_1 .

This is a typical sheet of thin altostratus, distinguished from cirrostratus by the absence of halo phenomena. The sun appears as though shining through ground glass. Below this sheet of altostratus there are masses of fractostratus which appear very dark. The fractostratus clouds which form below altostratus (pl. 15), should be coded L_6 and the altostratus M_1 or M_2 , according to circumstances. (Photo at Aberdeen, Scotland, by G. A. Clarke.)

26. Typical Altostratus, Thick (or Nimbostratus), M_2 .

This picture shows a layer of altostratus which covers practically the whole sky. Its thickness varies considerably. The sun shows in a lighter patch where the fibrous structure is evident. If the sun were behind the darker part of the cloud it would be completely hidden. (Photo by M. Pulvé in the International Atlas.)

27. Typical Altostratus, Thick, M_2 .

This view from Mount Washington shows a sheet of altostratus above, with a band of brighter sky near the horizon. This cloud sheet is coded M_2 . When progressive development results in the formation of fractostratus or fractocumulus clouds below the altostratus (or nimbostratus) sheet (pl. 17) the lower clouds are then coded L_6 . (Photo by C. F. Brooks.)

28. Altocumulus, or High Stratocumulus, at One Level Only, M_3 .

The clouds in this photograph would probably be classed as altocumulus by the majority of observers. The masses are rather large, however, and could properly be called stratocumulus. The criterion is that the diameters of the smallest of the well-defined and regularly arranged elements must not exceed the width of three fingers with the arm extended if they are to be called altocumulus. In either case they are coded M_3 . (Photo taken near Crozet, Va., by A. C. Lapsley.)

29. Altocumulus, or High Stratocumulus, at One Level Only, M_3 .

In this case the clouds are more surely altocumulus. It appears that the cloud sheet exists at one level only. The cloud masses here are more nearly globular than in the preceding example. Shading is plainly visible on the under surfaces of the thicker cloudlets. The sheet (M_3) does not increase in amount; if it increases materially it should be coded M_5 . (Photo on Mount Weather, Va., by A. J. Weed.)

30. Altocumulus in Small Isolated Patches, More or Less Lenticular in Shape, M_4 .

These clouds appear on the lateral edge of a disturbance or in mountainous districts. This picture was taken in the lee of Mount Washington during a gale from the northwest. Clouds of this type are sometimes called "standing" clouds because they appear stationary, although they are actually in constant process of formation on the side toward the wind and evaporation on the other side. (Photo by C. F. Brooks.)

31. Altocumulus in Patches, Showing Signs of Evaporation and Being More or Less Lenticular in Shape, M_4 .

This is another type in which small cloudlets are grouped in patches more or less lenticular in shape (roughly like the cross-section of a lens). The cloud patches are sometimes at different levels and usually show signs of evaporation. In this code classification, the total amount of clouds is not large and they are usually more delicate than clouds coded M_5 . (Photo at Cheyenne, Wyo., by H. T. Floreen.)

32. Altocumulus Arranged in More or Less Parallel Bands, Advancing Over the Sky, M_5 .

In this picture the altocumulus clouds are arranged in more or less parallel bands. The layer is of irregular thickness with signs of evaporation in places. To be coded M_5 the net result must be an increase in the amount of cloud. Although there are signs of evaporation, the proportions of the sheet and its regular structure differentiate it from clouds coded M_4 . (Photo taken near Crozet, Va., by A. C. Lapsley.)

33. Altocumulus Formed by a Spreading Out of the Tops of Cumulus, M_6 .

In the upper part of this picture there are altocumulus clouds which are evidently derived from the tops of cumulus clouds in the neighborhood. They are fairly thick in places but are thinning out elsewhere. When there is doubt whether these clouds are altocumulus or stratocumulus, they should be coded M_6 so that, as in this case, the cumulus clouds also present may be reported, using code L_2 or L_3 as may be appropriate. (Anonymous.)

34. Altocumulus Associated With Altostratus, M_7 .

There are two layers of altocumulus in this picture. At the higher level there are more or less globular cloudlets, especially at the left. There is a patch of clear sky near the center of the picture. Dark fibrous veils of altostratus can be seen at the upper right, while the clouds in the lower part of the photograph are altocumulus at a lower level with some of the characteristics of altostratus. (Photo at Cheyenne, Wyo., by H. T. Floreen.)

35. Altocumulus With a Partially Altostratus Character, M_7 .

This is a layer of altocumulus with a rippled or corrugated under surface. Formerly this cloud was called "wrinkled altostratus" but the International definitions now place a cloud sheet of this character, with definite relief on the under surface, in the class of *altocumulus opacus*. The layer shown here should be coded M_7 . (Photo at Fort Worth, Tex., by E. H. Karrer.)

36. Altocumulus Associated With Altostratus, M_7 .

In this picture there is a layer of altostratus associated with considerable amounts of altocumulus at a lower level. A sky of this type is commonly observed in the central region of a weak disturbance. The photograph was taken shortly after the passage of a cold front. (Photo at Portland, Oreg., by V. T. Horn.)

37. *Alto cumulus Castellatus*, M_8 .

In the upper part of the picture there are horizontal bands with small masses having a vertical development (*altocumulus castellatus*). In places the small masses are reduced to thin wisps. There are also some streaks of cirrus and, near the mountains in the distance, some swelling cumulus clouds which would be coded L_2 . (Photo on Mount Wilson, Calif., by F. Ellermann.)

38. *Alto cumulus* in Scattered Cumuliform Tufts, M_8 .

In this picture, especially to the left, there are small cumuliform tufts (*castellatus*) with a tendency toward domed upper surfaces. Trails of virga appear like wisps of cirrus. Above and to the right the clouds are breaking up into poorly defined globular masses (*floccus*). These clouds are indicative of steep lapse rates and are precursors of thunderstorms. (Photo at Blue Hill Observatory, Milton, Mass., by C. F. Brooks.)

39. Altocumulus in Several Sheets at Different Levels, Associated With Thick Fibrous Veils and a Chaotic Appearance of the Sky, M_9 .

This picture shows a portion of a thundery sky. At the middle and right near the upper margin there is a patch of clear sky. The clouds in the middle and upper levels are poorly defined. These clouds were preceded by *altocumulus castellatus* and *altocumulus floccus* and were accompanied by thunderstorms in the vicinity. (Photo at Washington, D. C., by G. Slocum.)

40. Altocumulus in Several Sheets at Different Levels, Associated With Thick Fibrous Veils and a Chaotic Appearance of the Sky, M_9 .

The sky described by this code classification has complex and varied aspects. In this picture there are cumulus clouds below and at the upper right. There are also patches of altocumulus and others with a cirriform aspect. The clouds are chaotic but not ragged. Altogether the sky has a distinct "thundery" tendency which is characteristic. (Photo at Manila, P. I., by C. E. Deppermann.)

41. Cirrus, Fine, not Increasing; Scarce, H_1 .

This form is distinguished chiefly by its scarceness and also by the fact that it does not increase in amount or tend to fuse into a cloud sheet or pass into cirrostratus. The cirrus plume in this picture was the only one in the sky; it did not increase in amount during the afternoon and disappeared entirely at sundown. (Photo at Washington, D. C., by G. Slocum.)

42. Cirrus, Fine, not Increasing; Plentiful but not a Continuous Layer, H_2 .

These clouds are delicate in texture, although a reproduction in black and white tends to give too thick an appearance to cirrus. It does not differ from the type coded as H_1 , except that it is more abundant over much of the sky. It does not increase in amount. (Photo at Cheyenne, Wyo., by H. T. Floreen.)

43. Cirrus of Anvil Clouds, H_3 .

The cirrus clouds in this picture are quite dense in places. The wisps of "spindrift" at the upper left are characteristic of a thundery tendency. Although the anvil shape is completely lost, these clouds were probably derived from cumulonimbus clouds at some considerable time preceding the taking of this picture. (Photo taken at Ebro Observatory, Tortosa, Spain.)

44. Cirrus of Anvil Clouds, H_3 .

In this picture the typical anvil is seen, composed entirely of dense cirrus, frayed out at the upper left. There are cumulus clouds below with the cirrus of another anvil in the distance at the right. The cumuliform parts of the main cumulonimbus have degenerated. This is a transitional stage between L_3 and H_3 . (Photo at Cheyenne, Wyo., by H. T. Floreen.)

45. Cirrus Increasing, Generally in the Form of Hooks Ending in a Point or in a Small Tuft, H_4 .

The streaks of cirrus in this picture have, here and there, an up-turned end or a small tuft. It is stipulated that the cirrus in this code classification shall increase both in time and in a certain direction, but they shall not merge into cirrostratus, which would call for code H_5 . (Photo on Mount Wilson, Calif., by F. Ellermann.)

46. Cirrus, or Cirrostratus, Advancing Over the Sky But Not More Than 45° Above the Horizon, H_5 .

The strands of cirrus in this picture are seen to fuse together into a sheet resembling cirrostratus. The advancing front of the sheet appears to be less than 45° above the horizon. In other cases, the sheet may, however, be of cirrostratus without any parts definitely resembling cirrus. The fact that the clouds are advancing over the sky must be determined by observation. (Photo on Mount Weather, Va., by A. J. Weed.)

47. Cirrus or Cirrostratus Advancing Over the Sky and More Than 45° Above the Horizon, H_6 .

Here the cirrus clouds are united in places to form patches like cirrostratus. This form is like the preceding one except that the clouds are more than 45° above the horizon. If the sheet covers the whole sky, however, code H_7 is used. In this picture parts of the sheet are cirrocumulus, which may be present in any of the code classifications from H_1 to H_6 . (Photo at Cheyenne, Wyo., by H. T. Floreen.)

48. Veil of Cirrostratus Covering the Whole Sky, H_7 .

The preceding type, while more than 45° above the horizon, did not cover the whole sky. The entire sky must be covered if the cloud is to be coded H_7 , which is presumably the case in this picture. The presence of a halo shows this sheet to be definitely cirrostratus. It has little detail but is plainly seen to be fibrous in places. (Photo at Aberdeen, Scotland, by G. A. Clarke.)

49. Cirrostratus Not Increasing and Not Covering the Whole Sky, H_3 .

Here is a sheet of cirrostratus (and parts of cirrocumulus) with clear sky along the horizon in one direction. If the cirrostratus covers most of the sky and the segment of blue sky is diminishing, it is coded H_6 . It is only when the segment of blue sky does not diminish that code H_8 is used. (Photo at Cheyenne, Wyo., by H. T. Floreen.)

50. Cirrostratus Not Increasing and Not Covering the Whole Sky, H_5 .

A sheet of dense cirrostratus covers nearly all of the sky. In this case the strip of clear sky near the horizon persisted for at least 12 hours; the upper clouds moving in a direction parallel to the edge of the sheet. The lower clouds in this picture should be coded L_1 and the upper clouds, H_5 . (Photo by G. A. Clarke in the International Atlas.)

51. Cirrocumulus Predominating, Associated With a Small Quantity of Cirrus, H_9 .

In this picture the cirrocumulus predominates but there is some cirrus, especially in the lower right portion. At the middle of the lower margin the transition from cirrus to cirrocumulus is evident. The latter is evolved by a degeneration of a mass of cirrus or a sheet of cirrostratus. The cloudlets are without definite shadows. (Photo at Cheyenne, Wyo., by H. T. Floreen.)

52. Cirrocumulus Predominating, Associated With a Mass of Cirrus, H_9 .

The individual cloudlets in this picture are without definite shadows and are associated with tufted cirrus in the lower portion of the picture. According to the new definition of cirrocumulus, its relationship to cirrus or cirrostratus is absolutely necessary. Cirrocumulus clouds may be associated with cirrus or cirrostratus in the other classifications but in H_9 the cirrocumulus predominates. (Photo on Mount Wilson, Calif., by F. Ellermann.)

AERIAL VIEWS OF CLOUDS

The illustrations which follow have been selected to show the upper surfaces of clouds as viewed from airplanes. When seen from above, the clouds at lower and intermediate levels do not present the same appearance as from below, hence it is not always possible, from an aerial view alone, to distinguish clouds according to the 10 genera in the international classification which is based on appearance from the ground. There are certain characteristics, however, which should be observed.

It is desirable that airplane pilots employed on meteorological work shall make a systematic study of clouds from the ground as well as from the air in order that the clouds may be correctly identified. In some instances, however, it will be necessary to give descriptions in plain language without code numbers or generic names.

Cirrus, cirrostratus, and cirrocumulus clouds are usually above the levels reached by airplane observers. When lower clouds cover the sky the airplane observer may supply valuable information as to high-level clouds which are not visible from the ground. Occasionally the airplane may pass through cirriform clouds composed of snowflakes or ice particles at moderate heights. In some instances ice particles may be seen sparkling in the sun when the particles are too widely separated to be visible as a cloud to an observer on the ground. Such conditions should be recorded.

Clouds in the intermediate and lower levels, when seen from above, often have the appearance of a continuous horizontal layer or sheet. Even when there are fairly large openings, the layer may appear unbroken when viewed at a distance. Near to and below the observer, the openings will be visible. It is important to note whether or not there are any openings.

Clouds in sheets or layers nearly always exhibit a rippled or lumpy surface above. The degree of roughness or turbulence should be noted. It may range from a slightly rippled effect to a pronounced lumpiness, with parts extending upward in the form of towers like the upper portions of cumulus clouds.

Sometimes a layer of clouds may be pierced by cumulus or cumulonimbus which develops below and grows until its summit protrudes above the layer. This structure should be carefully distinguished from the development of cumulus clouds in detached but numerous masses so that their tops when viewed in perspective toward the horizon will appear as a rippled or lumpy sheet.

The height and thickness of cloud sheets are also important.

In general, aerial observations should include notes as to the following features:

1. Date, time, and place.
2. Cloud genera when known.
3. Height of base.

4. Height of upper surface.
5. Description of structure:
 - a. Detached flat clouds.
 - b. Detached clouds with vertical development.
 - c. Layer with openings.
 - d. Continuous layer.
6. Appearance of upper surface of clouds:
 - a. Smooth or slightly rippled.
 - b. Lumpy or rough.
 - c. With cumuliform bulges.
 - d. With towers and tops resembling cumulonimbus.
7. The presence of clouds at two or more levels should be noted and described separately.
8. Presence of ice, snow, or water droplets should be noted in passing through clouds.
9. Separation of the particles of ice, water, or snow, that is, are they widely separated so that the cloud appears like a thin mist or does the cloud appear dense when the observer is passing through it?

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