Met Office

Clouds

National Meteorological Library and Archive
Factsheet 1 — An introduction to clouds

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Introduction

A cloud is an aggregate of very small water droplets, ice crystals, or a mixture of both, with its base above the Earth's surface. With the exception of certain rare types (nacreous and noctilucent) and the occasional occurrence of cirrus in the lower stratosphere, clouds are confined to the troposphere. They are formed mainly as the result of vertical motion of air, as in convection, or in forced ascent over high ground, or in the large-scale vertical motion associated with depressions and fronts.

The nature of clouds

The classification of clouds is based upon that originated by Luke Howard (1772—1864), a London pharmacist and amateur meteorologist. In 1803 Howard, wrote a book called 'Essay on the Modification of Clouds' and named the various cloud structures he had studied. He used the word 'hair' to describe cirrus, heap for cumulus, layer for stratus and rain-bearing for nimbus. He illustrated it with a series of engravings depicting the main cloud types that he named. Later he added 'alto' and 'fracto', meaning middle and broken. The terms were readily accepted by the meteorological community and are still used across the world today.

Figure 1. Luke Howard.

The details of a more precise classification occupied the attention of meteorologists in many countries during the latter part of the nineteenth century. A classification was agreed at the International Meteorological Conference in Munich in 1891, and in 1896 the first edition of the *International Cloud Atlas* appeared.

An International Commission for the Study of Clouds was set up in 1921 and produced the *International Atlas of Clouds and of Types of Skies* in 1932, preceded by an abridged edition in 1930 for use of observers to meet the requirements of coding changes. New editions of both publications followed in 1939.

A new *International Cloud Atlas* was published in two volumes in 1956 by the World Meteorological Organization (WMO).

How clouds form

A cloud is defined as 'a visible aggregate of minute droplets of water or particles of ice or a mixture of both floating in the free air'. Each droplet has a diameter of about a hundredth of a millimetre and each cubic metre of air will contain 100 million droplets. Because the droplets are so small, they can remain in liquid form in temperatures of -30 °C. If so, they are called supercooled droplets.

Clouds at higher and extremely cold levels in the atmosphere are composed of ice crystals — these can be about a tenth of a millimetre long.

Clouds form when the invisible water vapour in the air condenses into visible water droplets or ice crystals. For this to happen, the parcel of air must be saturated, i.e. unable to hold all the water it contains in vapour form, so it starts to condense into a liquid or solid form. There are two ways by which saturation is reached:

a. By increasing the water content in the air, e.g. through evaporation, to a point where the air can hold no more.

b. By cooling the air so that it reaches its dew point — this is the temperature at which condensation occurs, and is unable to 'hold' any more water. Figure 2 shows how there is a maximum amount of water vapour the air, at a given temperature, can hold. In general, the warmer the air, the more water vapour it can hold. Therefore, reducing its temperature decreases its ability to hold water vapour so that condensation occurs.

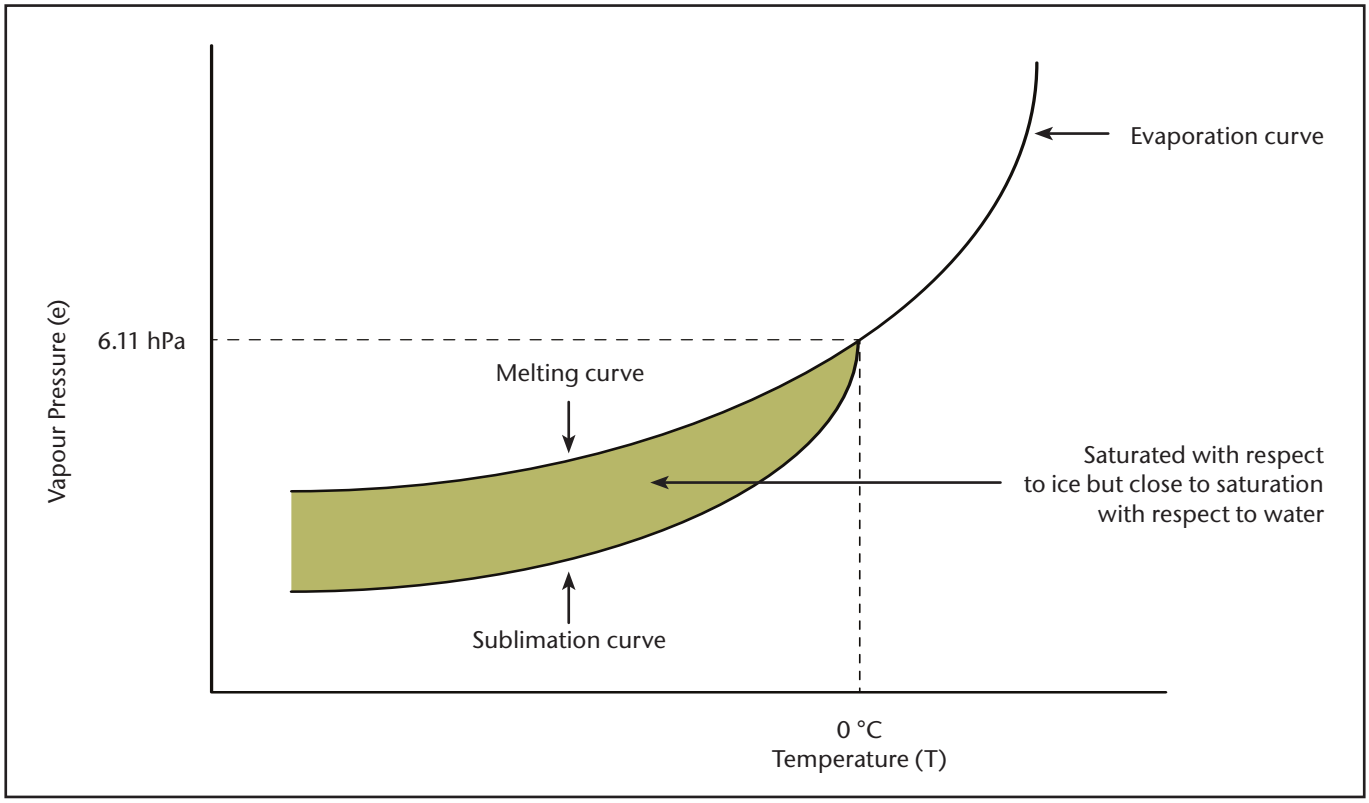


Figure 2. There is a maximum amount of water vapour the air, at a given temperature, can hold.

Method (b) is the usual way that clouds are produced, and it is associated with air rising in the lower part of the atmosphere. As the air rises it expands due to lower atmospheric pressure, and the energy used in expansion causes the air to cool. Generally speaking, for each 100 metres which the air rises, it will cool by 1 °C, as shown in Figure 9. The rate of cooling will vary depending on the water content, or humidity, of the air. Moist parcels of air may cool more slowly, at a rate of 0.5 °C per 100 metres.

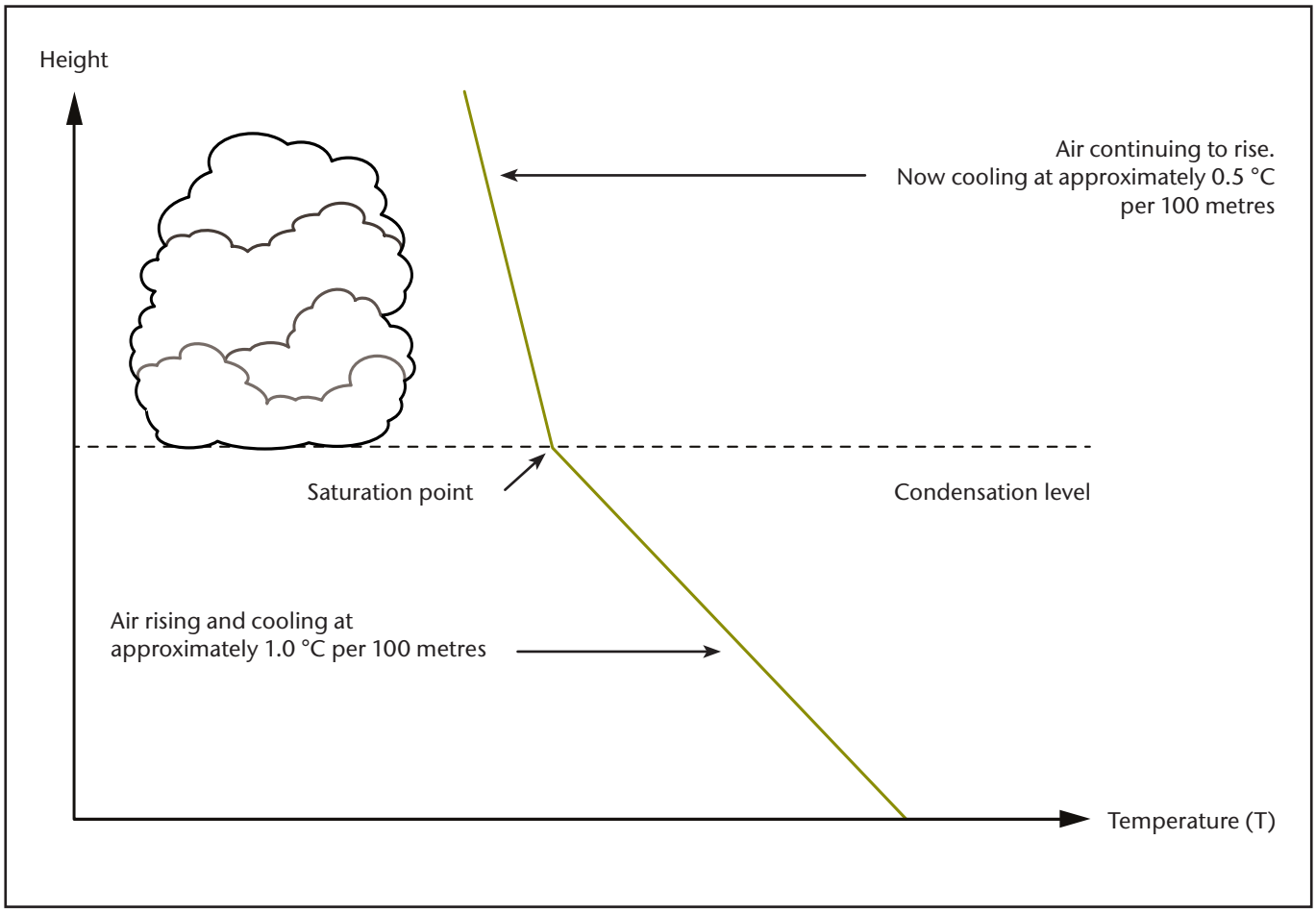


Figure 3. Temperature profile of a parcel of air as it rises through the atmosphere.

Therefore, the vertical ascent of air will reduce its ability to hold water vapour, so that condensation occurs. The height at which dew point is reached and clouds form is called the condensation level.

Five factors which can lead to air rising and cooling

- Surface heating — The ground is heated by the sun which heats the air in contact with it causing it to rise. The rising columns of air are often called **thermals**. Clouds caused by surface heating tend to be cumulus-type clouds.

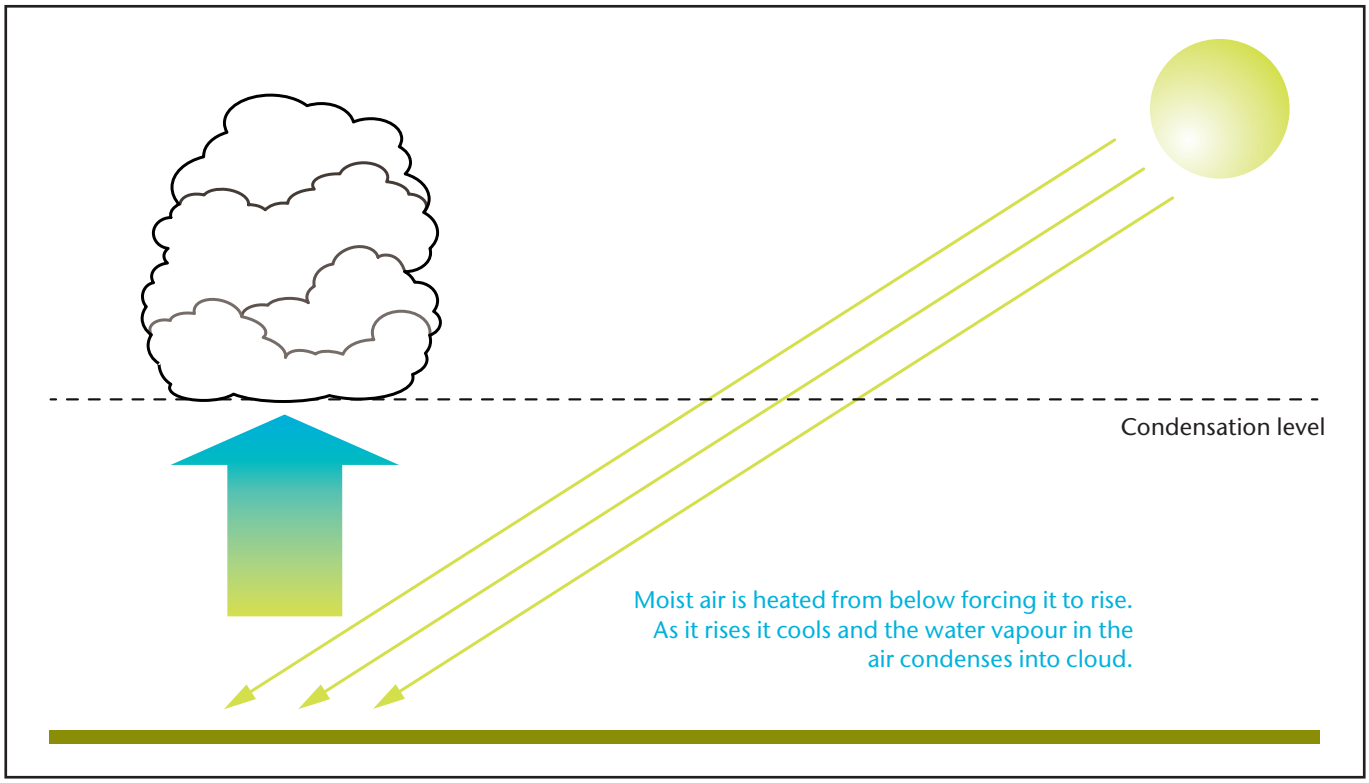


Figure 4. Clouds caused by surface heating.

- Frontal — A mass of warm air rising up over a mass of cold, dense air. The boundary is called a 'front'. Clouds formed by frontal activity tend to be layered cloud. For more information about weather fronts, see fact sheet number 10 in this series.
- Topography — Air forced to rise over a barrier of mountains or hills. This is known as orographic uplift. Clouds caused by topography tend to be layered cloud.

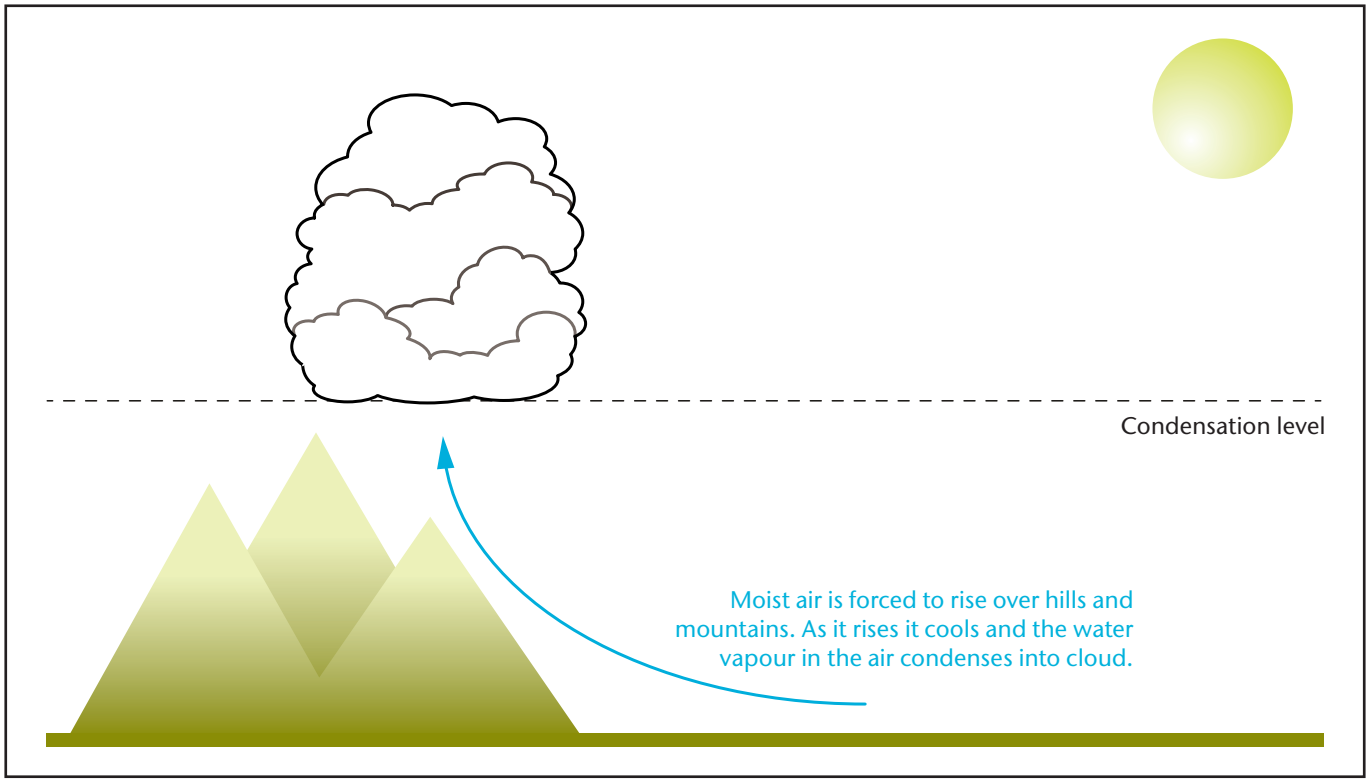


Figure 5. Clouds caused by topography.

Convergence - Streams of air flowing from different directions are forced to rise where they meet.

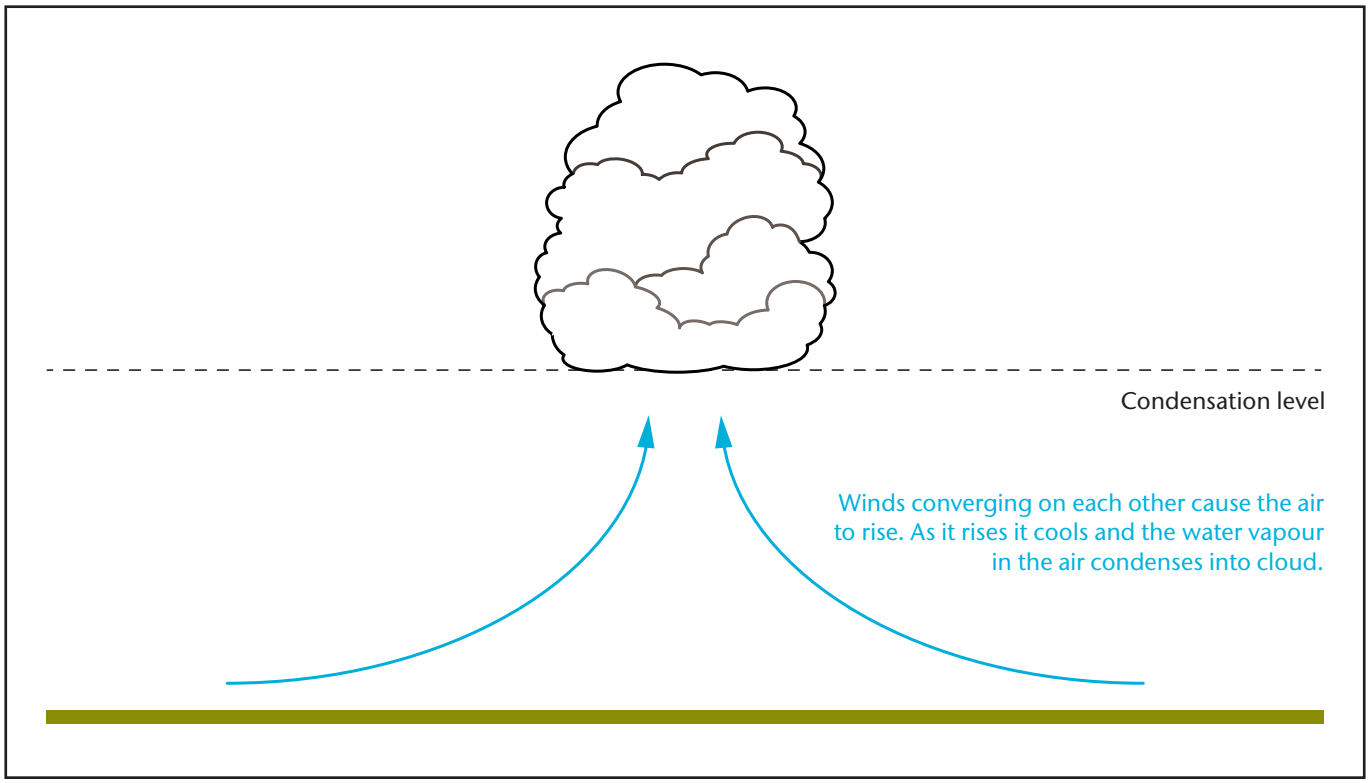


Figure 6. Clouds caused by convergence.

- Turbulence — A sudden change in wind speed with height creating turbulent eddies in the air. The last two can produce either cumulus-type cloud or layered cloud depending upon the state of the atmosphere.

Another important factor to consider is that water vapour needs something to condense onto. Floating in the air are millions of minute salt, dust and smoke particles known as **condensation nuclei** which enable condensation to take place when the air is just saturated.

Aid to cloud identification

If, especially during the hours of darkness, an observer has difficulty in identifying the cloud types following the onset of precipitation, the table below can be used as a guide to the cloud types which may be present from the nature of the precipitation.

	Cloud type					
Precipitation	As	Ns	Sc	St	Cu[#]	Cb[#]
Rain	*	*	*		*	*
Drizzle				*		
Snow	*	*	*	*	*	*
Snow pellets			*		*	*
Hail						*
Small hail						*
Ice pellets	*	*				
Snow grains				*		
[#]Showery precipitation						

Cloud heights

Observations have shown that cloud levels (with the exception of nacreous and noctilucent clouds) vary over a range of altitudes from near sea level to perhaps 18 kilometres (60,000 feet) in the tropics, 14 kilometres (45,000 feet) in middle latitudes, and 8 kilometres (25,000 feet) in polar regions.

By convention, the vertical extent of the atmosphere in which clouds are usually present is divided into three layers: high, medium and low. Each layer is defined by a range of altitudes between which clouds of certain types occur most frequently. The layers overlap and the approximate limits vary with the latitude as shown in the table below. Some clouds usually have their bases in the low level but may reach into the medium or high levels.

Level	Polar regions	Temperate regions	Tropical regions
High	3 to 8 km (10,000 to 25,000 feet)	5 to 14 km (16,500 to 45,000 feet)	6 to 18 km (20,000 to 60,000 feet)
Medium	2 to 4 km (6,500 to 13,000 feet)	2 to 7 km (6,500 to 23,000 feet)	2 to 8 km (6,500 to 25,000 feet)
Low	From the Earth's surface to 2 km (6,500 feet)	From the Earth's surface to 2 km (6,500 feet)	From the Earth's surface to 2 km (6,500 feet)

When the height of the base of a particular cloud is known, the use of levels may assist the observer to identify the cloud.

Heights of the base of cloud genera above ground level in the British Isles

Cloud genera	Usual range of height of base		Wider range of height of base sometimes observed, and other remarks	
	metres	feet	metres	feet
Low				
Stratus	Surface to 600	Surface to 2000	Surface to 1,200	Surface to 4,000
Stratocumulus	300 to 1,350	1,000 to 4,500	300 to 2,000	1,000 to 6,500
Cumulus	300 to 1,500	1,000 to 5,000	300 to 2,000	1,000 to 6,500
Cumulonimbus	600 to 1,500	2,000 to 5,000	300 to 2,000	1,000 to 6,500
	kilometres	feet		
Medium			Note	
Nimbostratus	Surface to 3	Surface to 10,000	1. Nimbostratus is considered a medium cloud for synoptic purposes, although it can extend to other levels.	
Altostratus	2 to 6	6,500 to 20,000	2. Altostratus may thicken with progressive lowering of the base to become nimbostratus.	
Altocumulus	2 to 6	6,500 to 20,000		
	kilometres	feet		
High			Note	
Cirrus			1. Cirrus from dissipating cumulonimbus may occur well below 6 km (20,000 feet) in winter.	
Cirrostratus	6 to 12	20,000 to 40,000	2. Cirrostratus may develop into altostratus.	
Cirrocumulus				

Classification of clouds

Following the *International Cloud Atlas*, the cloud forms are classified in terms of 'genera', 'species' and 'varieties'. A description of these terms follows, with an explanation of the subdivisions which can be used to define a particular cloud formation in more detail.

The range of ways in which clouds can be formed and the variable nature of the atmosphere give rise to the enormous variety of shapes, sizes and textures of clouds.

- Genera

Cloud forms are divided into 10 main groups, called genera. A given cloud belongs to only one genus. The genera, together with their accepted form of abbreviation, are:

Low	Medium	High
Stratus (St) Stratocumulus (Sc) Cumulus (Cu) Cumulonimbus (Cb)	Altocumulus (Ac) Altostratus (As) Nimbostratus (Ns) (Nimbostratus extends to other levels)	Cirrus (Ci) Cirrocumulus (Cc) Cirrostratus (Cs)

- Species

Peculiarities in the shape of clouds and differences in their internal structure have led to the subdivision of most of the cloud genera into species. Altostratus and nimbostratus are the only genera which are not so divided. The full list of cloud species is:

Fractus (fra) – clouds in the form of irregular and ragged shreds. This term applies only to stratus and cumulus clouds.

Nebulosus (neb) – a cloud like a nebulous veil or layer, showing no distinct details. This term applied mainly to stratus and cirrostratus clouds.

Stratiformis (str) – clouds spread out in an extensive horizontal sheet or layer. This term applies to stratocumulus, altocumulus and, occasionally, cirrocumulus clouds.

Lenticularis (len) – clouds having the shape of a lens or almond, often very elongated and usually with well-defined outlines; they occasionally show irisation (iridescence). Such clouds appear most often in cloud formations of orographic origin, but may also occur in regions without marked orography. This term applies mainly to stratocumulus, altocumulus and cirrocumulus clouds.

Castellanus (cas) – clouds which present, in at least some portion of their upper part, cumuliform protuberances in the form of turrets which generally give the clouds a crenellated appearance. The turrets, some of which are taller than they are wide, may be connected by a common base and seem to be arranged in lines. The castellanus character is especially evident when clouds are seen from a distance. This term applies to stratocumulus, altocumulus, cirrus and cirrocumulus clouds.

Humilis (hum) – clouds of only slight vertical extent; they generally appear flattened. This term only applies to cumulus cloud.

Mediocris (med) – clouds of moderate vertical extent, the tops of which show fairly small protuberances. This term only applies to cumulus cloud.

Congestus (con) – clouds which are markedly sprouting and are often of great vertical extent; their bulging upper part frequently resembles a cauliflower. This term only applies to cumulus cloud.

Calvus (cal) – clouds in which at least some of the protuberances of the upper part are beginning to lose their cumuliform outlines but in which no cirriform parts can be distinguished. Protuberances and sprouts tend to form a whitish mass with more or less vertical striations. This term only applies to cumulonimbus cloud.

Capillatus (cap) – clouds characterised by the presence, mostly in its upper portion, of distinct cirriform parts of clearly fibrous or striated structure, frequently having the form of an anvil, a plume or a vast, more or less disorderly, mass of hair. This term only applies to cumulonimbus cloud.

Floccus (flo) – a species in which each cloud unit is a small tuft with a cumuliform appearance, the lower part of which is more or less ragged and often accompanied by virga. This term applies to altocumulus, cirrus and cirrocumulus clouds.

Fibratus (fib) – detached clouds or a thin cloud veil, consisting of nearly straight or more or less irregular curved filaments which do not terminate in hooks or tufts. This term applies mainly to cirrus and cirrocumulus clouds.

Spissatus (spi) – clouds of sufficient optical thickness to appear greyish when viewed towards the sun. This term only applies to cirrus cloud.

Uncinus (unc) — clouds often shaped like a comma, terminating at the top in a hook, or in a tuft whose upper part is not in the form of a rounded protuberance. This term only applies to cirrus cloud.

- Varieties

Special features in appearance and degree of transparency of clouds have led to the concept of varieties. For example, a cloud with a definite wave characteristic would be termed 'undulatus' as in undulating. The full list of cloud varieties is:

Duplicatus (du) – superposed cloud patches, sheets or layers at slightly different levels, sometimes partly merged. This term applies mainly to stratocumulus, altocumulus, altostratus, cirrus and cirrocumulus clouds.

Intortus (in) – clouds in which the filaments are very irregularly curved and often seemingly entangled in a capricious manner. This term only applies to cirrus cloud.

Lacunosus (la) – cloud patches, sheets or layers, usually rather thin marked by more or less regular distributed round holes, many of them with fringed edges. Cloud elements and clear spaces are often arranged in a manner suggesting a net or a honeycomb. This term applies mainly to altocumulus and cirrocumulus, and on rare occasions to stratocumulus clouds.

Radiatus (ra) – clouds showing broad parallel bands or arranged in parallel bands which, owing to the effect of perspective, seem to converge towards a point on the horizon or, when in bands cross the whole sky, towards two opposite points on the horizon, called 'radiation point(s)'. This term applies mainly to stratocumulus, cumulus, altocumulus, altostratus and cirrus clouds.

Vertebratus (ve) – clouds whose filaments are arranged in a manner suggestive of vertebrae, ribs or a fish skeleton. This term applies mainly to cirrus cloud.

Opacus (op) – an extensive cloud patch, sheet or layer, the greater part of which is sufficiently opaque to mask the sun or moon completely. This term applies to stratus, stratocumulus, altostratus and altocumulus clouds.

Cumulogenitus (cugen) – clouds formed by the spreading out of cumulus. This term applies to stratocumulus and altocumulus clouds.

Perlucidus (pe) – an extensive cloud patch, sheet or layer, with distinct but sometimes very small spaces between the elements. The spaces allow the sun, the moon, the blue of the sky or overlying clouds to be seen. The variety perlucidus may be observed in combination with the translucidus or opacus. This term applies to stratocumulus and altocumulus clouds.

Translucidus (tr) – clouds in an extensive patch, sheet or layer, the greater parts of which is sufficiently translucent to reveal the position of the sun or moon. This term applies to stratus, stratocumulus, altostratus and altocumulus clouds.

Undulatus (un) – clouds in patches, sheets or layers, showing undulations. These undulations may be observed in fairly uniform cloud layers or in clouds composed of elements, separate or merged.

Low clouds

Following the *International Cloud Atlas*, the cloud forms are classified in terms of 'genera', 'species' and 'varieties'. Descriptions of these terms for the four types of low cloud follow, with an explanation of the subdivisions which can be used to define a particular cloud formation in more detail.

The range of ways in which clouds can be formed and the variable nature of the atmosphere give rise to the enormous variety of shapes, sizes and textures of clouds.

Low cloud forms are divided into four main groups, called genera. A given cloud belongs to only one genus. The genera, together with their accepted form of abbreviation, are:

- Cumulus (Cu)
- Stratocumulus (Sc)
- Stratus (St)
- Cumulonimbus (Cb)

Each genera can be subdivided, according to their size and shape, into a number of species. The genera, together with their associated species, including their relevant international cloud symbol and WMO classification are:

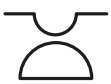
Cloud genera and species	International cloud symbol	WMO classification
Cumulus *fractus* (Cu *fra*)		C_L1
Cumulus *humilis* (Cu *hum*)		C_L1
Cumulus *mediocris* (Cu *med*)		C_L2
Cumulus *congestus* (Cu *con*)		C_L2
Stratocumulus *cumulogenitus* (Sc *cugen*)		C_L4
Stratocumulus *castellanus* (Sc *cas*)		C_L5
Stratocumulus *lenticularis* (Sc *len*)		C_L5
Stratocumulus *stratiformis* (Sc *str*)		C_L5
Stratus *nebulosus* (St *neb*)		C_L6
Stratus *fractus* (St *fra*)		C_L7
Cumulonimbus *calvus* (Cb *cal*)		C_L3
Cumulonimbus *capillatus* (Cb *cap*)		C_L9
Cumulus and stratocumulus at different heights		C_L8

Figure 7. International cloud symbols and WMO classification for low cloud.

Examples of low cloud types

(Genera: cumulus, stratocumulus, stratus and cumulonimbus)

- Cumulus (Cu)

Latin: *cumulus* – heap

Species: *fractus (fra), humilis (hum), mediocris (med) and congestus (con)*

Detached clouds, generally dense and with sharp outlines, developing vertically in the form of rising mounds, domes or towers, of which the bulging upper part often resembles a cauliflower. The sunlit parts of these clouds are mostly brilliant white; their base is relatively dark and nearly horizontal. Sometimes cumulus is ragged.

Cumulus clouds are detached although, when viewed from a distance, they may appear to have merged owing to the effect of perspective. Owing to their generally great vertical extent, cumulus may spread out and form stratocumulus or altocumulus cumulogenitus or, alternatively, penetrate existing layers of altocumulus or stratocumulus. Providing the cumuliform cloud remain detached from one another, they are still called cumulus. It can sometimes happen that a very large precipitating cumulus directly above an observer will exhibit none of the features normally associated with this genus, and it may be confused with altostratus or nimbostratus.

Examples of cumulus (genera and species) are:

Cumulus *fractus* **(Cu** *fra***)**

Figure 8. Cumulus *fractus* (C_L1) (© M. Clark).

Cumulus *humilis* **(Cu** *hum***)**

Figure 9. Cumulus *humilis* (C_L1) (© J. Corey).

Cumulus *mediocris* **(Cu** *med***)**

Figure 10. Cumulus *mediocris* (C_L2) (© J. Corey).

Cumulus ***congestus*** **(Cu** ***con*****)**

Figure 11. Cumulus *congestus* (C_L2) (© R. Bird).

- Stratocumulus (Str)

Latin: *stratus* – flattened; *cumulus* – heap

Species: *cumulogenitus (cugen), castellanus (cas), lenticularis (len) and stratiformis (sta)*

Grey or whitish, or both grey and whitish, patch, sheet or layer of cloud which almost always has dark parts, composed of tessellations, rounded masses, rolls, etc. which are non-fibrous (except for virga) and which may or may not be merged; most of the regular arranged small elements have an apparent width of more than 5°. (If a centimetre rule is held at arm's length, each centimetre will approximate to 1°).

Stratocumulus may sometimes be confused with altocumulus. If most of the regular arranged elements, when observed at an angle of more than 30° above the horizon, have an apparent width of more than 5°, the cloud is stratocumulus. Generally stratocumulus is composed of water droplets and, when it is not very thick, a corona or irisation is sometimes seen. However, in very cold weather, it may produce abundant ice-crystal virga.

Examples of stratocumulus (genera and species) are:

Stratocumulus ***cumulogenitus*** **(Sc** ***cugen*****)**

Figure 12. Stratocumulus *cumulogenitus* (C_L4) (© J. Corey).

Stratocumulus *castellanus* **(Sc** *cas***)**

Figure 13. Stratocumulus *castellanus* (C_L5) (© J. Corey).

Stratocumulus *lenticularis* **(Sc** *len***)**

Figure 14. Stratocumulus *lenticularis* (C_L5) (© M. Clark).

Stratocumulus ***stratiformis*** **(Sc** ***str*****)**

Figure 15. Stratocumulus *stratiformis* (C_L5) (© M. Clark).

Figure 16. Stratocumulus *stratiformis* (C_L5) (© M. Clark).

- Stratus (St)

(Latin: *stratus* – flattened or spread out)

Species: *nebulosus (neb) and fractus (fra)*

Generally grey cloud layer with a fairly uniform base, which may give drizzle, snow or snow grains. When the sun is visible through the cloud its outline is clearly discernable. Stratus does not produce halo phenomena except possible at very low temperatures. Sometimes stratus appears in the form of ragged patches.

Stratus may develop from stratocumulus when the cloud base of the latter becomes lower or loses its relief or apparent subdivisions. The lifting of a fog layer due to warming or an increase in the wind speed is another common mode of formation. During the formation or dissipation it can appear as more or less joined fragments with varying luminance as stratus fractus but this stage is usually fairly short. It is usually composed of small water droplets and, if the cloud is thin, these can give rise to a corona.

Examples of stratus (genera and species) are:

Stratus *nebulosus* (St *neb*)

Figure 17. Stratus *nebulosus* (C_L6) (© S. Warnock).

Stratus ***fractus*** **(St** ***fra*****)**

Figure 18. Stratus *fractus* ($C_L 7$) (© M. Clark).

- Cumulonimbus (Cb)

(Latin: *cumulus* – heap; *nimbus* – rainy cloud)

Species: *calvus (cal) and capillatus (cap)*

Heavy and dense cloud, of considerable vertical extent, in the form of a mountain or huge towers. At least part of its upper portion is usually smooth, or fibrous or striated, and nearly always flattened; this part often spreads out in the shape of an anvil or vast plume. Under the base of this cloud, which is often very dark, there are frequently low ragged clouds either merged with it or not, and precipitation sometimes in the form of virga.

Cumulonimbus clouds normally develop from large cumulus but they can also do so from stratocumulus castellanus or altocumulus castellanus. When they cover a large expanse of sky the under surface can present the appearance of nimbostratus. The character of the precipitation may be of assistance in identifying the cloud. Cumulonimbus gives showers, very often quite heavy for comparatively short periods of time.

If hail, thunder or lightning are observed then, by convention, the cloud is cumulonimbus. The evolution of the cloud can also aid identification. The change from large cumulus with domed tops and a hard outline (produced by water drops) to a top with a softer fibrous outline (produced by ice crystals) marks the change from cumulus to cumulonimbus.

This genus can be described as a ‘cloud factory’; it may produce extensive thick patches of cirrus spissatus, altocumulus, altostratus or stratocumulus by the spreading out of its upper portions. The spreading of the highest part usually leads to the formation of an anvil; if the wind increases with height, the upper portion of the cloud is carried downwind in the shape of a half anvil or vast plume.

Examples of cumulonimbus (genera and species) are:

Cumulonimbus *calvus* **(Cb** *cal***)**

Figure 19. Cumulonimbus *calvus* (C_L3) (© M.J.O. Dutton).

Cumulonimbus ***capillatus*** **(Cb** ***cap*****)**

Figure 20. Cumulonimbus *capillatus* (C_L9) (© M. Clark).

Cumulus (Cu) and Stratocumulus (Sc) at different heights

The code figure C_L8 is used for cumulus and stratocumulus, other than the stratocumulus formed from the spreading out of cumulus C_L4 that have their bases at different heights.

Usually the cumulus forms beneath patches or a sheet of stratocumulus and may even thrust its way into or through the stratocumulus. Unlike some C_L4, the cumulus of C_L8 does not widen upwards towards the stratocumulus layer. A thinned or even cleared area may surround the cumulus column.

Less frequently the cumulus appears above the stratocumulus.

Figure 21. Cumulus and stratocumulus at different heights (C_L8) (© M. Clark).

Medium clouds

Following the *International Cloud Atlas*, the cloud forms are classified in terms of 'genera', 'species' and 'varieties'. Descriptions of these terms for the three types of medium cloud follow, with an explanation of the subdivisions which can be used to define a particular cloud formation in more detail.

The range of ways in which clouds can be formed and the variable nature of the atmosphere give rise to the enormous variety of shapes, sizes and textures of clouds.

Medium cloud forms are divided into three main groups, called genera. A given cloud belongs to only one genus. The genera, together with their accepted form of abbreviation, are:

- Altostratus (As)
- Nimbostratus (Ns)
- Altocumulus (Ac)

Altocumulus can be subdivided into species according to its size and shape. This rule does not apply to nimbostratus or altostratus which does not have any species associated with them. Altostratus does, however, have two varieties associated with it, namely, altostratus *translucidous* and altostratus *opacus*. The genera, together with their associated species (or varieties in the case of altostratus), including their relevant international cloud symbol and WMO classification are:

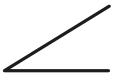
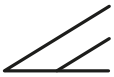
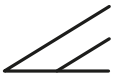
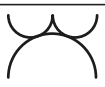
Cloud genera and species	International cloud symbol	WMO classification
Altostratus *translucidous* (As *tra*)		C_M1
Altostratus *opacus* (As *op*)		C_M2
Nimbostratus		C_M2
Altocumulus *stratiformis* (Ac *str*)		C_M3
Altocumulus *stratiformis* (Ac *str*)		C_M5
Altocumulus *stratiformis* (Ac *str*)		C_M7
Altocumulus *lenticularis* (Ac *len*)		C_M4
Altocumulus *castellanus* (Ac *cas*)		C_M8
Altocumulus *floccus* (Ac *flo*)		C_M8
Altocumulus *cumulogenitus* (Ac *cugen*)		C_M6
Altocumulus – of a chaotic sky		C_M9

Figure 22. International cloud symbols and WMO classification for medium cloud.

Examples of medium cloud types

(Genera: altostratus, nimbostratus and altocumulus)

- Altostratus (As)

(Latin: *altum* – height; *stratus* – flattened or spread out)

Varieties: *translucidous (tra) and opacus (op)*

Greyish or bluish cloud sheet or layer of striated, fibrous or uniform appearance, totally or partly covering the sky, and having parts thin enough to reveal the sun at least vaguely, as if through ground glass. Altostratus does not show halo phenomena.

Altostratus prevents objects on the ground from casting shadows. If the presence of the sun or moon can be detected, this indicates altostratus rather than nimbostratus. The former has a less uniform base. If it is very thick and dark, differences in thickness may cause relatively light patches between different parts, but the surface never shows real relief, and the striated or fibrous structure is always seen in the body of the cloud. At night, if there is any doubt as to whether it is altostratus or nimbostratus when no rain or snow is falling, then, by convention, it is called altostratus. Altostratus is never white, as thin stratus may be when viewed more or less towards the sun.

Examples of altostratus (genera and varieties – no species exist for altostratus) are:

Altostratus ***translucidus*** **(As** ***tra*****)**

Figure 23. Altostratus *translucidous* (C_M1) (© J.F.P. Galvin).

Altostratus ***opacus*** **(As** ***op*****)**

Figure 24. Altostratus *opacus* (C_M2) (© S. Jebson).

- Nimbostratus (Ns)

(Latin: *nimbus* – rainy cloud; *stratus* – flattened or spread out)

No species or varieties exist for nimbostratus.

Grey cloud layer, often dark, the appearance of which is rendered diffuse by more or less continuously falling rain or snow which, in most cases, reaches the ground. It is thick enough throughout to blot out the sun. Low ragged clouds frequently occur below the layer, with which they may or may not merge.

Nimbostratus generally forms from thickening altostratus or when a well developed cumulonimbus thickens and spreads out. Note that if hail, thunder or lightning are produced by the cloud it is called cumulonimbus. Nimbostratus is a thick dense cloud and can be distinguished from thick stratus by the type of precipitation it produces.

It is also generally an extensive cloud, the base of which can be partially or totally hidden by ragged clouds (pannas), and care must be taken not to confuse these with the base of the nimbostratus.

Example of nimbostratus is:

Nimbostratus (Ns)

Figure 25. Nimbostratus (C_M2) (© F. Pouncy).

- Altocumulus (Ac)

(Latin: *altum* – height*; cumulus* – heap)

Species: *stratiformis (str), lenticularis (len), castellanus (cas) and floccus (flo)*

White or grey, or both white and grey, patch, sheet or layer of cloud, generally with shading, and composed of laminae, rounded masses, rolls, etc. which are sometimes partly fibrous or diffuse and which may or may not be merged; most of the regularly arranged small elements usually have an apparent width of between 1 and 5°.

This genus can be confused with cirrocumulus and stratocumulus. If the cloud elements exhibit any shading, the cloud is altocumulus not cirrocumulus even if the elements have an apparent width of less the 1°. Clouds without shading are altocumulus if most of the regularly arranged elements, when observed at more than 30° above the horizon, have an apparent width of 1 to 5°. (Under similar conditions of observation, stratocumulus elements will have an apparent width of over 5°). Altocumulus sometimes produces descending trails of fibrous appearance (virga), and coronae and irisation are often observed in thin parts of the cloud.

Examples of altocumulus (genera and species/varieties) are:

Altocumulus ***stratiformis*** **(Ac** ***str*****)**

Figure 26. Altocumulus *stratiformis* (C_M3) (© S. Jebson).

Altocumulus ***stratiformis*** **(Ac** ***str*****)**

Figure 27. Altocumulus *stratiformis* (C_M5) (© S. Jebson).

Altocumulus *stratiformis* (Ac *str*) – in a single layer

Figure 28. Altocumulus *stratiformis* (C_M7) in a single layer (© S. Jebson).

Altocumulus *stratiformis* (Ac *str*) – at more than one level

Figure 29. Altocumulus *stratiformis* (C_M7) at more than one level (© M. Clark).

Altocumulus *stratiformis* (Ac *str*) – with altostratus or nimbostratus

Figure 30. Altocumulus *stratiformis* (C_M7) with altostratus or nimbostratus (© C.S. Broomfield).

Altocumulus *lenticularis* (Ac *len*)

Figure 31. Altocumulus *lenticularis* (C_M4) (© D. Moore).

Altocumulus *castellanus* **(Ac cas)**

Figure 32. Altocumulus *castellanus* (C_M8) (© M. Clark).

Altocumulus *floccus* **(Ac *flo*)**

Figure 33. Altocumulus *floccus* (C_M8) (© J. Bower).

Altocumulus ***cumulogenitus*** **(Ac cugen)**

Figure 34. Altocumulus *cumulogenitus* (C_M6) (© J.F.P. Galvin).

- Altocumulus of a chaotic sky

Altocumulus of a chaotic sky generally occurs at several levels. The sky is characterised by its heavy, stagnant appearance. There are more or less broken cloud sheets of poorly defined clouds of all transitional forms from rather low, thick altocumulus, to high, thin altostratus.

There is generally a mixture of low level and high level clouds also present in this type of sky.

Figure 35. Altocumulus – of a chaotic sky (C_M9) (© R.K. Pilsbury).

High cloud

High cloud forms are divided into three main groups, called genera. A given cloud belongs to only one genus. The genera, together with their accepted form of abbreviation, are:

- Cirrus (Ci)
- Cirrostratus (Cs)
- Cirrocumulus (Cc)

Each genera can be subdivided, according to their size and shape, into a number of species.

The genera, together with their associated species (or varieties in the case of altostratus), including their relevant international cloud symbol and WMO classification are:

Cloud genera and species	International cloud symbol	WMO classification
Cirrus *fibratus* (Ci *fib*)		C_H1
Cirrus *uncinus* (Ci *unc*)		C_H1
Cirrus *spissatus* (Ci *spi*)		C_H2
Cirrus *floccus* (Ci *flo*)		C_H2
Cirrus *castellanus* (Ci *cas*)		C_H2
Cirrus *spissatus* (Ci *spi*) – dense cirrus from cumulonimbus		C_H3
Cirrus *fibratus* (Ci *fib*) – progressively invading the sky		C_H4
Cirrus *uncinus* (Ci *unc*) – progressively invading the sky		C_H4
Cirrostratus (Cs) – below 45°		C_H5
Cirrostratus (Cs) – above 45°		C_H6
Cirrostratus *fibratus* (Cs *fib*) – covering the whole sky		C_H7
Cirrostratus *nebulosus* (Cs *neb*) – covering the whole sky		C_H7
Cirrostratus (Cs) – not covering the whole sky nor progressively invading it		C_H8
Cirrocumulus *stratiformis* (Cc *str*)		C_H9
Cirrocumulus *floccus* (Cc *flo*)		C_H9
Cirrocumulus *lenticularis* (Cc *len*)		C_H9

Figure 36. International cloud symbols and WMO classification for high cloud.

Examples of high cloud types

(Genera: cirrus, cirrostratus and cirrocumulus)

- Cirrus (Ci)

(Latin: *cirrus* – lock or tuft of hair)

Detached clouds in the form of white delicate filaments, or white or mostly white patches or narrow bands. These clouds have a fibrous (hair-like) appearance, or a silky sheen, or both.

Cirrus is whiter than any other cloud in the same part of the sky. With the sun on the horizon, it remains white whilst other clouds are tinted yellow or orange, but as the sun sinks below the horizon the cirrus takes on these colours too and the lower clouds become dark or grey. The reverse is true at dawn when the cirrus is the first to show colouration. It is of a mainly fibrous or silky appearance with no cloud elements, grains or ripples which distinguishes it from cirrocumulus. Cirrus is of a discontinuous structure and of limited horizontal extent which is the distinction between it and cirrostratus. Dense cirrus patches or tufts of cirrus may contain ice crystals large enough to fall to give trails of some vertical extent. If these crystals melt they appear greyish.

Examples of cirrus (genera and species) are:

Cirrus ***fibratus*** **(Ci** ***fib*****)**

Figure 37. Cirrus *fibratus* (C_H1) with Cumulus *mediocris* (C_L2) below (© S. Jebson).

Cirrus *uncinus* (Ci *unc*)

Figure 38. Cirrus *uncinus* (C_H1) with Cumulus *mediocris* (C_L2) below (© M. Clark).

Cirrus *spissatus* (Ci *spi*)

Figure 39. Cirrus *spissatus* (C_H2) (© M. Clark).

Cirrus *floccus* (Ci *flo*)

Figure 40. Cirrus *floccus* (C_H2) (© C.S. Broomfield).

Cirrus *castellanus* (Ci *cas*)

Figure 41. Cirrus *castellanus* (C_H2) (© J.F.P. Galvin).

Cirrus *spissatus* (Ci *spi*) – dense cirrus from cumulonimbus

Figure 42. Cirrus *spissatus* (C_H3) – dense cirrus from cumulonimbus (© S. Jebson).

Cirrus progressively invading the sky

Figure 43. Cirrus *fibratus* (C_H4) – progressively invading the sky (© M. Clark).

Figure 44. Cirrus *uncinus* (C_H4) – progressively invading the sky (© S.D. Burt).

Cirrostratus (Cs)

(Latin: *cirrus* – lock or tuft of hair; *stratus* – flattened or spread out)

Transparent whitish cloud veil of fibrous or smooth appearance, totally or partly covering the sky, and generally producing halo phenomena.

This cloud usually forms a veil of great horizontal extent, without structure and of a diffuse general appearance. It is composed almost entirely of ice crystals and can be so thin that the presence of a halo may be the only indication of its existence. Its apparent motion is slow, as are changes in its appearance and thickness. Cirrostratus, when not covering the whole sky, may have a clear-cut edge but more often it is fringed with cirrus. A veil of haze may sometimes have the appearance of cirrostratus but the haze veil is opalescent or has a dirty yellowish or brownish colour. Shadows will normally continue to be cast when the sun is shining through cirrostratus, at least when the sun is high; when the sun is less than about 30° above the horizon the relatively longer path through the cirrostratus veil may reduce the light intensity so much that shadows do not form.

Cirrostratus can be reported in four distinct World Meteorological Organization classifications, these are: C_H5, C_H6, C_H7 and C_H8. The specifications for each type are:

- C_H5 used when cirrus, often in bands, with cirrostratus, or cirrostratus on its own, progressively invading the sky, and growing denser as it does so, but the continuous veil of cloud does not reach 45° above the horizon.
- C_H6 used when cirrus, often in bands, with cirrostratus, or cirrostratus on its own, progressively invading the sky, and growing denser as it does so, with the continuous veil of cloud extending more than 45° above the horizon, although without the sky being totally covered.
- C_H7 used when a veil of cirrostratus nebulosus or cirrostratus fibratus covers the entire sky.
- C_H8 used when a veil of cirrostratus which neither covers the entire sky nor progressively invades it.

Examples of cirrostratus (genera and species) are:

Cirrostratus (below 45°)

Figure 45. Cirrostratus (C_H5) – below 45° (© M. Clark).

Cirrostratus (above 45°)

Figure 46. Cirrostratus (C_H6) – above 45° (© S.D. Burt).

Cirrostratus (covering the whole sky)

Figure 47. Cirrostratus *fibratus* (C_H7) – covering the whole sky (© M. Clark).

Figure 48. Cirrostratus *nebulosus* (C_H7) – covering the whole sky (© M. Clark).

Cirrostratus (not covering the whole sky nor progressively invading it)

Figure 49. Cirrostratus (C_H8) – not covering the entire sky nor progressively invading it (© J. Corey).

Cirrocumulus (Cc)

(Latin: *cirrus* – lock or tuft of hair; *cumulus* – heap)

This white patch, sheet or layer of cloud without shading, composed of very small elements in the form of grains, ripples, etc. merged or separate, and more or less regularly arranged; most of the elements have an apparent width of less than 1°.

This cloud often forms as a result of the transformation of cirrus or cirrostratus. It is rippled and subdivided into very small cloudlets without any shading. It is composed almost exclusively of ice crystals and can include parts which are fibrous or silky in appearance but these do not collectively constitute its greater part.

Care should be taken when a layer of altocumulus is dispersing that the small elements on the edge of the sheet are not confused with cirrocumulus.

Examples of cirrocumulus (genera and species) are:

Cirrocumulus *stratiformis* **(Cc str)**

Figure 50. Cirrocumulus *stratiformis* (C_H9) (© Crown).

Cirrocumulus *floccus* **(Cc flo)**

Figure 51. Cirrocumulus *floccus* (C_H9) (© J. Corey).

Cirrocumulus *lenticularis* **(Cc len)**

Figure 52. Cirrocumulus *lenticularis* (C_H9) (© J. Corey).

Supplementary features and accessory clouds

The indication of genus, species and variety is not always sufficient to describe the cloud completely. The cloud may sometimes have supplementary features or may be accompanied by other, usually smaller, clouds which are known as accessory clouds and which may be separate or partly merged with the main cloud. Supplementary features and accessory clouds may occur at any level of the cloud, above it or below it. One or more supplementary features or accessory clouds may occur simultaneously with the same cloud.

Definitions of the supplementary features are:

- **Virga** – (Latin: *virga* meaning rod)

  Vertical or inclined trails of precipitation (fallstreaks), attached to the under surface of a cloud, which do not reach the Earth's surface. This supplementary feature occurs mostly with stratocumulus, cumulus, cumulonimbus, altostratus, altocumulus, nimbostratus and cirrocumulus.

Figure 53. Virga falling out of altocumulus *castellanus* cloud (© J. Corey).

- **Mamma** – (Latin: *mamma* – udder)

  Hanging protuberances, like udders, on the under surface of a cloud. This supplementary feature occurs mostly with stratocumulus and cumulonimbus.

Figure 54. Mamma or mammatus cloud (© M. Clark).

- **Praecipitatio** – (Latin: *praecipitatio* meaning fall)

  Precipitation (rain, drizzle, snow, hail, etc) falling from a cloud and reaching the Earth's surface. (Although precipitation is normally considered a hydrometeor, it is treated here as a supplementary feature because it appears an as extension of the cloud.) This supplementary feature is mostly encountered with stratus, stratocumulus, cumulus, cumulonimbus, altostratus and nimbostratus.

Figure 55. Rain (praeciptatio) shower over Exeter (© M. Clark).

- **Arcus** – (Latin: *arcus* meaning arch)

  A dense horizontal roll, with more or less tattered edges, situated on the lower front part of certain clouds and having, when extensive, the appearance of a dark menacing arch. This supplementary feature occurs with cumulonimbus and, less often, with cumulus.

Figure 56. Arcus cloud (© M. Clark).

- **Incus** – (Latin: *incus* meaning anvil)

  The upper portion of a cumulonimbus spread out in the shape of an anvil, with a smooth fibrous or striated appearance.

Figure 57. Incus (© J.W. Warwicker).

- **Tuba** – (Latin: *tuba* meaning trumpet)

  Cloud column or inverted cloud cone (funnel cloud) protruding from a cloud base; it constitutes the cloudy manifestation of a more or less intense vortex.

  This supplementary feature occurs with cumulonimbus and, less often, with cumulus. The diameter of the cloud column, which is normally of the order of 10 metres, may in certain regions occasionally reach some hundreds of metres.

Figure 58. Tuba or funnel cloud (© M. Clark).

Definitions of accessory clouds are:

- **Pannus** – (Latin: *pannus* meaning shred)

  Ragged shreds, sometimes constituting a continuous layer, situated below another cloud and sometimes attached to it. This accessory cloud occurs mostly with cumulus, cumulonimbus, altostratus and nimbostratus.

Figure 59. Pannus (© C.S. Broomfield).

- **Pileus** – (Latin: *pileus* meaning cap)

  An accessory cloud of small horizontal extent in the form of a cap or hood above the top, or attached to the upper part, of a cumuliform cloud which often penetrates it. Pileus clouds may sometimes be observed one above the other. Pileus occurs principally with cumulus and cumulonimbus.

Figure 60. Pileus (© M. Clark).

- **Velum** – (Latin: *velum* meaning sail of ship)

  An accessory cloud veil of great horizontal extent, close above or attached to the upper part of one or several cumuliform clouds which often pierce it. Velum occurs principally with cumulus and cumulonimbus.

Figure 61. Velum (© R. Bird).

Special clouds

Nacreous and noctilucent clouds occur at high altitudes and may be observed from comparatively restricted geographical locations. Both may be seen from the British Isles but usually only in the higher latitudes.

- Nacreous clouds

  Nacreous clouds are a rare type of stratospheric cloud and were previously termed 'mother-of-pearl' clouds. These clouds are mainly observed in Scotland and Scandinavia but have occasionally been reported from Alaska and from France during periods of a strong west to north-west airstream. These clouds occur at an altitude between 21 and 30 km and require a temperature approaching -90 °C to form. Such a temperature is only likely to be approached occasionally during December, January and, less likely, February in the northern hemisphere.

  The clouds are somewhat lenticular in form, very delicate in structure, and show brilliant irisation at angular distances up to about 40° from the sun. Irisation reaches its maximum brilliance when the sun is several degrees below the horizon. Later, with the sun still further down, the various colours are replaced by a general coloration which changes from orange to pink and contrasts vividly with the darkening sky.

  Still later the clouds become greyish, then the colours reappear, though with greatly reduced intensity, before they finally fade out. Up to about two hours after sunset, the nacreous clouds can still be distinguished as tenuous grey clouds standing out against the starry sky. If there is moonlight, they may be visible throughout the night. Before dawn, this sequence is repeated in reverse order. By day, nacreous clouds often resemble cirrus. If, after sunset, cirrus and nacreous clouds coexist, the nacreous clouds still show bright colours after the cirrus has already turned grey. Nacreous clouds show little or no movement.

Figure 62. Nacreous cloud (© P.J.B. Nye).

- Noctilucent clouds

  Clouds resembling thin cirrus, but usually with a bluish or silvery colour, or sometimes orange to red; they stand out against the night sky.

  These clouds occur at great heights, about 80 km, and they remain sunlit long after sunset. They are visible only at night in that part of the sky where they are directly illuminated by sunlight and when the sky background is dark enough to permit their weak luminescence to be seen.

  Noctilucent clouds have been observed only in latitudes higher than 45° N. The northern limit is uncertain because of prevailing cloudiness and the lack of observing sites but is probably at least 80° N. At about latitude 55° N the clouds are seen most frequently in late June and early July. They are usually observed only in the summer months.

  Noctilucent clouds usually appear in the form of thin cirrus-like streaks, sometimes only one or two isolated filaments being visible while at other times the cloud elements are closely compacted into an almost continuous mass resembling cirrocumulus or altocumulus. Noctilucent clouds can usually be distinguished from ordinary clouds by the fact that they remain brighter than the sky background and glow with a pearly, silvery light, generally showing tinges of blue colouration.

Other clouds

- Pyrocumulus

  A term given to the cumulus cloud that forms over an intense source of heat on the ground, such as a heath or forest fire. It does not form part of the official WMO cloud classification and is, in any case, an unhappy mixture of Greek and Latin.

Figure 64. Pyrocumulus (© M. Kidds).

- Fumulus

  A term given to the cumulus cloud that forms over an intense source of heat such as a power station. Again, it does not form part of the official WMO cloud classification.

Figure 65. Fumulus (© J. Bower).

- Orographic clouds

  Cloud which is formed by forced uplift of air over high ground. The reduction of pressure within the rising air mass produces adiabatic cooling and, if the air is sufficiently moist, condensation. Lenticular wave clouds, including those formed well to leeward of the high ground, are common orographic clouds; stratus, cumulus and cirrus clouds are also sometimes orographic in origin.

Figure 66. Orographic stratus (© R.K. Pilsbury).

Figure 67. Orographic altocumulus lenticularis (standing wave cloud (© A. Gilkes).

Figure 68. Orographic cumulus (banner cloud) (© M.J.O. Dutton).

- Contrails (condensation trails)

  An initially thin trail of water droplets or ice crystals produced by an aircraft engine exhaust when the humidifying effect of the water vapour exceeds the opposed heating effect of the exhaust air (exhaust trail). Such trails generally broaden rapidly and evaporate as mixing with drier air proceeds; when the atmosphere is already moist, however, they may be very persistent.

Figure 69. Contrails (aircraft condensation trails) (© S. Jebson).

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