PREFACE TO THE 1939 EDITION

The first published classification of clouds only dates back to the beginning of the 19th century and was the work of Lamarck (1802). This celebrated naturalist did not set out to classify all possible clouds; he confined himself to distinguishing certain forms which seemed to him to be the manifestation of general causes which it would be useful to recognize. But this work, in spite of its real value, did not make any impression even in France and his nomenclature does not seem to have been used by anyone. Perhaps this was due to his choice of somewhat peculiar French names which would not readily be adopted in other countries or perhaps the paper was discredited through appearing in the same publication (Annuaire Meteorologique), as forecasts based upon astrological data.

One year later Luke Howard published in England a cloud classification which, in striking contrast, achieved very great success and which is the basis of the existing classification. Whereas Lamarck contented himself with defining and naming a certain number of interesting forms, Howard set out to establish a complete classification covering all possible cases. He distinguished three simple, fundamental classes-Cirrus, Cumulus, Stratus - from which all others were derived by transition or association. This conception is in some respects incorrect. If Cirrus and Cumulus are entitled to occupy a privileged position in the classification, the first representing the purest type of cloud formed of ice crystals in the high regions of the atmosphere, and the second being pre-eminently a cloud of liquid particles in the lower regions, what Howard calls Stratus does not constitute a type of the same order as the preceding two. It is not defined in terms relating to the physical state of its elements, and it may be found at any altitude. From a practical point of view, however, Howard arrived at much the same results as Lamarck. Four of Lamarck's five principal types appear under different names in Howard's nomenclature. It is remarkable that these two men, of such different scientific culture and never having come in contact with each other, should have arrived independently at such compatible results.

In 1840, the German meteorologist Kaemtz added Stratocumulus to Howard's forms, giving a precise definition which is in agreement with modern usage.

Renou, Director of the observatories at Parc Saint-Maur and Montsouris gave in his "Instructions météorologiques" (1855) a classification of clouds to which may be ascribed the definite origin of several names in the present nomenclature: Cirro-Cumulus, Cirro-Stratus, Alto-Cumulus and Alto-Stratus. He was the first to introduce the two latter types into the "Bulletin de l'Observatoire de Montsouris" and his example was soon followed by the observatory at Upsala. He thus introduced clouds of medium height between low clouds and those of the Cirrus family and began the development of the

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1 The preface to the 1939 edition was nearly identical with that of the 1932 edition. The modifications introduced into the text of the 1939 edition consisted of revised abbreviations of cloud forms, changes in the clouds code and changes in the symbols and descriptions of various weather phenomena.

2 In this brief historical note, much use has been made of Louis Besson's very interesting work: Aperçu historique sur la Classification des Nuages, Memorial de l'Office National Meteorologique de France, No. 2, Paris 1923.
idea which resulted in the adoption of height as a criterion, established later by Hildebrandsson. To him is also due the definite distinction at different levels between detached and continuous clouds.

In 1863, Poey, who took observations at Havana, made known some original ideas which did not perhaps receive as much respect as they deserved, firstly because good and bad were so closely associated in them and also because he set out to create a classification of all types, without any reference at all to the main outlines which since Howard had been slowly but surely emerging from the successive attempts in Europe. It should, however, be remembered that credit is due to him for defining Fracto-Cumulus, some radiatus varieties (under the name of Fracto-) and mammatus varieties (under the name of Globo-). In particular, he described very clearly the central sky in a depression by distinguishing the two layers, one above the other: the sheet of Altostratus (under the name of Pallia-Cirrus) and the layer of Fractostratus or of Fractocumulus (under the name of Pallia-Cumulus).

In 1879, Hildebrandsson, Director of Upsala Observatory, was the first to use photography in the study and classification of cloud forms. In his work entitled: "Sur la classification des nuages employee a l'Observatoire Meteorologique d'Upsala", he included an atlas of 16 photographs. The classification adopted was that of Howard with a few modifications. These changes concerned especially Nimbus, which was not assigned to every rainy cloud complex (notably not to Cumulo-Nimbus), but only to the dark, lower layer of a rainy sky, Stratus which was assigned to fog raised from the ground and remaining at some distance from the Earth and Cumulo-Stratus which, following Kaemtz's example, was assigned to heavy, heaped up masses of Cumulus; from Kaemtz, Hildebrandsson also adopted Strato-Cumulus. In his first work, Hildebrandsson kept closely to his desire to adhere to Howard's plan, but at the same time took later works into consideration.

A little later, Weilbach and Ritter proposed classifications too greatly divergent from Howard's (which in the main had already been generally accepted) to have any chance of success - as happened later in the case of those of Maze, Clayton and Clement Ley. Credit is, however, due to these authors for interesting definitions of species (subdivisions of large genera) or of varieties (particular aspects to be observed at different heights) and to Weilbach for the introduction of Cumulo-Nimbus or thunder cloud, clearly distinguished from Cumulus even when "compositus".

Finally in 1887, Hildebrandsson and Abercromby published a classification of clouds in which they endeavoured to reconcile existing customs and, while keeping to Howard's scheme, to effect an inclusion of later acquisitions, notably those due to Renou (introduction of Alto-Cumulus and of Alto-Stratus, distinction at each stage between the detached and continuous forms) and to Weilbach (introduction of Cumulo-Nimbus, the allocation of Cumulus and thundery clouds to a distinct family). Abercromby had previously made two journeys round the world (thus giving a fine example of scientific probity) in order to assure himself that the cloud forms were the same in all parts - a fact that is, however, only true as a first approximation. One of the principal characteristics of this classification is the importance attached to height as a criterion, since in the opinion of the authors the foremost application of cloud observations was the determination of the direction of the wind at different altitudes. They grouped the clouds in four levels, the mean heights of which they fixed provisionally from measurements made in Sweden. The international classification was the direct offspring of Hildebrandsson's and Abercromby's classification without any great modification.

The International Meteorological Conference, held at Munich in 1891, expressly recommended these authors' classification and gave its sanction to the appointment of a special committee entrusted with its final consideration and publication with illustrations in atlas form. This committee met at Upsala in August 1894 and proceeded to choose the illustrations to be
reproduced. With this object in view, an exhibition of more than three
d Hundred cloud photographs or sketches had been arranged. The publication
commission, consisting of Hildebrandsson, Riggenbach and Teisserenc de
Bart, had to contend with great technical and more particularly financial
difficulties. In the end, Teisserenc de Bort took upon himself the sole
responsibility for the production of the atlas which appeared in 1896. This
work contained 28 coloured plates accompanied by a text in three languages
(French, German, English) giving definitions and descriptions of the clouds
together with instructions on how to observe them.

The classification laid down in the International Atlas soon became official
and came into almost general use in all countries. Nearly all meteorologists who
subsequently published cloud studies adopted this nomenclature; but
frequently it was found to be lacking in details; thus a number of meteorologists
- notably Clayden and Vincent - were led to create new species or varieties
without interfering with the primary forms.

Thus, thanks to a sustained effort, initiated by Howard, continued by
Renou and then by Hildebrandsson and the International Meteorological
Committee, an end was made to the confusion which had reigned for nearly
a century in one of the most important domains of meteorology.
The first International Atlas constituted a great advance by making cloud
observations throughout the world truly comparable with one another.

The 1910 reprint, which contained only slight modifications, had been
exhausted for many years when the International Commission for the Study
of Clouds was created in London in 1921. The President, Sir Napier Shaw,
started the revision of the classification by bringing forward for discussion a
memoir in which he gave his own personal ideas and appealed to all members
to make suggestions; the enquiry thus set on foot grew so rapidly that in 1925,
Sir Napier Shaw's successor thought it necessary to concentrate all the
activities of the Commission upon the problem of the revision of the
International Atlas.

This task had become necessary for several reasons. First of all, there
was a very practical reason: it was becoming urgent that the observers should
be supplied with new atlases lest the quality of the observations should
degenerate and differences of interpretation reappear. But, in addition to this
practical reason, there were also deeper ones: the work of 1896, remarkable
as it had been at the time, was evidently not perfect. From the single, but
essential point of view of the standardization of observations, the experience
of thirty years had revealed several gaps and instances of lack of precision,
which had led to incompatible traditions in different nations as regards certain
points. Moreover, meteorology had developed considerably, especially since
aviation had become general. When Teisserenc de Bort and Hildebrandsson
published the first atlas, the principal problem they had in mind was the
general circulation; they considered the clouds above all as aerial floats,
capable of revealing upper currents, and were intent upon producing a
classification which would make the different types of clouds correspond with
heights determined as exactly as possible. But since that period,
meteorologists had become more and more interested in clouds as such. The
multiplication of cloud observations and the extended data included in
synoptic messages - which received due recognition in the new international
code, Copenhagen 1929 - made possible direct synoptic studies of their
distribution and paved the way for the idea of "sky" and "cloud system", the
value of which had been clearly demonstrated by the International Cloud
Week, organised by the Commission for the Study of Clouds in 1923.

Observations from aeroplanes made familiar cloud aspects which were
previously unknown, made them known more intimately and more completely;
finally, new theories normally based upon the hydrodynamical and
thermodynamical interpretation of soundings determined their physical
signification and their role in disturbances. These new and very interesting
points of view had to be definitely recognised.

When the Commission for the Study of Clouds met in Paris in 1926 to
take account of the results of the vast enquiry which it had inaugurated and to
lay the foundations of a new atlas, it found itself confronted by an abundance
of literature and very diverse suggestions. Very wisely, it adopted the
principle that it should only touch with extreme caution a classification which
had stood the test of years and been received as it were with unanimous
agreement by our predecessors. It decided to make only such modifications
as were necessary to dissipate misunderstandings and further the uniformity
of observations, at the same time, however, laying less stress upon the
importance of height as a basis of classification.

While recognizing the necessity of paving the way for a secondary
classification, it took care not to attempt its completion nor to subdivide
excessively the main categories henceforth called "genera"; it made a rule
only to introduce "species" which were generally accepted by all, leaving the
way clear for progressive additions in future. Having thus given witness to a
prudent, conservative spirit and placed the work of 1896 in a secure position,
the Commission for the Study of Clouds proceeded, on the other hand, to
give practical satisfaction to the new spirit. Having from the outset considered
it premature to attempt a cloud classification based upon physical properties
- reserving the study of that question until after a new International Cloud Year
(conceived in connection with and to be realized at the same time as the Polar
Year 1932-1933) - it adhered to this attitude and refused to rely upon any
theory, however attractive it might appear. Nevertheless, it decided to put on
record information which had been acquired by observation in the sky or on
the charts. Thus it was resolved to include:

(1) A chapter on the observation of clouds from aircraft for which the
well-known work of Mr. C.K.M. Douglas, aviator as well as meteorologist, was
largely drawn upon;

(2) A classification of "types of skies", based upon the cloud structures in
depressions, as emerging from the work of the Norwegian and French
schools; in order to mark the importance of this innovation, the title of the Atlas
was altered to "International Atlas of Clouds and of Types of Skies".

The Commission for the Study of Clouds met a second time in Zurich in
September 1926 to make definite arrangements for the projected atlas.
Meanwhile, an imposing collection of photographs of clouds, skies and aerial
views - borrowed mainly from the collections of Messrs. Cave, Clarke and
Quenisset and of the Fundacio Concepicio Rabel - had been assembled to
provide abundant illustrations for the atlas.

In order that the Commission's project should be subjected to the widest
criticism before the final atlas was undertaken, the Director of the French
Office National Meteorologique decided to issue at the expense of his Office
the Commission's project in the form of a "Provisional Atlas". The wide
distribution of this atlas answered the purpose perfectly; remarks and
suggestions flowed in from all parts of the world. These numerous documents
were examined at Barcelona in 1929 by the Commission and all the
suggestions were examined and classified with great care. The illustration of
the Atlas was also carefully reviewed and the Commission's task in this
respect was facilitated to an extraordinary extent by the magnificent exhibition
of cloud photographs arranged by the Fundacio Concepicio Rabel at the time
of the meeting.

The Commission for the Study of Clouds met again at Copenhagen in
September 1929 at the time of the meeting of the Conference of Directors.
The suggestions received since the meeting at Barcelona were considered and the final scheme agreed, except for a few details. It was proposed that an extract of the Complete Atlas for the use of the observers should be published quickly in order to facilitate the application of the new International Code, in which observations of the types of skies figured largely.

The question of publication could be approached in exceptionally favourable circumstances, thanks to the truly magnificent gift of a Catalonian Maecenas, Rafael Patxot, to whom cloud science was already indebted for the interesting work of the Fundacio Concepcio Rabel; this generous contribution made it possible to print 1,000 free copies of the Complete Atlas and to offer it, as also the abridged edition, for sale at a very low price. A Sub-Commission was appointed, with Professor Süring as President, to prepare a programme for the Cloud Year and to study the physical processes of cloud formation and evolution with a view to compiling eventually an appendix to the General Atlas. Two other appendices were suggested, one on tropical clouds, the other on special local formations and the preparation of these two parts was delegated to Dr. Braak and Dr. Bergeron respectively. The Conference of Directors approved the Commission’s propositions in their entirety and delegated its powers, as far as the production of the atlas was concerned, to a special Sub-Commission.
The work was carried out largely at Paris in the course of 1930 by Messrs. Süring, Bergeron, and Wehrle. The German and English translations were prepared by Dr. Keil, Mr. Cave and the Meteorological Office, London. The abridged edition finally appeared in 1930, just before the new code came into force. Another year was required to finish the illustrations of the Complete Atlas and the chapters not included in the abridged edition. Meanwhile, the Süring Sub-Commission had held meetings at Brussels (December 1930) and at Frankfurt (December 1931), and it seemed opportune to incorporate in the Complete Atlas a part of the work relating to the observation of clouds and hydrometeors.

The book now appearing bears the sub-title: "I. General Atlas" (the second and following volumes will consist of the appendices to be published later) and consists of a text and a collection of 174 plates.

The text is divided into five sections:

1) CLOUDS — The amended text of the old Atlas. The principal modifications are:

(a) the definition of Cirrocumulus which is more restricted than formerly;
(b) the distinction between Cumulus and Cumulonimbus; the latter being characterised by ice crystals in its summit or by showers;
(c) the distinction between Altocumulus and Stratocumulus;
(d) the introduction of Nimbostratus (low Altostratus) in order to avoid confusion (due to the equivocal definition of Nimbus) between the low, rainy layer resulting from the downward extension of Altostratus and the very low, closely packed clouds (Fractostratus or Fractocumulus of bad weather) which often form beneath the Altostratus or the above-mentioned low layer.

The commentaries to the definitions have been considerably enlarged in the form of "Explanatory remarks", written from a very practical standpoint with special reference to the needs of observers and stressing the distinctions between kindred forms. In some cases, species have been introduced but as previously stated this secondary classification is intentionally limited to cases on which there is unanimous agreement; it is moreover considerably simplified by the addition of a certain number of varieties common to different levels. In order to mark the fact that the names of the clouds have become symbols, the etymology of which should not be unduly stressed, they have in all cases been written as a single word.

2) CODE — The second part consists of a practical and detailed commentary for the use of observers, with explanatory remarks concerning the general arrangement and hints how to avoid confusion in the specifications of the new code of low, middle and high clouds; it would perhaps be more appropriate to call it a code of the types of skies, since the arrangement of cloud masses in the sky plays an essential role in it and it has been conceived in such a fashion that all types of sky classified in the fifth part can be represented by the combination of three figures.

It was thought best to abstain from all "synoptic" considerations in the text, the observer being supposed to ignore the general situation; nevertheless, it is not desirable that he should be deprived entirely of the real help to be derived from connecting the type of sky with the evolution of disturbances. There will therefore be found at the end of this section a diagram showing where the different lower, middle and upper skies specified in the code are situated relative to a disturbance.

3) CLOUD DIARY — This section, which has been inserted at the suggestion of Dr. Bergeron, has been taken from the papers prepared by the Suring Sub-Commission for the Cloud Year. It includes a model table for noting cloud observations and detailed instructions of how entries should be made in it. These are supplemented by precise
descriptions of different hydrometeors or weather phenomena, a subject which has given rise to divergent national traditions and in which there was need of amendment and unification.
(4) OBSERVATION OF CLOUDS FROM AIRCRAFT - As the classification of clouds is based upon their appearance as seen from the ground, it seemed useful to add a note on their appearance from the point of view of the observer in an aircraft, inasmuch as the more complete knowledge which he may acquire from the fact that he can get near to and on top of them (at least, in the case of lower and middle clouds) makes it possible to simplify the classification considerably by including only the really essential distinctions in structure. The increase in the number of meteorological flights especially in connection with temperature soundings, necessitated the inclusion of this chapter.

(5) TYPES OF SKIES - The enumeration of the genera or even of the species of clouds in the sky at a given moment does not suffice to characterize the type of sky, that is to say, to specify precisely the sector of the disturbance affecting the place of observation and, in consequence, it does not indicate the general character of the "weather". What really characterizes the type of sky is the aggregate of individual clouds and their organization. A special classification of skies is therefore needed which, while being in accordance with the experience of qualified observers, shall also be consistent with the nature of the physical processes and the structure of disturbances. In addition, such classification facilitates the identification of cloud genera and in certain cases (especially in thundery conditions) it compensates, at least in parts, for vagueness.

Collection of plates - The total number of plates is 174 (101 photographs taken from the ground, 22 from aeroplanes and 51 for types of sky), 31 of which are in two colours. Two colours are used where there is occasion to distinguish the blue of the sky from the shadows of the clouds. Most of these are included in the abridged edition, which is intended for the use of the general mass of observers who need detailed guidance. Each plate is accompanied by explanatory notes and a schematic representation on the same scale as the photograph, setting out its essential characteristics.

Thanks to the generosity of Mr. Cave, who has done so much for cloud science, the appendix dealing with tropical clouds edited by Dr. Braak, constituting Volume II of the complete work, has already appeared in French in connection with the requirements of the Polar Year. It is hoped that the appendix dealing with special clouds, constituting Volume III will appear soon. This will include, in particular, Professor Stormer's beautiful photographs of stratosphere clouds. Finally, it is also hoped that the results of the Cloud Year will enable the Sühring Sub-Commission to prepare a fourth volume dealing with the physical processes involved in the formation of clouds, which will be epoch-making in the history of meteorology.

E. DELCAMBRE,
President of the International Commission for the Study of Clouds.
PREFACE TO THE 1956 EDITION

The International Commission for the Study of Clouds (C.E.N.) of the International Meteorological Organization (I.M.O.), created in 1921, was dissolved by the Extraordinary Conference of Directors (London, 1946). It was replaced by the Committee for the Study of Clouds and Hydrometeors (C.C.H.), established by the International Meteorological Committee of the International Meteorological Organization in compliance with a resolution of the Commission for Synoptic Weather Information (Resolution 16, C.S.W.I., Paris, 1946). The Conference of Directors of the International Meteorological Organization instructed the C.C.H. to prepare a revised and up to date version of the International Atlas of Clouds and Types of Skies (Resolution 153, CD, Washington 1947). The decision to prepare a new atlas was inspired, on the one hand, by the exhaustion of the previous 1939 edition and, on the other hand, by new developments in our knowledge of clouds and hydrometeors, as well as by modifications in international cloud codes.


An Editing Committee, consisting of M. Mezin (President), R. Beaufils (Secretary), R. Beaulieu, Bessemoulin and M. Bonnet, prepared documents between sessions.

In 1951, when the I.M.O. was replaced by the World Meteorological Organization (W.M.O.), the Committee for the Study of Clouds and Hydrometeors proposed to the First Congress of W.M.O. that the new edition of the Cloud Atlas should consist of four volumes and it presented a draft of Volumes I, II and III. Volumes I and III covered essentially the same ground as Volume I of the present Atlas and Volume II was a collection of photographs of clouds and meteors. Volume IV was intended to be a treatise on the physics of clouds and meteors.

The First Congress of the World Meteorological Organization decided (Resolution 18, Cg-I) to refer the draft to the Commission for Synoptic Meteorology (C.S.M.) for further study and completion. The Committee for the Study of Clouds and Hydrometeors itself became a "Working Group for the Study of Clouds and Hydrometeors" attached to the Commission for Synoptic Meteorology (Resolution 35, Cg-I).

The contents of the Atlas and plans for its publication were discussed at the Second and Third Sessions of the Executive Committee (Lausanne, 1951; Geneva, 1952). It was decided that an Abridged Atlas in one volume consisting of a condensed text and a selection of photographs, for the use of surface observers, and an Album designed to meet the limited but special needs of airborne observers, should also be prepared (Resolution 9, EC-II; Resolution 36, EC-III).

The Working Group for the Study of Clouds and Hydrometeors presented to the First Session of C.S.M. (Washington, 1953) an improved version of the original draft submitted to Congress. The improvement resulted from further study at various sessions of the Working Group and from remarks received from members of the Commission to whom copies had been distributed.

The Commission for Synoptic Meteorology recommended (Recommendation 49, 'CSM-1) that the Complete Atlas should consist of only two volumes (Volume I...
containing the text and Volume II the plates). It also formally recommended the
publication of an Abridged Atlas and of an International Cloud Album for airborne
observers. Finally, C.S.M. considered that a compendium on the physics of clouds
and meteors, though highly desirable, should not at present form part of the Cloud
Atlas.
The Working Group for the Study of Clouds and Hydrometeors was dissolved by C.S.M. However, a few individuals were requested to continue and to complete the work of the Committee for the Study of Clouds and Hydrometeors.

At its Fourth Session (Geneva, 1953), the Executive Committee adopted Recommendation 49 of C.S.M. and directed the Secretary-General to take the necessary steps, in consultation with the President of C.S.M. when required, for an early publication of the Atlas (Resolution 30, EC-IV).

The English text was then passed to Mr. E.G. Bilham for editing, in accordance with the wishes of the Commission for Synoptic Meteorology and a decision by the Executive Committee.

During the translation of the text of the Complete Atlas into French, for which Mr. J. Bessemoulin was responsible in accordance with a request by C.S.M., it became obvious that many parts required thorough revision. A special editing committee was then established consisting of the following persons: Dr. W. Bleeke, Dr. M.A. Alaka, Mr. R. Beaufils and Mr. J. Bessemoulin. This committee met several times in Geneva and in De Bilt and established the final English and French texts.

The President of the Commission for Synoptic Meteorology accepts responsibility for the changes thus made in the original text which was studied at the First Session of the Commission; these changes were necessary in order to avoid ambiguities and internal inconsistencies.

The content of the present Volume I, which is essentially descriptive and explanatory, differs materially from that of the former "General Atlas".

The grouping of clouds into "cloud families" has been abandoned; the classification into genera has been maintained but some details in the definitions have been modified.

The species and the varieties have been extended and considerably modified. The same remark applies to the "accidental details" which have been renamed "supplementary features" and "accessory clouds". A new concept, that of "mother-cloud", has been introduced.

Certain "special clouds" are discussed separately; a brief description is given of the most important of these clouds, such as nacreous clouds, noctilucent clouds, etc.

The "Note on the Observation of Clouds from Aircraft" of the former General Atlas has been replaced by a chapter describing the particular appearance presented by clouds when they are observed from aircraft.

The part "Types of Skies" of the former General Atlas has been deleted. New points of view have arisen and existing ideas, particularly with regard to tropical skies, are in the course of evolution, thus making it difficult to synthesize the various existing concepts.

The chapter "Definition of Hydrometeors" of the former General Atlas has been considerably expanded. The former classification of hydrometeors has been replaced by a classification dividing meteors into four groups. The term "hydrometeors" designates the first of these groups, and applies solely to aqueous meteors. The descriptions of the hydrometeors are based mainly on those adopted at Salzburg in 1937. The other groups of meteors are "lithometeors", "photometeors" and "electrometeors".

The parts intended primarily for the use of observers have also been expanded.
Part III contains more elaborate instructions for observing clouds and meteors. Part IV gives two models of a "Journal of clouds and meteors". Part V contains detailed instructions and pictorial guides for the coding of clouds.

The final change consists of the addition of Appendices providing information of a general nature and an Alphabetical Index to simplify consultation of the Atlas.

Volume II is a collection of 224 plates in black and white and in colour, the object of which is to illustrate the text of Volume I. The plates consist of photographs of clouds (viewed from the Earth's surface and from aircraft) and of certain meteors; each photograph is accompanied by an explanatory legend.

The French Meteorological Service has contributed materially to the preparation of the texts and the photographic plates and their legends. The Netherlands' Meteorological Service also gave considerable assistance during the final stages of the preparation of the Cloud Atlas.

The undersigned who have been closely connected with the preparation and publication of the Cloud Atlas wish to thank all those who have contributed to the texts, and in particular Messrs. J. Bessemoulin and R. Beaufils of the French Meteorological Service and Dr. M.A. Alaka of the Secretariat of W.M.O., for their enthusiastic assistance during the final phase of the composition of the text. They also thank all the persons who provided photographs to illustrate the International Cloud Atlas.

W. BLEEKER, President of the Commission for Synoptic Meteorology

A. VIAUT, President of the Committee for the Study of Clouds and Hydrometeors
De Bilt, Paris, 4 April 1956.
PREFACE TO THE 1975 EDITION OF VOLUME I

The previous edition of the International Cloud Atlas, which appeared in 1956, consisted of two volumes: Volume I, containing a descriptive and explanatory text, and Volume II, containing a set of plates intended to illustrate the text. The present publication is a new edition of Volume I designed to replace the original edition. The preface describes the circumstances which led to the decision to publish a new edition and pays tribute to the numerous meteorologists who have devoted part of their time and efforts to the preparation of this new, and greatly improved, version of the text of the Atlas.

At its fourth session (Wiesbaden, 1966), the Commission for Synoptic Meteorology (CSM) examined the replies received from Members to an inquiry on the visibility criteria used for reporting mist and fog and also on the question of whether mist and fog should be considered as one and the same hydrometeor. It is pointed out in this connexion that, in the 1956 edition of the International Cloud Atlas, these phenomena were treated as two distinct hydrometeors.

CSM considered that mist and fog were produced by the same processes and that they should be regarded as one and the same hydrometeor, on the understanding, however, that the terms "fog" and "mist" might continue to be used to denote different intensities of the phenomenon, the term "mist" being synonymous with a slight fog, and the visibility limit of 1 000 metres, used hitherto, being maintained as a criterion of intensity.

At the same session, CSM also examined a proposal to revise the definitions and descriptions of hydrometeors contained in the 1956 edition of the International Cloud Atlas. The reason for the proposal was that there had been important advances in the physics of hydrometeors since CSM had recommended the use of the descriptions.

The Commission agreed that such a review was needed, particularly as regards hydrometeors appearing in polar and mountainous areas. For this purpose it decided to set up a Working Group on Description of Hydrometeors (Resolution 8 (CSM-IV)) composed of the following members: L. Dufour (Belgium), chairman of the group and representative of the Commission for Aerology, G. A. Gensler (Switzerland), E. Hesstvedt (Norway), H. D. Parry (United States of America), B. V. Ramanamurthy (India) and A. Rouaud (France).

The group recommended, in the first place, that a cloud should be classified as a hydrometeor, which would call for a change in the definition of "cloud", which did not refer to such a classification. The definition of "meteor" also had to be changed, because the latter had hitherto been defined as "a phenomenon other than a cloud ...". The group also reviewed all the definitions and descriptions of hydrometeors other than clouds.

Following the recommendations made by the Working Group on Description of Hydrometeors set up by Resolution 8 (CSM-IV), CSM recommended, at its fifth session (Geneva, 1970), that the revised definitions and descriptions of hydrometeors other than clouds should be adopted and that Volume I of the International Cloud Atlas should be amended accordingly (Recommendation 41 (CSM-V)). At its twenty-second session, the Executive Committee approved this recommendation and requested the Secretary-General of WMO to arrange for the publication of the revised text (Resolution 14 (EC-XXII)).

In view of the fact that the 1956 edition of Volume I of the International Cloud Atlas was out of print and that the principle adopted by Sixth Congress to the effect that any publication constituting an annex to the Technical Regulations -which was partially true of Volume I of the Atlas - should be transformed into a Manual, the Advisory Working Group of the Commission for Basic Systems (CBS-formerly the Commission for Synoptic Meteorology (CSM)) considered, at its second session (Geneva, "1971), that a preliminary draft of a new edition of the volume should be prepared, containing, in principle, only such texts as had the legal status of provisions of the Technical Regulations, including, of course, the revised definitions adopted by CSM at its fifth
In accordance with the above-mentioned decision of the CBS Advisory Working Group, an expert (Mr. A. Durget, France) was invited to revise Volume I of the International Cloud Atlas. At its sixth session (Belgrade, 1974), CBS recommended that the draft revised text should be published to replace the 1956 edition and that the Secretary-General should be requested to arrange for the publication of an appropriate amendment to the Abridged Atlas to bring it into line with the new edition of Volume I of the International Cloud Atlas (Recommendation 18 (CBS-VI)). At its twenty-sixth session, the Executive Committee approved this recommendation and requested the Secretary-General to implement it (Resolution 3 (EC-XXVI)).

During his work on the revision of the Atlas, the expert decided that it was virtually impossible, and certainly not desirable, to exclude from the Atlas those parts of the 1956 edition which did not have the legal status of the provisions of the Technical Regulations. Some of those parts could not, in fact, be separated from the passages to which they referred and which were retained as being provisions of the Technical Regulations without their deletion seriously affecting the clarity and consistency of the work. Other parts not having the status of Technical Regulations and whose inclusion in the Atlas was not strictly speaking indispensable deserved none the less to be maintained in view of their great value for users of the Atlas. Part IV, however, of the 1956 edition of Volume I - entitled "Journal of clouds and meteors" - had not been included in the new edition since it was not of international interest.

Since the two volumes of the International Cloud Atlas are well known under this title, the same title has been retained for the present edition. But for reasons of consistency with other WMO publications constituting annexes to the Technical Regulations and accordingly described as "Manuals", this publication also bears the subtitle "Manual on the observation of clouds and other meteors".

Moreover, those parts of the book having the legal status of Technical Regulations are distinguished from the rest by a different type of print. Similarly, a system of paragraph numbering similar to that used in the Technical Regulations has been employed.

As a consequence of the adoption of the new definition of "cloud", which is now regarded as a hydrometeor, and having regard to the corresponding change in the definition of "meteor", it was thought necessary to re-arrange the layout of the Atlas completely, by changing the order of the parts and chapters so as to give the definitions of "meteor" and "hydrometeor" before dealing in detail with clouds and other meteors.

The present edition of Volume I thus consists of three parts. The first, in addition to the new definition of "meteor", contains a general classification of meteors into hydrometeors (including clouds), lithometeors, photometeors and electrometeors, as well as definitions of each of these four groups of phenomena. These various texts have been taken from Chapter I of Part II of the 1956 edition of Volume I, taking into account, in their wording, the new concepts set forth in Recommendation 41 (CSM-V) approved by Resolution 14 (EC-XXII).

Part II deals exclusively with clouds. It recapitulates, with a few essentially drafting changes, the various chapters dealing with clouds in the 1956 edition of Volume I: definition of a cloud and classification of cloud; definitions of the genera, species and varieties, etc., of clouds; descriptions of clouds; orographic influences; clouds as seen from aircraft; special clouds; observation of clouds from the Earth's surface; the coding of clouds in the codes $C_L$, $C_M$ and $C_H$ and the corresponding symbols.

Part III deals with meteors other than clouds. It consists of three chapters: classification of, and symbols for, meteors other than clouds; definitions and description of meteors other than clouds; and observation of these meteors from the Earth's surface. The texts relating to hydrometeors have been introduced in the new version given in Recommendation 41 (CSM-V), with certain drafting amendments.
The three appendices to the 1956 edition of Volume I, namely: Appendix I - Etymology of Latin names of clouds, Appendix II - Historical bibliography of cloud classification, and Appendix III - Bibliography of cloud nomenclature, have been maintained unchanged in the present edition of the Atlas. The alphabetical index of words and expressions has also been maintained with appropriate updating.

On behalf of the World Meteorological Organization, I should like here to express my gratitude to Mr. L. Dufour and to the members of his working group, as well as to Mr. A. Durget, for their valuable contributions to the preparation of this edition of the volume.

D. A. DAVIES
Secretary-General
FOREWORD TO THE 1987 EDITION OF VOLUME II

With this new, thoroughly revised edition of Volume II of the International Cloud Atlas a key publication is once again made available for professional meteorologists as well as for a wide circle of interested amateurs. For meteorologists this is a fundamental handbook, for others a source of acquaintance with the spectacular world of clouds.

The present internationally adopted system of cloud classification is the result of work which started in the nineteenth century. The first studies on the topic were published by J. B. Lamarck (1802) and L. Howard (1803). The first attempt to use photography for cloud classification was made by H. Hildebrandsson (1879), in Uppsala, who prepared a cloud atlas of 16 photographs. The further development of this work, following the recommendation of an International Meteorological Conference which took place in Munich in 1891, resulted in the publication in 1896 of the first International Atlas, containing 28 coloured plates accompanied by definitions and descriptions of clouds and instructions on cloud observations in three languages (French, German, English). The first International Atlas, which was then adopted in almost all countries, was a great step forward in making internationally comparable cloud observations. This Atlas was reprinted in 1910, without substantial amendments. The subject of further refinement of cloud classification still remained to the fore, however, during the following decades. As a result the International Atlas of Clouds and Study of the Sky, Volume I, General Atlas was published in 1932 by the International Commission for the Study of Clouds. A modified edition of the same work appeared in 1939, under the title International Atlas of Clouds and of Types of Skies, Volume I, General Atlas. The latter contained 174 plates: 101 cloud photographs taken from the ground and 22 from aeroplanes, and 51 photographs of types of sky. From those photographs, 31 were printed in two colours (grey and blue) to distinguish between the blue of the sky and the shadows of the clouds. Each plate was accompanied by explanatory notes and a schematic drawing on the same scale as the photograph, showing the essential characteristics of the type of cloud.

When the World Meteorological Organization (WMO) came into being in 1951 in place of the non-governmental International Meteorological Organization, the First Meteorological Congress noted the need for a new International Cloud Atlas and referred the task to the Commission for Synoptic Meteorology. Within a relatively short time very substantial work was accomplished and the new Atlas was published in 1956 in two volumes: Volume I contained a descriptive and explanatory text on the whole range of hydrometeors (including clouds), lithometeors, photometeors and electrometeors; Volume II contained a collection of 224 plates (123 in black and white and 101 in colour) of photographs of clouds and of certain meteors. Each photograph in Volume II was accompanied by an explanatory text, to enable the pictures in Volume II to be understood without the detailed technical definitions and descriptions contained in Volume I.

The 1956 edition of Volume II has not been reprinted or revised until the preparation of the present edition. A revised version of Volume I, however, was published in 1975 under the title Manual on the Observation of Clouds and Other Meteors. In the meantime there have been substantial advances in techniques of cloud photography and a growing requirement for more photographs taken at locations outside Europe.

In 1981 a WMO Informal Planning Meeting on Volume II of the International Cloud Atlas drew up a plan for the preparation of a new edition. It recommended the deletion of 26 black-and-white plates and eight in colour, and their replacement by 41 new colour plates selected from a large number of photographs received from various countries. The section containing illustrations of certain meteors was also expanded by the addition of nine more plates. The legends for the new plates selected by the Informal Planning Meeting were edited by the chairman of the meeting, Mr. R. L. Holle,
of the U.S. National Oceanic and Atmospheric Administration, and those for the new
plates in the section on meteors by Mr. C. S. Broomfield, of the U.K.
Meteorological Office.

Later it became apparent that many of the original photographs of the 1956
edition had deteriorated with time to an extent excluding the possibility of their inclusion
in the new edition. Moreover, it was felt that the geographical distribution of the
photographs was still somewhat restricted and that the balance between the various
sections could be improved. With the approval of the president of the Commission for
Basic Systems, it was therefore decided to revise the Atlas extensively, bearing in
mind the urgent requirement for the new edition, and Mr. Holle kindly agreed to
undertake this complex task, including the soliciting at short notice of new photographs
from specialists. The final editorial work was carried out by the WMO Secretariat. The
result of the work, the present Volume II of the International Cloud Atlas, contains 196
pages of photographs, 161 in colour and 35 in black and white. Each illustration is
accompanied by an explanatory text.

The excellent work of the consultants and the authorization willingly given by all
contributors for publication of photographs in both the original volume and this new
edition are gratefully acknowledged. Particular thanks are due to the printer, whose
painstaking work permitted much of the original material to be conserved and blended
harmoniously with the new contributions.

It is felt that this new edition of the Atlas, besides being a most valuable reference
work for meteorologists and those working in aviation, in agriculture and at sea, will
also be a fascinating addition to the amateur's bookshelf.

(G.O.P. Obasi)
Secretary-General
PREFACE TO THE PRESENT EDITION

[To be provided prior to publication]
INTRODUCTORY NOTE

Certain parts of this publication constitute Annex I to the Technical Regulations and have the legal status of standard practices and procedures.

The sections, paragraphs and sub-paragraphs having the status of an Annex to the Technical Regulations, except for the footnotes, are numbered in bold type. In Chapter III.2 only the definitions printed in italics have this status.
PART I – METEOROLOGICAL METEORS: DEFINITION AND GENERAL CLASSIFICATION
I.1 - METEOROLOGICAL DEFINITION OF A METEOR

In meteorology, a phenomenon observed in the atmosphere or on the surface of the Earth is known as a meteor. It may be a form of precipitation, a suspension, or a deposit of liquid or solid particles. It is generally visible to human observers, but in the case of thunder it is audible.

Sometimes names of meteors are also applied to related concepts. For instance, the word "snow" may refer to a type of hydrometeor (ensemble of falling particles), to snow cover (ensemble of particles lying on the ground), or to the substance snow (as in "snow blown from mountains", snowball). The constituent particles of snow in these three cases are either snow crystals or snowflakes.

Also, certain meteors are named based on their constituent particles; for example, the hydrometeor "snow grains" is an ensemble of falling snow grains.

I.2 - GENERAL CLASSIFICATION OF METEORS

The nature of meteorological meteors is quite varied. However, by considering their constituent particles or the physical processes surrounding their occurrence, meteors are classified into four groups, namely hydrometeors, lithometeors, photometeors and electrometeors.

I.2.1 Hydrometeors

A hydrometeor consists of liquid or solid water particles. Hydrometeors may fall through the atmosphere or be suspended in it, may be blown by the wind from the Earth's surface, or may be deposited on other objects. Snow or water on the ground is, by convention, not considered a hydrometeor.

We describe the following five types of hydrometeors:

<table>
<thead>
<tr>
<th>Suspended particles</th>
</tr>
</thead>
<tbody>
<tr>
<td>• clouds,</td>
</tr>
<tr>
<td>• fog (&quot;fog&quot; and &quot;mist&quot;)</td>
</tr>
<tr>
<td>• ice fog</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Falling particles (precipitation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• From clouds: rain, drizzle, snow, snow grains, snow pellets, hail and ice pellets.</td>
</tr>
<tr>
<td>• From clear air: diamond dust</td>
</tr>
</tbody>
</table>

Precipitation can reach the Earth's surface or completely evaporate while falling (virga). When the falling particles reach the observer, it is usually easy to identify the type of precipitation. This identification can then assist in identifying the cloud type especially at night.

Hydrometeors consisting of falling particles may occur as fairly uniform precipitation (intermittent or continuous) or as showers. Showers are characterized by their abrupt beginning and end, and by rapid and sometimes strong variation in the precipitation intensity. Drops and solid particles falling in a shower are generally larger than those falling in non-showery precipitation. Showers only fall from convective clouds (Cumulonimbus and Cumulus); uniform (non-showery) precipitation usually falls from stratiform clouds (mainly Altostratus and Nimbostratus). From this, the hydrometeor type can be useful to identify cloud genera,
especially at night.

**Particles raised by the wind from the Earth’s surface**
- drifting snow
- blowing snow
- spray

These are confined to near the surface.

**Deposit of particles that can occur either as**
- drops of water (deposits of fog droplets or dew)
- a collection of ice particles, usually individually distinguishable although they are often partially merged (white dew, hoar frost and rime)
- smooth uniform layers of ice in which no pellet structure can be distinguished (glaze)

**Spouts**
- when seen at sea, spouts appear as a cloud column or cone made up of water droplets raised from the sea surface, and are considered a hydrometeor.
- Spouts occurring on land are typically made up of solid, non-aqueous particles. In this case they cannot strictly be classified as hydrometeors. However, the presence of the cloud column or cone is a basic criterion and therefore spouts are classified in this Atlas within the group of hydrometeors.

<table>
<thead>
<tr>
<th>Hydrometeor</th>
<th>Phenomena</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspended particles</td>
<td>• clouds,</td>
</tr>
<tr>
<td></td>
<td>• fog (&quot;fog&quot; and &quot;mist&quot;)</td>
</tr>
<tr>
<td></td>
<td>• ice fog</td>
</tr>
<tr>
<td>Falling particles (precipitation)</td>
<td>• from clouds: rain, drizzle, snow, snow grains, snow pellets, hail and ice pellets.</td>
</tr>
<tr>
<td></td>
<td>• from clear air: diamond dust</td>
</tr>
<tr>
<td>Particles raised by the wind from the Earth’s surface</td>
<td>• drifting snow</td>
</tr>
<tr>
<td></td>
<td>• blowing snow</td>
</tr>
<tr>
<td></td>
<td>• spray</td>
</tr>
<tr>
<td>Deposit of particles that can occur either as</td>
<td>• drops of water (deposits of fog droplets or dew)</td>
</tr>
<tr>
<td></td>
<td>• a collection of ice particles, usually individually distinguishable although they are often partially merged (white dew, hoar frost and rime)</td>
</tr>
<tr>
<td></td>
<td>• smooth uniform layers of ice in which no pellet structure can be distinguished (glaze)</td>
</tr>
<tr>
<td>Spouts</td>
<td>• funnel cloud:</td>
</tr>
<tr>
<td></td>
<td>• water spout over water</td>
</tr>
<tr>
<td></td>
<td>• tornado over land</td>
</tr>
</tbody>
</table>
Cloud forms (genera) associated with each hydrometeor type.

<table>
<thead>
<tr>
<th>Falling hydrometeor</th>
<th>Altostratus</th>
<th>Nimbostratus</th>
<th>Stratocumulus</th>
<th>Stratus</th>
<th>Cumulus</th>
<th>Cumulonimbus</th>
<th>No cloud</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rain</td>
<td>Possible</td>
<td>Usual</td>
<td>Possible</td>
<td></td>
<td>Possible showers</td>
<td>Usual showers</td>
<td></td>
</tr>
<tr>
<td>Drizzle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snow</td>
<td>Possible</td>
<td>Possible</td>
<td>Possible</td>
<td>Possible showers</td>
<td>Possible showers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snow grains</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snow pellets</td>
<td></td>
<td></td>
<td>Possible</td>
<td>Possible showers</td>
<td>Possible showers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diamond dust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Possible</td>
</tr>
<tr>
<td>Hail (large and small)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Possible showers</td>
</tr>
<tr>
<td>Ice pellets</td>
<td>Possible</td>
<td>Possible</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 1.2.2 Lithometeors

**Lithometeors**

A lithometeor consists of an ensemble of particles, most of which are solid and non-aqueous. The particles are either suspended in the air or lifted by the wind from the ground.

- Suspended particles are *haze, dust haze and smoke*. They consist of very small dust particles, sea-salt particles, or combustion products (e.g. from forest fires).
- Particles lifted by the wind are *drifting and blowing dust or sand, dust storm or sandstorm, and dust whirl or sand whirl*. When well developed, a dust whirl is known as a dust devil.

### 1.2.3.

**Photometeors**

Optical phenomenon produced by the reflection, refraction, diffraction or interference of light from the sun or the moon.

- On or inside clouds: *halo phenomena, coronae, irisations and glory*;
- On or inside some hydrometeors or lithometeors: *halo phenomena, coronae, glory, rainbow, Bishop’s ring and crepuscular rays*;
- In clear air: *mirage, shimmer, scintillation, green flash and twilight colours*. 
1.2.4 Electrometeors

Photometeors

An electrometeor is a visible or audible manifestation of atmospheric electricity. Electrometeors can be:

- related to discontinuous electrical discharges (*lightning, thunder*)
- more or less continuous (*Saint Elmo's fire, polar aurora*).
PART II – CLOUDS
II.1 – INTRODUCTION AND PRINCIPLES OF CLOUD CLASSIFICATION

II.1.1

Definition of a cloud

A cloud is a hydrometeor consisting of minute particles of liquid water or ice, or of both, suspended in the atmosphere and usually not touching the ground. It may also include larger particles of liquid water or ice as well as non-aqueous liquid or solid particles such as those present in fumes, smoke or dust.

II.1.2

Appearance of clouds

Appearance is best described by dimensions, shape, structure, texture, luminance and colour of the cloud. These factors are considered for each of the characteristic cloud forms.

II.1.2.1

LUMINANCE

Light reflected, scattered and transmitted by its constituent particles determines the luminance of a cloud. This light comes, for the most part, direct from the luminary (sun or moon or stars) or from the sky; it may also come from the surface of the earth, being particularly strong when ice fields or snowfields reflect sunlight or moonlight.

The luminance of a cloud may be modified by intervening haze. When haze is present between the observer and the cloud, it may, depending on its thickness and the direction of the incident light, either diminish or increase the luminance of the cloud. Haze also diminishes the contrast that reveals the shape, structure and texture of the cloud. Luminance may also be modified by optical phenomena such as haloes, rainbows, coronae, glories, etc. ("Photometeors" in Part III of this Atlas).

During daytime, the luminance of the clouds is sufficiently high to make them easily observable. On a moonlit night, clouds are visible when the moon is more than a quarter full. In its darker phases, the moon is not bright enough to reveal clouds far from it, especially when the clouds are thin. On a moonless night, clouds are generally invisible; sometimes, however, their presence may be deduced from the obscuration of stars (noting that stars near the horizon can be obscured due to haze), of polar aurora, of zodiacal light etc.

Clouds are visible at night in areas with sufficiently strong artificial lighting. Over large cities, clouds may be revealed by direct illumination from below. An artificially illuminated layer of clouds may provide a bright background against which lower cloud fragments stand out.

When a slightly opaque cloud is illuminated from behind, its luminance is at a maximum in the direction of the luminary. It decreases away from the luminary; the thinner the cloud, the more rapid the decrease. Clouds of greater optical thickness (measure of the degree to which the cloud prevents light from passing through) show only a slight decrease in luminance with distance from the luminary. Still greater thickness and opacity make it impossible even to determine the position of the luminary. When the sun or moon is behind a dense isolated cloud, the latter shows a brilliantly illuminated border, and luminous streaks alternating with shadowed bands may be seen around it.
As the optical thickness of a cloud layer often varies from one portion of the layer to another; the luminary may therefore be perceptible through one part of the cloud but not through another. The varying optical thickness and the luminance of the cloud layer, especially at short angular distances from sun or moon, may change considerably with time owing to the movement of the cloud.

In the case of a uniformly and sufficiently opaque cloud layer, the luminary may be perceptible when it is not too far from the zenith, but may be completely masked when close to the horizon. Sufficiently opaque cloud layers sometimes show a maximum luminance at the zenith when the sun or moon is at low elevation.

The light reflected from a cloud to the observer is at a maximum when the cloud is opposite to the luminary. The luminance is stronger the greater the denseness of the cloud and its thickness in the line of sight. When sufficiently dense and deep, the cloud reveals shades of grey showing a more or less clear relief; the more tangential the direction of illumination, the more extensive the range of shades.

Finally, appreciable differences in luminance exist between clouds composed of water droplets and clouds composed of ice crystals. Ice crystal clouds are usually more transparent than water droplet clouds owing to their thinness and to the sparseness of the ice particles. Certain ice crystal clouds, however, occur in thick patches and, can have a high concentration of ice particles. When these clouds are illuminated from behind, they show marked shading. They are, however, brilliantly white in reflected light.

II.1.2.2

COLOUR

Since light of all wavelengths is almost equally strongly diffused by clouds, the colour of the clouds depends primarily on that of the incident light. Haze between observer and cloud may modify cloud colours; e.g., it tends to make distant clouds look yellow, orange or red. Cloud colours are also influenced by special luminous phenomena (“Photometeors” in Part III of this Atlas).

When the sun is sufficiently high above the horizon, clouds or portions of clouds that chiefly diffuse light from the sun are white or grey. Parts that receive light mainly from the blue-sky are bluish grey. When the illumination by the sun and the sky is extremely weak, the clouds tend to take the colour of the surface below them.

When the sun approaches the horizon, its colour may change from yellow through orange to red; the sky in the vicinity of the sun and the clouds show a corresponding coloration. The blue of the sky and the colour of the underlying surface may still influence the colours of the clouds. Cloud colours also vary with the height of the cloud and its relative position with regard to observer and sun.

When the sun is close to the horizon, high clouds may still look almost white whilst low clouds show a strong orange or red coloration. These differences in colour make it possible to obtain an idea of the relative altitudes of the clouds; noting that clouds at the same level appear less red when seen towards the sun than when viewed away from it.

When the sun is just above or on the horizon, it may redden the under surface of a cloud; when this surface is corrugated, its coloration is distributed in bands alternately lighter (yellowish or reddish tint) and darker (other tints), which make the relief more apparent.
When the sun is just below the horizon, the lowest clouds, in the shadow of the earth, are grey; clouds at the middle levels are rose coloured and those very high may be whitish.

At night, the luminance of clouds is usually too weak for colour vision; all perceptible clouds appear black to grey, except those illuminated by the moon, which present a whitish appearance. Special illumination (fires, lights of large cities, polar aurora, etc.) may sometimes give a more or less marked colouring to certain clouds.

II.1.3

**Principles of cloud classification**

Clouds continuously evolve and appear in an infinite variety of forms. However, there is a limited number of characteristic forms frequently observed all over the world, into which clouds are broadly grouped into a classification scheme. The scheme uses genera, species and varieties. This is similar to the systems used in classification of plants or animals, and similarly uses Latin names.

There are some intermediate or transitional forms of clouds, although observed fairly frequently, that are not described in the classification scheme. The transitional forms are of little interest; they are less stable and in appearance are not very different from the definitions of the characteristic forms.

There are also clouds, rarely or occasionally observed and usually only in certain parts of the world, that are not included in the present classification scheme. Special clouds are described in Chapter II.6.

II.1.3.1

** GENERA **

The classification of clouds has ten main groups, called genera. Each observed cloud is a member of one, and only one, genus.

II.1.3.2

** SPECIES **

Most of the genera are subdivided into species, based on the shape of the clouds or their internal structure. A cloud, observed in the sky and identified as a specific genus, may bear the name of only one species.

II.1.3.3

** VARIETIES **

Varieties are different arrangements of the visible elements of clouds and varying degrees of transparency.

A variety may be common to several genera and a cloud may show characteristics of more than one variety. When this is the case all the observed varieties are included in the name of the cloud.

II.1.3.4

** SUPPLEMENTARY 'FEATURES AND ACCESSORY CLOUDS **

A cloud may show supplementary features attached to it, or may be accompanied by accessory clouds, sometimes partly merged with its main body. "Supplementary features" and "accessory clouds" may occur at any level of the cloud, or above or below it.
One or more supplementary features or accessory clouds may be observed simultaneously with the same cloud.

II.1.3.5

MOTHER-CLOUDS and SPECIAL CLOUDS

Clouds may form in clear air. They may also form or grow from other clouds, called "mother-clouds". Depending on the change, one of two suffixes may be used.

a) "genitus" suffix. A part of a cloud may develop and more or less pronounced extensions may form. These extensions, whether attached to the mother-cloud or not, may become clouds of a genus different from that of the mother-cloud. They are then given the name of the appropriate genus, followed by the name of the genus of the mother-cloud with the addition of the suffix "genitus" (e.g. Cirrus altocumulogenitus, Stratocumulus cumulogenitus).

b) "mutatus" suffix: The whole or a large part of a cloud may undergo complete internal transformation, changing from one genus into another. The new cloud is given the name of the appropriate genus, followed by the name of the genus of the mother-cloud with the addition of the suffix "mutatus" (e.g. Cirrus cirrostratomutatus, Stratus stratocumulomutatus). The internal transformation should not be confused with changes in appearance resulting from the relative movement of clouds and observer.

In addition, there are special cases where clouds may form or grow as a consequence of certain, often localised, generating factors. These may be either natural, or the result of human activity. Several cases of "Special clouds" can be distinguished:

a) "flammagenitus": Clouds may develop as a consequence of convection initiated by heat from forest fires, wild-fires or from volcanic eruption activity. Clouds that are clearly observed to have originated as a consequence of localised natural heat sources, such as forest fires, wild-fires or volcanic activity and which, at least in part, consist of water drops, will be given the name relevant to the genus followed, if appropriate, by the species, variety and any supplementary features, and finally by the Special Cloud name "flammagenitus", (e.g. Cumulus congestus flammagenitus, Cumulonimbus calvus flammagenitus). [Note: cumulus flammagenitus is also known by the unofficial, common name, 'pyrocumulus'].

b) "homogenitus": Clouds may also develop as a consequence of human activity. Examples are aircraft condensation trails (Contrails), or clouds resulting from industry, such as cumuliform clouds generated by rising thermals above power station cooling towers. Clouds that are clearly observed to have originated specifically as a consequence of human activity will be given the name of the appropriate genus, followed by the Special Cloud name "homogenitus". For example: Cumulus cloud formed above industrial plants will be known as Cumulus (and, if appropriate, the species, variety and any supplementary features) followed by the Special Cloud name homogenitus; e.g. Cumulus mediocris homogenitus.

c) Aircraft condensation trails (Contrails) that have persisted for at least 10 minutes will be given the name of the genus, Cirrus, followed only by the Special Cloud name "homogenitus", i.e. a Contrail will be known only as Cirrus homogenitus. Because new, or recently formed aircraft condensation trails may undergo a fairly rapid state of change and may display a variety of transient shapes, no species, varieties or supplementary features will be applied to the name.
d) "homomutatus": Persistent contrails (Cirrus homogenitus) may be observed, over a period of time and under the influence of strong upper winds, to grow and spread out over a larger portion of sky, and undergo internal transformation such that the cloud eventually takes on the appearance of more natural cirri-form clouds. In this instance, the resulting clouds will be given the name of the appropriate genus (e.g. cirrus, cirrocumulus, or cirrostratus) followed by any appropriate species, variety and supplementary features, followed by the Special Cloud name "homomutatus", (e.g. cirrus floccus homomutatus, cirrus fibratus homomutatus).

e) "cataractagenitus": Clouds may develop locally in the vicinity of large waterfalls as a consequence of water broken up into spray by the falls. The downdraft caused by the falling water is compensated by locally ascending motion of the air. These Special Clouds will be given the name of the appropriate genus, followed by any appropriate species, variety and supplementary feature, and followed by the Special Cloud name "cataractagenitus" (e.g. Cumulus mediocris cataractagenitus, Stratus fractus cataractagenitus).

f) "silvagenitus": Clouds may develop locally over forests as a result of increased humidity due to evaporation and evapotranspiration from the tree canopy. These Special Clouds will be given the name of the appropriate genus, followed by any appropriate species, variety and supplementary feature, and followed by the Special Cloud name "silvagenitus" (e.g. Stratus fractus silvagenitus).
### Table of Classification of Clouds

<table>
<thead>
<tr>
<th>GENERA</th>
<th>SPECIES</th>
<th>VARIETIES</th>
<th>Supplementary Features and Accessory Clouds</th>
<th>MOTHER-CLOUDS and SPECIAL CLOUDS (most commonly occurring mother-clouds are listed in the same order as genera)</th>
</tr>
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<td>(listed by frequency of observation)</td>
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**Editorial Note:** New classifications in this table are denoted by yellow highlighting.
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### Table of Abbreviations and Symbols of Clouds

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<th>GENERA</th>
<th>SPECIES</th>
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<td>Designations</td>
<td>Abbreviations</td>
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<td>altostratogenitus</td>
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</tbody>
</table>

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II.2- DEFINITIONS OF CLOUDS

II.2.1

Some useful concepts

II.2.1.1

HEIGHT, ALTITUDE, VERTICAL EXTENT

HEIGHT: Vertical distance from the point of observation (which may be on a hill or a mountain) to the point being measured.

HEIGHT OF CLOUD BASE: Surface observations - height above ground level of the cloud base; aircraft observers – height above sea level of the cloud base.

ALTITUDE: Vertical distance from mean sea level to the point being measured

VERTICAL EXTENT: Vertical distance from the cloud base to its top

II.2.1.2

LEVELS

Clouds are generally encountered over a range of altitudes varying from sea level to the top of the troposphere (the tropopause). The troposphere has been vertically divided into three levels: high, middle and low. Each level is defined by the range of levels at which clouds of certain genera occur most frequently. The levels overlap and their limits vary with latitude.

Table #: Approximate heights, and genera in each, of the levels

<table>
<thead>
<tr>
<th>Levels</th>
<th>Genera</th>
<th>Polar Regions</th>
<th>Temperate Regions</th>
<th>Tropical Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Cirrus</td>
<td>3 – 8 km (10 000 – 25 000 ft)</td>
<td>5 – 13 km (16 500 – 45 000 ft)</td>
<td>6 – 18 km (20 000 – 60 000 ft)</td>
</tr>
<tr>
<td></td>
<td>Cirrocumulus</td>
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<tr>
<td></td>
<td>Cirrostratus</td>
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</tr>
<tr>
<td>Middle</td>
<td>Altocumulus</td>
<td>2 – 4 km (6 500 – 13 000 ft)</td>
<td>2 – 7 km (6 500 – 23 000 ft)</td>
<td>2 – 8 km (6 500 – 25 000 ft)</td>
</tr>
<tr>
<td></td>
<td>Altostratus</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nimbostratus</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Low</td>
<td>Stratus</td>
<td>From the Earth’s surface to 2 km (0 – 6 500 ft)</td>
<td>From the Earth’s surface to 2 km (0 – 6 500 ft)</td>
<td>From the Earth’s surface to 2 km (0 – 6 500 ft)</td>
</tr>
<tr>
<td></td>
<td>Stratocumulus</td>
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<tr>
<td></td>
<td>Cumulus</td>
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<tr>
<td></td>
<td>Cumulonimbus</td>
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</tbody>
</table>

Most clouds are confined within their level with a few notable exceptions:

(a) Altostratus is usually found in the middle level, but it often extends higher;

(b) Nimbostratus is almost invariably found in the middle level, but it usually extends into the other two levels;

(c) Cumulus and Cumulonimbus usually have their bases in the low level, but their vertical extent is often so great that their tops may reach into the middle and high levels.
When the height of a particular cloud is known, the concept of levels may be of some help to the observer in identifying this cloud. The genus can be determined by making a choice from among the genera normally encountered in the level corresponding to its height.

### II.2.2

**Definitions of clouds**

[Editorial Comment: the definitions of this section from the previous edition of the ICA have been moved to the tables below with very little change. New definitions are highlighted in yellow in their respective table]

### II.2.2.1

#### GENERA

Consideration of the most typical forms of clouds leads to the recognition of ten genera. The definitions of the genera given below do not cover all possible aspects, but are limited to a description of the main types and of the essential characteristics necessary to distinguish a given genus from genera having a somewhat similar appearance.

<table>
<thead>
<tr>
<th><strong>Cirrus</strong></th>
<th>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.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cirrocumulus</strong></td>
<td>Thin, 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 one degree.</td>
</tr>
<tr>
<td><strong>Cirrostratus</strong></td>
<td>Transparent, whitish cloud veil of fibrous (hair-like) or smooth appearance, totally or partly covering the sky, and generally producing halo phenomena.</td>
</tr>
<tr>
<td><strong>Altostratus</strong></td>
<td>Greyish or bluish cloud sheet or layer of striated (grooves or channels in cloud formations, arranged parallel to the flow of the air), fibrous or uniform appearance, totally or partly covering the sky, and having parts thin enough to reveal the sun at least vaguely, as through ground glass or frosted glass. Altostratus does not show halo phenomena.</td>
</tr>
<tr>
<td><strong>Nimbostratus</strong></td>
<td>Grey cloud layer, often dark, the appearance of which is made 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</td>
</tr>
<tr>
<td>Species</td>
<td>Description</td>
</tr>
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<td>------------------</td>
<td>-----------------------------------------------------------------------------</td>
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<tr>
<td><strong>Stratocumulus</strong></td>
<td>Grey or whitish, or both grey and whitish, patch, sheet or layer of cloud which almost always has dark parts an arrangement of shapes closely fitted together in a repeated pattern without gaps or overlapping (referred to as tessellations), rounded masses, rolls, etc., which are non-fibrous (except for virga) and which may or may not be merged; most of the regularly arranged small elements have an apparent width of more than five degrees.</td>
</tr>
<tr>
<td><strong>Stratus</strong></td>
<td>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 discernible. Stratus does not produce halo phenomena except, possibly, at very low temperatures. Sometimes Stratus appears in the form of ragged patches.</td>
</tr>
<tr>
<td><strong>Cumulus</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Cumulonimbus</strong></td>
<td>Heavy and dense cloud, with a 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.</td>
</tr>
</tbody>
</table>

### II.2.2 Species

Most cloud genera are subdivided into species due to peculiarities in the shape of clouds and differences in their internal structure.

A cloud belonging to a certain genus, may bear the name of one species only; this means that the species are mutually exclusive. On the other hand, certain species may be common to several genera. When none of the definitions of the species are relevant to a genus, no species is indicated.

- **Fibratus**: Detached clouds or a thin cloud veil, consisting of nearly straight or more or less irregularly curved filaments which do not terminate in hooks or tufts. This term applies mainly to Cirrus and Cirrostratus.
- **Uncinus**: Cirrus often shaped like a comma, terminating at the top in a hook, or in a tuft,
<table>
<thead>
<tr>
<th>Cloud Type</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>the upper part of which is not in the form of a rounded protuberance.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Spissatus</strong></td>
<td>Cirrus of sufficient optical thickness appearing greyish when viewed towards the sun.</td>
</tr>
<tr>
<td><strong>Castellanus</strong></td>
<td>Clouds which present, in at least some portion of their upper part, cumuliform protuberances in the form of turrets or towers (crenelated), some of which are taller than they are wide, and are connected by a common base and seem to be arranged in lines. The castellanus character is especially evident when the clouds are seen from the side. This term applies to Cirrus, Cirrocumulus, Altocumulus and Stratocumulus.</td>
</tr>
<tr>
<td><strong>Floccus</strong></td>
<td>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 Cirrus, Cirrocumulus and Altocumulus.</td>
</tr>
<tr>
<td><strong>Stratiformis</strong></td>
<td>Clouds spread out in an extensive horizontal sheet or layer. This term applies to Altocumulus, Stratocumulus and, occasionally, to Cirrocumulus.</td>
</tr>
<tr>
<td><strong>Nebulosus</strong></td>
<td>A cloud like a nebulous or ill-defined veil or layer of clouds showing no distinct details. This term applies mainly to Cirrostratus and Stratus.</td>
</tr>
<tr>
<td><strong>Lenticularis</strong></td>
<td>Clouds having the shape of lenses or almonds, often very elongated and usually with well defined outlines; they occasionally show irisations. 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 Cirrocumulus, Altocumulus and Stratocumulus.</td>
</tr>
<tr>
<td><strong>Volutus</strong></td>
<td>A long, typically low, horizontal, detached, tube-shaped cloud mass, often appearing to roll slowly about a horizontal axis. The roll cloud, volutus, is a soliton, not attached to other clouds and is an example of an undular bore. This species applies mostly to Stratocumulus and rarely Altocumulus.</td>
</tr>
<tr>
<td><strong>Fractus</strong></td>
<td>Clouds in the form of irregular shreds, which have a clearly ragged appearance. This term applies only to Stratus and Cumulus.</td>
</tr>
<tr>
<td><strong>Humilis</strong></td>
<td>Cumulus clouds of only a slight vertical extent; they generally appear flattened</td>
</tr>
<tr>
<td><strong>Mediocris</strong></td>
<td>Cumulus clouds of moderate vertical extent, the tops of which show fairly small protuberances.</td>
</tr>
<tr>
<td><strong>Congestus</strong></td>
<td>Cumulus clouds which are markedly sprouting and are often of great vertical extent; their bulging upper part frequently resembles a cauliflower.</td>
</tr>
</tbody>
</table>
**Calvus**

Cumulonimbus in which at least some protuberances of the upper part are beginning to lose their cumuliform outlines but in which no cirriform parts can be distinguished. Protuberances and sproutings tend to form a whitish mass, with more or less vertical striations (Grooves or channels in cloud formations, arranged parallel to the flow of air and therefore depicting the airflow).

**Capillatus**

Cumulonimbus characterized 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. Cumulonimbus capillatus is usually accompanied by a shower or by a thunderstorm, often with squalls and sometimes with hail; it frequently produces very well-defined virga.

| TABLE OF SPECIES AND THE GENERA WITH WHICH THEY MOST FREQUENTLY OCCUR |
|-----------------------------|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Genera                      | Cl   | Cc   | Cs   | Ac   | As   | Ns   | Sc   | St   | Cu   | Cb   |
| fibratus (fib)              | ●    | ●    |      |      |      |      |      |      |      |      |
| uncinus (unc)               | ●    |      |      |      |      |      |      |      |      |      |
| spissatus (spi)             | ●    |      |      |      |      |      |      |      |      |      |
| castellanus (cas)           | ●    | ●    | ●    |      | ●    |      |      |      |      |      |
| floccus (flo)               | ●    | ●    | ●    |      | ●    |      |      |      |      |      |
| stratiformis (str)          | ●    | ●    |      |      |      |      |      |      |      |      |
| nebulosus (neb)             | ●    |      |      |      |      | ●    |      |      |      |      |
| lenticularus (len)          | ●    | ●    |      |      |      |      |      |      |      |      |
| volutus (vol)               |      | ●    | ●    |      |      |      |      |      |      |      |
| fractus (fra)               |      | ●    | ●    |      |      |      |      |      |      |      |
| humilis (hum)               |      |      | ●    |      |      |      |      |      |      |      |
| mediocris (med)             |      |      |      | ●    |      |      |      |      |      |      |
| congestus (con)             |      |      |      |      | ●    |      |      |      |      |      |
| calvus (cal)                |      |      |      |      |      |      | ●    |      |      |      |
| capillatus (cap)            |      |      |      |      |      |      |      | ●    |      |      |
1151 **11.2.2.3**

1152 **VARIETIES**

1153 Varieties are the arrangements of the macroscopic elements and the degree of transparency of the genera.

1154 - A given cloud may bear the names of different varieties, which means that varieties are not mutually exclusive.

1155 - The exceptions to this are the varieties translucidus and opacus both of which are mutually exclusive.

1156 - On the other hand, certain varieties may be present in several genera.

1157 - The fact that a number of varieties has been established does not imply that a specific cloud must necessarily receive the name of one or more of those varieties.

<table>
<thead>
<tr>
<th>Arrangement of macroscopic elements</th>
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<tbody>
<tr>
<td><strong>Intortus</strong></td>
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<tr>
<td><strong>Vertebratus</strong></td>
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<tr>
<td><strong>Undulatus</strong></td>
</tr>
<tr>
<td><strong>Radiatus</strong></td>
</tr>
<tr>
<td><strong>Lacunosus</strong></td>
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<tr>
<td><strong>Duplicatus</strong></td>
</tr>
</tbody>
</table>
Altostratus and Stratocumulus.

**Translucidus**

Clouds in an extensive patch, sheet or layer, the greater part of which is sufficiently translucent to reveal the position of the sun or moon. This term applies to Altocumulus, Altostratus, Stratocumulus and Stratus.

**Perlucidus**

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 over-lying clouds to be seen. It may also be observed in combination with the varieties translucidus or opacus. This term applies to Altocumulus and Stratocumulus.

**Opacus**

An extensive cloud patch, sheet or layer, the greater part of which is sufficiently opaque to mask completely the sun or moon. This term applies to Altocumulus, Altostratus, Stratocumulus and Stratus.

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### VARIETIES AND THE GENERA WITH WHICH THEY MOST FREQUENTLY OCCUR

[Editorial Note: The following table from the 1975 edition did not map across well from the original pdf file to the word equivalent. The version of the table proposed for the new edition contains the same information, but simply has a different appearance]

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Ci</th>
<th>Cc</th>
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<td>translucidus (tr)</td>
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<td>perlucidus (pe)</td>
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<td>opacus (op)</td>
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</tbody>
</table>
Clouds sometimes have supplementary features attached to them or may be accompanied by other usually smaller clouds, known as accessory clouds which are separate from their main body or partly merged with it. A given cloud may present simultaneously one or more supplementary features or accessory clouds, which means that supplementary features and accessory clouds are not mutually exclusive.

<table>
<thead>
<tr>
<th>Supplementary features</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Incus</strong></td>
<td>The upper portion of a Cumulonimbus spread out in the shape of an anvil with a smooth, fibrous or striated appearance.</td>
</tr>
<tr>
<td><strong>Mamma</strong></td>
<td>Hanging protuberances, like udders, on the under surface of a cloud. Occurs mostly with Cirrus, Cirrocumulus, Altocumulus, Altostratus, Stratocumulus and Cumulonimbus.</td>
</tr>
<tr>
<td><strong>Virga</strong></td>
<td>Vertical or inclined trails of precipitation (fallstreaks) attached to the under surface of a cloud which do not reach the Earth’s surface. Occurs mostly with Cirrocumulus, Altocumulus, Altostratus, Nimbostratus, Stratocumulus, Cumulus and Cumulonimbus.</td>
</tr>
<tr>
<td><strong>Praecipitatio</strong></td>
<td>Precipitation (rain, drizzle, snow, ice pellets, hail, etc.) falling from a cloud and reaching the Earth’s surface. Mostly encountered with Altostratus, Nimbostratus, Stratocumulus, Stratus, Cumulus and Cumulonimbus.</td>
</tr>
<tr>
<td><strong>Arcus</strong></td>
<td>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. Occurs with Cumulonimbus and, less often, with Cumulus.</td>
</tr>
<tr>
<td><strong>Tuba</strong></td>
<td>Cloud column or inverted cloud cone, protruding from a cloud base; it constitutes the cloudy manifestation of a more or less intense vortex.</td>
</tr>
<tr>
<td><strong>Asperitas</strong></td>
<td>Well-defined, wave-like structures in the underside of the cloud; more chaotic and with less horizontal organization than the variety undulatus. Asperitas is characterized by localized waves in the cloud base, either smooth or dappled with smaller features, sometimes descending into sharp points, as if viewing a roughened sea surface from below. Varying levels of illumination and thickness of the cloud can lead to dramatic visual effects. Occurs mostly with Stratocumulus and Altocumulus.</td>
</tr>
<tr>
<td><strong>Fluctus</strong></td>
<td>A relatively short-lived wave formation, usually on the top surface of the cloud, in the form of curls, or breaking waves (Kelvin-Helmholtz waves). Occurs mostly with Cirrus, Altocumulus, Stratocumulus, Stratus and occasionally Cumulus.</td>
</tr>
<tr>
<td><strong>Cavum</strong></td>
<td>A well-defined generally circular (sometimes linear) hole in a thin layer of supercooled water droplet cloud. Virga or wisps of cirrus typically fall from the central part of the hole, which generally grows larger with time. Cavum is typically a circular feature when viewed from directly beneath, but may appear oval shaped when viewed from a distance. When resulting directly from the interaction of an aircraft with the cloud, it is generally linear (in the form of a dissipation trail). Virga typically falls from the progressively widening dissipation trail.</td>
</tr>
<tr>
<td>Accessory clouds</td>
<td>Occurs in Altocumulus and Cirrocumulus and rarely Stratocumulus.</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Murus</td>
<td>A localized, persistent, and often abrupt lowering of cloud from the base of a cumulonimbus from which tuba (spouts) sometimes form. Usually associated with a supercell or severe multi-cell storm; typically develop in the rain-free portion of a Cumulonimbus and indicate an area of strong updraft. Murus showing significant rotation and vertical motion may result in the formation of tuba (spouts). Commonly known as a ‘wall cloud’</td>
</tr>
<tr>
<td>Cauda</td>
<td>A horizontal, tail shaped cloud (not a funnel) at low levels extending from the main precipitation region of a supercell Cumulonimbus to the murus (wall cloud). They are typically attached to the wall cloud and the base of both is typically at the same height. Cloud motion is away from the precipitation area and towards the murus, with rapid upward motion often observed near the junction of the tail and wall clouds. Commonly known as a ‘tail cloud’.</td>
</tr>
<tr>
<td>Pileus</td>
<td>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 that often penetrates it. Several pileus may fairly often be observed in superposition. Occurs principally with Cumulus and Cumulonimbus.</td>
</tr>
<tr>
<td>Velum</td>
<td>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. Occurs principally with Cumulus and Cumulonimbus.</td>
</tr>
<tr>
<td>Pannus</td>
<td>Ragged shreds sometimes constituting a continuous layer, situated below another cloud and sometimes attached to it. Occurs mostly with Altostratus, Nimbostratus, Cumulus and Cumulonimbus.</td>
</tr>
<tr>
<td>Flumen</td>
<td>Bands of low clouds associated with a supercell severe convective storm, arranged parallel to the low-level winds and moving into or towards the supercell. These accessory clouds form on an inflow band into a supercell storm along the pseudo-warm front. The cloud elements move towards the updraft into the supercell, the base being at about the same height as the updraft base. Note that Flumen are not attached to the Murus wall cloud and the cloud base is higher than the wall cloud. One particular type of inflow band cloud is the, so called, ‘Beaver’s Tail’. This is distinguished by a relatively broad, flat appearance suggestive of a beaver’s tail.</td>
</tr>
</tbody>
</table>
SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS AND THE GENERA WITH WHICH THEY MOST FREQUENTLY OCCUR

[Editorial Note: The following table from the 1975 edition did not map across well from the original pdf file to the word equivalent. The version of the table proposed for the new edition contains the same information (except for the inclusion of the new classifications), but simply has a different appearance]

<table>
<thead>
<tr>
<th>Genera</th>
<th>Cl</th>
<th>Cc</th>
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II.3 — DESCRIPTIONS OF CLOUDS

II.3.1

Cirrus (Ci) (Howard 1803)

II.3.1.1

DEFINITION

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.

II.3.1.2

SPECIES

*Cirrus fibratus* (Ci fib) — BESSON 1921, CCH 1953

Nearly straight or more or less irregularly curved white filaments, which are always fine and do not terminate in hooks or tufts. The filaments are, for the most part, distinct from one another.

*Cirrus uncinus* (Ci unc) — MAZE 1889

Cirrus without grey parts, often shaped like a comma, terminating at the top in a hook, or in a tuft the upper part of which is not in the form of a protuberance.

*Cirrus spissatus* (Ci spi) — CCH 1953

Cirrus in patches, sufficiently dense to appear greyish when viewed towards the sun; it may also veil the sun, obscure its outline or even hide it. Cirrus spissatus often originates from the upper part of a Cumulonimbus.

*Cirrus castellanus* (Ci cas) — CCH 1953

Fairly dense Cirrus in the form of small rounded and fibrous turrets or masses rising from a common base, and sometimes having a crenelated (castle battlement) appearance. The apparent width of the turret like protuberances may be smaller or greater than 1° when observed at an angle of more than 30° above the horizon; distinct to Cirrocumulus castellanus
where the width is less than 1°. A width of 1° is approximately the width of the little finger at arm's length.

Cirrusfloccus (Ci flo) — VINCENT 1903, CEN 1930

Cirrus in the form of more or less isolated, small, rounded tufts, often with trails. The apparent width of the tufts may be smaller or greater than one degree when observed at an angle of more than 30 degrees above the horizon; distinct to Cirrocumulus castellanus where the width is less than 1°. A width of 1° is approximately the width of the little finger at arm's length.

II.3.1.3

VARIETIES

Cirrusintortus (Ci in) — CCH 1953

Cirrus, the filaments of which are very irregularly curved and often seemingly entangled in an irregular manner.
Cirrus arranged in parallel bands which, owing to the effect of perspective; appear to converge towards one point or towards two opposite points of the horizon. These bands are often partly composed of Cirrocumulus or Cirrostratus.

Cirrus vertebatus (Ci ve) — MAZE 1889, OSTHOFF

Cirrus, the elements of which are arranged in a manner suggestive of vertebrae, ribs, or a fish skeleton.

Cirrus duplicatus (Ci du) — MAZE 1889

Cirrus arranged in superposed layers at slightly different levels, sometimes merged in places. Most Cirrus fibratus and Cirrus uncinus belong to this variety.

II.3.1.4

Supplementary Features and Accessory Clouds

Cirrus, usually of the species spissatus, sometimes shows mamma.

II.3.1.5

Clouds from Which Cirrus May Form

Cirrus often evolves from:

- virga of Cirrocumulus (Ci cirrocumulogenitus); or
- virga of Altocumulus (Ci altocumulogenitus), or
- the upper part of a Cumulonimbus (Ci cumulonimbogenitus)

Cirrus clouds may also form as a result of the transformation of non-uniform Cirrostratus by evaporation of its thinner parts (Ci cirrostratomutatus).

II.3.1.6

Main Differences Between Cirrus and Similar Clouds of Other Genera

Cirrus is distinguished from Cirrocumulus by:

- its mainly fibrous or silky appearance;
- the absence of small cloud elements in the form of grains, ripples, etc;
- the absence of a corona or irisation;
- possible shading in thick Cirrus and no shading in Cirrocumulus;
the absence of virga

Cirrus is distinguished from *Cirrostratus* by:
- its discontinuous structure or, if they are in patches or bands, by their small horizontal extent or the narrowness of their continuous parts;
- sometimes being thick enough to mask the sun or moon, Cirrostratus is always thin enough to mask the disk of the sun or moon;
- the absence of undulations;
- possible mamma, usually in the species *spissatus*;
- the absence of a corona;
- only having, at best, a partial circular halo;

Cirrus near the horizon may be difficult to distinguish from Cirrostratus, owing to the effect of perspective.

Cirrus is distinguished from *Altocumulus* by:
- its mainly fibrous or silky appearance;
- the absence of cloud elements in the form of laminae, rolls, etc;
- the usual absence of any shading and only partial shading in the species *spissatus*;
- the absence of undulations;
- the absence of virga;
- the absence of a corona

Thick Cirrus is distinguished from *Altostratus* patches by:
- smaller horizontal extent;
- mostly white appearance;
- the absence of precipitation or virga;
- the absence of undulations

II.3.1. 7

PHYSICAL CONSTITUTION

Cirrus is composed almost exclusively of ice crystals. These crystals are in general very small; together with their sparseness this accounts for the transparency of most Cirrus clouds.

Dense Cirrus patches or Cirrus in tufts may contain ice crystals large enough to acquire an appreciable terminal velocity. Trails of considerable vertical extent fall from the base of Cirrus.

Infrequently, the ice crystals in the trails melt into small water droplets; the trails are then greyish, in contrast with their usual white appearance. A rainbow may form.

The trails curve irregularly or slant as a result of wind shear and of the variation in size of the constituent particles; consequently, Cirrus filaments near the horizon do not appear parallel to it.

Halo phenomena may occur; circular halos almost never show a complete ring, due to the narrowness of the Cirrus clouds.
EXPLANATORY REMARKS

Cirrus tufts with rounded tops often form in clear air. Fibrous trails may appear under the tufts; the tops then gradually lose their roundness. Subsequently, the tufts may disappear completely; the clouds are then in the form of filaments (species fibratus or uncinis).

Cirrus in the form of filaments may develop also from dense Cirrus patches, from Altocumulus castellanus and floccus and, occasionally at very low temperatures, from Cumulus congestus.

Cirrus may also form from aircraft condensation trails (contrails) that have persisted for at least 10 minutes (Ci homogenitus). No species, varieties or supplementary features are identified with Cirrus homogenitus as new or recently formed aircraft condensation trails usually undergo a fairly rapid state of change and may display a variety of transient shapes.

Persistent contrails (Ci homogenitus) can, over a period of time and under the influence of strong upper winds, take on the form of species and/or varieties of Cirrus. When this occurs, the Cirrus is identified by relevant species and varieties followed by homomutatus.

Colour:

At all times of day, Cirrus not too close to the horizon is white, whiter than any other cloud in the same part of the sky [Fig 26].

With the sun on the horizon it is whitish, while lower clouds may be tinted yellow or orange [Fig 27].

When the sun sinks below the horizon, Cirrus high in the sky is yellow, then pink, red and finally grey. The colour sequence is reversed at dawn.

Cirrus near the horizon often takes a yellowish or orange tint [Fig 28] owing to the great thickness of air traversed by the light in passing from the cloud to the observer. These tints are less conspicuous in clouds in the low and middle levels.

II.3.2

Cirrocumulus (Cc) (HOWARD 1803; RENOU 1855)

II.3.2.1

DEFINITION

Thin, 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 one degree.

II.3.2.2

SPECIES

Cirrocumulus stratiformis (Cc str) - CCH 1953

Cirrocumulus in the form of a relatively extensive sheet or layer, sometimes showing breaks.
Cirrocumulus lenticularis (Cc len) - LEY 1894, CEN 1930

Lens or almond shaped patches of Cirrocumulus; often very elongated and usually with well-defined outlines. The patches are more or less isolated, mostly smooth and are very white throughout. Iridisation is sometimes observed in these clouds.

Cirrocumulus castellanus (Cc cas) - CCH 1953

Cirrocumulus where some elements are vertically developed in the form of small turrets, rising from a common horizontal base. The apparent width of the turrets is always less than one degree, when observed at an angle of more than 30 degrees above the horizon. Castellanus develops due to instability at that level.

Cirrocumulus floccus (Cc flo) - VINCENT 1903, CCH 1953

Very small cumuliform tufts, the lower parts of which are more or less ragged. The apparent width of each tuft is always less than one degree, when observed at an angle of more than 30 degrees above the horizon. Floccus develops due to instability at that level. Cirrocumulus floccus sometimes evolves from Cirrocumulus castellanus the base of the latter having dissipated.

II.3.2.3

VARIETIES

Cirrocumulus undulatus (Cc un) - CLAYTON 1896, CCH 1953

Cirrocumulus showing one or two systems of undulations.

Cirrocumulus lacunosus (Cc Ia) - CCH 1953

Cirrocumulus in a patch, sheet or layer, showing small more or less regularly distributed round holes, many of them with fringed edges. Cloud elements and clear spaces are often arranged like a net or a honeycomb.

II.3.2.4

SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS

Small virga may be present, particularly falling from Cirrocumulus castellanus and floccus. Cirrocumulus occasionally shows mamma. Cavum is rarely observed and only when the Cirrocumulus consists of strongly supercooled water droplets.

II.3.2.5
CLOUDS FROM WHICH CIRROCUMULUS MAY FORM

Cirrocumulus often forms from the:
- transformation of Cirrus (Cc cirro\textit{mutatus}); or
- transformation of Cirrostratus (Cc cirro\textit{stratomutatus}); or
- decrease in size of the elements of a patch, sheet or layer of Altocumulus (Cc \textit{altocumulomutatus});

Persistent contrails (Ci \textit{homogenitus}) can, over a period of time and under the influence of strong upper winds, transform into Cirrocumulus (Cc \textit{homomutatus}).

MAIN DIFFERENCES BETWEEN CIRROCUMULUS AND SIMILAR CLOUDS OF OTHER GENERA

Cirrocumulus is distinguished from Cirrus by:
- having ripples or grains; any fibrous, silky or smooth portions do not collectively constitute its greater part;
- possible virga;
- no shading;
- no partial circular halo or any other halo phenomena

Cirrocumulus is distinguished from Cirrostratus by:
- having ripples or grains; any fibrous, silky or smooth portions do not collectively constitute its greater part;
- usually being thin enough to show the disk of the sun or moon but sometimes thicker so that only the position of the sun or moon is revealed;
- possible irisation;
- no halo phenomena;
- possible virga;
- possible mamma

Cirrocumulus differs from Altocumulus by:
- most of its elements being very small (an apparent width of less than one° when observed at an angle of more than 30° above the horizon);
- not having any shading;
- no halo (uncommon in Altocumulus and usually only a partial halo when of circular nature)

PHYSICAL CONSTITUTION

Cirrocumulus is composed almost exclusively of ice crystals; strongly supercooled water droplets may occur but are usually rapidly replaced by ice crystals.

A corona or irisation may sometimes be observed.
EXPLANATORY REMARKS

Lens or almonds shaped Cirrocumulus elements may be produced by local orographic lifting of a layer of moist air.

In middle and high latitudes, Cirrocumulus is usually observed with Cirrus and/or Cirrostratus.

In low latitudes, Cirrocumulus is less often accompanied by Cirrus or Cirrostratus.

A cloud is not identified as Cirrocumulus if it consists of a patch of incompletely developed small elements, such as often observed on the edges of a patch or sheet of Altocumulus or those sometimes present in separate patches at the same level as Altocumulus.

In case of doubt, a cloud should be identified as Cirrocumulus only when it has evolved from, or is obviously connected with Cirrus or Cirrostratus.

Cirrostratus (Cs) (HOWARD 1803; RENOU 1855)

DEFINITION

Transparent, whitish cloud veil of fibrous (hair-like) or smooth appearance, totally or partly covering the sky, often producing halo phenomena.

SPECIES

Cirrostratus fibratus (Cs fib) - BESSON 1921, CCH 1953

A fibrous veil of Cirrostratus in which thin striations can be observed. Cirrostratus fibratus may develop from Cirrus fibratus or less likely, Cirrus spissatus.

Cirrostratus nebulosus (Cs neb) - CLAYDEN 1905

A nebulous veil of Cirrostratus with no distinct detail. Sometimes the veil is so light that it is barely visible; it may also be relatively dense and easily visible.

VARIETIES

Cirrostratus duplicatus (Cs du) - MAZE 1889, DE QUERVAIN 1908, CCH 1953

Cirrostratus arranged in superposed sheets or layers, at slightly different levels, sometimes partly merged.

Cirrostratus undulatus (Cs un) - CCH 1953

Cirrostratus showing undulations.

SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS

None

CLOUDS FROM WHICH CIRROSTRATUS MAY FORM
Cirrostratus may form by:

- merging of elements of Cirrus (Cs cirromutatus);
- merging of elements of Cirrocumulus (Cs cirrocumulomutatus);
- ice crystals falling from Cirrocumulus (Cs cirrocumulogenitus);
- the thinning of Altostratus (Cs altostratomutatus);
- the spreading out of the anvil of a Cumulonimbus (Cs cumulonimbogenitus).

Persistent contrails (Ci homogenitus) can, over a period of time and under the influence of strong upper winds, transform into Cirrostratus (Cs homomutatus). Occasionally, multiple persistent contrails (Ci homogenitus) may spread and give almost complete sky coverage of Cirrostratus.

MAIN DIFFERENCES BETWEEN CIRROSTRATUS AND SIMILAR CLOUDS OF OTHER GENERA

Cirrostratus is distinguished from Cirrus by:

- being in the form of a veil, usually of great horizontal extent; when seen in patches it is usually forming or dissipating;
- having no distinct details such as filaments and undulations when of the species nebulosus;
- always being thin enough to show the disk of the sun or moon;
- displaying numerous halo phenomena and when of the circular form, the halos are usually complete circles;
- possible corona;
- no mamma.

Cirrostratus is distinguished from Cirrocumulus by:

- the absence of very fine elements in the form of grains;
- possibility of being partly shaded;
- no irisation;
- halo phenomena;
- no mamma
- no virga;

Cirrostratus is distinguished from Altocumulus by:

- the absence of rounded masses or turrets;
- never being completely shaded;
- no irisation;
- no mamma;
- no virga;

Cirrostratus is distinguished from Altostratus by:

- being thin enough to show the disk of the sun or moon, except when the sun or moon is low on the horizon; Altostratus translucidus will reveal the position of the sun or moon; Altostratus opacus will obscure the sun or moon;
- being partly shaded or having no shading; Altostratus translucidus is partly shaded; Altostratus opacus is shaded throughout;
- usual presence of halo phenomena;
- no mamma,
- no precipitation;
- no virga
Cirrostratus can be confused with very thin Stratus that, at angular distances of less than 45° from the sun, may appear very white. Cirrostratus:

- is whitish throughout;
- may have a fibrous appearance;
- often displays halo phenomena; Stratus only displays halo phenomena on rare occasions when it consist of small ice particles.

Cirrostratus can be confused for a veil of haze and is difficult to discern through haze. Haze is opalescent or has a dirty yellowish to brownish colour. Cirrostratus is greyish in areas if there is partial shading; else it is white throughout.

**PHYSICAL CONSTITUTION**

Cirrostratus is a cloud of moderate vertical extent and is composed of a relatively sparse number of mainly small ice crystals. These factors combine to account for the transparency of this cloud through which the disk (outline) of the sun is visible, at least when the sun is not too close to the horizon.

Sometimes Cirrostratus ice crystals are large enough to acquire an appreciable terminal velocity and trailing filaments form. This gives these Cirrostratus clouds a fibrous appearance.

Halo phenomena are often observed in thin Cirrostratus; sometimes the veil of Cirrostratus is so thin that a halo provides the only indication of its presence.

**EXPLANATORY REMARKS**

Cirrostratus, not completely covering the sky usually has an irregular border fringed with Cirrus; or may infrequently be straight edged and clear cut.

Cirrostratus is never thick enough to prevent objects on the ground from casting shadows, at least when the sun is high above the horizon. When the sun is low (less than about 30°) the relatively longer light path through a Cirrostratus veil may reduce the light intensity so much that shadows do not exist.

The remarks about the colours of Cirrus are, to a great extent, also valid for Cirrostratus.

**II.3.4**

**Altocumulus (Ac)** (RENOU 1870)

**II.3.4.1**

**DEFINITION**

White or grey, or both white and grey, patch, sheet or layer of cloud, generally with shading, 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 between one and five degrees.
II.3.4.2

SPECIES

*Altocumulus stratiformis (Ac str)* - CCH 1953

An extensive sheet or layer of separate or merged elements. This is by far the most frequent species.

*Altocumulus lenticularis (Ac len)* - LEY 1894, CEN 1930

A patch in the shape of a lens or almond, often very elongated and usually with well defined outlines. The patch can be small elements, closely grouped together; or one generally smooth unit with pronounced shadings. Irisation is occasionally visible.

*Altocumulus castellanus (Ac cas)* - CCH 1953

Cumuliform turrets rising vertically from cloud elements connected by a common horizontal base. The turrets:

- seem to be arranged in lines;
- give the cloud a crenelated (castle battlement) appearance;
- are sometimes taller than they are wide;
- are especially evident when the cloud is seen from the side.

Altocumulus castellanus is an indicator of instability at that level; when it acquires considerable vertical extent, it is classified as:

- *Cumulus congestus altocumulogenitus* if it is strongly sprouting or is of great vertical extent;
- *Cumulonimbus altocumulogenitus* if part of its upper portion is smooth, fibrous or striated, or if the cloud produces lightning, thunder or showers of hail.

*Altocumulus floccus (Ac flo)* - VINCENT 1903

Small tufts of cumuliform appearance; the lower parts of the tufts are generally ragged and often accompanied by fibrous trails (ice crystal virga). Altocumulus floccus is an indication of instability at that level. Altocumulus floccus sometimes forms as a result of the dissipation of the base of Altocumulus castellanus.

*Altocumulus volutus (Ac vol)* - __ 2016

A long, horizontal, detached, tube-shaped cloud mass, often appearing to roll slowly about a horizontal axis. It usually occurs as a single line and seldom extends from horizon to horizon.

This species of Altocumulus is rare.

II.3.4.3

VARIETIES

*Altocumulus translucidus (Ac tr)* - CEN 1930
A patch, sheet or layer of Altocumulus, the greater part is sufficiently translucent to reveal the position of the sun or moon. This variety often occurs in the species stratiformis and lenticularis.

*Altocumulus perlucidus* (Ac pe) - CCH 1953

A patch, sheet or layer of Altocumulus where the spaces between the elements allow the sun, the moon, the blue of the sky or higher clouds to be seen. This variety often occurs in the species stratiformis.

*Altocumulus opacus* (Ac op) - CEN 1930

A patch, sheet or layer of Altocumulus, the greater part is sufficiently opaque to mask completely the sun or moon. Most often, the base of this variety of Altocumulus is even and its apparent subdivision into merged elements results from the irregularity of its upper surface. The base is sometimes uneven and the elements then stand out in true relief, particularly with a low sun. The variety opacus occurs fairly often in the species stratiformis.

*Altocumulus duplicatus* (Ac du) - MAZE 1889, DE QUERVAIN 1908, CEN 1926

Altocumulus of two or more superposed patches, sheets or layers, close together and sometimes partly merged. This variety occurs in the species stratiformis and lenticularis.

*Altocumulus undulatus* (Ac un) - CLAYTON 1896, CEN 1930

Altocumulus composed of separate or merged elements, either elongated and broadly parallel, or arranged in ranks and files having the appearance of two distinct systems of undulations.

*Altocumulus radiatus* (Ac ra) - CEN 1926

Altocumulus with approximately straight parallel bands. The bands appear to converge towards one point, or two opposite points of the horizon.

*Altocumulus lacunosus* (Ac la) - CCH 1953

Sheet, layer or patches of Altocumulus showing more or less regularly distributed round holes, many of them with fringed edges. The cloud elements and clear spaces are often arranged in a net or honeycomb manner. The details change rapidly.

### II.3.4.4

**SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS**

Virga appears with most species of Altocumulus. Altocumulus floccus frequently dissipates, leaving very white trails of ice crystal virga. If the Altocumulus floccus completely dissipates, the virga is identified as *Cirrus altocumulogenitus*.

Mamma, cavum, fluctus and asperitas are sometimes visible in Altocumulus.
II.3.4.5 CLOUDS FROM WHICH ALTOCUMULUS MAY FORM

Altocumulus may form by:

- an increase in size or a thickening of at least some elements of a patch, sheet or layer of Cirrocumulus (Ac cirrocumulomutatus);
- subdivision of a layer of Stratocumulus (Ac stratocumulomutatus);
- transformation of Altostratus (Ac altostratomutatus);
- transformation of Nimbostratus (Ac nimbostratomutatus);
- spreading of the tops of Cumulus when they reach a middle level stable layer (Ac cumulogenitus). The vertical development of the Cumulus may:
  - cease at the stable layer, resulting in patches of Alto cumulus spreading out from the top of the Cumulus;
  - temporarily stop at the stable layer and then resume their growth in places or throughout, resulting in Alto cumulus on the sides of the Cumulus;

Alto cumulus may also be observed on or near the sides of Cumulonimbus. This Alto cumulus often forms while the mother-cloud is still in the Cumulus stage. Nevertheless, the Alto cumulus is classified as cumulonimbogenitus, not cumulogenitus.

II.3.4.6 MAIN DIFFERENCES BETWEEN ALTOCUMULUS AND SIMILAR CLOUDS OF OTHER GENERA

Alto cumulus is distinguished from Cirrus by:

- the absence of a mainly fibrous or silky appearance;
- the presence of cloud elements in the form of laminae, rolls, etc;
- possible shading throughout which never occurs with Cirrus;
- usually being partly shaded as against Cirrus usually being without shading;
- the possibility of cloud elements arranged in undulations;
- possible virga;
- the usual presence of a corona

Alto cumulus sometimes produces descending trails of fibrous appearance (ice crystal virga). The cloud is identified as Alto cumulus and not as Cirrus, as long as the cloud has a part without a fibrous appearance or a silky sheen.

Alto cumulus is distinguished from Cirrocumulus by:

- the presence of any shading, even if most of the regularly arranged cloud elements have an apparent width of less than 1°;
- most of the regularly arranged elements having an apparent width of between 1 and 5°, even if the cloud has no shading;
- possibile halo phenomena

Alto cumulus is distinguished from Altostratus by:

- the presence of thin plates, rounded masses, rolls, etc;
• possibly being thin enough to see the disk of the sun or moon; Altostratus will only reveal the position of the sun or moon or completely mask the sun or moon;
• the absence of the accessory cloud pannus;
• the absence of any precipitation; Altostratus may produce rain, snow or ice pellets;
• the absence of halo phenomena or irisation

Altocumulus is distinguished from Stratocumulus by:
• most of the regularly arranged elements having, when observed at an angle of more than 30° above the horizon, an apparent width between 1 and 5°;
• the absence of any precipitation; Stratocumulus can have weak falls of rain, snow or snow pellets

Altocumulus floccus is distinguished from Cumulus fractus, humilis and mediocris by:
• often having fibrous trails (virga) compared to the often flat base of the Cumulus;
• generally being smaller than the Cumulus

II.3.4.7
PHYSICAL CONSTITUTION

Altocumulus is invariably composed of water droplets. This is evident from the fairly low transparency of the elements and that the elements show sharp outlines when separate. When the temperature is very low, ice crystals may form. If the droplets then evaporate, the cloud becomes entirely an ice cloud and its elements cease to present sharp outlines. The formation of ice crystals may take place in all species of Altocumulus; it occurs most frequently in Altocumulus castellanus and floccus.

A corona or irisation is often observed in thin parts of Altocumulus.

The halo phenomena parhelia or luminous pillars are sometimes seen in Altocumulus, indicating the presence of tabular-shaped ice crystals.

II.3.4.8
EXPLANATORY REMARKS

During the initial stages of its formation, Altocumulus is frequently a fairly smooth cloud of moderate horizontal extent. This cloud then subdivides into more or less regularly arranged small elements, in the form of laminae or tessellations.

Altocumulus in the shape of lenses or almonds often forms in clear air as a result of local orographic lifting of a layer of moist air.

Altocumulus frequently occurs at different levels in the same sky and is in many instances associated with Altostratus. In this case, the air is often hazy immediately below the sheets or layers of Altocumulus or between the elements constituting them.

II.3.5

Altostratus (As) (RENOU 1877)

II.3.5.1
DEFINITION
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 through ground glass. Altostratus does not show halo phenomena.

II.3.5.2
SPECIES
Altostratus is not subdivided into species owing to the uniformity of its appearance and general structure.

II.3.5.3
VARIETIES

Altostratus translucidus (As tr) — CEN 1926
Altostratus, the greater part of which is sufficiently translucent to reveal the position of the sun or moon.

Altostratus opacus (As op) - BESSON 1921
Altostratus, the greater part of which is sufficiently opaque to mask completely the sun or moon.

Altostratus duplicatus (As du) - MAZE 1889, DE QUERVAIN 1908, CEN 1926
Altostratus composed of two or more superposed layers, at slightly different levels, sometimes partly merged. This variety is rarely seen in Altostratus.

Altostratus undulatus (As un) - CLAYTON 1896, CEN 1930
Altostratus showing undulations.

Altostratus radiatus (As ra) - CEN 1926, CCH 1953
Altostratus showing broad parallel bands that appear to converge towards one point or towards two opposite points of the horizon. This variety is rarely seen in Altostratus.

II.3.5.4
SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS
Virga and praecipitatio may be clearly visible. Pannus clouds may be observed under Altostratus.
Altostratus may show mamma.

II.3.5.5

CLOUDS FROM WHICH ALTOSTRATUS MAY FORM

Altostratus may form:

- by the thickening of a veil of Cirrostratus (As cirrostratomutatus);
- sometimes by the thinning of a layer of Nimbostratus (As nimbostratomutatus);
- from an Altocumulus layer when widespread ice crystal virga falls from the latter (As altocumulogenitus);
- sometimes, particularly in the tropics, by the spreading out of the middle or upper part of Cumulonimbus (As cumulonimbogenitus).

II.3.5.6

MAIN DIFFERENCES BETWEEN ALTOSTRATUS AND SIMILAR CLOUDS OF OTHER GENERA

Altostratus breaking up into patches is distinguished from Cirrus spissatus (dense) by:

- having greater horizontal extent;
- being predominantly grey;
- the possibility of precipitation in the form of rain, snow or ice pellets;
- the possibility of coronae.

High Altostratus translucidus (thin) is distinguished from Cirrostratus by:

- Altostratus preventing objects on the ground from casting shadows;
- the possibility of the sun having a ground glass effect (blurred outline of the sun);
- the absence of any halo phenomena.

Altostratus sometimes has gaps or breaks where the Altostratus could be confused for a similar layer of Altocumulus (Image 18) or Stratocumulus. Altostratus has a more uniform appearance.

A low layer of Altostratus opacus (thick) is distinguished from similar Nimbostratus by:

- the presence of thinner parts through which the sun is, or could be, vaguely revealed;
- being a lighter shade of grey;
- having a less uniform base than the Nimbostratus;
- possible mamma with the Altostratus.
Visually distinguishing Nimbostratus from Altostratus on moonless nights is difficult, if possible at all. When rain, snow or snow pellets reach the Earth's surface, the cloud is identified as Nimbostratus.

Altostratus translucidus (thin) is distinguished from Stratus by:
- the sun having a ground glass effect (blurred outline of the sun);
- always having some shading and not being white, as thin Stratus may be when observed toward the sun.

Altostratus opacus (thick) is distinguished from Stratus nebulosus opacus (thick) by:
- the layer being thin enough somewhere to reveal the position of the sun;
- the type and intensity of precipitation. Snow is common to both clouds but will be of a greater intensity with Altostratus. Rain and ice pellets are unique to Altostratus; weak drizzle and snow grains are unique to Stratus;
- possible mamma

In the absence of thin parts near the sun, precipitation or mamma, it can be difficult to distinguish between these two clouds. A continuous watch will assist, as Stratus opacus usually does not occur in combination with other cloud genera. Altostratus rarely forms without the presence of high level clouds.

II.3.5.7
PHYSICAL CONSTITUTION

Altostratus is generally a layer of great horizontal extent [several tens or hundreds of kilometres] and fairly considerable vertical extent [several hundreds or thousands of metres].

Altostratus is composed of water droplets and ice crystals. In the most complete case [Figure 1], three superposed parts can be distinguished:

(a) an upper part, composed wholly or mainly of ice crystals;
(b) a middle part, composed of a mixture of ice crystals, snow crystals or snowflakes and supercooled water droplets;
(c) a lower part, composed wholly or mainly of ordinary or supercooled water droplets or drops.

Sometimes the cloud may consist of only two parts, either:
- an upper part like (a) and a lower part like (c) [Figure 2]; or
- an upper part like (b) and a lower part like (c) [Figure 3].

Less frequently, the entire cloud may also be like (a) [Figure 4] or like (b) [Figure 5] alone.
The constituent particles in the lower part of Altostratus are so numerous that the outline of the sun or moon is always blurred. Surface observers will never see halo phenomena. In the thickest parts, the position of the sun or moon may be completely concealed.

Raindrops or snowflakes are often present in Altostratus and below its base. When precipitation reaches the ground, it is generally of the "continuous" type and in the form of rain, snow or ice pellets.

II.3.5.8

EXPLANATORY REMARKS

The base of Altostratus occasionally shows a mamma-like or ragged appearance due to rain or snow virga. Isolated virga are clearly seen when rain, before evaporating, falls farther in some places than in others.

Precipitation sometimes makes it difficult to distinguish a cloud base; particularly when uniformly falling snow completely evaporates before reaching the ground. If, however, snow melts rapidly into rain, an apparent base may be observed at the melting level, as the visibility through rain is greater than through snow. This "base" is very clearly visible when the rain layer is thin, which is the case for instance if the raindrops quickly evaporate; it may be completely obscured when the rain layer is thick.

Pannus clouds may be present. They:

- occur under the Altostratus in the lower turbulent layers when these are moistened by evaporation from precipitation;
- show a tendency to form near the 0°C level where the cooling of the air by melting snow increases the instability of the layer underneath;

In the initial stage of formation, pannus clouds are small, sparse and well separated. They usually occur at a considerable distance below the under surface of the Altostratus;

Later, with a thickening Altostratus and a lowering of its base, this distance is greatly reduced. At the same time, the pannus clouds increase in size and number and may merge into a quasi-continuous layer.

II.3.6

**Nimbostratus (Ns) (CEN 1930)**

II.3.6.1

DEFINITION
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.

**II.3.6.2**

**SPECIES**

No species are distinguished in Nimbostratus.

**II.3.6.3**

**VARIETIES**

Nimbostratus has no varieties.

**II.3.6.4**

**SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS**

Virga and praecipitatio in the form of rain, snow or ice pellets are the supplementary features associated with Nimbostratus.

The accessory cloud pannus is frequently observed under Nimbostratus.

**II.3.6.5**

**CLOUDS FROM WHICH NIMBOSTRATUS MAY FORM**

Nimbostratus develops:

- usually from thickening Altostratus (Ns altostratomitatus);
- rarely from the thickening of a layer of Stratocumulus (Ns stratocumulomitatus);
- rarely from the thickening of a layer of Altocumulus (Ns altocumulomitatus);
- sometimes by the spreading out of Cumulonimbus (Ns cumulonimbogenitus);
- very rarely, when these clouds produce rain, by the spreading out of Cumulus congestus (Ns cumulogenitus).

**II.3.6.6**

**MAIN DIFFERENCES BETWEEN NIMBOSTRATUS AND SIMILAR CLOUDS OF OTHER GENERA**
Nimbostratus is distinguished from *Altostratus opacus* (thick) by:

- generally having a darker grey colour than *Altostratus*;
- being thick enough throughout to hide the sun or moon; only the thicker parts of *Altostratus opacus* hide the sun or moon. On moonless nights there may be doubt regarding the identification of Nimbostratus or Altostratus. The cloud is identified as Nimbostratus when precipitation (rain, snow or ice pellets) reaches the ground;
- When discernable, usually having a lower base than *Altostratus*;
- sometimes having the appearance of being illuminated from the inside; this feature is never found in *Altostratus*;

Nimbostratus is distinguished from *Altocumulus stratiformis opacus* (thick layer):

- by falls of rain, snow or ice pellets; no precipitation falls from *Altocumulus*;
- having no features and usually no discernible base; *Altocumulus* has clearly defined elements and a distinct lower surface;

Nimbostratus is distinguished from *Stratocumulus stratiformis opacus* (thick layer) by:

- having no features and usually no discernible base; *Stratocumulus* has clearly defined elements (merged or separated) and a distinct lower surface;
- falls of rain, snow or ice pellets; *Stratocumulus* has infrequent weak falls of rain, snow or snow pellets;

Nimbostratus is distinguished from *Stratus nebulosus opacus* (thick layer without distinct detail):

- falls of rain, snow or ice pellets; *Stratus* has weak falls of drizzle, snow or snow grains;
- thick *Stratus* usually develops in the absence of other low or middle level clouds; Nimbostratus usually evolves from an overcast layer of Altostratus;

When the observer is beneath a cloud having the appearance of Nimbostratus, but accompanied by lightning, thunder or hail, the cloud is classified as *Cumulonimbus*.

**PHYSICAL CONSTITUTION**

Nimbostratus generally covers a wide area and is of great vertical extent. It is composed of water droplets (sometimes supercooled) and raindrops, of snow crystals and snowflakes, or of a mixture of these liquid and solid particles. The high concentration of particles and the great vertical extent of the cloud prevent direct sunlight from being observed through it. The cloud produces rain, snow or ice pellets which, however, do not necessarily reach the ground.
Il.3.6.8

EXPLANATORY REMARKS

Nimbostratus usually develops from thickening Altostratus, the base of which gradually lowers. When the cloud becomes thick enough throughout to mask the sun, it is classified as Nimbostratus. Nimbostratus usually appears as if illuminated from inside. This is a result of the absence of small cloud droplets in its lower parts, whereby more light penetrates from above than in the case of non-precipitating clouds of the same depth. The small cloud droplets in the lower parts of the cloud are swept out by precipitation or they evaporate owing to the presence of colder raindrops or snowflakes in the cloud.

Although Nimbostratus generally has no clear under surface, an apparent base is sometimes discernible. This "base" is situated at the level where the snow melts into rain and is due to the poorer visibility in snow than in rain. The melting level can be seen only when it is sufficiently low and when the precipitation is not too heavy. The under surface of Nimbostratus is often partially or totally hidden by pannus clouds resulting from turbulence in the layers under its base, which are moistened by partial evaporation of precipitation. At first, these pannus clouds consist of separate units; they may later merge into a continuous layer extending up to the Nimbostratus. When the pannus covers a large expanse of the sky, care should be exercised in order not to confuse it with the under surface of Nimbostratus. Although pannus clouds have a tendency to dissipate, chiefly by the coalescence of their small particles with raindrops or snowflakes falling through them, they continue to reform. In heavy precipitation, however, the pannus particles are swept out faster than they can be replaced and the pannus clouds disappear.

In the tropics, particularly during short lulls in the rainfall, Nimbostratus can be seen breaking up into several different cloud layers, which rapidly merge again. The clouds then often show a very characteristic livid colour with variations of luminance, probably due to internal gaps.

II.3.7

Stratocumulus (Sc) (KAEMTZ 1841)

II.3.7.1

DEFINITION

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 regularly arranged small elements have an apparent width of more than five degrees.

II.3.7.2

SPECIES

Stratocumulus stratiformis (Sc str) - CCH 1953
Rolls or large rounded masses arranged in an extended sheet or layer. The elements are more or less flattened. This species is the most common.

Stratocumulus lenticularis (Sc len) - LEY 1894, CEN 1930

A patch of Stratocumulus, in the shape of a lens or almond, often very elongated and usually with well defined outlines. The patch is either composed of small elements (an apparent width greater than 5° degrees when observed at an angle of more than 30° above the horizon), closely grouped together, or consists of one more or less smooth and usually dark unit. Irisation is possible. This species of Stratocumulus is fairly rare.

Stratocumulus castellanus (Sc cas) - CCH 1953

Cumuliform turrets rising vertically from cloud elements connected by a common horizontal base. The turrets:

- seem to be arranged in lines;
- give the cloud a crenelated (castle battlement) appearance;
- are sometimes taller than they are wide;
- are especially evident when the cloud is seen from the side.

Stratocumulus castellanus can grow to a considerable size and develop into:

- Cumulus congestus stratocumulogenitus if it is strongly sprouting or is of great vertical extent;
- Cumulonimbus stratocumulogenitus if part of its upper portion is smooth, fibrous or striated, or if the cloud produces lightning, thunder or showers of hail.

Stratocumulus volutus (Sc vol) - ??? 2016

A long, horizontal, detached, tube-shaped cloud mass, often appearing to roll slowly about a horizontal axis. They usually occur singularly but are occasionally observed in successive lines of clouds. This species of Stratocumulus is rare.

Stratocumulus floccus (Sc flo) - ??? 2016

Small tufts of cumuliform appearance; the lower parts of the tufts are generally ragged and, at very low temperatures, accompanied by fibrous trails (ice crystal virga). Stratocumulus floccus is an indication of instability at that level. Stratocumulus floccus often forms as a result of the dissipation of the base of Stratocumulus castellanus.

II.3.7.3

VARIETIES

Stratocumulus translucidus (Sc tr) - CEN 1930

A patch, sheet or layer of Stratocumulus that is nowhere very dense. The greater part of the cloud is sufficiently translucent to reveal the position of the sun or moon; the cloud may even allow the blue of the sky to be faintly distinguished where its elements join.
Stratocumulus perlucidus (Sc pe) - CCH 1953

A patch, sheet or layer of Stratocumulus where the spaces between the elements allow the sun, the moon, the blue of the sky or higher clouds to be seen.

Stratocumulus opacus (Sc op) - CEN 1930

Dense Stratocumulus composed of a continuous or nearly continuous sheet or layer of large dark rolls or rounded masses, most of which are sufficiently opaque to hide the sun or moon. The base of Stratocumulus opacus is sometimes even, and its apparent subdivision into merged elements results from the irregularity of its upper surface. More often, however, the under surface is uneven, and the elements stand out in true relief.

Stratocumulus duplicatus (Sc du) - CCH 1953

Stratocumulus comprising two or more broadly horizontal superposed patches, sheets or layers, close together, sometimes partly merged. This variety occurs in the species stratiformis and lenticularis.

Stratocumulus undulatus (Sc un) - CLAYTON 1896, CEN 1930

A layer composed of fairly large and often grey elements, arranged in a system of nearly parallel lines. A double system of undulations is sometime visible in the form of transverse lines that cross the main system. The elements then appear to be arranged in “rank and file”.

Stratocumulus undulatus occurs in the species stratiformis.

Stratocumulus radiatus (Sc ra) - CEN 1926

Stratocumulus showing broad, nearly parallel bands that, owing to the effect of perspective, appear to converge towards a point or towards opposite points of the horizon. This variety looks similar to Cumulus arranged in files (“cloud streets”), the difference being the Cumulus is individual cells arranged in files. Stratocumulus radiatus occurs in the species stratiformis.

Stratocumulus lacunosus (Sc la) - CCH 1953

Stratocumulus, in a sheet or layer or in patches, with more or less regularly distributed round holes, many of them with fringed edges. The cloud elements and clear spaces are often arranged in a net or honeycomb manner. The details change rapidly.

II.3.7.4

SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS

Stratocumulus may show asperitas and fluctus and at very low temperatures cavum.

Stratocumulus may also how mamma; its under surface then presents an accentuated relief in the form of udders or inverted mounds that even appear to be on the point of detaching themselves from
the cloud.

Stratocumulus mamma can be confused with Altostratus opacus with a mammilated (wrinkled) appearance.

Virga may also occur under Stratocumulus, especially at very low surface temperatures.

The feature praecipitatio rarely occurs. When it does, the precipitation (rain, snow or snow pellets) is only of weak intensity.

II.3.7.5

CLOUDS FROM WHICH STRATOCUMULUS MAY FORM

Stratocumulus may form:

- from Altocumulus when the small elements grow to a sufficient size (Sc altocumulomutatus);
- sometimes near the base of Altostratus, as a result of turbulence or convection in the layers moistened by evaporating precipitation (Sc altostratogenitus);
- more often near the base of Nimbostratus, as a result of turbulence or convection in the layers moistened by evaporating precipitation (Sc nimbostratogenitus);
- from the thinning of Nimbostratus, signifying the end of a rain event (Sc nimbostratomutatus);
- from the of the lifting of a layer of Stratus (Sc stratomutatus);
- from the convective or turbulent transformation of Stratus, with or without change of height (Sc stratomutatus);
- by spreading of the tops of Cumulus when they reach a stable layer (Sc cumulogenitus); usually the mid to upper part of the Cumulus gradually widens in proximity to the stable layer. The vertical development of Cumulus may:
  - cease at the stable layer, resulting in patches of Stratocumulus spreading out from the top of the Cumulus; often the Cumulus dissipates completely from the base upwards;
  - temporarily stop at the stable layer and then resume their growth in places or throughout, resulting in Stratocumulus on the side/s of the Cumulus;
- from Cumulus (Sc cumulogenitus) when towers lean and spread or are detached and spread due to strong wind shear;
- from Cumulus (Sc cumulogenitus) when convection ceases in the late afternoon and evening and the domed tops of the Cumulus clouds flatten;
- by the spreading out of Cumulonimbus (Sc cumulonimbogenitus). Stratocumulus may be observed on or near the sides of Cumulonimbus and often forms while the Cumulonimbus is still in the Cumulus stage. Nevertheless, the Stratocumulus is classified as cumulonimbogenitus, not cumulogenitus;
- by the spreading out of some of the lower parts of an existing Cumulonimbus (Sc cumulonimbogenitus).

Cumulus or Cumulonimbus towers can also pass through a pre-existing layer of Stratocumulus formed independently of them. When this occurs:

- the Cumulus or Cumulonimbus do not widen upward towards the Stratocumulus layer;
- a thinned or even a cleared zone frequently appears in the Stratocumulus around the cumuliform towers.

I.I.3.7.6

MAIN DIFFERENCES BETWEEN STRATOCUMULUS AND SIMILAR CLOUDS OF OTHER GENERA
Stratocumulus can, in extremely cold weather, produce abundant ice crystal virga from which halo phenomena may be observed. This Stratocumulus is distinguished from Cirrostratus nebulosus by:

- showing some evidence of elements, rounded masses, rolls, etc;
- greater opacity than that of Cirrostratus

Stratocumulus is distinguished from Altocumulus by:

- most of the regularly arranged elements having, when observed at an angle of more than 30° above the horizon, an apparent width greater than 5° (3 fingers at arm’s length);
- possible precipitation in the form of weak falls of rain, or snow;

An extensive layer of Stratocumulus is distinguished from Altostratus by:

- having a less uniform base;
- the presence of elements, rounded masses, rolls, etc;
- appearing non-fibrous, except at extremely low temperatures; Altostratus often has a fibrous appearance;
- very weak and infrequent precipitation in the form of rain, snow or snow pellets, Altostratus can have light, or occasionally moderate, falls of rain, snow or ice pellets;

Stratocumulus stratiformis opacus (thick extensive layer) is distinguished from Nimbostratus by:

- having a less uniform base;
- the presence of elements, rounded masses, rolls, etc;
- precipitation in the form of rain, snow or snow pellets being weak in intensity and infrequent in occurrence; Nimbostratus usually has falls of rain, possible falls of snow or ice pellets that can be up to heavy in intensity;
- possible asperitas or mamma;
- absence of pannus, a usual feature of Nimbostratus

Stratocumulus is distinguished from Stratus by:

- the presence of elements, rounded masses, rolls, etc;
- usual absence of a ragged structure, a feature of Stratus fractus; Stratocumulus floccus has a ragged lower part with a cumuliform tuft at the top;
- weak falls of rain, snow or snow pellets; Stratus has falls of drizzle, snow or snow grains;
- possible mamma;
- possible virga; the low base of Stratus ensures precipitation reaches the ground;
- possible corona;

Stratocumulus is distinguished from Cumulus by:

- elements usually occurring in groups or patches and generally have flat tops;
- occasionally having tops in the form of domes or turrets that rise from merged bases;
- possibly being shaded throughout, Cumulus is noted for its brilliant white sunlight parts;
- the absence of arcus, tuba, pileus, velum and pannus;
- precipitation falling uniformly in an intermittent or continuous nature; Cumulus is noted for precipitation falling in the form of showers;
- usual absence of any form of rainbow

Stratocumulus floccus may bear a strong resemblance to Cumulus fractus frayed by a fairly strong wind or Cumulus mediocris with irregular bases on days of fresh to strong winds. Stratocumulus floccus is
distinguished from these species of Cumulus by:

- usually having a very ragged lower part; if there is evidence of a partial flat base it rapidly dissipates;
- base unusually high compared to an expected base for Cumulus; Cumulus may even be observed at a lower base

If there is doubt as to the identification, the cloud is identified as the appropriate Cumulus species.

I.I.3.7.7

PHYSICAL CONSTITUTION

Stratocumulus is composed of water droplets, sometimes accompanied by raindrops or, more rarely, by snow pellets, snow crystals and snowflakes. Any ice crystals present are usually too sparse to give the cloud a fibrous appearance. During extremely cold weather, Stratocumulus may produce abundant ice crystal virga that may be accompanied by halo phenomena. When Stratocumulus is not very thick, a corona or irisation is sometimes observed.

II.3.7.8

EXPLANATORY REMARKS

The appearance of Stratocumulus is similar to that of Altocumulus. Owing to its generally lower height, the elements of Stratocumulus look larger and, at times, smoother than those of Altocumulus. Stratocumulus elements are often arranged in lines or groups, showing a single or double system of undulations. Elements may be more or less separate; however the cloud layer is more often continuous, sometimes with gaps. The under surface of a continuous cloud layer is often uneven and presents a relief in the form of creases, mamma, etc.

II.3.8

Stratus (St) (HOWARD 1803; HILDEBRANDSSON AND ABERCROMBY 1887)

II.3.8.1

DEFINITION

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 discernible. Stratus does not produce halo phenomena except, possibly, at very low temperatures. Sometimes Stratus appears in the form of ragged patches.
II.3.8.2 SPECIES

*Stratus nebulosus* (St neb) - CLAYDEN 1905, CCH 1953

Nebulous, grey, fairly uniform layer of Stratus. This is the most common species.

*Stratus fractus* (St fra) - CEN 1930, CCH 1953

Stratus occurring in the form of irregular ragged shreds the outlines of which change continuously and often rapidly.

II.3.8.3 VARIETIES

*Stratus opacus* (St op) – BESSON 1921, CCH 1953

Patch, sheet or layer of Stratus, the major part of which is so opaque that it completely masks the sun or moon. This is the most common variety.

*Stratus translucidus* (St tr) – CEN 1926, CCH 1953

Patch, sheet or layer of Stratus, the major part of which is sufficiently translucent to reveal the outline of the sun or moon.

*Stratus undulatus* (Stun) – CLAYTON 1896, CCH 1953

Patch, sheet or layer of Stratus showing undulations. This variety does not occur very often.

II.3.8.4 SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS

The only supplementary feature of Stratus is praecipitatio (precipitation in the form of drizzle, snow and snow grains).

II.3.8.5 CLOUDS FROM WHICH STRATUS MAY FORM
Stratus may form from the transformation of *Stratocumulus* (St stratocumulomutatus) when it thickens and lowers forming a fairly uniform base; or the base stays at the same height but loses its relief or its subdivisions.

Precipitating Stratocumulus can thicken and lower and lose its relief or subdivisions. This is not transformation to Stratus. If the precipitating Stratocumulus is devoid of relief or subdivisions for an extended period of time, consideration must be given to the cloud having transformed to Nimbostratus.

Stratus often forms from the slow lifting of a *fog layer*, due to warming of the Earth’s surface or an increase in wind speed.

Stratus fractus of wet weather (the conditions which generally exist during precipitation and a short time before and after) is often produced by Altostratus, Nimbostratus or Cumulonimbus (St fra altostratogenitus, St fra nimbostratogenitus or St fra cumulonimbogenitus); it may also result from precipitating Cumulus (St fra cumulogenitus).

### II.3.8.6

**MAIN DIFFERENCES BETWEEN STRATUS AND SIMILAR CLOUDS OF OTHER GENERA**

Stratus can occasionally resemble *Cirrus* when it is frayed by the wind into the form of coarse fibres (Stratus fractus). The fibres:

- are not as white (except when viewed towards the sun) as Cirrus fibres;
- are not as spread out as Cirrus fibres;
- change in appearance rapidly; Cirrus is noted for slow change.

Thin Stratus (translucidus) is distinguished from *Cirrostratus* by:

- not being so completely white except when viewed towards the sun;
- possible coronae

Stratus is distinguished from *Altostratus* by;

- the outline of the sun not being blurred; that is the disk or partial disk of the sun is discernible;
- the absence of shading in thin Stratus when viewed toward the sun; Altostratus always has shading;
- precipitation in the form of drizzle or snow grains; Altostratus has rain and ice pellets; snow can occur with both clouds
Stratus nebulosus opacus (thick) closely resembles Nimbostratus and may very easily be confused with it. It is distinguished from Nimbostratus by:

- having a more clearly defined and more uniform base than Nimbostratus;
- having a "dry" appearance, contrasting to the "wet" appearance of Nimbostratus;
- producing only weak falls of drizzle, snow or snow grains, whereas Nimbostratus nearly always produces rain, snow or ice pellets;
- not usually being preceded by other clouds of the low and middle level; Nimbostratus nearly always succeeds other clouds, usually of the middle level, or develops from a pre-existing cloud.

Stratus translucidus (thin) is distinguished from Nimbostratus by the disk of the sun being discernible, at least through its thinnest parts; Nimbostratus masks the sun or moon throughout.

Stratus is distinguished from Stratocumulus by there being no evidence of elements, merged or separate.

Stratus fractus is distinguished from Cumulus fractus in that it is less white and less dense. It also has less vertical development, since it owes its formation mainly to turbulence, not heating of the air near the earth’s surface.

II.3.B. 7
PHYSICAL CONSTITUTION

Stratus is usually composed of small water droplets. When very thin, Stratus may produce a corona around the sun or moon. At low temperatures, Stratus may consist of small ice particles. The ice cloud is usually thin and on rare occasions, may produce halo phenomena.

Stratus, when dense or thick, often contains drizzle droplets and sometimes snow or snow grains. It may then have a dark or even a threatening appearance.

Stratus with a low optical thickness, usually of the variety translucidus, often shows a smoky greyish tint like that of fog when viewed at more than 90° from the sun.

II.3.B.8
EXPLANATORY REMARKS

Stratus forms under the combined effect of cooling in the lower layers of the troposphere and turbulence due to the wind.

Over land, the cooling may be a result of nighttime cooling which is particularly marked when the sky is clear and the wind is weak, or by advection of relatively warm air over colder ground. Over sea, the cooling is mainly due to advection of relatively warm air over colder water surface.

Stratus is sometimes observed as more or less joined cloud fragments with varying luminance. These
Stratus fractus clouds constitute a transitory stage during the formation or the dissipation of the more common extensive uniform Stratus layer. The transitory stage is usually very short.

Stratus fractus clouds may also form as accessory clouds (pannus) under Altostratus, Nimbostratus, Cumulonimbus and precipitating Cumulus. They develop as a result of turbulence in the moistened layers under these clouds.

Stratus may develop locally in the vicinity of large waterfalls as a consequence of water broken up into spray by the falls. The Stratus will be classified by any appropriate species, variety and supplementary feature, followed by *cataractagenitus*.

Stratus may develop locally over forests as a result of increased humidity due to evaporation and evapotranspiration from the tree canopy. The Stratus will be classified by any appropriate species, variety and supplementary feature followed by *silvagenitus*.

### II.3.9

#### Cumulus (Cu)

*(HOWARD 1803)*

### II.3.9.1

**DEFINITION**

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.

### II.3.9.2

**SPECIES**

*Cumulus humilis* (Cu hum) - VINCENT 1907

Cumulus characterized by only a small vertical extent and appearing generally as if flattened. Cumulus humilis clouds never produce precipitation.

*Cumulus mediocris* (Cu med) - CCH 1953

Cumulus of moderate vertical extent, with small protuberances and sproutings at their tops. Cumulus mediocris generally produce no precipitation.

*Cumulus congestus* (Cu con) - MAZE 1889
Strongly sprouting Cumulus with generally sharp outlines and often great vertical extent. The bulging upper part of Cumulus congestus frequently resembles a cauliflower. Cumulus congestus may produce precipitation in the form of showers of rain, snow or snow pellets. In the tropics they often release abundant rain in the form of showers.

Cumulus congestus sometimes resemble narrow, very high towers. The tops of these towers may detach themselves successively from the main body of the cloud. They are then carried away by the wind and usually rapidly disintegrate, occasionally producing virga.

Cumulus congestus usually results from the development of Cumulus mediocris or infrequently, Altocumulus castellanus or Stratocumulus castellanus. Cumulus congestus often develops into Cumulonimbus; this transformation is:

- visually revealed by the smooth appearance or by the fibrous or striated texture of its upper portion;
- apparent when lightning, thunder or showers of hail are observed.

*Cumulus fractus* (Cu fra) – POEY, 1863, CCH 1953

Small Cumulus with very ragged edges and with outlines continuously undergoing changes that are often rapid.

**II.3.9.3**

**VARIETIES**

*Cumulus radiatus* (Cu ra) - CCH 1953

Cumulus arranged in lines nearly parallel to the wind direction (cloud streets) and usually of the species mediocris. Due to perspective, these lines seem to converge towards a point or towards opposite points of the horizon.

**II.3.9.4**

**SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS**

Cumulus may show: pileus, velum, virga, praecipitatio (the precipitation occurs in the form of showers), fluctus (occasionally in the species humilis), arcus (rarely), pannus (rarely) and tuba (very rarely).

**II.3.9.5**

**CLOUDS FROM WHICH CUMULUS MAY FORM**

Cumulus is often preceded by hazy spots in the sky out of which the clouds develop.

Cumulus may form:

- from the development of *Altocumulus* castellanus (Cu congestus altocumulogenitus);
- from the development of Stratocumulus castellanus (Cu congestus stratocumulogenitus);
- by the transformation of Stratocumulus (Cu stratocumulomutatus); or
- by the transformation of Stratus (Cu stratomutatus); this frequently occurs in the morning over
Cumulus fractus of wet weather forms under Altostratus, Nimbostratus, Cumulonimbus or precipitating Cumulus (Cu fra altostratogenitus, nimostratogenitus, cumulonimbogenitus or cumulogenitus).

II.3.9.6

MAIN DIFFERENCES BETWEEN CUMULUS AND SIMILAR CLOUDS OF OTHER GENERA

Cumulus is distinguished from most Altocumulus and Stratocumulus by being detached and dome-shaped. When viewed from a distance, Cumulus clouds may appear merged, owing to the effect of perspective. Care should be taken not to confuse distant Cumulus with Altocumulus or Stratocumulus.

Cumulus tops may:
- spread and form Stratocumulus cumulogenitus or Altocumulus cumulogenitus;
- penetrate and pass through existing layers of Stratocumulus or Altocumulus; or
- merge with Altostratus or Nimbostratus.

The Cumulus clouds that are spreading, penetrating or merging continue to be identified as Cumulus as long as they remain detached from one another or they have relatively considerable vertical extent.

When an extensive precipitating Cumulus is directly above, it can be confused with Altostratus or Nimbostratus or perhaps Stratocumulus stratiformis opacus (thick layer). If the precipitation is in the form of showers the cloud is Cumulus. A continuous watch will also assist as Altostratus, Nimbostratus and Stratocumulus stratiformis opacus are noted for their longevity; a feature not characteristic of Cumulus cloud.

Cumulus congestus of great vertical extent is distinguished from Cumulonimbus by:
- the edges of the bulging upper parts being sharply defined and having no fibrous or striated texture;
- no lightning, thunder or showers of hail.

Cumulus mediocris (with irregular bases and ragged in parts due to fresh to strong winds) and Cumulus fractus (frayed by strong winds) are distinguished from Stratocumulus flocus by:
- part of the base being flat; Stratocumulus flocus usually has a very ragged lower part; if there is evidence of a flat base it rapidly dissipates;
- the vertical structure of the cloud leaning strongly downwind;
- continuous and rapid changes in the outlines of Cumulus fractus

If there is doubt as to the identification, the cloud is identified as the appropriate Cumulus species.

Cumulus fractus is distinguished from Stratus fractus by:
- generally greater vertical extent;
- usually whiter and less transparent appearance;
- possible rounded or dome shaped tops, Stratus fractus always occurs as ragged shreds.

II.3.9.7

PHYSICAL CONSTITUTION
Cumulus is composed mainly of water droplets. When of great vertical extent, Cumulus may release precipitation in the form of showers of rain, snow or snow pellets. Ice crystals may form in those parts of a Cumulus where the temperature is well below 0° C. The ice crystals grow at the expense of evaporating super-cooled water droplets, transforming the cloud into Cumulonimbus. In cold weather, when the temperature in the entire cloud is well below 0° C, this process leads to the degeneration of the cloud into diffuse trails of snow.

II.3.9.8

EXPLANATORY REMARKS

Cumulus develops:
- in convection currents resulting from heating near the Earth's surface;
- due to cooling or advection of cold air (instability) in higher layers;
- from lifting of air layers where vertical expansion results in cooling;

The characteristics of Cumulus clouds depend essentially on their vertical extent; that is the vertical distance between their base and the stable layer that has inhibited vertical development.

The degree of stability and thickness of the stable layer determine how effective this layer is at inhibiting vertical development. When it is very stable, for example a strong inversion, the tops of Cumulus clouds will spread out forming Stratocumulus cumulogenitus or Altocumulus cumulogenitus. When it is stable but not very thick, the spreading out of the tops of Cumulus clouds may be only in parts or momentarily and then some tops may penetrate it.

Comments on vertical extent.

When Cumulus have:
- great vertical extent (a low base and a high stable layer) the Cumulus is of the species congestus. The vertical extent of Cumulus in tropical regions (when not under the influence of a trade wind inversion) is generally much greater than elsewhere;
- moderate vertical extent (base and stable layer are reasonably close together) Cumulus mediocris tops may spread out forming either Stratocumulus or Altocumulus;
- small vertical extent (base and stable layer are very close together) the Cumulus has a flattened appearance (Cumulus humilis). They may even spread out in their entirety into Stratocumulus or Altocumulus.

Cumulus may dissipate during the day as the surface air temperature rises and the Cumulus base rises until its height exceeds, sometimes considerably, that of the stable layer.

When there is no vertical extent (stable layer is lower than the level where sufficient cooling had occurred for condensation to take place) Cumulus may be present but only if there is a mechanism forcing air to rise to reach the level where condensation could have occurred. Orographic lift is an example of a forcing mechanism.

Diurnal variation in Cumulus activity:
- is generally pronounced over land. On clear mornings, with the sun rapidly heating the surface of the ground, conditions are favourable for the formation of Cumulus. This formation may begin early, when the lapse rate is steep and the relative humidity is high; it begins late, if it occurs at all, when the lapse rate is small and the relative humidity is low. After having reached a maximum, usually in mid-afternoon, the Cumulus activity decreases and finally the clouds disappear in the late afternoon or early evening.
- Is so small over the open oceans that its existence is sometimes doubtful. When it exists,
maximum Cumulus activity appears to occur in the late hours of the night.

- near coasts has Cumulus forming over the land by day in connection with the sea breeze and over the sea by night in connection with the land breeze.

**Comments on illumination**

When a well-developed Cumulus is:

- observed opposite the sun, the diffuse reflection of the sunlight falling on the surface of the cloud reveals the relief of the protuberances by very pronounced differences in luminance;
- illuminated from the side, Cumulus shows strongly contrasted shading;
- illuminated from behind, the Cumulus appears relatively dark, with an extremely brilliant border (every cloud has a sliver lining);
- against a background of cirriform (ice) clouds and away from the horizon, Cumulus appears a little less white than the cirriform clouds and its margins appear grey, even when the Cumulus is directly illuminated by the sun.

Whatever the illumination of the Cumulus may be, its base is generally grey.

Cumulus may develop in convection initiated by heat from forest fires, wild-fires or from volcanic eruption activity. The Cumulus will be classified by any appropriate species, variety and supplementary feature, followed by *flammagenitus* (e.g. Cumulus congestus flammagenitus).

Cumulus may develop as a consequence of human activity such as forming in convection initiated above power station cooling towers. When Cumulus is clearly observed to have originated as a consequence of human activity it will be classified by any appropriate species, variety and any supplementary features followed by the *homogenitus* (e.g. Cumulus mediocris homogenitus).

Cumulus may develop locally in the vicinity of large waterfalls as a consequence of water broken up into spray by the falls. The Cumulus will be classified by any appropriate species, variety and supplementary feature, followed by *cataractagenitus* (e.g. Cumulus mediocris cataractagenitus).

**II.3.10**

**Cumulonimbus (Cb) (WEILBACH 1880)**

**II.3.10.1**

**DEFINITION**

Heavy and dense cloud, with a 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.
II.3.10.2

SPECIES

*Cumulonimbus calvus* (Cb cal) - CEN 1926

Cumulonimbus where the sproutings of the upper parts are indistinct and flattened and have the appearance of a whitish mass without sharp outlines. No fibrous or striated parts are visible. *Cumulonimbus calvus* usually produces precipitation; when it reaches the ground it is in the form of showers.

*Cumulonimbus capillatus* (Cb cap) - CEN 1926

Cumulonimbus where the upper portion has cirriform parts of clearly fibrous or striated structure, frequently in the shape of an anvil (*Cumulonimbus capillatus incus*), a plume or a vast disorderly mass of hair. In very cold air masses the fibrous structure often extends virtually throughout the cloud.

*Cumulonimbus capillatus* is usually accompanied by a shower or by a thunderstorm, often with wind squalls and sometimes with hail; it frequently produces very distinct virga.

II.3.10.3

VARIETIES

*Cumulonimbus* has no varieties.

II.3.10.4

SUPPLEMENTARY FEATURES AND ACCESSORY CLOUDS

*Cumulonimbus* may show:

- praecipitatio (showers of rain, snow, snow pellets, or hailstones);
- virga;
- pannus;
- incus;
- mamma (observed frequently on the base of the projecting portion of the anvil, less frequently on the base of the cloud);
- pileus, velum, arcus and murus;
- cauda, flumen and tuba are rarely observed.

II.3.10.5
CLOUDS FROM WHICH CUMULONIMBUS MAY FORM

Cumulonimbus most commonly evolves from *Cumulus congestus* (Cb cumulogenitus or Cb cumulomutatus) that was formed in the normal manner [see paragraphs II.3.9.7 and II.3.9.8].

Cumulonimbus also forms:
- from *Altocumulus* castellanus (Cb altocumulogenitus); the base of the Cumulonimbus is unusually high
- from *Stratocumulus* castellanus (Cb stratocumulogenitus);
- by the transformation and development of a portion of *Altostratus* or *Nimbostratus* (Cb altostratogenitus or Cb nimbostratogenitus).

In the majority of these cases, the transformation into Cumulonimbus passes through the Cumulus congestus stage.

II.3.10.6

MAIN DIFFERENCES BETWEEN CUMULONIMBUS AND SIMILAR CLOUDS OF OTHER GENERA

When Cumulonimbus covers a large expanse of the sky, it can easily be confused with *Nimbostratus*, especially when identification is based solely on the appearance of the under surface. The character of the precipitation may help to distinguish Cumulonimbus from Nimbostratus. If the precipitation is of the showery type, or if it is accompanied by lightning, thunder or hail, the cloud is Cumulonimbus.

Certain Cumulonimbus clouds appear nearly identical with *Cumulus congestus*. The cloud is identified as Cumulonimbus as soon as at least a part of its upper portion loses the sharpness of its outlines or presents a fibrous or striated texture. If it is not possible to decide on the basis of the above criteria whether a cloud is a Cumulonimbus or Cumulus, it is identified as Cumulonimbus if it is accompanied by lightning, thunder or hail.

II.3.10.7

PHYSICAL CONSTITUTION

Cumulonimbus is composed of water droplets and, especially in its upper portion, of ice crystals. It also contains large raindrops and, often, snowflakes, snow pellets, or hailstones. The water droplets and raindrops may be substantially supercooled.
II.3.10.8

EXPLANATORY REMARKS

The conditions under which Cumulonimbus clouds occur are similar to those which are favourable for the development of Cumulus congestus (see paragraph II.3.9.8). The transformation of Cumulus congestus into Cumulonimbus is due to the formation of ice particles in its upper part. The presence of ice particles is evident when some or all of the upper part loses the sharpness of its outlines or acquires a fibrous or striated texture.

Cumulonimbus clouds may appear either as isolated clouds or in the form of a continuous line of clouds resembling a very extensive wall.

In certain cases, the upper portion of Cumulonimbus clouds may be merged with Altostratus or Nimbostratus. Cumulonimbus may also develop within the general mass of Altostratus or Nimbostratus.

Low, ragged accessory clouds (pannus) often develop under Cumulonimbus; these clouds are at first separated from one another, but they may later merge so as to form a continuous layer partially or totally in contact with the Cumulonimbus base.

Cumulonimbus may be described as a "cloud factory"; it can produce thick patches or sheets of Cirrus spissatus, Alto cumulus, Altostratus or Stratocumulus by the spreading out of its upper portions and by the dissipation of the lower parts. The spreading of the highest part usually leads to the formation of an anvil; if the wind increases strongly with altitude, the cloud top spreads only downwind, assuming the shape of a half anvil or in some cases of a vast plume.

Cumulonimbus is rare in polar regions and more frequent in temperate and tropical regions.

Cumulonimbus may develop from convection initiated by heat from forest fires, wild-fires or from volcanic eruption activity. Cumulonimbus that is clearly observed to have originated as a consequence of localised natural heat sources will be classified by any appropriate species, variety and supplementary feature, followed by flammagenitus.