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Cloud Dynamics using Fall Velocity and Nucleation Geometry of Clouds

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Abstract. Agriculture is the main occupation in most of the developing countries which depends on rainfall mostly. Now, since many researchers have undergone to predict rainfall, they are not a huge success. Due to changes in the climatic conditions around the globe, these predictions are not at a higher level. In our Research to predict the rainfall, we are using pressure points which are present on a cloud, and we are using, this data to configure the rainfall in a particular region. The data for the research was supplied from ISRO satellites.

Keywords: Rainfall; Prediction; types of Clouds; Forecating; Geometric Position

1. Introduction

It is know that weather is an important constituent to know the future of mankind. Weather can be predicted in many ways. It can be predicted by using satellite images, radar images, image processing, data mining etc. The satellites used for weather prediction are known as Baro-satellites. We mainly confined to the analysis of a cloud, whether a cloud is a rain cloud or a dry cloud. The composition of the cloud based on various facts considering the composition of the cloud and static discharge of the cloud can be predicted.

A cloud can be predicted by comparing the picture of the cloud with those available in the database. Here, we must consider that the geographical position of a cloud has to be considered for the better results. The geographical position of a cloud can be found by knowing the latitudes and longitudes available which are used to determine the position of any object on the surface of the earth. The cloud image must be of pixellographic form, because the analysis of the cloud is based on the pixels of the image.

To analyze a cloud, we must fix a reference quantity to which it has to be calculated and compared to achieve easy comparison with that of database images. Here, we take pressure as a quantity (derived fundamental) for this purpose. Since, the data can be varied with the analysis this fixed fundamental is of more importance. The pressure can be calculated by analyzing some points on the image of a cloud known as Pressure points. Now, considering the analysis of a cloud, in which the data of the cloud has to be determined by using the data mining technique. In this context, we have to fix the reference axis of the cloud. The position of the cloud has to be determined by using latitudes and longitudes, this helps to determine the velocity of the wind and direction of the wind. Now, the image of the cloud has to be taken and the image has to be divided into some pixellographs. The area corresponding to the given pressure points can be obtained by using this form. Thus mapping has been done between reality and relativity.

2. Classification of Clouds

At the simplest level clouds are classified into two types. They are flat stratus cloud and puffy cumulus cloud. Stratus clouds occur in layers at various heights and indicate that the atmosphere is stable, with little vertical air movement. Cumulus clouds occur when there is vertical movement of air and the atmosphere is unstable. Small cumulus cloud can occur at any height. A large cumulus cloud with dark base is likely to cause strong up currents with large wind shifts around the base.

Clouds are also defined by height- cirrostratus is a very high sheet of thin white cloud which can form a halo round the sun or moon; altostratus is high layered cloud; altocumulus is a layer of small cumulus, sometimes forming ripples, known as a mackerel sky.

Cirrus cloud is the high, white, curled, steaks of cloud known as mares' tails. With a falling barometer, this usually indicates the approaching warm front of a depression with associated veering wind and rain. It can be followed by lower levels of altostratus, stratus and nimbostratus cloud. Usually this brings rain; nimbus just means bearing rain. After the warm front there is broken cloud, sometimes with light rain and poor visibility. Then comes the cold front, which at worst may be thundery cumulonimbus with heavy rain and squalls. Finally after the cold we have to come back to front cumulus with clear skies and showers, and stronger veering winds.

2.1. Low Level Clouds

These clouds are at an altitude ranging between 0 and 2 km from the surface of the Earth.


(a) (b)


(c) (d)

Fig.1. Low Level Clouds

2.1.1. Stratus

A stratus cloud (fig. 1.a) is a cloud belonging to a class characterized by horizontal layering with a uniform base, as opposed to convective clouds that are as tall or taller than wide (these are termed cumulus clouds). More specifically, the term stratus is used to describe flat, hazy, featureless clouds of low altitude varying in color from dark gray to nearly white. Stratus clouds may produce a light drizzle or snow. A "cloudy day" usually features a sky filled with stratus clouds obscuring the disk of the sun. These clouds are essentially above-ground fog formed either through the lifting of morning fog or when cold air moves at low altitudes over a region.

2.1.2. Stratocumulus

A stratocumulus (fig. 1.b) cloud belongs to a class of clouds characterized by large dark, rounded masses, usually in groups, lines, or waves, the individual elements being larger than those in altocumuli, and the whole being at a lower altitude, usually below 2,400 m (8,000 ft). Weak convective currents create shallow cloud layers because of drier, stable air above preventing continued vertical development.

2.1.3. Cumulus

Cumulus clouds (fig. 1.c) are a type of cloud with noticeable vertical development and clearly defined edges. Cumulus means "heap" or "pile" in Latin. They are often described as "puffy" or "cotton-like" in appearance. Cumulus clouds may appear alone, in lines, or in clusters. Cumulus clouds are often precursors of other types of clouds, such as cumulonimbus, when influenced by weather factors such as instability, moisture, and temperature gradient. Cumulus clouds are part of the larger category of cumuliform clouds, which include cumulus, cumulus congestus, and cumulonimbus clouds, among others. The most intense cumulus and cumulonimbus clouds may be associated with severe weather phenomena such as hail, waterspouts and tornadoes.

2.1.4. Cumulonimbus

Cumulonimbus (fig. 1.d) is a towering vertical cloud (family D2) that is very tall, dense, and involved in thunderstorms and other inclement weather. Cumulonimbus originates from Latin: Cumulus "Heap" and nimbus "cloud". It is a result of atmospheric instability. These clouds can form alone, in clusters, or along a cold front in a squall line. They can create lightning and other dangerous weather. Cumulonimbus clouds form from cumulus clouds (namely from cumulus congestus) and can further develop into a supercell, a severe thunderstorm with special features.

2.2. Medium Level Clouds

These are the clouds situated at the altitudes 2 and 4 Km from the surface of the earth.

(a) **(b)** **(c)**

Fig. 2. Middle Level Clouds

2.2.1. Alto Cumulus

Altocumulus (Alto, "high", cumulus, "heaped") shown in fig. 2.a is a cloud belonging to a class characterized by globular masses or rolls in layers or patches, the individual elements being larger and darker than those of cirrocumulus and smaller than those of stratocumulus. Like other cumulus clouds, altocumulus signifies convection. It is usually white or gray, and often occurs in sheets or patches with wavy, rounded masses or rolls. A sheet of partially conjoined altocumulus perlucidus is sometimes found preceding a weakening warm front, where the altostratus is starting to fragment, resulting in patches of altocumulus perlucidus between the areas of altostratus, or more rarely, an entire sky of the perlucidus variety. Altocumulus is also often seen in a fragmented form behind a frontal system alongside stratus fractus or stratocumulus. Altocumulus is also commonly found between the warm and cold fronts in a depression, although this is often hidden by lower clouds. Towering altocumulus, known as altocumulus castellanus, frequently signals the development of thunderstorms later in the day, as it shows instability and convection in the middle levels of the troposphere, the area where towering cumulus clouds can turn into cumulonimbus. It is therefore one of three warning clouds often recorded by the aviation industry, the other two being towering cumulus and cumulonimbus. Altocumulus generally forms about 6,500 feet to 20,000 feet (2,000 to 6,100 meters) above ground level, a similar level to altostratus formations and satellite photography has revealed that the two types of cloud can create formations that can stretch for thousands of square miles. Extensive altocumulus formations, particularly if they take the form of undulates are often referred to as altocumulus mackerel sky.One form of altocumulus, altocumulus lenticularis (lenticular cloud) can resemble flying saucers and may be occasionally be mistaken for “unidentified flying objects”. This is formed by uplift usually associated with mountains. There may be another rare type of altocumulus, altocumulus undulatus asperatus, but this has not been officially named yet.

2.2.2. Alto Stratus

Altostratus (fig. 2.b) is a cloud belonging to a class characterized by a generally uniform gray to bluish-gray sheet or layer, lighter in color than nimbostratus and darker than cirrostratus. The sun can be seen through thin altostratus, but thicker layers can be quite opaque. They can look similar to lower altitude stratus clouds.

2.2.3. Nimbus

A nimbus cloud (fig. 2.c) is a cloud that produces precipitation. Usually the precipitation reaches the ground as rain, hail, snow, or sleet. Falling precipitation may evaporate as virga. Since, nimbus clouds are dense with water; they appear darker than other clouds. Additionally, nimbus clouds can be characterized by their great height. Nimbus clouds are formed at low altitudes and are typically spread uniformly across the sky.

2.3. High Level Clouds

These clouds generally occur at the altitudes ranging between 5 and 15 km from the surface of the earth.

(a) (b) (c)

Fig.3. High Level Clouds

2.3.1. Cirrus

Cirrus clouds (fig. 3.a) are a genus of atmospheric clouds generally characterized by thin, wispy strands, giving them their name from the Latin word *cirrus* meaning a ringlet or curling lock of hair. The strands of cloud sometimes appear in tufts of a distinctive form referred to by the common name of mares' tails.

Cirrus clouds generally appear white or light grey in color. They form when water vapor undergoes deposition at altitudes above 5,000 m (16,500 ft) in temperate regions and above 6,100 m (20,000 ft) in tropical regions. They also form from the outflow of tropical cyclones or the anvils of cumulonimbus clouds. Since these cirrus clouds arrive in advance of the frontal system or tropical cyclone, they indicate that the weather conditions may soon deteriorate. While they indicate the arrival of precipitation (rain), cirrus clouds themselves produce only fall streaks (falling ice crystals that evaporate before landing on the ground).

Jet stream-powered cirrus clouds can grow long enough to stretch across continents, but they remain only a few kilometers deep. When visible light interacts with the ice crystals in cirrus clouds, it produces optical phenomena such as sun dogs and haloes. Cirrus clouds are known to raise the temperature of the air beneath them by an average of 10 ℃ (18 ℉). When they become so extensive that they are virtually indistinguishable from one another, they form a sheet of high cloud called cirrostratus. Convection at high altitudes can produce another high based genus called cirrocumulus, a pattern of small cloud tufts that contain droplets of super cooled water. Cirrus clouds form on other planets, including Mars, Jupiter, Saturn, Uranus, and possibly Neptune. They have even been seen on Titan, one of Saturn's moons. Some of these extraterrestrial cirrus clouds are composed of ammonia or methane ice rather than water ice. The term *cirrus* is also used for certain interstellar clouds composed of sub-micrometer sized dust grains.

2.3.2. Cirrocumulus

Cirrocumulus clouds (fig. 3.b) form in sheets or patches and do not cast shadows. They commonly appear in regular, rippling patterns or in rows of clouds with clear areas between. Cirrocumulus are, like other members of the cumuliform category, formed via convective processes. Significant growth of these patches indicates high-altitude instability and can signal the approach of poorer weather. The ice crystals in the bottoms of cirrocumulus clouds tend to be in the form of hexagonal cylinders. They are not solid, but instead tend to have stepped funnels coming in from the ends. Towards the top of the cloud, these crystals have a tendency to clump together. These clouds do not last long, and they tend to change into cirrus because as the water vapor continues to deposit on the ice crystals, they eventually begin to fall, destroying the upward convection. The cloud then dissipates into cirrus. Cirrocumulus clouds come in four species: stratiformis, lenticularis, castellanus, and floccus. They are iridescent when the constituent super cooled water droplets are all about the same size.

2.3.3. Cirrostratus

Cirrostratus clouds (fig. 3.c) can appear as a milky sheen in the sky or as a striated sheet. They are sometimes similar to altostratus and are distinguishable from the latter because the sun or moon is always clearly visible through transparent cirrostratus, in contrast to altostratus which tends to be opaque or translucent. Cirrostratus comes in two species, fibratus and nebulosus. The ice crystals in these clouds vary depending upon the height in the cloud. Towards the bottom, at temperatures of around −35 ℃ (−31 ℉) to −45 ℃ (−49 ℉), the crystals tend to be long, solid, hexagonal columns. Towards the top of the cloud, at temperatures of around −47 ℃ (−53 ℉) to −52 ℃ (−62 ℉), the predominant crystal types are thick, hexagonal plates and short, solid, hexagonal columns. These clouds produce halos very commonly, and sometimes the halo is the only thing that indicates the presence of the cloud. They are formed by warm, moist air being lifted slowly to a very high altitude. When a warm front approaches, cirrostratus clouds deepen and lower into altostratus, and rain usually begins 12 to 24 hours later.

3. Dynamics of Clouds

Generally clouds follow Quasi-Geostrophic motion, clouds usually involve on the mesoscale and convective scale. The Coriolis and horizontal pressure gradient forces are in a state of quasi-geostrophic balance, especially in midlatitudes. Under this type of balance, the horizontal velocity and length scales in both the x and y directions are characteristic of the large scale atmospheric motion. If the pressure, height and vertical velocity scales are also characteristic of the large scale flow, then the horizontal wind is given, to first approximation, by its geostrophic values:

$$v_g = u_g\, i + v_g\, j = \frac{1}{\rho f}\left(-p_y i + p_x j\right) \tag{1}$$

The Newton’s second law of motion for the movement of air in the atmosphere is given by the equation (2):

$$\frac{Dv}{Dt} = -\frac{1}{\rho}\nabla p - fk * v - gk + F \tag{2}$$

When horizontal flow becomes highly circular as in a hurricane, it is convenient to consider the air motions in a cylindrical co-ordinate system, with the center of the circulation as the origin. If the circulation is assumed to be axially symmetric and devoid of fraction, then the horizontal components of the equation of motion (2) are:

$$\frac{Du}{Dt} = -\frac{1}{\rho}\frac{\partial p}{\partial r} + fv + \frac{v^2}{r} \tag{3}$$

$$\frac{Dv}{Dt} = -fu - \frac{uv}{r} \tag{4}$$

In case of gradient–wind balance in terms of angular momentum, where m = f * r where they constitute wind force and radius of earth.

$$m \equiv rv + \frac{fr^2}{2} \tag{5}$$

The hydrostatic balance of a cloud is generally expressed by

$$\frac{\partial \Phi}{\partial p} = -\alpha \tag{6}$$

$$-\frac{1}{p}\nabla p = -\nabla_p \Phi \tag{7}$$

Here, $$\nabla_p = i\left(\frac{\partial}{\partial x}\right)_{y,p,t} + j\left(\frac{\partial}{\partial y}\right)_{x,p,t} + k\left(\frac{\partial}{\partial p}\right)_{x,y,t} \tag{8}$$

When the air flow circulation is both hydrostatic and geostrophic motions, at different altitudes are given by

$$f\,\frac{\partial v_g}{\partial p} = \frac{\partial \alpha}{\partial y} i - \frac{\partial \alpha}{\partial x} j \tag{9}$$

There is another balance which forms a special phenomenon, where a cylindrical column of fluid may be circulating across a vertical column.

$$\frac{Dv}{Dt} = -\frac{1}{\rho}\nabla p \tag{10}$$

When the component accelerations are in radial and azimuthal directions

$$\frac{Du}{Dt} = -\frac{1}{\rho}\frac{\partial p}{\partial r} + \frac{v^2}{r} \tag{11}$$

Consider the potential temperature in the environment increases with height, a parcel of air displaced upward and downward adiabatically will experience a restoring force in which upward displaced air becomes negative buoyant and downward displaced air becomes positive buoyant. In order to determine this oscillatory tendency, we consider a theory known as parcel theory, in which air buoyancy is considered in packets known as parcels.

$$B = g\,\frac{\theta^*}{\theta_o} \tag{12}$$

While the vertical component of equation reduces the first law of thermodynamics to

$$\frac{Dw}{Dt} = B \tag{13}$$

$$\frac{DB}{Dt} = w\,N_0^2 \tag{14}$$

Here, $$N_0^2 = \frac{g}{\theta_o}\frac{\partial \theta_0}{\partial z} \tag{15}$$

Combining the above equations (13) and (14), we get

$$\frac{D^2 w}{Dt^2} + wN_0^2 = 0 \tag{16}$$

The upward and downward movements will cause oscillations with certain frequency N_0 known as the buoyancy frequency.

$$N^2 = \frac{g}{\theta}\frac{\partial \overline{\theta}}{\partial z} \tag{17}$$

Buoyancy frequency is the primary indicator of the atmosphere to vertical displacement. If $N_0^2 > 0$ parcels will tend towards the downward motion, $N_0^2 < 0$ then they will behave in a different manner.

Due to the presence of buoyancy a restoring force is developed in the fluid which leads to the occurrence of wave motions. In an ideal fluid these wave motions can be easily identified, in which one of the layer of fluid of uniform density ρ_1 lies under another layer of uniform but of lower density ρ_2.

Now both layers are considered to be in hydrostatic and mesostrophic balance. The mean depth is calculated as $\bar{h}$ and depth is perturbed by a small amount h’. Total depth h= $\bar{h}$+h’. The horizontal pressure gradient in the x-direction is

$$-g\left(\frac{\delta\rho}{\rho t}\right)h_x^! \qquad \text{Here,} \quad \delta\rho = \frac{\rho_1}{-\rho_2} \tag{18}$$

Then the linearized perturbation forms the Boussinesq equation of motion and continuity equation for a basic state of constant mean motion only in x direction are

$$u_t^! + \bar{u}\, u_x^! = g\frac{\delta\rho}{\rho_1} h_x^! \quad \text{and} \tag{19}$$

$$u_t^! + w_z^! = 0 \tag{20}$$

Vertical velocity at h if the lower boundary is bounded below by a rigid flat surface

$$h_t^! + \bar{u}\, h_x^! + u_x^!\, \bar{h} = 0 \tag{21}$$

By combining the above both equations (19) and (21), we get

$$\left(\frac{\partial}{\partial t} + \bar{u}\frac{\partial}{\partial x}\right)^2 h^! - \frac{g\bar{h}\,\partial\rho}{\rho 1} h_{xx}^! = 0 \tag{22}$$

Thus, the perturbation in the depth of the lower layer of fluid propagates in the form of a wave number k moving at phase speed c, as the buoyancy force successively restores the depth of the fluid to its mean height at one location and the excess mass is transferred to the adjacent location in x, where a new perturbation is created upon which the buoyancy must act. The symbols used for the above equations are given in table 1.

Table 1 List of symbols

Symbol	Quantity
v_g	Geostrophic wind
i	Vector in x direction
j	Vector in y direction
ρ	Density
f	Coriolis parameter
p	Pressure of air
t	Time
v	Three dimensional velocity of a parcel of air
∇	Three dimensional gradient operator
g	Magnitude of the gravitational acceleration
k	Wave number in x direction
F	Molecular friction force
r	Radial coordination
ϕ	Geopotential
α	Specific volume
N_0	Frequency of oscillation
B	Buoyancy
θ	Potential Temperature

4. Observations

The figures and observations of all the data regarding the physics and dynamics of clouds are derived by using the above given equations such as quasi-static equation, buoyancy equation, equilibrium vapor equation, balance equations, continuity equations etc.

Water droplets inside the clouds have some weight and are subjected to gravitational force which will lead to fall of the particles as precipitation. The force exerted on the water droplet due to gravity is largely offset by the frictional resistance caused by the air. As the particle is accelerated downward due to gravity its motions is increasingly opposed by the frictional force of the air since the velocity of the particle increases as it reaches the earth surface. Its final speed is called terminal fall speed 'V'. V is a function of drop radius 'R', which is negligible until the drop reaches a radius of 0.1 mm which is the threshold size separating cloud droplets from precipitation droplets.

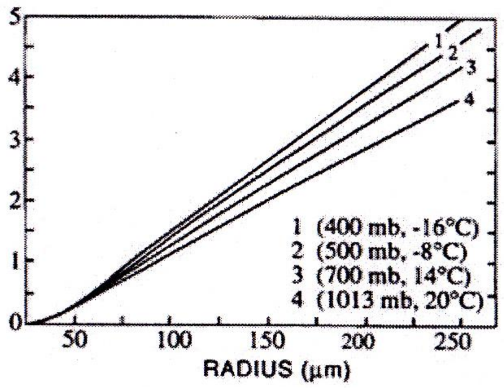

Fig. 4. Terminal fall velocity of water drops <500μm *(from Beard and Pruppacher 1969).*

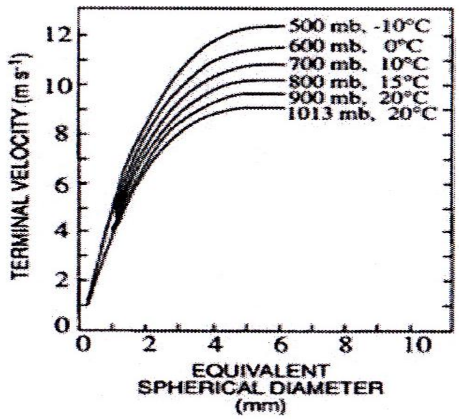

Fig. 5. Terminal fall velocity of water drops >500μm *(from Beard and Pruppacher 1969).*

The smallest precipitation drops of size between 0.1 – 0.25 mm radius are called drizzle. Drops > 0.25 mm radius are called rain. For both drizzle and rain the terminal fall velocities increase with increase of drop radius which will be represented as V(R). For larger drops V(R) increases at a lower rate, shown in fig.4. For larger drops, V(R) increases at the lower rate as shown in fig. 5.

If the ice particles collect other ice particles the process is called aggregation. If the ice particles collect liquid drops the process is called riming. Table 2 shows the basic habits of ice crystals with temperature

Table 2: Variations in the Basic Habits of Ice Crystals with Temperature

Temperature (^{0}C)	Basic habit	Types of crystal at slight water supersaturation
0 to -4	Plate like	Thin hexagonal plates
-4 to -10	Prism like	Needles (-4 to -6^{0}C)
		Hollow columns (-5 to-10^{0}C)
-10 to -22	Plate like	Sector plates (-10 to -12^{0}C)
		Dendrites (-12 to -16^{0}C)
		Sector plates (-16 to -22^{0}C)
-22 to -50	Prism like	Hollow Columns

Source: Wallace and Hobbs (1977)

The sizes of collected no aggregates are shown as function of temperature as shown in fig.6. The size of collected samples increase sharply above -5^{o}C and the aggregation does not exist below -20^{0}C. The next maximum peak occurs between -10^{o}C and -16^{o}C.

Ice enhancement: fig.7 compares some measurements of ice particle concentration in cumuliform clouds with the concentration of ice nuclei from expansion chamber measurements at cloud – top temperature.

The microphysical process by which the concentrations of ice particles become so highly enhanced relative to the number of nuclei which would appear to be active, some hypothetical concepts are suggested.

I. Fragmentation of ice crystals: The crystals are delicate that may break up into pieces as a result of collision between them and due to thermal energy developed due to collisions.
II. Ice splinter production in riming: From the laboratory experiment it has been found that when super cooled droplets > 23μm in diameter collide with an ice surface at a speed of >= 1.4 m/s at a temperature between -3 and -8^oC, small ice splinters are produced.
III. Contact nucleation: When certain aerosol particles come in contact with super cooled droplets they can cause nucleation at higher temperatures.

Condensation or Deposition Nucleation: When the ambient super saturation temperature rises above 1 % with respect to water, condensation or deposition nucleation occurs. Observations show that these speeds depend on particle type, size and degree of riming. Snow crystals and un-rimed to moderately rimed aggregates of crystals drift downward at speeds of 0.3-1.5 m/s. Graupel fall speeds increase sharply from 1-3m/s over a narrow size range of 1-3 mm as shown in fig.8 and fig.9. Empirical formulas of fall speeds of snow and Graupel are given in fig.8 and fig.10.

In the fig. 8 open circle (upper most curve) indicates Graupel fall speeds, other curves are for rimed crystals (dot in circle), needles (filled circle with slash), spatial dendrites (triangle), powder snow (x) and in the fig. 9 the observations leads that combination of side planes (a type of branched crystal), bullets and columns (circles, dotted curve), side planes (triangles, solid curve), radiating assemblages of dendrites (asterisks, dashed curve), dendrites (squares, dashed-dot curves).

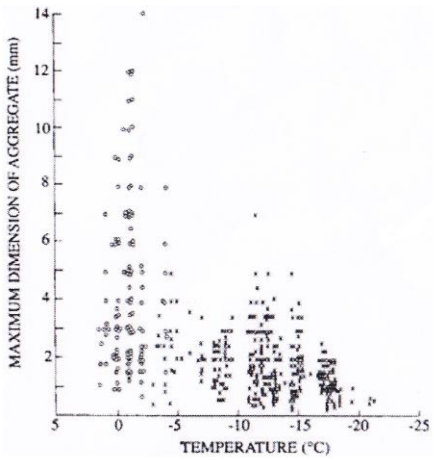

Fig.6. Maximum dimensions of natural aggregates of ice crystals as a function of temperature (From Hobbs. 1973b)

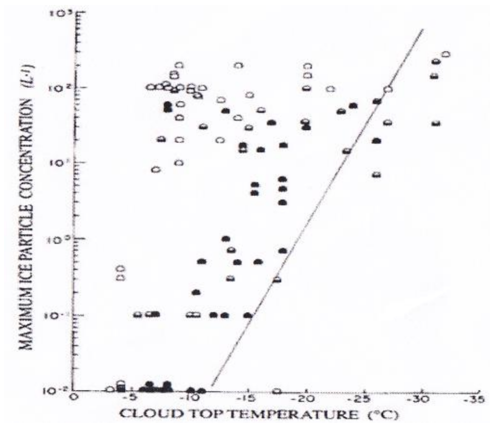

Fig.7. Maximum ice particle concentration observed in mature and aging maritime, continental and transitional cumuliform clouds (From Hobbs and Rangno.1985).

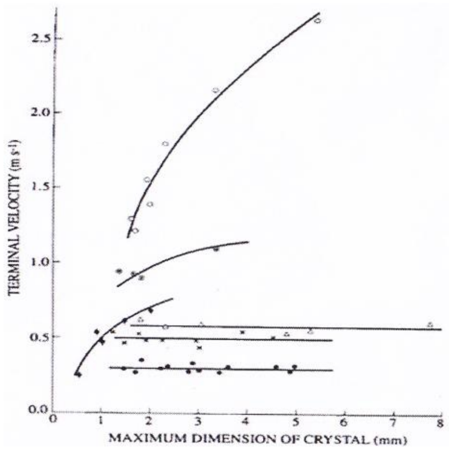

Fig. 8. Terminal fall velocity of water drops <500μm *(from Beard and Pruppacher 1969).*

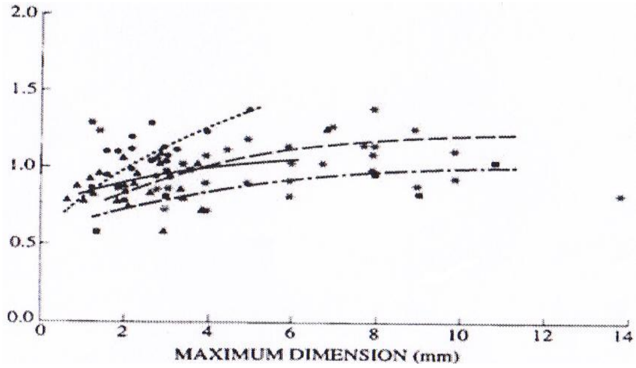

Fig. 9. Terminal fall velocity of water drops >500μm *(from Beard and Pruppacher 1969).*

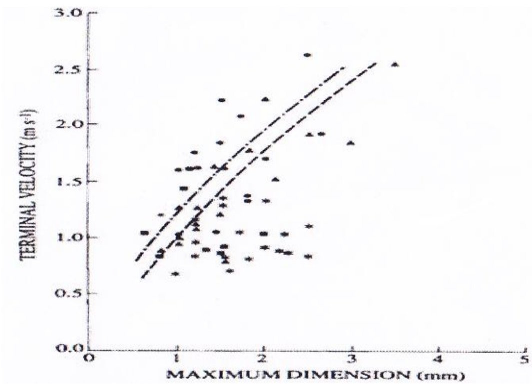

Fig.10. Terminal velocity and maximum dimension measurements for Graupel and Graupel – like snow (From Hobbs, 1974. Based on data from Locatelli and Hobbs. 1974)

5. Conclusion

Thus the dynamics of the cloud are determined by using fall velocity and nucleation of clouds. In order to specify the dynamics the ice nucleation concept and energy balance equations are considered. This will help in the categorization of the clouds. The future works includes use of new techniques using image processing, clustering and wavelet transformation to determine the rainfall of the clouds using automatic compiler machine language. It also includes the prediction and determination of the amount of rainfall, velocity of rainfall, area of rainfall etc. of the clouds.

Dynamics and Physics of the cloud can be easily understood using the dynamic property equations such as buoyancy, quasi-static principles etc using Houze's cloud dynamics [1]. The attenuation probability distribution for a particular area can be estimated from available information on rainfall rate observed in the area of interest [2]. Designing line of sight (LOS) are satellite link systems, needs yearly point rain rate statistics for several percentages of time, in the location of interest [3]. Antecedent rainfall and evaporation were very different and resulted in a wide range of soil moisture conditions. The high spatial variability of rainfall events within this region resulted in moisture conditions with distinct spatial patterns. Analysis showed correlation between the decrease in brightness, temperature after a rainfall and the amount of rain [4]. A feature based neural network mappraoch for rainfall prediction. We use a four layer neural network to automatically learn the internal relationship between Geo stationary meteorological satellite Ghls data and rainfall intensity distribution [5]. Using the data obtained over a winter, rainy seasons, and the prediction error with a neural technique is reduced about 60% than that with the cross correlation method [6]. The global model and analysis system, called GDAPS, has been set up in the CrayC9O environment. The 5-day global forecast was made available twice a day [7]. The analysis of the terminal fall velocities of water drops which is considered as a function of temperature [8]. Variations in the basic habits of ice crystals with temperature [9]. The dimensions of natural aggregates of ice crystals as a function of the temperature of air [10]. Maximum ice particle concentration observed in mature and aging maritime [11]. The relationship between terminal fall speeds and maximum dimension of a crystal are given [12]. Terminal velocity and maximum dimension measurements for un-rimed to moderately rimed aggregates [13]. The water continuity model with the conversions of water substance from one state to another in a bulk which leads to the production of Graupel etc [14].

6. References

[1] Robert A Houze Jr., "Cloud Dynamics", Academic Press, California, 2011.

[2] M.S. Pontes M R B P L Jimenez,N L Damasceno on "Enlace- Analysis and Prediction of Rainfall rate and Rain attenuation distributions"

[3] F. Moupfouma and L. Martin, "Point Rainfall rate cumulative distribution function valid at various locations," Electrionics Letters 19th August 1993 Vol 29 No 17.

[4] Thomas J. Jackson, David M. Le Vine, Andrew J. Griffis, David C. Goodrich, Thomas J. Schmugge, Calvin T. Swift, Peggy E. O' Niell, " IEEE Transactions on Geo science and Remote Sensing, Vol 31, No.4, July".

[5] Tao Chen and Mikio Takagi, "Rainfall Prediction of Geostationary Matereological Satellite Images using artificial Neural network"

[6] K. Ochiai, H. Suzuki, S. Suzuki, N. Sonehara and Y. Tokunaga, "Snowfall and Rainfall Forecasting from the images of weather radar with Artificial Neural Network,"

[7] Sang-won Joo, Nam-Ouk Kim in "The impact of GMS (Geostationary Metreological Satellite) data in the GDAPS (Global Data Assimilation and Prediction System) "

[8] Beard and Pruppacher, "fall of velocity conditions" 1969 reprinted with permission from the American Meteorological Society.

[9] Wallace and Hobbs, "Habits of ice crystals" 1977.

[10] Hobbs, "Aggregation of clouds with temperature" 1973b reprinted with permission of Oxford University Press.

[11] Hobbs and Rangno, "The variation of maximum ice particle concentration with cloud top temperature" 1985 reprinted with permission of American Meteorological Society.

[12] Nakaya and Terida, "Fall speed variation with size of crystal" 1935.

[13] Locatelli and Hobbs, "Terminal velocity and maximum dimension measurements" 1974 reprinted with permission of Oxford University Press.

[14] Rutledge and Hobbs, "Water continuity models" 1984 reproduced with the permission from American Meteorological Society.