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## SHORTER CONTRIBUTION

# NOTE ON THE HEIGHT OF THE CUMULO-NIMBUS CLOUDS OF THE TROPICAL REGIONS NEIGHBOURING KINSHASA*

by

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## ABSTRACT

Height measurement of cumulo-nimbus clouds and the surrounding cirri in tropical Africa are given and compared with the heights of cumulo-nimbus clouds and cirri in temperate regions.

## 1. INTRODUCTION

It should perhaps be interesting to compare Ryan's (1959) observations of heights of cirrus cloud in Australia with observations taken in Africa, for in both cases they are from tropical regions of about the same latitude.

The observations reported here were taken during the rainy season of 1953-1954 (approximately eight months), but it is only recently that the opportunity arose for completing the notes and writing the article.

## 2. DESCRIPTION

Thanks to the radar installed in the Meteorological Office at the airport of Kinshasa* being placed at our disposal by that service, it has been possible, for one complete rainy season, to take measurements of convective cloud heights.

This radar, of maritime type, manufactured by the Radiomarine Corporation of America, and with a range of 64 kilometres (≈ 40 miles), helps to detect stormy zones or more exactly cells of heavy rain in cumulo-nimbus clouds, as well as zones of general rain, and to follow their evolution. Measurements were made every time cumulo-nimbus clouds were present in the stormy zones during the rainy season; this involved no less than one hundred measurements.

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* Kinshasa : Capital of the Democratic Republic of the Congo, Africa, 04° 19'S, 15° 18'E, 300 m of altitude (≈ 1,000 ft).

The echoes of general rain and of the cumulo-nimbus cells appearing on the radar screen are clearly distinct from each other; the former appears like a blurred echo sometimes difficult to circumscribe; the latter on the contrary presents a bright echo.

The object of our study was to measure the average height of tropical cumulo-nimbus clouds around Kinshasa, and to compare it to the average height of the cumulo-nimbus clouds of temperate regions.

Cumulo-nimbus clouds are by no means rare during the rainy season. They were frequently observed as parts of the stormy zones at the outskirts of Kinshasa and measurements made of the vertical distances from their summits to the ground. The following notes and discussion are based on those measurements.

Around the bright echoes of cumulo-nimbus cells the frequent observation of blurred echoes, that is echoes of rain, indicated that intense cumulo-nimbus cells were indeed being observed. Generally the cumulo-nimbus, seen by the naked eye as a big mass stretching over tens of kilometres, appears as a very small echo on the radar screen, as only intense rain cells are detected.

The radar has enabled estimation of the range of the cumulo-nimbus cells in relation to radar position. It is known that the bright echo which appears on the radar screen corresponds more or less to the centre of the visible cloud in question. We can also assume without much error that the development of a given cumulo-nimbus cell is almost vertical and that its summit would be on the vertical passing through the echo centre. So by measuring with a theodolite the angle ( $\alpha$ ) formed by the straight line joining the summit of a given cumulo-nimbus seen with the naked eye and the horizontal, and obtaining by means of the radar the distance (L) between the base of the cumulo-nimbus and our observing position, it was possible to calculate the height H shown in the Fig. 1 and it was noted that this height reaches more than 10,000 metres ( $\simeq$ 33,000 ft). This does not take the anvil into account.

Indeed, this method cannot be used to estimate the height of the anvil of a cumulo-nimbus, because the anvil can stretch over tens of kilometres around the vertical passing through the centre of the cell, and an intended measurement of the angle formed by the straight line joining the top of the anvil and the horizontal very often becomes in reality a measurement of the angle ($\gamma$ in Fig. 1) formed by the straight line joining the edge of the anvil and the horizontal. This is of no value, for we do not know the projection ( $\ell$ ) of this straight line on the horizontal. This difficulty can be avoided by following closely the formation of the anvil, which generally originates from a mass (B) (illustrated in the Fig. 1) other than the main mass (A) of the cumulo-nimbus, and measuring the angle ( $\beta$ ) formed by the straight line joining the top of the extension (B) and the horizontal, some time before this extension is transformed into an anvil.

To go further into the question the complete evolution of some cumulo-nimbus clouds have been followed. We have observed - and this is a well-known fact - that the anvil is formed only when the cumulo-nimbus has developed and "ripened". At that moment, emerging out of the massive and sometimes very large body of the cumulo-nimbus, another cloud mass in the form of a column or of a cupola appears, much smaller and of more delicate appearance than the main body of the cumulo-nimbus. This column may develop considerably in height, but little horizontally, the upper part of the top of this extension becoming less and less

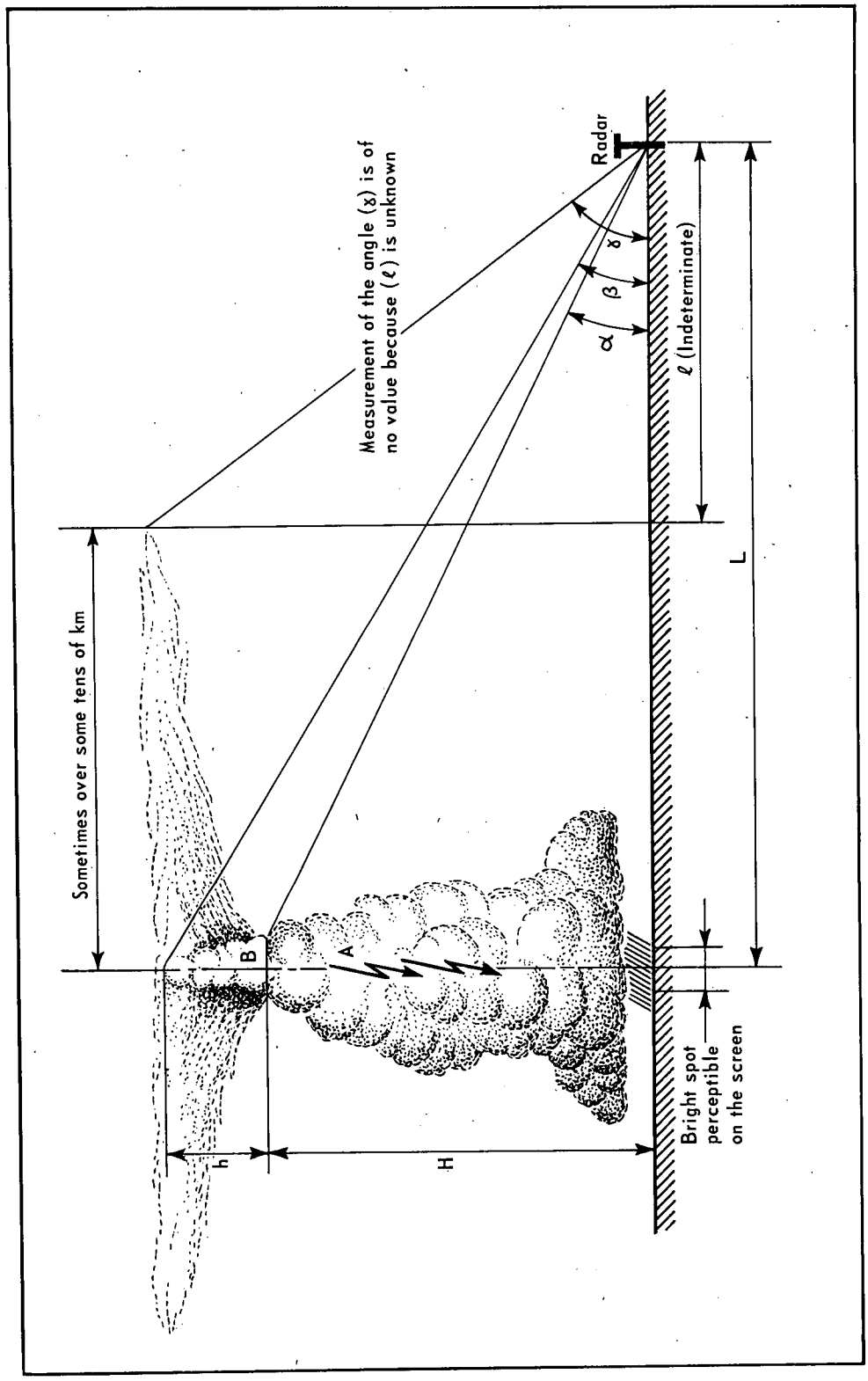


Fig. 1. Illustration of a cumulonimbus cell with vertical extension and horizontally spreading anvil, showing distances from and angles subtended at the radar

"massive" on the whole, and at a certain moment it "spreads", generally but not always after the appearance over the summit of an aureola which is called the "scarf". At that moment, the formation of the cumulo-nimbus seems to be completed and its vertical development ended. On the other hand, the horizontal development of the part that emerged out of the top of the massive body of the cumulo-nimbus goes on now comparatively quickly and sometimes over tens of kilometres, giving rise to what we generally call the anvil. Because the spread of the column in question coming from cumulo-nimbus cloud is the end of its vertical development, it has been possible to estimate the height of the anvil, by measuring the angle which is formed by the straight line joining the summit of such column immediately before the "spread" and the horizontal. Simple trigonometrical calculation has enabled us to estimate the average depth (h in Fig. 1) of the anvil, which is in the neighbourhood of 2,400 m ( ≈ 8,000 ft). The average height of the complete cumulo-nimbus, that is, of the main mass plus the anvil, is therefore in the neighbourhood of 12,400 m ( ≈ 41,000 ft). Corrections allowing for the effect of the earth's curvature is of little importance for our results, being no more than 340 metres for 64 kilometres range of the radar.

The anvils, which detach themselves from the cumulo-nimbus clouds, form cirrus clouds. These observations therefore lead to the somewhat unexpected conclusion, that the base of cirrus clouds is in the neighbourhood of 12,000 m ( ≈ 40,000 ft). Some support for these observations is found in reports of pilots of D.C. 6 aircraft at about 6,000 m ( ≈ 20,000 ft) who have affirmed that they never reached the cirri. On the other hand the pilots of Comet aircraft have estimated the cirrus base at about 12,000 m (≈ 40,000 ft). Ryan (1959) has reported on a small sample of aircraft observations (5 occasions) of cirrus in the intertropic convergence zone between Darwin and Biak. On each occasion cirrus occupied the 40,000 ft flight layer and the peak height of the top of the layers was 54,000 ft.

## 3. CONCLUSIONS

It is concluded from the observations discussed above that:

(1) The tropical cumulo-nimbus clouds due to thermic action are on the average more developed in height (12,400 m, approximately 41,000 ft) than the similar cumulo-nimbus clouds of temperate regions (6,000-10,000 m, approximately 20,000-30,000 ft).

(2) The base of cirrus clouds is much higher in tropical regions than in temperate regions, where it only reaches 6,000 m ( ≈ 20,000 ft). It follows that data on *extreme* heights of tropical cumulo-nimbus may be important in route planning future "Concorde" operations across the equator.

## REFERENCES


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