ESTIMATION OF CLOUD HEIGHTS AT SUNRISE/SUNSET

Clouds are the visible manifestations of atmospheric processes. As such, cloud observations have been systematically recorded at many places over the world for over a century. Cloud type and amount observations have been fairly accurate. However, visual estimation of heights is very subjective and in the case of medium and high clouds often erroneous. Recent studies based on jet aircraft reports indicate that cirriform clouds and cumulonimbus tops, encountered in flight are actually much higher than the estimates of ground-observers (Deshpande, 1964, 1965). The error is sometimes as high as 15-20,000 ft. in the tropics.

2. In the case of the lower and medium clouds, the observer is able to judge cloud heights in relation to topographic features such as hill-tops. However, no such reference points are available for estimating heights of clouds in the upper troposphere. Accurate cloud-height observations are essential to aviators for safe navigation. Poor visibility, icing, severe turbulence or even hailstorms sometimes encountered in clouds are great flying hazards. At present the sub-sonic jet aircraft cruise in the upper troposphere while in a few years supersonic transports will have to climb or descend through the tropopause. Clouds near the tropopause may affect the performance of jet aircraft, particularly SSTs. Any aid for the better estimation of cloud heights to ground-observers has, therefore, considerable operational significance.

3. Sun's rays light up mountain tops earlier than valleys in the mornings and fade later from the tops in the evenings. To an observer at a height the sun is visible when it is actually some distance below the horizon of a sea-level observer. From any height, the sea-horizon is below the horizontal by an angle called 'Dip'. The value of the dip of the visible horizon for any height can be easily calculated. It is required to be corrected for refraction and the semi-diameter of sun to find the times of sunrise or sunset. Air Almanac (1965) provides graphs to find correction to the tabulated times of sunrise and sunset at ground level for various declinations and depressions of the sun below the horizon at different latitudes. Using these graphs, values of extension of duration of sunlight with increasing height over Indian latitudes have been calculated for all days in the year. Fig. 1 gives these values for the latitudes 10°N to 30°N at 5-degree intervals and for heights from 10,000 to 60,000 ft. To find the height of any cloud at sunrise/sunset, the observer has simply to note the difference between the times of sun's rays first lighting up the clouds and the ground in the morning and in the evening the time difference between the sunset at the ground and fading of sun's rays from the clouds. In the graph of appropriate latitude (Fig. 1), the height corresponding to the date (abscissa) and the time interval (ordinate) will be the height of the cloud.

4. In the above method, the times of sunrise or sunset at the ground refer to a station directly below the cloud under observation. If the cloud is not overhead, these times have to be calculated. If the clouds are to the east, the sunrise and sunset at a point directly below the clouds will be earlier, while if the clouds are to the west these will be later than those at the observation point. For each degree longitude, (roughly 69 miles), the sunrise/sunset time differs by four minutes.

5. An actual example is given below to illustrate the above method.

A towering Cb cell was observed about 20 miles west of Bangalore on 25 July 1965. The times of sunset at Bangalore and of fading of sun-rays from the Cb top were 1849 and 1910 IST respectively. The sunset time at a point directly below the Cb cloud would be later than at Bangalore by (4 x 20)/69 = 1.2 minutes, i.e., it would be 1850.2 IST. The time interval between the sunsets at the Cb top level and at the ground directly below is, therefore, 19-8 minutes. For the date and time interval, Fig. 1 indicates the height of Cb as 50,000 ft.

6. The method suggested above is subject to three limitations. Civil twilight may sometimes illuminate the cloud base or top as distinct from illumination by direct sunlight after the sea-level sunset or before sea-level sunrise. Secondly it may be difficult on some occasions to observe the actual time of sunrise/sunset at the cloud level if intervening cloud layers screen off the sun's rays or if the visibility is poor. It enables the observer to estimate cloud heights only twice a day, namely at
To find height of cloud:
1. Note the time difference (minutes) between sunrise/sunset at the cloud and the ground below.
2. Refer to the graph for the nearest latitude.
3. Read off the height (in feet) corresponding to the date and time difference. (10,000 ft = 3048 metres)
4. If the cloud is not overhead, calculate the time of sunrise/sunset at a point directly below the cloud, by applying a correction of 4 minutes for every 60 miles due west/east of observation point.

sunrise and sunset. Nevertheless under favourable atmospheric conditions, cloud height measurements using the method are possible. The method is simple and inexpensive. As only time differences are involved it is fairly accurate. It is felt that regular attempts made by weather observers to use the method will give them valuable training in estimating cloud heights more accurately than at present.

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D. V. DESHPANDE

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ON THE ROLE OF THE PERTURBATIONS OF THE SOUTHWEST MONSOON IN RELATION TO HIGH LEVEL EAST WIND MAXIMA OVER INDIA

1. Recently, Joseph (1967) pointed out that for the Indian area the level of east wind maximum in July 1966 is highest around 15°–18°N and slopes down both to the north and south. Many of the 200-mb charts of this month show two distinct jet axes 10°–15° latitude apart, the northern jet axis being of very limited longitudinal extent. He postulated that double jets occur on 200-mb charts due to the inverted V-shaped nature of the north–south vertical profile of the level of maximum wind. It may be stated that Joseph’s study relates mainly to conditions of active monsoon.

1.1. The cause for the above mentioned phenomena can be attributed to the remarkable effect of the monsoon perturbations on the upper tropospheric easterly flow over India and on the topography of the east wind maximum as well. This is illustrated below.

2. To have a proper appreciation of the extent to which the perturbations of the strong monsoon can affect upper tropospheric flow patterns over India, it will be necessary to isolate the contributions due to these perturbations from the typical flow pattern prevailing during the regime of strong monsoon over India. For this purpose, one will have to filter out from strong monsoon flow pattern the residual flow pattern which would have prevailed had there been no monsoon perturbations. In the present study, weak monsoon conditions are taken as representing adequately the essentials of this residual flow pattern. The procedure followed is given here.

2.1. Two epochs, one of strong (8 to 21 August 1963) and another one of weak monsoon (11 to 24 July 1963) were chosen. For each of the two epochs, mean resultant winds for 900, 850 mb and other standard pressure levels aloft up to 150 mb for all the available Indian rawin stations and also for Karachi and Colombo were worked out. In respect of each of the levels mentioned above and for each station, the wind data for weak monsoon were vectorially subtracted from the corresponding values for strong monsoon and the resulting vector differences were taken to represent the effects of perturbations which prevailed during the regime of strong monsoon. Fig. 1 represents these wind vector differences, for different levels.

3. It will be seen from Fig. 1 that in the mean, the perturbations of strong monsoon appear as two cycloonic vortices at either end of a trough line which runs from north Konkan to north Coastal Andhra Pradesh. It is interesting to note that both the vortices and the trough line extend practically from sea level to even as high an altitude as 200-mb level. In this connection it may be stated that the perturbation at western end of the trough line is generally believed to affect only in and near mid-tropospheric levels (Ramage 1963, Miller and Keshavanurty 1967) whereas the method adopted in this study indicates that the effect of this perturbation also extends practically throughout the major part of the troposphere. The consequences of such an effect on the activity of the Arabian Sea branch of the monsoon are being studied in detail using the data of a number of years.

3.1. Considering for the present, the two perturbations and the axis of the trough at 300 and 200-mb levels in Fig. 1, it will be seen that their effect will be to contribute a westerly component to the south of the trough line, i.e., roughly south of 21°N and an easterly component to its north. As the unperturbed currents at these levels are fairly strong easterlies (south of Lat. 25°N) the effect of the perturbations on these will be to increase the (easterly) wind speed north of 21°N and decrease the same south of that latitude. The effect of the perturbations on stations like Trivandrum and Colombo which are far to the south is relatively small as can be seen from the weak westerly components for these stations and