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ESTIMATION OF THE HEIGHT OF TOPS OF VERTICAL DEVELOPMENT CLOUDS APPEARING IN SATELLITE PICTURES OF THE SUNGLINT OVER OCEAN AREAS *

Y. R. NENE AND M. N. GOKHALE

Office of the Deputy Director General of Observatories (Forecasting), Poona-5, India

ABSTRACT

Satellite pictures of clouds appearing over the sunglint provide a means of estimating the height of cloud tops over ocean areas. The shadows cast by the convective clouds are often clearly seen over the glint area and can be used for the estimation of the heights of the tops of the associated clouds. The method adopted for this purpose is described in this paper.

INTRODUCTION

ESTIMATION of height of objects by measuring the lengths of their shadows in sunglint is a very simple procedure for objects on land. Weather satellites which view the clouds and their shadows have made it possible to extent this method to the determination of height of cloud tops. In general, shadows of clouds cannot be seen over land or sea surface. Under favourable conditions, they can be seen when clouds exist over sunglint. Sunglint is the image of the sun seen on water surfaces and appears as a bright spot. It provides a luminous background for the dark cloud shadow.

Satellite pictures taken by ESSA-8 on 14th and 15th October 1970 over Indian region show vertical development clouds with shadows in glint regions. The height of these clouds is estimated and reported in the present paper. The sea level situation prevailing on these two days around the glint region is shown in the accompanying maps.

The two main quantities which are required for the estimation of height of cloud top are (i) the angle of incidence of sun's rays over the sunglint and (ii) the length of the cloud shadow. These are obtained from the satellite pictures as explained below:

The angle of incidence of the sun's rays at the centre of the glint is calculated from the angles sub-tended by the great circle distance between the sub satellite point (marked on the picture by a 'cross') and the centre of the glint at (i) the centre of Earth and (ii) the satellite camera. Figure 1 depicts the geometry involved in this calculation.

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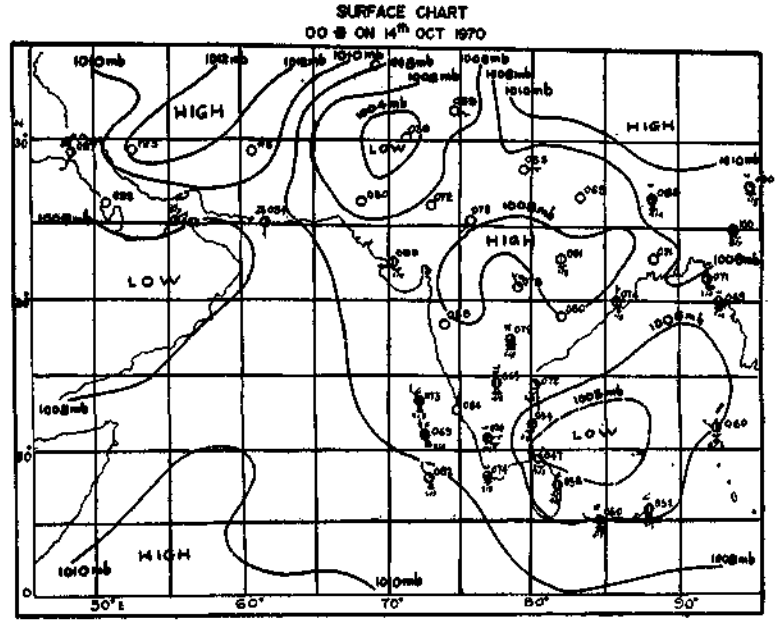
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00 ⊕ ON 14th OCT 1970
HIGH
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HIGH
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LOW
LOW
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1010mb
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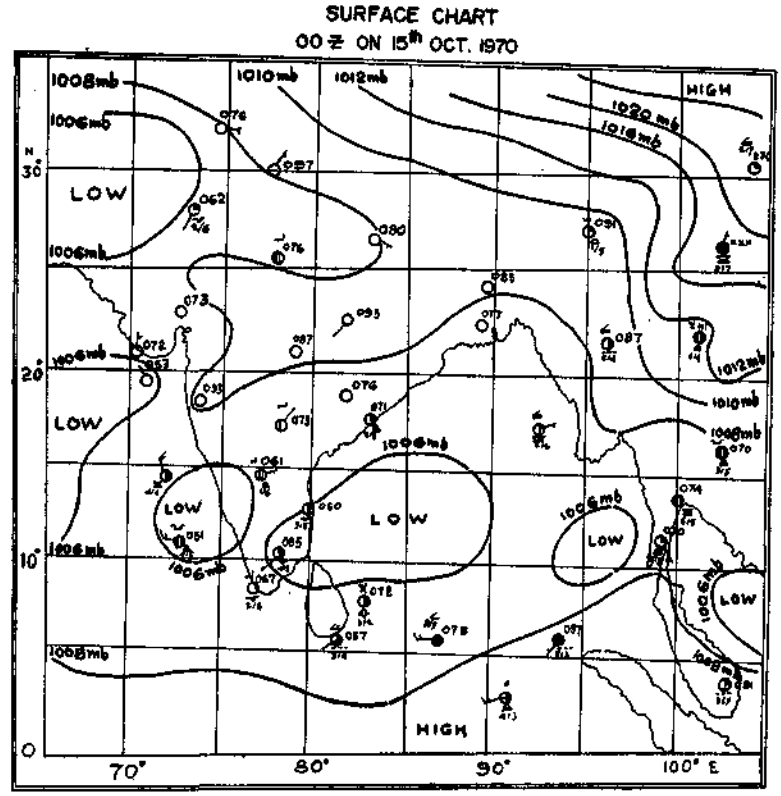
1006mb
30°
20°
0
50°E
60°
70°
80°
90°

Fig. 2.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00 ⊕ ON 15th OCT. 1970
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1020mb
1018mb
1012mb
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1006mb
30°
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10°
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70°
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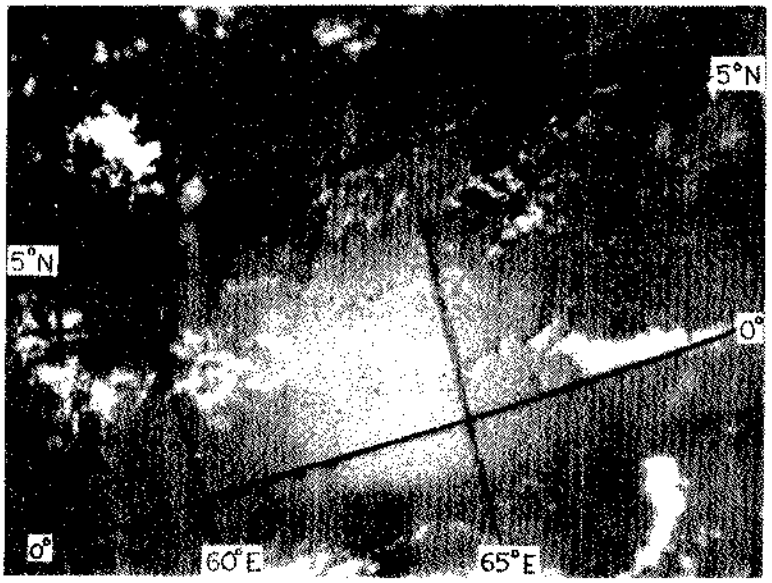
100° E

Fig. 3.



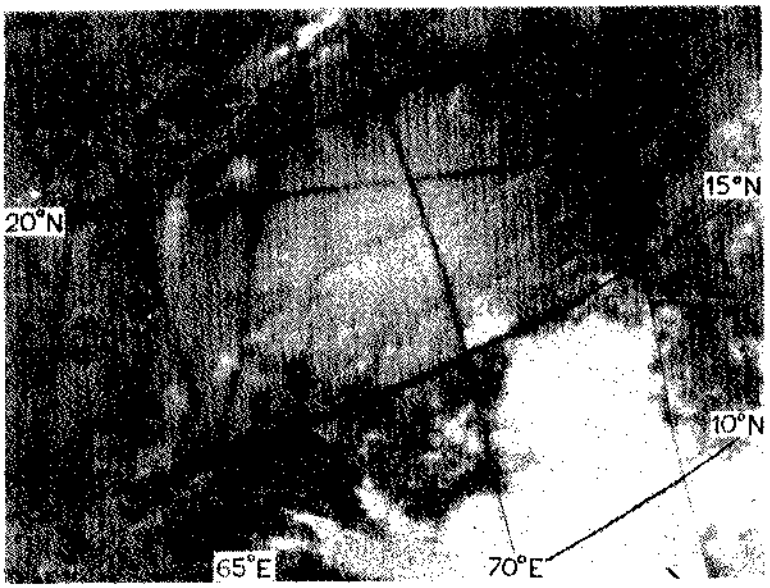


Plate 1: (Top) Clouds over sunglint in the southwest Arabian Sea on 14-10-1970; and (Bottom) Clouds over sunglint in the East Central Arabian Sea on 14-10-1970.

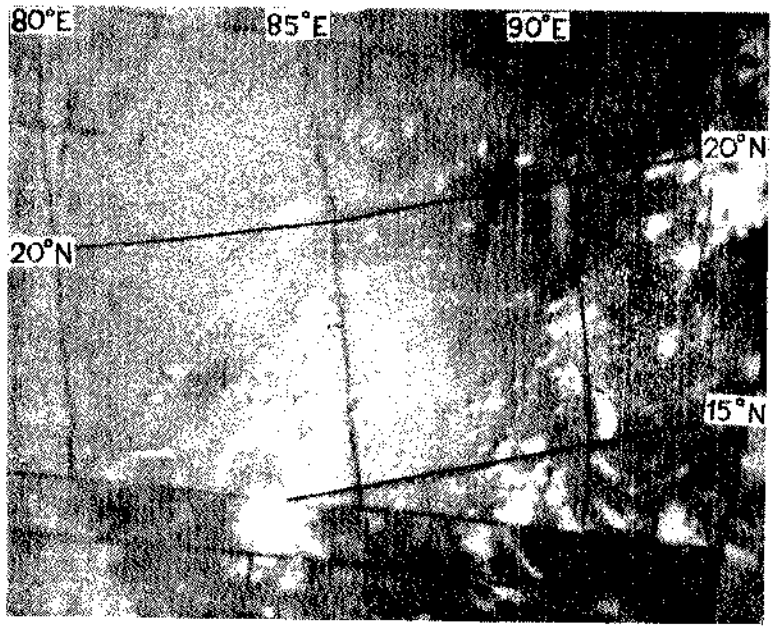


Plate II Clouds over sunglint in the West Central Bay of Bengal on 15-10-1970

The shadow lengths are measured in a direction parallel to the line joining the sub-satellite point and the centre of the glint. All the lengths are first measured in degrees and then expressed in kilometres. The shadow length divided by the tangent of the angles of incidence of the sun's rays gives the height of the cloud tops above sea level. Table 1, shows the quantities measured from the accompanying pictures.

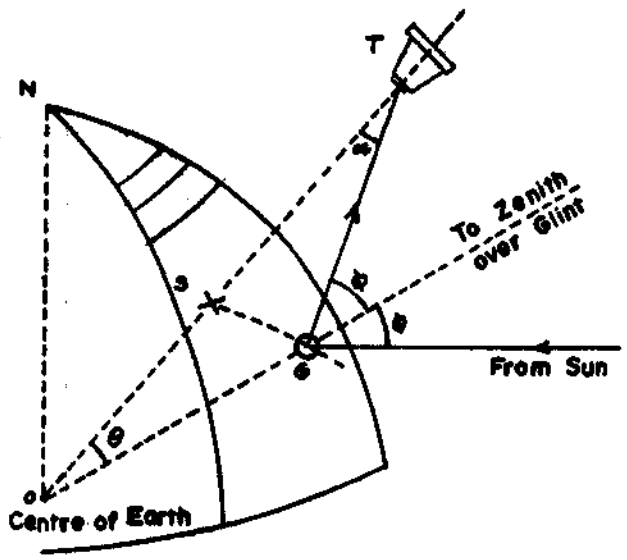


Fig. 1. Geometry involved in the calculation.

T = satellite Camera; S = subsatellite point;
G = sunglint; O = centre of the earth;
SOG = θ STG = α
$\phi = \alpha + \theta$ angle of incidence of the sun's rays over the centre of glint.

If x = length of the shadow of a cloud, $\frac{X}{\tan \phi}$ = the height of the cloud top.

Table 1

Date	Position of sub. Sat. point Lat.	Long.	Centre of sunglint		$\theta°$	$\alpha°$	Angle of Incidence $\phi = \theta + \alpha$	Length of shadow	Height of cloud top
14-10-70	3.6°N	58.8°E	1.3°N	64°E	5.9°	23.0°	28.9°	7 kms	12.7 kms
								10.6 kms	19. 5 kms
14-10-70	21.7°	64.2°	17.5°N	69°E	6.2°	27.6°	33.8°	14.4 kms	21.5 kms
15-10-70	22.2°N	80.3°E	17°N	86.3°E	7.4°	28.5°	35.9°	16.1 kms	32.2 kms
								8.0 kms	11.1 kms

CONCLUSION

The study indicates that some clouds in the equatorial trough region over Indian seas grow to very great height and the method developed for obtaining cloud top heights promises to provide a new useful technique.