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Vertical echoes observations by S-band radar

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ABSTRACT. Narrow vertical echoes have been observed by the S-band cyclone warning radar at Bombay which has peak power of 1000 kW. These vertical echoes were observed upto the height of 18 km on the RHI-scope and were not continuously straight line but broken in between at definite places. Initially on some occasions these were reported as very high thunderstorm echoes, but on subsequent observations these echoes were observed stationary having segments. Later on these echoes were observed on clear sky days and also associated with anomalous propogation. This study points to the cause as being that of side lobe radiation.

1. Introduction

While observing the thunderstorm echoes on the RHI-scope, it was noticed that on numerous occasions the sharp vertical echoes are protruding above thunderstorm echo as if small convective currents are reaching much above the top of the thunderstorm cell and were reported as the tall thunderstorm echoes. But when the thunderstorm cells started dissipating these echoes were not effected. Then it was realised that serious errors have been made in reporting the height of the thunderstorm echoes. The vertical echoes were studied with great care and the peculiar appearance of these echoes relative to the rest of the permanent echoes, thunderstorm echoes and anomalous echoes made us to revise our thinking that excessive heights reported can be an error.

2. Vertical echoes

The observations made on PPI-scope shown in Fig.1 shows that permanent echoes at an elevation of 0.9°(the beam width of the S-band radar in use is 1.8°). It is seen that the permanent echoes are mostly to the east of the station except very few echoes to the northwest of the station. Now if the antenna is raised to higher elevation, the permanent echoes start disappearing and the features associated with the permanent echoes are no longer seen. But the echoes take the shape as if made of small dots or/and dashes having their curvature to the centre of the radarscope. Fig. 2 is the typical example at an elevation of antenna at 9.7°. The difference between the cloud echo and the side lobe echo is clearly seen in the photograph of the PPI-scope. On further raising the antenna it is noticed that the farthest echoes disappear first and the nearest last. These echoes are also not observed beyond 85 km from the centre of the radarscope. In the RHI mode in Figs. 3 to 5 on different days and on different azimuths these echoes appear as sharp vertical echoes broken at some places. On the days of thunderstorm clouds these echoes (Fig. 3) are lost inside the cloud upto the top of the cloud the vertical echo protrusions are again seen. The maximum height in some of these echoes is seen upto 18 km in RHI-scope.

Another important feature which can be seen is that the breaks in the vertical echoes appear in all these echoes at the same elevation of the antenna at one time (Fig. 4). Another noticeable point is that these echoes are stationary in their character.

3. Discussion

Vertical echoes noticed on a number of occasions on the RHI-scope of the 10-cm cyclone warning radar at Bombay were initially thought of the echoes from the clouds only as they were noticed along with them. But since these vertical echoes were not at all effected even on dissipation of clouds, these were studied carefully. These are believed to be from the energy present in the side lobes. As the antenna is lifted up the main lobe first clears the permanent structures, then the small break is seen on the RHI-scope because of negligible transmitted energy available in between the main lobe and the first side lobe. On further raising the antenna, the first side lobe strike the permanent structures the echo again appears. This way the vertical echo is seen on the RHI-scope with the breaks in between at the same elevation at one direction at one

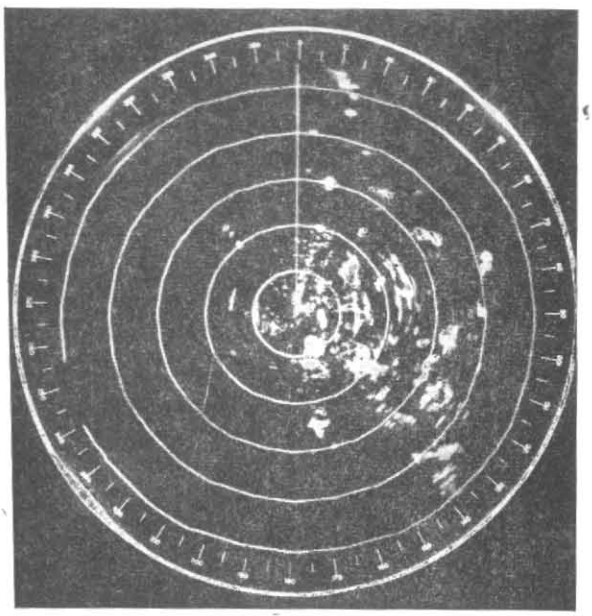

Fig. 1. Radar picture of 8 October 1975 at 0914 IST
(Range 500 km, Elevation 0.5°, Ring interval 100 km)

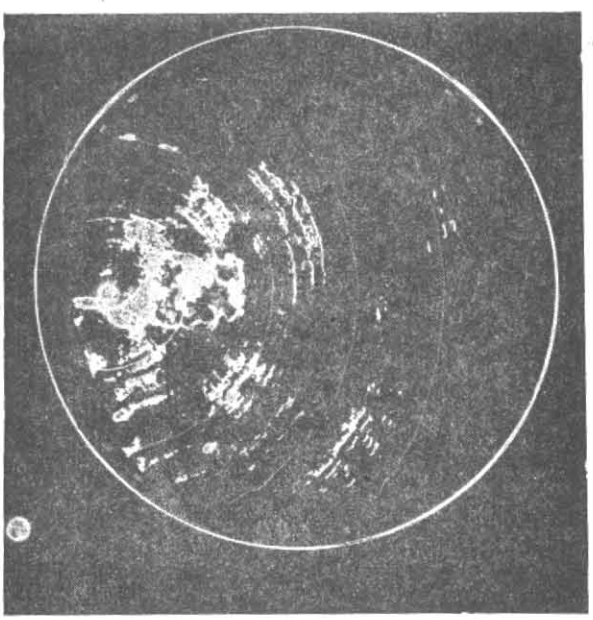

Fig. 2. Radar picture of 14 August 1975 at 0944 IST
(Typical example of an elevation of antenna at 9.7°)

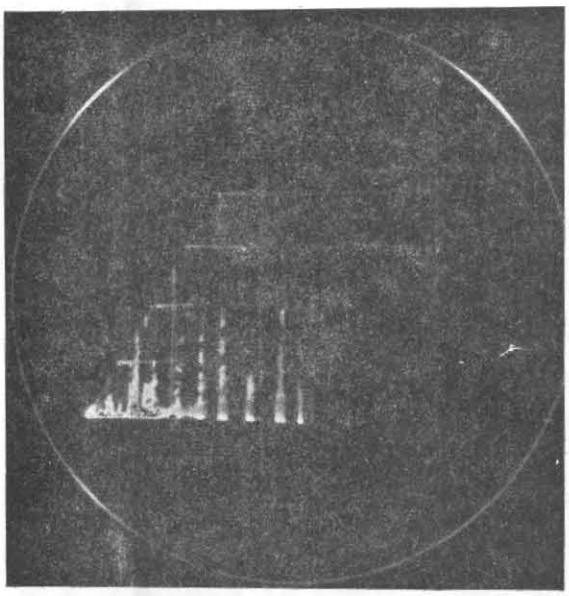

Fig. 3. Radar picture of 7 August 1975 at 0852 IST

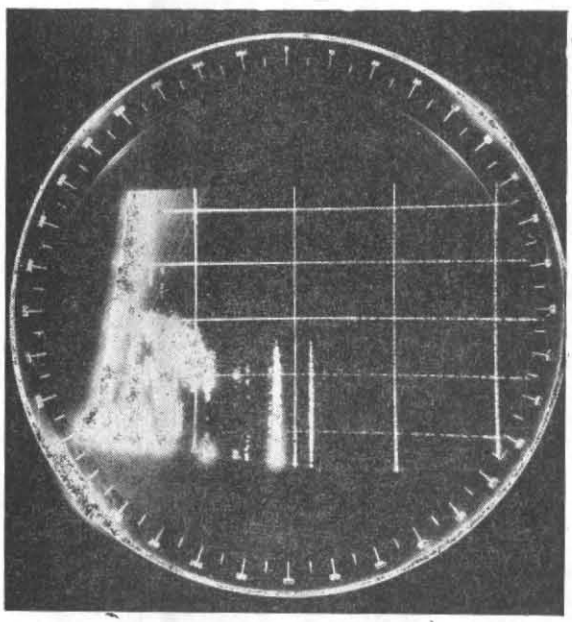

Fig. 4. Radar picture of 21 September 1975 at Bombay

time and finally no echo is seen till the energy is not quite sufficient to give any appreciable echo return.

By similar arguments the vertical echoes occurrence over the thunderstorm clouds can also be explained. A caution has to be taken while reporting the height of the cloud tops.

These vertical echoes are seen at the positions of the permanent objects and as well as that of the clouds mainly thunderstorms and when the vertical echoes are noticed at the positions of thunderstorm clouds, the mistake is likely to occur in the measurement of the top of the clouds. The brightness of the thunderstorm cells and these of vertical echoes are different

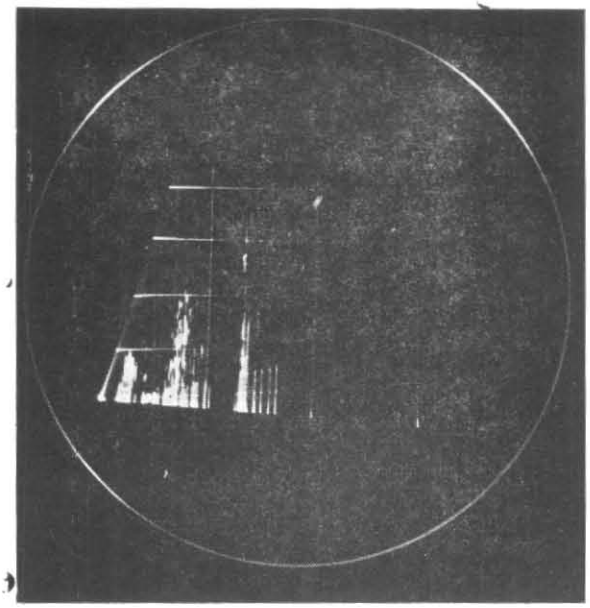

Fig. 5. Radar picture of 14 August 1975 at 0902 IST at Bombay

and the vertical echoes can be omitted by reducing the gain for each range where the echoes are seen, but this procedure can be adopted by an experienced radar operator.

Further these vertical echoes can cause a great problem while scanning for isolated thunderstorm cells especially those lying over the permanent echo positions.

4. Conclusion

From this study it appears that the vertical echoes are not the real echoes caused by the main lobe of the radar beam, but are the results of side lobes of the radiation. At times these vertical echoes are easy to identify, while at other times these are difficult to identify. Therefore, special care should be taken in determining the top of the clouds to avoid the misleading data.

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