ASPECT SENSITIVE CHARACTERISTICS OF RADAR BACKSCATTERERS AT VHF: STUDIES USING SIMULTANEOUS OBSERVATIONS OF GADANKI MST RADAR AND GPS SONDE

A.K.Ghosh, Siddarth Shankar Das, A.K.Patra, D.Narayana Rao
V.K.Anandan and A.R.Jain

National MST Radar Facility, P.B.No-123, Tirupati-517502, A.P., India
e-mail: asish_gh@rediffmail.com

Introduction

Study of aspect sensitivity at VHF in the lower atmosphere is of significant interest to the radar community, as it is important to understand the characteristics of the radar backscatterer for better interpretation of the spectral parameters, which represent a number of atmospheric parameters. The shape and the generation mechanisms of scattering refractive irregularities, at various height levels in troposphere and lower stratosphere (up to 25 km) region, are still yet to be fully understood. There are two main causative mechanisms for aspect sensitivity of radar backscattering: (i) specular reflectors and (ii) anisotropic refractive index irregularities (*Gage and Green,* 1978; *Doviak and Zrnic*, 1984; *Hocking and Hamza*, 1997). The contribution of each of these mechanisms at various height levels, however, could not be well determined due to lack of simultaneous high resolution radar and *in-situ* measurements of background atmospheric parameters. In this context, any measurement made simultaneously using radar and high resolution in-situ measurements of the background atmospheric parameters are of significant value. In this paper, an attempt is made to understand the origin of the aspect sensitivity characteristics of the radar backscatterers at VHF using simultaneous MST radar and GPS sonde (Vaisala type) observations carried out from radar site, Gadanki (13.5^{o}N, 79.2^{o}E), during September-October 2002.

Results and Discussion

Figure 1 shows the height profiles of the echo power for the different beam zenith angles (0°, 6°, 9°, 12° and 15°) in E-W and N-S plane for 25 September (top panel) and 8 October (bottom panel) 2002. The vertical and horizontal arrows in each panel represent the noise level of radar observations and the height of the tropical tropopause obtained from GPS sonde respectively. On 25 September there appears to be two distinct regions where the observed radar echoes are aspect sensitive, one in height region of 7-11.5 km and other one above 15 km in both the planes (E-W and N-S). The received echo powers at higher beam angles (>9°) are almost equal. On 8 October, in contrast to that of 25 September, the observed echo powers do not appear to be aspect sensitive anywhere below 18 km. However, above 18 km, the observed echo powers are highly aspect sensitive. The height profiles of echo power on 25 September show a clear wave modulation with vertical wavelength of 1-2 km. Similar signature, however, are not present in the case of 8 October. To understand the difference of the aspect sensitivity as a function of height for the two days, the background atmospheric parameters viz. square of Brunt-Vaisla frequency (N^2) from GPS sonde and square of vertical shears of horizontal wind speed from radar and Richardson number (Ri) from both GPS sonde and radar are plotted in Figure 2. The negative values of N^2 in this figure indicate regions of convective instability, and the values of Ri (0-0.25) indicate the regions of dynamic instability, the conditions that can give rise to turbulence. From Figures 1 and 2, it can be seen that wherever N^2 is high, wind shear is low, and Ri is high, the power difference between different beam zenith angles is high. This is more specific for lower beam zenith angle, indicating that the aspect sensitivity is caused by the thermal stable structures of the atmosphere (*Luce et al.* [2001] and *Jain et al.* [2001]). From Figures 1 and 2, it can also be observed that wherever N^2 is low or negative in spite of wind shear being either high or low, the echo powers for all the beam zenith angles are the same, indicating that the regions are highly turbulent and atmosphere is well mixed. For understanding the characteristics of the backscatterers the parameter θ_s (aspect angle) profiles are estimated using the observed echo power for beam combinations (0˚, 6˚), (0˚, 9˚) and (0˚, 12˚) and (0˚, 15˚) for both the planes (E-W and N-S) observed on both the days and are presented in Figure 3. The figure shows that in some height regions θ_s could not be computed since Power of smaller beam zenith angle is less than that of higher beam zenith angle. This type of situation could arise due to the passage of atmospheric waves over the radar site, which could cause fluctuations in vertical and oblique beam echo power [*Hobbs and Reid,* 2000]. Figure 3 shows that wherever aspect sensitivity is high (low) θ_s is small (large) indicating that the backscatterers are anisotropic (isotropic) in nature.

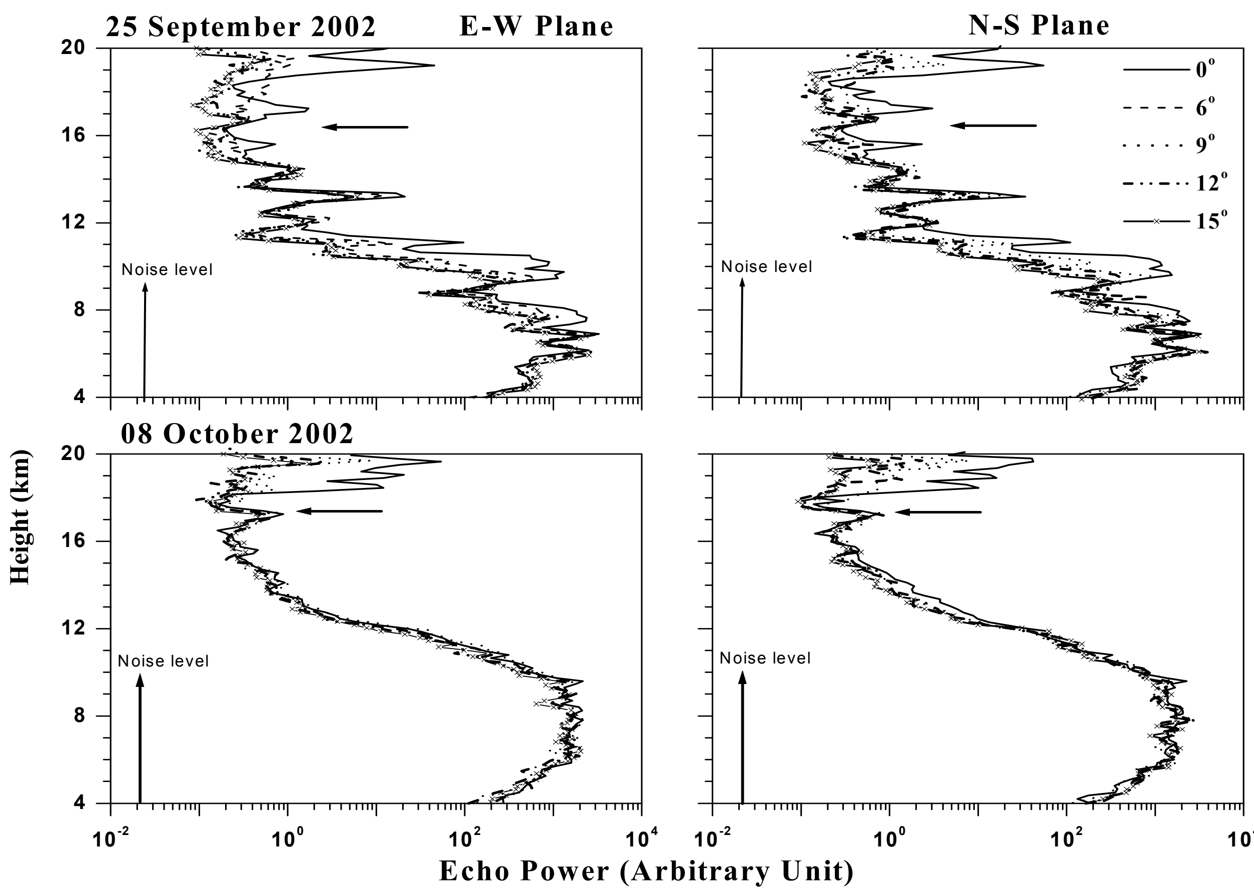

Figure 1: Height profiles of radar echo power for different beam positions in E-W and N-S planes for 25 September and 8 October 2002. The vertical and horizontal arrows in each panel represent the noise level of radar observations and the height of the tropical tropopause reported by GPS sonde observations respectively

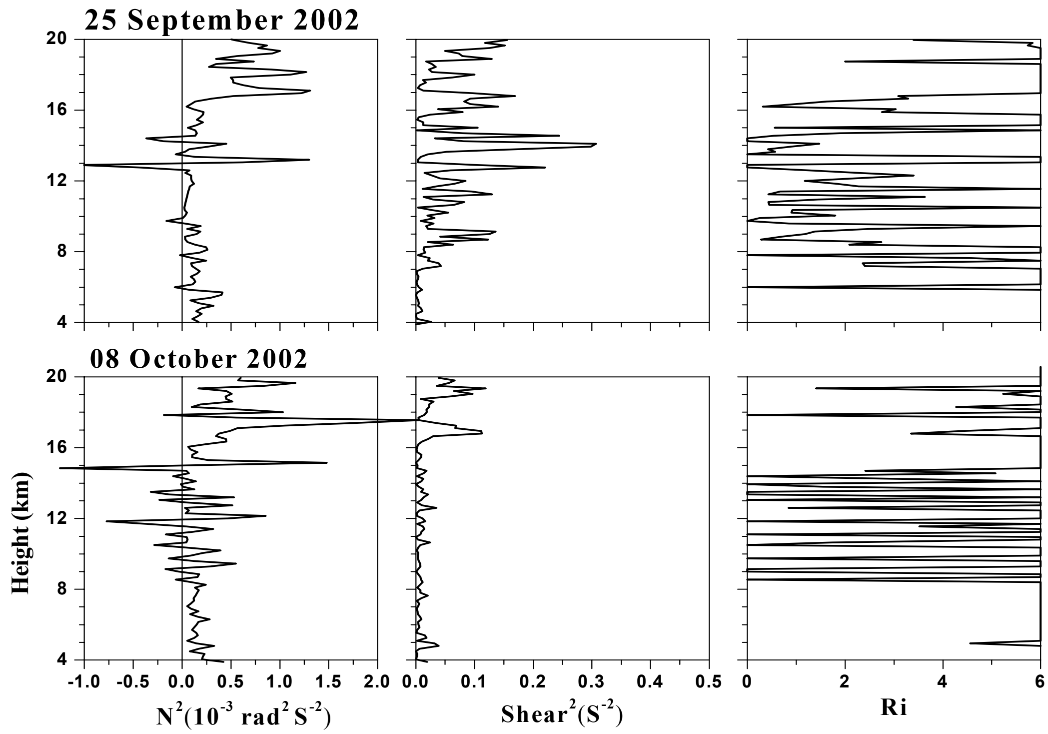

Figure 2: Height profiles of square of Brunt-Vaisala frequency (N^2) from GPS sonde, the square of the vertical shear of horizontal wind speed ($shear^2$) from radar and Richardson number (Ri) using GPS sonde and radar observations.

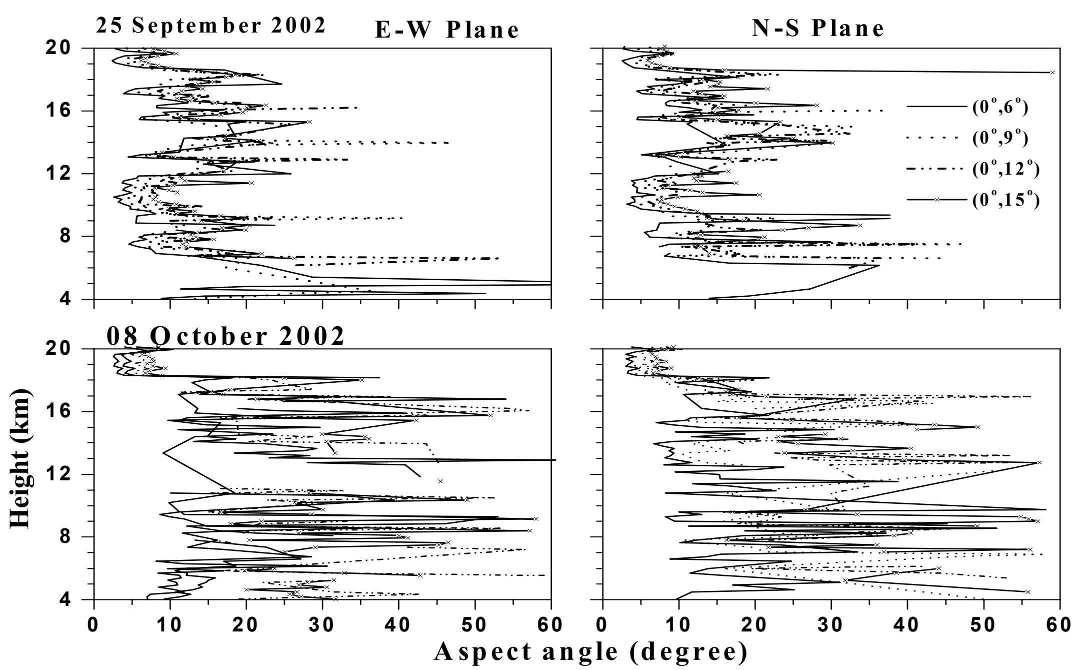

Figure3: Height profiles of θ_s for various beam combinations in E-W and N-S planes for 25 September and 8 October 2002. Each of these beam combinations use zenith beam as reference.

Summary

From the aspect sensitivity measurements presented here the following points can be brought out

(i) While the height region of 16-20 km is in general, aspect sensitive, the aspect sensitivity characteristics of the region below depends on the background atmospheric conditions.

(ii) The height profiles of θ_s reveal that in the regions of high aspect sensitivity the radar backscatterers are highly anisotropic in nature and wherever aspect sensitivity is less the backscatterers are isotropic in nature.

(iii) The layers of enhanced atmospheric stability (N^2) and low wind shear are found to be the cause of enhanced aspect sensitivity especially in the upper troposphere and lower stratospheric regions [*Luce et al,* 2001].

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