**P7.3** ANOMALOUS PROPAGATION EFFECTS ON WEATHER RADAR BEAM BLOCKAGE CORRECTIONS

Joan Bech*
Servei de Meteorologia de Catalunya, Spain
Bernat Codina, Jeroni Lorente
Dep. Astronomia i Meteorologia, Universitat de Barcelona, Spain
David Bebbington
Wave Propagation Laboratory, Essex University, United Kingdom

## 1. INTRODUCTION

Weather radars operating in complex orographic areas usually suffer from partial or total beam blockage caused by surrounding mountains. This shielding effect may restrict seriuosly the use of the lowest antenna elevation angles which provide the most useful information for rainfall rate estimation at ground level. Therefore, beam blockage correction schemes have to be applied in order to minimize the effect of topography, specially if quantitative rainfall estimations are required. In this paper we examine the effect of changing the radar beam propagation conditions upon the blockage correction. Particular results for the Vallirana weather radar, located at 650 m above sea level near Barcelona (NE Spain), are presented.

## 2. ANOMALOUS PROPAGATION

Propagation conditions have been calculated from 12 Z radiosonde observations collected in Barcelona; see Bech *et al.* (2000) for more details. After quality controlling the data, 862 radiosoundings were used to calculate duct occurrence and vertical refractivity gradients (VRG) for the layers 0 to 1 km and 0 to 4 km above sea level. The mode value of the VRG for the first 1000 m was –40 $km^{-1}$ (standard propagation), the maxima and minima were –119 $km^{-1}$ and –15 $km^{-1}$ , respectively, and 2% of the cases presented VRG below —90 $km^{-1}$. Ducting layers within the first 1000 m appeared in 37% of the cases and 60% of them had VRG below 300 $km^{-1}$.

## 3. WEATHER RADAR BEAM BLOCKAGE

### *3.1 Interception Function*

The blocked percentage area of the radar beam cross section by topography may be expressed as a function of the radius of the beam cross section, *a*, and the difference of the average height of the terrain and the center of the radar beam, *y* (see Figure 1). Depending on the relative position of the beam height respect to topography, *y* may be either positive or negative.

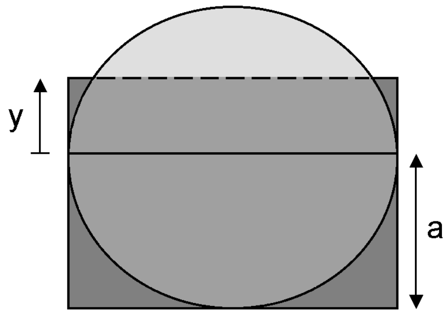


**Figure 1.** Elements considered in the radar beam blockage: *a*, radius of the radar beam cross section, and *y*, difference between the center of the radar beam and the topography.

According to these definitions, partial beam blockage occurs when $-a < y < a$ , total beam blockage means that $y \geq a$ and, finally, $y \leq -a$ implies there is no blockage at all. Using the notation intoduced above, it can be seen that beam blockage (BB) may be written as :

$$BB = \frac{y\sqrt{a^2 - y^2} + a^2 \arcsin\frac{y}{a} + \frac{\pi \cdot a^2}{2}}{\pi \cdot a^2} . \quad (1)$$

The height of the center of the radar beam, *h*, is given at a distance *r* by the expression (see, for example, Doviak and Zrnic, 1992):

$$h = \sqrt{r^2 + (k_e R)^2 + 2 r k_e R \sin E} - k_e R + H_0, \quad (2)$$

where *R* is the Earth's radius, $k_e$ is ratio between *R* and the equivalent Earth's radius, *E* the antenna elevation angle and $H_0$ the antenna height. Atmospheric propagation conditions

**Corresponding author address:* Joan Bech, Serv. Met. Catalunya, Diagonal 525, Barcelona 08029, SPAIN; e-mail: wjbech@correu.gencat.es

information is contained in $k_e$, which may be written as:

$$k_e = \frac{1}{1 + R\left(\frac{dN}{dh}\right)}. \qquad (3)$$

Substituting (3) and (2) in (1), an expression of the beam blockage in terms of the propagation conditions is obtained.

### *3.2 Ground targets*

Five clutter targets which presented partial beam blockage under normal conditions were chosen to examine the effects of changing the VRG. Table 1 shows some characteristics of each target.

**TABLE 1**

| TARGET | DISTANCE (km) | HEIGHT (m) |
|---|---|---|
| MNT | 26 | 1100 |
| LML | 32 | 1000 |
| MNY | 65 | 1600 |
| RDA | 82 | 2000 |
| TLP | 92 | 2400 |

### *3.3 Beam blocking correction*

To evaluate the effects of anomalous propagation, the partial beam blocking correction scheme used in the NEXRAD Precipitation Processing System has been considered. This scheme (Fulton *et. al*, 1998) is applied to beams partially shielded between 10% and 60% and consists of modifying equivalent reflectivity factor measurements by adding 1 to 4 dBZ depending on the degree of occultation. It is used with other corrections such as a test on the vertical echo continuity and a sectorized hydrid scan (Shedd *et al.*, 1991).

## 4. RESULTS AND DISCUSSION

Assuming an homogeneous VRG for the whole radar beam and substituting the observed extreme VRG values (–119 $km^{-1}$ and –15 $km^{-1}$), the differences found in occultation compared to standard propagation ranged from 5% to 20% (see Figure 2).

Greater corrections (up to 4 dBZ) appear considering VRG of 0 (subrefraction) and –156 $km^{-1}$ (almost pure ducting conditions).

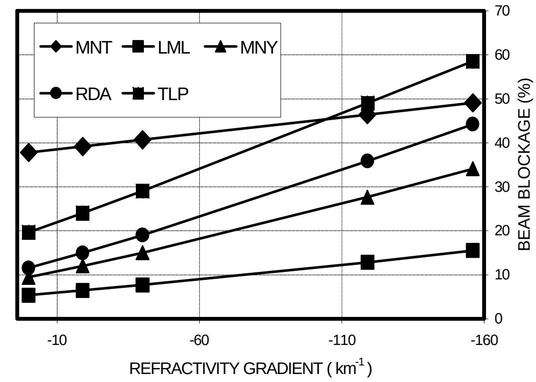


**Figure 2.** Beam blockage vs. refractivity gradient plot for five selected clutter targets.

Therefore, under anaprop conditions, partial beam blockage corrections based in assuming standard propagation may lead to inaccurate results. For instance, extreme anaprop cases where partial beam blockage is incremented significantly but does not reach 60% would not be detected in a vertical echo continuity test but may produce a wrong correction of 4 dBZ. To detect such cases, information about the observed or forecasted VRG in the radar coverage area, if available, might be incorporated in the correction schemes as a quality control.

## 5. REFERENCES


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