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Interaction Between Beam Blockage and Vertical Reflectivity Gradients

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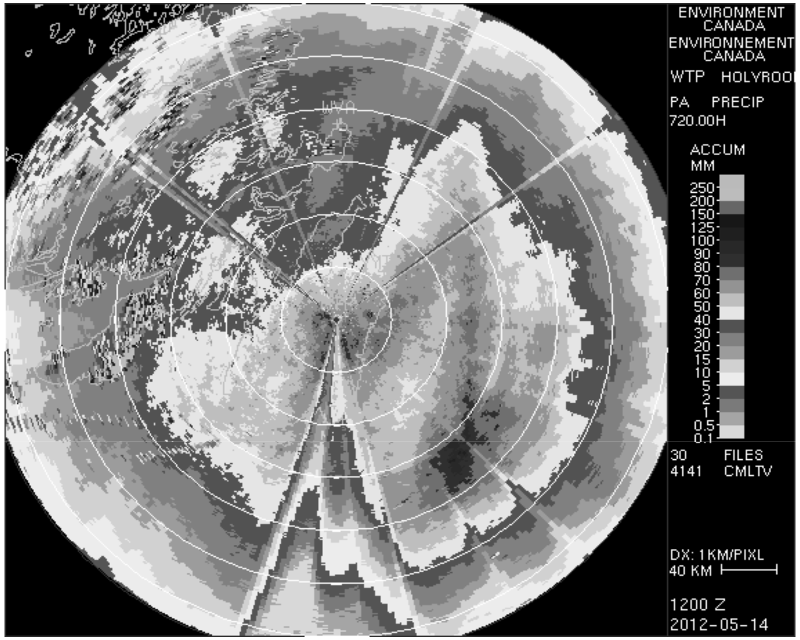
The Issue

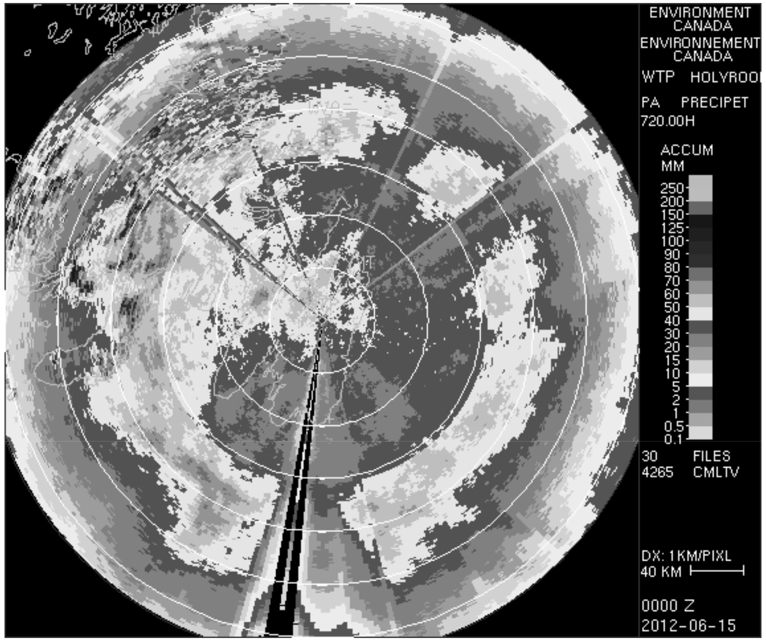
- Most versions of blockage correction of mono-pol data appear to assume uniform beam filling, which is not always true.
- This presentation summarizes work on partial blockage in the presence of vertical reflectivity gradients within the beam.

Motivation

- Mid-latitude winter precipitation systems tend to be shallower, so low elevation angles are desired to avoid "overshooting" the precipitation at long range.
- On the other hand low elevation angles increase the amount of partial blockage of the beam by hills, trees, buildings, etc.
- Since blockage sources like trees and buildings close to the radar are not included in digital terrain maps (DEMs), we have examined such case using statistics of echoes. The results seem to vary season-to-season and even case-to-case.

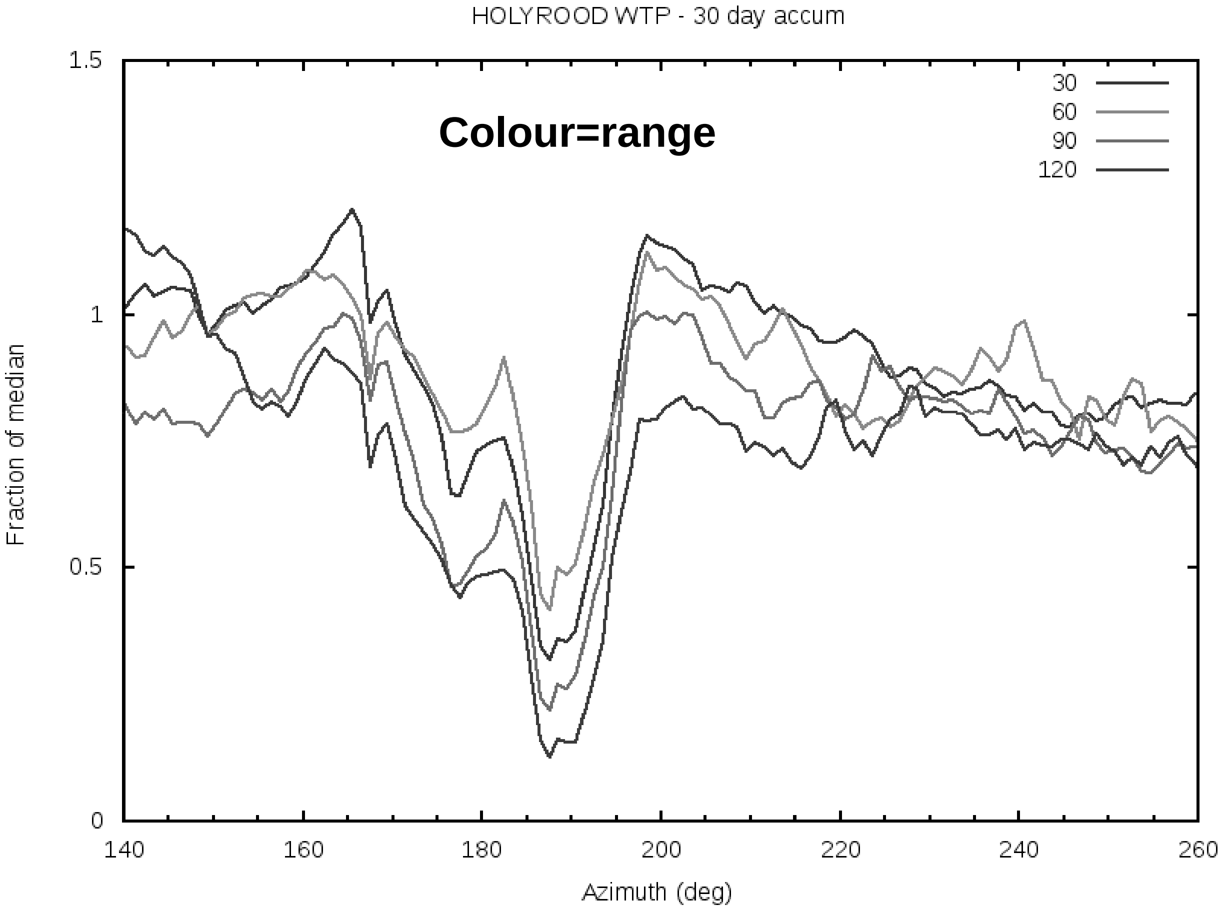
Blockage Varies: 30day Accumulations

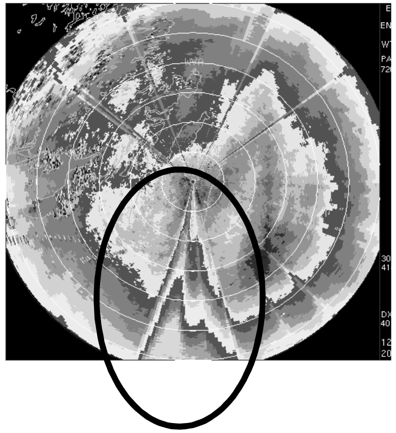




Holyrood Radar “WTP” (Doppler / Mono-pol.)
Partial blockage to the south due to hills and trees within a few kilometres of the radar. The pattern of blockage to south seems to vary between cases and with range,

Variation with azimuth – obs.





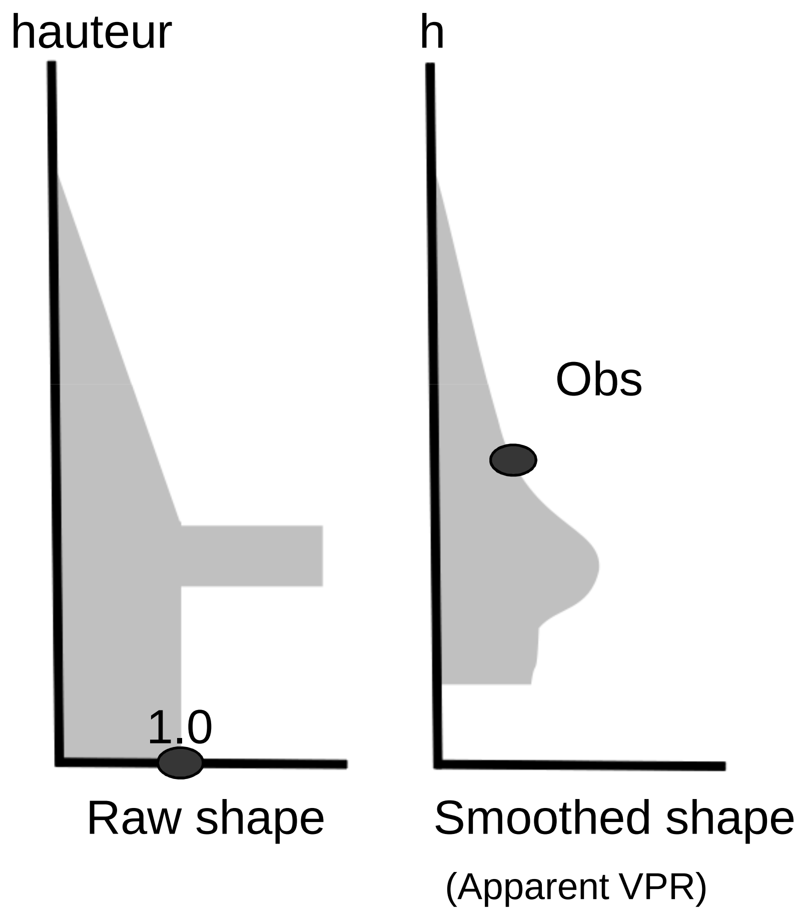
“Normalized” by median at range

Conceptual VPR Correction

- At its simplest, one scales the observed Z by the ratio of observed, beam smoothed, shape profile, S, to surface value of shape.

- $Z_{est} = Z_{obs} * (S_{sfc} / S_{obs})$

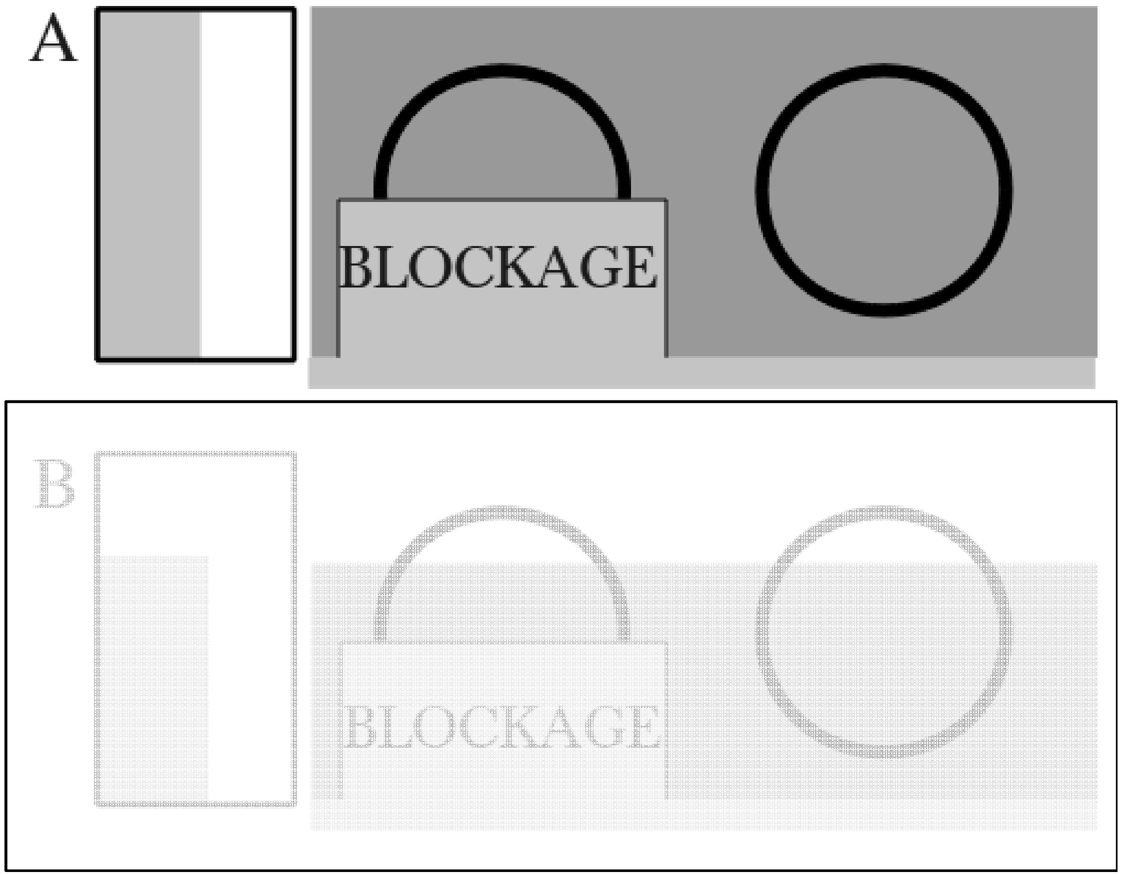
- Assumes there is no partial blockage.



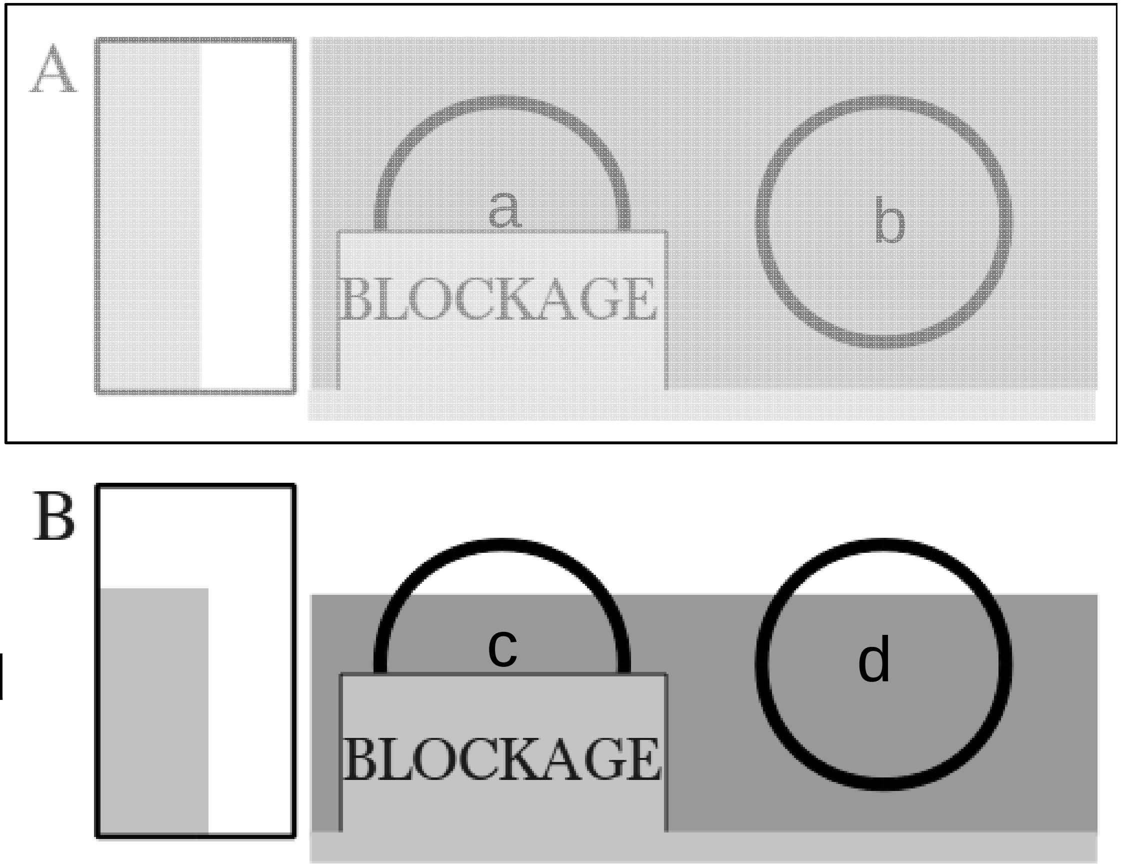
Conceptual Blockage Correction

- Frame A: If beam is full, the fractional reduction of measurements is simply the fraction of beam that is obscured, F:

$$Z_{corr} = Z_{obs} / F$$



Conceptual Blockage Correction



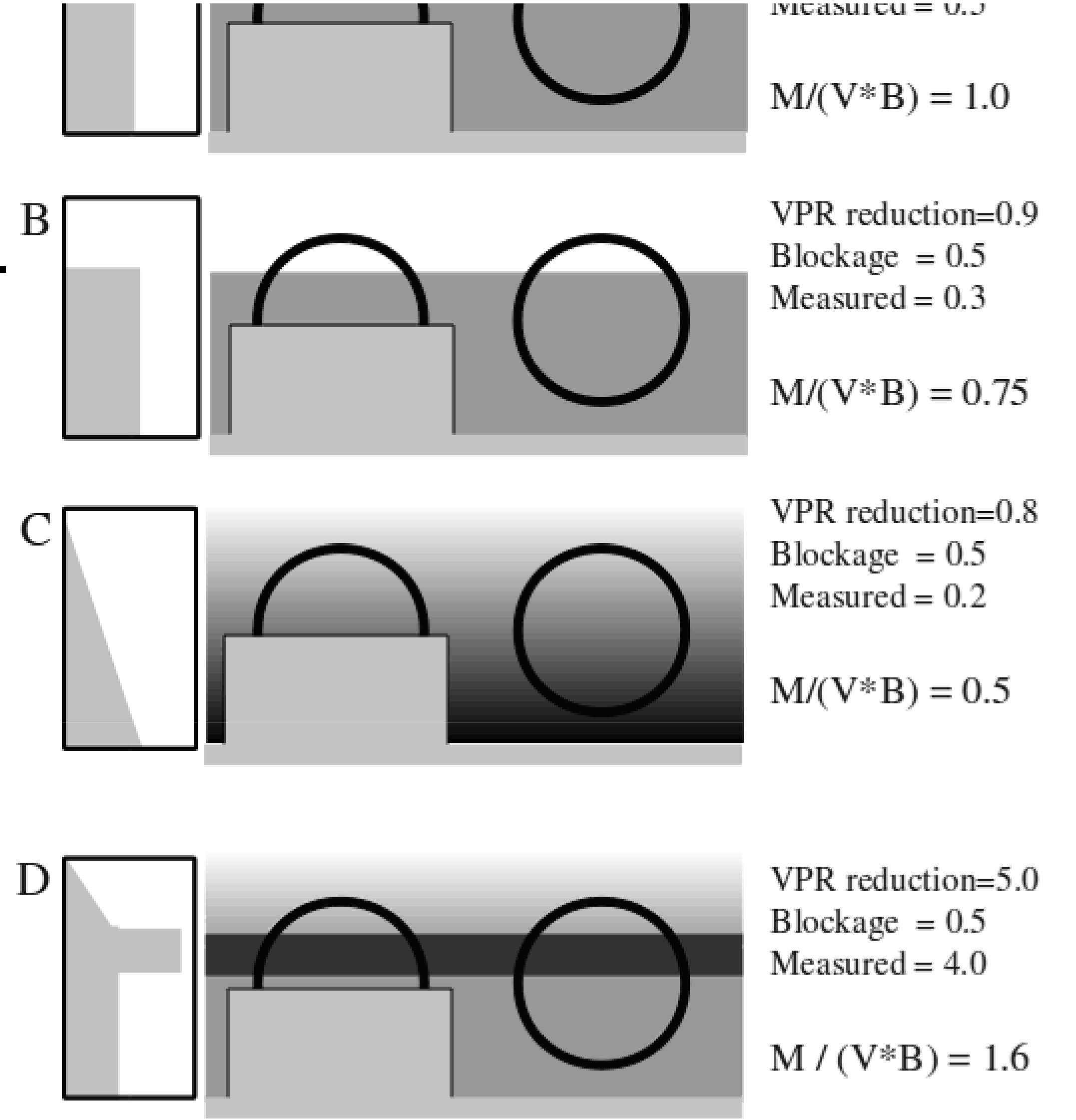
- Frame B: If beam is partially filled the fractional reduction relative to unblocked values is greater.
- The simple method under-compensates

a/b ~ 0.5

c/d ~ 0.3

More profiles

- In reality, profiles in snow have strong continuous gradients (Frame C)
- A bright band, BB, may be present. (Frame D)
- Note that for the BB case the simple blockage method overcompensates.



4 profiles of reflectivity (left) as seen by a beam that is 50% blocked (centre) or unblocked (right). The results of multiplicative correction to 50% blockage case are shown on right.

Full Equations

In the presence of blockage we need to know the reflectivity profile, V, the antenna gain, G, and the lowest unblocked elevation, E, and do horrible math:

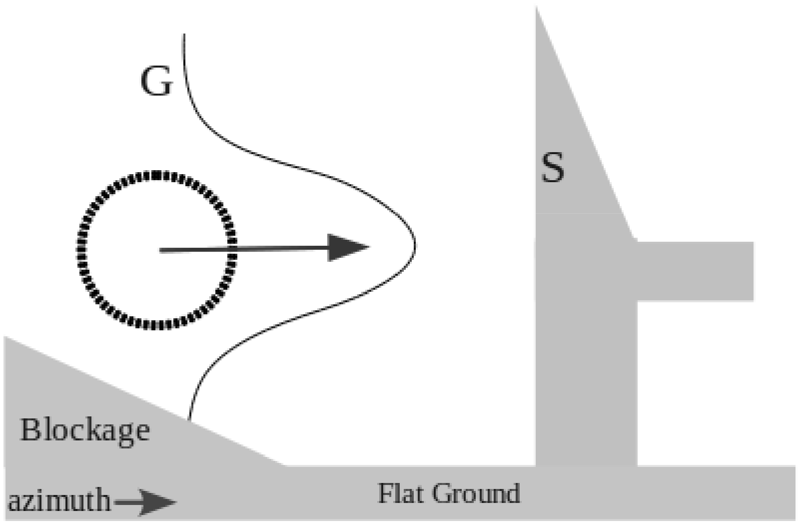
$$Z_{observed}(a_0, e_0, r) = \int_0^{2\pi} \int_{E(a,r)}^{\pi} G^2(a - a_0, e - e_0) V(e)\, de\, da$$

L is the conversion to surface with VPR and blockage

$$L(a_0, e_0, r) = Z_{observed}(a_0, e_0, r) / Z_{sfc} = \int_0^{2\pi} \int_{E(a,r)}^{\pi} G^2(a - a_0, e) S(e)\, de\, da$$

Numerical Simulations

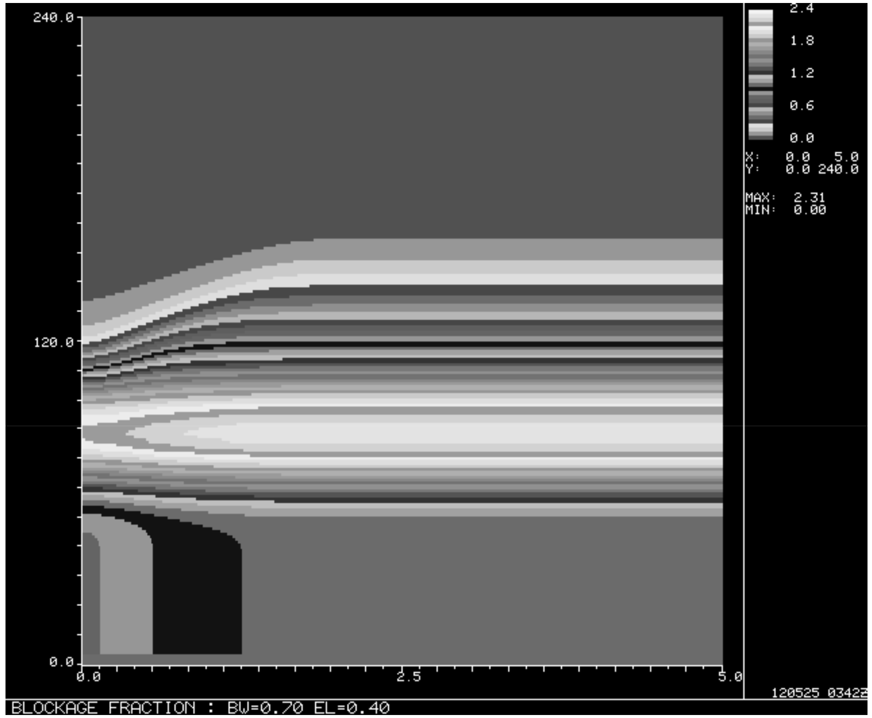
- Place a triangular obstruction at left of domain (symmetric).
- "Scan" beam past it to look at different degrees of blockage as function of range.
- A shape S is given for the VPR.
- Case were done with different beam widths, elevation angles and VPR shapes.
- Propagation effects due to beam bending and Earth curvature included.



Sample Results: Bright Band Case

Look at ratio, L, of the observed values to the “true” surface value. This combines partial blockage and VPR effects.

Range (km)

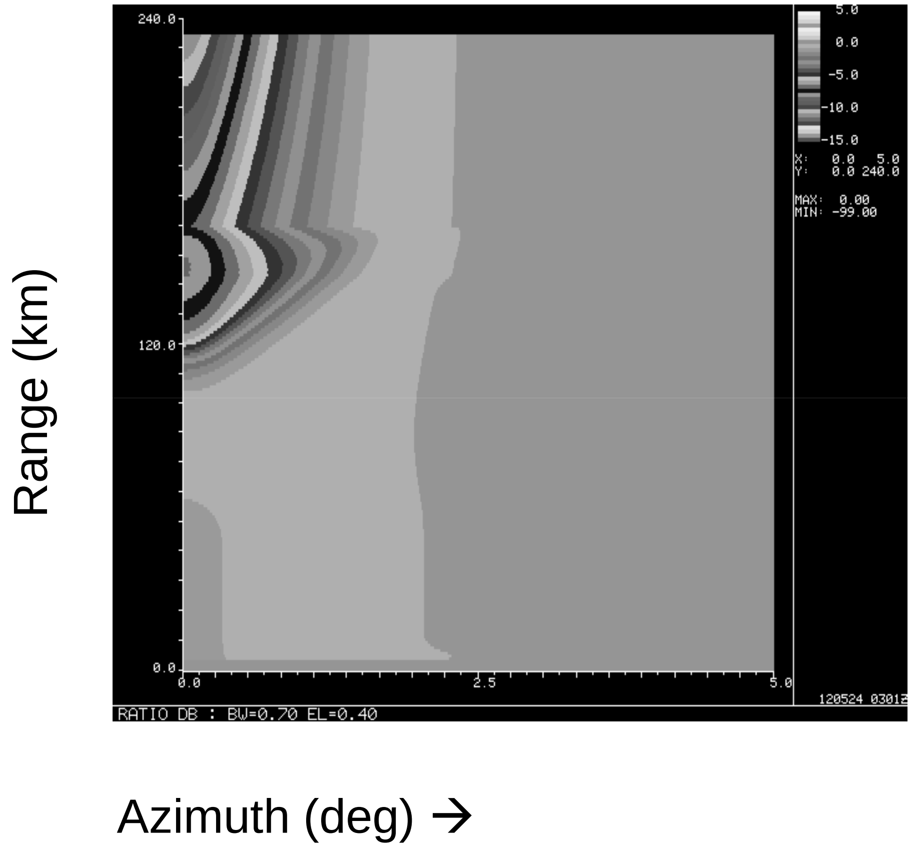


Azimuth (deg) →

L = ratio of observed to surface

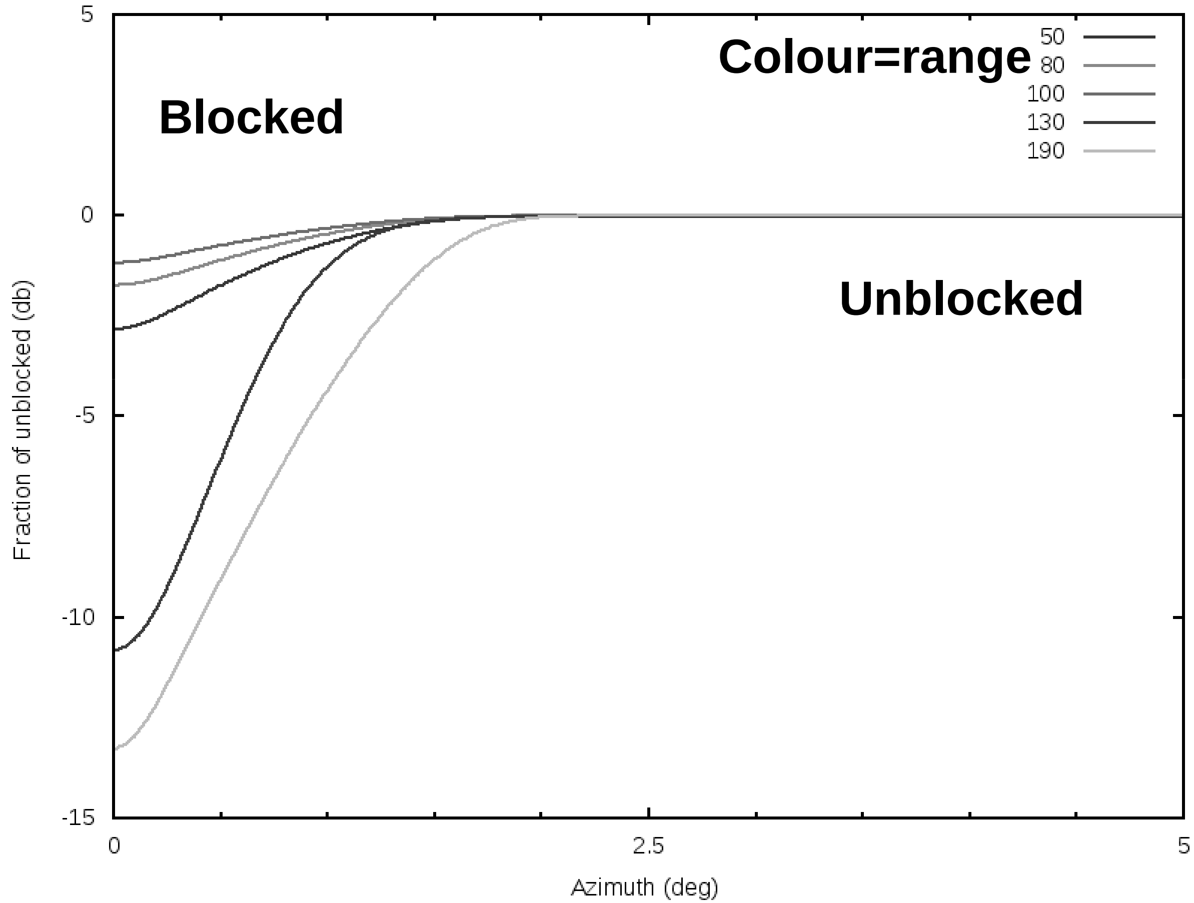
Sample Results: Bright Band Case

- Look at ratio of the observed Z to unblocked Z.
- Blockage with VPR removed.
- Complex pattern that varies with range and degree of blockage.



Change to VPR correction

- Cross sections through ratio (db) at constant range. In principle the VPR needs to be corrected by this range dependent factor, not a simple fraction of beam obscured.



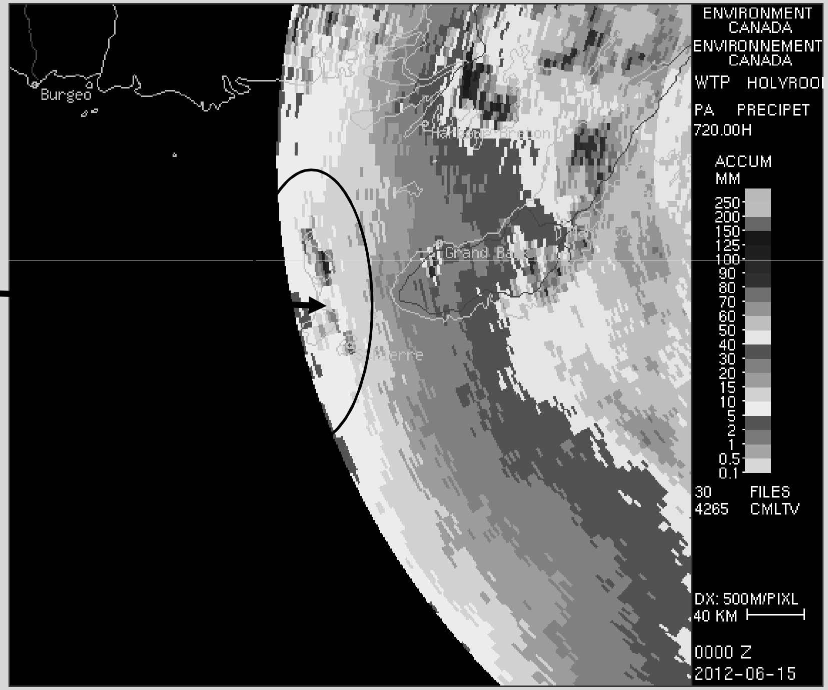
Discussion

- Effects due to vertical gradients within the beam do seem to be a plausible explanation for at least a portion of the variability of signal reduction by partial blockage. Other factors, such as changes in refractive index gradients, will certainly also play a role.
- Need to re-examine out cases in the light of this explanation. Frequency? Predictors?
- The situation is quite complex so it is still unclear what one should do in an operational setting.
- Is there a role for dual polarization in this problem?

QUESTIONS / COMMENTS?

Who noticed French territory in first radar image?

Collectivité territoriale de Saint-Pierre-et-Miquelon



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