METR 5004 Homework Assignment #1

Due by the start of class Wednesday November 6

1.1 Given radar parameters, cite the formulas to determine the unambiguous velocity and unambiguous range. (10 points)

1.2 Describe the changes in the observed Doppler velocity when the true velocity of a scatterer continuously increases from zero to values larger than the Nyquist velocity (i.e., unambiguous velocity). (15 points)

1.3 Describe how nearby ground scatterers can obscure Polarimetric and Doppler measurements in storms at ranges beyond the ground scatterers. (15 points)

1.4 (a) Compute the error in range to a scatterer at r = 300 km if one assumes free space propagation velocity c instead of the velocity c/n in the atmosphere where $n = 1.000300$. (b) What is the difference in echo phase for a 10-cm wavelength radar for these two different speeds of propagation? (20 points) For extra credit: What would be the phase difference observed in the I,Q phasor diagram? What would be the phase difference observed in the I,Q phasor diagram if the scatterer was displaced an additional 1 cm away from the radar (i.e., at range 300km +1 cm)?

1.5 Results from an early morning sounding is given in the Table below:

Height ASL (m)	P(mbar)	T ($^\circ$C)	P_w (mbar)
362	962	18.4	16.7
899	904	21.2	11.6
1219	871	19.6	10.0
1829	811	17.5	7.4
2439	755	12.3	6.2
3923	630	0.0	5.5
5487	516	-9.4	2.7
6402	458	-14.7	1.7
7621	389	-22.0	0.8
9944	281	-39.9	0.1

The atmospheric refractivity N, an accepted measure of the refractive index n, is related to n as

$N = (n-1) \times 10^6$, where N is $N = (77.6/T)(P + 4810P_w/T)$, P and P_w are the total pressure and partial pressure of water vapor in millibars, and T is in kelvins.

Compute and plot the dependence of N vs height h and compare this height dependence with that of a reference atmosphere given as

$$N_{ref} = 313\exp[-0.1439\ h(km)].$$

Explain the origin of the marked differences between these two vertical profiles of N. Using the N profile obtained from the morning sounding, determine the gradient of n in the lower atmosphere (i.e., the first few hundred meters) and compute the effective earth's radius using the formula (Doviak and Zrnic, 2006, Eq.(2.27)

$$a_e = \frac{a}{1 + a\left(\dfrac{dn}{dh}\right)} = k_e a$$

where a is the earth's radius. Repeat for the reference atmosphere. How does each of these effective earth's radii compare with the $k_e = 4/3$rds earth radius model?

Assume a radar beam has an elevation angle of 0.0° and there are not obstructions to the beam. What is the difference in beam heights at a range of 100 km if the beam is propagating in a reference atmosphere versus that height when the beam propagates in the observed atmosphere? (40 points)