ATMO 489: Radar Meteorology

Laboratory #1, 09/04/06

Radar Scanning, Part I

Due: By beginning of next lab session

Note on Collaboration:

Unlike exams, which must reflect your own individual effort, working toward solutions to problems in laboratory assignments can be a collaborative endeavor. However, each student *must* write her/his own answer in her/his own words to each question. We will *not* accept verbatim copies of answers for any laboratory assignment.

Introduction:

The purpose of this laboratory assignment is to introduce you to some first principles of radar operations and scanning, using the Aggie Doppler Radar (ADRAD). We will demonstrate RHI (Range Height Indicator) and PPI (Plan Position Indicator) scans and scan volumes and consider some properties of each.

Questions (50 points):

1. Radar rotation and scan times (16 points):

a. (6 points) A typical meteorological radar can rotate in azimuth (θ) or elevation (α) angle at angular rates of 1° s^{-1} to 30° s^{-1}. Assuming you rotate the radar at varying rotation rates ($d\theta/dt$) given below at a single fixed elevation angle for θ degrees in azimuth, calculate the scan time (t, seconds) it takes for each of the following PPI sector scans.

θ	$d\theta/dt = 12° s^{-1}$	$d\theta/dt = 18° s^{-1}$
120°		
180°		
360°		

b. (4 points) A "PPI sector volume" can be comprised of multiple, consecutive PPI sector scans. The antenna will rotate θ degrees in azimuth at a fixed elevation angle (α_1) and then tilt upward in elevation angle by ($\Delta\alpha$) to the next elevation angle (α_2) and rotate θ degrees in azimuth in the opposite direction. This process can be repeated for multiple elevation angles (α_1, α_2, … α_N). Based on your table above, estimate how long (T, seconds) it will take a 9-tilt (i.e., N=9) PPI sector volume for θ = 120° at $d\theta/dt = 18° s^{-1}$.

c. (6 points) Compare this estimated time to the actual scan time for a 9-tilt, 120° PPI sector volume executed on the ADRAD (Aggie Doppler Radar) for $\alpha_N = 15°$. Are the estimated and actual sector volume scan times (T) the same? What happens to T if you change $\Delta\alpha$? Explain your results.

2. (14 points)

a) (4 points) Describe what happens to your sampled radar data when you change the pulse repetition frequency (PRF)? Give an example at two different PRF's.

b) (6 points) Derive an expression for the maximum unambiguous range (R_{max}) for a pulsed meteorological radar given the pulse repetition frequency (PRF) and the speed of light ($c = 2.998 \times 10^8$ m s^{-1}).

c) (4 points) For each of the following PRF's, calculate R_{max}

PRF (Hz)	R_{max} (km)
300	
600	
1000	
3000	

3. (4 points) Run a 1-tilt surveillance scan with low PRF (588 Hz). Describe qualitatively what you see in radar reflectivity and Doppler velocity.

4. (8 points) A radar samples a weather echo at a fixed range R (km) while rotating in azimuth at $d\theta/dt$. Assume that the radar transmits a pencil beam with an azimuthal beamwidth (Θ) of approximately 1°. Since we are trying to measure weather echo at a fixed, discrete location, explain why it is safe to assume that the radar is approximately stationary during the measurement of weather echo from a single radar pulse?

5. (8 points) An RHI sector volume can be comprised of multiple, consecutive RHI sector scans. The antenna will rotate upward α degrees in elevation at a fixed elevation angle (θ_1) and then move sideways in azimuth angle by ($\Delta\theta$) to the next azimuth angle (θ_2) and rotate downward α degrees in elevation. Therefore, meteorological phenomena can be sampled by both RHI and PPI sector volumes. Explain the relative advantages and disadvantages of each scanning approach.