Knowledge Expectations for METR 4623
Radar Meteorology

Purpose: This document describes the principal concepts, technical skills, and fundamental understanding that all students are expected to possess upon completing METR 4623, Remote Sensing in Meteorology. Individual instructors may deviate somewhat from the specific topics and order listed here.

Pre-requisites: Grade of C or better in METR 3223, METR 3613, MATH 3113.

Students should have a basic understanding of the structure, physics and thermodynamics of the atmosphere prior to starting this course.

Goal of the Course: This course develops quantitative relationships between the physical characteristics of a target or set of targets illuminated by a radar pulse and the quantities measured by weather radar. The capabilities and limitations of the various radar system designs are examined to determine their impact on applications. A full treatment of Doppler principles, including interpretation of Doppler radar data, is provided. Polarimetric and phased array radar are introduced.

Topical Knowledge Expectations

I. Characteristics of a weather radar

- Understand the various components of a weather radar system, their function and limitation, including different types of transmitters.
- Understand what is meant by beamwidth, sidelobes, gain, unambiguous range, unambiguous velocity, the Doppler dilemma, and other common terms in weather radar.
- Understand the tradeoff in designing major components of a weather radar system.
- Be able to summarize the major characteristics of common weather radar systems, such as the WSR-88D and TDWR, and their sampling strategies.

II. The radar equation

- Understand the propagation of electromagnetic radiation through the earth's atmosphere including the 4/3 R rule.
- Understand how to compute the height of the beam above the earth's surface as a function of the vertical distribution of temperature and moisture.
- Be able to identify conditions associated with anomalous propagation and be able to identify AP in weather radar data.
- Understand the difference between the radar equation for point and distributed targets.
- Understand the impact of various radar parameters on sensitivity of the radar system.
- Understand the relationship between the radar cross-section, radar reflectivity, and particles sizes for dielectric spheres undergoing Rayleigh scattering.
- Be aware of the character of particle size distributions for different type of hydrometeors.
- Be able to identify non-Rayleigh scattering such as hail spikes and reflectivity flares.

- Understand how polarization diversity can be used to determine additional characteristics of precipitation particles within clouds.
- Be able to distinguish between hail and heavy rain using polarimetric data.
- Understand the frequency dependence of attenuation on radar returns and how to compensate for attenuation.
- Be able to identify regions affected by attenuation within a radar data set.

III. Doppler principles

- Understand the relationship between Doppler phase shift and radial motion of a target along a radar beam.
- Understand the relationship between pulse repetition frequency, the wavelength of the transmitted pulse, and the maximum radial velocity (i.e. the Nyquist velocity) that can be measured by weather radar.
- Be able to derive the relationship between the maximum unambiguous range and Nyquist velocity.
- Be able to identify regions that are velocity aliased in a Doppler data set.
- Be able to identify the Doppler patterns associated with idealized flows and simple wind profiles.
- Understand how dual-PRF sampling can be used to extend the effective unambiguous velocity.
- Understand the concept of the power spectrum and spectrum width.
- Understand the relationship between spectrum width and atmospheric turbulence.

IV. Applications

- Understand the relationship between radar reflectivity and rain rate and the sources of uncertainty in rain rate—reflectivity relationships.
- Understand how polarimetric data can be used to reduce the uncertainty in radar-derived rainfall estimates.
- Understand the principle behind retrievals of the vertical wind profiles using velocity-azimuth display analysis techniques.
- Be able to derive VADs for a given wind direction and wind speed.
- Understand the principles behind dual-Doppler analyses and the sources of error in dual-Doppler wind retrievals.
- Be able to use conceptual models of cloud systems such as supercells and squall lines to identify signatures associated with convective and mesoscale processes.

V. Special Topics

- Understand airborne radar systems and the sampling strategy used to measure winds within cloud systems.
- Understand the basic concept of Phased Array radars and how they can be used to rapidly sample the atmosphere.