MAGIC

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A newsletter for non-scientists (and scientists) interested in MAGIC

The last two updates discussed how the Doppler effect can be used by radars to provide information on the sizes of raindrops falling in still air: an upward-pointing radar measures the Doppler shifts from falling raindrops, which are used to compute their terminal velocities, and from these the sizes of the raindrops can be computed. The strength of the signal measured by the radar for a given Doppler shift tells how many drops of the corresponding size are sampled.

In actual conditions, however, when downdrafts (or updrafts) are present (which they typically will be when rain occurs), the Doppler signal alone cannot be used to determine raindrop sizes and numbers, as the speeds determined by the radar will not be the terminal velocities of the raindrops. To determine these terminal velocities (which are the speeds of the raindrops relative to the air) from measurements made by the radar (which are the speeds of the raindrops relative to the ground), the speed of the downdraft (or updraft) is also required. The graph of the Doppler signal looks the same with a downdraft (or updraft) as without one, except that the graph is shifted left or right by an amount that depends on the speed of the downdraft (or updraft). What is required is a way to anchor this graph – to know how much to shift it left or right to line it up on the correct values. There are two approaches for doing this (and thus for determining the downdraft, or updraft, speed), one for light drizzle and one for heavier rain.

The approach for light drizzle makes use of the fact, discussed in the last update, that cloud drops have extremely small terminal velocities and require minutes to fall several meters. Compared to drizzle drops, for instance, which have terminal velocities of nearly a meter per second, cloud drops are essentially standing still with respect to the surrounding air. Thus, the speed of cloud drops measured by an upward-pointing radar using the Doppler effect is equal to the speed of the surrounding air, i.e., the speed of the downdraft (or updraft). As the terminal velocities of cloud drops are nearly zero, this becomes our anchor and we know how to line up the graph of the Doppler signal. The amount by which we have to move the Doppler signal to line up the lowest value to zero is the downdraft (or updraft) speed, and once this is known the speeds of drops of all sizes can be determined, and from these their sizes.

This approach works well for drizzle and light rain, but not under conditions of heavy rain. In these situations, the radar signal is dominated by the larger drops, and it is attenuated by the falling rain. To determine downdraft (or updraft) speed in heavy rain conditions we must employ a different approach, one that requires more detailed knowledge of how small water drops interact with radar waves. This will be discussed in the next update.

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Please address any questions or comments to elewis@bnl.gov.
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