Corrections for Airborne Doppler Velocity with Nadir Pointing Wband Radar

Fairall et al. 2014, give the basic equations for the observed Doppler velocity:



Where



And



Here θ, φ, and ψ are the pitch, roll, and heading of the aircraft; *SOG* and *COG* and are the speed over ground and course over ground; *U* and *Dir* are the true wind speed and direction at the altitude of the radar range gate; *Vg* is the mean fall velocity of the rain. Here we use the convention that the wind direction indicates the direction ‘to’ as opposed to ‘from; also, fall velocity is positive down.

Because we have restricted our analysis to small roll (±2 deg), we can simplify the equations by setting φ=0. In that case, the mean fall velocity can be written



There is also a special case when the return is from the ocean surface. Then *Vg*=0 and *U*=surface current velocity which is negligible. Thus



So we can write



If the wind speed contribution is small, then measured Doppler velocity can be corrected by Doppler velocity of the surface return. For an airspeed of 150 m/s and a wind speed of 15 m/s, *VdopS* is about 5 m/s while the second term is about ±0.5 m/s at a pitch of 2 deg.

Another interesting case occurs for level flight at a fixed bank angle. This is the way the aircraft does a complete circle. In this case pitch is zero and we can write



Where we have kept a term for the surface current of speed *Uc* and direction *Dirc*. In principle, the surface current speed and direction can be determined by a complete circle of the aircraft.



For light winds, so the aircraft speed term gives a Doppler velocity of ±1 m/s. The Doppler velocity associated with the surface current will be ±0.1 m/s. So it is unlikely that surface currents can be determined this way. An example of observations of Doppler shift as a function of aircraft heading is shown below. In this case winds were light and the measured Doppler shift is normalized by the sine of the bank angle (10 deg). The Doppler shift should be 0 when flying upwind or downwind; it is maximum when the heading is 90 deg greater than the wind direction. The maximum of Doppler/sin(φ) is the wind speed [about 4 m/s to the east] and the direction is the zero crossing point [about 100 deg]. The second figure shows calculations of the Doppler shift for a windspeed of 5 m/s to the East and an airspeed of 150 m/s. If we assume a surface current of 0.5 m/s then we get the green line in the figure/



