Introduction

VAD (Velocity Azimuth Display) scans acquire measurements of radial velocity relative to the location of the lidar in probe volumes whose location is determined by:

- Fixed elevation angle
- Fixed radial distance
- Variable azimuth angle

Locations at constant height lie on an arc up to 360 degrees in extent on an inverted conical surface.

VLD (Velocity Linear Display) scans acquire measurements of radial velocity relative to the location of the lidar in probe volumes whose location is determined by:

- Variable elevation angle
- Variable radial distance
- Variable azimuth angle

Locations at constant height lie on a horizontal line on an inclined plane that is swept by the lidar beam.

Why VLD? It may be desirable to orientate the lidar beam using a single reflective optical component, i.e. a mirror

- Low cost
- Easy implementation
- Reduced optical losses
- Simple verification of pointing accuracy by injecting visible laser signal into the beamline (c.f. refractive elements with wavelength dependent refractive index)

As the beam angle of incidence is scanned the beam is swept over a plane rather than a conical surface. VLD techniques may be required with relatively simple lidar systems whose beam orientation relies on a single reflective optical component. Processing proceeds in a similar manner to VAD processing, i.e. by fitting a sinusoid to line of sight radial components of the wind velocity vector. The projection of the wind velocity vector onto a plane is acquired, which allows only a 2-dimensional wind vector to be resolved, i.e. assumptions are required about 3rd component w. The technique may find application in simple circumstances such as in flat terrain or offshore.

Scan geometries

An arc scan (or sector scan, or PPI) has a fixed elevation angle. The line of sight sweeps a conical surface as azimuth angle is varied.

Method

The line of sight (LoS) radius vectors $r$ from the lidar to the locus of points along the line $v$ where we acquire radial velocities has the equation $r = r_0 + te_v$, where $e_v$ is the unit vector parallel with line $v$.

Consider a “pseudo-azimuth” $\alpha$, the angle between the central line of sight other radius vectors. We acquire measurements of radial velocity $v_{LoS}$ at distances $r$ along the line of sight

$$r = r_0/(\cos \alpha)$$

These are at a constant height $z$

Then, in analogy to VAD scans, we see we can fit a sinusoid to these measurements:

$$v_{LoS} = A \sin(\alpha + B)$$

We see that

$$A = [(e_v U)^2 + (e_{\phi} U)^2]^{1/2}$$

Assuming the vertical component $w$ of wind velocity vector $U$ is zero, the magnitude $U$ of the projection of $U$ onto the plane defined by unit vectors

- $e_\phi$ along the central line of sight $r_0$
- $e_v$ perpendicular to $r_0$, along the line $r_0 + te_v$

is then

$$U = A / \cos \phi = A / (1 - \sin^2 \phi)^{1/2}$$

where $\phi$ is the elevation angle of the projection of $U$ on the inclined plane, given by

$$\sin \phi = \sin \phi_0 \cos B$$

The direction of the projection of $U$ in the same plane is

$$B = \tan^{-1}(e_\phi U / e_v U)$$

The wind direction $\theta$ is then obtained from

$$\tan \theta = \tan B / (\cos \phi_0)$$