3.3B ESTIMATING UNBIASED HORIZONTAL VELOCITY COMPONENTS FROM ST/MST RADAR MEASUREMENTS: A CASE STUDY

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In this paper we present a self-editing quick-look procedure in use at the Sunset radar (GREEN et al., 1979) for determining relatively unbiased hourly estimates of the u and v components of the wind with an example application to data taken when a jet stream was overhead. The technique presented here should be applicable to all height ranges, though only ST results are presented here.

ESTIMATING THE HORIZONTAL WIND COMPONENTS

The vertical wind component, w, may be measured directly by pointing the radar beam straight up. The east and west components of the wind, u and v, however, must be estimated by projecting to the horizontal plane the radial velocity, vr, actually observed by pointing the radar suitably off zenith (see Figure 1):

$$u = [vr * \csc(T) - w * \mathrm{ctn}(T)] * \sin(A)$$

$$v = [vr * \csc(T) - w * \mathrm{ctn}(T)] * \cos(A)$$

where T is the zenith angle and A is azimuth angle measured from north. The above equations apply when the sign of vr is taken positive for a reflecting volume moving away from the radar. At most ST/MST radars the azimuth angle A is restricted to a multiple of 90 degrees, so that the cos(A) and sin(A) factors merely provide the proper sign.

PRACTICAL IMPORTANCE OF THE W TERM

A rough estimate of u or v may be obtained by neglecting the vertical motion term. Figure 2 exhibits the error thus produced in these estimates for various values of w. Note that for a value of w greater than .27 m/s, an error in u or v greater than 1 m/s is produced for the typical zenith angle of 15 degrees.

Time series of vertical velocities observed at the Sunset radar located in the foothills about 12 km east of the continental divide and at the Platteville radar in the plains 60 km further east are shown in Figure 3 (ECKLUND et al., 1982). Supposing that we want u and v components accurate to 1 m/s we see that for the mountain location the .27 m/s threshold of w is nearly always exceeded during this period in March. At the Platteville radar, on the other hand, perhaps only a third of this nearly three week period contains velocities which excede the threshold. However, the periods that do need correction tend to appear in the later part of the day, and could cause a systematic diurnal bias. In any event, this third of the data must be corrected for vertical velocity effects if the 1 m/s criterion is to be satisfied.

THE QUICK LOOK

It is not too hard to see from this same figure that the large ws are often accompanied by large changes in w with time. This presents a problem if these changes occur frequently enough that the w measured at one time is not appropriate to correct radial velocities measured at another, since the vertical

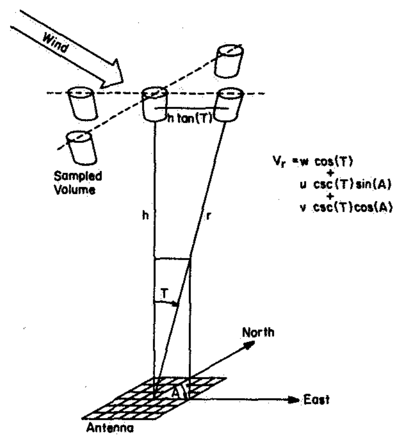

Figure 1.

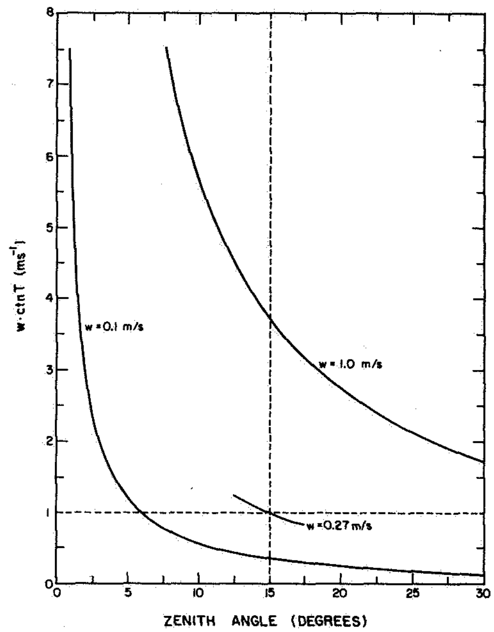

Figure 2. Size of w correction for for various values of w.

and horizontal components are usually measured sequentially. The solution, when it is not necessary to have closely spaced data, is to apply a filter to the observed components. To obtain hourly values a simple filter choice would be to take the hourly mean. This would require data editing, however, as a few non-atmospheric echoes nearly always occur in a long data set. We have chosen instead, for a quick-look procedure, to use the hourly median, which has similar characteristics for good data but is more resistent to occasional bad values. Thus the medians of all the radial components (including w) are found over each hour, then the u and v are calculated from the projection equations above using these median values.

A CASE STUDY

A good example of the effectiveness of this technique is demonstrated by the data taken on March 28, 1983 while a small jet stream was moving over the Sunset radar. The radar was set to look sequentially in 5 directions as shown in Figure 1: vertical, 15 degrees north, 15 degrees east, 15 degrees south and finally 15 degrees west. This sequence was repeated continuously for four hours. The vertical direction, of course, provides direct measurement of w over the radar, two of the orientations provide information on the u and two on the v component. Figure 4a shows an example of the three components estimated with neglect of the effect of w on u and v, and Figure 4b the three components estimated by including the effect of w.

The greatly improved agreement demonstrates the correction is significant and appropriate. The remaining substantial differences between the two u profiles and the two v profiles, however, are also of interest. They indicate real spatial variations due to orographic effects, including a lee wave induced in the atmospheric flow by the nearby continental divide. In this situation the seemingly redundant measurements of the horizontal components of the wind are,

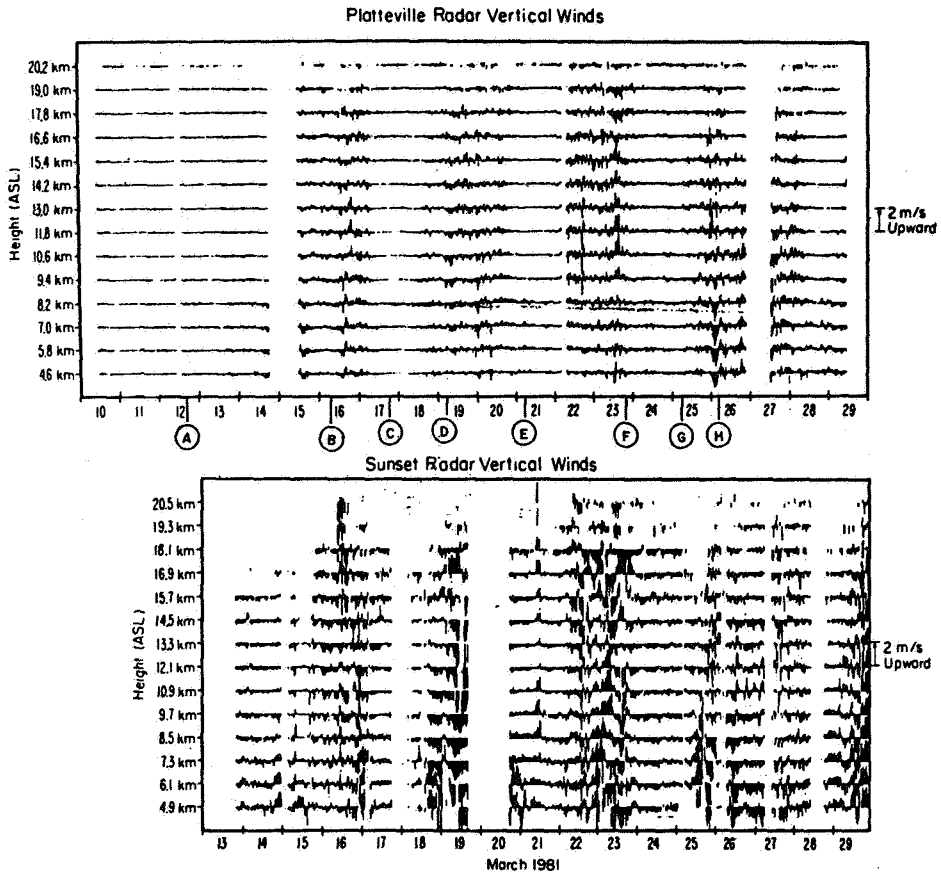

Figure 3. Fifteen-minute-averaged vertical velocities over Platteville and Sunset, Colorado, for the complete experimental period (after ECKLUND et al., 1982).

in fact, not redundant. They provide information crucial to the modelling of an atmospheric flow containing horizontal shear.

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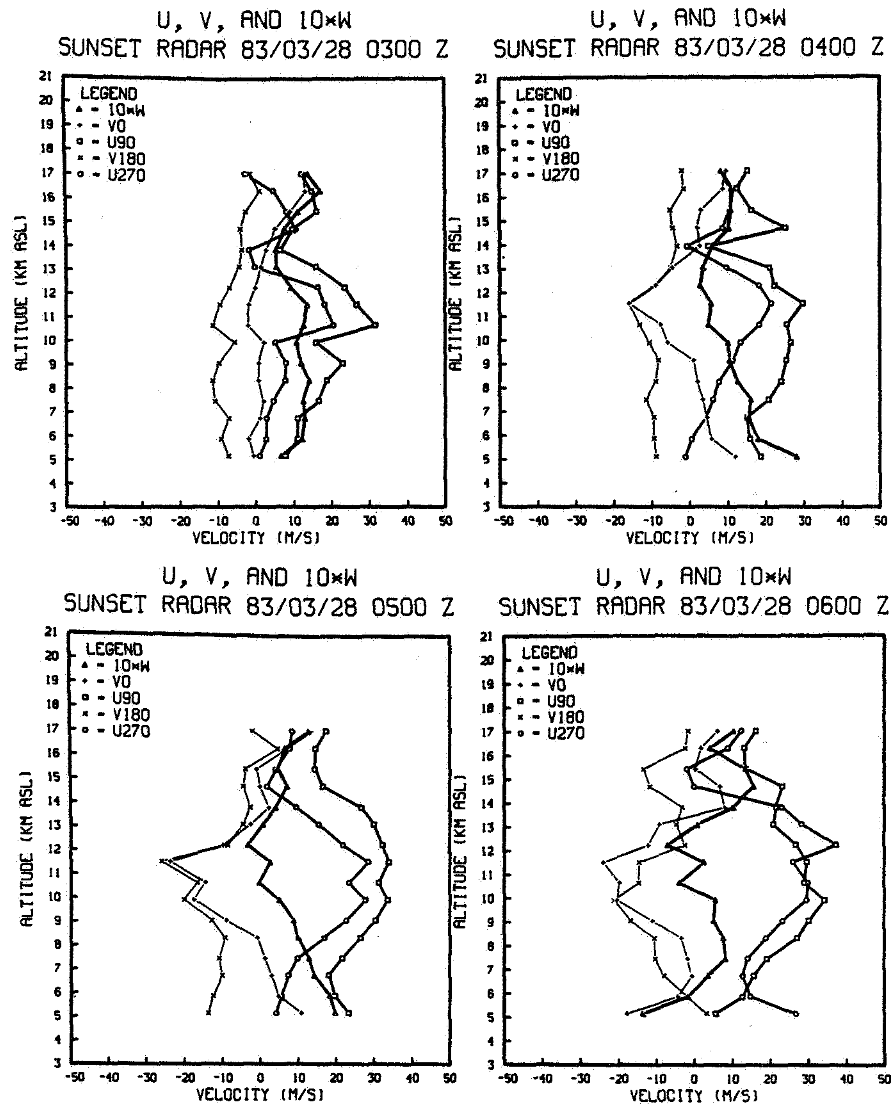
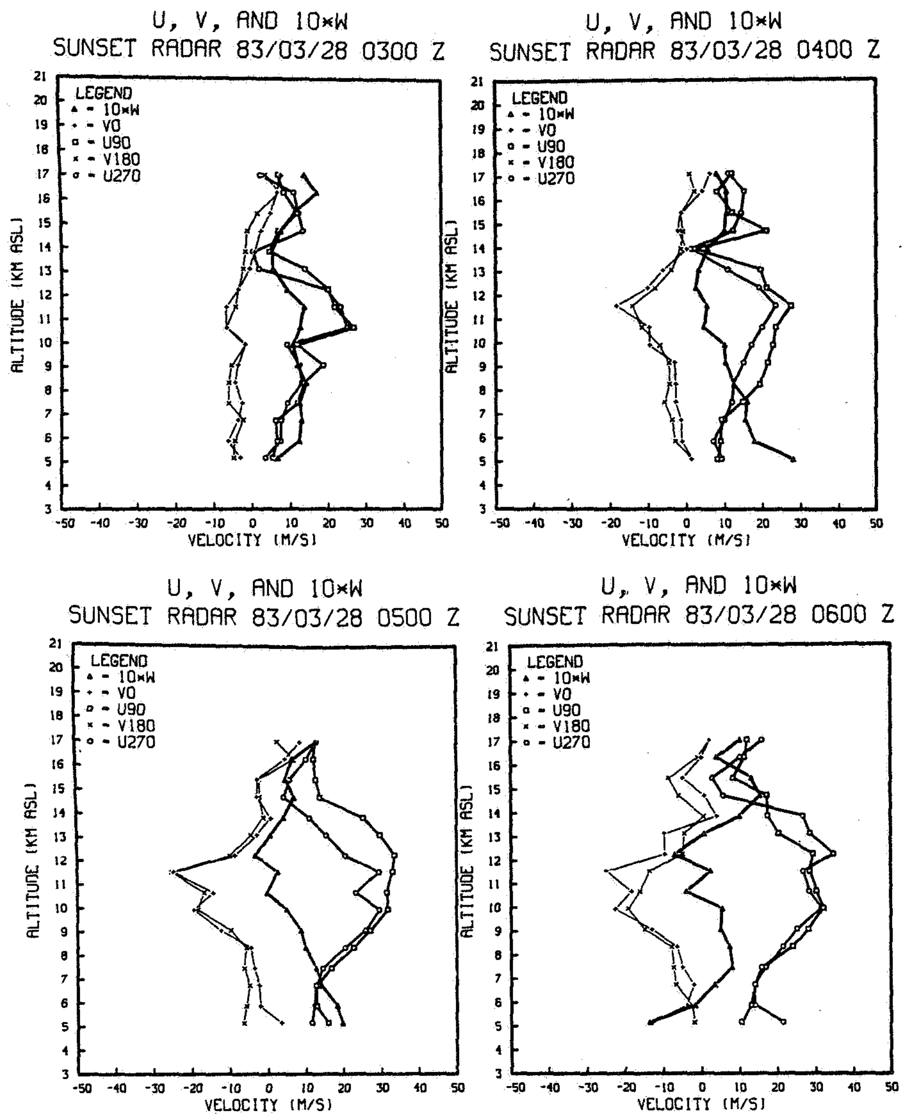

U, V, AND 10*W
SUNSET RADAR 83/03/28 0300 Z
U, V, AND 10*W
SUNSET RADAR 83/03/28 0400 Z
U, V, AND 10*W
SUNSET RADAR 83/03/28 0500 Z
U, V, AND 10*W
SUNSET RADAR 83/03/28 0600 Z
LEGEND
10*W
V0
U90
V180
U270
ALTITUDE (KM ASL)
VELOCITY (M/S)

Figure 4a.


U, V, AND 10*W
SUNSET RADAR 83/03/28 0300 Z
LEGEND
▲ - 10*W
• - V0
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U, V, AND 10*W
SUNSET RADAR 83/03/28 0600 Z

Figure 4b.