7.1B ELIMINATION OF RANGE-ALIASED ECHOES IN VHF RADARS

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Very high frequency radars designed to measure tropospheric wind profiles usually detect scattering to a maximum height of about 20 km. If the antenna elevation angle is 45 degrees or more above the horizon, the maximum range of interest is less than 30 km. A VHF pulsed Doppler radar wind Profiler can, therefore, be operated at high pulse repetition rates (~5 kHz). The maximum bandwidth allowed (by frequency allocation or by the antenna) is about 0.5 MHz (at most) so a radar with uncoded pulses can operate with a duty cycle of 1 to 10%, depending on the desired height resolution. This is approximately the duty cycle allowed in many transmitters. Therefore it is often possible to operate a tropospheric-wind Profiler that utilizes all the average power available from the transmitter without the complexity of coded pulses. However the VHF radar can detect echoes from the mesosphere on occasion and, with high pulse repetition rates, these echoes will occur at the same apparent range as the tropospheric echoes of interest. These mesospheric echoes may, at times, be stronger than the tropospheric signals. The range-aliased mesospheric echoes can be greatly attenuated or effectively eliminated as described below.

First, suppose that the phase of the transmitted pulse varies randomly from pulse to pulse. This random phase occurs if the transmitter uses a pulsed oscillator instead of a pulsed amplifier, as in a microwave radar with a magnetron (oscillator) transmitter. If the transmitter uses an amplifier the phase can be varied from pulse to pulse by introducing a phase shift on a low-level reference oscillator just prior to each transmitted pulse. The phase of the reference oscillator is kept constant while all echoes from the unambiguous range interval are received. (The unambiguous range interval is 0 to cT/2 where c is velocity of propagation and T is the pulse repetition period). Then, as in a magnetron microwave Doppler radar, the signals from range-aliased targets will be incoherent and cause an increase in noise, but they will not produce a Doppler spectrum that can compete with (or be mistaken for) the tropospheric Doppler spectrum. It is possible to choose any ambiguous range interval ($n\,cT/2 < R < (n + 1)cT/2$) for coherent reception while targets at all other ranges are incoherent by selecting the phase of the reference oscillator used during reception to be equal to that used in previous transmitted pulses. Range-aliased signals that appear as white noise in the Doppler spectrum are much less troublesome than if they were coherent. However, because VHF radars with high pulse repetition rates can use time-domain integration of the video samples from consecutive pulses, the range-aliased echoes can be greatly attenuated or effectively eliminated rather than made incoherent (causing increased noise).

Next, let the phase of the transmitted pulse change from pulse to pulse with a pseudorandom binary code. Then signals in the range 0 to cT/2 will add in the time-domain integrator just as though the transmitter had constant phase, but range-aliased signals will add or subtract depending on the phase of the code during reception relative to the phase during transmission of a prior pulse. If the signal phase of the range-aliased targets remains constant during the time-domain integration period, the range-aliased signals will cancel if there are as many positive as there are negative elements in the code. A pseudorandom code can cancel the signals (except for at most 1 pulse) for all range-aliased intervals. If the range-aliased signals are in motion but have small velocity compared with $\pm \lambda/4MT$, where M is the number of samples averaged in the time domain, then the cancellation of range-aliased echoes is still effective. If this were not so, one could not perform time-domain integration on the signals from the range of interest. In fact, when targets are in motion, the cancellation of the range-aliased signals is more efficient than the coherent addition of the desired signals, because in the latter case signals must remain nearly in phase throughout time MT, while in the former case cancellation occurs during subintervals of MT.

The VHF radars in the Colorado Wind Profiler Network have been designed to operate at high pulse repetition rates with uncoded pulses and to be able to reject mesospheric echoes on the basis of the above considerations. We have not as yet implemented the mesospheric echo cancelling feature.