# 1 Scattering mechanisms

The unique characteristic of RWP is their use of longer wavelengths, in comparison with classical weather radars. The typical wavelength range is from about 20 cm (L-Band) to about 6 m (VHF). Electromagnetic waves in this range are scattered at fluctuations of the refractive index of particle-free 'clear air' which are almost omnipresent due to the turbulent state of the atmosphere. This effect is called clear-air scattering, it can be fully understood only on the basis of the theory of radio-wave propagation through the turbulent atmosphere. This theory, pioneered by V. Tatarskii, is a synthesis of Maxwell's classical Electrodynamics and Kolmogorov's statistical turbulence theory. While this physical effect is the main reason for calling RWP's also clear-air radars, there are other scattering processes, which need to be taken into account when dealing with RWP's in practice.

The following two atmospheric scattering processes are especially important:

- Clear air scattering
- Particle scattering

However, additional scattering and echoing effects are observed with RWP's:

- Scattering at unbound electric charges
- Reflections from airborne objects
- Reflections from the ground surrounding the RWP (through antenna sidelobes)

# 2 Radar hardware

Depending on their particular hardware architecture, RWP can be classified into three main groups (Muschinski et.al., 2005):

Single signal systems are the most frequently used wind profiler type, see Law et.al., 2002,Carter et.al., 1995, Ecklund et.al., 1988, Strauch et.al., 1984. They are monostatic pulse radars using one single carrier frequency with the hardware architecture resembling that of a typical Doppler radar system. The term single signal refers to the characteristics of the instruments sampling function, which can be regarded as an integral kernel function that maps a field describing the physical properties of the atmosphere relevant for the actual scattering process to the received radar (voltage or current) signal. For clear-air scattering, this is the scalar field of the refractive index (or permittivity) irregularities.

Example: 482 MHz profiler

# 3 Signal processing

The purpose of signal processing is to convert the measured electrical signal to meteorological parameters. Key aspects are to extract as much information as possible, with the specific purpose of obtaining accurate, unbiased estimates of the characteristics of the desired atmospheric echoes, to estimate the confidence/accuracy of the measurement and to mitigate effects of clutter or interfering signals, see e.g. Fabry and Keeler (2003)

The quality of signal processing largely determines the accuracy and precision of the final data. It is often useful to find a problem adapted mathematical representation of the signal which allows an easier physical interpretation by providing a simpler, structural description. This is frequently done through a transformation. The choice is crucial for signal processing tasks, like detection, classification, and estimation. As long as there is little a-priori knowledge about the signal, the signal representation should require only few assumptions.

- RWP receiver signal properties

The majority of RWP's today uses the same standard signal processing, which is essentially based on spectral estimation. It can be grouped into the following main steps:

- Demodulation, range gating and A/D conversion
- Digital pre-filtering
- Estimation of the Doppler spectrum
- Signal detection, classification and moment estimation

# 4 Wind determination

For single signal RWP's, the method of Doppler beam swinging (DBS) is employed to determine the wind vector.

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