Coherent detection lidars have evolved over time and gradually become the de facto instruments for high resolution measurement of atmospheric boundary layer winds. The earlier versions of these lidars were bulky, expensive, and suffered from environmental effects such as temperature and vibrations. However, with the advent of fiber-optic communications a new class of stable, cost-effective, and low-maintenance optical components became available to the lidar community. Coherent detection lidars share many similarities with the high-speed fiber-optic communications. As a result, the new fiber-optic technology was quickly adopted in these lidars. Although coherent detection lidars, especially all-fiber coherent detection lidars, have benefited from the technology available in coherent fiber-optic communications, a considerable gap (in both research and technology) seems to exist between the two. In this thesis, I have presented some of the advances in fiber-optic technology, originally developed for high-speed data transmission, and shown how they can be integrated in micropulse and continuous-wave all-fiber coherent detection lidars. The presented technologies not only enable the possibility for performance improvements in existing lidars but also pave the way for the application of coherent detection lidars in areas where their presence was neither plausible nor easy to realize. This thesis, composed of an introduction and four scientific papers and one manuscript, specifically presents the adoption of some of the contemporary fiber-optic communications transceiver architectures in coherent detection lidars. In paper I a new short-range all-fiber coherent Doppler lidar employing an image-reject homodyne receiver is described and demonstrated. In Paper II two different approaches to signal processing, necessary for the estimation of mean velocity from the spectra, are discussed and the associated advantages and disadvantages such as the signal to noise ratio and signal processing overhead are discussed. The performance of the system proposed in paper I is put to test in a real measurement campaign the results of which are discussed in Paper III. In Paper IV a patent-pending long-range polarization-diversity coherent Doppler lidar is presented. The system benefits from an improved transmit power (thanks to the availability of two erbium-doped fiber amplifiers separated in polarization) while having the ability to detect the depolarized backscatter signals. The ability to detect the degree of depolarization enables the characterization of aerosol types associated with each measurement range. Eventually, it is shown in Paper V that by adopting the image-reject homodyne receiver in an all-fiber coherent detection lidar, the spectrum of the Rayleigh or the spontaneous Rayleigh-Brillouin scattering (depending on the operating conditions) can be resolved. The system benefits from an eye-safe 1.5μm laser and can provide simultaneous measurements of temperature, pressure, and wind. The focus of the paper in Paper V is the temperature measurement capability of the system, provided as the proof of concept through numerical simulations.

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