

Lower Atmospheric Wind Profiler Signal Processing

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Abstract: This paper focuses on the signal processing techniques of lower atmospheric wind profilers that are very important tools in the measurement of wind direction and velocity within the boundary layer. The profiler measures high temporal and spatial resolution wind profiles through Doppler-shifted radar or acoustic signals. In order to enhance data reliability, reducing noise, clutter suppression, and accurate spectrum analysis is given high priority in the study. The evaluation of performance improvements is done in case of advanced methods such as adaptive filtering and Fourier-based processing. These advances in signal processing technique are useful in climate research, weather forecasting and the safety of aircraft in the lower atmosphere, as more accurate wind measurements can be made.

Keywords: Window, Moments, LAWP, Clutter, Signal to noise ratio

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I. Introduction

Lower atmospheric wind profilers are remote sensing instruments used in the atmospheric boundary layer to measure the wind direction and speed in various altitudes. These systems are typically radar or sodar (sound detection and ranging) technologies, which analyze the Doppler shift of backscattered signals of air turbulence. Since the profiler has to supply useful wind data with the raw signals it receives sometimes congested and noisy, correct signal processing is a must. Such matters as signal attenuation, environmental noise, and ground clutter can seriously affect the data quality.

Originally, to enhance the ratio of signal to noise, to resolve atmospheric returns separate, and to accurately estimate wind components, sophisticated signal processing techniques are employed. The paper will look at the signal processing algorithms, primarily spectral analysis, filtering, and clutter rejection algorithms, which are being utilized in the modern wind profilers. To ensure precise wind profiling which has numerous uses including weather forecasting, climate surveillance, and air traffic control, these techniques need to be enhanced.

II. Signal Processing Steps

Signal processing in lower atmospheric wind profilers contains several important stages. Noise and ground clutter are removed first by digitization and pre-processing of the raw signals received by radar or sodar. Next, a separation of ambient echoes and unwanted reflections is carried out through windowing and filtering. The fundamental stage involves extracting Doppler frequency shifts brought on by moving air parcels by spectral analysis, frequently with the help of Fourier transforms. Along the beam direction, these frequency alterations correlate to components of wind velocity. Lastly, the three-dimensional wind vector is calculated by combining data from various beam angles. To guarantee accurate and dependable wind profiles, post-processing may involve smoothing and quality control [2].

III. Experimental Results

The signal to noise ratio plot for each beam is displayed in the figure below. SNR has been plotted on the x-axis and height on the y-axis for all heights up to 3 km. We can see that the SNR was strong at lower elevations and that the Kaiser window had a higher SNR than any other window [1].

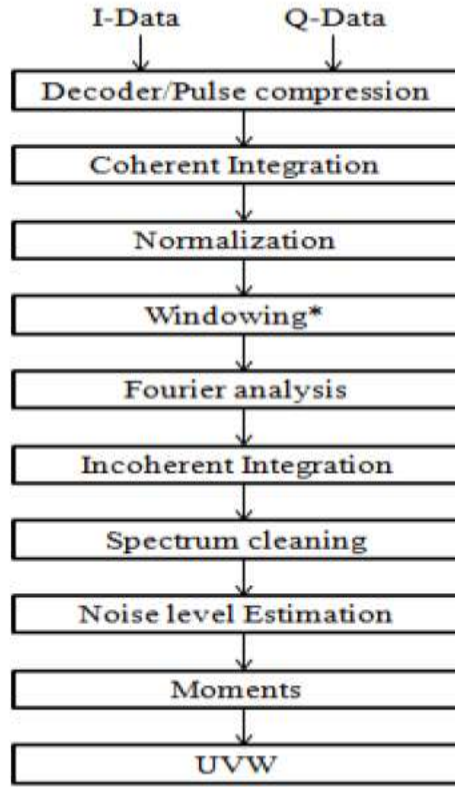


Fig 1: LAWP block diagram of signal processing

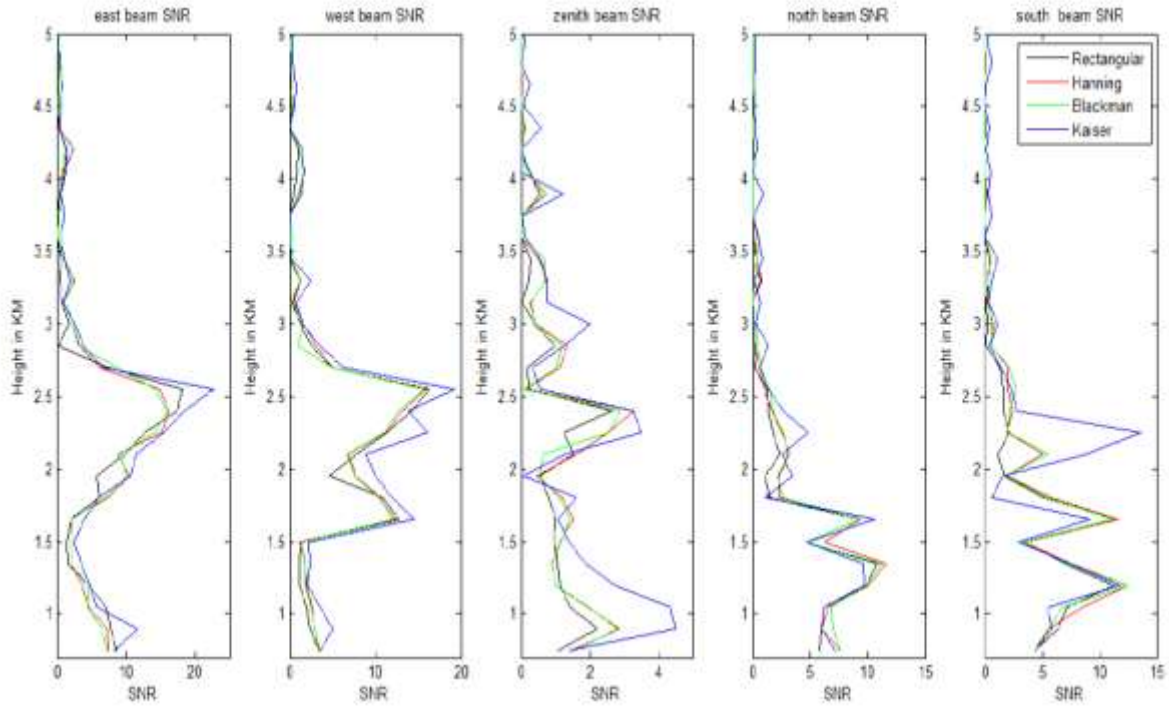


Fig 2: Signal to Noise ratio for West, East, North and South

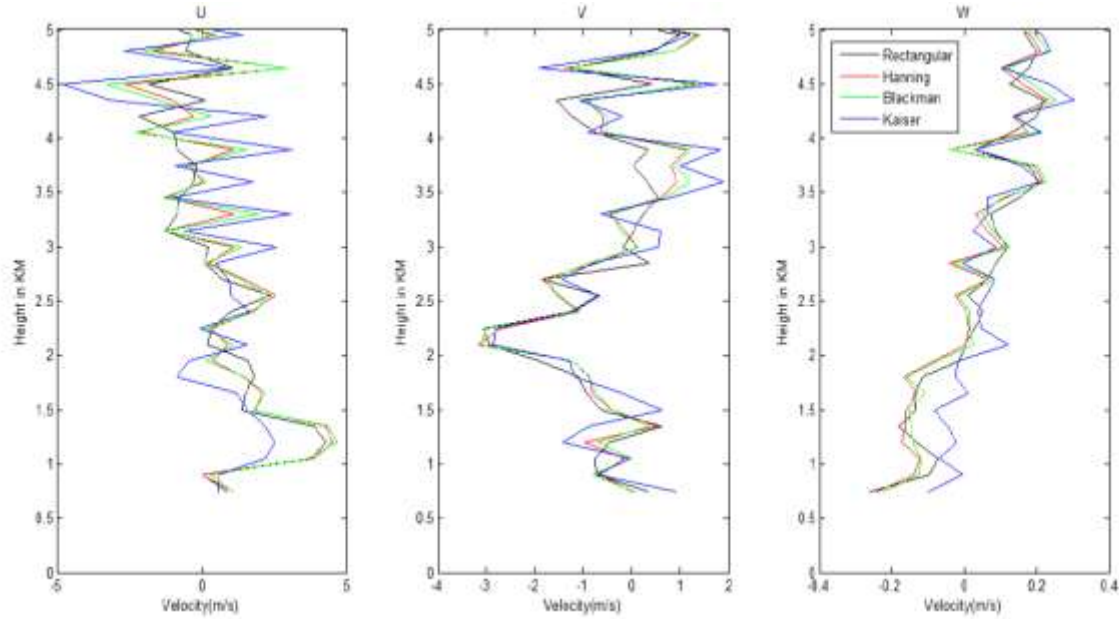


Fig 3: Windows for different velocities

IV. Conclusion

The necessity and significance of signal processing methods utilizing windowing in radar are discussed in this study. In this study, Hanning, Blackman, and rectangular Kaiser windows undergo analysis, and the outcomes are contrasted with one another. It has been shown that the Kaiser window effectively lowers the noise present in radar echoes. Kaiser Window is hence useful for improving side lobe suppression and the signal to noise ratio.

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