

Visitor Research Report

Visitor Name: Professor Dong Wu
Ocean University of China

Area of Research: Atmospheric and Ocean Science

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Goal:

Wind field is an important atmospheric parameter and measurement of global wind distributions is required. Therefore, global wind measurement using a Doppler lidar from space has been recommended by the atmospheric sciences community. Correctly modeling and simulating wind lidar performance is a very important prelaunch step necessary for the success of a mission. However, historically, modeling of spaceborne Doppler lidar performance has assumed idealized atmospheres, often with no consideration of cloud cover, aerosol loading, or variations in albedo (background signal). With the advent of spaceborne lidar instruments such as CALIPSO, it is now possible to simulate Doppler lidar performance while considering actual atmospheric variability. This study is to use the CALIPSO aerosol data to generate detailed simulations of coherent Doppler lidar performance in the clear air condition.

Strategy:

Wind measurements in clear air conditions are studied for a 2.1- μm coherent Doppler lidar using computer simulation based on the aerosol information from the CALIPSO measurements. Heterodyne detection theory developed by Frehlich and Kavaya (1991) for coherent Doppler lidar measurements is selected and applied in the simulation work. An empirical wavelength conversion function is used to derive the global distributions of atmospheric backscatter coefficients at 2.1 μm from the CALIPSO aerosol measurement at 532 nm and 1064 nm.

Accomplishments:

First, a computer simulation tool has been developed that is essentially based on the heterodyne detection theory by Frehlich and Kavaya. The tool can simulate both ground- and space-based measurements, with lidar system parameters adjustable. The aerosol global distributions observed by the CALIPSO lidar are used for space-based simulations. The low frequency (lf) and high frequency (hf) behaviors of the signal-to-noise ratio (SNR) and heterodyne efficiency were estimated as a function of range for typical values of refractive turbulence structure parameter C_n^2 for a ground-based coherent lidar system to evaluate the simulation tool developed.

The developed simulation tool has been applied to a space-based coherent wind lidar measurement. The corresponding RMS radial velocity errors were estimated for the case

of a pulse pair frequency estimator. In the space-based simulation, the global 3D 532nm attenuated backscatter distribution was obtained from the CALIPSO Level 2 aerosol profile data. The CALIPSO aerosol profiles (532nm) were further averaged to derive zonal distributions of aerosol backscatter and then were converted to vertical distributions at 2.1 μm using an empirical wavelength conversion function (Srivastava et.al., 2001). Based on these vertical distributions of atmospheric backscatter coefficients at 2.1 μm , radial velocity error distributions were calculated for a uniformly distributed C_n^2 and for a distribution of C_n^2 measured for clear air conditions. The simulation results show that a global wind measurement of the lower troposphere from space is feasible with a proper system design and signal (vertical and horizontal) average.

Future Work:

The simulation work in this report is based on modeling using analytical approximate which need to be examined extensively for the validity of use in space operation using numerical simulations. The airborne Cloud Physics Lidar measurements of aerosols at 355 nm, 532 nm, and 1064 nm will be used for testing the theory used for estimating aerosol backscatter at 2 μm wave length. Another work is to simulate the performance of the space-based wind measurements in all weather conditions (i.e., including clear air and cloudy conditions). In this context, one challenging work is to model the impact of overlying high clouds on the wind measurement.

Pending Publications:

A full length report with detailed simulation results is currently under development.

Seminar Presented:

Simulation on coherent wind lidar performance