Correction of Small Misalignments in Lidar Wind Velocity Retrievals

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Ground-based LiDAR (Light Detection and Ranging) systems are used to measure mean wind flow and turbulence statistics in the atmospheric boundary layer. This study addresses how small pitch and roll angles in the instrument can bias wind velocity retrievals in the east north-vertical coordinate system. Despite best efforts to manually achieve a zero-tilt setup, nontrivial small misalignments often remain. To address this, we derive perturbation-based equations that include first-order pitch and roll terms when converting from the lidar's radial velocities in spherical coordinates (range, azimuth, elevation) to Cartesian velocities. In the limit of zero pitch and roll, these equations reduce to the standard formulations commonly used for lidar velocity retrievals. Our approach avoids second-order terms (pitch^2, roll^2, pitch$\times$roll). We demonstrate that accounting for small tilt angles significantly improves accuracy over neglecting them. The results offer an opportunity to correct residual misalignments in lidar wind velocity measurements.

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