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A Comparison of IM-CW Lidar Modulation Techniques for ASCENDS CO_2 Column Measurements from Space

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Global atmospheric carbon dioxide (CO_2) measurements through the Active Sensing of CO_2 Emissions over Nights, Days, and Seasons (ASCENDS) Decadal Survey recommended space mission are critical for improving our understanding of CO_2 sources and sinks. IM-CW (Intensity Modulated Continuous Wave) lidar techniques are investigated as a means of facilitating CO_2 measurements from space to meet the ASCENDS science requirements. In previous laboratory and flight experiments we have successfully used linear swept frequency modulation to discriminate surface lidar returns from intermediate aerosol and cloud contamination. Furthermore, high accuracy and precision ranging to the surface as well as to the top of intermediate clouds, which is a requirement for the inversion of the CO_2 column-mixing ratio from the instrument optical depth measurements, has been demonstrated with the linear swept frequency modulation technique. We are concurrently investigating advanced techniques to help improve the auto-correlation properties of the transmitted waveform implemented through physical hardware to make cloud rejection more robust in special restricted scenarios. Several different carrier based modulation techniques are compared including orthogonal linear swept, orthogonal non-linear swept, and Binary Phase Shift Keying (BPSK). Techniques are investigated that reduce or eliminate sidelobes. These techniques have excellent auto-correlation properties while possessing a finite bandwidth (by way of a new cyclic digital filter), which will reduce bias error in the presence of multiple scatterers. Our analyses show that the studied modulation techniques can increase the accuracy of CO_2 column measurements from space. A comparison of various properties such as signal to noise ratio (SNR) and time-bandwidth product are discussed.