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The use of ground-based Doppler lidar in Iceland: turbulence measurement, dust detection, and the application of machine learning

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Lidar systems have been used widely to measure wind profiles and atmospheric aerosols. The scanning Doppler lidars operated by the Icelandic Meteorological Office (IMO) can provide continuous measurements of the wind velocity and direction based on the Doppler effect from the emitted signals, as well as the backscatter coefficient and depolarization ratio for retrieving aerosol properties. In this project, we investigate the use of Doppler lidar in Iceland, especially for enhancing aviation safety. By analyzing the data three main tasks have been tackled: i) atmospheric turbulence measurements; ii) airborne aerosol detection; iii) real-time lidar signal classification with machine learning algorithms. An algorithm has been developed based on Kolmogorov theory to retrieve eddy dissipation ratio, as an indicator of turbulence intensity, from lidar wind measurements, and the method has been tested on two cases in 2017. With a combination of ceilometer, sun-photometer and other instruments, the Doppler lidar shows the ability to detect aerosols, including dust and volcanic ash in Iceland. With both supervised and unsupervised machine learning algorithms, two models have been developed to identify the noise signal and classify the lidar measurements, which could provide a real-time lidar signal classification for the end-users. The results indicate that the Doppler lidar may significantly improve aviation safety and complement meteorological measurements by detecting atmospheric turbulence or volcanic ash clouds in Iceland.