An initial assessment of the Robust And Compact Hybrid Environmental Lidar (RACHEL)

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Introduction

RACHEL is a four-channel, coaxial Raman lidar system designed to be portable and automated with the capacity to scan the entire sky. The prototype system utilises a frequency-tripled Nd:YAG laser with an average pulse energy of 65 mJ. The return signal is observed coaxially with a commercial Schmidt-Cassegrain telescope, achieving excellent low-level coverage.

A series of dichroic and interference filters separate the return into four channels, measured by photon-counting PMTs. In addition, a neutral density filter prevents saturation of the elastic channel's detector where the Raman channels are sensitive. These components can be easily replaced to investigate different species and are currently assembled to observe the elastic backscatter and the Raman backscattering from nitrogen and water vapour, with the fourth channel currently unused.

Performance

For this study, RACHEL was deployed at the Chilbolton Observatory in southern England [2]. This rural site continuously operates a range of instruments, including a ceiliometer, cloud radar, various lidars, radiometers, and surface meteorology measurements. The performance of RACHEL is being assessed by its correlation against these instruments. Initial results are very promising, with consistent observations through the entire observable range (fig. 1).

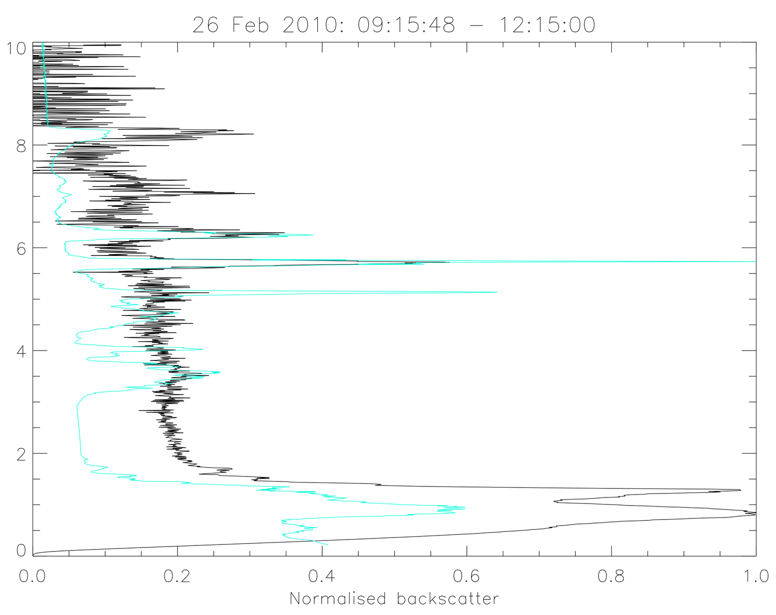

FIGURE 1: Peak-normalised ABC profile observed by RACHEL (black) and the Chilbolton UV lidar (blue) on a cloudy day. The Chilbolton profiles have been vertically smoothed.

The Chilbolton data are tabulated as attenuated backscatter coefficients (ABC), which correct the return signal for range, background, laser power, the instrument overlap function, and Rayleigh scattering (assuming a standard atmosphere calibrated to surface measurements [1]).

Excellent coverage of the planetary boundary layer (PBL) and lower troposphere is achieved, with reliable measurements to a range of 4 (7) km during the day (night) for the elastic channel and 2 (6) km for the nitrogen Raman channel (5 min averages). Water vapour measurements are under assessment, but reliable signals have been observed up to a range of 2 km at night (using longer averages). These measurements indicate that the RACHEL system is well placed to observe the evolution of the PBL continuously, especially urban pollution.

Eyjafjallajökull Eruption

The RACHEL system monitored the evolution of the ash plume at Chilbolton during the Eyjafjallajökull eruption. It was first observed at 1230 UT on April 16th (fig. 2) and descends towards the PBL. The strong depolarization ratio exhibited by the cloud suggests it is volcanic ash.

Overnight, the ash is seen to mix into the PBL, forming a layered structure (fig. 3) that is dissipated by convection in the morning. This behaviour is repeated the next day. During this time, PBL height remains unusually high and stable from day to night. The passing of a weak frontal system at midday on the 19th significantly depletes the ash concentration.

Conclusions

The RACHEL system is capable of continuous, unattended operation of a Raman lidar system in a range of urban and rural environments with the capacity to monitor aerosols and, potentially, water vapour in the PBL and lower troposphere. Over the coming months we aim to develop optimal estimation retrieval algorithms to retrieve high quality measurements of the ash plume making use of the multitude of measurements collected at the Chilbolton Observatory.

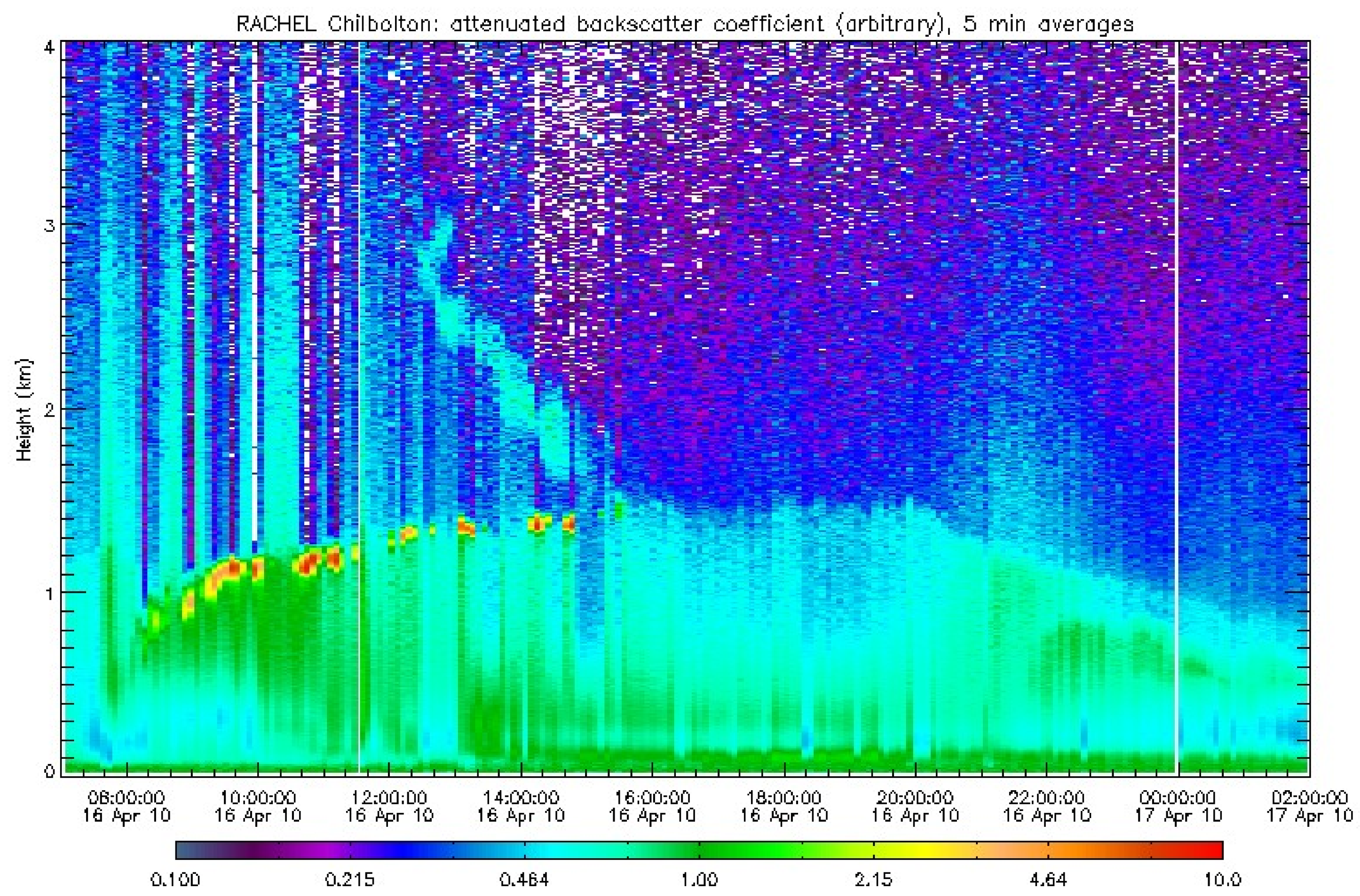

FIGURE 2: The initial appearance of the ash cloud, plotted as ABC on an arbitrary scale.

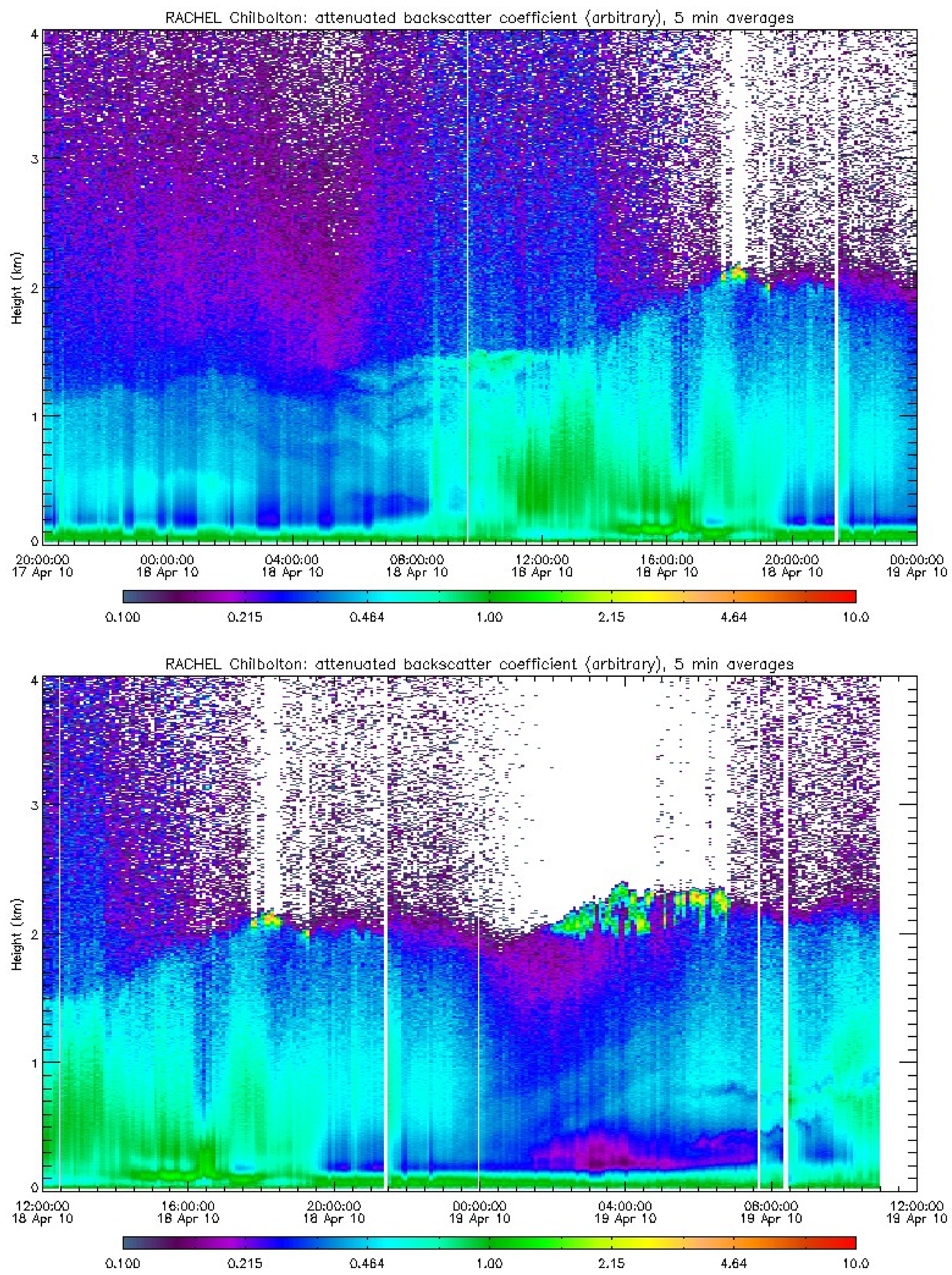

FIGURE 3: These highlight layered structures observed within the PBL after the passing of the ash cloud. These layers are dispursed in the morning with the convective PBL, but reform overnight.

Acknowledgements

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References

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