Supplement of

Transport of Canadian forest fire smoke over the UK as observed by lidar

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1 Capel Dewi Raman LIDAR

The Capel Dewi Raman lidar is a biaxial ultraviolet lidar based on that used for the EARLINET project in 1999–2002 [Wandinger et al., 2004]. Since then, it has been updated and now contains a Continuum 8030 Nd-YAG laser emitting pulses at 354.7 nm at 30 Hz with pulse energy 300 mJ. A tenfold beam-expanding telescope directs the light vertically into the atmosphere. The receiver is based on a 1 m diameter mirror used in a Nasmyth-Cassegrain configuration, which directs the backscattered radiation through a collimator on to a dichroic beamsplitter (Fig. S1). This beamsplitter reflects and transmits radiation with wavelength greater or less than 397 nm, respectively, into the receiver channels. Interference filters centred around 387 and 408 nm isolate Raman scattering from nitrogen and water vapour respectively (Table 1). A third channel measures elastic backscattered radiation reflected from the other two filters. The receiver is mainly sensitive to the polarisation component parallel to the laser, which reduces background noise in the Raman channels but does not permit measurements of the aerosol backscatter when there is a significant cross-polarised component.

The lidar is designed for free tropospheric measurements and so the receiver field-of-view does not fully overlap the laser beam below 2 km. Measurements below 2 km are therefore not used here.

![Figure S1: Schematic diagram of the Capel Dewi Raman lidar](image-url)

<table>
<thead>
<tr>
<th>Channel</th>
<th>Centre Wavelength</th>
<th>Bandwidth (FWHM)</th>
<th>Measured Transmission at λm</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>H2O</td>
<td>408</td>
<td>1.7</td>
<td>407.5</td>
<td>22</td>
</tr>
<tr>
<td>N2</td>
<td>387</td>
<td>2.6</td>
<td>386.7</td>
<td>22</td>
</tr>
<tr>
<td>Elastic</td>
<td>355</td>
<td>5.0</td>
<td>354.7</td>
<td>60</td>
</tr>
</tbody>
</table>

Table 1: Interference filter characteristics for Capel Dewi lidar (FWHM is full width half maximum). Blocking on the Raman filters at 354.7 nm is 10^{-8}. Neutral density filters are used in the elastic channel to avoid saturating the signal at low altitude.

The signals are measured using EMI 9124 photomultipliers and a photon-counting electronics system (ORTEC PCI-MCS) with range resolution 15 m (100 ns time bins). A dead time of 10 ns is applied in the counting system, and corrected accord-
4 Retrieval method

The power received by a lidar, $P(z)$, obeys the lidar equation [Wandinger, 2005], which for elastic ($P_e$) and Raman ($P_R$) scattering takes the form:

$$P_e(z) \propto [\beta_{aer}(z) + \beta_{ray}(z)] \exp\left[-2 \int_0^z (\sigma_{ray} n(z) + \alpha(z)) dz\right]$$

(2)

and

$$P_R(z) \propto \beta_{ram}(z) \exp\left[-\int_0^z ((\sigma_{ram} + \sigma_{ray}) n(z) + 2\alpha(z)) dz\right]$$

(3)

respectively. Here, $\beta_{aer}$, $\beta_{ray}$ and $\beta_{ram}$ are the backscatter coefficients for aerosol, elastic molecular (Rayleigh) and Raman scattering respectively, $n(z)$ is the number density of air molecules, $z$ is the height above the lidar, and $\sigma_{ram}$ and $\sigma_{ray}$ are the scattering cross-sections for Raman and Rayleigh scattering by air molecules, which are taken to be $1.929 \times 10^{-30}$ m$^2$ and $2.76 \times 10^{-30}$ m$^2$ respectively [Bates, 1984]. The extinction coefficient of aerosol, $\alpha$, is assumed to be the same at the elastic and Raman wavelengths.

5 SEVIRI observations on 22-23 May 2016

Figure S2: SEVIRI Day Natural Colour RGB images from 1830 UTC 22 May (top left); 0445 UTC 23 May, top right; 1945 UTC 23 May, bottom left; and 1930 UTC 24 May (bottom right). Smoke appears as faint blue-grey streaks. The red-brown streak in the North Sea shown in the bottom right image is the shadow of a smoke streak on some low-lying water clouds. Images taken from EUMETSAT web site.

The EUMETSAT Natural Colour RGB analysis of SEVIRI data shows the arrival of smoke over the UK (Fig. S2). At 1830 UTC on 22 May, a ribbon of smoke extended from northern Spain to Iceland, passing west of Ireland. By 0445 UTC on the 23rd, this ribbon lay along the Irish Sea, just passing over Camborne at the western tip of Cornwall (consistent with the ceilometer evidence). By 1945 UTC on the 23rd, smoke covered most of the west of the UK and Ireland, and shows a similar pattern 24 hours later.

References


