FROM OPERATIONAL CEILOMETER NETWORK TO OPERATIONAL LIDAR NETWORK

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ABSTRACT

During the eruption of Eyjafjallajökull in 2010, the Met Office ceilometers (Laser Cloud Based Recorders - LCBR) provided reasonable information about volcanic ash plumes over the United Kingdom [1]. This capability triggered the development of an operational system to provide quick looks of the range corrected signals (*RCS*) in near-real-time (NRT). Moreover, the Met Office acquired eleven Jenoptik ceilometers to supplement the operational ceilometer network. The combined network became operational in 2012 and currently comprises a total of 43 ceilometers reporting backscatter profiles in NRT. In 2013, Civil Aviation Authority (CAA) and the Department for transport (DfT) sponsored the acquisition of 9 fixed lidars and one mobile unit (each accompanied by a sunphotometer), to further improve the quantitative monitoring of volcanic ash. The current status of both ceilometer and lidar/sun-photometer networks is discussed and further developments are proposed.

1. INTRODUCTION

The Met Office hosts and runs the London Volcanic Ash Advisory Centre (VAAC) as part of the nine VAACs worldwide. The VAAC forecasters produce volcanic ash advisories and guidance products using a combination of various observation of volcanic plume (i.e. ground-based, satellite-based and aircraft-based observations as well as weather forecast and dispersion models) [2]. The ground-based observations in the UK are currently provided by the ceilometer network and by the end of 2016 additionally by the VA network (Lidar and sun-photometer network for Volcanic Ash observations). A full description of the remote sensing capabilities for volcanic ash observation at the Met Office is presented by Marenco et al. [3].

The ultimate goal for the VA network is to provide estimates of the volcanic ash concentrations within the volcanic plumes for VAAC. In order to reduce uncertainties in such estimations, a thorough quality control of the input data is performed.

2. MET OFFICE CEILOMETER NETWORK

The Met Office ceilometer network includes 32 Vaisala (25 of CL31 and 7 of CT25k) and 11 Jenoptik (Nimbus) ceilometers. Most of CT25k were replaced with CL31 during 2014 while the remaining seven will be upgraded this year. NRT plots of *RCS*, overlapped with cloud base height (*CBH*) are available internally to Met Office as well as externally within few hours delay (http://www.dwd.de/ceilomap). Note that some sites have both Vaisala and Jenoptik instruments while two sites are located overseas (Gibraltar and St Helena). The *NRT* plots are updated every 15 min. More recently, a further six stations from Ireland were added to this ceilometer network. Currently, the plots are updated each six hours (to be improved to hourly data soon).

The data flow for the ceilometer network (and in future for the VA network) is shown in Fig. 1. Data from ceilometers C_1, C_2,… C_n arrive to Met Office ftp server and then they are directed towards HERMES which is the Observations central processing system. The ceilometers data are temporally stored in HERMES database. The data are processed and then stored in MetDB (Met Office database). Once processed, the raw data are moved to MASS (Managed Archive Storage System). The website plots are generated using processed data stored in MetDB. Various errors are monitored and reported to the network manager.

The Met Office ceilometer network is shown in Fig. 2. The user selects a location and the image of *RCS* over the latest 24h is shown (Fig. 3). The option of plotting up to 15 km altitude range is available for Jenoptik ceilometers. The temporal resolution is 30s for all instruments. The spatial resolution is different for the three instruments (15m for Vaisala CT25 and Jenoptik and 10m or 20m for Vaisala CL31). Plots with the latest three days are available internally for all the stations.

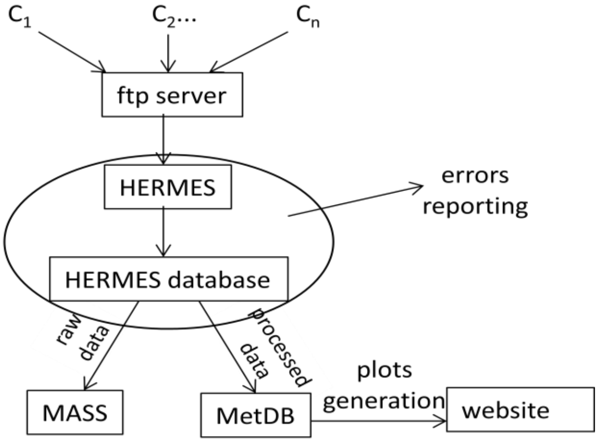

Fig. 1. Data flow chart for ceilometer network.

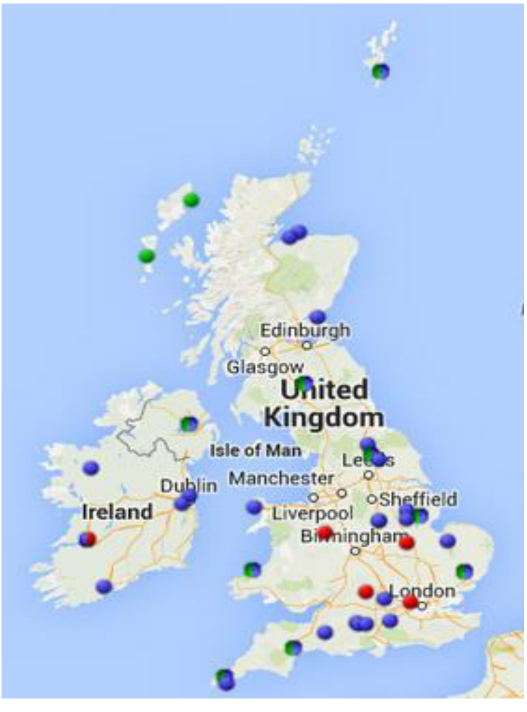

Fig. 2. The Met Office ceilometer network. Green dots represent Jenoptik ceilometers while blue and red dots represent Vaisala CL31 and CT25 ceilometers respectively.

Besides the primary use of the operational ceilometer network as ground-based observation for VAAC, this network can also provide valuable information for monitoring pollution events and validating air quality model parameters.

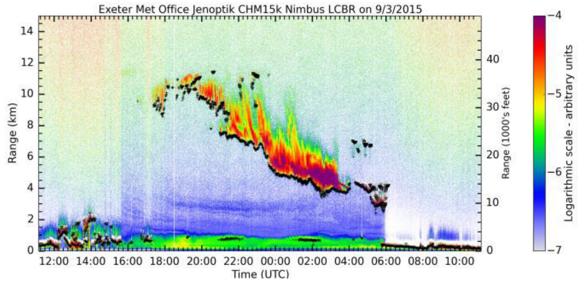

Fig. 3. Example of *RCS* from the Jenoptik ceilometer at Exeter (logarithmic scale).

Figure 4 shows an example of Saharan dust outbreak over UK in March 2014. Comparisons with AQUM (Air Quality Unified Model) are investigated. AQUM is a limited area configuration of the Unified model used to provide operational air quality forecast at the regional scale. The model includes relevant tropospheric chemistry and aerosol processes. At present time the model domain covers part of Western Europe, including the UK, at a horizontal resolution of 12 km x 12 km [4]. The model revealed enhanced particulate matter (PM) concentrations over the end of March, especially on 30th (Fig. 5). Unusual high Planetary Boundary Layer is observed over Exeter (Figs. 4-5).

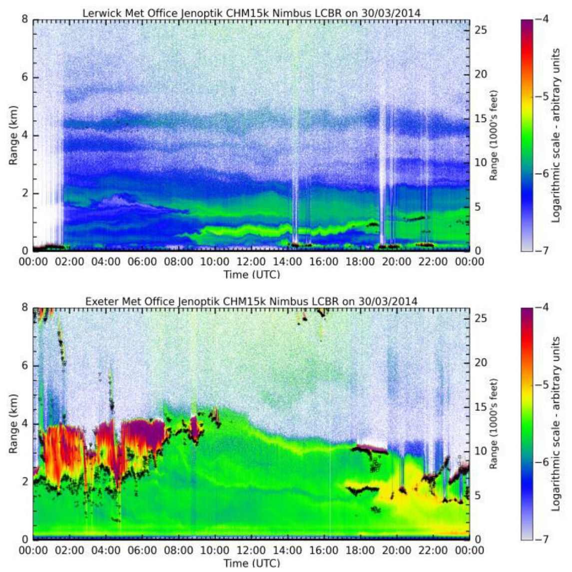

Fig. 4. Saharan dust intrusion, 30/03/2014 at Lerwick (a) and Exeter (b).

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Other pollution events (e.g. smoke fires) will be shown during ILRC presentation.

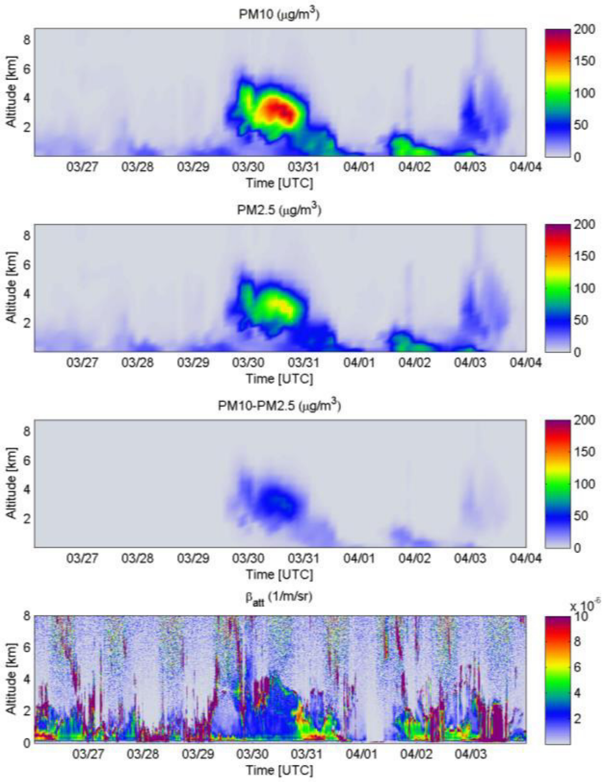

Fig. 5. Concentrations of PM10, PM2.5 and PM10 – PM2.5 (representing coarse aerosols) from AQUM as well as particle backscatter coefficient retrieved from Jenoptik ceilometer, in Exeter.

3. MET OFFICE VA NEWORK

The procurement of the lidars was initiated in 2013 and by the end of March 2014 the first two systems were ordered. The VA network is also equipped with sunphotometers. The sunphotometers were all acquired during 2013 from Cimel (CE318 NE DPS9). The lidars' manufacturer is Raymetrics. The Lidar is an UV Raman Lidar with depolarization capability (polar and co-polar). The Lidar was designed according to several specific requirements as appropriate for operational use. The lidar should work unattended and self-recover after various faults. For safety reasons, the laser output is eye-safe at the emission (after beam expansion) for 10s exposure. Thus, the energy per pulse is ~50mJ/pulse while the pulse repetition rate is 20Hz. The laser is a CFR200 from Quantel. The telescope has a 30cm diameter. The full overlap is ~250m which corresponds to a ~2.2 mrad FOV. The laser beam divergence after collimation and expansion is ~0.21mrad. The envisaged resolutions for operational use are 1 min and 15 m. However, the particles optical properties will be retrieved to a coarse resolution (at least 10min temporal resolution). Additional safety features include four interlocks which stop the laser operating during specific conditions. More details on the technical characteristics of the Lidar will be given during ILRC presentation.

The first two systems were delivered by the end of November 2014. One system was installed at Camborne, in SW England (Fig. 6) while the other system was installed in a van (mobile unit). Factory Acceptance Tests were performed at the manufacturer site in Athens in October 2014, while the Site Acceptance Tests were performed between December 2014 and February 2015. The most important requirement over the data quality was the provision of good signal to noise ratio (*SNR*) profiles over certain altitude ranges, as required for each channel.

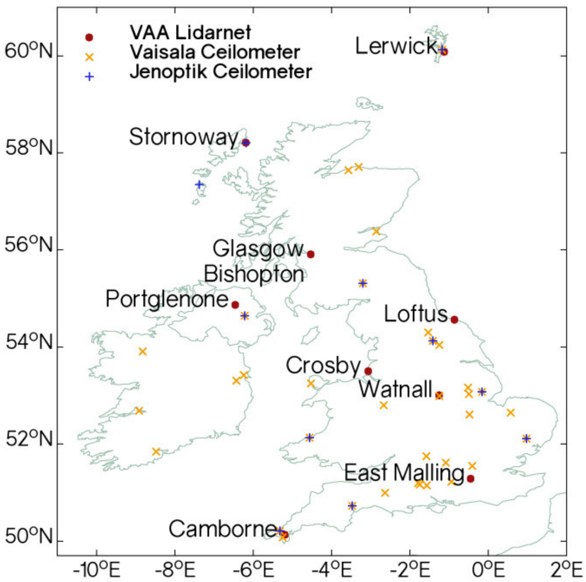

Fig. 6. The Met Office lidar network. Also shown, ceilometer network.

At the moment, the procurement of the remaining 8 systems is in progress. The project aims to have the network installed and operational by April 2016. The locations of the Lidar network are shown in Fig. 6.

An example of the *SNR* is shown in Fig. 7 for the

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mobile Lidar for 10min temporal resolution profiles for both day (7:30-9:20) (a) and night (00:00-06:00) (b) conditions. In general, for both systems, a *SNR*=10 is found above 10km in most of the analyzed periods (day and night) for elastic channels. For Raman channel, *SNR*=10 exceeds 10km during night and 2-5km during day. An example of *RCS* and *VDR* is given in Fig. 8.

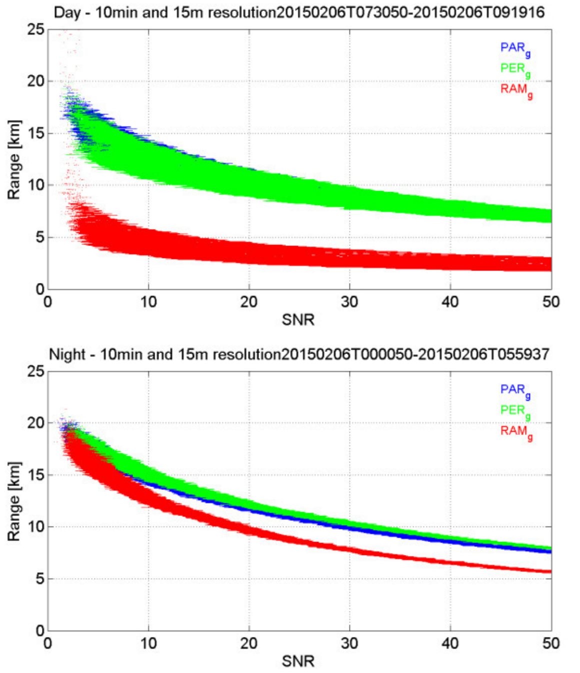

Fig. 7. SNR for all receiving channels (co-polar PARg, cross-polar PERg and N_2 Raman RAMg). “g” stands for glued signal.

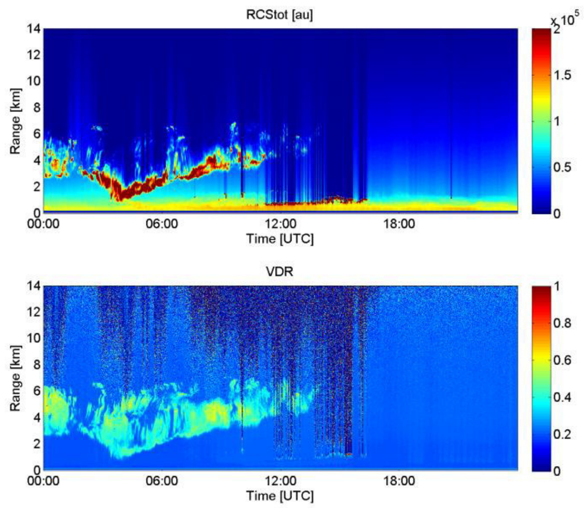

Fig. 8. *RCS* and *VDR* recorded on 03/02/2015 at Exeter.

Currently, various aspects of the data quality control (QC) are under development. In an operational context these QC algorithm have to be applied in real-time and therefore robust procedures have to be developed and implemented. This will require the statistical studies of the gluing coefficients, the depolarization constant and of various techniques to derive the Lidar calibration.

NRT plots will be available for *RCS* and *VDR* along with aerosol optical depth and Ångström coefficient provided by sunphotometer.

A complete illustration of the Lidar capabilities (including the retrieval of the particles optical properties) will be given during ILRC.

4. CONCLUSIONS

Coordinated measurements by both the ceilometer network and lidar network will improve the spatial coverage over UK for volcanic ash monitoring as well as other pollution events.

Synergetic measurements by the aircraft as well as satellites retrievals and dispersion models output will bring a more comprehensive knowledge of the pollutants, from their dynamics to their microphysical and optical properties.

ACKNOWLEDGEMENT

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