COMPARISON OF SPALINET NETWORK LIDAR MEASUREMENTS WITH MODELS FORECASTS DURING THE EYJAFJALLA EVENT

F. Molero[1], M. Sicard[2], J.L. Guerrero-Rascado[3-4], F. Navas-Guzmán[4], S. Tomás[2], J. Preißler[3], D. Kumar[2], F. Rocandenbosch[2], L. Alados-Arboledas[4], F. Wagner[3], A. Comeron[2], M. Pujadas[1]

[1]*Grupo de Contaminación atmosférica, CIEMAT, Avda Complutense, 22. 28040 Madrid, Spain.* f.molero@ciemat.es
[2]*Department of Signal Theory and Communications, Remote Sensing Laboratory, Univ. Politècnica de Catalunya / Institut d'Estudis Espacials de Catalunya, c/ Jordi Girona, 1-3, 08034, Barcelona, Spain.* msicard@tsc.upc.edu
[3]*Évora Geophysics Centre (CGE), U. Évora, Rua Româo Ramalho 59, 7000, Évora Portugal* .fwagner@uevora.pt
[4]*Centro Andaluz de Medio Ambiente (CEAMA), Av. del Mediterráneo s/n, 18071, Granada, Spain,* alados@ugr.es

ABSTRACT

An assessment of the model forecast for the Eyjafjalla volcanic event has been performed for the Iberian Peninsula. Vertical profiles measured by a network of lidar instruments have been compared with the predictions provided by two models. The event over the Iberian Peninsula, which occurred between the 5th and 8th of May, 2010, was reasonably well captured by both models, although some discrepancies in temporal and spatial accuracy respect to the lidar profiles are commented. The assessment is limited due to interference of the lidar measurements by low clouds and rain.

1. INTRODUCTION

During April, 2010, the European airspace paralyzed for six days after the strong eruption of the Eyjafjalla volcano (Iceland), due to the international aviation guidelines recommending that no planes should fly through airspace that contains volcanic ash. This event has clearly shown how widespread the consequences of a volcanic eruption can be and raised the issue about the accuracy of the alert systems, mainly based in models of volcanic ash dispersal. The evolution in space and time of the volcanic plume was forecasted by several models, such as EURAD or FLEXPART, based on information about wind speed and direction, along with data about concentration, composition and size of the ash particles. Criticism of the models argues that they overestimated the extent of the ash cloud, increasing the economic impact of the situation.

Several days after the major event that started on 14 April, a plume from a new eruption of the Eyjafjalla volcano reached the Iberian Peninsula, where several lidar systems were monitoring the atmosphere coordinated in the framework of the SPALINET network[1]. Such networks of lidar stations can play a double role, characterizing the plume over its vertical at a given time and validating models forecast. In this work, the predictions provided by the EURAD and FLEXTRA models have been compared with the measurements provided by the lidar network in order to assess their accuracy. The assessment is limited due to interference of the lidar measurements by low clouds and rain.

2. EXPERIMENTAL SET UP

SPALINET, the Spanish and Portuguese Aerosol LIdar NETwork, (www.lidar.es/spalinet/en)[1] is formed by 10 research centers and universities distributed over the Iberian Peninsula and the Canary Islands. During the volcanic event, the following stations were operated on a regular basis:

- Centro de Geofísica de Évora (38.57ºN, 7.91ºW, Évora, Portugal);
- Universidad de Granada (37.16ºN, 3.58ºW, Granada, Spain);
- Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (40.46ºN, 3.72ºW, Madrid, Spain);
- Universitat Politècnica de Catalunya (41.39ºN, 2.11ºE, Barcelona, Spain);

Each station operate a multi-wavelength (355-532-1064 nm) Raman lidar, providing vertically-resolved profiles of extinction and backscattering coefficients. The "quicklook" images at 532 nm, obtained by interpolating the range-corrected signals in altitude and time, have been compared with the models forecast.

Forecasts from two different models have been analyzed. Firstly, the **EUR**opean **A**ir Pollution **D**ispersion (**EURAD**) model system (http://www.eurad.uni-koeln.de/index_e.html)[2], that simulates the physical, chemical and dynamical processes which control emission, production, transport and deposition of atmospheric trace species, providing concentrations of these trace species in the troposphere over Europe and their removal from the atmosphere by wet and dry deposition. During the Eyjafjalla event, this system served as a forecasting tool, but the EURAD

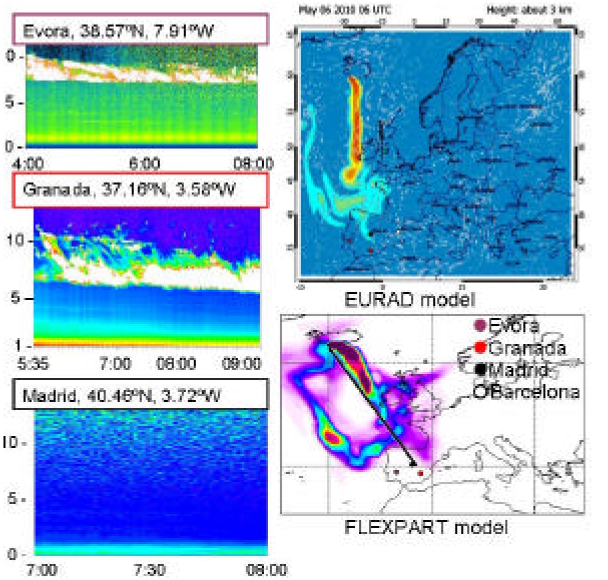

Figure 1. Comparison of model predictions for 6 May, at 06 UTC, for EURAD (Top right panel) and FLEXPART (Bottom right panel) with the quicklooks for Évora (Top left panel, 04-08UTC), Granada (Central left panel, 05-09UTC) and Madrid (Bottom left panel, 07-08UTC).

system can also serve for scientific analyses with the possibility to assimilate remote sensing data of all kinds, opening the future possibility of improvements of the model forecast by ingesting lidar profiles.

The other model is the particle dispersion model FLEXPART (http://transport.nilu.no/flexpart)[3] based on Global Forecast System (GFS) data of the National

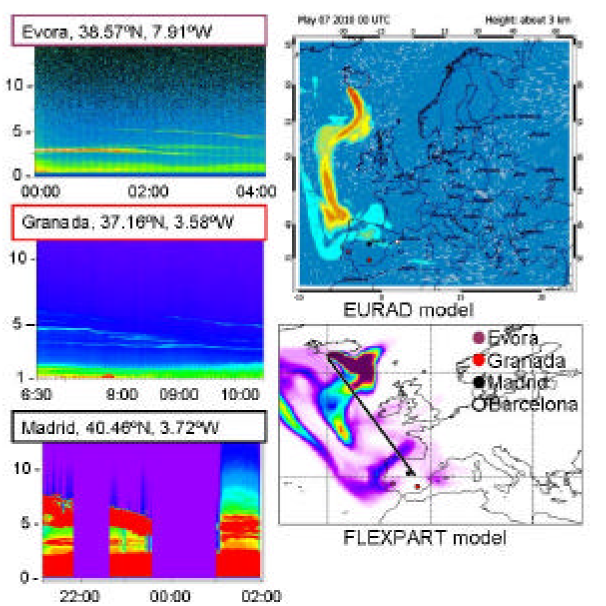

Figure 2. Same as Figure 1 but for 7 May, at 00 UTC, with the quicklooks for Evora (Top left panel, 00-04UTC), Granada (Central left panel, 06-10UTC) and Madrid (Bottom left panel, 22-02UTC).

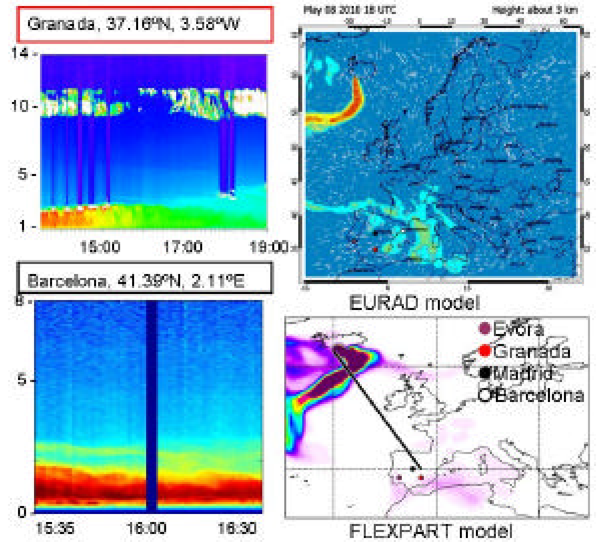

Figure 3. Same as Figure 1, but for 8 May, at 18 UTC, with the quicklooks for Granada (Top left panel, 14-19UTC) and Barcelona (Bottom left panel, 15-17UTC).

Centre for Environmental Prediction (NCEP). Tracer masses are carried by particles following trajectories calculated using the GFS winds and stochastic components for turbulence and convection, assuming aerosol-like removal by dry and wet deposition (VO-AER special volcano tracer).

3. RESULTS AND DISCUSSION

The arrival of volcanic ashes was first observed on the evening of 5 May. At Évora, the westernmost station of those considered in this work, a thin layer, at about 4 km ASL height was observed from 20:30 UTC on. Also, Granada station detected thin and very weak layers at 3 and 5 km from 18:00 UTC on. No volcanic ash was detected over the other network stations, although low clouds interfered the lidar measurements over Madrid and Barcelona at some times, forbidding a proper characterization of the atmosphere above. Figure 1 show the model predictions for 6 May, at 00 UTC, when thin layers were observed over Évora and Granada at about 3-4 km. Although the EURAD model (top right panel) predicted volcanic ash over Madrid, it was not observed. On the other hand, none of the models predicted the layers detected over Évora and Granada.

The next day, 6 May, several aerosol layers were detected over Granada and Évora between 2.5 and 5 km along the whole day, slowly subsiding towards the mixing layer, while at Madrid the volcanic ash was detected at 21 UTC and continued along the night, with presence of mid-altitude clouds. Barcelona station could not perform measurements due to persistent rain. On 7 May, the volcanic ash layers reached their highest optical depths and they were located just over the boundary layer at Granada, Évora and Madrid, but low clouds interfered the measurements at some times. Figure 2 shows the models prediction on 7 May, at 00 UTC compared with the quicklooks detected over Évora, Granada and Madrid. Both models (Right panels) predict correctly the passage of a volcanic ash plume over the Iberian Peninsula, but with a delay of about 12 hours. The shape of the ash cloud, with stronger presence at the south of the Iberian Peninsula, agrees reasonably well with the layers measured by the lidar stations. However, further analysis of the lidar vertical profiles is required in order to obtain mass concentration, either by integrating in the ash layer, which will be comparable with the EURAD predictions, or by integrating along the whole atmospheric column, to compare with the FLEXPART forecast.

The event ended on 8 May, when a clean airmass from the Atlantic ocean washed the atmosphere from the West. Volcanic ash layer were detected over Barcelona at 2.5 km, just over the mixing layer, and, less clearly, over Granada, while low clouds and rain forbade measurements over Évora and Madrid. Figure 3 shows the situation on 8 May, at 18UTC, when both models (Right panels) predicted a change in the meteorological situation that transported the volcanic plume to the West, while the remaining ashes of previous days moved to the Mediterranean sea, over Barcelona and Granada for the EURAD model, and only over Granada for the FLEXPART model.

4. CONCLUSIONS

An assessment of the model prediction for the Eyjafjalla volcanic event has been performed for the Iberian Peninsula. The SPALINET lidar network has proved its valuable utility in these situations. Both models tested, EURAD and FLEXPART, predicted correctly the passage of a volcanic ash plume over the Iberian Peninsula those days, although with a temporal delay of 12 hours. The shape of the predicted ash cloud resembles the layers measured by lidar, but with low spatial accuracy. Regarding that the decision to close the European airspace at the beginning of the Eyjafjalla event was mainly based on models and, also, the economic effect of the airspace closings, it seems that modeling and monitoring of volcanic ash dispersion in the atmosphere needs to be improved. The short episode analysed in this work provides a good case study to test lidar profiles ingestion into models in order to produce better estimates of ash concentrations in the atmosphere.

ACKNOWLEDGMENTS

The Norwegian Institute for Air Research (NILU) and the Rhenish Institute for Environmental Research of the University of Cologne are acknowledged for providing the FLEXPART and EURAD results used in this study.

This work is supported by the European Union under the project EARLINET-ASOS (EU Coordination Action, contract nº 025991 (RICA)); by the MICINN under the Complementary Actions CGL2008-01330-E/CLI and CGL2009-08031-E/CLI;

REFERENCES

[1] Sicard, M., F. Molero, J. L. Guerrero-Rascado, R. Pedrós, F. J. Expósito, C. Córdoba-Jabonero, J. M. Bolarín, A. Comerón, F. Rocadenbosch, M. Pujadas, L. Alados-Arboledas, J. A. Martinez-Lozano, J. P. Díaz, M. Gil, A. Requena, F. Navas-Guzmán, J. M. Moreno 2009: Aerosol lidar intercomparison in the framework of SPALINET – the SPAnish LIdar NETwork: methodology and results *IEEE Trans. Geosci Remote Sens*., **47**, pp. 3547 – 3559.

[2] Hass, H. 1991: Description of the EURAD Chemistry-Transport-Model version2 (CTM2), *Mitteilungen aus dem Institut für Geophysik und Meteorologie der Universität zu Köln*, 83.

[3] Stohl, A., C. Forster, A. Frank, P. Seibert, and G. Wotawa, 2005: Technical Note: The Lagrangian particle dispersion model FLEXPART version 6.2. *Atmos. Chem. Phys*. **5**, pp. 2461-2474.