Joint Analysis of Modelled and EARLINET Extinction, JAMEE

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- **Introduction and motivation**

Providing information on aerosol extinction profiles, LIDAR instruments offer a unique possibility of evaluating vertical distribution of aerosols in the atmosphere calculated with climate and chemical transport models. Compared to more traditional ground-based in-situ monitoring, LIDAR measurements are still relatively a new data type for modelers and thus requires new knowledge and better understanding the data in order to properly interpret the results and make the best use of LIDAR products. Performing joint analysis of LIDAR and model data contributes to strengthening the link between the EARLINET and modeling community and promoting a wider use of LIDAR data for comparison with model calculations.

- **Scientific objectives**

Within the ACTRIS project, EARLINET data have recently been incorporated in the AeroCom database, which allows visual comparison of the measurements with extinction profiles calculated with AeroCom models. Aerosol extinction profiles calculated with the EMEP/MSC-W model have been compared with EARLINET climatological (over 13 years) dataset, trying to explain the regional and seasonal differences based on those long-term data.

Further joint EMEP-EARLINET study was focused on the period of EMEP/ACTRIS intensive measurements dedicated to mineral dust in June-July 2012. The region of the study was the whole of Europe, while a special interest in southern Europe/Mediterranean area heavily influenced by Saharan dust intrusions. The first results of comparison between the EMEP model and EARLINET sites were presented at the Dust 2014 Conference. The first results and findings have evoked a further need for deeper investigation into the deviations between the model and measurements. In this project, our joint endeavors have been based upon the work started last year with a main objective to carry out an in-depth analysis of model vs. EARLINET data in order to achieve a better understanding of the reasons for discrepancies.

- **Reason for choosing station**

CIAO observatory is one of the most advanced infrastructures for ground based remote sensing in Europe equipped by multi-wavelength LIDAR and scanning cloud radar plus operative instruments. The main equipment currently running at CIAO are multi-wavelength Raman LIDAR for aerosol optical properties, plus many other instruments which could be of interest for this project, i.e. CIMEL CE-318 Sun photometer, and scanning microwave profiler MP3014. CIAO data follow data quality protocol developed in the frame of the international networks and based on redundancy of the instruments. Furthermore, CIAO observatory participated in joint EMEP/ACTRIS intensive measurements period in June-July 2012, which was dedicated to mineral dust. In addition to in situ surface measurements of mineral dust, LIDAR measured aerosol extinction profiles represent a very valuable dataset for model evaluation and studying of background aerosol, as well as transport of mineral dust during Saharan outbreaks.

- **Method and experimental set-up**

During the access to CIAO, the visiting scientist gained a good overview over instruments operating within the infrastructure and their overall capability. Practical demonstrations of the instrumentation and discussions with all the CIAO personnel helped acquiring information about state-of-the-art remote sensing

technique for atmospheric aerosol measurements. In particular, a useful knowledge of the main technical operation principles of CIAO's LIDAR have been obtained, including overview of measurement parameters, their uncertainties and data products. The exchange of information on LIDAR and modeling data has contributed to a better understanding between the two research communities and thus building a platform for further collaborative comparison works between model calculations and LIDAR measurements. During the TNA project, the visiting scientist and CIAO personnel faced the problem of comparing and discussing measurements and modeled profiles selecting as first database the data related to the joint EMEP/ACTRIS intensive measurements period in June-July 2012.

The goal of our study is twofold: to compare and interpret results from EMEP/MSC-W model versus LIDAR extinction data for the entire measurement period and to evaluate the model's ability to reproduce observed dust episodes. For this purpose, EMEP model has been set up to calculate aerosol extinction profiles and AOD for 2012. The model was run on a European scale, using 50x50 km horizontal resolution and 20 vertical layers up to ca. 16 km. In addition to total aerosol extinction, the model calculates extinction profiles due to the individual aerosol components, thus providing auxiliary information for interpreting the results. The output from the model used for comparison with LIDAR measurements are aerosol extinction profiles. Though LIDAR measurements offer more data for backscatter profiles, which are also of higher accuracy compared to extinction, we look at aerosol extinction profiles, as the EMEP model does not presently allow calculations of aerosol backscatter (due to its bulk-mass aerosol representation). A set of EARLINET sites which participated at the EMEP/ACTRIS measurement period in June-July 2012 has been selected for this work. For those sites, hourly extinction profiles at 20 model layers have been extracted from the EMEP model for the considered period, both total and for individual aerosol components. The corresponding LIDAR data (which have much fine vertical resolution) have been aggregated to the 20 of model layers, so that for each layer both model and LIDAR extinctions represent the average layer value. Finally, making consistent with respect to time datasets from model and LIDAR have been made.

- **Preliminary results and conclusions**

Thus carrying on the earlier works, further processing of model and Lidar extinction profile data have been performed in the course of the project days. Datasets from the EMEP model and LIDAR measurements have been compiled in an adequate format in order to perform visualization and further statistical analysis. The main challenge in data handling was to aggregate them to the same vertical levels and time periods/average, as described above. First plots of the time evolution of extinction profiles during the continuous 72h measurements on 9-12 July have been produced for selected sites (see example for Limassol in Hellas in Figure 1 a, b). In addition, model calculated contribution due to individual aerosol components to the total extinction has also been visualized (see example for extinction due to mineral dust in Fig. 1c). A fairly good general agreement in the pattern of extinction temporal evolution has been found between model results and measurements during 9-12 July. Still, there are some disagreements in extinction values, which are to be analyzed in the following works.

Furthermore, the consistent (in space and time) model and LIDAR extinction datasets have been constructed for the entire measurement period

- **Outcome and future studies**

For the first sub-goal, we have made plans for further thorough quantitative analyses of the differences between calculated and measured extinction for the measurement period of June-July 2012. The degree of agreement between the model and LIDAR will be characterized in terms of e.g. correlation, biases, as functions of height and time and for two wavelengths of 355 and 532 nm. The analysis will also include a qualitative comparison of the evolution of extinction profiles during 72 hour continuous LIDAR measurements in the period of 9-12 July at all selected sites. Regarding the second sub-goal, we shall focus on in-depth analysis of comparison between model calculated and EARLINET observed Saharan dust plumes

during dust episodes, aiming at explaining the agreements/disagreements and also identify new model tests. As an example, using measurements of relative humidity by the radiometer microwave profiler could be used to check the accuracy of the modelled aerosol hygroscopic growth and its effect on aerosol extinction. To facilitate the data interpretation, the information of aerosol chemical composition and size fractions will be available from the EMEP model.

Among the main outcomes of the project is improved knowledge and understanding by the visiting scientist of Lidar measurement techniques and data products, which is very beneficial for data understanding and interpretation.

Finally, the structure and content of a joint paper presenting the results and findings from model vs. LIDAR extinction profiles during the EMEP-ACTRIS measurement period has been outlined. The first draft is planned to be made in autumn 2015.

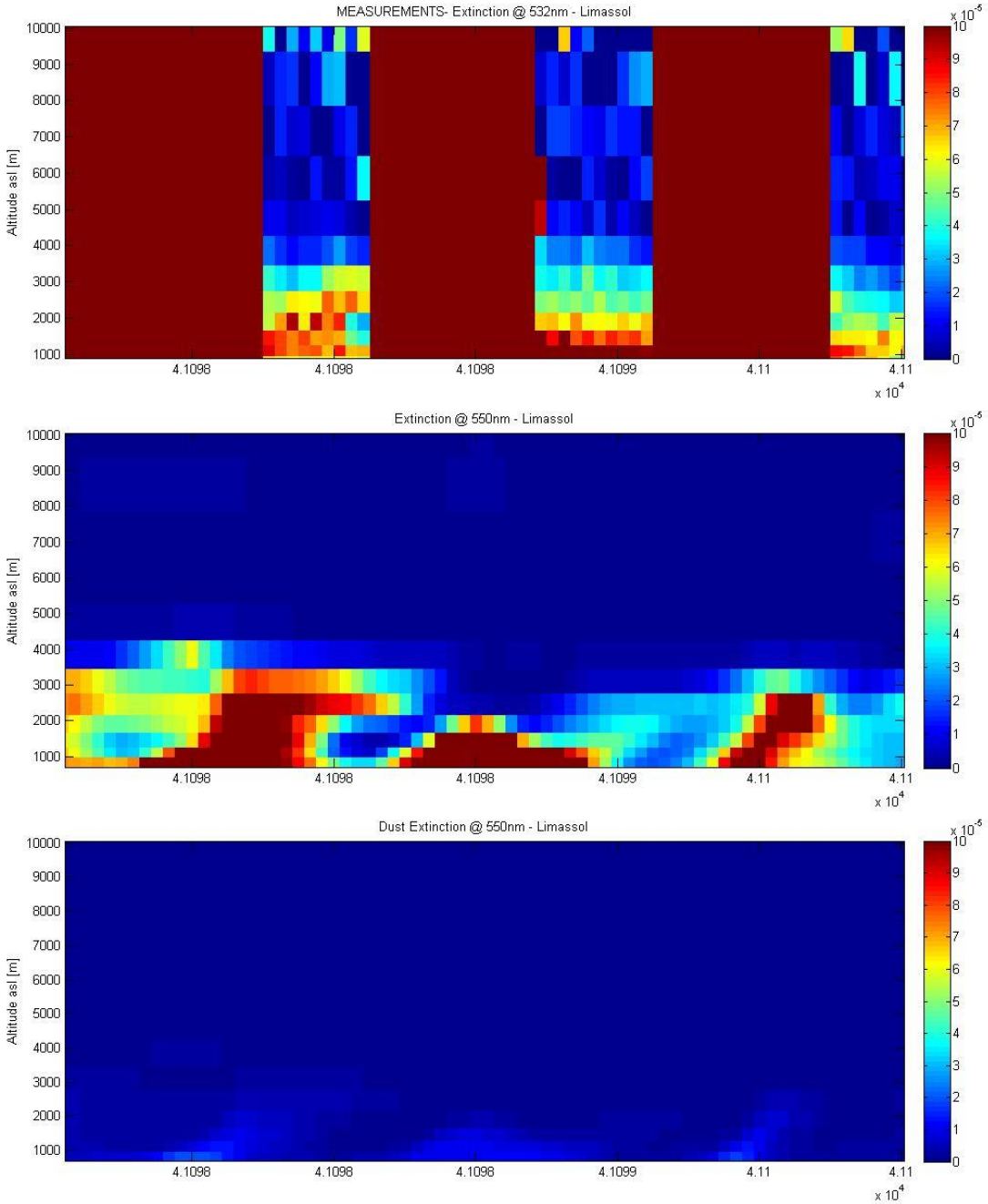

Figure 1. Temporal evolution of aerosol extinction profiles at Limasson (Greece) during 9-11 July: a) LIDAR measurements, b) EMEP model calculated; and c) for mineral dust extinction from the EMEP model.

- **References**

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