THE POTENTIAL OF THE SYNERGY OF SUNPHOTOMETER AND LIDAR DATA TO VALIDATE VERTICAL PROFILES OF THE AEROSOL MASS CONCENTRATION ESTIMATED BY AN AIR QUALITY MODEL

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ABSTRACT

Vertical profiles of the aerosol mass concentration derived by the Lidar/Radiometer Inversion Code (LIRIC), that uses combined sunphotometer and lidar data, were used in order to validate the aerosol mass concentration profiles estimated by the air quality model CAMx. Lidar and CIMEL measurements performed at the Laboratory of Atmospheric Physics of the Aristotle University of Thessaloniki, Greece (40.5N, 22.9E) from the period 2013-2014 were used in this study.

1. ALGORITHMS AND MODELS

CAMx is an air quality model (ENVIRON, 2010) that can provide, among others, the vertical mass concentration profiles of PM2.5 and PM10 aerosol. Input data include meteorological fields from the WRF model, natural and anthropogenic emission data, landuse and photochemistry data. Natural emissions include windblown dust from soils, sea salt aerosol and vegetation non-methane volatile organic compounds (NMVOCs) formating secondary organic aerosols (SOA), while anthropogenic emissions include fossil fuel burning procedures like heating, industry, transportation and energy production at power plants. Waste treatment and disposal, agricultural activities like biomass burning and fertilization and extraction and distribution of fossil fuels and geothermal energy are also considered. It is important to mention that the emissions due to dust resuspension during agricultural activities and road traffic as well as the Saharan dust emissions are not currently included. Saharan dust emissions are taken into account only indirectly from the model's chemical boundary conditions taken from the chemistry transport model IFS-MOZART. A nesting technique is being used to increase accuracy near the area of interest and thus the spatial resolution is 30x30km in the European domain, 10x10km in the East Mediterranean domain and 2x2km around Athens and Thessaloniki. More on the simulations of CAMx for Thessaloniki can be found in *Poupkou et al.*, 2012.

LIRIC algorithm utilizes both sunphotometer data that have been processed by AERONET algorithms and elastic backscatter lidar data at three wavelengths (355nm, 532nm and 1064nm) in order to estimate the aerosol concentration profiles for fine and coarse particles. The algorithmic inversion is described in detail in *Chaikovski et al.* 2012.

2. METHODOLOGY

The aerosol mass concentration profiles of the fine and coarse mode derived by CAMx were compared with the respective profiles derived by the retrieval algorithm. For the coarse mode particles, forecasts of the Saharan dust transportation model BSC-DREAM8bV2 were also taken into account. Each of the retrieval algorithm's profiles was matched to the models' profile with the best agreement within a time window of four hours before and after the central measurement. Since LIRIC derived profiles are in

ppb units it was necessary to convert them in μgr/m^3 in order to compare them with the models' profiles (see e.g. *Kokkalis et al.*, 2013). We assumed a mean density of 1.5 μgr/m^3 for the fine mode and 2.6 μgr/m^3 for the coarse mode. These values are typical for the fine and coarse mode particles respectively (see e.g. *Kokkalis et al.*, 2013).

Mean concentration profiles of CAMx and LIRIC were derived for both modes. For the calculation of the mean bias error, the root mean square error and the temporal correlation coefficient it was necessary to interpolate LIRIC and CAMx profiles to the same vertical resolution.

Optical Properties of Aerosols and Clouds (OPAC), a software that can provide optical properties of aerosol mixtures [*Hess et al.*, 1998], was also employed in order to calculate the Angstrom exponent values for 355nm/532nm and 532nm/1064nm for each of the model's profiles, aiming for a comparison with the Angstrom exponent values derived by the retrieval algorithm for each measurement.

3. RESULTS

The mean concentration profiles for the fine mode particles and the respective mean bias error are presented below.

The comparison of the aerosol fine mode concentration profiles presented in Figure 1 shows good agreement between CAMx and the retrieval algorithm, especially above 1.5km. The mean bias error shown in Figure 2, is slightly above 5 μgr/m^3 below 1km and ranges between 0-5 μgr/m^3 in the layer between 1 and 5km. Only nine cases were included since the data availability of concurrent Lidar and CIMEL measurements and CAMx forecasts was low.

As far as the aerosol coarse mode concentration profiles is considered, both CAMx and BSC-DREAM8bV2 values are severely underestimated (not shown here), although, in cases of Saharan dust transportation events there is an agreement between the profiles of BSC-DREAM8bV2 model and the retrieval algorithm. A typical case is presented in Figure 3.

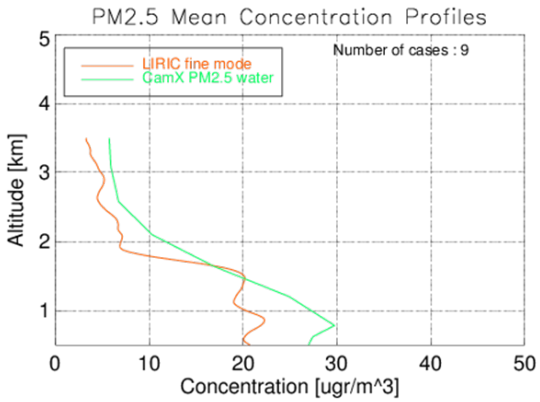

Figure 1. Comparison of the mean concentration profiles derived by CAMx and LIRIC for the fine mode particles.

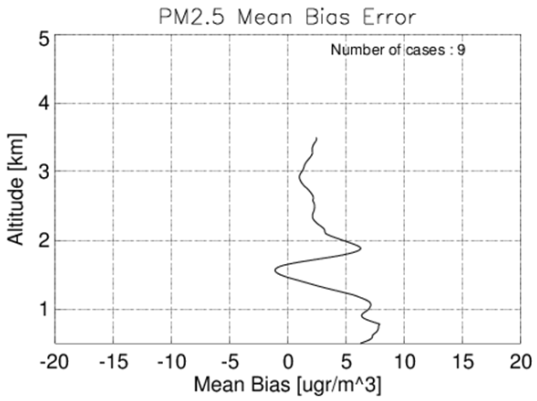

Figure 2. Mean bias error profile between CAMx and LIRIC for the fine mode particles.

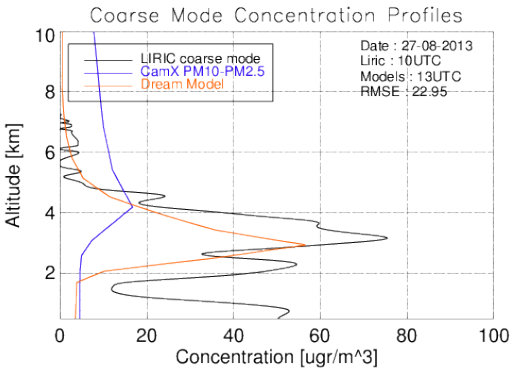

Figure 3. Comparison of the aerosol coarse mode concentration profiles between LIRIC [black], CAMx [blue] and BSC-DREAM8bV2 [red].

The aerosol Angstrom exponent comparison resulted in an underestimation of the values derived by OPAC for both 355nm-532nm and 532nm-1064nm spectral regions. The scatterplots of OPAC and LIRIC derived Angstrom exponent values are presented in Figures 4 and 5.

There is some linear behavior in both graphs. The Pearson correlation coefficient is 0.49 in the 355nm-532nm region and 0.60 in the 532nm-1064nm region. There are indications that CAMx is underestimating the sea salt emission. Greater sea salt values could lead to OPAC calculating smaller Angstrom values since sea salt consist mainly of coarse mode particles.

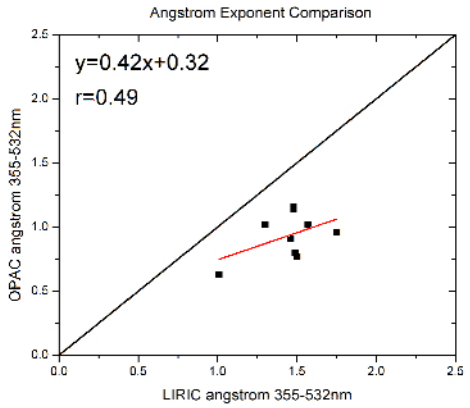

Figure 4. Scatterplot of the Aerosol Angstrom Exponent 355nm-532nm derived by LIRIC and OPAC.

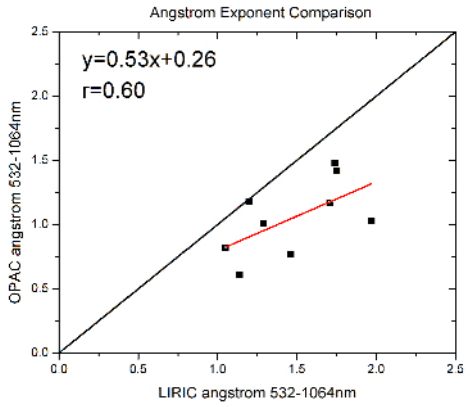

Figure 5. Scatterplot of the Aerosol Angstrom Exponent 532nm-1064nm derived by LIRIC and OPAC.

4. CONCLUSIONS

The comparison of the aerosol fine mode concentration profiles resulted in a good agreement between the model and the retrieval estimates, with the vertical mean bias mostly ranging between 0 and 5 μgr/m^3. As far as the aerosol coarse mode concentration profiles is considered, CAMx severely underestimates the aerosol concentration This probably occurs because aerosol emission sources outside the domain of CAMx, like Sahara desert, are not directly included in the model's emissions. In addition emissions from local dust sources are underestimated in CAMx. In cases of Saharan dust transport events there is a reasonable agreement between BSC-DREAM8bV2 model and the retrieval algorithm. The aerosol Angstrom exponent comparison resulted in an underestimation of the values derived by OPAC for both 355-532nm and 532-1064nm spectral regions, showing however a significant correlation of 0.5 to 0.6

5. FUTURE PLANS

Processing and comparison of additional cases in order to produce more accurate results is under progress. Furthermore the validation with a new run of CAMx is planned, which will use updated emission inventories.

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