ADVANTAGES OF REMOTE SENSING

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1. INTRODUCTION

Atmospheric aerosols are one of the most variable components of the Earth’s atmospheric environment, and their influence on energy budget is known [1]. Aerosols influence the climate via two ways: the direct effect by scattering and absorbing incoming solar radiation and the indirect effect which modify the microphysical and hence the radiative properties, amount and lifetime of clouds. Depending on composition, aerosols can absorb solar radiation in the atmosphere, producing further cooling of the surface and warming the atmosphere. Though the main aerosol source is natural, anthropogenic emissions have made aerosol levels increase dramatically over the past century. Aerosols also have been implicated in human health effects, visibility reduction in urban and regional areas, acidic deposition and altering Earth’s radiation balance [2]. The impact of aerosol on climate and environment has been an issue for the international scientific research community [3].

Aerosol parameters can be measured in situ (mostly by standardized methods) or by remote sensing from ground, aircraft, or satellite [4]. There are two types of remote sensing instruments: active and passive. Active instruments send a pulse of energy from the sensor to the object and then receive the radiation that is reflected or backscatter from the object (RADAR, LIDAR etc.). Passive sensors detect natural energy that is emitted by Sun or reflected by the aerosols, molecules and clouds (sun photometer etc.).

This paper describes the aerosol optical properties for a study case using a CE 318 sun photometer and a LIDAR system. Both instruments are installed at the Mechanical Engineering Faculty of Timișoara (45.74 N; 21.22 E) and the sun photometer is connected to the federal network AERONET. The origin of the air masses transporting the aerosols was investigated by running HYSPLIT model (Hybrid Single-Particle Lagrangian Integrated Trajectory) [5].

Instruments used in this article were developed in the framework of ROmanian LIDar NETwork (ROLINET) and Romanian Atmospheric Research 3D Observatory (RADO) projects.

2. METHODOLOGY

2.1. LIDAR system

The TOLI LIDAR system (Figure 1) presents a monostatic biaxial configuration and consists of a transmitter, a receiving system, a spectral selection
unit, a detection system and a system of recording and storing data [6].

![Fig. 1. TOLI LIDAR system](image1)

The conception of the TOLI LIDAR is based on a multiple wavelength system, with four channels: two elastics (355 nm, 532 nm) and two Raman (387 nm, 607 nm) ones. The system is dedicated to identifying aerosol (height of layers, radius of the particles, optical depth of the layers etc.) and clouds investigation in the low atmosphere (0-15 km), at high temporal (1 minute – during day time, 5 minutes – by night time) and spatial resolution (7.5 m). The transmitter is a pulsed solid Nd:YAG [7], [8] laser at 30 Hz repetition rate. The diameter of the beam is 6 mm at a divergence of 0.75 mrad, but before being transmitted into the atmosphere is expanded by a factor of five. This is achieved by a beam expander, optimized for the wavelengths of the laser and the resulting divergence is 0.15 mrad.

2.2. Sun photometer

The sun photometer is installed on the roof of the Mechanical Engineering Faculty (45.74 N; 21.22 E). It consists of an optical head, an electronic box and a robot (Fig. 2). The optical head has two channel systems: the sun collimator, and the sky collimator. The sun tracking is equipped with a 4-quadrant detector. The electronic box contains two microprocessors for real time operation for data acquisition and motion control. In automatic mode, a ‘wet sensor’ detects precipitation and forces the instrument to park and to protect the optics. The robot is automatically moved by step-by-step motors in two directions: the zenith and azimuth planes.

![Fig. 2. Sun photometer](image2)

The sun photometer accomplishes two basic measurements, either direct sun or sky, both within several programmed sequences. The direct sun measurements are made in eight spectral bands (340, 380, 440, 500, 670, 870, 940 and 1020 nm) requiring approximately 10 seconds. The 940 nm channel is used for column water abundance determination. These interference filters are located in a filter wheel which is rotated by a direct drive stepping motor. Sky measurements are performed at 440 nm, 670 nm, 870 nm, and 1020 nm. Two basic sky observation sequences are recorded: the “almucantar” and the “principal plane” [9].

3. RESULTS AND DISCUSSIONS

Figure 3 presents significant results obtained at 532 nm with the system at a spatial resolution of 7.5 m and 1 min time resolution. The aerosols’ layers can be easily observed, as they are having a considerable thickness between 7 and 12 km. They consist mainly of clouds formed from nucleation on aerosol particles. A thin layer situated at 4 km and a good homogeneity of the planetary boundary layer up to 2000 m is visible [6].

![Fig. 3. RCS image from 26.04.2011, 1:10 PM GMT](image3)

The homogeneity below planetary boundary layer is demonstrating that the weather was calm, without turbulence. Because for all the measurements a 30 Hz repetition rate is used, the resulting image of the RCS is smooth and also characterized by a good signal to noise ratio [6].

The type of aerosol particles was determined by means of aerosol optical depth (AOD), single scattering albedo (SSA) and its dependence on wavelength, Ångström parameter and particle size distribution. The aerosol type was assessed by comparing the measurement values with data reported in [10, 11].

Another parameter used in most of the parametric models is the Ångström turbidity coefficient, $\beta$ [12].
As the name says, it is a measure of the turbidity of the atmosphere, defined as the aerosol optical depth at a wavelength of 1 μm. Typically, β range is between 0 (no aerosols into the atmosphere) and 0.5 (very high concentration of aerosols). According to [13] the degree of atmospheric turbidity can be divided into 3 classes. For β < 0.1 the turbidity is low. When 0.1 < β < 0.3 the turbidity can be considered as moderate and for β > 0.3, the turbidity is considered high.

Table 1 presents the main parameters of aerosol obtained from data sun photometer for April 27, 2011.

<table>
<thead>
<tr>
<th>Time GMT</th>
<th>AOD (440 nm)</th>
<th>AOD (500 nm)</th>
<th>Angstrom parameter</th>
<th>Ångstrom Turbidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:18</td>
<td>0.1815</td>
<td>0.1572</td>
<td>0.7265</td>
<td>0.1097</td>
</tr>
<tr>
<td>11:33</td>
<td>0.1687</td>
<td>0.1432</td>
<td>0.9124</td>
<td>0.0896</td>
</tr>
<tr>
<td>13:03</td>
<td>0.2821</td>
<td>0.2582</td>
<td>0.4127</td>
<td>0.2119</td>
</tr>
<tr>
<td>13:41</td>
<td>0.2334</td>
<td>0.2094</td>
<td>0.5694</td>
<td>0.1573</td>
</tr>
<tr>
<td>13:59</td>
<td>0.2877</td>
<td>0.2621</td>
<td>0.4271</td>
<td>0.2139</td>
</tr>
<tr>
<td>14:35</td>
<td>0.2274</td>
<td>0.1998</td>
<td>0.6918</td>
<td>0.1408</td>
</tr>
<tr>
<td>14:52</td>
<td>0.2594</td>
<td>0.2325</td>
<td>0.5652</td>
<td>0.1753</td>
</tr>
<tr>
<td>15:06</td>
<td>0.2691</td>
<td>0.2398</td>
<td>0.5919</td>
<td>0.1785</td>
</tr>
<tr>
<td>15:17</td>
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<td>0.2648</td>
<td>0.5700</td>
<td>0.1996</td>
</tr>
<tr>
<td>15:44</td>
<td>0.3162</td>
<td>0.2794</td>
<td>0.6858</td>
<td>0.1966</td>
</tr>
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<td>15:50</td>
<td>0.2683</td>
<td>0.2314</td>
<td>0.8572</td>
<td>0.1481</td>
</tr>
<tr>
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<td>0.2272</td>
<td>0.9217</td>
<td>0.1395</td>
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<tr>
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<td>0.2360</td>
<td>0.8484</td>
<td>0.1514</td>
</tr>
<tr>
<td>16:00</td>
<td>0.2658</td>
<td>0.2294</td>
<td>0.9017</td>
<td>0.1423</td>
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<td>0.2805</td>
<td>0.2435</td>
<td>0.8474</td>
<td>0.15591</td>
</tr>
</tbody>
</table>

Figure 4 presents the dependence between Ångström parameter and aerosol optical depth, indicating aerosol presence in atmosphere.

Figure 4. Aerosol optical depth as function of Ångström parameter for 26.04.2011.

In order to explain data, backward trajectories were analyzed using HYSPLIT model (Hybrid Single-Particle Lagrangian Integrated Trajectory) [5]. Air masses trajectories were found to be oriented from northern Africa towards the South of Europe (Fig. 5).

The value of Ångström turbidity coefficient for 13:03 GMT is larger than 0.2, this means that the existing aerosol can be observed in a thick layer according to Figures 3 and 5.

4. CONCLUSIONS

From measurements with sun photometer on April 26, 2011, the following conclusions result:

– the increase of AOD (AOD440 varies from 0.3 to 0.58, where the subscript represents the wavelength in nm) while the water vapor column content was low,
– the increase of SSA with wavelength (SSA440 = 0.97 to SSA1020 = 0.99), the value of the Ångström parameter is below 1, and the increase of the coarse mode concentration, indicate intrusions in the atmosphere.
– the imaginary part of the refractive index was found in the range 0.003±0.001.

The aerosol presence was observed also from LIDAR measurements and HYSPLIT model.

Acknowledgements

The authors acknowledge the support from the project AirQ - Novel Tool for Urban Air Quality Monitoring, No. 93/03.01.2012/ 5 Ro-Fr 2012.

REFERENCES

[2] * * * http://www.ipcc.ch


