Graphical user interface to the aerosol profile retrieval algorithm utilizing combined lidar and CIMEL Sun photometer data

Software installation guide

Note: *in addition to the components included in the installation package, the software requires also Microsoft Access to be installed on your computer in order to work properly. The software will run on Windows XP and higher operating systems.*

1. Install the Python(x,y) distribution of the Python programming language:

You may either run the **"Python(x,y)-2.6.6.0.exe"** file included in the installation or download the newest version of the package from http://www.pythonxy.com.

During the setup process, please pay special attention to the "Choose Components" pane (Fig. 1):

- Select "Full" in the "Select the type of install" combobox or make sure that at least the following libraries are selected under the "Python" group of the component tree: "PyQt", "PyQwt", "SetupTools", "h5py", "Pywin32", "xlrd", and "xlwt".
- If you want the software to be usable by several users, expand "Install for" and check "All Users".
- If you want the Python language interpreter to be installed in a directory different from "C:\Python26", expand "Directories" and check "Custom". You will be prompted to select an appropriate directory later on. Note however that you may not place the Python interpreter on a directory path that contains spaces.
- Optionally clear "Eclipse" and "Other" checkboxes in the component tree if you do not plan to use the software development tools bundled with Python(x,y).

Note: *you may need to restart your computer to complete the installation process.*

2. Install the MATLAB Compiler Runtime:

Run the **"MCRInstaller.exe"** file included in the installation and follow the instructions.

3. Install the aerosol profile retrieving software itself:

Unpack the contents of **"ProfileRetriever.zip"** file to a convenient location on your hard drive. The software should be immediately ready for use.

To run an application, switch to the "ProfileRetriever" folder and double-click the corresponding file:

- to launch the aerosol profile retrieval graphical user interface program, double-click **"ProfileRetriever.pyw"**;
- to launch the viewer of aerosol profile output database files, double-click **"ProfileViewer.pyw"**.

Alternatively, you may manually create shortcuts to these files and place them on the Desktop or in Start menu.

You may change location of the "ProfileRetriever" application folder at any time in the future, if required.

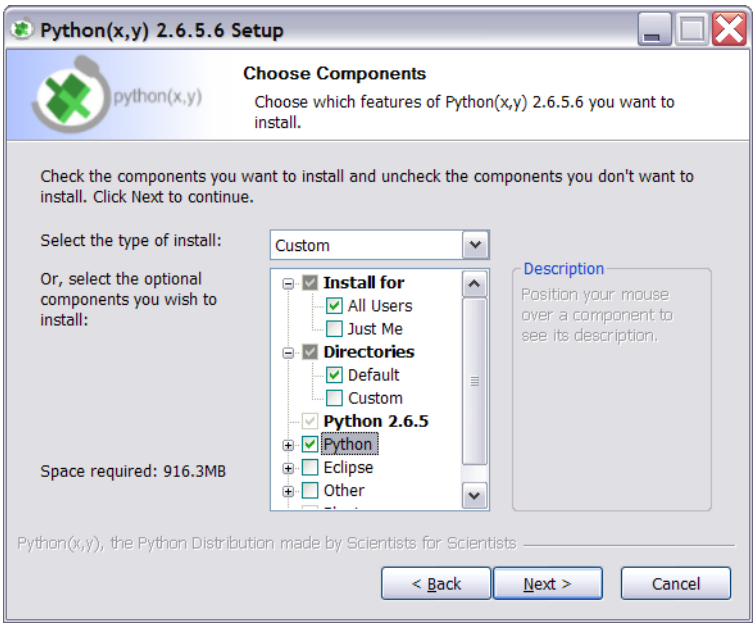


Fig. 1. Choose Components pane of the Python(x,y) installation wizard

Software user guide

The software consists of two graphical user interface applications, launched by means of opening **"ProfileRetriever.pyw"** and **"ProfileViewer.pyw"** files located at the root of "ProfileRetriever" folder extracted from the "ProfileRetriever.zip" archive.

"ProfileRetriever.pyw" is the main application. It is responsible for selection and graphical visualization of input data and the process of retrieval of aerosol mode concentration profiles itself.

"ProfileViewer.pyw" is an auxiliary application intended for browsing of retrieved aerosol profile databases created within the main application.

Graphical user interface of the "ProfileRetriever" application is represented on Fig. 2. Application window is divided vertically into three primary parts, marked off with red rectangles on the figure.

1. Selection of the lidar input data

The upper part of the main application window ("Lidar input", see Fig. 2) is responsible for selection of lidar input data. Software input is assumed to be a processed lidar measurement database in Microsoft Access format, prepared in "TropoExport" application. To select a database file, one has to press the "" button to the right of the field displaying the file name.

The database is represented in the form of a table with the following columns:

- "Date", "TStart": date and time of the beginning of the lidar measurement;
- "TStop": time of the lidar measurement completion;
- "Wave": wavelength of the measurement, in nanometers;
- "Polar": mode of taking polarization into account during the measurement: "0" in case of a measurement without taking polarization into account; "1" in case of parallel orientation of the receiver for linearly polarized light; "2" in case of perpendicular orientation of the receiver for linearly polarized light;
- "Step", "Zenith": lidar signal discretization parameters: "Step" defines discretization step in meters along the nominal sounding track; "Zenith" is the zenith angle of the track in degrees;

- "Left", "Right": indices of the first and the last nodes of the lidar signal grid section selected to be used in aerosol profile retrieval (index 0 corresponds to lidar signal received from the range of 0 to "Step" meters off the measurement point along the nominal sounding track);
- "Local ID": textual identifier that was assigned to the lidar measurement during the lidar experiment.

In the table, only those measurements are displayed that have been specially selected and prepared for aerosol profile retrieval in the "TropoExport" application (i. e., those measurements for which the "TropoExport" database field value is "1").

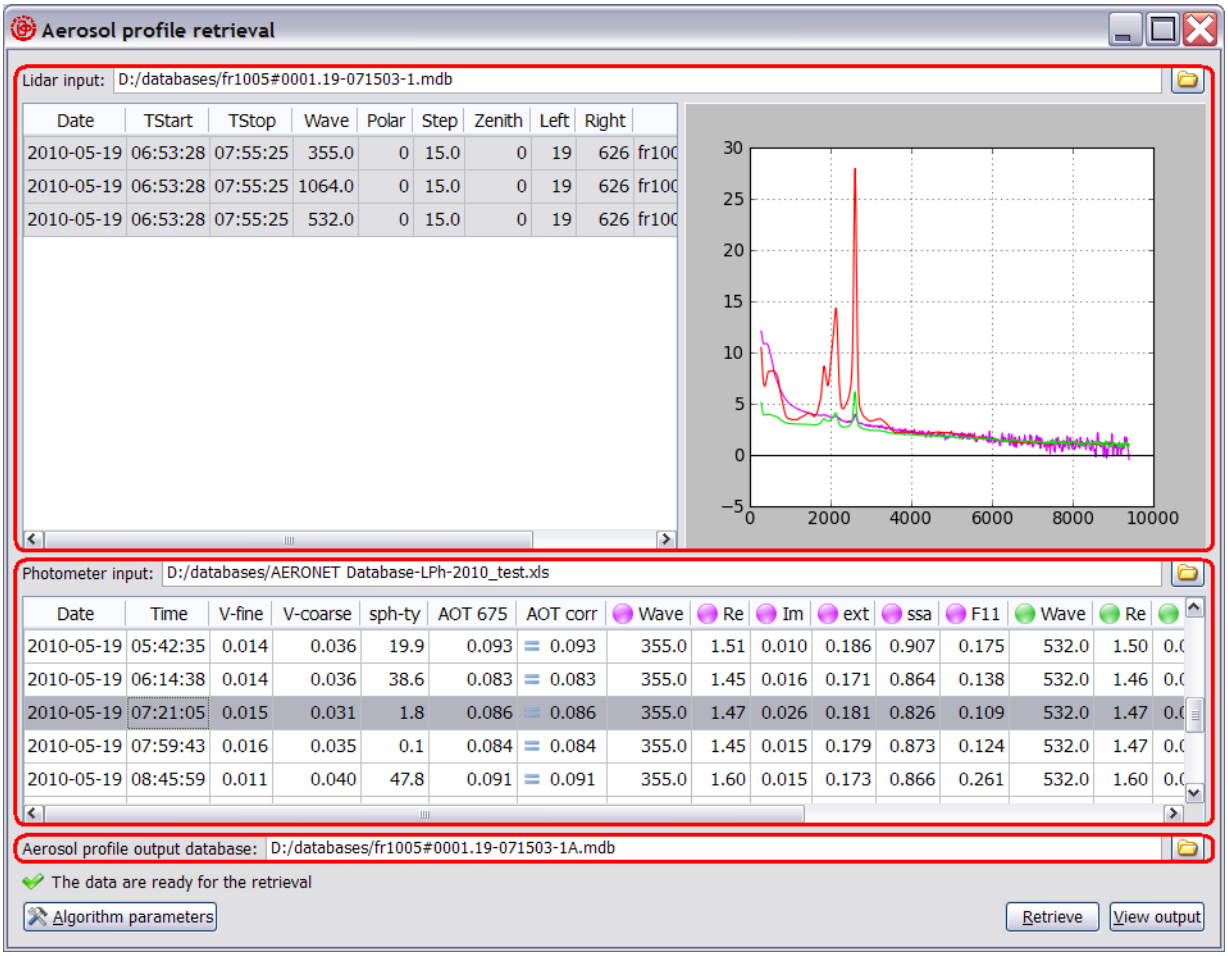


Fig. 2. Graphical user interface of the "ProfileRetriever" application

To retrieve aerosol profiles, one has to select three lidar measurements, so that one measurement is selected for each of the 532, 1064, and 355 nm wavelengths. Measurement selection is performed by clicking a table row with the mouse or by moving the table cursor to one of the row's cells and pressing the spacebar key. A measurement is available for selection only if its wavelength is among those mentioned above and if its mode of taking polarization into account ("Polar") is either "0" or "1".

Lidar signals selected for the retrieval are displayed on the plot to the right of the table. Signals at 532 nm wavelength are displayed in green color; signals at 1064 nm use red color, and signals at 355 nm use purple color. Horizontal axis represents height above the measurement point in meters; vertical axis represents the values of the lidar signals divided by their average values around the reference points. Reference point index for each of the signals is defined in the "TropoExport"

application. The plot displays those signal sections only that have been selected to be used in aerosol profile retrieval.

It is possible to adjust sizes of window sections occupied by the table and the plot by dragging their vertical boundary with the mouse.

2. Selection of the radiometric input data

The middle part of the main application window ("Photometer input", see Fig. 2) is responsible for selection of the radiometric measurement that corresponds to the lidar data selected in the upper part of the window (see section 1). Radiometric measurement data are assumed to be stored in a specially prepared file in Microsoft Excel format. File selection is accomplished via the "  " button to the right of the field displaying the file name.

The contents of the radiometric data file are represented in the form of a table with the following columns:

- "Date", "Time": date and time of the radiometric measurement;
- "V-fine", "V-coarse": volumetric concentrations of fine and coarse aerosol modes that have been retrieved on the basis of the radiometric measurement, in $\mu m^3/\mu m^2$ (representing aerosol volume for an atmosphere column with 1 μm^2 cross section);
- "sph-ty": fraction of spherical aerosol particles that has been retrieved on the basis of the radiometric measurement, in percents;
- "AOT 675": aerosol optical thickness at the 675 nm wavelength;
- "AOT corr": manually corrected value for the "AOT 675" column, used in cases when it's not possible to select a full-scale radiometric measurement that had been carried out right at the time of the lidar experiment;
- "Wave": wavelength in nanometers;
- "Re": real part of the complex refractive index at the given wavelength;
- "Im": imaginary part of the complex refractive index at the given wavelength;
- "ext": aerosol optical thickness at the given wavelength;
- "ssa": aerosol single scattering albedo at the given wavelength;
- "F11": main element of the aerosol scattering matrix at the given wavelength.

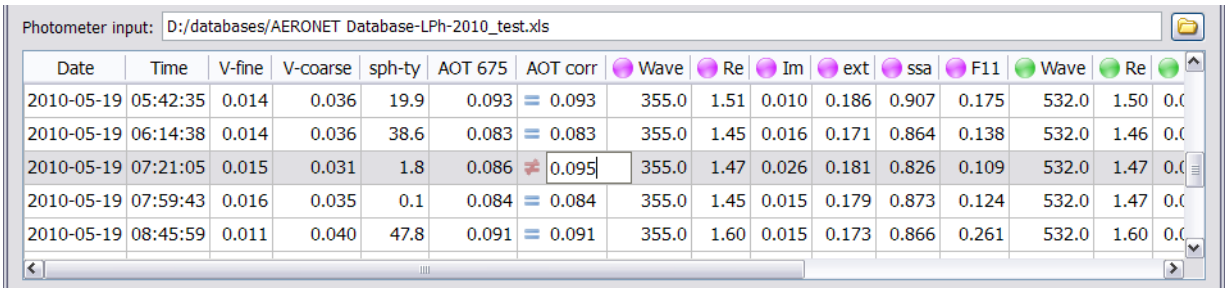


Fig. 3. A cell of the "AOT corr" column being edited

Table columns marked with round color icons correspond to calculated aerosol optical characteristics stored in the input file, covering the same three wavelengths at which lidar measurements are carried out.

"AOT corr" table column is intended for manual correction of measured aerosol optical thickness in cases when there's no precise time match between lidar and radiometric measurements. In such cases, it is assumed that aerosol constitution and mode ratio may both be regarded as nearly constant

during the given time period, with aerosol optical thickness being the only aerosol parameter that varies with time. Corrected value for the aerosol optical thickness, in its turn, may be obtained from one of the ordinary radiometric measurements, which are usually carried out much more often than full-scale measurements.

Values in the "AOT corr" column may be edited by double-clicking a cell with the mouse or by pressing "F2" key on the keyboard (see Fig. 3). A cell's icon will look like an equals sign if values in "AOT 675" and "AOT corr" columns are the same, and like a not equal sign otherwise. Red color of an icon indicates that the cell's current value is different from the value that had been read initially from the input file. Values denoted by red color icons will be lost when the application window is closed or when the radiometric measurements file is reopened.

To retrieve aerosol profiles, one has to select a measurement from the table by either clicking a table row with the mouse or by moving the table cursor to one of the row's cells and pressing the spacebar key.

It is possible to adjust sizes of the upper and the middle parts of the window (responsible for lidar and radiometric input data, respectively) by dragging their horizontal boundary with the mouse (see Fig. 2).

3. Selection of the aerosol profile database file

The lower part of the main application window ("Aerosol profile output database", see Fig. 2) is intended for pointing out a database file in Microsoft Access format to append the results of aerosol mode profile retrievals to. When the "  " button is pressed, a dialog box is opened that may be used to either select an existing file or create a new empty database. In the latter case, one has to switch to the folder where the file is to be created in, using the dialog, then enter the new database name in the "File name" field (see Fig. 4) and press the "Save" button.

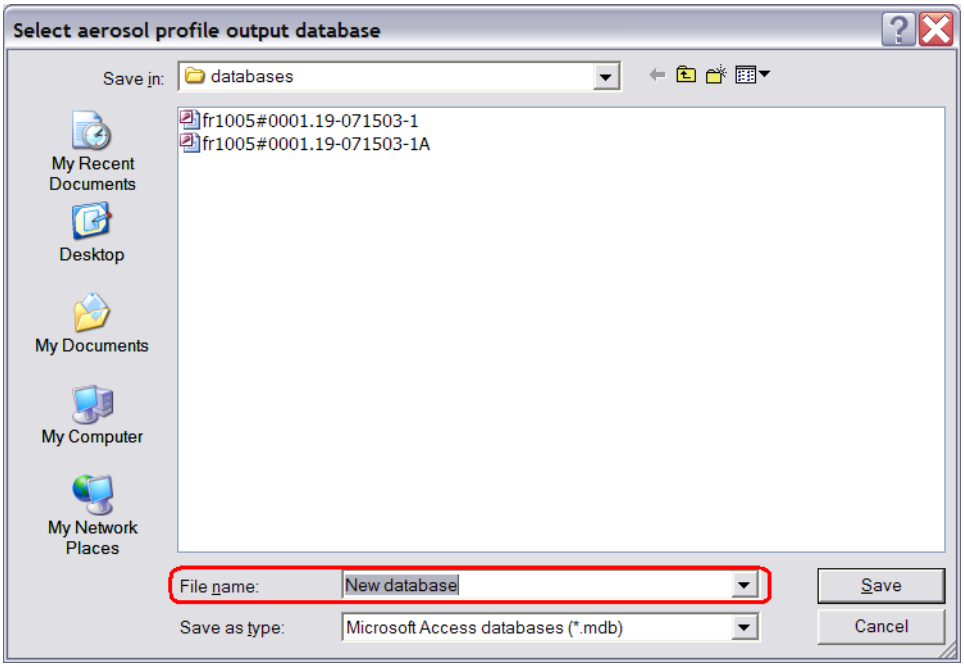


Fig. 4. Creating a new aerosol profile database

4. Running the aerosol profile retrieval algorithm

Aerosol mode profile retrieval algorithm is invoked by pressing the “Retrieve” button located in the lower right corner of the main application window (see Fig. 2). If the retrieval is not possible for some reason, “Retrieve” button will be disabled, and the status bar at the bottom of the application window will contain an appropriate error message instead of “The data are ready for the retrieval” text.

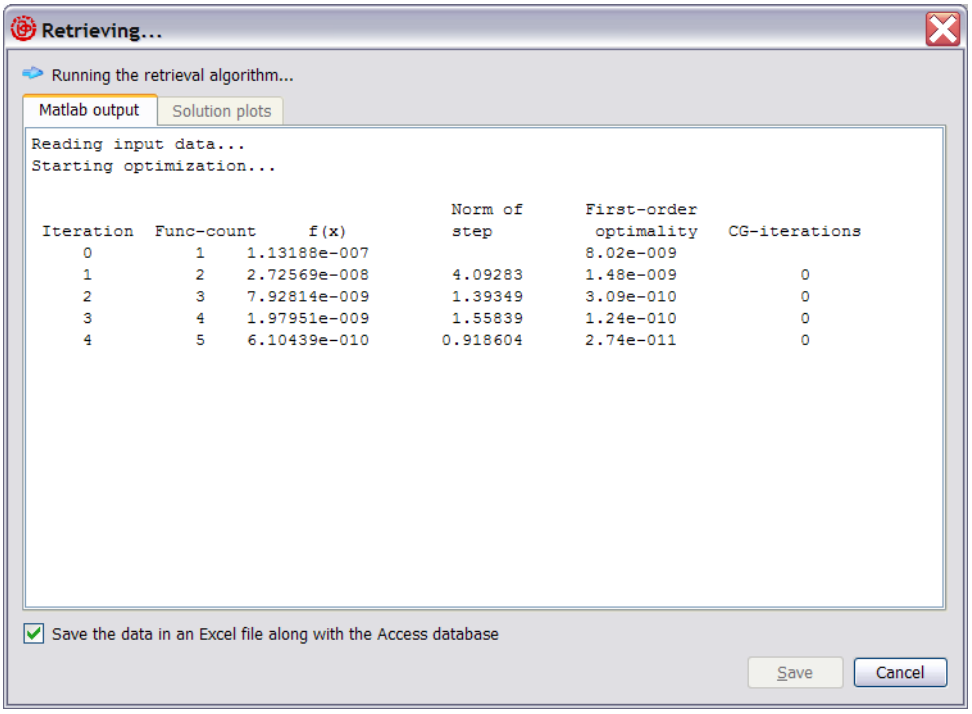


Fig. 5. Aerosol mode concentration profiles retrieval in progress

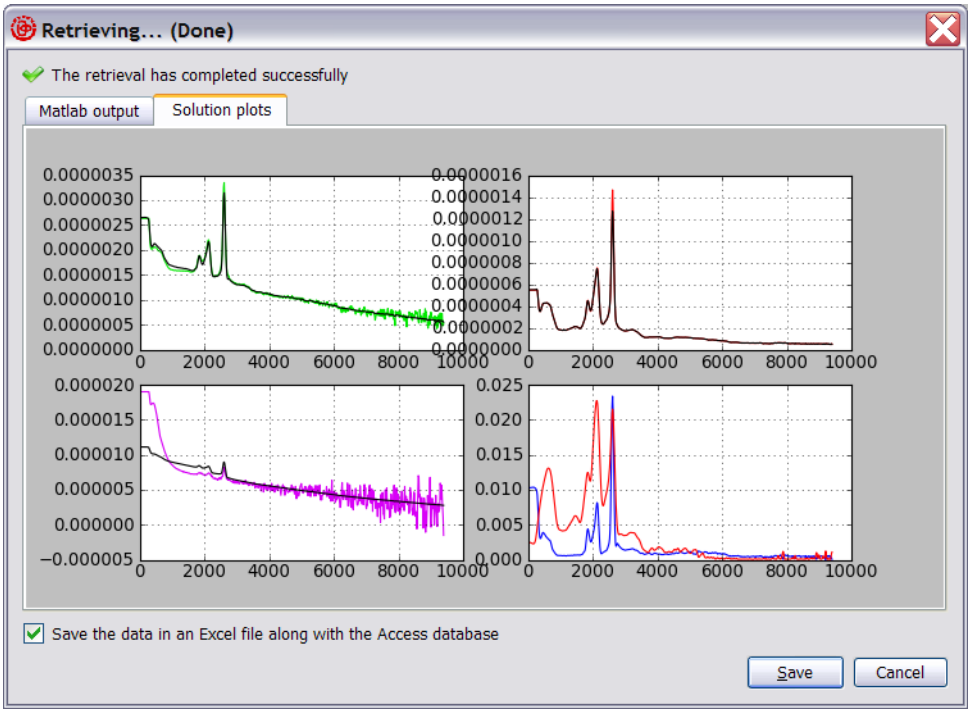


Fig. 6. Aerosol mode concentration profiles retrieval results

Appearance of the dialog box that reflects the retrieval progress is presented on Fig. 5. In case of a success, plots that visually characterize the retrieval results are displayed in the dialog upon completion of the algorithm (Fig. 6).

Horizontal axes of all of the plots represent heights above the measurement point in meters. The lower right plot displays the retrieved aerosol mode concentration profiles. Blue color is used to represent fine mode concentration profile, and red color is used for coarse mode concentration profile. The remaining three plots visually characterize the extent to which the retrieved aerosol model corresponds with lidar measurement data. Black color is used for lidar signals calculated on the basis of the retrieved aerosol model, whereas green, red, and purple colors are used for lidar signals that were actually measured at 532, 1064, and 355 nm wavelengths, respectively.

Retrieved aerosol profiles are appended to the previously selected database (see section 3) when the "Save" button is pressed. There is also a means of saving the retrieval results in a file in Microsoft Excel format along with the database. If the corresponding checkbox is set in the lower part of the dialog window, the data will be written to the Excel file once they get appended to the database.

Name of the Excel file is determined by replacing the ".mdb" extension of the database file name with ".xls". Structure of the Excel file resembles that of the database and makes it possible to store an arbitrary number of data records. If the file does not exist when the saving occurs, then a new file is created, holding a single data record. Otherwise, the data record being saved is appended to the existing file.

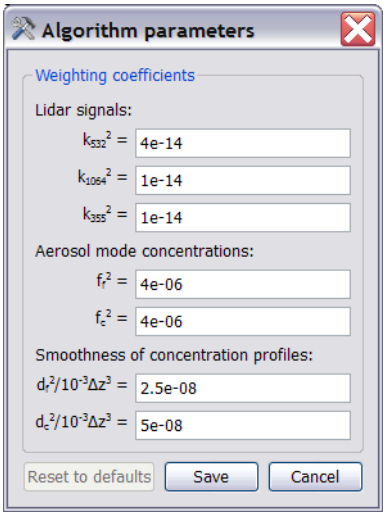


Fig. 7. Algorithm parameters dialog box

5. Adjustment of the algorithm's weighting coefficients

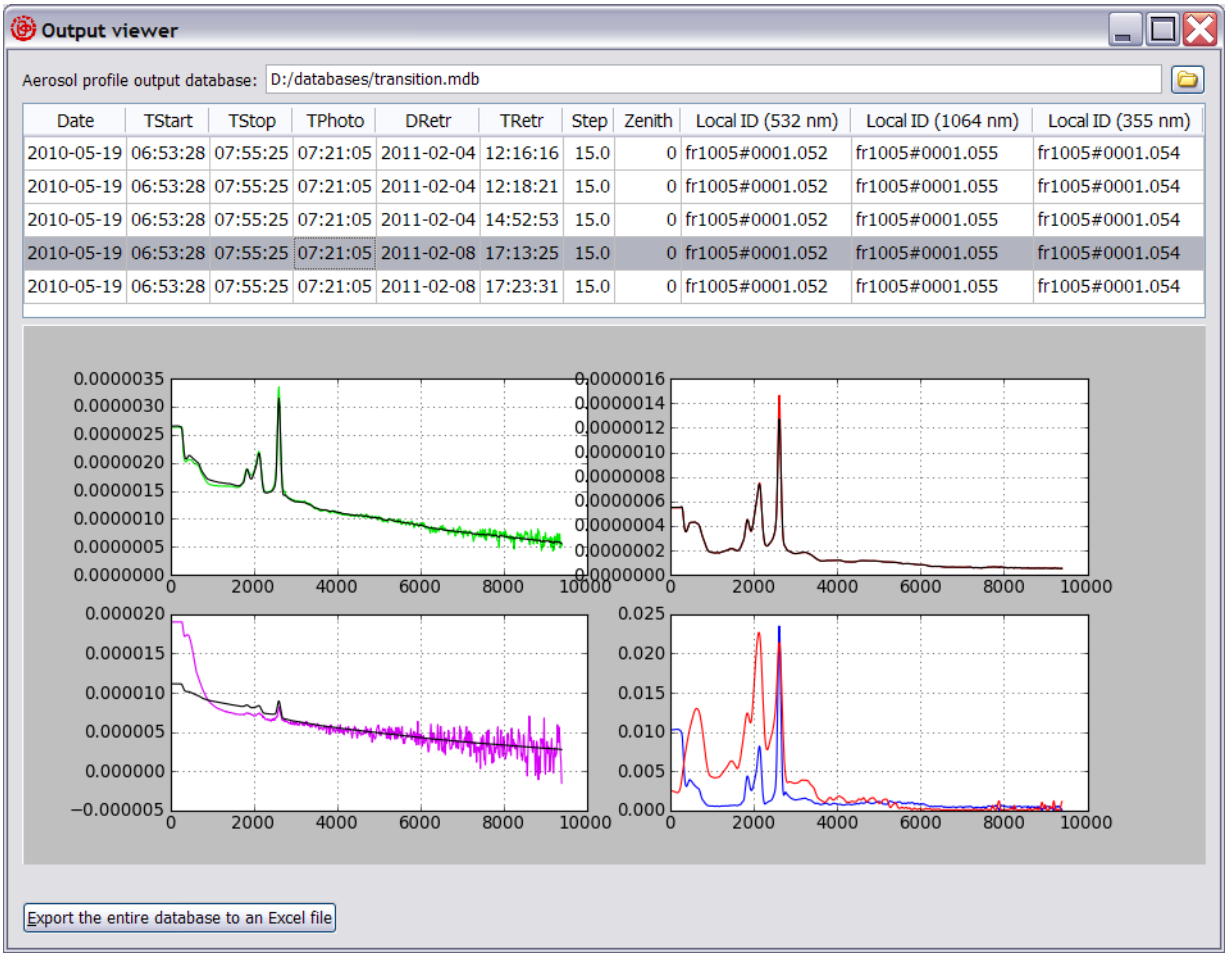
The function that is minimized by the algorithm includes lidar signal residuals, at three wavelengths, and also residuals for total aerosol mode concentrations (2 terms) and 2 more terms responsible for smoothness of the profiles being retrieved. Simultaneous optimization of several heterogeneous parameters is accomplished by introduction of weighting coefficients whose values are chosen on the basis of the algorithm's convergence analysis. On the other hand, to perform the convergence study, one has to be able to assign arbitrary values to the weighting coefficients. Possibility of the latter is implemented in the software by means of the "Algorithm parameters" dialog box (Fig. 7), invoked via the button of the same name that is located in the lower left corner of the main application window (see Fig. 2).

Pressing the “Save” button will apply new weighting coefficient values for all the subsequent runs of the retrieval algorithm. Pressing “Reset to defaults” button will reset all the values displayed in the dialog to their defaults defined within the application’s program code. Pressing “Cancel” button will close the dialog without saving the changes.

6. Browsing of retrieved aerosol profile databases

For browsing of retrieved aerosol mode concentration profile databases, a separate **“ProfileViewer”** application is provided, that may be launched either on its own or via the “View output” button located in the lower right corner of the main application window (see Fig. 2). The difference between these launch methods is as follows:

- if the application is launched on its own, then the database that was opened in the application during its last run will be opened at the startup, and none of the database records will be initially selected;
- if the application is launched via the “View output” button, then the database selected in the lower part of the main application window (see section 3) will be opened at the startup, with its last data record being initially selected.



Date	TStart	TStop	TPhoto	DRetr	TRetr	Step	Zenith	Local ID (532 nm)	Local ID (1064 nm)	Local ID (355 nm)
2010-05-19	06:53:28	07:55:25	07:21:05	2011-02-04	12:16:16	15.0	0	fr1005#0001.052	fr1005#0001.055	fr1005#0001.054
2010-05-19	06:53:28	07:55:25	07:21:05	2011-02-04	12:18:21	15.0	0	fr1005#0001.052	fr1005#0001.055	fr1005#0001.054
2010-05-19	06:53:28	07:55:25	07:21:05	2011-02-04	14:52:53	15.0	0	fr1005#0001.052	fr1005#0001.055	fr1005#0001.054
2010-05-19	06:53:28	07:55:25	07:21:05	2011-02-08	17:13:25	15.0	0	fr1005#0001.052	fr1005#0001.055	fr1005#0001.054
2010-05-19	06:53:28	07:55:25	07:21:05	2011-02-08	17:23:31	15.0	0	fr1005#0001.052	fr1005#0001.055	fr1005#0001.054

Fig. 8. Graphical user interface of the “ProfileViewer” application

Graphical user interface of the “ProfileViewer” application is represented on Fig. 8. To select a database file to be displayed in the application window, one has to press the “” button located in the

top right corner of the window. The contents of the database are represented in the form of a table with the following columns:

- “Date”, “TStart”: date and time of the beginning of the earliest of the lidar measurements used in the retrieval;
- “TStop”: completion time of the latest of the lidar measurements used in the retrieval;
- “TPhoto”: time of the radiometric measurement;
- “DRetr”, “TRetr” : completion date and time of the aerosol profile retrieval algorithm run;
- “Step”, “Zenith”: lidar signal discretization parameters (identical for all of the three signals), with the same meaning as in the single signal case (see section 1);
- “Local ID (...)”: textual identifiers of the lidar measurements used in the retrieval.

In the lower part of the application window, plots that visually characterize results of the currently selected retrieval are displayed as well. These plots represent the same data that are displayed upon successful completion of aerosol profile retrieval in the dialog box described in section 4.

It is possible to adjust sizes of window sections occupied by the table and the plots by dragging their horizontal boundary with the mouse.

It is also possible to export the entire database being displayed to a file in Microsoft Excel format with “ProfileViewer”. Name of the file and its structure will be the same as those used in Excel file saving procedure in the aerosol profile retrieval dialog box (see section 4). To launch the export, one has to press the corresponding button located in the lower left corner of the application window.