CALITOO

SunPhotometer

User Manual

October 2016

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This manual is not a contractual document and the information contained herein are subject to change without notice.
Please read this manual carefully before using your photometer.

This manual as well as technical informations, tutorials and software configuration of the photometer are available on our website :

http://www.calitoo.fr

Summary

Introduction

This document allows you to take control of the photometer CALITOO and make measurements with a scientific value. Its use is suited to the terrain and the manipulation of public schoolchildren under the Calisph'air operation.

Calisph'Air(1) is an educational project for the **study of the atmosphere and climate** that accompanies **satellite missions** to study the atmosphere Parasol, Calipso, IASI ...

This project is developed within the framework of **educational and scientific international GLOBE program**(2), which brings together students, teachers and scientists around the observation and collection of environmental data. GLOBE brings together through the Internet, more than 15,000 schools and 26,000 teachers worldwide.

The program has a study of aerosols, with Calipso data as well as measurements from the ground, with a sun photometer.

(1) http://www.cnes.fr/web/CNES-fr/7167-calisph-air.php

(2) http://globefrance.org/

In the first part, we will guide you in using the photometer.

The second part presents the use of PC software and downloading data.

Part Appendix lists the specifications of the device.

Revisions

Version 1.0 – September 2013

- Downloading the photometer data to a PC

Version 1.2 – March 2015

- Change of format of the date and time to respect the international format (ISO8610).
- Ability to work with the data of a photometer without connecting the photometer to the PC.
- "Visu" tool to view data in the form of curves.
- 'Langley' tool for Langley calibrations of the photometer

Version 2.0 – October 2015

- Monitoring tool to display the photometer data in real time on a curve.
- Intercalibration tool for calibration with professional standard photometers (Aeronet).
- AOT-Calculator tool to compute AOT by manually entering all other parameters.
- AOT Processing tool to re-compute the AOT of old measurements after a new calibration.
- Uses the decimal separator of the host computer.
- Ability to update the firmware of the Calitoo device via internet.

Version 2.5 – October 2016

- Display on the photometer of the Angström coefficient when taking measurements and reading the data.
- "Visu" tool is upgraded with the "Angström" button to compute and display the Angström coefficient of each measurement point on a small graph and a gauge
- “Export” tool to collect all the data of a photometer in a zip file to be exchanged with other people.
- “Import” tool to import a photometer zip and visualize the data of this photometer with Calitoo PC software.

1 Starting with Calitoo

1.1 Batteries

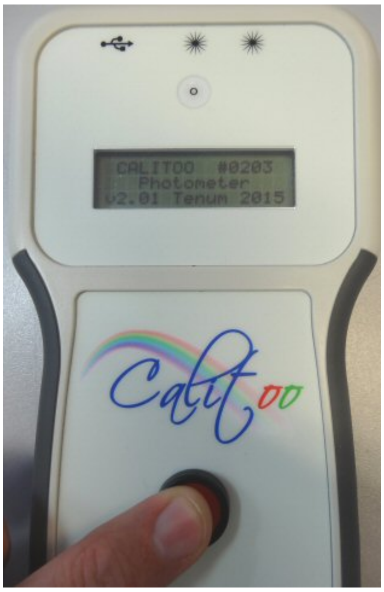
The photometer uses 4 AA batteries located under the hatch at the rear of the unit.

The implementation is facilitated by first placing the side '+' of the battery into place.

You can also use rechargeable batteries

1.2 Power ON

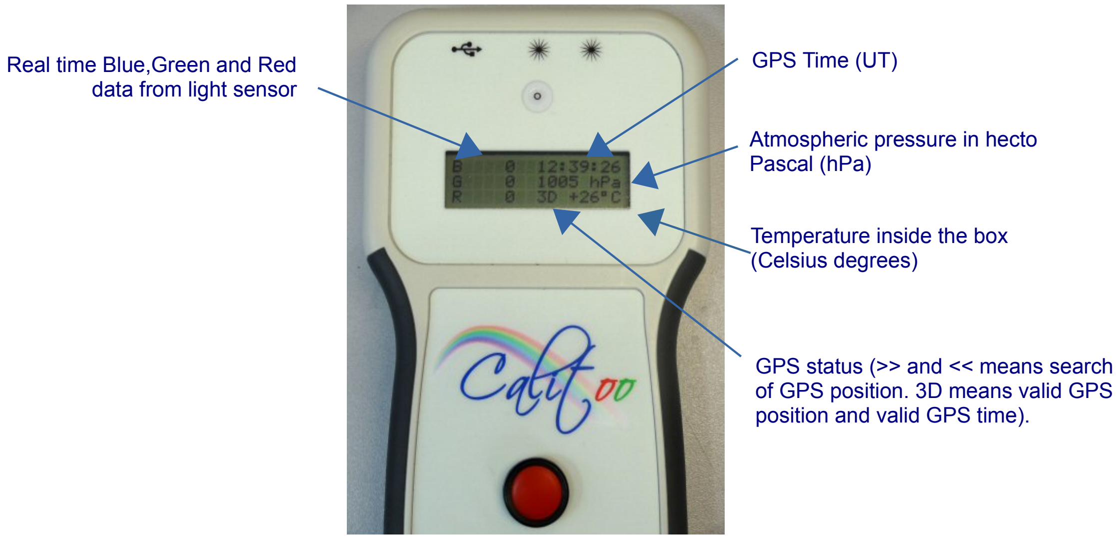
The photometer is turned on by pressing for 2 seconds on the center button.



As soon as the text appears, you can release the button and the unit is in operation.

1.3 First measurements

After turning the welcome page, the photometer indicates that it is in measuring mode and displays basic informations :

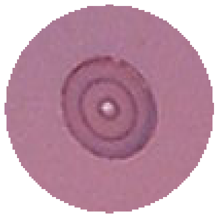


Once the GPS photometer is 3D, you can start measuring.
If the GPS is not in 3D, you can not do recordable measurement

1.4 Point to the Sun

Pointing the photometer is manual, it is facilitated by the sighting device located above the LCD screen.

You have to stand facing the Sun stably and quickly bring the bright spot in the middle of the target pointer and keep the same time measures.



The Sun spot is on the center of the target : the photometer is pointed.

1.5 Maximum

The goal is to get the maximum value in three colors during about 1mn of search.

Click the button on the photometer and you go to the page maximum measurements (assuming of course that you had stayed on the base page described above).

While keeping an eye on the target, you monitor the numerical measured values on the screen. When maximums do not change, after about one minute, you go on to the next step.

1.6 AOT display

After displaying maximum values page, by pressing one more time on red button, Calitoo computes AOT and displays results on a new page.

If results seems be wrong for you, you can choose to do not recording it (see section 1.8)

1.7 Alpha display

Click on the button again and you are on the fourth page, the page of the Alpha parameter or Angström coefficient.

This coefficient allows to characterize the type of particles detected by RGB light measurements. Computation method is detailed in Appendix 4.2.

R2 is a certitude index. 1.00 is a total certitude with the calculated Alpha while 0.50 is 50% of certitude.

1.8 Memorization

Click the button again and you are on the fifth page that is recording. You can read the complete sequence of operation of the button in the annexes

The photometer will ask if you want to record (the measures).

If this is the case, you should always press the button, but this time hold it down until **Recorded !** appears at the bottom of the screen.

Then you release the button and find yourself on the base page for a new round of measures.

If you are not satisfied with your measurement and you do not want to save, a single click will cancel the operation and you find yourself back on the base page for a new measurement cycle.

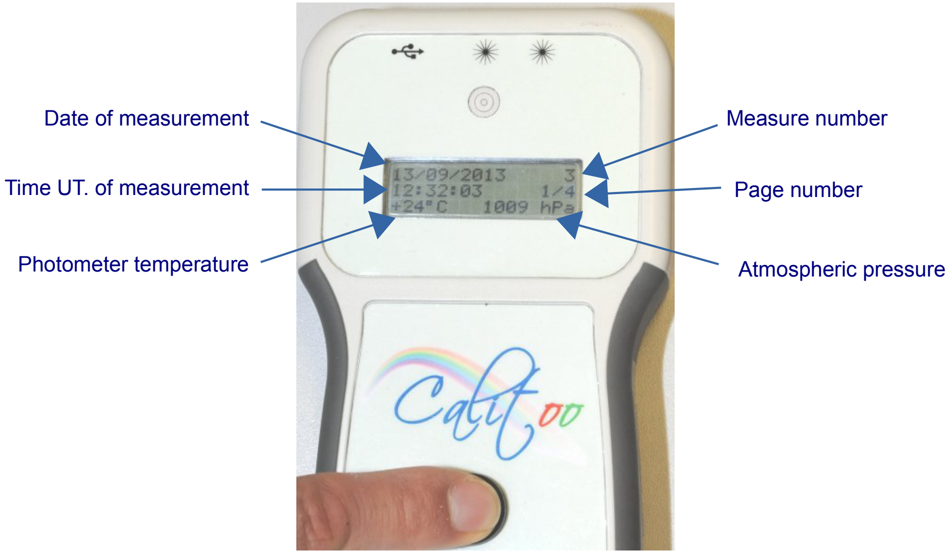
1.9 Reading data

To read the latest measurements, you go to the basic page and do a long button press on the photometer.

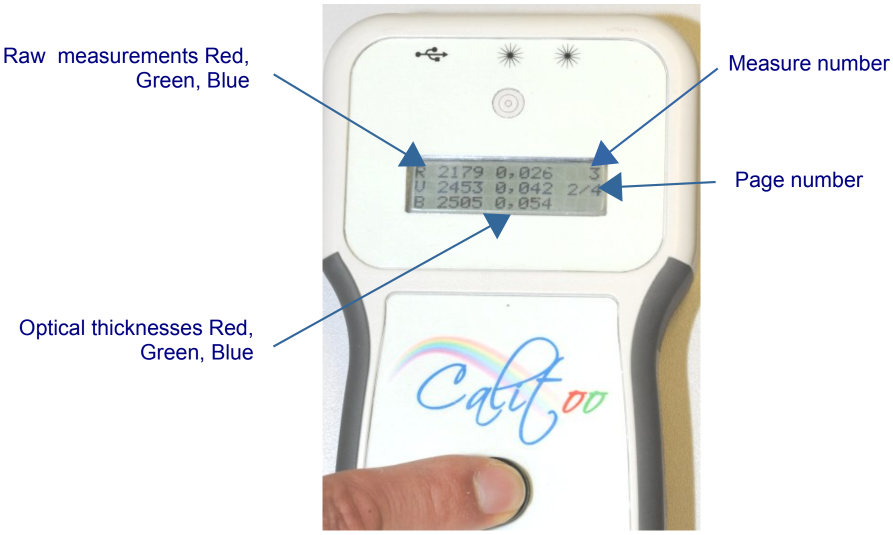
As soon as he tells **Mode READING** you release the button.

Every step, starting with the most recent, is presented in 3 pages :

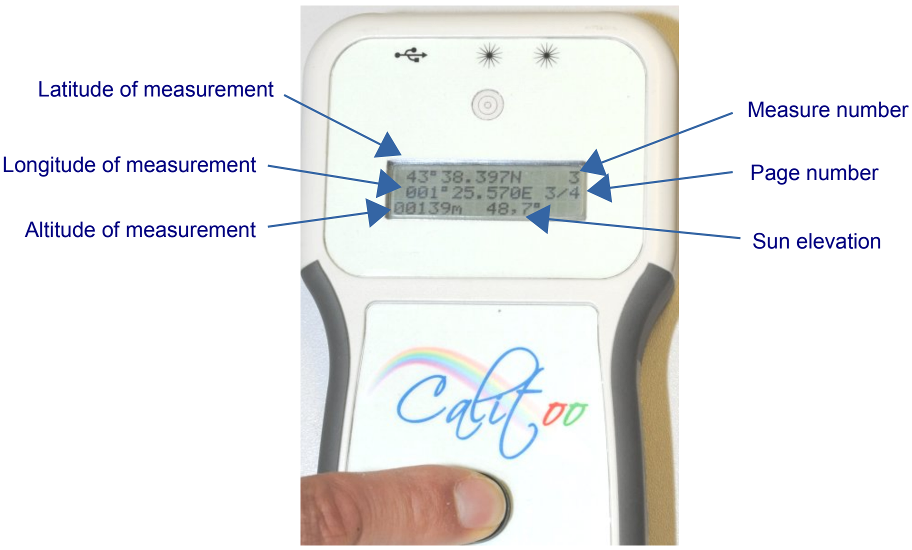
Page 1/4



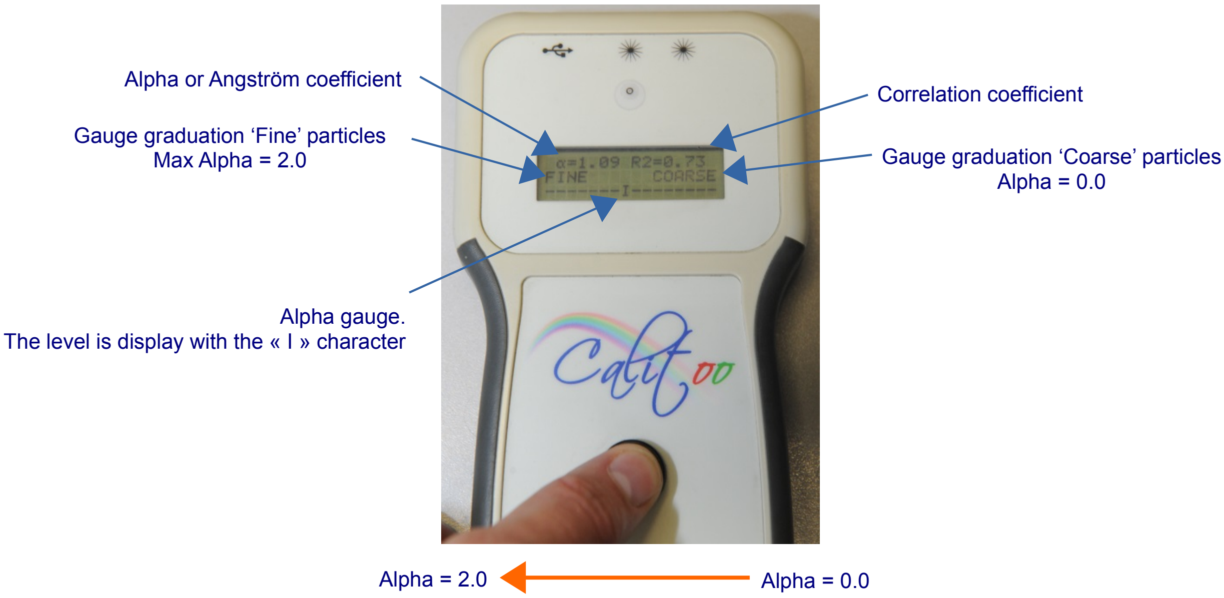
Page 2/4



Page 3/3



Page 4/4

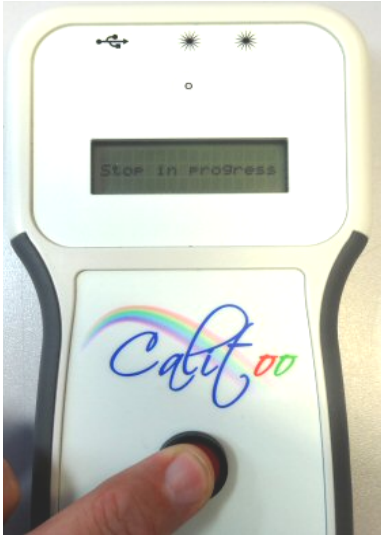


1.10 Mode change

To switch back to the **Mode MEASURING**, you have to long press the red button. Release the button when the new mode is displayed.

1.11 End of working

To turn off the photometer must be left long press the button to the message: **Stop in progress**... Release the button and the photometer is turned off.

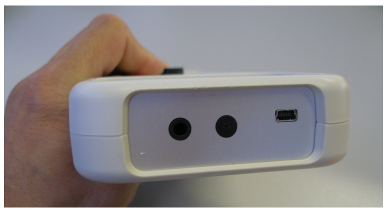


When the photometer is stand by during 30 minutes at least, it automaticaly turn off to preserve battery power.

1.12 Cautions

Your photometer is an optical measuring instrument and should not hinder the path of sunlight to the sensor.

To do this, we deliver with an adhesive in front of the holes in the viewfinder and the sensor. After use, we strongly recommend that you do the same.



Do not forget to remove the tape to your measurements 

2 PC software

2.1 Downloading and install

The PC software used to download data from photometer and process measurements is freely enable on our web site.

We have written Windows, Mac_OS and Linux versions.

We guest you to read tutorial sheet of each operating system you can found in annexe section of this user manual ?

Before starting the program, it is imperative connect the photometer PC and turn it on.

2.2 Start the software

Double-click the icon starts the program will start by searching to establish the software connection with the photometer. (Figure 1)

Once the operation is successful, the screen displays the photometer **CONFIG** mode and the program indicates the serial number of the photometer connected (Figure 2).

It is possible to start without connect the photometer (see §2.3.2)

The program offers through the following tabs :
Identity : Indication of unique serial number identifying the photometer. It will be included in the data files produced.

Data : Management of stored data (download and delete)

No : calibration parameters (No.) of the three measurement channels.

Rayleigh : Parameters for the calculation of molecular diffusion coefficient in calculating the optical thickness of the three measurement channels.

Ozone : Parameters for the calculation of the contribution of ozone in the calculation of the optical thickness of red and green (blue is negligible).

Tools : Open access of a tools set for measurements processing and calibrations operations.

Figure 1

Figure 2

2.3 Data downloading

2.3.1 Data staying in photometer memory

Downloading data is proposed in **Data** tab of the software (Figure 3).

A single click on the folder icon and the operation is started (Figure 4).

Figure 3

Figure 4

2.3.2 Working with data without connecting the photometer

You can use the software without connecting the photometer to the computer.

If the software does not detect a connection with a photometer, he suggests :

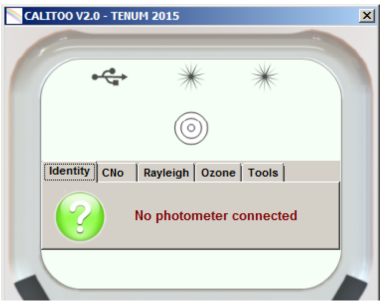


Figure 5

It is possible that despite all, the software initiates a connection with a search of Calitoo (**Figure 1**).

Just click on the question mark icon to perform a direct link to the data folder of your photometer or if you have more than one device, a list of numbers of photometers to choose from.

Figure 6

2.4 Data erasing

The icon representing a broom and a memory, erases all 999 measures that may contain the memory of the photometer.
The program asks you to confirm (**Figure 7**). If your answer is OK, erasure is performed.

Warning : erasing operation is final .

Figure 7

2.5 Scientific parameters

Your Calitoo is sold calibrated. The calibration parameters are stored in the photometer and are visible on the web site www.calitoo.com, in the Calibration tab.

Be careful if you change these values, knowingly or after a new calibration or if you notice any differences with calibration parameters online. .

To send the new values to photometer you have to edit it and to click on the submit button.

They will be stored in the photometer even after a power off and used for calculations of optical thicknesses of the new measurements.

Measurements made before this change will remain unchanged. If these must be rectified, the only way is to redo the calculations with the **AOT Processing** tool described below.

Parameters are:

- **No** : is the numerical value that give your photometer if it came out of the Earth's atmosphere (Figure 6).
- **Rayleigh** : is a coefficient that takes into account the distribution of light at a specific wavelength by the molecules of the clean air.
- **Ozone** : is the contribution of stratospheric ozone to the optical thickness. It is zero for blue.

For more information of calculation method,
read in the annexes :**4.1 Optical thickness calculation**

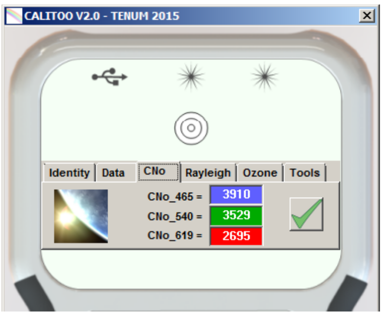


Figure 8

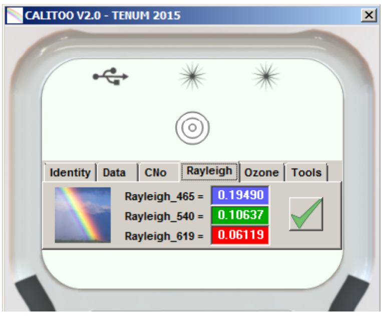


Figure 9

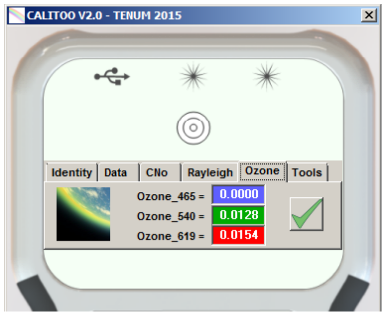


Figure 10

2.6 Work ending

To quit the configuration and data management, just close the main program window.

3 Toolbox

The last tab offers a software toolkit.
Click on the toolbox icon to see available tools :

We use some of these tools for the calibration and adjustment of photometers during manufacture. We put at your disposal as they can be used with different objectives:

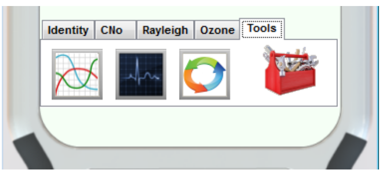
Teaching goal : Your students can experience the calibration methods, make autonomous measurement devices, etc.

Autonomy and quality : You can maintain a good quality measurement by making or doing calibrations over the world.

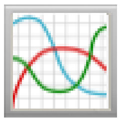
Here is a description of the seven tools in this software release :

- Data display
- Monitoring
- Langley type calibration
- Aeronet Inter-calibration
- AOT caluculator
- AOT processing
- Import/export data from other photometers devices

The software displays on the tool tab, the three most used tools to facilitate their access. Be careful, during the first use, you have to open the toolbox to choose your primary tools.



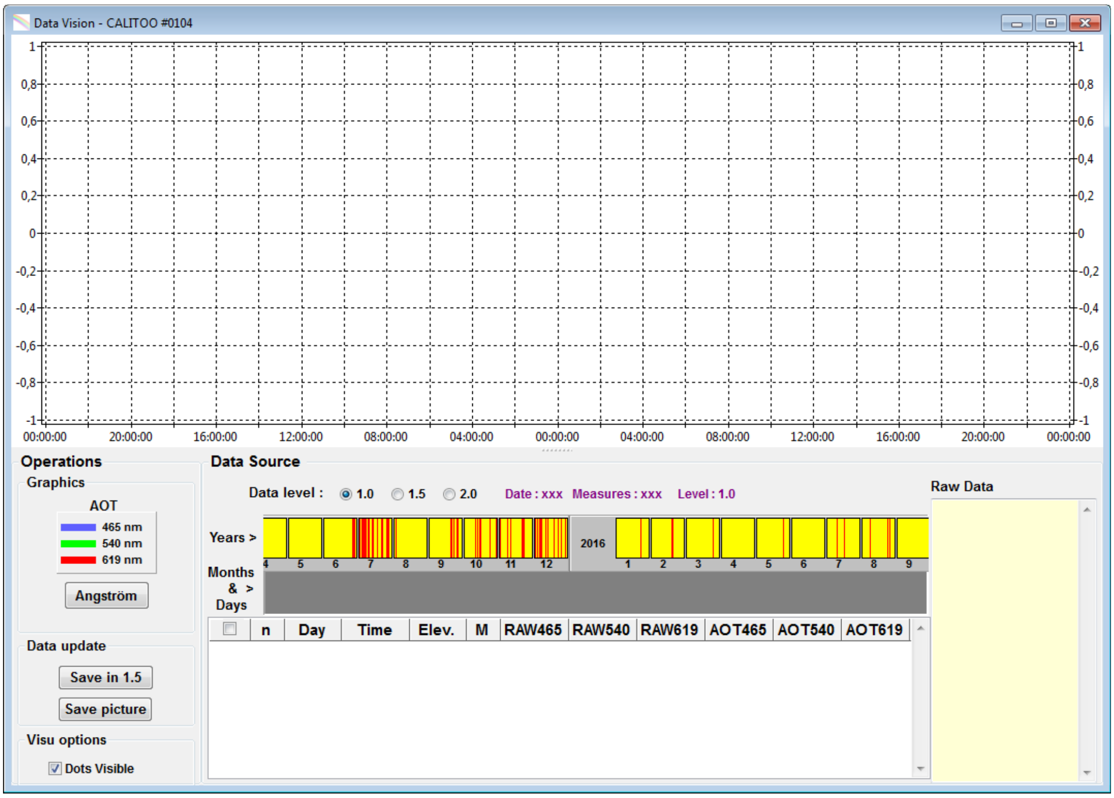
3.1 Data Visualization



After taking measurements of optical thicknesses, it is important to quickly view the data in the form of curves to begin their processing and interpretation of results.

3.1.1 Displaying data curves

Here is the window appears on the screen just after clicking on the icon **Data visualization**



This windows is composed of the following items :

Data Source panel

Panel Indicates the presence of available data. These data are previously downloaded from the photometer selected.

You choose the period of the measurements to visualize in a few clicks.

The data related to your choices are rows in a table below the calendar and text viewer in the **Raw Data**.

Curves display grid.

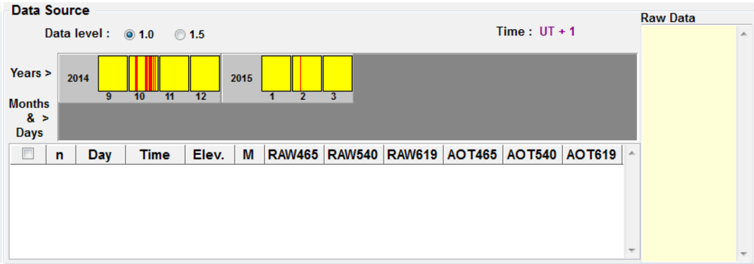
The three AOT curves are displayed according to the time (GMT).

Operations panel

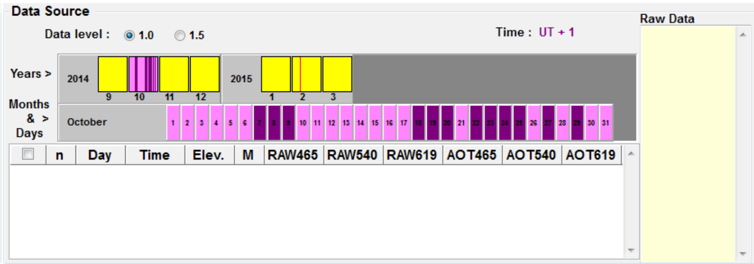
Indicates the legend of the displayed curves and allows backing up data after processing

3.1.2 Select measurements period to display

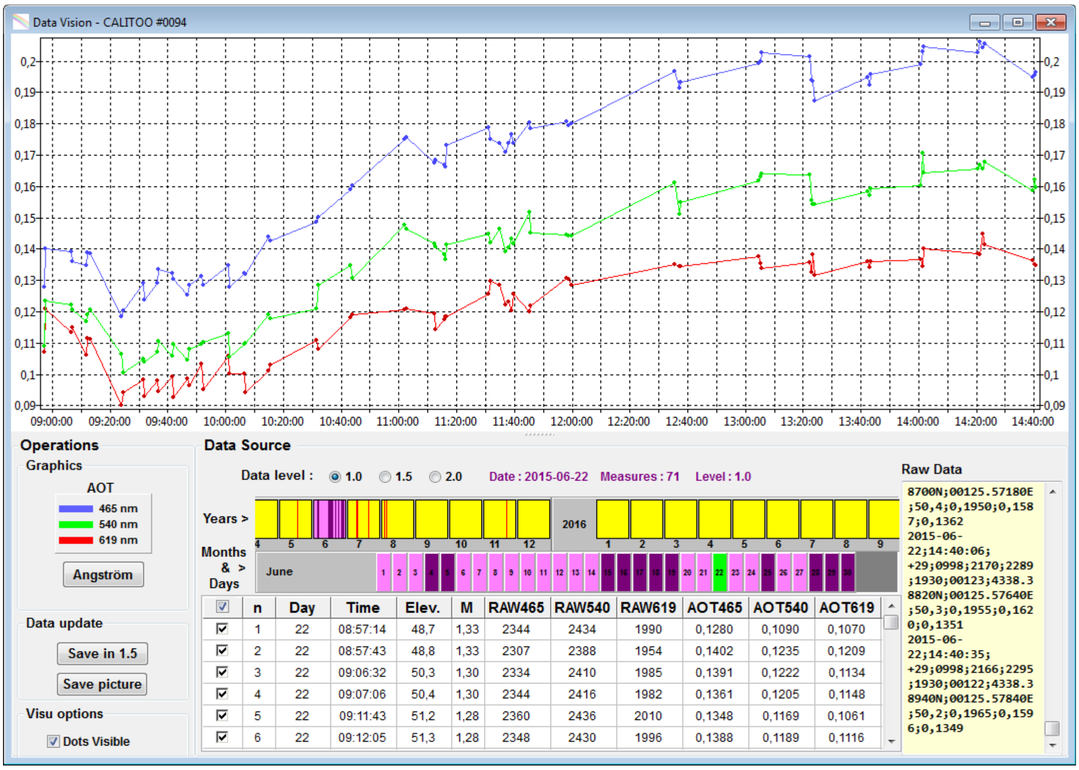
Graphical calendar allows you to view a glance whether photometer data exist :



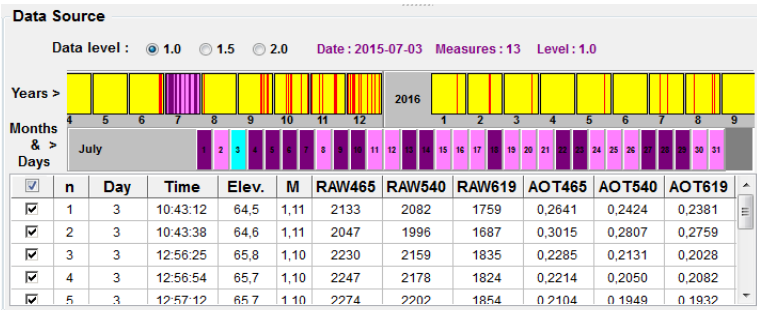
Select year month and day containing the data you want to work. The panel of months and years is sliding with the mouse.



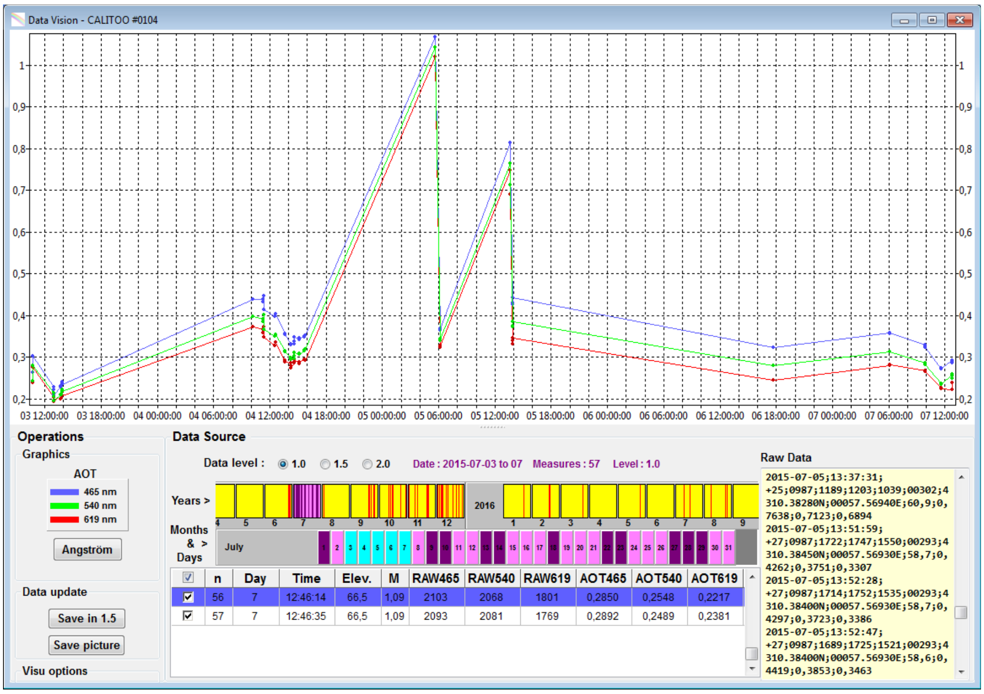
The data is immediately displayed at once in the data table, the data text viewer and curves drawing :



You can view the data of several days : one must press Shift while clicking the first and last day of the selected interval.



Note that day boxes are colored in light blue



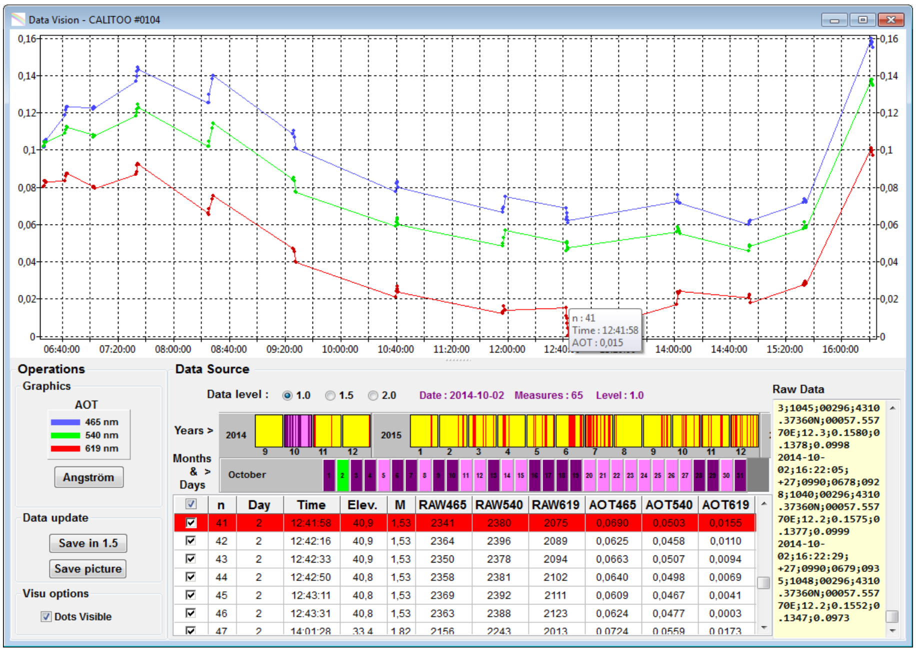
3.1.3 Manual data filtering

The manual filtering remove wrong data in your scientific user eyes.

For example, applying the rule: "The best measure is the one that gives the lowest optical thickness," to a group of three measures taken following, you will keep the point of the lowest value.

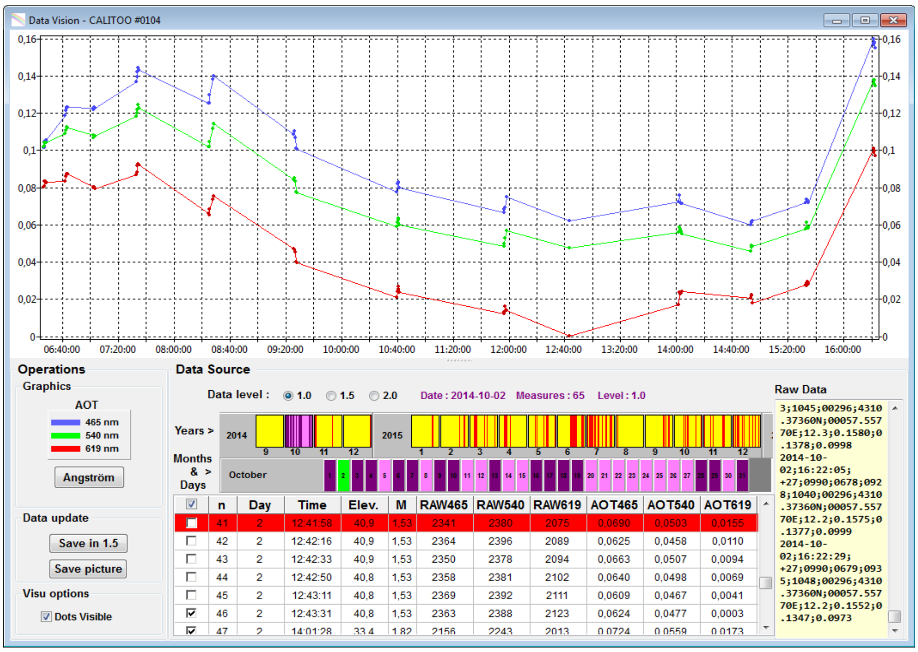
How to delete point ?

You move the mouse pointer over a curve point : the line of the corresponding data in the table is highlighted by the appropriate color.



Raw data taken october 2nd 2014

Just uncheck the line to erase data curves (dots n = 41 and following)



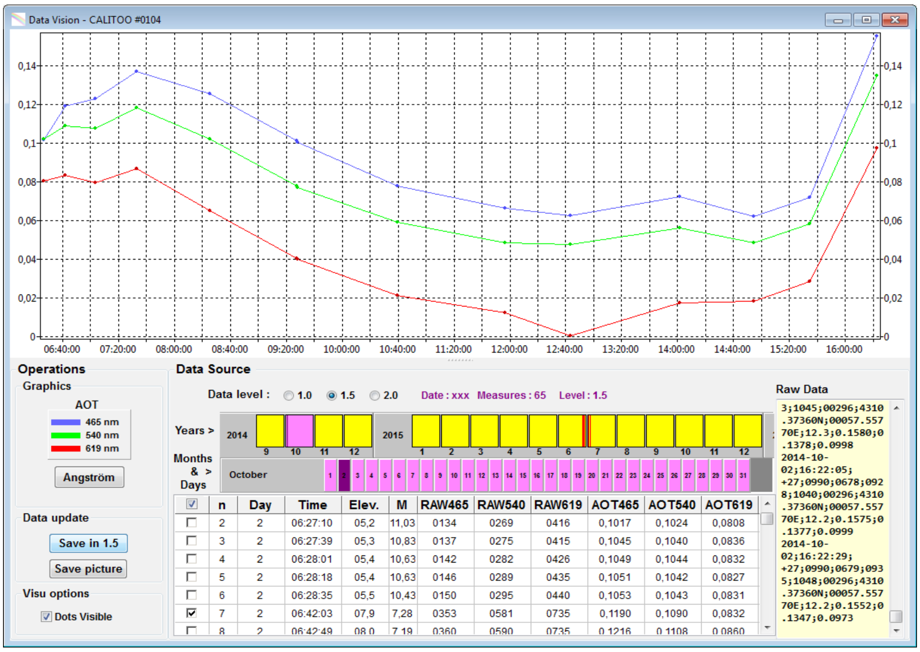
Data filtering in progress

Other reasons may cause you to delete data :

- AOT too fast variations may indicate the passage of a light veil over the sun: it should eliminate AOT higher values (smoothing the top) of a group in the time measurements .

[See screenshot before and after delete]

- Very hight AOT values. We estimate that more than 0.5, the optical thickness is too hight to be only caused by aerosols and the role of atmospheric haze is not negligible .



When the job is finished, the processed data should be saved by clicking the [Save in 1.5] button. The data is now type 1.5 and stored in the appropriate folder.

See Appendix 4.7 for file descriptions.

3.1.4 Size particles determination

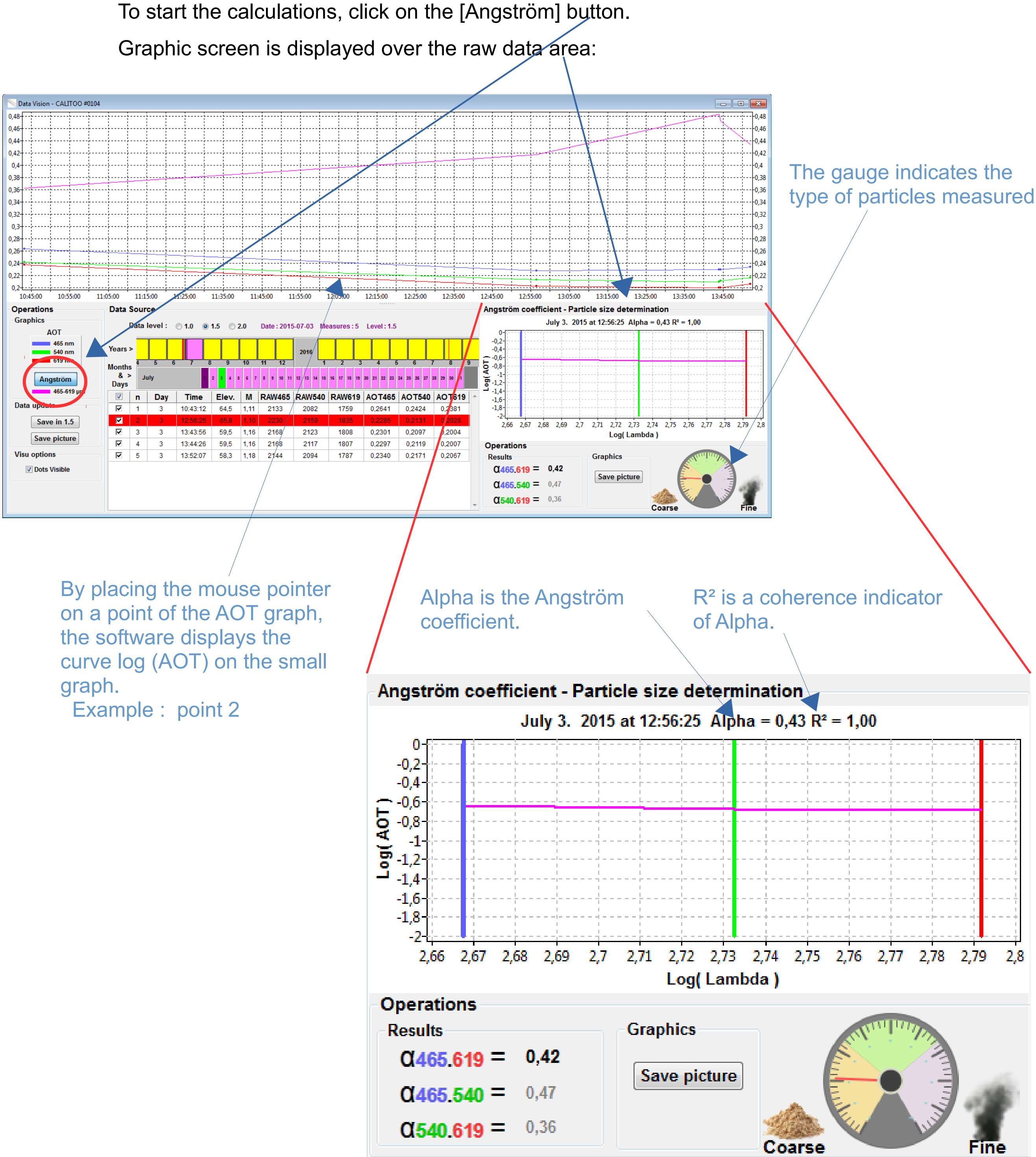
The Angström coefficient noted Alpha, makes possible to determine the size range of the measured aerosols. The computation of alpha is described in Appendix 2.4,

The small (Fine) aerosols are similar to smoke and those of large size (Coarse) are of the "dust" type.

The Calitoo is able to differentiate the fumes of forest fires from the sand of the Sahara brought by the wind over Europe.

To start the calculations, click on the [Angström] button.

Graphic screen is displayed over the raw data area:

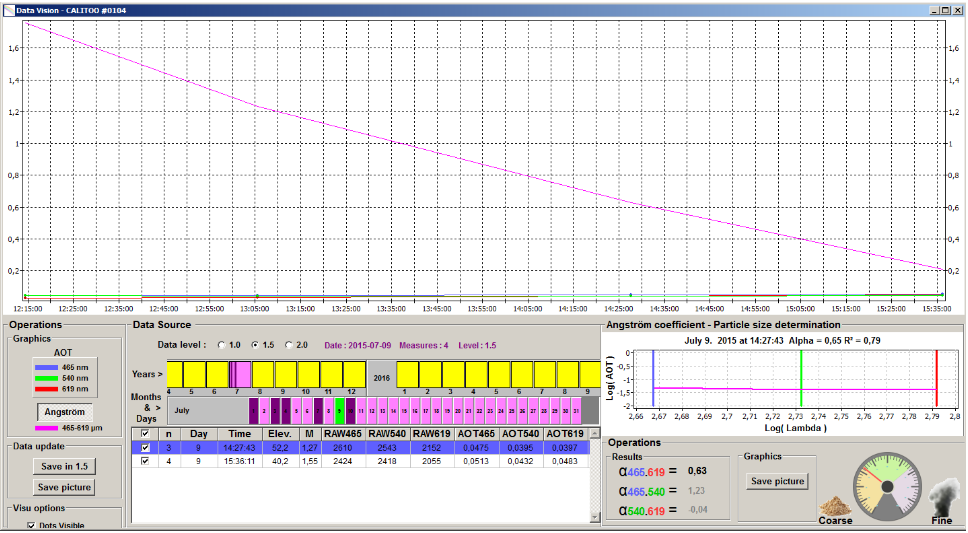


Mathematically, Alpha is the steering coefficient of the slope of the straight line formed by the decimal logarithms of the AOTs as decimal logarithms of their wavelength (Also, you can use Neperian logarithms for the two axes).

Be careful : interpretation of results is tricky. There are several signs to take into account to validate what you measure.

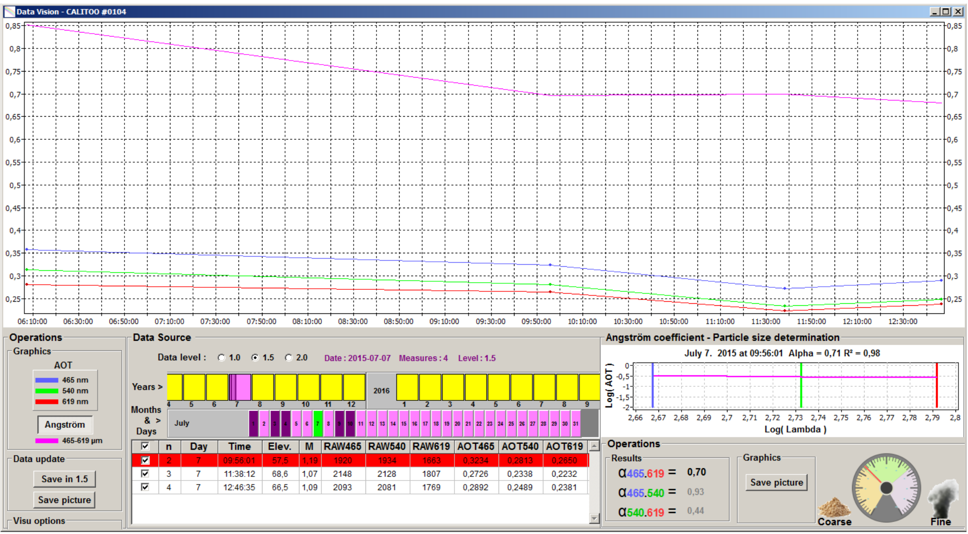
1 / The coefficient of Angström varies very little in one day.

2 / The correlation coefficient R² is an indicator of the coherence of a measure. If it is less than 0.95, the results must be considered unreliable.



Here we go from fine to coarse particles in 3 hours. A variation of the Alpha of 1.4 is enormous!

The R² of the points of the day oscillate between 0.97 and 0.72, which confirms the impossibility of interpreting these results.



In this case, Alpha varies from 0.15 in 6 hours and the R² are all close to 1.

The interpretation of the results can be taken into account. It will be possible to check on websites the presence of particles in the atmosphere of the observation site :

[Prévision de la concentration de poussière (Université d'Athène)]

3.2 Data monitoring

The monitoring tool perform autocratically real-time measurements. You can choose data acquisition rate.

Results are displayed by curve drawings and text numbers.

3.2.1 Raw data monitoring

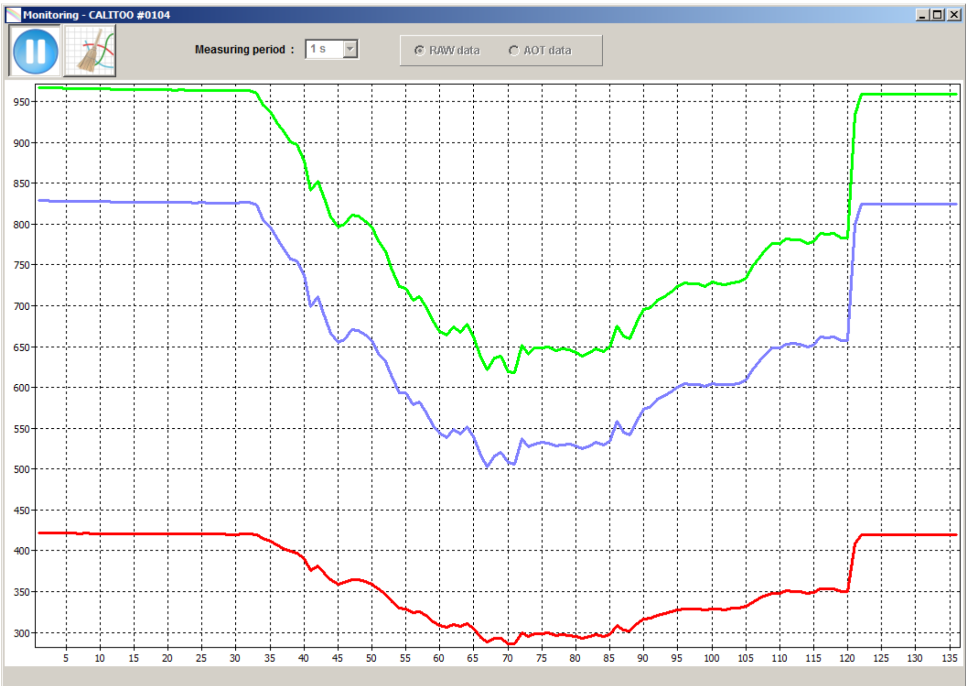
We use this mode to find optical alignment with the Sun and so place the target circle in good position for each Calitoo device.

We enable you this tool because it can be used to guide an automatic system mounted on motorized platform, by example.

Photometer take measurements up to 5 data per seconds.

To start measurements, click on blue button at the top left of the monitoring screen.

Example of raw measurement curves made with the mounting of the following page:



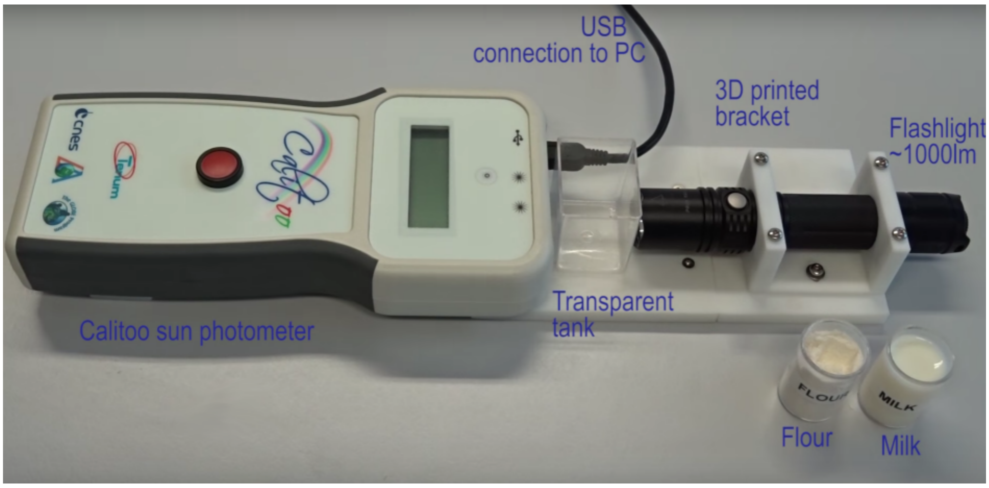
Raw measurements monitoring

3.2.2 Experimenting AOT monitoring

Understanding by experimentation is important in aerosols studies.

Aerosols can be modeled using particles in water that behave similarly to those in the air.
The use of water makes it possible to keep the particles in suspension longer, to remain in a restricted area (aquarium) and does not require an enormous volume (about seven in^3). Finally, the experimenter can easily change the type of particle to be observed..

Here is a montage that uses a high power LED lamp and a device that allows to align the Calitoo with the lamp while leaving a space to place the mini aquarium that contains the water :



Picture from video clip which explains the experiment

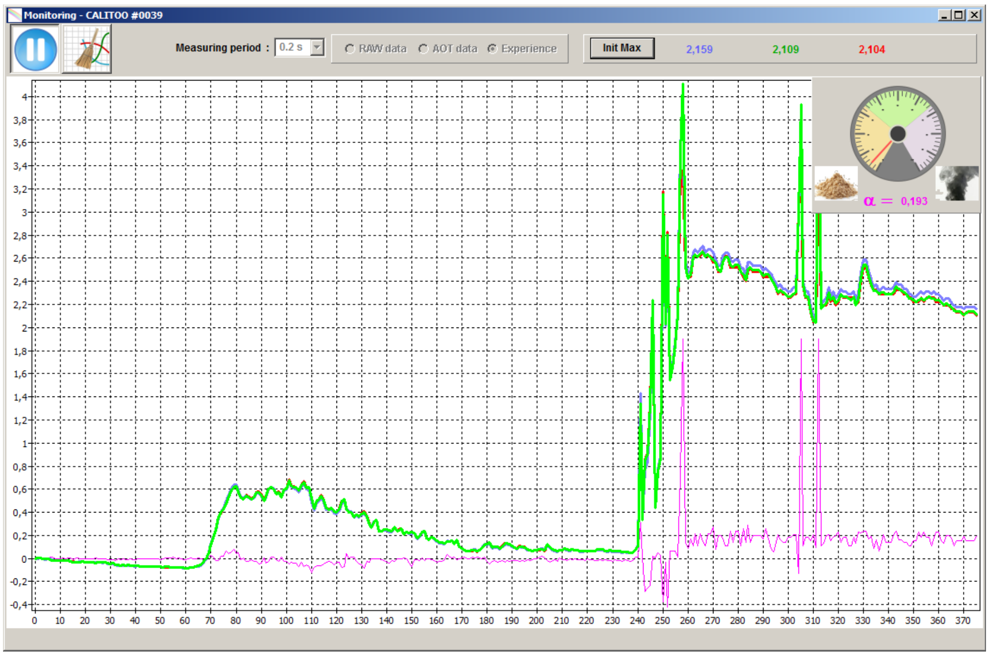
[Calitoo video experiment]

Results of measurements with milk: The Angström coefficient (Alpha) is high, indicating the presence of fine particles in majority.

Visually, the blue, green and red curves are spaced apart.

Results of measurements with flour: The Angström coefficient (Alpha) is low, indicating the presence of large particles in majority.

Visually, the curves blue, green and red are tight.



Tenum distributes a complete kit to repeat these experiments in class or in training.

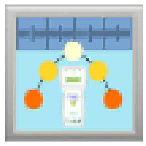
[Particle sizer on web site Tenum shop]

Other possible project :

Automatically measure continuously in the manner of the photometers of the Aeronet network : a motorized device to point the Sun before each measurement.

It is therefore fairly easy to make an aerosol profile for a full day.

3.3 Langley calibration



3.3.1 Principle

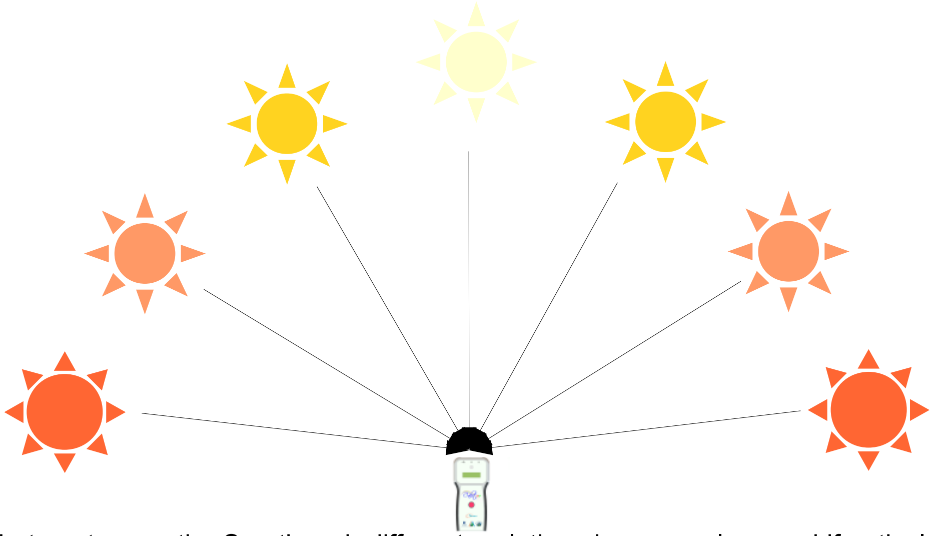
The photometer calibration consist to determine by measurements and calculs, the light raw value given by a device at the atmosphere top, in a precise lengthwave.

In the case of the Calitoo, calibration coefficients are binary numbers and named CN_0 (Numérique zéro). We have CN_0_465 for the blue, CN_0_540 for the green and CN_0_619 for the red.

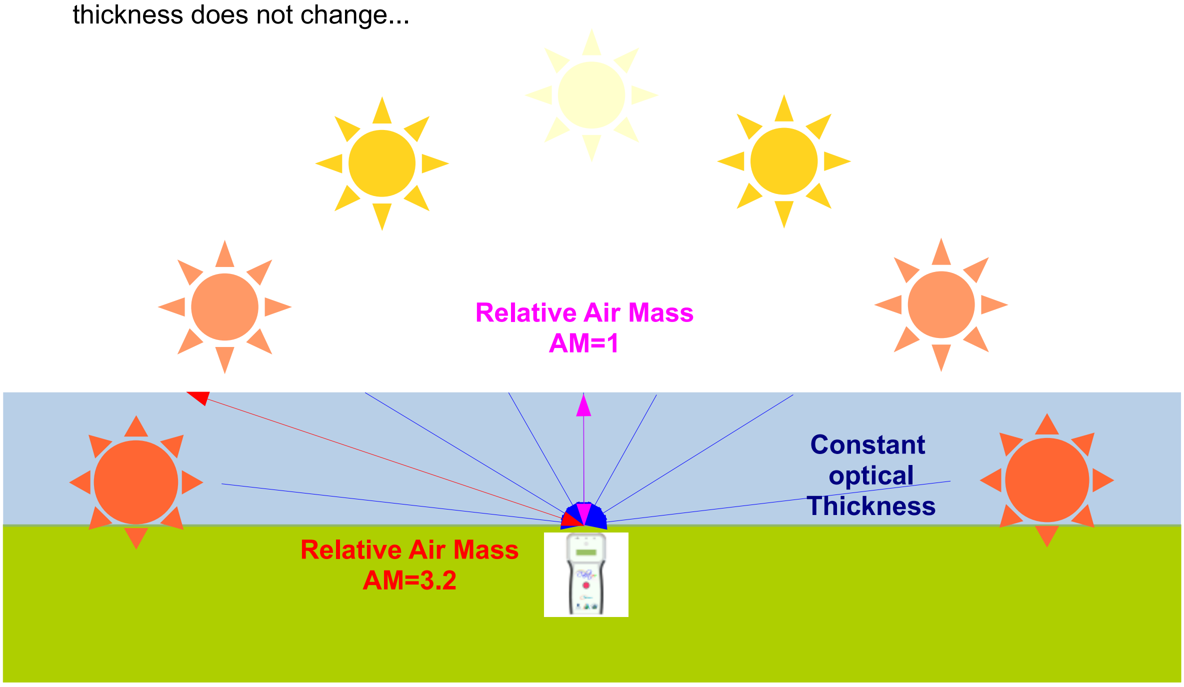
3.3.2 Method

Langley method consist to take light measurement with differents atmospheric thickness

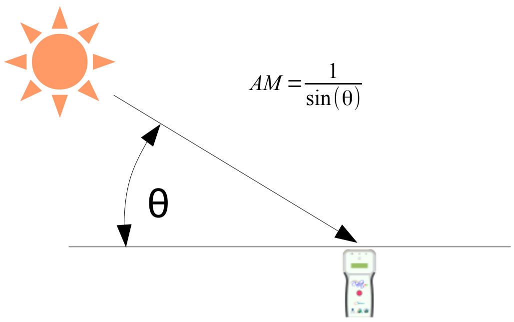
Otherwise, optical thickness must not change. You have to take measurements by calm and stable weather.

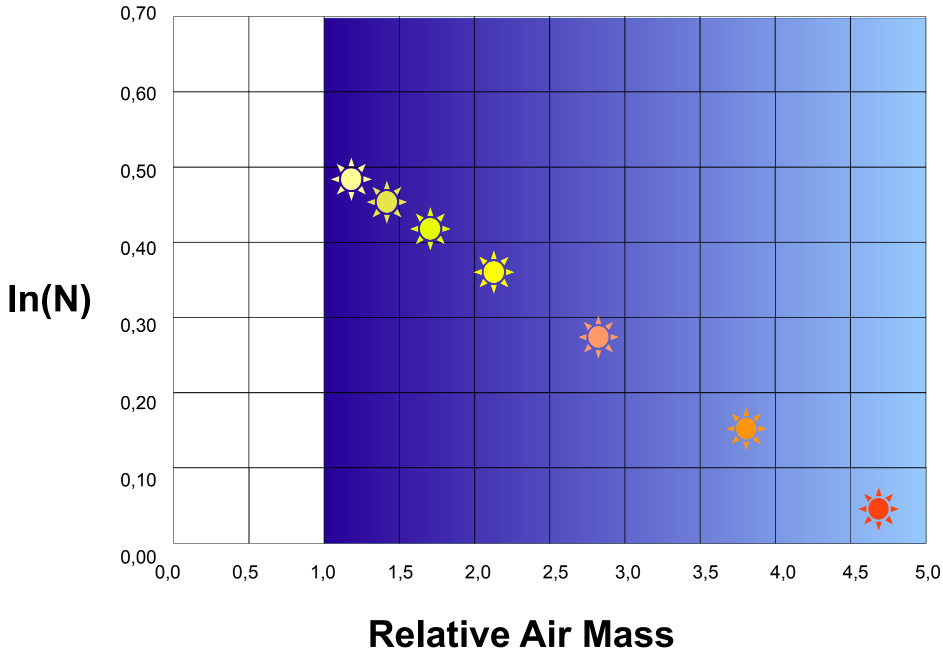


If photometer sea the Sun though differents relative air mass values and if optical thickness does not change...

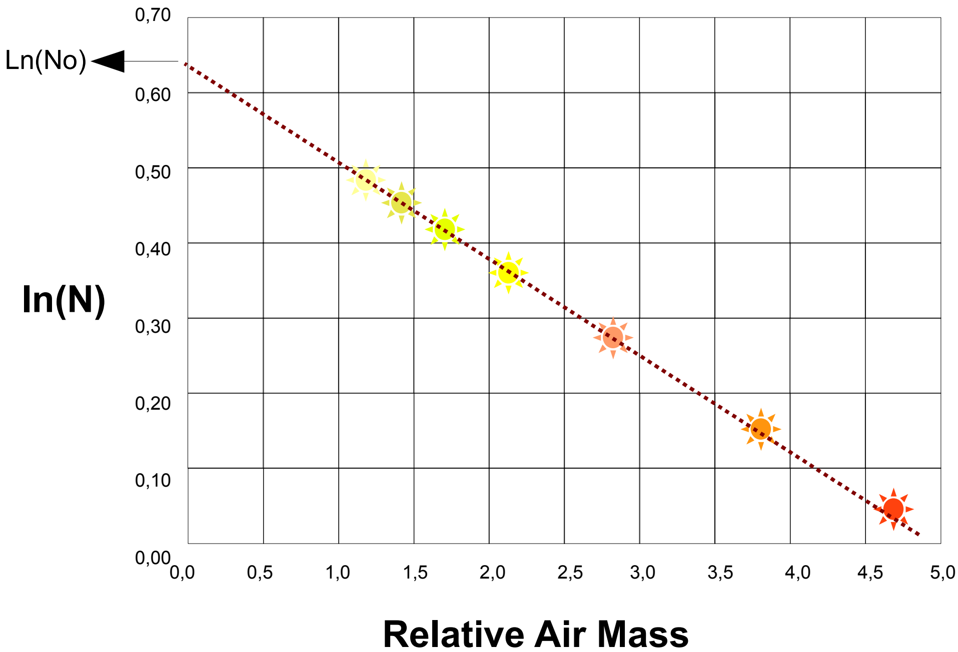


...then, the measurement logarithm is proportional to relative air mass (AM)





By fitting a line through the data (linear regression), the intersection of said line with the y-axis, where m = 0, is the logarithm of the measurement that the instrument would produce if it were no atmosphere Ln (No).



3.3.3 How to do ?

To perform a Langley type calibration, choose a day of good and stable weather to have a constant optical thickness throughout the day. That is to say, a clear sky without clouds above sea level, without wind.

The sites in altitude, away from cities offer more easily this type of sky. We must stay on the same site for all measurements.

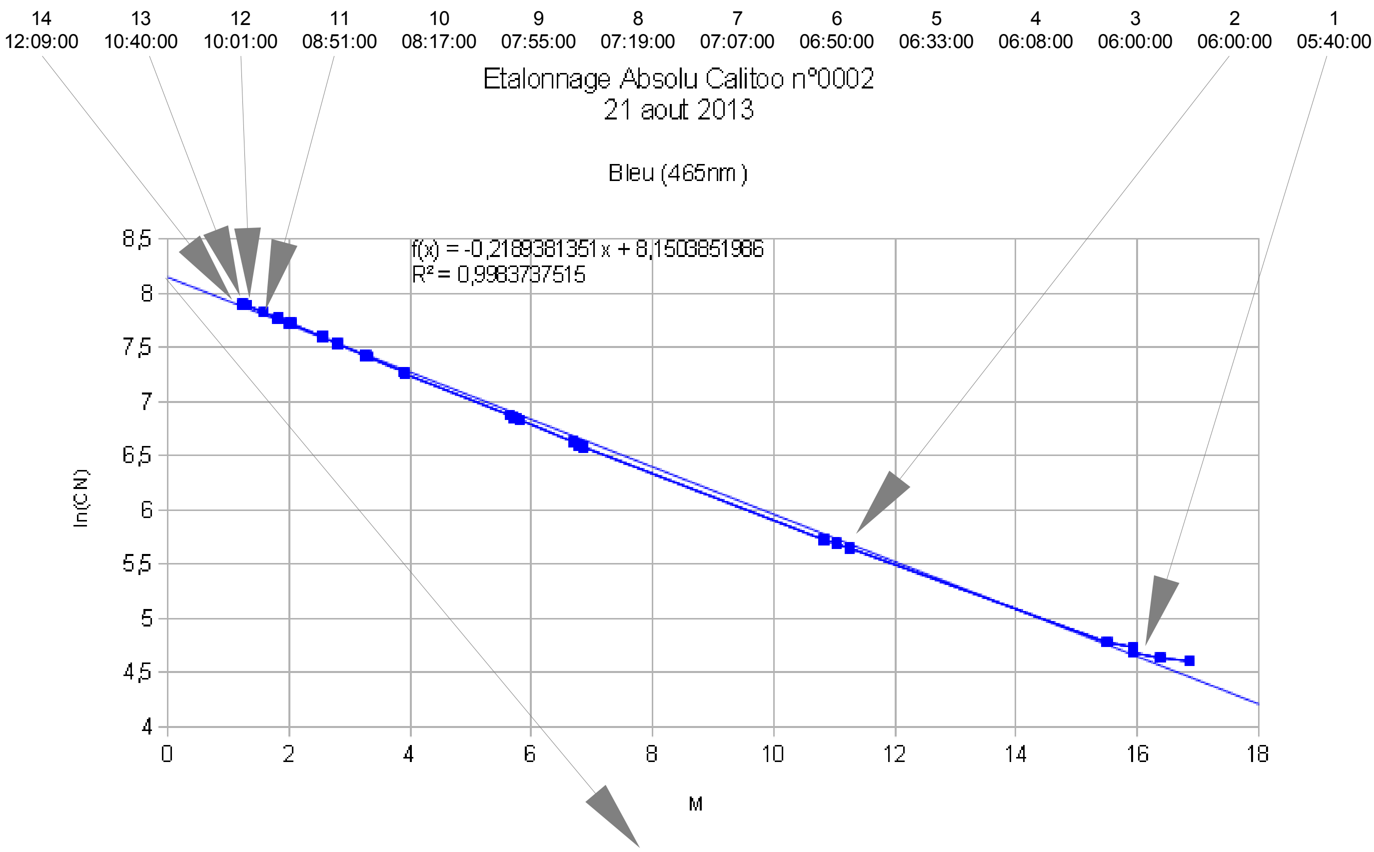
So take action one or two hours after sunrise until solar noon least the place. (Red Sun is going to pale yellow Sun on the previous graph).

Continuing the afternoon, we get the "down" curve, which theoretically merges with the "rising" curve. This can be a weather stability index of the day.

It is not recommended to perform calibrations during winter because the sun is low on the horizon, the air mass is not enough to approach 1 (over 2.5 on the winter solstice so that it reaches 1.07 at the summer solstice for example in Toulouse, in the south of France).

During the measuring morning of measurements, you should take at least five series from 3 to 5 measurements.

Here are measurements taken August 21, 2013 near Toulouse in blue color. The data were gathered in a spreadsheet and the equation of the trend line has been displayed, allowing us to calculate the CN_0 parameter.



CN_0_465 = exp(8,1503851986) => CN_0_465 = 3465

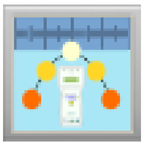
3.3.4 Calibration with software

The PC software for managing the Calitoo has a Langley calibration tool. We will illustrate its handling by an example :

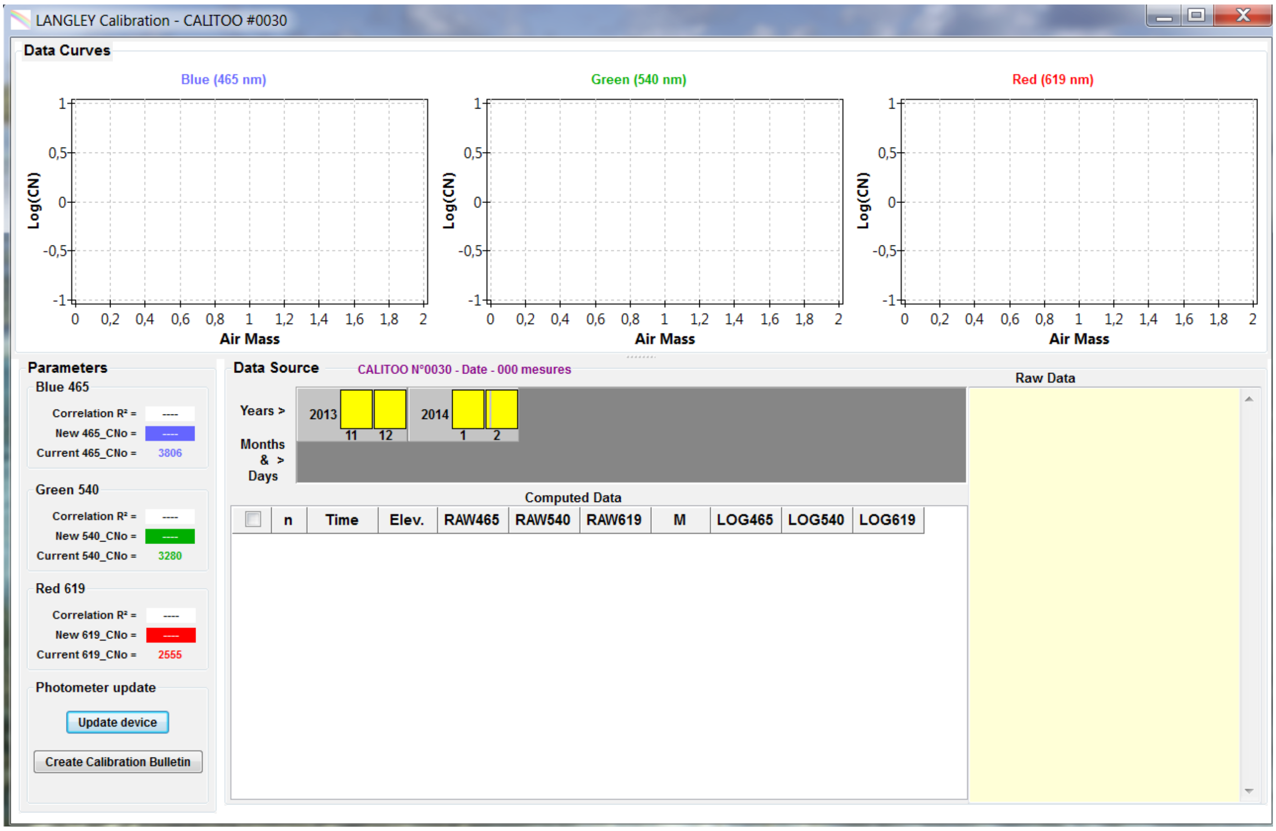
The photometer Calitoo No. 30 has been used Tuesday, February 4th, 2014 to take several sets of measures in order to achieve Langley calibration.

The first step written on page 13, allows you to download photometers data on your computer.

Then you go to the Tools tab and click on the icon “Langley calibration”.



The windows LANGLEY Calibration opens and look like this :



The window consists of three areas:

- The Data Curves area displays the measurement points and the approximation straight lines. You can enlarge them for better reading by double clicking it. The same action makes them resume their original size. .

- The Parameters panel displays the numerical values of the initial calibration coefficients and new coefficients calculated in real time and correlation coefficients (Deviation between the measurements curve and the straight line of approximation. The closer it is to 1 , is the best approximation) .

The Photometer update allows :

- update directly in the connected photometer, the three coefficients CN_0 with new values.

- create a calibration report in PDF format (that is the one that comes printed in the box of your instrument) .

- The Data Source panel allows you to retrieve data according to the day, month and year to which they were taken. We start by detailing the area which is the first task to proceed calibration .

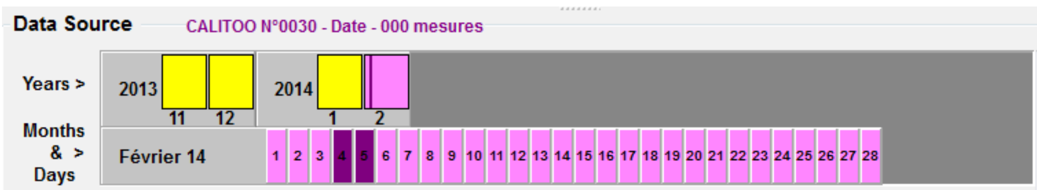
3.3.5 Data Source

Data are displayed as a calendar showing the years, months and days.

Day for which measures have been taken are displayed as red bars on the yellow background of the month. The calendar starts with the photometer manufacture date and ends the month of the current date.

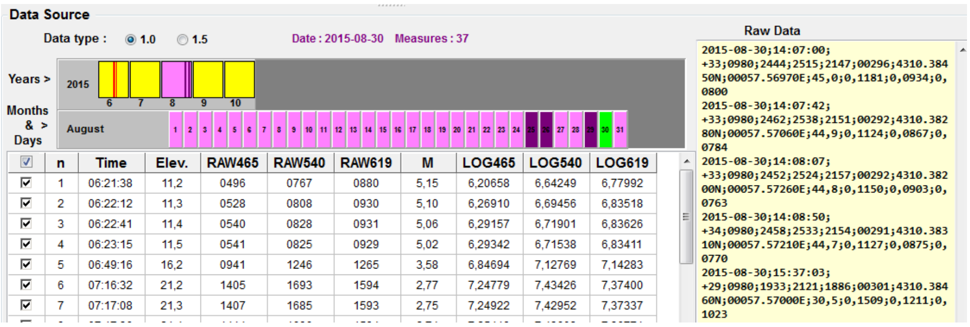
Here the photometer was manufactured in November 2013 and measurements at the beginning of February 2014.

Clicking the yellow rectangle in the month of February 2014 refines research data :



We see that the available data correspond to measurements made on February 4th and 5th 2014.

We will click on February 4th to see these measurements :



Data are immediately loaded, displayed and processed.

Some details on the Data Source area :

The purple text in the window displays the date when data were taken and the number of measurements used in the calculation. We will see below how to use these data.

Raw data can be seen, as they have been downloaded from the memory of the photometer, in the yellow section on the right side of the window.

The table presents the measurements in rows in chronological order of implementation.

n : Order of measurement

Time : Time of measurement

Elev : Solar elevation (angle between the ground and the Sun) in degrees.

RAW465, **RAW540** and **RAW619** : Raw measurement values in three wavelengths.

M : Calculated air mass (see page 18)

LOG465, **LOG540** and **LOG619** : natural logarithms of raw measurements.

Selecting data

You can choose to use or not, a measure for the calculation of calibration coefficients.

To remove a measurement from calculation set, you have to uncheck the box at the start of the line in the table. After this action, all calculations are redone, the curves are traced and the number of measurements used (purple text) is decremented.

The objective is to use the best measures to improve the quality of the calculated coefficients.

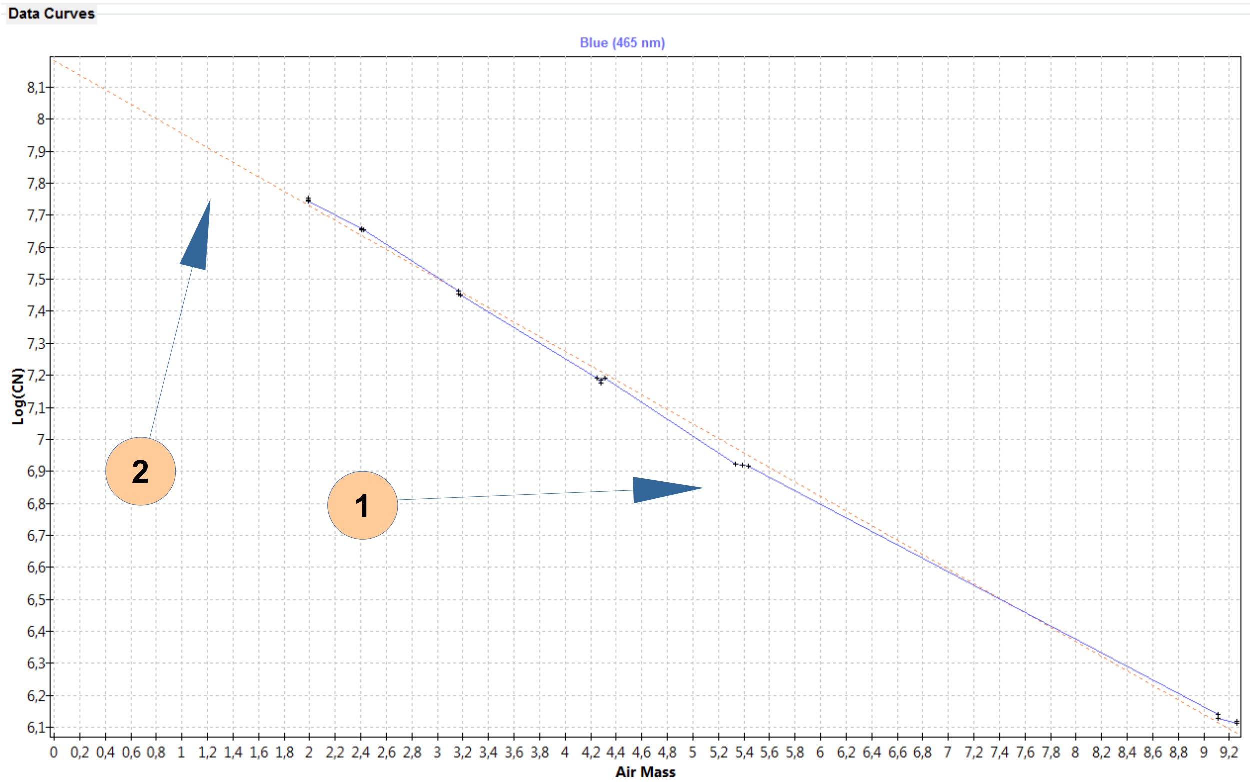
You have to :

- Monitor the correlation coefficients that must come as close as possible to 1.

- Use a minimum of 5 different sets of measurements

3.3.6 Measurements curves

For each wavelength, two curves are drawn :

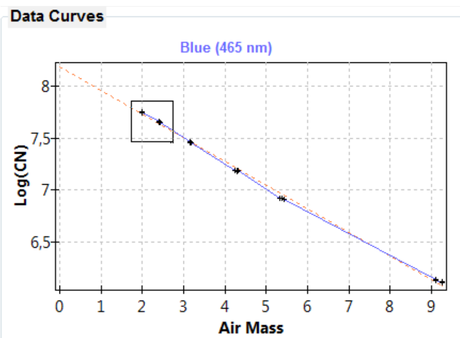


1- The curve connects calculated points (log). Points are shown as small black crosses

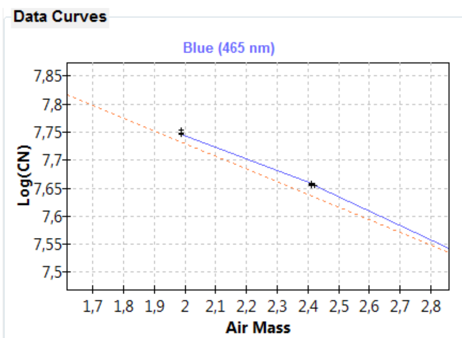
2- Approximation straight line (in dotted lines) whose intersection with the y-axis will display the CN_0.

You can view the curve in a larger format by double-clicking on it, as in our example.

Zooming is also possible by enclosing with the mouse button pressed the party to zoom. Operation to the top left point to the bottom right under (1) and release the mouse button: zoom is performed (2).



(1)



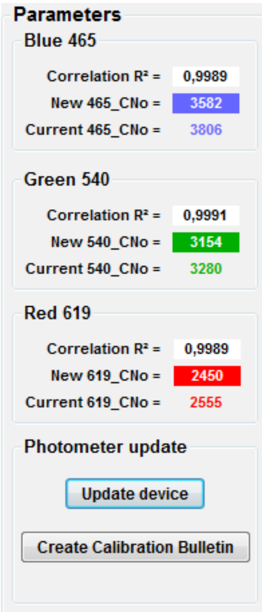
(2)

To un-zoom, doing the same operation but from the lower right to upper left.

Before trying to publish a calibration bulletin, make sure that the curves have a presentable scientifically. We recommend that you leave the three curves on the same scale in order to have a coherent set when publishing..

3.3.7 The calibration parameters

For each wavelength, the current calibration parameter is displayed as the new parameter calculated. This will allow you to assess the new calibration in the comparison. Too much difference between these values may be a sign of a problem for your photometer (clogged or dirty sensor).



The three decimal correlation coefficient used to assess the consistency of the measurements for calibration. A good calibration should have a ratio above 0.99, absolutely 1.

Updating coefficients

The "Update device" button to transmit the USB link the new coefficients connected to the photometer.

Calibration bulletin publication

Once satisfied with your work, you must create the calibration bulletin will file two forms: a text file and a PDF file that are described in the following paragraph..

WARNING ! CREATE BULLETIN CALIBRATION DOES NOT AUTOMATICALLY UPDATE THE FACTORS CALIBRATION PHOTOMETER !

3.3.8 Organization on the hard disk

For the photometer identified No xxxx, when the user chooses to produce a calibration report, data is written to the file :

<*username*>/CalitooData/xxxx/xxxx_CALIBRATION/xxxx_LANGLEY/

A text file and a PDF file is produced.

Example content file : CAL0030_20140204_LAN.txt

```
LANGLEY CALIBRATION METHOD
CALITOO #0030
--------------------
Date : 2014-02-04
Latitude : 43°38.38540N
Longitude: 001°25.59330E
Altitude : 00104M
Used Data: 26
--------------------
CN0_465=3582
CN0_540=3154
CN0_619=2450
--------------------
R²_465=0.9989
R²_540=0.9991
R²_619=0.9989
-------------------------------------------
Used;n;Time;Elevation;RAW465;RAW540;RAW619;M;LOG465;LOG540;LOG619
1;1;07:49:48;06.2;0454;0711;0838;9.26;6.11810;6.56667;6.73102
1;2;07:50:06;06.2;0452;0711;0844;9.26;6.11368;6.56667;6.73815
1;3;07:50:23;06.3;0459;0719;0848;9.11;6.12905;6.57786;6.74288
1;4;07:50:33;06.3;0464;0722;0852;9.11;6.13988;6.58203;6.74759
1;5;08:18:47;10.6;1008;1268;1268;5.44;6.91572;7.14520;7.14520
1;6;08:19:05;10.7;1011;1268;1270;5.39;6.91870;7.14520;7.14677
1;7;08:19:23;10.7;1010;1274;1277;5.39;6.91771;7.14992;7.15227
1;8;08:19:42;10.8;1015;1274;1274;5.34;6.92264;7.14992;7.14992
1;9;08:38:04;13.4;1326;1543;1466;4.32;7.18992;7.34148;7.29029
1;10;08:38:21;13.5;1321;1544;1468;4.28;7.18614;7.34213;7.29166
1;11;08:38:39;13.5;1307;1536;1469;4.28;7.17549;7.33694;7.29234
1;12;08:38:53;13.6;1328;1544;1464;4.25;7.19143;7.34213;7.28893
1;13;09:14:30;18.3;1722;1857;1676;3.18;7.45124;7.52672;7.42417
1;14;09:14:48;18.4;1729;1869;1677;3.17;7.45530;7.53316;7.42476
1;15;09:15:04;18.4;1741;1873;1676;3.17;7.46221;7.53530;7.42417
1;16;09:15:29;18.4;1745;1879;1687;3.17;7.46451;7.53849;7.43071
1;17;10:09:44;24.4;2111;2160;1861;2.42;7.65492;7.67786;7.52887
1;18;10:09:58;24.5;2111;2151;1870;2.41;7.65492;7.67369;7.53369
1;19;10:10:20;24.5;2110;2149;1863;2.41;7.65444;7.67276;7.52994
1;20;10:10:38;24.5;2115;2158;1860;2.41;7.65681;7.67694;7.52833
1;21;10:10:54;24.5;2119;2152;1865;2.41;7.65870;7.67415;7.53102
1;22;11:58:52;30.2;2311;2294;1952;1.99;7.74544;7.73805;7.57661
1;23;11:59:09;30.2;2312;2312;1956;1.99;7.74587;7.74587;7.57866
1;24;11:59:28;30.2;2319;2307;1962;1.99;7.74889;7.74370;7.58172
1;25;11:59:46;30.2;2318;2298;1957;1.99;7.74846;7.73979;7.57917
1;26;12:00:08;30.2;2330;2315;1970;1.99;7.75362;7.74716;7.58579
0;27;13:38:40;26.6;2043;2052;1759;2.23;7.62217;7.62657;7.47250
```

The description of the data columns is identical to the table on Appendix 4.7.

In the first column, if the measurement line was used was a "1" if a "0". These indications are used for the calculation of calibration coefficients.

3.3.9 Log file

At each change of calibration parameters, the software updates a log file. It is located in the folder :

<*username*>/CalitooData/xxxx/xxxx_Log.txt

for our example and is called : **0030_Log.txt**

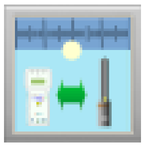
Here are its contents:

```
Calitoo #1302-0030
-------------

2013-12-14 13:14:32
-------------------------------------------------------------
CN0_465=3423;RAY_465=0.19490
CN0_540=3132;RAY_540=0.10637;OZ_540=0.0128
CN0_619=2455;RAY_619=0.06281;OZ_619=0.0154

2014-02-21 09:43:10
-------------------------------------------------------------
CN0_465=3582;RAY_465=0.19490
CN0_540=3154;RAY_540=0.10637;OZ_540=0.0128
CN0_619=2450;RAY_619=0.06281;OZ_619=0.0154
```

We see that the photometer No. 30 received the first calibration coefficients December 14th, 2013 and new coefficients, February 21th, 2014.

This log will track the evolution of each meter and will help to refine the accuracy of measurements.

3.4 Intercalibration



3.4.1 Principle

The photometer calibration consist to determine by measurements and calculations, the light raw value given by a device at the atmosphere top, in a precise wavelength.

In the case of the Calitoo, calibration coefficients are binary numbers and named CN_0 (Count Numeric zero). We have CN_0_465 for the blue, CN_0_540 for the green and CN_0_619 for the red.

3.4.2 Method

The inter-calibration is a calibration method that uses data from reference photometer to compute AOT data that should measure the photometer to be calibrated. With these AOT and with a reverse calculation, we find the calibration coefficients (Cn_0) . Ideally, you should do both photometer measures at the same time and same place.

For now, one method of intercalibration is offered : AERONET intercalibration.

This method uses Aeronet network photometers as reference devices,. They are a world reference for measurements of aerosols.

The CALITOO intercalibration method witch will use a Calitoo photometer as etalon, is being validated and will be available in a future version of this software.

3.4.3 What is AERONET ?

The program AERONET (Aerosol RObotic NETwork) is a network of land aerosol measurements made by NASA and PHOTON (photometry for Operational Processing Standards satellite; Univ. De Lille 1, CNES and CNRS-INSU).

It is greatly expanded by the networks and employees of national agencies, institutes, universities, individual researchers and partners.

The program feeds an active database for the long term, into the public domain and easily accessible.

It includes the optical aerosol measurements, micro-physical and radiative properties of aerosols for research.

Participants in AERONET provide optical observations distributed globally, spectral depth of aerosols (AOD), the reversion products, the precipitable water in the various aerosol systems

Aerosols data are optical depth measurements. They are distributed in three quality levels: Level 1.0 (gross measures), Level 1.5 (cleaned measures, made without cloud), and the level 2.0 (Quality measures ensured by a second calibration). Inversions, precipitable water, and other AOD-dependent products are derived from these levels and may implement additional quality control.

3.4.4 How to do ?

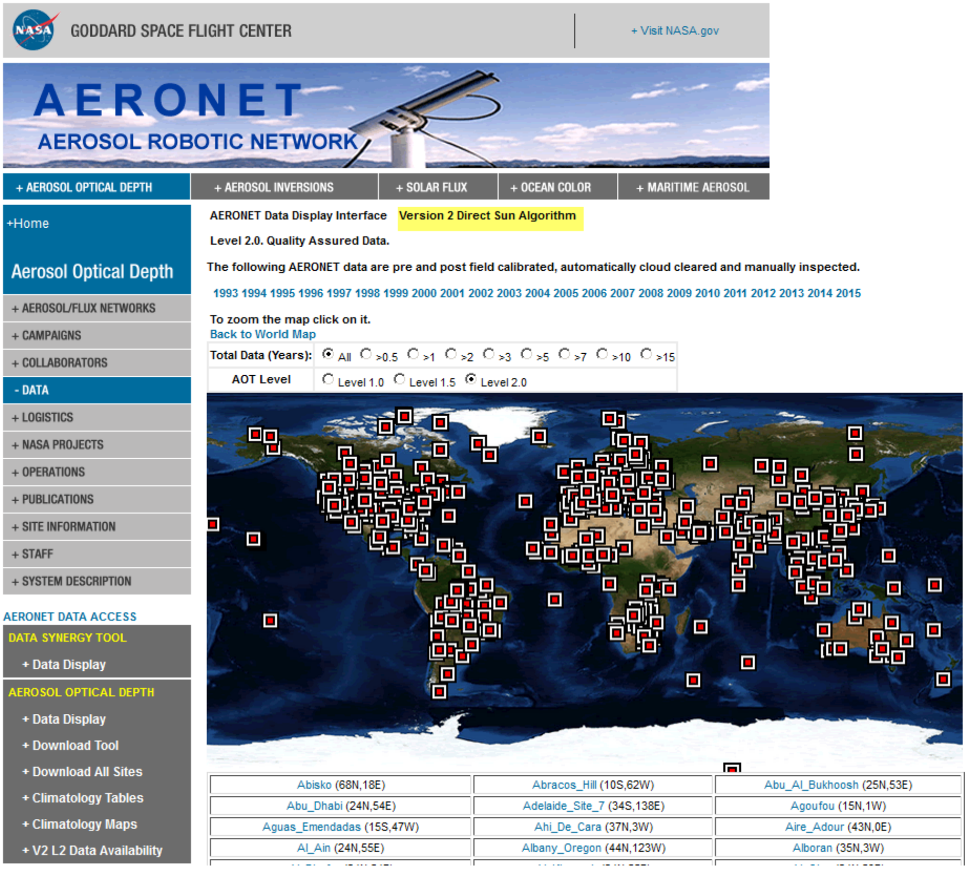
The first thing to do is find the Aeronet station nearest to the place where you plan on making your measurements. A distance of 20km between you and the site Aeronet seems to be a maximum for the validity of the operation.

You will find the location of internet stations :

http://aeronet.gsfc.nasa.gov/

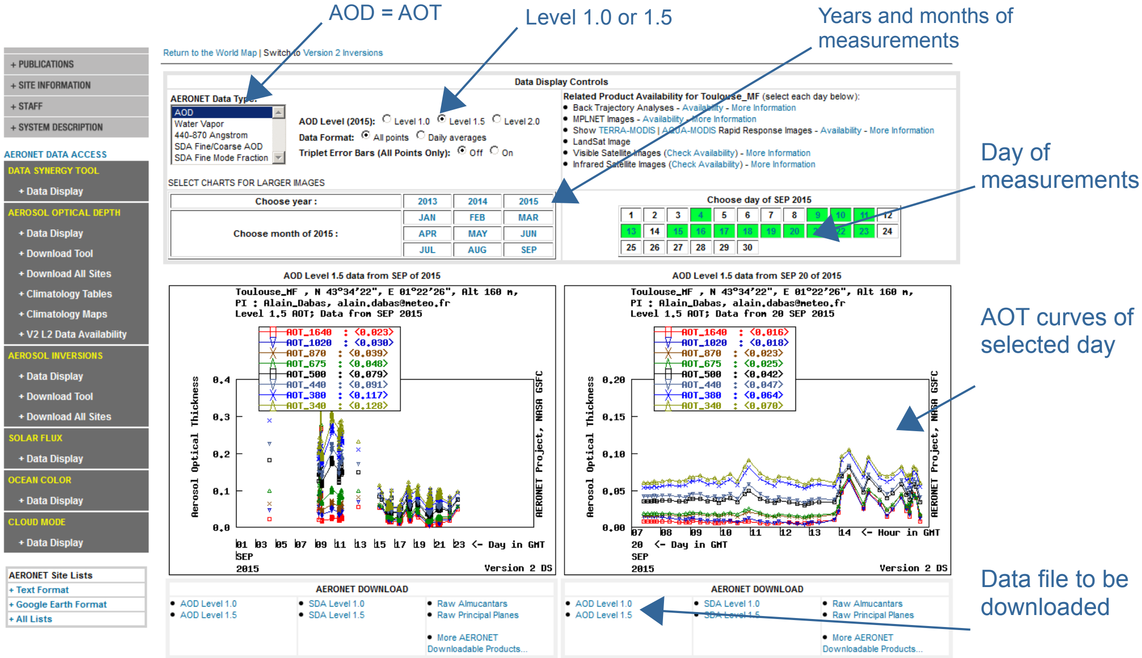
Perform measurements with the Calitoo to be calibrated by a sunny weather and a stable atmosphere. The aim is to achieve these measures in the same weather conditions as the Aeronet station.

Once the measurements, it will download on the website of Aeronet, the data file containing the precious AOT: :



Select station with the help of the map and the name suggested in the table below.

When you are on the page of your Aeronet station (Example: Toulouse_MF), select the desired data type: AOD (Atmospheric Optical Depth = AOT) and *Level 1.5* if possible (to have only valid and not given those taken with clouds), otherwise *Level 1.0*.



You can view the curves of AOT on the site, to see if they are fairly horizontal (sign of a stable atmosphere during the day measures).

Finally, it will download the (.zip) file and unzip it to the folder :

***<username>*/CalitooData/AeronetData**

The name of a data file uses the following syntax :

YYMMDD_YYMMDD_STATION.levNN

avec : YY :year MM :month DD :Day

NN : data lev (10 for 1.0, 15 for 1.5 and 20 for 2.0)

For our example shown above, we downloaded the file :

150920_150920_Toulouse_MF.lev15

3.4.5 Inter-calibration with software

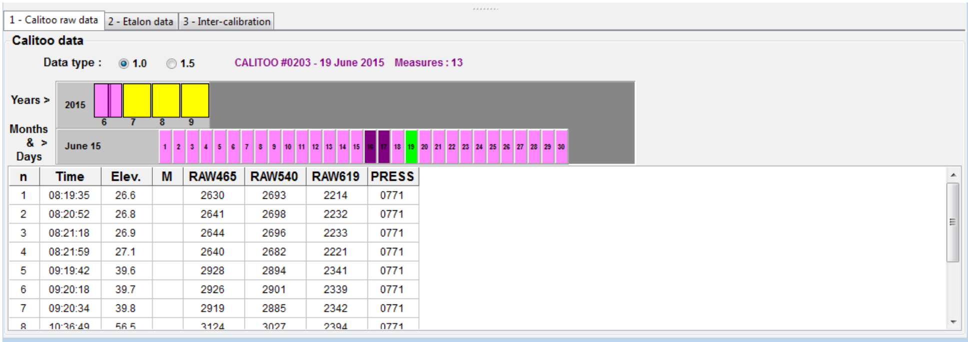
We assume photometers the data has been downloaded on your computer and the Aeronet data file, copied to the *AeronetData* folder.

The operation takes place in three steps: choice of photometer calibration data, choice of reference data and finally, calculations and results display.

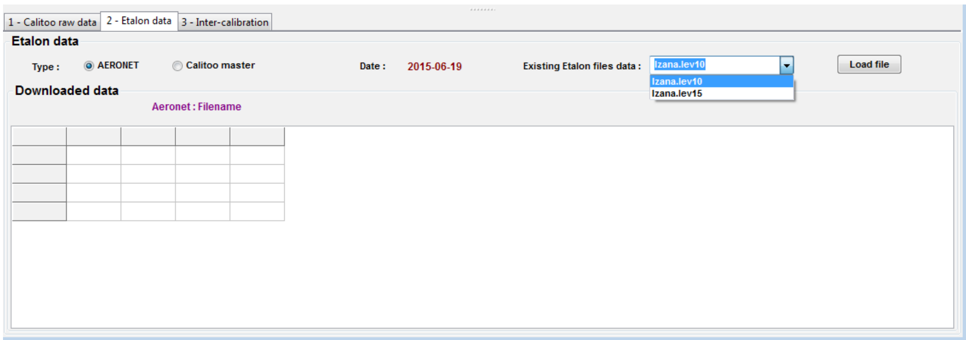
These steps are presented in the form of three tabs in the lower part of the window :

Step 1 : (*Calitoo raw data*) Data of Calitoo to be calibrated.

It consists in choosing the raw data in accordance with the measurement recording date with the calendar interface.

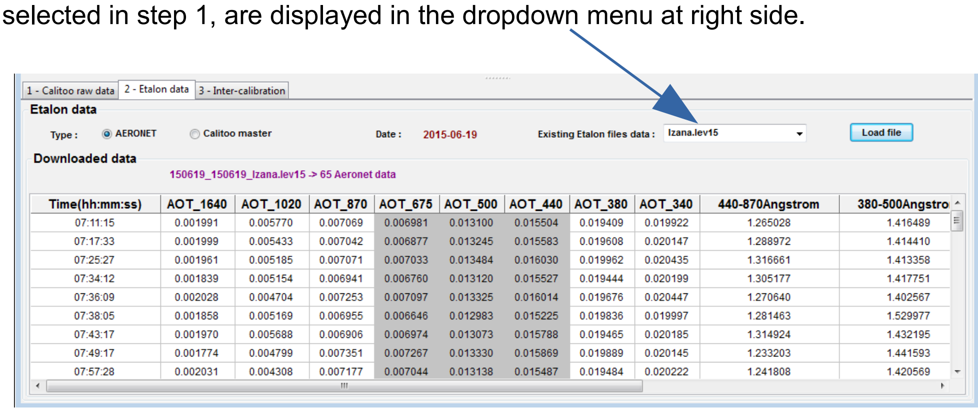


Step 2 : (*Etalon data*) Data of reference photometer.



<u>Eronet data</u> (For the moment, only Aeronet type is available).

The data files of the photometer calibration in the folder ***<username>*/CalitooData/AeronetData** and dated the same day as the selected in step 1, are displayed in the dropdown menu at right side.



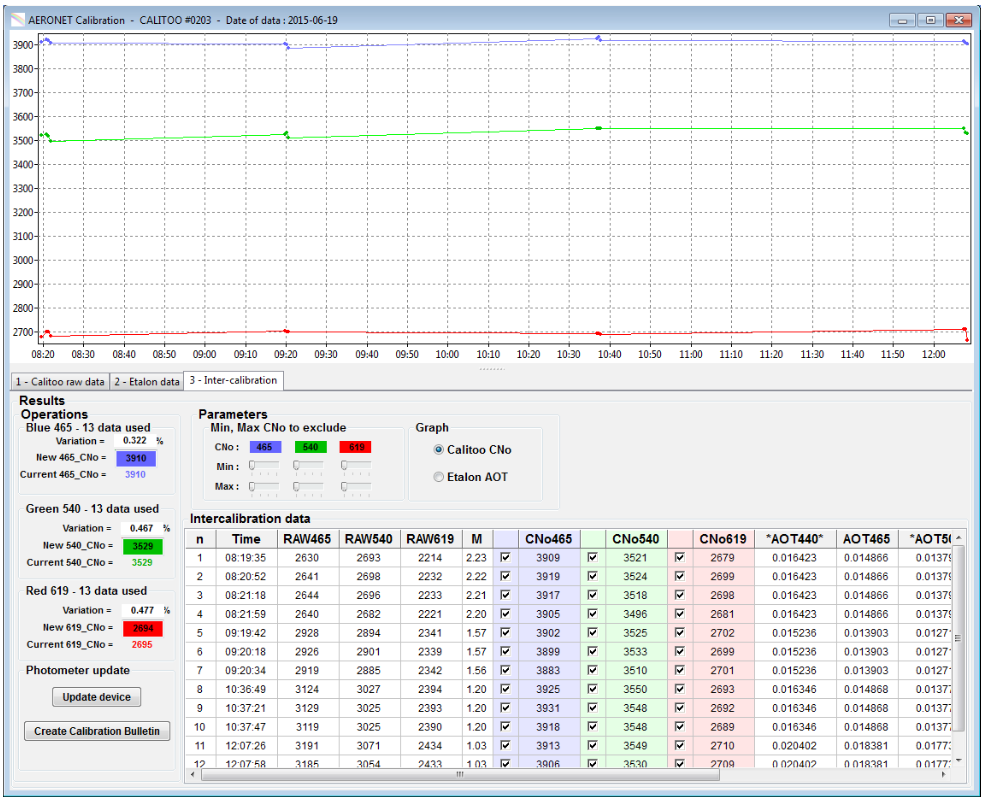
You must confirm your choice by clicking the *Load file* button and go on.

Step 3 : (Inter-calibration) Results and update the photometer.

The last step shows the calculation results of inter-calibration: the three new Calitoo CN_0 coefficients.

The curves represented various CN_0 calculated. For each wavelength will be sought to have a curve approximating a horizontal line.

It is possible to improve this, by eliminating the extreme points (min and max) of the curve. To do this, use the small slider in the Parameters panel. (Min, Max CN_0 to exclude).

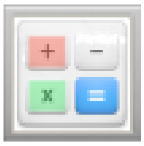


You can also do this manually by clicking the check boxes in the table of values, in front of the data to remove.

The goal is to obtain variations of less than 0.5% for each channel.

Once satisfied with your results, you can update your photometer (provided of course it is connected) and create a calibration bulletin.

3.5 AOT calculator



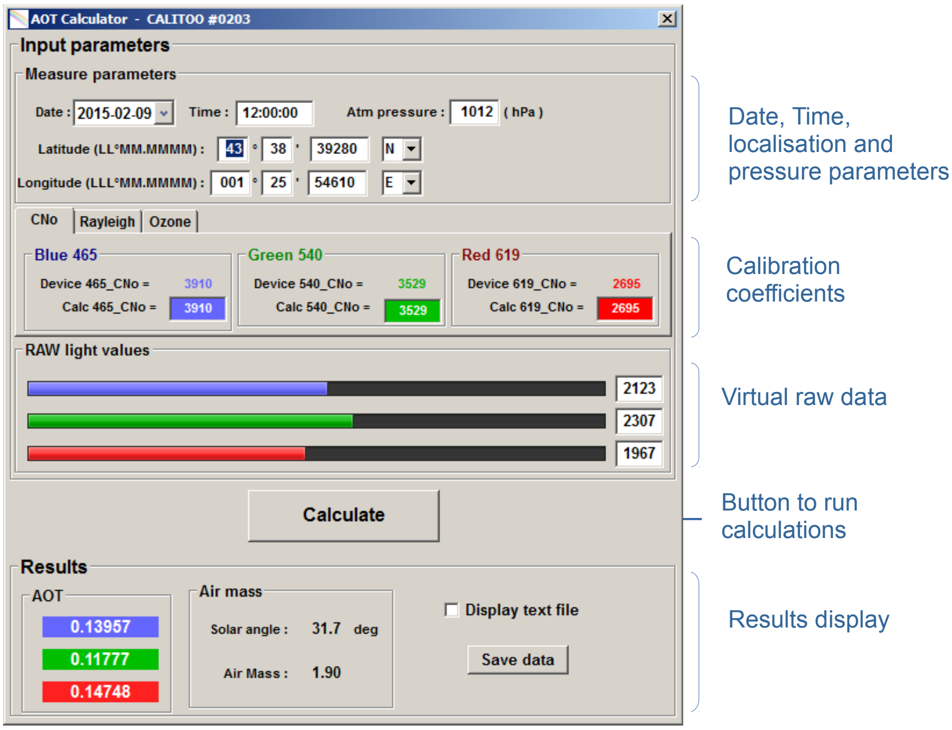
3.5.1 Principle

The idea is to provide a tool to study the influence of each parameter in the calculation of an optical thickness.

For example, with the same measurement, study the results to other latitudes, or study results with different CN_0 coefficient.

3.5.2 Calculation with the software

To perform AOT calculations, it is imperative to connect the photometer to the PC before starting the software. in fact, it is in the photometer that the calculations are made.



Calculation results are immediately readable. They are also available in a file to allow you to draw curves of study.

This file is located in the folder :

***<username>*/CalitooData/nnnn/**

The file is named *CalculatorData.csv* and contains such information :

```
Date;Time;Pressure;Latitude;Longitude;B_Raw;G_RAW;R_RAW;B_AOT;G_AOT;R_AOT;B_CN0;G_CN0;R_CN0;B_Ray;G_Ray;R_Ray;G_Oz;R_Oz
2015-02-09;12:00:00;1012;4338.39280N;00125.54610E;1600;1600;1600;0.28800;0.30996;0.21143;3910;3530;2698;0.19490;0.10637;0.06119;0.0128;0.0154
2015-02-09;12:00:00;1012;4338.39280N;00125.54610E;1700;1700;1700;0.25618;0.27815;0.17961;3910;3530;2698;0.19490;0.10637;0.06119;0.0128;0.0154
2015-02-09;12:00:00;1012;4338.39280N;00125.54610E;1800;1800;1800;0.22619;0.24815;0.14962;3910;3530;2698;0.19490;0.10637;0.06119;0.0128;0.0154
```

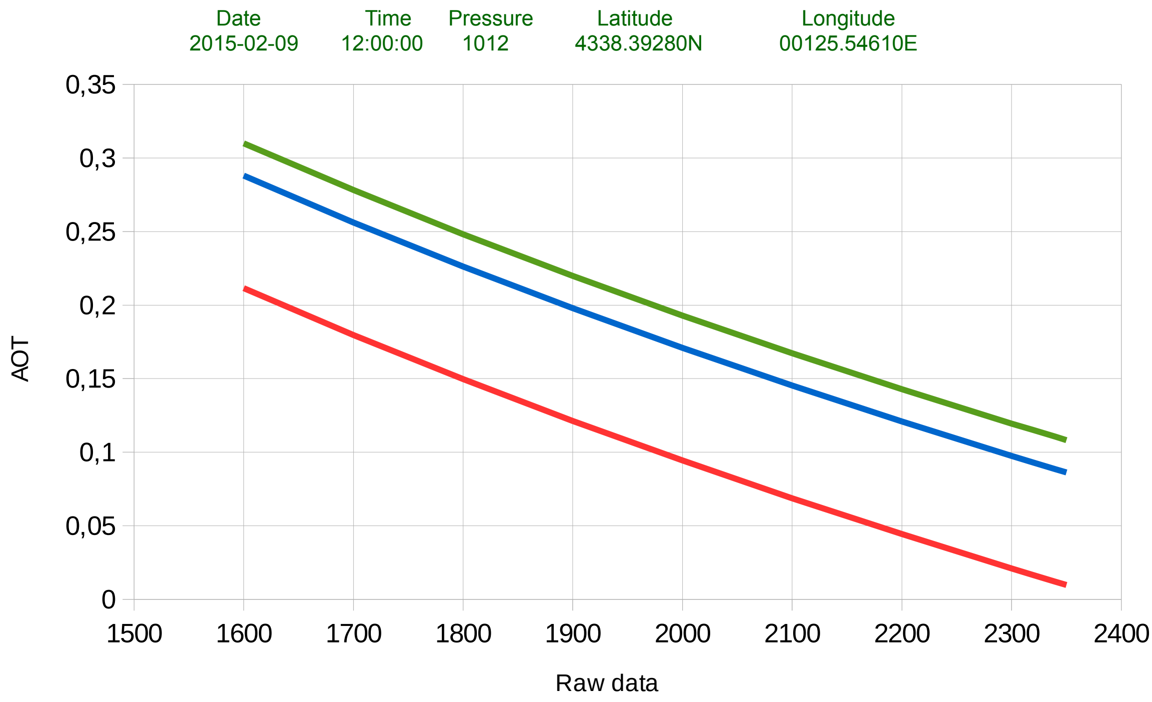
Ready to be imported into a spreadsheet.

Please note this file is unique, a new set of AOT calculations with writing results to a file will result in overwriting of the previous series.

3.5.3 Graphic plots

We want by example, to know the influence of raw measurements on the value of AOT.

AOT calculator and work on spreadsheets allows for this type curves for a place, a date and a fixed time :



3.6 AOT processing

3.6.1 Principle

The processing of AOT data retrieves old measurements and re-calculate the optical thickness based on new calibration coefficients.

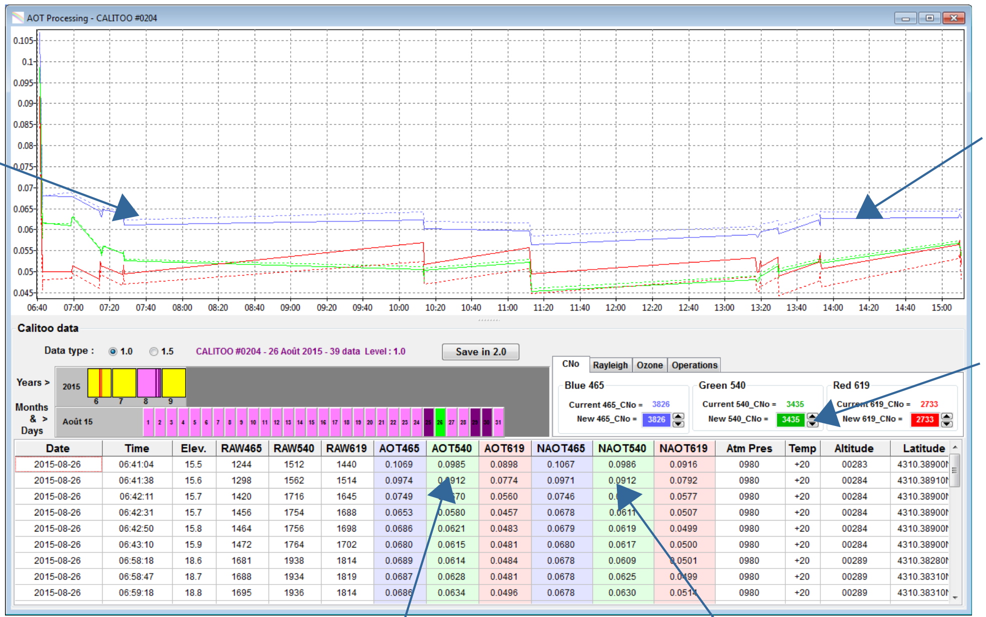
This will usually happen after a new calibration of the photometer. It can also be carried out on an experimental basis.

3.6.2 Re-calculation with software

After loading the data you want to work with, into the computer, click the tool icon *AOT Processing*.

The software displays the original AOT curves (dotted) and the curves recalculated from current coefficients in solid lines.

Here's what can be achieved on the screen :

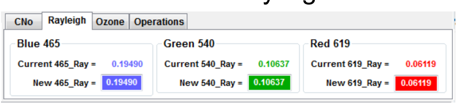


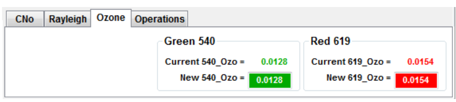
3.6.3 Change settings

The role of the parameters is quickly and easily readable: the curves are redrawn every variation of parameters.

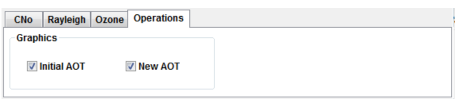
CN_0 with arrows

The coefficients of Rayleigh and ozone only with an editor.





Visualization of curves



However, for a re-calculation of AOT, you do not have a setting to change and they have already been updated with the new calibration.

3.6.4 Data writting

Data recalculated after a new calibration is saved by clicking the "Save in 2.0" button (level 2.0) in the xxxx_20 file for Calitoo No xxxx :

***<username>*/CalitooData/xxxx/xxxx_20/**

Here, for example, the content of the file 2.0 photometer Calitoo # 0204 :

```
Calitoo #1506-0204 Level 2.0
----------------------------------------
CN0_465=3826;RAY_465=0.19490
CN0_540=3435;RAY_540=0.10637;OZ_540=0.0128
CN0_619=2733;RAY_619=0.06119;OZ_619=0.0154
-------------------------------------------------------------------
Date;Time;Temperature;Pression;RAW465;RAW540;RAW619;Altitude;Latitude;Longitude;Elevation;AOT465;AOT540;AOT619
2015-08-26;06:41:04;+20;0980;1244;1512;1440;00283;4310.38900N;00057.56890E;15.5;0.1067;0.0986;0.0916
2015-08-26;06:41:38;+20;0980;1298;1562;1514;00284;4310.38910N;00057.57240E;15.6;0.0971;0.0912;0.0792
2015-08-26;06:42:11;+20;0980;1420;1716;1645;00284;4310.38900N;00057.57250E;15.7;0.0746;0.0670;0.0577
```

3.7 Data exchange

3.7.1 Data exportation

The "Export" function collects all the data acquired with your photometer in a Zip file.

So, it's easy to transmit all data in only one file on USB key or by mail.

To export, you must connect your photometer with the software, go into the toolbox and click on the icon (see above).

Choose where to write the Zip file to your computer and validate.

It is possible to export data from photometers whose data you have previously imported (see 3.7.2).

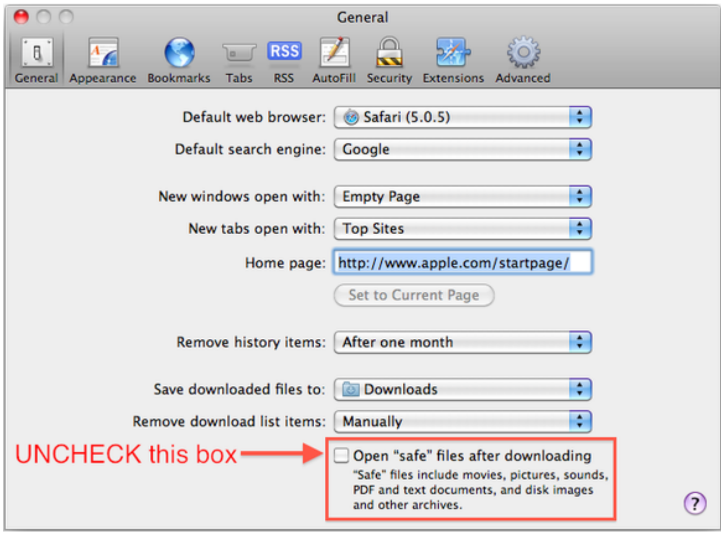
In this case, load the data as described in chapter 2.3.2 and proceed as before to access the export function.

3.7.2 Data importation

The complementary function of the preceding one allows to retrieve on his computer the data of a Calitoo of another observer who will have them exporter in the way described above.

The software tells you if data from the same photometer already exists on your machine. A validation will not destroy the old measurements, but they will eventually be complemented by the more sensitive data.

<u>Note</u>: on a Mac, if you use Safari to download a Zip data file, you should know that it will not be automatically unzipped from the option in the preferences :



4 Appendix

4.1 Optical thickness calculation

Beer-Lambert law applied to the atmosphere

$$I(\lambda)=I_0(\lambda)\cdot\exp(-m(\tau_a+\tau_g+\tau_{NO2}+\tau_w+\tau_{O3}+\tau_r))$$ **[1]**

I_0 : sunlight intensity outside the atmosphere

I : Light received on the ground

λ is the wavelength of light

τa : aerosols transparency coefficient

τg : gaz (CO_2 et O_2) transparency coefficient

τ_{NO2} : Nitrogen dioxide transparency coefficient (pollution)

τ_w : water vapor transparency coefficient

τ_{O3} : Ozone transparency coefficient

τr : Rayleigh scattering coefficient

m : Air mass coefficient through which light (optical path)

$$m=\frac{1}{\sin(\theta)}$$ θ is position angle of the Sun with the horizon

In the case of aerosols measures, the equation will be simplified by considering that the atmospheric optical total thickness depends only on the dissipation of the light by the molecules (Rayleigh) by ozone molecules (O_3) and aerosol . We distinguish the "natural" contribution (molecular) and "contaminating" (aerosols + others).

Contributions due to ozone (and perhaps other absorbing gases under certain conditions) and aerosols can be separated after the measurement or using climate data and average values of ozone depending on latitude eg , or by using the total of air column with the time and place of collection of the actual measurement data. Satellite mounted instruments such as the Total Ozone Mapping Spectrometer (4) (TOMS) provide such data.

(4) http://ozoneaq.gsfc.nasa.gov

Equation [1] becomes : $I(\lambda)=I_0(\lambda)\cdot\exp(-m(\tau_a+\tau_r+\tau_{O3}))$

We search to determine τa.

τr coefficient is proportional to the ratio of atmospheric pressure measured at the observation point by pressure measured by the level of the surface of the sea (p/p0) and therefore :

$$\tau_r=a_R\cdot\frac{p}{p_0}$$

$\tau O3$, coefficient is supply by LOA for green and red light length. In the blue light, this coefficient is null.

Our photometer returns a value directly proportional to the light intensity.
We will call : N.
If the photometer was outside the earth atmosphere (1 AU[5] of the sun) for measuring the brightness of the sun, it would give N_0 value.

(5) Astronomical Unit. It is equal to the average Earth-Sun distance (150 million kilometers).

$$N = N_0 \cdot \exp(-m(\tau_a + a_R \cdot \frac{p}{p_0} + \tau_{o3}))$$

We will introduce a correction term taking into account the Earth-Sun distance varies depending on the day of the year.

$$N = N_0 \cdot [\frac{r_0}{r}]^2 \cdot \exp(-m(\tau_a + a_R \cdot \frac{p}{p_0} + \tau_{o3}))$$

With $\boldsymbol{r_0}$, the distance of 1 AU and $\boldsymbol{r}$ then Sun-Earth distance at measure date (in AU).

$$r = \frac{[1-e^2]}{[1+e\cos(2\pi\frac{n}{365})]}$$ Avec $e = 0.0167$

We now express τa, optical thickness due to aerosols, according to the other terms

$$\ln(N) - \ln(N_0 \cdot [\frac{r_0}{r}]^2) = -m(\tau_a + a_R \cdot \frac{p}{p_0} + \tau_{o3})$$

$$\tau_a = \frac{[\ln(N_0 \cdot [\frac{r_0}{r}]^2) - \ln(N)]}{m} - a_R \cdot \frac{p}{p_0} - \tau_{o3} \quad [2]$$

The Aerosol Optical thickness is denoted AOT.

The part of this thickness created by aerosol is called Aerosol Optical Depth noted AOD

Calibration parameters

- N_0 parameters are determined by calibration (No_465 for blue, No_540 for green and No_619 for red)

- a_R is calculated :

  For CALITOO, this parameters are :

WaveLength (µm)	a_R
0.465	0.19490
0.540	0.10637
0.619	0.06119

- τ_{O3} : is supplied by le LOA - Aeronet

4.2 Particle characterization

It is possible to determine the distribution in number and size of the particles constituting the aerosol. These particles whose diameter is between 10-3 and 100 microns are particularly concentrated over the industrialized regions of the Northern Hemisphere.

The Ångström coefficient is a sensitive index to the size distribution of aerosols. It is inversely related to the average particle size of the aerosol particles are the more smaller, the exponent is high.

This coefficient is also a good indicator of the proportion of atmospheric precipitable water, where the aerosol concentration plays now recognized as a very important role. It allows to anticipate the volume expected in a season precipitation. Depending on the concentration of water present in the atmosphere, a higher coefficient of favoring the concentration of the clouds and rain.

Calculation :

The Angström coefficient α is calculated with Optical thickness data (τa_n) taken at two different wavelength λ_1 and λ_2 :

$$\tau a_1 = \beta.\lambda_1^{-\alpha}$$

$$\tau a_2 = \beta.\lambda_2^{-\alpha} \quad \Leftrightarrow \quad \tau a_1 / \tau a_2 = \lambda_1^{-\alpha} / \lambda_2^{-\alpha} \quad \Leftrightarrow \quad \log(\tau a_1 / \tau a_2) = -\alpha \,.\, \log(\lambda_1 / \lambda_2)$$

$$\Leftrightarrow \quad \log(\tau a_1 / \tau a_2) = \alpha \,.\, \log(\lambda_2 / \lambda_1)$$

$$\Leftrightarrow \quad \alpha = \log(\tau a_1 / \tau a_2) / \log(\lambda_2 / \lambda_1)$$

The typical value range α is from 0.5 to 2.5 with an average value of 1.3 for natural atmosphere.

Example :

Seysses, september 1st 2010 at 12h11:19 UT.

$\lambda_1 = 0.675\ \mu m$ $\quad \tau a_1 = 0.10$

$\lambda_2 = 0.532\ \mu m$ $\quad \tau a_2 = 0.13$

Calculation of α :

$$\alpha = \log(0{,}100 / 0{,}135) / \log(0{,}532 / 0{,}675) = \mathbf{1{,}126}$$

Note: Both neperian logarithms and decimal logarithms can be used. For consistency with the programs of Calitoo and the PC software which have their own computational constraints, the "Ln" have been replaced here by "Log" from the 2016 version of this document.

Aerosol global map : Aerosol Size GlobalMaps

4.3 Install with Windows

This software has been tested with success under Windows® XP, 7 et 8.

Start by downloading the archive file : `Calitoo_v2.5_windows.zip` from our website

http://www.calitoo.fr/index.php?page=logiciel-pc

Open the archive and extract the `Calitoo_v2.5` folder on your desktop.

Folder contents :

```
Calitoo_setup.exe
CDM v2.12.06 WHQL Certified.exe
2.5_Changes.txt
```

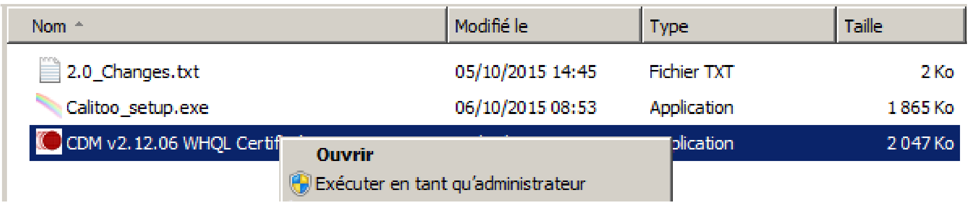
4.3.1 Installing USB-FTDI driver

This must be done before connecting for the first time the photometer to the PC via the USB port and Calitoo before starting the program.

We will install a driver that transforms the USB port to a virtual serial port.

This requires run as administrator, the FTDI Driver file :

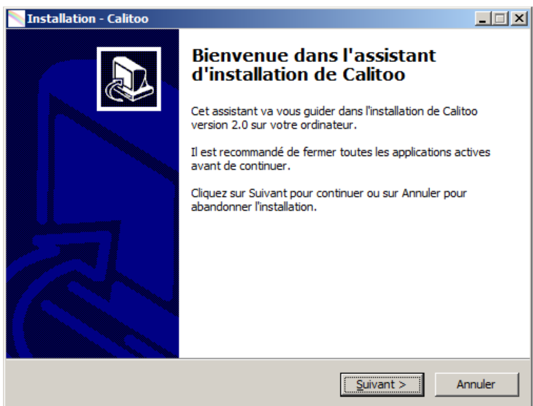
```
CDM v2.12.06 WHQL Certified.exe
```



Mouse right button on the Driver FTDI icon.

4.3.2 Calitoo V2.0 software installation

Just click on the *Calitoo_setup.exe* and follow the prompts to install the program



4.4 Installation under Linux

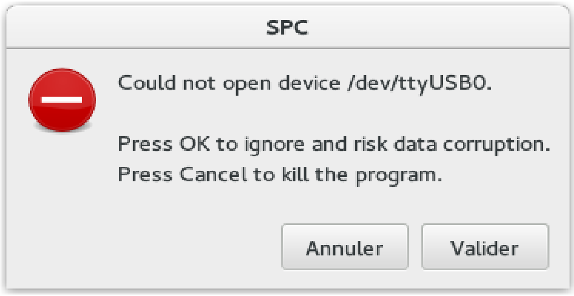
4.4.1 USB-FTDI driver configuration

With Linux, the FTDI driver is automatically installed, however some distributions for accessing the virtual serial port. It should ensure that you, as a user, you can access in reading and writing to this port. Here is an example with FEDORA :

When connecting a photometer by USB to a Linux PC, the system recognizes the driver and installs a new device in the / dev: among other files, we find :

/dev/ttyUSB0 which disappears when the photometer is offline .

This device is used natively by root and group dialout but not by any user who wishes to connect :



Connect and power a calitoo to the USB port of PC_Linux,

- Use a terminal and go to **/dev**
- Type the command: **ls -al**
- Identify in the dev list, the file **ttyUSB0**

You should have this:

```
crw-rw----.  1  root      dialout   188,   0   10 août   12:00   ttyUSB0
```

We will add a new rule that will allow read access and write to everyone in the device ***ttyUSB0*** :

skip as root : ***sudo -i***

In the folder **/etc/udev/rules.d/** create a file ***usbserial.rules*** in which add the following rule :

```
KERNEL=="ttyUSB0", GROUP= "dialout", MODE= "666"
```

By example, to edit enter : ***gedit usbserial.rules***

When **udev** will load the device **ttyUSB0** , it joins the **dialout** group (as previously) but now will assign permissions to read and write for everyone.

Reload the rules by typing : ***udevadm control –reload-rules***

Un-plug and re-plug the photometer.

Now when you view the folder contents ***/dev/*** with ***ls -al*** you read :

```
crw-rw-rw-.  1  root      dialout   188,    0   10 août   12:11    ttyUSB0
```

and when running the program, the connection to the USB port is now allowed for all users of the machine

.

4.4.2 Software installation

This software has been tested with success under Fedora21, Debian 8.1, Mint, Ubuntu.

Start by downloading the archive file : `Calitoo_v2.5_Linux.zip` from our website

http://www.calitoo.fr/index.php?page=logiciel-pc

Open the archive and extract the Calitoo_v2.5 folder on your desktop.

Folder contents :

```
Calitoo
calitoo.ico
Calitoo.desktop
```

The program is directly executable file.

We leave it to you to create links for a quick launch from the desktop of your Linux distribution.

4.5 Installation under Mac-OS

Dowloading virtual disk `calitoo.dmg` from our website :

http://www.calitoo.fr/index.php?page=logiciel-pc

Click on the file `calitoo_v2.5.dmg` icon to open virtual disk `calitoo_v2.5` on the desktop :

Folder contents :


```
Calitoo
Calitoo_v2.5.app
FTDIUSBSerialDriver_v2_3.dmg
FTDIUSBSerialDriver_v2_2_18.dmg
Driver_Note.rtf
```

4.5.1 Installing USB-FTDI driver

This must be done before connecting for the first time the photometer to the PC via the USB port and Calitoo before starting the program.

Two driver files are provided and must be used depending on the version of your MAC-OS X system

- Driver_2.2.18 for Mac OS X 10.3 to 10.8

- Driver_2.3 for Mac OS X 10.9 and above.

4.5.2 Software installation

There is not strictly speaking installation: the program file is directly accessible in the virtual disk created by the downloaded dmg file.

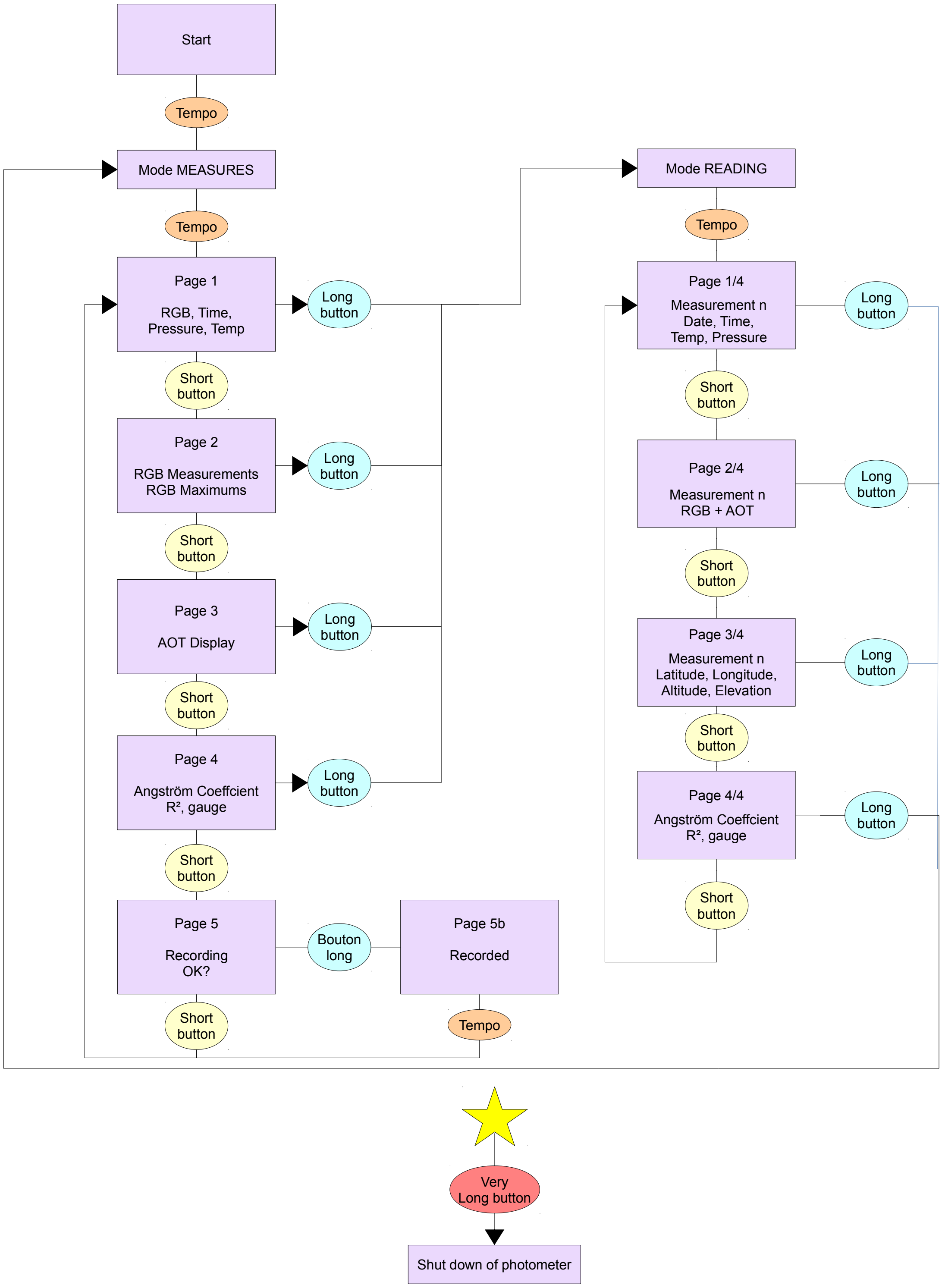
Calitoo_v2.5 in the virtual disk, click the Calitoo.app file to start the program.

On first use, your Mac protection system probably tell you this:

It will just press the CTRL key while clicking again on the icon Calitoo.app

You have to click OK to continue until software startup.

4.6 Red button sequence on photometer



4.7 Organization of data into the computer

Working folder « CalitooData » is located at user folder root :

```
CalitooData
            0002
                      0002_10
                                 0002_20130912_133706_10.txt
                                 0002_20130913_082411_10.txt

                      0002_15
                                 0002_20130905_1724456_15.txt

                      0002_20
                                 0002_20130905_1724456_20.txt

                      0002_CALIBRATION
                                 0002_LANGLEY
                                           CAL0002_20130915_LAN.pdf
                                           CAL0002_20130915_LAN.txt

                                 0002_AERONET
                                           CAL0002_20140908_AER.pdf
                                           CAL0002_20140908_AER.txt
                      0002_GRAPHICS
                                 0002_20140908_15.bmp
                      calculator.ini
                      0002_log.txt

            AeronetData
                      140908_140908_Izana.lev10
                      140908_140908_Izana.lev15
                      150618_150618_Izana.lev15

            Calitoo.ini
```

0002 : Identification number of the photometer it produced data found in this folder.

0002_10 : Folder of raw data of #0002 photometer. We used Aeronet nomination : 10 that is 1.0 for raw data. We never rewrite data in this folder, except during photometer data downloading.

1.0 = Raw data (digital light flux + AOT computed onboard the photometer).

1.5 = Unpleased data are deleted (Clouds, wrong pointage, manual filtering, etc).

2.0 = New computed AOT with new calibration parameters from a the last calibration campaign.

0002_20130912_133706_10.txt

File name is generated by the software.

The name is composed, by order :

Photometer number

Here is the #0002

Date of the first measurements of the file.

Here is September 12 2013 at 13:37:06 UT.

Data type (or level)

Here is 10 that is 1.0 of Aeronet level type.

Data file format

Photometer identification : Year, Month of manufacturing and unique order number.

Calibration parameters : (by example)
CN0_619 : No in red (619 nm)
RAY_465 : Rayleigh parameter in blue (465 nm)
OZ_540 : Ozone parameter in green (540 nm)

The ozone parameter is always null in blue color.

```
CALITOO #1310-0002
------------------------------------------
CN0_619=3945;RAY_619=0.06281;OZ_619=0.0154
CN0_540=3251;RAY_540=0.10637;OZ_540=0.0128
CN0_465=3250;RAY_465=0.19490
----------------------------------------------------------------------
Date;Time;Temperature;Pression;RAW465;RAW540;RAW619;Altitude;Latitude;Longitude;Elevation;AOT465;AOT540;AOT619;Alpha;R2
2013-09-12;13:37:06;+28;1006;2039;2132;1895;00154;4338.40656N;00125.57830E;43.4;0.1090;0.0929;0.0822;1.23;0.97
2013-09-12;13:37:37;+28;1006;2038;2130;1900;00148;4338.40957N;00125.57657E;43,3;0.1100;0.0939;0.0812;0.95;0,99
```

Line containing description of the different columns
RAW : Numerical raw measurments
AOT : Optical Thickness calculated by photometer firmware

Attention, the decimal numbers will use the separator ('.' Or ',') of the host computer.

In its current version, the software for MAC-OS imposes the '.' for separator regardless of the setting of the host computer.