CALITOO

SunPhotometer

User Manual

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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

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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.

1.Starting with Calitoo

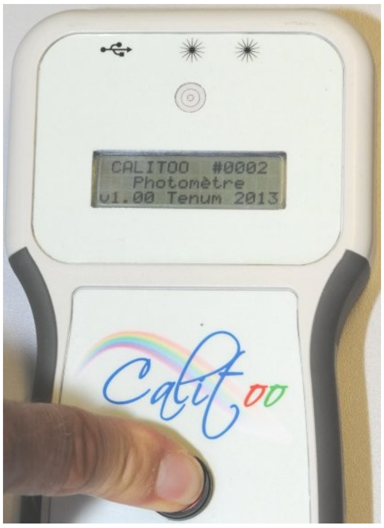
Batteries

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.

Power ON

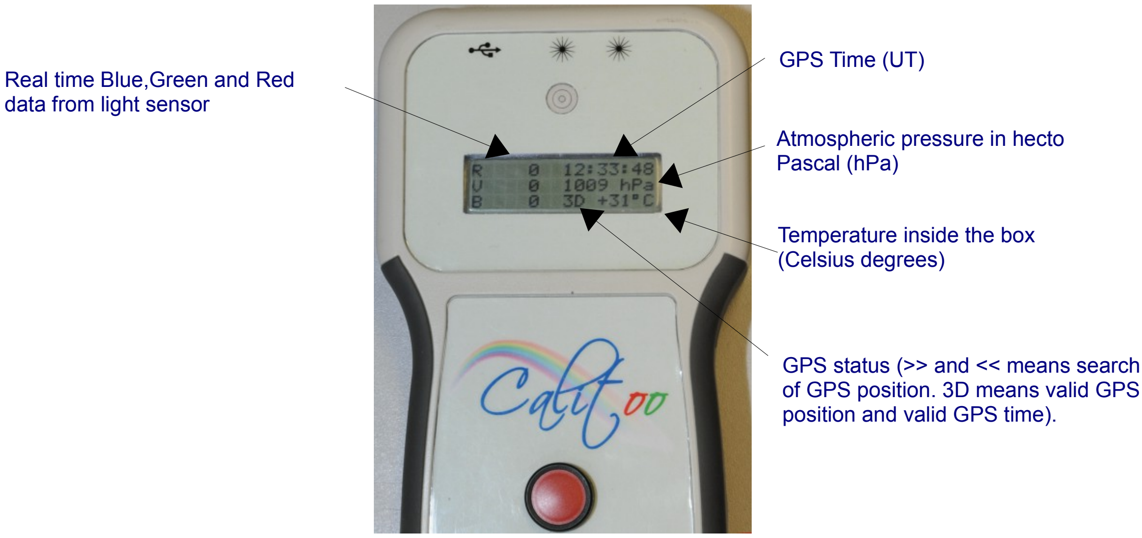
The photometer is turned on by pressing for 2 seconds on the center button.



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

First measures

After turning the page and last presentation, the photometer indicates that it is in measuring mode and displays the basic information:



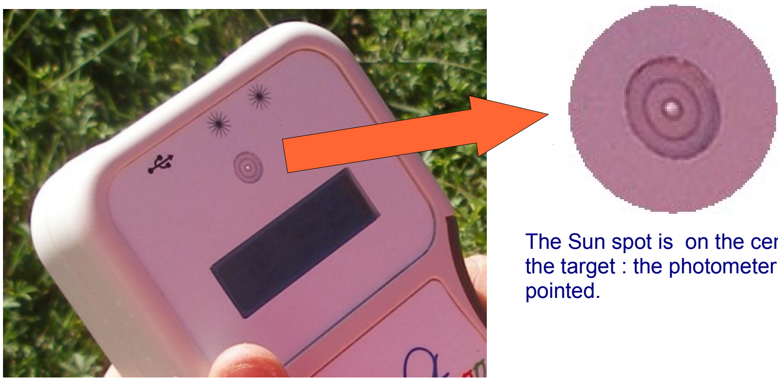
Once the GPS photometer is 3D, you can start measuring.

If the GPS is not in 3D, you can not do recordable measurement

Point to the Sun

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

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.

Maximum

The goal is to get the maximum value in RGB 1 minute tally. Click the button on the photometer and you go to the page maximum measures (assuming of course that you had stayed on the base page described above). While keeping an eye on the target, you monitor the numerical maximum measured values on the display. When they do not change, after about a minute, you make storing measurements.

Memory

Click the button again and you're on the third page is the record.
The photometer will ask if you want to save (the measures).

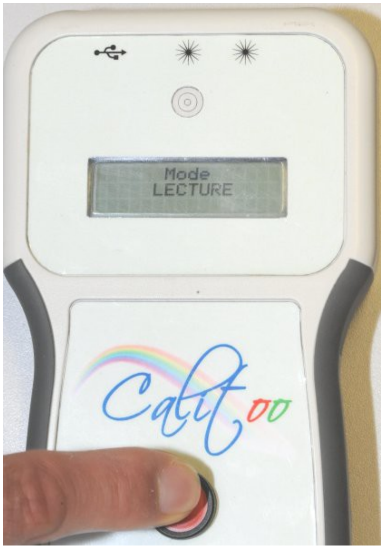
If this is the case, you should always press the button, but this time hold it down until REGISTERED! appears at the bottom of the screen.

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.

Reading data

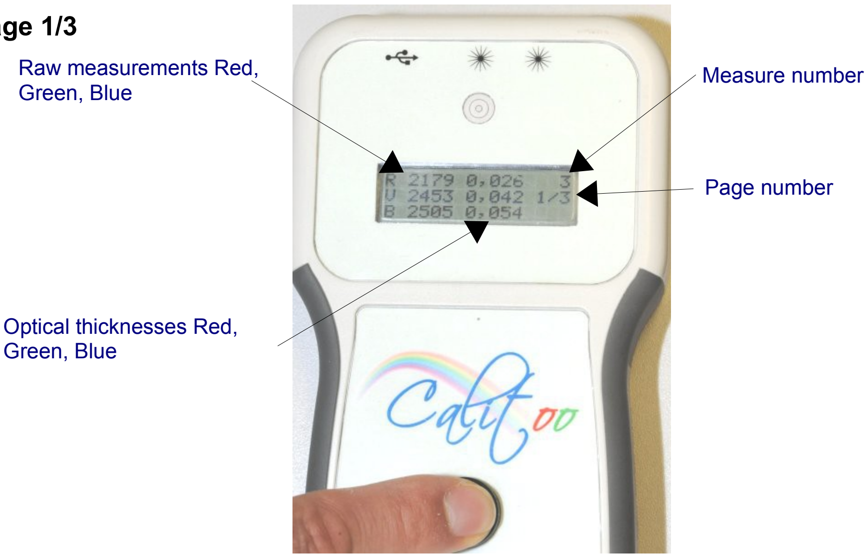
To read the latest measurements, you go to the basic page and do a long button presses on the photometer.



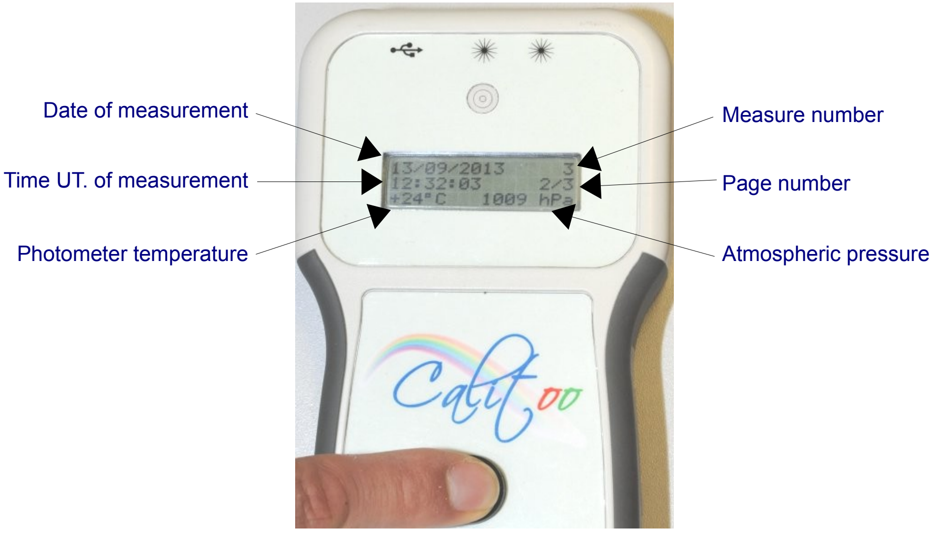
As soon as he tells you release the **PLAY** mode button.

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

Page 1/3



Page 2/3



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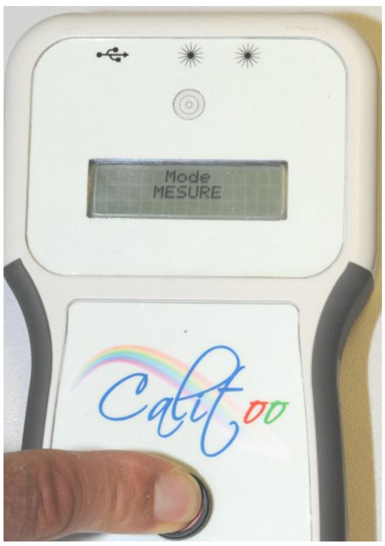
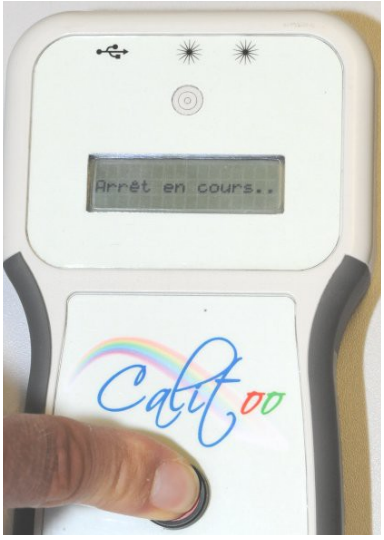
Mode change

To switch to the PLAYBACK mode MEASURE mode, you have to long press the red button. Release the button when the new mode is displayed.



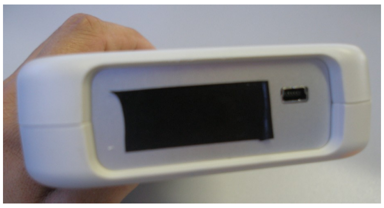
End of working

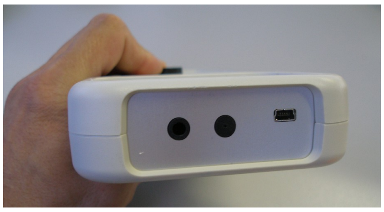
To turn off the photometer must be left long press the button to the message: **Stop in progress**... Release the button and the photometer is turned off.



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

Downloading and install

Before connecting for the first time your photometer to your PC, it is necessary to install a driver that converts a USB port into a virtual serial port.

This requires downloading the file FTDI Driver (*) and run it.

This must be done before connecting the USB to the photometer and Calitoo before starting the program.

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

Calitoo The program can be used directly without installation.

We recommend that you create a folder Calitoo in the place that best suits you on the hard drive of your PC and copy the downloaded file Calitooxx.exe.

There is a 32bit version and a 64bit version of the program. If you do not know what type of your system, take the 32bit.

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

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).

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).

Figure 1

Figure 2

Data: Downloading

Downloading data is proposed in section 2 of the software (Figure 3).
A single click on the folder with a green arrow and the operation is started (Figure 4).

Figure 3

Figure 4

Organization of data in the PC

The working folder (named Calitoo) contains the Calitoo program. Tree example for photometer n°0002 and n°0004 which are used on only one computer :

```
Calitoo
          0002
               0002_10
                         0002_20130912_133706_10.txt
                         0002_20130913_082411_10.txt
          0004
               0004_10
                         0004_20130905_1724456_10.txt
```

0002 : Identification number of the photometer which produced the data in that folder.

0002_10 : Folder containing the raw data type 1.0 (Aeronet name) :

1.0 = Raw data + AOT calculated onboard photometer

1.5 = The outliers are deleted (Clouds, bad score, filters, etc.) + calibration data

2.0 = AOT has been validated (corrections made by a second calibration)

002_20130912_133706_10.txt

The name of the data file is generated automatically by the program.
It comprises, in order :

The number of the photometer.

Here the n°2

The date of the first measure in the file.

Here : September 12, 2013 at 13h 37mn 06s UT

The Data type :

Here 10 meaning 1.0 (Aeronet type).

Data file format

Example :

Photometer id: Year and month of manufacture and unique number.

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

Ozone coefficient in blue is null all the time.

```
CALITOO #1310-0002
------------------------------------------
CN0_465=3945;RAY_465=0.19490
CN0_540=3251;RAY_540=0.10637;OZ_540=0.0128
CN0_619=2850;RAY_619=0.06281;OZ_619=0.0154
----------------------------------------------------------------------
Date time;Temperature;Pression;RAW465;RAW540;RAW619;Altitude;Latitude;Longitude;Elevation;AOT465;AOT540;AOT619
12/09/2013 13:37:06;+28;1006;0060;0116;0139;00154;4338.40656N;00125.57830E;43,4;2,6524;2,1589;2,0925
12/09/2013 13:37:37;+28;1006;0070;0136;0156;00148;4338.40957N;00125.57657E;43,3;2,5436;2,0472;2,0108
```

Line with data columns names
RAW : numerical raw data
AOT : optical thicknesses computed onboard the photometer

The above file is named : 002_20130912_133706_10.txt

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 4). If your answer is OK, erasure is performed.

Figure 5

Scientific parameters

Your Calitoo is sent calibrated. The calibration parameters are stored in the photometer and are visible on the site Calitoo.fr 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 measures.

Measurements made before this change will remain unchanged. If these must be rectified, the only way is to repeat the calculations with a spreadsheet after downloading to a PC.

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 read Annexes : **Optical thickness calculation**

Figure 6

Figure 7

Figure 8

Terminate your work

To quit the configuration and data management, just close the program window by clicking the X in the upper right corner.

3.ANNEXES

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://jwocky.gsfc.nasa.gov/

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

We search to determine τ_a.

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 :

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

τ_{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).

We now express τ_a, 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

Wavelength (µm)	T_Ozone
0.465	0.0000
0.540	0.0128
0.619	0.0154

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 :

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

$\tau a_2 = \beta.\lambda_2^{-\alpha}$ $\iff$ $\tau a_1 / \tau a_2 = \lambda_1^{-\alpha} / \lambda_2^{-\alpha}$ $\iff$ $\ln(\tau a_1 / \tau a_2) = -\alpha \,.\, \ln(\lambda_1 / \lambda_2)$

$\iff$ $\ln(\tau a_1 / \tau a_2) = \alpha \,.\, \ln(\lambda_2 / \lambda_1)$

$\iff$ $\alpha = \ln(\tau a_1 / \tau a_2) / \ln(\lambda_2 / \lambda_1)$

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.

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

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

Calculation of α :

$\alpha = \ln(0.100 / 0.135) / \ln(0.532 / 0.675) =$ **<u>1.126</u>**