CALISPH’AIR, AN EDUCATIONAL PROJECT TO STUDY
THE ROLE OF AEROSOLS IN AIR QUALITY AND CLIMATE

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The 10th grade students from Maintenon High School have been taking part in the educational project Calisph’air for the second year running. These students are attending an exploratory class called “Science and Laboratory”.

Later, during the March measurement campaign, we will study white light, absorption spectra, Beer-Lambert and a photodiode. (Figure 1)

![Figure 1. Synopsis](image)

1. STUDY THICKNESS OF THE ABSORBING MEDIUM

1.1 One measures the absorption of the white light by a medium which one increases the thickness gradually. (Figure 2) One uses here plastic blades cut out in a transparent sheet (for retro projector), a luxmeter and a source of white light (polychromatic).

![Figure 2. Experience and photo](image)

We then trace the light intensity transmitted (I) according to the numbers of plastic blades for a polychromatic light.

We obtained (this curve where it is noticed that at more we place squares at more the light is absorbed by these sheets transparencies, our professor said to us that the shape of this curve resembles an exponential mathematical function which we do not know yet. (Figure 3)

**Conclusion:** the light intensity decreases with an increasing number of plastic blade.

1.2 On an optical rail, one aligns, in the order, from right to left, a lamp with a diaphragm and with a red filter of color, a framework carries slide, on which one will pile up small plastic squares, cut out in a sheet for retro projector. Lastly, one places two sensors of light, before the framework carries slide, the other afterwards.

We know that when a light of \( I_0 \) intensity passes through a solution, part of this one is absorbed by the aqueous solution. Intensity \( I \) of the transmitted light is thus lower than \( I_0 \). One defines \( A \) the absorptance the solution like:

\[
A = \log \left( \frac{I_0}{I} \right) \quad \text{Eq. 1}
\]

One also speaks about transmittance \( T \) defined by the relation:

\[
T = \frac{I}{I_0} \quad \text{i.e.} \quad A = - \log T \quad \text{Eq. 2}
\]

We then trace the absorptance of the plastic blades according to the numbers of plastic blades for a wavelength fixed (red). (Figure 4)
A number of plastic blades $n$  

Figure 4. Curve : $A = f(N)$

Conclusion: we note that there is proportionality between $A$ and the number of blade, this relation makes us think to the law of Beer-Lambert which we studied in class where this time the blades were replaced by nickel sulphate solutions (Ni SO4 (aq)) with different concentrations (scale of colour). (Figure 5)

2. CLOUD AND DIFFUSION OF THE LIGHT

In a calm atmosphere, transparent, of constant temperature the light is also propagated in straight line. However the light meets on its way through the atmosphere of many microscopic particles which will behave like as many sources of light and which will return the light in all the directions and in particular towards our eye. It is said that there is diffusion of the light. (Figure 6)

We then trace the light intensity transmitted and diffused according to the milk mass added (in gram).

Figure 6. experience

We trace the received intensities this time in W/m $^2$ according to the quantity of added milk particles. In blue, the transmitted light decreases quickly then is stabilized, perhaps because of milk saturation of solution. (Figure 7) In red, the diffused light decreases less quickly, the phenomenon of reflection is perhaps proportional.

Conclusion: the milk concentration (cloud) has an influence on the transmission and the diffusion of the light.

3. MEASUREMENTS AND INTERPRETATION

Example of calculation:

Date: April 8, 2011

Calibration of the solar, constant photometer($V_o$) : $3.370$ V
Solar angle of altitude : $56^\circ$
Pressure of the station : $1012.0$ hPa ; Pressure on the sea level : $1016.3$ hPa
Obscure tension : $0.003$ V
Tension of measured sunlight : $1.904$ V
Channel of the solar photometer : green

April 8, 2011, is the 97ème day of the year, thus one calculates the distance Ground/Sun :  
$$R = (1 - 0.0167^2)[1 + 0.0167 \times \cos(2 \times \Pi \times (97/365))] = 1.0014$$
The relative mass of air is : $m = 1/\sin(56^\circ) = 1.2062$
The optical thickness of aerosol is:

\[
AOT = \frac{\ln(V_o/R^2) - \ln(V - V_{dark}) - a_s(p/p_o)m}{\ln(V_o/R^2)} = \frac{1.2121 - 0.6423 - 0.1659}{1.2062} = 0.3348
\]

This optical thickness can be expressed as a percentage of sunlight to a particular wavelength which reaches the surface of the ground after having crossed a relative mass of air of 1:

\[
\% \text{ of transmission} = 100 \times e^{-AOT} = 100 \times e^{-0.3348} = 71.5\%
\]

**Exploitation 1**

Comparison with the data **AERONET** (AEROSOL ROBOTIC NETWORK)

(https://aeronet.gsfc.nasa.gov/cgi-bin/type_one_station_opera_v2_new?site=Porquerolles&nachal=0&year=19&month=3&day=7&aero_water=0&level=1&if_day=0&if_err=0&year_or_month=0)

On the island of Porquerolles, a photometer records the every day the Optical Thicknesses to various wavelengths.

For April 8, our Red Optical Thickness is correct but our Optical Thickness green is a little large. Porquerolles is an island with a few kilometers of the centre town of Hyeres, it is perhaps that we undergo an urban pollution.

**Exploitation 2**

Comparison with the data **ICARE**

(http://www.icare.univ-lille1.fr/)

Date: April 8, 2011

Our measurements at **11h25 (GMT)**:

- **AOT** Green Channel. (505 nm): 0.335 AOT
- **AOT** Red Channel. (625 nm): 0.127 AOT

Thus we used another site which gives us the indices of pollution, the town of Hyeres has with a few meters from here a sensor of pollution. **(Figure 10)**

At this hour of collective measurement, a rather important rate of particle lower than 10 µm and of ozone was detected, which could explain a rather high value our optical thickness in the green.

We have a larger measurement for the **AOT Green** which can be explained thanks to the site: http://www.atmopaca.org (Figure 11)

Fine particles of diameter lower than 10 µm (PM10): 49 µg/cm³; Ozone: 111 µg/cm³

**Figure 11. Mesures**

Statement with **Park Hôtel, 16 Avenue de Belgique 83400 HYERES (France)**

Type: urban; Startup: 21-04-2004; Altitude: 33 meters at 11h00 (GMT)
AOT. Green Channel. (505 nm) : 0.335 AOT
AOT Red Channel. (625 nm) : 0.127 AOT

The data of Icare give statements of aerosols.
In red the passage of the satellites i.e. 12h36 and us 11h25. Hours GMT are almost identical.
The data allow us thanks to the Aqua/Modis satellites to 550 nm, a few minutes, our Optical Thickness Green is in agreement with the measurement of the satellite. (Figure 12)

**Exploitation 3**
Comparison with the data of CALIPSO

Then the Calipso satellite gives measurements to the vertical of its passage in aerosol and cloud. (Figure 13)

Co-ordinates GPS of Maintenon are : (30 m - Lat. 43.144 - Long. 6.131)

With our latitude, Calipso measures a certain presence of aerosol in altitude.

**Exploitation 4**
Fukushima (Japan) (Figure 14)

We then if the cloud of Fukushima had arrived to France and which type of particles brought it sought?

It brought cesium 134 (Figure 13) and iodine 131 (Figure 16) particles which are also aerosols as shows it these two graphs where the iodine 131 rate lies between 0.15 and 0.20 nBq/m³ (measurements carried out with Seyne / Mer).
A quantity of disintegration a second and per cubic meter rather significant.

The iodine atom has a diameter of 0,28 µm and the cesium has a diameter of approximately of 0,60 µm.
**Exploitation 5**

Pollens (Toulon, France)

We noticed on avoid-break cars a yellow film of particles yellow. The series of measurement is in spring and pollen is propagated in great quantity in our area. In Toulon where a sensor of pollen is based, we note that the beginning of April is rich in particles of cypress, plane tree, … *(Figure 1)*

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*Figure 17. Synopsis*

http://www.pollens.fr/accueil.php

**Conclusion :** a high rate of pollens at the beginning of April

**4. CONCLUSION**

It should be remembered that the green channel rather collects aerosols of small sizes such as fume or air pollutions, whereas red channel collects the aerosols of big size such as dust.

We can conclude that for April 8, 2011, thanks to the green channel, we have particles of the air pollution type (ozone, dioxide of sulphur, nitrogen dioxide,…) and of the traces of particulate iodine 131 (2 mBq/m³ in Cherbourg ~ source IRSN) and of cesium 134 and thanks to the red channel, we have dust natural pollens type. These particles are small sizes (lower than 10 μm).

The aerosols can affect meteorology and the climate. They have complex properties. According to their forms, their sizes and their compositions, they can reflect the sunlight to space and to cool the atmosphere, they can also absorb the sunlight and heat the atmosphere.

**5. THANKS**

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Students: