WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR INSTRUMENTS AND METHODS OF OBSERVATION

CIMO MANAGEMENT GROUP
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OTHER BUSINESS

Proposal for a ceilometer and lidar intercomparison

(Submitted by Florence Besson, Meteofrance)

Summary and purpose of document

This document provides information on the experience made by MeteoFrance in the intercomparison of lidars and ceilometers.

ACTION PROPOSED

The MG is invited to consider this information, when discussing which intercomparisons should be addressed as a priority by CIMO and how such a project should be planned and carried out in case it should be pursued within CIMO.

Context

- Eyjafjallajökull eruption in April-May 2010
  - 107,000 flights cancellations during an 8-day period
  - 10 million passengers stuck in airports
  - ~ € 1.3 billion according to IATA (International Air Transport Association)
- Difficulties for London VAAC (Volcanic Ash Advisory Centre) to provide accurate informations about the ash plume.

→ Toulouse VAAC asked Météo-France to find solutions to detect volcanic ashes

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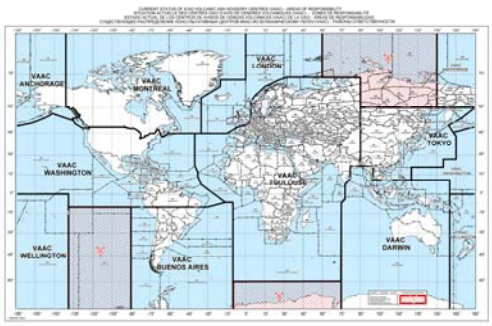
Toulouse VAAC Requirements

- Detect and identify volcanic ashes from the ground to 12 km. Distinguish volcanic ash from sand aerosols or clouds.
- Assess volcanic ash concentration. VAAC thresholds are:
  - 0.2 mg/m3
  - 2 mg/m3
  - 4 mg/m3



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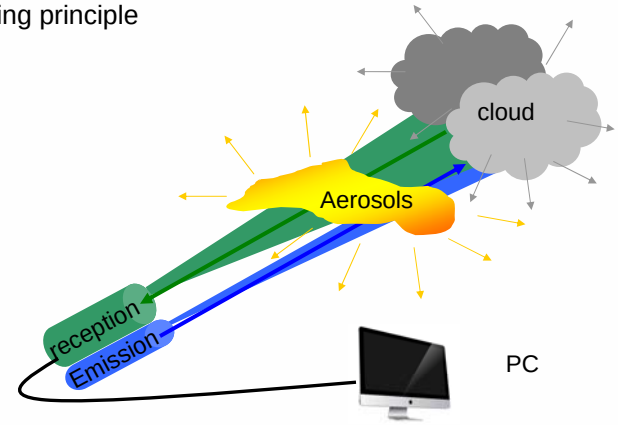
Lidar technology

- Operating principle



- A good technology to measure ash from ground, but are there operational instruments ?

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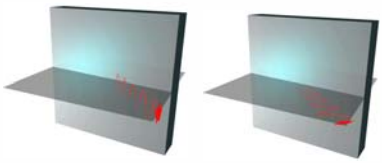
What do we need ?

- Are all commercial lidars operational ? We need :
  - Easy installation
  - Rare and predictable maintenance (eg : no lamp to be changed …)
  - High robustness
  - … and working lidars !



- What wavelength do we need ?
- Do we need double polarisation ?
- Do we need Raman N2 Channel ?

- Ceilometers (done to measure clouds base height) are small lidars. Are they adequate to measure ash up to 12 km ?

- Impossible to assess properly a lidar on paper
  => it's necessary to test them ! => intercomparisons

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2012 Intercomparisons

We need … :

- A location where there are some dust events (dust features are close to ash ones) … and not too many clouds !
  - Note that we can't assess the lidar measuring what we want to measure (ash) !
- To get a good assessment, we need to compare lidars data with in situ measurements (plane, radiosounding) and a reference lidar
- Some human resources close to the instruments (to maintain them)
- Because of these needs, we had to make 2 intercomparisons
  - Toulouse (dust events, sunny, human resources)
  - Candillargues (dust events, sunny, authorizations for reference lidars and plane flights)

2012 : Toulouse Intercomparison (1)

- 4 lidars and 3 ceilometers

- IR, Visible and UV wavelengths
- 1 photometer
  - to be able to assess the Aerosols Optical Depth (AOD) of the lidar
  - To assess the relevance of this instruments (it allows to measure and calculate AOD and to assess the size of the particles)
- Not so easy to write and sign agreements with manufacturers : we signed rentals, purchases and loans.
- Problems with delivery times (shipping times, lidar production delay for new instruments …) => hard to get them working together

2012 : Toulouse Intercomparison (2)

- High human resources consumption to maintain the instruments operating, for example :
  - data dissemination problems,
  - Stop of lasers
  - Computing crash
  - Spider in the photometer
  - Contact with manufacturers (they couldn't check data in live because they couldn't connect to Météo-France network)

2012 : Candillargues Intercomparison

Goal : to compare

- **1 lidar** from the Toulouse intercomparison
  - UV Raman N2 Channel

With :

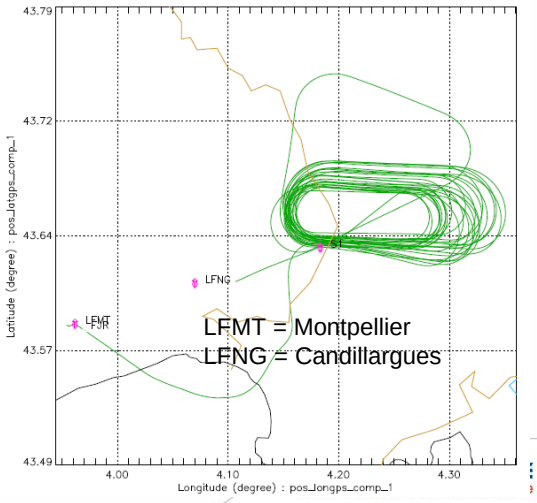
- **a reference lidar** : Mobilis lidar
  - (multi-λ + Raman N2 channel)

And :

- **In situ measurements** :
  - SAFIRE plane : granulometry, concentration
  - LOAC radiosonde

2012 : Candillargues Intercomparison

- Some difficulties to get lidar emission authorizations (contacts with aviation civile authorities) + SAFIRE flights authorizations



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2012 : Candillargues Intercomparison

LOAC : Light Optical Aerosol Counter

Measurements at 2 scattering angles :

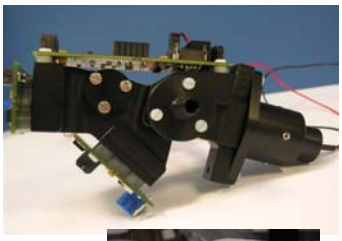
12°, where the scattered light is ~ insensitive to the nature of the aerosols

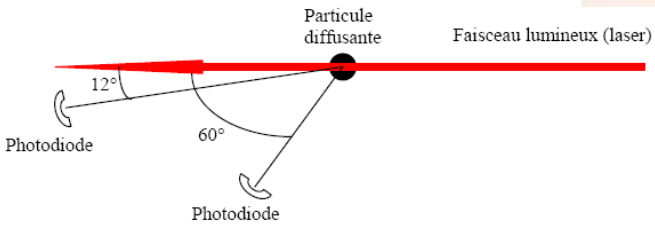
60°, where the scattered light is very sensitive to the nature of the aerosols

Combining the measurements

=> accurate determination of the size distribution

=> estimation of the main nature of the aerosols





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2012 : Candillargues Intercomparison

- 3 people needed to operate a LOAC radiosounding
  - Special software to program the fall (usually in the mid-atmosphere) to be able to get the radiosonde back
  - Special software to track the LOAC and get it back before radiosounds chasers !
- Dust events (in Candillargues and Toulouse) were forecast with MOCAGE model (Météo-France chemistry and transport model)

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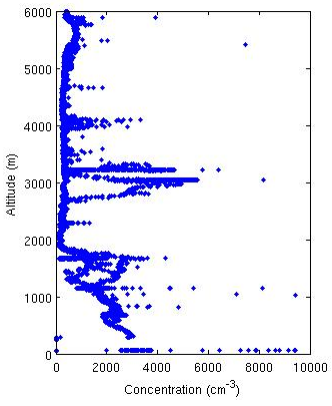
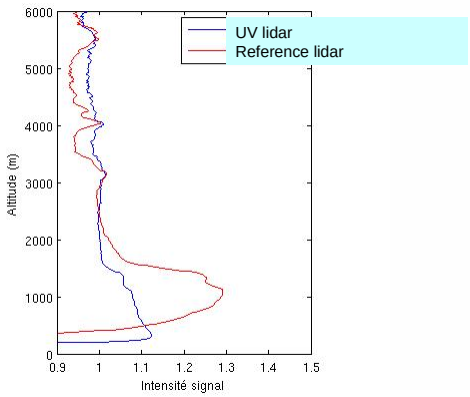
2012 : Candillargues Intercomparison



Condensation particle counter



12/10/2012 : 'Clean air' but good correlation

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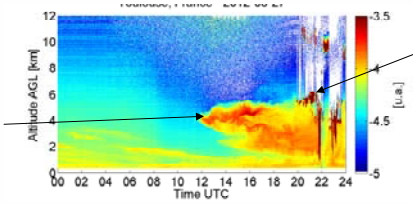
How to deal with the data

- Météo-France wanted to get its own results (to be independent from the manufacturers).

→we used different algorithms to retrieve and visualise lidar data (they come from french laboratories).

- Several issues:
  - Manufacturers raw data are not always raw data per se: sometimes they make corrections we can't even know.
  - Different file format: ASCII, binary, NetCDF.

Aerosol layer



Cloud + shower

Example of the 27th of june, 2012

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Algorithms: STRAT

- STRAT from the SIRTA (french lab). Morille et al., 2010.

Converts a raw data file into a NetCDF file. Plot range corrected signal and makes a classification.

Raw data → NetCDF file → Plots → Classification

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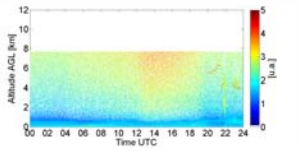
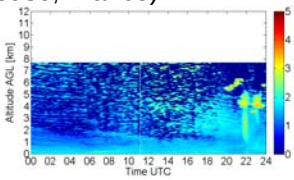
Algorithms: STRAT

- Smoothing (June, 27th 2012 – Toulouse, France)

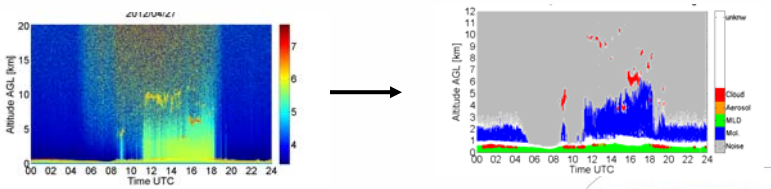


Range corrected signal.



Smoothed signal: the aerosol layer is more viewable

- Classification: Makes a classification using a range corrected signal



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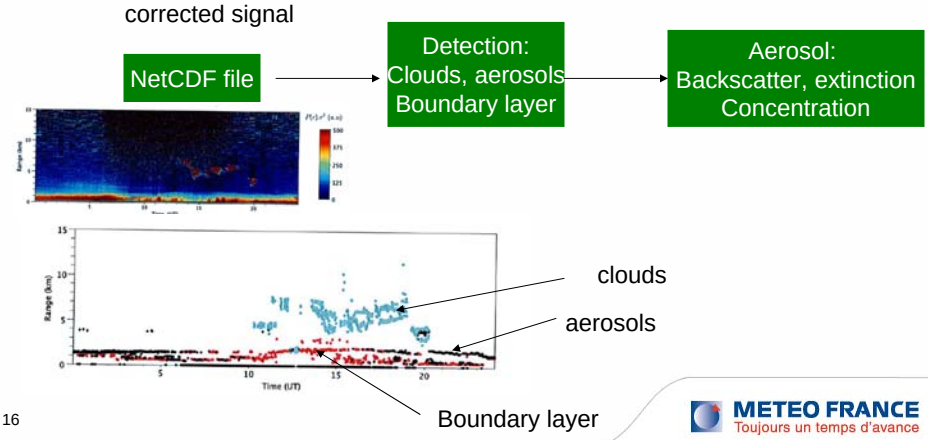
Algorithms: BASIC

- BASIC from the LOA (french lab). Mortier, 2013.
  - How it works: allows the retrievial of lidars parameters (backscatter, extinction coefficients and aerosol concentrations) from a range corrected signal



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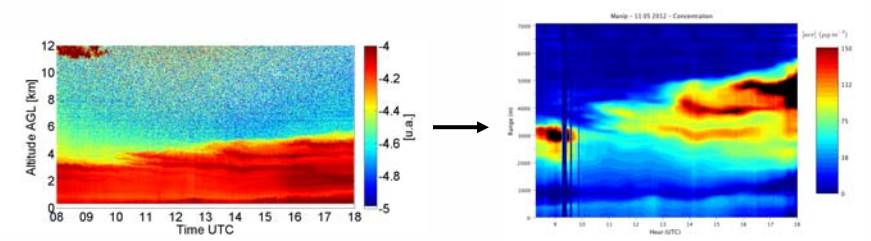
Algorithms: BASIC

- Aerosol concentration (May, 11st 2012)

→ determination of massic aerosol concentration from a range corrected signal



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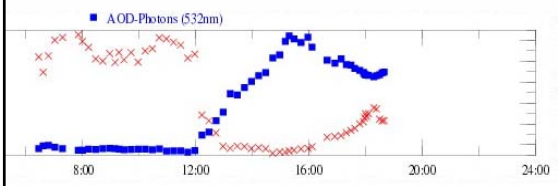
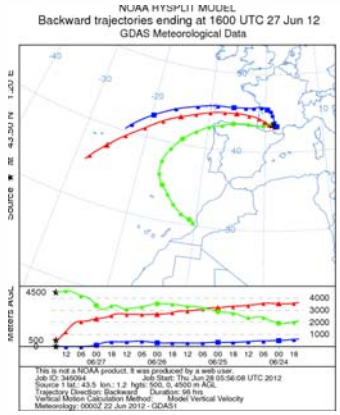
Eg : June, 27th 2012 - Toulouse, France

- Saharan dust advected in mid-troposphere: yellowish sky in Toulouse, southern France.

- Higher AOD values in the afternoon : 0.6 at 532 nm and smaller Angstrom coefficient = bigger particles





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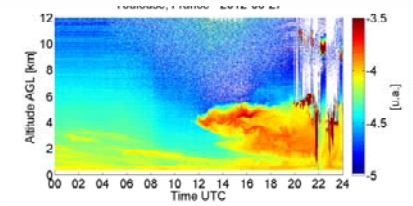
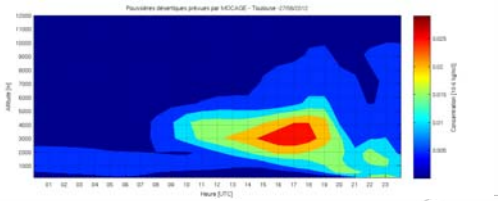
Eg : June, 27th 2012 - Toulouse, France (2)

- A dust event forecasted by Mocage :
  - Lidar



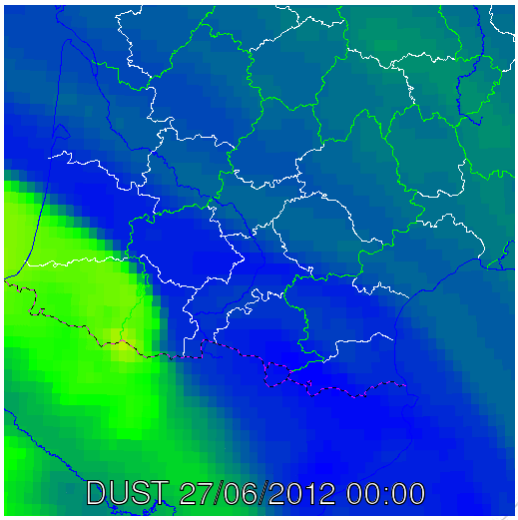
  - Mocage



Good correlation

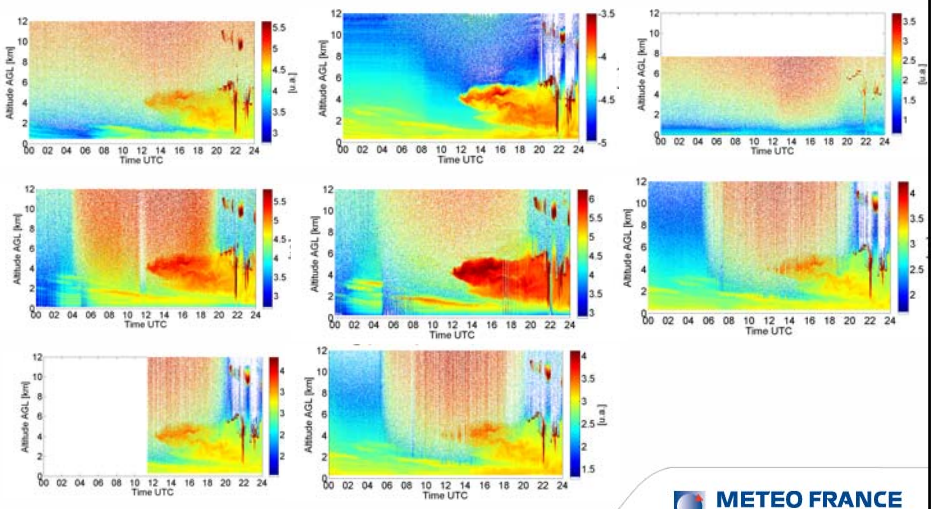
Eg : June, 27th 2012 - Toulouse, France (3)

- A dust event forecasted by Mocage :



Eg : June, 27th 2012 - Toulouse, France (4)

These plots are all available lidars data on June, 27th 2012 during the campaign.



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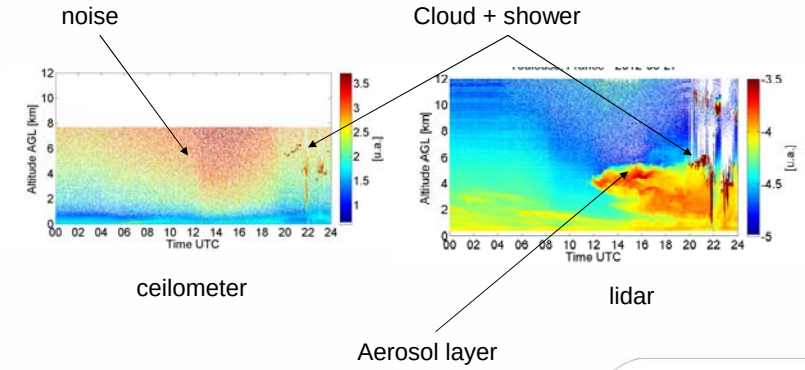
Eg : June, 27th 2012 - Toulouse, France (5)

- Differences between ceilometers and lidars:
  - Ceilometer (left): lots of noise. It was not able to see the aerosols layer.
  - Lidar (right): the aerosol layer is clearly visible.



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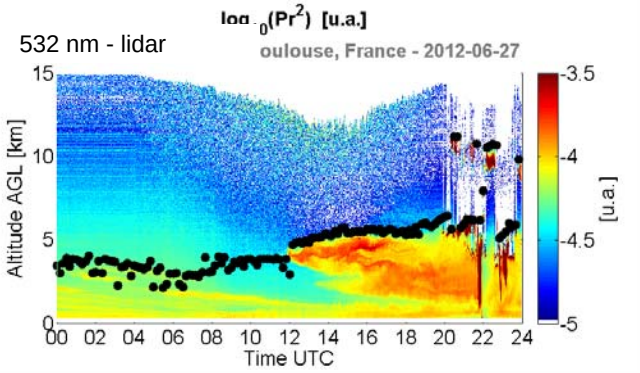
Eg : June, 27th 2012 - Toulouse, France (6)

- Wavelength
  - IR: weak molecular range. Problems of lidar calibration, and hard to define a range

532 nm - lidar



Range of an IR ceilometer in dark point : range = top of the dust layer !
(Pr2 of a green lidar)

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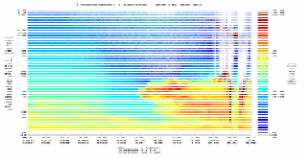
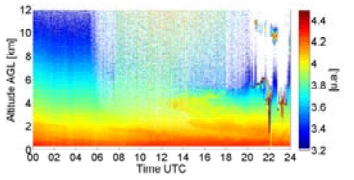
Eg : June, 27th 2012 - Toulouse, France (7)

- Wavelength
  - UV: molecules are the main component of the lidar signal

Green





UV

- Hard to compare instruments with each other because of their very different technology (wavelength, laser energy, detection mode…)
- We also showed that :
  - Double polarisation interesting by giving information about sphericity of the particle
  - Raman N2 channel promissing, but we didn't have our own algorithm able to deal with N2 raman channel

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Easier intercomparison if ..

- Only already operational lidars and ceilometers
- We precisely define how to compare the data (e.g : how to define the range)
- Treatment algorithms ready
- A place without too many clouds appreciated !
- A reference lidar
- A place with some ash clouds (default : dust ?) … or to be able to afford an artificial ash cloud as EasyJet ?!

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