Recent developments of Sun-photometer/Lidar observations for aerosols characterization and monitoring

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Sun-photometer :

Since a long time now (1992-1993), LOA is involved in AERONET **Network** development and leading, in France, sun-photometry activity (Africa, France, Europe) dedicated to aerosol characterization and monitoring (labelled Service d'Observation from INSU/CNRS in 1998).

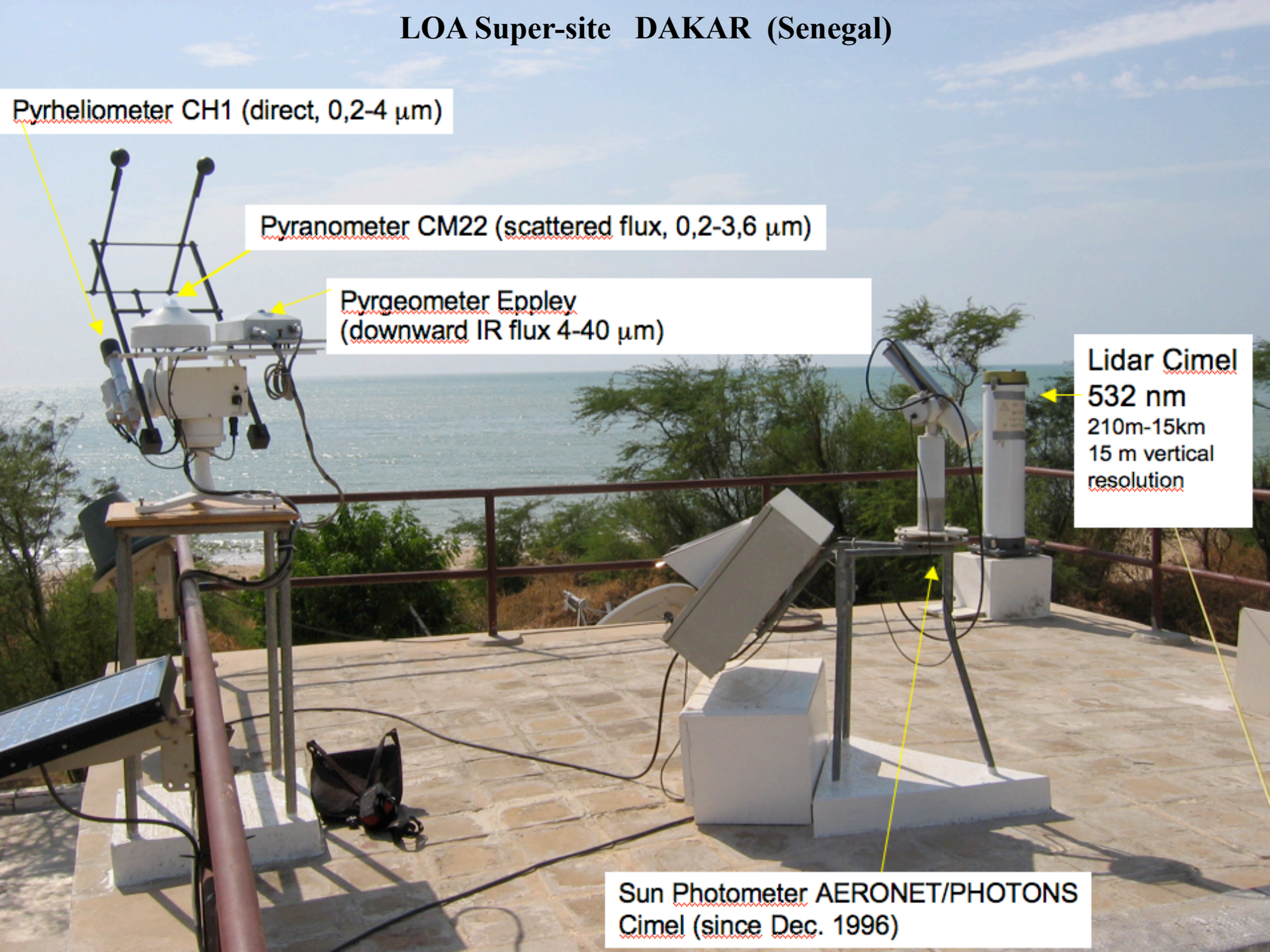
Characteristics of AERONET : homogeneity in instrumentation (robust, autonomy), real time data acquisition and data/products publication, automatic and centralized processing, Data Quality Policy, Public domain (can access to aerosol /water vapor parameters at our favorite site without being specislt of sun-photometry).

Lidar :

Becoming more simple, cheaper and automatic, for several years, micro-LIDAR systems are developing and are operated by more and more research laboratories.

Since 2005-2006, LOA started routine (24/7) Lidar observations with a CIMEL micro-Lidar (532 nm, elastic backscatter) at M'Bour (Dakar, LOA super-site, preliminary analysis of 2-3 years data by Léon et al).

LOA Super-site DAKAR (Senegal)



Since 2005-2006, LOA started routine (24/7) Lidar observations with a CIMEL micro-Lidar (532 nm, elastic backscatter) at M'Bour (Dakar, LOA super-site, preliminary analysis of 2006-2007-2008 (8 months) years data by Léon et al).

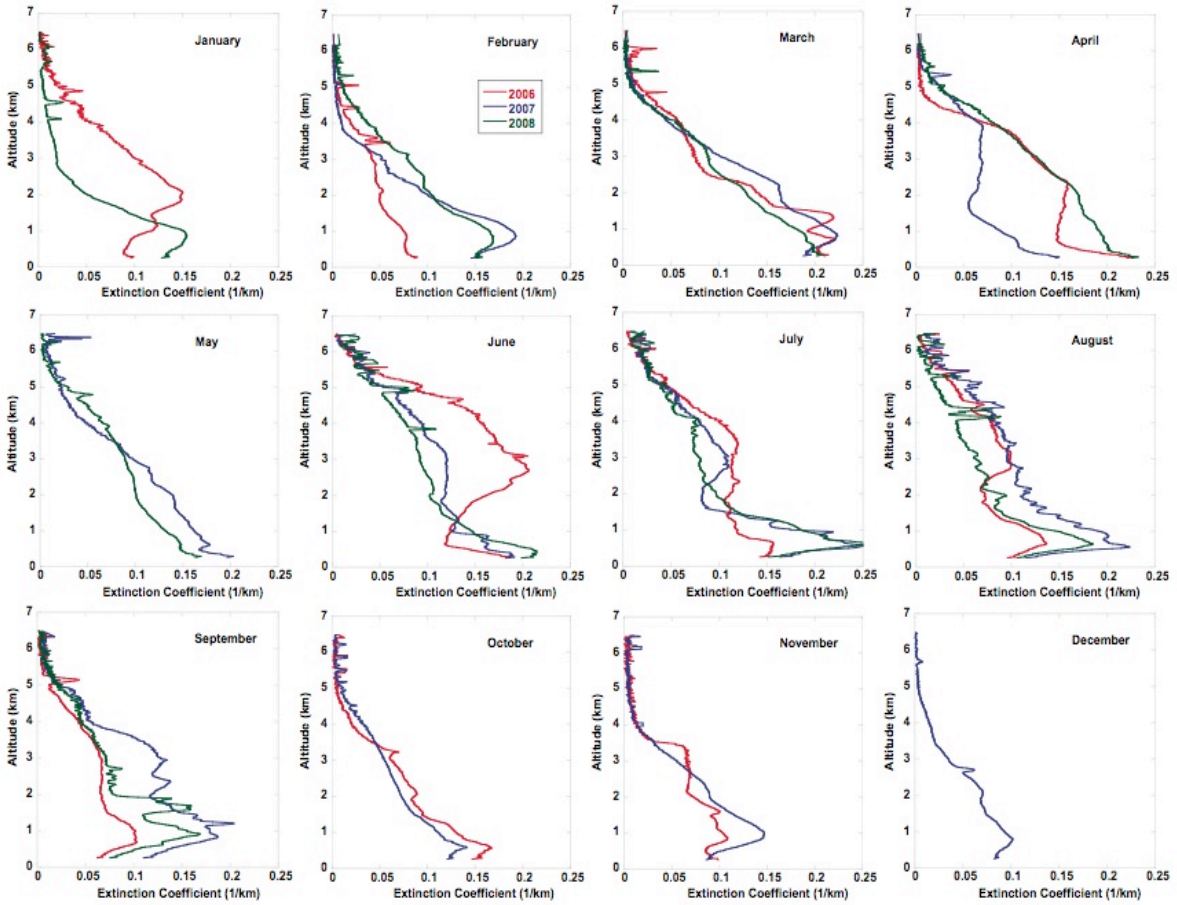


Figure 2 : monthly average vertical profiles of aerosol extinction at 532 nm for (red solid line) 2006, (blue solid line) 2007 and (green solid line) 2008.

Since 2006-2007, LOA started Lidar routine observations + specific campaign with a CIMEL micro-Lidar at in Lille University Campus.

Same instruments as in Dakar
+ temporary experiment or campaign (Spring 2010)

Transportable LIDAR system from NASB - Belarus (Chaïkovsky et al.,)

Objectives : start Variability and trend analysis two contrasted sites (Dakar, dust) and (Lille, urban). Data (2006->2012 : 7 years, Ph.D program for Augustin Mortier)

Needs : provide homogeneous processing and data quality assured for all the archive existing and futur data. Since 2008-2009, LOA designed and continuously improved LOA/Lidar data base and processing / visualization system combining sun-photometer data and lidar data :

LOA/LIDAR network

Data base (http://www-loa.univ-lille1.fr/Instruments/lidar/**)** (C. Deroo, LOA)**:**

AERONET & LIDAR
LIDAR (permanent & temporary, mobile)
Calibration database memory of LIDAR systems evolution / maintenance (T. Podvin, LOA)

Processing / visualization system combining sun-photometer (AOD) and lidar data (532 nm) (C. Deroo, LOA)

- real time processing (simple approach hence not perfect, but automatic, data transfer by ftp)
- reprocessing tools (update software, introduce new modules, thresholds, …)
- public domain

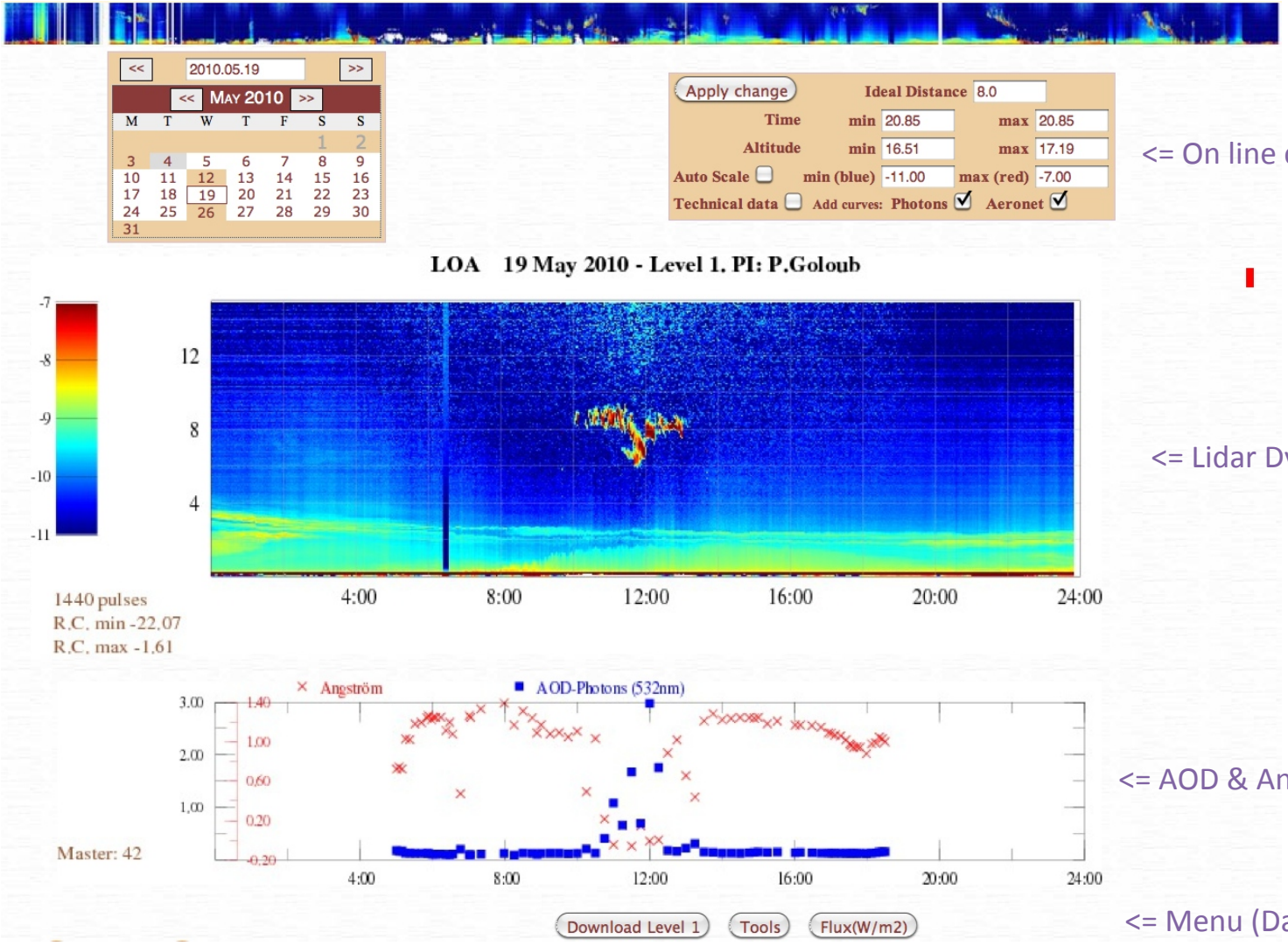
Development of an operational 24h/7d LIDAR/sunphotometer system

http://www-loa.univ-lille1.fr/Instruments/lidar/

CIMEL (532 nm) - Lille / Dakar / Guadeloupe

Routine day time inversions of $\sigma_{a,ext}(z)$ + average extinction to backscatter ratio

Existing database : Dakar : 5 years, Lille : 4 years; Guadeloupe (< 1 year)



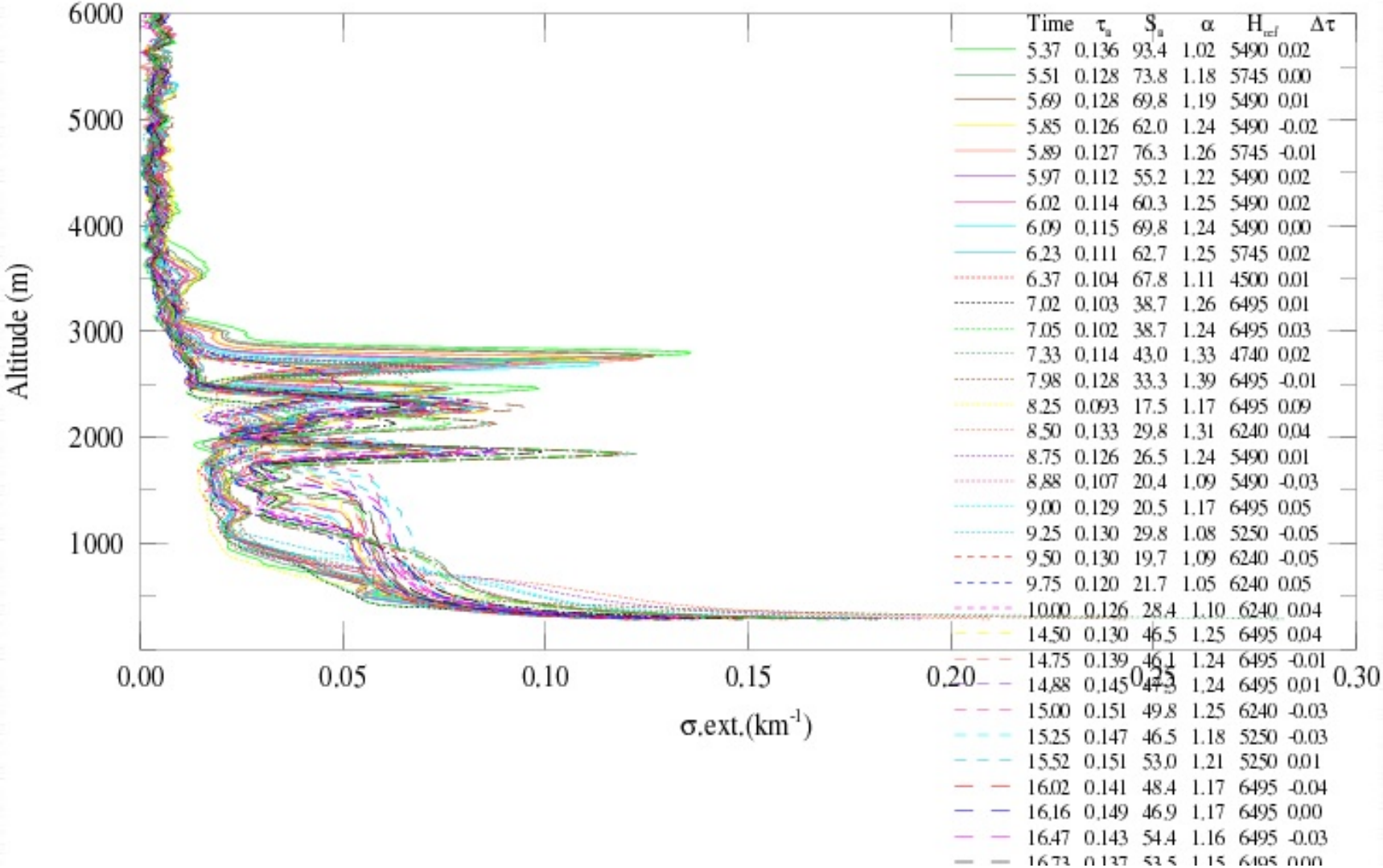
<= Monthly overview

<= On line change of Quick-Look Aspect

<= Lidar Dynamic Quick-Look

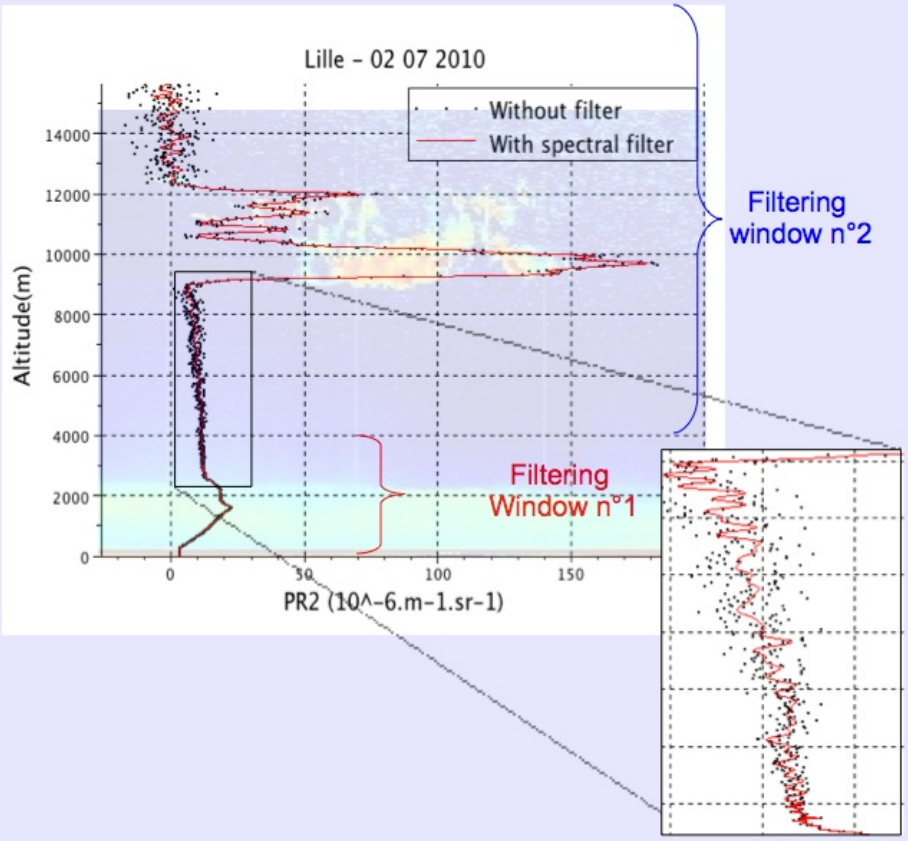
<= AOD & Angström (sun-photometer)

<= Menu (Data, Inversion (tools),...)


LOA 19 May 2010 - Level 1.5 - PI: P.Goloub
Altitude (m)
6000
5000
4000
3000
2000
1000
0.00
0.05
0.10
0.15
0.20
0.25
0.30
σ.ext.(km-1)
Time τa Sa α Href Δτ
5.37 0.136 93.4 1.02 5490 0.02
5.51 0.128 73.8 1.18 5745 0.00
5.69 0.128 69.8 1.19 5490 0.01
5.85 0.126 62.0 1.24 5490 -0.02
5.89 0.127 76.3 1.26 5745 -0.01
5.97 0.112 55.2 1.22 5490 0.02
6.02 0.114 60.3 1.25 5490 0.02
6.09 0.115 69.8 1.24 5490 0.00
6.23 0.111 62.7 1.25 5745 0.02
6.37 0.104 67.8 1.11 4500 0.01
7.02 0.103 38.7 1.26 6495 0.01
7.05 0.102 38.7 1.24 6495 0.03
7.33 0.114 43.0 1.33 4740 0.02
7.98 0.128 33.3 1.39 6495 -0.01
8.25 0.093 17.5 1.17 6495 0.09
8.50 0.133 29.8 1.31 6240 0.04
8.75 0.126 26.5 1.24 5490 0.01
8.88 0.107 20.4 1.09 5490 -0.03
9.00 0.129 20.5 1.17 6495 0.05
9.25 0.130 29.8 1.08 5250 -0.05
9.50 0.130 19.7 1.09 6240 -0.05
9.75 0.120 21.7 1.05 6240 0.05
10.00 0.126 28.4 1.10 6240 0.04
14.50 0.130 46.5 1.25 6495 0.04
14.75 0.139 46.1 1.24 6495 -0.01
14.88 0.145 47.3 1.24 6495 0.01
15.00 0.151 49.8 1.25 6240 -0.03
15.25 0.147 46.5 1.18 5250 -0.03
15.52 0.151 53.0 1.21 5250 0.01
16.02 0.141 48.4 1.17 6495 -0.04
16.16 0.149 46.9 1.17 6495 0.00
16.47 0.143 54.4 1.16 6495 -0.03
16.73 0.137 53.5 1.15 6495 0.00

Increasing of data quality

- **Spectral filter** with Fourier Transform



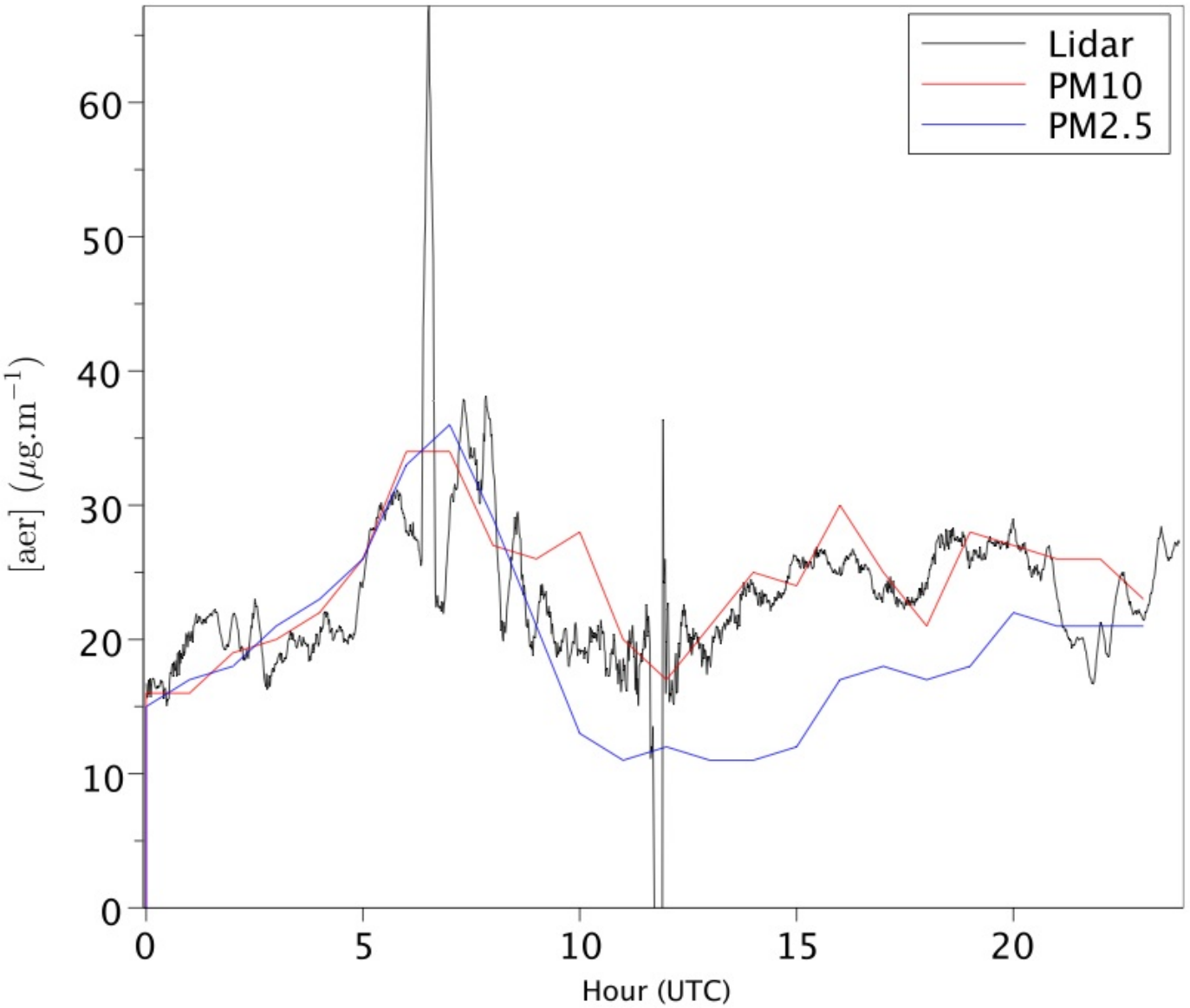
Increasing of inversion quality

- Determination of the **inversion top altitude** Z_{ref} with the convergence of the AOD_{Lidar} derived from the extinction profiles

Retrievements informations

Level 1 | Inversions with $AOD_{sunphotometer}$ – Result : $\sigma_{ext,aer}(z)$, $\overline{S}_a$	Opened to public
Level 1.5 | Inversions with $AOD_{sunphotometer}$ AERONET lev 1.5 – Results : $\sigma_{ext,aer}(z)$, $\overline{S}_a$	Not yet visible to public
Level 2 (2011) | Inversions $AOD_{sunphotometer}$ when no clouds (detection algorithm) + Night inversions - Results : $\sigma_{ext,aer}(z)$, $\overline{S}_a$, Boundary Layer Height, Aerosol Layer Detection, Accuracy, PMx	Future (2011)

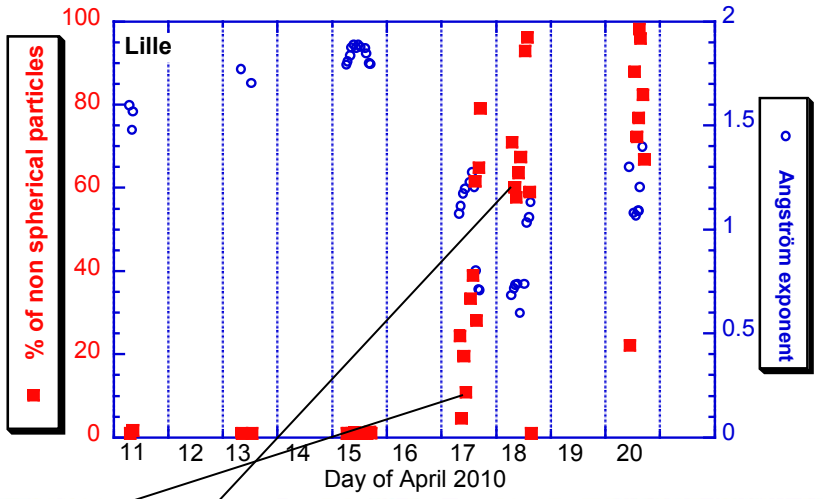
Estimate if PM by considering AERONET retrievals (size distribution) and Lidar Inversion (example for Lille site, evaluation against PM measurements close to Lille Campus)



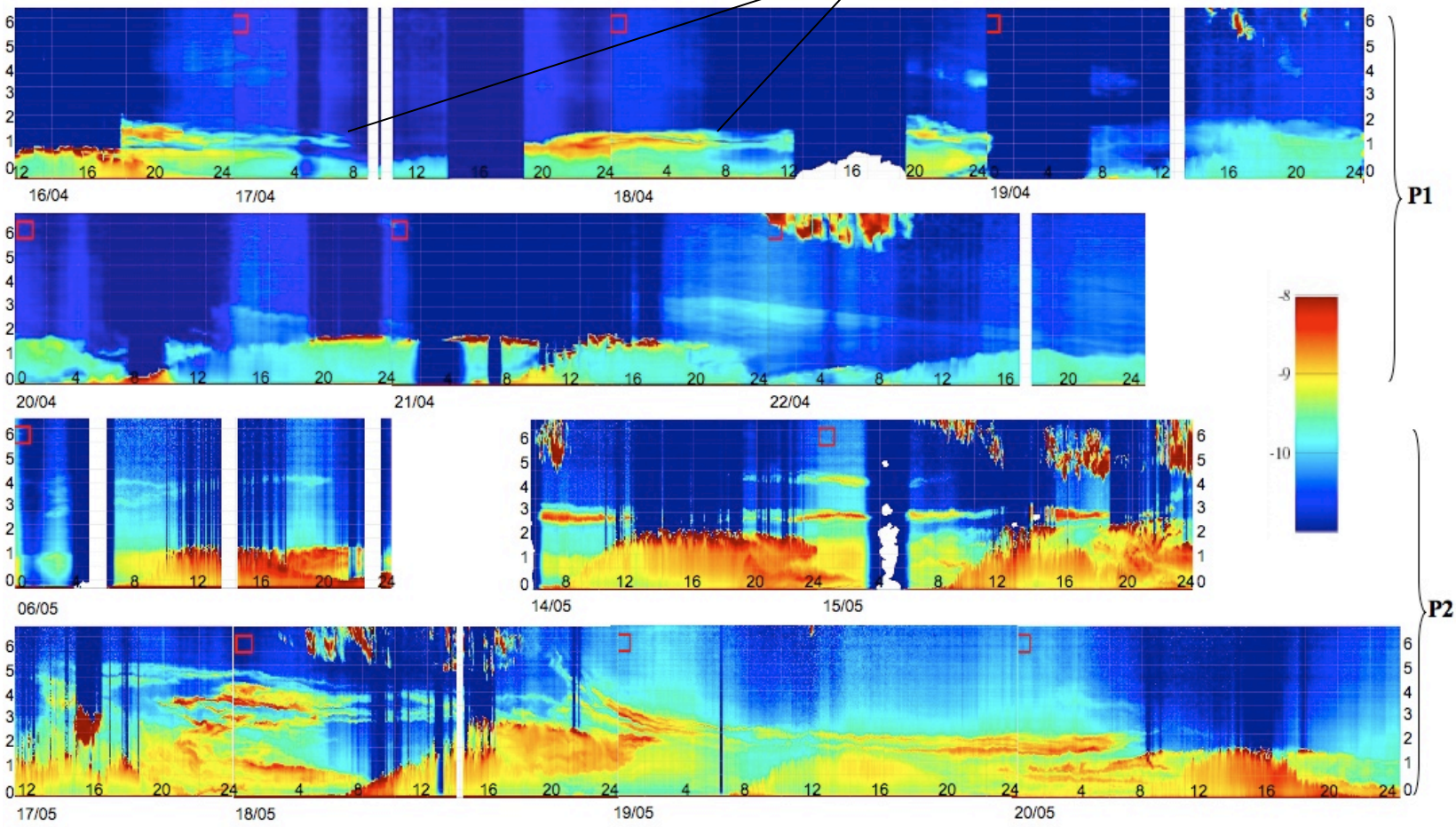
Volcanic Ash Plumes over Lille during Eyjafjoll

From sunphotometer operated in Lille =>

NS fraction suddenly increased !



From LIDAR operated in Lille



Date	Time (UT)	Altitude (m)	$\sigma_{ext\ (532nm)}$ (km^{-1})	τ_{ash}/τ (532nm)	C_a ($\mu g/m^3$)	Min-Max ($\mu g/m^3$)
17/04	06h52	1410	[0,091-0,103]	0,028/0,18	115	60-170
	11h57	1665	[0,007-0,008]	0,007/0,13	10	5-15
	18h58	1350	[0,236-0,272]	0,10/0,25	300	150-450
18/04	06h46	1495	[0,29-0,33]	0,16/0,36	360	180-540
	20h46	1640	[0,20-0,23]	0,08/0,30	260	130-390
06/05	18h21	4200	[0,020-0,023]	0,006/0,34	25	10-40
14/05	09h55	2760	[0,20-0,22]	0,07/0,20	240	120-360
15/05	06h45	2890	[0,17-0,20]	0,07/0,40	220	110-330
18/05	11h25	3260	[0,13-0,14]	0,08/0,23	160	80-240
	18h05	2775	[0,14-0,15]	0,13/0,29	170	85-255
19/05	07h25	2655	[0,074-0,082]	0,04/0,11	90	45-135
	12h05	2455	[0,065-0,07]	0,04/0,13	75	40-110
	18h05	2295	[0,058-0,063]	0,03/0,14	70	35-105
	20h05	1890	[0,08-0,09]	0,06/0,14	100	50-150
20/05	05h05	1960	[0,15-0,16]	0,08/0,16	180	90-270

Table 1: Summary of the main characteristics of volcanic ash layer detected over Lille.

Current Status of Data processing : automatic mode (AOD + Lidar Irradiance (z))
(dynamic, reprocessing tools,…)

Futur Development :

- add on-line tools for user to apply inversion (change inversion parameters …, manual mode for adaptating to specific events or complex situation (volcano).

- Inclusion of mobile lidar/sun-photometer platform

Mobile Sun-tracking Photometer : PLASMA

(prototype version developed in LOA by C. Verwaerde, JY. Balois and D. Tanre)

People involved in the project : Y. Karol (Thesis), SO PHOTONS/AERONET)

Introduction

Automobile

PLASMA (*Photomètre Léger Aéroporté pour la Surveillance des Masses d'Air*) is a sun tracking photometer based on board of an aircraft which measure AOD during flight and therefore **provide spectral AOD** (0.34 – 2.25 µm) **as a function of the altitude**.

One of the main PLASMA's objectives is **validation of AOD vertical profiles provided by lidar**.

PLASMA on the plane

Eyjafjöll **volcanic ash layers**
19 of May 2010
at an altitude of 2500 m

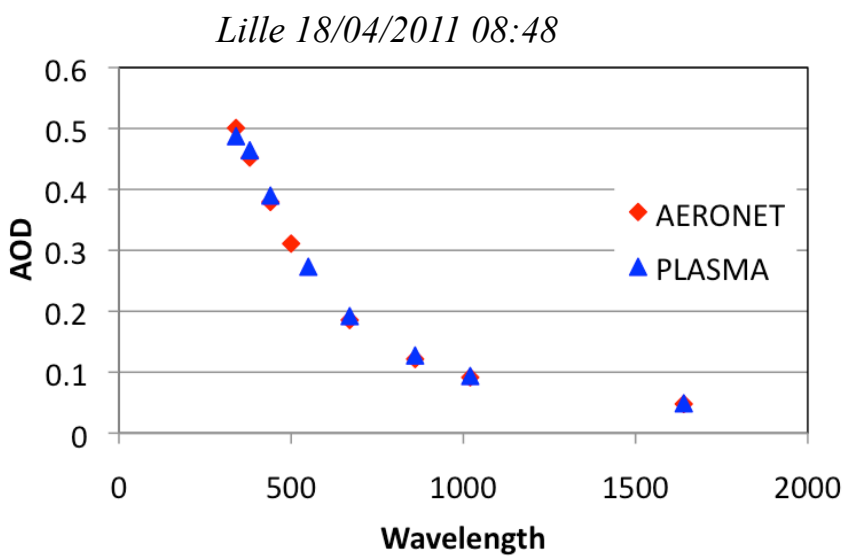
Spectral AOD inversion (Dubovik code restricted to AOD : 340 to 2200 nm)

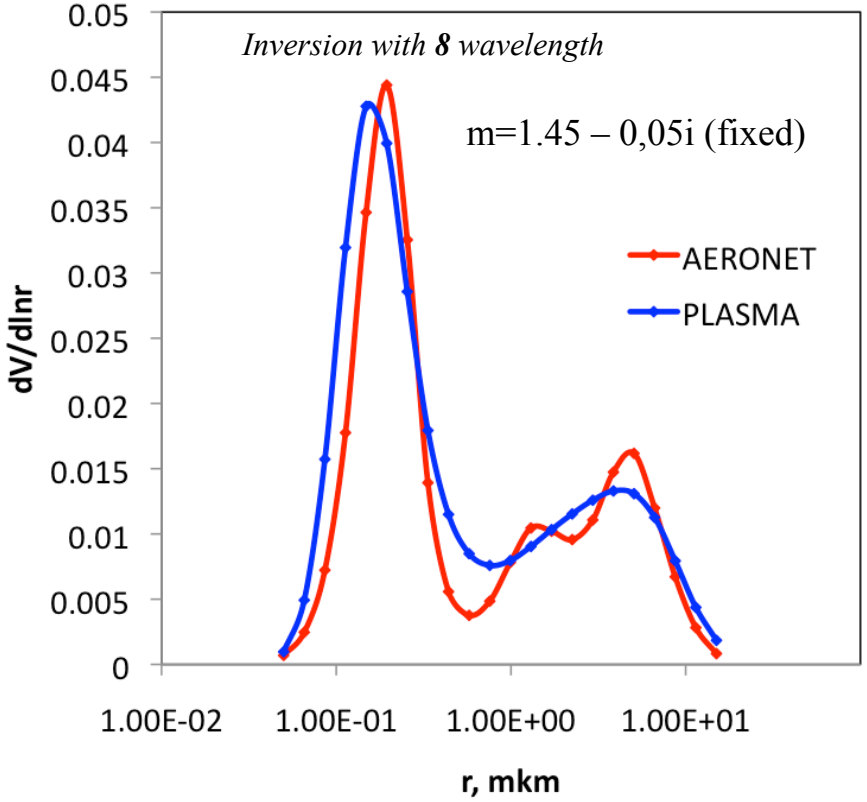
1- Sensitivity study to size distribution shape : under-progress

(fine mode ofently retrieved, coarse mode less accurate but refractive index cannot be retrieved)

Compute spectral AOD in the PLASMA channels for various size distribution → Invert size distributions

2- Inversion of real data and comparison to AERONET





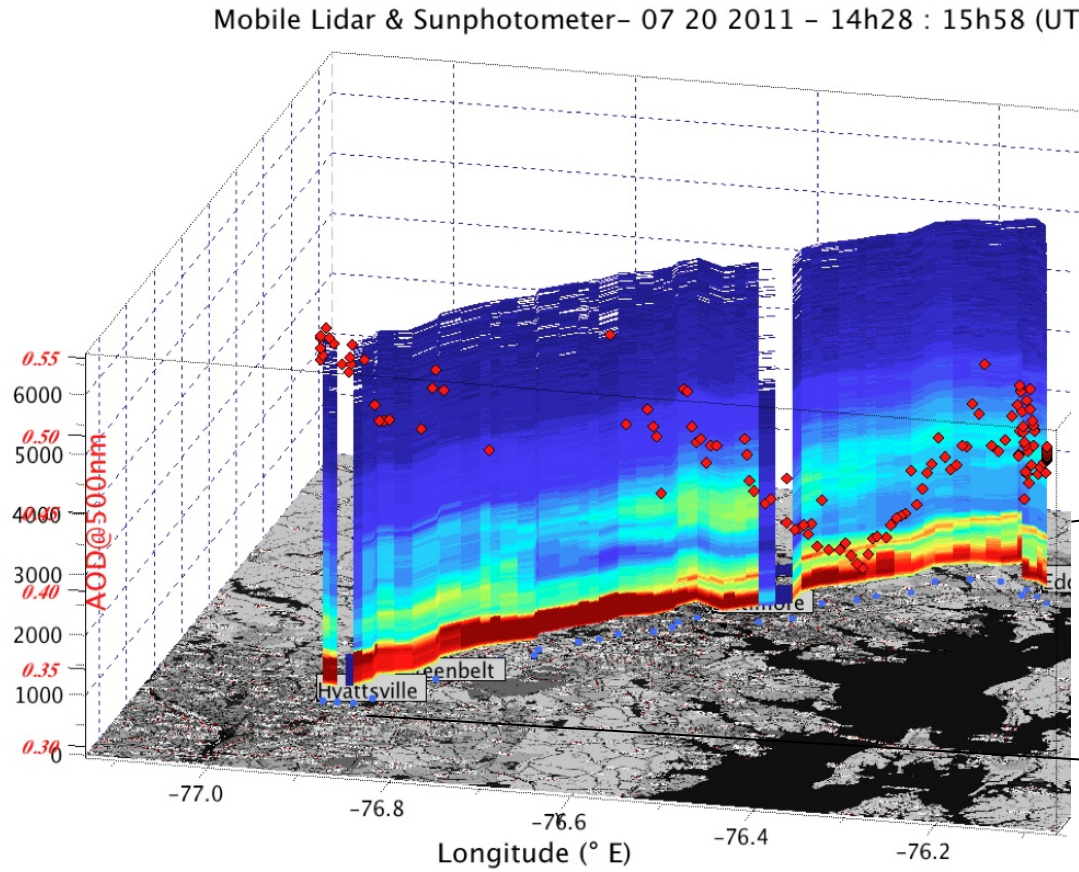
Then we put together PLASMA and CIMEL micro-Lidar during DRAGON experiment

⇒ Recent developments include Mobile Platform in the system (first field campaign during DRAGON, USA, July 2011)

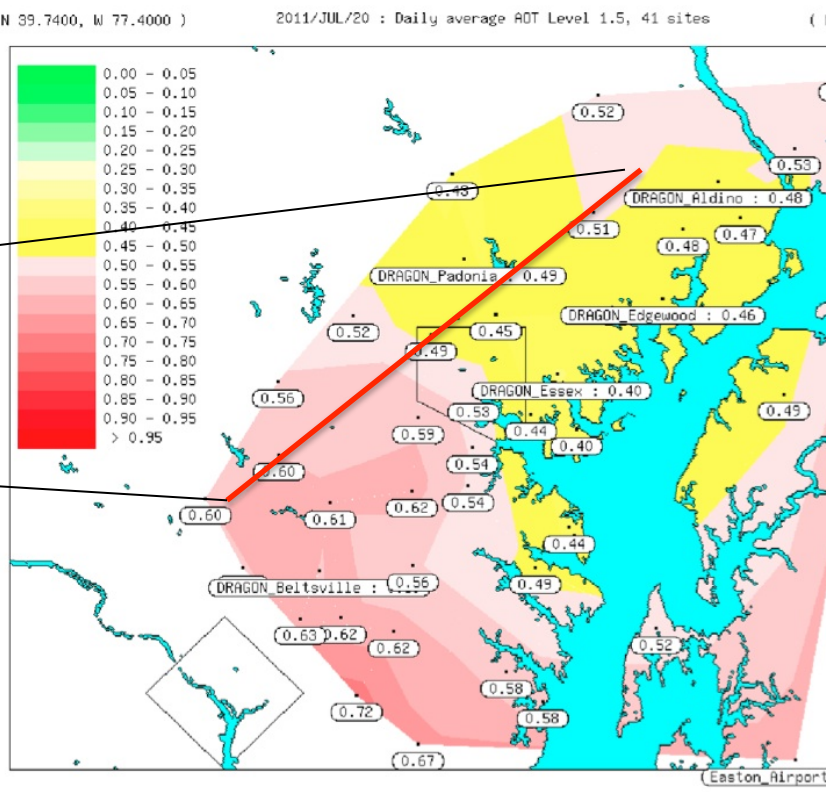
The US version (« volvo »), during DRAGON

LOA/Lidar data base includes DRAGON :
15 days of experiment (AOD 550 from 0.03 to 0.75)
78 hours of measurements
4300 km !

Mobile Platform (micro-Lidar and sun-photometer)



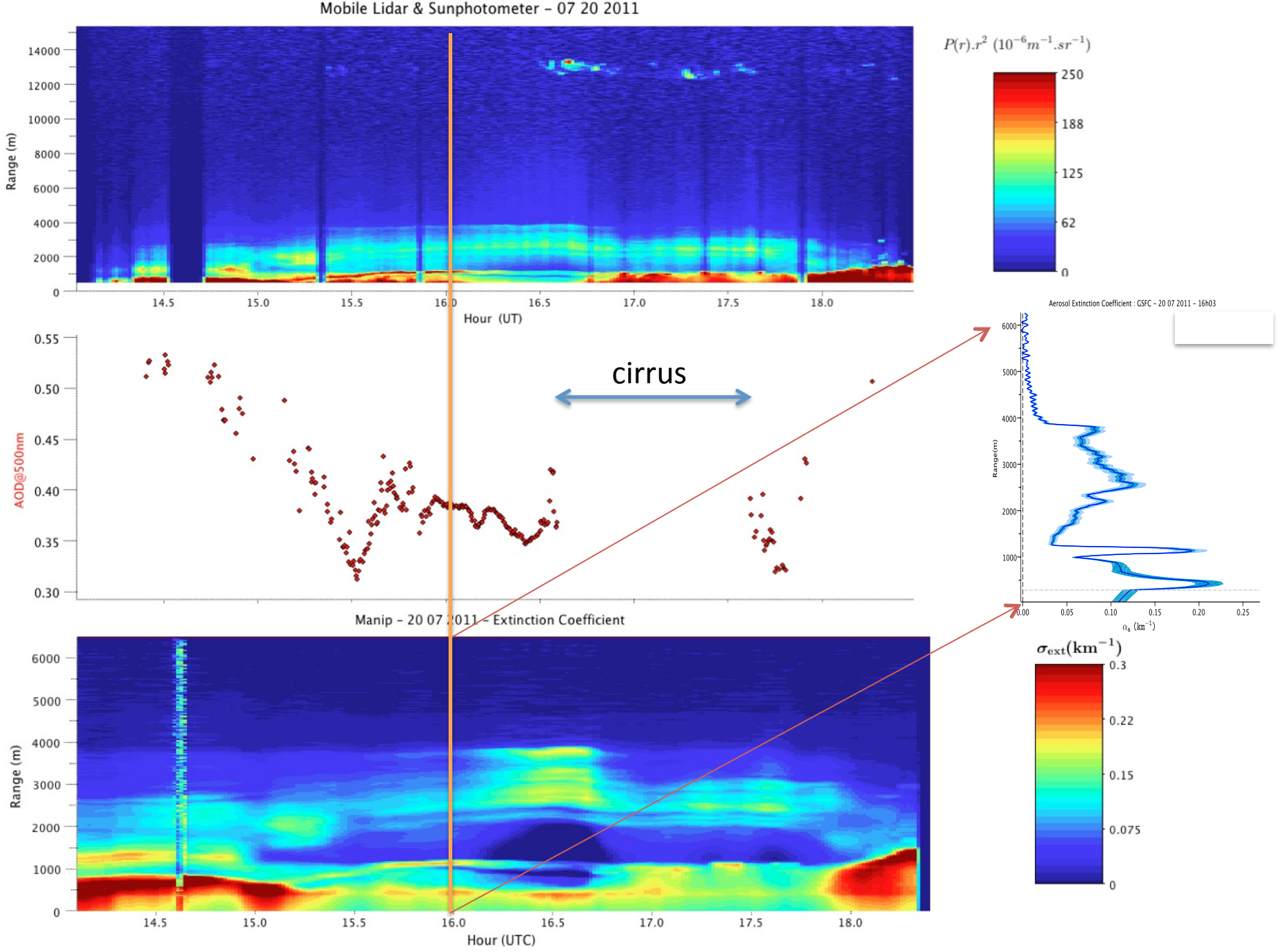
Mobile Platform (LOA-GSFC)
(sampled within 1h30)



=> Minimum AOD Plasma consistent with AERONET derived Map => validation of Plasma

DRAGON Stations (GSFC-daily average)

- Participation to future Field Campaign (Mistral, Charmex) for PLASMA
- Regional use of mobile platform (North of France, next DRAGON ?)
- Implementation of enhanced inversion on our processing system (sunphotometer AOD and Sky radiance + LIDAR irradiance, (Lopatin et al., 2011)
- Contribution to ORAURE (national observing system)


Mobile Lidar & Sunphotometer – 07 20 2011
Range (m)
Hour (UT)
$P(r).r^2$ $(10^{-6}m^{-1}.sr^{-1})$
250
188
125
62
0
AOD@500nm
cirrus
Aerosol Extinction Coefficient : GSFC – 20 07 2011 – 16h03
Range(m)
α_a (km^{-1})
Manip – 20 07 2011 – Extinction Coefficient
Range (m)
Hour (UTC)
$\sigma_{ext}(km^{-1})$
0.3
0.22
0.15
0.075
0