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

Laboratoire d'Optique Atmosphérique

Université de Lille / CNRS

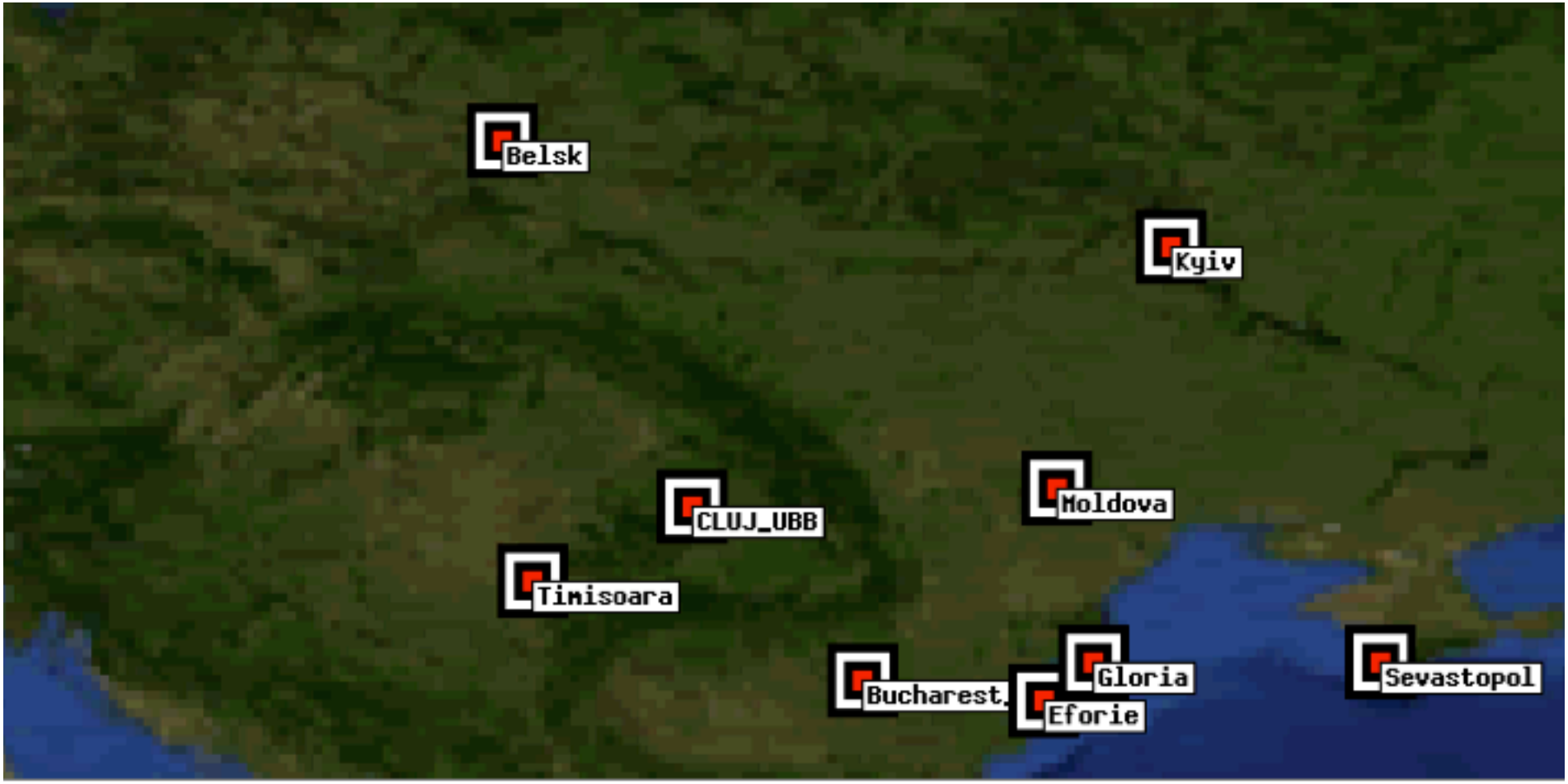
France

Presenter : P. Goloub

Contributors : D. Tanré, T. Podvin, L. Blarel, C. Deroo, A. Mortier, Y. Karol,C., O. Dubovik, Verwaerde, JY Balois, A. Lopatin

Aerosol characterization : from passive remote sensing from ground-based Sun-photometry : since a long time now (1992-1993), LOA is involved in aerosol characterization and monitoring within AERONET **Network** (leader for observations in France, West Africa) and since 2000 more and more sites in Europe (ACTRIS FP7)).

Romania



Belsk (51N,20E)	Bucharest_Inoe (44N,26E)	CLUJ_UBB (46N,23E)
Eforie (44N,28E)	Gloria (44N,29E)	Kyiv (50N,30E)
Moldova (47N,28E)	Sevastopol (44N,33E)	Timisoara (45N,21E)

Bucharest, Eforie, Cluj + Timisoara + Iasi within ROLINET …

Aerosol characterization : passive remote sensing from ground-based Sun-photometry : since a long time now (1992-1993), LOA is involved in aerosol characterization and monitoring within AERONET **Network** (leader for observations in France, Africa West) and since 2000 in Europe (ACTRIS-FP7).

Characteristics of AERONET : homogenity in instrumentation (robust, autonomy), real time data acquisition and data/products publication, centralized and automomatic processing, Data Quality Insurrance, Public domain.

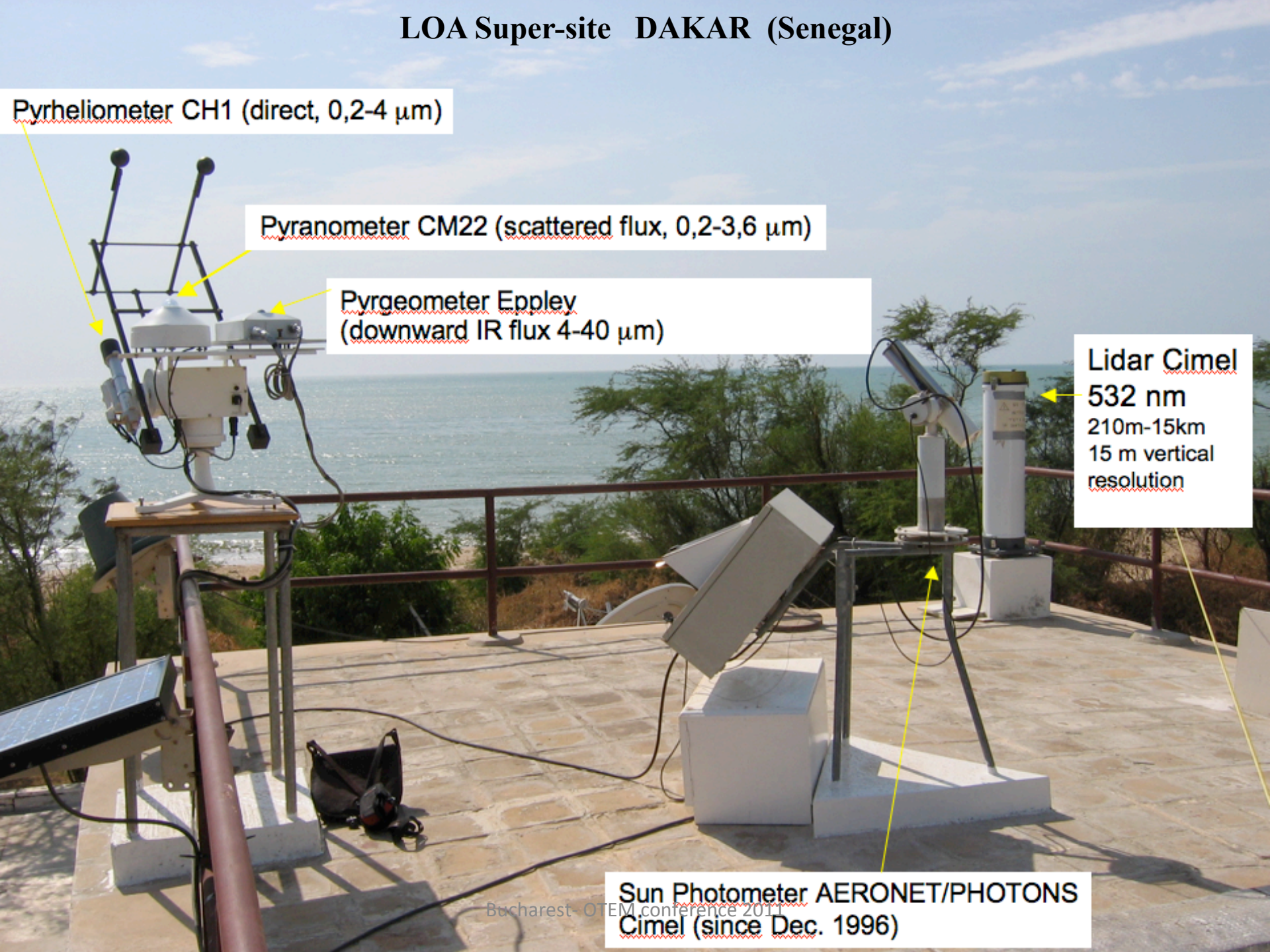
Pretty nice amount of *column integrated* aerosol parameters are retrieved and available. However, their vertical distributions are not available and require active system like lidar.

Lidar : more complex systems but becoming more simple, cheaper and automatic.
For several years, micro-LIDAR systems are developing and are operated by more and more research laboratories, not being specialized in lidar design and building.

Sun-photometer data combined with lidar data yields improvement of aerosol characterization

Since 2005-2006, LOA started routine Lidar observations (24/7) with a CIMEL micro-Lidar (532 nm, elastic backscatter) at different locations

LOA Super-site DAKAR (Senegal)



Since 2005-2006, routine Lidar observations (532 nm, elastic backscatter) at M'Bour (Dakar, LOA super-site)

Preliminary analysis of 2006 (1 year)-2007 (1 year)-2008 (8 months) data by Léon et al).

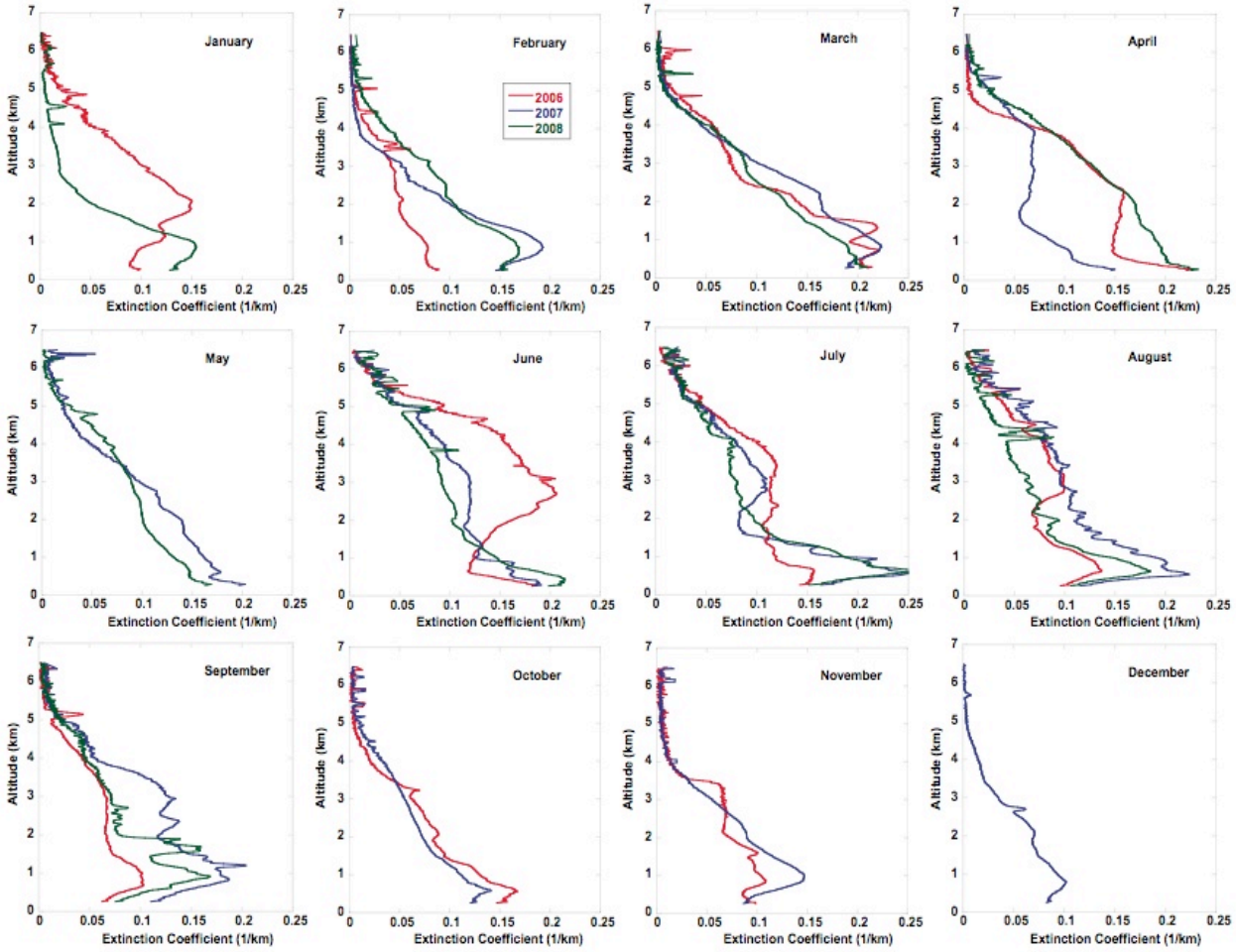
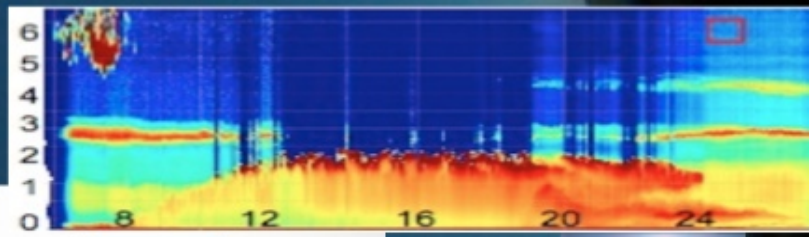
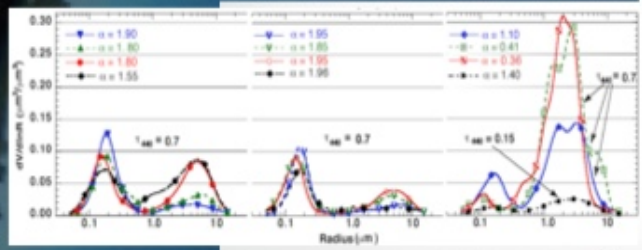


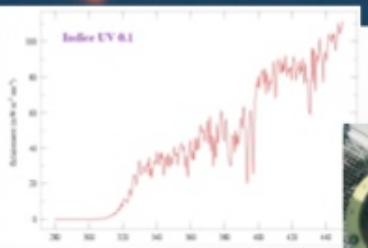
Figure 2 : monthly average vertical profiles of aerosol extinction at 532 nm for (red solid line) 2006, (blue solid line) 2007 and (green solid line) 2008.

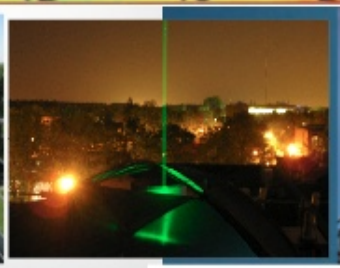
3 more years available and under analysis ….

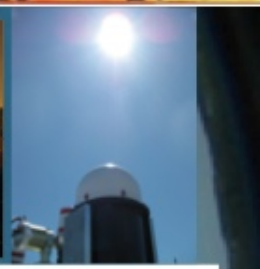
LOA Atmospheric Observatory

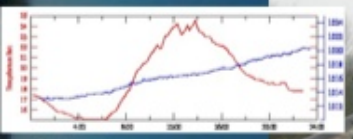


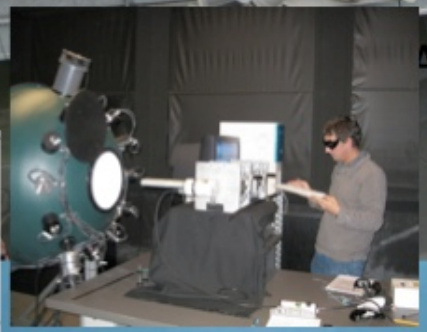


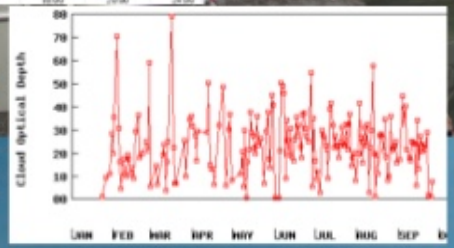


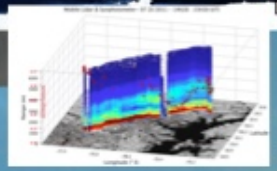












Université Lille1 Sciences et Technologies
Cité Scientifique 59655 Villeneuve d'Ascq

Since 2006-2007, LOA started Lidar routine observations at Lille University campus +.

Temporary experiment or campaign (Spring 2010)
With additional transportable system
like multi-wavelength lidar through cooperation

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

Objectives : continue and analyze variability at these 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 assurance for all the existing archive and as automatized as possible data processing.

Since 2008-2009, LOA designed and continuously improves LOA/Lidar data base and processing / visualization tools 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 (permanent & temporary, mobile)
"Calibration" database (memory of LIDAR systems evolution / maintenance (T. Podvin, LOA))

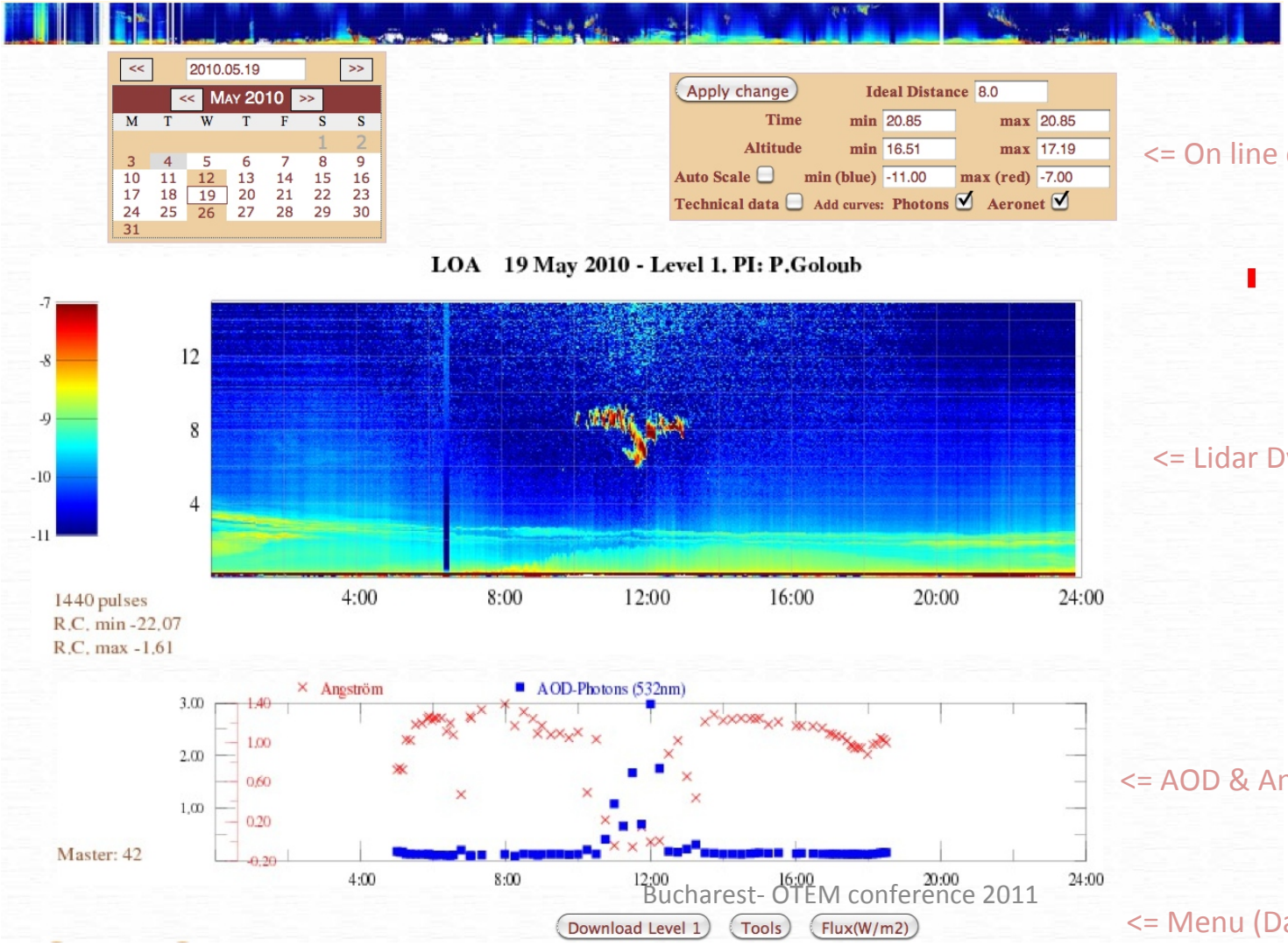
Processing / visualization system combining sun-photometer (AOD) and lidar data (532 nm) (C. Deroo, LOA)

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

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

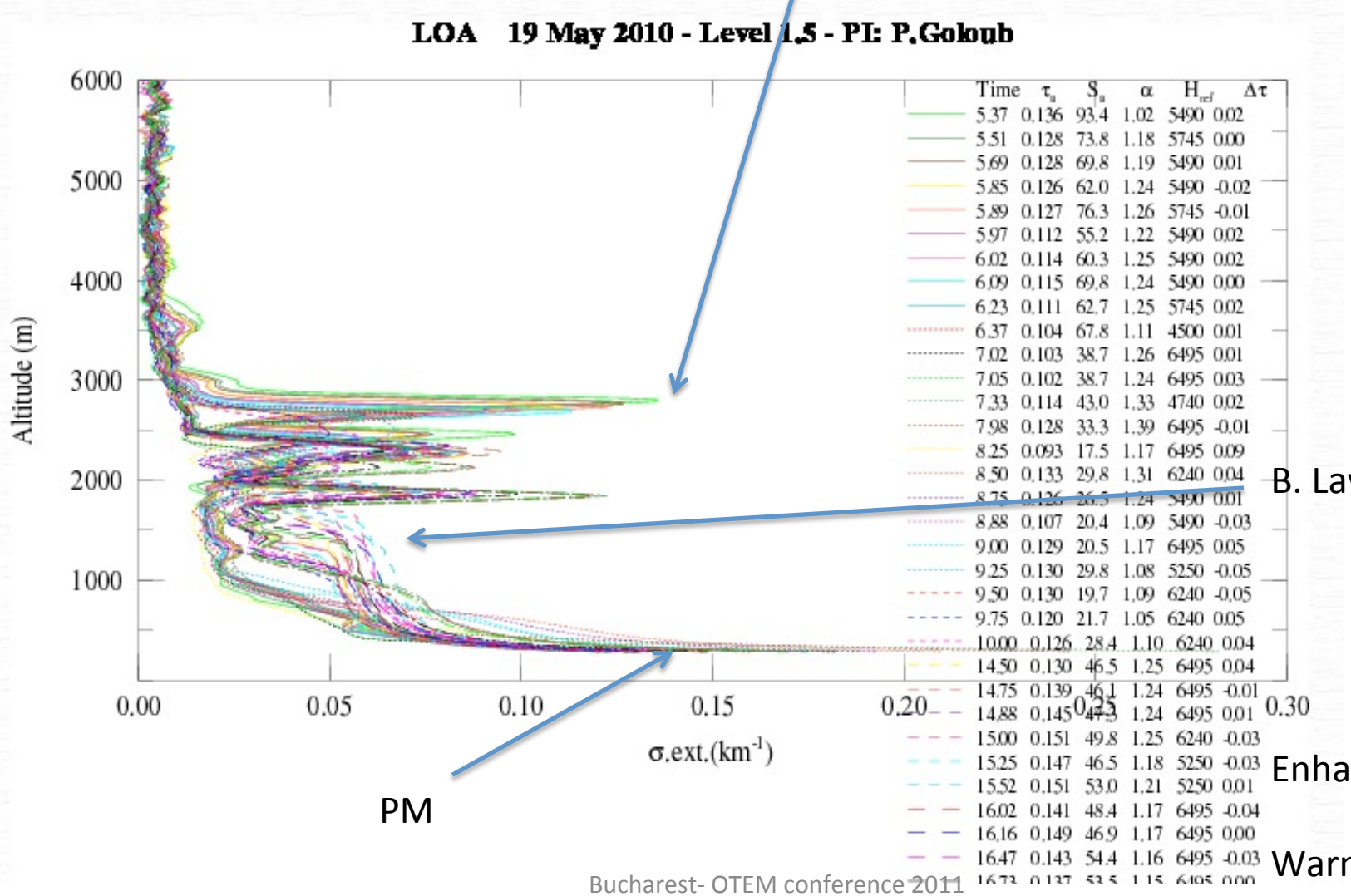
<= Lidar Dynamic Quick-Look

<= AOD & Angström (sun-photometer)

<= Menu (Data, Inversion (tools),…)

Dust, biomass burning, ash concentration

Cloud detection



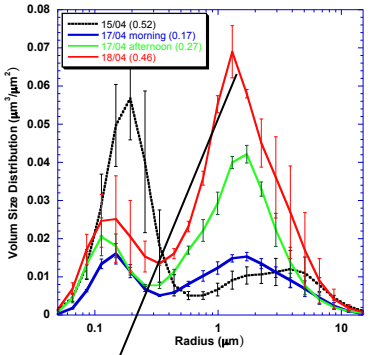
B. Layer Height

Enhanced inversion

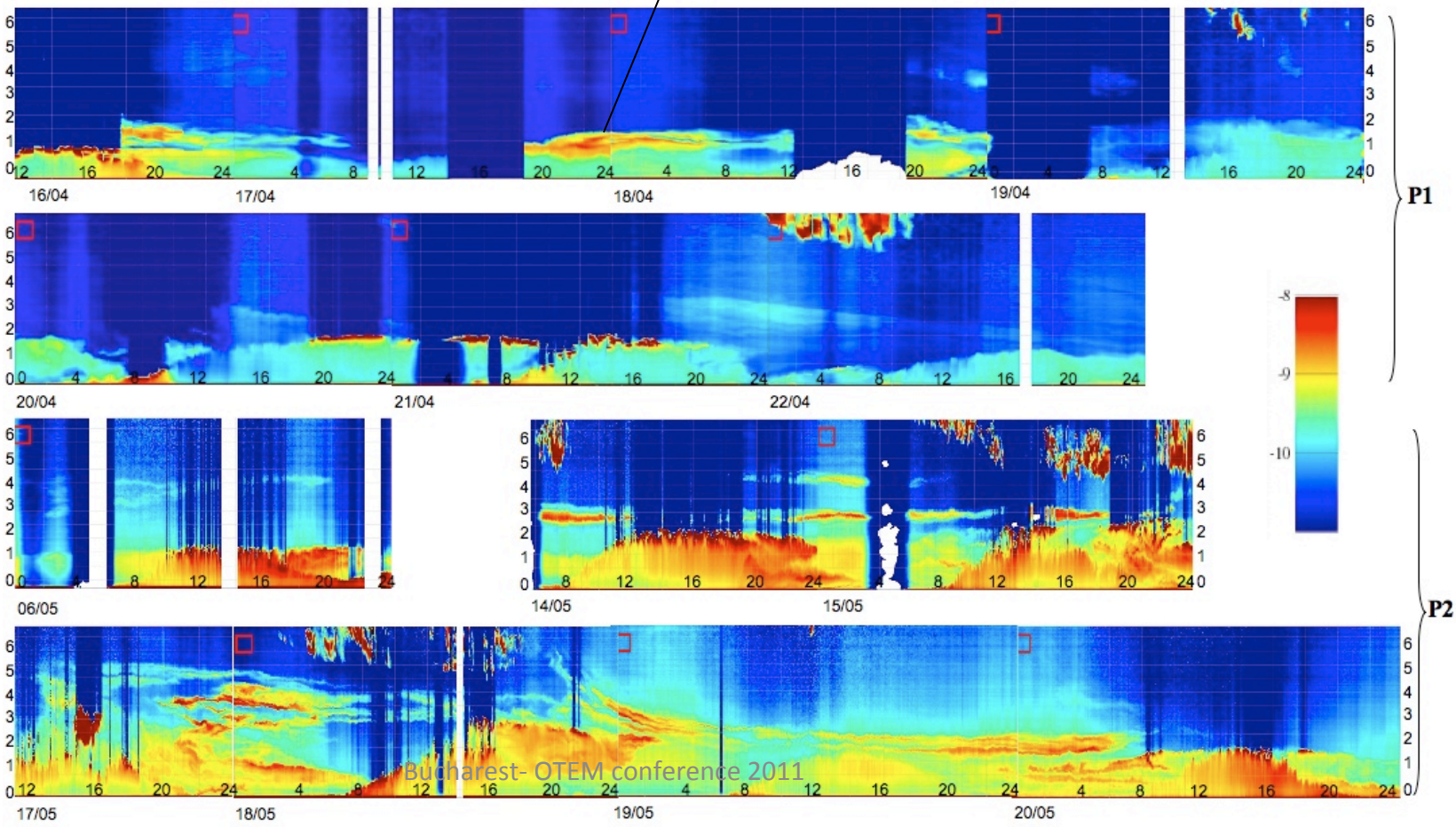
PM

Warning Flags

Volcanic Ash Plumes over Lille during Eyjafjoll



From routine LIDAR observation 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,…)

Future Developments :

- add on-line tools for user to apply inversion (change inversion parameters …, manual mode for adaptating to specific events or complex situation (volcano).
- Introduction of advanced inversion code (*Lopatin et al.,*) under development in LOA
- 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

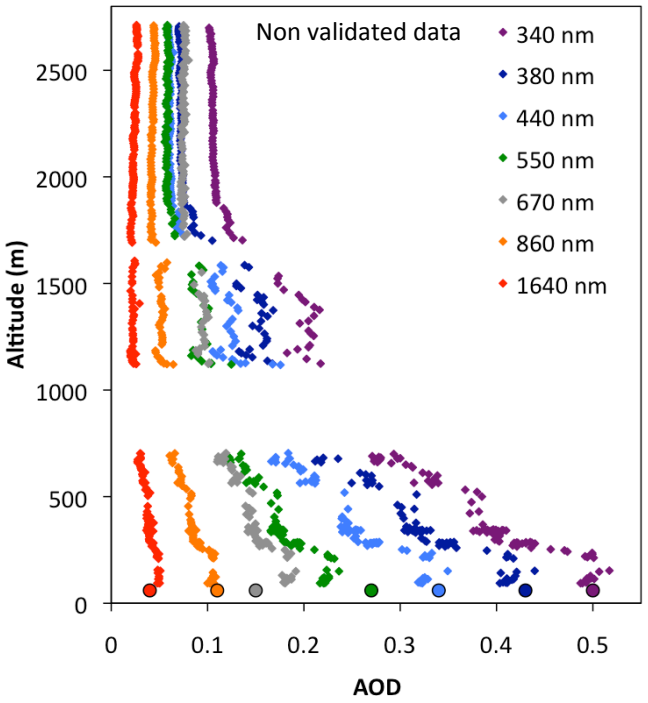
PLASMA (*Photomètre Léger Aéroporté pour la Surveillance des Masses d'Air*) is a sun tracking photometer based on board of an aircraft which measure AOD during flight and therefore **provide spectral AOD** (0.34 – 2.25 µm) **as a function of the altitude**.

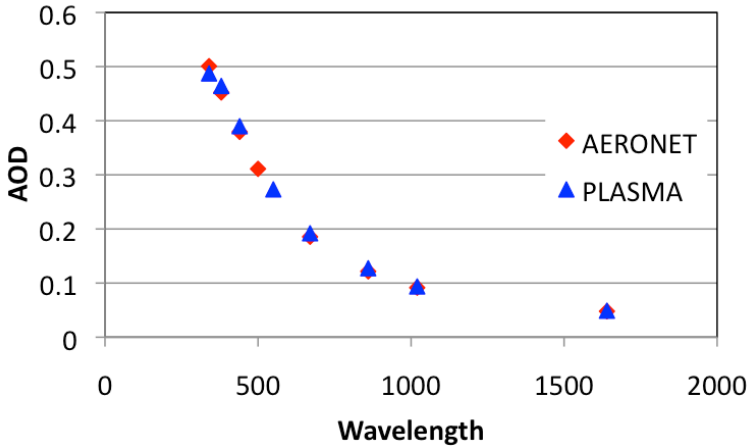
One of the main PLASMA's objectives is **validation of AOD vertical profiles provided by lidar**.

PLASMA on the plane

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

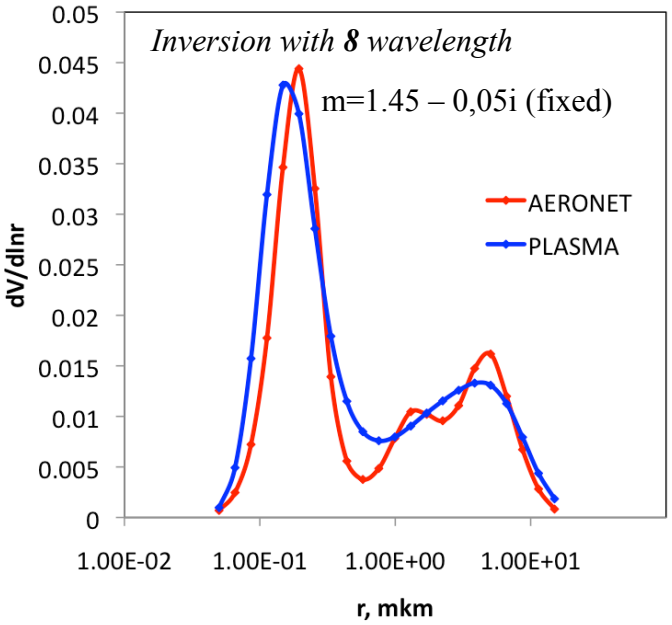
What measures PLASMA ?





$$\sigma_{ext}^{a}(z) = \frac{d\tau_{ext}^{a}}{dz}$$

$$\sigma_{ext}^{a}(z) = \int \pi r^2 . Q_{ext}(m, r/\lambda) . n(r,z) . dr$$



n(r,z), fine, coarse mode (z)

Combination with lidar for constraining inversion …

Work under progress (Y. Karol, Ph.D thesis, LOA, Univ. Lille)

- DRAGON FIELD CAMPAIGN -

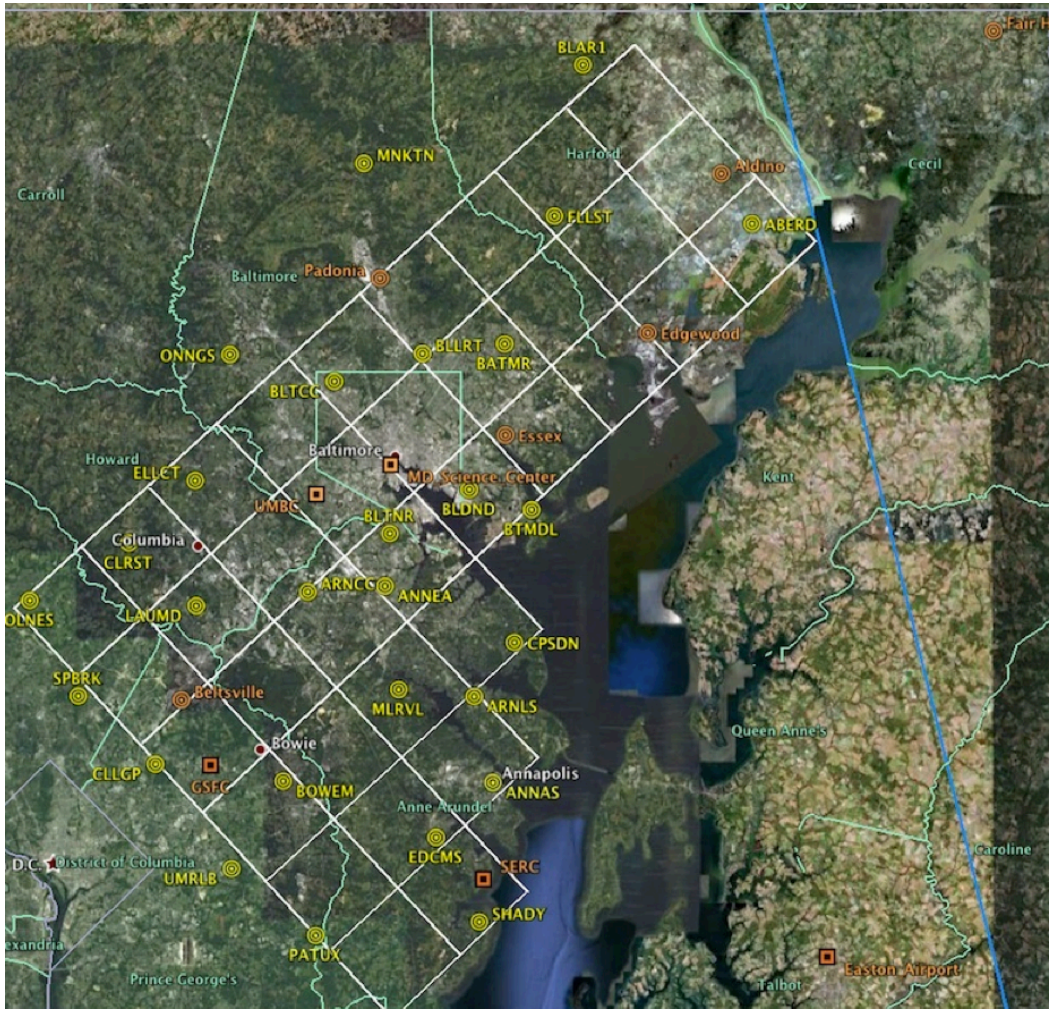
Distributed Regional Aerosol Gridded Observation Networks (DRAGON)-USA 2011

Establish a mesoscale gridded network of sun photometers that encompasses, urban, agricultural and mountain landscapes over the Washington DC metro area

Involve ground-based instrumentation + airborne

Analysis spatial variability of aerosol properties

AOD 550 from 0.03 to 0.75



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

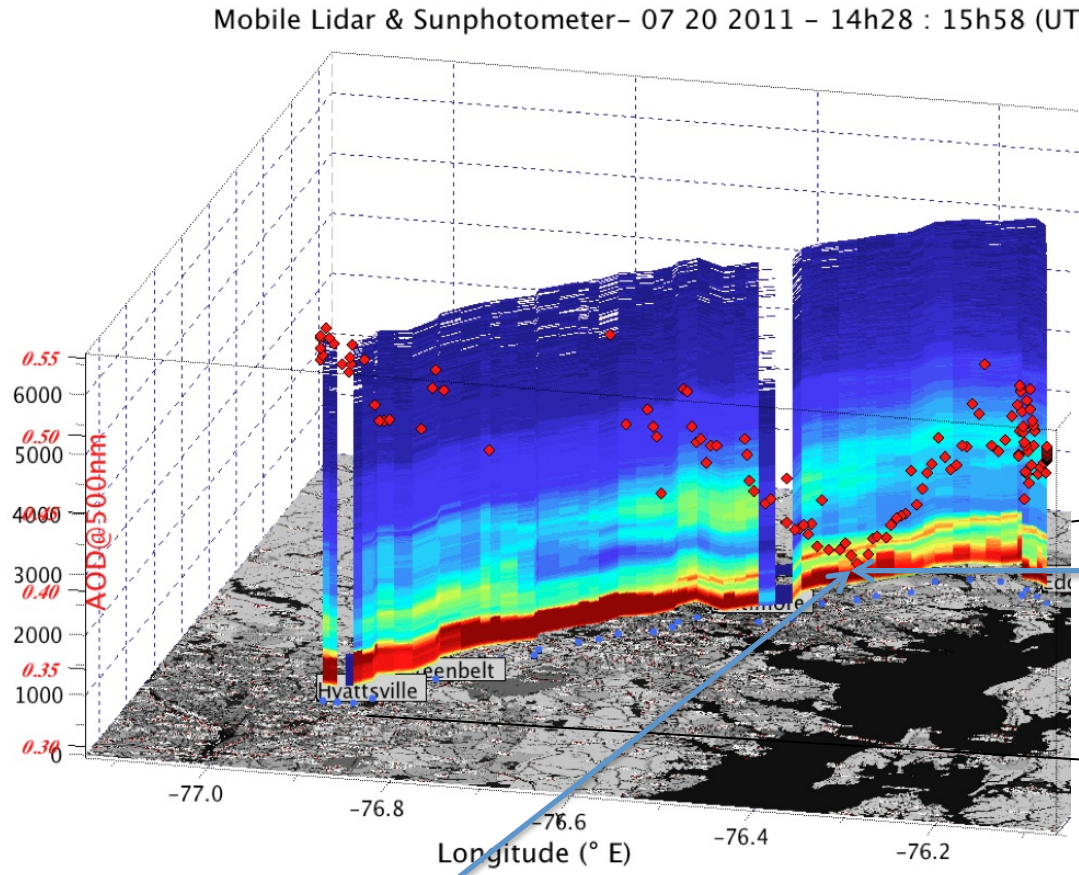
⇒ Recent developments include Mobile Platform in the system (first field campaign during DRAGON, USA, July 2011)

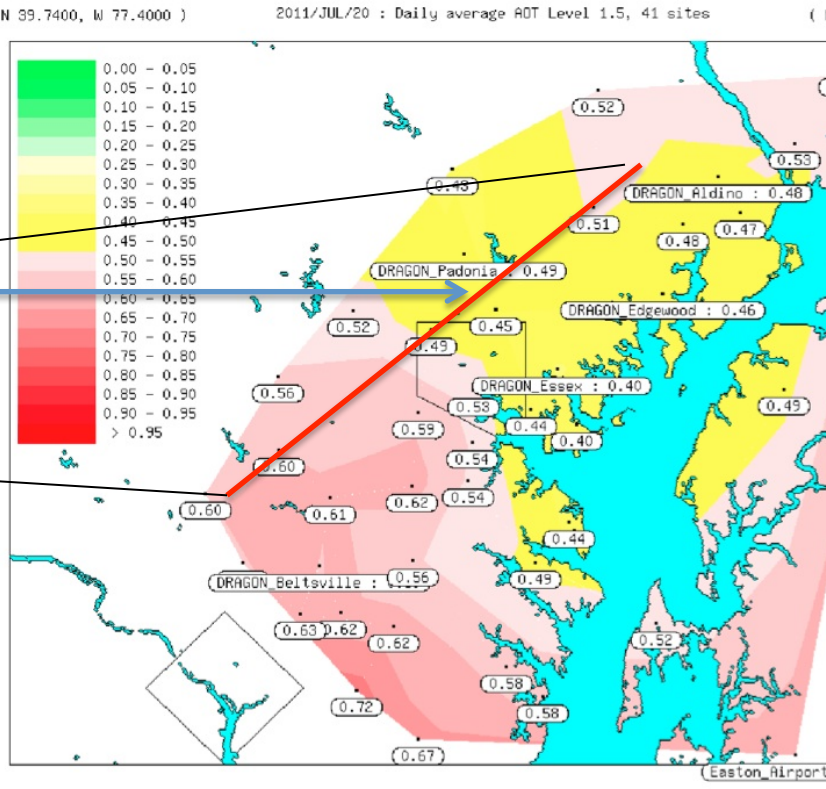
The « US » version during DRAGON

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)=> structure of pollution plume

Mortier A. Ph.D work, LOA, Univ. Lille





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

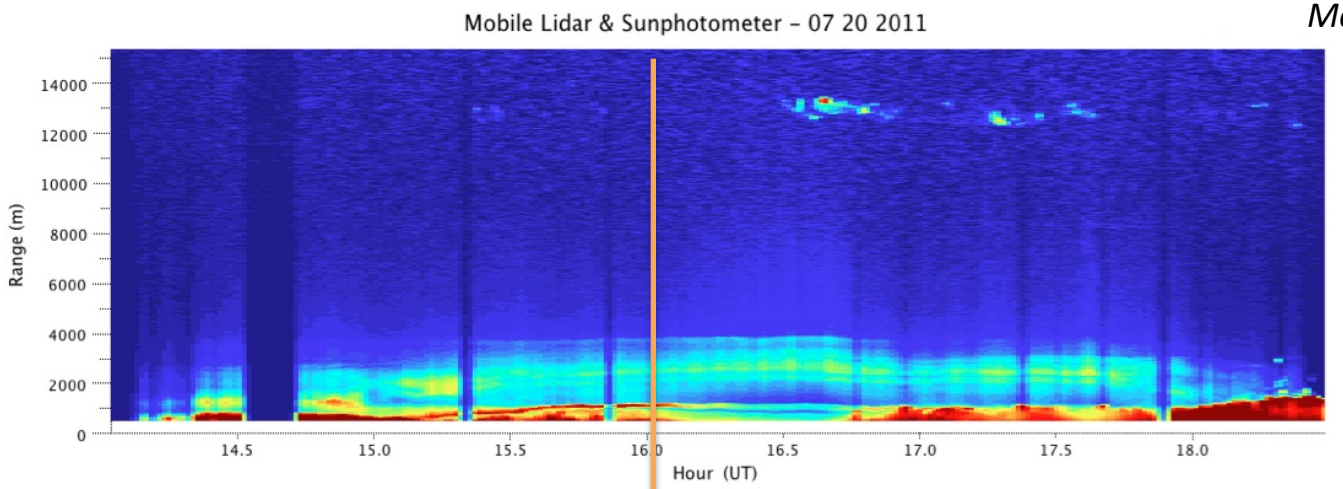
⇒ Minimum AOD detected by PLASMA consistent with AERONET derived Map.

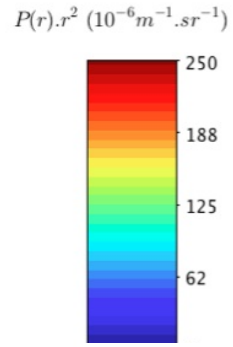
⇒ Angström exponent + water vapour

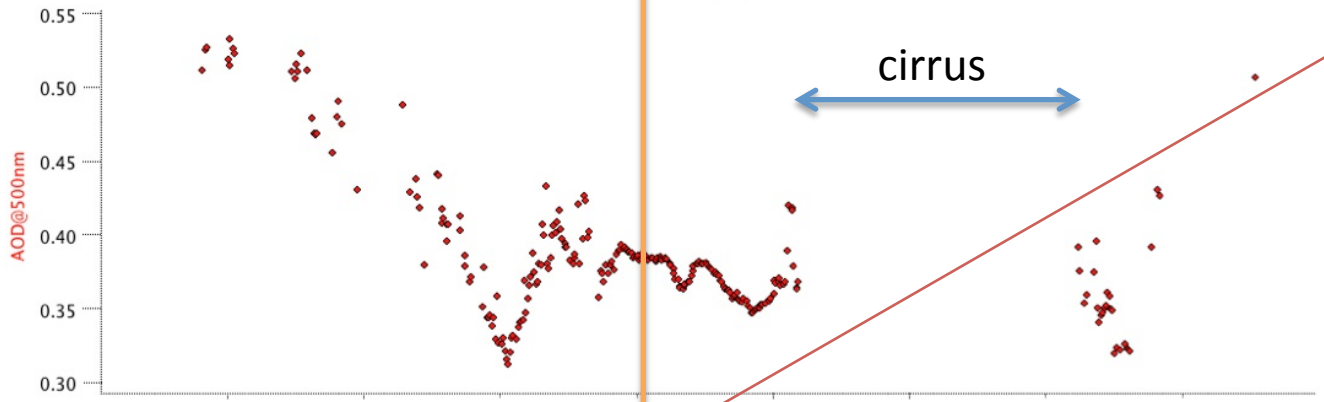
DRAGON Stations (GSFC-daily average)

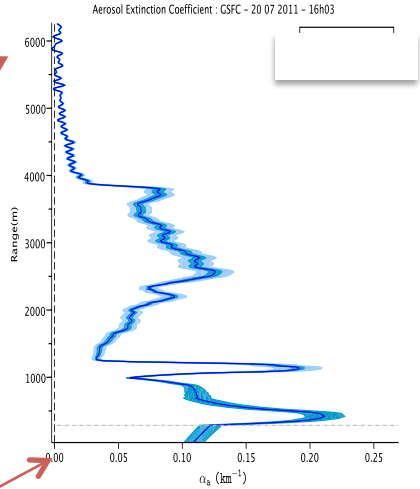
Lidar backscattered signal combined with PLASMA AOD

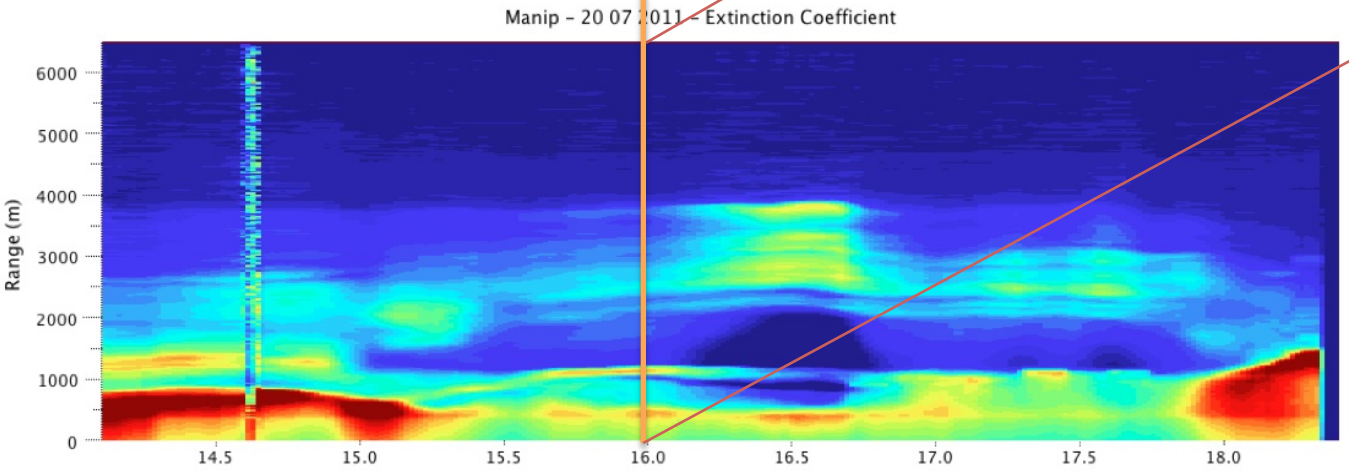
Mortier A. Ph.D work, LOA, Univ. Lille

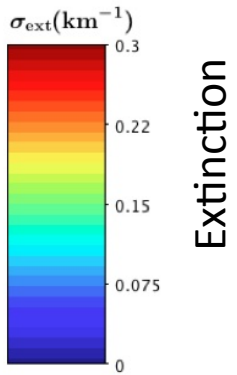








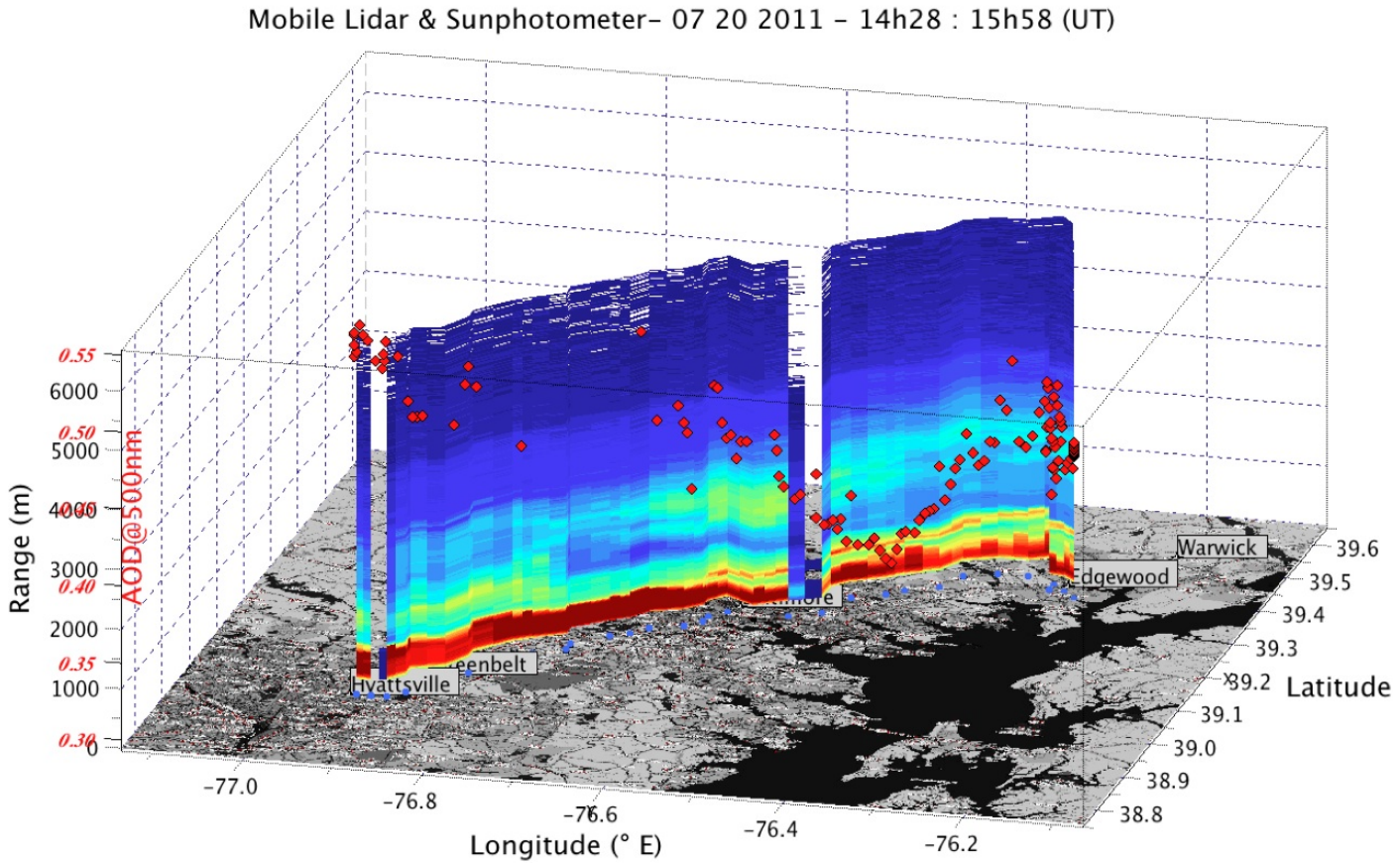




- Participation to future Field Campaigns in Mediterranean region (Charmex, Chemistry-Aerosol Mediterranean Experiment) on airplane
- Regional use of mobile platform (North of France, next DRAGON in Japan/Korea)
- Implementation of enhanced inversion in our processing system (Lopatin et al., 2011)
- Variability analysis for Lille and Dakar …
- Contribution to ORAURE (national observing system)

Observatory for Innovative Researches on Aerosols during Extreme Events and for Long-term Monitoring

Thank you !


Mobile Lidar & Sunphotometer- 07 20 2011 - 14h28 : 15h58 (UT)
Range (m)
AOD@500nm
0.55
0.50
0.40
0.35
0.30
6000
5000
4000
3000
2000
1000
0
Warwick
Hyattsville
-77.0
-76.8
-76.6
-76.4
-76.2
Longitude (° E)
39.6
39.5
39.4
39.3
39.2
39.1
39.0
38.9
38.8
Latitude