THE MEGAPOLI PARIS CAMPAIGN FOR URBAN AEROSOL CHARACTERISATION – A COMPREHENSIVE DATA SET FOR AIR QUALITY MODEL EVALUATION

M. Beekmann (1), A. Borbon (1), J. Sciare (2), V. Gros (2), A. Prevot (3), U. Baltensperger (3), A. Wiedensohler (4), F. Drewnick (5), S. Pandis (6), A. Baklanov (7), M. Lawrence (5), ***and the MEGAPOLI Paris- campaign team***

(1) LISA, France, (2) LSCE, France, (3) PSI, Switzerland, (4) IfT, Germany, (5) MPI, Germany, (6) FORTH, Greece, (7) DMI, Denmark,

HARMO June 1 – 4 2010, Paris

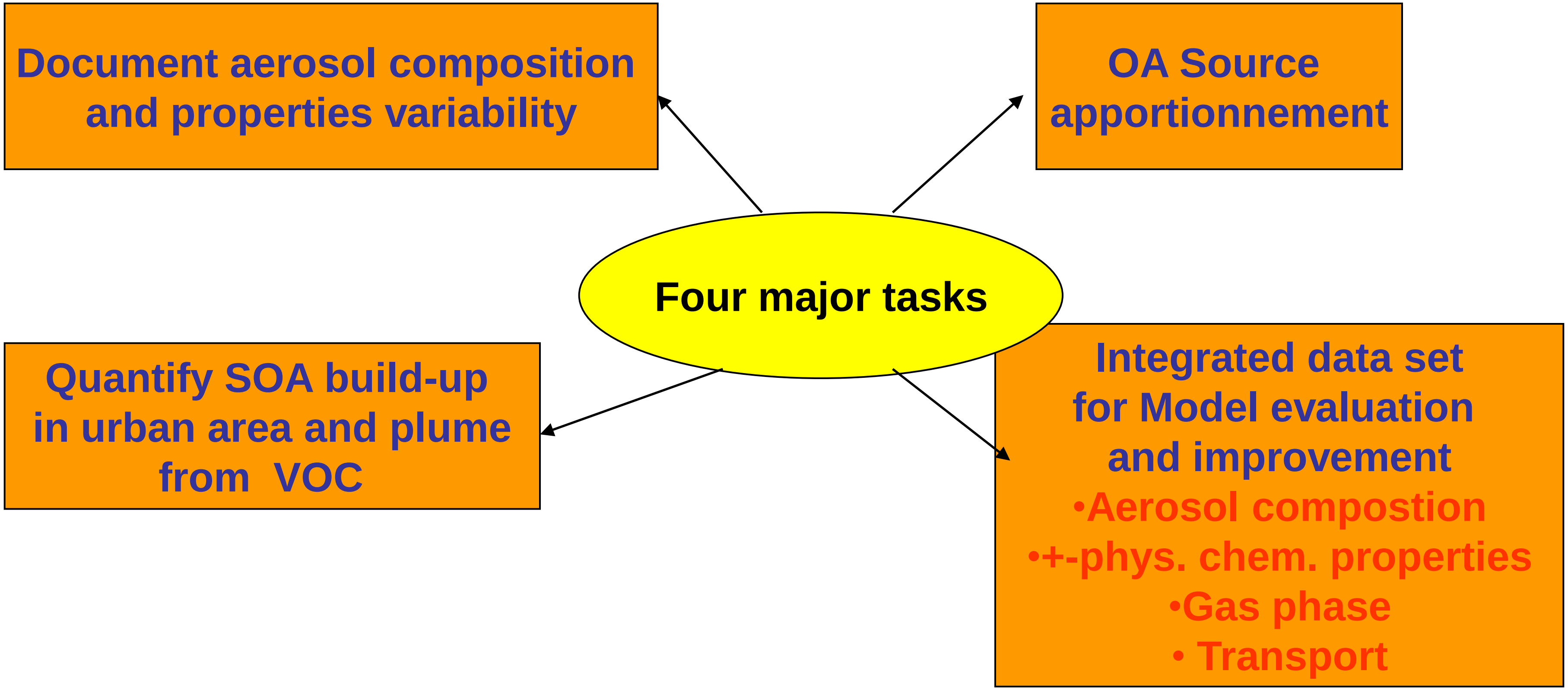
I. FP7 MEGAPOLI OBJECTIVES

- **The main objectives**
- Objective 1: to assess impacts of megacities and large air-pollution “hot-spots” on local, regional, and global air quality;
- Objective 2: to quantify feedbacks between megacity air quality, local and regional climate, and global climate change;
- Objective 3: to develop improved integrated tools for prediction of air pollution in megacities and their surrounding areas

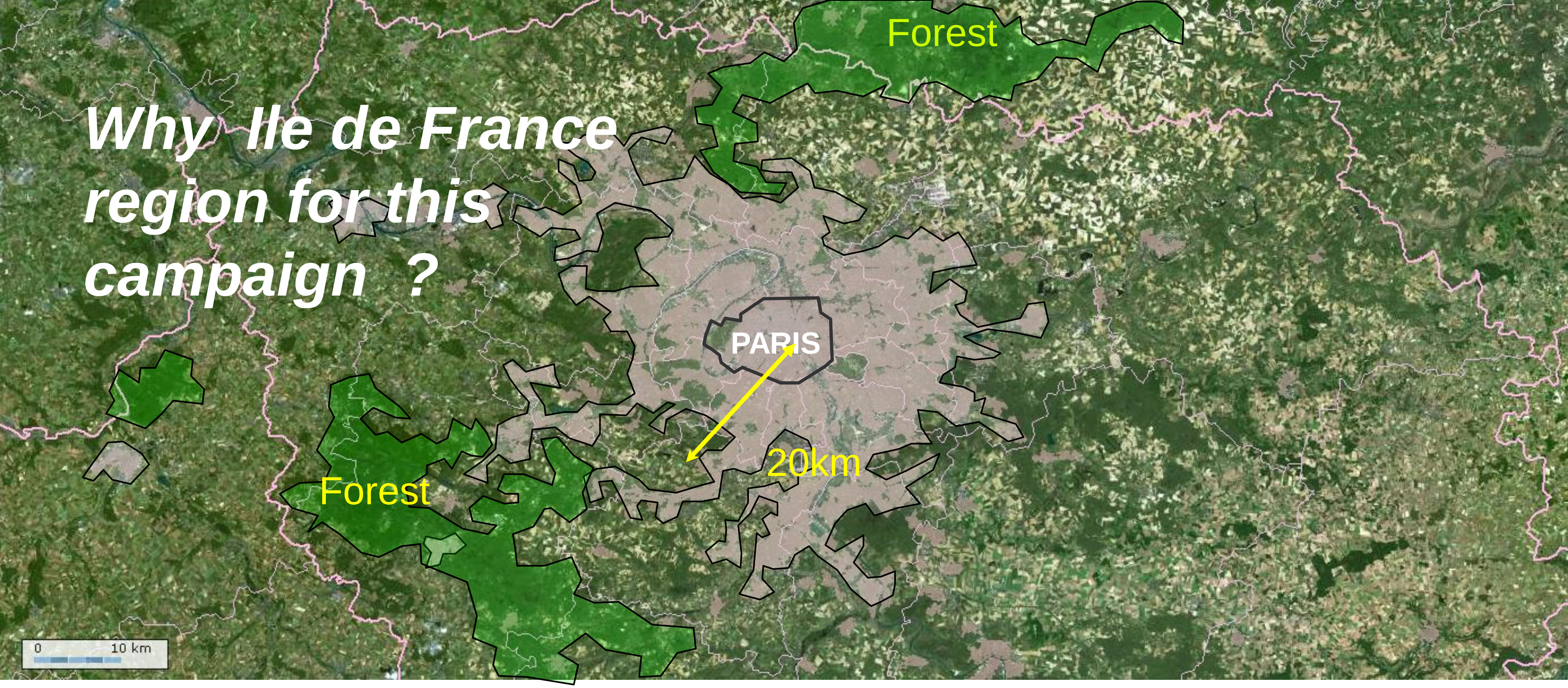
Megacities: Emissions, urban, regional and Global Atmospheric POLlution and climate effects, and Integrated tools for assessment and mitigation

Ile de France Campaign objectives

- provide new experimental data to better quantify sources of primary and secondary organic aerosol in a large agglomeration and its plume



Why Ile de France region for this campaign ?



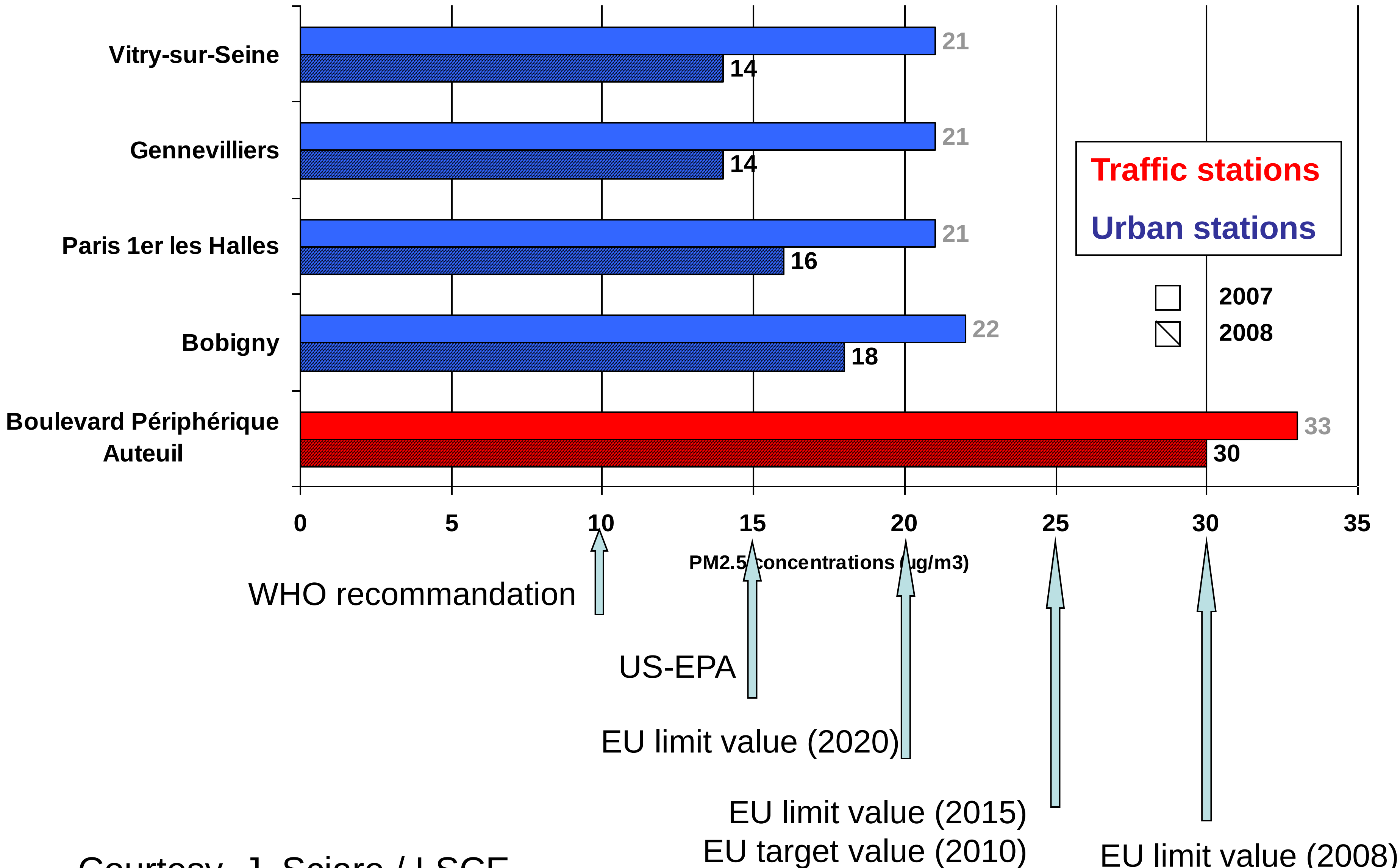
Region **Ile-de-France** = **12 million inhabitants** (20% of the French population

Population density (PARIS)= 20,000 inh. / km²

Surrounded by rural areas

Dense scientific infrastructure

Annual $PM_{2.5}$ mean concentrations in 2007 and 2008



Courtesy J. Sciare / LSCE

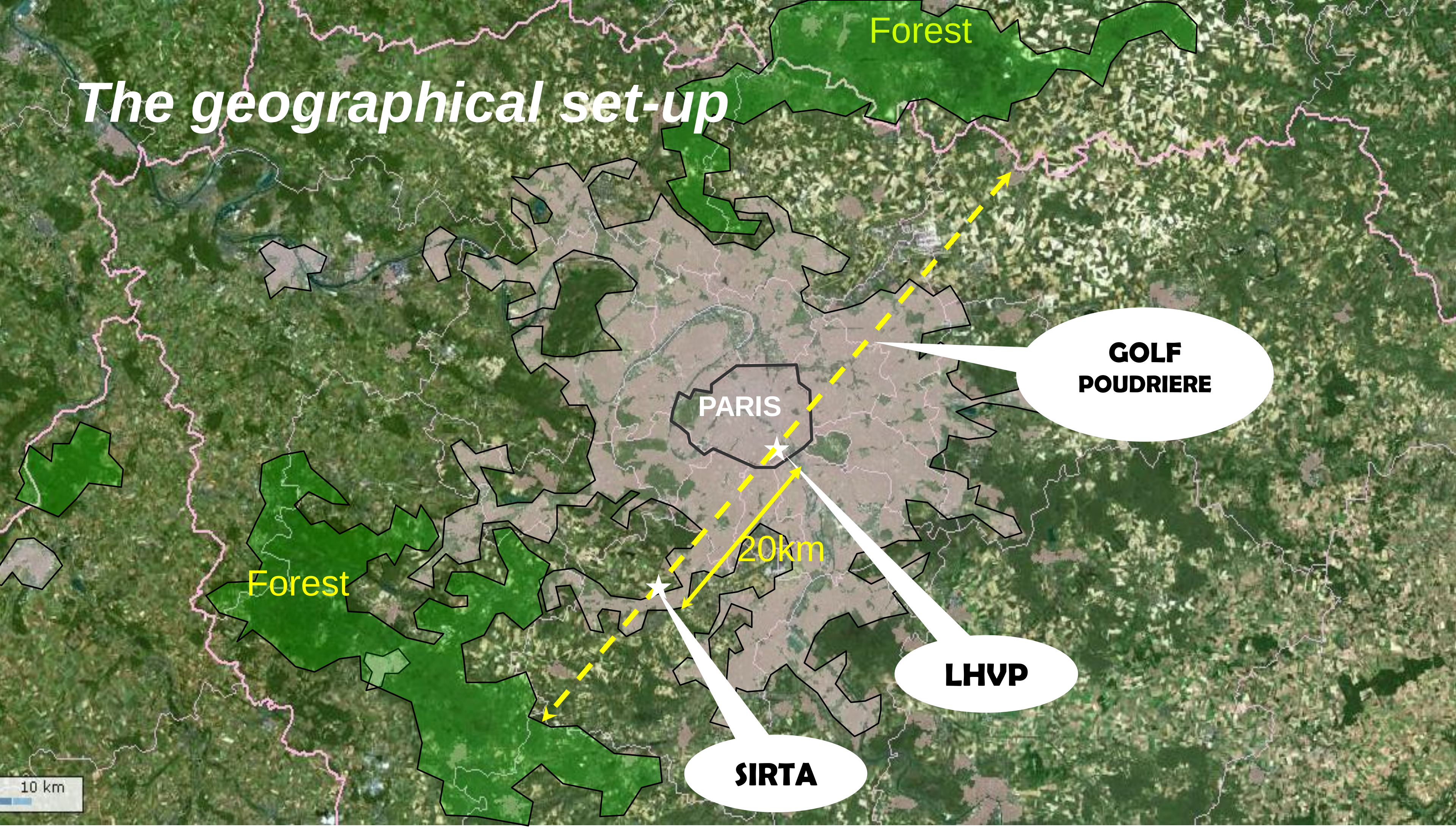
II. Campaign set-up

- Summer (July) 2009 campaign
- Winter (January 15 – Febraury 15) campaign

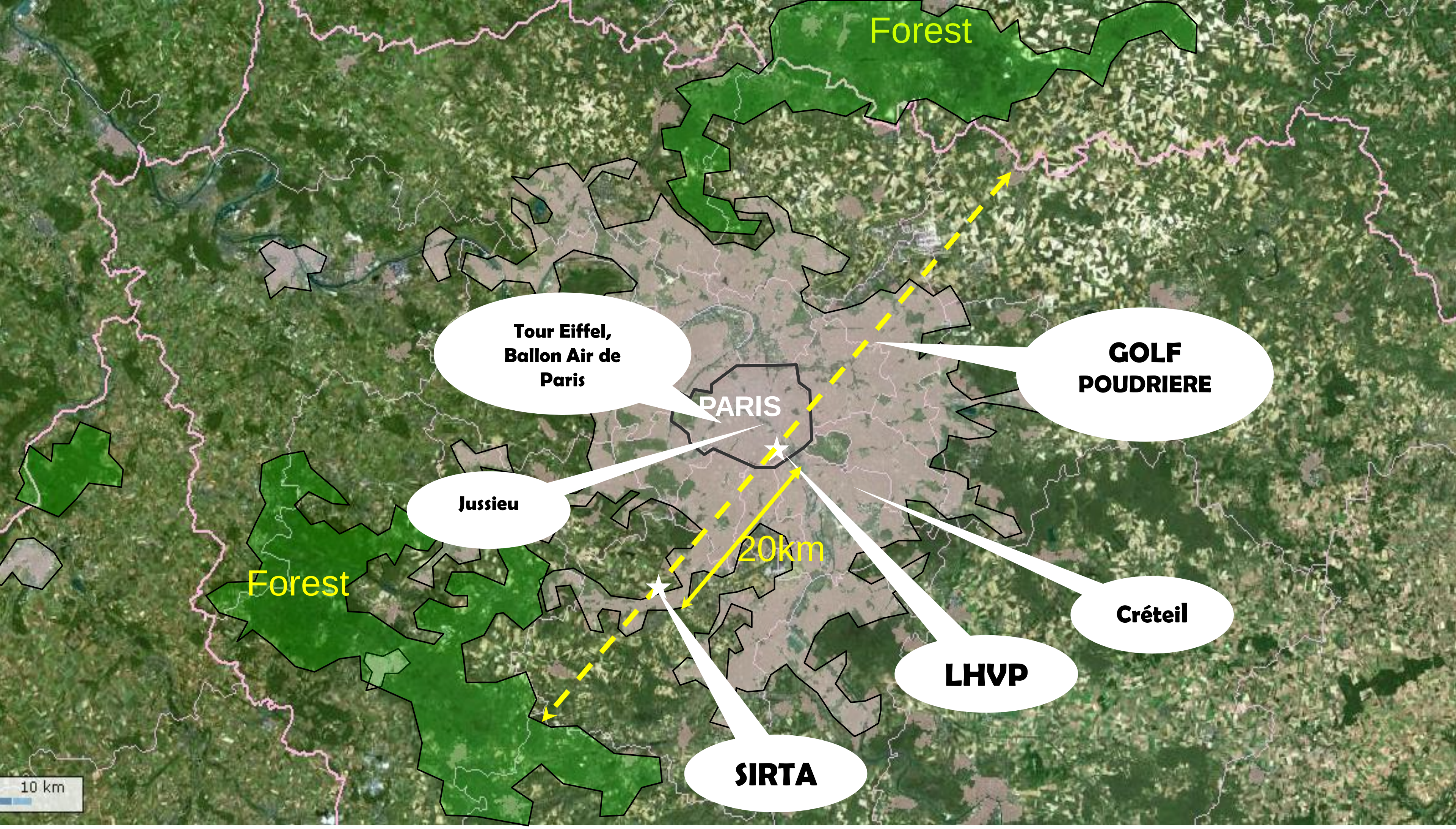
Instrumentation set-up and parameters measured

* In situ
  ** Gases:
    *** pollution tracers: CO, O3, NOx, NOy,
    *** aerosol precursors: (O)VOC (cartridges, PTR-MS….), H2SO4
    *** radical budget : OH, HO2, HONO, J's
  ** Aerosol
    *** mass, size and number
    *** physical properties (volatility, optical, hygroscopicity)
    *** chemical composition: OA components and individual species, BC, dust, ions, …
      **** rapid AMS, PILS, MAAP, ECOC
      **** detailed (filters with ~100 individual compounds)
  ** Dynamic (wind , T, turbulent fluxes, …)

* Remote
  ** spectroscopic -> gas columns (NO2, HCHO, CO, O3, …..)
  ** Lidar (backscatter, partly multi-λ, polarized)
  ** wind profils (sodar, lidar)



3 primary sites => full suite of *in situ* measurements / + meteo at SIRTA.



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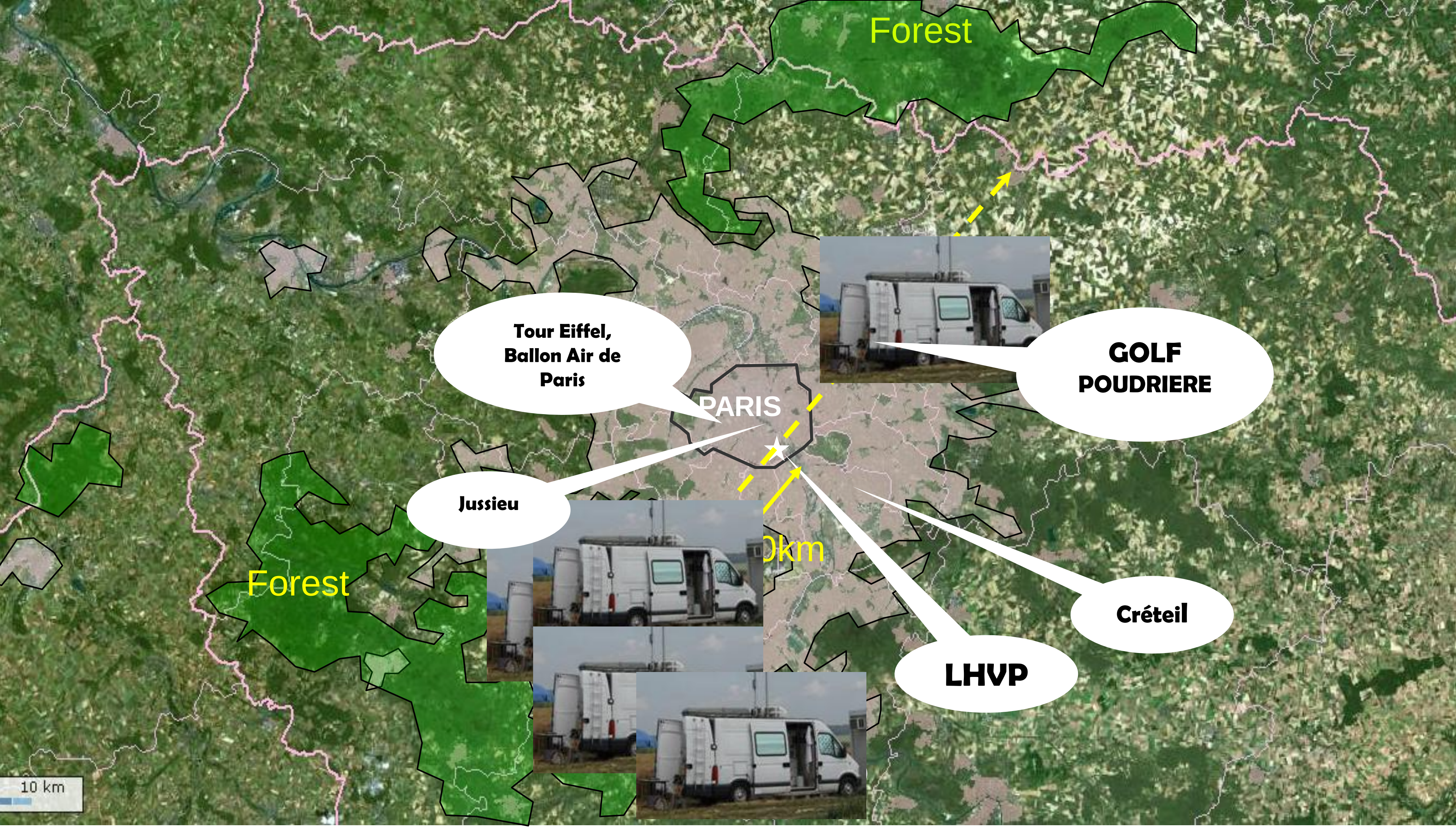
3 secondary sites => lidar and spectrospcopic measurments / or in some situ



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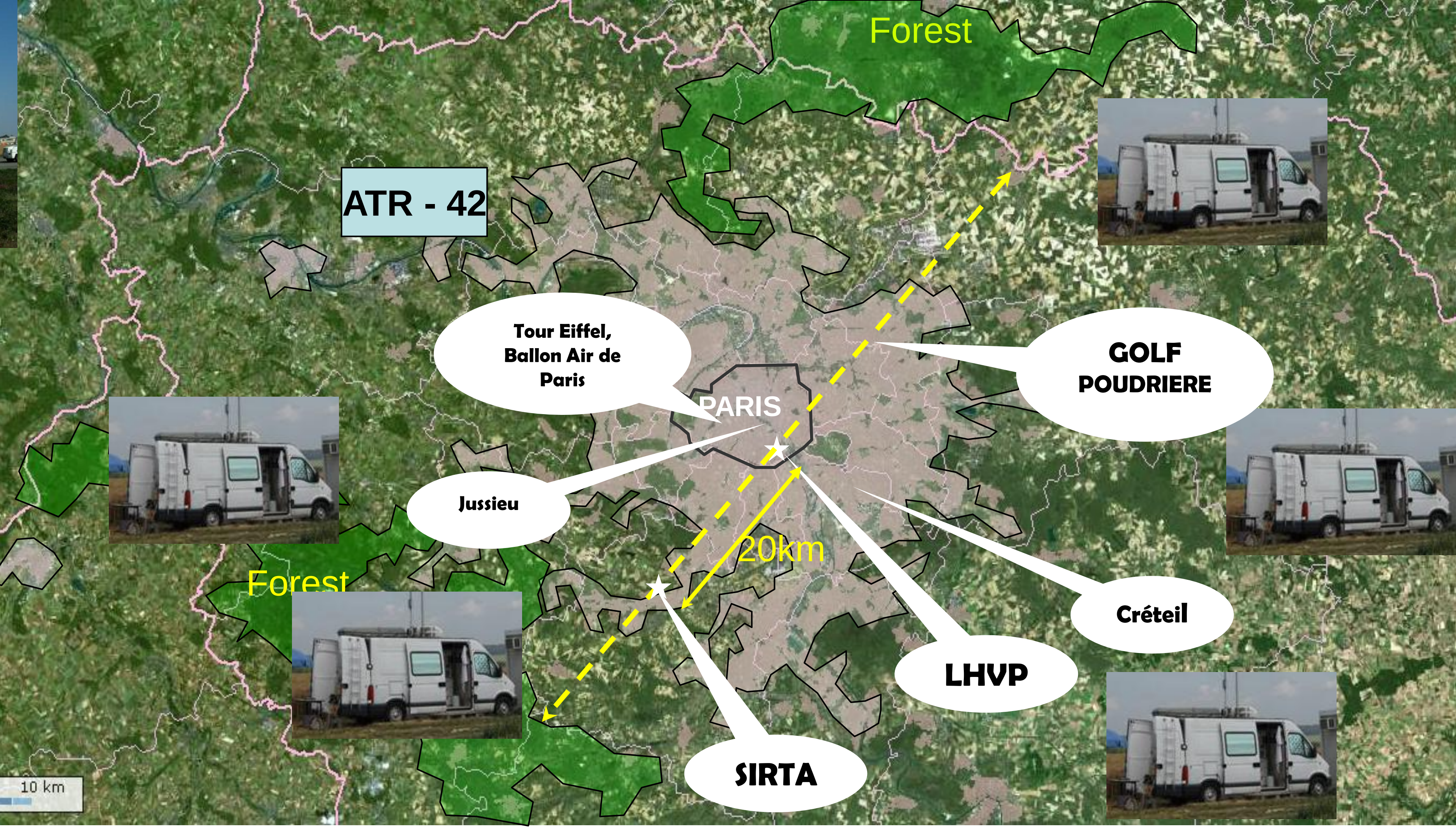
3 mobile labs => full in situ measurements (PSI + MPI) + Univ Duisburg

1 mobile lab => lidar measurements (CEA) **1 mobile lab** => MAXDOAS (MPI)



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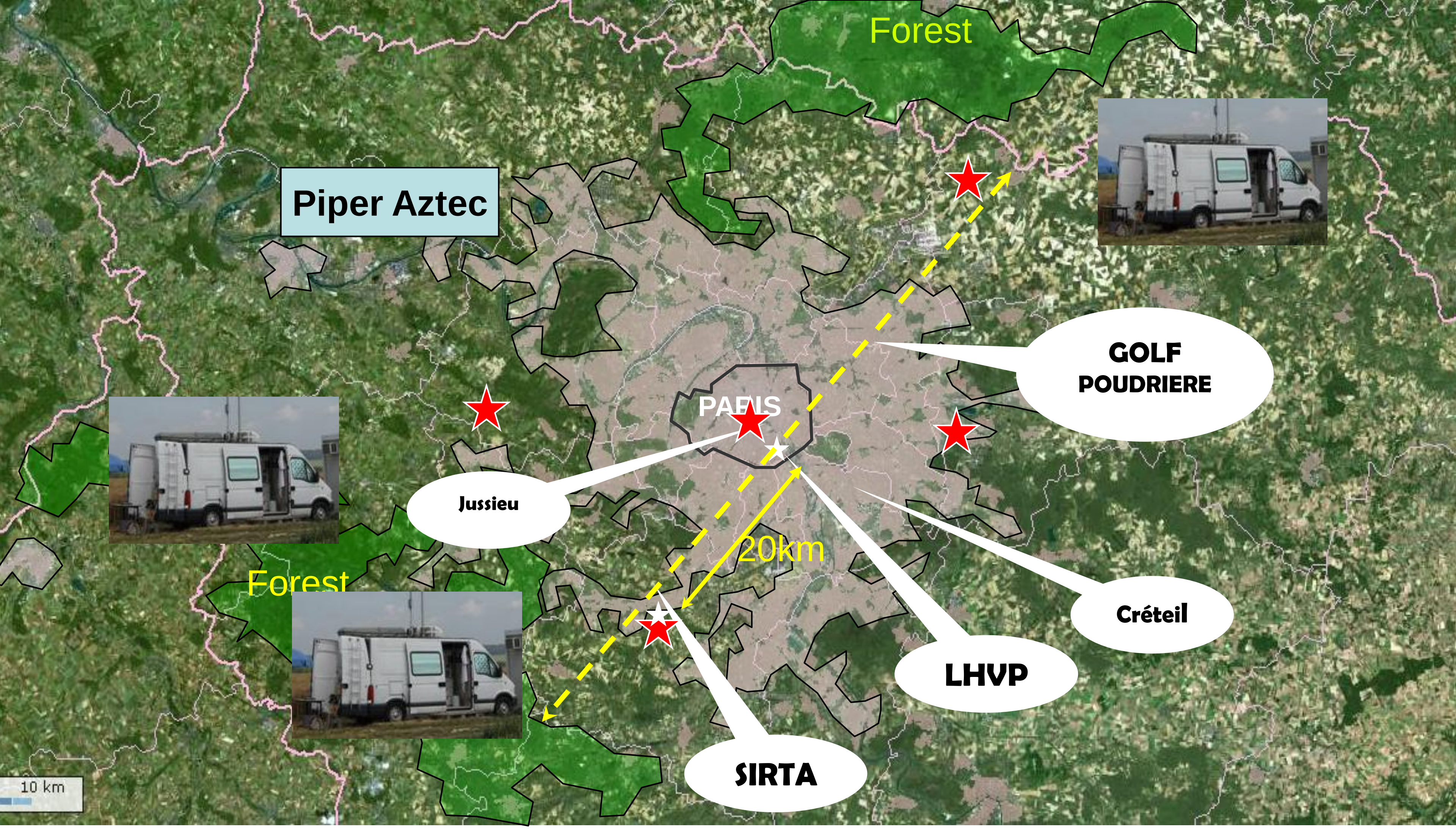
3 mobile labs => full in situ measurements (PSI + MPI) + Univ Duisburg
1 mobile lab => lidar measurements (CEA) **1 mobile lab** => MAXDOAS (MPI)
1 aircraft ATR-42 => full in situ measurements (SAFIRE, CNRS, MPI)



In addition during winter => **ALS - LEOSPHERE lidar network (five sites)**

Organisation / Participants

Initial FP7 partners :

- CNRS (LISA, LSCE, GAME, LaMP, LGGE, subcontractor SAFIRE), PSI, IfT, FORTH, Univ. Helsinki

Additionnal EU Participants :

- MPI, Univ. College Cork, FMI, Univ. Duisburg

Additional French Participants :

- AIRPARIF, CEREA, Ecole de Mines, INERIS, LCME, LCP-IRA, LATMOS, LHVP, QUALAIR, SIRTA/LMD/IPSL

lead : M. Beekmann (LISA-CNRS), U. Baltensperger (PSI)

- Ground based segment : Jean Sciare, Valerie Gros (LSCE)
- Airborne segment : Agnès Borbon (LISA)
- Ad hoc coordinating commitee with above persons, MEGAPOLI coordinators, aircraft instrument PI's, and site responsibles

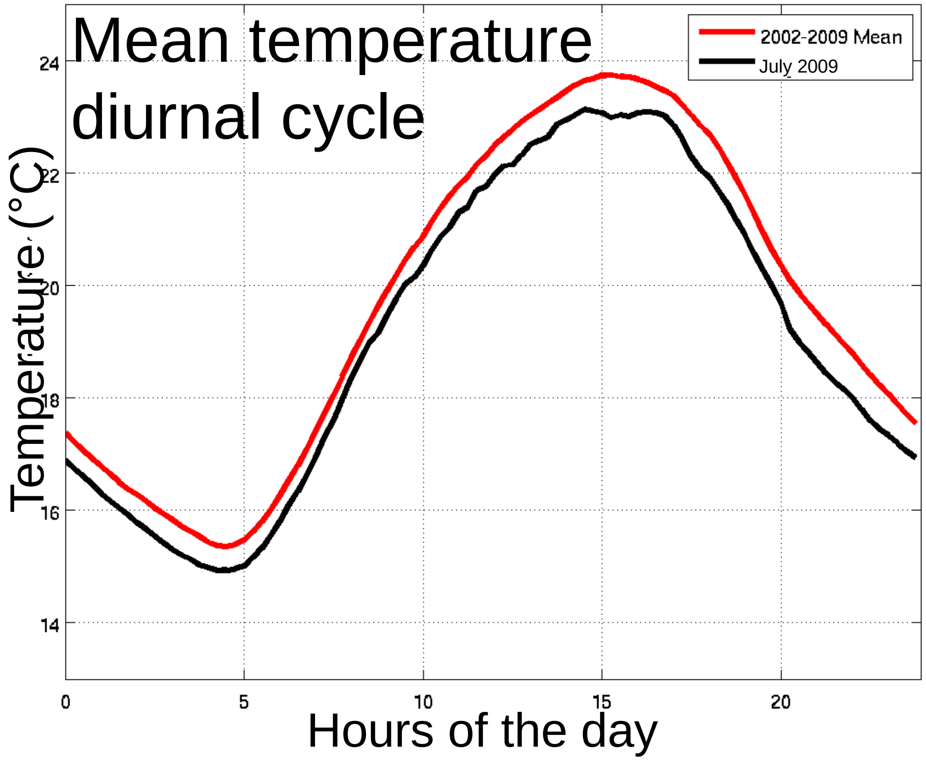
III. First campaign results and how to be used for model evaluation

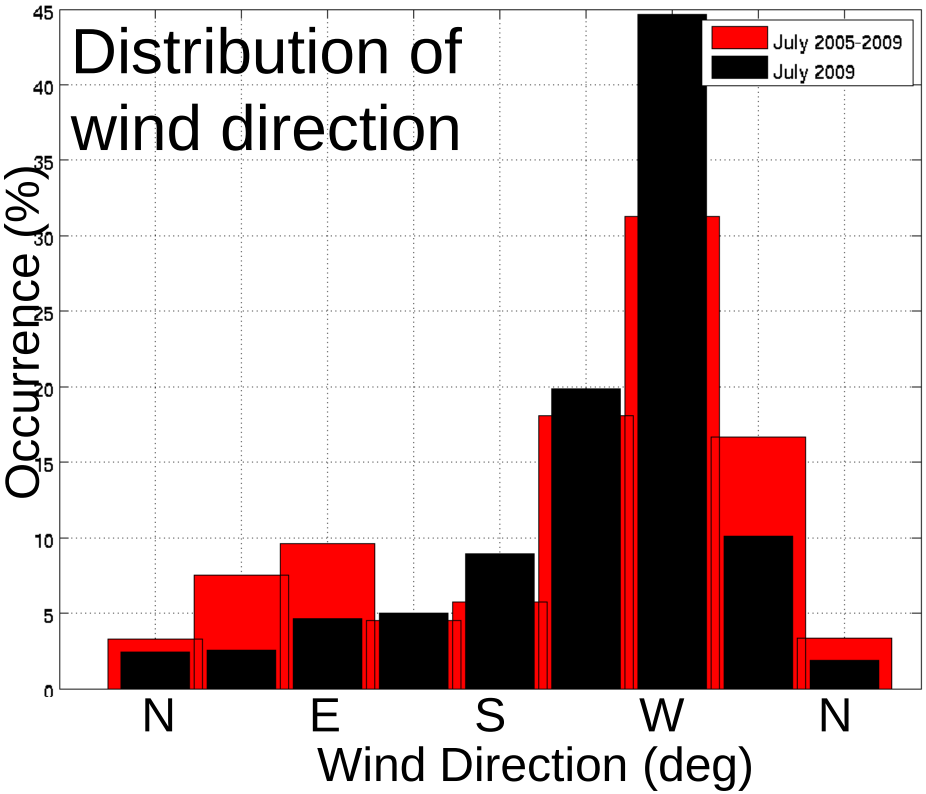
- Meteo / Transport
- Emissions
- Gas phase chemistry
- (Organic) aerosol chemical composition
- Aerosol properties

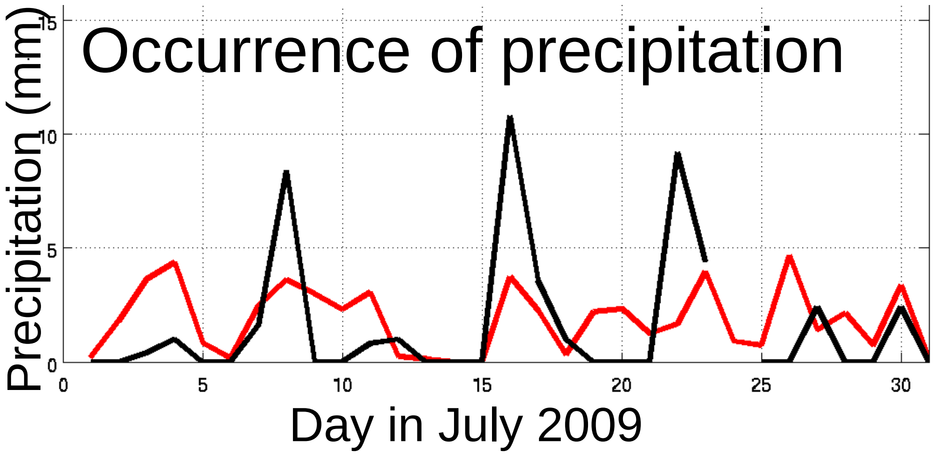
Meteo / Transport

Measurement type performed	**Model parameter or process to be evaluated**
Lidar and sodar wind profiles	Synoptic wind speed
Radiosounding wind and T profiles	Synoptic wind speed and boundary layer height
Surface meteo network (temperature)	Urban heat island effect
Lidar (ceilometer) derived boundary layer height	Urban heat island effect on BL height
Passive emission tracers (urban scale NOx, urban + plume BC and NOy)	Urban scale dispersion (cumulated with uncertainty on emissions), regional scale advection

Surface meteorology in July 2009 SIRTA (suburban sit)





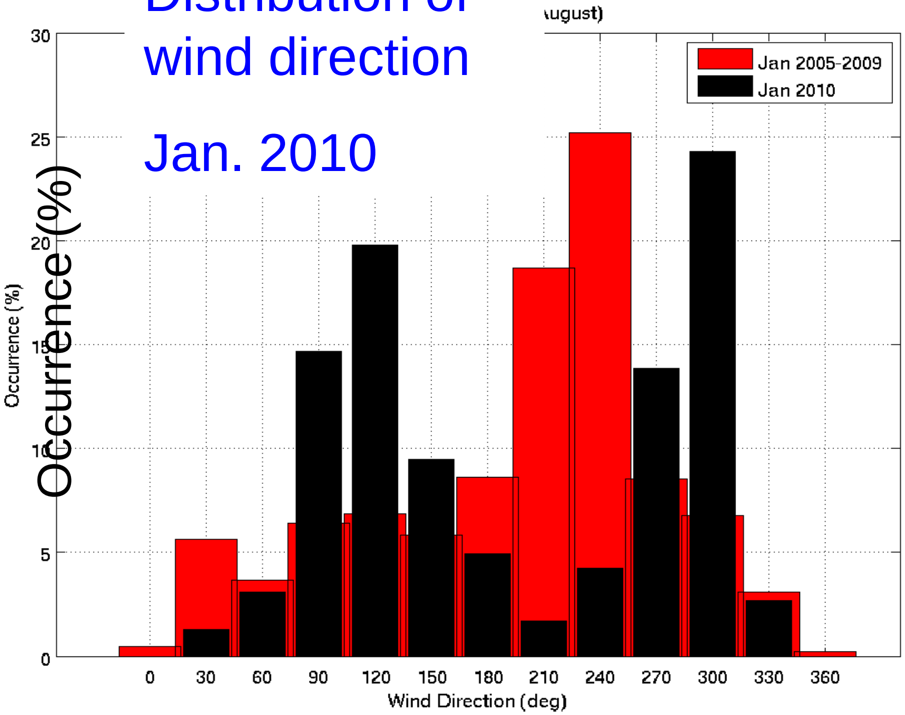


Measurements made at SIRTA

Surface meteorology in Jan/feb 2010 SIRTA (periurban)

Distribution of wind direction

Jan. 2010



Occurrence (%)

N E S W N

Wind Direction (deg)

Measurements made at SIRTA/IPSL

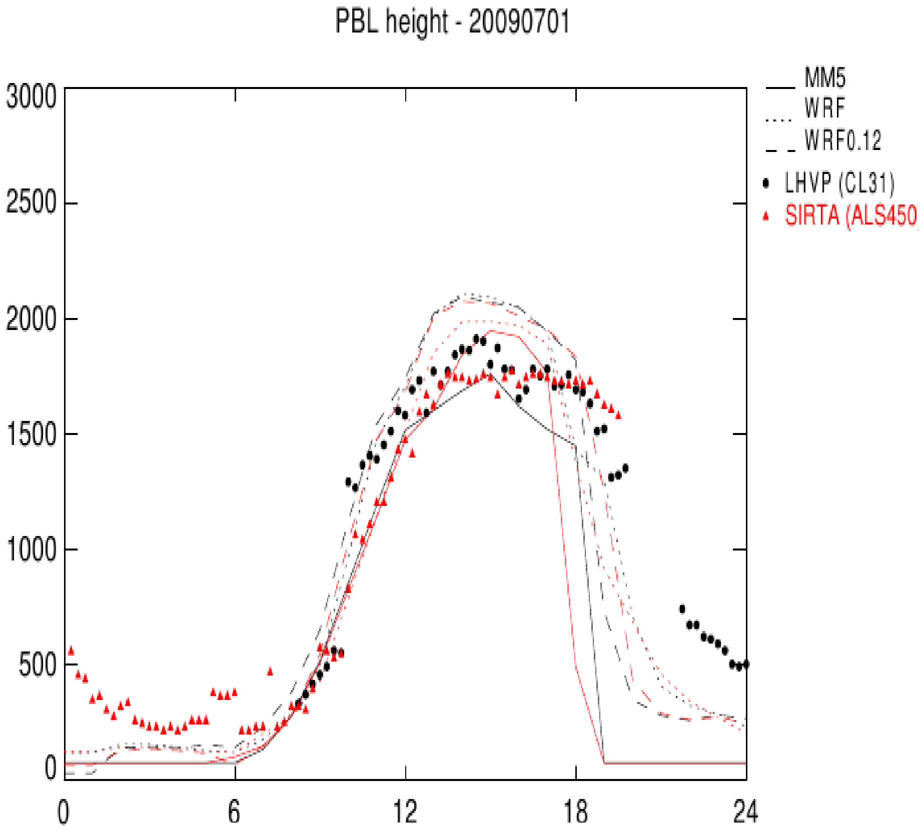
Ecole Polytechnique, Palaiseau

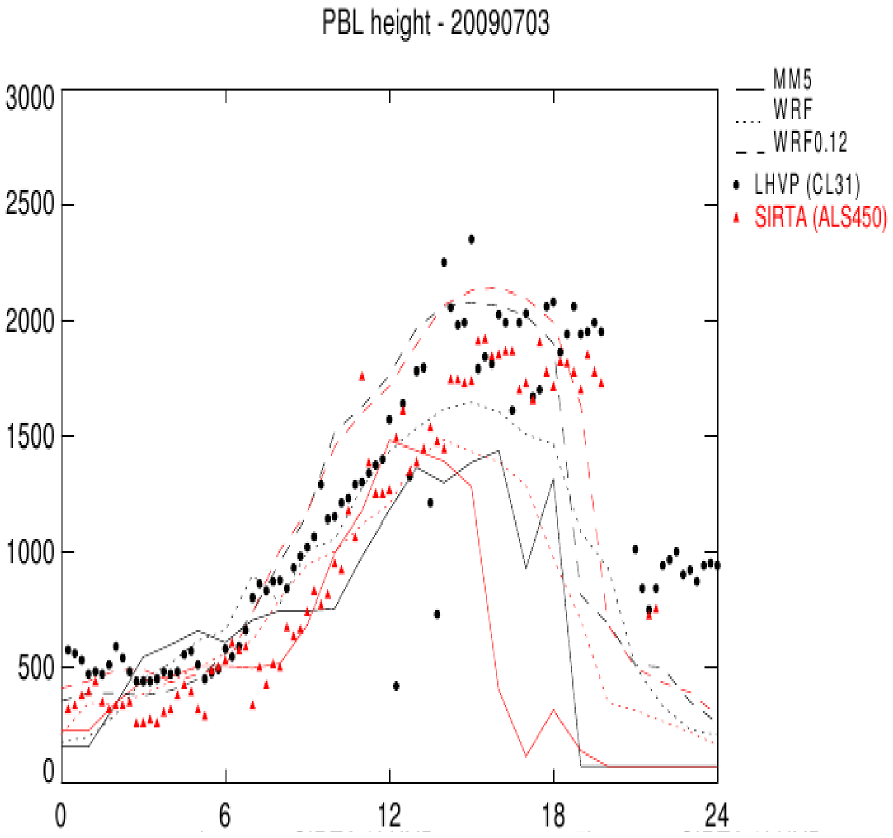
M. Haeffelin SIRTA / IPSL

Snow and fog at the SIRTA site

PBL height derived from lidar and ceilometer measurements

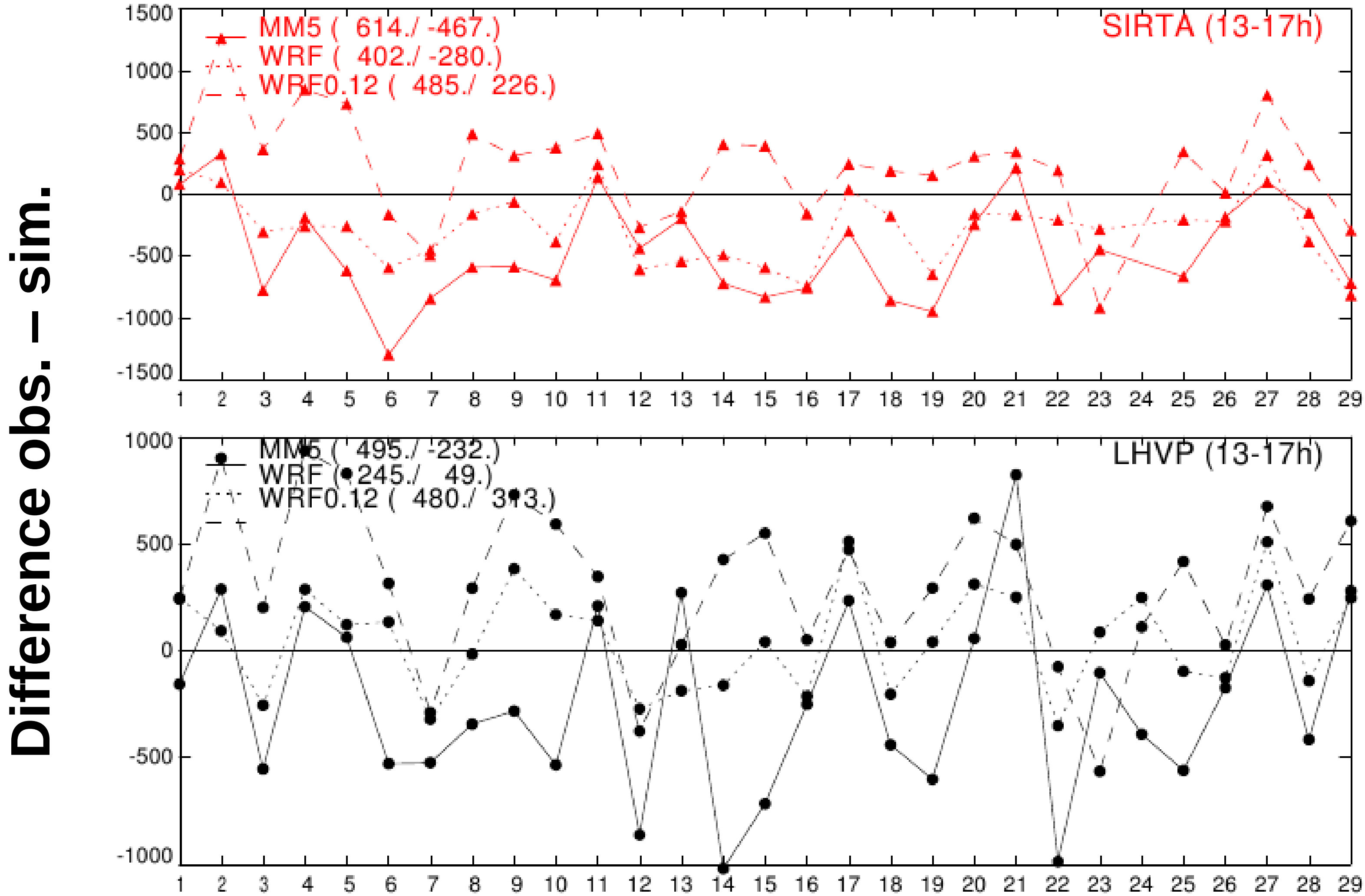
LHVP – SIRTA vs. MM5 and WRF





Courtesy
M. Haeffelin, SIRTA

Systematic comparison for July 2009 (afternoon)

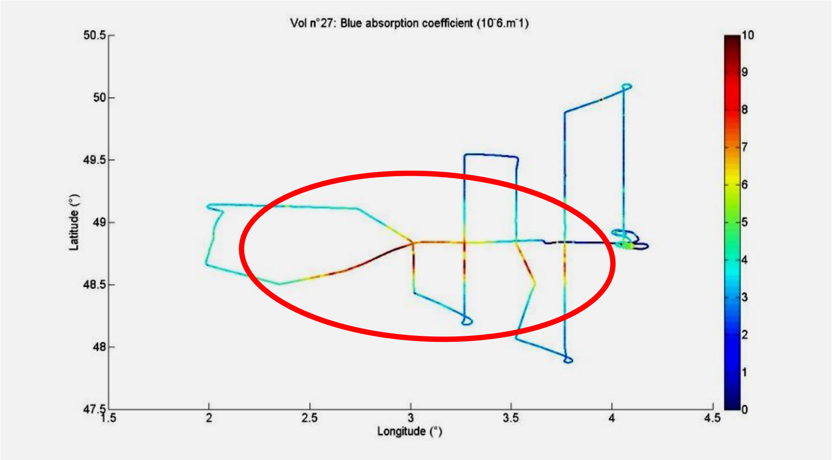


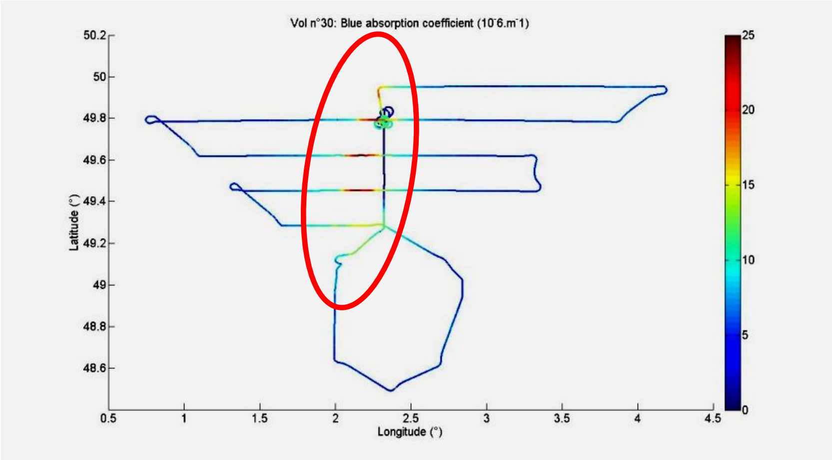
Mesures ATR-42 Aethalometer

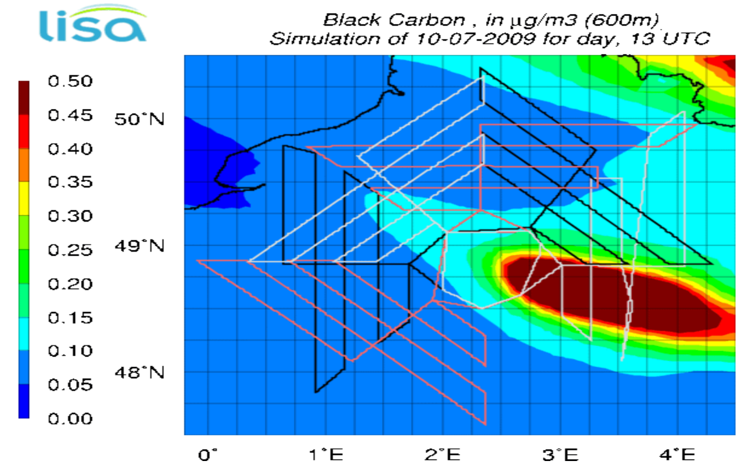
(A. Schwarzeboeck, CNRS/ Lamp)

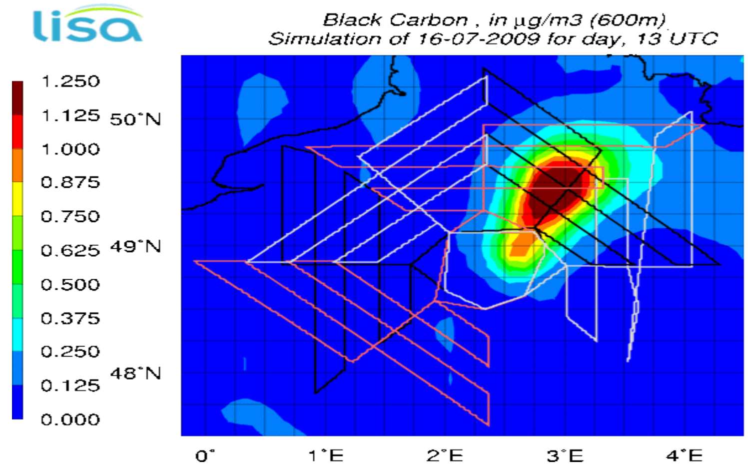
Simulations avec NFS/MM5/ CHIMERE

Q. Zhang, M. Beekmann LISA





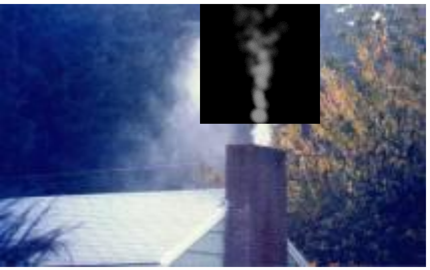


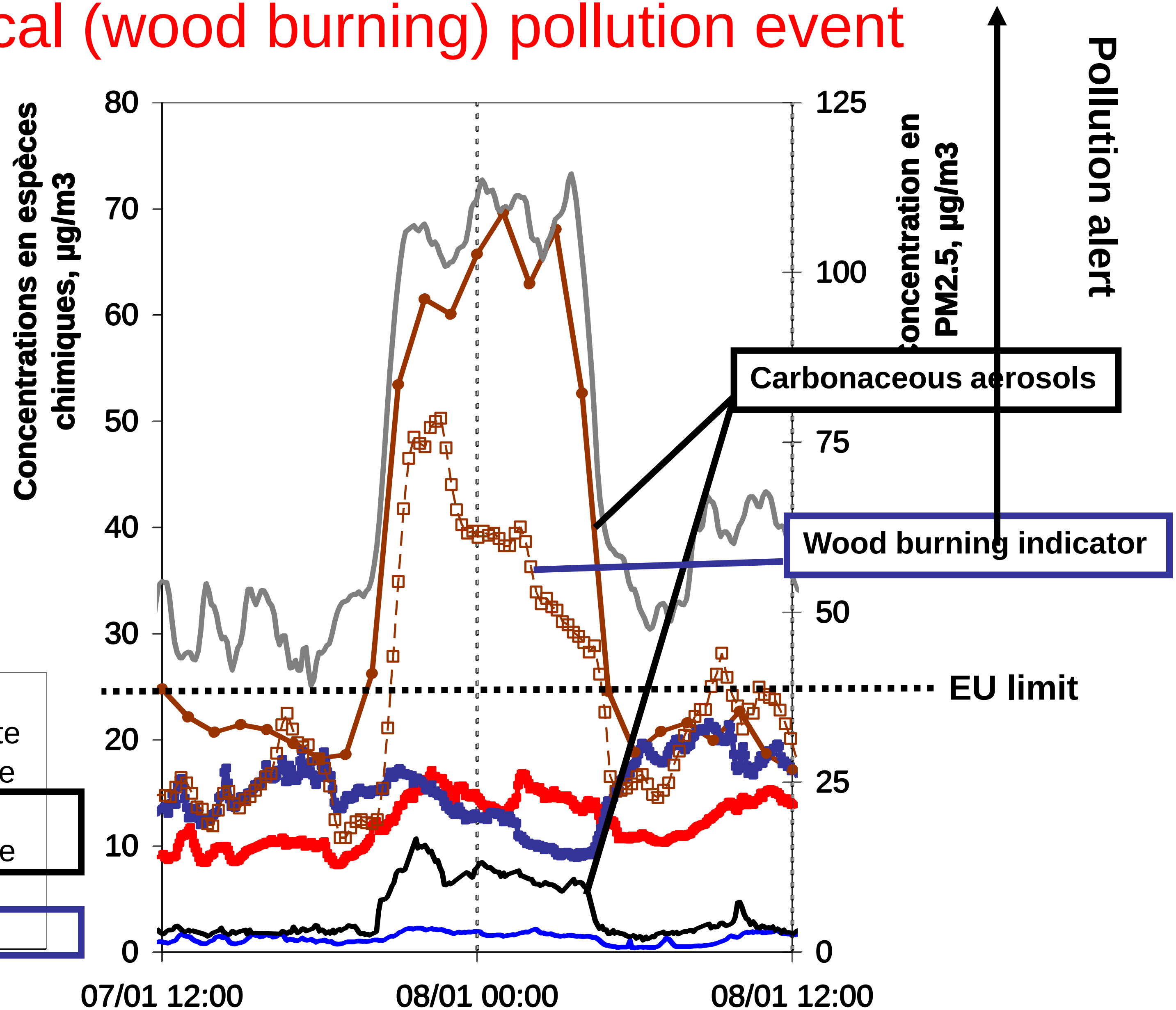


Emissions

Measurement type performed	**Model parameter or process to be evaluated**
Airborne plume measurements of emission tracers (NOy, VOC, BC)	NOx, VOC, BC emissions (spatially integrated over Paris agglomeration)
Urban scale VOC ratios	VOC emission ratios, source distribution
PM chemical composition (individual tracers) , C14 ratio	PM and organic aerosol emission source distribution, modern vs. old OA
Airborne measurements of biogenic VOC and oxidation products	Biogenic VOC emissions over forested areas surrounding Paris agglomeration

Specific local (wood burning) pollution event



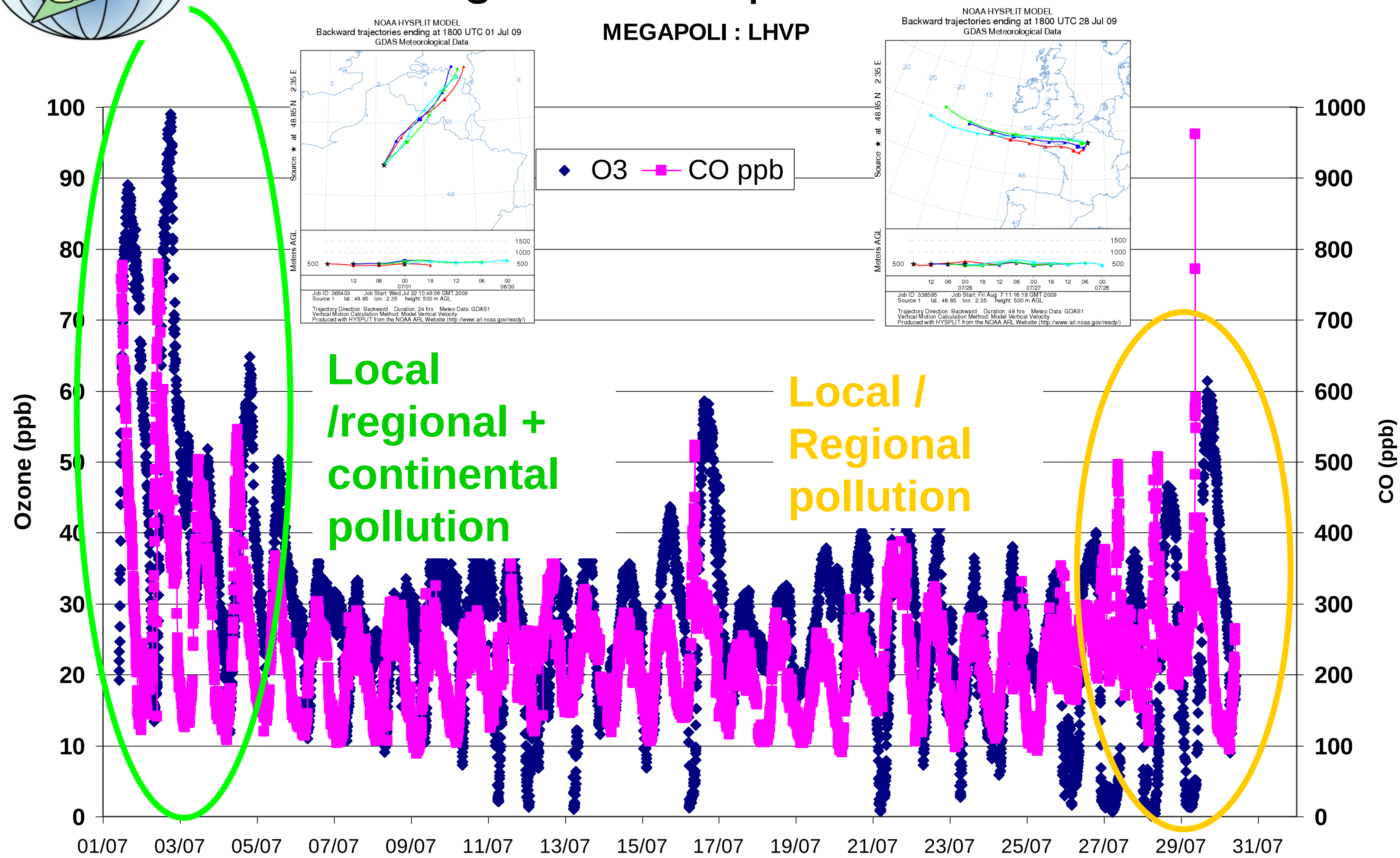


Courtesy J. Sciare (LSCE)

Gas phase chemistry

Measurement type performed	**Model parameter or process to be evaluated**
Oxidant (sum O3+NO2) content	Ozone formation efficiency
Urban scale + plume NOy species	NOx processing , NOy budget
Urban scale + plume VOC species	VOC reactivity + secondary VOC build-up
Odd hydrogen radical and source/ sink measurements, VOC ratios of different reactivity	Odd hydrogen (OH, HO_2, RO_2) radical budget, Oxidation capacity

LHVP: long-lived compounds time series



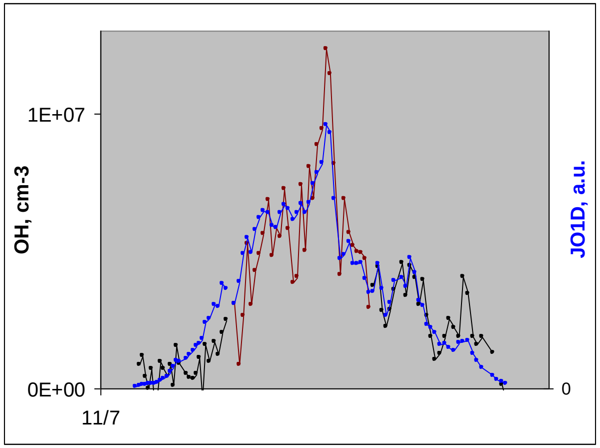
Courtesy V. Gros, LSCE

Diurnal radical profiles at SIRTA SAMU

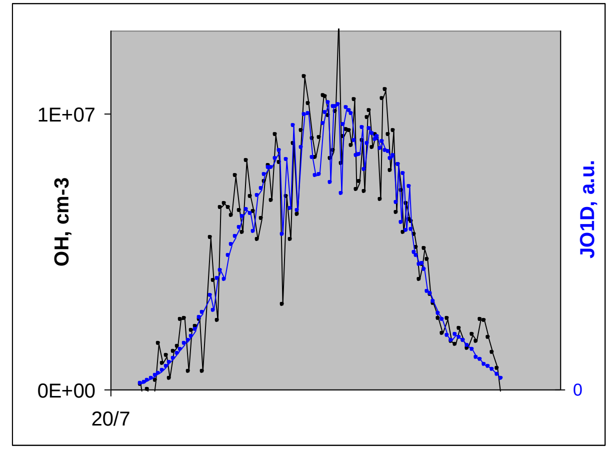
July 11

July 20

OH



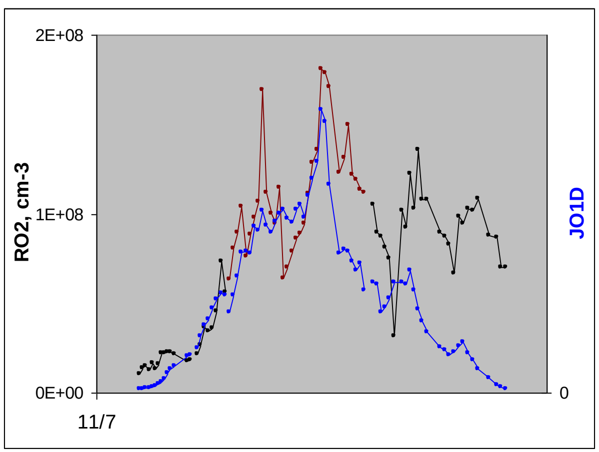
OH



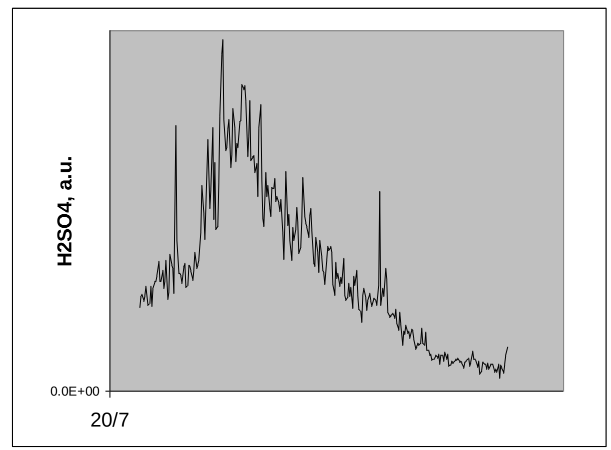
Blue

JO1D

RO_2



H_2SO_4



Combination with HOx source and sink measuements

⇒ Radical closure experiment

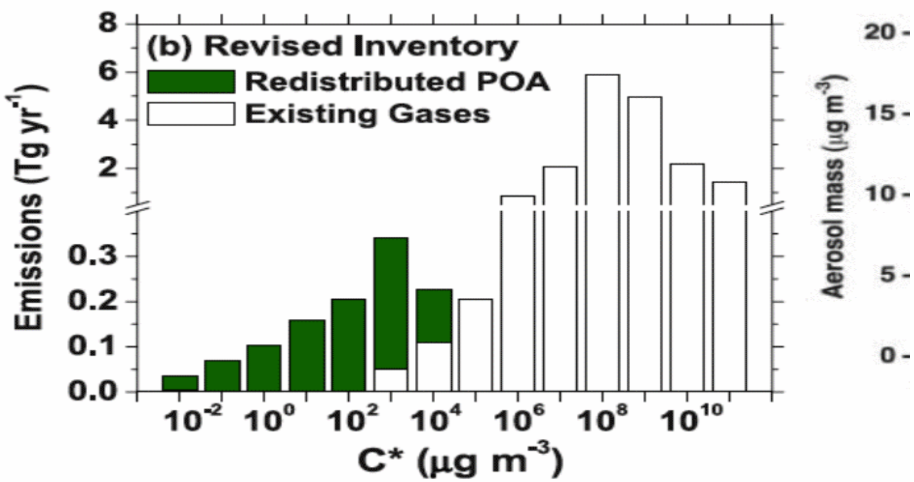
Courtesy A. Kukui, LATMOS

Aerosol chemistry

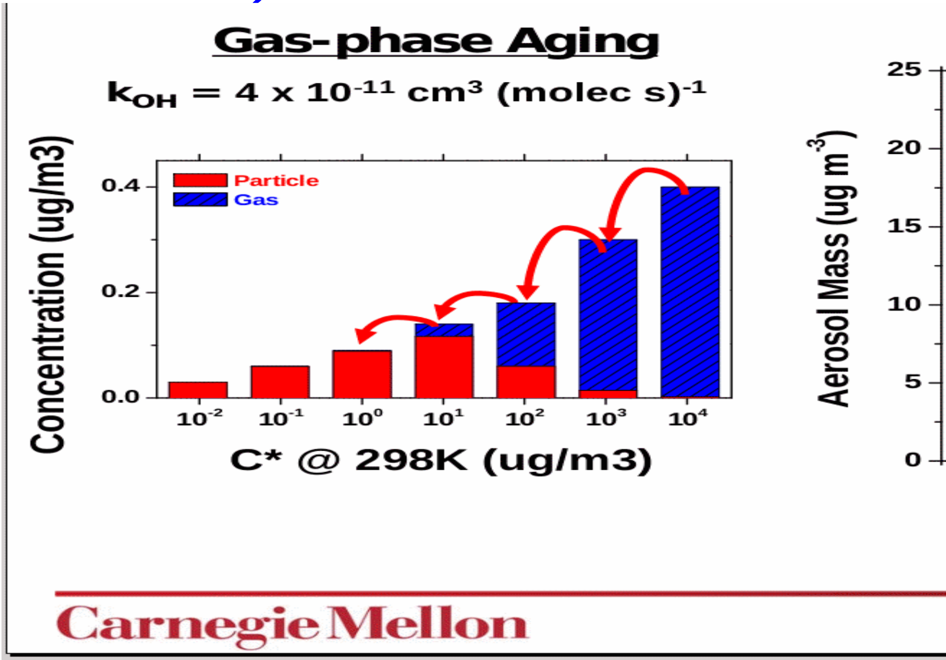
Measurement type performed	**Model parameter or process to be evaluated**
Chemical PM1, PM2.5 mass closure (AMS, PILS, …)	Secondary and inorganic aerosol formation
AMS HOA + OOA AMS elemental (H,C,O) ratio	Oxidative state of organic aerosol
OOA/ CO ratio versus –log(NOx/NOy) OOA/ OX ratio	Normalized (emissions, photochemistry) secondary aerosol build-up

Context: Large uncertainties on primary and secondary organic sources

POA is semivolatile and can be oxidised !
(Robinson et al., 2007)

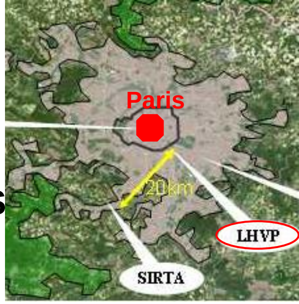


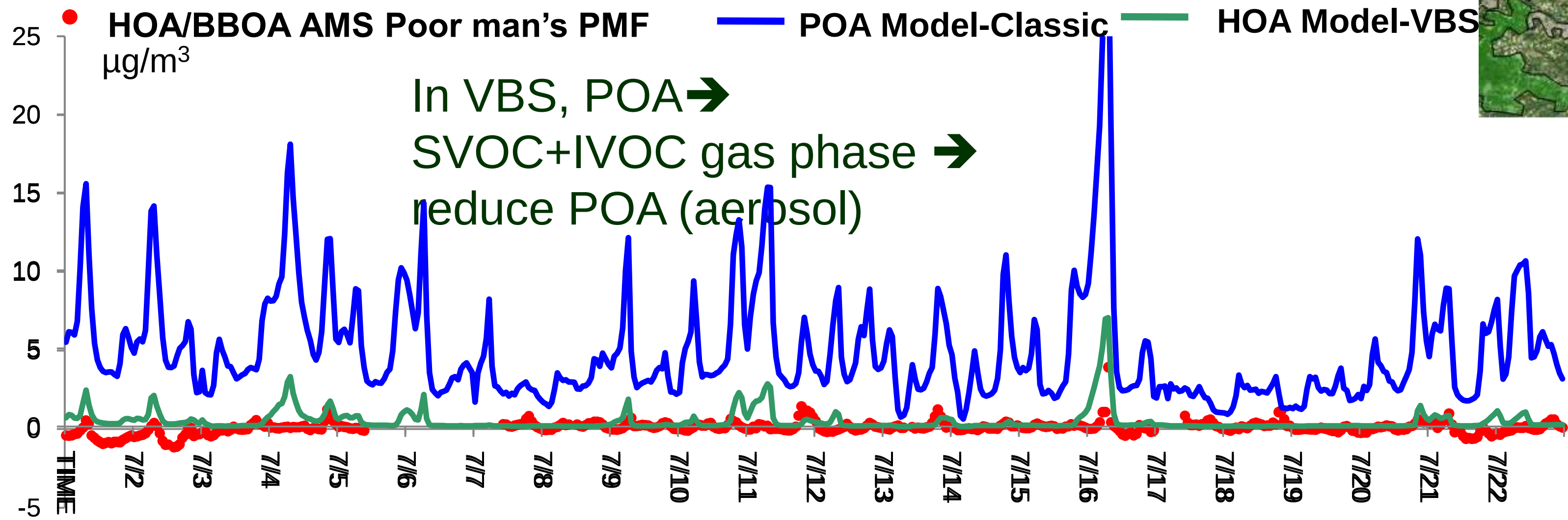
Shrivastava et al., JGR 2008

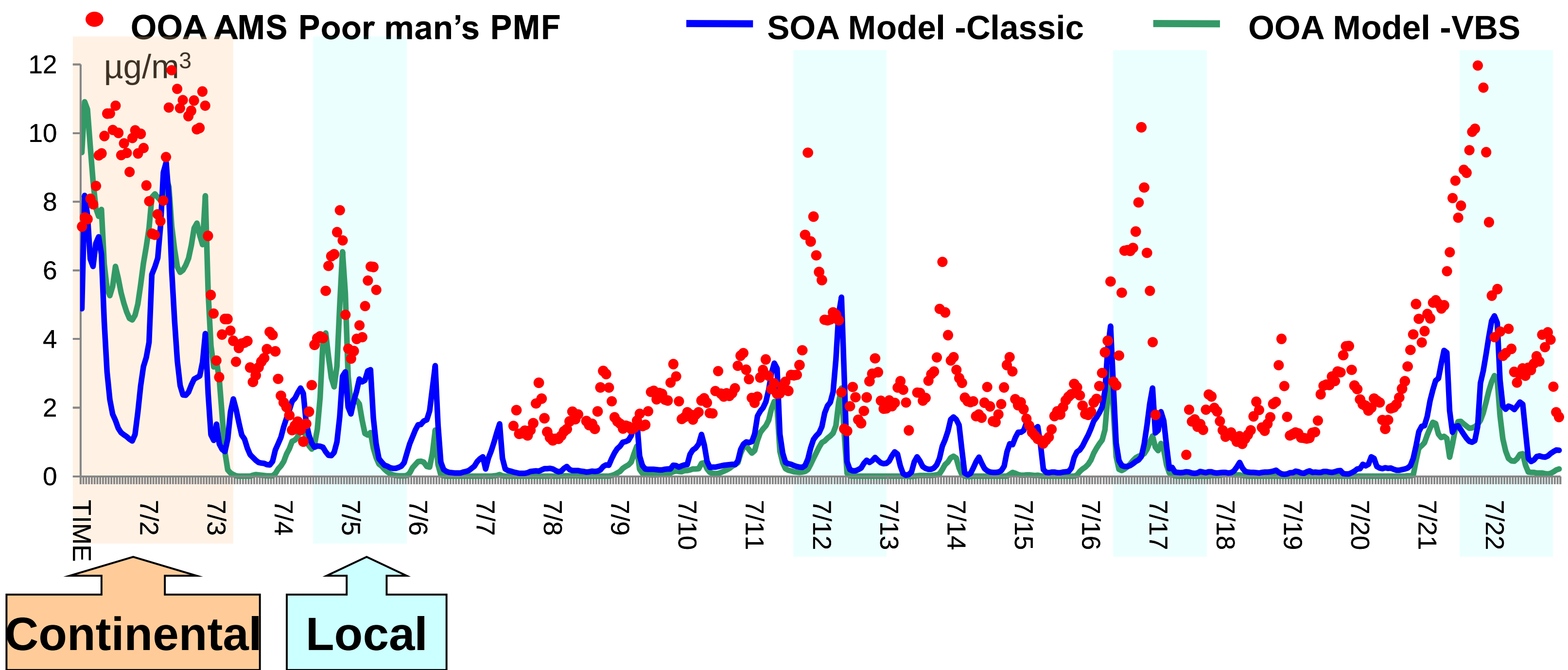


In addition **=> Aging of SOA :**
Oxidation, Oligomerisation / Polymerisation
talk Q.J. Zhang on Thursday morning

Simulation results (LHVP-Urban site) vs. ground based AMS measurements (PM1)

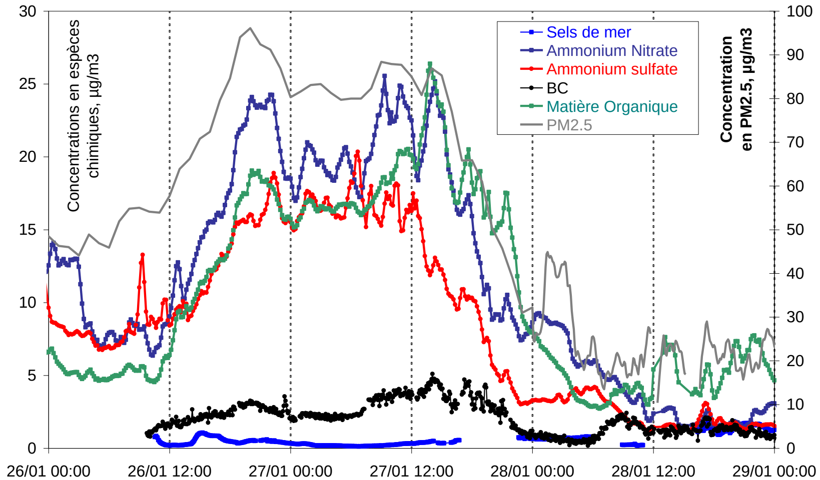


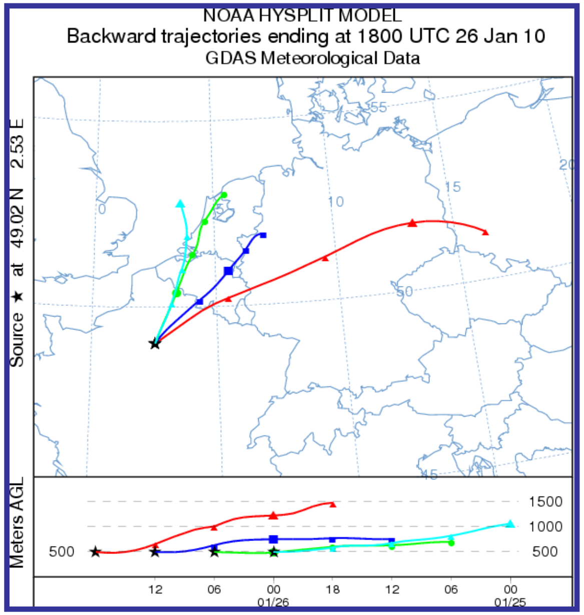




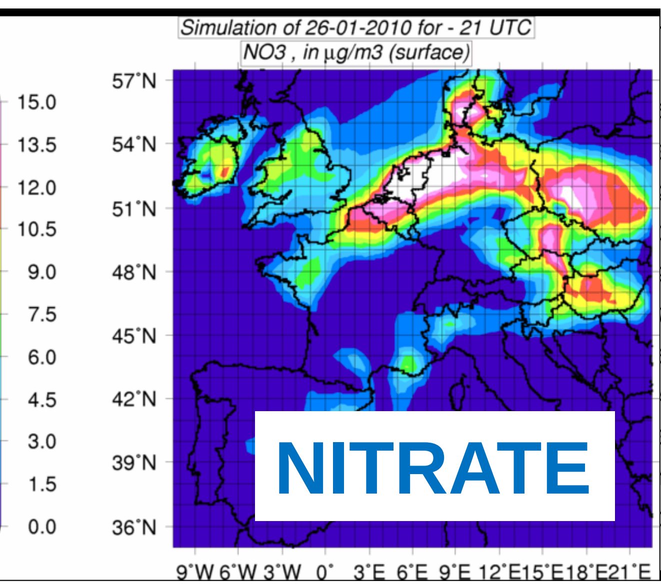
The continental advection case: January 26-28

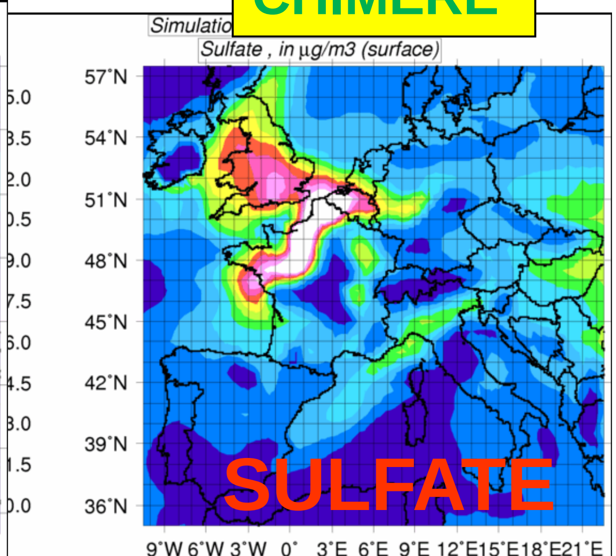
OBS. + CHIMERE simulations

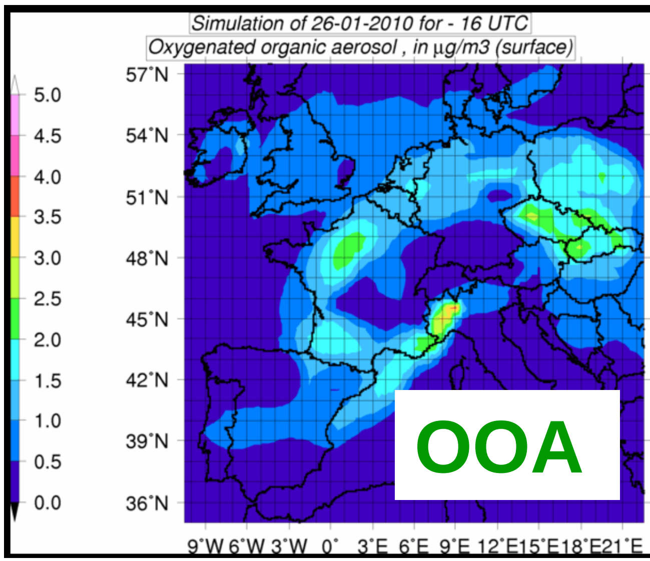




CHIMERE





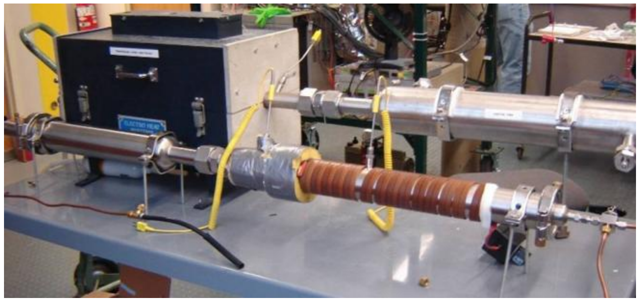


Aerosol properties

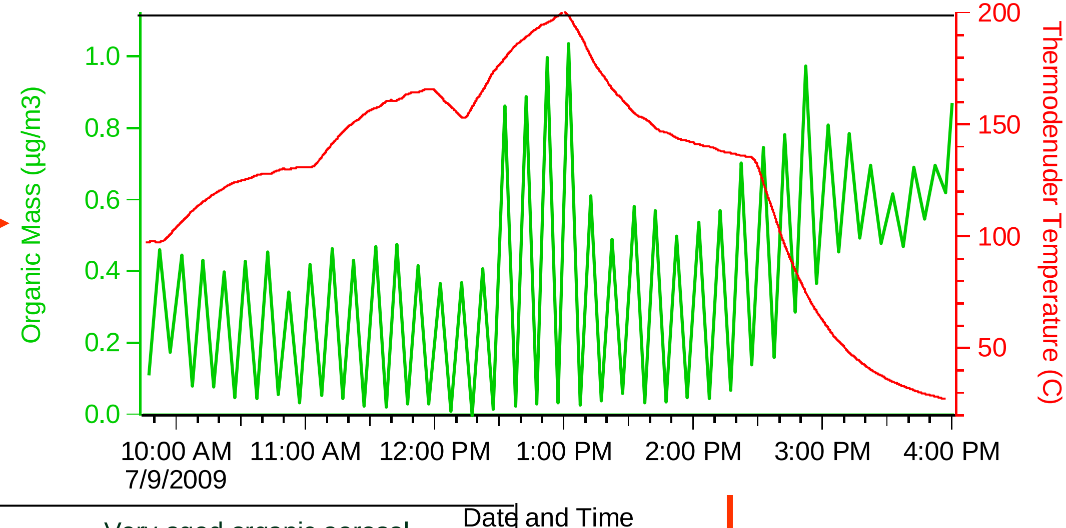
Measurement type performed	**Model parameter or process to be evaluated**
Aerosol size distribution, hygroscopicity	Correct representation of nucleation, coagulation, hygroscopic growth in models
Hygroscopicity and single particle measurements	Representation of mixing state
Volatility measurements	Volatility representation of organic aerosol

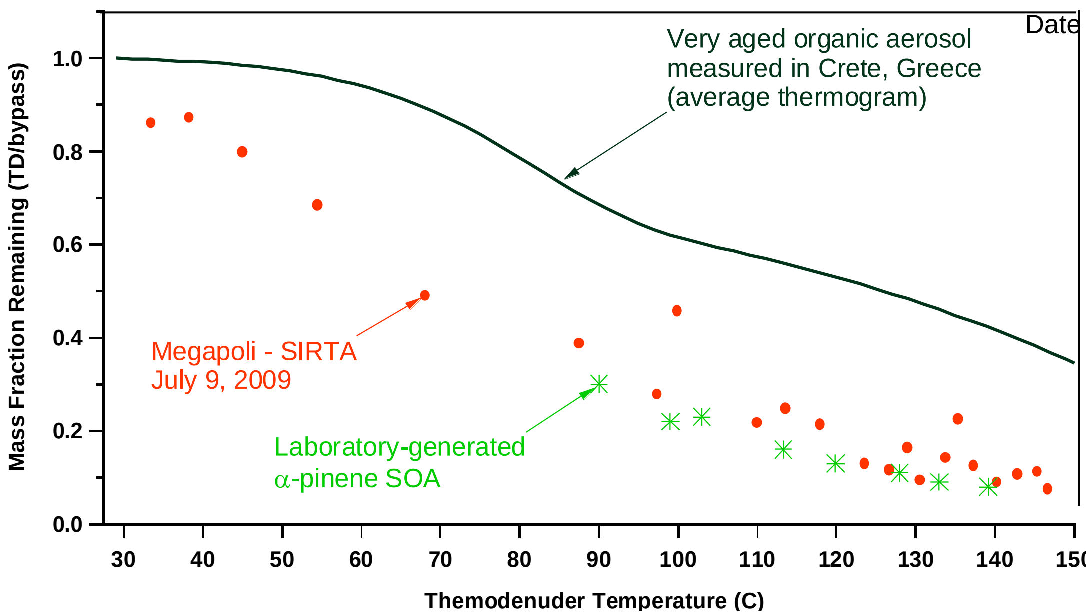
Organic PM Volatility (SIRTA)

Thermodenuder+SMPS+PSI AMS



Ambient + Heated Organic PM vs Time





Typical thermogram
(roughly half the OA evaporated at 80°C)

results from FORTH & CM S.Pandis et al.

Conclusion

- Megapoli Paris campaign data will allow extensive evaluation of urban / regional scale air quality models
- Pollution plume is well identified at 100 – 150 km downwind from Paris even for rather clean conditions in summer
- Oxygenated organic aerosol (OOA) seems to be major OA component during summer (preliminary result)
- Winter : much larger gas phase and aerosol concentrations of both local/regional and continental origin
- Strong wood burning source for OA in winter

More material

http://megapoli.dmi.dk/

http://megapoli.lisa.univ-paris12.fr

- Acknowledgements

Support from
FP7 / MEGAPOLI
ANR French national program
French LEFE-CHAT / ADEME
Ile de France Soutien SEPPE IdF
Other national + lab support

Logistical support
SIRTA , LHVP , Golf de la Poudrière

Forecast
PREVAIR www.prevair.org

Acknowledgements MEGAPOLI team

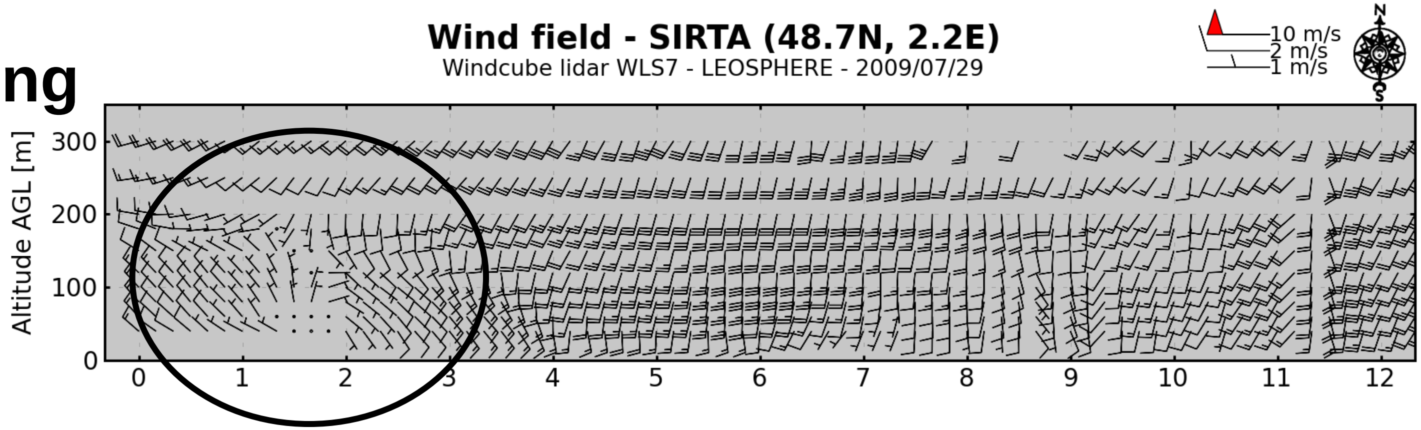
- *M. Beekmann[1], U. Baltensperger[2], A. Borbon[1], J. Sciare[3], V. Gros[3], A. Baklanov[4], M. Lawrence[5], S. Pandis[6], V.Kostenidou[6], M.Psichoudaki[6], L. Gomes[7], P. Tulet[7], A. Wiedensohler[8], A. Held[*], L. Poulain[8], K.Kamilli[8], W. Birmli[8], A. Schwarzenboeck[9], K. Sellegri[9], A. Colomb[9], J.M. Pichon[9], E.Fernay[9], J.L. Jaffrezo[10], P. Laj[10], C. Afif[1], V. Ait-Helal[1]*, B. Aumont[1], S. Chevailler[1], P. Chelin[1], I. Coll[1], J.F. Doussin[1], R. Durand-Jolibois[1], H. Mac Leod[1], V. Michoud[1], K. Miet[1], N. Grand[1], S. Perrier[1], H. Petetin[1], T. Raventos[1], C. Schmechtig[1], G. Siour[1], C. Viatte[1], Q. Zhang[1]**, P. Chazette[3], M. Bressi[3], M. Lopez[5], P. Royer[3], R. Sarda-Esteve[3], F. Drewnick[5], J. Schneider[5], M. Brands[5], S. Bormann[5], K. Dzepina[5], F. Freutel[5], S. Gallavardin[5], T. Klimach[5], T. Marbach[5], R. Shaiganfar[5], S.L. Von der Weiden[5], T. Wagner[5], S.Zorn[5], P. De Carlo[2], A. Prevot[2], M. Crippa[2], C. Mohr[2], Marie Laborde[2], M. Gysel[2], Roberto Chirico[2], Maarten Heringa[2], A. Butet[11], A. Bourdon[11], E. Mathieu[11], T. Perrin[11], SAFIRE team, J.Wenger[12], R. Healy[12], I.O. Connor[12], E. Mc Gillicuddy[12], P. Alto[13], J.P.Jalkanen[13], M. Kulmala[13], P Lameloise[14], V. Ghersi[14], O. Sanchez[14], A. Kauffman[14], H. Marfaing[14], C. Honoré[14], L. Chiappini[15], O. Favez[15], F. Melleux[15], G. Aymoz[15], B. Bessagnet[15], L. Rouil[15], S. Rossignol[15], M. Haeffelin[16], C. Pietras[16], J. C. Dupont[16], and the SIRTA team, S. Kukui[17], E. Dieudonné[17], F. Ravetta[17], J.C.Raut[17],G. Ancellet[17], F. Goutail[17], J.L Besombes[18], N. Marchand[19], Y. Le Moullec[20], J. Cuesta[21],Y.Te[21], N. Laccoge[22], S. Lolli[23], L. Sauvage[23], S.Loannec[23], D. Ptak[24], A. Schmidt[24], S. Conil[25], M. Boquet[26],*

[1]Laboratoire InterUniversitaire des Systèmes Atmosphériques (LISA), Université Paris Est et 7, CNRS, Créteil, France, [2] Paul Scherrer Institut, Villingen, Switzerland, [3]Laboratoire des Sciences du Climat et de l'Environnement (LSCE), Gif sur Yvette, France,, [4] Danish Meteorological Institute, Copenhagen, Denmark, [5]Max-Planck-Institute for Chemistry, Mainz, Germany, [6]Foundation for Research and Technology, Hellas, University of Patras, Greece, [7]Game,Centre National de Recherche Météorologique, Toulouse , France , [8]Institut für Troposphärenforschung, Leipzig, Germany, [9]Laboratoire de Météorologie Physique, Clermont-Ferrand, France, [10]Laboratoire de Glaciologie et Géophysique de l'Environnement, Grenoble, France , [11]SAFIRE, Toulouse, France, [12]University College Cork, Ireland, [13]University Helsinki, Finland , [14]AIRPARIF, Paris, France, [15]INERIS, France, ,[16]SIRTA/IPSL, Palaiseau, France, [17]Laboratoire Atmosphères, Milieux, Observations Spatiales, Paris, France, ,[18]Laboratoire de Chimie Moléculaire et Environnement, Chambery, France, [19]Laboratoire de Chimie Provence, Marseille, France, [20]Laboratoire de l'Hygiène de la Ville de Paris, France,, [21]Laboratorie de Météorologie Dynamique, Palaiseau, France , [22]Département Environnement et Chimie, Ecole de Mines de Douais, France, ,, [23]LEOSPHERE, France, [24]Universität Duisburg-Essen), Germany, [25]ANDRA, Châtenay-Malabry, France, [26]CEREA, Marne La Vallée, France , **also ARIA-Technologie. France

Photo-gallerie

Wind profiling by Lidar

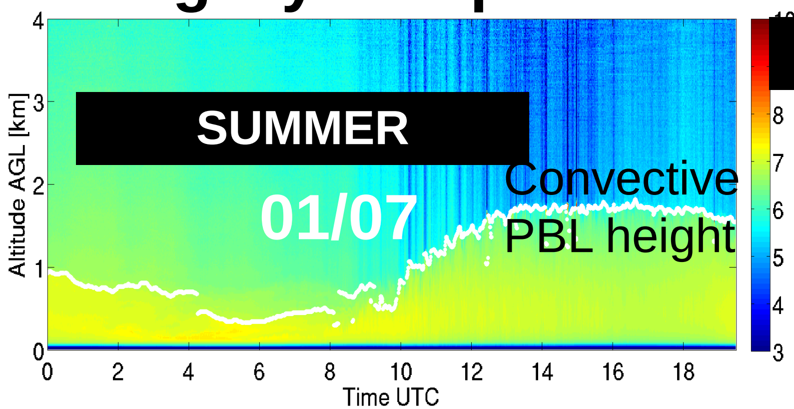
29/07

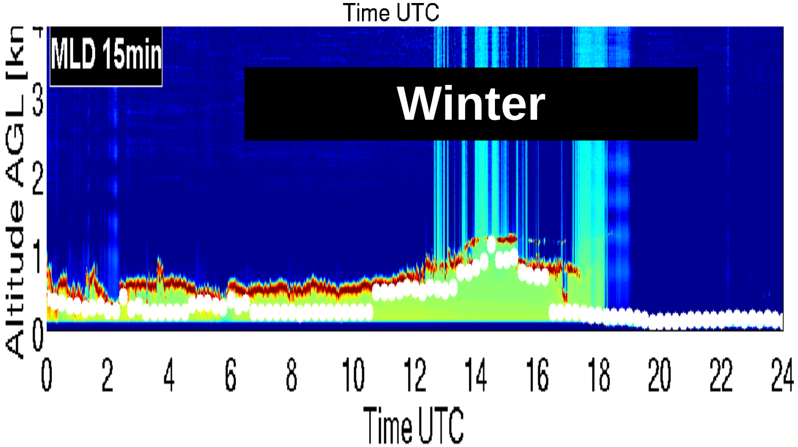


Courtesy M. Haeffelin, SIRTA

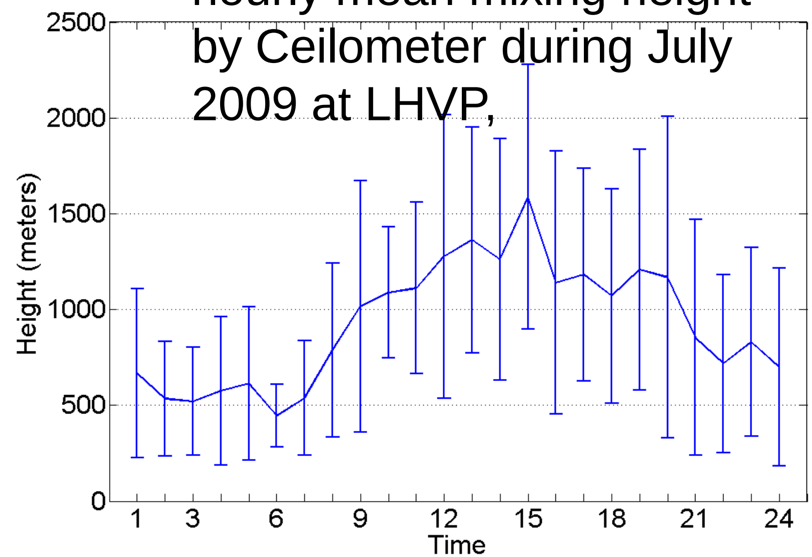
Mixing layer depth retrieval by lidar

ALS450 - SIRTA



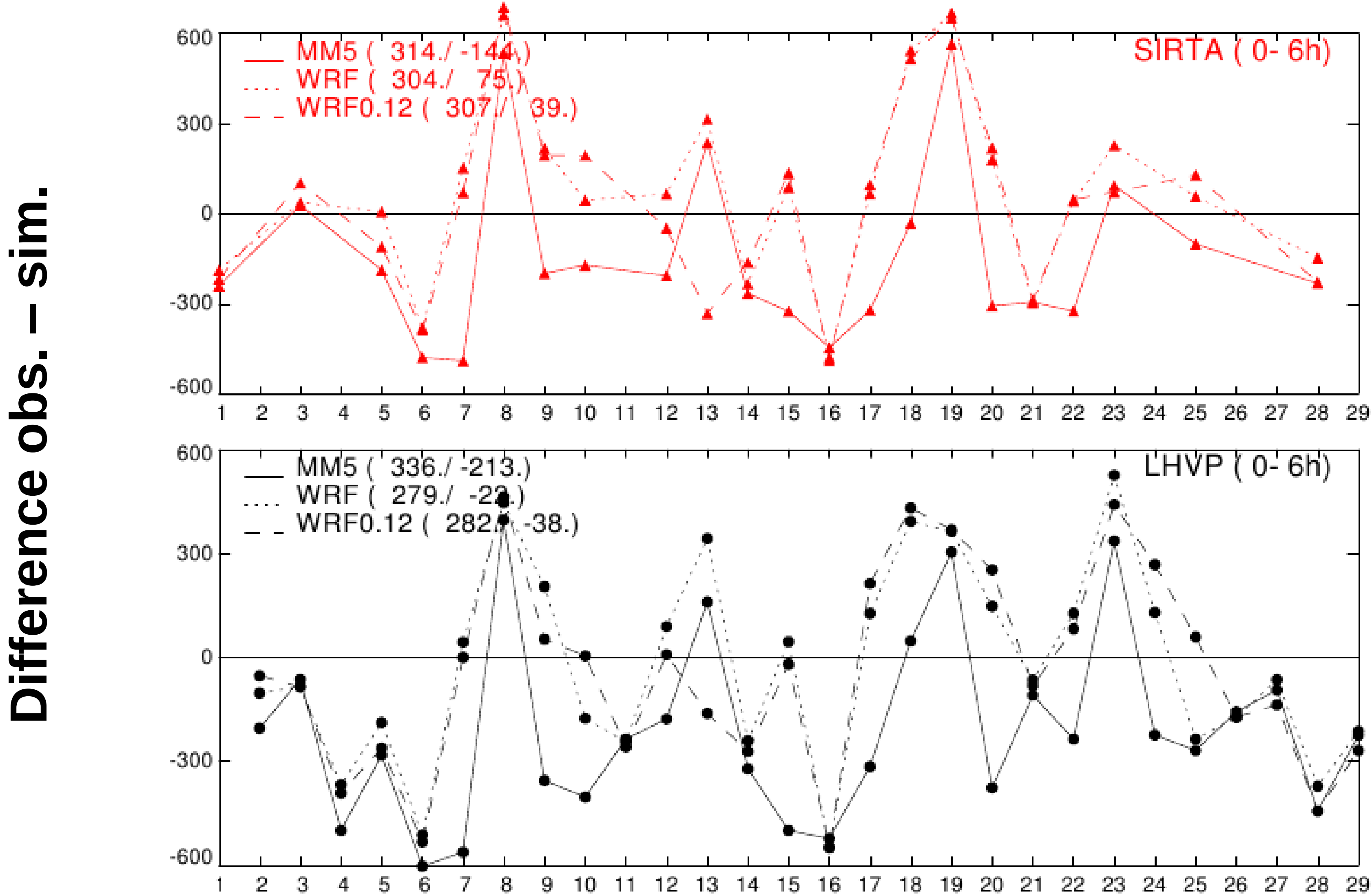


hourly mean mixing height by Ceilometer during July 2009 at LHVP,



Courtesy N. Eresmaa , FMI

Systematic comparison for July 2009 (night)



Model vs AMS PM1 observations at urban site during July 2009 [μg/m^3]