Factors influencing urban carbonaceous aerosols: comparison of Beijing (RP China), Paris (France), Cairo (Egypt) and Ouagadougou (Burkina Fasso)

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Fine and coarse aerosols were sampled in various urban environments applying same methodology

The purpose was to scrutinize the seasonal variations of source fingerprints and aerosol transformations

Methodology is based on filter-based size segregated aerosol sampling And a chemical mass balance methodology*, to achieve their chemical closure

* Guinot, Sciare, et al., *Atmospheric Chemistry and Physics*, **2007**, 7 , 1657-1670
Sciare et al., *Atmospheric Chemistry and Physics*, **2005**, 5 , 2253-2265.

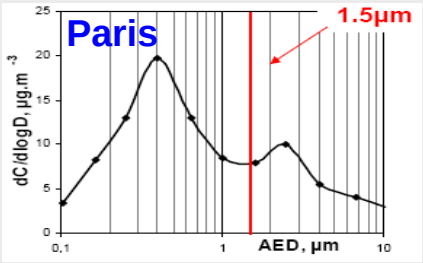
By filtration : separation coarse/fine modes

Paris = $PM_{1.5}$, Beijing = $PM_{2.5}$, Ouagadougou and Cairo = PM_1

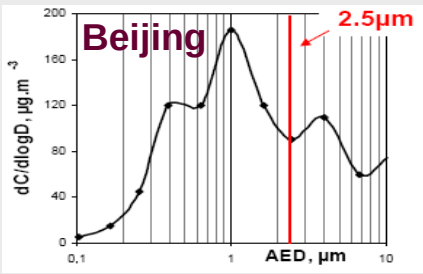
By impaction

accurate mass size distribution (13 size-bins from 0.03µm to >10µm)

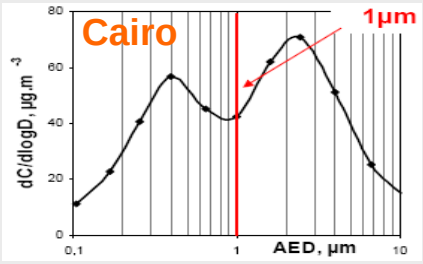
average → 5 winter and 5 summer samplings



average → 5 winter and 5 summer samplings



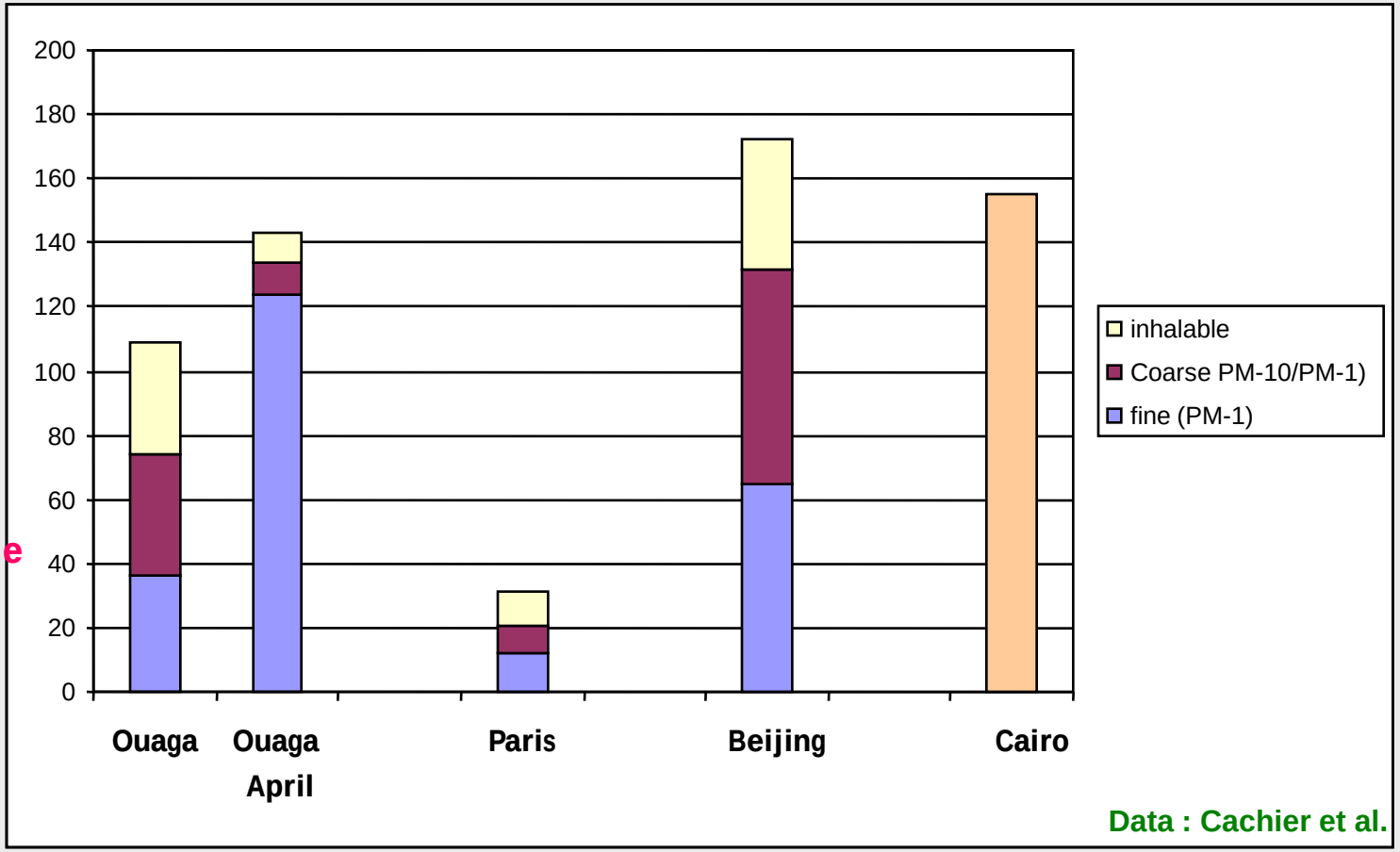
average → 8 fall and 5 spring samplings



Comparison of aerosol mass for 3 megacities and a smaller city
annual means

Limit in China

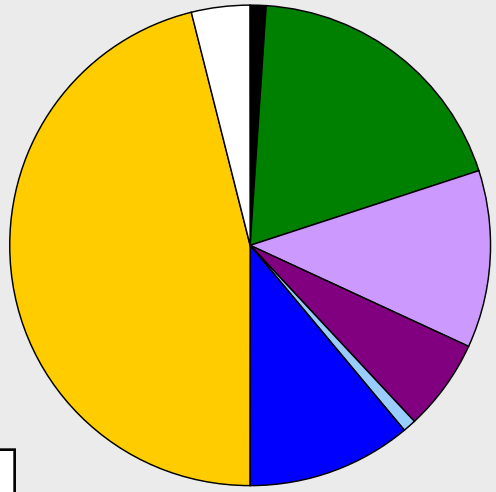
Limit in Europe



Coarse particles (annual means)

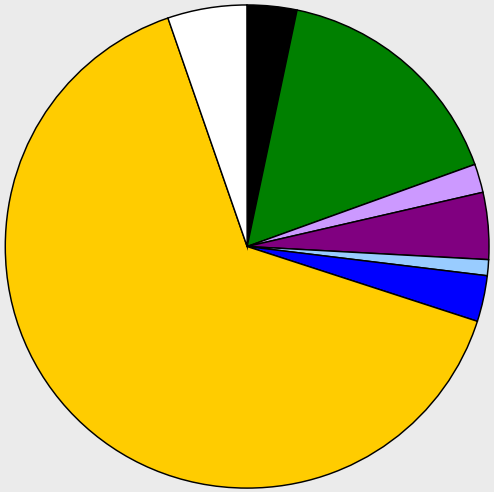
Paris, ~**15**µg.m^{-3}

(annual mean 2005)



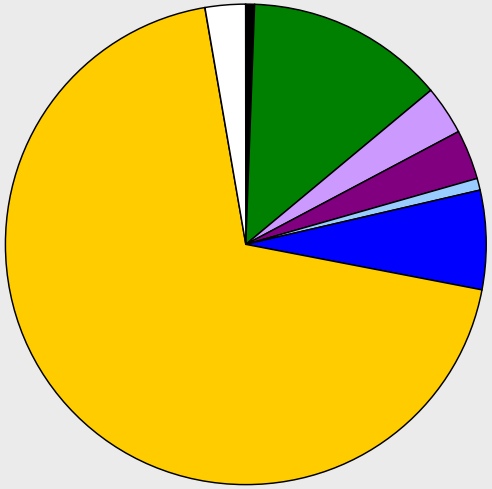
Beijing, ~**80**µg.m^{-3}

(annual mean 2003)



Cairo, ~100µg.m^{-3}

(mean fall 2004 and spring 2005)



- **EC**
- **POM**
- **NO3-**
- **nssSO42-**
- **NH4+**
- **Sea salt**
- **Dust**
- **others**

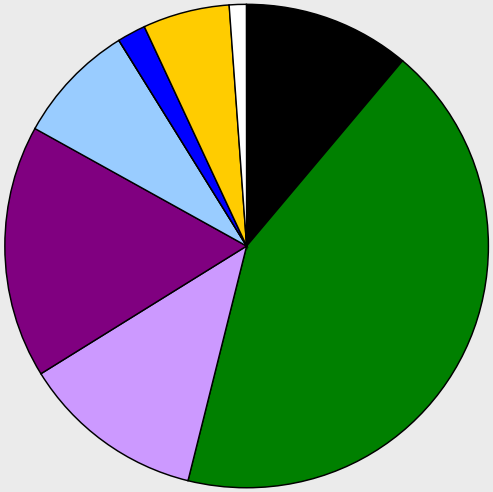
Dust and sea salt particles mixed with anthropogenic species

Coarse particles form a significant sink of gaseous species **including acidic VOC**

Fine particles (annual means)

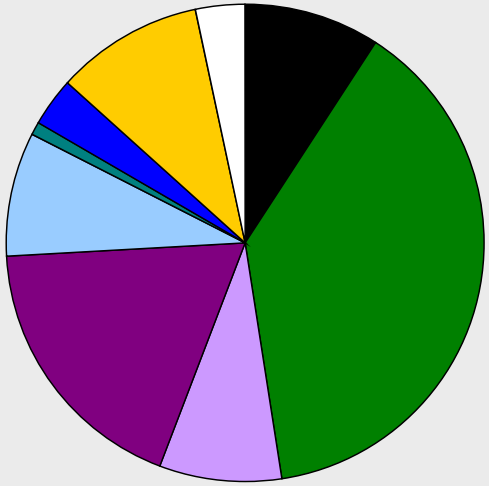
Paris, ~**15**µg.m^{-3}

(annual mean 2005)



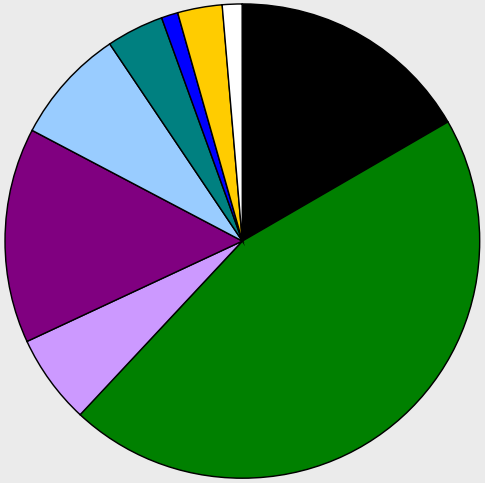
Beijing, ~**65**µg.m^{-3}

(annual mean 2003)



Cairo, ~**80**µg.m^{-3}

(mean fall 2004 and spring 2005)



- **EC**
- **POM**
- **NO3-**
- **nssSO42-**
- **NH4+**
- **nssCl-**
- **sea salt**
- **dust**
- **n. d.**

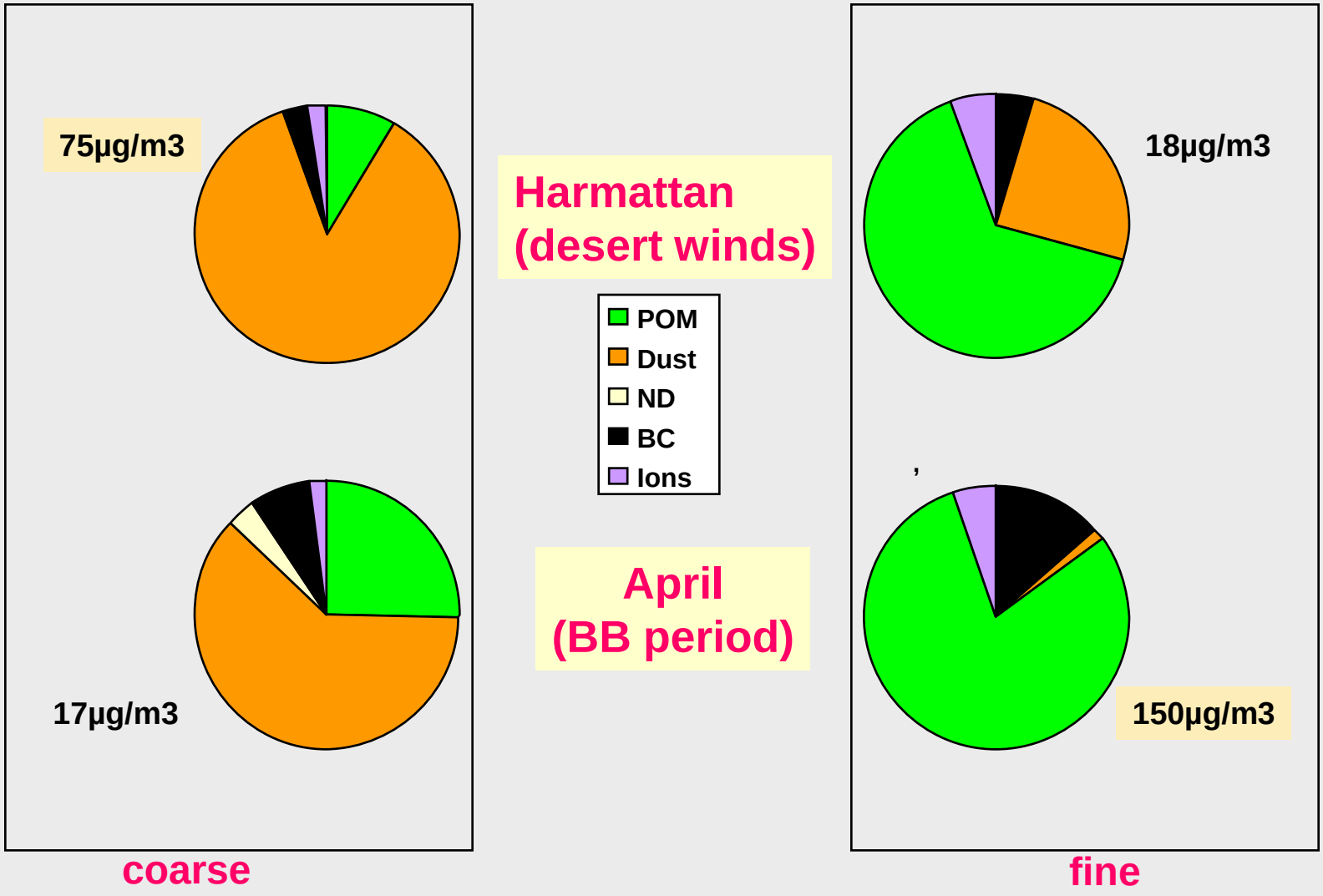
major fraction is carbonaceous

this feature is enhanced in summer

OUAGADOUGOU Field Experiments

Ouagadougou: fine particles from various combustion processes

Ouagadougou coarse and fine aerosols



PARIS Field Experiments

Laboratoire des Sciences du Climat et de l'environnement

Organics during summer in PARIS Insights to SOA properties

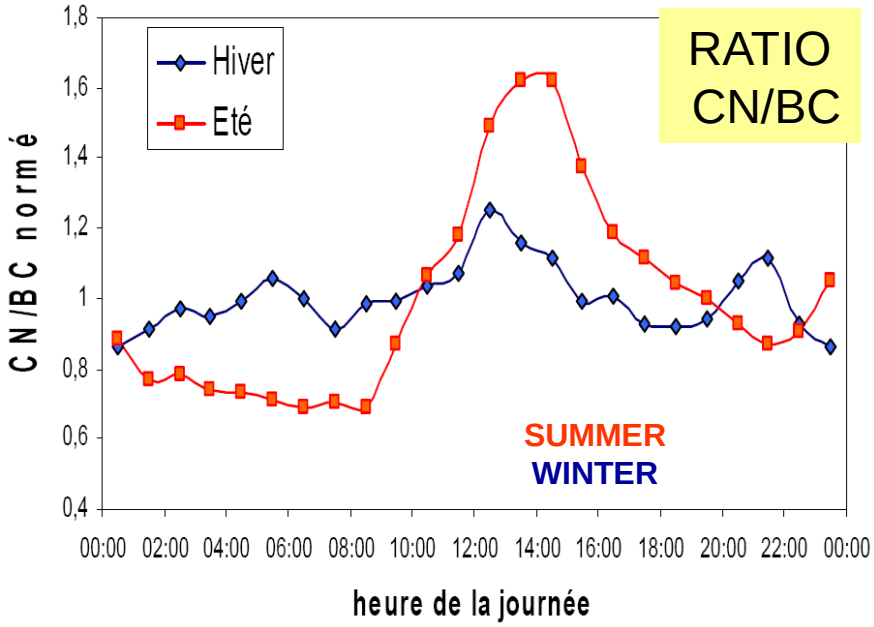


Figure II-9: variations diurnes moyennes du rapport CN/BC en été et en hiver

Formation of new particles in summer during the afternoon

⇩

Photochemical driven processes

Composition of C aerosols in the nano size mode (<100nm)

WSOC may also be use as surrogate to describe the ageing of UF organics in Paris

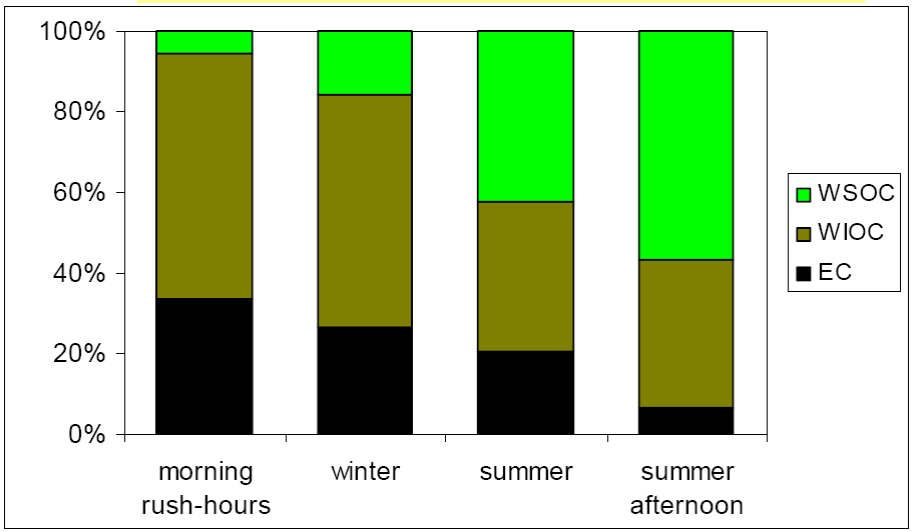
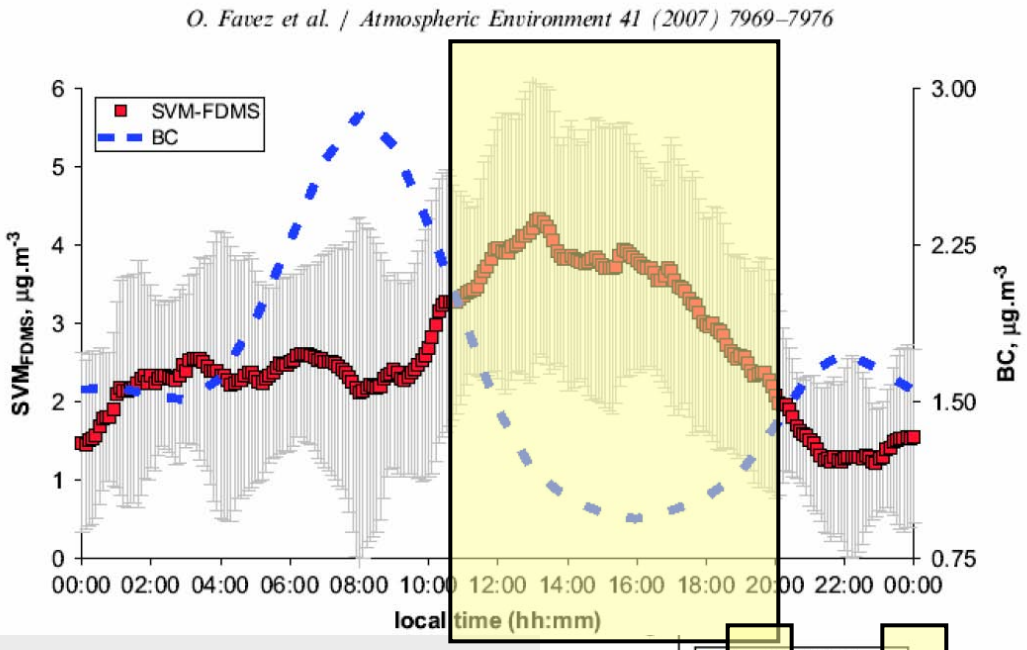


Figure 9: Contributions of EC, WIOC and WSOC to total carbon within the $PM_{0.1}$ fraction retrieved from LPI samplings.

O. Favez, Thesis 2008

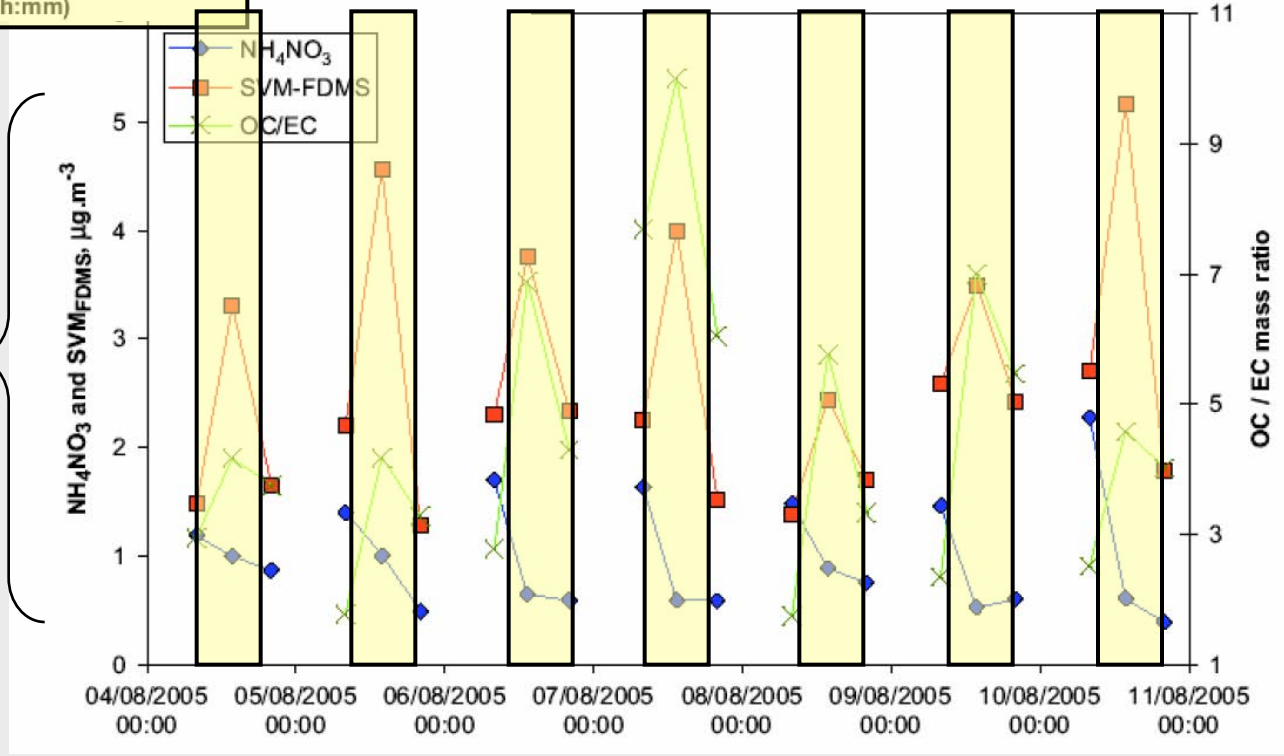
Organics during summer in PARIS
Insights to SOA properties



Formation of semi-volatile species during the afternoon

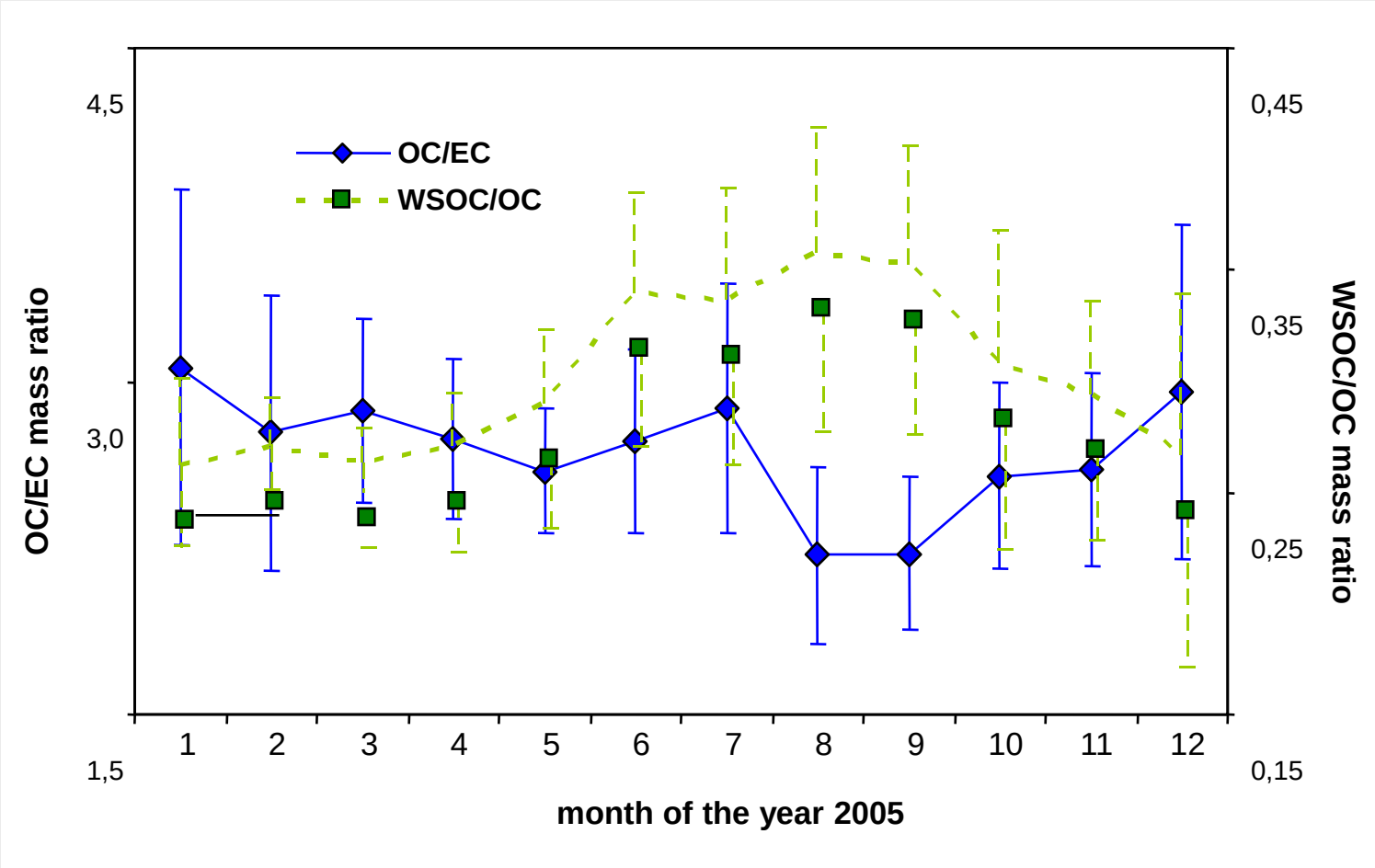
Formation of SOA during the afternoon

SVOM ?



Favez et al., Atmos. Environ., 2007

Paris: secondary organic aerosols in the fine mode



In Paris, **SOA** are traced by **WSOC** : aerosol enrichment in summer

BEIJING Field Experiments

$PM_{2.5}$ / TEOM-FDMS
& Filter Sampling (PM, Ions, WSOC)

$PM_{2.5}$ / PILS-IC (Anions & Cations)

EC-OC Sunset Field Instr. in $PM_{2.5}$ (EC, BC, OC)

Nephelometers in tandem in $PM_{2.5}$ (dry & ambient RH)

VOC (C_2-C_{12}), O_3, CO

Partisol in $PM_{2.5}$ (EC, OC, WSOC)

Aethalometers in tandem ($PM_{2.5}$ & $PM_{0.25}$)

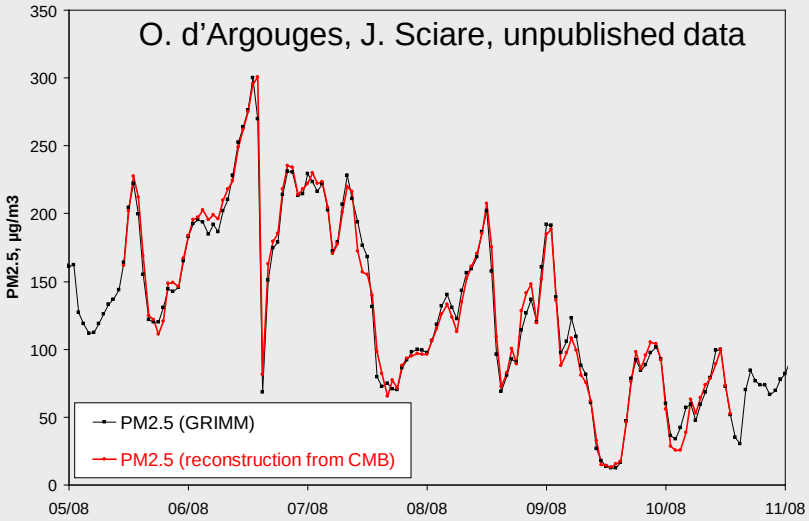
Aethalometer

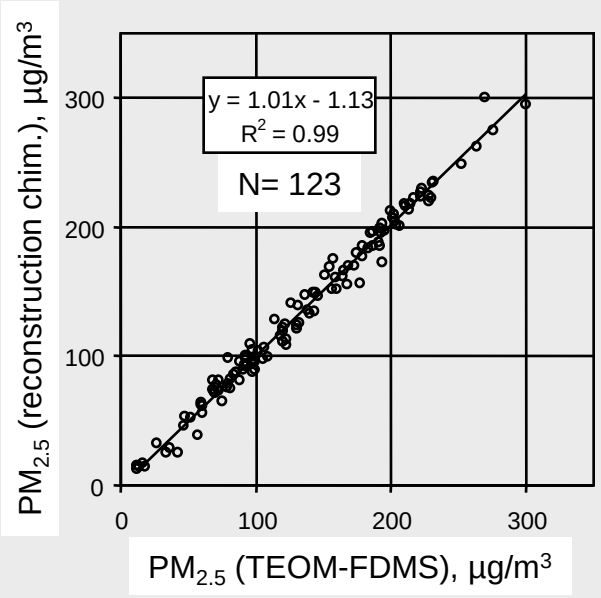
$PM_{2.5}$ (CMB) = [$(NH_4)_2SO_4$] + [$(NH_4)NO_3$] + [$(NH_4)Cl$] + [dust] + [sea salt] + **[EC]** + [POM] *

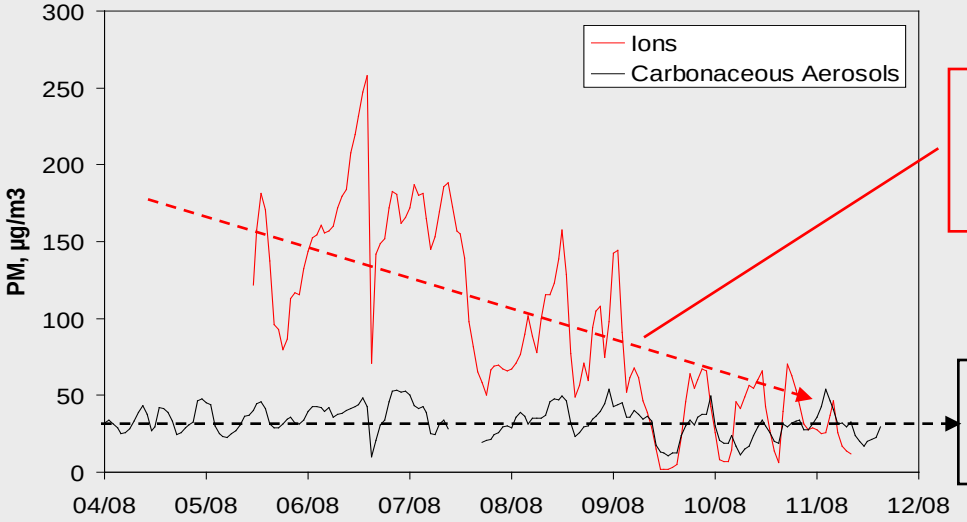
* [POM] = 1.8 x [OC]

PILS-IC

EC-OC
Sunset Field Inst.





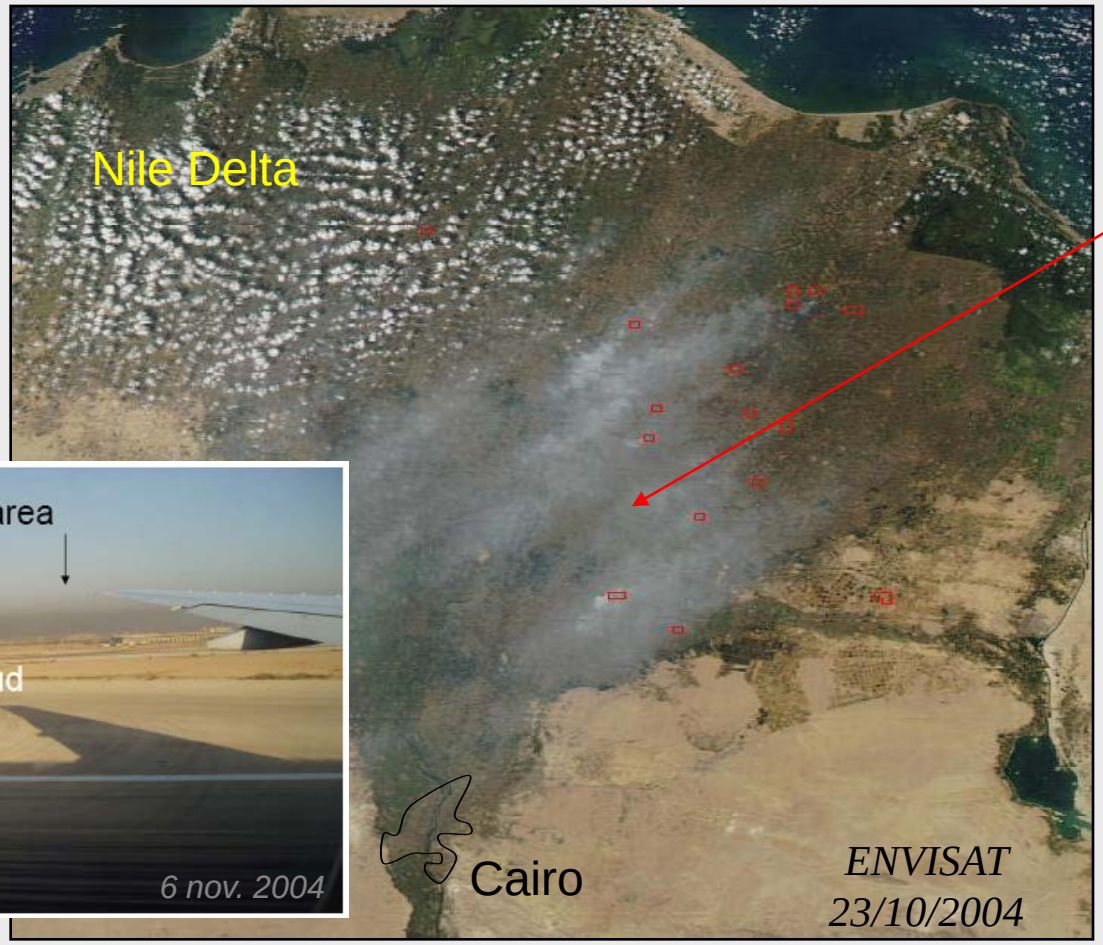


Drop of ions
(Ammonium sulfate, Ammonium nitrate)
= regional input

Stable carbonaceous emissions
= traffic (urban input)

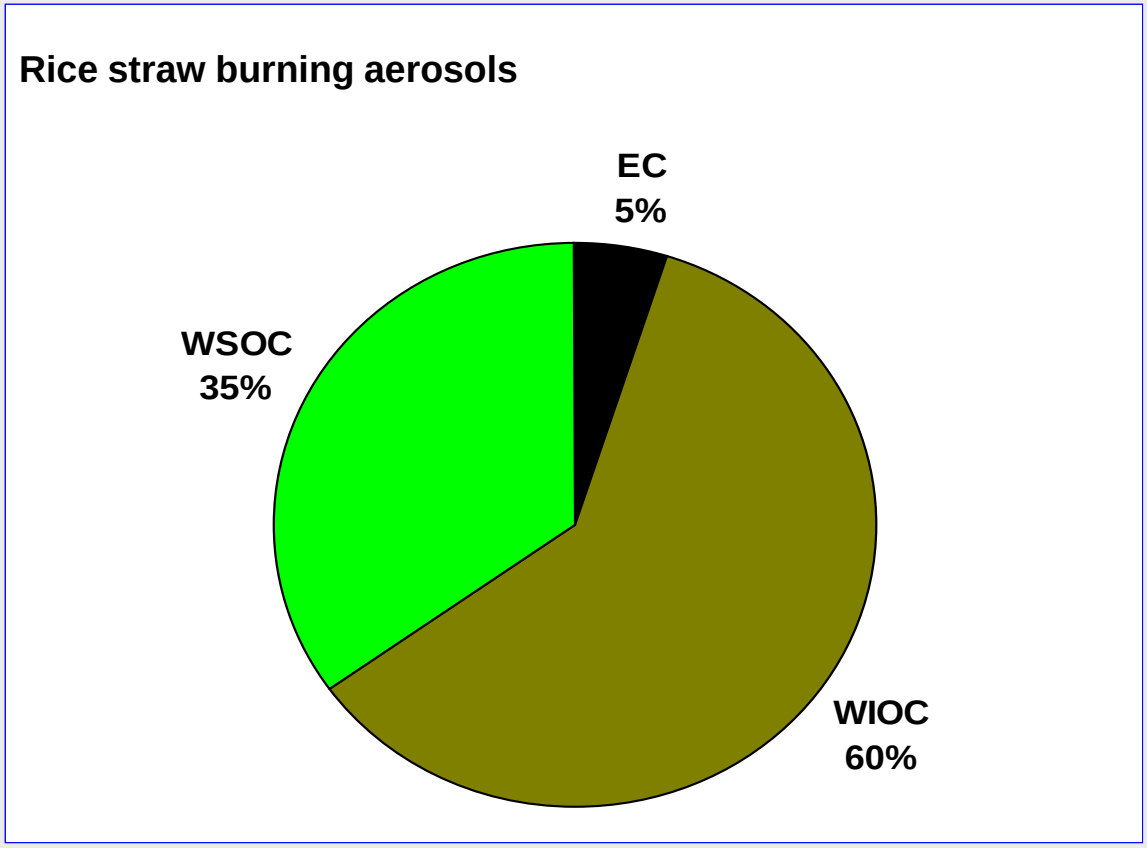
CAIRO Field Experiments

Cairo November 2004 (« black cloud season »): tracking biomass burning aerosols



On-field rice straw burning plumes

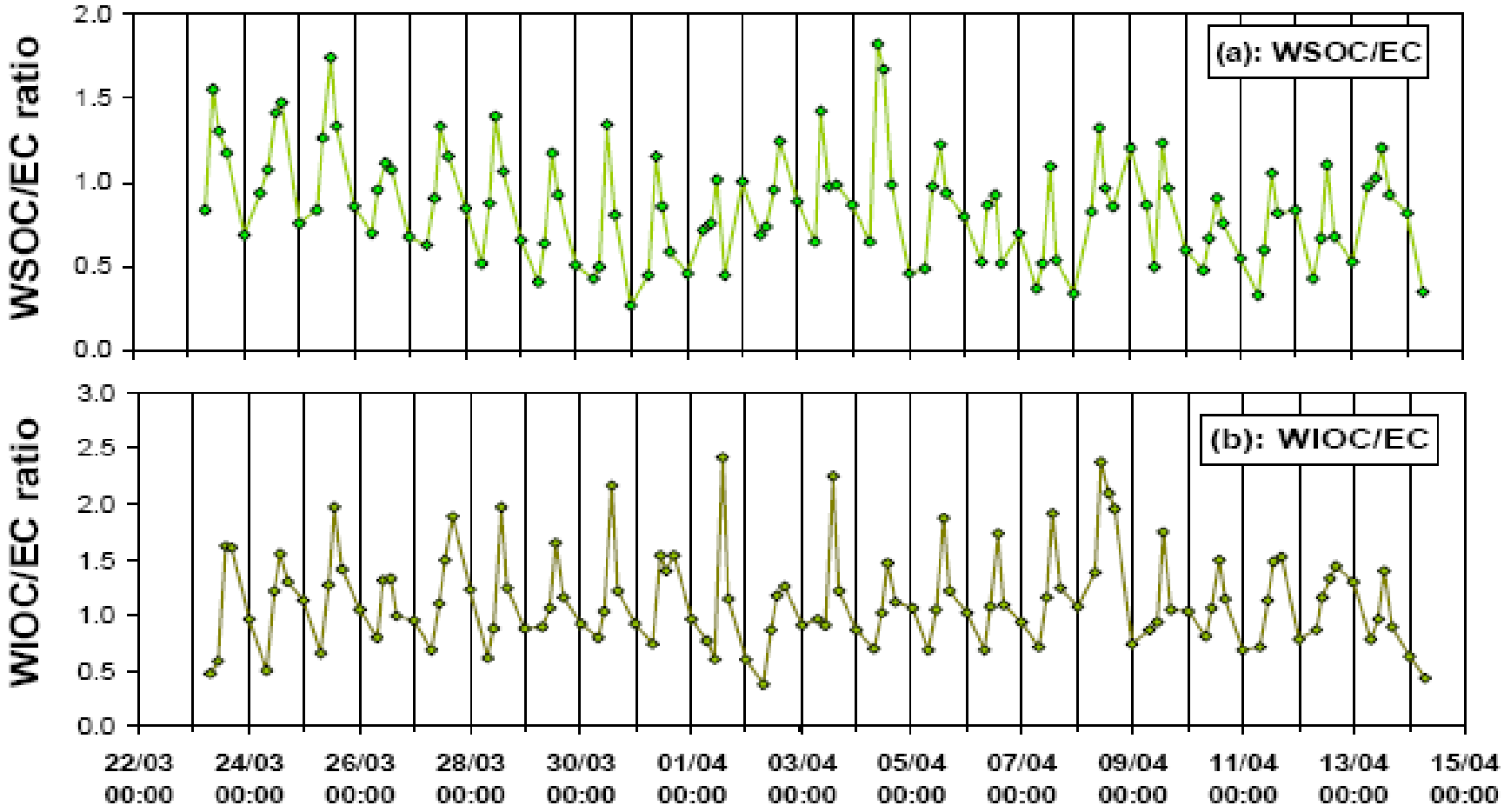
« Cairo Black Cloud »



- Poor EC content
- Biomass burning aerosols enriched in both soluble AND insoluble OM

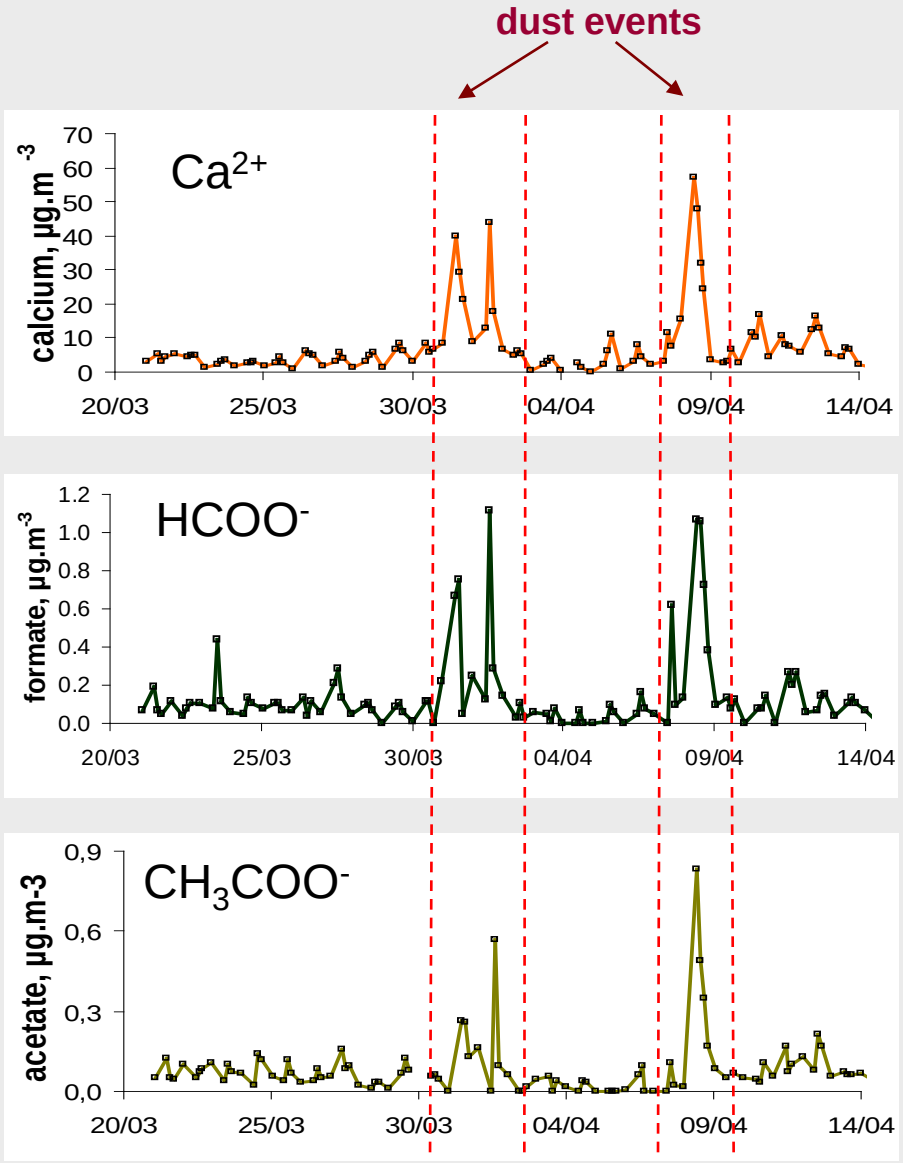
Evidence of « fresh » SOA formation

Cairo fine aerosol WSOC/EC & WIOC/EC ratio diurnal evolution



SOA in Cairo contain WSOC and WSIOC in comparable amounts

SOA formation onto dust particles: Cairo spring 2005



Concluding Remarks

The chemical mass closure allows source discrimination and/or the identification of some gas-to particle interactions when particles are size discriminated at least in fine and coarse aerosols. Biomass burning is found of major importance in many urban areas (even in Beijing)

For all cities and for somewhat different reasons, carbonaceous particles form the major and often overwhelming fraction of the fine aerosols.

In the coarse aerosol fractions, organic carbon is present presumably as both primary and secondary particles. The latter are assessed to originate primarily from gas-particle interactions of acidic organic gases with dust particles, creating a significant anthropogenic fraction in the coarse mode.

Both fine and coarse particles show variable amounts of water soluble organic carbon (WSOC) which is shown to depend on different factors such as the source type, the importance of secondary aerosol formation and the aerosol matrix. Interestingly in Cairo SOA were found to contain large amounts of WIOC*

* Favez, O., J. Sciare, H. Cachier, S.C. Alfaro, M.M. Abdelwahab, Significant formation of water-insoluble secondary organic aerosols in semi-arid urban environment, Geophys. Res. Lett., in press, **2008**

The END!!!!