

CARBO TRAF

EUROPEAN FP7 PROJECT

Development of a
Decision Support System for Reducing
Black Carbon & CO₂ Emissions
by Adaptive Traffic Management

Jim Mills
Air Monitors Ltd



Road Traffic & Air Pollution



- Road traffic is the single largest source of urban air pollution
- Most UK AQMA's are declared due to traffic pollution
- Traffic exhaust contains NO, NO₂, CO, **CO₂**, VOC's and particulates (mainly **black carbon** aka **soot**)
- Reducing **CO₂** can only be achieved by
 - Using less fuel
 - Driving less
- Reducing **soot** can be achieved by
 - improved combustion
 - particle filters
 - driving style
 - traffic management

SOOT, CO2 & Climate Change



CO2

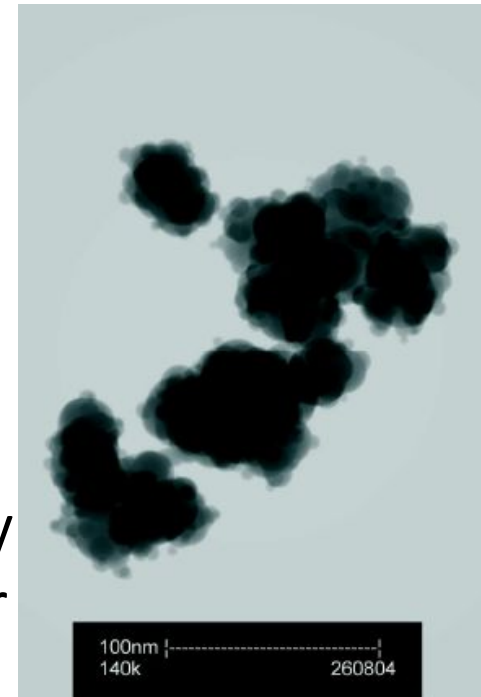
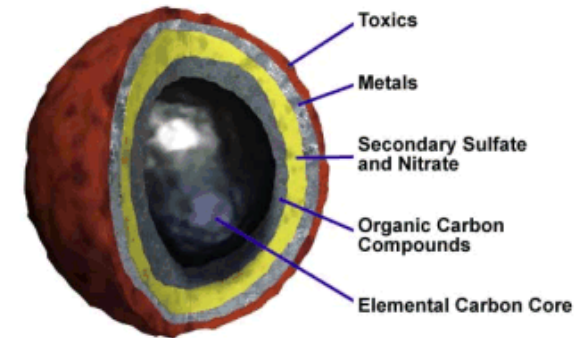
- CO2 is #1 driver of climate change
- CO2 stays in the atmosphere for many years / decades
- CO2 is slowly absorbed by trees, the ocean etc
- Action taken now will take many years to have beneficial effect

SOOT

- Soot is #2 driver of climate change
- Soot stays in the atmosphere for a few weeks
- Soot falls on snow causing it to melt much faster
- Action taken now will deliver benefit next month

Black Carbon (SOOT)

- **Soot** is a general term that refers to impure carbon particles resulting from the incomplete combustion of a hydrocarbon.
- **Soot** is the product of gas-phase combustion processes and includes the residual fuel particles that may become airborne during pyrolysis.
- **Airborne soot** can contain polycyclic aromatic hydrocarbons (PAHs) known mutagens which are classified as a "known human carcinogen" by the International Agency for Research on Cancer (IARC).



Current PM Standards



- PM10 & PM2.5 **Mass Concentration Standards**

- × Treat all components of PM equally
- × Do not distinguish between anthropogenic & natural sources
- × Ultra fines are almost undetected

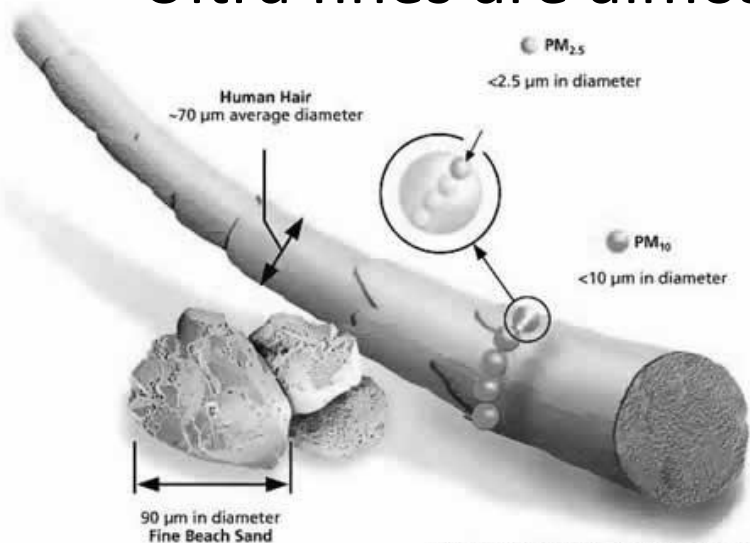


Image courtesy of EPA, Office of Research and Development

Size	Mass
PM 10	1
PM 2.5	0.025
PM 1	0.001
PM 0.1	0.000001

PARTICULATE POLLUTION HAS NOT GONE AWAY

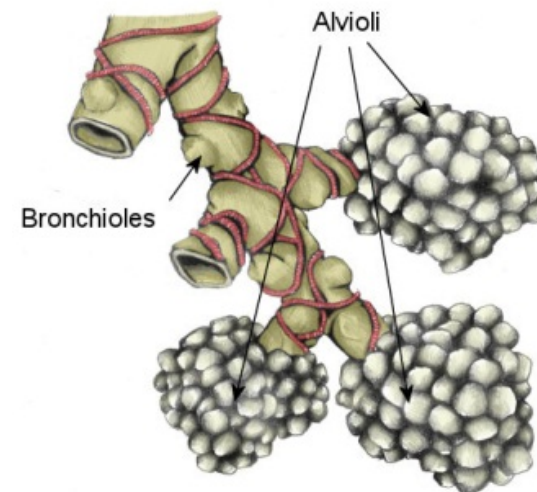


IT'S JUST BECOME INVISIBLE

Soot, CO2 & Health



- Soot particles are very small and can enter the deepest parts of the lungs and smallest of these can pass through the alveoli and into the blood
- Soot particles often contain PAH's and Dioxins which are carcinogenic
- Recent studies showed soot concentration is 3-4 times higher for cyclists than pedestrians on the same road in London (Grigg et al)



Black Carbon as an Additional Indicator of the Adverse Health Effects of Airborne Particles Compared with PM₁₀ and PM_{2.5}

Nicole A.H. Janssen¹, Gerard Hoek², Milena Simic-Lawson³, Paul Fischer¹, Leendert van Bree⁴, Harry ten Brink⁵, Menno Keuken⁶, Richard W. Atkinson³, H. Ross Anderson⁷, Bert Brunekreef^{2,8}, Flemming R. Cassee¹ nicole.janssen@rivm.nl

Background: Current air quality standards for particulate matter (PM) use the PM mass concentration [PM with aerodynamic diameters $\leq 10 \mu\text{m}$ (PM₁₀) or $\leq 2.5 \mu\text{m}$ (PM_{2.5})] as a metric. It has been suggested that particles from combustion sources are more relevant to human health than are particles from other sources, but the impact of policies directed at reducing PM from combustion processes is usually relatively small when effects are estimated for a reduction in the total mass concentration.

Results: Estimated health effects of a $1\text{-}\mu\text{g}/\text{m}^3$ increase in exposure were greater for BCP than for PM₁₀ or PM_{2.5}, but estimated effects of an interquartile range increase were similar. Two-pollutant models in time-series studies suggested that the effect of BCP was more robust than the effect of PM mass. The estimated increase in life expectancy associated with a hypothetical traffic abatement measure was **four to nine times higher when expressed in BCP** compared with an equivalent change in PM_{2.5} mass.

Conclusion: **BCP is a valuable additional air quality indicator to evaluate the health risks of air quality dominated by primary combustion particles.**

Soot & PM from Traffic

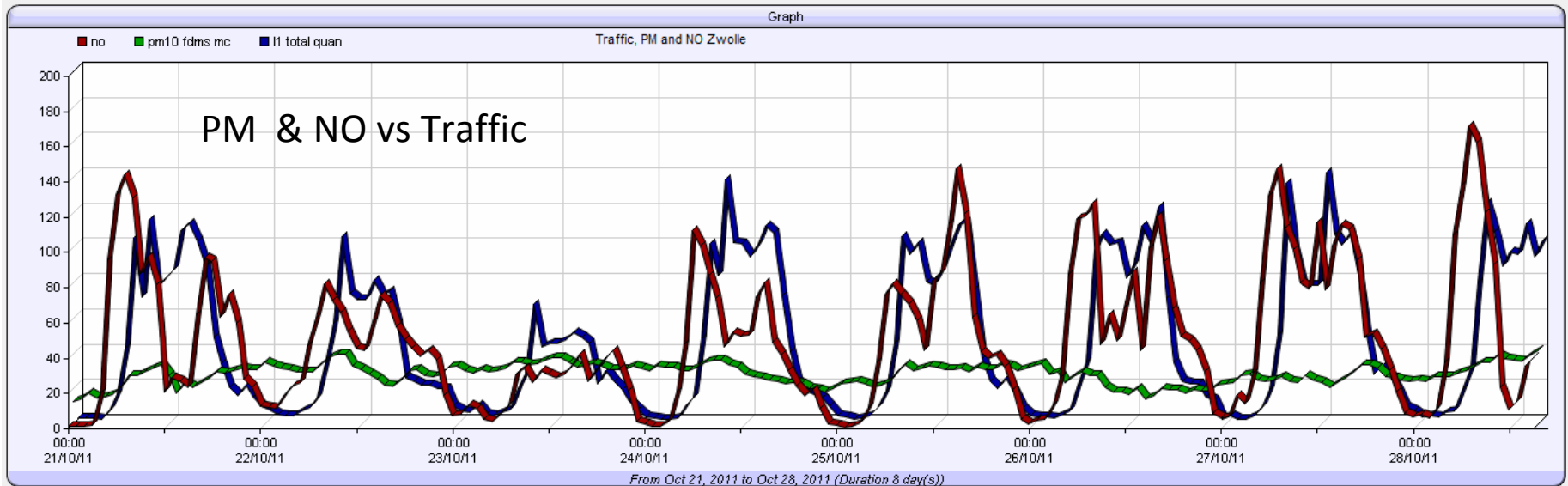
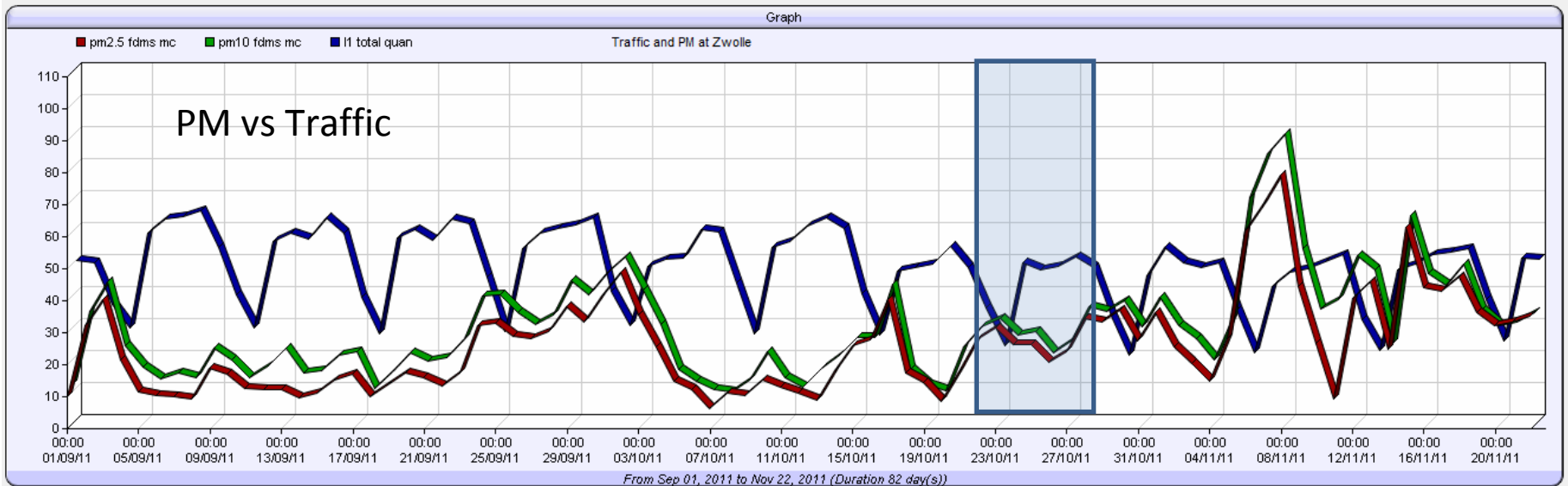


- PM mass **DOES NOT** correlate well with traffic volume
 - Most PM mass monitored is NOT locally emitted
 - Some PM is secondary (formed in the air)
 - Some PM is semi volatile (e.g. NH_3NO_4)
 - PM Mass is difficult to monitor
- Soot **DOES** correlate well with traffic
 - Soot emissions vary with stop/start cycles
 - Soot emissions are an indication of poor maintenance
 - Soot is readily measured due to its blackness
 - PAH's & Dioxins can also be detected using *Aethalometry



* Aethalometers measure particle absorption at different wavelengths

Traffic & PM



PM and Soot vs Traffic Volume

Black Carbon Instead of Particle Mass Concentration as an Indicator for the Traffic Related Particles in the Brussels Capital Region

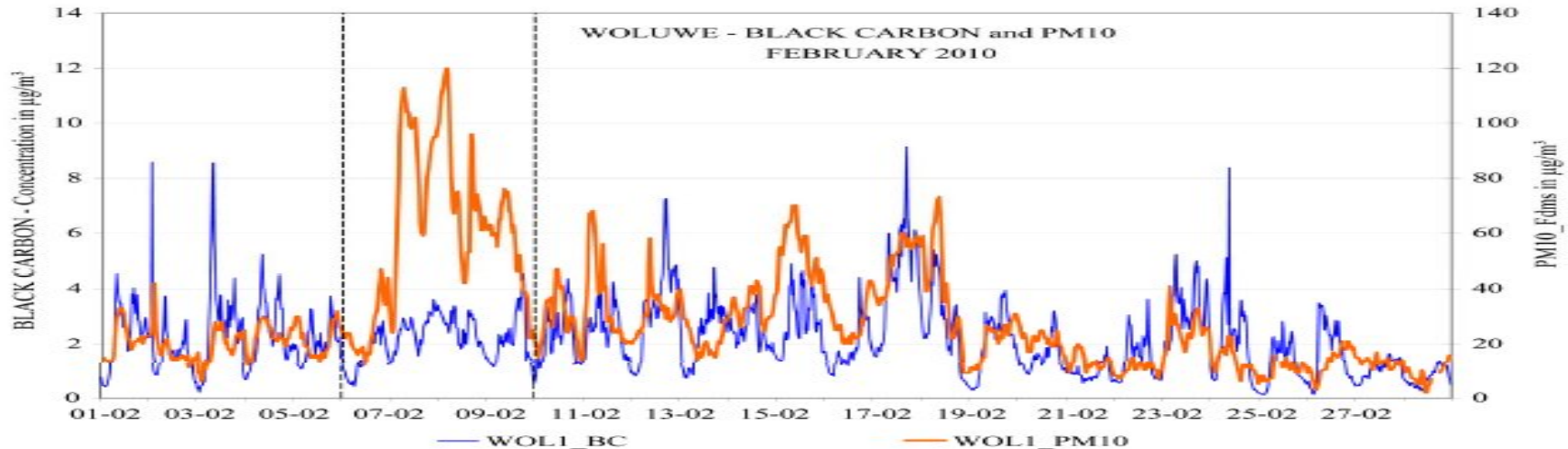
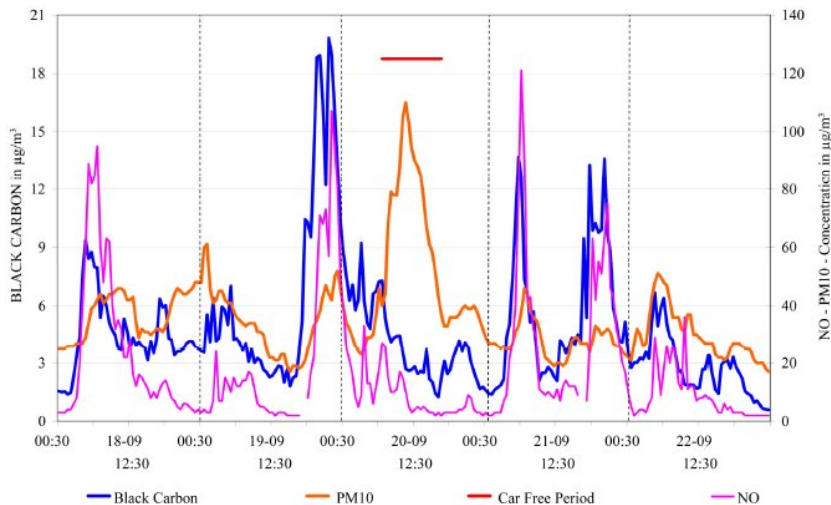


Figure 4. Black Carbon and PM10—Woluwe site—February 2010, Evolution half hourly concentration values.



Black Carbon Instead of Particle Mass Concentration as an Indicator for the Traffic Related Particles in the Brussels Capital Region

Peter Vandecasteele¹, Michiel Fierens¹, Olivier Braem¹, Zsolt Olt²

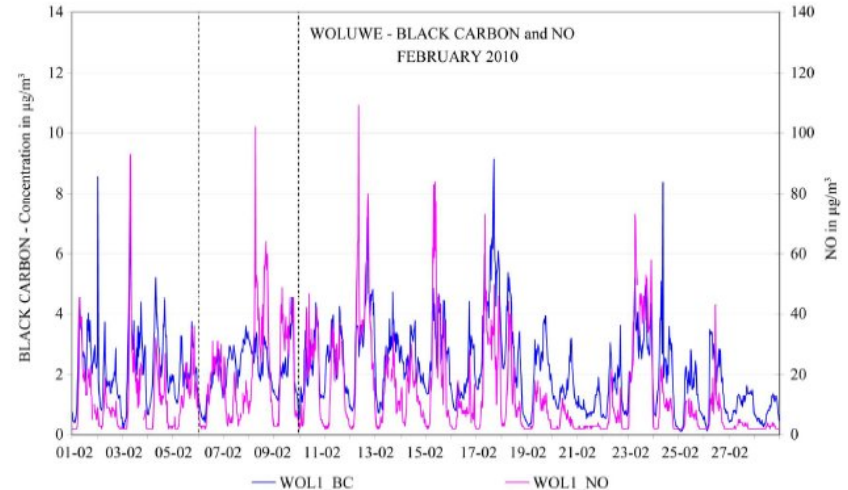
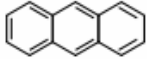
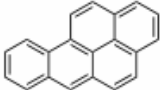
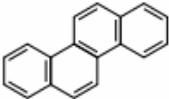


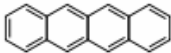

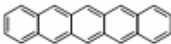
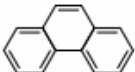
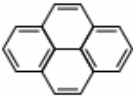
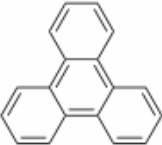
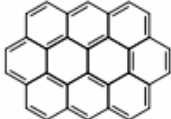


Figure 5. Black Carbon and NO—Woluwe site—February 2010, Evolution half hourly concentration values.

Soot & PAH's

Chemical compound		Chemical compound	
Anthracene		Benzo[a]pyrene	
Chrysene		Coronene	
Corannulene		Tetracene	
Naphthalene		Pentacene	
Phenanthrene		Pyrene	
Triphenylene		Ovalene	

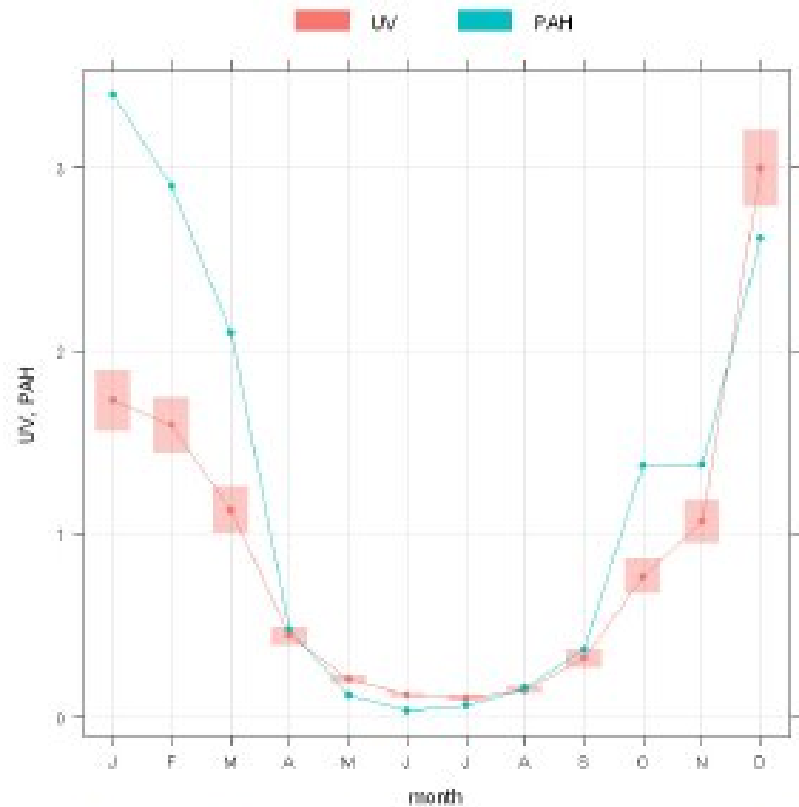


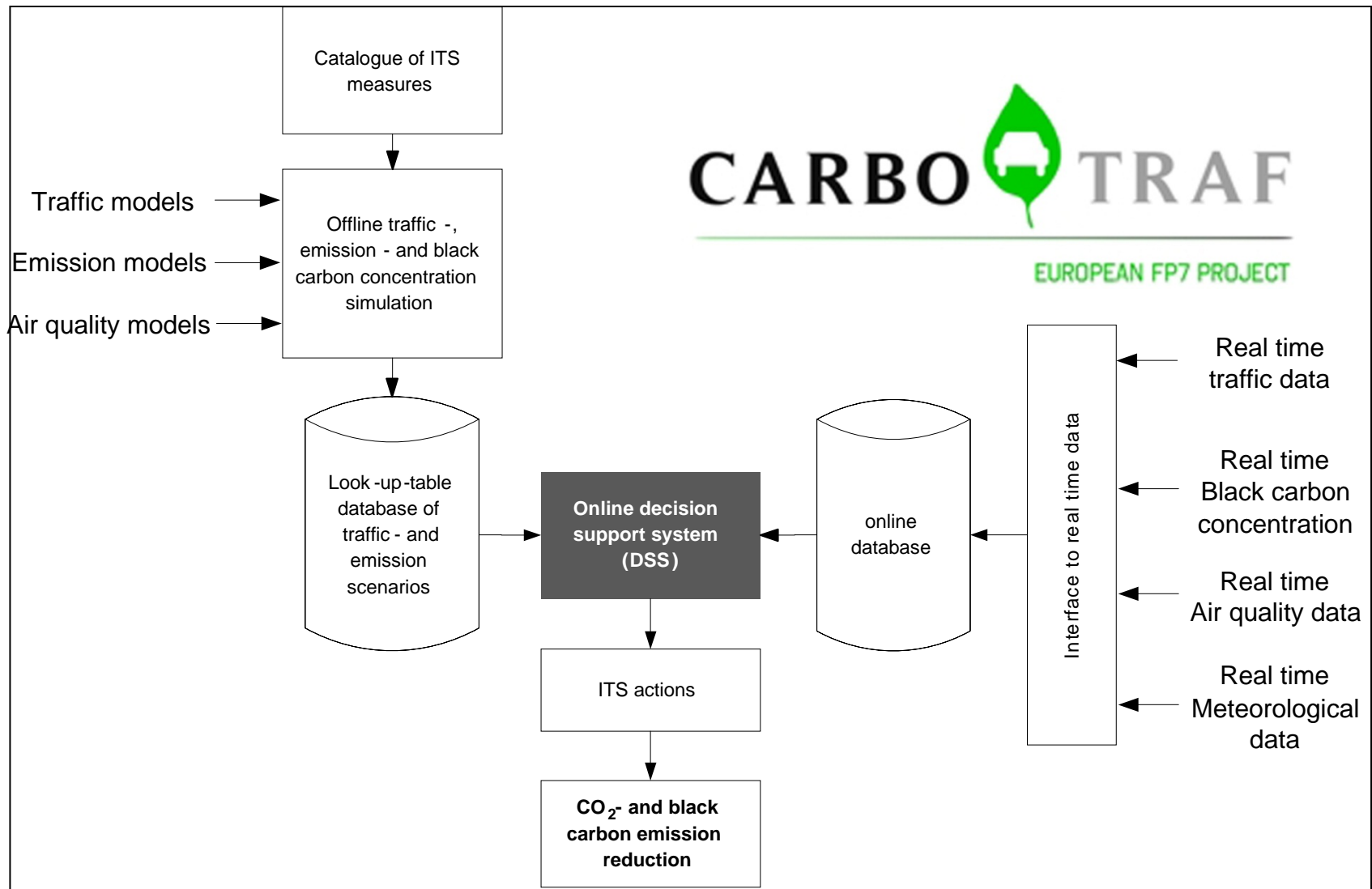
Figure 24 Benzo[a]pyrene and UV component concentrations measured at Dunmurry in 2010

Reducing Soot Emissions



- **Soot** emissions from road traffic can be substantially reduced by avoiding start/stop driving
- **Intelligent Traffic Systems (ITS)** informed by real time monitoring of soot & traffic flow can keep traffic flowing and reduce emissions
- **CARBOTRAF** aims to use monitoring and modelling of traffic & emissions to build a decision support system

CARBOTRAF Concept



CARBOTRAF Partners

Research



Imperial College
London

Industry



City of Glasgow



City of Graz



Traffic

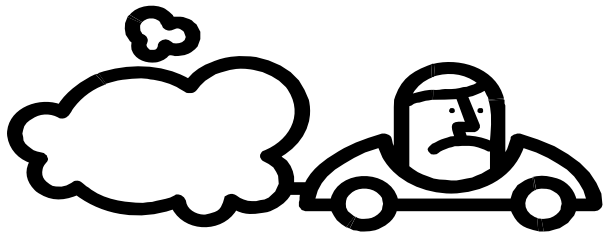
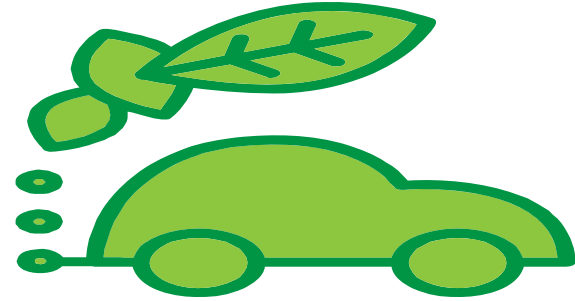
CO₂ / BC / Environment

Aims & Objectives



- **Create a proven concept involving sensors & control technologies for CO₂ and BC emissions reduction for urban traffic**
- **Investigate BC emission factors to integrate with traffic and air quality models**
- **Refine an optical traffic data sensor for sensing emission relevant traffic parameters**
- **Create a decision support system and tools with a catalogue of traffic scenarios to support traffic control centres towards adaptive traffic management aimed at emission reduction**
- **Use the test sites in Glasgow & Graz in order to evaluate the results independently**
- **Provide a handbook with recommendations for emission reduction strategies**

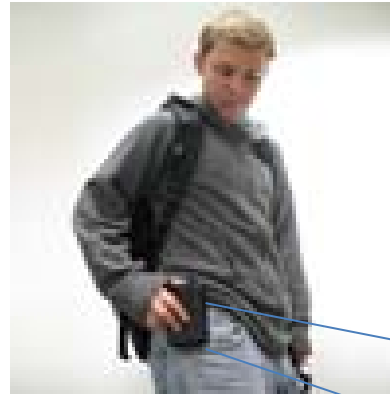
Stop / Start = Higher Emissions



Monitoring Soot



NETWORK CONTINUOUS MONITORS



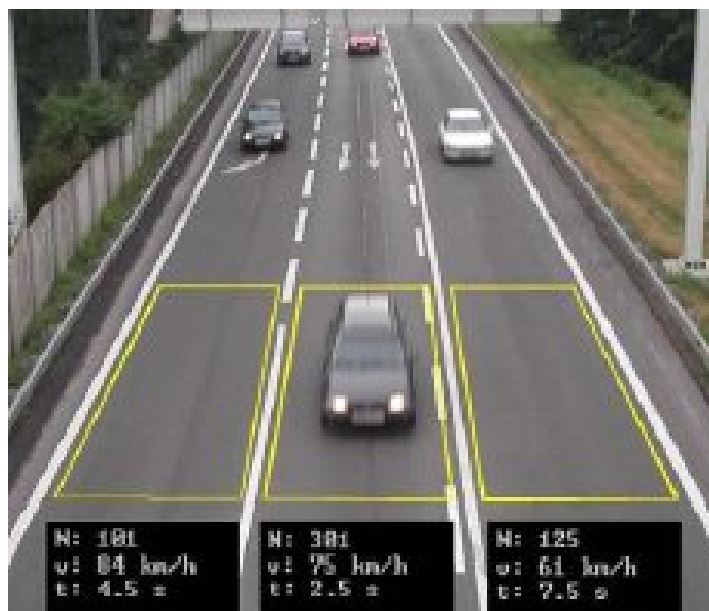
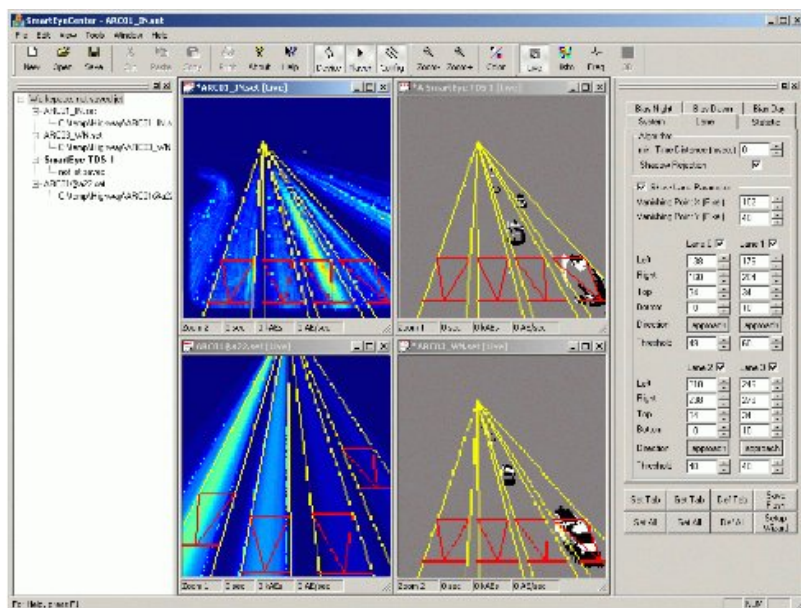
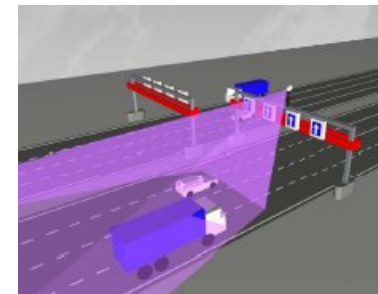
PERSONAL MONITOR



LABORATORY MONITOR



Monitoring Traffic



Supplementary Monitoring

- **Existing** City Monitoring Sites
- **Nano Particle** Counters
- **CO2** Sensors
- **DUVAS** (Fast Response Portable Multi Gas Monitor)



Conclusions



- **SOOT** is bad for our health & the climate
- **SOOT** emissions can be reduced without damaging the economy
- **SOOT** is a better indicator of traffic pollution than PM_x
- **SOOT** is a defined pollutant (Carbon)
- **SOOT** is easy to measure (and therefore control)
- **SOOT** reductions have an immediate positive effect on climate change

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GET YOUR SOOT 'BUG' AT AIR MONITORS BOOTH

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