Evaluation of a Decision Support System for Reducing CO2 and Black Carbon Emissions by Adaptive Traffic Management (CARBOTRAF): Analysis of Real Time Data

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Introduction

Traffic congestion with frequent "stop & go" situations causes substantial CO_2 and black carbon (BC) emissions. Current traffic control systems are designed to improve traffic flow and reduce congestion.

The CARBOTRAF system is a DSS (Decision Support system) for traffic optimization. The system combines real-time monitoring of traffic and air pollution with simulation models for emission and local air quality prediction in order to deliver on-line recommendations for alternative adaptive traffic management. The DSS will inform the traffic manager on alternative scenarios and the resulting impact of all alternatives options on CO_2 and BC emissions, and travel time and traffic density.

The aim of introducing a CARBOTRAF system is to reduce CO_2 and BC emissions and improve air quality by optimizing the traffic flows. The CARBOTRAF system will be developed and implemented within the framework of a FP7 (ICT for Transport) project (CARBOTRAF) and will be tested in the two pilot cities Graz and Glasgow.

Test sites

The test site in Graz comprises two main arterial roads linking the Mur valley to the north of the city with the inner city centre. ITS (Intelligent Traffic Systems) actions that are implemented are VMS and traffic light optimization. A VMS (Variable Message Sign) will inform drivers on the approach to the test site on current conditions and advise the drivers to take the alternative route in case of traffic problems on the other arterial road. Traffic light optimization will be implemented by selecting the most appropriate fixed time plan.

In order to evaluate the CARBOTRAF system in Graz, five additional traffic sensors are installed in the test site (Figure 1: B, D, E, F, G). Two BC monitors are installed at each of the arterial roads (AQ6, AQ7) and one additional monitor at the AQ monitoring station in the centre of the test site (Graz North). The later one is used as urban background station to take into account changing background concentrations due to changing meteo conditions.

Figure 1:

Test site Graz with traffic sensors installed (B, C, E, F, G) and BC monitors (AQ6, AQ7, AQ10/Graz Nord)

The test site in Glasgow is located in the West End of the city and is a known area of high pollution due to traffic. Local stakeholders expressed their preference to this area because it has congestion and pollution problems for many years. ITS actions that are implemented are VMS and traffic light optimization. VMS is used to reroute drivers away from congested area (Byres Road) where BC and CO_2 emissions are expected to be high and air quality can be improved by decreasing the amount of traffic and decrease the stop-and go. The VMS can display “Congestion in Byres Road take alternative routes”. Traffic light optimization using different time plans will be implemented at the junctions where traffic lights are currently running on fixed time and use BIAS, a technology that can implement adaptive traffic flow optimization. (on Byres Road at the crossings: Highburgh Road /University Ave and Church Street.)

To evaluate the CARBOTRAF system three traffic sensors are installed and an additional one is planned to be installed (near AQ B) in the test site (Figure 2:C, D, E). Two BC monitors are installed near the main roads in the test site (Figure 2: AQ A and AQ B). AQ A is dedicated to evaluate the impact of the CARBOTRAF system on local Air Quality. AQ B is used as reference station (non-affected site) and also for model evaluation.

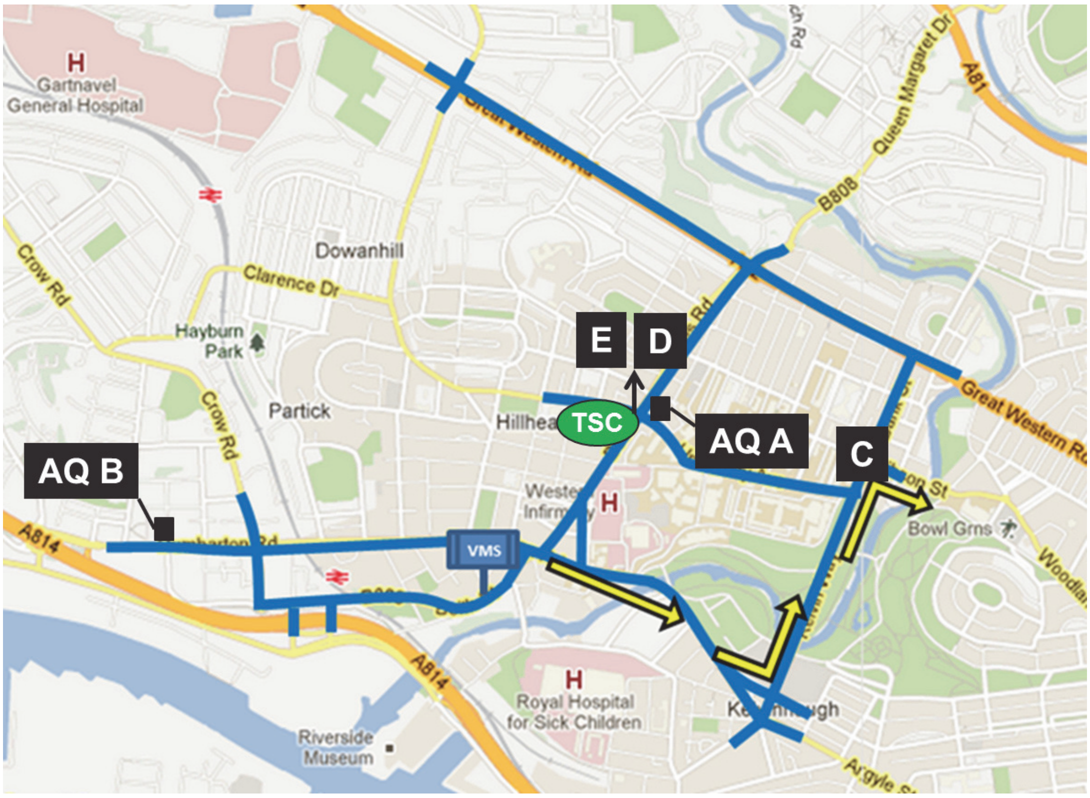

Figure 2: Test site Glasgow with implemented ITS action (VMS and TSC), BC monitors (AQ A and AQ B), traffic sensors (C, D, E)

Traffic sensors are TDS

BC is measured using an Aethalometer (type AE-42 for AQ10_Graz Nord and type AE22 for all other sites). The instrument measures BC concentrations in real time by measuring the rate of change in absorption of transmitted light due to continuous collection of aerosol deposit on a quartz fiber tape.

Smart eye cameras (TDS) measure traffic counts (as function of size: cars and trucks). In addition, acceleration distribution is measured. In this way, data can give insight in traffic dynamics.

Figure 3: Measurement devices installed in the test sites: AE22 (left) and TDS (right)

Evaluation approach

The evaluation has to demonstrate that project goals as well as specific stakeholders aspirations have been met. To follow up and evaluate the effects of the ITS actions a set of key performance indicators (KPIs) is defined. The full set of KPIs takes into account project objectives and specific stakeholders' aspirations.

Three types of KPI values will be used:

- KPI values simulated in the off line micro-simulations stored in the DSS (sKPI)

- KPI values calculated by the DSS through interpolation of the scenarios stored in the DSS (iKPI)

- KPI values measured during evaluation (mKPI): real time measured data

The evaluation is performed on three levels. Level 1 will evaluate if the DSS correctly predicts the outcome of specific ITS scenario's in terms of traffic, emissions and air quality. Level 2 will evaluate the impact of the specific ITS measures in terms of reduced emissions, traffic flow and air quality. Level 3 will evaluate the benefits of the entire system.. (e.g. taking into account the number of times that ITS actions are implemented.)

Results

This paper will further discuss the results of the reference data before the DSS is installed.

Figure 4 shows data from a recent week in Graz (7/8/14 – 14/8/14). BC concentrations at both arterial roads (in green (AQ6) and red (AQ7)) and Graz Nord (background location, in blue) are displayed. Vehicle numbers for Graz are displayed for locations near the BC monitors (green (location C close to AQ7) and red (location G, closed to AQ7)) and for an additional location at the western arterial (location B). Increased BC concentrations are measured at both roadside locations compared to Graz Nord and show a clearly daily pattern. This indicates that traffic results in a significant increase of BC concentrations. The BC pattern corresponds to vehicle numbers but also to the acceleration profiles observed (not shown). Higher concentrations are measured at the West arterial. This is a more build environment and therefore, similar traffic emissions can result in higher concentrations near the road. This relation between meteorological conditions will be further investigated.

Figure 5 shows the correlation for BC measured at the street locations (AQ7 and AQ6) compared to the urban background location (Graz Nord). The good correlation indicates that the concentrtaions measuerd at the traffic sites are also influence by background concentrations. traffic shows that the concentrations are

All stations show lower average concentration during weekends compared to weekdays. This is due to reduced tyraffic during the weekends.

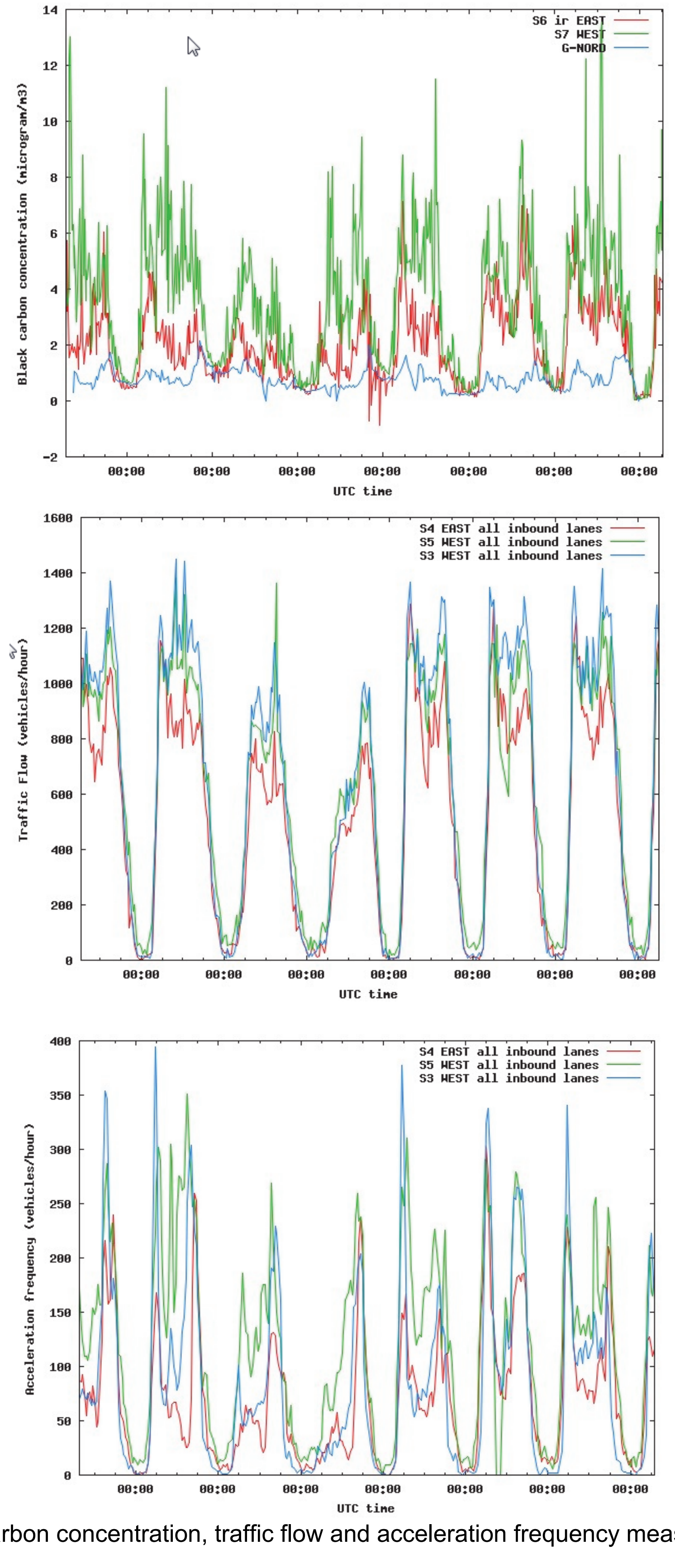

Figure 4: Black carbon concentration, traffic flow and acceleration frequency measured in Graz

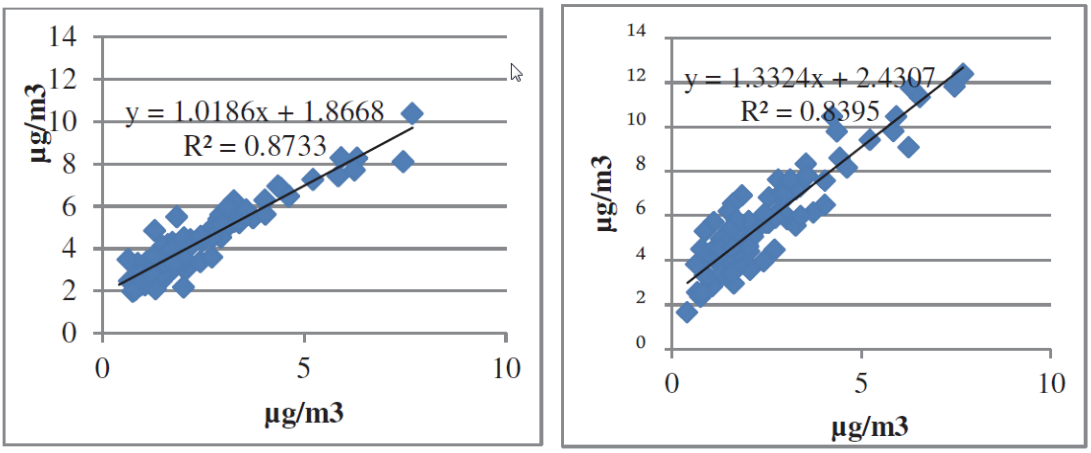

Figure 5: Correlation of BC at AQ6 versus AQGraz Nord (left) and BC at AQ7 versus AQ Graz Nord (right)

Figure 6 shows black carbon concentrations (in black) and PM_{10} concentrations (in orange) measured at Byres road (AQ A). BC showsmostly a clearly daily pattern whereas PM_{10} does not.

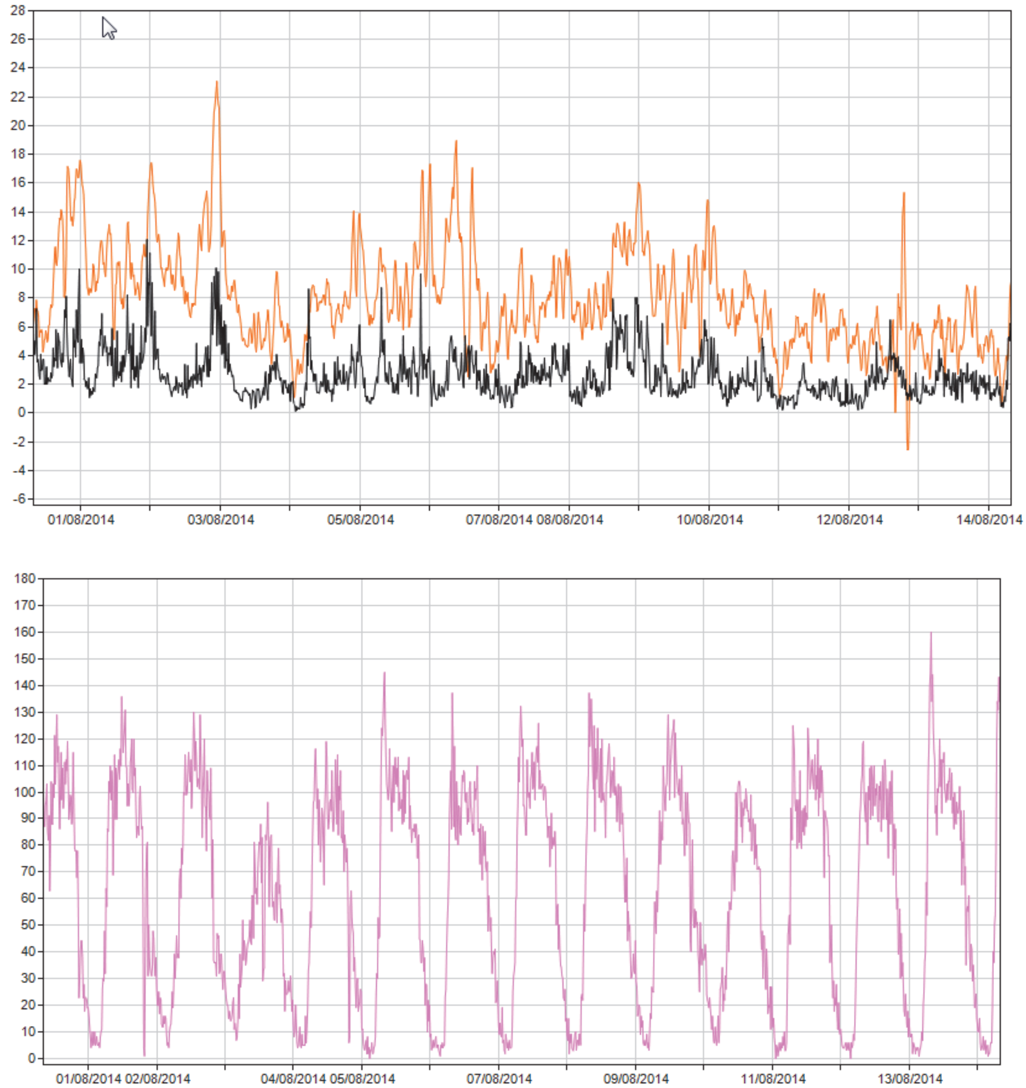

Figure 6: BC and PM_{10} concentrations in µg/m^3 (top) and total traffic counts (below) in #/15 minutes, measured at Byres Road in Glasgow

Conclusions and future work

First analysis showed that traffic strongly affects local BC concentrations close to the road. Not only traffic counts, are important but also traffic dynamics have a significant effect on Air quality. In addition data show that BC concentration is a better indicator for traffic pollution, compared to PM (particulate Matter). The poster will further present detailed analysis of analysis of the reference period.

The CARBOTRAF system was installed in Graz in the first half of August 2014 and is expected to be fully operational beginning of September. The evaluation period will run until end of February. Data from the reference period will be compared to the test period using real time data to evaluate the effect of the system on traffic and air quality.

More information on the project can be found on the CARBOTRAF website http://carbotraf.eu/ .

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