



CARBOTRAF:

**DSS for reducing pollutant
emissions by adaptive traffic**

management

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Project Aims & Objectives

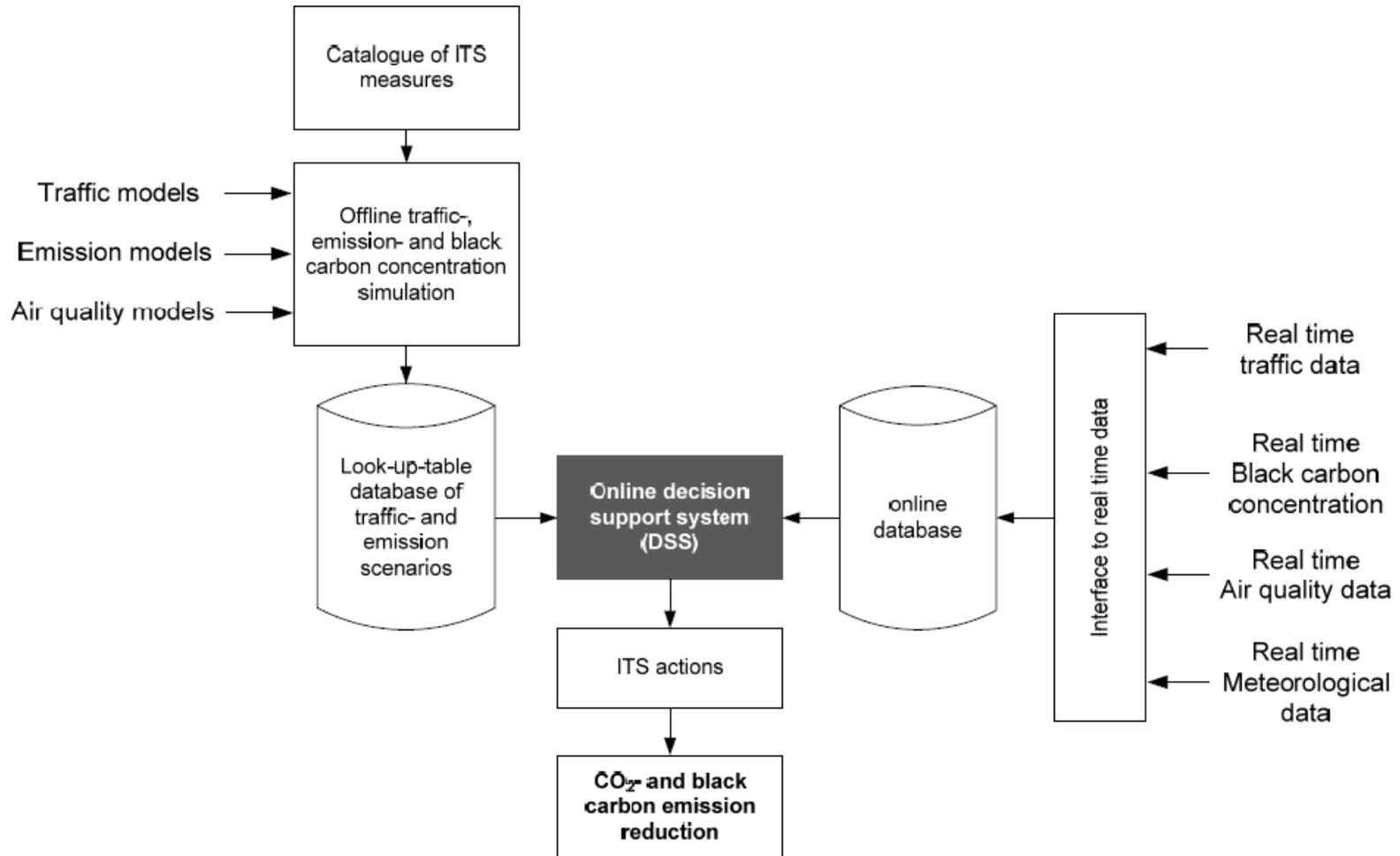
- » development of a **decision support system** (DSS) for adaptively influencing traffic in real-time to reduce **black carbon** (BC) and **carbon dioxide** (CO₂) emissions caused by road transport in urban areas
- » Create a proven concept
- » Integrate emission and air quality models
- » Evaluate results in test cities
- » Handbook with recommendations for pollutant emission and concentration reduction strategies



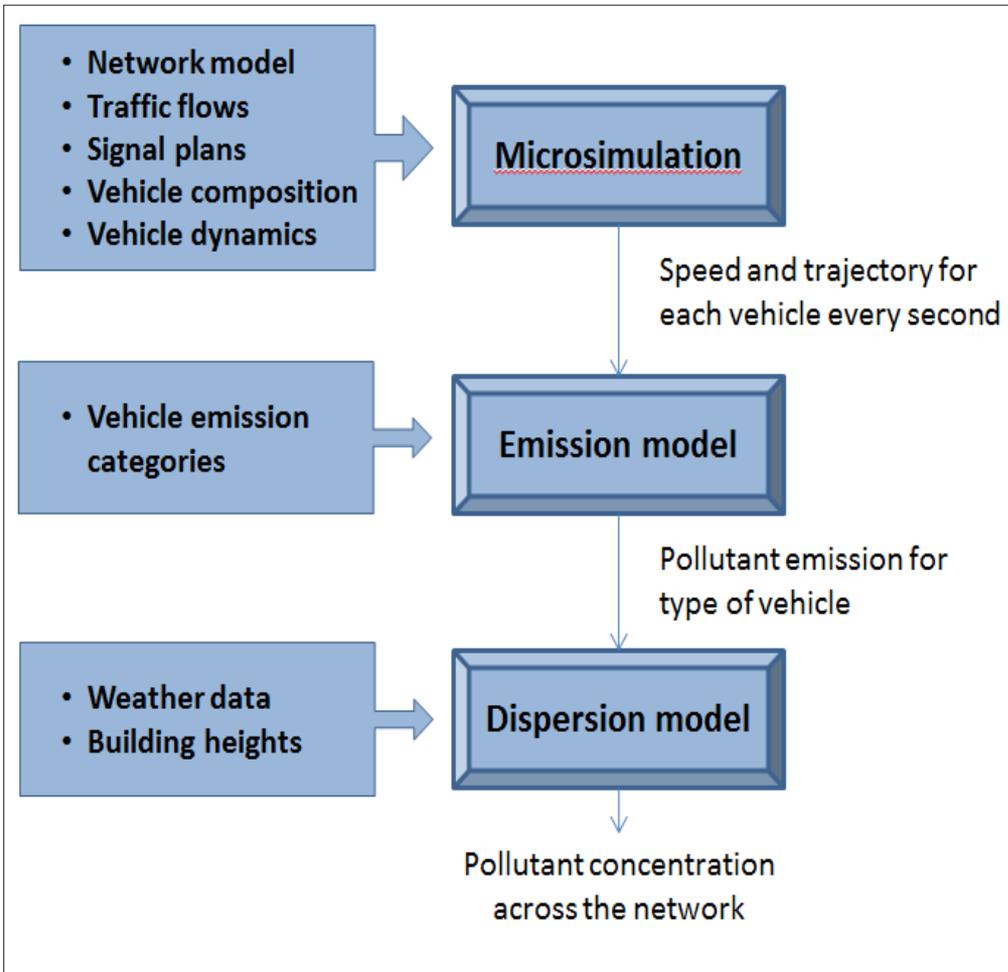
<http://carbotraf.com/>



Concept



Methodology



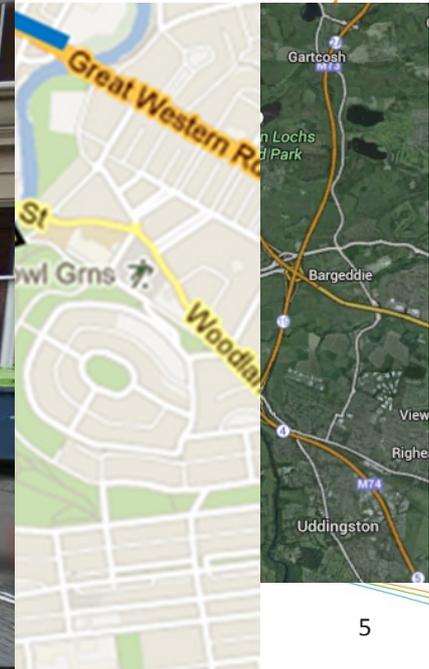
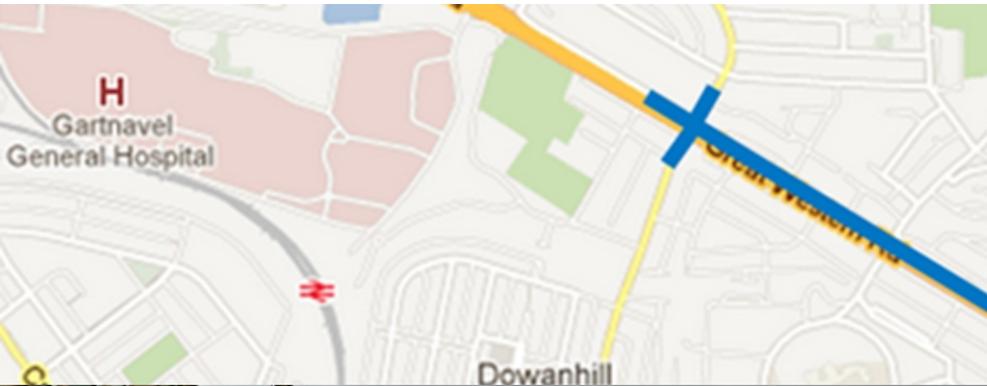
S-Paramics (Glasgow)
VISSIM (Graz)

AIRE + COPERT IV

Dispersion model: IFDM
Street canyon module: OSPM



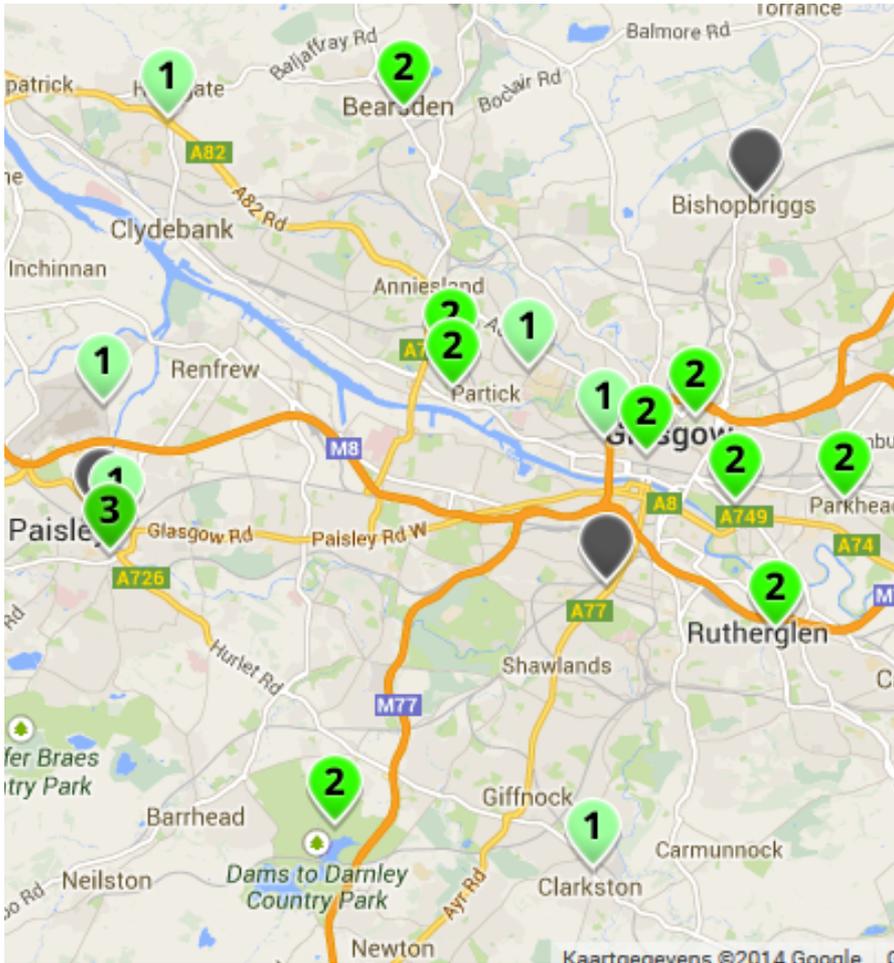
Test site Glasgow



Test site Graz



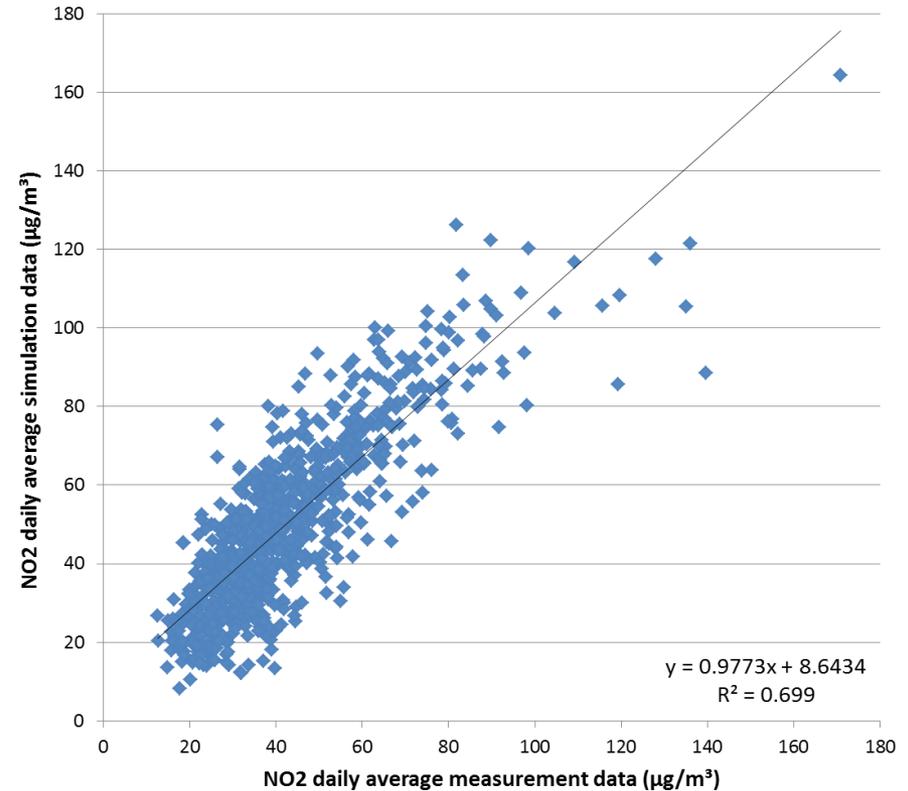
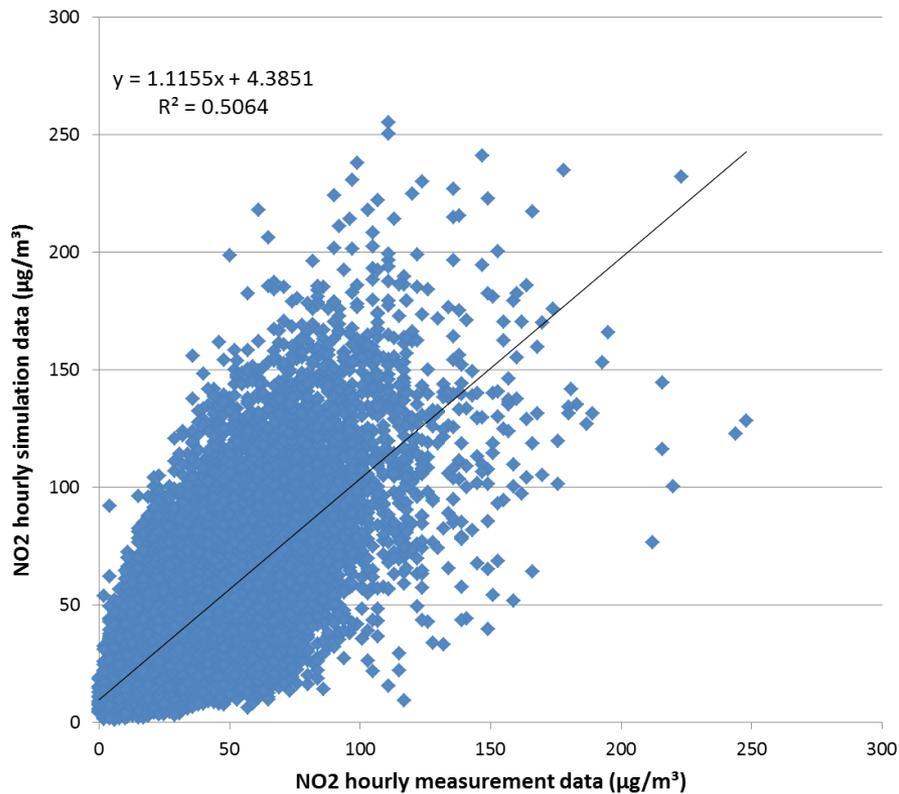
Validation Glasgow



- 1) background concentration from stations around Glasgow, determined based upon wind direction
- 2) Meteorology: Glasgow Airport
- 3) Traffic emission data: Glasgow base scenario received from Imperial, NOX-split of 0.20
- 4) Non-traffic emissions: National Atmospheric Emission Inventory (NAEI) of the UK (1x1 km²)
- 5) Grid: a receptor grid has been determined with increased resolution close to traffic sources
- 6) Time profiles from traffic data

NO2 temporal validation

	Byres Road	Anderston
BIAS	18%	33%
RMSE	34%	59%
R2	0.70	0.56



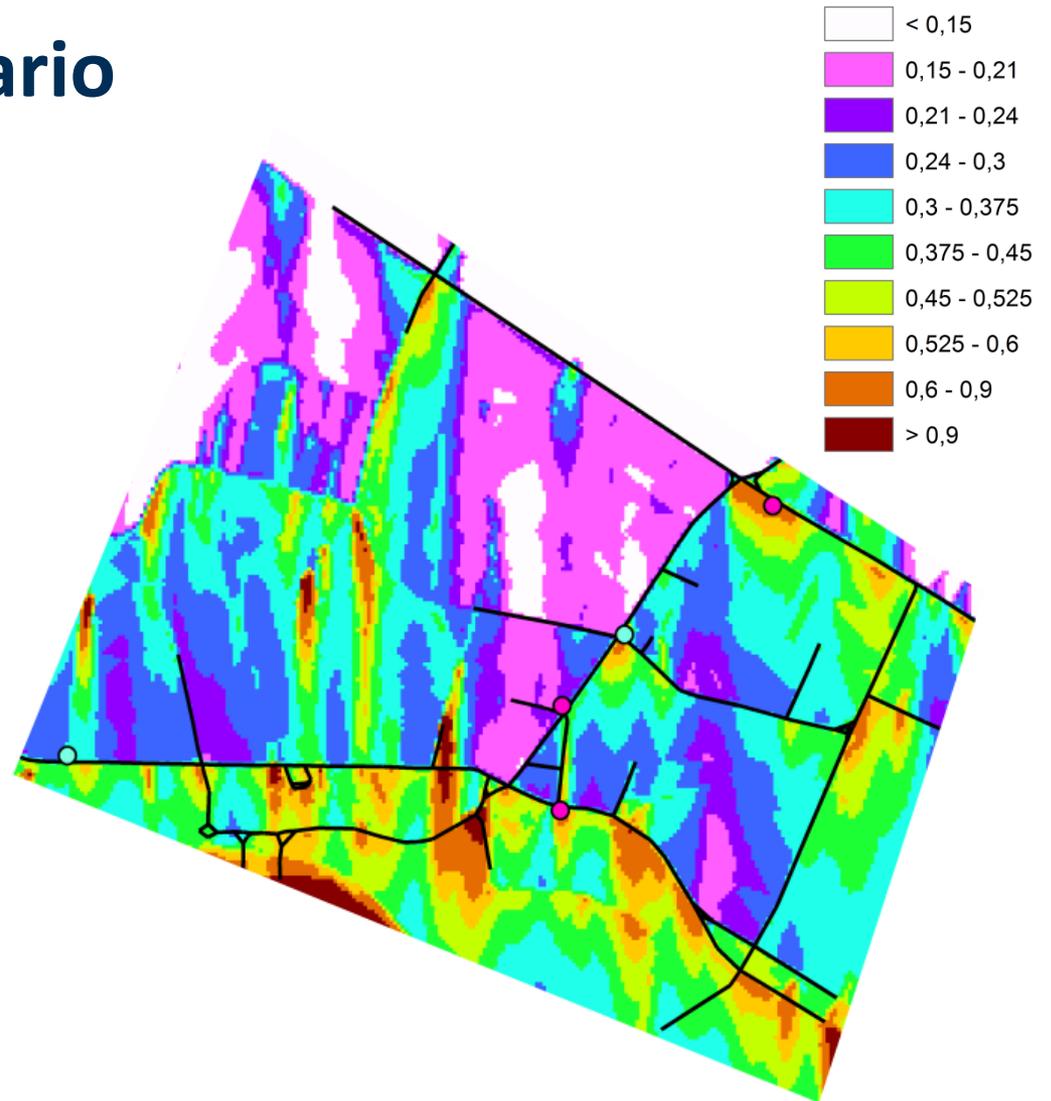
measuring station Byres Road (2009 – 2011)

Glasgow Total BC Emissions (g/h)

Difference between base and traffic scenarios											
Boundary conditions											
Scenario	Base	TS1	TS2	VMS10	VMS20	VMS30	TS3	TS3_VMS10	TS3_VMS20	TS3_VMS30	
1	155.3	156.7	148.0	154.8	154.4	153.4	153.9	152.8	150.5	150.4	
2	152.9	152.7	148.2	155.3	153.5	154.7	151.3	154.2	153.2	151.1	
3	151.8	153.2	150.2	152.3	151.9	152.3	151.3	147.5	150.8	148.8	
4	163.2	166.7	161.0	164.7	165.2	167.1	165.0	162.6	162.2	164.5	
5	154.8	153.9	154.0	154.8	156.7	156.7	156.5	153.0	154.3	152.7	
average	155.6	156.6	152.3	156.4	156.3	156.8	155.6	154.0	154.2	153.5	
Boundary conditions											
Scenario	Base	TS1	TS2	VMS10	VMS20	VMS30	TS3	TS3_VMS10	TS3_VMS20	TS3_VMS30	
1	100%	101%	95%	100%	99%	99%	99%	98%	97%	97%	
2	100%	100%	97%	102%	100%	101%	99%	101%	100%	99%	
3	100%	101%	99%	100%	100%	100%	100%	97%	99%	98%	
4	100%	102%	99%	101%	101%	102%	101%	100%	99%	101%	
5	100%	99%	99%	100%	101%	101%	101%	99%	100%	99%	
average	100%	101%	98%	101%	100%	101%	100%	99%	99%	99%	

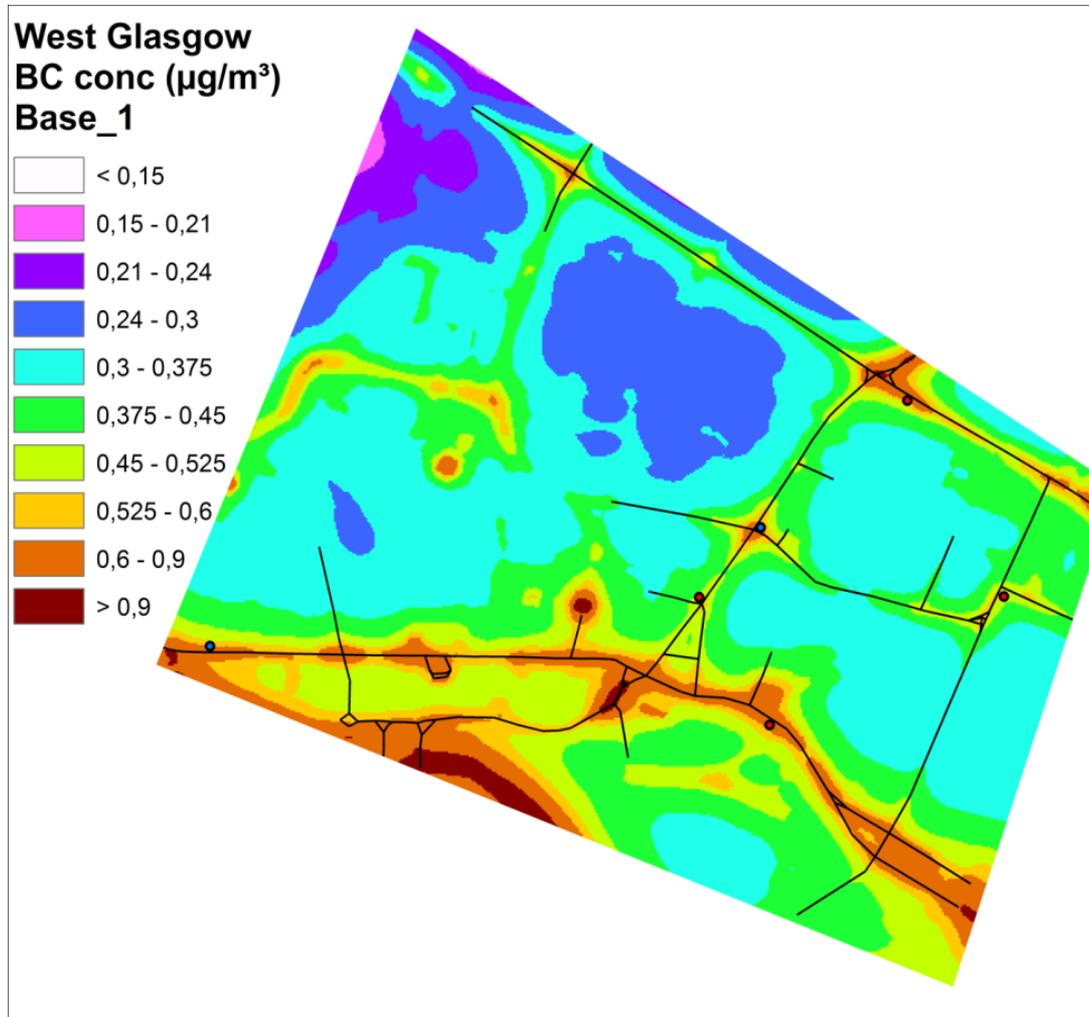
Glasgow Base Scenario

- » AQ simulations for DSS:
- » 7 stability classes, 36 wind directions, fixed wind speed => 252 meteo conditions
- » 10 scenarios, 5 boundary conditions
- » Total of 12600 simulations



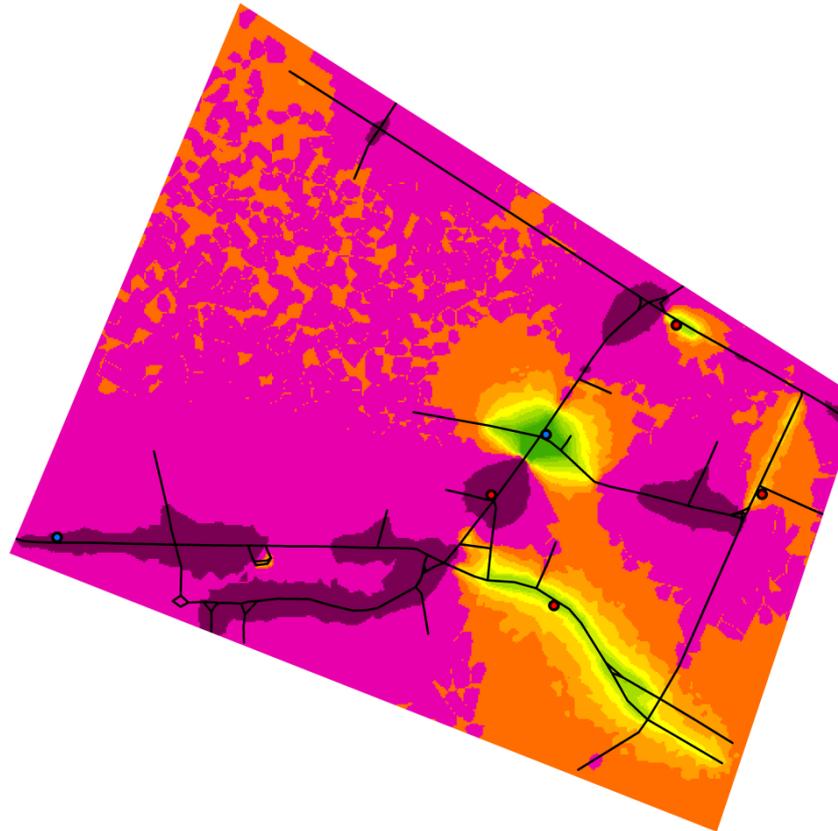
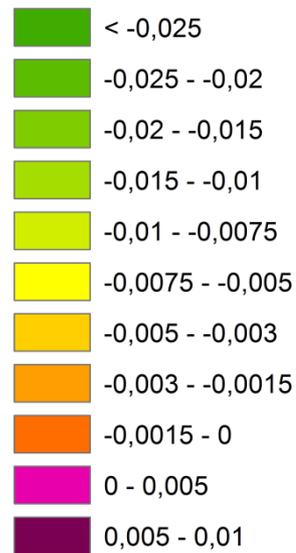
BC concentration map for Northern wind and stability class 1 for the base scenario – boundary condition 1

Glasgow Base Scenario

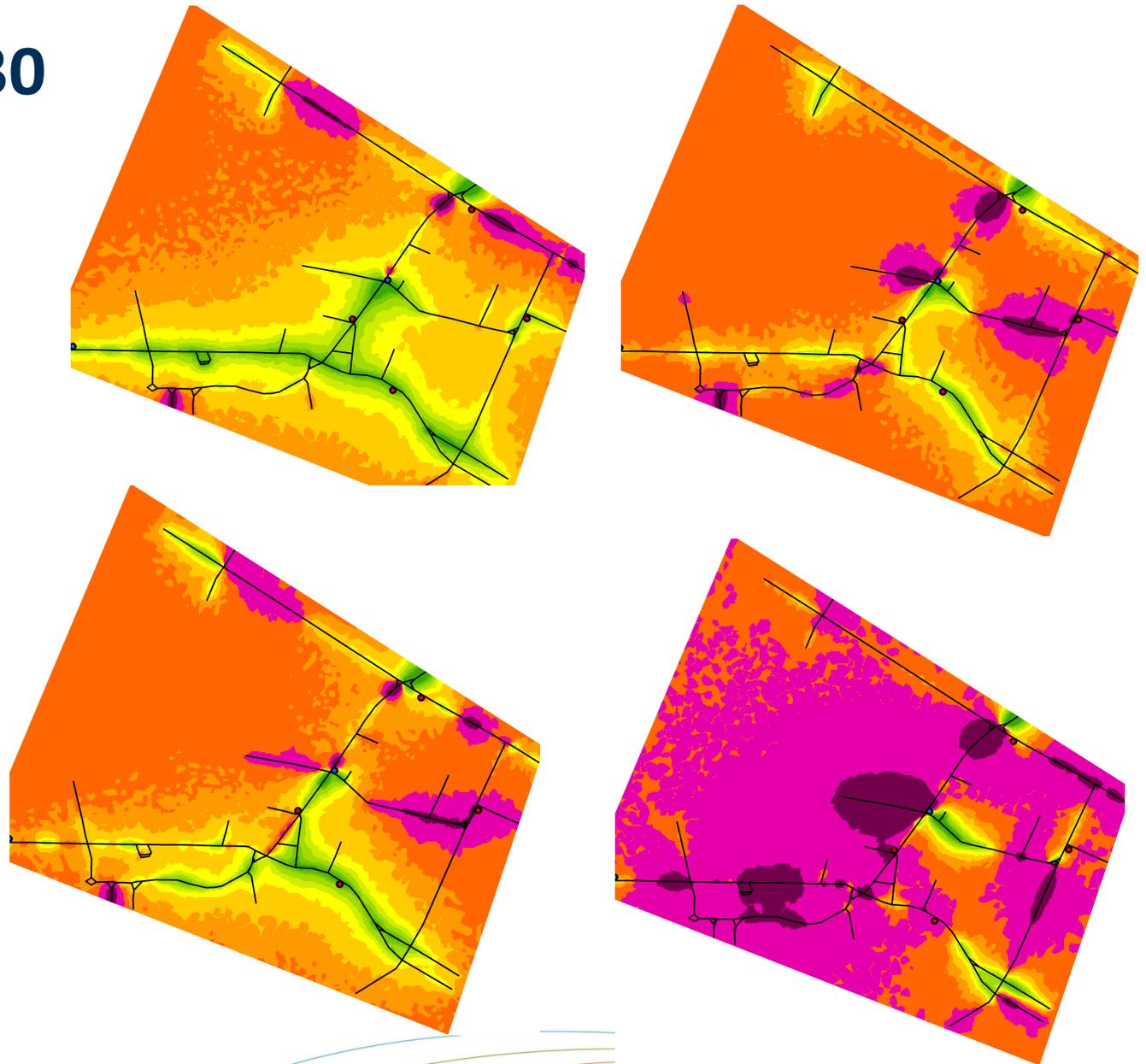


Glasgow BC concentration difference maps

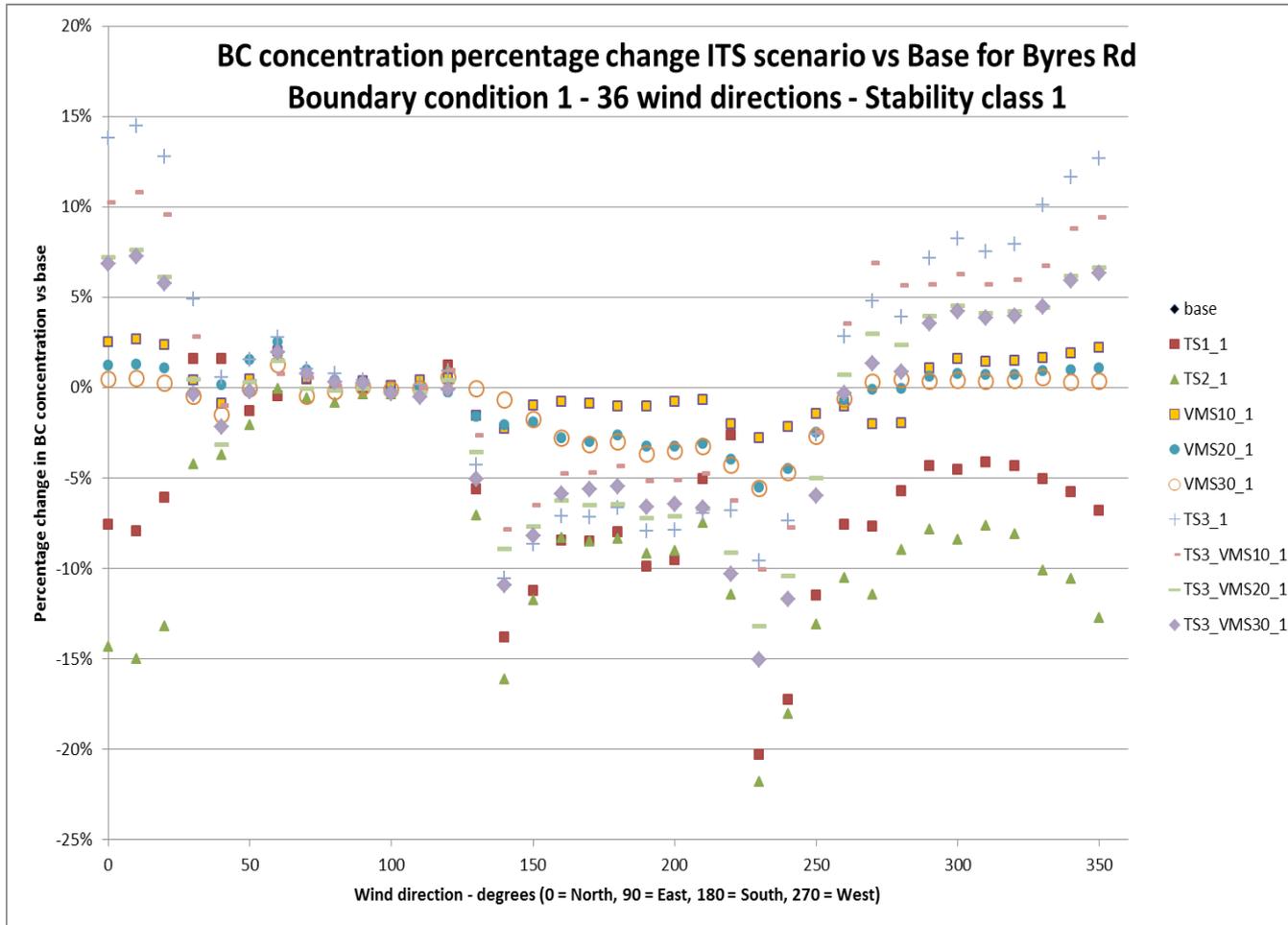
West Glasgow
BC conc ($\mu\text{g}/\text{m}^3$)
TS1_1 - BC1



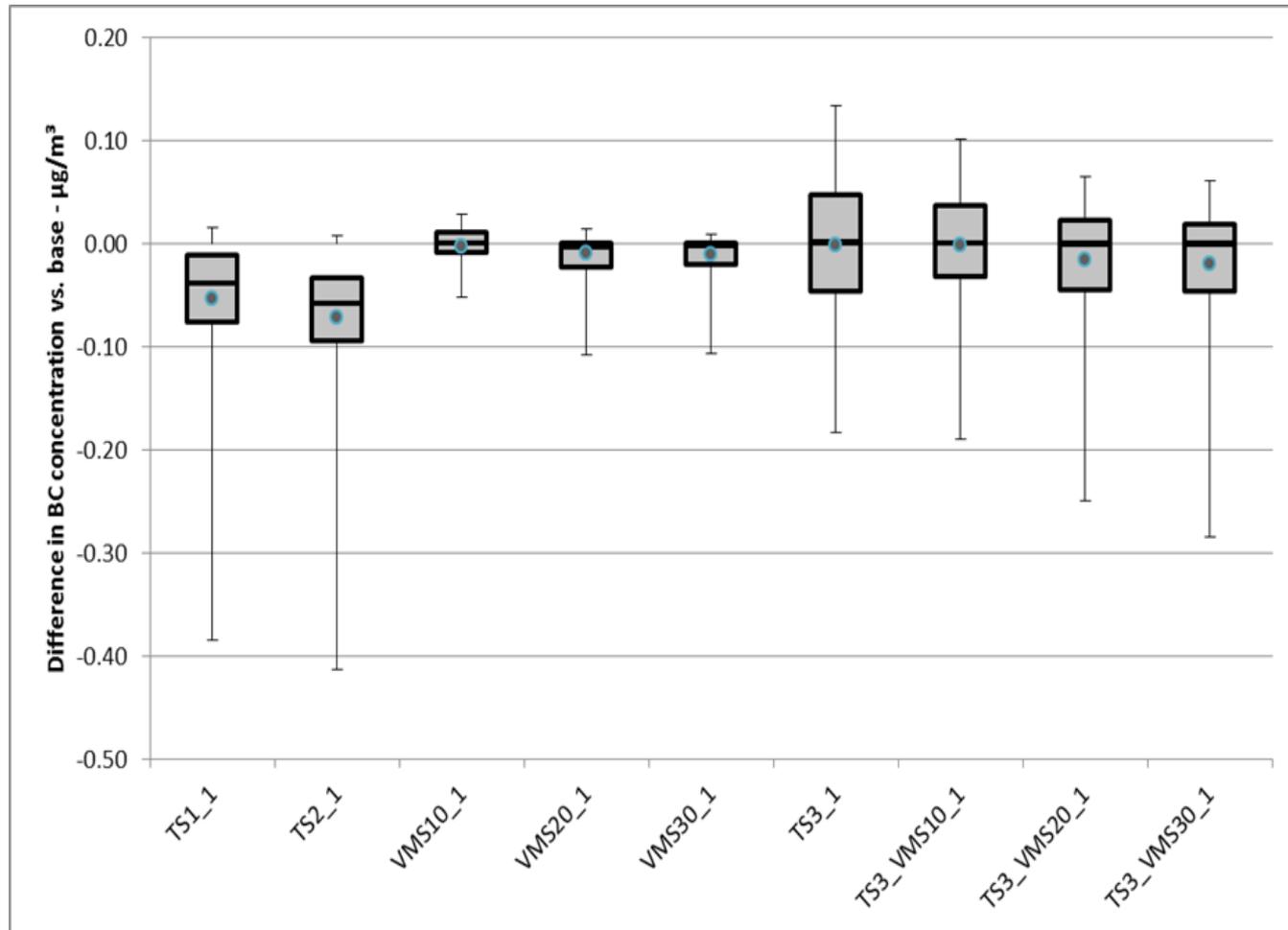
TSC3-VMS30



Glasgow ITS impact



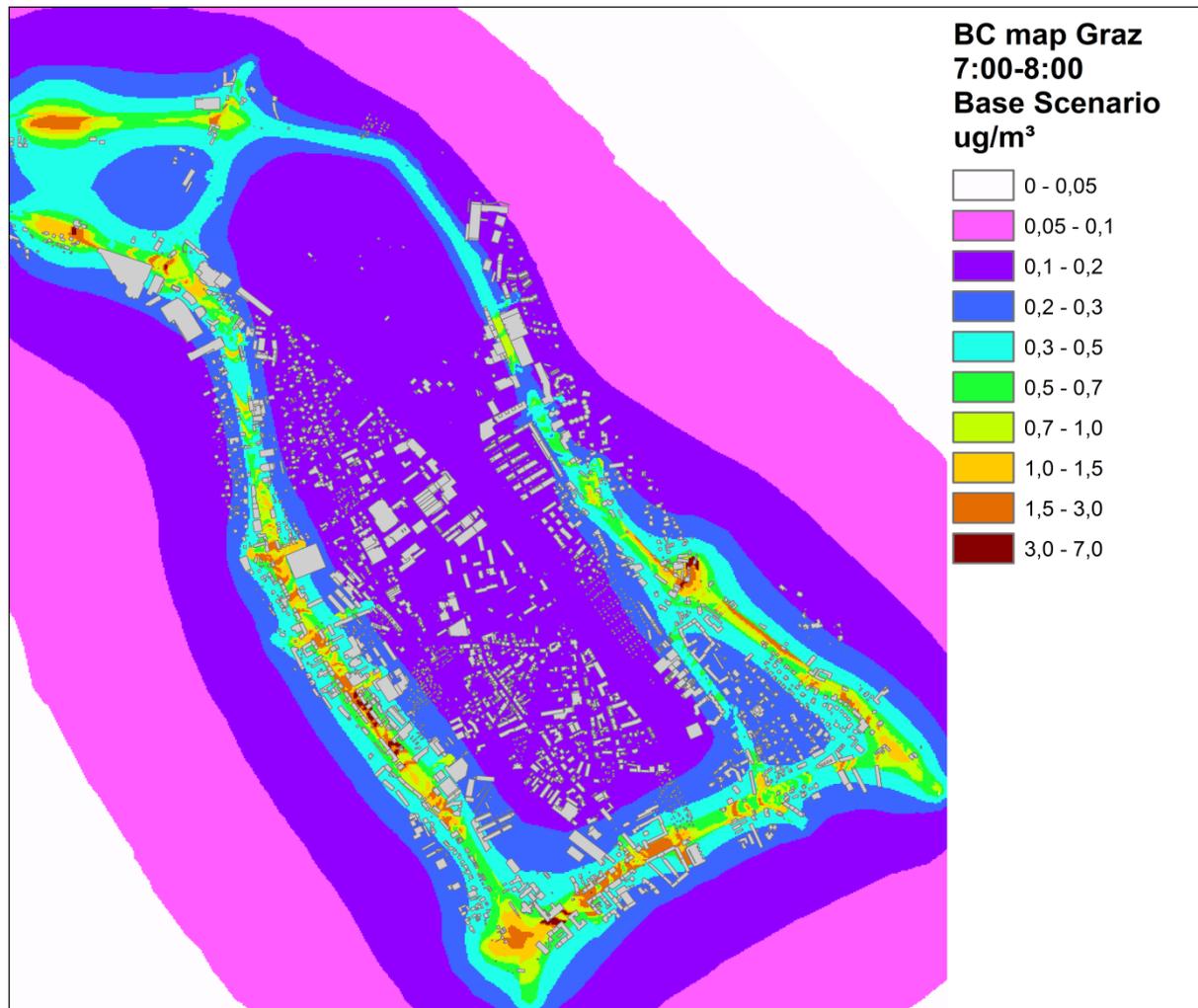
Glasgow ITS impact

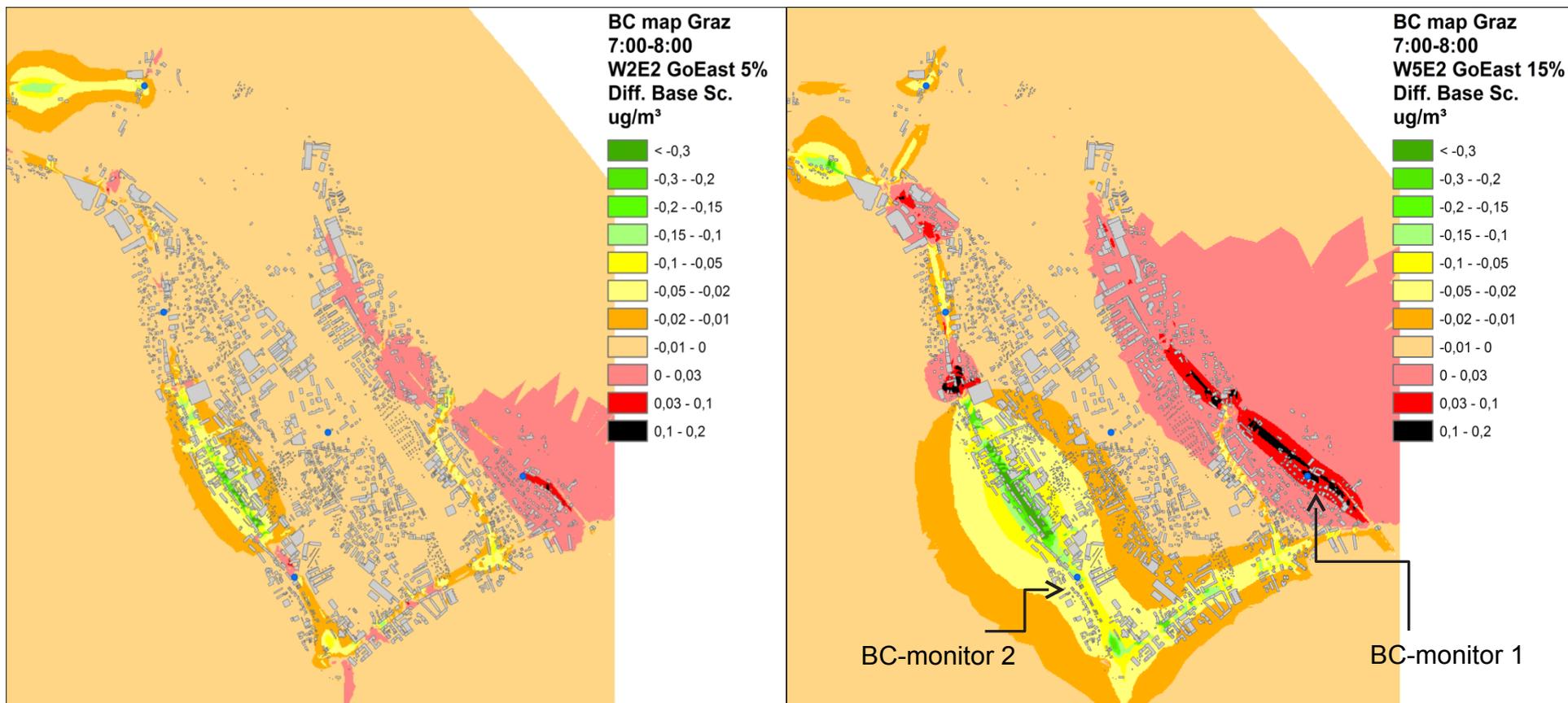


Graz Emissions

Traffic light Program	VMS	Compliance	Graz: BC total emissions over the network (g)			Graz: percentage respective base scenario		
			Increase (6-7)	Maximum (6:30-7:30)	Decrease (7-8)	(6-7)	(6:30-7:30)	(7-8)
W2E2	do nothing	/	372	488.3	537.9	100%	100%	100%
W2E2	Go East	5	368.2	493.7	529.9	99%	101%	99%
W2E2	Go East	10	368.6	479.7	522.2	99%	98%	97%
W2E2	Go East	15	365	476.9	518.7	98%	98%	96%
W2E2	Go West	5	367	486.2	533.8	99%	100%	99%
W2E2	Go West	10	367.4	488.5	543	99%	100%	101%
W2E2	Go West	15	368.1	493.3	542.5	99%	101%	101%
W2E5	Go West	5	366.6	484.7	517.3	99%	99%	96%
W2E5	Go West	10	370.7	482.8	522.2	100%	99%	97%
W2E5	Go West	15	369.9	487.1	527.4	99%	100%	98%
W5E2	Go East	5	370.5	488.6	532.8	100%	100%	99%
W5E2	Go East	10	370.4	483.7	527.9	100%	99%	98%
W5E2	Go East	15	370.6	480.2	522.3	100%	98%	97%

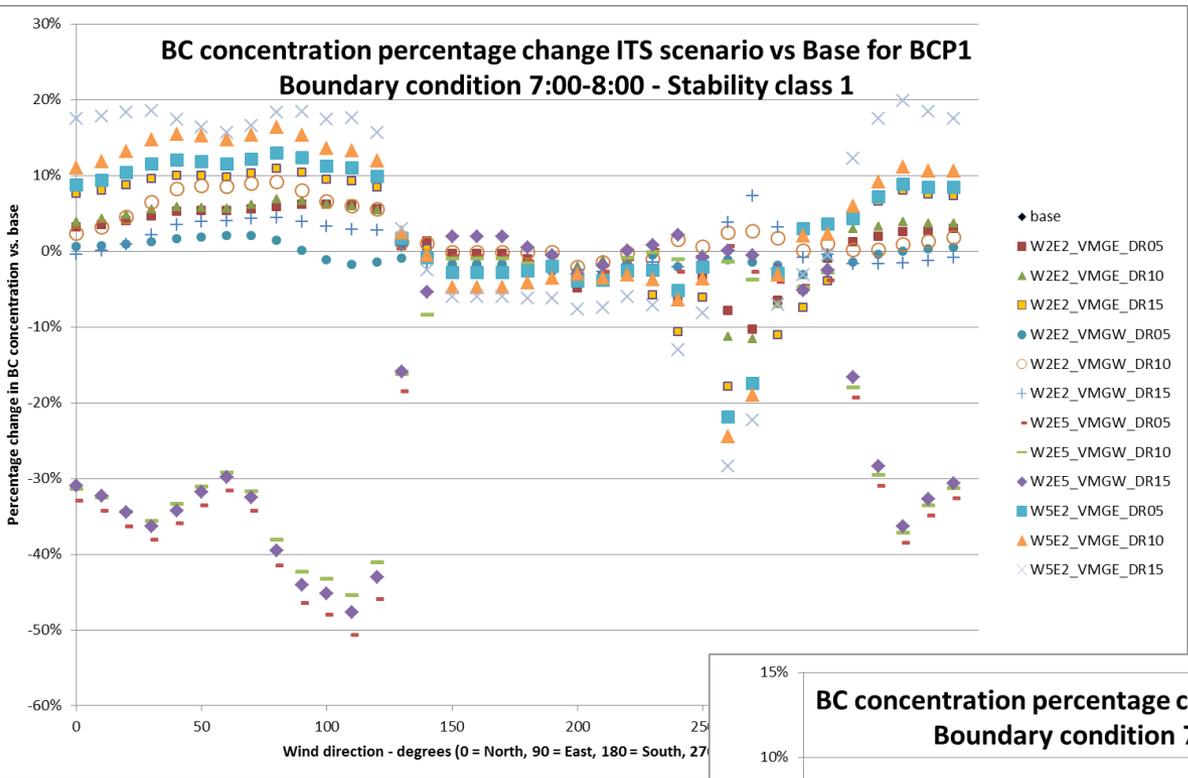
Graz



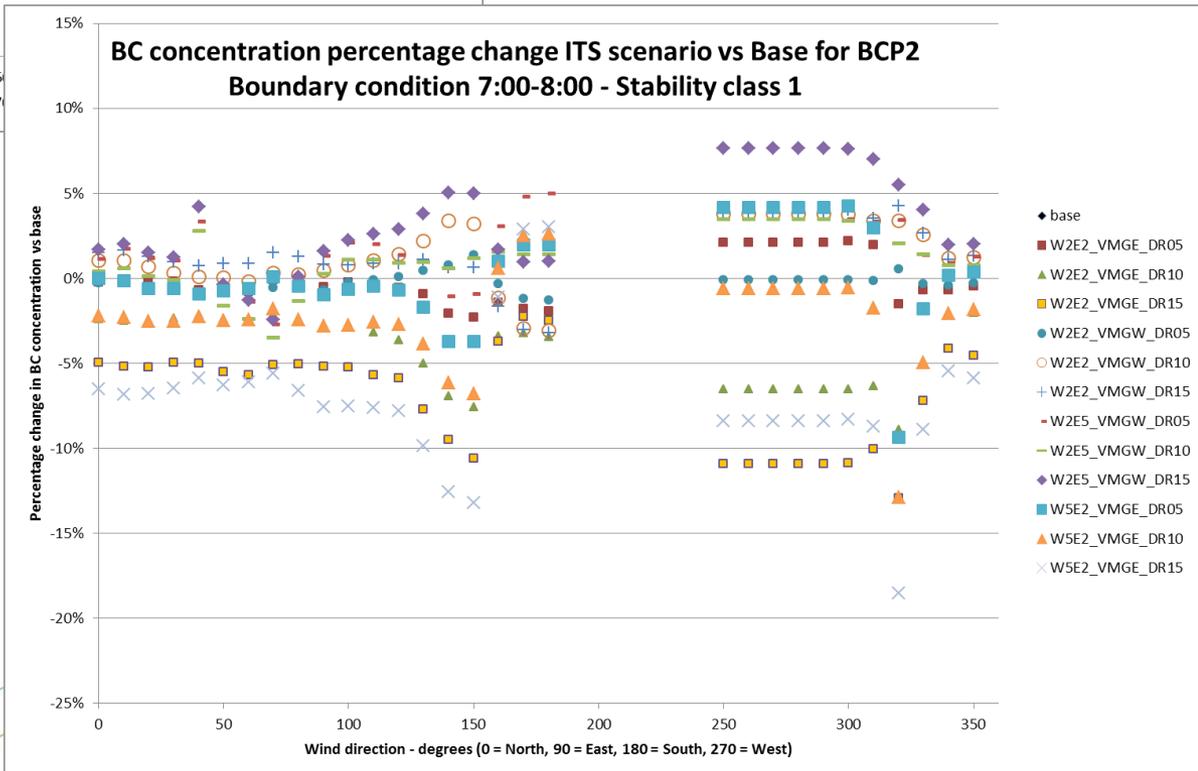


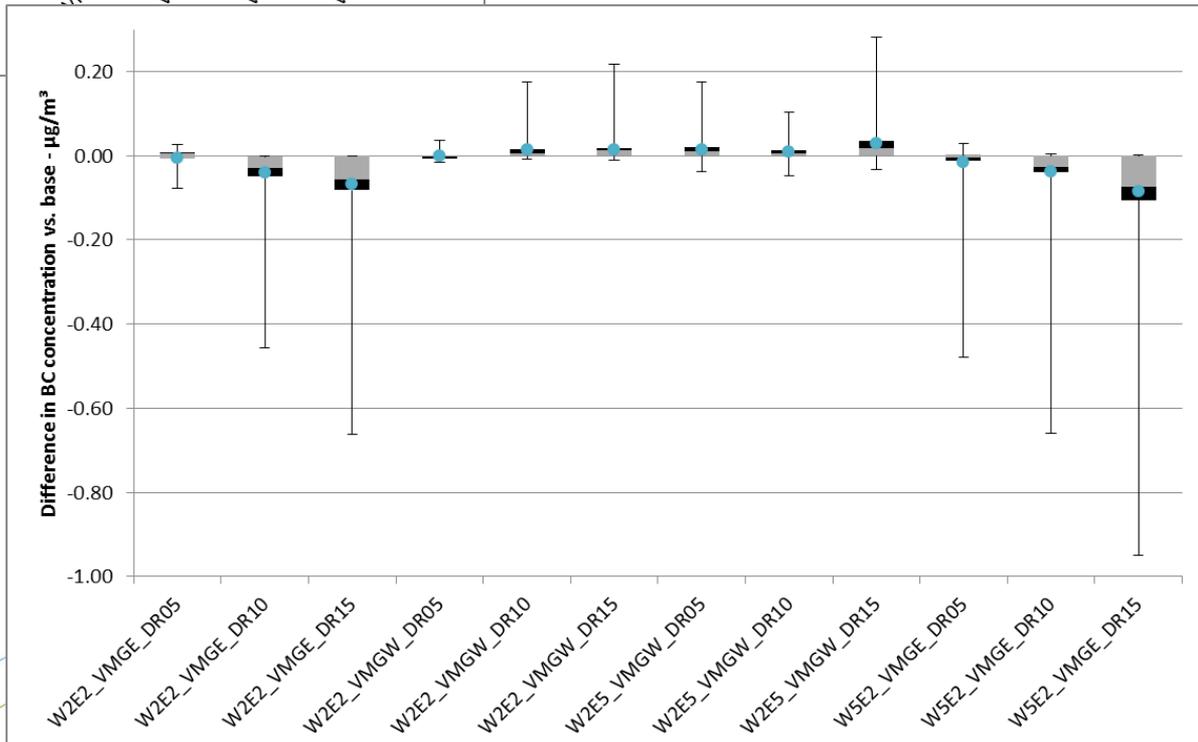
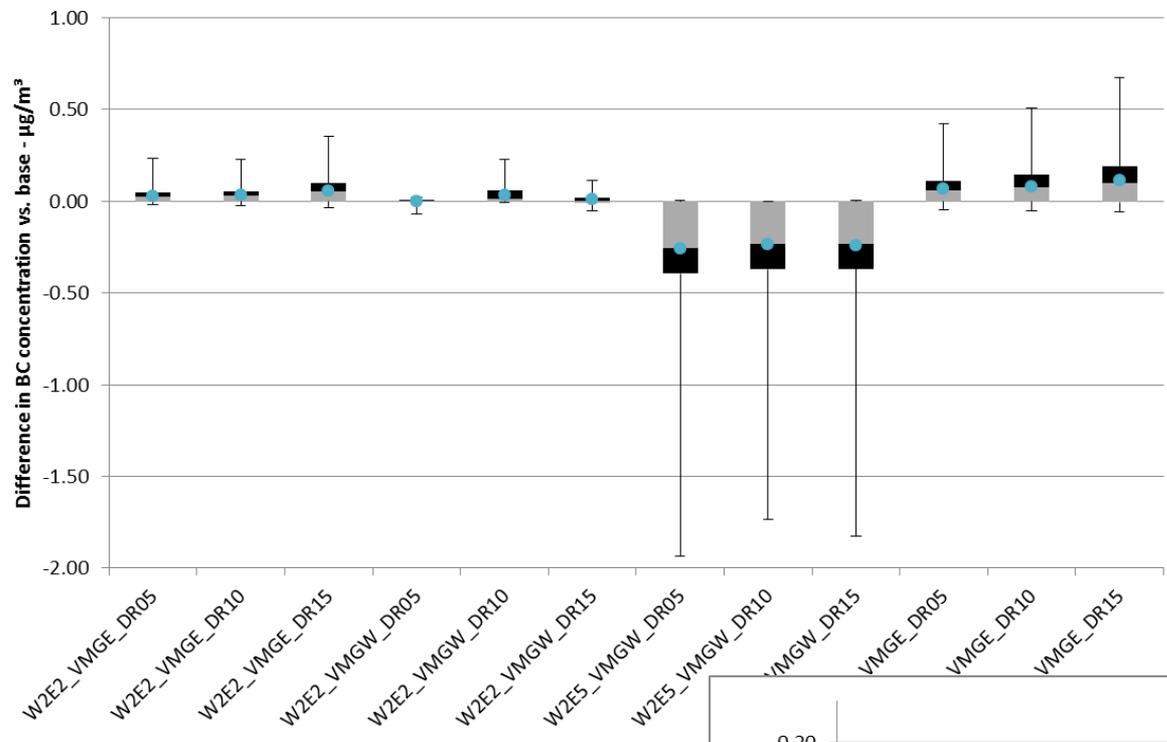
Difference in BC concentration between ITS scenarios and the respective base scenario. Concentrations have been averaged over all 252 meteo conditions.

BC concentration percentage change ITS scenario vs Base for BCP1 Boundary condition 7:00-8:00 - Stability class 1



BC concentration percentage change ITS scenario vs Base for BCP2 Boundary condition 7:00-8:00 - Stability class 1





boundary condition 7:00 – 8:00



Preview WebUi (98:a1f7ce91bb19) Graz Asfnag Glasgow Situation Glasgow Action Proposals Log out "master"

Lagebild

Aktuelle Situation (06:17 @ 01.08.14)

Ampelprogramm: Normal

Ost (Gabenstraße)

Relative Reisezeit (+/- min)	-0	06:10 @ 01.08.14
Russkonzentration (µg/m³)	6.7	08:00 @ 01.08.14

West (Wienerstraße)

Relative Reisezeit (+/- min)	+5	08:10 @ 01.08.14
Russkonzentration (µg/m³)	4.3	07:55 @ 01.08.14

Emissionen bei Normalprogramm

Gesamt CO ₂ (kg/h)	----	---
Gesamt Russ (µg/h)	----	---

Infotafel A9

Ausschalten ▾

Empf. Graz Nord ▾

Empf. Gratk. Süd ▾

Ringbetrieb

Vorgeschlagene Maßnahmen (10:05 @ 01.08.14)

StG 30-S2, StG 32-S2, Empf. Gratk. Süd	Russ 1.002 kg/h	CO ₂ 16.522 t/h	Reisezeit --/-- min	Akzeptieren	Ablehnen ▾
StG 30-S2, StG 32-S5, Empf. Graz Nord	Russ 1.002 kg/h	CO ₂ 16.530 t/h	Reisezeit --/-- min	Akzeptieren	Ablehnen ▾
StG 30-S5, StG 32-S2, Empf. Gratk. Süd	Russ 1.007 kg/h	CO ₂ 16.630 t/h	Reisezeit --/-- min	Akzeptieren	Ablehnen ▾

Conclusions

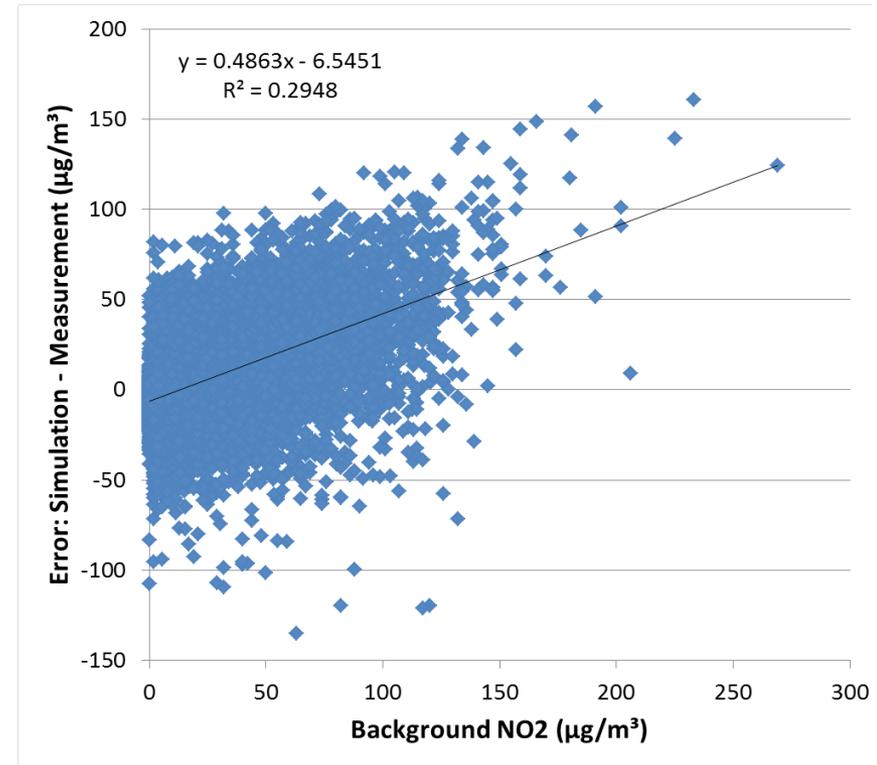
- » Potential impact of DSS on air quality analysed
- » Changes of BC emissions over the full network of -5% to +2%
- » Average impact in range of -0.3 to +0.1 $\mu\text{g}/\text{m}^3$
- » Maximal influence for individual meteo conditions -0.2 to -2.0 $\mu\text{g}/\text{m}^3$

- » ITS measures potential to significantly improve the air quality at crucial locations
- » Averaged over the full test site the effects remain fairly limited

NO2 Validation Glasgow

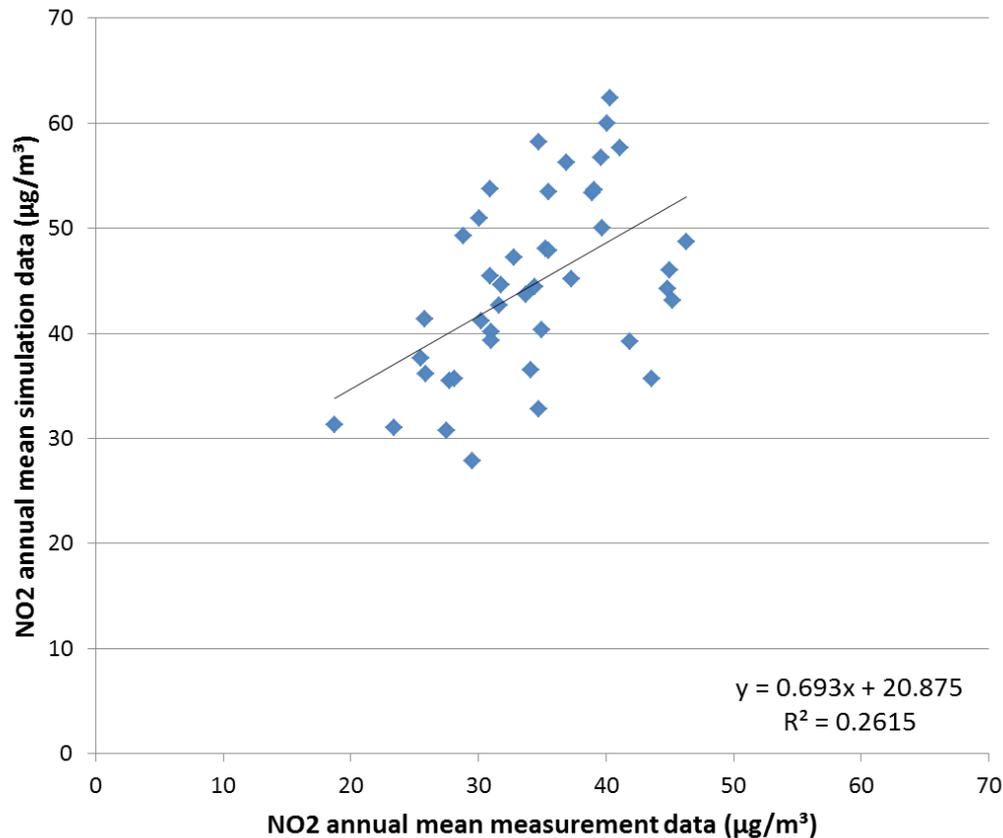
The bias ($\mu\text{g}/\text{m}^3$) per wind sector for the station Byres Road.

Wind direction	Background Station	Bias ($\mu\text{g}/\text{m}^3$)
20-90°	East Dunbartonshire: Bishopsbriggs	8.0
90-160°	Glasgow City Chambers	22.0
160-225°	Waulkmill Glen Reservoir	-8.7
225-260°	Paisley Gordon	18.45
260-300°	Paisley Glasgow Airport	4.6
300-340°	Clydebank	-4.3
340-20°	Bearsden	37.5



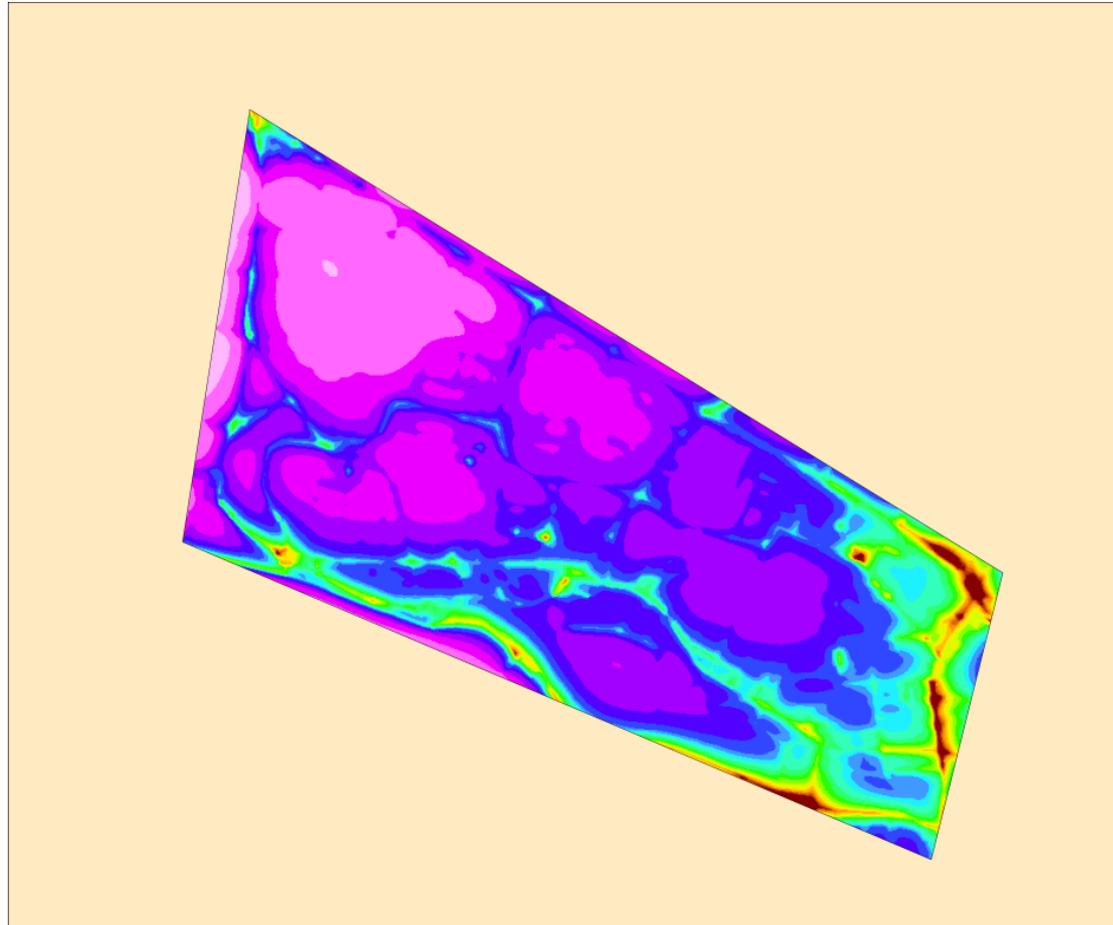
Scatter plot of the difference between the simulated and measured NO₂ concentration against the applied background value.

NO2 spatial validation

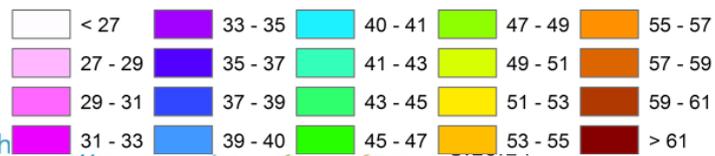


Scatter plot of the NO2 annual mean IFDM simulated concentrations against the NO2 diffusion tube measurement data from the (2009 – 2011).

Year average historical pollutant maps



Average NO₂ concentrations 2011 ($\mu\text{g}/\text{m}^3$) Glasgow West



BC and PM10 emissions per 10.000 km covered by traffic in Graz, Glasgow and Antwerp

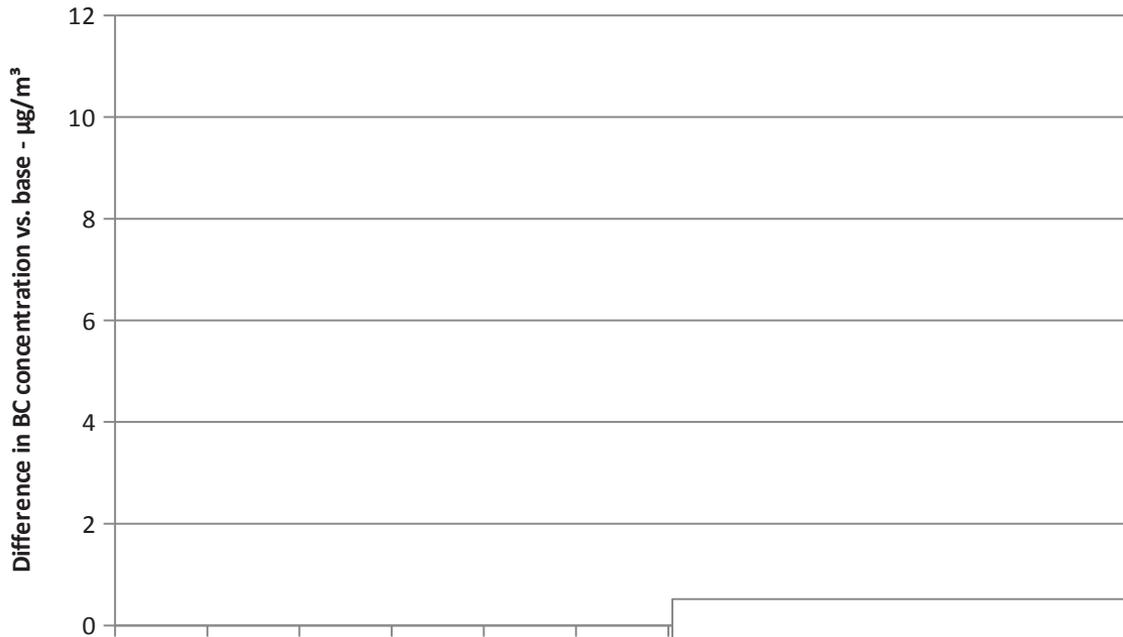
	PM10 (g)	BC (g)	ratio BC/PM10	average speed (km/h)
Glasgow	297.1	165.6	0.56	24.3
Graz	412.5	195.6	0.47	36
Antwerp	438.1	228.7	0.52	?

Glasgow Traffic

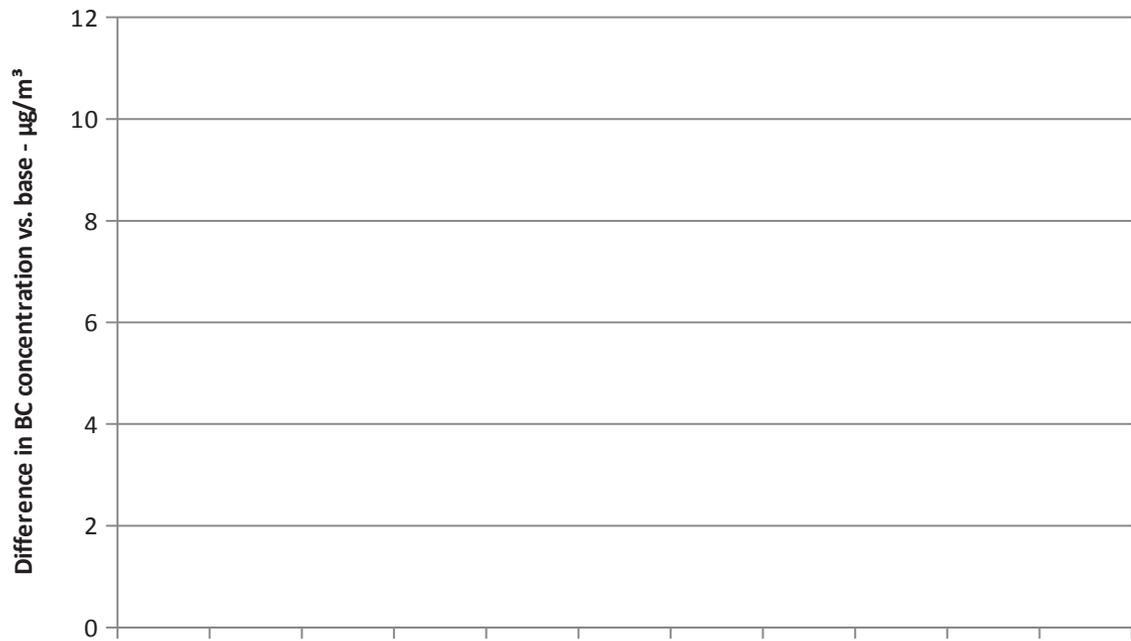
Count	
11	
10	
9	
8	
7	
6	
5	
4	
3	
2	
1	

Traffic congestion???

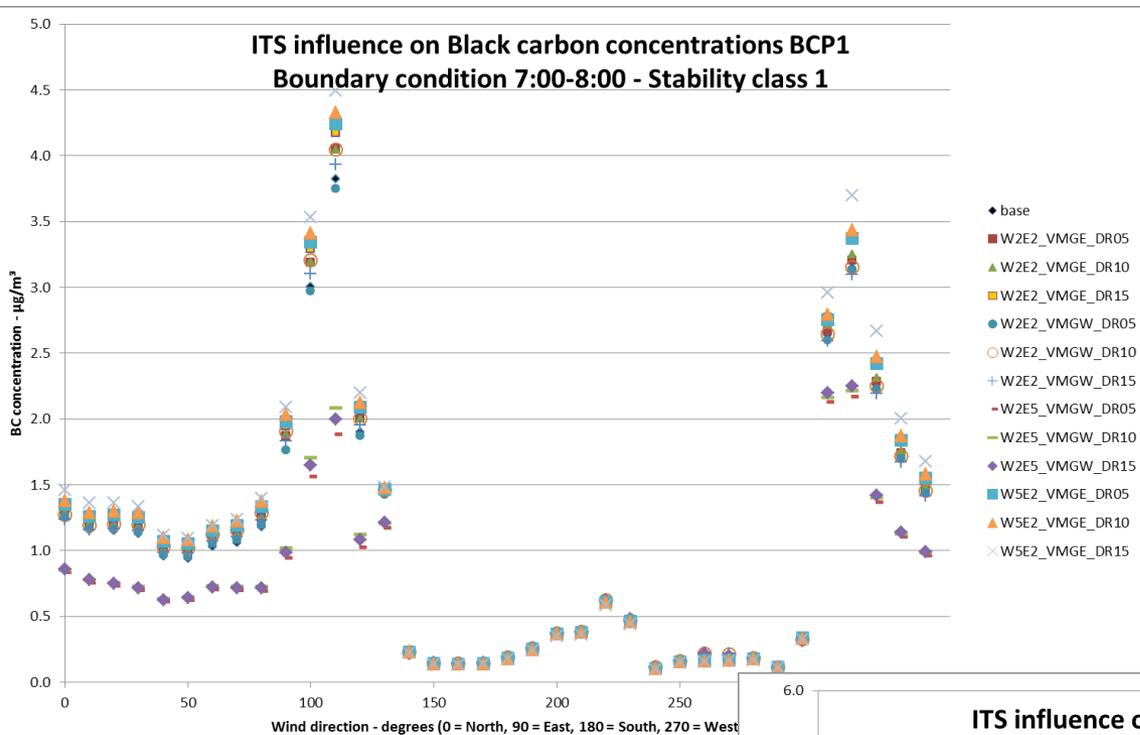
Mean Speed (mph)	
11	
10	
9	
8	
7	
6	
5	
4	
3	
2	



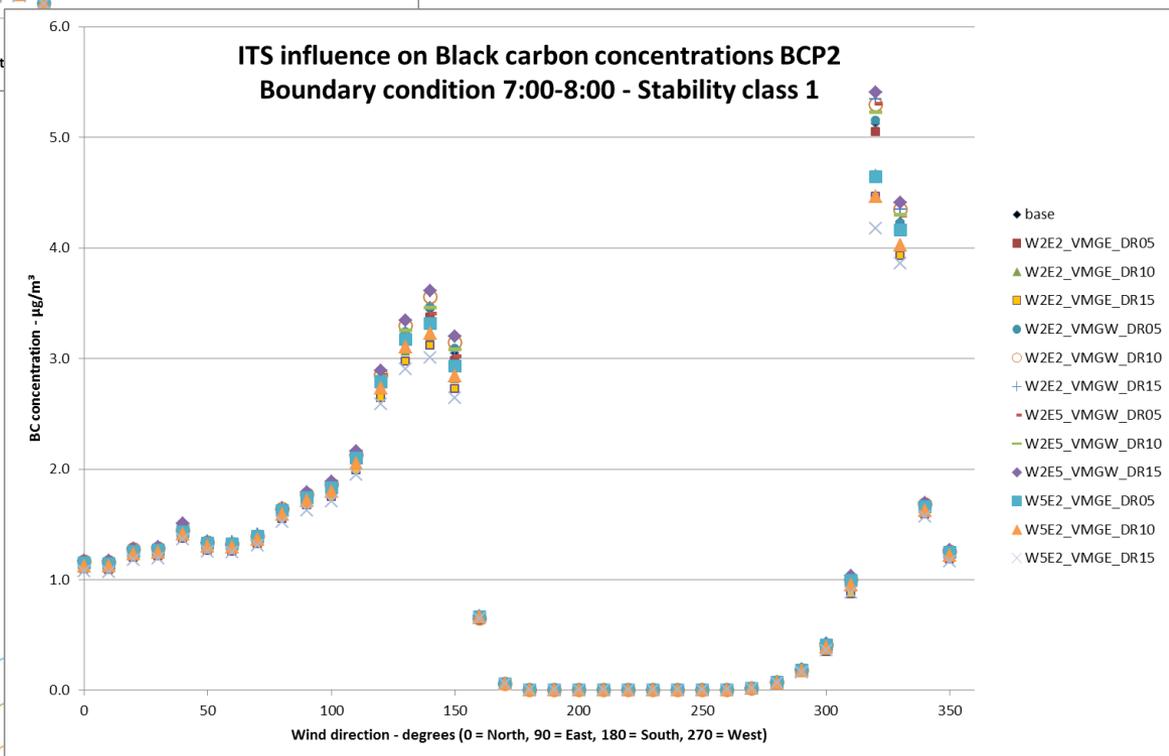
6:00 – 7:00



ITS influence on Black carbon concentrations BCP1 Boundary condition 7:00-8:00 - Stability class 1



ITS influence on Black carbon concentrations BCP2 Boundary condition 7:00-8:00 - Stability class 1



Glasgow ITS impact

