

Breathe London Mobile Monitoring: Instrument Uncertainty Documentation

Section 2 (O<sub>3</sub>, LDSA, and Black Carbon)

19 Oct 2020

Table 1: Instrument Uncertainty Summary Table<sup>1</sup>

**Bold** statistic for each row represents the dominant uncertainty for that species

Instrument	Species	MDL	Precision between co-located cars	Precision during zero checks	Manufacturer Specified
2B Technologies Model 211-G	O <sub>3</sub>	3.2 ppb	± <b>10%</b>	± 1.07 ppb	Accuracy: Greater of 1.0 ppb or 2% of reading
Naneos Partector Aerosol Dosimeter	LDSA	2.1 um <sup>2</sup> cm <sup>-3</sup>	± 8%	± 0.69 um <sup>2</sup> cm <sup>-3</sup>	<b>Accuracy: ± 30%</b>
Magee Scientific Aethalometer Model AE33	BC	1.5 ug/m <sup>3</sup>	± <b>15%</b>	± 0.49 ug/m <sup>3</sup>	Not specified

<sup>1</sup>The uncertainties are summarized for each species by reporting the statistic from the vehicle with the greater uncertainty under each metric (MDL, precision, etc.). See Bias section for individual instrument biases.

Table 2: Manufacturer Instrument Specifications

Instrument	Species	Manufacturer Specs
2B Technologies Model 211-G	O <sub>3</sub>	Precision (1σ; rms noise): Greater of 0.5 ppb or 1% of reading for 10-s average Accuracy: Greater of 1.0 ppb or 2% of reading Limit of Detection (2σ): 1.0 ppb for 10-s average
Naneos Partector Aerosol Dosimeter	LDSA	Accuracy: ± 30% Noise floor: ~ 1 ug <sup>2</sup> /cm <sup>3</sup> Particle size range: 10 nm to 10 um
Magee Scientific Aethalometer Model AE33	BC	Detection Limit (1 hour): < 0.005 ug/m <sup>3</sup>

**Method Detection Limit (MDL)**

The MDL is calculated using 1 hz zero time series data. Sources of zero timeseries data include weekly (~5 minute) zero checks performed at NPL, longer (~1 hour) zero checks performed at NPL, and

instrument-initiated zero checks (for NO<sub>2</sub> only). We calculate the +3 $\sigma$  MDL for each distinct zero period and define the instrument MDL as the median MDL across all valid zero periods.

vehicle	species	unit	total n (s)	n distinct periods	mdl
27522	BC	ng/m3	9560	10	1479.029
27533	BC	ng/m3	7428	8	1059.313
27522	LDSA	um2cm-3	8950	12	1.3246
27533	LDSA	um2cm-3	9613	9	2.0717
27522	O3	ppb	3652	6	3.2041
27533	O3	ppb	3566	9	3.0461

### Precision during zero checks

Instrument precision is defined as the 1 $\sigma$  noise from the 1hz zero timeseries. Sources of zero timeseries data include weekly (~5 minute) zero checks performed at NPL, longer (~1 hour) zero checks performed at NPL, and instrument-initiated zero checks (for NO<sub>2</sub> only). The precision is first calculated for each distinct span or zero period, and the final result is the median from all valid periods.

vehicle	species	unit	Reference concentration	total n (s)	n distinct periods	1 $\sigma$
27522	BC	ng/m3	0	9560	10	493.0095
27533	BC	ng/m3	0	7428	8	353.1043
27522	LDSA	um2cm-3	0	8950	12	0.4415
27533	LDSA	um2cm-3	0	9613	9	0.6906
27522	O3	ppb	0	3652	6	1.068
27533	O3	ppb	0	3566	9	1.0154

### Bias

Instrument bias is calculated from the span and zero timeseries data, where observed is the measured 1 Hz value and target is the reference concentration (of 0 for zero data):

$$bias = median (observed - target)$$

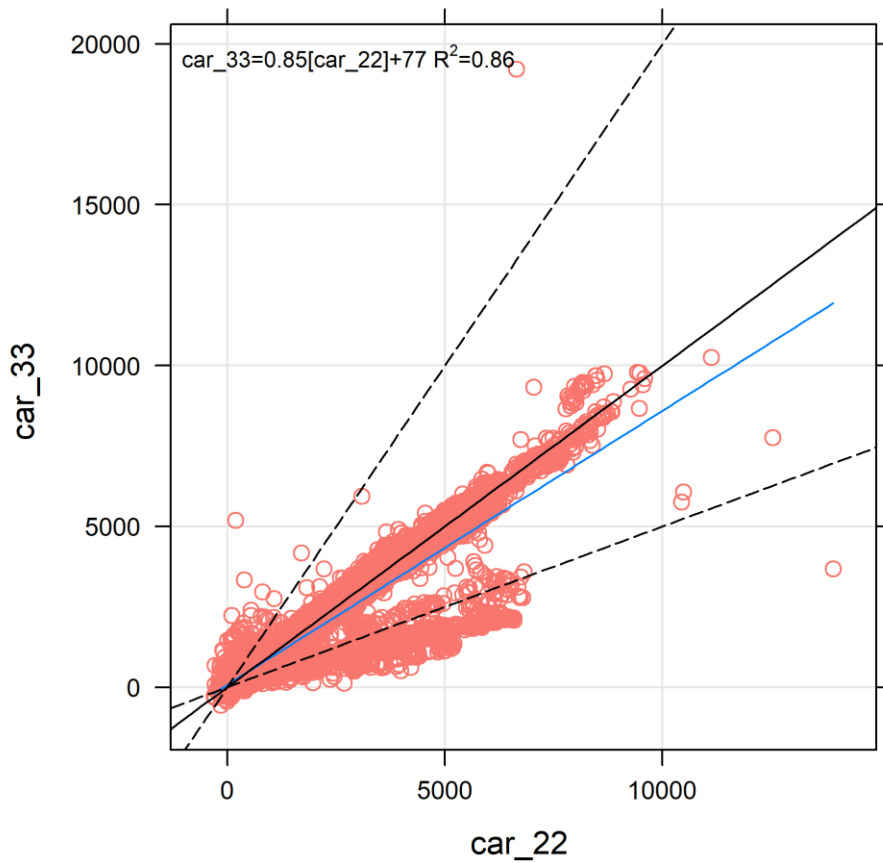
Sources of timeseries data are 5-minute weekly zero checks performed at NPL. The bias is first calculated for each distinct span or zero period, and the final result is the median from all valid periods.

vehicle	species	unit	Reference concentration	total n (s)	n distinct periods	median bias
27522	BC	ng/m3	0	9560	10	-1
27533	BC	ng/m3	0	7428	8	-12
27522	LDSA	um2cm-3	0	8950	12	0.6
27533	LDSA	um2cm-3	0	9613	9	0.9
27522	O3	ppb	0	3652	6	0.85
27533	O3	ppb	0	3566	9	0.7

### Precision between co-located cars

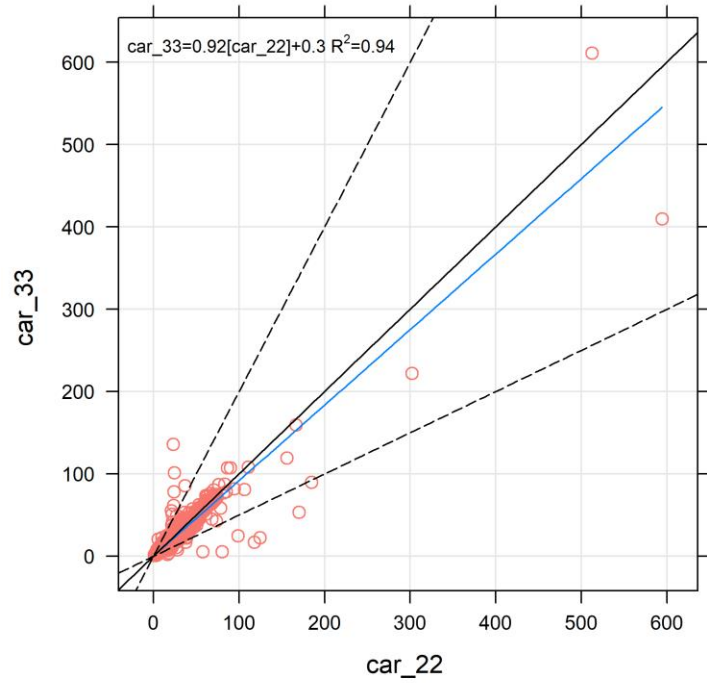
As we do not have comparisons to reference concentrations for the three pollutants in this document (in the form of a multipoint calibration or reference instrument collocation, etc.), we use extended collocations between the two vehicles to intercompare 1-minute mean instrument observations and estimate relative uncertainty of the two instruments. We quantify this as the % slope difference from unity (slope=1).

BC



*Note: The irregular behavior in this scatterplot has not yet been investigated as we have not done any analyses of the Black Carbon data. However, the pattern of multiple clusters suggests that during a certain period of time, the performance of one instrument may have diverged. We will examine the underlying cause as we look into BC data in the future.*

# LDSA



# O<sub>3</sub>

