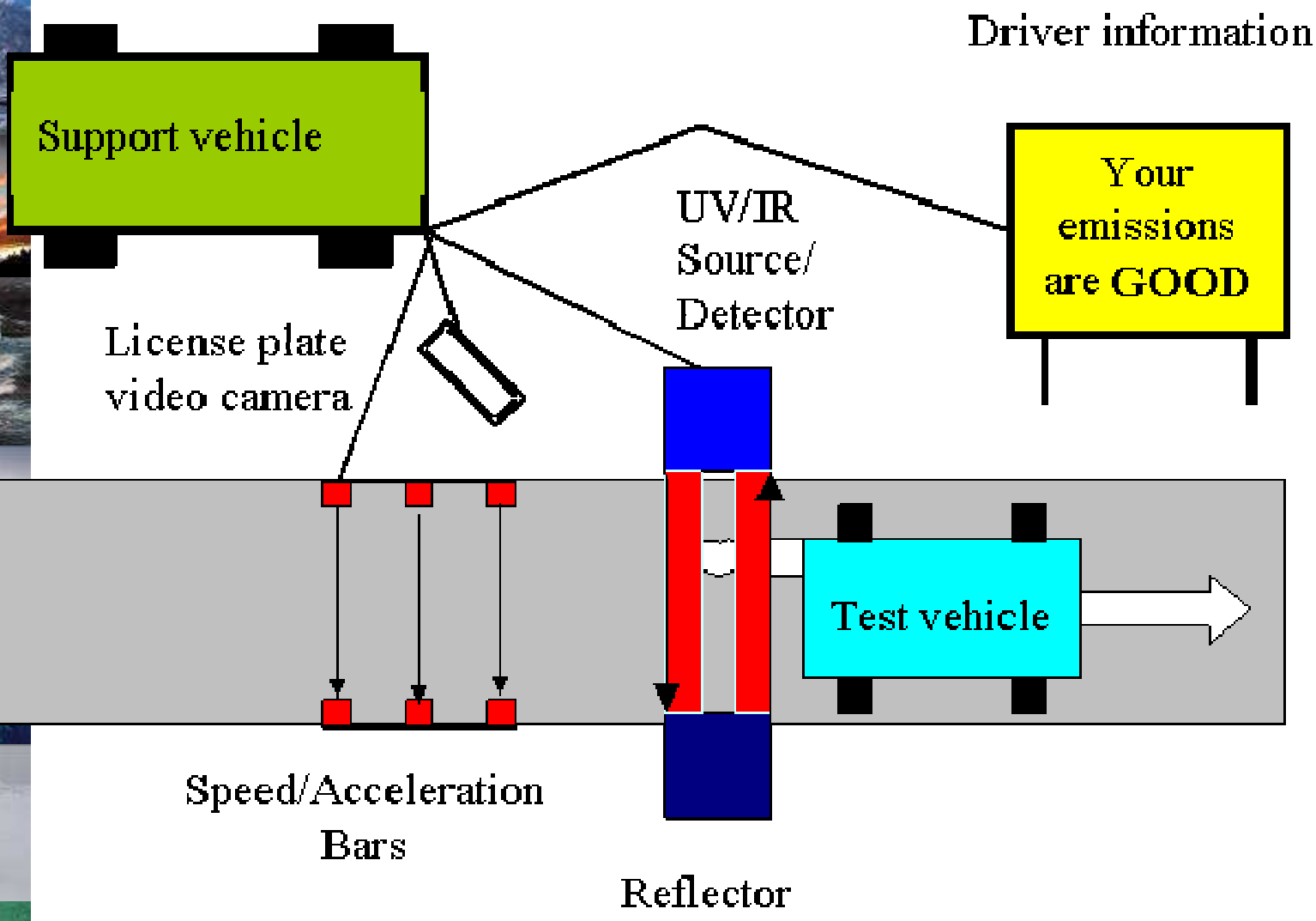
# ON-ROAD MEASUREMENTS TO IMPROVE UNDERSTANDING OF VEHICLE EMISSIONS

Jeff Bluett

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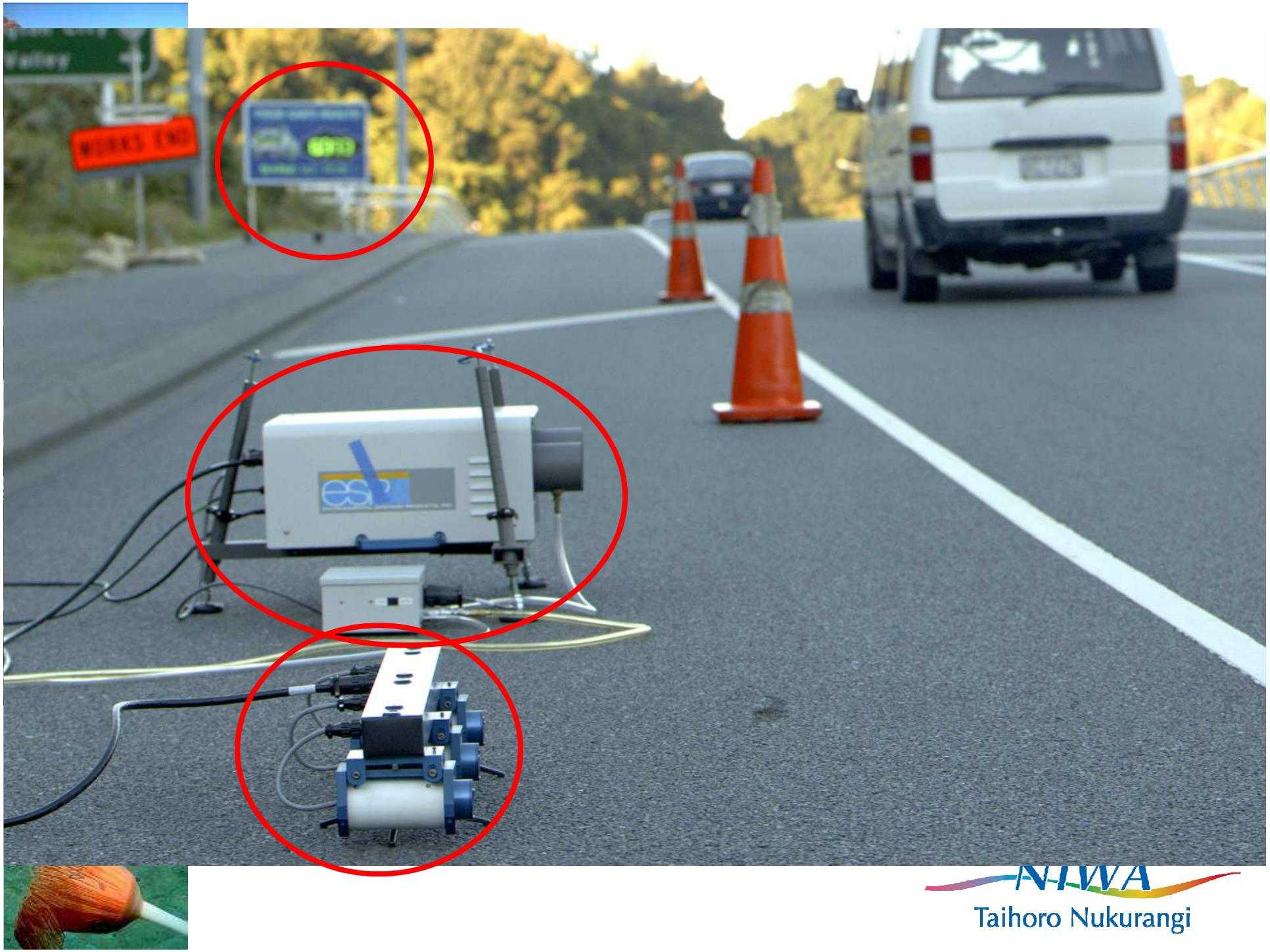


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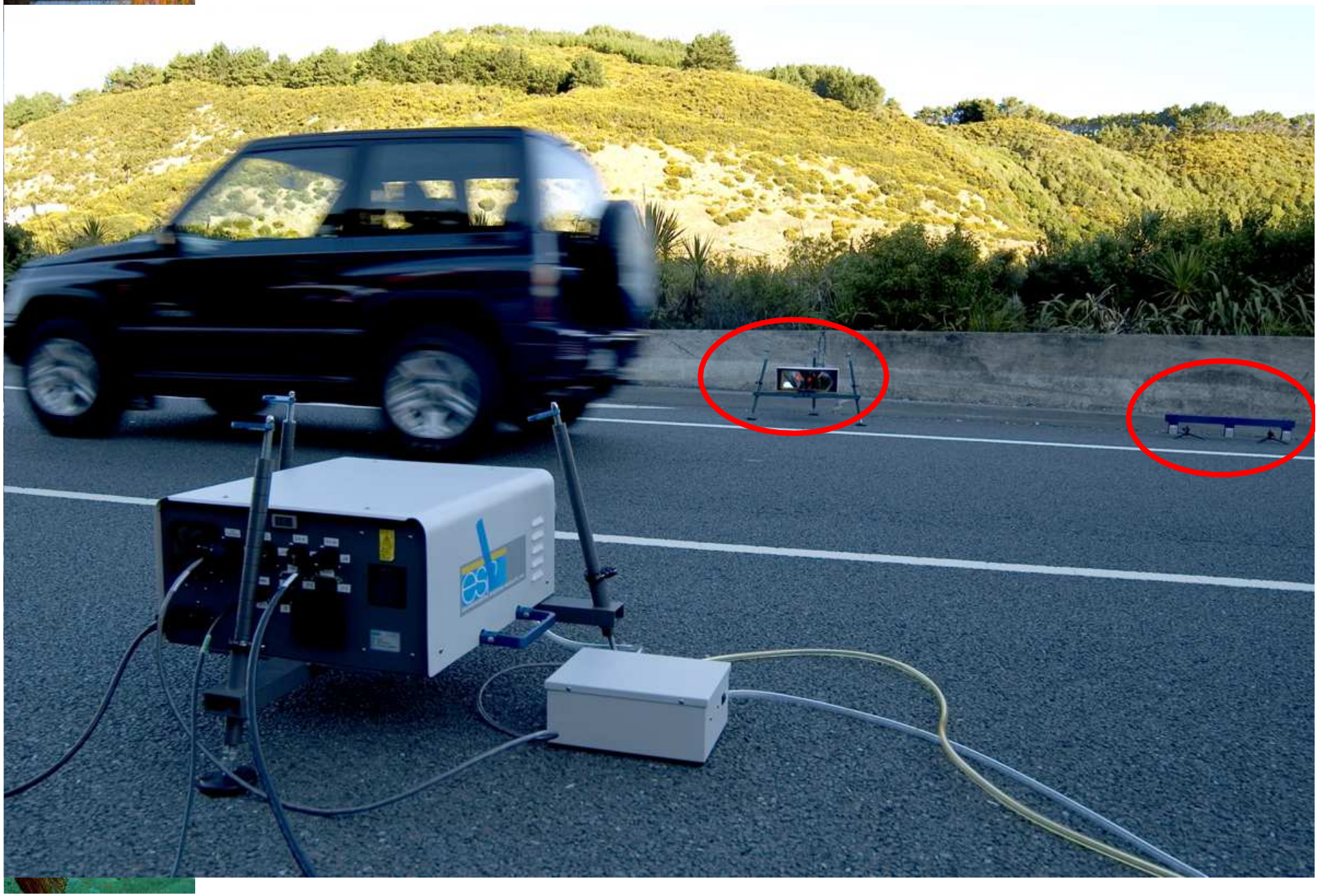

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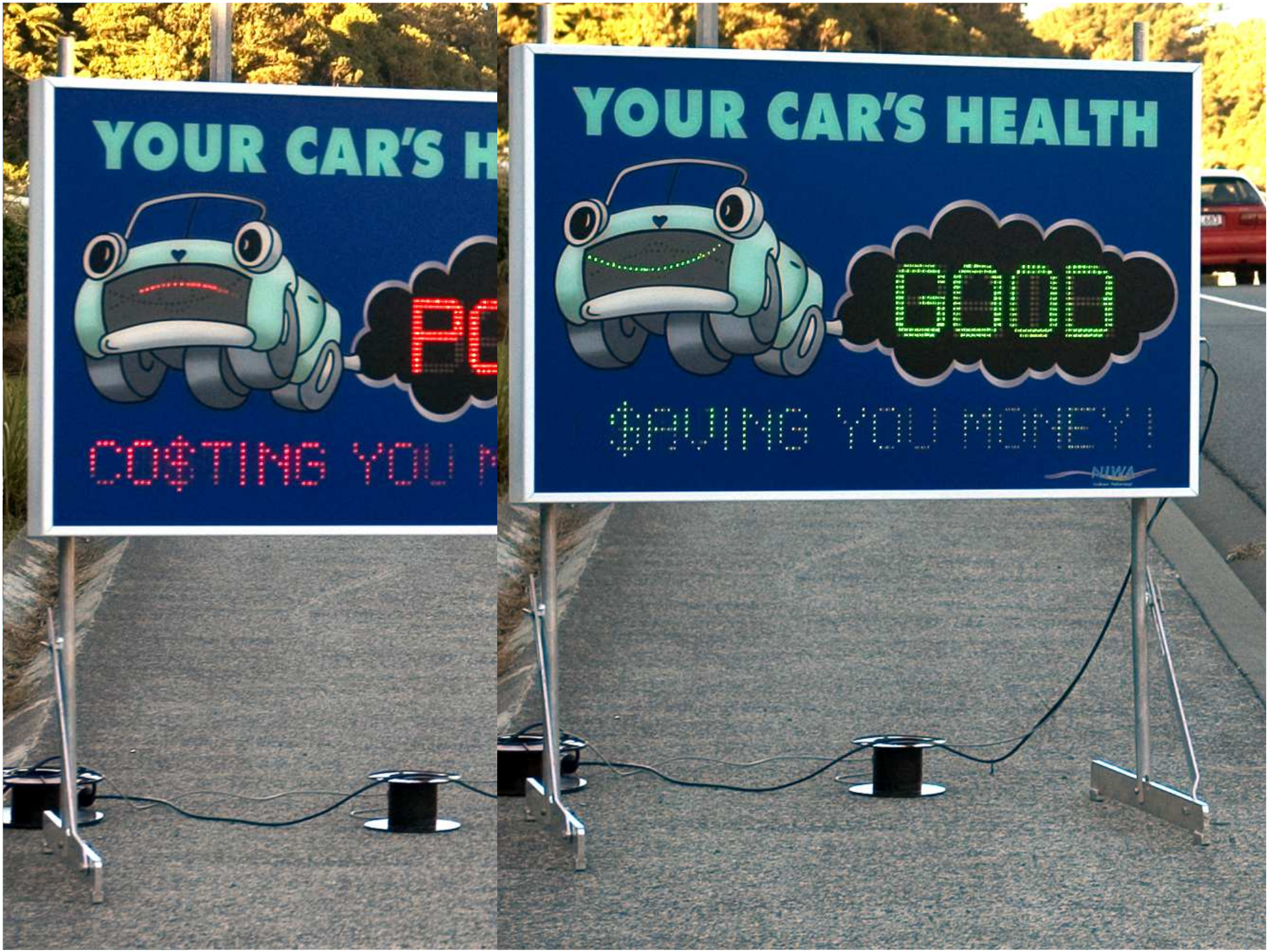
20050525460 1AKAUC403599.jpg
FQ 1160
Speed Accel
CO
$CO_2$
HC
NO
Opacity
55.976 1.535 V 1.84 13.66 402.2 1724.25 0.1391 24.84 30 V


YOUR CAR'S H
CO$TING YOU
YOUR CAR'S HEALTH
GOOD
$AVING YOU MONEY!

# Vehicle Fleet Emission Database

RSD: Emission and speed/accel data

Vehicle data- Licence plate

Make/model

Petrol/Diesel

Year

Engine size

Vehicle Fleet Emission database

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# 1. Laboratory vs Real-World Emission Tests

- Laboratory Tests
  - Dynamometer with particulate filters and gas analysers
  - Drive cycle measurement
  - Lots of data from a limited number of “tame” vehicles
- Real-World Test
  - Road-side RSD equipment – “open path” measurements
  - Snap shot measurement
  - Relatively small amount of data from a large number of “wild” vehicles

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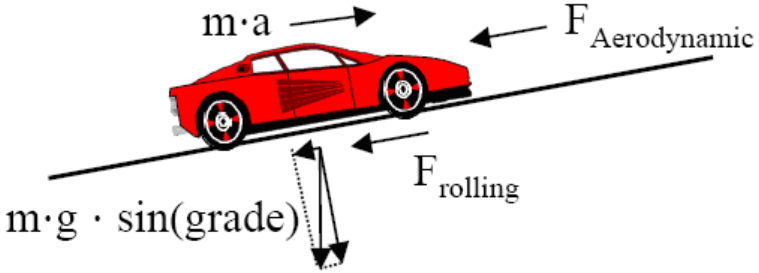
# Vehicle Specific Power




$$VSP = \frac{\text{Power}}{\text{Mass}} = \frac{\frac{d}{dt}(E_{Kinetic} + E_{Potential}) + F_{Rolling} \cdot v + F_{Aerodynamic} \cdot v + F_{internal\ friction} \cdot v}{m} =$$

$$\approx v \cdot a \cdot (1 + \varepsilon_i) + g \cdot grade \cdot v + g \cdot C_R \cdot v + \frac{1}{2} \rho_a C_D \frac{A}{m} (v + v_w)^2 \cdot v + C_{if} \cdot v =$$

$$\approx 1.1 \cdot v \cdot a + 9.81 \cdot grade + 0.213 \cdot v + 0.000305 \cdot (v + v_w)^2 \cdot v$$

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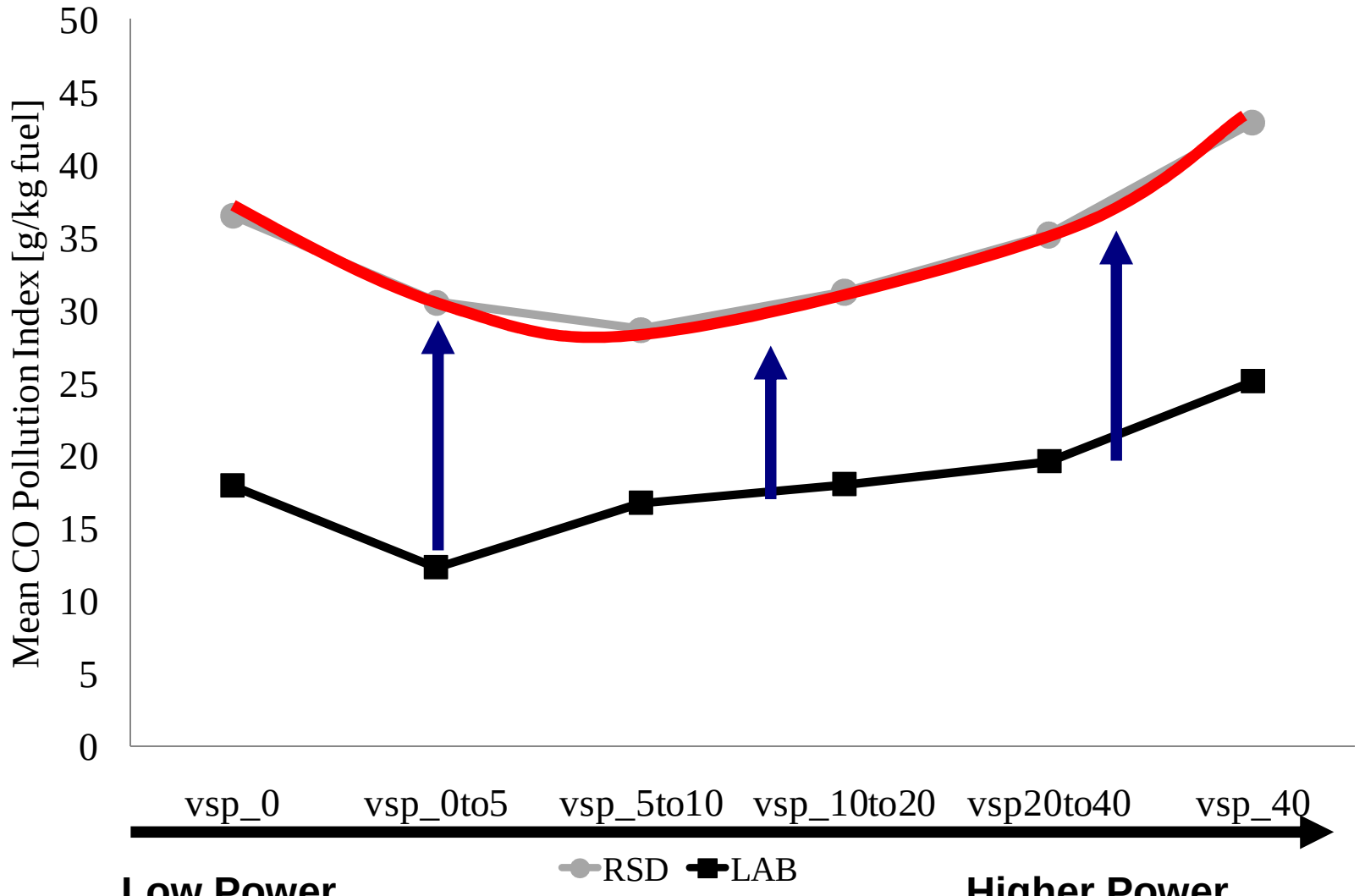
# Emissions by VSP

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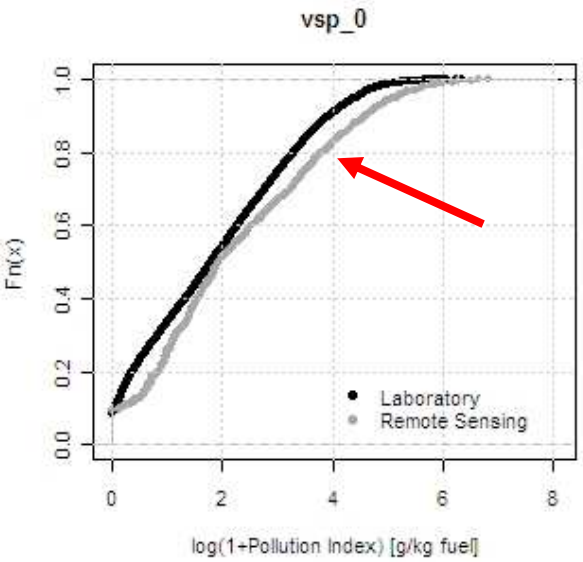


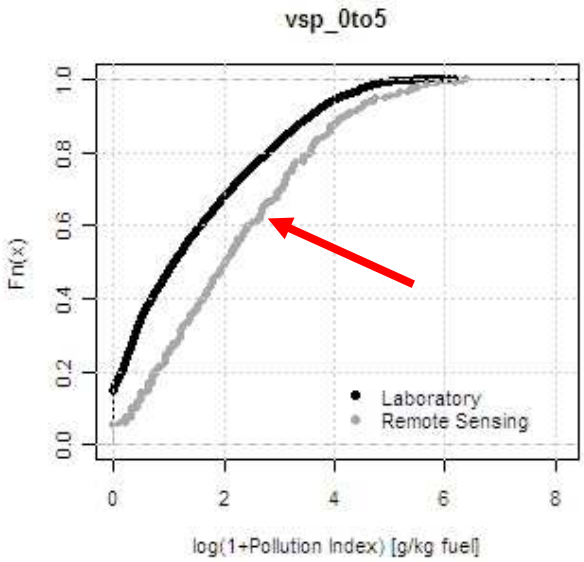


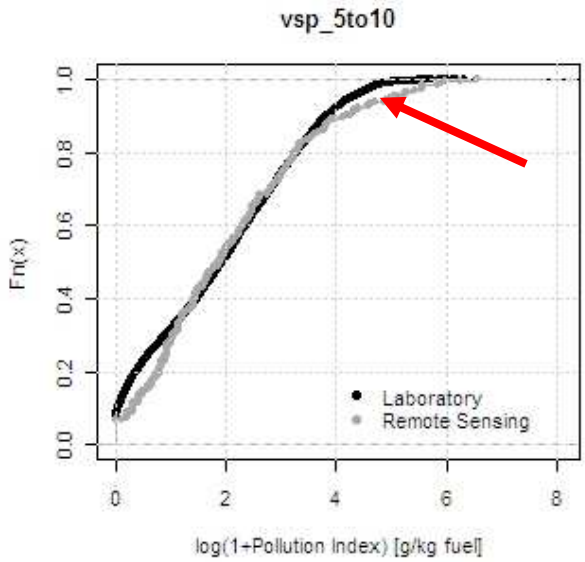


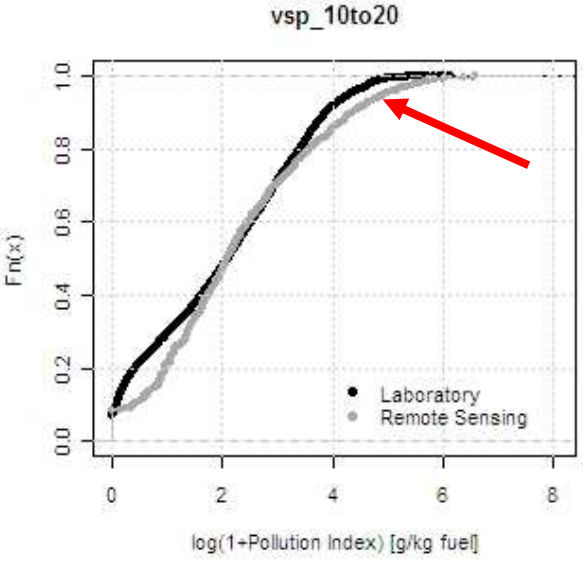


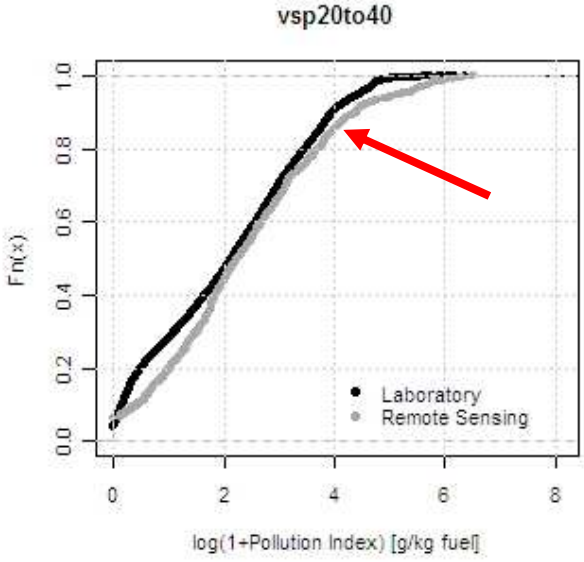


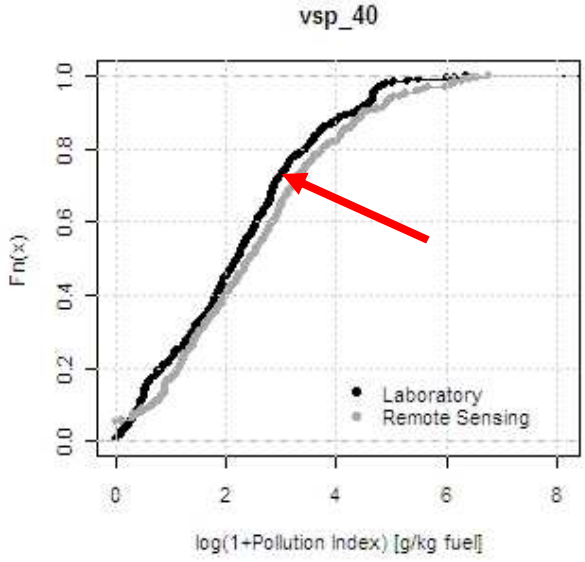


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# Conclusions

- Improved method of comparing laboratory and road-side data
- Initial trail
  - Perth data
  - Petrol cars ADR 37/01 (3,500 vehicles)
- RSD measurements tend to be higher
- Effect of gross emitters missed in laboratory testing?
- Develop correction factor for emission models based on laboratory tests

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# 2. Validation of NZ Emissions Models

INPUT SHEET

repeat a previous run

Entry required in white cells. Entry optional in grey cells

step 1 select year 2005

step 2 run number 2

step 3 optional fleet profile

| | tonnes | | % of VKT default values 2005 | % of VKT optional user entry |
|---|---|---|---|---|
| cars | | petrol | 70.5% | 68.0% |
| | | diesel | 8.0% | 9.2% |
| LCV | <3.5 | petrol | 4.5% | 13.7% |
| | | diesel | 9.2% | 5.8% |
| HCV | 3.5-7.5 | diesel | 1.8% | 1.7% |
| | 7.5-16 | diesel | 1.2% | 0.8% |
| | 16-32 | diesel | 3.1% | 0.9% |
| | >32 | diesel | 1.0% | 0.0% |
| BUSES | >3.5 | diesel | 0.6% | 0.1% |
| | | | | 100% |

step 4 optional model inputs

| | default values | optional user entry | options |
|---|---|---|---|
| average trip length (km) | 8.8 | | 0 to 100 |
| ambient temperature °C | 20 | | -10 to 30 |
| petrol fuel type - see worksheet | 3 | | 0 to 6 |
| diesel fuel type - see worksheet | 3 | | 0 to 5 |
| consider cold start? | yes | | no |
| consider degradation? | yes | | no |
| % of catalyst not working - old vehicles | 15% | | 0-100% |
| % of catalyst not working - new vehicle | 0% | | 0-100% |

| Vehicle type | Number of wheels default values | optional user entry |
|---|---|---|
| Car | 4 | |
| LCV | 4 | |
| HCV 3.5-7.5 t | 6 | |
| HCV 7.5-16 t | 6 | |
| HCV 16-32 t | 8 | |
| HCV >32 t | 8 | |
| Buses >3.5 t | 6 | |

Step 5 define average speed

| | | |
|---|---|---|
| cars | 41.5 | km/h |
| LCV's | 35.4 | km/h |
| HCV's/buses | 38.4 | km/h |

step 6 calculate emissions factors

Vehicle Emissions Prediction Model

VEPM Version 2.20

Developed for the Auckland Regional Council by Uniservices.
With default fleet data from the Ministry of Transport Vehicle Fleet Model

Continue

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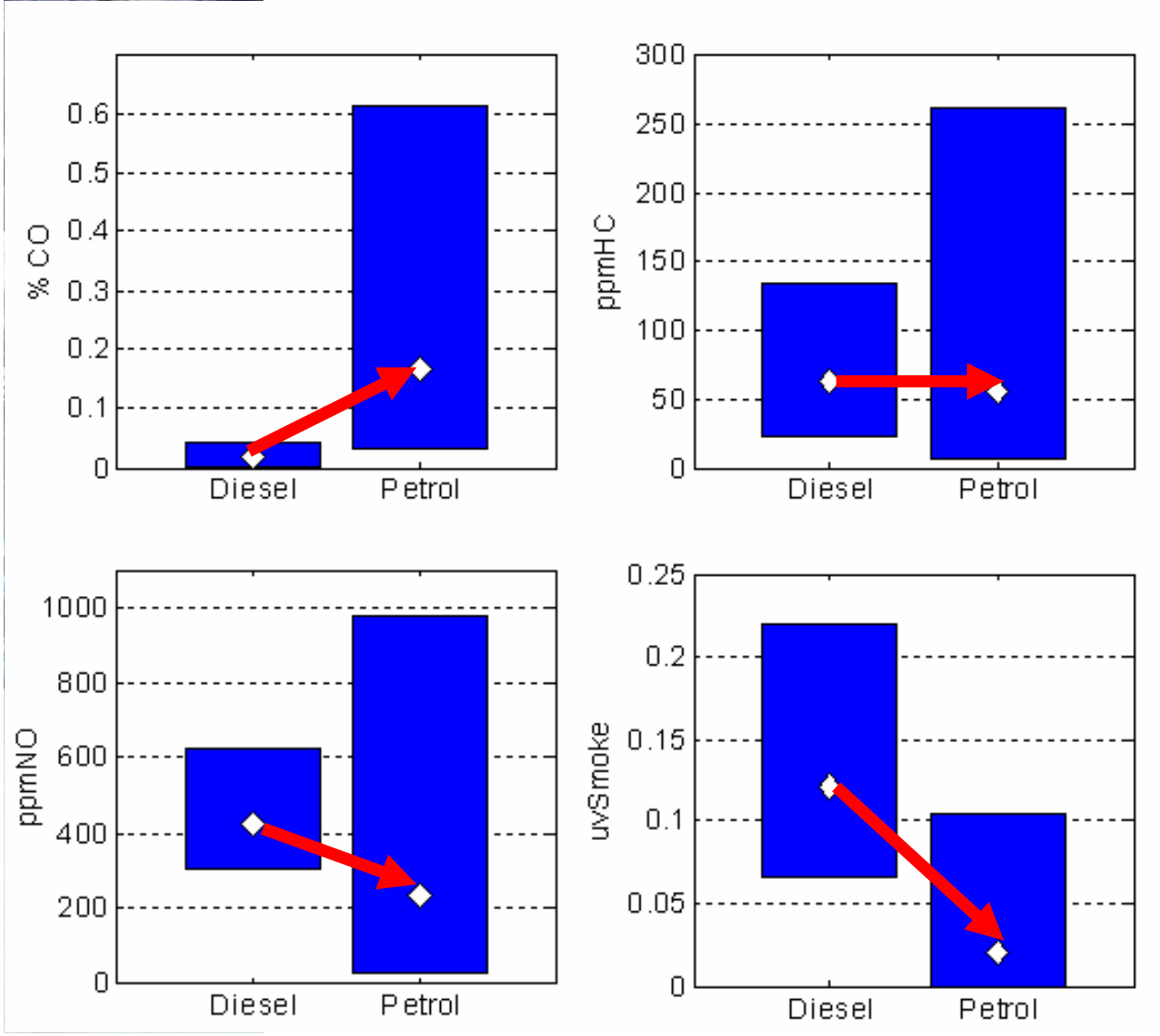
# "*Reality Checks*" – Relative Comparisons

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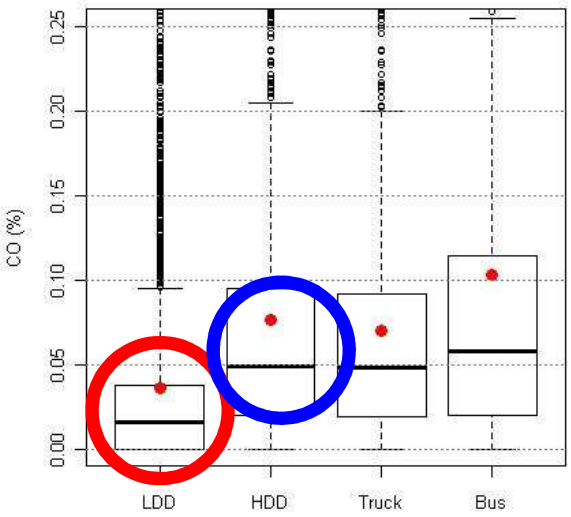
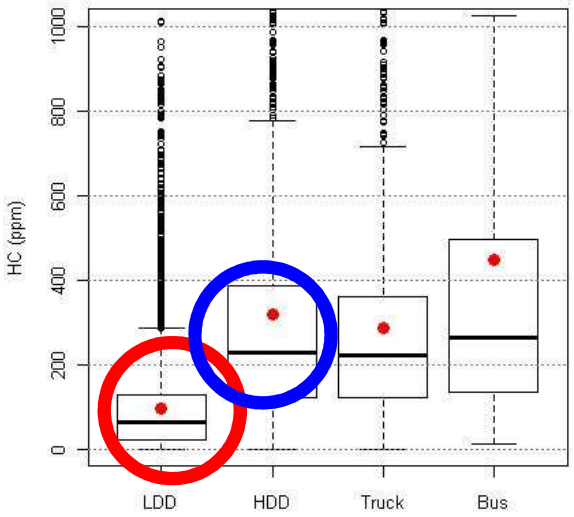
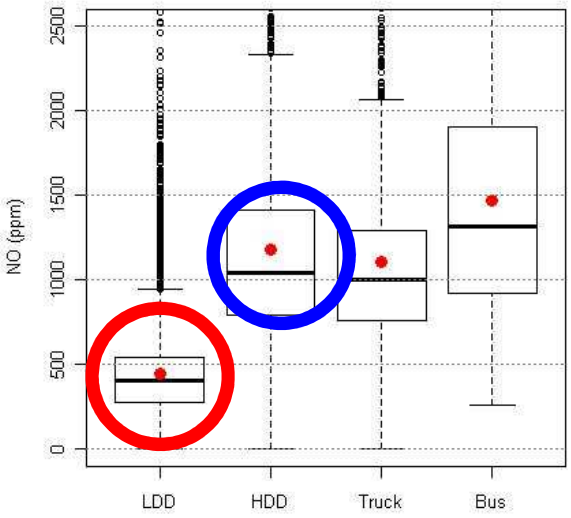
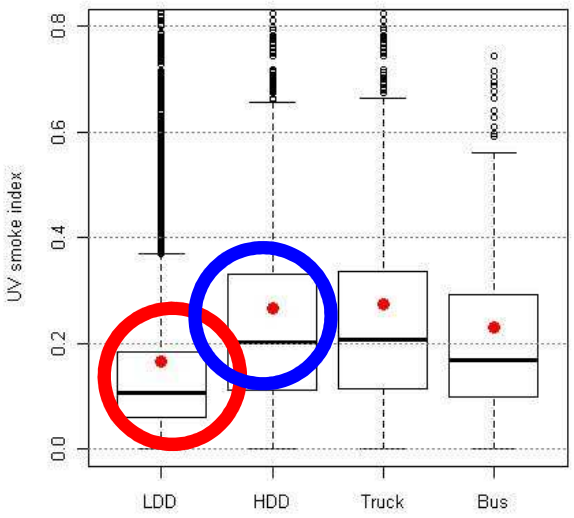
# Vehicle type – Diesel LDD vs HDD

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# Comparison of modelled and measured emission factors

RSD data: %CO

chemisty

g CO/litre of fuel

Vehicle fuel efficiency

g CO/km

vehicle travel

Some UNCERTAINTY

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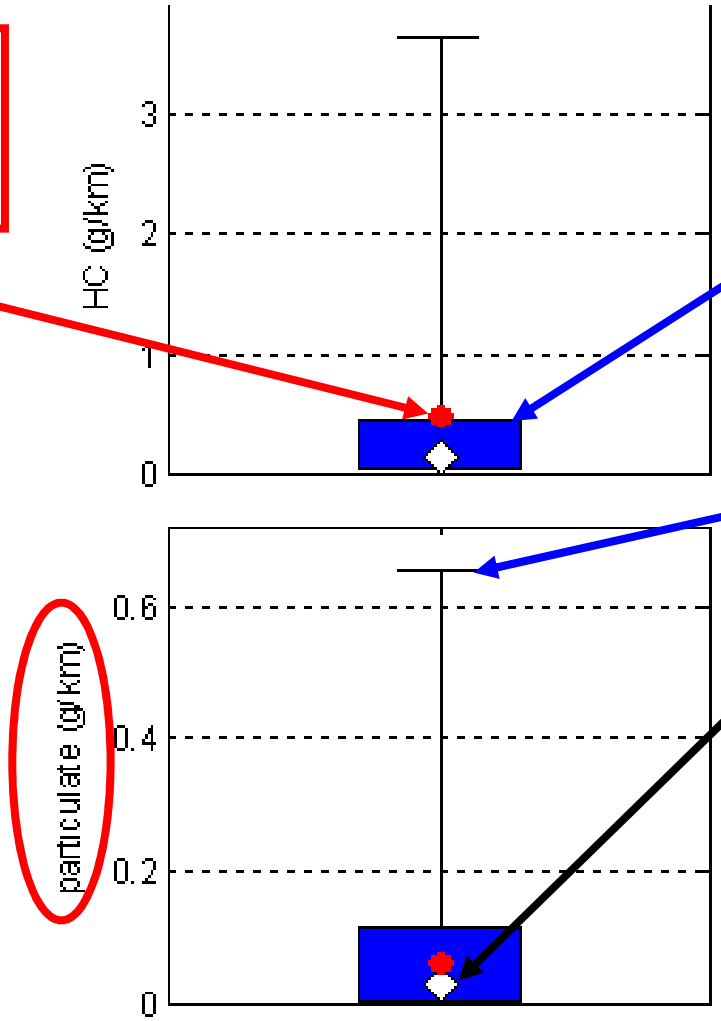
# Results: Example charts

Red diamonds: VEPM emission factor




Box and Whisker plots: On-road data

Box: Inter-quartile range (25 to 75)

Whiskers: 95% CI

White diamond: Median value

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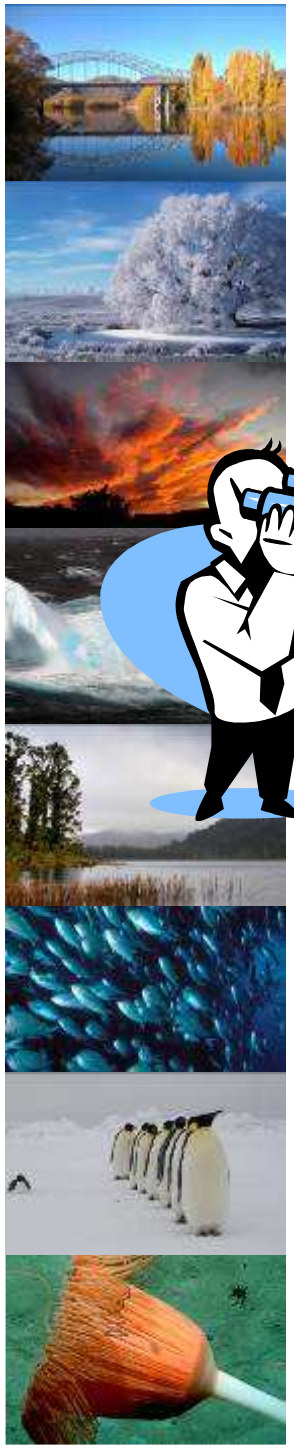
# Results 1: Fleet average





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# Conclusions

- Potential value of real-word data to improve confidence in NZ emission factors and models
- Still loads of (exciting!) work to be done

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# 3. Trends in Vehicle Emissions

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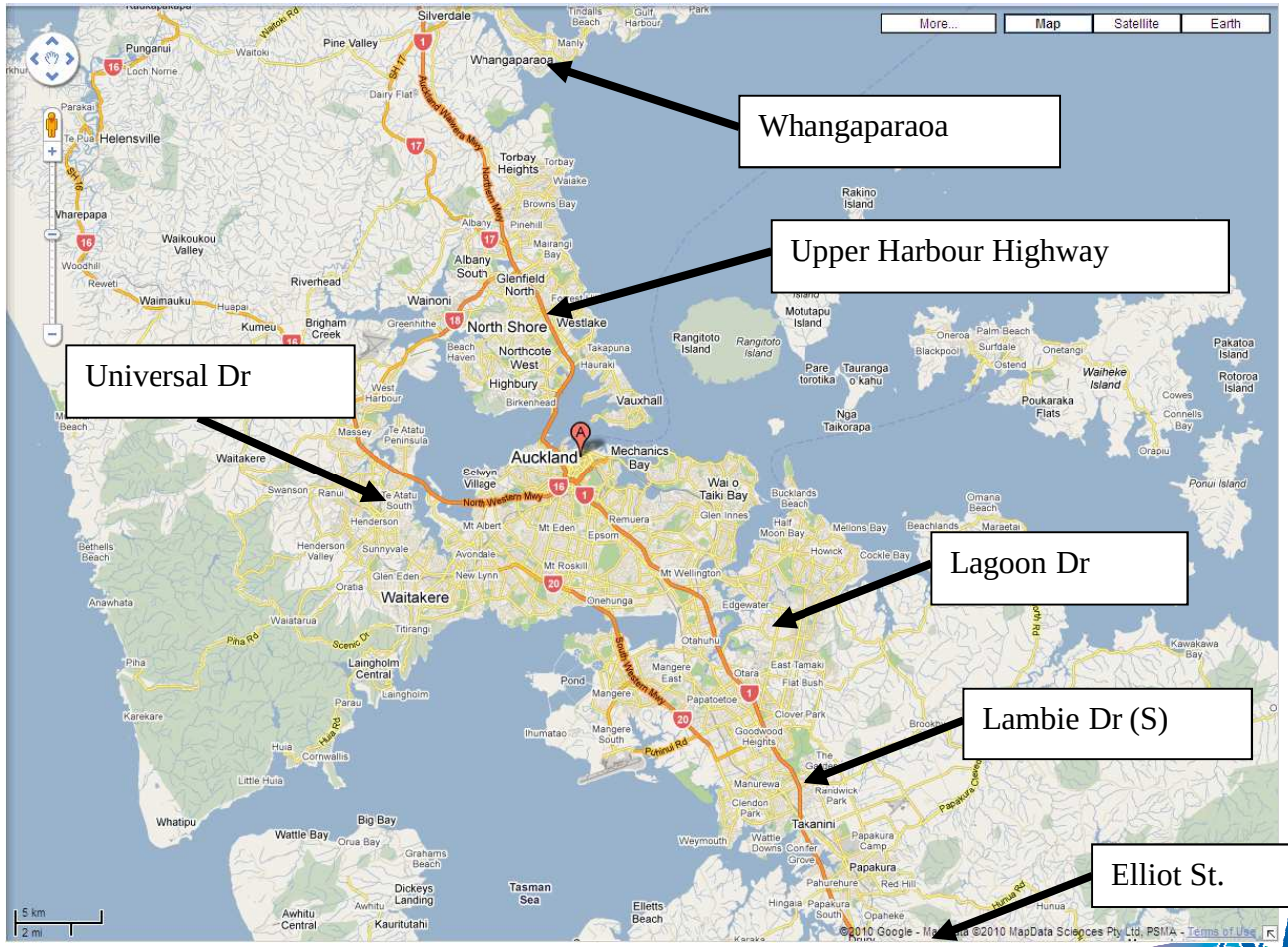
# Monitorng Sites

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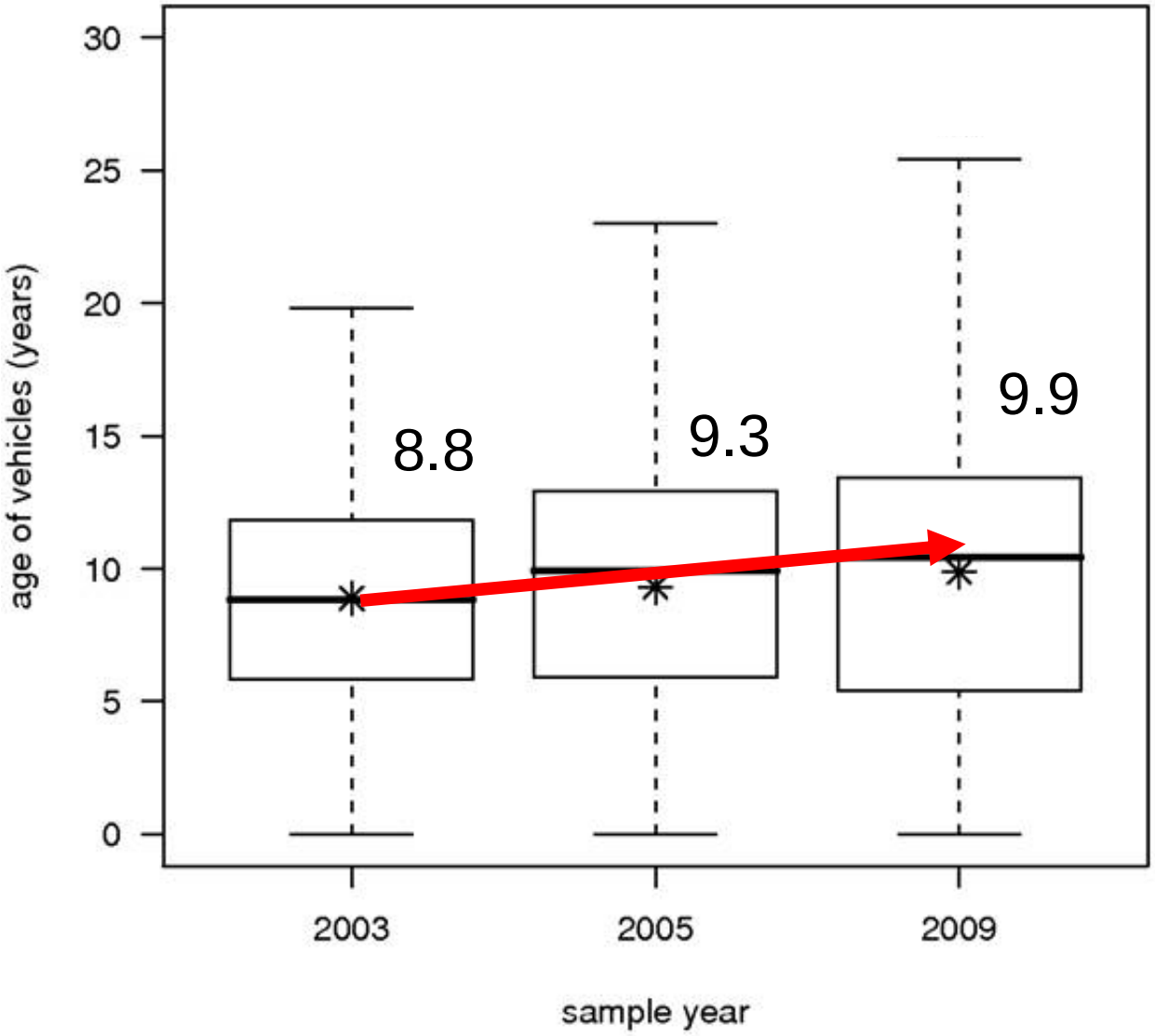
# Light Duty Fleet Vehicle Age

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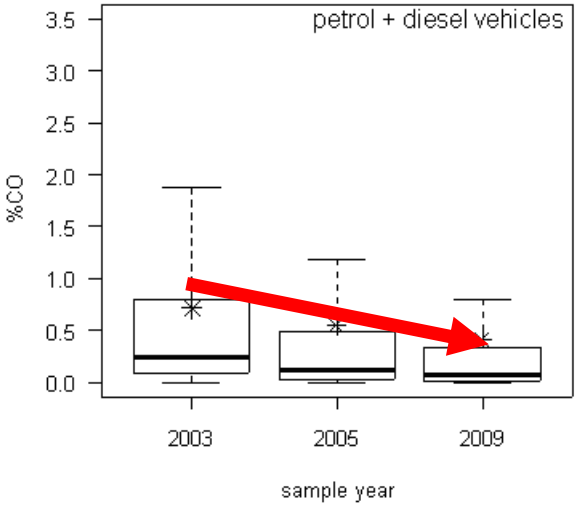
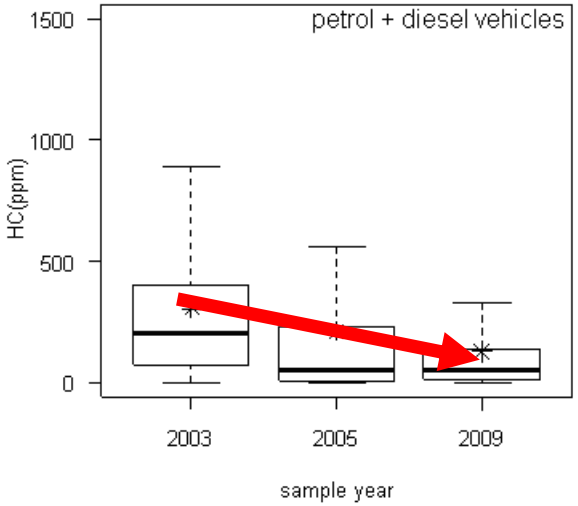
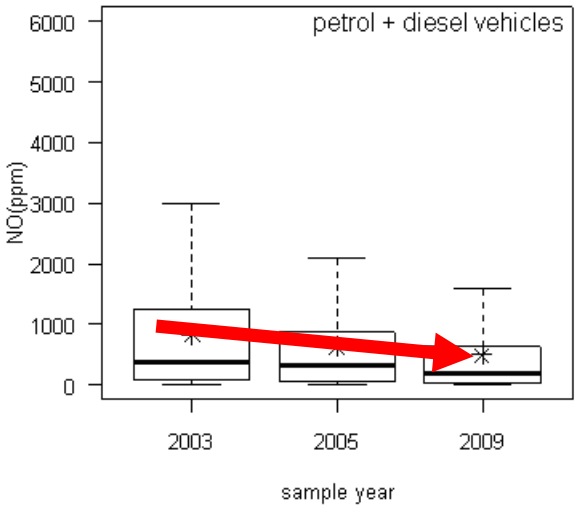
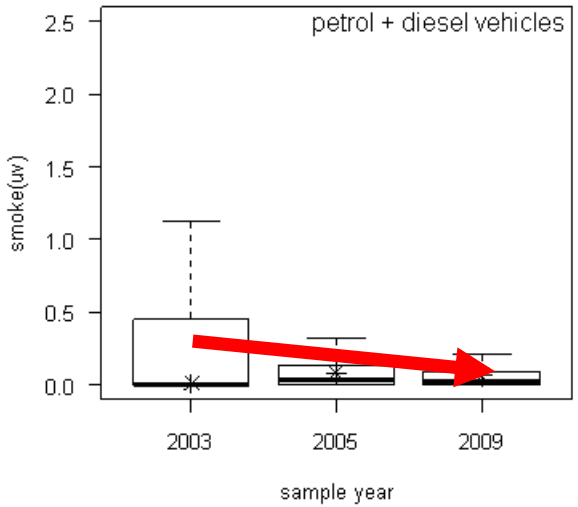
# ns

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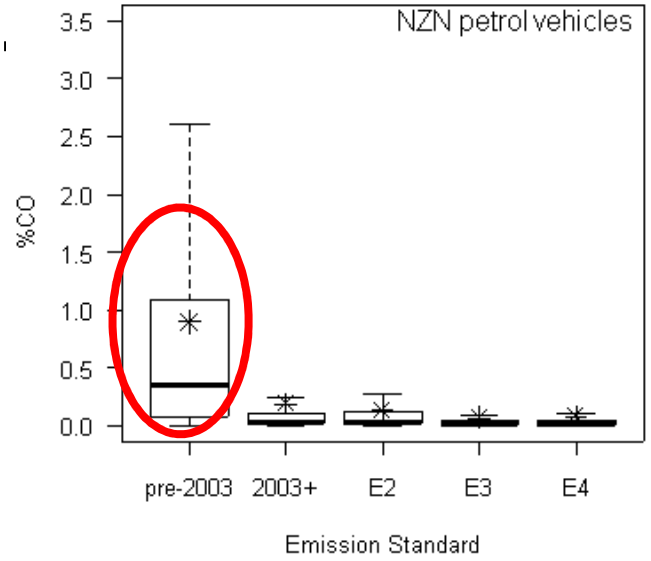
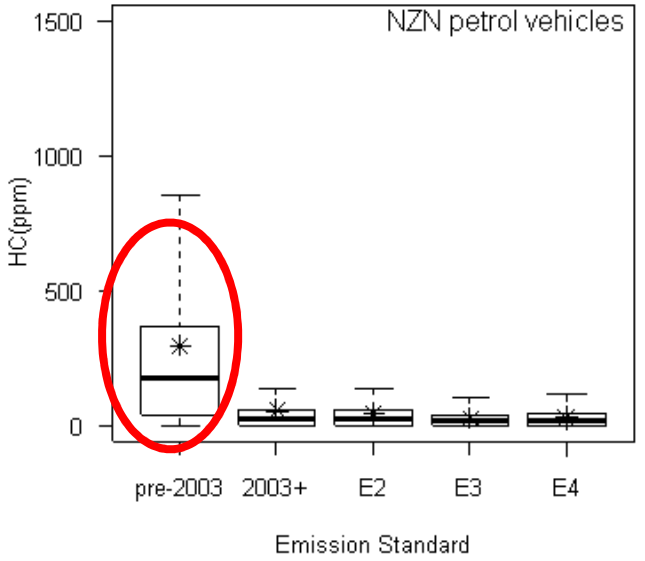
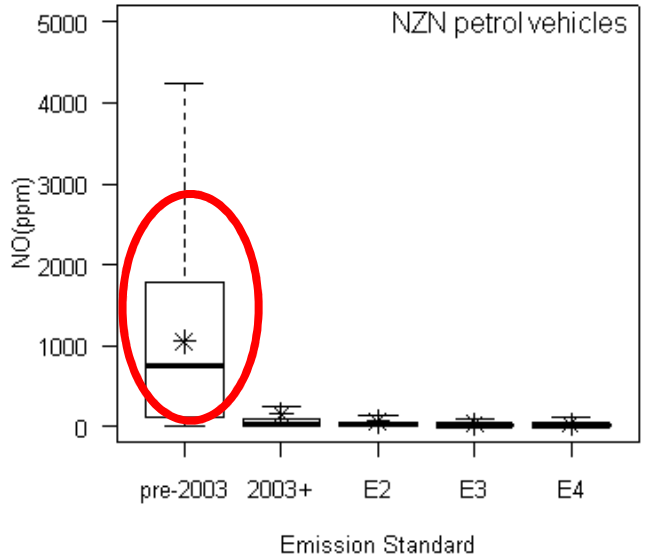
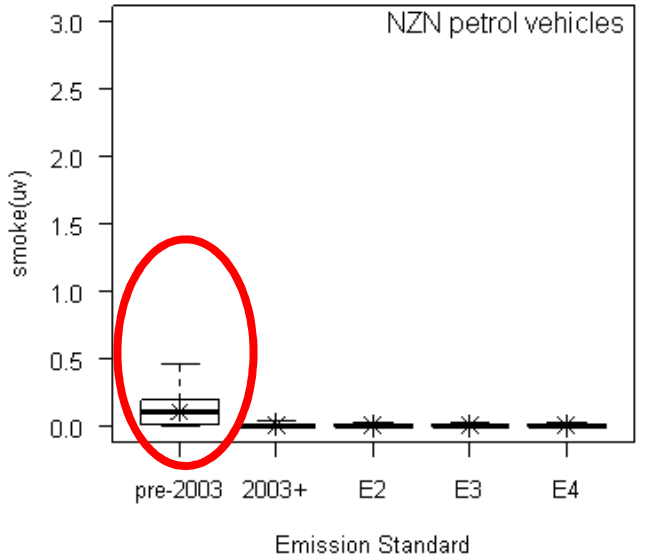
# E


NZN petrol vehicles
%CO
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
pre-2003
2003+
E2
E3
E4
Emission Standard


NZN petrol vehicles
HC(ppm)
1500
1000
500
0
pre-2003
2003+
E2
E3
E4
Emission Standard


NZN petrol vehicles
NO(ppm)
5000
4000
3000
2000
1000
0
pre-2003
2003+
E2
E3
E4
Emission Standard


NZN petrol vehicles
smoke(uv)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
pre-2003
2003+
E2
E3
E4
Emission Standard

# Other details

- Very interesting results
  - Petrol vs diesel
  - New Zealand (NZN) new vs Japanese imported used (JPU)
  - Emission standards (NZN and JPU)
  - Odometer reading
- 100 page report
- Review edits currently being made
- Release date last week in November

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# Emission Trends Project Dissemination Workshop

- Details to be confirmed
- Preliminary arrangements
  - Auckland
  - Tuesday 7 December
  - 9:30 to 12:30
  - Lunch provided
  - Free!
- See Rob Hannaby to register interest

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# Acknowledgements


- Robin Smit – (PAEHolmes Australia)
- Janet Petersen - (Auckland Council)
- Gerda Kuschel - (Emission Impossible)
- Rob Hannaby – (NZTA)
- Research Steering Group for the Emission Trends project - (Iain, Janet, Rob, Louise and Haobo)
- Lou Reddish - (NIWA)


THANK YOU

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