

# **LDV Real Driving Emissions:**

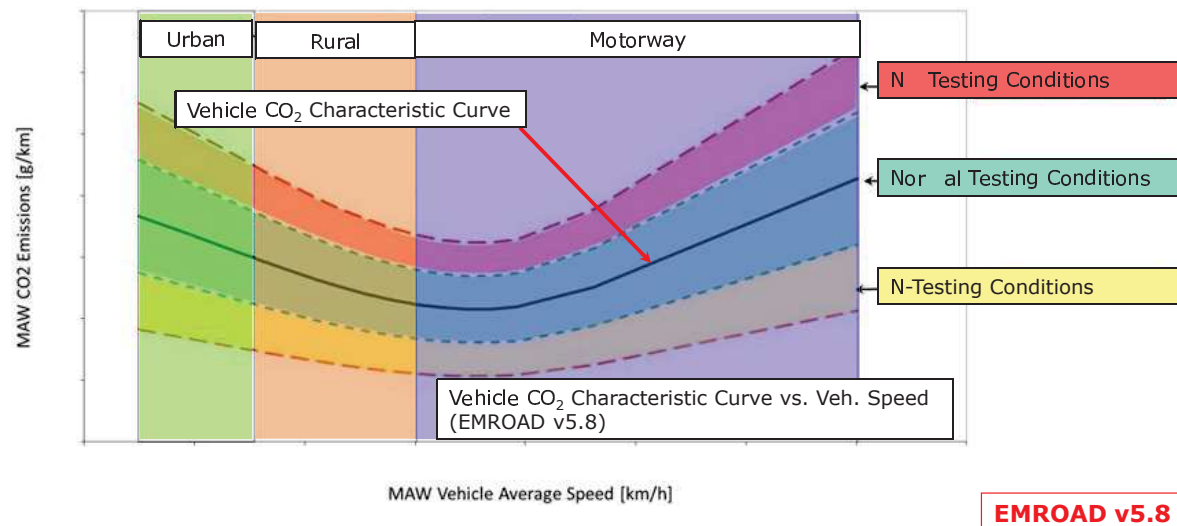
- MAW evaluation method - EMROAD 5.8 -**
- Status of work -**

**RDE DE Task Force Meeting, March 20, 2014**

- **Basics and issues documented until version 5.7**
- **Proposed improvements**
- **Results for first 5 vehicles**

# Reminder: Moving Averaging Window Basics

- Averaging by sub-sets (windows), step 1s
- Averaging reference: CO<sub>2</sub> based (1/2 WLTP)
- g/km currently calculated in the windows
- Windows evaluated and sorted in different categories (normal or not, urban, rural, motorway,...)
- 'Normal windows currently within +/- 25% of the reference



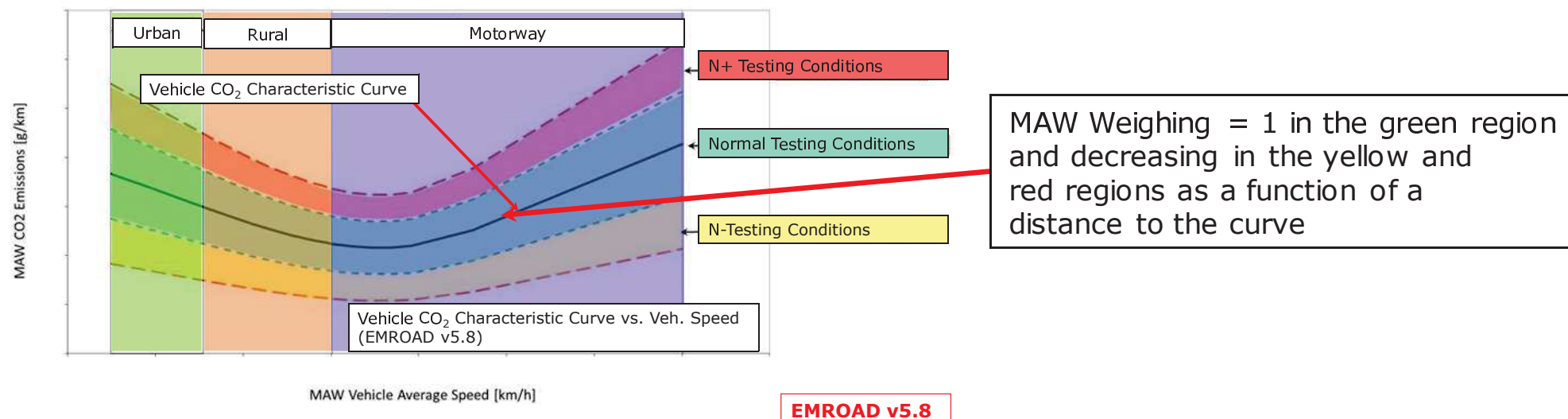
# Main issues documented until version 5.7



- **Exclusion of windows close to the normal driving band (currently  $\pm 25\%$  from the reference CO<sub>2</sub> curve)**
- **Selection of appropriate indicators for decision making (50, 90<sup>th</sup> percentiles or average from the distribution of MAW emissions)**
- **Potentially insufficient sensitivity of the CO<sub>2</sub> indicator to address situations which may be regarded as soft/severe or anomalous (high dynamics = pumping, anomalous gear-shifting strategy,...)**

# Improvements (to be implemented under 5.8)

- **Weighing function for the MAWs with respect to their distance to the reference curve**
- **Emissions are calculated as weighted average of the MAW emissions, therefore providing a single value**
- **Advantage: mitigates the effect of 'strict' boundaries between the different areas, the result is a single average value**
- **Disadvantage: loss in sensitivity for interpreting the MAW results (No 50 and 90<sup>th</sup> percentiles any longer)**



# Improvements (to be implemented under 5.8)



- **Indicator of the test “normality”: Average distance of the Urban/Rural/Motorway windows (in %) to the reference curve (NB: This indicator currently provided for information only and is not used within the method)**
- **(Additional indicators (e.g. RPA) for soft/severe or anomalous situations)**

# Testing Conditions: Completeness and Normality



- Normal driving is defined from reference CO2 emissions (or energy consumption) to the type approval cycle.
- The CO2 reference for normal driving is not a fixed value but varies as a function of the vehicle average speed = CO2 characteristic curve
- Tolerances around the curve define normal driving.
- The 'distance' of a window to the curve (above = positive or below = negative) defines the degree of severity (the further from the reference curve, the less the window is normal)

Completeness = 10% for the current calculations (but we recommend a Min. 15% of U/R/M windows, once proper recommendations are available for the route selection and composition)

Normality = Min. 50% of normal windows within the U/R/M categories

# Testing Conditions: Completeness and Normality



- The current methods settings are “calibrated” from the first vehicles in the database, tested on several different routes.
- The method is designed to force the testing to achieve a maximum number of windows within the normal band (currently Tolerance 1 =  $\pm 25\%$  around the reference), which is usually easy if sufficient care is exercised for the route selection.

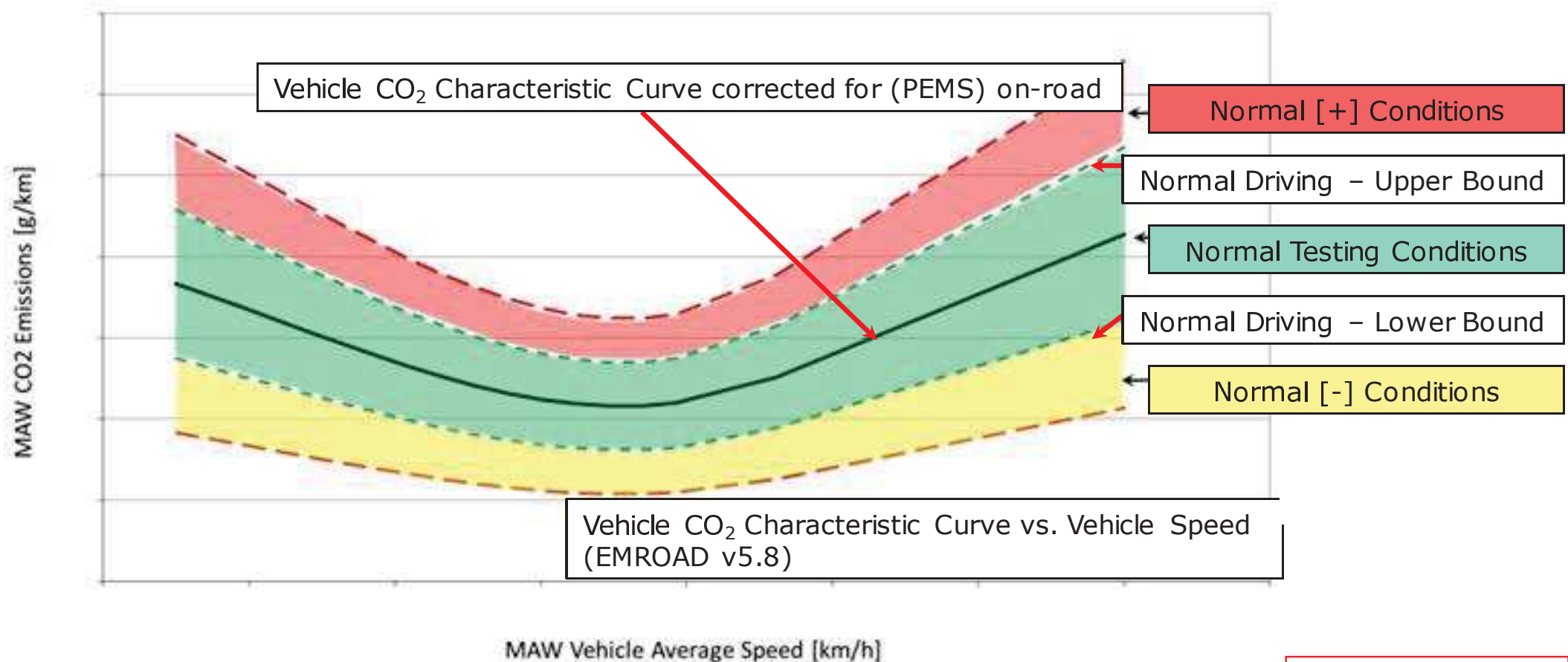


# Supporting slides and results



# Testing Conditions: Completeness and Normality

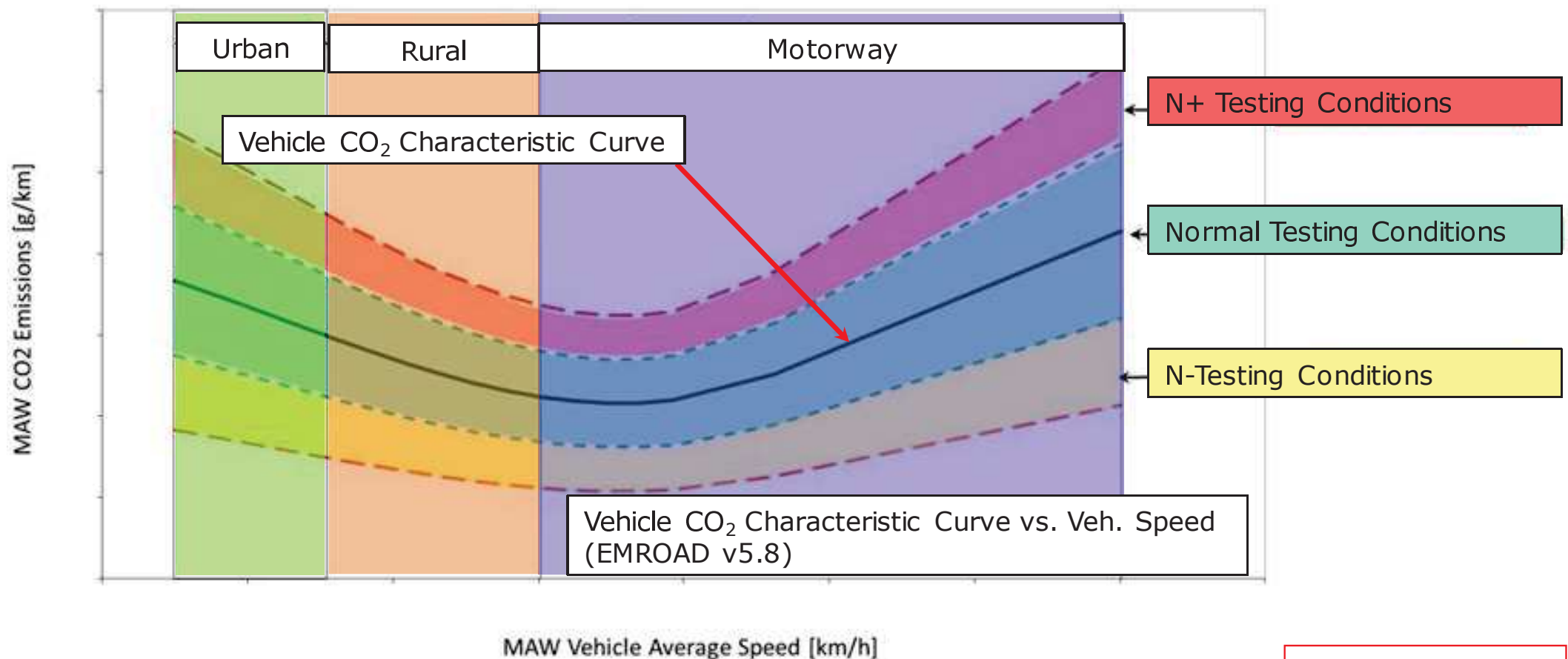
- **MAW (CO<sub>2</sub>-Average Speed) may fall in three different areas:**
  - ❑ **Normal driving (MAW within Normal Driving Upper & Lower Bounds);**
  - ❑ **Normal [+] driving (MAW within Severe & Normal Driving Upper Bounds);**
  - ❑ **Normal [-] (MAW within Severe & Normal Driving Lower Bounds).**



# Testing Conditions: Completeness and Normality

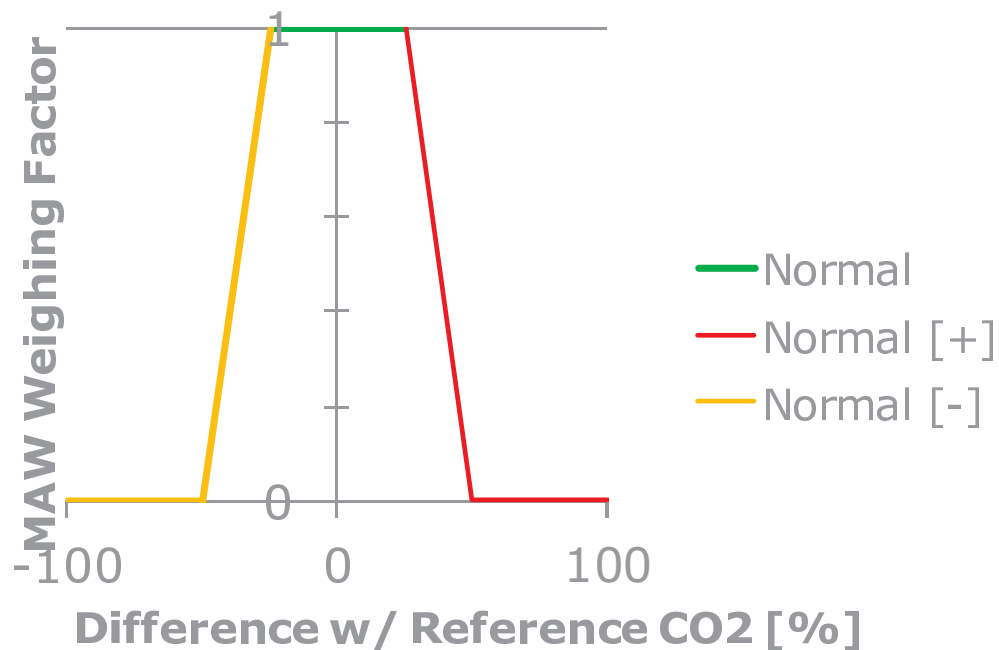
➤ **MAW** are also classified as Urban/Rural/Motorway using:

- ❑ **Urban driving (U)** ( $0 \leq \text{Veh.Speed}_{\text{MAW}} [\text{km/h}] < 45$ );
- ❑ **Rural driving (R)** ( $45 \leq \text{Veh.Speed}_{\text{MAW}} [\text{km/h}] < 80$ );
- ❑ **Motorway driving (M)** ( $80 \leq \text{Veh.Speed}_{\text{MAW}} [\text{km/h}]$ ).



# MAW Weighing Function

- **Tolerances for normal driving and weighing:**
  - ❑ **Tolerance 1 (currently 25%) = Normal driving – Weighing factor = 1**
  - ❑ **Tolerance 2 (currently 50%) = Normal + (or severe) and Normal - (or soft) regions - Weighing factor = Decreasing from 1 to 0 at  $\pm 50\%$**



# Testing Conditions: MAW implementation flexibility

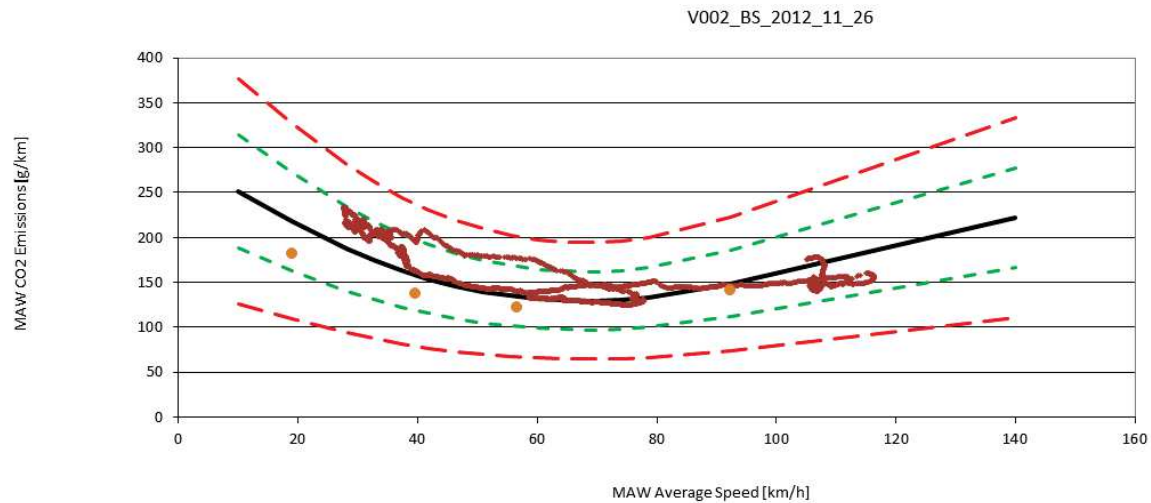


- "Normalization effects" which could give lower (or zero) weighing factors to windows outside the  $\pm$ Tolerance 1 (25%) band will occur for tests which include a significant amount of windows outside the band.
- These "Normalization effects" will very often appear only for specific driving conditions (U/R/M) and not for the results over the entire test. => Possibility to repeat only a part of the test, not the entire test
- Should a vehicle fail in meeting the minimum requirements for the normal windows, the manufacturer could – upon request – increase the value of Tolerance 1 by steps of 1% till the 50% of normal windows is reached (Similar mechanisms exist for HDV PEMS testing)

# Additional “backup” elements



- **Additional (Method specific or not) indicators (e.g. RPA) for soft/severe or anomalous testing situations**
- **Proposal = if the vehicle is found to fail, such indicators shall be used in a second step to validate/invalidate windows and/or the test**
- **Examples of MAW (i.e. method specific) indicators for driving dynamics (soft/severe)**



ALL WINDOWS			
2262	1147	784	4193
54	27	19	
16.04	7.10	-8.70	
0.07	0.05	0.05	
0.26	0.15	0.10	
0.00E+00	0.00E+00	0.00E+00	

Completeness = minimum share of U/R/M windows  
(proposal : >15% of all windows)

Severity Category >		MAIN RESULTS					NORMAL R-T1<W<R+T1			
		URBAN	RURAL	MOT.	CORRECT ED U/R/M WEIGHT	ALL	URBAN	RURAL	MOT.	
NUMBER OF WINDOWS							2183	1035	784	4002
% (WITHIN THE CATEGORY)							55	26	20	
% (W / ALL WINDOWS)							97	90	100	
SEVERITY INDICES		15.56	4.76	-8.70			15.56	4.76	-8.70	
CO_EMISSIONS	g/km	0.08	0.05	0.05	0.06	0.06	0.07	0.05	0.05	
NOx_EMISSIONS	g/km	0.27	0.15	0.10	0.17	0.19	0.26	0.14	0.10	
PN_EMISSIONS	#/km	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	

"Normality" Indices (0=Normal, >0 Severe, <0 Soft) – For information, not used for eval.

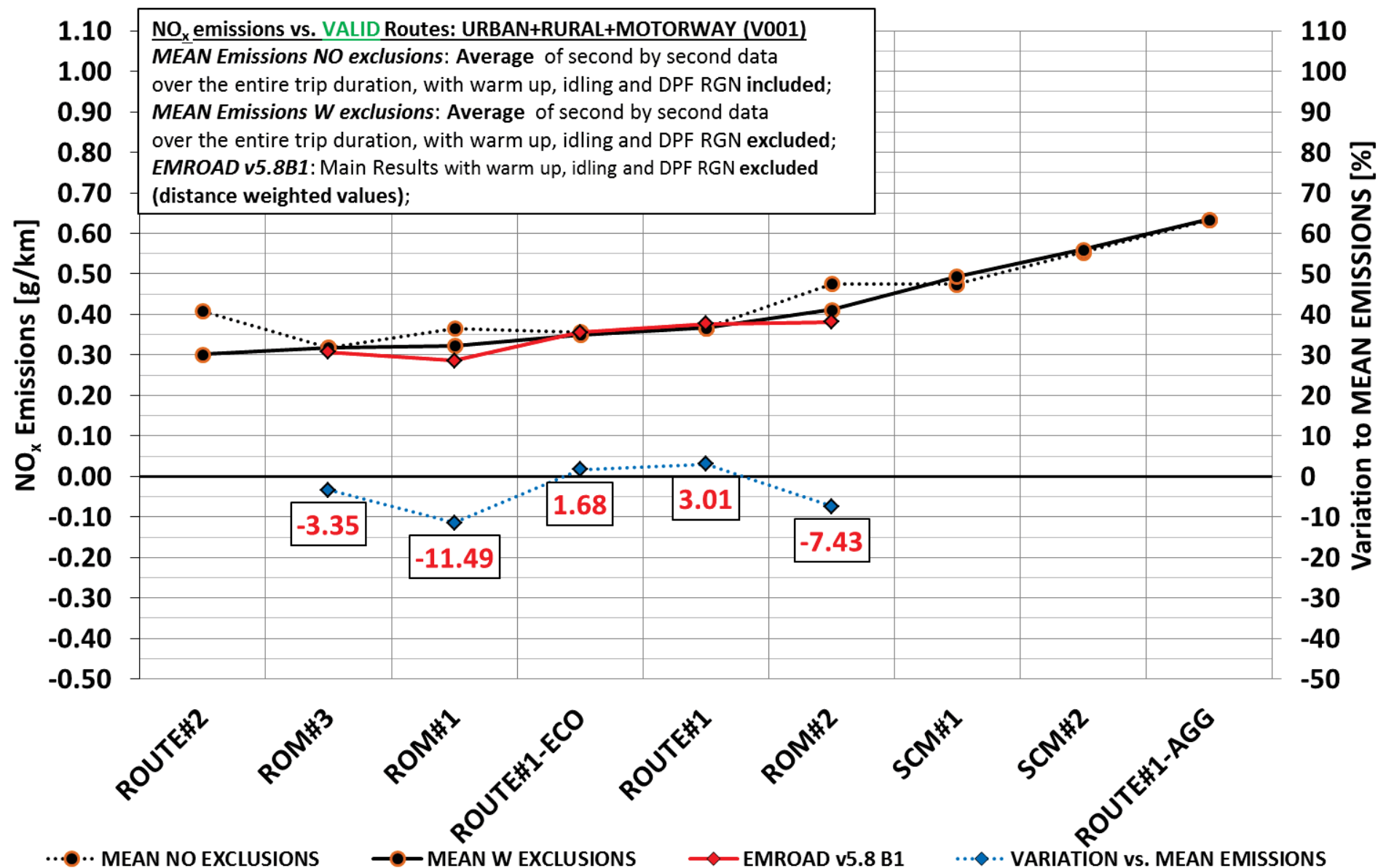
Emissions corrected for a balanced (1/3, 1/3, 1/3, distance) U/R/M trip composition

Emissions corresponding to the realized route using the realized shares of U/R/M driving

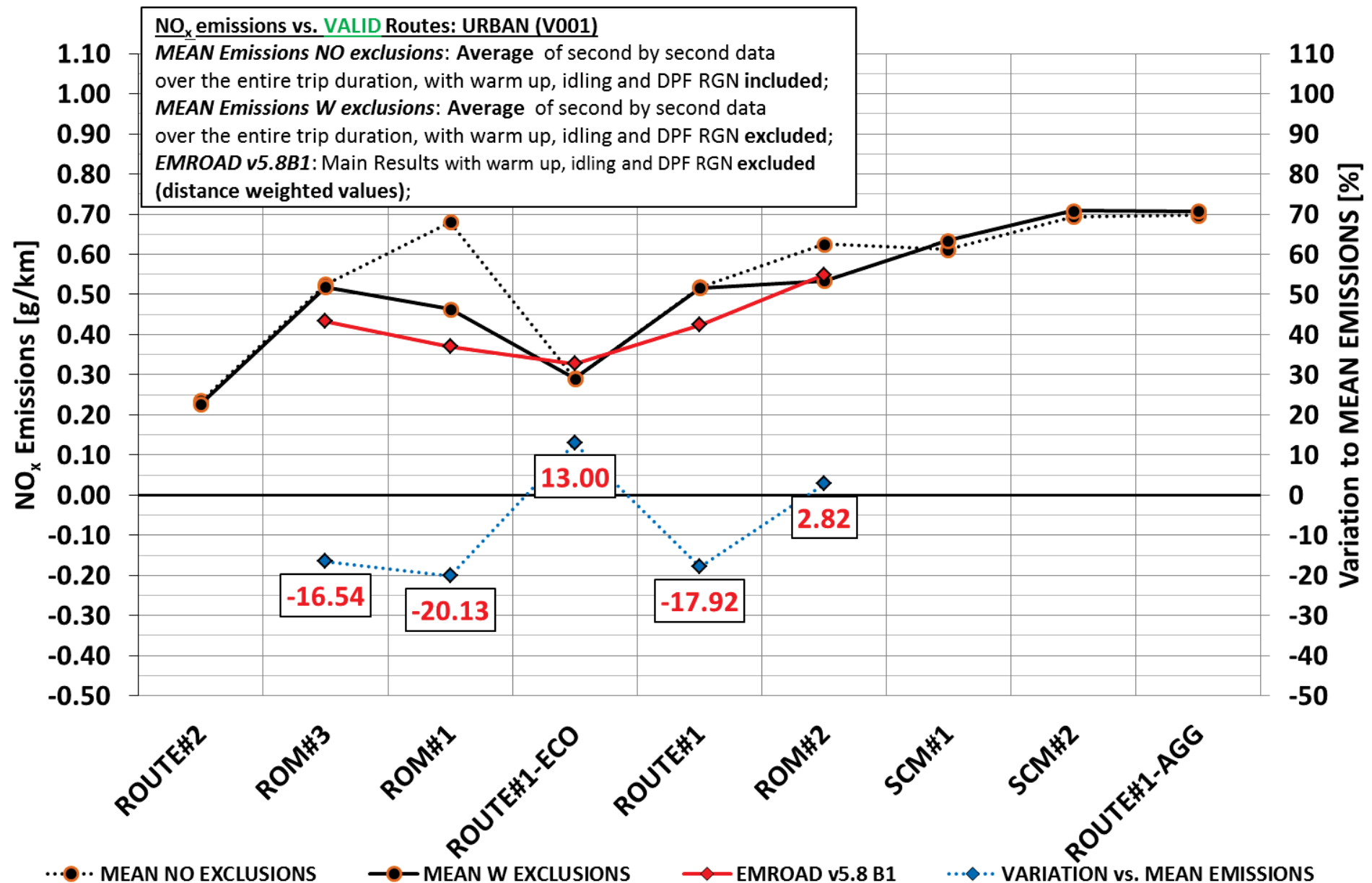
Normality= Percentage of normal windows within the U/R/M categories (>50%)



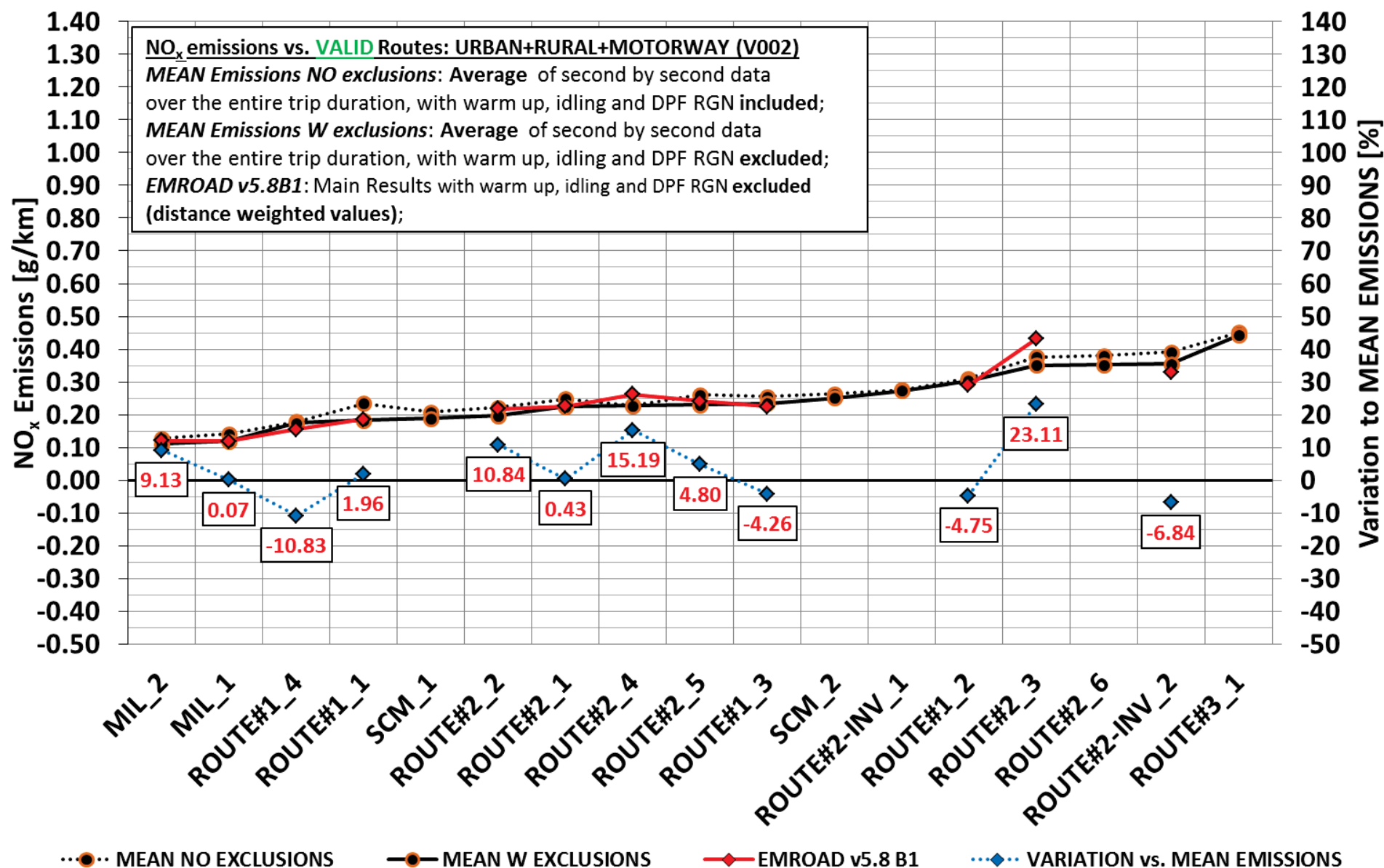
# Vehicle 001 - All



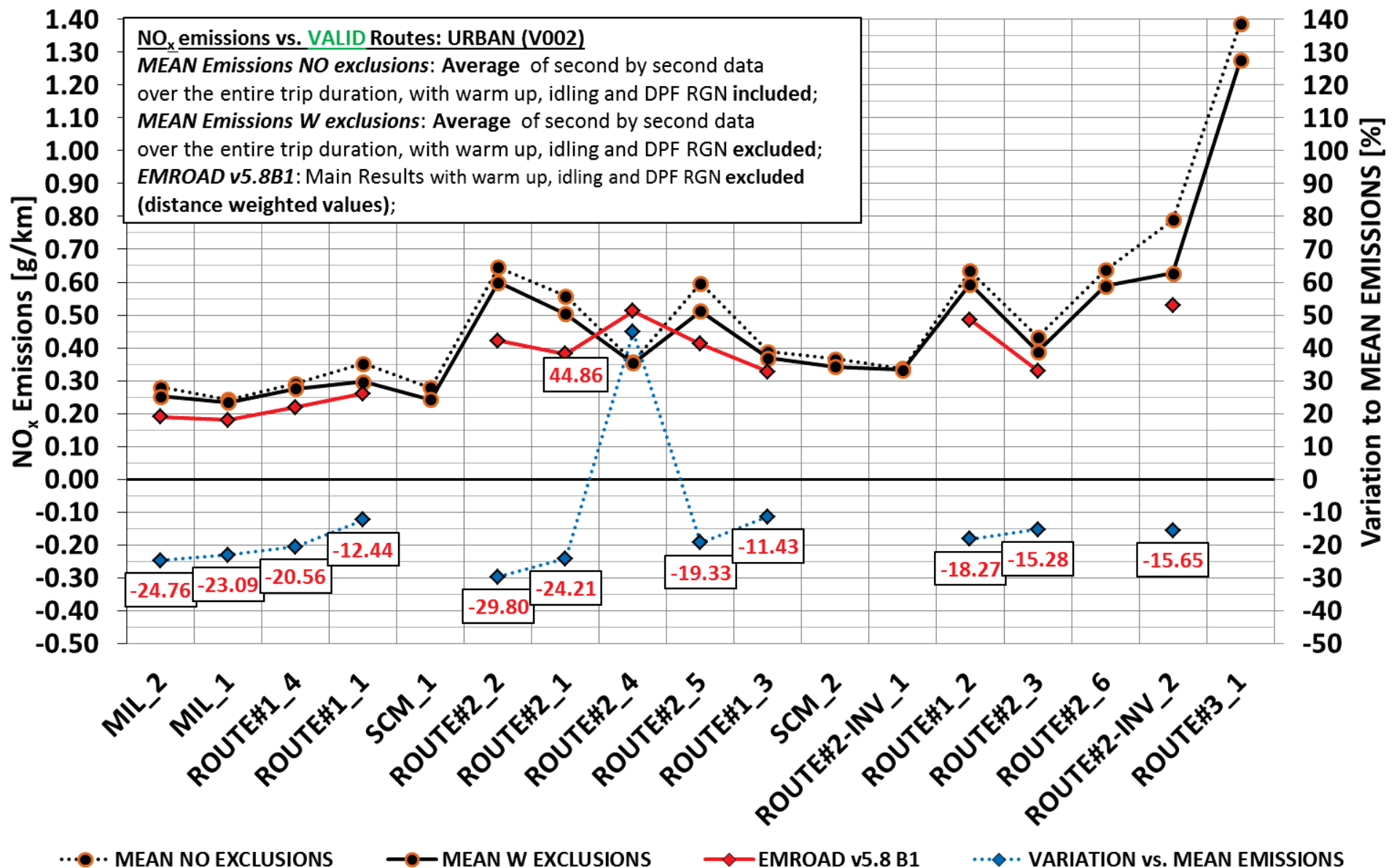
# Vehicle 001 - Urban



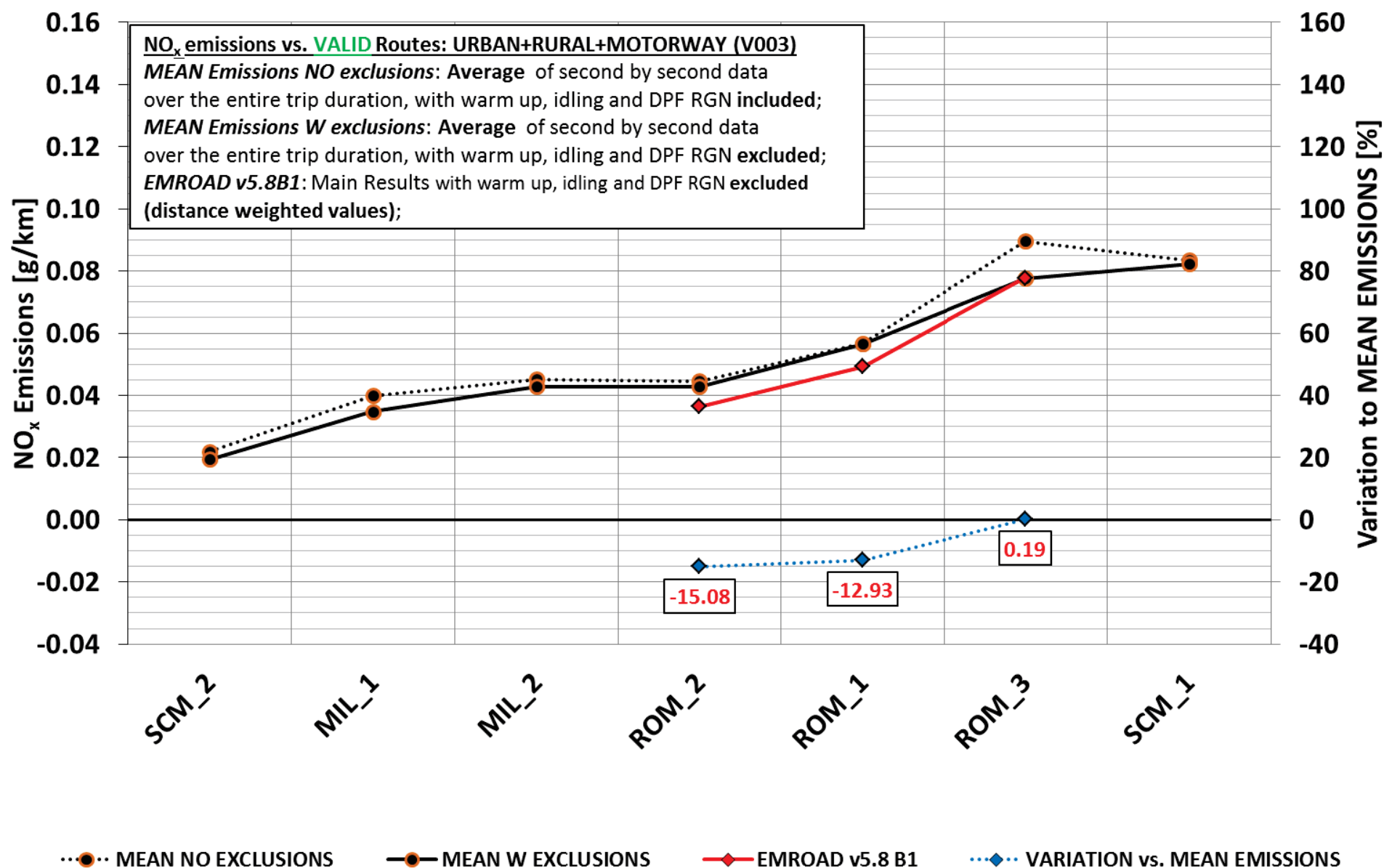
# Vehicle 002 - All



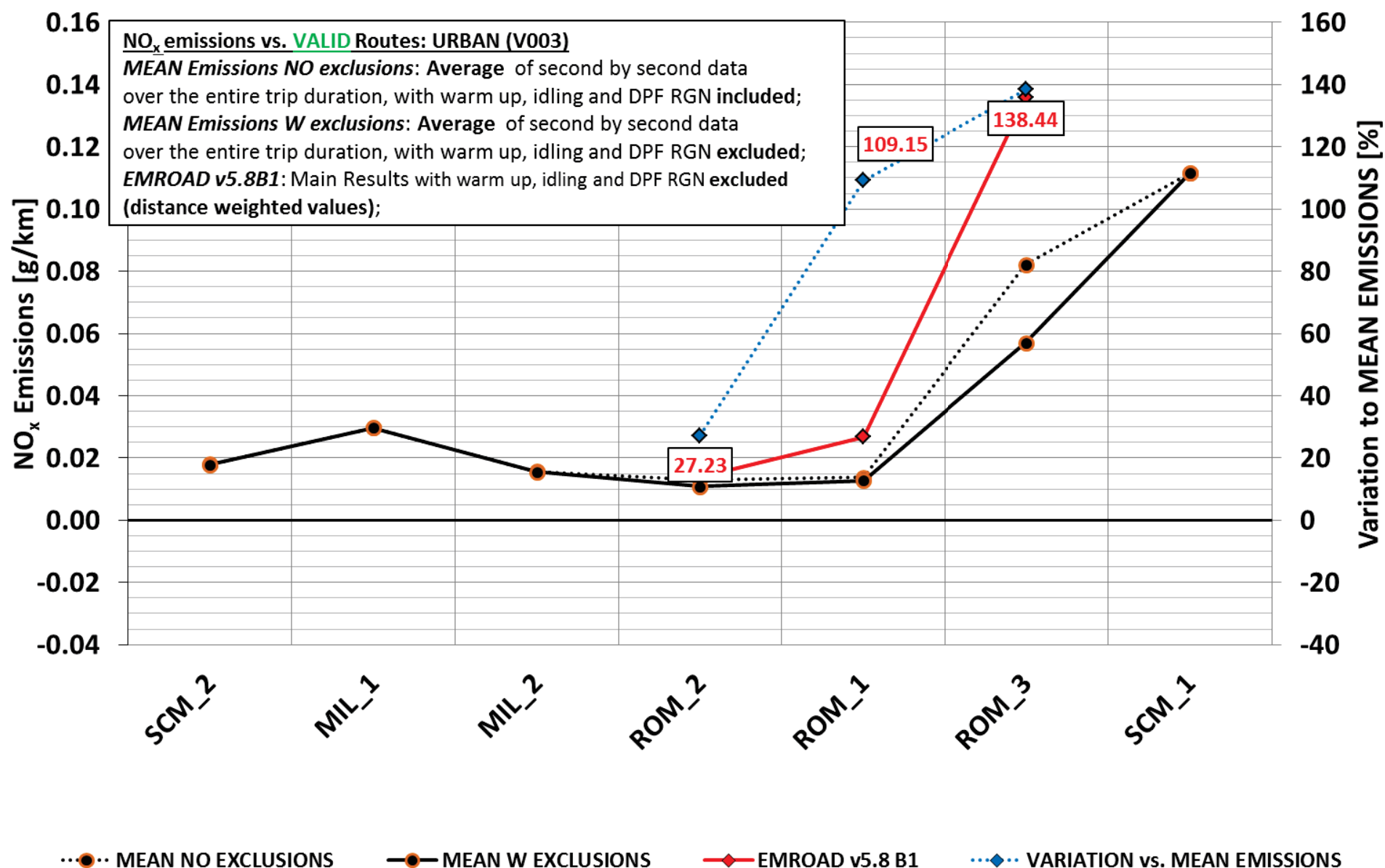
# Vehicle 002 - Urban



# Vehicle 003 - All

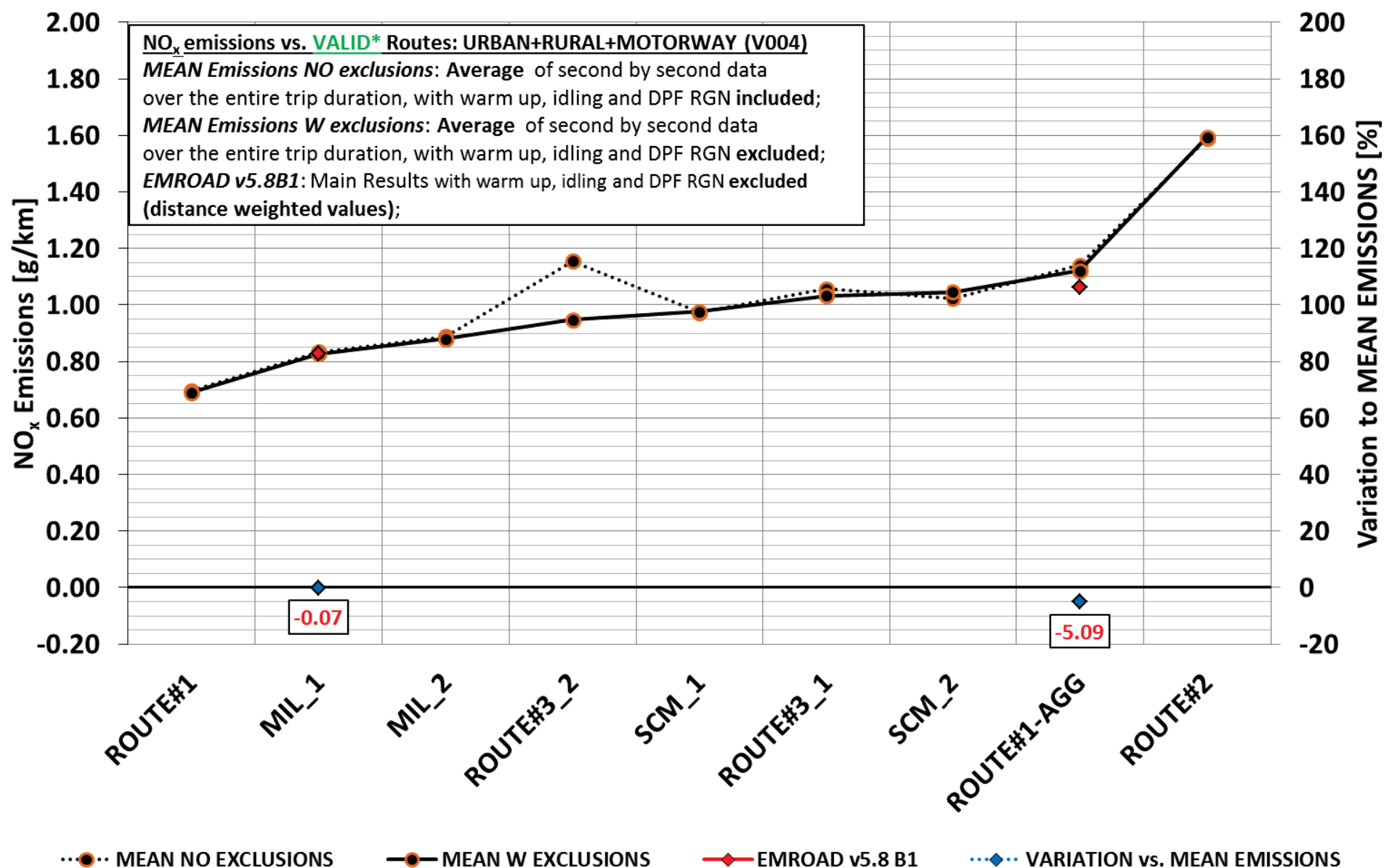


# Vehicle 003 - Urban

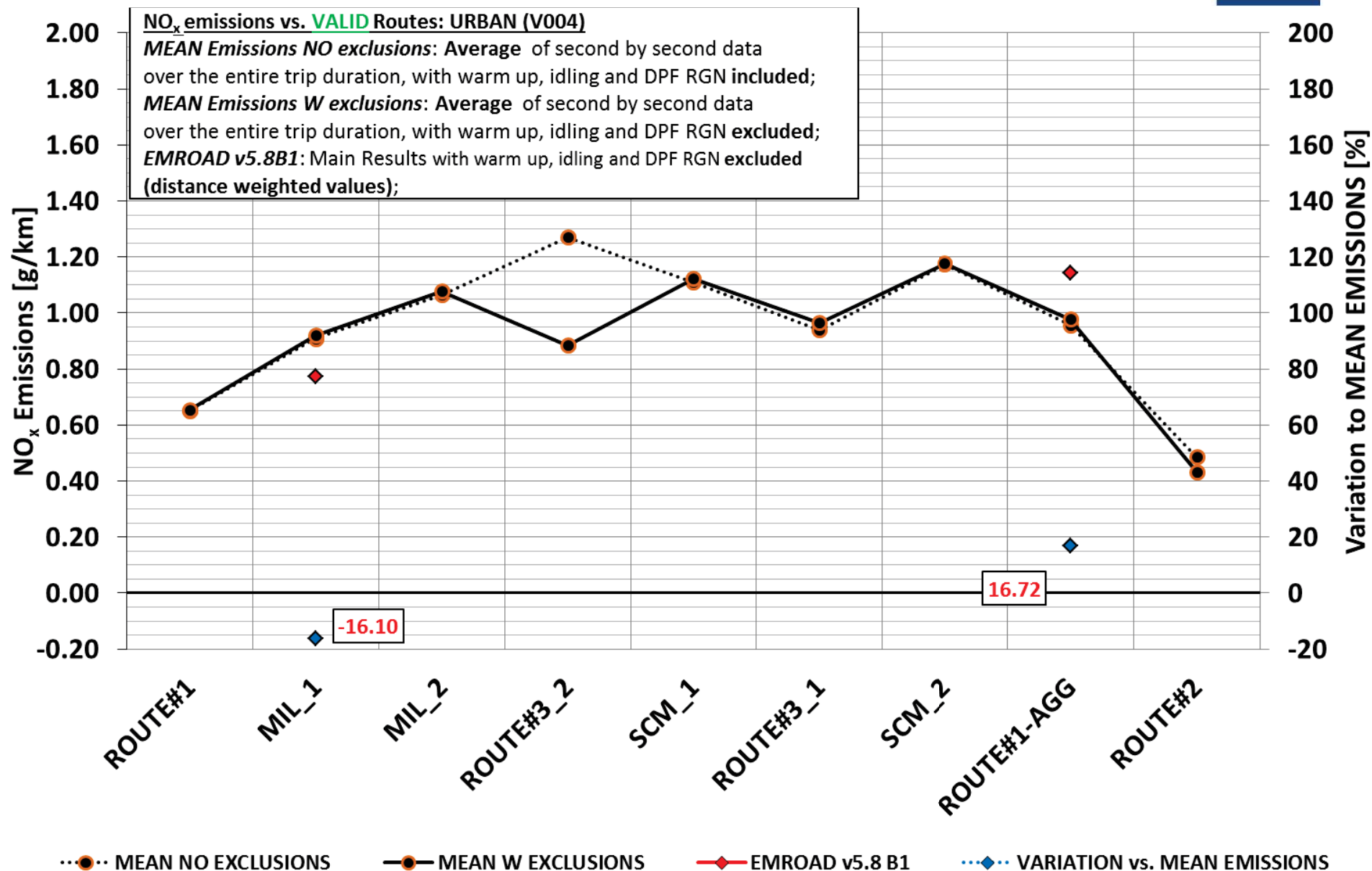




# Vehicle 004 - All

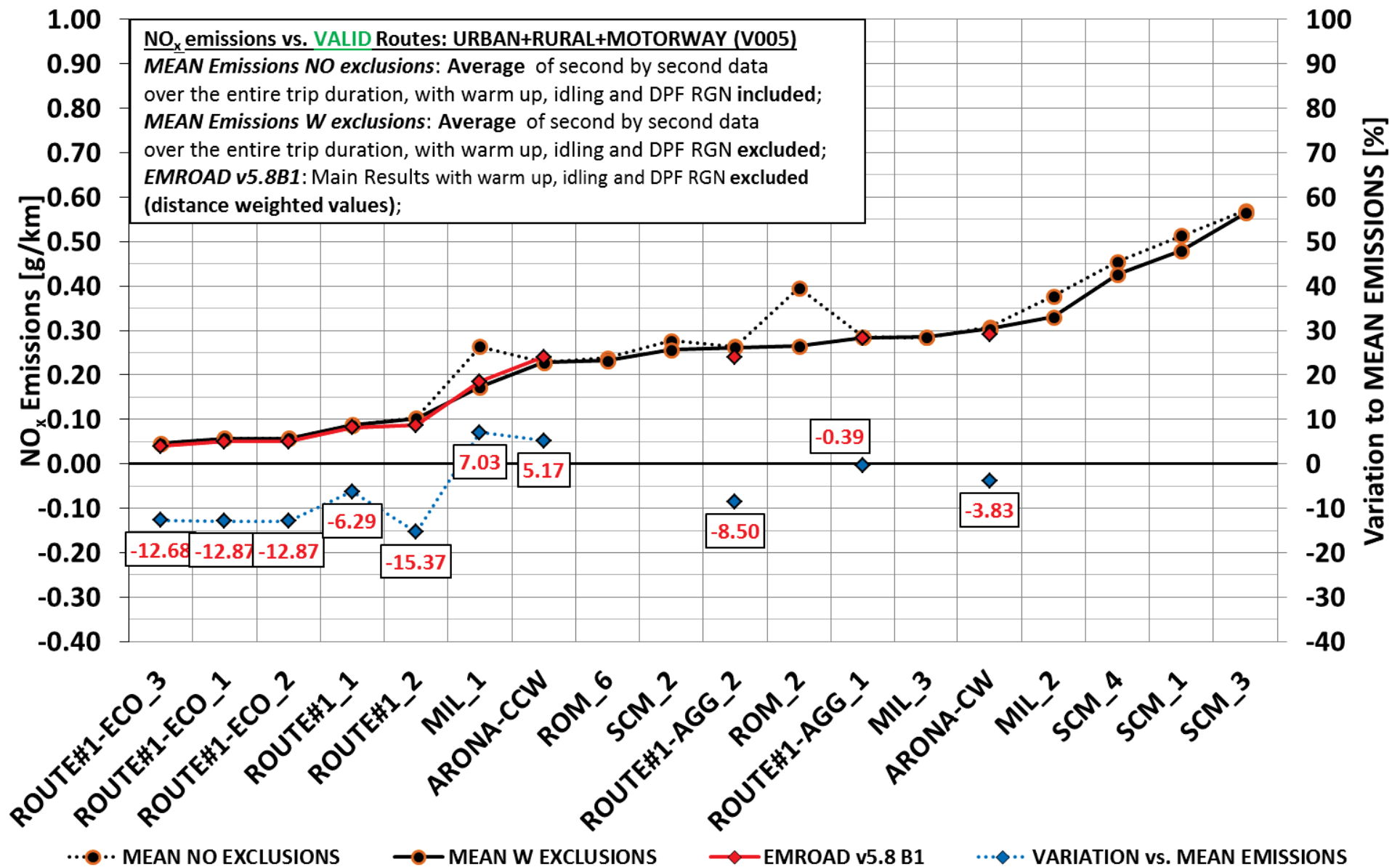


# Vehicle 004 - Urban





# Vehicle 005 - All



# Vehicle 005 - Urban

