Introduction of COPERT IV and Pollemission

Ruiwei Chen

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On-road traffic emissions

- For each link, the hot emission is:

$$E = E_{hot} + E_{cold}$$

$$E_{hot,i,j}(g) = e_{hot,i,j}(g.km^{-1}) \times N_j(veh) \times M_j(km.veh^{-1})$$

- $e_{hot,\,i,\,j}$: **emission factor** for pollutant i, for vehicle technology j →computed by COPERT IV formula
- N_j : **number of vehicles** of technology j on the link
- M_j : **mileage** per vehicle, equivalent to link length in case study

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- N_j : **number of vehicles** of technology j on the link
- M_j : **mileage** per vehicle, equivalent to link length in case study

Inputs from traffic:
- number of vehicles, average speed

Pollutant type

- CO, FC, HC, NOx, PM, VOC
- In the code of Pollemission:

  c.pollutant_CO , c.pollutant_FC c.pollutant_HC

  c.pollutant_NOx c.pollutant_PM c.pollutant_VOC

Vehicle type

Passenger car (PC), Heavy Duty Vehicle (HDV)
Light Commercial Vehicle (LCV)
Bus, Motorcycle, Moped

Fuel type: Gasoline, Diesel

In Code of pollemission:
c.vehicle_type_bus
c.vehicle_type_light_commercial_vehicle
c.vehicle_type_motorcycle
c.vehicle_type_heavy_duty_vehicle
c.vehicle_type_moped
c.vehicle_type_passenger_car

Vehicle type

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Fuel type: Gasoline, Diesel

In Code of pollemission:
c.vehicle_type_bus
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c.vehicle_type_motorcycle
c.vehicle_type_heavy_duty_vehicle
c.vehicle_type_moped
c.vehicle_type_passenger_car

For HDV and Bus, there are more detailed categories

Emission standard type (P16)

Table 2-2: Summary of all vehicle classes covered by the methodology

Vehicle category	Type	Legislation/technology
Passenger cars	Gasoline <0.8 l	Euro 4 — 98/69/EC Stage 2005
		Euro 5 — EC 715/2007
		Euro 6 — EC 715/2007
		Euro 6c — EC 715/2007
	Gasoline 0.8-1.4 l 1.4–2.0 l >2.0 l	PRE ECE
		ECE 15/00-01
		ECE 15/02
		ECE 15/03
		ECE 15/04
		Improved conventional
		Open loop
		Euro 1 — 91/441/EEC
		Euro 2 — 94/12/EC
		Euro 3 — 98/69/EC Stage 2000
		Euro 4 — 98/69/EC Stage 2005
		Euro 5 — EC 715/2007
		Euro 6 — EC 715/2007
		Euro 6c — EC 715/2007

Emission standard type in Pollemission

- Passenger cars and Light commercial vehicles:

c.class_PRE_ECE

c.class_Improved_Conventional

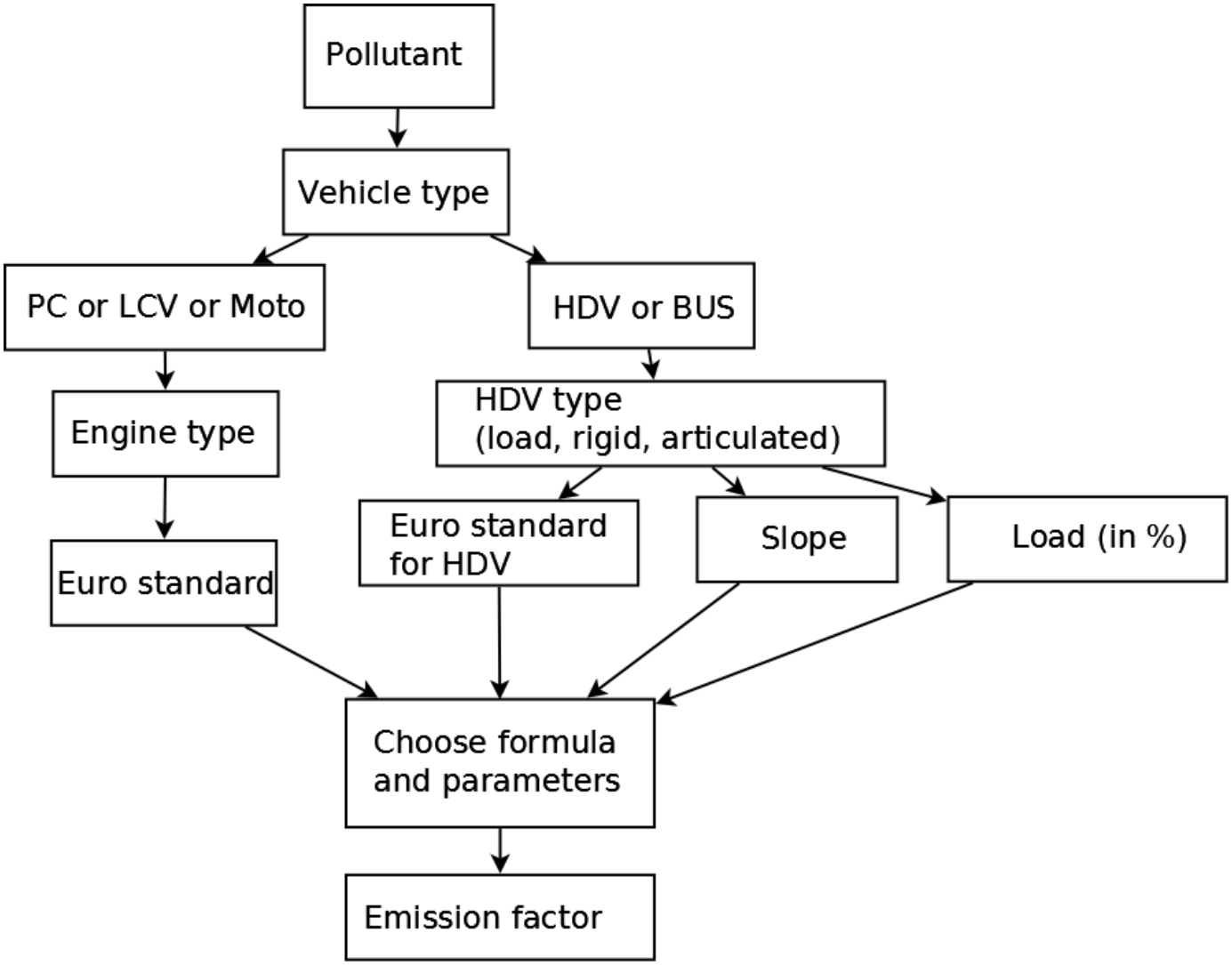
c.class_Open_loop
c.class_ECE_15_00_or_01
c.class_ECE_15_02
c.class_ECE_15_03
c.class_ECE_15_04

c.class_Euro1 to c.class_Euro6c

- Heavy Duty Vehicles:

c.class_hdv_Conventional
c.class_hdv_Euro_I
c.class_hdv_Euro_II
c.class_hdv_Euro_III
c.class_hdv_Euro_IV
c.class_hdv_Euro_V_SCR
c.class_hdv_Euro_V_EGR
c.class_hdv_Euro_VI

Calculate emission factor (hot)



Example for calculate emission factor

Hot emission factor (HEF) is a function of the vehicle average speed v, for a given pollutant i and a given class of vehicle technology j. For example, for NOx, the HEF is formulated by:

$$e_{\text{hot}} = g_{\text{NOx,euro1\_euro4}}(v) = \frac{a + c \times v + e \times v^2}{1 + b \times v + d \times v^2},$$

For gasoline PC of Euro 5 to Euro 6c, the formulation is then:

$$e_{\text{hot}} = g_{\text{NOx,euro5\_euro6}}(v) = a \times v^5 + b \times v^4 + c \times v^3 + d \times v^2 + e \times v + f.$$

Where to find the formula and parameters?

https://www.eea.europa.eu/publications/emep-eea-guidebook-2013

- Document: Part B -1.A.3.b.i-iv Road transport 2014.pdf
- Data information file: 1.A.3.b.i-iv Exhaust emissions from road transport annex HDV files.zip

Example: P57

3.4.3.1 Gasoline passenger cars

Pre Euro – 'Conventional'

Hot Emissions

Hot emission factors for conventional vehicles are given in Table 3-35, Table 3-36 and Table 3-37 for different pollutants, and Table 3-38 provides fuel consumption factors for the same vehicles.. The separate equations are valid for different speed ranges and engine capacity classes.

Table 3-35: Speed dependency of CO emission factors for gasoline passenger cars

Vehicle class	Engine capacity	Speed range (km/h)	CO emission factor (g/km)	R^2
PRE ECE	All capacities>0.8 l	10–100	$281V^{-0.630}$	0.924
	All capacities>0.8 l	100–130	$0.112V + 4.32$	-
ECE 15-00/01	All capacities>0.8 l	10–50	$313V^{-0.760}$	0.898
	All capacities>0.8 l	50–130	$27.22 - 0.406V + 0.0032V^2$	0.158
ECE 15-02	All capacities>0.8 l	10–60	$300V^{-0.797}$	0.747
	All capacities>0.8 l	60–130	$26.260 - 0.440V + 0.0026V^2$	0.102
ECE 15-03	All capacities>0.8 l	10–20	$161.36 - 45.62\ln(V)$	0.790
	All capacities>0.8 l	20–130	$37.92 - 0.680V + 0.00377V^2$	0.247
ECE 15-04	All capacities>0.8 l	10–60	$260.788 \cdot V^{-0.910}$	0.825
	All capacities>0.8 l	60–130	$14.653 - 0.220V + 0.001163V^2$	0.613

Example: P60 Euro 1 and later

$$EF = (a + c \times V + e \times V^2)/(1 + b \times V + d \times V^2) \quad (25)$$

$$EF = a \times V^5 + b \times V^4 + c \times V^3 + d \times V^2 + e \times V + f \quad (26)$$

$$EF = (a + c \times V + e \times V^2 + f / V)/(1 + b \times V + d \times V^2) \quad (27)$$

$$EF = a \times V^b + c \times V^d \quad (28)$$

Pollutant or FC	Emission Standard	Engine capacity	Eq. Nb.	Speed Range (km/h)	R^2	a	b	c	d	e	f
CO	Euro 1	All>0.8 l	(25)	10–130	0.87	1.12E+01	1.29E-01	-1.02E-01	-9.47E-04	6.77E-04	
	Euro 2	All>0.8 l		10–130	0.97	6.05E+01	3.50E+00	1.52E-01	-2.52E-02	-1.68E-04	
	Euro 3	All>0.8 l		10–130	0.97	7.17E+01	3.54E+01	1.14E+01	-2.48E-01		
	Euro 4	All		10–130	0.93	1.36E-01	-1.41E-02	-8.91E-04	4.99E-05		
	Euro 5	All	(26)	5–130	0.840	-1.35E-10	7.86E-08	-1.22E-05	7.75E-04	-1.97E-02	3.98E-01
	Euro 6	All		5–130	0.886	-6.50E-11	4.78E-08	-7.79E-06	5.06E-04	-1.38E-02	3.54E-01
	Euro 6c	All		5–130	0.901	-4.42E-11	4.04E-08	-6.73E-06	4.34E-04	-1.17E-02	3.38E-01
HC	Euro 1	All>0.8 l	(25)	5–130	0.82	1.35E+00	1.78E-01	-6.77E-03	-1.27E-03		
	Euro 2	All>0.8 l		10–130	0.95	4.11E+06	1.66E+06	-1.45E+04	-1.03E+04		
	Euro 3	All>0.8 l		10–130	0.88	5.57E-02	3.65E-02	-1.10E-03	-1.88E-04	1.25E-05	
	Euro 4	All		10–130	0.10	1.18E-02		-3.47E-05		8.84E-07	

Example: for HDV cars, the Excel file

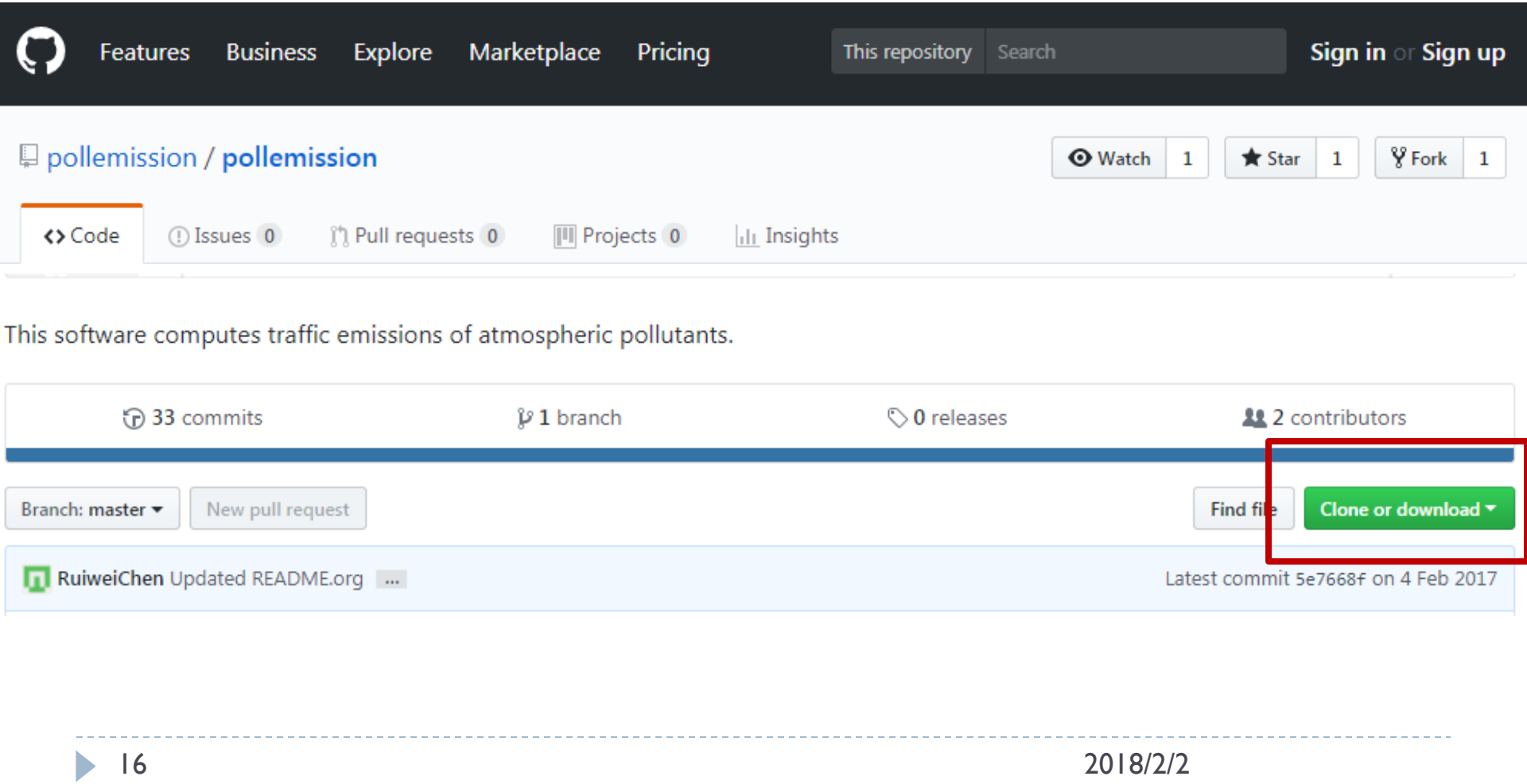
	A	B
1	**No.**	**Formula**
2	Equation 1	y = (((((Alpha * (Speed ^ 3)) + (Beta * (Speed ^ 2))) + (Gamma * Speed)) + Delta))
3	Equation 2	y = ((((Alpha * (Speed ^ 2)) + (Beta * Speed)) + Gamma))
4	Equation 3	y = (((Alpha * (Beta ^ Speed)) * (Speed ^ Gamma)))
5	Equation 4	y = (((Alpha * (Speed ^ Beta)) + (Gamma * (Speed ^ Delta))))
6	Equation 5	y = (((Alpha + (Beta * Speed)) ^ ((-1) / Gamma)))
7	Equation 6	y = (((Alpha + (Beta * Speed)) + (((Gamma - Beta) * (1 - Exp(((-1) * Delta) * Speed))) / Delta)))
8	Equation 7	y = (((Epsilon + (Alpha * Exp(((-1) * Beta) * Speed))) + (Gamma * Exp(((-1) * Delta) * Speed))))
9	Equation 8	y = ((1 / (((Gamma * (Speed ^ 2)) + (Beta * Speed)) + Alpha)))
10	Equation 9	y = ((1 / (Alpha + (Beta * (Speed ^ Gamma)))))
11	Equation 10	y = ((1 / (Alpha + (Beta * Speed))))
12	Equation 11	y = ((Alpha - (Beta * Exp(((-1) * Gamma) * (Speed ^ Delta)))))
13	Equation 12	y = ((Alpha / (1 + (Beta * Exp(((-1) * Gamma) * Speed)))))
14	Equation 13	y = ((Alpha + (Beta / (1 + Exp((((-1) * Gamma) + (Delta * Log(Speed))) + (Epsilon * Speed))))))
15	Equation 14	y = ((Gamma + (Alpha * Exp(((-1) * Beta) * Speed))))
16	Equation 15	y = ((Gamma + (Alpha * Exp(Beta * Speed))))
17	Equation 16	y = (Exp((Alpha + (Beta / Speed)) + (Gamma * Log(Speed))))

Example: for HDV cars, the Excel file

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Sector	Sub-Sector	Technology	Euro N	Load	Slope	Pollutant	Alpha	Beta	Gamma	Delta	Epsilon	Zita	Ita	Thita
2	Heavy Duty Trucks	Rigid <=7,5 t	HD Euro V - EGR	5	0	0%	CO	1,096	1,003	13,881	-1,235	0,000	0,000	0,000	0,000
3	Heavy Duty Trucks	Rigid <=7,5 t	HD Euro V - EGR	5	50	0%	CO	1,163	1,056	19,581	-1,373	0,000	0,000	0,000	0,000
4	Heavy Duty Trucks	Rigid <=7,5 t	HD Euro V - EGR	5	100	0%	CO	1,254	1,138	25,663	-1,489	0,000	0,000	0,000	0,000
5	Heavy Duty Trucks	Rigid <=7,5 t	HD Euro V - EGR	5	0	2%	CO	1,279	1,178	13,853	-1,231	0,000	0,000	0,000	0,000
6	Heavy Duty Trucks	Rigid <=7,5 t	HD Euro V - EGR	5	50	2%	CO	-9,514	-2,398	5,424	-0,804	0,000	0,000	0,000	0,000
7	Heavy Duty Trucks	Rigid <=7,5 t	HD Euro V - EGR	5	100	2%	CO	1,872	1,773	11,842	-1,278	0,000	0,000	0,000	0,000
8	Heavy Duty Trucks	Rigid <=7,5 t	HD Euro V - EGR	5	0	4%	CO	1,986	-1,583	-0,860	0,000	0,000	0,000	0,000	0,000
9	Heavy Duty Trucks	Rigid <=7,5 t	HD Euro V - EGR	5	50	4%	CO	2,354	-1,698	-0,957	0,000	0,000	0,000	0,000	0,000
10	Heavy Duty Trucks	Rigid <=7,5 t	HD Euro V - EGR	5	100	4%	CO	3,181	3,193	4,978	-1,058	0,000	0,000	0,000	0,000
11	Heavy Duty Trucks	Rigid <=7,5 t	HD Euro V - EGR	5	0	6%	CO	3,076	3,115	3,075	-0,891	0,000	0,000	0,000	0,000
12	Heavy Duty Trucks	Rigid <=7,5 t	HD Euro V - EGR	5	50	6%	CO	4,197	4,259	3,011	-0,957	0,000	0,000	0,000	0,000
13	Heavy Duty Trucks	Rigid <=7,5 t	HD Euro V - EGR	5	100	6%	CO	5,185	5,227	3,380	-1,060	0,000	0,000	0,000	0,000

In pollemission – copert.py

https://github.com/pollemission/pollemission



In pollemission – copert.py

- All the hot emission formula are already programmed in Pollemission, update till the version of 2016
- The example file: example_compute.py

```
import copert
c = copert.Copert("input/PC_parameter.csv", "input/LDV_parameter.csv "   ,
                  "input/HDV_parameter.csv", "input/Moto_parameter.csv")


print c.HEFGasolinePassengerCar(pollutant = c.pollutant_CO,
                                speed = 60., # in km/h
                                copert_class = c.class_Euro_5,
                                engine_capacity = c.engine_capacity_0p8_to_1p4) # in l
```

Pollemission Hands-on

- Open a terminal
- - ipython

- In the interface of ipython: import the class copert

```
In [1]: import copert

In [2]:
```

Pollemission Hands-on

- In the interface of ipython:

```
In [1]: import copert

In [2]: c = copert.Copert("input/PC_parameter.csv", "input/LDV_parameter.csv",
                          "input/HDV_parameter.csv", "input/Moto_parameter.csv")
```

- The variable in the class copert can be seen:
- Type: c. <TAB>

Pollemission Hands-on

- In the interface of ipython:

```
In [1]: import copert

In [2]: c = copert.Copert("input/PC_parameter.csv", "input/LDV_parameter.csv",
   ...:                   "input/HDV_parameter.csv", "input/Moto_parameter.csv")
```

```
c.pollutant_CO
c.pollutant_FC
c.pollutant_HC
c.pollutant_NOx
c.pollutant_PM
c.pollutant_VOC
```

```
c.HEFDieselPassengerCar
c.HEFGasolinePassengerCar
c.HEFHeavyDutyVehicle
c.HEFLightCommercialVehicle
```

```
c.class_ECE_15_00_or_01
c.class_ECE_15_02
c.class_ECE_15_03
c.class_ECE_15_04
c.class_Euro_1
c.class_Euro_2
c.class_Euro_3
c.class_Euro_3_GDI
c.class_Euro_4
c.class_Euro_5
c.class_Euro_6
c.class_Euro_6c
c.class_Improved_Conventional
c.class_Open_loop
c.class_PRE_ECE
c.class_hdv_Conventional
c.class_hdv_Euro_I
c.class_hdv_Euro_II
c.class_hdv_Euro_III
c.class_hdv_Euro_IV
c.class_hdv_Euro_VI
c.class_hdv_Euro_V_EGR
c.class_hdv_Euro_V_SCR
```

Pollemission Hands-on

- In the interface of ipython:

```
In [1]: import copert

In [2]: c = copert.Copert("input/PC_parameter.csv", "input/LDV_parameter.csv",
   ...:                   "input/HDV_parameter.csv", "input/Moto_parameter.csv")
```

```
In [5]: print c.HEFGasolinePassengerCar(pollutant = c.pollutant_CO,
                                        speed = 60., # in km/h
                                        copert_class = c.class_Euro_5,
                                        engine_capacity = c.engine_capacity_0p8_to_1p4) # in l
```

Pollemission Hands-on

- In the interface of ipython:

```
In [1]: import copert

In [2]: c = copert.Copert("input/PC_parameter.csv", "input/LDV_parameter.csv",
   ...:                   "input/HDV_parameter.csv", "input/Moto_parameter.csv")
```

```
In [5]: print c.HEFGasolinePassengerCar(pollutant = c.pollutant_CO,
                                        speed = 60., # in km/h
                                        copert_class = c.class_Euro_5,
                                        engine_capacity = c.engine_capacity_0p8_to_1p4) # in l
```

0.272488820636

Pollemission Hands-on

- In the interface of ipython:

```
In [1]: import copert

In [2]: c = copert.Copert("input/PC_parameter.csv", "input/LDV_parameter.csv",
   ...:                   "input/HDV_parameter.csv", "input/Moto_parameter.csv")
```

- Gasoline Passenger Car, NOx,
  speed = 30. veh/h, Euro 3,
  Engine capacity: 1.4L – 2.0 L
  Document : P60

Pollemission Hands-on

- In the interface of ipython:

```
In [1]: import copert

In [2]: c = copert.Copert("input/PC_parameter.csv", "input/LDV_parameter.csv",
   ...:                   "input/HDV_parameter.csv", "input/Moto_parameter.csv")
```

- Gasoline Passenger Car, NOx,
  speed = 30. veh/h, Euro 3,
  Engine capacity: 1.4L – 2.0 L
  Document : P60

```
In [7]: print c.HEFGasolinePassengerCar(pollutant = c.pollutant_NOx,
                                       speed = 30., # in km/h
                                       copert_class = c.class_Euro_3,
                                       engine_capacity = c.engine_capacity_1p4_to_2) # in l
```

Pollemission Hands-on

- In the interface of ipython:

```
In [1]: import copert

In [2]: c = copert.Copert("input/PC_parameter.csv", "input/LDV_parameter.csv",
   ...:                   "input/HDV_parameter.csv", "input/Moto_parameter.csv")
```

- Gasoline Passenger Car, NOx,
  speed = 30. veh/h, Euro 3,
  Engine capacity: 1.4L – 2.0 L
  Document : P60

0.0807444791185

```
In [7]: print c.HEFGasolinePassengerCar(pollutant = c.pollutant_NOx,
                                       speed = 30., # in km/h
                                       copert_class = c.class_Euro_3,
                                       engine_capacity = c.engine_capacity_1p4_to_2) # in l
```

Pollemission Hands-on

- Remarks:

For passenger cars, the equations and parameters for Euro 5, Euro 6 and Euro 6c have been updated in 2016. New parameters are integrated in “input/PC_parameter.csv”, the values in the Document of EEA are not taken in Pollemission for theses classes.

Pollemission Hands-on HDV

- HDV type

```
c.hdv_type_articulated_14_20  c.hdv_type_articulated_34_40
c.hdv_type_articulated_20_28  c.hdv_type_articulated_40_50
c.hdv_type_articulated_28_34  c.hdv_type_articulated_50_60
```

- Slope: 0%, ±2%, ±4%, ±6%
- LOAD : 0%, 50%, 100%

```
c.slope_0
c.slope_2
c.slope_4
c.slope_6
c.slope_negative_2
c.slope_negative_4
c.slope_negative_6
```

```
c.hdv_load_0
c.hdv_load_100
c.hdv_load_50
```

Pollemission Hands-on HDV

- Pollutant: CO
- Speed = 30 veh/h
- Vehicle category: HDV
- HDV type: rigid 14 – 20t
- Emission class Euro III
- Load: 50%
- Slope: +4%

```
c.HEFHeavyDutyVehicle(speed = 30,
                      vehicle_category = c.vehicle_type_heavy_duty_vehicle,
                      hdv_type = c.hdv_type_rigid_14_20,
                      hdv_copert_class = c.class_hdv_Euro_III,
                      pollutant = c.pollutant_CO,
                      load = c.hdv_load_50,
                      slope = c.slope_4)
```

Pollemission Hands-on HDV

- Pollutant: CO
- Speed = 30 veh/h
- Vehicle category: HDV
- HDV type: rigid 14 – 20t
- Emission class Euro III
- Load: 50%
- Slope: +4%

```
c.HEFHeavyDutyVehicle(speed = 30,
                      vehicle_category = c.vehicle_type_heavy_duty_vehicle,
                      hdv_type = c.hdv_type_rigid_14_20,
                      hdv_copert_class = c.class_hdv_Euro_III,
                      pollutant = c.pollutant_CO,
                      load = c.hdv_load_50,
                      slope = c.slope_4)
```

2.32098769899

Pollemission Hands-on HDV

- Pollutant: NOx
- Speed = 60 veh/h
- Vehicle category: HDV
- HDV type: articulated 34 – 40t
- Emission class Euro IV
- Load: 100%
- Slope: 0%

Pollemission Hands-on HDV

- Pollutant: NOx
- Speed = 60 veh/h
- Vehicle category: HDV
- HDV type: articulated 34 – 40t
- Emission class Euro IV
- Load: 100%
- Slope: 0%

```
In [11]: print c.HEFHeavyDutyVehicle(speed = 60,
                                    vehicle_category = c.vehicle_type_heavy_duty_vehicle,
                                    hdv_type = c.hdv_type_articulated_34_40,
                                    hdv_copert_class = c.class_hdv_Euro_IV,
                                    pollutant = c.pollutant_NOx,
                                    load = c.hdv_load_100,
                                    slope = c.slope_0)
```

Pollemission Hands-on HDV

- Pollutant: NOx
- Speed = 60 veh/h
- Vehicle category: HDV
- HDV type: articulated 34 – 40t
- Emission class Euro IV
- Load: 100%
- Slope: 0%

```
In [11]: print c.HEFHeavyDutyVehicle(speed = 60,
                                    vehicle_category = c.vehicle_type_heavy_duty_vehicle,
                                    hdv_type = c.hdv_type_articulated_34_40,
                                    hdv_copert_class = c.class_hdv_Euro_IV,
                                    pollutant = c.pollutant_NOx,
                                    load = c.hdv_load_100,
                                    slope = c.slope_0)
```

6.04453106501

Link-resolution CO emission : 25 links
Example for passenger cars (PCs)

- Input data: input/*.dat , inputs at link-resolution
- Speed (km/h), traffic (veh), link length (km), gasoline PC share

flow.dat speed.dat link_osm.dat gasoline_proportion.dat

flow.dat
1600.
1400.
1200.
1170.
900.
790.
1060.
1500.
700.
900.
1000.
800.
800.
1000.
1000.
800.
900.
600.
800.
600.
800.
900.
1000.
1200.
1200.

speed.dat
30.
30.
30.
45.
60.
40.
55.
30.
30.
20.
40.
40.
60.
60.
60.
60.
50.
80.
50.
30.
30.
50.
30.
70.
70.

link_osm.dat
0.03
0.022
0.026
0.024
0.033
0.096
0.082
0.034
0.086
0.037
0.069
0.027
0.238
0.068
0.038
0.035
0.220
0.260
0.290
0.062
0.040
0.214
0.032
0.020
0.340

gasoline_proportion.dat
0.292
0.292
0.292
0.292
0.292
0.292
0.292
0.292
0.292
0.292
0.292
0.292
0.292
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0.292
0.292
0.292
0.292
0.292
0.292
0.292
0.292
0.292
0.292

Share of gasoline PCs on each link is assumed to be the same

Speed range 10 – 120 veh/h

Link-resolution CO emission : 25 links Example for passenger cars (PCs)

Share share of engine capacity : not the same between diesel and gasoline cars

- engine_capacity_diesel.dat
- engine_capacity_gasoline.dat

Table 3: Distribution of engine type and engine capacity in France (André et al., 2013)

Engine type (proportion in all PCs, in %)	Engine capacity	Proportion in each category (in %)
gasoline ($\theta_{\text{gaso}} = 29.2$)	$< 1.4\,\text{L}$ ($\tau_{\text{gaso},<1.4l}$)	59.9
	$1.4 - 2.0\,\text{L}$ ($\tau_{\text{gaso},1.4-2.0l}$)	34.6
	$> 2.0\,\text{L}$ ($\tau_{\text{gaso},>2.0l}$)	3.8
Diesel ($\theta_{\text{diesel}} = 70.6$)	$< 1.4\,\text{L}$ ($\tau_{\text{diesel},<1.4l}$)	9.8
	$1.4 - 2.0\,\text{L}$ ($\tau_{\text{diesel},1.4-2.0l}$)	77.8
	$> 2.0\,\text{L}$ ($\tau_{\text{diesel},>2.0l}$)	12.5

Link-resolution CO emission : 25 links Example for passenger cars (PCs)

Share share of engine capacity : not the same between diesel and gasoline cars

- engine_capacity_diesel.dat v.s. engine_capacity_gasoline.dat

0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125
0.098	0.778	0.125

0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038
0.599	0.346	0.038

Link-resolution CO emission : 25 links Example for passenger cars (PCs)

1. Share of PC of different EURO standards are assumed to be the same for all links
2. The share is the same for gasoline / diesel PCs

Distribution of emission standard technology in France (André et al., 2013)

Emission standard technology	Proportion in all PCs (in %)
Pre-Euro ($\tau_{\text{pre-euro}}$)	3.6
Euro 1 (τ_{euro1})	6.6
Euro 2 (τ_{euro2})	14.0
Euro 3 (τ_{euro3})	33.5
Euro 4 (τ_{euro4})	39.9
Euro 5 (τ_{euro5})	2.4

Link-resolution CO emission : 25 links Example for passenger cars (PCs)

1. Share of PC of different EURO standards are assumed to be the same for all links
2. The share is the same for gasoline / diesel PCs

- copert_class_proportion_diesel.dat
- copert_class_proportion_gasoline.dat

Column order in these two .dat file:

[class_PRE_ECE, class_ECE_15_00_or_01, class_ECE_15_02, class_ECE_15_03, class_ECE_15_04, class_Improved_Conventional, class_Open_loop, class_Euro_1, cop.class_Euro_2, class_Euro_3, class_Euro_4, class_Euro_5, class_Euro_6, class_Euro_6c]

14 columns correspond to 14 Euro standards in copert.py

Link-resolution CO emission : 25 links Example for passenger cars (PCs)

1. Share of PC of different EURO standards are assumed to be the same for all links
2. The share is the same for gasoline / diesel PCs

- copert_class_proportion_diesel.dat
- copert_class_proportion_gasoline.dat

0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.

Link-resolution CO emission : 25 links Example for passenger cars (PCs)

1. Share of PC of different EURO standards are assumed to be the same for all links
2. The share is the same for gasoline / diesel PCs

- copert_class_proportion_diesel.dat
- copert_class_proportion_gasoline.dat

0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.399	0.024	0.	0.
0.	0.	0.	0.	0.036	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.399	0.024	0.	0.
0.	0.	0.	0.	0.036	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.399	0.024	0.	0.
0.	0.	0.	0.	0.036	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.399	0.024	0.	0.
0.	0.	0.	0.	0.036	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.
0.	0.	0.	0.	0.036	0.	0.	0.066	0.14	0.335	0.399	0.024	0.	0.

14 columns correspond to 14 Euro standards in copert.py

Link-resolution CO emission : 25 links
Example for passenger cars (PCs)

FINALLY

```
>> python example_emission_link_level.py
```

CO Emission in g for each link is saved in :

- output/ link_hot_emission.txt

Thank you very much!

Paper based on Pollemission codes:

Chen, R. V. Aguiléra, V. Mallet, F. Cohn, D. Poulet, F. Brocheton. **A sensitivity study of road transportation emissions at metropolitan scale,** *Journal of Earth Sciences and Geotechnical Engineering. 7, 151-173 (2017)*

https://github.com/pollemission