Anonymous Referee #1

__General comments__

This study presents the recent developments of the TEB model related to the implementation of anthropogenic heat sources coming from traffic and their impact on road surface temperatures.

This work is of great interest in terms of comprehension of processes as well as application for road network maintenance and road safety. However, this paper shows important weaknesses in its form and content. From my point of view, it requires a very important improvement work before considering any publication.

- The equations and the description of physical processes must be reviewed and improved or corrected. The equations and the description of physical processes must be reviewed and improved. There is a lot of inaccuracies and vagueness.

Answer: Additional information will be provided about the equations describing the physical processes associated to traffic. This is described in the answers to referees in the text below.

- The experimental study and the numerical experiments are very few described and developed. Many information are missing; this makes comprehension and evaluation of this study more difficult.

Answer: Additional information will be provided concerning the experimental study, the numerical aspects and modifications with respect to the initial configuration of TEB, as indicated in the answers to referees in the text below.

- Regarding the evaluation of the TEB model, it seems to me crucial to evaluate first the model in the case without traffic ; so that, the authors may focus in the following step on the evaluation of the new parameterization.

Answer: The configuration of the experimental site is such that there is no traffic at night. The evaluation without traffic is then already included in the work presented here. Additional details will be provided in the answers to referees in the text below.

- The bibliography seems to be very exhaustive. Indeed, the paper includes a lot of references but there are not discussed, thereby limiting the interest of such a bibliography.

Answer: References are now discussed to increase their interest, as indicated later in the answers to referees.

- English needs to be improved.

Answer: English will improved, with the article read by an English speaking person.

- The figures are sometimes not clear (for instance Fig.4 is too small and not readable). Some figures are also redundant (Fig8a and Fig9a).

Answer: Figures quality was improved with a larger Fig. 4, and redundancy avoided. Fig 8 will be fully dedicated to first approach and Fig. 9 to second approach.

Question

Abstract

"A forecast of the snowfall helps winter coordinate on operating services, reducing the cost of the maintenance actions, and the environmental impacts caused by an inappropriate use of de-icing."

It is not clear in the abstract what you are talking about... You should specify that the issue is the road network maintenance.

Answer: the sentence will be modified as follows "A forecast of the snowfall helps road network winter maintenance, ensure better coordination between services, costs control, and the reduction of environmental impacts caused by an inappropriate use of deicers."

Question

"Physical numerical models provide such forecast, and do need an accurate description of the infrastructure along with meteorological parameters."

The transition between context and objectives of the study must be improved

Answer: the text will be modified as follows "In order to determine the possible accumulation of snow on pavement, the forecast of the road surface temperature (RST) is mandatory. Weather outstations are used along these networks to identify the evolution of pavement status, and to build a prediction through their data analysis. Physical numerical models provide such forecast, and do need an accurate description of the infrastructure along with meteorological parameters. The objective of this study was to build a reliable urban RST forecast with a detailed integration of traffic in the Town Energy Balance (TEB) numerical model for winter maintenance."

Question

P4738, L16

"During the winter period, precipitations could accumulate on pavement surface, with a specific danger in the case of snow and black ice since it reduces they reduce road grip and therefore ~~impacts~~ impact the road user's safety"

Answer: the sentence will be modified as follows "During the winter period, precipitations could accumulate on pavement surface, with a specific danger in the case of snow and black ice since they reduce road grip and therefore impact the road user's safety"

Question

P4738, L18

"One of the roles of maintenance services during winter is to ensure the road network use ..."

Answer: the sentence will be modified as follows "One of the roles of maintenance services during winter is to ensure the network practicability, and France winter season

for road services runs from the 15th of October of a year till the 15th of March of the next year."

Question

P4739, L8

"Improvement of these models consisted in including a spatial component to incorporate the influence of both meteorological and geographical parameters."

This sentence is not clear.

Answer**: the sentence will be modified as follows "Improvement of these models consisted in reaching a forecast for a full network by incorporating the influence of both meteorological and geographical parameters."**

Question

P4739, L14

"The ~~flux~~ heat (?) fluxes associated to the traffic was investigated in details for their introduction into this model."

Answer**: the sentence will be modified as follows "The heat fluxes associated to the traffic were investigated in details for their introduction into this model."**

Question

"The modification in the energy balance caused by *the presence of vehicles in the streets* was then evaluated."

Answer**: the sentence will be modified as follows "The modification in the energy balance caused by the presence of vehicles was then evaluated."**

Question

Section2, 1st paragraph

You give a series of references for numerical models, but there is no details and no comments about the different models: which models? which processes? potential weakness or inaccuracy of these models, comparison between them?...

Answer**: the text will be modified as follows "(...) Accumulation of snow or ice on roads generates hazardous traffic conditions. Several models exist and are based on the forecast of the road surface status. The heat flux associated with passing vehicle was partially taken into account by some models (IceBreak (Shao, 1996), IceMister (Chapman, 2001), energy balance model from U.K. Meteorological Office with a modified radiation scheme (Jacobs, 1996)) or neglected by some others (DMI-Hirlam-R (Sass, 1992), energy balance model from U.K. Meteorological Office (Rayer, 1987), ISBA-Route/CROCUS (Bouilloud, 2006, 2010)). Shao and Lister (Shao, 1996) included traffic through a modification of the exchange coefficient between road surface and the atmosphere layer above it, and a correction of neat infrared radiation the road received**

according to traffic density. Chapman et al. (Chapman, 2001) have selected three traffic effects: increase of RST through a correction factor, a change in neat infrared balance due to passing vehicles with a coefficient to the emitted radiation, and an increase in turbulent exchange by adding 2 ms^{-1} to wind speed. Jacobs and Raatz (Jacobs, 1996) have considered that traffic increased turbulent exchanges, and therefore imposed a minimal wind speed of 5.14 ms^{-1} during daytime, and of 2.57 ms^{-1} during the night and the holidays seasons. In such cases, only specific physical processes associated to traffic are considered as relevant, while other are neglected. None provided nor analyzed the relative importance in terms of energy fluxes of these processes related to the presence of vehicles. (...)"

Question

P4740, L2

You mention the different direct and indirect processes (related to the presence of vehicles) that emit heat and impact road temperature. Based on literature, could you provide a quantitative evaluation of the different impacts?

Answer: the text will be modified as follows "(...) Traffic motion will also cause additional mixing of air above the road surface promoting increased turbulent flow. The bibliographic study has conducted to the identification of the different processes associated to traffic, and their contribution to an increase of 2°C to 3°C of RST. But the data in the literature did not enable to provide a quantitative evaluation of these different impacts. Prusa et al. (Prusa, 2002) have used physical equations and thermodynamic laws to evaluate the thermal input of some of the processes associated to traffic (exhaust system, engine, friction, etc.). Their approach did not provide the contribution of each process, nor was validated by an experimental study. Farmer et al. (1989) showed that the general cumulative effect of these impacts on the diurnal temperature cycle is to promote warmer RST on heavily trafficked roads. (...)"

Question

P4740, L17

"Chapman et al. (2001) showed that traffic could cause up to 2°C difference between inside and outside the highways and that the identification of traffic impacts on RST is relatively difficult."

Does the 2°C difference refer to RST?

This part of the test is not clear (the link between the two parts of the sentence); why is it difficult to identify traffic impacts?

Answer: The text will be modified as follows "Chapman et al. (Chapman, 2001) have indicated a difference in RST of 2 °C between inside and outside the highways. They also indicated that the accurately evaluation of the traffic heat input on RST is relatively difficult because, first of the plurality of the impact process, and secondly the change of the heat input according to these parameters (traffic density, vehicles speed, road topographic profile and atmospheric stability, etc.)"

Question

P4740, L27

"All the references quoted before are related to the winter season and ~~shows~~ show that the traffic has a significant effect on the RST..."

Answer: The text was modified as follows "All the references quoted before are related to the winter season and show that the traffic has a significant effect on the RST, especially near traffic signals and/or on the roads with high density of traffic."

Question

P4741, L1

"It consisted in integrating the theoretical traffic description into TEB numerical model dedicated to urban configuration to numerically quantify how much the traffic energy input affects the RST and on the basis of field experimental measurements and data (weather, traffic)."

This sentence is not clear, would you say:

"It consisted in integrating the theoretical traffic description into TEB numerical model dedicated to urban configuration, and then to quantify how much the traffic energy input affects the RST both on the basis of experimental measurements (weather, traffic) and numerical experiments."?

Answer: The sentence will be changed as suggested "It consisted in integrating the theoretical traffic description into TEB numerical model dedicated to urban configuration, and then to quantify how much the traffic energy input affects the RST both on the basis of field experimental measurements (weather, traffic) and numerical experiments."

Question

P4741, L9

"Urban atmospheric layer" should be replaced by "urban canopy".

Answer: The sentence will be modified as indicated below for section 3.1.

Question

P4741, L12

"or at higher resolution" should be replaced by "or few hundred meters".

Answer: The sentence will be modified as indicated below for section 3.1.

Question

P4741, L14

You mention different possible approaches to model traffic impact but do not give any details and explanations.

Answer: The text will be modified as follows "In the study presented here, an analysis is conducted on the possible ways to take into account traffic impact in the modeling of the RST in the winter season on the basis of Prusa and Fujimoto approaches (Prusa, 2002; Fujimoto, 2006, 2007, 2012). The one of Prusa et al. consisted in incorporating a global energy source representative of the traffic heat input. Fujimoto approach is based on an explicit representation of the different physical processes related to traffic.

Question

Section 3.1

The general approach and the physical processes of the TEB model are not correctly outlined here.

I really do not see the point of presenting all equations of TEB since they are already presented in details in previous paper (Masson 2000 and Lemonsu et al. 2012). Besides, the description of the longwave radiation budget does not seem necessary here. You should include only equations that are relevant for understanding how traffic emissions are taken into account and how the model can be improved.

Answer: The general approach and the physical processes of TEB will be outlined as follows "The TEB model is aimed to the parametrization of the interactions between the town and the urban atmospheric canopy, and is valid for a grid mesh larger than a few hundred meters. It is based on the canyon hypothesis (Masson, 2000; Masson et al. 2013; Lemonsu et al., 2012)".

Equations (1), (7) to (11), (13) and (14) will be kept so the reader could identify the modifications implemented with the approach developed to take the traffic into account. Equations (2) to (6) will be removed.

The text will be changed as follows " Figure 2 also shows the radiative interaction coefficients $LW_{x\_to\_y}$ between the various components x and y (sun, road, walls, garden, snow) of the urban canyon. The urban canyon interacts with the road surface, and the interactions are represented by the coefficients ($LW_{x\_to\_y}$), as specified by Masson (2000)."

Equations numbers will be adapted in the final paper.

Question

In Eq10 and 11: AC is the aerodynamic conductance =1/R (Cp is missing in equations, check also Eq24 and 25)

Answer: Equations (10), (11), (24) and (25) were checked and corrections will be made as follows.

$$ S_a = \frac{\rho_{air} c_p}{R_{road}} (RST - T_{lowcan}) = \rho_{air} c_p AC_{road} (RST - T_{lowcan}) $$

(10)

$$L = \frac{\rho_{air}L_v}{R_{road_{watt}}}(Q_{sat\_road} - Q_{canyon}) = \rho_{air}L_v AC_{road_{watt}}(Q_{sat\_road} - Q_{canyon})$$
(11)

$$S_a = \rho_{air}c_p AC_{road}(RST - T_{lowcan})$$ (24)

$$L = \rho_{air}L_v AC_{road_{watt}}(Q_{sat\_road} - Q_{canyon})$$ (25)

Question

I think the choice in names of variables in TEB equations is not always coherent with the previous papers (for instance S_a and L).

Answer: Variables names are different from the ones used in the literature (Masson et al. 2002 et Lemonsu et al 2012). This choice is consistent with abbreviations used in the model, and will ease the distinction between previous and new parametrization.

Question

P4744, L16

"The values that were assigned to these two parameters are $Q_{E\_traffic} = 0$ Wm^{-2} and $Q_{H\_traffic} = 20$ Wm^{-2}. "

These fluxes are prescribed by users. They are not necessarily 0 and 20 Wm^{-2}. Besides they are not constant but they follow a very simple diurnal cycle: fluxes are zero at nighttime and equal to the prescribed values at daytime.

Answer: Precisions will be brought to the text accordingly, and the text will become "The values that were assigned to these two parameters are $Q_{E\_traffic} = 0$ W m^{-2} and $Q_{H\_traffic} = 20$ W m^{-2}, based on Pigeon analysis of traffic inputs (Pigeon, 2007; 2008). These fluxes follow a simple diurnal cycle (zero at nighttime and equal to the prescribed values at daytime)."

Question

P4744, L16

"The turbulent flow of urban canyon interacts with the road surface energy balance through the interactions radiative coefficient (LWx_to_y) defined previously."

I do not understand this sentence.

Answer: The sentence will be modified as follows "The urban canyon interacts with the road surface, and the interactions are represented by the coefficients ($LW_{x\_to\_y}$) quoted previously."

Question

The parameterization for traffic was not implemented by Pigeon et al. (2008) and the fluxes are not constant even if their prescription is very simple (see my previous comment).

Answer: the corrections will be made and the text modified to specify the position of Pigeon et al., and the variation of this flux text will be modified as follows "This first approach is based on a study conducted by Pigeon et al. (2008)."

Question

According to Guibet (~~Guibet,~~ 1998), the NHC ~~(Jkg^{-1})~~ is equal to 42700 Jkg^{-1} for gasoline and 42600 Jkg^{-1} for diesel. The fuel density ρ_{fuel} ~~(kgL^{-1})~~ is equal 0.775 kgL^{-1} for gasoline and 0.845 kgL^{-1} for diesel. The average fuel consumption FE (km L-1) depends on the type of fuel and on the type of traffic. In the study made by Colombert (~~Colombert,~~ 2008), FE is of the order of 8.5 kmL^{-1} (this includes among others over-consumption due to air conditioning: 3.1 L.100km^{-1} for gasoline cars in urban cycle and 3.2 L.100km^{-1} for diesel ones).

Please, check the units in this section; I think they are not always consistent.

Answer: The text will be modified as follows :"According to Guibet (1998), the NHC is equal to 42700 Jkg^{-1} for gasoline and 42600 Jkg^{-1} for diesel. The fuel density ρfuel is equal 0.775 kgL^{-1} for gasoline and 0.845 kgL^{-1} for diesel. The average fuel consumption FE (km L^{-1}) depends on the type of fuel and on the type of traffic. In the study made by Colombert (2008), FE is of the order of 8.5 kmL^{-1} (this includes among others over-consumption due to air conditioning: 3.1 L.100km^{-1} for gasoline cars in urban cycle and 3.2 L.100km^{-1} for diesel ones)."

Units were checked and they are consistent, Q_v being an energy per travel distance.

Question

P4746, L11

Why do you prescribe a width of 10m for the streets?

Answer: The specification of the width came too early in the text and will be removed. Nevertheless, the selected width is equal to 12 m, as indicated at the beginning of section 4. It is representative of the width of the Charles III street where experimental study was implemented.

Question

Section 3.3

The equations must be presented here since it is the objective of the paper.

The figure presenting the processes (Fig4) is not readable.

Answer: Parameterization of thermal fluxes generated by vehicles will be detailed. The following text and additional equations will be inserted in section 3.3, after the sentence " Khalifa et al (2014) have identified an impact factor for each traffic physical process to evaluate its contribution, as indicated in Figure 4b and Table 2.", and before the

sentence "The parameters chosen for the description of the road and the impact zone of their associated physical processes is partial."

In the following study, we attempted to summarize the different approaches found in the literature and which have been analyzed in order to identify and to evaluate the different thermal traffic processes. Once the physical phenomena are identified, a choice was made on the equations used for their description, and their adaptation for their integration into the TEB model.

As so, and according to Fujimoto et al. (2006), the tire frictional heat flux S_t (W m^{-2}) due to tire friction can be evaluated with Newton's law of cooling as follows:

$$S_t = \alpha_{tp}\left(T_t - RST\right)$$

This equation is valid for an extended temperature range (Fujimoto, 2010). α_{tp} is the heat transfer coefficient between the tire and the road surface (Wm^{-2}K^{-1}), T_t is the tire temperature (K) and RST the road surface temperature (K) as mentioned above. In 2006, Fujimoto et al. (2006) have shown that the tire temperature depends on the ambient air temperature and the vehicle velocity. For a velocity lower than 70 km h^{-1}, the tire temperature is expressed by the following equation:

$$T_t = 0.9\left(T_{air} - 273.16\right) + 0.33V_{veh} + 273.16$$

T_{air} is the ambient air temperature (K) and Vveh is the vehicle velocity (km h^{-1}). The heat transfer coefficient α_{tp} between tire and road surface (W m^{-2}K^{-1}) is determined by Browne et al. (1980) and is defined by the following relationship:

$$\alpha_{tp} = 5.9 + 3.7V_{veh}$$

Vehicle-induced turbulence can be also an important factor to modify the energy exchange between the air and the road surface in urban area, especially under conditions of low wind speeds which are typical for urban canyon. The turbulence generated by the passing vehicles promotes a forced convection between the road surface and the surrounding atmosphere. This physical process has been studied by several authors (Prusa, 2002; Sato, 2004; Fujimoto, 2012). In 2012, Fujimoto et al (Fujimoto, 2012) have defined an approach to assess the vehicle sensible heat flux S_{va} (Wm^{-2}) due to vehicle-induced turbulence. Their approach consisted in defining a heat transfer coefficient αs (Wm^{-2}K^{-1}) between the road surface and the surrounding atmosphere, depending to the vehicles velocity.

$$S_{va} = \alpha_s\left(T_{air} - RST\right)$$

α_s is estimated from the natural wind velocity V_w (ms^{-1}) using the following equation:

$$\alpha_s = 10.4V_w^{0.7} + 2.2$$

The radiative heat flux R_v (Wm^{-2}) emitted downward from the bottom of a vehicle has been studied by several authors (Ishikawa, 1999; Prusa, 2002, Takahashi, 2005; Fujimoto, 2007). These studies reported that radiant heat from the bottom of a vehicle significantly affects the heat balance on a road surface, and may be evaluated by the Stefan-Boltzmann law:

$$R_v = \varepsilon_{veh} \sigma T_v^4$$

ε_{veh} is the vehicle emissivity, σ the Stephan-Boltzmann constant, and T_v is the vehicle temperature. In order to ease calculation, the heterogeneity of materials constituting the vehicles bottom surface was neglected and an average value was therefore chosen ($\varepsilon_{veh} = 0.95$). In this study, the vehicle will be represented by two temperatures. One is representative of the lower part, T_{veh_inf} (K), and another one of the upper part, T_{veh_sup} (K). T_{veh_inf} can be evaluated with the frame of the study of Fujimoto et al. (Fujimoto, 2006).

$$T_{veh\_inf} = \left[0.2(T_{air} + 44) + 0.2(T_{air} + 25.9) + 0.6(T_{air} + 20.3) \right]$$

It is assumed that the upper part of the circulating vehicle body is at a thermal equilibrium with air. Then, T_{veh_sup} is assumed equal to the ambient air temperature (K).

$$T_{veh\_sup} = T_{air}$$

The infrared radiative flux emitted by the lower ($F_{IR\_veh\_inf}$) and upper ($F_{IR\_veh\_sup}$) parts of the vehicle are thus evaluated in the following way:

$$F_{IR\_veh\_inf} = \varepsilon_{veh} \sigma \left[0.2(T_{air} + 44)^4 + 0.2(T_{air} + 25.9)^4 + 0.6(T_{air} + 20.3)^4 \right]$$

$$F_{IR\_veh\_sup} = \varepsilon_{veh} \sigma T_{air}^4$$

Fuel consumed by the vehicle is transformed into different type of energy necessary to operate the vehicle. The major part is transformed into kinetic energy for vehicle circulating and electric energy to the battery and all electric components of the vehicle. The part left is transformed into heat flux will be generated by the engine and the exhaust system. Based on physical approaches and thermodynamic laws, Prusa et al. (Prusa, 2002) assessed heat flow generated by the engine S_m (Wm^{-2}) and exhaust system E_{ex} (Wm^{-2}), explained by the following equations:

$$E_{ex} = m_{ex} C_{ex} (T_{ex} - T_{air})$$

$$S_m = \alpha_{comb} m_{H_2O} m_{ex} \lambda_{fg}$$

The parameters of these equations depend on the traffic conditions. E_{ex} (Wm^{-2}) and S_m (Wm^{-2}) respectively are the exhaust and the engine sensible heats, T_{ex} the exhaust system exit temperature (K) and the selected value is 350 K, m_{ex} is the combustion products mass flow rate considered as constant and equal to 0.0323 kgs^{-1}, C_{ex} is the specific heat of the combustion products (1.16 kJkg^{-1}K^{-1}). m_{H2O} is the water vapor mass fraction in the exhaust system considered constant and which chosen value is 0.089, α_{comb} is the fraction of water vapor that condenses, and λ_{fg} is the latent heat of condensation of water vapor (equal to 2.50 MJ kg^{-1}). Maximum effects are achieved with α_{comb}=1. All values indicated above were given in the article of Prusa et al. (Prusa, 2002).

Traffic also impacts the energy balance by an intermittent interruption of the radiative flux towards the surface of the road. This phenomenon is called vehicle shield and depends on the traffic parameters. Vehicle shield firstly prevents the incident solar radiation to reach the surface of the road. It consequently leads to a loss of energy on the surface energy balance, and secondly it blocks the radiation emitted by the road surface. This physical traffic process can be evaluated by a shield effect coefficient C_{shield} (dimensionless number). The vehicle shield effect on the road has been investigated by Khalifa et *al.* (2014) and can be defined by the following expression:

$$C_{shield} = \frac{T_{veh}}{t_{time}} D_{traffic}(t)$$

t_{time} is the modeling time step (s), $D_{traffic}$ represent the traffic density (dimensionless number) and T_{veh} is the shielding time caused by the passage of one vehicle (s), equal to the ratio between the length and the vehicle velocity.

Traffic influences the heat transfer coefficient between the road surface and the surrounding atmosphere by increasing the air aerodynamic resistance. This process has been studied by several authors and different approaches were used to its evaluation (Chapman 2001; Prusa, 2002; Jacobs 2006, Denby and Sandvor 2012). We will use here the one of Denby and Sandvor (2012) illustrated by the following equation:

$$AC_{road}^* = AC_{road} + C_{shield} AC_{traffic}$$

$$AC_{road-watt}^* = AC_{road-watt} + C_{shield} AC_{traffic}$$

AC^*_{road} and $AC^*_{road\_watt}$ respectively are the aerodynamic conductance of a dry and a wet circulated road. They are computed with the ones of a non circulated road, AC_{road} and $AC_{road-watt}$, and the aerodynamic conductance specific to traffic $AC_{traffic}$=10^{-3} experimentally determined by Denby and Sundvor (Denby, 2012), and validated with the model NORTRIP.

The incidence of traffic on solar radiation will be performed as follows:

$$R_{ns}^* = R_{sd}^* + R_{su}^*$$

$$R_{sd}^* = (1 - C_{sheild}) R_{sd} + C_{sheild} a_{road\_veh} R_{su}$$

$$R_{su}^* = (1 - C_{sheild}) R_{su} + C_{sheild} a_{veh\_inf} R_{su}$$

a_{veh_inf} is the albedo of the lower part of vehicles, and is consedered as esqual to the road albedo. a_{road} is the road albedo, a_{veh} the one of vehicles, and a_{road_veh} an albedo including the one of the road and the one of vehicles for a circulated zone, calculated with the following equation.

$$a_{road\_veh} = (1 - C_{sheild}) a_{road} + C_{masque} a_{veh}$$

The application to another urban site will be possible if traffic data is available, or considering a generic traffic density profile representative of the site. In the case of an entire city, considering the canyon hypothesis, an average traffic density could be selected, and the chosen parameterization applied, though partition of local climate zone necessary.

Question

Again, you refer to many papers but without adding information since the references are not commented.

Answer: The following text will be added as comments of the references "(...) equations modified to take into account these processes in the TEB model was carried out and fully described in a previous paper (Khalifa, 2014). These impacts were the topic of many research papers from many authors. Some effects were studied by Chapman et al (Chapman 2001), and Jacobs and Raatz (Jacobs 2006), and mentioned previously. A detailed description of physical processes associated to traffic is provided by Prusa et al. (Prusa, 2002), which included the friction from tires, a forced convection on road surface and surrounding atmosphere, a modification of radiation budget on the road due to the presence of vehicles, the emission of long wave radiation by their lower parts. Fujimoto (Fujimoto, 2006, 2007, 2008, 2010, 2012) gave an extended description of RST changes due to tire friction, with a heat transfer coefficient function of the vehicles speed, and tires temperature experimentally identified as dependant of air temperature and vehicles speed, along with the heat from the lower part of vehicles, and the heat and moisture heats from the exhaust systems. The turbulent sensible heat was investigated also investigated (Sato, 2004) with a heat transfer coefficient dependent of vehicle speed. The radiative fluxes emitted by the upper and lower parts of vehicles was also specifically considered by Ishikawa et al. (Ishikawa, 1999) and Takahashi et al. (Takahashi, 2005), and were based on the Stefan-Boltzmann law. A presentation of equations modified to take into account these processes in the TEB model was carried out and fully described in a previous paper (Khalifa, 2014), and is illustrated in Figure 4a. (...)"

Question

The explicit modeling of traffic effect induces a significant number of new input parameters for the model. They are listed in the text, but you do not explain how they are defined (for

instance, how is computed the shield coefficient presented in Fig3?), and how they could be generalized to other urban sites or even for an entire city.

Answer: The details previously provided to equations in section 3.3 will answer to this question.

Question

P4747, L23

"This second approach of traffic integration in the TEB model based in the resolution of ~~tow~~ town surface energy balances."

Answer: The sentence will be replaced by "This second approach of traffic integration in the TEB model based in the resolution of town surface energy balances."

Question

Eq22 and Eq23

I guess there is a mistake in equations: $(1-C_{shield})$ should be replaced by C_{shield}.

Answer: the equations will be corrected as follows

$$R^*_{ld} = (1 - C_{shield})R_{ld} + C_{shield}\ R_{IR\_veh\_inf}$$

$$R^*_{lu} = (1 - C_{shield})R_{lu} + C_{shield}\ R_{IR\_veh\_sup}$$

Question

The modifications of the radiation budget by including $F_{IR\_veh\_inf}$ and $F_{IR\_veh\_sup}$ are not clearly explained.

Answer: The details previously provided to equations in section 3.3 will answer to this question.

Question

Eq24 and 25

How are computed AC* and ACwat*??

Answer: The details previously provided to equations in section 3.3 will answer to this question, and a corresponding bibliographic reference added (Denby and Sundvor, 2012).

Question

Section 4.1

The experimental site and setup are not precisely described. For instance, what are the road parts with and without traffic? Are they comparable?

Answer: Additional details will be provided about the experimental site (street orientation, lanes widths). The following text will be added to the paragraph used as introduction to section 4 "This street is straight orientated west-east slightly north, and consisted in one non circulated lane, of nearly 3 m wide, and two circulated ones, for a total width nearly 6m, with a one-direction vehicles flow going east.", and the first sentence of section 4.1 will be modified as follows " RST and atmospheric measurements were obtained using a vehicle parked in the selected street in the non-circulated lane, with a whole data acquisition on its board (Figure 6a).".

Questions

Section 4.2

Same comment for TEB simulation: The configuration of the simulation is not precisely explained, and it lacks many information regarding forcing data and input parameters for TEB. For instance:

What is the forcing height for meteorological data?

Answer: The forcing height for meteorological data is 2.5 m.

How do you deal with the fact that meteorological measurements are available at 2m above the ground and that TEB must be forced above the top of canopy?

Answer: Depending on the presence or the absence of a coupling with an atmospheric model, TEB can either be forced with parameters at 2.5 m or 10 m above the ground. In the present study, the coupling is not present. Therefore, it is consistent to take meteorological measurements available at 2 m as forcing data.

What is the building density?

Answer: The selected building density is $a_{bât} = 0.70$ (this abbreviation is used by the TEB model and is defined in the OPTION.nam file). This element will be added to the text.

How do you built radiative forcing for TEB including direct and scattered solar radiation, as well as infrared radiation? (are these data directly provided by the meteorological station?)

Answer: Direct and diffuse radiation is calculated by the TEB model based on the data of global radiation. Indeed, the global incoming solar radiation is assumed to be about 80% direct and 20% diffuse.

TEB is forced by specific humidity instead relative humidity

Answer: Yes, the relative humidity was used as input data to the TEB model, and it calculates the specific humidity for forcing.

Question

P4751, L19

"There is a clear relationship between hourly variation of thermal traffic contribution (Fig. 3) and hourly RST variation too."

Please clarify this sentence.

Answer: The following text will replace the sentence "The RST is also greater in a zone submitted to traffic with respect to another one traffic-free. This was observed in a full urban configuration. Traffic variations are cyclic, with peaks during commuting hours (7-9 am, and 4-7 pm local time). RST is greater in the circulated zone with respect to the non-circulated one, with specific increases during these commuting moments. There is a clear relationship between hourly variation of thermal traffic contribution (Figure 3) and hourly RST variation."

Question

Eq28

The equation is wrong. If road emissivity is unchanged for road with or without traffic, I think that the relationship should be: $RST = {}'\sqrt{\frac{1}{3}T_{without}^4 + \frac{2}{3}T_{with}^4}$

Answer: Indeed, the equation could be adapted if emissivity is unchanged. Nevertheless, leaving the equation as it is, correcting the position of $1/\sigma\varepsilon_{road}$, clearly indicates that an average is made on two flux densities.

Question

Section 5.2

The first step in the evaluation of the TEB parameterization is to verify the ability of TEB to simulate the air canyon temperature for a street without traffic. If this comparison is good, then you can add the traffic effect and investigate the improvement brought by your new parameterizations.

Answer: As indicated in the literature, experiments have been conducted over circulated and non circulated zones (Lemonsu et al., 2008 ; Lemonsu et al., 2010). TEB has already been validated to simulate the air canyon temperature for a street without traffic, or with heat flux from traffic neglected (Leroyer et al., 2010). These reference will be added to the bibliography. The following figure shows the comparison between field measurements and simulation results of T_{air} with the TEB model in its initial configuration (IC) without any consideration of traffic for our first experiment. During nighttime, there is no traffic and TEB provided results in good agreement with field data.
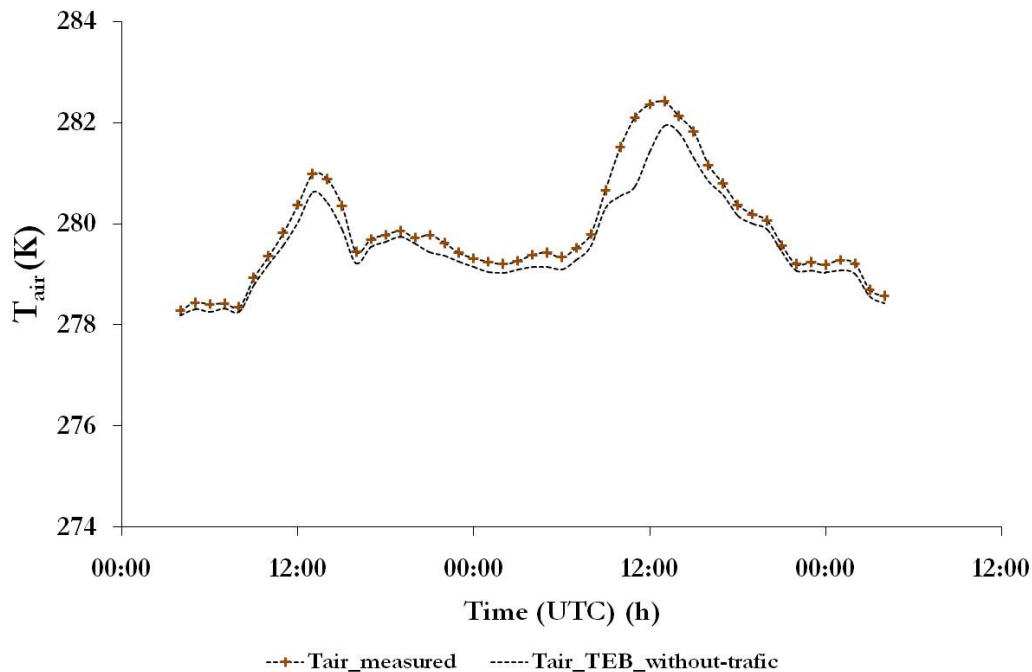
Figure. Comparison between field measurements and the results of T_{air} simulated by TEB model in its initial configuration (IC) without any consideration of traffic

Section 5.3

What is the traffic flux that is prescribed in TEB?? Is it the daily cycle presented in Fig.3 ? The flux is here expressed in W/m²; is it W per m² of road or of town as it is specified in TEB?

Answer: In the integration of traffic in TEB according to the first approach, the traffic heat input has a daily cycle presented in Figure 3. The traffic is considered, as in the initial configuration, as a source of heat added to the turbulent heat flux of urban canyon. This flux is expressed in W per m² of road.

According to Fig8 or Fig9, it is shown that the 1st approach does not improve significantly the results in comparison to the default approach. RST increases a little bit but the daily cycle remains unchanged despite a better description of the heat release due to traffic. Can you comment this result?

Answer: The text will be modified as follows "(…) In fact, the heat flux generated by the traffic was included under this initial configuration for the modeling of the overall heat flow in the urban canyon, this to assess this specific impact of anthropogenic heat flux on the urban comfort. Indeed, the modification of this first approach mainly consisted in having a daily variation of traffic heat into the canyon which was greater up to nearly 40 Wm-2 (Figure 3) at a given moment of the day. This change in the energy, without significantly modifying its daily cycle, slightly increased the RST. It might reveal also

some missing energy from the traffic. This initial configuration of traffic in the TEB model can be valid according to the objective for which was taken into account, but it does not meet to the objective of our study about the evaluation of the traffic thermal impacts on the RST modeling. (…)"

Question

The results are significantly improved by the new parameterization (2nd approach). It would be especially interesting to evaluate the impact of the different processes that have been implemented. The modification of radiation terms probably plays the strongest role.

Answer: The objective of this paper was firstly and mainly to describe a new parameterization of traffic into the TEB model. As indicated in the conclusion, a sensitivity study to evaluate the impact of the different processes will be undertaken in a coming future.

Question

Fig.12

The comparison between the air temperature measured in the canyon and simulated by the default version of TEB seems different in Fig.8 and Fig.12.

Answer: Data in Figure 8 and 12 was checked and there is no difference. These figures represent T_{air} results in different modeling cases with two different scales (274K-286 K for Figure 8, 276K-284K for Figure 12). The same scale will be used for both figures.

Question

Section 5.4.2

I do not find the sensitivity study really relevant. As said previously, I would find more interesting to evaluate the sensitivity of the results to the different terms of the new parameterization and of the input parameters.

Answer: As indicated in the conclusion, a sensitivity of the results to the different terms of the new parameterization will be undertaken, based on the available data, and with the benefit of additional field data. The objective of this paper remains to describe a new parameterization of traffic into the TEB model.