**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "Tempo-spatial variation of emission inventories of speciated volatile organic compounds from on-road vehicles in China" *by* H. Cai and S. D. Xie
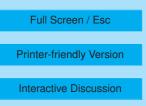
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General Response: We appreciate the referee's in-depth comments, which are useful for us to improve the clarity and the quality of this study, and to explain better certain key aspects of this study. Accordingly, we have listed our responses to your comments which have been classified and summarized as follows:

1. This methodology is very similar to previous works for China (Klimont et al., 2002; Streets et al., 2003; Wei et al., 2008) and has few improvements.

Response: We appreciate the referee's criticism. We have compared our methodology as well as the results with previous work, and the major differences and more

details are included in the revised manuscript. Generally, we compiled six emission profiles corresponding to distinct vehicle categories running under particular modes, as well as the gasoline evaporation emission profile, which ensured a better estimation of the real-world emission inventories of speciated NMVOC including as many as 69 species. Besides, our speciated emission inventories gridded at a high spatial resolution covered a long period of time, and the manuscript included a discussion about the temporal variation of contributions of various vehicle categories to speciated NMVOC groups, which to the best of our knowledge has been the first time to report such results. It is therefore believed that these are some improvements and will be useful for further air quality simulation (like the simulation of ozone and SOA formation), health impact assessment and control strategy devised by policy-makers.

2. Compared with their previous paper (Bo et al., 2008), the only new work involved in this paper is using VOC profiles to calculate the long term trend of speciated VOC emissions from China's vehicle fleet, but the quality of their results was downgraded by the rough method and bold assumptions.

Response: We have summarized our new work and some improvements of our study above, in comparison with previous work. Besides, we would hardly agree with the referee's criticism about our method and assumptions. Generally, our method focused on the determination of appropriate emission profiles based on a wide review of literature relevant with emission profiles corresponding to various vehicle categories running under particular modes, and we did not assume any bold hypothesis. Thus, we believe the results were credible. In the following, we have responded and explained to all the specific comments, criticism and questions from the referee to prove the credibility of our method and results.

3. In the meanwhile, the method of simply averaging various VOC profiles is quite questionable (see specific comments below).

Specific comment 1: Page 11056, Line 4-23. This method is quite questionable. The

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different profiles should not be simply averaged since they differed in the number of samples, the types and technologies of tested vehicles, and the measurement methods. A simple example is, a study with ~100 vehicles were usually more reliable than a study with a few vehicles. We can find that the profiles varied significantly for several important species. The authors should carefully compare the different profiles and give appropriate weights for the profiles if an average profile is used.

Specific comment 2: Page 11056, Line 11, how is the profile normalized?

Response to specific comment 1: Before the way of averaging different profiles was applied, the six distinct types of emission profiles were determined based on corresponding measurement of the same vehicle type under the same or similar running modes, to make sure that different emission profiles of the same type were comparable and could be averaged. As for the number of measurement samples involved in each specific study, we did not treat them differently, since there was no authoritative assessment of the reliability levels of various studies and we respect for every work done and trust the credibility of their results due to reliable measurement method and detailed experiment procedures. This is why we did not assign different weights to different profiles of the same type and simply treated each specific profile equal, which we believe is reasonable. The referee pointed out that the profiles varied significantly for several important species. We have noticed that there were indeed some notably different weight proportions for some species from different profiles measured by different researchers. However, measurement of speciated NMVOC normally required elaborate instrumental and strict experimental method, from which the results had certain level of deviation, but were still within the acceptable quality level of a certain degree of confidence. Even for well-controlled comparison experiments, the result deviation could reach [-51.8%, 72.4%] (Tang et al., 2008). Nevertheless, we admit that our way of averaging profiles can cause some uncertainty for the determined profiles and the final emission inventories. Therefore, we conducted a Monte-Carlo based uncertainty analysis to quantify the inaccuracy, which turned out to be quite acceptable.

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Response to specific comment 2: The relative weight proportion (w%) of each specific species in a particular emission profile to be determined was normalized to the total weight proportion (w%) of all species included in that profile, to avoid unrealistic over-estimate or underestimate of the relative weight proportions (w%) of individual species, and to reduce the potential discrepancy between the estimated emission profile and the ideal one, which is not yet available and supposed to be perfectly representative of the real-world situation based on statistically adequate measurements. This method of normalization has been widely used in other studies (Na et al., 2002, 2004; Schmitz et al., 2000; Kirchstetter et al., 1996; Duffy and Nelson, 1995; Duffy et al., 1999; Niedojadlo et al., 2007), including the information-intensive profile database of USEPA's SPECIATE (2008).

4. First, I am particularly troubled by the lack of detailed information on how some important parameters were generated (see specific comments below). This leaves the reader uncertain about the validity of the data used in this estimation.

Specific comment 1: Page 11055, Line 15, the authors need to explain how the cold start emissions were calculated, especially how they obtained the data of soak time distributions for different vehicle types in China. The authors refer readers to Reference Cai and Xie (2007), but this information is not given in this reference.

Specific comment 2: Page 11055, Line 16, "a normal (20 km/h) and (40 km/h) mode or a freeway (80 km/h) normal" need to be explained more. Also, I think these three speeds are too far from being representative of vehicle speeds in China during the past 25 years. The average speed has changed a lot from 1980 to 2005. Moreover, the average speeds differ significantly among different city sizes in China, 20 km/h is common only in large cities such as Beijing and Shanghai. For most cities in China, the average speed is over 30 km/h or even higher. Since the 1990s, numerous studies have been conducted to understand the driving patterns in China, and the authors should to look into these studies to improve their estimations.

Specific comment 3: Page 11057, Line 9-10, the authors said "Table 3 summarizes the utilization rate of TWC among gasoline vehicles based on the governmental statistical data (NBS, 2006)." As far as I know, Chinese statistics did not release the utilization rates of TWC. Utilization rates of TWC are very important in the entire estimation as TWC affects VOC emissions significantly, so the authors need to present clearly how the utilization rates of TWC among gasoline vehicles were generated based on the government statistical data.

Response to specific comment 1: Thanks to the referee for putting forward this important issue, which has a great impact on the estimation of vehicular NMVOC emissions, since it has been estimated that in the USA between 10% and 30% of traffic NMVOC emissions come from cold start emissions (Lents et al., 2004). Therefore, we used the standard CORINAIR methodology incorporated by COPERT to calculate the cold start emission factors of various vehicle categories (Ntzaichristos and Samaras, 2000). By this methodology, the cold emissions are calculated as additional emissions per km over hot emissions, and the formula and related details can be referred to Ntzaichristos and Samaras (2000). To apply this methodology, the parameters requiring determination include: (1) the average trip length per vehicle trip (Ltrip). We used the default value of 12.4 km by COPERT since the Ltrip for annual vehicle circulation should be found in the range of 8 to 15 km according to a relevant analysis (André et al., 1998), and it is proposed to use this value of 12.4 km unless firm national estimates are available (Ntzaichristos and Samaras, 2000). Recently some domestic studies on the Ltrip in China revealed that the Ltrips for buses, private cars and taxies in Beijing were 8.5, 24.0 and 10.0 km, respectively (Shi et al., 2009), and the Ltrips for buses and private cars were 9.5 and 7.2 km, respectively, in Hangzhou, the capital city of Zhejiang province (Liu and Wang, 2004) and that the Ltrip is usually a little bit more than 10.0 km in several cities of Guangdong province (Zhang, 2005). These studies could justify our selection of the 12.4 km value, given the lack of more credible information; (2) the average monthly ambient temperature. These data for every province of China over the studied period were obtained from China Meteorological Administration; and (3)

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the catalyst technology dependent cold start correction factor. This factor is a function of the level of emission legislation conformity for gasoline catalyst vehicles and the functions for different gasoline catalyst vehicles are included in the CORINAIR methodology. The determination of the level of emission legislation conformity for gasoline catalyst vehicles in China can be referred to established methodology (Cai and Xie, 2007). Therefore, the calculation of cold start emissions by the CORINAIR methodology does not need soak time distributions for different vehicle types. Actually, hot soak emissions belong to part of evaporative NMVOC emissions, and its estimation by the standard CORINAIR methodology as we used depends on average monthly ambient temperatures and the fuel volatility RVP of each province of China, which were obtained by established methodology (Cai and Xie, 2007).

Response to specific comment 2: Actually, we have considered the temporal variation of average speeds during the estimation of total NMVOC emissions in previous work (Cai and Xie, 2007), where we chosen 30 km/h and 20 km/h to represent the urban traffic situation in the 1980's and the following years, respectively, mainly based on domestic studies on driving patterns in China: Wang et al. (2007) reported that the average speeds in directly governed cities (Beijing, Shanghai, Tianjin and Chongqing) and capital cities were all below 30km/h and the speeds in Beijing, Chongqing, Chengdu, Changchun, Jiutai, Mianyang, Jilin and Zitong, eight representative cities of all types, were 20.5, 27.4, 25.3, 25.8, 23.2, 32.2, 33.3 and 30.3 km/h, respectively; Liu and Ding (2000) reported that the average speeds in most cities were below 20 km/h, with an exception of the coastal city of Dalian with a speed of 33.5 km/h; Ye et al. (2007) reported that the average speeds on the High-speed roads, the Main roads and other roads were 27.5, 20.8 and 14.6 km/h, respectively; Yao et al. (2006) reported that the average speeds in the city of Ningbo was only 22.8 km/h; Yao et al. (2004) reported that the average speeds on urban roads and rural roads in Chengdu were 21.7 and 49.8 km/h, respectively; Lei (2007) measured the driving cycles on a bunch of urban roads in the city of Wuhan and reported the average speeds were around 20 km/h. Based on these studies, it is clear that there were no significant differences in

average speeds among different city sizes in China and we believe that 20 km/h was representative for urban average speed in most cities of China. Nevertheless, we have conducted an uncertainty analysis of the emission inventories, with a particular focus on the bias of neglecting possibly various average speeds, to improve the quality of our estimated emission inventories. Moreover, to clear the referee's mind of doubt about the representativeness of 20 km/h and 30km/h for urban, 40 km/h for rural and 80 km/h for freeway in China during the past 25 years, we have the following explanations: the vehicle population in Chinese cities in the 1980's was much smaller than the years of 2000-2005, and the smoother traffic flow and much less traffic jams tended to raise the average speeds of vehicles. However, the conditions of both roads and vehicles were much poorer in the 1980's than recently, which hindered the raise of speeds to a high level. Taking into account of these two factors that influenced the average speeds, it is reasonable to believe that the average urban speeds were relatively higher in the 1980's (30 km/h) and decreased later (20 km/h), with the rapid growth of vehicle population in Chinese cities and relatively slower improvement of the road and vehicle conditions. As for the rural speeds which remained constant, it was because the rural road condition in the 1980's was generally poorer than the urban road condition, but the vehicles could probably run more fluently at around 40 km/h than running under the urban conditions, due to much less traffic and loose traffic management (no traffic lights at all) on rural roads. Later in the 1990's and recent years, the positive effect of the improvement of rural road and vehicle conditions on the raise of speed was substantially offset by the negative effect of the rapid growth of vehicle population running on rural roads. Therefore, it is reasonable to assume that the speed of 40 km/h remain constant throughout the studied period especially when no more convincing data on such speed were available. Finally, the case of freeway speeds was simple as the regulation on freeway speed has almost remained the same since such type of road appeared in China in 1989, despite the improvement of road and vehicle conditions. Therefore, the speed of 80 km/h on freeway roads was assumed to remain constant for the entire period of study.

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Response to specific comment 3: It is true that Chinese statistical bureaus do not release the utilization rates of TWC but they do release annual population data of various vehicle categories, including gasoline vehicles of various technologies with different engine cylinder capacities for all provinces. Meanwhile, China formulated a regulation that required installing TWC on new gasoline vehicles coming into use from year 2000 (MEP, 1999), and another regulation prescribed that unleaded gasoline would be provided for civil transportation from the beginning of year 2000 (GAQSIQ, 1999), which ensured the satisfaction of the fuel quality requirement of using TWC by gasoline vehicles. Taking these factors into account, it is reasonable to assume that gasoline vehicles coming into use during the period of 1980-1995 were non-TWC gasoline vehicles, and all newly-used gasoline vehicles since 2000 were TWC gasoline vehicles. Therefore, for the period of 2000-2005 when both TWC gasoline vehicles and non-TWC gasoline vehicles were running, the utilization rate of TWC for a specific year can be calculated based on the cumulative population of newly-used gasoline vehicles since 2000 and the total gasoline vehicle population in that year. For example, the TWC utilization rate in 2000 was the proportion of newly-used gasoline vehicles in that year to the total gasoline vehicle population in 2000, and TWC utilization rate in 2001 was the ratio of the sum of newly-used gasoline vehicles in 2000 and 2001 to the total gasoline vehicle population in 2001.

5. Second, there is another concern that without in depth discussions in the paper the conclusions drawn by the authors cannot be substantiated. As a specific study focused on vehicle emissions, the discussion part should include the follows: (1) Comparison with other studies. This is not the first work addressing speciated VOC emissions in China. The authors should compare their estimates with previous studies (Klimont et al., 2002, Streets et al., 2003, Wei et al., 2008) as well as tunnel/road side based VOC profiles (Tsai et al., 2006; Tang et al., 2008); (2) how the emission trends were driven by the recent regulations; and (3) how the emissions impact temporal and spatial patterns of the ozone formation potentials. Also, the SPECIATE database by USEPA should be included in the comparison as it contains a huge database and has been extensively

used in VOC speciation studies.

Response: We have compared our results with the previous work in details, and have discussed about the differences between estimates based on SPECIATE profiles and our estimates, as well as the impact of recent emission regulations on emission trends, which was included in a new section named "Comparison of Speciated NMVOC Emission Inventories with Previous Estimates and Uncertainty Analysis" in the revised manuscript. Given that our current study focuses on the estimation of vehicular speciated emissions and the discussion about temporal variation and spatial distribution of emissions, the topic of how the emissions impact temporal and spatial patterns of the ozone formation potentials is not included as we believe study on this important issue should be conducted individually based on particular theory and methodology. Besides, we had actually looked into previous work including Tang et al. (2008) before our seven profiles were compiled based on a wide literature review. Profiles obtained from tunnel studies like Tang et al. (2008) included mixtures of gasoline and diesel exhaust, evaporative sources, etc. While these types of profiles may be useful for source apportionment modeling, they are not suitable for the purposes of emission inventory development since they are mixtures of many emission sources. Tsai et al. (2006) measured the vehicular fuel composition in four cities of South China, and found that the toluene percent compositions for gasoline collected in the cities were all significant higher than values reported from US, Canada and Korea (Conner et al., 1995; Mclaren et al., 1996; Na et al., 2004), which we used to compiled the gasoline vapor profile. Meantime, we have looked into another recently domestic research which reported that the weight proportion of toluene in the vapor of the commonly-used domestic gasoline was 3.33% (Lu et al., 2003), much lower than the 14% for Zhuhai and 10% for Guangzhou reported by Tsai et al. (2006) and much closer to the values we had referred to. To better assess the quality of our estimates, we have reanalyzed in our revised manuscript the uncertainty in relevant with the gasoline vapor profile, taking into account of the results of Lu et al. (2003) and Tsai et al. (2006).

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6. Page 11055, Line 15-16, "which includes six situations corresponding to specific vehicle category", the six situations were unclear, and need to be clarified.

Response: Thanks to the referee for pointing out this obscure statement. The six situations refer to different vehicle categories running under particular modes which resulted in six distinct emission profiles. These six situations are: (1) gasoline vehicles with TWC (three-way catalysts) running under the normal mode (20 km/h and 40 km/h); (2) gasoline vehicles without TWC running under the normal mode; (3) gasoline vehicles running under the freeway mode (80 km/h); (4) diesel vehicles running under the normal mode; (5) diesel vehicles running under the freeway mode; and (6) the emission profile for motorcycles.

7. Page 11057, Line 11, it is more reasonable to allocate vehicle emissions by road networks than total GDP (Zheng et al., 2009).

Response: Thanks to the referee for recommending a theoretically good method for spatial allocation of vehicular emissions. Actually, we tried to allocate our emission inventories based on road networks. However, it turned out not to work for several reasons. First, the accuracy and reliability of the recommended method depend to a great extent on whether the detailed road network data throughout China is available or not. Unfortunately, the complete data required by such a method are not available and the public generally only have the access to some information on the road network in some developed regions of China, like Beijing, Shanghai, and the Pearl River Delta in Guangdong Province, with the road network information in the vast rural areas and many underdeveloped cities of China a mystery. Moreover, construction of new road network and reconstruction of older one go ceaselessly and so rapid that it is very tough and often simply impossible to track and obtain the ever changing road network information. This situation of lack of necessary and reliable road network data becomes more serious for the earlier years of 1980-2000, when off-grade road and non-cement or non-asphalt paved road occupied a dominant proportion and very little road network information could be obtained for even major cities. Because of this, we were finally

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forced to quit the method for the spatial allocation of emissions. Second, it is true that the method recommended by the referee has been applied in some studies and the results turned out to be sound. However, the study by Zheng et al. (2009) focused on a limited area where the social and economic development was at a high level and the road network information was relatively complete, assuring the successful application of their method. Thus, the data-demanding characteristic of the method hinders its application in larger scale regions like the entire Guangdong province and many other provinces of China, where the local road network data are incomplete and unable to meet the strict standards required by the road network-based method. Therefore, we abandoned the road network-based method to avoid possibly larger uncertainty and inaccuracy due to serious lack of data than the GDP-based method, which we finally selected and applied at a national scale for the whole studied period of 1980-2005, based on the proved strong correlation between emissions and GDP. Moreover, compared with the road network-based method, the GDP-based method could ensure the consistency and comparability of the time-series results and meantime keep the possible inaccuracy to an acceptable level. Nevertheless, we have also pointed out the limitation of our way of spatial allocation in our response to the comment of referee #2.

8. Page 11058, Line 6-7, "197 million vehicles in 2005" seems not correct, please check.

Response: Thanks to the referee for carefully pointing out our lapsus calami. The right number was 107 million (Cai and Xie, 2007). We have corrected this in the revised manuscript.

9. Page 11058, Line 11, "increase of the VMT", there is no evidence to say VMT in China is increasing these years. Actually, VMT usually drops when total vehicle stock increases. To be precise, it would be better to remove this. Or, it will be beneficial if the authors can give the references that prove VMT in China is increasing.

Response: As justified by previous work (Cai and Xie, 2007; Bo et al., 2008), which

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were based on the annual VMT data reported in literatures (Li et al., 2003; Zhang et al., 2004; He, 1999; Hu et al., 2002; Yu and Yu., 2008; Ye et al., 2007; Fu et al., 2008), VMT in China did increase. Besides, the road length in China had increased from 890 thousand kilometers in 1978 to 3580 thousand kilometers in 2007, and the freeway length had broken through 60 thousand kilometers by the end of 2008, it is therefore believed that the annual VMT increased as well with the substantial development of the road infrastructure in China. This was quite similar with the situation in the USA, where the VMT increased with the growth of lane miles during the period of 1980-2007, with a positive correlation coefficient of 0.93 between them (USDT, 2008).

10. Page 11058, Line 20, please explain why the proportion of evaporation emissions would grow.

Response: Generally, evaporation emissions depend on the engine technology of vehicles, fuel properties and the average monthly ambient temperatures. First, the impact of fuel properties on the changing proportion of evaporation emissions could be neglected, because the fuel properties had few changes during the period of 2000-2005, since the national standards of gasoline for motor vehicles in operation (GAQSIQ, 1999) remained the same during the period, and was not replaced by a new one (GAQSIQ, 2006) until the end of 2006. Besides, the average monthly ambient temperatures in every province of China during the period showed little variance and therefore had little influence on the changing proportion of evaporation emissions. Finally, we focused on the impact of the emission standard updates of motorcycles, which was the major reason: it was true that, for gasoline passenger cars and gasoline light duty vehicles, the emission factors of both exhaust and evaporation emissions decreased with the introduction of stricter emission standards. However, for these gasoline vehicles, there was no significant difference in the decreases of both exhaust and evaporation emission factors. This means that the impact of stricter emission standards implemented by these gasoline vehicles was not the answer to the referee's question. However, we should not ignore another type of gasoline vehicles with a tremendous

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population-motorcycles, and they were exactly the primary cause for the increase of the proportion of evaporation emissions for the period of 2000-2005: emission factors of motorcycles in China were high and had no control measures for fuel evaporation emission, resulting in huge quantities of NMVOC emissions due to evaporation (MEP, 2007; Chan, 2002; Tsai, 2006). This situation stayed not improved until stricter emission standards for motorcycles came into force in 2007, when the limit for evaporation had a definite value of 2 g/km, and the limits for exhaust emissions were 0.8 and 0.3 g/km for motorcycles with cylinder capacities not exceeding 150 mL and those exceeding 150 mL, respectively (MEP and GAQSIQ, 2007a, 2007b), in comparison with the previously prescribed limits for exhaust emissions of as high as 4 g/km for two-stroke motorcycles and 3 g/km for four-stroke motorcycles, which came into force in 2000 (MEP and GAQSIQ, 2000), when there was no control standard for evaporation emissions. Therefore, the emission standard updates for motorcycles revealed that, for motorcycles, the evaporation emission factor was always higher than the exhaust emission factor, leading to more evaporation emissions than exhaust emissions from motorcycles and thus the increase of the proportion of evaporation emissions of motorcycles. Finally, the increase of the proportion of evaporation emissions of the whole vehicle fleet was driven by the ever growing population of motorcycles producing more evaporation emissions.

11. Page 11059, Line 7-12, "Although light duty vehicles (LDV) and heavy duty vehicles (HDV), and motorcycles were recognized the primary contributors to total NMVOC emissions in the 1980s and for the period of 1990–2005, respectively, contributions of vehicle categories to the emissions of speciated NMVOC groups varied. . .", I am not sure the meaning of this sentence.

Response: We have rewritten the sentence to make it clear: Although it has been recognized that light duty vehicles (LDV) and heavy duty vehicles (HDV) were the primary contributors to total NMVOC emissions in the 1980s, and motorcycles dominated in the total emission contribution for the period of 1990-2005 (Cai and Xie, 2007), contribu-

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tions of vehicle categories to the emissions of speciated NMVOC groups varied.

12. Page 11059, Line 17-28 and its following paragraphs. For these paragraphs, the analysis is difficult to understand because the terms of "passenger cars (PCs)", "light-duty vehicles (LDVs)", "heavy-duty vehicles (HDVs)" and "buses" are confusing. In this area, it is a common sense that PCs are a part of LDVs, and large buses are a part of HDVs. If the authors have different definitions for these terms, they may need to specify their vehicle categories somewhere at the front of the paper, so the readers could understand these paragraphs.

Response: The terms of PCs, LDVs, HDVs and Buses were vehicle categories defined by COPERT (Ntzaichristos and Samaras, 2000) and we have converted the vehicle categories defined by Chinese regulations to those by COPERT when we used COPERT to calculate the emission factors of various categories. To avoid any misunderstanding, we would remind the readers to refer to established methodology (Cai and Xie, 2007) for details.

13. Page 11062, Line 6-7, "revealed that the NMVOC emission per unit of output was much higher in China, mostly due to higher emission factors of vehicles and higher VMT in China". This is not true. US VMT is not lower than China VMT. I suggest the authors to look into the Highway Statistics Series released by US Department of Transportation to make a careful comparison of VMT between the U.S. and China, and then make a precise statement here.

Response: Thanks to the referee for providing the data source of VMT in the U.S., which help us correct our imprecise statement about the VMT difference between the two countries and then make a precise one. Upon careful comparison, we admit that VMT in China was actually lower than that in the U.S. during the same period, as the Highway Statistics Series released by US Department of Transportation reported that the VMT in the U.S. in 2005 was about 3.0 trillion miles (USDT, 2008) compared with the approximate 1.6 trillion miles in China in 2005. Given that the NMVOC emissions

in China and the U.S. in 2005 were quite close, this discrepancy of VMT between the two countries revealed that the emission per unit VMT in China was higher than that in the U.S.. In other words, emission factors in China were higher. Therefore, one key point to maintain the economic growth and meantime slow down the emission growth in China should be promoting faster implementation of stricter emission regulations that allow lower emission factors, so that the NMVOC emission per unit of output in China would decrease. In conclusion, we have corrected our previously imprecise statement and added the above discussion about the relationship of the discrepancy of NMVOC emission per unit of output with the discrepancy of VMT between China and the U.S. in the corresponding part of the revised manuscript.

14. Page 11068, Uncertainty analysis, the authors "ignored the uncertainty of the gross NMVOC emissions since they were estimated by a reliable methodology using best available raw data of emission factors and activity data (Cai and Xie, 2007)." The uncertainties of total NMVOC emissions can not be ignored as it could be significant (Streets et al., 2003; Bo et al., 2008). The authors need to present the total uncertainties of speciated VOC emissions caused by the uncertainties in total VOC emissions and VOC profiles. No matter how reliable the methodology and data are, an emission inventory always has uncertainties, especially for an inventory for China. For example, people always estimate Chinese VMT values based on very limited surveys and make a bunch of assumptions because Chinese government doesn't release VMT data, and I am sure that (Cai and Xie, 2007) used the same way to obtain VMT, this method definitely will involve uncertainties. Also, as mentioned above, the authors used very limited speed ranges to represent vehicle speeds in all Chinese cities during 25 years, this can not be called "best available raw data", since many studies are already available to provide more reliable speed data than what were used in this paper.

Response: Thanks to the referee for his/her criticism about the ignorance of the uncertainty analysis of the total NMVOC emissions. To improve the quality of our emission inventories, we have conducted a Monte-Carlo based uncertainty analysis to quan-

tify and present in the revised manuscript the total uncertainties of speciated NMVOC emissions, including the uncertainty in total NMVOC emissions caused by speed-dependent emission factors and VMT of various vehicle categories, as well as the uncertainty of NMVOC profiles, which has been reassessed with particular consideration of some recent studies focusing on the measurement of domestic gasoline vapor profiles in China (Lu et al., 2003 and Tsai et al., 2006). The details are included in the new section of Comparison of Speciated NMVOC Emission Inventories with Previous Estimates and Uncertainty Analysis in the revised manuscript.

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