Response to Referee #1

The authors developed a high-resolution vehicle emission inventory of air pollutants in China for the year 2008. The emission inventory is essential and important data for atmospheric science community as well as policymaker and the topic certainly is suitable for ACP. The manuscript presents the sophisticated methodology based on activity data and emission factors at county-level. The author's inventory has some advantages in the spatial distribution and in the input data.

Reliability and accuracy of an emission inventory rely on data certainties of activities and emission factors. In this paper, the authors have established new database on the activity data, emission factors, and spatial allocation factors to reflect the regional situation. Especially, they have developed a new method for China to assess vehicle emissions based on regional information of county-level vehicle population estimated by city-level functions and province-level technology distribution calculated by provincial vehicle stock and survival functions. In terms of emission factors, they determined monthly county-level emission factors simulated by the vehicle emission model using China's on-road vehicle emission corrections and county-level meteorological corrections. Also, the authors developed the gridded inventory with high-resolution of 0.05 degree based on allocation weights for the vehicle kilometers traveled and the finer road-network map. Such efforts have made this new emission inventory study more reliable and complete compared to others previously reported.

Consequently, the contents of this manuscript are suitable for the publication of ACP. However, there are some questions and problems in methodology and data. I am recommending the acceptance of this paper after major revisions.

Response: We thank the reviewer for the constructive comments. We address the comments as below.

(Major comments)

(1)Page 32010, Eq. (1): Eq. (1), which is a vehicle population-based approach, doesn't take account of inter-county traffic. On the other hand, the inter-county traffic has an important role of vehicle emissions as described in lines 10-11 of page 32017 ("Heavy duty trucks run more frequently on inter-county than on county roads"). The authors should analysis and discuss the influences on spatial allocation of emissions. Additionally, the assumption in lines 20-21 of page 32017 ("all use of passenger vehicles occurred within the city boundary and the use of trucks within the province boundary") is unclear in the relation to Eq. (1).

Response: Eq. (1) is used to calculate emissions for vehicles registered in a given county. We have clarified this in the revised manuscript. Actually, we do consider inter-county traffic when allocating emissions to different road types. We allocated the county-level emissions calculated by Eq. (1) to different road types (highways, national, provincial, and county roads, as defined in Table 1) on the basis of VKT weighting factors that take into account the inter-county traffic, as documented in Sect. 2.5.

(2)Page 32012, Eq. (3): The left hand is proportional to the city-level per-capita GDP with slope of [beta]. Fig.1b shows that the slope [beta] is in inverse proportional to the GDP. Consequently, the left hand of Eq. (3) is independent on GDP. This is very curious. The

authors should analyze and discuss about this point more carefully.

Response: The Eq. (3) is used to simulate the β value of each individual city from the historical time series data. For a specific city, β is a fixed value which regressed from GDP and vehicle population during 2001-2010. While Fig. 1b is used to illustrate the relationship between per-capita GDP and β values of different cities in the same province for a given year. For the cities in the same province, city-level β is inversely proportional to city-level per-capita GDP of the same year, representing that the growth rate of vehicle ownership are driven by GDP per-capita. The Eq. (3) and Fig. 1b are used to present two different concepts and we cannot simply multiply them together. In the revised manuscript, we have rewritten the Sect. 2.2 and change the title of Fig. 1b, to make it more straightforward.

(3)Page 32016, lines 10-11: It is considered that the driving pattern strongly depends on traffic characteristics of each county. The assumption of "same driving pattern for all counties" is too rough. At least, the authors should analysis and discuss about the uncertainty caused by this assumption.

Response: We agree with the reviewer that driving pattern varies by county. However, it is very difficult to take into account driving patterns for individual counties due to the lack of data.

The national average driving patterns used in this work are calculated on the basis of measurements in about 20 cities in China. In the discussion section of the revised manuscript, we conducted a sensitivity analysis to evaluate the effect of driving patterns on CO emission factors of LDBs for Beijing and Changchun, one megacity with frequent traffic congestions and one midsize city with less traffic congestions. We found that using local driven cycles will lead to 6% increase of CO emission factor in Beijing and 18% decrease in Changchun respectively, comparing with national average driving cycles.

(4)Page 32016, lines 24-28: The authors need to explain in detail how to set the correction factor and demonstrate their values.

Response: The correction factor is the ratio of measured emission factors to modeled emission factors from the IVE model using the same parameters (driving patterns, meteorological parameters, and accumulated mileage) as the measurement conditions. Measured emission factors are collected in 12 Chinese cites using the portable emissions measurement system (PEMS) during the past ten years (Wang et al., 2005; Yao et al., 2007, 2011; Liu et al., 2009; Huo et al., 2012a, b). We explained this method in detail in the Sect. 2.4 of the revised manuscript and demonstrated their values.

(5)Page 32017, lines 2-4: The author's method of VKT allocation weights on different types of roads to split vehicle activity is an interesting method for spatial allocation. However, the driving pattern (and emission factors) varied largely between road types. The variation of emission factors due to road types should be reflected in estimation of county-level emissions.

Response: We agree with the reviewer that driving pattern varies by road types (and in different cities). However, as we stated above, it is very difficult to take into account the spatial variation of driving patterns in this work due to the lack of data. Resolving this would require large scale investigation of driving patterns across China. We conducted a sensitivity analysis to evaluate the effect of driving patterns on emission factors and found that the

differences of emission factors due to the variation of driving cycles are likely within 20%. We hope the reviewer can acknowledge this.

(Minor comments)

(1)Title: The new method of this work has great advantages in the spatial distribution characteristics. On the other hand, the author's effort in high temporal resolution is relatively small and only is development of monthly emission factors corrected by monthly variation of meteorological parameters. For higher temporal resolution of vehicle emissions, not only monthly variation (including VKT) but also daily and weekly variations should be considered. As a result, the title "A new vehicle emission inventory for China with high spatial resolution" may be more suitable for author's work.

Response: We agree. We changed the title to "High-resolution mapping of vehicle emissions in China in 2008" to make it more specific.

(2)Page 32008, line 3: REAS inventory uses road density as a surrogate for grid allocation.(Ref.) Page 4422 of Ohara et al. (2007)

Response: Thank the reviewer for pointing it out. It is corrected in the revised manuscript.

(3)Page 32008, line 20: It is better that "Therefore" is replaced by "Consequently" or other term.

Response: Corrected.

(4)Page 32010, lines 3-5: Why is motor cycle excluded in this work?

Response: We didn't include motorcycle in this work mainly because the growth pattern of motorcycle stock doesn't follow the GDP-related Gompertz function (Wang et al., 2006). Therefore the method of refining spatial resolution of activities from province to county developed in this manuscript is not applicable to motorcycles.

(5)Page 32026, lines 19-25: The reviewer can't find from Fig. 14b and c that M1 and M2 methods causes "significant bias". Fig.14b and c or Fig.14d and e seem to demonstrate that M1 is closer to "this work" than M2. It is suggested that the authors add some discussions about this reason.

Response: Fig. 14 suggests that M1 is closer to "this work" than M2 for large urban areas (>200,000 population per grid). This is because using population as spatial proxy tends to allocate more emissions in urban area. However, M2 was not able to identify emission hotspots in big cities, because city roads are not included in DCW and few emissions could be allocated to urban areas. We have removed the statement of "significant bias" and added some discussions in the revised manuscript.

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