Reviewer 2#

This manuscript compared several bottom-up CH4 emission inventories, investigated the spatial-temporal patterns of CH4 emissions in China, and tried to explain the discrepancies between different data products to evaluate those emission inventories. However, I think the authors did not successfully achieve their research aim.

First, the comparison between different inventories did not provide any more information on the CH4 emission characteristics in China. The previous bottom-up emission inventories have already presented what this study has shown here. This research has produced very few new findings.

Response: Thank you for your comments. Indeed, we stand with you that several individual studies have been done in emission estimates for global and reginal studies (e.g. EDGAR, REAS, CEDS, and PKU, etc.) and here we are not to provide a new dataset in this study. However, there remain significant merits in our study, which will mainly benefit the research community.

First, existing individual estimates (e.g. bottom-up approach) exhibited wide ranges due to the complex emitting processes, large amount of activity data, and various site-specific emission factors (Höglund-Isaksson, 2012; Saunois et al., 2020). While “true” emissions cannot be known, by comparing different datasets can enable identification of the reasons for those disparities and sources of uncertainties (Andrew, 2020). This is an important way forward in improving accuracy of CH_4 emission inventories. To the best of our knowledge, such comparisons have seldom been conducted, particularly for CH_4 emissions across different sectors at the national scale of China.

Second, we have actually presented the new findings by gathering all the publicly available emission dataset. For example, we quantitatively compared all the collected estimates and explored the reasons for differences both in amount and spatial-temporal pattern. We provided a state-of-the-art mean and uncertainty estimates of national total and sectoral CH_4 emissions (Fig. 5 and Table S3). Our results reveal that REAS is a potential outlier, which presents an abnormal increasing trend of China’s CH_4 emissions (Fig. 1). Further, the global inventories like CEDS and EDGAR are widely used as priori emissions for atmospheric transport or assimilation researches. However, emissions from coal mining estimated by EDGAR show notable bias toward Shanxi province (Fig. 4f). Emissions from energy sector in CEDS show an extremely higher estimates of 40 Tg CH_4 in 2010, while other inventories are within ranges of 22-27 Tg CH_4 (Table S3). The uncertainty in priori information will bias top-down estimates and their interpretations (Sheng et al., 2019). Spatially, emissions hotspots (grid > 33 g CH_4 m^{-2} yr^{-1}) in PKU and EDGAR were generally located in the North China Plain and south China, which are densely populated areas, energy production regions, and agriculture-dominant regions. However, such patterns were not presented in GAINS and REAS, with a lack of emissions hotspots in the southern China and biased allocation of the majority emissions towards Shanxi provinces. The incomplete information on emission patterns may mislead or bias mitigation efforts for CH_4 emission reductions. These findings provide useful information for research groups developing emission inventories; improve understanding of China's CH_4 emissions; for targeting mitigation efforts; and reduce estimates uncertainty.

Third, we have provided all the gathered datasets in a more publicly obtainable place (Table S2 and https://figshare.com/articles/dataset/Data_zip/12720989 (Lin et al., 2020) with a DOI (10.6084/m9.figshare.12720989.v2), many of them were previously documented in literatures but can hardly be available.

Last but not least, this paper is a review article type in ESSD rather than a research article. Review and data synthesis is a common and traditional type of research. For example, Saunois et al. (2020) and Andrew (2020) reviewed the global CH_4 emissions and sinks and global fossil fuel CO_2 emissions, respectively. For China, Han et al. (2020) recently conducted a study on China's fossil fuel CO_2 comparison. All of these studies collect as many data sets as possible on a topic and compared them in a systematical way: such as total time-series emissions, spatial patterns, and time changes in spatial distributions. The conclusion and implications of such studies can have significant importance on both scientific and social communities.

Second, the authors just compared the emission values between different inventories, however, such a simple analysis and comparison cannot provide us an evaluation of anthropogenic CH4 emissions inventories (mentioned by the paper title). Many explanations of the discrepancies between different inventories did not provide any evidence and cannot fully convince me.

Response: This study synthesizes the publicly available emissions datasets, and then compared them in detailed source categories and explained the differences quantitatively where possible. Some discrepancies were because that their estimates are largely depend on national-based activity data and defaulted emission factors, which hardly fully interpret the variation of local condition, and characteristics of emission sources. However, some differences were difficult to explain without further input data (e.g. proxy data). Moreover, we revised the title to "A comparative study of anthropogenic CH_4 emissions over China based on the ensemble of bottom-up inventories".

Besides the comprehensive comparisons, we also provided composite estimates for both national total and sectoral emissions based on these data sets (Fig. 5). Before the analyses in this paper, people even do not have a whole picture of the total and sectoral emissions and do not have a clear reference system. Moreover, we improved explanations by dig into the original data, e.g., in Lines 218-222, Lines 282-284 and Lines 333-335 to explore estimates differences in key emitters: rice cultivation, coal mines, and waste treatment.

Third, the analysis of emission spatial distributions did not make sense because the global and regional inventories listed in Table 1 typically allocated the country- and province-level emission estimates to grid cells to create emission maps. Some of the selected spatial allocation proxies are rather arbitrary in my opinion, which can-not provide us accurate emission mapping results. Therefore, the comparisons shown in Figures 2 to 4 cannot give us any useful information.

Response: We admit that the spatial resolution of the datasets depends highly on the original country- or province-level emissions estimates. There can be one of the main reasons for the large uncertainties when allocating the large-scale data to small grids. The utilization of proxies, though arbitrary to some extent, is helpful for down-scaling the country/region specific emissions into grids when proxies present spatial details relvent to methane emissions. This is the acceptable approach in many existing studies that provided spatial allocation of emission estimates. The widely used EDGAR gridded dataset in atmospheric transport and inversion studies set a good example. Using energy sector (mainly controlled by coal mining) as an example (Fig. 2), PKU disaggregates the provincial activity data using the geolocations of coal mines from Liu et al. (2015) (4264 sites), and thus its spatial distribution is more reliable, which is further validated by Sheng et al. (2019) (Fig. 4l). EDGAR v4.2 originally used 328 coal mines with locations for China from world coal association (https://eerscmap.usgs.gov/wocqi) as point emissions to disaggregate the amount of national emissions (Greet et al., 2019), and then updates locations from Liu et al. (2015). However, emissions from coal mining estimated by EDGAR still have notable biases toward Shanxi province (Fig. 4f). Emissions produced by GAINS and REAS also show a clustered spatial distribution in the North China Plain (Fig. 2n and 2r). Indeed, spatial proxy data plays an important role in determining the distribution of CH_4 emissions, and regional activity data and localized emission factors also strongly influence the emissions pattern. Moreover, for rice cultivation emissions, PKU and Zhang et al., (2017) both used provincial cultivating areas and thus showed very consistent spatial distributions in southern China, while EDGAR used IRRI data and produced high emissions in Fujian and Zhejiang provinces, where rice areas are not so large. The objective of this comparative study is to analyze the differences among existing datasets when they applied diverse approaches to produce spatial and temporal detailed information of the methane emissions. We are not to defend the applicability of their approaches but focus on the magnitude and characteristics of the differences and the implication for datasets revision and policy-making.

Although the spatial distribution of China's CH4 emissions was presented by previous individual studies, the comprehensive presentations are limited. Fig. 2 and 4 not only present the magnitude and spatial location of each contributing sources emissions, but also quantify the frequency of emissions at grid cell level to identify the features of spatial discrepancy among inventories (Fig. 2 q-t). For example, the emission frequency of energy sector revealed that EDGAR was largely determined by a large proportion of high emitting grids (grid cell> 60 g CH_4 m^{-2} yr^{-1}, 75% of energy emissions, Fig. 2r), which may lead to spatial bias in top-down estimates. Moreover, estimates from more detailed subsectors are helpful to explain the source of differences between inventories (for example the coal mining emissions). As illustrated in Fig. 4, REAS presents lower estimates in rice cultivation (9%-107%) and in livestock (2%-34%) than other inventories, while 50%-57% higher estimates in coal mining. Furthermore, independent detailed subsector data, e.g. Sheng et al. (2019) developed coal mine emissions based on more than 10000 coal mines, Lin et al. (2011) produced livestock emissions based on county-level activity data, and Zhang et al. (2017) simulated rice emissions by using the detailed regional water management data and provincial organic matter application rates, are used to evaluate the amount and spatial pattern of estimates among inventories (Fig. 4j-o).

Finally, I do not agree that the authors said "This study, to the best of our knowledge, provides the first quantitative analysis of the amount and spatiotemporal patterns of CH4 emissions in China" in the conclusion section because of my comments above.
Response: Thanks for the comment. After major revisions and the literature review we did, we think 'comprehensive' is more appropriate than the word 'best' in this conclusive sentence. We collected and formed a comprehensive datasets (13 inventories), including 5 gridded datasets (global and regional scale) and 8 published tabular datasets (national and provincial level) (Table 1 and Table S1), and have presented a comprehensive review of China's CH_4 emissions. The magnitude, spatial distribution, inter-annual variability, and source contributions of emissions among inventories are compared in a systematical way to improve understanding China's CH_4 emissions and its uncertainty. Our result show that anthropogenic CH_4 emissions in China differ widely among inventories (16 Tg CH_4 yr^{-1}) in 2010 (Table S2), and reliable estimates of their differences and exploring the reasons are highly important. Our works shed light on the sources of differences and uncertainties among the current available inventories, and provide some suggestions for developing and optimizing CH_4 emission estimates, especially for high CH_4 emitting regions.

Overall, I don't see much scientific significance in this paper though it summarized plenty of data and did some analysis. The paper is not well written and needs lots of editing. I fear I cannot recommend this paper for publication in its current form
Response: As an country with widespread rice and coal production areas and a growing human population with billions of people, China is a large emitter of CH_4. A lot of studies have produced estimates of the methane emission from sources in China and datasets with spatial details have been compiled. Those datasets differed greatly not only in national/regional magnitudes but also in spatial patterns and temporal variations owing to many reasons including, as mentioned by the reviewer, the downscaling approaches with proxies. The scientific significance of this study is to make comprehensive comparison of the existing datasets of methane emissions from sources of China in order to figure out in what ways and to what extent they differed. The results of the comparative analysis is useful for the revision of the datasets and the further studies and policy-making concerning methane emissions in China. In this revision of the MS, we have carefully addressed all the comments and suggestions of the two reviewers and have dug further into the datasets we collected. We also have invited native English editor to thoroughly polish our language. Here, we briefly summarize the highlights of our study:

1) Using 13 state-of-the-art inventories, we provide a comprehensive comparison and

analyses on China's anthropogenic CH_4 emissions, which would be done by individual studies and not yet conducted in previous studies. Detailed source categories are considered to identify the discrepancies and sources of uncertainty among inventories, which have a great implication for both researchers and policy makers;

2) We collected and provided key datasets for inventory development, the sector-specific emission factors and proxy data in Table S3-S6.

We hope these major revisions and improvements will address the concerns of the reviewer.

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