Referee comments on:

"Inventory of anthropogenic methane emissions in Mainland China from 1980 to 2010".

2016-04-13

As the authors rightly point out, there are large discrepancies in existing bottom-up inventories of anthropogenic methane emissions for China and there is scope to improve these using more detailed information on a sector level from both international and national sources. In general, I find this paper a thorough contribution in this genre, which adds to existing inventories by the extensive use of data from national Chinese sources, thereby allowing in several sources to go beyond the use of default IPCC emission factors.

I have, however, some concerns on the emission estimations at the sector level, which I would like addressed by the authors. I list them below by sector.

Livestock:

The estimations of CH4 emissions follow standard IPCC methodology, which may explain why emissions fall within a close range of other inventories in Figure 2. I find it somewhat problematic that no adjustment has been made for the use of farm anaerobic digesters in China. I am also surprised that there would be no information available on this when China is since long a world leader on small-scale bio-digesters. I do understand that there is limited information on the number of digesters only digesting manure, since this is not very common. To get reasonable energy efficiency of the digestion, the manure needs to be mixed with at least 20 percent other organic material e.g., straw, food residuals, crop residues. Hence, you would need to look for the number of farm biogas installations that co-digest manure with other organic residues and make assumptions on the fraction of the feedstock that is manure. On p. 15 row 24 you mention that "35 million bio-digesters have been built for CH4 utilization between 1996 and 2010 and capture annually 15 bcm biogas." If the methane content of the biogas is 60%, then it means that 9 bcm CH4 (or about 6 Tg CH4) is captured and utilized annually. Although only some fraction of this can be referred to as methane emissions reduced compared to the practice of not treating manure in digesters, it is still likely to be a significant fraction out of the about 10 Tg CH4 estimated to be released from livestock according to Figure 2. As China is one of few countries with a widespread use of rural small-scale digesters, I find it problematic not at all accounting for this effect on methane emissions.

Rice cultivation:

The estimation of methane emissions from rice cultivation in China based on Yan et al. 2013 is in my opinion state-of-the-art.

Biomass and biofuel burning:

The estimation of methane from this sector draws on information from several national studies and appears robust. I would however like to know how these estimates compare with existing estimates from satellite images of biomass burning e.g., from GFED. To what extent are the estimates consistent/inconsistent?

Coal exploitation:

For this sector, the authors have access to extensive information about depths of coal mines in different provinces as well as the extent of surface mining as opposed to the more common underground mining. This is among the most comprehensive estimates of methane emissions from coal mining in China that I have seen. I have only one question and that is if the authors have been able to assess the prevalence of pre-mining degasification and if the effect of an increasing use of this in China (which is happening according to GMI) in the last decade has been taken into consideration? Is this part of the increased utilization of CH4 from mines that the authors discuss?

Oil and natural gas systems:

I find the emission estimations of this sector the weakest point of the paper and I would like the authors to revise the emission estimations for this sector. The authors claim they are using default emission factors from IPCC (2006), but as shown in the Table below, the emission factor used for oil production is only 15% of the very low end of the IPCC default factor for oil production. For natural gas, the emission factor used is close to the very low end of the IPCC default range. I also include for comparison the corresponding emission factors used by the USA and Canada for their reporting to the UNFCCC. Just like the US and Canada, China's oil and natural gas fields are mostly on-shore and therefore likely to have relatively high emissions from unintended leakage (i.e., fugitive emissions from leakage that are not due to venting of associated petroleum gas (APG)). Moreover, NOAA estimates from satellite images of gas flares that China flares between 2 and 3 bcm of gas annually over the period 1994 to 2010. Most of this gas can be referred to flaring of associated gas primarily from oil production. Although there is not much methane being released from the flaring of associate gas as such, the flaring indicates that there is most likely also venting going on. E.g., for the Canadian province of Alberta, Johnson and Coderre (2011) estimate from measurements that out of total APG generated from conventional oil wells, 97% is recovered for reinjection or utilization, 2.1%

is flared and 0.8% is vented. If we would assume similar circumstances for oil production in China as for conventional oil wells in Canada, it would mean that between 0.76 and 1.1 bcm APG is vented annually from Chinese oil production. If we assume the methane content of APG to be 85% and use the conversion factor 0.7178 kg CH4/m3 CH4, then China would be venting somewhere between 460 and 670 kt CH4 annually from oil production (which is ten times higher than the authors' estimate for 1990, see Table 1). Adding emissions of unintended leakage would increase this number even further. Similar questions can be raised for the emission factor that the authors is using for gas production, transmission and distribution. It seems unreasonably low. Preferable emissions should be estimated separately for gas production, long-distance gas transmission and distribution networks.

Table 1: Methane emission factors for oil and gas systems. Note the emissions factors used in the reviewed paper for China of 0.36 kg/t for oil and 2.77 g/m3 for gas have been converted to kt CH4/PJ to facilitate the comparison.

		China Reviewed paper	IPCC (2006) vol.2 Tables 4.2.4 and 4.2.5	USA NIR (2015)	UNFCCC (2014)		Canada NIR (2015)		
		1990	Range of default efs kt CH4/PJ produced	1990	2000	2010	1990	2000	2010
Oil production (EIA, 2015)	PJ	6280		16428	13003	12244			
CH4 from oil systems	kt CH4	54		1260	1496	1406.52			
Ef oil systems	kt CH4/PJ	0.009	Vented associated gas: 0.056-0.39 Flaring associated gas: 0.0001-0.001 Unintended leakage: 0-0.11 Oil refinery: 0.0006-0.0015 **Sum oil systems: 0.057-0.502**	0.077	0.115	0.115	0.25 (conventional oil) 0.07-0.13 (unconv. oil)		
Natural gas production (EIA, 2015)	PJ	617		19335	20744	23007			
CH4 from natural gas systems	kt CH4	40		7164	7459	6412.76			
Ef gas systems	kt CH4/PJ	0.065	Vented associated gas: 0 Flaring associated gas: 0.000005-0.00005 Unintended leakage: 0.01-0.66 Gas transmission & storage: 0.004-0.13 Gas distribution networks: 0.024-0.30 **Sum gas systems: 0.038-1.09**	0.371	0.360	0.279	0.15-0.16 (gas production)		

Finally, on p.9 row 15, authors mention that the province attribution of emissions from oil and gas systems has been done using GDP. There must surely be information available on the geographical distribution of oil and gas production in China. In particular for oil production, almost all emissions are released during extraction and GDP is not likely to be a good measure for the geographical attribution of these emissions.

Fossil fuels combustion:

Use of default IPCC emission factors, which seems appropriate.

Landfills:

Use of FOD method, which is the recommended IPCC method. The levelling off of emissions from landfills towards the end of the period (visible in Figure 2) is explained by an increase in composting and incineration. Estimates seem consistent across mentioned studies.

Wastewater:

Estimates emissions from both domestic and industrial sources. No additional comments.