Supplement of

Long-term historical trends in air pollutant emissions in Asia: Regional Emission inventory in ASia (REAS) version 3

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Differences between REASv3.2 and REASv3.1

1. Introduction

Datasets of Regional Emission inventory in ASia version 3.1 (REASv3.1) were released from REAS data download site (https://www.nies.go.jp/REAS/) together with a publication of Kurokawa et al. (2019) from December 2019. The datasets were revised though the revision processes of Kurokawa et al. (2019) and the updated data are available as REASv3.2 from the data down load site.

The methodology of both versions was the same and the differences between REASv3.2 and REASv3.1 were mostly by correction of errors in data and system used for REASv3.1. The purpose of this document is to present degrees of differences between REASv3.2 and REASv3.1 especially for users who have already used REASv3.1. Note that following acronyms were used in this document: Southeast Asia (SEA), East Asia other than China and Japan (OEA), and South Asia other than India (OSA).

2. SO_2

Figure 1 compares total SO_2 emissions in China, India, Japan, SEA, OEA, and OSA. There were no clear differences except for Japan and OSA. For Japan, large discrepancies were found between 1970 and 1985: 7%, 22%, and 16% to total of REASv3.1 in 1970, 1980, and 1985, respectively. These differences were mainly caused by errors in settings of sulfur contents in heavy fuel oil in the industry sector. For OSA, discrepancies were found after around 2000: 6%, 5%, and 5% in 2005, 2010, and 2015. These differences were caused by errors in settings of sulfur contents in coal in Pakistan.

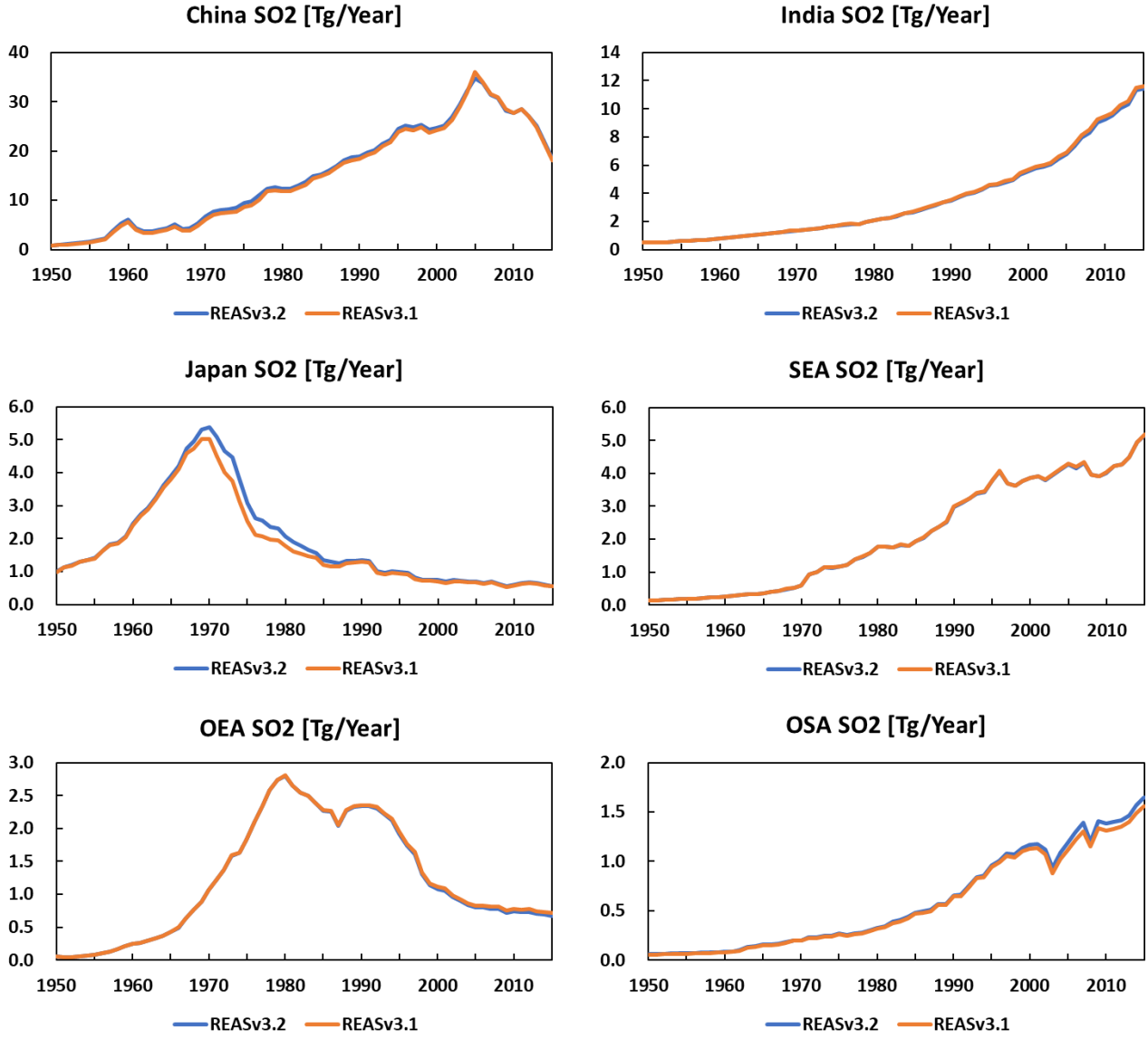

Figure 1. Differences of total SO_2 emissions in China, India, Japan, SEA, OEA, and OSA between REASv3.2 (blue line) and REASv3.1 (red line).

3. NO_x

Figure 2 compares total NO_x emissions in China, India, Japan, SEA, OEA, and OSA. Somewhat discrepancies were found in all countries and regions. For China, values of REASv3.2 are larger than those of REASv3.1. The largest discrepancies of about 10% to total of REASv3.1 were found around 2000. For other years, the differences were about 7%, 5%, and 3% in 1990, 2010, and 2015. On the other hand, for India, values of REASv3.2 were smaller than REASv3.1. After around 1990, the discrepancies were around 5-7%. Similarly, for Japan, SEA, and OSA, values of REASv3.2 are smaller than those of REAS3.1. For Japan, emissions of REASv3.2 were smaller than REASv3.1 about 5-6% in 1990s and 7-8% after early 2000s. The differences were larger in SEA. The emission amounts of REASv3.2 were smaller about 14-17% from early 1980s to late 1990s and about 10-12% after 2000s. For OSA, after 1980s, values of REASv3.2 were about 5-10% smaller than REASv3.1. On the contrary, for OEA, emissions of REASv3.2 were about 20% higher than REASv3.1 and for other years, the differences were 8%, 18%, 14%, and 4% in 1990, 1995, 2005, and 2010, respectively. The common major causes of these discrepancies in all countries and regions were the road transport sector (Fig. 3). There were errors in settings of the emission factors. Another relatively large differences were in fuel combustion emissions in the agricultural sector of the domestic sector. The emission factors for diesel oil were incorrect except for Japan and higher values were adopted in REASv3.2. The differences in the agricultural sub-sector to total emissions of REASv3.1 were 3-4%, 4-7%, 2-5%, 3-6%, and 4-6% in China, India, OEA, OSA, and SEA, respectively.

4. CO

Figure 4 compares total CO emissions in China, India, Japan, SEA, OEA, and OSA. Relatively large discrepancies were clearly found in China and SEA. For other countries and regions, even though differences of total emissions were small, there were discrepancies in sector level emissions. For China, emissions of REASv3.2 were smaller than REASv3.1. The differences were 6-8%, 9-13%, and 15-20% to total of REASv3.1 during 2013-2015, 2001-2012, and 1970-2000. The causes of these differences were mistakes in settings of emission factors for the industry and road transport sectors. Comparisons of emissions from the industry and road transport sectors between REASv3.2 and REASv3.1 were plotted in Fig. 5. Emissions in SEA of REASv3.2 were also smaller than REASv3.1. The discrepancies were 8-10% after 1995 and 11-14% before 1994. One reason is correction of errors in biofuel data (settings of relative ratios of fuelwood, crop residue, and animal waste in primary solid biofuels) which reduced emissions from the residential sector. Another is errors in settings of emission factors of coal combustion in the industry sector. Similar correction of the emission factors for coal combustion of the industry sector were done for India and OSA. On the other hand, revision of emission factors for motor cycles and correction of emission factors for diesel combustion in the agricultural sub-sector of the domestic sector increased CO emissions of REASv3.2 from REASv3.1 and then, differences in total emissions were small in India and OSA. For Japan and OEA, differences between REASv3.2 and REASv3.1 were generally small for all sectors.

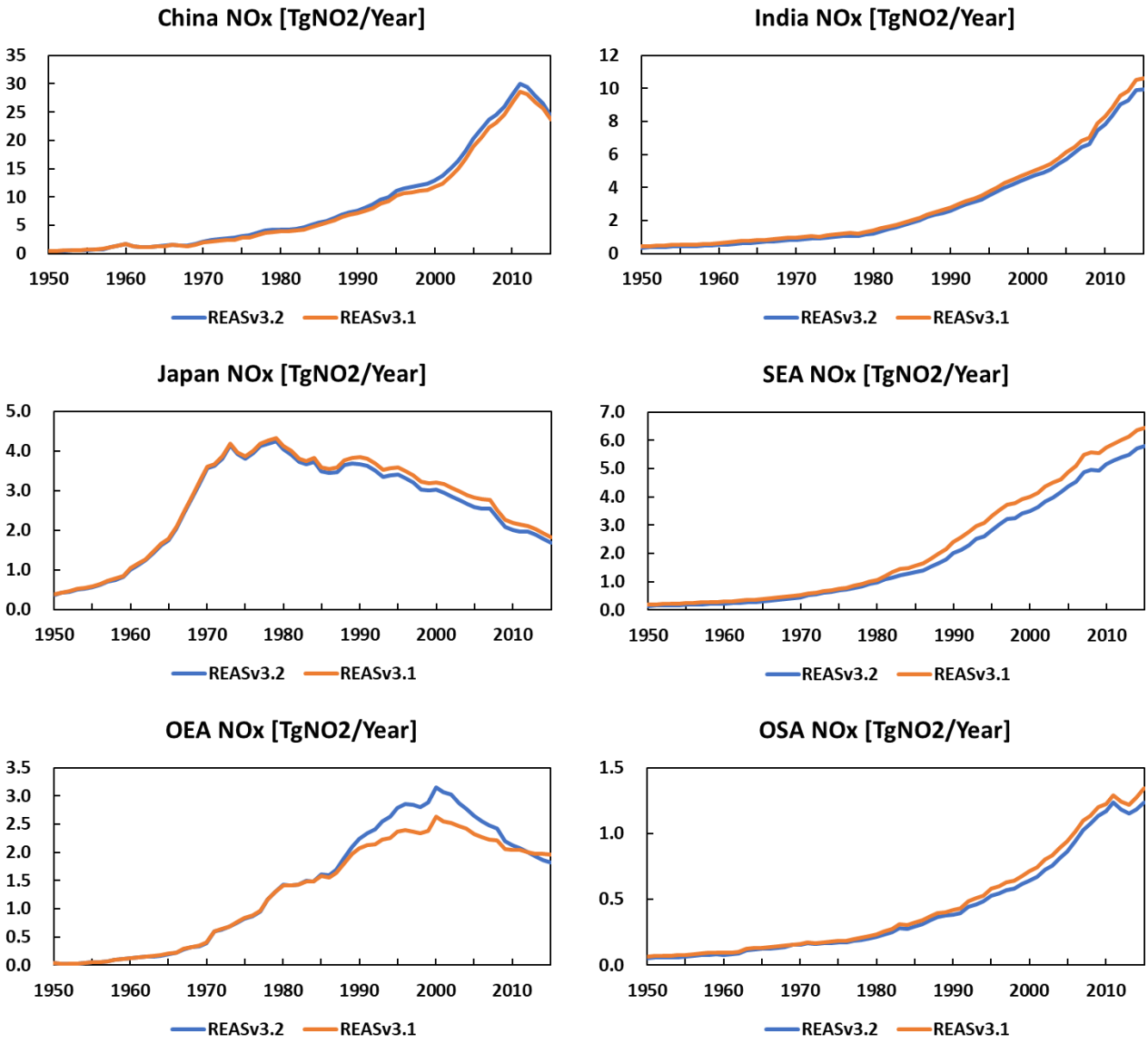

Figure 2. Differences of total NO_x emissions in China, India, Japan, SEA, OEA, and OSA between REASv3.2 (blue line) and REASv3.1 (red line).

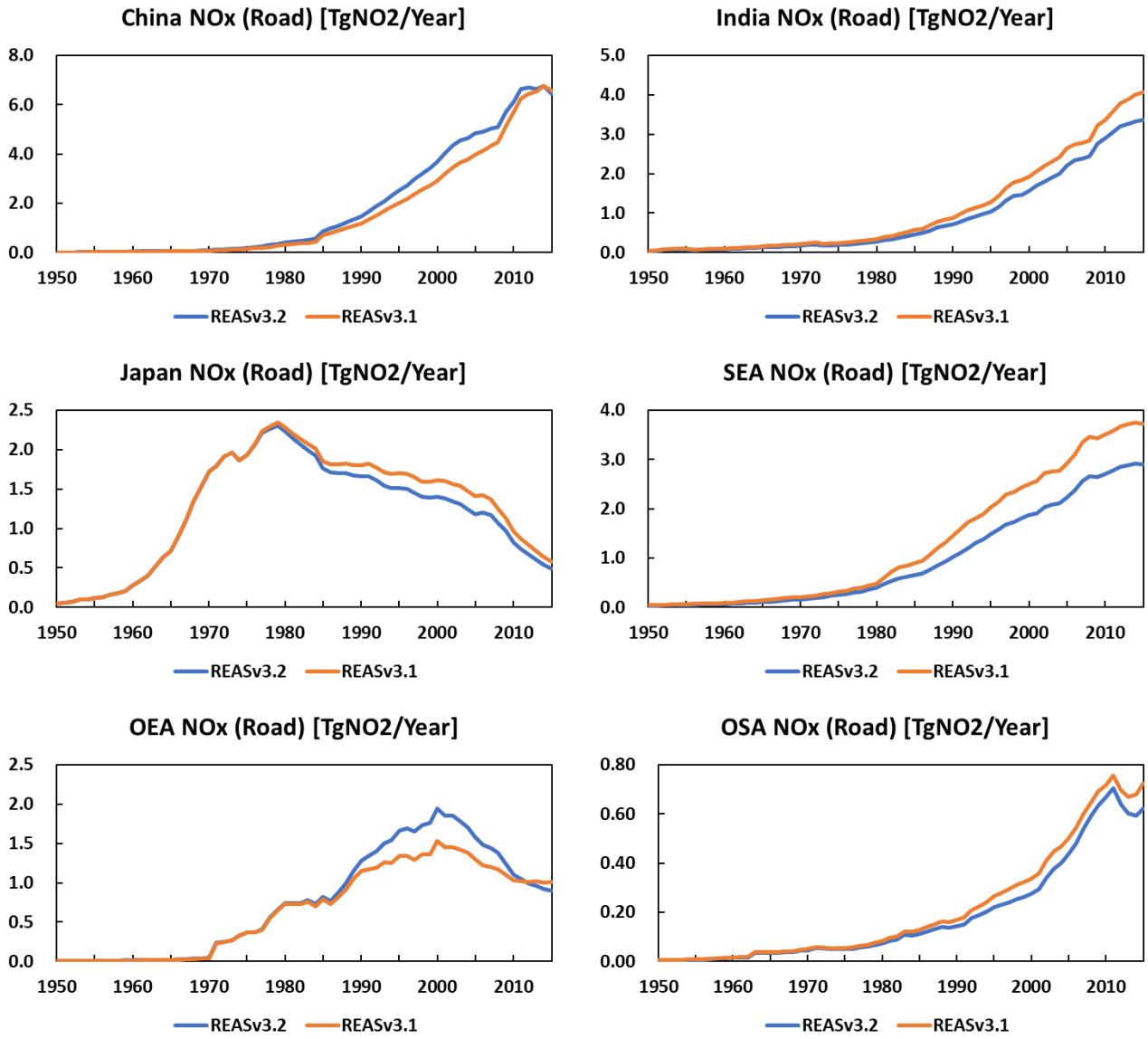

Figure 3. Differences of NO_x emissions from the road transport sector in China, India, Japan, SEA, OEA, and OSA between REASv3.2 (red line) and REASv3.1 (red line).

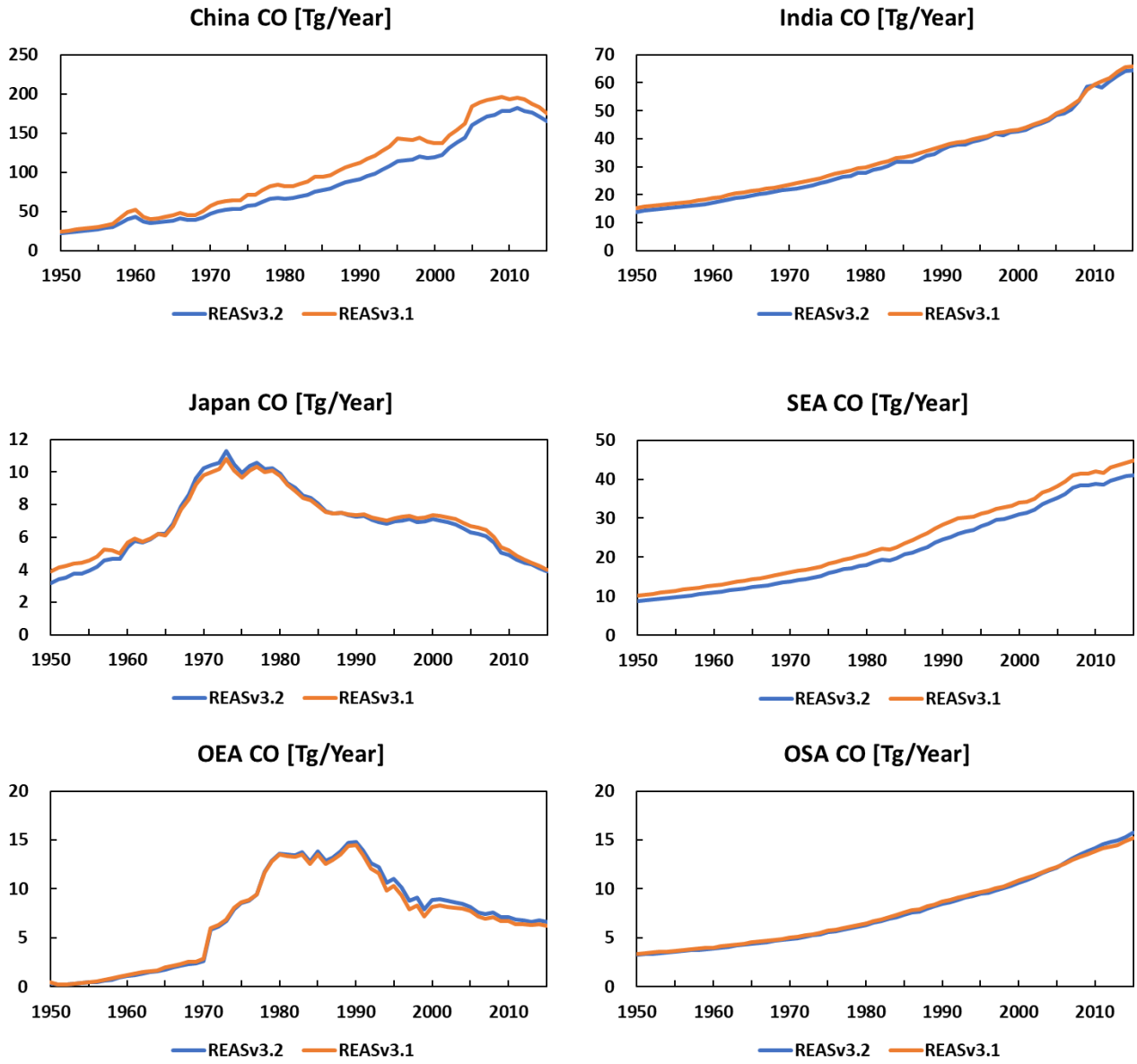

Figure 4. Differences of total CO emissions in China, India, Japan, SEA, OEA, and OSA between REASv3.2 (blue line) and REASv3.1 (red line).

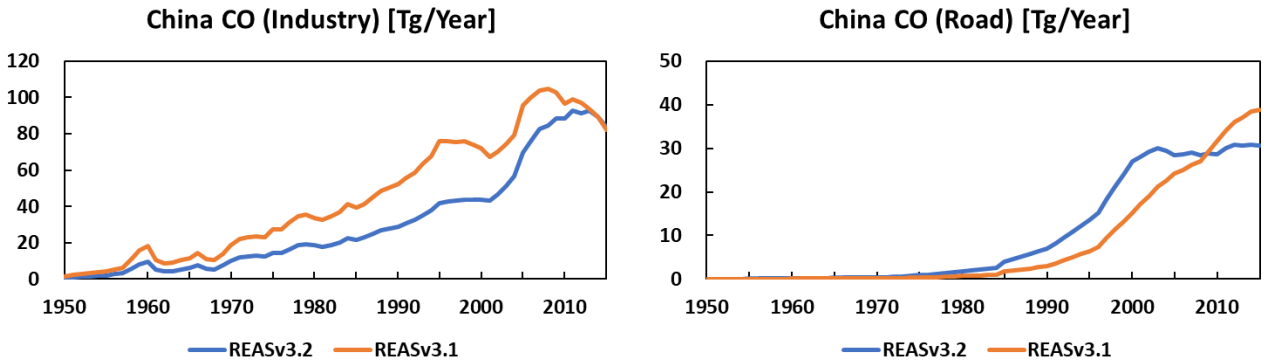

Figure 5. Differences of CO emissions from the industry and road transport sectors in China between REASv3.2 (blue line) and REASv3.1 (red line).

5. NMVOC

Figure 6 compares total NMVOC emissions in China, India, Japan, SEA, OEA, and OSA. Somewhat discrepancies were found in all countries and regions. Two major sources which caused the differences are biofuel combustion and exhaust emissions from road vehicles. In REASv3.2, settings of the emission factors for biofuel and those for road vehicles were revised from REASv3.1. For China, emissions from biofuel combustion in REASv3.2 were smaller than REASv3.1 and the differences to total emissions of REASv3.1 were 20%, 15%, 10%, and 4% in 1985, 1995, 2005, and 2015, respectively. On the other hand, for emissions from road transport, emissions of REASv3.2 were larger during late 1990s and late 2000s and then, after early 2010s, the values of REASv3.2 were smaller than REASv3.1. For India, Japan, and SEA, majority of differences between REASv3.2 and REASv3.1 were caused by revision of biofuel emission factors. Particularly for Japan, relatively large discrepancies before 1965 were mainly caused by revision of emission factors for charcoal combustion. For OEA, the majority of the differences were correction of errors in settings of emission factors for road transport. For OSA, the differences were mainly caused by revision of emission factor for biofuels, but after late 1990s, emissions from road vehicles in REASv3.2 became larger than REASv3.1 by revision of emission factors. Then, differences of total emissions in OSA were becoming smaller after 2005.

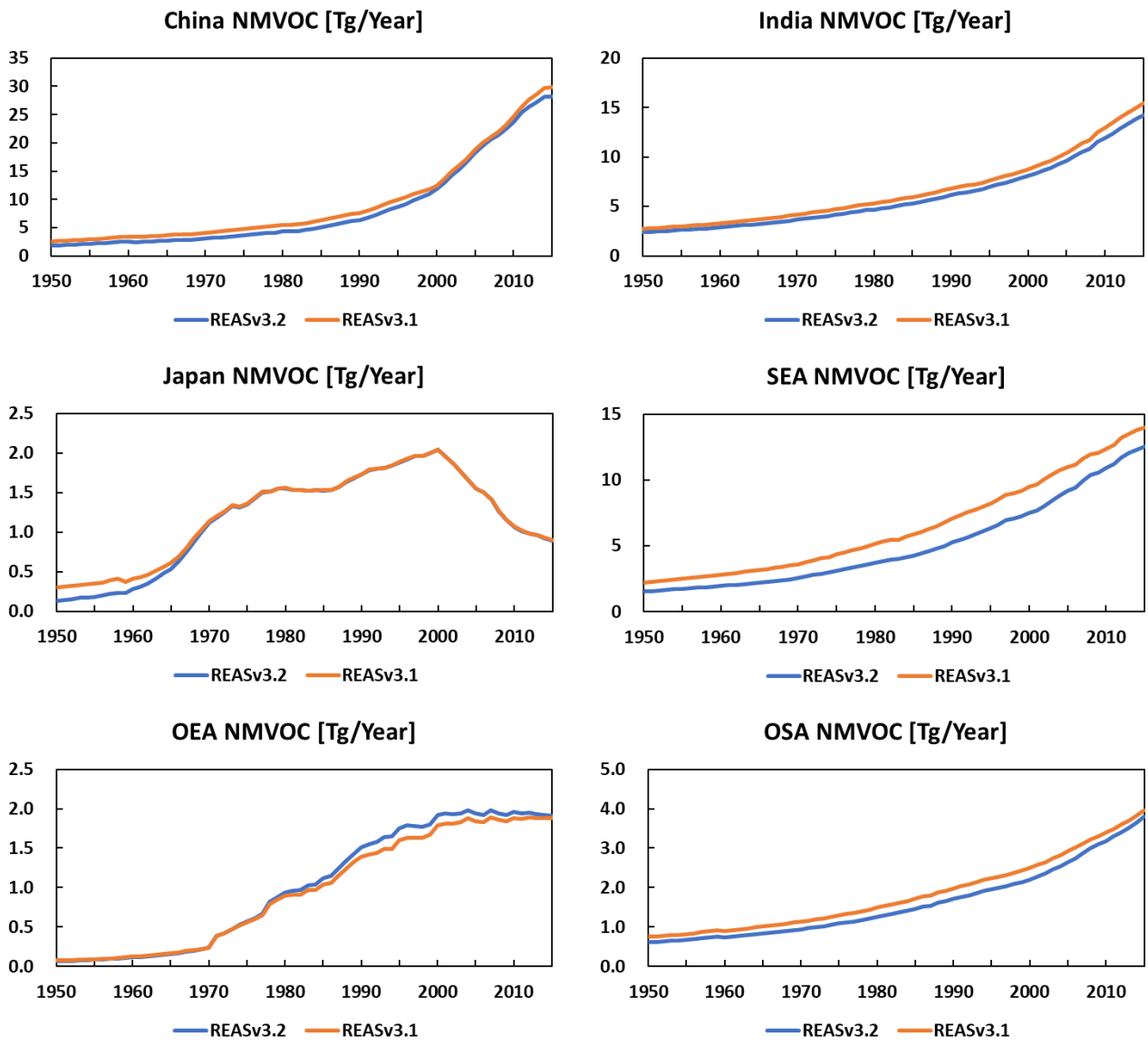

Figure 6. Differences of total NMVOC emissions in China, India, Japan, SEA, OEA, and OSA between REASv3.2 (blue line) and REASv3.1 (red line).

6. NH_3

Figure 7 compares total NH_3 emissions in China, India, Japan, SEA, OEA, and OSA. For NH_3, differences between REASv3.2 and REASv3.1 were negligible for all countries and regions.

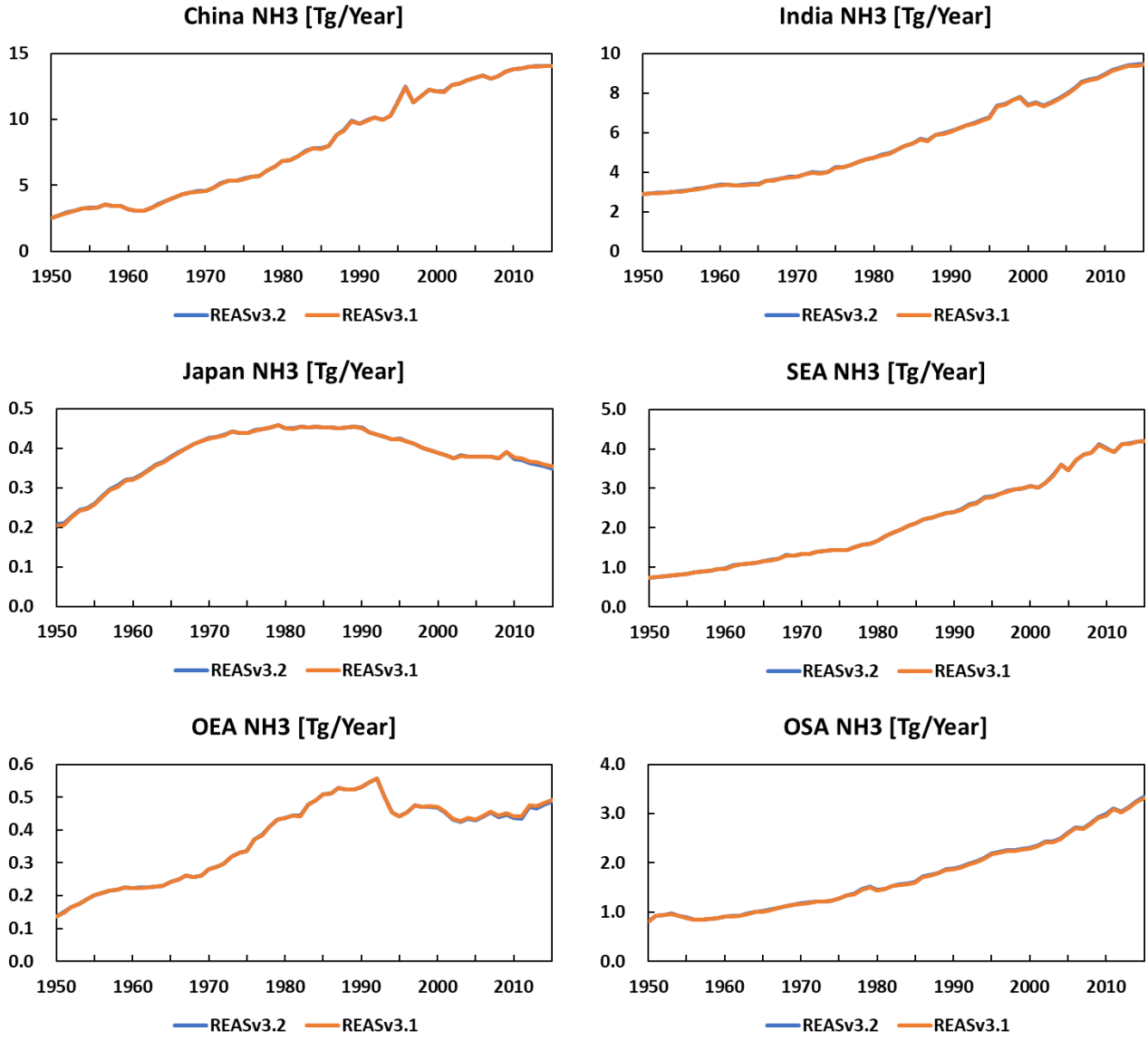

Figure 7. Differences of total NH_3 emissions in China, India, Japan, SEA, OEA, and OSA between REASv3.2 (blue line) and REASv3.1 (red line).

7. CO_2

Figure 8 compares total CO_2 emissions in China, India, Japan, SEA, OEA, and OSA. For CO_2, differences between REASv3.2 and REASv3.1 were negligible for all countries and regions.

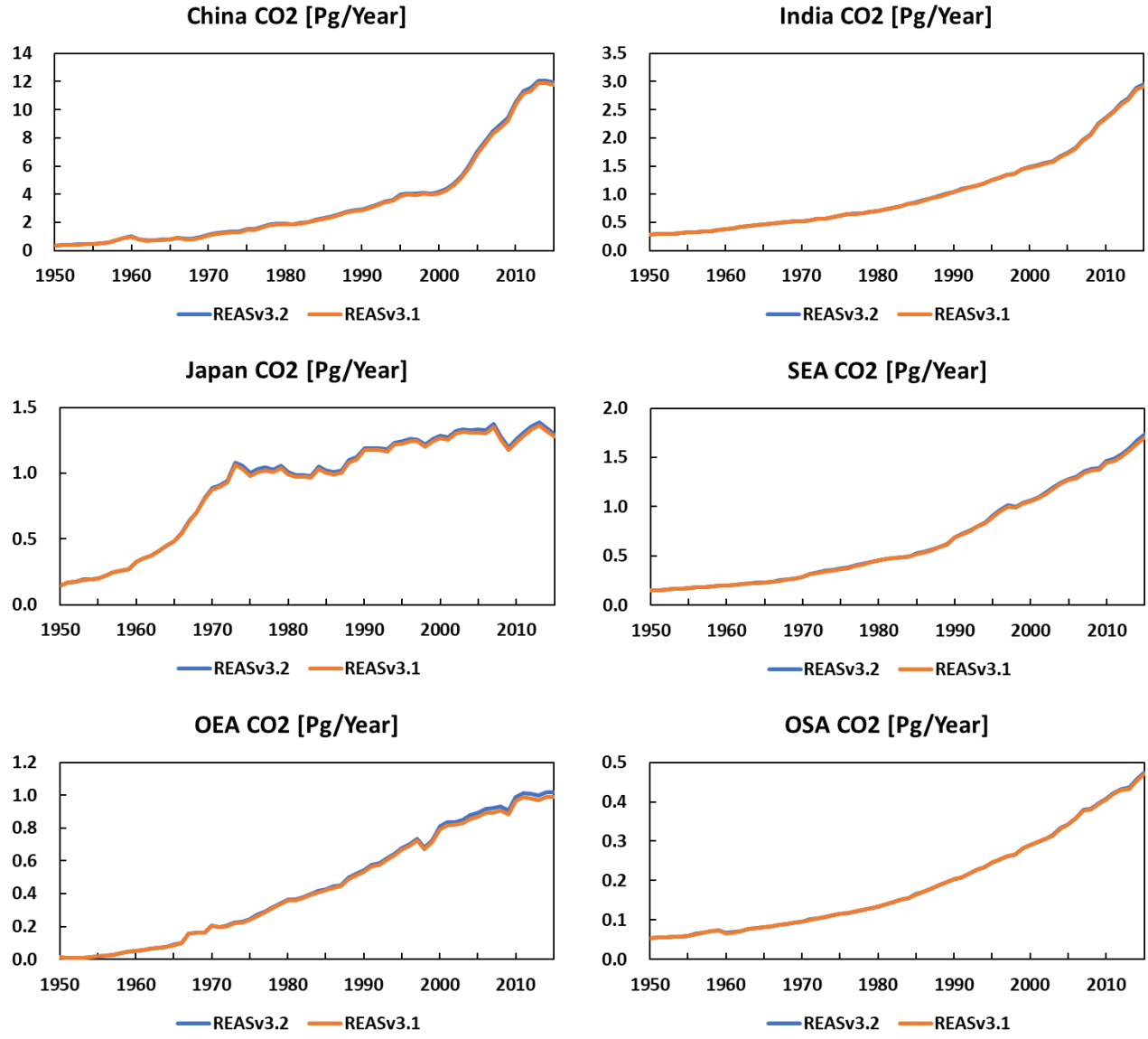

Figure 8. Differences of total CO_2 emissions in China, India, Japan, SEA, OEA, and OSA between REASv3.2 (blue line) and REASv3.1 (red line).

8. PM_{10} and $PM_{2.5}$

Figures 9 and 10 respectively compare total emissions of PM_{10} and $PM_{2.5}$ in China, India, Japan, SEA, OEA, and OSA. Differences between REASv3.2 and REASv3.1 were negligible for China, but for other countries and regions, there were clear discrepancies. For India, Japan, and OEA, relatively large differences appeared at different timings. Causes of the discrepancies were correction of emission factors for non-combustion emissions from cement production and oil refinery. The different timings depended on increasing effects of activity data and penetration rates of abatement equipment. For SEA and OSA, in addition to differences in the industry sector by the same causes for India, Japan, and OEA, emissions from biofuel combustion in REASv3.2 were smaller in SEA and larger in OSA. These differences were caused by correction of errors in biofuel data (settings of relative ratios of fuelwood, crop residue, and animal waste in primary solid biofuels).

9. BC

Figure 11 compares total emissions of BC in China, India, Japan, SEA, OEA, and OSA. Differences between REASv3.2 and REASv3.1 were negligible for China and Japan, but for other countries and regions, there were clear discrepancies. Emissions of REASv3.2 in India, SEA, and OSA were generally smaller than those of REASv3.1. These were mainly caused by revision of emission factors for biofuel combustion. On the other hand, for SEA, emissions from road transport were increased by correction of emission factors, but amounts of the differences were smaller than those from biofuel combustion. For OEA, emissions of REASv3.2 were smaller than REASv3.1 before 1990 and after 2000. The causes of these discrepancies were correction of emission factors for brown coal in the industry sector before 1990 and revision of emission factors for road vehicles after 2000.

10. OC

Figure 12 compares total emissions of OC in China, India, Japan, SEA, OEA, and OSA. Somewhat discrepancies were found in all countries and regions. For China, the differences were mainly caused by revision of emission factors for diesel oil combustion in the agricultural sub-sectors of the domestic sector. For India, Japan, SEA, and OSA, emissions of REASv3.2 were smaller than those of REASv3.1 due to revision of emission factors for biofuel combustion. The same as for NMVOC, the differences in Japan were mainly caused by revision of emission factors for charcoal combustion. For OEA, emissions of REASv3.2 were larger than REASv3.1 during 1970-2000 due to revision of emission factors for brown coal in the industry sector.

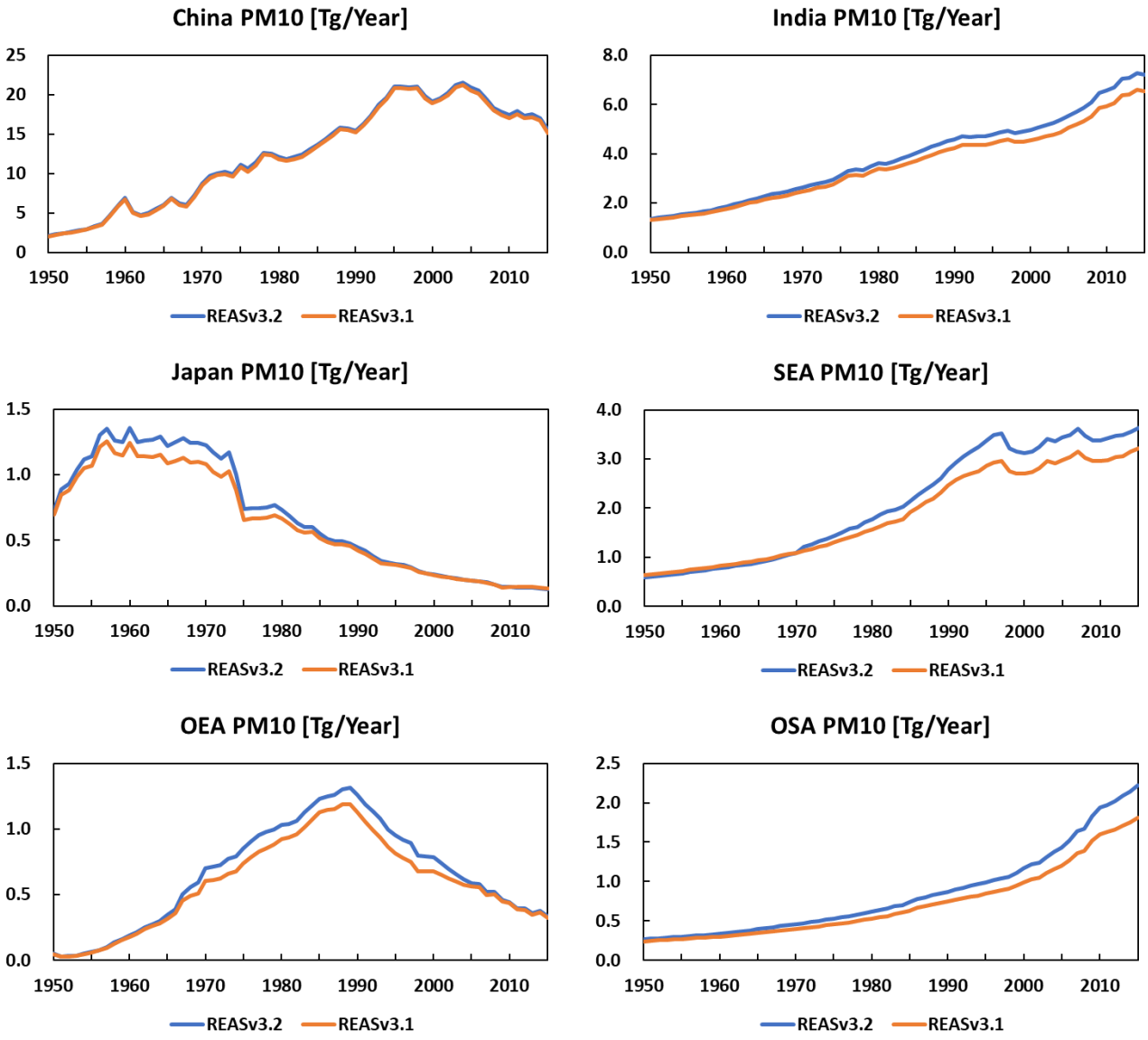

Figure 9. Differences of total PM_{10} emissions in China, India, Japan, SEA, OEA, and OSA between REASv3.2 (blue line) and REASv3.1 (red line).

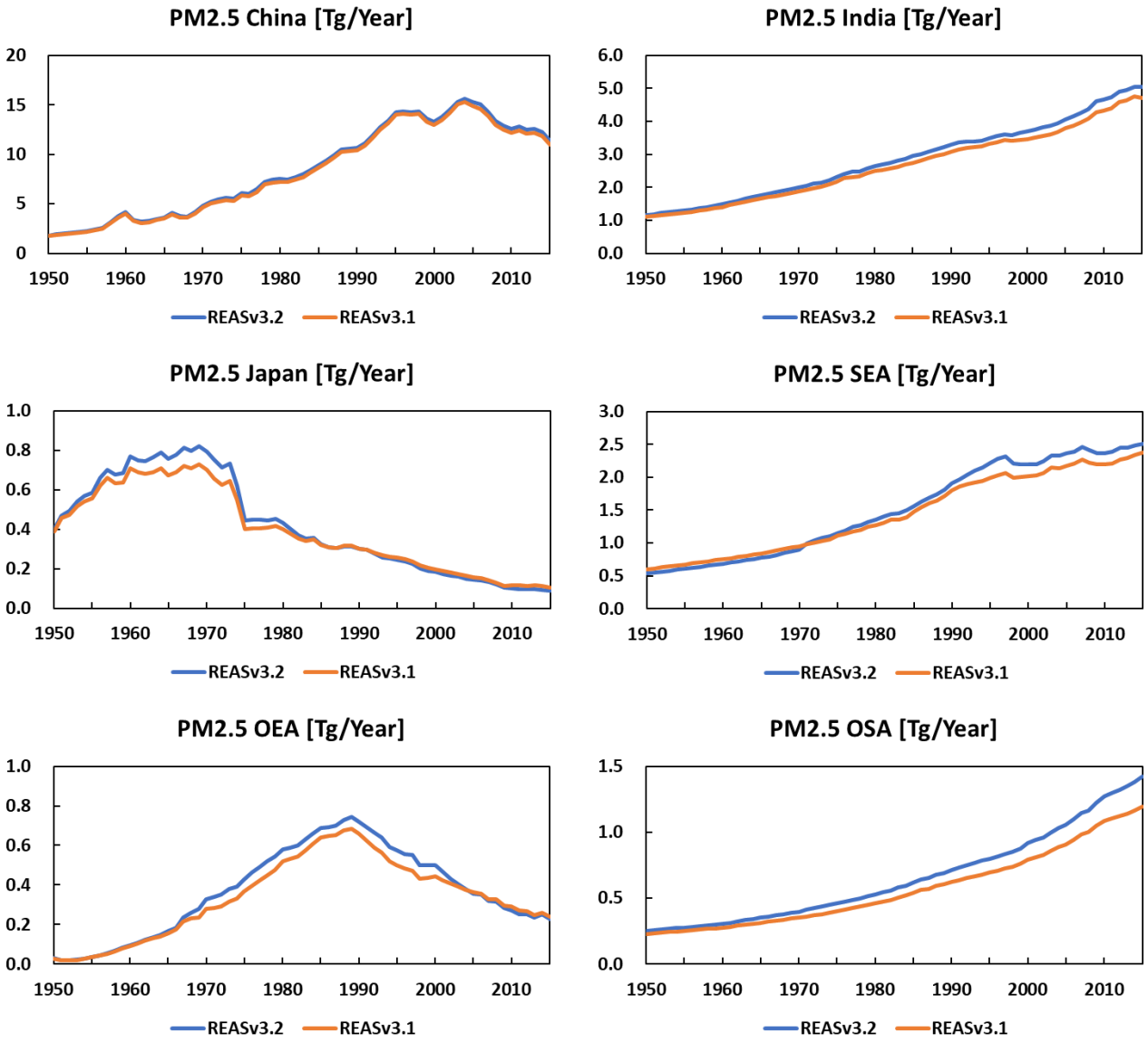

Figure 10. Differences of total $PM_{2.5}$ emissions in China, India, Japan, SEA, OEA, and OSA between REASv3.2 (blue line) and REASv3.1 (red line).

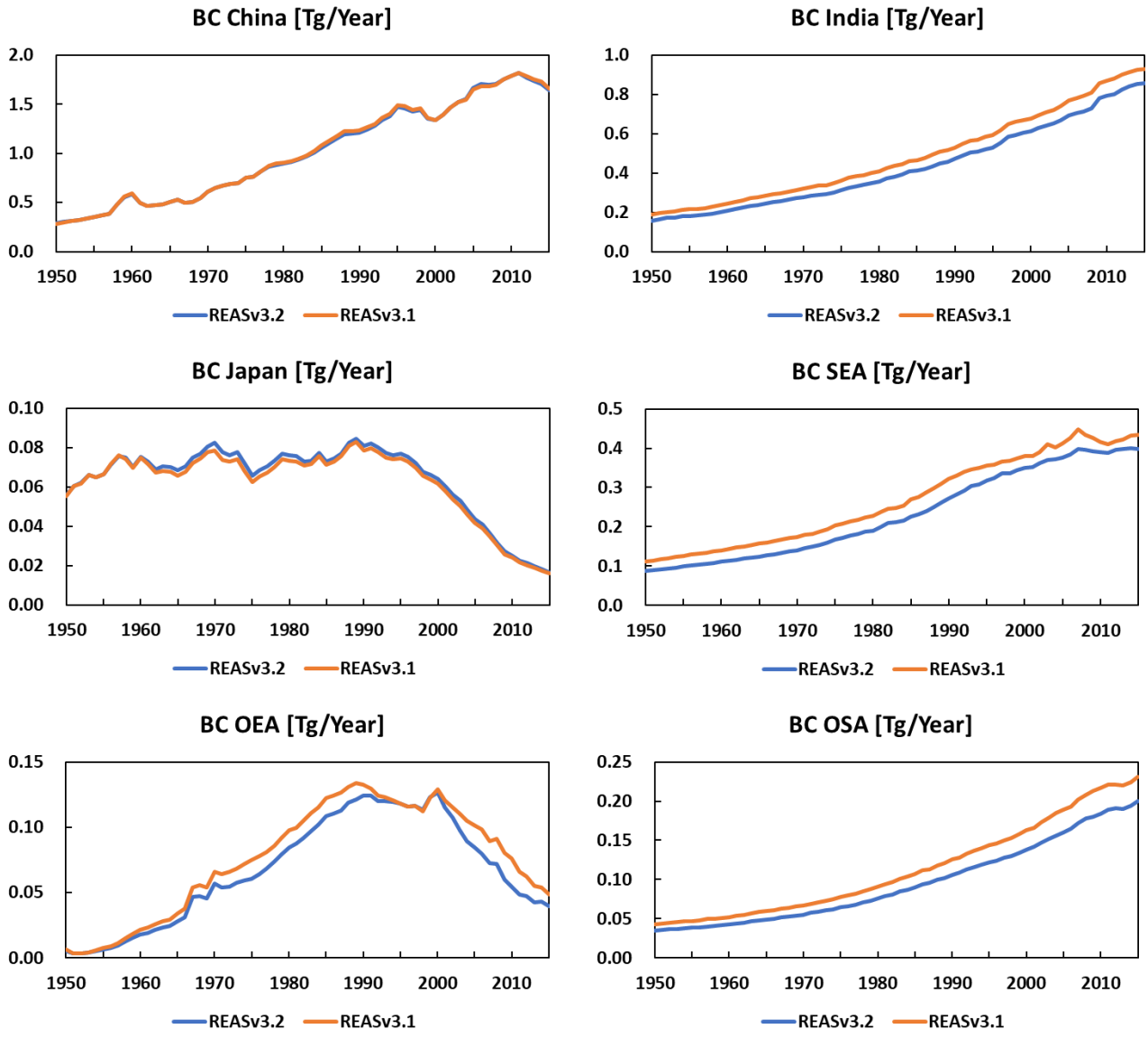

Figure 11. Differences of total BC emissions in China, India, Japan, SEA, OEA, and OSA between REASv3.2 (blue line) and REASv3.1 (red line).

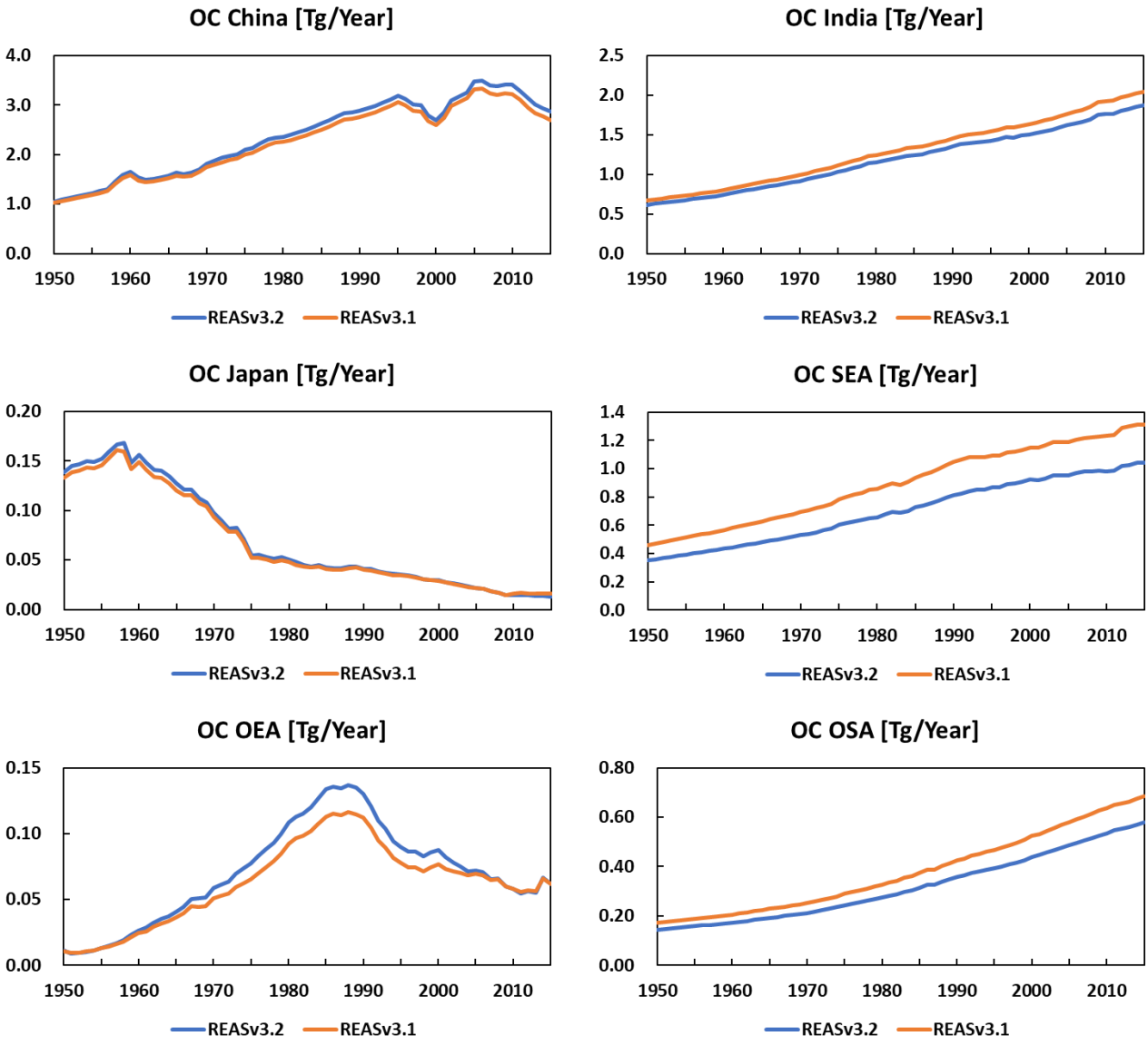

Figure 12. Differences of total OC emissions in China, India, Japan, SEA, OEA, and OSA between REASv3.2 (blue line) and REASv3.1 (red line).

References

Kurokawa, J. and Ohara, T.: Long-term historical trends in air pollutant emissions in Asia: Regional Emission inventory in ASia (REAS) version 3.1, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2019-1122, 2019.