

*We are indeed grateful to the reviewers for their insights and critiques. The following is our point-to-point response to their questions.*

Review 2:

One thing that wasn't clear to me is how frequent are these episodes of enhanced vertical transport. The authors identify just 3 cases across several years. Are these episodes hard to spot in the sparse data? Very infrequent? If the latter, do they add up to an important contribution regionally? world-wide? Does the model see more of them? Or are they a case study to more easily learn about vertical transport? It would be very useful to read more background.

*Thanks for the points. More background information is now provided and discussed in Sect. 5.1. The frequency of high CO episodes observed by MOZAIC around Narita was summarized in original Table 2. The frequency of high CO episodes appeared in MOPITT and GEOS-Chem data is provided in a new Table 3. According to these data, it is likely that the high CO episodes shown in this study occurred 2-4 times every 100 days for each lower, middle and upper troposphere over the Sea of Japan and the East China Sea. GEOS-Chem does not see more high CO episodes in the free troposphere than MOZAIC or MOPITT. Overall, MOZAIC observed slightly more transport of high CO to the upper troposphere, while GEOS-Chem simulates more transport of CO (with lower abundances) to the middle and lower troposphere. According to Tables 2 and 3, air mass with 200-300 ppbv CO is transported to 400-200 hPa at a frequency of 10-20 times per 100 days, or approximately once a week. This can have significant impacts on the air quality downwind. The transport mechanisms and CO source contributions revealed in this study can also be applicable for these CO episodes, even at lower CO abundances or lower altitudes.*

In general, I think the sections should be shortened and made more concise, especially given the lack of quantitative information. The authors are strongly encouraged to add quantitative information.

*The contents in the original Sect.5 (Discussion) are substantially removed. We have added more quantitative information in Discussion and in Table 3.*

p28025, l 5-10. It's a bit confusing to read about demonstrating MOPITT's vertical sensitivity, since I thought it was MOPITT's vertical sensitivity that was being used to evaluate the vertical transport, not the other way around. It would be great to be clear about that here already.

*MOPITT data are analyzed in two ways in this study. First, the vertical sensitivity of MOPITT is evaluated with the coincident MOZAIC data (see Figures 1, 2 and 3) and further illustrated with in the high CO episodes in comparison with the MOZAIC data (see Figure 5). Second, the vertical variation in CO captured by MOPITT is used to diagnose vertical transport of*

CO (Figure 6).

p28027, l 17-19. It would be great to put the list of parameters at the beginning of this subsection, otherwise, it's a bit unclear what "analyses" include Section 2.5 Are the met data described in 2.3 used only to drive FLEXPART? Perhaps it's better to combine those two sections then, similarly to how GMAO met fields are in the same section as GEOS-Chem Section 2.6.

*The list of parameters is moved to the beginning of this section. We added "In addition to driving FLEXPART, the FNL data are used to analyze the meteorological conditions including the surface pressure, wind fields, and development of a cyclone." We moved this section right ahead of the section on FLEXPART.*

Is the full chemistry version of GEOS-Chem being used as implied or is it just tagged CO/single tracer simulation?

*GEOS-Chem was used in the full chemistry mode. This information is added into the text.*

p.28030, l20-21. I don't understand the concept of "difference between averaging kernels", is it its diagonals?

*The difference is the averaging kernel for each retrieved pressure level between version 5 and version 4.*

Section 4.1 It's an interesting reconstruction of the history of a pollution plume, but I'm not sure how much of this was not known before. It's not clear what's new here. Is it that pollution is transported via WCB? That it is lofted 9 km? That it reaches Canada? That MOPITT and models agree? None of this sounds new, so it would be helpful if the authors stated more explicitly what new insights they have gained here. I'm also curious what does GEOS-Chem say about this case study.

*Thanks for the comments. New insights gained from this case are now discussed at the end of Sect. 4.1. More detail on GEOS-Chem simulation for this case is provided in Sect. 5.5.*

p28036, l2. "This source is confirmed in the GEOS-Chem simulation". Are the authors really relying more on GEOS-Chem than MOPITT to confirm cases of vertical transport of pollution? Shouldn't it be the other way around? especially at 700hPa. Naturally, it would be good to have independent data set here, but I guess MOZAIC was not available? It would be good if the sections were a bit more parallel (each commenting on the skill of both models and availability and quality of both data sets) Is Figure 12 necessary?

*Thanks for the points. This study aims for solving puzzles of vertical transport of CO, using observations from MOZAIC and MOPITT and simulations from FLEXPART and GEOS-Chem, as well as other data. All the data and*

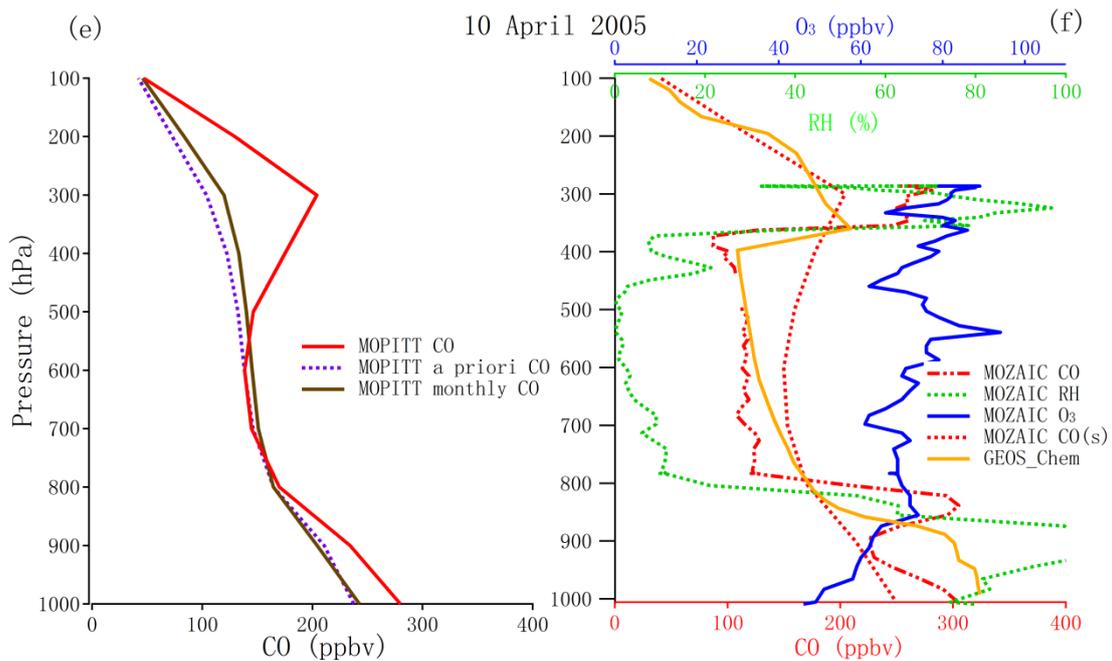
*simulations were integrated to examine if they support or complement each other without particular preference to one dataset or simulation. In this case, elevated CO plumes around 700 hPa is captured in MOZAIC and MOPITT data and GEOS-Chem simulation (Figures 4, 5, 6), while in the upper troposphere, the elevated CO is missed in MOZAIC data but captured by GEOS-Chem (Figure 11), and weakly detected by MOPITT (Figure 6b). Because both MOPITT and MOZAIC data only show the sum of CO from all sources so we used fire data and GEOS-Chem simulation to separate different sources. We have replaced the word “confirm” with “recognized” to express ourselves more clearly. We have made the sections more balanced with the observations and simulations. We have commented on the skill of both models in Sect. 5.4 and availability and quality of MOPITT data in Sect.5.5. Figure 12 is necessary because it illustrates an important finding in this study (see Sect. 4.2).*

p28038, l 1-3 How was this somewhat random time frame chosen? I'm sure there was a good reason, but it's not clear from the text what it was.

*Thanks for pointing this out. We did backward trajectories first from the boxed area in Figure 4b, and these trajectories indicate the most particles mainly came from the large fire regions starting from 11 March 2004. We have explained this now in the text.*

p28038, l 21. It's a bit difficult to believe that different altitude of this plume as identified by MOPITT is an indication of MOPITT's ability to resolve vertical structure. While this could be true given how good MOPITT instrument is in general, the earlier section relied more on GEOS-Chem than MOPITT to even identify the plume, so here I am wondering if we should take MOPITT at face value or wonder what GEOS-Chem is showing in this case.

*As mentioned earlier, we did not particularly rely on one dataset or simulation. Instead, we put all the data and simulations together to examine if they support or complement each other. We did examine the GEOS-Chem profile over the boxed area in Figure 4c. GEOS-Chem also shows elevated CO plumes around 400-200 hPa (shown below), which supports the MOZAIC and MOPITT observations. The GEOS-Chem profile was not included in Figure 5f in order to keep it simple and focused, while the signal of the CO plume was illustrated and discussed in Figures 14 and 15.*



Section 5 Discussion. It's hard to tell what is the exciting findings. Is it that there was high CO documented? Is it that topography affects vertical CO transport? Is either new and/or surprising? Please tell the reader so. It all seems intuitive and the section is purely qualitative, so it's not clear that anything new is being reported. It would also be helpful to have quantitative information. For example, how does topography affect CO transport, does it have to be a mountain region? only in the north/east/west/south? does any of this or could any of this vary with seasons? It's hard to draw conclusions from individual case studies.

*Thanks for the points. The background information is provided in Sect. 5.1. The topography effects are discussed in Sect. 4.2. This section is rewritten to address the reviewer questions. The main contributions of this study include (1) observing rare high CO episodes in the free troposphere in East Asia, (2) identifying distinct transport mechanisms, pathways, and CO sources for these episodes, (3) supporting and extending a proposed mechanism of the leeside troughs over the Indochina peninsula in promoting vertical transport of pollutants, and (4) analyzing MOPITT data from perspective of its vertical sensitivity at synoptic scale.*

p28044, I28-29 It's not clear why the statistical analysis couldn't be done here already. Authors should consider doing at least preliminary work on that.

*In the previous manuscript, we suggested this work as a direction for further studies. This suggested work requires long-term analysis, or at least longer than 5 year. In order to provide accurate statistics, careful examinations of each WCB for the period are needed. This is a large undertaking itself and also beyond the scope of this study. It does not affect the conclusions of this study.*

p28045-28046. These whole pages (and the remainder of that section) can be deleted, especially the first paragraph. It's just repeating background information.

*This part is largely shortened. The application of MOPITT data is one of the major focuses of this study so some discussion on this perspective is desirable. We now emphasize more on new insights gained from this study.*

p28048, l17 replace "interplaying" with "interacting"?

*Replaced.*

Figures: figure captions and labels are a bit too small to be readable, especially on figures 1-7, figure 11.

*Figure captions and labels are enlarged for these figures.*