

Review of the paper:

“Determination of the chemical equator from GEOS-Chem model...”

written by Xiaoyu Sun et al.,

### **General Comments:**

The paper presents a method to determine the hemispheric boundary of air mass transport between the two hemispheres called the chemical equator, which has not been topic of many studies so far. Particularly, it focuses on the Tropical West Pacific region. The location of chemical equator is calculated from the artificial tracers simulated by the GEOS-Chem model. The authors investigate the vertical structure of the chemical equator and compare the chemical equator to the tropical rain belt and the convergence of the wind fields. The topic of this paper falls into the scope of ACP. However, major revisions are required to the manuscript before it is suitable for publication. As described below, there needs to be (1) improved justification of the method to determine the chemical equator, (2) clarification of which vertical level are the chemical equator results based on, (3) application of the chemical equator defined here in understanding the inter-hemispheric transport of air, and (4) more proof to support the interpretation of some results.

### **Major comments:**

- Previous study (Hamilton et al., 2008) used a sharp gradient in the chemical background to determine the chemical equator. This study defines the chemical equator as the location where the tracer concentration is the same to the average of the trend component over the tropics (30° S-30° N). Did the authors compare the chemical equator determined here to that calculated from the gradient of tracers?

Hamilton, J. F., et al. (2008), Observations of an atmospheric chemical equator and its implications for the tropical warm pool region, *J. Geophys. Res.*, 113, D20313, doi:10.1029/2008JD009940.

- The chemical equator can be obtained from the surface to the tropopause. It is unclear which vertical level are the results in the paper based on. Please check the whole manuscript from the method to the results and clarify.
- Since it is the chemical equator, it is good to know the connection between the location of the chemical equator and the distribution of atmospheric compositions (e.g. CO, SF<sub>6</sub>) using satellite observations or model output. It will help to understand the inter-hemispheric transport of pollutants considering the difference of the tracer distribution in northern and southern hemisphere.
- The Western Pacific Monsoon and other circulations make the Tropical Western Pacific region complex. Except the large seasonal migration, what is the unique feature of the chemical equator over the Tropical Western Pacific comparing to that over the other regions. There needs be more discussions of chemical equator over the Tropical Western Pacific versus that over the other regions.

- There are a lot of interpretations regarding the air mass transport without relevant plots. It might be easier to understand the relative contributions from the source domains and air mass inter-hemispheric transport if the authors include the distribution of the artificial tracers from 30° N - 90° N and 30° S - 90° S.

### Minor and technical comments:

- P1 L12  
".....meaning the speed of the migration of the CE decreases with the altitude", do you mean the seasonality of the migration of the CE in the lower altitude is larger than that in the higher altitude?
- P2 L47  
".....discussed. (Nicholson, 2009, 2018)." → ".....discussed (Nicholson, 2009, 2018)."
- P3 L88  
".....zonal range of 30° N - 90° N..." → ".....zonal range of 30° N - 90° N and 30° S - 90° S..."
- P4 L92  
"The time series of the tracer averaged zonally..." → "The time series of the tracer released from 30° N - 90° N averaged zonally..."  
Figure presents two source domains. Please specify the source domain to avoid the confusion.
- P4 L98-L99  
"Since the variation around the trend does not vary with the level of the time series", what do you mean here? What is "the level of the time series"? Do you mean different time period or different vertical level? If it is different time period or altitude, I don't understand why the variation around the trend does not change.
- P4 L103  
"Figure 3 shows the decomposition of the time series of the passive tracer." → "Figure 3 shows the decomposition of the time series of the passive tracer released from 30° N - 90° N."
- P4 L112  
"he longitude and attitude..." → "he longitude and latitude"
- P4 L112  
"The trend in each grid box and each time step is meridional averaged in the longitude of range of -180° to 180° and zonally averaged in the latitude range of 30° S to 30° N". It seems like this sentence might be "The trend in each time step is zonally averaged in the longitude of range of -180° to 180° and meridionally averaged in the latitude range of 30° S to 30° N"
- P4 L120-121  
"For example, if the tracer concentration in a grid box is higher than  $\overline{T}_t$ , this grid box is located on the NH, and vice versa for the SH." The authors should mention this is for the tracers originated from 30° N - 90° N.

- P5 L149  
"Figure 4 shows the daily locations of the CE-SH and CE-SH..." → "Figure 4 shows the daily locations of the CE-NH and CE-SH..."
- P6 L156-L157  
"The north of the boundary at 20° S is dominated by the airmass transport from NH". I'm not sure about this interpretation, especially for the region from 20° S to equator. Do you have the results about airmass distribution?
- P6 L157  
"...except Africa..." → "...except Atlantic and Africa..."
- P6 L174-L177  
It is better to introduce Figure 6 before Figure 7.
- P6 L178  
"...in the literature of (Fueglistaler et al., 2004)" → "...in the literature of Fueglistaler et al. (2004)"
- P6 L186-L87  
"In the NH winter, ... in boreal winter from December to February." repetitive winter in one sentence.
- P7 L203  
"the CE-SH and CE-SH" → "the CE-NH and CE-SH".
- P7 L209-L210  
"less than 2 km" → "below 2 km".  
"while the area above...", it is better to specify the latitude range.  
"From April" → "In April and May"
- P7 L212  
"while CE-SH slopes from the ground to 2 km and is relatively vertical to the ground", it might be better to change as "while CE-SH from the ground to 2 km is relatively vertical to the ground"
- P7 L217-L218  
Like the question I addressed in the abstract, how to understand the movement speed of CE here? Is it monthly movement speed?
- P8 L228  
"the CE-SH / CE-SH..." → "the CE-SH / CE-NH".
- P10 L289-L290  
"The north-south migration of the CE is consistent with the maximum rain rate during a year." It is not always consistent, especially in JJA (Figure 10).

- P17  
Figure 3(b): legend ( $6^{\circ}$  S,  $127.5^{\circ}$  E)  
Caption: (a) [ $6.0^{\circ}$  N,  $127.5^{\circ}$  E] and (b) [ $6.0^{\circ}$  S,  $127.5^{\circ}$  E].
- P22  
It is better to include a vertical dashed line along latitude = 0 in Figure 8.
- P23  
Caption: This sentence "The data in this plot are also zonally averaged in the TWP region specified in Fig. 5." is not necessary since "averaged over the West Pacific region" was mentioned before in the caption.
- P24  
Please include coordinate in Figure 10.

### **Recommendation**

Read the manuscript thoroughly. Further improvements to the text clarity is necessary.