

## ***Interactive comment on* “Transpacific transport of Benzo[a]pyrene emitted from Asia: importance of warm conveyor belt and interannual variations” by Y. Zhang et al.**

### **Anonymous Referee #2**

Received and published: 14 October 2011

Review of Zhang et al.: Transpacific transport of Benzo[a]pyrene emitted from Asia: importance of warm conveyor belt and interannual variations

Understanding the transport of pollutants from one continent to another is an important research field and more studies and measurements are needed to quantify the different transport mechanisms of different pollutants.

However, to my mind, the paper still has some weaknesses which have to be clarified before publication.

Major comments:

1) Section 2.4: Here it is stated that the model results agree with the observations and that the model can therefore be used in order to investigate the transpacific transport. However, based on the comparison shown in figure 1 I would not draw such a conclusion and discuss the results much more carefully. In the plots 1d, 1f and 1g the axis of the modeled and observed BaP concentrations differ (unit is  $\text{pg}/\text{m}^3$  for modeled and  $\text{ng}/\text{m}^3$  for observations). Either it is a mistake in the axis notation or the concentrations differ orders of magnitude. There are some time periods where there is a good correlation, however there are others where there is no agreement at all. I would like to see more explanation why the model is right for the one case whereas it cannot capture the observed concentrations in other cases. Furthermore it is not clear to me, how the time episodes that are displayed in figure 1 were chosen. How did you select the dates (periods) for which you show the comparison? You state in section 2.2 that there is an emission inventory for PAH for the year 2004. However, in figure 1 you show time series of modeled and observed values between 2001-10-22 (in 1c) and 2006-05-12 (in 1g). Which emissions have been used for the other years than 2004 and are the results then comparable to the year 2004 if the emissions are based on other sources? And why did you not show the same time period for all stations? It would be very nice if you could clarify this point.

2) Section 3.5: In this section you say that a warm conveyor belt (WCB) was important for the transport of BaP to North America. Unfortunately you only show wind errors at 1200m above ground in order to support this hypothesis. However, a WCB is a coherent air stream that ascends from the atmospheric boundary layer in the warm sector of a cyclone ahead of the cold front to the upper troposphere where it turns to the east quite often. During the ascent, clouds are formed and precipitation is produced. In satellite pictures it is represented by an elongated cloud band ahead of the cold front. A WCB cannot be represented by wind vectors close to the ground. This is no evidence of the existence of a WCB. In order to proof that a WCB transported BaP to North America it is necessary to calculate forward trajectories from the emission source regions and to see whether there is a coherent bundle of trajectories that travels over

the North Pacific. The existence of a comma-shaped pattern in BaP concentration at 1200m height is also no evidence of a WCB. The comma-shaped cloud pattern of an extra-tropical cyclone does not form in a height of 1200m. Furthermore, the air masses in which the clouds form that lead to the comma-shaped pattern often observed from space have different origins such that it is not logical that BaP from the same source region can be found in the air mass ahead of the warm front as well as in the warm sector. I would appreciate very much if you could explain in more detail what exactly you mean, how you define a WCB, how you identify its existence and how you can know that the BaP is transported in the WCB airstream. A WCB leads to the transport of pollutants to the upper troposphere, primarily. Thus, it is not clear how this airstream afterward descends such that it can reach the measurement site. More analysis of the atmospheric flow is necessary here, especially as the importance of WCBS is already stated in the title of the paper.

Minor comments:

- 1) title: “importance of a warm conveyor belt”, as you only show one WCB example
- 2) Abstract: you mention the importance of a WCB in the title, it should therefore be mentioned in the abstract as well.
- 3) page ..81, line 24: Killin et al. Instead of Kellin et al.
- 4) page ..82,line 4: the abbreviation PCB should be introduced
- 5) page ..83, line 10: explain the abbreviation BaP although it is already in the title
- 6) page ..83, line 14: “The” global model ... instead of “a” global model
- 7) page ..83, line 22: How many vertical levels are there and how are they spaced in the boundary layer and in the free troposphere?
- 8) page ..84, line 14: ..of “the” atmosphere
- 9) page ..84, line 15: .. by OH radicals

10) page ..84, eq. 1: please describe for what the indices 1,2 and 3 stand for.

11) page ..85, line 11: ..to those for “the” soil compartment.

12) page ..86, line 7: PAHs with OH radicals

13) page ..87, top: You state that emissions west of 60°E were not considered as they do not reach to North America. However, they could be transported to the source regions you consider and therefore change the concentrations and/or chemical reactions there?

14) page ..86, line 10: you say that the model has been run with emissions over the whole Asian continent, although you stated above (in line 1) that emissions west of 60° E were neglected. Please clarify.

15) Section 2.4: Why do you display different time periods for every station? Please explain your selection (see also major comment 1).

16) Figure 1: please check the axis labels, especially the units of the concentrations shown and emphasize that the axis differ for the observed and modeled concentrations. (see also major comment 1)

17) page ..88, line 23: Did you mean: Figure 2a represents the annual mean BaP concentration ?

18) page ..89, line 11: ..on the south of “the” plateau...

19) page ..89, line 11-15. You state that in winter, descending air parcels over this region inhibit the lofting of pollutants and refer to figure 2b. However, figure 2b shows an annual mean.

20) page ..89, line 22-24: Here you say that the descending air streams at the western coast of North America are dry air streams behind cold fronts. Why did you draw this conclusion? Is there any evidence of this in your data or do you have references for that? This is an important part of the atmospheric flow which brings the pollution down

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to the measurement site and should therefore be investigated in much more detail (see also major comment 2).

21) page ..90, line 10: Besides the influence of emissions

22) page ..90, line 11: westerlies

23) page ..90, line 13: Do you have another reference than Wallace and Hobbs as this is a quite good but general introduction to atmospheric science. Some more reference about the flow features in these regions would be appreciated.

24) page ..90, line 20: East Asian

25) figure 3, caption: monthly mean column BaP concentration over North America. How is North America defined in this case? Draw a box around the considered region.

26) figure 3, caption: in a height of 1200 m above ground? Otherwise there shouldn't be any values over mountains.

27) page ..92, lines 5 and 13. You say that BaP was enhanced by 4 pgm<sup>3</sup> and 6 pgm<sup>3</sup>, respectively. Could you explained compared to when and where it was enhanced.

28) page ..93, line 13: ...1200 m above ground?...

29) page ..95, line 1: ...of such "a" transport ...

30) page ..95, line 24: Reference Jacob and Winner 2009 is missing in the reference list at the end

31) page ..96, lines 15.18: Could you explain in more detail what you mean here?

32) page ..97, line 8: .. interannual fluctuations

33) page ..97, lines 9-10: You say that there is a decreasing trend during 1948-2007, especially after the 1970s. Is there any evidence for this from measurements as well?

References:

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If you mention the WCBs you could reference

for a WCB climatology:

Eckhardt S., Stohl, A., Wernli H., James P., Forster C. And Spichtinger N., 2004: A 15 year climatology of warm conveyor belts, *J. Climate* 17: 218-237

and for WCBs in general

-Browning K.A., 1986: Conceptual models of precipitation systems. *Weather Forecasting* 1:23-41

or

-Carlson, T.N., 1980: Airflow through midlatitude cyclones and the comma cloud pattern. *Mon. Weather Rev.* 108: 1498-1509

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Interactive comment on *Atmos. Chem. Phys. Discuss.*, 11, 18979, 2011.

ACPD

11, C10376–C10381,  
2011

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