Author Comment to Referee #2

ACP Discussions: acpd-15-9941-2015
(Editor - Federico Fierli)
'Impact of different Asian source regions on the composition of the Asian monsoon anticyclone and on the extratropical lowermost stratosphere'

We thank Referee #2 for his very good evaluation. Following the reviewers advice we elaborate some minor points, which strengthen the findings of our paper. Our reply to the reviewer comments is listed in detail below. Questions and comments of the referee are shown in italics.

This paper reports characteristics of monsoon anticyclone, impact of emissions from India, China and Southeast Asia on the composition of anticyclone and transport path- ways to the lower stratosphere. The results from CLaMS model are supported by MLS observations. This paper highlights new and important findings. I recommend the paper to be published in ACP after the following minor comments are addressed.

Minor comments

1. P9945, L27. The reason for choice of year 2012 should be mentioned. Was it El- Niño/La-Nina year? Or normal monsoon? Or QBO Easterly/westerly phase? These phenomena affect the monsoon circulation and therefore transport into monsoon anticyclone.

$\surd$ The following text is added in the revised version of the paper:

'The summer 2012 is a good example for normal monsoon conditions. The rainfall in India was normal based on the rainfall data set of 306 rain gauges in India provided by the Indian Institute of Tropical Meteorology in Pune, India (see http://www.tropmet.res.in/~kolli/mol/Monsoon/Historical/air.html). A strong relation between rainfall (droughts or floods) during the Indian summer monsoon to El Niño and La Niña events have been established (e. g.

Webster et al., 1998; Kumar et al., 2006). In summer 2012, neutral conditions for the El Niño/Southern Oscillation (ENSO) occurred based on the Oceanic Niño Index (ONI) (see http://ggweather.com/enso/oni.htm).'

The relation of the Quasi-Biennial-Oscillation (QBO) in stratospheric equatorial winds to Indian summer monsoon rainfall is discussed in the last years (e.g. Chattopadhyay and Bhatla, 2001, International Journal of Climatology; Claud and Terray, 2007, Journal of Climate; Mohankumar and Pillai, 2008, Journal of Atmospheric and Solar-Terrestrical Physics), however there is no clear result to how the QBO is related to normal monsoon conditions. Therefore we decided that a discussion about the possible connection between QBO and Indian summer monsoon in the year 2012 should not be added to our paper.

2. Section 3.1.1 is very lengthy and should be shortened. The discussion on eddy shedding is not clear. 'The second anticyclone moves towards Pacific Ocean along subtropical westerly jet'? Consider revising this.

√ We shortened section 3.1.1. by removing the paragraph about the 2 modes (symmetric - antisymmetric) in the revised version of the paper. The paragraph about the eddy shedding is also removed.

3. P9957, L26. 'On 20 September 2012 (see Fig. 7, bottom), the anticyclone is shifted to the south'. Is this related to monsoon withdrawal?

√ In the revised version of the paper, we replaced the 20 September 2012 by 12 September 2012 to remove the discussion about the eddy shedding event, which is not important for the main message of the paper. During September a strong broadening of the spatial distribution of the emission tracer for India/China towards the tropics is found. This is likely related to the monsoon withdrawal as shown in the following new figure (Fig. 1) introduced in the revised version of the paper.

4. P9960 L10-11. Temporal evaluation of tracers in the anticyclone and its oscillation with 30-60 days periodicity show connections with movement of monsoon trough. This indicates that the lower level convergence (monsoon trough) and upper level divergence (anticyclone) vary coherently. The two anticyclones (Tibetan and Iranian mode) observed in MLS, which are simu-

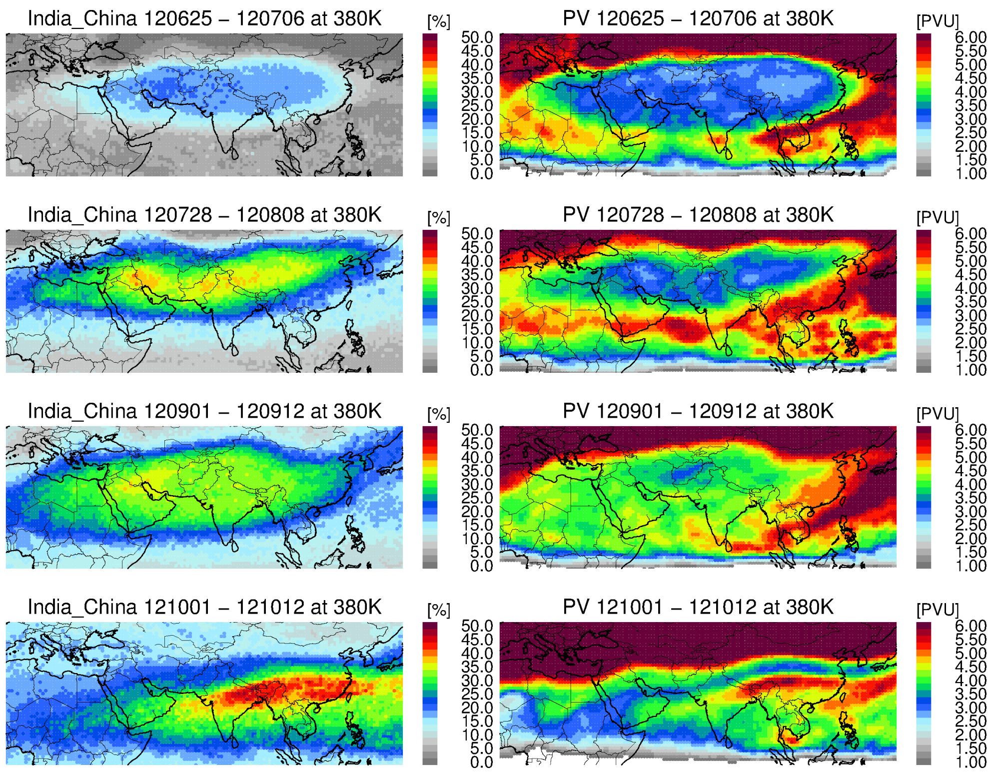

Figure 1: Tweleve-day mean values of the contribution of the emission tracer for India/China (left) and PV (right) during four different phases of the Asian monsoon anticyclone: early-phase (top) , mid-phase (2nd row), end-phase (3rd row) of the anticyclone and after the breakup (bottom).

lated by CLaMs too, should have corresponding two low pressure areas in the lower troposphere. The figure depicting this will support your results

Our simulations show that a south-north shift in the contribution of different emission tracers for Asia within the Asian monsoon anticyclone occurred during the summer 2012 and also a slight northward shift of the anticyclone itself. This behaviour is possibly linked to the northward moving long-term interseasonal variations (30 to 60 day oscillations) found in climatological analyses of monsoon activity like convection and rainfall (e.g. Goswami, 2012, and references therein). The calculated composition of different emission tracers within the Asian monsoon anticyclone is a fingerprint of the regional and temporal variations of convective processes causing strong upward transport within the Asian monsoon anticyclone in summer 2012. However, in spite of a considerable effort analysing meterological data set, we could not find any clear evidence that lower level convergence (monsoon trough) and upper level divergence (anticyclone) vary coherently. Therefore, we can not provide a appropriate figure. We agree that the connection between the movement of the lower level monsoon trough and the movement of the anticyclone is an interesting open question.

5. P9961 L8-9. Statement 'however the contributions of the different emission tracers are in general lower' is not clear

$\surd$ We revised the following sentence

'Further, even if no PV criterion is applied and all air parcels within the geographical limits (black box in Fig. 7) are considered to calculate the mean values, the same qualitative evolution emerges of the contributions of different emission tracers within the anticyclone at 380 K, however the mean values of the single emission tracers are in general lower (not shown here).'

as follows:

'Further, even if no PV criterion is applied and all air parcels within the geographical limits (black box in Fig. 7 of the paper) are considered to calculate the mean values, the same qualitative evolution emerges of the contributions of different emission tracers within the anticyclone at 380 K, however then highest contributions from Southeast Asia up to 11% and 19% are calculated in mid-June/mid-July and October, respectively. The contribution of air masses from North India are also at the maximum in the intervening period from mid-July to mid-August and reach values up to 13% (not shown here).'

6. Mean values of contributions of emission tracers for India/China, Southeast Asia, and Western Pacific etc should be mentioned in the conclusion section.

$\surd$ We added the mean values as follows:

'In the early ($\approx$ June to mid-July) and late period ($\approx$ mid-August to October) of the monsoon season 2012, contributions from Southeast Asia are highest (up to 13% and 23%, respectively, using a value of 4.5 PVU to mark the edge of the anticyclone). In the intervening period ($\approx$ mid-July to mid-August), air masses from North India have the strongest impact (up to 18%).'

7. P9968 L15-19. The high contribution from SE Asia in early May-June and late monsoon period (Sep-Oct) may due to migration of monsoon trough. During this period it is generally over SE Asia. Authors should confirm this and make an assertive statement.

See above point 4.)

References

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