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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Atmospheric brown clouds reach the Tibetan Plateau by crossing the Himalayas" *by* Z. L. Lüthi et al.

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Anonymous Referee 1

We thank the referee for his/her comments, which were very helpful to improve our manuscript. Below, we address the specific comments individually.

In this paper, a pollution episode occurred over the TP was studied based on ground and satellite remote sensing data. A detail analysis of the back trajectories calculated from a numerical model with high spatial resolution was performed to figure out the

source of the pollution and how it transported to the TP. It was pointed out that ABC reached the TP by crossing the Himalayas. The research looks interesting but the paper is not well written.

Major concerns:

1. Air pollution reaching the TP from its surrounding regions were widely studied, for example, Kuhlmann and Quaas (ACP, 2010, 10, 4673−4688) studied longrange transport of aerosols based on three consecutive premonsoon seasons from CALIOPSO data. They stated that "CALIPSO lidar satellite data, providing vertically resolved images of aerosols, shows aerosol concentrations to be highest in the lowest 5 km of the atmosphere with only little amounts reaching the TP altitude". The major point of this ACPD manuscript is that aerosols can reach the TP altitude. So there seems some inconsistency between these two researches. Note that Kuhlmann and Quaas reached their conclusion based on measurements in three seasons, however, only a case study was performed by Luthi et al. My major point is that caution should be taken for the conclusion if it is derived from only a very extraordinary event.

We agree that studies like the one published by Kuhlmann and Quaas present complex aerosol analysis over the TP and its surrounding areas for seasonal time scales. With our work we would like to show that polluted air masses are lifted to high atmospheric levels and that they are advected into Tibet during occasional and at times severe episodes that take place under certain meteorological conditions. It might be difficult to identify such events through statistics of entire seasons or with CALIPSO data alone. Therefore we based the event selection on the high−temporal resolution AERONET data; the sparse AERONET datasets from the HTP at the time when our study was done led us to perform a detailed analysis of the well documented March 2009 pollution event. The magnitude of pollution contribution from the March 2009 event has been put in the context of seven further trans−Himalayan events retrieved during 2009 and 2010, and of the total annual pollution advection at Nam Co. We also agree that further studies are urgently needed to investigate the occurrence, trends, causes and effects

ACPD
14, C12064–C12068, 2015

of such episodes.

2. The paper is not well organized. For example, section 2 concerns methods and data. I don't see any introduction to methods. The title of section 3.1, "Air quality measurements in the HTP region" is not suitable. First, air quality generally refers to PM2.5 or pollution trace gases. Here, the major data are derived from remote sensing of columnintegrated aerosol optical properties. The title of section 3.1.1 "ABC determination" looks somewhat the methodology. Furthermore, I'm not sure what's the difference between section 3.1 and 3.1.1. In section 3.2, the authors used CALIOP and in situ data to describe this event. So the logic is not very clear and I have to say it is very hard to follow.

We agree and have changed the structure of the paper significantly. The logic should be much clearer to follow in the revised version of the manuscript.

3. From Figure 2, it is very clear that there is an inconsistency between AERONET and in situ data, for example, BC concentration is high during Apr. 14âĂŘ20, but AOD does not follow this pattern. Obviously, some words are required for this fact.

Thank you for this remark. The following sentence was added to the revised version of the manuscript "Elevated concentrations levels of BC and of FMF at the EvK2 station were retrieved during the 13−19 March event and also during the second half of April 2009; it is interesting to note that the BC−to−FMF rates differ between the March 2009 and the April 2009 events, possibly caused by varying aerosol type contributions to the polluted air masses reaching the measurement site."

4. Uncertainty of SDA method should be discussed.

Thank you for the comment. Detailed discussion on the uncertainty and validation of SDA (Spectral Deconvolution Algorithm) can be found at O'Neill et al. (2003, already cited in the paper) and at the AERONET website: http://aeronet.gsfc.nasa.gov/new_web/PDF/tauf_tauc_technical_memo.pdf. In addi-

ACPD
14, C12064–C12068, 2015

tion, O'Neill et al. (GRL, 2008) investigated various observations at extremely clean Arctic environment and showed that the fine−mode AOD from AERONET is reliable. This result, we think, supports the usage of SDA in the HTP region of this study. We think that detailed discussion on SDA is out of the scope of this study because of its complexity. Instead, we cite the above document and O'Neill et al. (GRL, 2008) in the revised manuscript.

Minor concerns:
1. FMF generally refers to fine mode fraction, not fine mode AOD

We agree, however for practical writing reasons we explicitly define FMF as fine mode AOD in our study.

2. P28112, L20, Two AAOD 500 nm datasets?

We have clarified the corresponding sentence. It now reads: "This AAOD 500 nm *dataset is used in this study to compare the light−absorbing aerosol distribution over southern Asia during the analyzed pollution event and during a "cleaner" period over the HTP and over the IGP."*

3. P28114, L14, what's meaning "15% to the yearly pollution occurrence"?

We apologize for this misleading statement – we have removed it from the manuscript and now only state that this episode was the most significant one of the 8 identified.

4. P28114, L21, the radiometer can work and does work on an overcast day.

The reviewer is correct. AERONET sun−sky radiometer generally works during both cloud−free and cloudy conditions. However, all aerosol products are only produced under cloud−free conditions (i.e., after cloud screening procedures). To clarify, in the revised manuscript, we rewrote the sentence to read: "No AERONET aerosol data was available for 15 March 2009, which was an overcast day."

5. P28115, L1523, I'm not clear whether the radiometer can see the new particle

ACPD
14, C12064–C12068, 2015

formation since the new particles is too tiny.

We agree with this comment. As Reviewer 3 also issued, it is hard to explain new nanoparticle formation and subsequent growth from FMF. So, we removed all sentences regarding new particle formation in the revised manuscript.

6. P28117, L710, references required.

This finding comes from our own data analysis, the sentence was changed to: "Several CALIOP transects that were retrieved over the past years were found to show significant extensions of pollution plumes "coating" the HTP. This indicates that the polluted air masses do not only accumulate in the valleys but can also cover large areas in this usually pristine region."

7. P28118, L1418, there is no any clues showing that aerosols reach the stratosphere.

In the current study, we do not examine whether it is likely for aerosols to be transported into the stratosphere. However, the mentioned study (a global climatology of STE) clearly shows that the HTP is a key area for transport from the PBL into the stratosphere. Hence, we point out the relevance of this area in the current manuscript.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 28105, 2014.