"Long-term (2001–2012) fine particulate matter (PM$_{2.5}$) and the impact on human health in Beijing, China" by Zheng et al.

General comments:

In this paper, Zhang et al established a relationship between PM$_{2.5}$ and AOD using the ground-based PM$_{2.5}$ observations from the US embassy in Beijing from 2010 to 2011. Based on this relationship and the AERONET AOD observations, they estimated daily PM$_{2.5}$ concentrations in the Central Beijing area for the period of 2001 to 2012. The authors also made efforts to estimate the annual premature mortality attributable to different diseases caused by PM$_{2.5}$ by employing concentration-response functions based on epidemiological cohort studies. This study is interesting as it shows an example of using satellite remote sensing method to estimate the ground-level PM$_{2.5}$ pollution and its impact on public health. I would recommend the paper to be published in ACP after revisions as suggested below.

One major concern of this paper is the uncertainty. Instead of point estimate, it is more encouraged that the authors present the range the uncertainty (or confidential interval). The current results presented by the authors suffer from uncertainty rising from a variety of sources, including the retrieval of ground-level PM$_{2.5}$ from AOD data, the estimation of total population, the use of concentration-response (C-R) function from other areas, and the uncertainty embedded in the C-R function during its development. If these uncertainties are not addressed or at least discussed in this paper, it will be very challenging for the authors to communicate the results and further interpret the data.

Specific comments:

1. Page 28660, Lines 7-13 and lines 13-25 are two topics. For example, Lines 12-13, author mentioned the factors that may affect the relationship between AOD and PM$_{2.5}$, while the next sentence is talking about the limitation of using ground-level PM concentrations in current epidemiological studies, it is hard to relate these two together in one paragraph. Suggest to split it into two paragraphs to make the flow clear.

2. Page 28660, Lines 12-13, authors need to add citation support to the statement "AOD and PM are related to atmospheric profiles, ambient conditions, as well as the chemical composition of aerosols". Besides, there is no incorporation of these parameters in the development of AOD-PM2.5 equation except BLH and RH. Are these parameters represented by BLH and RH? If then, the authors may need to reorganize the context to make this clear.

3. The authors mentioned twice that the relationship between AOD and $PM_{2.5}$ is influenced by the chemical components of particles, both on Page 28660 Line 13 and on page 28664 line21. However, this parameter was not incorporated into the AOD-$PM_{2.5}$ equation; neither is discussed regarding its impact on the uncertainty of the results. Further elaboration on this statement is needed.

4. Page 28660, lines 13-25, the time series method in the epidemiological studies and the study conducted in this paper are two different kinds of research. The former one is to develop the C-R function from known $PM_{2.5}$ concentration and mortality data, while the latter uses the developed C-R function and PM concentration to estimate the mortality. It is confusing to use the comparison these two research as a motivation of this paper.

5. Page 28662, Line 9, why AOD at wavelength 550nm is selected to derive the ground-level $PM_{2.5}$?

6. Page 28665, Line 3, it says "g is an empirical fit coefficient, and it equals 1 in this study." What is the evidence for this value to be set to 1?

7. Page 28662, the seasonal distribution and characteristics of AOD was presented. How does it affect the estimation of the ground-level $PM_{2.5}$ concentration and mortality caused? The seasonal variability in PM concentration and mortality should also be discussed.