<u>Response to referee report #1</u>

We thank Referee #1 for the valuable comments. Below we give a point-to-point response to comments by referee. The referee's comments are given in italic font, while our response is given in bold font.

While I find the topic of the manuscript timely and intriguing, I think that the paper is too thin on content and there is little independent information presented or literature citations given to support their weak conclusions.

In our paper we conclude that NOx emissions would have been 30 % higher and SO2 concentrations would be 3 times higher as they are today without the strong air quality regulations taken in the last 10 years. This is not a weak conclusion for a country with such serious air pollution problems. The conclusions come from careful analysis of satellite data as shown in our paper. All independent sources are properly referenced.

For instance, the authors do not really discuss or quantify the "effectiveness of air quality policy", as given in the title, beyond saying that the trends in space-based air quality data appear somewhat consistent.

The effectiveness is literally quantified as 30 % and factor 3 for respectively NOx and SO2. As shown in the paper this reduction is only an effect of air quality regulations and excluding all economic effects. It is not clear to us what text the referee refers to with "*trends in space-based air quality data appear somewhat consistent.***".**

Further analysis is needed before this manuscript should be published or before it can live up to what is promised by the title.

Please, specify what analysis you feel is missing.

Comments

Abstract. Please clearly say in the abstract what is new and interesting about your work.

New in this paper is that the effect of air quality measures is quantified by dividing the air pollutant emissions by the fossil fuel use, which leads to a trend in emission factor measured from space. We will emphasize this in the update of the paper. This can be done successfully because satellite products and algorithms have improved greatly. Satellite measurement indicate independently that NOx emissions in China peaked in 2012 and are greatly reduced since.

"unprecedented accuracy" – you didn't show this or even really discuss this.

The term "unprecented" indeed sounds somewhat dramatic, but it only states that our new data set improves over old ones. We will replace this with the more neutral "improved". The improved accuracy is mentioned and further discussed in Theys et al. (2015) and Ding et al. (2015, 2016).

The abstract does not have any interesting or strong conclusions.

See comments above.

Introduction. 1st paragraph. 1st sentence. Why are satellite instruments "especially effective"?

We agree the wording is not entirely logic and we will change the sentence into:

" Satellite instruments can monitor air quality from space by mapping e.g. aerosols and tropospheric ozone, but are especially useful for emission estimates in observing the relatively short-living gases nitrogen dioxide (NO2) and sulphur dioxide (SO2)"

2nd sentence. What improved datasets? 4th sentence. How is this data set "improved"? Accuracy?

The Improved datasets are directly discussed after this sentence in the same paragraph. SO2 from OMI described in Theys et al. (2015), and NOx emissions from OMI with DECSO v4, described in Ding et al. (2015, 2016). The accuracy is described in these papers. For SO2 the column concentrations are on average within 12 % in agreement with ground observations. NOx emissions have an accuracy of about 20% in each grid cell. We will add this information to the text.

Please put your work into the context of other studies of emissions and trends over China. There are quite a few recent ones to discuss that use satellite data. Please include the new paper by McLinden et al. (Nature). Many of these discuss individual emission sources, such as power plants. However, you do not, which would be necessary to estimate the effectiveness of environmental regulations.

McLinden et al. (Nature) was published 1 week <u>after</u> we submitted this paper, but we will of course refer and discuss this work in the update of our paper. Other studies about emissions and trends over China that are referred or discussed in our paper are Richter et al. (2005), van der A et al. (2006), Stavrakou et al. (2008), Kurokawa et al. (2009), Lee et al. (2010), Li et al (2011), He H. et al. (2012), Zhang et al. (2012), Yang et al. (2013), Mijling et al. (2013), Fioletov et al. (2015), Krotkov et al. (2015), and Liu et al. (2016).

Indeed we discuss the emissions on a provincial level to give an overview for a country which harbours at least 1000 power plants. A single power plant is therefore not representative for the air quality regulations. That is why we use the total fossil fuel use in combination with satellite observations. We present a new method to estimate the total effectiveness of environmental

regulations, by directly relating the emissions to the fossil fuel consumption in the country. This top-down approach saves us the effort of evaluating all individual contributions.

Section 3.2. There are many speculations here. Back up them up with provincial data. Please overplot fuel consumption data in Figure 3.

Section 3.2 Unfortunately the fuel consumption data for Chinese provinces is not publicly available, which limits our possibilities. However, many regulations are nation-wide as are our main analysis and conclusions. The fuel consumption data is shown in Figure 5.

Section 3.3. Are the trends in OMI NO2 consistent with the provincial emissions data? Please plot.

Section 3.3 We have done our analysis on the NOx emission data from inversions and not on NO2 concentrations, since emissions are clearly localised while concentrations are strongly affected by transport and meteorology. The quality of the inversion has been assessed in Mijling et al. [2013]. Also emissions are directly affected by air quality regulations.

Section 3.4. Again, I'm interested in the provincial data.

Unfortunately the fuel consumption data for provinces is not publicly available. Perhaps the reviewer is aware of sources we overlooked?

Figures 1 & 2. Need to have a map of provinces for the reader to refer to with major cities. Most readers will not know provincial names. It may also help to plot the locations of major power plants.

We will add a map with the provinces of China (and power plant density) for convenience of the reader.