

Interactive comment on “Abundance and distribution of gaseous ammonia and particulate ammonium at Delhi (India)” by S. Singh and U. C. Kulshrestha (bg-2011-361)

Referee's comments:

The study by Singh and Kulshrestha decrease a significant and important knowledge gab: Ammonia and Ammonium concentrations in India. Alone due to that, the paper is important!

The current paper is nice and short. In the Introduction, the authors state that Europe and India are two largest emitters of ammonia. However the study (e.g. table 1) does not really compare with European studies of measured ammonia. I will suggest that the manuscript as a minimum takes into account studies that includes measured concentrations of ammonia from large emitting countries like England, Netherlands, Germany, Poland or Denmark.

The study also includes a most important data set: Average diurnal variation of ammonia (Fig 5). This also makes the paper important. The authors argue that these variations might be due to atmospheric conditions trapping ammonia near ground level. Is this phenomena a typical feature of India? Additionally, these observations should be compared to other studies in especially Europe that focus on the diurnal variation in order to advance science with respect to this phenomena.

Additionally, ammonia volatilization is a temperature dependent process. Increasing temperatures greatly increase the ammonia emissions. However, the temperature also changes meteorological processes such as boundary layer height and inversions during night time. In the recent European Nitrogen Assessment (see summary by Sutton et al., 2011) and <http://www.nine-esf.org/ENA-Book> it is suggested that one of the major limitations to understanding ammonia and its fate is the limited mechanistic description of the emissions processes throughout the day and during the season and how this relates to climatic variables such as temperature, wind and humidity. Attempts to address this problem has been suggested several years ago (Gyldenkærne et al., 2005; Skjøth et al., 2004) by mechanistic descriptions of both seasonal and diurnal variations of ammonia emissions. Furthermore, models have been provided as open source to enhance international collaboration within this subject (Skjøth et al., 2011). Initiatives to broaden these ideas to global scale are now underway, but the above suggested methodologies might have clear limitations. These limitations could be suggested using the observations in this manuscript and it could be related to a) description of emissions processes, b) the associated descriptions of atmospheric conditions by using models to describe events such as inversions or c) the limited information of humans as a source to ammonia in some emissions models.

The discussion of the authors results in relations to the topics in the previous section could be omitted. However, if the authors choose to discuss their observations in relation to the above studies and furthermore also suggest improvements in the mechanistics descriptions that are relevant for their geographical area, the value of this study would indeed increase and enhance the possibility for a global action on describing ammonia and its fate in the environment.

Finally, I would defnetly suggest that the authors continue their studies on ammonia in their regions and publish these results. One possibility could be obtain simoultanious observations from the city as well as in a more remote region in order to determine if their observed values (that are very high) are that high for the entire region or if this high level is an urban feature alone.

Reply of Authors:

We thank the referee for his valuable comments. We really appreciate his observation about the need of $\text{NH}_3/\text{NH}_4^+$ chemistry studies in Indian region. We agree with him that this study definitely opens up the scope of international collaboration for Nitrogen studies in India. As per the suggestion, we have incorporated the measured concentrations of $\text{NH}_3/\text{NH}_4^+$ at UK sites in Table 1. As per the explanation of diurnal variation of Ammonia concentration i.e. the stable atmospheric conditions, we would like to mention that this is not the typical case in our region. Night-time higher concentrations of NH_3 have also been reported earlier due to stable atmosphere in India by Singh et al (2001) as well as in United States by Cadle et al (1982). As per the suggestion of referee, we have modified Fig. 4. We appreciate the suggestion of referee to study $\text{NH}_3/\text{NH}_4^+$ at city as well as remote sites. In this regard, we have already proposed the extension of $\text{NH}_3/\text{NH}_4^+$ measurements to the rural and industrial sites.