*Response to comments*

*We appreciate the comments of the editor. Our responses are shown in italics beneath each editor's comments.*

You have replied to two points of reviewer #1 in your response, however i could not find an adequate adaptation and discussion of these points in the manuscript. Could you please add these. The reviewer pointed out that a coupling to vegetation properties is required instead. I think the reviewer made a strong point here, which has to be discussed in the manuscript.

The reviewer statements I am referring to are:

"I doubt whether the bi-directional approach as proposed by Zhang et al. (2010) is the appropriate way to model spatial variations in bi-directional ammonia exchange with the surface. In my opinion, it is wrong to couple the soil emission potential to land-use categories as it is a soil property and not a vegetation property. Therefore, it's not strange that results of the bi-directional dry deposition scheme are not convincingly better than the results of the uni-directional deposition schemes."

*Our response to this comment posted on the discussion webpage reads: "The scheme of Zhang et al. (2010) is similar in theory to other bi-directional schemes currently used in the community. Two key parameters are needed in the scheme – stomatal and soil emission potentials. Assigning stomatal emission potentials to vary with land use category is a reasonable approach, in our opinion. Because a portion of soil emissions comes from decomposition of the litterfall from previous years, soil emission potentials could also be related to land use category. However, other factors could dominate soil emissions, such as wet deposition at natural areas or fertilization over agricultural lands. In the latter case, soil emission could vary substantially both spatially and temporally, under which conditions the default values in the Zhang et al. (2010) are likely need to be adjusted, as pointed out by this Reviewer and shown in the present study. Thus, a better approach would be to make use of additional information such as the agricultural activities, in the regions where such information is available, while use the model proposed values at location where such information is not available. Such an approach has been adopted by USEPA CMAQ (Pleim et al., 2013, JGR 118, 3794-3806) and a similar approach has also been used in a Wichink Kruit et al. (2010) as pointed out by this Reviewer; but it should be noted that such information is not available in many regions around the world. Thus, evaluating the applicability of the new bi-directional scheme is needed which is the main purpose of the present study. Although the bi-directional scheme is not statistically better than the uni-deposition schemes over the whole region studied here, the bi-directional approach can result in improved results from simple adjustments of emission potentials while the uni-directional schemes cannot because concentrations at some sites were overestimated while at other sites, underestimated."*

*To reflect the above response in the paper, the following text from Line 18 to 21 on Page 6083:*

*"This approach is especially useful for regional-scale air quality models because those values are generally not measured at regional scales and are not explicitly calculated in regional-scale models. "*

*has been modified and more discussion has been added based on our responses. It now reads:*

*"It should be noted that soil emission potential is a soil property and not a vegetation property and thus, assigning the soil emission potential values based on land-use category might not be appropriate in some cases. However, considering that a portion of soil emissions comes from decomposition of the litterfall from previous years, soil emission potentials could, to some extent, be related to land use category. It is worth to mention that other factors could dominate soil emissions, such as wet deposition at natural areas or fertilization over agricultural lands. In the latter case, soil emission could vary substantially both spatially and temporally, under which conditions the default values in Zhang et al. (2010) are likely needed to be adjusted. For example, Pleim et al. (2013) and Wichink Kruit et al. (2010) made use of information on agricultural activities to better estimate soil emissions. Knowing that soil properties are not available at regional scales in many cases, the approach proposed in Zhang et al. (2010) should be a reasonable first approximation. This is especially the case for non-managed forest canopies where soil emissions are much smaller than stomatal emissions."*

" p 6081 l 6: What is meant with improved representation "here? Improved compared to what? And why?"

*Our response to this comment posted on the discussion webpage reads: "The improved representation here in the ZDD scheme means including a newly developed non-stomatal resistance formulation, a realistic treatment of cuticle and ground resistance in winter and the handling of seasonally-dependent input parameter, which is compared to its earlier version. The improvement is expected to provide more realistic deposition velocities, especially for wet canopies, and to be easily adopted into air quality models."*

*The following text from Lines 5-17 on Page 6081:*

*"The ZDD scheme (Fig. 1) employs a methodology similar to the WDD scheme; however, it includes an improved representation of a number of non-stomatal resistances, including in-canopy aerodynamic ($R_{ac}$), soil ($R_g$), and cuticle resistances ($R_{cut}$). Instead of using a constant non-stomatal resistance for a particular season and land type, ZDD calculates non-stomatal resistance for two archetypal gas-phase species, $SO_2$ and $O_3$, as a function of friction velocity, relative humidity, and canopy wetness, as well as biological factors, such as canopy type, leaf area index (LAI), and growing period. Non-stomatal resistances for other species are scaled as a weighted average to those of $SO_2$ and $O_3$ based on similarities or differences of their chemical and physical characteristics. Other improvements of the ZDD scheme include a more realistic treatment of cuticle and ground resistance in winter and the specification of seasonally-dependent input parameters, including LAI, roughness length and resistance components (Zhang et al., 2003)."*

*has been changed to:*

*"The ZDD scheme (Fig. 1) employs a similar methodology to that of the WDD scheme, but with improved representation of non-stomatal resistance components and handling of seasonally-dependent*

*input parameters. The non-stomatal resistance components in the WDD scheme consist of in-canopy aerodynamic ($R_{ac}$), soil ($R_g$), and cuticle resistances ($R_{cut}$) and were assigned constant values for a particular season and land type. In contrast, the ZDD scheme calculates these non-stomatal resistance components as a function of friction velocity, relative humidity, and canopy wetness, as well as biological factors, such as canopy type, leaf area index (LAI), and growing period, and is believed to be more realistic than using constant values. Substantial information on land use category specified input parameters including LAI and roughness length is adopted to reflect more realistic seasonal variations (Zhang et al., 2003). Note that the effects of low temperature and snow are also considered in the ZDD scheme to obtain more realistic cuticle and ground resistances in winter."*