Supporting Information for

High efficiency of livestock ammonia emission controls on alleviating particulate nitrate during a severe winter haze episode in northern China

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Introduction

This supporting information consists of the following parts. Firstly, Figure S1 and S2 provide the validation of the model performance about ISORROPIA and WRF-Chem by comparing predictions to measurements. Secondly, Figure S3 provides the comparison of the spatial distributions of livestock NH_3 emissions between base case and emission reduction case in December 2015 in northern China. Thirdly, Figure S4 provides the molar ratio (R) and the particulate NO_3^- reduction rate of each observation data point in December 2015 and December 2016. Finally, Table S1 provides the comparison of NH_3 EFs for different livestock among China (present), China (after taking manure management measures), USA, Europe and Global.

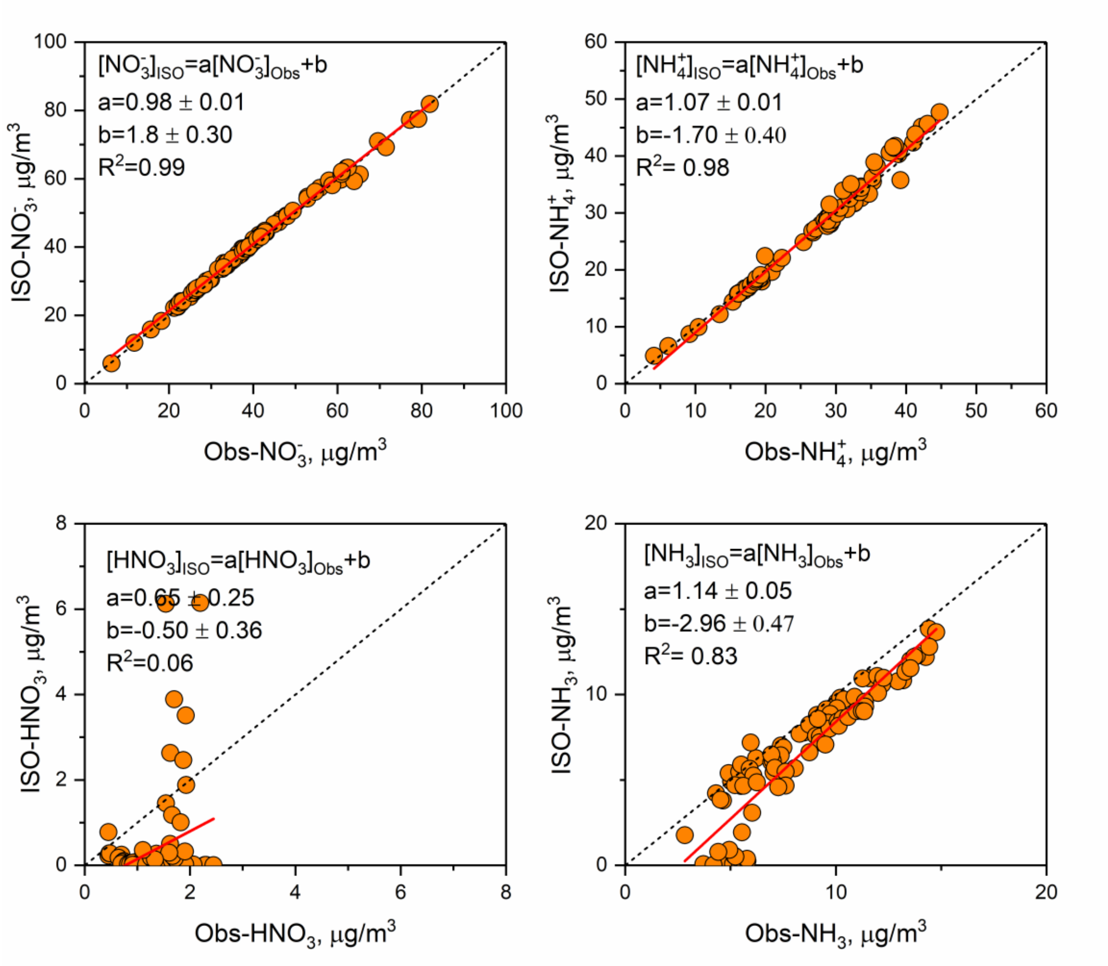

Figure S1. The comparison of particle nitrate (NO_3^-), ammonium (NH_4^+), gaseous HNO_3 and gaseous NH_3 between observations and ISORROPIA-II simulations during six severe haze cases.

We quantify the performance of ISORROPIA-II by using the error metric, the mean bias (MB), MB=$\frac{1}{N}\sum_i^n(I_i - O_i)$, where I_i represents predictions of ISORROPIA-II for data point i, O_i represents the corresponding observations and n is the total number of data points.

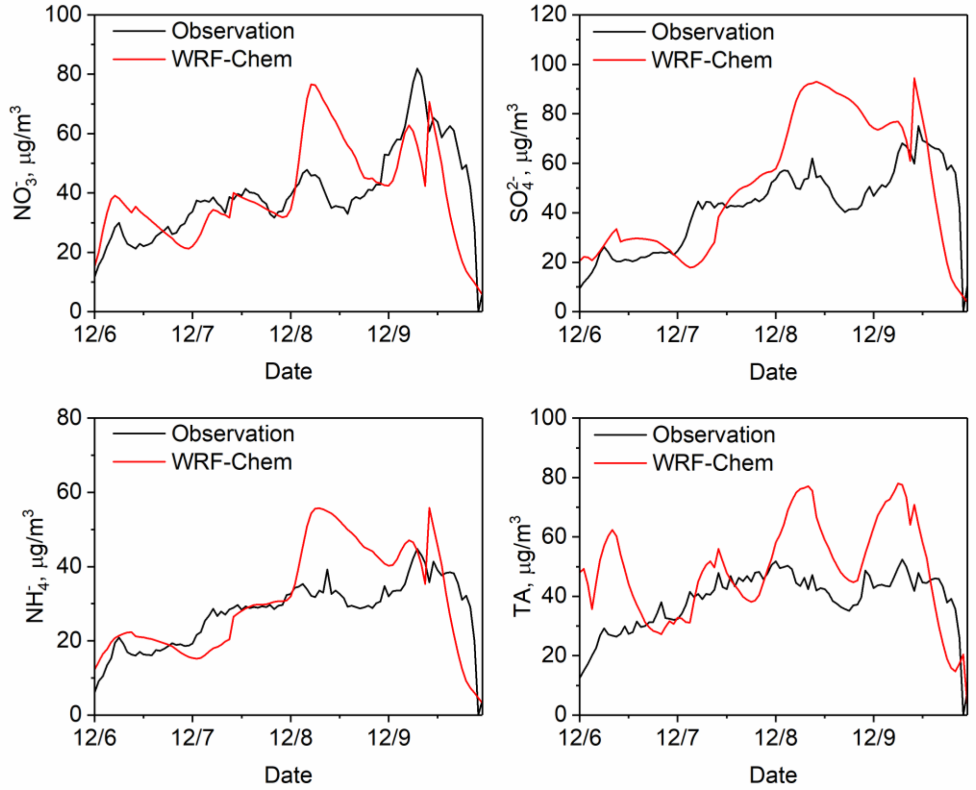

Figure S2. The comparison of particle nitrate (NO_3^-), sulfate (SO_4^{2-}), ammonium (NH_4^+) and total ammonia (TA) between observations and WRF-Chem simulations during case 1 (from 6 to 10, December 2015).

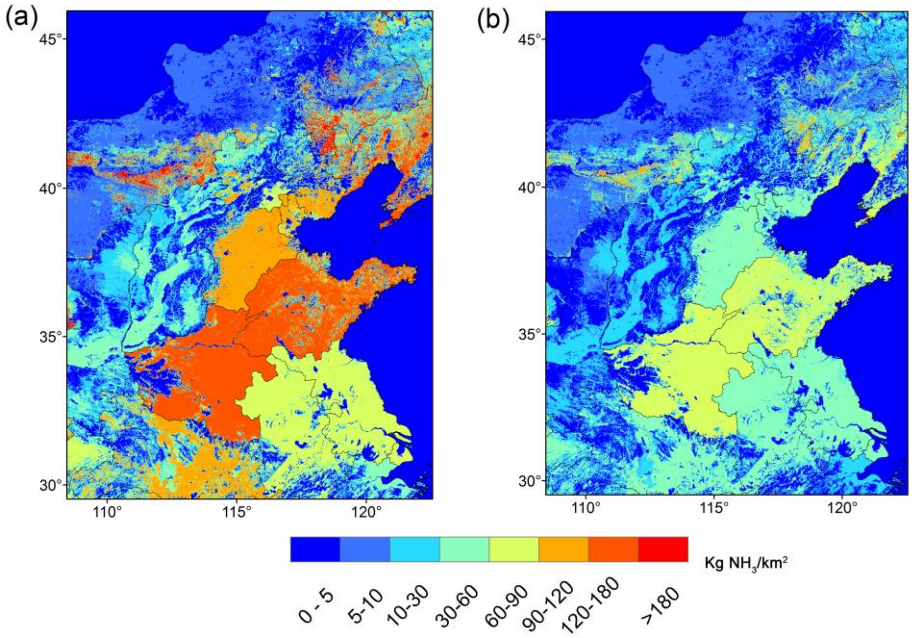

Figure S3. The comparison of the spatial distributions of livestock NH_3 emissions between **(a)** the base case and **(b)** the emission reduction case in December 2015 in northern China.

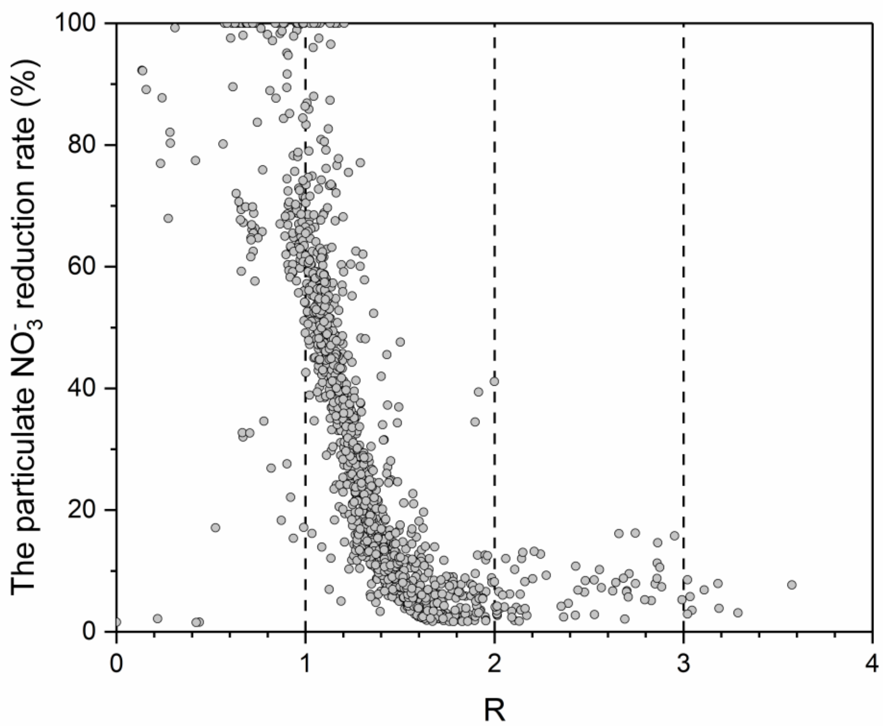

Figure S4. The molar ratio (R) and the particulate NO_3^- reduction rate of each observation data point in December 2015 and December 2016. The particulate NO_3^-

reduction rate is predicted by ISORROPIA-II under the condition of 40% TA reduction.

Table 1. Comparison of NH_3 EFs for different livestock among China (present), China (simulated taking manure management measures), USA, Europe and Global.

Livestock	NH_3 EFs (Kg/(1000kg N)/year)				
	China[a]	China (after)	USA[b]	Europe[c]	Global[d]
Swine	636	232	263	537	398
Beef cattle	423	172	276	224	230
Sheep	337	156	205	90	50
Goat	337	156	406	90	45

Note. The unit of emission factor used Kg per 1,000 kg of nitrogen (N) per year to unify different amounts of livestock excrement in various regions.

[a](Huang et al., 2014) [b](Agency, 2015) [c](Amon; et al., 2016) [d](Bouwman et al., 1997)

References

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