



Supplement of

Evaluating present-day and future impacts of agricultural ammonia emissions on atmospheric chemistry and climate

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Supplementary Material

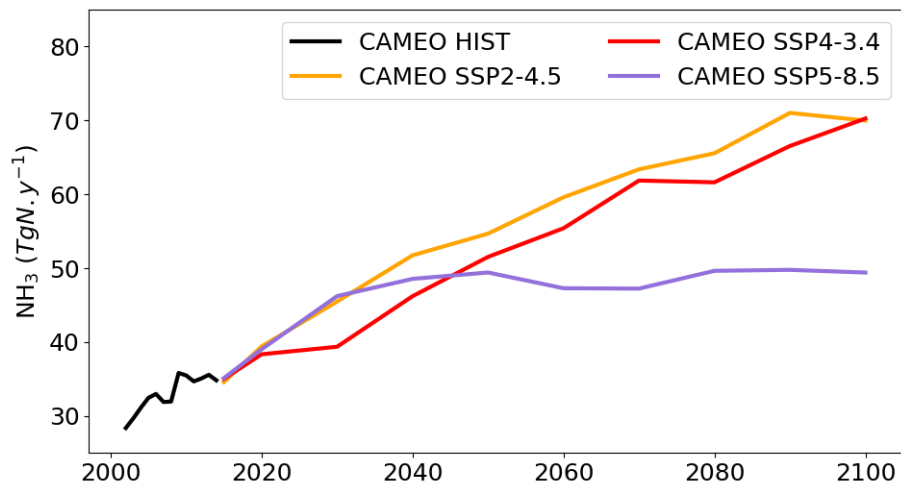


Figure S1. Evolution of the global agricultural NH₃ emissions for SSP2-4.5, SSP4-3.4 and SSP5-8.5 from CAMEO under future climate, in TgN.yr⁻¹. Please note that SSP2-4.5 is not exploited in the current study.

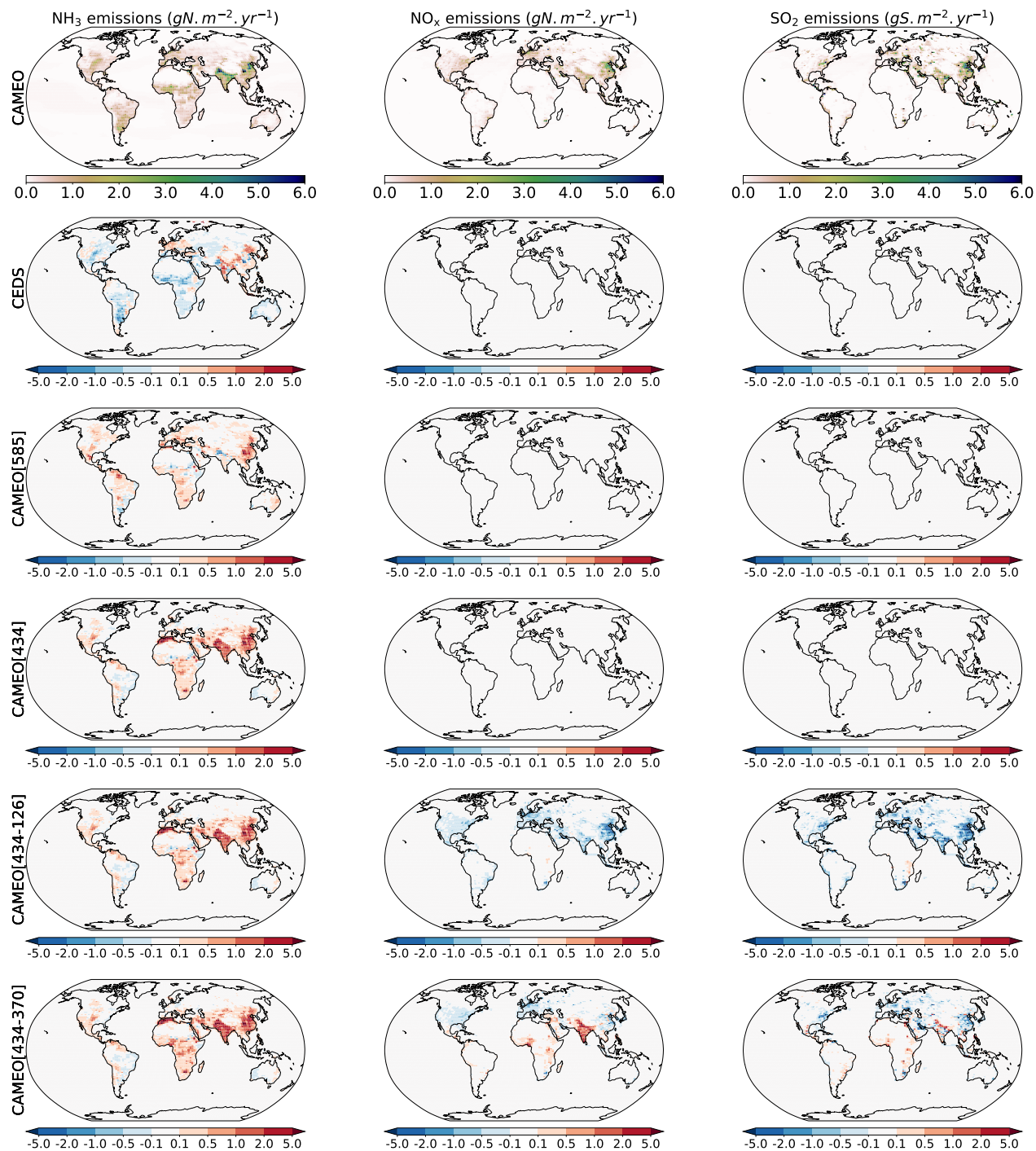


Figure S2. Annual emissions of NH_3 (first column), NO_x (second column), SO_2 (third column) ($\text{gNm}^{-2}\text{yr}^{-1}$, $\text{gSm}^{-2}\text{yr}^{-1}$) simulated by LMDz-INCA. Emissions are shown for CAMEO (first row; in 2014) and the anomalies between the CEDS or CAMEO[SSPi] and CAMEO simulations ([SSPi]:585, 434, 434-126 and 434-370 in rows 2-5; in 2100).

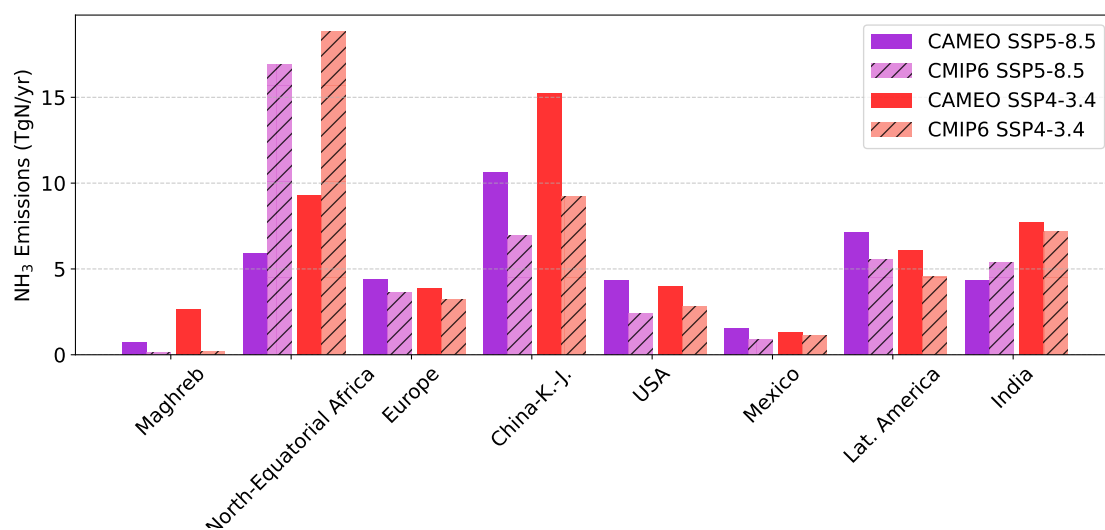


Figure S3. Regional agricultural NH_3 emissions simulated by CAMEO and from the CMIP6 inventory (striped bars) averaged over 2090-2100 for SSP5-8.5 (purple bars) and SSP4-3.4 (red bars). ($\text{TgN}\cdot\text{yr}^{-1}$).

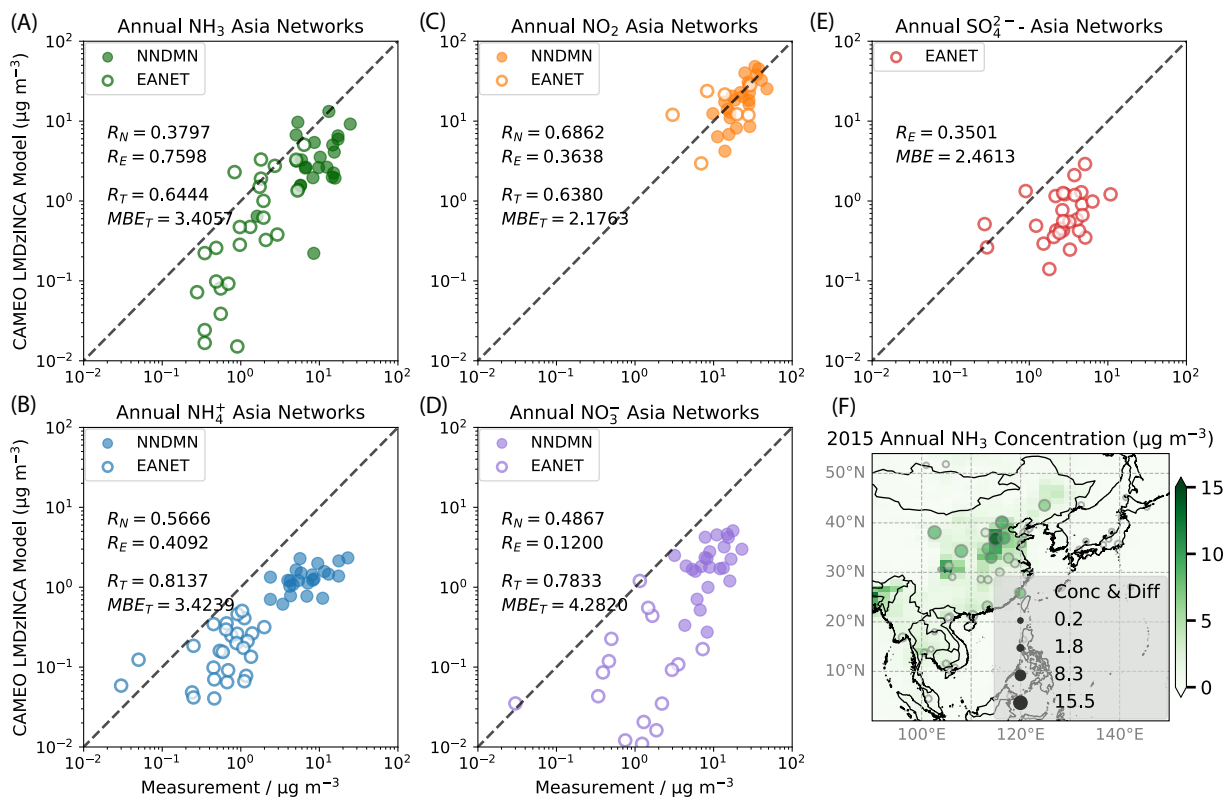


Figure S4. Scatter plots of annual mean modelled (CAMEO run) and measured NH_3 , NO_2 , SO_4^{2-} , NH_4^+ and NO_3^- concentrations at East Asian and Southeast Asian monitoring network locations for 2015. In each plot, the dashed black line is the 1 : 1 line. R_N is for NNDMN network. R_E is for the EANET network. R_T is the overall correlation coefficient between the model and all measurements shown. MBE_T is the overall Mean Bias Error between the model and all measurements shown. Note the log scale used in the plot. Annual surface NH_3 simulated concentrations are also shown along with the observation values mapped with circles. The size of the circle indicates the absolute difference with the modelled value. ($\mu\text{g} \cdot \text{m}^{-3}$).

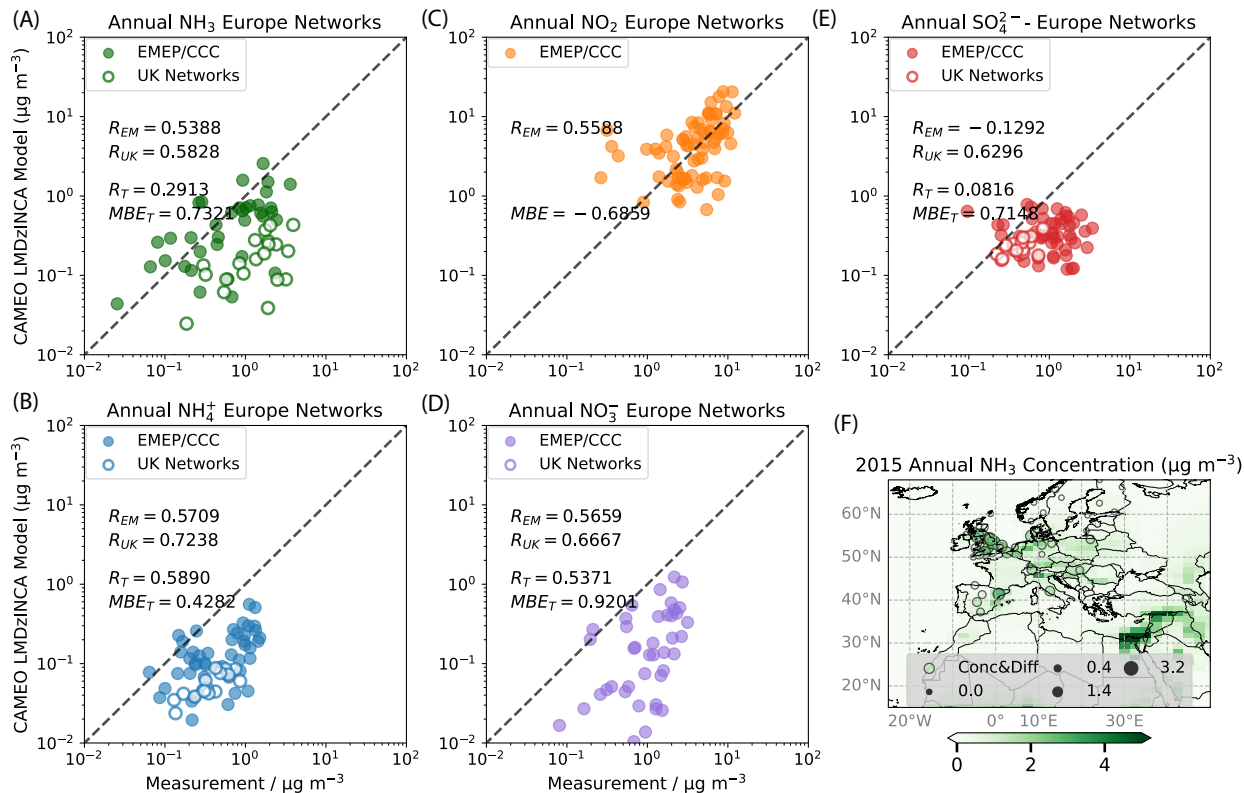


Figure S5. Scatter plots of annual mean modelled (CAMEO run) and measured NH₃, NO₂, SO₄²⁻, NH₄⁺ and NO₃⁻ concentrations at European and UK monitoring network locations for 2015. In each plot, the dashed black line is the 1 : 1 line. R_{EM} is for EMEP/CCC network. R_{UK} is for the UK network. R_T is the overall correlation coefficient between the model and all measurements shown. MBE_T is the overall Mean Bias Error between the model and all measurements shown. Note the log scale used in the plot. Annual surface NH₃ simulated concentrations are also shown along with the observation values mapped with circles. The size of the circle indicates the absolute difference with the modelled value. (μg.m⁻³).

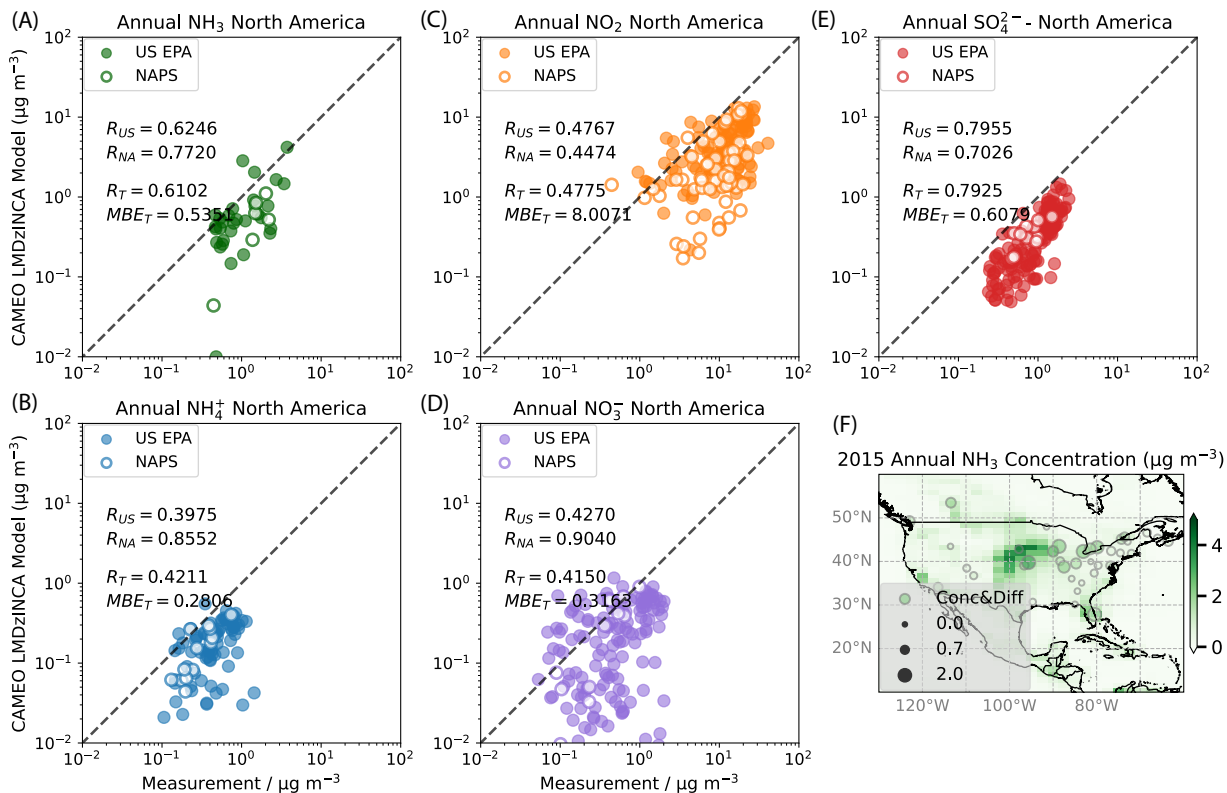


Figure S6. Scatter plots of annual mean modelled (CAMEO run) and measured NH_3 , NO_2 , SO_4^{2-} , NH_4^+ and NO_3^- concentrations at North American monitoring network locations for 2015. In each plot, the dashed black line is the 1 : 1 line. R_{US} is for the US EPA/AMoN network. R_{NA} is for the NAPS network. R_T is the overall correlation coefficient between the model and all measurements shown. MBE_T is the overall Mean Bias Error between the model and all measurements shown. Note the log scale used in the plot. Annual surface NH_3 simulated concentrations are also shown along with the observation values mapped with circles. The size of the circle indicates the absolute difference with the modelled value. ($\mu\text{g.m}^{-3}$).

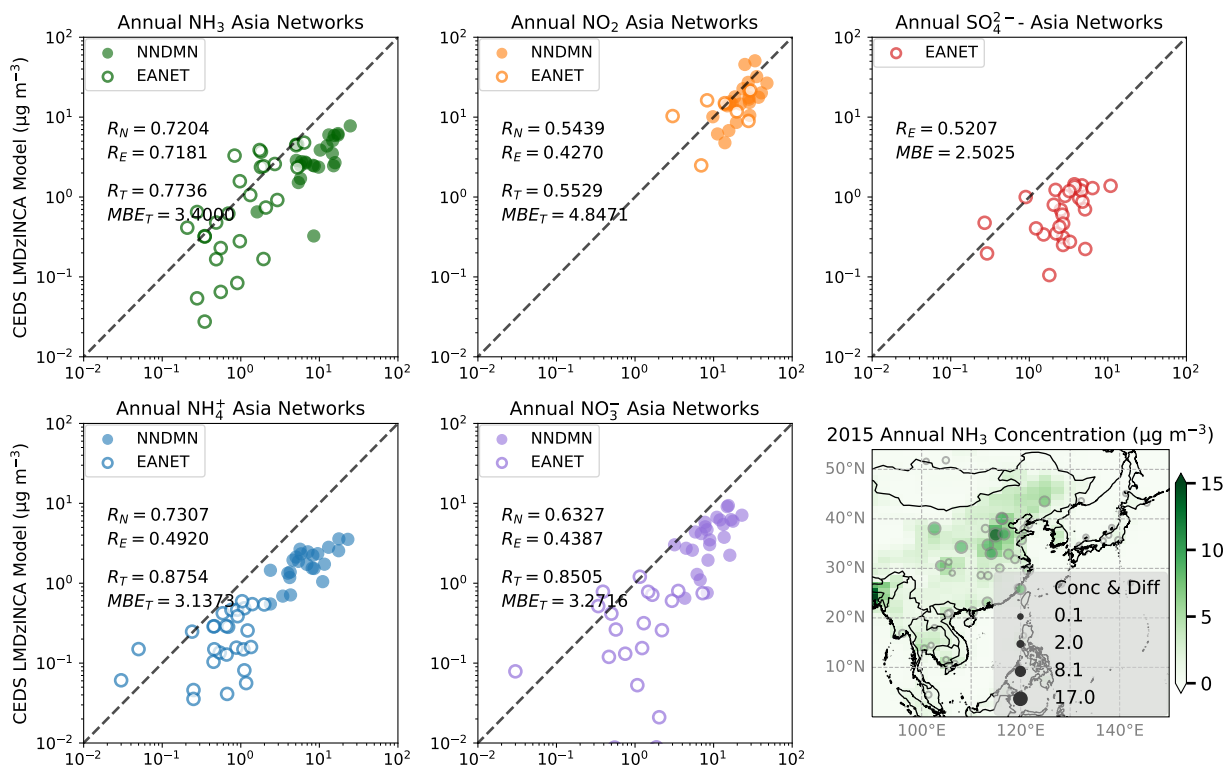


Figure S7. Scatter plots of annual mean modelled (CEDS run) and measured NH_3 , NO_2 , SO_4^{2-} , NH_4^+ and NO_3^- concentrations at East Asian and Southeast Asian monitoring network locations for 2015. In each plot, the dashed black line is the 1 : 1 line. R_N is for NNDMN network. R_E is for the EANET network. R_T is the overall correlation coefficient between the model and all measurements shown. MBE_T is the overall Mean Bias Error between the model and all measurements shown. Note the log scale used in the plot. Annual surface NH_3 simulated concentrations are also shown along with the observation values mapped with circles. The size of the circle indicates the absolute difference with the modelled value. ($\mu\text{g.m}^{-3}$).

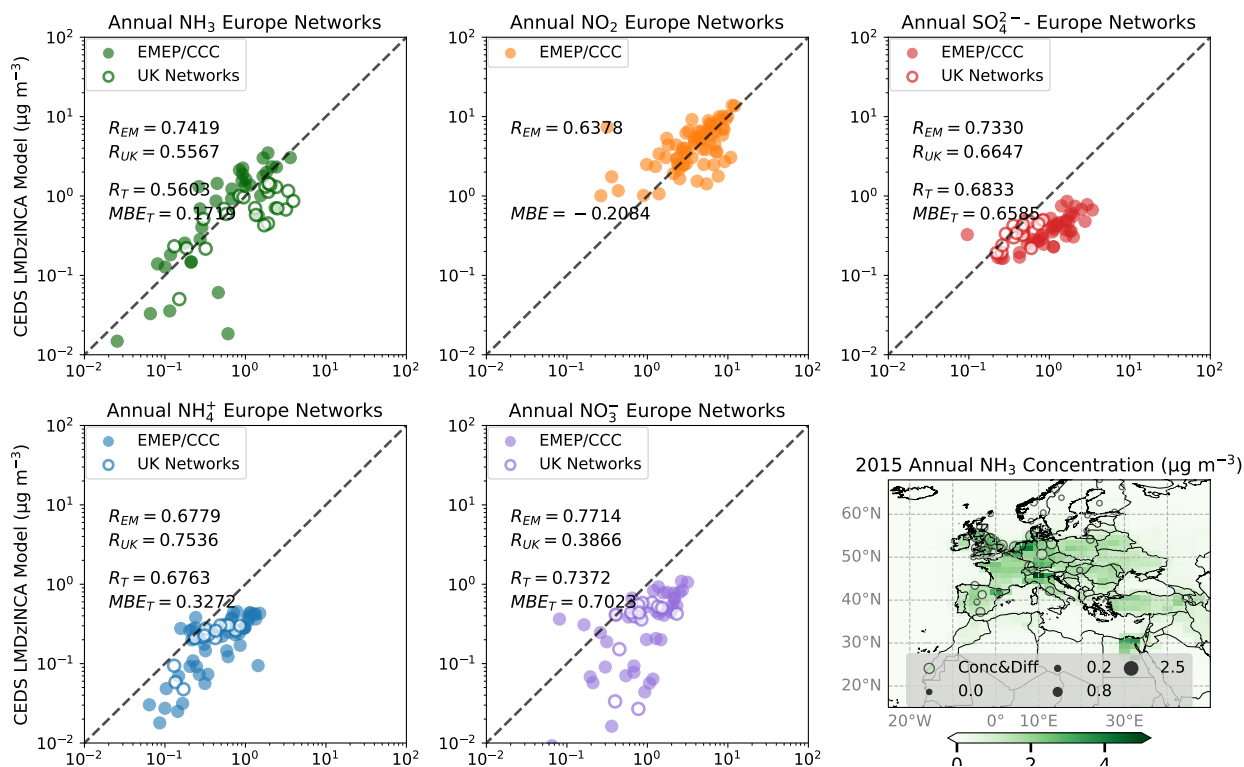


Figure S8. Scatter plots of annual mean modelled (CEDS run) and measured NH_3 , NO_2 , SO_4^{2-} , NH_4^+ and NO_3^- concentrations at European and UK monitoring network locations for 2015. In each plot, the dashed black line is the 1 : 1 line. REM is for EMEP/CCC network. RUK is for the UK network. RT is the overall correlation coefficient between the model and all measurements shown. MBET is the overall Mean Bias Error between the model and all measurements shown. Note the log scale used in the plot. Annual surface NH_3 simulated concentrations are also shown along with the observation values mapped with circles. The size of the circle indicates the absolute difference with the modelled value. ($\mu\text{g.m}^{-3}$).

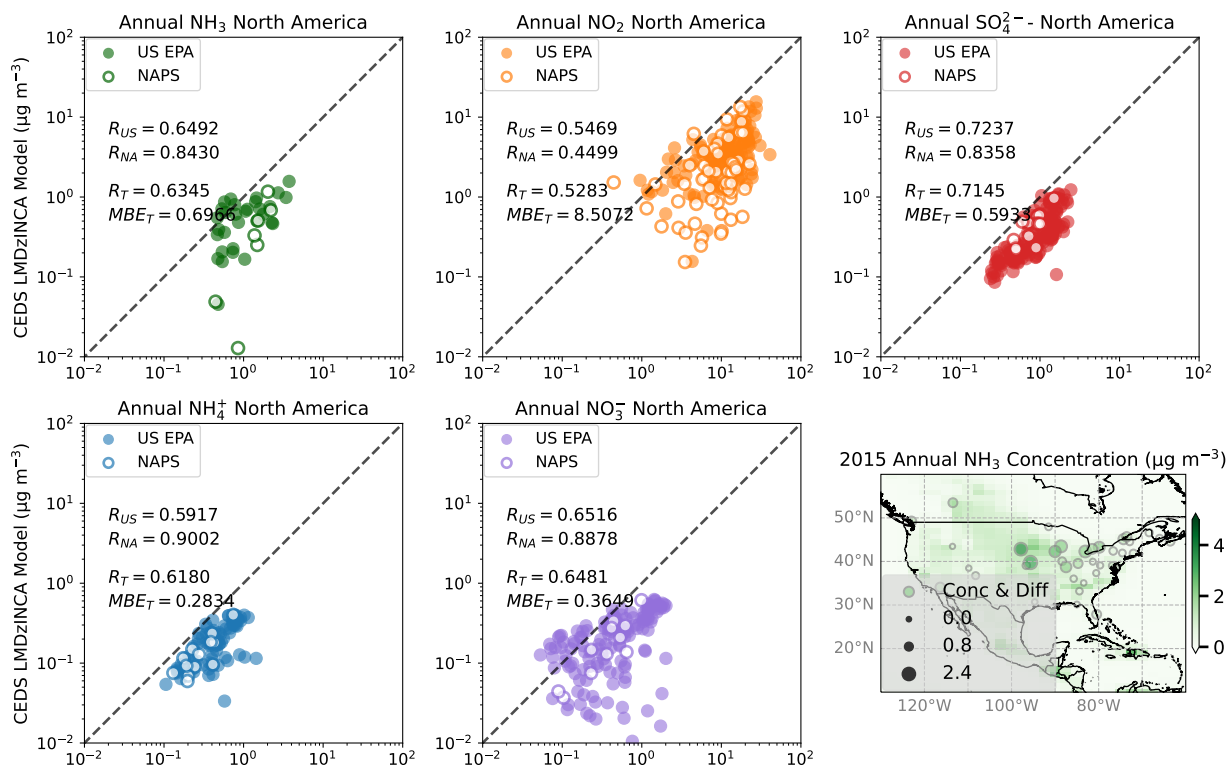


Figure S9. Scatter plots of annual mean modelled (CEDS run) and measured NH_3 , NO_2 , SO_4^{2-} , NH_4^+ and NO_3^- concentrations at European and UK monitoring network locations for 2015. In each plot, the dashed black line is the 1 : 1 line. RUS is for the US/EPA network. RNA is for the NAPS network. RT is the overall correlation coefficient between the model and all measurements shown. MBET is the overall Mean Bias Error between the model and all measurements shown. Note the log scale used in the plot. Annual surface NH_3 simulated concentrations are also shown along with the observation values mapped with circles. The size of the circle indicates the absolute difference with the modelled value. ($\mu\text{g.m}^{-3}$).

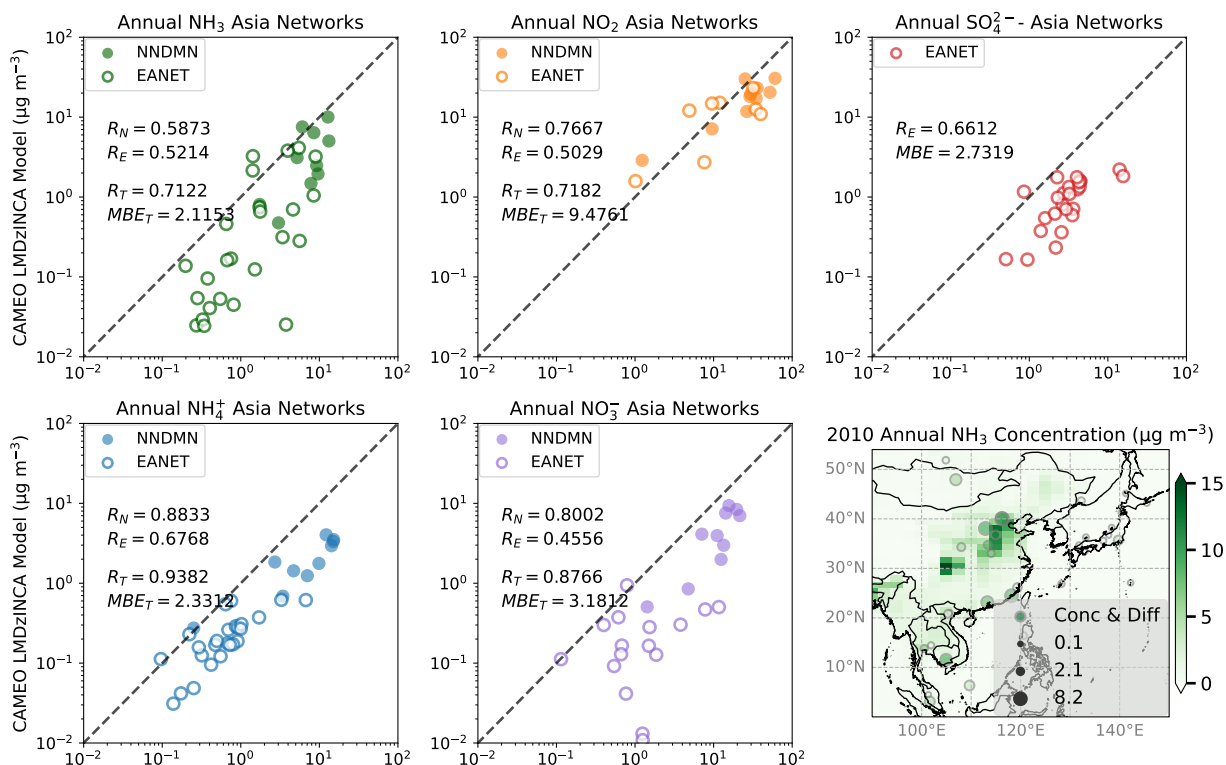


Figure S10. Scatter plots of annual mean modelled (CAMEO run) and measured NH_3 , NO_2 , SO_4^{2-} , NH_4^+ and NO_3^- concentrations at East Asian and Southeast Asian monitoring network locations for 2010. In each plot, the dashed black line is the 1 : 1 line. R_N is for NNDMN network. R_E is for the EANET network. R_T is the overall correlation coefficient between the model and all measurements shown. MBE_T is the overall Mean Bias Error between the model and all measurements shown. Note the log scale used in the plot. Annual surface NH_3 simulated concentrations are also shown along with the observation values mapped with circles. The size of the circle indicates the absolute difference with the modelled value. ($\mu g \cdot m^{-3}$).

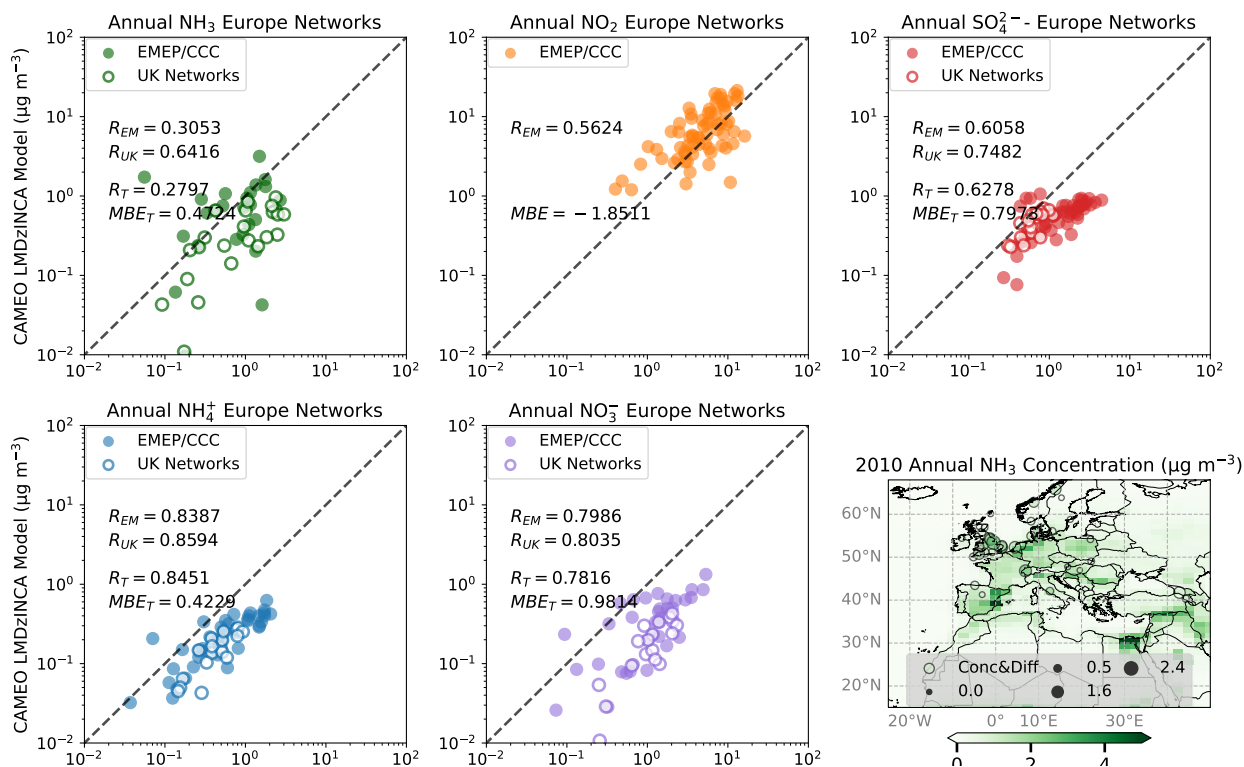


Figure S11. Scatter plots of annual mean modelled (CAMEO run) and measured NH_3 , NO_2 , SO_4^{2-} , NH_4^+ and NO_3^- concentrations at European and UK monitoring network locations for 2010. In each plot, the dashed black line is the 1 : 1 line. REM is for EMEP/CCC network. RUK is for the UK network. RT is the overall correlation coefficient between the model and all measurements shown. MBET is the overall Mean Bias Error between the model and all measurements shown. Note the log scale used in the plot. Annual surface NH_3 simulated concentrations are also shown along with the observation values mapped with circles. The size of the circle indicates the absolute difference with the modelled value. ($\mu\text{g.m}^{-3}$).

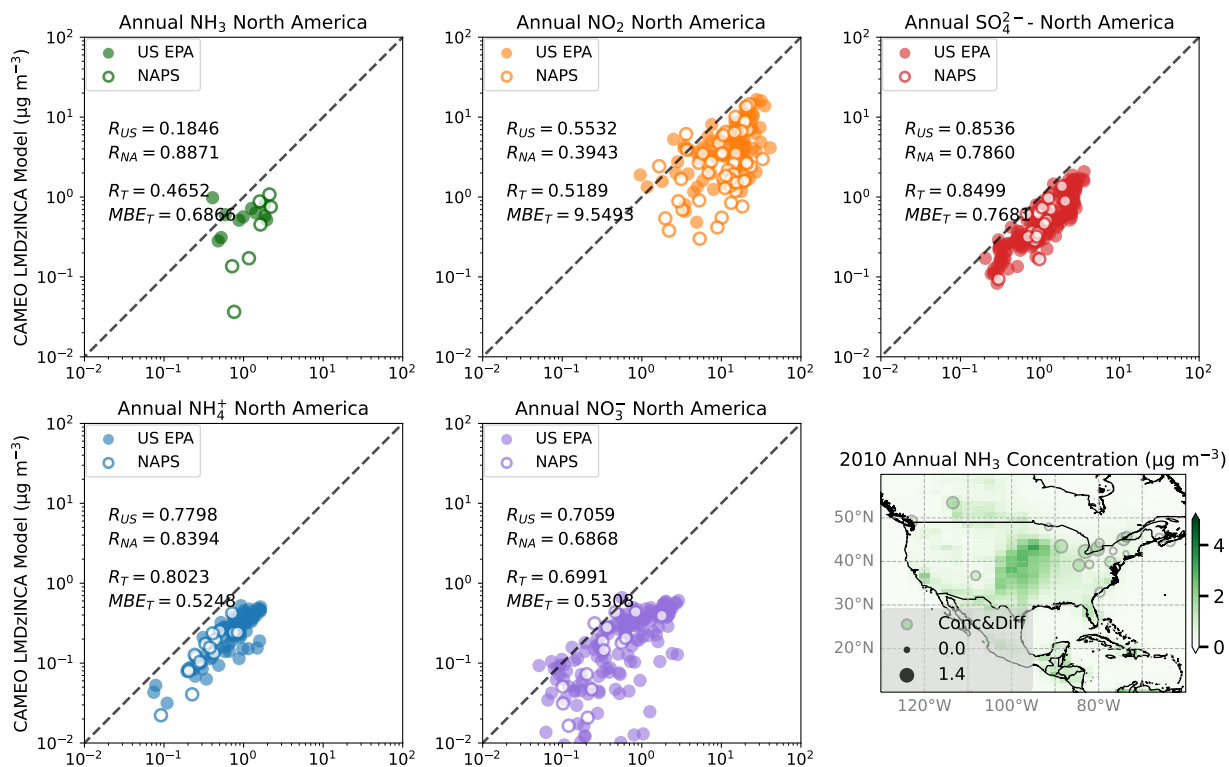


Figure S12. Scatter plots of annual mean modelled (CAMEO run) and measured NH_3 , NO_2 , SO_4^{2-} , NH_4^+ and NO_3^- concentrations at European and UK monitoring network locations for 2010. In each plot, the dashed black line is the 1 : 1 line. R_{US} is for the US/EPA network. R_{NA} is for the NAPS network. R_T is the overall correlation coefficient between the model and all measurements shown. MBE_T is the overall Mean Bias Error between the model and all measurements shown. Note the log scale used in the plot. Annual surface NH_3 simulated concentrations are also shown along with the observation values mapped with circles. The size of the circle indicates the absolute difference with the modelled value. ($\mu\text{g.m}^{-3}$).

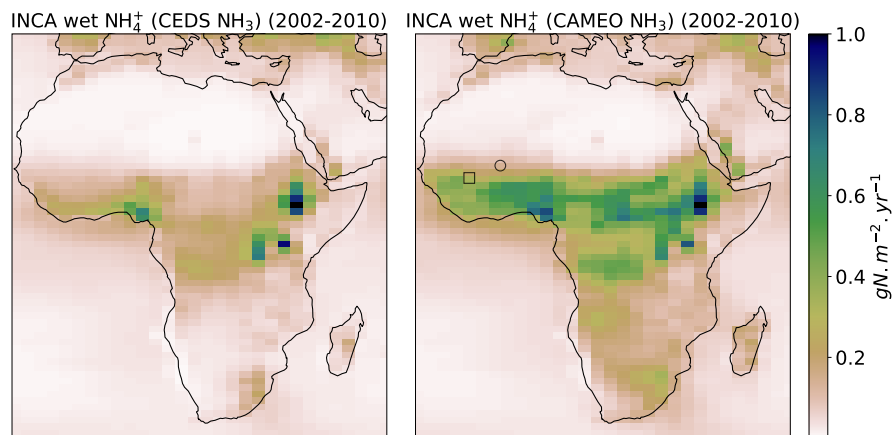


Figure S13. Annual mean wet NH_4^+ deposition simulated by LMD-INCA where CEDS (left) and CAMEO (right) emissions are prescribed for present-day conditions (2002-2010). The circle and square represent the ground-observational station of Agoufou and Katibougou used in Figure S11. ($\text{gNm}^{-2}\text{yr}^{-1}$).

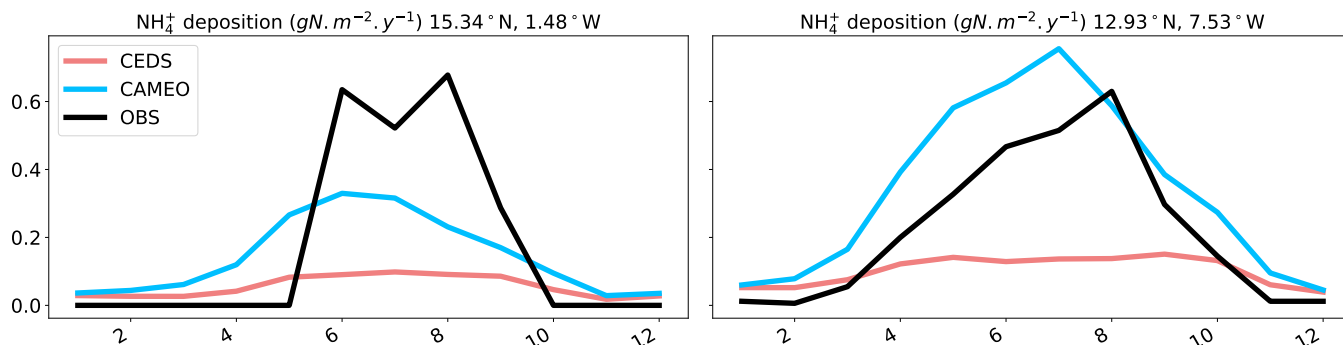


Figure S14. Simulated and observed wet deposition of ammonium in Agoufou and Katibougou (2002-2010). As in Vira et al. (2022), the simulated wet deposition includes both scavenged aerosol-phase ammonium and the dissolved gaseous ammonia. ($\text{gNm}^{-2}\text{yr}^{-1}$).

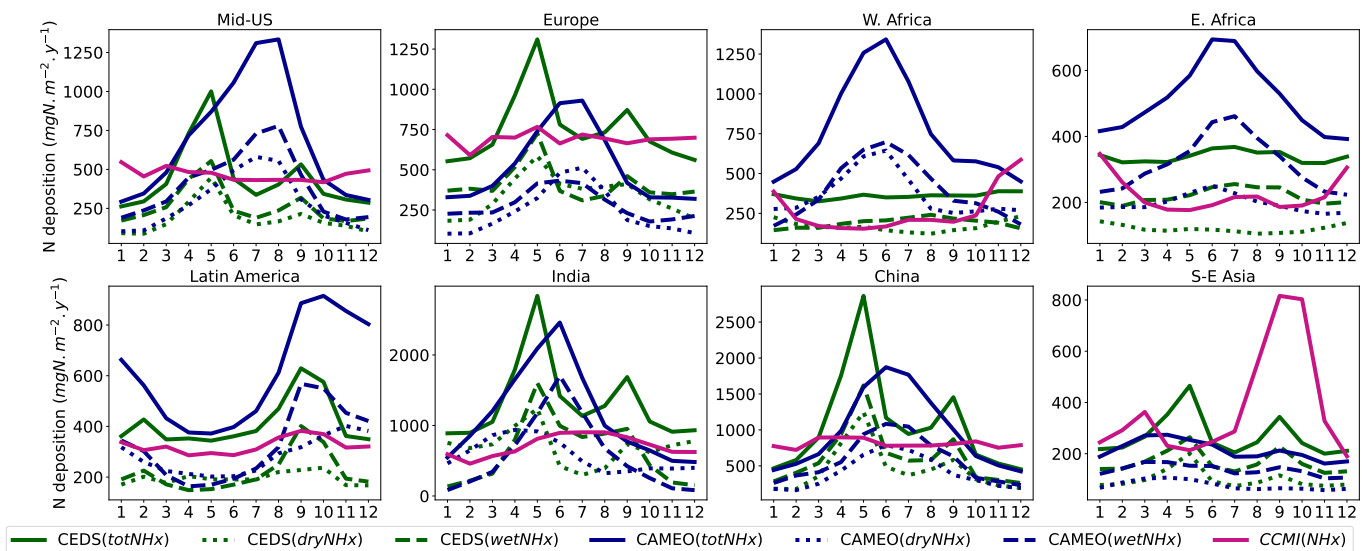


Figure S15. Regional monthly total NH_x deposition in $\text{mgN} \cdot \text{m}^{-2} \cdot \text{yr}^{-1}$ from CEDS and CAMEO simulations (green and blue respectively) and CCMI (in purple) for 2010-2014. Dry (dotted lines) and wet (dashed lines) NH_x deposition from INCA are also plotted. Regions are defined in Fig. 8

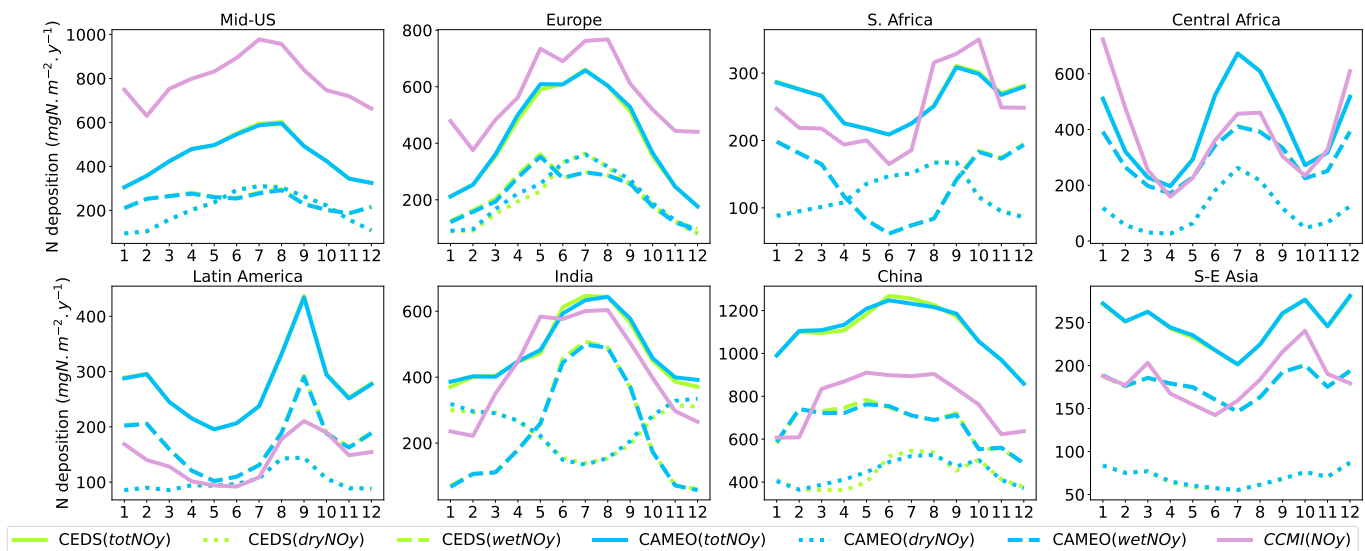


Figure S16. Regional monthly total NO_y deposition in $\text{mgN} \cdot \text{m}^{-2} \cdot \text{yr}^{-1}$ from CEDS and CAMEO simulations (green and blue respectively) and CCMI (in pink) for 2010-2014. Dry (dotted lines) and wet (dashed lines) NO_y deposition from LMDZ-INCA are also plotted. Please note that CEDS time series equal CAMEO in Latin America, Central Africa and South Africa. Regions are defined in Fig. 8

References

- 5 Vira, J., Hess, P., Ossohou, M., and Galy-Lacaux, C.: Evaluation of interactive and prescribed agricultural ammonia emissions for simulating atmospheric composition in CAM-chem, *Atmospheric Chemistry and Physics*, 22, 1883–1904, <https://doi.org/10.5194/acp-22-1883-2022>, 2022.