Fig. S1 Modelled annual surface concentration of SO_4^{2-}, NO_3^{2-} and NH_4^+ aerosol for 2014. Filled circles indicate measured annual means for 2014 compiled from Air Quality System (AQS) of Environmental Protection Department (EPD) for United States (US), National Atmospheric Chemistry (NAtChem) database for Canada, European Monitoring and Evaluation Programme (EMEP) for Europe, Acid Deposition Monitoring Network in East Asia (EANET) for eastern Asia, and Geng et al. (2017) for China. The data from AQS, NAtChem, EMEP and EANET.
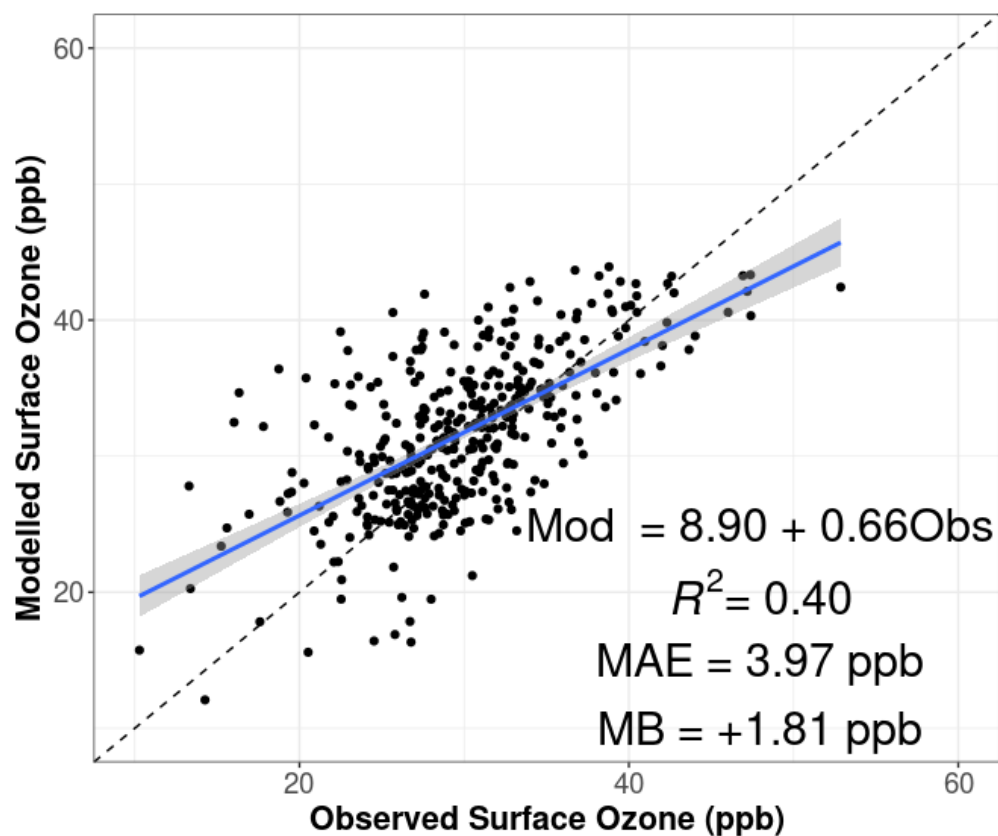
Fig. S2 Comparison between mean modelled and observed surface ozone compiled by Sofen et al. (2016) at 2014. MAE and MB represents the mean absolute error and mean bias, respectively.
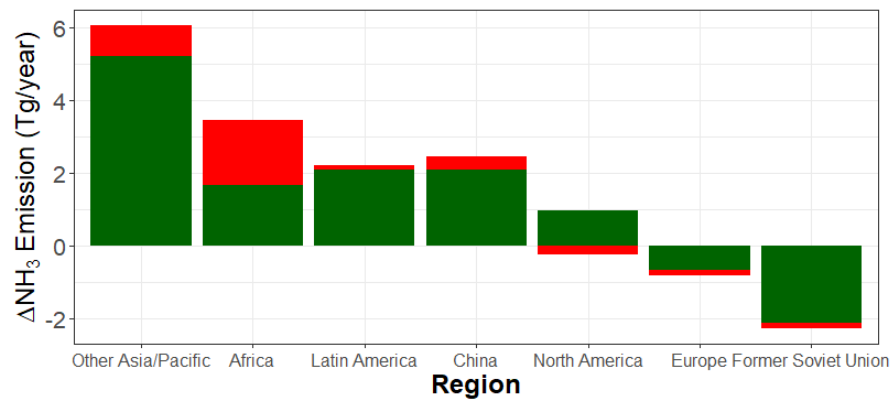
Figure S3. Regionally changes (2014 – 1992) in agricultural and non-agricultural NH$_3$ emissions from CEDS.
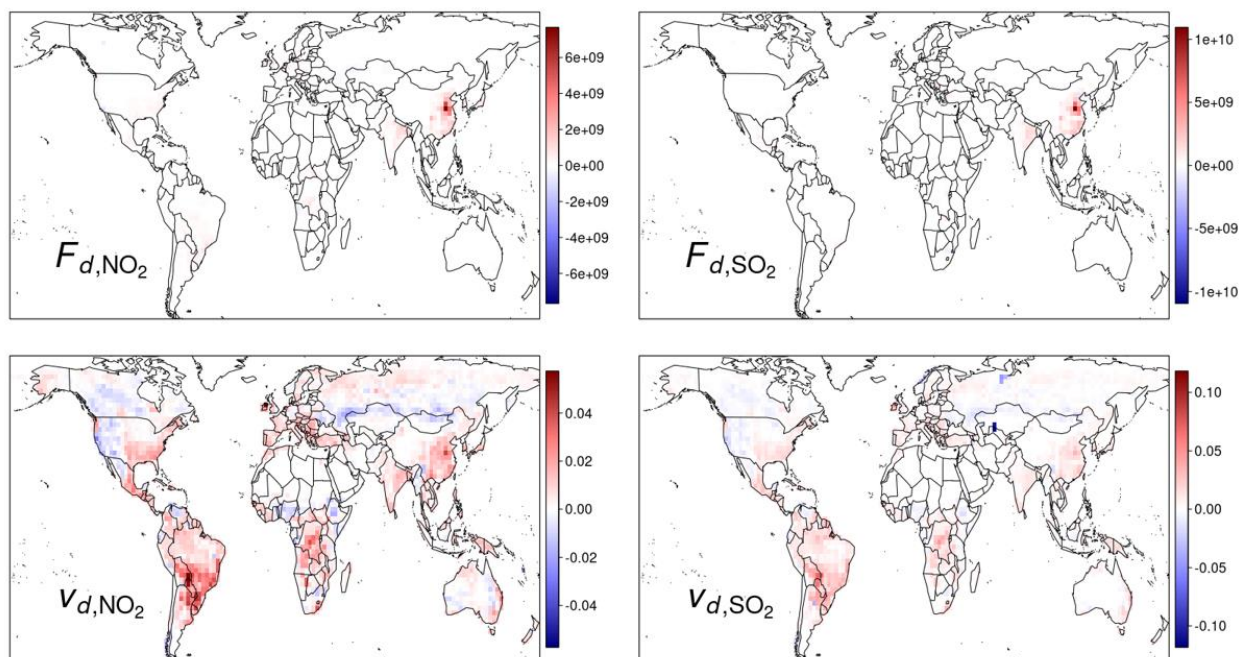
Figure S4. LULCC-induced changes in annual mean dry deposition (v_d) velocity (cm s^{-1}) and flux (F_d) (molec cm^{-2} s^{-1}) in of NO$_2$ and SO$_2$.
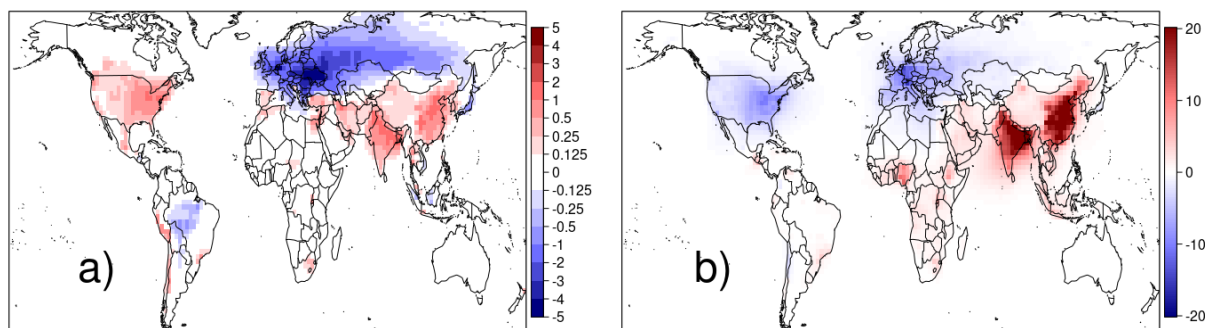
Figure S5. Change in annual mean PM$_{2.5}$ (in µg m^{-3}) due to a) LULCC and changes in agricultural emissions at 1992 anthropogenic emissions background (simulation 5 – simulation 1), and b) anthropogenic emission changes (including agricultural emissions) (simulation 4 – simulation 5).
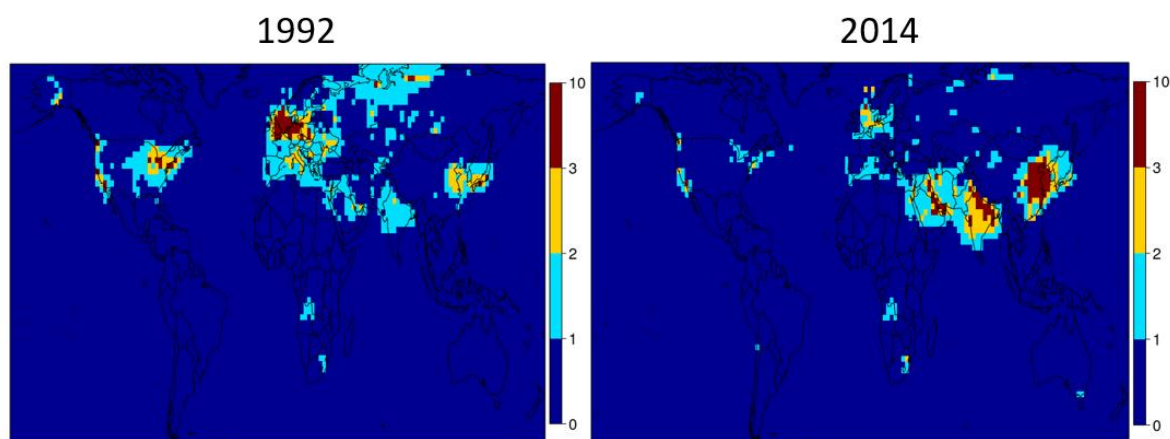
Figure S6. Annual mean surface HNO$_3$/H$_2$O$_2$ ratio under 1992 and 2014 anthropogenic emission background.
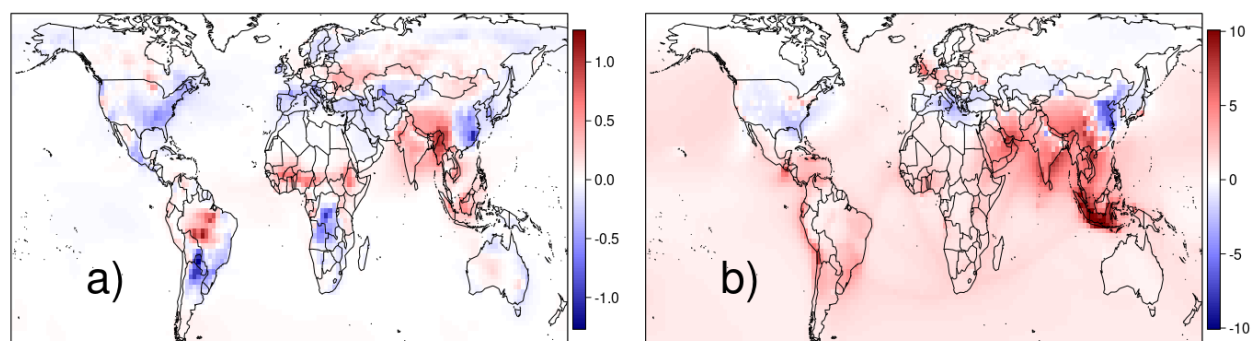
Figure S7. Change in annual mean surface O$_3$ (in ppbv) due to a) LULCC and changes in agricultural emissions at 1992 anthropogenic emissions background (simulation 5 – simulation 1), and b) anthropogenic emissions changes (including agricultural emissions) (simulation 4 – simulation 5).
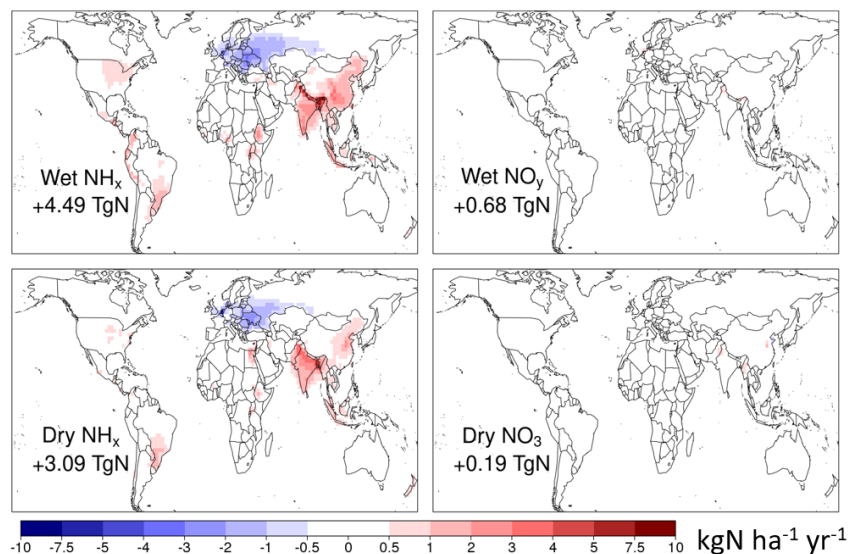
Figure S8. Contribution of different pathways (wet vs dry, reduced (NH_x) vs oxidized (NO_y)) to the changes in total nitrogen deposition. $NH_x \equiv NH_3 + NH_4$ and $NO_y \equiv NO + NO_2 + HONO +$ organic nitrates + aerosol nitrate.

Region	Species	Mod	Obs	Mod/Obs
	SO_4^{2-}	0.88	1.27	0.70
US	NO_3^-	0.77	0.93	0.83
	NH_4^+	0.54	0.69	0.79
	SO_4^{2-}	0.78	0.92	0.85
Canada	NO_3^-	0.84	0.44	1.92
	NH_4^+	0.52	0.36	1.46
	SO_4^{2-}	1.84	2.08	0.88
Europe	NO_3^-	1.67	1.51	1.10
	NH_4^+	1.16	1.11	1.05
	SO_4^{2-}	8.53	18.93	0.45
China	NO_3^-	6.16	10.15	0.61
	NH_4^+	4.83	7.61	0.64
	SO_4^{2-}	2.33	3.64	0.64
EANET	NO_3^-	1.09	1.31	0.84
	NH_4^+	1.15	1.01	1.14

Table S1. Comparison between modelled and observed annual average surface sulphate, nitrate and ammonium aerosol mass (in µg m^{-3}) over different region/observational network. Measurements are compiled from Air Quality System (AQS) of Environmental Protection Department (EPD) for United States (US), National Atmospheric Chemistry (NAtChem) database for Canada, European Monitoring and Evaluation Programme (EMEP) for Europe, Acid Deposition Monitoring Network in East Asia (EANET) for eastern Asia, and Geng et al. (2017) for China. The data from AQS, NAtChem, EMEP and EANET are collect in 2014.

Region	Countries included
Former Soviet Union (FSU)	Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan
Western Europe (WEU)	Austria, Belgium, Switzerland, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Iceland, Italy, Luxembourg, Netherlands, Norway, Portugal, Sweden
Central and eastern Europe (CEU)	Albania, Bulgaria, Bosnia and Herzegovina, Cyprus, Czechia, Estonia, Croatia, Hungary, Kosovo, Lithuania, Latvia, Montenegro, Poland, Romania, Serbia, Slovakia, Slovenia
China	China
South Asia (SAs)	Afghanistan, Bangladesh, Bhutan, India, Sri Lanka, Nepal, Pakistan
Middle East (ME)	United Arab Emirates, Egypt, Iran, Iraq, Israel, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, West Bank, Yemen
Southeast Asia (SEA)	Brunei, Indonesia, Cambodia, Laos, Myanmar, Malaysia, Philippines, Thailand, Vietnam
Japan and Korea (JK)	Japan, South Korea, North Korea
Australasia (Aus)	Australia, Fiji, New Caledonia, New Zealand, Papua New Guinea, Solomon Islands, Vanuatu
North America (NAm)	Canada, United States
Central America (CAm)	Belize, Costa Rica, Cuba, Guatemala, Honduras, Haiti, Jamaica, Mexico, Nicaragua, Panama, Puerto Rico, El Salvador, Trinidad and Tobago
South America (SAm)	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Peru, Paraguay, Suriname, Uruguay, Venezuela, French Guiana
Northern Africa (NAf)	Algeria, Libya, Morocco, Tunisia
Western Africa (WAf)	Benin, Burkina Faso, Ivory Coast, Cameroon, Gabon, Ghana, Guinea, Gambia, Guinea Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Chad, Togo
Southern Africa (SAf)	Angola, Botswana, Lesotho, Mozambique, Malawi, Namibia, Swaziland, South Africa, Zambia, Zimbabwe
Eastern Africa (EAf)	Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Somaliland, Somalia, Uganda

Table S2. Definition of regions.

Region[†]	$\Delta PM_{2.5(LULCC+agr\_emis,1992)}$	$\Delta O_{3(LULCC+agr\_emis,1992)}$
FSU	-0.69 (-1.95)	-
WEU	-0.49 (-1.24)	-
CEU	-2.03 (-2.22)	-
China	+0.34 (+0.75)	+0.09 (-0.21)
SAs	+0.55 (+0.82)	+0.26 (+0.25)
ME	+0.20 (+0.33)	-
SEA	+0.21 (+0.17)	+0.32 (+0.26)
JK	-0.08 (-0.23)	-
NAm	+0.15 (+0.56)	-0.05 (-0.21)
CAm	+0.10 (+0.22)	-
WAf	-	+0.20 (+0.30)
EAf	-	+0.16 (+0.27)
Global	-0.08 (+0.23)	+0.01 (+0.03)

Table S3. Changes in area averaged, and population-weighted (in parentheses), annual mean surface PM$_{2.5}$ ($\Delta PM_{2.5(LULCC+agr\_emis,1992)}$, in μg m^{-3}) and O$_3$ ($\Delta O_{3(LULCC+agr\_emis,1992)}$, in ppbv) concentrations due to combined effects of LULCC and agricultural emission evaluated under 1992 anthropogenic emission background. Results only from regions with area- or population-weighted average $\Delta PM_{2.5(LULCC+agr\_emis,1992)}$ > 0.2 μg m^{-3} or $\Delta O_{3(LULCC+agr\_emis,1992)}$ > 0.2 ppbv are shown.

[†]**The definitions and abbreviations of all regions can be found in Table S2.**