Supplementary Information for

Uncertainties in fertilizer-induced emissions of soil nitrogen oxide and the associated impacts on ground-level ozone and methane

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2 Tables;

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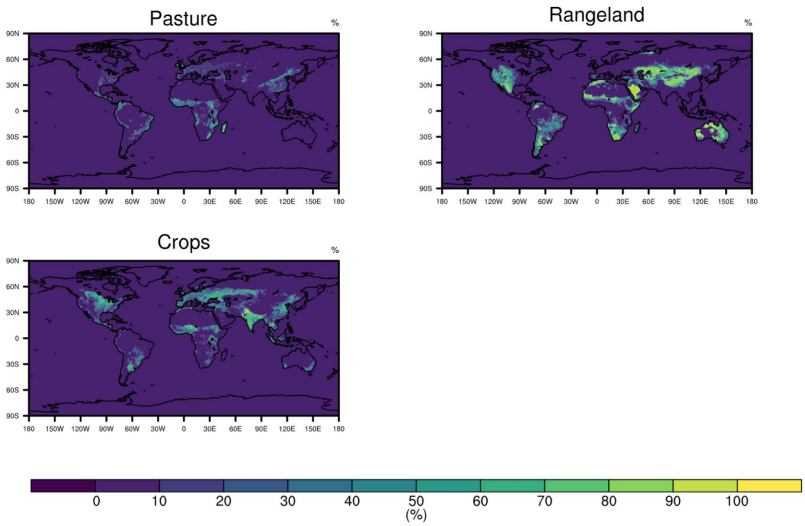

Figure S1. The global pattern of land-use categories used in this study to transform the unit of N fertilizer loadings from kg N per hectare grid area to kg N per hectare pasture, rangeland or crop. The map is from the Land-Use Harmonization (LUH2) (*https://luh.umd.edu/*)

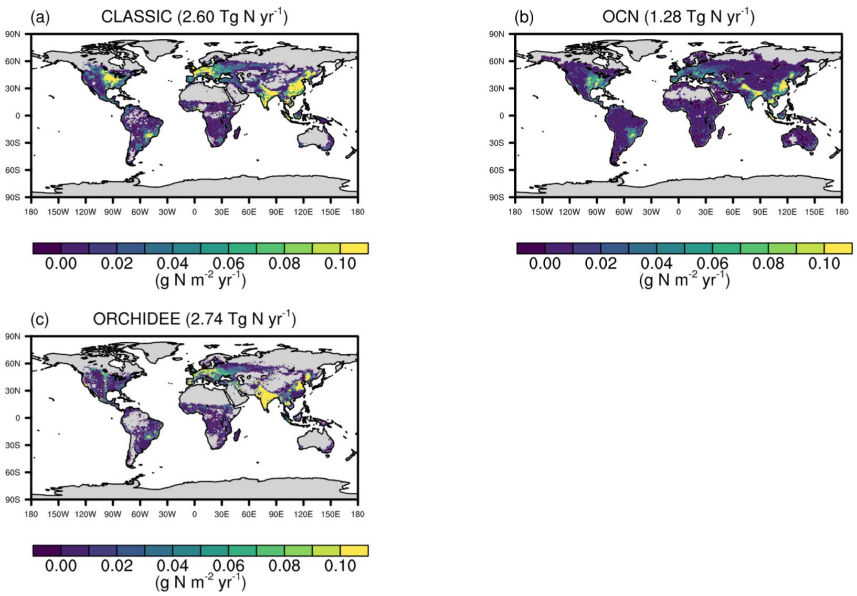

Figure S2. The global pattern of N fertilizer-induced soil NO_x emissions in 2019 simulated by three NMIP2 members. (a) the CLASSIC model; (b) the OCN model and (c) the ORCHIDEE model.

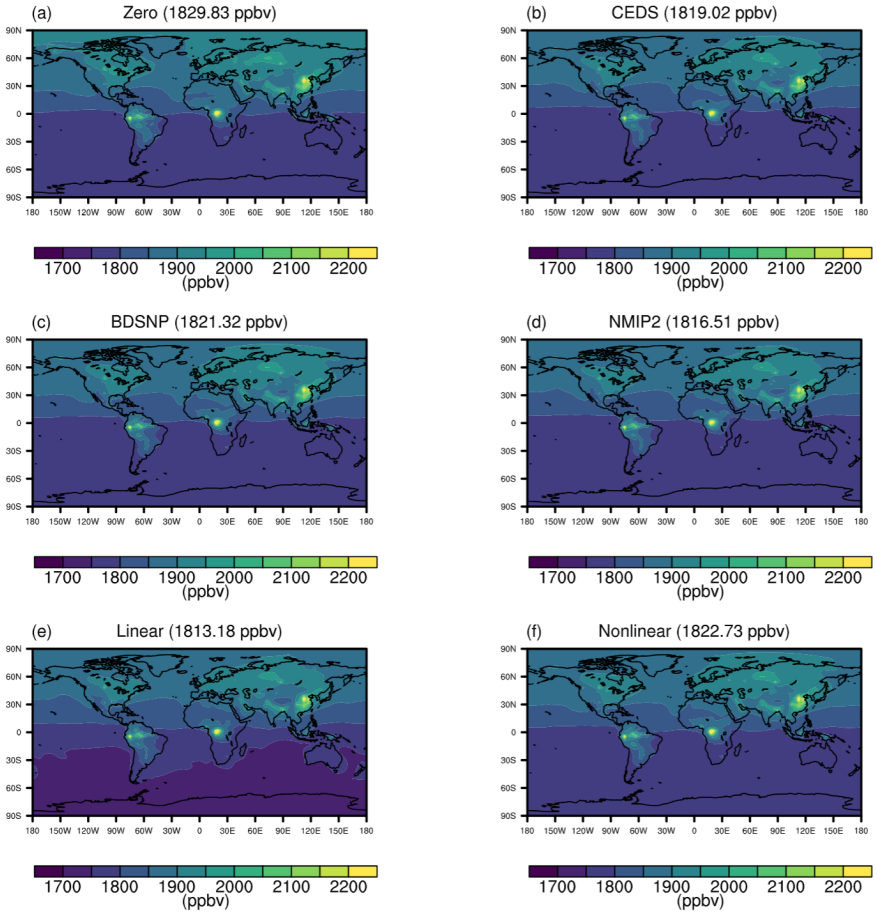

Figure S3. The simulated global surface CH_4 concentrations with different sensitivity experiments. The OH concentrations of each experiment are obtained from the corresponded GEOS-Chem sensitivity experiments with full chemistry mechanisms.

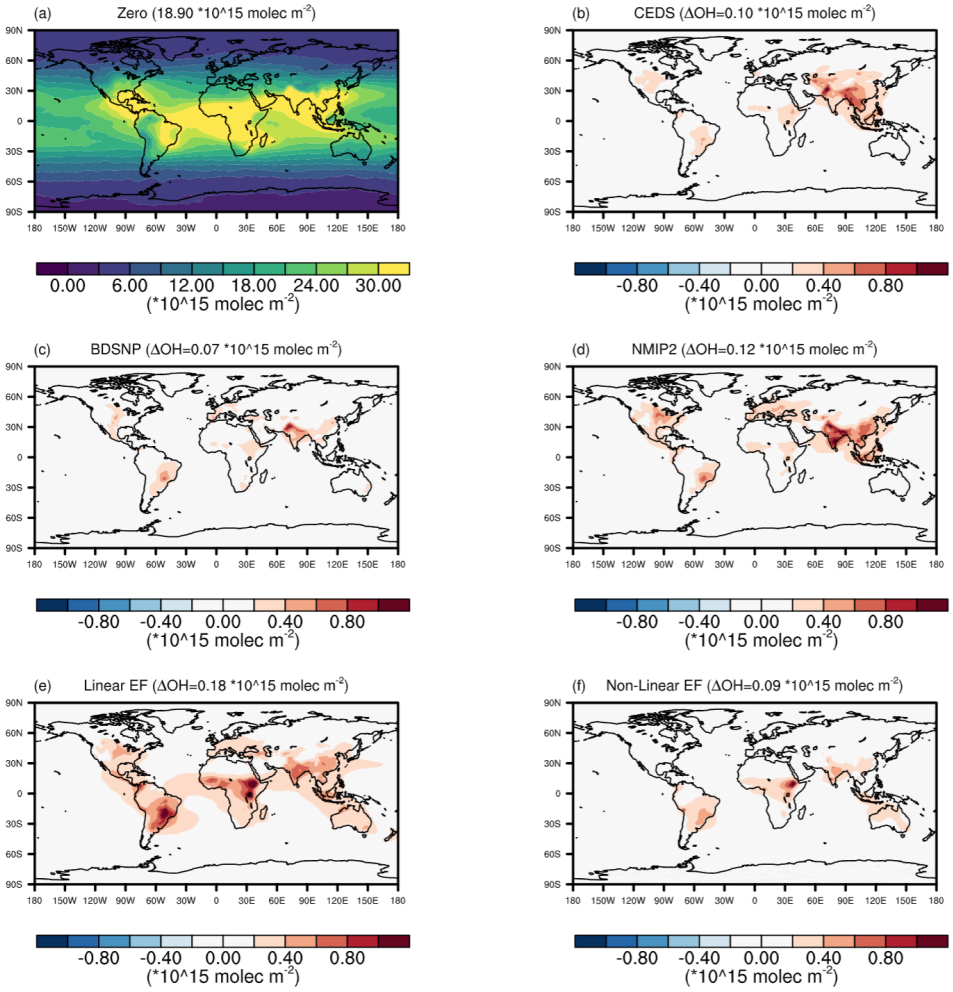

Figure S4. The annual-mean tropospheric column OH concentrations simulated by different GEOS-Chem sensitivity experiments. (a) The OH spatial pattern in the Zero simulation. (b)-(f) The differences of annual-mean tropospheric column OH between varied sensitivity experiments and the Zero experiments. The numbers in the sub-titles are the global averages of tropospheric column OH.

Table S1. NMIP2 configuration and sensitivity experiments to isolate the contributions of synthetic fertilizer and manure to the soil NO_x emissions. '1850' indicates that the loading of synthetic fertilizer or manure is fixed at the level of 1850, while '1850-2019' indicates transient loadings based on the HaNi dataset. Other environmental forcings, e.g. the climate data, CO_2 concentration and land use change, are followed the historical transient data from 1850 to 2019 in each sensitivity experiment.

Experiment name	Synthetic fertilizer application	Manure application
SH1	1850-2019	1850-2019
SH2	1850	1850-2019
SH3	1850-2019	1850
Model members used in this study: CLASSIC, OCN and ORCHIDEE		

Table S2. The sources and sinks of CH_4 (unit: Tg CH_4 yr^{-1}) applied in the GEOS-Chem model and the comparison to the IPCC AR6 budget (Canadell.J.G et al., 2021).

	This study	IPCC AR6*
	Sources	
Fossil fuels	117.6	115 (114-116)
Agriculture and waste	238.9	208 (192-230)
Livestock	121.7	109 (106-115)
Rice cultivation	36.5	31 (25-37)
Waste water and landfill	80.7	64 (55-77)
Biomass burning and biofuels	17.4	30 (22-39)
Biomass burning	17.4	17 (14-26)
Biofuels		10 (8-13)
Other anthropogenic sources	24	
Wetland	144	149 (102-182)
Other natural sources	104.6**	222 (143-306)
Sum of sources	646.5	727 (581-872)
	Sinks	
Total chemical loss	623	602 (496-754)
Soil absorption	17	30 (11-49)
Sum of sinks	640	632 (507-803)

*Values are from the bottom-up estimates over 2008-2017

** This other natural sources in GEOS-Chem is scaled up from 13.6 to 104.6 Tg CH_4 yr^{-1} to keep the balance of the total CH_4 budget, as the natural sources of CH_4 remained largest uncertainties among all sectors.

References

Canadell.J.G, Monteiro, P. M. S., Costa, M. H., Cunha, L. C. d., Cox, P. M., Eliseev, A. V., Henson, S., Ishii, M., Jaccard, S., Koven, C., Lohila, A., Patra, P. K., Piao, S., Rogelj, J., Syampungani, S., Zaehle, S., and Zickfeld, a. K.: Global Carbon and other Biogeochemical Cycles and Feedbacks. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, 673–816, https://doi.org/10.1017/9781009157896.007, 2021.