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Sensitivity of climate effects of hydrogen to leakage size, location, and chemical background

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Supplementary figures

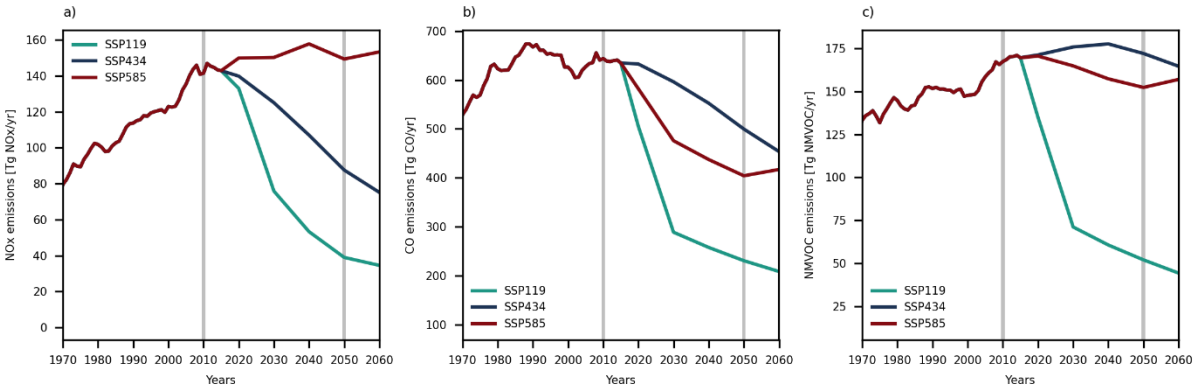

Figure S1: Historical (Hoesly et al., 2018) and future (Gidden et al., 2019) anthropogenic emissions of a) NOx, b) CO and c) NMVOCs for the three SSPs used in this study. In this study the emissions for the years 2010 and 2050 are used in the model simulations (vertical gray line).

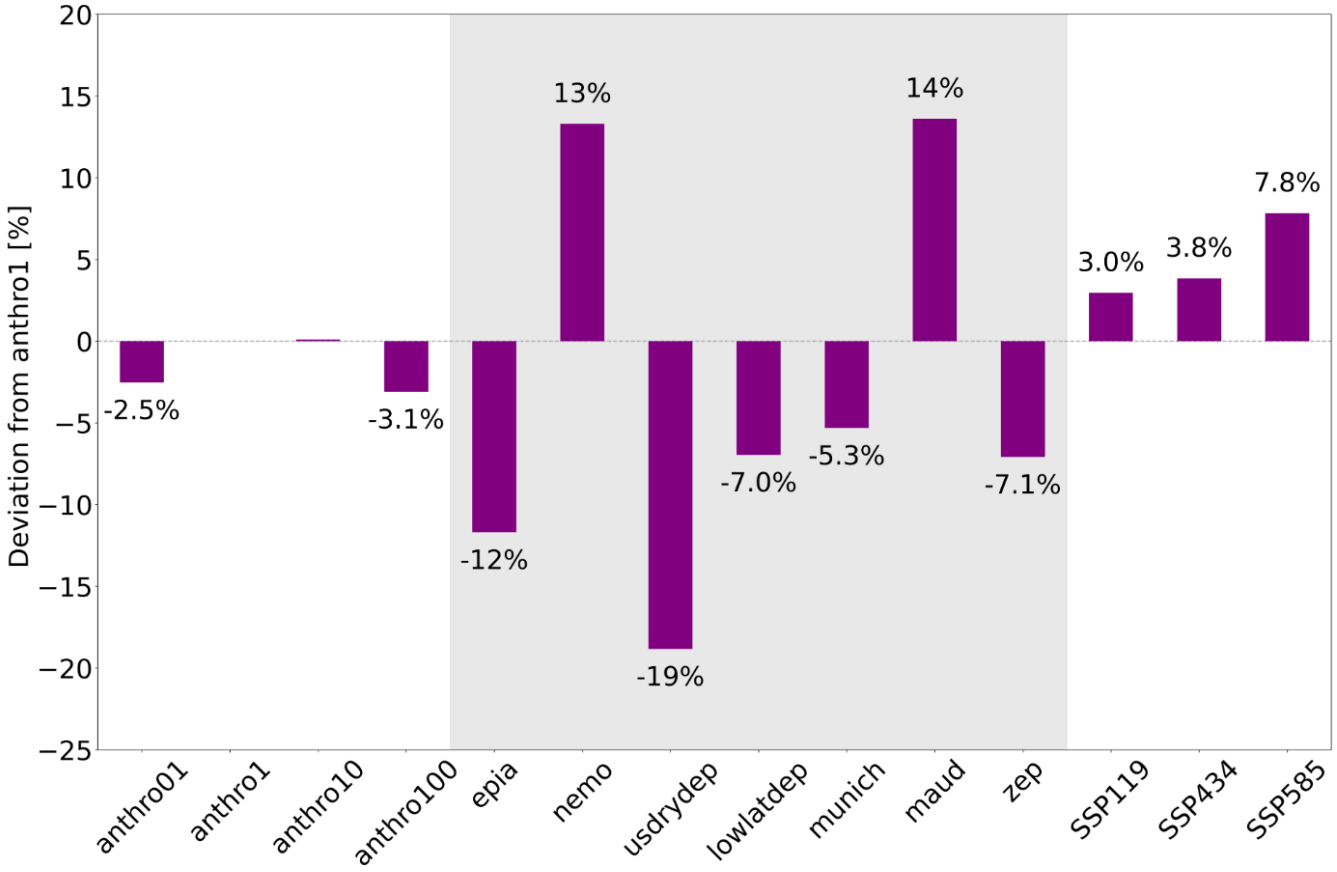

Figure S2: For each sensitivity test, the deviation of H_2 GWP100 relative to anthro1 given as percentages.

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Supplementary tables

Table S1: H_2 GWP100 values presented in Fig. 3.

	CH4dir	CH4indir	O3	O3 CH4ind	strat H2O	strat H2O CH4ind	Total
anthro01	3.26	1.52	2.13	2.79	1.87	0.65	12.2
anthro1	3.29	1.53	2.38	2.81	1.87	0.66	12.5
anthro10	3.28	1.52	2.42	2.80	1.88	0.66	12.6
anthro100	3.11	1.45	2.41	2.66	1.90	0.62	12.2
epia	2.95	1.37	2.06	2.53	1.57	0.59	11.1
nemo	3.80	1.76	2.59	3.25	2.05	0.76	14.2
usdrydep	2.71	1.26	1.89	2.32	1.45	0.54	10.2
lowlatdep	3.02	1.40	2.27	2.58	1.80	0.60	11.7
munich	3.16	1.47	2.22	2.70	1.69	0.63	11.9
maud	3.80	1.77	2.62	3.25	2.05	0.76	14.2
zep	3.12	1.45	2.14	2.67	1.65	0.62	11.7
SSP119	3.18	1.64	2.48	2.94	1.95	0.73	12.9
SSP434	3.18	2.26	2.05	2.79	1.96	0.79	13.0
SSP585	3.43	2.31	2.01	3.03	1.92	0.83	13.5

Table S2: Changes in atmospheric composition and effective radiative forcing due to a flux of hydrogen (1 Tg yr^{-1}). In the first column, the hydrogen flux (in Tg yr^{-1}) in each perturbation simulation is shown. The rest of the columns show hydrogen surface concentrations (in ppb), methane surface concentrations (in ppb), methane flux (Tg yr^{-1}), ERF (in Wm-2) from methane, ozone, stratospheric water vapor due to a flux of 1 Tg yr^{-1} hydrogen.

	Flux H2 [Tg/yr]	Surf. conc. H2 per flux [ppb yr/Tg]	Surf. conc. CH4 per flux [ppb yr/Tg]	Flux CH4/Flux H2 [Tg CH4/Tg H2]	CH4 RF per flux [mW m-2 yr/ Tg]	ozone RF per flux [mW m-2 yr/ Tg]	Strat. H2O RF per flux [mW m-2 yr/ Tg]
anthro01	0.10	6.27	1.11	0.30	0.43	0.19	0.17
anthro1	0.99	6.27	1.12	0.31	0.43	0.21	0.17
anthro10	9.90	6.28	1.12	0.31	0.43	0.22	0.17
anthro100	99.07	6.35	1.06	0.29	0.41	0.22	0.17
epia	0.99	6.05	1.01	0.28	0.39	0.18	0.14
nemo	0.99	7.92	1.29	0.35	0.50	0.23	0.18
usdrydep	0.99	5.20	0.92	0.25	0.36	0.17	0.13
lowlatdep	0.99	5.48	1.03	0.28	0.40	0.20	0.16
munich	0.99	6.32	1.08	0.29	0.41	0.20	0.15
maud	0.99	9.24	1.29	0.35	0.50	0.23	0.18
zep	0.99	6.69	1.06	0.29	0.41	0.19	0.15
SSP119	9.90	6.36	1.12	0.30	0.43	0.22	0.17
SSP434	9.90	6.53	1.26	0.30	0.49	0.18	0.18
SSP585	9.89	6.42	1.33	0.32	0.51	0.18	0.17

Table S3: Changes in atmospheric composition and effective radiative forcing due to a flux of methane (1 Tg yr^{-1}). In the first column the methane flux in the perturbations. The rest of the columns show change in methane surface concentration (in ppb), ERF (in mW m^{-2}) for ozone and stratospheric water vapor due to a methane flux of 1 Tg yr^{-1}.

	Flux CH4 [Tg/yr]	Surf. conc. CH4 per flux [ppb yr/Tg]	ozone RF per flux [mW m-2 yr/ Tg]	Strat H2O RF per flux [mW m-2 yr/ Tg]
anthro01	49.7	3.65	0.82	0.19
anthro1	49.7	3.65	0.82	0.19
anthro10	49.7	3.65	0.82	0.19
anthro100	49.7	3.65	0.82	0.19
epia	49.7	3.65	0.82	0.19
nemo	49.7	3.65	0.82	0.19
usdrydep	49.7	3.65	0.82	0.19
lowlatdep	49.7	3.65	0.82	0.19
munich	49.7	3.65	0.82	0.19
maud	49.7	3.65	0.82	0.19
zep	49.7	3.65	0.82	0.19
SSP119	37.8	3.78	0.89	0.22
SSP434	52.1	4.27	0.84	0.24
SSP585	58.6	4.17	0.85	0.23

Table S4: Similar to Table S2, but for total changes that include the methane induced changes. The numbers include the changes directly due to the hydrogen perturbation (Table S2) and the changes due to methane changes (Table S3) mapped by the methane flux per hydrogen flux (column 4 in Table S2).

	Flux H2 [Tg/yr]	Surf. conc. H2 per flux [ppb yr/Tg]	Surf. conc. CH4 per flux [ppb yr/Tg]	Flux CH4/Flux H2 [Tg CH4/Tg H2]	CH4 RF per flux [mW m-2 yr/ Tg]	ozone RF per flux [mW m-2 yr/ Tg]	Strat. H2O RF per flux [mW m-2 yr/ Tg]
antro01	0.10	6.27	1.11	0.30	0.43	0.44	0.23
antro1	0.99	6.27	1.12	0.31	0.43	0.47	0.23
antro10	9.90	6.28	1.12	0.31	0.43	0.47	0.23
antro100	99.07	6.35	1.06	0.29	0.41	0.45	0.23
epia	0.99	6.05	1.01	0.28	0.39	0.41	0.19
nemo	0.99	7.92	1.29	0.35	0.50	0.52	0.25
usdrydep	0.99	5.20	0.92	0.25	0.36	0.38	0.18
lowlatdep	0.99	5.48	1.03	0.28	0.40	0.43	0.21
munich	0.99	6.32	1.08	0.29	0.41	0.44	0.21
maud	0.99	9.24	1.29	0.35	0.50	0.53	0.25
zep	0.99	6.69	1.06	0.29	0.41	0.43	0.20
SSP119	9.90	6.36	1.12	0.30	0.43	0.48	0.24
SSP434	9.90	6.53	1.26	0.30	0.49	0.43	0.25
SSP585	9.89	6.42	1.33	0.32	0.51	0.45	0.25

Table S5: The methane induced contribution to the H_2 GWP100 given as percentages [%].

	O3 CH4ind [%]	CH4 ind [%]	Strat H2O CH4ind [%]
anthro01	56.7	31.7	25.8
anthro1	54.1	31.7	26.0
anthro10	53.7	31.7	25.9
anthro100	52.4	31.7	24.7
epia	55.1	31.7	27.3
nemo	55.6	31.7	27.0
usdrydep	55.1	31.7	27.2
lowlatdep	53.2	31.7	25.1
munich	54.9	31.7	27.2
maud	55.3	31.7	27.0
zep	55.5	31.7	27.5
SSP119	54.2	34.0	27.2
SSP434	57.7	41.6	28.7
SSP585	60.2	40.3	30.2

Table S6: Percent contribution to H_2 GWP100. The methane induced and direct effects of the GWP100 are combined.

	O3	CH4	strat H2O
anthro01	40.2	39.1	20.6
anthro1	41.4	38.4	20.2
anthro10	41.6	38.2	20.2
anthro100	41.8	37.5	20.7
epia	41.4	39.1	19.5
nemo	41.1	39.1	19.8
usdrydep	41.4	39.0	19.6
lowlatdep	41.6	37.9	20.6
munich	41.4	39.0	19.5
maud	41.2	39.1	19.7
zep	41.3	39.2	19.5
SSP119	42.0	37.3	20.8
SSP434	37.1	41.8	21.1
SSP585	37.3	42.5	20.3

Table S7: Methane GWP100 presented in Fig. 5.

	present-day	SSP119	SSP434	SSP585
O3	9.2	9.9	9.4	9.5
CH4	15.7	16.3	18.4	18.0
strat H2O	2.1	2.5	2.7	2.6
Total	27.0	28.6	30.5	30.0

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