Supplementary Information to 'Influence of individual models and studies on quantitative mitigation findings in the IPCC Sixth Assessment Report'

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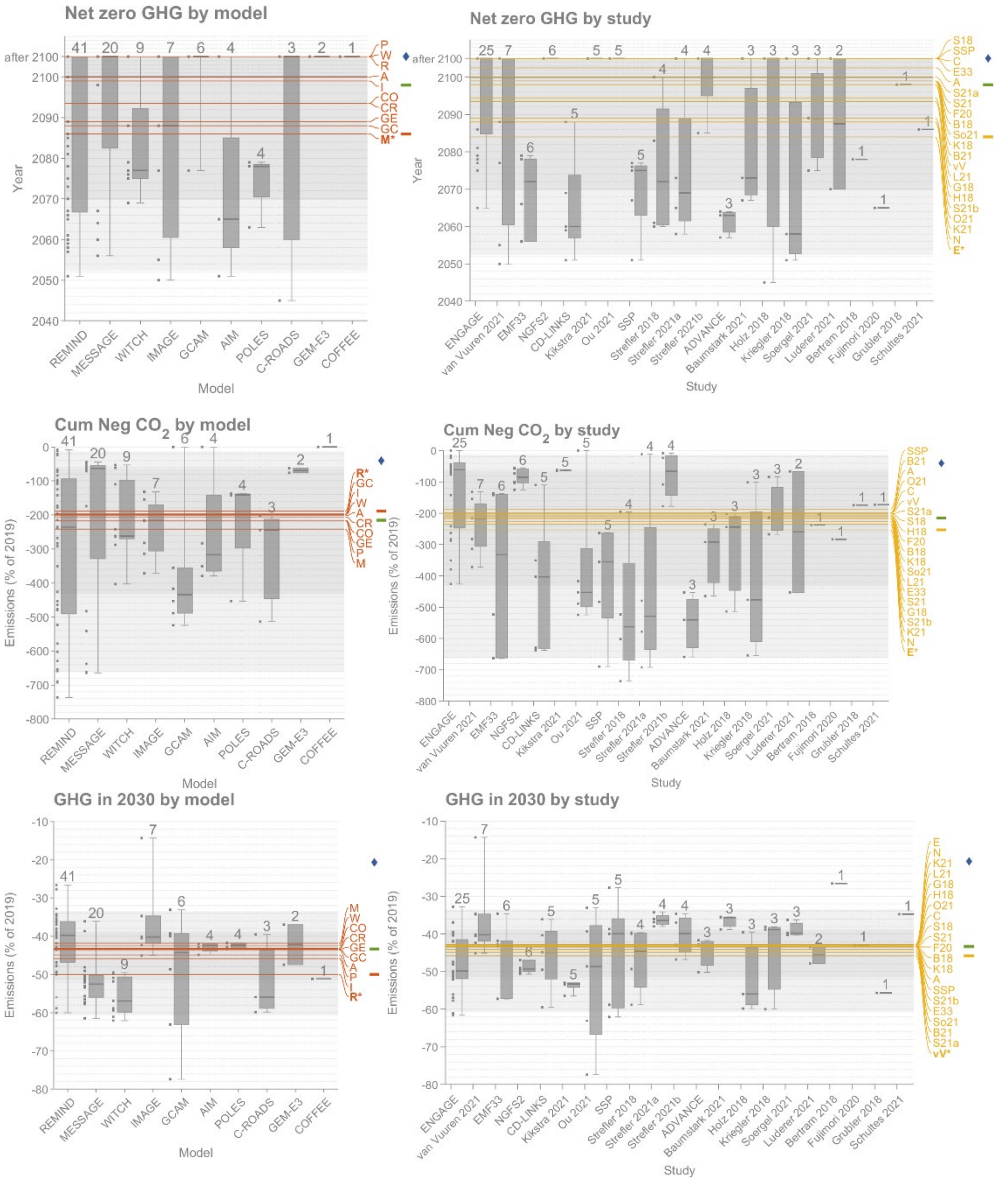
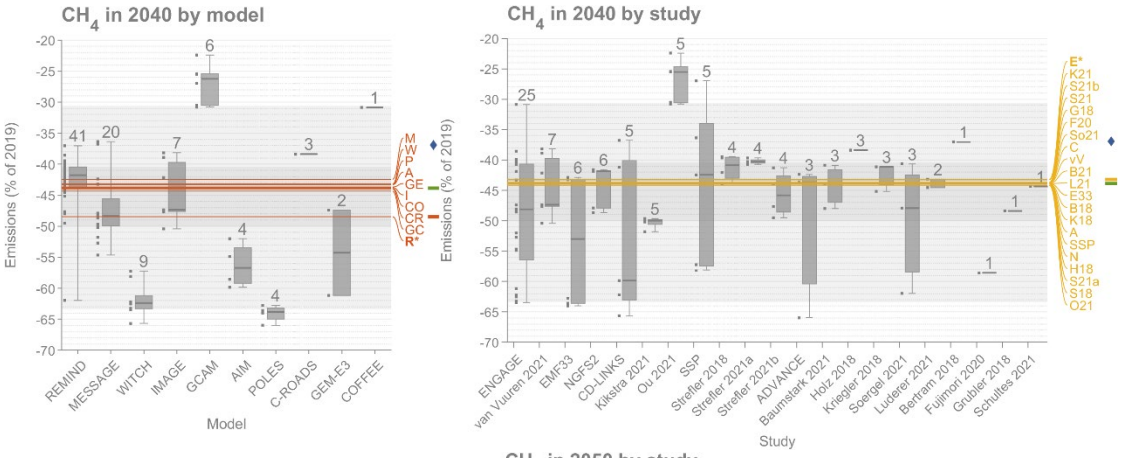


SI Figure 1 Impact of removing individual models and studies on median values for all the AR6 WGIII SPM findings shown in Figure 3. All variables are from scenarios that limit global warming to 1.5°C (>50%) (C1 category). Boxes show the minimum and maximum, interquartile ranges, and median of each model/study. The number of scenarios from each model/study is shown at the top of each box and the data points are shown to the left. Models and studies are ordered according to the number of scenarios, with the model/study with the most scenarios furthest left. Long, solid horizontal lines show median values when models (red) and studies (yellow) are removed one-by-one, with letters at the end of each line indicating the model/study that has been removed. Short, red and yellow horizontal lines to the right of the figures show the median values when the models/studies with the largest impact are removed. The letter for the corresponding model or study is bolded and starred. The short green lines show the reported 1.5°C medians and the blue diamonds show the reported 2°C medians. The dark grey background patches show the interquartile ranges and the light grey background patches show the 5th-95th percentile ranges. 'Net zero GHG' is the year of net zero GHG emissions. Values above 2100 on the y-axis indicate 'after 2100' which means zero was not reached before 2100 (and may not be reached, by scenario design). 'Neg CO_2' is cumulative net-negative CO_2 emissions between the year of net zero and 2100. 'CCS' stands for Carbon Capture and Storage and 'wo' stands for without. Data: IPCC AR6 Scenarios Database (Byers et al., 2022).



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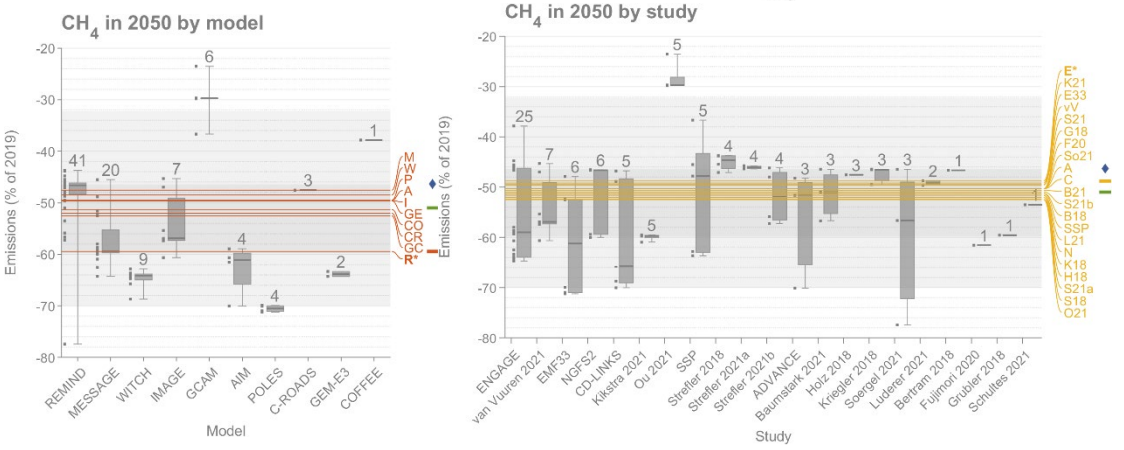

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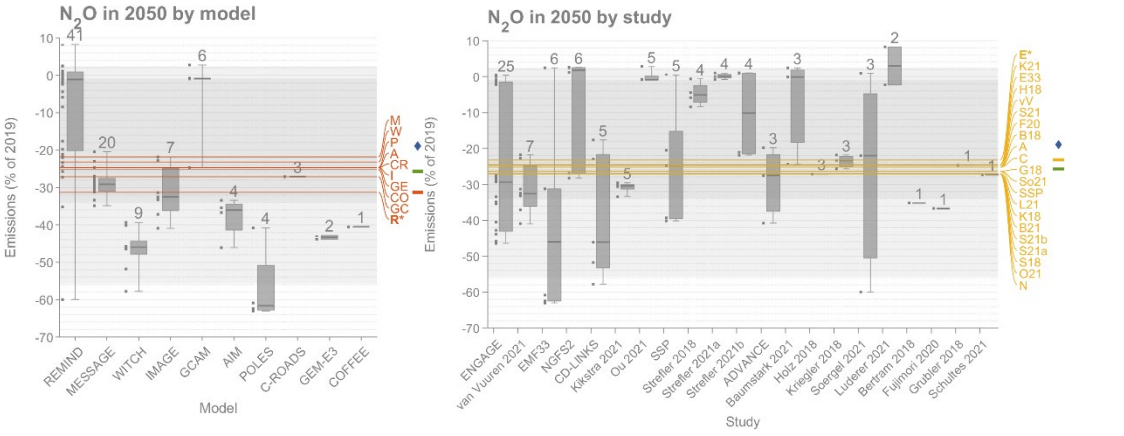

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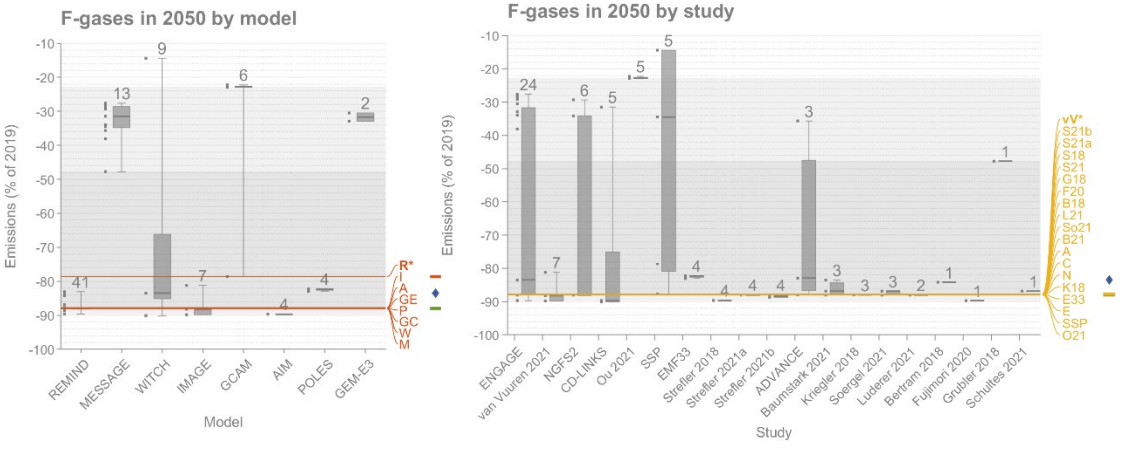

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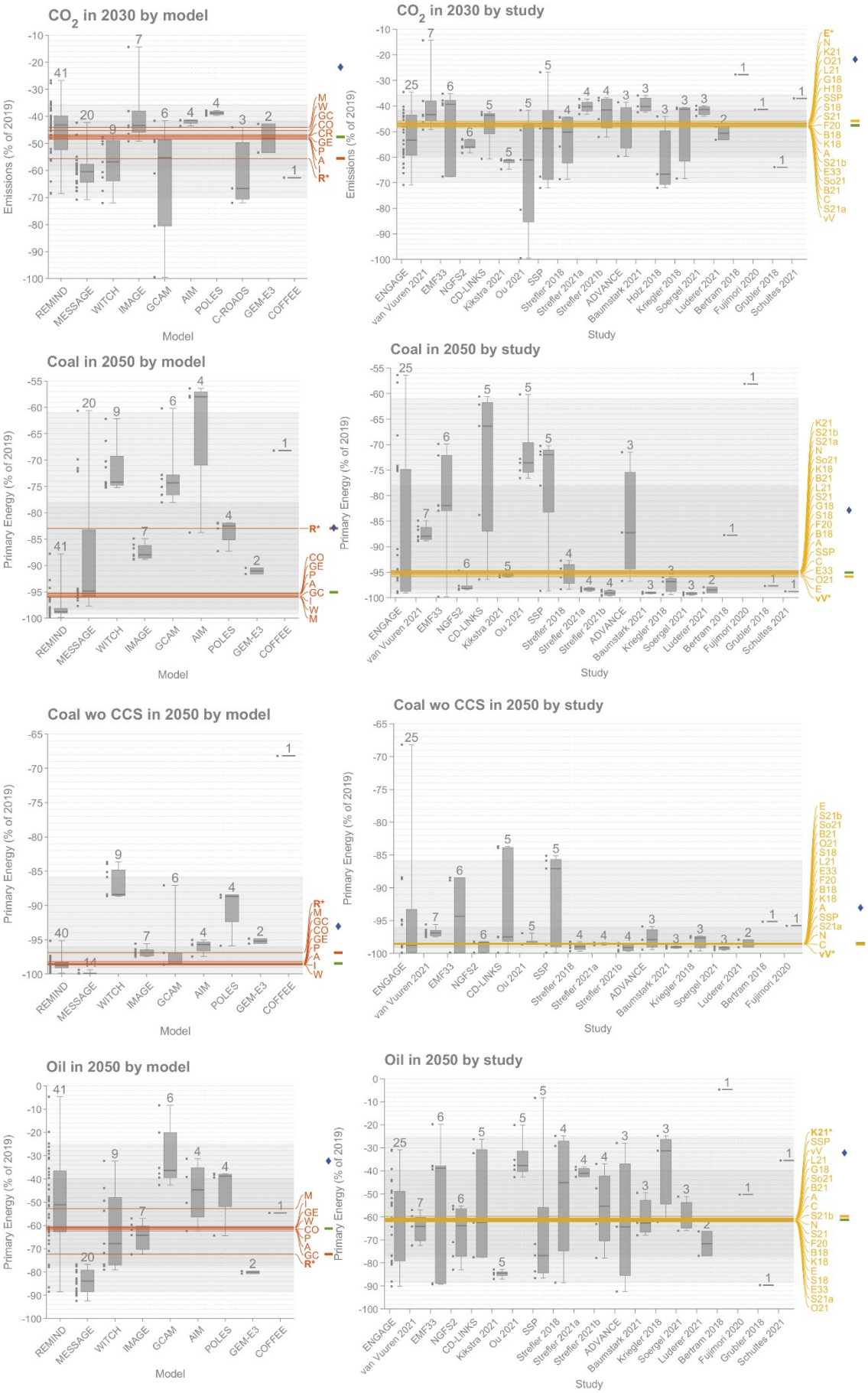

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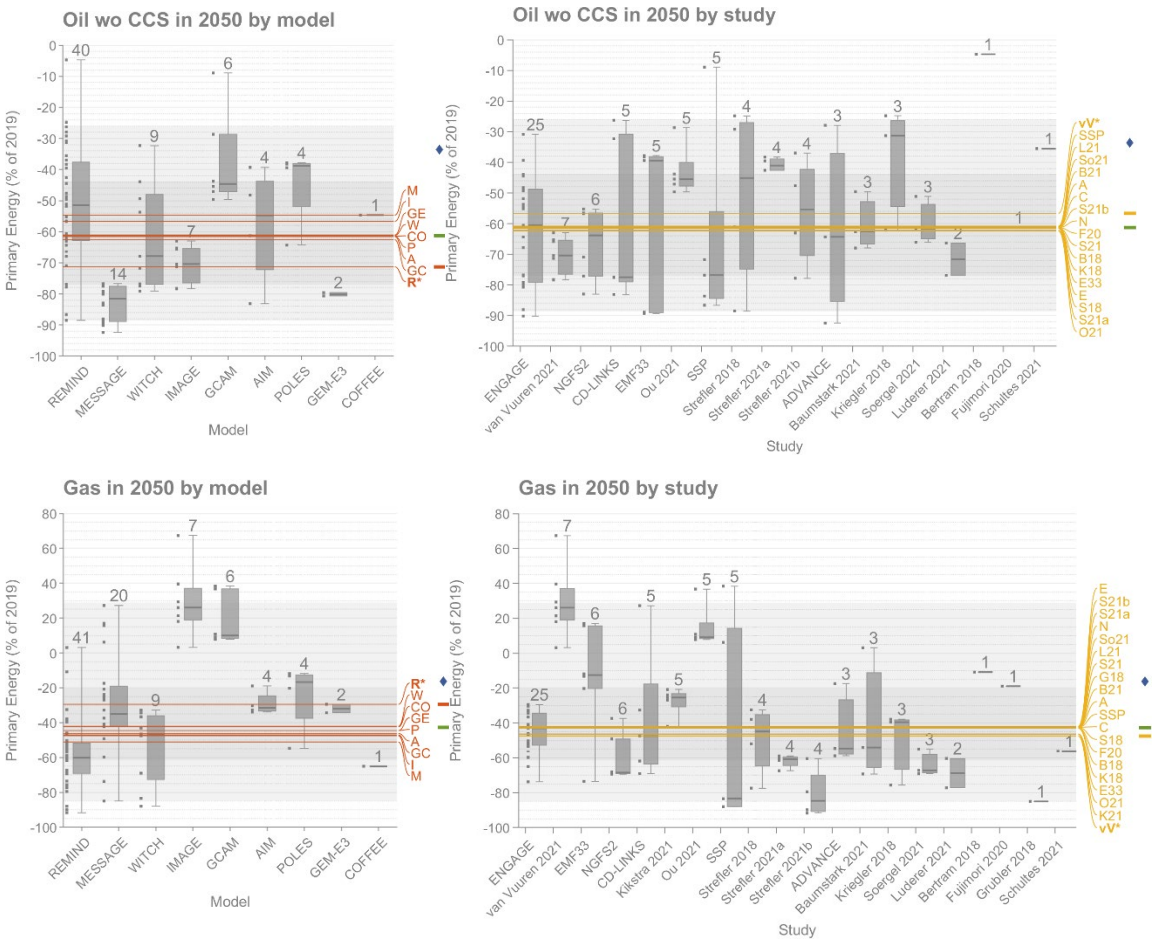

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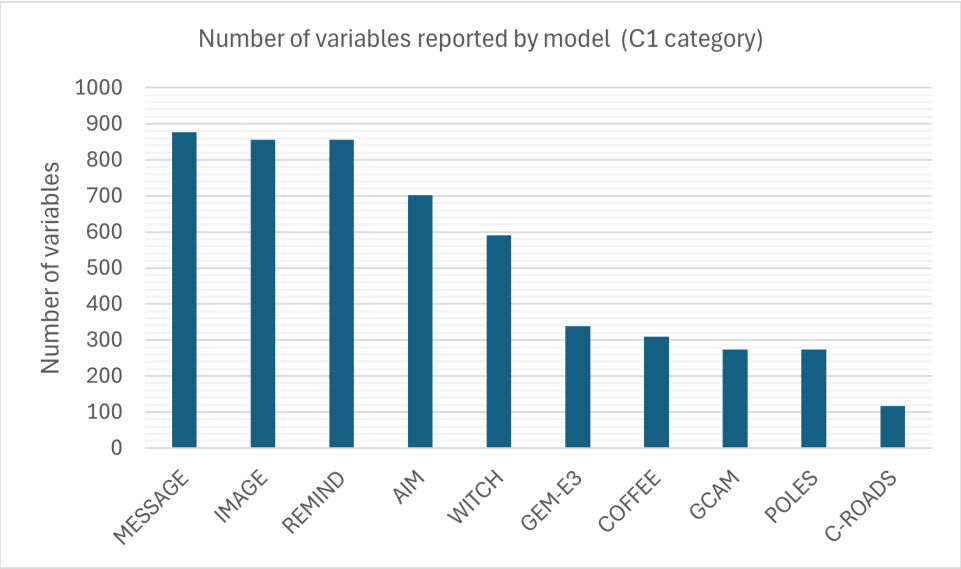
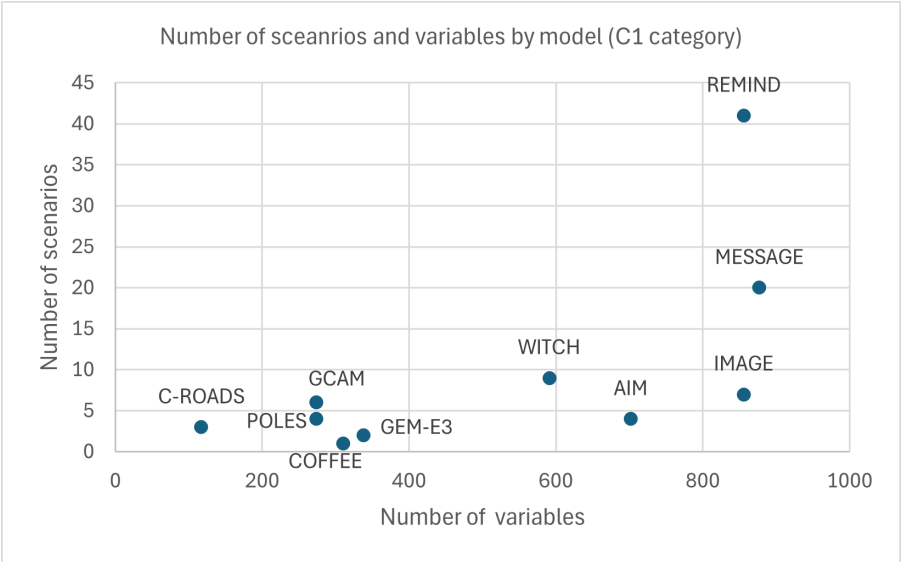
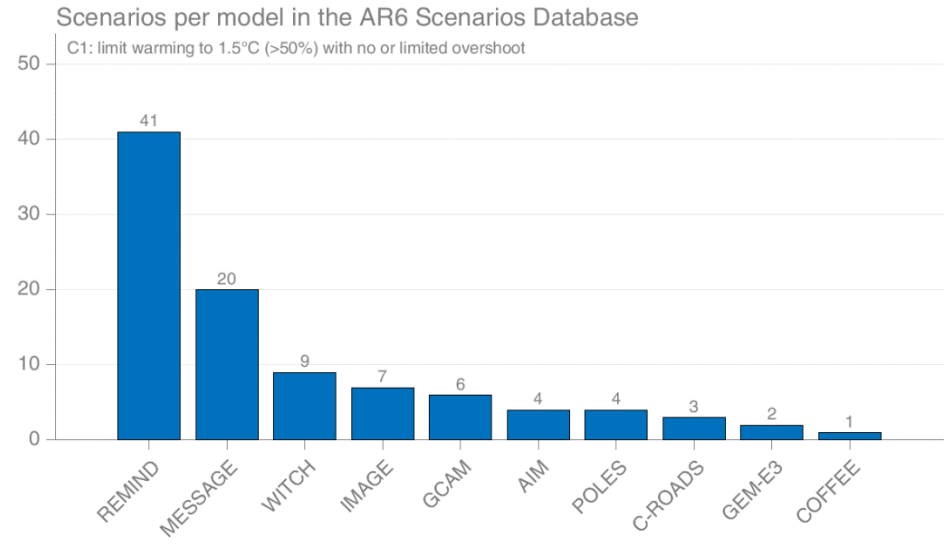
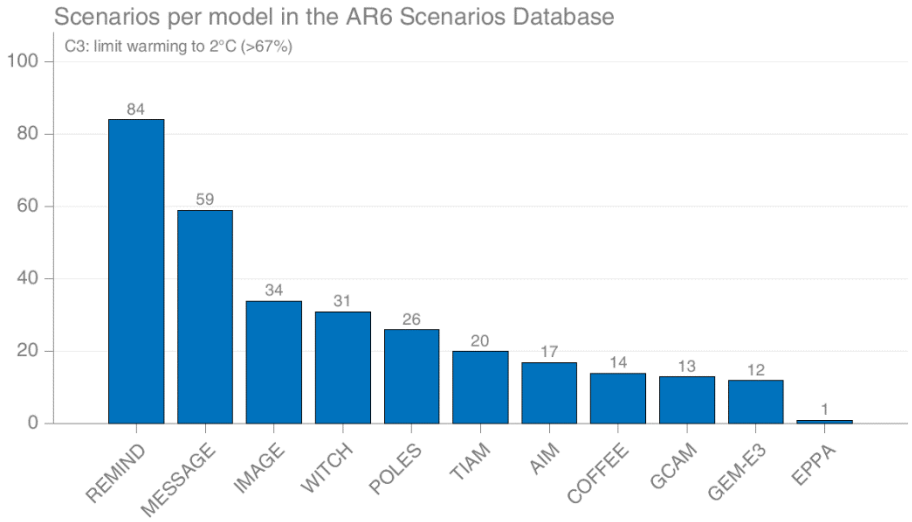


SI Figure 2 Total number of scenario variables reported by each model (across all scenarios) in the C1 climate category (1.5°C scenarios with no or limited overshoot). Only scenarios that passed vetting and received a climate assessment are included. The total number of distinct variables in the database (reported by at least one model in at least one scenarios) is 1442. Data: IPCC AR6 Scenarios Database(Byers et al., 2022).

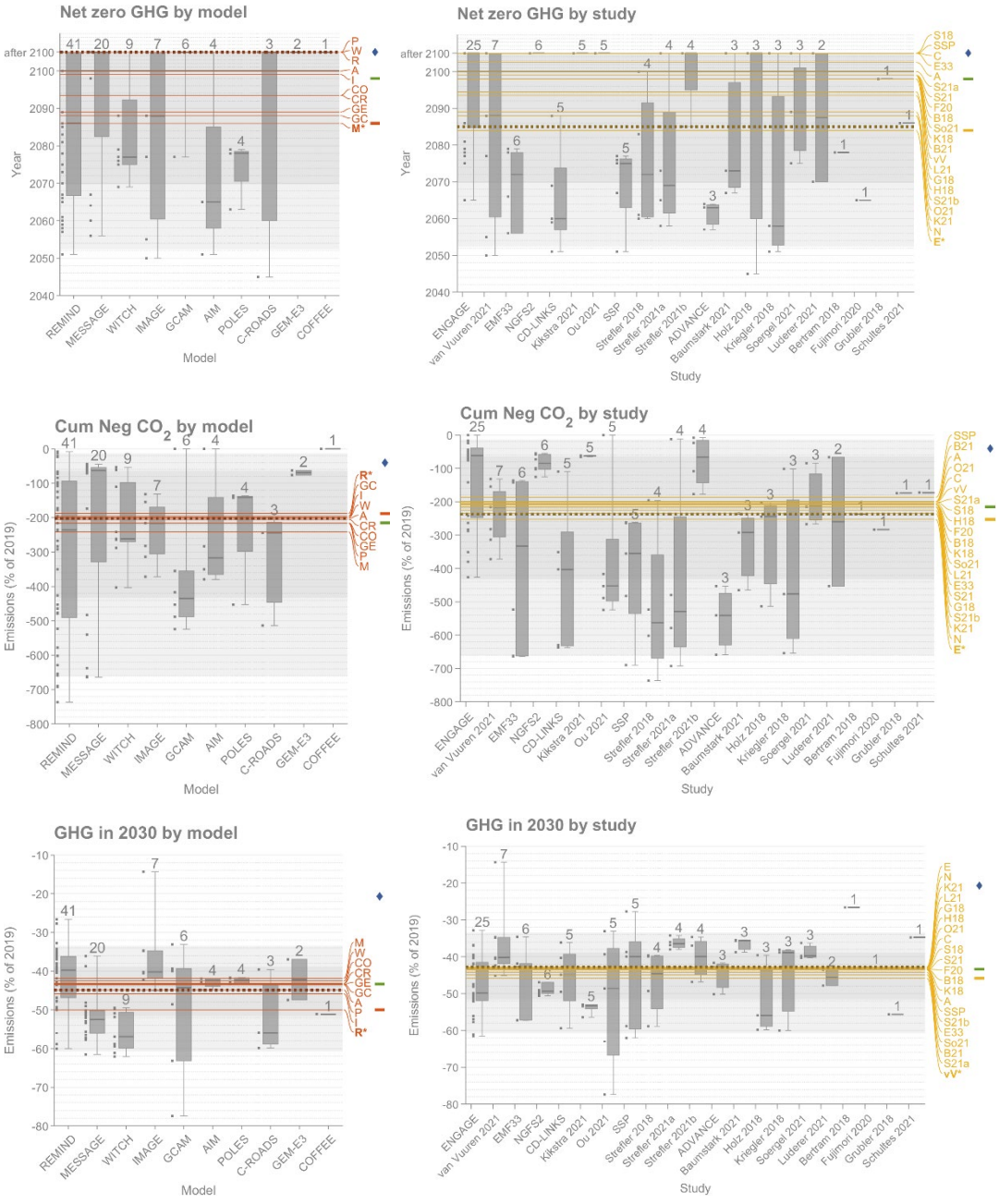


SI Figure 3 Number of scenarios and number of variables by model in the C1 category. Data: IPCC AR6 Scenarios Database (Byers et al., 2022).

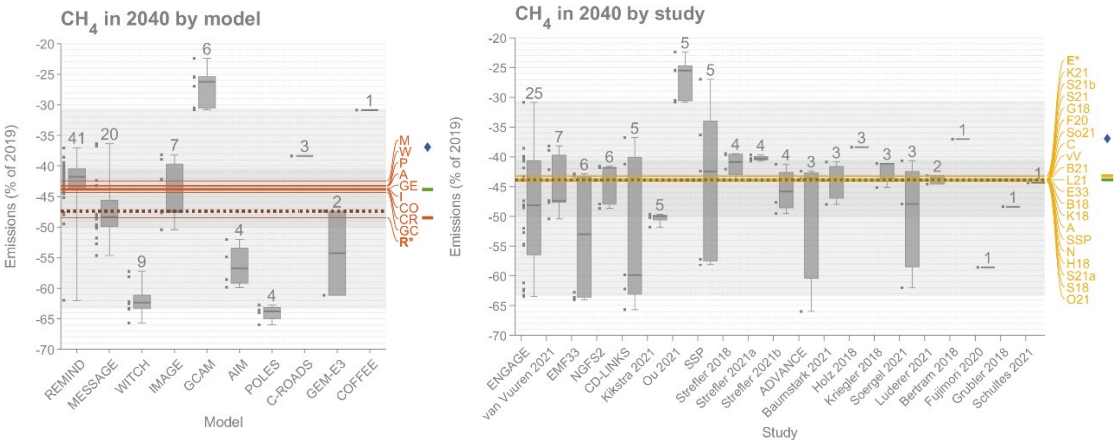




SI Figure 4 Number of scenarios by model in the IPCC AR6 Scenarios Database in the C1 category (upper panel) and the C3 category (lower panel). Only scenarios that passed vetting and received a climate assessment are shown (97 scenarios in the C1 category and 311 scenarios in the C3 category). The scenario-based mitigation findings in the AR6 WGIII SPM are based on these scenarios. Data: IPCC AR6 Scenarios Database(Byers et al., 2022).



SI Figure 5 Model- and study weighted medians for all AR6 WGIII SPM variables shown in Figure 3. All variables are from scenarios that limit global warming to 1.5°C (>50%) (C1 category). Boxes show the minimum and maximum, interquartile ranges, and median of each model/study. The number of scenarios from each model/study is shown at the top of each box and the data points are shown to the left. Models and studies are ordered according to the number of scenarios, with the model/study with the most scenarios furthest left. Long, solid horizontal lines show median values when models (red) and studies (yellow) are removed one-by-one, with letters at the end of each line indicating the model/study that has been removed. Short, red and yellow horizontal lines to the right of the figures show the median values when the models/studies with the largest impact are removed. The letter for the corresponding model or study is bolded and starred. Long, dashed horizontal lines show medians weighted by model (red) and by study (yellow). The short green lines show the reported 1.5°C medians and the blue diamonds show the reported 2°C medians. The dark grey background patches show the interquartile ranges and the light grey background patches show the 5th-95th percentile ranges. 'Net zero GHG' is the year of net zero GHG emissions. Values above 2100 on the y-axis indicate 'after 2100' which means zero was not reached before 2100 (and may not be reached, by scenario design). 'Neg CO_2' is cumulative net-negative CO_2 emissions between the year of net zero and 2100. 'CCS' stands for Carbon Capture and Storage and 'wo' stands for without. Data: IPCC AR6 Scenarios Database (Byers et al., 2022).



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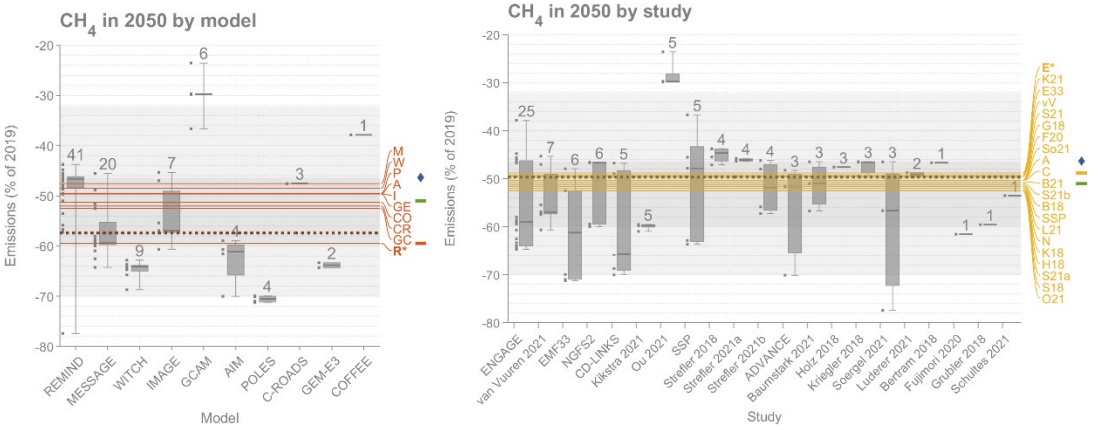

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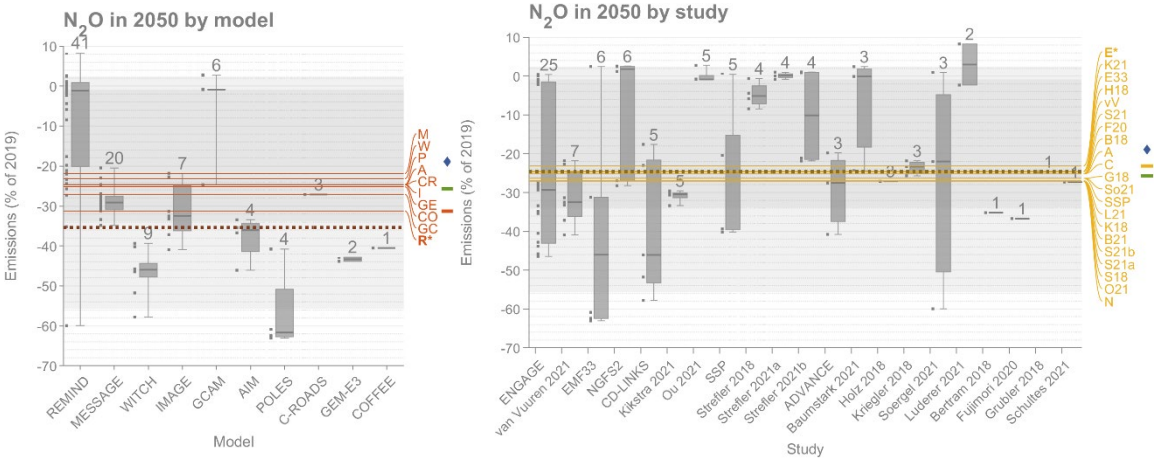

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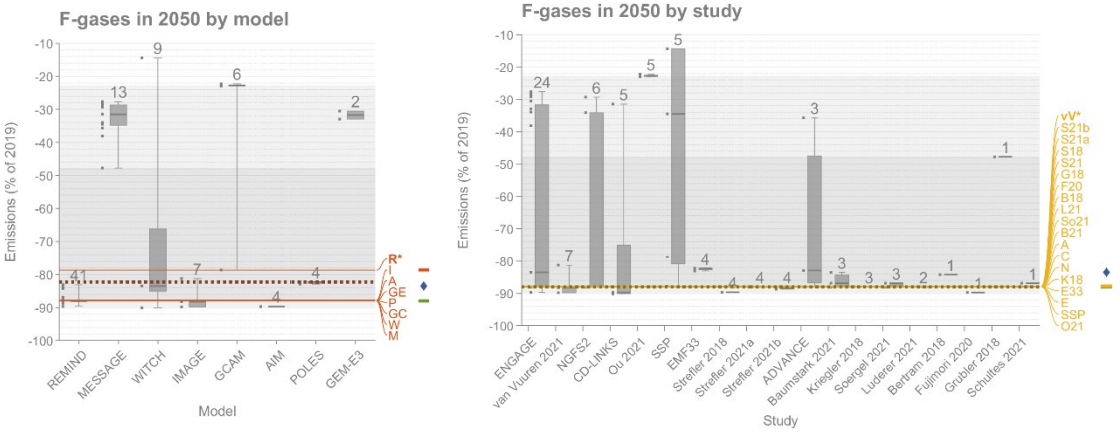

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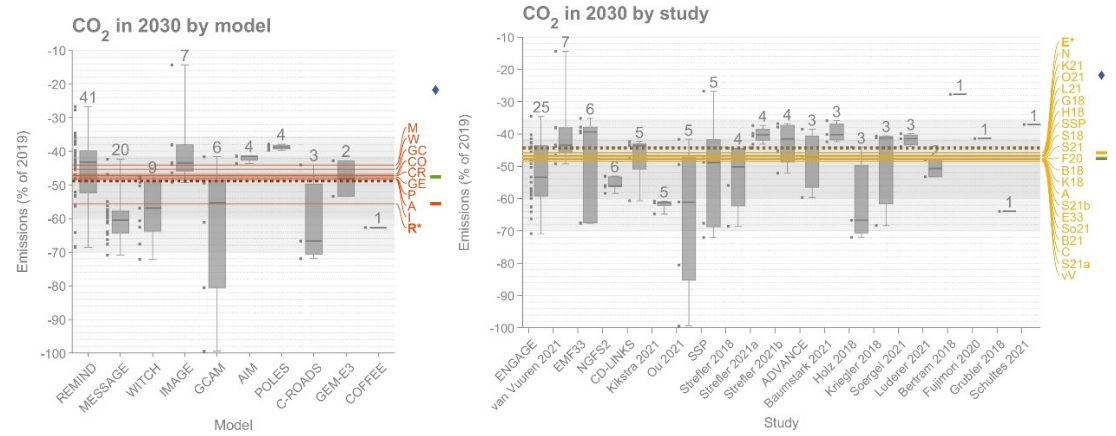

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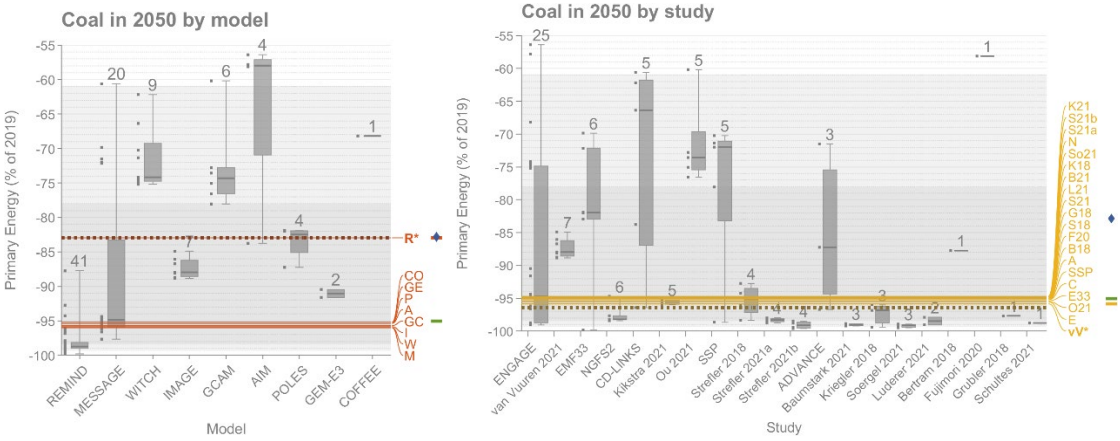

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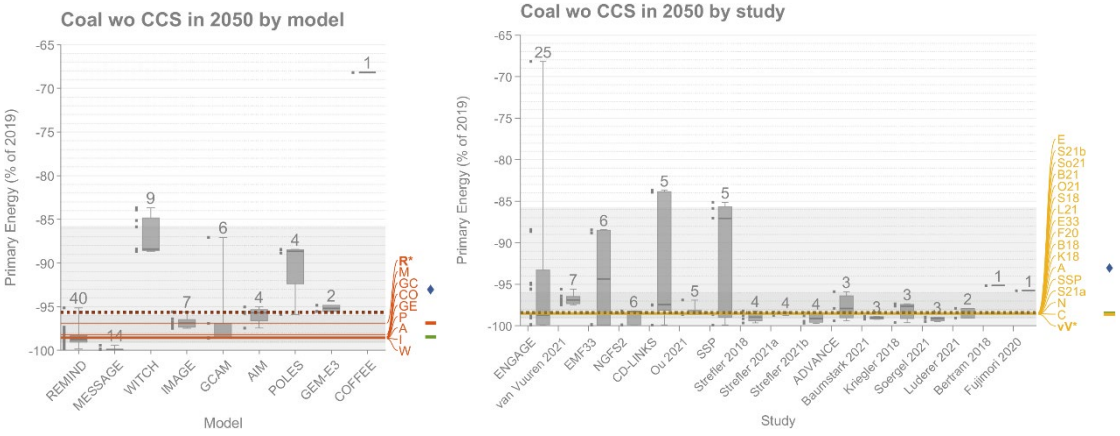

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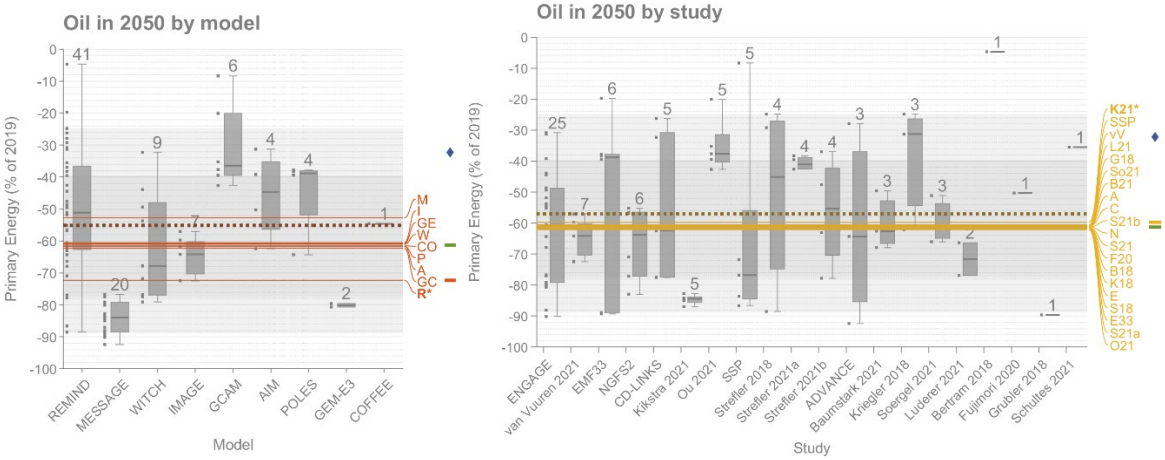

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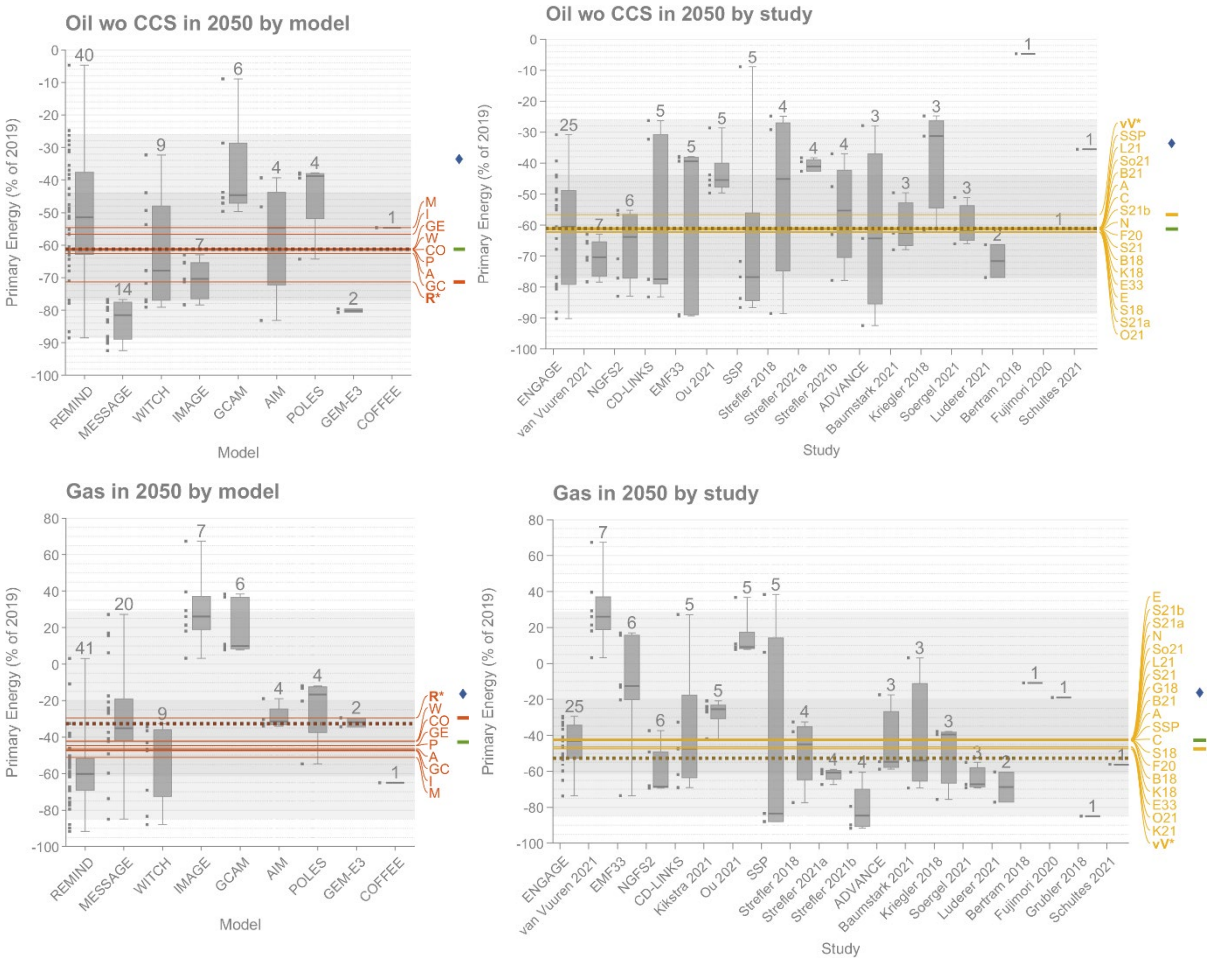

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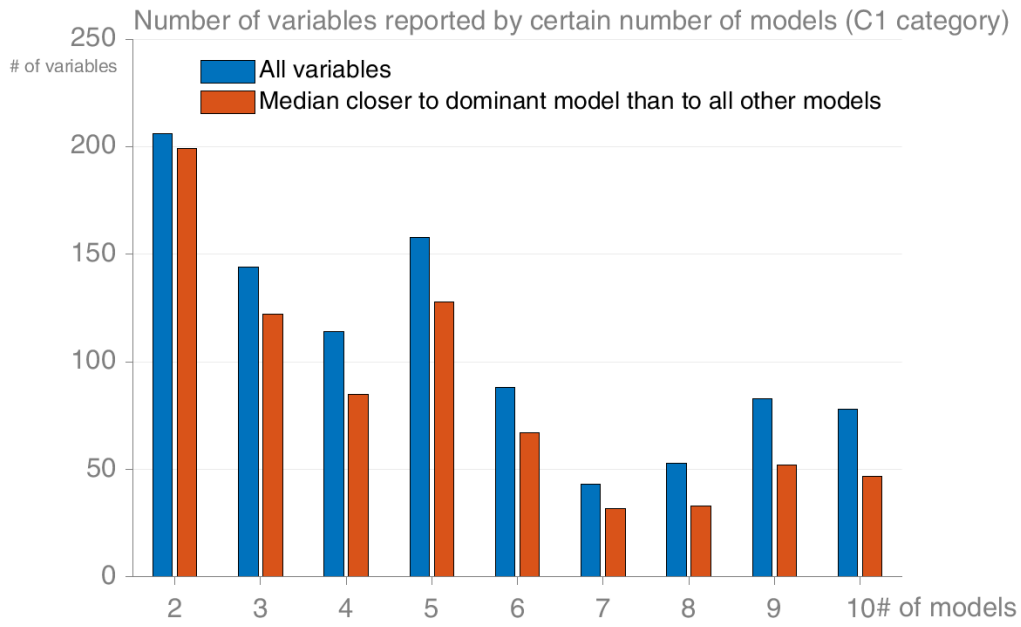

SI Figure 6 Number of variables in the C1 category (1.5°C scenarios with no or limited overshoot) reported by a certain number of models. The total number of variables reported by a certain number of models is shown by the blue bars. The number of variables for which the median is closer to the median of the dominant model than to the median of all the other models is shown by the red bars. Data: IPCC AR6 Scenarios Database (Byers et al., 2022).

Supplementary Tables

SI Table 1 Models contributing with global scenarios in the AR6 scenarios database and number of scenarios from each model in each scenario category (All, Vetted, Vetted and Climate assessed). The 13 models responsible for the scenarios that passed vetting and received a climate category are shaded green.

Model Name	**Number of scenarios in different climate categories**		
	All scenarios	Vetted Scenarios	Vetted with Climate Assessment
AIM	165	62	55
BET	16		
C-GEM	32	32	
C-ROADS	6	6	6
C3IAM	14	5	
CGE-MOD	32	32	
COFFEE	84	65	65
DART	32	17	
DNE21+	49	9	
E3ME	10	10	
EC-MSMR	32	32	
EDF-GEPA	32	32	
EDGE-Buildings	16	8	
ENV-Linkages	15	7	
ENVISAGE	32	32	
EPPA	10	7	7
En-ROADS	3		
FARM	13		
GAINS	2	2	
GCAM	157	79	48
GEM-E3	52	45	41
GEMINI-E3	6	6	
GENeSYS-MOD	1	1	
GMM-17	4	4	
GRAPE	18		
Global TIMES	14		
Global Transportation Roadmap	4	4	
HEB	2		
ICES-EMF	32	32	
ICES-XPS	11		
IEA	1	1	
IIASAPOP	5		
IMACLIM	71	31	
IMAGE	156	144	142
LUT-ESTM	1		
MAgPIE	3	3	
MERGE-ETL	3	1	1
MESSAGE	297	266	266
MIGRATION	10	10	
MUSE	11	5	
McKinsey	3		
POLES	138	115	114
PROMETHEUS	7	7	
REMIND	323	297	297
REmap	2	2	
SNOW_GL_HH_v1	32	32	
Shell	1		
TEA	32	32	
TIAM	95	62	45
WEGDYN	32	32	
WEM	2	2	
WITCH	176	115	115
# Scenarios	**2297**	**1686**	**1202**
# Models	**52**	**41**	**13**

SI Table 2 Model names used in the analysis and corresponding acronyms used in the figures and Table 1. Model names are based on the full model names in the AR6 scenarios database as shown in this table. The unique model names listed here include all models that contributed with at least one scenario that passed vetting and received a climate category. The full model names listed include all the models that contributed with scenarios to the AR6 Scenarios Database, including model versions that contributed with scenarios that did not pass vetting and did not receive a climate assessment.

Model name (unique)	Acronyms used in figures	Full model names in AR6 Scenarios Database
AIM	A	AIM/CGE 2.0, AIM/CGE 2.1, AIM/CGE 2.2, AIM/Hub-Global 2.0
C-ROADS	CR	C-ROADS-5.005
COFFEE	CO	COFFEE 1.1, COPPE-COFFEE 1.0
EPPA		EPPA 6
GCAM	GC	GCAM 4.0, GCAM 4.2, GCAM 5.2, GCAM 5.3, GCAM5.2_NET, GCAM-PR 5.3
GEM-E3	GE	GEM-E3 V1, GEM-E3_V2021,
IMAGE	I	IMAGE 3.0, IMAGE 3.0.1, IMAGE 3.0.2, IMAGE 3.2,
MERGE-ETL		MERGE-ETL 6.0,
MESSAGE	M	MESSAGE V.3, MESSAGE-GLOBIOM 1.0, MESSAGEix-GLOBIOM 1.0, MESSAGEix-GLOBIOM_1.1, MESSAGEix-GLOBIOM_1.2, MESSAGEix-GLOBIOM_GEI 1.0, MESSAGE-Transport V.5
POLES	P	POLES ADVANCE, POLES CD-LINKS, POLES EMF30, POLES EMF33, POLES ENGAGE, POLES GECO2019,
REMIND	R	REMIND 1.6, REMIND 1.7, REMIND 2.1, REMIND_EU 2.0, REMIND-Buildings 2.0, REMIND-H13 2.1, REMIND-MAgPIE 1.5, REMIND-MAgPIE 1.7-3.0, REMIND-MAgPIE 2.0-4.1, REMIND-MAgPIE 2.1-4.2, REMIND-MAgPIE 2.1-4.3, REMIND-Transport 2.1
TIAM		TIAM-ECN 1.1, TIAM-ECN AFR 1.1, TIAM-ECN KEN 1.1, TIAM-ECN ETH 1.1, TIAM-ECN MDG 1.1, TIAM-Grantham 1.0, TIAM-Grantham 3.2, TIAM-UCL 4.1.1, TIAM-WORLD 1.0
WITCH	W	WITCH 4.6, WITCH 5.0, WITCH-GLOBIOM 3.1, WITCH-GLOBIOM 4.2, WITCH-GLOBIOM 4.4

SI Table 3 Study names used in the analysis and corresponding acronyms used in the figures and Table 1. All study names are the same as the 'project_study' given in the AR6 scenarios database metadata.

Study name (unique) (same as the 'project_study' in the AR6 Scenarios Database)	Acronyms used in the figures
ADVANCE	A
Bauer 2020	
Baumstark 2021	B21
Bertram 2018	B18
CD-LINKS	C
COMMIT	
EMF30	
EMF33	E33
Emmerling 2019	
ENGAGE	E
Fujimori 2020	F20
Giannousakis 2020	
Grubler 2018	G18
Guo 2021	
Holz 2018	H18
Kikstra 2021	K21
Kriegler 2018	K18
Levesque 2021	
Luderer 2021	L21
Marcucci 2017	
NGFS2	N
Ou 2021	O21
PR Policy MIP	
Rottoli 2021	
Schultes 2021	S21
Soergel 2021	So21
SSP	SSP
Strefler 2018	S18
Strefler 2021a	S21a
Strefler 2021b	S21b
Van Vuuren 2021	vV

Supplementary Text

Supplementary Text 1: ENGAGE study impact on median net-zero GHG year

The ENGAGE study (Riahi et al., 2021) had a goal to explore emission scenarios with less temperature overshoot. To do this the ENGAGE ran two types of mitigation scenarios: 1) a conventional scenario with a 2100 cumulative CO_2 budget that allowed net-negative CO_2 emissions in the second half the century and thereby temperature overshoot, 2) a scenario with the same cumulative CO_2 emissions, but a constraint that required CO_2 emissions to not go below zero, thereby minimising temperature overshoot. The study included nine IAMs and used around 17 cumulative CO_2 budget constraints, and in addition to the two types of mitigation scenarios, included baseline and policy scenarios. Consequently, the study generated hundreds of scenarios, 591 of the 1202 scenarios in the vetted and climate assessed IPCC database.

The ENGAGE scenario design has a direct impact on the year of net zero GHG emissions: Most (not all) of the conventional scenarios reach net zero GHG emissions before 2100, while none of the constrained scenarios achieve net zero GHG emissions. The net zero CO_2 emission year is less impacted, as all scenarios reach net zero CO_2 emissions. They then either continue to net negative CO_2 emissions or maintain net zero CO_2 emissions until 2100. These latter scenarios have positive GHG emissions to 2100 since non-CO_2 emissions are non-zero.

The large number of scenarios from the ENGAGE study, with two very specific scenario designs, in the database explains the large impact on median net-zero GHG year from the ENGAGE study. Hypothetically, if all scenario combinations were run by all models, the distribution of net zero CO_2 or GHG years would be purely bimodal with the median between the two modes. This in itself is a demonstration of the challenge in using statistical distributions of the scenarios database.

Supplementary Text 2: Differences in variables reporting across models

Because different models report different variables (SI Figure 2) and no models report all variables, the model with the most scenarios in the C1 and C3 categories (SI Figure 4), is not the dominant model for every variable (Supplementary Data 1). That different variables are reported by different models has two implications. First, it means that the number of models that report a variable depends on the variable (SI Figure 2). When only a few models report a variable, the impact on the median of the dominant model is generally larger. In the C1 category, many variables are reported by only a few models, and for these variables, the median is almost always closer to the dominant model than to all the other models (SI Figure 6). But even for the variables that are reported by all or most of the models in the C1 category, the median is closer to the median of the dominant model than to the median of all the other models in most cases (SI Figure 6). Second, it means that the number of variables reported by different models plays a role. In general, models that report more variables are likely to be the dominant model for more variables. In the C1 category, for example, IMAGE is the dominant model for more variables than WITCH, even though the two models have a similar number of scenarios (Figure 4, SI Figure 4). This is because IMAGE reports more variables than WITCH and because many of the variables reported by IMAGE are less frequently reported by models with even more scenarios (REMIND, MESSAGE and WITCH), making IMAGE the dominant model for these (Supplementary Data 1). Still, even though MESSAGE and IMAGE both report the same or more variables than REMIND, the large fraction of scenarios from REMIND in the C1

category (41 out of 97) means that REMIND is the most common dominant model in significantly more cases. In general, models with more scenarios tend to also report more variables, which means that these two effects go in the same direction (SI Figure 3). But overall, the number of scenarios (SI Figure 4) is a better predictor of model dominance (Figure 4) than the number of variables reported (SI Figure 2).

References

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