



Supplement of

Evaluation of soil carbon simulation in CMIP6 Earth system models

Rebecca M. Varney et al.

Correspondence to: Rebecca M. Varney (r.varney@exeter.ac.uk)

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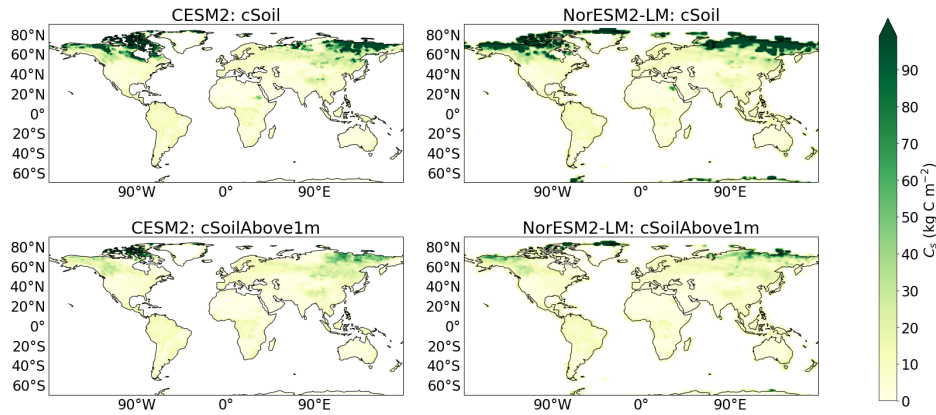


Figure S1. Maps comparing the soil carbon (C_s) output variables $cSoil$ and $cSoilAbove1m$ in the historical simulation (1950-2000) of the CMIP6 models CESM2 and NorESM2-LM.

Table S1. CMIP6 Spatial Correlations. The table presents correlation coefficients (r-values to 3 s.f.) showing the spatial correlation between the CMIP6 ESM and observations, for the following climate variables: soil carbon (C_s), soil moisture (θ), Net Primary Productivity (NPP), heterotrophic respiration (R_h) and soil carbon turnover time (τ_s).

Earth System Model	C_s		θ		NPP		R_h		τ_s	
	r-value	RMSE	r-value	RMSE	r-value	RMSE	r-value	RMSE	r-value	RMSE
ACCESS-ESM1.5	0.324	9.58	0.592	0.0658	0.753	0.265	0.761	0.247	0.226	510
BCC-CSM2-MR	0.490	15.1	0.657	0.0700	0.782	0.261	0.779	0.243	0.313	217
CanESM5	0.298	9.79	0.612	0.0811	0.655	0.404	0.568	0.472	0.464	184
CESM2	0.225	16.7	0.428	0.157	0.749	0.254	0.720	0.259	0.294	362
CNRM-ESM2-1	0.630	8.84	0.684	0.0866	0.782	0.245	0.699	0.263	0.319	208
GFDL-ESM4	0.458	10.6	0.667	0.0654	0.759	0.255	0.716	0.258	0.277	229
IPSL-CM6A-LR	0.104	11.1	0.726	0.0504	0.733	0.262	0.752	0.242	0.332	193
MIROC-ES2L	0.437	10.5	0.687	0.0793	0.763	0.291	0.731	0.283	0.247	186
MPI-ESM1.2-LR	0.422	8.70	0.682	0.0607	0.785	0.362	0.811	0.302	0.138	122
NorESM2-LM	0.222	11.3	0.410	0.163	0.734	0.271	0.706	0.264	0.232	772
UKESM1-0-LL	0.115	13.1	0.653	0.0944	0.816	0.305	0.760	0.319	0.265	180
Ensemble mean	0.250	8.20	0.648	0.0974	0.836	0.200	0.816	0.315	0.267	223

Supplementary Material

Table S2. CMIP5 Spatial Correlations. The table presents correlation coefficients (r-values to 3 s.f.) showing the spatial correlation between the CMIP5 ESM and observations, for the following climate variables: soil carbon (C_s), soil moisture (θ), Net Primary Productivity (NPP), heterotrophic respiration (R_h) and soil carbon turnover time (τ_s).

Earth System Model	C_s		θ		NPP		R_h		τ_s	
	r-value	RMSE	r-value	RMSE	r-value	RMSE	r-value	RMSE	r-value	RMSE
BNU-ESM	0.332	10.4	0.420	0.0760	0.652	0.318	0.703	0.279	0.0177	233
CCSM4	-0.0193	11.7	0.622	0.122	0.753	0.284	-	0.242	0.349	143
CanESM2	0.325	10.7	0.581	0.0855	0.469	0.388	0.548	0.376	0.285	212
GFDL-ESM2G	0.492	12.3	0.627	0.0594	0.589	0.385	0.618	0.325	0.156	262
GISS-E2-R	0.126	22.1	0.595	0.0773	0.274	0.403	0.425	0.327	0.257	163
HadGEM2-ES	0.230	9.87	0.581	0.0920	0.764	0.425	0.744	0.437	0.123	174
IPSL-CM5A-LR	0.587	7.95	0.539	0.130	0.647	0.463	0.650	0.352	0.229	205
MIROC-ESM	0.596	15.6	0.641	0.0746	0.606	0.299	0.675	0.253	0.200	180
MPI-ESM-LR	-0.114	22.1	-	-	0.764	0.450	0.766	0.311	0.321	109
NorESM1-M	0.0112	11.4	0.665	0.0585	0.674	0.327	0.734	0.267	0.284	153
Ensemble mean	0.380	8.93	0.675	0.0861	0.711	0.277	0.709	0.317	0.188	228

Table S3. CMIP6 Spatial Correlations. The table shows r-values representing the spatial correlation between soil carbon (C_s) to Net Primary Productivity (NPP) and soil carbon turnover time (τ_s), and NPP and τ_s to soil moisture (θ) and temperature (T), from each ESM and the observations. All rounded to 3 significant figures.

Earth System Model	C_s -NPP	NPP- θ	NPP-T	C_s - τ_s	τ_s - θ	τ_s -T
ACCESS-ESM1.5	0.644	-0.288	0.566	-0.181	-0.0871	-0.0872
BCC-CSM2-MR	0.214	-0.329	0.543	0.129	0.229	-0.368
CanESM5	0.789	0.0423	0.301	-0.216	0.430	-0.781
CESM2 (cSoilAbove1m)	0.134	0.0211	0.549	-0.00142	0.242	-0.266
<i>CESM2 (cSoil)</i>	<i>-0.00720</i>	-	-	<i>0.214</i>	<i>0.335</i>	<i>-0.287</i>
CNRM-ESM2-1	0.645	0.0102	0.594	0.0188	-0.0533	-0.314
GFDL-ESM4	0.573	0.697	0.196	-0.100	0.0420	-0.537
IPSL-CM6A-LR	0.871	0.333	0.541	-0.219	0.431	-0.431
MIROC-ES2L	0.630	0.154	0.545	0.144	0.111	-0.268
MPI-ESM1.2-LR	0.704	0.657	0.548	-0.278	-0.319	0.158
NorESM2-LM (cSoilAbove1m)	0.261	0.499	0.232	0.153	0.357	-0.448
<i>NorESM2-LM (cSoil)</i>	<i>0.0293</i>	-	-	<i>0.308</i>	<i>0.252</i>	<i>-0.317</i>
UKESM1-0-LL	0.749	0.587	0.563	-0.0933	0.0618	-0.299
Ensemble mean	0.424	0.494	0.257	-0.0605	0.198	-0.398
Benchmark datasets	-0.0229	0.646	0.435	0.232	-0.239	-0.296

Table S4. CMIP5 Spatial Correlations. The table shows r-values representing the spatial correlation between soil carbon (C_s) to Net Primary Productivity (NPP) and soil carbon turnover time (τ_s), and NPP and τ_s to soil moisture (θ) and temperature (T), from each ESM and the observations. All rounded to 3 significant figures.

Earth System Model	C_s -NPP	NPP- θ	NPP-T	C_s - τ_s	τ_s - θ	τ_s -T
BNU-ESM	0.623	-0.420	0.513	-0.131	0.0351	-0.0775
CCSM4	-0.00541	-0.348	0.551	-0.181	0.450	-0.301
CanESM2	0.687	0.0603	0.212	0.188	0.357	-0.689
GFDL-ESM2G	0.428	0.767	0.213	0.0337	-0.0889	-0.293
GISS-E2-R	-0.156	0.492	-0.0113	0.897	-0.0382	-0.473
HadGEM2-ES	0.776	0.558	0.529	-0.165	0.0317	-0.355
IPSL-CM5A-LR	0.500	0.302	0.201	0.379	0.492	-0.685
MIROC-ESM	0.466	0.649	0.702	0.119	0.0432	-0.236
MPI-ESM-LR	0.681	-	0.653	0.0682	-	-0.159
NorESM1-M	0.898	0.0987	0.228	-0.150	0.0836	-0.242
Ensemble mean	0.222	0.258	0.230	0.108	0.210	-0.314
Benchmark datasets	-0.0229	0.646	0.435	0.232	-0.239	-0.296