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Supporting Information for

Permafrost carbon: progress understanding controls, stocks, and fluxes across terrestrial ecosystems in the Pan-Arctic region

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Supplementary Table 1. Models included in the annual NEE comparison. See Hugelius et al., 2023, for further information.

Model type	**Model name**	**Details and reference**
Upscaling	-	An ensemble of 5 statistical and machine learning model predictions of NEE (Virkkala et al. 2021)
Atmospheric inversions	CAMS	Produced by the Global Carbon Project; total land CO2 flux adjusted for fossil fuel emissions, cement carbonation sink, and lateral fluxes (Friedlingstein et al. 2022)
Atmospheric inversions	sEXTocNEET	Produced by the Global Carbon Project; total land CO2 flux adjusted for fossil fuel emissions, cement carbonation sink, and lateral fluxes (Friedlingstein et al. 2022)
Atmospheric inversions	CTE	Produced by the Global Carbon Project; total land CO2 flux adjusted for fossil fuel emissions, cement carbonation sink, and lateral fluxes (Friedlingstein et al. 2022)
Atmospheric inversions	NISMON	Produced by the Global Carbon Project; total land CO2 flux adjusted for fossil fuel emissions, cement carbonation sink, and lateral fluxes (Friedlingstein et al. 2022)
Atmospheric inversions	CMS_Flux	Produced by the Global Carbon Project; total land CO2 flux adjusted for fossil fuel emissions, cement carbonation sink, and lateral fluxes (Friedlingstein et al. 2022)
Atmospheric inversions	UoE	Produced by the Global Carbon Project; total land CO2 flux adjusted for fossil fuel emissions, cement carbonation sink, and lateral fluxes (Friedlingstein et al. 2022)
Process models: coupled CMIP6 models	ACCESS-ESM1-5	Based on historical model runs (Eyring et al. 2016)
Process models: coupled CMIP6 models	BCC-ESM1	Based on historical model runs (Eyring et al. 2016)
Process models: coupled CMIP6 models	CanESM5	Based on historical model runs (Eyring et al. 2016)
Process models: coupled CMIP6 models	CESM2	Based on historical model runs (Eyring et al. 2016); CESM2 includes permafrost carbon in the model

Process models: coupled CMIP6 models	CMCC-ESM2	Based on historical model runs (Eyring et al. 2016)
Process models: coupled CMIP6 models	CNRM-ESM2	Based on historical model runs (Eyring et al. 2016)
Process models: coupled CMIP6 models	GFDL-ESM4	Based on historical model runs (Eyring et al. 2016)
Process models: coupled CMIP6 models	IPSL-CM6A	Based on historical model runs (Eyring et al. 2016)
Process models: coupled CMIP6 models	MIROC-ES2L	Based on historical model runs (Eyring et al. 2016)
Process models: coupled CMIP6 models	MPI-ESM1-2-LR	Based on historical model runs (Eyring et al. 2016)
Process models: coupled CMIP6 models	NorESM2-LM	Based on historical model runs (Eyring et al. 2016); NorESM2-LM includes permafrost carbon in the model
Process models: coupled CMIP6 models	UKESM1-0-LL	Based on historical model runs (Eyring et al. 2016)
Process models: land surface models included in ISIMIP 2b configuration	DLEM	(Frieler et al. 2017)
Process models: land surface models included in ISIMIP 2b configuration	JULES	(Frieler et al. 2017)
Process models: land surface models included in ISIMIP 2b configuration	LPJ-GUESS	(Frieler et al. 2017)
Process models: land surface models included in ISIMIP 2b configuration	LPJML	(Frieler et al. 2017)
Process models: land surface models included in ISIMIP 2b configuration	ORCHIDEE-DGVM	(Frieler et al. 2017)

Process models: land surface models included in ISIMIP 2b configuration	ORCHIDEE-GFDL	(Frieler et al. 2017)
Process models: land surface models included in ISIMIP 2b configuration	VISIT	(Frieler et al. 2017)

Supplementary Text

Models used in the regional analysis

We summarized average annual terrestrial NEE (GPP-Reco) from 1) two process-based model intercomparisons, the Coupled Model Intercomparison Project Phase 6 (CMIP6) Earth system models (Eyring et al. 2016) and the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) terrestrial ecosystem models (Frieler et al. 2017); 2) atmospheric inversions used in the Global Carbon Project (Friedlingstein et al. 2022); 3) upscaling (i.e., machine learning) (Virkkala et al. 2021); and 4) site-level (i.e., field data synthesis) categories (Virkkala et al. 2021) (Supplementary Table 1). We included a subset of CMIP6 models (12 in total) that had soil thermal processes at several depths to assure they had some information about the freeze-thaw patterns in the permafrost region. We included 7 models that were participating in the 2b (models driven by similar climate data) configuration in ISIMIP for the terrestrial ecosystem models. Inversions were further masked by fire CO2 emission estimates from GFED4s (van de Wees et al. 2022). The same model outputs were also used in a recent RECAPP-2 permafrost synthesis that provides carbon and nitrogen budgets for the entire region (Hugelius et al., 2023). We focus on the period 2002-2014 during which all outputs exist; however the ISIMIP model outputs only cover the 2002-2005 period. The models represent terrestrial NEE (GPP-Reco excluding fires) in a similar way across all the models except for inversions that also include vertical CO2 fluxes from water bodies.

Determination of regional boundaries

The regions within the broader RECCAP2 regions (Hugelius et al., 2023) were split by a combination of geographical boundaries, including political and ecotonal boundaries (Dinerstein et al., 2017) as shown in Figure 2. For North America, these areas included Alaska, Canadian Tundra, boreal western Canada, and eastern Canada. The split between Eastern and Western Canada used the provincial border between Ontario and Manitoba. For Eurasia, these regions included Western Eurasia (northern Europe and western Russia), Siberian tundra (excluding the mountain tundra in central Siberia). Eastern Siberia and western Siberia were split by the West and East Siberian ecotones. The Russian Far East was grouped into two categories: Eastern Siberia and Siberian tundra using the tundra ecotonal boundary.

Supplementary References

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