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Air temperature and precipitation constraining the modelled wetland methane emissions in a boreal region in northern Europe

Tuula Aalto et al.

Correspondence to: Tuula Aalto (tuula.aalto@fmi.fi)

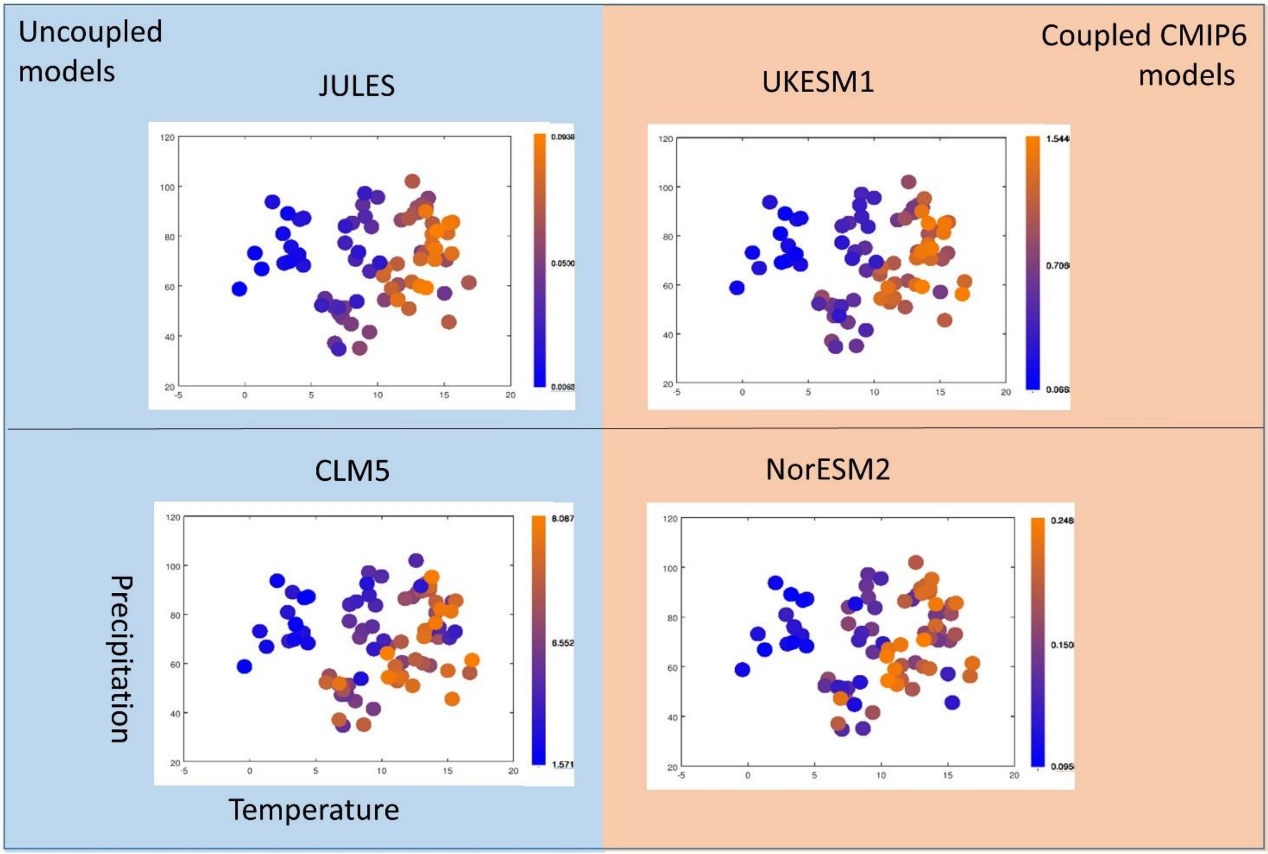

Figure S1. Temperature and precipitation responses of wetland methane emissions in Fennoscandia from JULES ecosystem model, uncoupled (left) and coupled (right) with UKESM1, and CLM5 model, uncoupled (left) and coupled (right) with NorESM2. Circles refer to monthly averages in May - October during years 2000-2017.

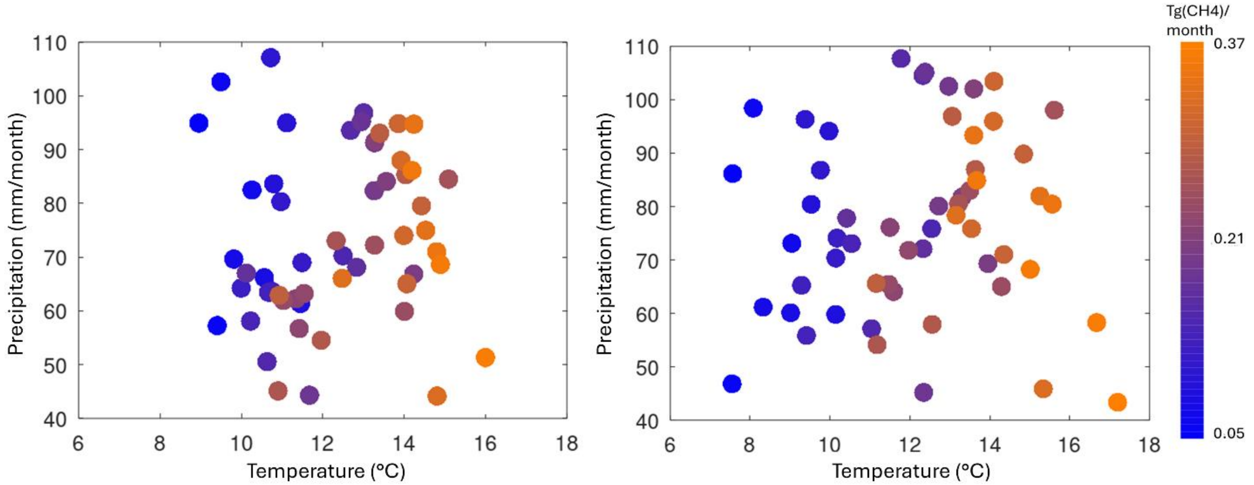

Figure S2: JSBACH-H ecosystem model results, plotted against left: CRU-HARMONIE (R^2_{Temp} =0.822, R^2_{Prec} = 0.054, $R^2_{TempPrec}$ = 0.834), right: CRU-JRA climate data (R^2_{Temp} =0.823, R^2_{Prec} = 0.0045, $R^2_{TempPrec}$ = 0.829).

Table S1. List of surface observation sites used in inversions (see also Figure 1). Data type is categorized into two measurements (discrete (D) and continuous (C)). Date max is limited to 2018/12, which was the last month in inversions.

Sitecode	Site Name	Country	Contributor	Longitude	Latitude	Height	Data type	Date min [year/month]	Date max [year/month]
BAL	Baltic Sea	Poland	NOAA/ESRL	17.22	55.35	28	D	1998/01	2011/06
BIR	Birkenes	Norway	NILU	8.25	58.39	219	C	2009/05	2018/12
HTM	Hyltemossa	Sweden	ICOS-ATC, LUND-CEC	13.42	56.10	265	C	2017/04	2018/12
KJN	Kjolnes	Norway	Univ. Exeter	29.23	70.85	20	C	2013/10	2018/12
KMP	Kumpula	Finland	FMI	24.96	60.20	53	C	2010/01	2018/12
NOR	Norunda	Sweden	ICOS-ATC, LUND-CEC	17.48	60.09	146	C	2017/04	2018/12
PAL	Pallas-Sammaltunturi, GAW station	Finland	NOAA/ESRL	24.12	67.97	570	D	2001/12	2018/12
PAL	Pallas-Sammaltunturi, GAW station	Finland	FMI	24.12	67.97	570	C	2004/02	2017/12
PAL	Pallas-Sammaltunturi, GAW station	Finland	ICOS-ATC, FMI	24.12	67.97	577	C	2017/09	2018/12
PUI	Puijo	Finland	ICOS-ATC, UEF	27.66	62.91	84	C	2011/11	2018/12
SMR	Hyytiala	Finland	ICOS-ATC, UHEL	24.29	61.85	306	C	2016/12	2018/12
SOD	Sodankylä	Finland	FMI	26.64	67.36	227	C	2012/01	2018/12
STM	Ocean Station “M”	Norway	NOAA/ESRL	2.00	66.00	5	D	1999/01	2009/11
SVB	Svartberget	Sweden	ICOS-ATC, SLU	19.78	64.26	385	C	2017/06	2018/12

UTO	Uto	Finland	ICOS-ATC, FMI	21.37	59.78	65	C	2018/03	2018/12
Stations outside study region									
CBW	Cabauw	Netherlands	University of Groningen	4.93	51.97	199	C	2005/01	2013/06
LIN	Lindenberg	Germany	ICOS-ATC, HPB	14.12	52.17	171	c	2015/10	2018/12
LUT	Lutjewad	Netherlands	ICOS-ATC, RUG	6.35	53.40	61	C	2018/08	2018/12
NGL	Neuglobsow	Germany	UBA-Germany	13.03	53.17	68.4	C	1999/01	2013/12
RGL	Ridge Hill	United Kingdom	UNIVBRIS -	2.54	52.00	294	C	2012/02	2017/12
TAC	Tacolneston	United Kingdom	NOAA/ESRL	1.14	52.52	236	D	2014/06	2016/01
TAC	Tacolneston	United Kingdom	UNIVBRIS	1.14	52.52	241	C	2013/01	2017/12
TER	Teriberka	Russian Federation	MGO	35.10	69.20	42	D	1999/01	2018/12
TOH	Torfhaus	Germany	ICOS-ATC, HPB	10.54	51.81	948	C	2017/12	2018/12

CTE-CH4	Posterior emission			Posterior/prior flux ratio		
Prior	R2 Temp	R2 Prec	R2 T&P	R2 Temp	R2 Prec	R2 T&P
LPX-Bern	0.01	0.57	0.57	0.48	0.15	0.59
JSBACH-H	0.72	0.06	0.75	0.01	0.38	0.40
GCP-prior	0.48	0.33	0.75	0.09	0.05	0.12

Table S2. Proportion of explained CH_4 emission and flux multiplier variances by temperature and precipitation. Flux results are from CTE-CH4 inversion model using three different priors (LPX-Bern, JSBACH-H and GCP-prior).

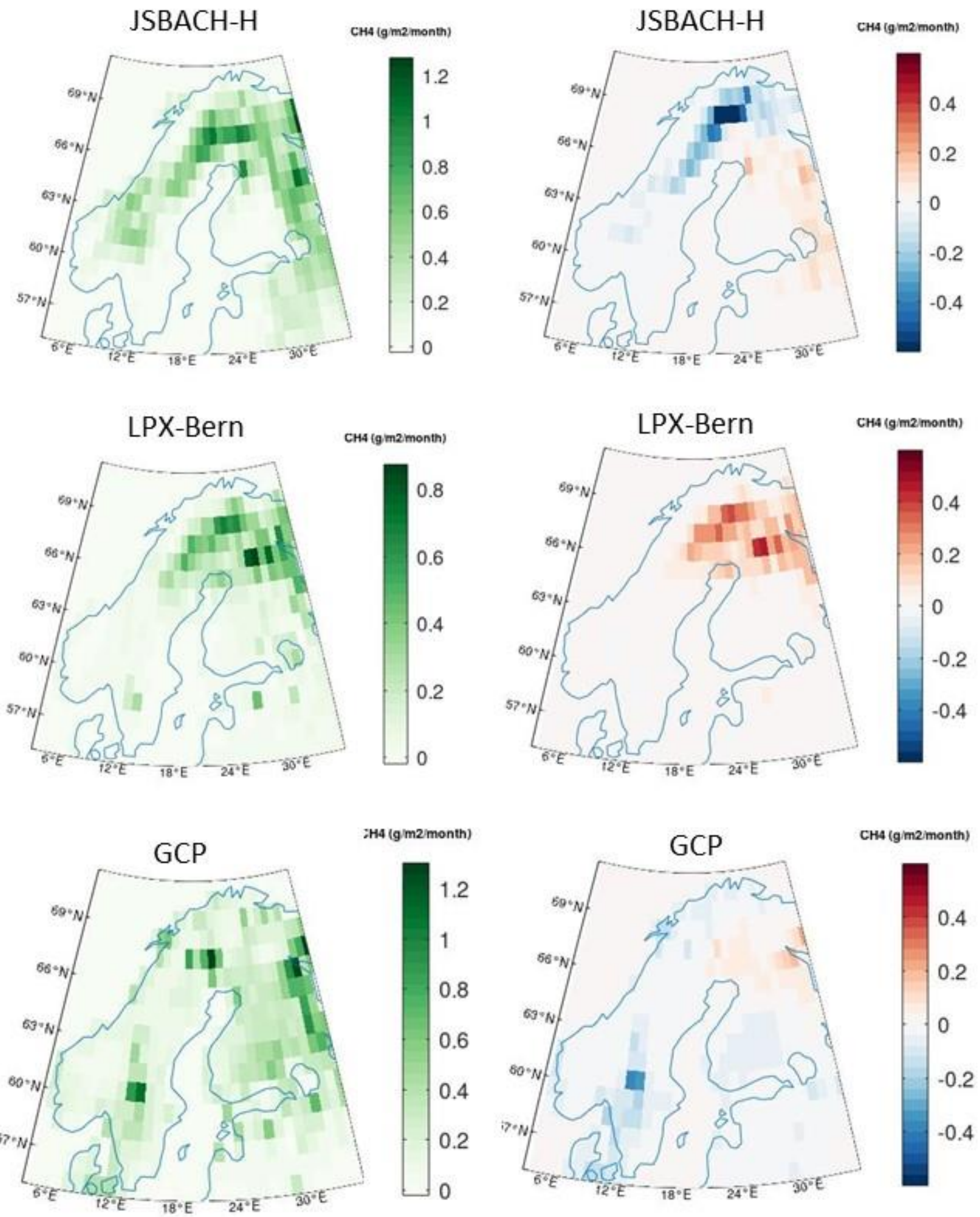

Figure S3. The posterior methane fluxes estimated by CTE-CH4 using JSBACH-H, LPX-Bern and GCP as priors (left column), and the difference between posterior and prior fluxes (right column).

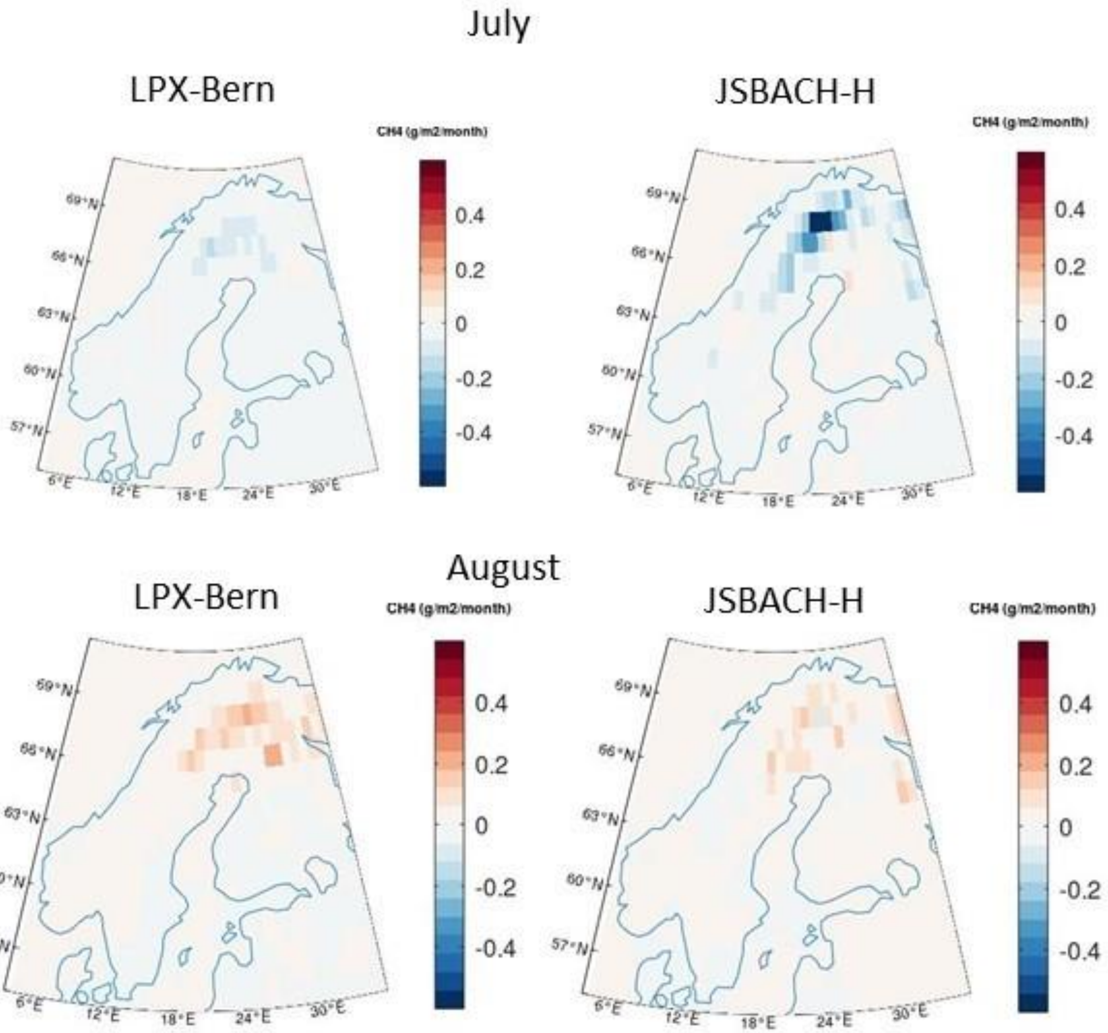

Figure S4. The deviation of the monthly posterior - prior flux adjustment, estimated by CTE-CH4 and using JSBACH-H or LPX-Bern as priors, from the seasonal average flux adjustment. The deviation was calculated as follows: ($F_{post,month}$ - $F_{prior,month}$) - ($F_{post,\ three\text{-}month\ average} - F_{prior,\ three\text{-}month\ average}$). Thus, in the case of JSBACH-H where seasonal average emissions were decreased in the posterior, they were decreased less in August and the deviation was positive. In the case of LPX-Bern the seasonal average emissions were increased in the posterior, and they were increased more in August, resulting in positive deviation.

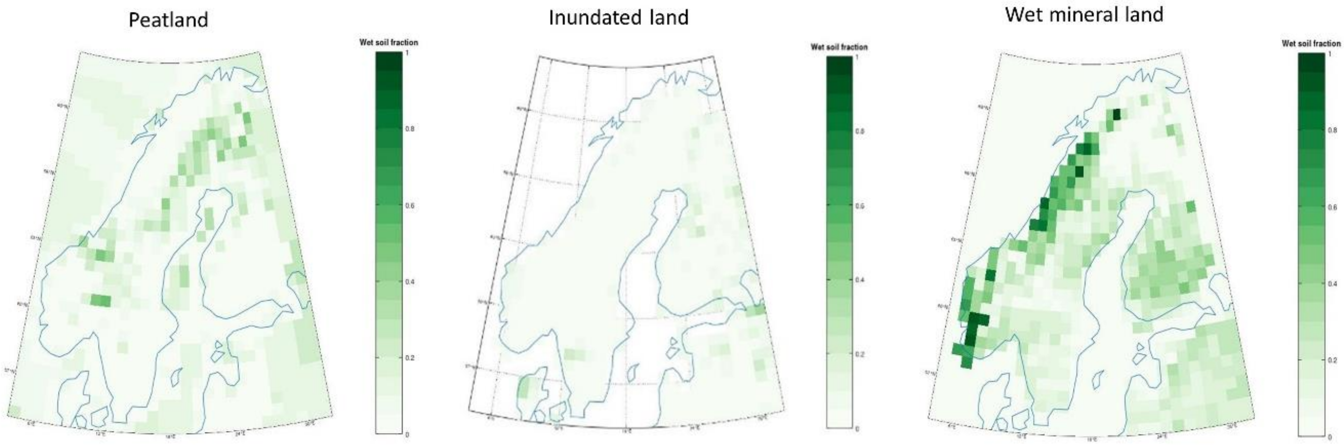

Figure S5: Methane emitting land areas in JSBACH-H model, including a) peatlands, b) inundated lands and c) wet mineral lands average for the month of August over years 2000 – 2018. Mineral soil was considered to be wet when the daily soil moisture, simulated for the 0.1 x 0.1 degree resolution grid cell, was high and there were methane emissions. Then the wetland fraction of the land area in that grid cell was 1.0, as the land area comprised of wet mineral land, inundated land and peatland, all emitting methane. The wet fraction of mineral lands was calculated from the individual daily 0.1 x 0.1 degree resolution grid cells up-scaled and averaged over the month in question and over years 2000 - 2018

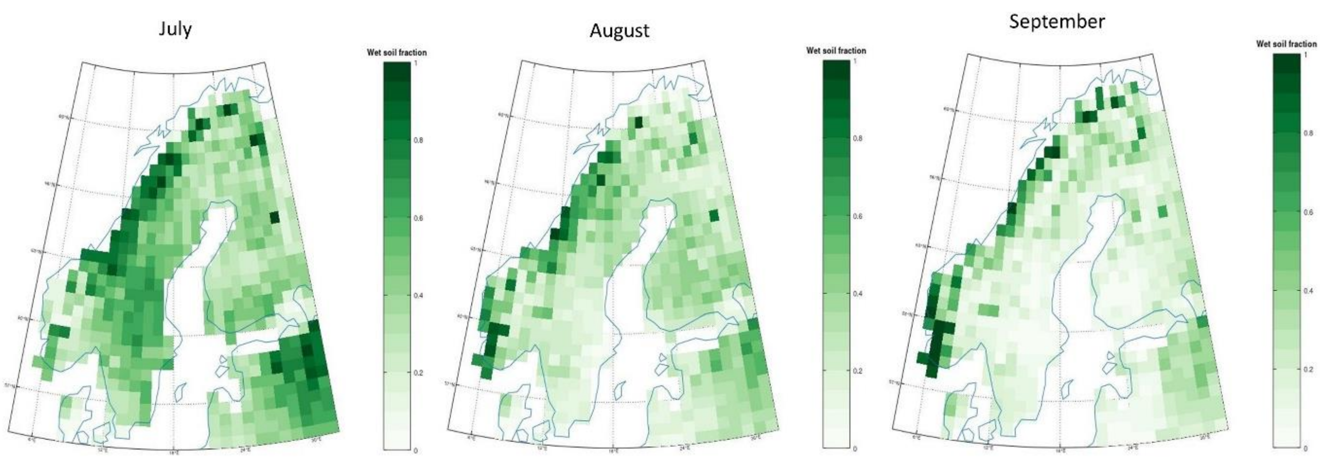

Figure S6: Methane emitting land areas (including peatlands + inundated lands + wet mineral lands) in JSBACH-H model, for the month of a) July, b) August and c) September. The wetland fraction is calculated as an average for the month in question over years 2000 – 2018.

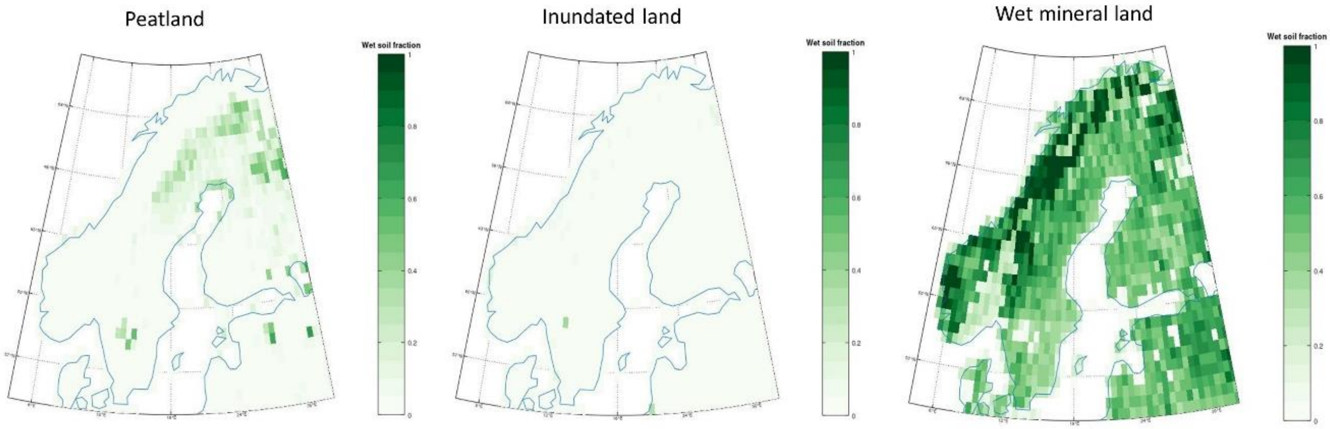

Figure S7: Methane emitting land areas in LPX-Bern model, including a) peatlands, b) inundated lands and c) wet mineral lands average for the month of August over years 2000 – 2018.

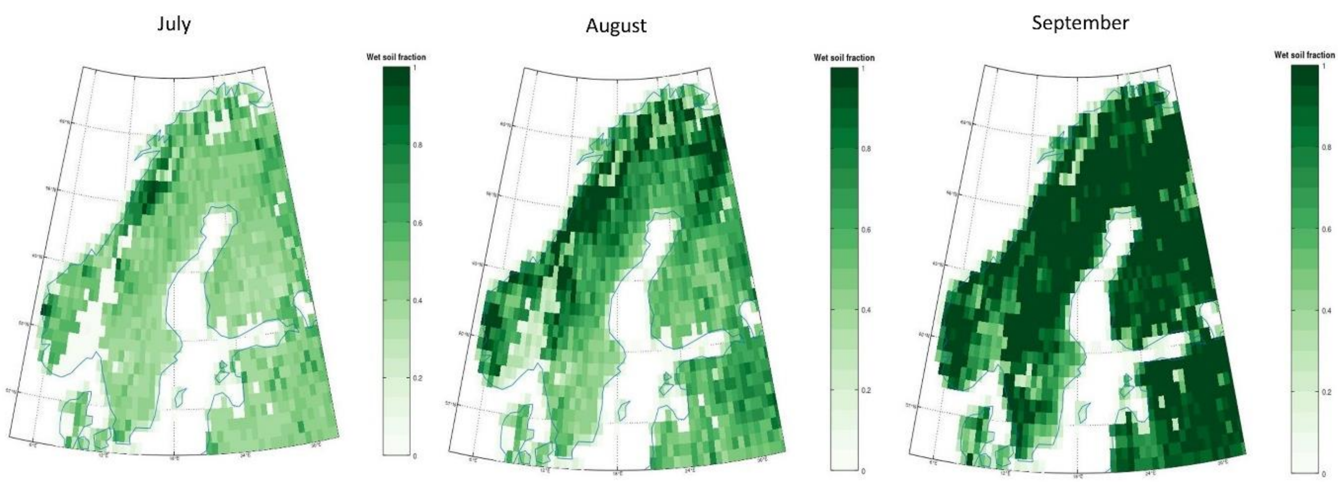

Figure S8: Methane emitting land areas (including peatlands + inundated lands + wet mineral lands) in LPX-Bern model, for the month of a) July, b) August and c) September. The wetland fraction is calculated as an average for the month in question over years 2000 – 2018.

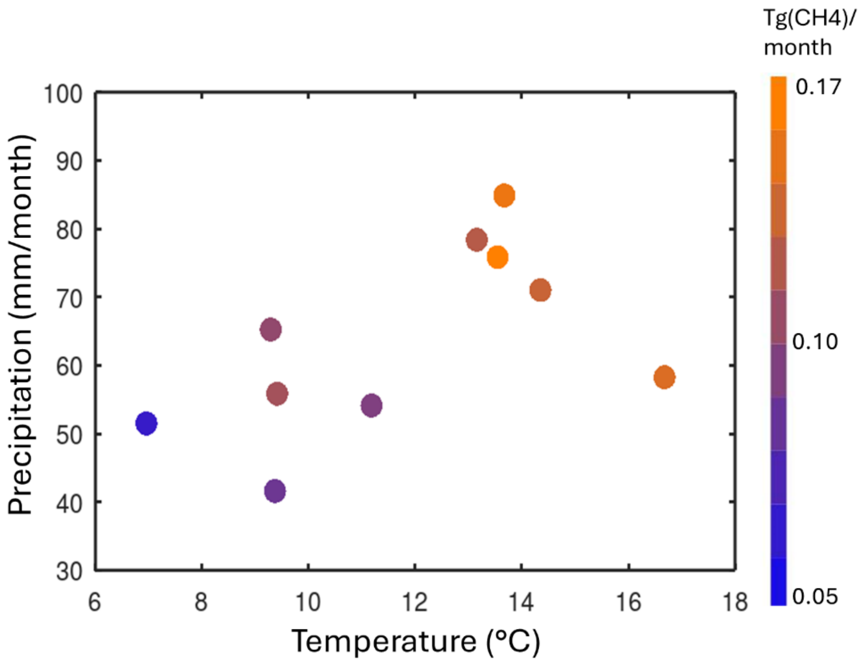

Figure S9. Temperature and precipitation responses of upscaled methane emissions in Fennoscandia. Circles refer to monthly averages in May - September during years 2013 - 2014. R^2_{Temp} =0.83, R^2_{Prec} = 0.54, $R^2_{TempPrec}$ = 0.91.