Supplementary material for manuscript 'A satellite data driven biophysical modeling approach for estimating northern peatland and tundra CO_2 and CH_4 fluxes'

Supplementary Tables

Table S1. Definitions for the symbols and abbreviations used to describe the TCF model components and required input information.

Model Component	Symbols	Definition	Units
General	T_s	Soil temperature	K
	T_{min}	Daily minimum air temperature	K
	SW_{rad}	Incident shortwave radiation	W/m^2
	VPD	Vapor pressure deficit	Pa
	$APAR$	Absorbed photosynthetically active radiation	MJ m^{-2}
	$FPAR$	Fraction photosynthetically active radiation	[ ]
	ε_{max}	Maximum plant light use efficiency	mgC MJ^{-1}
	ε	Light use efficiency with environ. constraints	mgC MJ^{-1}
	θ	Volumetric water content	d^{-1}
	θ_{opt}	Soil moisture optimum	[ ]
	φ_s	Saturated pore volume	m^{-3} d^{-1}
	φ_a	Aerated pore volume	m^{-3} d^{-1}
CO_2 Model	CUE	Plant carbon use efficiency (NPP/GPP)	[ ]
	C_{met}	Metabolic carbon pool	gC m^{-2}
	C_{str}	Structural carbon pool	gC m^{-2}
	C_{rec}	Recalcitrant carbon pool	gC m^{-2}
	F_{met}	Fraction of NPP into C_{met}	[ ]
	F_{str}	Fraction of C_{met} allocated to C_{str}	[ ]
	F_{rec}	Fraction of C_{str} allocated to C_{rec}	[ ]
	R_a	Autotrophic respiration	gC m^{-2} d^{-1}
	R_h	Heterotrophic respiration	gC m^{-2} d^{-1}
	R_{eco}	Ecosystem respiration	gC m^{-2} d^{-1}
	K_p	Potential soil decomposition rate	d^{-1}
	K_{met}	Modified soil decomposition rate	d^{-1}
	T_{mult}	Temperature multiplier for K_p	[ ]
	T_{ref}	Reference temperature for T_{mult}	K
	W_{mult}	Soil moisture multiplier for K_p	[ ]

9 **Table S1 continued.**

Model Component	Symbols	Definition	Units
Soil CH_4 Production	R_{CH4}	Daily CH_4 production	mgC m^{-2} d^{-1}
	C_{CH4}	Total CH_4 storage	mgC m^{-2}
	R_o	CH_4 production rate	µM CH_4 d^{-1}
	Q_{10p}	Q_{10} temperature modifier, CH_4 production	K
	T_p	Reference temperature, CH_4 production	K
	F_{total}	Total CH_4 emission	mgC m^{-2} d^{-1}
	F_{plant}	Plant CH_4 transport	mgC m^{-2} d^{-2}
	F_{diff}	Diffusion CH_4 transport	mgC m^{-2} d^{-3}
	F_{ebull}	Ebullition CH_4 transport	mgC m^{-2} d^{-4}
Plant Transport	C_p	Plant CH_4 transport rate	d^{-1}
	P_{trans}	Transport modifier for C_p	[ ]
	f_{grow}	Plant growth scalar, based on GPP	d^{-1}
	μ_m	Mean daily wind velocity	m s^{-1}
	g_a	Aerodynamic conductance	m s^{-1}
	λ	Aerodynamic modifier	d^{-1}
	k	von Karman constant (for g_a)	[ ]
	z_m	Anemometer height	m
	d	Zero-plane displacement height (for g_a)	m
	z_{om}	Roughness length, momentum (for g_a)	m
	z_{ov}	Roughness length, heat/vapor transfer (for g_a)	m
	P_{ox}	Fraction oxidized during plant transport	[ ]
Diffusion And Ebullition	P_{diff}	Potential CH_4 diffusion	mgC m^{-2} d^{-1}
	R_{ox}	CH_4 oxidation	mgC m^{-2} d^{-1}
	A_{CH4}	Atmospheric CH_4	µM CH_4
	D_e	Effective soil diffusion rate	µM CH_4 d^{-1}
	D_{air}	CH_4 diffusion rate, aerated fraction	µM CH_4 d^{-1}
	D_{water}	CH_4 diffusion rate, saturated fraction	µM CH_4 d^{-1}
	τ	Soil tortuosity coefficient	[ ]
	L_s	Length of soil profile	m
	V_{max}	Maximum reaction rate,	µM CH_4 d^{-1}
	K_m	Substrate conc. at 1/2 V_{max}	µM CH_4
	Q_{10d}	Q_{10} temperature modifier, CH_4 diffusion	[ ]
	T_d	Reference temperature, CH_4 oxidation	K
	υ_e	CH_4 threshold for ebullition	µM
	C_e	CH_4 ebullition transport rate	µM d^{-1}

Table S2. Parameter values used for site-specific peatland (Biome 1) and wet tundra (Biome 2) TCF model CO_2 and CH_4 flux simulations.

TCF Component	Parameter		Tower Site:	SM	SK	LR	KY	ZK	BA
			Biome:	**1**	**1**	**2**	**2**	**2**	**2**
GPP	e_{max}	mgC MJ^{-1}		0.82	0.82	0.82	0.82	0.82	0.82
	θ_{min}	Fract.		0.15	0.15	0.15	0.15	0.15	0.15
	θ_{max}	Fract.		0.75	0.72	0.75	0.70	0.75	0.75
R_{eco}	CUE	Fract.		0.45	0.35	0.55	0.55	0.5	0.5
	K_p	d^{-1}		0.03	0.03	0.03	0.03	0.03	0.03
	F_{met}	Fract.		0.65	0.52	0.72	0.72	0.72	0.72
	T_{ref}	K		293	293	297	293	297	297
CH_4	ϕ	Fract.		0.75	0.75	0.70	0.70	0.70	0.70
	R_o	μM CH_4 d^{-1}		22.4	15.4	9.2	10.8	10.8	10.8*
	T_p	K		287	288	289	287	287	287
	Q_{10p}	[ ]		3.5	3.5	4	3.9	3.5	3.8
	P_{trans}	[ ]		8	9	7	7	7	7
	P_{ox}	Fract.		0.8	0.8	0.7	0.7	0.7	0.7
	A_{CH4}	μM CH_4		0.11	0.11	0.11	0.11	0.11	0.11
	V_{max}	μM CH_4 d^{-1}		120	120	120	120	120	120
	K_m	μM CH_4		1	1	1	1	1	1
	T_d	K		274	274	274	274	274	274
	Q_{10d}	[ ]		2	2	2	2	2	2
	υ_e	μM		500	500	500	500	500	500
	C_e	μM d^{-1}		3	3	3	3	3	3

*A R_o value of 4.5 was used for BA 2007 to account for flooding disturbance impacts on substrate availability and methanogenesis.

Supplementary Figure

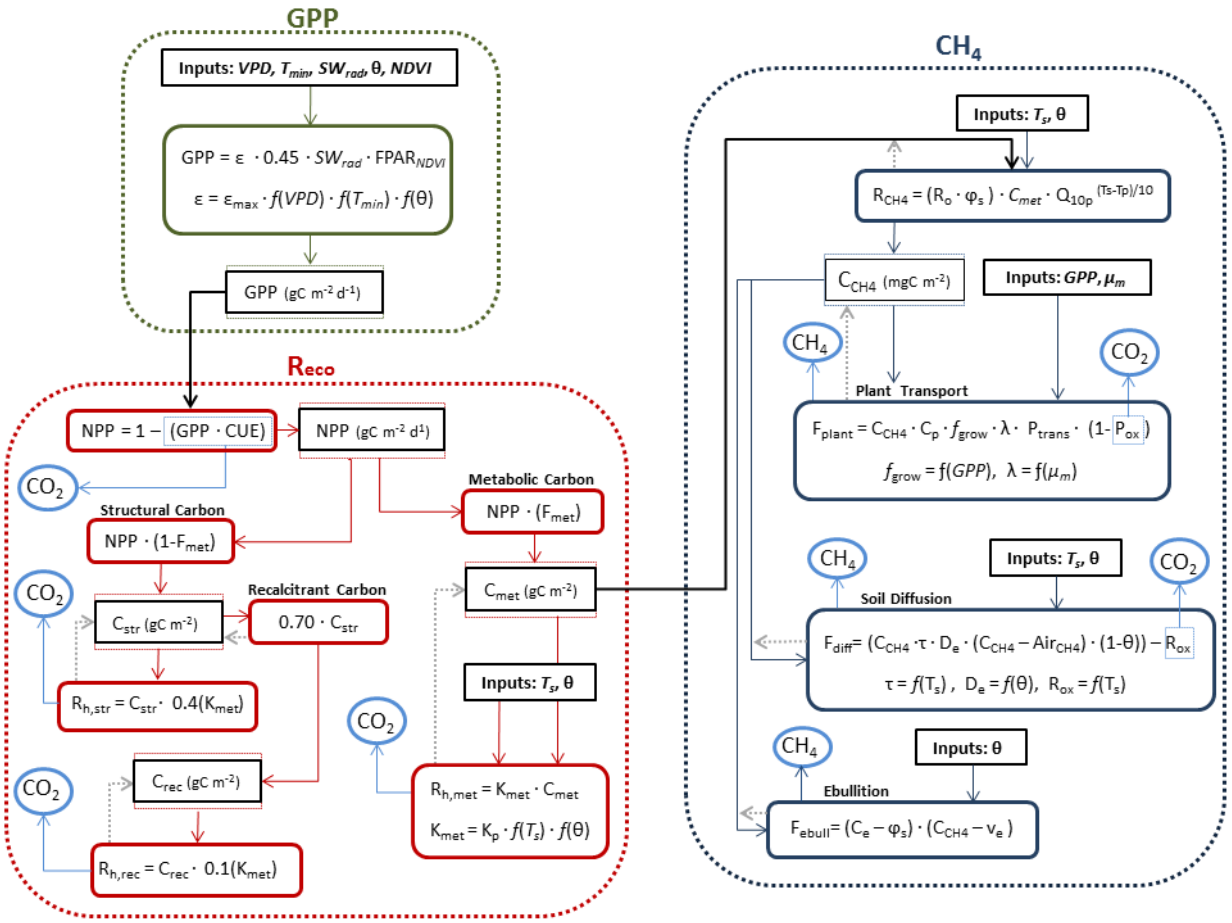

Fig. S1. TCF algorithm flow diagram for the *GPP* (in green), R_{eco} (in red) and CH_4 (in blue) modules. Rectangular boxes denote primary environmental inputs (single border) or model derived stored carbon pools (double border) including C_{met}, C_{str}, C_{rec} and C_{CH4}. Rounded rectangles indicate major process calculations. Arrows show the direction of data flow. The dashed lines specify where pool updates occur at each daily time step to account for carbon losses.