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Partitioning growing season water balance within a forested boreal catchment using sap flux, eddy covariance, and a process-based model

Nataliia Kozii et al.

Correspondence to: Niles Hasselquist (niles.hasselquist@gmail.com)

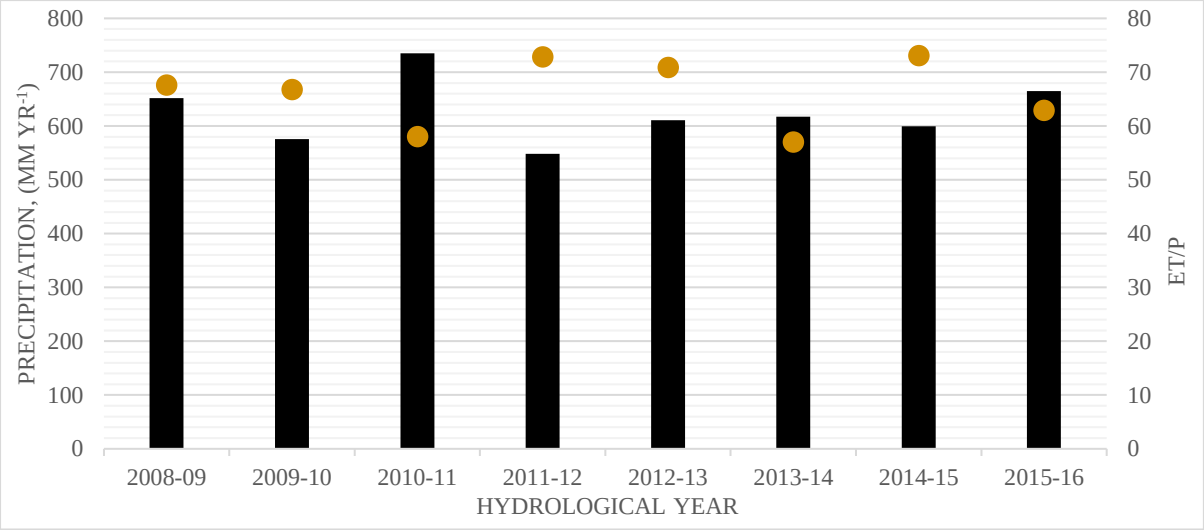

Figure S1. Annual precipitation (dots) and fraction of ET/P (bars) over 8 hydrological years within the C2 catchment.

Table S1. The 10 canopy attributes that has the highest correlation to seasonal I_C/P.

		Canopy Attributes									
Throughfall collector	Seasonal I_C/P	ElevMAD medium	ElevIQ	Total return count	Elev variance	ElevL2	Total return Count above 200	All returns Above 200	ElevAAD	Totall returns	Elevstddev
1	0.30	2.9	6.5	260.0	29.0	2.9	213.0	213.0	4.4	260.0	5.4
2	0.23	2.7	4.5	167.0	16.9	2.3	150.0	150.0	3.1	167.0	4.1
3	0.40	2.8	7.1	260.0	22.1	2.6	212.0	212.0	3.9	260.0	4.7
4	0.76	5.1	10.5	339.0	39.8	3.6	298.0	298.0	5.4	339.0	6.3
5	0.59	4.0	8.4	271.0	28.3	3.1	216.0	216.0	4.5	271.0	5.3
6	0.48	3.8	10.0	257.0	34.1	3.3	216.0	216.0	5.0	257.0	5.8
7	0.33	3.3	5.9	187.0	21.4	2.6	122.0	122.0	3.7	187.0	4.6
8	0.69	4.9	9.2	298.0	29.9	3.2	252.0	252.0	4.7	298.0	5.5
9	0.21	3.3	8.3	231.0	27.8	3.0	200.0	200.0	4.5	231.0	5.3
10	0.30	1.7	3.2	263.0	14.0	2.0	229.0	229.0	2.8	263.0	3.7
11	0.20	2.3	8.0	207.0	26.3	2.8	164.0	164.0	4.3	207.0	5.1
12	0.18	1.9	4.4	256.0	9.2	1.7	236.0	236.0	2.5	256.0	3.0
13	0.27	2.1	3.8	219.0	6.5	1.5	169.0	169.0	2.2	219.0	2.6
14	0.29	2.5	4.8	249.0	10.0	1.8	207.0	207.0	2.7	249.0	3.2
15	0.10	1.6	3.1	190.0	6.8	1.5	126.0	126.0	2.1	190.0	2.6
16	0.26	2.3	4.6	223.0	9.0	1.7	193.0	193.0	2.4	223.0	3.0
17	0.30	2.8	5.5	140.0	12.3	2.0	132.0	132.0	3.0	140.0	3.5
18	0.02	0.0	0.0	101.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.37	3.4	6.6	221.0	19.6	2.5	206.0	206.0	3.7	221.0	4.4
20	0.30	2.1	4.0	179.0	17.9	2.2	156.0	156.0	3.1	179.0	4.2
21	0.07	1.1	2.2	112.0	3.7	1.0	42.0	42.0	1.3	112.0	1.9
22	0.25	1.2	2.6	184.0	2.6	0.9	138.0	138.0	1.4	184.0	1.6
23	0.17	1.1	2.3	172.0	3.3	1.0	128.0	128.0	1.4	172.0	1.8
24	0.15	1.1	2.2	204.0	2.3	0.9	133.0	133.0	1.2	204.0	1.5
25	0.27	1.0	1.6	232.0	1.8	0.8	154.0	154.0	1.0	232.0	1.3
Correlation between IC/P and canopy attributes		0.77	0.62	0.60	0.59	0.59	0.57	0.57	0.57	0.55	0.54

ElevMADmedium = the median of the absolute deviations from the overall median
ElevIQ = interquartile distance of elevations within the plot
Total return count = total number of all returns of the plot
Elevvariance = variance of elevations within the plot
ElevL2 = second L-moment of the return heights of the plot
Total return count above 200 = total number of all returns of the plot above 2 meters

All returns above 200 = number of returns above 2 meters
ElevAAD = average absolute deviation
Totall returns = number of all returns of the plot
Elevstddev = standard deviation of elevations within the plot

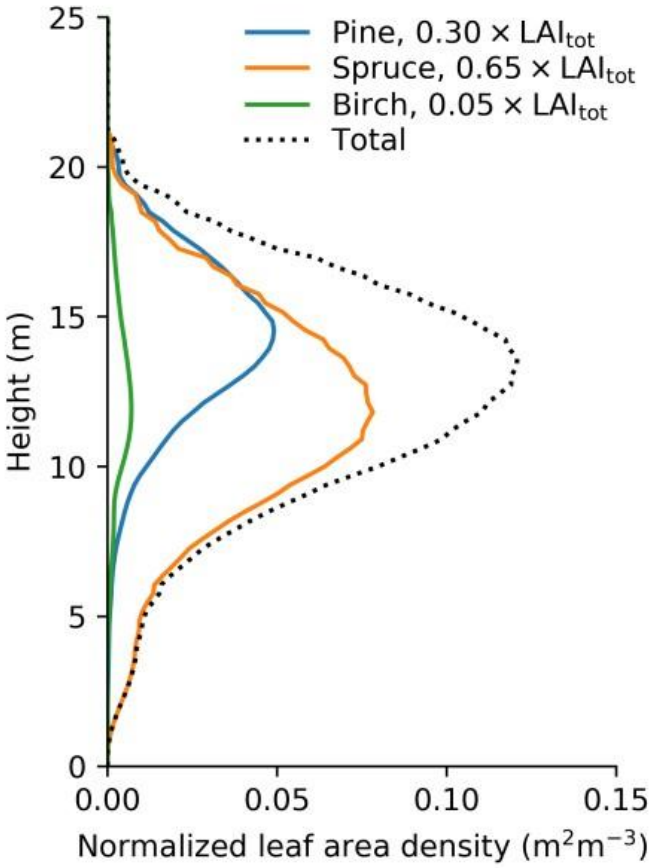

Figure S2. Normalized leaf area density distributions for main tree species and their fraction of total stand leaf area index (LAI_{tot}) with the C2 subcatchment.

Table S2. Model parameter values applied in simulations (for plant type specific parameters see Table S2).

Description	Parameter value	Source
Canopy radiation parameters		
Clumping coefficient (-)	0.7	(Campbell and Norman, 1998)
Leaf-angle distribution (-)	1.0 (spherical)	(Campbell and Norman, 1998)
Shoot PAR albedo (-)	0.1	Adjusted to match canopy albedo
Shoot NIR albedo (-)	0.39	Adjusted to match canopy albedo
Leaf emissivity (-)	0.98	(Campbell and Norman, 1998)
Canopy flow parameters		
Normalized horizontal pressure gradient (m s^{-2})	0.01	
Foliage drag coefficient (-)	0.15	(Lee et al., 1994)
Schmidt number for H_20, T, CO_2	2.0	
Canopy interception parameters		
Maximum interception storage (mm)	0.2–0.5 × LAI	(Watanabe and Mizutani, 1996)
Leaf orientation factor (-)	0.5 (random)	(Watanabe and Mizutani, 1996)
Plant type parameters for photosynthesis–stomatal conductance model		
Carboxylation capacity V_{cmax} at 25°C (µmol m^{-2} s^{-1})[a]	V_{cmax25}	see Table 2
Electron transport capacity J_{max} at 25°C (µmol m^{-2} s^{-1})[a]	1.97 × V_{cmax25}	(Kattge and Knorr, 2007)
Leaf dark respiration rate r_d at 25°C (µmol m^{-2} s^{-1})[a]	0.023 × V_{cmax25}	(Launiainen et al., 2015)
Co-limitation parameter	0.95	
Curvature of electron transport light response (-)	0.7	(Launiainen et al., 2015)
Quantum yield parameter (mol mol^{-1})	0.2	(Launiainen et al., 2015)
Stomatal model slope (-)[b]	g_1	see Table 2
Residual conductance (mol m^{-2} s^{-1})[b]	g_0	see Table 2
Bryophyte layer parameters		
Height (m)	0.095	(Soudzilovskaia et al., 2013)
Roughness height (m)	0.01	(Launiainen et al., 2015)
Bulk density (kg m^{-3})	17.1	(Soudzilovskaia et al., 2013)
Total pore volume (m^3 m^{-3})	0.98	(Voortman et al., 2014)
Maximum gravimetric water content, w_{max} (g g^{-1})	10	(Soudzilovskaia et al., 2013)
Minimum gravimetric water content (g g^{-1})	1.5	(Launiainen et al., 2015)
Van Genuchten water retention parameter (cm^{-1})	0.13	(Voortman et al., 2014)
Van Genuchten water retention parameter (-)	2.17	(Voortman et al., 2014)
Saturated hydraulic conductivity (m/h)	4.2 × 10^{-4}	(Voortman et al., 2014)

Pore connectivity (-)	-2.37	(Voortman et al., 2014)
Emissivity (-)	0.98	(Campbell and Norman, 1998)
PAR albedo at w_{max} (-)[c]	0.11	(Bubier et al., 1997)
NIR albedo at w_{max} (-)[c]	0.29	(Bubier et al., 1997)
Top soil layer parameters		
Depth (m)	0.1	2 × measurement depth of soil temperature and moisture
Porosity (m^3/m^3)	0.8	(Launiainen et al., 2015)
Residual water content (m^3/m^3)	0.01	(Launiainen et al., 2015)
Van Genuchten water retention parameter (cm^{-1})	0.7	(Launiainen et al., 2015)
Van Genuchten water retention parameter (-)	1.25	(Launiainen et al., 2015)
Saturated hydraulic conductivity (m/h)	0.015	(Launiainen et al., 2015)
Thermal conductivity of solids (W/m/K)	2.17	Derived from soil composition[d]
Heat capacity of solids ($MJ/m^3/K$)	2.35	Derived from soil composition[d]

[a] Temperature response curves of V_{cmax} and J_{max} are adopted from Kattge and Knorr (2007) and of r_d from Launiainen et al. (2015)

[b] Parameters of Medlyn et al. (2011) optimal stomatal conductance model

[c] Response of albedo to bryophyte water content (Kieloaho and Launianen, 2018)

[d] Soil composition of top soil layer adopted from Jauhiainen (2004) and thermal properties soil materials from Tian et al. (2016) and Campbell and Norman (1998)

Table S3. Plant type specific model parameter values applied in simulations.

Description	Parameter value			
	Spruce	**Pine**	**Birch**	**Understory**
Maximum LAI, LAI_{max} (m^2/m^2)[a]	$0.31 \times LAI_{tot}$	$0.64 \times LAI_{tot}$	$0.05 \times LAI_{tot}$	0.4–0.8
Minimum LAI (m^2/m^2)[a]	$0.8 \times LAI_{max}$	$0.8 \times LAI_{max}$	$0.1 \times LAI_{max}$	$0.5 \times LAI_{max}$
Minimum value for seasonal cycle modifier (-)[b]	0.1	0.1	0.01	0.01
Characteristic leaf length scale (m)	0.02	0.02	0.05	0.05
Nitrogen attenuation coefficient (-)	0.5	0.5	0.2	0
V_{cmax25} (µmol m^{-2} s^{-1})	60	50	45	40
Stomatal model slope g_1 (-)	2.5	2.5	4.5	4.5
Residual conductance g_0 (mol m^{-2} s^{-1})	0.004	0.004	0.01	0.01

[a] Seasonal development of LAI starts when the degree day sum (T_{base} = 5°C) exceeds 45 days and reaches maturation at 250 days. Leaf senescence in autumn follows Launiainen et al. (2015). LAI_{tot} = 3.4–6.9 m^2 m^{-2}.

[b] Seasonal cycle modifier for photosynthetic capacity is based on the delayed effect of temperature (Kolari et al., 2007; Launiainen et al., 2015).

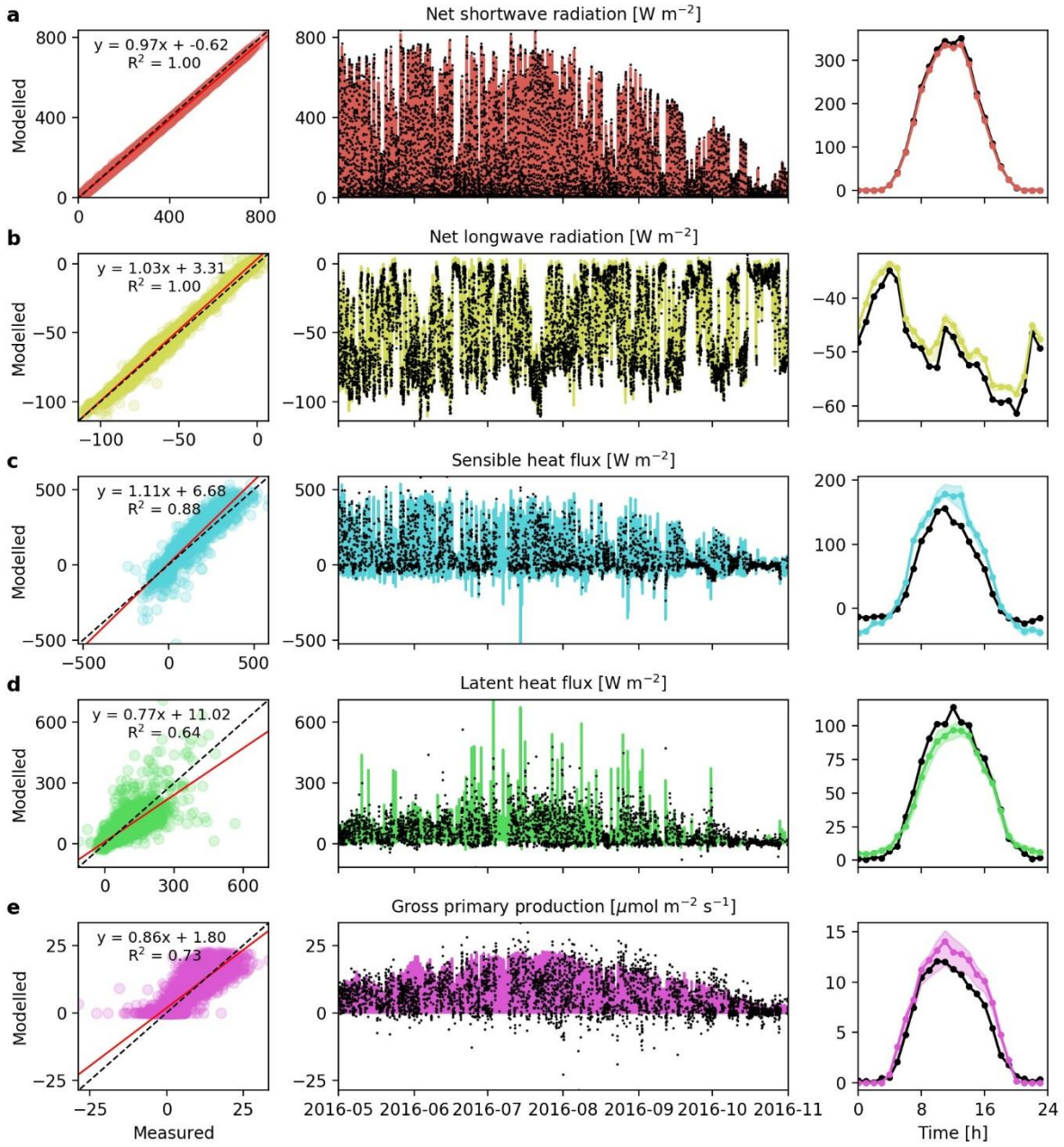

Figure S3. Scatter plot comparison, time series and average diurnal cycle for measured and modelled components of net radiation (a-b), sensible heat flux (c), latent heat flux (d), and gross primary production (e). Eddy covariance data (c-e) is non-gapfilled and only model results of times with data available are plotted in diurnal cycles. Modeled data are in colors and measured in black.

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