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Validation of 3D-CMCC Forest Ecosystem Model (v.5.1) against eddy covariance data for 10 European forest sites

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Supplementary material - Table captions

Table S1 (a) Performance statistics (r, NRMSE, MEF and MABstd) are reported as derived from daily and monthly series of GPP_{MD} vs. GPP_{EC} values (X dataset) operated over long-term annual scale. The (*) (**) (***) refers, respectively, to p-value < 0.05, 0.01 and 001 in correlation between GPP_{EC} and GPP_{MD} data. In addition, long term average of annual GPP_{EC} and GPP_{MD} values (gC m^{-2} yr^{-1}) are shown. (b) as in (a) but for the Y dataset using the decomposition technique proposed by Zhao et al. (2012).

Table S2 Performance statistics (r, NRMSE, MEF and MABstd) are reported as derived from daily and monthly series of GPP_{MD} vs. GPP_{EC} values (X dataset) operated over long-term seasonal scale. Values for DBF species in DJF are missing since the model does not produce any GPP flux during that season. The (*) (**) (***) refers, respectively, to p-value < 0.05, 0.01 and 0.001 in correlation between GPP_{EC} and GPP_{MD} data.

Table S3 List of species-related parameters with description, units and differences from Collalti et al. (2014).

Table S1

(a)	X_{daily}				$X_{monthly}$				X_{yearly}					
Site	r	NRMSE	MEF	MABstd	r	NRMSE	MEF	MABstd	r	NRMSE	MEF	MABstd	GPP_{MD} (gCm^{-2} yr^{-1})	GPP_{EC} (gCm^{-2} yr^{-1})
DE-Hai	0.92***	0.40	0.84	0.25	0.97***	0.24	0.94	0.16	0.32	1.08	-0.34	0.90	1474	1511
DK-Sor	0.89***	0.51	0.74	0.34	0.97***	0.27	0.93	0.18	-0.02	1.82	-2.72	1.58	1901	1947
FR-Hes	0.79***	0.77	0.41	0.48	0.94***	0.36	0.87	0.23	0.01	1.18	-0.62	1.07	1726	1622
IT-Col	0.85***	0.59	0.65	0.37	0.90***	0.46	0.78	0.30	0.14	1.11	-0.32	0.92	1412	1362
FR-Pue	0.83***	0.78	0.40	0.58	0.89***	0.66	0.56	0.50	0.76**	1.12	-0.38	0.95	1463	1305
IT-Cpz	0.57***	1.02	-0.04	0.83	0.72***	0.90	0.19	0.76	-0.46	2.43	-5.73	1.98	1409	1727
DE-Tha (1S)	0.90***	0.46	0.79	0.31	0.96***	0.27	0.93	0.19	0.29	0.93	0.04	0.82	1840	1869
FI-Hyy	0.91***	0.48	0.77	0.31	0.96***	0.29	0.91	0.20	0.52	1.04	-0.18	0.86	1119	1068
IT-Ren(2L-2C)	0.82***	0.62	0.61	0.44	0.95***	0.30	0.91	0.23	-0.54	1.41	-1.49	1.10	1349	1362
BE-Bra (P_Q-3L)	0.77***	0.65	0.57	0.46	0.93***	0.39	0.84	0.28	-0.1	1.27	-0.93	1.08	1141	1193
Average	0.82	0.63	0.57	0.44	0.92	0.41	0.79	0.3	0.09	1.34	-1.27	1.12	1483	1497

(b)	Y_{daily}				$Y_{monthly}$			
Site	r	NRMSE	MEF	MABstd	r	NRMSE	MEF	MABstd
DE-Hai	0.72***	1.04	-0.08	0.66	0.97***	0.23	0.94	0.16
DK-Sor	0.46***	1.39	-0.94	0.86	0.97***	0.25	0.94	0.18
FR-Hes	0.39***	1.51	-1.27	0.96	0.96***	0.30	0.91	0.23
IT-Col	0.53***	1.19	-0.41	0.77	0.91***	0.43	0.81	0.31
FR-Pue	0.72***	0.96	0.08	0.72	0.90***	0.61	0.63	0.51
IT-Cpz	0.24***	1.23	-0.52	0.90	0.81***	0.63	0.60	0.49
DE-Tha (1S)	0.72***	0.92	0.15	0.65	0.97***	0.24	0.94	0.18
FI-Hyy	0.73***	1.16	-0.34	0.75	0.97***	0.28	0.92	0.21
IT-Ren(2L-2C)	0.36***	1.24	-0.54	0.87	0.97***	0.25	0.94	0.20
BE-Bra (P_Q-3L)	0.25***	1.18	-0.39	0.83	0.94***	0.36	0.87	0.27
Average	0.51	1.18	-0.43	0.80	0.94	0.36	0.85	0.27

Table S2

MONTHLY

Site	DJF				MAM				JJA				SON			
	r	NRMSE	MEF	MABstd	r	NRMSE	MEF	MABstd	r	NRMSE	MEF	MABstd	r	NRMSE	MEF	MABstd
DE-Hai	-	-	-	0.68	0.98***	0.48	0.76	0.35	0.64***	1.02	-0.08	0.82	0.99***	0.17	0.97	0.13
DK-Sor	-	-	-	1.22	0.95***	0.45	0.79	0.37	0.77***	0.64	0.57	0.50	0.97***	0.46	0.78	0.29
FR-Hes	-	-	-	1.01	0.97***	0.24	0.94	0.19	0.32	0.99	-0.02	0.80	0.90***	0.57	0.66	0.42
IT-Col	-	-	-	0.47	0.77***	0.72	0.48	0.47	0.25	1.16	-0.38	0.93	0.70***	0.79	0.37	0.49
FR-Pue	0.80***	1.17	-0.42	1.03	0.81***	1.19	-0.46	0.96	0.83***	0.80	0.34	0.66	0.74***	0.81	0.32	0.60
IT-Cpz	0.05	1.56	-1.53	1.40	0.06	1.49	-1.32	1.26	0.50*	1.07	-0.21	0.91	0.58**	1.15	-0.38	0.96
DE-Tha (1S)	0.88***	0.48	0.77	0.34	0.93***	0.43	0.81	0.35	0.57***	0.96	0.04	0.78	0.96***	0.33	0.89	0.27
FI-Hyy	0.71***	0.94	0.09	0.42	0.96***	0.63	0.59	0.47	0.62***	0.99	-0.01	0.74	0.96***	0.49	0.75	0.41
IT-Ren(2L-2C)	0.42	1.15	-0.43	0.79	0.90***	0.42	0.81	0.32	0.32	1.00	-0.08	0.81	0.92***	0.47	0.77	0.41
BE-Bra (P_Q-3L)	0.67**	1.48	-1.31	1.20	0.91***	0.51	0.73	0.44	0.23	1.37	-0.99	1.11	0.86***	0.51	0.73	0.40
Average	0.59	1.13	-0.47	0.85	0.82	0.66	0.41	0.52	0.50	1.00	-0.08	0.81	0.86	0.57	0.58	0.44

DAILY

Site	DJF				MAM				JJA				SON			
	r	NRMSE	MEF	MABstd	r	NRMSE	MEF	MABstd	R	NRMSE	MEF	MABstd	r	NRMSE	MEF	MABstd
DE-Hai	-	-	-	0.70	0.88***	0.81	0.34	0.52	0.74***	0.91	0.16	0.75	0.94***	0.36	0.87	0.25
DK-Sor	-	-	-	0.81	0.85***	0.73	0.46	0.54	0.48***	1.12	-0.25	0.87	0.87***	0.7	0.51	0.48
FR-Hes	-	-	-	0.74	0.77***	0.84	0.29	0.52	0.17***	1.36	-0.85	1.12	0.71***	1.06	-0.12	0.69
IT-Col	-	-	-	0.71	0.69***	0.87	0.24	0.53	0.42***	1.18	-0.40	0.91	0.71***	0.84	0.29	0.56
FR-Pue	0.84***	0.77	0.41	0.63	0.79***	1.12	-0.27	0.87	0.72***	0.89	0.21	0.73	0.75***	0.79	0.38	0.59
IT-Cpz	0.21***	1.38	-0.92	1.19	0.16***	1.41	-0.99	1.15	0.36***	1.15	-0.33	0.93	0.46***	1.16	-0.35	0.95
DE-Tha (1S)	0.74***	0.83	0.31	0.54	0.84***	0.68	0.54	0.51	0.63***	0.93	0.13	0.73	0.90***	0.53	0.72	0.39
FI-Hyy	0.35***	0.96	0.07	0.57	0.86***	0.94	0.11	0.62	0.73***	1.07	-0.14	0.86	0.91***	0.53	0.72	0.40
IT-Ren(2L-2C)	0.23***	1.29	-0.67	0.88	0.73***	0.77	0.4	0.6	0.22***	1.27	-0.61	1.00	0.72***	0.79	0.38	0.56
BE-Bra (P_Q-3L)	0.33***	1.06	-0.13	0.80	0.65***	0.80	0.36	0.62	0.16***	1.37	-0.87	1.09	0.70***	0.75	0.43	0.55
Average	0.45	1.05	-0.15	0.76	0.72	0.90	0.15	0.65	0.46	1.12	-0.30	0.90	0.77	0.75	0.38	0.54

Table S3

Description of species-related parameter	Symbol	Unit	Added from Collalti et al., 2014
Phenology type	S_{phen}	-	X
Light use efficiency max	ε_x	gC molPAR^{-1}	
Foliar extinction coefficient	k	-	
Albedo	A	%	X
LAI for max canopy conductance	L_{cmax}	m^2 m^{-2}	
LAI for max canopy interception	L_{imax}	m^2 m^{-2}	
Maximum proportion of rainfall intercepted and evaporated from the canopy	i_{rmax}	%	
Specific Leaf Area	SLA	cm^{2}gC^{-1}	
Ratio of shaded to sunlit projected SLA	SLA_r	%	X
Branch and bark fraction at juvenile age	p_{BB0}	-	
Branch and bark fraction at mature age	p_{BB}	-	
Age at which $p_{BB}=(p_{BB0}+p_{BB})/2$	t_{BB}	year	
Min basic density for juvenile tree	ρ_{min}	t m^{-3}	
Min basic density for mature tree	ρ_{max}	t m^{-3}	
Age at which $\rho=(p_{min}+p_{max})/2$	t_ρ	year	
Stomatal response to VPD	k_D	mbar	
Canopy boundary layer conductance	g_B	m s^{-1}	
Max canopy conductance	g_{cmax}	m s^{-1}	
Maximum age	t_X	year	
Relative age to give f_age modifier = 0.5	r_{age}	-	
Power of relative age in f_age modifier	n_{age}	-	
Min temperature for growth	T_{min}	°C	
Max temperature for growth	T_{max}	°C	
Opt temperature for growth	T_{opt}	°C	
Thermic sum for starting growth	T_{start}	°C	X
Min day length for leaf fall	DL_{min}	hours	X
Moisture ratio deficit which gives to f_soil modifier = 0.5	c_ϑ	-	
Power of moisture ratio deficit	n_ϑ	-	
Allocation parameter	ω	-	
Parameter controlling allocation to leaves	ε_L	-	
Parameter controlling allocation to stem	ε_S	-	
Parameter controlling allocation to roots	ε_R	-	
Parameter controlling allocation to fruit	ε_F	-	X
New fine root C : new leaf C	FR_CL_C	%	X

New stem C : new leaf C	S_CL_C	%	X
New coarse root C : new stem C	CR_CS_C	%	X
New live C : Total C	LW_CTW_C	%	X
Carbon-Nitrogen ratio of leaves	CN_{L}	%	X
Carbon-Nitrogen ratio of fine roots	CN_{FR}	%	X
Carbon-Nitrogen ratio of live wood	CN_{LW}	%	X
Carbon-Nitrogen ratio of dead wood	CN_{DW}	%	X
Days of budburst	*DBB*	day	X
Litterfall as a fraction of growing season	*LFG*	%	X
Leaf life span	*LLS*	year	X
Annual leaves and fine root turnover	LFR_t	%	X
Annual coarse root turnover	CR_t	%	X
Annual sapwood turnover	SW_t	%	X
Annual branch turnover	B_t	%	X
Max stem mass per tree at 1000 trees/ha	W_{Sx1000}	kg DM tree^{-1}	
Power in self-thinning law	n_N	-	
Maximum ratio DBH-crown diameter for low density	$DBHDC_{max}$	-	
Minimum ratio DBH-crown diameter for high density	$DBHDC_{min}$	-	
a parameter for sapwood	SAP_a	-	X
b parameter for sapwood	SAP_b	-	X
Sapwood max leaf area ratio	SAP_{max}	-	X
Sapwood-NSC ratio	SAP_{NSC}	%	X
Max height	H_{max}	m	
Max DBH	D_{max}	cm	
Constant in stem mass vs. diameter relationship	*stemConst*	-	
Power in stem mass vs. diameter relationship	*stemPower*	-	
H/D ratio in partitioning for high density	HD_{max}	-	
H/D ratio in partitioning for low density	HD_{min}	-	
Slope of asymptotic height	H_{power}	-	
Chapman-Richards asymptotic maximum height	CR_A	-	
Chapman-Richards exponential decay parameter	CR_B	-	
Chapman-Richards shape parameter	CR_C	-	