Supplement to: Temporal interpolation of land surface fluxes derived from remote sensing - results with an Unmanned Aerial System

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Table S1. Model parameters and equations. The extinction coefficients for PAR (k_{PAR}) and for net radiation (k_{Rn}) were equal to 0.5 and 0.6, respectively (Fisher et al., 2008; Impens and Lemeur, 1969; Ross, 1975). RH is the relative humidity.

Parameter	Description	Equation	Reference
f_g	Green canopy fraction	$f_g = f_{APAR}/f_{IPAR}$	Fisher et al. (2008)
f_M	Plant moisture constraint	$f_M = f_{APAR}/\max(f_{APAR})$	Fisher et al. (2008)
f_{Ta}	Plant temperature constraint	$f_{Ta} = 1.1814 \cdot [1 + e^{0.3(-T_o-10+T_a)}]^{-1}[1 + e^{0.2(T_o-10-Ta)}]^{-1}$	Potter et al. (1993)
f_{SM}	SM constraint	$f_{SM} = \theta_e$	Fisher et al. (2008)
f_{VPD}	Vapor pressure deficit constraint	$f_{VPD} = 1/(1 + VPD/D0)$	Lohammar et al. (1980)
PARc	PAR intercepted by the canopy	$PARc = PAR - PARs$	Ruimy et al. (1999)
PARs	PAR for the soil	$PARs = PAR \cdot e^{-k_{PAR} \cdot LAI}$	Ruimy et al. (1999)
Rnc	Net radiation for the canopy	$Rnc = Rn - Rns$	Fisher et al. (2008)
Rns	Net radiation for the soil	$Rns = Rn \cdot e^{-k_{Rn} \cdot LAI}$	Fisher et al. (2008)
LAI	Leaf area index	$LAI = -\ln(1 - f_{IPAR})/k_{PAR}$	Ruimy et al. (1999)
SAVI	Soil adjusted vegetation index	$SAVI = 0.45\ NDVI + 0.132$	Huete (1988)
f_{APAR}	Fraction of PAR absorbed by green vegetation cover	$f_{APAR} = 1.4\ SAVI - 0.05$	Fisher et al. (2008)
f_{IPAR}	Fraction of PAR intercepted by total vegetation cover.	$f_{IPAR} = 1.0\ NDVI - 0.05$	Fisher et al. (2008)
T_o	Optimum plant growth temperature	T_a at $\max\{PAR \cdot f_{APAR} \cdot T_a/VPD\}$ 16.51 °C for this study	Fisher et al. (2008)
D_0	Empirical coefficient for VPD	15 hPa	Leuning et al. (1995)

Table S2. Information of model inputs to run SVEN at half hour time steps

Input	Description	Unit
SW_{in}	Incoming shortwave radiation	$W \cdot m^{-2}$
LW_{in}	Incoming longwave radiation	$W \cdot m^{-2}$
T_a	Air temperature	℃
RH	Relative air humidity	%
WS	Wind speed	$m \cdot s^{-1}$
Ps	Air pressure	Pa
P	Precipitation	$mm \cdot h^{-1}$
z	Canopy height	m
NDVI	Normalized Difference Vegetation Index	\

Table S3. Information on model initial conditions

Initial conditions	Description	Unit
CWS_{in}	Initial canopy water storage	m
SWS_{in}	Initial soil water storage	m
T_{s0}	Initial surface temperature	℃
T_{d0}	Initial deep soil temperature	℃

Table S4. Information on model outputs

Output	Description	Unit
T_s	Surface temperature	℃
T_d	Deep soil temperature	℃
LW_{out}	Outgoing longwave radiation	$W \cdot m^{-2}$
SW_{out}	Outgoing shortwave radiation	$W \cdot m^{-2}$
Rn	Net radiation	$W \cdot m^{-2}$
G	Ground heat flux	$W \cdot m^{-2}$
LE	Latent heat flux	$W \cdot m^{-2}$
H	Sensible heat flux	$W \cdot m^{-2}$
GPP	Gross Primary Productivity	$g \cdot C \cdot m^{-2} \cdot d^{-1}$
CWS	Canopy Water Storage	m
θ	Volumetric SM	$m^3 \cdot m^{-3}$
R	Surface runoff	$m \cdot s^{-1}$
Q_{per}	Percolation	$m \cdot s^{-1}$

Table S5. Parameter values of the Mualem model for different soil texture classes (Carsel and Parrish, 1988). θ_r is the residual soil moisture ($m^3 \cdot m^{-3}$). θ_s is the saturated soil moisture ($m^3 \cdot m^{-3}$). n is the fitting parameter of the Mualem model. K_s is the infiltration rate for the saturated soil ($mm \cdot h^{-1}$). Values in the brackets are standard deviations.

Texture class	θ_r	θ_s	n	K_s
Sand	0.045 (0.010)	0.43 (0.06)	2.68 (0.29)	297.00 (156.0)
Loamy sand	0.057 (0.015)	0.41 (0.09)	2.28 (0.27)	145.90 (113.6)
Sandy loam	0.065 (0.017)	0.41 (0.09)	1.89 (0.17)	44.20 (56.3)
Loam	0.078 (0.013)	0.43 (0.10)	1.56 (0.11)	10.40 (18.2)
Silt	0.034 (0.010)	0.46 (0.11)	1.37 (0.05)	2.50 (3.3)
Silt loam	0.067 (0.015)	0.45 (0.08)	1.41 (0.12)	4.50 (12.3)
Sandy clay loam	0.100 (0.006)	0.39 (0.07)	1.48 (0.13)	13.10 (27.4)
Clay loam	0.095 (0.010)	0.41 (0.09)	1.31 (0.09)	2.60 (7.0)
Silty clay loam	0.089 (0.009)	0.43 (0.07)	1.23 (0.06)	0.70 (1.9)
Sandy clay	0.100 (0.013)	0.38 (0.05)	1.23 (0.10)	1.20 (2.8)
Silty clay	0.070 (0.023)	0.36 (0.07)	1.09 (0.06)	0.20 (1.1)
Clay	0.068 (0.034)	0.38 (0.09)	1.09 (0.09)	2.00 (4.2)

Reference

Carsel, R. F. and Parrish, R. S.: Developing joint probability distributions of soil water retention characteristics, Water Resour. Res., 24(5), 755–769, doi:10.1029/WR024i005p00755, 1988.

Fisher, J. B., Tu, K. P. and Baldocchi, D. D.: Global estimates of the land-atmosphere water flux based on monthly AVHRR and ISLSCP-II data, validated at 16 FLUXNET sites, Remote Sens. Environ., 112(3), 901–919, doi:10.1016/j.rse.2007.06.025, 2008.

Huete, A. R.: A soil-adjusted vegetation index (SAVI), Remote Sens. Environ., 25(3), 295–309, doi:10.1016/0034-4257(88)90106-X, 1988.

Impens, I. and Lemeur, R.: Extinction of net radiation in different crop canopies, Arch. für Meteorol. Geophys. und Bioklimatologie Ser. B, 17(4), 403–412, doi:10.1007/BF02243377, 1969.

LEUNING, R.: A critical appraisal of a combined stomatal-photosynthesis model for C3 plants, Plant. Cell Environ., 18(4), 339–355, doi:10.1111/j.1365-3040.1995.tb00370.x, 1995.

Lohammar, T., Larsson, S., Linder, S. and Falk, S. O.: FAST: Simulation Models of Gaseous Exchange in Scots Pine, Ecol. Bull., (32), 505–523, doi:10.2307/20112831, 1980.

Potter, C. S., Randerson, J. T., Field, C. B., Matson, P. A., Vitousek, P. M., Mooney, H. A. and Klooster, S. A.: Terrestrial ecosystem production: A process model based on global satellite and surface data, Global Biogeochem. Cycles, 7(4), 811–841, doi:10.1029/93GB02725, 1993.

Ross, J.: Radiative transfer in plant communities, Veg. Atmos., 13–55, 1975.

Ruimy, A., Kergoat, L. and Bondeau, A.: Comparing global models of terrestrial net primary productivity (NPP): Analysis of differences in light absorption and light-use efficiency, Glob. Chang. Biol., 5(SUPPL. 1), 56–64, doi:10.1046/j.1365-2486.1999.00007.x, 1999.