# Supplementary material

**Table S1. Parameters used by diFUME model in the Equations of Table A1, along with their units, a short description, and the references used for determining their value. diFUME does not discriminate between different vegetation types, using approximate values for temperate deciduous broadleaved trees and grasses (Stagakis et al., 2023).**

| Parameter | Value | Units | Description | Reference |
|---|---|---|---|---|
| $A_{max}$ | 15 | μmol $CO_2$ $m^{-2}$ $s^{-1}$ | maximum leaf gross photosynthetic rate | Stagakis et al., 2023; Larcher, 2003 |
| $a$ | 0.045 | mol $CO_2$ $mol^{-1}$ PAR | quantum yield for $CO_2$ assimilation | Rogers et al., 2017 |
| $a_1$ | 25 | N/A | empirical coefficient in Leuning (1995) model | Leuning, 1995 |
| $b$ | 0.65 | N/A | empirical coefficient in β-factor formula | this study |
| $b_1$ | 5 | N/A | empirical coefficient | Stagakis et al., 2023 |
| $D_o$ | 0.3 | kPa | empirically determined coefficient for the VPD scalar inside Leuning (1995) model | this study |
| $D_{sc}$ | 1 | N/A | daylight scalar for dark respiration inhibition during day (1: no inhibition) | this study |
| $E_0$ | 487.75 | K | temperature sensitivity parameter for soil respiration | this study |
| $g_o$ | 0.01 | mol $CO_2$ $m^{-2}$ $s^{-1}$ | residual stomatal conductance for CO2 ($g_s$ when $A_{net}$ = 0, PAR = 0). | Leuning, 1995 |
| $Q_{10}$ | 1.85 | N/A | temperature sensitivity of leaf respiration | Heskel et al., 2016 |
| $R_{l,ref}$ | 1.53 | μmol $CO_2$ $m^{-2}$ $s^{-1}$ | reference leaf respiration at $T_{air}$ = 25 °C | Heskel et al., 2016 |
| $R_{S,ref}$ | 2.49 | μmol $CO_2$ $m^{-2}$ $s^{-1}$ | reference soil respiration at $T_{soil}$ = 10 °C | this study |
| $T_{air}$ | input | °C | air temperature | - |
| $T_{opt}$ | 23 | °C | optimum air temperature for gross photosynthesis | Larcher, 2003 |
| $T_0$ | -46 | °C | low-temperature limit for soil respiration | Lloyd and Taylor, 1994 |
| $T_{ref,S}$ | 10 | °C | reference soil temperature for soil respiration | Lloyd and Taylor, 1994 |
| $T_{ref,l}$ | 25 | °C | reference air temperature for leaf respiration | Heskel et al., 2016 |
| $T_{soil}$ | input | °C | soil temperature | - |
| $VPD$ | input | kPa | vapour pressure deficit | - |
| $W$ | 10 | °C | width of the bell-shape curve at $f(T_{air})$ = 0.5 | Larcher, 2003 |
| $\theta$ | input | $m^3$ $m^{-3}$ | soil volumetric water content | - |
| $\theta_{ref}$ | 0.4 | $m^3$ $m^{-3}$ | saturated soil volumetric water content | Stagakis et al., 2023 |
| $\theta_g$ | 0.1 | $m^3$ $m^{-3}$ | minimum soil volumetric water content, limit to stomatal conductance | this study |
| $\theta_0$ | 0.04 | $m^3$ $m^{-3}$ | minimum soil volumetric water content, limit to soil respiration | Stagakis et al., 2023 |
| $\lambda_{soil}$ | input | N/A | land cover fraction covered by soil or grass | - |

**Table S2. Parameters used by JSBACH in the equations in Table A1, along with their units, a short description, and the references used for determining their value. For additional details on the model equations see Reick et al. (2021). Other parameters that have been altered in this study are also listed.**

| Parameter | Trees | Lawn | Units | Description | Reference |
|---|---|---|---|---|---|
| $A_{stress}$ | simulated | | $\mu mol(CO_2)\ m^{-2}$ (leaf) $s^{-1}$ | Carbon assimilation under water stress | - |
| $CC$ | 1.25 | 1.25 | N/A | Relative cost to produce one carbon | Ryan, 1991 |
| $C_h$ | simulated | | $\mu mol(CO_2)\ m^{-2}$ | Humus carbon pool | - |
| $F_{grazing}$ | simulated | | $\mu mol(CO_2)\ m^{-2}\ s^{-1}$ | Grazing losses of the green C pool to herbivores | - |
| $F_{soil}$ | simulated | | $\mu mol(CO_2)\ m^{-2}\ s^{-1}$ | $CO_2$ flux from litter pools to the atmosphere | - |
| $f_{faeces}$ | 0.3 | 0.3 | N/A | Fraction of carbon from herbivore faeces that goes into the green litter pool | Halliday, 2003 |
| $f_{ws}$ | simulated | | N/A | Factor that depends on soil moisture in the root zone and specific humidity | - |
| $f_{leaf}$ | 0.4 | 0.4 | N/A | A fixed fraction of canopy maintenance respiration that makes up the dark respiration | Knorr, 2000 |
| $g_L^{H_2O}$ | simulated | | $m\ s^{-1}$ | Canopy conductance in absence of water stress | - |
| $g_{L,stress}^{H_2O}$ | simulated | | $m\ s^{-1}$ | Canopy conductance taking into account water stress | - |
| $J_{C,stress}$ | simulated | | $\mu mol(CO_2)\ m^{-2}$ (leaf) $s^{-1}$ | Actual carboxylation rate under water stress | - |
| $J_{E,stress}$ | simulated | | $\mu mol(CO_2)\ m^{-2}$ (leaf) $s^{-1}$ | Actual electron transport rate under water stress | - |
| $k$ | 0.1 | 0.09 | N/A | LAI growth rate during growth phase | this study |
| $k_h$ | simulated | | $s^{-1}$ | Carbon loss rate from humus pool | - |
| $LAI_{max}$ | 3.6–4.1 | 3.0 | $m^2\ m^{-2}$ | Maximum leaf area index | this study |
| $p$ | veg: 0.004 rest: 0.1 | growth: 0.1 dry: 0.015 | N/A | LAI shedding rate (trees: vegetative and rest phase; grass: growth and dry season) | this study |
| $R_g$ | simulated | | $\mu mol(CO_2)\ m^{-2}\ s^{-1}$ | Growth respiration | - |
| $R_h$ | simulated | | $\mu mol(CO_2)\ m^{-2}\ s^{-1}$ | Heterotrophic respiration | - |
| $R_m$ | simulated | | $\mu mol(CO_2)\ m^{-2}\ s^{-1}$ | Maintenance respiration | - |
| $r_d$ | 0.605 | 0.8602 | $\mu mol(CO_2)\ m^{-2}$ (leaf) $s^{-1}$ | Dark respiration at 25 °C, fraction of $V_{max}$ | this study |
| Additional parameters that were altered in this study | | | | | |
| $J_{max}$ | 104.5 | 148.6 | $\mu mol(CO_2)\ m^{-2}$ (leaf) $s^{-1}$ | Maximum electron transport rate at 25 °C | this study |
| $T_{alt}$ | 4.0–4.5 | | °C | Alternation temperature | this study |
| $\theta_{cap}$ | 0.32–0.39 | 0.32–0.34 | $m\ m^{-1}$ | Volumetric soil field capacity | this study |
| $\theta_{pwp}$ | 0.13–0.21 | 0.135–0.165 | $m\ m^{-1}$ | Volumetric wilting point | this study |

| | | | | | |
|---|---|---|---|---|---|
| $V_{max}$ | 55.0 | 78.2 | μmol($CO_2$) $m^{-2}$ (leaf) $s^{-1}$ | Maximum carboxylation rate at 25 °C | this study |
| $z_{root}$ | 0.5 | 0.12 | m | Root depth | this study |

**Table S3. Parameters used by SUEWS model in the Equations of Table A1, along with their units, a short description, and the references used for determining their value.**

| Parameter | Trees | Lawn | Units | Description | Reference |
|---|---|---|---|---|---|
| $fr_i$ | 0.21 | 0.18 | N/A | Fraction of each vegetation type i | this study |
| $F_{pho,max,i}$ | 8.3 | 8.92 | μmol $m^{-2}$ $s^{-1}$ | Maximum potential photosynthesis | Havu et al., 2024 |
| $LAI_{max,i}$ | 4.8 | 3 | $m^2$ $m^{-2}$ | Full leaf-on summertime value | |
| $LAI_{min,i}$ | 0.66 | 1.6 | $m^2$ $m^{-2}$ | Leaf-off wintertime value | |
| $T_{air}$ | simulated | | °C | Air temperature | Järvi et al., 2011 |
| $\Delta q$ | input | | g/kg | Specific humidity | |
| $\Delta\theta$ | simulated | | mm | Soil moisture deficit | |
| $K_{\downarrow}$ | input | | W $m^{-2}$ | Incoming shortwave radiation | |
| $T_L$ | -10 | -10 | °C | Lower air temperature limit | |
| $T_H$ | 55 | 55 | °C | Upper air temperature limit | |
| $G_5$ | 30 | 30 | °C | Parameter related to temperature dependence | Havu et al., 2024 |
| $G_3$ | 0.66 | 0.538 | N/A | Parameter related to VPD dependence | |
| $G_4$ | 0.89 | 0.87 | N/A | Parameter related to VPD dependence | |
| $G_6$ | 0.36 | 0.55 | $mm^{-1}$ | Parameter related to soil moisture dependence | |
| $G_2$ | 477 | 263.5 | W $m^{-2}$ | Parameter related to $K_{\downarrow}$ dependence | |
| $\Delta\theta_{WP}$ | 132.5 | 143 | mm | Wilting point deficit | |
| $K_{\downarrow max}$ | 1200 | 1200 | W $m^{-2}$ | Maximum incoming shortwave radiation | Järvi et al., 2011 |
| $a_i$ | 0.78 | 1.7 | N/A | Empirical soil and vegetation respiration coefficient | Havu et al., 2024 |
| $b_i$ | 0.08 | 0.06 | N/A | Empirical soil and vegetation respiration coefficient | |
| $\omega_{1,GDD,i}$ | 0.04 | 0.04 | N/A | Parameter for LAI calculation | Järvi et al., 2014 |
| $\omega_{2,GDD,i}$ | 0.0005 | 0.0005 | N/A | Parameter for LAI calculation | Järvi et al., 2011 |
| $\omega_{1,SDD,i}$ | -1.5 | -1.5 | N/A | Parameter for LAI calculation | Järvi et al., 2014 |
| $\omega_{1,SDD,i}$ | 0.0025 | 0.0025 | N/A | Parameter for LAI calculation | Järvi et al., 2014, modified |
| $GDD$ | 300 | 300 | days | The growing degree days (GDD) needed for full capacity of the leaf area index | Järvi et al., 2011 |
| $SDD$ | -300 | -300 | days | The senescence degree days (SDD) needed to initiate leaf off | Järvi et al., 2011, modified |
| $T_{base,GDD}$ | 5 | 5 | °C | Base Temperature for initiating growing degree days (GDD) for leaf growth | Järvi et al., 2011 |
| $T_{base,SDD}$ | 10 | 10 | °C | Base temperature for initiating senescence degree days (SDD) for leaf off | |

**Table S4 Parameters used by VPRM model in the Equations of Table A1, along with their units, a short description, and the references used for determining their value.**

| Parameter | Trees | Lawn | Units | Description | Reference |
|---|---|---|---|---|---|
| $\lambda$ | -0.16 | -0.13 | µmol $CO_2$ $m^{-2}$ $s^{-1}$ | light use efficiency | Glauch et al. *submitted* |
| $PAR$ | input | | µmol $m^{-2}$ $s^{-1}$ | photosynthetically active radiation | |
| $PAR_0$ | 356.99 | 545.61 | µmol $m^{-2}$ $s^{-1}$ | half-saturation value | |
| $\alpha$ | 0.22 | 0.40 | µmol $CO_2$ $m^{-2}$ $s^{-1}$ /$^0$C | empirical coefficient | |
| $\beta$ | 1.09 | 0.42 | µmol $CO_2$ $m^{-2}$ $s^{-1}$ | empirical coefficient | |
| $T$ | input | | °C | air temperature | |
| $T_{max}$ | 40 | 40 | °C | maximum temperature for photosynthesis | |
| $T_{min}$ | 0 | 2 | °C | minimum temperature for photosynthesis | |
| $T_{opt}$ | 20 | 18 | °C | optimal temperature for photosynthesis | |
| $T_{low}$ | 0 | 0 | °C | to account for the persistence of soil respiration in winter | |

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