The TSEB model, first proposed by Norman et al. [22], is a widely used approach to simulate surface flux with various land cover types [23-25].

It is based on the energy balance principle, which can be described as follows:

$$R_{\mathrm{n}} \approx H + LE + G \quad \text{(S1)}$$

$$R_{n,s} \approx H_S + LE_S + G \quad \text{(S2)}$$

$$R_{n,c} \approx H_C + LE_C \quad \text{(S3)}$$

where *Rn* is the net radiation (i.e., incoming radiation minus outgoing radiation), *H* is the sensible heat flux, *LE* is the latent heat flux, and *G* is the soil heat flux. The subscripts *C* and *S* refer to the canopy and soil, respectively. Due to some additional flux that we always neglect, such as heat advection, the symbol "≈" is used here.

The critical process in the TSEB model is partitioning the surface radiometric temperature (i.e., T_{rad}) into soil and canopy temperature, which can be achieved using Eq. (S4):

$$T_{rad}^4(\theta) = f_C(\theta)T_C^4 + [1 - f_C(\theta)]T_S^4 \quad \text{(S4)}$$

where ϑ is the view angle, $f_c(\vartheta)$ is the vegetation fractional cover at the viewing angle, T_c is the canopy surface temperature, and T_s is the soil surface temperature. The value of $f_c(\vartheta)$ is derived from Eq. (S5):

$$f_c(\theta) = 1 - exp(\frac{-K_b\Omega(\theta)F}{cos(\theta)}) \quad \text{(S5)}$$

$$\Omega(\theta) = \frac{\Omega(0)}{\Omega(0) + ((1 - \Omega(0))\, exp(-2.2(\theta)^{3.34})} \quad \text{(S6)}$$

where K_b is set to 0.5 from experience, $\Omega(\vartheta)$ is the vegetation clumping factor at the viewing angle, which is calculated by Eq. (S6), and *F* represents the LAI that was input to the model.

After that, the sensible heat flux of the canopy and soil can be determined using Eq. (S7) and Eq. (S8), respectively:

$$H_C = \rho_{air}C_P\frac{T_S - T_{AC}}{R_X} \quad \text{(S7)}$$

$$H_S = \rho_{air}C_P\frac{T_S - T_{AC}}{R_S} \quad \text{(S8)}$$

where ρ_{air} is the density of the air (kg m^{-3}), C_P is the heat capacity of the air, T_{AC} is the air temperature in the canopy, R_X is the boundary layer resistance of the canopy, and R_S is the resistance of the boundary directly above the soil surface to heat flow.

Where R_X and R_S are computed as follows:

$$R_S = \frac{1}{c(T_S - T_A)^{1/3} + bu_s} \quad \text{(S9)}$$

$$R_X = \frac{C'}{F}\left(\frac{l_w}{U_{d_0+z_{0M}}}\right)^{1/2} \quad \text{(S10)}$$

where U is the wind speed (m s^{-1}), T_A is the air temperature (k), d_0 is the zero-plane displacement height (m), Z_{0M} is the roughness length for momentum (m), and l_w is the average leaf width (m). The parameters c and b are determined by the turbulent length scale in the canopy.. C' is set to 90 $s^{1/2}m^{-1}$. Combining the Priestley–Taylor formula with the linearization approximation to the resistance approach, which is described in detail by Norman et al. [22], T_c can be estimated by the following equation:

$$T_{ci} = T_a + \frac{R_{n,c}R_{ah}}{\rho C_P}\left(1 - \alpha_{PT} f_g \frac{g_{stress}}{g_a}\frac{\Delta}{\Delta + \gamma}\right) \quad \text{(S11)}$$

$$T_s = T_a + \frac{(R_{n,s} - G_0)(R_{ah} + R_s)}{\rho C_P}\left(1 - \alpha_s f_s \frac{\Delta}{\Delta + \gamma}\right) \quad \text{(S12)}$$

where T_{ci} is the initial vegetation temperature, T_a is the air temperature, $R_{n,c}$ is the soil net radiation, $R_{a,h}$ is the aerodynamic resistance of turbulent heat transfer between the reference height and measured height of the vegetation, α_{PT} is the Priestley–Taylor coefficient for vegetation (initially set to 1.26 , but when the soil moisture reaches saturation it will close to 2), f_g is the fraction of green vegetation, Δ is the slope of the saturation vapor pressure–temperature curve, γ is the psychrometric constant, f_s is the soil water stress factor to express the influence of water stress on soil evaporation, and g_{stress}/g_a is the plant transpiration factor 27.

The soil surface evaporation varies with soil moisture content. A soil water stress factor ($f_{s\text{-}song}$) was introduced to the TSEB model under a wet soil surface (i.e., an irrigated area in the growing season) by Song et al. [28], while an analogical factor ($f_{s\text{-}merlin}$) under dry conditions was also introduced by Merlin et al. [29] through the soil texture information. But both of the above factors have limitations in some way; the factor $f_{s\text{-}song}$ may lead to an underestimation of soil surface temperature, since it cannot restrict the process of water loss from the soil surface adequately when the soil surface moisture is near the field capacity. To fill this gap, a new stress expression f_s was introduced, which covers the full range of soil water content. This compensates for the limitations of $f_{s\text{-}merlin}$ and $f_{s\text{-}song}$.

$$f_{s-song} = \frac{2}{1 + \left(\frac{\theta}{\theta_0}\right)^{-2}} \quad \text{(S13)}$$

$$f_{s-merlin} = \frac{1}{2} - \frac{1}{2} cos(\frac{\theta}{\theta_{max}}) \quad \text{(S14)}$$

$$f_s = \sqrt{f_{s-song} f_{s-merlin}} \quad \text{(S15)}$$

where ϑ is the water content in the soil layer, θ_0 is the soil moisture at wilting, and ϑ_{max} is the saturating soil moisture.

The canopy net radiation and soil net radiation can be calculated via Eqs. (S16) and (S17), respectively:

$$R_{n,c} = \left(1 - \tau_{longwave}\right)(L_{\downarrow} + \varepsilon_s T_s^4 - 2\varepsilon_c T_c^4) + (1 - \tau_{solar})(1 - \alpha_c) S_{\downarrow} \quad \text{(S16)}$$

$$R_{n,s} = \tau_{longwave} L_{\downarrow} + (1 - \tau_{longwave}) \varepsilon_c T_c^4 - \varepsilon_s T_s^4 + \tau_{solar}(1 - \alpha_s) S_{\downarrow} \quad \text{(S17)}$$

where τ is the radiation transmission rate, ε is the radiation emissivity, α is the albedo, the subscript *longwave* represents solar longwave radiation, *solar* represents solar shortwave radiation, $L_{\downarrow}$ is the downward longwave radiation, and $S_{\downarrow}$ is the downward shortwave radiation.

The soil heat flux G_0 can be determined from Eq. (S18)

$$G_0 = (a \bullet cos(\frac{2\pi}{b}(t + c)) R_{n,s} \quad \text{(S18)}$$

where *a, b,* and *c* are constants that are based on plentiful real data, defined as the maximum ratio (a = 0.3), the shape of the sinusoidal curve (b = 80,000 s), and the phase shift of the sinusoidal curve (c = 3600 s), while *t* is the solar time angle.

After that, based on the energy balance model, the latent heat flux of the soil and canopy can be calculated.

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