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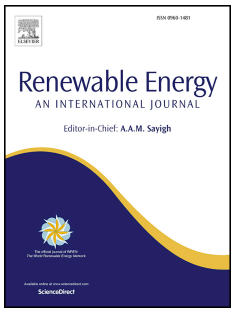

A simple heat and moisture transfer model to predict ground temperature for shallow ground heat exchangers

Maha Chalhoub, Michel Bernier, Yves Coquet, Mikael Philippe

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Nomenclature

Latin symbols	*LAI* leaf area index
a surface albedo	**Greek symbols**
b_1, b_2, b_3 empirical parameters describing the relationship between soil thermal conductivity and water content	α soil thermal diffusivity, m^2/s
C volumetric heat capacity, $J/(m^3K)$	Δ slope of the saturation vapor pressure curve, kPa/K
Clay soil clay content, % (by weight)	ε soil emissivity
c_m air specific heat, J/(kgK)	γ psychrometric constant
d displacement height, m	θ soil volumetric water content, cm^3/cm^3
E actual evaporation, $kg/(m^2s)$ or (mm/s)	θ_r residual soil water content, cm^3/cm^3
e_a actual vapor pressure, kPa	θ_s saturated soil water content, cm^3/cm^3
E_P evaporation potential, mm/s	θ_1 soil water content of the upper layer in the soil water budget model, mm
e_s saturation vapor pressure, kPa	θ_2 soil water content of the deeper layer in the soil water budget model, mm
f_m volumetric fraction of solid	θ^* soil moisture storage capacity, mm
f_{OM} volumetric fraction of organic matter	θ_1^* soil moisture storage capacity of the upper layer, mm
G heat transfer from/to soil, W/m^2	θ_2^* soil moisture storage capacity of the deeper layer, mm
H sensible heat flux, W/m^2	ρ_a air density, kg/m^3
h_c crop height, m	ρ_b soil bulk density, g/cm^3
h_1 thickness of the upper layer in the soil water budget model, mm	ρ_{OM} bulk density of soil organic matter, g/cm^3
h_2 thickness of the deeper layer in the soil water budget model, mm	ρ_s soil solid particle density, g/cm^3
k thermal conductivity, W/(mK)	ρ_w water density, kg/m^3
k von Karman constant (0.41)	σ Stephan-Boltzman constant, W/m^2K^4
L latent heat of vaporization of water, J/kg	P rainfall rate, mm/s
OM soil organic matter content, % (by weight)	r_a aerodynamic resistance, s/m
R_a incoming long-wave radiation emitted by the atmosphere, W/m^2	**Subscripts and superscripts**
r_c crop canopy resistance, s/m	i grid number
RH relative humidity	^{j} time step number
R_n net radiation, W/m^2	**Acronyms**
R_s net short-wave radiation, W/m^2	GHE Ground Heat Exchangers
r_1 stomatal resistance of a single leaf, s/m	GSHP Ground Source Heat Pump
t time, s	FAO Food and Agriculture Organization
T soil temperature, K	*Ef* Efficiency
T_a air temperature at a height of 2 m, K	*ME* Mean absolute error
T_s soil surface temperature, K	*MBE* Mean bias error
u, wind speed at height z_m, m/s	
z depth, m	
z_{oh} roughness length for water vapor, m	
z_{om} roughness length for momentum, m	
z_m measuring height of wind speed, air temperature and air humidity, m	
$\emptyset$ soil porosity	