Definition

Values and Units

αReflectivity of a surface (albedo)IsIntercepted incident Shortwave radation $ε_L$ Emissivity compared to a perfect black body0.9 to 0.98 for soils/veg $σ$ Stefan-Boltzmann constant5.67x10 ⁸ W m ⁻¹ K ⁻⁴ TTemperature in KelvinKHSensible heat flux (heating the air)W m ⁻² λE Latent heat flux (evaporation)W m ⁻² λ Heat of vaporization of water2454 kJ kg ⁻¹ at 20°CEEvaporation ratekg m- ² s ⁻¹ GStorage of heat by soil and stems (trunks)F $β$ Bowen Ratio, ratio of sensible to latent heat losses or H/ λE VDWater pressure deficit- e_w Saturated vapor pressure of water at the surface temp= e_a Vapor pressure of the air- $f(u)$ Function of air circulation associated with wind speed= E_{eq} Evaporation rate in equilibrium with specific surfacem s ⁻¹ ϵ Change of latent heat relative to change of sensible heat= 0 Air saturation deficit- ρ Density of Airkg m ⁻³ g_b boundary layer conductance for water vaporm s ⁻¹ G_V Gas constant for water vapor0.462 m ³ kPa kg ⁻¹ K ⁻¹ T_k Air temperature in Kelvin- J Joulesm ⁻² kgs ⁻² WWattsm ⁻² kgs ⁻³	R _n	Net radiation	$J m^{-2}s^{-1} $ or $W m^{-2}$
Is εLIntercepted incident Shortwave radation0.9 to 0.98 for soils/veg 0.9 to 0.9 to 0.98 for soils/veg 0.9 to 0.9 to 0.98 for soils/veg 0.9 to 0.98 for soils/veg 0.9 to 0.9 to 0.98 for soils/veg 0.9 to 0.9 to	α	Reflectivity of a surface (albedo)	
εLEmissivity compared to a perfect black body0.9 to 0.98 for soils/vegσStefan-Boltzmann constant5.67x108 W m ⁻¹ K ⁻⁴ TTemperature in KelvinKHSensible heat flux (heating the air)W m ⁻² λELatent heat flux (evaporation)W m ⁻² λHeat of vaporization of water2454 kJ kg ⁻¹ at 20°CEEvaporation ratekg m ⁻² s ⁻¹ GStorage of heat by soil and stems (trunks)FβBowen Ratio, ratio of sensible to latent heat losses or H/ λE-DWater pressure deficit-ewSaturated vapor pressure of water at the surface temp-eaVapor pressure of the air-f(u)Function of air circulation associated with wind speed-E _{eq} Evaporation rate in equilibrium with specific surfacem s ⁻¹ εChange of latent heat relative to change of sensible heat=0.7185e ^{0.0544T} D(Pa)Air saturation deficit-ρDensity of Airkg m ⁻³ gbboundary layer conductance for water vaporm s ⁻¹ ζ= $\rho(\epsilon+1) G_v T_k$ (This is a combination term)-ζvGas constant for water vapor0.462 m ³ kPa kg ⁻¹ K ⁻¹ TkAir temperature in Kelvin-JJoulesm ⁻² kgs ⁻² WWattsm ⁻² kgs ⁻³	Is	Intercepted incident Shortwave radation	
$ \begin{array}{lll} \sigma & Stefan-Boltzmann constant & 5.67x10^8 W m^{-1} K^{-4} \\ T & Temperature in Kelvin & K \\ H & Sensible heat flux (heating the air) & W m^{-2} \\ \lambda E & Latent heat flux (evaporation) & W m^{-2} \\ \lambda & Heat of vaporization of water & 2454 kJ kg^{-1} at 20°C \\ E & Evaporation rate & kg m^{-2} s^{-1} \\ G & Storage of heat by soil and stems (trunks) \\ \beta & Bowen Ratio, ratio of sensible to latent heat losses or H/ \lambda E \\ D & Water pressure deficit \\ e_w & Saturated vapor pressure of water at the surface temp \\ e_a & Vapor pressure of the air \\ f(u) & Function of air circulation associated with wind speed \\ E_{eq} & Evaporation rate in equilibrium with specific surface m s^{-1} \\ \epsilon & Change of latent heat relative to change of sensible heat \\ D(Pa) & Air saturation deficit \\ \rho & Density of Air \\ g_b & boundary layer conductance for water vapor \\ G_v & Gas constant for water vapor \\ G_v & Gas constant for water vapor \\ T_k & Air temperature in Kelvin \\ J & Joules \\ W & Watts \\ \end{array}$	ε _L	Emissivity compared to a perfect black body	0.9 to 0.98 for soils/veg
TTemperature in KelvinKHSensible heat flux (heating the air)W m² λ ELatent heat flux (evaporation)W m² λ Heat of vaporization of water2454 kJ kg²¹ at 20°CEEvaporation ratekg m²s²¹GStorage of heat by soil and stems (trunks)K β Bowen Ratio, ratio of sensible to latent heat losses or H/ λ EKDWater pressure deficitKewSaturated vapor pressure of water at the surface tempKeaVapor pressure of the airFf(u)Function of air circulation associated with wind speedKEeqEvaporation rate in equilibrium with specific surfacem s¹ ϵ Change of latent heat relative to change of sensible heat=0.7185 $e^{0.0544T}$ D(Pa)Air saturation deficitKg m³gbboundary layer conductance for water vaporm s¹ ζ = $\rho(\epsilon+1) G_v T_k$ (This is a combination term)Kg m² ζ_v Gas constant for water vapor0.462 m³ kPa kg²¹ K⁻¹T_kAir temperature in KelvinTJJoulesm²kgs²²WWattsm²kgs³	σ	Stefan-Boltzmann constant	$5.67 \times 10^8 \text{ W m}^{-1} \text{K}^{-4}$
HSensible heat flux (heating the air)W m²λELatent heat flux (evaporation)W m²λHeat of vaporization of water2454 kJ kg¹ at 20°CEEvaporation ratekg m²s¹GStorage of heat by soil and stems (trunks)kgβBowen Ratio, ratio of sensible to latent heat losses or H/ λEDWater pressure deficit e_w Saturated vapor pressure of water at the surface temp e_a Vapor pressure of the air $f(u)$ Function of air circulation associated with wind speed E_{eq} Evaporation rate in equilibrium with specific surfacem s¹ ρ Ohange of latent heat relative to change of sensible heat=0.7185 $e^{0.0544T}$ D(Pa)Air saturation deficitm s¹ ρ Density of Airkg m³ g_b boundary layer conductance for water vaporm s¹ ζ $= \rho (\varepsilon + 1) G_v T_k$ (This is a combination term) G_v Gas constant for water vapor0.462 m³ kPa kg¹ K⁻¹ T_k Air temperature in Kelvinm²kgs²² W Wattsm²kgs³	Т	Temperature in Kelvin	K
$\begin{array}{llllllllllllllllllllllllllllllllllll$	Н	Sensible heat flux (heating the air)	$W m^{-2}$
λHeat of vaporization of water2454 kJ kg ⁻¹ at 20°CEEvaporation ratekg m-2s ⁻¹ GStorage of heat by soil and stems (trunks)kg m-2s ⁻¹ βBowen Ratio, ratio of sensible to latent heat losses or H/ λ E-DWater pressure deficit-ewSaturated vapor pressure of water at the surface temp-eaVapor pressure of the air-f(u)Function of air circulation associated with wind speed-EeqEvaporation rate in equilibrium with specific surfacem s ⁻¹ cChange of latent heat relative to change of sensible heat=0.7185e ^{0.0544T} D(Pa)Air saturation deficit- ρ Density of Airkg m ⁻³ gbboundary layer conductance for water vaporm s ⁻¹ GvGas constant for water vapor0.462 m ³ kPa kg ⁻¹ K ⁻¹ T_kAir temperature in Kelvin-JJoulesm ⁻² kgs ⁻² WWattsm ² kgs ⁻³	λΕ	Latent heat flux (evaporation)	$W m^{-2}$
EEvaporation ratekg m-2s^{-1}GStorage of heat by soil and stems (trunks)kg m-2s^{-1}βBowen Ratio, ratio of sensible to latent heat losses or H/ λEkg m-2s^{-1}DWater pressure deficitkg m-2s^{-1} e_w Saturated vapor pressure of water at the surface tempkg m-2s^{-1} e_a Vapor pressure of the airkg m-2s^{-1}f(u)Function of air circulation associated with wind speedkg m-2s^{-1} E_{eq} Evaporation rate in equilibrium with specific surfacem s^{-1} ϵ Change of latent heat relative to change of sensible heat=0.7185e^{0.0544T}D(Pa)Air saturation deficitm s^{-1} ρ Density of Airkg m^{-3} g_b boundary layer conductance for water vaporm s^{-1} ζ = $\rho(\epsilon+1) G_v T_k$ (This is a combination term)K2 m ³ kPa kg^{-1} K^{-1} G_v Gas constant for water vapor0.462 m ³ kPa kg^{-1} K^{-1} I_k Air temperature in Kelvinm^{-2}kgs^{-2} M Wattsm^{2}kgs^{-3}	λ	Heat of vaporization of water	2454 kJ kg ⁻¹ at 20°C
$\begin{array}{llllllllllllllllllllllllllllllllllll$	Е	Evaporation rate	$kg m^{-2}s^{-1}$
βBowen Ratio, ratio of sensible to latent heat losses or H/ λEDWater pressure deficit e_w Saturated vapor pressure of water at the surface temp e_a Vapor pressure of the airf(u)Function of air circulation associated with wind speed E_{eq} Evaporation rate in equilibrium with specific surfacem s ⁻¹ ϵ Change of latent heat relative to change of sensible heat=0.7185 $e^{0.0544T}$ D(Pa)Air saturation deficitm s ⁻¹ ρ Density of Airkg m ⁻³ g_b boundary layer conductance for water vaporm s ⁻¹ ζ = $\rho(\epsilon+1) G_v T_k$ (This is a combination term)0.462 m ³ kPa kg ⁻¹ K ⁻¹ G_v Gas constant for water vaporm ⁻² kgs ⁻² I_k Air temperature in Kelvinm ⁻² kgs ⁻³ J Joulesm ⁻² kgs ⁻³	G	Storage of heat by soil and stems (trunks)	
$\begin{array}{llllllllllllllllllllllllllllllllllll$	β	Bowen Ratio, ratio of sensible to latent heat losses or H/ λE	
$\begin{array}{llllllllllllllllllllllllllllllllllll$	D	Water pressure deficit	
$ \begin{array}{lll} e_a & \mbox{Vapor pressure of the air} & & \mbox{Interval} & Interva$	ew	Saturated vapor pressure of water at the surface temp	
$\begin{array}{llllllllllllllllllllllllllllllllllll$	ea	Vapor pressure of the air	
$\begin{array}{lll} E_{eq} & Evaporation rate in equilibrium with specific surface & m \ s^{-1} & = 0.7185 e^{0.0544T} \\ \hline \epsilon & Change of latent heat relative to change of sensible heat & = 0.7185 e^{0.0544T} \\ D(Pa) & Air saturation deficit & kg \ m^{-3} & g_b & boundary layer conductance for water vapor & m \ s^{-1} & g_b & boundary layer conductance for water vapor & m \ s^{-1} & g_b & gas constant for water vapor & 0.462 \ m^3 \ kPa \ kg^{-1} \ K^{-1} & T_k & Air temperature in Kelvin & & \\ J & Joules & m^{-2} \ kg \ s^{-3} & & \\ W & Watts & m^{-2} \ kg \ s^{-3} & & \end{array}$	<i>f</i> (u)	Function of air circulation associated with wind speed	
$ \begin{array}{lll} \epsilon & \mbox{Change of latent heat relative to change of sensible heat} & =0.7185e^{0.0544T} \\ D(Pa) & \mbox{Air saturation deficit} & & & & & & \\ \hline \rho & \mbox{Density of Air} & & & & & & & \\ \hline g_b & & & & & & & & \\ \hline g_b & & & & & & & \\ \hline g_b & & & & & & & \\ \hline g_b & & & & & & & \\ \hline g_b & & & & & & & \\ \hline g_b & & & & & & & \\ \hline g_b & & & \\ \hline g_b & & & \\ \hline g_b & & & & \\ \hline g_b $	E _{eq}	Evaporation rate in equilibrium with specific surface	$m s^{-1}$
$\begin{array}{llllllllllllllllllllllllllllllllllll$	3	Change of latent heat relative to change of sensible heat	$=0.7185e^{0.0544T}$
$\begin{array}{lll} \rho & \mbox{ Density of Air} & \mbox{kg m}^{-3} \\ g_b & \mbox{ boundary layer conductance for water vapor} & \mbox{m s}^{-1} \\ \zeta & = \rho \left(\epsilon + 1 \right) G_v T_k \ \mbox{ (This is a combination term)} \\ G_v & \mbox{ Gas constant for water vapor} & 0.462 m^3 \text{kPa kg}^{-1} \text{K}^{-1} \\ T_k & \mbox{ Air temperature in Kelvin} \\ J & \mbox{ Joules} & \mbox{m}^{-2} \mbox{kgs}^{-2} \\ W & \mbox{ Watts} & \mbox{m}^{-2} \mbox{kgs}^{-3} \end{array}$	D(Pa)	Air saturation deficit	
$\begin{array}{ll} g_b & \mbox{boundary layer conductance for water vapor} & \mbox{m s}^{-1} \\ \zeta & = \rho \left(\epsilon + 1 \right) G_v T_k \ \mbox{(This is a combination term)} \\ G_v & \mbox{Gas constant for water vapor} & 0.462 m^3 kPa kg^{-1} K^{-1} \\ T_k & \mbox{Air temperature in Kelvin} \\ J & \mbox{Joules} & \mbox{m}^{-2} kgs^{-2} \\ W & \mbox{Watts} & \mbox{m}^{-2} kgs^{-3} \end{array}$	ρ	Density of Air	kg m ⁻³
$ \begin{array}{ll} \zeta &= \rho \left(\epsilon + 1 \right) G_v T_k & (\text{This is a combination term}) \\ G_v & \text{Gas constant for water vapor} & 0.462 \text{m}^3 \text{kPa kg}^{-1} \text{K}^{-1} \\ T_k & \text{Air temperature in Kelvin} \\ J & \text{Joules} & \text{m}^{-2} \text{kgs}^{-2} \\ W & \text{Watts} & \text{m}^{-2} \text{kgs}^{-3} \end{array} $	g_b	boundary layer conductance for water vapor	$\mathrm{m}\mathrm{s}^{-1}$
$\begin{array}{ll} G_v & \mbox{Gas constant for water vapor} & 0.462 \ m^3 \ kPa \ kg^{-1} \ K^{-1} \\ T_k & \mbox{Air temperature in Kelvin} \\ J & \mbox{Joules} & \mbox{m}^{-2} \ kgs^{-2} \\ W & \mbox{Watts} & \mbox{m}^{-2} \ kgs^{-3} \end{array}$	ζ	= $\rho (\epsilon + 1) G_v T_k$ (This is a combination term)	
$ \begin{array}{ll} T_k & \mbox{Air temperature in Kelvin} \\ J & \mbox{Joules} & \mbox{m}^{-2}\mbox{kgs}^{-2} \\ W & \mbox{Watts} & \mbox{m}^{-2}\mbox{kgs}^{-3} \end{array} $	G_v	Gas constant for water vapor	$0.462 \text{ m}^3 \text{ kPa kg}^{-1} \text{ K}^{-1}$
JJoulesm ⁻² kgs ⁻² WWattsm ⁻² kgs ⁻³	T_k	Air temperature in Kelvin	
W Watts m ⁻² kgs ⁻³	J	Joules	m ⁻² kgs ⁻²
	W	Watts	m ⁻² kgs ⁻³

Equations

 $\begin{array}{l} R_n = (1 - \alpha) \ I_s + \epsilon_L \ \sigma \ T^4 \ (surface) - \sigma \ T^4 \ (sky) \\ \text{Net Radiation} = \text{short wave radiation} + \text{long wave radiation} \end{array}$

 $\begin{array}{ll} R_n \text{-} G = H + \lambda E & 2.2 \\ \text{Net Radiation} - \text{Heat Storage} = \text{Sensible Heat Flux} + \text{Latent Heat Flux} \\ \text{Net Radiation} - \text{heat storage} = \text{Heating of the ATM without evaporation and the evaporation of water} \end{array}$

 $\lambda E = R_n / (1 + \beta)$ 2.3 Prediction for latent heat loss (assuming heat storage is minimal)

$\mathbf{E} = (\mathbf{e}_{\rm w} - \mathbf{e}_{\rm a}) \mathbf{f}(\mathbf{e}_{\rm w} - \mathbf{e}_{\rm a})$	(u)	2.4		
Evaporation rate = evaporation close to surface * air circulation				
$e_w > e_a$	Water evaporates from the surface into the air			
$e_w = e_a$	Local equilibrium so no evaporation net change in v	vater		
$e_w < e_a$	Water condenses from the air to the surface			

$\mathbf{E} = \mathbf{E}_{eq} + \mathbf{D} \mathbf{g}_{b} / \boldsymbol{\zeta}$	2.5
Calculating evaporation without knowing surface temperature	

$$E_{eq} = (\epsilon / \rho \lambda (\epsilon + 1) R_n$$
 2.6

 $\zeta = \rho (\varepsilon + 1) G_v T_k$

So:

 $E = (\epsilon / \rho \lambda (\epsilon + 1) R_n) + D g_b / (\rho (\epsilon + 1) G_v T_k)$