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1 NIHM_Modular LandScape Model model description

The main mathematical formulations applied in NIHM-MLSM are described here. Symbols are detailed in a specific list for simplicity.

1.1 Energy balance model

Assuming steady state, energy balance at the soil surface can be formulated as:

\[ R_n - \rho_n \lambda (E + Tr) - G - H = 0, \]  

(1)

Here, \( R_n \) [W.m\(^{-2}\)] is the net radiation reaching the surface; \( \rho_n \lambda E \) [W.m\(^{-2}\)] is the surface latent heat flux related to evaporation; \( \rho_n \lambda Tr \) [W.m\(^{-2}\)] is the surface latent heat flux related to transpiration; \( H \) [W.m\(^{-2}\)] represents the sensible heat flux (also termed conductive heat flux) between the surface and the atmosphere; and \( G \) [W.m\(^{-2}\)] is the conductive heat flux between the surface and the soil.

1.1.1 Estimation of the net radiation

Soil net radiation \( R_n \) is rendered by (Haghighi et al., 2017):

\[ R_n = R_{s\downarrow} (1 - \alpha) + \zeta \epsilon (\epsilon_a T_a^4 - T_s^4), \]  

(2)

where \( R_{s\downarrow} \) [W.m\(^{-2}\)] is the solar incoming radiation (short wave radiation), \( \alpha \) [-] is the albedo, \( \zeta \) [kg.s\(^{-3}\).K\(^{-4}\)] is the Stefan-Boltzmann constant, \( \epsilon \) [-] is the surface emissivity, \( \epsilon_a \) [-] is the air emissivity; and \( T_a \) [K] and \( T_s \) [K] are the air and surface temperature, respectively.

If the incoming long wave radiation \( R_{L\downarrow} \) is known, the net radiation reads:

\[ R_n = R_{s\downarrow} (1 - \alpha) + \epsilon R_{L\downarrow} - \epsilon_s T_s^4, \]  

(3)

Energy balance in NIHM-MLSM is formulated for the canopy, which is turn represented by a foliage layer and a soil layer with negligible heat capacity. The canopy layer is assumed to be semi-transparent with a reflectivity associated with the Beer-Lambert type transmission (Deardorff, 1978). Using the resistance analogy based on Ohm’s law, conductive heat fluxes \( G \) and \( H \) are expressed in terms of the near-surface gradient of temperature.

1.1.2 Energy balance in the canopy

For the surface near the canopy layer, the components of the energy balance are:
$$R_n = R_s \{ 1 - \alpha \} \left( 1 - e^{-K_W \text{LAI} \gamma} \right) + \epsilon_c R_{\text{LAI}} - \epsilon_c T_c^4$$

$$H = \frac{P_c e}{r_{ac}} (T_c - T_s)$$

$$\rho \lambda T_r = \frac{P_c e}{(r_{ac} + r_c)} \left[e_{\text{out}} (T_c) - e_s \right]$$

Evaporation is included in the interception of precipitation by the vegetation (Kergoat, 1998); we refer to Section 2.1 for additional details. Knowledge of the aerodynamic canopy resistance $r_{ac}$ and the stomatal canopy resistance $r_c$ is required to solve system of Eqs. (4).

### 1.1.2.1 Aerodynamic canopy resistance

The aerodynamic canopy resistance ($r_{ac}$) is computed as:

$$r_{ac} = \frac{\log \left( \frac{z_u - d_u}{z_{ou}} \right)}{k^2 \cdot u_c}$$

Aerodynamic roughness parameters for vegetated areas are related to the vegetation height, $h_c$, by the empirical formulations of Brutsaert (1982):

$$\begin{align*}
z_u &= h_c + W_T \\
z_h &= z_u \\
d_u &= 2/3 \cdot h_c \\
d_h &= d_u \\
z_{ou} &= 0.123 h_c \\
z_{oh} &= 0.1 z_{ou}
\end{align*}$$

Wind speed, $u_c$, is computed by:

$$u_c = \begin{cases} u \log \left( \frac{z_u}{z_{um}} \right)^{\kappa_u} & z_u > z_{um} \\
u & z_u \leq z_{um} \end{cases}$$

with $\kappa_u = 0.413$ (Brutsaert, 2005).

### 1.1.2.2 Stomatal canopy resistance

In the literature, stomatal conductance is typically preferred to its inverse, i.e., the stomatal resistance. Stomatal conductance is calculated using a Jarvis-type multiplicative model (Cox et al. 1998; Jarvis 1976) and it is affected by environmental factors embedded in efficiency functions (solar radiation, air temperature, vapor pressure deficit, and CO$_2$ concentration). The LAI is used to scale stomatal conductance to canopy conductance, i.e.,

$$g_c = g_s^{\text{max}} \left( F_{\text{PAR}} F_{\text{VPD}} F_{T} F_{\text{CO}_2} \right)$$
Here, $sg_{\text{max}}$ is the maximum value of the stomatal conductance, $LAI_{\text{act}}$ is the active part of the LAI. Considering the whole canopy as a ‘big leaf’, the active part of the canopy is equal to $LAI$ or $LAI/2$ if only one half of the big leaf is considered (Allen et al., 2004).

The efficiency functions $F$ are defined by:

$$ F_{\text{PAR}} = \ln \left( \frac{R_s^* + K_{\text{ext}} R_S^\perp}{R_s^* + K_{\text{ext}} R_S^\perp \exp(-K_{\text{ext}} LAI)} \right), $$

(9)

where $R_s^*$ is a parameter that varies between 30 and 300 W/m² depending on species (Saugier and Katerji, 1991).

The function $F_{\text{VPD}}$ takes water pressure deficit into account as (Avissar et al., 1985):

$$ F_{\text{VPD}} = \left[ 1 + \exp(-2.86 \Delta e - 3.110^{-6}) \right]^{-1}, $$

(10)

where $\Delta e$ is vapor pressure difference between the canopy layer surface and the ambient air.

The function $F_T$ describes the temperature dependence of the stomatal resistance and is expressed as:

$$ F_T = \frac{T_u - T_{\text{min}}}{T_{\text{opt}} - T_{\text{min}}} \left( \frac{T_{\max} - T_u}{T_{\text{opt}} - T_{\text{min}}} \right)^{(T_{\max} - T_{\text{opt}})/(T_{\text{opt}} - T_{\text{min}})}. $$

(11)

The optimal temperature $T_{\text{opt}}$ is around 20 to 30°C (Baldocchi et al., 1991), $T_{\text{min}}$ and $T_{\text{max}}$ being about 5°C and 45°C, respectively (Jarvis, 1976).

$F_{\text{CO}_2}$ depends on the CO$_2$ concentration in the atmosphere according to:

$$ F_{\text{CO}_2} = \frac{1}{1.4 - 0.4 \text{CO}_2 / \text{CO}_2^*}, $$

(12)

where $\text{CO}_2$ [ppm] is carbon dioxide concentration in and $\text{CO}_2^*$ [ppm] is the reference carbon dioxide concentration (which is usually set at 330 ppm) (Stockle et al., 1992).

### 1.1.3 Energy balance at the soil surface

For the soil surface, the components of the energy balance equation are:

$$ \begin{cases} R_{s,s} = R_{S_s} (1 - \alpha_s) e^{-K_{\text{ext}} LAI} + \varepsilon_s R_{L_s} - \varepsilon_s \gamma_s T_s^4 \\ G = \frac{\rho_s c_s}{r_s} (T_s - T_g) \\ H = \frac{\rho_s c_s}{r_{as}} (T_s - T_a) \\ \rho_w \lambda E = \frac{\rho_s c_s}{\gamma r_{as}} (e_s^{\text{sat}} (T_s) - e_s) \end{cases} $$

(13)
The aerodynamic soil resistance, \( r_{as} \), is computed using the formulation of Choudhury and Monteith (1988) and Shuttleworth and Gurney (1990), i.e.,

\[
\begin{align*}
    r_{as}^0 &= \frac{\ln\left(\frac{z_a}{z_{st}}\right)^2}{k^2 u_z} \\
    r_{as} &= \begin{cases} 
        \frac{r_{as}^0}{1 + Ri}^2 & Ri < 0 \\
        \frac{r_{as}^0}{1 + Ri}^{0.75} & Ri > 0 
    \end{cases} \\
    Ri &= 5g \left( z_a - d_a \right) \frac{T_a - T_s}{T_a u^2}
\end{align*}
\]  

(14)

The quantity \( r_{as}^0 \) is considered as the resistance under neutral conditions (i.e., corresponding to no temperature or vapor pressure differences at a horizontal surface of roughness \( z_{st} \)). Under non-neutral conditions, \( r_{as} \) is modified using the Richardson number \( Ri \).

Ground conduction is considered as a fraction of soil net radiation (Choudhury et al., 1987; Kustas and Daughtry, 1990):

\[
G = \alpha Rn,
\]

(15)

Here, \( \alpha = 0.50 \) or 0.70 for bare soil or open water, respectively.

1.2 Water balance in the atmosphere-vegetation-soil system

1.2.1 Water balance in the canopy

Interception by the forest canopy plays a critical role by diverting significant quantities of precipitation that would otherwise be directed to soil moisture, transpiration, and surface and groundwater recharge. Key concepts of the water balance model include:

- the intercepted water \( I_c \) is evaporated and does not contribute to the throughfall;
- the excess of water is partly stored in the canopy, whose storage capacity \( S_c \) is limited to a maximum value \( S_c^{\text{max}} \);
- throughfall is the remaining part of exceeding water.

The amount of water intercepted by the canopy is given by (Kergouat, 1998):

\[
I_c = P_s \kappa_p LAI,
\]

(16)

where \( \kappa_p \) is the rainfall interception coefficient whose value varies between 0.01 and 0.06 (Kergouat, 1998).

There are two different contributions to throughfall, i.e.,:

- the amount of water above the maximum storage capacity, defined by:
  \[
  T_{p1} = \left( S_c - S_c^{\text{max}} \right) / \Delta t
  \]
  (17)
- and the canopy leakage, defined by:
  \[
  T_{p2} = S_c (1 - K_c) / \Delta t
  \]
  (18)
Water balance in the canopy is therefore expressed as:

\[
\begin{align*}
\frac{dS}{dt} &= P_t - E_c - T_p \\
E_c &= I_c \\
T_p &= T_{p1} + T_{p2}
\end{align*}
\] (19)

\(P_t\), \(S_c\), and \(T_p\) corresponding to the rainfall rate, the actual canopy storage, and the throughfall, respectively.

The maximum canopy storage capacity is estimated by (von Hoyningen-Huene, 1983):

\[
S_c^{\text{max}} = \left(0.935 + 0.498 \cdot \text{LAI} - 0.00575 \cdot \text{LAI}^2 \right) \cdot 10^{-3}.
\] (20)

1.2.2 The snow routine

The model is an adaptation of the snow module of the HBV hydrological model (Seibert and Bergström, 2022; Seibert and Vis, 2012). The first step consists in splitting precipitation (after interception) in either snow, rain, or both. This is achieved through the following formulations:

\[
\begin{align*}
P_s &= T_p, \quad P_{s0} = 0, \quad T \geq T_s^{\text{max}} \\
P_s &= 0, \quad P_{s0} = T_p, \quad T \leq T_s^{\text{min}} \\
P_s &= \kappa_s T_p, \quad P_{s0} = (1 - \kappa_s) T_p, \quad T_s^{\text{min}} < T < T_s^{\text{max}}
\end{align*}
\] (21)

where \(P_s\) and \(P_{s0}\) denote the amount of water and snow reaching the soils surface, respectively; \(T_s^{\text{min}}\) and \(T_s^{\text{max}}\) are the two temperature thresholds, set to -3°C and 1°C, respectively; and \(\kappa_s\) is a proportional factor varying linearly from 0 at \(T_s^{\text{min}}\) to 1 at \(T_s^{\text{max}}\).

We use a conceptual model based on snowpack temperature to estimate snow volume and snowmelt flux. The average snow pack temperature is estimated through (Neitsch et al., 2002):

\[
T_{\text{Sn}}^{n+1} = \min \left(0, w_n T_{\text{Sn}}^n + (1 - w_n) \cdot T_A^n \right),
\] (22)

where \(T_{\text{Sn}}^n\) is the snow pack temperature [°C] at time step \(n\), \(T_A^n\) is the air temperature [°C], and \(w_n\) is a user defined weighting factor, here set to 0.3.

The stored snow volume is updated accordingly. Snow melting takes place only if the temperature is higher than the user defined melting temperature \(T_m\) (set to 0 °C in this model) and if the snow pack temperature is 0 °C. When these two conditions are fulfilled, the melted snow flux is given by:

\[
Q_{\text{Sn}} = \kappa_{\text{Sn}} \left(T_A^n - T_{\text{Sn}}^n \right),
\] (23)

where \(Q_{\text{Sn}}\) is the melted snow flux and \(\kappa_{\text{Sn}}\) is a proportionality coefficient, also termed degree-day factor, which is set to \(10^{-4}\) m/s/°C.
1.2.3 Flow in the unsaturated zone

Flow in the unsaturated zone is described by a series of reservoirs. The first two represent the litter and the root zone, respectively. Each reservoir is defined by the water content at saturation, \( \theta_s \), the water content at wilting point, considered as the residual water content, \( \theta_r \), and the water content at field capacity, \( \theta_c \).

Throughfall and melted snow infiltrate in the litter layer. Evaporation computed by energy balance at soil surface occurs in this layer only, and is depending on the water content. The water drained from the litter layer enters the root layer. Transpiration, estimated by energy balance at the canopy, occurs in this layer only, and is depending on the available water. Drainage from these two layers is estimated in two ways: (i) the water volume above the layer field capacity is drained immediately, representing water movement through gravity; (ii) when the water content lies between the field capacity and the wilting point (residual water content), drainage is computed as an exponential function of the available water.

Water balance for a given layer is formulated as:

\[
T_e \frac{d\theta}{dt} = Q_{in} - Q_s - Q_d,
\]

where \( T_e \) is the layer thickness, \( \theta \) is the volumetric water content, \( Q_{in} \) is water infiltration (throughfall and melted snow for the first layer), \( Q_s \) is the sink/source term due to evaporation or transpiration, and \( Q_d \) is the drainage flux leaving the layer and supplying the next one.

For the first layer, if the water content is greater than porosity, \( \theta^{n+1} \) is set to the saturated water content \( \theta_s \) and the amount of infiltrated water is reduced accordingly, assuming that runoff occurs.

The drainage \( Q_d \) is computed through:

\[
\begin{align*}
Q_d &= (\theta - \theta_s) / \Delta t & \text{if } \theta \geq \theta_s \\
Q_d &= (e^{\kappa_d(\theta - \theta_s)} - 1.00) / \Delta t & \text{if } \theta_s \leq \theta \leq \theta_c \\
Q_d &= 0.0 & \text{if } \theta \leq \theta_r
\end{align*}
\]

where \( \kappa_d \) is the drainage coefficient.

In this version of NIHM-MLSM, the root zone drainage is considered as groundwater recharge.
2 Estimation of canopy albedo

Values of albedo used in NIHM-MLSM are provided by satellite data and correspond to average values at the pixel size. Since information on land use are available (through Corine Land Cover), it is possible to distinguish bare soils from vegetated areas and assess energy balance.

Following Taconnet et al. (1986), we consider a soil layer below the canopy that allows accounting for the reflection of the radiation trapped between soil and vegetation. The global albedo, $\alpha_g$, of this system is given by (Taconnet et al., 1986):

$$\alpha_g = \sigma_c \alpha_c + \frac{\alpha_s (1-\sigma_s)^2}{1-\sigma_c \alpha_c \alpha_s},$$

with:

$$\sigma_c = 1 - \exp(-K_{ext} \text{LAI}).$$

From the global albedo, $\alpha_g$, and assuming that the soil albedo, $\alpha_s$, is known, it is possible to estimate the canopy albedo by:

$$\left(\sigma_c^2 \alpha_s \right) \alpha_c^2 - \sigma_c \left( \alpha_g \alpha_s +1 \right) \alpha_c + \left( \alpha_g - \alpha_s (1-\sigma_s)^2 \right) = 0$$

It can be readily shown that Eq. (28) has always two real solutions and only one, i.e.:

$$\alpha_c = \frac{\left( \alpha_g \alpha_s +1 \right) - \sqrt{\left( \alpha_g \alpha_s -1 \right)^2 + 4 \alpha_s^2 (1-\sigma_s)^2}}{2\sigma_c \alpha_s}.$$
### NIHM_Modular LandScape Model symbol list

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c_a$</td>
<td>Specific heat of dry air at constant pressure</td>
<td>J/kg/K</td>
<td>$1.013 \times 10^3$</td>
</tr>
<tr>
<td>$CO_2$</td>
<td>Carbone dioxide concentration (ppm)</td>
<td>kg/kg</td>
<td></td>
</tr>
<tr>
<td>$d_h$</td>
<td>Reference elevation for humidity</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>$d_a$</td>
<td>Evaporation flux</td>
<td>m/s</td>
<td></td>
</tr>
<tr>
<td>$E_c$</td>
<td>Evaporation flux from the canopy</td>
<td>m/s</td>
<td></td>
</tr>
<tr>
<td>$e_a$</td>
<td>Air partial water vapor pressure.</td>
<td>Pa</td>
<td></td>
</tr>
<tr>
<td>$e_s$</td>
<td>Vapor pressure.</td>
<td>Pa</td>
<td></td>
</tr>
<tr>
<td>$e_{s_{\text{sat}}}$</td>
<td>Vapor pressure at saturation.</td>
<td>Pa</td>
<td></td>
</tr>
<tr>
<td>$F_{CO_2}$</td>
<td>CO$_2$ efficiency function.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>$F_{PAR}$</td>
<td>Photosynthetic active radiation efficiency function.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>$F_T$</td>
<td>Temperature efficiency function.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>$F_{VPD}$</td>
<td>Vapor pressure deficit efficiency function.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>$G$</td>
<td>Conductive heat flux between surface and the ground</td>
<td>W/m$^2$</td>
<td></td>
</tr>
<tr>
<td>$g$</td>
<td>Gravity</td>
<td>m/s$^2$</td>
<td>9.81</td>
</tr>
<tr>
<td>$g_e$</td>
<td>Canopy conductance</td>
<td>m/s</td>
<td></td>
</tr>
<tr>
<td>$g_s^{\text{max}}$</td>
<td>Maximum conductance of fully open stomata</td>
<td>m/s</td>
<td></td>
</tr>
<tr>
<td>$H$</td>
<td>Sensible heat flux (conductive heat flux) between the surface and the atmosphere</td>
<td>W/m$^2$</td>
<td></td>
</tr>
<tr>
<td>$h_c$</td>
<td>Canopy height</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>$I_c$</td>
<td>Water interception by the canopy</td>
<td>m/s</td>
<td></td>
</tr>
<tr>
<td>$K_{\text{ext}}$</td>
<td>Attenuation coefficient depending on the vegetation</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>$k$</td>
<td>Von Karman constant</td>
<td>-</td>
<td>0.40</td>
</tr>
<tr>
<td>$LAI$</td>
<td>Leaf area index</td>
<td>m$^2$/m$^2$</td>
<td></td>
</tr>
<tr>
<td>$LAI_{\text{act}}$</td>
<td>Active part of the LAI</td>
<td>m$^2$/m$^2$</td>
<td></td>
</tr>
<tr>
<td>$P_{\text{atm}}$</td>
<td>Air pressure</td>
<td>Pa</td>
<td></td>
</tr>
<tr>
<td>$PAR$</td>
<td>Photosynthetic active radiation (400–700 nm)</td>
<td>W/m$^2$</td>
<td></td>
</tr>
<tr>
<td>$P_r$</td>
<td>Precipitation</td>
<td>m/s</td>
<td></td>
</tr>
<tr>
<td>$P_s$</td>
<td>Precipitation as liquid</td>
<td>m/s</td>
<td></td>
</tr>
<tr>
<td>$P_{sn}$</td>
<td>Precipitation as snow</td>
<td>m/s</td>
<td></td>
</tr>
<tr>
<td>$Q_{\text{sm}}$</td>
<td>Melted snow infiltration flux</td>
<td>m/s</td>
<td></td>
</tr>
</tbody>
</table>
\( Q_{in} \) Reservoir inflow water flux \( m/s \)

\( Q_{dr} \) Reservoir drainage water flux \( m/s \)

\( Q_s \) Sink/source term in the soil reservoir (evaporation for litter layer, transpiration for the root zone) \( m/s \)

\( q_a \) Air specific humidity \( kg/kg \)

\( R_{SW} \) Short wave radiation incoming from the sun (400–2500 nm) \( W/m^2 \)

\( R_{IR} \) Long wave (infra-red) incoming radiation \( W/m^2 \)

\( Ri \) Richardson number -

\( R_n \) Net radiation \( W/m^2 \)

\( r_{ac} \) Aerodynamic resistance of the canopy surface \( s/m \)

\( r_{as} \) Aerodynamic resistance of the soil surface \( s/m \)

\( r_0 \) Soil surface aerodynamic resistance at neutral conditions \( s/m \)

\( r_c \) Canopy resistance \( s/m \)

\( r_g \) Soil resistance to heat exchange \( s/m \)

\( S_c \) Canopy water storage capacity \( m \)

\( S_c^{max} \) Canopy maximum water storage capacity \( m \)

\( T_a \) Air temperature \( K \)

\( T_c \) Near canopy surface temperature \( K \)

\( T_s \) Near soil surface temperature \( K \)

\( Tr \) Transpiration flux \( m/s \)

\( T_{min} \) Minimal temperature threshold for stomatal resistance. \( K \)

\( T_{max} \) Maximal temperature threshold for stomatal resistance. \( K \)

\( T_{opt} \) Optimal temperature for stomatal resistance. \( K \)

\( T_{smin} \) Minimal temperature threshold for liquid/snow partition. \( K \)

\( T_{smax} \) Maximal temperature threshold for liquid/snow partition. \( K \)

\( T_{sm} \) Snow melting threshold coefficient -

\( T_L \) Layer thickness \( m \)

\( T_p \) Throughfall \( m/s \)

\( T_{pl} \) Throughfall from water excess \( m/s \)

\( T_{p2} \) Throughfall from canopy drainage \( m/s \)

\( u \) Measured wind speed \( m/s \)

\( u_c \) Corrected wind speed \( m/s \)

\( w_m \) Weighting coefficient for snow storage - 0.30
$W_T$ Turbulence layer thickness above canopy  
$z_{uw}, z_{uh}$ Height above the canopy layer for wind and humidity  
$z_{um}$ Elevation at which wind speed has been measured  
$z_{ss}$ Soil roughness length  
$z_{sr}, z_{oh}$ Roughness length for momentum and humidity

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Unit</th>
<th>Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_c, \alpha_s$</td>
<td>Canopy and soil albedo.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$\chi$</td>
<td>Psychrometric function.</td>
<td>Pa/K</td>
<td>-</td>
</tr>
<tr>
<td>$\Delta e$</td>
<td>Vapor pressure difference between the canopy layer surface and the ambient air.</td>
<td>Pa</td>
<td>-</td>
</tr>
<tr>
<td>$\varepsilon_a, \varepsilon_c, \varepsilon_s$</td>
<td>Air, canopy and soil emissivity and absorptivity.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$\zeta$</td>
<td>Stefan-Boltzmann constant.</td>
<td>W/m/K$^4$</td>
<td>$5.670 \times 10^{-8}$</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Water content.</td>
<td>m$^3$/m$^3$</td>
<td>-</td>
</tr>
<tr>
<td>$\theta_f$</td>
<td>Water content at field capacity.</td>
<td>m$^3$/m$^3$</td>
<td>-</td>
</tr>
<tr>
<td>$\theta_w$</td>
<td>Water content at the wilting point.</td>
<td>m$^3$/m$^3$</td>
<td>-</td>
</tr>
<tr>
<td>$\theta_s$</td>
<td>Water content at saturation.</td>
<td>m$^3$/m$^3$</td>
<td>-</td>
</tr>
<tr>
<td>$\kappa_d$</td>
<td>Drainage coefficient.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$\kappa_p$</td>
<td>Rainfall interception coefficient.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$\kappa_{sn}$</td>
<td>Water/snow partition coefficient.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$\kappa_{sm}$</td>
<td>Degree day factor for snow melting.</td>
<td>m/s/°C</td>
<td>$10^4$</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>Latent heat of water vaporization.</td>
<td>J/kg</td>
<td>$2.45 \times 10^6$</td>
</tr>
<tr>
<td>$\rho_a$</td>
<td>Air density.</td>
<td>kg/m$^3$</td>
<td>1.204</td>
</tr>
<tr>
<td>$\rho_w$</td>
<td>Water density.</td>
<td>kg/m$^3$</td>
<td>999.9</td>
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</table>
4 Parameter identification codes for the sensitivity analysis

<table>
<thead>
<tr>
<th>Id</th>
<th>Parameter</th>
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<tbody>
<tr>
<td>1-12</td>
<td>LAI</td>
</tr>
<tr>
<td>13-24</td>
<td>Albedo</td>
</tr>
<tr>
<td>25</td>
<td>Root zone field capacity</td>
</tr>
<tr>
<td>26</td>
<td>Root zone porosity</td>
</tr>
<tr>
<td>27</td>
<td>Litter drainage rate</td>
</tr>
<tr>
<td>28</td>
<td>Root zone drainage rate</td>
</tr>
<tr>
<td>29</td>
<td>Litter layer thickness</td>
</tr>
<tr>
<td>30</td>
<td>Litter layer porosity</td>
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<td>31</td>
<td>Litter zone field capacity</td>
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<tr>
<td>32</td>
<td>Rainfall interception coefficient</td>
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<tr>
<td>33</td>
<td>Canopy radiation attenuation coefficient</td>
</tr>
<tr>
<td>34</td>
<td>Root zone thickness</td>
</tr>
<tr>
<td>35</td>
<td>Maximum conductance of fully open stomata</td>
</tr>
<tr>
<td>36</td>
<td>Canopy height</td>
</tr>
</tbody>
</table>

The five last lines are repeated for each type of vegetation.
References


