

Manitou 2001-2002 Data, Version 1.3.

A new set of derived heat-flux calculations were added to the data based on Philip's correction:

$$G_s = G_m[1 - \beta r(1 - \epsilon^{-1})]$$

Where G_s is the soil heat-flux, G_m is the measured heat flux, β is a constant (1.31 for Thermonetics, 1.70 for REBS), r is the aspect ratio of the heat-flux plate (thickness/width; ~0.15 for Thermonetics, 0.102 for REBS), and ϵ^{-1} is the ratio of thermal conductivity of the soil to the heat-flux plate, λ_s/λ_p .

For the Thermonetics sensors used the aspect ratio was:

$$\begin{aligned} 5 \text{ cm: } r &= 0.1554 \\ 10 \text{ cm: } r &= 0.1511 \\ 30 \text{ cm: } r &= 0.1603 \end{aligned}$$

Soil thermal conductivity was estimated from the site empirical model:

$$\begin{aligned} \lambda_{\text{unburned}} &= 0.1234\rho_b + 8.21\theta_v \text{ (Wm}^{-1}\text{K}^{-1}\text{)} \\ \lambda_{\text{burned}} &= 0.486\rho_b + 2.70\theta_v \text{ (Wm}^{-1}\text{K}^{-1}\text{)} \end{aligned}$$

where ρ_b is the soil bulk density and θ_v is the soil volumetric water content. During the January 2002 burn, the model was changed from unburned to burned the moment that sensible heat-flux due to the burn was detected (note, this was difficult to define, so the moment heat-flux switched signs was chosen). The model was not switched below 0.1 m because the heat-flux and temperatures were insufficient to justify it. It is assumed that all burns in the meadow and forest (reps 5 and 6) were insufficient to justify switching from the unburned to the burned model.

Soil bulk density was estimated from the site empirical model:

$$\text{rep 1: } \rho_b = 1.405 + 1.18z \text{ (Mgm}^{-3}\text{)}$$

where z is the depth (m), and rep 1 is the "old-slash" site. There were few measurements of bulk density at the meadow and forest sites (reps 5 and 6). Previous statistically analysis was ambiguous, yet there was reason to believe the soil density was similar at all three reps, thus the one model above was used for reps 5 and 6 as well. The empirical model was only valid over the range 0-0.2 m. For the Philip correction the model was also used for 0.3 m, at which point the density was assumed constant with increasing depth at 1.76 Mgm⁻³.

Water content was not measured at any of the reps until day 198 of 2002 (long after the sensors were removed).

The water content of the slash-pile (rep 1) was straightforward to guess. From field observations and photographs the soil was extremely dry when sensors were installed (2001 day 285). The slash-pile was amended six days later (day 291) during which time there was no measurable precipitation (Manitou Headquarters data). The slash-pile was on top of the soil until it was burned (2002 day 11). From

then until the sensors were removed (2002 day 81) only 10.7 mm (0.42") of precipitation fell. The most in one day was 3.3 mm (0.13") and there were a minimum of three non-precipitation days between events (excluding days 73 to 81, when consecutive days precipitated, yet the total for those days was still only 4.6 mm or 0.18"). Therefore, the water content was assumed constant at all depths for the duration of rep1 measurements to be $0.02 \text{ m}^3\text{m}^{-3}$.

The water content of the forest and meadow (reps 5 and 6) was not as straightforward to guess. Photographs from installation on 2001 day 88 show the soil probably had moderate water content ($0.15 \text{ m}^3\text{m}^{-3}$ was estimated from the photographs and personal experience). Manitou Headquarters recorded 216.7 mm (8.53") of precipitation fell from 2001 days 88 through 260. From 2001 day 261 until the sensors were removed (2002 day 66) only 19.8 mm (0.78") of precipitation fell. Data collected from Mark Platten on the day of the burn (2001 day 313) estimated soil water content at $0.02\text{-}0.03 \text{ m}^3\text{m}^{-3}$. Thus, a guess of water content at reps 5 and 6 had three parts: a constant $0.15 \text{ m}^3\text{m}^{-3}$ from 2001 days 88 through 260, a constant $0.02 \text{ m}^3\text{m}^{-3}$ from 2001 day 313 through 2002 day 66, and a linearly decreasing water content from $0.15 \text{ m}^3\text{m}^{-3}$ to $0.02 \text{ m}^3\text{m}^{-3}$ from 2001 days 261 to 313.

Thermal conductivity of the Thermonetics heat-flux plates were estimated from:

$$\lambda(T) = K(T) \cdot (NP_c t)$$

where $K(T)$ is the temperature dependent heat-flux plate calibration (introduced in version 1. 3), N is the number of junctions per heat-flux plate, P_c is the thermoelectric power ($5/9 \cdot 0.023 \text{ mVC}^{-1}$), and t is the plate thickness (m). Missing temperature data was linearly interpolated over time.

For the Thermonetics sensors used the thermal conductivity was estimated from:

$$\begin{aligned} 5 \text{ cm: } \lambda(T) &= 0.001693 \cdot T + 0.5757 \text{ Wm}^{-1}\text{K}^{-1} \\ 10 \text{ cm: } \lambda(T) &= 0.002074 \cdot T + 0.5858 \text{ Wm}^{-1}\text{K}^{-1} \\ 30 \text{ cm: } \lambda(T) &= 0.002300 \cdot T + 0.7332 \text{ Wm}^{-1}\text{K}^{-1} \end{aligned}$$

Thermal conductivity of the REBS plates was $1.22 \text{ Wm}^{-1}\text{K}^{-1}$.

References:

Philip, J.R. 1961. The theory of heat flux meters. J. Geophys. Res. 66:571-579.