# Note on the application of the Philip correction to the REBS heat flux measurements

Steven Oncley

May 9, 2005

The presence of a heat flux plate in the soil distorts the heat flow through the soil, if the thermal conductivity of the plate is not equal to that of the soil. From Philip (1961), we have

$$f(\epsilon) = \frac{G_p}{G_s} = \frac{1}{1 - 1.92\frac{T}{D}(1 - \epsilon^{-1})} \tag{1}$$

where $G_p$ and $G_s$ are the heat flux through the plate and through the soil, $T = 3.93$ mm is the plate thickness, $D = 38.56$ mm is the plate diameter, $\epsilon = \lambda_p/\lambda_s$, $\lambda_p$=1.22 Wm$^{-1}$K$^{-1}$ is the thermal conductivity of the plate and $\lambda_s$ is the thermal conductivity of the soil. The manufacturer's calibration medium has a thermal conductivity $\lambda_c$=0.906 Wm$^{-1}$K$^{-1}$ and output a measured value $G_m$ based on this conductivity. Thus,

$$G_s = \frac{G_p}{f(\lambda_p/\lambda_s)} = \frac{G_m f(\lambda_p/\lambda_c)}{f(\lambda_p/\lambda_s)} = \frac{1.053 G_m}{f(\lambda_p/\lambda_s)}. \tag{2}$$

To use this correction, we need to know $\lambda_s$.

From Lange's Handbook of Chemistry (11th ed.), $\lambda_{dry.soil} = 0.14\, Wm^{-1}K^{-1}$ and $\lambda_{water} = 0.6\; Wm^{-1}K^{-1}$. For soil moisture content in the range from 0.10 to 0.40, a mass-weighted total thermal conductivity

$$\lambda_s = \frac{Q_{soil}}{1 + Q_{soil}}\lambda_{water} + \frac{1}{1 + Q_{soil}}\lambda_{dry.soil} \tag{3}$$

produces values of $0.18 - 0.27\; Wm^{-1}K^{-1}$. (I'm not sure that this mass-weighting formuation is correct.) For these values of $\lambda_s$, $f(\lambda_p/\lambda_c)/f(\lambda_p/\lambda_s) = 0.88 - 0.89$. Thus, our measured soil heat flux would be about 12% low. Note that actual values of $\lambda_{dry.soil}$ could be quite different. Nevertheless, I would guess that 10% is a typical error for uncorrected $G_{soil}$.

In 2002 (FLOSSII), we started using the Hukseflux TP01 in our deployments which reports $\lambda_s$, so now it is possible to implement this correction routinely.

## Reference

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