$$
\begin{aligned}
P^2 &= \left(\frac{4\pi^2}{GM}\right)\ {}^3 \\
\text{Incoming energy} &= \left(\frac{L_*}{4\pi a^2}\right)\ \pi R^2 \\
\text{Outgoing energy} &= \left(\sigma T^4\right)\ 4\pi R^2 \\
\left(\frac{L_*}{4\pi a^2}\right)\ \pi R^2 &= \left(\sigma T^4\right)\ 4\pi R^2 \\
T^4 &= \frac{L_*}{16\pi a^2 \sigma} \\
\frac{T_{\mathrm{b}}}{T_{\mathrm{Earth}}} &= \left(\frac{0.00155/1.0}{(0.05/1.0)^2}\right)^{1/4} \\
&= 0.89
\end{aligned}
$$