

SUPPLEMENTARY FILE S2

A. Derivation of Equation 7

Following Hay 1993 (Eq. 1) we can write:

$$\cos(i) = \cos(s) \cos(i_{CTX}) + \sin(s) \sin(i_{CTX}) \cos(a - b) \quad (\text{A.1})$$

where i_{CTX} is CTX data incidence angle for a horizontal surface (represents solar zenith angle) [°], i is the i_{CTX} corrected against relief characteristics (represents an angle of incidence between the sun and normal to the surface) [°], s is slope angle [°], a is the azimuth angle of the sun [°], b is the azimuth angle of the slope [°].

Introducing:

$$b = 180^\circ - e \quad (\text{A.2})$$

where e is aspect [°], to equation A.1, we obtain:

$$\cos(i) = \cos(s) \cos(i_{CTX}) + \sin(s) \sin(i_{CTX}) \cos(a - (180^\circ - e)) \quad (\text{A.3})$$

To calculate the azimuth angle, we first use Eq.4 of Hay (1993):

$$\cos(a) = \frac{\sin(\varphi) \cos(i_{CTX}) - \sin \delta}{\cos(\varphi) \sin(i_{CTX})} \quad (\text{A.4})$$

where φ is latitude [°], δ is solar declination [°]. Subsequently, we introduce Eqs. 11 and 12 of Cucumo et al. (1997) obtaining:

$$a = \arccos\left(\frac{\sin(\varphi) \cos(i_{CTX}) - \sin(\delta)}{\cos(\varphi) \sin(i_{CTX})}\right) \text{ if } t < 12 \text{ or } -\arccos\left(\frac{\sin(\varphi) \cos(i_{CTX}) - \sin(\delta)}{\cos(\varphi) \sin(i_{CTX})}\right) \text{ if } t > 12 \quad (\text{A.5})$$

where t is solar local time given in hour.

Introducing Eq. A.5 into Eq. A.3, we obtain:

$$\begin{aligned} \cos(i) &= \cos(s) \cos(i_{CTX}) + \sin(s) \sin(i_{CTX}) * \cos \left(\arccos \left(\frac{\sin(\varphi) \cos(i_{CTX}) - \sin(\delta)}{\cos(\varphi) \sin(i_{CTX})} \right) - (180^\circ - e) \right) \text{ if } t < 12 \text{ or} \\ \cos(i) &= \cos(s) \cos(i_{CTX}) + \sin(s) \sin(i_{CTX}) * \cos \left(-\arccos \left(\frac{\sin(\varphi) \cos(i_{CTX}) - \sin(\delta)}{\cos(\varphi) \sin(i_{CTX})} \right) - (180^\circ - e) \right) \text{ if } t > 12 \end{aligned} \quad (\text{A.6})$$

Introducing the following equation A.7 to equation A.6:

$$\sin(\delta) = \sin(\epsilon) \sin(Ls + x * \sin(Ls - Ls^P)) \quad (\text{A.7})$$

where Ls is solar longitude [$^\circ$], Ls^P is longitude of the perihelion = 251° , ϵ is Mars axial tilt = 25.32° , implying $\sin(T) = -0.428$; x is Mars orbital eccentricity = 0.0935, we obtain:

$$\begin{aligned} \cos(i) &= \cos(s) \cos(i_{CTX}) + \sin(s) \sin(i_{CTX}) \cos \left(\arccos \left(\frac{\sin(\varphi) \cos(i_{CTX}) + 0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))}{\cos(\varphi) \sin(i_{CTX})} \right) - (180^\circ - e) \right) \text{ if } t < 12 \text{ or} \\ \cos(i) &= \cos(s) \cos(i_{CTX}) + \sin(s) \sin(i_{CTX}) \cos \left(-\arccos \left(\frac{\sin(\varphi) \cos(i_{CTX}) + 0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))}{\cos(\varphi) \sin(i_{CTX})} \right) - (180^\circ - e) \right) \text{ if } t > 12 \end{aligned} \quad (\text{A.8})$$

and consequently:

$$\begin{aligned} i &= \arccos \left[\cos(s) \cos(i_{CTX}) + \sin(s) \sin(i_{CTX}) * \cos \left(\arccos \left(\frac{\sin(\varphi) * \cos(i_{CTX}) + 0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))}{\cos(\varphi) \sin(i_{CTX})} \right) - (180^\circ - e) \right) \right] \text{ if } t \\ &\quad < 12 \text{ or} \\ i &= \arccos \left[\cos(s) \cos(i_{CTX}) + \sin(s) \sin(i_{CTX}) \right. \\ &\quad \left. * \cos \left(-\arccos \left(\frac{\sin(\varphi) * \cos(i_{CTX}) + 0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))}{\cos(\varphi) \sin(i_{CTX})} \right) - (180^\circ - e) \right) \right] \text{ if } t > 12 \end{aligned} \quad (\text{A.9})$$

In the main text, Eq. A.9 is referred to as Eq 7, with the right side terms of the Equation renamed as $\arccos(L)$ and $\arccos(M)$ for the sake of simplicity:

$$\begin{aligned} i &= \arccos(L) \text{ if } t < 12 \\ \text{or } i &= \arccos(M) \text{ if } t > 12 \end{aligned} \quad (6)$$

B. Derivation of Eq. 8

To derive Eq.8, we recall the simple equation for instant incident radiation (I_i) :

$$I_i = F \cdot \cos i \quad (\text{B.1})$$

where F stands for the mean total solar irradiance. We then combine Eq. A.8 with Eq. B.1, obtaining:

$$\begin{aligned} I_i &= F \left[\cos(s) \cos(i_{CTX}) + \sin(s) \sin(i_{CTX}) \cos \left(\arccos \left(\frac{\sin(\varphi) \cos(i_{CTX}) - 0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))}{\cos(\varphi) \sin(i_{CTX})} \right) - (180^\circ - e) \right) \right] \text{ if } t < 12 \text{ or} \\ I_i &= F \left[\cos(s) \cos(i_{CTX}) + \sin(s) \sin(i_{CTX}) \cos \left(-\arccos \left(\frac{\sin(\varphi) \cos(i_{CTX}) - 0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))}{\cos(\varphi) \sin(i_{CTX})} \right) - (180^\circ - e) \right) \right] \text{ if } t > 12 \end{aligned} \quad (\text{B.2})$$

To obtain $\sum I_i^{4-t_d}$ we need to integrate Eq. B.2 over the time interval between 4 and t_d :

$$\begin{aligned} \sum I_i^{4-t_d} &= \int_6^{12} F \left[\cos(s) \cos(i_{CTX}) + \sin(s) \sin(i_{CTX}) \cos \left(\arccos \left(\frac{\sin(\varphi) \cos(i_{CTX}) - 0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))}{\cos(\varphi) \sin(i_{CTX})} \right) - (180^\circ - e) \right) \right] \\ &\quad + \int_{12}^{t_d} F \left[\cos(s) \cos(i_{CTX}) + \sin(s) \sin(i_{CTX}) \cos \left(-\arccos \left(\frac{\sin(\varphi) \cos(i_{CTX}) - 0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))}{\cos(\varphi) \sin(i_{CTX})} \right) - (180^\circ - e) \right) \right] \end{aligned} \quad (\text{B.3})$$

The t term is hidden in this equation under the $\cos i_{CTX}$ and $\sin i_{CTX}$ terms. As mentioned while deriving Eq. 7, i_{CTX} represents the solar zenith angle. Its cosine is calculated as follows (Hay 1993, Eq. 3):

$$\cos(i_{CTX}) = \sin(\varphi) \sin(\delta) + \sin(\varphi) \sin(\delta) \cos(h) \quad (\text{B.4})$$

where h is the hour angle of the Sun defined as a function of time using the following conversion:

$$h = 180^\circ - 15t \quad (\text{B.5})$$

Combining equations A.7, B.4, and B.5, we obtain:

$$\cos(i_{CTX}) = \sin(\varphi) \sin(0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ)) + \sin(\varphi) \sin(0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ)) \cos(180^\circ - 15t)) \quad (\text{B.6})$$

and based on trigonometric identities:

$$\sin(i_{CTX}) = \sqrt{1 - (-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ)) \sin(\varphi) + \cos(\varphi) \cos(\arcsin(-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))) \cos(180^\circ - 15t))}^2 \quad (\text{B.7})$$

Finally, combining equations B.3, B.6, and B.7 we obtain the final equation:

$$\begin{aligned}
\int_4^{t_d} I_I = & \int_4^{12} F \left[\cos(s) * (-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ)) \sin(\varphi) + \cos(\varphi) \cos(\arcsin(-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))) \cos(180^\circ - 15t)) + \right. \\
& + \sin(s) \sqrt{1 - (-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ)) \sin(\varphi) + \cos(\varphi) \cos(\arcsin(-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))) \cos(180^\circ - 15t)))^2} * \\
& * \cos \left(\arccos \left(\frac{\sin(\varphi) * [(-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ)) \sin(\varphi) + \cos(\varphi) \cos(\arcsin(-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))) \cos(180^\circ - 15t))] + 0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))}{\cos(\varphi) \sqrt{1 - (-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ)) \sin(\varphi) + \cos(\varphi) \cos(\arcsin(-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))) \cos(180^\circ - 15t)))^2}} \right) - (180^\circ - e) \right) \Big] + \\
& + \int_{12}^{t_d} F \left[\cos(s) * (-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ)) \sin(\varphi) + \cos(\varphi) \cos(\arcsin(-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))) \cos(180^\circ - 15t)) + \right. \\
& + \sin(s) \sqrt{1 - (-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ)) \sin(\varphi) + \cos(\varphi) \cos(\arcsin(-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))) \cos(180^\circ - 15t)))^2} * \\
& * \cos \left(-\arccos \left(\frac{\sin(\varphi) * [(-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ)) \sin(\varphi) + \cos(\varphi) \cos(\arcsin(-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))) \cos(180^\circ - 15t))] + 0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))}{\cos(\varphi) \sqrt{1 - (-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ)) \sin(\varphi) + \cos(\varphi) \cos(\arcsin(-0.428 \sin(Ls + 0.0935 \sin(Ls - 251^\circ))) \cos(180^\circ - 15t)))^2}} \right) - (180^\circ - e) \right) \Big]
\end{aligned} \tag{B.8}$$

where $\int_4^{t_d} I_I$ is the total received incident radiation integrated over time interval between the daytime acquisition time and 4:00.

Eq. B.8 corresponds to Eq. 8 in the text, where the two long terms on the right side of the equation are renamed $\int_4^{12} I_I$ and $\int_{12}^{t_d} I_I$ for the sake of simplicity:

$$\int_4^{t_d} I_I = \int_4^{12} I_I + \int_{12}^{t_d} I_I \tag{7}$$

To solve this equation, the middle Riemann sum of 13 (in our case) one-hour wide sub-intervals is applied. Sunrise time is variable (for example depending on slope inclination and orientation) and the sub-intervals preceding the sunrise yield negative values. These negative values are converted to zero. The heat accumulated in the system is in constant exchange with the surroundings. The heat accumulated in the morning sub-intervals is subject to a longer exchange with the surroundings, and therefore a relatively larger part of this heat is lost from the system. To approximate this effect, we apply a linear time-based correction by dividing every element of the Riemann sum through $(t_d - t_i)$, where, t_i is the middle time of a given subinterval, and t_d is time when the daytime image was taken. The sub-intervals divided by $(t_d - t_i)$ are finally summed up to yield the final I_I the value used for the ΔT .