Ecography

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Supplementary material

Appendix.1

Operative temperature was calculated using the approach from Bakken and Gates in 1975 (Equation A1):

Equation A1

$$T_e = \frac{R_{abs} + At_g + hc}{S + hc}$$

Where At_g is air temperature at ground level, hc is the convection coefficient (Equation A2), S is the Thermal radiation heat transfer coefficient (Equation A5) and R_{abs} is the absorbed radiation (Equation A 3).

The convection heat transfer coefficient is developed from (Mitchell 1976) as:

Equation A2

$$hc = \frac{\left(\frac{SVL * ws}{kv}\right)^n * Cl * Atc}{SVL}$$

Where SVL is the characteristic dimension of the animal (Snout-vent length, 13cm), ws is the wind speed, kv is the air kinematic viscosity and Atc is the air thermal conductivity. Cl and n are two dimensionless constant taken from Mitchel 1976.

R_{abs} is developed from Porter et al. 1973:

Equation A3

$$R_{abs} = P_s * \alpha_s * \left(F *_h S_o + 0.5 * S_d + 0.5 * S_r\right) + 0.5 * \alpha_l * \left(S_{l,a} + S_{l,g}\right)$$

Where P_s is the proportion of the animal facing direct sun, α_s is the absorbance of shortwave radiation of the skin, F is the view factor of the organism (0.5), ${}_hS_o$ is the shortwave radiation reaching the surface, S_d is the shortwave diffuse radiation reaching the surface, S_r is the reflected shortwave radiation reaching the surface, α_l is the absorbance of the skin of the animal to longwave radiation (0.95), S_{la} is the longwave radiation reaching the surface and $S_{l,g}$ is the longwave radiation coming from the earth surface. In our case, the WRF-ARW model did not provide separate variables for direct and diffuse shortwave radiation but an integrated variable for downwelling shortwave radiation, so we unified both components leaving the equation as:

Equation A4

$$R_{abs} = P_s * \alpha_s * \left(F *_h S_{od} + 0.5 * S_r\right) + 0.5 * \alpha_l * \left(S_{l,a} + S_{l,g}\right)$$

Where ${}_hS_{od}$ is the total downweling shortwave solar radiation.

S is calculated from from (Bakken and Gates 1975).

Equation A5

$$S = Ta^3 * \varepsilon * 4 * \sigma$$

Where *Ta* is the air temperature at 2m height.

Table A1 List of RCM output variables used in for the calculation of Operative Temperatures.

WRF-ARW model variable	Use in our model
u 13 0 x-wind component (m s-1)	Zonal wind component*
v 13 0 y-wind component (m s-1)	Meridional wind component*
t2 1 0 TEMP at 2 M (K)	Air Temperature at 2m
tsk 1 0 SURFACE SKIN TEMPERATURE (K)	Air Temperature at ground level
lwdnb 1 0 INSTANTANEOUS DOWNWELLING LONGWAVE FLUX AT BOTTOM (W m-2)	Longwave radiation reaching the surface
swupb 1 0 INSTANTANEOUS UPWELLING SHORTWAVE FLUX AT BOTTOM (W m-2)	Reflected shortwave radiation
swdnb 1 0 INSTANTANEOUS DOWNWELLING SHORTWAVE FLUX AT BOTTOM (W m-2)	Shortwave radiation reaching the surface
lwupb 1 0 INSTANTANEOUS UPWELLING LONGWAVE FLUX AT BOTTOM (W m-2)	Longwave radiation coming from the earth surface

*Wind speed is calculated as the modulus of the x and y components of the variables.

Table A2 List of RCM output variables used in for the calculation of Operative Temperatures.

Symbol	Parameter	Value
SVL	Snout-vent length	0.13m
Cl	Dimensionless constant 1	0.35
n	Dimensionless constant 2	0.6
P_s	Proportion of the animal facing direct sun	1
α_s	Sbsorbance of shortwave radiation of the skin	0.85
F	View factor of the organism	0.5
αl	Absorbance of the skin of the animal to longwave radiation	0.95
Atc	Air thermal conductivity	0.0257 W/m.K
kv	Air kinematic viscosity	15.11 x 10-6 m2/s

Bibliography cited in Supporting online materials:

Bakken, G. S. and Gates, D. M. 1975. Heat transfer analysis of animals: Some implications for field ecology, physiology, and evolution. - In: Perspectives of Biophysical Ecology. Ecological Studies. Springer, pp. 255–290.

Mitchell, J. W. 1976. Heat transfer from spheres and other animal forms. - Biophys. J. 16: 561–569.