**Appendix S2**

*Using an artificial neural network to predict operative temperatures*

Due to the sampling protocol at our high-Arctic site, we had 643 1-h gaps in our operative temperature time series. To estimate the percentage of time on a given day that buntings would have been behaviorally constrained from heat it was necessary to fill these gaps. Using an artificial neural network (nn), we predicted operative temperatures based on seven radiative and meteorological variables observed at the NOAA broadband radiation station (figure S1). Specifically, the input layer of the neural network included air temperature, wind speed (m/s), downwelling shortwave radiation flux (calculated as the sum of the contributions from diffuse and direct shortwave radiation; W/m2), reflected shortwave radiation flux (W/m2), albedo (calculated as the ratio of the reflected shortwave radiation flux to downwelling shortwave radiation flux), net longwave radiation flux (calculated by subtracting the longwave radiation flux emitted by the surface from the downwelling longwave radiation flux; W/m2), and diffuse fraction as a measure of the proportional influence of the direct sun and a proxy for cloudiness (calculated as the ratio of diffuse shortwave flux to total downwelling shortwave flux). Before training and testing the neural network, we applied a ranging standardization to the data, resulting in the data ranging between 0 and 1 [1]. We fitted the network with one hidden layer comprised of five neurons and trained the model using a random sample of 90% of the data set (1,752 values). The model was tested on a random sample of 10% of the data set (195 observations). We cross-validated the neural network by repeating the process (i.e., training, testing, and calculating mean square prediction error) 20 times consecutively. The neural network predicted hourly operative temperatures with an average mean square error of 1.8°C (range = 1.2 to 2.7°C; fig. S2).

Diagram

Description automatically generated

**Figure S1**. The plotted artificial neural network with the 7 radiative and meteorological variables in the input layer, the 1 hidden layer with 5 neurons and the operative temperature (Te) output layer.



**Figure S2**. The mean square error from the artificial neural network (nn).

**References**

1. Quinn GP, Keough MJ. 2002 *Experimental Design and Data Analysis for Biologists*. Cambridge University Press. (doi:10.1017/CBO9780511806384)