Are 'downscaled' climate models good enough for occupancy modeling? A test with data from American pika habitat on Niwot Ridge

Crystal S. Gonzalez[1], Chris Ray[2], and Airy Peralta Gonzalez[2];
[1]University of Colorado-Boulder College of Engineering, [2]University of Colorado-Boulder Department of Ecology and Evolutionary Biology

Motivation

Researchers need accurate temperatures to understand how the pika is responding to climate change. Downscaled temperatures from models like PRISM could be different from temperatures measured in the field. Do the models represent the precise temperatures pikas are experiencing in their territories?

Background

As climate change advances, many species are expected to shift their distributions[1]. Ecologists use models to infer how species' ranges will shift, and to assess whether we will lose their ecological services[2,3]. However, most of the models used to predict species' distributions are based on environmental variables recorded at large scales, which might not represent the environments that smaller animals experience. In this study, we compare downscaled temperature models[4,5] to *in situ* temperature records obtained from sensors measuring air temperature in territories of the American pika, a climate indicator species, to evaluate whether downscaled models are predictive.

Image is a picture I took during an observation on July 12, 2021, on the West Knoll of Niwot Ridge, Colorado.

Data and Approach

- Part 1: To determine the variation in temperatures recorded by sensors in the field, 19 sensors (U-series and H-series HOBO data loggers manufactured by Onset Corporation) were deployed at a singe point near the study site from November 2020 through June 2021. Data from these 19 sensors were analyzed to obtain the standard error (SE) of monthly mean, minimum and maximum temperatures measured *in situ*.
- Part 2: Field data on ambient temperature at a pika study site on Niwot Ridge (Boulder County, Colorado, Latitude 40.06839, Longitude -105.77347) were collected by several U- and H-series HOBOs deployed in sequence during 2015-2019. These field data were compared with PRISM[4] gridded monthly climate data at 800 m resolution, downscaled for the study point[5].

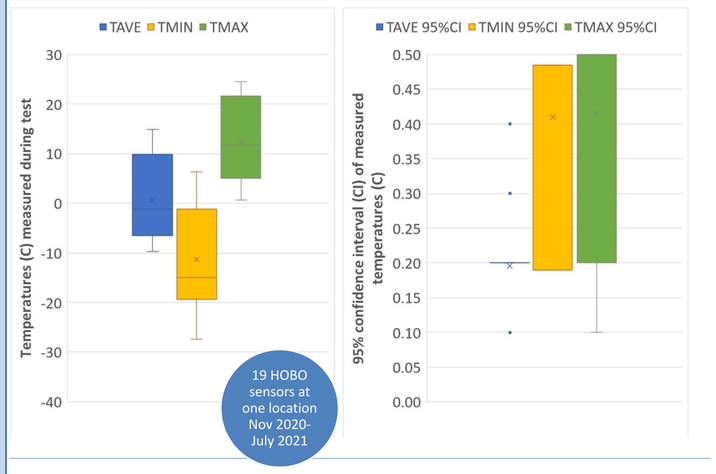
Niwot Ridge field sensor location. Field data were compared with modeled data from http://climatena.ca.

Methods

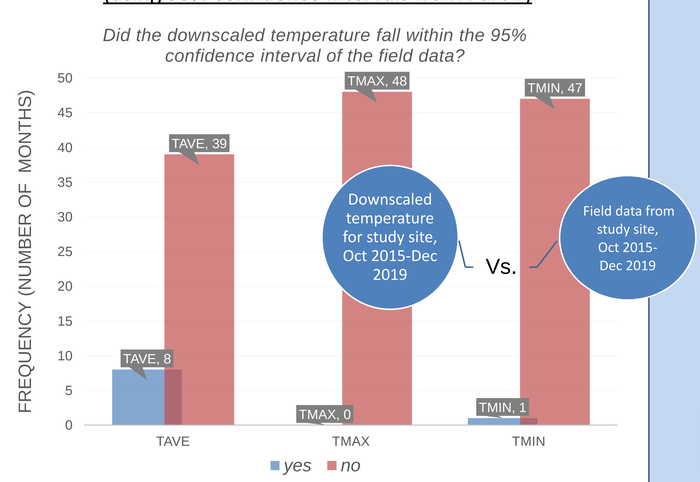
1. Measured error in field sensors (n=19), calculating 95% confidence intervals for monthly average, minimum and maximum temperatures.
2. Used paired t-tests to determine whether standard error (SE) differed between monthly average, minimum and maximum temperatures.
3. Obtained downscaled temperatures for a location where ambient temperature had been measured for several years during a pika study.
4. Obtained the monthly average, minimum and maximum temperatures from field sensors deployed in sequence at the specific location.
5. Using appropriate SE values for the monthly average, minimum or maximum temperature measured in the field, determined whether each downscaled temperature statistic fell within the 95% confidence interval (±2SE) of the corresponding field temperature statistic.

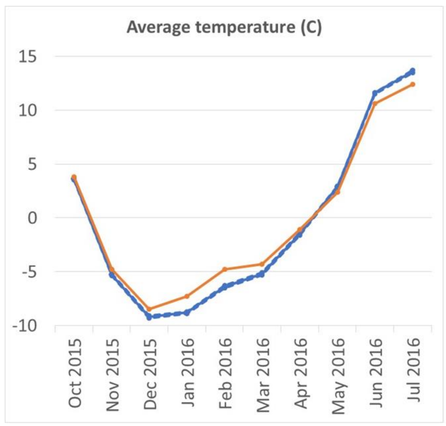
Results / Observations

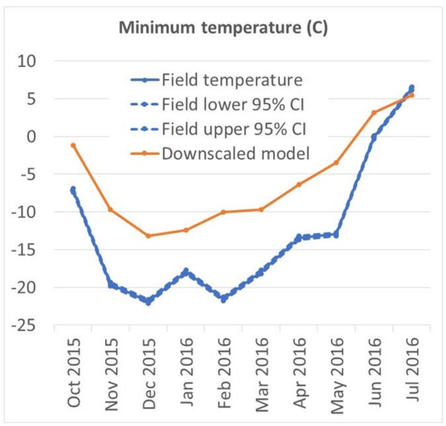
Part 1: Field sensor precision

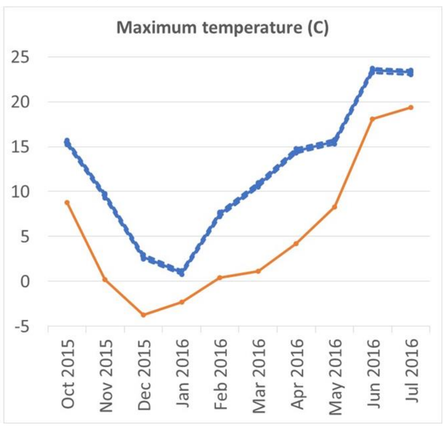


Part 2: Comparing downscaled model with field data (using 95% confidence intervals from Part 1)









- All field-sensor measurements agreed within ½ °C.
- Errors in field-sensor temperature were not related to absolute temperature in our test.
- Only 16% of the downscaled monthly mean temperatures fell within the 95% confidence intervals of the field data.
- Downscaled monthly minimum and maximum temperatures almost never fell within the 95% confidence intervals of the field data.
- Downscaled monthly minima and maxima were far less extreme than values measured in the field.

Conclusions

- Our results show that a downscaled model failed to predict the extremes of temperature on a rocky slope inhabited by pikas.
- It is important to accurately measure the environmental variables experienced by organisms because inaccurate data could interfere with effective modeling and species management.

A pika trapped for mark-resight on Niwot Ridge. Photo by Chris Ray.

References

1. Nature. 2020. Shifting habitat. Nature Climate Change, 10: 377. https://doi.org/10.1038/s41558-020-0789-x
2. Schwalm, D., Epps, C., Rodhouse, T., Monahan W., Castillo, J., Ray, C., Jeffress, M. 2016. Habitat availability and gene flow influence diverging local population trajectories under scenarios of climate change: a place-based approach. Global Change biology, 22 (4): 1572-1584.
3. Phillips, O., et al. 2008. The changing Amazon forest. Philos: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2374914/
4. Daly C, et al. 2008. Physiographically sensitive mapping of climatological temperature and precipitation across the conterminous United States. Int J Climatol. 8(15):2031–64
5. Wang, T., et al. 2016. Locally Downscaled and Spatially Customizable Climate Data for Historical and Future Periods for North America. PLoS One 11(6): e0156720.

Acknowledgements

I would like to thank
- My mentor Dr. Chris Ray - for providing not only al data and scientific knowledge, but to be such an amazing and kind human, thank you for explaining every little detail no only one but several times to me.
- To mentor Airy Gonzalez Peralta because she was there even before our internship start. To give me the opportunity to be hiking, observing and help me to understand why studying a PHD is remarkable and wonderful. Thank you for all your help.
- The RECCS team especially, Bec Batchelor, Alicia Christensen, Dana Stamo Jeffrey Schmidt and Anne Gold, for the opportunity you provide and support during this internship
- The RECCS Program is funded by the National Science Foundation (grant number EAR 1757930.)

For more information, contact crgo2043@colorado.edu