

Microclimate Influence on Bird Arrival Behavior Field Campaign Report

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March 2016

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Office of Science, Office of Biological and Environmental Research

Executive Summary

Using our own prototype sensor arrays that were deployed to collect microclimate data, we were able to visualize distinct differences in temperature, wind speed, and humidity over very small ranges of distance. We collected data across four polygons within the Barrow Environmental Observatory site. Our prototype microclimate arrays were based on an Arduino microcontroller, DS18B20 temperature sensors, DHT11 relative humidity/temperature sensors, and Vernier anemometers. Data were obtained in a small grid pattern with four sensors spaced 60 cm apart along the x-axis, and moved at 60 cm increments along a y-line across a polygon. Overlaying bird nest location with such data has allowed us to better answer our research question, “How do Arctic birds choose where to nest to maximize fitness in harsh Arctic environments?”

Contents

Executive Summary	iii
1.0 Background.....	1
2.0 Notable Events or Highlights	2
3.0 Lessons Learned	2
4.0 Results	2
5.0 Public Outreach	3
6.0 Publications	3
6.1 Journal Articles/Manuscripts.....	3
6.2 Meeting Abstracts/Presentations/Posters	3

Figures

1 Survey area within the Barrow Environmental Observatory	1
2 Main poster presented at the Virginia Science Festival.....	4
3 Photo collage poster presented at the Virginia Science Festival.....	5

1.0 Background

The co-Principal Investigators for this campaign were Rhett Herman, Professor of Physics, and Sara O'Brien, Assistant Professor of Biology, both at Radford University in Radford, Virginia. Two student research assistants accompanied them—Jordan Eagle and Maddy King, both undergraduates at Radford University.

The purpose of this campaign was to conduct a preliminary test of a custom-designed microcontroller-based microclimate sensor. The sensor post was 1m tall, with 15 temperature sensors (DS18B20), four relative humidity/temperature sensors (DHT11), four anemometers (Vernier), and one red-green-blue light sensor (ISL29125). The sensors were driven by a single Arduino microcontroller that ported data in real time to a laptop computer via a universal serial bus cable. These sensors were deployed on Arctic (permafrost) polygon landforms within the Barrow Environmental Observatory. Data were obtained June 8 through 12, 2015.

Four of these sensors were deployed simultaneously in a line along the x-axis, with each sensor approximately 60 cm from the next. The sensors obtained data for 5 minutes, and all four were moved 60 cm further along the y-axis until a polygon was crossed. The study lines varied from 15 to 22 m in length. Four polygons were studied extensively, along with one shorter line approximately 3 m long using just one sensor. The survey area is shown in Figure 1, along with the outlines of the four main polygons. The latitude and longitude at the mid-point of the polygons are approximately 71.275772° , -156.638927° .



Figure 1. Survey area within the Barrow Environmental Observatory. The four main survey polygons are outlined in red.

2.0 Notable Events or Highlights

There were no unusual meteorological events. Our observations of rapidly decreasing temperature within the first 1 m of the surface were expected.

Our main equipment issues dealt with the need to power the microcontrollers and store the data using laptop computers connected to the microcontrollers via universal serial bus cables. This meant that the battery life of the computers was the determining factor for the amount of data that could be obtained. This was not influenced by the local weather.

3.0 Lessons Learned

This trip was an internally funded exercise designed to initiate development of low-cost microclimate sensors for field campaigns. Because of the short time available for development of this technology, we were unable to properly shield the temperature sensors from heating by both ambient sunlight and radiation from the ground. Such shielding will have to be developed.

The red-green-blue sensor was quickly saturated, so it was not suitable for the amount of ambient sunlight encountered. The sensors were appropriate for indoor lighting only. We were able to point them away from direct sunlight so we could at least measure some differences in red-green-blue light levels, but this data could not be published as it does not accurately reflect the true red-green light levels. In the future, we will have to obtain red-green-blue sensors that are either more directional or can withstand direct sunlight.

Data were collected by the microcontrollers and fed directly into nearby laptop computers. We are developing mounts for micro-Secure Digital cards that can store data for later retrieval.

We are developing battery packs that will relieve the need for the nearby computers to power the microcontrollers. In addition, we are developing a solar panel and charger system that may be mounted on the tops of the posts for long-term deployments.

4.0 Results

In brief, the results include:

- This technology (low-cost, microcontroller-based microclimate sensor posts costing under \$200) will work once the design is improved. This “proof of principle” was the main goal of this campaign.
- The temperature decreased rapidly within the first ~25 cm from the surface, as expected. The vertical data density (distribution of temperature sensors) was adequate to accurately track this in real time.
- Winds decreased quickly in accordance with the usual wind “friction-layer” effect.
- Further analysis will be required (potentially because of a lack of shielding from ambient sunlight), but the preliminary results indicate that temperatures near the surface (i.e., within the first few centimeters) remained constant before rapidly decreasing.

Further research opportunities will be pursued once the design is refined and tested further. Our main issue is to develop a low-cost solution for shielding the sensors from ambient sunlight and radiation from the ground to obtain accurate data at a given height above the ground.

5.0 Public Outreach

We gave a talk on our work at the Tuzzy Library in Barrow, Alaska, on Saturday, June 13, 2015. This talk was open to the public and had about 30 attendees. The audience included both the general public and visiting scientists.

A news story and release was disseminated by the University Relations Office of Radford University about this work.¹

Two large posters about this work were presented in a day-long session open to the public at the Virginia Science Festival (<http://www.cpe.vt.edu/sciencefestival/exhibitors.html>) events at Virginia Tech in Blacksburg, Virginia, on September 26, 2015. At least several hundred people either stopped by or read the posters while they were attending the overall festival. This is a regional event advertised throughout southwestern Virginia, and is free and open to the public. These are shown in Figure 2 and Figure 3.

6.0 Publications

6.1 Journal Articles/Manuscripts

No campaign-specific journal articles have been published yet. However, an article describing the method and equipment in this study (low-cost, microcontroller-based microclimate array) is being prepared and will be submitted to for publication (e.g., the *American Journal of Physics*).

6.2 Meeting Abstracts/Presentations/Posters

None. The posters mentioned in Section 5.0 above were contributed posters in the open-to-the-public Virginia Science Festival held at Virginia Tech on September 26, 2015.

¹ <http://www.radford.edu/content/radfordcore/home/news/releases/2015/july/radford-research-team-ventures-to-arctic-tundra.html>



Location! Location! Location!

Exploring the Influence of Microclimate on Arctic Bird Behavior

Presenters: Drs. Sara O'Brien (Dept. of Biology) & Rhett Herman (Dept. of Physics)
Student Co-authors: Jordan Eagle (Physics '16) and Madison King (Biology '18)
Radford University College of Science and Technology, Radford, VA



Background

Why the Arctic?

- Birds migrate many hundreds, if not thousands, of miles to the Arctic to breed.
- Migration uses an enormous amount of energy, but birds have to trade off stored energy (extra weight) for aerodynamics.
- Birds are not certain what their breeding grounds will look like when they get there.
- Birds must adjust accordingly to ensure they maximize the short breeding window.
- Birds are pressured to find a nesting site quickly to maximize the short Arctic breeding season.
- However, weather is unpredictable so they must also choose a spot that ensures eggs and nestlings survive.
- Must consider predators and weather when finding a nesting site.

What looks and feels the same to us, may not appear that way to the birds...

- How do they choose a nesting site?*






Dunlin Black-bellied plover Pectoral Sandpiper



Lapland Longspur nests, eggs and nestlings

What is the "Microclimate"?

Microclimate is defined as the local changes in a small area in characteristics such as temperature, wind speed, light, and humidity in a small area of habitat.

In order to see and feel what the birds do....we have got get down to their level and record what they might feel.



Big Questions

Exploring spatial influences on microclimate:

- How does microclimate vary across a polygon on the tundra?*

Exploring temporal influences on microclimate:

- How does microclimate vary over time in a particular spot on a polygon?*

Exploring microclimate influences on breeding behavior:

- How does microclimate vary among areas on a polygon that have a nest and areas that do not have a nest?*





How did we do it?

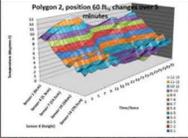


Constructed "Mothership" array

- Studies abrupt changes in microclimate including temperature, relative humidity, and red, green, and blue wavelength intensities of light.
- 4 other arrays to study temperature with same spacing as the temperature sensors on the Mothership to cover more area across one polygon.
- Arduino microcontroller reads sensors and recorded on computer.



What did we find?



- Temperature, humidity and windspeed profiles show significant changes across a polygon.
- Where a bird nests on a polygon could be driven in part by microclimate profiles.

What's next?

- RU microclimate sensor 2.0
- Scale up!
- Keep exploring how technology can be used to answer pressing questions on the effects of climate change.

Acknowledgements & Contacts

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- The RU Biology and Physics Departments
- For additional information contact: Sara O'Brien (sobrien@radford.edu) Rhett Herman (rherman@radford.edu)




Figure 2. Main poster presented at the Virginia Science Festival.



Figure 3. Photo collage poster presented at the Virginia Science Festival.

