# Genetic analysis of heat tolerance in Holsteins using test-day production records and NASA POWER meteorological data


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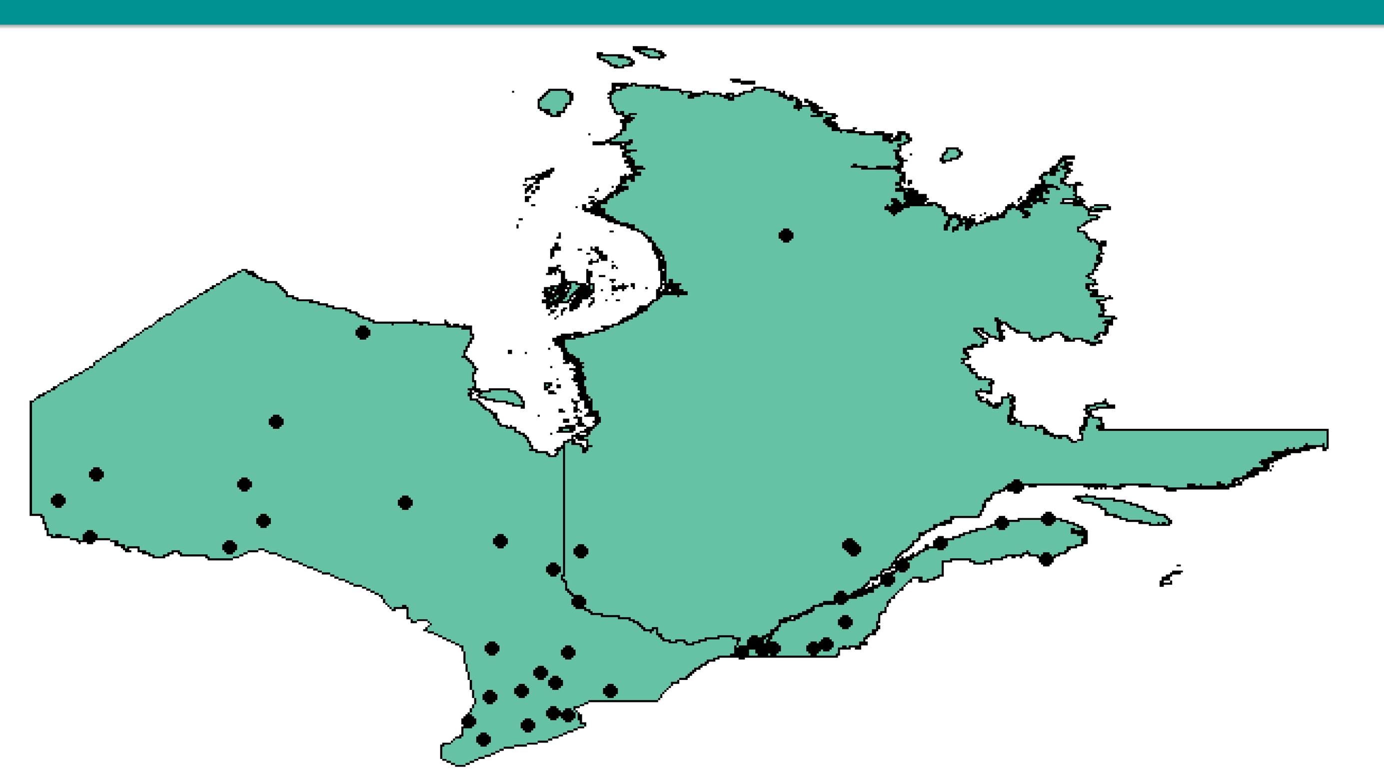
## Introduction

- Heat stress negatively effects the health, productivity, and welfare of dairy cattle, as well as the profitability of a dairy farm
- **Heat tolerance:** Individuals that can maintain their production potential despite being exposed to increasingly high heat loads
- **Challenge:** Herds can be situated far from weather stations which can also have data gaps
- **Opportunity:** Implement satellite and model-based estimates from NASA POWER* as an alternative resource of meteorological data

## Objectives

1. **Compare weather parameter values collected from weather stations to NASA POWER estimates**
2. **Estimate temperature humidity index thresholds and genetic components of heat tolerance in Canadian dairy cattle herds**



**Weather Station Locations in Ontario and Quebec used for the Comparison**

## Daily Weather Data

- **Sample:** 47 locations in Ontario & Quebec, Canada with weather data from 2009 to 2019
- **Parameters:** Ambient Temperature, Relative Humidity, Dewpoint Temperature, and Wind Speed
- **Sources:** NASA POWER and Environment and Climate Change Canada

## Data Quality Check

- Exclude stations with missing data using a 85% selection threshold
- Plot stations on geographical grid with 0.5º resolution and subset one station per grid box

## Temperature Humidity Indices

$$THI1 = (1.8 \times (AT) + 32) - [0.55 - 0.0055(RH)] \times (1.8 \times (AT) - 26)$$ [1]

$$THI2 = AT + (0.36 \times DP) + 41.2$$ [2]

## Ordinary Least Squares Regression

## Results

**Table 1.** Results from the linear regression analyses of NASA POWER estimates on weather station parameters and THI values.

| Parameter | df | β | $R^2$ | RMSE | p-value |
|---|---|---|---|---|---|
| Average Relative Humidity (%) | 186622 | 0.788 | 0.3697 | 10.63 | < 0.001 |
| Average Wind Speed (km/hr) | 187422 | 0.552 | 0.3323 | 5.25 | < 0.001 |
| Minimum Wind Speed (km/hr) | 187422 | 0.549 | 0.3273 | 3.71 | < 0.001 |
| Maximum Wind Speed (km/hr) | 187422 | 0.505 | 0.2354 | 8.14 | < 0.001 |
| Average Dewpoint Temperature (°C) | 186795 | 1.02 | 0.9695 | 2.05 | < 0.001 |
| Average Ambient Temperature (°C) | 187907 | 0.969 | 0.9750 | 1.95 | < 0.001 |
| Minimum Ambient Temperature (°C) | 187907 | 0.955 | 0.9505 | 2.74 | < 0.001 |
| Maximum Ambient Temperature(°C) | 187907 | 0.968 | 0.9700 | 2.20 | < 0.001 |
| Average THI1[1] | 186621 | 0.918 | 0.9625 | 3.79 | < 0.001 |
| Average THI2[1] | 186795 | 0.979 | 0.9796 | 2.40 | < 0.001 |
| Maximum THI1[23] | 187748 | 0.837 | 0.9568 | 3.72 | < 0.001 |
| Maximum THI2[24] | 187792 | 0.970 | 0.9770 | 2.54 | < 0.001 |

[1] THI values calculated using AT = daily average ambient temperature (°C), RH = daily average relative humidity (%), DP = daily average dewpoint temperature (°C)

[2] AT was substituted for daily maximum ambient temperature for both satellite and station THI equations

[3] RH was substituted for daily minimum relative humidity for the station THI equation

[4] DP was substituted for daily maximum dewpoint temperature for the station THI equation

## Conclusions

- Ambient temperatures, dewpoint temperatures, and THI values from NASA Power estimates and from weather stations are highly correlated and are on a similar scale
- NASA POWER estimates are a viable alterative to weather station data in heat tolerance studies, which could increase sample size and accuracy of results
- **Next Step:** Implement a segmented linear polynomial to estimate THI thresholds at which production traits begin to decay in each province


1. Bernabucci et al., 2014. The effects of heat stress in Italian Holstein dairy cattle. J.Dairy Sci. 97:471-486
2. Armstrong, 1993. Environmental Modification to Reduce Heat Stress. Western Large Herd Dairy Management Conference, Las Vegas, Nevada.


* National Aeronautics and Space Administration Prediction of Worldwide Energy Resources