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Data Article

Dataset of temperature, humidity, and actuator states of an east-facing South African Greenhouse Tunnel

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ABSTRACT

A greenhouse tunnel in Stellenbosch, South Africa was used for testing a generic sensing system for monitoring and control of climatic conditions in the tunnel. Three temperature and humidity sensors were used to record data throughout the day in 5 min intervals. Bambara Nuts, a climate change-resilient and nutritious crop, were grown in a separate study in the tunnel using an aeroponics system. These were chosen as it is regarded as the norm in autonomous greenhouse temperature control in the region. During data collection, the sensors were placed at the front, middle, and back of the tunnel. At the front, there was an industrial extraction fan, and at the back, there was an evaporative cooling wet wall. The fan and wet wall were controlled using the middle sensor data that was averaged every minute to determine if the fan and wet wall should be on or off. The hysteresis band used as a threshold was to turn the fan on when the middle temperature reached 30 °C and to turn it off it was 22 °C. This data collection method extended from

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31 December 2022 to 13 June 2023, collecting 162 days of temperature and humidity data for that period.

Specifications Table

Subject	Agriculture Engineering
Specific subject area	Specifically, this study encompassed the area of precision agriculture and the use of sensors to control growing conditions for different plants.
Data format	Raw, filtered
Type of data	Table, numbers, boolean
Data collection	Three temperature and humidity sensors (DHT22) were placed at the front, middle, and back of a greenhouse tunnel. This spacing was approximately 12 meters from the greenhouse tunnel's entrance. The sensors were connected to a Raspberry Pi that recorded data every 5 min. To avoid errors, the front, middle, and back sensors were measured every minute, and after 5 min, an average was taken of the front temperature and humidity, the middle temperature and humidity, and the back temperature and humidity. The middle temperature, however, was sampled every 10 s and stored in an array. After a minute, the median value from that array was then used to control the fan and wet wall state. If the temperature was above 30 °C, the fan and wet wall were turned on. If the temperature was below 22 °C, the fan was turned off. These thresholds were determined through experiments to determine the best response by the crops growing in the tunnel. The front, middle, and back's averaged temperature and humidity were stored in a CSV file on the Raspberry Pi and this file was exported to DropBox at the end of the day. The CSV files were then aggregated to form the dataset.
Data source location	Stellenbosch University, Welgevallen Farm, Stellenbosch, South Africa Latitude/Longitude: -33.942445282720755, 18.86738953754131
Data accessibility	Repository name: Temperature and Humidity Dataset of an East-Facing South African Greenhouse Tunnel Data identification number: 10.17632/54htxm94bv.1 Direct URL to data: https://data.mendeley.com/datasets/54htxm94bv/1

1. Value of the Data

- As this is the first data set for a greenhouse tunnel with this specific orientation, size, and location, the value of the data extends to potential further studies at understanding the thermal characteristics of greenhouses in Sub-Saharan Africa and steps forward to better precision agriculture implementations for farmers and researchers.
- Farmers and agricultural science researchers who use precision agriculture (in particular greenhouse tunnels) can use this data for their purposes and studies.
- With similar orientation and sized greenhouses, researchers can use the trends found in this dataset to understand the temperature differences of their greenhouses before planting specific crops in specific areas. Also, researchers can see the effect of evaporative cooling wet walls and extraction fans in closed greenhouses.

2. Data Description

In this dataset, there are three different files: *Training Set.csv, Test Set.csv*, and *Full Data Set.csv.*

2.1. Training Set.csv and Test Set.csv

These two files have been aggregated with data from meteoblue.com (www.meteoblue.com), a paid weather archiving service. This dataset was used for support vector regression (SVR) prediction algorithms and only used the middle temperature. The data has the following fields: date, time, minute, solar radiation, outside temperature (T[n-1]), Actual temperature middle (T[n-1]), fan on/off, actual temperature middle (T[n]). Solar radiation and outside temperature were in hourly intervals but then were linearly interpolated into 5 min intervals. T[n] is used to identify the current time step, and T[n-1] refers to the previous time step. Instead of using one file, the training and test were split the full 42-day period into 8 days for the test set and 34 days for the training set.

2.2. Full Data Set.csv

The full data set then encapsulates 162 days of data. The structure is as follows: Date, time, front temperature, front humidity, middle temperature, middle humidity, back temperature, back humidity, and fan/wet wall state. This data is raw and has not been analyzed or cleaned.

3. Experimental Design, Materials And Methods

A closed greenhouse tunnel at The Welgevallen Experimental Farm (Stellenbosch University, South Africa) was used to thermally model the temperature within the tunnel. These models were a Support Vector Regression (SVR) model used to simulate temperatures one hour in advance, and an analytical, physics-based model was used to describe the longitudinal effect on the greenhouse temperature due to the evaporative cooling caused by the fan and the wet wall.

Three temperature and humidity sensors were used. The DHT22 (Fig. 3) was selected as it can measure temperature (-40 °C to 80 °C) and humidity (0 to 100 %) simultaneously. The accuracy for these measurements is ± 2 % for humidity and a maximum error of ± 0.5 °C.

For the training and test set (https://data.mendeley.com/drafts/54htxm94bv), data was captured between 18 November and 30 December 2022 (42 days). For the full data set, data was collected between 31 December 2022 and 14 June 2023 which includes mainly summer data and a few months of winter data. The tunnel is dome-shaped (Fig. 1) and is 28 m in length, 9 m in width, and 3 meters in height. The wet wall is approximately 5.9 m in length, 1.7 m in height, and 0.21 m in depth. The three temperature and humidity sensors were placed twelve meters apart, starting from the entrance of the tunnel to the wet wall on the opposite end. They were placed about 1.5 m relative to the ground as this would prevent any effect from the ground and the greenhouse cover on temperature measurements. The fan occupies approximately one-third of the wall space next to the entrance of the tunnel and the front temperature and humidity

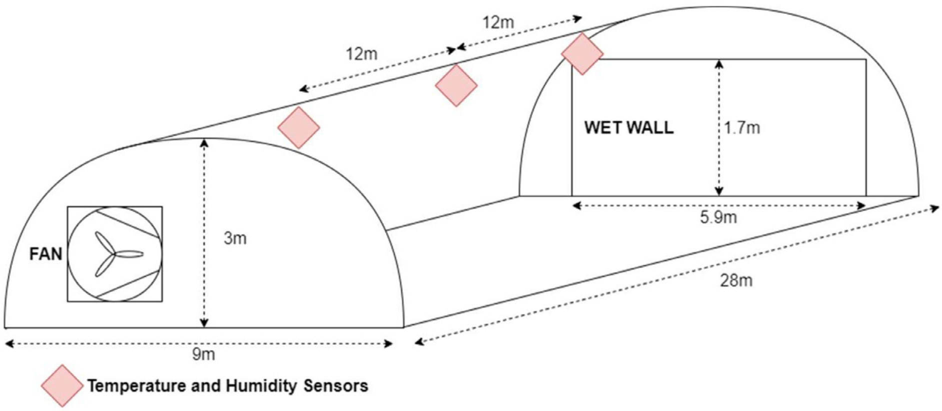

Fig. 1. Layout of the tunnel with an estimated distance between each sensor.

sensor (Fig. 1). An aeroponics system consisting of multiple black containers growing Bambara ground nuts was being trialed at the same time in the greenhouse tunnel between the front and middle sensors (Fig. 2). The wet wall, used for evaporative cooling, was made of porous cellulose material. This wall passed hot ambient air from outside of the tunnel over cooler running water to produce an evaporative cooling effect when the subsequent water vapor evaporated.

Fig. 2. Crops, aeroponics system, and wet wall present inside the greenhouse tunnel during experimentation.

Fig. 3. The DHT22 sensor that can measure both temperature and humidity.

3.1. Sensor and Control Mechanism Selection

The DHT22 temperature and humidity sensor was used for its price and efficiency in measuring both temperature and humidity. The front and back sensors measured every minute and were averaged after 5 min. The middle sensor, however, measured every 10 s, and a median value was used to control the fan and wet wall automatically. After 5 min, these measurements were also averaged. A Raspberry Pi Model 3B was used for CSV creation, sensor data aggregation, telemetry (to Telegram), and data storage through Dropbox's API.

3.2. Temperature Control of the Tunnel

As mentioned above, the middle sensor controlled the fan and wet wall state automatically. The threshold for turning on both apparatuses was 30 °C, and to turn it off it was 22 °C, creating an 8 °C hysteresis band. These values were chosen based on the response from the plants being grown in the tunnel and a large hysteresis band was needed to prevent the switching gears on the fan from aging due to continuous switching on and off.

4. Limitations

The middle and front sensors were close to an aeroponics system that used 28 black containers. The temperature and humidity influences of this system on the internal temperatures of the tunnel are unknown. The sensors were placed about half a meter above these containers to avoid (as much as possible) any influence.

Ethics Statement

The dataset described in this article does not involve any human subjects, animal experiments, or data collected from social media platforms.

Data Availability

Temperature and Humidity Dataset of an East-Facing South African Greenhouse Tunnel (Original data) (Mendeley Data).

CRediT Author Statement

Keegan Hull: Conceptualization, Methodology, Software, Writing – review & editing; **Mosima Mabitsela:** Conceptualization, Methodology, Writing – review & editing; **Ethel Phiri:** Conceptualization, Methodology, Software, Writing – review & editing, Supervision; **Marthinus Booysen:** Conceptualization, Methodology, Software, Writing – review & editing, Supervision.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.