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GIVING BEEKEEPING GUIDANCE BY COMPUTATIONAL-ASSISTED DECISION MAKING

EU Horizon 2020 Research and Innovation Action

A MONITORING SYSTEM FOR CARBON DIOXIDE AND HUMIDITY IN HONEYBEE HIVES

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NTU Nottingham Trent University

A monitoring system for carbon dioxide and humidity in honeybee hives
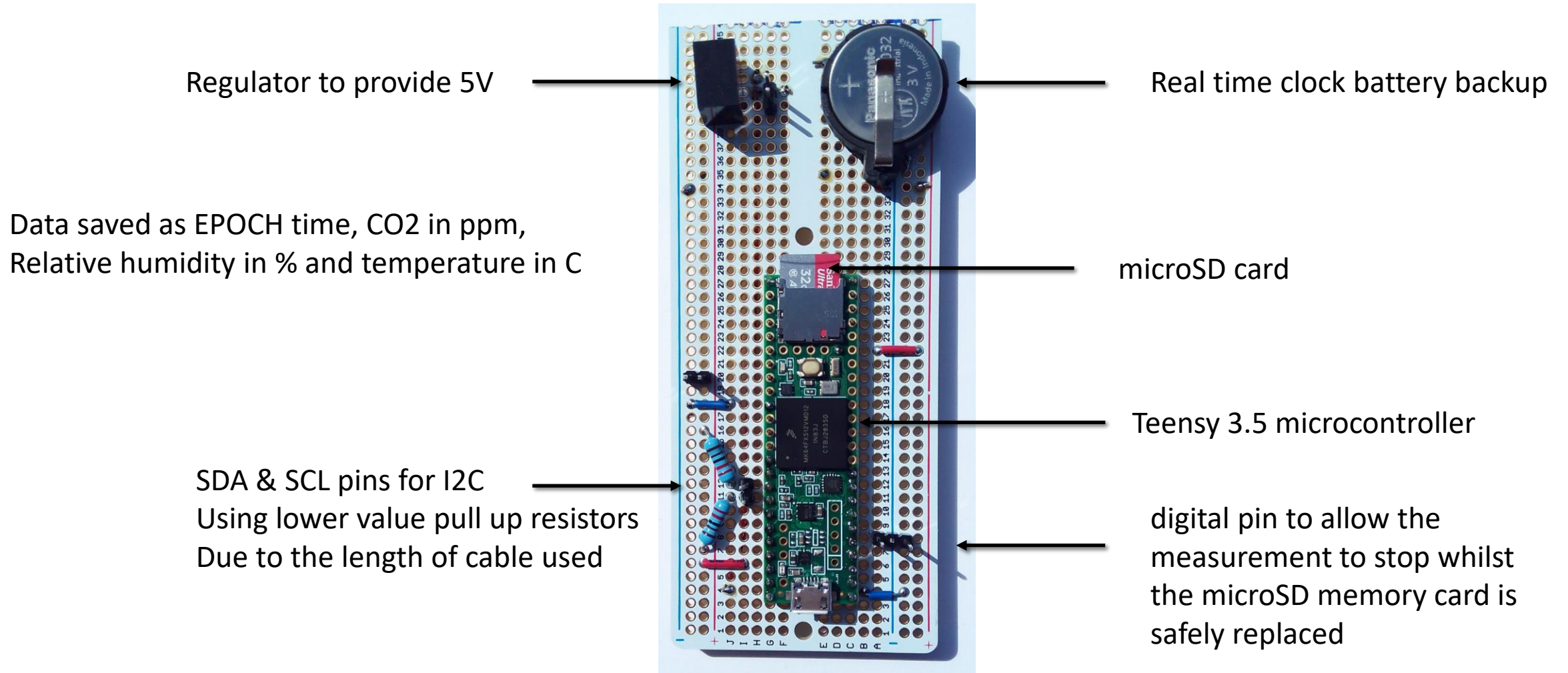Michael I Newton, Adam McVeigh, Costas Tsakonas and Martin Bencsik

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- Carbon dioxide has long been known as a narcotic for the honeybee and has been used to immobilize them during scientific manipulation or transfer. Higher levels in the hive are also believed to initiate fanning behaviour. For calibrated CO_2 measurement, the nondispersive infrared (NDIR) sensor is the closest sensor to meeting the requirements for hive installation.

- Water vapour is water in its gaseous state and water vapor in the air is called humidity. Temperature and humidity are two of the most important factors affecting the health and survival of honeybee colonies. Humidity is known to play a vital role in the development of brood.

- In this work we investigate the use of the Sensirion SCD30 and SCD41 for application in honeybee hives as these provide CO_2 measurement in a range up to 40,000ppm in addition to providing relative humidity and temperature data

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- This is a picture of an observation hive using a modified British National brood box at NTU campus in Nottingham UK;

- A pipe through the wall allows bees to leave and enter the hive;

- The modification allows a frame to be lifted for observation and then replaced;

- One SCD30 gas sensor has been installed in a frame in the brood box and two sensors (one SCD30 and one SCD41) in the to the top of the hive (crown board);

- Although sensors have been installed in several other hives, all data in this presentation was from this colony.
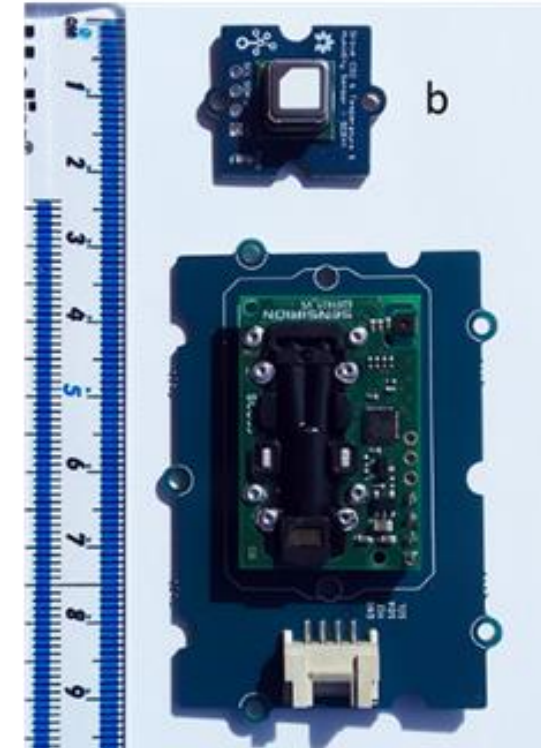
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Regulator to provide 5V

Real time clock battery backup

Data saved as EPOCH time, CO2 in ppm,
Relative humidity in % and temperature in C

microSD card

Teensy 3.5 microcontroller

SDA & SCL pins for I2C
Using lower value pull up resistors
Due to the length of cable used

digital pin to allow the
measurement to stop whilst
the microSD memory card is
safely replaced

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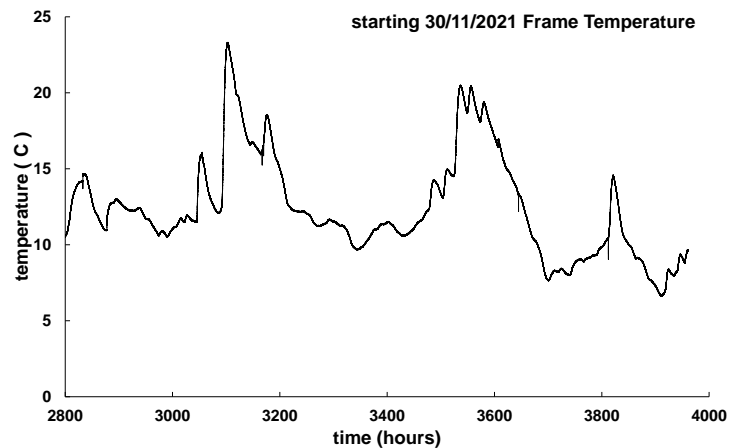
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(a) SCD30 installed in brood box frame showing propolis coating on the protective mesh.

(a) SCD30 (lower) and SCD41 (upper) sensors with rule to show relative sizes of the two devices.

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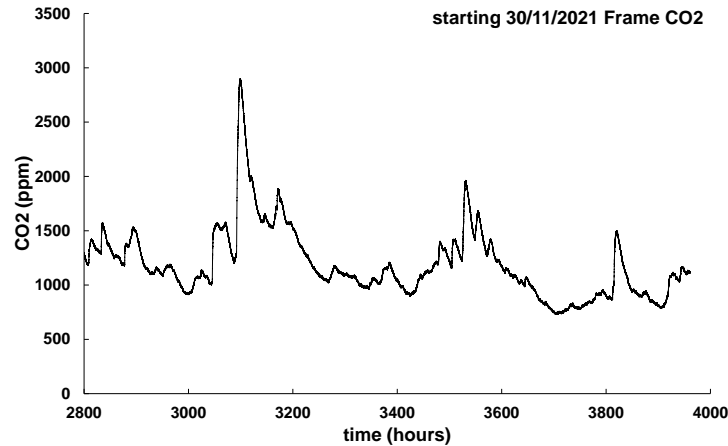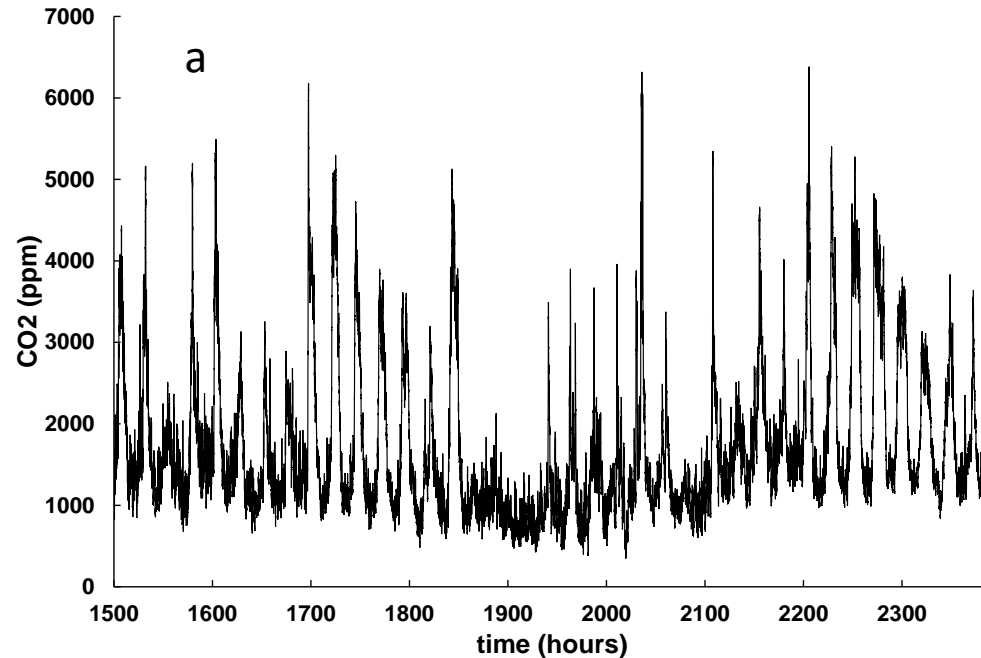Michael I Newton, Adam McVeigh, Costas Tsakonas and Martin Bencsik

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starting 01/09/2021 Frame CO2

starting 01/09/2021 Frame Temperature
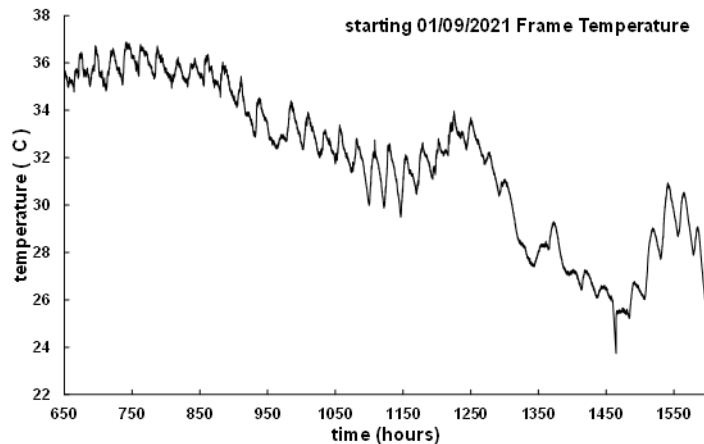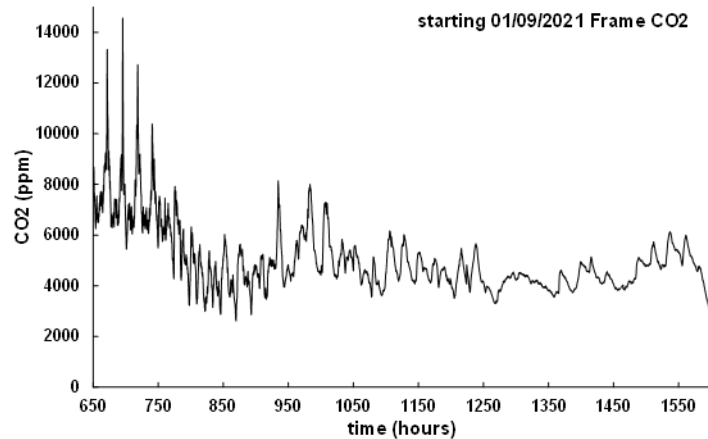
- The CO_2 in a brood frame over a thirty-seven-day period starting at the beginning of September 2021 when the colony was initially active on the frame;

- There is a significant daily variation in CO_2 and the peak levels in the hive are ten times that conducive to human health;

- The corresponding temperature shown in the lower graph displaying daily variation;

- The temperatures are initially conducive to brood rearing and then drop significantly beyond 1250 hours.

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starting 30/11/2021 Frame CO2

starting 30/11/2021 Frame Temperature

- The CO_2 in a brood frame over a thirty-seven-day period starting at the end of November 2021 when the colony was initially active on the frame;

- There is still some daily variation in CO_2 and the peak levels in the hive still high compared to ambient air;

- The corresponding temperature shown in the lower graph;

- The temperatures suggest that the colony were not active on the frame.

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CO2 measured using a SCD41 in the crown board of the observation hive over a thirty-seven-day period starting in March 2022 exhibiting a clear daily variation
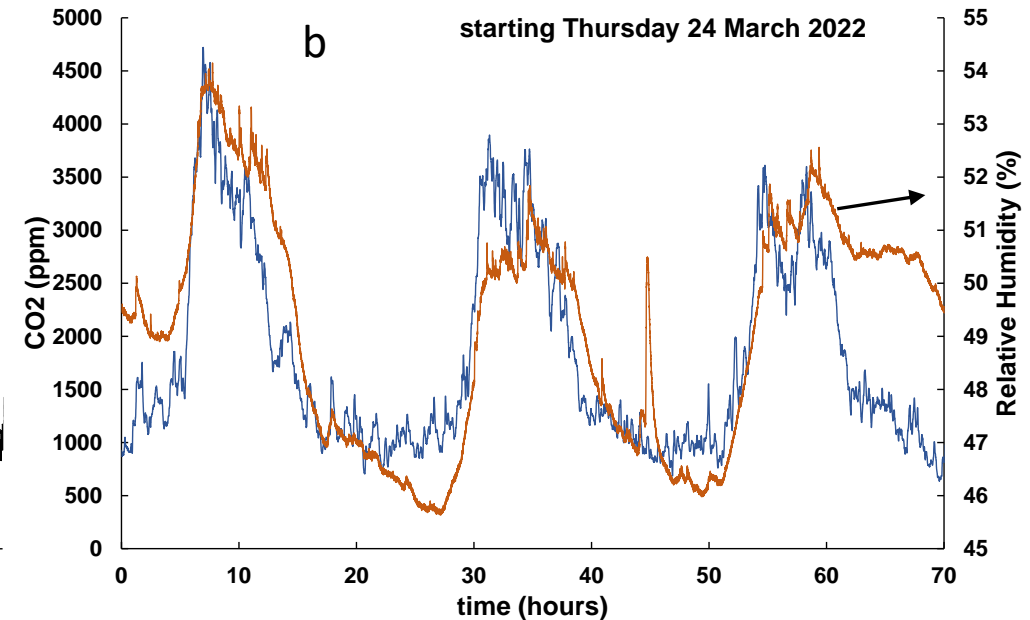
CO2 (blue line) and corresponding relative humidity (orange line) over a three-day period showing them following similar daily change.

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Conclusion

- We have demonstrated a reliable system, based on the Teensy 3.5 microcontroller, for the long term monitoring of humidity and carbon dioxide in honeybee hives providing thousands of hours of data with excellent temporal resolution;

- Two different NDIR based sensors, SCD30 and SCD41, have both been demonstrated to be appropriate for this but with the SCD41 having a significantly smaller footprint;

- Both daily variations and longer-term trends in both CO2 and humidity have been observed;

- Positioning a sensor in the frame reflect more accurately the true values experienced by the workers whilst the easier positioning above the brood box continues to reflect the daily and long term trends but at lower levels;

- Even at the lowest values of CO2, the data was far in excess of the values that would be conducive to human health.

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