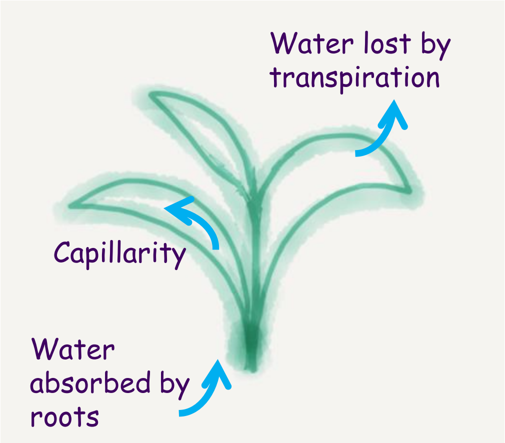
Urban Agriculture

Dr. Ruchi Choudhary

Rebecca Ward, The Alan Turing Institute
Dr. Flora Roumpani, The Alan Turing Institute
Dr. Tomas Lazauskas, The Alan Turing Institute
Dr. Paul Fidler, Centre for Smart Infrastructure & Construction
Dr. Kathryn Leeming, U. of Warwick
Melanie Jans-Singh, PhD Student, U. of Cambridge

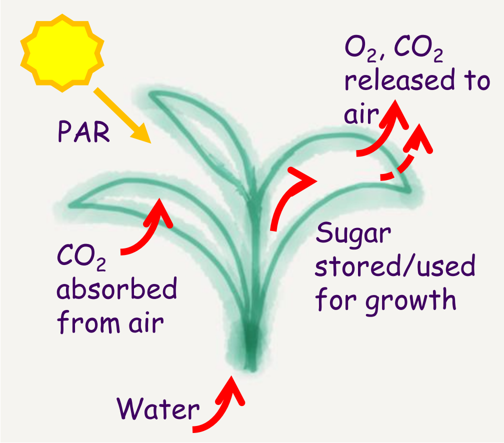
Why Urban Agriculture?

transpiration



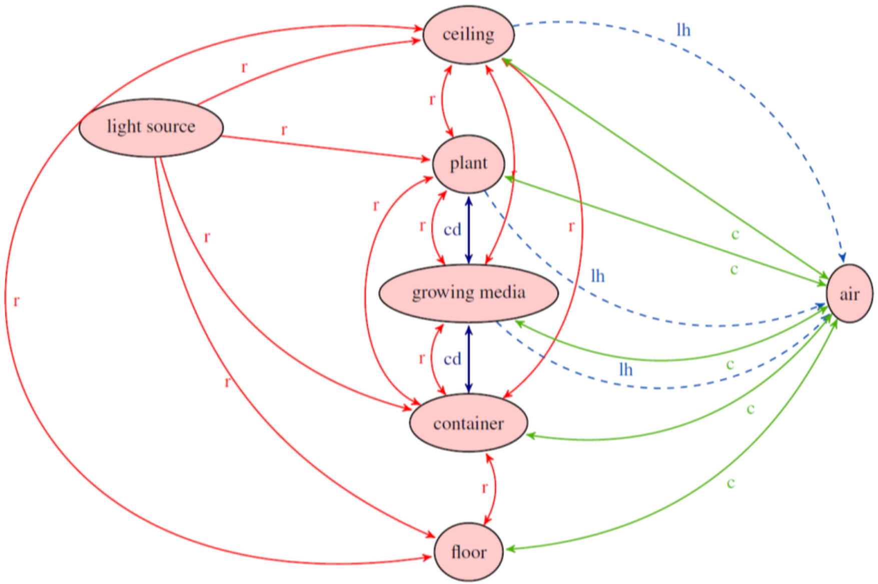
impact: cooling, increase in moisture content of air

photosynthesis



impact: net removal of $CO_{2,}$ addition of O_2

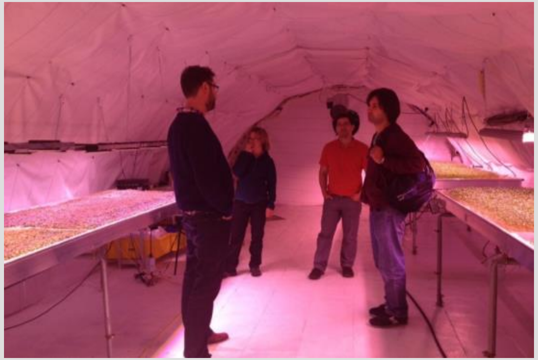
Research Challenges



- models of heat & mass exchange and plant growth. Largely empirical and limited to specific crops
- No models that couple greenhouse environment with standard buildings
- Monitoring difficult as environments are often bespoke

Growing Underground: our poster child…

Derelict Tunnels

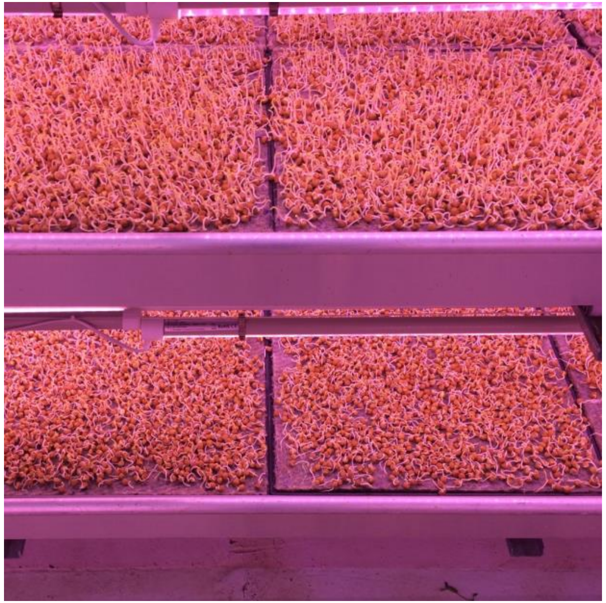


Initial Farm Trials

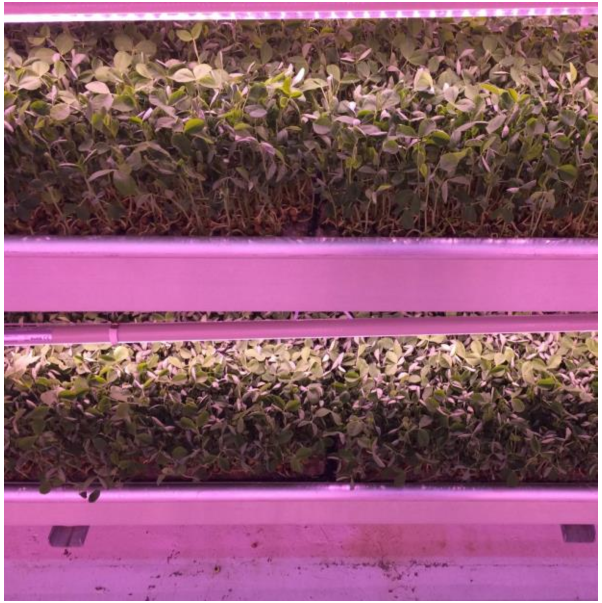
Commercial Farm (2015-)

03/02/2022

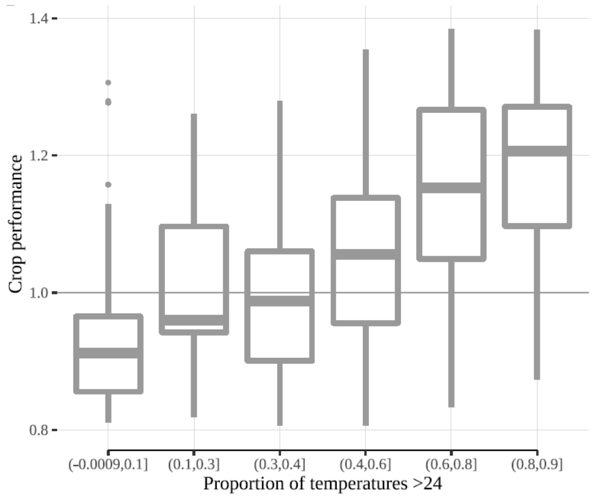
Increase yield and minimise energy



Peashoots: 5 days



10 days



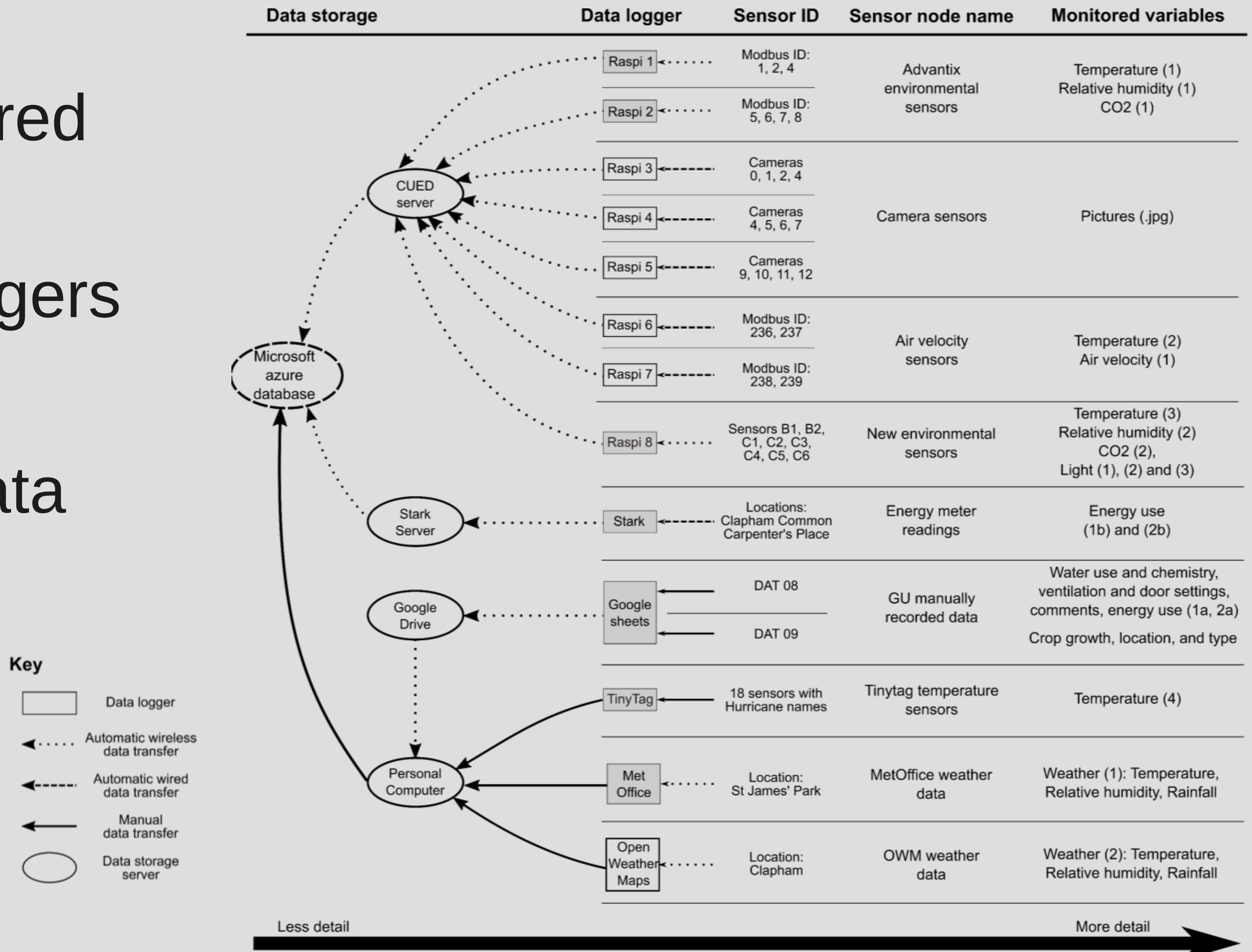
Performance with temperature

– 89 monitored variables

– 8 data loggers

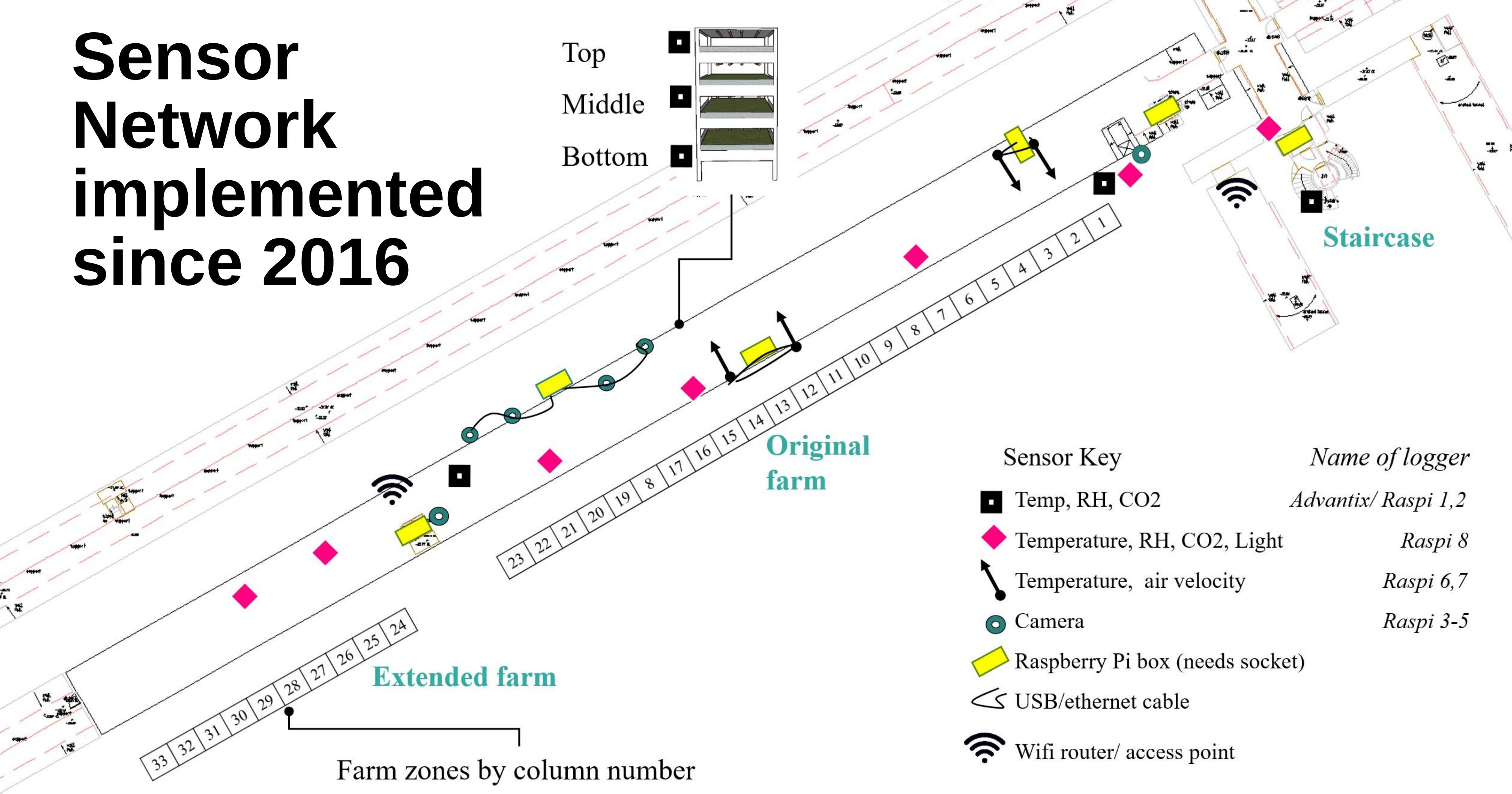
– 2 APIs

– Manual data collection

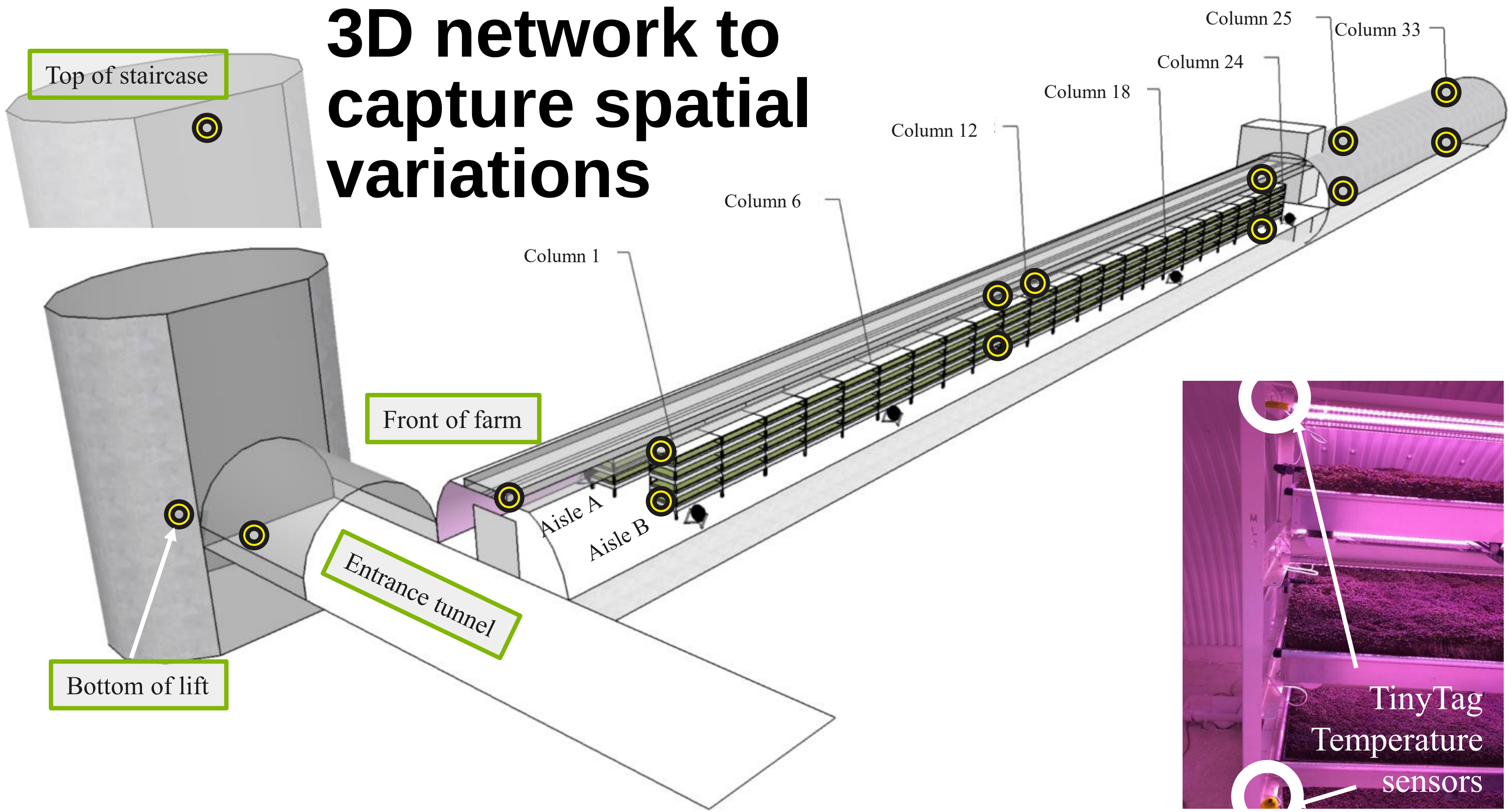


23/02/2022

Sensor Network implemented since 2016



3D network to capture spatial variations




Trust
DSP
10-5
Trust


12
B
M
L
G

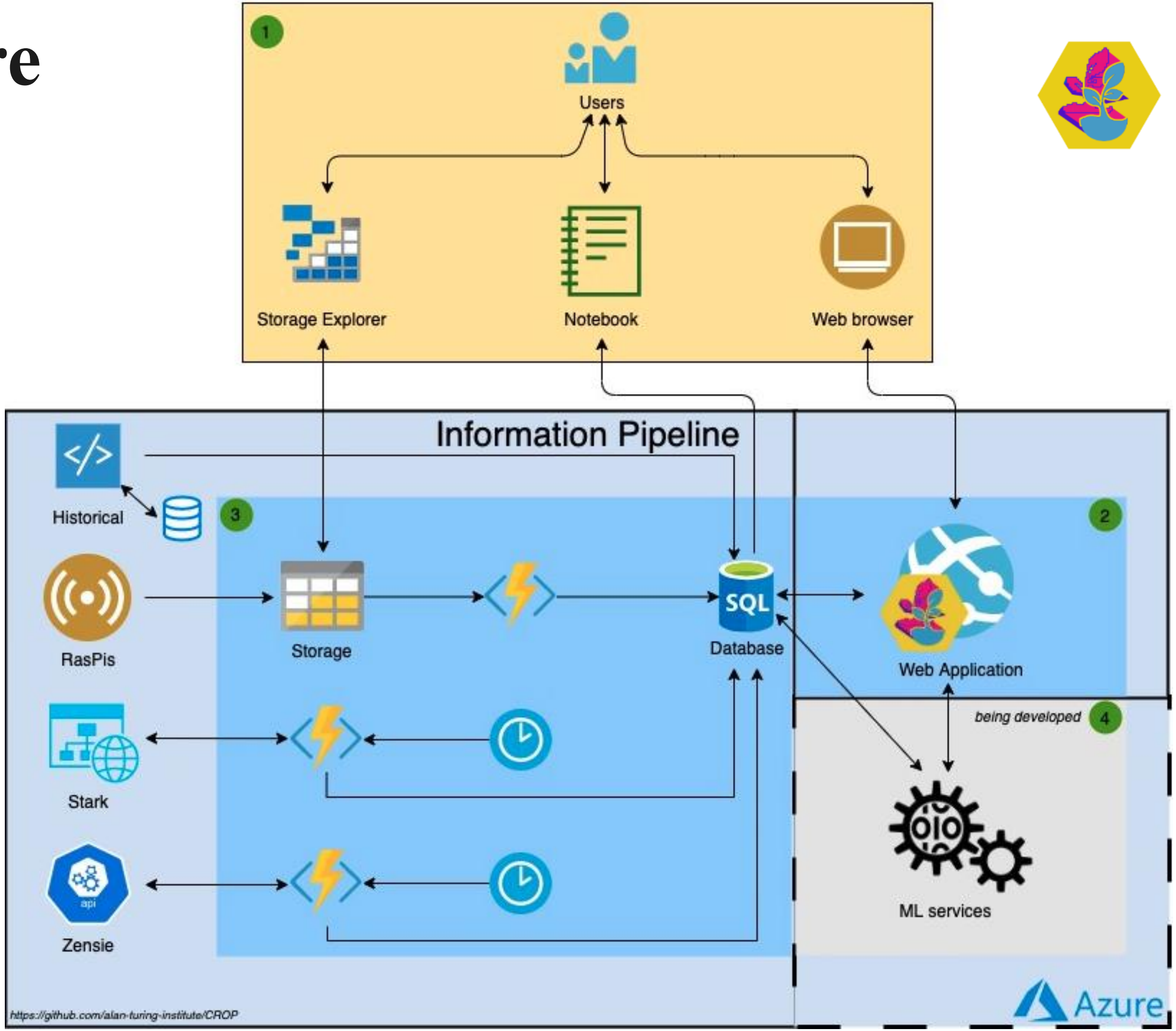
CROP Architecture

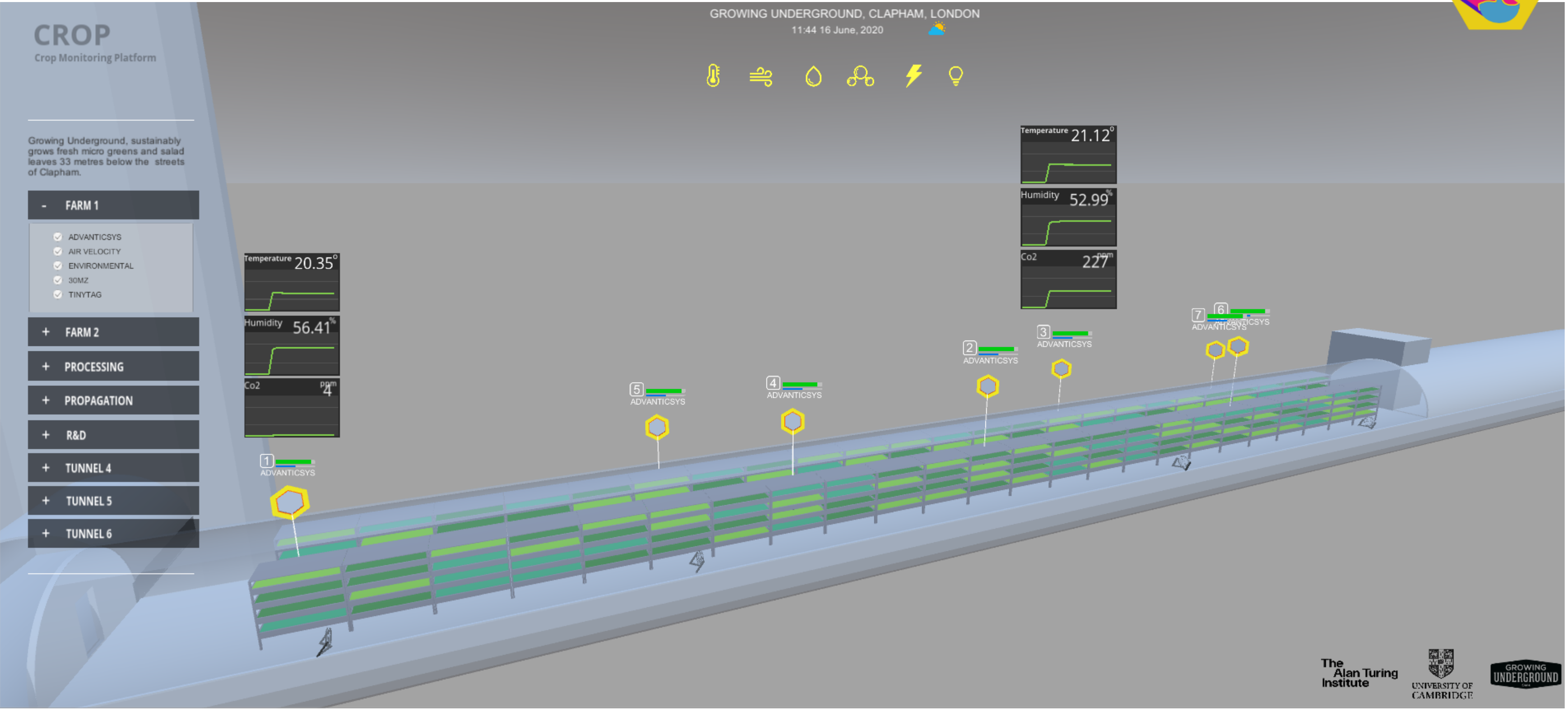
1 Users can **access** the CROP platform and database using multiple ways.

2 CROP **web application** is the main interface for the digital twin. Users can explore collected heterogeneous IoT sensor data, analyse farm conditions at various points in time, use the developed 3D visualisation tools.

3 CROP **database** is constantly updated from multiple streams of data: Zensie API, Stark energy usage platform, custom made (Raspberry Pi) sensors, and others.

4 CROP **machine learning services** integrate automated prediction and calibration models into the platform.





The Alan Turing Institute

CSIC Cambridge Centre for Smart Infrastructure & Construction

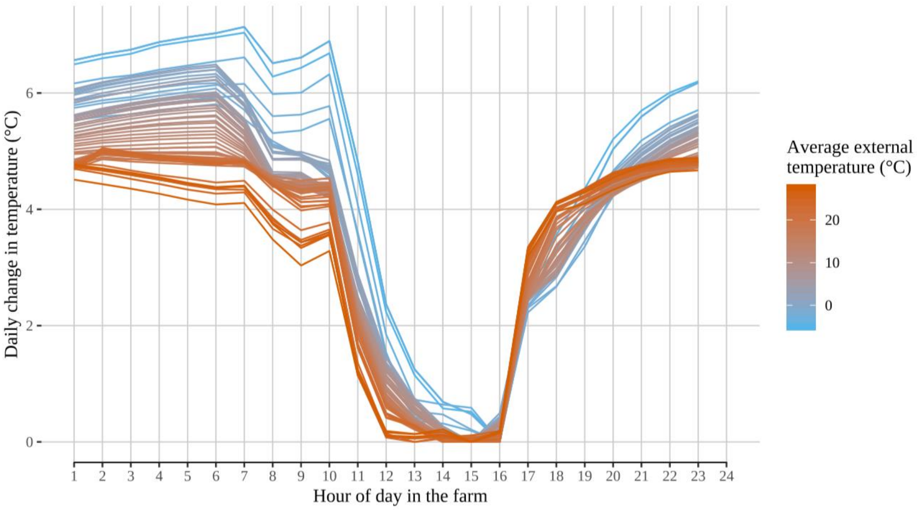
UNIVERSITY OF CAMBRIDGE
Department of Engineering

The Alan Turing Institute

CSIC Cambridge Centre for Smart Infrastructure & Construction

UNIVERSITY OF CAMBRIDGE Department of Engineering

Temperature forecasting: too hot to grow?

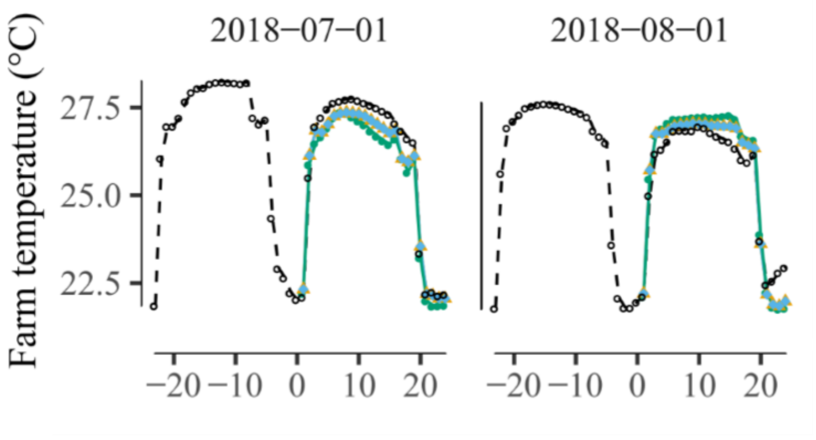


- Temperatures have changing mean, and an irregular, changing daily shape
- Energy readings are used to infer the lighting schedule as this is the main process behind the temperature changes
- Bayesian dynamic linear model with data-driven seasonal component handles typical and atypical forecasts, important for optimising yield
- Flexible to new data streams

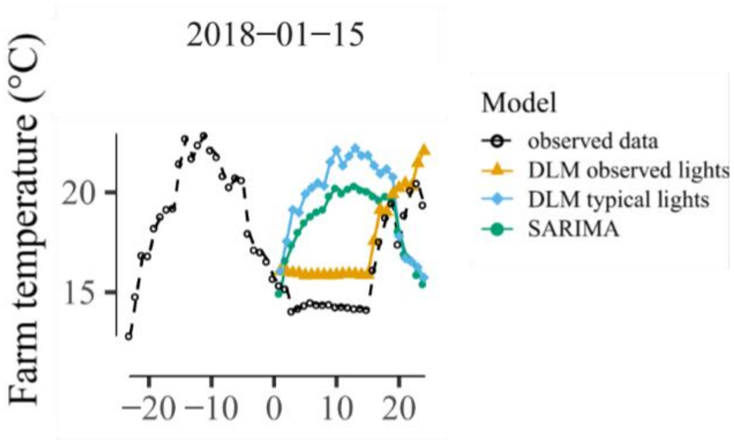
Digital twin: use model to suggest operational changes and feedback to improve model

The Alan Turing Institute
CSIC Cambridge Centre for Smart Infrastructure & Construction
UNIVERSITY OF CAMBRIDGE Department of Engineering

Temperature forecasting

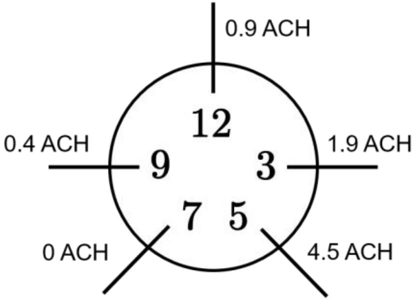


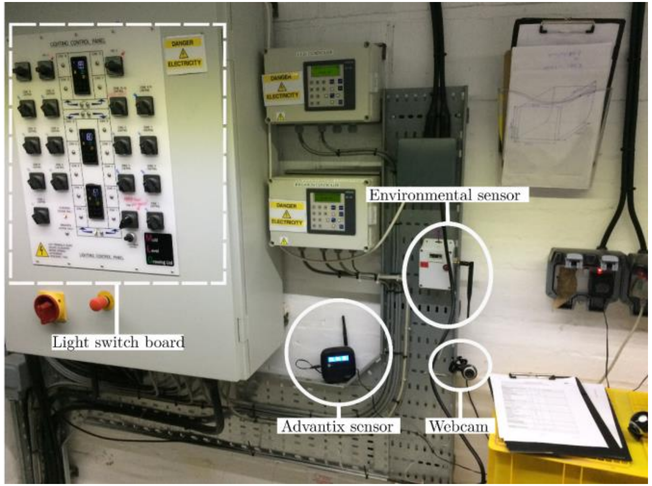
Typical lighting days: bespoke and traditional forecasts are similar



Atypical lighting days: data-driven method can forecast the effect on temperature by utilising the unique lighting pattern (lights switched on much later than usual)

Meaningful bespoke outputs





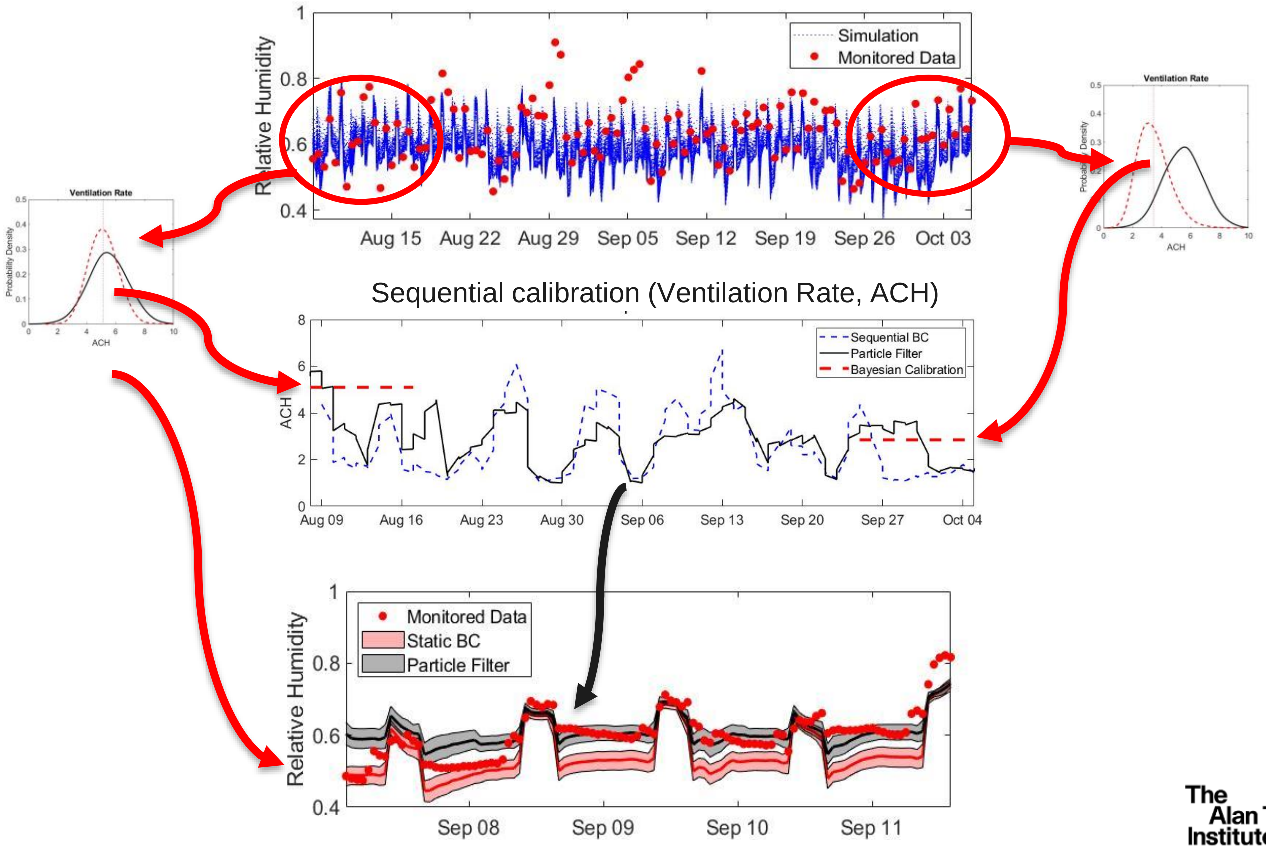
Turn ventilation setting to 3 o'clock

Recommend to place peashoots in zone 6

Lights were on for 20 hours yesterday

Continuous calibration of physics-based model

Physics-based model is used to simulate tunnel environment and to model future scenarios



Bayesian Calibration gives only static estimates of calibration parameters

For time-varying parameters a Particle Filter or sequential Bayesian Calibration approach gives continuously updated estimates of parameter values

Updated parameter estimates are used in simulation to give better estimates of environmental conditions

The Alan Turing Institute

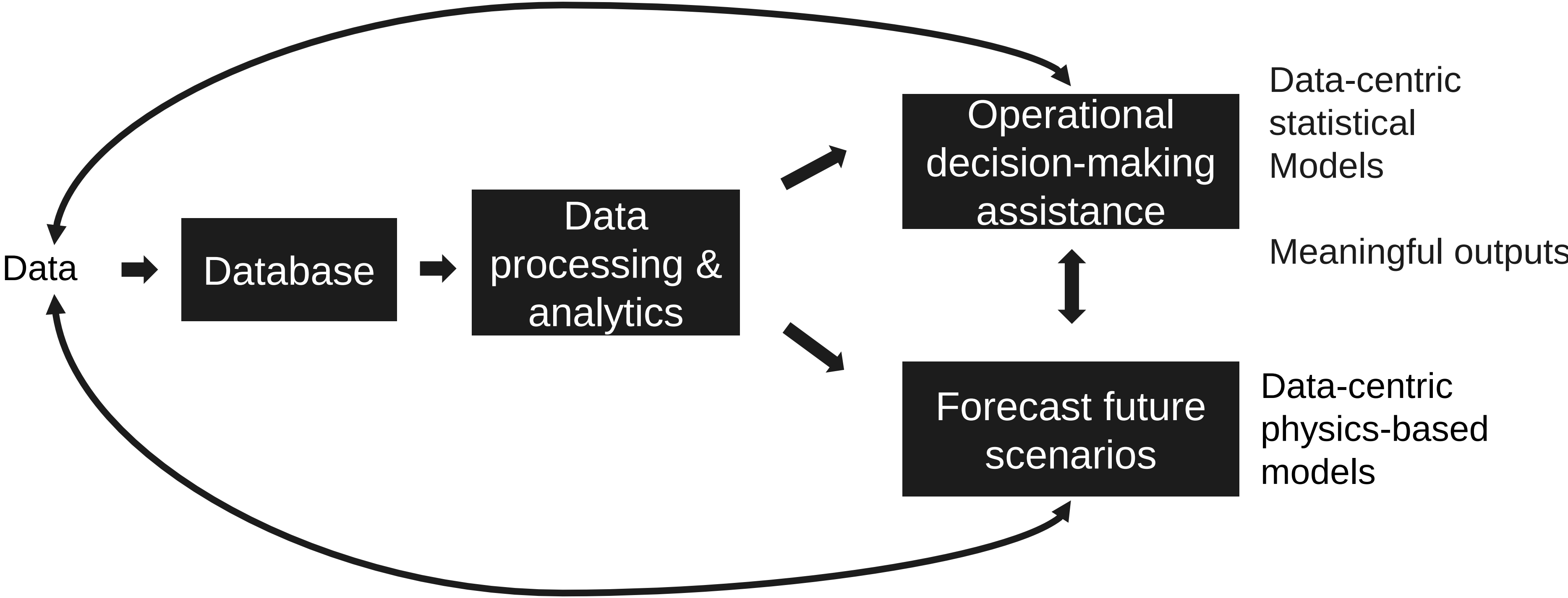
CSIC Cambridge Centre for Smart Infrastructure & Construction

UNIVERSITY OF CAMBRIDGE
Department of Engineering

Benefits of the Digital Twin

- Continuously monitored data are uploaded to a central database for ease of access
- Data are extracted from the database for continuous calibration of the physics-based model
- The physics-based model with calibrated parameters is used to simulate potential scenarios for mitigation of undesirable environmental conditions
- Farm operators are alerted to potential problems and proposed remedial actions

Benefits of the digital twin



Questions?