



Assessment and Deployment of Bird Carried Meteorological Sensors for Microclimate Measurements in Urban Terrain

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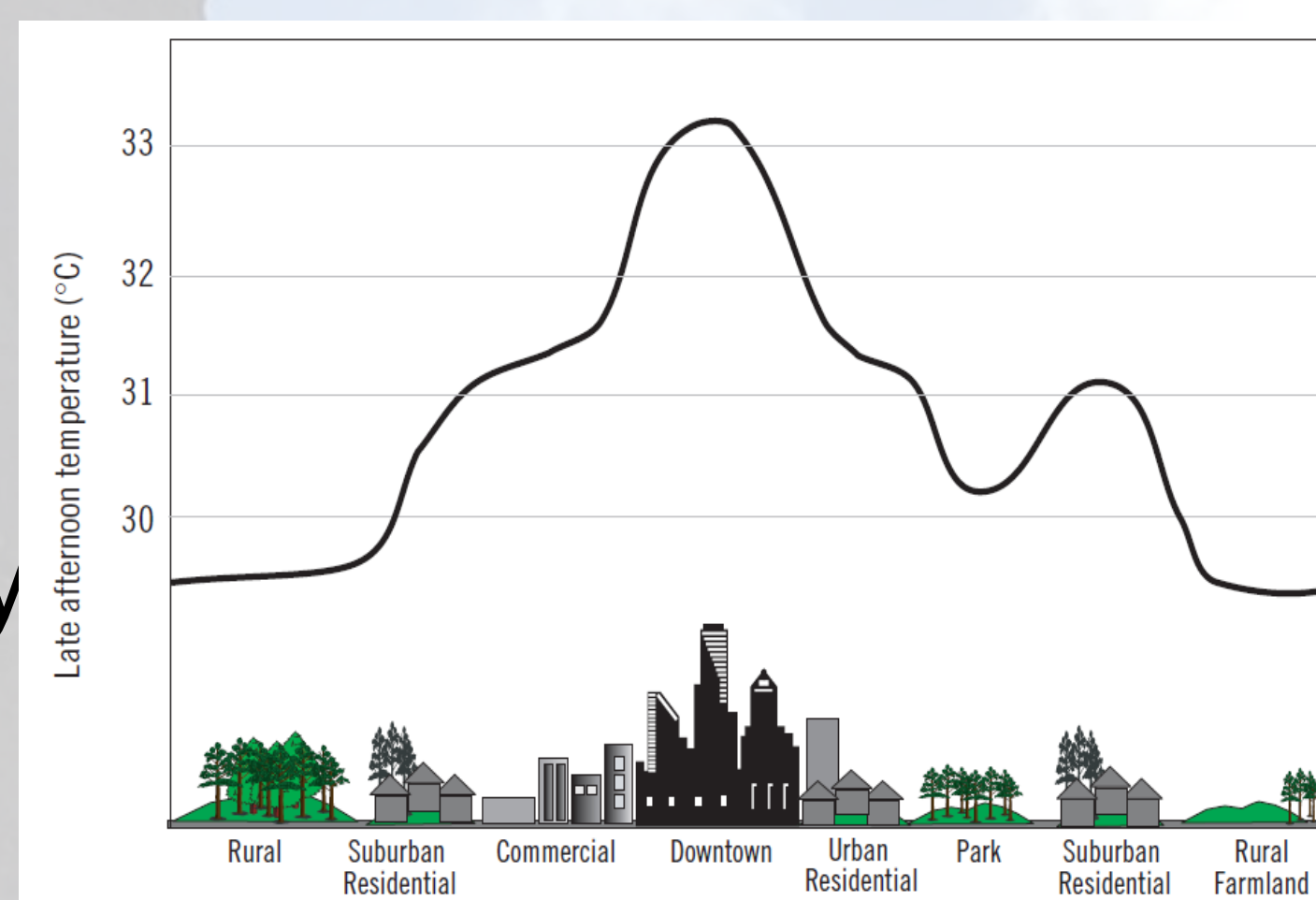
1. Cityflocks Project Description

Meteorological measurements above the urban canopy are required to assess spatial variability and dynamics of urban boundary layers.

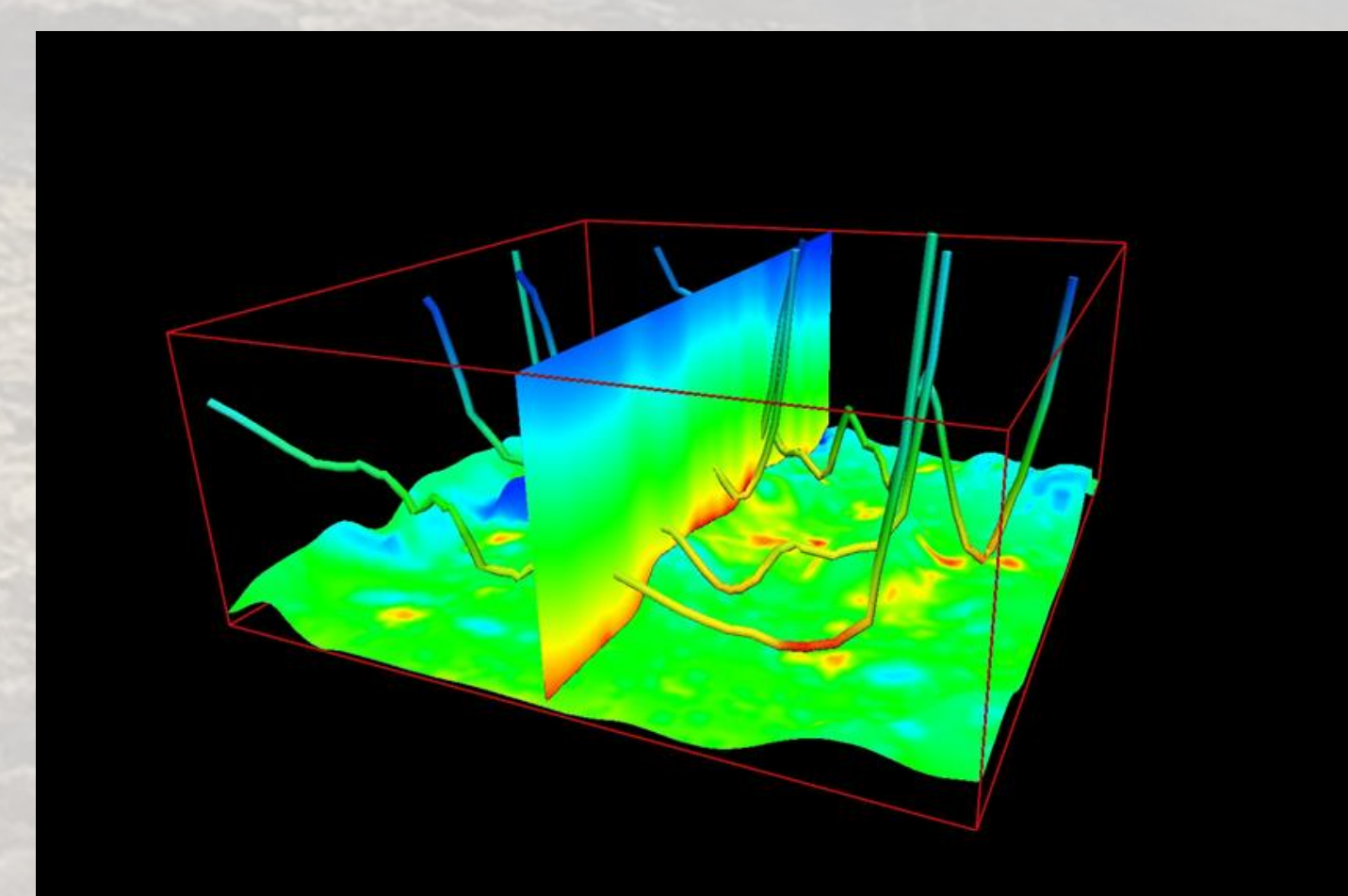
Implications for:

- (i) urban weather prediction;
- (ii) event forecasting (e.g. heatwaves, climatic conditions during sporting events, releases of hazardous substances);
- (iii) air pollution modelling; and
- (iv) sustainable urban planning for high-density livable cities

Drones are not easily permitted to fly across city rooftops; bird carried sensors may offer a method to fill this measurement gap.

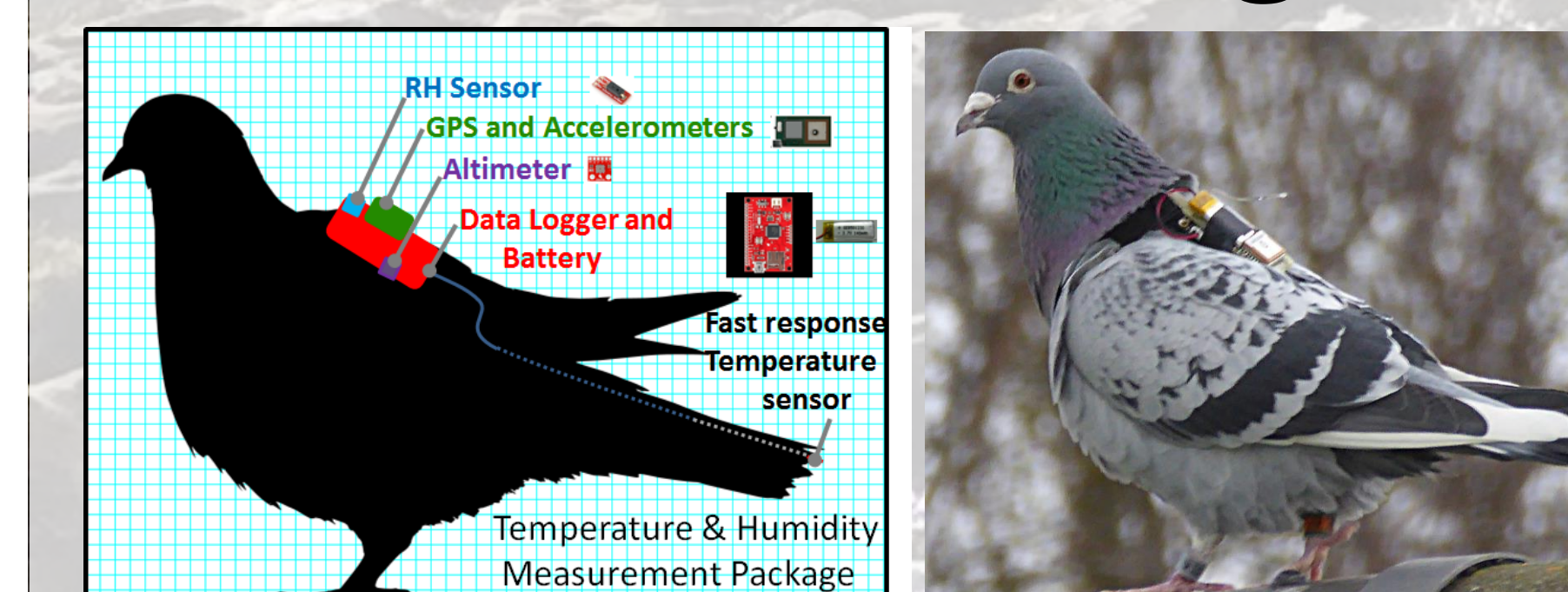


Urban Heat Island Temperature profile (Lemman and Warren, 2004)

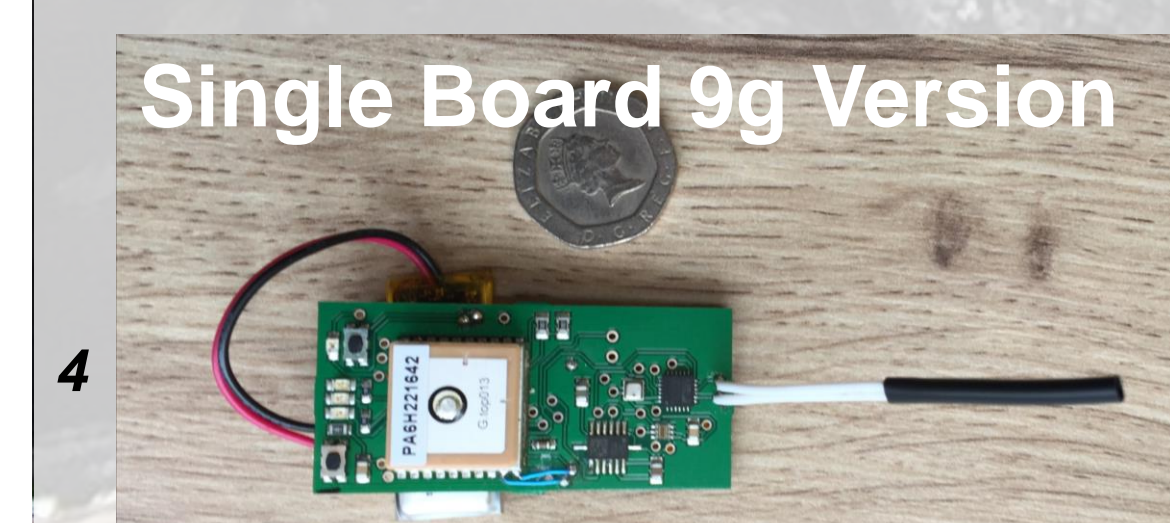


Example model temperature field output with simulated bird temperature flight paths

2. Sensor Package



Proposal schematic (left) showing original design for a lightweight bird-carried sensor package. Developed sensor on right.

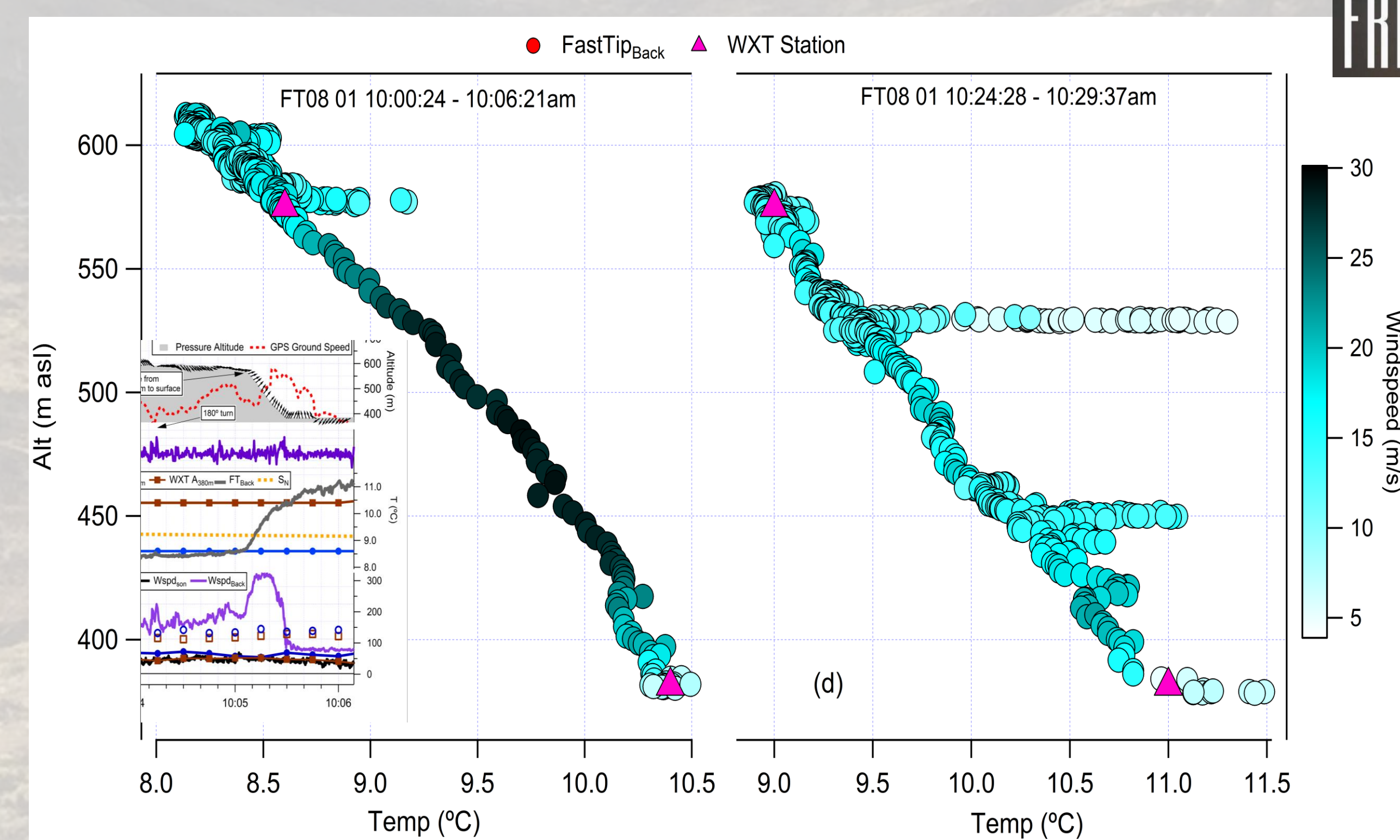


- GPS
- 1100mAh Lipo battery
- Voltage regulator (3.3V to 5V)
- Ambient Pressure sensor
- Microcontroller (Pi-zero)
- 2 x Fast temperature sensors (0.1 second response time)
- 3-axis Accelerometer
- 3-axis Gyroscope
- Ambient light sensor
- Airspeed Sensor (optional)
- CO2 sensor optional)

3. Eagle tests in complex terrain



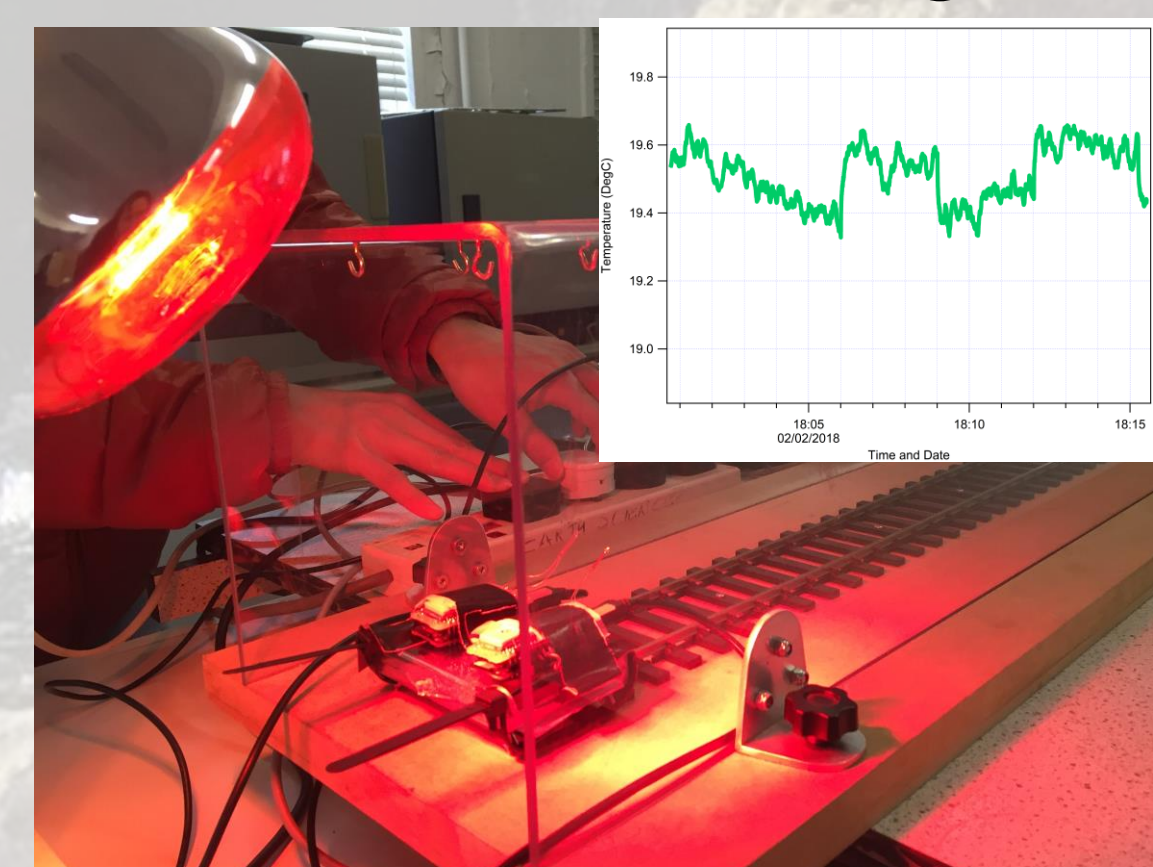
Prototype sensor flown in complex Scottish landscape on the back of trained Eagles to test the sensors response to bird's body heat and ability to respond quickly enough to measure meteorological dynamics (Thomas *et al.* 2017).



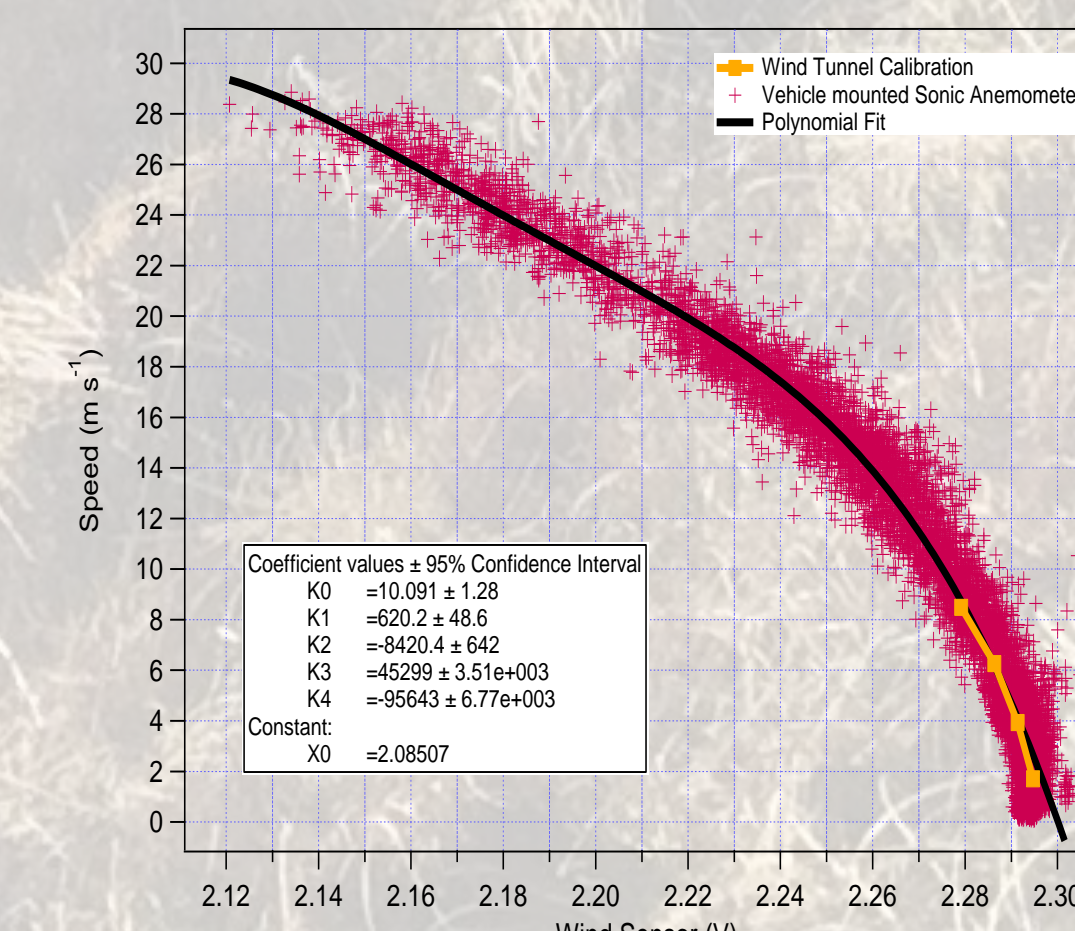
Temperature profiles measured with bird mounted sensor (FastTipBack) compared to surface weather stations (WXT)

4. Characterisations

In addition to chamber calibration of temperature sensors, other calibrations and characterisations were performed including:



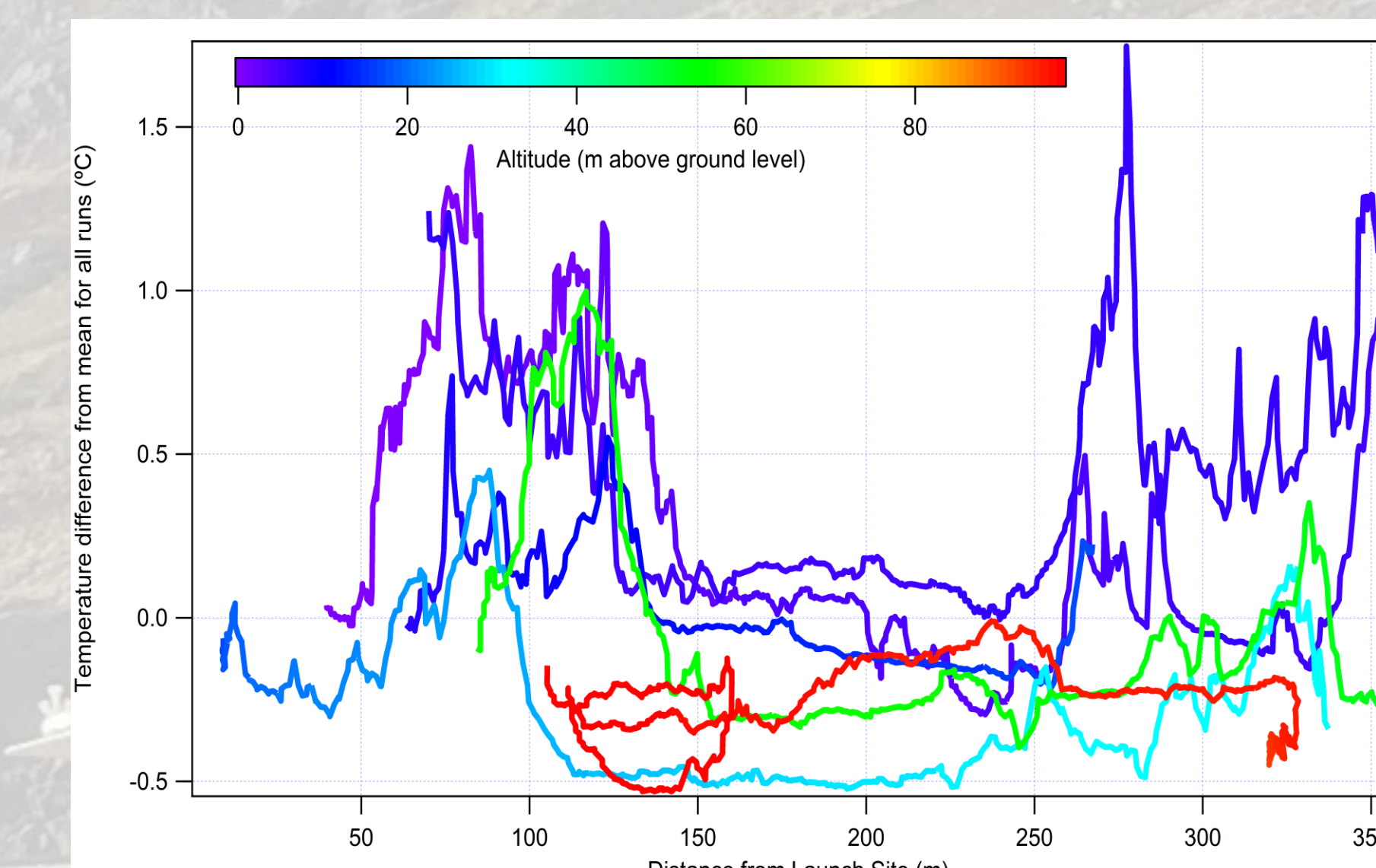
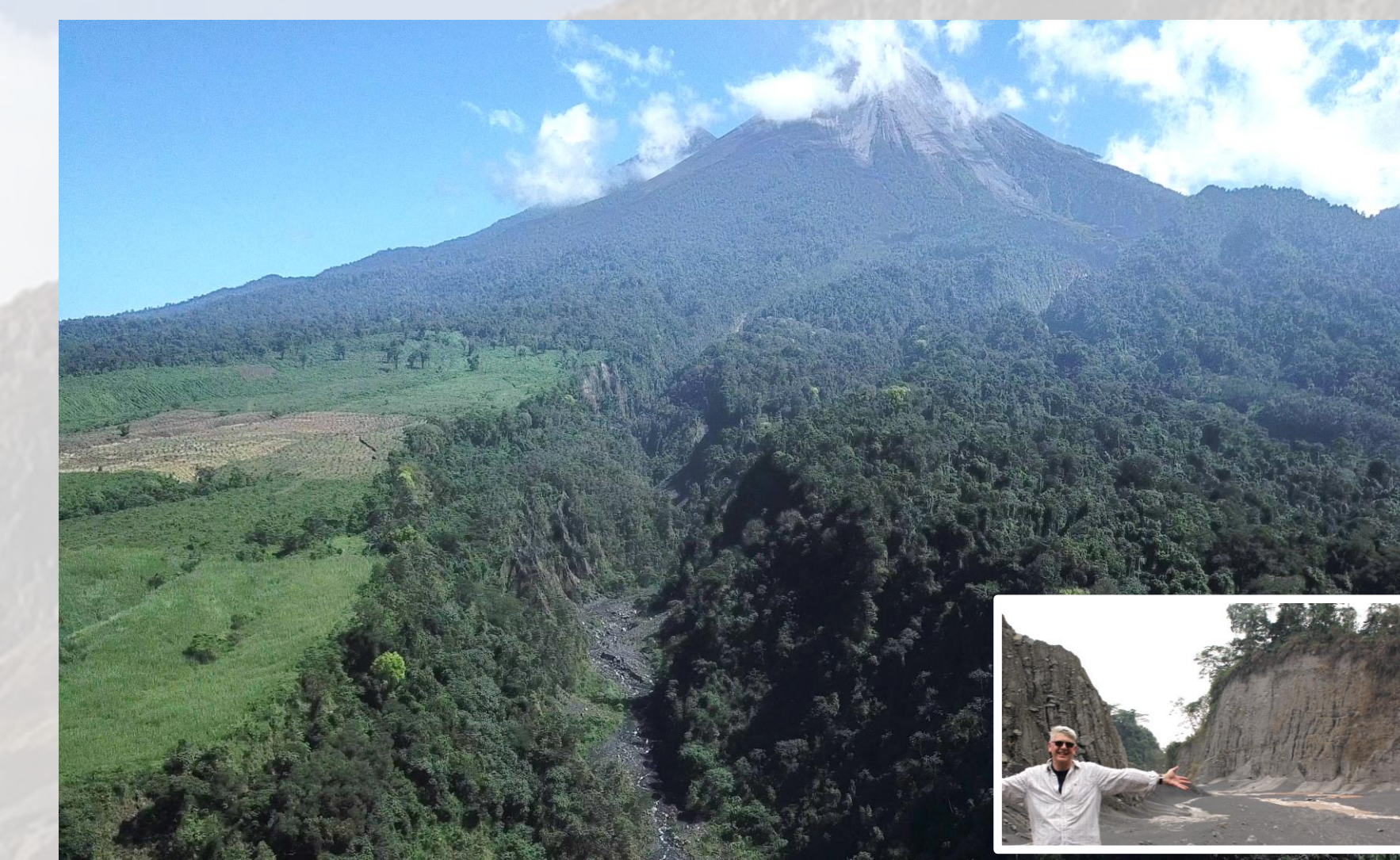
Sensor heating tests in wind tunnel at 6.7 m/s with 650W/m² heating. Indicates a heating effect of 0.12 °C.



Wind speed calibrations using wind tunnel and car mounted sensors

5. Canyon Overflights

Test of temperature response to surface heating effects by flying on a drone over a Barranca (canyon) formed by an active volcano.



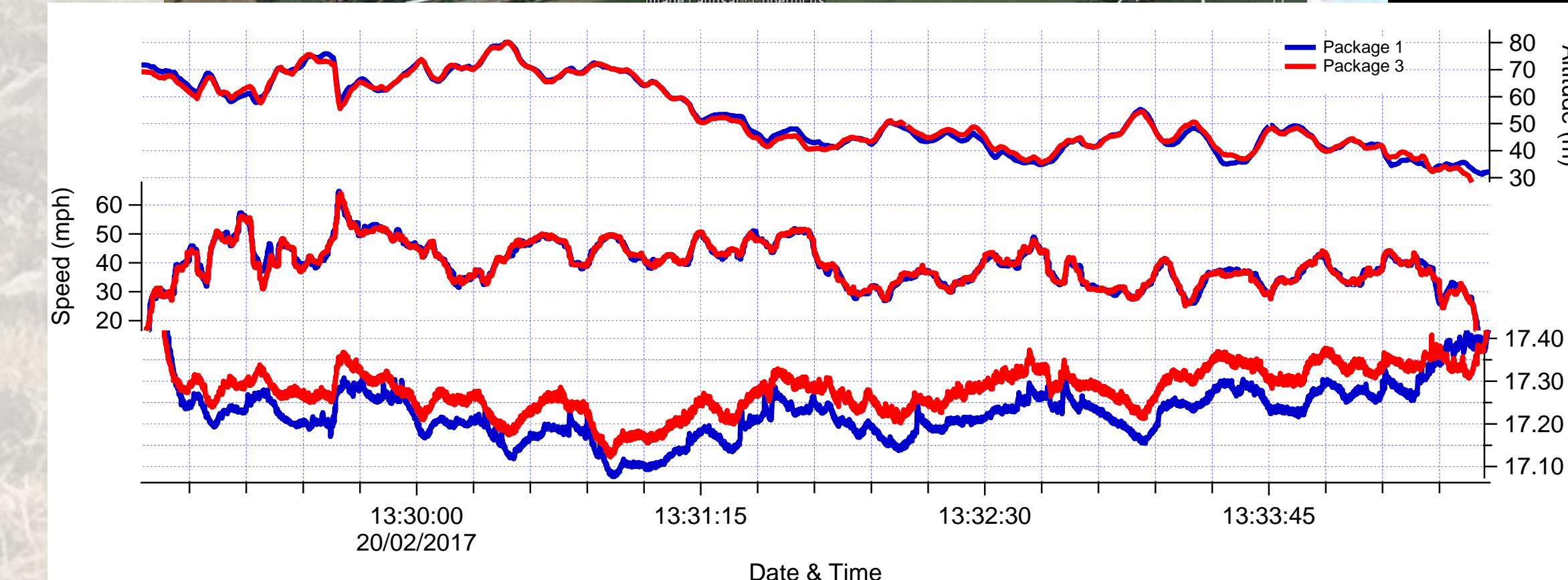
Multiple temperature transects collected at different heights help investigate the height at which the contrasting temperatures of the surface elements blend together.

6. Pigeon Tests

Initial testing of minaturised sensor package carried by homing pigeons



Pigeon carrying GPS package



Left: Altitude, ground speed and temperature data for two pigeons carrying sensor packages.



References and Acknowledgements

Lemmen, Donald Stanley. & Warren, Fiona J. & Climate Change Impacts and Adaptation Program (Canada). (2004). *Climate change impacts and adaptation : a Canadian perspective : summary*. [Ottawa]: Climate Change Impacts and Adaptation Program
Thomas, R.M., et al., *Avian Sensor Packages for Meteorological Measurements in Complex Terrain and Urban Environments*. Bulletin of the American Meteorological Society 2017. (In press. Early release available: <http://journals.ametsoc.org/doi/10.1175/BAMS-D-16-0181.1>)

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