Low-cost, Road Surface Temperature sensing enabled by the Internet of Things

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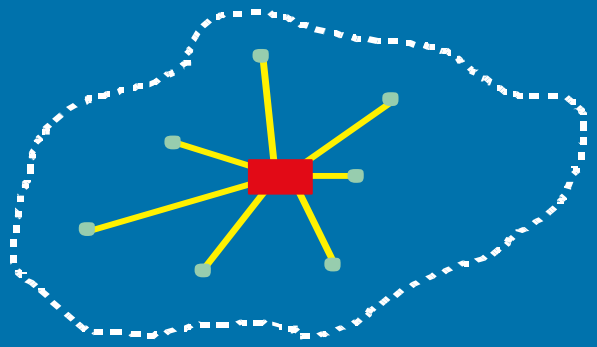
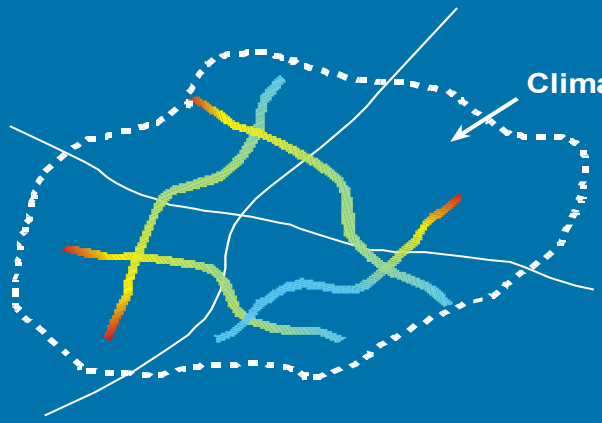
1984
ICE DETECTION



outstations

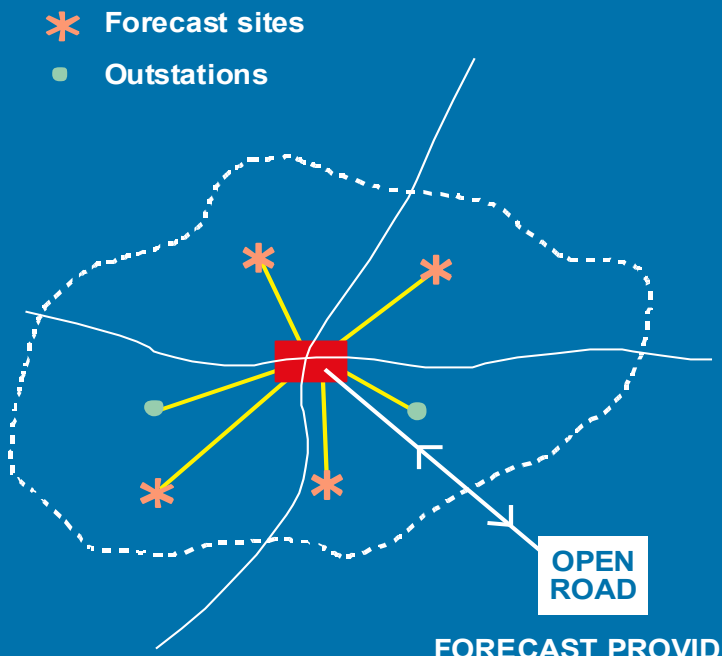
instation

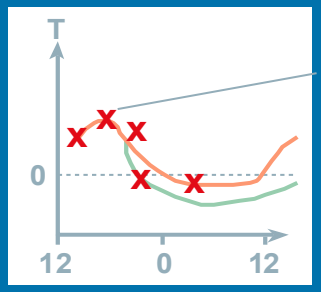
THERMAL MAPPING

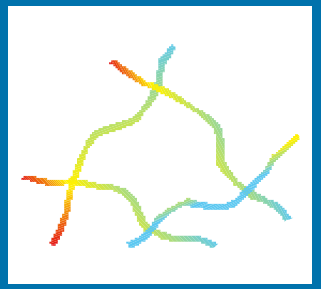


First Thermal Map in UK - A9 Scotland April 1984

Ⓑ 1986 ICE PREDICTION



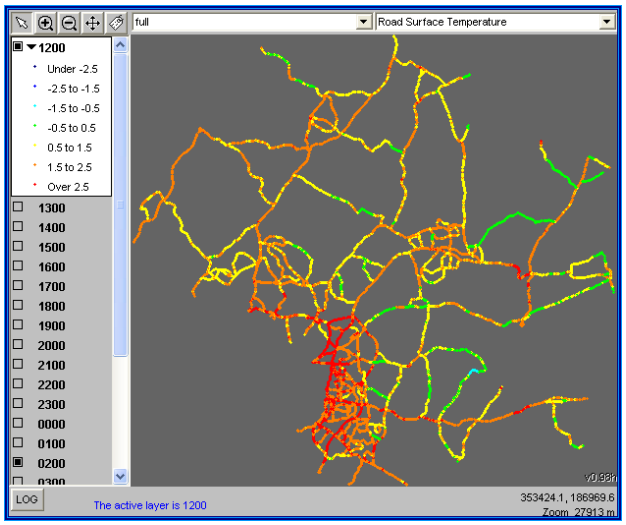


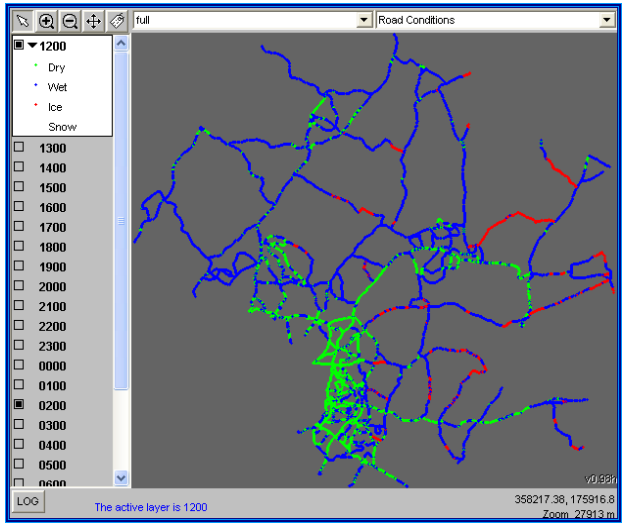


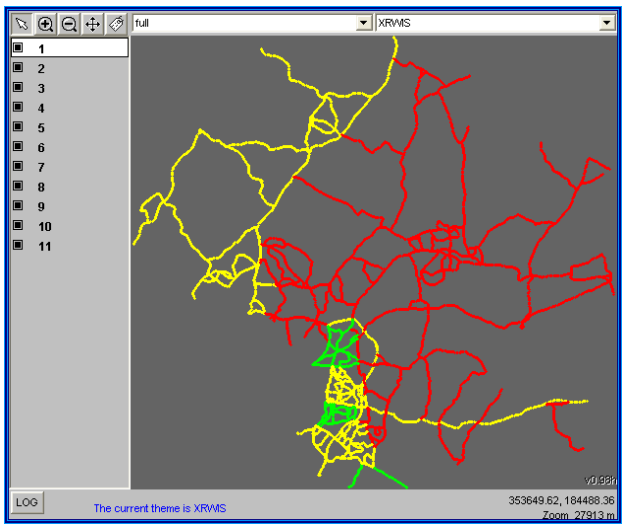
Forecast Thermal Maps

Route-based forecasting

- A new paradigm in winter road maintenance
- Spatial interpolations between 'point' outstations no longer reliant on thermal mapping
- Instead, interpolations are made by modelling the influence of geography on the road surface at 1000s of points around the road network.
- Essentially running the forecast model 1000s of times with little changes (perturbations) with respect to local geography
- Enables the engineer to turn the gritter on and off selectively and save £££££s but…







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Selective Salting

- Selective salting is still not happening

- In an age of litigation, users are very wary about relying on model output to this level.
- Hence, a lack of sufficient technologies to verify / supplement route based forecasts is a big problem:
  - Thermal mapping = good spatial resolution, but poor temporal resolution
  - Outstations = good temporal resolution but very site specific
- How do you verify a route based forecast?

- Solve the verification problem and the savings and potential of all these approaches becomes unlocked:
  - Route based forecasting
  - Selective Salting
  - Dynamic Routing

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The Internet of Things

- Literally means things that connect to the internet
  - Computers
  - Smart Phones
  - Curtains, lights, central heating...
  - Sensors
- Since 2008, these things now outnumber users online
- Lots of potential via the smart cities agenda
  - Miniaturisation of technology
  - Decreasing cost of sensor networks
- How can winter road maintenance benefit?
  - Proprietary high resolution sensor networks
  - Connected gritters
  - Connected vehicles (mobile data and vehicle data translator)

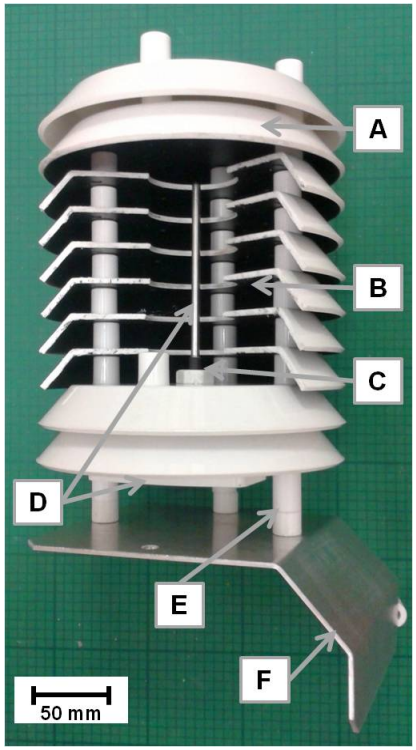
Low Cost Air Temperature Sensors

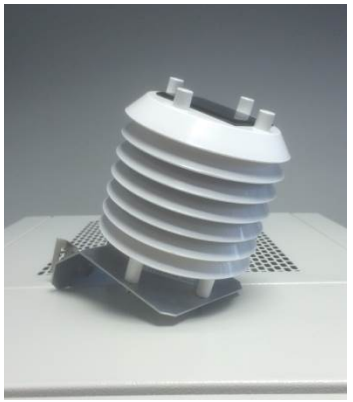
- alta**sense** is inspired by a sensor developed by the University of Birmingham on the NERC Network of Sensors project HiTemp

- Bespoke self contained air temperature sensor was designed to produce a high resolution network across Birmingham:
  - 10kΩ Negative Temperature Coefficient Thermistor
  - Bespoke radiation shield
  - Comms provided via a wireless communication card
  - Power provided from a Lithium-Thionyl Chloride battery which last for 3 years under ideal conditions
  - Very cheap - $120!
  - Tested at UKMO calibration lab with an absolute error of ±0.22°C

- Can be deployed anywhere where there is a WiFi network (e.g. smart cities & roads)

- A good example of a low cost thing in the IoT
  - No ongoing costs for communication / power
  - Cheap to install in a large network
  - Has led to a number of succesful 'spin-off' projects





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*winter**sense** is an EPSRC project, co-created with Amey, that is adapting the technology to measure road surface temperatures for gritting applications.*

- Thermistor replaced with a low cost IR thermopile sensor.
- Sensors relay data back to central server using existing city-wide Wi-Fi installed by Amey
- High resolution network will quantify thermal variations around the road network (up to 20°C on a marginal night)
- Save money by selective salting and dynamic routing

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The ‘wintersensor’

- Based on the Melexis Infrared Thermopile
  - 5° Field of View
  - Range of -40 to 125°C
- Powered by 3.6 V Lithium-Thionyl Chloride battery
- Standard IEEE 802.11 b/g/n 2.4 GHz WiFi
- Cost of around $200 per node

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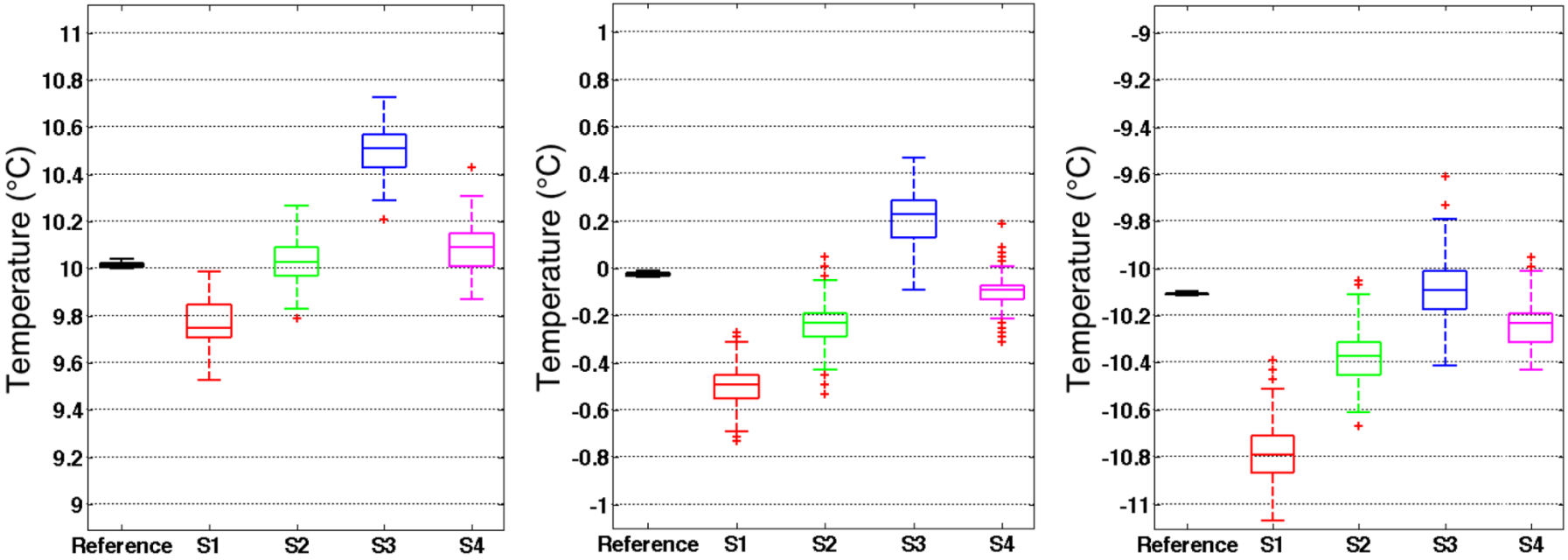
Is it any good?



REFERENCE (°C):	10.02	-0.02	-10.11
S1	-0.24 (0.09)	-0.47 (0.10)	-0.67 (0.12)
S2	0.01 (0.09)	-0.21 (0.10)	-0.27 (0.11)
S3	0.49 (0.09)	0.24 (0.11)	0.02 (0.13)
S4	0.07 (0.09)	-0.07 (0.08)	-0.13 (0.09)

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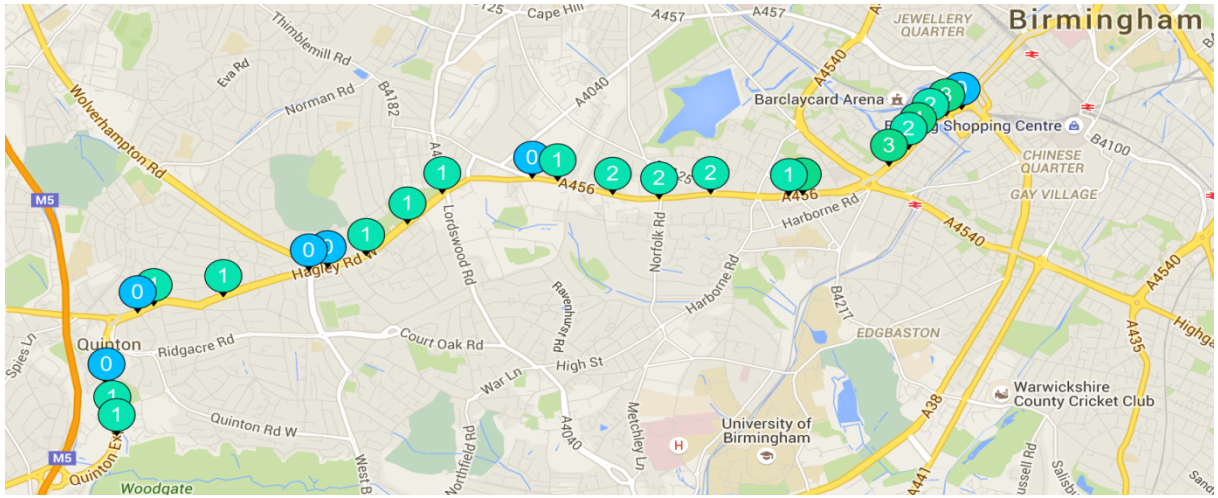
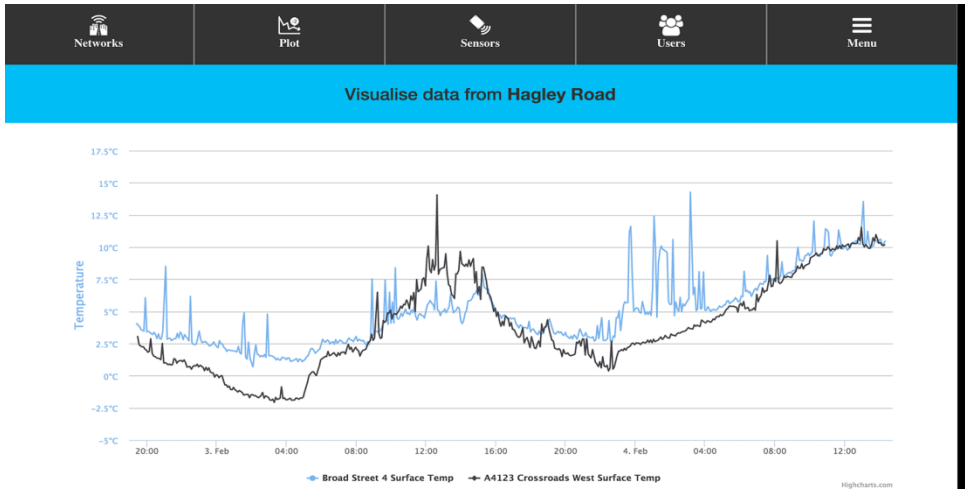
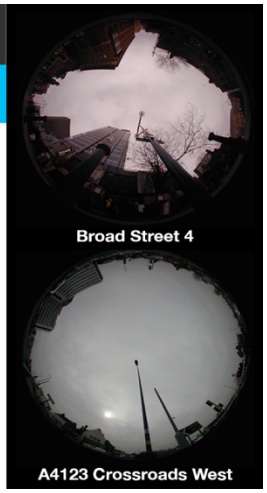
Field Deployment







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Thoughts…

- Good measurements can be made very cheaply!
- Some challenges to overcome with IoT
  - Wireless access
  - Battery life
- Just how 'game-changing' is this?
  - High resolution and open data have never been previously available
  - New ways of measuring make old techniques redundant or is it complementary?
  - New generation of forecast models to assimilate and process the data?
  - Confidence to selective salt now on the horizon?
  - Future role of weather forecasts – are we on the cusp of a return to ice detection?
- Traditional lines of instrumentation manufacturers and forecasters are becoming blurred
  - Who are the winners and losers?
- www.wintersense.com