

# Area Forecast Model for Winter Road Maintenance over a Road Network

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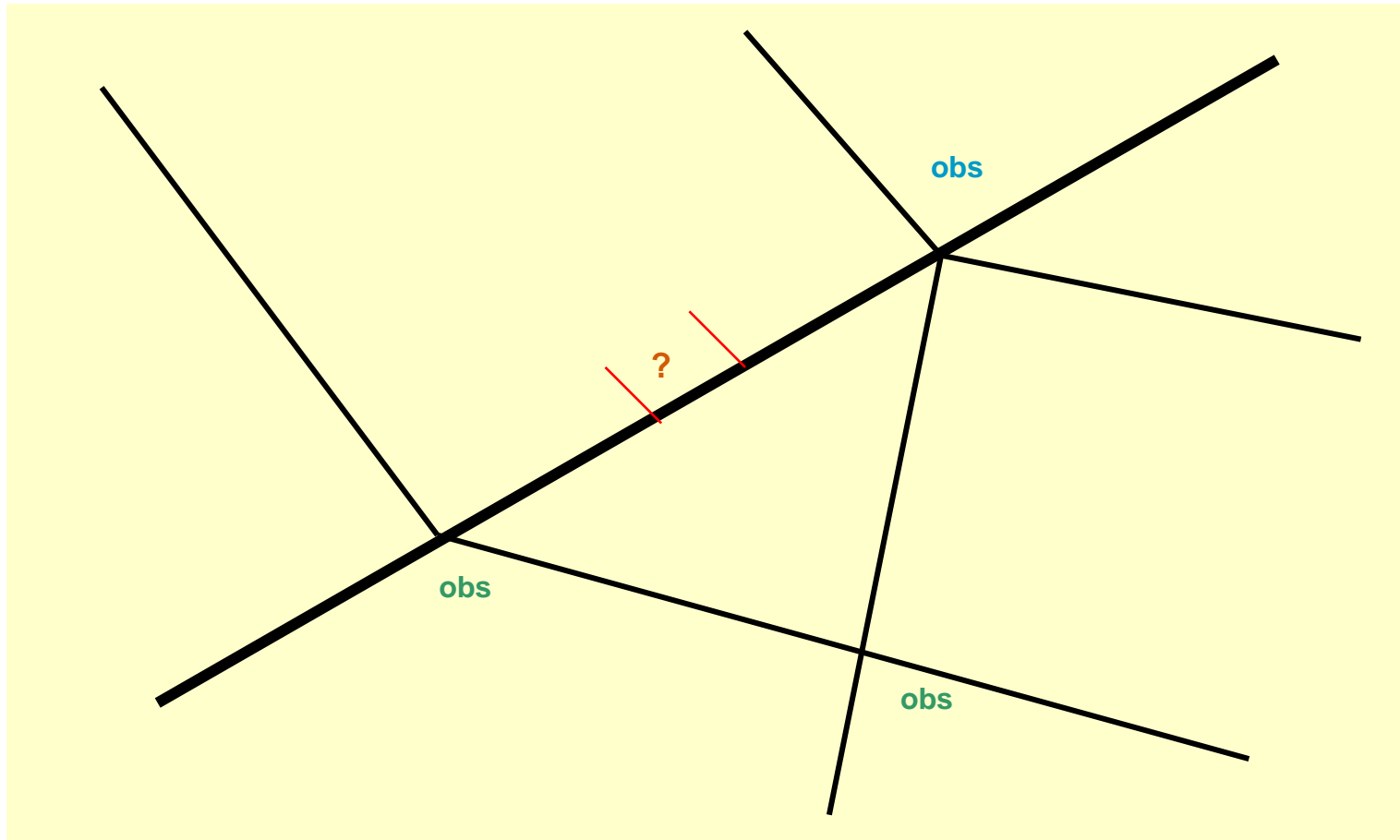
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# Road Weather Forecasts

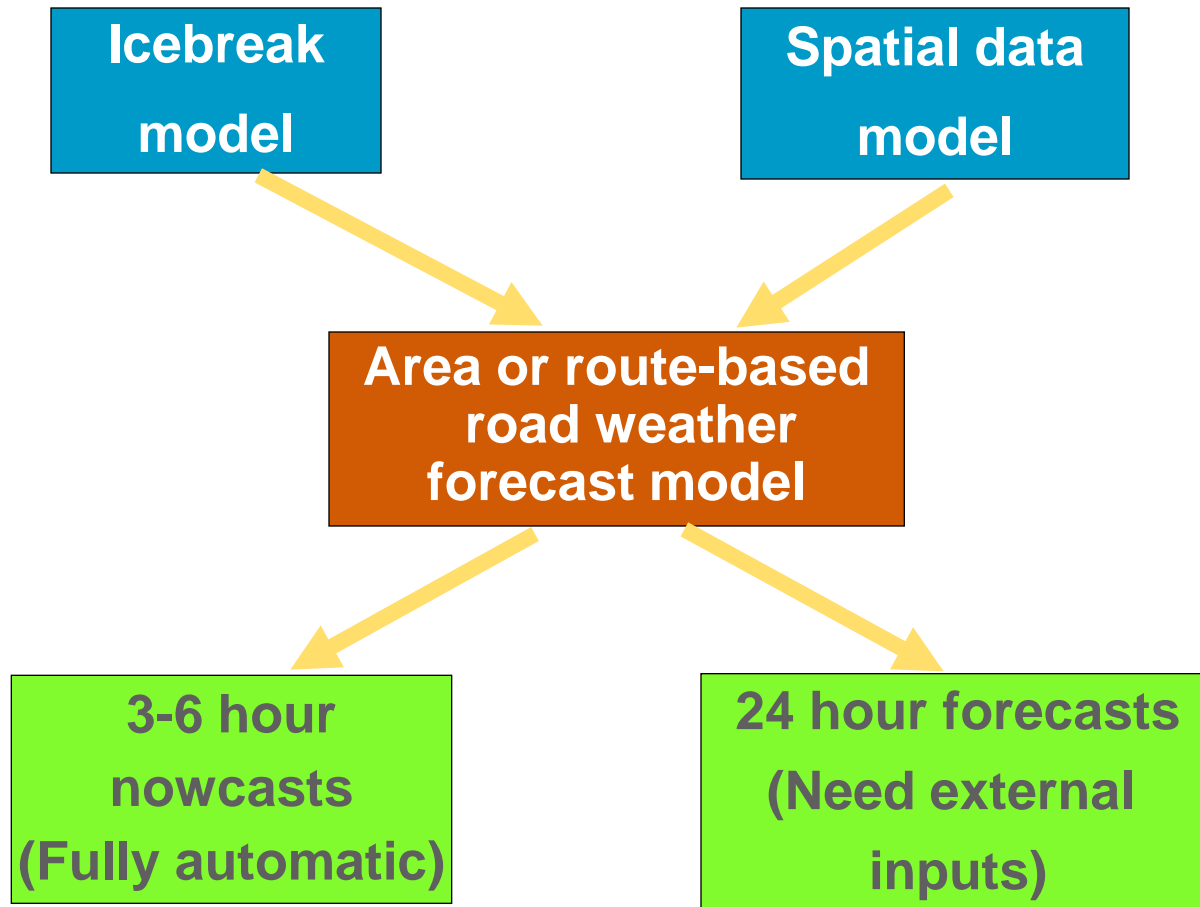
- Road authorities need to treat (grit & salt in winter; water in summer) road in order to keep road safe for road users
- They need to know where and when bad road conditions to happen
- Roadside weather stations provide valuable info about local point weather conditions



# Why Area or Route-based Forecast?



# What Is Vaisala Area Forecast Model?

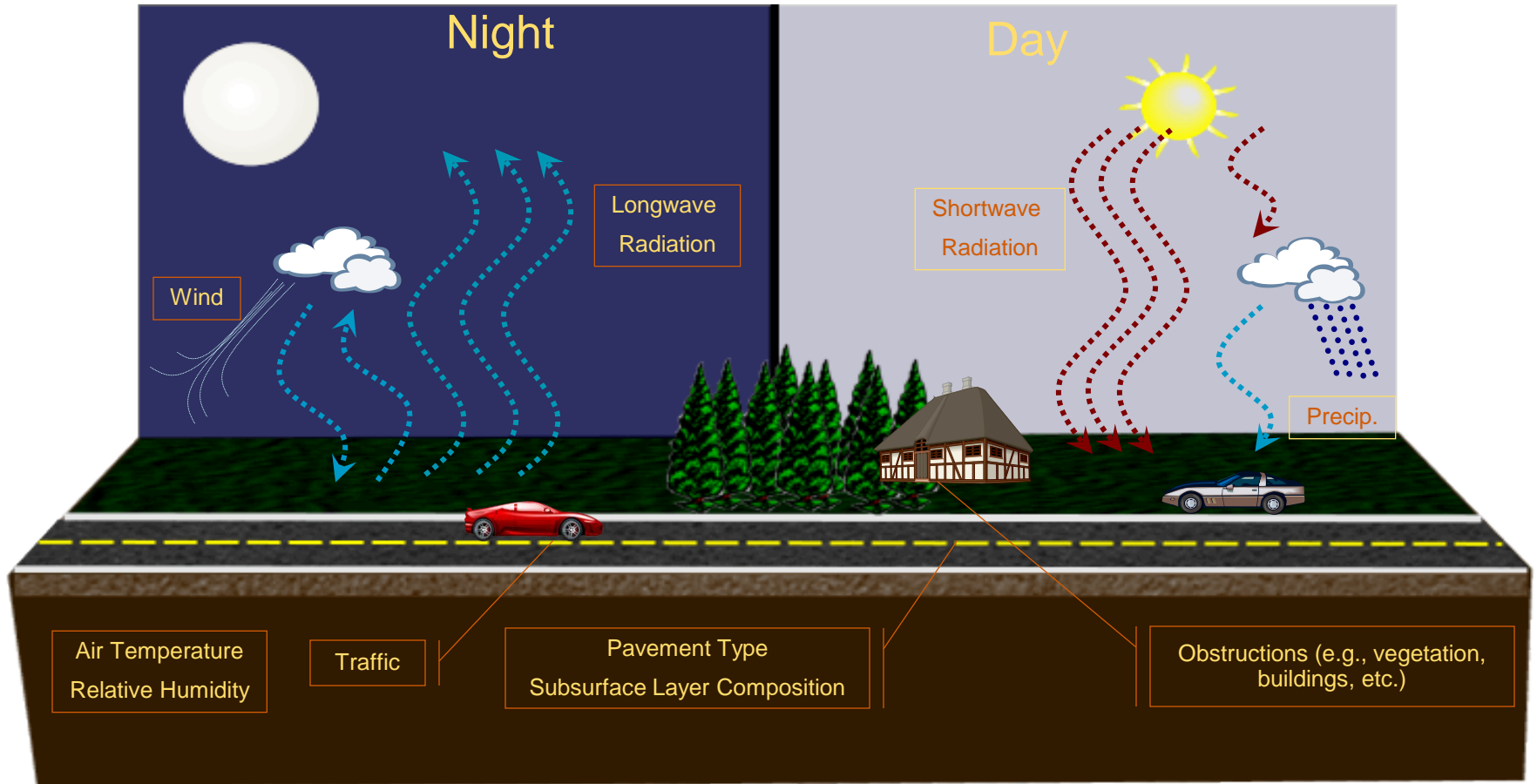


# What Does the Model Do?

- Timely forecasts of  $T_s$ ,  $T_a$ ,  $T_d$ ,  $W_s$ , cloud cover, and friction index (FI) over a road network
- Not only when, but also where icing, snow and water accumulation is likely
- Important information for dynamic salting & ploughing
- Nowcast mode:
  - depending on sensor measurements
  - fully automatically
  - low costs without expensive external inputs or labour cost

# IceBreak Model

$$C \frac{\partial T}{\partial t} = \frac{\partial}{\partial z} \left( \kappa \frac{\partial T}{\partial z} \right)$$



# Spatial Data Model

- A 2-D inverse distance weighting (IDW) model:
  - n - number of neighbouring observation stations
  - $z_j$  - interpolated value at station j
  - $z_i$  - observation at neighbouring i
  - $d_{ij}$  - distance between stations i and j
  - $\beta$  &  $\delta$  - parameters to be optimised

$$z_j = \frac{\sum_{i=1}^n \frac{z_i}{(d_{ij} + \delta)^\beta}}{\sum_{i=1}^n \frac{1}{(d_{ij} + \delta)^\beta}}$$

# Forecast/Nowcast over Road Network

- Dividing road into sections (e.g., 200m in length);
- Calculate Sky View Factor (SVF) & shading effect
- Taking into account of different road types & topography
- Taking in local geographical and environmental information such as grid reference, height, road type (motorway, A-road or B-road), land use (urban, woodland, water etc.);
- Projecting boundary conditions at observation stations with embedded statistical models in IceBreak;
- Interpolating initial RST and projected boundary conditions to road sections;
- Running IceBreak at all road sections and observation stations.



# Test Areas and Data

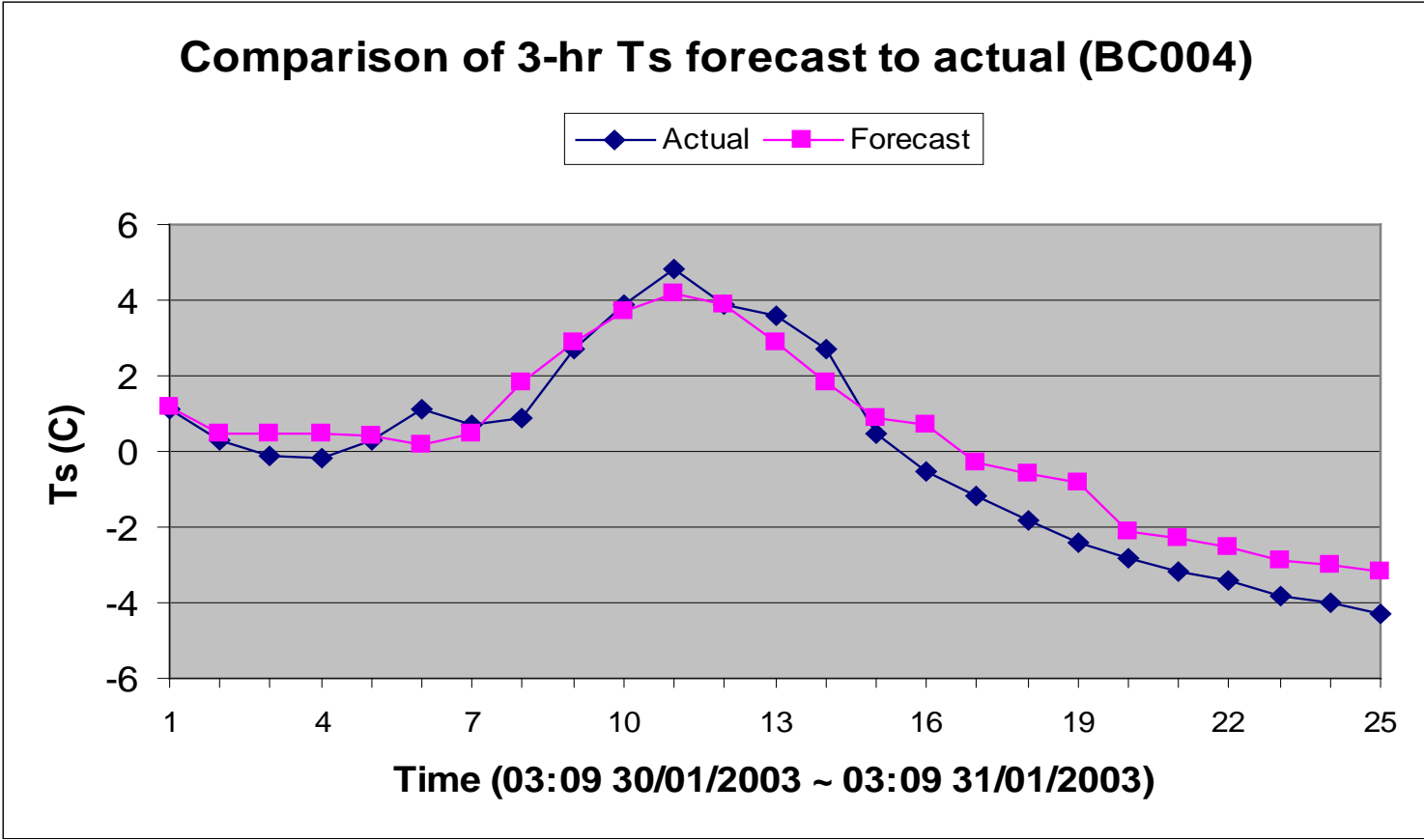
- West Midland & Glasgow city, UK
  - 27 roadside weather stations in West Midland (70x80km)
  - 29 RWS & Thermal Mapping surveys in Glasgow City and surrounding area
- Geographical data
  - UK Ordnance Survey (OS) Meridian dataset
  - GIS & Map Algebra
- Meteorological data
  - Measurements from roadside weather stations
- 3-hour ahead nowcasting

# Point Comparison: 3-hour Nowcasting

- UK West Midlands: 27 sites, one month data (Jan. 2003);
- Each site was left out and treated as a forecast point in a single one-month long run;
- All sites were left out in turn and then compared with sensor measurements at the sites;
- Overall weighed statistics with sample number = 91196

	Abs. err	Bias	SD	RMS
Ts:	1.04	-0.34	1.06	1.31
Ta:	0.73	0.30	0.89	0.98
Td:	0.63	-0.01	0.83	0.88
WS:	1.56	-0.51	1.39	1.94

# Example of 3-hour Ts nowcast at WM

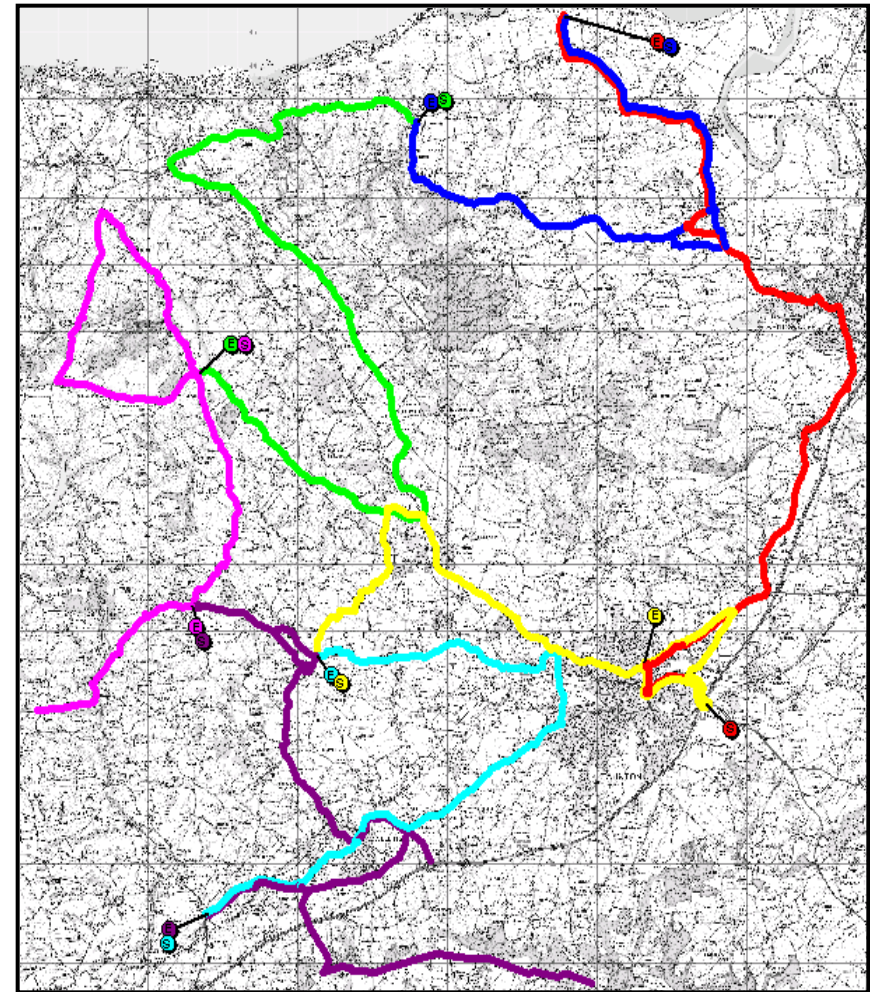
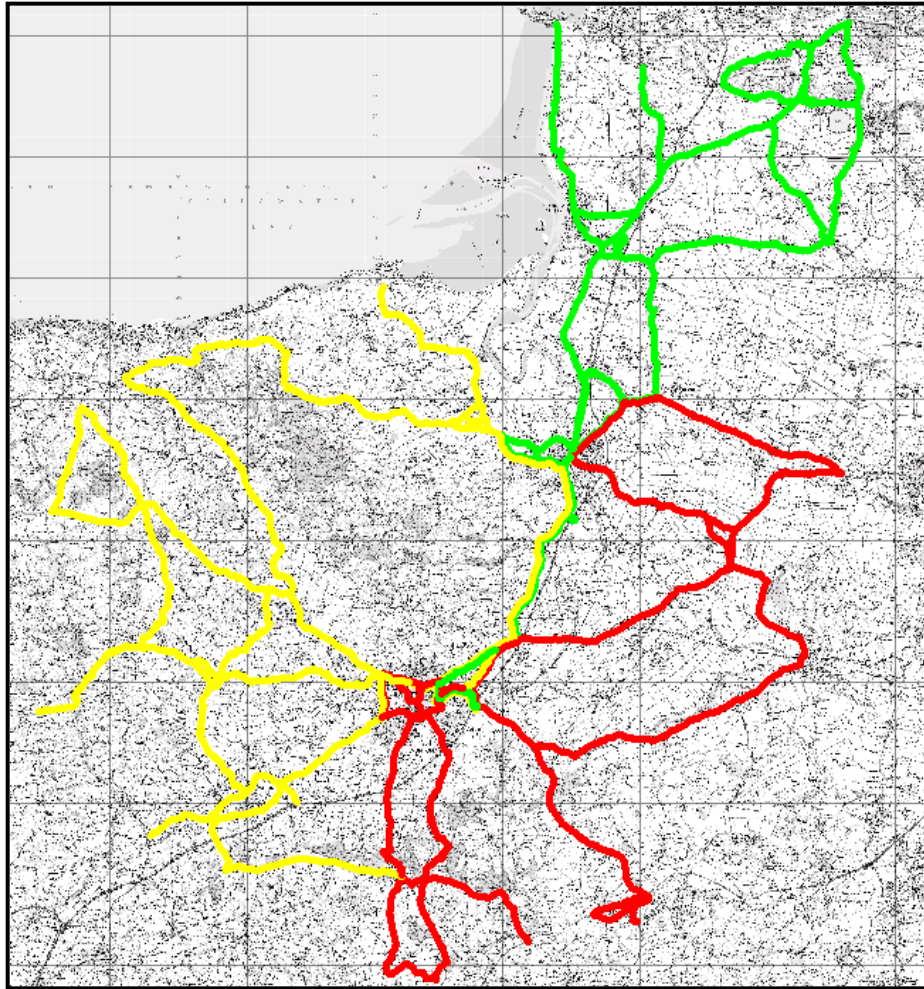


# What is Thermal Mapping?

- Specially equipped vehicle
- Infrared thermometer automatically logs road surface temperatures
- Logging is distance based
  - vehicles travel at normal speed limits, with no disruption to surrounding traffic
- Data tagged with GPS coordinates
- Meteorological conditions monitored and recorded throughout survey
- Data processed and presented in desired format



# Thermal Mapping Planning and Route Maps

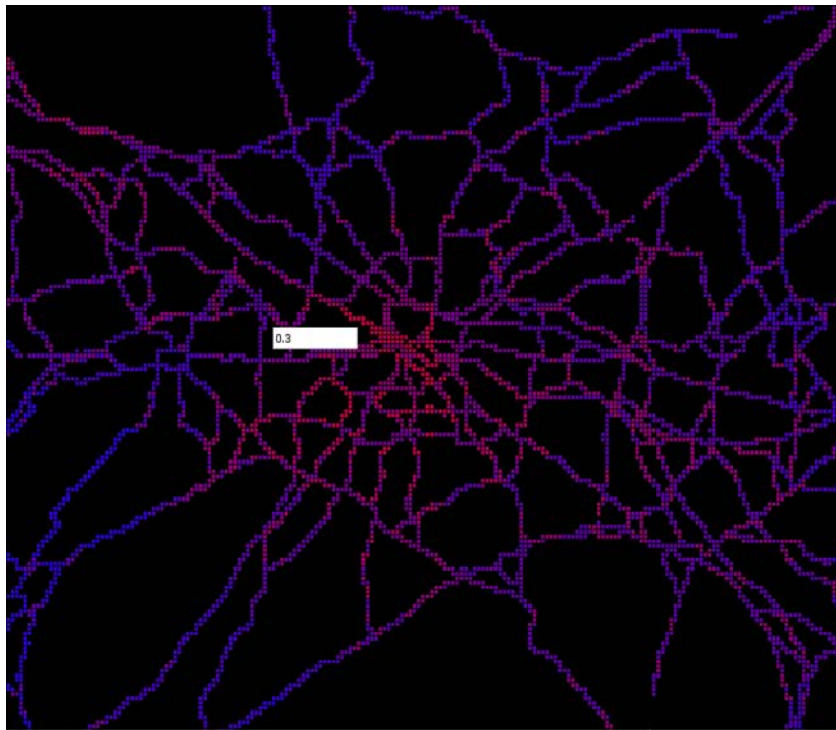


# Comparison of Ts Nowcast over Road Network with Thermal Mapping

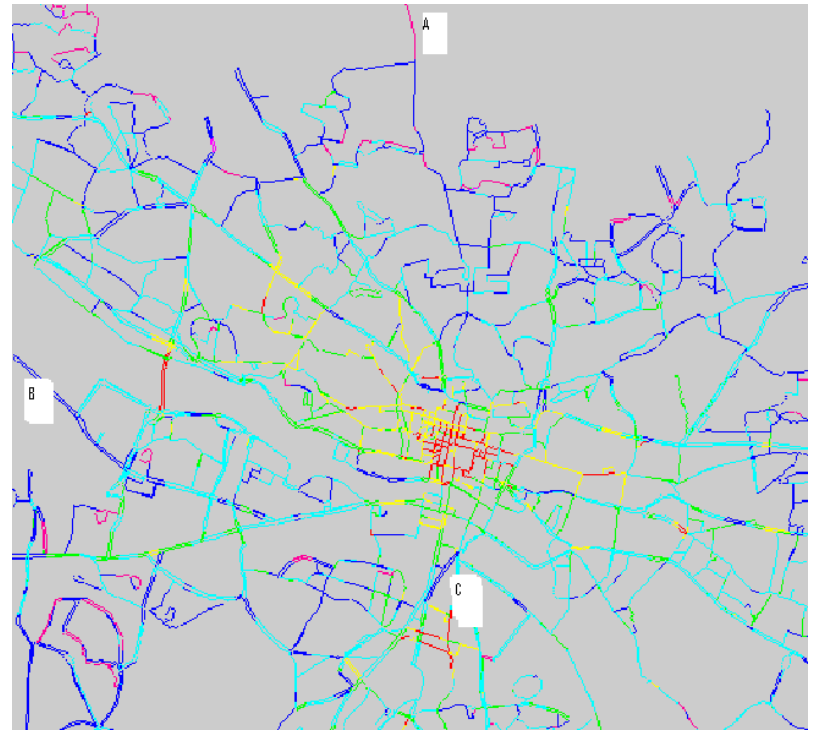
- Glasgow and surrounding areas
  - Urban, suburban and rural areas
- Thermal Mapping surveys
  - Extreme night (22-23 Mar 2003)
  - Damped night (24-25 Mar 2003)
- 29 roadside stations
- 3-hour ahead nowcasting for the Thermal Mapping nights
- Comparing spatial patterns/trends of Ts and Ts at selected sections

# Spatial Trend of Ts on Extreme Night

Nowcast

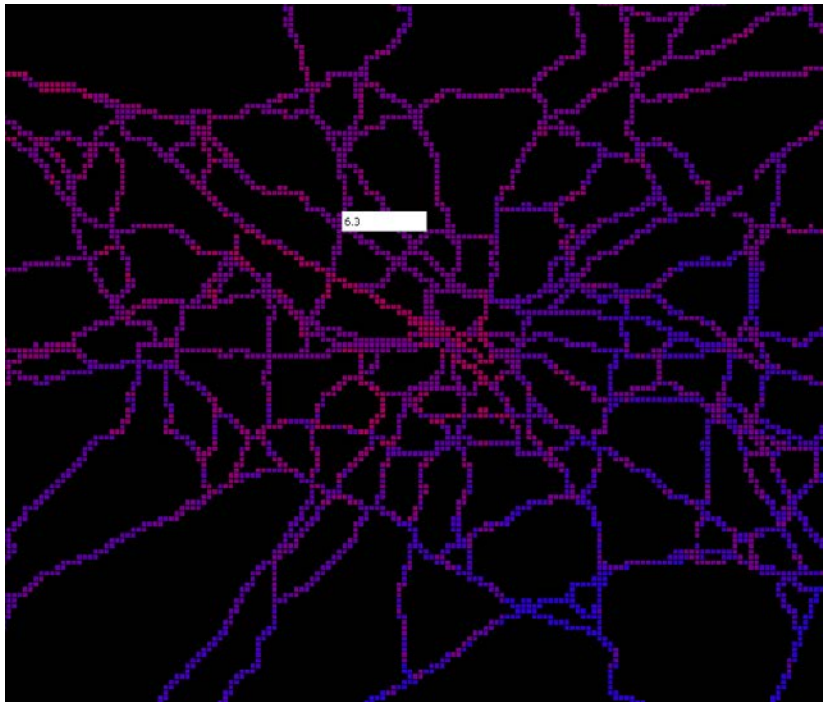


Thermal Mapping

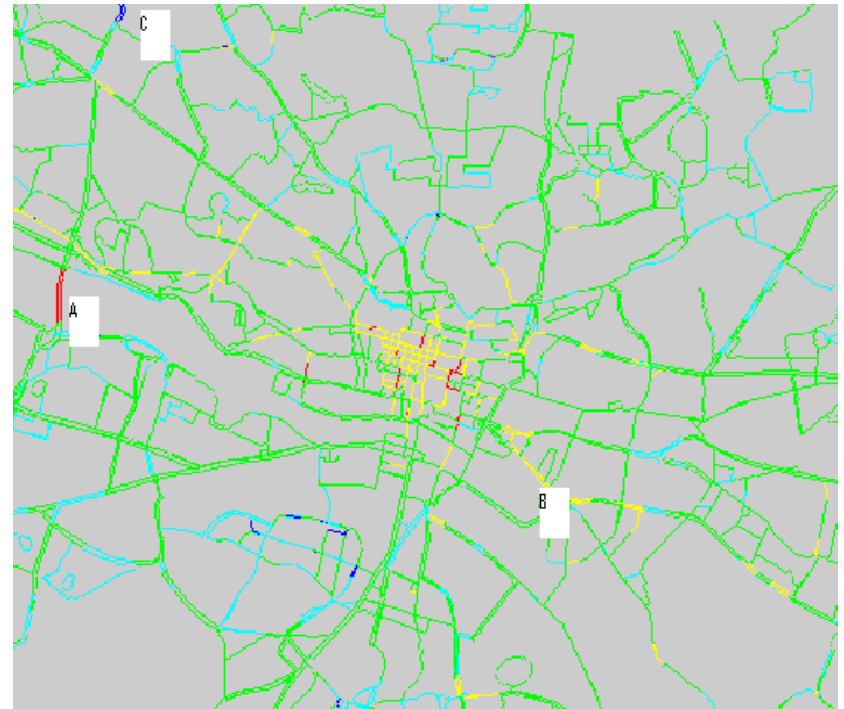


# Spatial Trend of Ts on Damped Night

Nowcast



Thermal Mapping





# Comparison of Ts at Selected Sections

<b>Extreme night (23 March 2003)</b>					
<b>Section</b>	<b>Easting</b>	<b>Northing</b>	<b>Road</b>	<b>Colour band on TM map</b>	<b>Temperature range on nowcast map</b>
A	2581	6711	A879	Red	Warm (3.5-3.7°C) and mild (1.3-1.7°C) sections
B	2525	6661	A8	Dark blue	Mostly cold (0.2-0.4°C) sections
C	2585	6637	A728	Dark blue	Cold (0.3°C) section with mild (1.7-1.9°C) sections
<b>Damped night (25 March 2003)</b>					
<b>Section</b>	<b>Easting</b>	<b>Northing</b>	<b>Road</b>	<b>Colour band on TM map</b>	<b>Temperature range on nowcast map</b>
A	2542	6665	A739	Red	Warm (7.8-9.0°C) sections
B	2603	6641	A749	Yellow	Mild (6.5-7.7°C) sections
C	2548	6696	A739	<i>Dark blue</i>	<i>Warm and mild sections</i>

# Summery

- Combining Icebreak with Spatial Data Model, AF model is able to provide numerical forecasts/nowcasts of Ts, surface state, friction/grip, etc.
- Verification is done at two levels: point/station & pattern
- The results show that
  - At station level, the 3-hr nowcasts are fairly accurate
  - Spatial pattern of Ts distribution is generally matched between forecast and TM measurement
  - However, there is some mismatch between forecast and TM measurement – due to ?
- Further tests on friction/grip forecast is desirable

**Thank You!**

***Questions?***

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