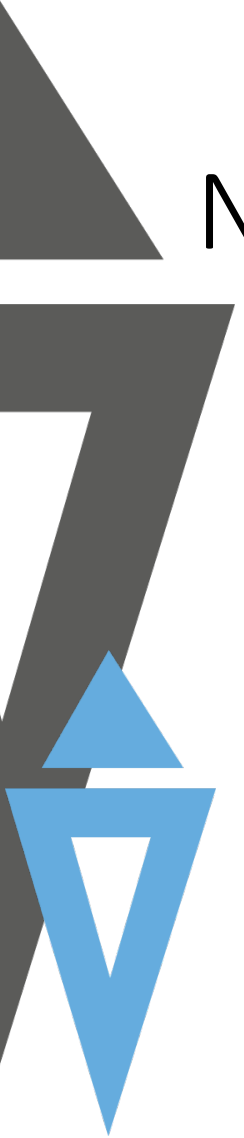
A large, stylized graphic on the left side of the page. It consists of a dark grey, angular shape that resembles a mountain peak or a stylized letter 'K'. Overlaid on this is a blue, stylized mountain peak icon with a small triangle on top, similar to the one in the KLIMATOR logo.

A glimpse of the future for
winter maintenance

No need for winter maintenance



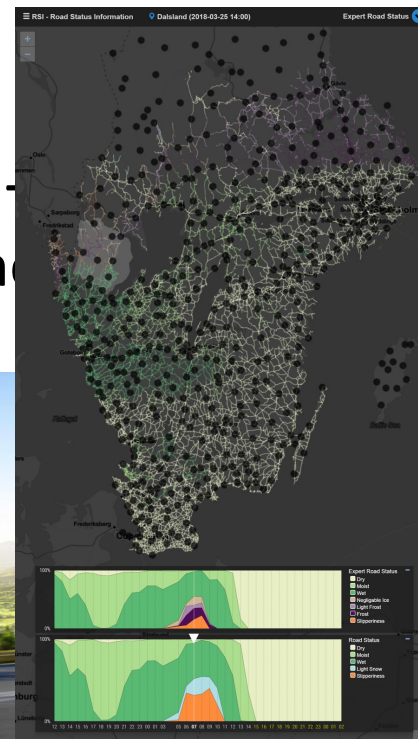
Maintenance today and in the (near) future

CURRENT

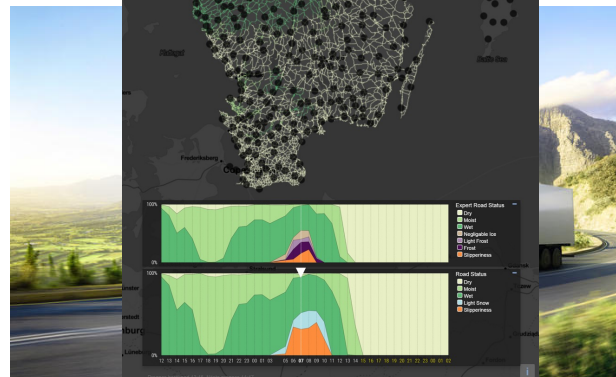
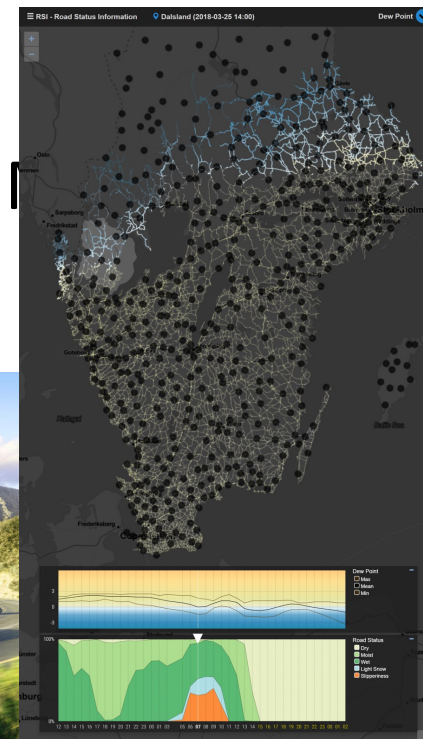
- What have we got now?
 - RSI – a tool to help you excel at your profession - performing maintenance.

FUTURE

- RWIS Station + Weather Forecast + Data
 -> Salting GPS route in the maintenance



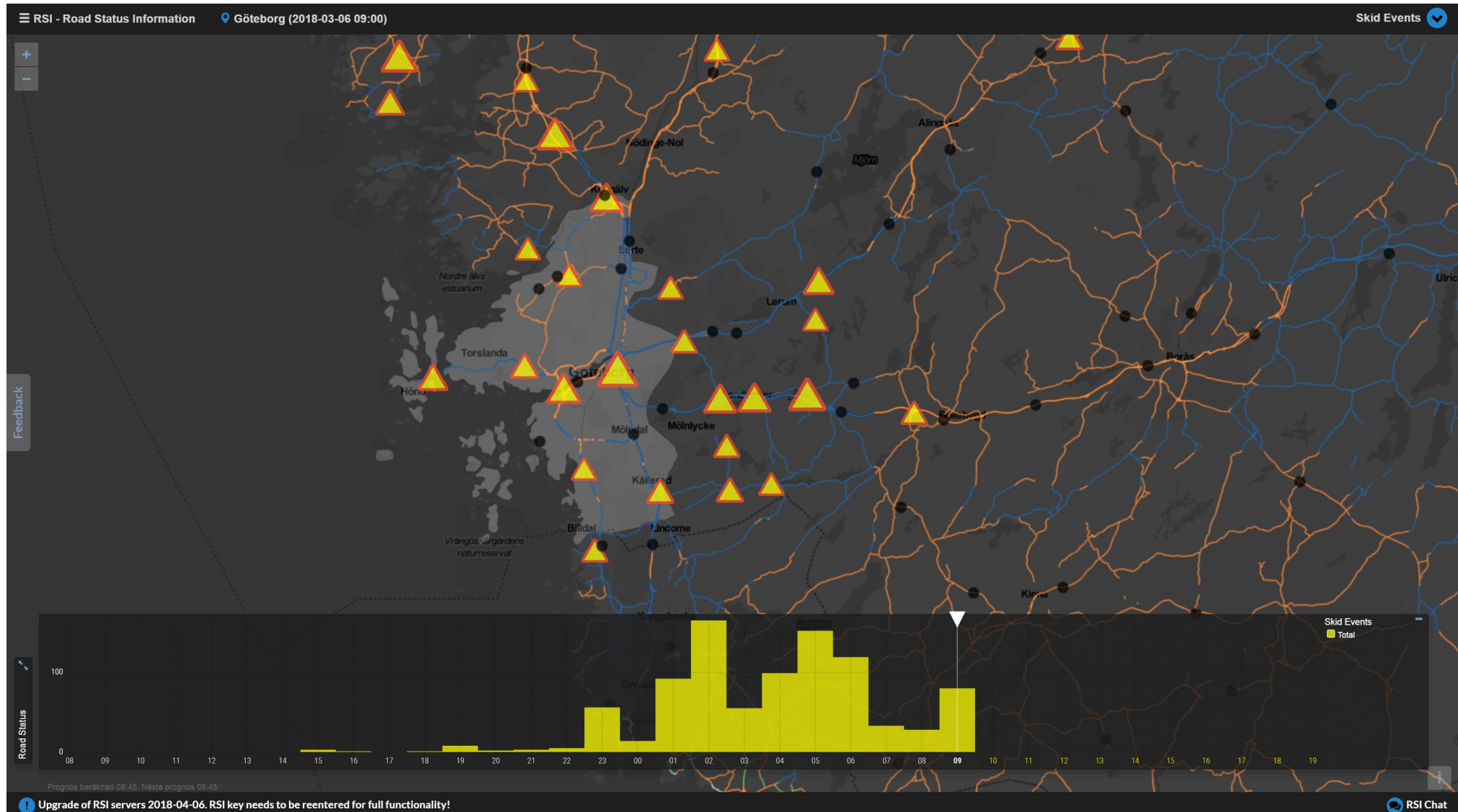
+ Data



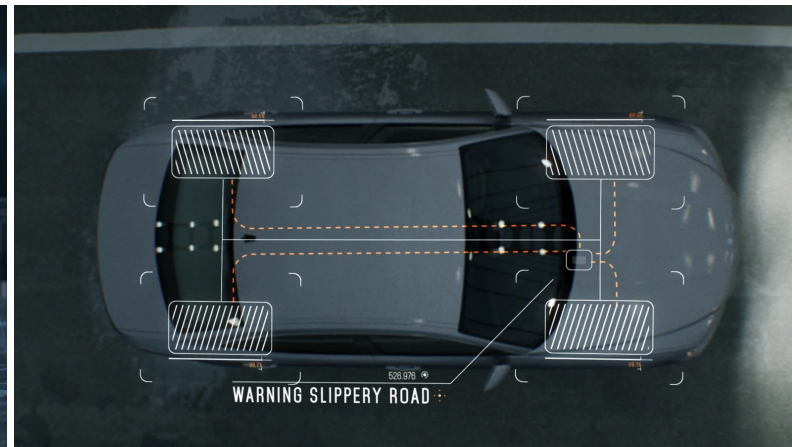
<https://www.computerworld.com/article/3084546/car-tech/nikola-motor-gets-23b-worth-of-preorders-for-electric-semi-trailer-truck.html>

h/article/what-is-the-you-need-to-know-autonomous-electric-

RSI application – friction alert

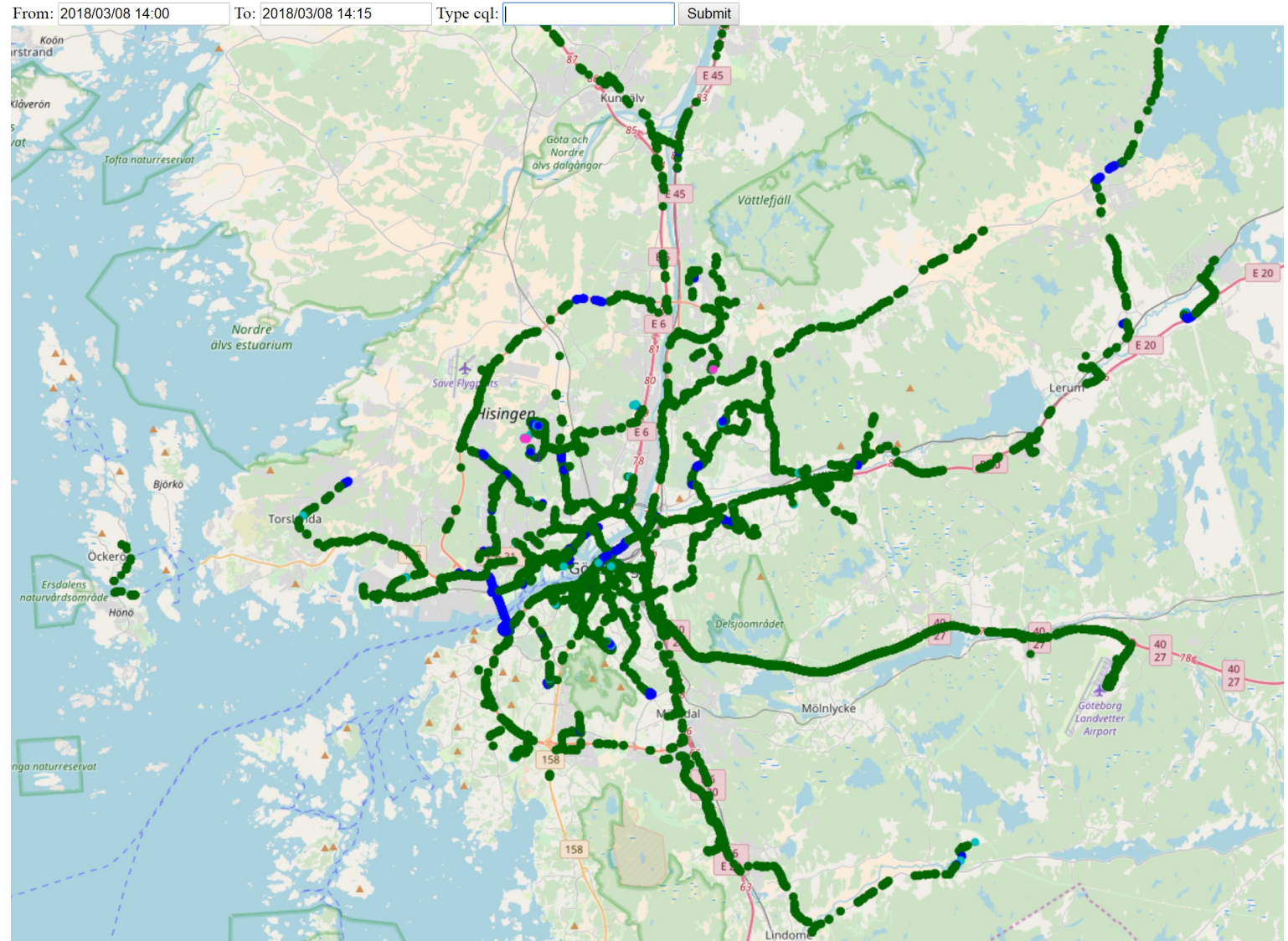


500 units primarily in
Gothenburg and Stockholm

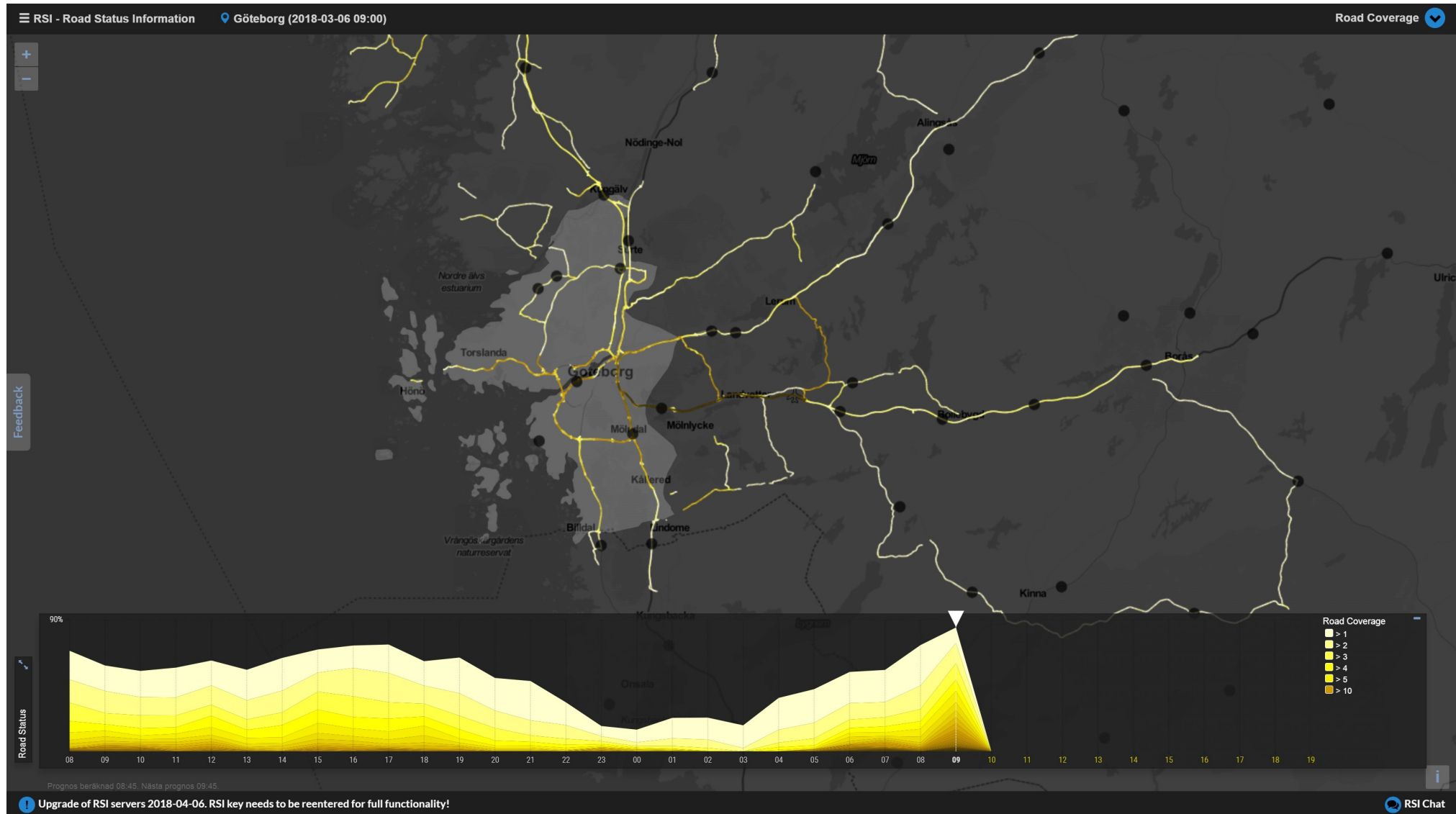


Data during 15 minutes

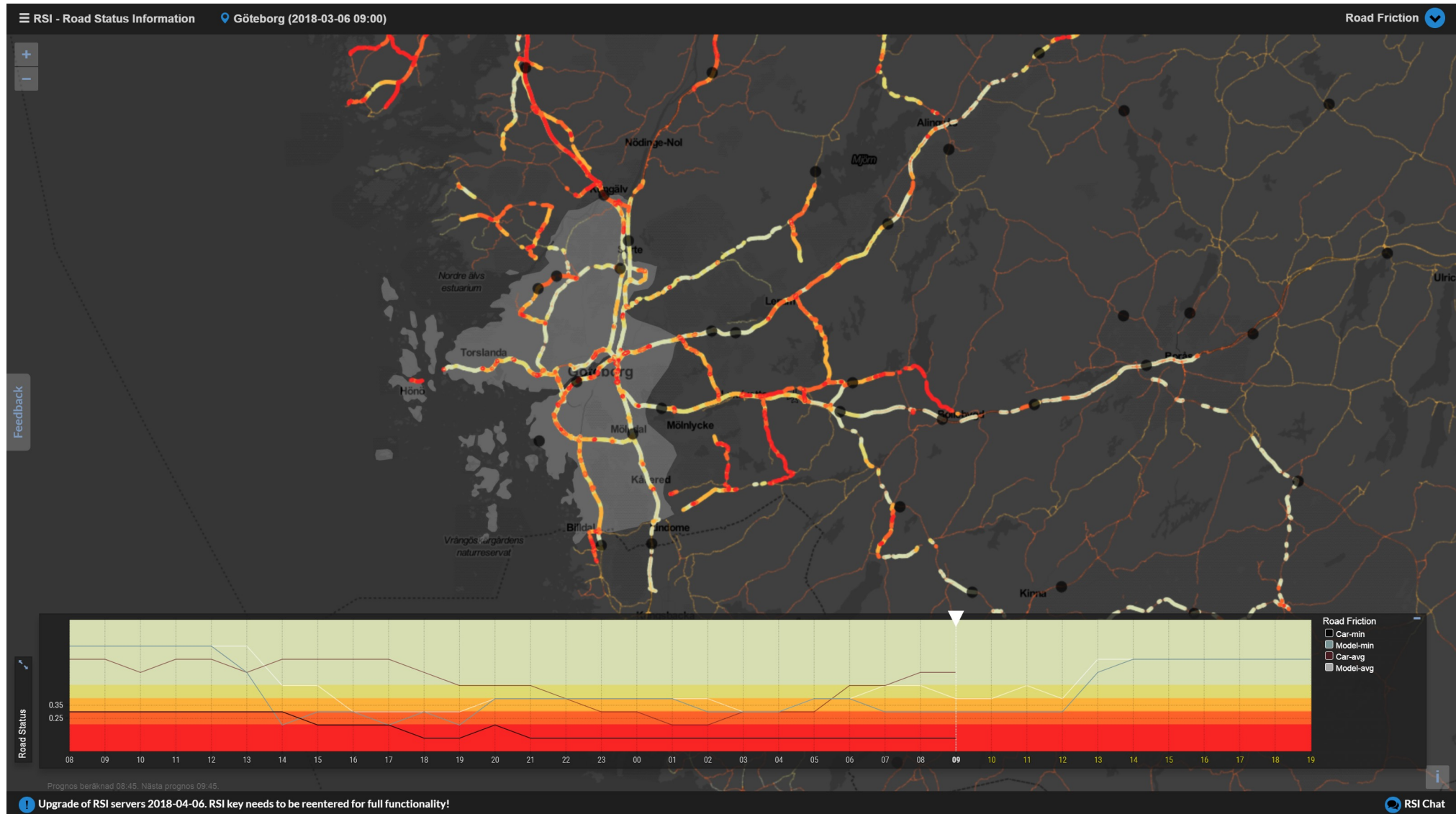
- Some of the 200 vehicles in the Gothenburg area



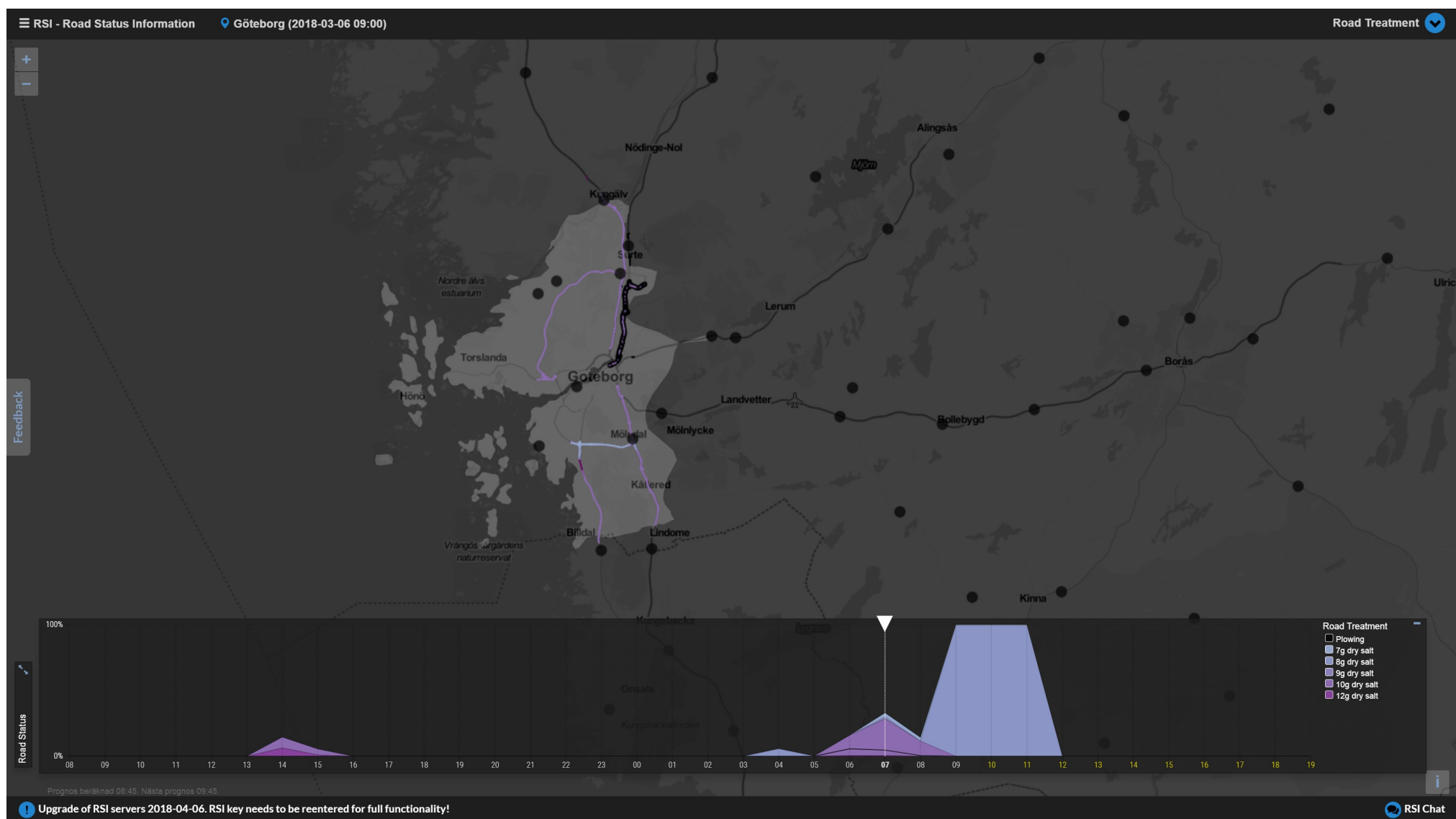
RSI application – Road coverage



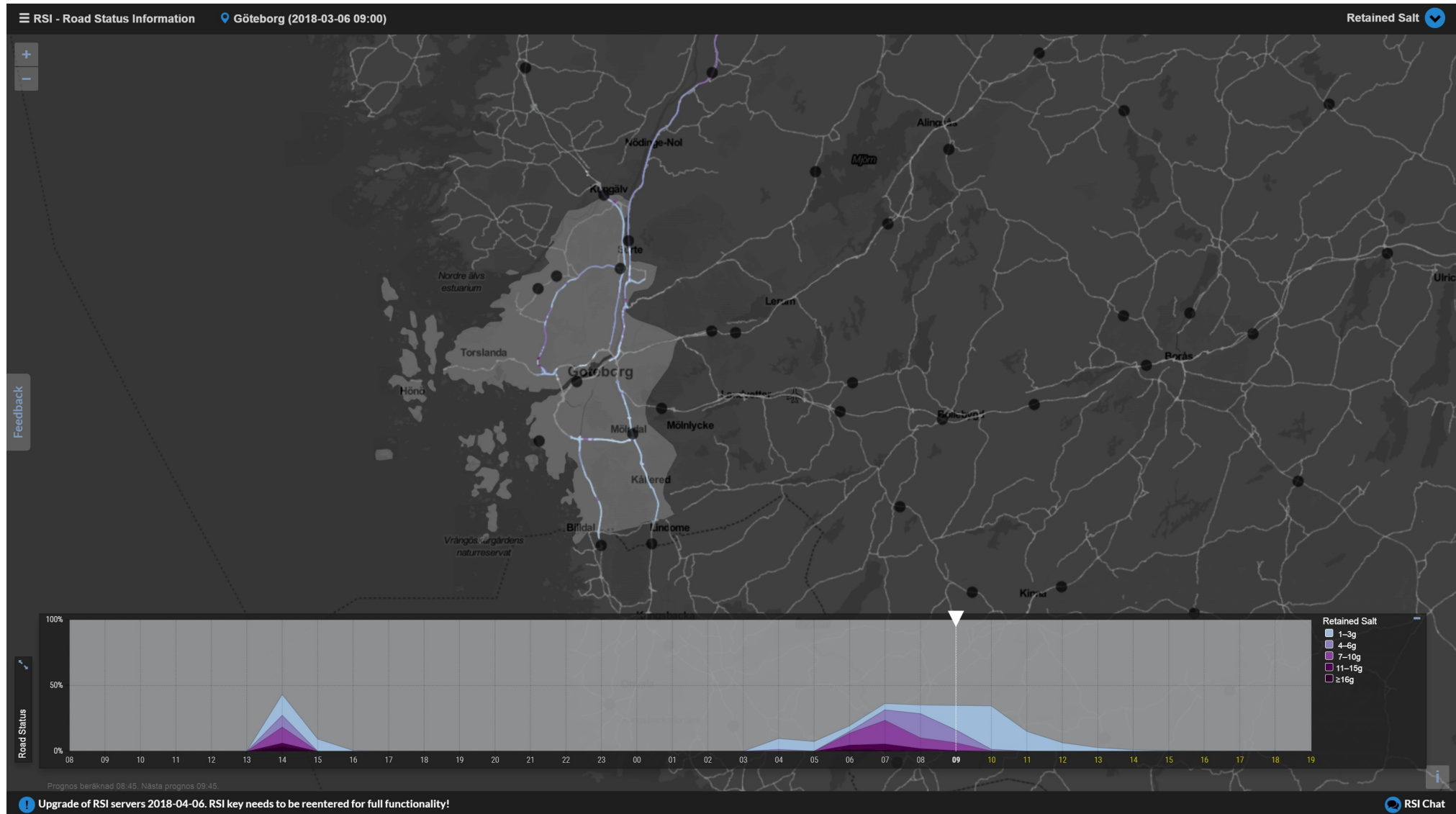
RSI application – Road friction



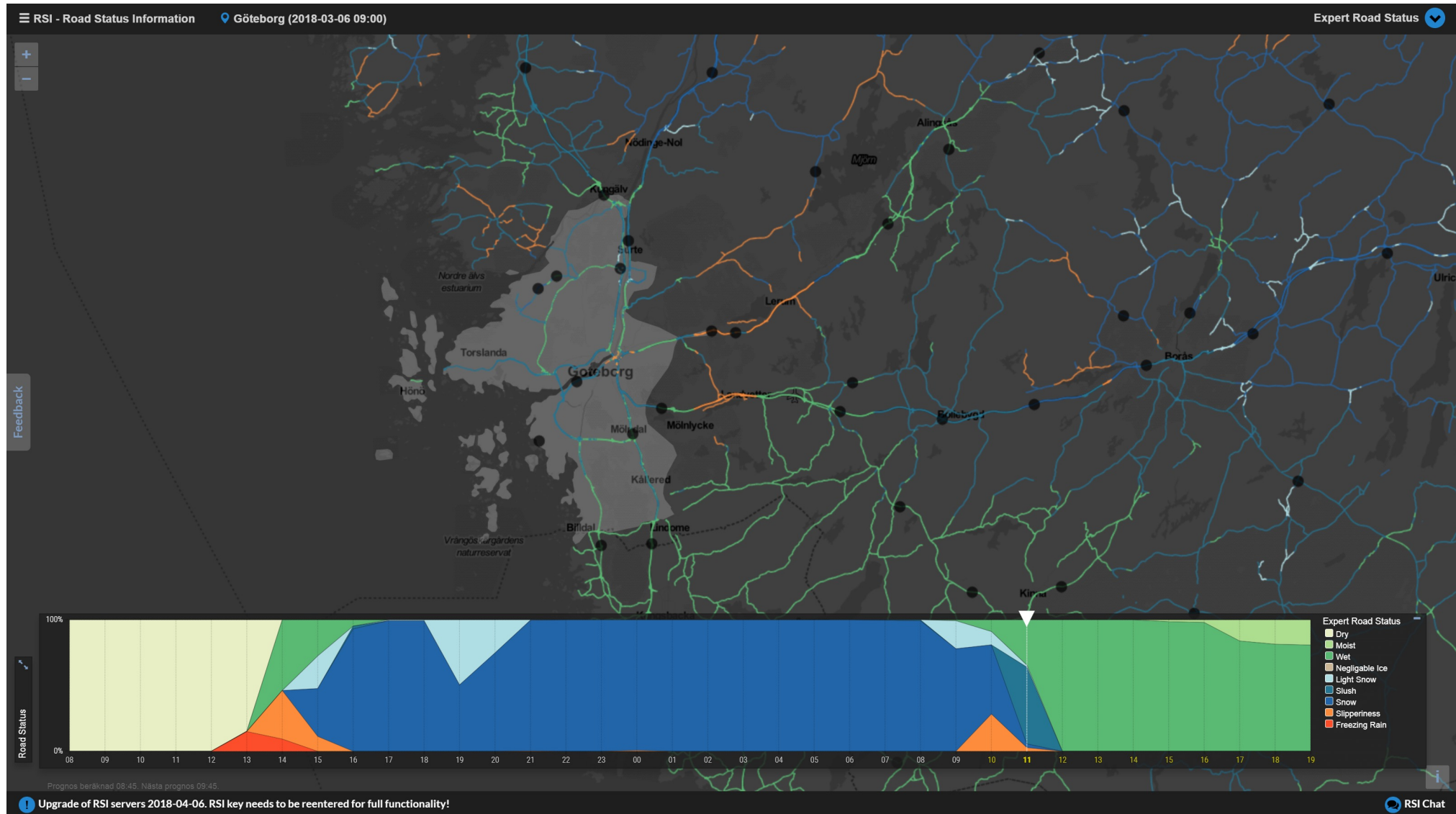
RSI application – Maintenance activities



RSI application – Residual salt



RSI application – Road Status



What is needed?

- Accurate route based forecast – but how?
 - Accurate road weather forecast
 - Current road conditions – but how?
 - Accurate in-data from RWIS and weather models, satellites, radar
 - Maintenance operations
 - Measurements of current conditions on the roads – but how?
 - Friction measurements along most roads in an area.
- Route optimizing tool based on road status forecast.
- Transfer optimized route to in-vehicle GPS

What is needed?

- Accurate route based forecast – but how?
 - Accurate road weather forecast

Accuracy of surface temperature

Mean Absolute Error

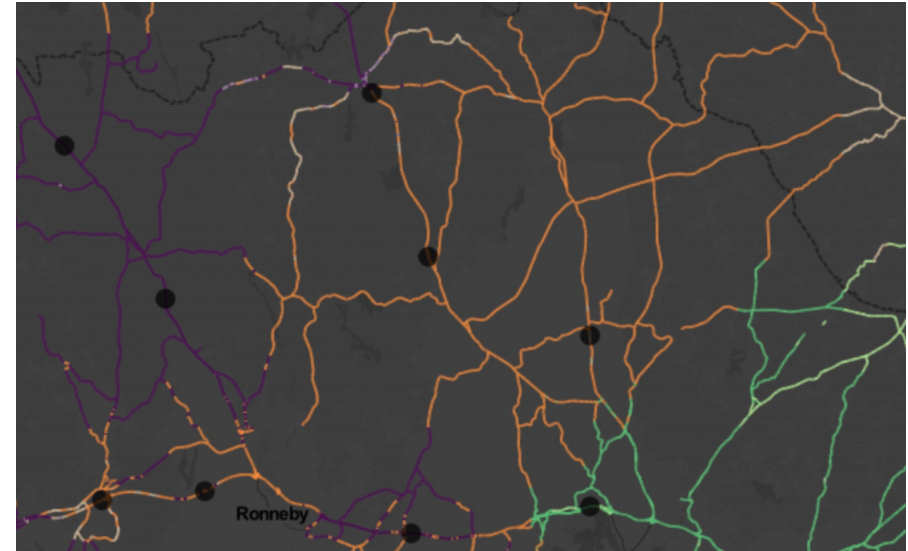
- Station forecasts
 - Goal - **4** hour forecast
 - More than 75 % of stations below 0.5 °C error for Dec and Jan
 - More than 75 % of stations below 0.8 °C error for Mar
 - Current - **4** hour forecast
 - 33% below 0.5 °C for Dec and 58% below 0.5 °C for Jan
 - 17% below 0.8 °C Mar
 - Goal - **10** hour forecast
 - More than 75 % of stations below 0.7 °C error for Dec and Jan
 - More than 75 % of stations below 1.0 °C error for Mar
 - Current - **10** hour forecast
 - 22% below 0.7 °C for Dec and 37% below 0.7 °C for Jan
 - 19% below 1.0 °C for Mar



Accuracy of surface temperature

Mean Absolute Error

- Segment interpolation
 - Goal nowcast
 - Below 0.35 °C for Dec and Jan
 - Below 0.65 °C for Mar
 - Current accuracy for nowcast
 - 0.49 °C for Dec and 0.45 °C for Jan
 - 0.86 °C for Mar

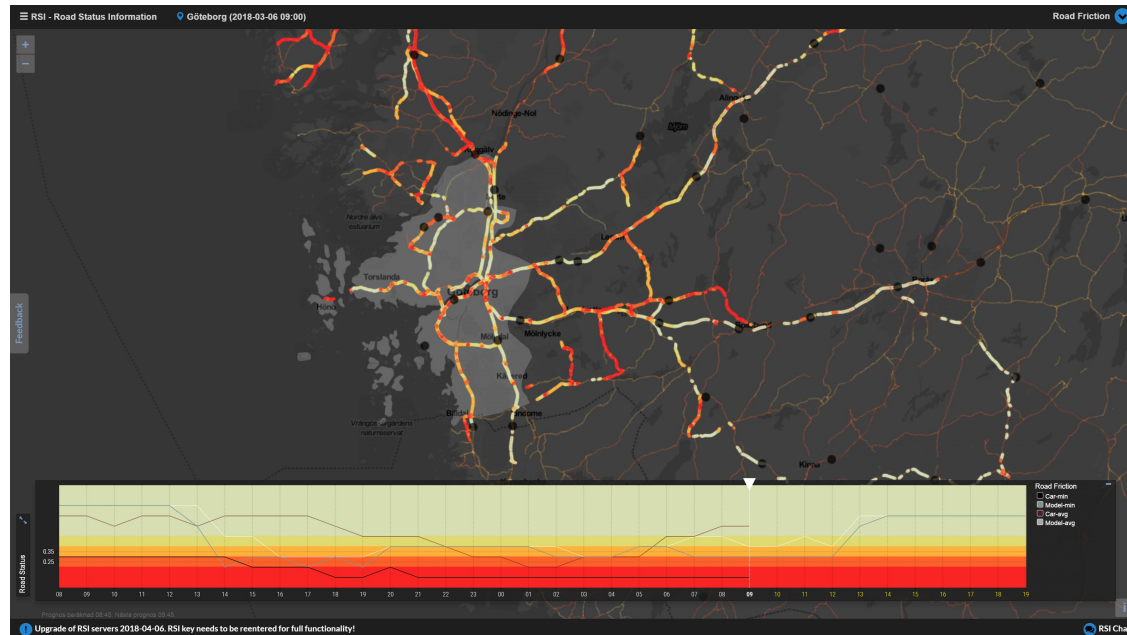


Accuracy for arbitrary segment.

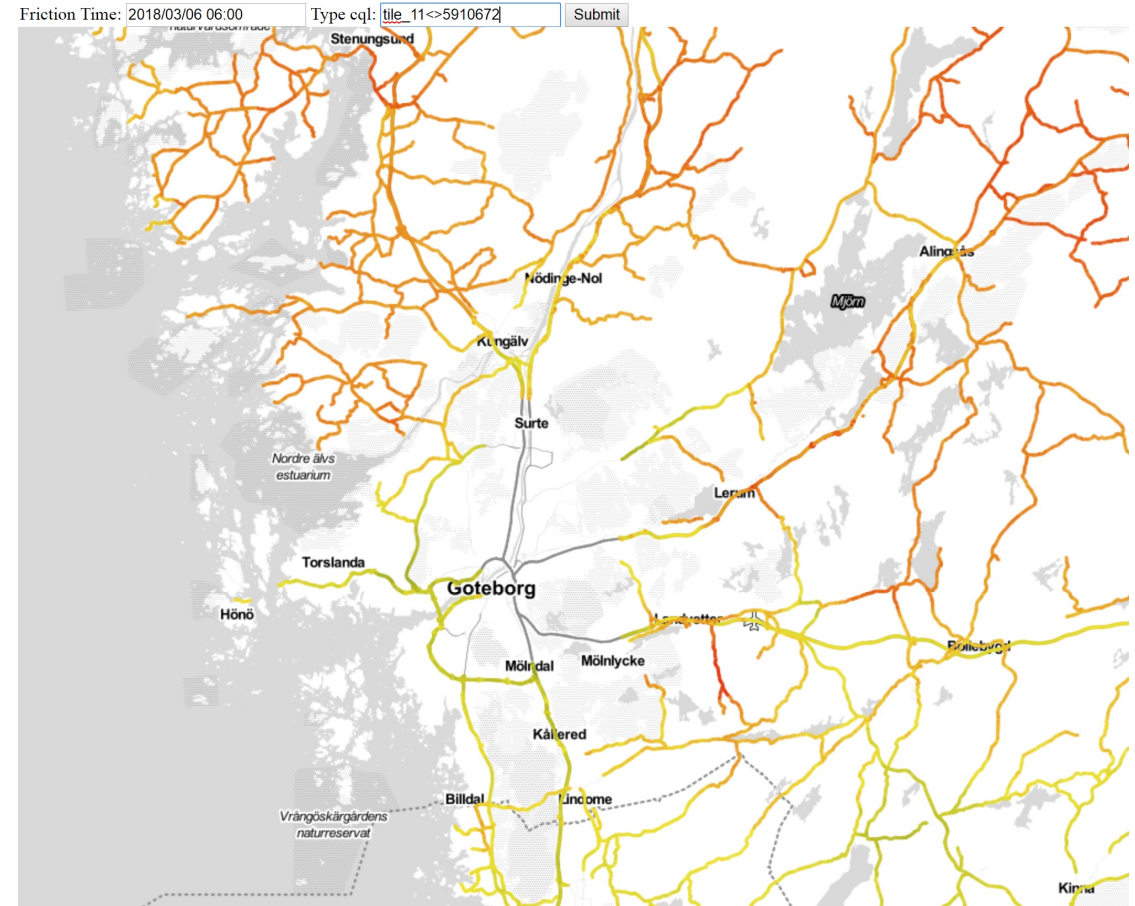
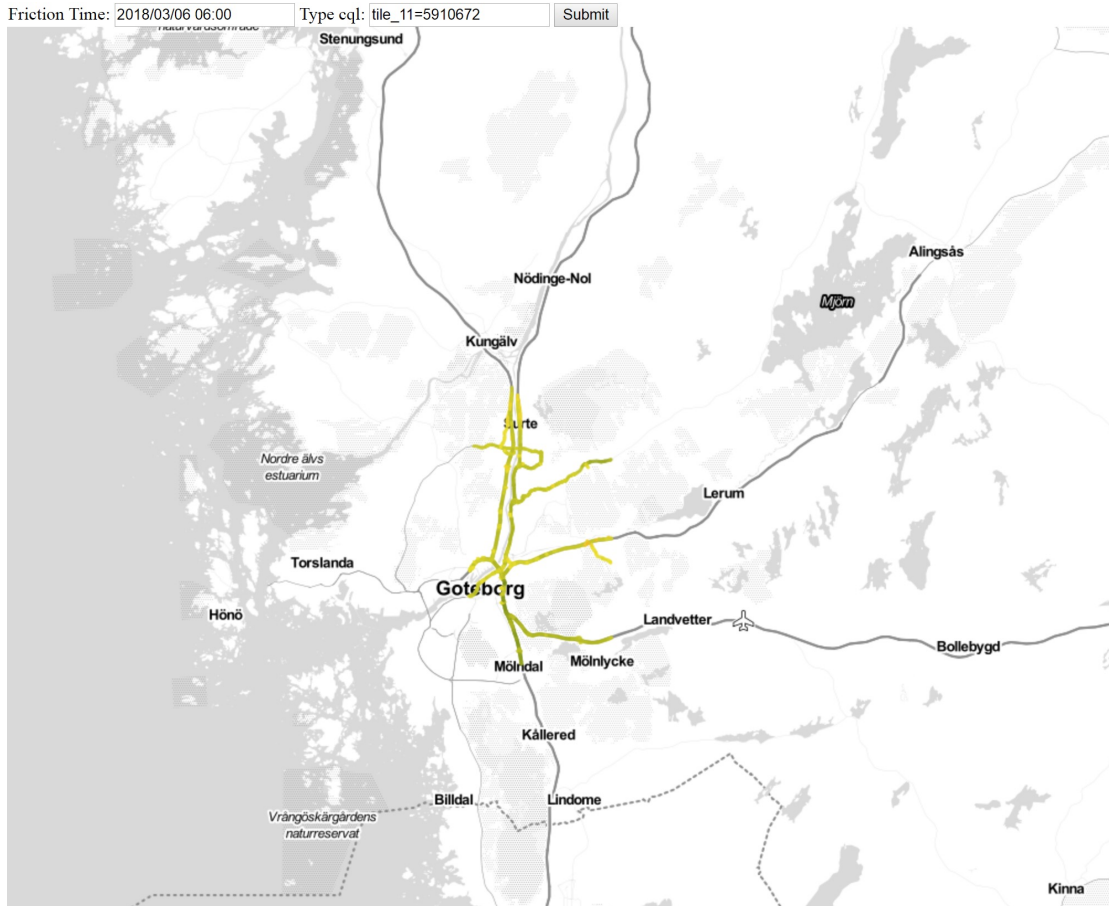
Evaluated by cross-validation, i.e. removing the evaluated station from prediction model.

What is needed?

- Current road conditions – but how?
 - Accurate in-data from RWIS and weather models, satellites, radar
 - Maintenance operations
 - Measurements of current conditions on the roads – but how?
 - Friction measurements along most roads in an area – extrapolate to the rest.



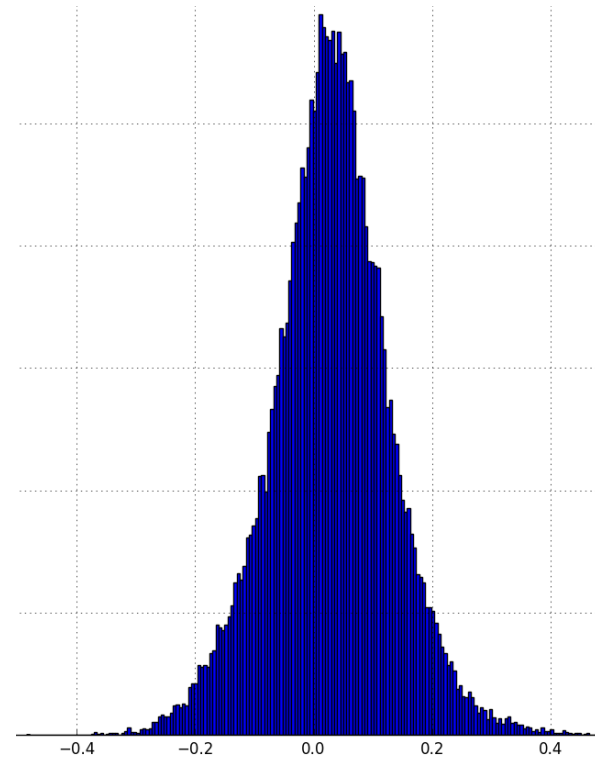
Tile removed from data set to validate



Friction model

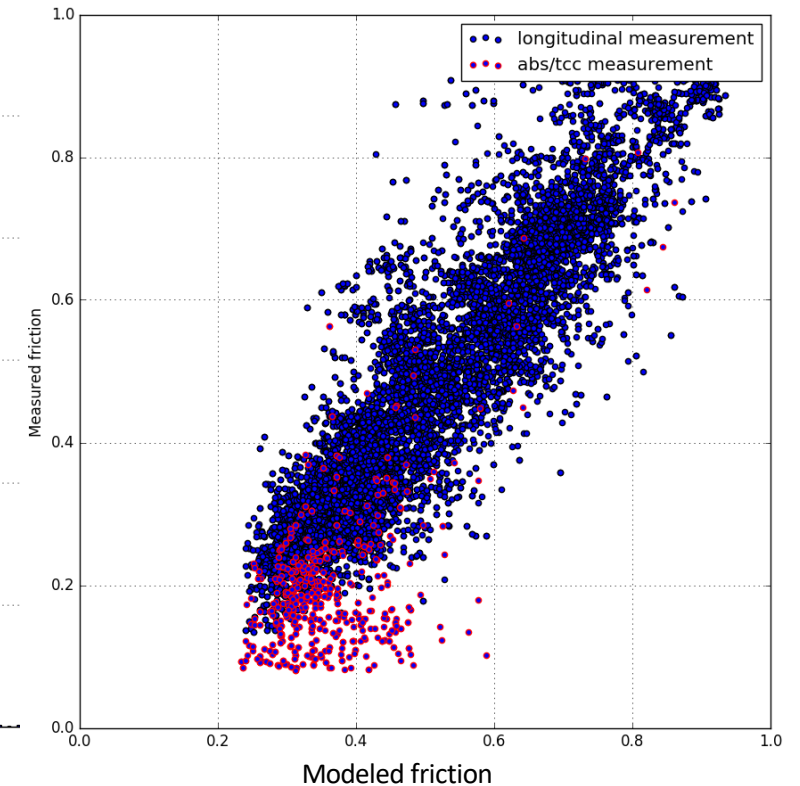
- Quality control:
 - Cross validation by exclusion of entire 11km map tiles.
 - Comparison of expected mean friction and measured friction.
 - Sample test period 6-8 March 2018
 - Context: Repeated heavy snowfalls. Large influence of traffic and maintenance on road condition.
 - Root mean squared error = 0.1μ
Inherent friction measurement
 $RMSE \approx 0.045\mu$

Error distribution



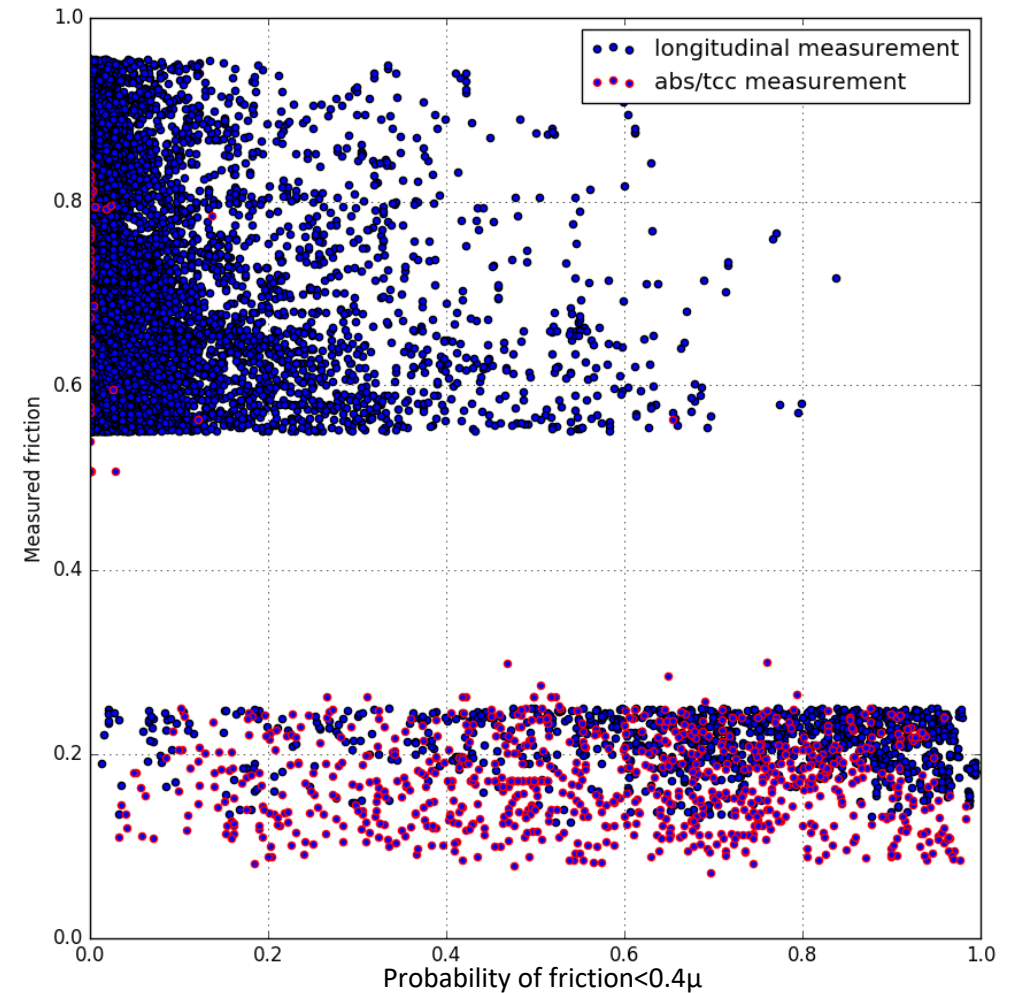
Klimator

Friction distribution



Hit rate analysis.

- The measurements were divided into:
 - Cases with high friction - lowerfriction $> 0.4\mu$
 - Cases with low friction - upperfriction $< 0.4\mu$
- The friction model predicted the probability for friction $< 0.4\mu$.
 - If the probability > 0.1 the road status was regarded as low friction, otherwise high friction.
- The missing part in the figure is measurements where upperfriction $> 0.4\mu$ or lowerfriction $< 0.4\mu$.
 - They are therefore not certain indicators of high or low friction.

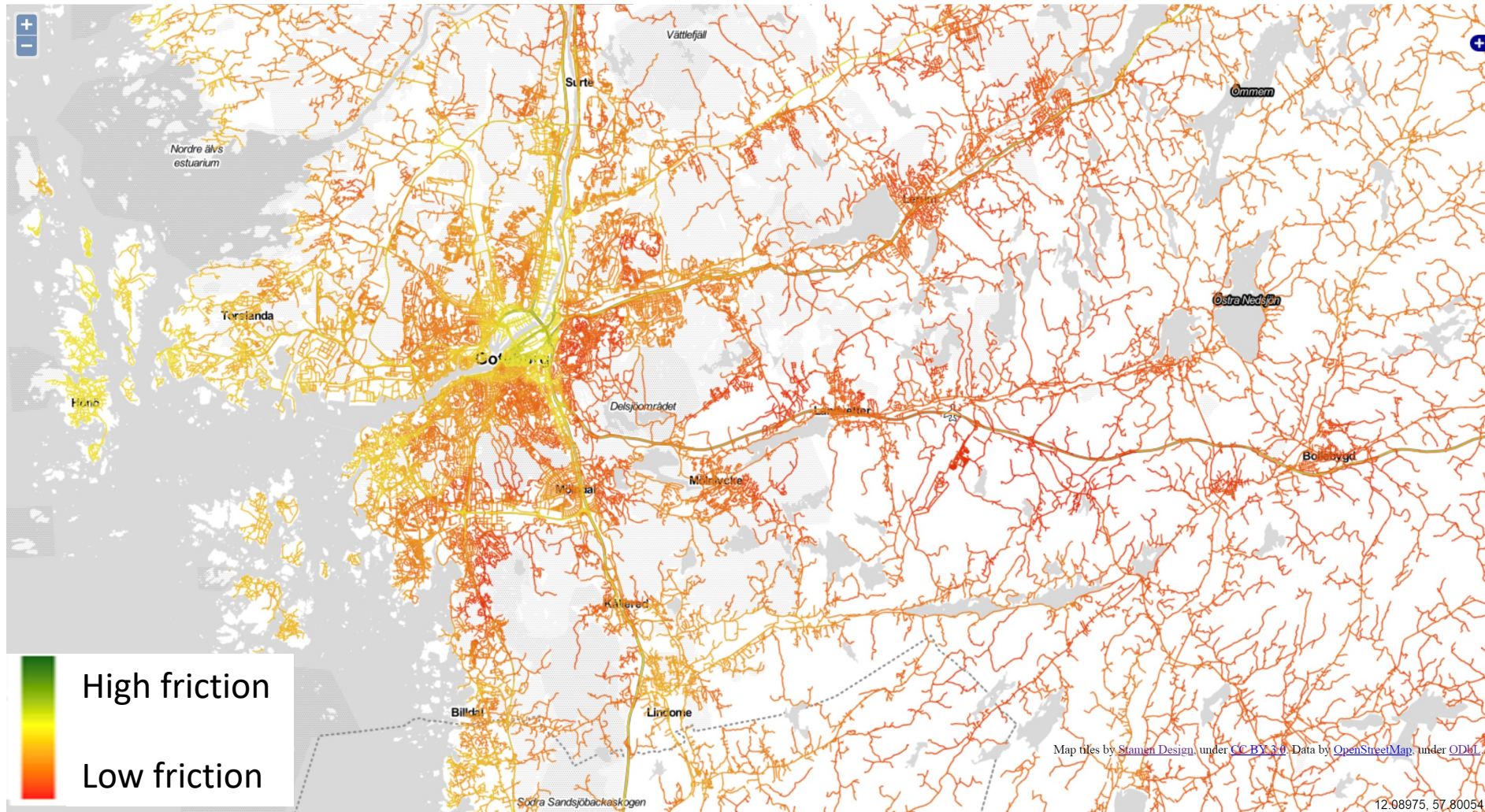


Hit rate friction model (6-8 March 2018)

Percent	Low friction Model	High friction Model
Low friction Observed	98%	2%
High friction Observed	5%	95%

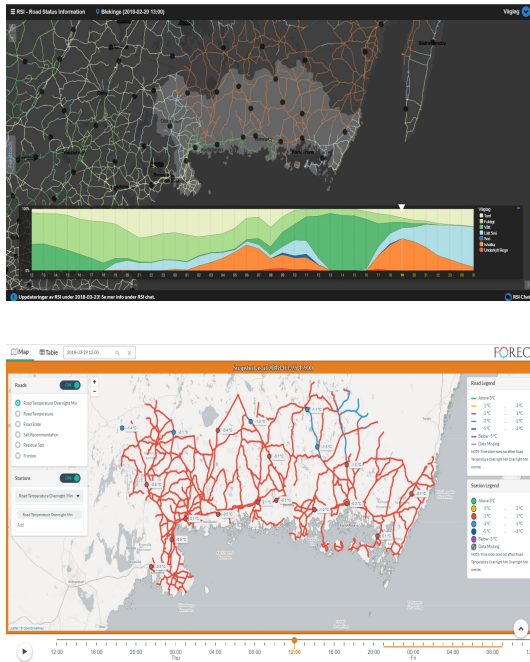
- Low proportion of missed low friction in model (2%).
- Slightly higher false warnings (5%).
- Friction is mostly correctly assessed in model (95%).
- By knowing the current conditions, several factors can be adjusted
 - snow/ice amount
 - maintenance activities
 - surface temperature.

Friction model – nowcast or forecast



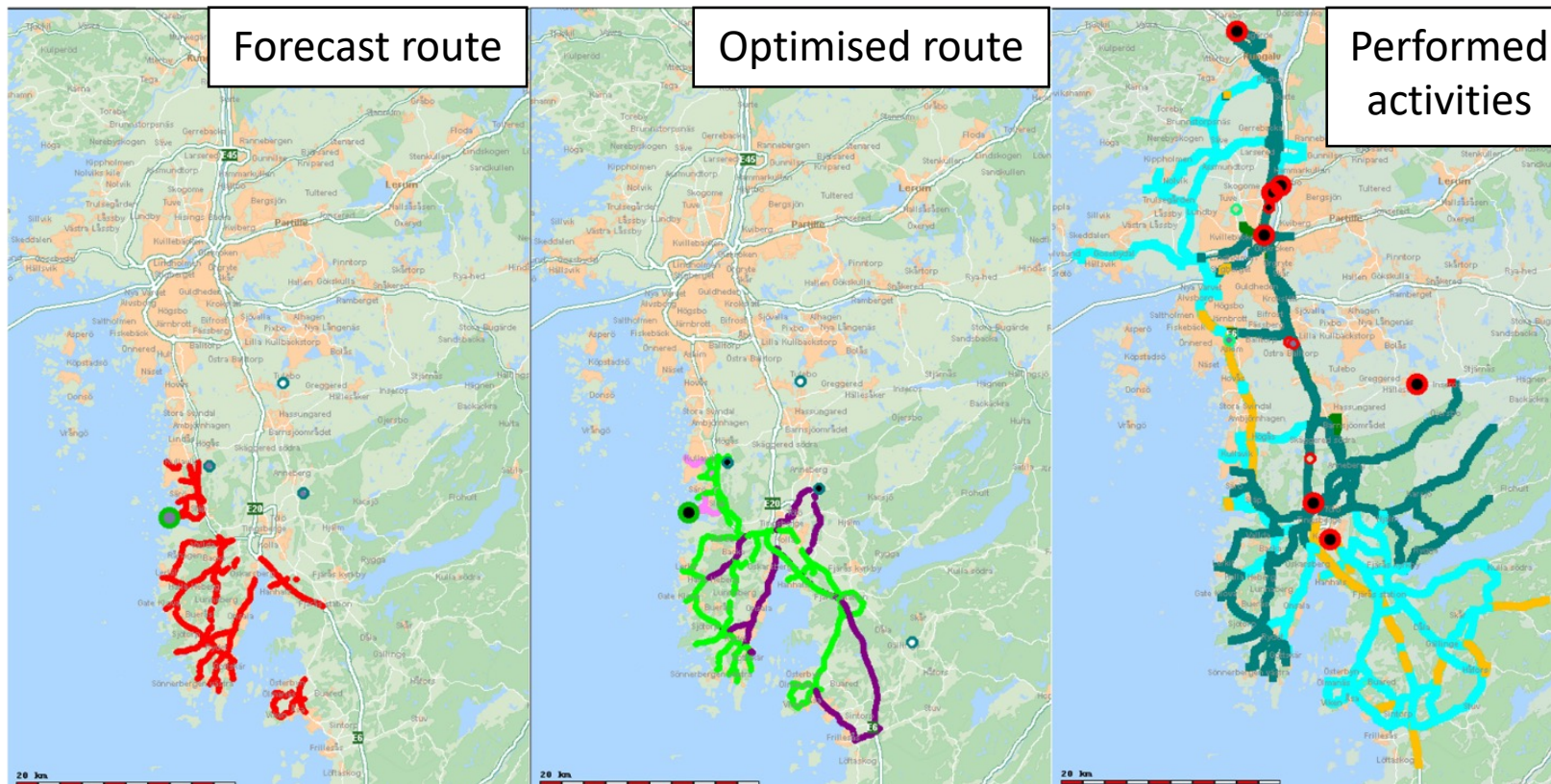
What is needed?

- Route optimizing tool based on road status forecast.
- Transfer optimized route to in-vehicle GPS



Why optimized routes?

- Calculated reduction of 18% under February 2017
- Calculated reduction of machine hours 15-25% throughout the year



Example 10PM, 12/2-2017 Gothenburg

Route optimization to GPS in truck

The screenshot displays the Klimator software interface, which is used for route optimization and GPS tracking in trucks. The interface is divided into several sections:

- Top Bar:** Contains navigation icons and a menu with options like 'Start', 'Fordonshistorik', 'Aktiviteter', 'Rutter', 'Rapporter', 'Åtgärdsplaner', 'Vinterhållning', 'Zoner', 'Objektåtgärder', 'Utkallning', 'Administration', 'Adresshistorik', and 'Ordrar'.
- Map:** A central map showing a green route through a rural area. A speed limit sign for 80 km/h is visible.
- Left Panel (Ruttgrupper):** Lists various route groups such as '<Blekinge_barmark>', '<Blekinge_inspektion>', '<Blekinge_Prognosrutt>', '<Blekinge_Prognosrutt_Optimerade>', and '<Blekinge_vinter>'. Below this is a table of routes.
- Table of Routes:**

Namn	Tid	Sträcka	Transporttid	Fordonsgroup	Färg
Kombi 001 JSL 1	01:28:57	59563	00:00:00	Blekinge_vinter	[Purple]
Kombi 002 & GC 13 Håkan	01:04:15	53702	00:00:00	Blekinge_vinter	[Green]
- Bottom Panel (Task List):** A table showing tasks for salt application ('Saltning') on 2018-04-03 at 07:00:00.

Rutt	Åtgärd	Fordon
OptimizedForecastRoute_RSI... 04-03 07:00]_[09:00..09:00]_[Blek... 1 (Combo)	Saltning	JSL 1 (Combo)
OptimizedForecastRoute_RSI... 04-03 07:00]_[09:00..09:00]_[Blek... Olsson (Combo)	Saltning	Håkan Olsson (Combo)
OptimizedForecastRoute_RSI... 04-03 07:00]_[09:00..09:00]_[Blek... Gräv 1 (Combo)	Saltning	Mörum Gräv 1 (Combo)
- Right Panel (GPS Interface):** Shows a detailed view of the route with a speed limit sign for 80 km/h. The current location is 'Bärvallen, Malung, Sälen'. The interface includes a speedometer showing 90 km/h and a distance to the next point of 64 km. A control panel on the right has buttons for 'SNÖRÖJNING', 'HALKBÄKÄMPNING', 'KOMBI', 'STÖRNING FORDON', 'STÖRNING ÖVRIGT', and 'LOGGA POSITION'.
- Bottom Bar:** Contains navigation icons, a speedometer showing 90 km/h, a distance to the next point of 64 km, and a time to the next point of 15 min.



Conclusions

- Accuracy of surface temperature nowcasts and forecasts are about the same magnitude as measurement error of sensor.
- With vehicle data (friction) included road status nowcasts and forecasts are precise and current conditions are known with high accuracy.
- GPS routes in salting vehicles can be created from salting recommendation based on road status forecasts.

A large, stylized graphic on the left side of the slide. It consists of a dark grey, angular shape that resembles a large letter 'K' or a mountain peak. Overlaid on this is a blue graphic that looks like a stylized 'V' or a mountain peak with a small triangle on top, similar to the one in the KLIMATOR logo.

The End

Thank you!