A glimpse of the future for winter maintenance

No need for winter maintenance

Maintenance today and in the (near) future

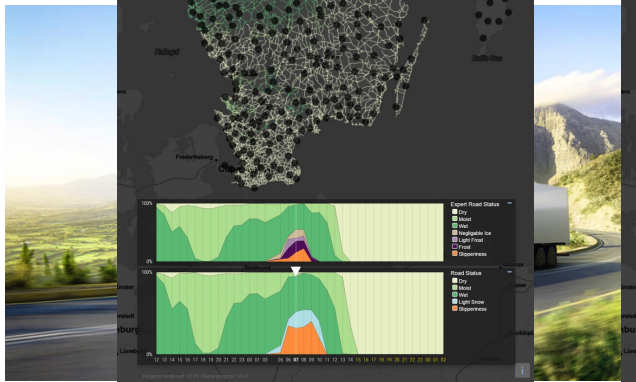
CURRENT

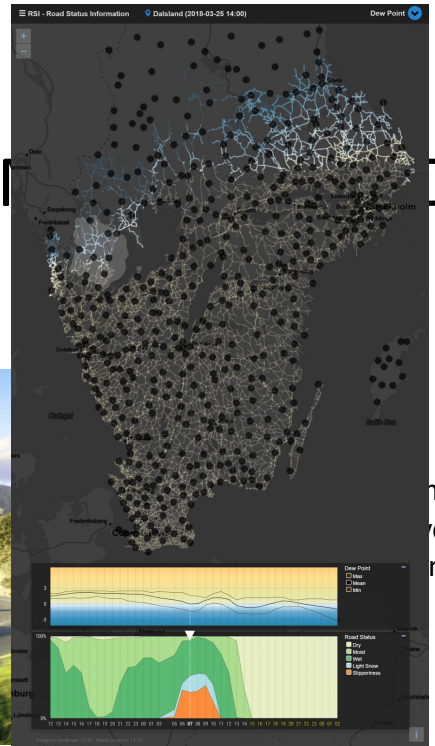
- What have we got now?
  - RSI – a tool to help you excel at your profession - performing maintenance.

FUTURE

- RWIS Station + Weather Forecast + [illegible] + [illegible]Data
  -> Salting GPS route in the maintenan[illegible]

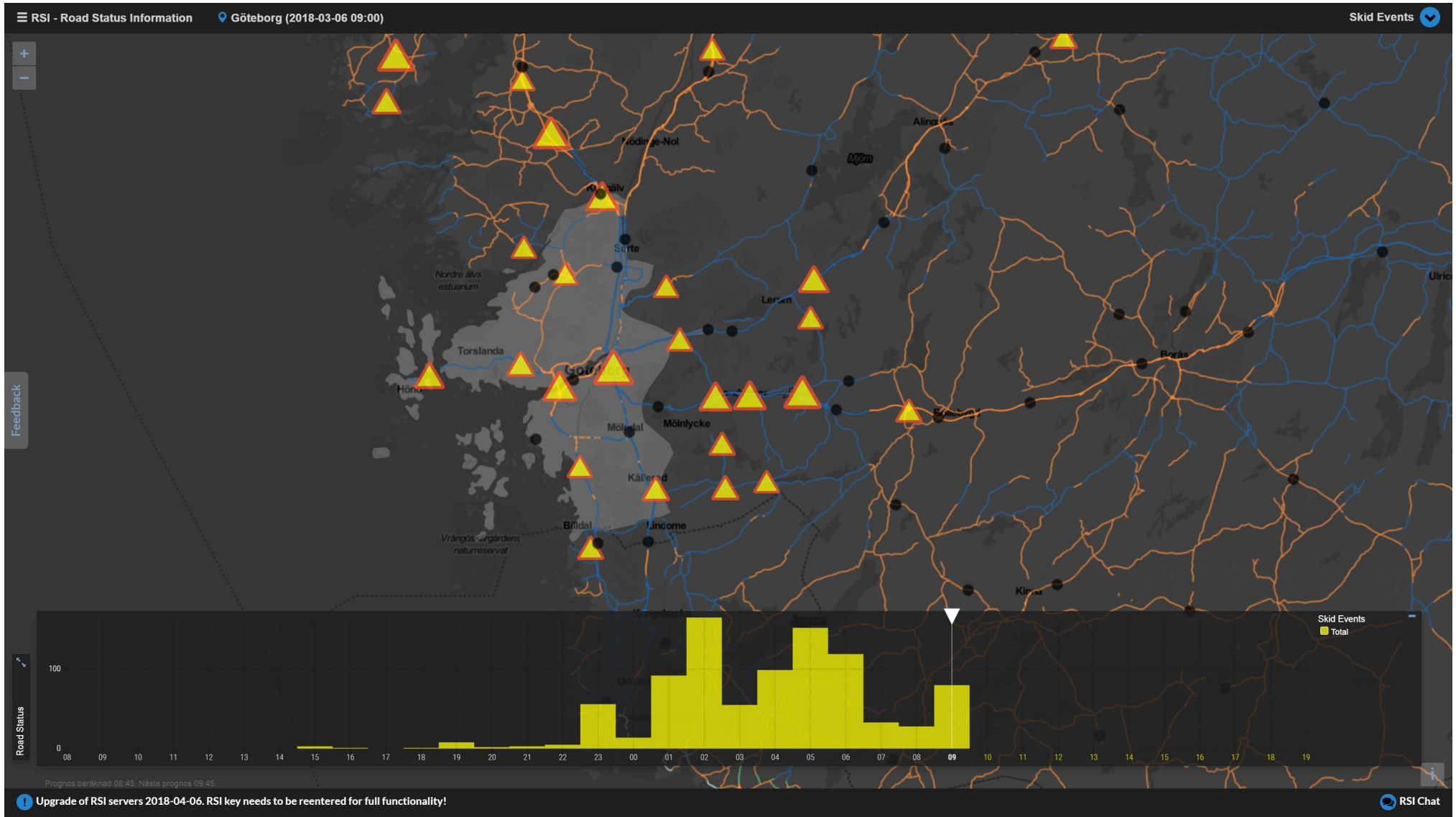
https://www.computerworld.com/article/3084546/car-tech/nikola-motor-gets-23b-worth-of-preorders-for-electric-semi-trailer-truck.html





[illegible]n/article/what-is-the-[illegible]ou-need-to-know-[illegible]nomous-electric-

RSI application – friction alert



500 units primarily in Gothenburg and Stockholm

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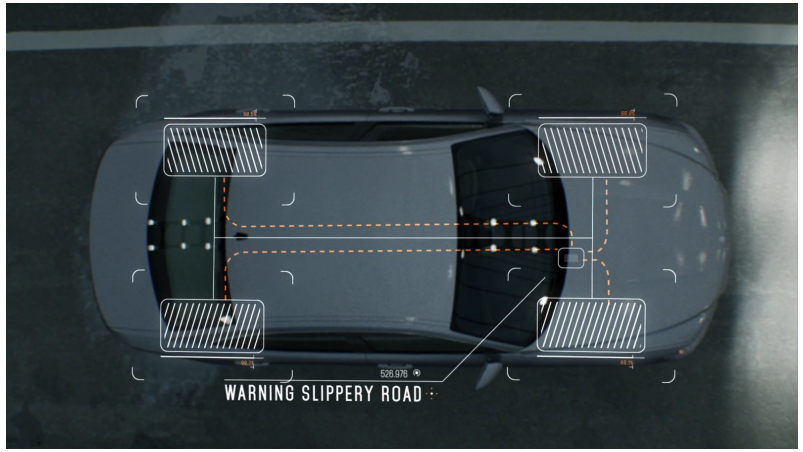
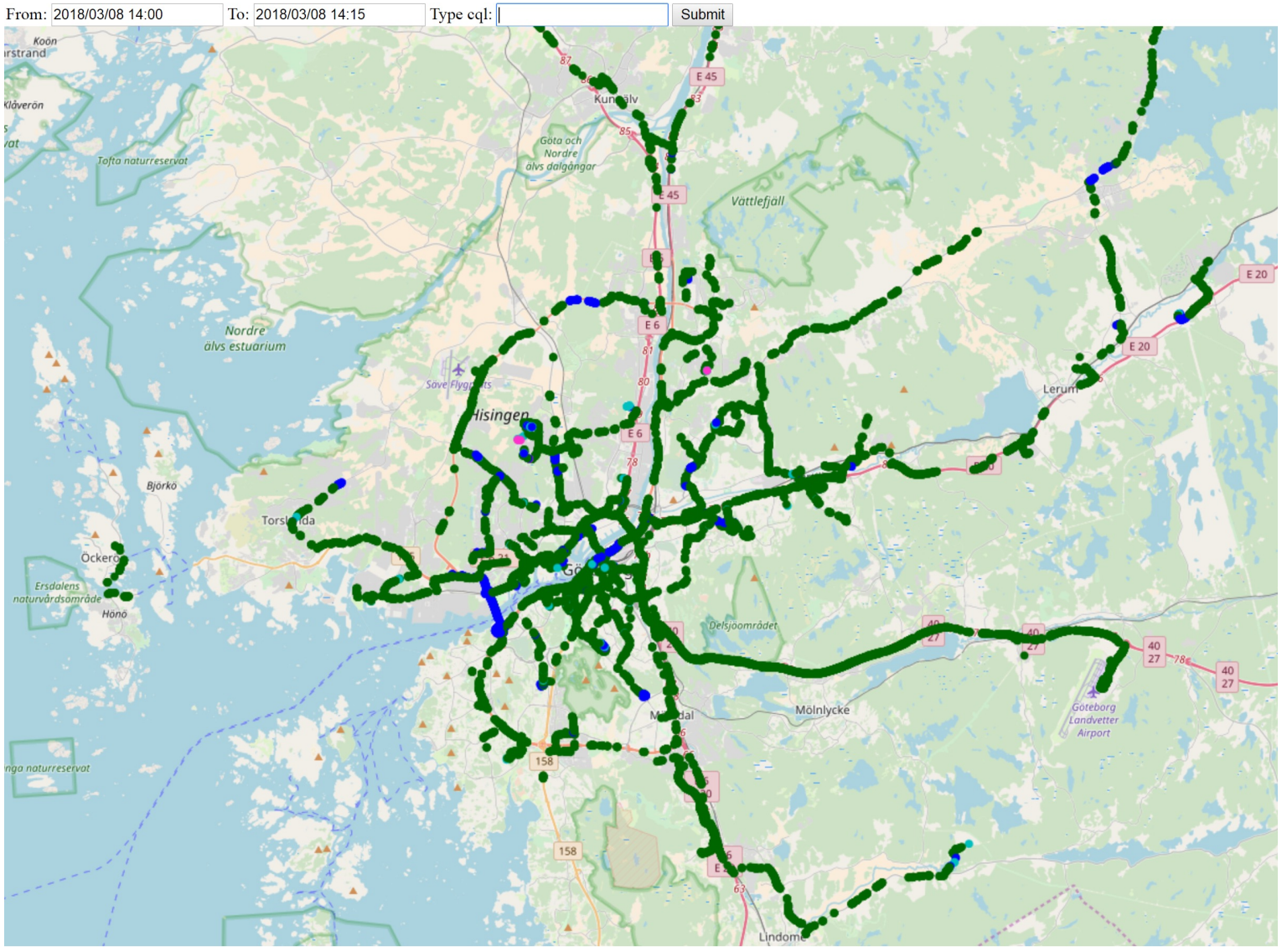
NIRA DYNAMICS

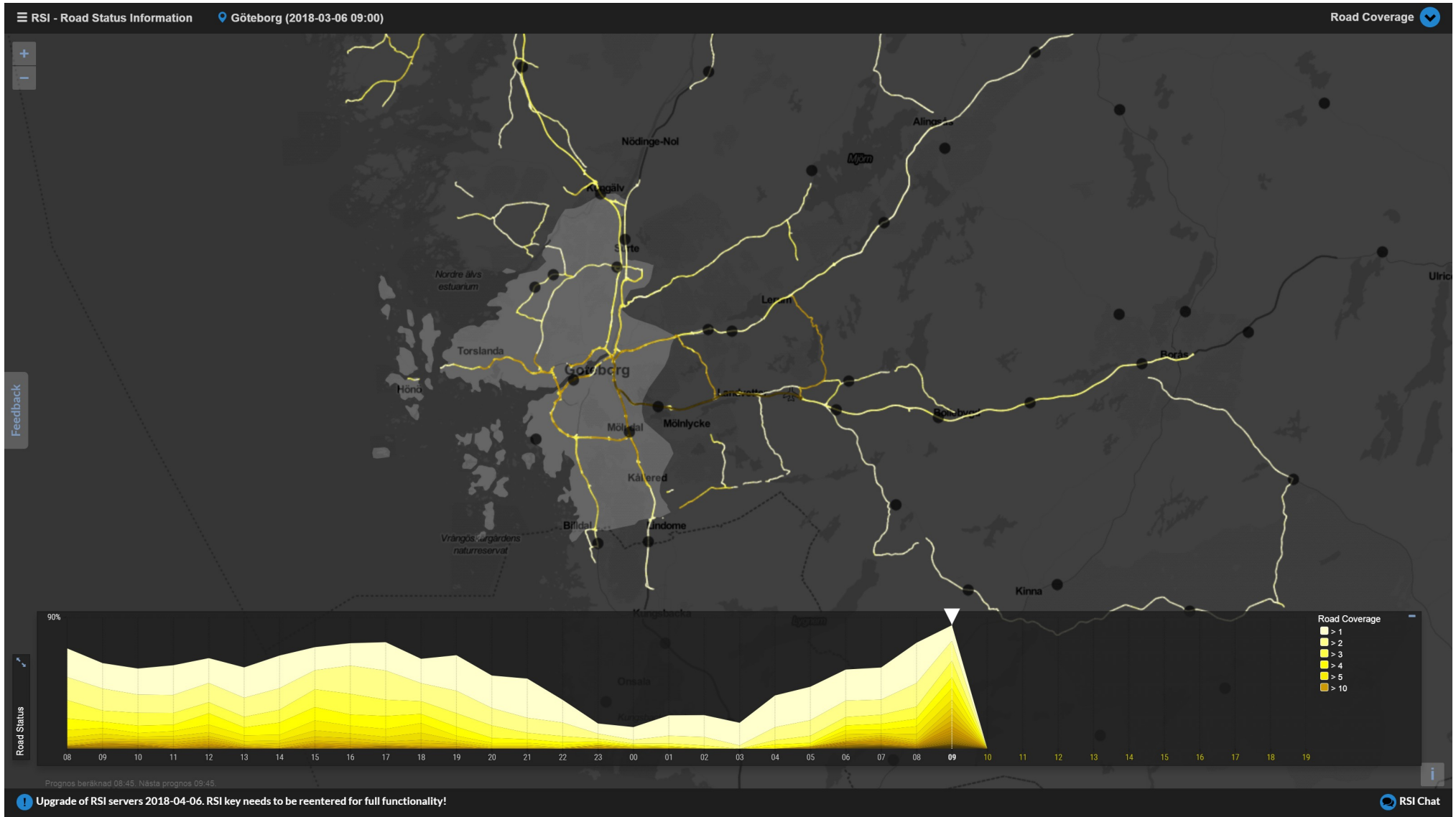


Data during 15 minutes

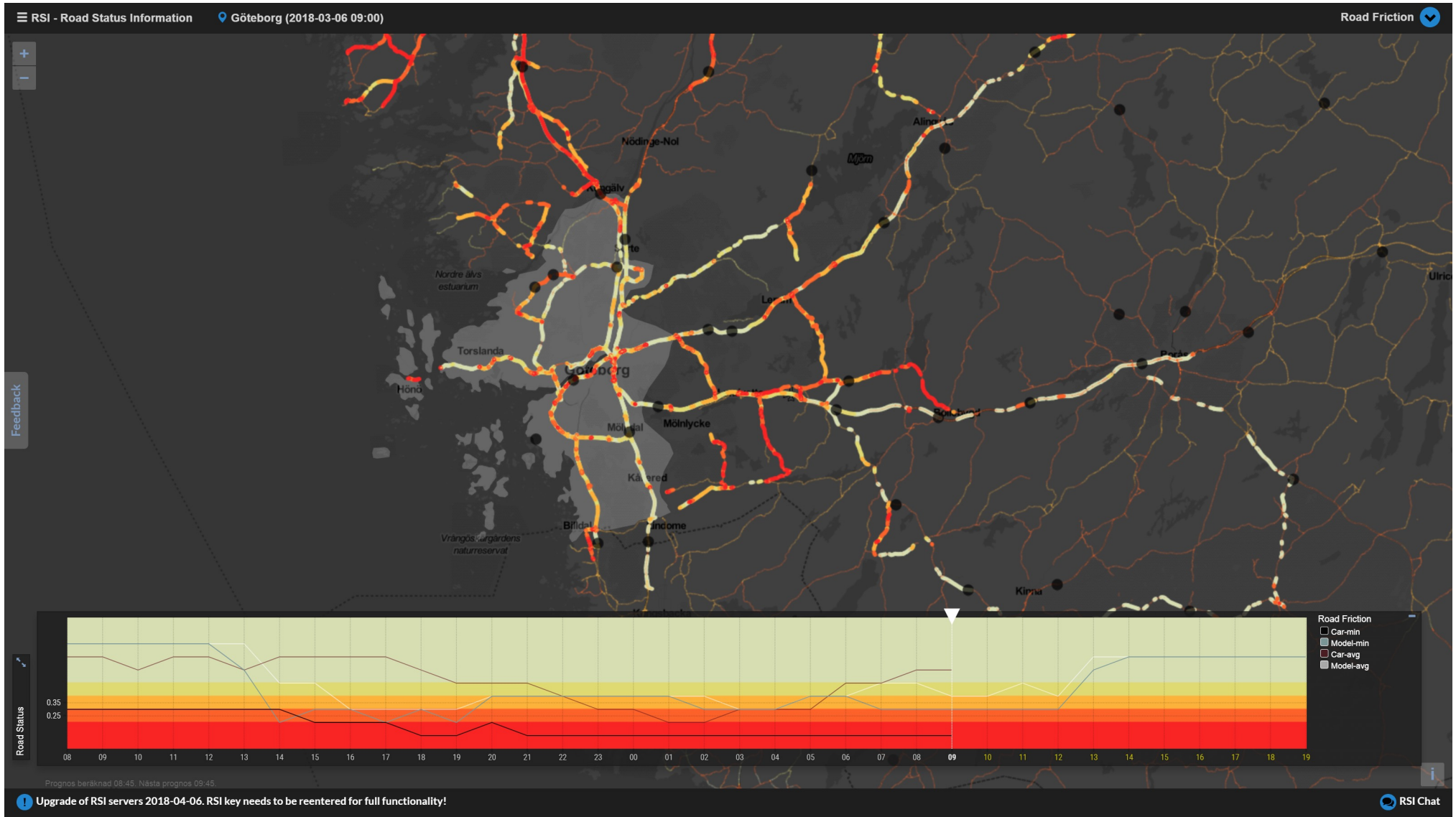
- Some of the 200 vehicles in the Gothenburg area



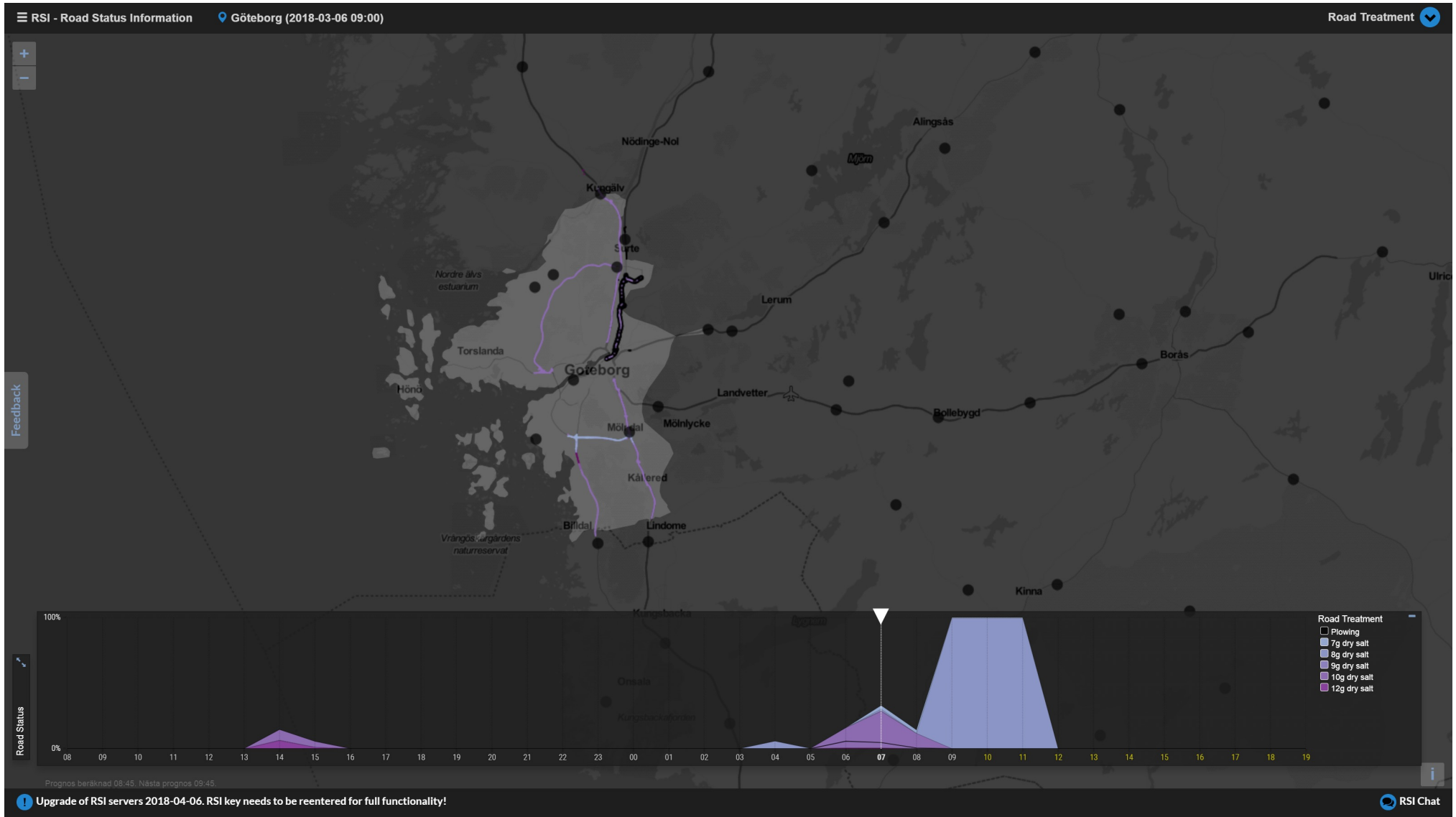
RSI application – Road coverage



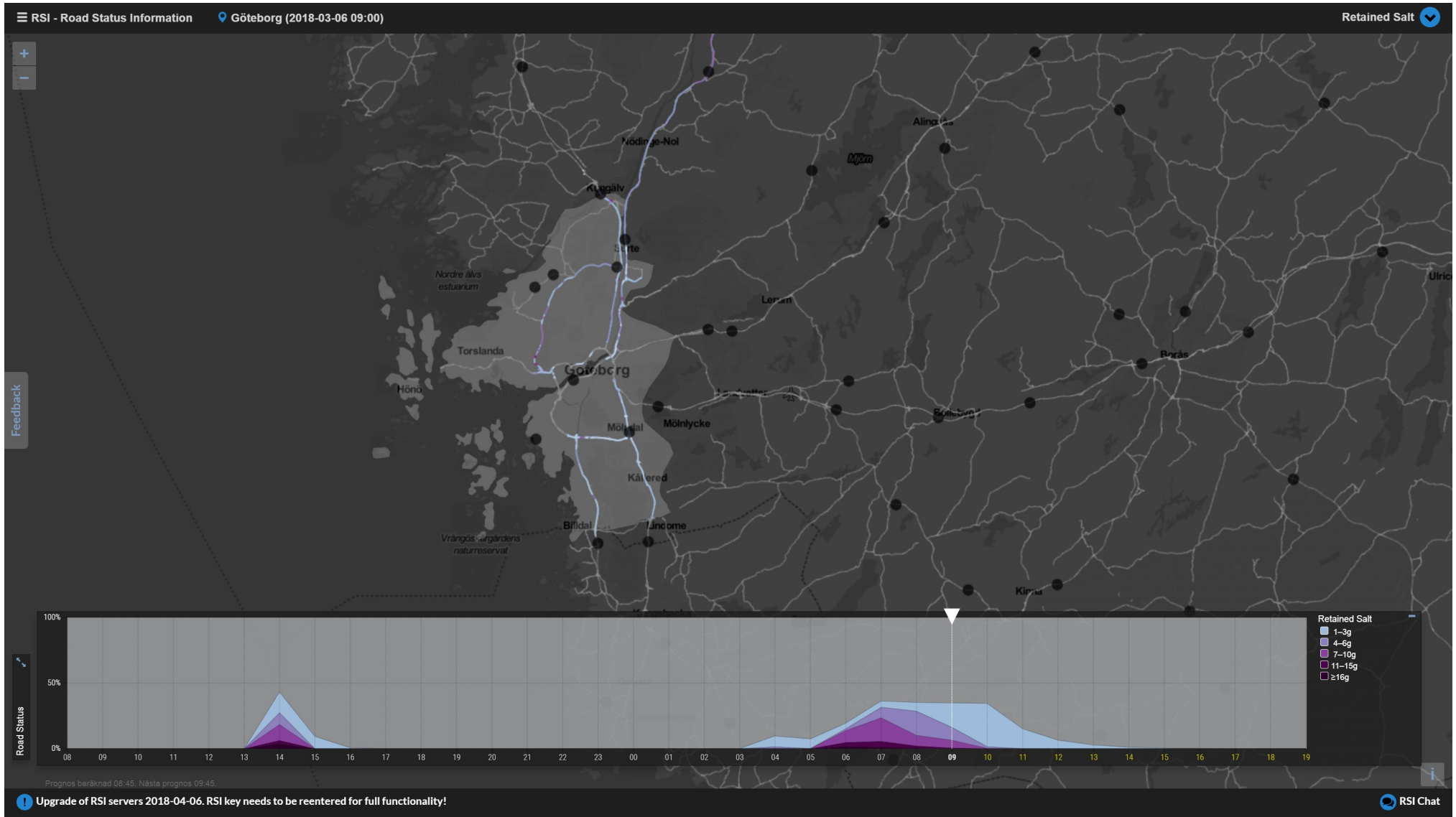
RSI application – Road friction



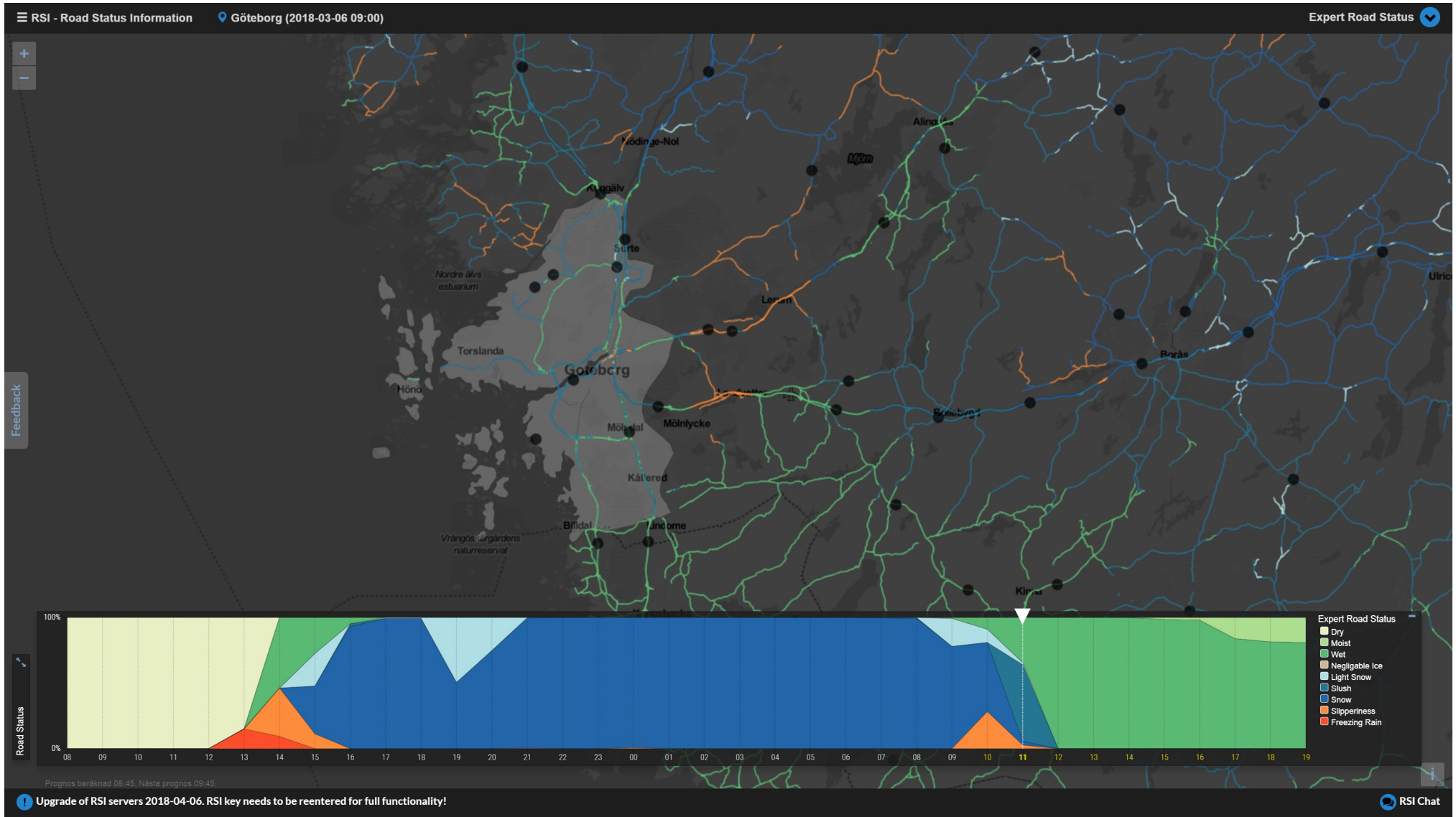
RSI application – Maintenance activities



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

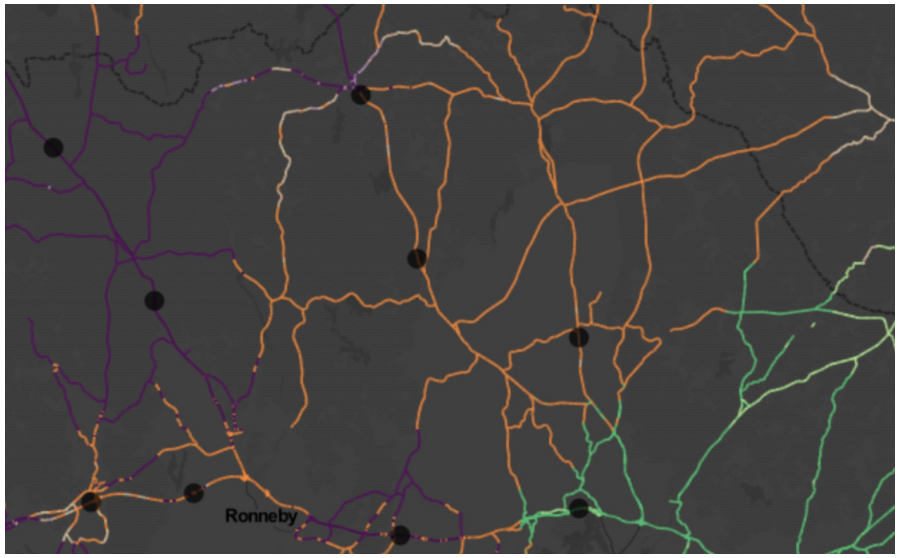
Mean Absolute Error

- 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

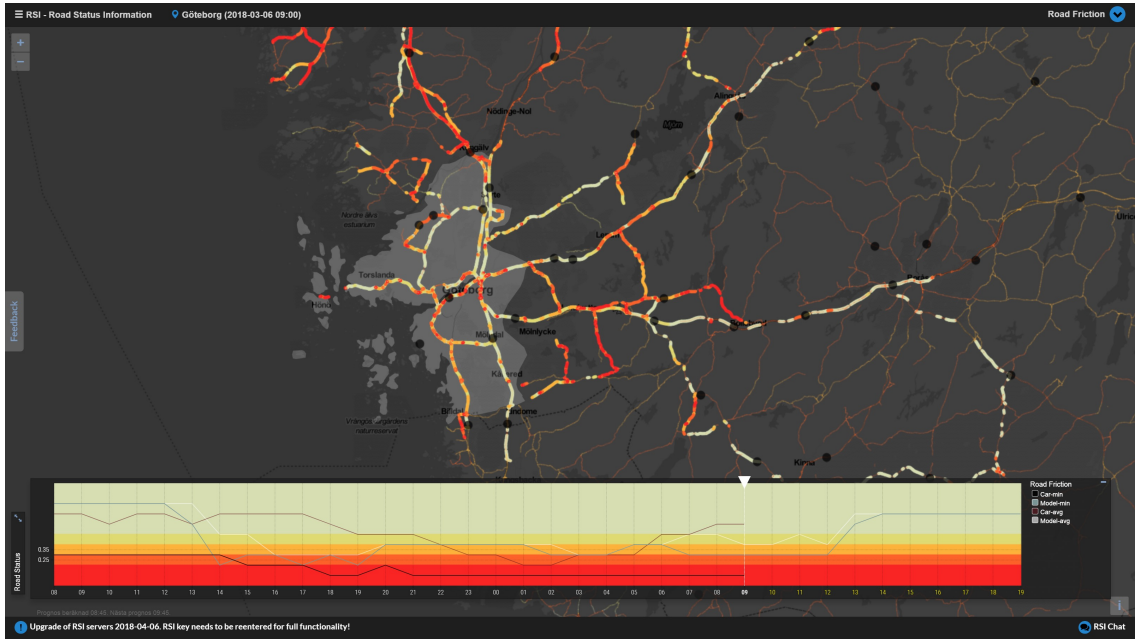


Accuracy for arbitrary segment.

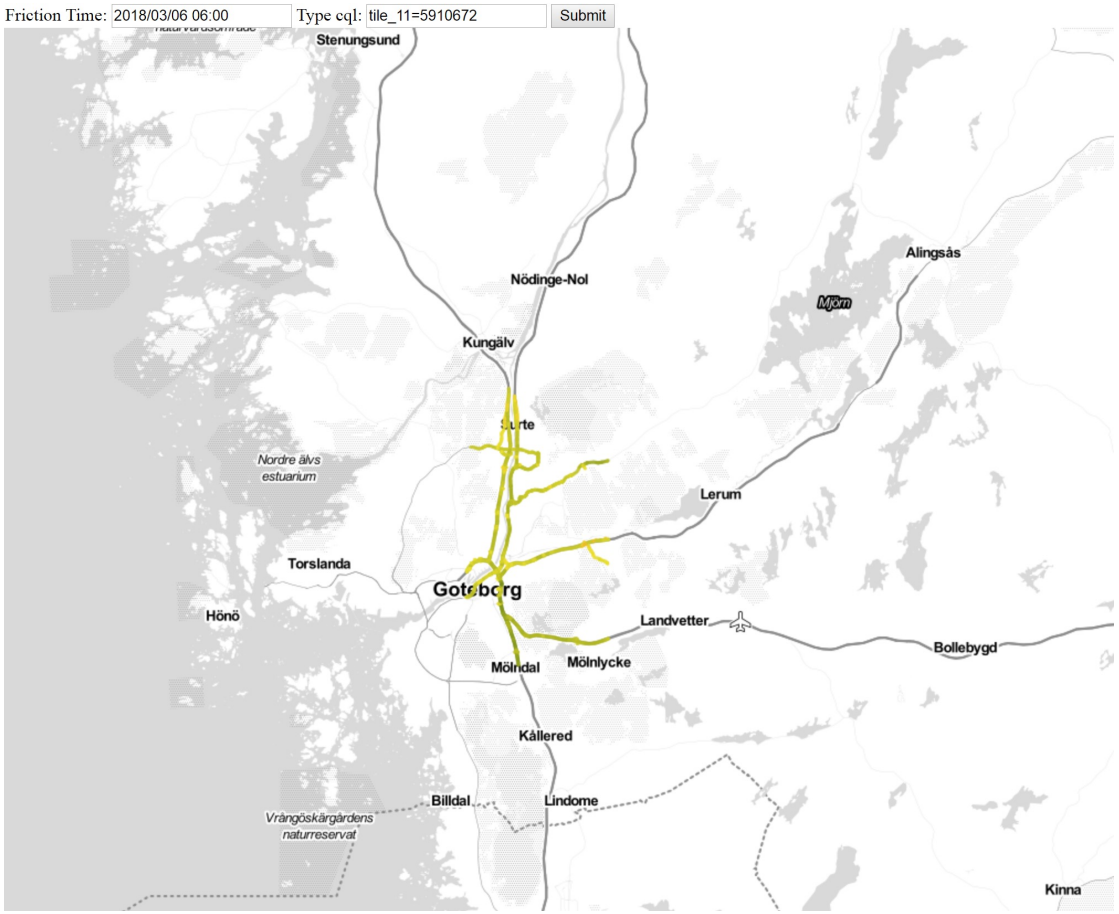
Evaluated by cross-validation, i.e. removing the evaluated station from prediction model.

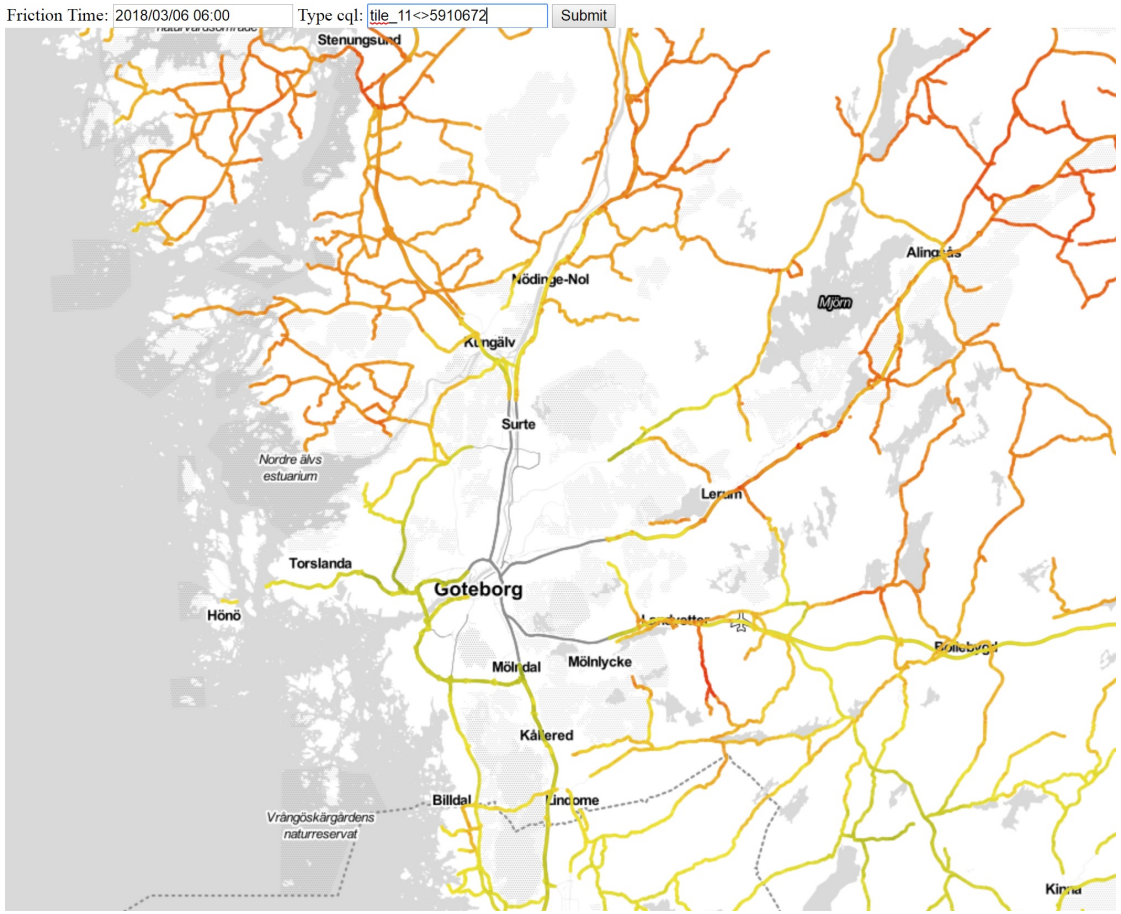
What is needed?

- 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

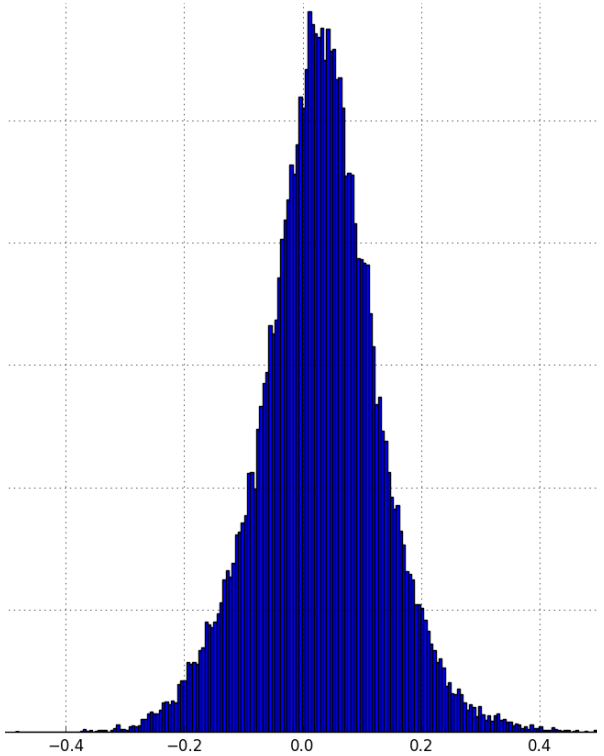




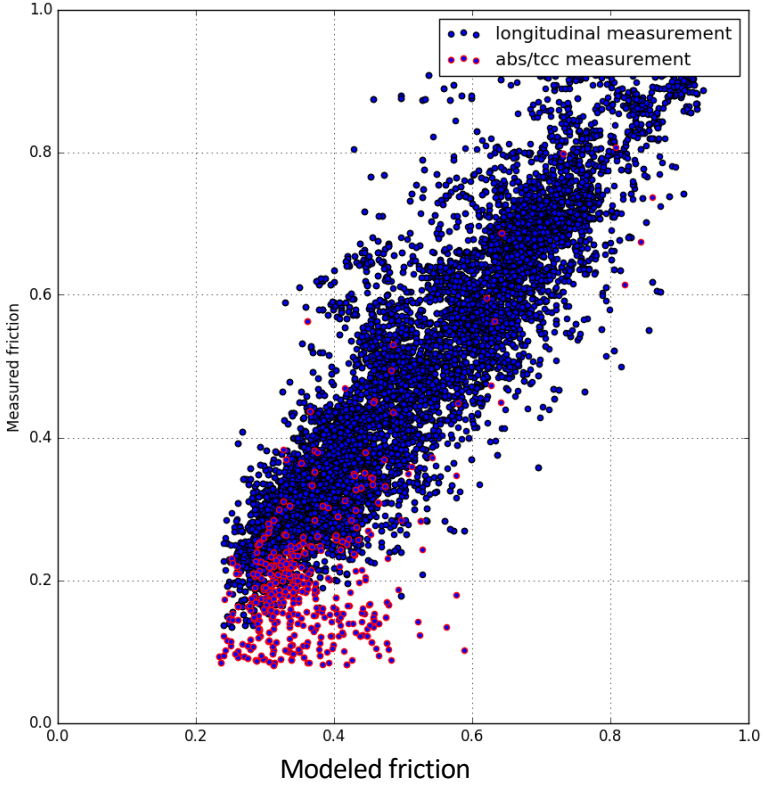
Friction model

- 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 ≈ 0.045μ

Error distribution

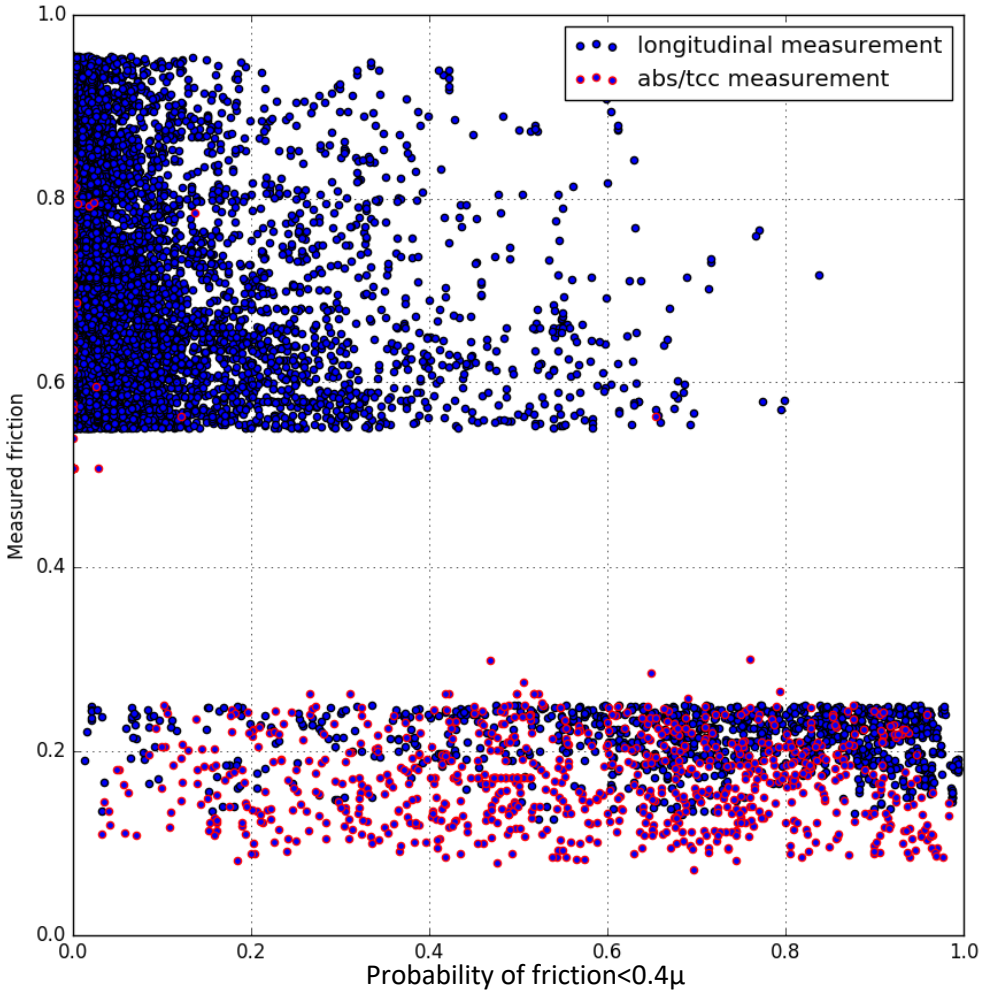


Friction distribution



Hit rate analysis.

- The measurements were divided into:
  - Cases with high friction - lowerfriction>0.4µ
  - Cases with low friction - upperfriction< 0.4µ
- The friction model predicted the probability for friction<0.4µ.
  - 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>0.4µ or lowerfriction<0.4µ.
  - They are therefore not certain indicators of high or low friction.



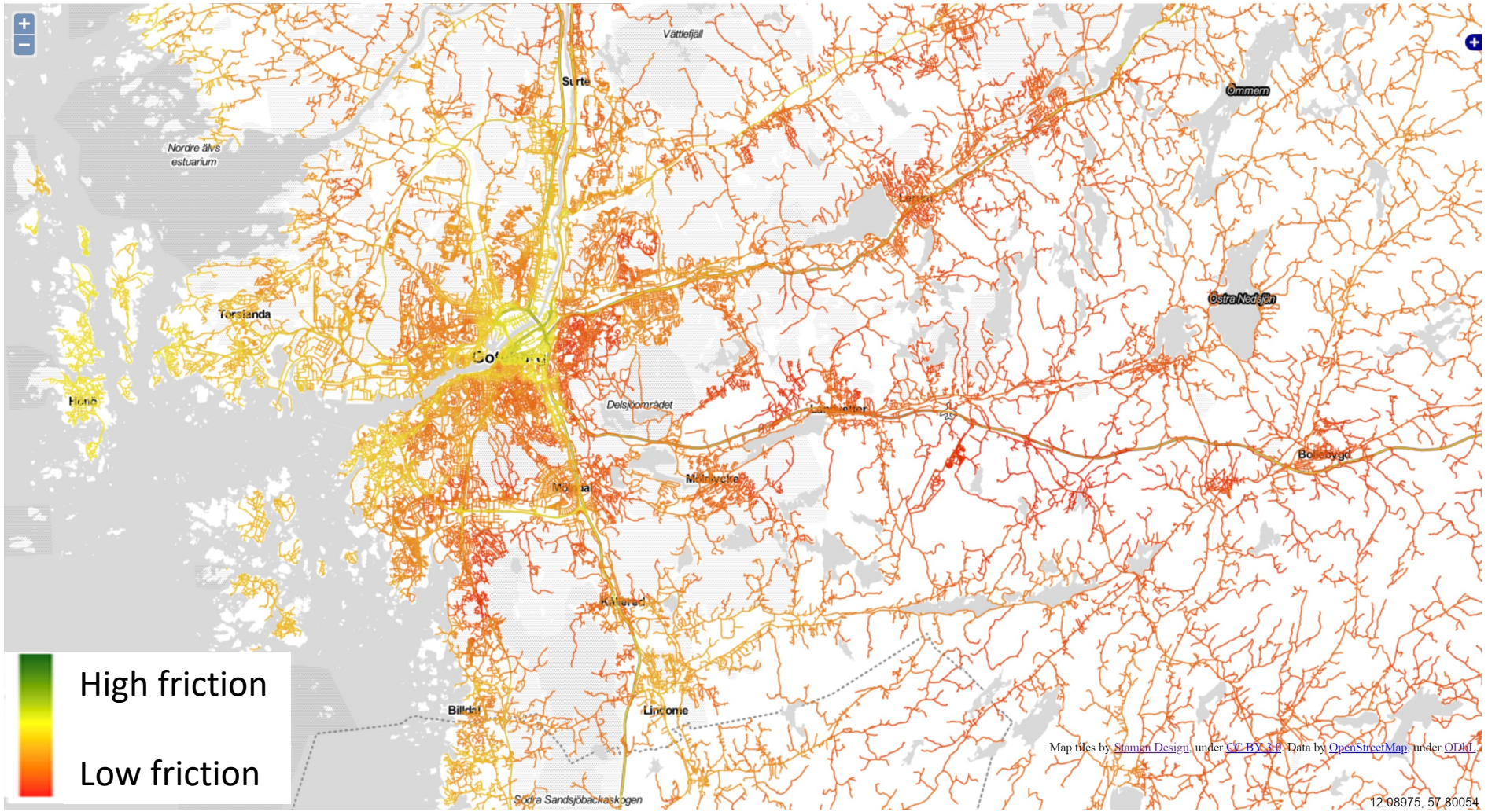
Hit rate friction model (6-8 March 2018)

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

- Low proporsion of missed low friction in model (2%).
- Slightly higher false warnings (5%).
- Friction is mostly correctly assessed in model (95%).

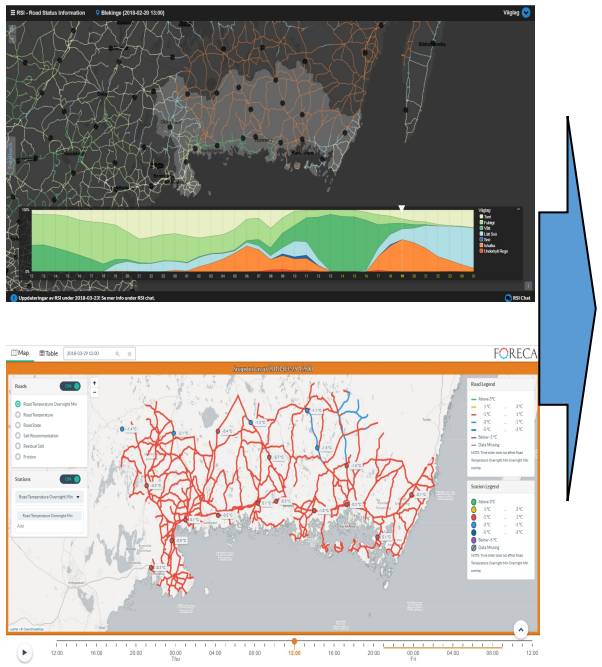
- By knowing the current conditions, several factors can be adjusted
  - snow/ice amount
  - maintenance activities
  - surface temperature.

Friction model – nowcast or forecast



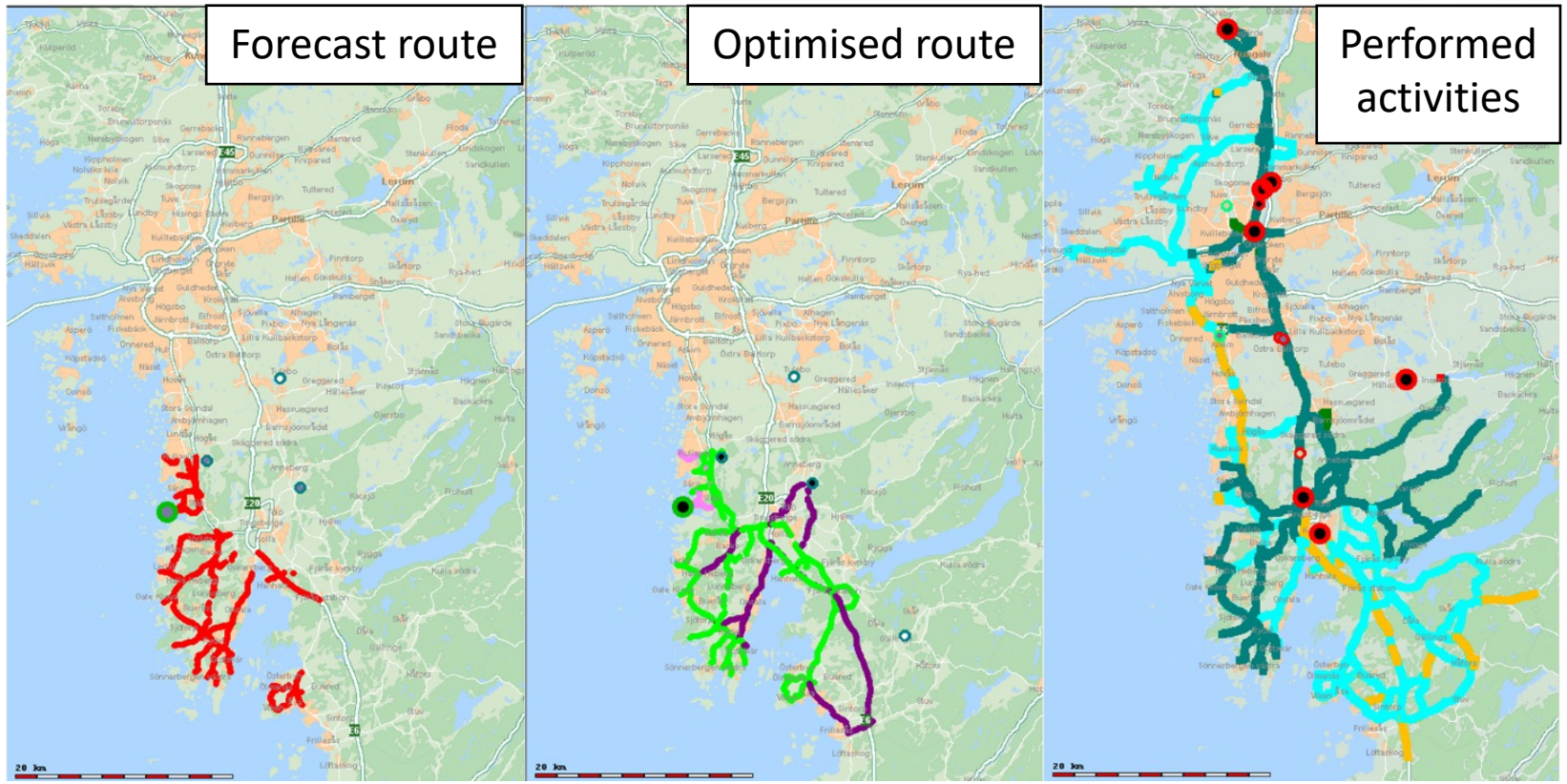
What is needed?

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



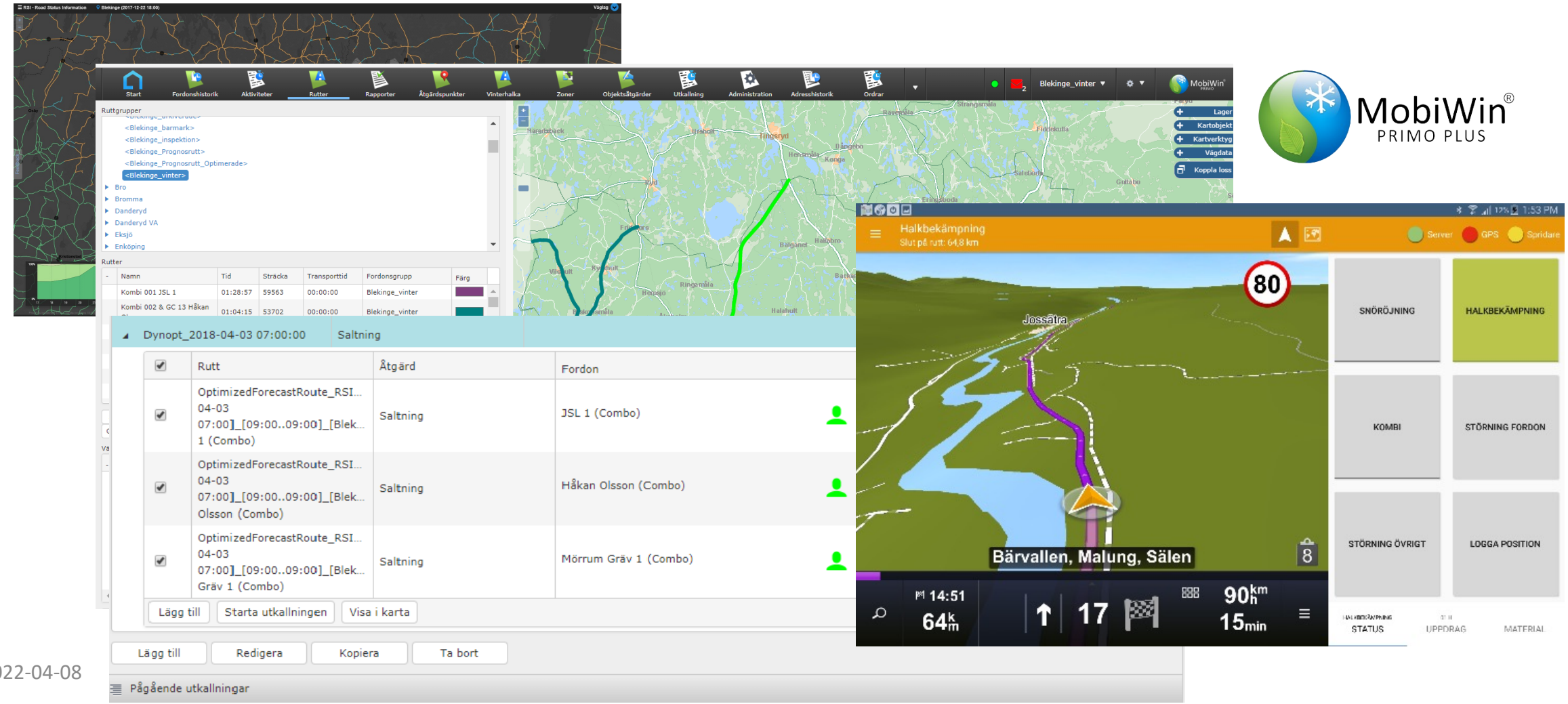
Why optimized routes?

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



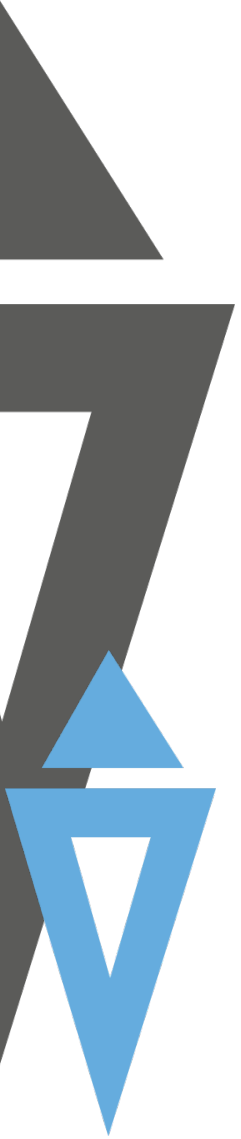
Example 10PM, 12/2-2017 Gothenburg

Route optimization to GPS in truck



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.



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The End

Thank you!