

Continuous Skid Resistance Test

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0. CONTENT

1. Introduction
2. Mobile Friction
3. Test Driving
4. Results
5. Discussion



1. INTRODUCTION: Continuous Skid Resistance Test

Purpose of the study:

1. Performance of Road Condition Monitor RCM411
 - Modeled friction based on detection of water and ice
 - Comparison to an absolute friction meter
2. How to exploit in winter maintenance?



2. MOBILE FRICTION: Road Condition Monitor

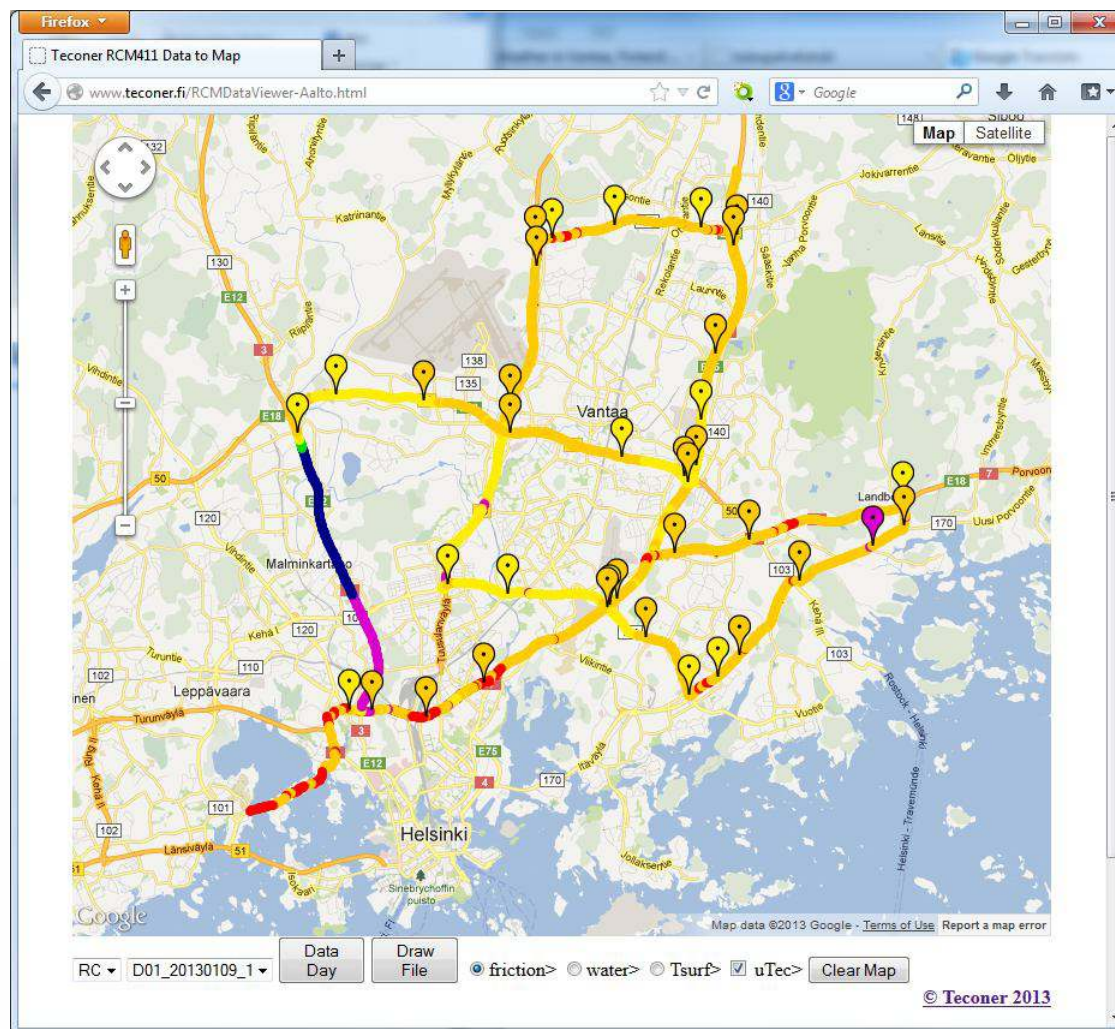
- Optical detection of water and ice
 - near infrared absorption
- Measured continuous information
 - road surface condition
 - dry, moist, wet, slushy, icy, snowy
 - thickness of water layer
 - **modeled friction**
 - road surface temperature
- User interface in a cell phone
 - **braking friction meter μ TEC**



2. MOBILE FRICTION: Map interface to data (1)

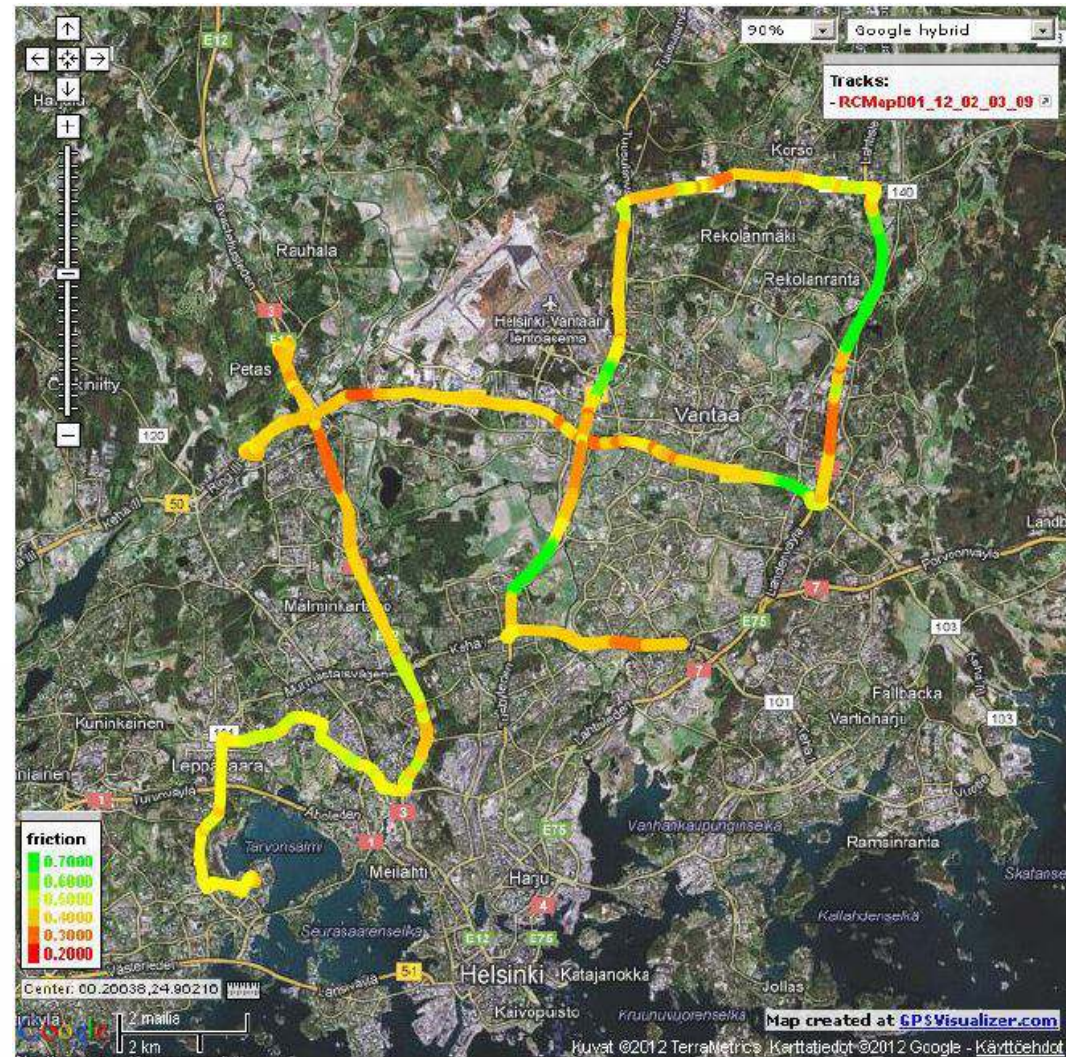
Colour	Friction	Surface state
green	~ 0.80	dry
dark blue	~ 0.75	moist
light blue	~ 0.65	wet
violet	~ 0.50	slushy
white	~ 0.40	snowy
yellow	~ 0.35	icy, thin or breaking
red	< 0.30	icy, thick and hard

- The droplets represent braking friction measurements



2. MOBILE FRICTION: Map interface to data (2)

- Optionally friction values can be plotted by varying hues of green - yellow - red



2. Mobile Friction: Braking Friction Meter as a reference

Braking Friction Meter μ TEC

- Cell phone application
 - Same interface with RCM 411
- Used as a reference meter
- Absolute friction readings
 - Physical coefficient of friction is measured
- Data communicated together with RCM 411 data: real time remote follow up feasible



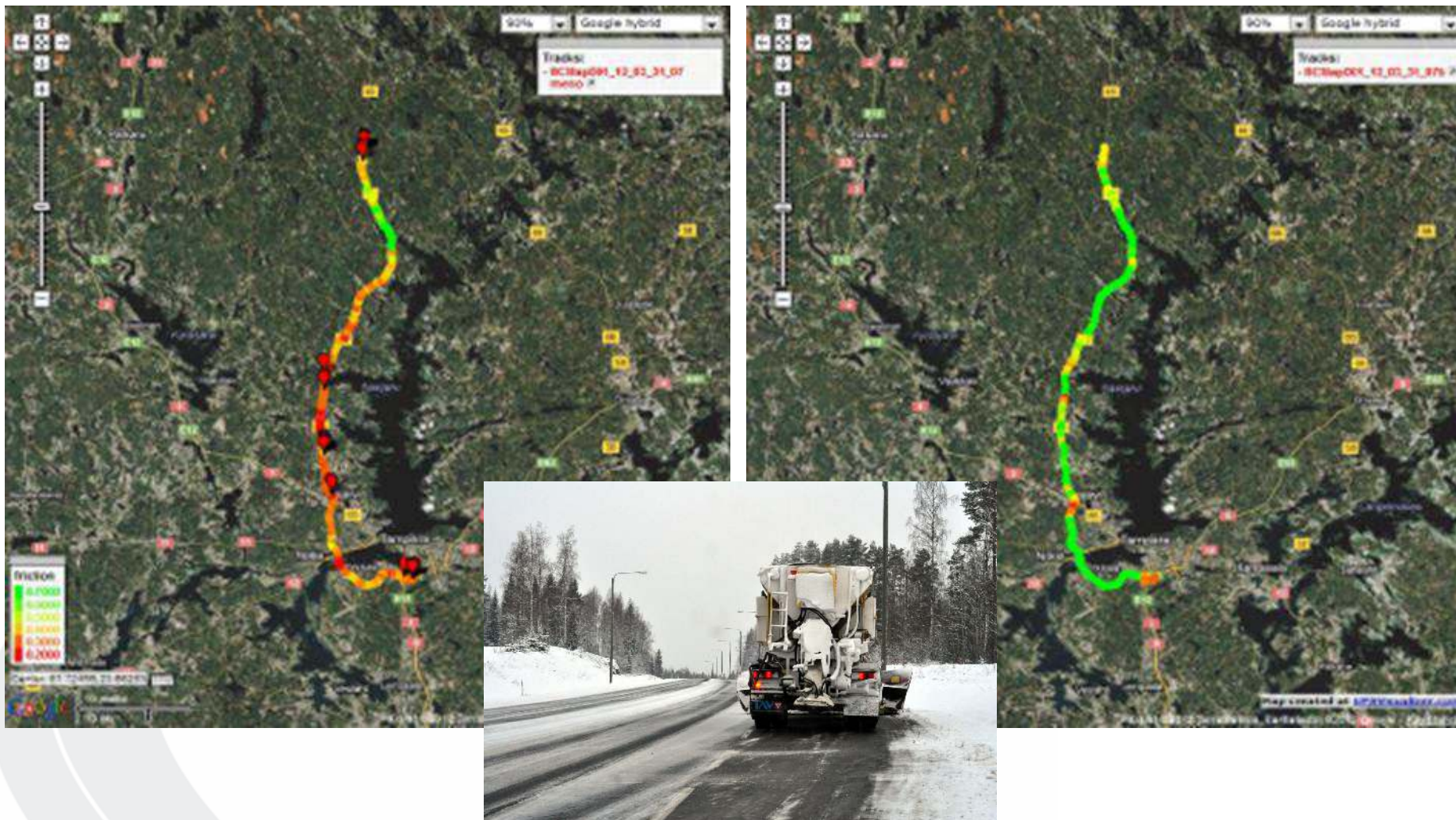
3. TEST DRIVING

Winter seasons 2011-2012 and 2012-2013

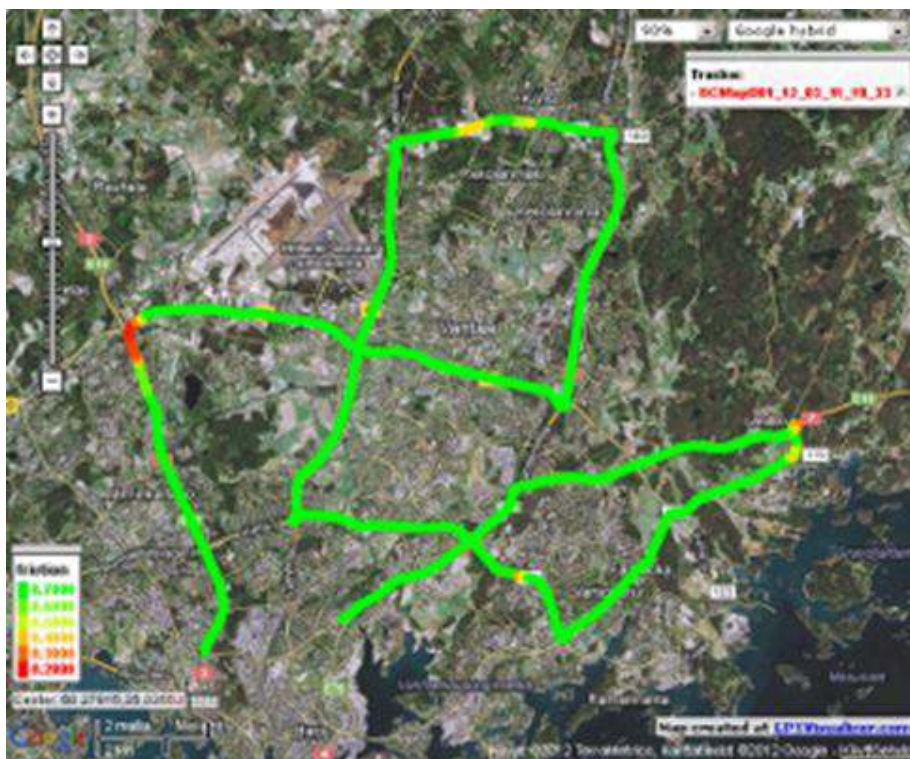
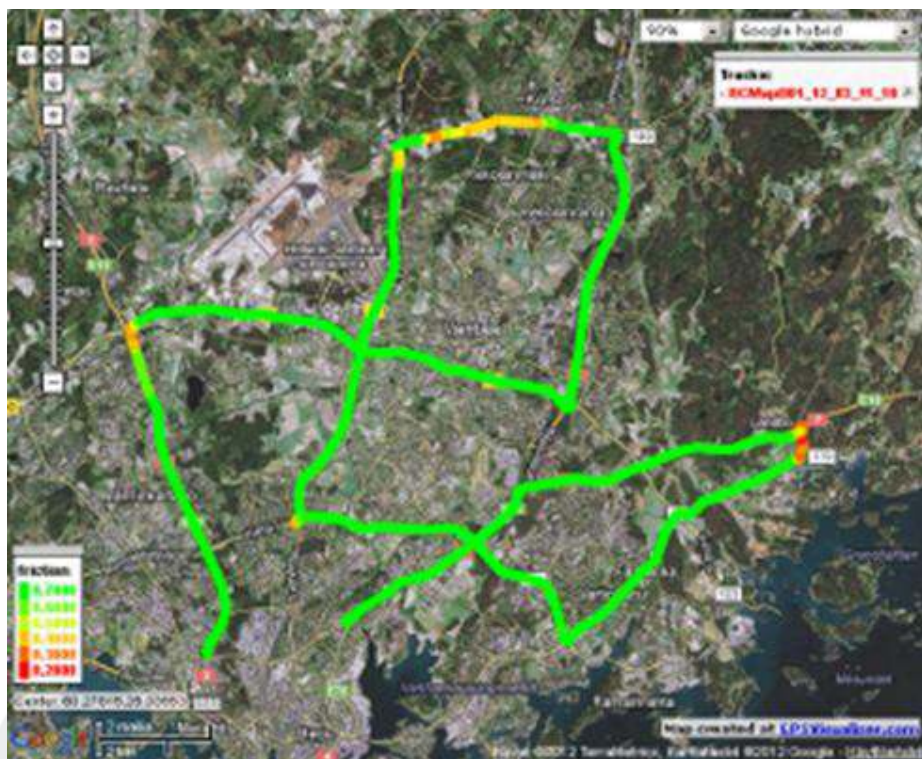
- During expected slippery conditions in South Finland
- 2000 km of fixed preselected route
- 8 times other routes
- 248 braking friction measurements



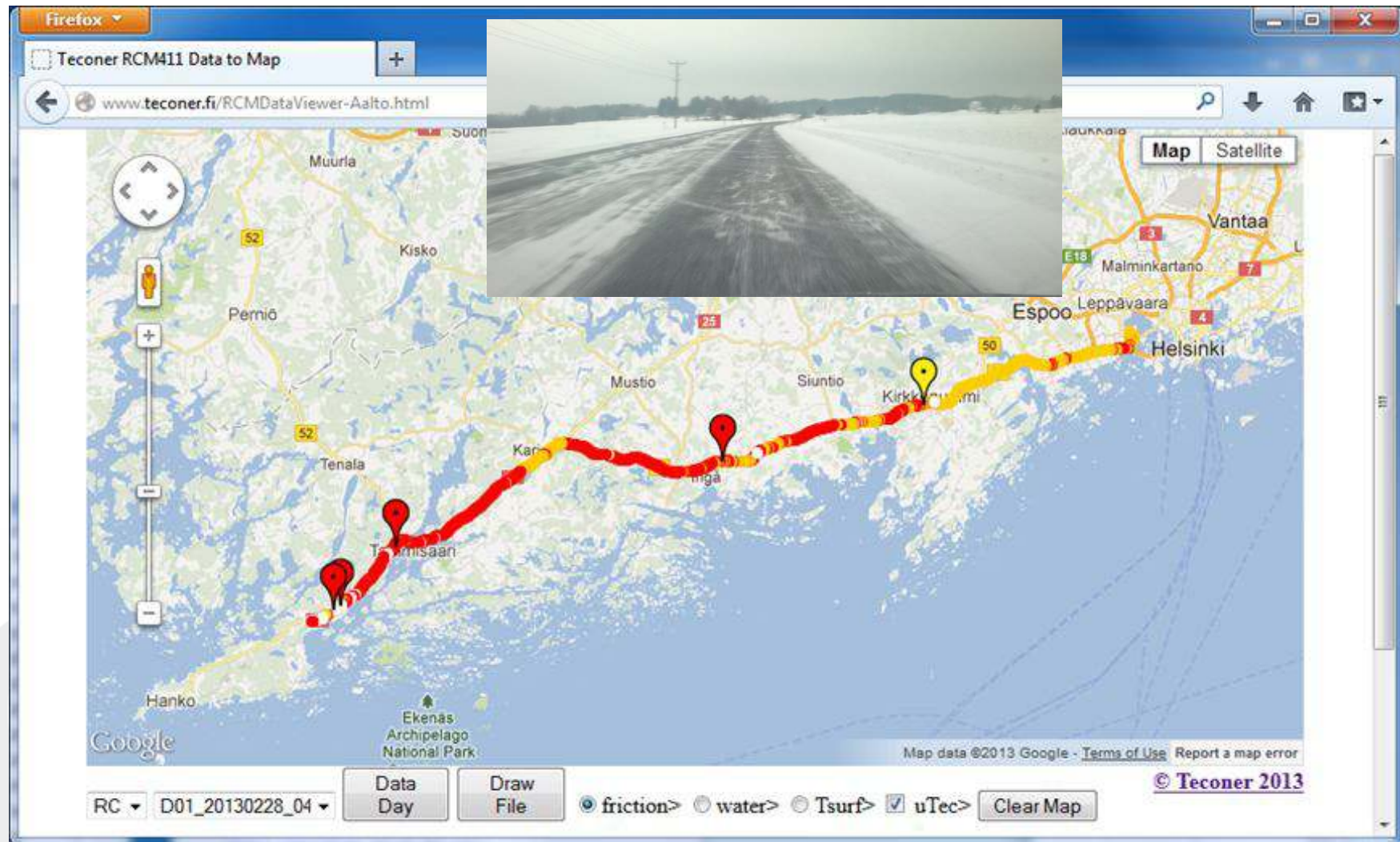
3. TEST DRIVING: example 1



3. TEST DRIVING: example 2



3. TEST DRIVING: example 3



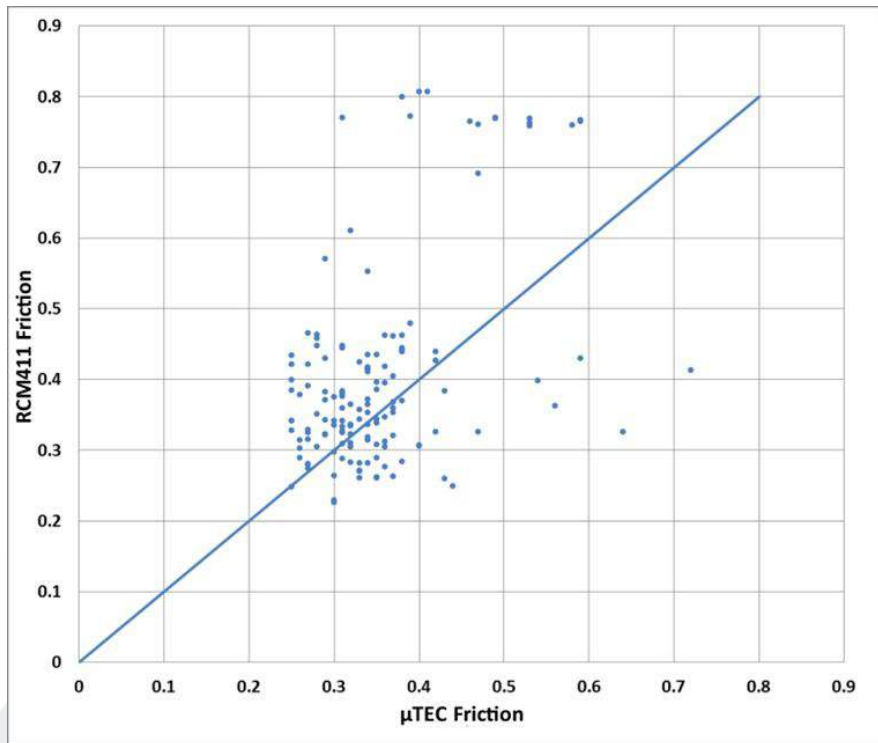
4. RESULTS: Winter 2011-2012

Summary of results for the 2011-2012 season as a Pivot table.

Count of RCM											
uTEC	<0.2	0.2-0.25	0.25-0.3	0.3-0.35	0.35-0.4	0.4-0.45	0.45-0.5	0.65-0.7	0.75-0.8	>0.8	Grand Total
<0.25											
0.25-0.3		1	1	6	4	3	2				17
0.3-0.35		1	7	7	8	6			1		30
0.35-0.4			2	4	1	4	1		2		14
0.4-0.45			1	1	1	1				2	6
0.45-0.5								1	4		5
0.5-0.55									3		3
0.55-0.6									3		3
0.7-0.75						1					1
Grand Total		2	11	18	14	15	3	1	13	2	79

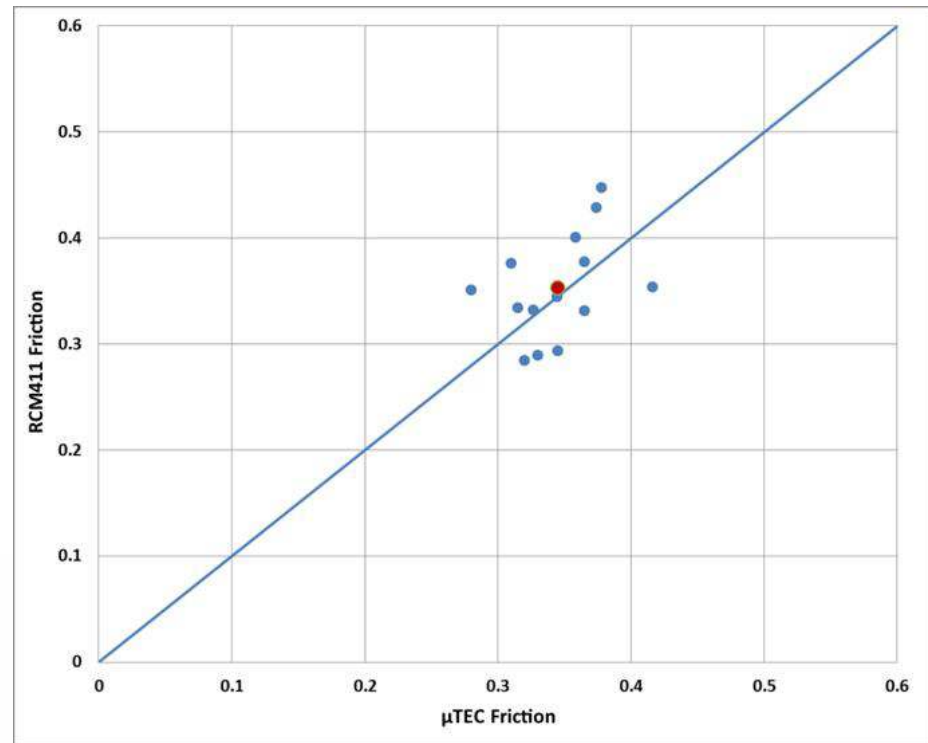
- Out of slippery cases 69.5 % are consistent within ± 0.05 !

4. RESULTS: Winter 2011-2012



All braking measurements.

- Std. Dev. of difference about 0.10



Average of single point measurements.

- Std. Deviation of difference 0.046

4. RESULTS: Winter 2012-2013

Searching for cases of very low (<0.30) and intermediate friction (>0.40).

Date	μ TEC	Test	Deviation	Average
08.01.2013	7	Test route	0.11	0.05
09.01.2013	15	Lahti-Vierumaki-Vaaksy-Lahti	0.11	-0.12
09.01.2013	37	Test route	0.10	-0.04
28.01.2013	5	Helsinki-Tammisaari	0.14	-0.02
29.01.2013	9	Otaniemi-Maantiekyla	0.12	-0.17
28.02.2013	33	Test route and Otaniemi-Salo	0.09	0.00
	106	μ TEC braking altogether		
		Weighted Standard Deviation	0.104	
		Weighted Average		-0.043

5. DISCUSSION

Validity of Braking Friction Meter as a reference

- estimated absolute accuracy on the order of 0.05 (1 s braking)
- effect of quality and type of tires (new studded winter tires)

Continuous Skid Resistance

- Accuracy 0.10 →
 - 6 classes of reduced friction 0.20 – 0.80

5. DISCUSSION ...

Applications

1. Quality control of winter maintenance (procurement, contractor, ...)

2. Training of winter maintenance personnel

3. On-board information to drivers

4. Spreading of de- or anti-icers

- calculate required amount based on measured data
- a small fraction of the amount shown by phase diagram is adequate (look at A. Klein-Paste, J. Wåhlin / Cold Regions Science and Technology 96 (2013), pages 1–7)

5. DISCUSSION

A. Klein-Paste, J. Wählin / Cold Regions Science and Technology 96 (2013) 1-7

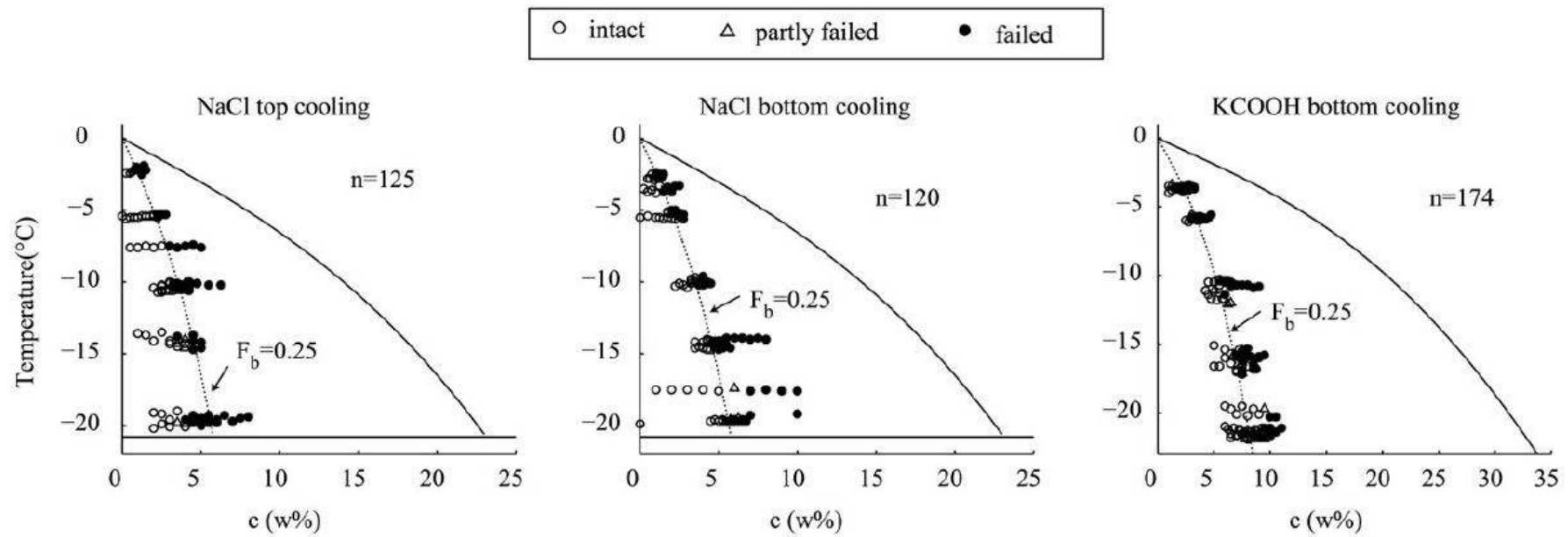


Fig. 4. Results of the mechanical testing for NaCl and KCOOH ice layers, presented in their phase diagrams.

6. CONCLUSION

Modelled continuous skid resistance measurements

- Feasible with an accuracy of 0.10

Potential savings in de- and anti-icing chemicals

- Measure friction
 - get salt concentration
- Look at the weather forecast!
- Calculate minimum required amount of de-icer!

$$0.1 \text{ mm} * 1 \% = 1 \text{ g/ m}^2 \text{ NaCl}$$

THANK YOU!