Continuous Skid Resistance Test

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0. CONTENT

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2. Mobile Friction
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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?

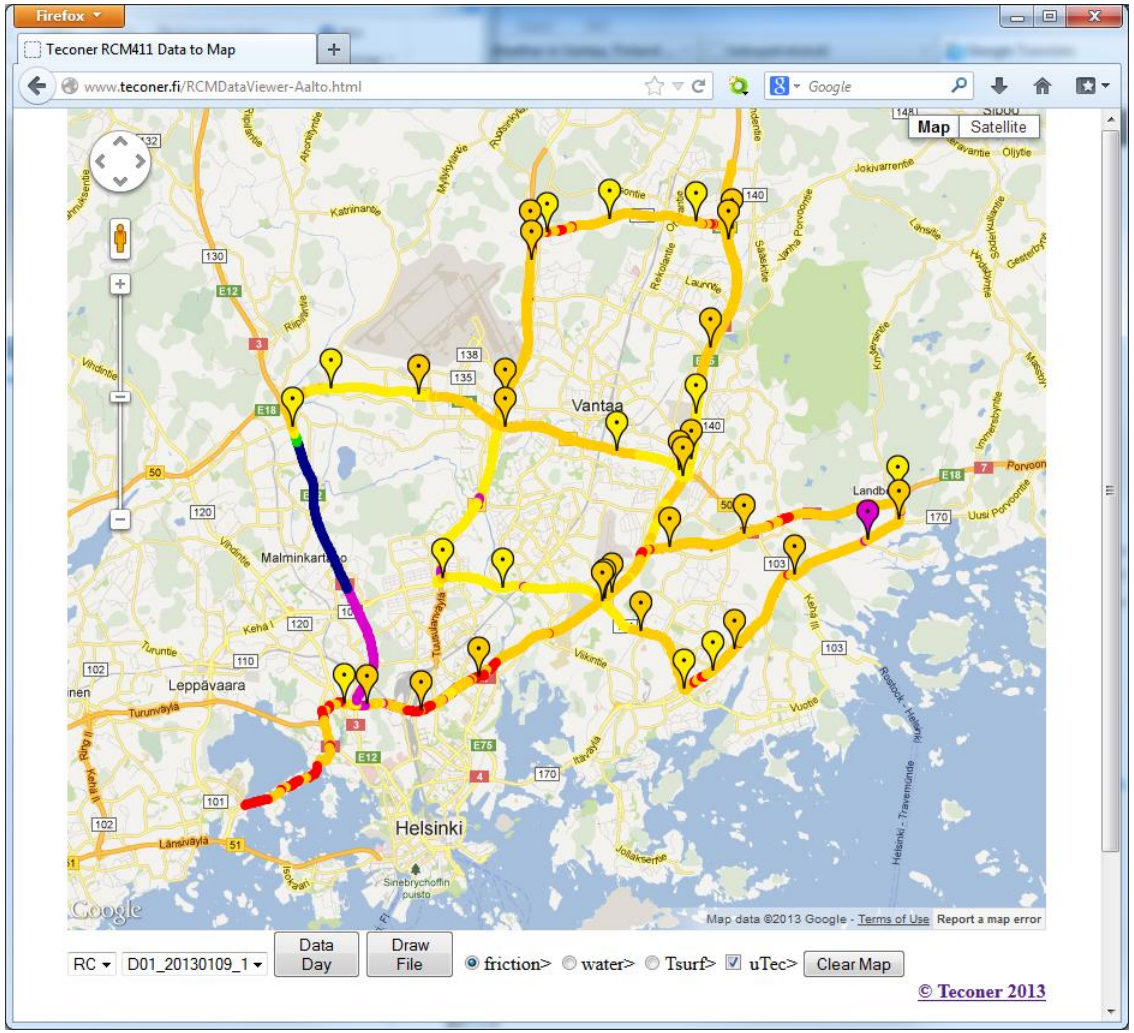
2. MOBILE FRICTION: Road Condition Monitor

- 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** µTEC

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

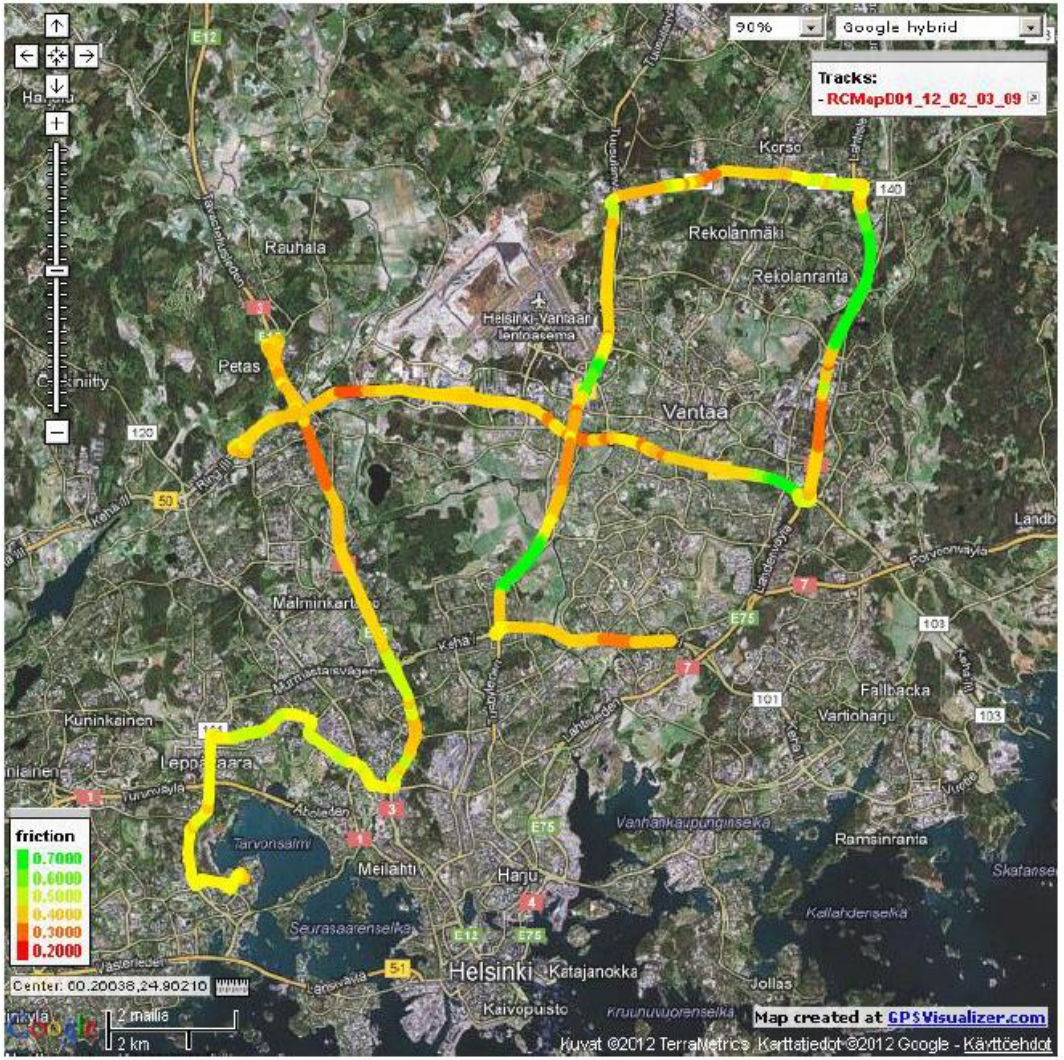
Colour	Friction	Surface state
green	~ 0.80	dry
dark blue	~ 0.75	moist
light blue	~ 0.65	wet
violet	~ 0.50	slushy
white	~ 0.40	snowy
yellow	~ 0.35	icy, thin or breaking
red	< 0.30	icy, thick and hard

- 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 µTEC

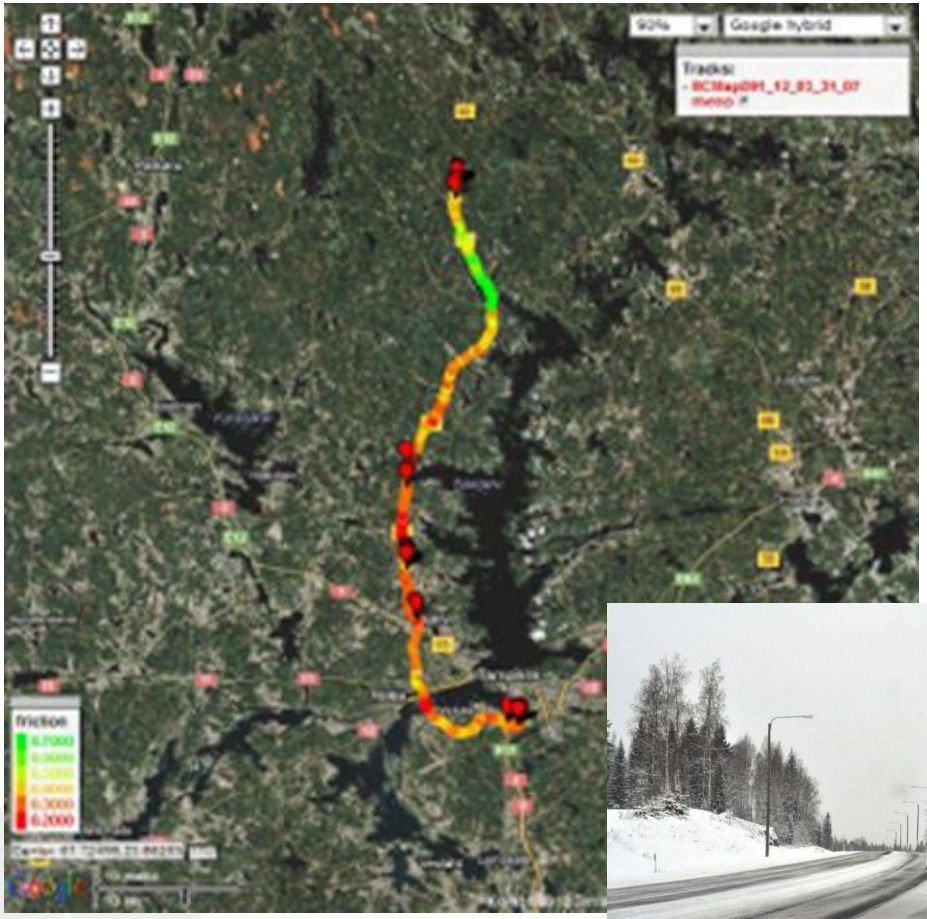
- Cell phone application
  - Same interface with RCM411
- Used as a reference meter
- Absolute friction readings
  - Physical coefficient of friction is measured
- Data communicated together with RCM411 data: real time remote follow up feasible

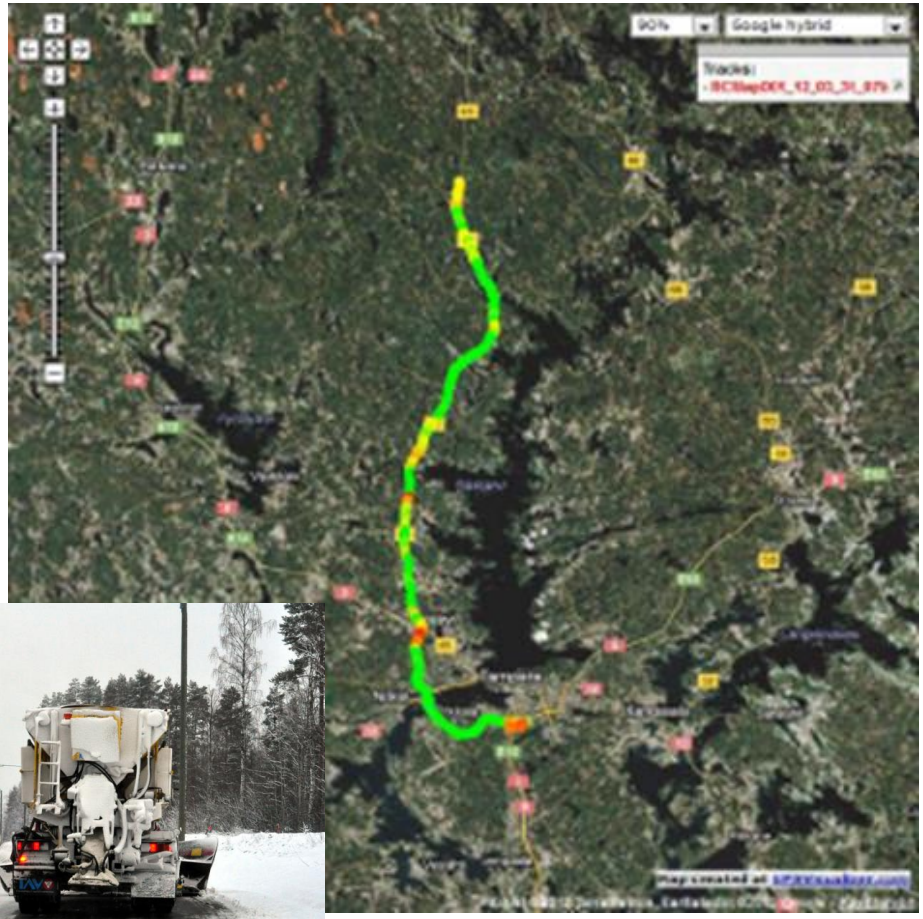
3. TEST DRIVING

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

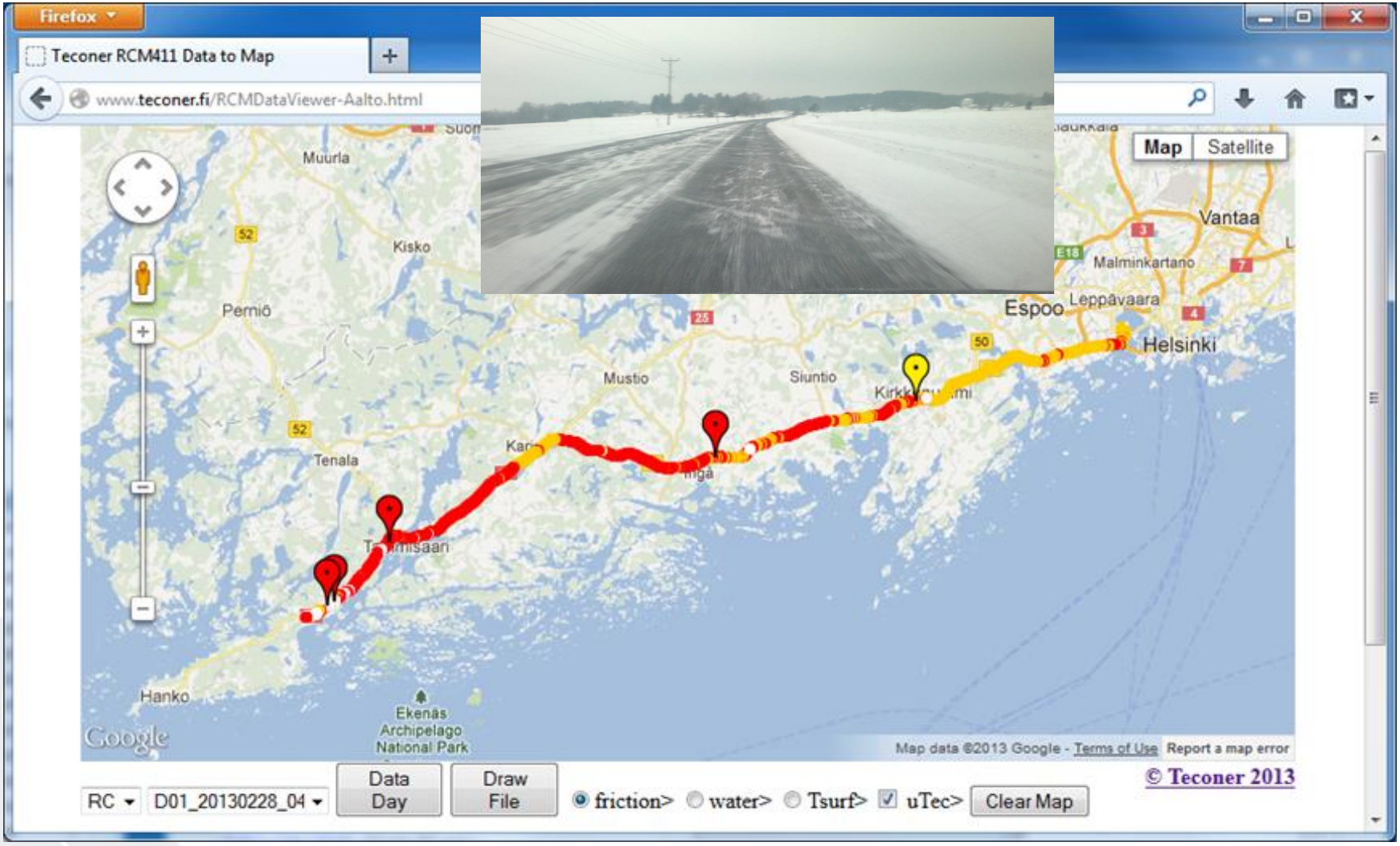
3. TEST DRIVING: example 1





3. TEST DRIVING: example 2

3. TEST DRIVING: example 3



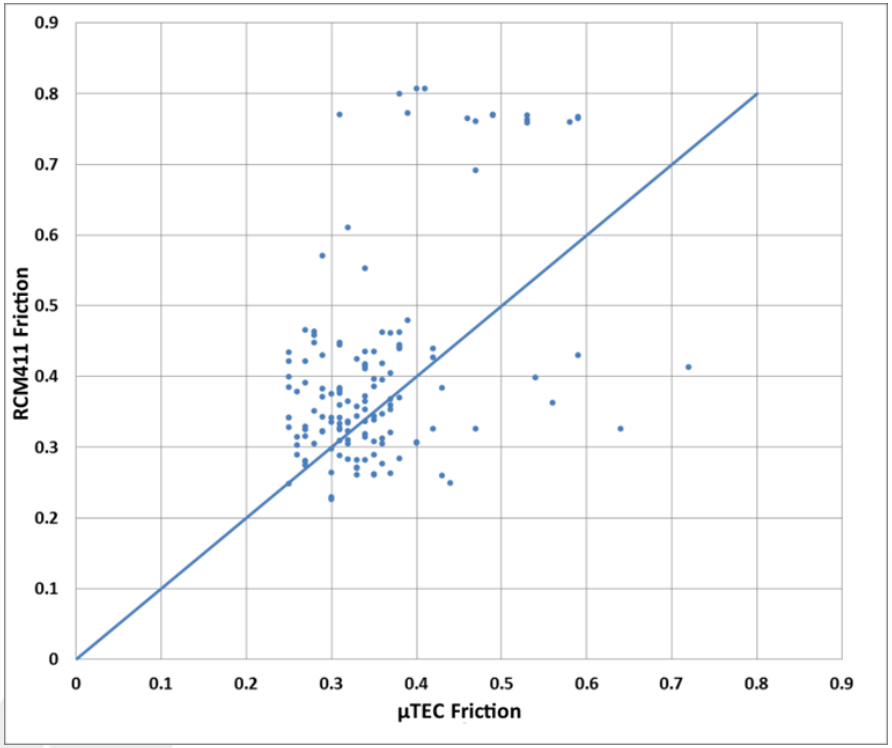
4. RESULTS: Winter 2011-2012

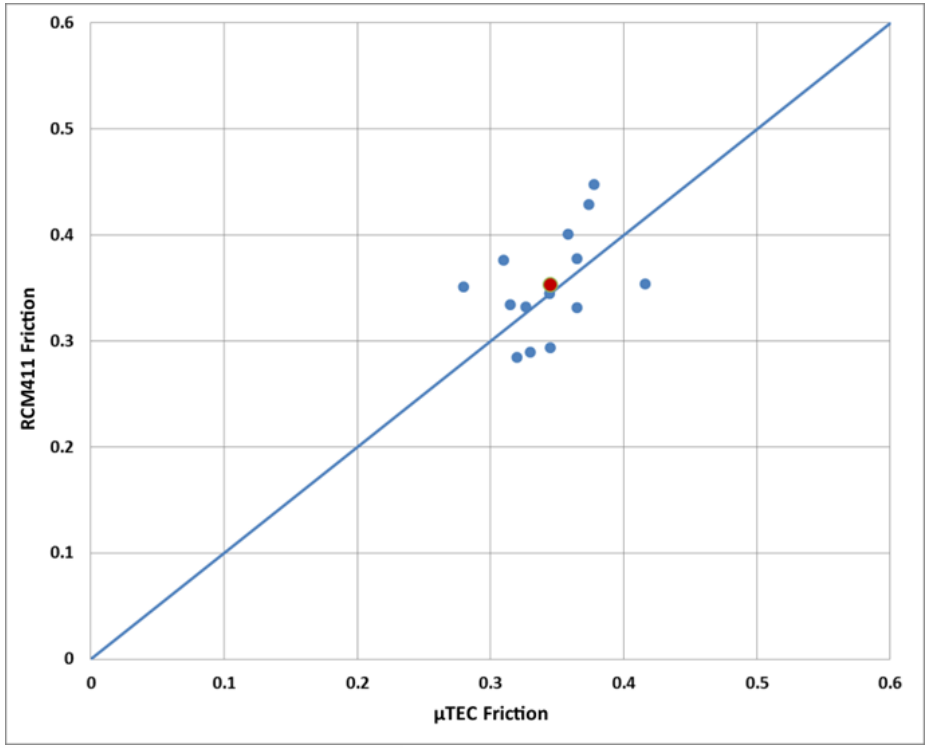
Summary of results for the 2011-2012 season as a Pivot table.

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	µTEC	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	µTEC brakings 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

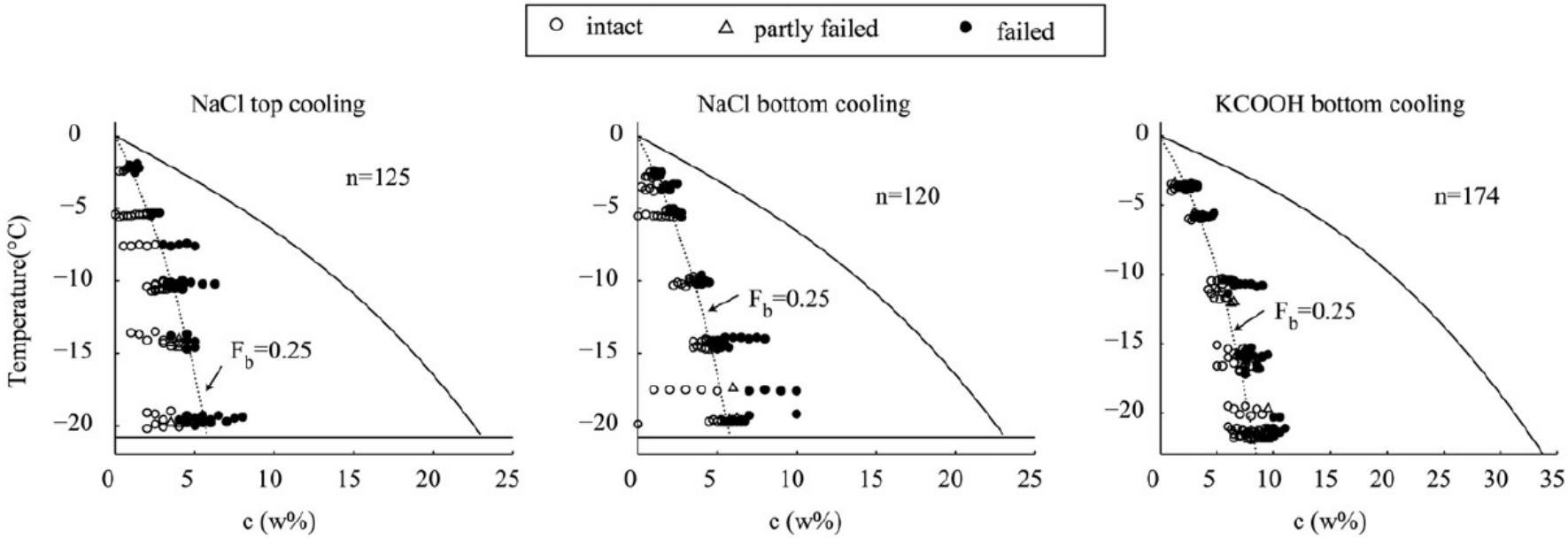


Fig. 4. Results of the mechanical testing for NaCl and KCOOH ice layers, presented in their phase diagrams.

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 mm * 1 % = 1 g/m² NaCl

THANK YOU!