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Laboratory test of road surface condition sensors

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Background - ROSTMOS project



Difficult to validate sensor data in detail in field studies

Tested sensors

Stationary sensors

Vaisala DSC211



Metsense 2Droad



Mobile sensors

Metsense
Metroad Mobile



Lufft MARWIS



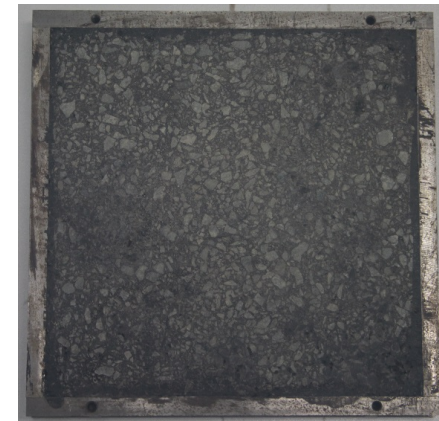
Teconer RCM411



Available data

	Road condition	Friction estimate	Water film thickness	Ice film thickness	Snow water equivalence	Ice fraction
DSC211	X	X	X	X	X	
2Droad	X					
Metroad	X	X				
MARWIS	X	X	X			X
RCM411	X	X	X			

What we did



30 cm

30 cm

Road surface:

- New black asphalt
- Grey old asphalt

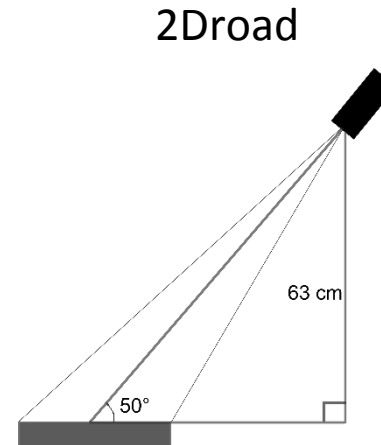
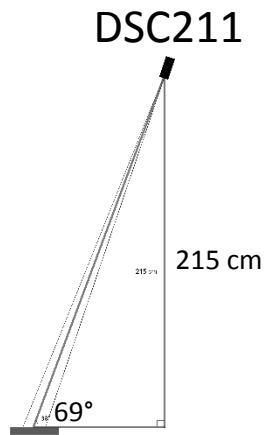
Road conditions:

- Snow, several types
- Ice, different ice layers
- Water, varying film thickness

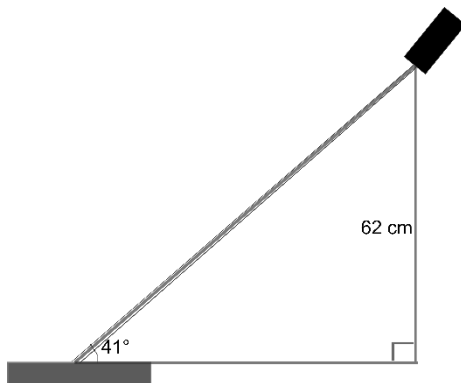
Test conditions:

- Snow and ice: -3°C
- Water: $+10^{\circ}\text{C}$

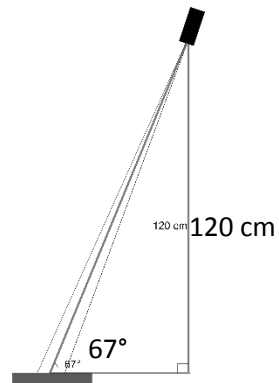
Measurement setup



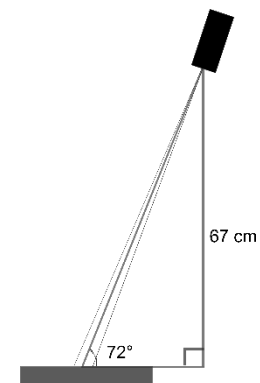
Metroad Mobile



MARWIS

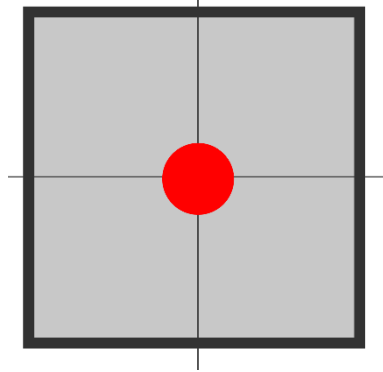


RCM411

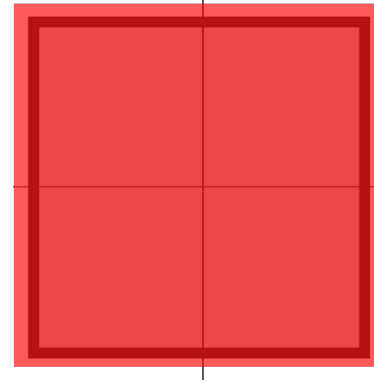


Sensing area

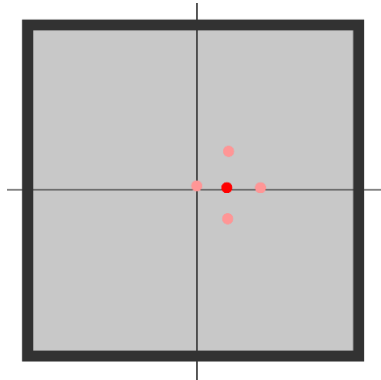
DSC211



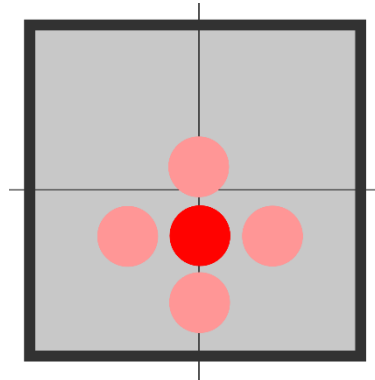
2Droad



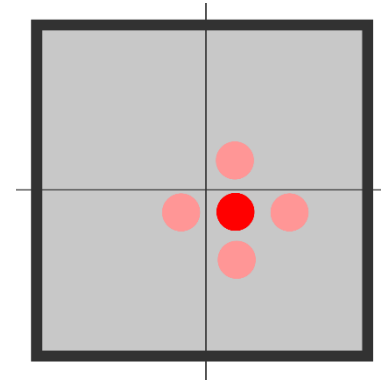
Metroad Mobile



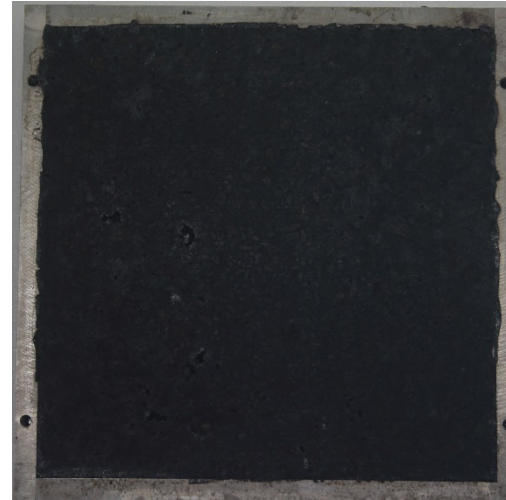
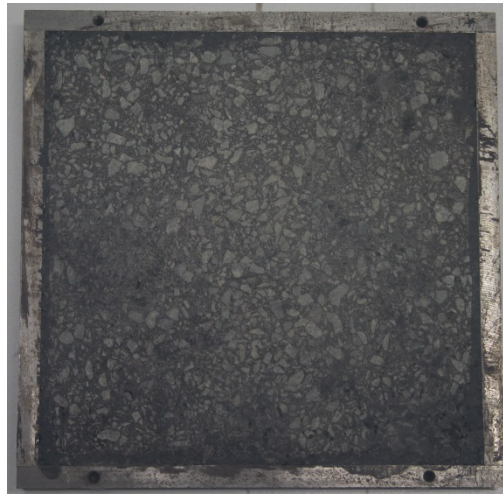
MARWIS



RCM411



Dry road results – road condition



	Gray asphalt	Black asphalt
DSC211	Dry	
2Droad	Dry	
Metroad	Dry	Dry
MARWIS	Dry	Dry
RCM411	Dry	Moist

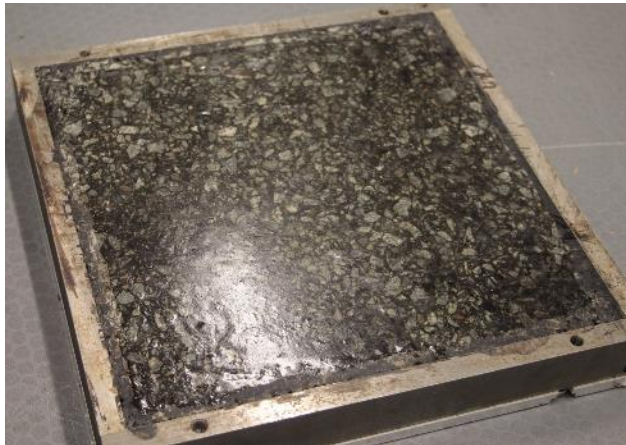
Wet road results – road condition



The surface state under the diagonal line come from the black asphalt plate

	0.5 mm	1 mm	2 mm	3 mm
DSC211	Wet	Wet	Wet	Wet
2Droad	Moist	Wet	Wet	Wet
Metroad	Wet	Frost Moist	Ice Wet	Wet
MARWIS	Wet	Wet	Wet	Wet
RCM411	Wet	Moist	Slush Wet+slush	Wet

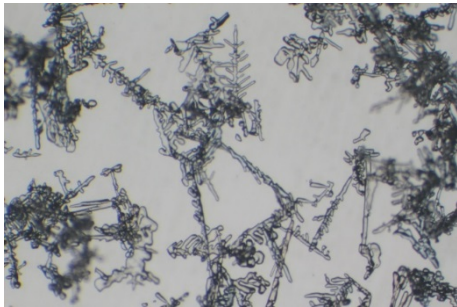
Icy road results – road condition



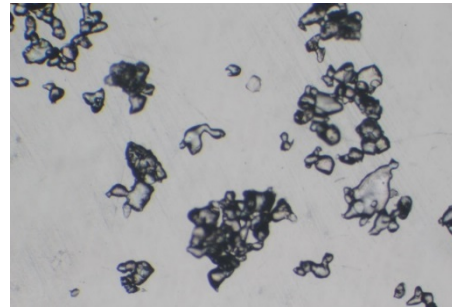
The surface state under the diagonal line come from the black asphalt plate

	0.5 mm	0.85 mm	2.15 mm	3.5 mm
DSC211	Ice	Ice	Ice	Ice
2Droad	Ice	Ice	Ice	Ice
Metroad	Frost	Ice	Ice / Wet	Ice / Wet
MARWIS	Ice	Ice	Wet	Wet
RCM411	Ice	Ice + snow / Ice	Ice / Ice + slush	Ice

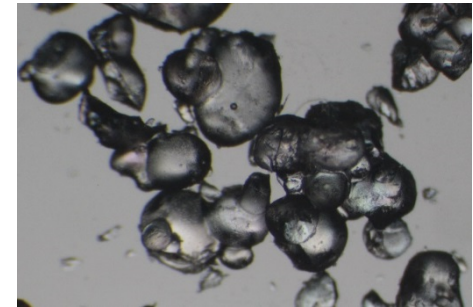
Snowy road results – road condition



Fresh



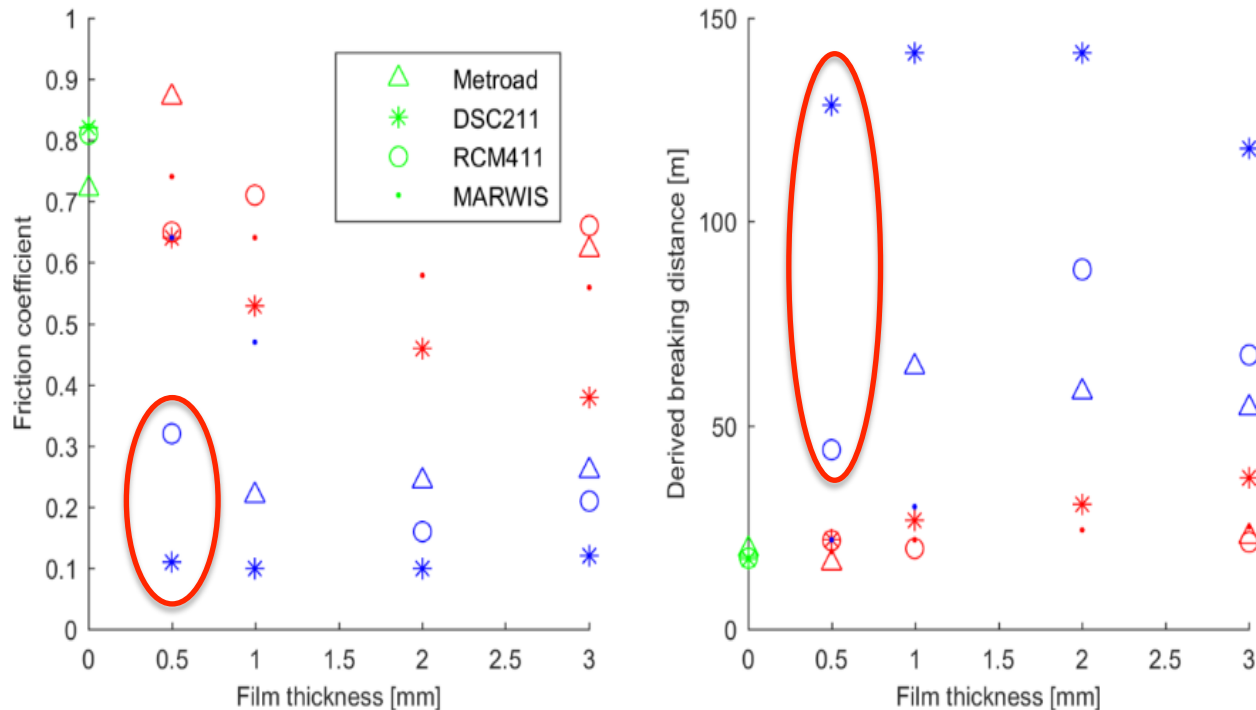
Old



Springsnow

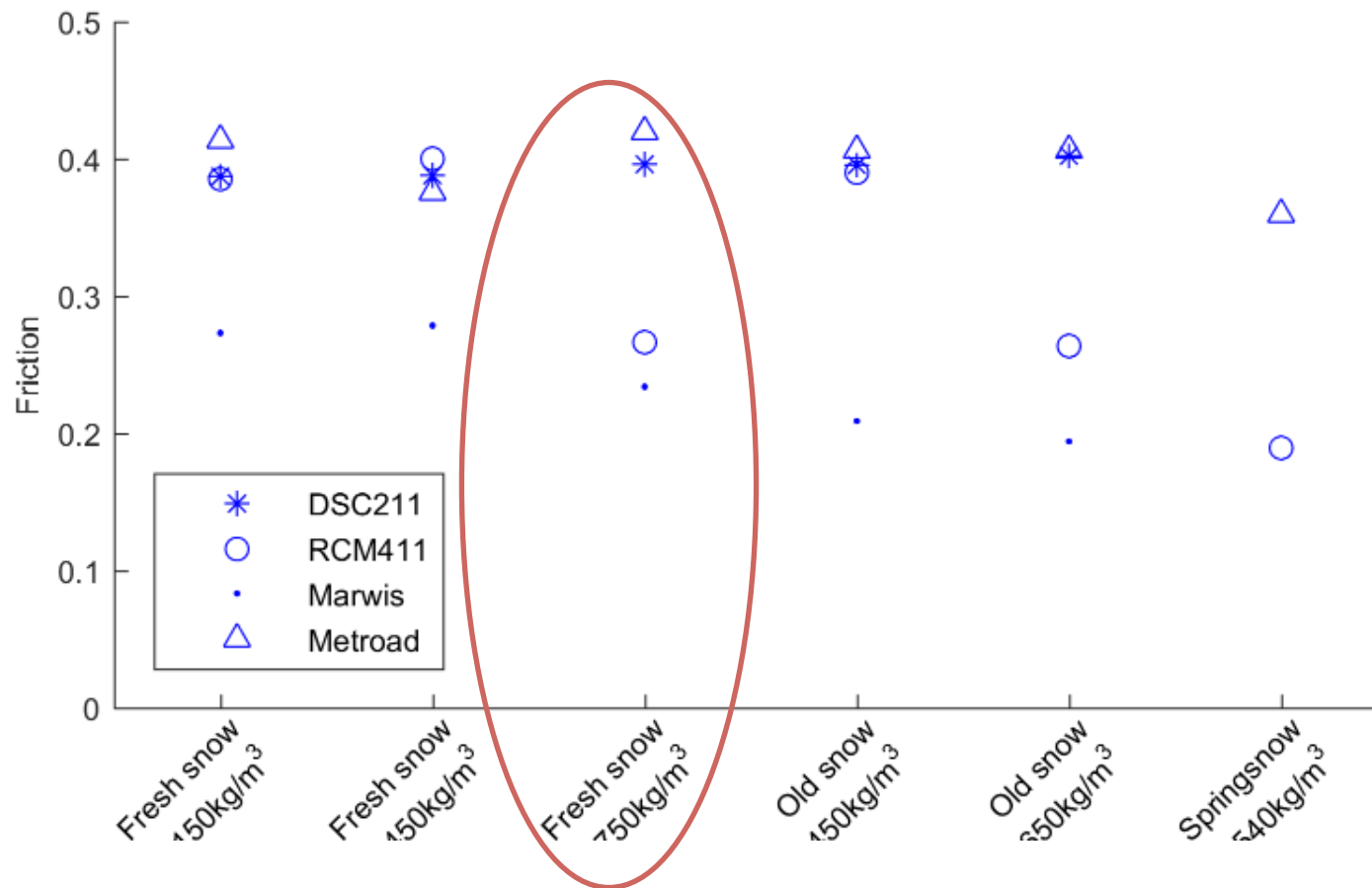
	Fresh Loose	Fresh 450 kg/m ³	Ice Fresh 750 kg/m³	Old loose	Old compact	Springsnow loose
DSC211	Snow	Snow	Snow	Snow	Snow	Ice
2Droad	Snow	Snow	Snow	Snow	Snow	Snow
Metroad	Snow	Snow	Snow	Snow	Snow	Snow
MARWIS	Snow	Snow	Snow	Snow	Snow	Snow + ice
RCM411	Snow	Snow	Snow	Snow	Snow	Snow

Friction – dry, wet and ice



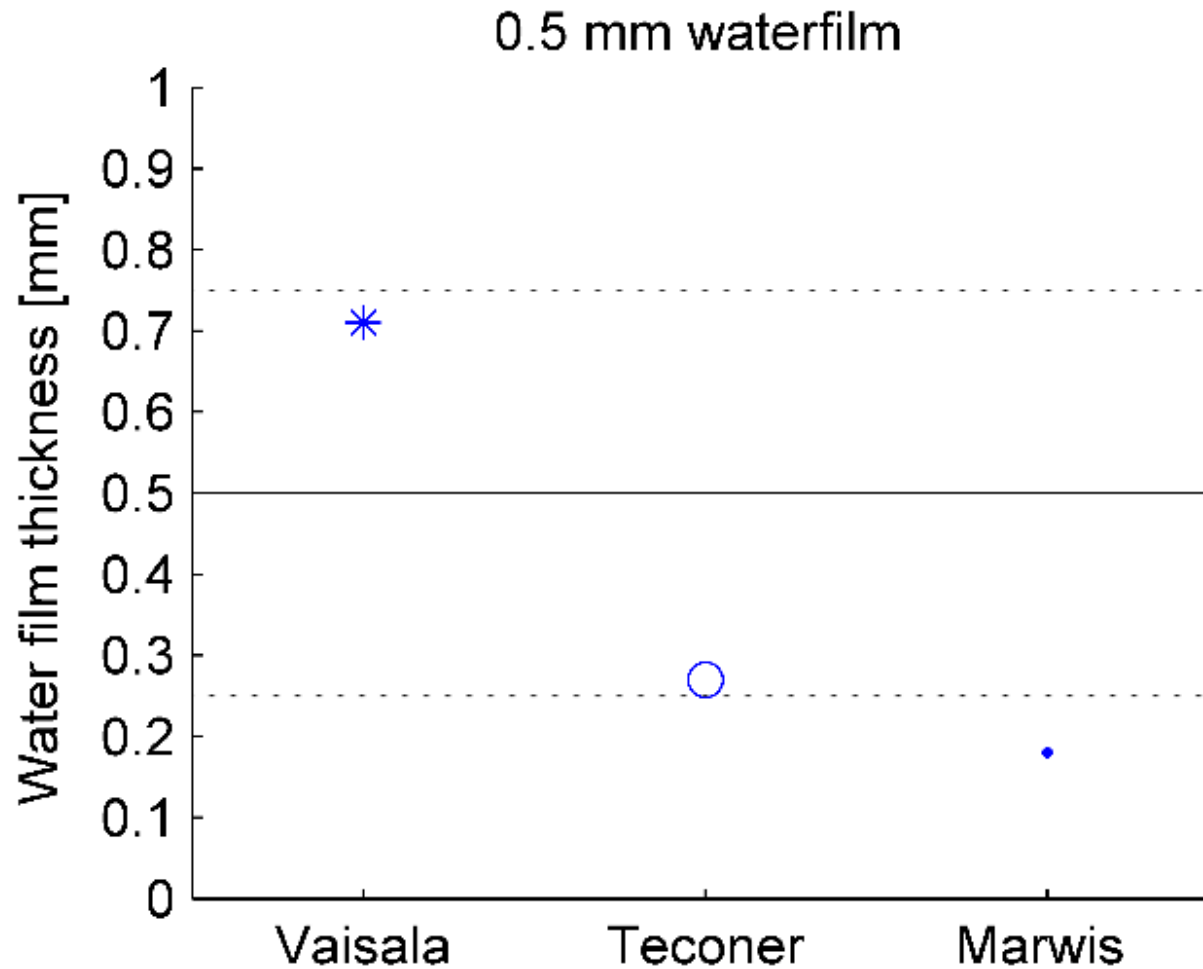
- Green marker – dry
- Red marker – wet
- Blue marker - ice
- Sensors agrees on general pattern
- Friction value spread of ~ 0.2 between sensors
- Derived breaking distance spread
 - Small for dry and water
 - Huge for ice

Snowy road results – friction

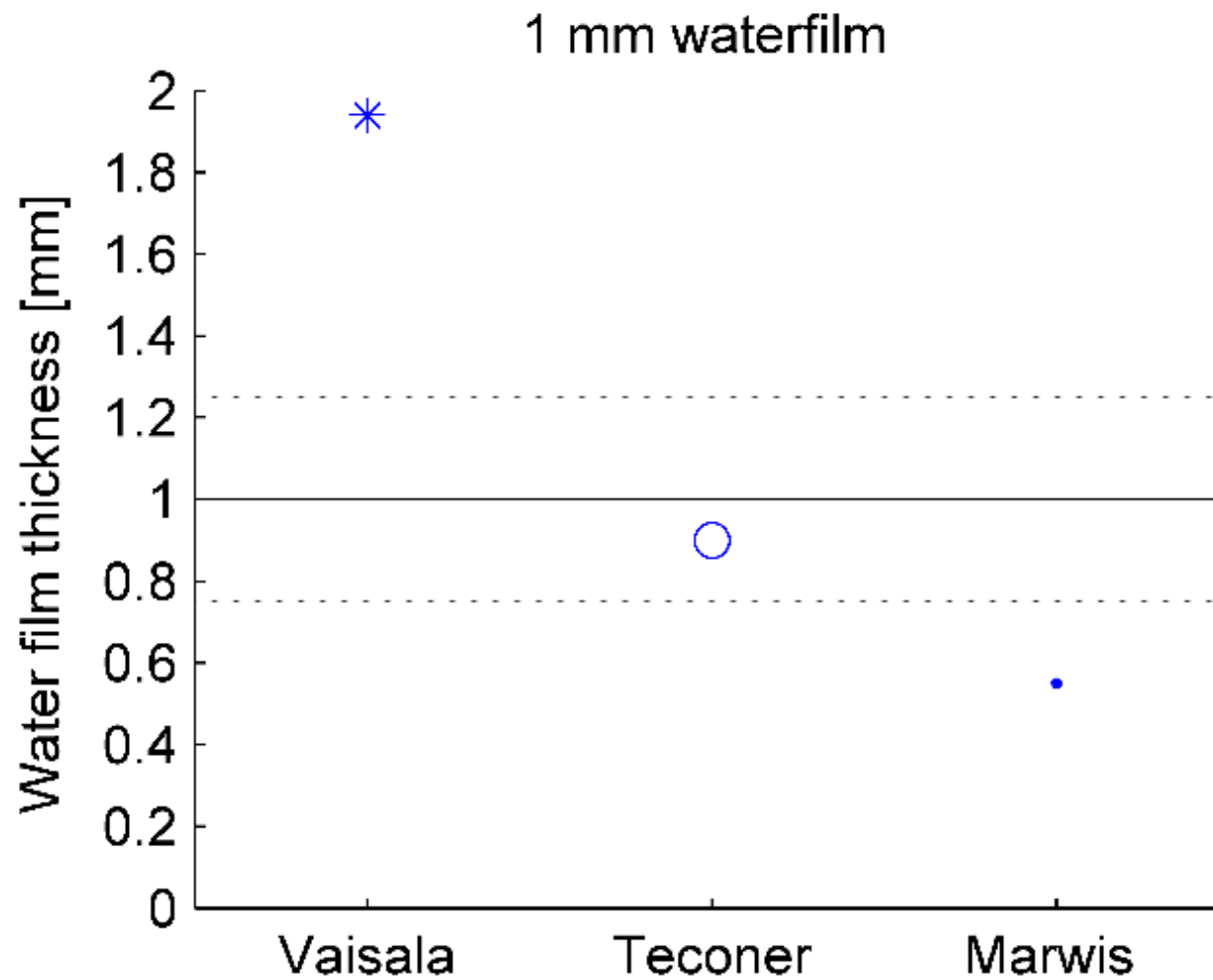


- Friction values relatively insensitive to snow type
- In reality – large difference between loose and compacted snow

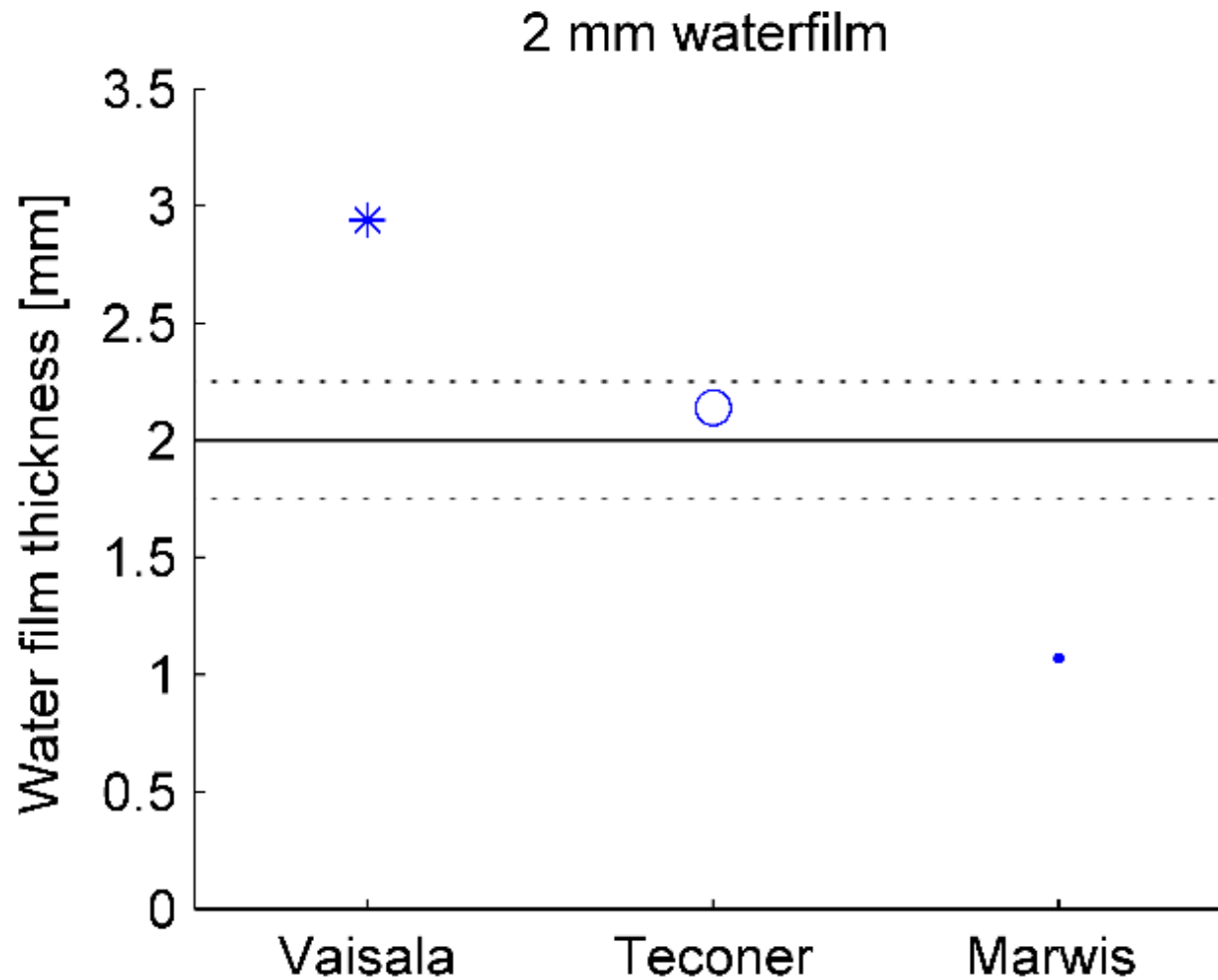
Water film thickness



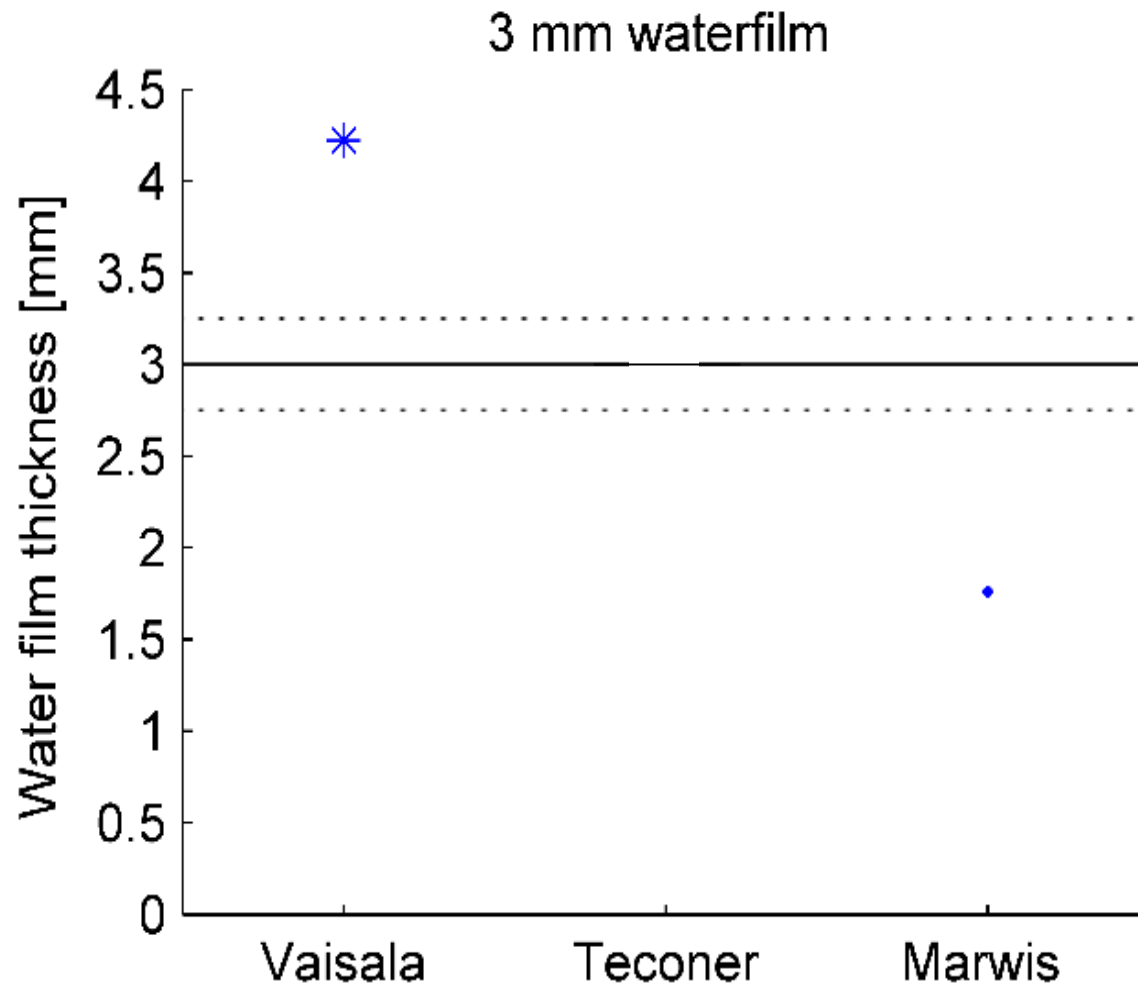
Water film thickness



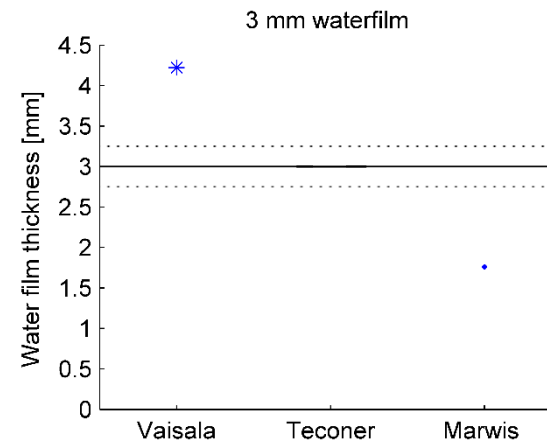
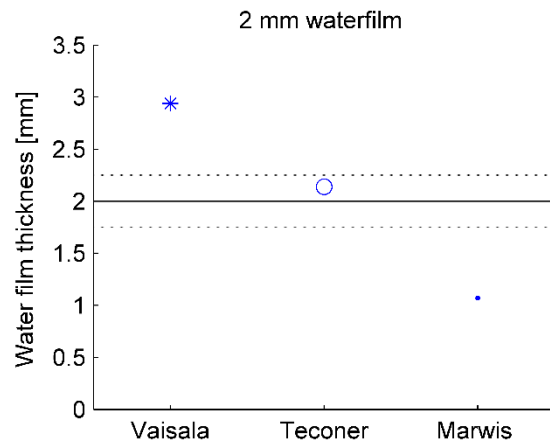
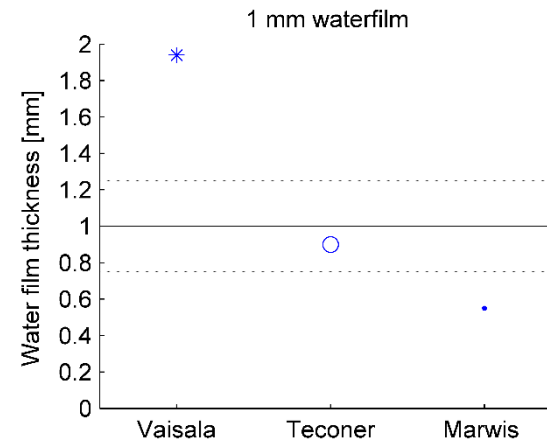
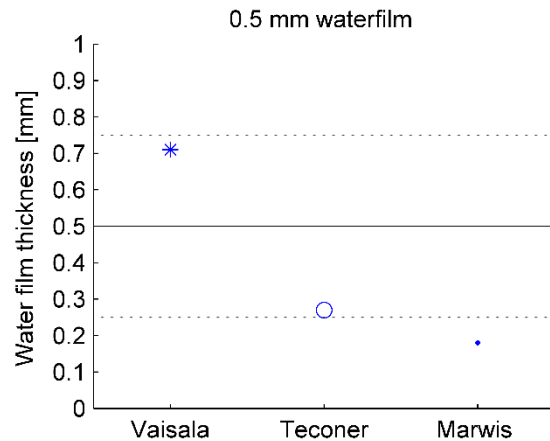
Water film thickness



Water film thickness



Water film thickness



- Sensor film thickness clearly increases with real water film thickness
- Error in range -50% to +100%, accuracy much less than resolution

Water film thickness

- Importance of road type

	1 mm		2 mm		3 mm	
	Gray	Black	Gray	Black	Gray	Black
MARWIS	0.6	0.3	1.1	0.6	1.8	0.9
RCM411	0.9	1.8	2.1	>3	>3	>3

Effect of changing substrate:

- MARWIS – measured film reduced to half
- Teconer – measured film doubled

Conclusions

- Classification generally good
 - Some difficulties to differentiate between ice and water
 - Somewhat sensitive to underlying asphalt type
 - Can not distinguish different snow-types
- Friction shows a spread of ~ 0.2 between sensors
 - Rather good for dry and wet road
 - Problematic for ice, the spread give huge difference in breaking distance
 - Friction insensitive to snow-type

Conclusions

- Waterfilm thickness
 - Good indication of actual film thickness
 - Accuracy much less than resolution
 - Sensitive to asphalt type
- Snow of different types and density – a challenge

Thank you for your attention



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