Which salt measurement gives the best guidance

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Methods of determining safety of the road surface against freezing

- Embedded sensors
  - Active and Passive
  - Measurement of salt from direct contact with surface liquid
- Remote sensing
  - Detection of ice crystals forming in solution
  - Secondary derived products

- The following presentation focusses on embedded sensing to understand better the differences between
- Concentration,
- Freezing point,
- Amount of chemical

Common outputs from embedded road sensors

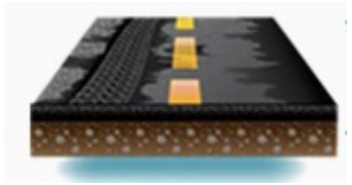
- Direct measurement of salinity is common in all embedded sensors through the use of electrical conductivity
- However the techniques vary
- **Direct measurement of Amount of Salt per unit area: [g/m²] - Vaisala**
- **A combined measurement of the water film thickness and the salinity delivers a report of Salt Concentration: [g/l] – other manufacturers**
  - Both methods can then be used to determine a freezing temperature,
  - However freezing temperature is calculated from the salt concentration, hence is heavily reliant on the water film thickness
  - Likewise the salt percentage is equally reliant on water layer thickness measurements
- Amount of Salt per unit area: [g/m²] is what we understand from chemical application methods from salt spreading controls hence offers some consistency with common understanding

Freezing Point Concentration Amount of Chemical

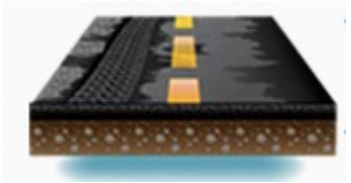
You have no idea if surface can tolerate change of water without freezing.
In both case readings are the same!

You know if surface can tolerate change of water without freezing

Freezing temp. -21Cº, 280g/l
Amount salt **20 g/m2**

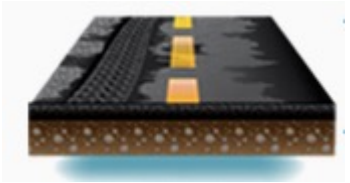


Freezing temp. -21Cº, 280g/l
Amount salt **3 g/m2**

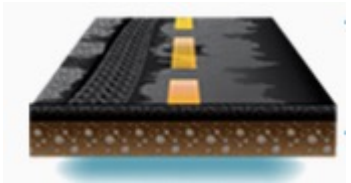


+ small rain event

Freezing temp. -6Cº, 90g/l
Amount salt **20 g/m2**



Freezing temp. -0.5 Cº, 10g/l
Amount salt **3 g/m2**



liquid layer small

⇩

small absolute change of water

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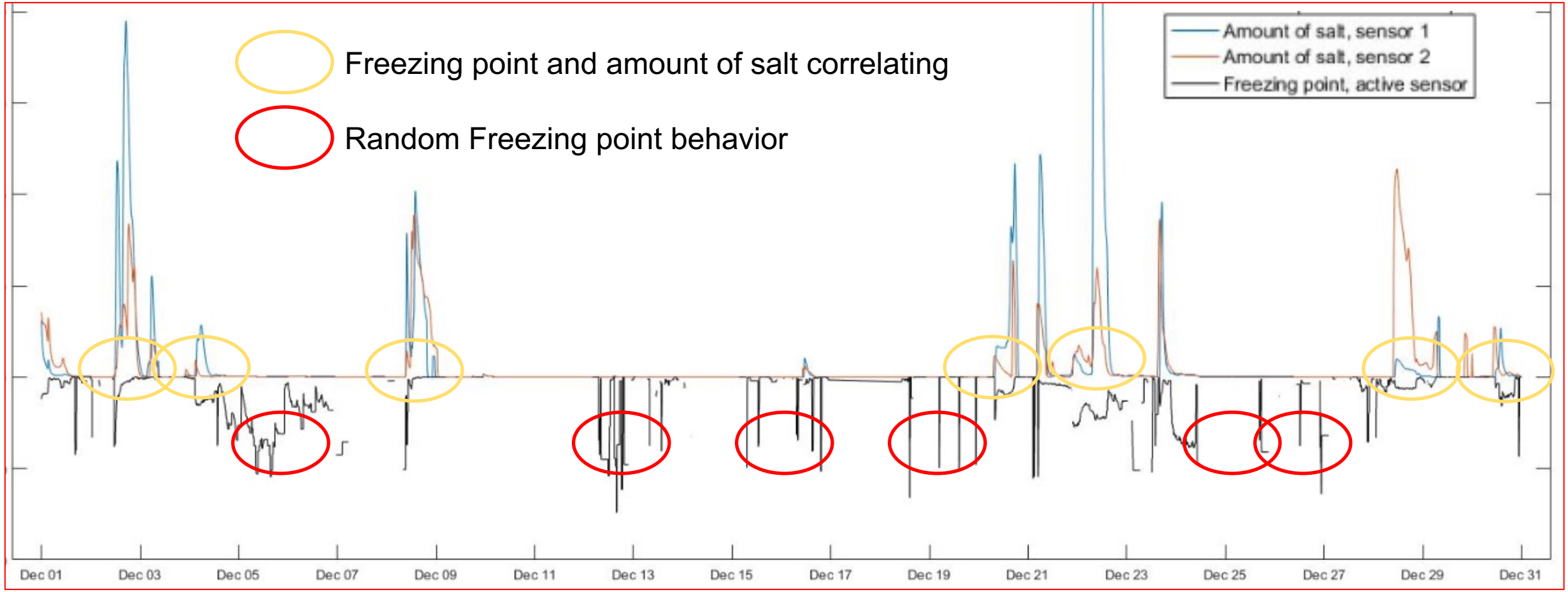
drastic change of freezing temperature

- Concentration or Freezing temperature is not as useful as it appears to be at first glance.
- **Amount of salt** will start to decrease only when wash off is starting hence gives a more reliable and stable indication of safety

Amount of salt from 2 passive sensors versus Freezing Point from an Active sensor

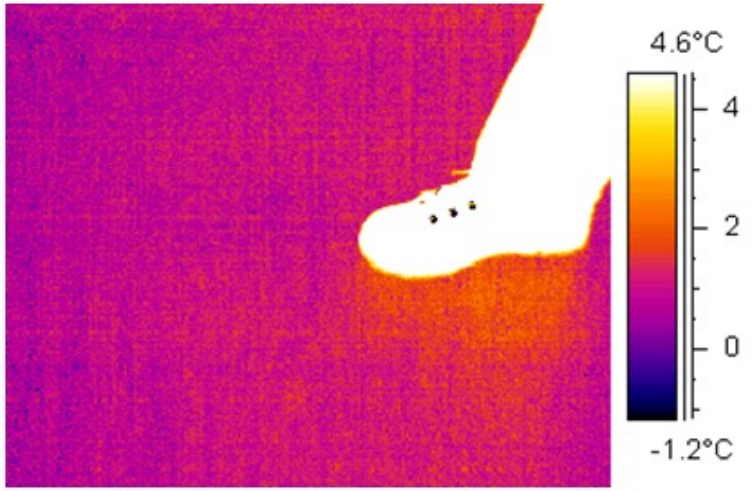


The problem when dealing with thin water layer events

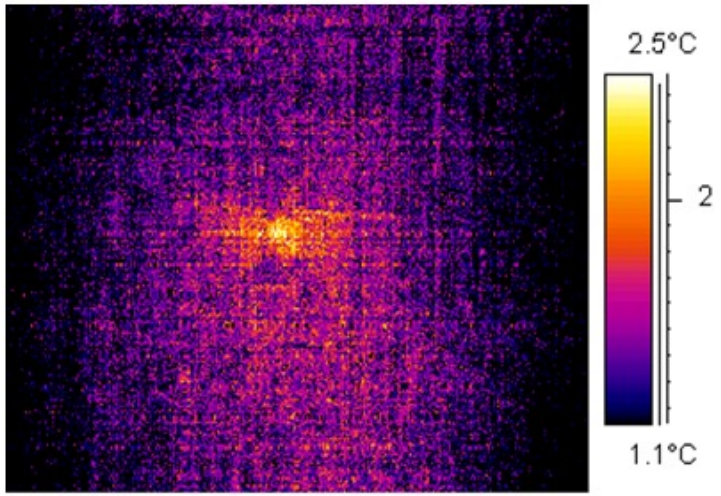
- When there is only a little moisture on the road and some salt, the concentration is very high and the freezing temperatures are low even with small amounts of salt.
- When the road surface dries up, then the concentration goes high and the freezing temperatures would go low and end up to the eutectic temperature (-21.1 C).
- Also water film thickness measurement accuracy is lower at very thin layers yielding to incorrect calculated values. (small deviation yields to dramatic change)

Reasons water film thickness change hence changing freezing point

- Multiple reasons
  - Car passes over sensor and splashes liquid away
  - Evaporation from dry air moving in over site
  - Question: does an active sensor affect the water film thickness through its heating cycle in the sensors local area?



Passive sensors do not interfere with the measurement area



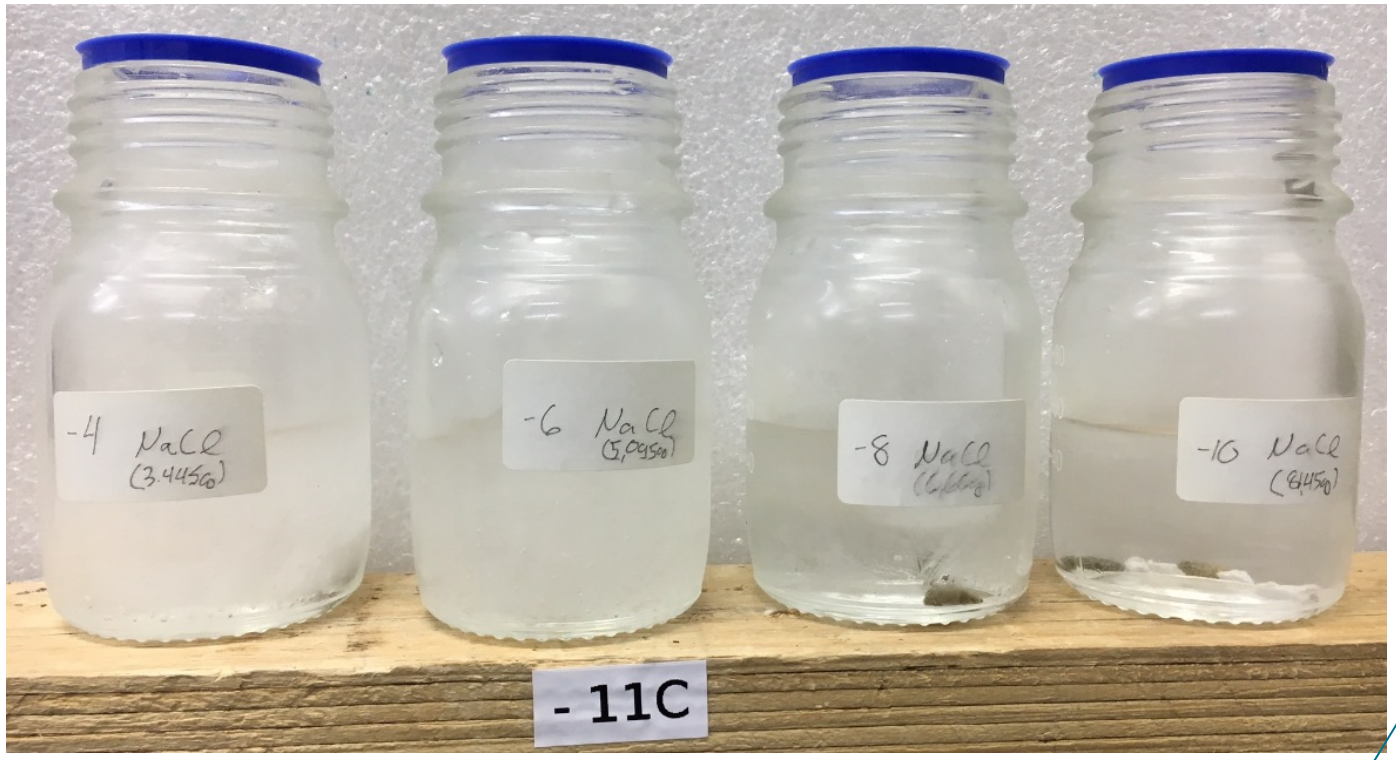
Active sensors have to discharge heat from the freezing cycle

Another problem with freezing point

- What does freezing point actually mean in practice?
  - Ice crystals start to form?
  - There is enough ice so that the road may get slippery?
  - Solution has frozen completely
- Freezing is actually a complicated and time consuming process
- Next example shows how the NaCl solution with different freezing points looks after 12 hours in -11 ºC climate chamber

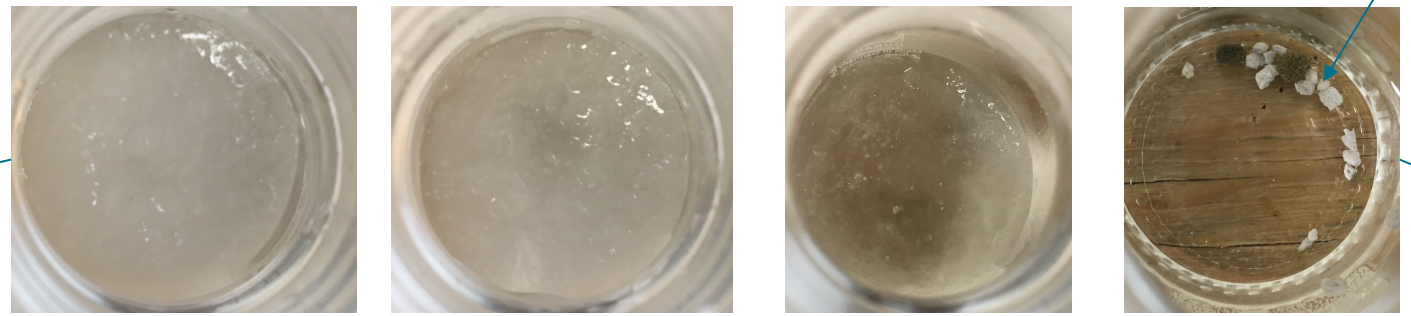
Chamber temperature: **-11 ºC**

Solution in chamber more than 12 hours. Boiling stones added to avoid super cooling. NOTE: freezing is slow process and images would look different at different times



boiling stones, not ice crystals!

Even solution freezing point 7 ºC higher than air temperature the solution remains in slushy condition



-4 ºC Tf -6 ºC Tf -8 ºC Tf -10 ºC Tf

Solution freezing point 1 ºC higher than air temperature the solution remains completely in liquid form. No crystals visible even with microscope

Summary

- We all spread salt in g/m^2 and is extremely helpful to know the residual amount of salt at a given time with same parameter g/m^2
- g/m^2 DOES NOT change when absolute change of water takes place (as others rapidly do) until wash-off starts
- At any given time viewing only the freezing point, concentration or salt % you are not able to know how the road surface will tolerate a change of water!
- g/m^2 indicates clearly how much residual salt you have on the road and you are able to gauge how much the road surface can tolerate a change of water layer
- Direct measurement of g/m^2 will give a clearer understanding of the extent of salt wash off during a rain event

Thank You for your time!