

Relevance of measuring the humidity immediately above the road.

Henrik Baad, Danish Road Directorate. ba@vd.dk
Søren Brodersen, Danish Met. Institute. sb@dmi.dk

Abstract.

Hoar frost formation is depending on the amount of water vapour in the air and the road surface temperature. But does it matter where and how high above the road the humidity is measured ?

Road climate within a few centimetres above the road is, depending on the weather situation, different from the climate above. In clear cold weather, a strong temperature inversion is created near the road. The road temperature drops significantly and the air immediately above the road cools. The cooling of the air means hoar frost formation on the road, but it also means that the amount of humidity in the air is lower in terms of the dew point value. Therefore the vertical dew point gradient will be positive and some difference between the dew point in 10cm and the dew point in 2m or higher should be expected. The Danish Road Directorate and Copenhagen city has performed measurements to prove the relevance of measuring dew point temperature 10cm above the road. The results indicate that these measurements should be taken into account when considering possibility of hoar frost formation in certain weather situations. The results are presented and the related weather situations described.

Introduction.

IRW roadstation “Vigerslevvej” in a residential area in the Copenhagen suburb “Valby” was established in 2001. From the beginning the station showed a tendency to be colder than the surroundings and often also indicating hoar frost formation as the surface temperature fell below the dewpoint. Inspection revealed in some cases that no hoar frost was forming despite these measurements, especially in clear, cold and calm conditions. Some years before this, a surface humidity installation was tested in vicinity of Odense at another IRW-station. Results from this experiment led us to install humidity/temperature measurement in about 10cm at the station Vigerslevvej. The purpose was to find out, if any systematic difference in dewpoint between surface and 250cm led to misinterpretations of the road condition.



The station surroundings are suburban, with a park to the southwest and a few 1-3 story buildings or residential houses near by. (Google)

The installation.

The 10cm “hut” is mounted at a horizontal surface between cycling path and pedestrians walk. The underlay is asphalt.

The master IRW-station has a standard RH/LT sensor (HMP45) which calculates dewpoint. The sensor is mounted 250cm above ground. It is equipped with precipitation type classification. There are 2 roadsensors, both indicating surface-temp. and temp. at -7cm below ground.

The sensors indicate if rime/ice is forming. This is expressed as “surface condition” and the depth of rime formation is expressed as water amount, as the sensors have build-in optical fibers to calculate standing water amount.

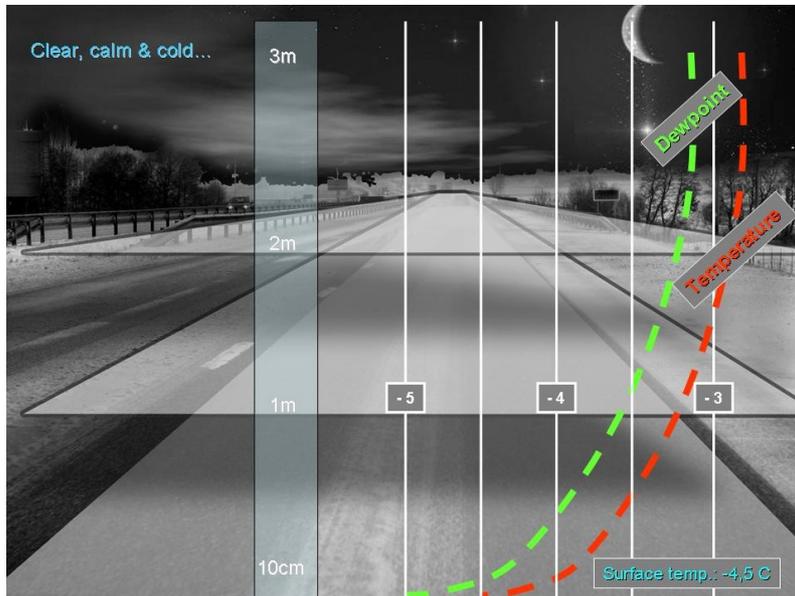


Furthermore the station is constructed with a ”hut” to measure dewpoint at 10cm. The “hut” or “radiation screen” is protecting the installation against snowmoving equipment etc. The HMP45 is installed in a 200x75mm plast tube, open in top/bottom to protect it from dirt and other particles. It holds a secondary printcard/slave, where all other sensors are duplicated from the master, except RH and air temp. This allows us to verify road condition as measured, to the anticipated frost formation intensity as expected, according to dewpoint in respectively 10cm and in 250cm.

Verification of the dewpoint sensors.

When installing the station in 2006 the measurements were controlled and each autumn the sensors are calibrated to a maximum deviation of 0,2 deg. C (+/- 0,1 deg. C) in relation to reference measurements.

Weather near the road surface.



In clear, calm and cold weather with strong radiation the surface layer is cold and the dewpoint near the surface lower than the dewpoint at 2-3m.

Comparing the dewpoint in 2-3m to the road temperature will mean a “false alarm”, because the moisture in the near-road layer is drained and the frost formation has stopped.

The hoar frost formation in clear, cold and calm weather is dependent on the mixing of humidity. Radiation brings the near-surface temperature to a fall and the air immediately above the road cools. Some frost formation takes place, but as the air near the surface is drained of moisture, the dewpoint falls and the frost formation stops. Comparing the dewpoint in 2-3m or higher, will in these situations lead to a false estimate of the frost formation intensity and duration.

Of course – and this is important – new mixing caused by wind or traffic will lead to frost formation instantly, as the more humid air in higher levels is brought in contact with the road surface.

Data:

We investigated all data from “Vigerslevvej” during a 2-year period, searching for situations satisfying these criteria:

- Road temp. below 0 deg. C
- Dewpoint 250cm higher than road temp.
- Dewpoint 10cm lower than road temp.

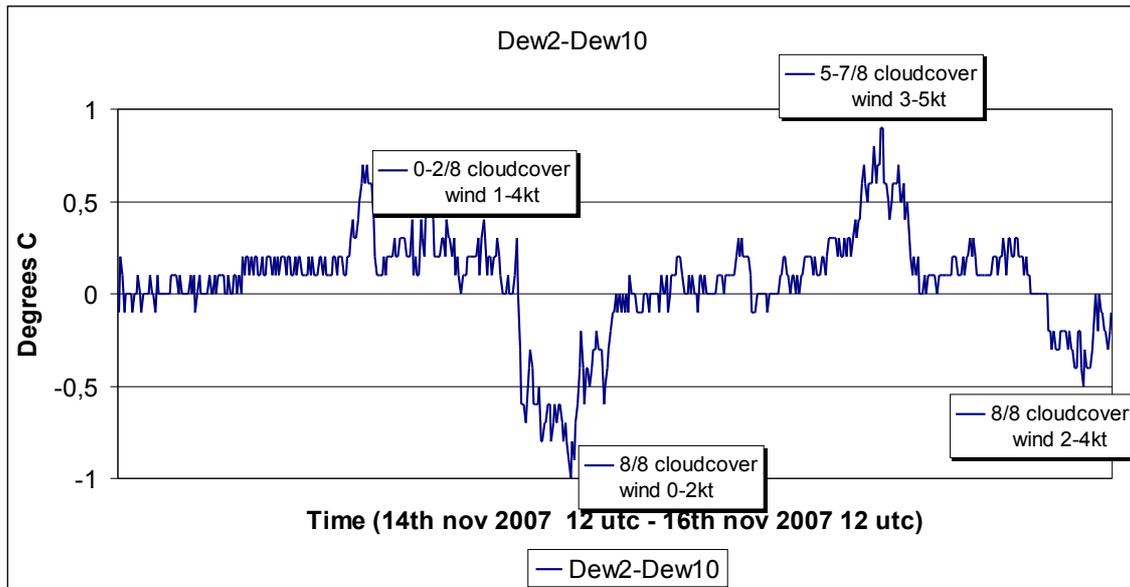
We found 14 cases where these conditions lasted for at least 2 hours, some up to around 12 hours.

We validated in all the cases the weather type with data from a synoptic station around 6km from “Vigerslevvej” : 06180 DMI.

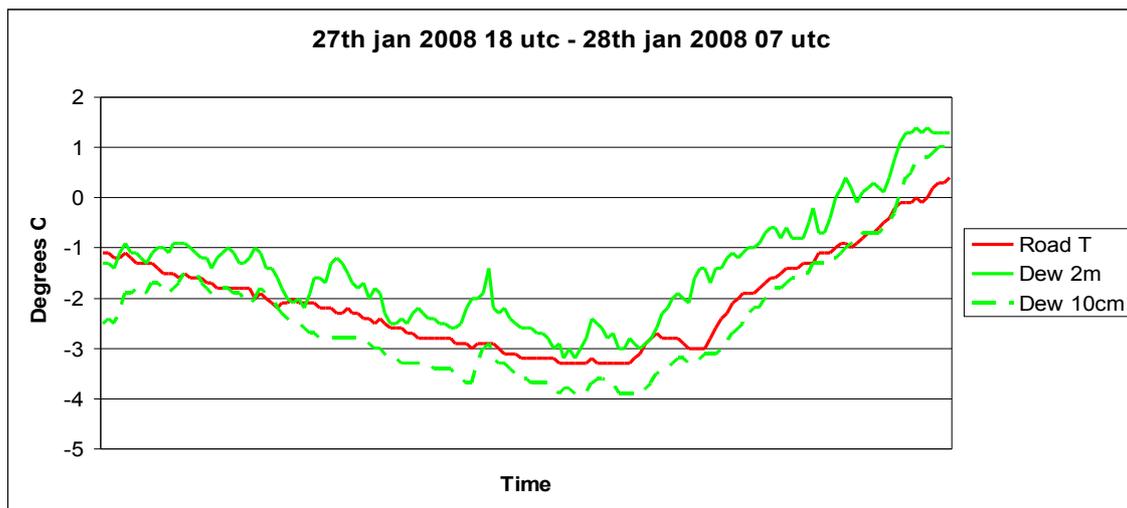
All situations fell in the category:

- Cloudcover 0-4/8 (0-50%)
- Windspeed 0-3 m/s.

The difference between dewpoint 10cm and dewpoint 250cm is generally between 0,1 and up to - in a few cases - a little less than 2 deg. C. The figure below illustrates the difference during 48 hours in a random weather situation with varying weather types.



We have chosen an example of one of the 14 cases (they would all look more or less alike) :



The road temperature is lower than the 250cm dewpoint, but higher than the 10cm dewpoint. Frost formation would be expected if you use the 250cm value – but not if you use the 10cm value.

Road condition measurement.

The station uses capacity and optic fibers activity to estimate ice, water and hoar frost formation.

We would have liked to illustrate the link between using 10cm dewpoint and onset of frost formation using the road condition device. We were looking for situations where the condition goes from “dry” to “moist” or “ice”, but in all the cases (except one doubtful) the sensor is moist or wet due to salt.

Concluding remarks.

Comparing dewpoint measurements in 10cm and 250cm reveals differences of up to around 2 deg. C. These differences are most common in clear calm conditions. In a cloudy, windy weather regime the differences are close to negligible.

The 10cm dewpoint is typically lower than 250cm, which leads to hoar frost formation at a later time than indicated by the 250cm dewpoint.

Measuring the dewpoint in vicinity of the surface will - in clear, calm and cold night-time weather - lead to a better result with regards to the onset and intensity of frost formation, provided that the equipment is not influenced by distracting factors such as for instance a snow cover.

Copenhagen 13 December 2009

Acknowledgements:

Thanks to Pernille Arnsfelt Hansen DMI for shuffling data and graphics