ROad State Monitoring System
ROSTMOST

Forecasting of road condition in winter time
State of the art

Author: Claus Petersen, Danish Meteorological Institute
CONTENTS

Contents........................................................................................................................................2
1. Summary ........................................................................................................................................3
2. Introduction ......................................................................................................................................3
3. State of the art .................................................................................................................................4
    3.1 Winter road conditions forecast ..............................................................................................4
4. Road Condition forecast ..................................................................................................................4
    4.1 Overview ..................................................................................................................................4
    4.2 Design of road condition models .............................................................................................5
5. Road weather information systems (RWIS) .................................................................................8
6. Forecast systems ............................................................................................................................8
    6.1 Climate forecast ......................................................................................................................8
    6.2 Numerical weather prediction models .....................................................................................8
    6.3 Nowcasting model ....................................................................................................................9
    6.4 NWP model using a road energy balance model ...................................................................9
    6.5 Route based forecasts .............................................................................................................9
7. Forecasted Parameters ..................................................................................................................13
    7.1 Site specific parameters ..........................................................................................................13
        7.1.1 Road surface temperature ...............................................................................................13
        7.1.2 Road subsurface temperature .........................................................................................13
        7.1.3 2 meter temperature ........................................................................................................13
        7.1.4 2 meter dew point temperature ........................................................................................13
        7.1.5 2 meter relative humidity ...............................................................................................13
        7.1.6 10 meter wind speed and direction ..................................................................................14
        7.1.7 Cloud cover .....................................................................................................................14
        7.1.8 Height of cloud base .........................................................................................................14
        7.1.9 Precipitation intensity and type .......................................................................................14
        7.1.10 Water and ice on the road ..............................................................................................14
        7.1.11 Visibility .......................................................................................................................14
        7.1.12 Skid resistance ..............................................................................................................14
        7.1.13 Alarm status .................................................................................................................15
    7.2 Overview parameters ...............................................................................................................15
        7.2.1 Precipitation intensity and precipitation type .................................................................15
        7.2.2 Nowcast of precipitation intensity ....................................................................................15
        7.2.3 Cloud cover ....................................................................................................................15
8. Forecast providers and internet resources .....................................................................................15
    8.1 Questionnaire ..........................................................................................................................15
    8.2 Results of questionnaire and internet research .......................................................................16
9. Outlook ..........................................................................................................................................19
10. References .....................................................................................................................................19
Appendix A ........................................................................................................................................21
1. **Summary**

This document has been made in the framework of Road STate Monitoring System project (ROSTMOS). The intention has been to describe the state of the art of forecasting of road condition in winter time. The market for forecasting road conditions is not as regulated as it is for equipment. There is no standard and most applications are ‘spin off’ from ordinary weather prediction system. This is most likely a consequence of that equipment is manufactured by private companies whereas forecasting traditionally has been a national duty. During the last years there has become consensus off what the basic requirements are for a forecasting system for winter road conditions. The European Union require competition and therefore it is now more necessary to work out detailed description of what is required of the system and what is expected from the delivers of forecast systems. This process has made the market for meteorological related forecasts more uniform. Still there are only two larger private companies on the Scandinavian market for winter road forecasts: FORECA and Meteogroup. The rest is smaller national companies or hardware suppliers of meteorological equipment who also can deliver simple forecast. In many European countries it is still the national weather service which is the main provider of meteorological forecasts. Most examples provide in this document have been taken from Danish Meteorological Institute as there exist only little public available material available for free use. It is not the intention to measure and compare the quality of the different forecast system mentioned in this document.

2. **Introduction**

There are many good reasons to know the present and future state of the road conditions. The public can be warned through mass media about the road conditions and reduce the driving speed or at least be aware of the danger. The relevant authorities can do preventive actions to keep the road safe and passable. In this picture there are several aspects to take into account. In mountainous areas roads may be closed in winter times or only be passable with special vehicles. In areas with low temperature and large snowfall in the winter months the roads may only be partial passable and chemical treatment of the roads may not be an option. However the weather forecasts are important for warnings of special dangerous situations in winter time such as snow storms and warning about snow drift. In dense populated areas the requirements to winter maintenance of the roads are higher. Time lost in slow moving traffic is costly and the cost of traffic accidents can be high both in life and injuries as well as the material damages. Further-more one single accident may block the traffic for several hours. Even though there are many good reasons to avoid slippery roads the level of winter road maintenance has to be measured in terms of a cost benefit analysis and also weight the social consequences in terms of reduction of accidents and the environmental pollution from chemical treatment of the roads. A part of the puzzle is also the cost of monitoring and forecasting of the road conditions and whether this is a good investment. This document will not consider the socio-economic aspects but only which methods are used for monitoring and forecasting of road conditions and how these can be used by the road
authorities. The main weight will be on the Nordic countries (Denmark, Norway, Finland, Iceland and Sweden) but most methods are applicable world-wide. This report tries to describe the state of the art of forecasting road conditions and Road Weather Information Systems (RWIS) but with special focus on the forecasting part of these systems. An excellent guide to RWIS and recommendation can be found on the SIRWEC homepage [White, 2006]. As RWIS and in particular forecasting of road conditions very often are commercial or only oriented towards a specific end user group there exist only a limited amount resources public available. The main source is therefore the 2 yearly conference held by the SIRWEC community [SIRWEC, 1992] and results obtained especially at DMI. It is the plan that this document will be updated in the coming years with the newest information. The reference list in the last section is far from complete but has been selected as a starting point and will also be updated in the future version of this document.

A questionnaire survey was furthermore done to examine what methods and products are available to forecast and monitor the road conditions. The results of the survey are presented in the section ‘Operational road forecasting systems’ and give and overview of the various products available on the market. Only very few private companies have a detailed description of their products and therefore the list should only be considered as a first attempt to examine the market of forecasting of road conditions. It is planned to make an updated list of internet resources and providers of forecast for winter road maintenance.

3. **STATE OF THE ART**

3.1 **WINTER ROAD CONDITIONS FORECAST**

As already stated there are some material to describe some recommendations and guidelines to RWIS and forecasting of winter road conditions. Most of the material can be found on the SIRWEC homepage [SIRWEC, 1992]. Especially [Mahoney, 2006] and [White, 2006] give some good insight. This document and the following chapters is therefore both meant as a guideline to both provider and clients of road condition forecasts. To some extend the state of the art is some minimum requirements and what in fact is available on the market and therefore more specialised products such as forecasts of avalanches along roads has not been described.

4. **ROAD CONDITION FORECAST**

4.1 **OVERVIEW**

Forecasting of road conditions is an establish science in the sense that all processes are well understood. However compared to more traditional weather forecast the focus is on the surface rather than on the near surface air conditions which is the main focus in more traditional numerical weather prediction (NWP). On the way to establish methods to predict road conditions there has therefore been tried various methods to produce a more specialized product for exactly this problem in order to optimize the forecast quality of the road...
conditions with special focus on the road surface temperature and the amount of water and ice on the road. The road condition forecast has been most focused on short range forecast up to about 6 hours whereas NWP models until recently have been optimized for forecast ranges from 6-48 hours. Typically the processing time of NWP models also means that the forecast first will be available about 2-6 hours after initial time of the model. This is too late to get optimal use of observations of the road surface conditions such as the temperature of the asphalt and for these reasons it has been meaningful to make road forecast as a specialized product.

Though climate and seasonal forecasts in the future will be more useful in the near future, it is the more traditional and specialized forecasts for the road conditions which in practice has been used by the road authorities as decision supporting/making tools (MDSS) for planning of preventive actions against slippery roads. The forecasts serve to balance two strategies:

1) Maximum security
2) Minimum costs

If the roads are always salted and a maximum staff are ready to move out cleaning the roads then it has high security and costs. Minimum costs would be never to do any actions. Both strategies are not based on common sense but should be balanced to get acceptable security and costs.

4.2 DESIGN OF ROAD CONDITION MODELS

As stated before all physical processes affecting the road conditions are well understood and can be modelled very precise. Figure 1 shows many of the processes affecting the road

Figure 1: Many processes must be taken into account in an energy balance model. In this figure melting/freezing of ice/water are not shown. Additionally shading objects like trees tend to reduce cooling by long wave radiation (sky-view) and heating by short wave radiation (shadows). It is also important to know the properties of the road material such as color (albedo), emissitivity, conductivity and heat capacity.
surface temperature. However as often observed the road surface temperature can have large variations within just few meters due to differential heating of the surface from solar radiation, long wave cooling, traffic, melting/freezing/evaporation of water/ice on the road and sheltering from the wind. To capture these differences it is necessary to know the initial conditions from observations and have perfect forecasts for the future of the atmospheric state. Additional, the so-called sky-view and directions to shadowing objects must be known. Figure 2 shows an image of the software used at DMI to manually calculate direction and angle to shadowing objects which also can be used to calculate the sky-view. The image is usually a 360 degree photo and obtained from a specialized camera (fish eye objective). The necessary input from a NWP model forecast are the energy fluxes from to atmosphere to the surface:

1) Downward long wave radiation
2) Short wave solar radiation
   a. Direct radiation
   b. Diffuse radiation
3) Near surface temperature
4) Near surface humidity
5) Near surface wind
6) Precipitation flux

From these parameters sensible and latent heat flux can be deduced. The road surface temperature is used to calculate the outgoing long wave radiation. Furthermore, the temperature change from phase transition of water (vapour ⇌ water ⇌ ice/snow ⇌ vapor) on the road or precipitation flux to the road surface can be estimated. In this energy budget the traffic should also be considered. Friction from tires tends to heat the road surface and turbulence from the traffic will affect the sensible heat flux to the surface and in general force...
the surface temperature towards the air temperature. The traffic also tends to remove water from the road as well as it can be assumed that snow and ice will be mechanical removed or chemical melted of salt applied to the road. Usually it can be assumed that water does not penetrate in to the road or that it is drained very fast from the road surface. Thereby the most important process to take in to account is heat conduction in the asphalt and soil layer beneath the road surface. Usually this is done by solving the heat equations using the fluxes from the atmosphere as forcing of the surface layer. This requires knowledge of the thermal properties of the road such as surface albedo, roughness and emissivity, heat capacity and conductivity of the layers in the road. As lower boundary condition at the road bed, the road temperature is constant or fixed to a climatic value. This is of minor importance provided that the depth of the modelled road is fairly large (>1-2 meter). The initial temperature profile of the road is usually unknown unless special equipment is installed in the road. Usually only the surface temperature and for some installations also the temperature in 1 to 2 more depths are measured. The simplest initial profile is to interpolate observations or assume a constant temperature profile in the road. However this will lead to spin-up problems in the beginning of the forecast and result in inaccurate forecast of road surface temperature. Instead a forecast of the temperature profile can be used as initial profile and additional be adjusted to fit temperature observations in the road. This can be refined by solving the heat conduction equations for the road for a historical period using observations of road surface temperature as surface conditions. It should be noted that nowcasting methods and thermal mapping data methods mentioned in the paragraph about route based forecasts, do not use a fully physically model. Here a statistic approach is used possible combined with parameterization which can be based on some of the above mentioned input. As an example the variation in solar radiation can to some extents, be predicted by knowing the geographically position and time of year and day. From this information the solar zenith and azimuth angle can be calculated and be used to estimate the
solar short wave radiation under the assumption of cloud free or cloudy conditions.

5. ROAD WEATHER INFORMATION SYSTEMS (RWIS)

RWIS is used for the equipment to measure the road conditions and the software to display observations. Most companies which provide RWIS usually have a complete solution. This includes hardware to observe the road conditions and to collect data, visualization software and very often also a possibility to make or display forecasts. In this document the forecast of weather related road conditions is considered to be a part of a RWIS or interface to a RWIS. Figure 3 shows an example of a RWIS from DMI (vejvejr.dk). The RWIS is usually not meant as a fully decision making system but as a tool for decision makers. However So-called Maintenance Decision Support Systems (MDSS) are becoming more integrated into RWIS systems and here forecasting of road surface conditions becomes a crucial part of the system and an import competition parameter.

6. FORECAST SYSTEMS

6.1 CLIMATE FORECAST

Traditionally it has been a public task to maintain the road network. Certain roads are private or paid by the users and here the maintenance will be taken care of the owners. Often private contractors are doing the maintenance for the road authorities but still the road authorities have the responsibility for the safety of the roads and therefore the monitoring of the roads is typical done by the road authorities. The first challenge is to know the more general climate conditions and adjust the needed winter maintenance infrastructure to an appropriate level. E.g in areas with few days in a year with winter weather it can be acceptable with chaotic conditions on the roads for some days instead of having rarely used equipment.

In the later section thermal mapping data (TMD) is described where observations from moving vehicle are used to get an image of the road climatology. This can be a useful tool to identify special problematic road sections and to plan where to set up monitoring equipment and how to design the most optimal winter maintenance strategy. (See also figure 6 for an example of thermal mapping data). Certain companies offer to identify problematic places and plan optimal routes for salting or snow removal.

Recently seasonal forecasts (1-6 months forecast) have become of increasing use to optimize weather depend systems. E.g. if the seasonal forecasts indicates that the next 1-3 months will be with-out winter weather the need for buying more salt can be reduced and thereby reduce the costs. It must be expected that this kind of forecast will have increased value in the future winter maintenance strategy.

6.2 NUMERICAL WEATHER PREDICTION MODELS

The most state of the art forecast from NWP models are generally used for a large range of applications. Typically it does not contain specially forecast of road surface temperature but more general the average surface temperature for a larger area. The forecast range is several
days and the focus is on synoptic to meso-scale which is in the range from about 5 kilometre to 1000 kilometre. Weather on scales below 5 kilometre is not well resolved or uncertain. The forecasts are sufficient for forecasting of major events such as snow storms and useful as indicator whether the winter maintenance preparedness should be alerted. These models will also include an energy balance model for the surface but will assume that the roads are fully exposed to sun and wind. Furthermore road observations will not be used for specific points.

6.3 NOWCASTING MODEL

A first strategy is to setup equipment to monitor the road conditions such as measuring road surface temperature or amount of ice on the road and then start actions when the measurements approach a critical condition. Some equipment is configured with software which can extrapolate the observations and make nowcasting (0-3 hour forecasts) of the road conditions some few hours ahead. This kind of forecast is based on statistics, linear trends or other sophisticated methods to analyse time series and can be quiet accurate under constant weather conditions. Often an energy balance model is included in the system. If the reaction time is short these forecasts may be sufficient. It should be clear that this type of forecasts will not be useful for forecasting snow fall or other forms of precipitation. This requires data from a NWP model. Many of the RWIS also includes the possibility to use NWP data to improve the forecast quality. Usually the provider of the hardware will typically not be provider of the NWP data.

6.4 NWP MODEL USING A ROAD ENERGY BALANCE MODEL

To get more exact short term or nowcasting forecasts models have been developed for forecasting of the road surface temperature. These so-called energy balance models contain equations of the processes previously described in road model considerations. Other features are also taken in to account such as shadows and sky-view angels (see figure 2 for an example) from the surroundings, detailed description of the asphalt surface and an accurate heat conduction model for the asphalt and sub layers. Additionally, observations of the road surface conditions are assimilated in to the model. In particular observation of the road surface temperature provides the model with perfect initial temperature conditions. The model is forced with input from a NWP model to calculate the future state of the road conditions. The weakness of this method is that the road conditions are only calculated in selected points very often where measurement instruments have been mounted in the road.

6.5 ROUTE BASED FORECASTS

Recently there has been a growing interest in prediction of the road conditions for the whole road network. Especially the up come of new
intelligent salt spreaders (see figure 4) has increased the research in how to use this new technology. Early studies such as [Gusstavson, 1998] gave a clear insight in the processes which lead to large variations in road surface temperature with in short distances. It has therefore been clear that the traditional point forecast at road stations where observations are done every 1-10 minutes cannot be used. Additionally the need of computer power increases when calculation of the road conditions for a road network is done rather than for a few points. Figure 5 illustrates the scales involved in route based road forecasts where the routes are in the highest resolution. The art is to combine information from all scales to get an optimal forecast of the road conditions. Data from databases usually have high resolution (such as topographic heights) whereas observations usually are sparse distributed and NWP data is usually somewhere between. In general there are two problems in doing route based forecasts. Firstly, the initial conditions are not known and secondly, the local conditions leading to the differences are difficult to examine by manual methods. [Chapman, 2001, 2004, 2005] did follow up much of the work by Gusstavson ET. al., 1998, however with a more user oriented approach and with use of new technology possibilities. In particular it was shown that shadows, surroundings objects near the road and sky-view can explain the main reasons to the temperature variations. Three approaches have been used to overcome these problems:

1) Use of thermal mapping data (TMD) (fingerprints, see next section).

Figure 5 The figure shows the northern tip of Jutland (Skagen, Denmark). The red dot is a road stations measuring road surface temperature. The black dots are the positions of the NWP grid. The blue dots are positions of a salting route where forecasts are performed at DMI. The distance between the black points is about 3 kilometer. Black line is coastline. Blue color is sea. Green color is land.
2) Detailed models using high resolution databases.
3) Mobile camera to capture the sky-view angle

Method 1) gives an overall estimate of the typical variations in temperature whereas the other method give a detailed picture of the surrounding objects. The initial temperature profile of the road surface is a more difficult task. The data from moving vehicles are not frequent enough to be used in practical applications (at the time being) and the number of road stations is too few. [Petersen, 2012] uses an optimal interpolation method to get the initial road surface temperature from the entire road network using observations from road stations and a first guess from a previous (one hour old) forecast.

In general this leads to two types of route based forecast (or eventually combination of both):

1. Forecast based on TMD using fingerprints

Thermal mapping data is obtained from vehicles which measure the temperature of the road surface with an inferred thermometer. By using this method a large amount of observations for the entire road network can be accumulated and used to make so-called fingerprints showing the spatial and timely variation in road surface temperature. Together with other information and classification of the TMD in to weather types these data can be used to make forecasts and climatology for the entire road network. Figure 6 shows an example of fingerprints from three salting routes in Southern Denmark. [Shao, 2000] makes an attempt to use TMD to make forecast by applying fuzzy logic. The draw back on this method is the difficulties in classification of TMD in to suitable categories. Typical the focus has been on situations with large variability such as calm and clear sky night conditions. Another issue is the quality of the TMD which requires a high quality equipment and often calibration of the hardware to ensure optimal quality. With increasing computer power and focus on high resolution numerical weather models with resolution close to one kilometer the focus on TMD has decreased. However TMD can be used to identify cold spots and is a great tool to find the best places to set up new road stations.

![Figure 6 Typical fingerprints for three different road sections in the southern Jutland in Denmark. The temperature should not been seen as direct measurements but as deviation from a mean temperature averaged over many datasets.](image)
2. High resolution weather model using an energy balance model to calculate the road conditions

This method is a simple extension of using a NWP model and an energy balance model for the entire road network. For the Danish areas [Petersen, 2012] the route based forecast increased the number of points from about 400 in the traditional point forecasts to 23000 points. As previously described the initial road surface temperature was obtained from an optimal interpolation method using observations from road stations and one hour forecast from the road network and the road stations points. The problem with sky-view angles, height and direction to shadowing objects were solved by using high resolution topographic data (figure 7) and GIS software to retrieve these observations. [Chapman, 2004] describes a method to obtain similar data by using a mobile fisheye camera to
obtain the sky-view. Other has later refined this technology and is now able to use it to map shadows and sky-view along the road network.

7. **FORECASTED PARAMETERS**

This paragraph gives an overview of relevant forecast parameters for use of forecasting of the road conditions. Many of the parameters can be measured while other parameters can be difficult to measure or require expensive equipment. It has been divided into two groups. The first group is site specific parameters which are quantities which can be measured at the site and directly be compared with forecasts. The second group is forecast maps which are used to get an overview of the road condition on larger scales.

7.1 **SITE SPECIFIC PARAMETERS**

7.1.1 **Road surface temperature**
This is a standard parameter measured at all road stations and is a basic parameter to forecast.

7.1.2 **Road subsurface temperature**
Many road stations also measure the temperature of the subsurface of the asphalt typically in 5 and 30 cm depth. However forecasts for these parameters are not widely used but are predicted by most road condition models.

7.1.3 **2 meter temperature**
The air temperature is a standard parameter measured at all road stations. Together with the measurement of dew point temperature and road surface temperature the 2 meter temperature gives an indication of the potential risk for dew/rime formation of the road and the evaporation potential from the road surface.

7.1.4 **2 meter dew point temperature**
The 2 meter dew point temperature is a standard parameter measured at all road stations. Together with the measurement of dew point temperature and road surface temperature the 2 meter temperature gives an indication of the potential risk for dew/rime formation of the road and the evaporation potential from the road surface.

7.1.5 **2 meter relative humidity**
This parameter is also a standard parameter. It can be calculated from 2 meter temperature and 2 meter dew point temperature. It can be used to give an estimate of the visibility and the potential for dew/rime formation on the road from airborne water particles.
7.1.6 10 meter wind speed and direction
This parameter is a standard parameter. It is used to estimate the risk of snow drift. For strong winds (cross winds) it can be used to estimate the driving risk for vehicles which are most affected by wind in combination with a low skid resistance.

7.1.7 Cloud cover
The cloud cover is measured at many meteorological stations but not often at road stations as the instrument is expensive. The cloud cover can also be measured from weather satellites but not with as high accuracy. Most forecast provides this parameter and it gives an indication of the potential long wave cooling of the road surface. For cloud free conditions it is known that certain type of pavements or locations are more sensitive to cloud cover. The cloud cover can give an indication of whether the forecasted road surface temperature is too high or too low.

7.1.8 Height of cloud base
The cloud cover itself is not sufficient to describe the long wave cooling. High clouds are colder and often thinner and result in large long wave cooling. The cloud base height gives an indication of the long wave cooling is high or low and should be used together with the cloud cover for the same reasons. Height of cloud base is measured at some meteorological stations but is not observed at road stations.

7.1.9 Precipitation intensity and type
Correct forecasted precipitation is essential for prediction of the road surface condition. The amount of water/ice on the road is importance for estimating the skid resistance. Furthermore evaporation of water on the road will decrease the road surface temperature. Snow is of course a key parameter to forecast both for preventive actions (spread salt before the snow starts) and for planning of snow removal. Most new road stations can measure precipitation intensity and type.

7.1.10 Water and ice on the road
This parameter is very much linked to the former mentioned parameter. Correct forecast of water and ice can be used to give an estimate of the needed salt dose. Most new road stations provide detection of the water level on the road. Both measurements and forecast are subjected with high uncertainties due to prediction of the exact location of showers. Also local traffic intensity and snow removal will be of importance.

7.1.11 Visibility
Visibility has a great importance on traffic safety. Most forecast systems predict visibility but not with high accuracy. Most new road stations measure the visibility.

7.1.12 Skid resistance
This parameter is difficult to measure and is not measured at most road stations. It is difficult to predict. Some providers of forecast give an estimate of the skid resistance calculated on background of the road surface temperature, snow/ice on the road, traffic intensity and the degree of how much the snow has been packed.
7.1.13 Alarm status

This is a diagnosed parameter which indicates the road conditions. The status could be indication of snow on the road, rime on the road, dry condition, wet condition, freezing condition etc.. The indication should be adjusted to local needs.

7.2 OVERVIEW PARAMETERS

The two parameters, cloud cover and precipitation intensity, in the paragraph has been chosen as these are comparable to parameters obtained from weather radars and weather satellites. These are used to get an overview of the weather development such as front and location of showers. These are often difficult to predict and point forecast can therefore not be used alone.

7.2.1 Precipitation intensity and precipitation type

Precipitation is important to forecast. Forecast of snow can be used to do preventive salting before snow fall and also to estimate amount of rain which will remove salt. As showers often are very local and difficult to forecast this parameter can be used to estimate the risk of showers and precipitation.

7.2.2 Nowcast of precipitation intensity

As it is difficult to predict the intensity and location of showers so-called nowcast models are used to calculate the precipitation intensity few hours ahead. This is often done by extrapolation of radar images.

7.2.3 Cloud cover

Forecasted cloud cover can be compared to satellite images from weather satellites. Local variations in road surface temperature are often a consequence of variations in cloud cover. As for rain and snow showers cloud cover can be difficult to predict with high accuracy. For these reasons an overview of the cloud cover can give indication of uncertainties in the forecast.

8. FORECAST PROVIDERS AND INTERNET RESOURCES

This section contains a list of internet resources about providers of forecast. It is based on an search on the internet and in particular the content of the SIRWEC homepage [SIRWEC, 1992]. Furthermore a questionnaire was sent to leading SIRWEC members and members of the METRo user group. The purpose of the questionnaire was to get an overview of providers of forecast of road conditions and a updated list of online resources. Only 14 people returned the questionnaire so only a few references has been obtained from this source. The most comprehensive list of internet sources can be obtained from SIRWEC homepage [SIRWEC, 1992]. Both the general links http://sirwec.org/links.htm and http://sirwec.org/history.htm which contains material from previous SIRWEC conferences.
8.1 QUESTIONNAIRE

Appendix A shows the questionnaire. The main purpose has been to get an online resource and reference to do own request at the provider of the forecast. It has not been the intention to evaluate the quality of forecasts but examine the market. As most forecast systems are unique and complex it is not possible to give a complete description of the systems. For a complete description of the systems the client should contact the provider of forecast for further details. The list is far from complete and it has been difficult to get good information from the different systems. Most of the products on the market are from national services. Two larger companies operating in the Nordic countries are FORECA and Meteogroup and their products have also been listed. Additionally hardware manufactures of RWIS are not included in the list. Some of these companies such as VAISALA with their IceBreak Forecasts can provide nowcast and also regular road condition forecast using input from forecast model. Boschung also provide a forecast and nowcast solution to their systems.

8.2 RESULTS OF QUESTIONNAIRE AND INTERNET RESEARCH

1. Country
1.1. Denmark
1.1.1. Product
1.1.1.1. vejvejr
1.1.1.1.1. Public available: No
1.1.1.1.2. Owner: Danish Meteorological Institute
1.1.1.1.3. Product page: http://vejvejr.dk
1.1.1.1.4. Further Information: http://vejvejr.dk/vejvejrinfor
1.1.1.1.5. Forecast of road conditions: Yes
1.1.1.1.6. Observations of road conditions: Yes
1.1.1.2. dmi.dk
1.1.1.2.1. Public available: Yes
1.1.1.2.2. Owner: Danish Meteorological Institute
1.1.1.2.3. Product page: http://www.dmi.dk/vejr/til-lands/glatfoere/
1.1.1.2.4. Further Information: http://www.dmi.dk/vejr/til-lands/glatfoere/
1.1.1.2.5. Forecast of road conditions: Yes
1.1.1.2.6. Observations of road conditions: Yes
1.2. England
1.2.1. Product
1.2.1.1. Route based forecasting
1.2.1.1.1. Public available: No
1.2.1.1.2. Owner: Met Office
1.2.1.1.3. Product page:
1.2.1.1.4. Further Information: http://www.metoffice.gov.uk/roads/route-based-forecasting
1.2.1.1.5. Forecast of road conditions: Yes
1.2.1.1.6. Observations of road conditions: Yes
1.2.1.2. RoadCast
1.2.1.2.1. Public available: No
1.2.1.2.2. Owner: Meteogroup
1.2.1.2.3. Product page:-
1.2.1.2.4. Further Information:  
1.2.1.2.5. Forecast of road conditions: Yes
1.2.1.2.6. Observations of road conditions: Yes

1.3. Finland
1.3.1. Product
1.3.1.1. special road weather forecast
1.3.1.1.1. Public available: No
1.3.1.1.2. Owner: FMI, Finnish Met Institute
1.3.1.1.3. Product page:
1.3.1.1.4. Further Information:
1.3.1.1.5. Forecast of road conditions:
1.3.1.1.6. Observations of road conditions:
1.3.1.2. Road condition forecast for public
1.3.1.2.1. Public available: Yes
1.3.1.2.2. Owner: FORECA
1.3.1.2.3. Product page: http://www2.liikennevirasto.fi/alk/keliennuste/
1.3.1.2.4. Further Information:
1.3.1.2.5. Forecast of road conditions: No
1.3.1.2.6. Observations of road conditions: Yes

1.3.1.3. Packed snow covered roads analysis
1.3.1.3.1. Public available: No
1.3.1.3.2. Owner: FORECA
1.3.1.3.3. Product page: Under construction
1.3.1.3.4. Further Information: http://sirwec.org/Papers/helsinki/76.pdf
1.3.1.3.5. Forecast of road conditions: Yes
1.3.1.3.6. Observations of road conditions: No

1.4. Iceland
1.4.1. Product
1.4.1.1. HIRLAM 5
1.4.1.1.1. Public available: Yes
1.4.1.1.2. Owner: Danish Meteorological Institute
1.4.1.1.3. Product page: http://brunnur.vedur.is
1.4.1.1.4. Further Information:
1.4.1.1.5. Forecast of road conditions: No
1.4.1.1.6. Observations of road conditions: No
1.4.1.2. ECMWF main forecast
1.4.1.2.1. Public available: Yes
1.4.1.2.2. Owner: ECMWF
1.4.1.2.3. Product page: http://brunnur.vedur.is
1.4.1.2.4. Further Information:
1.4.1.2.5. Forecast of road conditions: No
1.4.1.2.6. Observations of road conditions: No
1.4.1.3. Harmonie 3 km
1.4.1.3.1. Public available: Yes
1.4.1.3.2. Owner: Icelandic Met Office
1.4.1.3.3. Product page: http://brunnur.vedur.is
1.4.1.3.4. Further Information:
1.4.1.3.5. Forecast of road conditions: No
1.4.1.3.6. Observations of road conditions: No
1.4.1.4. http://www.vegagerdin.is/english
1.4.1.4.1. Public available: Yes
1.4.1.4.2. Owner: The Icelandic Road and Costal Administration
1.4.1.4.3. Product page: http://www.vegagerdin.is/english
1.4.1.4.4. Further Information:
1.4.1.4.5. Forecast of road conditions: No
1.4.1.4.6. Observations of road conditions: Yes

1.5. Norway
1.5.1. Product
1.5.1.1. vegvær
1.5.1.1.1. Public available: No
1.5.1.1.2. Owner: Norwegian Meteorological Institute
1.5.1.1.3. Product page: http://vegvesen.no/vegvar
1.5.1.1.4. Further Information: http://vejvejr.dk/vejvejrinfo/
1.5.1.1.5. Forecast of road conditions: Yes
1.5.1.1.6. Observations of road conditions: Yes
1.5.1.2. Halo
1.5.1.2.1. Public available: No
1.5.1.2.2. Owner: Norwegian Meteorological Institute
1.5.1.2.3. Product page: https://halo.met.no
1.5.1.2.4. Further Information:
1.5.1.2.5. Forecast of road conditions: No
1.5.1.2.6. Observations of road conditions: No

1.6. Sweden
1.6.1. Product Trafikverkets VVis
1.6.1.1. Public available:
1.6.1.1.1. Owner: Trafikverket in Sweden
1.6.1.1.3. Product page: http://trafikinfo.trafikverket.se/LIT/#url=Vagtrafiken/Karta
1.6.1.1.5. Forecast of road conditions:
1.6.1.1.6. Observations of road conditions:

1.7. Slovakia
1.7.1. Product
1.7.1.1. Special meteorological information for road maintenance
1.7.1.1.1. Public available:
1.7.1.1.2. Owner: Slovak hydrometeorological institute
1.7.1.1.3. Product page:
1.7.1.1.4. Further Information:
1.7.1.1.5. Forecast of road conditions:
1.7.1.1.6. Observations of road conditions:
1.8. Slovenia

1.8.1. Product

1.8.1.1. Road weather information system for Slovene Roads Agency

1.8.1.1.1. Public available: Yes
1.8.1.1.2. Owner: Slovenian Environment Agency
1.8.1.1.3. Product page: http://drsc.cgplus.si/CVIS/module/station/default.aspx
1.8.1.1.4. Further Information:
1.8.1.1.5. Forecast of road conditions: No
1.8.1.1.6. Observations of road conditions: Yes

1.9. Companies

1.9.1. Product

1.9.1.1. Roadcast

1.9.1.1.1. Public available: No
1.9.1.1.2. Owner: Meteogroup
1.9.1.1.3. Product page:
1.9.1.1.4. Further Information: http://www.roadcast.co.uk (Also other homepages)
1.9.1.1.5. Forecast of road conditions: Yes
1.9.1.1.6. Observations of road conditions: Yes

1.9.1.2. Road maintenance

1.9.1.2.1. Public available: No
1.9.1.2.2. Owner: FORECA
1.9.1.2.3. Product page:
1.9.1.2.5. Forecast of road conditions: Yes
1.9.1.2.6. Observations of road conditions: Yes

9. Outlook

Even though many providers of forecasts deliver the same type of products there do not exist a standard. However there is now some consensus of the requirements of a forecasting system for winter road maintenance. This document has been written as a starting point from scratch to define what is meant by forecasting and what parameters which are required as minimum. The reference list is far from complete and a full list of providers of forecast for winter road maintenance should also be updated. For the hardware suppliers of RWIS there exists a board of people who can define market standards. A similar facility for forecasting could ease the future development of forecasting tools and the complicated process of selecting the right provider of forecasts for winter road maintenance.

10. References


APPENDIX A

State of the art in winter road forecasting

The purpose of this questionnaire is to collect information of what methods and products are used to forecast winter road conditions such as road surface temperature, ice on the road or road friction. The collected data will be used in a project called ROad STate MOnitoring System (ROSTMOS) and the intention is that information will be public available and also presented at next SIRWEC meeting. It is not the intention to compare the quality of different methods or promote certain type of forecasts but only get an overview of possibilities and what the present standard is.

Data collection

All data are collected through google form by Claus Petersen Danish Meteorological Institute, Lyngbyvej 100, Copenhagen. email: cp@dmi.dk. Phone: +4539157442.

I will appreciate to receive answer before 28 October 2014. However later is also fine

Even a partially filled out form will have value for me

Anonymous data

If you do not want information of connection between client/user and provider to be visible please indicate it here. See also the help text if you want data to be kept anonymous.

☐ I want data to be anonymous

Name

Write just name of country name to make answer anonymous


Titel

Do not fill out if you want to keep answer anonymous


e-mail

Do not fill out if you want to keep answer anonymous
Affiliation: Name of company or public institution
Do not fill out if you want to keep answer anonymous

This questionnaire is not relevant for me or I do not have sufficient time
If you do not have time or this questionnaire can not be answered by you. It would be helpful if you could provide the email address or contact information for the relevant person

☐ I cannot answer the questionnaire
☐ I have not time
☐ I do not want to answer the questionnaire
☐ Other: ____________________________

Are you a client/user or provider of road forecasts

☐ Client/end user
☐ Provider
☐ Other: ____________________________

What kind of forecast product do you use or provide
(You can enter 3 different products)

Write the name of the product(s). E.g Danish Meteorological Institute provides vejvejr.dk. The relevant homepage for more information is vejvejr.dk/vejvejrinfo/. You can write more than 1 product. The system should be some kind of Road Weather Information System (RWIS) with a user interface or it could just be ordinary forecasts not specialized for road condition.

Enter name of product 1
Write just p1 if you want data to be anonymous

Enter company name for product 1
Write just p1 if you want data to be anonymous
Enter name of home or information page for product 1
Write just p1 if you want data to be anonymous

Enter name of product 2
Write just p2 if you want data to be anonymous

Enter company name for product 2
Write just p2 if you want data to be anonymous

Enter name of home or information page for product 2
Write just p2 if you want data to be anonymous

Enter name of product 3
Write just p3 if you want data to be anonymous

Enter company name for product 3
Write just p3 if you want data to be anonymous

Enter name of home or information page for product 3
Write just p3 if you want data to be anonymous

Enter forecast methods for the products to your best knowledge

Numerical weather prediction model means that a full atmospheric model is used to calculate the future weather.

Statistical forecast means that short range forecast is done based on the present observed weather and the past weather. Statistics can also be used to improve forecasts from numerical weather prediction models.

Route based forecast means that the forecast is done over the entire road network rather
than in few points.

Point forecast means that the forecast is done in selected points which typically is the location of road stations.

Road Weather Information System (RWIS) interface is typically the part of the system where the forecast and observations along the roads are displayed.

Use of road observations in forecast are usually used in energy balance models to provide optimal initial conditions of road surface temperature.

An energy balance model calculates the future state of the road surface. This can be temperature and water/ice/snow on the road

Product 1
- Numerical weather prediction model (NWP) is used to predict the weather
- Statistical forecast is used to forecast or improve forecast of road conditions
- Route based forecast is available as a part of the system
- Point forecast for user specific points is available as a part of the system
- There is a RWIS interface to the system
- Road observations are used to improve the forecast
- An energy balance model is used to forecast road surface temperature

Product 2
- Numerical weather prediction model (NWP) is used to predict the weather
- Statistical forecast is used to forecast or improve forecast of road conditions
- Route based forecast is available as a part of the system
- Point forecast for user specific points is available as a part of the system
- There is a RWIS interface to the system
- Road observations are used to improve the forecast
- An energy balance model is used to forecast road surface temperature

Product 3
- Numerical weather prediction model (NWP) is used to predict the weather
- Statistical forecast is used to forecast or improve forecast of road conditions
☐ Route based forecast is available as a part of the system
☐ Point forecast for user specific points is available as a part of the system
☐ There is a RWIS interface to the system
☐ Road observations are used to improve the forecast
☐ An energy balance model is used to forecast road surface temperature

Use of forecasts
What is the forecast used for.
☐ Planning of preventive salting.
☐ Planning of salting routes.
☐ Plans for salting strategy. Eg how much salt to spread
☐ Do you use forecast of Rime
☐ Do you use forecast of Snow fall/snow drift

special issues
☐ Are the forecast useful at low temperatures
☐ Low temperatures are not an issue
☐ Are the forecast useful in mountain areas
☐ Mountains are not an issue

To your best knowledge list names of providers of road forecast in your country
This also includes Road Weather Information systems with statistical based forecasts

Other comments to the questionnaire
If you have additional information or comments about this questionnaire
Never submit passwords through Google Forms.