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New techniques for route-based forecasting

Andrew Brown, Simon Jackson, Peter Murkin, Peter Sheridan, Alasdair Skea, Samantha Smith, Anthony Veal, Simon Vosper, Met Office (UK)

Progress with the development of a route-based forecasting system is described. It uses a high resolution (4km) Numerical Weather Prediction model and new downscaling techniques to obtain high resolution meteorological data along the required routes. These are then used to drive a surface energy balance model to predict road temeperature and state. The road model is run appoximately every kilometre, although with extra forecast points inserted in areas of particular interest (e.g. at the bottom of a small valley). The strengths and weaknesses of this approach relative to others (e.g. thermal mapping) are discussed.

One of the key effects causing significant along-route variations is the presence of orography. The use of high resolution NWP data immediately gives a better representation of these effects than can be captured by coarser models. However, significant topographic variations still occur on scales not represented by the NWP models. The development of new techniques to better represent the effects of small-scale variations is described. The first of these is a height-based correction based on a lapse rate derived from the variation of temperature with height in a stencil centred on the point of interest. The second is a valley parametrization which additionally represents the extra cooling caused by local sheltering in small-scale valleys. They have been developed and validated using a combination of an analysis of fixed sensor and thermal survey data, supplemented by extensive use of idealized numerical modelling.

In common with other energy balance models, detailed information on shading and skyview at each site is required. Progress with estimating these parameters through a fully GIS-based approach is also described.

■ ID 17

SRIS - Slippery Road Information System

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RCC GVC Göteborg University (SWEDEN)

In today's society we have come to rely on our roads to be in perfect condition to get us where we're supposed to be in time. In-real-time reports about the prevailing road conditions are important to be able to make correct decisions about maintenance activities, lowered speed limits or closure of roads. If such information is reached by all different kinds of road users they can plan their routs ahead knowing the conditions of the roads before getting into the

car. In Sweden there are over 700 Road Weather Information System (RWIS) stations in use, along the roads. The system gives detailed information about the road weather in regard of temperatures, both in the air but also on the road surface, precipitation, in amount and type, as well as wind information. Since the temperatures are measured both in the air and on the road surface, different temperature variations can be used to derive the transportation of moist air towards the ground. Such information makes it possible to predict hoarfrost and rime on the roads. Precipitation together with wind information also makes it possible to detect snow drifting. The probable state of the roads can be estimated by the use of RWIS. The stations give detailed but fixed point information and can not show the state of the roads in-between RWIS stations. Preformed maintenance activities or specific weather situations are not considered in the system, hence the need for improvements, in ways of increased and improved information. The maintenance personnel in Sweden use the information from RWIS together with information from weather forecasts to plan their work.

The lack of information about the actual road conditions makes it difficult to map trends and perform extensive analysis which could visualize the efficiency potential for, for instance, more accurate activities and more efficient rout planning for winter mainten As mentioned in the earlier section a large portion of the drivers have a poor recollection of where slipperiness occurs on the roads. They have hence limited possibilities to adjust their driving to prevailing conditions. The drivers needs a system that easily and user-friendly can bring them in real time information about where there are slippery conditions on the roads.

■ ID 35

Rule of the Impact of Fog on Expressway in China

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There are serious potential hidden perils to drive on expressway in fog, and traffic safety is also an important worldwide problem under the same weather condition. Nowadays, the police close the expressway to avoid crash in China, which actually take completely the freeway traffic capacity as the price. By analyzing national main expressway weather forecast in this two years, we can conclude countrywide fog frequency, the characteristic and frequency of main expressway affected by fog, and summarize the influence rule of fog on expressway, which are beneficial to provide the reference and guide for expressway weather forecast, a guarantee for improving the driving safety in fog, and a basis for identifying and monitoring the sectors where the fog is always appearing, and targeting to take effective management and control measures.

■ ID 33

How do we verify route based forecasts?

David Hammond, Dr. Lee Chapman and Prof. John E. Thornes
University of Birmingham (UK)

The road weather market in the United Kingdom is currently in a transition phase with an increasing number of local authorities changing to a route based forecasting system. The development of route based forecasting solutions however has brought with it a new challenge relating to the verification of the forecasts – how do we verify a route based forecast? The existing techniques for verifying the accuracy of route based forecasts have a number of limitations which makes their use as a verification tool questionable. Model validation however is crucial to the success of route based forecasting, and a standardised set of verification techniques are required for route based forecasts if the ultimate goal of selective salting is to ever be realised. Standardised verification techniques will bring consistency to the validation process, enabling weaknesses in the forecast model to be more easily identified and resolved, thus improving forecast accuracy even further. They will also increase confidence in the model, which is crucial if local authorities are ever to have the confidence to simply treat one section of road and risk leaving another warmer section untreated. Similarly, with increased confidence in the model local authorities should be more receptive to the idea of optimising their salting routes, something which offers the potential for even greater financial savings. This paper provides a critical analysis of the current verification techniques in use with respect to route based forecasting in an attempt to create a standardised set of techniques which it is hoped will have a positive impact on a number of different fronts. Increased forecast accuracy should lead to better treatment decisions which will ultimately help to reduce the number of weather-related road traffic accidents. Economically, the realisation of selective salting should bring huge financial savings to local authorities, and from an environmental perspective, selective salting would lead to smaller quantities of salt entering road runoff.

■ ID 2

Experimental service for high-resolution slipperiness risk forecasts in Finland

Dr. Pirkko Saarikivi and Mikko Malmivuo[1], Foreca Consulting Ltd, [1]VTT (FINLAND)

In February-April 2007, a new experimental high-resolution forecast service called "Kelipilotti" was implemented between the cities of Turku and Pori in south-western Finland. The 140 km long route was divided into 11 smaller road stretches, for which the service generated once per hour detailed local forecasts of various weather parameters and slipperiness risks. Weather forecasts were based on a very-high-resolution atmospheric model with 0,1 degree (about 10 km) spatial accuracy.

Each issued forecast had a temporal resolution of three successive two-hour periods.

Warnings for slipperiness were generated and shown in four different categories: risk caused by snowfall, freezing rain, freezing of wet road surface, and hoar frost. The forecasts were shown for road users through the Finnish Road Administration's public traffic information Internet service. A simplified text version was implemented for mobile devices. This report reviews the functionality of the service, the response of users and presents analyses of the system's ability to forecast slipperiness in various weather situations.

Weather during the test pilot was not very cooperative, as due to the exceptionally mild winter of 2006-2007, only a few true winter weather situations occurred. However, enough warnings were generated to perform an overall analysis of the forecasting accuracy. When pilot forecasts were compared to the traditional, regional six-hour road weather forecasts, it was concluded that the forecast accuracy was roughly at the same level. By analysing the pilot's slipperiness warning data it was detected that the pilot logically generated more warnings during the night than during the day. Pilot service generated a number of slipperiness warnings that only applied to one particular stretch of the road, which can be interpreted as the pilot forecasting procedure utilising the stretch of road divisions quite efficiently. In particular, towards the end of the winter, the pilot generated more warnings than the traditional six-hour road weather forecast. This is probably due to the fact that the pilot did not take into account any information on winter maintenance, but forecasted the risk that would occur due to weather alone, without any maintenance actions.

The user interviews made before pilot launch revealed the traffic and weather duty officers' need for more frequent and more detailed weather forecasts. User feedback was collected using a feedback form on the pilot's web page. Ninety-two per cent of the 34 people who sent feedback felt that the pilot service was better than the traditional six-hour road weather forecast. In conclusion, the pilot service worked relatively well compared to the objectives set for the system. Second test period will run through winter 2007-2008.

■ ID 11

Road weather predictions produced by MetGIS

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MetGIS is a new, Java-based, combined **M**eteorological and **G**eographic **I**nformation **S**ystem, with a specific emphasis on snow and mountain weather. This constantly upgraded prediction scheme has been developed within the framework of interdisciplinary international research projects with contributions from Austria, Switzerland, Japan, Peru, Chile, Argentina and the USA. A principal focus of the system is the automated production of high-resolution, down-scaled forecast maps of meteorological parameters to support wintry road maintenance operations. Since the beginning of 2007, these maps are accessible to traffic operation centers via an easy-to-use, partly password-protected web interface (see http://www.univie.ac.at/AMK/metgis), constructed in collaboration with Austrian highway authorities.

The geographic part of the system includes a topographic database relying on data of the Shuttle Radar Topographic Mission (SRTM, horizontal resolution approx. 90m) and representations of roads, rivers, railway lines, political borders and cities. On top of these, partly linked to terrain features, down-scaled meteorological information can be visualized in a variety of display styles. Meteorological forecast data of any numerical model can be used as a start point for the downscaling procedures, provided the model output is compatible with NetCDF or GrADS-compatible formats. Currently the real-time output of the GFS (Global Forecast System of the US National Weather Service), is used as a base for MetGIS forecasts. Displayed parameters include precipitation and fresh snow amounts, the snow limit, temperature and the mode of precipitation (snow, sleet, rain). The detailed terrain representation included in MetGIS allows for an easy detection of road sections above the snow line or the freezing level.

For the future a variety of improvements of MetGIS are feasible, such as the inclusion of road weather sensors in the system to detect and adjust forecast errors. Specific parameters of the valley geometry, easily computed from the high-resolution terrain, can be used to meliorate the prediction of the height of the snow line. Energy balance models, assessing the system inherent terrain slope and orientation, can be used to meliorate the temperature forecast. Moreover, the system is already prepared for the integration of the output of snow cover models.

■ ID 4

A new step towards a road stretch forecasting system

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DMI has for 15 years developed a short range forecasting system to predict slippery roads with high accuracy. The focus on this subject has increased as a consequence of a wish of a more effective and safe traffic. More computer power, high resolution numerical weather prediction (NWP) models and an increased monitoring of the road with new equipment have opened up more possibilities to deliver accurate short range forecasts of the road conditions. The keystone in DMI's existing model system is a NWP model where the main strategy has been to minimize errors arising from this model. It has been most important to improve short range forecasting of cloud cover and near surface air temperature and humidity. Even though much can be achieved by using a high resolution NWP model it is realized that there are still limitations associated with data-assimilation and the currently used model resolution. DMI has until now focused on prediction of the road condition at specific points (about 300 points in the Danish road network) where measurements of road conditions are performed with an interval of about 10 minutes. These data are both used in data-assimilation and verification of the road condition model, and results show that errors are significantly reduced by using such data in short range forecasting of road conditions.

An additional source of observations is obtained from moving vehicles equipped with GPS (Global Position System) and temperature measurement sensors. These data are much more sparse, infrequent and randomly distributed compared to traditional and stationary measurements along the road network. However, these observations can be used to verify forecasts of road conditions for a road stretch rather than a single point and possibly be used to obtain a statistical insight to the variation of the road condition on a very local scale.

All together these possibilities are used in an ongoing project focused on prediction of the road conditions for all main roads in Denmark with a resolution of approximately 1 kilometer. At the moment this is about 17000 road stretches which should be compared to the existing 300 points. Preliminary results and further plans for this project are described here.

The quality of forecasted road condition (here in terms of road surface temperature) are verified for selected road stretches for 3 seasons and compared to the quality of point forecasts where continuous measurements are done with high frequency. The impact of NWP model resolution is tested on selected cases and it is examined how well the local structure of road condition can be simulated and to what extent post processing can be done to improve road stretch forecasts.

■ ID 3

Development Project ColdSpots: Towards More Detailed Road Condition Forecasts

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The objective of the three-year project "ColdSpots" (2005-07) was to improve present weather and road condition forecast methods and models by establishing and utilizing a novelty database which covers detailed local information on problematic road sections in Finland. A wealth of information has long been available in various databases, such as registers of road structures and traffic accidents, feedback on road maintenance activities and quality control data. However, this information has been unavailable to the developers of weather forecast models, until now.

ColdSopts was initiated in 2005, with first analyzing the available information and compiling the necessary databases. A test set of some fifty most problematic locations were selected based on accidents having occurred due to slipperiness of the road surface and, additionally, based on the human knowledge of individual road features by local road maintenance experts.

One principal goal was to study how much road weather varies along the roads and what is the cause of these variations. According to observations, surface temperature and friction as well as road conditions can vary dramatically even within very short distances, depending much on prevailing weather. In addition, much of the observed variations are caused by environmental circumstances like topography, proximity of waters, openness of road etc. Some of these variations can be explained by environmental issues but there are features that cannot be easily explained.

During the second phase, 2006-07, road weather conditions were observed using new optical instrumentation attached to mobile cars. This mobile observing effort enabled thermal and friction mapping along the roads. Furthermore, the measurements gave information on the state of the road (snow, ice, dry, etc.). The mobile observations indicated that there can be large fluctuations also between the fixed road weather stations.

The bottlenecks of road weather modeling were analyzed. Some of the environmental circumstances can potentially be taken into account when further developing the road weather model, but not all. Thermal and sky view mapping could be helpful techniques when aiming at more accurate road weather forecasts.

The ColdSpots project was co-funded by the Ministry of Transport and Communications in Finland, the Finnish Road Administration, and the consortium of the three participating partners: Finnish Meteorological Institute, Foreca Ltd and Destia.

■ ID 26

Small-scale road surface temperature and condition variations across a road profile

Dr. Lee Chapman, Professor John E. Thornes
University of Birmingham (UK)

Since inception, Road Weather Information Systems (RWIS) have relied on point measurements from outstations to initiate and verify daily forecasts. Initially, spatial extrapolation was achieved by thermal mapping, but this is gradually being replaced by route-based forecasting techniques. Both techniques are similar in the sense that they use a point measurement taken from an outstation to provide a spatial forecast of road surface temperatures (RST) around the road network at varying resolutions. A substantial research effort has been undertaken to understand and model the complex environmental conditions and mechanisms responsible for the variation in RST around the road network. In particular, the interaction of varying geographical parameters around the road network such as altitude, landuse, road construction, topography, etc have been used to develop local climatological models and next generation RWIS products. This paper takes the approach to the next level and explains how the same methodology can be used to look at variation in road condition across a road, instead of just along a road.

The variation in road surface temperature and condition across a road surface is considerably less than that encountered around a road network, but can still be in excess of 5°C. Although many geographical parameters (e.g. altitude and topography) can be assumed constant across the profile, others will vary on a small scale and result in differential temperatures and condition. For example, traffic can account for up to 2°C variation on multi-lane roads, where as sky-view factor and shading effects may cause temperature variations of around 3°C. These differences provide a problem for both weather forecasters and winter maintenance engineers. Forecasters are limited by the geographical survey data to hand, which is still ultimately point data (albeit at a higher resolution of typically 50m) where as engineers are effectively over-salting the highway as they are duty-bound to treat roads with respect to the 'worst case scenario' encountered on the cross profile.

■ ID 1

The Danish Road Weather Information System

Pernille Arnsfelt Hansen, Søren Brodersen
Danish Meteorological Institute (DENMARK)

The Danish Road Weather Information System is a result of many years of unique cooperation and development between The Danish Meteorological Institute and the Danish Road Directorate in coordination with other road authorities and input from the users. The system now includes all the information needed to make good decisions whether to start preventive salting against slippery roads or not.

When designing a RWIS-system it is important that the information is easy accessible and easy for the users to understand. It's well known that not all users have the same background and education. The Danish RWIS-system has solved this problem with a simple but informative colour coding of the so called alarm-status for the road observations. The same colour coding is used for presentation of the results from the numerical road condition model. Besides the system includes online weather radar- and satellite images and live webcams along the roads.

This presentation will give an insight in the way information and functionalities are presented in the Danish RWIS-system and the thoughts and ideas behind the design.

■ ID 13

Weather prediction for the road industry

Andrew Brown, Simon Jackson, Peter Murkin, Alasdair Skea, Samantha Smith, Anthony Veal, Met Office (UK)

The quality of any road forecast is crucially dependent on the accuracy of the meteorological data used in its preparation. In this lecture we review the strengths and weaknesses of the current numerical weather prediction models, focussing on variables of relevance to the road industry.

We also discuss the opportunities presented by the new generation of high-resolution models which are starting to be used operationally in many countries. Typically these models have resolutions (grid-spacings) of a few kilometres or less. This allows much more accurate prediction of topographic effects (e.g. cold air pooling and fog formation in valleys) than can be achieved with coarser resolution models and post-processing techniques.

It also allows prediction of the development of showers and convective storms in a way which is impossible with coarser scale models. Higher vertical resolution is also found to allow improved prediction of thin stratocumulus clouds and, in turn, better near-surface and road temperature predictions.

In spite of the advantages of these new models, their use does present some challenges to the road forecaster. For example, data volumes are inevitably increased. The high resolution fields will also include much more detail, some features of which (e.g. the exact timing or positioning of a shower) may not be reliable. The advantages of a probabilitistic interpretation, ideally of an ensemble of high resolution models, will be discussed.

■ ID 16

AWIS: an Airport Winter Information System

Eros Pasero, Walter Moniaci, Giovanni Raimondo, Politecnico of Torino (ITALY)

AWIS, Airport Winter Information System, is a research project funded by Piedmont Authority, Italy, with the goal to improve the reliability of a large airport during winter events.

Even though airports differ from the environment of roadways, they have several key points in common. For this reason the concept of an Airport Weather Information System is quite similar to a Road Winter Information System. In fact, the problems connected to the difficulties during the winter period on the airport runways consider the following parameters :

- Security of the user
- Accessibility of the runway (delays, closure)
- Corrosion of maintenance vehicles, aircrafts and runway surfaces due to treatment with de-icing substances

- Prevision of the surface conditions in order to organize maintenance activities just in time
- Higher reliability of the control process of the surface of the runway
- Higher trust of users in the control authorities

Therefore, the objectives of an AWIS are various and contribute to a higher security level of the airport especially during winter emergencies and result in an improved image of the airport reliability.

Obviously, a great synergy has to exist between the airport management and the runway Management. Therefore the project involves the management of the international airport of Turin, Italy, which will be the first airport to test such a security system and to provide a reference model. But an Airport Winter Information System can strongly improve all the aspects of the management of the winter events, such as weather reports, control of the pavements conditions, field condition assessments, passengers safety, global air traffic efficiency. All these aspects will be verified on the Turin airport during the three years long project. But the ambitions of this project are much more foresighted. The final AWIS packet will be the studio of a prototype system to be used in any airport. The new techniques studied to improve the behavior of the pavement during winter events will be used by asphalt companies for other similar applications. The knowledge of the behavior of this pavements with rain, ice and snow and the techniques used to optimize the de-icing treatments will be an improvement for salt spreaders systems. Local meteo forecast systems will be strongly improved by the new nowcasting tools that will be installed and tested in the airport to prevent dangerous winter events. Also a new short distance radar will be developed to forecast snow precipitations in limited areas. Last, but not the least, efficient models of data treatments and information communication will be studied to have the maximum efficiency both from the air traffic management (ENIAC) and from the passenger point of view.

■ ID 43

Winter Maintenance / Cost Benefit

The U.S. Federal Highway Administration Winter Road Maintenance Decision Support System (MDSS): Recent Enhancements and Refinements

Dr. Kevin R. Petty and William P. Mahoney III,
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In an effort to mitigate the challenges associated with winter maintenance decisions, the United States Federal Highway Administration (FHWA) initiated a project aimed at developing a winter road Maintenance Decision Support System (MDSS). The goals of the MDSS project are to construct a functional prototype MDSS that can provide objective guidance to winter road maintenance decision makers concerning the appropriate treatment strategies (treatment types, timing, rates, and locations) to use to control roadway snow and ice during adverse winter weather events, and develop a prototype that will also serve as a catalyst for additional research and development by the private sector. To date, four versions of the MDSS prototype code have been made freely available to the surface transportation stakeholder community; A fifth MDSS release is slated for the fall of 2007.

The prototype uses current weather observations and numerical model predictions from the United States National Weather Service to create route-specific analyses and forecasts (48 hours) of atmospheric conditions. The current version of the system uses METRo, an energy balance model developed by Environment Canada, to generate predictions of pavement conditions along each route of interest. Treatment recommendations, which are based on standard rules of practice for effective deicing and anti-icing operations, are constructed using current and forecasted atmospheric and road condition information. Forecast data, along with treatment recommendations, are presented to end users via an interactive Java-based display. Through this interface, users can examine and select recommended treatment strategies produced by the system, as well as investigate alternative courses of action and ascertain the anticipated consequences of action or inaction.

Over the last three years, the FHWA MDSS prototype has been demonstrated in Colorado. During this period, the system was accessible to maintenance managers in the Denver Metropolitan area. As a result of the demonstration activities, the MDSS has undergone a number of recent improvements and refinements, which have been based primarily on end user feedback and lessons learned. This paper provides a comprehensive overview of the FHWA MDSS Release 5.0 prototype, including the latest system enhancements and refinements.

■ ID 29

Development and Operation of the Winter Maintenance Support System

Naoto Takahashi, Roberto A. Tokunaga, Motoki Asano and Nobuyoshi Ishikawa
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In northern communities, keeping the safe, effective and efficient travel during the wintertime is an important theme and road administrations conduct various snow and ice control operations to provide as good roadway condition as possible. With the limitation of the budgets and the high expectation of the public for keeping good roadway condition, it is necessary to conduct winter maintenance operations more efficiently.

Accurate forecasting of road surface icing is essential to achieve the adequate and appropriate winter road surface management programs. For instance, anti-icing operation is a proactive preventive approach being desirable to apply early enough to ice from forming; otherwise, it requires forecasting accurately road-surface conditions for winter maintenance decision. Especially, it needs developing the approach to predict road icing scientifically as road surface condition changes suddenly with rapidly changing of climate conditions. Besides, in order to form operational party by prior decision or to start operational work on appropriate timing, it requires providing forecasting information to road authorities as soon as possible.

Such system providing road weather information and forecasting information of road surface condition to road authorities is known as Road Weather Information System (RWIS) or Maintenance Decision Support System (MDSS). For several years, our institution has undertaken developing forecasting method and the "Winter Maintenance Support System" suitable for Japan's geographical feature, weather and existing snow and ice control activities in cooperation with other relevant organizations. For instance, the project involves the meteorological agency that provides weather-related data and designs weather forecast scheme, academic institution supporting to develop the road-surface temperature prediction model that takes into account the effect of running vehicles and surrounding environment with applying heat balance approach, and road authorities and contractors giving ideas about selection of the information service item and its interface.

The project began observing the weather and road surface temperature and developing the prediction model in 2004, and in 2005 the prototype started experimentally providing the information to road authorities and contractors through the Internet. Then, the system has been practically used while improving the model and interface as the need arises.

This paper describes the conceptual framework of the prediction model and of the information system, and details of the practical/operational situation.

■ ID 21

Cost effective monitoring of RWIS – Communication and maintenance

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In order to improve availability of road wheather measurements and to minimize the cost of transmission expenses, Danish Road Institute (DRI) has developed and fully implemented a system to superwise all RWIS units and according communication lines in the Danish Road Weather Data system.

In Denmark measuring data from different types of measuring stations are collected in a common presentation system VejVejr. From the beginning the communication was depending of "state of the art" for communication on the delivery time. This meant that collection was done via 3 different types of network. Quite naturally this was very difficult both to maintain and the cost was very high. In 2005 it was decided, that collection of all information's from measuring station should be done via IP/Internet compatible connections.

At the beginning of winter season 2007/2008 309 of 312 measuring stations has been converted to communicate via IP compatible connections.

Independently of type of measuring station DRI has developed the necessary interface between the measuring station and the IP network.

The interface is intelligent, and DRI has access to the full range of functionality in the measuring stations. Upload of new versions and configurations can be done very easy and with high reliability.

Technical supervision programs for both communication lines and measuring stations are available and can be used from any access point to the IP network/Internet.

At the same time the presence of IP network at a measuring station has made it possible to equip selected locations with video cameras to watch both traffic performance and special weather situations (e.g. snowfall). This information's have been integrated in VejVejr and are available in parallel to the measured data.

It can be concluded, that the conversion of communication lines into IP compatible network has given advantages and improvements both the winter surveillance centres and the technical maintenance center. It has to be mentioned the total cost of running the data collection at the same time has been lowered.

■ ID 24

Salting of winter roads – a discussion of salt amount versus concentration

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Important aims for winter maintenance of roads are to achieve a high level of accessibility, regularity and traffic safety during the wintertime. Securing a sufficient level of friction between vehicle tires and the road surface are essential to achieve these aims. Snow and ice removal and friction control are therefore the most important activities in winter maintenance of roads. Mechanical and chemical methods are used both for snow and ice removal and for friction control.

Independent of the purpose of a salting action, whether it is to prevent freezing (anti-icing), to melt ice or snow (de-icing), or to prevent the build-up of snow pack on road surfaces (anti--compaction and anti-adhesion), there are several critical factors that determine the effectiveness of the application. The most critical factors are timing and spreading rate. How much salt there is on the road surface is critical for the road surface conditions and whether or not ice formation or snow compaction occurs. How long the salt remains on the road surface after application is therefore vital for the road surface conditions. The person making the decision when to salt and how much to spread benefits from having knowledge of how much salt can be expected to remain on the road surface of previous salt applications.

This paper address a discussion on the subject on measuring salt on road surface in amount per unit area versus concentration in fluid. Salt concentrations are measured e.g. by road sensors, either by passive sensor using electric conductivity or active sensor measuring the freezing point. Salt amount per unit area can by current knowledge only be measured by a manual method using Sobo 20. Both measures (amount and concentration) can give useful information about road surface characteristics but they do not give the same type of information, and are not comparable. In situations with for example falling road temperatures concentration measurements give valuable information on the risk for icing. On the contrary, in situation with risk of precipitation, concentrations measurements say nothing about the risk of dilution, and thereby freezing road surfaces. On a fairly dry or little moist road surface one can have a high salt concentration, while the amount of salt per unit area can be quite low.

By example from field observation, measurements with Sobo 20 and data from road sensor this discussion is illustrated. The importance of this two concepts of measuring salt on road surfaces in the decision making process are discussed.

■ ID 31

Adaptation of roads winter maintenance strategies to weather influences

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Game theory and operations research were used to study the adaptation of roads winter maintenance strategies to weather influences. Economic models in the loss-matrix form were discussed. Matrix elements take into account losses of the maintenance deports and users of roads by the various roads weather forecast alternative.

All losses are divided into two components:

1) Expenditures which are necessary for the road winter maintenance,

2) Losses in the transport complex from unsatisfactory road conditions (decrease of speed on a slippery road surface, possible accident losses, the effects on the environment).

The results of the computing tests were reported.

■ ID 15

Estimation amount of snow deposit on the road

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For the purpose of providing road safety in winter the road service team carries out a complex of activities. The standards in force for winter service presuppose timely removal of ice sediments and clearing of the road surface from snow.

The main type of winter slipperiness on most of the territory of Russia is snow coasting. One of the way of his prevention is a well-timed clearing the roads from snow. The technology of work presupposes repeated passing of snow-removal machines. The interval between passages of machines is determined by the intensity of snowfall and the requirements of the winter service standards.

At snowfall (hard precipitation at wind speed under 5 m per second) snow covers the road surface with an even layer and it is easy to calculate the parameters of snow removal.

At a wind velocity exuding 5 m per second snowdrifts occur and the snow cover becomes uneven on some areas of the road surface. It is possible the intensity of snow deposit if the snowing do not.

The intensity of the snow blockades depends on a big number of factors, both weather and road. The quantitative estimation of those factors is an important problem which has not got its solution yet. The article under consideration gives the results of the research on quantitative estimation of snow piled on different parts of roads during blizzards. The methods of mathematical modeling were used to solve the problem.

There suggested a mathematical model giving a general description of processes of snow piling on roads. This model helps to substantiate the basic weather and road factors which are necessarily have to be taken into account. Their list is given in the article.

The article also considers mathematical models describing snowdrift, snow bring to a certain sections of a road, snow blockades of low embankment, opened and unopened ditch. Data provided by automatic road meteorological stations can serve as initial data for calculations.

The realization of the models in the form of computer program is considered. There given an example of the calculation for certain road section. There given the results of estimation of coincidence of the results of modeling with the results of observation of the control section of the roads. The results of modeling can be used to support the decision making in managing the road winter maintenance.

■ ID 14

A comprehensive Winter Maintenance Management System to increase Road Safety and Traffic Flow

Dr.-Ing. Thorsten CYPRA

Boschung Mecatronic AG (SWITZERLAND)

Major goals of road operations are safety, environmental protection, economics and the necessary optimisation of these issues in delivering quality winter maintenance services. For increasing road safety the needs are high quality prediction and sensor technologies as well as appropriate winter service treatments at the right time. Next to road safety mobility is an important factor in local economies; uninterrupted traffic is a basic requirement for the effective development of the economy and society. A significant increase in traffic volumes on roads has an effect on quality of traffic flow and safety. That means the aim of road management must be that a road user can drive a certain distance in a predictable time as safely and reliably in winter as in summer. As a consequence, the standards of winter maintenance for a road network have become very high. Therefore, winter maintenance must be organised optimally and operations have to be enacted extremely quickly. Because of the complexness of meteorological, traffic and winter service processes, the persons in charge of winter maintenance need a comprehensive Winter Maintenance Management System. The importance of a comprehensive Winter Maintenance Management System can increase according to a possible climate change with short heavy snowfalls in wintertime to activate the right treatments at the right time.

This clearly shows the need for Maintenance Decision Support Systems (MDSS) to efficiently and safely manage infrastructure systems in wintertime. A solution to this is the Management System BORRMA-web MDSS inside (Boschung Road and Runway Management). This system clearly displays all important elements in one view, such as dynamic maps, Road Weather Stations (GFS- ice early warning), Fixed Automated Spray Technology (FAST), vehicle operation data and location of winter service vehicles, road conditions etc. for real-time, future, and past events. Especially useful is the combination of local measurements (RWIS-Stations) and weather forecasts allowing detailed predictions and alerts for each forecasted Road Weather Segment (road section with similar microclimatic conditions). This means that differentiated danger levels of road conditions can be shown on the dynamic map for a forecast time of up to 72 hours. Additionally, with the Vehicle Data Management tool with online data transmission, the operator has a clear overview of the actual location of all winter maintenance vehicles and their operation. Additionally Fixed Automated Spray Systems can be visualized and managed out of the same system by a special synoptic.

The collection, combination and visualisation of all this information and predictions of the Maintenance Decision Support System give the operator the possibility to make decisions efficiently and to manage dynamically, which increase road safety and improve traffic flow.

■ ID 27

Evaluation of winter weather conditions from the winter road maintenance point of view – principles and experiences

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Czech Hydrometeorological Institute (CZ)

This presentation describes and discusses up to now experiences in Dept. of Climatology of Czech Hydrometeorological Institute with evaluation of winter weather conditions from view of winter road maintenance. Experiences with evaluations of these conditions with regard to winter maintenance outputs in the Czech Republic are described, too. Discussion will include different points of view on possibilities and methods of evaluation. Attention is paid to problems with retrieval of basis of road network and winter maintenance outputs.

■ ID 40

Winter Maintenance Index

RNDr. Vít Květoň, CSc.; Ing. Tomáš Juřík; Ing. Martin Balajka; Ing. Tomáš Pospíšek
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Winter Maintenance Index (WMI) is a system of deep analysis and comparison of road winter maintenance performance and costs depending on real meteorological conditions on a defined road network. In a situation that in many countries winter road maintenance has been privatized, the use of such analysis and control tool has become more important to make a qualitative interpretation of the costs. WMI is a unique tool that takes the evaluation and control of winter road maintenance performance (e.g. salting, plowing) to complete new levels.

The comparison of maintenance level among different contractors independently of climate, terrain, altitude, and road length… is now available. Based on this analysis it is possible to detect divergences from the standard level and separate any isolated or long-time anomalies and unjustified raising of costs. It is also possible to establish objective and precise regional/national „winter maintenance standards" which allows resources allocation optimalization as well as helps to increase traffic safety.

The purpose of Winter Maintenance Index is to give an objective indication of winter severity and especially to compare maintenance performances among different contractors or centers working in different climate conditions. Unlike currently used systems it is the first time that not only winter severity is calculated for specific regions but also a long-term average or maintenance standard" in that particular region is found.

The key advantage of WMI lies in the innovative way of „calculating the winter" that has not been possible using other methods. Detailed analysis of performance and cost-effective

control of winter maintenance is much easier and for clients – road authorities - brings noticeable savings – up to 10 % of total winter maintenance expenses while keeping safety standards high.

■ ID 39

Decision Support System (DSS) for road weather conditions -trial in the Czech Republic

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Road weather Information Systems (RWIS) is used for helping maintenance personal to take the right decision regarding salting and ploughing activities. These types of systems have been in use for many years and have been shown to be a very good help for the maintenance people. However, the system was originally designed and build for a maintenance system consisting of small surveillance areas, well trained personal who also had good local knowledge both of field station environments as well as the local road network. Today most National Road Administrations need to lower costs associated with winter maintenance and therefore small surveillance areas are lumped together forming bigger ones. In doing so the local knowledge of roads and field stations among other things are often lost and forgotten.

RWIS-systems normally forms a very good tool for taking decisions regarding maintenance activities but to be used in its full potential it is very important that the user are well trained and experienced to interpret all the data that are produced by the system. An interview study among maintenance personal performed in Sweden by Ljungberg (2002) clearly showed that the personal experienced their work to be very stress full and they where often afraid to take the wrong decision as the consequences could be so fatal. What the personal asked for was some help to make better use of the system and also to help taking the right decision regarding type and timing of activities. In order to meet these demands research and development regarding a decision support system has been conducted at the University of Göteborg, Sweden, for several years. The aim of these studies have been to develop the present RWIS into a system which gives INFORMATION not only data regarding the present and upcoming need for winter maintenance activities, i.e, a tool for taking the right decision regarding:

- when to perform activity
- where to perform activity
- type of activity

■ ID 36

Study on the energy-saving measures and the introduction of renewable energy for the winter season road management instructions in Aomori Pref. in Japan

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Introduction

Aomori Pref. is located to the north end of Honshu of Japan and is a heavy snowfall area eminent in Japan. It is characteristic that the ground snowstorm by strong seasonal wind. In such winter season road weather, spontaneous light delineators for the ground snowstorm from Japan Sea mainly, and no-sprinkling melting snow institutions are required for the safe traffic of a road. Also, the technical development with regard to energy-saving goes on, ignited by two degrees oil crisis of international scale generated in 1970's in Japan. Now eminent energy-saving measures are carried out in the world. Energy-saving measures of a road management institution of the winter season and a case study of renewable energy were carried out in several places and showed an interesting result. Those results become a guideline to other existing institutions and the road management institution that should be upgraded in future in Aomori Pref. Then, the guideline for the energy-saving measure and the renewable energy introduction were made.

Results of the energy-saving diagnosis

1. A power factor, a excess air factor and COP (coefficient of performance) should be measured and confirmed in operation. And the driving efficiency compares it with a design value, and a remedy should be done.

2. If it is considered that an institution in operation uses energy in a surplus, an improvement plan should be carried out.

3. Lighting rate of illumination of a tunnel should be changed in an entrance part and central part, and should carry out energy-saving.

4. As for the reflection board of illumination of a tunnel, the illuminance considerably improves by cleaning.

5. As for the lighting of the road overall, Mercury lamps should be exchanged to high efficiency lamps (i.e. sodium-vapor lamps and LED), because on a life cycle cost, high efficiency lamps are cheaper than mercury lamps.

6. The measure that the power factor approaches 100% about electric power should be carried out.

7. For energy management, it is required that surveying instruments are installed.

8. It can be chosen a cheaper contract system by scrutinizing a quantity of maximum use and a use time zone of electricity.

9. The institution which selective killing lightings, alternate operations of melting snow devices are possible should be controlled in consideration of weather situation.

10. The improvement plan needs to be carried out on the basis of the inspection record of the device at the time of operation and the end of winter.

Results of case study of renewable energy

1. Changing the oil boiler for the melting snow instruction to the wood pellet boiler in Aomori city.

2. Construction of wind-generated electricity in Noheji town.

3. Changing the electric heat type melting snow institution to the underground heat pump type device in Hirosaki city.

4. Flexibility of surplus electricity of the existing power generation in the Shimoyu reservoir

5. The micro size hydropower generation in the Michinoku high way.

Outline of „The energy-saving measures and introduction of renewable energy for road management instructions in Aomori Pref."

Four following policies that reduction of a life cycle cost, reduction of greenhouse gas could expect became a basis. And, based on examples in Aomori Pref., the guideline for plain energy--saving measures and introduction of renewable energy for road management instructions were made.

1. Switch from oil boilers to wood pellet boilers should be carried out.

2. On electricity, electricity of self generation (a bio diesel fuel dynamo power generation, wind--generated electricity, a photovoltaic power generation), and examination of the flexibility use of a government electricity company should be done.

3. Examination of a direction adopting a underground heat pump (a heat pipe) which included the subsurface water use should be done than an air heat pump.

4. Switch from a commercial power supply to a spontaneous light type delineator (a photovoltaic power generation, wind-generated electricity) should be carried out.

■ ID 20

Sensors and Equipment

Observing the variability of road and weather conditions with hybrid mobile and fixed sensors

Dr. Pirkko Saarikivi, Marjo Hippi[1], Pertti Nurmi[1] and Jussi Sipilä[2]

Foreca Consulting Ltd, [1]Finnish Meteorological Institute, [2]Destia (FINLAND)

Finnish project ColdSpots (2005-2007) studied the possibilities to improve the accuracy and resolution of road weather forecasts. Special attention was paid to road stretches, which experts in road maintenance had selected due to known problems with freezing or other weather hazards. These stretches or spots also had had more than average traffic accidents.

In the project, it was soon realised that in order to analyse the local effects causing these dangerous spots on highways, the present fixed observing network was not dense enough. Thus a new mobile method was developed to observe the local variations in very fine detail. Recently developed optical sensors where attached in the rear of a car, and data was continuously collected while driving along the highways in different weather situations. Observations were stored every five seconds, corresponding to a spatial resolution of about 100 meters. The position of the car was measured once per second with a GPS receiver. This paper analyses the results and compares the ability of fixed and mobile weather and road condition measurements to reveal the local variations along highways.

Unfortunately, winter 2006-2007 was the shortest and warmest ever measured in Southern Finland, winterly road conditions lasting barely six weeks. However, in January-Februay 2007 project team succeeded to measure eleven cases. The observed parameters include air temperature, road surface temperature, air moisture, amount of water, ice and snow on the road surface, and the derived road surface friction value. Local variability of these parameters was very large in some weather situations, especially in very cold and calm cases when radiative cooling and pooling of cold air had been strong during the previous night. In most other situations the variations in weather parameters were relatively small, but friction varied often quite drastically. The observations reveal also very clearly the difference between well maintained highways and poorly cleaned streets in the Helsinki capital area.

It is concluded that the use of optical road condition sensors in a mobile way, combined with the existing fixed road weather observing network, provides very valuable observational data for detailed local analysis of various weather cases and proper microclimatic studies on highways. There is a definitive need to continue the development of hybrid road condition observing systems and find an optimal, cost-effective combination of both systems. Hybrid observing systems are a necessity for detailed road condition research studies, but once becoming operational, those would greately enhance and improve the observational input for operational winter maintenance systems.

■ ID 10

Problems in Visibility Measurement of Road in Blowing Snow

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The reduced visibility by the snowstorm or the fog often causes multiple accidents. To detect the reduced visibility by the snowstorm or the fog, the visibility meter is installed in the environmental sensor station (ESS). In the standard that United States FHWA showed, it is shown to installed the visibility meter at 6.5-10 feet (about 2-3m) in the height of the meteorological observation tower build at 30-50 feet (about 10-15m) from the roadside. However, the visibility is greatly different in case of snowstorm depending on the position and height.

To clarify the difference of a spatial visibility in the road section, authors measured the mass flux of snow (the mass of the snow particle that passed through the unit cross-sectional area at the unit time) on the flat section and the low-bank section of the test road in the Ishikari Blowing Snow Test Field. Mass fluxes of snow were measured by the net type blowing-snow traps at 15m windward from roadside (at a height of 1.2m above the snow surface) and on the road way (at a height of 1.2m and 2.4m). In the following, the windward point is called the reference point.

The measurement was done 35 times in four days when the snowstorm was generated between January and February, 2003. The height of the snowbank on the roadside during the measurement was 0.4-1.1m. When data was analyzed, mass flux was converted into the visibility by using the experimental equation of the visibility and the mass flux that the authors had shown by the past research.

The ratio of the visibility by the height of 1.2m on the roadway to the visibility of the reference point was 0.1-1.4, and the ratio of the visibility by the height of 2.4m on the roadway was 0.2-2.1. In the extreme case, the visibility on the roadway was 60m while the visibility of the reference point was 660m. Especially, the visibility on the roadway has worsened remarkably compared with the visibility of the reference point when the snowbank on the road side is high.

These results clarified that the visibility measured with the visibility meter installed at the ESS and the visibility that had been seen from the driver while driving in the snowstorm were different. That is, it is necessary to consider spatial differences of the visibility at the snowstorm when the measurement value of the visibility is interpreted.

■ ID 8

Remote sensors tests on Lithuanian roads

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There is constant demand for high quality road surface state sensors to road maintenances works in winter so when Vaisala Oyj released new generation products – remote road surface state DSC111 and road surface temperature, air temperature and humidity DST111 it was suggested to test them on real conditions under the pilot project in Lithuania.

DSC111/DST111 sensors set was mounted on motorway E77 (Riga – Siauliai – Taurage – Kaliningrad) in Northern part of Lithuania near the already operating Road Weather Station (RWS), equipped with the following sensors: passive road surface, air temperature and humidity, road surface temperature, precipitation type and amount, wind speed and direction, visibility. Road Weather Camera (RWC) with IR lamp was also included in this set. Test was run from the 6th of December, 2006 to the 17th of April, 2007 (till the end of the cold season). Along with the automatic measurements, periodic field studies of road surface's state during non standard weather conditions were pursued. All datasets were possible to be compared in between.

The main objective of this study was to compare data from the remote sensors with RWS, RWC and the periodic measurements and to evaluate operative potential of these sensors on Lithuanian roads.

Road surface temperature values were very similar (diff. 0.05°C) if temperatures were below 5°C limit when comparing DST111 and RWS data. Temperature range level was permissible (standard dev. 0.6°C) and the data was possible to be used for the road condition forecast. However, when the road surface temperature exceeded 10°C the difference between the two sensors increased (even to 4-7°C). Remote sensor is not recommended to be used during the warm season.

Remote sensor DSC111 data was mostly correct and representative when compared with the field measurements. The most inadequate results were under heavy driving conditions (ice / rammed snow on road surface). First reason was that the remote sensor was able to recognize 0.01 mm thick water film on the road's surface which human and other devices could not recognise. And the other reason was that the remote sensor has a narrow-gauge field of view which was decreasing under snow conditions compared to the road surface size.

Also correct and representative results were obtained after the comparison of the remote sensor's DSC111 and RWC's datasets. It is considered that RWC is very useful as an extra device especially for particular road segments (bridge, hill foots ant tops etc.). The measurement results were the most different under heavy driving conditions (wet / damp road weather surface). The primary reasons for inadequacy were different thermal road conditions (RWC was turned more to the bridge-side while DSC111 was turned more to the road) and the diverse spread of salt on the road surface.

Remote sensor's DSC111/DST111 complementing, installing, mounting, calibrating, software updating, maintaining tests ran mostly well for Lithuanian conditions. Since winter season of 2006-2007 was very short and atypically warm, there is a need for further testing during the 2007-2008 season. We need to evaluate all pros and cons; data mismatch cases are to be considered and after the 2007-2008 season decide whether the extensive usage of these sensors in Lithuania is necessary.

■ ID 7

Intelligent Road Weather Forecasting in the "CARLINK" Platform

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Finnish Meteorological Institute (FINLAND)

The objective and main focus of the international R&D project "CARLINK" (Wireless Traffic Service Platform for Linking Cars) is to develop an intelligent wireless traffic service platform between cars, supported with wireless transceivers along the roads. More than ten collaborators representing three nations, Finland, Luxembourg and Spain, have joined this three-year (2006-08) endeavour. Each of the participating countries have their own site-specific applications which relate to real-time observing and forecasting of local road weather (Finland), intelligent services for public transportation (Luxembourg), and urban traffic management (Spain). The Finnish road weather application is being managed by Finnish Meteorological Institute (FMI)

There are diverse technical solutions available for car-to-car communication, most commonly applying bilateral communication between two vehicles, or broadcasting information from one vehicle or infrastructure to vehicles in the surrounding area. The CARLINK approach is to adapt an intelligent hybrid wireless traffic service platform supported with wireless transceivers acting as access points along the roads. Communication between cars is arranged in an ad-hoc manner together with wireless base station connection to the background network. Various wireless local area network technologies and ad hoc networking technologies are integrated (WLAN, WiMAX, cellular networks). Integration is necessary to guarantee sufficient coverage and data transmission ability within the whole application area (along highways and roads, urban streets). The coverage will be tested in distinct adverse weather conditions by applying the local road weather model. Likewise the Finnish road weather application, various other applications such as accident or traffic jam information can be integrated into a similar framework. These will be investigated by the other partners of the project.

A wealth of observed weather information is available at road weather observing sites which are typically located along the main highways in Finland. However, the spatial distribution of these stations is not adequate to depict the intermittent and variable weather conditions, especially during wintertime. Finnish Meteorological Institute runs an operational road weather forecast model during the cold season of the year. The model is a one point energy balance model which produces a.o. air and surface temperature forecasts and also defines the condition of the road surface (e.g. snow, ice, frost, wet, dry). The model uses as its input data from the road weather observing sites

Modern cars are equipped with an increasing number of diverse observing systems which can measure weather related parameters like the ambient temperature and the friction of tires. Such data can be aggregated practically continuously in the data terminal equipment of the cars. It is the idea in CARLINK to collect some of these data from cruising cars to be fed in the road weather model, in support of the more conventional observations. Consequently, the CARLINK framework is expected to provide more detailed spatial and temporal road weather forecasts than the present operational system. A system test and demonstration will take place during spring 2008 along a pre-specified road stretch on the major highway E18 in Finland.

The CARLINK project belongs under the EU Eureka cluster programme Celtic and is co-funded by Finnish Funding Agency for Technology and Innovation (TEKES).

■ ID 25

Fusion of xFCD and local road weather data

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The subject of the presentation will be the project "reliable determination of weather-related road surface condition", which is funded by the German Federal Ministry for Transport (BMVBS) and its executive organ, the Federal Highway Research Institute (BASt). The project is carried out by the Chair of Traffic Engineering and Control of Munich University of Technology.

Motivation for this project was the high number of traffic accidents caused by critical road surface conditions. In the course of the project, practical methods for increasing the traffic safety that will exceed the functionality of conventional traffic control systems will be developed. A major characteristic of traffic control algorithms in traffic control systems (e.g. reduced speed limit because of critical road surface condition such as ice or water) is the spatial extrapolation from locally detected road weather and road surface condition data to whole road stretches. The basic idea of the project is to aggregate locally detected road weather data and extended Floating Car Data (xFCD) towards more reliable and more accurate information about road condition on the stretch.

Objective of the project is the development of a concept for the fusion of xFCD and locally detected data. Using these data in the course of this project to be developed adequate forecast models shall lead to optimized information on (critical) road surface conditions and a sustainable reduction of traffic accidents.

For the development and verification of the forecast models an extensive database will be built. Therefore, two dedicated probe vehicles (a car (Audi A4) and a van (VW Caravelle)) will be launched to collect data in the Greater Munich. Both vehicles are equipped with a notebook, which is connected to the CAN (Controller Area Network)-Bus. A software tool collects information about e. g. anti-lock braking system. No additional sensors have to be installed such that the algorithms could not only be applied to the data collected by the collected probes, but also to the data collected by normal state-of-the-art vehicles. The local road weather data are provided by the Bavarian Highway State Authority (ABDS) and will be collected by their standard data collection system in operation. Advantage of this approach is that the results can be transferred to real world applications easily.

Depending on the availability of different data types, applications for (1) traffic control and (2) winter maintenance will be developed. Traffic control and winter maintenance are typical target applications for optimized data road surface condition monitoring and will benefit from more reliable information in terms of the ability of more efficient and timely disposition of winter maintenance service vehicles and a faster and more reliable warning of the drivers. Hence an increase in acceptance of traffic control methods by the drivers is expected.

Experiences in operating a test site for road weather and road surface condition monitoring have shown that a continuous plausibility check of data shall be a core part of the project. Thus, plausibility (cross-)checks for locally detected road weather data are applied and developed for XFCD.

The projected duration is from 10/2007 to 04/2009.

■ ID 19

Observing Road Weather Conditions Using Passenger Vehicles

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The acquisition of road weather information on temporal and spatial scales that will support advancements in timely, accurate diagnoses and forecasts of near surface conditions will inherently result in an increase in roadway safety and mobility. Currently, in the United States, heavy reliance is placed on automated airport observing platforms, mesonets, and remote sensing technologies for information concerning the planetary boundary layer; however, these data do not provide adequate amounts of near surface information at the scales required by the roadway transportation community. Although the deployment and use of Road Weather Information Systems has aided in the diagnosis and prediction of road weather conditions at select points along routes, there remains a need for a denser network of weather and road condition observations.

A potential solution to the need for high-resolution atmospheric and road condition data can be found in a United States Department of Transportation (USDOT) initiative called Vehicle Infrastructure Integration (VII). The concept of VII involves vehicle-to-vehicle and vehicle-to-infrastructure communications through Dedicated Short Range Communications (DSRC-wireless radio communication at 5.9 GHz). Automobiles will have the capacity to wirelessly transmit and receive messages that carry information concerning road weather conditions. For example, vehicle data elements such as temperature, wiper state, and Automated Braking System (ABS) status can be transmitted and used to directly or indirectly assess weather and road conditions. It is envisioned that VII-enabled weather-related data will result in the enhancement and development of operation-specific road weather products and applications for surface transportation stakeholders, such as traffic, incident, maintenance and emergency managers, weather information providers, and the traveling public.

During the spring of 2008, a Proof of Concept (PoC) will be conducted in the Detroit, Michigan area, with support from the USDOT. The fundamental goals of the VII PoC include demonstrating and examining elements of the VII concept (e.g., data flow) and exploring the viability of using VII-enabled data in the development of various applications. This paper discusses and summarizes current and future weather-related mobile data elements, road weather applications and product improvements and developments that may result from VII-enabled data, and the research and development being conducted by the USDOT Federal Highway Administration's Road Weather Management Program in an effort to facilitate the use of VII-enabled weather and road condition data.

■ ID 30

Intelligent UMB Road Sensors and Advanced Road Weather Information System (ARWIS)

Karl E. Schedler, Pavel Stingl

ChanGroup s.r.o, general representative of LUFFT GmbH and micKS MSR GmbH (GERMANY, CZ)

A new modular fieldbus based technology was developed by LUFFT GmbH Fellbach, Germany. The UMB Technology offers all necessary sensor types for road and weather conditions as well as intelligent road pavement sensors and microwave radar based precipitation detection and present weather recognition. The technology was designed for low power consumption to enable solar or fuel cell power supply.

Reliable, easy to operate and cost effective monitoring stations on the roadside are the most important data source for advanced road weather information systems (ARWIS). As well as input for service operation platforms for traveller and traffic information.

In cooperation with Czech Hydrometeorological Institute and The Road and Motorway Directorate of the Czech Republic, ARWIS, developed by ChanGroup s.r.o., became common platform for road maintenance system of the Czech Republic, aimed at highly specialized, very fast and precise exchange of information for decision support in winter road maintenance.

ARWIS is highly modularized, object oriented system developed on Linux/Unix (C++ and Apache/PHP) platform, as data source independent system. The import subsystem can be very quickly reorganized to accept new data source, by supplying of new import module, which converts data delivered on data channel to internal system protocol, which can be interpreted by system as any other data source. In present time system knows how to handle SH10, SH70 and BUFR meteorological protocols supplied by CHMI, RMD CR internal XML protocol for transmission of road weather stations data, and many other internal protocols used for direct communication between database servers including Oracle, MySQL, Interbase/Firebird, MSSQL etc. ARWIS is now part of system for winter road maintenance (JSMIS).

For Traveller and Traffic information a road weather service operation platform was developed by micKS MSR GmbH in cooperation with BMW and the consortium of the Bavarian Traffic Information Agency and in the framework of the eMOTION project supported by the European Commission. The platform processes data from intelligent road site sensors and various meteorological data sources and produces TMC messages according to the ALERT-C standards.

■ ID 48

Presentation and Interpretation

PLAUSIBILITY OF ROAD WEATHER DATA

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A high number of traffic accidents occurs during critical road weather conditions. Thus an important objective of Traffic Control Systems is to increase traffic safety through a dynamic reaction (e.g. warning, information, speed limit) not only to prevailing traffic situations, but also to current road weather and road surface conditions.

Especially data of precipitation intensity, visibility and waterfilm thickness are important input parameters for traffic control algorithms. For this purpose sensors must detect critical road weather conditions sufficiently accurate and fast. The suitability of sensors must be tested, which should be done under real conditions.

Therefore, a test site for road weather and road surface condition monitoring has been established near Munich / Germany.

The test site project is supported financially as well as organizationally by the Federal Ministry of Transport, Building and Urban Affairs (BMVBS) and the Federal Highway Research Institute (BASt). A working group (AK) of Germany's Road and Transportation Research Association (FGSV) serves as a supervisory board for the project. The actual test site is operated by the Bavarian Highway State Authority (ABDS); the monitoring and evaluation is carried out by the Chair of Traffic Engineering and Control of Munich University of Technology.

The purposes of operating a test site are:

1. To evaluate sensors in order to give dedicated feedback to the manufacturers towards potential weaknesses of their sensors. The sensors in the test site are mainly assessed according to the plausibility of the result delivered and the reaction time.

2. To assess the applicability of different sensors and technologies. Therefore prototypes or sensors originally used in other application areas (avionics, intelligent vehicular systems) are being tested.

3. In addition, extended analysis of critical road weather and road surface conditions (road wetness, reduced sight, precipitation intensity) and the according traffic control measures are being carried out.

4. To derive plausibility checks for road weather data from meteorological correlations for the automatic on-line detection of erroneous measurements.

The research and application presented here concentrates on 4.), as it is of major interest to the operating agencies, to detect malfunctioning sensors quickly and reliably in order to take measures to remove a prevailing problem. Erroneous information may be based on one of several potential problems: Hardware problems, software bugs, external sources (it turned out that there are several sources of disturbance in road weather data recording, for example dust of combine harvesters and cobwebs that lead to "correct" measurements (e.g. reduced visibility) but erroneous interpretations (fog)). According false displays in variable message signs have to be avoided by a monitoring system of plausibility checks.

Several studies have shown that the acceptance of variable traffic signs by road users is largely dependent on the plausibility of the displayed information. Several plausibility checks were developed, tested and optimized. To apply them on a large database of historical data, the plausibility checks have been implemented in a prototype software tool. The recommended plausibility checks for application in real traffic control systems will be published as a technical bulletin in 2008.

The research in the test site will be continued until the end of 2008. Results about improvements in the quality of road weather sensors and their data will be made public.

■ ID 18

CHMI Services for Winter Maintenance of Roads and Highways

Dr. Jan Sulan, Dr. Miroslav Škuthan, The Czech Hydrometeorological Institute (CZ)

Aim of this paper is to present current state-of-the-art of road meteorology in national meteorological service of the Czech Republic. Our country is situated in complex terrain. There are several mountainous ridges around the borders and some highlands also inside the territory. This is the reason why the Czech Hydrometeorological Institute operates besides central forecasting office also six other regional branches, some of them with night shifts.

The concept of text forecasts for winter maintenance has been used since the season 1995/96 when it was developed for distribution via Teletext. Special forecasts for each political region and segments of highways have 9 hours lead time and are issued every 6 hours with some overlap period. Text and table format enables to distinguish probability of precipitation occurrence to the level of districts, to estimate snow accumulation and danger phenomena for different altitudes and in some approach timing of weather changes. Teletext was replaced by RWIS with password protected access. Forecasts are at road manager's disposal during a few minutes. In case of unexpected change of weather warning is delivered mostly by phone. Verification of regular forecasts will be presented in the paper.

Special forecasts are prepared with knowledge of data from road weather sensors and their behaviour during last night. Problem with fragmented network of road weather stations (more than five technologies) was overcome by duty to deliver data in unified code. After some competition the project of national RWIS was successful and the access to data server was opened before winter 2006/2007. During 2008 development of CHMI database system is going to finish and the road weather data downloaded from the server of Road and Highway Directorate will be transformed to BUFR for presentation in meteorological visualization system Visual Weather and also for international exchange with neighbouring meteorological services.

Until now the Ice Break forecasting module was applied in Vaisala technology installed on our highways. During next two years energy balance model will be developed in co-operation with the Institute of Atmospheric Physics AS CR to support winter maintenance of the whole road network of the Czech Republic.

■ ID 41

Providing of Traffic Information Related to Dispatcher Systems

RNDr. Marie Filakovská, Ing. Jan Rada, VARS BRNO a.s. (CZ)

Operating dispatcher systems processing weather forecast data, meteorological data, and road condition data support dispatcher control of road management. They provide valuable traffic information data as well.

Traffic information come from the following information sources - Unified Road Meteorology Information System and Winter Maintenance Information System.

Unified Road Meteorology Information System provides selected information from meteorological stations and weather forecast service.

Winter Maintenance Information System provides information on road surface condition including recommendations based on road condition and traffic status.

Information from both systems:

- is spatially located with respect to unified road network and has its own geographical interpretation. Meteorological stations are represented as point objects, while weather forecasts relate to specific regions and are represented as polygons. Road condition data relate to regions (polygons) or road segments (lines).

- is encoded using the Alert-C protocol (specific for traffic information).

The data is transferred via XML interface to National Traffic Center. Then, it is further distributed using websites, data output, information boards, and RDS-TMC. Target user community include public service, private organizations, and broad public (e.g. drivers).

■ ID 51

NIGHT ICING POTENTIAL DEMONSTRATION PROJECT

Paul J. DeLannoy, Senior Associate, AMEC Earth and Environmental (CANADA)

This paper presents a very cost-effective approach for the preparation of thermal fingerprints and the forecasting of potential night icing situations. A Nova Scotia Transportation and Public Works (NS TPW) patrol vehicle equipped with an infra-red (IR) sensor and an Automatic Vehicle Location (AVL) service was used to perform IR data runs along a section of highway 104 in Pictou County, Nova Scotia. The signal from the IR sensor was fed directly into the AVL unit which relayed the positional, timing, and temperature information directly to the AVL provider, Grey Island.

AMEC meteorologists coordinated the IR runs with NS TPW staff and extracted the Grey Island AVL data daily for analysis against the weather from the previous night. The data were mathematically filtered, aligned, and averaged. Thermal fingerprints for three weather types (Extreme, Intermediate, and Damped) were produced in a GIS format.

The thermal fingerprints for highway 104 were then associated with the two Road Weather Information Systems (RWIS) along the route. The route was divided into equal segments and the coldest temperature deviation from the mean along each segment was assigned to the entire segment. Forecasts of pavement temperature and air dew point were used with the fingerprint corresponding to the coming nights prevailing forecast weather to determine the earliest time at which frost could form for each road segment. The resulting GIS map with colour coded road segments and time stamps of the potential onset of icing provides an effective new road maintenance operations planning tool.

A GIS-based format for thermal fingerprints and forecast presentation will be presented. The logic and steps in the production of this innovative Night Icing Potential (NIP) chart product will be presented and its limitations described.

■ ID 34

The Design and Application of the Fine-resolution Road Weather Information System to Improve Special Meteorological Services over the Greater Beijing Metropolitan Area in North China

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(CHINA)

In the Greater Beijing metropolitan area of North China (Beijing-Tianjin-Hebei Areas), one fine--resolution road weather information system is design and applied to improve the special meteorological services. This system is composed of four sub-systems, that is, an intense monitoring network consistent of 16 road stations of ROSA, Vaisala company of Finland and 100 more auto weather stations partly with atmospheric visibility measurement, one rapid cycling numerical weather prediction system updating forecast every 3 hours for future prediction with WRF model coupled with Noah land surface model system, two domain two-way nested run with the fine--resolutions of 9/3km, a statistical interpretation sub-system for numerical products based on the nonlinear method of support vector machine, and an auto web deliver platform coupled with geographic information system(GIS). Furthermore, the three-dimension variational data assimilation system WRFVAR is incorporated into the numerical weather system at the initial time of each update forecasting. With above data assimilation system, the local intense observations, such as the atmospheric water vapor data of the ground-based GPS-MET network and surface meteorological data of auto weather and road stations, are efficiently assimilated into forecasting system to improve prediction except of the routine meteorological data (e.g. radiosounding, pilot and synoptic observation, et.al.). In this paper, we would like briefly introduce the design of the fine-resolution road weather information system, especially we conduct a thorough discussion on the fine-resolution numerical prediction system and the characteristic of atmospheric visibility's evolution and the corresponding physical analysis in the Beijing Expressway based on the fine -resolution temporal observation data, and present its all-sided development and preliminary application in the operational meteorological service.

Keyword: road weather information, atmospheric visibility, special meteorological service, data assimilation, rapid update cycling system.

■ ID 9

Effects of Vehicle Heat on Road Surface Temperature of Dry Condition

Akihiro FUJIMOTO, Hiroshi WATANABE and Teruyuki FUKUHARA

University of Fukui (JAPAN)

There are very few heat balance models in consideration of the thermal effects of a vehicle on the road surface temperature as far as we know, so that the road surface temperature is determined only by the structure of road and climate conditions. Therefore, the change of the road surface temperature due to vehicle passage has been ignored even for a heavy-traffic road.

In this paper, the vehicle heats such as tire frictional heat, radiant heat from the bottom of a vehicle (vehicle radiant heat) and sensible heat due to vehicle passage (vehicle sensible heat) were formulized from the field and indoor experiments.

The temperature on the bottom of a vehicle was measured by a thermograph, and the vehicle radiant heat distribution in the longitudinal direction was formulized as a function of ambient air temperature and the distance from the front of vehicle. The tire frictional heat was expressed by Newton's law of cooling, i.e. the product of the heat transfer coefficient, α_{tp}, and the temperature difference between tire and road surface. The tire temperature was calculated by ambient air temperature and vehicle speed. The value of α_{tp} was 60W/m^{2}K for a dry road surface. The vehicle sensible heat was given as the product of the heat transfer coefficient, α_s, and the temperature difference between the road surface and ambient air temperature. The value of α_s was in proportion to the 0.7 power of wind velocity, V_w, induced by vehicle passage. The increase in V_w and subsequent attenuation of Vw with time were obtained from the field experiment using two cars with different sizes and an anemometer. In addition, the shielding effect of a vehicle on the solar radiation and downward sky radiation was taken into consideration in the model.

The proposed vehicle heat model was applied to the weather and traffic conditions at Futamata in Myoko city, Niigata, Japan, and the surface temperature of a dry road subjected to the vehicle heats was calculated in order to verify the validity of the vehicle heat model. The model could reproduce the road surface temperature in a non-vehicle passage area. Comparing the road surface temperature in a vehicle-passage area with that in the non-vehicle passage area, it was found that the former was about 3 lower than the latter in the daytime, but this temperature difference decreased to about 0.5 after sunset. The ratio of the vehicle heat to a total of all the heat flux across the road surface was -9 to -15% (the minus means road cooling) in the daytime due to the shielding effect, subsequently became positive (maximum 5%) by the vehicle radiant heat associated with the increase in traffic volume in the evening and then again became minus by the vehicle sensible heat.

■ ID 5

Defining climatic parameters for selecting strategies for winter maintenance of roads

Harald Norem, Norwegian University for Science and Technology (NTNU) (NORWAY)

The scope of the presentation is to establish climatic parameters that may be helpful in selecting the strategies for winter maintenance and to present recommendations how to use them for selecting the strategies.

Salting and gritting are the main methods for friction control on winter roads. In the last years the method of warm wetted sand method has been developed and the method represents an alternative to salting in stable cold climates.

The report is based on analysis of the data assembled for the VTI project “Winter Model”, and presents mainly comparisons between accident data, operational standards for winter maintenance and climatic conditions in the different regions of Sweden. The analyses revealed that salted roads in the central and southern part of Sweden had lower accident rates than the unsalted road network. In the Upper Northern Sweden it was quite opposite; the salted roads had higher accident rates than the unsalted roads, and substantially higher than on the salted roads in the more southern parts. The main reason for the difference is assumed to be an effect of the very cold winters in Northern Sweden, having average January temperatures in the range of -15 to -18°C, compared to -1 to -6 in the more central areas.

Three climatic parameters are developed, which are assumed to describe whether salting or gritting is favourable/non-favourable for friction control. The parameters are in first hand used on a monthly basis and are dimensionless. The parameters are:

Winter Severity Index, W_{sev}; proportion of road surface temperature recordings <-8°C. The Severity Index describes the ratio of time when salting has limited efficiency.

Winter Stability Index, W_{stab}; proportion of days favourable for the warm wetted sand method, which is defined as 24 hour periods with road surface temperatures below -1°C and less than 3 mm precipitation within 6 hours.

Winter Instability Index, W_{inst}; proportion of road surface temperature fluctuations around 0°C per day

Salt is assumed to have positive effects on roads having average daily traffic above 2000 vehicles and in areas and periods where Wsev <0,2, which means that less than 20 % of the recordings of the road surface temperatures are below -8°C. The warm wetted sand method is most favourable in cold stable climates. The lower limit for using warm wetted sand is set to approximately 0,3 for the stability index, Wstab, which means that there is a 30 % probability that the positive effect of the warm wetted sand method remain for at least 24 hours. In areas and in periods with low stability and frequent fluctuations around 0°C, use of dry sand is probably the only alternative to salt at moment.

■ ID 22

A quantitative analysis of risk based on climatic factors on the roads in Iran

Dr. Majid Habibi Nokhandan[1], Dr. Javad Bazrafshan[2], Dr. Khalil Gorbani[2]

Atmospheric and Meteorological Research Center (ASMERC), Climatological Research Institute[1], Tehran University [2] (IRAN)

Climatic factors such as rain, snow, strong winds and icy roads are largely responsible for road accidents in various periods of the year and in various parts of the world. This study first examines the frequency of these factors in Iran. Then, using a quantitative method of risk analysis, the study identifies the potential for the climatic risk affecting road safety and then prepares risk maps in the GIS environment in various months of the year for the whole country. A study of risk maps shows that the months of the year may be divided into two periods in terms of accidents potential: a) April to October, when the roads face small or moderate numbers of accidents. In this period, strong winds play an important role in road accidents especially in windswept regions. b) November to March, when the potential for road accidents gradually increases, reaching its peak in January. In this period, snow, rain and icy roads are the most important causes of accidents especially on mountainous roads.

Keywords: quantitative method of risk analysis, climatic factors, road accidents, GIS, Iran

■ ID 46

Climate change and UK Highways maintenance

Miss Hazel Thornton, R Harrison, Carlo Buontempo and Dr. Andrew Brown

Met Office (UK)

The publication of the IPCC 4th assessment report concludes that warming of the climate system is unequivocal. There is evidence for climate change in the 20th century in both observational and modelling studies. Predicting and analysing the impacts of climate change involves several stages. These will be outlined and the sources of uncertainty related to each stage will be examined.

Projections from the UK Climate Impacts Programme (UKCIP) have been used to analyse the potential impact of climate change on the operations of the UK Highways Agency. A number of areas of potential sensitivity have been identified and include: the impact of changes in extreme temperature on surface material and gritting requirement, the impact of changes in extreme precipitation on drainage from roads, structures and on earthwork stability and erosion.

This UK-based case study illustrates some of the potential impacts of climate change that planners and operators of infrastructure networks need to consider and adapt to. This presentatiuon will highlight how climate science can inform decision-making.

■ ID 23

Education / Cooperation

The Use of Cultural Road Weather Forecast Symbols

Professor John E Thornes, University of Birmingham (UK)

Globally £6 billion is spent every winter to keep roads open and safe and the salting decision is based almost entirely on the road weather forecast. In the United Kingdom there are approximately 3500 salting routes and the highway engineers want accurate weather forecasts presented in a format that can be understand quickly and decisively. The 'traffic light' colour coding for each salting route (red = roads require salting, yellow = standby, roads may require salting, green = no action required) is presented in GIS format over the internet. Previously, weather forecasts have always been presented using weather (nature) symbols/signifiers. The use of cultural signifiers is of great value as the highway engineers have no meteorological background. This does not imply that accuracy or quality is being lost, for example in transforming interval road temperature forecast data into an ordinal series of colours. In reality the accuracy and quality is increased, as the visual front-end of the weather forecasts is just the top layer of information. All of the interval data is available for inspection as drill-down layers below the front-end visualisation. However, rather than confuse the end user with huge amounts of forecast data, which could lead to a variety of decisions being made by different end users with the same information, the visual cultural image helps to provide high-quality, consistent levels of service across the whole country. The forecast is continuously available on the internet and updated every six hours. All the technical information contained in the colour choice is available to the user, and the thresholds and colours can be interactively changed before the season starts. Feedback from the users and road weather sensors can be fed into the forecasts in real time. The production of these images can be tuned in order to build in a safety factor, so that accuracy can be sacrificed for the public good. This also has implications for both the training of road weather forecasters and the highway engineers. There has been a tendency to try and educate highway engineers in great detail about how the weather works – this is a very difficult task. It is better to present the forecast in a straight forward and undisputable way using cultural symbols that everyone can understand.

■ ID 6

Educational programme of the road weather principles subject which is lectured in the Czech University of Life Sciences Prague

Dr. Ing. Jan Pivec, Czech University of Life Sciences Prague (CZ)

Subject provides essential knowledge about Earth's atmosphere and physical processes that determine its properties and behavior; atmospheric composition and energy, water in the atmosphere and air circulation (global, synoptic and local scales). Course continues in the description of climate on the World. Special accent is emphasized to the problems of transport meteorology and weather forecast process. Road meteorology topic includes information about Standing International Road Weather Commission (SIRWEC and SERWEC), Road Weather Information System (RWIS) as well and finally brings the basics about transport climatography of the World. Important attention is devoted to the RWIS national and regional systems, products as well as sensors from the main important producers from Sweden, Switzerland, Finland, Germany and USA. From special practicing programme it is interesting computation of the depth of pavement freezing and the risk of the frost deposit formation assignment. The practical example of the student's seminary works will be presented.

■ ID 37

Road Meteorology and International Cooperation

Dr. Miroslav Škuthan[1], Dr. Daniel Glanc[2]

Czech Hydrometeorological Institute[1], DELTA Consult[2] (CZ)

The recent political changes within the European territory and the ongoing progress in information technologies opened hitherto unsuspected possibilities for cooperation in the field of road meteorology. This concerns mutual exchange of data and road weather information on one hand and cooperation in optimizing of utilized methods on the other.

Czech Republic (The road administration and the national weather service) was active in organizing and supporting projects of international cooperation with neighbouring countries since the year 2001.

This activity identified the basic topics in this field. On several international workshops themes like unification of data acquisition, data format standards and information presentation were covered.

This presentation summarizes the results and experiences from the past seven years of international cooperation with emphasis on creation of Central European Road Weather Information System. The proposed system is a major contribution for traffic safety and efficient winter road maintenance in the region.

■ ID 42

Poster Section

ROADIDEA: Road Map for Radical Innovations in European Transport Services

Dr. Pirkko Saarikivi, Foreca Consulting Ltd (FINLADND)

ROADIDEA is a research project funded by the European Commission Seventh Framework Programme. This two and a half year project starts in December 2007 and will be executed by a Consortium of fourteen members from nine European countries. The total EU funding is 3,3 Million Euros.

The basic argument of ROADIDEA is that effective accessibility to all kinds of useful background information combined with advanced data fusion methods and technological information platforms with high level of standardization are prerequisites for creation of innovative mobility services. These help developing better information infrastructure as well as public and private services providing clean, cafe and efficient mobility for people and goods. The hypothesis is a framework for technical development that will be verified in Northern, Central and South-Eastern parts of Europe. The differences of the existing transport systems and available data sources are analysed as well as the problems caused by local climate and geography. The main focus for research will be road transport with all its user sectors, but co- and multimodality and other forms of transport will be included.

ROADIDEA will study incidents such as slipperiness caused by the freezing of road surfaces, local thick fog formation in the Po Valley region, heavy thunderstorms in Hungary, and gale winds in Adriatic coast, where the Bora wind at times throws lorries off the road and bridges have to be shut down. The progress of global warming does not take away the particular problems of Central Europe and Scandinavia, such as freezing rain and snow blizzards. Basically, the methodology used in ROADIDEA is generic and can be thus used anywhere in Europe, and the same system architecture can be utilised for all types of data such as road surface friction, travel times, exhaust emissions, vehicle speeds, pedestrian movements, etc.

In several occasions, the project innovates in a systematic way new service concepts and improvements to existing systems and background models, utilizing new kinds of data and data fusion. Using a user - rather than a technology- centered approach, ideas are screened and evaluated by end users, leaving the best and most potential ones for further study and development. These key innovations are projected to the existing European transport infrastructure and systems, thus revealing the key development targets and bottlenecks. During the following development phases, the barriers for innovations and measures to remove those barriers are identified, and tackled when possible. As a final result, ROADIDEA will present a road map to a more innovative and competitive European transport service sector

■ ID 12

The Experience of the Efficient Planning of RWS network in Moscow Region

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Central Aerological Observatory (CAO), Federal Service for Hydrometeorology and Enviromental Monitoring (RUSSIA)

The climate of Moscow Region is highly variable, winter precipitation in particular. Snowfalls present the greatest difficulty in winter motor road maintenance.

With Moscow Region divided into 6 areas, climatic estimates have been obtained for each of them with a view to road winter maintenance problem. The areas were distinguished by relief parameters, using a specially evaluated mean relief matrix.

The coefficient of correlation "relief vs. precipitation" was estimated by calculating a sample linear coefficient of the correlation between similar elements of the matrices of relief and precipitation fields.

For planning the RWS network efficiently, it is required that measurement data from a single site inside a specific area be sufficiently representative of the whole area. A root-mean-square error is taken as error criterion.

The number of network sites in a separate area depends on the space-and-time precipitation parameter variability and the given interpolation error. The density of RWS network for the areas of Moscow Region has been estimated, using a correlation analysis for solid and mixed precipitation fields. An RWS arrangement pattern for Moscow Region has been proposed.

■ ID 44

Spatial Analysis of Weather Related Road Accidents in Iran

Dr. Majid Habibi Nokhandan[1], Gholam Abass Fallah Ghalhari[2], Saeid Ghatre Samani[3]

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Road safety is an important basis in traffic and transportation engineering. Over the past decades, the number of deaths and injuries related to road accidents has increased considerably in developing countries specially in Iran. Road accidents are the consequence of the combined effect of behavioral, technological and environmental factors. Iran has a specific kind of climate due to its geographical location and some effective factors like topography and distance from water bodies. There are 237 dangerous and snow prone passes. Many of these passes are blocked during cold months by heavy snowfalls, avalanches, blizzards, black ice, dense fogs. This causes considerable damage to the economy of the country.

In this article, the spatial dimension of weather related road accidents is examined using data extracted from Police Accident Report Forms. Variations in accident frequency in fine weather, rain, storm, fog and snow are detailed and comparison made between frequency of accident occurrence and weather condition across Iran provinces. Findings establish that there is a marked correlation between weather related accident and the geographical distribution of weather conditions. The result showed that rain was one of the most important factors in road accidents. According to obtained results on visibility data; provinces of Fars and Hormozgan in rain, Chaharmahal and Ardebil in snow fall, Ardebil and Zanjan in fog, Sistan and Baluchestan and Yazd in storm condition were most vulnerable regions.

Keywords: Road safety, road accidents, weather conditions, Rain, spatial distribution.

■ ID 45

A case study on Prediction of temperatures variation trend in mountainous roads by a numerical mesoscale model

Abbas Ranjbar Saadatabadi, Ph.D [1], Majid Habibi Nokhandan, Ph.D[2]

I.R. Iran Meteorological Organization[1], Atmospheric and Meteorological Research Center (ASMERC), Climatological Research Institute[2] (IRAN)

Atmospheric situation forecasting of mountain regions has always been important regarding to its various aspects such as research on water resources, road transportation an so on, but the exact forecasting quantities temperature, precipitation and humidity in mountain regions and topographically complicated areas is one of the main meteorological problems. This paper attempts to summaries how we can forecast temperature trends to purpose ice formation on surface roads in mountain area, by using a numerical mesoscale model. The most transportation problems and road risks occur when low pressure dynamic systems act over area. The prediction of road weather conditions requires the production of forecasts of temperature, precipitation and humidity at the road surface. It is a big challenge to obtain sufficient forecast accuracy of the road weather. In recent years, there has been a growing among authorities in getting predictions for temperature trend for ice formation on roads. Since proper decisions about road salting require accurate predictions of ice formation several hours' ahead, valuable warnings of road ice could be issued to the public as well.

In this study, some samples of low dynamic systems acting on Alborz mountain (Haraz and Firuzkuh roads) causing heavy precipitation and intense icing, and another sample atmospheric situation on area have been simulated by using mesoscale meteorological model which is called limited area model MM5.

MM5 is run with two-way nested grids initialized at 1200UTC using initial and boundary conditions from the NCEP's operational Aviation model output. It is configured with two domains. The outer domain has a horizontal grid spacing of 15 km and covers the large area, and an inner

domain that has a horizontal grid spacing of 5 km and covers Alborz mountain and Tehran area. The number of grid points and grid width amount to 135 95 with 15 km, and 64 64 with 5 km for domain 1, and 2, respectively. The MM5 produces 3-hourly output to 72 hours in nested 15 km and 5 km grids. MRF and BETS-MILLER schemes are used to parameterizations of convection and boundary layer processes respectively. The model was run for two different weather situations, one with a presence of dynamical low pressure that produced sever precipitation and ice formation, and the other one with a stable system over the region. The model outputs for the innermost nest were studied for the first 72 hours of the forecast. The model results were compared with observed 2m temperature at Abali, Firuzkuh and Aloodegi stations.

At first, a number of experiments were carried out for different biases at observation locations and performs an analysis over the grid to estimate the spatial field of model forecast bias. Comparison of height from level between the topography used in the MM5 model and the selected meteorology station indicated existence of errors in the heights of topography used in the model. The height difference is a factor leading to forecast errors in the model. For each model grid point, the bias computed at the nearest 3 observation stations which are within 300-450 m vertical elevation from the model grid point elevation and are of the same basic landuse category as the model grid point are averaged. The heights for the station of Abali and Aloodegi are underestimated and for the Firuzkuh station overestimated in the model. Surface temperature prediction for the station higher than 2000m in height Abali and Aloodegi are more exact than prediction for the station lower than 2000m in height. For better justification, the need to compare more selected station seems to be urgent. So mesoscale model forecasts can contain significant systematic errors for forecasts of temperature trends. Because these biases are so systematic, some methods can be successfully used to correct for them.

Experiment 2 was set up to assess the effect of increasing vertical levels. Increasing the number of vertical level in the model from 23 to 40 levels, do not reveal significant improvements in the forecasted temperature fields, that considering height of present stations, increasing number of vertical levels in lower parts could be one of factors for that.

Regarding shortcomings of numerical models in mountainous regions with complex topography as beside Alborz predictions of the MM5 model were of acceptable accuracy. If the temperature variations trend to be predicted by the model with a relatively good accuracy, then icing can be predictable. With more experiments and suitable physical schemes in boundary layer of the model and possible past processing using statistical methods, instead of using estimated correction coefficients more accurate predications can be expected. But in these regions that even the number of target stations are not enough, prediction of variation trend of meteorology quantities with comparable acceptable accuracy can be quiet beneficial.

Key words: Numerical mesoscale model, Mountainous Roads, boundary layer processes, Road Weather

■ ID 47

Presentation of a climatic classification with approach on road pavement management for west and northwest of Iran

Payman Mahmoudi
University of Sistan and Baluchestan (IRAN)

Since the early times the primary methods were used to make civil projects and especially transportation networks at present time which is designed complex and exact method, the climate and its properties have usually had direct interference for making tendency of structure as an important and vital parameter.

Iran which has located in western south of Asia between the altitudes from the northern grids 25 – 40, had been had the pass way of different climatic systems and masses in which its result has been nothing but produce the various climatic regions on its land. So regarding the variety of regions in this land, there is exactly necessary a great attention to climatic phenomena to manufacture and exploit of transportation projects .Then in this study to achieve the classifications having the same climatic properties making attention to use to the west and northern west region of the country base on road pavement management necessary.

The making this classification, it has been exploited for period of 15 years through 10 meteorology parameter from 38 synoptic stations in thr regions. Firstly, the achieved that has been converted to the standard Z score then selected by Cluster Analysis method, as an advanced statistical analysis to clustering the stations and finally those classifications. The produced classification was placed on the under groundwater zoning and the final classification produced at GIS environment. For the latest step the necessary suggestions were presented to correctly road pavement management for each class.

Word keys: Iran – classification- road pavement- cluster analysis- GIS

■ ID 28

Statistical forecasting of traffic flow rate

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Road traffic is a consequence of population activity to which many individuals participate. In spite of this, the traffic flow does not exhibit completely random character since the population activity is synchronized to a high extent. The synchronization is stimulated externally by environment due to variable illumination by solar light and weather conditions, and internally by population itself due to agreements about working days and holidays. The external stimulation can be physically described by the time and variables representing weather conditions, while the internal

one has to be modelled by some specific dynamic law. Consequently, we consider the road traffic flow as a non-autonomous dynamic phenomenon and describe its properties statistically by a non-parametric model. The basic information for the creation of the model is extracted from records of traffic flow rate and related environmental variables. In this presentation we represent the time variable by a periodically changing hour, and a day-code variable that takes into account the character of a day specified by the calendar, while the weather variables are not considered explicitly. Based on the time series of these variables and the recorded traffic flow rate an optimal predictor of the traffic flow generator is created by using conditional average estimator. The condition is comprised of the hour, day-code and a certain number of past flow rate data. As an example the traffic flow rate at a representative point on a Slovenian high-way is modelled. The model is then utilized to forecast the future traffic flow rate. Seasonal variation is accounted by including into the modelling just a proper section of the past flow rate record. Applicability of this statistical method is indicated by the correlation coefficient r of the forecasted and really observed traffic flow time series. Forecasting in the year 2007 yields the mean value <r>~0.95 which indicates a rather accurate modelling. The performance of forecasting generally depends on the combination of variables representing the condition. This dependence is demonstrated in the presentation by changing the number of past flow rate data in the condition. An optimal combination of variables comprising the condition is estimated by the analysis of correlation coefficient value. The resulting optimal combination provides new information for the theoretical treatment of traffic flow dynamics.

■ ID 50

The Conference Committee of Experts

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SIRWEC Beginnings

In February 1984 an International Road Weather Conference was held in Delft and in the Hague. The conference was arranged by the committee responsible for COST 30 BIS Theme 2-Detection of weather conditions. This conference was attended by over 50 people from 13 countries. In discussions about concluding COST 30 BIS, the meeting appointed a voluntary steering committee of seven people, on an ad hoc basis, to draw up an agenda for future co-operation. The results from the demonstration, the research work and the conference have proved that there is an urgent need for further research and international co-operation in the field of weather conditions on the roads.

The steering committee met at Birmingham University in September 1984. A constitution for the Standing European Road Weather Commission (SERWEC) was agreed. The constitution was approved by the Second European Road Weather Conference, which was held in Copenhagen from 26th February to 1st March 1985.

SERWEC became International in 1992 in the US, thus changing its name to SIRWEC accordingly.

Year Conference number City Country

1984	1st	Conference	The Hague	Netherlands
1985	2nd	Conference	Copenhagen	Netherlands
1986	3rd	Conference	Tampere	Finland
1988	4th	Conference	Florence	Italy
1990	5th	Conference	Tromsö	Norway
1992	6th	Conference	Minneapolis	USA
1994	7th	Conference	Seefeld	Austria
1996	8th	Conference	Birmingham	UK
1998	9th	Conference	Lulea	Sweden
2000	10th	Conference	Davos	Switzerland
2002	11th	Conference	Sapporo	Japan
2004	12th	Conference	Bingen	Germany
2006	13th	Conference	Torino	Italy

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