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IMPLEMENTATION OF A RESIDUAL SALT MODEL

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Summary

A REsidual Salt Model (RESM) is used to estimate the need for sating. There are several use of a RESM. In case there is no salt on the road the RESM can be used to estimate the needed dose of salt to avoid slippery roads. If the road is already salted the RESM will estimate the need for additional salting. Further-more the RESM is useful to make differential salting of the road network depending on local conditions. All together the RESM is needed in a Management Decision Support System for winter maintenance. This enables dynamic salting routes as well as a planning tool for optimal timing and dose when salting the road network. In this report implementation of MOdelling Residual Salt (MORS) model at Danish Meteorological Institute (DMI) is described. The model was developed in the framework of NordFoU (nordfou.org) [1].

Introduction

In many situations it is obvious that salt has to be spread. This would be a direct consequence of the present weather such as snow fall, icy or wet roads. After the salt are spread it will often in these cases be removed very fast by run-off of water, melting water or mechanical by vehicles. Even if large amount of salt are spread it will soon be flushed away. Additional to this process traffic can splash the water away from the road. Also evaporation

and condensation of dew and rime to the road can have an important role and strong wind will also enhance the process. In many other situations the salt will not disappear so fast. This could be on by-cycle lanes and in less travelled roads. Further-more in relative dry situations dominated by rime or dew in the night time the road is only exposed to little water and minor traffic. As a part of a development of Management Decision Support System for winter maintenance, models to simulate these processes have become more and more requested. Recently a RESM was implemented at DMI. The model is based on a project developed in the framework of NordFoU [1]. The detailed description of the model can be obtained from nordfou.org [1].

Model description

The details of the model is described in [1]. Here we will only outline the basic model properties. In practice the road is divided into two parts:

- Wheel tracks (Wt)
- Between wheel tracks (Bt)

In that sense the model can be seen as a two box model. The basic parameters to describe the road is

- Width of the road
- Slope of the road
- Roughness of the road

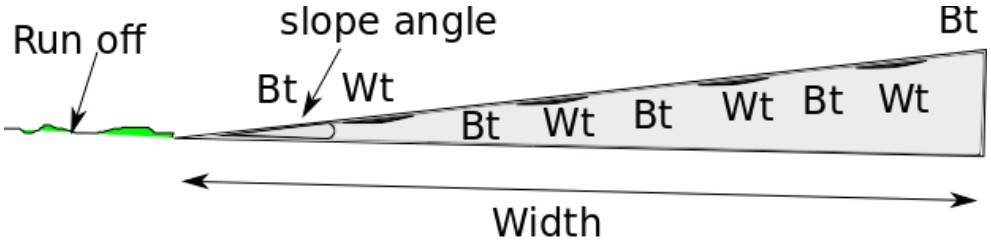

Fig 1. The road is divided into wheel tracks and between tracks and a run-off zone.

(Fig 1) shows the properties of a standard road. It does not matter how many wheel tracks the road has. This is implicit contained in the road width. The output from the model is basically four parameters

1. Salt in Wt
2. Salt in Bt
3. Water in Wt
4. Water in Bt

These four parameters should also be known as initial conditions and is obtained partly from a first guess from a previous model run and partly from reported salting. The salting data are obtained from the Danish Road Directorate (vd.dk) and contain information of the amount of salt spread, type of salt, position and time of day. If the model is cold started the four parameters are all set to 0. The model consists of an equation for each parameter. The basic forcing of the model is salting information, precipitation, wind and traffic density.

Water and salt start to run off the road when the water height reach a critical level. The run off is enhanced by precipitation, wind and traffic. Further-more there is an exchange of water and salt between wheel tracks and between tracks. In order to take dew and rime in to account evaporation and condensation on the road are also calculated.

The model run in two different modes

1. Assimilation mode
2. Forecast mode

In assimilation mode information of spread salt is inserted during the model run. Further-more radar data is used to provide precise information of precipitation. In principle also real time data of traffic density can be used but for the time being only a statistical product of traffic density is used. For wind speed and calculation of evaporation/condensation input from a Numerical Weather Prediction (NWP) model is used. In forecast mode it is assumed

that salt is not spread. Also radar data is re-placed with forecasts of precipitation from a NWP model. The use of radar data is crucial as precipitation is one of the main uncertainties in the calculation of residual salt and using radar data in the assimilation mode is necessary to get good initial conditions.

Results

The RESM were initially in the framework of NordFou tested developed and tested against field experiment and at test sites. However the RESM was not brought into an operational environment. In the first implementation at DMI the goal has been to setup an operational model and do subjective verification. Does the model as expected? (Fig 2) shows salt in wheel track as a function of time under different weather conditions for a road station in Denmark where the initial condition is set to 15 g/m^2 salt on the road. In these cases the traffic density has been set to a fix value with little traffic. As expected salt is removed fastest in the light rain case. In the dry case salt is removed slowest and the rime case is in the middle. This is completely as expected. For the time being there is few good observations of residual salt and the most reliable observations are done manually often referred to the instrument as SOBO 20 measurements which are very costly in man power. It is also the experience that the variability of residual salt can be very large when measured. As precipitation is a key parameter forecasting of residual salt will depend of the quality of rain forecasts. The quality also depend of forecasts of traffic density and history of spread salt. It is well-known that the information of spread salt is uncertain. All together this will result in uncertain initial conditions. The forecast of residual salt depends also on parameters with high uncertainties in particular precipitation. For this reason radar data is used in the assimilation step of the model.

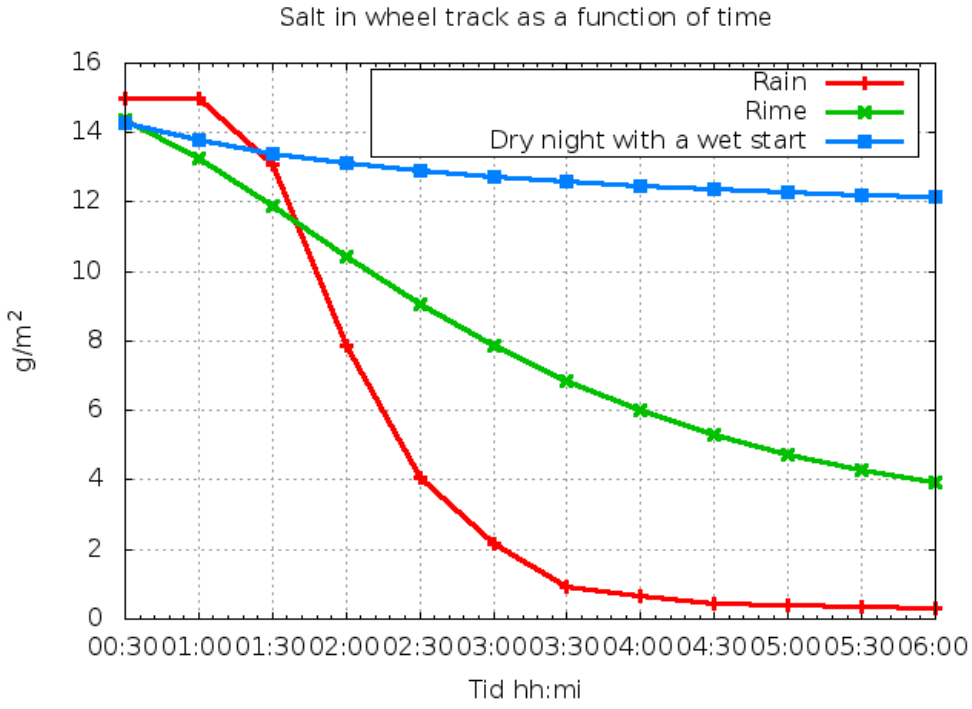

Fig. 2. Tree experiments of residual salt as function of time are shown. Initial time of the model is 00:00 UTC in Denmark and residual salt is set to 15 g/m^2. Output from the model is every 30 minutes.

Conclusion

The RESM has been implemented successfully. Technically the system is complex and requires input of many parameters as well as the initial state of the road. In particular the amount of spread data have large variability and this is also the case for precipitation. However if these conditions are known the model can perform good forecasts. In cases where the uncertainties are high the model can be used to estimate the potential salt loss by running the model with a pre-set value of salt as shown in the experiments in (Fig 2). It is expected that the model will be operational in 2022 and that the model quality will be subjectively verified by users of the product and also from SOBO 20 measurements when these become available,

Acknowledgements

The implementation and development of the RESM has been done in corporation with the Danish Road Directorate (vd.dk) and the model is adopted from NordFoU.

References

[1] NordFoU (nordfou.org). **2015**. Implementing guide *http://www.nordfou.org/Documents/MORS/MORS_Implementeringsguide.pdf* (accessed 2022-04-29). Language in Swedish.