THE COUPLED ROAD WEATHER AND ROAD DUST MODELLING SYSTEM FOR AIR QUALITY FORECASTS IN NORWAY

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Summary

Since 2019 an operational air quality forecast system has been implemented in Norway. Part of this forecast system includes the prediction of road weather and road dust emissions, which are an important source of air pollution in Nordic countries. It is necessary to forecast road weather since it controls the surface conditions and the emission and accumulation of road dust. The model used is the NORTRIP model. This paper briefly describes the coupled road weather and road dust model, it’s application in Norway and the exploratory web site used to monitor road weather conditions, road dust accumulation and emissions, air quality, meteorology, as well as real time traffic and winter road maintenance activities.

The forecasting system

The air quality forecasting system, which includes a road weather and road dust emission forecast using NORTRIP [1,2], is available to the public through a web site hosted by the Norwegian Environment Agency [3]. 66 hour forecasts are made 4 times a day at a spatial resolution from 50 – 250 m for all of Norway. These forecasts are publicly available, Figure 1. Access to the underlying road weather part of the forecast system is through an additional web site, hosted by the Norwegian Meteorological Institute [4]. Road weather calculations are made for all public roads in Norway, around 720 000 individual road links. More information concerning the air quality modelling and forecasting can be found in [5].

Fig. 1. Example of the air quality forecast for PM_{10} in the Oslo region showing high emissions from road dust on the major arterial roads. Forecast for April 12’th 2024 at 1 pm. [3].

The NORTRIP model

The NORTRIP model consists of a water/snow/ice mass balance module, a surface energy balance module and a road dust (sand/salt and road/tyre/brake wear) mass balance module. Road dust emissions are calculated based on the surface conditions, with emissions of road dust available only under dry conditions and with the accumulation of mass on the road surface during wet conditions. Wet removal processes for road dust and water/ice/snow include drainage, vehicle spray and snow removal. Salt and dust binder are included in the model, impacting on both the freezing temperature and the vapour pressure deficit. The model is described in [1,2] and has been applied in a number of applications outside of the forecasting [6,7].

The model uses information on studded tyre share, traffic volume data, road quality, meteorological data and winter maintenance data to calculate these emissions. Traffic information is provided per road link from the Norwegian National Road Database [8] (NVDB) and winter maintenance activities are usually prescribed as a set of rules per municipality. Meteorological forecast data is from the AROME-MetCoOp modelling system [9]. Real time winter maintenance data can also be implemented in the model when available.

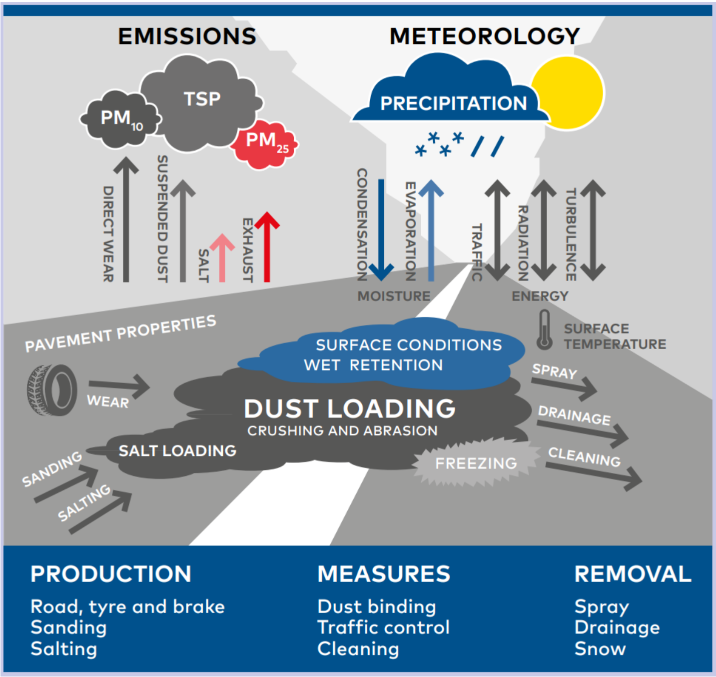

Fig. 2. Schematic representation of the processes described by NORTRIP. Taken from [10].

Exploratory web application

Whilst the air quality is the final result of the forecasting system, road weather has come into greater focus as the most sensitive process for predicting air quality. To enable a better understanding of the road weather aspects of the model an exploratory web site has been developed [4], which is publicly open. This web site allows a direct comparison between a number of measured and modelled parameters, listed in Table 1. These parameters are available at measurement sites which include, roadside meteorological sites, air quality measurement sites, traffic camera sites, traffic counting sites and customised sites. Forecasts for the coming 2 days are provided, and historical data can be explored. Examples of road surface temperature and air quality forecasts are shown in Figures 3 and 4 respectively.

Table 1. Modelled and observed parameters available on the road weather web site [4].

Parameters	**Description**	**Observed(O)/ Modelled(M)**
Traffic counts	Comparison of modelled and observed traffic at traffic counting sites	O/M
Road surface temperature	Comparison of modelled and observed road surface temperature at roadside meteorological sites	O/M
Road surface conditions	Comparison of modelled and observed (when available) road surface conditions at road side meteorological sites	O/M
Road surface energy balance	Modelled surface energy balance	M
Meteorology	Modelled and observed precipitation, air temperature, relative humidity and wind speed and direction	O/M
Air quality	Comparison of modelled and observed air quality at air quality stations including NO_2, PM_{10}, $PM_{2.5}$ and O_3	O/M
Surface dust and salt loading	Modelled road dust (PM_{200}), sand, dust binder and salt loading	M
Road dust emissions	Emissions from each road link of PM_{10}	M
Winter road maintenance activities	Mostly modelled but also real time data from Trondheim Municipality is available for comparison	O/M
Roadside cameras	From the Public Road Authorities	O
Street view	From Google	O

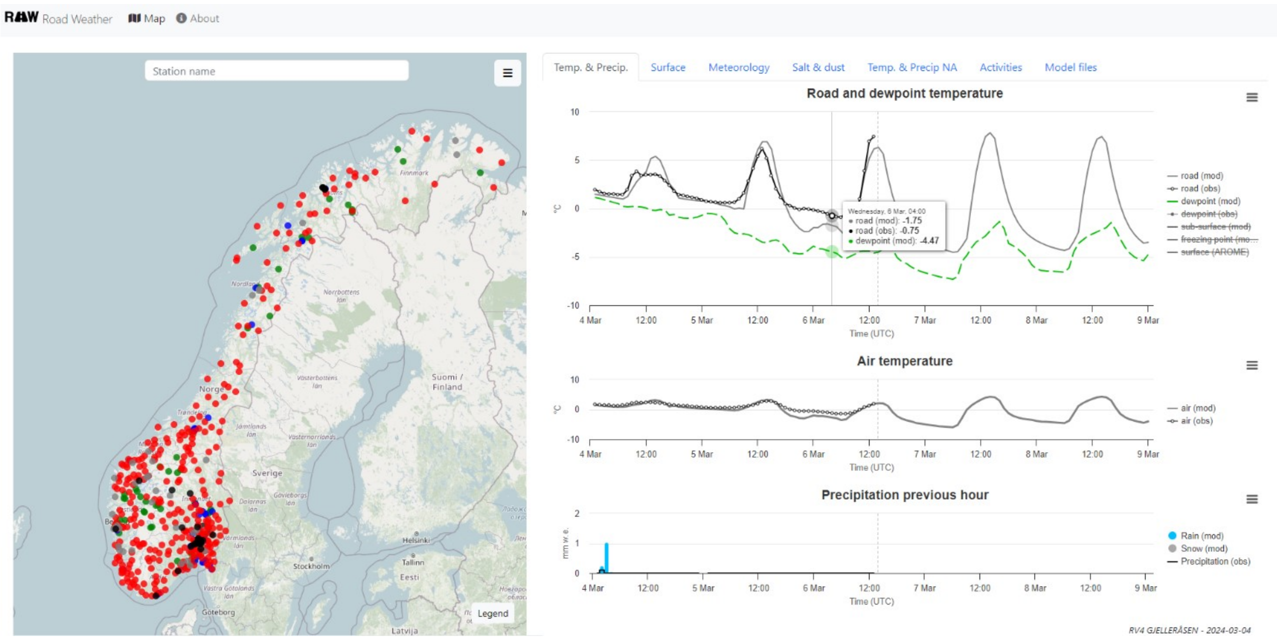

Fig 3. Start page of the exploratory web site [4]. On the left is a map showing all the available measurement sites. On the right road surface temperature, dew point temperature, air temperature and precipitation, both modelled and observed.

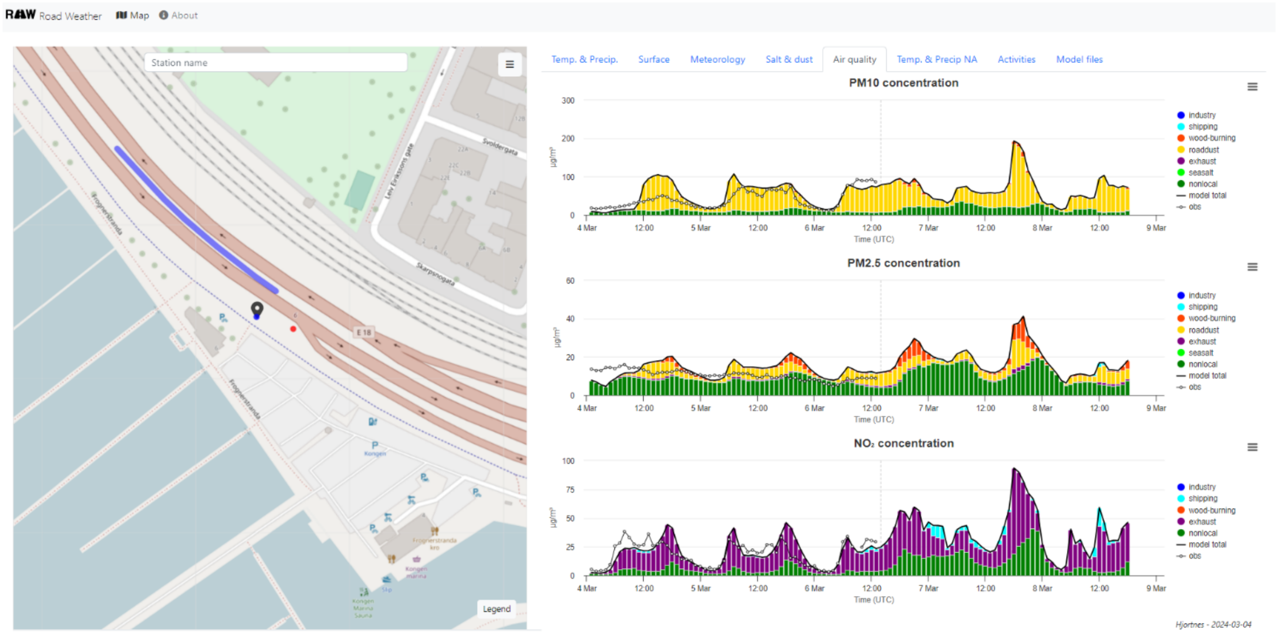

Fig 4. Air quality page of the exploratory web site [4]. On the left is a map showing the chosen measurement site. On the right observed and modelled PM_{10}, $PM_{2.5}$ and NO_2. The yellow colour indicates modelled contributions to PM from road dust emissions.

Recent and upcoming developments

The road weather aspects of the modelling are to be improved in the current and near future. Already real time road winter maintenance data have been implemented in the model for one municipality, Trondheim, where data has been made available. Roadside cameras are currently being used to train machine learning algorithms to recognize road surface conditions. These will then be used to help initialise the forecasts, along with the few stations currently measuring road surface conditions. The current forecasts for road surface temperature do not use observations for initialisation of the forecasts. Suitable interpolation routines will be developed to allow a more observationally based initialisation to be implemented.

Conclusions

Though initially developed for air quality applications the NORTRIP model has shown itself to be a useful and reliable road weather model. It's dual functionality of road weather and road dust emissions makes it unique. Coupling of these two processes is essential in air quality applications since the road dust emissions are controlled by road surface conditions. Correctly predicting the state of the road surface has shown itself to be challenging, so extra efforts are currently being made to improve the road weather aspects of the model. This will be to the benefit of not just air quality applications, but also road maintenance operators, transport firms and the public at large.

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