NEW APPROACHES IN MODELLING OF WEATHER IMPACT ON TRAFFIC FLOW

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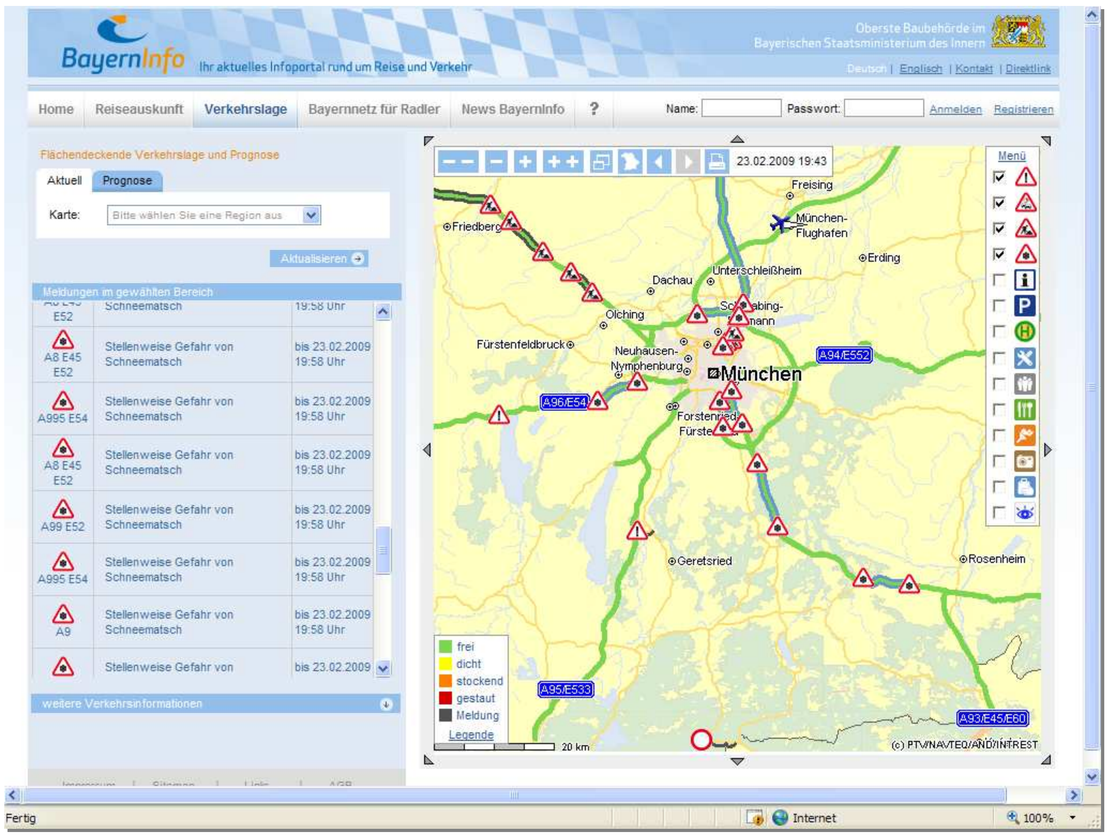
Introduction

The knowledge about the influence of certain weather conditions on traffic flow and driving behaviour become more and more an important issue for transportation authorities as well as for road users. The accuracy of travel time prediction and traffic condition forecast decreases significantly without considering the weather and road surface condition. A lot of research works are published in the past covering different isolated aspects of weather conditions and the influence on traffic or driving behaviour, such as aquaplaning, tire friction, effect of rain etc. But there is no comprehensive model available, describing the impact of all weather aspects on the traffic flow. The aim of the work was, to fill that gap.
The model provides the parameters of a complete fundamental diagram of highway lanes due to certain weather parameters, which could be obtained from weather forecasts. The model approach was developed in two ways. First by using theoretical driving dynamic relationships with the key parameters tire friction and visibility for the structure of the model. And second by analysing real weather and road surface condition data in correlation with acquired traffic flow data. An innovative description model for the fundamental diagram based on the velocity and traffic density level was used. Therefore the fundamental diagram can be described by a few basic parameters e.g. free velocity, critical traffic density and velocity and maximal density. These parameters can be expressed in dependency to the weather condition. The paper describes the basic principle of the model approach and shows results of the analysis and also demonstrates applications for winter maintenance decision and for traffic information services. The model approach was also used for estimation of capacity reduction of highway lanes under adverse weather conditions. The capacity reduction factors associated to weather condition classes have proven there reliability in field tests under the framework of a research project “congestion prevention on winter conditions” by order of the German federal highway institute. Existing road weather information operation platforms can be enhanced in order to give outputs to weather calibration of traffic forecast models.

Road Weather Information Service Operation Platform

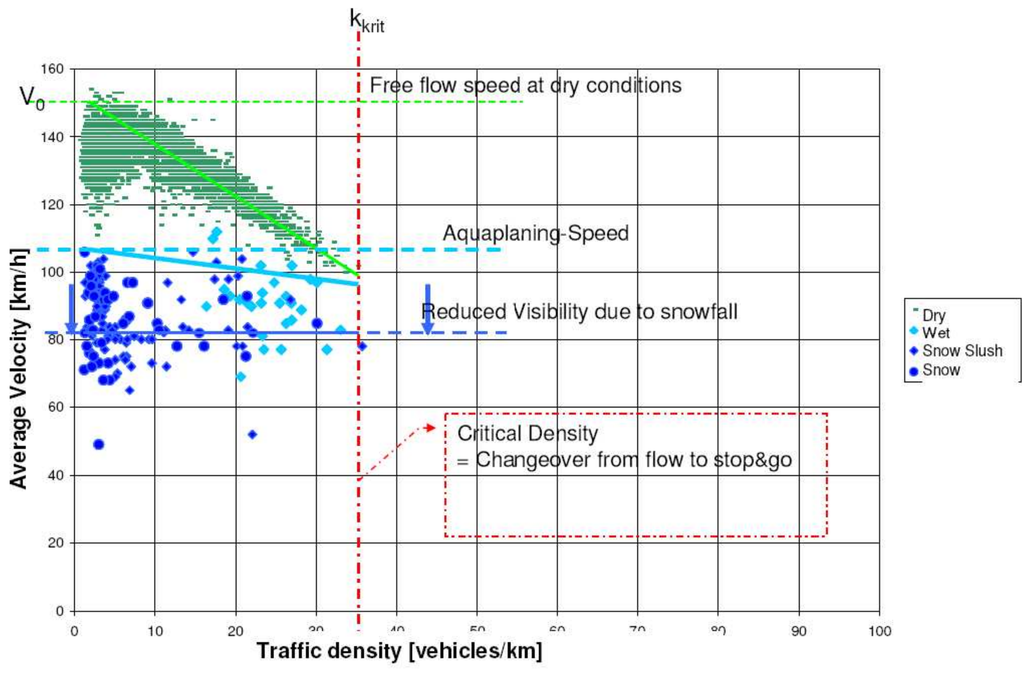
Weather incidents like thunderstorms and strong showers, fog, chilling humidity, and snowfall represent serious safety risks on roads. Local thunderstorms will inevitably lead to a prolongation of travel time. Appointments cannot be kept; individual stress and the risk of accidents are rising. Sleekness caused by rain, snow and ice is playing a vital role in about 30 % of all accidents within Germany and similar situations are discovered in other European countries. Finra encountered that the accident rate under snow condition is principle two times bigger than on bare, dry roads. But the risk of accidents is even 10 … 30 times higher if a critical road condition like snow or ice occurs unexpectedly [3].
This risk can be reduced by accurate, road related warnings of unfavourable weather and road conditions. Therefore a road weather information platform was developed by micKS MSR GmbH under support and cooperation by the BMW Group FIZ and also in cooperation with the T-Traffic company ddg GmbH. Under the framework of the Bavarian traffic information agency VIB a fully regularly operational weather platform was established (see front end example in below figure).
This service operation platform is able to process different meteorological and road weather data sources, which also can have various time and geographical references and producing TMC coded warnings and messages referenced to short road sections based on digital map links or TMC locator. The fusion of various data sources is achieved by a knowledge base.



Front End Example of www.bayerninfo.de

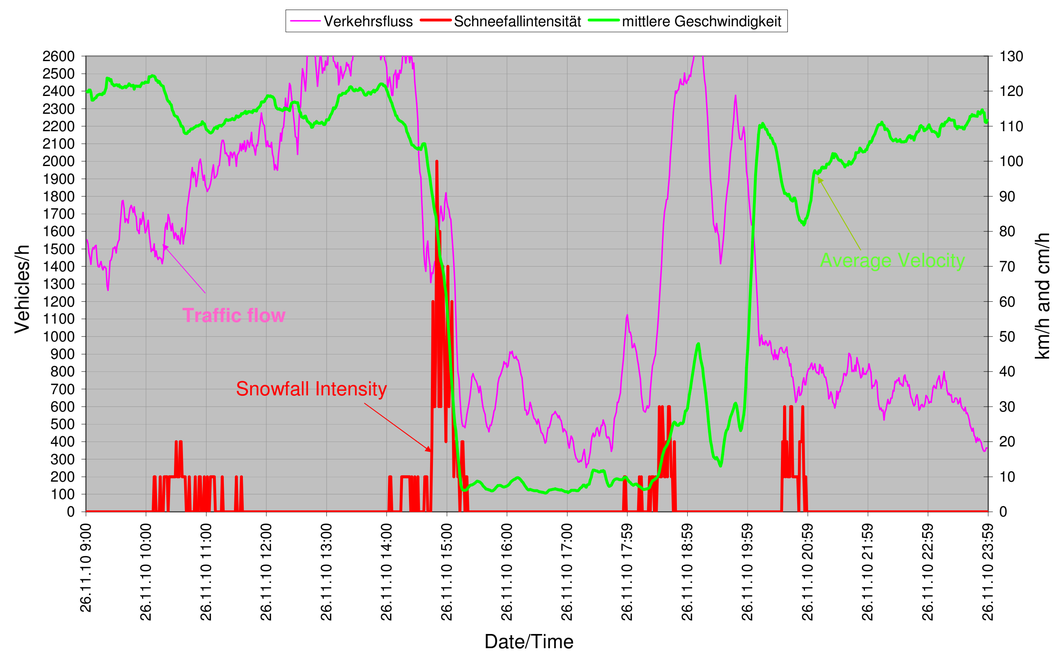
Modelling of Traffic Flow due to Weather Conditions

The traffic&weather model approach using the fundamental diagram model of Ning Wu [4], which uses a few key parameters in the velocity/density diagram, such as free flow speed, critical speed and density and time gab for the 3 traffic flow phases. The traffic&weather model approach is targeted on the description of these key parameters in dependency of the weather parameter. The weather parameters used, can be actual measured by road weather remote sensors or forecasted in order to enhance traffic flow and travel time forecast. The model approach was also proofed under the framework of the research project “Prevention of tailbacks by determining the "critical traffic volume" on federal motorways in winter”, supported by the German Highway Institute (BASt). Here the model was used to determine the traffic capacity of road section due to certain weather condition classes. Traffic data and road weather data where compared with the model output (see figure below). A more comprehensive German/Austrian research cooperation project “WOLKE” is currently in progress.



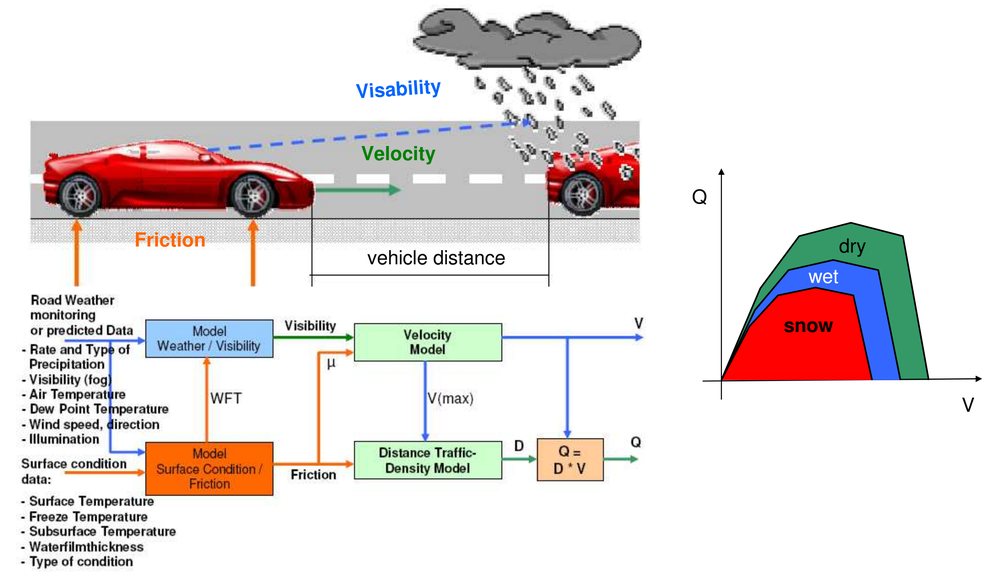
By integrating the traffic&weather model, the road weather information service operation platform is able to give actual or forecasted fundamental diagram parameters like free speed and capacity for every road segment (or link) in order to determine the expected travel time for each segment.

Analysis of Traffic Data and Road Weather Data

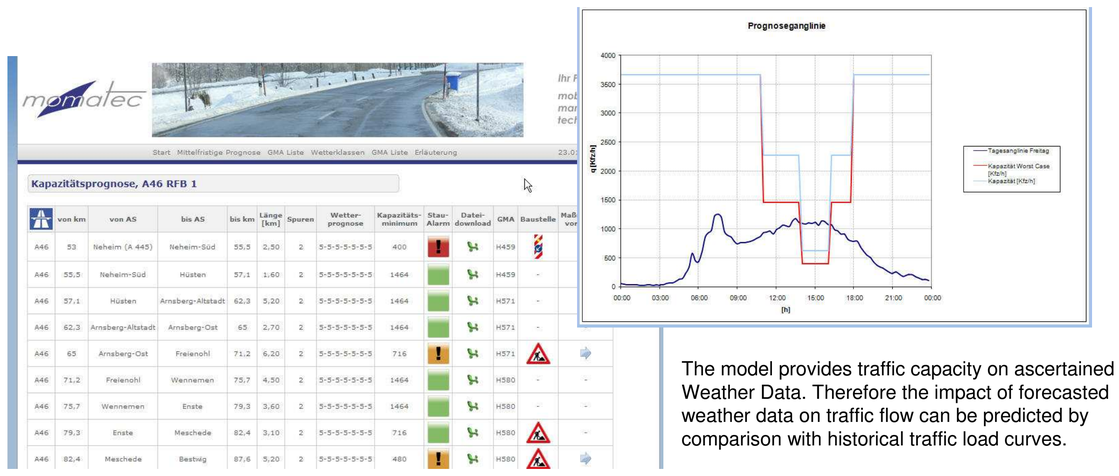


The above diagram shows a situation on Bavarian Highway A8 with high traffic intensity and a significant high snowfall rate where at first the visibility reduction causes a fast increase of the velocity of the vehicles and then a critical road surface condition causes accidents. The accidents are the reason why the congestion last significantly longer, than normally after the snowfall discontinues.

Complete Model describing the fundamental diagram due to Road Weather Measures



Application example: Maintenance Decision Support - Forecast of Weather related Traffic congestion



The model provides traffic capacity on ascertained Weather Data. Therefore the impact of forecasted weather data on traffic flow can be predicted by comparison with historical traffic load curves.

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