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A road map towards implementing a probabilistic road weather information system

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ABSTRACT

The German National Weather Service runs a dedicated forecast system for providing detailed information on the road conditions in Germany. This road condition and weather information system, called SWIS (Straßenzustands- und Wetter-Informations-System), was set up about 20 years ago with the objective to support the efficient management of the German road network, especially during winter time. It aims to enable decision-makers to optimize their planning and distribute their resources in the most cost-effective way. Considering the inevitable uncertainties of weather forecasts, and recognizing the potential benefits of incorporating reliable predictions of these uncertainties in the decision-making process, we are in the process of extending our forecast system to incorporate such probabilistic information. Whilst the technical implementation of such a system seems to be a relatively straightforward process, it is expected that the transfer of the probabilistic information into the decision-making processes of the users might pose the greater challenge. This contribution will outline the road map and first user feedback on the implementation of the probabilistic component in SWIS.

Keywords: road weather forecasts, probabilistic information, decision-making

1 INTRODUCTION

The road condition and weather information system of the German Nation Weather Service (DWD), called SWIS (Straßenzustands- und Wetter-Informations-System), was initially set up in the early nineties [1]. After the early years, when the system was continuously maintained and improved, there have been only few further developments, mainly due to a serious lack of resources. However, in order to improve this suboptimal situation, more recently it has been possible to reallocate personnel resources and to reinstate a SWIS development team. The task of this team is firstly to assess the current status of the system, in particular possible deficiencies and potential for improvements, and secondly to develop and implement the most useful improvements. In order to achieve the best possible benefit for the user community, all these developments have to be done in close collaboration with the users. That is, the communication at the interface between users and developers is a crucial part of the whole process.

This contribution will outline the basic features of the current system in the next section, describe the development plans in section 3, discuss our first experiences with user communication and feedback, and finish with a summary and brief outlook on further steps.

2 CURRENT SYSTEM

From the users point of view, the current system provides all relevant information and forecasts necessary for an effective management of the road maintenance in one comprehensive system. That is, both observations and forecasts are presented to the users in a common framework when accessing the so-called SWIS-GBG (where GBG stands for "Geschlossene Benutzer Gruppe", which can be translated to "restricted access user group"). Insofar users have easy access to observations and forecasts of the variables which are specifically related to the road network, i.e. road-conditions and -temperatures, but also the so-called meteorological variables like air temperature, dew point, wind, etc. are provided at the same time. The users expect that the meteorological and

road-specific forecast variables are consistent with each other, especially in such a closely related system. As such, it is important that both the meteorological and road-specific variables are calculated and presented in a consistent manner. For the current system this has not always been the case because some of the products are based on representative or average data, which could cause certain inconsistencies in some situations. Therefore, the consistency of the whole product range will be one major aspect for further development plans.

In the current system, the following products are mainly used by the user community:

- **General road weather forecasts**, describing the general weather situation for larger areas in Germany (the "Bundesländer"). These forecasts are produced five times a day in the form of a text forecast for day 1-3 and numerical forecast for day 3-10.

- **Detailed road area weather forecasts**, providing eight times a day the forecasts of road-temperature and -conditions, air temperature, precipitation, wind, and cloud cover as tabulated values for a lead time of 27 hours.

- **Point forecasts**, producing every hour forecasts at all available road observation stations in Germany with 7 hours lead time.

- **City weather**, consisting of a textual forecast, provided for the area surrounding the particular city, and the numerical values of the 24 h forecasts for the related road observation station.

The detailed road area weather forecasts, which are also called "SWIS tables", can be regarded as key product of the whole suite of SWIS forecasts. However, the particular way they are currently produced can cause some inconsistencies and difficulties in their interpretation. The underlying problem lies in the fact, that there is no full consistency between the initial conditions and atmospheric forcing used to drive the Energy Balance Model. As illustrated in Figure 1, on the one hand the EBM uses the observed road temperature of a single, representative road observation station as starting value (blue circle), and on the other hand the area average value of the predicted atmospheric conditions over the forecast period is used as forcing (red square, averaging the green circles). These values are then used as input for the EBM, so that the predicted values of road temperatures and -conditions are based on a mixture of area average values and local observations. In particular when comparing this "hybrid" forecast values with local observations at stations, inconsistent results are inevitable.

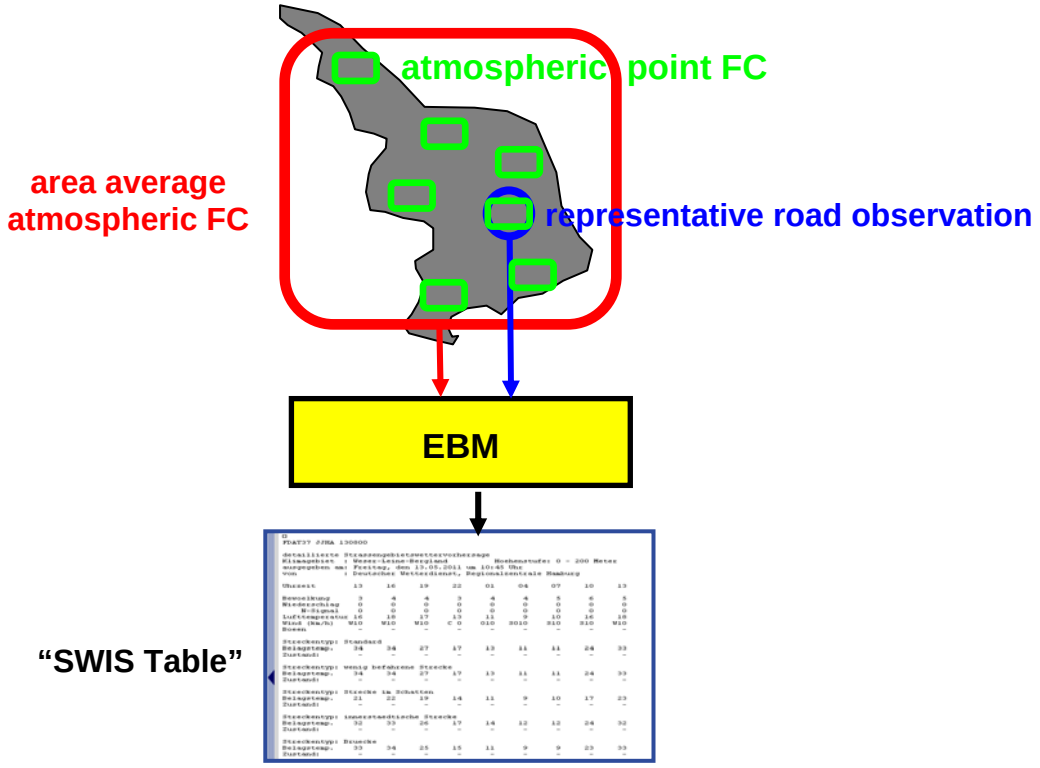

Figure 1. Current principle of producing the detailed raod area weather forecasts, i.s. the "SWIS tables".

3 DEVELOPMENT PLANS

In order to avoid above described inconsistencies and to generally improve the system to provide more detailed information for supporting the decision-making process of the users, the following two-step concept has been developed.

3.1 Introduction of information on spatial variability

The first step of the development process is incorporate information on the spatial variability of the forecast into the system. In order to make informed decisions for the efficient management of the road network, it is important to not only have information on the average conditions in larger areas, but to be aware of possible extremes in the area under consideration.

To support this requirement, in the future system the Energy Balance Model will not be run by using only average forcing conditions for the pre-determined so-called “SWIS areas”, but it will be run individually for every available road observation station (Fig. 2). That is, in contrast to the current system, we will use the individual road observations (blue circle) and the respective atmospheric forecasts (green square) at each individual station to run the EBM. After producing these individual forecasts for road-conditions and -temperature, there is the possibility to either create the current-type “SWIS tables” or new-type “SWIS graphs”. Here the users have the possibility to individually choose a number of locations of their special interest, which are consequently used to create the graphs. This new form of displaying the forecast information has the advantage that, on the one hand users can individually choose their points of interest, and on the other hand they get a quick overview of the variability of the forecasts over space and time.

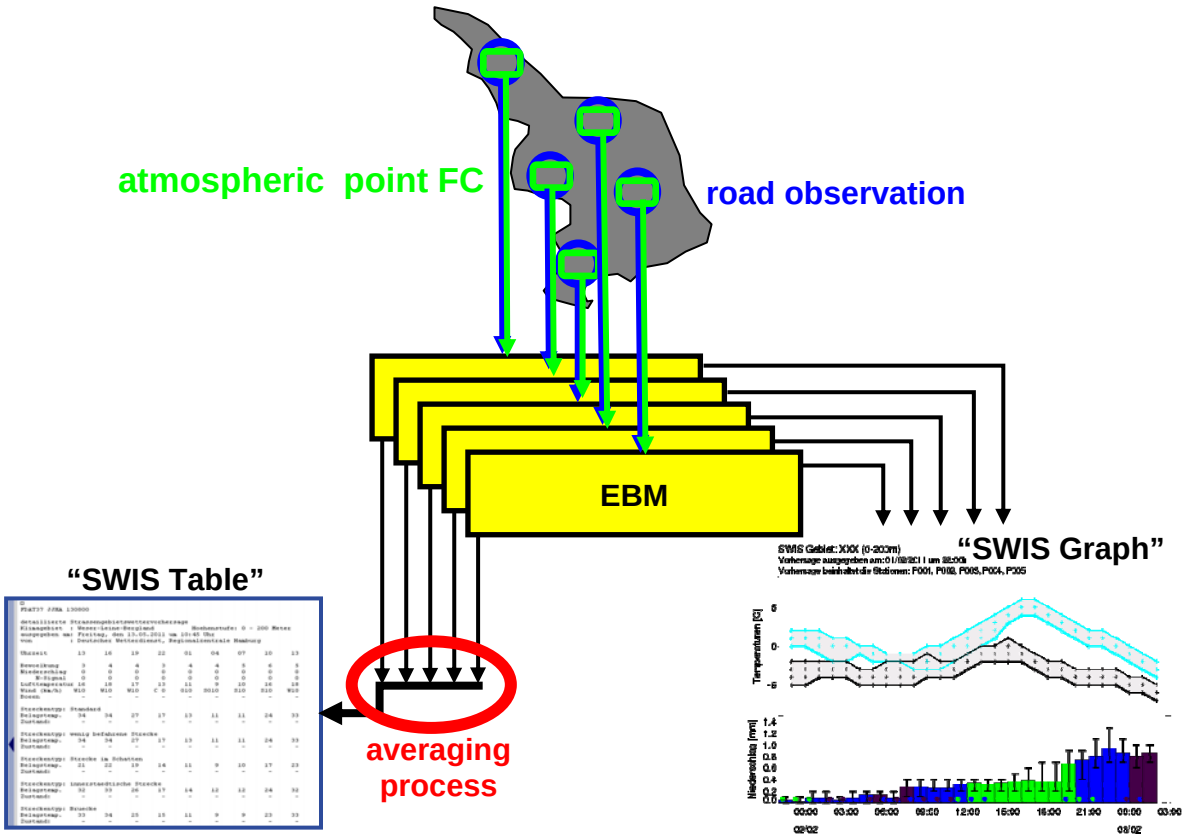

Figure 2. New principle of producing the detailed raod area weather forecasts, i.e. both the current-type “SWIS tables” and new-type “SWIS graphs”.

3.2 Introduction of information on uncertainties

The second step in the new concept will be to incorporate uncertainty information on both errors in the observations and forecasts into the system. This will be done by running a whole ensemble of EBM forecasts for a single station (Fig. 3). The ensemble is created by taking into account both the uncertainty in the observation of the initial condition and the uncertainty of the atmospheric forecast used as forcing for the Energy Balance Model. That is, the observation of road-temperatures at the station will be perturbed by the observation error, and the forecast error will be represented by using an ensemble of point forecasts for that particular station. As a result the system will create an ensemble of forecasts for individual stations, which will be used to produce probabilistic forecasts products.

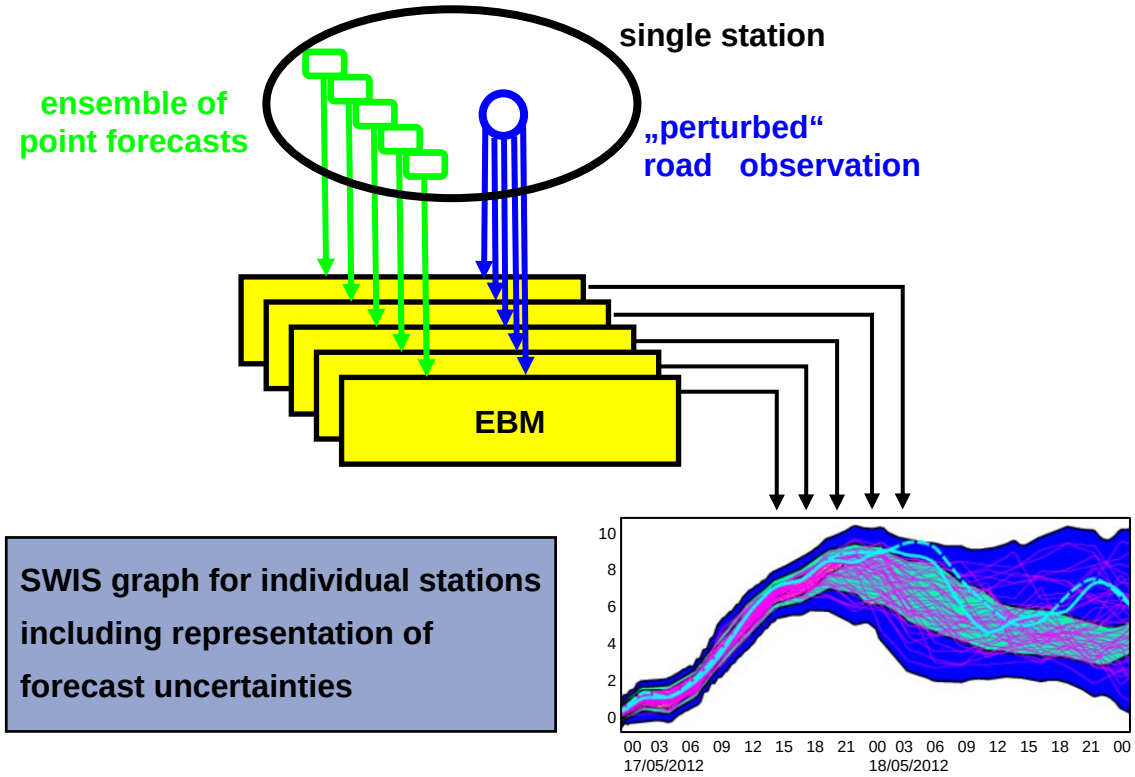

Figure 3. New concept of extending the deterministic SWIS forecasts to a probabilistic system.

4 USER FEEDBACK

Users of forecast products generally have two main requirements, i.e. they want to know (i) as precisely as possible and (ii) as early as possible about future developments. However, it is well known that there are limits to the predictability of the atmosphere [2]. Therefore, it can very beneficial to base ones decisions on probabilistic information [3]. On the other hand, it is not always straightforward how best to incorporate such probabilistic information into the decision/making process of the specific application. In order to make optimal use of this information, close collaboration and intense communication has to be established between forecast developers and users.

After having presented first ideas on future developments for the system, including the incorporation of information on spatial variability and uncertainties of the forecasts, we received the following feedback from the users:

- The new generation of road agents entering the service is happy to work with new technologies including new (probabilistic) forecast products
- Established products should not be withdrawn, or only if they are replaced by other products giving comparable information
- Information overload has to be avoided

- The forecast product range should facilitate both a quick overview of the situation and the possibility for a more detailed assessment
- The focus of the decision-making lies on the forecast range of 1-2 days. Longer forecast ranges of up to seasonal timescales can be of interest and may be tested at a later stage
- The development of new system components and forecast products should incorporate feedback from (test) user groups

Further developments will take into account this and future feedback of the user groups.

5 SUMMARY

The process of improving and extending the current road condition and weather information system of the German Nation Weather Service has been started by developing a two-step concept to incorporate information on the spatial variability and uncertainties of the forecasts into the system. This concept has been presented to users and first feedback suggests that – although some work has to be done to successfully incorporate this new information into the decision-making process of the users – the new products are generally well received and promise to be beneficial for further supporting the efficient management of the German road network.

The next steps will be to implement the new concept into the operational system, to perform further verification and sensitivity studies using different forcing datasets, and – last but not least – collecting and implementing further user feedback on the utility of the new features and products.

6 REFERENCES

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