Providing an Optimized Dataset for Road Weather Forecasts

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Abstract

The concept for „Objective Optimization" describes a system to integrate different sources of weather information into one single local forecast product. Two main objectives are the automatic and continuous relaxation of the forecast guidance given by numerical weather prediction (NWP) models towards the actual observation and the automatic integration of nowcasting products. The system is currently under development at the Deutscher Wetterdienst (DWD).

1. Introduction

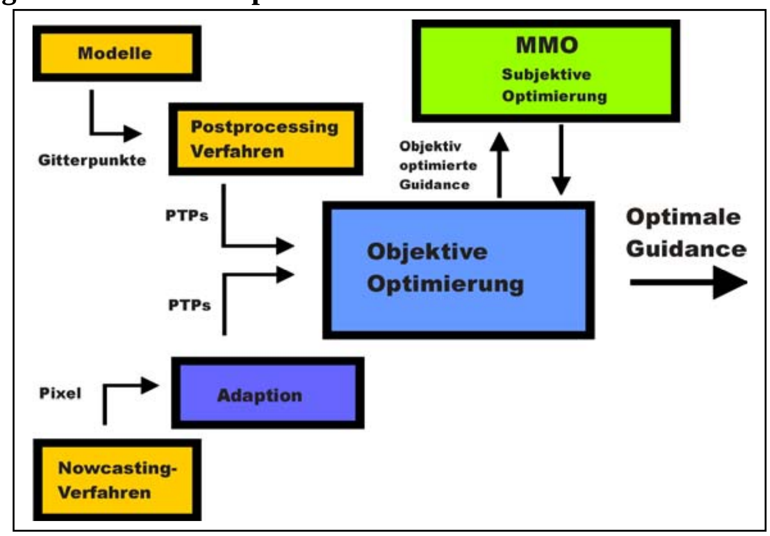
Generally, the process of local weather forecast is based upon the assessment of a large variety of different point forecasts from numerical model output, observational data, and nowcasting products, mainly from remote sensing techniques such as radar and satellite. In order to issue a single forecast all these data sources have to be evaluated, the most valuable information has to be identified, and different data has to be combined by the forecaster into one final forecast product. By doing so, the forecaster includes his/her meteorological experience, his knowledge of the synoptic situation and of the specific site characteristics. Some of the necessary steps in achieving the local forecast can be grouped into the following activities:

- Selection of a guidance from numerical weather prediction (NWP):
  At DWD several approaches are currently being used to derive point forecast guidance from NWP results. Two statistical postprocessing schemes, namely Model Output Statistics (MOS) and a Kalman filter, are applied to the forecast data of the global atmospheric model (GME) of DWD. The Kalman scheme is also applied to the results of the high resolution local model (LM). Additionally, the unprocessed grid point information of both models is provided as Direct Model Output (DMO).
- Correction of NWP guidance on the basis of recent observations:
  NWP guidance is provided on the base of two model runs for initialization times at 00UTC and 12UTC. The postprocessing results are generally available around six hours after the initialization time. In the meantime, observational data was received which has not been yet assimilated into the weather guidance.
  Part of the forecaster's work is the comparison of NWP guidance to the observed development and a possible correction towards the observations. In a recent paper describing the forecast work at the Canadian Meteorological Center it has been estimated that a considerable part of the forecasting work consists in the manual merging of the latest observations (Landry *et al.*, 2003).
  Additional nowcasting products on the basis of remote sensing data (e.g. radar and satellite) are routinely being included in the assessment of local weather. Generally, these data sources provide pixel information with a spatial coverage where no conventional observations are available. Loops of subsequent images allow an immediate spatial extrapolation and a good estimate of corrections necessary due to advection.

The assessment of all available data types, the required work in decision taking and merging of information is a challenging task. It requires ususally considerable personal resources. The

manual correction by an experienced forecaster can not be omitted, in particular in the context of a high quality forecast input needed for the initialization of the energy balance model. However, the time restrictions in issueing a forecast for developments within the next 1 to 3 hours for a large number of sites to be processed (e.g. 450 road weather monitoring stations in Germany) do set a clear limit to the potential of even the most experienced meteorologist. Hence, any support in minimizing the manual workload appears helpful. Less manual work allows the forecaster to concentrate on phenomena which are wrongly forecast and cannot be corrected automatically.
The Deutscher Wetterdienst (DWD) is planing to support the forecast process by the automatic production of one single guidance, so-called optimal guidance. These corrections are applied by using a set of plausible algorithms (objective optimization). Finally, the guidance data resulting from these correction process undergoes a final manual quality check and optional further corrections (subjective optimization). The overall process is illustrated below (Figure 1).

Figure 1: Production process of local weather forecast.



The features of the system „objective optimization“ currently under development are:

- Selection of guidance information:
  This can be considered as a suggestion for the selection of the various guidance types described above. The selection represents the past observed skill of the different data sources. The skill of the different data sources is subject to the continous operational verification of local weather forecasts at DWD.
- Continous relaxation of numerical weather guidance towards observations:
  This is intended to ensure a consistent transition between the latest observed weather element and the corresponding element within the guidance data.
- Temporal extrapolation of observational corrections to future time:
  The corrections applied at the time of the observation are extrapolated to correct the next time steps. This approach represents a trend forecast for these corrections. It affects the next few hours.
- Spatial spreading and extrapolation of synoptic information:
  Pixel information from remote sensing data will be included to spread horizontally synoptic information. In addition, the displacement of these analysed patterns with time will include advective processes.

2. Relaxation of a guidance towards observation

The observed corrections of guidance data due to observed values are extrapolated to future time steps. The extrapolation is based on a structure function which attempts to describe the temporal autocorrelation in a simple way. The effect is illustrated in Figure 2.

$$W(t) = W_{absolut} * EXP\left(-(1/T_{trend})*(t_{guide} - t_{obs})^{S} \right)$$

The exact shape of the structure functions can be customized by a few parameter to accomodate for the statistical characteristics (Weingärtner, 1987) of different elements (Figure 2):

- W_absolut: Absolutes Gewicht der Beobachtung
- S: Exponent (exponentieller Abfall bzw. Normalverteilung)
- T_trend: charakteristischer Zeitscale (Halbwertszeit bzw. Standardabweichung

Figure 2: Temporal autocorrelation for different elements (2m temperature and mean sea level pressure at 18:00 UTC at one location).

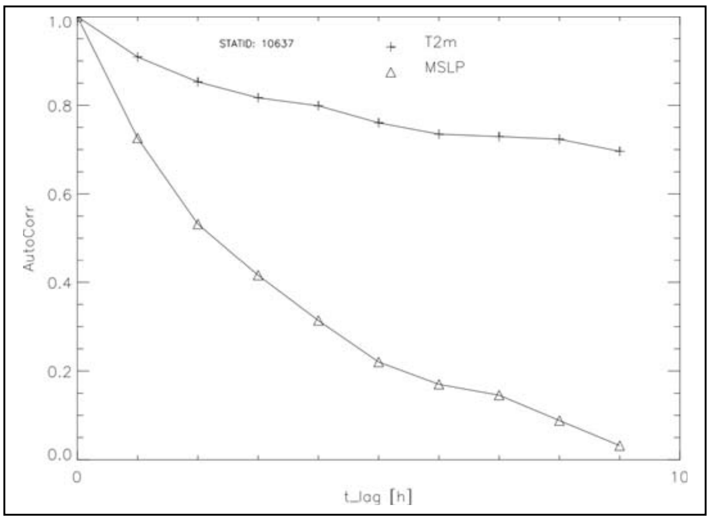
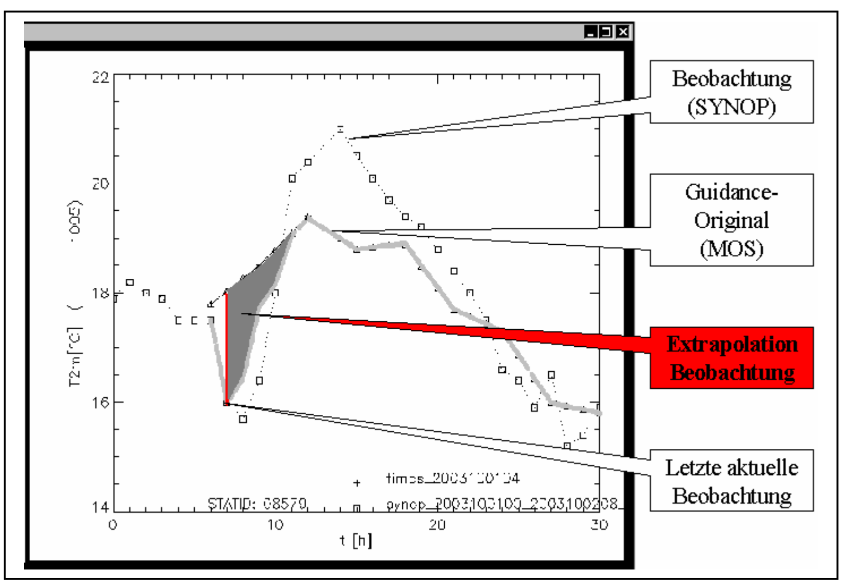


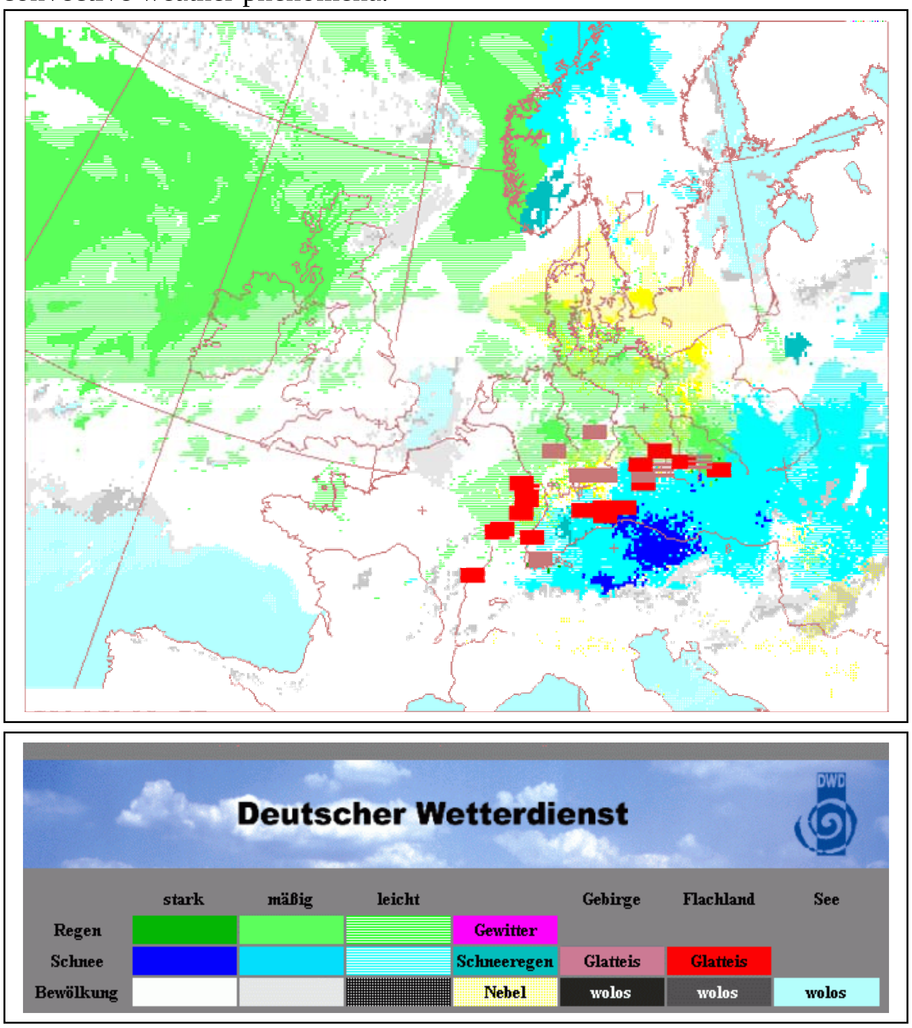
Figure 3: Temporal extrapolation of difference between guidance (MOS) and latest observed value.



3. Adaptation of nowcasting data

The extrapolation of local information into time is appropriate during synoptic situations, when there is little change. However, when there are e.g. air mass changes, nowcasting methods become important. A simple nowcasting method is the extrapolation of a current radar or satellite image. Thus, it is possible to advect weather information observed upstream. The nowcasting product to be included first in the „objective optimization“ is the so-called „satellite weather“. It combines satellite information and surface observations. This product has been presented in the context of road weather forecast before (Raatz and Niebrügge, 2002). An example of this product is shown in Figure 4. The synoptic situation between 13-14 January 2003 was determined by considerable precipitation with the phase changing from snow to rain causing the corresponding road icing conditions. The red symbols mark this situation in the vicinity of changing precipitation pase from snow to ice.

Example of a nowcasting product called „satellite weather“. The analysed product can be extrapolated up to 3 hours. The results are fairly good for stratiform clouds, less accurate for convective weather phenomena.



4. Summary and outlook

This paper describes the setup of a system, called „objective optimization“, which supports the production of surface weather forecasts at specific locations. The main potential of this system is expected in the following areas:

1. Support in selection the information from various sources ,
2. continuous automatic corrections of the NWP guidance due to recent observations,
3. providing the best possible guidance as input for further automatic production and further forecast methods
4. minimizing manual work: a) especially important for nowcasting, when there is little time and b) providing the opportunity to concentrate on the interpretation of the synoptic situation.

The Deutscher Wetterdienst plans to use the optimal guidance as input for the energy balance model to predict road weather in different ways:

1. as input to predict road weather for the next 24 hrs for an area (minor road network),
2. as input to predict site specific road weather for the next 24 hrs (highways, major road network),
3. as input to predict site specific road weather for the next 1 to 3 hrs.

5. References

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