The human factor in the severe weather prediction process

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Abstract

The prediction of severe weather and the issue of related warnings is an essential task of the DWD. To improve weather forecasts and especially the prediction of severe events several changes of the NWP models of the Deutscher Wetterdienst have been made. EPS products – for the medium range as well as for the very short range predictions – are more and more accepted by the forecaster and included in the prediction process.

The most severe events are combined with heavy convection, NWP models are not able to predict convective events related to the scale of district-based warnings, therefore it is not possible to prepare and issue regional very specified warnings well in advance. The preparation, issue and monitoring of warnings is finally the key business of the forecaster. He has a limited time frame to come to a decision, so he is able to take into account a small and case-dependent choice of products only. Nowcasting tools using radar and MSG data becomes essential, a NWP based Nowcasting system based on the LM (LMK) is under development. Visualisation and Nowcasting systems supposed to be a support. A great variety of products - NWP forecasts, observations as well as Nowcasting tools will be integrated into NinJo that becomes operationally in the near future.

A highly-developed NWP system is the basis to predict severe and extreme weather events and issue related warnings. To improve the NWP at the DWD the global model GME and the local model LM has been developed and significantly improved. The main steps from the forecasters point of view will be shown in the table below.

	GME	LME
Main steps	– 12/2003: MODIS used, Use of pseudoprofiles derived from the ECMWF anaylsis – 03/2004: Improvement of the parametrisation of the distribution and development of sea ice → more realistic mslp pattern over polar region – 09/2004: 40 km, L40, levels below 800 hPa the same as ECMWF T511, first level in 10m, introduction of the soil model (7 levels, better parametrisation of surface processes (snow melting, freesing of water,...) → limprovement of T2m and Td2m forecasts – 08/2005: Modification of the friction length → preventing unrealistic high wind gusts in mountain areas – 12/2005: Introduction of predicted snow density, snowcover as output parameter – 01/2006: Introduction of radiances of polar-orbiting satellites	– 04/2004: Drift of hydrometeors → prevents „dry valleys" and unrealistic high precip values on the windward side of mountains – 07/2004: Wind profiler data used – 10/2004: Introduction of the predicted precip used for initial conditions – 08/2005: Reduction of the evaporation over water → more realistic slp pattern and accumulated precipitation totals – 09/2005: Introduction of the LME (domain Europe), ... T + 78 h – 01/2006: Introduction of predicted snow density, snowcover as a output parameter Under development: LMK, 2.8 km, T+18 h, runs every 3 h, lagged EPS → will delelop convective pattern, deep convection has not to be parametrisized any longer
Curr version (11/2005)	Triangular grid, resolution 40 km, 40 levels, time step 133.33 s	LME: resolution 7 km, L40, domain Europe, time step: 40 s

Table 1 Recent developments in NWP models at the DWD

A NWP system on a high level is essential for risk assessments in the early medium range and for successful warnings in the short range. The main warning activity included the preparation, transmission and the monitoring of district-based warnings has to be done in the time scale of the Very Short Range and Nowcasting, i.e. for a lead time below 12 hours. An observation system operating on a high and reliable level is essential.

NWP models (even the highest developed and most regionalized models) because of the chaotic character of severe related pattern not able to deal with

- Severe events caused by strong (deep) convection
- Severe weather events related to a high baroclinic instability

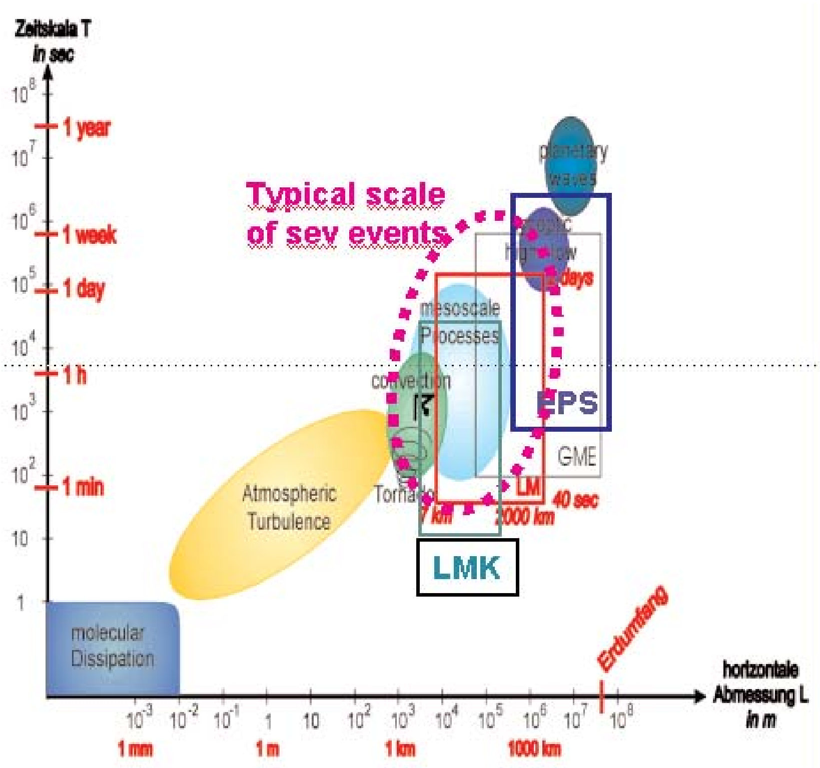

Fig. 1 Typical scale of weather related pattern and models

The forecaster is confrontated during the shifts with a huge amount of information. Many of these data he has to take into consideration for the preparation and maintainance of forecasts and warnings. Informations provided by different ways

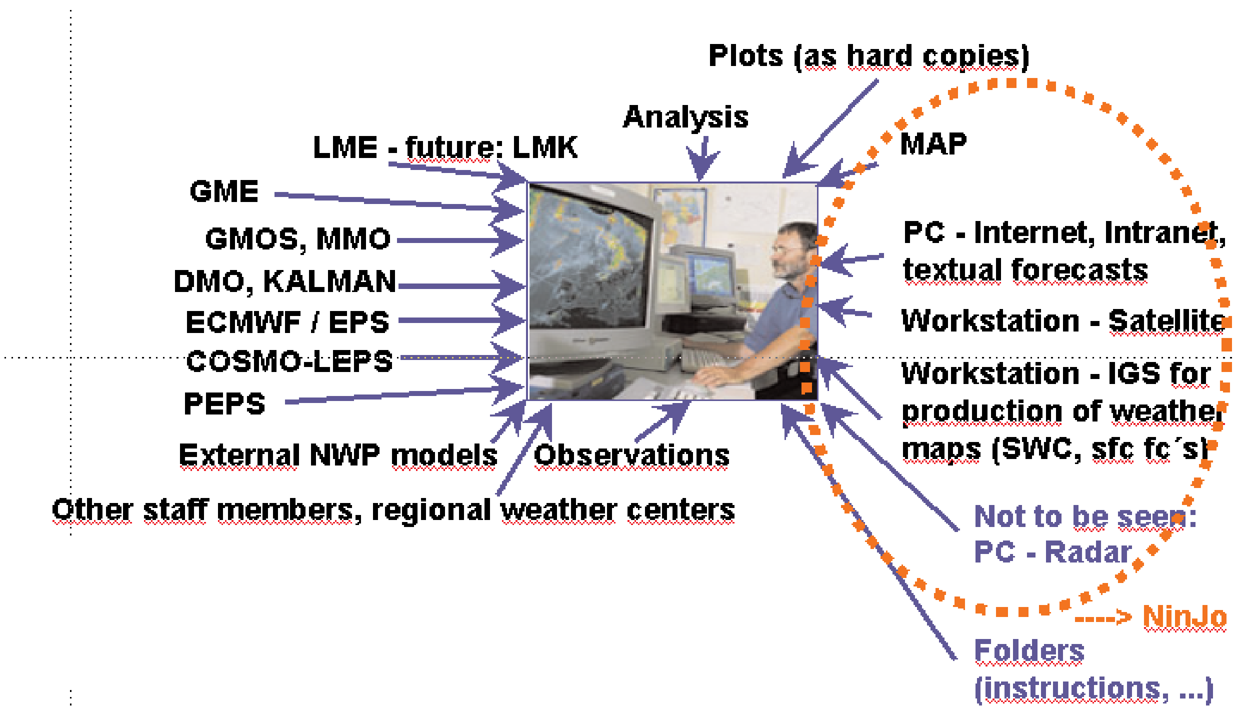

Fig. 2 Informations used in operational shifts

To reduce the number of systems dramatically and to replace systems running out of service like the current MAP system the NinJo project has been started. NinJo is a work-station project, the DWD (together with the Metservices of Denmark, Canada, Switzerland and the Military Metservice of Germany) is developing a java-based workstation.

It will replace the current hard- and software in the near future when it contains at least its functionality and it runs stable enough for operational use. The advantage of NinJo is that it has been made flexible and it can be expanded easily by additional functions making the forecasters job easier. NinJo is highly configurable for everyone needs (forecaster, meteorologist in the research department, aviation forecasters, military service, system administrators, ...). The forecaster has to and will learn to work with NinJo very quickly. NWP models, high developed observation systems, presentation and production tools representing the „state of the art" could and will support the forecaster. A few of this tools (a selection only) will be described briefly:

	NinJo	Current system
Automon	Monitoring of warnings and observations. An alert will be provided if a defined threshold of a parameter will be exceeded. Forecaster has to adapt warnings. Soon available: Surface observations. Later available: Radar and lightning. In the future: alert, if first guess of the model will differ from observations by a certain and defined value	Not available
MMO	Modification of point-related predictions by the forecaster. Several consistency checks included. In the case of inconsistency correction advice provided. Test version implemented.	Difficult to handle, without of any consistency checks.
Aviation	All aviation relevant observations, forecasts and tools unified under one layer. Test version is implemented.	Aviation-related items under sfc data and TEMP data
EPM	Edition, production and monitoring of warnings easier and faster possible. Trial version under development. Warnings will be generated in any case manually.	Pop up a window that hide current obs.
EPS	Still under consideration, layer should contain all EPS forecasts available in the internet and intranet and should allow to add more parameter and change thresholds.	Not available

Table 2 Comparison between NinJo and the current MAP system for several tools

The final decision whether to issue a severe weather related warning or not has to be done manually. Certain thresholds given for several weather elements. If the forecaster will expect an excess of these thresholds he has to issue a related warning. This expectation could be based on NWP prediction, but much more on observations by remote techniques or by upstream located (manned and automatic) synop stations. Conceptual models (Comma shape, dry intrusion, ... for satellite pictures, hook echo for radar) are often helpful.

Event	Threshold	Prewarn time	remarks
Heavy Thunderstorm	Hail Diameter> 1.5 cm Rain > 25 mm / 1 h Wind gusts > 104 km/h	1 - 0 h	Prewarn time could be exceeded in case of well-organized squall lines
Heavy rain (convect)	> 25 mm / 1 h > 35 mm / 6 h	2 - 5 h	
Freezing rain	Widespread event, longer duration	3 - 6 h	Forecaster has to decide case-dependent
Gusts of gale force	> 104 km/h	6 - 12 h	Highlands > 800 m case-dependent
Heavy snow	> 10 cm / 6 h > 15 cm / 12 h	6 - 12 h	Higher thresholds above 800 m asl
Snow drift	Wind gusts > Bft 8 and Snow cover > 10 cm	6 - 12 h	
Continuous rain	> 40 mm / 12 h > 50 mm / 24 h > 60 mm / 48 h	12 - 2 h	Prewarn time should be exceeded in case of well-predicted pattern
Snow melting	Snow cover > 15 cm and rain	12 - 2 h	Prewarn time should be exceeded in case of well-predicted pattern

Table 2 Severe weather warning criteria and prewarn times applied by the DWD

Prewarn times (time between the issue/publication of a warning and its validity) and the use of severe weather prewarnings has been fixed and unified. The table below shows an overview. These prewarn times depends from the predictability of the event. If the severe weather related pattern by NWP clear and consistent predictable it is possible (and desired) to prepare and publicate a related warning earlier. The higher the severity of an event the higher the potential lost of the customer will be. Under these conditions the warning should be publicated as early as possible (or at least to reach the maximum of the user community). Expressed by other words it makes no sense if a forecaster will wait to be inline with the prewarn time without receiving updated informations related to the event (may be by the next model run) meanwhile the customer / user has closed his office or is already sleeping

If an event has been observed already additional informations from other regional weather centers, road authorities, police stations or traffic messages in the radio are helpful. Often informations, obtained from visual observations by meteorological interested people, provided in the internet. These data are able to fill gaps in the synop observation network, but a forecaster should use it with care.

If a forecaster has to issue a warning case-dependent the experience of the forecaster is asked. For several parameters such as freezing rain, gusts over mountain areas and severe convective events observed treshold or objective criteria are not available or often not applicable. It depends from the individual synoptical situation whether a severe weather warning has to be issued or not. In the case of freezing rain the effect on the road infratructure is dependent from the vertical profile of temperature and humidity and the precipitation duration and type (snow? Ice pellets? Instantly freezing rain?), respectively. A severe weather gale warning for districts containing tops of mountains is useful only if the mountain could be easily climbed by tourists using the own car or a train or walking a short distance. This is the case for the tops of the highlands over Central and Eastern Germany. If the top of the mountain could be reached by cable car only it has to be switched of earlier. Criteria for severe weather warnings caused by thunderstorms applicable. The intensity of convective precipitations could be derived by radar, thresholds related to heavy precipitation are available. If the convective pattern will be driven by the mid-tropospheric flow very fast this thresholds are not applicable. Under these conditions gusts related to the convective system becoming more important.

To derive point-based forecasts several statistical procedures are used. A direct model output will be applicated on the GME and LM, KALMAN-filtering is available for the LM. Model Output Statistics are calculated from the GME and the ECMWF´s 12 UTC run of the day before and additionally as a mix of the both (MOS-MIX). Statistical procedures are helpful to guide the forecaster under „normal" conditions (without severe weather). The MOS-MIX is providing the best guidance for temperature by reducing the bias to a minimum, but for wind gusts often it seems to be unsuitable. In the case of severe weather statistical model interpretation methods are in general less helpful because related weather pattern will be smoothed out.

EPS tools providing already in the early medium range signals related to severe weather. The EFI, derived from the ECMWF EPS as well as the uncalibrated EZMWF EPS and COSMO-LEPS derived probabilities in use to prepare and deliver risk assessments and early warnings. Signals derived from EPS tools could be supported by external NWP models (GFS, UKMO, ...) or not. PEPS derived probabilities as an EPS consisting of regional and local models from several NWP centres over Europe allows a better regional assignment of this severe weather related signals during the short-range. Thresholds of probabilities as a decision making tool to guide the forecaster are not fixed. More experience using EPS tools, objective verifications and calibrations are needed. On the other side a lot of this EPS products are experimental.

It has to be taken into consideration additionally the cost-lost-ratio of the user (general public, special customers, authorities, ...), the season and the past weather conditions before the onset of the event. If the first cold air outbreak and heavy snow has to be expected a severe weather warning makes sense even if the threshold of snow cover will not be exceeded and disruptions in traffic etc. has to be expected. The result of heavy precipitation (flooding, mud slides etc.) is much more intense if the observed precipitation for this region during the previous time is well above the climatological precipitation values.

Taking all these facts into consideration an automatisation of the warning activity of the DWD is not possible up to now. The process of generation, transmission and the maintainance of warnings is too complex. A lot of products / forecasts running without of an interaction by a forecaster, but all these automatically generated products could be used as a supporting tool for warnings only. A successful warning activity is not only dependent from a technical infrastructure and a NWP on a high level. A dense and developed observation network as a combination of manned and automated stations as well as remote sensing techniques to cover the complete territory are essential. The last but most important part of the chain is the experienced forecaster who knows to select the relevant information at the right time, who is able to interpret the signals provided by NWP systems, satellite and the observation network and to make the correct decision that helps the user and customer of the warnings and the general public to minimize the weather related risks and prevents loss of live, health and property.