Recent developments in severe weather forecasting at the DWD

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Abstract

The prediction of severe weather and the issue of related warnings is one of the key business of the DWD. To improve weather forecasts and especially the prediction of severe events some changes of the NWP models of the Deutscher Wetterdienst has been made. The warning strategy and German NWP model chain will be shown briefly. The most severe events are in connection with deep convection. The COSMO—DE model (horizontal resolution 2.8 km, former LM-K) became operational last year and should simulate deep convection. Preliminary verification results based on case studies will be discussed.

In October 2007 NinJo, the new visualization and production system, finally turned into operation. The development of NinJo is still going on. Details of the development process will be presented.

1. Warning strategy of the DWD – a brief introduction

The warning strategy of the DWD consists of three parts:

	High-impact Weather Risk Assessment	Warning situation report	District-based warnings
Content Description Validity	Expected high-impact weather will be listed and in respect of an excess of thresholds of (severe) warning criteria expressed – event very likely / likely – event might be possible Valid 0 + 36 ... 0 + 144 hrs Updated four times per day	Expected high-impact weather, additional information to district-based warnings (syn situation, validity of warnings...) important for understanding the warning situation shown by the district-based warning html-based map Valid up to 0 + 36 hrs	Warning(s) as text bulletins for users and customers. Valid 0 + 3 ... 12 hrs, sometimes (deep convection) below 3 hrs. Clickable html-based map for Germany. Selecting one of the more than 400 districts the text bulletin of the valid warning will be shown.
Preferable used tools	EFI, ECMWF Probabilities (MS page, det models (from several centers) COSMO-LEPS	Det Models (global + LAM´s), SRNWP PEPS	COSMO_EU, -DE, SRNWP PEPS, Obs network (Synop, radar, sat, lightning)

Table 1 Columns of the warning strategy of the DWD

The High-impact Weather Risk Assessment will be prepared and issued by the Central Forecasting only. This is one of the main tasks of the meteorologist, responsible for medium-range forecasts.

Warning situation reports and individual warnings are part to the business of the Regional Forecast Offices for their area of responsibility consisting of one or more federal countries. The German territory is divided into 7 areas served by Regional Forecast Offices located in Hamburg, Essen, Potsdam, Leipzig, Offenbach, Stuttgart and Munich. Additionally, a “Central Warning situation report” is produced in the Central forecasting by the Supervisor. Warning situation reports are actualized 4 times a day, in severe weather situations much more frequently to cover rapid developments.

Warnings for individual districts are prepared and issued by the Regional Forecast Office for their area of responsibility by the duty Forecaster. Users are disaster and flood prevention staff, fire brigades, other authorities, media and the general public. The Supervisor (or shift leader) in the Central Forecasting has to guide the warning process for the whole German territory. He doesn´t produce any district-based warnings, he is responsible for a binding character of the warning concept, by other words, the Supervisor has to enforce the single-voice principle, he is responsible for a homogeneous warning concept of overriding importance. That contains a lot of coordination work. The concept of the guidance of the warning activity by the Supervisor has been established and is well accepted by the meteorologists in the Regional Forecast offices.

Warning criteria have already been discussed in detail by the paper published for the proceedings of the Tenth Workshop on Meteorological Operational Systems, held at ECMWF, 14 – 18 Nov 2005. Warning criteria and -procedure are well-tried and left mainly unchanged on the whole.

2 The NWP model chain of the DWD

Highly developed NWP models are indispensable for the prediction of the future state of the atmosphere and especially high-impact weather forecasts. Therefore the DWD is managing an own model chain. Hundreds of automatically generated products based on the model chain and/or produced in combination with the ECMWF output delivered daily for customers and users. A few products are adaptable by the forecasters only, when additionally other models are introduced into decision making process.

The NWP model chain of the DWD consists of three parts: The GME as the Global model provides the initial and boundary conditions for the regional COSMO-EU (former LME) model. The GME runs twice a day up to 174 hours (00 and 12 UTC and at 06 and 18 UTC up to 48 hours.

The COSMO-DE (former LMK) model will be driven by the COSMO-EU that also supplies lateral conditions for the COSMO-DE model. COSMO-EU is providing forecasts up to 78 hours (00 and 12 UTC) and up to a forecast lead time of 48 hours starting from the 06 and 18 UTC analysis. The COSMO-DE model runs every 3 hours up to 18 hours lead time and provides a frequent update of the forecast. Most important characteristics of the models are shown below:

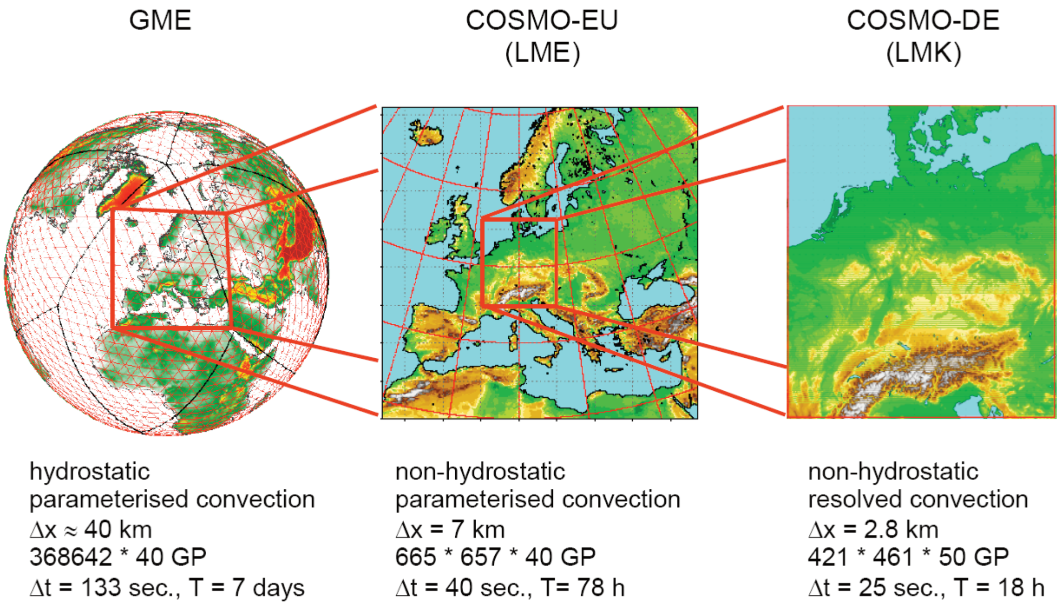

Fig. 1 Most important characteristics of the NWP model chain of the DWD (Courtesy of Thomas Hanisch)

GME and COSMO-EU meanwhile are models of a mature state, GME is since 1998 in operation. Models have been several times improved, development is still going on. The upgrades of the GME and COSMO-EU model during the last 2 years briefly summarized by the table below. For the models of the COSMO group an index for the detection of convective supercells is under development.

GME	COSMO-EU
– 12/2005: Introduction of a prognostic density of snow cover → Reduction of the cold bias during clear-sky nights in winter – 04/ 2006: runoff reduced by enhanced infiltration in the ground → Reduction of the warm bias during summer (heat waves) – 05/2006: Additional model runs: 48h-forecasts starting from 06 UTC analysis (also COSMO-EU) – 06/2006: MET8-derived „Atmospheric Motion Vector"-winds humidity analysis modified → Improvement of the precip forecasts by reduction of the positive humidity bias in the lower troposphere – 01/2007: Modification of Snow analysis (also COSMO_EU) → More realistic analysis of snow depth (without alterations between runs) – 05/2007: MET7 and MET9 Winds, MODIS Winds in BUFR Format → Significant improvement of the forecasts in both hemispheres	– 04/2006: Improved quality control for radiosonde humidity data – 06/2006: Additional 06 and 18 UTC run – 01/2007: Modified micro-physics with increasing drifting of orographic precip → More realistic precip forecasts in the mountains (Luv-lee-effects) – 05/2007: Variational Soil moisture analysis adjusted for frozen soil – 07/2007: Improved quality control for radiosonde humidity data and multi-level data check + Output extended by CAPE and CIN

Table 2 Most important improvements of the GME and COSMO-EU model of the DWD

As already mentioned early 2007 the COSMO-DE model (still known as LM-K) turned into operation. COSMO-DE is simulating deep moist convection and the life cycle of Cb clusters. A frequent update every 3 hours allows a monitoring of relevant signals for high-impact weather in the forecast. The forecaster can make his own choice from a huge number of parameters. Fields are produced at least for hourly time steps. Animations on a html web page (stand-alone as well as combined with COSMO-EU) may be displayed, even the weather situation, expressed by ww-symbols, has been made available. Consecutive runs verifying at the same time may be compared. Many of them are already available in NinJo.

Examples for a situation with a poor predictability (Thunderstorms, 27 May, 2007) and a well-predictable event (wind-storm event, 02 December, 2007) are shown below.

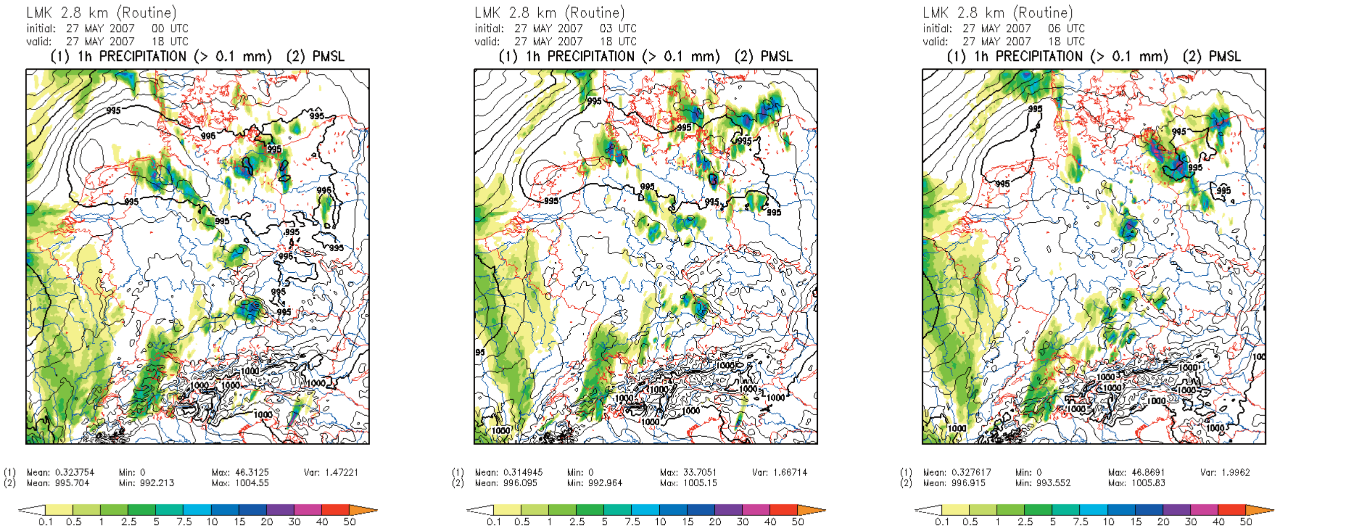

Fig. 2 Precipitation, accumulated over 1 hour, verifying 27 May, 18 UTC. Runs started at 00, 03 and 06 UTC. The predicted severe precipitation pattern showed a high inconsistency between the runs. However, the most severe thunderstorms are predicted for the northeast part of Germany.

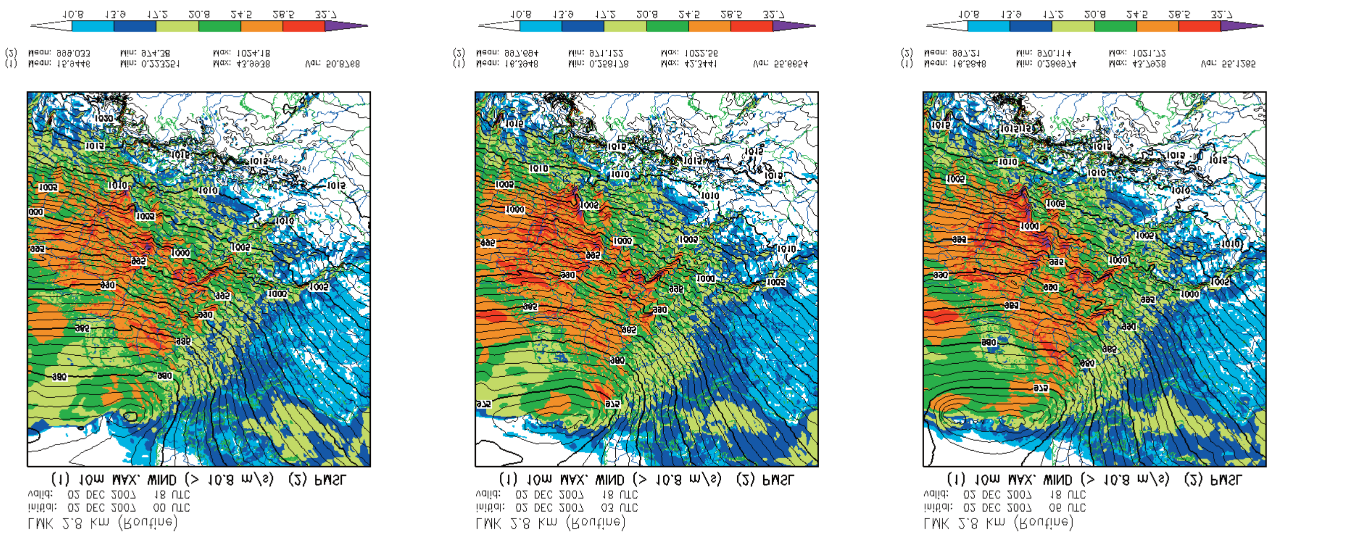

Fig. 3: Wind gust forecasts, verifying 02 December, 18 UTC. Model runs 00, 03 and 06 UTC. In this case it is quite difficult to detect synoptic-relevant alterations from run to run.

COSMO-DE not always satisfied forecasters expectations. This is the case if the troposphere is highly unstable and the development of air mass borne deep convection pattern is expected. Already well-developed convection pattern is not caught by the next run or shifted far away from the initial position. Although the forecaster can get an impression about the potential of the situation related to the maximum of precipitation or wind gust but there is no exact localisation of the events. If the convection was been triggered by synoptic features like a through or a cold front results are better and the convective pattern will be kept for a longer time.

The COSMO-DE sometimes didn´t make a good job during blocking situations in autumn and winter when the cooling in combination with the increased moisture of the boundary layer lead to a development of an inversion situation. In these cases the boundary layer is drying too fast in the model with the consequence that fog and low clouds have been disappeared too fast and the temperature has been increased in the model related to verifying observations.

The weaknesses of the COSMO-DE as described above are an indication that boundary layer processes still not sufficiently parameterised. The development of the COSMO-DE model is going on. Improvements are expected before the onset of the convective season in late spring. Site-specific forecasts are under development as well as an EPS using different sets of boundary conditions.

3 NinJo - a challenge for developers and users

The project "NinJo" (New Integrated Java application) has been started in the year 2000 to develop and create a multi-purpose meteorological workstation based on the current highest level of computing using xml for configuration, menus etc based on Java. A modular structure enables a high flexibility and allows an easy extension of the system. NinJo has been designed for meteorological experts providing a complete set of layers supporting the whole forecasting process. The main task of NinJo is the presentation and handling of all meteorological information to support the decision making process of the forecaster. The previous system MAP (Meteorological Application Programme) was at this time already more than 12 years on operation and difficult to expand and to maintain, workstations went out of service. There was a need to replace the aged system.

The NinJo-Project is an international collaboration between the Deutscher Wetterdienst (DWD), the Geophysical Service of German Armed Force, the Swiss Meteorological Service (Meteoswiss), the Danish Meteorological Institute (DMI) and the Meteorological Service of Canada (MSC). NinJo turned into operation at the DWD in September 2007. Parallel usage of the previous system IGS is still going on until NinJo „Product" available (Analysis, Significant weather map for VFR flights, Forecast maps with fronts). By an interactive editor integrated into NinJo in the near future the user will be able to produce analysis and forecast maps. It has been planned additionally to create a number of graphic products in a batch mode.

To increase the acceptance of the forecasters according to NinJo its handling and functions have been improved generally. The general handling is close to the functionality of the Windows Explorer. The menus (where I can find which data) were sorted similar to MAP. The documentation has been kept updated related to the latest release of NinJo. So-called Super-Users teaching the forecaster team showing an efficient use of the new system and functionalities. Favourites were introduced for different levels of the use and the maintaining of NinJo (user, department, administrators).

The user is able to combine data layers representing a specific selection of meteorological data from the large variety of available information as shown by the figure below. Layers are independent of each other and therefore stackable, could be set active, duplicated or removed. Each layer is containing a certain type of data. There is an overall time management.

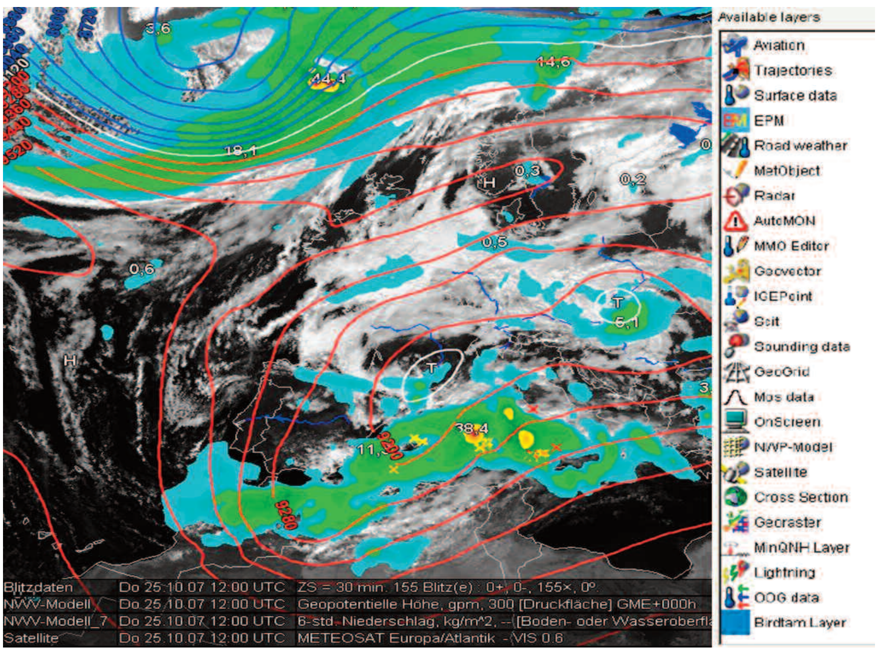

Fig. 4 Screenshot from NinJo and layers containing specific type of data.

The NinJo desktop is highly configurable, every user can define his own environment characterized by an own choice of layers related to his task, own maps and geographical data, colour tables, animations, secondary scenes. There already a comprehensive choice of favourites and sessions predefined by administrators and the department. These configuration could be adopted for own needs saved as well as own settings as "session" and "favourites" (similar to the web) to keep these configurations for the next session.

Due to the modular structure of NinJo there is still not everything available what represents the "state of the art" in NWP and what is desirable for forecasters. Therefore only a few EPS-based products and tools are available. Forecasters need EPS-based information from several, sometimes unreliable sources from the web and the DWD´s intranet. A presentation and visualisation system for meteorological experts containing no or almost any EPS information is incomplete. To improve that the development of an own NinJo layer for EPS-based products has been started recently.

The objective of the EPS-layer in NinJo is to provide products from several models and systems characterised by different physics and resolutions and covering different domains at one platform (NinJo) only. Therefore different EPS forecasts are easier comparable by shift meteorologists. EPS based products could be easier set into relation to relevant deterministic products or even compared to observations. To enforce this the general design of the EPS layer will be approached to the Model data layer which one of the most used layers of NinJo is. Forecasters are quite familiar with the handling of this layer. The content of the future EPS layer will be shown by the figure below.

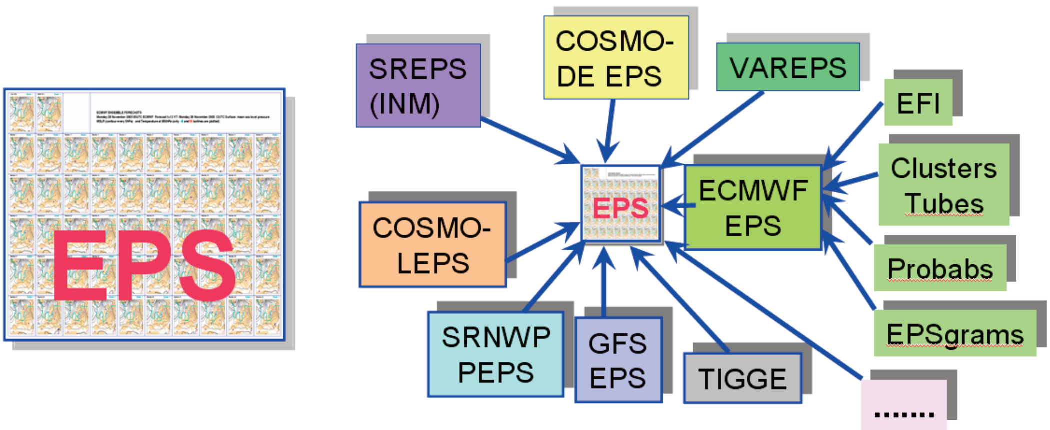

Fig. 5 Future content of the EPS layer in NinJo

The development of the EPS layer is a process going on for a few years. The set of EPS forecasts will be expanded step by step because several EPS based products are still under development, other ones are already available. Some products will be calculated at the ECMWF, others at the DWD´s high-performance computer system, by other words, NinJo will be used mainly for presentation and visualisation of the products and not for processing tasks.

In the meantime EPS based forecasts and products are well accepted by the forecaster community and highly desired as a tool for the decision-making process. Even more and more educated customers and users are getting familiar with EPS-based products and how to take more benefit by using it. A weather forecast of the state of the art and especially the prediction of severe and/or high impact weather are unimaginable without including EPS based tools. The integration of EPS tools into NinJo by an EPS layer will take that into consideration.