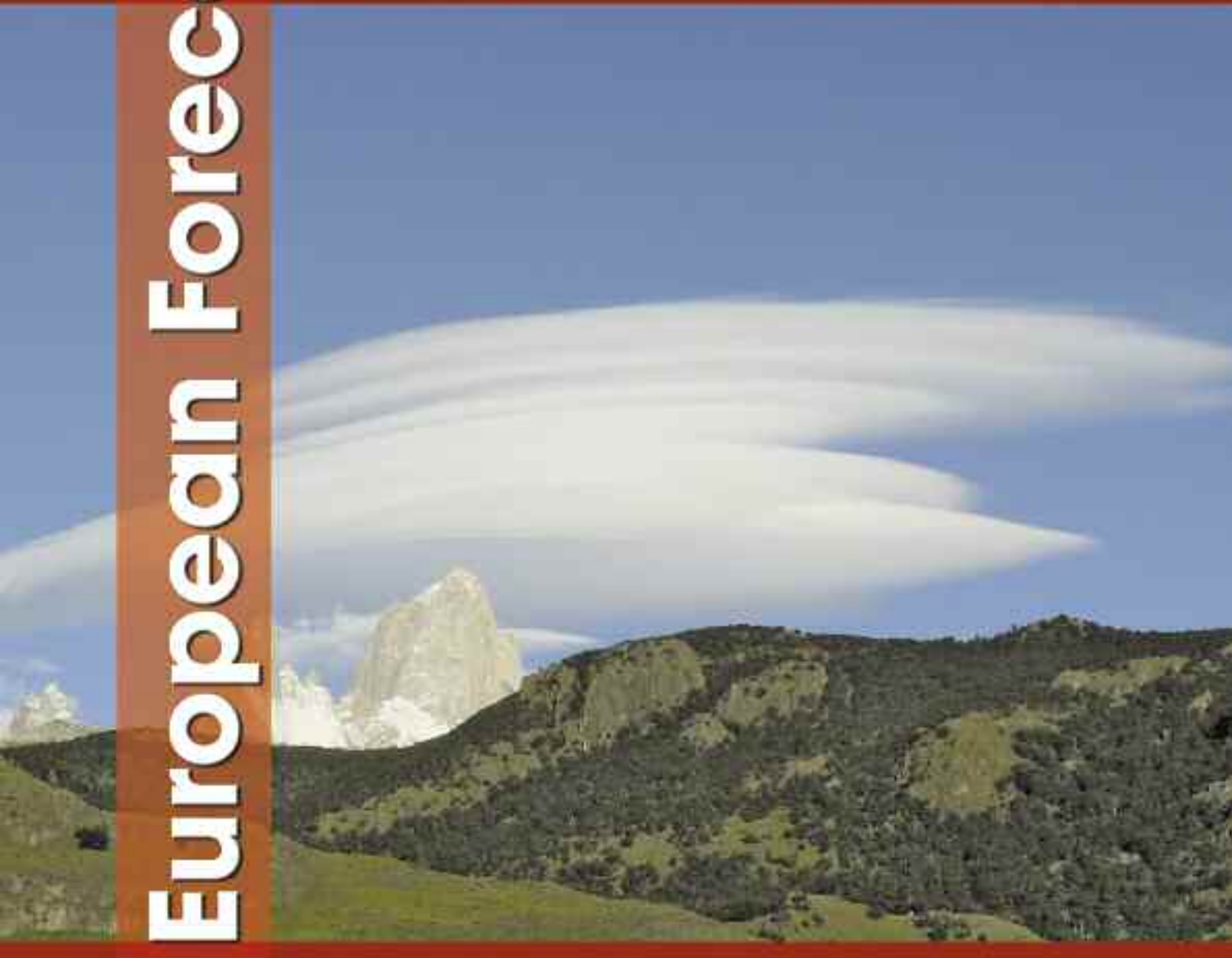
The European Forecaster



Newsletter
of the WGCEF

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Contents

Crédit: Fabien Gillet

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Introduction

Dear readers,

Time is running. The remembrance of our last meeting at DMI still fresh in our minds, while already focussing on our next meeting. With high expectations we gathered for this 2008 Copenhagen meeting and indeed the programme offered a broad perspective on “human related” topics related to severe weather forecasting and warnings. The stress that forecasters experience during high impact weather episodes, together with their high feeling for responsibility is often making a cocktail filled with tricky human factors. Being aware of these factors and sharing thoughts and expectations together with others, is probably the best solution to deal and take advantage of this.

At my institute I noticed that, while forecasters were thinking efficiency is already at its top, new developments are coming up, trying to be even more efficient. A tendency to act low key and rely more on automated model output when the weather is not expected to be dangerous can be seen. While at the other side, more attention and human skill will be put in high impact weather. In the near future, this way of thinking will probably also imply more weather depending shift strategies. Next to this a tendency towards more dedicated meteorological consultancy within the public domain can be seen. For critical weather related crisis processes, a meteorologist will be present within external governmental decision teams.

For sure these and other new developments will also be seen at your service. To enable ourselves to learn from this, we highlighted these “New Developments” to be the main topic for our next meeting.

Again a beautiful coloured edition of the European Forecaster newsletter, the 14th edition lies in front of you. All topics discussed the 4th of October in Copenhagen can be read. I call up on all of us to recommend this edition to all our colleagues. I also call up on all readers to send in new contributions for the next (15th) edition. The European Forecaster is a great platform to share knowledge and experience amongst forecasters. All articles again were reviewed by Will Lang with kind assistance from Nick Grahame (both from UKMO). Bernard Roulet and Météo France made it possible again to present you this high quality printed edition. Many thanks also to André-Charles Letestu (Météo Suisse) who updated our website **www.euroforecaster.org** with actual information on the Working Group together with website links. Our web archive shows the previous editions of the Newsletter.

I wish you many inspiring reading hours and hope to see you during our next WGCEF meeting, Saturday 3rd of October 2009 at Météo France in Toulouse.

Frank **Kroonenberg**
Chairperson of WGCEF

Notes of the WGCEF meeting in Copenhagen, Saturday 4th October 2008

Starting time: 10:00

Introductions and agree agenda

• Many of the participants will be replaced at the next meeting in Toulouse by younger forecasters
• 26 participants joined the meeting
• Absence announcements from Nick Grahame, Greece, Estonia, Malta, Micheletti (OsMER), Norway
• Agenda was agreed

Actions from the last meeting

• Action 1 - is covered by the programme
• Action 2 - answers to the enquiry are presented in the agenda
• Action 3 - verifications shall be continued
• Action 4 - Jean Quiby did not answer, action postponed to the next meeting

Report of the chairman

• Meteoalarm received the communication award
• EUMETCAL conference in Toulouse: computer added learning
• Tendency in general forecasting: more advice to clients, special products for customers, tendency to optimise these procedures, tendency to more automated products
• Problem: if the weather is calm, less staff are on shift (KNMI, DWD)

Mikkel Madvig, Right Management Ltd., DK, human factor session
"Managing decisions and decision making pressures in weather forecasting"

Discussion of Newsletter No.13 and WGCEF website

• Meteo France is willing to print the newsletter next time, co-ordinator Bernard Roulet
• Will Lang will review the articles for the newsletter, the articles shall be sent to Will Lang, Met Office, UK, deadline Christmas time
• Website shall cover more information for the actual meeting
• List of representatives has been updated during the meeting

Short EMMA/Meteoalarm update by Frank Kroonenberg

Status and future contributions
Access to the internal page is distributed by **Karin.Buchauer@zamg.ac.at**

Contributions from WGCEF members

Human factor session, 7 presentations (KNMI, DWD, FMI, GR, B, ZAMG, UKMO), the presenters of Norway and Poland were absent

Contributions from WGCEF members

Severe weather verification session, 4 presentations (DMI, GR, ZAMG, MF)

The presentations can be found on the WGCEF website.

Plan of action 2009

These following topics had been proposed in the meeting

1 - Changing NMS's, "New working structures and upcoming plans"
2 - Verification of meteorological products (objective- and subjective- and impact verification)
3 - Description and use of short term ensemble forecasting at NMS's
4 - Examples of high resolution NWP-model use
5 - E-learning facilities now and in the future

Due to time constraints for open discussion, it was agreed that the chairman and the vice-chairman would make a decision to choose 2 topics from the 5 proposals.

These were as follows:
- **Changing NMS's, "New working structures and upcoming plans"**
- **Verification of meteorological products (objective- and subjective- and impact verification)**

Date and place of the next meeting

In connection with the next ECAM the WGCEF meeting will take place in Toulouse on Saturday 5 October 2009, Meteo-France is kindly asked to host the meeting.

Any other business and closure of the meeting

There was no other business and the chairman closed the meeting at 17:30.

About the Nature of the Forecaster Profession and the Human Contribution to Very Short Range Forecasts

Introduction

To maintain proficiency and professional skill the forecaster needs opportunities for training and self-study. In the long run, cumulative work experience is gained naturally in the job itself. The case-studies and other articles with a special Europe-centered view in this publication will be of use to us in learning and gathering information. Certainly, a thoughtful contemplation of our profession, its demands, and the future of forecasting is in the interest of the forecaster community.

An often expressed, though not necessarily well-founded, view on the future of weather forecasting is that the importance of a human forecaster will self-evidently diminish. The Copenhagen topic "the Human Factor", and Gaia & Fontannaz's article "The Human Side of Weather Forecasting"(1) draw attention to important but insufficiently discussed subjects. I wish to stimulate discussion and possibly raise some new questions for colleagues to consider. My focus and special concern is the role of humans in nowcasting and very short range warnings and aviation forecasts.

About the forecaster's professional expertise and consciousness

Let's assume you are chatting with someone you don't know very well and they find out you are a weather forecaster. Every one of us certainly has experience of the interest and generally positive curiosity that is quite often aroused in a situation like that. Quite often it quickly becomes apparent, however, that your companion's understanding of the profession of a meteorologist or the essentials of weather forecasting is comparatively shallow.

It is entirely understandable and forgivable that an ordinary person doesn't know very much about our work. We do have a rare, perhaps an exceptional profession. A much more interesting question is whether we ourselves understand the nature of our own job completely. In particular, it is crucial to find out if this understanding is adequate in our national weather services. At least a satisfactory comprehension is needed among those who do not work as forecasters but make decisions which concern our daily job. This is a topic I think should be discussed much more extensively.

I am suggesting that there exists a basic, partly subconscious confrontation that tends to dominate our thinking about forecasting: Is it *primarily a technical process* that needs some human interference to generate forecasts, or is it *exercising of a profession* that requires scientific and technical knowledge but human contribution and ambition as well? I would venture to suggest that this confrontation is a paradigm that quite often underlies different views on e.g. the forecaster's role in the future. If we adopt the former "technical" view, we are apt to see the continuously improving forecasts as an inevitable automatic result of new model versions or radar products. The latter "professional" view more realistically reminds us of the fact that one important driving force behind any advancement, any invention or improvement, is the human factor, someone asking "how to provide better service, more useful forecasts, create something we haven't seen yet?" Tools are important, but more important is the intelligent use of the tools and the possible innovative ideas and new goals.

Generally speaking, it is easy to list the forecaster's needs: sufficient weather information, proper equipment and professional ability together yield good forecasts and accurate warnings. But when analyzed in detail, several questions immediately arise: What is the forecasting job really made of? What about the requirements for the necessary education and training, practical skills, and the ability to cope with stress and hectic situations?

Additionally, one can ask how the situation has changed for instance during the last 30 years. At a first glance it might seem that the work has become easier due to e.g. the superb achievements in the field of NWP. Firm opinions are sometimes expressed about the future change in weather forecasting, e.g. the inevitably diminishing human role in the future. On the other hand, it is perhaps not quite as clearly seen that the development and advancements also mean new, fresh challenges in the forecasting room.

It is also worth considering who generally understands and is able to extensively evaluate our work. Job analysis focusing on the work done in the forecasting room could produce new and significant knowledge. However, so far as our profession is concerned, I am aware of only a few investigations, mainly from the 1990s and 2000s. The report on warning forecasting by Klein Associates Inc.(2) is in my opinion constitutive in this field. Some profound, straightforward and often visionary discussion can be found from Doswell(3,4). Stuart et al.(5) emphasize the significance of understanding the psyche of forecasters and the importance of proper education. In the European context Gaia and Fontannaz's(1) article is possibly a pioneering effort and therefore much appreciated by colleagues.

In Finland, perhaps in other countries as well, the importance of the 24/7 service and the special warnings and other products for authorities and military are widely acknowledged and appreciated. The need to be able to forecast extreme or troublesome phenomena more successfully has increased. I see here a discernible trend which lends support to the idea that we will need to further our understanding of the real nature of the forecaster's job in the future. The sustainable organizing of such services naturally requires a clear view of how to recruit proficient and enthusiastic staff, how to encourage middle-aged, experienced forecasters to keep up and how to organize the most tiring shifts. And finally: how to construct a working environment that is both ergonomical and cognitively stimulating.

Above I have mentioned several issues related to the work and professional expertise of the forecaster. A thorough, all-inclusive solution would be beyond the scope of this article (and certainly likewise unreachable with my expertise), but I hope a simple and partial answer could be presented. It concentrates on the question "what is a good forecaster like?" The suggestion presented hereafter is significantly inspired by Doswell(3) and it will condense the answer into five points. I warmly recommend reading the entire essay to anybody interested in the subject.

First of all – quite simply – a good forecaster is interested in the weather. The phenomena fascinate regardless of working hours or holiday periods. On the job the forecaster is sometimes able to discover new challenges even in a simple synoptic situation. It is worth noting that there are many top level researchers with a keen and regular interest in actual weather situations in the forecasting room. A good forecaster does not perceive the weather only as grid values and fields on the screen. Rather, the present state in the atmosphere is seen as weather phenomena with names and characteristics. The behavior of these phenomena can vary in different times and places but is hopefully possible to understand. It is seen as a professional challenge rather than routine work.

In the second instance: a good forecaster works in collaboration with colleagues, is inquisitive and eager to learn. When possible, interactive working is more effective than struggling alone. Learning by doing together is not only fruitful but fun at its best.

A capable meteorologist appreciates technical experts and the necessary technology. At the same time the forecaster is a demanding customer: ready and willing to test new tools but critical, too. An awareness of the new features and possible meteorological constraints in the technical working environment is a crucial part of the proficiency in forecasting. Good forecasters know when the automated forecasts will be useful and when they will be wrong.

Certain physical and mental characteristics are needed in the forecasting room: being able to tolerate irregular working times, to cope with uncertainty, to be on the alert for unexpected situations. The work must be completed in the required time frame, so rather a lot of decisiveness is needed, too.

Finally: a good forecaster has extensive knowledge of the needs of the forecast end-user on one hand and the meteorological basis of the forecasting process on the other hand. Relative to the customer, this means simultaneous ambition and realism: the forecaster wants to offer best possible service, but is willing to recognize the existing meteorological uncertainties. The confidence of the customer is the most valuable "capital" we have. We are familiar with the concepts of medical or economic ethics – meteorological ethics could as well be a useful and relevant term!

Aviation weather forecasts are often warnings by nature

Traditionally, the term "severe weather" means phenomena related to strong cumulonimbus clouds or generally violent winds and torrential rain. Increasingly it is seen that we might as well include very poor visibilities and particularly low ceiling situations in the same category: "Lives can depend on the accurate and continuous monitoring of short-lived but severe weather situations such as fog or thunderstorms" (EUMETSAT Newsletter[6]). It is well-known that in "high latitude regions" like Scandinavia, Canada and Alaska we do have long-lasting episodes of bad aviation weather, which is demanding to forecast. In central parts of Europe the most critical time seems to be the winter solstice like before Christmas 2006, when severe fog caused chaos at London's airports[9].

Aviation meteorology has a long history and the work is internationally regulated. Some products, like Terminal Area Forecasts (TAFs), Significant Weather Charts (SWCs) or numerous military products are made round the clock at certain airports and air bases, and are therefore sometimes seen as "routine" forecasts. However, it is vital to be aware of the warning nature of these forecasts. Even in fair weather, it is possible that the forecasting process requires exclusionary reasoning of some dangerous elements though the final product may be simple: "everything OK, CAVOK, no warning". In difficult conditions aviation forecasts very quickly become more complicated and they have apparent warning components. In that case aviation forecasting is as demanding as any near-future weather warning responsibility. The three-dimensional aspect in aviation means additional struggle in the forecasting room: it is conceivable to have CAVOK on ground level but reason to issue a warning for higher altitudes.

So, the close relationship between aviation and other safety-weather products is evident. An interesting question is how the accuracy of such forecasts and their value to the customer is measured. By verifying a large amount of forecasts and studying e.g. mean errors? Or, after all, could a single crucial warning be much more valuable than hundreds of "routine" forecasts? What about the warning that was never given? The economic benefit, risk minimization or even the potential prevention of an accident would have been extremely important to the customer. No quick or even unambiguous answer exists.

Finally, there's one delicate process to consider. To what extent are (semi-)automatic tools needed in warning generation and where is the human contribution most crucial when aiming for the best results? Doswell[3] points out that so far as phenomena related to strong Cb clouds are concerned, the automatic warning algorithm output from radar systems already shows a tendency to become the de facto warning system. However, forecasting subtle very low cloud and visibility situations is different in nature and may not be suited to automatically tripped alarms. Naturally automatic "beep-systems" in the forecasting room which give a warning when certain limit values are crossed, are of help as forecaster guidance.

Human forecasters – busy and necessary in the future?

Some years ago, when the future of the forecaster's job was considered, the vision of full automation in forecasting was brought up every so often. Today, it seems that the diversity of forecast products and the customers' needs is widely understood and the prevailing view has become that the human input in the process will remain but significantly decrease. But how adequate and *meteorologically* well-founded is this view, the unavoidable diminishing of the human role? It is a common definition that the human forecaster is needed as long as she or he is able to add value to the numerical forecasts. Does that mean that the day will unavoidably come when an objective meteorological point, i.e. a certain quality-level of the models is reached: “from now on the forecasts will be high quality stuff without any human intervention”?

The primary objective of the final part of this paper will be to show there is a firm *meteorological basis* to expect and argue that 1. in “the window” of nowcasting and very short range forecasting special human challenges are faced and they will remain in the future, 2. the concept of “the human ability to add value” needs a proper definition and somewhat broader and more critical consideration than it has received hitherto and 3. the human input will remain, not self-evidently wither. It will be understood that other motives, particularly economic ones, for the diminishing of the human role may exist. In this article, no attempt will be made to discuss these.

So, the concept of the forecaster’s ability to add value to NWP seems to be essential for the future of our work. Interestingly, a respectable definition of the concept or analytical discussion, for that matter, is not easy to find. When examining the matter more closely, several definitions emerge. One line of thought is founded on the assumption that there is a tolerably good NWP value or field available and the human’s role is to fix it if necessary. The human ability, if it exists, should be seen both in the individual forecast and in verification results as well. Forecasting is predominantly seen as delivering values, fields and products to the customer.

Probably this somewhat constricted definition often dominates discussion of the human role in forecasting. It is vitally important to understand that this definition is inadequate in the fields of nowcasting and very short range forecasting. When working in this timescale, a method founded on the NWP is only one technique among several others (see e.g. Table 1., partly adapted from the EUMETSAT Newsletter(6)). Besides, most of these techniques relate to the nowcasting of rain, not the focal aviation parameters, i.e. visibility and ceiling.

Moreover, warnings and most aviation forecasts for the next few hours naturally consist of considerable number of subelements. Some parameters (e.g. upper winds) one can unquestionably pick directly from the models (Roebber et al.(8)) or they lend themselves to other types of automation. However, there remain weather elements which are more reliably and successfully, quite frequently necessarily, nowcast by techniques other than pure NWP. We can see that this period of time or “near-future forecasting window” where the utilization of other techniques is essential, has a non-explicit, situation-dependent duration: typically a few hours but sometimes longer. The salient point is that here we actually face the region where other means than NWP may be the only possibility to forecast. At least in the near future reasoning, extrapolation, combination and merging of data, and human interpretation of weak signals required in the utilization of other forecast subelements will play a vital role.

It is of supreme importance to realize that this window will not disappear in the foreseeable future, if ever. The simple reason is that the gigantic stream from the constantly developing observation systems often (hopefully) enables almost immediate pattern recognition as well as monitoring or extrapolating of the phenomena. But, on the contrary, the full assimilation of all the information in the NWP system will be a formidable, in fact endless challenge and will always involve at least some time lag, which could be crucial in rapid forecasting situations. So the conclusion is that the human ability to add value can and should mean more than simply touching up the NWP fields. *It additionally and particularly means the human-based intelligent and professional operating in the near-future forecasting window.*

Secondly the human role in adding value means that regardless of the forecasting techniques the customers and forecast end-users have the possibility to consult the forecaster on duty. A fruitful and adequate interaction is possible only with a substantial situational awareness on the forecaster side. No less than the past, present and future weather must be mastered. Forecasting is not only delivering values, fields and products, but more: service that suits the customer’s needs.

An overworked forecaster with an unsatisfying working environment for monitoring the present situation is "blind". We might reasonably call this state of affairs the modern form of the meteorological cancer. If the nature of the work is poorly understood, and the predominating requirement in the forecasting room is that of effectiveness, the risk of "cancer" will grow.

In the third place, a noteworthy aspect in the human ability to add value is the idea of cumulative, practical 24/7 experience of the forecaster. Not only the forecaster's experience of various weather situations, but also their knowledge of the customers' needs and the forecasting process is valuable in developing better quality products. Experience shows that new ideas and service innovations quite often emerge from the practical challenges first encountered in the forecasting room. When the potential of numerical modelling grows, the expectations human forecasters face will without a doubt increase, not ease up.

Building a better service undoubtedly means that all parties (research-operations-customers) need to be involved in the process. There are reasons for arguing that a capable forecaster has excellent readiness and competence, a unique chance, to act in a two-way intermediary role, to build the bridge between all parties.

Finally, the model development itself suggests that the human role may remain significant but take new and challenging forms. Here we refer to the new high-resolution models. For instance Schultz et.al[7] state: "High-resolution model output cannot be interpreted the same way as a coarser-resolution model output. Communication of high-resolution forecasts to end users is not simple (i.e., you cannot just send raw model output to users and expect them to use it). Forecasters need to be retrained. This ensures jobs for good forecasters in the future."

Acknowledgements

I am grateful to Antti Pelkonen, the Finnish representative in the WGCEF, for encouragement and many fruitful discussions, and to Topi Mastosalo and Prof. David Schultz for their valuable comments. For several years, Janne Kotro and Elena Saltikoff have given me some vital insights concerning the "near future" forecasting problem.

Table 1: Nowcasting is supported by a number of techniques

- Persistence
- Interpolation & linear extrapolation
- Advection of phenomena, based e.g. on model winds or Atmospheric Motion Vectors
- Conceptual models, well-defined meteorological features associated with patterns of cloud/rain distribution and clearly visible in satellite/radar imagery; a model can help to predict the evolution of the feature and its associated weather
- Methods based on determining the initial state of the atmosphere and/or interpretation of weak signals in order to determine the probability of the phenomenon (decision-trees/ checklists/ ingredients)
- Human experience
- Numerical methods
- Utilization of historical/statistical data(base), e.g. individual statistical peculiarities in the airport cloud and visibility distribution

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Timo **Erkkilä**
Finnish Meteorological Institute

The human factor in issuing severe weather forecasts

Introduction

I have been a forecaster now for about 25 years. During the first years in this wonderful job, the job structure was based mainly on the knowledge gained during my meteorological study and the practicing period as an apprentice whilst being defined by the working instructions available on shift. These aspects could be seen as essential objective background features to perform as a junior forecaster.

As the years went by, I became increasingly aware that besides an objective part there were also other more subjective elements involved. These more human related and psychological subjective elements become really important when the forecaster is preparing to issue severe weather forecasts, probably even more so after a growing number of working years/experience.

I have always been fascinated with this human and psychological factor. Having discussed this subject from time to time, I noticed some reluctance from colleagues who tended to think that forecasters should only work objectively. It is my belief that it is impossible to erase this human factor while forecasters remain responsible for issuing severe weather forecasts. Let us accept this fact.

We should therefore take more advantage from this human factor. Looking at things from this perspective it is even possible to improve the skills of your service in this field. This article is meant to give you a better feeling for the elements involved and for solutions that will optimise the most important feature in your service - your human factor.

Shaking the worst meteorological cocktail

Every operational forecaster will encounter many occasions during their career when the weather could go one way or the other. Uncertainty can increase dramatically as lead times increase and this does influence the actions of the forecaster. For this reason we rely more and more on probabilistic ensemble scenarios for the medium range forecast period: D+3 to D+10. From experience we know that uncertainties may enter the forecast at a much earlier stage and this is why many weather services are developing short range ensemble models and techniques. We also know that the largest 'added value' gained from the forecaster, as the expert on weather forecasting, is expected within the first 24 hours of the forecast. In most services this H+24 period more or less corresponds to the period in which severe weather forecasts and warnings are issued. Looking at my service, particularly for this H+24 period, we are currently not very well equipped with tools to assist in assessing uncertainties or alternative scenarios. The best we can do is look at the ECMWF EPS for short lead time periods, but EPS perturbations are optimised for much longer lead times. Another possibility is to apply poor mans ensemble techniques, such as PEPS or a combination and comparison of other models that are available to your service. The forecaster then has to consider if there are uncertainties in synoptic-scale developments and/or related to more mesoscale phenomena such as CB-clusters and MCS features. For this crucial H+0 to H+24 forecast period, the lack of objective tools will put more pressure on the forecaster especially during potential severe weather situations. This combination of having poor additional support to estimate uncertainties together with time pressures and a high level of responsibility is the worst cocktail one can shake for the forecaster. On the other hand, however, it can focus the forecaster on achieving optimal skill performance based on meteorological knowledge and experience.

The risks in risk assessment

Experience is gained in a number of ways. It will involve both good and bad forecasts and warning events from the past. This kind of experience together with non-meteorological facts will trigger all kinds of psychological effects for the forecaster in charge. I will give a list of examples below.

However, there is one particular scenario that is worth highlighting initially. I have always thought that a poor forecast of a severe weather event (ranked as a "missed warning with high impact on society") would raise utmost caution within the forecast room during any similar event that followed. In other words, there would be heightened awareness in order not to miss such an event again. This is certainly true, but referring to Mr. Marco Gaia's presentation during the 2007 EMS/ECAM meeting in El Escorial, the converse can also occur in dramatic fashion. MeteoSwiss had model evidence to suggest a **potentially** high impact weather situation that would lead to a high risk of flash floods in Central Ticino. The forecaster on duty issued a warning of extreme weather but the event did not occur and the warning was subsequently verified as a false alarm. Not long after the same forecaster neglected a much clearer signal from the model, due to the psychological impact of their previous experience. This time a high impact event actually **occurred** and a missed alarm was noted (The article from Gaia and Fontannaz can be found in the 13th edition of The European Forecaster, the WGCEF Newsletter).

Listing some triggering examples for human behaviour in forecasters

This "human factor" was promoted as the central topic for the 2008 WGCEF meeting at DMI in Copenhagen. Within the 14th edition of this "European Forecaster" you will find the spin off from this interesting meeting.

When preparing for the 2008 WGCEF meeting, an interesting e-mail exchange with Will Lang (Met Office) took place. Will had compiled a short summary of possible human factors that might influence the issuing severe weather forecasts and warnings (additional comments by the author are in italics):

• There can be problems regarding consistency of decision-making from event to event. For example, an earlier false alarm might bias interpretation of the next event even though the events are totally independent, *tending to under forecast next time (the Gaia example). Also an earlier missed alarm will greatly influence the decision making process in a subsequent similar situation, with a tendency to over-forecast*

• How to achieve a consistent approach from different forecasters *(one forecaster could be more prudent than the other)*

• Eyes being drawn to one particular event (perhaps a day or two ahead) which may distract from a potentially more disruptive event on a smaller scale in the near future

• 'Holding ones nerve' versus 'when to give up on an event that becomes increasingly unlikely'

• Dealing with conflicting model guidance. A so-called 'rogue' model run may be leading the way to a different evolution and a change of emphasis

• Handling a decision once it has been made and the 'roller-coaster' effect when the media latch onto the story. It is often difficult to backtrack on a severe event once a warning has been issued

• Warnings may not be a true reflection of real probability criteria. Related to the previous point…Once the media are in full flow, the severe weather story can assume a life of its own and be difficult to control. Consequently there is a temptation not to issue a warning until a high degree of certainty exists – much higher than the defined probability threshold for issuing the warning

• Pressure from senior management – different personalities and interests often come into play. Collaborative decision-making spreads responsibility but can delay the issue of a warning significantly by the time various parties have been consulted

• End of shift syndrome – human nature can sometimes mean that insufficient weight is attached to new information that runs counter to earlier ideas. For this reason warnings can be missed

• Model guidance with respect to convection can often be erratic *(mesoscale events)*

• Lack of relevant observational data can compound problems especially with respect to marginal rain/snow and *freezing rain events (small spatial scale events)*

• IT issues – dissemination problems can be an added source of delay and pressure

• Awareness of the possibility of post-event criticism can create pressure

Some other human factors (added by the author):

• Workloads too high, inadequate technical facilities and poor accommodation can have a negative effect on the quality of forecaster output

• Pressure upon your service, whether from governmental origin or due to competition from other services might influence forecaster decisions

• Strong media attention and criticism is likely to influence your next decision

• Forecasters tend to look merely at meteorological thresholds when issuing severe weather warnings. These thresholds are normally linked to expected social disruption but the vulnerability of society may be dynamic, meaning that at certain times the environment can be more vulnerable such that lower meteorological thresholds and/or lower probability thresholds are more applicable. Forecasters and procedures should encompass a greater sensitivity to such issues

• In general too much stress can distract forecaster concentration and sharpness. A WGCEF survey performed during 2008 and involving almost 30 European National Met Services (NMS's), proved that the stress factor for 68% of respondents is sometimes (too) high. Forecasters from the 22 responding NMS's all felt stress. The amount of stress was ranked as: Neutral stress by 1 NMS, Moderate stress by 6 NMS's, High stress by 12 NMS's, Very High stress by 3 NMS's

• For the survey question "If forecasters are aware of the impact warnings or inadequate warnings can have in terms of damage and loss of life" - 21 out of 22 answered with a clear YES. This means that there is a very high awareness amongst all forecasters of the impact that their warnings have on society, in terms of helping the authorities to take mitigating action. This feeling of high responsibility, shared by all forecasters, is a stress factor in itself

Advantages within these Human factors

In principle these human factors are strongly related with:

• Earlier job related experiences within meteorology

• Personal sensitivity to external factors

• Individual character structure

If you look at this simplified listing there seems to be a substantial learning issue involved. Learning will enrich your meteorological forecasting capability and will also make you more sensitive to the outside world for which your forecasts and warnings are meant. One problem with the human factor is that on the one hand, it can help to serve the more tailored needs of society but on the other hand, it might also override common sense or neglect other objective information from models, methods and consistency. So if we want to take full advantage out of these human influences we should **equalize peak emotions.**

Optimising your severe weather warning system and taking advantage of the human factor at the same time; "An ideal warning system"

In general

It could be a wise decision to try to *separate meteorologically induced stress from the everyday stresses of life*. In this way forecasters will only focus on stress related directly to the weather, model outputs and so on. They should try to form objective choices and output through good shift co-operation and structured shift discussions. A team of experts can deal with the everyday stress outside the forecast room but this expert team should interact with the forecaster(s) on shift.

Collaborative decision making

• Shift meteorologists should have discussions if severe weather warning thresholds are likely to be exceeded. By sharing this meteorological discussion, focussing on the (un)certainties and assessing the risk of the 'worst case scenario', the human factor will not get lost but will be more equalized without overlooking the essential points

• Once the meteorological expert judgement from the operational shift is made, an Expert Team can become involved in the decision making process. The added value of this Expert Team is to assess the initial vulnerability of society and to judge other relevant information relating to potential impacts from the expected severe weather event

• The final "yes or no" decision for the issue of the severe weather warning can be made within this Expert Team. It can be an internal expert team from your institute or a mixed team where you involve people from your national civil protection agencies as well. You might also use video conferencing to support the Expert Team.

The Expert Team will make an initial impact assessment on the expected situation for:

1 - Initial vulnerability: depending on rush hours, weekdays or weekends, national holidays, etc. Your meteorological thresholds might need to be more flexible at this time if you want to link them to changing initial vulnerability. Lower thresholds or lower confidence percentages may be set to trigger the warning
2 - Has similar weather been experienced already over many days during a recent period or is a new event expected? Too many high impact warnings for the same phenomenon over short time periods are overdone and will devalue the external trust in your severe weather warnings. Alternative ways of warning, by using lower colour codes for instance, might be more applicable here
3 - Is the expected event really exceptional in a climatological sense? In such cases the outside world will not be used to it and will be less prepared for proper action as well
4 - Is there any specific political and/or media attention on your institute that could influence a final "yes or no" decision? This might be the case due to a recently missed alarm or perhaps a recent false alarm as well. Also commercial competitors watching closely might be an important factor

5 - Is there any additional media strategy required from your institutional Press officer, perhaps to enhance the awareness in the outside world if a warning is issued? Or if you do not issue, is it necessary to take any other action?
6 - Are there any potential problems within your IT-system? They can badly influence the image of your institute during warning episodes
7 - In general is there any need to bring in additional staff on shift or elsewhere (Press department, IT, …)
8 - Taking all these aspects into account, a final decision should be taken on whether or not to issue the warning. If you decide not to issue an alternative way of warning, perhaps on a lower (yellow) level, should be considered. If there is disagreement within the Expert Team there should be one person who will take the final decision.
9 - The decision making process within the Expert Team should be documented in a short report and communicated to the operational shift

KNMI Experiences after three years of collaborative decision making

• Shift discussion on exceeding meteorological thresholds à At the end of the operational forecasters discussion we make the outcome transparent by letting each of the meteorologists give their personal confidence percentage that the warning threshold will be exceeded within the lead time period. The result of this judgement will trigger the Expert Team

• To make the initial impact assessment the KNMI Expert Team consists of: the Head of Operations (chairman), the Shift leader in charge, a Climatological expert, the Press officer, an IT-department representative, perhaps a model specific expert and an expert on agreed warning procedures

• During the first year there was a great deal of reluctance and criticism from the meteorologists who generally felt less responsible and less competent. However, once forecasters became more aware that the Expert Team were making decisions based on mainly non- meteorological and strategic aspects, there was a much better feeling of acceptance. The fact that operational meteorologists are sharing their responsibilities with others is also leading to less stress on shift

• System is better balanced towards Hit/Miss/False alarm ratios

• There is less criticism from society and civil protection agencies, probably due to a better linkage between severe weather and expected impacts in the outside world

• At this moment the Expert Team consists of only KNMI experts. For the “Red” warnings we have to link with civil protection (CP) agencies by phone. In future we also want better linkage to CP for orange warnings, in order to improve our impact assessment within the Expert Team

Warning and Decision scheme:

General specification for warning thresholds

• Criteria for each parameter, impact/damage related
• Minimum affected area size to be defined
• Criteria should link to differences from climatology
• Lead time definition for each warning
• Warnings should be categorized with colours, according to meteoalarm.eu definition
• A minimum likelihood percentage should be defined on which warnings will be triggered and colours will be assigned

Decision scheme	
Meteorological elements Exceeding of thresholds within agreed lead times should be discussed by the meteorologists on shift. This collaborative decision process is managed by the senior-forecaster and should equalize subjective choices and human factors	**Other elements (external)** • Triggered by the meteorological discussion if thresholds are expected to be exceeded • An expert team could be the decisive trigger for the final issuance of the severe weather warning • This decision can be taken on impact assessment and other external factors

Frank **Kroonenberg,**
KNMI

Evaluation of Severe Weather Warnings at the Austrian National Weather Service

Figure 1: Example of a public warning.

Introduction

During recent years the importance of severe weather warnings has grown significantly. The Austrian national weather service ZAMG provides warnings of several high-impact weather parameters for the public and for governmental institutions. The meteorological parameters included in the current warning system are wind, rain, snow, thunderstorms/hail and freezing rain. Figure 1 shows an example for a public warning as it can be seen on the ZAMG website. The warnings are issued for the different political districts in Austria.

Knowledge of the quality of the warnings, and the resulting information about the potential for further improvement of the system, is of similar importance to the existence of the warning system itself. In order to obtain this information, resources at ZAMG were invested to perform an objective evaluation of the warning system. At present, objective verification is computed for the parameters wind, rain and thunderstorms. In this article, the verification method is briefly described.

Method

For each parameter there are three categories used to indicate the severity of the warning situation (colours yellow, orange and red corresponding to increasing severity levels 1, 2 and 3, respectively). The thresholds used to determine these levels are based on climatological information, and so vary from district to district.

As the severe weather warnings are issued for the different political districts in Austria the verification is done for each district separately.

Wind

The verification of wind warnings is done using station observations, so in the first step the available stations have to be assigned to the different districts. As some of the stations are not representative for a given district due to their location (e.g. in a mountainous area), special care has to be taken during the assignment. Another complication is the fact that there are some districts with no station situated inside. To guarantee that there is at least one station used for verification per district, representative stations in the surrounding districts have to be chosen instead. Once this assignment is done, the verification works in the following way.

The chosen verification period is split into intervals of 12 hours. For each district the maximum wind gust occurring in each 12 hour interval is determined. In a case where the maximum wind gust exceeds the threshold it has to be verified whether a warning is covering the given 12 hour interval. The resulting

Figure 2: Storm event in Vienna, picture by Georg Pistotnik (ZAMG).

observation-forecast pairs can be arranged in a 4x4 contingency table, which finally allows computation of several scores (ETS, POD, FAR, …) yielding numerical values to give objective interpretations concerning the skill of the warning. The used sample size is thus simply twice the number of days used for verification.

As wind is in general one of the parameters with good forecast skill, the first results surprisingly showed rather low scores (especially for POD). In fact that the scores were significantly lower for verification periods in summer, so it was easy to isolate strong wind events connected to thunderstorms as the main reason for this behavior.

The possible occurrence of strong winds during thunderstorms is explicitly included in the thunderstorm warning and therefore no separate wind warning is issued in these situations, and the existence of a valid thunderstorm for a given interval has to be counted as a correct warning during the wind warning verification.

Besides this there are some other aspects to be considered (e.g. the minimum period length for the time between the issue time of the warning and the occurrence of the event), but as the impact on the final scores is rather low (compared to the counting of thunderstorm warnings), it is not necessary to mention all of them in detail in this article.

Rain

For the evaluation of the heavy rain warnings, INCA (Integrated Nowcasting through Comprehensive Analysis) rain analysis fields are used on observational data. INCA is an analysis and nowcasting tool which is being developed at ZAMG. INCA produces 2D analysis and nowcasting fields for precipitation (and other parameters) on a grid with a horizontal resolution of 1km by combining rain gauge and radar data. A detailed description can be found in Haiden et. al 2007.

The splitting of the verification period into intervals of 12 hours is not so easily applicable for rain. The main reason for this is the fact that the definition of a "no-observation" event is more difficult. In the case of wind warnings the occurrence of the maximum gust can be easily assigned to a 12 hour period. In the case of rain this assignment would be more arbitrary, as the final sum of rain falling is the crucial ingredient for flooding and not the maximum rain rate during a given interval. Further, a heavy rain warning showing high skill by forecasting the exact amount of rain can easily turn into a wrong forecast in the case of using the interval-splitting method when the exact timing for the beginning and the end of a precipitation period is not predicted correctly but shifted in time. That is why it was decided not to use split intervals. As a consequence one has to abstain from having full 4x4 contingency tables at present. The verification is therefore done in two separate parts.

In the first part the issued rain warnings are verified by determining the corresponding observed value for the given warning period and district. As the observational data is available in gridded format, one has to search for the maximum value of precipitation among the grid points belonging to the given district. In order to account for the fact that predicting the correct amount of rain should be counted as a correct warning even in situations when warning and observed period are not identical, a time shift (warning period – observed period) is allowed up to a certain extent. Finally it is possible to fill a 4x3 matrix with observation-forecast pairs and compute scores like FAR.

Figure 3: Flooded street, picture by Georg Pistotnik (ZAMG).

The second part evaluates to what extent observed rain events are covered by warnings. The most difficult part here is to determine start, duration, end and intensity for a single observed rain event. One has to take into account several things in order to be able to build up a representative data set for the observed events (e.g. the maximum period length between two rainfall periods with zero observations for counting it as a single event, etc.). Once this is done it is again possible to fill a contingency table (this time 3x4) and compute scores like POD. As with wind one also has to account for the fact that in the case of heavy rainfall events connected with thunderstorms, the meteorologist does not necessarily have to issue a separate rain warning, as this information is explicitly included in the thunderstorm warning.

Figure 4: Thunderstorm over Vienna, picture by Christoph Wittmann (ZAMG).

Thunderstorms

The verification of thunderstorm warnings is done similarly, in that it is a two-way verification, again abstaining from the existence of a full 4x4 contingency table. For thunderstorms it might be easier to apply a split-interval technique (e.g. 24h intervals), but for the moment this is not used.

As with rain warnings, one verifies the issued warnings by determining whether lightning is registered during the given warning period in the area of the district first. In the second step one has to build up a data set with observed thunderstorm events (based on lightning) and determine whether warnings can be found for these events. Building up a data set of thunderstorm events again raises certain difficulties when trying to determine start, end and duration of a single thunderstorm event. But this task is easier to accomplish than in the rain case. Finally, the resulting 3x4 and 4x3 contingency tables again allow the computation of scores like POD and FAR.

Results and Conclusions

An example for a wind warning verification for a district located in the northeastern part of Austria can be found in figure 2. The scores calculated based on the contingency tables shown yield: 0.78 for ETS, 0.92 for POD, 0.87 for SR and 1.06 for BIAS. So 92.47 percent of the cases when the observed gust speed exceeded the lowest threshold within a 12 hour period a warning was issued (in time) by the forecasters (POD). The 4x4 table gives more details about a slight tendency for overwarning, which can also be seen in the BIAS value. ETS is remarkably high (0.78) indicating a significant gain in skill compared to a system issuing random warnings based on the sample climatology.

		Forecasting				
		0	1	2	3	Σ
Observation	0	442	13	0	0	**455**
	1	7	64	6	0	**77**
	2	0	3	5	3	**11**
	3	0	1	3	1	**5**
	Σ	**449**	**81**	**14**	**4**	**458**

		Forecasting		
		Yes	No	Σ
Observation	Yes	66	7	**93**
	No	13	442	**455**
	Σ	**99**	**81**	**548**

Figure 5: Example of a contingency table for wind warnings.

In general, the results for the evaluation of the wind warnings are encouraging, yielding average values for POD, SR, ETS and BIAS for Austria of 0.84, 0.62, 0.53 and 1.36.

The results for rain and thunderstorm warnings clearly show that in general, the skill of rain and thunderstorm warnings is lower compared to wind, but this fact is not surprising as these parameters are known to have less predictability compared to wind. The average results for Austria are rain and thunderstorm: 0.54 and 0.51 for POD, 0.78 and 0.59 for SR.

The evaluation of the warning system yields objective information about the overall quality of the severe weather warnings. Detailed study of the verification result can bring valuable information for the forecasters by exposing districts and/or regions with significant

high or low skill of the warnings, suggesting areas for an extensive study. Up to now the warning verification is done for the severe events wind, snow and thunderstorm. Evaluating other parameters like snow and especially freezing rain is more difficult due to the lack of explicit measurements, but possibilities for doing that have to be further explored anyway.

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Christoph **Wittmann**
ZAMG

Verification of Extreme Weather Phenomena in HELLAS

Introduction

Weather warnings for specific extreme weather phenomena are issued by the Hellenic National Meteorological Service. In this work, the phenomena for which the specific warnings are issued, the issuance criteria, and the methodology used for the verification purposes are presented.

Background

Weather warnings for specific extreme weather phenomena as well as early warnings are issued by the Hellenic National Meteorological Service. Early warnings are rarer and issued only for specific reasons.

The phenomena for which the specific warnings are issued are:

- Extreme air temperature values
- Heavy snowfall
- Very heavy rainfall
- Heavy hail fall
- Gales

Specific warnings are issued according to the criteria set in Meteoalarm, when the phenomenon is forecast for an extended area - orange colour - or even in a limited area - red colour. The limits are different for each region but in all cases warnings are always issued when the forecast wind speed is at least 60km/h or wind gusts exceed 80km/h. If the total amount of 12h or 24h rainfall is greater than a specific amount in each area, a warning is issued. Another reason to issue a warning is if snowfall for rural areas is over 5 cm and for urban areas over 2 cm. Another case where a warning is issued is when very strong thunderstorms are forecast with wind gust ≥ 80km/h, or when there is a significant possibility of flooding or hail of diameter ≥ 1 cm. The criteria for very high and very low temperature warnings are also specified in regions compatible with Meteoalarm.

The recipients of the specific weather warnings are the General Secretariat for Civil Protection, the Ministry of Defence, the Athens News Agency, the Ministry for Mercantile Marine and Island Policy, the Fire Brigade, the Hellenic Police, the Regional Meteorological Centers and all the Meteorological Offices.

Analysis

Quality control is performed by NMC for both routine forecasts and specific warnings with daily checks. Moreover, every month a presentation of the monthly results is made by the verification department of the Meteorological Center emphasizing special cases e.g. extreme weather phenomena or large deviations from normal.

The verification of forecasts is performed as follows:

- The forecast temperature values are compared with the ones observed and acquired through the HNMS station network.

• Rainfall, snowfall and thunderstorm forecast values are also compared with the ones observed and acquired through the HNMS station network, while additional information is collected from other bodies' networks (e.g. NOA, Ministry of Agriculture, etc.) and media (radio, television).

• Wind speed and direction forecast values are compared with the ones observed and acquired through the HNMS station network while additional information is collected from other bodies' networks (e.g. NOA, Ministry of Agriculture, etc.), media as well as from the Buoys Network of the Hellenic Centre for Marine Research.

Verification of forecasts is performed with the aid of the *Hellenic Verification Scheme* (HeVeS). The basic definitions of the terms used are:

• **Precision (P)** is the number of successful forecasts for the specific phenomenon out of the total forecasts for the same phenomenon.

• **Recall (R)** is the number of successful forecasts for the specific phenomenon out of the total number of days that the specific phenomenon occured.

• **Fall-Out** is the number of the unsuccessful forecasts for the specific phenomenon out of the total number of days that this phenomenon did not occur.

• **F-measure** is the weighted harmonic mean of Precision (P) and Recall (R) and is defined as:

The more general formula is:
Two commonly used F measures are :
for β=2 i.e. Recall weights twice as much as Precision and
for β=0.5 i.e. Precision weights twice as much as Recall. After years of study HNMS have ended up using the value β=1.2 for the verification of extreme weather phenomena i.e. to use the $F_{1.2}$ measure.

Administration set as targets:

• The value 0.8 for $F_{1.2}$ for the services provided (Precision 80%)

• The Recall value to =1 in cases where the word "possibility" is used in the forecast text.

Case study

An example of the application of the above methodology is given below:

• 25 cases of extreme weather phenomena were recorded in Greece during the previous year.

• HNMS successfully predicted 23 of them.

• The possibility of occurrence was given to the remaining 2.

• 30 specific warnings were issued.

That gives:

• Precision = 0.83

• Recall = 0.92

• Fall-Out = 0.005. And $\mathbf{F_{1.2} = 0.88}$

Thus we can demonstrate a very good percentage of success.

Chryssoula Petrou , Head of the Operational Support Department of HNMC
Thomas Mavroudakis, Head of the Verification Department of HNMC
Panayiotis Giannopoulos, Forecaster.

Forecasting severe weather events, more than 24 hours ahead at Météo-France: A plea for a human expertise

Introduction

For the short range, typically **24 hours ahead,** severe weather forecast procedures have been in effect for a long time. The French “vigilance” watch map, operational since 2001, puts in concrete form the primary role of METEO FRANCE in the domain of protection of persons and goods, and has proved generally successful. Improvements in numerical weather prediction during recent years, now enable a focus on forecasting dangerous weather phenomena at longer ranges (e.g. within the Medium Range between D+2 and D+4 – see Figures 1, 2) and beyond the requirements for triggering a “Vigilance” warning. However, this can’t be just a simple extension of the validity of the vigilance watch map, because uncertainty generally quickly increases with the forecast range and makes a **deterministic** approach difficult. At present, no specific products are available for governmental services, media, or general public for this type of forecast. This article deals with an experiment that has been conducted at the national forecast service of METEO FRANCE for 3 years.

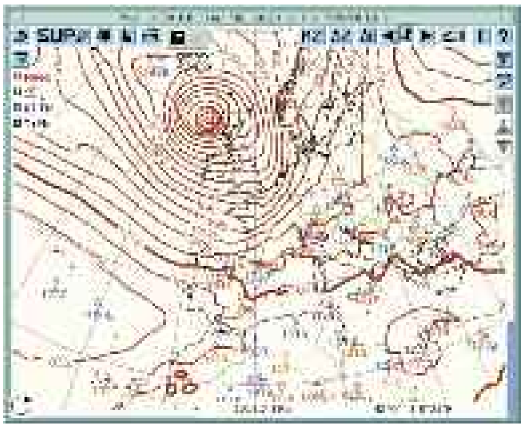


Figure 1: An example of a D+4 forecast by the ECMWF model, the storm Johanna on 2008-03-10.

There has been much research on forecasting severe or hazardous weather events, mostly based on the ensemble prediction system (EPS) - see **“References”.** In general, the idea is to provide indices or probabilities according to different severe or abnormal weather thresholds using sophisticated methods of calibration in time and space. The outputs can be displayed in two forms: On the one hand, for **a given location** with the time evolution of the distribution of parameters above severe weather thresholds, and on the other hand, for **a given time or a time-window,** with the probabilities associated with these thresholds on a geographical area. Accuracy and skill of these forecasts have been shown but interpretation of these outputs is not often simple for users who lack any meteorological background. It’s not easy to provide these users directly with these kinds of products in a way that can be easily understood by non-professional meteorologists.

Figure 2: The vigilance watch map, issued by METEO-FRANCE for this day at 6 o’clock in the morning. Some formalised information could have been indicated four days ahead…

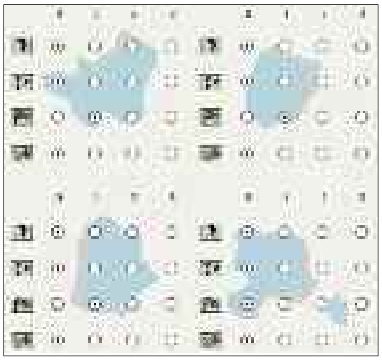


Figure 3: The "web" form filled in by the forecasters each morning. The example of the D+4 forecast for the cyclone Johanna on 2008-03-10.

Method

In our experiment, the approach used in the vigilance procedure is retained. For a given geographical area, an estimation of the risk of dangerous phenomenon occurrence has to be provided for ranges beyond the period covered by the vigilance watch map, for each given day, from D+2 to D+4. As it is impractical to work at the scale of the administrative units (Departments), France is divided into four parts, which are on a spatial scale more relevant for these forecast ranges. This zoning is as close as possible to the METEO FRANCE regional service zoning. Within each zone, a risk index is selected from: no risk (0), unlikely (1), likely (2), certain (3). The phenomena considered are violent winds, heavy rain, violent thunderstorms and snow/ice. Each morning since 2005, forecasters have assessed the risk index based on their study of the deterministic models, EPS products, EFI and so on, and filled in the "web" form (figure 3). It is important to mention that forecasters are familiar with this system, which has been in use for rare and uncertain events for a long time.

Use and limits

Two aspects must be investigated:

1 - From the forecaster's point of view, the most important question is this: for each risk index level, what was the outcome? What percentage of forecasts for each index actually correspond to severe weather events?

2 - From the user's point of view, the key issue is this: for the observed conditions, what was the forecast? Is the forecast able to discriminate between events and non-events?

The answers to these questions will lead to the **forecast formulation,** to put the forecast in a significant concrete form **(the final product)** for the decision maker, and to estimate the potential usefulness for him.

The first step was to choose **reference** or **"truth" data** about severe weather events. In this study, it is the colour of the vigilance watch map at the scale of the defined quarters of France. A dangerous phenomenon depending on the parameter is considered to happen when at least, one department received an orange or red level within the quarter and day examined.

The best way to investigate **the first point** is to plot the frequency of occurrence of an event against the forecast risk index, leading to reliability and sharpness diagrams. These are very informative. Some results are presented in figures 4 and 5. Of course the season is taken into account depending on the parameters (eg. snow will never be forecast in the summer!).

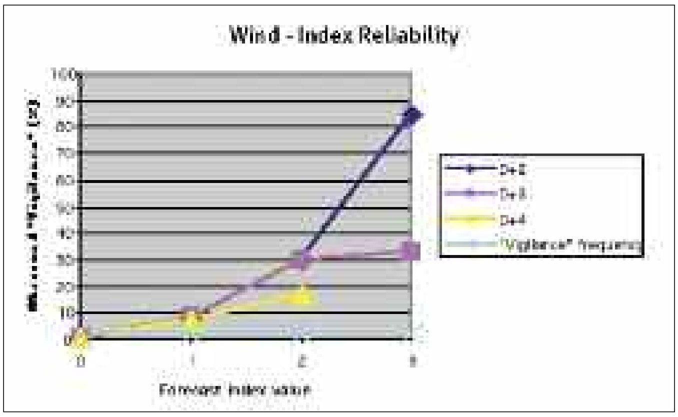


Figure 4:"Reliability" diagram and "Sharpness" table for the Wind over all four quarters of France. For each index level, the rate of observed "Vigilance" is calculated. The table gives the number of cases.

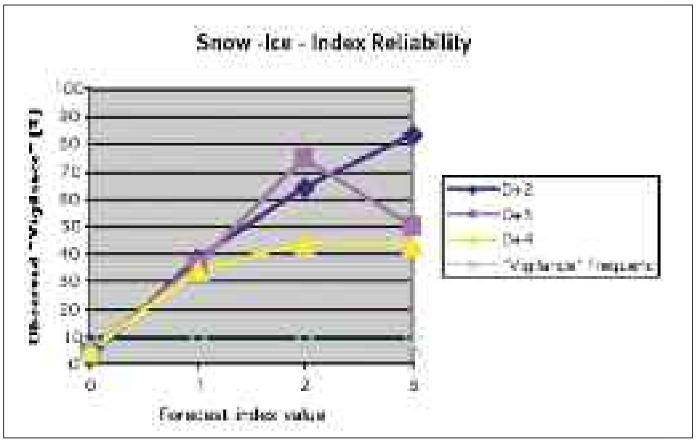


Figure 5: "Reliability" diagram and "Sharpness" table for Snow-Ice - total of all four quarters of France.

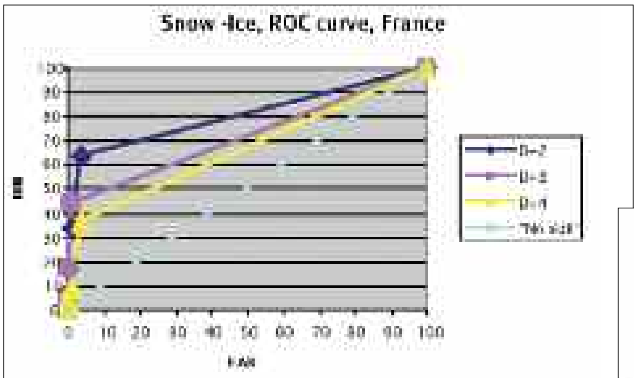
The first conclusions which could be drawn are as follows:

Sharpness is generally important. Forecasters take risks by choosing high-level index, especially at D+2. At this range, reliability can be considered as excellent with discrimination between the four levels of the index, and a significant difference from the "climatological" frequency of vigilance. In particular for index 0, the misses (severe weather events observed but not forecast) are very low, and for index 1, significantly above the average frequency of severe weather events. Beyond D+2, the discrimination between index 2 and 3 becomes quickly weak, whereas the discrimination remains much the same for index 0 and 1. We notice as well that the behaviour of the forecast (slope of curves) varies with the parameter being considered which surprises forecasters. This is also an opportunity to give them feedback about their own forecast process.

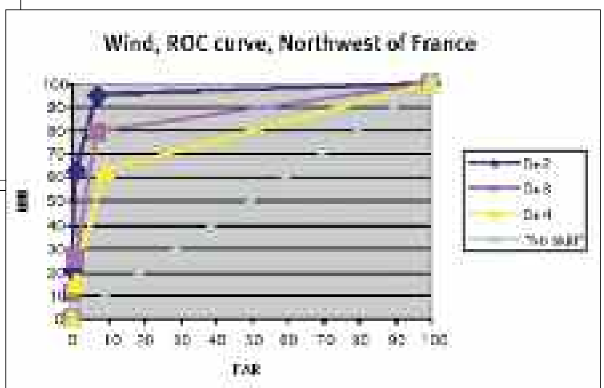
The second point can be synthesized by drawing ROC curves (figures 6, 7, 8), less well known among the forecasters community than Reliability diagrams but equally useful. Consider the following contingency table:

		Forecast		
Observed		Yes	No	Total
	Yes	Hits	Misses	Observed yes
	No	False alarms	Correct negatives	Observed no
	Total	Forecast yes	Forecast no	TOTAL

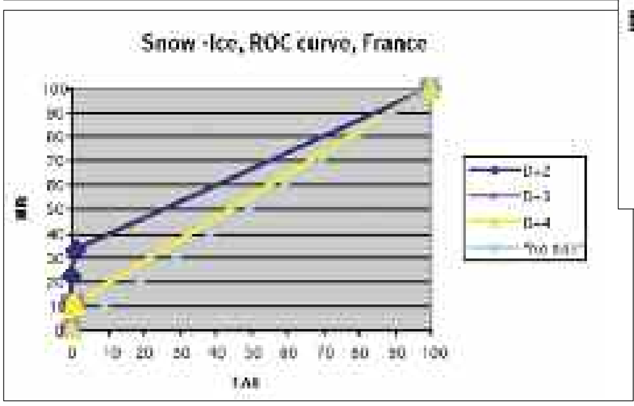
ROC curves plot Hit Rate (**HR**=Hits/(Hits+ Misses), representing the fraction of observed "yes" events correctly forecast) against False Alarm Rate (**FAR**= (False alarms+Correct negatives), representing the fraction of observed "No" events incorrectly forecast as "Yes") for a range of index thresholds (values 1,2,3 together, then 2 and 3 together, and lastly 3 alone).



◀ *Figure 6: ROC curves for Snow-Ice - total of the four quarters of France.*



▲ *Figure 7: ROC curves for the Wind for the northwest quarter of France.*



◀ *Figure 8: ROC curves for the Wind for the northeast quarter of France.*

The graphs show clear evidence of skill, in particular for violent wind within the northwest region of France (points are near the upper-left part of the graph where HR=1, FAR=0). The results are less good within the northeast region with no discriminating power at D+3 and D+4 (curves near the straight line HR=FAR), showing large differences at regional scale! In that case, explanation can be found in the continental character or the smaller scale of phenomena leading to violent winds on the northeast of France, making the forecast trickier in this area than on the northwest part. This is another chance to make forecasters aware of these difficulties!

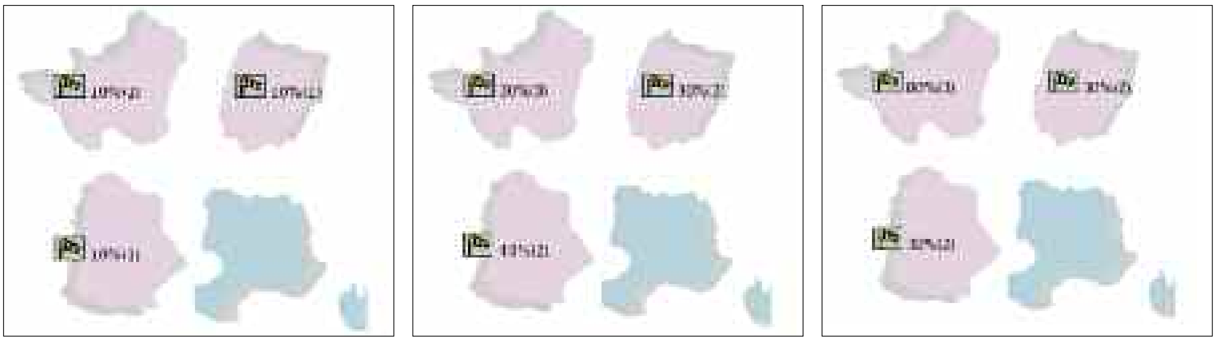
Final product

The idea is simply to provide, in real time, the probabilities corresponding to the reliability of the chosen index for each parameter (figures 9, 10, 11), taking into account:

- The sample representativeness. Reliability is calculated at the regional scale if the sample size is sufficient, or at scale of France as a whole if the sample size is small.

- The discrimination between indexes. Reliability is calculated for each index if the discrimination is sufficient, or for a combination of indexes if the discrimination is not sufficient. For example at D+3, three relevant indexes have to be considered: 0, 1 and, 2 and 3 taken together (Wind and Snow-Ice).

Of Course, these probabilities will be refined as the sample sizes increase. The evolution of the risk level day after day could be also examined.



Figures 9, 10, 11: The final product: the production issued for the situation on 2008-03-10, from D+4 (left) to D+2 (right) forecast. These charts daily are available on an internal webpage.

Conclusion

The first results make the forecasters very confident in their capacity to produce relevant information about severe weather events more than 24 hours ahead, and to draw a decision maker's attention to the threat. Despite small sample sizes, the forecast reliability is established and will obviously improve day by day. Forecasters are now used to systematically discussing the risk index after looking at the numerous EPS products and deterministic models. This experiment gives the opportunity to communicate in terms of probabilities, the most appropriate way in this case but not the most common at METEO-FRANCE. A trial is due to be held this autumn with a few governmental services in order to evaluate the potential usefulness of this type of forecast. But some questions from users already show that the properties of probabilities must be explained. In fact, one still thinks that a probability of 50% corresponds to the toss of a coin, whereas it's significantly high when the climatological frequency of the phenomenon is low. Finally, the most important criticism, which already emerges, concerns the zoning of France into four parts. We believe that the method remains valid because a decision maker will always be responsible for a given geographical area and would like quickly to know what might occur within this area. The zoning has to be then well defined. An example of this principle could be applied with METEOALARM chart at the scale of European countries.

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Bruno **Gillet-Chaulet**
bruno.gillet-chaulet@meteo.fr

Severe Weather Warning and Management of Pressure and Stress at DWD

Introduction

Resolution of numerical weather models and nowcasting-tools has improved very much in recent years. This is why Deutscher Wetterdienst (DWD) started a three-stage temporal warning concept in 2001, extending this to a spatial resolution of about 350 districts in 2003.

Especially in mass media, competition has developed between the national weather service and many private weather companies since the beginning of the 1990s. This competition has spread out into the weather warning business.

This competition and a few unfortunate severe weather incidents have increased pressure on DWD and its forecasters considerably in recent years.

Severe weather warning at DWD

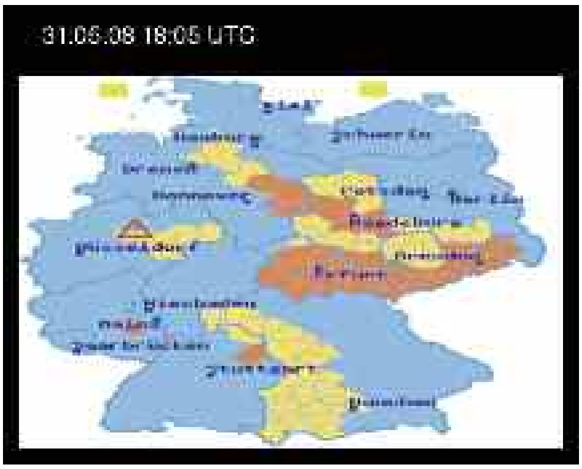
Deutscher Wetterdienst issues warnings in a three-stage temporal warning concept since 2001 and at spatial resolution of about 350 districts since 2003. In mountainous counties the vertical resolution of warnings is in 3 stages.

The three-stage temporal warning concept means that, in a timescale of 7 to 3 days, early warnings of a severe weather incident will be issued at relatively coarse resolution.

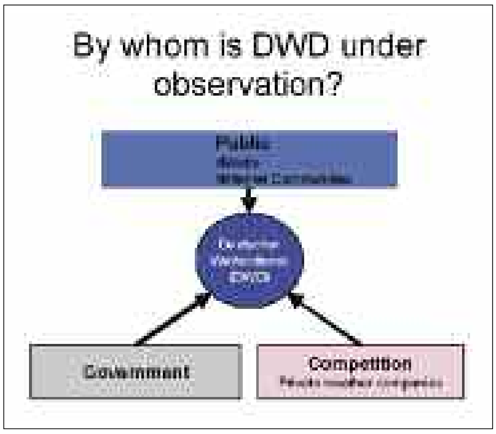
3 to 1 days before an incident occurs, prewarnings are issued on the basis of the 7 regional forecast centers. Depending on the scale of the incidents actual warnings are issued 12 to 1 hours before the incident.

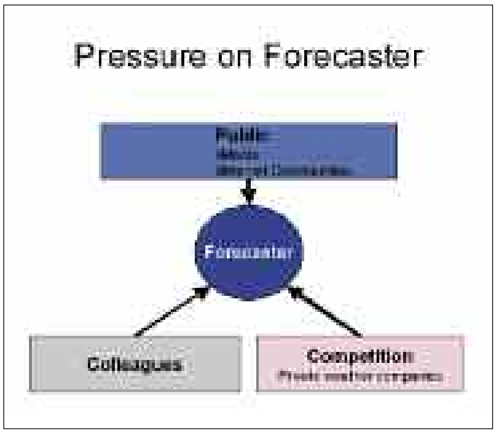
Severe warning thresholds:

- **Torrential rain (≥25mm/1h)**
- **Long lasting rain (≥40mm/12h)**
- **Gale force wind (≥Bft 11)**
- **Heavy snowfall (≥10 cm/6h)**
- **Widespread freezing rain**



◀ *Example of DWD severe warning website*





Pressure on DWD and forecasters

Especially in the media sector, competition has developed between the public weather service and many private weathercompanies since the beginning of the 1990s.

Also private services have started to supply their customers and the public with weather warnings in the last few years. This has increased competition between the national weather service and private companies even more. This competition and a few unfortunate severe weather incidents have increased pressure on DWD and its forecasters considerably in the last years.

While private weathercompanies had a strong appearance in the medias and made propaganda for their product they always said, in contrast to the state-owned weatherservice, they are not financed by taxpayers money. Hence DWD has been eagerly watched by the public in medias and internet chatrooms, by private companies and at last by the government more and more.

Because the warning process is not fully automated, but still assisted by the forecaster, pressure on the national weather service is transferred to the forecasters.

So forecasters are under particular pressure from the public, and from vigilant competitors always waiting for mistakes. Even colleagues who are less in the forefront of forecasting operations can have a pressure impact on forecasters.

Immediate reports

DWD is used to the challenge of severe weather warnings and false forecasts.

How does DWD deal with this challenge?

- **Transparency**
  - Weather reports are issued on the internet
  - Warnings are issued on the internet
- **Information management**
  - Internal bulletins
  - external bulletins
- **Verification**

Therefore it has issued internal immediate reports since 2001, in which special weather situations are studied. The subjects of these immediate reports are the synoptic situation, quality of the numerical models and forecast tools, quality of early and actual warnings as well as the evaluation of the warning management of the central and regional forecasting offices.

Since competition between the national weather service and the private weather industry has become stronger, the reports have, in the interests of transparency, been disseminated for all weather warnings on the internet.In addition, information management was increased by systematizising immediate reports.

- **Regional immediate report**
  - if there was a severe weather warning in one of the responsible local areas.
  - if there was a severe weather incident in the regional area without being warned.
- **Time of issue: 07.00h next morning**
- **National immediate report**
  - if there was a severe weather warning in at least 7 local warning areas.
  - if there was a severe weather incident without being warned.
- **Time of issue: 07.00h next morning**

However this requires a lot of time and effort by the workforce. Because of almost daily severe weather warnings more than 50 immediate reports were issued due to strong convective situations in summer 2008.

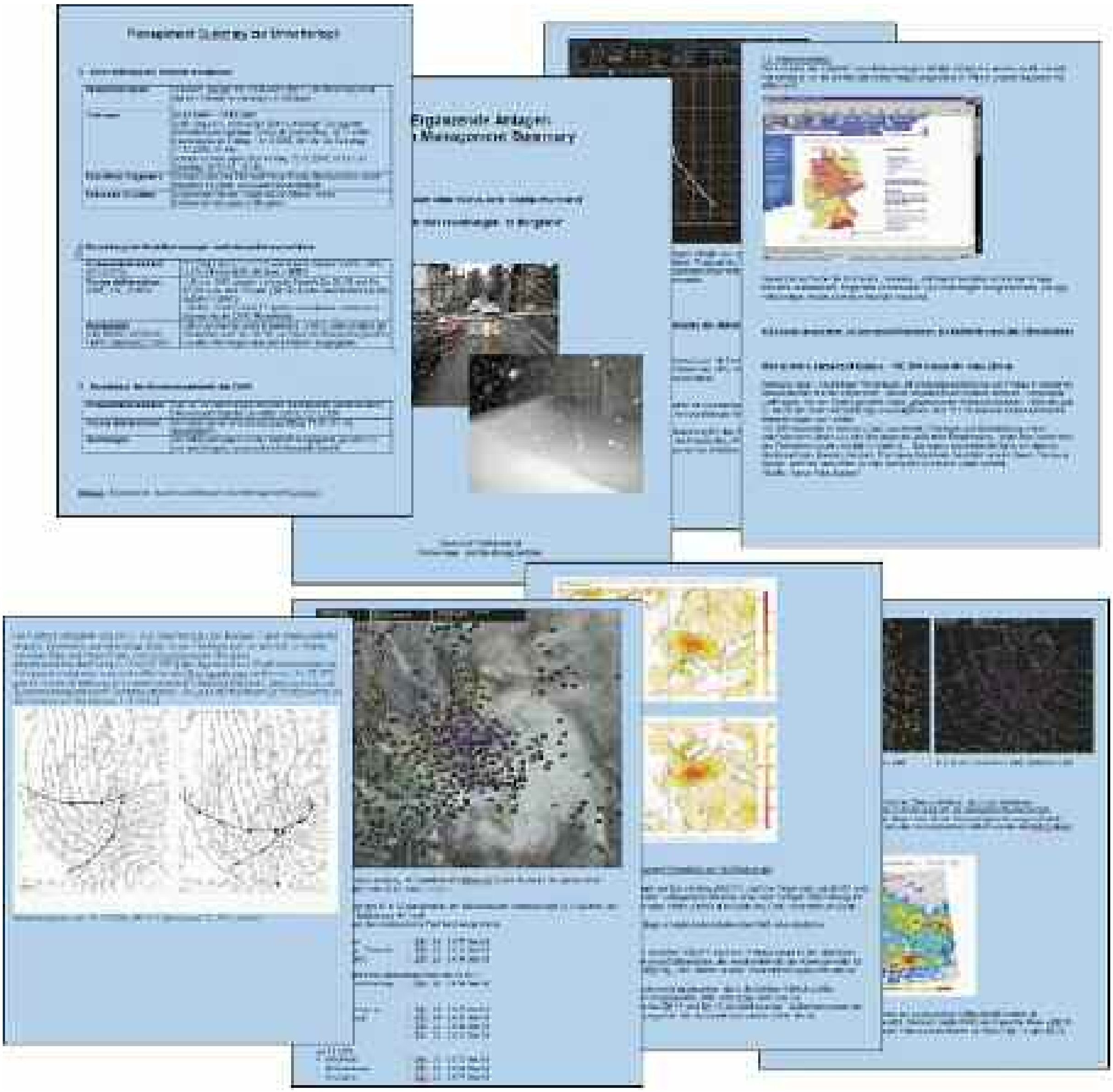
Management summary and verification report

In case of a severe weather situation which covered most of Germany and caused considerable destruction, a comprehensive "Management Summary" is issued.

It will be handed over to internal department of the weather service and the government.

Verification reports, which are issued quarterly, are increasing transparency of the warning process and lower the pressure on DWD and forecasters.

Klaus **Baehnke**
Deutscher Wetterdienst



The European Forecaster 31

Breaking the ice
The human element
in Met office road ice forecasting

Introduction

A common theme of recent WGCEF meetings has been the need for forecasters to assert their continued vital importance to many meteo-rological products and services. Indeed, increasing sophistication of models and availability of observations brings us a new set of forecasting challenges, in which we play the critical role in interpreting and communicating the impacts of weather to end users.

This article describes how forecast production processes used in Open Road – the Met Office's road ice forecasting service – have been radically changed to improve flexibility and efficiency, while maintaining quality in an increasingly competitive environment.A combination of structural, procedural and technical improvements have been made to reduce the time forecasters spend on routine production in order to free up time for skilled forecasting tasks.

It is intended that similar methods will be used to enhance performance in other areas of our forecasting operations in the near future.

Backgroud – 'Open Road'

The Met Office's road hazard forecasting service, 'OpenRoad', has been though several incarnations since it was launched across the UK in 1986. But the basic structure of the product remains: a series of site-specific graphs of Road Surface Temperature and Road State covering a 24hr period, together with explanatory text forecasts dealing with conditions across the customer's entire region of responsibility. Forecasts are then monitored overnight, and amended when certain thresholds of forecast accuracy are exceeded.

In its latest configuration, model 'first guess' curves are created using post-processed output from our 4km mesoscale model. As of the 08/09 winter season, we have around 170 customers, most of whom require 24hr text forecasts.

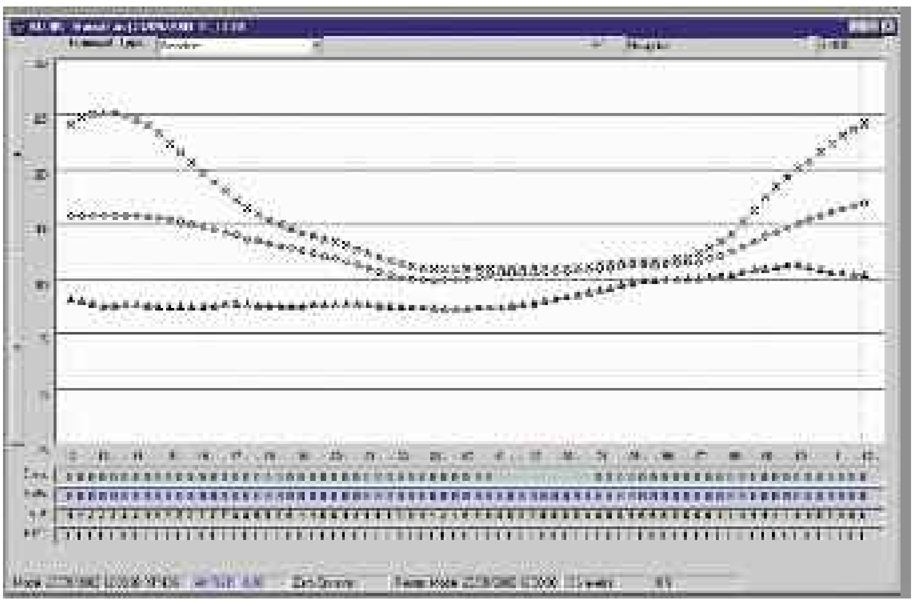


Figure 1: An OpenRoad Ice Prediction Graph, showing Air Temperature (red), Road Surface Temperature (Green) and Dew Point (blue). Road State, Precipitation Type and Cloud Amounts are displayed beneath.

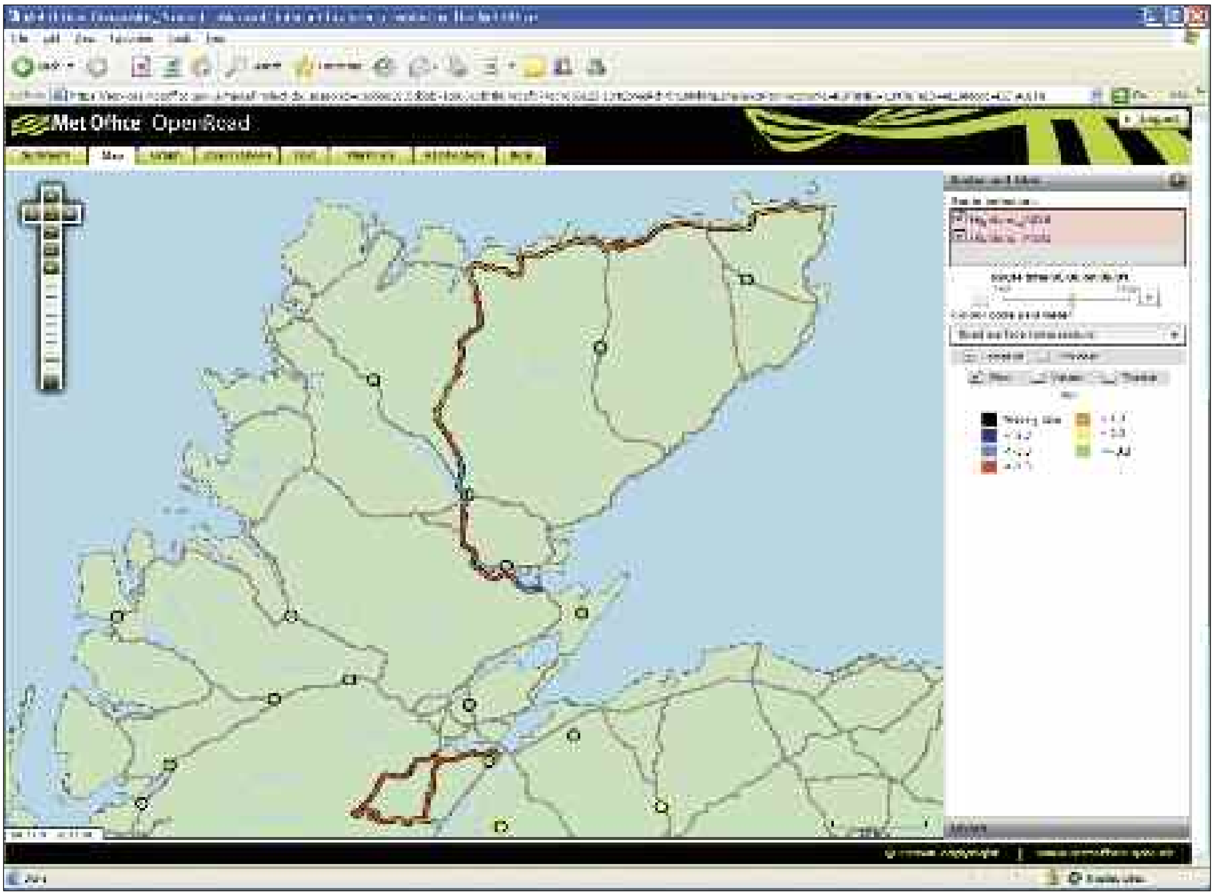
Figure 2: An OpenRoad 24hr text forecast.

Approximately 350 forecaster-derived graphs are produced, and we monitor the output from ~1000 sensor sites. Production has traditionally been labour intensive – even in trivial 'no hazards' situations - with initial creation of text and graphs each day taking 5 or 6 forecasters up to 5 hours each. Subsequent monitoring, amendment and consultation is highly weather-dependent, and can be particularly stressful in snow or in marginal ice/frost situations.

The road weather market is highly competitive in the UK. The Met Office is required to tender for contracts to the UK Highways Agency, local authorities, and their subcontractors. Various commercial weather companies have offered increasing levels of competition in recent years, using data primarily derived from US models.

OpenRoad ('OR') now incorporates a 'Route-Based' (rather than site-specific) capability, forecasting for many thousands of route segments. The need to monitor and interpret these forecasts, let alone intervene manually, suggested that our past production methods had to change.

Figure 3: Screenshot of the Route-Based Forecasting (RBF) system. Trial routes are colour-coded by RST in this example.



Production changes

The Philosophy

The forecaster is the vital controlling, decision-making element in a complex and technical production system. They are also a relatively expensive resource. They should therefore be able to do their jobs unhindered by technicalities and mundane tasks. By analogy with an airline pilot, or an air-traffic controller, we aimed to provide as much support to the human element in terms of automated systems and decision-making aids as possible.

The new production process is also designed to:

• Enable support of future Route-Based forecasting system.

• Address concerns about excessive workloads and forecaster stress in the busiest situations.

• Design an operation which can be scaled to fit expected weather, increasing efficiency and providing an even workload for all.

• Ensure forecaster intervention is limited to situations in which it is relevant to customer needs.

Structural Changes

Since forecast production was centralised to Exeter several years ago, we have continued to operate in a 'pseudo-regional' structure, with each OpenRoad forecast position working independently and looking after a set geographical area. In the new system, we have introduced a Team Leader who coordinates operations of a much more flexible team of up to 6 production forecasters.

The Team Leader's role is to :

• Decide staffing levels for the coming shifts based on expected weather and workload.

• Decide how to distribute the forecasting team efforts across the different regions of the UK.

• Determine consequences of Chief Forecaster guidance for road hazards and impacts.

• Enforce Best Practice and Business Rules.

• Monitor quality and consistency, and have overall responsibility for OR output.

Within the production team, resources are focussed towards customers in areas likely to experience high-impact weather. Elsewhere, production is semi-automated (see below) and should be accomplished by a single forecaster. Thus the regional model has been abandoned in favour of concentrating forecasters' effort to where it matters most.

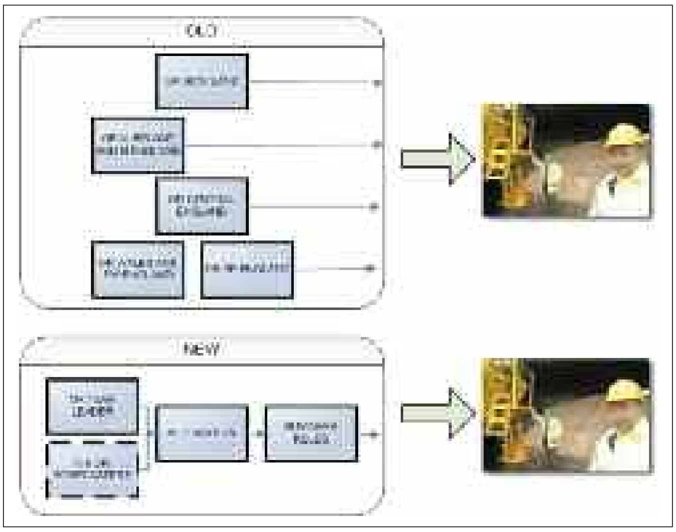


Figure 4: Comparison of old and new OpenRoad production team structures, with flexibility and automation replacing fixed regional responsibility.

Technical Changes

A suite of new production tools were developed to automate parts of the forecast process. The primary aim of many of these tools is to make routine forecasts of trivial ('GREEN') forecasts simple, and to make forecasting in other situations much easier. In the case in which conditions across the UK are uniformly mild, it should be possible for one forecaster to produce all the forecasts in very little time. All other forecasters may 'stood down', and deployed in other roles or allowed to go home. At the heart of the system lie applications which create text forecasts based on reusable text elements and first-guess model data. These are accompanied by additional forecast monitoring and intervention tools.

In normal, more complex, weather situations the tools enable us to employ human forecasting skills where they are needed most – leaving 'the machine' to forecast for areas which are milder, or in which the model is deemed to be performing sufficiently well.

Procedural Changes

Ideas of Best Practice were collected, agreed and published, and new forecasters were trained in these methods. But in addition to this, we worked with our scientists and business staff to formulate a set of rules which, when followed, allow the forecasting team to deliver maximum impact for minimum cost, without an excessive workload. For example,these 'Business Rules' include instructions on when forecasters should intervene on automated output, which models to use, and guidelines on how many staff should be used to cover certain weather situations.

Used in a coordinated manner along with the other changes described, Business Rules are a powerful tool in ensuring forecast quality, consistency and efficiency.

Results and conclusions

Winter 08/09 in the UK was the coldest since the mid-1990s. During early February, many areas, including the densely-populated South East, experienced their heaviest snowfall in 18 years. Despite this, we have managed to enhance forecast accuracy and quality, with a significant reduction in production costs. The new working methods have also proved broadly popular with both experienced and with newly-qualified forecasters.

There remain some aspects of the process which are stressful, excessively time-consuming, or are an inappropriate use of a forecaster's time. Further improvements are due to be made before the 09/10 winter season which will seek to address some of these issues.

A general review of the Met Office's forecasting activities is now underway, with a major theme being defining the future role of the forecaster. The benefits of the changes described above have been recognised, and it is hoped that many of the ideas can be applied to other aspects of our forecasting operations.

The authors would like to thank the Winter 08/09 Forecasting Team.

Will **Lang,** Jonathan **Dutton,**
Alison **Eadie** and Baden **Hall**
Met Office, UK

The Project MAP D-PHASE

Introduction

In 2004, the MAP (Mesoscale Alpine Project) Steering Committee mandated a working group to explore the possibility and interest of a fourth phase, that of demonstration. From the many achievements of MAP, the following have been chosen as the topic for the MAP Forecast Demonstration Project (MAP FDP):

- Forecasting heavy precipitation and related flooding events in the Alpine region
- The associated issues of orographically enhanced precipitation.
- High-resolution numerical weather prediction and hydrological processes.

The project thereby addresses the entire forecasting chain ranging from observations, ensemble forecasting, high-resolution cloud-resolving atmospheric modelling (km-scale), hydrological modelling, and nowcasting to decision making by end users (civil protection authorities, water management and hydrological agencies, etc.), i.e., it sets up an end-to-end forecasting system.

To emphasize the main objective of the fourth phase of MAP, the MAP FDP is referred to as D-PHASE, which stands for Demonstration of Probabilistic Hydrological and Atmospheric Simulation of flood Events in the Alpine region. It is a Forecast Demonstration Project (FDP) of the WWRP (World Weather Research Programme of the WMO). The neighbouring Alpine countries have entered this project.

Objectives

The main objectives of the project are:

- Assessing the degree of predictability for precipitation and flood events as a function of event size, precipitation amount, event character (e.g. convective versus stratiform), and lead time;
- Demonstrating the potential of operational high-resolution atmospheric models in capturing the relevant processes responsible for heavy precipitation events in complex terrain;
- Demonstrating the ability of hydrological models to provide a timely and skilful forecast of runoff and water levels;
- Assessing the prospects of very short-term predictions of heavy precipitation and severe convection over orography, using tailored heuristic techniques and real-time observations from radar, automated surface networks, soundings, and satellites (nowcasting);
- Establishing a better link between atmospheric and hydrological scientists and the actual end users. This includes matching the improved possibilities from the hydro-meteorological models with the relevant needs of the end users.

MAP D-PHASE

The MAP D-PHASE project is the 4th and last phase of "MAP". It aims to demonstrate the benefits that MAP has brought to forecasting, in this case for heavy precipitation and associated flooding in the Alps. The demonstration has been carried out during the summer and autumn 2007. This project involves many meteorological and hydrological specialists at international and regional level.

A platform has been developed to visualize model generated alarms for different thresholds and accumulation times (3h, 6h, 12h, 24h, 48h and 72h) using approximately 24 models and 7 ensemble model products. The chosen areas represent a balance between meteorological and hydrological catchments. The 3 alert levels are determined according to return periods. The Platform allows visualisation of the meteorological model fields and meteograms, nowcasting tools (radar etc …) and hydrological information.

Every day the forecaster subjectively evaluates the quality of the guidance given by high resolution multi-models and ensemble approaches and also the utility of such a Platform (the model alarm approach). The importance of nowcasting tools versus models was also evaluated.

All the data, alerts and feedback are archived, mainly for verification purposes.

Finally, the feedback from the forecasters, hydrologists and end users will be analysed; meanwhile, the numerical models will be objectively evaluated.

The Visualisation Platform (VP)

The concept of the visualisation platform has been designed mainly by MeteoSwiss and realised by Next Generation Software (Salzburg, Austria); it allows the forecaster, the hydrologist and some end users to consult information such as deterministic and probabilistic models' alarm system, nowcasting tools, hydrological models etc. It is also through this platform that the users are able to submit their feedback.

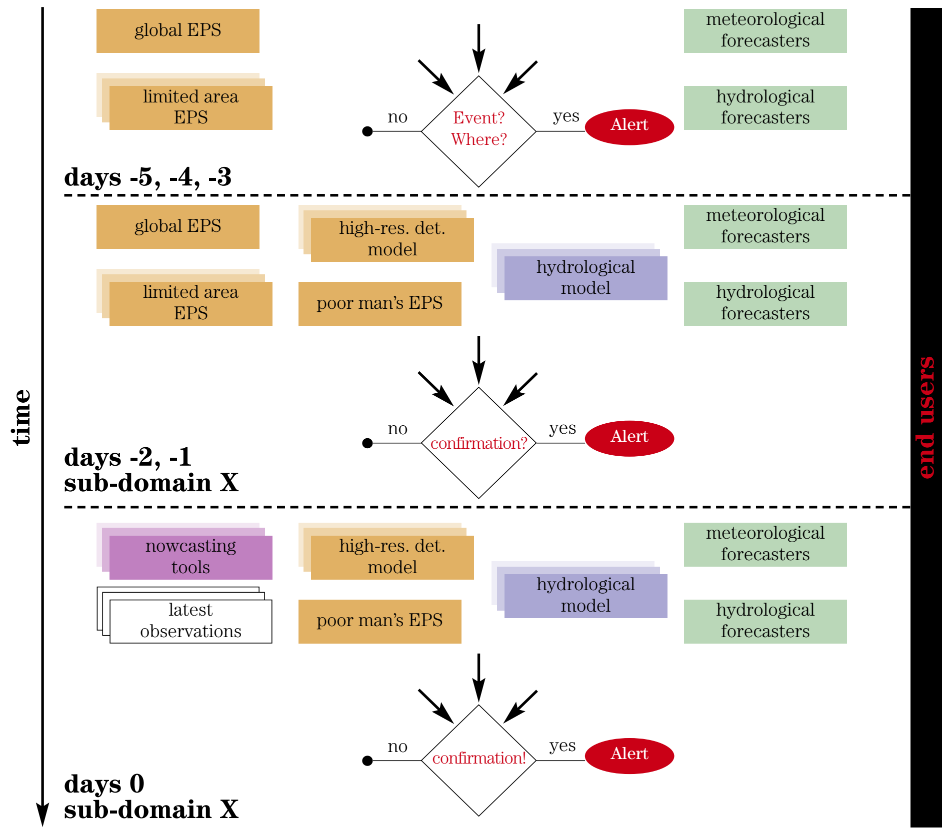


Figure 1: Conceptual sketch of the real-time end-to-end forecasting system for D-PHASE.

Forecasting Alarms

The diagram on fig 1 shows the decision process for issuing an alert. Between 3 and 5 days prior to the event, the forecaster analyses the ensemble forecast. The platform provides the average and the maximum precipitation of the ensemble. At this stage the forecaster can decide whether to issue a warning.

Between 1 and 2 days before the event, the fine mesh models are added to the diagnostic, each of them providing the maximum precipitation for a region. The alarm can be then confirmed or discarded. Meanwhile, hydrologists consult runoff models for various rivers.

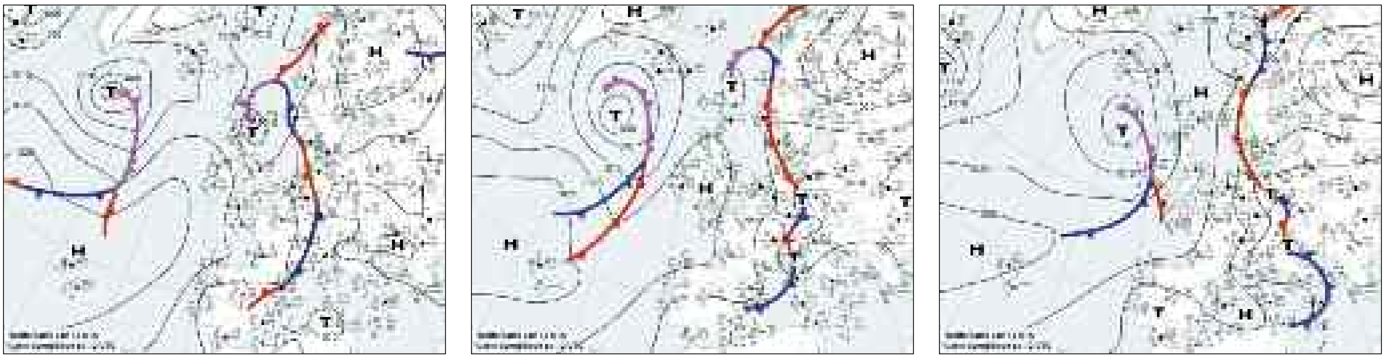
Finally, nowcasting tools are added to the analysis and help to localize and improve the forecast amount of rain.

Feedback by the forecaster

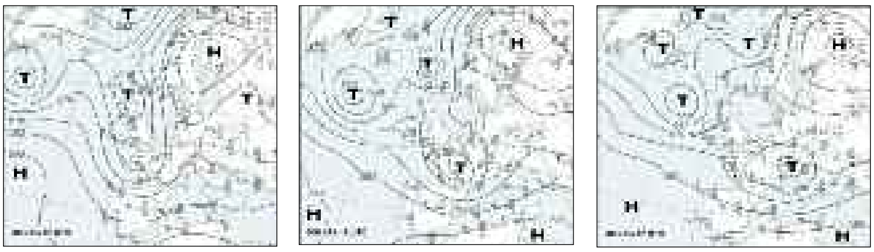
Every day during the experiment period, the forecaster fills an evaluation form which consists of the following:

The description of the weather type, the type of event etc ….
Which model and data did the forecaster use for analysing the weather situation?
Which element supported the forecaster in his decision?

Similar feedback is provided by hydrologists and end users such as civil security officers.



▲ *Figure 2: a,b,c surface chart analysis on respectively the 7th, 8th and 9th at 12z.*



▶ *d,e,f 500 HPa chart on respectively the 7th, 8th and 9th at 12z.*

Case Study: Heavy Rain Between the 7th and 9th August 2007

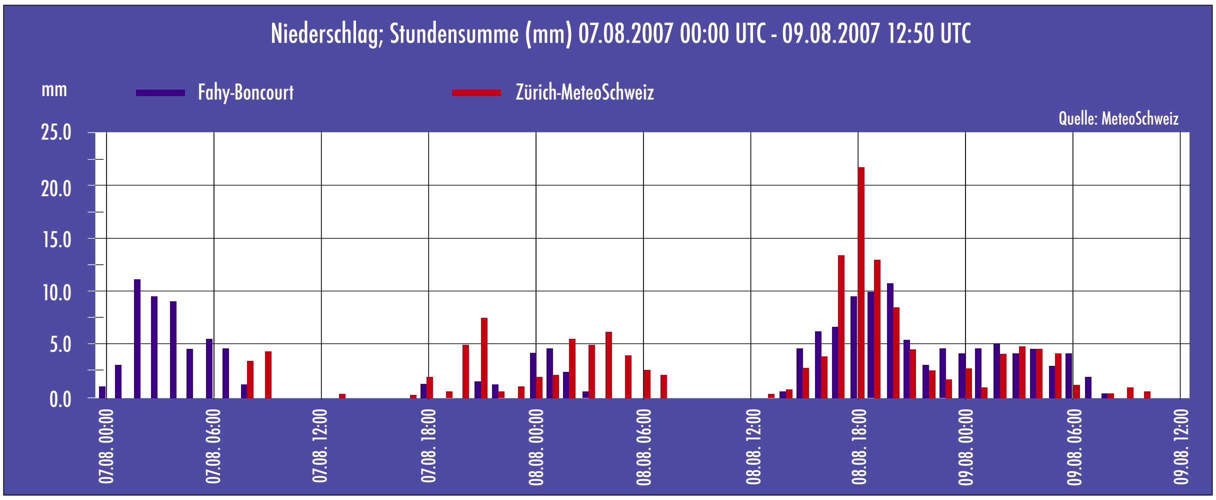
Many flood warnings were issued in Switzerland during the demonstration period; the most serious happened between the 7th and 9th August. Fig 2 shows the surface and the 500 HPa chart at 12z on the 7th, 8th and 9th August.

On the 7th, a front, associated with an upper trough, approached the western part of Switzerland. On the 8th, the trough created a cut-off centred over the “Massif Central” in France. The front started undulating and finally, on the 9th, the upper low moved eastward forcing the front to move backwards. These situations are known as “return from the east” and usually cause heavy precipitations in eastern Switzerland.

Figure 3 shows the hourly precipitation at Zurich and Fahy (50 km south west of Basel).

On the 7th, most of the precipitation was associated with pre-frontal instability, as a convergence zone moved eastward. On the 8th, the front produced moderate rain whilst crossing Switzerland and during the night of the 8th and the morning of the 9th; the heaviest precipitation was associated with the moist flow from the Mediterranean Sea.

The 72-hour total precipitation over Switzerland is shown in figure 4. The heaviest rain was recorded near Zurich, Basel and along the northern foothills of the Alps.



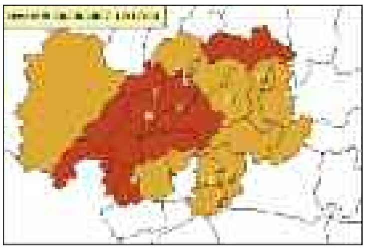
▲ *Figure 3: hourly precipitation at Zurich and Fahy.*

◀ *Figure 4: 72 hours precipitation from 6z on the 7th to 6z on the 10th.*

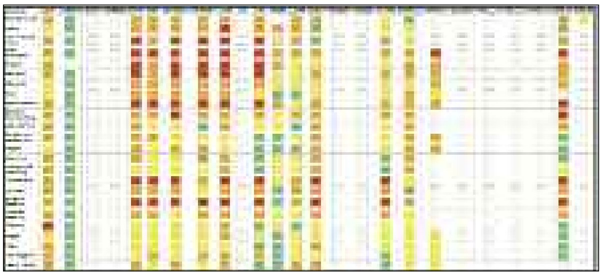
MAP D-PHASE platform

The visualization platform contains 3 levels; the maps shown here are as seen on the 8th August 2007 at midday. At level 1 (figure 5a) the map shows the regions coloured according to the degree of warning. The squares correspond to locations on rivers where runoff is measured. By selecting a square the hydrologist can access the model's runoff forecast. Since the data of many models are used in the platform, the alerts shown in this map correspond to the highest grid point value of precipitation of all models.

Level 2 (figure 5b) is reached by clicking on the map. It shows, for each region and each model, the highest degree of alert for each model. Finally, by selecting a region, the forecaster can reach level 3 (figure 6) which provides details on the duration of the alarm, the quantities of precipitation and when the threshold would be reached for which time-lag (3, 6, 12, 24, 48 and 72 hours). The triangle indicates the end of the alarm period. The colours, green, yellow, orange and red correspond to different alarm levels (green means no alarm). The levels are different for each region and fixed according to the return periods, respectively 60 days, 180 days and 10 years. The amounts of precipitation forecast by the deterministic and ensemble models are available on this level.



◀ *Figure 5a: Platform MAP D-PHASE, level 1; map of the alarms region.*



▲ *Figure 5b: Platform MAP D-PHASE, level 2; details of the model alerts.*

◀ *Figure 6: Platform MAP D-PHASE, level 3; periods of thealerts.*

This example shows the benefit of such a platform Most of the models showed an alarm during this event, and moreover, it is possible to visualize the precipitation distribution for all models on the same format.

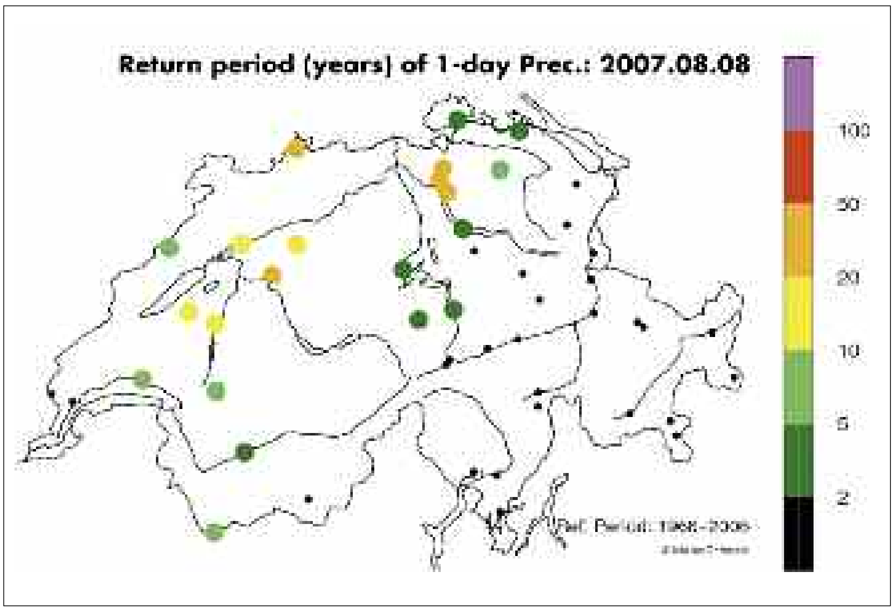


Figure 7: One day precipitation according to the return period.

Finally, figure 7 shows one day's precipitation (on the 8th August) according to the return period. The alarms issued during this event have been fully justified; the MAP D-PHASE platform has proved to be a valuable aid.

Conclusion

The demonstration period finished in November 2007. The feedback so far has been very positive, mainly concerning the visualisation platform. Its main benefit was to have all the model's alarms readily available on the same screen and on the same format. The strength of the platform is to be able to see the sum of the precipitation for different accumulation time and threshold. Usually, models provide precipitation accumulation over a fixed length of time.

Some informal contacts with hydrologists and end users have enhanced the usefulness of such systems. A large number of end users have been involved in this project; it contributed in bringing together the meteorological and hydrological communities.

The models verification will provide a feedback to the forecaster about its quality during the events. The forecasters have requested to include large-scale models such as ECMWF into such a platform, in order to monitor warnings 3 or 5 days prior the event.

Hopefully, WGCEF's web site would benefit from the visualization platform of MAP D-PHASE to construct a tool which will display different output models on the same format.

More details about this project are available at:
http://www.map.meteoswiss.ch/map-doc/dphase/dphase_info.htm

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André-Charles **Letestu**, Lionel **Fontannaz**
MeteoSwiss

Representatives

Working Group for Cooperation between European Forecasters (WGCEF)

The Netherlands

Mr Frank Kroonenberg
Senior meteorologist
Chairperson
(KNMI) Royal Netherlands
Meteorological Institute
P.O. Box 201
NL-3730 AE DeBilt
Frank.Kroonenberg@knmi.nl

Austria

Dr Herbert Gmoser
Head of the Operational
Forecasting Division
Vice Chairperson
Zentralanstalt für Meteorologie
und Geodynamik
HoheWarte 38
A-1191 Wien
herbert.gmoser@zamg.ac.at

Albania

Mr Metodi Marku
Forecaster
Section of Weather forecasting
Instiutute for Hydrometeorology
Rruga Durrësit, 219
AL - Tiranë
metodimarku@yahoo.com

Belgium

Mr Jean Nemeghaire
Forecaster and assistant
Operational forecasting division
Royal Meteorological Institute
of Belgium
3 av Circulaire
B-1180 Bruxelles
jean.nemeghaire@oma.be

Belgocontrol

Mr Hans Plets
Scientific Meteorologist
Belgocontrol
Brussel National Airport
B-1930 Zaventem
hans_plets@belgocontrol.be

Bulgaria

Mr Andrey Bogatchev
Researcher Operational suite
of ALADIN_BG
Department of Weather
Forecasting
National Institute
of Meteorology and Hydrology
66 Tsarigradsko chausse blvd
BG-1784 Sofia
andro@forecast.meteo.bg

Croatia

Ms Branka Ivancan-Picek
Assistant Director
Meteorological
and Hydrological Service
Gric 3
HR-10000 Zagreb
picek@cirus.dhz.hr

Cyprus

Dr Silas Michaelides
Meteorological Office
CY-7130 Larnaca-Airport
cssilas@ucy.ac.cy

CzechRepublik

Mr Marjan Sandev
Head of CFO
CHMI- Dept of Meteorology
Na Sabatce 17
CZ-143 06 Praha 4-Komorany
sandev@chmi.cz

Denmark

Mr Knud Jakob Simonsen
Head of Division
Public weather service
Mr Soren Brodersen
Senior Meteorologist Aviation
Danish Meteorological Institute
Lyngbyvej 100
DK-2100 Copenhagen
kjs@dmi.dk
sb@dmi.dk

Estonia

Ms Merike Merlain
Head of forecasting division
Estonian Meteorological
and Hydrological Institute
Toompuiestee 24
EST-10149 Tallinn
merike.merilain@emhi.ee

Finland

Mr Antti Pelkonen
Aviation forecaster
Finnish Meteorological Institute
Aviation and Military
Weather Service
Varikontie 14
FI-33960 Pirkkala
antti.pelkonen@fmi.fi

Former Yugoslav Republic of Macedonia

Ms Rada Avramovska
Head
Division of weather forcasting
Hydrometeorological Service
Skupi BB
MK-1000 Skopje
avramovska@yahoo.com

France

Mr Bernard Roulet
Chef de prévision
Météo-France
DP/Prévision générale
42 av G. Coriolis
F-31057-Toulouse Cedex
bernard.roulet@meteo.fr

Germany

Mr Klaus Baehnke
Deutscher Wetterdienst
Abt. Basisvorhersagen
WV 12-VBZ
Kaiserleistr. 42
D-63067 Offenbach am Main
klaus.baehnke@dwd.de

Germany

Mr Klaus Hager
Chief,
Met. Office FBW 32
German Military Geophysical
Organisation
Schabstadtkaserne
D-86836 Klosterlechfeld
klaus.hager@t-online.de

Greece

Ms Konstantina Zeini
Forecaster
Ms Chryssoula Petrou
Head of Operational support
Mr Panagiotis Giannopoulos
Forecaster
Hellenic National Meteorological
Service
14, El. Venizelou St.
GR-16777 Hellinikon - Athens
kzein@ath.forthnet.gr
xpetrou@hnms.gr
pgiannop1@yahoo.com

Hungary

Ms Marta Sallai
Head
Division for weather forecasting
Meteorological service
of the Republic of Hungary
P.O. Box 38
H-1525 Budapest
sallai.m@met.hu

Ireland

Ms Evelyn Cusack
Forecaster
Customer Service division
Met. Eireann
Glasnevin Hill
IRL-Dublin 11
Evelyn.cusack@rte.ie

Italy

Dr Teodoro La Rocca
Head
"medium and short range
forecast"
Italian Meteorological Service
Forecasting department
Aeroporto De Bernardi
Via di Pratica di Mare km 7
I-00040 Pomezia (Roma)
larocca@meteoam.it

OSMER

Mr. Stefano Micheletti
Head of OSMER
OSMER
via Oberdan, 18/a
I-33040 VISCO UD
Stefano.micheletti@osmer.fvg.it

Lithuania

Ms. Vida Raliene
Head
Division of weather forecasts
Lithuanian Hydrometeorological
service
6 Rudnios Street
LT-09300 Vilnius
vida@meteo.lt

Luxembourg

Mr. Claude Sales
Service Meteorologique
de Luxembourg
B.P. 273
L-2012 Luxembourg
clsales@pt.lu

Malt

Dr Charles Galdies
Malta International Airport pl
charles.galdies@maltairport.com

Norway

Mr Norvald Bjergene
Senior adviser
Meteorological Department
Norwegian Meteorological
Institute
POB 43 Blindern
N-0313 Oslo
norvald.bjergene@met.no

Norway

Ms Karen-Helén Doublet
Head of regional division
Regional division
for western Norway
Norwegian Meteorological
Institute
Regional division for western
Norway
Allégaten 70
N-5007 Bergen
karen.helen.doublet@met.no

Poland

Mr Jaroslaw Bochenski
IMGW Poland
UL. Podlesna 61
01-650 Warsaw
Meteo.warszawa@imgw.pl

Portugal

**Ms Teresa Maria
G.A. Abrantes**
Head,
Division of weather forecast
Forecast
Rua C-Aeroporto de Lisboa
P-1700 Lisboa
Teresa.Abrantes@meteo.pt

Romania

Ms Aurora Stan-Sion
Head of forecasting
National Institute of Meteorology
and Hydrology
Sos Bucaresti-Ploiesti 97
RO-71552 Bucharest
aurora.stan@meteo.inmh.ro

Slovenia

Mr Janez Markosek
Head of the weather forecast department
Environmental Agency
of the Republic of Slovenia
Vojkova 1B
SI-1000 Ljubljana
janez.markosek@gov.si

Slovak Republic

Mr Vladimir Pastircak
Slovac Hydrometeorological Institute
Jeséniova 17
SK-83315 Bratislava
vladimir.pastircak@shmu.sk

Spain

Mr Angel Alcazar
Head
National forecasting service
Instituto Naciuonal
de meteorologia
Leonardo Prieto Castro, 8
E-28071 Madrid
aalcazar@inm.es

Sweden

Mr Mikael Hellgren
Head of Meteorological
Forecasting and Warning
SMHI
Folkborgsvägen 1
S-60176 Norrkoping
mikael.hellgren@smhi.se

Switzerland

Dr André-Charles Letestu
MétéoSuisse
7 bis av de la Paix
1211 Genève 2
andre-charles.letestu@
meteosuisse.ch

Ukraine

Mr Nikolai Kulbida
Head of Ukrainian Hydromet Centre
Ukrainian Hydrometeorological Centre
Zolotovorotskaya Oulitza 6
UA-252601 Kiev 34
kulbida@ukrweather.kiev.ua

United Kingdom

Mr Will Lang
Guidance Unit forecaster
Fastnet 1
Met Office
FitzRoy Road
Exeter EX1 3PB
United Kingdom
will.lang@metoffice.gov.uk