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 f*reezing 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

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