The human side of weather forecasting

Introduction

Some years ago, during the introductory session of the Initial Forecasting Course at the Met Office College, the lecturer described the job of the weather forecaster with more or less the following words: *"As a weather forecaster you will be asked to make decisions in situations where you will be under tight time constraints and face uncertainty, you will have huge amounts of data available, some of it contradictory and most of it not really of significance to you, and you will be constantly looking for the correct data, which will not normally be at your disposal".*

After some years, I'm now convinced that "to be able to decide" is one of the key competences of a weather forecaster. And it is still not always a simple task, despite the improvement in the tools and systems at our disposal.

An example of a bad decision

On the 3rd October 2006, flash flooding occurred in the central part of Ticino (Switzerland), on the southern slopes of the Swiss Alps. This resulted in damage within a number of valleys, disruption to communication links and a fatality. The exceptional rainfall was caused by the passage of an intense cold front, combined with the movement of a small low-pressure system, which crossed the alpine barrier during the late afternoon. The potential for such a frontal system was identified some days in advance by synoptic considerations and by the numerical weather prediction models as well. Unfortunately, no warnings were issued by the regional forecasting centre and the civil authorities and rescue teams were partially taken by surprise.

The post-event analysis of the flash flooding provided some interesting results about how decisions were taken in the forecaster team and on the thought processes that led to the decision not to send out any warnings. It was clearly recognised that in this case the "human side" of the decision-making process was the critical point. Indeed the forecaster on duty, despite having recognised the dangerous potential of the approaching frontal system, was confronted with opposing signals between the high-resolution model solution and the ensemble models. With these contradicting indications, the final decision was strongly influenced by a "short term experience". Two weeks before, the same forecaster was faced with a similar severe weather situation and the warning he issued turned out subsequently to be a false alarm. The conclusions drawn from a post-event analysis of that event were effectively translated and applied two weeks later to the new situation and led to a missed warning.

The human side of weather forecasting: the decision-making process

Taking decisions has always been one of the central points of the forecasters job. Understanding how weather forecasters make their decisions means understanding the cognitive processes of the human forecaster to enable sensible interpretation of data and added value to a forecast. Consider the following questions:

• How do humans use weather information to produce forecasts?

• What expertise does a forecaster apply to allow him/her to make the judgment that a weather event could be extreme?

• How can a forecaster pick out the important signals in model guidance or in observational data amongst large volumes of less relevant information?

These are the types of questions that have been at the centre of interest for some researchers for many years and, in some cases, they are still waiting for an answer. Providing answers to these questions is equivalent to trying to understand the nature of expertise in assessing weather situations and forecasting their development.

Despite a lot of research in other fields where people take decisions normally under time constraints or in stress situations (e.g. fire fighters, police, medical teams, army etc.) it seems that up to now, less knowledge has been gained in the understanding of cognitive tasks and the nature of expertise in weather forecasting. Over the last few years the necessity of increasing our knowledge about the cognitive process in weather forecasting has been recognised. Some research has been done ([1],[2]) and some workshops and conferences have been organized ([3],[4]). The first results of this research have shown some peculiarities in the decision- making processes of experienced weather forecasters ([5]). Because of the huge amounts of data that forecasters face, analytical decision-making processes are limited by time constrains. Therefore heuristics (i.e. intuitive) approaches are virtually mandatory. Klein ([6]) describes the decision-making process of the experienced weather forecaster with a recognition-primed decision model, which combines both analysis and intuition. Also the differences between experienced (expert) and inexperienced (novice) forecasters have been studied. It seems that experts and novices use very similar types of reasoning strategies but experts have a larger repertoire of routine and thus a larger range of ways to size up situations; experts are more likely to question the data and are more effective in data analysis, recognising better patterns and key factors. They use a lot of intuition, are able to manage uncertainty and risk, and have the ability to recover from errors.

We cannot forget that, since all the activities are performed in the forecast room, each decision-making process is strong influenced by the interaction of the human forecaster with the technical systems (software and hardware) at his/her disposal and is constantly subjected to external influences (coming from the work environment in a general sense). It is possible to describe these interactions with a simplified SHELL model (see Fig. 1), which group the different sources of interaction into classes (designed as "blocks")[7]. The results of the actions of the operator can only be maximised if the contact surfaces between the different "blocks" are good and smooth. Therefore it is possible to seek a wide variety of ways to improve results relating to the decisions made by the forecaster. In very general terms, we can summarise all the interactions between the Liveware-block of the operator and all other blocks with the term "human factors".

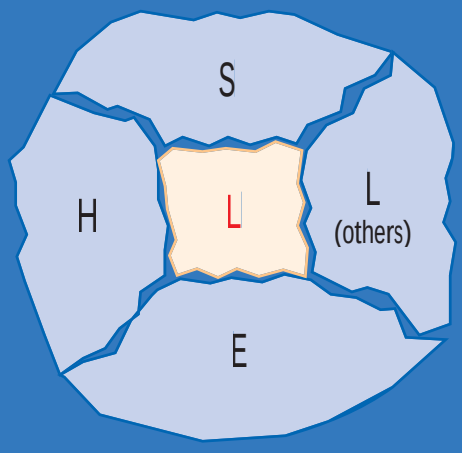

Figure 1: The SHELL model

S: Software: guidelines, routine and emergency procedures, …

H: Hardware: all the technology tools used in the forecast room (for meteorological analysis, for communication, for production, …).

E: Environment: the ergonomics of the hardware, the "climate" and the social culture of the office, the family, the friends, …

L (others): Liveware: people around the operator (‡ forecaster colleagues, users, authorities, journalists, etc.).

L: Liveware, the operator (‡ in our case: the weather forecaster).

The technology challenge

Over the last few years a lot of research has been done to improve numerical weather prediction (NWP) whilst new tools have been developed for much improved analysis and visualisation of the meteorological data. However in some cases the introduction of these new technological systems into the regular daily forecasting process has been not so straightforward because forecasters were not always enthusiastic to adopt the new tools and models. Moreover, even when the systems were well integrated into forecaster practice, an improvement in the quality of weather forecasting was not always as expected.

I think that a possible explanation can be found in a lack of consideration of what I have called "the human factors" during the development and introduction of the new systems. With respect to the SHELL model, it is possible that we have concentrated our efforts too much in improving the single blocks (especially the "hardware" and the "software" blocks) whilst neglecting the contact surfaces between the blocks. Indeed we cannot forget that each change in the forecasters work environment has an effect on the human, especially when we make a technological change or introduce a new tool. There is a cognitive dimension in the use of each technology that must not be neglected. Experts recognise patterns, identify key issues from the data, build mental models and take an active stance. However, if inappropriately developed technology presents too much data it can disconnect the human from the process and weaken the mental models of the human forecaster, making them less adaptive and more passive. This is the so-called *technology challenge*: new technology can hinder greatly the forecast process if used incorrectly.

Sometimes experienced forecasters can be stimulated by the introduction of new technology, which gives them the opportunity to analyse meteorological data in new and creative ways. There can be negative aspects, however, when the introduction of new technologies meets strong resistance among the forecasters because they are obliged to change their preferred ways of working. This can interfere with the cognitive processes that enable forecasters to interpret the data correctly to aid their decision-making.

The future role of the human in the weather forecasting process

As in previous years, I think it is certain that technical developments will continue at a rapid pace. New tools will be introduced and NWP will improve further. I am convinced that if we want to maximise the benefits of these new systems, we cannot forget the "human side" of the technology. As technical and scientific solutions are developed, we must ensure that the new tools take account of the cognitive dimension. An awareness of the cognitive processes present in weather forecasting can:

- help to improve the design of new technical tools
- develop more efficient training courses to learn how to use these tools
- reorganise the work of the forecasting team with respect to the new tools
- improve the quality of the entire weather service
- avoid, or at least minimise, the "bad decisions".

Recent discussions about the future role of the human have demonstrated clearly that he/she will only be able to maintain that role if there is an ability to add value to NWP models and automatically generated forecasts. Situations in which I believe the human forecaster has the skills and competences to maintain a role are those involving severe weather. In the case of Switzerland, where there are regions of complex topography, numerical models still have some problems in forecasting severe weather events despite the improvements of recent years (e.g. higher resolution). It is in these situations that experienced human forecasters can potentially add important value to NWP models and automatically generated forecasts now and in the future as their role in the forecast and decision-making process evolves.

During severe weather situations the human decision-making process is put under a lot of pressure and taking the right decision can become very difficult and require a lot of experience. Therefore we can maintain and reinforce the role of the human forecaster if we are able to give the forecaster the opportunity to find ways to continue to gain expertise in a rapidly changing technological environment. This is possible only if we devote more effort, time and research in order to better understand the cognitive process of weather forecasting and - more important - if we are able to translate our knowledge into best practice. For example, education and training courses (basic, continuing professional development and on-the-job experience as well) should be designed to build on quality experience. Also new technical tools, which are expected to change the work practices of the forecaster, should be developed and introduced in such a way that they really respect the human cognitive processes.

Conclusion

The "human side" is an important component in weather forecasting, as the case study of 3rd October 2006 has demonstrated. This component should be considered seriously if we want to maintain a role for the human in the forecasting process for the future and if we want to enhance quality within the National Meteorological Services across Europe.

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[7] Adapted from the Workshop: *Supporting Expertise in Weather Forecasting A Human Factors Workshop (with a cognitive spin)* organized by MSC Canada, Toronto, 23 – 25 May 2007

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