Forecast Strategy at the Met office

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Introduction

Forecasting has changed over the last 35 years from manual methods (using pencils and rubbers to assimilate data and developing conceptual models and other empirical rules to predict the state of the atmosphere) to more automated techniques with Numerical Weather Prediction (NWP) at its core. A good example of how things have moved on is depicted in Fig(s)1 – slide 5, showing the 1953 floods which devastated parts of Holland, Belgium and Southeastern England. This depicts a forecast of the event using current NWP capability but based on a simple synoptic analysis of the time. The forecast would have given excellent guidance of the storm, even though it did not have the benefit of important satellite data which was not available at the time.

During this period the role of the forecaster has changed from being at the heart of the prediction process to more one of post-processing the NWP data through interpretation and adding local detail before onward dissemination to the customer. However even today the production process is still relatively manually intensive due to the inability of models to accurately predict many of the boundary layer phenomenon that are important to some customers, such as visibility and low cloud.

This paper outlines a strategy to take us smoothly from where we are today, to a time in the future when the whole production process may be automated. This will be achieved by having finer-resolution models and more sophisticated probabilistic approaches for handling any remaining uncertainties. However there is still likely to be a role for the human in the provision of high-value consultancy services based on the output from the automated process. Also the human will be involved in quality assurance when dealing with severe weather or other highly sensitive events.

The forecasting strategy must reflect the long-term business and marketing needs of the Met Office for it to be fully effective and must match in with that from other parts of production and the college. It is also vital that this strategy focuses on increasing awareness in society of the benefits of sound meteorological and environmental advice, through detailed cost–benefit studies. Also it is in the interests of the whole meteorological community that the total revenue grows in real term as new markets are opened up. This will help overcome the loss in some of the more traditional areas of weather forecast provision which will become largely automated.

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Drivers for change

a. Customers and their changing requirements
Over the next few years there will be a continued drive from our customers to reduce costs for meteorological services, whilst at the same time maintaining or improving overall quality. There will also be threats to our markets from competition, especially from other global players, making it important to become 'lean and mean' whilst also looking for partnerships, particularly within Europe.

b. Greater need to address outcomes
There must also be a shift in emphasis from the traditional weather forecast to outcomes which describe what a weather prediction means for a customer in terms of his/her decision-making and business need. This means that providers of services will need to understand of how customers use meteorological information. Also it offers the opportunities for greater integration between the operations of the service provider and customers.

As the political and financial fallout from the effects of severe weather grows there will be an increasing need for impact studies. As a consequence meteorological organisations will be called upon to take on a larger role in risk management and amelioration of natural disasters. To do this successfully meteorological organisations will need to work in collaboration with many other agencies which can provide non-meteorological expertise.

c. Advances in science and technology
Over the past 20 years there has been a major advance in the accuracy of NWP. There is no doubt that this improvement will continue as we develop more sophisticated models with greater resolution, better and more intelligent ways to assimilate all sources of information and more powerful supercomputers to run the models. Some working in the field predict that by 2025 the data problem for weather prediction will be solved. Observational errors as we know them today will have been eliminated. Global weather prediction models with 1 km horizontal resolution will have reached the theoretical limits of predictability theory. This is probably a simplified view of life but undoubtedly new advanced data assimilation procedures and techniques for extracting more information from ensembles at all forecast ranges will significantly increase the accuracy of the forecasts and reduce human involvement in the production process.

Strategy—continued automation

Our main strategy to reconcile the cost versus quality dilema has to be continued automation of the forecasting process, to minimise the need for human intervention, especially at the lower end of the value chain (see fig 2 – slide 7) . This will also release forecaster effort from relatively mundane, routine tasks, to greater utilisation of their meteorological skills at the higher value-added end of the market through meteorological consultancy.

Meteorological consultants will need greater business awareness as well as meteorological understanding to work at the interface between the weather and its impact. They will need to understand the strengths and weaknesses of the automated data that will be delivered to users as well as the technicalities of the business they are dealing with. Of course some of this is already happening – a forecaster on a defence site is effectively a consultant by presenting the information in a mission-specific way. Clearly over the next few years much of the consultant’s role of today could also be automated using complex decision-making models driven by meteorological data streams. However where judgement is required for severe weather or other highly sensitive events the role of the human in an assurance role is likely to remain at the top end of the value added chain.

Constraints –the boundary layer problem

Although progress in NWP accuracy has been marked over the past 30 years, the complex physics of the boundary layer has been much harder to resolve with little real progress in low cloud and fog prediction in the last 50 years. It is likely that it will take a significant number of years for models to resolve those important boundary layer parameters. Consequently there will be a relatively long period of partial or semi automation, as well as full automation for certain products such as upper winds for aviation. This is about where we are now with the forecaster presented with a first draft from the model which is ‘improved’ before final delivery to customers. At present, largely because of boundary layer errors, there are certain product ranges where humans continue to add significant if slowly decreasing value. However there is a large amount of duplication because many of the errors are uncorrected biases in current models or synoptic-scale errors common to a number of forecasting sites.

Dealing with constraints – Post-processing

It will take may years for the physics of the boundary layer to be resolved satisfactorily and other methods will be pursued to help 'correct' the raw NWP using a combination of human and statistical applications.

a. Fields Modification
One key strand of the strategy to deal with this is the philosophy of 'change once, use many' with central quality control of NWP output using a technique described as Fields Modification (FM.)

A new FM application has just become operational in the Operations Centre based around mesoscale weather, adding to the dynamical consistency imposed by PV which the original scheme offers. The forecasters now have the ability to make detailed changes to model cloud, precipitation and surface temperature fields from a mesoscale model. Parameters are generally linked by simple rules-based relationships (e.g. making sure that there is realistic cloud cover where rain has been added; giving fog where cloud base is lowered to orography level). In this way realistic mesoscale detail can be imposed on output from a coarser scale model. Whereas the first field modification system addresses the requirements of guidance to other forecasters in supplying fields which define the synoptic situation, the new system deals with the important weather parameters which are required by end users. An example of the FM approach is shown in Figs 3 (a-d) on slides 9 and 10. Fig 3a shows the raw model product with light rain and snow over Eastern England. The modified field is shown at Fig b with heavier snow 'pasted' in by the forecaster. Figs 3c&d shows the radar picture and reality on the ground after the event, emphasising the value added by the forecaster. It is planned that gridded output from this process will feed into downstream systems ranging from TV graphics to automated forecast systems. It is also planned to use the modified output to drive application models such as that used for the prediction of road surface temperatures.

Once the new system is in place, the emphasis will shift to increasing the quality and use of first-draft products by correcting data streams as a stepping stone to the longer-term goal of fuller automation. First-draft output improves efficiency and increases flexibility in service provision. Also it is made easier to assess the value that is being added at each stage in the production process. Doing this is key to informing future production decisions and any changes required to the strategy.

b. Quality control and statistical/application models
Use of the FM technique may only be required for 10 years or less as more accurate models will reduce the need for the fields to be modified. Clearly consistency of the products will also need to be addressed so, in parallel with the work to improve the models, there will be enhanced quality control of automatic output using checks against climatology, statistical models to correct local biases and derive customer outcomes. Also application and site-specific models and expert systems will be developed so that in time the first draft will be good enough to meet the full range of customer needs, releasing forecaster effort to add value higher up the value chain or in other parts of the organisation.

c. Probabilistic/ensembles
Another way to deal with uncertainties in the forecast is post-processing is through the use of ensembles to give probabilistic information. At present this approach is mainly used for the medium range, but the use of ensembles will be extended into shorter forecast periods including boundary layer forecasts of fog and low cloud. As models go to increasingly higher resolution we will start to resolve instabilities which are currently averaged out by parameterisation. Thus, in moving to higher resolution models, there is a need to have a coherent strategy of the use of ensembles and statistical post-processing to account for the

forecast uncertainty. Also it is important to continue to work with customers to optimise their decision-making based on such probabilistic forecasts.

Severe weather effects are slowly moving up the political agenda as global warming scenarios predict an increase in flooding events, similar to that which struck central Europe during the summer of 2002. Planners and emergency authorities need to minimise the risk and we need to emphasise the use of probabilistic information to achieve an efficient outcome.

Infrastructure changes—the network

The networks of offices within the Met Office will be subject to further review as customer requirements change and more automation takes place. The argument about central versus local has become less relevant as models improve and so the infrastructure required to meet customer need will require further appraisal and redesign.

a. Central
Currently the main central forecasting function is carried out in the Operations Centre. This centre is responsible for adding value to the NWP products through guidance and for the production of generic maps for aviation and other centralised products for the various business areas. In future the focus will be more on quality assurance and business continuity with a start made on shifting the emphasis from product generation to quality control of automatic output.

b. Local
The role of the local production unit will be to concentrate on customer-specific consultancy rather than local modification to take account of phenomena not captured by the site-specific forecasting system. This consultancy will be improved by the development of ‘market models’ that use meteorological data and process it into large volumes of user specific information, similar to that used currently in defence for Tactical Decision Aids

As the local centres become more consultancy based the network will need to be more flexible and adaptable to customer needs. Whether this will be in the form of more centralised offices concentrating on market sectors or a shift in emphasis to collocation with important customers, such as those dealing with aviation and the environment, is open to debate. Where forecasts are made should be less important than reducing the time to market of new products and services and maximising the use of web technology.

Planning the human role

a. Training
The production strategy will impact on the training and career development of forecasters as we evolve and consolidate the two key parts of the value-added chain of central post-processing and service delivery. The skills base of forecaster/consultants will be broadened as their traditional role in generic production diminishes. It will also have clear implications for the work practices of forecasters as the emphasis shifts from production methods to service delivery techniques, with greater emphasis on the role of communication and presentation.

Training will become more modularised as the days of the generic forecaster that does everything comes to an end. Over the period of 10 to 15 years time it is likely that human involvement in post-processing and guidance at the centre will be phased out as the need for emphasis on pure meteorology become much less relevant.

b. Careers

Forecasting will cease to be a career in itself with the expansion of part-time sharing of jobs with other areas such as R&D and training. Forecasting should be seen as a good apprenticeship for more varied work later in the Met Office rather than an end in itself. This will develop the competencies of forecasters and be of much greater value to the organisation as a whole. So the emphasis will be on a career in the organisation rather than in forecasting per se.

Other issues to consider

a. Monitoring value
To help make key decisions to successfully implement the production strategy we need to monitor the complete value-added chain and make sure that value is added in the most effective way so that duplication is eliminated. This will involve more widespread use and more intelligent forms of verification.

b. Diversification
As well as concentrating on services providing outcomes further diversification is likely into related fields such hydrology and the environment with severe disruptive events given special attention through impact studies. This is likely to require closer links with associated areas such as hydrology and oceanography (as is currently the case in some countries) with the establishment of joint flood control centres. These changes will need to be reflected in the skills base of future environmental consultants.

c. Business continuity considerations
The forecasting production strategy is reliant upon there being a robust and effective IT systems and communications infrastructure. Our business continuity programme is aimed at the cost-effective elimination of single points of failure within the underpinning IT infrastructure. This should enable key services to be maintained to customers during any emergency events, from a small-scale system failure through to a total loss of one of our production sites.

d. Observations strategy
The production strategy needs to be reflected in our observation strategy. The needs of the NWP system and the forecasters/consultants will become increasingly different. Forecasters will make more use of web cam technology and pictorial remote sensing information. On the other hand NWP will rely on more conventional information, albeit increasingly asynoptic and with greater emphasis on remote sensed data. To reduce costs the observational networks will become more automated but with ‘intelligent’ use of all types of information. This should result in more effective data for both the consultant and the NWP system.

Concluding remarks

We are now entering a period of semi-automation of the forecasting production process on the road to full automation. Forecasters will continue to move up the value chain and concentrate more on the needs of the customer as their more traditional production role ceases. It is envisaged that in about twenty year’s time there will be almost full automation of forecast production accompanied by the demise of the generic forecaster. However the need for people with meteorological training to provide high-valued environmental consultancy is likely to grow as society focuses on outcomes rather than simple weather forecasts, but their number will wax and wane depending on economic cycles.