Australian Marine Forecasting System

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1 Introduction

This paper briefly describes how the Australian Integrated Forecasting System (AIFS) rationalised many of the systems associated with the forecasting process by bringing multiple systems together onto the one platform. Included is a look at the main components utilised in the Australian Marine Forecast System for improving the combination of people with machines to "get it right". These include visualisation, graphical editing, automatic text generation, graphics preparation and verification.

2 Background

The forecasting office of the early nineties took advantage of growing communications and computing capabilities. This allowed more work to be done with fewer forecasters. The proliferation and maintenance of so many systems, however, was an administrative nightmare. Another problem was that forecasting offices were running out of space as many of the systems were on their own PC or workstation. The role of AIFS (Kelly and Gigliotti, 1997) was to rationalise these systems while allowing the forecaster to spend more time on the science of meteorology.

So far, AIFS has facilitated a more extensive range of timely forecasts and warnings by allowing forecasters to prepare the basic forecasts, which populate a forecast database. Special products are then prepared automatically by extracting the various components from the forecast database.

AIFS also integrated many office systems, including forecasting aids, that were used to gather and display information the meteorologist uses as part of the forecast process. The problem is that although communications are getting faster and faster, Numerical Weather Prediction (NWP) output and data sources continue to grow in size and users of forecast products are demanding more and better performance. Thus, forecasters want AIFS to do more to allow them to meet the growing expectations on their time.

AIFS is a combination of packages for viewing data and NWP, managing databases and the preparation and distribution of messages. It runs on a Unix X-Windows platform and is mostly written in C and a scientific visualisation language IDL. Unfortunately, many of the applications developed by non-AIFS (Regional) staff, being PC based, are not easily ported to a Unix platform. AIFS hardware is principally IBM and HP based, although Linux is being considered as a low cost alternative hardware platform for the next generation of applications.

More recently the AIFS development team have been trialing Java 2D and 3D in association with VISAD (Hibbard, 1997) (Hibbard, VISAD Home Page) as this is becoming more robust and has the advantage of being platform independent. Java is also proving useful for mimicking some of the PC developed applications operational staff want to see become part of AIFS.

3 AIFS and the forecast process

Forecasters need to understand a weather situation and their approach is obviously task and situation dependent. Given the time constraints on forecasters, they will only use what is easy to access, or at least, what they know will be worth the time and effort to locate and view. The basic visualisation tools used at present allow overlaying and animating model output and observational data, including satellite images. Forecasters also utilise colour and 2D or 3D displays. Current AIFS applications include those that display the following meteorological data: Satellite and radar imagery, surface and upper air observations and numerical model output. (See figure 1, Sample AIFS display.) In order to improve speed, many operational staff routinely run these applications in the background to prepare graphical products that are then made accessible via the web.

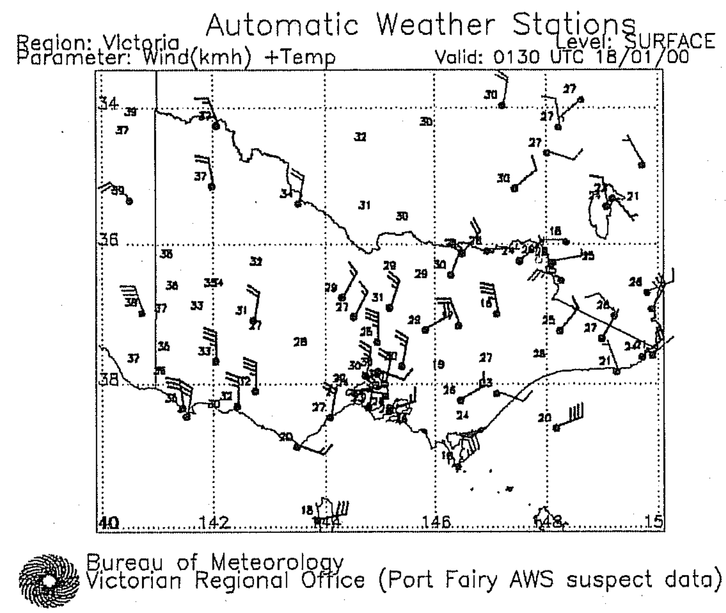

Figure 1 : Sample AIFS display application

Forecasters prepare text and graphics products using the product preparation routines in AIFS. As forecasters find themselves increasingly transferring the contents of models into forecasts, which is a time consuming task, they want the option of having some software to write the first draft of forecasts from the model data. In addition, there is a growing demand for graphical products to be made available via facsimile and the Internet. The AIFS communications component is used to distribute the forecasts and products.

Already many graphical products are being created directly within AIFS from NWP and the forecast and observation databases, however, there is no component in AIFS for automatic generation of the required text products. This is because differing forecasts require different accuracy standards, terminology and syntax. Many simple statements on weather can require the use of complex artificial intelligence based systems. Conversely some forecasts have simple language rules and structure which are more easily created. This was the case with WindMap, a

PC system developed by John Bally for the Tasmania/Antarctic office. (See figure 2, WindMap display).

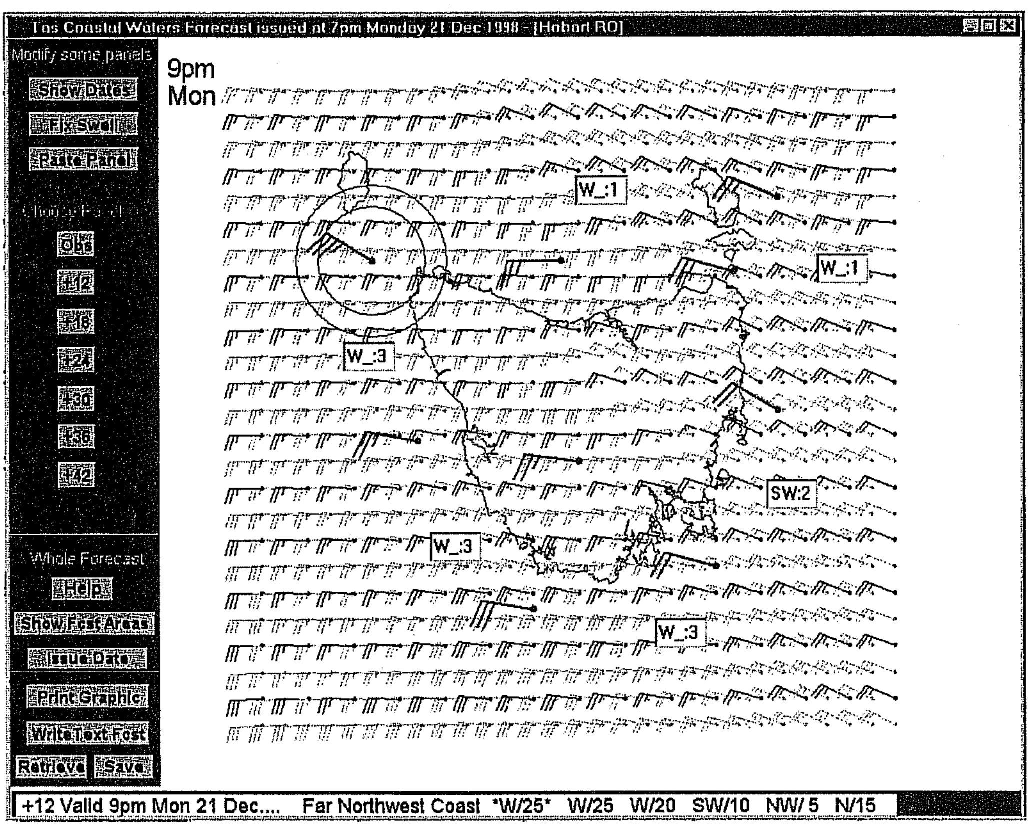

Figure 2: View of WindMap windfield and swell modification screen

WindMap prepares text and graphical coastal waters products directly from model output fields. It does this by mapping the model wind fields to a single wind barb for each 6-hour time step for each of the coastal sections. Forecasters can use WindMap to modify the forecast wind fields by dragging and rotating the wind barbs. Because the coastal waters forecast can be constructed from one field, it makes sense to edit the fields to change the forecast. Swell conditions are also edited for each time and coastal component.

Once the user is satisfied with the components, WindMap then generates the written and graphical forecast wind and sea conditions. Forecasters can increase or decrease the detail of the text products by use of a slider button. Because WindMap has been so popular with regional staff it has provided the impetus for the generalised Australian Marine Forecast System AMFS.

4 The AMFS Project

The AMFS has been designed so that the forecaster has a single integrated interface, which enables them to perform most of the tasks of the forecast process. It is bringing together the paradigm of numerical weather prediction and human expertise with an increased emphasis on

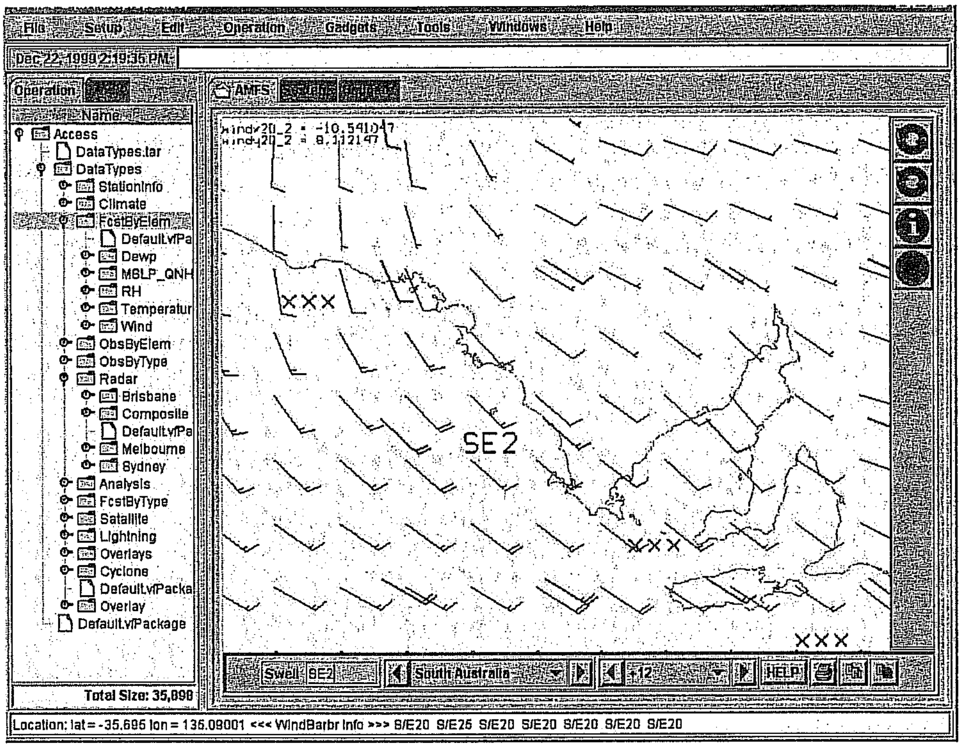

Figure 3: Example of AMFS interface

verification, training and learning. This is the essence of the next phase of AIFS (known as AIFS II). The heart of the system is its graphical editing of numeric fields to allow automatic generation of text and graphic marine products along with the ability to measure the impact of manual intervention.

The AMFS was chosen as an initial prototype of the next phase of AIFS because:

- Initial requirements are relatively well known through the Tasmania/Antarctica Region's experience with WindMap;
- The graphical editor requirements are relatively simple in the first instance since they are 2D and the domain is fixed;
- Automatic text generation for coastal waters has been identified as one of the easier forms of text generation because of simple syntax and small vocabulary; and
- It trials key components recommended for the next generation of AIFS, namely the graphical editor, the forecast database, and the product and the verification statistics generation modules.

5 Functions

The AMFS is an interactive graphical based tool that will allow forecasters to view and manipulate NWP data at a variety of locations and forecast periods. It will also display observational data from specific sites. Both NWP and observational data will be displayed over the top of an underlying coastline map. The overall AMFS "look and feel" conforms to standards required of AIFS graphical applications. The system will be able to run in real-time and archive modes and be capable of generating verification statistics.

The data display and manipulation component is based on WindMap, that is, all NWP and observational data will be displayed as wind barbs at specific forecast locations on screen. The user can directly manipulate NWP data, represented as wind barbs, at forecast grid points using a mouse and keyboard combination. (See Figure 3 for an example of AMFS interface)

6 Project Development Strategy

A component-based approach has been adopted to allow the Bureau to source key elements of the system from other agencies and organisations. For instance, the advanced visualisation component, VisAD, is being sourced from the University of Wisconson (UoW) and the automatic text generation module will similarly draw on local and overseas experts in the field.

An AIFS proof of concept prototype modelled on WindMap has been developed to demonstrate the feasibility of integrating such an application into AIFS and to stimulate discussion and feedback from operational forecasters. Extensive use will be made of user feedback via a number of mechanisms, including interaction with local AMFS coordinators in each forecast office.

7 Project Phases

The project is divided into 3 phases, with development currently in phase 1. These 3 phases are described below.

Phase 1: Integrated Visualisation, Graphical Editor, and Graphical Output.

- Visualisation of NWP guidance, observational data and satellite imagery;
- Development of a Graphical Wind Editor to allow manual adjustment of NWP guidance wind fields; and
- Generation of at least one graphical output product such as a graphical coastal waters forecast;

Phase 2: Advanced Visualisation, Graphical Editor, and extended Graphical Output

- Advanced interactive graphical editor features such as "spray can" or "rubber band" adjustment of fields;
- Advanced visualisation functions such as animation and integration and display of radar data;
- Display of streamline wind fields, and performance tuning of application; and
- Extension of graphical output products to include high seas forecasts.

Phase 3: Automatic Text Generation

Current automatic text generation technology in use at the Bureau of Meteorology is based on the Computer Worded Forecast model. Such technology does not scale well as complexity of text and variety of output products increase, for example, Public Weather products. More advanced methods, known as Natural Language Generation (NLG) or Knowledge Based Text Generation (KBTG), are recommended. This phase will involve close liaison with recognised experts in the area, over a two-year period. The first year will be for the generation of text for coastal waters forecasts, while the second year will be for an extension to high seas forecasts.

8 Operational Evaluation

A critical component of the AMFS will be user feedback to ensure that the objectives of automating the forecast process are achieved. Therefore, operational evaluations of the AMFS phases, which include stakeholder reporting, are planned.

9 Verification

In today's world of reducing resources and increasing accountability, forecasters need to know how well they are performing. Furthermore, any improvements to forecast skill need to be maintained because performance monitoring is essential to help minimise any unwanted trends or bad habits.

Verification should be on both the raw and the modified fields and they should be verified against observations. Experience shows that verification against observations can be more convincing than verification against model analyses as occasionally model analyses miss critical features.

In addition, a benchmark needs to be maintained. Australia has long records of the Yes/No forecasts for wind warnings along with the lead times. Thus, it is important to keep providing these statistics for reporting purposes and measuring long term trends.

Forecasters need to know if they are adding value. Once they know where and when they add value they can direct their effort to where it is needed most. Verification provides the forecaster with confidence in the models so they will be less inclined to modify fields if models don't require it. Knowing where a model performs well and knowing where it regularly needs modification is also good feedback for modellers so they can see where development is required.

10 Training

Involvement of professional trainers is critical particularly in the planning stages, and immediately before and during each Operational Evaluation stage. This will be carried out in-house through "Train the Trainers" workshops and other forecaster training sessions (eg, Advanced Forecaster Course) where suitable.

11 Summary

AIFS has come a long way in meeting its aim of freeing forecasters from tedious product preparation work so they can concentrate more on the meteorology. However, forecasters are asking for AIFS to go further and generate worded forecasts from NWP, which they can then edit and use to prepare other products. This technique was shown to be feasible by the Tasmania/Antarctic office, which developed a PC application "WindMap" for preparing coastal waters forecasts.

AMFS must provide the functionality of WindMap for the preparation of coastal waters forecasts for all forecasting offices. It will build on experience from AIFS and WindMap, meeting AIFS standards, especially those relating to adaptability and ease of configuration. It will utilise key elements of visualisation, graphical editing, automatic text generation and verification.

If successful, AMFS methodologies and techniques will be applied to aviation and general weather forecasting within AIFS.

12 Acknowledgments

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