In this issue

European Centre for Medium-Range Weather Forecasts

Shinfield Park, Reading, RG2 9AX, UK

Fax: +44 118 986 9450

Telephone: National 0118 949 9000

International . . . . +44 118 949 9000

Internet URL . . . . http://www.ecmwf.int

Cover

Wind and waves are now coupled in the latest cycle of the model - see page 2.

Editorial

Up to now ECMWF has run separate atmospheric and ocean wave forecast models. With the introduction of the latest cycle of the model, [namely Cycle 18 release 6 of the Integrated Forecasting System (IFS)], ECMWF is running a coupled atmospheric ocean wave forecast model. The article on page 2 presents some of the rationale behind this coupling.

The economic aspect of weather forecasting is one of the crucial considerations for end users of such forecasts. The potential economic benefits of the relatively new forecasting tool EPS (Ensemble Prediction System) comes under an initial scrutiny in the article on page 8.

An initial look at ECMWF's work in the field of seasonal weather forecasting was given in ECMWF Newsletter No. 77 (autumn 1997). A first update is now presented in this current issue (see pages 13-19), covering the recent decline of the El Niño event.

Member State users can access ECMWF's computer systems via a variety of means, all of which are SecurID card protected. An update on these various card-protected services is given on page 20.

With Windows NT systems becoming more popular the question arises on integrating such systems into an existing Unix based environment. There are various options, some of which are discussed in the article on page 21.

More and more of the computer documentation is becoming on-line based, especially around the concept of HTML files. The article on page 22 outlines the Centre's current status in the move of its documentation to HTML.

Changes to the Operational Forecasting System

An hourly, two-way coupling of the atmospheric and ocean-wave model was introduced on 29 June 1998. Predicted ocean waves now provide information to the atmospheric boundary layer.

Other modifications introduced at the same time (Cy18r6) were:

1. the use of both significant and standard level winds, temperatures and humidities from radiosondes (geopotential is no longer used);
2. the use of extra off-time data, mostly SYNOPs and DRIBUs;
3. the use of 1D-Var SSM/I total column water vapour;
4. extension of the use of GOES high-resolution winds to the northern extratropics;
5. the use of more TOVS channels over land;
6. the observation operator for 10m winds is now unified for scatterometer, DRIBU and SYNOP observations.

Planned changes

- Increase in the number of model levels from 31 to 50, with the majority of the extra levels occurring in the stratosphere, the top of the model will be moved from 10 to 0.1 hPa;
- Use of TOVS and ATOVS level Ib radiance data from the NOAA satellites.

Brian Norris

Progress with wind-wave interaction

In a previous Newsletter article (Janssen,1994) we discussed some of the direct practical benefits of ocean wave forecasting and the benefits ocean wave information may have for atmospheric modelling and data assimilation. One of the benefits of ocean waves for the atmosphere may come from a more accurate treatment of the momentum exchange between atmosphere and the ocean surface, since the efficiency of the momentum exchange depends on the steepness of the ocean waves. Waves that are just generated by wind (we call this 'young' wind sea) are steeper than mature wind seas. Steeper waves provide a rougher surface and therefore give rise to a larger momentum transfer. We discussed a synoptic example which showed that the sea-state dependent momentum transfer may have consequences for the evolution of a depression, whilst there was also systematic impact on the climate of the atmosphere and the ocean waves. In the present article we shall describe some recent results we have obtained with Cy18R6 of the IFS which includes the effects of wind-wave interaction. In addition, since ocean waves are now an integral part of the IFS, ensemble prediction of waves is now part of the EPS. Afirst example is discussed, which suggests that the EPS for waves contains useful information on swell prediction in the medium range.

Model setup

Ocean waves affect the air-sea momentum transfer, and also the heat and moisture transfer over the oceans. In the previous versions of the atmospheric model the air-sea momentum transfer was modelled by means of the Charnock relation for the roughness length. The Charnock relation only models the average effect of ocean waves on the momentum transfer and therefore this momentum transfer depends only on wind speed. However, nowadays it is known that the Charnock parameter used in the parametrization of the momentum transfer is not a constant but may vary by a factor of 10 (typically from 0.01 to 0.1) depending on the stage of development of the ocean waves. In order to accommodate for this the theory of wind-wave interaction was extended by including the feedback of ocean waves on the mean airflow, resulting in a sea-state dependent Charnock parameter (Komen et al,1994). This interaction is currently known as two-way interaction and it requires the tight coupling of the atmospheric model and the wave model. In this two-way interaction mode the atmospheric model determines the surface winds needed to generate the ocean waves, while the wave model determines the amount of momentum that has been received from the atmosphere, and uses that information to determine the Charnock parameter which is returned to the atmospheric model. The effect is relevant in rapidly varying circumstances such as may occur near a low and near fronts. Additional benefits of this tight coupling are that the wind fields that drive the waves may be updated more frequently (previously this was done every 6 hours while presently winds are updated every hour) and that information such as the air-sea temperature difference and the air-sea density ratio may be passed to the wave model.

The atmospheric model has been modified to allow for this two-way interaction. Also, the analysis suite was changed. In 3D-Var, the first guess is modified in a manner consistent with the coupled physics, while also Altimeter wave height data are assimilated. In 4D-Var, both first-guess and trajectory calculations are performed in coupled mode, while the minimisation is done with a constant Charnock parameter. Altimeter data are assimilated in the final trajectory.

Results

Early results on weather forecasting with the present setup, but with earlier cycles of the IFS and T213 resolution, have been reported during the air-sea interaction symposium last year (Janssen et al,1997). Although considerable synoptic differences were found in both forecast surface pressure and wave height field, in general the differences were found to be of small scale therefore resulting in only a modest positive impact on scores for atmospheric parameters. However, impact on scores for wave height and surface wind speed was somewhat larger.

In order to illustrate the relatively small scale of the impact of the sea state dependent roughness we discuss the case of a rapidly moving low from FASTEX. This event started on the 17th of February just south of New Foundland and arrived two days later west of Scotland. The day 2 forecast of this case is shown in Figure 1 and the surface pressure in the run with two-way interaction (coupled for short) is lower by 7 hPa, in good agreement with the coupled analyzed pressure of that low. Such differences in surface pressure result in considerable differences in the strength of the surface wind and therefore in wave height. In this case the wave height increased from 9 to 13 m (not shown). Because of the small scale of the differences there is hardly any change in anomaly correlation over the North Atlantic area; in fact, at day 2 of the forecast both coupled and control experiment have anomaly correlations close to 100%.

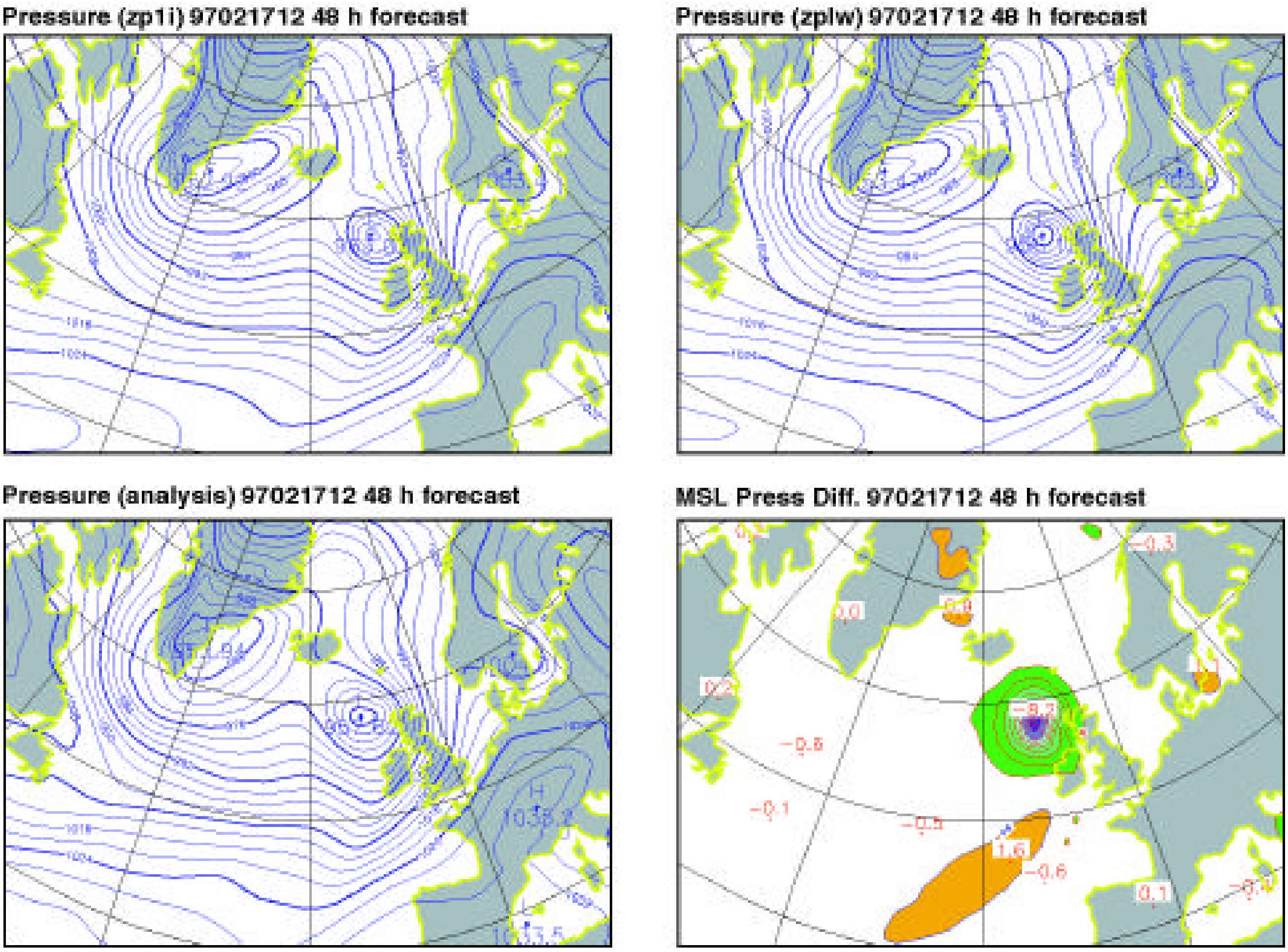


Figure 1: *Comparison of 2 day forecasted surface pressure of the FASTEX IOP-17 event from control(top left panel) and coupled(top right panel) experiment. Differences between coupled and control are shown in the bottom right panel while the verifying analysis is from the coupled experiment. Date is the 17th of February 1997.*

The next example concerns the day 2 forecast of the 24th of December 1997 for the North Pacific and is discussed here because it is an (exceptional) example of large scale impact of two-way interaction on the atmospheric circulation. Figure 2 shows the comparison of the coupled day 2 forecast with the control forecast. Substantial, large scale differences in the surface pressure can be seen, and a better agreement between the coupled forecast and analysis is noted. As a result considerable improvements in the scores for surface pressure were obtained for the whole 10 day period. The different pressure distributions result in differences in surface wind field and wave height field. Figure 3 shows the comparison between coupled and control wave height forecast and verifying analysis on midnight of the 27th of December 1997. Differences between coupled and control wave height reach 4 m and the coupled forecast is in better agreement with the verifying analysis, while the control forecast is too high. This finding agrees with the property that the control forecasting system systematically has too high waves in particular in the later stages of the forecast range.

Recent experimentation with the T_L319 version of the IFS system has given the impression that the impact of the waves on the atmosphere has increased somewhat. This is illustrated in Figure 4 where we show scores from the Southern Hemisphere, an area where previously we have not seen any systematic impact. The Figure compares T_L319 results with the coupled version of Cy18R6 with the uncoupled one for an 18 day period in December 1997. There is positive impact for the 1000, 500 and even 200 hPa geopotential height field. Note that the impact of two way interaction on the upper layers of the atmosphere was also noted in the climate runs of Janssen and Viterbo (1996). It is probably caused by the fact that changes in surface friction have an impact of barotropic nature on the atmosphere, thus modifying the whole atmospheric column. A similar impact, albeit of smaller amplitude, was noted on the Southern Hemisphere scores during the e-suite which was run over 74 cases between 16th of April 1998 and 28th of June 1998. (The e-suite result should however be interpreted with care regarding the impact of waves on the atmosphere because Cy18R6 was compared with Cy18R5 and Cy18R6 contains in addition to two-way interaction of wind and waves numerous changes in the data assimilation, such as a new treatment of radio sonde data, assimilation of SSM/I total Column Water Vapour and the use of TOVS

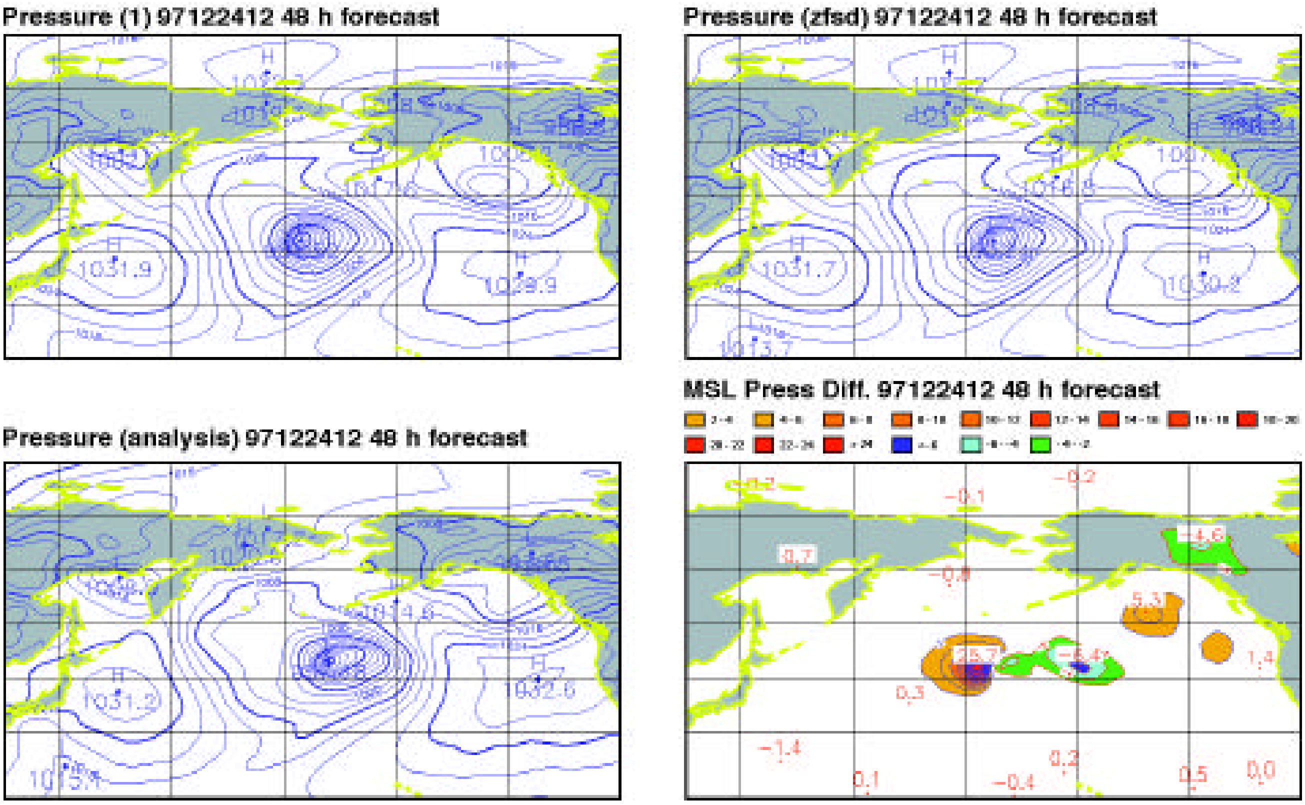


Figure 2: *Day 2 forecast of surface pressure for the 24th of December 1997. Area is North Pacific.*

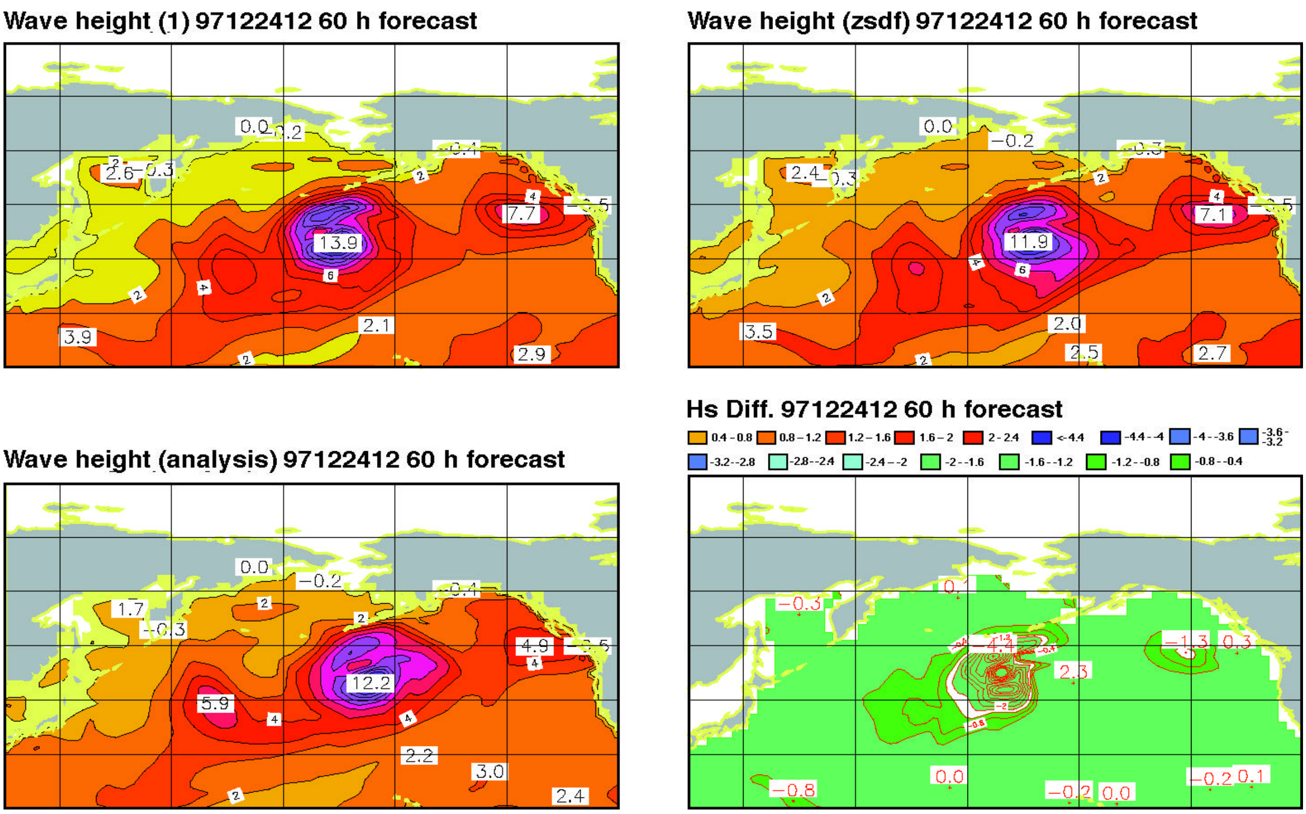


Figure 3: *Day 2½ forecast of wave height for the 24th of December 1997. The control (uncoupled) forecast is shown in the top left panel, the coupled forecast in the top right panel and the verifying analysis in the bottom left panel. The difference between the coupled and uncoupled forecasts is shown in the bottom right panel.*

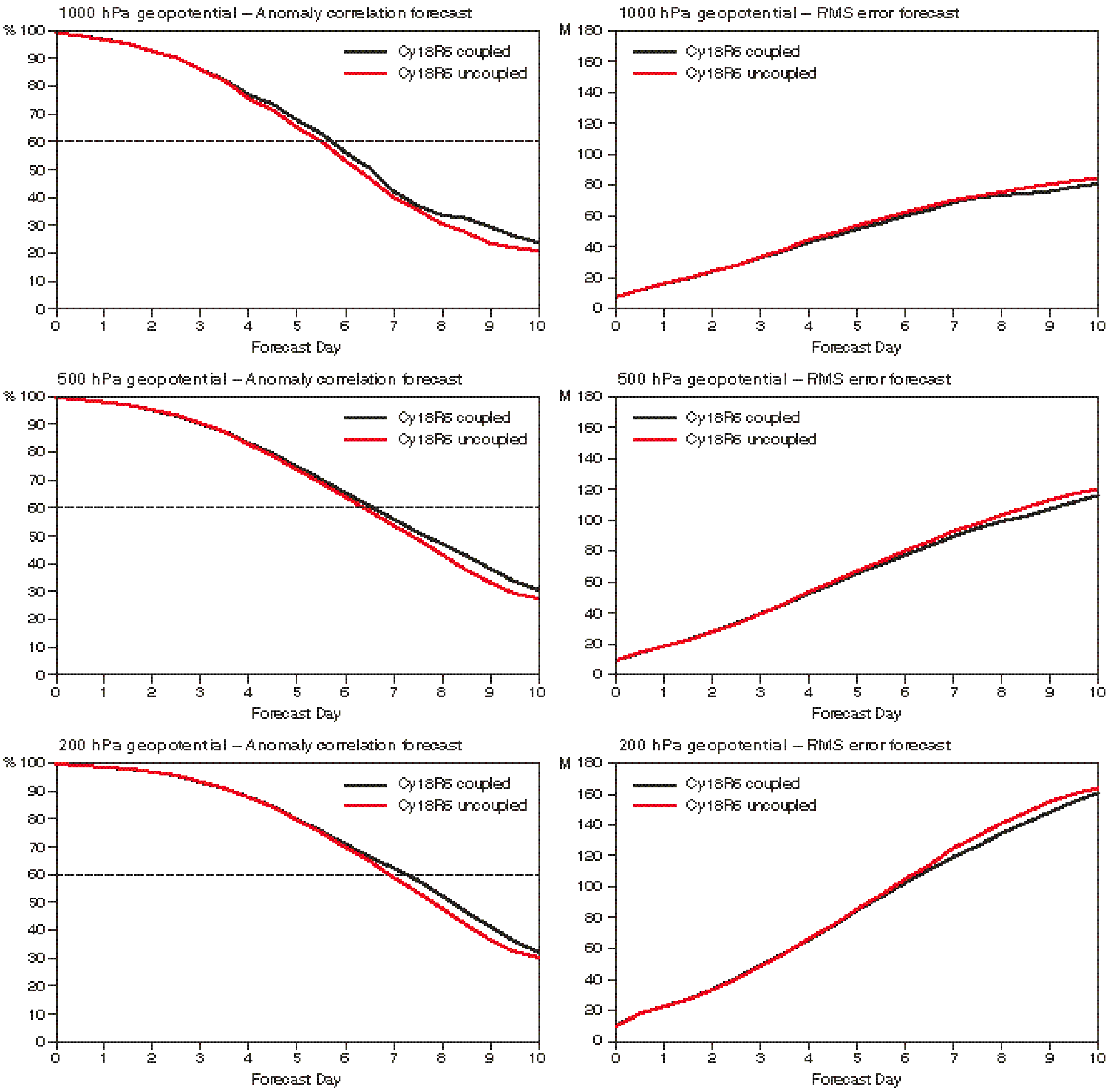


***Figure 4:** Scores for 1000, 500 and 200 Geopotential height for Southern Hemisphere for a 18 day period in December 1997. Comparison of Coupled version of Cy18R6 with uncoupled one.*

radiances over land). Nevertheless, as shown in Figure 5 the reductions in systematic error and standard deviation of error in wave height and surface wind speed are of a similar size as found from previous experimentation. We remark that in particular the reduction of the systematic wave height error during the forecast is quite considerable and suggests that we have removed a problem which was present in our forecasting system during the past few years.

EPS waves

We have also made the necessary preparations for the EPS system to include the two-way interaction of wind and waves. As a consequence, ensemble products for waves are also being produced. At the time of writing the quality of these products is being assessed, prior to their dissemination to the Member States.

One of the most important applications of wave forecasting is the prediction of the timely arrival of low-frequency swells. An example of such a case is given in Figure 6 where we show plume diagrams of wind speed, peak period and significant wave height for buoy 51001 near Hawaii. Concentrating on the plume diagram for the peak period, it is seen that according to the deterministic forecast one would expect low-frequency swells to arrive after 5 days in the forecast, while according to the control forecast low-frequency swells only arrive after seven and a half days. The majority of the members of the ensemble indicate however that no low-frequency swell arrives in the 10 day forecast period, which is confirmed by the EPS forecast of the next day and the verifying analysis.

This suggests that the ensemble product of waves might contain useful information, and we will study this in a more systematic fashion by determining optimal ship routes for every member of the ensemble. In order to obtain sufficient data to do reliable statistics this study will cover a number of months over the coming Autumn and Winter season, since we shall take crossings from Europe to the USA over the North Atlantic.

Conclusion

We have seen that there are advantages for atmosphere and ocean waves when the two models are coupled. In the near future we hope to be able to further exploit the benefits of two-way interaction. On the one hand this may be achieved by means of a more accurate representation of the wave generation process by wind. For example, it is known that the growth of waves by wind depends on the air-sea density ratio and the stability of the air column. Presently, we take a constant value for the density ratio, while in practice this ratio may vary by 10%, in particular during cold-air outbreaks. Also, at the moment we assume for wave generation a neutrally stable airflow whereas in practice there may be strong deviations from neutrality, again during cold-air outbreaks. In the context of a coupled wind-wave system it will be relatively straightforward to pass the relevant information from the atmospheric part of the IFS to the wave part. In addition, since in a coupled system the sea state is known, this may help in providing a more accurate determination of the ocean surface albedo, while sea state information may also be of help in the interpretation of satellite observing systems such as the scatterometer, SSM/I and AMSU (Advanced Micro wave Sounding unit, just recently launched).

On the other hand, observed wave data (cf. Janssen,1994) may give beneficial information on the atmospheric state over the oceans and a coupled wind wave system seems to be the ideal framework to make optimal use of wave observations to specify the initial weather state over the oceans.

References

Janssen, P.A.E.M.,1994: Weather and wave prediction over the Oceans, ECMWF Newsletter,**67**, 3-15.

Komen, G.J., **L. Cavaleri**, **M. Donelan**, **K. Hasselmann**, **S. Hasselmann**, and **P.A.E.M. Janssen**, 1994: Dynamics and Modelling of ocean waves, *Cambridge University Press.*

Janssen, P.A.E.M., **J.D. Doyle**, **J. Bidlot**, **B. Hansen**, **L. Isaksen** and **P. Viterbo**, 1997: Impact of Ocean Waves on the Atmosphere. Seminar on Atmosphere-Surface Interaction, 8-12 September at ECMWF, Shinfield Park, Reading, U.K.

Janssen, P.A.E.M. and **P. Viterbo**, 1996: Ocean Waves and the atmospheric climate. *J. of Climate*, **9**, 1269-1287.

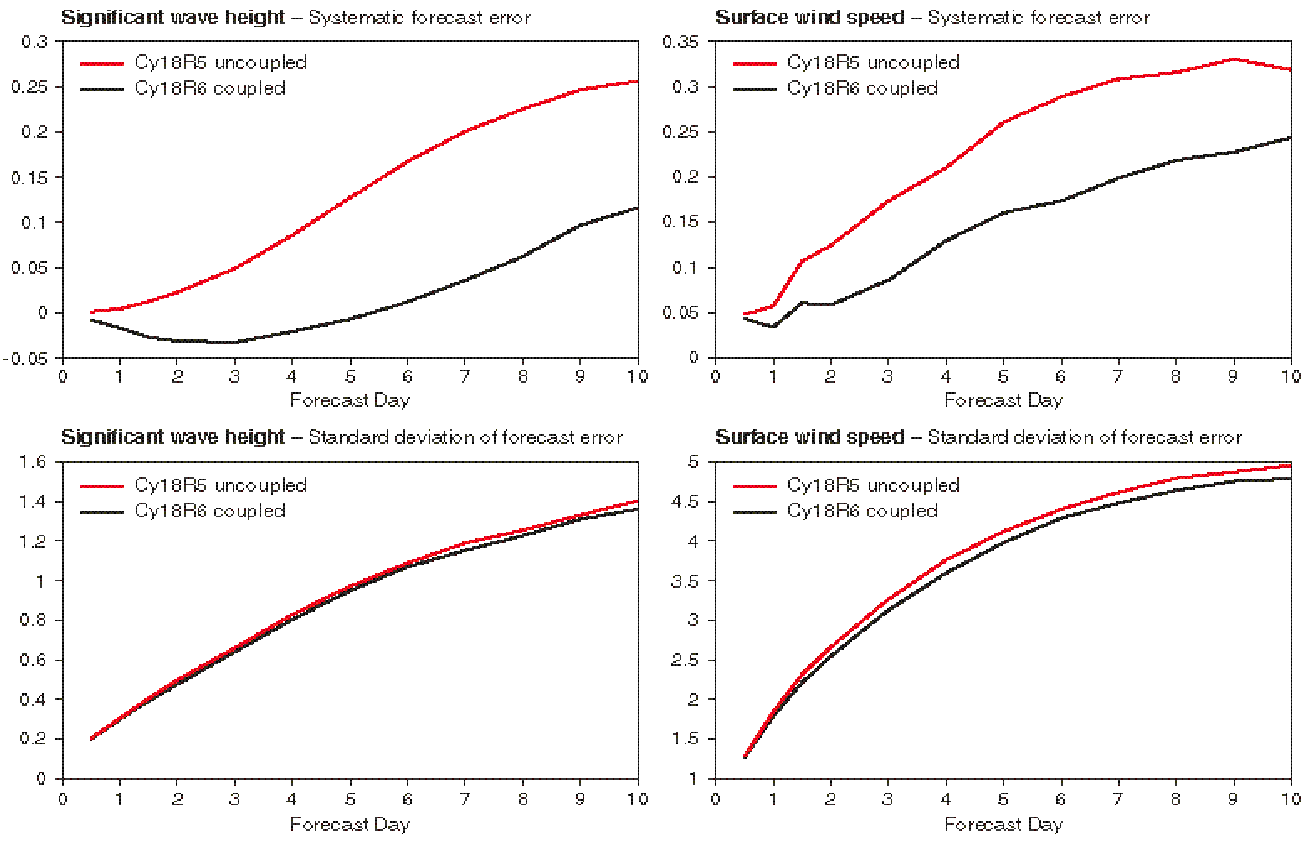


Figure 5: *Comparison of systematic forecast error and standard deviation of forecast error for significant wave height and surface wind speed. Period is 16th of April until 28th of June 1998. Area is Southern Hemisphere.*

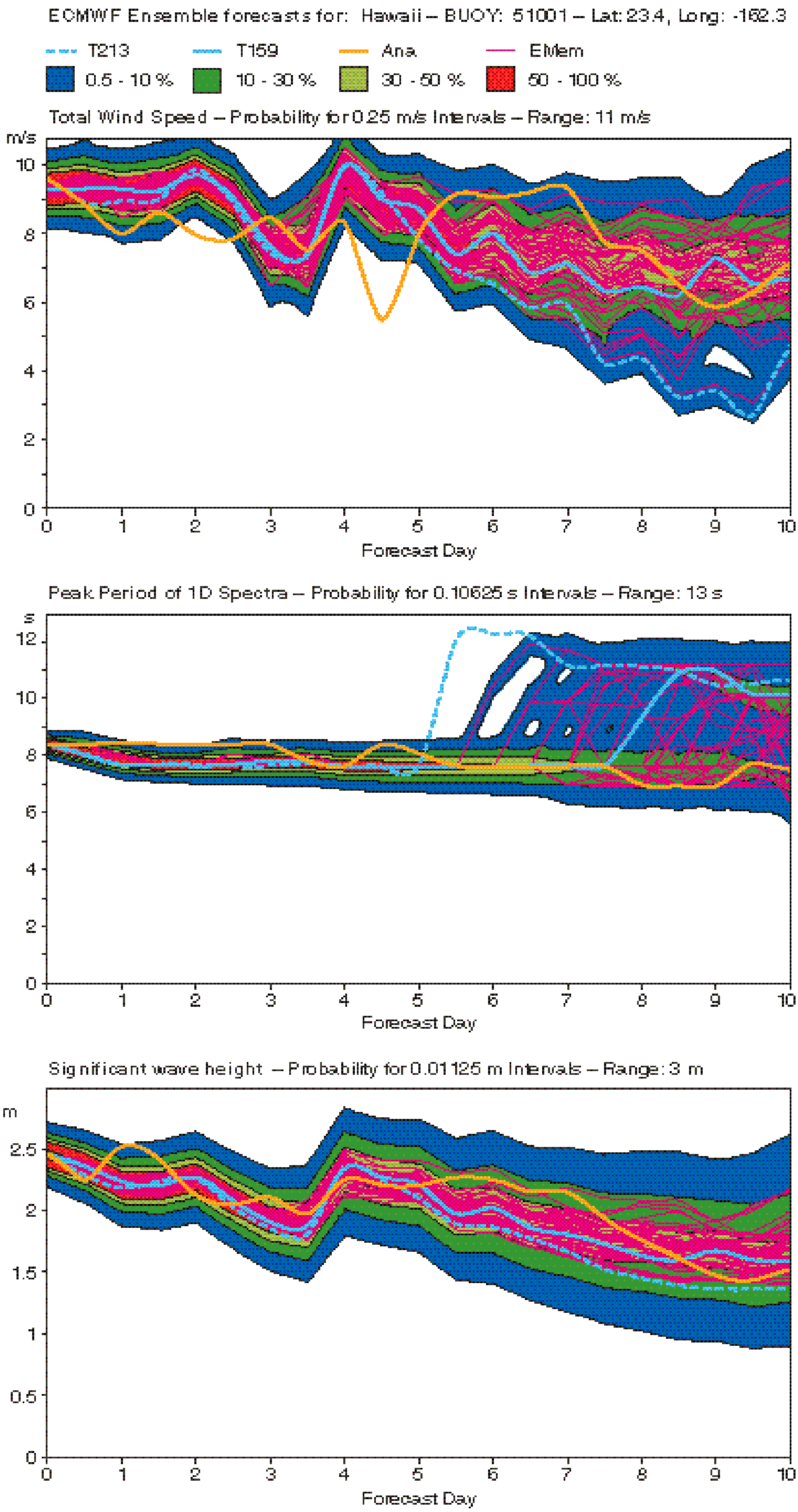


Figure 6: *Plume diagram of surface wind speed, peak period and significant wave height for buoy 51001 located North West of Hawaii. Forecast date is 23rd of June 1998.*

Peter Janssen

Obtaining economic value from the EPS

The performance of the EPS is routinely monitored using a range of verification measures (see the article on EPS verification in ECMWF Newsletter no. 72). This assessment demonstrates that the EPS is a skilful prediction system and has been used to illustrate the improvement of the enhanced EPS introduced in December 1996 (ECMWF Newsletter no. 74). However, these measures do not explicitly address the question which is perhaps of most concern to potential users, namely “Is the EPS worth paying for?”

Providing an answer to such a question is not straightforward. To benefit from a forecast, a potential user must have alternative courses of action available, the consequences of which will depend on the weather that occurs. If, by using forecasts, the user decides on actions which he would not otherwise take, and benefits economically from these alternative actions, then the forecasts have been of value to the user. Thus, a proper evaluation of the benefits of a forecast system to a particular user will involve not only the intrinsic skill of the forecasts, but also detailed knowledge of the exact weather-sensitivity and decision-making process of the user.

Although specific cases may be complex, the general concept of forecast value can be demonstrated using a simple model of the decision process. Results indicate at least qualitatively the value of the forecasts and the framework can be extended if more information is available for a particular user. This approach expresses the performance of the EPS in a way perhaps more directly relevant to end users than the traditional skill measures.

For further discussion on the issue of forecast value together with a summary of recent research see the recent book “Economic Value of Weather and Climate Forecasts”, eds. Katz and Murphy (CUP, 1997).

The cost-loss ratio decision model

Consider a decision maker who has just two alternatives, to take action or to do nothing, the choice of which depends exclusively on his belief that a given weather event E will occur or not. Taking action incurs a cost C irrespective of the outcome. If the event does occur and no action has been taken then the decision maker incurs a loss L. For example, the weather event could be the occurrence of ice on roads and the action “to grit the roads”; C would be the cost of the gritting procedure while L would be the economic loss due to traffic delays and accidents on icy roads. The expense associated with each combination of action and occurrence of E is shown in table 1 (the expense matrix).

		Weather event occurs	
		No	Yes
Take action	No	0	L
	Yes	C	C

Table 1: *Expense matrix: cost and loss for different outcomes*

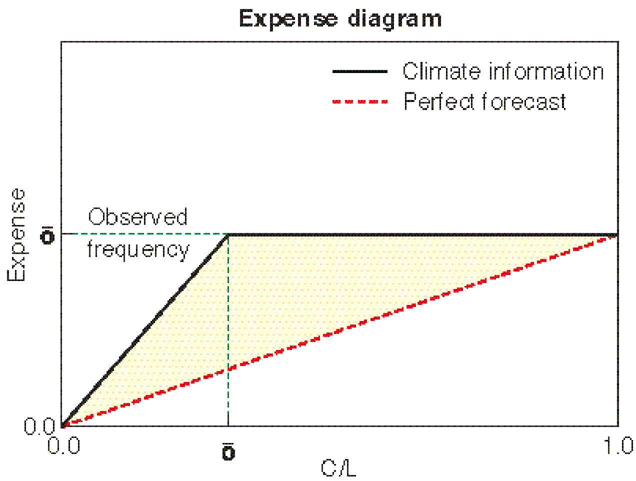


Figure 1: *Mean expense per unit loss for decisions based on climate information or made with perfect knowledge of future weather. Both depend on cost-loss ratio and observed frequency of the event.*

The decision maker wishes to pursue a strategy which will minimise any losses over a large number of cases. If only climatological information is available there are just two options: either always take protective action or never protect. Always taking action incurs a cost C on each occasion (irrespective of whether the event occurs or not), while if action is never taken the loss L occurs only on that proportion o of occasions when the event occurs, hence the average expense is oL. Thus in the absence of information other than climatology, the optimal course of action is always act if $C < oL$ and never act otherwise.

It is convenient to consider the expense of the various courses of action in terms of the “cost-loss” ratio C/L. If the cost of protection is greater than the potential loss there is no benefit to be obtained from taking any protective action. Thus C/L need only be considered to be in the range 0 to 1. The mean expense per unit loss (*ME*) can be plotted as a function of C/L on an expense diagram (figure 1). The minimum *ME* given climate information is shown by the solid curve. The dashed curve shows the minimum expense which could be obtained given perfect knowledge of the future weather - the decision maker would only need to take action when the event was going to occur and would never incur a loss, so the *ME* would be $o(C/L)$. Of course, given the chaotic nature of the atmosphere and our inevitably uncertain knowledge of the exact initial state of the atmosphere, such perfect forecasts are not likely to be achieved in practice. However, there is clearly potential for reduction of the *ME* from that of climatological information towards the perfect-forecast limit.

Event	Jan–Feb 1998			
	FAR	HR	KS	$\bar{o}$
T < -8K	0.039	0.445	0.406	0.058
T < -4K	0.144	0.611	0.468	0.228
T > +4K	0.091	0.548	0.457	0.179
T > +8K	0.027	0.393	0.367	0.043

Table 2: *Skill of the EPS control forecasts of temperature over Europe*

The provision of additional information in the form of forecasts may allow the decision maker to revise his strategy and reduce his expected expense. The extent by which the expense is reduced is a measure of the value of the forecasts to the decision maker. We define the value *V* of a forecast system as the reduction in ME as a proportion of that which would be achieved by a perfect forecast. Thus maximum value *V=1* will be obtained from a perfect forecast system, while *V=0* for a climate forecast. If $V > 0$ then the user will benefit from the system.

Skill and value for a deterministic forecast system

Consider first a deterministic forecast system, that is each forecast is a simple statement either that a given weather event will occur or that it will not occur. The value of the system depends on the hit rate (HR) and false alarm rate (FAR) of the forecasts, on the observed frequency of the event, and on the user-specific cost-loss ratio (see appendix).

The performance of the EPS control forecast for the prediction of T+144 850 hPa temperature anomalies exceeding certain thresholds is shown in table 2 for January and February 1998 over Europe. The skill of the forecasts is measured using the Kuipers skill score (KS, see appendix) - a perfect forecast will score 1, random or constant forecasts score 0, so a positive score is indicative of skill. The control forecast has substantial skill for all thresholds. Forecasts for the smaller thresholds are more skilful than for the more extreme events, and positive anomalies appear more difficult to predict than negative anomalies. However the question for potential users is how does this skill relate to the economic value of the forecasts?

For a given weather event and forecast system, o , *HR* and *FAR* are given and the economic value *V* of the forecast system depends only on the cost-loss ratio. *V* is shown in figure 2 as a function of C/L for the forecasts of the four events. Although the model is skilful according to the scores in table 2, it is clear that the usefulness to a decision maker depends greatly on his particular cost-loss ratio. For C/L greater than about 0.6 none of the event forecasts are useful; for C/L between 0.1 and 0.5 forecasts of the ±4K events are useful, while for C/L less than 0.1 it is only the forecasts of larger anomalies which have value.

Maximum value always occurs for $C/L = o$; at this point the expense of taking either climatological option (always or never protect) is the same: climatology does not help the decision maker and the forecast has the greatest benefit. As the cost approaches the limits of 0 and 1, the climatological options become harder to beat - high expense resulting from even occasional incorrect forecasts outweighs the low expenditure of the default action.

The maximum value itself is equal to the Kuipers score given in table 2. Thus the skill is related to the usefulness of the forecasts: *KS* is the maximum value that can be obtained from the system. Whether this potential maximum value will be achieved depends on the cost-loss ratio of the user; the closer C/L is to o the higher will be the value. Note that this maximum value is independent of C/L and o; if two systems predicting different events (with quite different o) have the same *KS* then the potential maximum value will be the same, but it will occur for different values of C/L, equal to the respective observed frequencies.

Probability forecasts

If forecasts are supplied to the decision maker as probabilities then the question facing the user is at what probability threshold should action be taken. Should the user take action if the event is forecast with a probability of, say, 50% or should he wait until the forecast is more certain (perhaps 80%)? Is there an optimum probability above which action should be taken?

In effect this choice of a threshold probability p^* converts the probability forecast to a deterministic one - consider

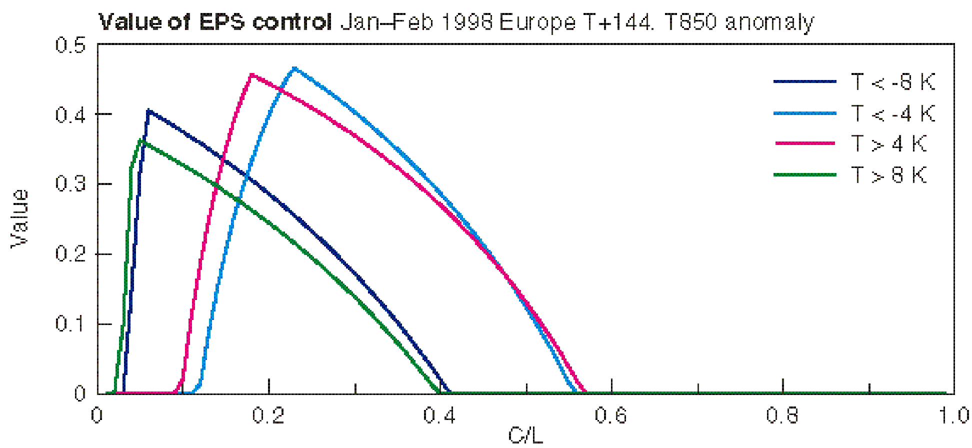


Figure 2: *Value of EPS control forecasts of 850 hPa temperature anomalies exceeding different thresholds.*

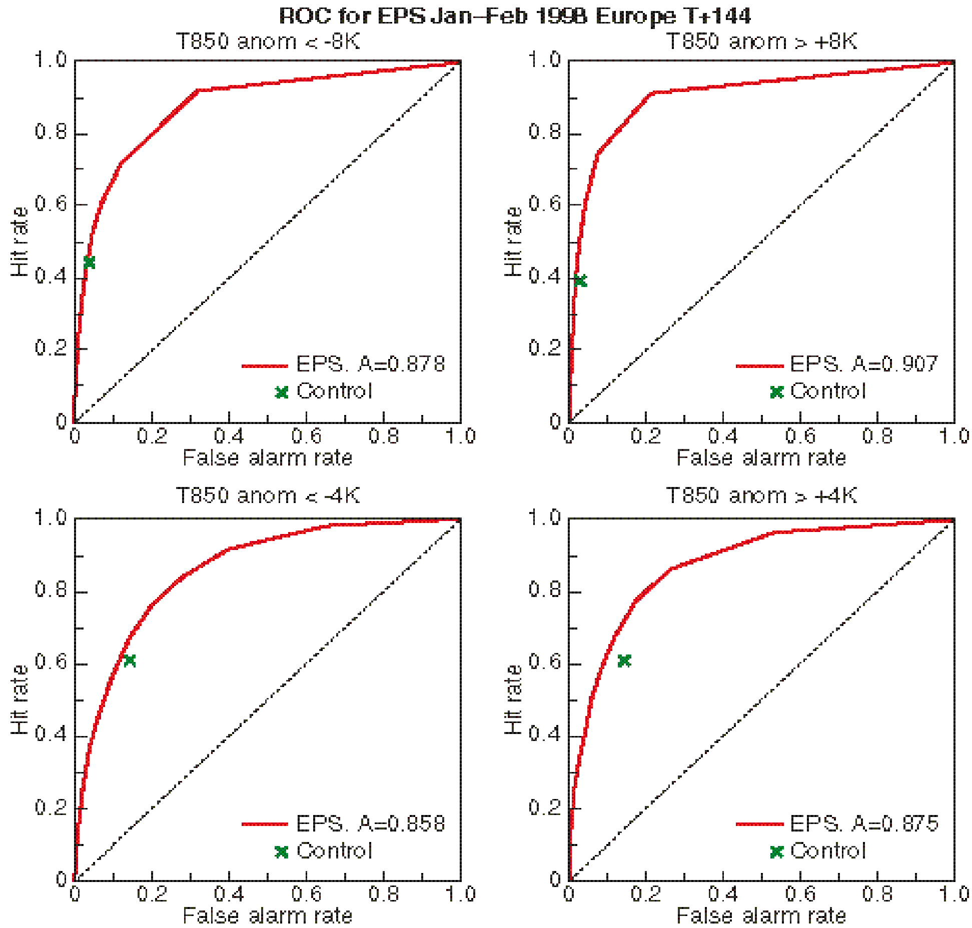


Figure 3: *ROCs for EPS forecasts of 850 hPa temperature anomalies.*

those forecasts with higher probability for the event as forecasts that the event will occur and those with lower probability as forecasts the event will not occur. For a given p^*, the value of the system can then be determined in the same way as for a deterministic system. By varying p^* from 0 to 1 a sequence of values for *HR* and *FAR* and hence *V* can be derived; the user can then choose that value of p^* which results in the largest value. Note that since *V* also depends on *o* and *C/L* the appropriate value of p^* will be different for different users and different weather events.

Probability forecasts of the temperature events considered in the previous section are produced using the EPS. The relative operating characteristic *(ROC)* is a plot of *HR* against *FAR* for a set of threshold probabilities p^* between 0 and 1 (figure 3). The endpoints of the *ROC* (1,1 and 0,0) result from the baseline actions of always forecasting or never forecasting the event respectively. A perfect forecast system, with *HR = 1* and *FAR = 0*, would give a point at the top left corner of the graph, so the closer the *ROC* is to the top left corner the better. If a forecast system had no ability to discriminate the occurrence of an event from nonoccurrence, then *HR* and *FAR* will always be equal and the *ROC* for the system would lie along the diagonal line *HR = FAR*. The area (*A*) under the *ROC* is used as an index of the quality of the forecast system. A perfect system would have *A = 1.0*, while the no-skill system (*HR = FAR*) would have *A = 0.5*. The areas under the *ROCs* of figure 3 are shown in the legend.

Also plotted in figure 3 are the *HR* and *FAR* for the control forecast (table 2). One of the benefits of the ROC is that it allows direct comparison of deterministic and probabilistic forecast systems. In this case the points for the control lie below the EPS *ROC*. These forecasts are less useful than the EPS for this event, since for the same *FAR* a higher hit rate is obtained using the EPS probabilities.

For each probability threshold p^*, the corresponding *HR* and *FAR* can be used to generate a value curve, just as in the deterministic case. The set of curves for the *T > +4K* event are shown in figure 4. The EPS forecasts have value for most users, although the benefit varies substantially for users with different cost-loss ratios. The most important feature of figure 4 is that the value depends crucially on the appropriate choice of threshold probability p^*. Users with small cost-loss ratios, i.e. relatively large potential losses, will gain maximum benefit by taking action even when the forecast probability is low, while for users with high cost, value is obtained by taking action only if there is high forecast probability for the event. An inappropriate choice of p^* can result in substantial reduction in forecast value. For example, a decision maker with a cost-loss ratio of 0.1 will receive 40% value by acting when the EPS probability is 10% or more, but would gain no value at all from the EPS if action was not taken until the forecast probability was greater than 50%.

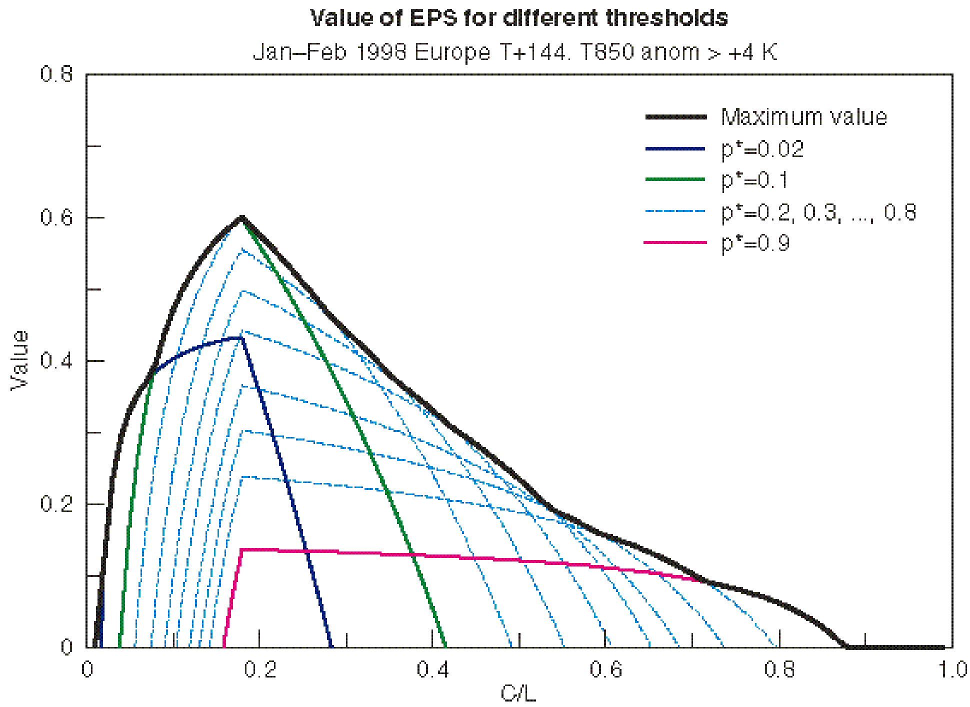


Figure 4: *Value of EPS forecasts for different choices of threshold prob - ability p*.*

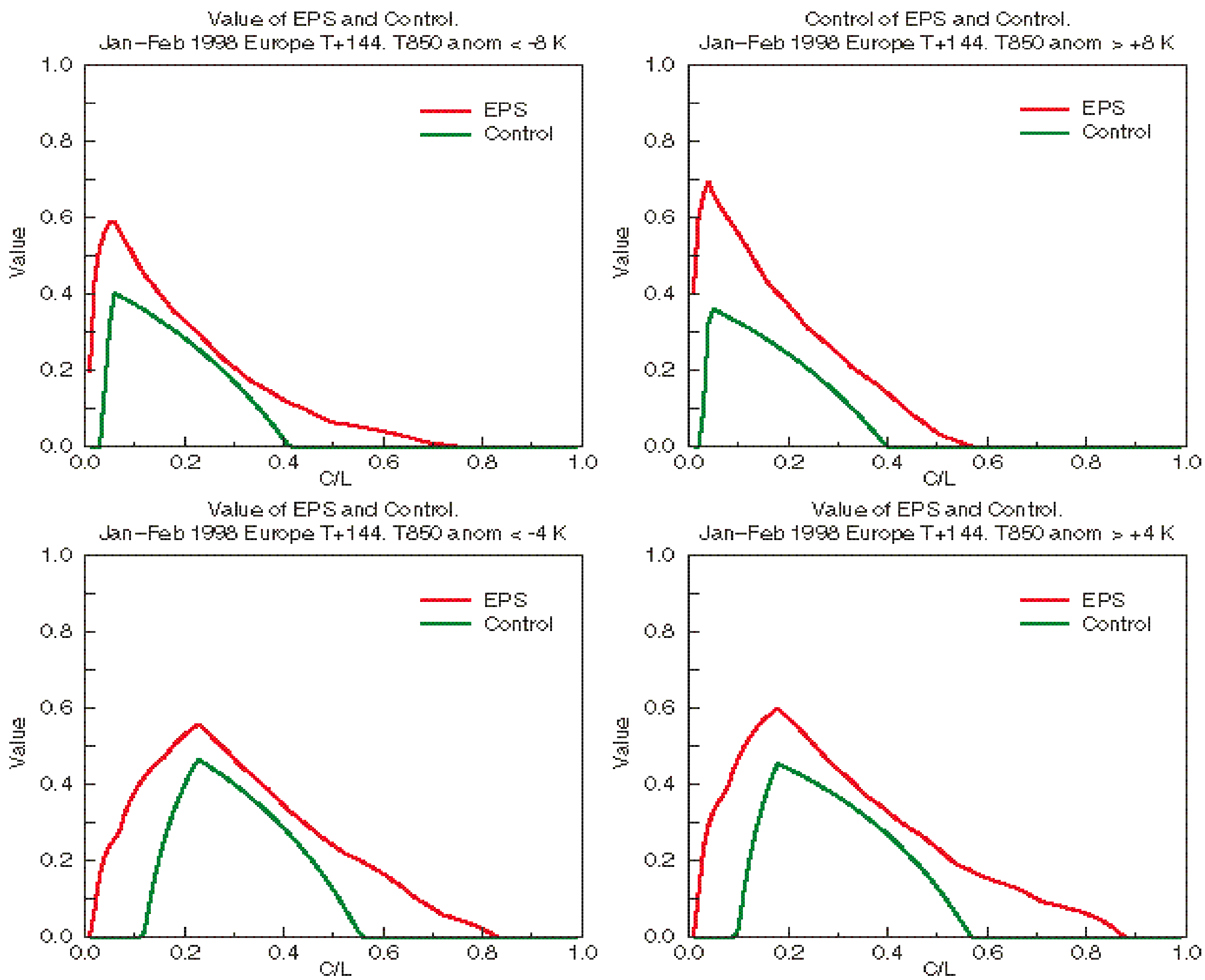


Figure 5: *Value of EPS probability forecasts and EPS control.*

This example illustrates the important advantage of providing probability information to users: the value of the EPS forecasts depends significantly on the choice of probability threshold p^* and on the user's cost-loss ratio. There is no single threshold for which the EPS has value for all users - different users must use different thresholds to benefit from the forecasts. If the forecast is reduced to a single deterministic one for all users, for instance by using the ensemble mean or by choosing an arbitrary threshold, the value to some users will be reduced and may even be eliminated completely.

Comparison of the value curves for the EPS probability forecasts and the control deterministic forecast highlights the advantage of the probability forecasts (figure 5). The flexibility of being able to choose the threshold probability greatly increases the range of users who will benefit from the forecasts. Even though the deterministic forecasts appear close to the EPS curves on the *ROCs*, the extra value of the probability forecasts can be substantial.

Conclusions

There is no simple relationship between the skill of a forecasting system and the value of that system to users. A simple cost-loss model of economic value can be used to give an indication of the potential benefit to a user in a more relevant way. While a system with no skill will not have value, it is not necessarily the case that a skilful system will be beneficial to a given user. The value of the system depends not only on the performance of the system (as measured by hit rate and false alarm rate) but also on the observed frequency of the event and, importantly, on the relevant costs of the user.

Probability forecasts are generally more useful than deterministic forecasts of comparable quality because of the facility for the user to select a probability threshold appropriate to his needs. The arbitrary determination of such a threshold without knowledge of the particular user's requirements can severely reduce the value of the system.

Although it may be difficult to determine the costs and losses for a particular user (users themselves may not readily have this information) the simple value curves presented here do present the forecast verification in a form relevant to the user's needs. The EPS will indeed have economic value to many users, providing at day six perhaps 60% of the savings which would be obtained with perfect knowledge of future weather. That surely is worth paying for.

Appendix

For a deterministic forecast system a contingency table can be constructed showing the proportion of correct and incorrect forecasts of a weather event occurring or not occurring (table 3). The hit rate (*HR*) is defined as the proportion of occurrences of the event which were correctly forecast, while the false alarm rate (*FAR*) is the proportion of nonoccurrences for which the event was (incorrectly) forecast. Note that both *HR* and *FAR* are expressed in terms

		Observed		
		No	Yes	
Forecast	No	a	b	a+b
	Yes	c	d	c+d
		a+c	b+d	

***Table 3:** Contingency table for forecast and occurrence of binary event*

of the observed relative frequency of the event o; it is assumed that $o > 0$, i.e. that the event does occur in the sample.

$$HR = \frac{d}{b+d} = \frac{d}{\bar{o}} \tag{1}$$

$$FAR = \frac{c}{a+c} = \frac{c}{(1-\bar{o})} \tag{2}$$

From table 3 and the expense matrix (table 1), the expected mean expense (ME) for the forecast system is:

$$ME = \frac{bL + (c+d)C}{L} = b + (c+d)\frac{C}{L} \tag{3}$$

This can be written in terms of HR and FAR using equations (1) and (2) as

$$ME = FAR\,\frac{C}{L}(1-\bar{o}) - HR\,\bar{o}\left(1 - \frac{C}{L}\right) + \bar{o} \tag{4}$$

The value of a forecast system is a measure of the improvement over the climatological ME. Here value is defined relative to the maximum possible improvement given by a hypothetical perfect forecast system

$$V = \frac{ME(climate) - ME(forecast)}{ME(climate) - ME(perfect)} \tag{5}$$

$$= \frac{\min\left(\frac{C}{L}, \bar{o}\right) - FAR\,\frac{C}{L}(1-\bar{o}) + HR\,\bar{o}\left(1 - \frac{C}{L}\right) - \bar{o}}{\min\left(\frac{C}{L}, \bar{o}\right) - \bar{o}\,\frac{C}{L}}$$

So the value of a particular forecast system depends on the external (to the system) parameters C/L and o, and the internal parameters *HR* and *FAR*. It can be shown that the maximum value V occurs for $C/L = o$, at which point $V = HR\text{-}FAR$.

Skill of the forecasts is measured using the Kuipers skill score (*KS*). In the notation of table 3, this can be written as:

$$KS = \frac{ad - bc}{(a+c)(b+d)} \tag{6}$$

The KS has the desirable characteristics that random or constant forecasts will score zero; perfect forecasts will have a score of 1. The *KS* can be rewritten in terms of the hit rate and false alarm rate as $KS = HR\text{-}FAR$. Thus, the Kuipers score is equal to the maximum value that can be obtained from the system.

David Richardson

Seasonal forecasting at ECMWF: an update

The seasonal forecast system was described in the autumn 1997 ECMWF newsletter (No 77). Since that time the ECMWF Council gave approval for distribution of seasonal forecast products on the World-Wide-Web in an experimental capacity. Forecasts within 35 degrees of the equator are available to all on http://www.ecmwf.int. Member States may access the full global products on http://w3ms/ecmwf/seasonal/index.html, but should be aware of the limitations of forecasts in the extratropics in general and especially over Europe. As discussed in the autumn newsletter, any prediction must be probabilistic in nature. Our web pages give two maps for each predicted field, the probability of occurrence and a measure of the amplitude. The fields currently posted are the integrated rainfall, the surface pressure and the 2 m temperature valid at 00 UTC, together with plume diagrams of the Sea Surface Temperature (SST) in Niño3, (a key region in the central east equatorial Pacific). A full and thorough evaluation of the skill of the seasonal prediction system has not been conducted so far. However, some preliminary remarks are appropriate. Results are shown here for both the recent 97/98 El Niño and also for earlier years of this decade.

Seasonal forecasting does not allow exact predictions, even for seasonally averaged values, but it should be possible to describe the probability distribution for weather, and hence calculate probabilities for any specified event. Our plots of the probability of above average temperature or rainfall are just one example of the sort of product that can be made; other possibilities might be the probability of mean temperature above a specific value or a quintile threshold, the probability of the number of rain days exceeding a certain value, the probability of either the mean maximum or absolute maximum temperature reaching a certain value, the number of heavy snowfall events, etc. The probabilistic nature of the forecasting makes verification a difficult issue, particularly because so far we have only a small number of cases to study. For cases where the (forecast) probability distributions are not much shifted from climate, then it is hard to know whether the forecast was good, unless perhaps the observed weather is very extreme. An essentially null forecast such as this might be of use, of course, if one could be confident that it implied that extreme weather would definitely not occur - but testing would have to cover many years to establish this. On the other hand, if the forecast is for a strong shift in the weather patterns for a particular year, then this provides a good opportunity to test the forecast system. It is still true that we are not able to predict exactly what will happen, but the test as to whether the observations lie within the predicted range becomes more powerful. In 1997 and 1998 our system has been forecasting strong shifts in global weather patterns, largely associated with the exceptional El Niño. This means that the last year or so are a very good period over which to assess the performance of our system. Afuller assessment

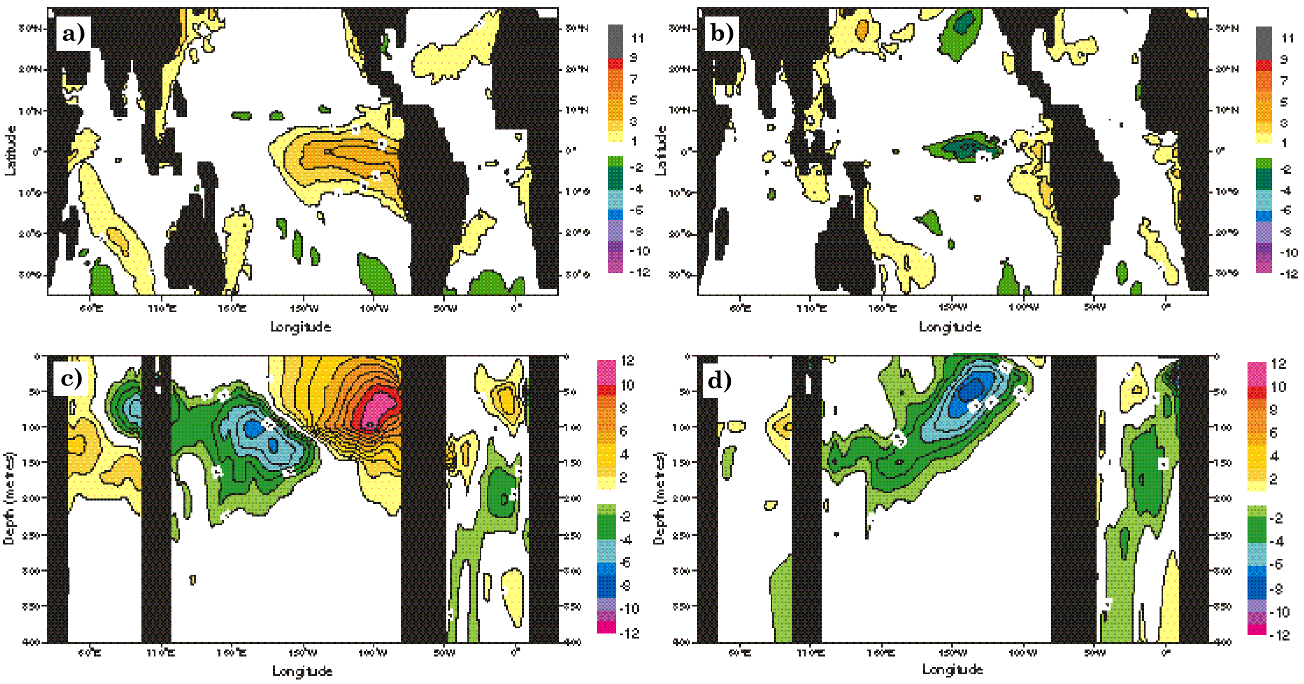


Figure 1: *Plot of sea surface temperature for a) the beginning of January, 1998, and b) the beginning of July 1998. Vertical sections of thermal anomalies along the equator are shown for the same times in c) and d). These figures show the large changes which have occurred in the space of 6 months from the peak of the warm phase of El Niño to the developing cold conditions in July. The contour interval is 1K. The zero contour is not plotted.*

will require the completion and analysis of forecasts covering a much longer period of time; this will be provided at some stage in the future.

The largest signal in the climate system on interannual timescales is that of El Niño. Last year saw one of the biggest recorded, in some respects bigger than 1982/3. May 1998 saw a precipitous decline in temperatures in the central equatorial Pacific which by early June had ceased to be warm and are now below average. There is the distinct possibility of a cold phase developing, sometimes known as La Niña. Figure 1a) shows the sea surface temperature anomalies at the beginning of January of this year, while Figure 1b) shows them at the beginning of July illustrating the rapid decay from warm anomalies of 5K to cold anomalies of -2K. Figures 1c) and 1d) show the temperature anomalies in the upper 400 m along the equator for the same times. The black vertical bands indicate the equatorial land masses which separate the three ocean basins. The temperatures in the subsurface ocean have changed by an even greater amount than at the surface, from a warm anomaly of 11K to a cold anomaly of -6K. In January '98, even though the surface and subsurface temperatures were very strongly above average in the east, the subsurface temperatures were cold in the west. This cold anomaly spread slowly eastward over the following 6 months to reach the surface in June.

Asuccessful seasonal forecast system must be capable of forecasting the development and demise of such a large El Niño event. How well did we do? In Figure 2, forecasts of Niño3 are shown for six different start months. Since December 1997 operational forecast system involves a 200 day forecast initiated every day. So in a typical month an ensemble of 30 or 31 members is generated. In earlier months the ensemble size was smaller and the forecast time shorter. The thick heavy line on Figure 2 shows the observed value of Niño3 SST. One can see that the overall

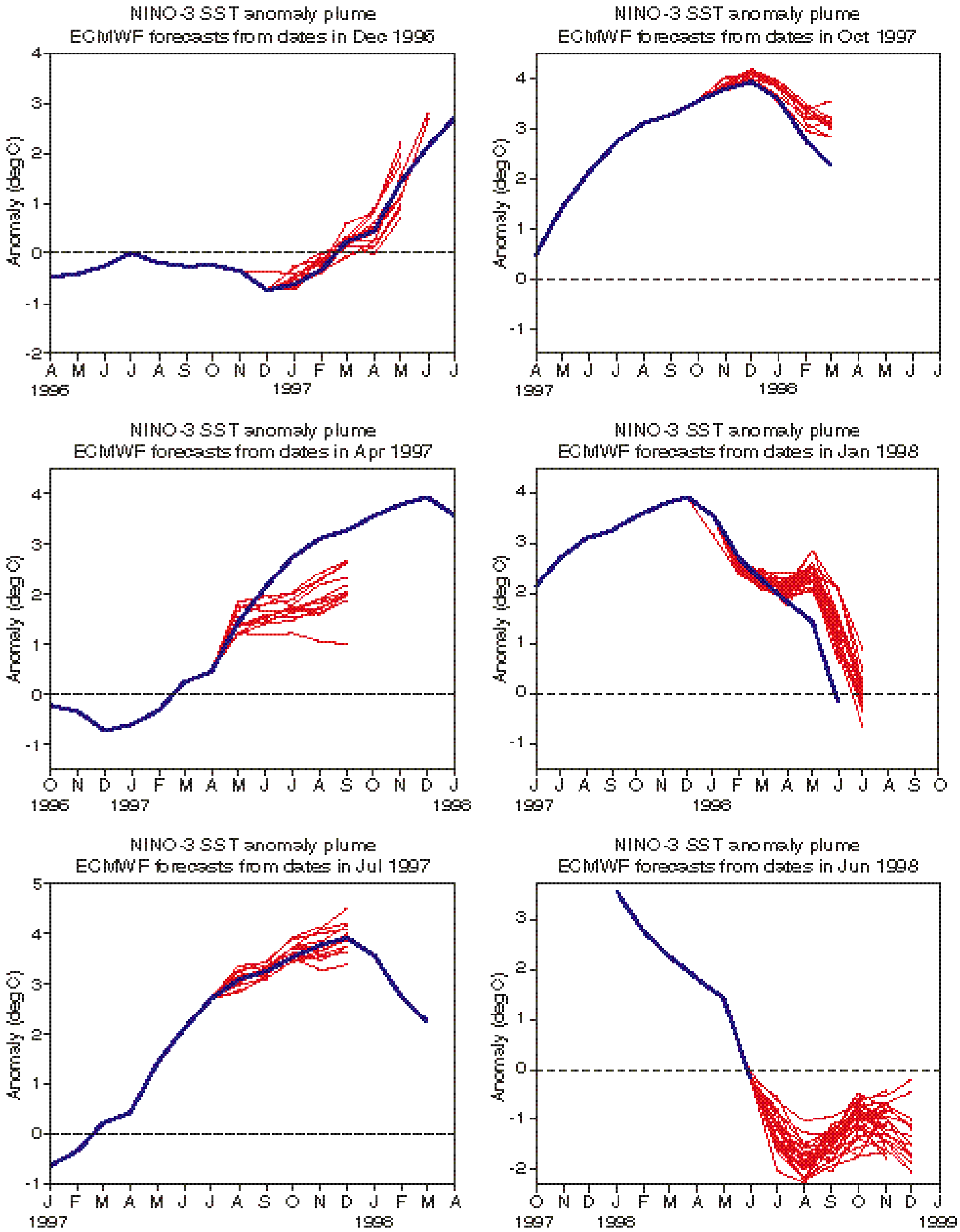


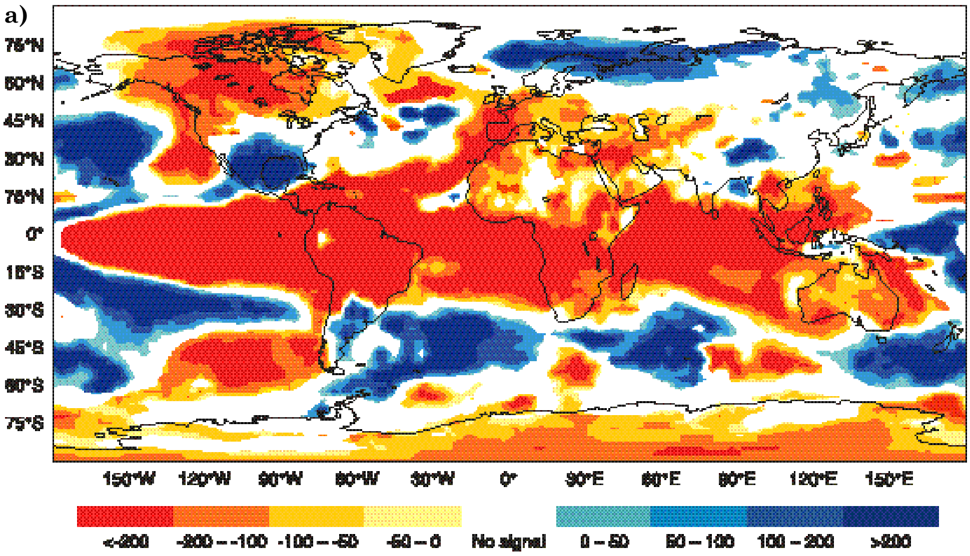
Figure 2: *Plot of Niño3 SST values as predicted for six different start months. The forecasts from December '96, July '97, October '97 were all good. Those from April '97 underpredict the El Niño growth. The rapid decrease in SST in the Spring of '98 is also underpredicted.*

ability of our system to forecast Niño3 SST's in 1997/98 has been good, better indeed than might have been expected.

There have been times, however, when the forecasts have been less good. Some of our worst forecasts of Niño3 SSTs were those initiated in April '97. All members of the ensemble in this case underpredicted the growth of the anomaly as Figure 2b) shows. In March '97, a major Intraseasonal Oscillation with associated Westerly-Wind-Bursts came out of the Indian Ocean into the west Pacific where large amplitude oceanic Kelvin-type waves were generated. These waves were strongly present in the ocean model initial conditions for forecasts initiated in April: it is surprising then that the model underpredicted the Niño3 SST. The reasons for this are not clear but there is some suggestion that the coupled model failed to amplify the signal when it reached the east Pacific. The other panels of Figure 2 show that forecasts from December 96, and July '97 were accurate, while those from October '97 slightly over-predicted the anomaly. Those initiated from January '98 show a very tight ensemble and indicated a very rapid decay of the El Niño. In fact Nature showed an even faster decline. The final panel predicts that cold conditions will last throughout the rest of the year.

Because the forecasts of the evolution of El Niño were good, it makes sense to analyze the results further and to look at the model predictions for fields other than SST and to consider the predictions globally. The predictions for the tropical Pacific made in October '97 for the subsequent 6 months were thought to be unlikely to be grossly wrong and therefore we had more confidence for this period than would be the case in non El Niño years. An important issue at that time was, "Will El Niño in the Pacific have a pronounced effect on European Winter climate?" Our forecast system gave a pretty categorical indication of mild conditions for much of Europe, although we have not verified that this was a consequence of El Niño. Figure 3a) shows the probability of above average 2 m temperature for December, January, February forecast from October '97. Deep red colours indicate high probability of above average temperature, while deep blue colours indicate high probability of below average temperature. Figure 3b) shows the observed anomalies of temperature for February '98 but is representative of the

a)



b)

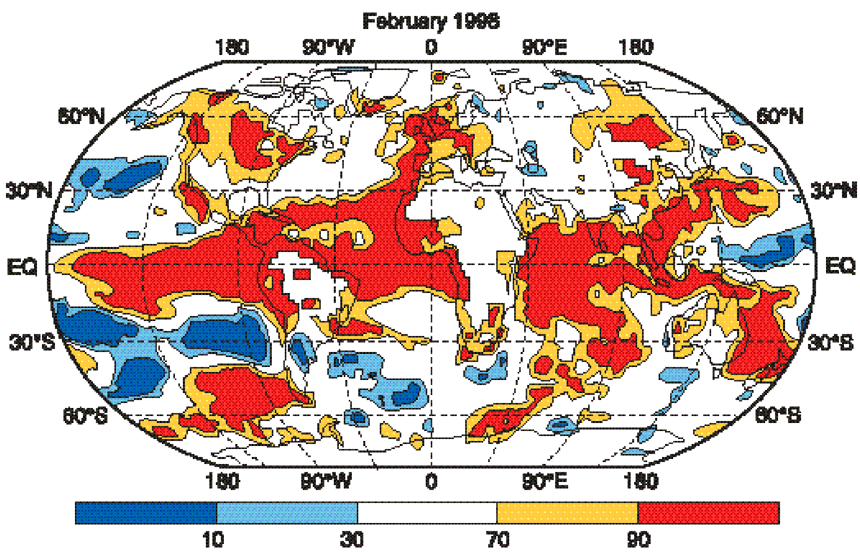


Figure 3: *Probability forecasts of:*

a) 2 m temperature for the winter of 1997/8 for forecasts initiated in October '97. Deep red colours indicate high probability of above average temperature. Deep blue colours indicate high probability of below average temperatures.

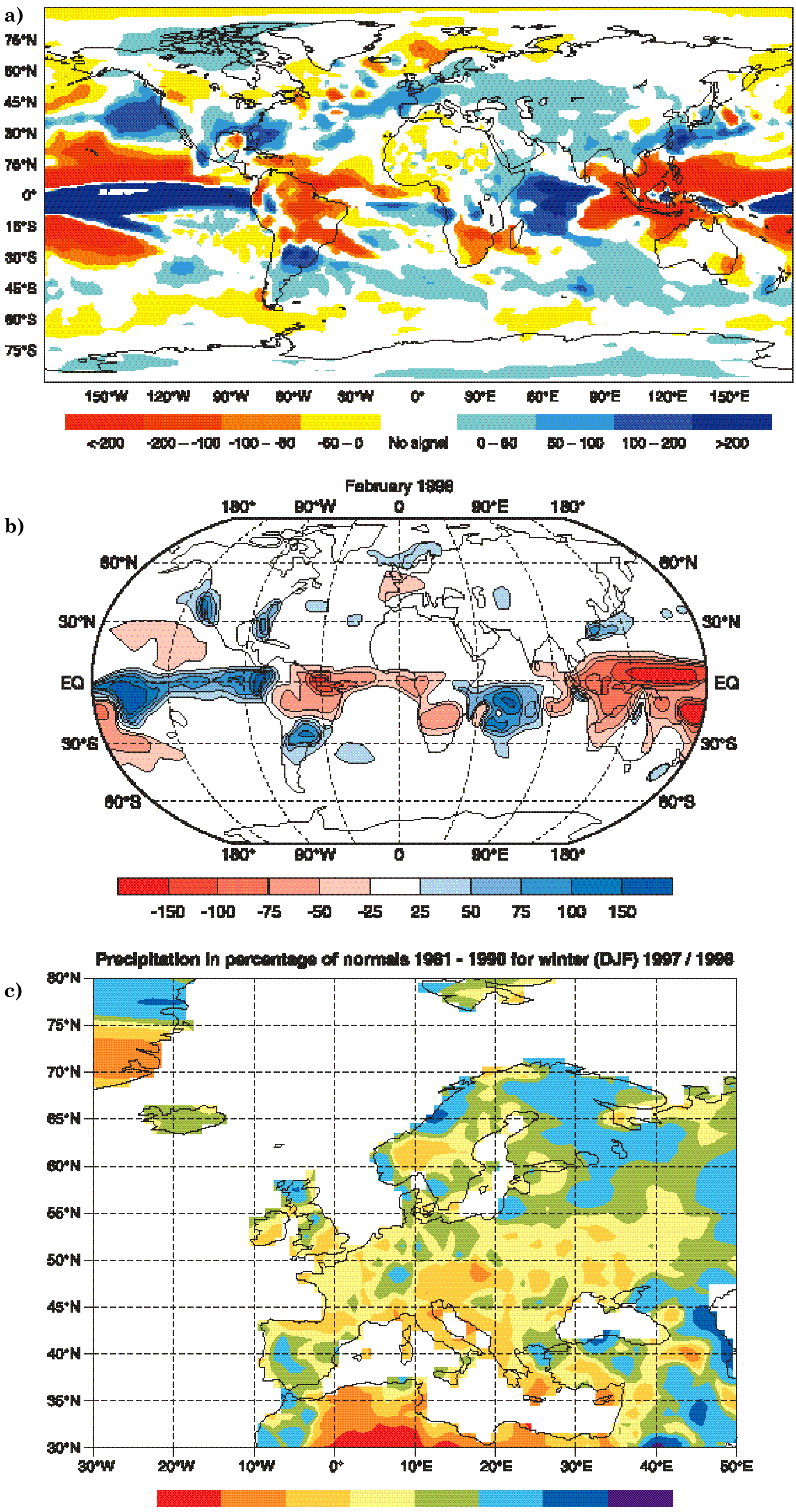
b) Observed temperature anomalies represented as percentiles. (Reproduced with permission from the Climate Analysis Center. See also http://nic.fb4.noaa.gov:80/products/analysis_monitoring/)

Figure 4: *Forecasts of:*

a) anomalous rainfall for the winter of 1997/8 for forecasts initiated in October 1997. Deep red colours indicate below average rainfall while deep blue colours indicate above average rainfall.

b) Observed rainfall anomalies in mm for February 1998. (Reproduced with permission from the Climate Analysis Center).

c) Observed rainfall anomalies for December 1997 to February 1998 for land in the European sector. (Reproduced with permission from Dr. B. Rudolf Global Climatology Prediction Centre (DWD)). See also http://www.dwd.de/research/gpcc.



earlier winter months. It does not correspond exactly to the forecast product, showing percentile behaviour, but indicates the very unusual warm conditions of the winter of 97/98. The similarity of this map and the probability map shown in Figure 3a) and in particular by the warm tropical Atlantic and the broad sweep of warmth from the southern Caribbean east/northeast to Europe is striking. North America was also warm in both predictions and observations. There are apparent disagreements in the Southern United States where below average temperatures were forecast in Figure 3a), but none observed on Figure 3b). In fact this region was cooler than normal though not as cool as forecast. There is no warm anomaly over Brazil in the analysis, but this just indicates lack of data rather than the absence of an anomaly.

Figure 4a) shows the probability for rainfall anomalies. Rainfall is a more chaotic variable, less likely to be skilful and more difficult to verify because of its small scale chaotic variability, but we include it here because of its potential importance. Figure 4b) is one estimate of rainfall for one month covering both land and sea. Although Figure 4b) is global and useful to give an estimate of tropical anomalies it is not useful for validating the predictions for the extra-tropics. A more detailed map from GPCC (Global Precipitation Climatology Centre) covering the same 3-month period as the forecasts, but just available for European land areas, is given in Figure 4c). Figure 4a) shows a general tendency for wetter northern Europe and, if anything, drier southern Europe, with the exception of Portugal and western Spain in the forecasts, while the verifications of Figure 4c) show similar patterns though they differ in detail. Indeed this figure shows clearly the small-scale structure of the observed rainfall anomalies. Such detail can not be reproduced by the coupled model whose resolution is much coarser than that observed. Detailed verification on a country by country basis is unlikely to be meaningful. In the tropics the broad-scale patterns of drought over the Indonesian region and over Amazonia seen in Figure 4b) are well forecast, though here too they differ in detail.

Figure 5 shows the anomalous height of the 500 hPa surface for DJF 97/98 from the coupled model prediction from October 1997 and the appropriate ECMWF analysis. The ensemble mean forecasts from the coupled model did a splendid job of predicting the anomaly in the region of the Aleutians, a pretty good job over the United States but less well over the European region. The centre of the low over the Atlantic was reasonably well located but its amplitude was only half that observed. This could be because of model error, discussed below, but could also reflect the lack of perfect predictability which would be expected even in a perfect system.

Is the level of skill shown on figs 2 to 5 typical or only attainable in windows of opportunity associated with large El Niño or La Nina's? Figure 6 is similar to Figure 5 except for a different year 1994/5. One can see that the forecast ensemble mean is much less able to represent the observed anomaly pattern, and in this sense the forecast is less skilful. (In another sense, the lack of a consistent signal in the forecast ensemble might be an accurate indicator that the future is undetermined). This low level of skill is typical of the model forecast performance during the period 1991-96. A substantial cause of this could be relatively low levels of predictability in the Northern Hemisphere flow during these years. However, ensemble integrations of the same atmosphere model using observed SSTs generally have better skill scores than the coupled integrations, and predictability estimates from the

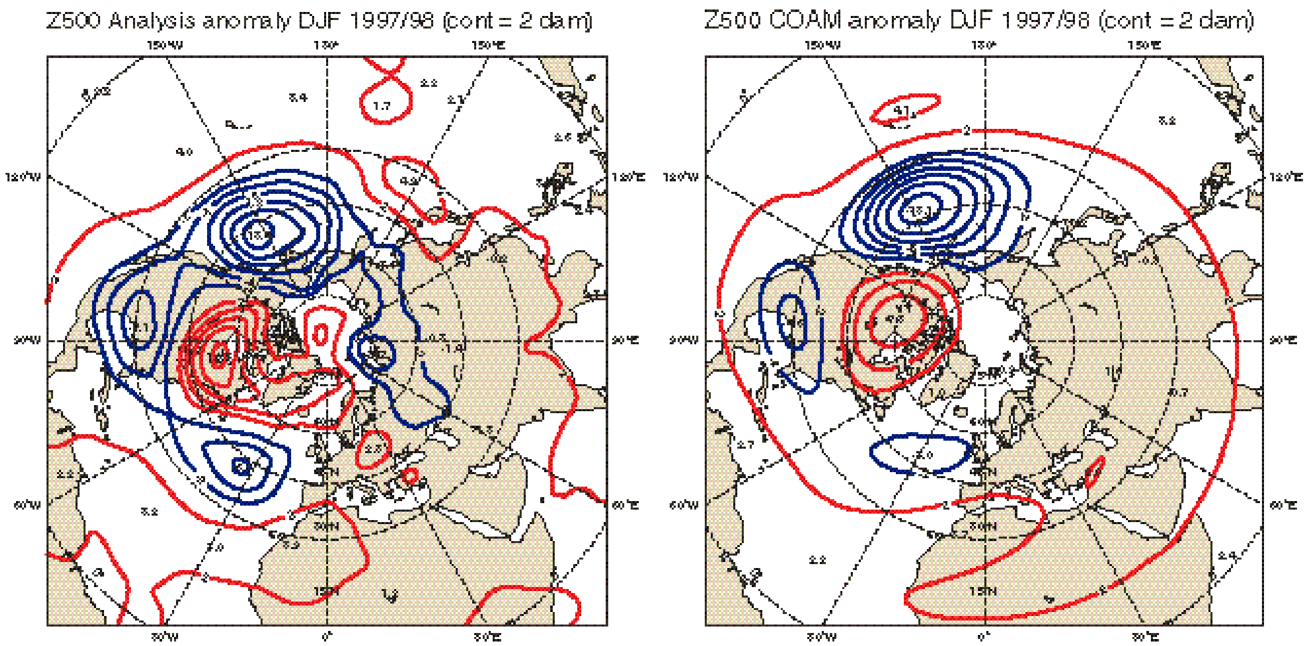


Figure 5: *The anomalous height of the 500 hPa surface for DJF 97/98 from the coupled model prediction from October 1997 (right) and the verifying ECMWF analysis (left).*

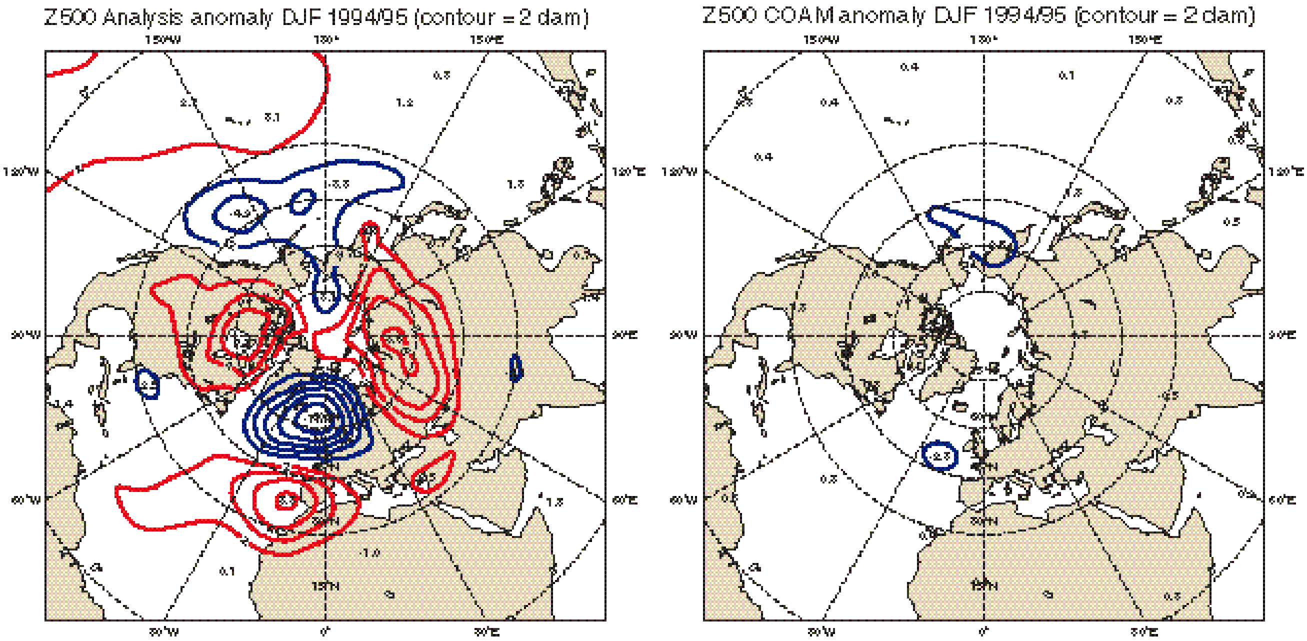


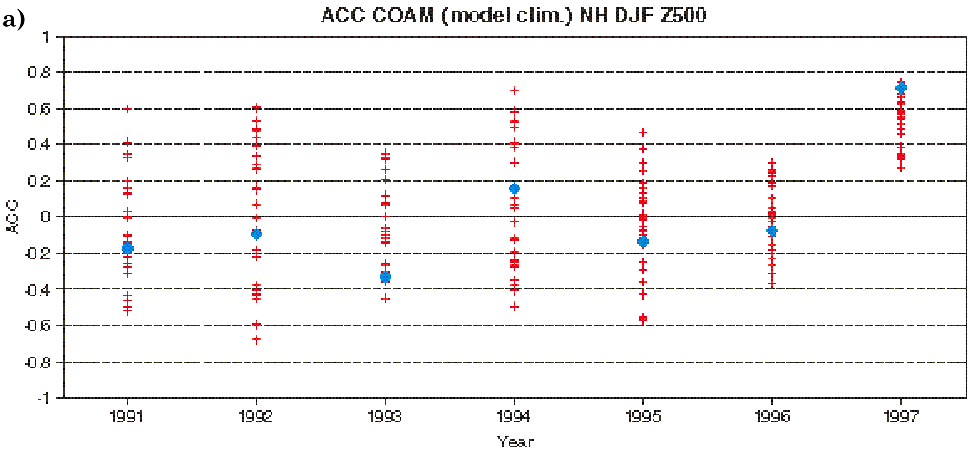
Figure 6: *As for Figure 5 but for 1994/5*

internal spread of the ensembles also suggest that better forecasts should be possible. Two significant causes of forecast error are uncertainty in the ocean initial conditions, and error in the coupled ocean-atmosphere model.

We expect significant errors in the ocean initial conditions in the key region of the equatorial Pacific, and we expect the errors to be worse prior to the mid 1990s. It is only in the last year or two that the equatorial Pacific TAO array has been fully operating and providing good wind and ocean thermal data. (The TAO array consists of approximately 60 buoys anchored to the sea bottom, with instrumentation capable of measuring the ocean thermal structure at 10 levels between the surface and 500 m and transmitting this data to satellite and then onto the GTS. In addition surface winds are measured and transmitted 3 times per day and also put on the GTS.) Our analysis of ocean initial conditions depends not just on in situ ocean data, but also on the forcing given to the ocean by the atmosphere. Variations in the quality of the wind stress and heat and fresh water fluxes provided by the ECMWF operational atmospheric analysis system give cause for concern, and probably also contributed to lower forecast skill in the early to mid 1990s. The 40-year re-analysis project (ERA-40) should give a more consistent set of forcing fields, which will help us produce improved analyses for the 1990s in the future.

One way to assess potential skill is to suppose one had perfect knowledge of the SST, and by making ensembles of integrations of an atmospheric model with prescribed SSTs quantify the extent to which the observed atmospheric response is reproducible. This has been done for the years 1991-1998 using the same version of the atmospheric model as is used in the coupled system. A comparison of individual and ensemble-mean skill scores (500 hPa height anomaly correlation coefficient) for both coupled and uncoupled forecasts is shown in Figure 7, for the northern hemisphere. The ensemble mean skill is shown by the diamonds. It can be seen that the ensemble mean forecast from the uncoupled runs with prescribed SSTs are systematically more skilful than the coupled forecasts (for the latter, only 1997 showed skill). For the uncoupled runs, the anomaly correlation skill scores were positive over the northern hemisphere in 5 out of 6 years, (and positive over Europe in 4 out of 6 years). Figure 7 also shows that there is a large spread in the skill of individual ensemble members, emphasising the effects of chaotic processes in middle latitudes, even for seasonal average quantities. The fact that the ensemble mean skill is higher than that of an individual member in 1997/8 may seem a little surprising at first sight. The observed pattern can be thought of as a combination of a part which results from slowly evolving boundary conditions and a part from chaotic processes. The former is predictable in this model scenario with prescribed SSTs, the latter is not. Averaging over the ensemble will tend to reduce the chaotic part which in general will not correlate well with that observed.

In both the coupled and uncoupled integrations, the systematic error in middle latitudes is large, comparable in magnitude to the interannual signal which one is trying to predict. For example in the European region, the systematic error in the height of the 500 hPa surface is ~ 13 dam, whereas the anomaly for 1997/8 was only 6 dam. Small wonder that the skill over Europe is limited. Preliminary results from a perfect model scenario whereby one member of the ensemble is chosen at random and taken as truth, and against which other ensemble members are then evaluated, shows that skill levels are considerably higher than those currently attained. Such analysis has been done both for the coupled model for the period 1991-1997 and for the PROVOST integrations a)



b)

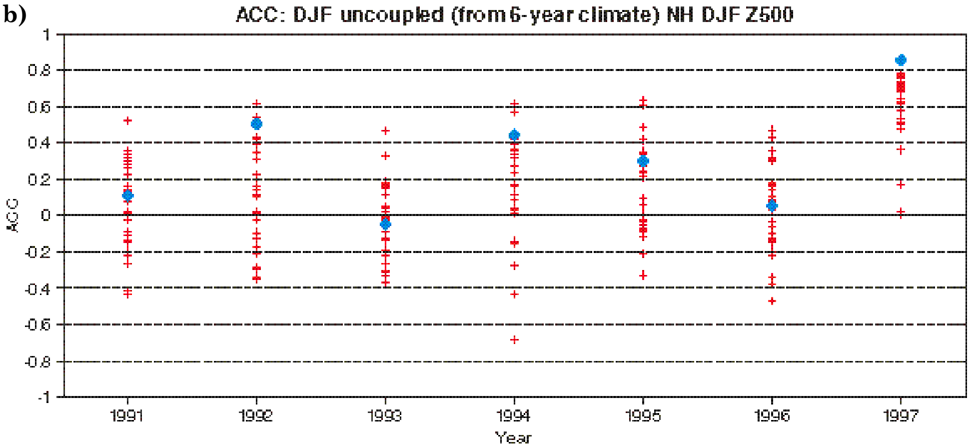


Figure 7:

a) Anomaly correlation of the individual ensemble members for the period 1991-98 (red crosses) and of the ensemble mean (blue diamonds) from the coupled integrations.

b) As a) but using observed SSTs.

using prescribed SSTs covering the period 1979-1993. This highlights the need to reduce systematic error in the model and to improve ocean initial conditions. In the extratropics most of the systematic error in the coupled system comes from the atmospheric model.

Conclusion

The coupled system has performed well in predicting equatorial Pacific sea surface temperatures for the recent El Niño event. There were at least two times when the forecasts were less than perfect. One was for forecasts for May-July of '97 when the model under-predicted the rapid rise in Niño3 SSTs, the other was for forecasts for May-June of '98 when the model under-predicted the rapid decline in Niño3 SSTs. Forecasts for tropical rainfall and temperature have generally been good for the recent El Niño. There is some indication of skill in the extratropics too. However, systematic error in atmospheric model integrations using prescribed SST and in the coupled integrations is large and this undoubtedly degrades any potential skill. Perfect model simulations indicate that the current system is operating considerably below it maximum potential. To improve the system requires a concerted effort to reduce the systematic error much of which originates in the atmospheric model. Improvements in ocean model resolution, physics and initialisation are also needed. This involves improvements to the analyzed fluxes of momentum, heat and fresh water, as well as a more comprehensive ocean observing system and more sophisticated ocean data assimilation schemes. Substantial work is also required to develop appropriate seasonal forecast products. Progress is expected in all of these in the years to come, but an optimal seasonal prediction system is still some way off.

Acknowledgements

The model integrations were partly carried out on a VPP300 machine donated by Fujitsu Limited. This work was supported in part by the European Commission.

The Seasonal Prediction group consists of: J Alves, D Anderson, M Balmaseda, Č Branković, T. Palmer, J Segschneider and T Stockdale.

David Anderson

Member State access to ECMWF's computers - a progress report

Three previous Newsletter articles have discussed why an access system based on smart cards was considered necessary (Newsletter No. 67, pp. 27-33), and then its implementation (Newsletters No. 70, pp. 18/19 & No. 73, pp. 30/31). This article reports on further progress.

During the course of 1994 the Centre successfully conducted a "secure batch trial" to evaluate whether it would be possible to adapt a smart card system to authenticate users in a batch job environment. After approval by the Technical Advisory Committee a proposal for a smart card authentication system was accepted by the Council at the end of 1994 and SecurID smart cards from Security Dynamics were chosen as the method of control.

In 1995 and 1996 various SecurID-card-protected services were introduced and have subsequently been enhanced and extended. Some of these services require special ECMWF software: the ecbatch software package is available to all Member States for all major UNIX platforms.

SecurID cards

Early this year the majority of SecurID cards were renewed, as the first set of cards distributed to the Member States was about to expire. This operation went very smoothly and the Member State Computing Representatives who are responsible for the local administration had only a little extra work to do.

Telnet

The only UNIX server directly reachable from Member States via telnet is 'ecgate1@ecmwf.int'. Telnet to 'ecgate1' is also possible via the Centre's firewall from specific Internet sites. All external access to 'ecgate1' and the firewall is authenticated via SecurID smart cards. From 'ecgate1' batch jobs can be submitted and a remote shell (rsh) invoked to 'ecgate2' and to the Centre's Fujitsu systems without further validation.

Ecbatch/eccmd utility (ecqsub, ecqstat, ecqdel)

The ecbatch/eccmd utility allows Member State users to submit batch jobs from their local systems to ECMWF (the 'ecqsub' function), plus carry out some job management functions (job status, job deletion, etc.).

Requests are authenticated with certificate-based signatures. To generate a certificate, the user will be prompted for his/her ECMWF user identifier and SecurID PASSCODE. The certificate is valid for ecqsub requests for a period of 12 hours from the time of its generation (7 days for ecqdel and ecqstat).

Originally it was necessary for the user to be logged in on a Member State system which has TCP/IP access to ecbatch@ecmwf.int via the leased lines. This restriction has been removed and access is now possible via the Internet both from Member State systems and specific non-Member State sites.

File transfer (ftp, eccopy, ecput, ecget, ecls)

Incoming ftp requests require strong authentication. Thus ecgate1@ecmwf.int now offers a version of ftp which prompts for smart card authentication rather than passwords. Files destined for another ECMWF host have to be transferred to ecgate1@ecmwf.int first, and then copied to the other host or accessed via NFS.

Eccopy provides a means to send files to a remote site from ECMWF without the need for ftp. It was originally only available via the leased lines to Member States. This restriction has also been removed and transfers are now possible via the Internet to Member State systems and specific non-Member State sites.

Ecput, ecget and ecls are further functions of the ecbatch/eccmd utility. They provide file transfer to and from ECMWF, plus file display.

MARS

MARS client software requires ecbatch/eccmd software to be installed because it uses one of the ecbatch/eccmd functions to validate MARS retrievals. The MARS client allows users to submit retrieval requests direct to the MARS system at ECMWF, without the need for batch jobs or interactive sessions at ECMWF.

The Member State user generates a MARS request locally. The MARS client will then obtain a signature from the ecbatch/eccmd software, connect to the MARS server running on an ECMWF host and transmit the signed request. Certificates for signing MARS requests expire after three months, which makes such MARS requests suitable for automated processing within Member States.

The validation of MARS requests from Cooperating Member States happens in the same fashion as for full Member States, but all other ECBATCH functions are disabled.

Future plans

The Centre is planning to extend the file functions of the ecbatch/eccmd utility to interface with ECFS permitting direct file exchange between Member States and the Centre's Data Handling System.

Dieter Niebel

UNIX and Windows NT integration

In any computing environment there will be a mixture of systems and in several installations today, including the European Centre for Medium-Range Weather Forecasts, this mixture includes UNIX and NT based systems. In order to make best use of these systems they need to be able to interoperate. This can be achieved via several different degrees of integration.

Microsoft has become a major force in the world of computing and has effectively defined de facto standards for office automation with packages like Word, PowerPoint, Excel, etc. As more and more documents are created using these packages it is a requirement to be able to work with them effectively, which means having the ability to run such software.

Levels of integration

The levels of possible integration range from the basic to sophisticated with many options in-between.

The most basic level of integration requires that there is a common network protocol available for communication - TCP/IP is available as standard in both NT and UNIX operating systems and is the usual choice.

The next level of integration is minimal application connectivity, as provided by ftp & telnet. These provide basic services such as copying files or getting an interactive session on a UNIX server.

At the other extreme is a highly integrated environment where there is common access to shared resources, including file storage, print services and authentication services. This level of integration is much harder to achieve.

File storage and print service integration

File storage is one of the basic services provided by both UNIX and NT - UNIX systems have used NFS for several years to share files, Windows systems use SMB services which provides similar functions. It is possible to implement SMB services on a UNIX server which allows Windows clients to access UNIX file systems. There are several ways to do this, using either freely available software such as SAMBA, or commercial products like VisionFS, AS9000, TotalNET Advanced Server, etc.

Windows systems can use lpr as a possible way of accessing printers connected to UNIX servers.

Graphical integration

Another area of possible integration is graphical integration - whereby an application running on one computer can display results on the screen of another. This has been possible using the X11 windowing system under UNIX for many years and there are commercial implementations of the X server available for PC/NT clients. This will allow applications running on UNIX machines to display on PC clients, but not the other way round. To be able to run applications on a PC and drive a graphical display on a UNIX machine, extra software on the PC side is required. There are various options for this software, for example Wincenter from NCD. Based on NT Server 3.51, it allows multiple graphical login sessions from remote machines, including UNIX clients, running applications such as Word on the PC but displaying on the remote system.

Microsoft has recently announced the availability of Windows NT4, Terminal Server edition (WTS), which provides the basis for the same kind of graphical integration, but using the NT4 operating system. WTS needs Metaframe software from Citrix and the latest version of Wincenter from NCD to provide integration into a UNIX environment.

Authentication integration

This is one of the hardest parts of integrating NT and UNIX systems as both systems have their own way of managing user accounts, passwords, and trust relationships. Both UNIX and NT can manage users in either networked or standalone style, e.g. UNIX uses NIS, and NT uses domain services to share account information.

As part of the SAMBA project it will be possible in a future release to implement the functionality of a Windows NT Primary Domain Controller on a UNIX server which could then be used to integrate account information. There is also a public domain package available called NISGINA, which allows a Windows NT client to authenticate against a standard UNIX NIS server. On some versions of UNIX (Solaris, Linux) it is possible to use a Primary Domain Controller as the master server for account information, which means that UNIX userids are authenticated against an NT server.

ECMWF's solution

At ECMWF we are using a pair of Wincenter servers to enable UNIX desktop users to access NT based applications, with UNIX home directories accessed through SAMBA. Wincenter authentication uses the standard UNIX NIS maps.

The NT desktop users use the UNIX based application Zmail for reading and composing e-mail, and can access UNIX servers using telnet as well. However, NT desktop users currently have separate passwords for authenticating in each of the UNIX and NT domains.

Stuart Mitchell

Computer User Documentation

Continuing the development of ECMWF's on-line documentation, much of the existing on-line material has now been converted to HTML. All this material is therefore accessible via web-based browsers by all registered ECMWF users. Go to the ECMWF home page (http://www.ecmwf.int) and click on the link "ECMWF help-pages" to enter the system. For Member State users accessing ECMWF via the Internet first click on "Support for ECMWF Member State users".

As well as previously available material, some of the Fujitsu manuals are now available on-line. Click on the appropriate link to see the current contents.

The number of printed ECMWF Computer Bulletins continues to decline. Since the list was last published (ECMWF Newsletter 74) the following Bulletins have been withdrawn: B1.0/2, B1.2/1, B5.2./5, B6.0/1, B8.3/1.

The current list of valid Computer Bulletins is therefore:

0.1/1	ECMWF Computer Division management and personnel list
0.2/3	Computer Security Policy
1.0/5	Passwords and SecurID cards
1.5/1	Advisory and visitor services
1.7/1	Migration from Cray
3.4/2	Integrated electronic mail services
3.4/3	INTERNET
5.2/8	Reference manual for MAGICS*
5.2/9	User's guide for MAGICS*
5.2/10	Pocket guide for MAGICS*
6.7/2	MARS user guide
8.2/1	Supporting incoming/outgoing magnetic tapes at ECMWF

* The three MAGICS manuals will shortly be replaced by one new manual

Andrew Lea

ECMWF Calendar 1998

Sep 7 - 11	Seminar - *Recent developments in numerical methods for atmospheric modelling*	
Sep 28 -30	Scientific Advisory Committee	*27th*
Oct 12 - 14	Technical Advisory Committee	*26th*
Oct 21 - 22	Finance Committee	*60th*
Nov 3 - 4	Policy Advisory Committee	
Nov 2 - 4	Workshop - *Diagnosis of Data Assimilation Systems*	
Nov 9 - 13	Workshop - *WGNE/GCSS/GMPP - Cloud processes in large-scale models*	
Nov 16 - 20	8th Workshop on *The use of Parallel Processors in Meteorology - Towards Teracomputing*	
Dec 2-3	Council	*49th*

ECMWF Publications

Technical Memoranda

No.252 **Morcrette, J-J.**, **S.A. Clough**, **E.J. Mlawer** and **M.J. Iacono**: Impact of a validated radiative transfer scheme, RRTM, on the ECMWF model climate and 10-day forecasts. March 1998

No.253 **Simmons,A.J.**, **A. Untch**, **C. Jakob**, **P. Kållberg** and **P. Undén**: Stratospheric water vapour and tropical tropopause temperatures in ECMWF analyses and multi-year simulations. April 1998

ECMWF Forecast and Verification Charts until the end of June.

Workshop Proceedings

Proceedings of a Workshop held at ECMWF on Orography, 10-12 November 1997.