Paolo D'Ingeo

It is with great sadness that we report the sudden death of Paolo D'Ingeo from a heart valve failure early on 5 September 1997.

Paolo D'Ingeo was born in Messina, Sicily, in November 1938. Having completed his secondary education, he entered the service of the 'Home Office' in 1959, and also began studying at Messina University in the same year. He graduated in Economics and Commerce in 1964. In 1964 he was promoted to a post in the Ministry of Defence, and two years later was again promoted and joined the Treasury Ministry. Immediately prior to joining ECMWF he was a Division Director in the General Inspectorate for the State Budget, Treasury Ministry.

Paolo joined ECMWF on 1 July 1976 as Head of the Finance Section. He held this post, which was enlarged to become the 'Finance and Supplies Section' in 1980, until the time of his death. He also held the post of Deputy Financial Comptroller.

Paolo was a meticulously thorough and conscientious Head of Finance. His relations with his section staff were, however, relaxed and easygoing, and he was a calm and affable colleague. Over the years he oversaw the introduction of more modern and hi-tech accounting and banking methods, and became adept himself in the use of the new technology.

He was, above all, dedicated to his family; his wife Gillian, and his daughter Magda. He was extremely proud of Magda's educational accomplishments, and he had seen her launched on a highly promising career; sadly he will not be able to follow this in years to come.

Our heartfelt sympathy goes out to Gillian and Magda at this tragic time.

In this issue

Cover

Too much rain in El Salvador damages a crop, too little rain in Australia parches the fields. Such climate variability might be predictable on a seasonal timescale - see article on page 2.

[Acknowledgements: Popperfoto (El Salvador); The Age newspaper (Australia)]

Editorial

In 1994 ECMWF's Council approved a three-year project to investigate the feasibility of seasonal forecasting. The project has shown that real-time seasonal forecasts can be produced which have some skill. Experimental forecasts are now being produced three times a week with a coupled atmosphere ocean model. Some results from that project are described in pages 2-8. Information is also available on ECMWF's web site (http://www.ecmwf.int).

Three more ECMWF Technical Memoranda are summarised on pages 9 - 10.

There has been an explosion of interest in, and use of, the Internet in the past few years. The result has been a severe performance problem as the links became overloaded. To alleviate this a pan-European network has been set up connecting national research networks at megabit speeds. It is known as TEN-34 (Trans European Network at 34 Mbps). ECMWF is involved (together with Deutscher Wetterdienst and Météo France) in a project called DAWN to monitor the performance and to demonstrate the value of the new network to advanced applications such as numerical weather prediction. A report on TEN-34 plus DAWN is to be found on pages 10 - 13.

Changes to the Operational Forecasting System

Recent changes

- A number of modifications were made on 27 August 1997, mostly concerning the use of satellite data (model cycle 16r3):

1. a revision of the use of TOVS radiances including the simplification and improvement of bias corrections. SATEM retrievals were replaced by the use of radiances above 100 hPa while HIRS12 were introduced both over sea and land;
2. Some quality control modifications with most impact on the way ERS-2 wind retrievals are handled.

Revisions were also made to the ocean albedo and to the momentum transport representation in the convection scheme. A correction was applied to computations of saturation vapour pressure with effect mainly in very cold conditions.

- On 11 November 1997, a modification was made to allow the assimilation of the new RTOVS format for NOAA-14 radiances (model cycle 18r1). NOAA-11 RTOVS have been assimilated since 1 December.
- On 25 November 1997, the first version of a four-dimensional variational data assimilation system (4D-Var) was introduced. It is based on an evolution of the previous 3D-Var system with a 6-hour cycling. Details will be given in a forthcoming newsletter article.
- A number of changes to the physical parametrization scheme were introduced on 16 December 1997 (model cycle 18r3):

1. a modification in the treatment of the water vapour absorption in the long-wave part of the radiation scheme;
2. a new method of moisture convergence closure;
3. a new treatment in the ice fall-out in the cloud scheme.

Planned changes

- An improved formulation of the two-time-level semi-Langrangian scheme.
- A new, more accurate resolved model orography.
- Coupling of the atmospheric and ocean-wave model.
- Revised initial perturbations for the EPS, to increase spread, particularly in the early part of the forecast range.

François Lalaurette

Seasonal forecasting at ECMWF

In the last few months there have been many reports of anomalous weather conditions in different parts of the globe: the droughts in Northern Australia, Papua New Guinea and Indonesia, the associated smoke pollution in the Malaysian and Indonesian region, hurricanes battering the west coast of Mexico, abundant rain on the coastal plains of South America in places where it hardly ever rains, transforming deserts into blooming meadows. The mighty Yellow river, 'China's Sorrow', has been particularly dry this year while Hong Kong has had record rainfall [(1)].

The effects are not just atmospheric. While the anchovy fishing in northern Peru all but ceased, the game fishing industry off Southern California has had a bumper time, with abundant supplies of tropical fish. Enjoying the warmer than usual water along the west coast of America, voracious mackerel (with a taste for young salmon) are heading north towards the Washington/British Columbian salmon fishing region. The sea level has also been changing. In parts of the west Pacific it has dropped by as much as 40 cms while rising by similar amounts in the equatorial east Pacific. And so the list of climate fluctuations, both atmospheric and oceanic, could go on. Although the weather always seems to be anomalous somewhere, this year seems to be more anomalous than most. Why? What is different this year from last?

The key lies far from our shores, in the vast expanses of the tropical Pacific, where the so-called El Niño has returned with a vengeance equalling and in some respects possibly exceeding the El Niño of 1982/83, which at that time was the most violent El Niño on record. The damage by some estimates was as high as 10 billion pounds with many thousands of people losing their lives in raging torrents or droughts depending on where they happened to live.

There is a tendency to blame any and all unusual weather conditions on El Niño. This is probably not justified. Even without an El Niño there would be weather disasters, but there is little doubt that its effects are almost global. Even here in Europe, half a world away from the source of the climate disaster, there are possibly El Niño effects. Although it becomes hard to ascribe any one disaster to El Niño, over the years, observations and modelling studies including those at ECMWF, have gone some way to clarify potential climate teleconnections.

One conceptual model of weather is that of a series of events which are (for practical purposes) unconnected: the weather next week is essentially independent of the weather this week. An example of such a model is an unbiased coin. If such a coin is tossed several hundred times, one would expect to find short runs of one face or other, say five heads in a row, purely by chance. If the heads are thought of as inactive weather systems, then such a run of heads might correspond to drought conditions. There is no point in seeking a physical cause for such a run. The 'drought' is simply the outcome of a series of chance processes and as such it is unpredictable. But weather patterns may not always be purely stochastic. Suppose the coin were slightly biased. Then a sequence of tosses would still throw up heads and tails in pretty much random ways as before, but a more careful analysis might reveal that there were slightly more heads than tails, which in our simple analogue, would correspond to below average rainfall. Individual weather systems may still be chaotic, but the statistics governing them may be perturbed in a deterministic and predictable way. In middle latitudes where we are living the bias from El Niño is likely to be fairly small, although in extreme events such as now it might be stronger. But closer to the Pacific, the bias will be much stronger to the point where in some cases the coin is heads on almost every toss. In major El Niño years, there might be no rain to speak of for months on end, as happened for example in parts of New Guinea this year.

How much of this year's climate anomalies is predictable is a hot topic of research. There are reasons for believing that some aspects of climate variability might be predictable on the seasonal timescale. Firstly, the lower boundary conditions of the atmosphere such as sea surface temperature (SST) or soil moisture may have a longer memory than the atmosphere and hence be at least partly predictable. Secondly there is a fairly comprehensive ocean observing system now in place in the equatorial Pacific which can measure upper ocean temperatures from the surface to depths of 500m. And finally models of the atmosphere and ocean have improved. To be sure these are still flawed and require extensive further refinement but they are good enough to use in developing a coupled system. Since it is the slower timescale in the ocean that brings predictability, any attempt to predict El Niño, or seasonal changes in general, must involve both atmospheric and oceanic models. So it was that the Council approved a programme in seasonal forecasting about 3 years ago. The group was assembled in July '95 and seasonal prediction development began. Here we present results from the comprehensive coupled atmosphere ocean model we have developed.

The atmosphere model component has a spectral resolution of T63 and a corresponding 1.875 degree grid for physical processes, while vertical resolution is 31 levels. The ocean resolution in the extratropics is about 2 degrees but is increased in the tropics to 0.5 degrees in the latitudinal direction, so as to resolve the equatorial waves which are important for El Niño. The two models are coupled globally and without flux corrections. The atmospheric and land surface initial conditions are taken from the ECMWF operational analysis.

An analysis of the ocean state is made using the forced response of the ocean and assimilating surface temperature analyses and all available sub-surface thermal ocean data. Salinity is currently not analyzed.

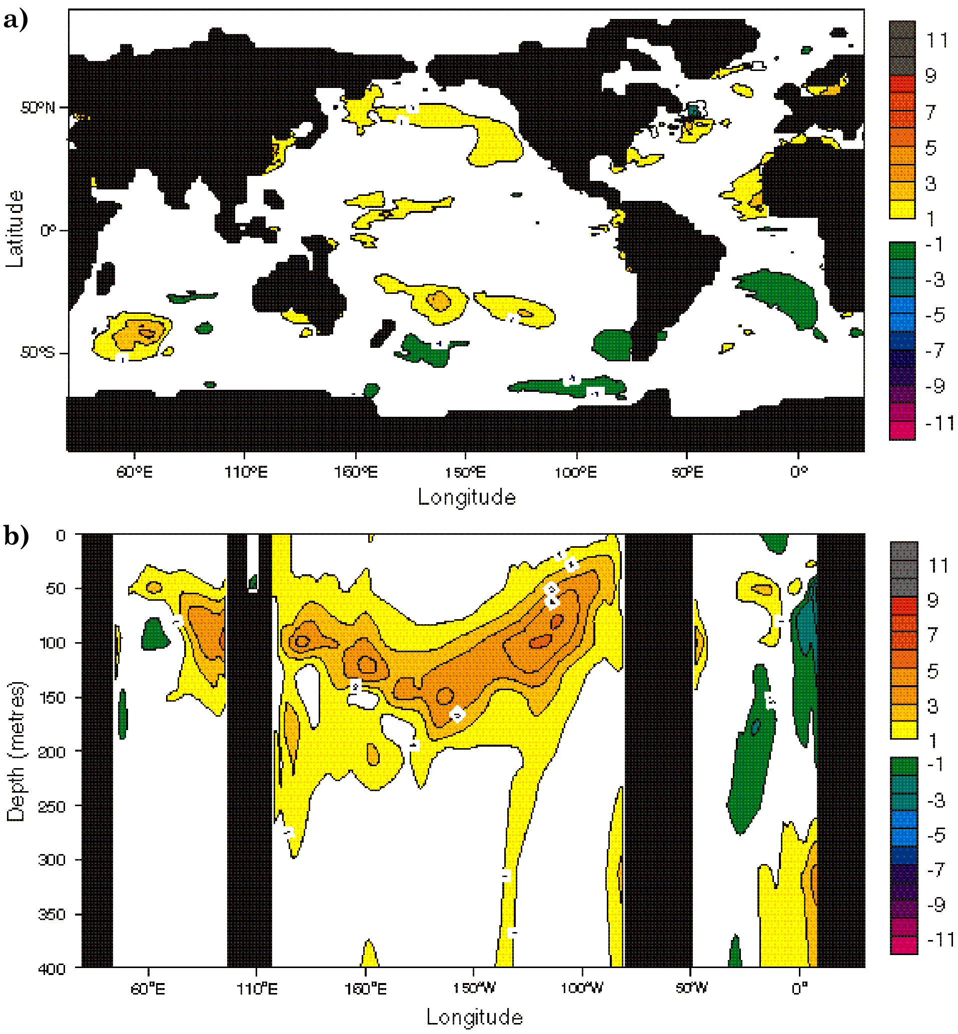

***Fig 1: a)** The Sea Surface Temperature anomaly at the beginning of March 1997. **b)** A vertical section along the equator of the thermal anomaly in the upper ocean. Although panel a shows almost no SST anomaly at this time, there is a sizeable thermal anomaly of up to 5K at about 100m below the surface. The contour interval is 1K in both plots.*

As an example of the results from our ocean analysis, figure 1a) shows the SST anomalies in March 1997 , and figure 1b) a vertical slice along the equator of the upper ocean temperature. Although panel a) shows no significant anomalies in the ocean SST, there were significant changes occurring in the subsurface ocean as seen in panel b). The subsurface anomalies may not alter the SST immediately or locally. Indeed these anomalies may propagate thousands of kilometres before they alter the SST. Nonetheless it is important to carry this subsurface information in a model as it may be the propagation of subsurface anomalies such as these which give the system predictability.

The forecast strategy is to couple directly the two components of atmosphere and ocean and integrate forward from the initial conditions. This inevitably leads to a drift in the climate of the coupled system, due to systematic errors in the component models. Such biases can be corrected for after running a model integration by removing the drift as estimated by a set of forecasts for an earlier period [2]. This drift correction is included in the plots we show later of forecast SST anomalies; it does not affect the evolution of the coupled model itself. Extensive experimentation for the 1980's and especially the '90s shows that our system has useful predictive skill.

The forecasts we present here come from our near-real-time experimental system, where three coupled forecasts are run from each week's ocean analysis. The atmosphere initial data are taken from the day before, the day of and the day after the ocean analysis, in order to create three different sets of initial conditions. Three integrations are used to increase our sampling of the chaotic part of the system, as will be discussed below. The forecasts are performed about two weeks after the nominal start date to allow for ocean data acquisition, and extend six months into the future.

This year is of special interest because of the development of strong El Niño conditions in the Pacific. Figure 2a) shows the observed SST anomalies in December 1996, when a weak cold anomaly was present in the east Pacific. Also shown is the observed anomaly in May 1997, by which time the El Niño warming had appeared (Figure 2b). The forecast anomaly for May, created by averaging the forecasts starting at different days in December, is shown in Figure 2c). This ensemble mean forecast is quite similar to that which was later observed to occur (Figure 2b).

To examine the temporal evolution of our forecasts, we make use of the NINO3 index, the average value of SST in the equatorial east Pacific in the region 5S-5N, 90-150W.

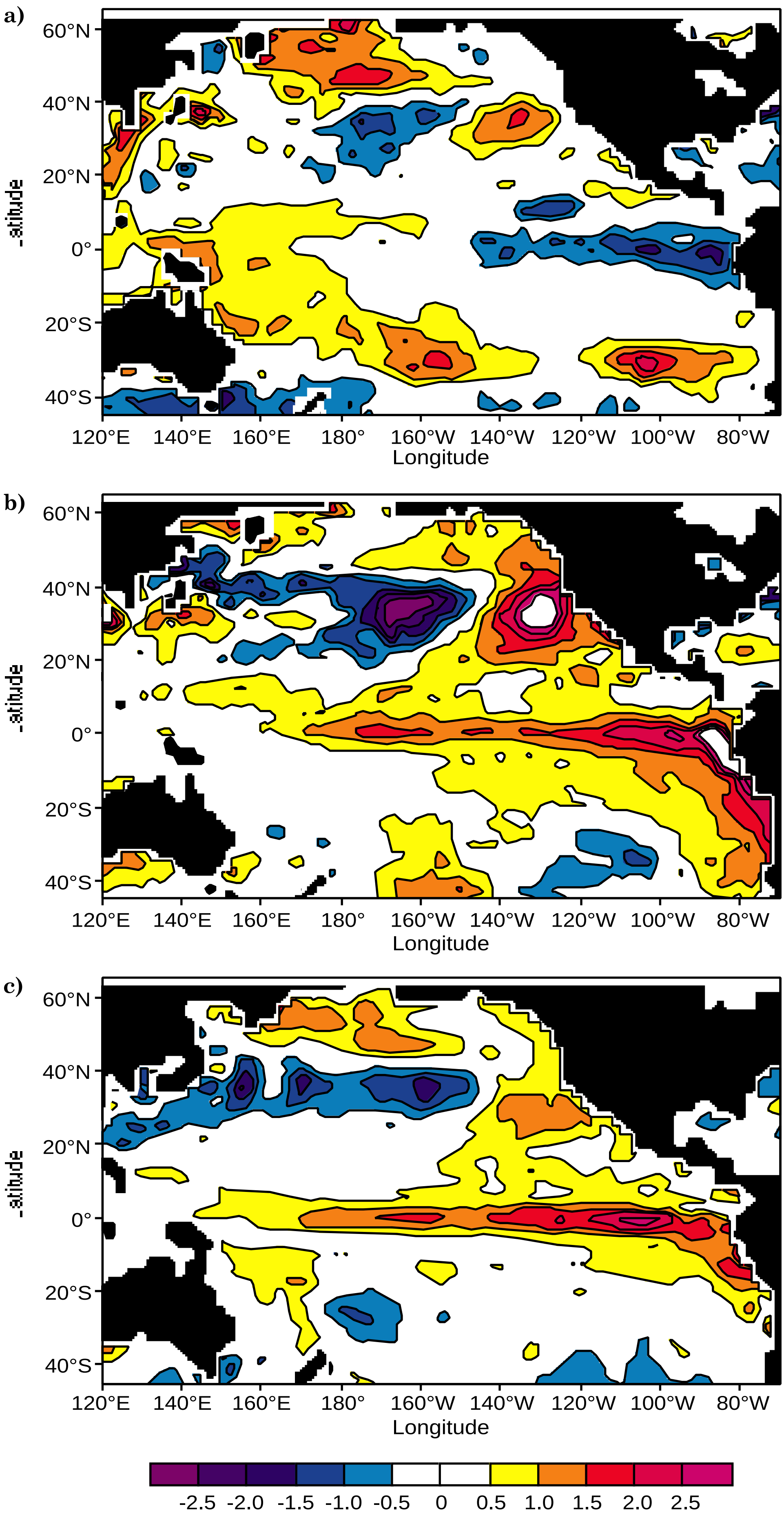

***Fig 2:** Plot of SST anomalies in the Pacific sector. **a)** Observed anomaly in December 1996; **b)** Observed anomaly in May 1997; **c)** Predicted SST anomaly for May 1997 from forecasts initiated during December 1996. Contour interval is 0.5°C. The change in equatorial SST was predicted quite well.*

Figure 3 shows the evolution of the Nino3 anomaly for our 6-month forecasts for start dates in a) November 96, b) February 97 c) May 97 d) August 97. There are typically 12 to 15 forecasts on each plot. The red line shows the observed SST. The forecasts are consistent in indicating the onset of a large El Niño in about May, although the amplitude of the event tends to be underestimated in the longer range of the forecasts. The spread of the forecasts starting in May 97 is larger than for other months and the forecasts from April 97 underpredict the development of the warming. Overall, figs 2 and 3 show that our model has consistently forecast the current warming very well. Although this level of skill should not be expected on all occasions, it is encouraging that the unusual timing of this year's warming has been well captured by our system.

It is clear from Figure 3 that there are appreciable differences between the individual forecasts. One might have hypothesized that these differences are primarily driven by noise in the ocean analyses, but we demonstrate here that atmospheric variability is a major source of the differences. It has long been realised that the atmosphere is highly nonlinear (chaotic) on the timescales of weather and that individual weather events are unpredictable beyond a few days. It is typically assumed, however, that the ocean does not react too much to this high frequency variability but acts as a filter and responds only in some smoother sense. Because of the feedbacks between ocean and atmosphere, different integrations of the coupled system would be expected to show some divergence of SST, but the importance of this for eg six month forecasts has remained unclear. Partly because of computer constraints, the rate of divergence seems never to have been tested with a coupled forecast GCM, although estimates have been made in other ways [3,4].

Extensive experimentation with our coupled system has shown that the rate of divergence, even in the tropical Pacific, can be surprisingly large. We illustrate this in Figure 4, showing three forecasts initiated for 21, 22 and 23 December 1996. The ocean state is the same in all three: only the atmospheric state changes. The plots show the predicted monthly mean temperature anomaly in May 1997. There is a substantial spread in predicted SST between the ensemble members: all show the overall warming, but there are differences of the order of half to 1K over quite large areas. Differences outside the tropics are also large, as expected, although there is some measure of both consistency and skill in the North Pacific.

This variability in tropical SST is a result of chaotic processes mainly of atmospheric origin. It indicates a limit to predictive skill beyond which we cannot go since the differences between panels a), b) and c) arise simply from different synoptic atmospheric events which are unpredictable beyond a few days. There will be other limitations to predictive skill: the model is not perfect, nor are the ocean initial conditions known precisely. With better models and better observing systems, one can anticipate that these latter limitations will be reduced in the years to come though undoubtedly not eliminated. The chaotic nature of the atmosphere imposes, however, a limit beyond which forecasts cannot be improved.

While prediction of tropical SST is a sine qua non, perhaps of greater practical importance is whether we can predict rainfall. Rainfall shows a substantially larger spread between individual forecasts than does SST, and this can make it difficult to establish unambiguously whether an ensemble mean rainfall pattern is meaningfully different from average conditions. By taking sufficiently large ensembles (of order 20), statistical tests can be used to distinguish whether an apparent signal is in fact significant. For this purpose we create an estimate of the climatological rainfall distribution using forecasts for the years 1991 - 96. Preliminary assessments of the rainfall variability within this period show that signals are often present (though rarely strong) in the northern mid-latitudes.

Figure 5 shows the ensemble-mean rainfall anomalies for June/July/August 1997, as predicted by our coupled system from initial dates in March and April. The ensemble has 27 members, and the reference climate is made up of 114 members (19 integrations for each of 6 years, all starting on the 1 April). We only plot the points which are significant at the 99% level.

Several features can be seen in this figure. There is much more signal in the tropics than in higher latitudes, as expected. Nonetheless, there are several substantial features in mid-latitudes, one of the most striking of which is the wet signal over south and central Europe. There are large areas where no signal shows on this plot. Plots with a less stringent cut-off (such as 95% or 90% rather than the 99% used) show much more extensive areas of colour, far beyond what might be expected under the null hypothesis of no signal. This map is therefore a conservative estimate of the regions for which a rainfall prediction might have been made for this year. The large and unusual El Niño of this summer means that this is not a typical level of predictability, however.

Even where there are apparent signals, care must be used in interpreting the map. This figure does not contain any explicit information on the predicted reliability of the signal: the mean anomaly is shown, but not the scatter of the individual ensemble members about it. As an example, a wet signal over south/central Europe is given by more than 80% of the ensemble members, which is a high (but not unanimous) degree of consistency. A dry signal over India is given by only 65 - 70% of ensemble members, and so the confidence in dry weather might be considered lower. The 99% significance level is related to our confidence that the probability distribution for the rainfall is shifted, not to our confidence that the actual realization of the rainfall will have an anomaly of the predicted sign.

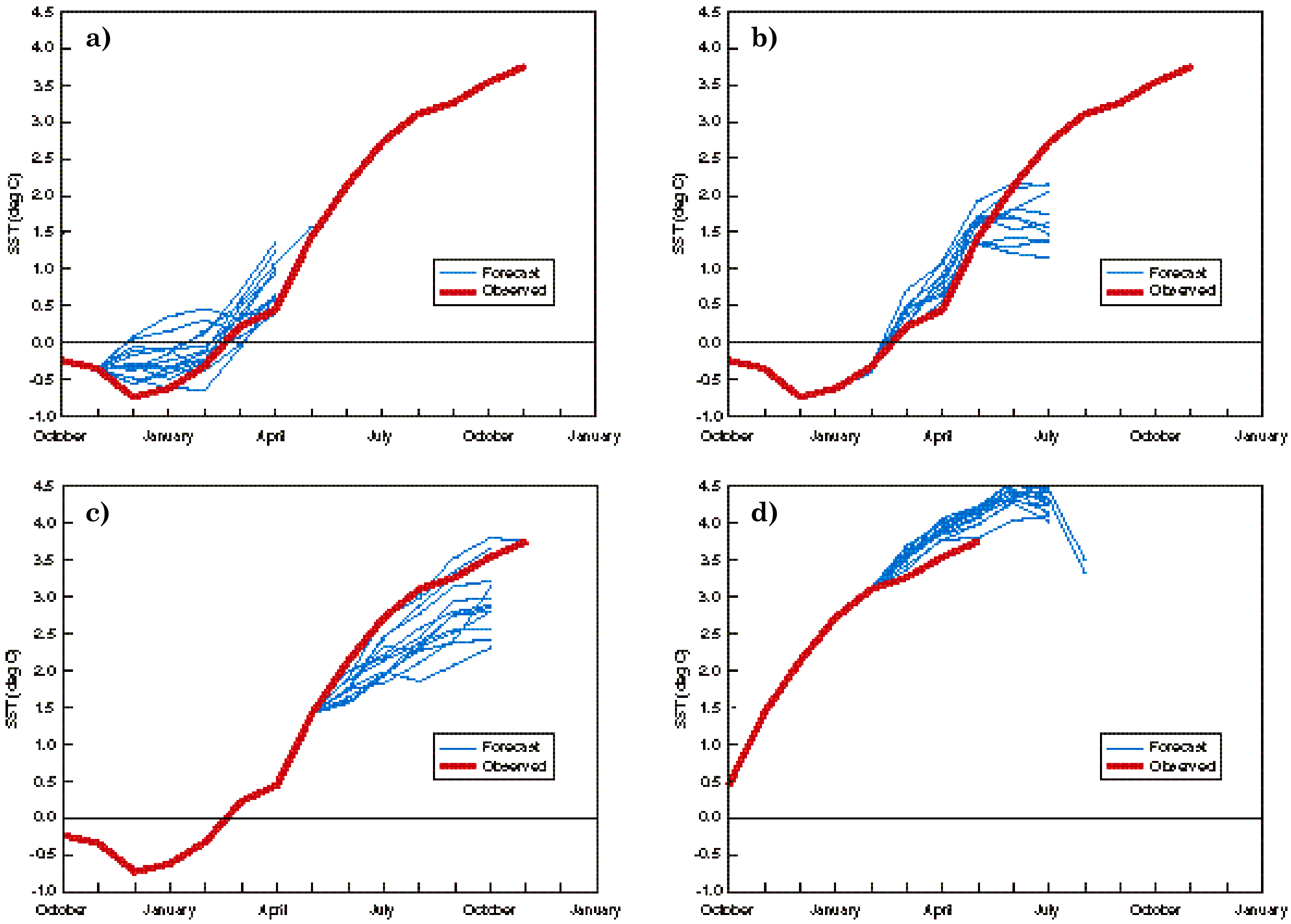

Fig 3: Plume of monthly mean SST anomalies predicted for the Nino3 region for forecasts initiated in ***a)*** *November 96,* ***b)*** *February 97,* ***c)*** *May 97 and* ***d)*** *August 97. Three forecasts are initiated weekly and run for six months. The heavy line shows the observed values.*

Proper verification of probabilistic forecasts will require large ensembles to define the forecast probability distributions, and large numbers of independent forecast periods to test statistically the relationship between forecast probability and actual outcome. This has not yet been done. For any individual case, one can never be sure that a match between forecast and observations is not simply fortuitous. Nonetheless, the strong wet signal over Europe was unprecedented compared to the previous six years of our test forecasts, and highly statistically significant. Although the pattern appears somewhat shifted compared to the observations so far available, we believe it likely that there is a physical connection with the exceptionally wet weather occurring across much of Europe this summer. If true, this means that the wet European summer weather is not in the category of a purely stochastic event, as discussed in the introduction, but rather is due to a predictable cause. Our results were somewhat unexpected but may indicate that closer scrutiny of what influences European climate is warranted.

It is tempting to link the rain with the most visible anomaly in the climate system, namely one of the largest El Niños this century, but this would be premature as there are other sources of predictability in the climate system whose importance we have yet to assess. In a system as non-linear as the earth's climate, it may often be a combination of factors which produce any given outcome. Nonetheless, the present El Niño is undoubtedly a large perturbation to the global circulation, and is likely to be a significant factor in many of the anomalies seen worldwide in recent months. Empirical studies show evidence of links between some aspects of European weather and El Niño and other factors, but correlations are relatively low [5,6]. More recent studies suggest that a clearer picture might emerge as more refined ways of analyzing the data are pursued [7]. Dynamical methods offer the best long term hope for making seasonal forecasts because of their greater generality and precision: that is, because of their ability to handle unprecedented situations and to treat non-linear combinations of factors which cannot be extracted empirically from the short observational records available to us. Although the current level of model error reduces significantly the reliability of the forecasts, our results suggest that useful model-based seasonal forecasting is possible. Future improvements in models and their initialization should increase the reliability and usefulness of such forecasts in the years to come.

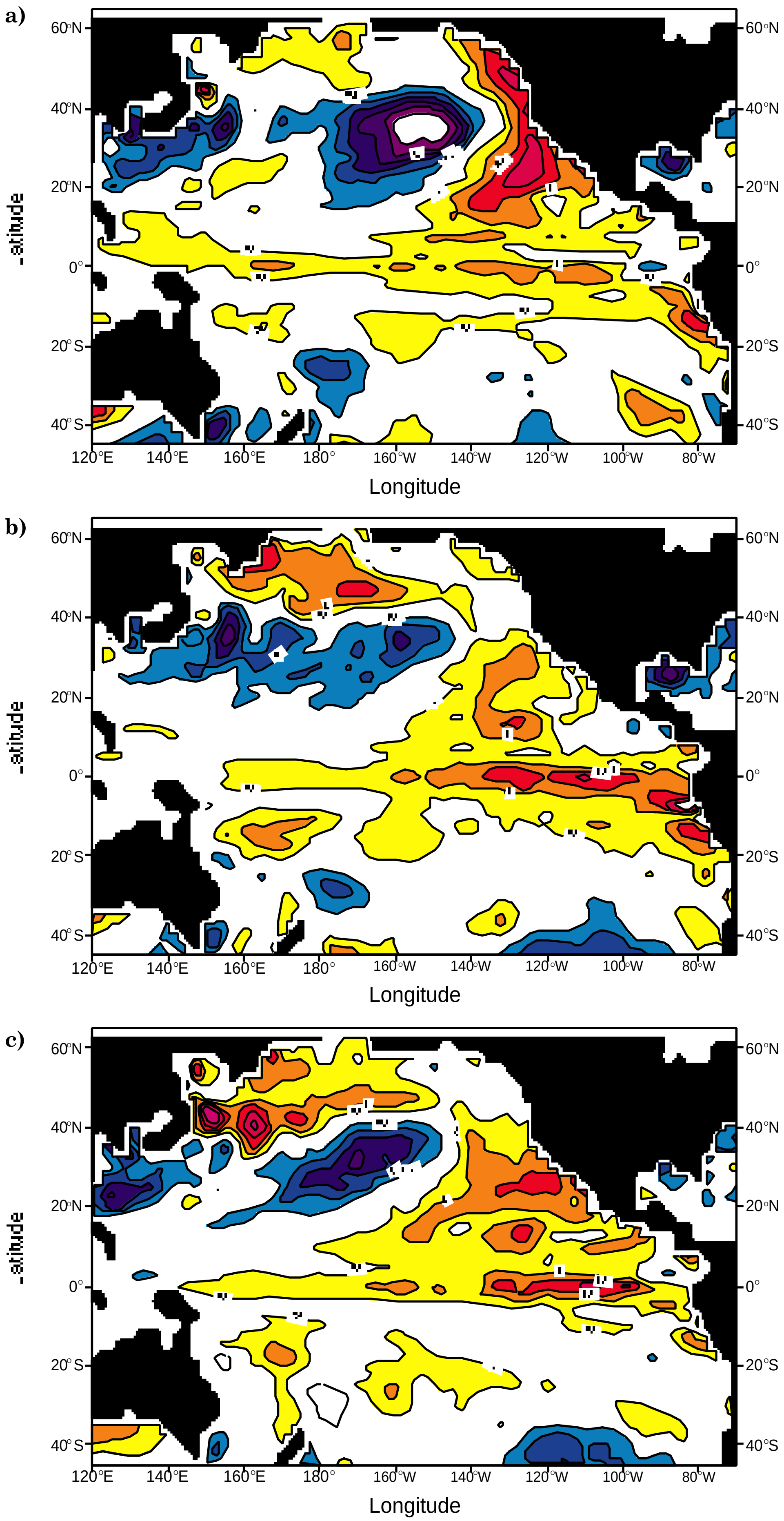

***Fig 4:** Predicted SST anomalies for May 1997, from forecasts with atmo - sphere initial conditions from: a) 21st December, b) 22nd December and c) 23rd December . Contour interval is 0.5 °C. Despite the identical ocean initial conditions there are significant differences between the plots showing the influence of differences in atmospheric initial conditions. None-the-less all show the same basic El Niño development.*

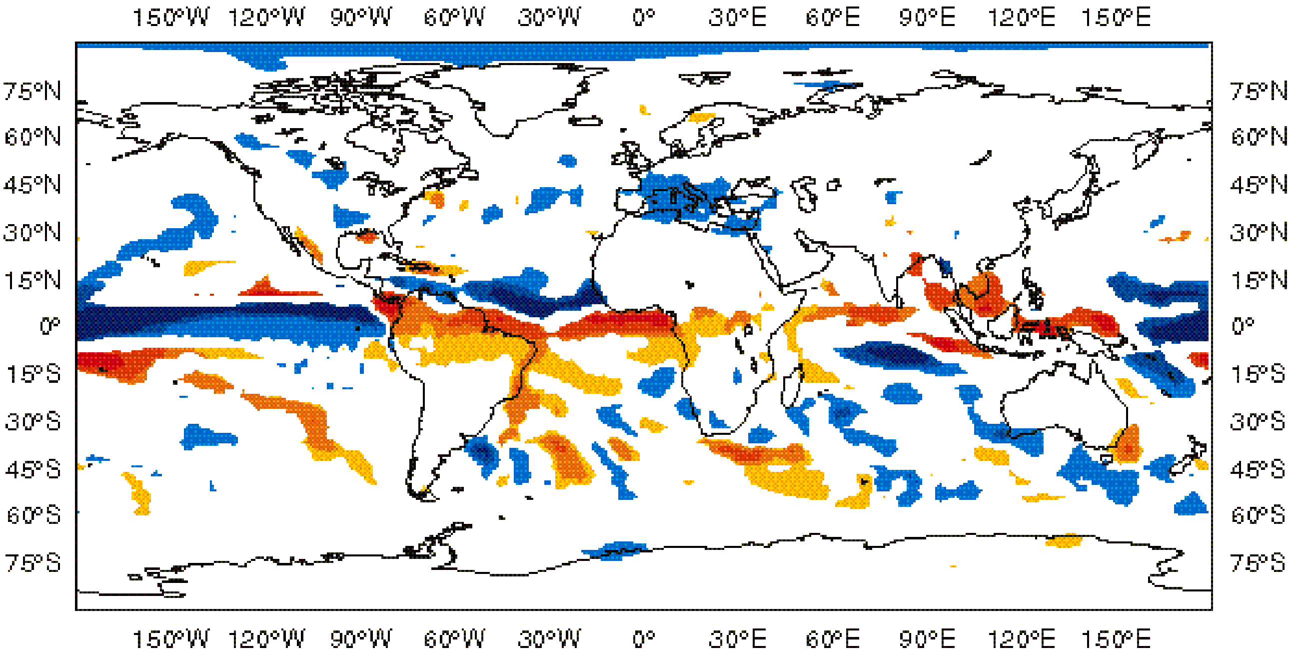

Fig 5: Rainfall anomalies for JJA from forecasts initiated in March and April. Only statistically significant (>99%) anomalies are shown. Particularly unusual is the significant anomaly over south/central Europe.

To the man in the street, some of this might seem somewhat remote. What he wants to know as he sits on a gloomy February night planning his fortnight's summer holiday, is whether the weather will be better in July than in August, in Greece than in Spain, in Snowdonia than in the Cullins. That we can not tell him. To be sure our models are still very far from perfect. With time the models will improve and the forecasts will get better, but we will still not be able to tell him. The reality is that we live in a turbulent world. The chaotic nature of that world means that detailed forecasts for a specific region for a short period in time are not possible. We should be able to give him a measure of the probability of above or below average rain for a season, however. The sophisticated holidaymaker could learn how to use these forecasts to increase the odds of a good choice and if he took enough holidays based on our forecasts then he should do better than random guessing.

The travel industry might be one sector of the economy which could use seasonal forecasts. There are other potential beneficiaries, but at present the user community is still ill-defined. Further development within for example the agricultural or power sector of the economy is needed in order to exploit the information in probability forecasts of seasonal evolution. One could look to the future where the coupled atmospheric-oceanic model is at the core of a sophisticated system, driving in turn models of crop yield, aquaculture or power demand and supply.

Information on seasonal prediction, including forecasts, is now available on the ECMWF web site.

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Acknowledgements

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The Seasonal Prediction group consists of:

D. Anderson, T. Stockdale, J. Alves, M. Balmaseda and J. Segschneider

Summary of ECMWF Technical Memorandum 226

Stability of a two-time-level semi-implicit integration scheme for gravity-wave motion

A.J. Simmons and C. Temperton

A study is made of the computational stability of semi-implicit treatments of gravity-wave motion suitable for use with two-time-level advection schemes. The analysis is for horizontally uniform reference values of temperature and surface pressure, and for hybrid pressure-based vertical coordinates. Stability requires use of reference temperatures that are warmer than those that can be used safely with the corresponding three-time-level scheme. The reference surface pressure should also be higher. When stable, the two-time-level scheme is damping, although the largest scales are damped less than by the three-time-level scheme if the latter uses a typical time-filtering. The first-order decentred averaging of gravity-wave tendencies used in a number of semi-Lagrangian models reduces the need for a relatively warm reference temperature profile, but causes a quite substantial damping of otherwise well-represented low-wavenumber modes. The low-wavenumber damping can be avoided by using an alternative, second-order averaging involving a third (past) time-level. For this alternative averaging, an economical spatial discretization is proposed that requires no additional departure point. Phase speeds show little sensitivity to these changes in formulation. All variants of the semi-implicit method substantially reduce the phase speeds of the fastest high-wavenumber modes when use is made of the large time-steps possible with semi-Lagrangian advection.

[Published in Monthly Weather Review 125 (1997), 600-615]

Summary of ECMWF Technical Memorandum 228

Note on the sea state dependence of the ocean surface albedo

Peter Janssen, Bernd Becker and Jean-Jacques Morcrette

There are several ways in which the sea state may play a role in the specification of the weather parameters over the oceans. For example, ocean waves extract momentum from the air flow and thus the momentum transfer depends on the steepness of the ocean waves. This sea-state dependent momentum transfer has impact on the atmospheric climate (Janssen and Viterbo,1996; Janssen, 1994), in particular on parameters such as the wind speed, surface pressure and wave height.

The sea state may also have impact on the ocean surface albedo. Essentially, the steeper the (short) ocean waves are, the rougher the ocean surface appears for the incoming sunlight and therefore the ocean surface albedo gets reduced. This effect was already discussed in a by now classic paper of Cox and Munk (1954) who were able to infer the roughness of the sea surface from photographs of the sun's glitter. In order to do so, Cox and Munk established a theoretical relationship between the surface roughness and the ocean surface albedo, where it was assumed that the probability distribution of the wave slope was Gaussian. It turns out that for normal incidence of the sun rays there is no impact of the sea state on the albedo while for grazing angle there is a considerable reduction of the ocean surface albedo by a factor of two or even more. Under the latter conditions shadowing by the crests of the waves also plays an important role and Saunders (1967) studied this difficult aspect of the reflection of sunlight by a rough ocean surface.

In the present Technical Memorandum we discuss possible consequences of a sea-state dependent ocean surface albedo on simulations of the climate of an atmospheric model. Based on the above-mentioned results of Cox and Munk and Saunders we developed for the two dimensional case (hence sunlight and ocean waves propagate in the same plane) an efficient algorithm that relates the ocean surface albedo and the roughness of ocean waves. Results from a one year simulation of the atmospheric climate by means of cy13r1 of ECMWF's atmospheric model with a sea state dependent albedo show a small impact on the radiation budget and a modest impact on the net heat flux (10 Wm^{-2}) in areas in the Northern Hemisphere whether the net heat flux is between 10 and 30 Wm^{-2}. As expected, no impact was found on the mean scores of a number ten day forecasts.

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Summary of ECMWF Technical Memorandum 231

The Viers-1 scatterometer model

PAEM Janssen, H Wallbrink, CJ Calkoen, D van Halsema, WA Oost and P Snoeij

In 1985 a group of four Dutch institutes, combining expertise in radar technology, water waves and meteorology, submitted a proposal to the Netherlands Remote Sensing Board for a systematic study of radar backscatter from the water surface. The study was aimed at the development of a physically based algorithm for the relationship between radar backscatter and the surface wind and would consist of laboratory experiments, experiments at sea from a fixed platform and theoretical studies of the relevant processes. The impetus for the proposal came from the expectation that in a few years time the ERS-1 satellite would be launched with, in its AMI package, a C-band scatterometer intended for the measurement of the wind speed and direction at sea from space. The project, which was approved and supported by the Board, therefore received the name Viers-1 for Verification and Interpretation of ERS-1. It lasted from 1987 until 1994 and has now indeed resulted in the physically based algorithm for which the project was started.

The first experiments in Viers-1 were conducted in 1987 in a large wind wave flume (length 100m), where especially the two dimensional distribution of the small wind waves (which are mainly responsible for the radar backscatter), and the radar directional effects of this distribution were studied. An even larger wave tank (length 213m) was transformed into a wind-wave flume in 1989 to study the effects of long waves on the short ones. In 1990 a final experiment was performed at Meetpost Noordwijk, a research platform 9 km off the Dutch coast, to obtain field data with which to check the model.

The development of that model meanwhile had started and a computer program was written, based on state-of-the-art knowledge of radar backscatter, wave modelling and air-sea interaction. Initially a model was made that calculated the radar backscatter under given conditions of wind and sea; later the model was inverted to obtain the wind from the radar backscatter. For operational purposes the model was coupled to the WAM wave model.

The crucial test for Viers-1 was a comparison of the algorithm with the CMOD4 model, which is mainly based on statistical fitting, using operational data. In this comparison it turned out that the results of Viers-1 were comparable with those of CMOD4, with Viers-1 outperforming CMOD4 slightly at both low and high wind speeds, but with CMOD4 providing a somewhat closer fit in backscatter space. This may be interpreted as an appreciable success for Viers-1: the model is the first of its kind and still has many possibilities for further improvement, whereas CMOD4 is probably the ultimate that can be obtained with a purely statistical approach.

TEN-34 and DAWN

TEN-34 (Trans European Network at 34 Mbps)

TEN-34 is the first Europe-wide high speed computer network for the research community. The TEN-34 Project consists of two elements: firstly, a pan-European 34 Mbps backbone network based on IP technology. The IP service in TEN-34 is supported by a mixture of high speed (up to 34 Mbps) leased lines and ATM Virtual Paths which are used as leased lines. Secondly, TEN-34 works with the JAMES project. This is a collaboration of European telecom operators who have established an experimental European ATM network, to trial ATM technology in a pan-European context. ATM (Asynchronous Transfer Mode) is a connection-oriented network technology, based on cell switching. ATM offers the possibility of flexible bandwidth assignment which is important for real-time multimedia applications.

The TEN-34 network consists of two subnets. The first is an IP service between the Unisource home countries Sweden, Netherlands, Switzerland and Spain, with Belgium sharing the Netherlands access point via a separate link to Amsterdam. Unisource also connects to the UK and Germany. The second subnet is a data transmission service based on ATM, which interconnects France, Germany, Italy, the UK, Luxembourg, Switzerland, Austria, Hungary and Greece. Connections to the Czech Republic and Slovenia are planned for later. The two subnetworks are connected at three points: London, Geneva and Frankfurt. Users get access to the TEN-34 network via their national research network. The current topology of the network is shown in figure 1, together with the line speeds (Mbps).

DAWN (Distributed Applications over Wide Area Networks)

Within Europe, there is a large research community working on the improvement of weather forecasts. These researchers are located at various national weather services, at universities, at research institutes throughout Europe, and at the European Centre for Medium-Range Weather Forecasts (ECMWF). There is a widespread willingness for collaborative efforts between these researchers leading to a strong requirement for

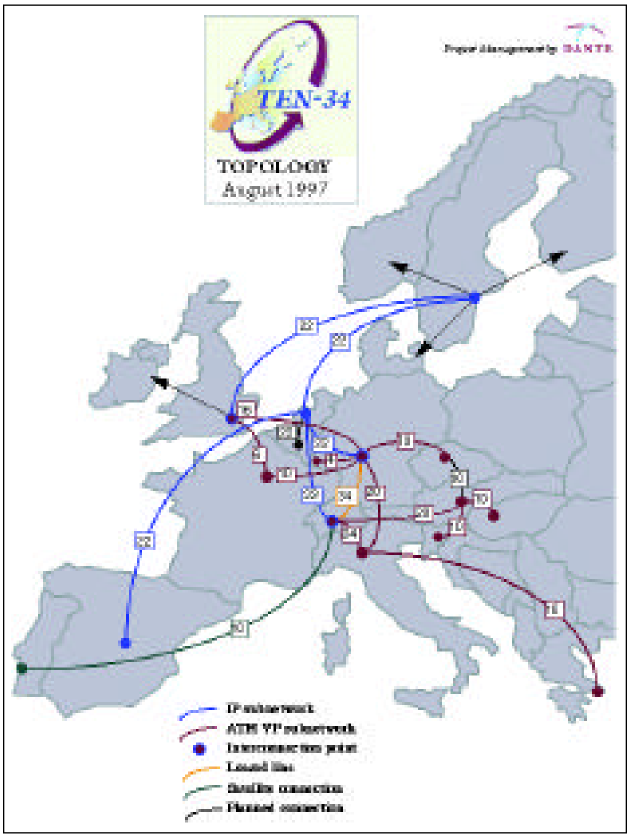

Fig 1: *The current topology of the network, together with the line speeds in Mbps.*

intercommunication. However, many of these potential collaborations are data intensive and cannot be supported by the currently available research networks.

TEN-34 is expected to provide a communication infrastructure which will allow a number of desired collaborative data intensive research activities to be carried out in an effective manner. There are several projects to monitor the TEN-34 network performance for advanced applications and to demonstrate the value of the new network. One of these is DAWN.

DAWN will study the impact of the TEN-34 network on advanced research applications within the weather forecasting community. The three partners of the project, the national weather services of France (METEO-FRANCE) and Germany (DWD), together with ECMWF, will study, develop and test the following applications: a Distributed Model Suite, Coupled Atmosphere/Ocean Models and the Modeller's Workbench.

The **Distributed Model Suite** will be used for the prediction of the spread of air pollutants. The necessary model framework will be developed outside of this project by a group of researchers located at DWD, the University of Stuttgart, the University of Cologne and the University of Karlsruhe. At this stage, DWD does not have the computing resources required to proceed with the development of the above model. However, DWD has an allocation of suitable resources at ECMWF. The availability of a high-speed connection between DWD and ECMWF allows the ECMWF resources to be integrated into the Distributed Model Suite, thus enabling the timely development of the air pollution model.

Coupled Atmosphere/Ocean Models are used for seasonal forecasting activities. To obtain a better understanding of the errors in coupled atmosphere/ocean models, it is desirable to evaluate, for example, a particular atmospheric model with a variety of ocean models. However, this typically requires the porting of the ocean model codes. Coupling models via suitable high-speed links allows such scientific evaluations to be performed avoiding the often substantial migration efforts.

The **Modeller's Workbench** is an integrated set of tools allowing researchers to access local and remote resources such as supercomputers and unique data archives, independent of their geographical location. The tools and interfaces of the Modeller's Workbench should present a uniform, seamless environment to the meteorologist, thus allowing him to use networked resources to accomplish computational research without the traditional overhead of having to learn the details of remote applications and system configurations. A number of the required components already exist; however, since international network connections in the past could not support the quantities of model input/output data to be moved, many interactive user interfaces were not designed for use over wide-area network links. With the introduction of the 34 Mbps backbone, a number of tools so far limited to local use can now be offered over the wide-area network.

Networking requirements & performance measurements

The selected DAWN applications have a diverse set of networking requirements, therefore validating different aspects of the TEN-34 network. The Distributed Model Suite moves bulk data between participating partners, requiring a high average bandwidth over a period of a few hours but posing no significant latency requirements. The Coupled Atmosphere/Ocean Models exchange bursts of data; here the latency of the data exchange is the critical factor. The Modeller's Workbench is an interactive application; the network must be able to support the chosen graphical user interfaces efficiently as well as the bulk transfer of the model input/output data.

The network performance will be monitored using two different methods:

a) For each application, a set of requirements specifying the average network bandwidth, acceptable variance of the bandwidth, message latency, etc. will be defined. Actual network performance will then be assessed against these parameters through the use of simple test programs simulating a load typical for the relevant application. Performance data will be compiled based on samples run at periods of the day appropriate for the anticipated use of the applications.

b) For each application, network performance will also be measured in a more subjective manner: research users will provide feedback on the usability of the implemented applications. This will establish whether the observed network performance matches users' requirements and expectations.

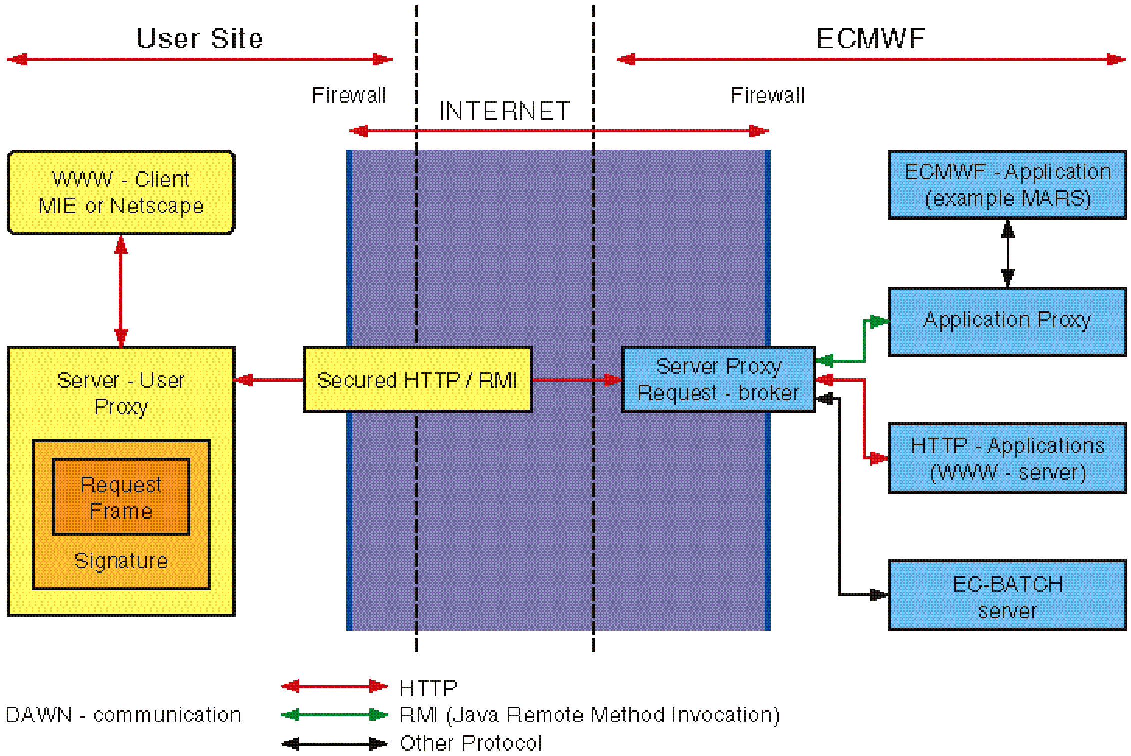

Fig 2: The basic structure of the communication of the emote site and ECMWF systems that will be used in Phase 1.

During the project, the requirement figures used for the tests in a) will be refined and adjusted according to user experiences from work with application prototypes.

ECMWF's initial activities

ECMWF will implement the first part of a Modeller's Workbench in Phase 1 and expand it to full functionality in Phase 2.

To provide a service for external Member State users via the Internet, whereby they can use resources of ECMWF without direct access to internal machines of the Centre, the service has to be made secure. Thus the first priority will be to address the security issues of applications run over public wide area networks. This requires the design and implementation of a security layer as a first step. The design and implementation of this security layer will include:

- prevention of direct routing into the Internet network
- authentication checking
- identification verification

To test the security layer an ECMWF-MARS service will be implemented as part of the Modeller's Workbench. In addition, two aspects of performance can be tested by providing an interactive MARS interface for external users. The interactive part (selection of the requested data) requires short response times, while the second part transfers a large amount of data but with no critical response time.

Figure 2 shows the basic structure of the communication of the remote site and ECMWF systems that will be used in Phase 1.

To guarantee widespread portability, it has been agreed to implement the main components at ECMWF using the programming language JAVA. There are also some security issues which make JAVA the preferred language for the project.

First results

Monitoring the TEN-34 network to METEO-FRANCE and DWD shows the network is already capable of delivering the following performance:

Round Trip Time (RTT)

The first test suite measured the Round Trip Time to a destination host on each partner site. These tests produced an indication of the reliability and latency of the connection. Message latency is defined as the time to respond to a request e.g. how soon a character is displayed after the keystroke has been made.

The results so far are (average times):

ECMWF <-> METEO-FRANCE	60 ms
ECMWF <-> DWD	30 ms

Throughput tests

The second test suite measured various aspects of network performance, such as:

(i) the quality of the network.

(ii) request/response time using a range of parameters, e.g. the sizes of the send and receive buffers, the message size

(iii) bulk data transfer throughput using various protocols.

Here the results are:

Buffer size	Average throughput between ECMWF and: METEO-FRANCE	DWD
64 byte	6.0 kbits/s	12 kbits/s
8 kbytes	600 kbits/s	800 kbits/s
64 kbytes	980 kbits/s	5800 kbits/s

These results have to be seen in relation to the connection speeds between each site and TEN-34, which are: ECMWF – 8 Mbits/s, METEO-FRANCE – 2 Mbits/s and DWD – 34 Mbits/s.

Later, the lost packet rate and the route to the destination will be monitored.

Overall, the first results indicate the network is good enough to run the advanced applications. However, further observations are needed to show if the network is stable enough to provide the required quality of service over a prolonged period.

Heinz Richter

ECMWF Calendar 1998

Feb 26 - 27	TAC Subgroup on RMDCN		
Feb 23 - 6 Mar	**Computer User Training Course**		
23 - 25 Feb	**COM1** - *Introduction for new users*		
25 - 27 Feb	**COM2** - *Fujitsu optimisation*		
2 Mar	**COM3** - *MARS*		
3 - 6 Mar	**COM4** - *Graphics*		
Mar 16 - 12 Jun	**Meteorological Training Course**		
16 - 24 Mar	**MET1**	*Numerical methods, adiabatic formulation*	
24 Mar - 3 Apr	**MET2**	*Data assimilation & use of satellite data*	
20 - 24 Apr	**MET3**	*General circulation, systematic model errors and predictability*	
27 Apr - 8 May	**MET4**	*Parametrization of diabatic processes*	
11 - 21 May, [2 - 12 Jun] *	**MET5**	*Use & interpretation of ECMWF products*	
May 6 - 7	Policy Advisory Committee		*9th*
May 11 - 12	Security Representatives meeting		

* two sessions if required

May 18 - 19	Finance Committee	*59th*
Jun 29 - 2 Jul	Workshop - *Modelling and data assimilation for land-surface processes*	
Jun 15 - 16	Expert meeting on EPS	
Jun 17 - 18	Seasonal Forecasting Users meeting	
Jun 23 - 24	Council	*48th*
Sep 7 - 11	Seminar - *Recent developments in numerical methods for atmospheric modelling*	
Sep 28 -30	Scientific Advisory Committee	*27th*
Oct 7 - 9	Technical Advisory Committee	*26th*
Oct 13 - 14	Finance Committee	*60th*
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	Workshop - *Parallel Processors*	
Dec 2-3	Council	*49th*