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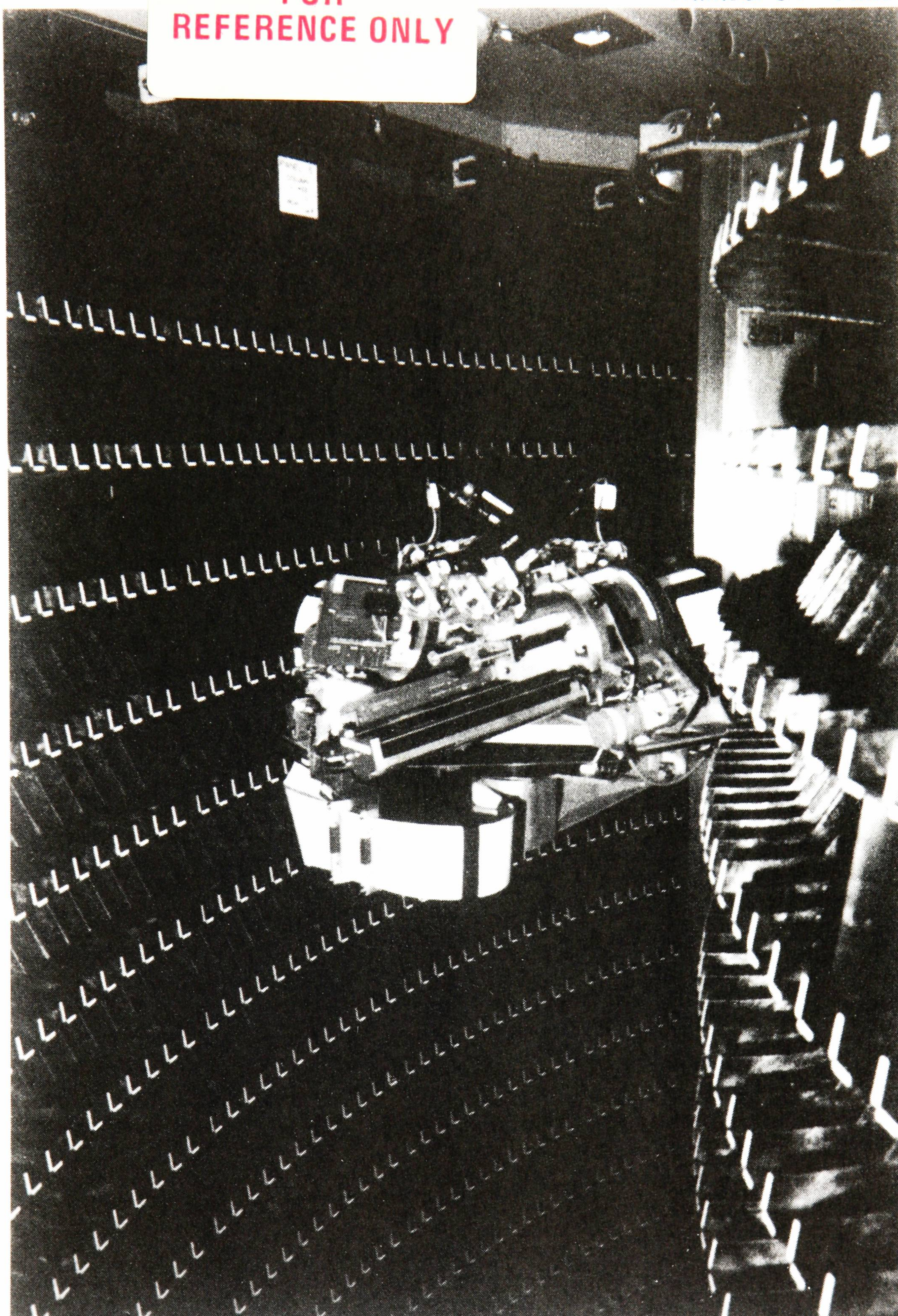

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European Centre for Medium-Range Weather Forecasts
Europäisches Zentrum für mittelfristige Wettervorhersage
Centre européen pour les prévisions météorologiques à moyen terme

IN THIS ISSUE

COVER: Inside the StorageTek silo: the robotic arm (including a camera for reading bar-code and selection) extracts the required cartridge and places it in the read/write unit (see article on page 26)

This Newsletter is edited and produced by User Support.

The next issue will appear in September 1991.

The articles in this issue cover a wide range of the Centre's technical installations and activities, comprising status reports on the ECNET telecommunication system and the internal ECMWF networks.

The newly-installed StorageTek robots, which form an automated cartridge retrieval and loading system, are described (see photo on front cover).

On the meteorological side, the Centre's involvement in the ERS-1 mission is reflected in an article on the satellite to be launched this year.

The model performance in predicting over Europe the 2m temperature and the cloud cover is assessed in an article on the verification of these parameters. The impact of recent model changes is discussed.

This issue also contains advance notice of the third workshop on Meteorological Operations Systems to be held in November this year.

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CHANGES TO THE OPERATIONAL FORECASTING SYSTEM

Recent changes

On 9 April 1991 the following modifications were implemented in the forecast model:

* modifications to the cloud and radiation subroutines, both to improve the cloud/radiation processes and to facilitate their use with increased vertical resolution. In particular, the over-lapping of cloud layers was changed from a random overlap to a maximum overlap assumption;

* a revised scheme for vertical diffusion in the free atmosphere, developed following the switching off of vertical diffusion above the PBL in 1988; the vertical mixing represented by the revised scheme is smaller by an order of magnitude than under the scheme which was operational until 1987;

* two revisions to the convection scheme, to ensure consistent cloud physics within the cloud model, and to introduce a cloudtop temperature check to improve the onset determination of shower precipitation.

(See article on page 3 concerning the impact of this change).

On 1 May 1991, a new procedure for the quality control of satellite temperature profiles was implemented; a preselection of the data to be passed to the analysis is made, using the high resolution cloud-cleared radiances received from NESDIS.

Planned changes

The first-guess checks of wind and humidity observations will be enhanced.

It is planned to implement a model with a substantially higher resolution, probably T213 31 levels, in the course of the next three months.

\- Bernard Strauss

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RECENT VERIFICATION OF 2m TEMPERATURE AND CLOUD COVER OVER EUROPE

Introduction

During the last few years, the use of direct model output of 2m temperature and cloud cover has increased in many Member States (cf Report on Application and Verification of ECMWF Products for 1990). At the same time, statistical adaptation is being widely used to improve the quality of the products, either by traditional perfect-prog or MOS technique, or by more efficient adaptive filtering techniques, such as Kalman filtering.

In the past year, several changes to the ECMWF model physics have been introduced which have a significant impact on the prediction of these parameters. These include:

* modified convection scheme and snow albedo under vegetation, on 16 May 1990,

* modified sea surface fluxes, with a major impact on evaporation, on 5 June 1990,

* new mean annual albedo, modified cloud and radiation subroutines and revised vertical diffusion scheme, on 9 April 1991.

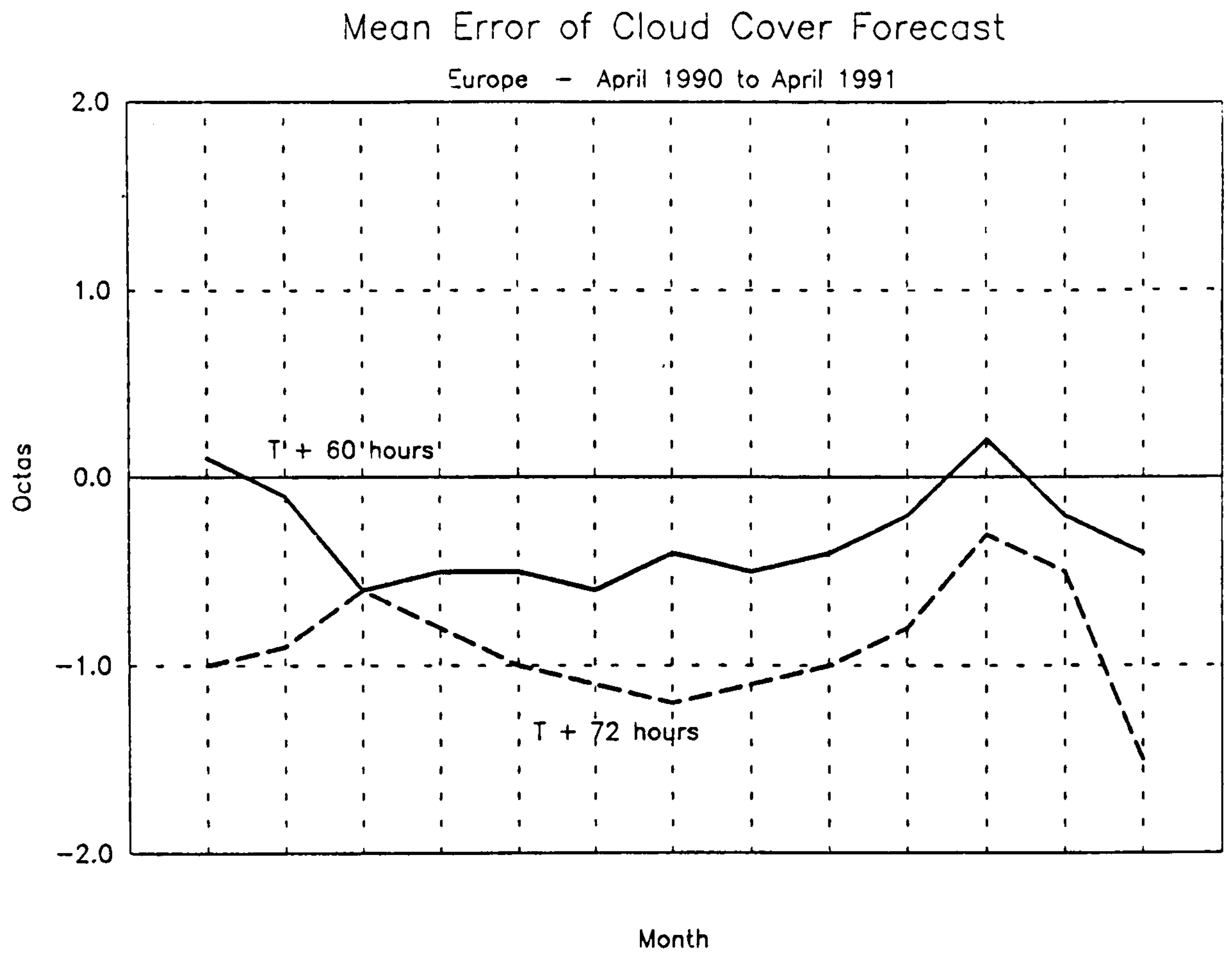
The quality of 2m temperature and cloud cover forecasts over Europe since the 1990 changes is discussed in the following paragraph. In the third section, the expected impact of the last change listed above is illustrated, with the aim of providing guidance to users of 2m temperature forecasts in statistical applications.

2m temperature and cloud cover verification over Europe in the past year

Verification of the forecast of 2m temperature and cloud cover over Europe since April 1990 is shown in Fig. 1, for T + 60 and T + 72 hour forecasts. The plotted values are the monthly means of the forecast error against synoptic observations. For 2m temperature, a correction for the difference between model orography and real orography has been applied.

In order to improve the statistical significance of the data set, the forecast errors interpolated at each station have been averaged over 200 x 200 km^2 boxes, so that the spatial distribution of the data is more uniform and their inter-correlation is reduced. It should also be noted that boxes with observations that are too inhomogeneous (regardless of the forecast values) have been excluded from the statistics on a day-to-day basis.

On average the forecast underestimates the cloud cover slightly more during the day, with little seasonal variation. The spread around the mean is large, with a standard deviation of about 3 octas.



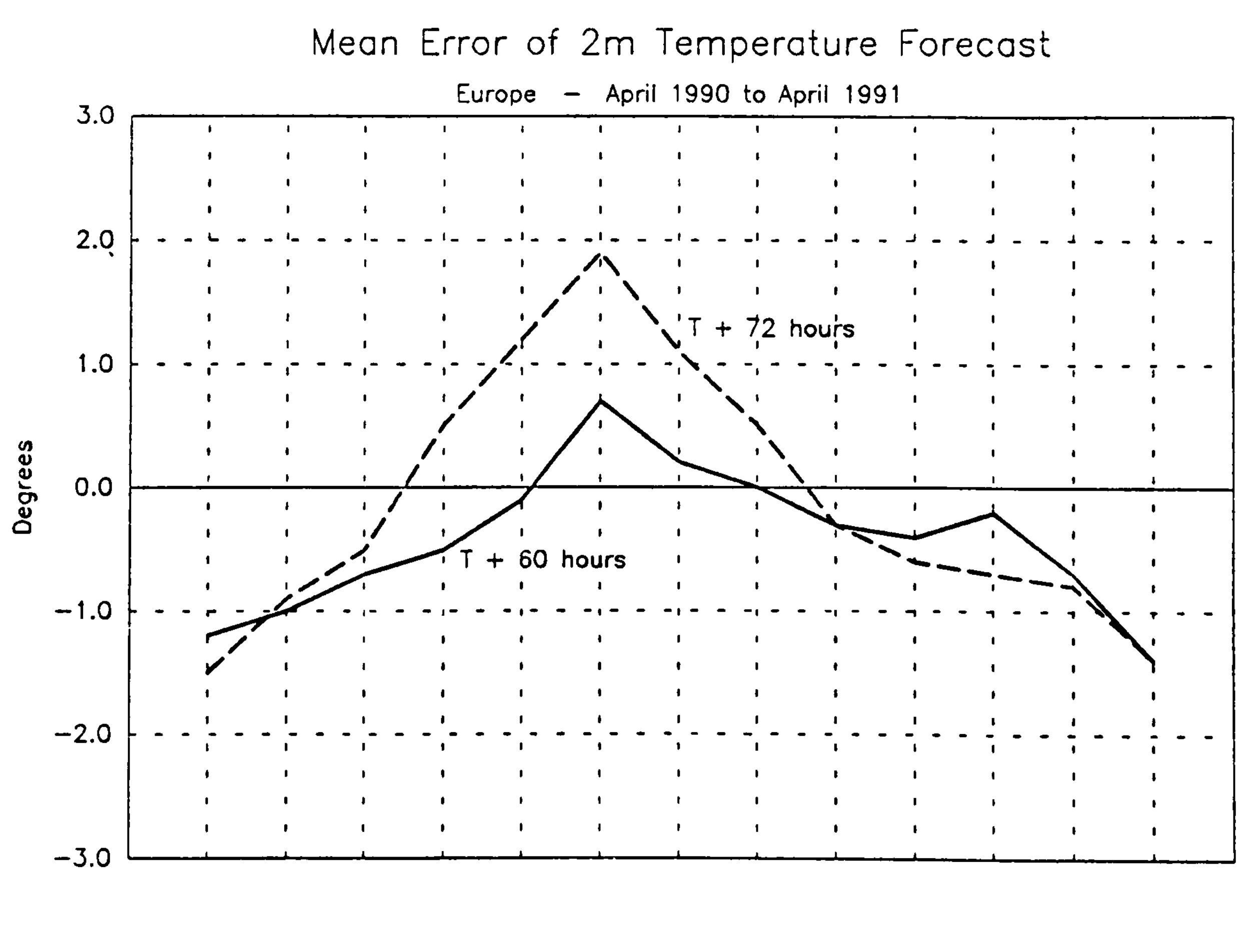


Fig. 1: Verification of cloud cover and 2m temperature forecasts over Europe against observations averaged per 200 x 200 km^2 boxes. Period April 1990 to April 1991. A correction for orography difference has been applied to 2m temperature forecasts.

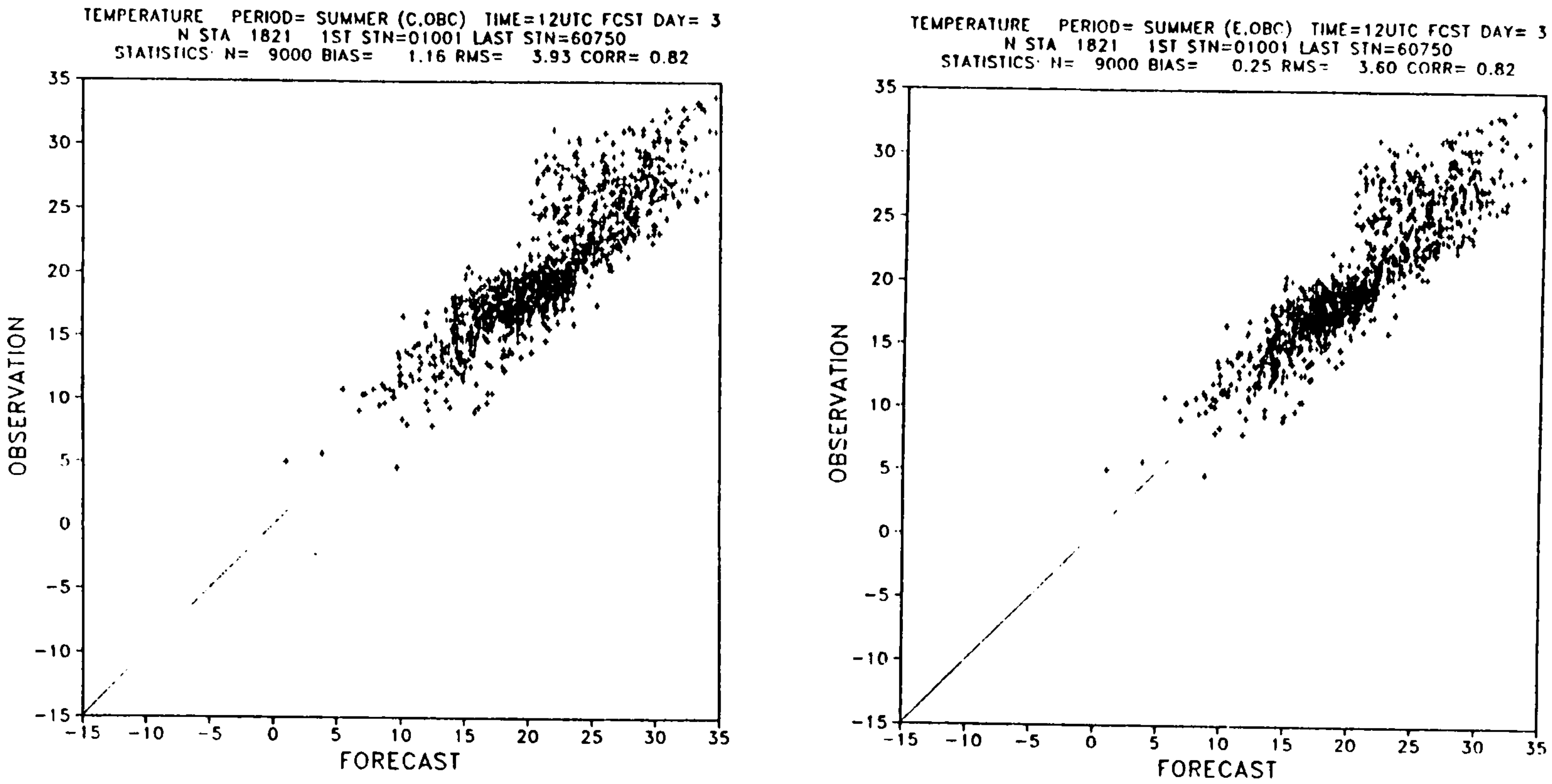


Fig. 2a

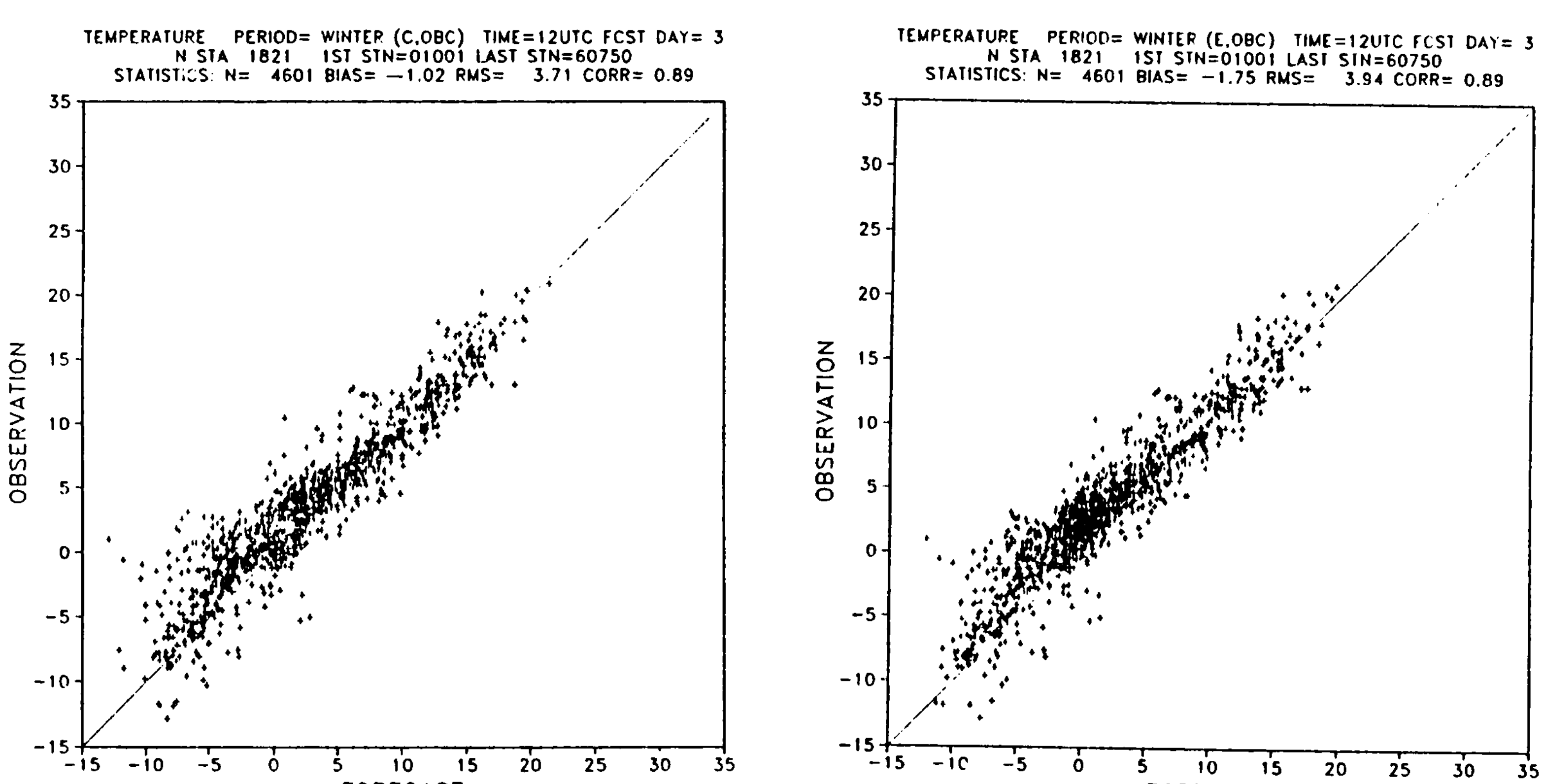
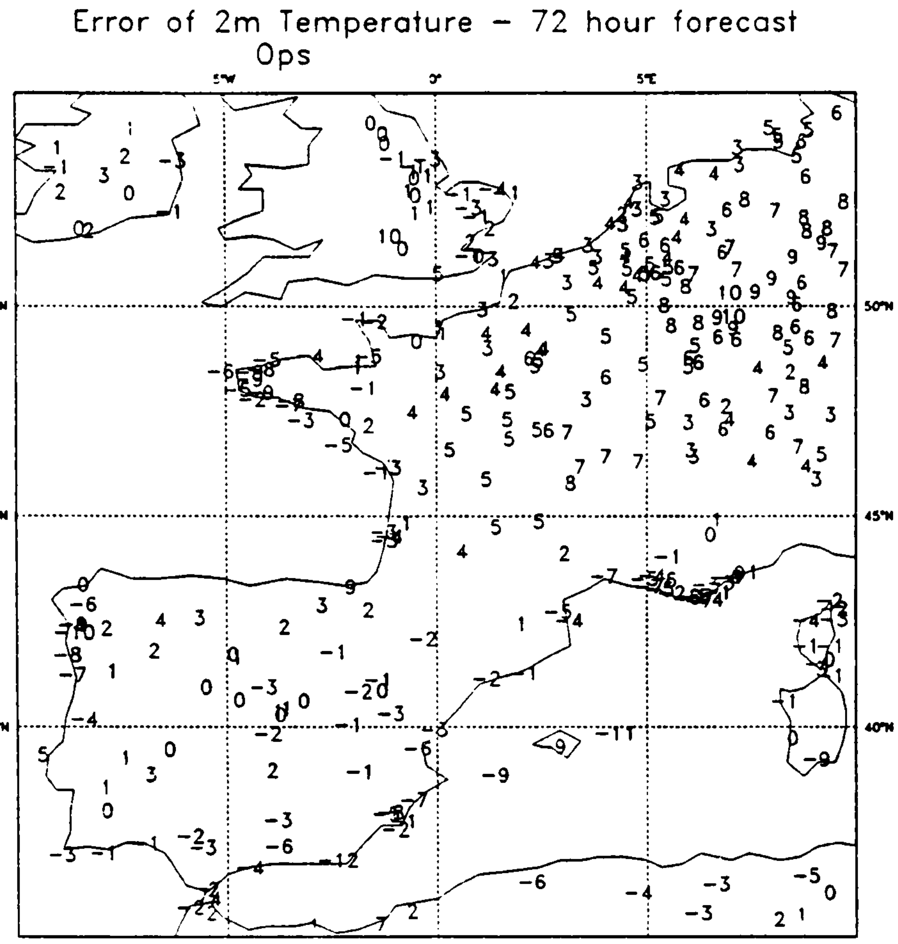


Fig. 2b

Fig. 2: Observed temperature versus predicted temperature at T+72 corrected for orography difference, for operational and experimental forecast runs; Fig. 2a: summer cases, Fig. 2b: winter cases.



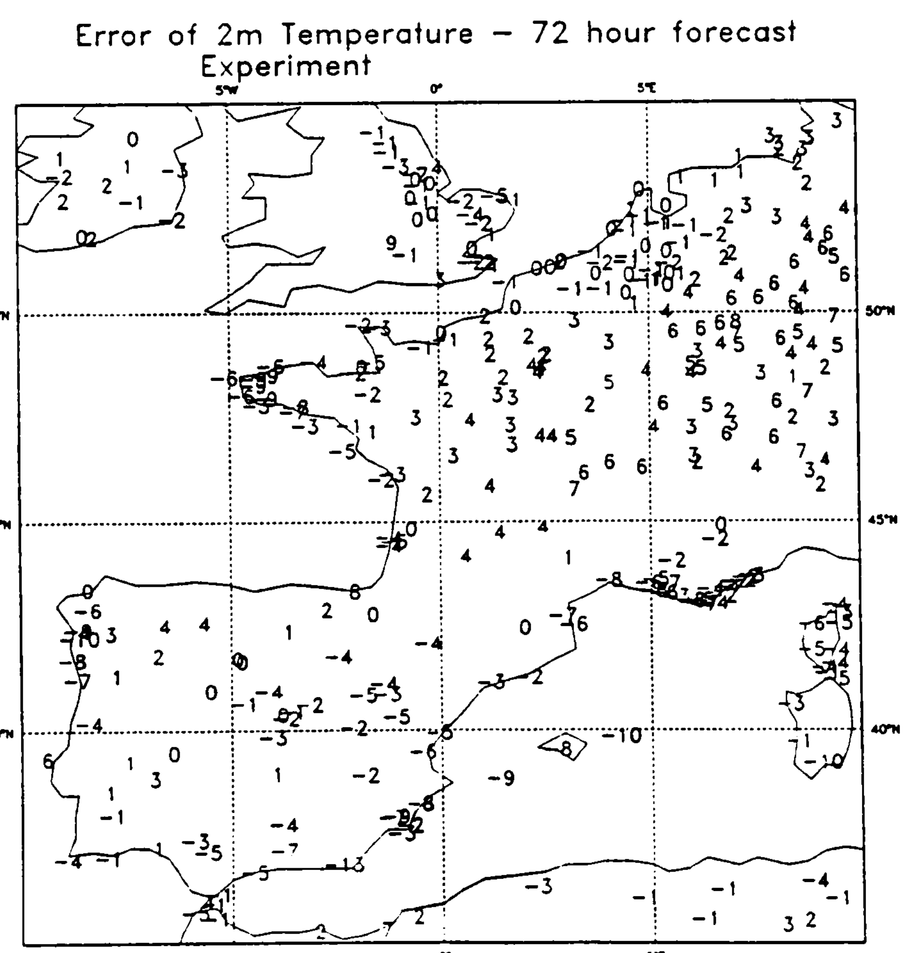


Fig. 3: Error of the 72-hour forecast of 2m temperature for the forecast based on 15 July 1990, operations (top) and experiment (bottom).

The curves for 2m temperature show a marked seasonal variation, as previously pointed out. The month with the greatest bias is September. Standard deviation values range from 2.5 to 3.5 degrees.

Expected impact of the recent change

The last points of each curve in Fig. 1 are based on the period 10-30 April 1991, i.e. the period after implementation of the change on 9 April. An overall effect of the change is to decrease the net radiation available at the surface, which has a significant impact on the temperature in the boundary layer. Although not clear from the data for April, this impact can be estimated from the experiments run by the Research Department prior to implementation.

Fig. 2a shows the impact at T + 72 hours over Europe in summer. The points correspond to the forecast against observed values (correction for orography applied) for eight summer experiments together. The bias is reduced from 1.2 to 0.3 degrees. In spring and autumn (four experiments), the bias is also reduced from 2.0 to 1.1 degrees. However, in winter (Fig. 2b, four experiments), the existing cold bias is increased from -1.0 to -1.8 degrees.

Similar plots for T + 60 hours forecast do not show any significant trend.

The average impact of the change on cloud cover over Europe is limited. There remain serious deficiencies in the local cloud forecast, which have a significant impact on 2m temperature, as shown in Fig. 3 (experiment based on 15 July 1990, T + 72 hour forecast verified against synoptic observations, without box averaging). In this example, several changes in the 2m temperature predicted by the experiment are due to local modifications of the cloudiness (e.g. over the Low Countries and over Corsica and Sardinia). At the same time, the overall bias over western Europe has been reduced by about 2 degrees.

Conclusion

The quality of the forecast of weather parameters such as 2m temperature and cloud cover is highly dependent on the physical parametrization used in the model. In the case of the recent model change, little impact on cloud cover over Europe should be seen on average, but significant differences can be expected for daytime forecasts of 2m temperature. It is not yet known to what extent this will interact with the effects of the forthcoming increase in model resolution.

Re-tuning of statistical applications using this parameter will in any case be required. In view of the model changes to be expected in the near future, designers of such applications should be encouraged to use adaptive filtering wherever possible (cf for example ECMWF Newsletter no 46, June 89, for an introduction to Kalman filtering).

- Bernard Strauss, Alex Rubli

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THE ERS-1 MISSION

ERS-1 is an ESA satellite designed for environmental studies. The project was conceived in 1977, for launch in 1987. As happens with large and complex projects, there has been some slippage in the launch date, and the current best guess is that it will be in July 1991.

The spacecraft (Fig. 1) is a radar engineer's delight, with three major radar systems on board, together with a number of other instruments.

Scatterometer

At the top of the figure, the set of three antennae are part of the wind scatterometer (SCAT). The scatterometer looks outwards and downwards to the right of the satellite track. It illuminates a patch of sea-surface with a radar beam from each antenna, and measures the radar return signal, which is mainly caused by Bragg scatter from short (5cm) wind-generated capillary waves. The radar return depends on the orientation of the waves in relation to the beam direction, and on the amplitude of the waves, which in turn depends on the wind speed. The three antennae provide three different surveys of the same patch of sea, and from this information wind direction and speed at the sea surface can be estimated, provided there are good statistical relations between wind and radar return. The main limitation is that there can be an ambiguity of about 180 degrees in the wind direction, partly inherent in the instrument design, and partly resulting from the inevitable noise in the measurements. This can usually be resolved using independent information. ECMWF will provide global wind forecasts to ESA to assist in dealing with this problem.

The scatterometer provides wind data in 25km wide cells in a swath 500km wide starting at 250km from nadir. Once per orbit, the data from the scatterometer are down-loaded from the tape recorder to one of the ground stations at Kiruna in Sweden, Maspalomas in the Canaries, Gatineau in Canada or Fucino in Italy. From there they are forwarded to ESRIN in Frascati where they are inserted into the meteorological networks. The geophysical low-bit-rate data from the other instruments will be disseminated in the same way.

Synthetic aperture radar

Just below the scatterometer antennae on Fig. 1 is the large (10m) antenna of the Synthetic Aperture Radar (SAR). SAR is a quite different radar instrument from the scatterometer, and has much higher power requirements. With elaborate signal processing it is possible to convert the effect of the motion of the antenna into the equivalent of a very long antenna, which provides high resolution radar images along a swath 100km wide to the side of the satellite track. Because the operating frequencies of the SAR and scatterometer are almost unaffected by cloud or rain there is an all-weather capability for

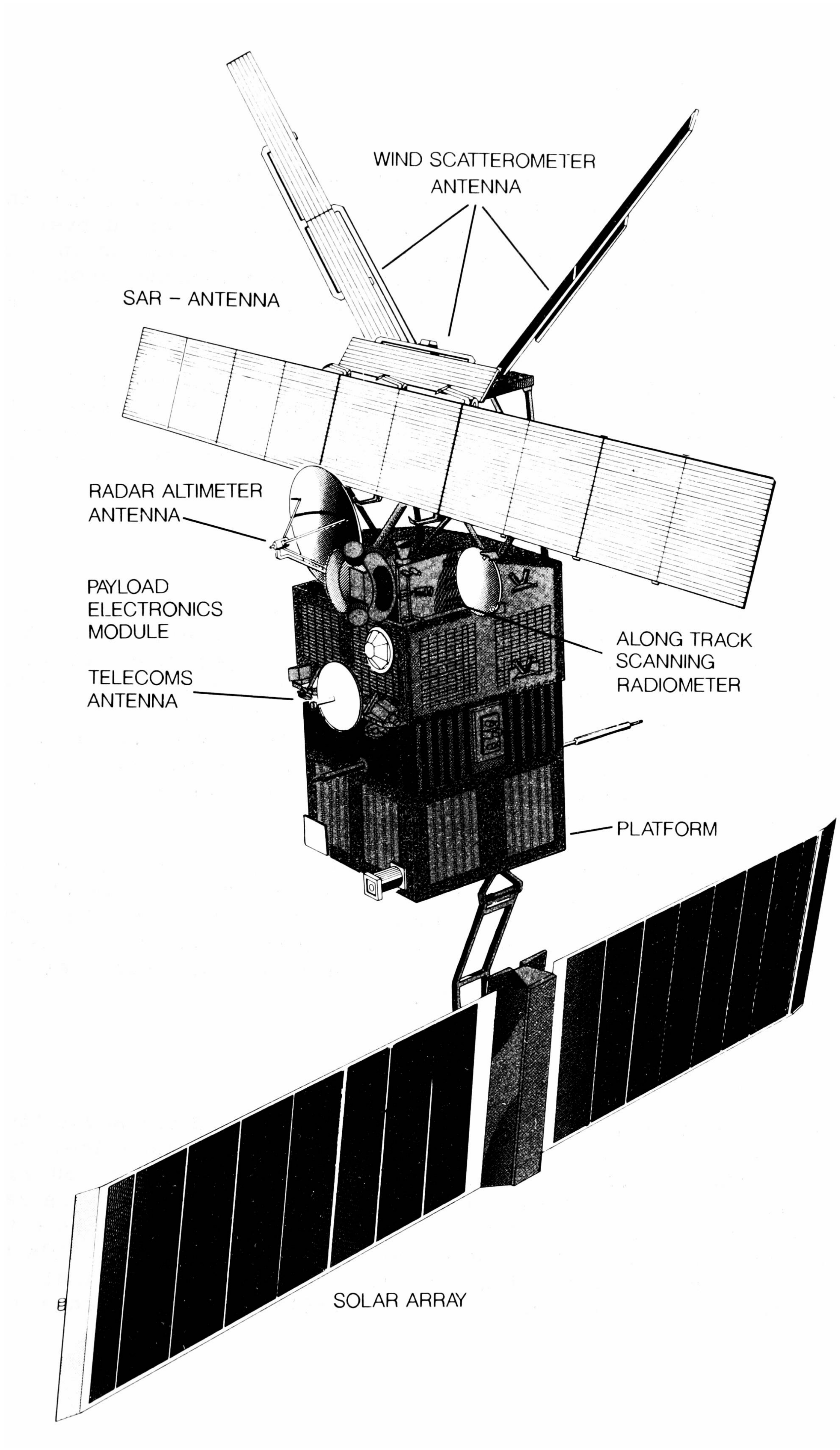

Fig. 1: The ERS-1 spacecraft
(Reprinted from ESA Bulletin No. 65 - February 1991)

monitoring the surface of the land and ocean in great detail. Ocean applications for SAR include studies of ocean surface waves, ocean internal waves, ship tracking, and ice-floe tracking. The radar return over land is sensitive to surface dielectric variations caused by variations in the state of vegetation, soil moisture, etc. Land applications include mapping, forest and crop studies, glaciology, geology, and earth resource studies (e.g mineral prospecting).

Given the huge data-rates involved, SAR only operates in image mode while the satellite is in view of a ground station. A number of non-European countries (including USA, Japan, Australia, Brazil, Ecuador, India, Indonesia) are installing SAR ground stations. The SAR data are expected to generate revenue for ESA.

Interactions of SAR and SCAT

The scatterometer and the SAR share much of their electronics, and the SAR in image mode cannot operate together with the scatterometer. The power requirements for SAR are such that it can be in operation for at most 7 minutes per orbit in daylight, and 3 mins per orbit in eclipse. As SAR data over Europe is of great interest to the ESA member states, SAR will be heavily used on day orbits near Europe. Twenty per cent day-time availability and 80% night-time availability of scatterometer data in the eastern Atlantic and European coastal seas is expected. Elsewhere over the world ocean almost continuous scatterometer operation is expected.

The SAR can also operate in wave-mode to take a quick look at a small 5km square patch of ocean once every 300km and produce a fourier transform of the resulting imagette. From this the surface wave spectrum can be recovered, provided one knows the modulation transfer function, and has a good first-guess at the spectrum. The WAM group will use the SAR imagettes for wave assimilation in the WAM model at ECMWF.

Radar Altimeter

Just below the SAR antenna in Fig. 1 is the large dish of the Radar Altimeter, which will operate at almost all times over ocean and land ice. The radar altimeter directs a carefully designed radar chirp at nadir, 50 times per second. Measurements of the return time enable measurement of the height of the satellite. From this the figure of the earth (the geoid) can be estimated, and thence the dynamic height of the ocean, from which it is possible to infer ocean currents. The intensity of the return signal enables estimation of the surface roughness (a flat sea is a good reflector), and hence the wind strength.

Lastly, the rate of rise of the return chirp enables estimation of the state of sea, and so the rms wave height. Besides its importance for the study of ocean currents, the altimeter will be used to estimate the volume of the Greenland and Antarctic ice-caps. This is a matter of some interest, given the concern about the greenhouse effect.

Along track scanning radiometer

Adjacent to the radar altimeter dish in Fig. 1 lie the port for the infra-red radiometers of the Along Track Scanning Radiometer (ATSR, a UK instrument) and the antenna of the associated microwave sensor (ATSR/M, a French instrument). These instruments are designed to give high precision measurements of sea-surface temperature, through the use of several frequencies and an actively cooled instrument.

Platform

The lower half of the satellite in Fig. 1 is taken up with the platform and solar array. The platform, based on the French SPOT-1 platform, provides the power, control, and telecommunications facilities needed to operate the satellite and down-load the data from the instruments. Management of the solar panel is considerably simplified by the fact that the satellite will be in sun-synchronous orbit.

Orbit characteristics

The satellite orbit will have an altitude of about 780km and an inclination of 98.52 degrees, so that it will be sun-synchronous. The descending equatorial crossing will be at about 10h.30, local time. The satellite orbit will drift slowly westward with time. If the satellite passes exactly overhead a given point on one day, it may not revisit the same point again for many days. In a 3-day repeat cycle the satellite will revisit exactly the same point (to within a kilometer) every three days. In such an orbit there are many areas that will never be seen by the satellite's instruments. Small changes in altitude (up to 20km) will be used to change the repeat cycle from 3 days for the commissioning phase in late 1991 (and for three-month dedicated 'Ice Phases' in early 1992 and early 1994), to 35 days for the main exploitation phase in 1992/3.

The orbit variations have little or no impact on operational meteorology. However the orbit has been the subject of impassioned debate between user communities with conflicting needs for exact repeat data (and for a variety of repeat cycles) and other user communities needing global coverage. The planned orbit is a compromise which optimizes benefits for the maximum number of users, taking account of their contribution to the project and their political and scientific standing.

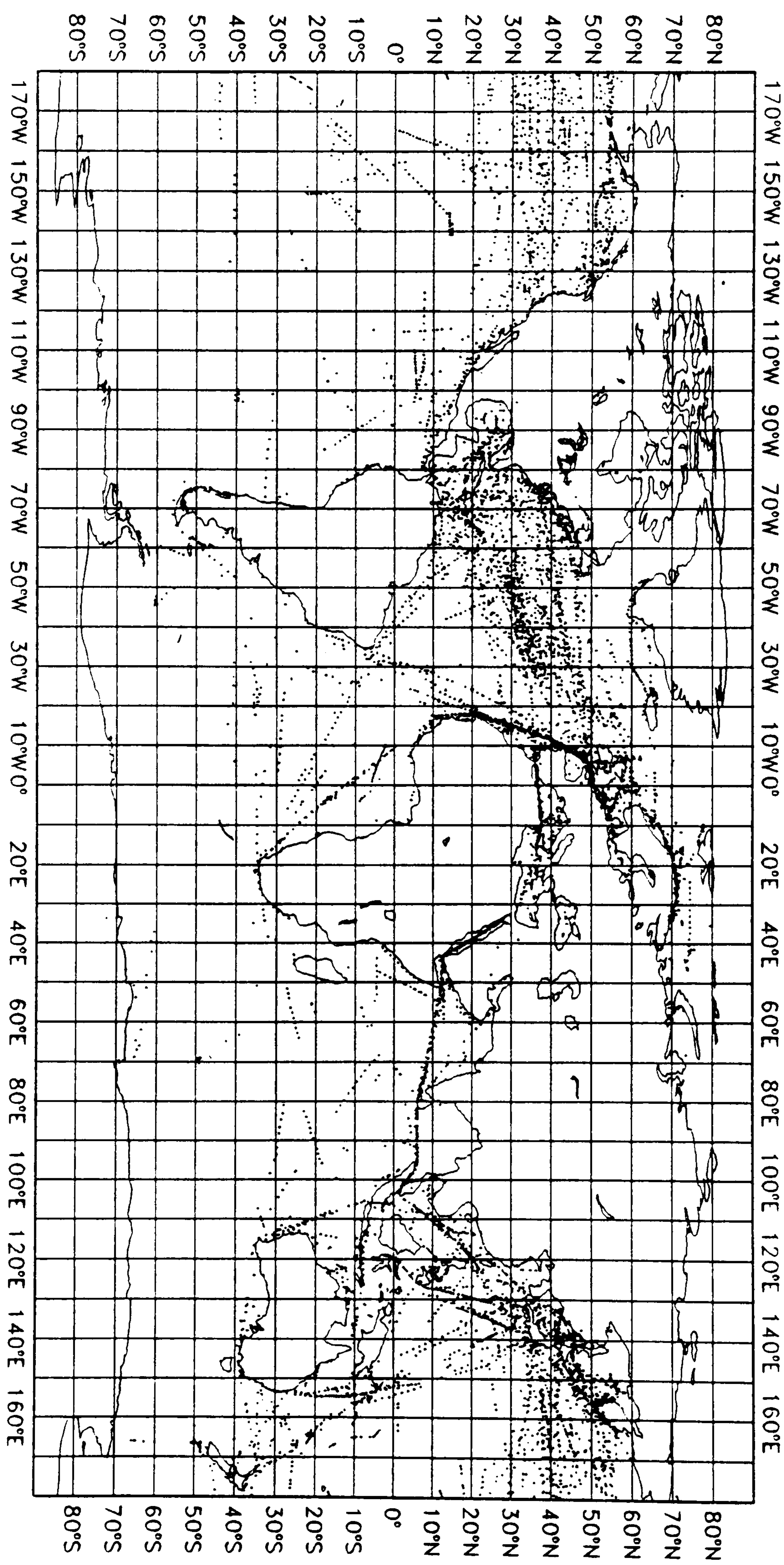

Fig. 2: Ship data received at ECMWF over a 3-day period
(1501 UTC, 1 April 1991 - 1500 UTC, 4 April 1991)

Geophysical calibration and validation

Before they can be used, the ERS-1 geophysical products must be calibrated and validated, using as many different methods as possible. Once the engineering calibration is completed, ESA will, in the autumn of 1991, mount a major field experiment in the Norwegian Sea to validate the wind and wave products. Because field campaigns are restricted in spatial and temporal coverage, ECMWF and other major NWP centres will collaborate with ESA to undertake a global validation of the products using operational data and assimilation fields.

It is hoped that monitoring of the wind and wave products in the operational assimilation systems will flag any significant problems with the data.

Since activities at ECMWF will start a few weeks after launch there will be an opportunity, before the fleet of aircraft and buoys are put to sea, to use operational data to estimate the parameters in the statistical relation between radar-return and wind. When the fleet returns we shall see how well this compares with the specialised data used to establish the 'sea-truth'.

Operational meteorological and oceanographic assimilation of the ERS-1 geophysical products

Once the ERS-1 products have been validated they must then be evaluated for use in data assimilation. ECMWF and other weather prediction centres are interested in assimilating the wind products from the scatterometer, the wind and wave height products from the altimeter, the wave spectra from the SAR, and in some cases, the sea surface temperature products from ATSR. Assimilated fields of these wind and wave products will be heavily used in oceanographic research related to the TOGA and WOCE programmes. Oceanographers will of course be very interested in the problems involved in assimilating the dynamic ocean height.

A great advantage of ERS-1 is the global coverage it will provide. Fig. 2 shows the coverage of ship data received at ECMWF for a typical three-day period. ERS-1 will provide global coverage of surface winds over the world ocean in a similar three day period, with a resolution of 25 km within the swath. We expect the ERS-1 data to be most useful in describing small-scale phenomena such as hurricanes and polar lows. Fig. 3 shows an example of wind coverage of a typhoon by the scatterometer on Seasat in 1978.

Cost of the project

The cost of the ERS-1 project is about 800 million accounting units. In addition to the investment by ESA, there are many national investments in the project, in the form of ground stations, snf processing centres. Fig. 4 shows the radome of one of the ground stations being set up in anticipation of the launch of ERS-1.

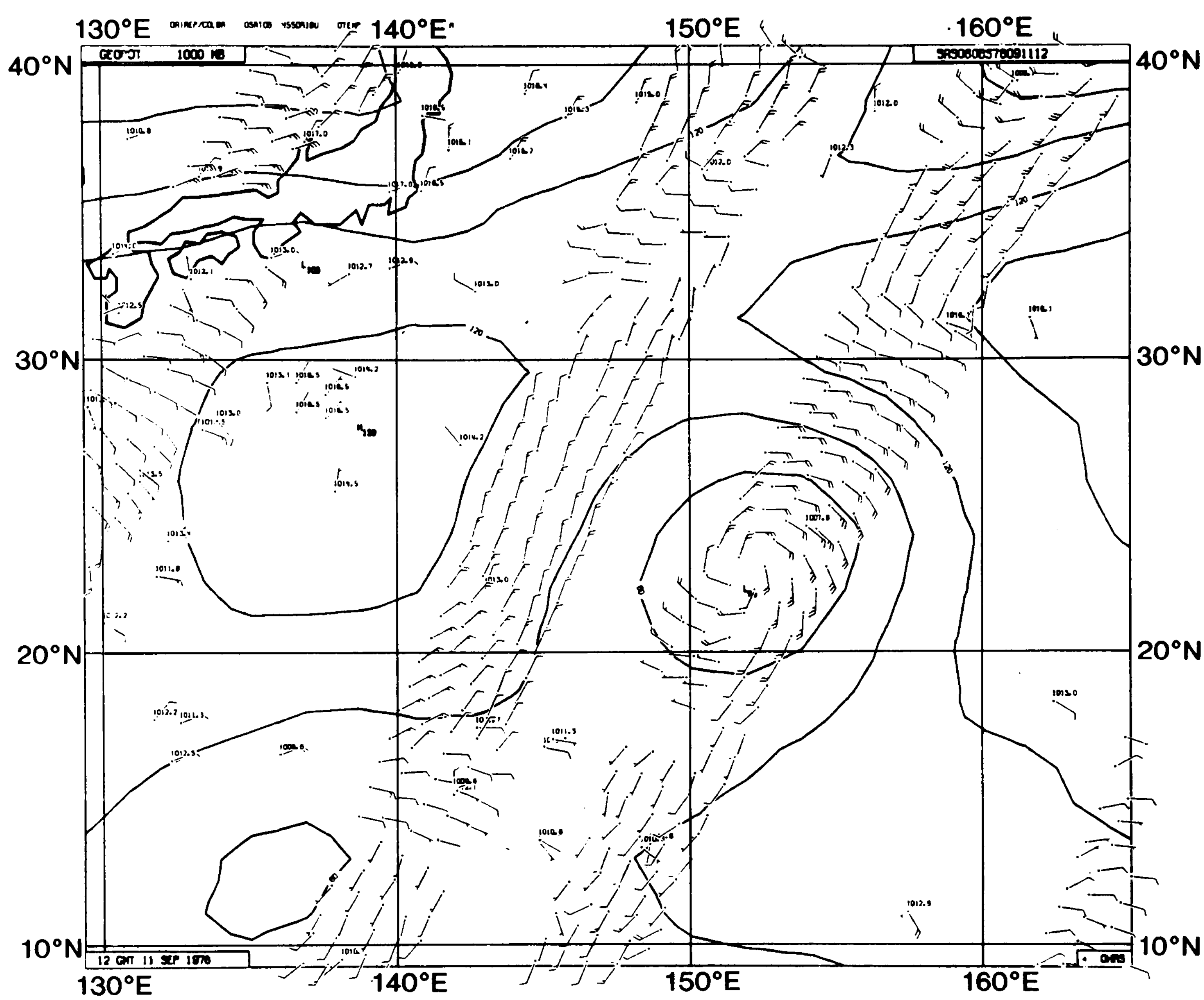

Fig. 3: Analysis from the assimilation experiment at 12Z on 11 September 1978, with SASS and ship observations superimposed

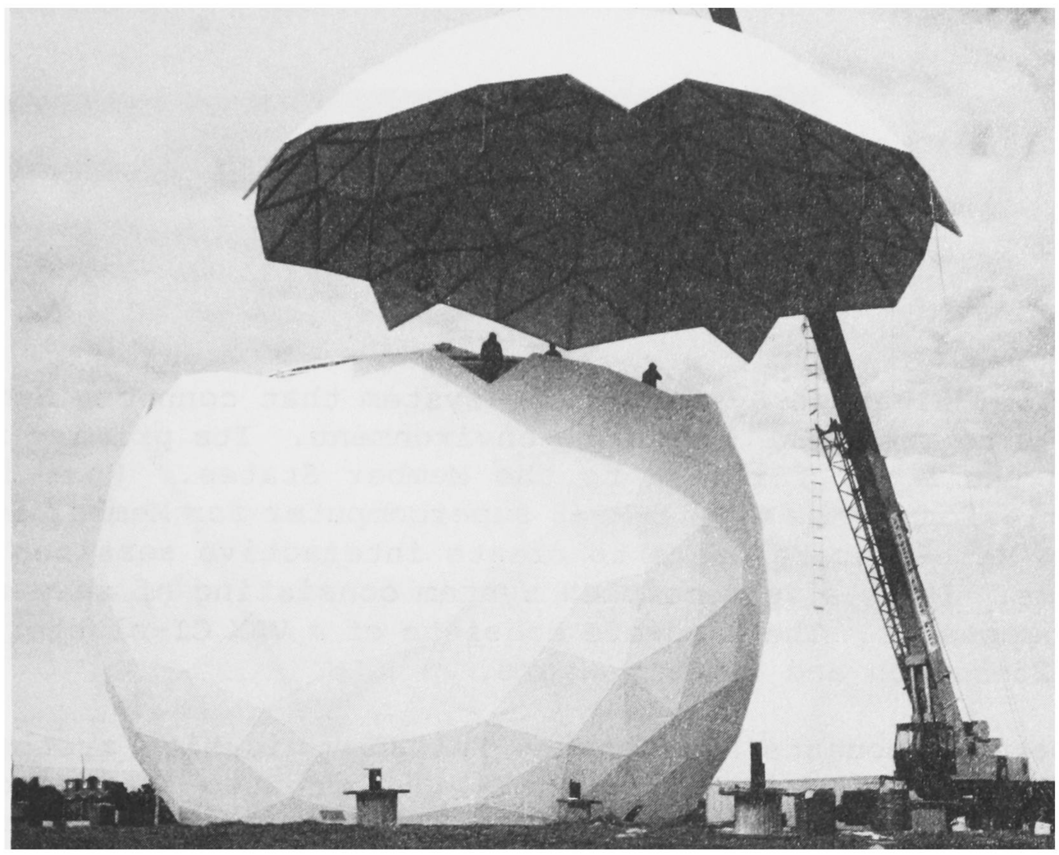

Fig. 4: Radome of a ground station in its final stages of construction

Future scatterometer programmes

ERS-1 should have a lifetime of three years or more, and so there should be little break in coverage if ERS-2 is launched in 1994 as planned. NASA's first scatterometer since Seasat should fly on the Japanese platform ADEOS in 1996; it will be a two-sided scatterometer, looking at both sides of the satellite track. ESA will include a two-sided scatterometer on its first polar platform in 1997/98, as will NASA on the EOS-A mission in 1998/9.

\- A. Hollingsworth

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THE ECNET TELECOMMUNICATION SYSTEM

Introduction

The ECNET Telecommunication System is the system that connects Member States computer systems to the ECMWF computing environment. Its primary function is to disseminate the ECMWF forecast to the Member States. Next it provides remote job submission to the Cray Y-MP/8 supercomputer for Member State users. It also enables Member State users to create interactive sessions with ECMWF computer systems. It is a very complex system consisting of several hardware and software components. The hardware consists of a VAX CI-cluster, DEC X.25-routers, an X.25-switch and CISCO routers.

The main software components are the **N**ew **T**ele**C**ommunication system (NTC) and the **N**ational **T**elecommunication **S**ystem (NTS). These two systems control the data transfer and interactive access. The NTC succeeded the RegneCentralen system and is based on the ECNET protocols defined by ECMWF in the early 1980's. The NTC became operational on a VAX cluster system in 1986. At present, 9 Member States use the NTC. As some Member States had their own VAX computers, a project was started in 1986 to use DECnet protocols for connections to these Member States. This project was the NTS system and became operational in December 1986. Nine Member States currently use the NTS system.

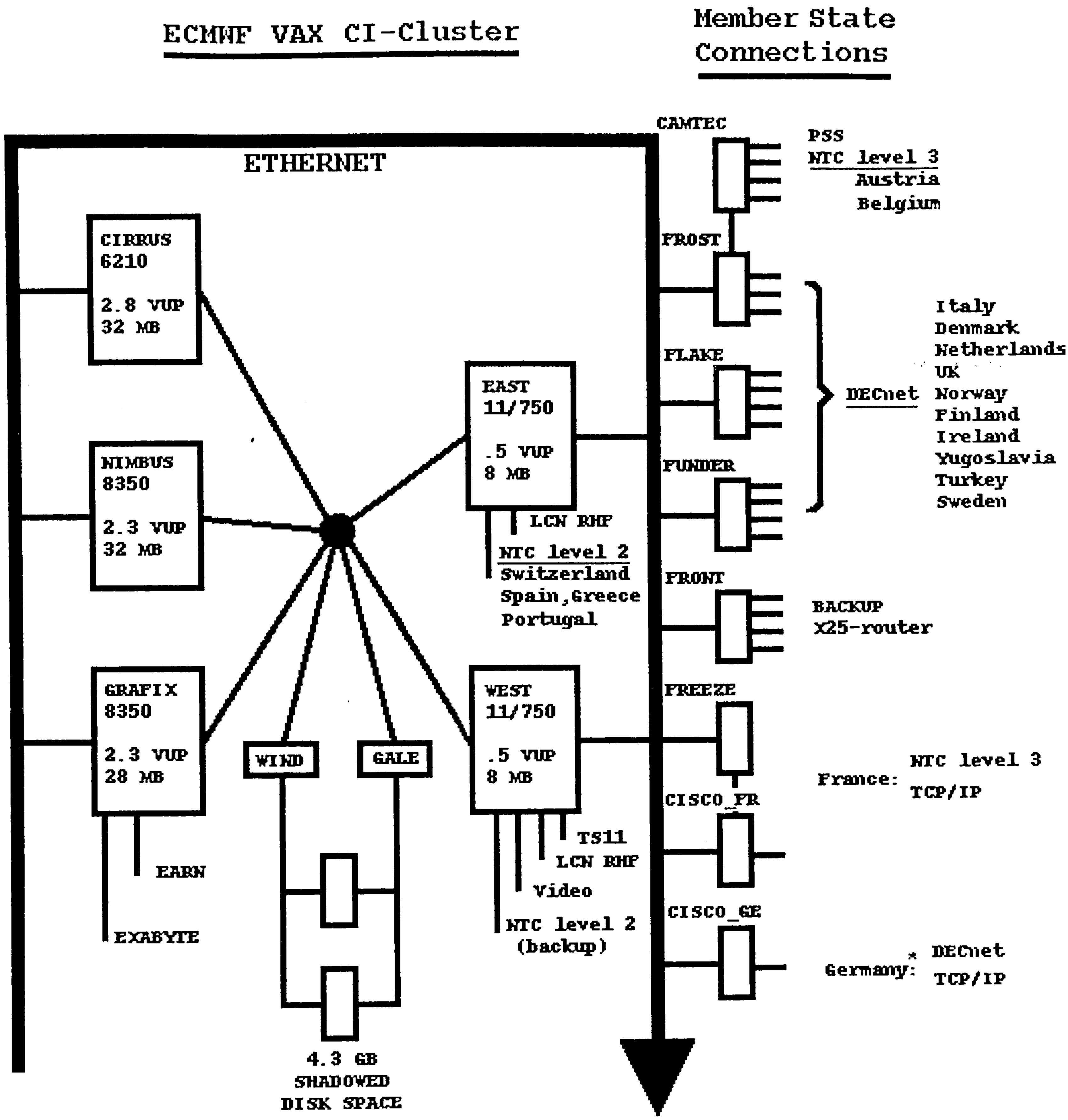
Hardware configuration

The ECNET Telecommunication System runs on a VAX/VMS cluster. Fig. 1 shows the current status of the hardware configuration and the Member State connections. There are at present four different types of connections in use.

1. The NTC system based on the ECNET protocols supports an HDLC type of connection which connects directly to an HDLC interface on a VAX 11/750. This is generally referred to as NTC level 2. This type of connection relies on specific hardware (the HDLC interface) used by the NTC software, and is only available on ECMWF's VAX 11/750.

2. The NTC also supports X.25-based connections called NTC level 3. This type of connection uses the X.25 protocols for the lower levels of the network protocol (ECNET). The Member State line connects via an X.25-switch (CAMTEC or CISCO-router) to a DEC X.25-router. This X.25-router has an Ethernet connection to the VAX with the NTC software.

3. The third type of connection is DECnet. The Member State line connects to the DEC X.25-router which supports both the X.25 and DECnet protocols. The NTS software controls data transfers for Member States with DECnet connections.



*) The line to Germany is being upgraded to a 64 Kbps link, supporting both DECnet and TCP/IP.

UNICOS
WORKSTATIONS
NOS/VE
IBM
PC NOVELL Network

Fig. 1: Current status of the ECNET hardware configuration and the Member State connections

4. A fourth type of connection is a TCP/IP link. At the moment this is under test with France. When this type of connection becomes operational, the data transfer to Member States with this type of connection will be controlled by the NTS software.

The speed of the links to Member States varies from 4.8 Kbps to 64 Kbps. There are limitations on the speed that can be used for NTC-type connections. This is because the ECNET protocol is old and cannot cope with high speeds (its maximum being about 9.6 - 14.4 Kbps). DECnet and TCP/IP protocols are better and more reliable. With these protocols it is only the hardware that puts a limit on the line speed. The DEC X.25-router and the CISCO router support speeds on wide area network connections of up to 2 Mbps.

File transfer

The primary function of the ECNET Telecommunication System is to disseminate the ECMWF forecast. It also provides Member State users with a remote job submission facility to the ECMWF CRAY Y-MP/8. The Remote Queuing System (RQS) package from Cray is used for this. All data transfers between ECMWF and the Member States use either the NTC or the NTS system. There are six groups of files that can be transferred: DD - Data Dissemination, DA - Data Acquisition, RJ - Remote Jobs, BO - Batch Output, PF - Permanent Files, and GX - Graphics Files. All these are supported on both the NTC and the NTS systems at ECMWF. With Member States using NTC it depends on their implementation of the ECNET protocols whether all file types are supported. There are also limitations of data transfer because of restrictions in the network protocol and the VMS operating system, e.g. the ECNET protocol restricts a file to 9999 records; VMS puts a limit on the record size of 32767 bytes; and with TCI/IP binary transfer one loses the file structure. Both the NTC and NTS use the VMS queuing mechanism to control file transfers. This gives a similar user interface and also a good recovery mechanism in case of transfer and/or system failures. Each Member State has one queue on the VAX cluster where file transfers are entered, and the VMS operating system passes requests to the queue control process. The NTC and NTS both have their own program for this queue control process (in VMS terminology this is called a symbiont). The NTC symbiont interfaces with the ECNET processes of the NTC system to transfer the file and the NTS system interfaces with standard VMS commands for DECnet and, in the near future, TCP/IP - FTP file transfers. The TCP/IP - FTP file transfers are being investigated as part of the pilot project for the 64 Kbps connection to France. The files queued for transfer are always copied to special directories to ensure an extra level of recovery. Computer Bulletin B3.5/1 describes in detail the user interface for transferring files to and from Member State computer systems.

Remote job submission is implemented via the Remote Queuing System from Cray UK Ltd. This system runs on the VAX CI-cluster and controls remote jobs submitted from the VAX to the CRAY Y-MP/8 and batch output files being returned. It does not provide direct links with the NTC/NTS systems (unlike its predecessor, RHF) so some extra processes on the VAX CI-cluster have been created to control incoming Member State remote jobs, so that they are passed on to RQS; batch output files returned from the Y-MP/8 have to be queued for transfer to the correct Member State.

Interactive service

The ECNET Telecommunication System also provides an interactive service. This service is accessible depending on the protocol used; four protocols are available for the interactive service. The first, the NTC ECNET protocol, is a very limited service and only provides one interactive session per Member State. This is a special session for limited control of data transfer and remote jobs for operators from Member States. The second protocol available is the X.29 protocol. This implements interactive sessions using the X.25 protocol; it can be used via the public X.25 network (PSS in the UK) or via the Member State leased lines that are connected to the X.25-switch, CISCO-router or DEC X.25-router. Member States need to have the appropriate hardware and software to use this service. For Member States with DECnet connections all nodes on the DECnet network of ECMWF are, in principle, reachable for both network and interactive operations. This also applies for future TCP/IP - TELNET connections. These last three types of connections (X.29, DECnet and TCP/IP) are tightly controlled and monitored, as ECMWF's expanding network requires extra security measures for the ECMWF computer systems, to prevent their unauthorised and improper use. The NTC ECNET interactive sessions are considered to be sufficiently secure (being on a leased line, and requiring in-depth knowledge of the NTC ECNET protocol).

Conclusion

The ECNET Telecommunication System has developed in the last few years into a very complex system. Moving to better and international standard protocols (DECnet, TCP/IP, OSI) has and will increase reliability and performance. The NTS system in particular has proved to be very flexible, in that it is independent of the network protocol used as long as there is a simple user interface for the protocol to transfer files. Work is now being carried out to integrate fully TCP/IP - FTP transfers within the NTS. On the hardware side, higher speed links (64 Kbps - 2 Mbps) will become more widely used. This will gradually eliminate ECNET protocols because of the restrictions they impose. Multi-protocol routers (such as the CISCO router) will become standard, making the move to a full implementation of the OSI network much easier.

- Tony Bakker

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INTERNAL NETWORKS AT ECMWF - CURRENT STATUS AND FUTURE PLANS

A vital service

A Local Area Network was first installed in the Centre in 1983. Since then reliance on the various networks has increased so much that the operational rôle could not be carried out without them. The networks are a strategic resource; the information arteries of the computing service.

Since the start in 1983 with Control Data's LCN, the Centre has added many more network facilities. DECnet, CDCnet, the PC network and the Sun workstations, general TCP/IP connections to all the major systems, and now TCP/IP connections to Member States, have successively been integrated into the overall system.

With a good local network service installed the computer systems can perform specialised functions, so that, as in the Centre's present system, the file services, interactive services, and high-speed floating point computation are located on different machines. This makes it possible to change and upgrade the individual systems without destroying the overall service.

Local networks and the services they offer are now expected as a matter of course in any computer service environment. To support the computing services vital to the Centre's operational and research rôles, constant monitoring of the networks is needed, and plans must be made to keep them up to date and effective.

Bits, bytes and copper wires

Data networks function at two distinct levels*. There is the **physical** level (e.g. wires, connectors and voltages), and the **logical** level (files, commands and data).

To connect computer systems physically, they must each use the same connector, the same type of wire, and must agree as to the voltages and timings used on the link. A physical connection is not sufficient, however. To get useful work out of the connection, it must be made at a logical level. To do this, the same **protocol** - the set of conventions governing a conversation between computers - must be used. Usually, the physical nature of the connection determines how much data can pass along it (its bandwidth), and the protocol determines what meanings the data may have (for example one might be able to transfer a file, start an interactive session, submit a job, issue a warning).

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* Actually, at many more than two (*pace* OSI), but these two are obvious to the observer.

At the Centre, a number of different physical connections are used for the networks: LCN (which is to be replaced in 1991); direct channel connections (from Cray to IBM and to CDC); IBM Token Ring (used between some of the office PCs and the IBM mainframe), the Ultra network and Ethernet. The Ethernet has the largest number of connections, and it carries a variety of protocols: the PC network, the VAXes, the CDC machines and the *open* protocol TCP/IP. All exist happily together on the same cable.

An open and shut case

In the early days of computer networks, the physical connections and the protocols which used them were usually part of a single package provided by the network supplier. This is true, for example, of Control Data's early mainframe network, LCN. The protocol which runs over LCN is called RHF; the physical connection used for RHF is LCN. Only LCN supports RHF, and only RHF can use LCN. This means that there is no possibility of taking a machine with some other type of network attachment and connecting it easily into an LCN/RHF network: the network is a **closed** one.

More recently, the computer industry has moved towards **open** networks. Openness means different things to different people: at its most ambitious it implies that any machine should be able to communicate with any other machine, using any available link, and without burdening users with details of physical connections. Most protocols today achieve a degree of openness: they can usually use a variety of physical connections from different suppliers.

However there are only two protocols (properly *protocol families,* since they each contain many different elements) which can claim to be truly open; these are **TCP/IP** and **OSI**. Some of the advantages of true open protocols are obvious: they allow computers to be assembled (like Lego bricks) into complex systems, and they obviate the need to worry about compatibility. They also eliminate dependence on a single supplier, and introduce a useful element of competition between suppliers.

With this generation of protocols, it is possible to make a logical connection between machines, even when there is no physical connection, provided both machines understand the same common protocol. Other machines in the network act as **gateways** (or **routers** or **bridges***) to complete the path. The Centre's Cray, for example, has physical connections only to the IBM and CDC mainframe computers, and to a Sun file server, yet it exchanges data with Sun workstations in offices, with the PC network, and with Member States.

The TCP/IP protocol family is available on all the Centre's machines. It is the protocol of choice for new applications, being very closely integrated with the UNIX operating system used on the Cray and on the workstations. TCP/IP is the world's most widely understood protocol, available for PCs to Supercomputers and on almost all systems between. Unfortunately, it is not

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* These terms have different technical meanings, but the essential function they describe is similar

very well standardised, and some systems may mysteriously fail to communicate with others using what should be the same protocol; nevertheless, this protocol at present offers the best option available.

For many years, the Centre has declared its intention to move to the use of OSI protocols as soon as practicable. OSI protocols have the advantage of being better standardised than TCP/IP, and the services available (file transport, interactive access, etc.) are generally more complete. Unfortunately, the OSI systems at present on the market are expensive to install, only partially implemented, and are slow compared to TCP/IP. The situation will continue to be monitored.

The LAN speed record

The different physical networks have very different characteristics when their capacity for data is measured.

The old LCN network can in theory handle up to 50 million bits per second in total, but only 6 million bits per second can be delivered to any one machine. It is intended to replace the LCN network during this year with an optical fibre system.

The Ethernet, by contrast, can carry only 10 million bits per second in total, but at least 8 million bits per second can be delivered to a single machine. (The server for the PC network alone can create this much traffic.) Because of the way in which Ethernet works, it is impossible to use more than about 80% of its capacity without bringing the entire network to a halt: it is important to keep track of how busy it is. In order to avoid problems of saturation some structural changes to Ethernet will be needed during 1991 - probably splitting it into several sections.

The replacement for the LCN network will be the optical fibre system known as FDDI. This has a theoretical maximum data rate of 100 million bits per second. It does not suffer from the Ethernet effect that traffic stops completely if too much is presented to the network, and it is therefore much more suitable for use as the main connection to the larger machines. FDDI connections will be made to IBM, CDC and DEC in 1991, and to most of the larger systems during 1992.

Even higher bandwidth than this will be needed for connections such as that between the Cray and the main file server (running the ECFILE service). At present these are handled with single point-to-point channel connections and closed protocols; it would obviously be better to use open protocols and connections. The probable open standard for connections which must handle this intense load is the HiPPI channel, which can handle 800 million bits per second in total. HiPPI is not truly a network (a HiPPI connection is only from point to point), and needs more equipment in the form of switches or routers to make a 'real' LAN.

All the abovementioned are either **bus** or **ring** networks, i.e. the network is in the form of an open-ended (bus) or closed loop (ring) cable, which visits each of the machines on the network. Quite different from these is a final contender for the speed record: the Ultra network. An experimental Ultra Hub 1000 has been installed, with connections to Cray, IBM and the Sun servers. The Ultra hub is a network in a single box; connections are taken to it from each of the computer systems it connects (a **star** network). The Ultra network has a total capacity of at least 1000 million bits per second, but in the Centre's installation it is limited by the connections to each machine which are quite slow; only 25 million bits per second is available to any single system. However, faster channels are available (a HiPPI channel can be used), and the Ultra may be useful for some high-speed networking needs.

Supply and demand

For the Centre's future networks, a model in which three different kinds of service coexist in a hierarchy is envisaged.

A low-performance (slow) service is needed for office areas, and for low to medium capacity machines. These will use Ethernet as they do today. Ethernet can now be connected very cheaply, and is very cost-effective for systems that can live within its limitations. The present large network will be broken down into several smaller departmental or functional networks; this allows higher demand from individual machines to be handled without choking the network.

The time when Ethernet can suffice for the strategic mainframe connections is coming to an end; a higher performance general-purpose network is needed. This network will carry traffic between mainframe machines, and also traffic between the separate Ethernets serving small machines. It will be constructed using FDDI (Fibre Distributed Data Interface) over twin optical fibre links. FDDI links can be fault tolerant, so that a break at any one point is not fatal to the network. The bandwidth of the FDDI network, 100 million bits per second, should be sufficient to meet demand for a number of years.

Finally, as already mentioned, a network will be needed to carry traffic between the Centre's main computing systems: in particular the supercomputer ('compute server') and the data handler ('file server'). It is estimated that the data rate needed on this connection will be about 24 Megabytes per second (200 million bits per second). This will probably be constructed using HiPPI channels, with an Ultra network hub and/or a HiPPI switch. Installation of this high-performance network is expected in 1994.

Wider issues

The use of open protocols on its internal networks provides a very convenient and useful way for the Centre to offer better service to Member States. Since TCP/IP can be used successfully on international links (*Wide Area* Networks), it is possible to interconnect the Centre's network with those of Member States and to use the same TCP/IP protocols as used for connections between the Centre's own machines. This can make use of the Centre's service much simpler for Member States, providing direct file transport and interactive connection.

An experiment is being conducted at present with a digital link to Meteo France, which carries 64 thousand bits per second. This is connected to the Ethernet through a router at each end of the line, effectively connecting the local network at the Centre with that at Meteo France. So far this has been quite successful, and provides a much better service to users there. A similar connection to Deutscher Wetterdienst will be installed very soon.

A report will be made to the Technical Advisory Committe in the Autumn on the progress of these links. If there is no adverse experience to report, it is likely that use of digital links with routers and TCP/IP protocols will become an approved means of connection to the Centre, allowing more Member States to take advantage of the improved service.

Conclusion

In the eight years since its first network installation, the Centre has become vitally dependent on the service provided by the networks. Without them, a computer centre of such a scale could neither be constructed nor operated effectively.

The plans for the networks should equip the Centre to meet increasing demands for network performance and reliability in the coming years. The results should also be apparent to Member States, with the provision of a reliable, fast and accessible service.

\- Richard Dixon

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COMPUTER USER TRAINING COURSE

The Centre is offering a computer user training course for Member States' personnel and ECMWF staff from 7-25 October 1991. Full information and a request for nominations has been sent out.

The course is divided into three one-week modules, and attendees can register for each module separately.

Week 1 An introduction to UNIX is offered, for those who have no knowledge of this operating system.

Week 2 Covers UNICOS extensions to UNIX, ECMWF utilities and the ECFILE file system.

Week 3 MARS and MAGICS; MARS is ECMWF's meteorological archive system, MAGICS is a meteorological graphics package.

As before, each week will consist partly of lectures and partly of practicals. In more detail, the three modules will consist of:

MODULE 1 (7 - 11 October 1991) UNIX

Introduction to UNIX history and basic structure
Introduction to the file system
Basic commands
File manipulation and attributes
I/O commands
Basic shell scripts
More advanced shell script handling.

MODULE 2 (14 - 18 October 1991) ECMWF'S UNICOS Service

System and hardware overview
UNICOS batch jobs
FORTRAN under UNICOS
ECFILE file storage system
Specialist file services, including sendtm.

MODULE 3 (21 - 24 October 1991) MARS & MAGICS

MARS
- Overview
- MARS data
  - Data format
  - Archive contents
- MARS utility
  - System description
  - User interface.

MAGICS
- Introduction and overview
- Concepts
  - Parameters
  - Subroutines
  - Action and pseudo-action routines
- Data input
- Plotting features
- MicroMAGICS.

- Andrew Lea

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STORAGETEK SILO INSTALLATION

In December 1990, the ECMWF Council approved the purchase of 4 automatic tape cartridge libraries (or silos) manufactured by StorageTek, with delivery to take place in 3 phases, in May 1991, May 1992 and May 1993.

The first phase involved the installion of two silos, each silo having 8 3480 cartridge transports. The two silos are connected by a pass-through port (also known colloquially as a "cat flap") so that cartridges can be moved robotically between them. Thus, to the system, the two silos appear as one.

Preparation really began with the relabelling of the cartridges. Each cartridge must have a label which is readable to both humans and machines. To achieve this the label is divided in halves, one being human readable and one a bar code. The Centre's requirements were slightly unusual in that a high quality standard bar code label was needed, and some time was spent negotiating this with the suppliers. Thereafter, StorageTek employed 6 staff for 4 weeks to relabel 26000 cartridges with the new labels.

The silos were delivered on Monday 15 April. As they measure 3.35 metres in diameter and 2.35 metres in height, a large volume of equipment was expected. In addition, however, since the silos are delivered "packed flat" a floor space of around 50 square metres was needed, plus a 12-metre long road trailer outside the building to take all the packaging.

StorageTek do not pre-assemble the silos at their manufacturing plant. Instead each mechanical component is tested there and the components which effectively make up the box and cartridge racking are assembled when they reach the customer. This method normally works well and the installation at ECMWF was no exception.

The first task was to assemble the floor panel and ensure that it was completely level. This is essential to the operation of the silo, and took almost the whole of the first day of installation. Then the walls were erected and the roof fitted. Since the dimensions of the silo are critical, it must be accurately constructed. It took three days in all to instal the two silos.

On Thursday 18 April the tape cartridge drives and controllers arrived and work began on their installation. At the same time the task of fitting the racks began. Nearly 600 racks had to be bolted into position; each rack has slots for 20 cartridges, and there are 11524 slots altogether!

By 1 May the equipment was ready for a 24-hour provisional acceptance test which was completed late on 2 May; it is currently undergoing a 30-day acceptance test.

Although the silos can hold a total of 2.3 terabytes of data, the tape library at the moment consists of around 6.5 terabytes. So, the tape cartridges which are put into the silos have to be carefully selected.

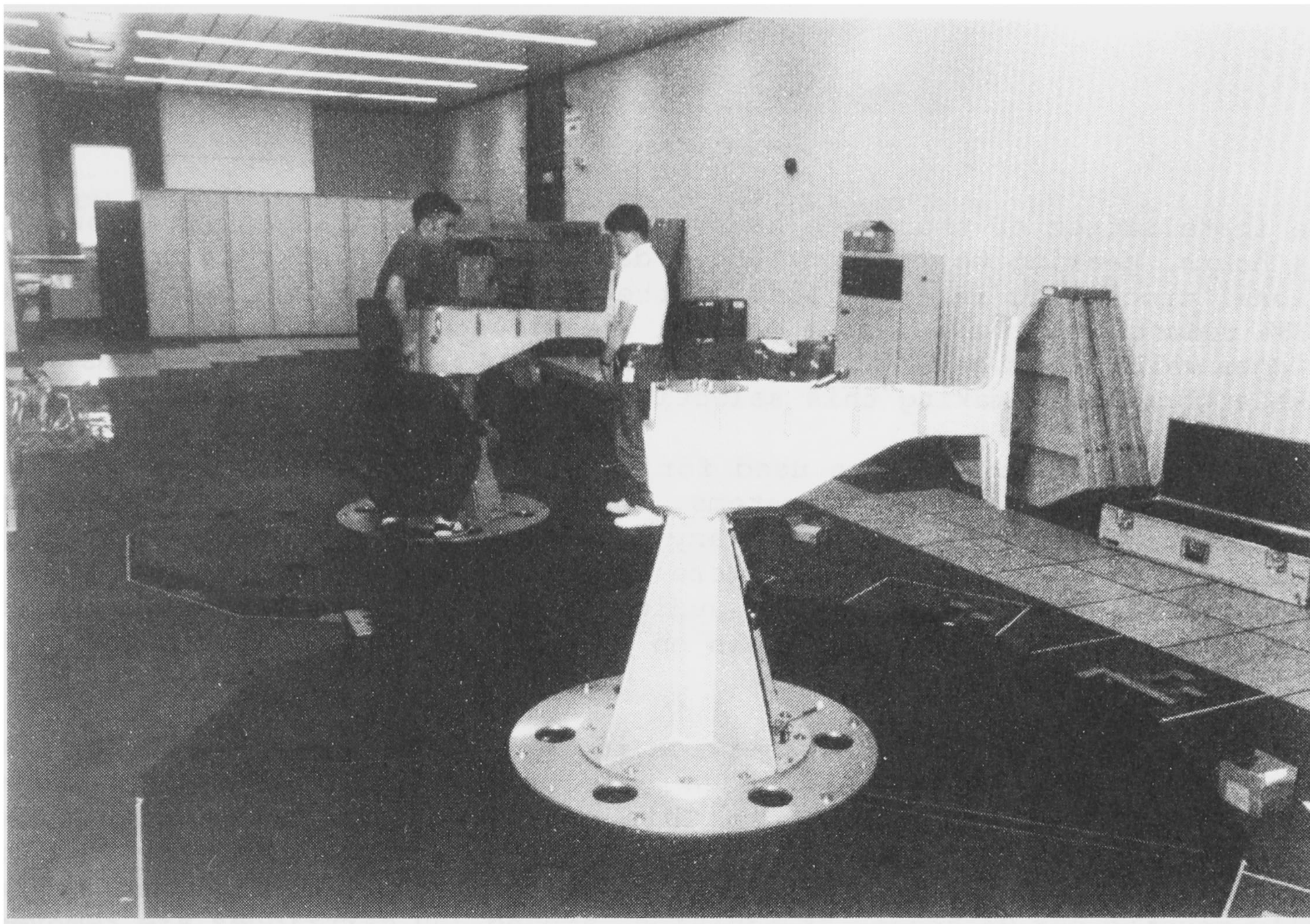

Fig. 1: The assembled floor panels of the two StorageTek silos

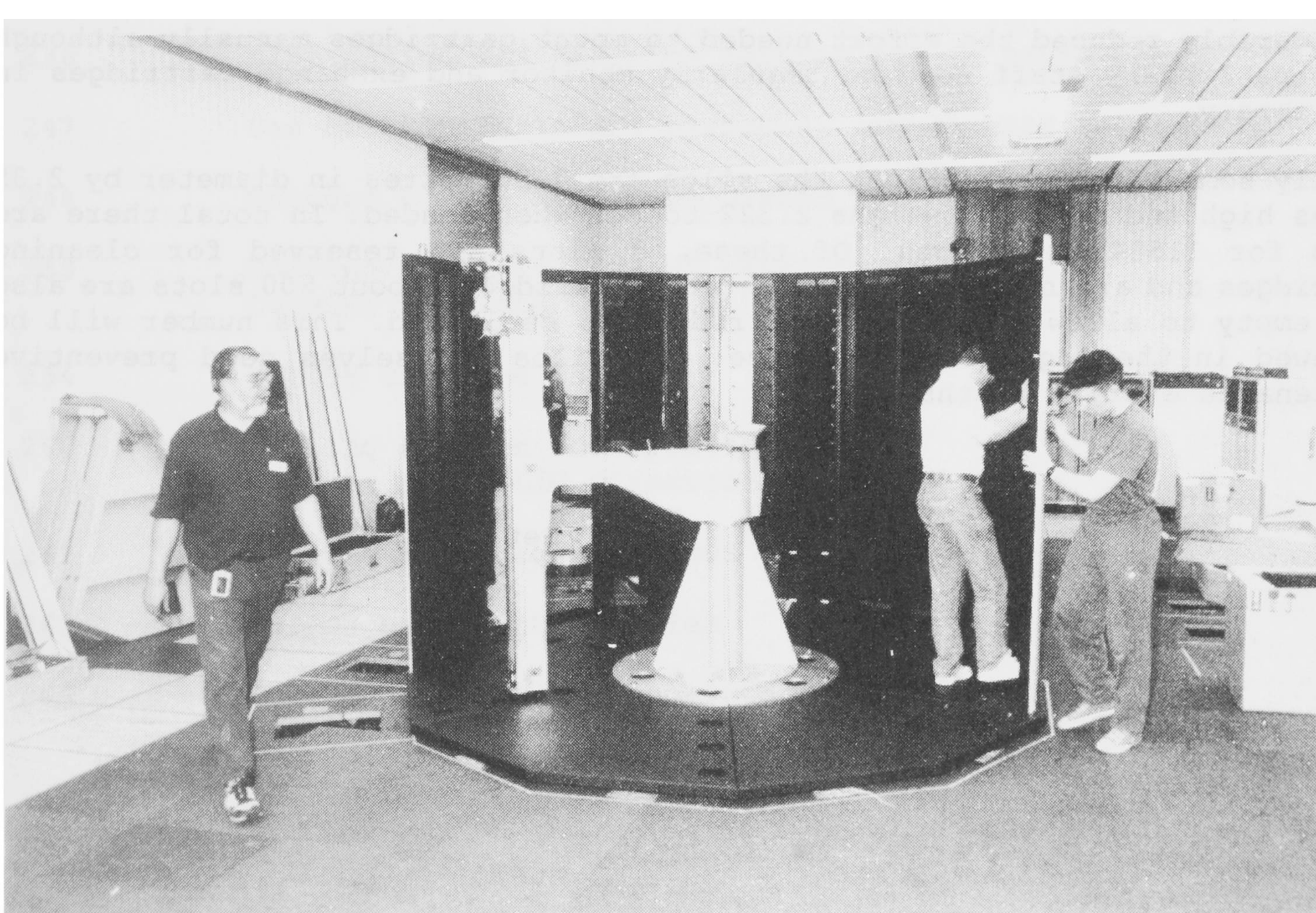

Fig. 2: The walls of the silos being fitted into place

Before installation of the silos an average of 1100 cartridges were mounted per 24 hours, peaking to 1500 or 1600 a day at the start of each month when additional processing is done. Loading the silos randomly would only result in a 33% reduction in manual tape mounts. The difficulty was in selecting the cartridges which would be mounted most frequently. Fortunately statistics were available to help in making this selection.

On 7 May the silos began to be used for various housekeeping tasks such as backups of the CFS and MARS systems. This gave some experience and an opportunity to discover and sort out any problems with the system. On 11 May, 13 people spent three hours loading more than 1000 cartridges into the silos. After the loading was complete an audit of the contents was made, which involved reading the bar coded labels on all the cartridges, and which took five hours.

Once the silos had been put into service it remained to be seen whether the correct range of cartridges had been selected. Almost immediately three cartridges had to be manually mounted. This was disappointing, but after these three, fewer than 10 cartridges had to be manually mounted during the rest of the weekend. Since then an average of 15 - 20 cartridges have had to be manually mounted per 24 hours. In addition, around 200 cartridges are removed from, and added to, the silo daily as part of the housekeeping process.

Early experiences with the silos have been very encouraging. We have considerably reduced the effort needed to mount cartridges manually although the tape library staff need to regularly monitor and exchange cartridges in the library.

Finally some vital statistics: the silos are 3.35 metres in diameter by 2.35 metres high and each one weighs 2.322 tonnes when loaded. In total there are slots for 11524 cartridges. Of these, 8 slots are reserved for cleaning cartridges and around 5 slots for testing cartridges. About 200 slots are also kept empty to allow additional cartridges to be loaded. This number will be reviewed in the light of experience. The silos themselves need preventive maintenance every 6 months.

\- Peter Gray

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STILL VALID NEWS SHEETS

Below is a list of News Sheets that still contain some valid information which has not been incorporated into the Bulletin set or republished in this Newsletter series (up to News Sheet 266). All other News Sheets are redundant and can be thrown away.

No.	Still Valid Article
204	VAX disk space control
205(8/7)	Mispositioned cursor under NOS/VE full screen editor
207	FORMAL changes under NOS/VE
212	MFICHE command from NOS/VE
214	NAG Fortran Library Mark 12 News Sheets on-line
224	Job information cards
230	Access to AB printer via NOS/VE CDCNET
235	VAX public directory - how to create
236	Alternative VAX graphics service for in house users
247	Use of CFSPATH/TARGET parameter within MARS retrievals
248	Changes to the Meteogram system
253	Copying/archiving NOS/VE catalogs to ECFILE Copying complete UNICOS directories to ECFILE
254	UNICOS carriage control
260	Wasting time on incomplete plots Changes to PUBLIC directories for VAX users
261	Meteogram system on UNICOS
263	UNICOS batch job examples
265	Lost UNICOS outputs submitted via RJE or VAX Microfiche changes
266	Reminders on how to import/export magnetic tapes

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THIRD WORKSHOP ON METEOROLOGICAL OPERATIONAL SYSTEMS

18 - 22 November 1991

Introduction

The planned biennial **Workshop on Meteorological Operational Systems**, to be held at ECMWF 18-22 November 1991, will be the third in the series. Much progress has been made over the years in developing the operational forecasting systems at ECMWF both from a meteorological and from a data management and processing point of view. Improved standards in computing, data communication, visualisation and formats have enabled the meteorological community to develop effective operational systems to generate, process, monitor and visualise data from global models and the global observing system. In particular, the introduction of a new generation of supercomputers and workstations based on common platforms, such as UNIX, NFS and X-Windows, paves the way for the development of operational systems, which are expected to have a high degree of commonality and portability.

The workshop will review the state of the art of meteorological operational systems and address future trends in the use of medium-range forecast products, data management and meteorological workstations.

USE AND PREDICTIVE SKILL OF NUMERICAL FORECASTS IN THE MEDIUM RANGE

The results of objective verification and subjective evaluation indicate that medium-range forecast products have now reached a high level of skill. The routine use of a wide range of model products as guidance for weather forecasting over and beyond a week has become an operational practice in most of the Member States. However, a number of problems remain as a matter of concern for the operational use of medium-range forecast products. Over the past years, ECMWF has addressed the issue of predictability as one of its main research activities. Member States are invited to present their views on, and expectations from, the predictive skill of medium-range forecast guidance.

OPERATIONAL DATA MANAGEMENT SYSTEMS

Experiences with the migration of meteorological applications to UNIX will be presented, illustrating particular applications which successfully exploit the UNIX facilities. The key to efficient meteorological application is the ability to access the data required. Recent attention has focused on the commercial data bases. Their advantages and disadvantages compared with the traditional "home made" data base systems will be presented. Also included will be items on data archiving, and the maintenance and enhancement of facilities for data dissemination. The use of high level languages and design standards to facilitate the portability of software systems will be highlighted.

METEOROLOGICAL WORKSTATION SYSTEMS

Meteorological workstation systems already exist in many services and development is in progress or planned in others. These systems give interactive access to relevant information for operational and research purposes. In addition, the availability of X-based Graphical User Interfaces (GUI), e.g. Motif and Xview, makes it possible to implement user-friendly interfaces that are portable across platforms. Current and planned meteorological workstation systems from both meteorological services and commercial companies will be presented.

- Horst Böttger

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ECMWF CALENDAR 1991

11-14 June	Symposium: Use of NWP products in medium-range weather forecasting in Europe
18-19 June	Council - 34th session
26 August	***ECMWF holiday***
9-13 September	Seminar: Numerical methods in atmospheric models
16-18 September	Workshop: Fine-scale modelling for parametrisation schemes
30 Sept.-2 October	Scientific Advisory Committee - 19th session
2-4 October	Technical Advisory Committee - 16th session
7-24 October	Computer User Training Course
8-10 October	Finance Committee - 47th session
13-15 November	Workshop: Predictability
18-22 November	Workshop: Meteorological operational systems
3-4 December	Council - 35th session
24-26 December	***ECMWF holiday***

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ECMWF PUBLICATIONS

Technical Memorandum No. 175	Use of SATOB satellite winds in a variational analysis scheme
Technical Memorandum No. 176	A fast radiative transfer model for satellite sounding systems
Technical Memorandum No. 177	Atmospheric instability and ensemble weather prediction February 1991
Technical Memorandum No. 178	Four dimensional variational data assimilation using the adjoint of a multilevel primitive equation model

ECMWF/WCRP Workshop on Clouds, Radiative Transfer and the Hydrological Cycle

Forecast and Verification Charts to 30 November 1990

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INDEX OF STILL VALID NEWSLETTER ARTICLES

This is an index of the major articles published in the ECMWF Newsletter plus those in the original ECMWF Technical Newsletter series. As one goes back in time, some points in these articles may have been superseded. When in doubt, contact the author or User Support.

METEOROLOGY (cont.)

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* T indicates the original Technical Newsletter series

USEFUL NAMES AND 'PHONE NUMBERS WITHIN ECMWF

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Head of Operations Department	- Michel Jarraud	OB 010A	2003
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Other methods of quick contact:	- Telex (No. 847908)		
	- Telefax (No. 869450)		
	- VMS MAIL addressed to ADVISORY		
REGISTRATION			
Project Identifiers	- Pam Prior	OB 225	2384
User Identifiers	- Tape Librarian	CB Hall	2315
COMPUTER OPERATIONS			
Console	- Shift Leaders	CB Hall	3333
Reception Counter	- Tape Librarian	CB Hall	2315
Tape Requests	- Tape Librarian	CB Hall	2315
Terminal Queries	- Norman Wiggins	CB 028	2308
Telecoms Fault Reporting	- Michael O'Brien	CB 035	2306
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LIBRARIES (ECLIB, NAG, etc.)	- John Greenaway	OB 226	2385
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Operations Section Head	- Bernard Strauss	OB 004	2420
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	- Anders Persson	OB 002	2421
	- Alex Rubli	OB 003	2425
Meteorological Operations Room	-	CB Hall	2426/7
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Systems Software Section Head	- Claus Hilberg	CB 133	2350
User Support Section Head	- Andrew Lea	OB 227	2380
Computer Operations Section Head	- Peter Gray	CB 023	2300
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Group Leader	- Jens Daabeck	OB 016	2375
RESEARCH DEPARTMENT			
Head of Research Department	- Anthony Hollingsworth	OB 119A	2005
Computer Co-ordinator	- David Dent	OB 123	2702

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* CB - Computer Block   OB - Office Block

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