European Centre for Medium Range Weather Forecasts

ECMWF NEWSLETTER

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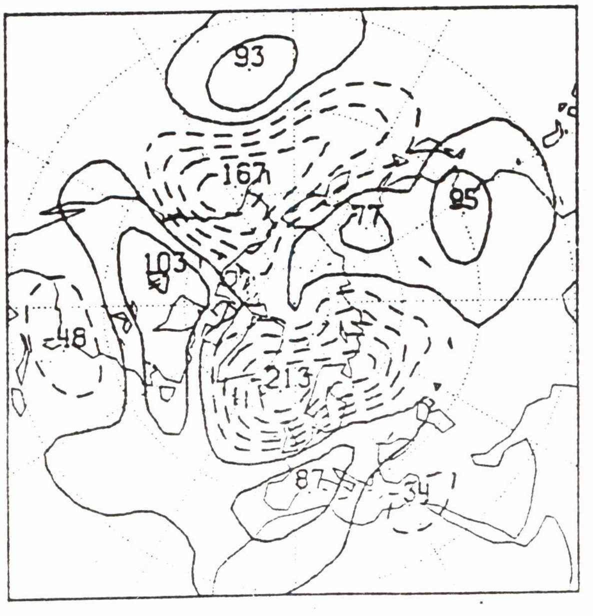

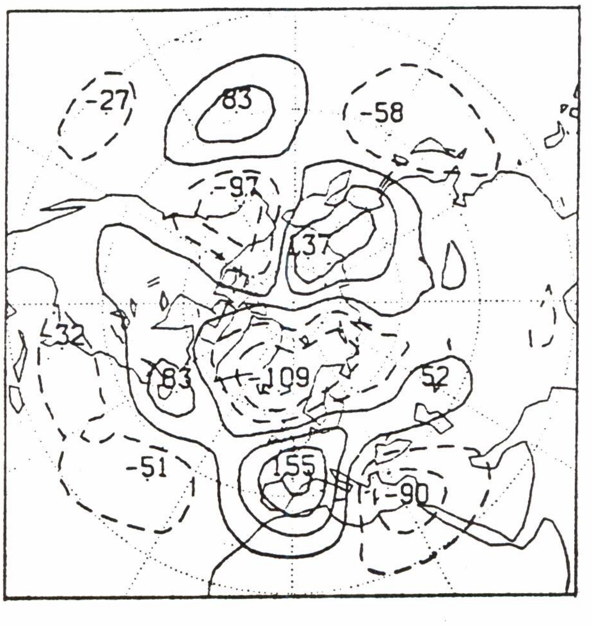

IN THIS ISSUE **Page**

METEOROLOGICAL

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GENERAL

COVER: Tropical-extratropical interaction and its impact on predictability (see article on page 3): 'Systematic' error in 500 mb height for days 11-20 for control forecasts (above) and integrations with tropics relaxed towards analyses (below), obtained by averaging the 4 respective forecast errors together. Contour interval 40m.

This Newsletter is edited and produced by User Support.

The next issue will appear in December 1989.

The affect of the uncertainty of predicting the weather patterns in the tropics on the skill of forecasting the flow in mid-latitude is highlighted in the first article in this issue. It deals with some experiments that were conducted on the impact of the tropics on the extratropics in a NWP model, and concludes that skilful prediction of the large-scale tropical flow is a pre-requisite for extratropical extended-range prediction. The second article highlights how bad wind observations from moored buoys in the tropical oceans caused problems in the ECMWF operational analysis.

ECMWF staff can now send, and be sent, messages through the EARN/Bitnet network. An outline of the service is given on page 20.

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CHANGES TO THE OPERATIONAL FORECASTING SYSTEM

Recent changes

(i) The surface analysis code was replaced on 16 August 1989. It was mainly a technical development, the analysis of surface variables now being performed inside the context of the main analysis program rather than in a separate step. Little meteorological impact should be seen on the sea surface temperature (SST) and snow analysis (the only surface variables currently analysed).

(ii) Various modifications to the analysis were implemented on 29 August 1989, the most significant of these being

(a) a tighter first-guess check for AIREPs reporting zero wind speed;

(b) assigning single level pressure (height) observations to the first-guess pressure level instead of the reported pressure - this will remove spurious analysis increments in the temperature of the lowest model level;

(c) rather than having a uniform global threshold the SATEM stability check will be made dependent on the first-guess error standard deviation.

Planned changes

(i) The SST analysis will use as input the 2 degree mesh SST analysis from NMC Washington (instead of the 5 degree mesh) so more details should be seen in this field.

(ii) Modifications will be made to the surface and sub-surface parametrisation scheme in the forecast model. These involve changes to the formulations of vegetation resistance, snow properties and roughness length over land. Minor impact on surface temperature and precipitation is expected.

- Alan Radford

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TROPICAL-EXTRATROPICAL INTERACTION ASSOCIATED WITH THE 30-60 DAY OSCILLATION AND ITS IMPACT ON MEDIUM- AND EXTENDED-RANGE PREDICTABILITY

1. Introduction

The work described in this article was motivated by the need to quantify the extent to which forecasts of extratropical large- scale flow were being impaired by our relatively poor forecast skill in the tropics. The project, conducted over the last two years and fully documented in Technical Memorandum No. 154 (also submitted to J. Atmos Sci) comprises three parts: an observational study, a mechanistic barotropic model study, and a study with the ECMWF forecast model using the so-called relaxation technique. Each part is briefly described below.

2. Observations

The purpose of the observational study was to quantify modes of low-frequency variability of the large-scale tropical flow, and to correlate them with large-scale variability in the extratropics. To do this we used tropical outgoing longwave radiation (OLR) data and northern hemisphere 500 mb data from seven winters (1980/81 to 1986/87). The OLR data is a good proxy for tropical convective activity and upper tropospheric divergence.

The seasonal cycle and interannual variability were removed from the OLR data, and the seasonal mean subtracted. An empirical orthogonal function (EOF) analysis was then performed on the OLR data. The first two EOFs (explaining about 30% of variance of 5-day mean fields) describe the 30-60 day oscillation (Madden and Julian, 1971) which is known to be a dominant mode of variability of the large-scale tropical flow.

Fig. 1 shows composite maps describing this tropical oscillation in four phase-quadrature components. Most of the amplitude of the mode occurs over the Indian Ocean and Tropical West Pacific. The negative contours correspond to reduced OLR and therefore a tendency for enhanced convective activity and upper divergence. In our data analysis, the oscillation has a mean period close to 48 days.

Fig. 2 shows a composite of 500 mb height anomaly. The compositing criterion was exactly the same as used in Fig. 1 (so, for example, the second EOF of OLR corresponding to every member of Fig. 2a was greater than one standard deviation). The anomaly patterns shown in Fig. 2 bear some resemblance to well known modes of variability of the northern hemisphere flow; for example the patterns in Fig. 2b,d project onto the so-called Pacific North American (PNA) mode, whilst the patterns in Fig. 2a,c have some projection onto the North Atlantic Oscillation (NAO) mode (Wallace and Gutzler, 1981).

3. Mechanistic Model Integrations

Rather than test the significance of the apparent correlation between the tropical 30-60 day mode, and teleconnection patterns in the extratropics, we decided to test the significance dynamically.

In order to do this, we ran a time-dependent barotropic model with two forcing functions. The first forcing was time independent, and ensured that the observed zonally varying climatological wintertime 300 mb flow satisfied the time-independent barotropic vorticity equation. The second time-dependent forcing was obtained from the observed EOfs of OLR described above; hence it represented the vorticity forcing associated with the tropical 30-60 day oscillation. The model was run through 8 cycles of 48 days, and results composited over the 8 cycles.

Fig. 3 shows the response of the model in the extratropics. Agreement with the observations in Fig. 2 is not perfect, though, in common with the observations, it can be seen that associated with the four phase-quadrature components of the forcing, the extratropical response projects onto the NAO mode (Figs. 3d,h), and onto the PNA mode (Fig. 3b,f).

In order to rationalise these results, we have compared this forced response with the dominant free barotropic mode of the zonally varying climatological 300 mb flow - the so-called SWB mode (named after the authors of Simmons et al, 1983). The SWB mode has a period of 45 days, and it too oscillates between the NAO and PNA modes. In order to optimally excite the SWB mode, it should be forced with a pattern that is correlated with the mode's adjoint structure. The SWB adjoint mode (also with 45 day period) has most of its amplitude over the Indian Ocean-West Pacific region, and the vorticity forcing associated with the observed composites of OLR shown in Fig. 1 certainly project positively onto this adjoint mode.

4. Forecast relaxation experiments

Motivated by these results, we decided to perform a series of forecast experiments using the ECMWF model, during periods when the 30-60 day oscillation was active. Four initial conditions were chosen. For each initial condition, five 20-day integrations were made: a control forecast, an integration in which the tropics was relaxed to the verifying analysis (i.e. a perfect tropical forecast), an integration in which the tropics was relaxed to the initial conditions (i.e. a persistent tropical forecast), and two further forecasts in which the extratropics were relaxed to the verifying and initial conditions respectively.

The relaxation technique has been used before at ECMWF, and consists of adding a fictitious linear relaxation term to the equations of motion. The coefficient of relaxation is a function of latitude and is allowed to vary smoothly between regions of no relaxation and fast relaxation.

a) Composite results

First we show diagrams giving forecast skill scores averaged over the four cases. We used three verification areas, each 120 degrees of longitude in extent: the "Atlantic" (90W-30E), "Asia" (30E-150E) and the "Pacific" (150E-90W). For the tropical relaxation experiments, the verification is performed within latitudes (30N-90N). For the extratropical relaxation experiments, the verification is performed within latitudes (20N-20S). The verification is performed only on fields truncated to T15.

In order to compare directly scores in the tropics and extratropics, it was decided to verify the forecasts in terms of anomaly correlation coefficient of 5-day mean 200 mb vorticity (and in addition, in the tropics, 200 mb divergence). These scores are shown in Fig. 4, averaged over all four experiments. The left hand column shows extratropical vorticity scores; the middle column shows tropical vorticity scores; the right hand column shows tropical divergence scores. Scores for the control forecast are shown as solid lines; scores for the experiments with relaxation towards the analysis are shown as dotted lines; scores for the experiments with relaxation towards initial conditions are shown as dashed lines.

From the left hand column, it can be seen that the biggest impact of tropical relaxation is in the Pacific region. Beyond day 10, the anomaly correlation coefficient in this region is about 0.3 for the control integration. With the tropics relaxed to the verifying analyses, the extratropical Pacific scores increase to about 0.5. With the tropics relaxed to the initial analysis, the Pacific scores decrease to about 0.1.

On average, the impact of relaxation over the extratropical Asian region is less pronounced than over the Pacific, and the impact of relaxation over the Atlantic appears to be smallest of all three areas. The relatively large impact over the Pacific region is to be expected, both from the observational data analysis, and from the results of Simmons et al (1983).

In the tropics, it can be seen from the centre and right hand columns that the impact of relaxation in midlatitudes is more pronounced on the nondivergent flow than on the divergent flow. As far as the regions are concerned, the impact of relaxation on 200 mb vorticity scores is equally large in the tropical pacific and Asian regions, and it is at least as strong as the impact in northern extratropics. One should also note that (with the exception of the tropical divergent flow in the Asian sector) forecasts with relaxation to the initial conditions are consistently less skilful than control forecasts, which is a further indication of a reciprocal interaction between tropical and extratropical low-frequency variability.

Fig. 5 shows the impact of tropical relaxation on 'systematic error' in extratropical 500 mb height. The control 'systematic error' is defined as the average error from days 11-20 over the four experiments and is shown in Fig. 5. It can be seen that there are two major negative centres over the north Pacific and north Atlantic, and positive height errors over north America, Europe and east Asia.

The day 11-20 extratropical systematic error in the experiments with the tropics relaxed to the verifying analysis is shown in Fig. 5. There is a large reduction in the magnitude of the negative north Pacific centre from 167m to 97m. Similarly, the systematic error over north America is also reduced. Over the Euro/Atlantic region, there is a marked reduction in the magnitude of the negative height anomaly over the north east Atlantic, but an increase in the positive height anomaly over Europe. As a result, the gradient in height error over the UK is not substantially reduced. This result, as well as the occasional decrease of skill scores over the Euro/Atlantic observed in some tropical relaxation experiments, suggests that over this region, extratropical errors might be locally compensated by tropical errors. Overall, however, it can be seen that with perfect tropical prognosis, the model extratropical systematic error can be reduced substantially on a time scale of 10 to 20 days.

The impact in the tropics of relaxation to the extratropical analysis is not shown. However, the largest impact is on the nondivergent flow, where systematic errors over the east Pacific are significantly reduced. By contrast, the impact of extratropical relaxation on systematic error in velocity potential is much weaker.

b) Individual cases of tropical relaxation

We show in Fig. 6, maps of 500 mb height for day 16-20 of the control integration (left column), the integration with relaxed tropics (middle column), and the verifying analysis (right column), for each individual case.

The verifying analysis for the 4 December 1984 case (first row) shows a split flow over eastern Europe (which had developed from a strong ridge in the preceding pentad) and a weak, broad ridge over the Pacific, indicating an elongated wavenumber two pattern to the flow overall. The control integration is clearly poor in all respects. The relaxed integration, on the other hand, has captured approximately the split European flow, and the positive height centre near 60E, 50N is simulated accurately. There is a weak ridge over the mid-Pacific, though its strength and position is not accurately reproduced.

The analysis for the 25 December 1984 case (second row) shows a northeast-southwest oriented ridge over the east Atlantic and the west coast of Europe with a cut-off low over eastern Europe. The control integration has weak counterparts to these features. However, in the relaxed integration, they are both strongly enhanced. Indeed over the British Isles, the relaxed experiment has developed an isolated maximum in geopotential height.

The analysis for the 22 January 1985 case is shown in the third row. The ridge over the Atlantic in the previous pentad has strongly weakened and the ridge over the Gulf of Alaska in the previous pentad has been replaced by a trough (not shown). In the relaxed experiment, the east Atlantic ridge is fairly strong, and the mid-Pacific ridge is too weak. However, the trough over the Gulf of Alaska is well simulated, and overall the flow is clearly superior to the control simulation.

The analysis for the 19 January 1986 case (fourth row) shows the intense dipole blocking discussed by Hoskins and Sardeshmukh (1986). Note also the strong ridge over the northeast Pacific. The European block is utterly missed in the control integration, but a significant ridge has developed in the relaxed experiment. Note also the cut-off low over southern Europe. Over the Pacific it can be seen that the relaxed experiment has simulated the strong ridge well, compared with the control integration.

Only in one of the four integrations (22 January) did we see a significant impact of tropical relaxation with respect to the control forecast in the range of days 6-10. However, for this case the EOF coefficients of OLR had very large variations between days 1 to 10.

5. Conclusions

Not many years ago, the domain of integration in most numerical weather prediction models did not include the tropics. As computational power increased, and as prediction progressed towards the medium range, it was recognised that there were occasions when the tropics had a measurable influence on the development of extratropical weather, and global models were developed. In this article we have attempted to show that, in addition, for prediction beyond the medium range, the impact of the tropics on the extratropics is typically, rather than occasionally, large.

The technique we have used to examine the impact of the tropics on the extratropics in an NWP model was through a relaxation of model fields to the verifying analysis, or initial analysis. However, the cases were chosen to occur during periods when the 30-60 day oscillation was active. These periods were identified by first performing a diagnostic analysis using observed fields of tropical OLR and extratropical geopotential height. We attempted to explain our results using barotropic theory, and idealised integrations of a barotropic model.

Parallel experiments were also run, in which extratropical fields were relaxed towards observed data, and a noticeable improvement was found on skill scores for the forecast tropical flow, in particular for its rotational component. These results are suggestive of a clear, reciprocal interaction between tropical and extratropical low frequency variability.

We conclude by stating that skilful prediction of the large-scale tropical flow is a prerequisite for extratropical extended-range prediction. Since tropical systematic errors in many NWP models are still quite sizeable, there is a requirement for considerable model improvement before extended-range forecasting can be considered viable.

- L. Ferranti, T. Palmer, F. Molteni, E. Klinker

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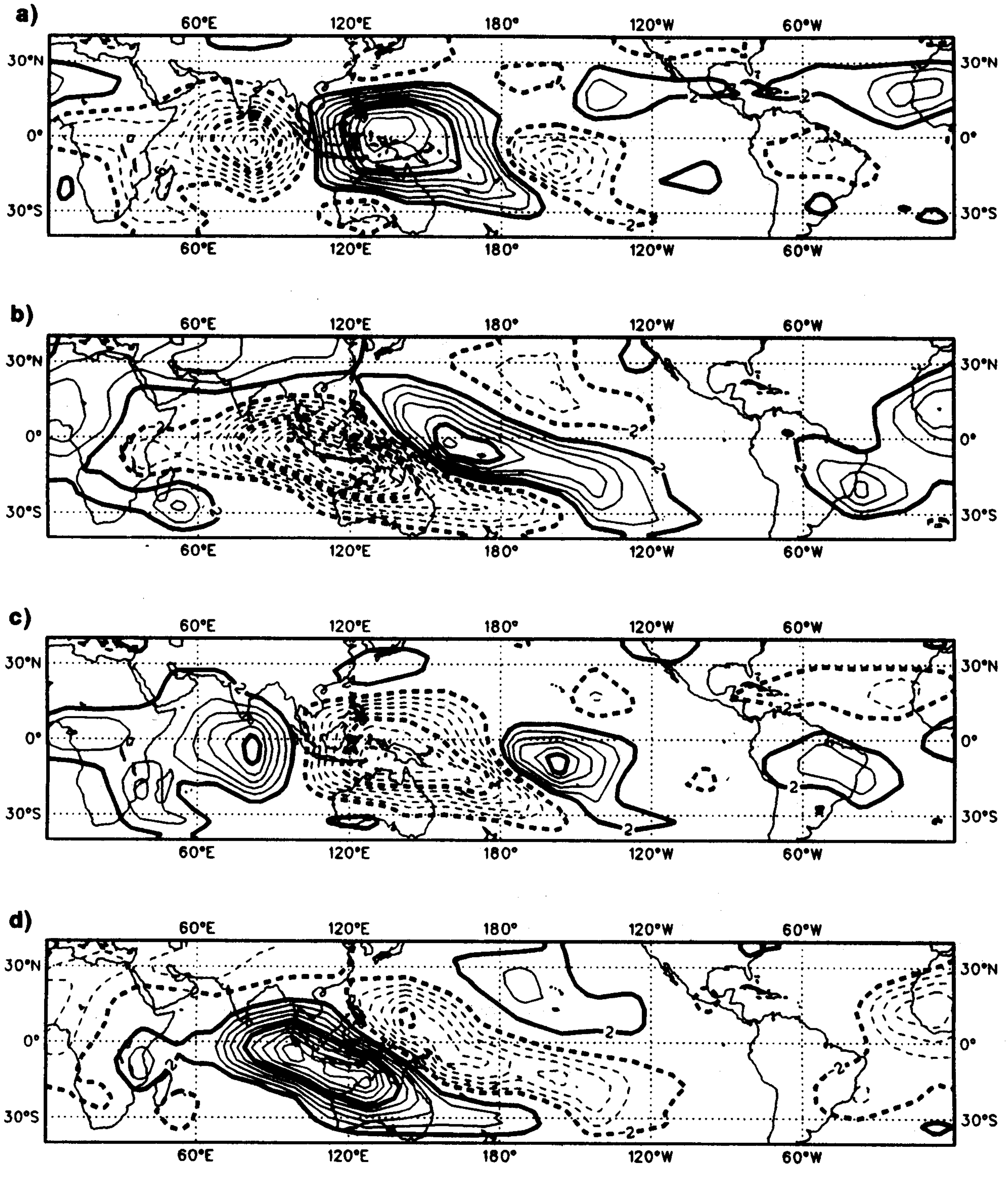

Fig. 1: Composite of OLR formed by taking from the 700 winter fields, days where a) the coefficient of the second EOF was greater than one standard deviation, b) the coefficient of the first EOF was greater than one standard deviation, c) the coefficient of the second EOF was less than minus one standard deviation, d) the coefficient of the first EOF was less than minus one standard deviation.
Contour interval 2 W/m².

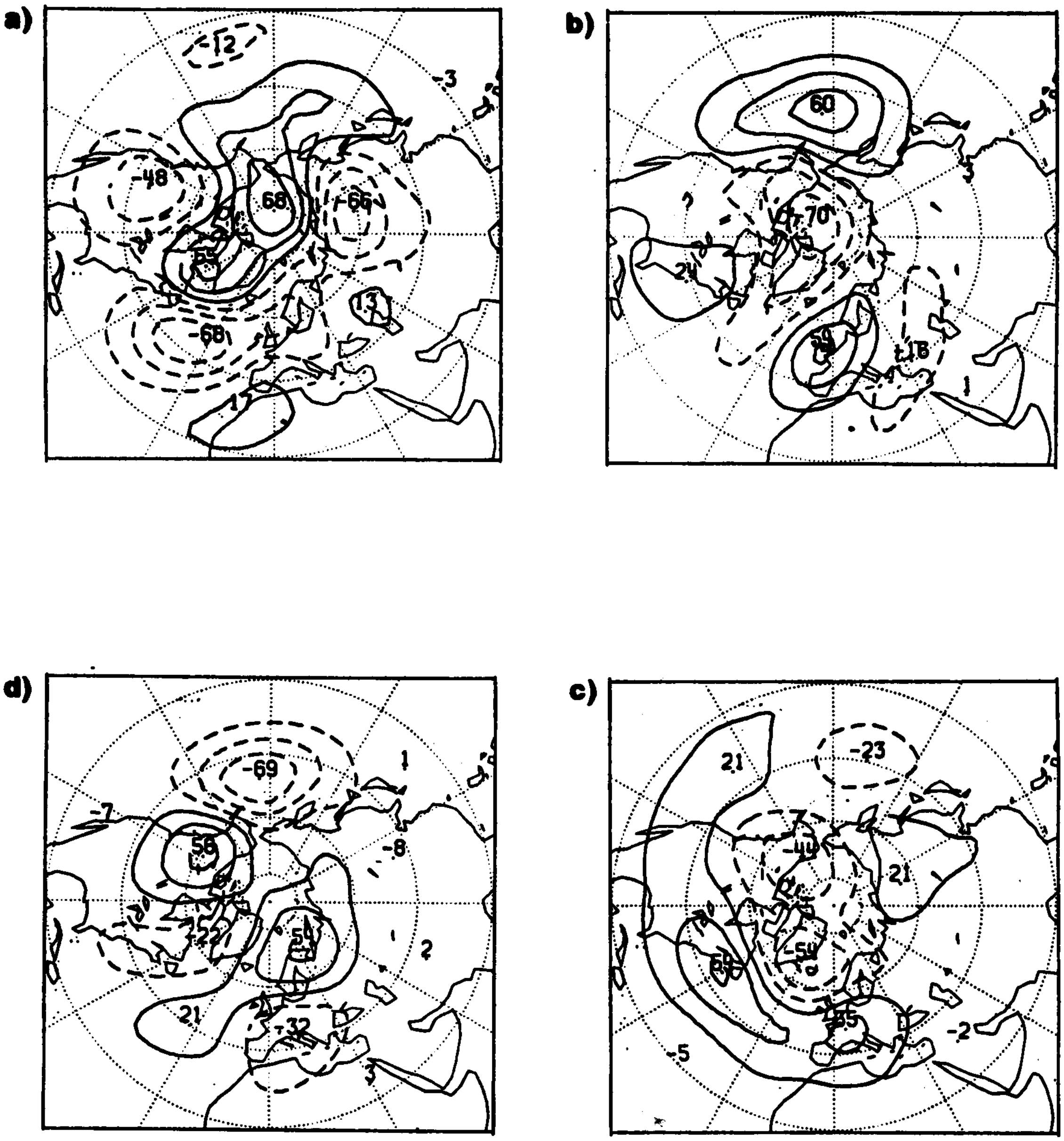

Fig. 2: Composite of extratropical 500 mb geopotential height (m) formed by taking from the 700 winter fields, days were a) the coefficient of the second EOF of OLR was greater than one standard deviation, b) the coefficient of the first EOF of OLR was greater than one standard deviation, c) the coefficient of the second EOF of OLR was less than minus one standard deviation, d) the coefficient of the first EOF of OLR was less than minus one standard deviation.
Contour interval 20 m.

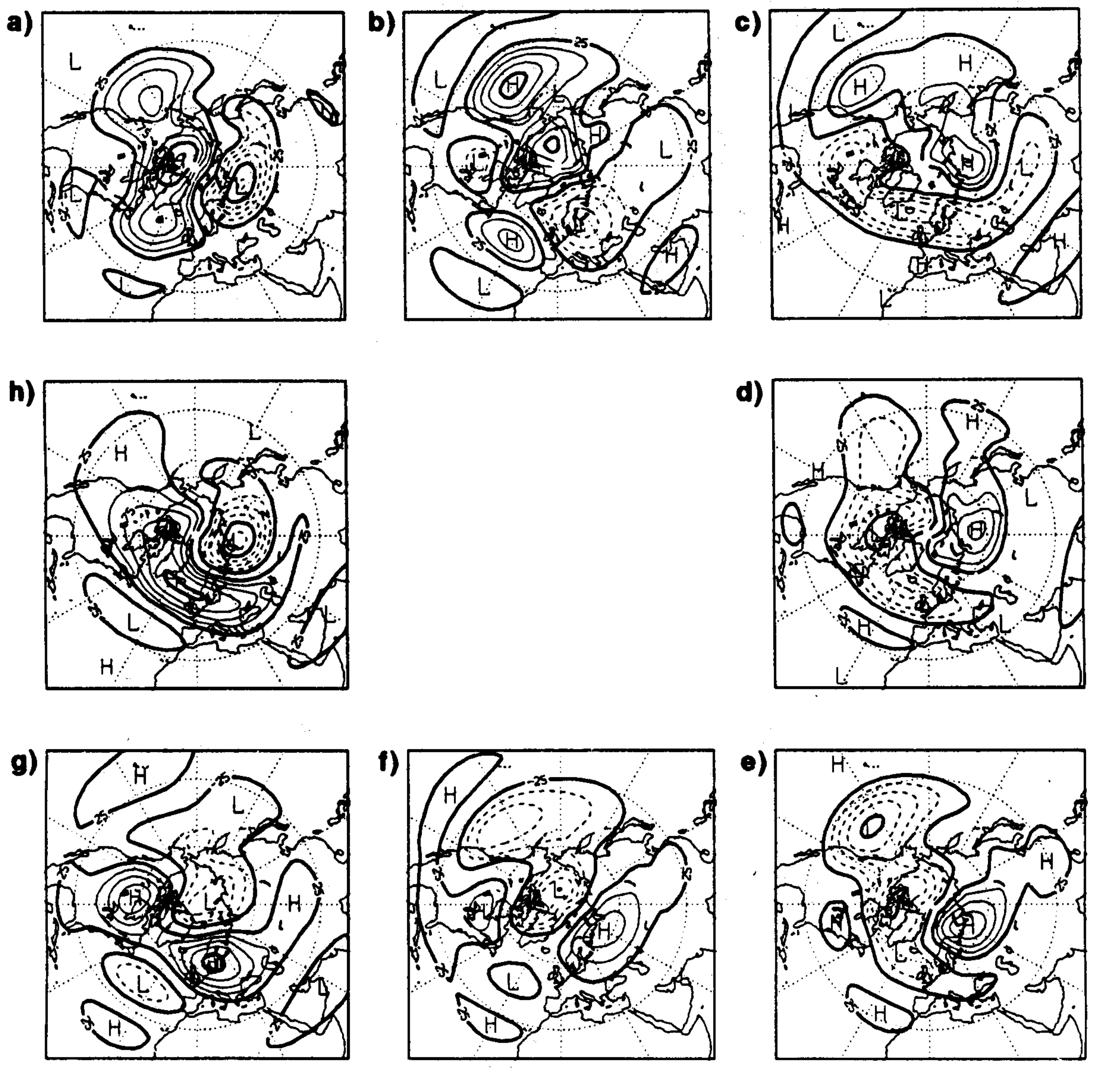

Fig. 3: Streamfunction response (multiplied by the Coriolos parameter) of a barotropic model forced using the observed EOFs of OLR describing the 30-60 day oscillation, integrated through eight 48-day cycles. a)-h) 6-day mean composites over the eight cycles. Contour interval 25 m.

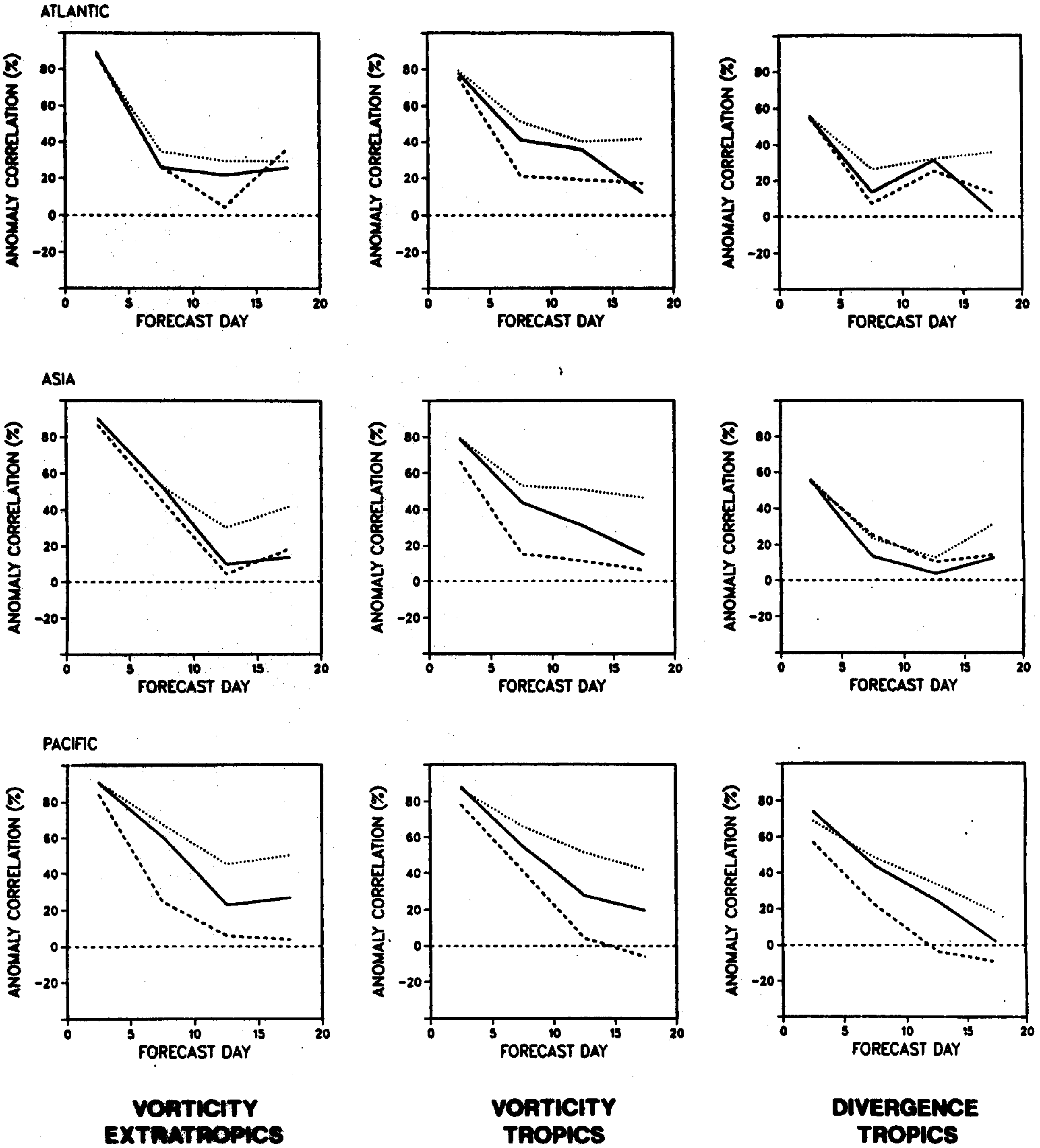

Fig. 4: Anomaly correlation coefficient of 5-day mean 200 mb vorticity, and divergence fields averaged over all four experiments. The left hand column shows extratropical vorticity scores; the middle column shows tropical vorticity scores; the right hand column shows tropical divergence scores. Scores for the control forecast are shown as solid lines; scores for the experiments with relaxation towards the analysis are shown as dotted lines; scores for the experiments with relaxation towards initial conditions are shown as dashed lines.

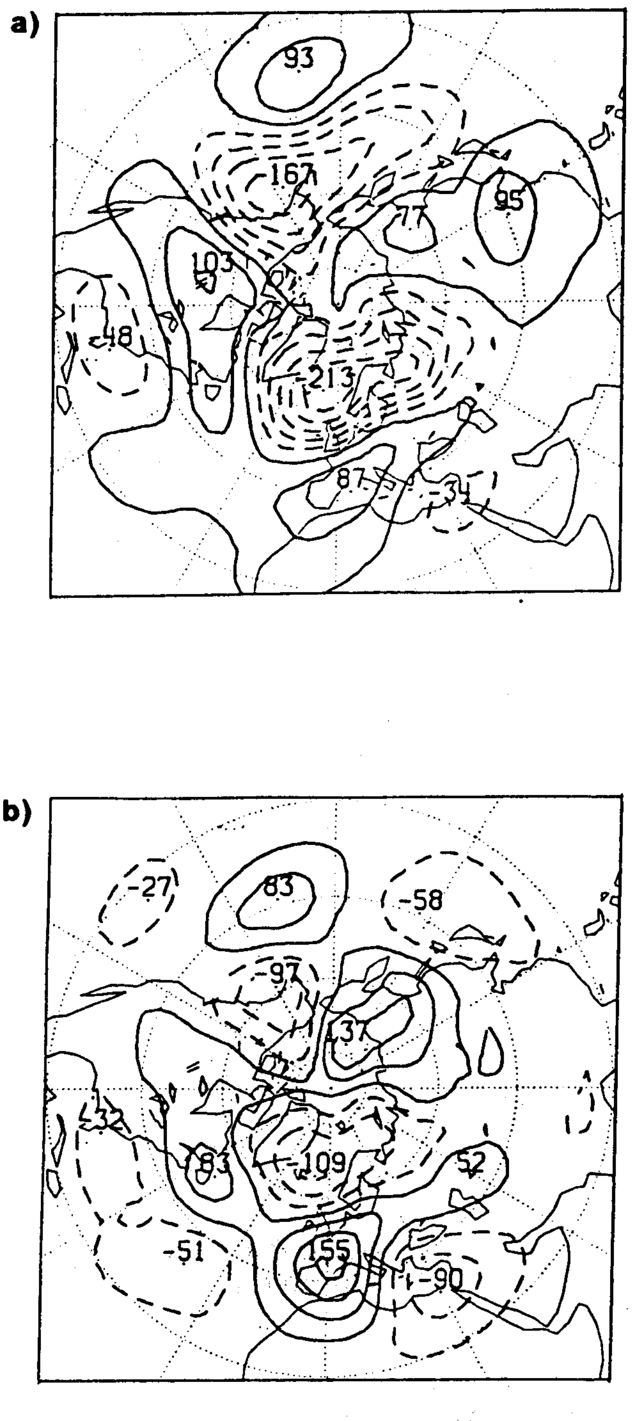

Fig. 5: 'Systematic' error in 500 mb height for days 11-20 for a) control forecasts, b) integrations with tropics relaxed towards analyses, obtained by averaging the four respective forecast errors together. Contour interval 40 m.

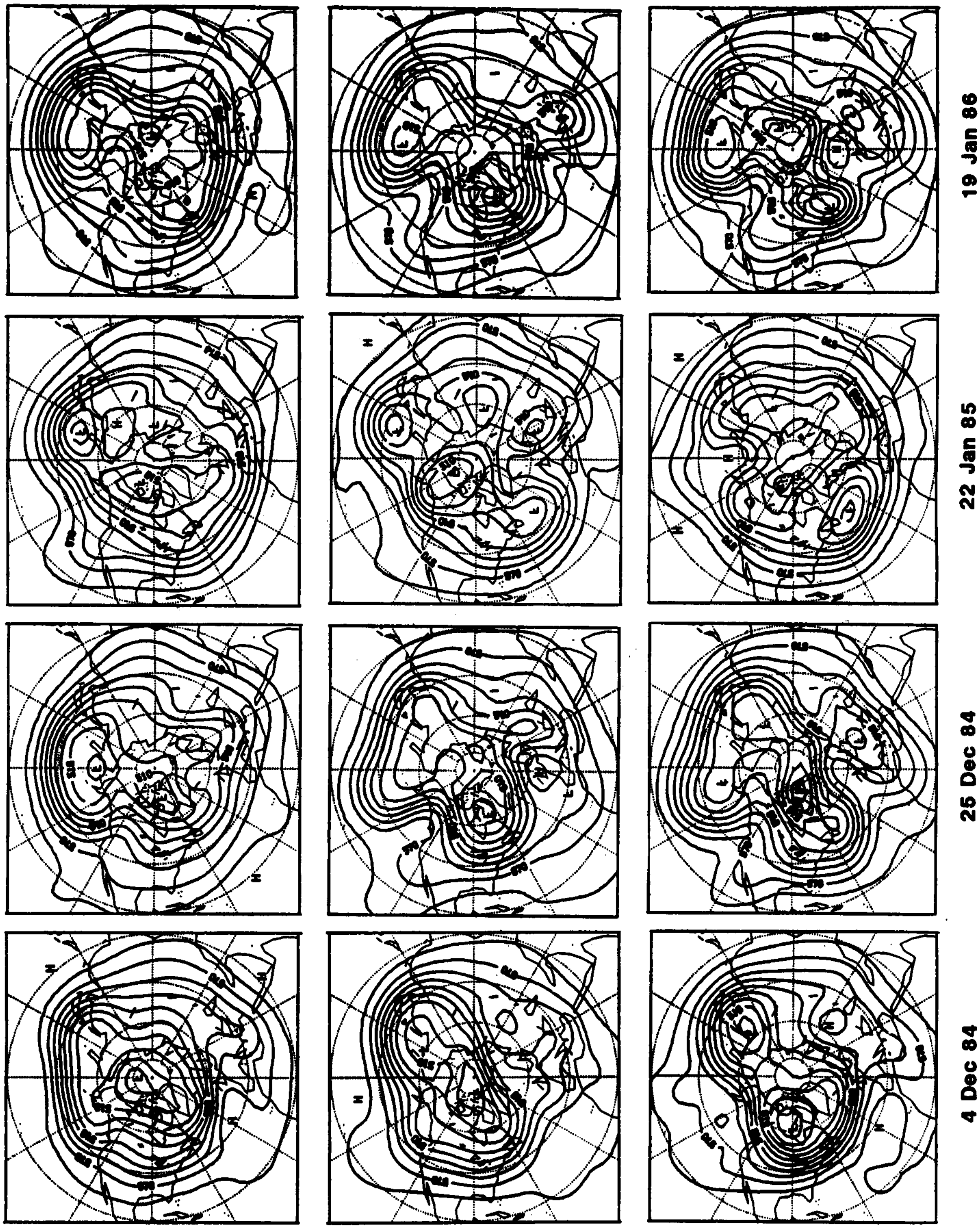

Fig. 6: Maps of 500 mb height for day 16-20 of the control integration (top row), the integration with relaxed tropics (middle row), and the verifying analysis (bottom row), for each individual case.

BAD BUOY DATA AFFECT ECMWF ANALYSIS IN THE TROPICS

Because of the poor data coverage in tropical ocean areas, bad sea surface observations may have a very negative impact on the analysis. The ECMWF tropical analyses are of particular interest for the meteorological and oceanographic community, as these analyses form the Level III Atmospheric Data Archive for TOGA. Sea surface observations of the atmosphere over the oceans are either produced by ships or by buoys. As a part of the national US-TOGA project, NOAA's Pacific Marine Environmental Laboratory (PMEL) operates a set of moored buoys (type ATLAS) in the tropical Pacific. The data are disseminated on the GTS and the wind observations used by the ECMWF data assimilation system.

ECMWF monitors regularly most of the meteorological data received over GTS. This monitoring has recently been extended to include wind observations from buoys. The usual method of evaluating the data quality is to compare the observed value with the value of the corresponding first-guess field. In the case of the PMEL observations the difference between first-guess and the reported wind directions were found to be abnormally high. A typical example is the buoy at 110W/2S: its June reports are plotted versus the corresponding first-guess values in Fig. 1a. According to the first-guess, easterly winds prevail. This is reasonable because the flow in this area is dominated by tradewinds. However, the reported wind directions are scattered around 270 degrees. Thus, the reports appear to be systematically wrong. The use of the bad data had a significant impact on the analysis, this can be documented by studying the case from 16 May 1989: in Figs. 2a and 2b the first-guess respectively the analysis field (wind arrows) are plotted together with the corresponding ATLAS-reports (wind flags). The first-guess predicts a uniform easterly wind field. The analysis adjusts the first-guess field in order to bring it as much as possible in accordance with the reported westerly winds. The easterly flow is not turned in a westerly, but the impact of the bad data causes weakening of the wind field and the uniform easterly tradewind flow is therefore disturbed in the area of the buoys.

The problem was brought to the attention of PMEL and NMC Washington where the observations are inserted onto the GTS. The problem was acknowledged and had been detected independently in the US. The wind observations were temporarily excluded from the ECMWF analysis and, at a later stage, also the transmission on the GTS was suspended.

ECMWF has since received confirmation from PMEL that Service ARGOS corrected their software which calculated wind direction on 11 July 1989. Recent monitoring results for July 1989 are displayed in Fig. 1b. The majority of the entries are now scattered around the diagonal. That means that the systematic error has disappeared and the data quality reaches now normal standards. (The data points in the upper left quadrant are related to observations in early July, i.e. before the correction was made).

- Alex Rubli

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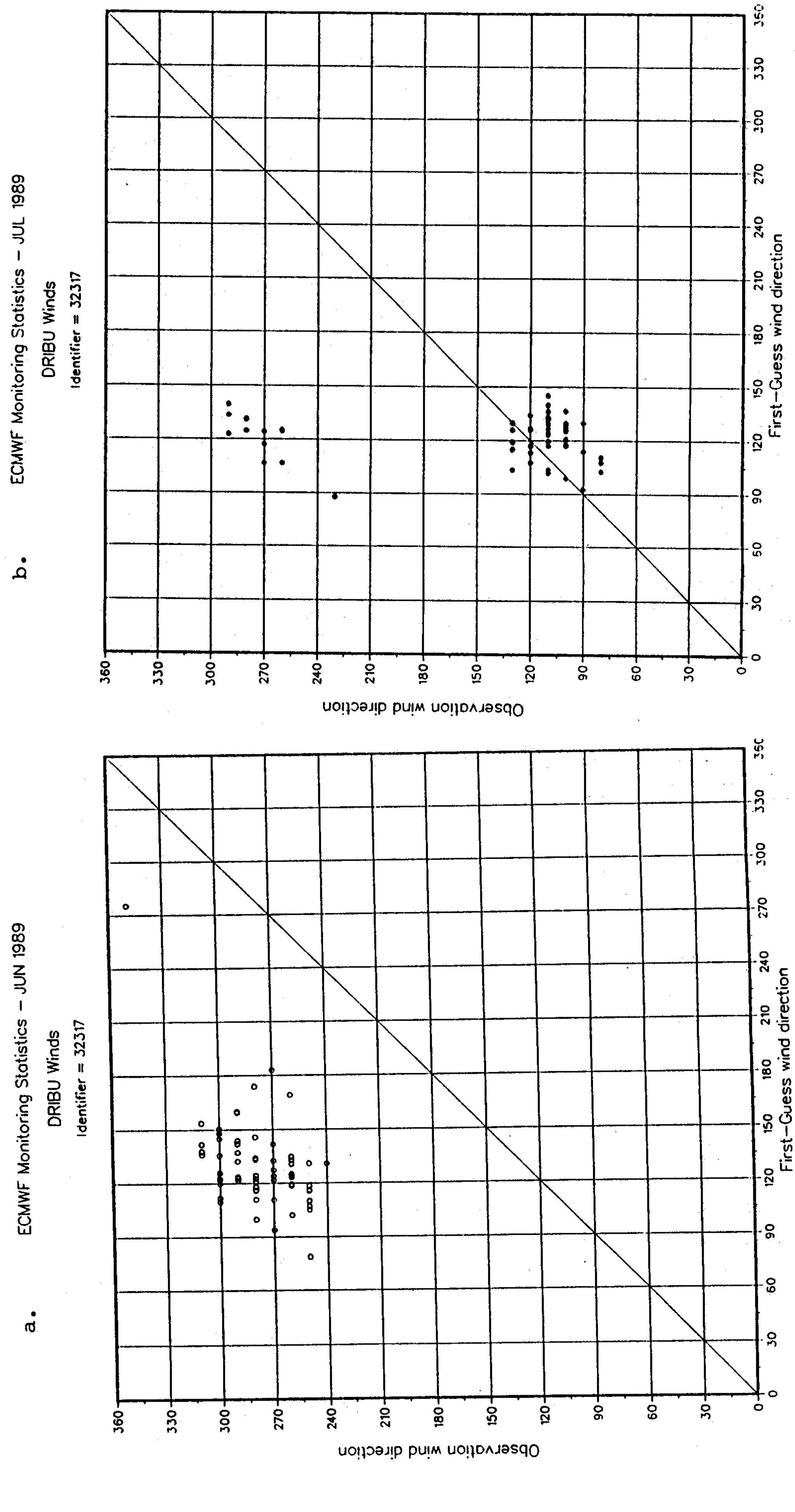

Fig. 1: Scatter diagram of the observed versus predicted wind directions at 110W 2S, buoy 32317, in June (Fig. 1a) and July 1989(Fig. 1b).

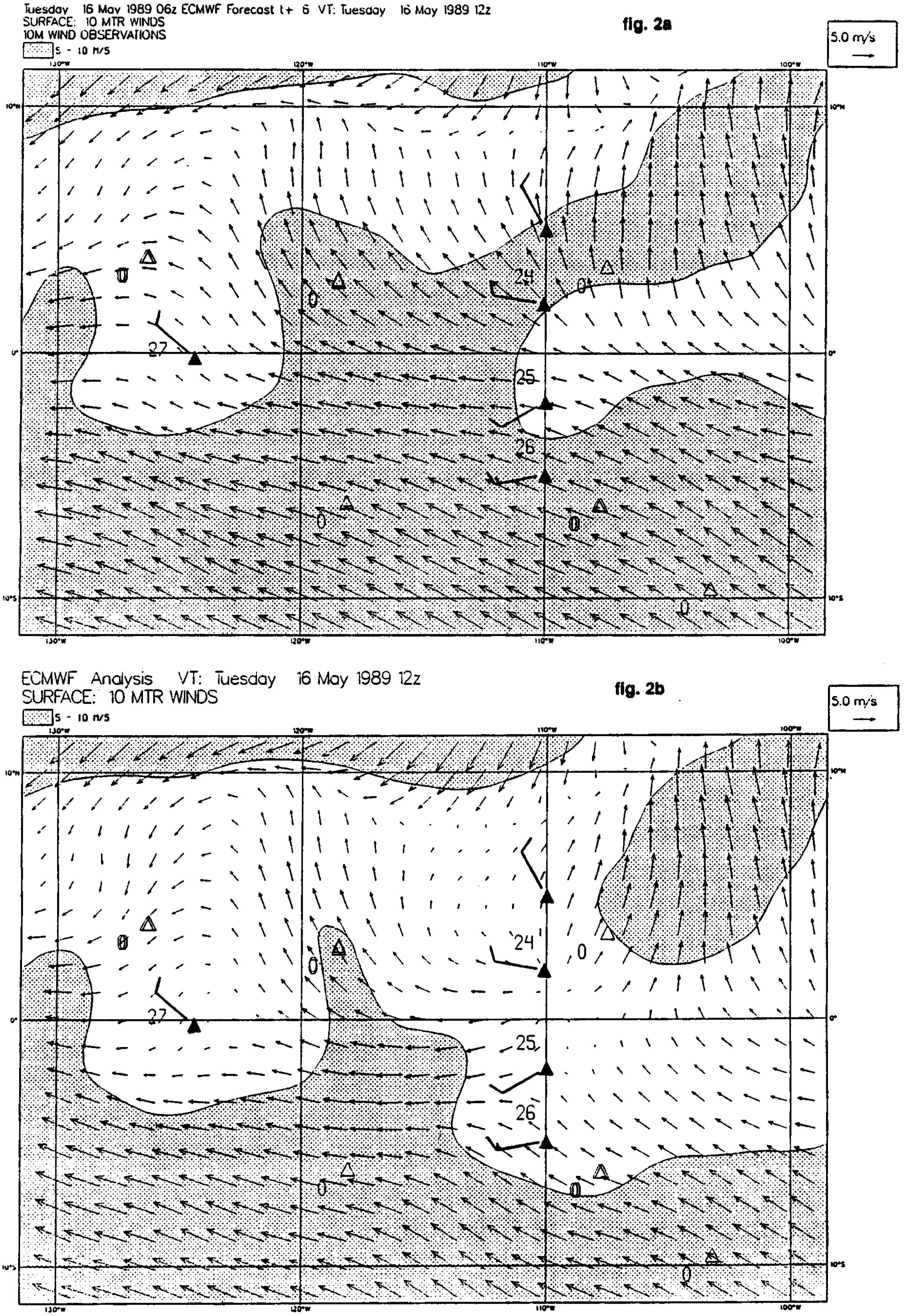

Fig. 2: First-guess and analysis of the 10m wind field (wind arrows) on 16 May 1989, 12 UTC, plotted together with the corresponding reports from the ATLAS buoys (wind flags).

EUROPEAN ACADEMIC RESEARCH NETWORK (EARN)

ECMWF has now a connection to the European Academic Research Network (EARN).

EARN is a computer network between academic institutions, such as universities or research centres, for the purpose of world-wide communication. A central computer in each country provides international connectivity and some central services. EARN is the European side of the network, Bitnet is the American equivalent, the two forming one network (often known as EARN/Bitnet).

ECMWF is connected to this network via the Rutherford Appleton Laboratory in Didcot through a 4.8 kbps link. At ECMWF the link terminates in the VAX cluster.

ECMWF's address on the EARN network is UKECMWF. The network name of an individual staff member is usually his surname, up to a maximum of 8 characters. Thus, the full address of an ECMWF staff member is "surname@UKECMWF".

Incoming mail is placed in the staff member's VAX MAIL directory at ECMWF, while undeliverable mail (e.g. to an unknown user) is written to a scratch directory (SYS_NJESPOOL), where anyone can search for lost mail. Incoming files are written into the staff members VAX login directory with a prefix $$.

Details of how ECMWF staff may use this network have been published in ECMWF Computer Bulletin B3.4/1, which was recently distributed internally within ECMWF.

- Tony Bakker

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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 236). All other News Sheets are redundant and can be thrown away.

No.	Still Valid Article
16	Checkpointing and program termination
67	Attention Cyber BUFFER IN users
73	Minimum Cyber field length
89	Minimum field length for Cray jobs
93	Stranger tapes
120	Non-permanent ACQUIRE to the Cray
121	Cyber job class structure
135	Local print file size limitations
140	PURGE policy change
158	Reduction in maximum print size for AB and AC
176	Archival of Cyber permanent files onto IBM mass storage
178	TIDs on Cray include 2 chara. TID plus 3 chara. source computer ID.
	Caution with ACQUIRE on RERUN jobs
186	PROCLIB changes
187	Maximum memory size for Cray jobs
189	ROUTEDF
190	Using ROUTE to direct RJE output to the Centre
194	Preventive maintenance schedules
198	Using the MOHAWK printer
201	New Cray job classes
203	Magnetic tape problems and hints on avoiding them
204	VAX disk space control
205(8/7)	Mispositioned cursor under NOS/VE full screen editor
207	FORMAL changes under NOS/VE
	Job submission from within a Cray job, using LAUNCH
208	Restriction of Cray JCL statement length
212	MFICHE command from NOS/VE
214	NAG Fortran Library Mark 12
	News Sheets on-line
215	MARS - data retrievals and model changes
219	MARS-Retrieval of most recent fields extraction utility
223	Corrections to ECFILE bulletins B8.3/1 and B8.3/2
	Aborting programs under VAX VMS
224	CRAY deferred class
	Job information cards
226	CRAY Class X
227	Extension of NOS/VE SUBCJ.
229	ECFILE audit facility
230	Access to AB printer via NOS/VE CDCNET
	Replot facility for DISPLOT
231	METGRAM under NOS/VE
232	NOS/VE passwords - how to change
235	VAX public directory - how to create

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ECMWF CALENDAR

4-8 September	Seminar - Ten years of medium-range forecasting
25-27 September	Scientific Advisory Committee - 17th session
27-29 September	Technical Advisory Committee - 14th session
3-5 October	Finance Committee - 44th session
29-30 November	Council - 31st session
4-8 December	Second workshop - Meteorological operational systems
25-27 December	*ECMWF holiday*

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ECMWF PUBLICATIONS

TECHNICAL REPORT NO. 63: A verification study of the global WAM model December 1987 - November 1988

WORKSHOP PROCEEDINGS: Parametrization of fluxes over land surface, 24-26 October 1988

Forecasts/Analysis charts up to 31 May 1989

Note: Latest issue of Forecast Report is No. 43 (June-August 1988).

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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.

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* T indicates the original Technical Newsletter series

USEFUL NAMES AND 'PHONE NUMBERS WITHIN ECMWF

			Room*	Ext.**
Director	-	Lennart Bengtsson	OB 202	2001
Acting Head of Operations Department	-	Geerd-R. Hoffmann	OB 010A	2050
ADVISORY OFFICE - Open 9-12, 14-17 daily			CB Hall	2801
Other methods of quick contact:	-	Telex (No. 847908) (Bleeper 139)		
	-	Telefax (No. 869450)		
	-	COMFILE (See Bulletin B1.5/1)		
	-	VMS MAIL adressed 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 Requests)	-	Tape Librarian	CB Hall	2315
Terminal Queries	-	Norman Wiggins	CB 028	2308
Operations Section Head	-	Peter Gray	CB 023	2370
Telecoms Fault Reporting	-	Michael O'Brien	CB 035	2306
DOCUMENTATION	-	Pam Prior	OB 225	2384
Distribution	-	Els Kooij-Connally	OB 316	2752
LIBRARIES (ECLIB, NAG, CERN, etc.)	-	John Greenaway	OB 226	2385
METEOROLOGICAL DIVISION				
Division Head	-	Horst Böttger	OB 007	2060
Applications Section Head	-	Rex Gibson	OB 101	2400
Operations Section Head	-	Bernard Strauss	OB 004	2420
Meteorological Analysts	-	Taskin Tuna	OB 005	2424
	-	Alan Radford	OB 002	2421
	-	Alex Rubli	OB 003	2425
Meteorological Operations Room	-		CB Hall	2426/2427
COMPUTER DIVISION				
Division Head	-	Geerd Hoffmann	OB 009A	2050
Operating Systems Section Head	-	Claus Hilberg	CB 018	2350
User Support Section Head	-	Andrew Lea	OB 227	2380
GRAPHICS GROUP				
Group Leader	-	Jens Daabeck	OB 016	2375
RESEARCH DEPARTMENT				
Head of Research Department	-	David Burridge	OB 119A	2005
Computer Co-ordinator	-	David Dent	OB 123	2702

* CB - Computer Block   OB - Office Block

** The ECMWF telephone number is READING (0734) 876000, international +44 734 876000, or direct dial to (0734) 499 + last three digits of individual extension number.

EARN/Bitnet: The ECMWF address on the EARN/Bitnet network is UKECMWF. Individual staff addresses are the first 8 characters of their surname, e.g. the Director's address is BENGTSSO@UKECMWF

DEC MAIL: Contact scientific and technical staff via VMS MAIL, addressed to surname