WINDS:TOWARDS BETTER WEATHER FORECASTS IN AFRICA.

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ABSTRACT:

Poor operational meteorological network in Africa has for a long time continued to make weather forecasting difficult. Data extracted from the operational meteorological satellites is therefore vital information for this region.
This paper describes, compares and evaluates the operational use of wind information disseminated via the MDD system to Africa; focussing at the Regional Specialized Meteorological Centre (RSMC), Nairobi, the African Centre of Meteorological Applications for Development (ACMAD), Niamey (Niger) and the Drought Monitoring Centre (DMC) in Nairobi.

1. INTRODUCTION

Meteorological services rely heavily on timely dissemination of meteorological observations and derived products.In many parts of the world telecommunications links provided by the WMO Global Telecommunications System (GTS), which is also used for interchange of meteorological data are satisfactory. However, extensive areas still suffer from a high degree of unreliability. Africa is particularly affected by the unreliability of the GTS. Fortunately, this region lies within the field of view of the Meteosat satellite. Such a combination of circumstances stimulated the development of the Meteorological Data Distribution (MDD) service with the specific objective of ensuring timely provision of meteorological information by using METEOSAT as means for data relay.

The operations of the African meteorological services are geared towards the demands they have to meet. This paper focuses on 3 regional meteorological centres in Africa to give a balanced overview of the use of wind information disseminated via the MDD service. These centres are the African Centre for Meteorological Applications and Development (ACMAD), The Drought Monitoring Centre (DMC) and the Regional Specialised Meteorological Centre (Nairobi). All these three centres have an operational MDD station as indicated in Table 1.

2. OBJECTIVE

The objective of this paper is to describe, compare and evaluate the use of wind information disseminated by the Meteorological Data Distribution (MDD) service to the 3 regional centres in Africa, which have been using the MDD system and have different climatic regimes or responsibilities to give a better and wider perspective in the use of the MDD service.

3. AREA

Africa lies between latitude 35°S to 37°N and longitude 18°W to 50°E. Therefore, Africa lies within the tropics, where much of its rain is mainly convective.

4. SCOPE

In describing and evaluating the use of the wind information received via the MDD system, this paper :-

- Discusses briefly the main weather/climate infuencing factors in Africa. This is considered important in the understanding of how the wind information is analysed, interpreted and incorporated into the weather forecasts.
- Verifies qualitatively, the analysed wind information against the validating "truth" provided by a coresponding Meteosat imagery, over a short period.
- Finally, the MDD's mission performance is evaluated for its immediate and long-term impact in the region.

5. THE METEOROLOGICAL DATA DISTRIBUTION (MDD) SYSTEM.

The MDD mission started during the 1990 as a new EUMETSAT service, supported by the current generation of Meteosat Operational Programme (MOP) satellites, these are METEOSAT 4,5 and 6.
The MDD system has two uplink stations in Bracknell and in Rome. These stations broadcast a selection of graphical and alphanumeric meteorological information.

5.1 The MDD product dissemination

The MDD uplink station in Rome transmits an unscheduled selection of SYNOP, TEMP, PILOT, AIREP, SATOB, TBUS, etc messages extracted from the GTS. While, the Bracknell uplink station transmits a wide selection of operational meteorological charts covering Africa, the Middle East, Europe, Asia, parts of America, the Indian and Atlantic Oceans from various meteorological centres. Among these charts, the following are the main wind charts used at the three regional centres:-

(a). Low -level
- . 10m winds & 2m temperatures
- . 900 hPa winds & temperatures
- . 850 hPa winds & temperatures.

(b). Medium - level
- . 700 hPa winds & temperatures
- . 500 hPa winds & temperatures

(c). Upper -level
- . 300 hPa winds & temperatures
- . 250 hPa winds & temperatures

. 200 hPa winds & temperatures

(d). SigWx charts.

.SigWx charts FL390
.SigWx charts FL340
.SigWx charts FL300
.SigWx charts FL240
.SigWx charts FL180
.SigWx charts FL100
.SigWx charts FL050

5.2 The MDD user stations.

The MDD user stations are mainly PC based. These workstations offer easy to use facilities such as data selection, display, archive and production of hardcopies. The PC based workstations are also easy to maintain in Africa.

5.3 Area of coverage

The reception coverage area is approximately 78 degrees from the sub-satellite point (within the field of view of the Meteosat).

5.4 Current status of MDD user stations in Africa

The MDD service currently serves Africa and the Middle East. There are nearly 22 MDD user stations in Africa, installed in 20 countries according to the latest MDD user status report for Africa, the OWSE-AF (II). Table 1. gives the latest status of MDD installations in Africa drawn from this report.

6. USE OF WIND INFORMATION DISSEMIN-ATED VIA TIIE MDD SYSTEM IN AFRICA.

As outlined in the scope (4.) above, it is important to have a good background of the characteristics of the main weather influencing systems in Africa , in order to appreciate the use of winds information in the region.

6.1 Main factors influencing weather in Africa.

The main systems that affects weather in Africa can be summarised as:-

- The African Monsoons
- The Inter Tropical Convergence Zone (ITCZ or ITD).
- Diurnal variations of winds
- The Easterly waves
- The Tropical Cyclones

6.1.1 The African monsoons.

The African monsoons are surface winds, which rarely reach levels over 5000m (Fig. 1.0 and 1.1). These wind regimes are controlled by the sub-tropical highs. As large parts of Africa consists of extensive highlands, the circulation near the earths' surface is well represented by the 850hPa (1500m) level above asl. At this level the air-flow is free from surface effects , such as friction. The monsoons have regional differentiation; resulting mainly from the nature of the African continent. *(Ref: H. Riehl - tropical meteorology).* The African monsoons can be classified into two:-

(i) The West African Monsoon.

The two seasonal airstreams (monsoons) influencing weather over West Africa are :-

- The "Harmattan" or the dry and dusty North-Easterly trade winds which occur during Northern winter (Fig. 1.0), ushering a dry spell in West Africa. These winds prevail upto 3000m.

- The "Monsoons" or the warm and humid South-Westerly trades occur during the southern winter. The south-westerly prevail and force the convergence zones further to the north as shown in Fig. 1.1, resulting into rains over most parts of west Africa.

During this period the West African Monsoons is characterised by:-

. The region to the North of the ITD has high temperatures of about 30C.

. In the neighbourhood of 600mb at 15°N the **African Easterly Jet** is observed.

. In the upper troposphere near 150mb at 7°N the **Tropical Easterly Jet** is observed.

These monsoons also cause the formation of squall lines.

Squall lines

The squall lines are meso-scale systems consisting of a narrow line of thunderstorm cells, which at times extend for hundreds of kilometres.

They move across west Africa and are regarded as the products of low-level convergence associated with the synoptic scale easterly waves in areas where the atmosphere is convectively or conditionally unstable (May-September).

The squall lines are largely dependant on the monsoons, as they absent when the monsoon retreats from most parts of wets Africa (November-March).Therefore, most precipitation over this region is from these deep convective systems.

(ii). The Monsoon of East-Africa.

The East African monsoons result from the migration of the pressure systems and their associated wind flow patterns following the movement of the sun.

During northern summer, the South-Easterlies bring into the region alot of moisture due to their long-track over the Ocean. The western branch flows further inland to form the Congo Air Boundary.

While during the Southern summer, the dry North-Easterlies , due to their long continental track, becoming North Westerlies on crossing on the equator invade Eastern Africa.

Due to the above differences in the seasonal monsoon characteristics, East Africas' rainfall is generally bi-modal with the two rainy and dry seasons. The wet seasons are locally known as "long" (march-may) and "short" (October - December).

Orography and large water-bodies within this region , result into variations of the seasonal rainfall patterns.

6.1.2 Diurnal variations of the general circulations

In many tropical areas diurnal variations in temperatures are significant. The thermal changes between day and night are the main driving force if the diurnal wind systems in the tropics as they differ in intensity over land and water surfaces and over highlands and lowlands. This is particularly important in Africa, as it has a long coast-line and varied physical features, such as the great rift valley, sea-breezes, etc.

6.1.3 The Easterly waves

Easterly waves are pertubations which travel in the tropical easterly flow on the equatorward sides of the subtropical cyclones. They occur in latitudes between 5 and 20 degrees. Easterly waves are fairly weak in low-levels and intensify attaining maximum intensity at about 600mb. Their origin can be traced as far east as the Sudan from where they propagate westwards and intensify culminating into squall lines in West Africa.

The Weather patterns associated with an easterly wave is such that low-level divergence takes place to the west of the trough resulting into fine weather. In the rear of the trough , however, the temperature inversions lifts due to low-level convergence. The moist surface layer of air therefore attains considerable depth. Extensive convective showers and thunderstorms often result.

6.1.4 The Inter-Tropical Convergence Zone

The Inter-Tropical Convergence Zone (ITCZ) results from the convergence of monsoonal winds (Fig 1.0 and 1.1). This results in convection making the ITCZ the main rain generating system in Africa.
The ITCZ shifts with the seasonal march of the sun as shown in Fig. 1.0 and 1.1.

6.1.5 Tropical Cyclones

The tropical cyclones form in pre-existing areas of disturbances, waves and shear lines. Deeping to pressure below 1000mb.
Tropical cyclones force winds extend as far as 300km from the centre.
The general wind flow patterns in an area of a tropical cyclone result in changes in weather patterns.
Fig 2.0 shows the formation and movement of tropical cyclones.

6.2 Principle techniques applied in Wind information analysis in Africa.

Climate can only be explained when meteorological processes causing each days weather can be understood. Weather on the other hand can only be explained and or forecasted if daily synoptic features and processes are accurately observed and analysed.Daily synoptic charts in most parts of Africa exhibit daily changing pressure patterns and the resulting weather changes. The pressure changes are small but just as frequent as they are varied. This poses an intricate forecasting problem in trying to determine how the observed or the anticipated pressure patterns will influence the weather.This issue is even more aggrievated by the fact that the poor regional meteorological network of conventional stations. Therefore, explainations of daily variations of weather and the seasonal variations of climate are better explained in terms of the behaviour of Air flows or winds in Africa.

6.2.1 Stream-line analysis.

In the detection of air-flow patterns or winds, stream-line analysis is the principle tool for tropical synoptic weather analysis for the detection of the main tropical synoptic features, such as the Inter Tropical Convergence Zone (ITCZ), Tropical Cyclones, depressions, monsoons, etc.

7. DISCUSSION

The use of wind information depends on the needs of the user community. The primary users of meteorological information in Africa are the aviation industry, agricultural sector, marine and general public.

7.1 Description of the use of the wind information and the preliminary evaluation results.

The description of the use of these graphical charts is done using a representative sample of the MDD transmitted charts which relate to 3 selected days in November 1993. These charts are compared with corresponding Meteosat imageries, with an aim of providing some preliminary evaluation of their usefulness. Further evaluation is carried out , to ascertain their time-liness, inorder for them to be incorporated to the routine weather bulletins, prepared at Met. services in Africa. This is done by comparing KMDs' operational schedule is used against the MDD schedule received from Bracknell.

7.1(a) Use of low-level wind information

. 10m winds & 2m temperatures
. 900hPa winds
. 850hPa winds/Isotherm
. WAFS FL(100,050)

Much of Southern and Eastern Africa is plateau whose altitude is near or approximately at 850hPa pressure level. This makes the 850hPa chart very important over most parts of Africa.
Figure 3.0 and 3.1, depict stream-line analysis on 850hPa wind and temperature chart on a 5° by 5° grid of 27/11/93 at 00Z and 10m winds and temperatures, 48hours forecast for the same day at 12Z. These are very important charts for the African met. services, though at first glance it shows a complicated wind-field patterns. The charts (Fig. 3.0 and 3.1) show important Airflow patterns in Africa, which explain the prevailing weather conditions in the region in conjuction with the mid-and upper-level charts.

Observations (Fig. 3.0 and 3.1)

(a) Convergent flow patterns
. Along the West African coast into the Atlantic Ocean.
. Over Central Africa running into South Africa.
. Southern sudan and parts of Northern Kenya.
. Over the Madagscar Island

(b) Divergent flow patterns
. Over North west Africa
. Areas of the Atlantic Ocean , close to the S.W coast of Africa.

On verification with the corresponding Meteosat full disc imagery (fig. 4) of 27/11/93 at 1200Z.
There is marked parralelism between the areas of convergent flow in the low-levels and the deep convective clouds.
This clearly potrays the different air-masses in play over Africa (see 6.1), originating from the sub-tropical highs, with a marked similarity between the two low-level charts.
This is even more emphasized by the temperature contrasts between the different air-masses.
Stream-line analysis is shown in these figures as an important tool in the detection of the Inter-Tropical Convergence Zone (ITCZ) and the Inter Tropical Discontinuity (ITD).

Purpose:
- Routine daily weather forecasts
- Aviation weather forecasts
- Marine
- Agriculture and Pest control.

7.1(b) MID - LEVELS
,700hPa winds/isotachs
.WAFS FL(240).

Wind charts in the Mid-level provide essential information as to how a column of air is ascending or descending a critical factor for convective clouds growth.
In this case stream-line analysis is also applied to the 700mb winds chart (Fig. 5). on this level.
This analysis assist the identification of divergent and convergent areas. Meaning ascent an air-mass or subsidence respectively.

Observations from Fig 5.0
Depict some important meteorological phenomena, such as:-
- Convergent flow over(areas of wind deceleration),Central and South Africa enhancing the ascent of the airmass over that region as seen earlier on fig 1.0 and 1.1.
- Divergent flow (areas of wind acceleration) over Arabia spreading into the Somalian coast and parts of the Central Kenya.

7.1(c) UPPER – LEVELS
. 300hPa winds
. WAFS FL(390,340,300).

Wind charts in Africa on the upper levels are mainly based on pilot observations in Africa. Radiosonde observations are few in the tropics and at most-times the observations are made at 1200 GMT and a few at 0000GMT. It is a well known fact, that weather or climate in Africa (or anywhere else) cannot be explained on the basis of convergence and divergence at a single level.
A three dimensional study to at least 330/200hPa is essential for development of significant rainfall, a sufficient depth of atmosphere must experience an upward motion, and experience indicates that rainfall in Africa is very unlikely to occur unless horizontal convergence occurs simultaneously at 2 or more adjacent low standard levels, usually 850 and 700hPa. At the same time, at some higher level aloft there must be a divergent pattern to provide compensating outflow for the ascending airmass.

Fig 6. depicts the wind flow patterns on 200Hpa of 27/11/93 at 1200Z a 72 hour forecast from the ECMWF, it is of the same period as in the above charts.

Observations from Fig.6
Clearly potrays a very marked trough-ridge-trough across North-Africa, with emphasised divergent over Morocco and parts of Algeria and a weak trough-ridge system over the Southern hemisphere.
Areas of Convergent flow:
. Cyclonic winds are clearly forecast over Nigeria and the Chad region.
. Mid-Atlantic Ocean (deceleration of winds)

Divergent flow areas:
. Over the Indian Ocean, areas close to the Malagasy Island
. S.E Africa, as winds accelerate into the Indian Ocean

Areas Strong winds:
Winds over 60 knots (jetstreams) are noticeable in North and South Africa.
This is very useful information for Aviation forecasts as shown in fig.7 , depicting a SigWx chart from MeteoFrance.

On cross-checking with the corresponding Meteosat image, areas of divergent flow on the 200hPa levels and convergent flow on the low and mid levels show, deep convective clouds.

(ii) Winds of over 60m/s are forecast in Fig 6., this is clearly shows the forecast area for the Sub-tropical Jetstream. On verifying it against the corresponding Meteosat imagery, there is clearly a region of a sharp contrast between extensive cirrus on the equatorward side and relatively clear skies and subsiding air on the poleward side of the jetstream.
Similar, features can be seen on Fig 7.

8. PRELIMINARY RESULTS

The preliminary evaluation of the MDD system and the products it disseminates indicate the following:-

(a). The perfomance of the MDD system

The MDD system has a proven performance in Africa. It simple works under the African environment because of the following reasons:-
. Inexpensive workstation
. Easy to operate and maintain
. MDD service is timely
. The Uplink stations and satellite operators are both efficient and reliable.

(b). Value Added Products (VAP) derived from the Wind Information received from the MDD system.

The stream-line analysis of wind fields provide the following user products in Africa:-

(a). Surface winds (stream-line analysis) for ITCZ location and the desert locust identification, a very useful product for both short-term and long-term forecasts.

(b). 850hPa stream-line analysis is used in explaining past weather and squall-line detection over West-Africa. ACMAD provides stream-line analysis for 850hPa as a product which is up-linked in Bracknell. Fig 1.1, depicts a similar product.

(c). Indian Ocean analysis and forecast, depends on stream-line analysis on surface winds.

(d). Upper level prognostic wind charts are used for aviation forecasts and this is primarily done for Flight Levels (FL) 300,340,390, other products include SIGWX, WINTEMS and ROFORS.

(c) Problem(s) in Africa.

(i). Upper air observations are few and expensive to maintain in Africa.
(ii). Areas near the equator do not obey the Geostrophy, because the coriolis parameter tends to zero.
(ii). NWP products are currently not being effectively utilised at the African national meteorological centres because of lack of training in their use.

9. RECOMMENDATIONS.

(a). It is fundamental for the normal forecasting operations of the the African met. services that it commands an extensive programme of reception of weather reports from both the North and south of the equator and that its forecasters are thoroughly versed in extra-tropical meteorology. This will assist them in attaining confidence in predicting the motion and developments of high and mid-latitude weather systems, since these have a direct effect within the the tropics.

(b). Use of satellite-imagery, satellite derived winds are vital for forecasting in Africa. Other uses include:-

. Tropical cyclone detection and tracking
. Jet-stream detection and extent
. Progression of weather systems over both hemispheres.
500hPa chart for North Africa and 300Hpa chart for Eastern and Central Africa).

(c). African forecasters need training courses of several weeks' or months' duration at the NWP product generating centres;

. Toulouse - (MeteoFrance)
. Bracknell - U.K.M.O
. Offenbach - D.W.D
. Reading - E.C.M.W.F

This will enable the African forecasters' appreciate the significance of the NWP products and exchange expertise and requirements of the Met. services.

(d). ACMAD, ought to develop training activities related to improvement of weather forecasting methods in Africa.

(e). A quality control centre should be instituted in Africa to check on the meteorological information disseminated via the MDD service. The results of this should reach both the producers and users.

(f). Finer mesh for the NWP products display of at least 2.5° by 2.5° (existing aviation maps have a resolution of 5° by 5°); for reasons explained in 6.1.2 (diurnal variation of winds in Africa).

(g). For the Africa and the Indian Ocean Islands, the following products are considered valuable and are not available, currently in the MDD service. For 00,24,48 and 72 hours range.

. Vertical velocity: 700/200 hPa
. Derived parameters from the Wind-field.
(a) Divergence: 700 hPa
(b) Convergence: 900 hPa
700 hPa
200 hPa
(c) Wind shear : 850/200 hPa.
(d) Detection of Quasi Biennal Oscillation : upto 30 hPa

10. CONCLUSION:

The MDD system works and has had a great impact in Africa. In concluding it is important to underscore the following:-

- The MDD system has made meteorological data and products (NWP) more available in Africa.
- It has introduced NWP from advanced European centres in Africa, which has significantly improved forecasting in the region, from subjective to more objective methods.
- Aviation forecasts are now based on WAFS, as MDD makes them more readily available.
- Cloud Motion Winds represent an important data source to NWP products, especially in data sparse areas, like the tropics and the Southern hemisphere.

References

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Tables & Figures

TABLE 1

COUNTRY	MANUFACTURER	LICENSE AGREEMENT
Cote d'Ivoire	Sofreavia	2.6.93
Djibouti	VCS	13.7.93
Egypt	BURL	
Ethiopia	BURL	13.7.92
Ghana	BURL	16.11 92
Lesotho	VCS	20.8.92
Madagascar	BURL	13.4.93
Malawi	VCS	16.11.92
Mauritius	BURL	16.11.92
Morocco	Tecnavia	30.6.93
Mozambique	VCS	16.11.92
Kenya	VCS	26.6.92
Kenya	BURL	
Namibia	BURL	
Niger	VCS	26.6.92
Niger (Agrhymet)	Sofreavia	
Niger (ACMAD)	Sofreavla	24.3,93
South Africa	Alden	
Sudan	Alden	20.7.92
Swaziland	VCS	30.6.92
Tanzania	BURL	
Uganda	Alden	16.11.92
Zambia	BURL	2.6.93
Zimbabwe	BURL	17.8.92

Table 1 shows the MDD equipment installed in the various countries in RA I.

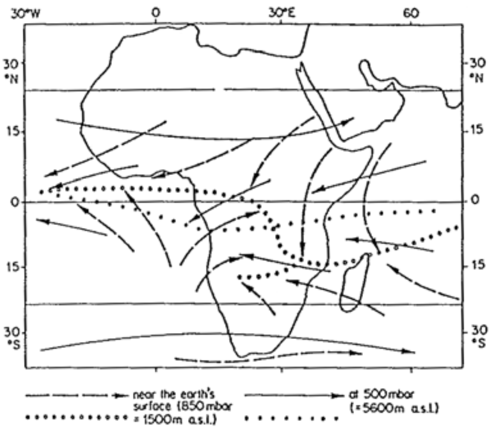

Figure 1.0The circulation over Africa during January at the 850 mbar and 500 mbar levels (arrows: winds; dots: convergence zones)

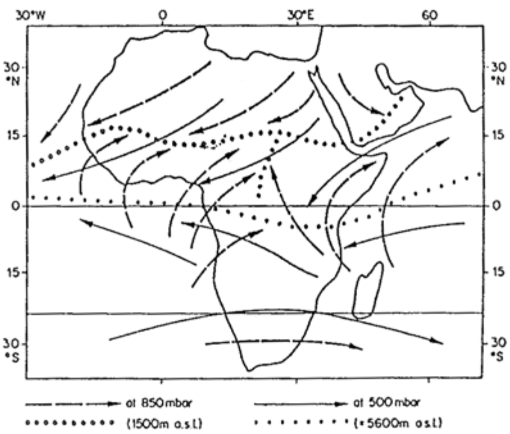

Figure 1.1 The circulation over Africa during July at the 850 mbar and 500 mbar levels (arrows: winds; dots: convergence zones)

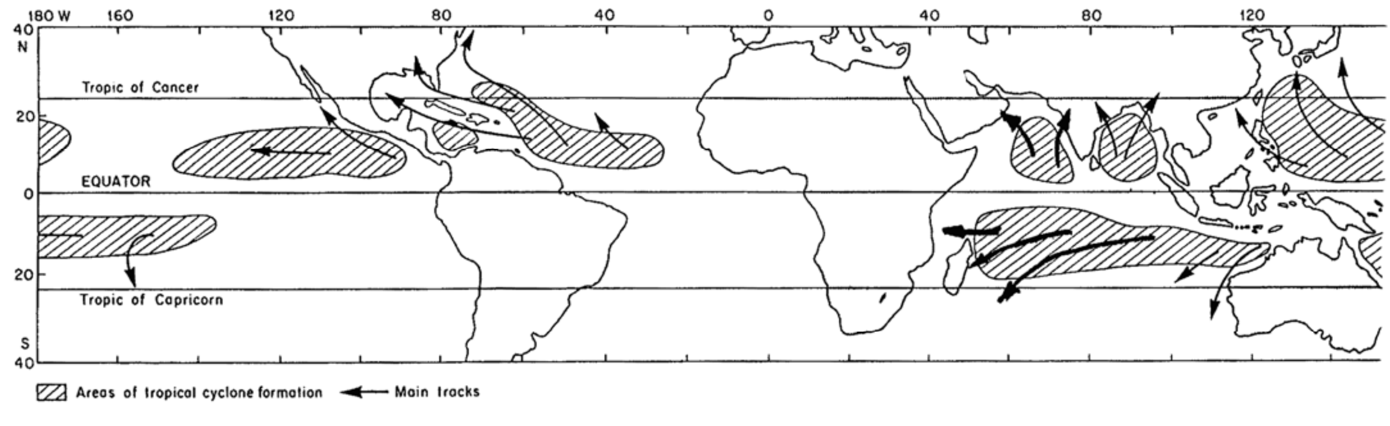

Figure 2.0 Formation and movements of tropical cyclones

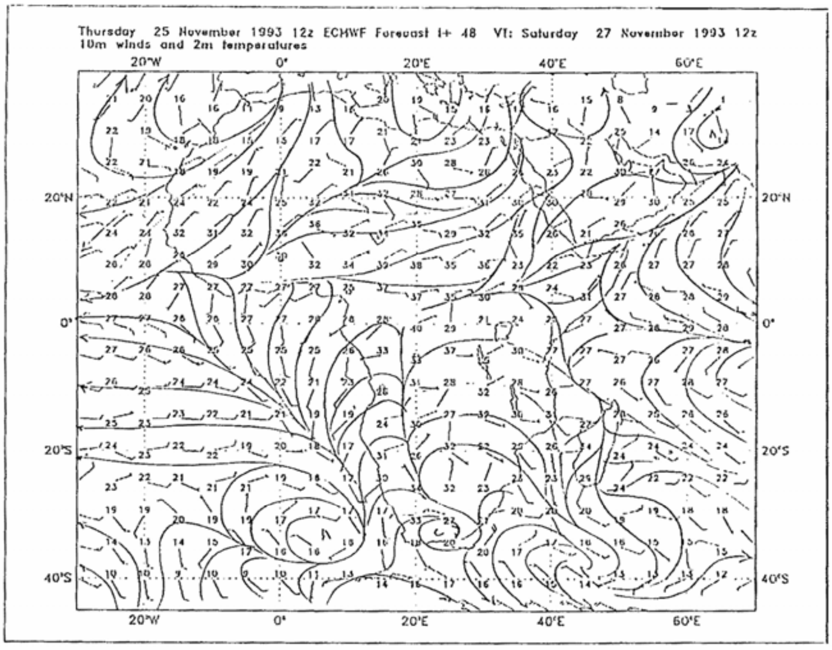

Fig. 3.1

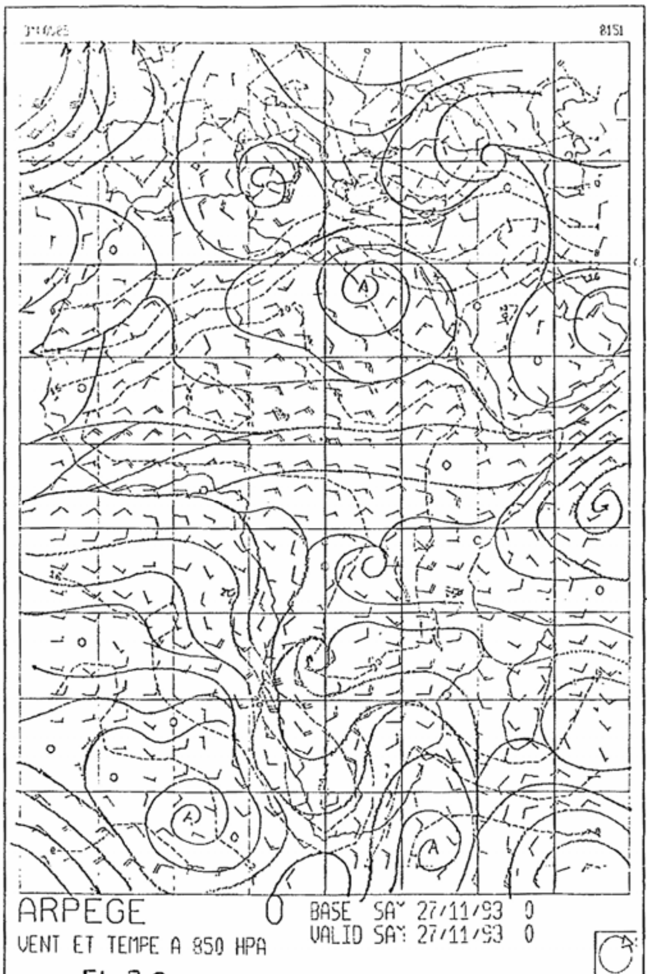

Fig. 3.0

Fig. 4.0

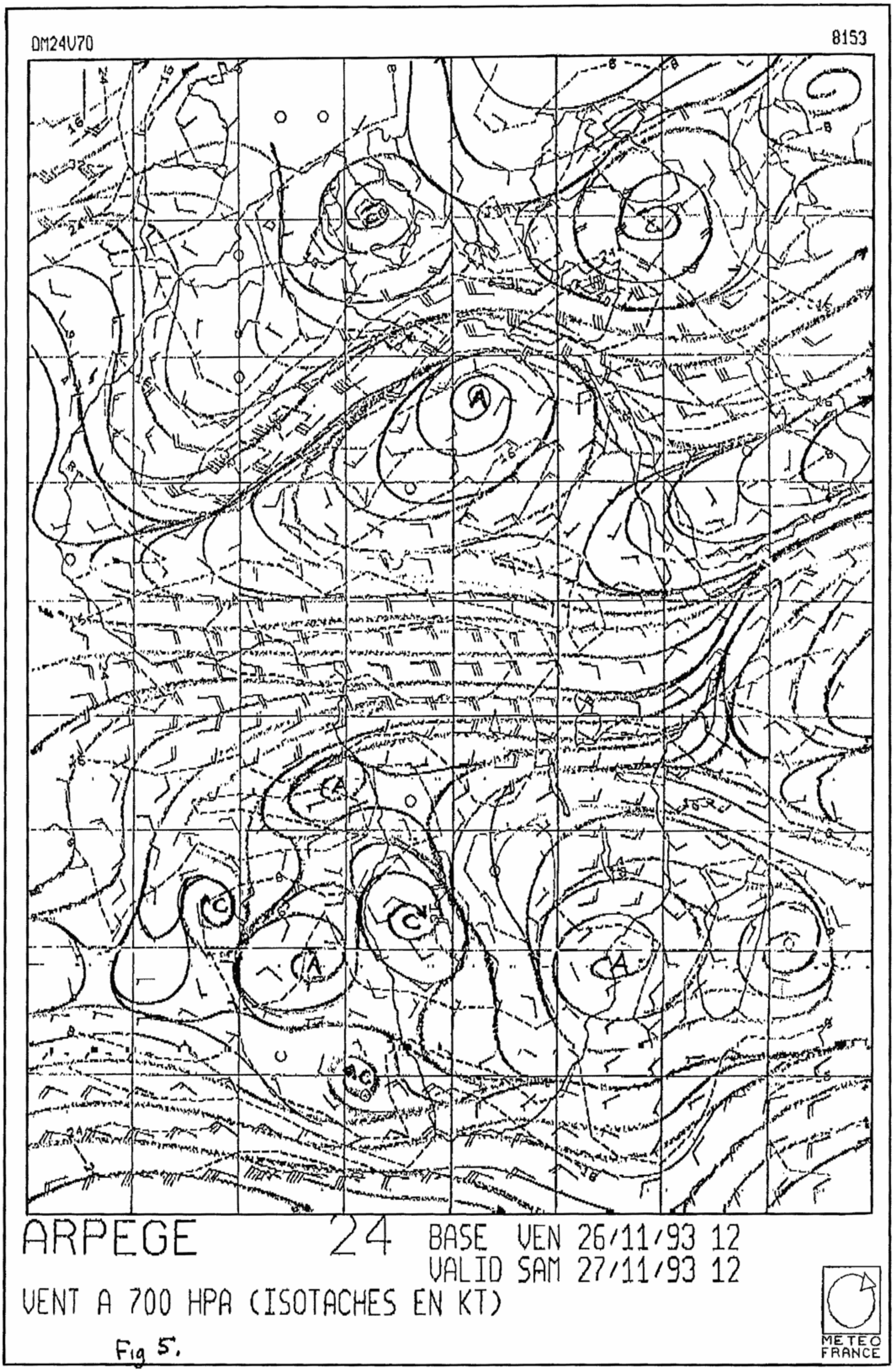
DM24V70
8153
ARPEGE
24
BASE VEN 26/11/93 12
VALID SAM 27/11/93 12
VENT A 700 HPA (ISOTACHES EN KT)
METEO FRANCE

Fig 5.

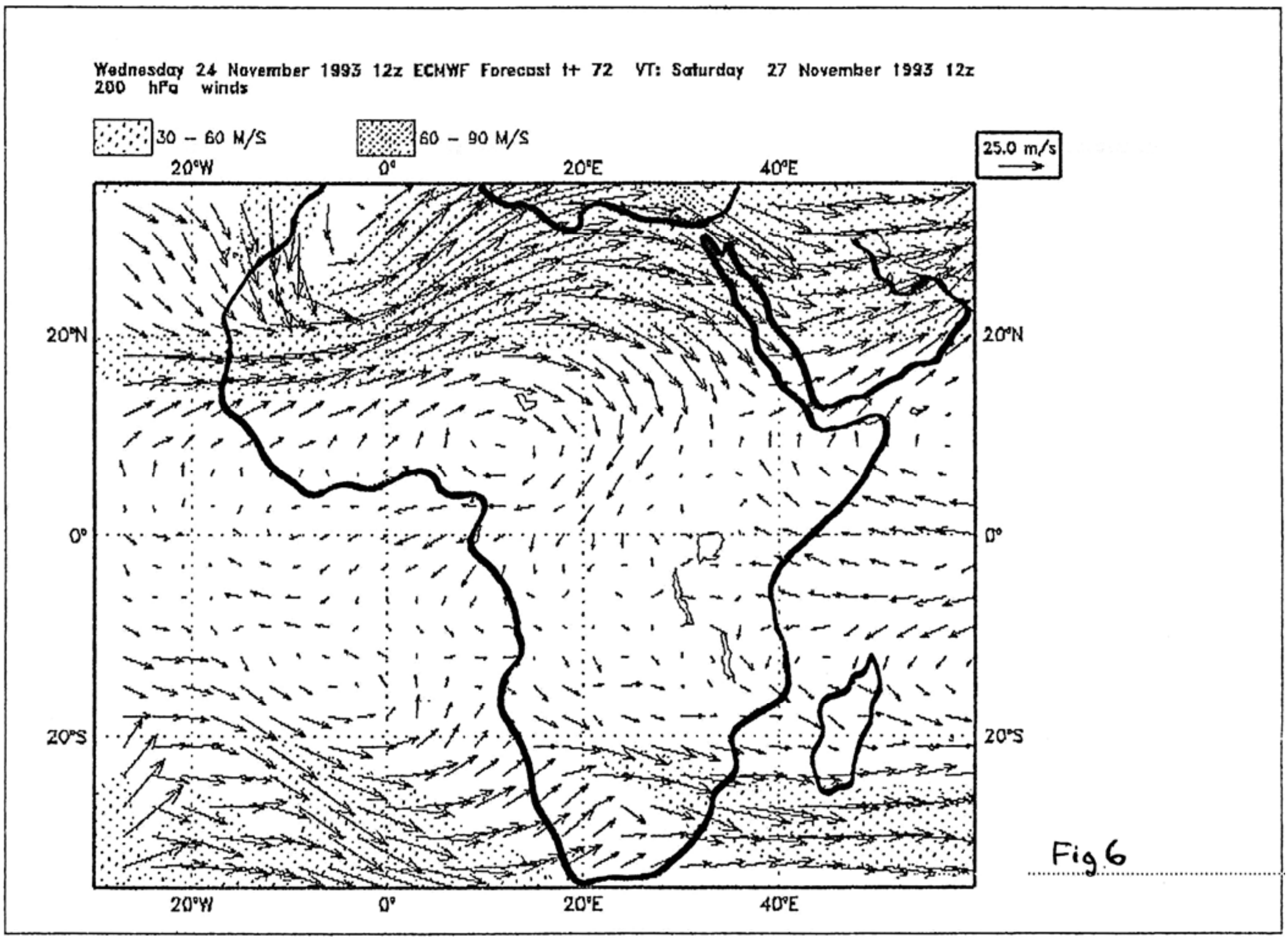
Wednesday 24 November 1993 12z ECMWF Forecast t+ 72 VT: Saturday 27 November 1993 12z
200 hPa winds
30 - 60 M/S
60 - 90 M/S
25.0 m/s
20°W
0°
20°E
40°E
20°N
0°
20°S

Fig 6

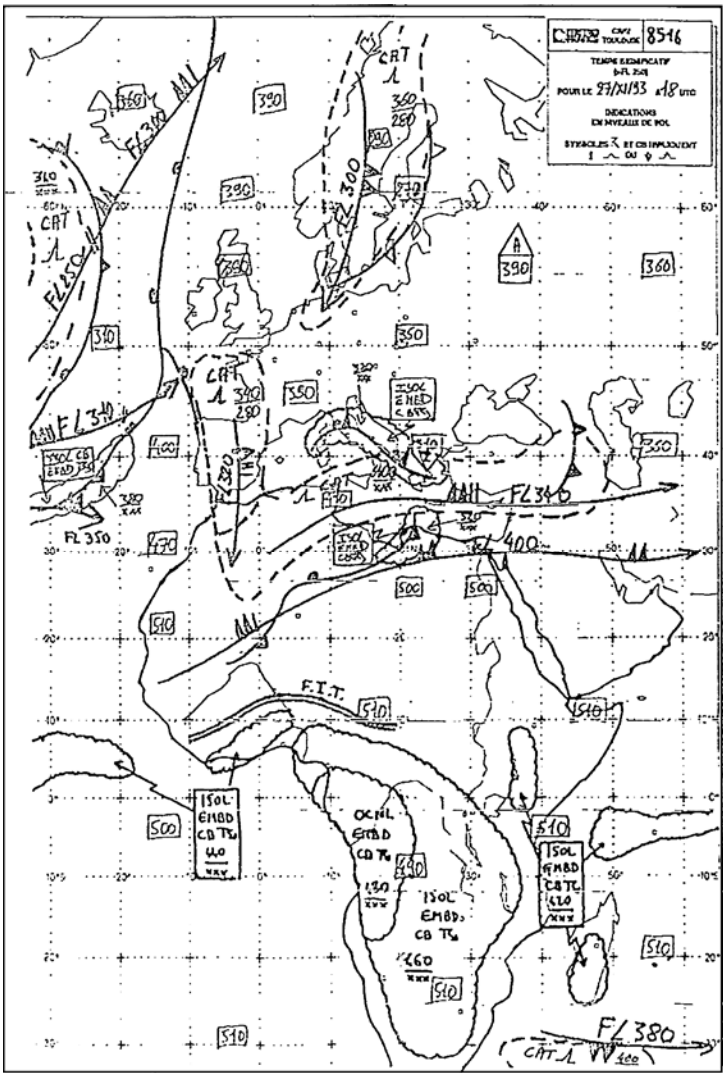
8516
CAT
FL 300
FL 340
FL 350
FL 380
F.I.T.
ISOL
EMBD
CB TS

Fig 7.0