# Western Region Technical Attachment
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# SOME DIFFERENCES BETWEEN THE NMC/ECMWF/UKMO MODELS AND WHAT IT MEANS TO THE NWS FORECASTER

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*[Editor's Note: This Technical Attachment is a joint effort on the part of Pete Mueller, who recently visited the ECMWF and UKMO offices while in Europe, and SSD. We thank Steve Zubrick, OM, for providing information about specific model characteristics.]*

## Introduction

Four medium-range (120 Hr) forecast graphics from two European numerical models are now available on the NWS AFOS network. The two European numerical models which NWS field offices will have an opportunity to examine are the United Kingdom Meteorological Office (UKMO) model and the European Center for Medium Range Weather Forecasts (ECMWF) model.[1] Both offices are located in Reading, England, approximately 40 miles west of London. There are significant differences in the organization of the two European offices and in the models they produce which this paper will help to distinguish.

## UKMO Overview

The UKMO is a multifaceted organization capable of providing many types of weather services and forecasts. Its major arteries include the operational meteorological services and the computer modelling branches. This unique marriage has allowed the UKMO to acquire state-of-the-art computer equipment as well as an advanced telecommunications system. In appearance, the UKMO is a combination of NMC and a large WSFO, all in one building.

Worldwide meteorological data are gathered in Reading, and processed by high speed computers. Data ingest into the model is carefully controlled, undergoing a series of tests to ensure that it is representative and accurate. If surface and upper air data fails any of the prescribed tests, it is then no longer considered. The UKMO model, like the NMC

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[1] The 120 hr ECMWF 500 mb and 1000 mb forecasts are under AFOS identifiers 5XE and OXE, respectively. The 120 hr UKMO 500 mb and 1000 mb forecasts are under AFOS identifiers 5XU and OXU, respectively.

model (MRF), is run twice each day, on 0000 UTC and 1200 UTC data. In contrast, the ECMWF model is run only once a day using 1200 UTC data.[2]

In addition to being a data collection and modelling center, the UKMO is the only operational meteorological office in England, similar in many respects to a WSFO. It is manned 24 hours a day, 7 days a week, 365 days a year, and provides daily weather forecasts to the British media, local and international pilots, as well as a large number of internal and external users. The UKMO office is responsible for providing local (short-term) and long-range forecasts. A major difference between the NWS and the UKMO is that the UKMO provides a variety of weather forecasts for the British Armed Services.

## ECMWF Overview

The ECMWF is vastly different from the UKMO. The ECMWF is a joint European venture with several participating countries including two communist east block countries. While the UKMO is fundamentally geared toward the operational aspects of meteorology, the ECMWF is geared more towards research and development.

ECMWF meteorologists are mostly modelers and researchers from the European communities which support the facility. The primary function of the ECMWF is to provide a state-of-the-art global model; no operational forecasts are made at the facility. Instead, model output is sent to the various European user communities as well as other international users. The European countries which provide monetary resources for the ECMWF model use the output to make their own day-to-day weather forecasts. A substantial portion of the high speed computer and meteorological resources are devoted to ensuring that all data used in model calculations are as error free as possible. If a station consistently fails a number of checks day after day, it is blacklisted and the data are not considered. A station can be removed from this list only after quality assurance has been guaranteed for a sufficient period of time. The ECMWF prides itself on the elaborate and painstaking procedures used to ensure quality data. Like the NMC models, the first guess field plays an important role in determining whether data is representative or not.

Since the ECMWF is primarily concerned with the quality of input data, while operational concerns are secondary, it is common for its 1200 UTC model run to not be available until 0000 UTC, 12 hours later. In the U.S., NMC is equally concerned about the high quality of data, but they also must meet operational deadlines set by their users, and, therefore, model output must be made available within a few hours after the data is valid.

The ECMWF global model is relatively new, about 10 years old, and has evolved into a model which has received critical acclaim throughout the international meteorological community. Constant improvement in the physics, mathematics, and horizontal and vertical resolution contribute to its ongoing success. ECMWF's acquisition of one of the

[2] The UKMO available on AFOS will be from the 0000 UTC run, while the ECMWF output will be from the previous day's 1200 UTC model run.

first CRAY computers[3] manufactured over 10 years ago contributed in large part to the early success at long-range atmospheric modelling.

## NMC vs. UKMO vs. ECMWF

1) Model Characteristics

Without going into too much detail, this section describes some of the general characteristics of each of the three global models.

The Medium Range Forecast (MRF) model produced by NMC (the one we are most familiar with) is a spectral model with a horizontal resolution of 80 waves and 18 vertical layers. It is run once a day on 0000 UTC data with a data cut-off of 6 hours. The time step used is 12 minutes. The method of analysis uses an optimum interpolation scheme with an analysis grid of 1.5°. Parameterization includes condensation and evaporation, simple diurnal radiation, shallow convection, vertical diffusion, surface fluxes, gravity wave drag, and the interaction of radiative fluxes with model-generated clouds.

The ECMWF model is also a spectral model, but with 106 horizontal waves and 16 vertical layers. The vertical coordinate is a hybrid coordinate similar to the sigma levels used in the MRF, however, there are 4 isobaric layers above the 16 sigma-type layers. The ECMWF model is also run once per day but on 1200 UTC data with a cut-off of 9 hours (due to the extensive quality control). The time step is 15 minutes. The analysis method uses a three-dimensional statistical interpolation and a quasi-regular grid of about 1.125° (160 x 220 points). Parameterization used in the ECMWF model includes condensation and evaporation of precipitation, shallow convection, boundary eddy fluxes, which depend on surface roughness, moisture fluxes dependent upon vegetation properties, and interaction between radiation and model-generated clouds similar to the MRF model.

The UKMO model, unlike the MRF and ECMWF, is a grid model rather than a spectral model. This makes it more susceptible to computational instability for long-range forecasts. The horizontal grid is 1.5° latitude x 1.875° longitude (or 150 x 180 km at the equator), and there are 15 sigma levels in the vertical. The UKMO model is run twice per day on both 0000 UTC and 1200 UTC data, and the data cut-off is 3 hours and 20 minutes. Since the UKMO is a grid model, a smaller time step of 5 minutes is used. The method of analysis used to put the data on the grid is a successive correction method. Parameterizations for the UKMO model include condensation and evaporation with an ice phase considered, surface and turbulent heat fluxes, a deep convective scheme based on parcel theory, drag from gravity waves caused by orography smaller than the grid size, and a non-interactive simple radiation scheme. Surface classifications involve land which is either wet, dry, ice, or snow, and the sea which is either open or ice.

2) Performance

Daily root-mean-square errors for a 30-day period (June 9, 1989 through July 9, 1989) for 500 mb 120 hour output over Europe (Figure 1) suggest that the performance of all three

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[3] Cray Research sold their second machine, serial #4 to ECMWF.

models is about the same for this time period. However, it does appear that the UKMO model performed a little better than the others during the second 15 days. Note that the large daily fluctuations appear to be damped significantly in both the NMC and, more so, in the UKMO model as compared to the ECMWF and German model (DWD). Any results from the plotted information should be used with extreme caution since this involves only a limited data sample.

Figure 2 illustrates similar scores by the ECMWF and the UKMO at 500 mb for nearly a three-year period, from August 1987 to May 1989. Monthly averaged root-mean-square errors indicate that the ECMWF model performance is approximately 10 meters better at 96 hours (NMC results were not available for this time period). It is impossible to conclude from these results that any one model is better than the others but it is clear that each model is capable of out-performing the others in certain situations.

## Overall Model Performance and Summary

While the debate continues on the merits of all three models, it is clear that, overall, numerical model guidance continues to improve over time. [Figure 3 illustrates the consistent model improvement during the past 30 years.] Clearly, our ability to predict weather events through the first 48 hours is substantially better than just five years ago. The advent of more powerful computers, coupled with improvement in model parameterization, and increasing horizontal and vertical resolution means that models will continue to better represent the actual state of the atmosphere. However, computer speed still remains a significant limiting factor.

As technology continues to advance, it is fortunate that all competing countries are willing to eagerly share meteorological data and forecast models with one another. Forecasts on both sides of the Atlantic should keep improving if meteorologists continue to share new information and technology.

## References:

Bulletin of the American Meteorological Society, Vol 70, Number 10, October 1989, pp. 1279-1284.

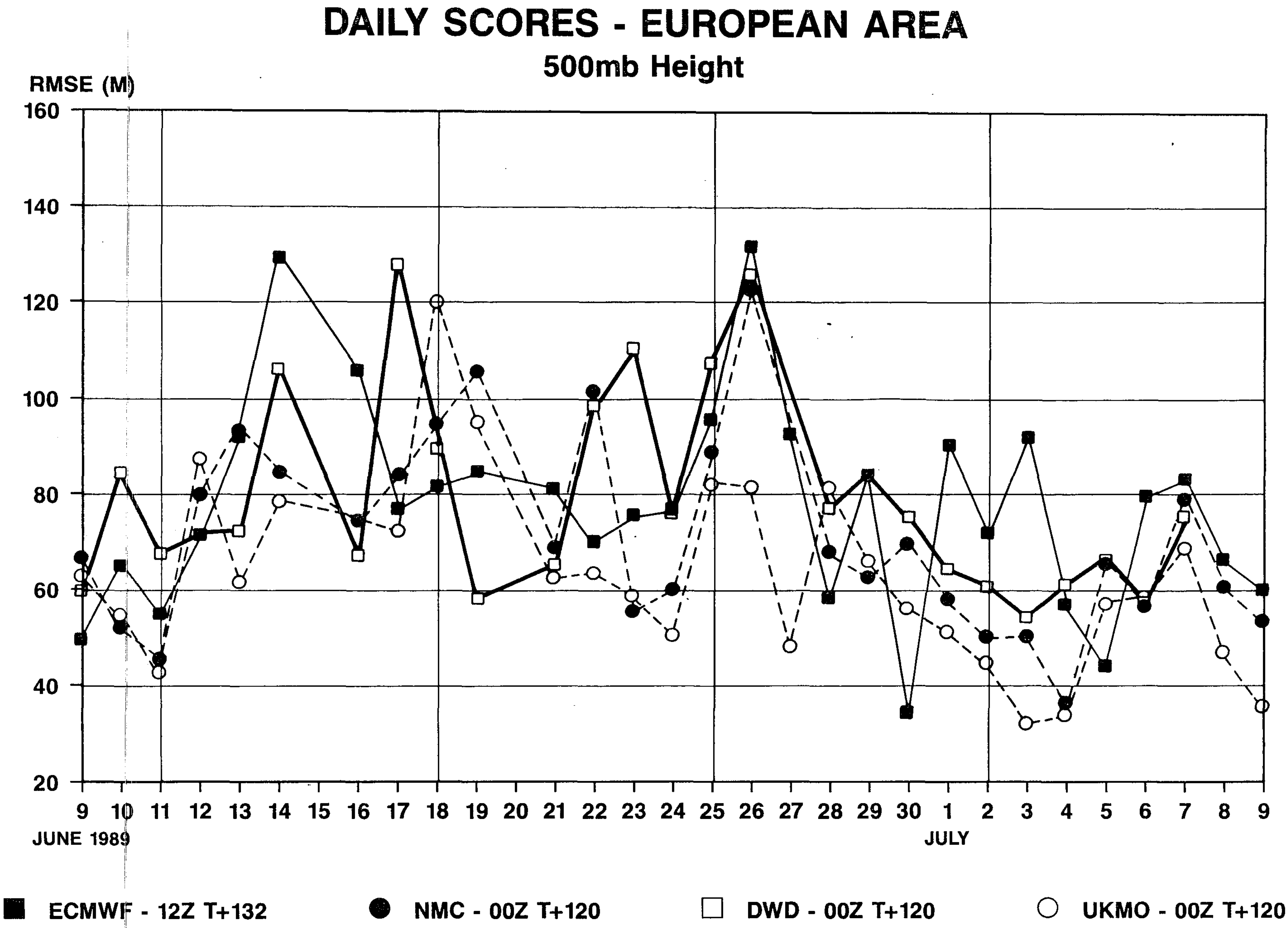



Figure 1

WS.NOV22a

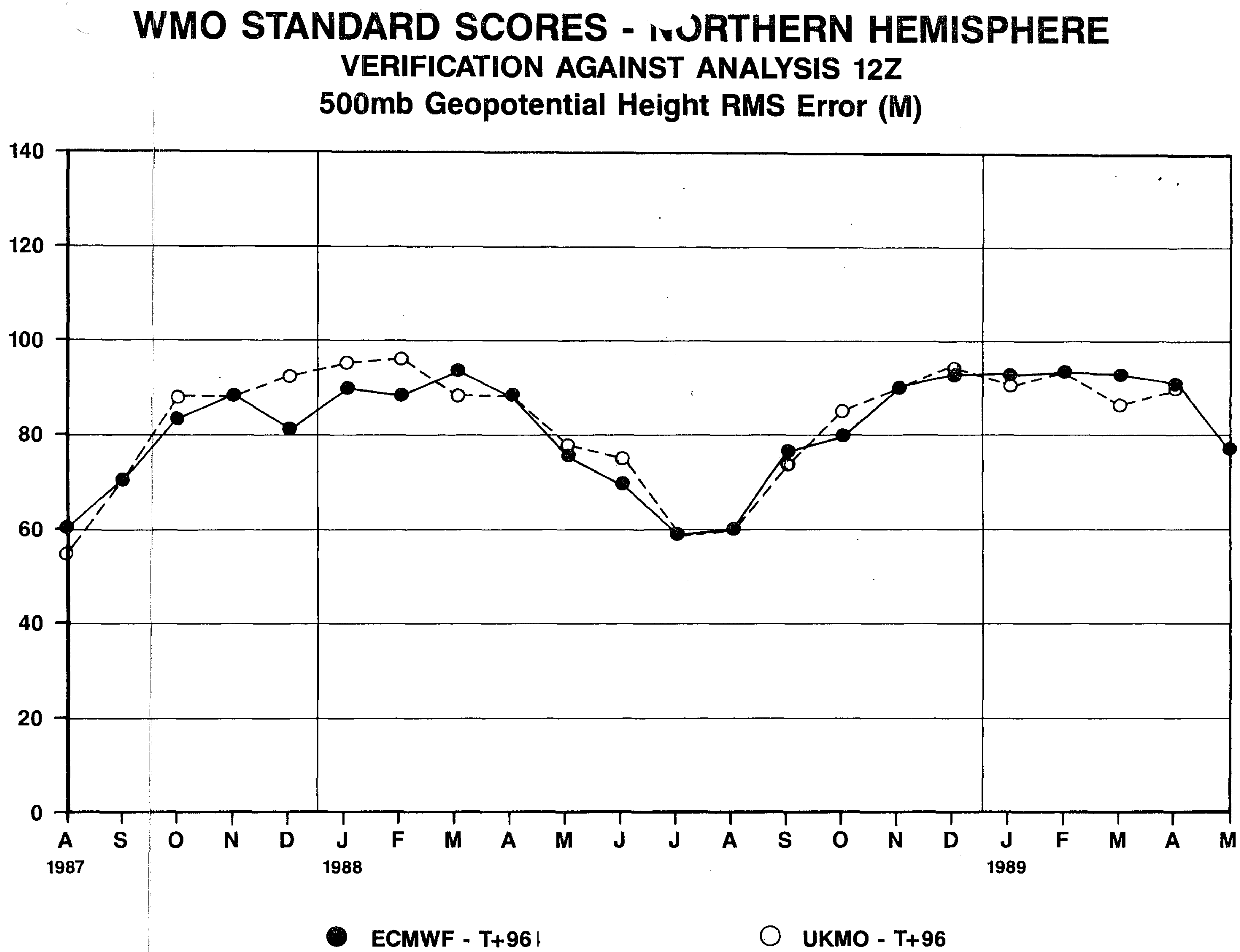
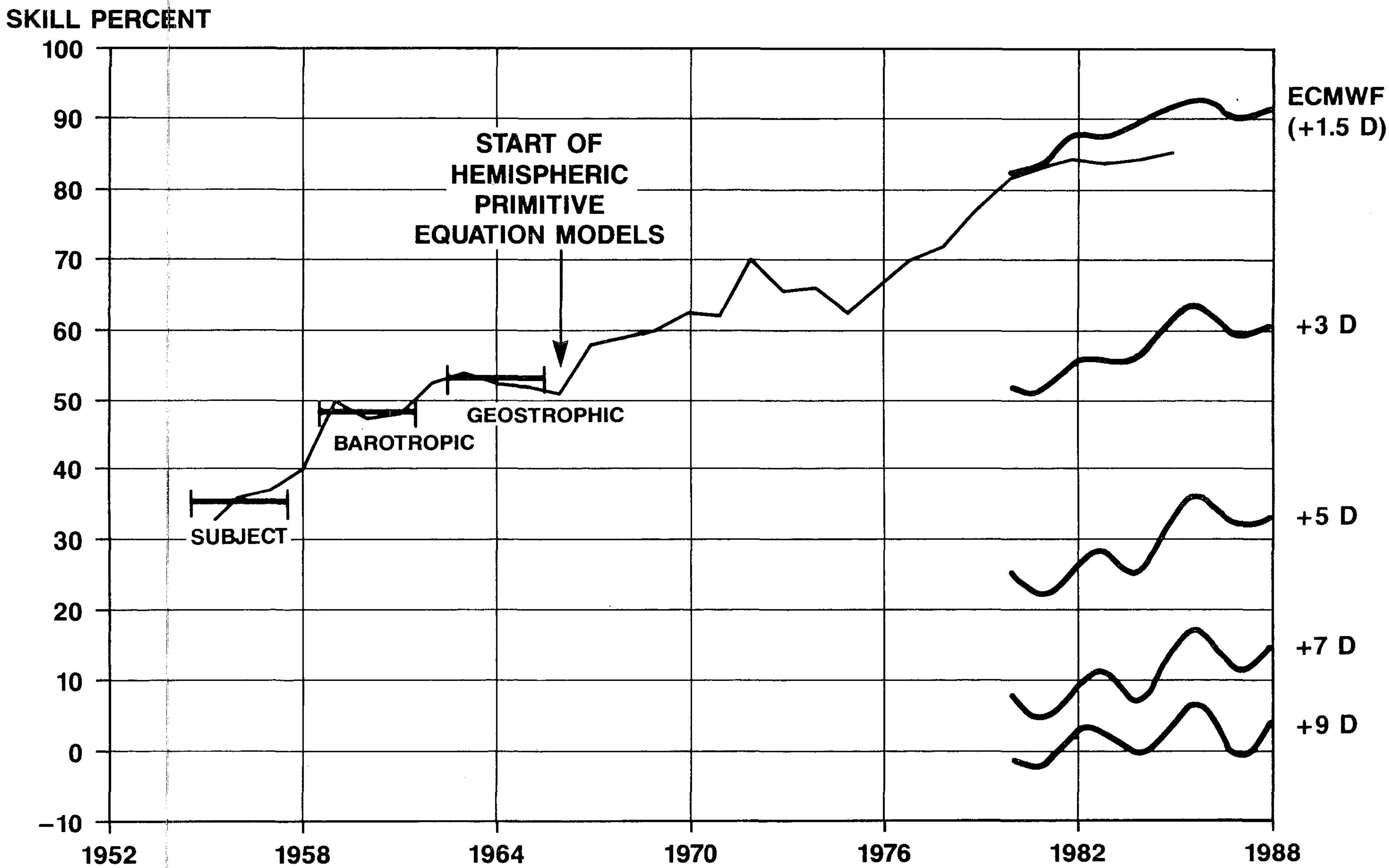



Figure 2

WS.NOV22c


SKILL PERCENT
100
90
80
70
60
50
40
30
20
10
0
−10
1952
1958
1964
1970
1976
1982
1988
START OF
HEMISPHERIC
PRIMITIVE
EQUATION MODELS
SUBJECT
BAROTROPIC
GEOSTROPHIC
ECMWF
(+1.5 D)
+3 D
+5 D
+7 D
+9 D

Fugure 3

# 30 DAY MEAN SCORES - EUROPEAN A

500mb Height

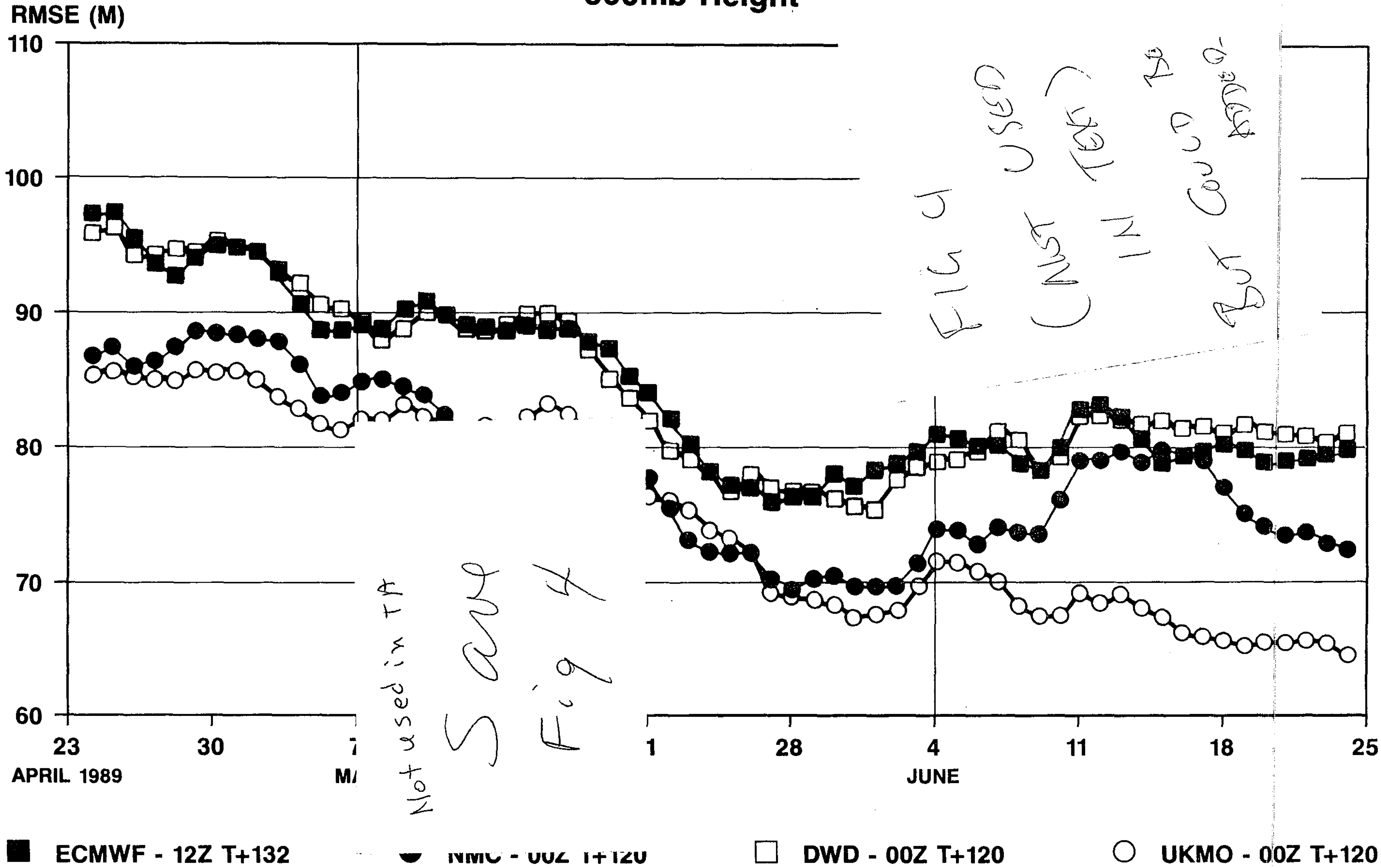



Fig 4 (not used in text) but could be added

Not used in TA
Same
Fig 4

WS.NOV22