1.23 A CASE STUDY OF THUNDERSTORM FORECASTING IN WEST AFRICA

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ABSTRACT

The development of Numerical Weather Prediction (NWP) techniques and the advent of satellites have permitted significant improvements in the real-time forecasts of various types of weather systems over West Africa. As for thunderstorms, for example, forecasts and warnings involve satellite images for detection and tracking. The paper therefore, examines the use of NWP products and satellite imageries in monitoring and forecasting the evolution and the decay of rain-producing weather systems. In particular, the thunderstorms, which were estimated to affect most coastal cities of West Africa by early morning of 5th March 1999, actually came. Based on the projected speed of 6 to 7 degrees of longitudes per day, the vortex located at 850 hPa level, on 4th March 1999 along (7°N, 10°E) was advanced westwards to affect some coastal cities by 5th March 1999. Interestingly, the convective activity which was first observed on the satellite pictures on 4th March 1999 over the high grounds of the region as mere cloud patches, developed and moved southwestwards. Also revealing, was the cloud-top radiative cooling which led to convective overturning and low-level convergence associated with vortices and asymptotes of convergence.

1.0 INTRODUCTION

The products, analysis and forecasts from the Global NWP models are now available in most West African main meteorological offices through the Meteorological Data Dissemination (MDD), systems via Global Telecommunication Systems (GTS). The problem of forecasting is basically related to the analysis and prediction of meso-scale motion systems, with scales ranging from 2 to 500 km. In order to cope with these short-lived, small-scale weather systems and supply users with timely weather information a Very-Short-Range Forecast (VSRF) system must be able to quickly collect observational data, process data, prepare a forecast and disseminate it to the user. Cornford, (2001), noted that, both lives and property values can be saved and economic benefits reaped by the use of VSRFs.

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early satellite-derived cloudiness compilation (Houze et al, 1976). In this study, it has been shown that cloud clusters have typical lifetimes of hours to a day, but may form part of much longer-lived weather systems. Sometimes these systems may evolve into squall lines when monitored from the satellite ground based station at Oshodi, Lagos – Nigeria. Therefore, forecasting the rain-producing weather systems, like thunderstorms, must be designed on the basis of users needs as well as meteorological, geographical and economic conditions.

2.0 STUDY AREA

West Africa is bounded by the Sahara Desert on the north, Atlantic Ocean on the south and Cameroun on the east (Fig. 1). It covers an area of about 420,000 square kilometers, with 15 countries. West Africa is one of the major geographical regions of Africa. The northern boundary is less clearly defined and is generally considered to follow the southern limit of the Sahara desert. The region is generally characterized by diversities in relief, climate, vegetation, soils, agricultural systems, peoples and religion.

3.0 METHOD OF ANALYSIS

The forecaster’s tools for forecasting the rain-producing systems include the Meteorological Data Dissemination (MDD) system, Primary Data User Station (PDUS), the MESSIR VISION and the High Resolution Picture Transmission (HRPT), system. In the objective analyses and re-analyses from the NWP forecast models, the synoptic systems observed at 850 hPa level (1,500 m above the surface), are displaced southwards, 2 to 3 degrees of latitudes over West Africa during the wet season. This occasional latitudinal displacement has been found to match with the satellite imageries available from the PDUS. In data-sparse areas, “bogus observations” are generated based on an interpretation of the imagery. This interpretive process is greatly simplified when the imagery is displayed on a visual display unit with the computed analysis and observational data superimposed. The development, movement and decay of individual cloud systems is monitored on a quasi-continuous basis employing cloud animation process. Thus, animation allows rates of development and movement to be easily quantified, thereby improving the accuracy of short-period forecasts. Animated displays allow forecasters to have a pictorial evidence of the expansion and cooling of cloud tops associated with major cyclonic developments.

4.0 APPLICATION OF NWP PRODUCTS AND SATELLITE IMAGERY

Presently, there is no Limited Area Model (LAM) for the short-range weather forecasting for West Africa. However, whenever feasible, full use is made of charts and prognosis rendered available by NWP techniques. The application of NWP products and Satellite data (as is currently done at the Central Forecast Office Lagos-Nigeria) has tremendously improved the general forecasting. The General Circulation Models (GCMs) used in forecasting include those of Meteo France, European Centre for Meteorological Weather Forecasts (ECMWF) and UK NWP models. The numerical techniques are based on the physical and dynamical evolution of synoptic systems. For example, for a low, the deepening or filling up, as determined by the pressure fall or rise at the centre are factors to look for in the charts. Also the strengthening or weakening as determined by the behaviour of the pressure gradient or winds are relevant facts to be noted. However, in preparing any weather forecast, it is necessary to consider how the synoptic systems shown on the current charts are likely to move and change during the forecast period. Satellite imagery is especially valuable in identifying and following mesoscale weather systems which might otherwise slip through the observing network undetected. The existence and organization of these smaller-scale features are often only recognizable from imagery.

5.0 THUNDERSTORMS OF 5th MARCH 1999

The convective activity which started around 1500 UTC on 4th March 1999 (Fig. 2.1), over mainly the mountainous areas of the region as mere cloud patches, developed and moved southwestwards to affect the
The thunderstorms which were estimated to affect most coastal cities by early morning of 5th March 1999, actually came (Fig. 2.2). Other conditions which facilitated the storm forecast were the vortices at 850 hPa level and sharp increases in pressure tendencies at the surface. Most of the precipitation centred in the coast where the cyclonic circulation of the southwesterlies was active. NWP model analysis also showed that the lifting effect along the mountain slopes played an important role in initiating convection. In particular, the Meteo France forecast models for 925 hPa, 10m winds and 850 hPa wind fields have been used to examine convections. Based on the projected speed of 6 to 7 degrees of longitudes per day, the vortex located at 850 hPa level, on 4th March 1999 along (7° N, 10°E) was advanced westwards to affect the coastal cities of West Africa by 5th March 1999 (Fig. 2.2). The vortex at 850 hPa (Fig. 2.3), was sustained by the moist southwesterly winds (from the south Atlantic Ocean) flowing into it. During the entire rainstorm, a cyclonic vortex stagnated at 850 hPa level, due to a mid-latitude trough which came in phase with the vortex. From the various analyses, and by using the NWP products, convective systems occur most frequently near or just to the west of the wave trough at 700 hPa level (Fig. 2.4).

6.0 SOCIO-ECONOMIC BENEFITS OF VSRF

The overall socio-economic benefits of Very-Short-Range Forecasts (VSRF) can be summarised below

(i) The forecast can bring about safety of lives and property. Safety reasons have motivated the use of weather forecasts. Weather forecasts or warnings for severe weather can prevent damages on structures and save human life.

(ii) VSRF is used to increase economic efficiency. In order words, it can be used to minimize weather induced losses. For instance, there is a potential for large economic savings by using VSRF to a large extent

(iii) VSRF can be used to improve environmental conditions and the quality of life. For instance, leisure time activities can be arranged and planned on the basis of weather forecast

7.0 HOW TO IMPROVE THE VSRF

(a) The VSRF system should be designed on the basis of users needs as well as meteorological, geographical and economic conditions

(b) A regional model or a Limited Area Model (LAM) can be developed for West Africa so that the basis for imposing Global models on regional parameters is avoided and therefore paves the way to more accurate weather forecasts.

(c) A VSRF system must be able to quickly collect observational data, process data, prepare a forecast and disseminate it to the appropriate user

CONCLUSION

The analyses of both satellite data and NWP products have strongly indicated the enhancement of convective activity in the trough region. The study however, noted that cloud clusters generally develop as mature organized systems near the centre of cyclonic vorticity and in the regions of an easterly wave where the strongest vertical motions are found. Various synoptic analyses have indicated that the convective systems over west Africa occur most frequently near or just to the wave trough at 700 hPa level. It has also been shown that the overall economic and social benefits of VSRFs can be enormous. Again, the new telecommunication technology permits the prompt transmission of detailed short-range weather forecasts to the general public and to specialized users.

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Fig. 1  Location Map of West Africa

Fig. 2.1  Infra-red satellite Cloud Image. 15:00 UTC, 4 March 1999
(Source: EUMETSAT)
Fig. 2.2 Infra-red satellite Cloud Image. 01: 30 UTC, 5 March 1999
(Source: EUMETSAT)
Fig. 2.4 700 hPa Streamline Analysis
0000 UTC, 5 March 1999