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MASTER

**Some Observations of a Subsynoptic
Scale Disturbance**

University of California

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SOME OBSERVATIONS OF A SUBSYNOPTIC SCALE DISTURBANCE

by

Sumner Barr, William E. Clements, and John Archuleta

ABSTRACT

A subsynoptic scale disturbance in the lower troposphere passed through the Georgia-South Carolina area during a field experiment in which supplementary meteorological data were available at the Savannah River Laboratory. Consistencies were noted in the fields of wind, temperature, and cloudiness, which aided in the documentation of the feature. This event is suggested as a useful case study for the application of mesoscale dynamical models.

I. INTRODUCTION

On 10 December 1975, a cooperative experiment was conducted by several participating laboratories including the Los Alamos Scientific Laboratory (LASL), the Savannah River Laboratory (SRL), the Air Resources Laboratory of the National Oceanic and Atmospheric Administration (NOAA), and the Brookhaven National Laboratory (BNL). Several atmospheric tracers were released concurrently from two sites at the Savannah River Plant (SRP) and collected at a ground-level crosswind sampling array located about 100 km downwind. The primary goals and details of the experiment are described elsewhere by Bench et al.¹ The purpose of the report is to describe a subsynoptic scale feature that appeared during the experiment and affected the wind and cloud fields. The diagnosis of time and space variations of wind, clouds, and associated convective turbulence was made in real time from the charts that are reproduced in this report and was found to be useful in the operational phase of the experiment and in the subsequent interpretation of results.

Primarily, the experiment gave an opportunity for a brief case study of a subsynoptic wave disturbance imbedded in a northwesterly flow in the middle troposphere. Similar amplitude meteorological features with lateral dimensions of about 100 km and related passage times of a few hours have been reported by Beran and Rogers,² Rogers and Sherr,³ and Barr, Long, and Miller.⁴

These features may affect the meteorological parameters of wind direction, temperature, pressure, and cloudiness on the short term. Unless the amplitude of the disturbance is unusually large, however, they may not appear in the commonly observed weather events of strong surface winds or precipitation. The 10 December 1975 disturbance was weak, particularly at ground level, and it would probably not have been recognized if we had not been interested in subtle wind direction properties for the transport of tracer material.

II. THE DISTURBANCE

The data base available for analysis includes the National Weather Service surface and upper air networks supplemented by approximately hourly pilot balloon observations at SRL between 0700 and 1700 EST and tower-based wind and temperature at SRL.

Figure 1 shows time-height cross sections of wind direction and speed obtained by visual theodolite tracking of pilot balloons released near the tracer release point. A tendency for the wind direction to veer to northerly appeared at an altitude of 1.5 km at 0800 EST and propagated down to 0.5 km by 1000 EST. This tendency was followed by a backing tendency to 270° that propagated similarly. After 1100 EST, this transient feature had passed, and the wind field settled into a relatively steady northwest flow at 7-10 m/s in the 1.5-km-deep boundary layer. Note that the surface winds at the balloon launch site underwent much smaller changes with time than the winds above 0.5 km.

Surface isobaric analyses for 0700 and 1300 EST, shown in Figs. 2 and 3, offer evidence of a weak low-pressure trough imbedded in the northwesterly flow. The trough line moves at about 10 m/s through South Carolina during the morning and is located in the SRL area at about 1300 EST. Surface reports suggest some slightly enhanced cumulus cloud activity near the trough but no obvious changes in wind speed or direction.

The key to the disturbance can be found in the 850-mbar (~1.5-km altitude) upper air analyses for 1900 EST on 9 December and 0700 and 1900 EST on 10 December (Figs. 4-6). At 1900 EST on the 9th (Fig. 4), a pool of cold air located in Illinois and Indiana. Associated with this cold air is a subsynoptic scale trough that shows up in Fig. 5 as a kink in the 850-mbar height pattern. The small-scale system moved through the major trough with the center of cold air in Tennessee and Kentucky and the minitrough line in northern Georgia by 0700 EST on the 10th (Fig. 5). With the continued movement of the subsynoptic wave through the SRL area, it is expected that the winds would veer to northerly or beyond, running essentially parallel to the height contours of Figs. 4-6. Then, with the weak gradients that were in Kentucky at 0700 EST, the wind would weaken, finally re-establishing under the northwesterly oriented contours after the short wave passed through.

A supporting piece of evidence for the short-wave/cold-pocket passage is in the 0700 EST upper air soundings for Athens, Georgia; Waycross, Georgia; and Charleston, South Carolina plus the observations of cloudiness during the day. The soundings, shown in Fig. 7, have a strong temperature inversion at 1.2 km above ground. This inversion was inconsistent with the observed development of cumulus between 1100 and 1500 EST at 1 to 1.5 km. The preferential advection of cold air at heights near and above 850 mbar could alter the inversion and allow deeper convection. To test the effect, estimated soundings were constructed for Athens at 1000, 1100, 1200, 1300, and 1500 EST

based on observed surface temperature and advected temperature fields at 850 and 700 mbar (Fig. 8).

This admittedly simplified model assumes linear interpolation in height above a shallow (~100-m) superadiabatic layer. The effects of surface heating and modification by ground based convection are acknowledged in the model, and it represents a reasonable test of the potential consequences of advection of the cool pocket aloft. Analysis of these soundings by the parcel method shows the initiation of moist convection at 1100, a maximum at 1300, and ending at 1500 EST. This coincides very closely with the observed clouds that were first noted at 1030 EST, reached 4/8 sky cover at 1300, and dissipated completely by 1700 EST.

In all likelihood, the analysis described above yields convenient but oversimplified results. The soundings for Athens, Charleston, and Greensboro at 1900 EST (not shown) show that the inversion is still present in the vicinity of the cold pocket. It is, however, much higher for stations near the cold air than for the stations farther away.

Satellite cloud photographs, Figs. 9-13, show an extensive quasi-stationary cloud mass in the midwestern United States with its eastern boundary coincident with the Appalachian Mountains from Tennessee to Pennsylvania. The eastern edge of the main cloud mass shows extensive orographic influence with widespread and persistent patterns of wave clouds.

The clear area along the Savannah River between Georgia and South Carolina sees the first evidence of cloudiness just northwest of the SRP at 1130 EST (Fig. 10). The area of cumulus cloud appears to develop in place through the Carolinas during the afternoon. There is evidence, however, of a gradual south-eastward drift of the area of instability as the clear gap between the stationary cloud mass and the leeside area of cumulus widens throughout the day. The clearing skies reported in the surface observations at the SRP in mid-afternoon is because the bulk of the cumulus cloud activity has drifted beyond the site.

The cloud pattern on a broader scale, Fig. 14, suggests a weak vortex structure offshore, south of Cape Hatteras, at 1600 EST.

Perhaps the most significant observation from the satellite photographs is an indication of the scale of the cumulus patch, a few hundred kilometers, which is consistent with the scale of the cold pocket and the associated short-wave trough.

III. SUMMARY

In this simple case study, we have not attempted to document the detailed dynamics of the 10 December 1975 phenomenon, but merely note its existence and observe some apparent consistencies between different observed variables. We would be pleased to see mesoscale dynamical models brought to bear on the case and would hope that the supplementary data collected in conjunction with the experiment might aid in the testing of mesoscale models.

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Fig. 1.
Time-height cross sections of wind
direction and speed (ms^{-1}) at the
SRP on 10 December 1975.

Fig. 2.
Sea-level isobaric analysis at
0700 EST on 10 December 1975.

Fig. 3.
Sea-level isobaric analysis at
1300 EST on 10 December 1975.

Fig. 4.
850 mbar heights (m) and temperature (°C) at 1900 EST on
9 December 1975.

Fig. 5.
850 mbar heights (m) and temperature ($^{\circ}\text{C}$) at 0700 EST on 10 December 1975.

Fig. 6.
850 mbar heights (m) and temperature ($^{\circ}\text{C}$) at 1900 EST on 10 December 1975.

Fig. 7.
Upper air soundings in the SRP area at 0700 EST, 10 December 1975.

Fig. 8.
Estimated soundings for Athens, Georgia, on 10 December 1975.

Fig. 9.
Satellite photograph of south-
eastern United States for 1030
EST on 10 December 1975. The
symbol x denotes position of the
SRP.

Fig. 10.
Satellite photograph at 1130 EST
on 10 December 1975.

Fig. 11.
Satellite photograph at 1230 EST
on 10 December 1975.

Fig. 12.
Satellite photograph at 1330 EST
on 10 December 1975.

Fig. 13.
Satellite photograph at 1430 EST
on 10 December 1975.

Fig. 14.
Satellite infrared image at 1600
EST on 10 December 1975.