On the Correlation of Radar Echoes over Florida with Various Meteorological Parameters

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1. Introduction

One of the more difficult forecast problems in Florida is summertime showers. Drastic changes often occur in the shower regime despite persistence of the major map features. Conditionally unstable air prevails during the summer season and small deviations in either the dynamics or thermodynamics of the atmosphere can produce rather dramatic changes in the convection. These deviations are extremely difficult to foresee. Gentry (1950) revealed the nonpersistent character of showers in the vicinity of Miami. Using 10 raingages, he recorded the number receiving rain each day. During five summers, there were almost equal numbers of days in which no stations reported rain, one station reported rain, two stations reported rain and so forth up to ten stations reporting rain. In other words, the shower regime is quite variable.

A number of people have investigated this problem with only limited success. Carson (1954) gives a very complete survey of many published as well as unpublished reports. All of these studies were based on raingage reports and therefore suffer from limitations imposed by the network of recorders. There was almost unanimous agreement that low-level moisture was a most important parameter.

During the summers of 1963 and 1964 a unique set of data was collected which offers a vast improvement over the rainfall records and lends itself to a study of the Florida shower problem (Frank *et al.*, 1967). Radar echoes were manually recorded on a 7.5 by 7.5 mi grid every 3 hr at Miami, Daytona Beach and Tampa. The radar sets were all placed on a 100-mi range. The areal coverage as well as the grid is shown in Fig. 1. From these data one can accurately obtain the percentage of the peninsula covered by radar echoes at each observing time. All echoes are assumed to be showers. Considering the geographical location and time of the year, this is probably reasonable.

In an attempt to discover conditions which are favorable for showers, the echo areal coverage was

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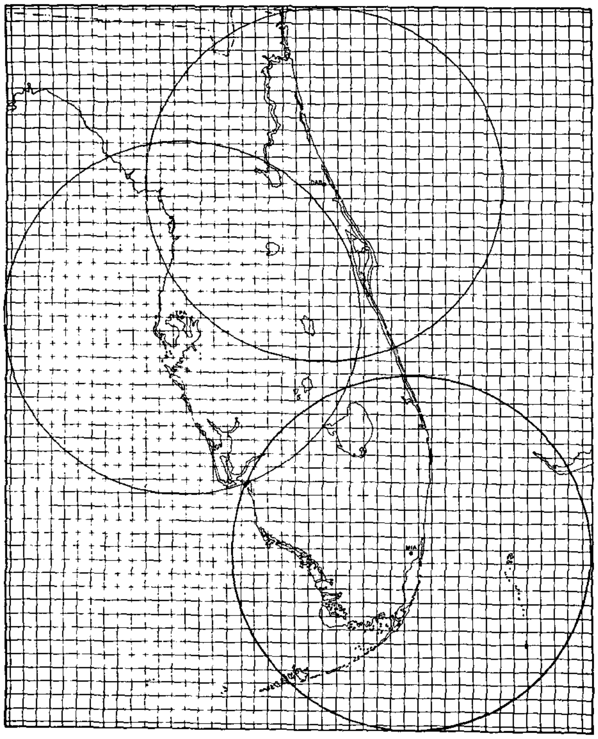

Fig. 1. Areal coverage and 7.5 by 7.5 mi grid used in obtaining radar echo coverage over Florida. Radar sets, placed on a 100-mi range, were located at Miami, Daytona Beach and Tampa.

correlated with a number of meteorological parameters which could be extracted from radiosonde observations. The parameters used are listed in Table 1. In all cases except divergence, vorticity and vertical motion, they represent averages from the three radiosonde stations at Jacksonville, Tampa and Miami. The correlations are between data taken from the morning sounding (1200 GMT) with afternoon echoes at 1300, 1600 and 1900 EST. Myers (1964) did a similar computation for central Pennsylvania.

The Bellamy triangle method (1949) was used in computing divergence, vorticity and 500-mb vertical motion. Jacksonville, Tampa and Miami form the apexes of the triangle. Day (1953) and Byers and Rodebush (1948) both used the Bellamy system to compute divergence over Florida. Byers and Rodebush used their divergence computations to support the hypothesis that the Florida thunderstorm maximum is due to a double seabreeze. Day found that "wet" days tended to be associated with stronger low-level convergence. However, divergence calculated this way is very sensitive and seriously affected by small errors, making it difficult to use in a day-to-day scheme.

2. Results

A survey of Table 1 reveals the following points:

1) The only significant correlations involve moisture. Poor correlations are obtained with the surface and 950-mb humidity because moisture is nearly always present at this level. The humidity correlations improve rapidily with height reaching a maximum at 650 mb. This means that showers are more likely with a deep moist layer. Chalker (1949) concluded the same thing in his study of air mass showers. This also supports the results of several studies cited by Carson.

2) Even though the magnitude of the other coefficients are generally near or below the significant level, the sign often agrees with what we would expect. The following might be noted:

a. Showers at 1300 and 1600 tend to be associated with warmer surface temperatures and cooler temperatures above 850 mb. This is also supported by the 24-hr 550-mb temperature change and the 850–550 mb lapse rate.
b. Showers are more likely with cyclonic vorticity aloft.

Table 1. Linear correlation coefficients relating the percentage of the Florida peninsula covered by radar echoes at the times specified and various parameters taken from the morning (1200 GMT) radiosonde observations at Jacksonville, Tampa and Miami. Data used in this table were collected during May through August 1963. Non-computed parameters (i.e., those other than divergence, vertical motion and vorticity) are averages from the three soundings.

1200 GMT Observations	Local time (EST) 1300	1600	1900
Surface humitity	0.21	0.21	0.24
950-mb humidity	0.40	0.38	0.18
850-mb humidity	0.56	0.60	0.48
750-mb humidity	0.60	0.54	0.37
650-mb humidity	0.65	0.66	0.46
Precipitable water	0.56	0.44	0.25
Surface divergence	0.17	0.11	−0.09
950-mb divergence	0.18	−0.09	−0.12
850-mb divergence	0.06	−0.20	−0.27
750-mb divergence	0.16	−0.09	−0.20
650-mb divergence	0.20	0.03	−0.08
550-mb divergence	−0.01	0.06	−0.06
500-mb vertical motion	0.22	−0.09	−0.26
Surface pressure	−0.11	−0.09	0.03
950-mb height	−0.08	−0.09	−0.02
850-mb height	−0.03	−0.04	0.01
750-mb height	0.00	−0.04	−0.04
650-mb height	0.00	−0.06	−0.07
550-mb height	−0.02	−0.10	−0.14
24-hr 550-mb height change	−0.17	−0.22	−0.09
Surface temperature	0.24	0.15	−0.02
950-mb temperature	0.11	0.01	−0.13
850-mb temperature	0.10	−0.01	−0.19
750-mb temperature	0.07	−0.01	−0.16
650-mb temperature	−0.09	−0.24	−0.29
550-mb temperature	−0.07	−0.18	−0.25
24-hr 550-mb temperature change	−0.04	−0.04	−0.15
Lapse rate (850–550 mb)	−0.17	−0.17	−0.06
Surface vorticity	−0.06	−0.04	−0.05
950-mb vorticity	0.09	0.03	0.09
850-mb vorticity	0.26	0.18	0.13
750-mb vorticity	0.19	0.09	0.03
650-mb vorticity	0.15	0.12	0.06
550-mb vorticity	0.18	0.24	0.23

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c. Showers are directly related to surface divergence.
d. Even though the poorest correlations involve the heights, showers are more likely with a 24-hr 550-mb height fall.

3) The correlations tend to be much better with the 1300 and 1600 observations than the 1900. This is because showers are more prevalent at the earlier times. Table 2 presents the average echo coverage (%) at various times during the day for July and August of 1963 and 1964. The shower distribution reaches a maximum during the afternoon between 1300 and 1600, then drops considerably by 1900.

TABLE 2. Average per cent of the Florida peninsula covered by radar echoes during the months of July and August, 1963 and 1964, for the times specified.

	Local time (EST)							
Month	0100	0400	0700	1000	1300	1600	1900	2200
July	4.1	4.1	4.7	11.8	19.6	19.7	12.5	6.2
August	1.2	1.3	2.2	6.4	19.4	23.3	14.8	4.2
July and August	2.7	2.7	3.5	9.1	19.5	21.5	13.6	5.2

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