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A COMPARISON OF PROBABILITY OF PRECIPITATION FORECASTS AND RADAR ESTIMATES OF RAINFALL AREAL COVERAGE

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1. Introduction

In this study we continue an investigation of summertime rainfall in southern Alabama and northwest Florida. Data from the summer of 1977 have been tabulated and are presented here for comparison with those from the summer of 1976 (see Smith, 1977, and Smith and Henderson, 1977).

2. Data

A brief review of the nature of the data and the scope of our investigation is in order. Basically, forecasts of the point probability of precipitation (PoP) are compared with observations of rainfall areal coverage as deduced from hourly radar data. Fig. 1 shows the eight forecast zones, four in Alabama and four in northwest Florida, which were used in the study. First period PoP forecasts for the 12-hour night (0000-1200GMT) and day (1200-2400GMT) periods were tabulated. These forecasts were prepared by the WSFO at Birmingham. A full explanation of the nature of the PoP forecasts was given in the earlier study (Smith, 1977). Areal coverage of rainfall within each zone was estimated for the same 12-hour periods by compositing hand-drawn hourly overlays. Observations from the WSR-57 radar at Pensacola were used. Details of this procedure and a discussion of its limitations were also given in the earlier study. The 1977 study period comprised the three month summer season (June through August).

Echo coverage was determined to the nearest 10% with an estimated accuracy of ± 10%. PoP values were extracted from the zone forecasts. Because precipitation is not mentioned in the zone forecasts unless the PoP is 20% or greater we could only form the large category "less than 20%" to include PoP forecasts of 0, 5 and 10%. In all respects the data sets from 1976 and 1977 were the same. That is, there were no changes in the nature of the PoP forecast procedure and the radar data were tabulated in the same way each year. Two factors should be kept in mind when comparing the results of each year's forecast/coverage analysis, however. First, results from the 1976 study encouraged us to establish a procedure with the WSO at Pensacola whereby that office telephoned zone estimates of rainfall coverage, from the radar data, to the forecasters at Birmingham in real-time. The daytime (nighttime) coverage estimates were received within a few hours after the close of the 12-hour period -- well before the PoP forecasts were final-

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Matthew Smith was a High School student aide at the WSFO, Birmingham during 1977.

ized for the following daytime (nighttime) period. This procedure began about mid-June, 1977. It is not known to what extent forecasters utilized this information in preparing their forecasts but possible effects are discussed below.

The second factor concerns the tabulation of the 1977 radar data. The procedure was unchanged from the previous summer but the subjective evaluation of total echo coverage within each zone was carried out by a different individual. It is possible that coverage estimates for the summer of 1977 might differ systematically from those of 1976. In fact, a test of just a few periods from 1977 suggested that the individual whose estimates were used for that summer tended to estimate daytime coverages about 10% greater than those of the individual whose estimates were used in 1976. Nighttime estimates of the two were virtually identical. The possible daytime bias should be kept in mind when comparing rainfall areal coverage for the two summers. Incidently, Pensacola's real-time estimates were not used in this study since it was not known exactly how they were arrived at.*

For a consideration of the theoretical relationships between the PoP forecasts (actually, the average point probability of rainfall for a zone) and the coincident observed areal coverage of rainfall (as estimated by radar for the same zone) readers are referred to Sections 2 and 3 of the 1976 study (Smith, 1977). That discussion should serve as background material for what follows here.

3. Characteristics of Summer Averages of PoP Forecasts and Radar Coverages

As was done in 1976, we begin our examination of the data with a look at summer averages without comparing specific PoP forecasts and coincident coverages. Recall that forecasts grouped as "less than 20%" contain unknown numbers of 0's, 5's and 10%'s. Again, we took an average of 5% for these forecasts although the true average is probably closer to 0% because 0% forecasts almost certainly outnumbered 10% forecasts. Estimated coverages of less than 10% represent cases where there were echoes in a zone but coverage was determined to be less than 10%.

The format of Table 1 is unchanged from last summer; for comparison 1976 data are shown in parentheses. The table shows averages of

a) Forecast probability
b) Areal echo coverage on all days (and nights)

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* The Pensacola estimates correlated extremely well with ours although there were a few cases of 30 to 50% differences in coverage estimates.

c) Areal echo coverage on days (nights) when an echo occurred somewhere in a zone, regardless of coverage
d) Frequency of occurrence of an echo somewhere in a zone
e) Rainfall frequency for the summer (determined from data at Dothan and Mobile in Alabama and Pensacola and Apalachicola in Florida)

Averages were formed for each group of four zones and for all eight zones combined.

It appears that the summer of 1977 was somewhat wetter than the previous summer. This can be seen by the higher frequency of echo-days/nights (d) and the greater daytime average areal coverages (b and c). Oddly, it seems that rain occurred more often in the summer nights of 1977, but on the average covered a smaller area, than in 1976. The differences in 1976/1977 coverages might be due in part to bias arising from a change in the individual who determined the coverages. Greater daytime coverages in 1977 are consistent with results of the test mentioned earlier, although the lower nighttime coverages in 1977 are inconsistent. Additional information in Table 1, however, suggests that bias is not the likely cause of the difference.

Recall that the average echo coverage on all days (b) should equal the product of the average coverage on rain days only (c) and the average frequency of occurrence of an echo somewhere in the zone (d) -- this is the familiar equation $P = C \times A$ which was presented in the earlier study. The 1977 data satisfy this equation precisely for each group of zones and for both the night and day periods (as did the 1976 data). Actually, barring computational error, there is no way the data set could not yield this result! The reader can determine this rather easily by expressing each term symbolically and then forming the product. Term (d) is not open to subjective evaluation -- in a given period there was either an echo in the zone or there was not. The other terms might be influenced by an analyst's bias, however. But Table 1 contains an "independent" bit of data, (e), the average rainfall frequency. Without reconstructing the argument presented in the earlier study it can be shown that if the rainfall is homogeneous within a zone then the frequency of occurrence of rain at any point in the zone (e) is equal to the average rainfall (echo) coverage (b). Table 1 shows that with one exception the data from 1977 verify this (as, of course, did the 1976 data). This correspondence of frequencies, based on radar and rainfall data, reinforces our confidence in the accuracy of the estimated echo coverages. Bias appears not to be a significant factor.

The average nighttime areal echo coverage in 1977 was about 17% -- very close to the 1976 average -- and the average rainfall frequency was about the same. During the summer days of 1977 the average coverage was much greater -- 40 to 45% -- and about 10% greater than the 1976 average. Note that the daytime Alabama zone average was about the same as the rainfall frequency estimated from data taken at Mobile and Dothan (~38%). However, the Florida zone average coverage (45%) was twice as large as the rainfall frequency (22%)! This large discrepancy is easily explained. It is likely that daytime echoes in the Florida zones were inland, thus, rainfall frequencies at Pensacola and Apalachicola, both coastal stations, were simply not representative of the Florida zones. The relatively high daytime frequencies of occurrence of echoes somewhere in the zones and the large average areal echo coverages suggest a high incidence of moist southerly flow, which also would result in a marked tendency for inland showers during the daytime (see Smith and Henderson, 1977). Data from 1976 showed the same tendency in the Florida zones during the daytime periods and some indication of the same effect at night. In general, the coastal stations are representative at night because showers tend to occur after midnight along the coastal strip, affecting the coastal stations with a frequency close to the measured areal coverage of rain.

A significant feature of Table 1 is the revelation that it rained somewhere in the Florida and Alabama zones almost every day during the summer of 1977 (on about 85% of the daytime periods). When it rained, moreover, the average zone coverage was around 50%! During the summer nights it rained somewhere on about two-thirds of the nights, covering on the average about one-fourth of the zone.

Now what about the PoP forecasts? Given a homogeneous rainfall distribution we know (and have shown for the 1977 data sample) that the average areal rainfall coverage (on all days - b) is the same as the rainfall frequency at any given point (e). It was shown in the earlier study that (b) and (e) are the same as the average point probability of rainfall -- which is just what our PoP forecasts are supposed to be! So, on the average, our forecast PoPs (a) should be the same as the average areal echo coverage (b) and the same as the average rainfall frequency (e). Were they in 1977? Yes and no! The daytime averages were close -- excellent for the Alabama zones, in fact. Interestingly, in the Florida zones the average PoP was slightly less than the average coverage (40% vs 45%). One is tempted to speculate that the PoPs were "hedged", consciously or otherwise, toward recognition of the lower rainfall frequency (22%) along the populated coastal strip. To a smaller extent the same effect can be seen in the 1976 data.

For the nighttime periods of 1977 there was a stunningly perfect correlation between the average forecast PoP and the average areal coverage -- but not the coverage on all days (the unconditional coverage)! Rather, the average PoPs were the same as the conditional areal coverage -- the average on just the rain days! It's as if for the summer of 1977 the forecasters said, "If it rains tonight somewhere in the zone your chances of being rained on are __%." Unfortunately, the nighttime PoPs represent overforecasting because forecasters failed to reflect the fact that about one-third of the time it did not rain anywhere in the zone. It is doubtful that forecasters consciously forecast the conditional areal coverage. Most likely their relatively high PoPs reflect an overestimate of the frequency of occurrence of rain in the zone and an overestimate of areal coverage when it was expected to rain. Most studies show that echoes dissipate very rapidly after about 5pm. We can investigate this further by considering individual PoP forecasts and areal coverages in later sections. By way of comparison, the 1976 data showed a tendency to overstate the nighttime PoP but the average PoPs were nowhere near the average conditional areal coverages.

4. Comparison of Frequencies: PoP Use and Observed Coverage

An examination of frequencies of use of individual PoP values and frequencies of observation of given areal coverage values in 1977 provides some interesting comparisons with 1976 data. Figs. 2 and 3 show these data in a form similar to that used in the earlier study. In general form the graphs showing frequency of use of the various PoP values are similar for 1976 and 1977. There are significant differences, however. Except as noted the following comments apply generally to the Florida and Alabama zones.

One gets the first impression from Fig. 2 that at night in 1977 PoPs of 30 to 50% were used with greater frequency than in 1976. During the day PoPs of 40 to 70% were used more frequently. Below these values, reduced frequencies of use were seen in 1977. As in 1976, with the exception of PoPs $<$ 20%, forecasters tended to use PoPs below about 50% with (occasionally much) greater frequencies than corresponding areal coverages were observed (compare corresponding curves in Figs. 2 and 3). Considerably fewer $<$ 20% forecasts, and comparatively fewer 20% forecasts, were made in 1977 -- the deficit apparently being made up for by a relative abundance of 30% to 50% PoPs in 1977. Note in Fig. 3 that the frequencies of occurrence of given areal coverages were not significantly different for the nighttime periods of the two years. During the day areal coverages in the middle ranges were slightly greater in 1977, particularly in the Florida zones. The tendency for higher PoPs, on the average, in 1977 presumably reflects the forecasters' realization of a "wetter" environment that summer. Regardless of whether the summer of 1977 was significantly wetter than the previous summer, forecasters quite possibly reacted to Pensacola's daily coverage estimates by issuing PoPs a little higher than those they might otherwise have used.

The reduced frequency of use in 1977 of PoPs less than 20% is unfortunate because it was not matched by a significant reduction in the frequency of occurrence of less than 20% coverage days. 20% PoP forecasts during the daytime were issued noticably less frequently in 1977 and the frequency of use closely matched the frequency of observation of 20% coverage (an improvement over 1976). At night, however, such forecasts were still greatly overused. The daytime "peak" in 1976 at 30% PoP forecasts was replaced in 1977 by a "hump" from 30 to 50%. During the nighttime periods the use of PoPs from about 30% to 50% occurred with frequencies about 5% greater than in 1976. This, along with the reduced frequency of $<$ 20% forecasts, accounts for the higher average PoP in 1977 -- and an average PoP incidently which matched the conditional areal coverage rather than the unconditional coverage!

PROBABLY THE MOST SIGNIFICANT FEATURE OF FIG. 3 is the indication that during the daytime periods of 1977 AREAL COVERAGES FROM 20% TO 100% OCCURRED WITH SIMILAR FREQUENCIES. This was seen in the 1976 data as well; in fact, daytime coverages from 20% to 100% were about the same for the two summers, averaging around 7%. Forecasters failed to reflect this in their PoP forecasts as, for the second year, frequencies of use averaged 15 - 20% for PoPs below 60% and fell to zero for PoPs greater than 80%. In other words, as in 1976, there was a "crossover" of forecast and observed frequency curves in the upper mid-ranges of forecast/coverage values. Observe in Figs. 2 and 3 that daytime PoPs above about 70% were made with less frequency than corresponding coverages were observed. For the second summer in a row no 90% or 100% daytime PoP forecasts were made for the zones used in the study. Interestingly, in the nighttime periods there were a few (four) 90% forecasts for the Alabama zones and one 100% forecast for a Florida zone. Although there were considerably more nighttime PoPs in the 70 to 100% range in 1977, nighttime areal coverages were above 70% so infrequently that their numbers were lost in the noise of the small data sample (except for a surprisingly large number of 100% coverage nights in the Florida zones -- seen also in the previous summer!).

5. Radar Indications of PoP Resolution and Reliability

We have examined average characteristics of PoP forecasts and areal coverages and seen that patterns of over- or underuse of certain PoP ranges were persistent from 1976 into the summer of 1977. Now, were there changes in 1977 in forecasters' over- or underforecast bias? How did individual PoP forecasts in the summer of 1977 compare with coincident observations of areal coverage? Were there significant differences from the previous summer? Fig. 4 provides answers. The figure shows the average of coverages which were observed for each possible PoP forecast value (solid lines) and the average of all PoP forecasts which were made when each decile areal coverage value was observed (broken lines). For example, considering all 40% nighttime PoP forecasts for Florida zones (upper left graph), the average observed coverage in those periods was about 30% (there were 47 such forecasts). For all periods when 30% coverage was observed in the Florida zones at night (15 cases) the average of the PoP forecasts for those periods was about 25%. In Fig. 4 fainter lines show data from the summer of 1976, as reproduced from Fig. 4 of Smith (1977).

It will not be necessary to repeat in detail here discussions from the earlier study concerning the significance of graphs such as those in Fig. 4. It will suffice to remind the reader that the broken lines graphically depict a kind of prefigurance -- they show how well given extents of areal coverage were forecast. They also reveal something about resolution -- showing how well forecasters were able to resolve the extent of areal coverage. The solid lines, on the other hand, show something like post agreement -- indicating how well given forecast PoP values verified against areal coverage. The solid lines are also quite analogous to the familiar graphs showing reliability, those in which frequency of rain is plotted against frequency of given forecast PoP values. The analogy holds because frequency of rain at a given point and average areal coverage are the same as long as the area is homogeneous in terms of rainfall distribution.

First, let's examine resolution of the PoP forecasts. Overall the broken lines in Fig. 4 show little change from 1976 to 1977. A major problem continues to be that as areal coverage increases to as much as 100% the averages of PoP forecasts increase only slightly -- never exceeding 40 to 50%. In other words, the forecasts lack resolution (or skill), especially in the middle PoP ranges. There is some indication of increased skill in the daytime forecasts of 1977. Average PoPs were 5 to 15% higher than in 1976 in the 30 to 80% coverage range. This apparently results from skill in applying the increased number of 40 to 70% PoP forecasts in the summer of 1977, over the number issued in 1976 (see Fig. 2). Unfortunately, the slopes of the broken lines are little changed from the previous summer, indicating a failure overall to selectively increase PoP forecasts on high coverage days and decrease PoPs on low coverage days -- the essence of resolution.

As pointed out in the earlier study, it is probably unreasonable to expect the broken curves of Fig. 4 to coincide with the diagonal dashed line. This would require forecasters to assess with complete accuracy both the likelihood of rain in the zone and the conditional areal coverage. A 100% PoP forecast is possible only if the forecaster is certain of the former and expects 100% coverage! Thus, we should not be surprised that the upper ends of the broken lines fall somewhat to the left of the dashed line. Obviously, however, resolution of summertime PoP forecasts is an area where considerable work remains to be done.

Now, were PoP forecasts reliable in the summer of 1977? Again, the answer must be a mixed, "Yes and no." The daytime curves for 1977 (solid lines, bottom graphs in Fig. 4) are similar to those of 1976 and lie close to the diagonal line (Ignoring for a moment PoPs above 50% in Alabama zones). We see that it rained over about 30% of the area on 30% forecasts, 50% of the area on 50% forecasts, and so on. But daytime PoP forecasts of 80% show a curious feature for the second summer in a row. Although only four such forecasts were made for Florida zones in 1977, they were quite reliable -- observed coverages were 70%, 80%, 100% and 100%. On the seven occasions with an 80% forecast in Alabama zones, however, coverage exceeded 50% only twice -- and average coverage was only 45%! The same general effect was seen for 70% forecasts in the two sets of zones. Based on two years' observations we suspect now that this is a significant feature. For some reason high PoP forecasts are more reliable for Florida zones than Alabama zones. On the other hand, comparison of the broken curves from the same daytime graphs shows that the Florida zone forecasts are no more skillful than the Alabama forecasts.

The graphs showing reliability of nighttime forecasts indicate a striking anomaly...for PoPs between 50 and 70% forecasters grossly overestimated rainfall probability! The effect is most pronounced for Florida zone forecasts. The anomaly was not seen in 1976; neither was there a hint of a similar problem in the daytime forecasts. For PoPs up to 40% the 1977 forecasts, like those in 1976, consistently overestimated the nighttime rainfall probability (on the average) but by only about 10%. However, for the Florida zones the 21 nighttime PoPs of 50% to 70% saw areal coverages of 20% or less on 19 of the 21 nights! (The greatest observed areal coverage was 50%). How can we explain this bias? Our first thought was that a single forecaster made all or most of the 21 Florida forecasts. In fact, they were distributed among five forecasters, so it is unlikely that simple bias is the answer.

A clue to the most likely cause lies in an examination of the antecedent areal coverage. For the daytime periods which preceded the 21 Florida forecasts the average observed coverage was 75%. On 11 of the 21 days the coverage was estimated to be 100%! It appears that forecasters were influenced by high areal coverage during the day and subsequently forecast PoPs of 50 to 70% for the following night. They may have expected showers to dissipate rapidly after dark (as climatology indicates), but if so they consistently underestimated how rapid the dissipation would be. But how did forecasters know that the daytime areal coverage was so great? Pensacola's coverage estimate was not received until long after the nighttime PoP forecast was made! If forecasters relied on their own estimates from satellite observations and other routine sources during the day, why did they not show the same nighttime bias the previous summer? We suspect that forecasters did infer a high coverage during the day but a fundamental cause of the high nighttime PoPs was this in connection with a realization that high areal coverages do occur at night. As a result of the 1976 study forecasters were urged to try to apply higher PoP values to the nighttime periods, and to do so with greater skill and frequency than had been the case in 1976. In addition, as the summer of 1977 progressed, it became clear that relatively high areal coverages at night were not uncommon (thanks to information received from Pensacola). There could well have been a tendency in 1977 to infer that high nighttime coverages followed high daytime coverages (i.e., persistence of echoes, however briefly, into the nighttime period). Unfortunately, this does not appear to be a good general forecast rule. It does appear, however, that results of the 1976 study may have adversely affected this aspect of forecast performance in 1977!

A final note...why were the average nighttime areal coverages so much higher for 80 to 100% PoPs? Apparently forecasters more reliably recognized cases of very high areal coverage. In other words, when they applied PoPs above 70% forecasters probably recognized a disturbed situation in which the usual diurnal cycle of shower activity was not operable. (On the eight occasions when an 80% PoP was forecast for the Florida zones at night the antecedent areal coverage for the daytime period was 100%!) It was only for cases for which upper-middle range (50-70%) PoPs were applied that forecasters seemed to misinterpret the nighttime precipitation mechanism.

6. Bits and Pieces

We have seen for the second summer that rainfall areal coverage estimates from radar provide valuable information for after-the-fact assessment of PoP forecasts. We had hoped that the availability of such data in real-time might lead to improved forecasts. While many of the forecasters at Birmingham have indicated that the reports from Pensacola were indeed helpful to them, there is no real indication from the 1977 summer data that forecasts were significantly better than those of the previous summer. However, there were noticeable differences in the frequencies of use of certain PoP values. Of course, it is difficult to determine to what extent a knowledge of areal coverage might have influenced the use of given PoP values. Since the real-time reports of coverage were new to the forecasters in 1977 it is probably not surprising that they were not fully utilized. Most of the forecasters have expressed a desire to see the reports continued and we must search for a systematic way to apply this new information.

Originally we had hoped that a knowledge of yesterday's rainfall areal coverage would be a useful predictor for today's coverage, and, hence, a guide for today's PoP forecast. Analysis of the 1976 summer data indicated that rainfall regimes are largely controlled by the low-level wind flow. Thus, simple persistence of coverage amounts is not likely to be a good predictor. Or is it? To investigate this, we plotted a scatter diagram of today's areal coverage versus yesterday's coverage. Only the daytime observations from the Florida coastal zones (2 and 4) were used. Fig. 5 shows that today's coverage was within 10% of yesterday's value about 40% of the time. Day-to-day coverage differed by more than 30% only about 30% of the time.

This result is somewhat surprising. It indicates that, even without considering changes in wind regimes, yesterday's coverage is, in fact, a potentially useful predictor of today's coverage. The lag correlation coefficient between days was 0.45 for the summer study period in 1977. Probably few, if any, of the predictors in NMC's MOS PoP forecast equations show such a high correlation for summer rainfall. It may be of additional interest that the forecasters' Brier score* for daytime forecasts for Florida zones 2 and 4 was 0.0762. The Brier score for simple persistence was 0.1131.

One aspect of our study deserves final attention because data from 1977 suggest that forecasters were increasingly aware of a significant feature: namely, variation of rainfall coverage (and point probability) from zone to zone. Table 2 shows the frequency of one-, two-, three- or four different coverage values or PoP forecast values in the four Alabama and four Florida zones. (As in 1976, coverage values were considered different only if they differed by 20% or more). While it is unlikely that forecasters consistently used, say, three different PoP values on just those days when nature assigned three distinct coverage values, Table 2 nevertheless gives some indication of forecasters' attempts to resolve different rainfall probabilities in the zone groups. In this regard, significant improvement was indicated for the summer of 1977 over the previous summer.

There was a pronounced tendency in 1976 to apply the same PoP value to all four zones in each group, both for daytime and nighttime periods. This was especially true for the Florida group of zones. Notice in the Table that for both groups and both periods the

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*The Brier score was taken to be

$$B = \frac{\sum (F - O)^2}{n}$$

where O = observed areal coverage
and F = forecast probability (or yesterday's observed coverage)

frequency of use of single PoP values was lowered in 1977. There was a marked increase in the use of two values. During the daytime periods single PoP values were still used twice as often as such uniform coverage was observed, but notice that on half of the summer days two or three values were applied in the Florida zones (compared with 16% of the time in 1976). Clearly, in 1977 forecasters were aware of the variability of rainfall coverage in each group of zones and tried harder to reflect that fact with their PoP forecasts. We can also observe from Table 2 that, with the possible exception of the Alabama zones during the daytime, there was not a large difference between 1976 and 1977 in the frequency of observation of one- to four different coverage values. We can wonder, then, why forecasters used more PoP values in 1977. Were they forecasting a greater variability in rainfall distribution; or were they responding to the findings of last summer's study -- the frequencies shown in parentheses in Table 2? Regardless, the change was in the right direction... except that the Table does not reveal how successfully the coverage variability was forecast!

7. Summary

Our analysis of summertime rainfall (echo) coverage and coincident forecast PoPs has yielded several important results. Our confidence in the validity of these results is strengthened by the high correlation between 1976 and 1977 analyses. We feel the two years' data support the following conclusions--

-- Areal coverage of rainfall can be accurately determined from an analysis of hourly radar data. Comparison of the radar results with rainfall frequencies provides a "ground truth" and may also be used to determine if rainfall observations are representative of an area.

-- It rains somewhere in a zone-sized area in southern Alabama and northwest Florida almost every summer day (frequency ~ 80%), and it rains on most of the nights (frequency ~ 60%). Thus, for the most part we can think of our daytime forecasts as being estimates of expected areal coverage...not just point probabilities.

-- Areal coverage of rainfall in the zones of southern Alabama and northwest Florida on summer days is just as likely to be 20% as 100%. The likelihood of any given decile coverage is about 5-10%.

-- On the whole, summer PoP forecasts are reliable; long term averages are the same as rainfall frequencies. However, PoPs of 20%, 30%,..., 100% are not equally reliable. Higher PoPs tend to be less reliable. For some reason forecasters use high PoPs much more reliably for Florida zones than for Alabama zones.

-- PoP forecasts of 30% or less are used much more frequently than corresponding areal coverages are observed, while PoPs of 80 to 100% are seldom used -- even though such high coverages are not uncommon, even at night. This results in poor resolution in summertime forecasts. As areal coverage increases from 20% to 100% the averages of PoP forecasts remain 30 to 50%.

Smith, Daniel L., 1977: An examination of probability of precipitation forecasts in light of rainfall areal coverage. NOAA Technical Memorandum NWS SR-89, 20pp.

Smith, Daniel L. and Kevin Henderson, 1977: Summertime rainfall regimes in southern Alabama and northwest Florida as deduced from wind-stratified radar data: preliminary study 1976. NOAA Technical Memorandum NWS SR-92, 15pp.

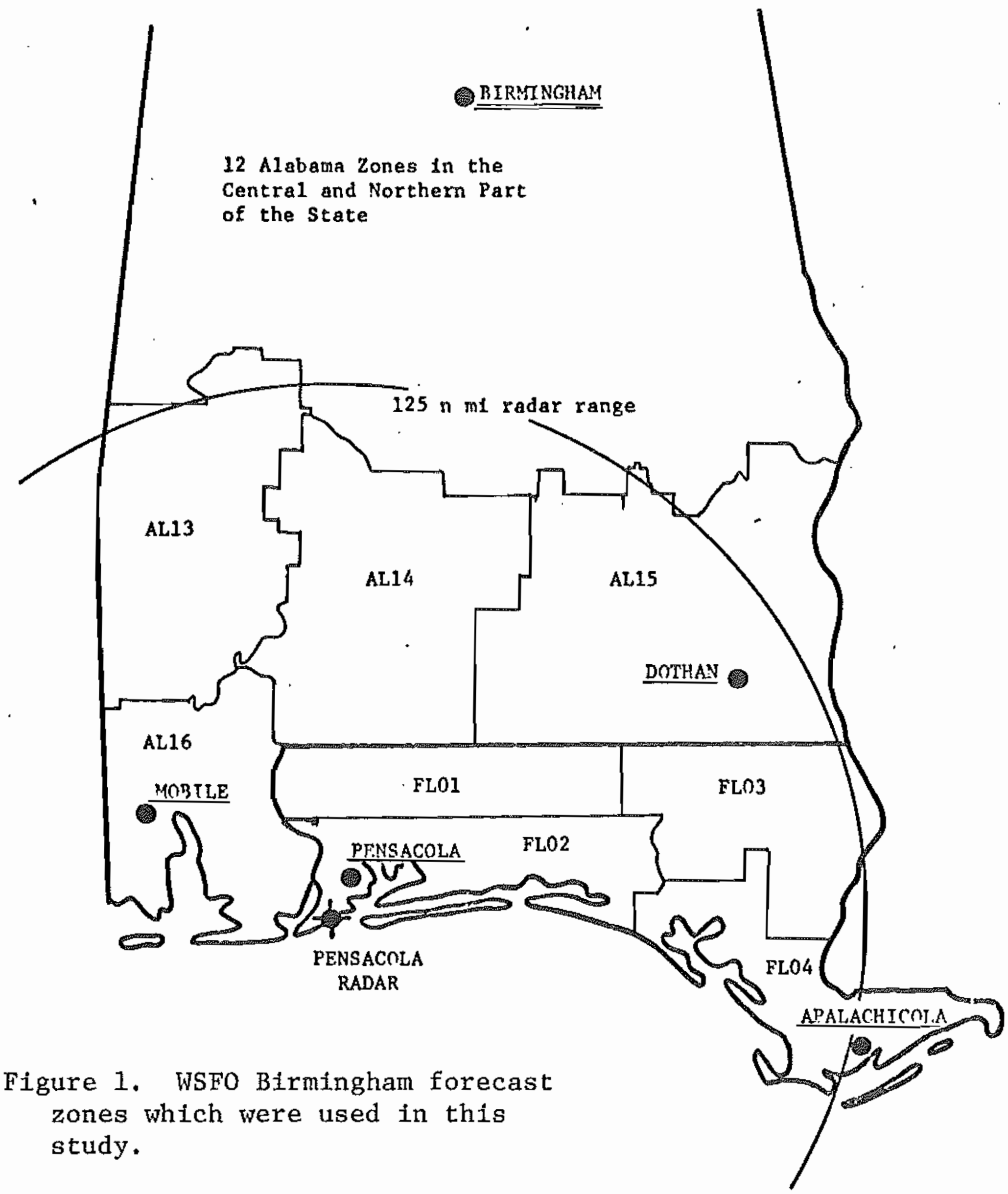

Figure 1. WSFO Birmingham forecast zones which were used in this study.

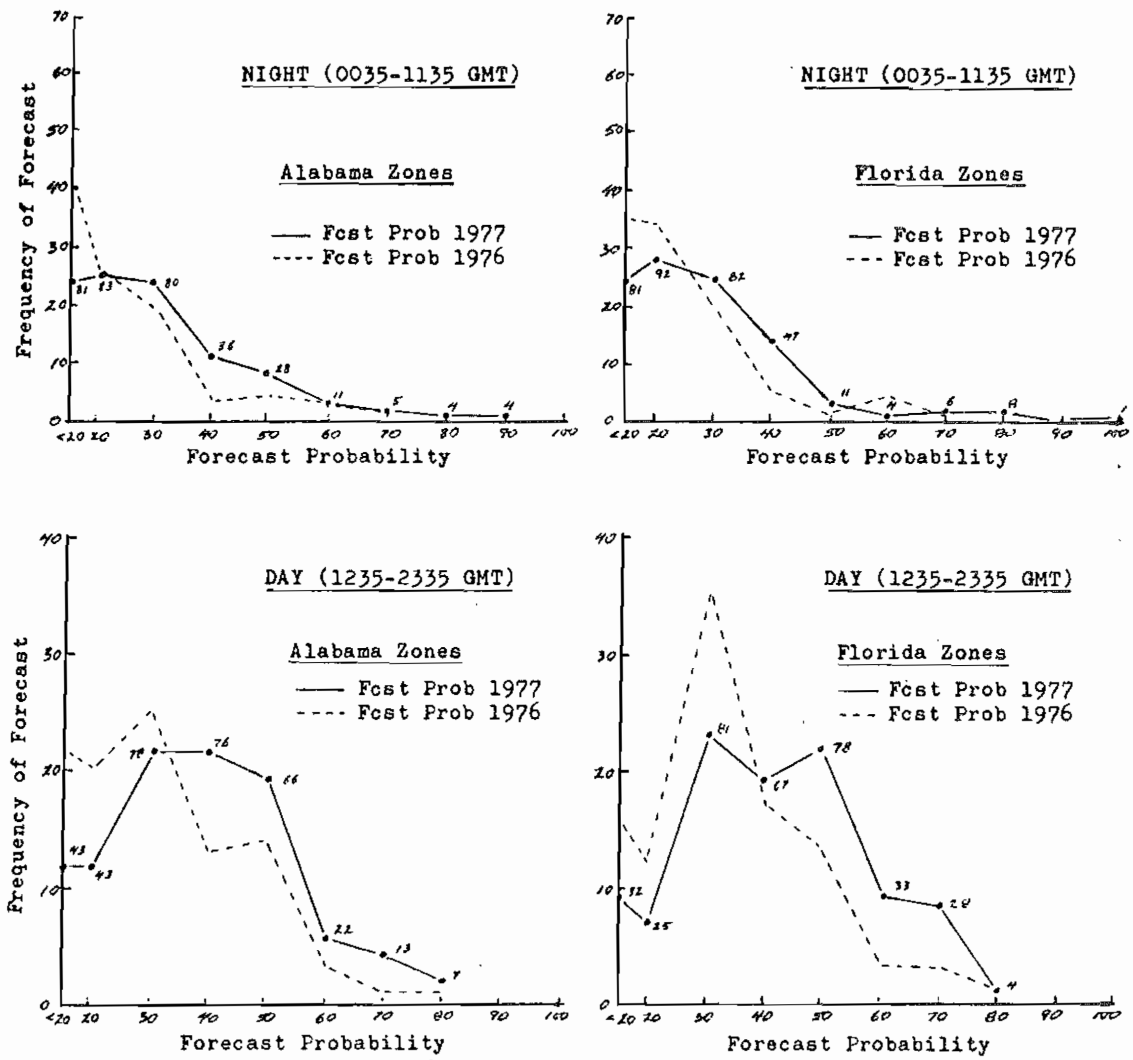

Figure 2. Frequencies of use of various PoP forecast values. Solid lines show data from study period 1 June to 31 August, 1977; broken lines are for the period 1 June to 8 August, 1976. Small numbers indicate number of forecasts in 1977 period.

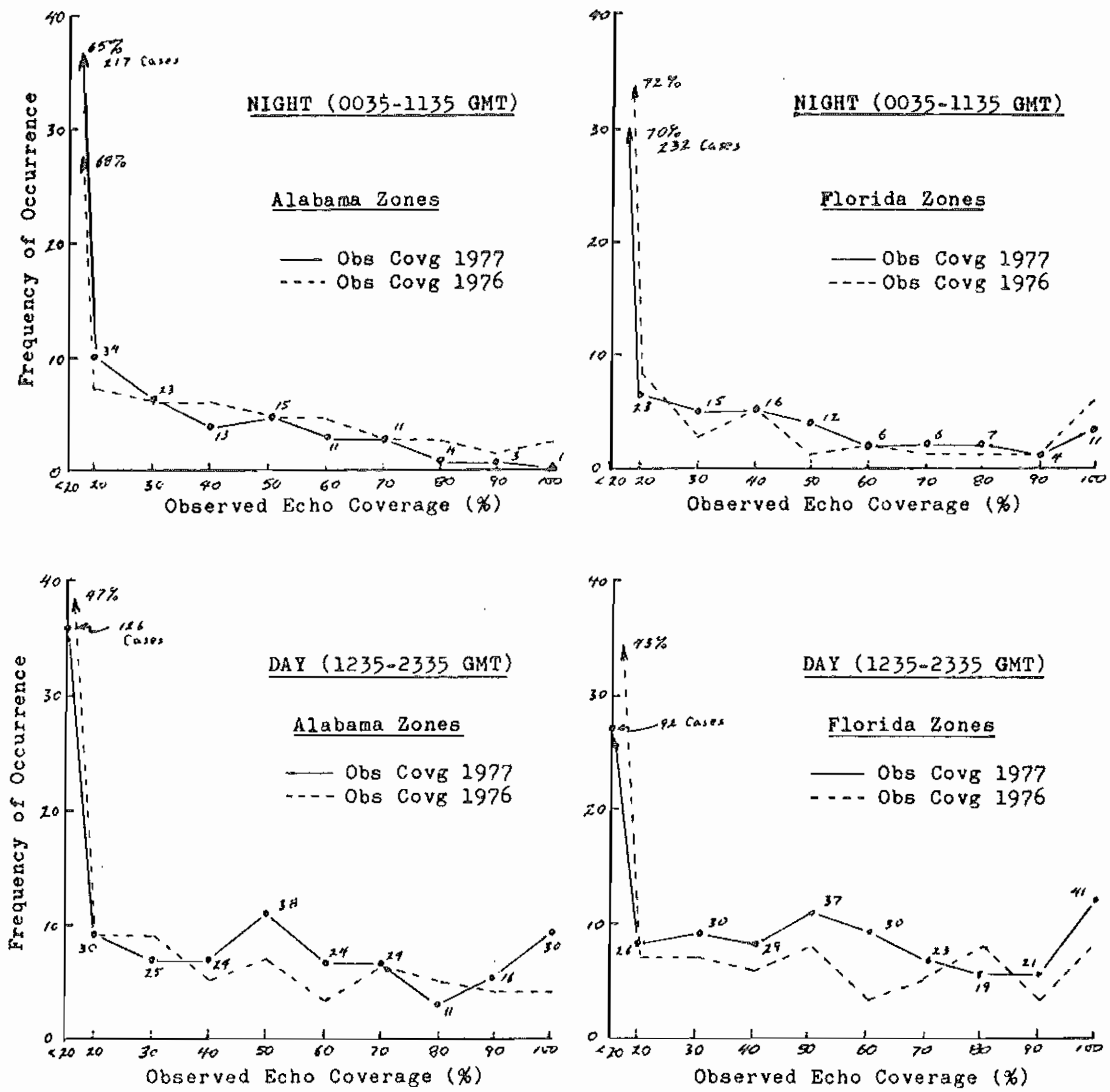

Figure 3. Frequencies of observation of various values of rainfall areal coverage (estimated from radar data). Solid lines for the 1977 study period; broken lines for 1976 data. Small numbers indicate number of occurrences.

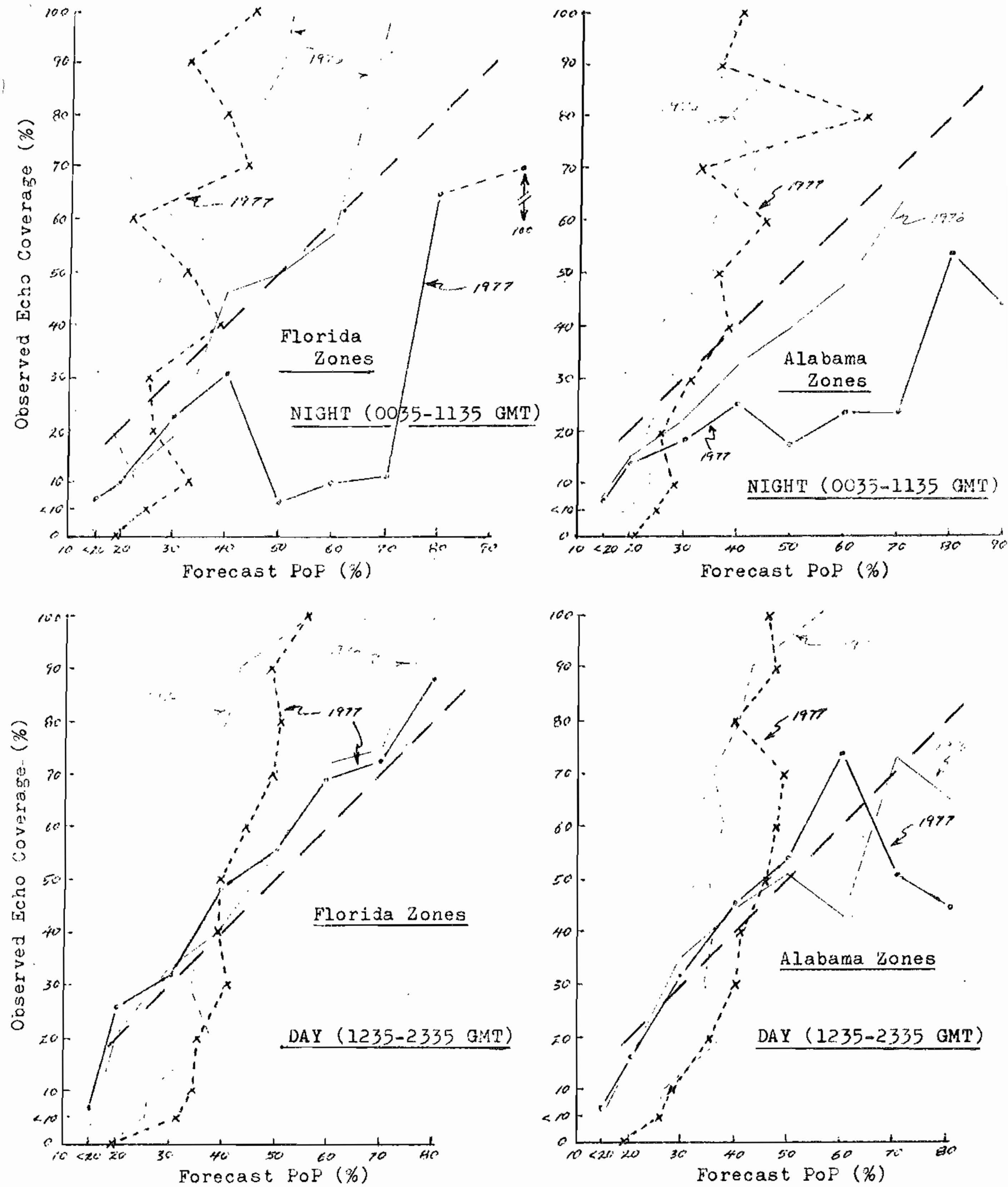

Figure 4. Average forecast PoP for various values of observed coverage (broken lines) and average observed coverage for various values of forecast PoP (solid lines). Light curves are 1976 data.

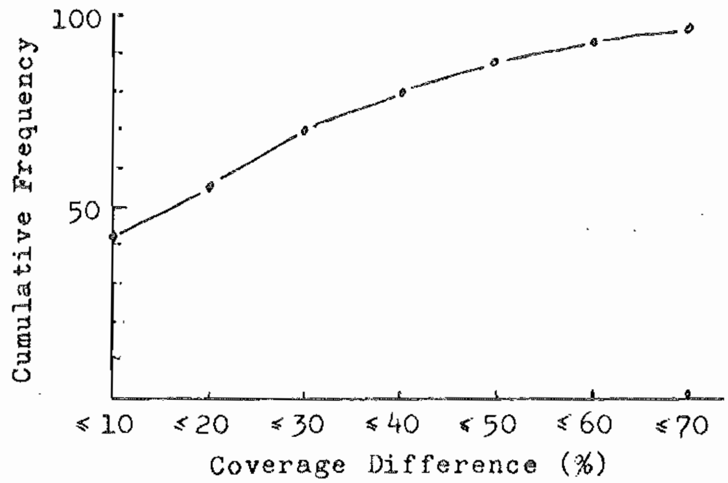

Figure 5. Cumulative frequency distribution for rainfall areal coverage difference "yesterday" and "today". About 40% of the time today's coverage differed from yesterday's by 10% or less; 70% of the time it differed by 30% or less; etc. Data are for the Florida coastal zones during the summer of 1977. See text for additional details.

	NIGHT Fla	NIGHT Ala	NIGHT Comb	DAY Fla	DAY Ala	DAY Comb
a) Average forecast PoP	26(20)	25(20)	25(20)	40(32)	36(29)	38(30)
b) Average areal echo coverage (all days)	17(16)	17(17)	17(16)	45(35)	38(30)	41(32)
c) Average areal echo coverage (rain days*)	27(31)	24(29)	25(29)	51(46)	45(40)	48(42)
d) Average freq of occrnce of echo in zone	63(52)	71(59)	67(56)	88(77)	85(76)	87(76)
e) Average rainfall freq	16(13)	18(16)	17(15)	22(25)	37(31)	30(28)

*Rain days are periods when an echo occurred somewhere in a zone, regardless of coverage.

Table 1. Averages derived from forecast probabilities and observed radar echo coverage during the period June 1 - August 31, 1977. Averages from the summer of 1976 are shown in parentheses (Smith, 1977).

		Values Used (Observed) One	Two	Three	Four
NIGHT					
AL Zones	Fcst PoP	49(59)	48(40)	2 (1)	
	Obs Covg	45(47)	34(29)	20(18)	1 (6)
FL Zones	Fcst PoP	64(76)	33(24)	4	
	Obs Covg	46(59)	34(31)	18 (7)	2 (3)
DAY		One	Two	Three	Four
AL Zones	Fcst PoP	38(60)	55(40)	6	1
	Obs Covg	20(33)	48(33)	28(19)	5 (4)
FL Zones	Fcst PoP	51(84)	44(16)	6	
	Obs Covg	24(27)	52(39)	22(33)	2 (1)

Table 2. Frequencies of use (observation) of 1-, 2-, 3- or 4 separate PoP values (areal coverages) for the four Florida and four Alabama zones used in the study. Frequencies for the summer of 1976 are shown in parentheses. Note a significant increase in the use of two PoP values for DAY periods.