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A PLAN FOR ACCURATE ESTIMATION OF DAILY AREA-MEAN RAINFALL DURING THE CAPE EXPERIMENT

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I. Introduction

The Convection and Precipitation/Electrification (CaPE) experiment took place in east central Florida from 8 July to 18 August, 1991. There were five research themes associated with CaPE. In broad terms they are: investigation of the evolution of the electric field in convective clouds, determination of meteorological and electrical conditions associated with lightning, development of mesoscale numerical forecasts (2-12 hr) and nowcasts (<2 hr) of convective initiation and remote estimation of rainfall. It is the last theme coupled with numerous raingage and streamgage measurements, satellite and aircraft remote sensing, radiosondes and other meteorological measurements in the atmospheric boundary layer that provide the basis for determining the hydrologic cycle for the CaPE experiment area. The largest component of the hydrologic cycle in this region is rainfall. An accurate determination of daily area-mean rainfall is important in correctly modeling its apportionment into runoff, infiltration and evapotranspiration. In order to achieve this goal a research plan was devised and initial analysis begun. The overall research plan is discussed with special emphasis placed on the adjustment of radar rainfall estimates to raingage rainfall.

II. Research Plan

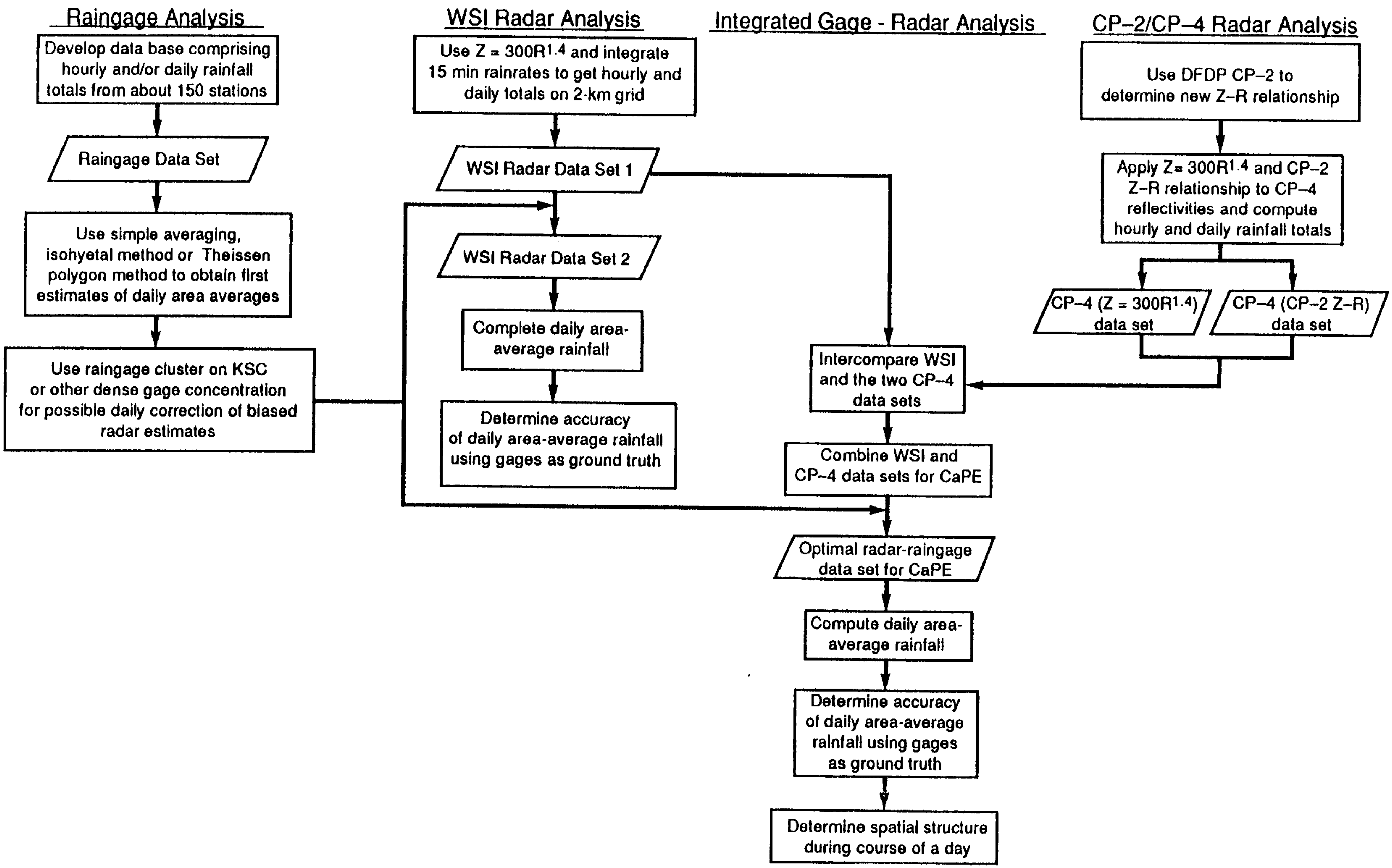
Fig. 1 show the Precipitation Analysis Work Plan. It comprises four channels of analysis: raingage, WSI radar, integrated gage-radar and CP-2/CP-4 radar. The purpose of the raingage analysis is to develop a high quality data set that can be used to estimate daily area-mean rainfall over two areas of CaPE: one relatively small area within which there is a dense concentration (a cluster) of gages and a much larger area where the concentration ranges from moderate to dense. The daily area-mean rainfall from analysis of the former area will be used to correct corresponding rainfall estimates derived from WSI radar. This is indicated in Fig. 1 by the connection from raingage analysis to WSI radar analysis.

In general, raingages provide a quite accurate measurement of rainfall at a point but comparatively inaccurate assesment over a large area. On the other hand radar provides good areal coverage but may require adjustment of the rainrates determined from the assumed Z-R relationship. A dense concentration of gages can yield rainfall data that can be used to determine a potential radar correction.

In a paper by Woodley et al. (1975), dealing with raingage-radar comparisons of convective rainfall in the Miami, FL area, a number of results were presented that are relevant to correcting the radar. It should be noted that similar types of raingages (tipping-bucket) and radars (WSR-57) were employed in both the Miami experiment and the CaPE experiment.

One of the results they found was a systematic 2% underestimate of point rainfall by the tipping-bucket gages when compared to dipstick gages. Since the latter are considered the standard for measuring point rainfall and the precipitation regimes in both experiments are similar, it may be necessary to upwardly adjust daily tipping-bucket rainfall amounts. There

Fig. 1 **Precipitation Analysis Work Plan**



are some locations in the CaPE experimental area that have both tipping-bucket and dipstick gages so that new intercomparisons can be made.

Based on measurements from collocated raingages they found that it was unreasonable to expect rainfall observations at a point to be accurate to better than 5 to 10%. The cause for these differences was apparently due to different gages and small differences in gage exposure. This result must be taken into consideration in comparing radar estimates to raingage observations in which the latter are considered the standard.

Comparisons between radar and raingages in clusters were performed using the "factor of difference" or FD, where FD is defined as G_i/G_F when $G_i \geq G_F$, or G_F/G_i when $G_i < G_F$. Thus FD>=1. G_F is the daily rainfall derived from radar and G_i is that from raingages. From clusters of gages ranging in size from 21 to 78 km^2 and gage density from 3 to 8 km^2/gage, they found that the average FD is 2.02 for rain volumes $<10^5$ m^3 and 1.50 for rain volumes $>=10^5$ m^3. The equivalent water depth for the rain volume criterion varies from about 0.8 mm to 1.2 mm over the range of cluster areas. These results show that the greater the rainfall the smaller the differences. This would be expected because greater rainfall is associated with larger storms which, in turn, encompass more raingages within a fixed array of gages.

In order to improve the estimation of rainfall by radar, daily radar-derived rainfall was multiplied by the ratio of the summed gage to summed radar rainfall from the 5 clusters, the total area of which was 340 km^2. (For CaPE there is one cluster of approximately 13 gages over about 80 km^2, corresponding to about 6 km^2/gage, a figure comparable to the gage density noted above.) When this adjustment was applied to a 655 km^2 mesonet containing 229 gages the FD was reduced from 1.53 to 1.38. This is equivalent to reducing the gage density from 60 km^2/gage to 25 km^2/gage.

It was found that when the size of the area increases from 655 km^2 to 1.3×10^4 km^2, about the area of CaPE, a gage density of 73 km^2/gage in the larger area should provide the same accuracy in daily areal estimates of rainfall as a gage density of 8 km^2/gage in the mesonet. If there were 73 km^2/gage in the CaPE area the FD would be within 1.2 90% of the time. While, ultimately, this gage density may be possible for the CaPE area, the gages are not uniformly distributed. Because of this it will be important to employ radar in order to obtain acceptable estimates of daily area-mean rainfall for CaPE.

The second column in Fig. 1 indicates that an adjustment derived from the cluster of raingages in CaPE will be applied to the radar estimates in a manner similar to that described by Woodley et al. (1975). Daily area-mean rainfall will be computed from this improved data set (WSI Radar Data Set 2). In addition, the accuracy (or inaccuracy) will be determined. Analysis of the dual-frequency dual-polarization CP-2 radar data, shown in the fourth column, may lead to an improved Z-R relationship for central Florida in summer. Because the CP-4 was used in the PPI mode and was located within the CaPE experiment area, it should be extremely useful to compare simultaneous reflectivities from this radar and the WSI composite radars which are located well outside CaPE.

This comparison is shown as the first step in the third column in Fig. 1. Continuing in this column, after adjusting the radar data using a daily correction derived from the gages, as previously discussed, an optimal daily area-mean rainfall data set is produced that includes estimation of its accuracy.

III. Summary

In moist tropical and subtropical climates the largest component of the hydrologic cycle is precipitation. The CaPE area is located in the latter climate. A plan for analyzing precipitation for the CaPE experimental area has been presented. The available measurements include well over 100 raingages of different types, composite radar reflectivities from NWS WSR-57 radars and two onsite high quality research radars. The principal objective of the analysis is to compute daily area-average rainfall for CaPE using an optimal radar-raingage data set and assess its accuracy.

Acknowledgments

The production of Fig. 1 was accomplished through many discussions with a number of individuals; among them are Bill Crosson, Steve Goodman and Chip Laymon. Their contributions are very much appreciated.

Reference

Woodley, W. L., A. R. Olsen, A. Herndon and V. Wiggert, "Comparison of gage and radar methods of convective rain measurement. J. Appl. Meteor., 14 (1975) 909-928