U.S. DEPARTMENT OF COMMERCE

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From:

"Radar and Rain-Gage Data Merging Methods--A Comparison" by Witold F. Krajewski (a poster presentation), AGU Symposium on Parameter Estimation for Rainfall-Runoff Models, San Francisco, Calif., Dec. 7-15, 1982.

(Lianne is looking into getting the poster printed until his paper is issued.)

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PURPOSE

EVALUATION OF TWO METHODS OF MERGING RADAR AND RAIN GAGE DATA

METHODS

1. DETERMINSTIC (BRANDES TECHNIQUE)
2. STATISTICAL (BASED ON GANDIN'S CONCEPT)

DATA

EVALUATION IS BASED ON DATA FROM RADAR AND RAIN GAGE FIELDS GENERATED BY DISTURBING THE OBSERVED RADAR RAINFALL FIELDS FROM THE GARP ATLANTIC TROPICAL EXPERIMENT (GATE)

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STATISTICAL METHOD

MODEL

$$Y = X_G \beta_G + X_R \beta_R + \varepsilon$$

WHERE

Y GRID ESTIMATE OF RAINFALL

X_G, X_R GAGE AND RADAR ESTIMATES FROM THE NEIGHBORHOOD OF GRID POINT

β_G, β_R APPROPRIATE REGRESSION COEFFICIENTS

SOLUTION

$$\hat{\beta} = (X^T X)^{-1} X^T Y$$

WHERE

$$\hat{\beta} = \begin{vmatrix} \hat{\beta}_G \\ \hat{\beta}_R \end{vmatrix}$$

$$X^T X = \begin{vmatrix} X_G^T X_G & X_G^T X_R \\ X_R^T X_G & X_R^T X_R \end{vmatrix}$$

$$X^T Y = \begin{vmatrix} X_G^T Y \\ X_R^T Y \end{vmatrix}$$

ALGORITHM

1. COMPUTE

$$X_G^T X_G, X_G^T X_R, X_R^T X_R$$

2. APPROXIMATE THEM WITH 2-D FUNCTION (E.G. GAUSS FUNCTION)

3. FOR EACH GRID POINT
   - USE THE APPROXIMATIONS TO ESTIMATE $X^T X, X^T Y$
   - FIND $\hat{\beta}$
   - PERFORM REGRESSION

DETERMINISTIC METHOD

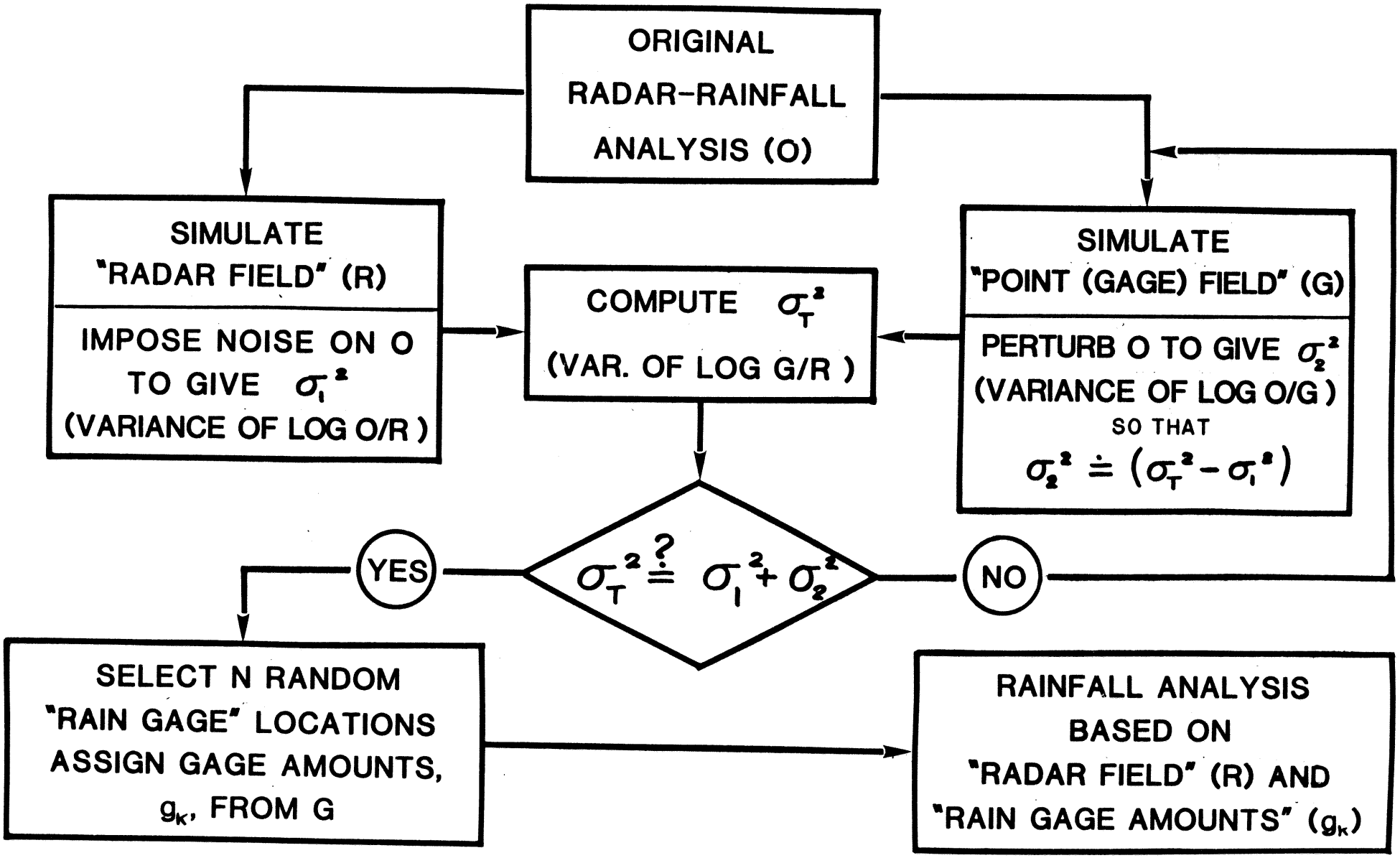
1. FOR EACH RAINGAGE OBSERVATION g_k AT LOCATION k ESTIMATE ASSOCIATED RADAR-RAINFALL QUANTITY r_k FROM THE RADAR FIELD $R_{i,j}$

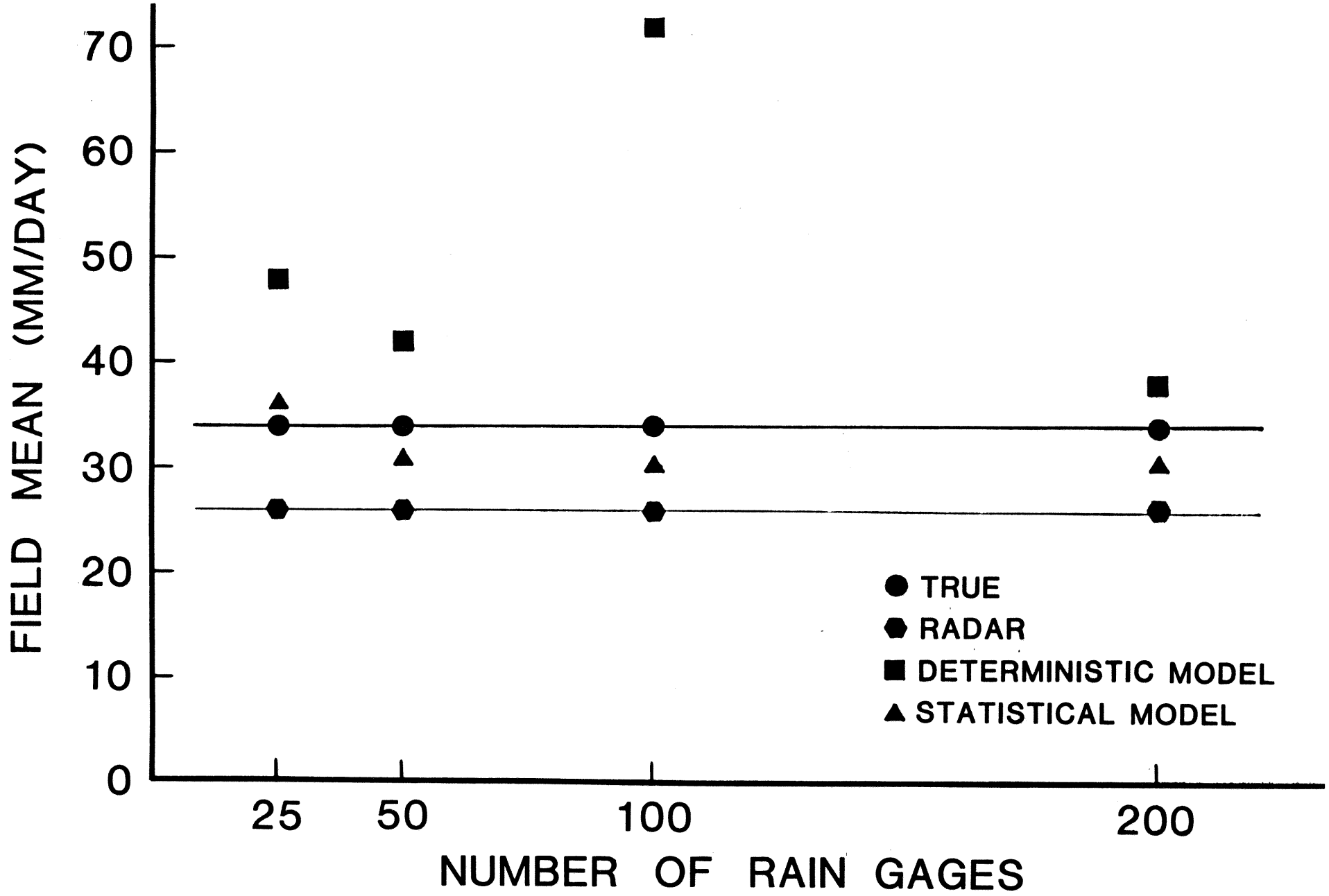
2. COMPUTE THE RATIO $P_k = \frac{g_k}{r_k}$ FOR $k = 1,\ldots,N$

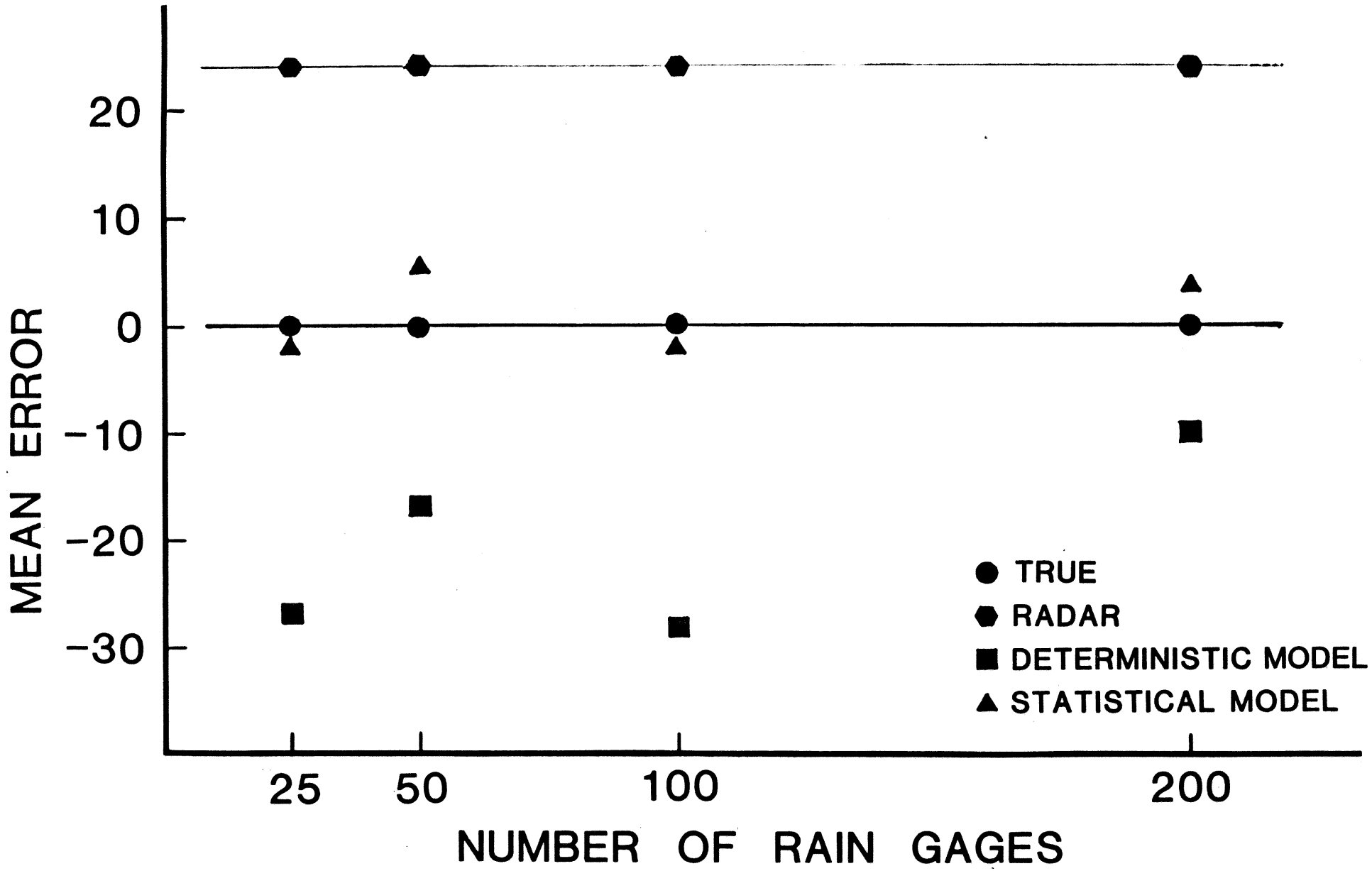
3. DERIVE CORRECTION FIELD $C_{i,j}$ FROM THE RATIOS P_k BY INTERPOLATING AND ADJUSTING BY MEANS OF AN EXPONENTIAL WEIGHTING FUNCTION OF THE DISTANCE, SIZE OF ANALYSIS AREA, AND NUMBER OF RAIN GAGES

4. COMPUTE THE CORRECTED ANALYSIS $A_{i,j} = C_{i,j} \cdot R_{i,j}$

DATA GENERATION




FIELD MEAN (MM/DAY)
70
60
50
40
30
20
10
0
25
50
100
200
NUMBER OF RAIN GAGES
TRUE
RADAR
DETERMINISTIC MODEL
STATISTICAL MODEL


MEAN ERROR
20
10
0
−10
−20
−30
25
50
100
200
NUMBER OF RAIN GAGES
TRUE
RADAR
DETERMINISTIC MODEL
STATISTICAL MODEL

STATISTIC / METHOD	FIELD MEAN (MM/DAY)						FIELD STANDARD DE		
	CASE						CAS		
	1	2	3	4	5	6	1	2	3
"TRUE" FIELD	24.3	4.3	31.7	15.2	34.9	34.9	20.4	8.6	39.9
GAGE FIELD	22.7	1.8	35.5	11.8	39.8	36.1	20.0	2.9	31.7
RADAR FIELD	29.3	3.6	29.6	17.4	27.4	27.4	38.8	8.2	59.0
DETERMINISTIC METHOD FIELD	27.8	3.6	37.4	16.7	41.3	76.0	33.3	8.1	51.2
STATISTICAL METHOD FIELD	24.9	2.3	28.8	13.3	31.9	28.9	29.8	5.7	44.3

NOTE: CASE 6 IS THE SAME AS CASE 5 , BUT FOR 100 RAIN GAGES. ALL OTHER CASE

DAILY DATA ANALYSIS

VIATION (MM/DAY)			CORRELATION WITH "TRUE" FIELD						MEAN ERROR (MM/DAY)				
E			CASE						CASE				
4	5	6	1	2	3	4	5	6	1	2	3	4	5
22.9	37.5	37.5	1.00	1.00	1.00	1.00	1.00	1.00	0.0	0.0	0.0	0.0	0.0
18.5	37.6	36.1											
39.2	29.7	29.7	0.49	0.84	0.56	0.80	0.67	0.67	−14.3	13.7	4.4	−10.4	25.8
30.6	41.3	91.2	0.71	0.83	0.79	0.83	0.75	0.78	−13.8	14.4	−17.9	−11.1	−18.9
28.6	31.9	35.5	0.46	0.34	0.61	0.64	0.74	0.74	−2.2	8.4	0.6	2.9	5.3

S ARE FOR 50 RAIN GAGES.

	STD. DEVIATION OF RESIDUALS(MM/DAY)						CPU TIME ON IBM 360/195 (SEC)					
	CASE						CASE					
6	1	2	3	4	5	6	1	2	3	4	5	6
0.0	0.0	0.0	0.0	0.0	0.0	0.0						
25.8	33.8	4.8	49.3	25.1	28.5	28.5						
-62.4	23.8	4.9	31.2	17.4	34.7	66.2	5	2	8	6	6	7
6.5	27.4	10.0	37.3	23.0	26.3	26.0	65	57	70	125	110	115

CONCLUSIONS

1. THE DETERMINISTIC METHOD SEEMS TO BE BIASED.

2. THE STATISTICAL METHOD DOES NOT SHOW INSTABILITY, WHILE THE DETERMINISTIC METHOD DOES.

3. GIVEN RAINFALL MEASUREMENTS, THE STATISTICAL METHOD MAY AND USUALLY DOES IMPROVE THEM, WHILE THE DETERMINISTIC METHOD MAY GIVE UNPREDICTABLE RESULTS.

4. THE STATISTICAL METHOD IS MORE APPROPRIATE FOR HYDROLOGIC APPLICATIONS.