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1. INTRODUCTION

The performance of hydrological models is usually evaluated on the basis of comparisons of observed and simulated flows and of the values of numerical verification criteria. The rationale underlying this approach is that there is a model with best performance for a given set of conditions and that it can be identified by the use of the above criteria.

As shown by Granger and Newbold (1977), a possible method for improving the performance of forecasts is to combine them in the form of weighted averages. The results of such combinations as reported in the literature (Granger and Newbold, 1977; Winkler and Makridakis, 1983) indicate that in many cases the combined forecasts outperform the forecasts based on individual methods.

The purpose of this study is to apply this idea to conceptual hydrological models. In this case, the simulated discharges of two or more hydrological models are combined by forming a weighted average of the simulated discharges. This approach is applied to the models included in the intercomparison of conceptual models of snowmelt runoff sponsored by the World Meteorological Organization (WMO, 1982).

The following brief description of the WMO Project will facilitate the understanding of the details of this report.

During the period 1978-1983 the World Meteorological Organization (WMO) carried out an international intercomparison of conceptual models of snowmelt runoff.

The aims of the project were:

- to assemble information on existing models used operationally to estimate snowmelt runoff;
- to compare snowmelt runoff models with regard to their structure, conceptual basis and data needs;
- to evaluate and obtain an insight into their performance and accuracy of estimation, and
- to disseminate the information and results obtained so as to popularize new approaches to forecasting snowmelt runoff and assist countries in the selection and application of models for this purpose.

Ten models submitted by seven countries were included in the project and fitted to six standard data sets submitted by six countries.

Each data set comprises a six-year calibration period and a four year verification period. Graphical and numerical verification criteria were used to analyse the results of the models; the final report is in preparation and will be published by WMO.

2. METHODOLOGY

Formulas for the combination of forecasts are given in Granger and Newbold (1977). The combined forecasts are weighted averages of the simulated values of the individual forecasts, where the weights are determined from the condition that the variance of the residuals of the combined forecast is minimized. In our application we combine the simulated discharges of two or three hydrological models.

Let y_{oi} = observed discharge
 y_{cik} = simulated discharge of model k
 e_{ik} = model residuals ($y_{oi} - y_{cik}$)
 i = index of the time unit (DAYS), $i = 1, 2, \dots, n$
 n = total number of observations
 k = index of models, $k = 1, 2, \dots, m$
 m = number of models in the combination

The steps of the computation are as follows:

- Compute the quantities $\sum_{i=1}^n (y_{oi} - y_{cik})^2 = \sum_{i=1}^n e_{ik}^2$ for all models, for the calibration period.
- The combined simulated values y'_{ci} are computed as weighted averages of the individual values:

$$y'_{ci} = w_1 y_{ci1} + \dots + w_m y_{cim} \quad (1)$$

where the weights w are given by the formula:

$$w_k = \frac{\left[\sum_{i=1}^n e_{ik}^2 \right]^{-1}}{\sum_{k=1}^m \left[\sum_{i=1}^n e_{ik}^2 \right]^{-1}} \quad (2)$$

in the case $m = 2$, the formula becomes:

$$w_1 = \frac{\sum_{i=1}^n e_{i2}^2}{\sum_{i=1}^n e_{i1}^2 + \sum_{i=1}^n e_{i2}^2} \quad (3)$$

$$w_2 = \frac{\sum_{i=1}^n e_{i1}^2}{\sum_{i=1}^n e_{i1}^2 + \sum_{i=1}^n e_{i2}^2} = 1 - w_1 \quad (4)$$

Granger and Newbold (1977) propose additional formulas for the weights, which take into account the correlations between model residuals. However, simulation studies reported by the above authors and by Winkler and Makridakis (1983) indicate that formula (2) gives better results. A number of comparisons carried out by the writers using the data of the Durance River indicates that the results obtained using weights taking into account the correlation between residuals are not better than those based on formula (2). Consequently, in this report, we use the simpler formula (2).

In a recent paper, Granger and Ramanathan (1984) state that better results are achieved by the use of a combination formula with a constant term and in which the weights are not constrained to add to unity. In order to test the degree of improvement due to this method, it was applied to the Durance River basin.

3. APPLICATION TO THE MODELS OF THE WMO INTERCOMPARISON STUDY

The models and the basins used in the Intercomparison Project are given in the following table:

BASINS	MODELS	
	MODEL	ABBREVIATION IN THIS REPORT
Durance (France)	UBC	UBC
W3 (U.S.A.)	CEQUEAU	CEQ
Dunajec (Poland)	ERM	ERM
Dischma (Switzerland)	NAM-II	NAM
Illecillewaet (Canada)	TANK	TAN
Kultsjon (Sweden)	HBV	HBV
	SRM	SRM
	SSARR	SSA
	PRMS	PRM
	NWSRFS	NWS
	DAILY MEAN ("Peasant")*	DAY

* This "model" was not included in the intercomparison project. It consists of the mean daily observed discharge for each day of the year derived from the calibration period.

3.1 Combinations of all pairs of simulated discharges

Using the approach described in the previous section, the simulated daily discharges of all models included in the WMO intercomparison study were combined in pairs for each basin. As an example, the results of the computation of weights w_1 for the Durance River, calibration period, complete year is given in Table 1 which also includes the sum of squares of the residuals.

The comparison of the weighted simulated discharge and the observed discharges is carried out on the basis of two numerical verification criteria (NTD and A) selected among those proposed by WMO (WMO, 1982).

These criteria are defined as follows:

- 1) NTD : one minus the ratio of the sum of squares of the daily residuals to the sum of squares of the deviations of the observed flows from their mean.

$$NTD = \frac{\sum_{i=1}^n (y_{oi} - \bar{y}_o)^2 - \sum_{i=1}^n (y_{ci} - y_{oi})^2}{\sum_{i=1}^n (y_{oi} - \bar{y}_o)^2} = 1 - \frac{\sum_{i=1}^n (y_{ci} - y_{oi})^2}{\sum_{i=1}^n (y_{oi} - \bar{y}_o)^2} \quad (5)$$

- 2) A : ratio of mean daily absolute error to the mean observed discharge.

$$A = \frac{\sum_{i=1}^n |y_{ci} - y_{oi}|}{n \bar{y}_o} \quad (6)$$

In the above equations:

y_{oi} : observed discharge

y_{ci} : simulated discharge or weighted discharge

y_o : mean observed discharge

n : total number of observations

The results of the combinations of all pairs of simulated discharges are shown in the following tables and graphs.

Tables 2 (criterion NTD) and 3 (criterion A) show the numbers of combinations investigated for each basin and period and the percentages of these combinations for which the criteria values of the weighted simulated discharges are better than the corresponding values of both individual simulated discharges.

Tables 4 and 5 give the numbers of combinations investigated for each basin and period and the percentages of these combinations for which the criterion values of the weighted simulated discharges are better than the corresponding values of individual simulated discharges.

Tables 6 to 17 and Figures 1 to 12 show the differences between the criterion values of the weighted simulated discharge and each of the individual simulated discharges.

An examination of Tables 2, 3, 4 and 5 shows that the weighted simulated discharges improve the criterion values in the majority of the combinations.

An examination of Tables 6 to 17 and Figures 1 to 12 indicates that the differences representing an improvement over the individual values are larger and more numerous than in the opposite case. An improvement is represented by a positive difference in the case of NTD and a negative difference in the case of A. On the figures, an improvement is represented by points to the left of the 45° line for the criterion NTD and to the right of the 45° line for the criterion A. The points corresponding to the two individual discharges are joined by horizontal lines. The previous tables and graphs summarize the results obtained for the complete periods of calibration and verification.

It is also interesting to examine the results of the combination of discharges on the annual values of the criteria. As an example, the annual values of the criterion NTD for the individual models are shown in Figure 13 for the Durance basin. Figure 14 shows the corresponding values of NTD for the combined discharge of UBC with each of the other models. A comparison of Figures 13 and 14 shows that the annual values of NTD are improved by the combination and that their ranges are reduced.

3.2 Combination of simulated discharges with a constant term and weight not constrained to add to unity

According this method, the constant term and the weights are determined by representing the observed discharges on the simulated discharges of the component models, for the calibration period. This method was applied to the data of the Durance River to determine the degree of improvement as compared to the method using formula (2).

Tables 18 and 19 give the results of this computation. A comparison with tables 6 and 7 shows that the improvement is very slight.

3.3 Combination of simulated discharges when the criteria values are within the same confidence interval

The results of the previous tables show that the combination of simulated discharges of different models is advantageous in most cases. As a further step, it is interesting to examine the case where the criterion values of the models are not significantly different, i.e. they lie within the confidence interval of the model with the better criterion value.

A method for estimating confidence intervals for the criteria values used in the WMO intercomparison project is described in a recent report by the writers (Cavadias and Morin, 1984). Representative results of this analysis are shown in Figures 15 and 16. Figure 15 shows the confidence intervals for the values of the criterion NTD for the Durance River and

Figure 16 shows the groups of models whose NTD values lie within the confidence interval of each of the models, computed on the basis of the calibration period, when the models are ranked in descending order of NTD values. If a model with a lower NTD value is within the confidence interval of a model with a higher NTD value, the difference between the two models is not statistically significant.

Table 20 gives the number of combinations investigated for each basin and period and the percentages of these combinations for which the criterion values of the weighted simulated discharges are better than the corresponding values of both individual simulated discharges.

A comparison of Table 20 with Table 2 indicates that the results are generally better in the case of Table 20.

A similar analysis could be carried out for the criterion A.

3.4 Weighted averages of three simulated discharges

Using formula (2) we can combine any number of simulated discharges and it is interesting to examine the results of such combinations.

Given the large number of possibilities for the combinations of three simulated discharges, Tables 21 and 22 and Figures 17 and 18 give these results for only selected combinations for the Durance River. This selection covers the range of values of the criteria.

A comparison with the corresponding results of the combination of two simulated discharges indicates that the performance of the combined discharges is improved slightly by the addition of a third weighted discharges.

4. CONCLUSION

The results of the present study are summarized in the following table:

	NTD	A
1) Overall percentage of improved combinations of two individual discharges	80.7%	80.3%
2) Overall percentage of improved combinations when the criteria values are within the same confidence interval	89.5%	-
3) Mean improvements in criteria values	0.067	0.047
4) Mean loss in criteria values	0.008	0.009

An examination of this table leads to the following conclusions:

- 1) Approximately 80% of the combinations of two simulated discharges have better criteria values than the component individual discharges.
- 2) The mean improvements in the criterion values are substantially larger than the losses in criterion values in cases where the combination does not result in an improvement.

- 3) In the case of combinations where the criteria values are within the same confidence interval, the percentage of improved combinations increases to about 90%.

Due to the large number of possibilities of combining three models, overall percentages such as the above were not computed for this case. However, the combination of three simulated discharges represents a slight improvement over the combination of two simulated discharges.

An additional result of the combination of simulated discharges is that the range of annual criterion values is reduced. This is desirable because the corresponding reduced confidence intervals result in a more consistent computation.

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TABLE 1. Weighted W to be use in the combination of pairs of simulated discharges. Durance River complete year.

	UBC	CEQ	ERM	NAM	TAN	HBV	SRM*	SSA	PRM	NWS	DAY
UBC		0.610†	0.719	0.506	0.527	0.591	-	0.502	0.638	0.484	0.679
CEQ			0.621	0.396	0.416	0.481	-	0.392	0.530	0.375	0.576
ERM				0.286	0.303	0.361	-	0.282	0.408	0.268	0.453
NAM					0.521	0.585	-	0.495	0.632	0.478	0.674
TAN						0.565	-	0.475	0.613	0.457	0.656
HBV							-	0.410	0.549	0.393	0.594
SRM*								-	-	-	-
SSA									0.637	0.482	0.678
PRM										0.347	0.546
NWS											0.693
$\sum_{i=1}^n e_i^2$	417 995	652 647	1 068 570	428 399	465 142	604 411	-	420 622	736 808	391 650	845 426

Note: The model "Day" is the set of mean daily observed discharges for each day of the year, derived from the calibration period.

† Weight applied to the model corresponding to the row. Example (0.610 UBC) + (1.0 - 0.610) CEQ

* Weights for SRM were not computed because the calibration period is incomplete.

TABLE 2. Number of combinations investigated and percentages of these combinations for which the criterion NTD of the weighted simulated discharges outperforms the corresponding values of both individual simulated discharges.

	DURANCE	W3	DUNAJEC	DISCHMA	ILLECILLE- WAET	KULTSJON	MEAN PERCENTAGE
<u>DAILY MODEL INCLUDED</u>							
Number of combinations	45	45	45	45	21	21	
COMPLETE YEAR							
Calibration period	100%	98%	76%	93%	100%	86%	92.2%
Verification period	69%	95%	67%	91%	57%	71%	75.0%
SNOWMELT SEASON							
Calibration period	91%	96%	80%	87%	100%	76%	88.3%
Verification period	42%	87%	71%	67%	62%	81%	68.3%
<u>DAILY MODEL EXCLUDED</u>							
Number of combinations	36	36	36	36	15	15	
COMPLETE YEAR							
Calibration period	100%	97%	78%	92%	100%	80%	91.6%
Verification period	75%	94%	72%	89%	80%	80%	81.7%
SNOWMELT SEASON							
Calibration period	89%	97%	78%	83%	100%	67%	85.7%
Verification period	50%	86%	78%	58%	87%	80%	73.2%

TABLE 3. Number of combinations investigated and percentages of these combinations for which the criterion A of the weighted simulated discharges outperforms the corresponding values of both individual simulated discharges.

	DURANCE	W3	DUNAJEC	DISCHMA	ILLECILLE- WAET	KULTSJON	MEAN PERCENTAGE
<u>DAILY MODEL INCLUDED</u>							
Number of combinations	45	45	45	45	21	21	
COMPLETE YEAR							
Calibration period	96%	89%	82%	93%	95%	90%	90.8%
Verification period	64%	82%	73%	95%	62%	71%	74.5%
SNOWMELT SEASON							
Calibration period	87%	98%	78%	96%	95%	76%	88.3%
Verification period	45%	89%	65%	78%	48%	71%	66.0%
<u>DAILY MODEL EXCLUDED</u>							
Number of combinations	36	36	36	36	15	15	
COMPLETE YEAR							
Calibration period	94%	86%	89%	92%	93%	87%	90.2%
Verification period	64%	81%	83%	94%	80%	80%	80.3%
SNOWMELT SEASON							
Calibration period	89%	97%	75%	94%	93%	67%	85.8%
Verification period	47%	92%	72%	72%	58%	73%	69.0%

TABLE 4. Number of combinations investigated and percentages of these combinations for which the criterion NTD of the weighted simulated discharges outperforms the corresponding values of the individual simulated discharges. Complete year, verification period.

	DURANCE	W3	DUNAJEC	DISCHMA	ILLECILLE- WAET	KULTSJON	MEAN PERCENTAGE
<u>DAILY MODEL INCLUDED</u>							
Number of combinations	9	9	9	9	6	6	
Models:							
UBC	100%	100%	89%	78%	83%	83%	88.8%
CEQ	89%	100%	67%	100%	67%	100%	87.2%
ERM	89%	-	100%	100%	83%	83%	91.0%
NAM	89%	100%	89%	100%	-	-	94.5%
TAN	78%	100%	67%	89%	67%	33%	72.3%
HBV	89%	100%	89%	100%	67%	100%	90.8%
SRM	-	100%	-	100%	-	-	100.0%
SAR	78%	100%	100%	89%	83%	100%	91.7%
PRM	100%	100%	56%	100%	-	-	89.0%
NWS	33%	78%	78%	-	-	-	63.0%
DAY	100%	100%	100%	100%	100%	100%	100.0%
Mean	75.6%	97.8%	83.5%	95.6%	78.6%	85.6%	88.0%
<u>DAILY MODEL EXCLUDED</u>							
Number of combinations	8	8	8	8	5	5	
Models:							
UBC	100%	100%	100%	75%	100%	100%	95.8%
CEQ	87%	100%	75%	100%	80%	100%	90.3%
ERM	100%	-	100%	100%	100%	100%	100.0%
NAM	87%	100%	100%	100%	-	-	96.7%
TAN	87%	100%	75%	87%	80%	40%	78.2%
HBV	100%	100%	87%	100%	80%	100%	94.5%
SRM	-	100%	-	100%	-	-	100.0%
SAR	87%	100%	100%	87%	100%	100%	95.7%
PRM	100%	100%	62%	100%	-	-	90.5%
NWS	37%	75%	75%	-	-	-	62.3%
Mean	87.2%	97.2%	86.0%	94.3%	90.0%	90.0%	90.4%

TABLE 5. Number of combinations investigated and percentages of these combinations for which the criterion A of the weighted simulated discharges outperforms the corresponding values of the individual simulated discharges. Complete year, verification period.

		DURANCE	W3	DUNAJEC	DISCHMA	ILLECILLE- WAET	KULTSJON	MEAN PERCENTAGE
<u>DAILY MODEL INCLUDED</u>								
Number of combinations		9	9	9	9	6	6	
Models:	UBC	100%	100%	89%	89%	83%	83%	90.7%
	CEQ	89%	100%	78%	100%	75%	100%	90.3%
	ERM	89%	-	100%	100%	100%	83%	94.4%
	NAM	89%	100%	100%	100%	-	-	97.2%
	TAN	56%	78%	78%	89%	83%	33%	69.5%
	HBV	56%	100%	78%	100%	50%	100%	80.7%
	SRM	-	100%	-	100%	-	-	100.0%
	SAR	89%	100%	78%	100%	83%	100%	91.7%
	PRM	100%	100%	78%	100%	-	-	94.5%
	NWS	55%	44%	100%	-	-	-	66.3%
	DAY	100%	100%	100%	100%	100%	100%	100.0%
Mean		82.3%	92.2%	87.9%	97.8%	82.0%	85.6%	88.6%
<u>DAILY MODEL EXCLUDED</u>								
Number of combinations		8	8	8	8	5	5	
Models:	UBC	100%	100%	100%	87%	100%	100%	97.8%
	CEQ	87%	100%	87%	100%	80%	100%	93.5%
	ERM	100%	-	100%	100%	100%	100%	100.0%
	NAM	87%	100%	100%	100%	-	-	96.7%
	TAN	71%	75%	75%	87%	100%	40%	74.7%
	HBV	71%	100%	87%	100%	60%	100%	86.3%
	SRM	-	100%	-	100%	-	-	100.0%
	SAR	87%	100%	87%	100%	100%	100%	95.7%
	PRM	100%	100%	87%	100%	-	-	96.7%
	NWS	50%	50%	100%	-	-	-	66.7%
Mean		83.7%	91.7%	91.4%	97.1%	90.0%	90.0%	90.8%

TABLE 6. Differences between the values of criterion NTD for the combined simulated discharges and each of the individual simulated discharges. Durance River, complete year, verification period.

	INDIVIDUAL CRITERION VALUE	UBC	CEQ	ERM	NAM	TAN	HBV	SRM	SSA	PRM	NWS	MEAN OF POSITIVE DIFFER- ENCES	MEAN OF NEGATIVE DIFFER- ENCES
UBC	0.868*	-	0.042*	0.031	0.037	0.059	0.047	-	0.062	0.012	0.066	0.044	-
CEQ	0.885	0.025	-	0.005	0.009	0.029	0.041	-	0.037	-0.015	0.045	0.028	-0.015
ERM	0.674	0.225	0.216	-	0.231	0.201	0.229	-	0.212	0.176	0.247	0.217	-
NAM	0.863	0.043	0.032	0.042	-	0.050	0.049	-	0.045	-0.009	0.055	0.045	-0.009
TAN	0.891	0.036	0.023	-0.016	0.021	-	0.028	-	0.023	0.007	0.045	0.026	-0.016
HBV	0.896	0.020	0.030	0.008	0.016	0.023	-	-	0.031	0.006	0.044	0.022	-
SRM	-	-	-	-	-	-	-	-	-	-	-	-	-
SSA	0.886	0.045	0.036	0.000	0.002	0.029	0.042	-	-	-0.002	0.044	0.031	-0.002
PRM	0.754	0.126	0.116	0.096	0.100	0.145	0.148	-	0.129	-	0.152	0.126	-
NWS	0.931	0.003	-0.001	-0.009	-0.014	0.005	0.009	-	-0.002	-0.025	-	0.006	-0.010
MEAN												0.061	-0.010

* The criterion NTD for the combined simulated discharges of models UBC-CEQ is $0.910 = 0.868 + 0.042$

Note: A positive difference indicates that the weighted simulated discharges is better than the individual simulated discharges

TABLE 7. Differences between the values of criterion A for the combined simulated discharges and each of the individual simulated discharges. Durance River, complete year, verification period.

	INDIVIDUAL CRITERION VALUE	UBC	CEQ	ERM	NAM	TAN	HBV	SRM	SSA	PRM	NWS	MEAN OF POSITIVE DIFFER- ENCES	MEAN OF NEGATIVE DIFFER- ENCES
UBC	0.209*	-	-0.012*	-0.017	-0.010	-0.044	-0.044	-	-0.048	-0.004	-0.048	-	-0.028
CEQ	0.243	-0.046	-	-0.025	-0.013	-0.054	-0.068	-	-0.065	0.013	-0.065	0.013	-0.048
ERM	0.334	-0.142	-0.116	-	-0.132	-0.133	-0.147	-	-0.141	-0.092	-0.159	-	-0.132
NAM	0.253	-0.055	-0.023	-0.051	-	-0.060	-0.058	-	-0.056	0.001	-0.067	0.001	-0.052
TAN	0.191	-0.027	-0.002	0.009	0.003	-	-0.028	-	-0.027	0.009	-0.036	0.007	-0.024
HBV	0.184	-0.019	-0.009	0.003	0.012	-0.021	-	-	-0.017	0.011	-0.029	0.009	-0.019
SRM	-	-	-	-	-	-	-	-	-	-	-	-	-
SSA	0.201	-0.040	-0.023	-0.007	-0.003	-0.036	-0.034	-	-	0.011	-0.034	0.011	-0.025
PRM	0.307	-0.102	-0.051	-0.065	-0.053	-0.107	-0.112	-	-0.096	-	-0.110	-	-0.087
NWS	0.167	-0.006	0.011	0.008	0.019	-0.012	-0.012	-	-0.001	0.030	-	0.017	-0.008
MEAN												0.010	-0.047

* The criterion A for the combined simulated discharges of models UBC-CEQ is $0.197 = 0.209 - 0.012$

Note: A negative difference indicates that the weighted simulated discharges is better than the individual simulated discharges

TABLE 8. Differences between the values of criterion NTD for the combined simulated discharges and each of the individual simulated discharges. W3 River, complete year, verification period.

	INDIVIDUAL CRITERION VALUE	UBC	CEQ	ERM	NAM	TAN	HBV	SRM	SSA	PRM	NWS	MEAN OF POSITIVE DIFFER- ENCES	MEAN OF NEGATIVE DIFFER- ENCES
UBC	0.765*	-	0.027*	-	0.076	0.122	0.029	0.081	0.071	0.077	0.146	0.079	-
CEQ	0.617	0.175	-	-	0.184	0.224	0.158	0.164	0.198	0.188	0.296	0.198	-
ERM	-	-	-	-	-	-	-	-	-	-	-	-	-
NAM	0.774	0.066	0.027	-	-	0.066	0.037	0.071	0.083	0.090	0.126	0.071	-
TAN	0.813	0.073	0.028	-	0.027	-	0.053	0.046	0.058	0.072	0.083	0.055	-
HBV	0.740	0.054	0.035	-	0.071	0.126	-	0.101	0.090	0.094	0.161	0.091	-
SRM	0.708	0.138	0.074	-	0.138	0.151	0.133	-	0.162	0.131	0.214	0.142	-
SSA	0.771	0.065	0.044	-	0.086	0.100	0.059	0.099	-	0.115	0.124	0.086	-
PRM	0.797	0.045	0.008	-	0.067	0.088	0.037	0.042	0.089	-	0.135	0.064	-
NWS	0.902	0.009	0.011	-	-0.001	-0.006	-0.001	0.020	-0.007	0.031	-	0.015	-0.004
MEAN												0.089	-0.004

* The criterion NTD for the combined simulated discharges of models UBC-CEQ is $0.792 = 0.765 + 0.027$

Note: A positive difference indicates that the weighted simulated discharges is better than the individual simulated discharges

TABLE 9. Differences between the values of criterion A for the combined simulated discharges and each of the individual simulated discharges. W3 River, complete year, verification period.

	INDIVIDUAL CRITERION VALUE	UBC	CEQ	ERM	NAM	TAN	HBV	SRM	SSA	PRM	NWS	MEAN OF POSITIVE DIFFER- ENCES	MEAN OF NEGATIVE DIFFER- ENCES
UBC	0.299*	-	-0.017*	-	-0.020	-0.088	-0.012	-0.030	-0.048	-0.043	-0.106	-	-0.046
CEQ	0.343	-0.061	-	-	-0.027	-0.109	-0.038	-0.007	-0.090	-0.059	-0.157	-	-0.069
ERM	-	-	-	-	-	-	-	-	-	-	-	-	-
NAM	0.362	-0.083	-0.046	-	-	-0.115	-0.052	-0.036	-0.095	-0.086	-0.151	-	-0.083
TAN	0.237	-0.026	-0.003	-	0.009	-	-0.013	0.011	-0.023	-0.027	-0.056	0.010	-0.025
HBV	0.345	-0.058	-0.040	-	-0.035	-0.121	-	-0.047	-0.076	-0.072	-0.134	-	-0.073
SRM	0.421	-0.152	-0.086	-	-0.095	-0.173	-0.123	-	-0.144	-0.131	-0.223	-	-0.140
SSA	0.274	-0.023	-0.021	-	-0.007	-0.059	-0.005	0.004	-	-0.045	-0.078	0.004	-0.034
PRM	0.301	-0.045	-0.017	-	-0.025	-0.090	-0.027	-0.011	-0.072	-	-0.125	-	-0.050
NWS	0.188	0.005	-0.002	-	0.022	-0.007	0.023	0.010	0.007	-0.012	-	0.014	-0.007
MEAN												0.009	-0.059

* The criterion A for the combined simulated discharges of models UBC-CEQ is $0.282 = 0.299 - 0.017$

Note: A negative difference indicates that the weighted simulated discharges is better than the individual simulated discharges

TABLE 10. Differences between the values of criterion NTD for the combined simulated discharges and each of the individual simulated discharges. Dunajec River, complete year, verification period.

	INDIVIDUAL CRITERION VALUE	UBC	CEQ	ERM	NAM	TAN	HBV	SRM	SSA	PRM	NWS	MEAN OF POSITIVE DIFFER- ENCES	MEAN OF NEGATIVE DIFFER- ENCES
UBC	0.709*	-	0.069*	0.014	0.077	0.082	0.080	-	0.051	0.079	0.108	0.070	-
CEQ	0.726	0.052	-	-0.023	0.027	0.075	0.051	-	-0.013	0.077	0.103	0.064	-0.018
ERM	0.454	0.268	0.249	-	0.208	0.312	0.307	-	0.189	0.328	0.344	0.276	-
NAM	0.661	0.125	0.092	0.001	-	0.140	0.115	-	0.034	0.151	0.159	0.102	-
TAN	0.790	0.000	0.011	-0.024	0.010	-	0.011	-	-0.005	0.028	0.039	0.016	-0.015
HBV	0.735	0.053	0.042	0.027	0.041	0.066	-	-	-0.006	0.073	0.078	0.054	-0.006
SRM	-	-	-	-	-	-	-	-	-	-	-	-	-
SSA	0.549	0.210	0.164	0.094	0.145	0.236	0.180	-	-	0.228	0.262	0.190	-
PRM	0.795	-0.008	0.008	-0.012	0.017	0.024	0.013	-	-0.018	-	0.042	0.021	-0.013
NWS	0.812	0.005	0.018	-0.013	0.008	0.017	0.001	-	-0.001	0.025	-	0.012	-0.007
MEAN												0.089	-0.012

* The criterion NTD for the combined simulated discharges of models UBC-CEQ is $0.778 = 0.709 + 0.069$

Note: A positive difference indicates that the weighted simulated discharges is better than the individual simulated discharges

TABLE 11. Differences between the values of criterion A for the combined simulated discharges and each of the individual simulated discharges. Dunajec River, complete year, verification period.

	INDIVIDUAL CRITERION VALUE	UBC	CEQ	ERM	NAM	TAN	HBV	SRM	SSA	PRM	NWS	MEAN OF POSITIVE DIFFER- ENCES	MEAN OF NEGATIVE DIFFER- ENCES
UBC	0.341*	-	-0.053*	-0.019	-0.051	-0.066	-0.064	-	-0.062	-0.061	-0.065	-	-0.055
CEQ	0.310	-0.021	-	0.004	-0.015	-0.057	-0.044	-	-0.029	-0.046	-0.055	0.004	-0.038
ERM	0.419	-0.096	-0.105	-	-0.069	-0.128	-0.112	-	-0.069	-0.124	-0.138	-	-0.105
NAM	0.396	-0.106	-0.102	-0.047	-	-0.125	-0.114	-	-0.072	-0.116	-0.123	-	-0.101
TAN	0.274	0.001	-0.022	0.016	-0.003	-	-0.009	-	-0.014	-0.020	-0.016	0.008	-0.014
HBV	0.301	-0.023	-0.035	0.006	-0.019	-0.036	-	-	-0.015	-0.039	-0.044	0.019	-0.030
SRM	-	-	-	-	-	-	-	-	-	-	-	-	-
SSA	0.337	-0.057	-0.056	0.013	-0.013	-0.077	-0.051	-	-	-0.057	-0.075	0.013	-0.055
PRM	0.283	-0.003	-0.020	0.012	-0.003	-0.029	-0.022	-	-0.004	-	-0.027	0.012	-0.015
NWS	0.285	-0.008	-0.030	-0.003	-0.012	-0.026	-0.028	-	-0.023	-0.029	-	-	-0.020
MEAN												0.011	-0.048

* The criterion A for the combined simulated discharges of models UBC-CEQ is $0.288 = 0.341 - 0.053$

Note: A negative difference indicates that the weighted simulated discharges is better than the individual simulated discharges

TABLE 12. Differences between the values of criterion NTD for the combined simulated discharges and each of the individual simulated discharges. Dischma River, complete year, verification period.

	INDIVIDUAL CRITERION VALUE	UBC	CEQ	ERM	NAM	TAN	HBV	SRM	SSA	PRM	NWS	MEAN OF POSITIVE DIFFER- ENCES	MEAN OF NEGATIVE DIFFER- ENCES
UBC	0.880*	-	0.012*	-0.007	0.001	0.019	0.005	0.014	0.009	-0.024	-	0.010	-0.015
CEQ	0.828	0.064	-	0.032	0.040	0.062	0.047	0.038	0.049	0.016	-	0.043	-
ERM	0.743	0.131	0.118	-	0.107	0.144	0.088	0.145	0.108	0.073	-	0.114	-
NAM	0.826	0.055	0.042	0.024	-	0.060	0.029	0.053	0.047	0.013	-	0.040	-
TAN	0.885	0.014	0.005	0.001	0.002	-	0.008	0.005	0.011	-0.005	-	0.007	-0.005
HBV	0.749	0.136	0.127	0.081	0.106	0.144	-	0.122	0.095	0.037	-	0.106	-
SRM	0.842	0.052	0.024	0.045	0.037	0.048	0.028	-	0.043	0.014	-	0.036	-
SSA	0.831	0.058	0.047	0.019	0.042	0.065	0.013	0.055	-	-0.006	-	0.043	-0.006
PRM	0.704	0.153	0.141	0.111	0.136	0.176	0.082	0.152	0.121	-	-	0.134	-
NWS	-	-	-	-	-	-	-	-	-	-	-	-	-
MEAN												0.059	-0.009

* The criterion NTD for the combined simulated discharges of models UBC-CEQ is $0.892 = (0.880 + 0.012)$

Note: A positive difference indicates that the weighted simulated discharges is better than the individual simulated discharges

TABLE 13. Differences between the values of criterion A for the combined simulated discharges and each of the individual simulated discharges. Dischma River, complete year, verification period.

	INDIVIDUAL CRITERION VALUE	UBC	CEQ	ERM	NAM	TAN	HBV	SRM	SSA	PRM	NWS	MEAN OF POSITIVE DIFFER- ENCES	MEAN OF NEGATIVE DIFFER- ENCES
UBC	0.213*	-	-0.009*	-0.011	-0.001	-0.025	-0.014	-0.018	-0.028	0.002	-	0.002	-0.015
CEQ	0.272	-0.069	-	-0.057	-0.040	-0.072	-0.055	-0.042	-0.066	-0.047	-	-	-0.056
ERM	0.256	-0.055	-0.041	-	-0.034	-0.067	-0.053	-0.066	-0.053	-0.027	-	-	-0.050
NAM	0.263	-0.051	-0.031	-0.041	-	-0.060	-0.040	-0.044	-0.059	-0.035	-	-	-0.045
TAN	0.202	-0.014	-0.002	-0.013	0.001	-	-0.013	-0.016	-0.019	-0.003	-	0.001	-0.011
HBV	0.238	-0.039	-0.021	-0.034	-0.015	-0.049	-	-0.024	-0.034	-0.002	-	-	-0.027
SRM	0.247	-0.052	-0.016	-0.057	-0.028	-0.061	-0.033	-	-0.048	-0.039	-	-	-0.042
SSA	0.221	-0.036	-0.015	-0.018	-0.017	-0.037	-0.017	-0.022	-	-0.005	-	-	-0.021
PRM	0.270	-0.056	-0.045	-0.040	-0.042	-0.071	-0.034	-0.062	-0.054	-	-	-	-0.050
NWS	-	-	-	-	-	-	-	-	-	-	-	-	-
MEAN												0.002	-0.035

* The criterion A for the combined simulated discharges of models UBC-CEQ is $0.204 = 0.213 - 0.009$

Note: A negative difference indicates that the weighted simulated discharges is better than the individual simulated discharges

TABLE 14. Differences between the values of criterion NTD for the combined simulated discharges and each of the individual simulated discharges. Illecillewaet River, complete year, verification period.

	INDIVIDUAL CRITERION VALUE	UBC	CEQ	ERM	NAM	TAN	HBV	SRM	SSA	PRM	NWS	MEAN OF POSITIVE DIFFER- ENCES	MEAN OF NEGATIVE DIFFER- ENCES
UBC	0.899*	-	0.032*	0.012	-	0.021	0.017	-	0.002	-	-	0.017	-
CEQ	0.907	0.024	-	-0.001	-	0.021	0.023	-	0.009	-	-	0.019	-0.001
ERM	0.805	0.106	0.101	-	-	0.119	0.107	-	0.079	-	-	0.102	-
NAM	-	-	-	-	-	-	-	-	-	-	-	-	-
TAN	0.914	0.006	0.014	0.010	-	-	0.010	-	0.000	-	-	0.008	-
HBV	0.907	0.009	0.023	0.005	-	0.017	-	-	-0.002	-	-	0.013	-0.002
SRM	-	-	-	-	-	-	-	-	-	-	-	-	-
SSA	0.858	0.042	0.057	0.025	-	0.055	0.047	-	-	-	-	0.045	-
PRM	-	-	-	-	-	-	-	-	-	-	-	-	-
NWS	-	-	-	-	-	-	-	-	-	-	-	-	-
MEAN												0.034	-0.002

* The criterion NTD for the combined simulated discharges of models UBC-CEQ is $0.931 = 0.899 + 0.032$

Note: A positive difference indicates that the weighted simulated discharges is better than the individual simulated discharges

TABLE 15. Differences between the values of criterion A for the combined simulated discharges and each of the individual simulated discharges. Illecillewaet River, complete year, verification period.

	INDIVIDUAL CRITERION VALUE	UBC	CEQ	ERM	NAM	TAN	HBV	SRM	SSA	PRM	NWS	MEAN OF POSITIVE DIFFER- ENCES	MEAN OF NEGATIVE DIFFER- ENCES
UBC	0.216*	-	-0.039*	-0.010	-	-0.024	-0.032	-	-0.006	-	-	-	-0.022
CEQ	0.187	-0.009	-	0.016	-	-0.010	-0.023	-	0.000	-	-	0.008	-0.014
ERM	0.315	-0.109	-0.112	-	-	-0.129	-0.123	-	-0.087	-	-	-	-0.112
NAM	-	-	-	-	-	-	-	-	-	-	-	-	-
TAN	0.199	-0.007	-0.023	-0.012	-	-	-0.023	-	-0.006	-	-	-	-0.014
HBV	0.190	-0.005	-0.026	0.002	-	-0.013	-	-	0.005	-	-	-0.019	-0.015
SRM	-	-	-	-	-	-	-	-	-	-	-	-	-
SSA	0.245	-0.035	-0.059	-0.017	-	-0.052	-0.050	-	-	-	-	-	-0.043
PRM	-	-	-	-	-	-	-	-	-	-	-	-	-
NWS	-	-	-	-	-	-	-	-	-	-	-	-	-
MEAN												0.013	-0.037

* The criterion A for the combined simulated discharges of models UBC-CEQ is $0.177 = 0.216 - 0.039$

Note: A negative difference indicates that the weighted simulated discharges is better than the individual simulated discharges

TABLE 16. Differences between the values of criterion NTD for the combined simulated discharges and each of the individual simulated discharges. Kultsjon River, complete year, verification period.

	INDIVIDUAL CRITERION VALUE	UBC	CEQ	ERM	NAM	TAN	HBV	SRM	SSA	PRM	NWS	MEAN OF POSITIVE DIFFER- ENCES	MEAN OF NEGATIVE DIFFER- ENCES
UBC	0.842*	-	0.007*	0.002	-	0.035	0.026	-	0.016	-	-	0.017	-
CEQ	0.712	0.137	-	0.111	-	0.149	0.135	-	0.043	-	-	0.135	-
ERM	0.759	0.085	0.064	-	-	0.114	0.094	-	0.062	-	-	0.083	-
NAM	-	-	-	-	-	-	-	-	-	-	-	-	-
TAN	0.877	0.000	-0.016	-0.004	-	-	0.008	-	-0.013	-	-	0.004	-0.011
HBV	0.828	0.040	0.019	0.025	-	0.056	-	-	0.011	-	-	0.030	-
SRM	-	-	-	-	-	-	-	-	-	-	-	-	-
SSA	0.740	0.119	0.016	0.081	-	0.124	0.100	-	-	-	-	0.088	-
PRM	-	-	-	-	-	-	-	-	-	-	-	-	-
NWS	-	-	-	-	-	-	-	-	-	-	-	-	-
MEAN												0.060	-0.011

* The criterion NTD for the combined simulated discharges of models UBC-CEQ is $0.849 = 0.842 + 0.007$

Note: A positive difference indicates that the weighted simulated discharges is better than the individual simulated discharges

TABLE 17. Differences between the values of criterion A for the combined simulated discharges and each of the individual simulated discharges. Kultsjon River, complete year, verification period.

	INDIVIDUAL CRITERION VALUE	UBC	CEQ	ERM	NAM	TAN	HBV	SRM	SSA	PRM	NWS	MEAN OF POSITIVE DIFFER- ENCES	MEAN OF NEGATIVE DIFFER- ENCES
UBC	0.362*	-	-0.013*	-0.003	-	-0.046	-0.024	-	-0.020	-	-	-	-0.021
CEQ	0.463	-0.114	-	-0.083	-	-0.128	-0.106	-	-0.035	-	-	-	-0.093
ERM	0.443	-0.084	-0.064	-	-	-0.118	-0.079	-	-0.067	-	-	-	-0.082
NAM	-	-	-	-	-	-	-	-	-	-	-	-	-
TAN	0.323	-0.007	0.012	0.002	-	-	-0.007	-	0.015	-	-	0.010	-0.007
HBV	0.416	-0.077	-0.059	-0.051	-	-0.100	-	-	-0.058	-	-	-	-0.069
SRM	-	-	-	-	-	-	-	-	-	-	-	-	-
SSA	0.440	-0.097	-0.012	-0.063	-	-0.101	-0.082	-	-	-	-	-	-0.071
PRM	-	-	-	-	-	-	-	-	-	-	-	-	-
NWS	-	-	-	-	-	-	-	-	-	-	-	-	-
MEAN												0.010	-0.057

* The criterion A for the combined simulated discharges of models UBC-CEQ is $0.349 = 0.362 - 0.013$

Note: A negative difference indicates that the weighted simulated discharges is better than the individual simulated discharges

TABLE 18. Differences between the values of criterion NTD for the combined simulated discharges and each of the individual simulated discharges. Durance River, complete year, verification period. Combination with constant term and no constraint on the weight.

	INDIVIDUAL CRITERION VALUE	UBC	CEQ	ERM	NAM	TAN	HBV	SRM	SSA	PRM	NWS	MEAN OF POSITIVE DIFFER- ENCES	MEAN OF NEGATIVE DIFFER- ENCES
UBC	0.868*	-	0.048	0.029	0.047	0.057	0.051	-	0.064	0.029	0.061	0.048	-
CEQ	0.885	0.031	-	-0.007	0.018	0.022	0.043	-	0.037	-0.001	0.036	0.031	-0.004
ERM	0.674	0.223	0.203	-	0.235	0.197	0.214	-	0.205	0.169	0.253	0.212	-
NAM	0.863	0.053	0.040	0.047	-	0.051	0.054	-	0.051	0.011	0.048	0.044	-
TAN	0.891	0.034	0.016	-0.020	0.022	-	0.021	-	0.021	0.009	0.043	0.024	-0.020
HBV	0.896	0.024	0.033	-0.007	0.021	0.016	-	-	0.026	0.019	0.037	0.025	-0.007
SRM	-	-	-	-	-	-	-	-	-	-	-	-	-
SSA	0.886	0.047	0.036	-0.007	0.028	0.027	0.037	-	-	0.008	0.042	0.032	-0.007
PRM	0.754	0.143	0.130	0.090	0.119	0.146	0.160	-	0.140	-	0.153	0.135	-
NWS	0.931	-0.002	-0.009	-0.003	-0.019	0.004	0.002	-	-0.004	-0.024	-	0.003	-0.010
MEAN												0.062	-0.009

* The criterion NTD for the combined simulated discharges of models UBC-CEQ is $0.916 = 0.868 + 0.048$

Note: A positive difference indicates that the weighted simulated discharges is better than the individual simulated discharges

TABLE 19. Differences between the values of criterion A for the combined simulated discharges and each of the individual simulated discharges. Durance River, complete year, verification period. Combination with constant term and no constraint on the weight.

	INDIVIDUAL CRITERION VALUE	UBC	CEQ	ERM	NAM	TAN	HBV	SRM	SSA	PRM	NWS	MEAN OF POSITIVE DIFFER- ENCES	MEAN OF NEGATIVE DIFFER- ENCES
UBC	0.209*	-	-0.019	-0.018	-0.022	-0.041	-0.044	-	-0.055	-0.020	-0.042	-	-0.033
CEQ	0.243	-0.053	-	-0.022	-0.025	-0.051	-0.071	-	-0.071	-0.003	-0.062	-	-0.045
ERM	0.334	-0.144	-0.113	-	-0.139	-0.132	-0.142	-	-0.145	-0.101	-0.158	-	-0.134
NAM	0.253	-0.067	-0.035	-0.058	-	-0.061	-0.063	-	-0.065	-0.018	-0.062	-	-0.061
TAN	0.191	-0.024	-	0.011	0.001	-	-0.020	-	-0.027	0.007	-0.028	0.006	-0.025
HBV	0.184	-0.019	-0.012	0.008	0.006	-0.012	-	-	-0.021	-0.005	-0.019	0.007	-0.015
SRM	-	-	-	-	-	-	-	-	-	-	-	-	-
SSA	0.201	-0.047	-0.029	-0.012	-0.012	-0.036	-0.038	-	-	-0.007	-0.028	-	-0.026
PRM	0.307	-0.118	-0.067	-0.074	-0.071	-0.109	-0.128	-	-0.114	-	-0.110	-	-0.099
NWS	0.167	-0.001	0.014	0.009	0.024	-0.004	-0.002	-	0.005	0.029	-	0.016	-0.002
MEAN												0.010	-0.049

* The criterion A for the combined simulated discharges of models UBC-CEQ is $0.190 = 0.209 - 0.019$

Note: A negative difference indicates that the weighted simulated discharges is better than the individual simulated discharges

TABLE 20. Combinations of pairs of simulated discharges within the confidence interval of the model with higher criterion values; number of combinations investigated and percentage of these combinations for which the criterion NTD of the weighted simulated discharges outperforms the corresponding values of both individual simulated discharges.

	DURANCE	W3	DUNAJEC	DISCHMA	ILLECILLE- WAET	KULTSJON	MEAN PERCENTAGE
<u>DAILY MODEL INCLUDED</u>							
COMPLETE YEAR							
Number of combinations	22	14	19	19	6	9	
Calibration period	100%	100%	95%	100%	100%	100%	99.2%
Verification period	82%	100%	84%	95%	50%	89%	83.3%
SNOWMELT SEASON							
Number of model combinations	21%	29%	30%	19%	7%	9%	
Calibration period	95%	100%	83%	100%	100%	100%	96.3%
Verification period	38%	86%	77%	84%	71%	100%	76.0%
<u>DAILY MODEL EXCLUDED</u>							
COMPLETE YEAR							
Number of combinations	19	14	19	18	4	7	
Calibration period	100%	100%	95%	100%	100%	100%	99.2%
Verification period	84%	100%	84%	94%	75%	100%	89.5%
SNOWMELT SEASON							
Number of model combinations	17%	29%	28%	17%	5%	7%	
Calibration period	94%	100%	89%	100%	100%	100%	97.2%
Verification period	47%	86%	75%	82%	80%	100%	78.3%

TABLE 21. Differences between the values of criterion NTD for the combined simulated discharges and each of the three individual simulated discharges. Durance River, complete year, verification period.

	INDIVIDUAL CRITERION VALUE	UBC	CEQ	ERM	NAM	TAN	HBV	SRM	SSA	PRM	NWS	MEAN OF POSITIVE DIFFER- ENCES	MEAN OF NEGATIVE DIFFER- ENCES
#		-	0.051*	0.262	0.067	0.053	0.045	-	0.057	0.168	-	0.100	-
UBC	0.868	-	0.068*	0.068	0.061	0.076	0.073	-	0.075	0.054	-	0.068	-
NWS	0.931	-	0.005*	0.006	-0.002	0.013	0.010	-	0.012	-0.008	-	0.009	-0.005
#		0.061	-	0.253	0.057	0.037	-	-	0.052	0.163	0.009	0.090	-
CEQ	0.885	0.044	-	0.042	0.035	0.043	-	-	0.053	0.031	0.055	0.043	-
HBV	0.896	0.033	-	0.032	0.024	0.033	-	-	0.042	0.021	0.044	0.032	-
#		0.024	-0.022	-	0.038	-0.043	-0.025	-	-0.023	0.084	-0.032	0.049	-0.029
ERM	0.674	0.218	0.189	-	0.226	0.174	0.197	-	0.188	0.164	0.224	0.197	-
DAY	0.554	0.339	0.310	-	0.347	0.295	0.318	-	0.309	0.284	0.345	0.318	-
MEAN												0.101	-0.017

* The criterion NTD for the combined simulated discharges of models CEQ-UBC-NWS is
 $0.936 = 0.885 + 0.051 = 0.868 + 0.068 = 0.931 + 0.005$

The third model of the group is indicated in the columns

Note: A positive difference indicates that the weighted simulated discharges is better than the individual simulated discharges

TABLE 22. Differences between the values of criterion A for the combined simulated discharges and each of the three individual simulated discharges. Durance River, complete year, verification period.

	INDIVIDUAL CRITERION VALUE	UBC	CEQ	ERM	NAM	TAN	HBV	SRM	SSA	PRM	NWS	MEAN OF POSITIVE DIFFER- ENCES	MEAN OF NEGATIVE DIFFER- ENCES
#	-	-	-0.073*	-0.172	-0.082	-0.041	-0.034	-	-0.048	-0.131	-	-	-0.083
UBC	0.209	-	-0.039*	-0.047	-0.038	-0.059	-0.059	-	-0.056	-0.033	-	-	-0.047
NWS	0.167	-	0.003*	-0.005	0.004	-0.017	-0.017	-	-0.015	0.009	-	0.005	-0.013
#	-	-0.040	-	-0.162	-0.062	-0.025	-	-	-0.042	-0.111	-0.007	-	-0.064
CEQ	0.243	-0.074	-	-0.071	-0.051	-0.077	-	-	-0.085	-0.047	-0.083	-	-0.070
HBV	0.184	-0.015	-	-0.012	0.008	-0.018	-	-	-0.025	0.012	-0.023	0.010	-0.019
#	-	-0.010	-0.030	-	-0.069	0.020	0.019	-	-0.006	-0.081	0.017	0.019	-0.039
ERM	0.334	-0.135	-0.121	-	-0.149	-0.123	-0.132	-	-0.140	-0.109	-0.150	-	-0.132
DAY	0.391	-0.192	-0.178	-	-0.206	-0.180	-0.188	-	-0.196	-0.165	-0.207	-	-0.189
MEAN													

* The criterion A for the combined simulated discharges of models CEQ-UBC-NWS is
 $0.170 = 0.243 + 0.073 = 0.209 + 0.039 = 0.167 + 0.003$

The third model of the group is indicated in the columns

Note: A negative difference indicates that the weighted simulated discharges is better than the individual simulated discharges

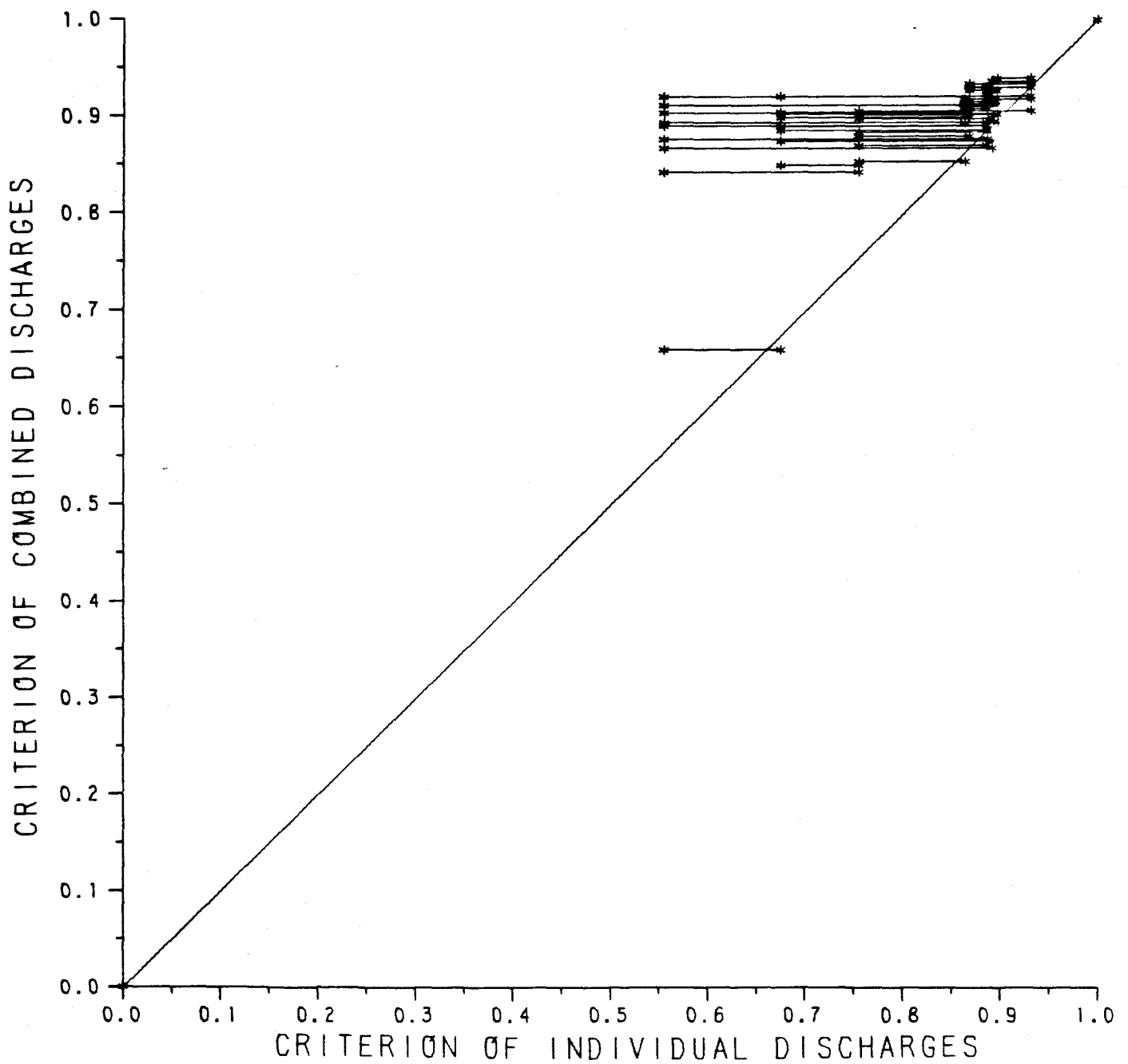


FIGURE 1. Combinations of pairs of simulated discharges. Values of criterion NTD for individual and combined discharges. Durance River, verification period, complete year.

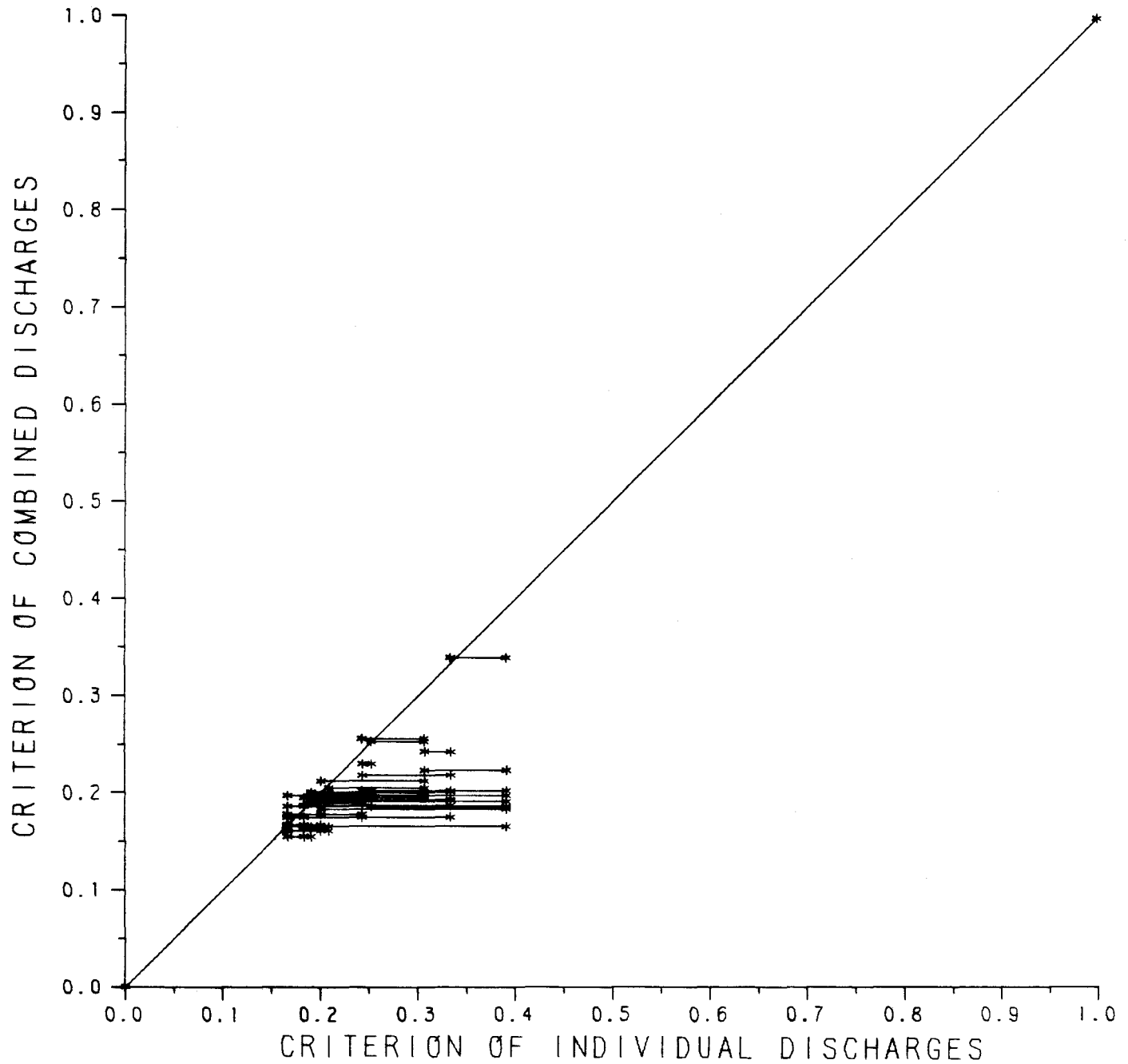


FIGURE 2. Combinations of pairs of simulated discharges. Values of criterion A for individual and combined discharges. Durance River, verification period, complete year.

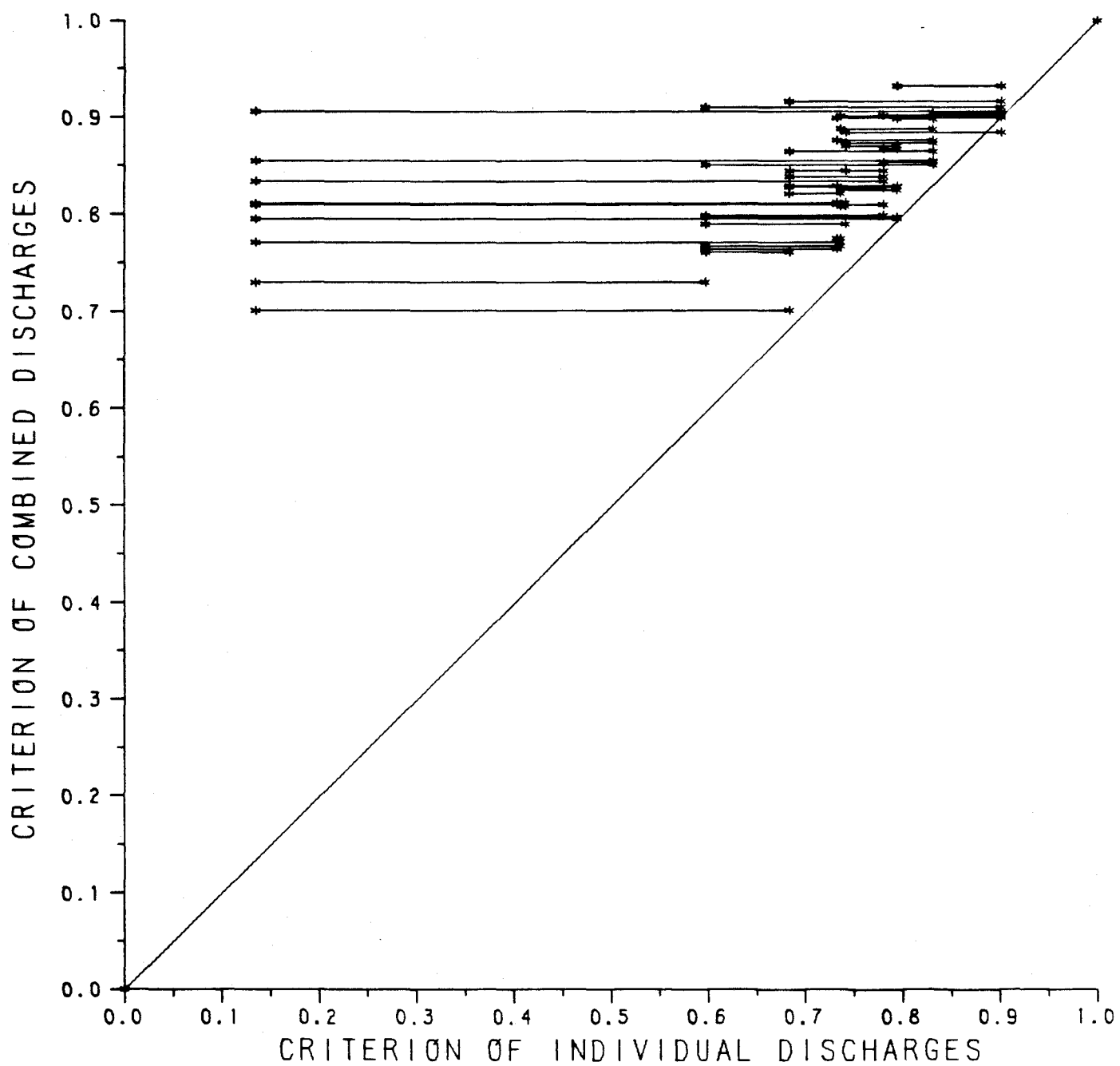


FIGURE 3. Combinations of pairs of simulated discharges. Values of criterion NTD for individual and combined discharges. W3 River, verification period, complete year.

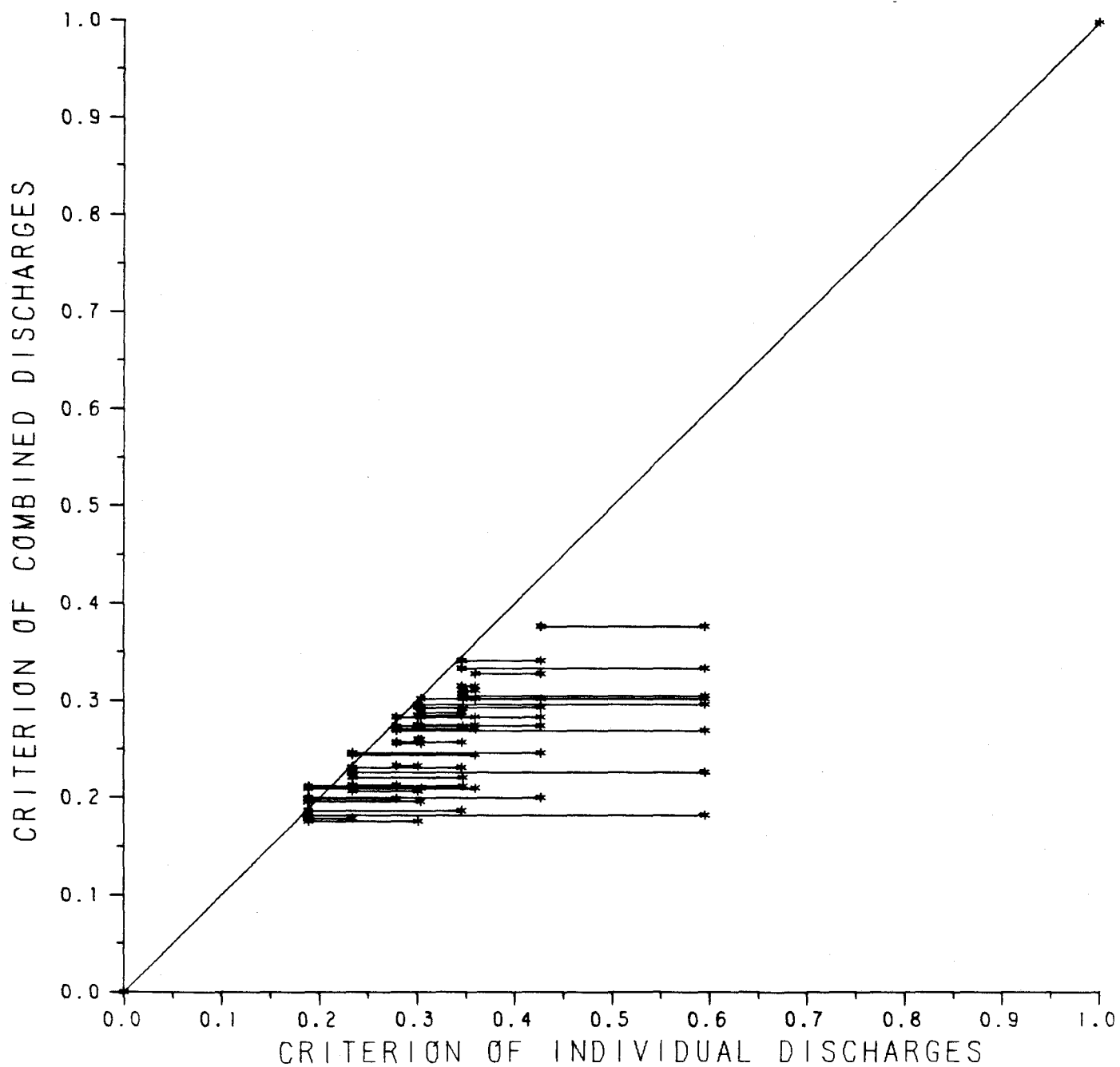


FIGURE 4. Combinations of pairs of simulated discharges. Values of criterion A for individual and combined discharges. W3 River, verification period, complete year.

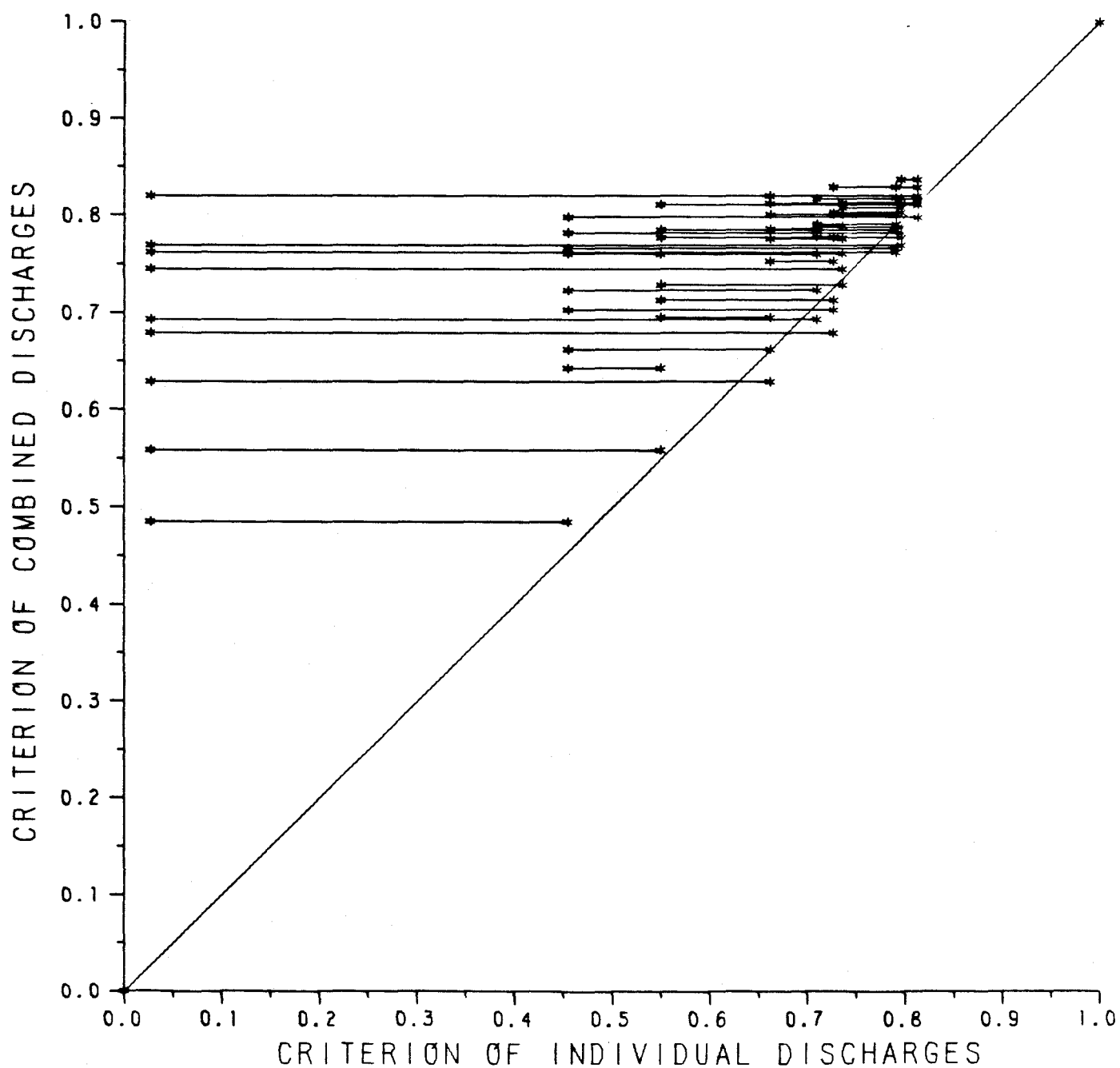


FIGURE 5. Combinations of pairs of simulated discharges. Values of criterion NTD for individual and combined discharges. Dunajec River, verification period, complete year.

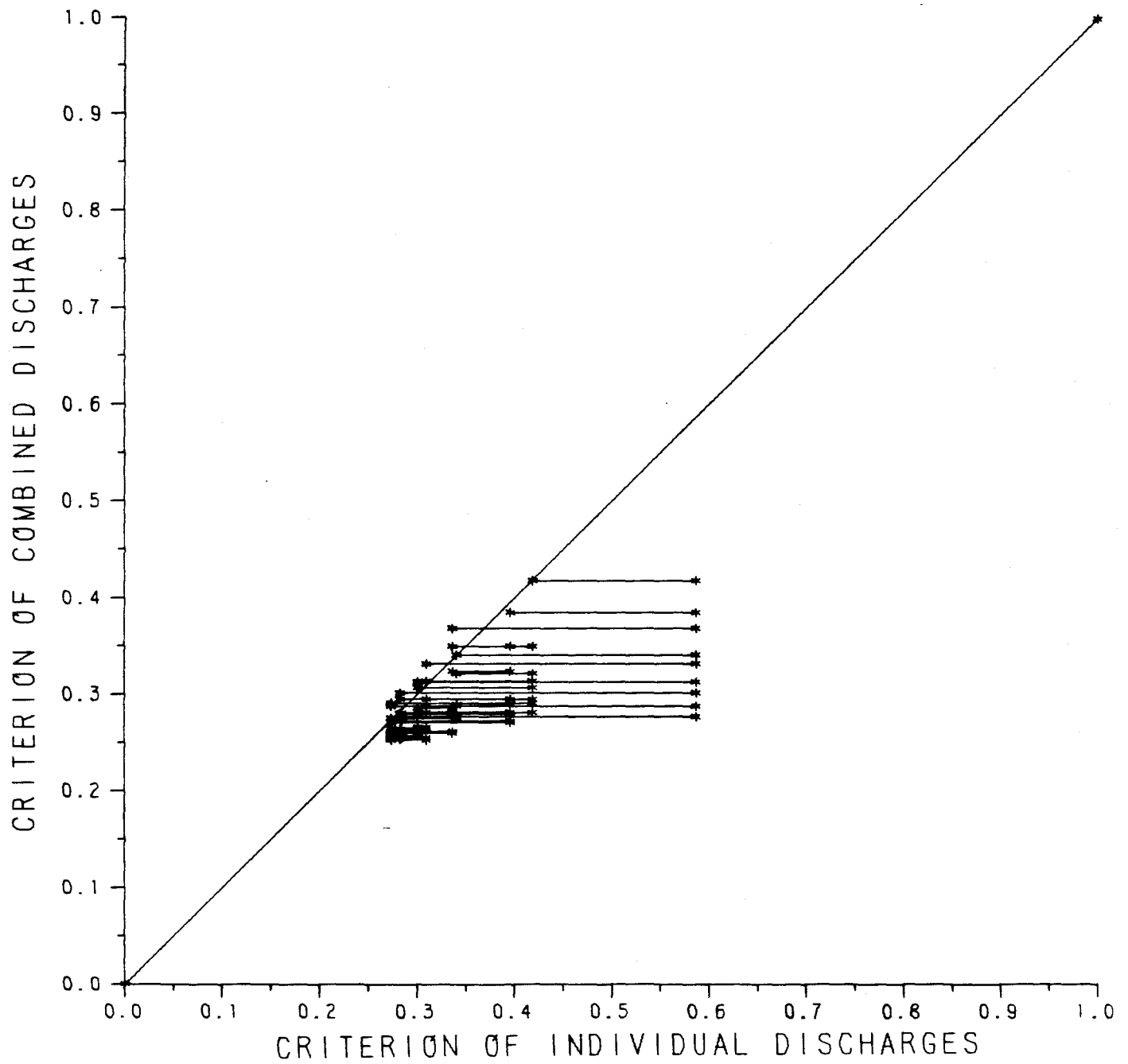


FIGURE 6. Combinations of pairs of simulated discharges. Values of criterion A for individual and combined discharges. Dunajec River, verification period, complete year.

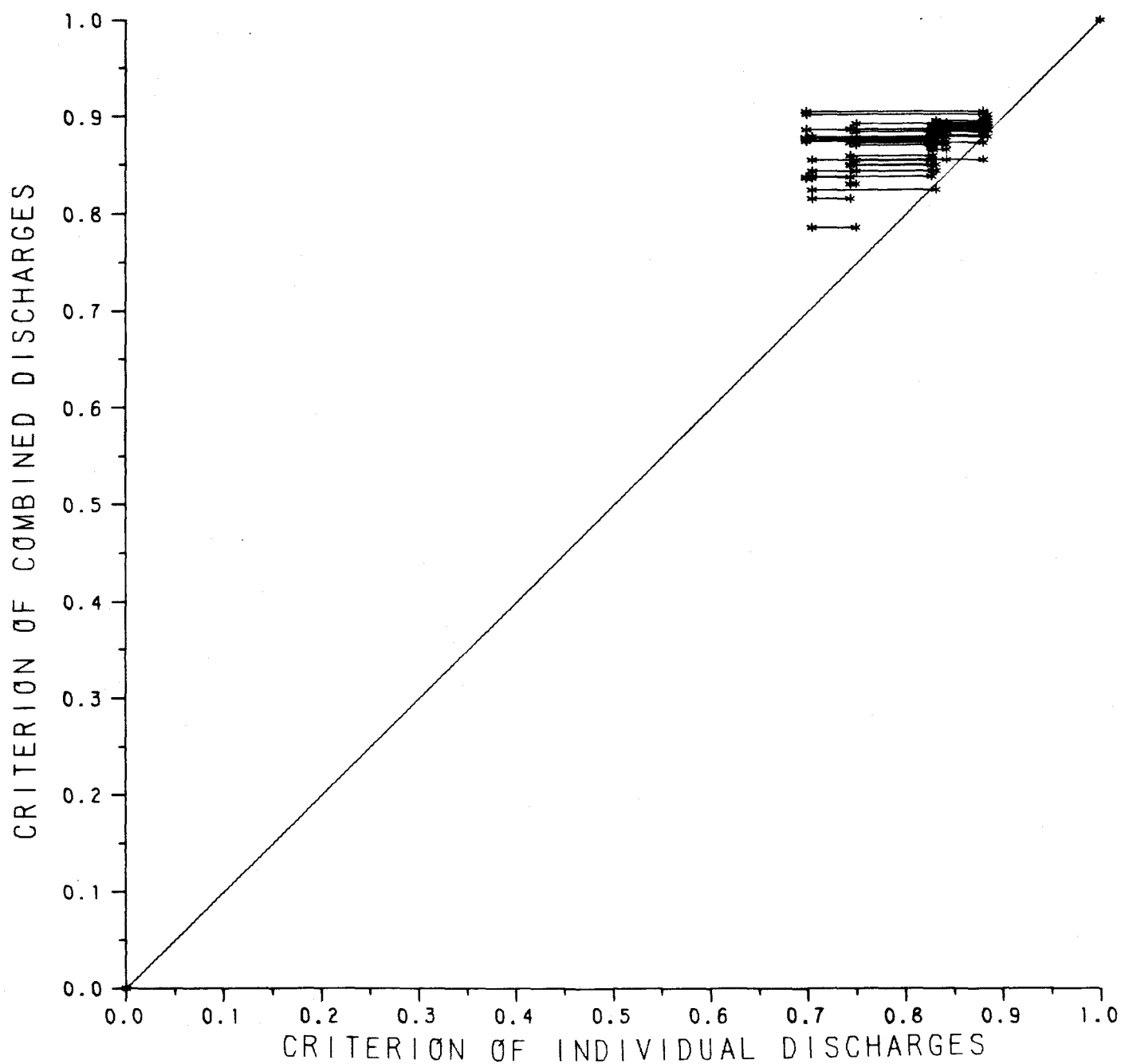


FIGURE 7. Combinations of pairs of simulated discharges. Values of criterion NTD for individual and combined discharges. Dischma River, verification period, complete year.

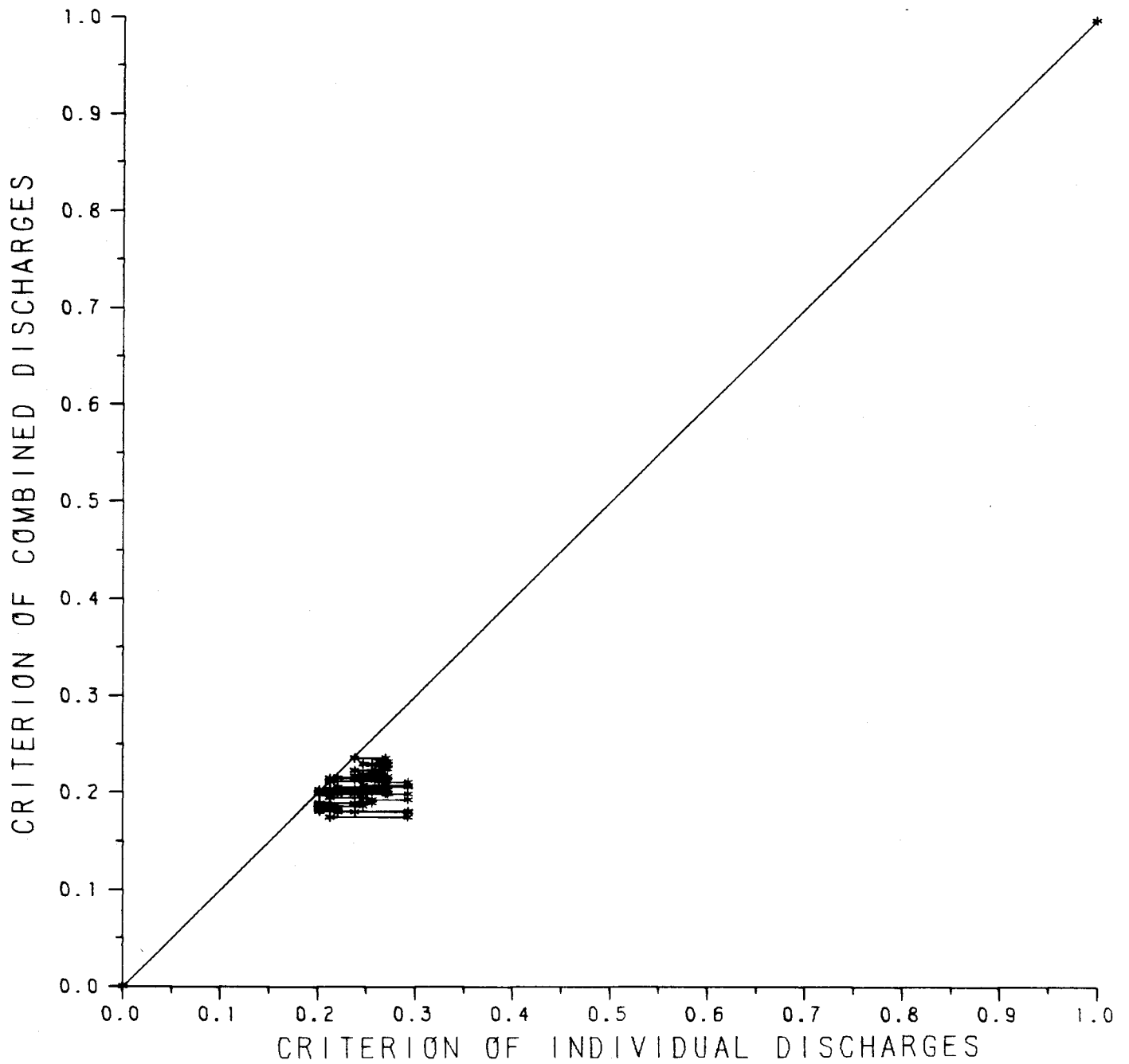


FIGURE 8. Combinations of pairs of simulated discharges. Values of criterion A for individual and combined discharges. Dischma River, verification period, complete year.

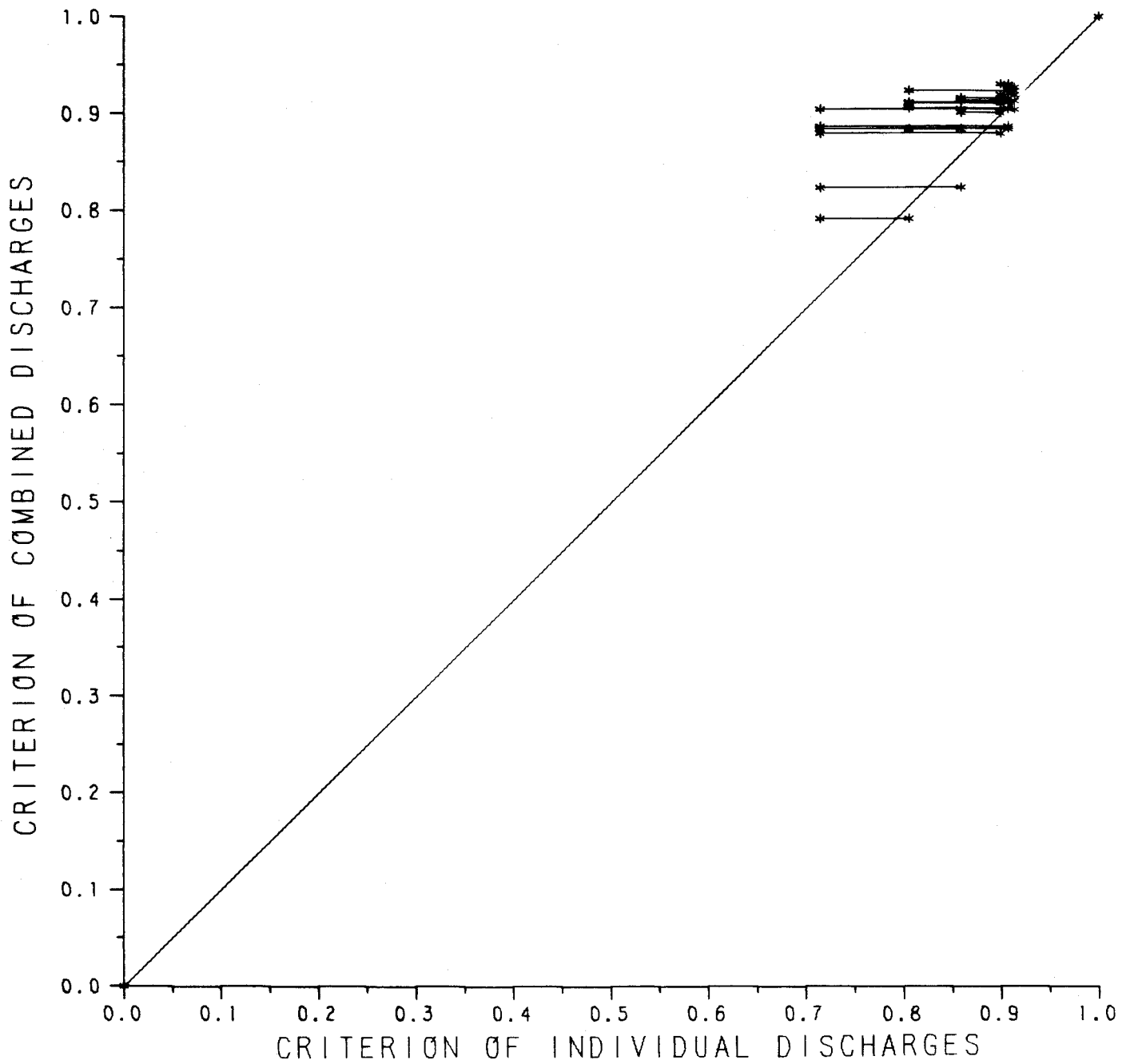


FIGURE 9. Combinations of pairs of simulated discharges. Values of criterion NTD for individual and combined discharges. Illecillewaet River, verification period, complete year.

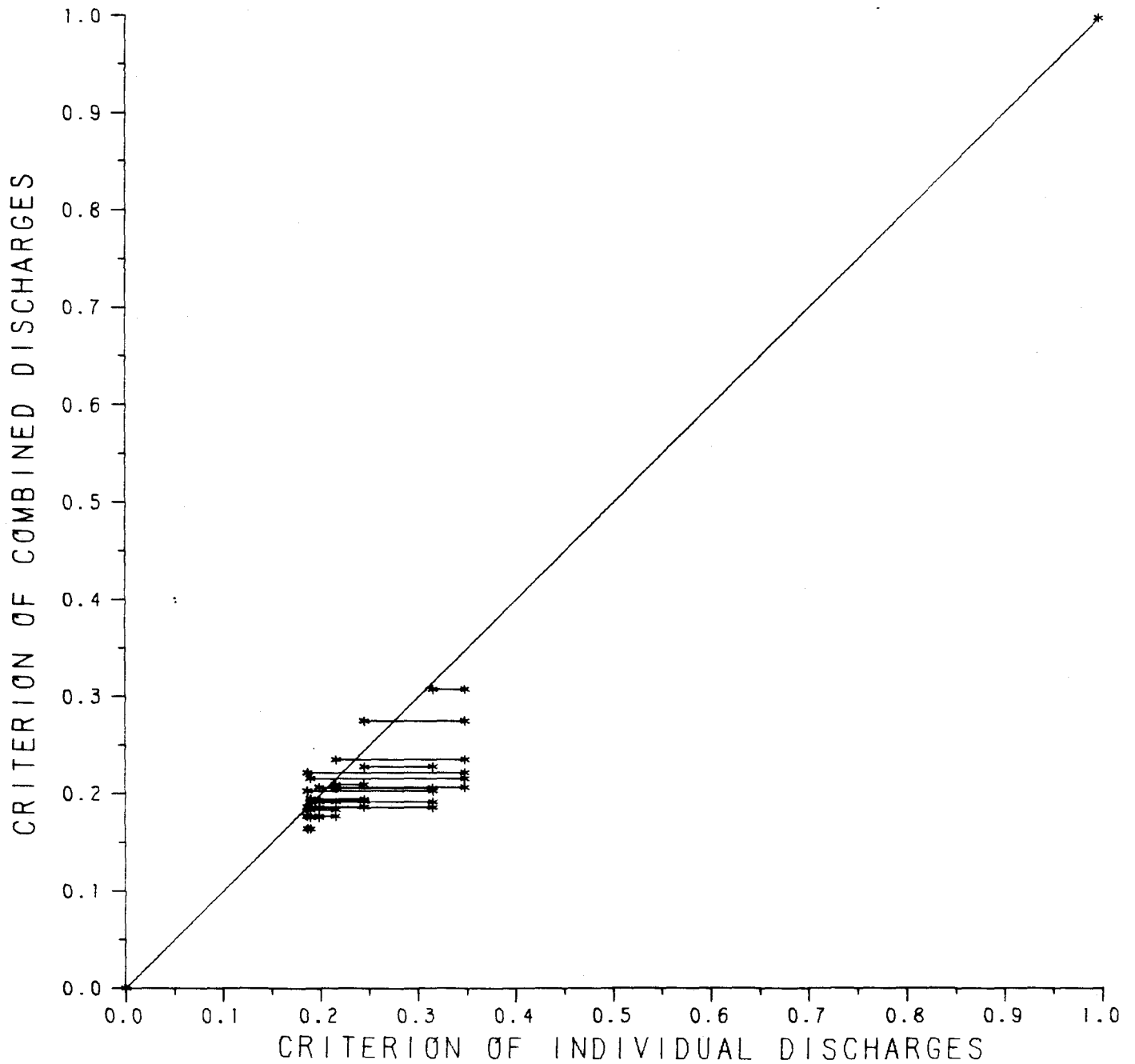


FIGURE 10. Combinations of pairs of simulated discharges. Values of criterion A for individual and combined discharges. Illecillewaet River, verification period, complete year.

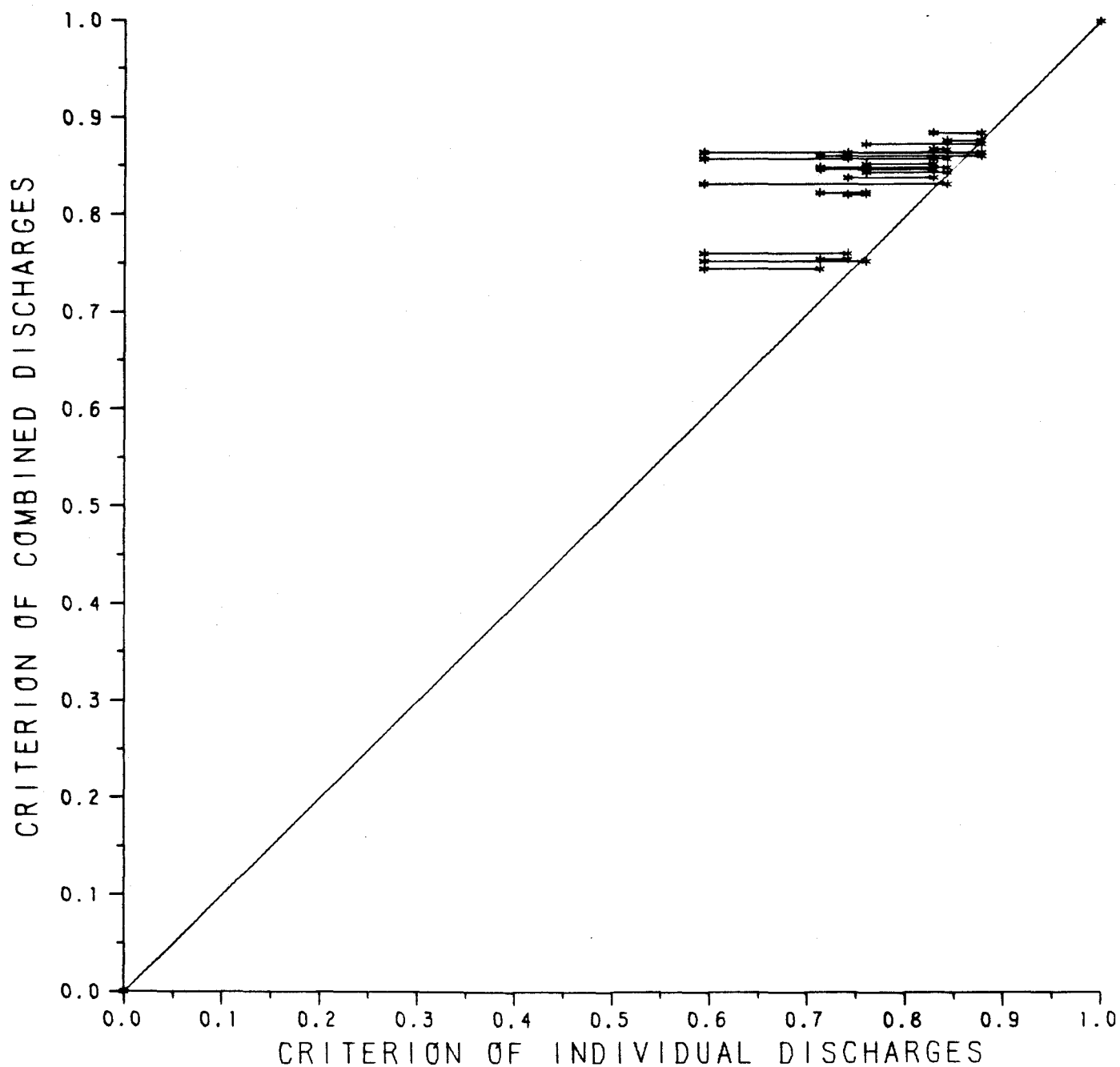


FIGURE 11. Combinations of pairs of simulated discharges. Values of criterion NTD for individual and combined discharges. Kultsjon River, verification period, complete year.

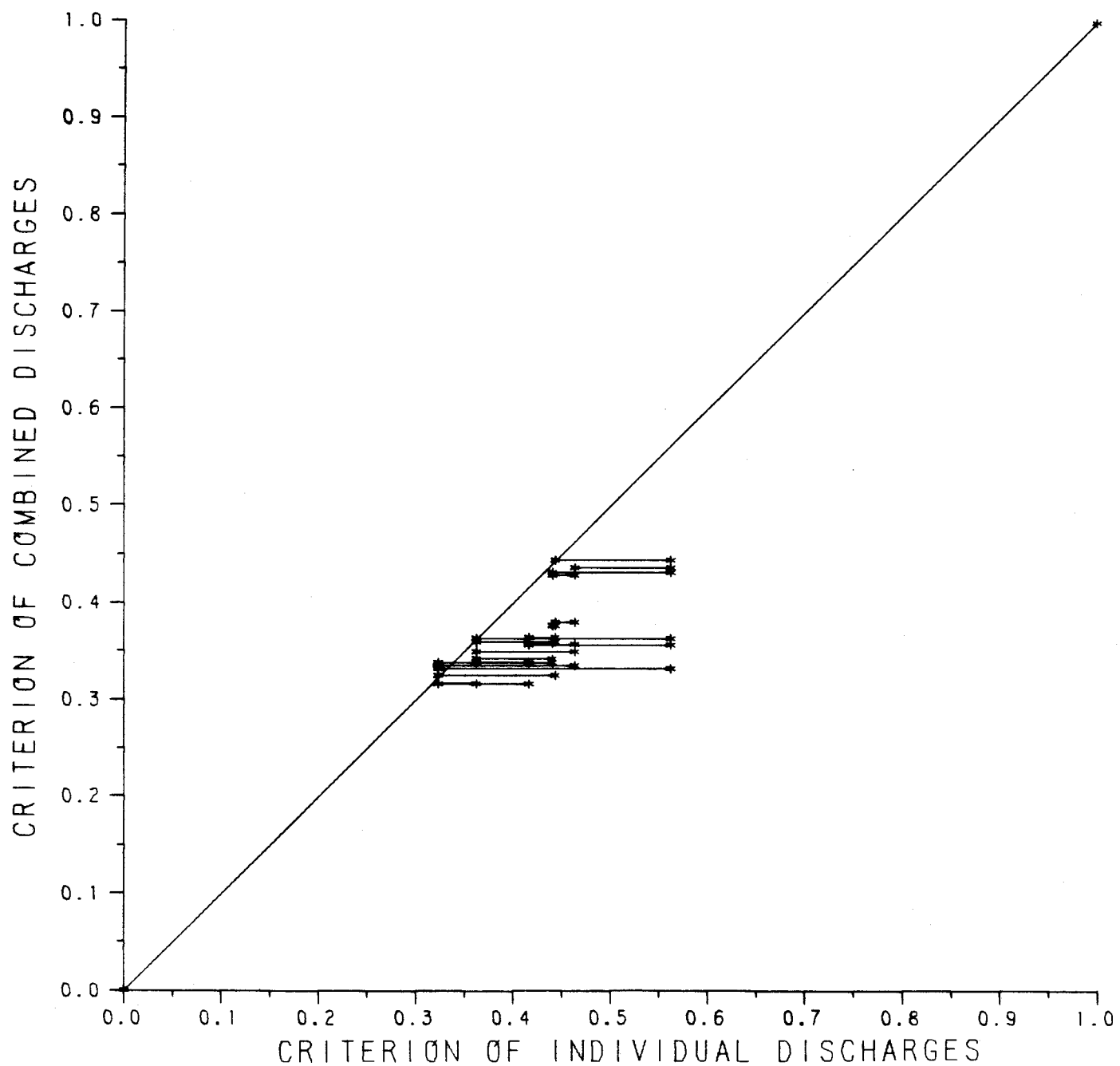
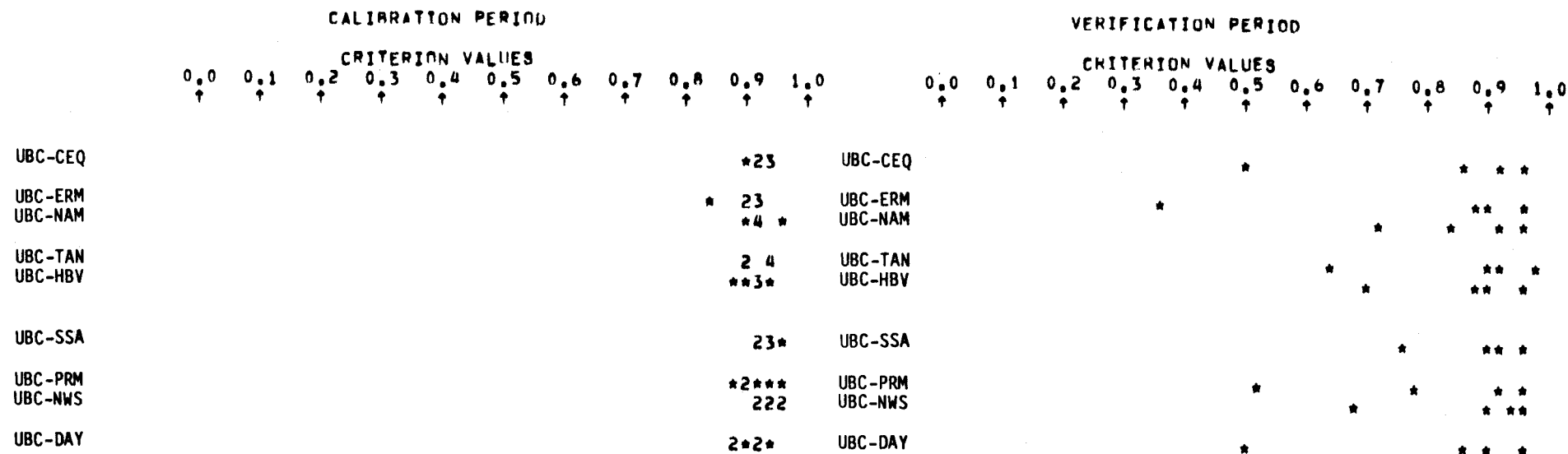


FIGURE 12. Combinations of pairs of simulated discharges. Values of criterion A for individual and combined discharges. Kultsjon River, verification period, complete year.



SNOWMELT SEASON

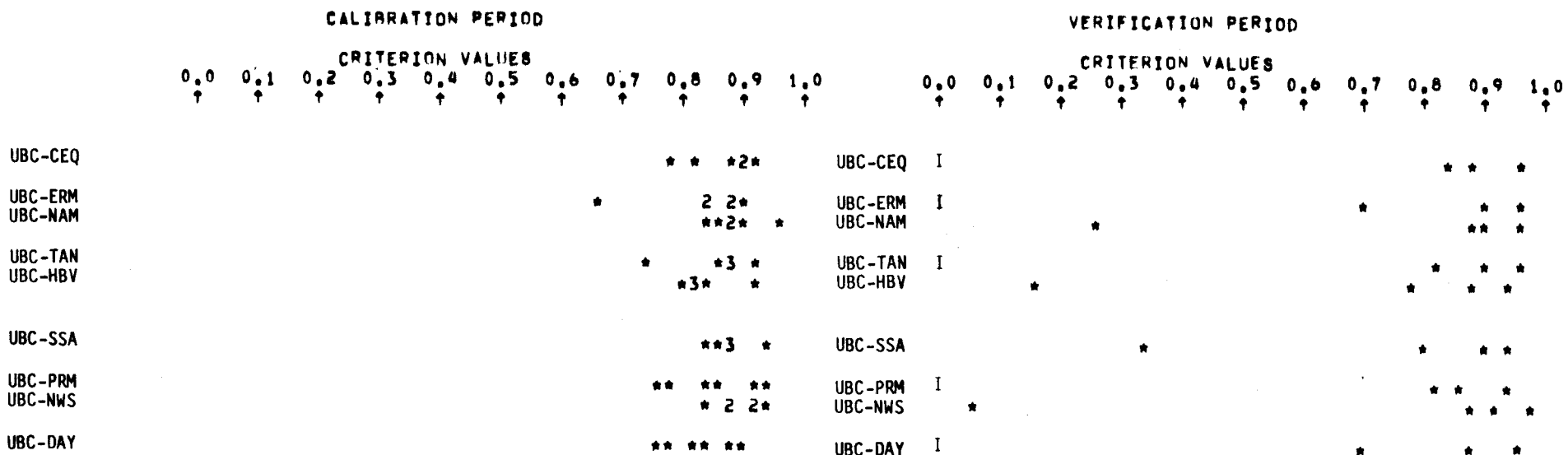


FIGURE 14. Annual criterion NTD values for two weighted simulated discharges. Durance River, complete year.

* : annual criterion values; digit : number of equal annual values; I : annual criterion values less than zero.



FIGURE 15. 95% confidence intervals based on Jackknife statistic for criterion NTD. Durance River. Complete year.

CALIBRATION PERIOD									
ERM	DAY	PRM	CEO	HBV	TAN	NAM	SSA	URC	NWS
NWS					*	*	*	*	0
URC					*	*	*	0	
SSA					*	*	0		
NAM				*	*	0			
TAN			*	*	0				
HBV	*	*	*	0					
CEO	*	*	*	0					
PRM	*	*	0						
DAY	*	0							
ERM	0								

VERIFICATION PERIOD										
DAY	ERM	PRM	NAM	SRM	URC	SSA	CEO	TAN	HBV	NWS
NWS										0
HBV			*	*	*	*	*	*	0	
TAN			*	*	*	*	*	0		
CEO			*	*	*	*	0			
SSA			*	*	*	0				
URC		*	*	*	0					
SRM			*	0						
NAM			0							
PRM	*	*	0							
ERM	*	0								
DAY	0									

CALIBRATION PERIOD									
DAY	ERM	PRM	HBV	CEO	SSA	TAN	URC	NWS	NAM
NAM					*	*	*	*	0
NWS					*	*	*	0	
URC					*	*	0		
TAN			*	*	0				
SSA					0				
CEO	*	*	*	*	0				
HBV	*	*	*	0					
PRM	*	*	0						
ERM	*	0							
DAY	0								

VERIFICATION PERIOD										
DAY	ERM	PRM	SSA	UBC	TAN	SRM	HRV	CEO	NAM	NWS
NWS						*	*	*	*	0
NAM						*	*	*	0	
CEO					*	*	*	0		
HRV			*	*	*	*	0			
SRM		*	*	*	*	0				
TAN		*	*	*	0					
UBC		*	*	0						
SSA		*	0							
PRM		0								
ERM	*	0								
DAY	0									

FIGURE 16. Model groups based on confidence intervals calculated by Jackknife statistic for criterion NTD. Durance River. Complete year.

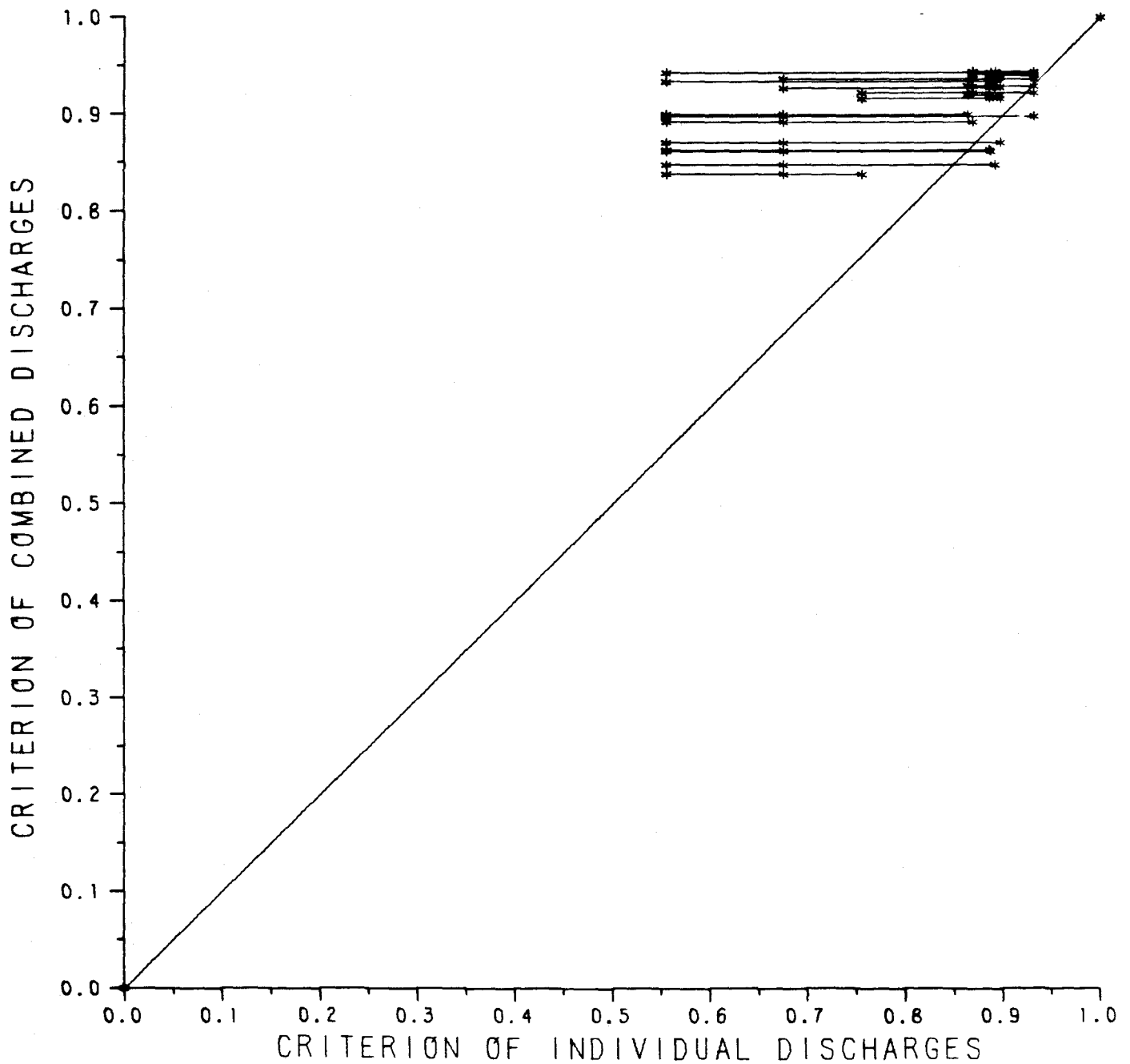


FIGURE 17. Combinations of three simulated discharges. Values of criterion NTD for individual and combined discharges. Durance River, verification period, complete year.

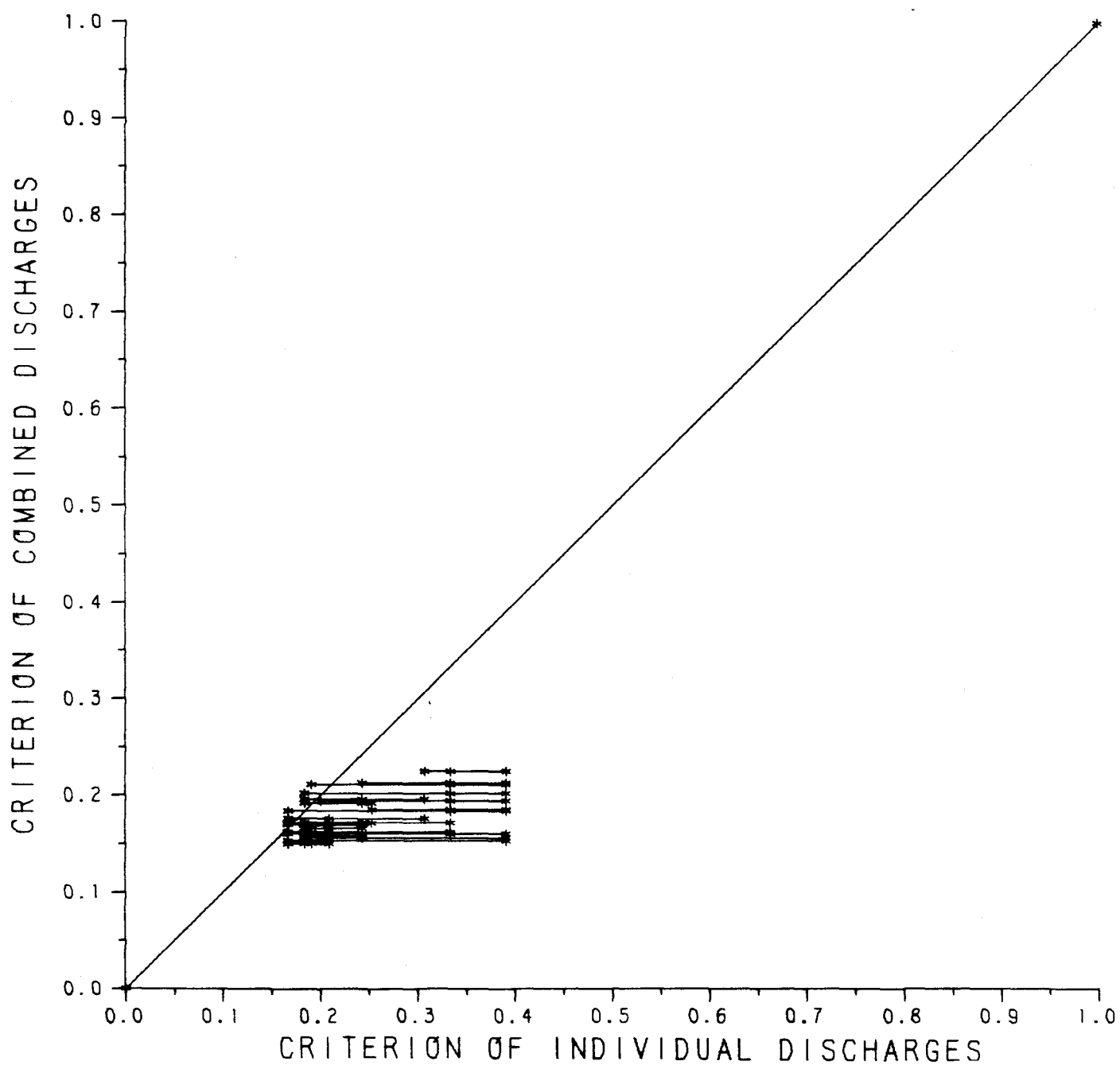


FIGURE 18. Combinations of three simulated discharges. Values of criterion A for individual and combined discharges. Durance River, verification period, complete year.