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Low flow regionalization by regression and hybrid methods

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INTRODUCTION

- ***Low Flow***

Knowledge of the magnitude of low flow events is required in order to drought management.

The 7-day, 10-year low flow ($Q_{7,10}$) is a commonly used low flow statistic. The ($Q_{7,10}$) is the average annual 7-day minimum flow that is expected to be average every 10 years.

...INTRODUCTION

In this study frequency of the 7-day annual low flow is specified and developed regional regression equations to estimate the low-flow frequency at ungaged sites.

...MATERIAL & METHODS

- ***Low flow models***

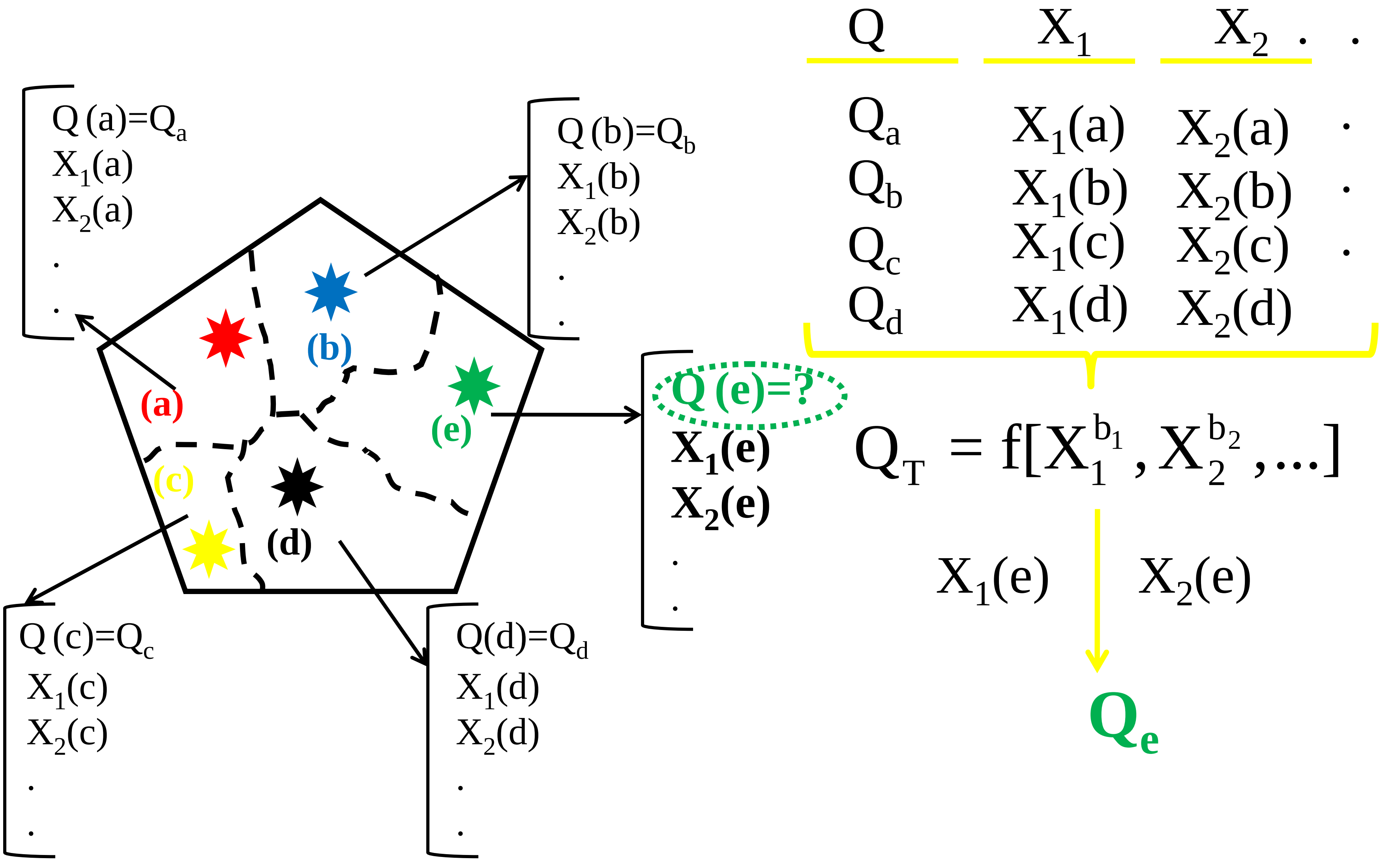
- Regression method

- Low flow index

- Regionalizing the frequency formula parameters

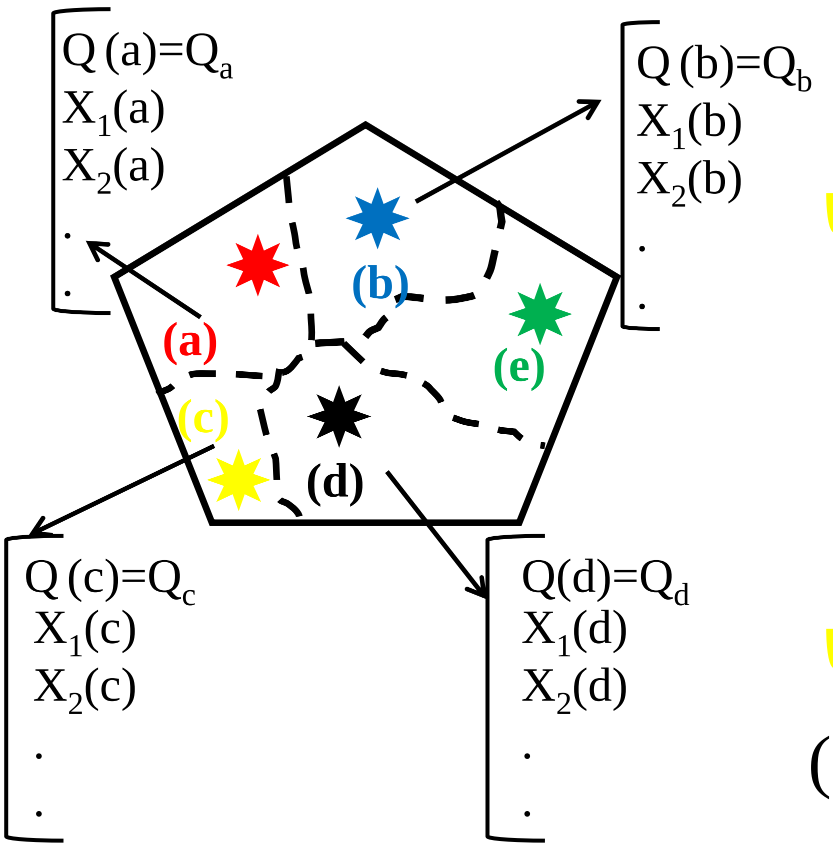
...MATERIAL & METHODS

- Regression method



...MATERIAL & METHODS

Select the best regression model



Q	X_1	X_2	X_3	. .
Q_a	$X_1(a)$	$X_2(a)$	$X_3(a)$	.
Q_b	$X_1(b)$	$X_2(b)$	$X_3(b)$	.
Q_c	$X_1(c)$	$X_2(c)$	$X_3(c)$	.
Q_d	$X_1(d)$	$X_2(d)$	$X_3(d)$	

$$Q_1 = f[X_1^{b_1}, X_2^{b_2}, X_3^{b_3}, \ldots]$$

$$Q_2 = f[X_1^{b_1}, X_2^{b_2}, \ldots]$$

$$Q_3 = f[X_1^{b_1}, X_3^{b_2}, \ldots]$$

.

.

e_i

$$(e_i = Q_i - \hat{Q}_i)$$

$VIF_i > 5$

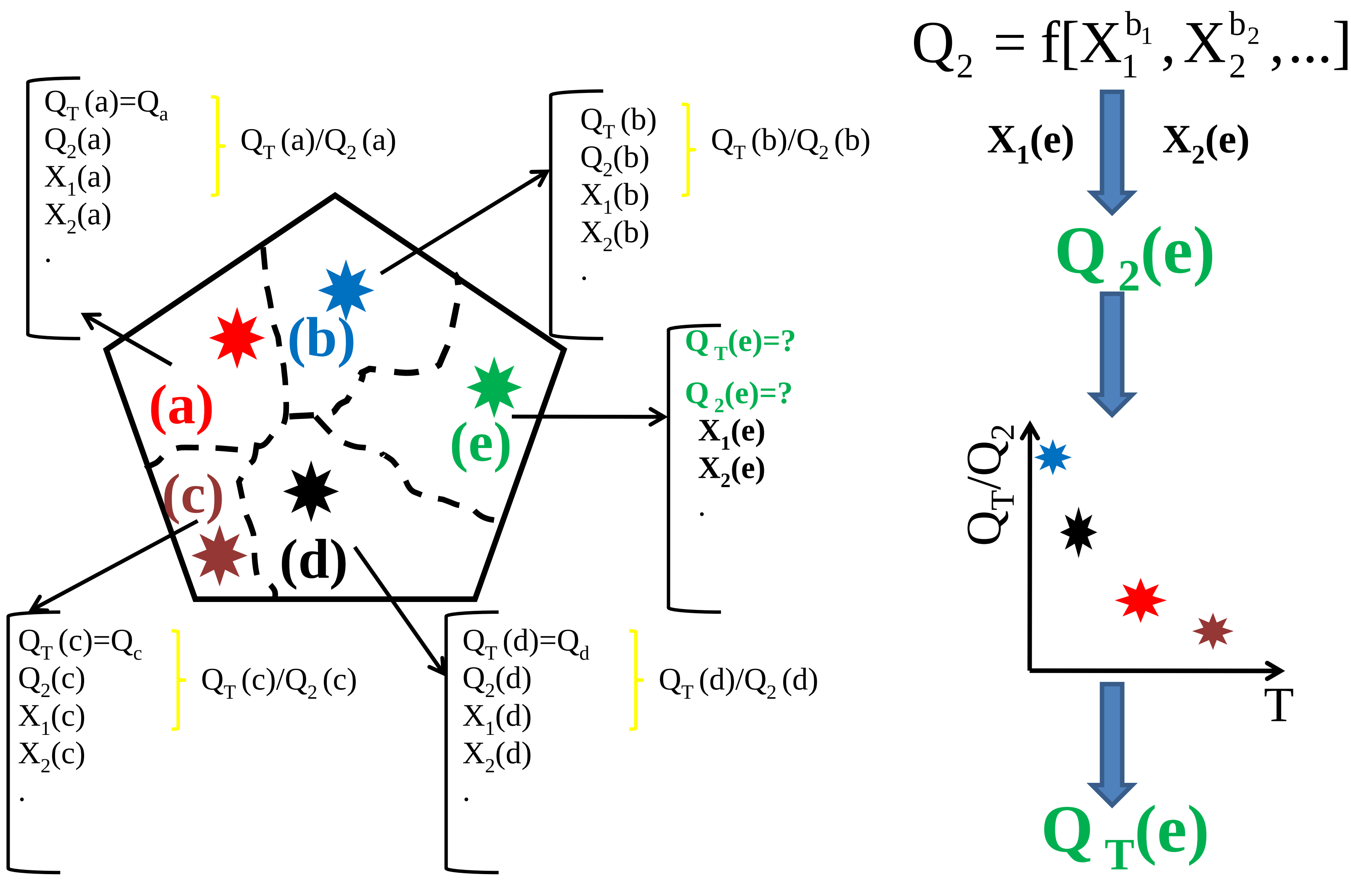
$$(VIF_j = \frac{1}{1 - R_j^2})$$

(R_j is the multiple correlation coefficient)

Q_i

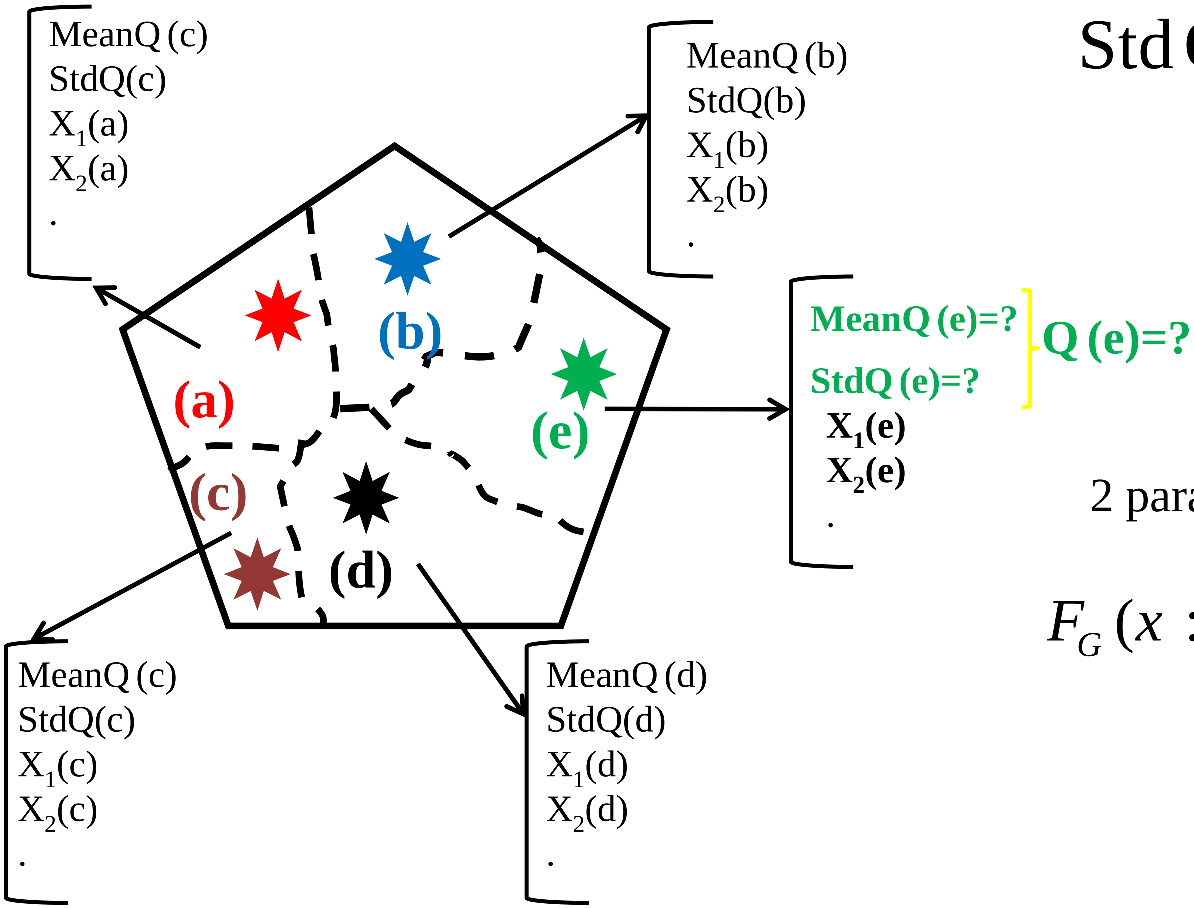
...MATERIAL & METHODS

- Low flow index method



...MATERIAL & METHODS

- Regionalizing the frequency formula parameters method



$$\text{Mean Q} = f[X_1^{b_1}, X_2^{b_2}, \ldots]$$

$$\text{Std Q} = f[X_1^{b_1}, X_2^{b_2}, \ldots]$$

MeanQ (e)

StdQ (e)

2 parameters gamma distribution

$$F_G(x : \alpha, \beta) = \int_0^{\infty} \frac{\alpha^{\beta} t^{\beta} e^{-\alpha} t}{t\Gamma(\beta)} dt$$

Q_T(e)

...MATERIAL & METHODS

-Hybrid method

1)The study area divide into some homogeneity classes

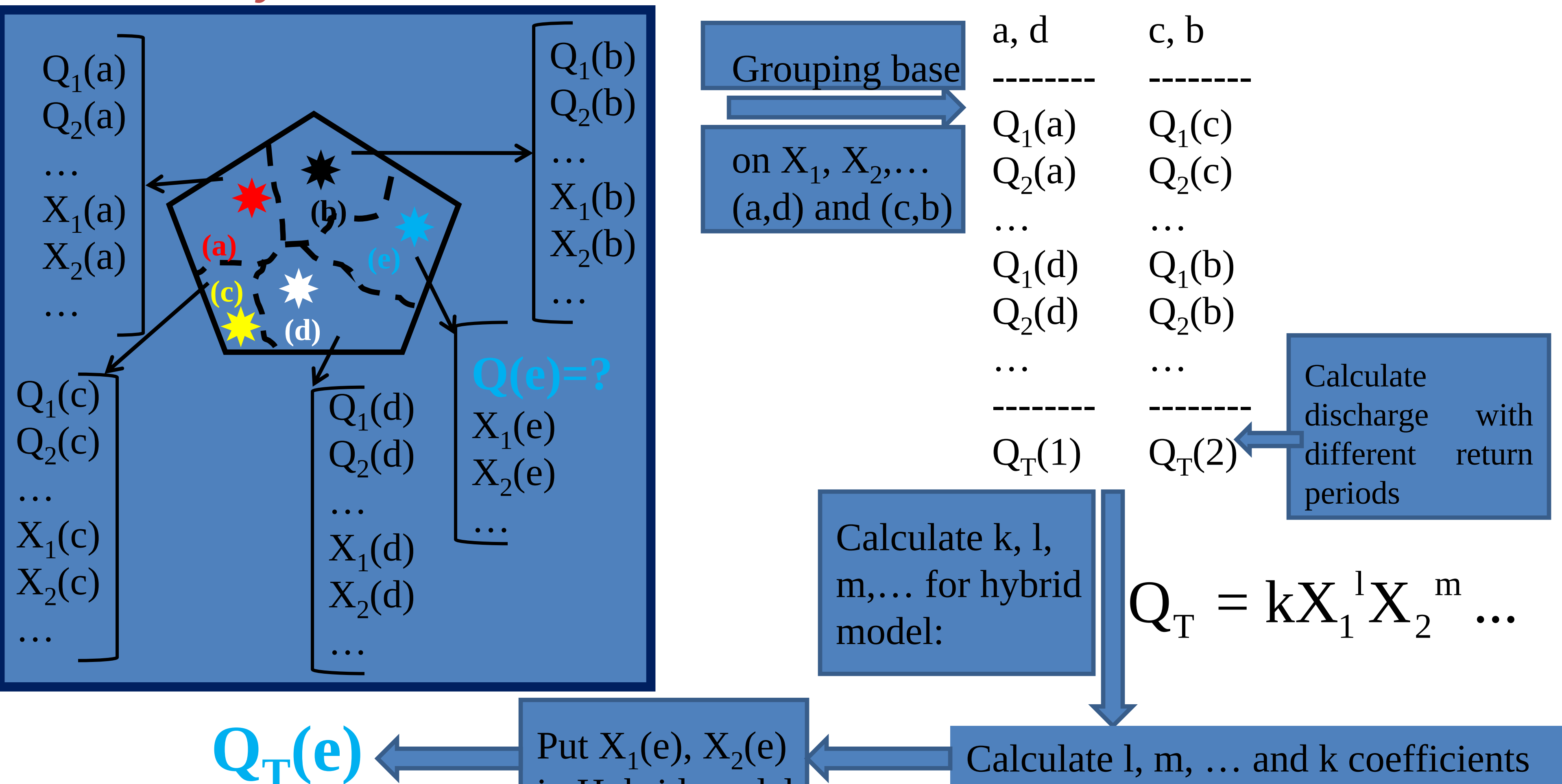
2)The parameters of Hybrid equation have been calculated:

$$Q_T = kX_1^l X_2^m \ldots$$

Q_T is discharge with T-year return period, X_1 and X_2 are independent hydrologic parameters and k is the constant component and l and m,... are the coefficients of the regression model.

...MATERIAL & METHODS

...Hybrid method

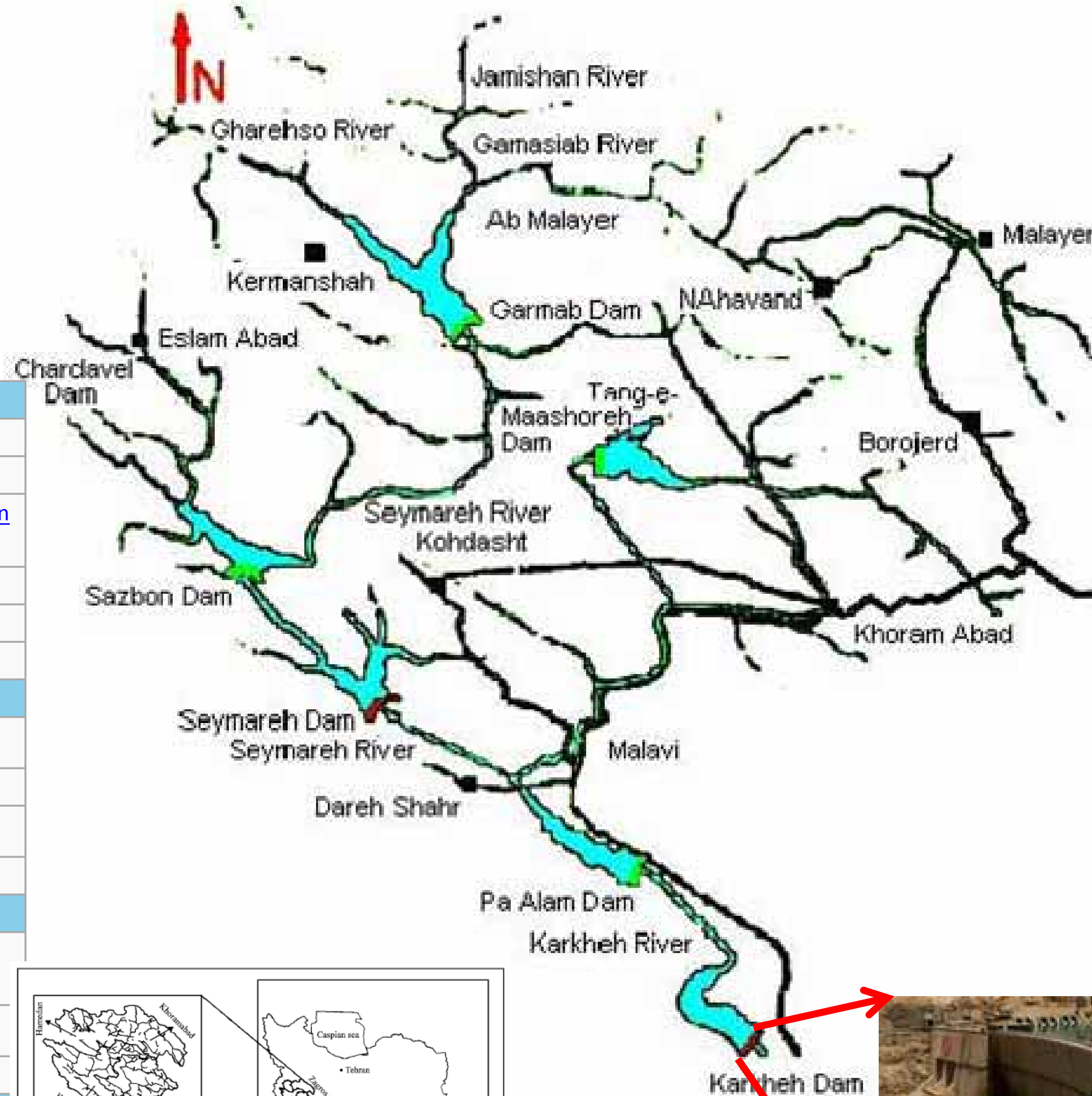


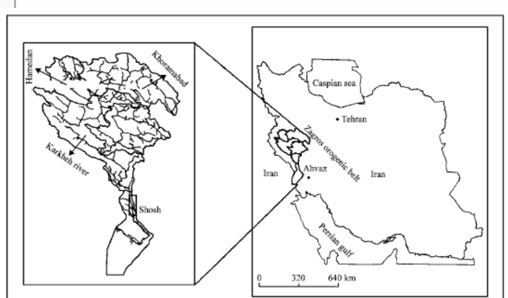
$$l_T = \frac{\sum_{i=1} \bar{A}_i Q_{Ti} - \frac{\left[\sum_{i=1}^{f} \bar{A}_i \sum_{i=1}^{f} Q_{Ti}\right]}{f}}{\sum_{i=1}^{f} \bar{A}_i^2 - \frac{\left[\sum_{i=1}^{f} \bar{A}_i\right]^2}{f}}$$

...MATERIAL & METHODS

Study area

Karkheh Dam	
Official name	Karkheh Dam
Location	Khūzestān-Iran
Coordinates	32°29′21″N48°07′36″ECoordinates: 32°29′21″N 48°07′36″E
Construction began	1992
Opening date	2001
Construction cost	$700 million
Dam and spillways	
Height	127m from foundation
Length	3030 m
Base width	1100 m (12m at crest)
Impounds	Karkheh River
Reservoir	
Capacity	5,900,000,000 m^3 (4,800,000 acre·ft)
Catchment area	42,000 km^2 (16,000 sq mi)
Surface area	162 km²
Power station	
Turbines	3
Installed capacity	420 MW (3x140 MW)[1]
Annual generation	934 GWh





RESULTS AND DISCUSSION

- ***Low flow models***

-Multivariate regression

1) 7-day low flows with different return periods (5, 10, 20, 25, 50 and 100 years) used

2) The most important physiographic characteristics that are effective on the low flow estimates have been selected.

...RESULTS AND DISCUSSION

3) Estimated regression models are as follows:

$$Q_5 = 10^{-0.44\,BR - 5.01\times10^{-4}\,E + 1.38\times10^{-4}\,A + 0.54}$$

$$Q_{10} = 10^{-0.46\,BR - 5.44\times10^{-4}\,E + 1.41\times10^{-4}\,A + 0.45}$$

$$Q_{20} = 10^{-0.48\,BR - 5.94\times10^{-4}\,E + 1.411\times10^{-4}\,A + 0.39}$$

$$Q_{25} = 2.54\times10^{-4}\,A + 0.12\,S - 1.77$$

$$Q_{50} = 2.21\times10^{-4}\,A + 0.11\,S - 1.59$$

$$Q_{100} = 1.95\times10^{-4}\,A + 0.10\,S - 1.44$$

A: Area (km^2), S: Slope (%), BR: Bifurcation Ratio (the ratio of the number of streams of any given order to the number of streams in next higher order (Schumn, 1956)), E: Elevation (m) and Q_T 7-day low flow with different return periods for a specific basin

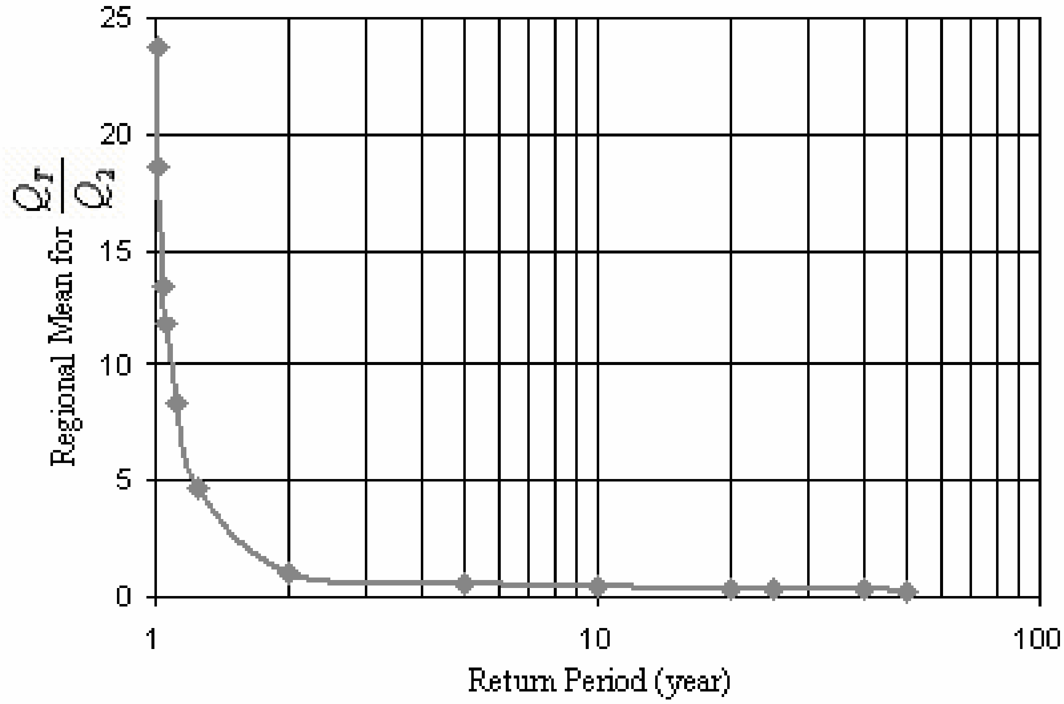
...RESULTS AND DISCUSSION

- Low flow index method

1) $Q_2 = 10^{-0.41BR-3.65\times10^{-1}E+1.38\times10^{-4}A+0.63}$

A: Area (km²), BR: Bifurcation Ratio, E: Elevation (m) and Q_2 7-day low flow with 2-year return period

2) regional frequency curve



3) calculate Q_T for a specific basin

...RESULTS AND DISCUSSION

- Regionalizing the frequency formula parameters method

1) The relation between average and standard deviation of 7-day low flows and characteristics of the basin are:

$$\text{Mean}(Q) = 10^{1.44\times10^{-4}\,A - 2.68\,\text{LogBR} - 2.8\times10^{-4}\,E + 0.59}$$

$$\text{Std}(Q) = 10^{6.15\times10^{-3}\,\text{MsL} - 0.26\,\text{LogE} - 0.20\,\text{BR} + 4.62\times10^{-2}}$$

Mean(Q) is the average of 7-day low flows (m^3/s), A is the area of basin (km^2), BR is bifurcation ratio, E is basin elevation (m), MsL is the mainstream length (km) and Std(Q) is the standard deviation of 7-day low flows series.

2) Put Mean(Q) and Std(Q) in cumulative distribution function of 2 parameters gamma distribution for calculating 7-day low flow values with different return periods in a specific basin.

...RESULTS AND DISCUSSION

- Hybrid method

The regional models for estimating low flows by this method are:

$$Q_5 = 4.87\,A^{-0.16}$$

$$Q_{10} = 14.10\,A^{-0.03}S^{-0.81}$$

$$Q_{20} = 2.35\,A^{-0.01}S^{-0.27}$$

$$Q_{25} = 1.77\,A^{-0.01}S^{-0.20}$$

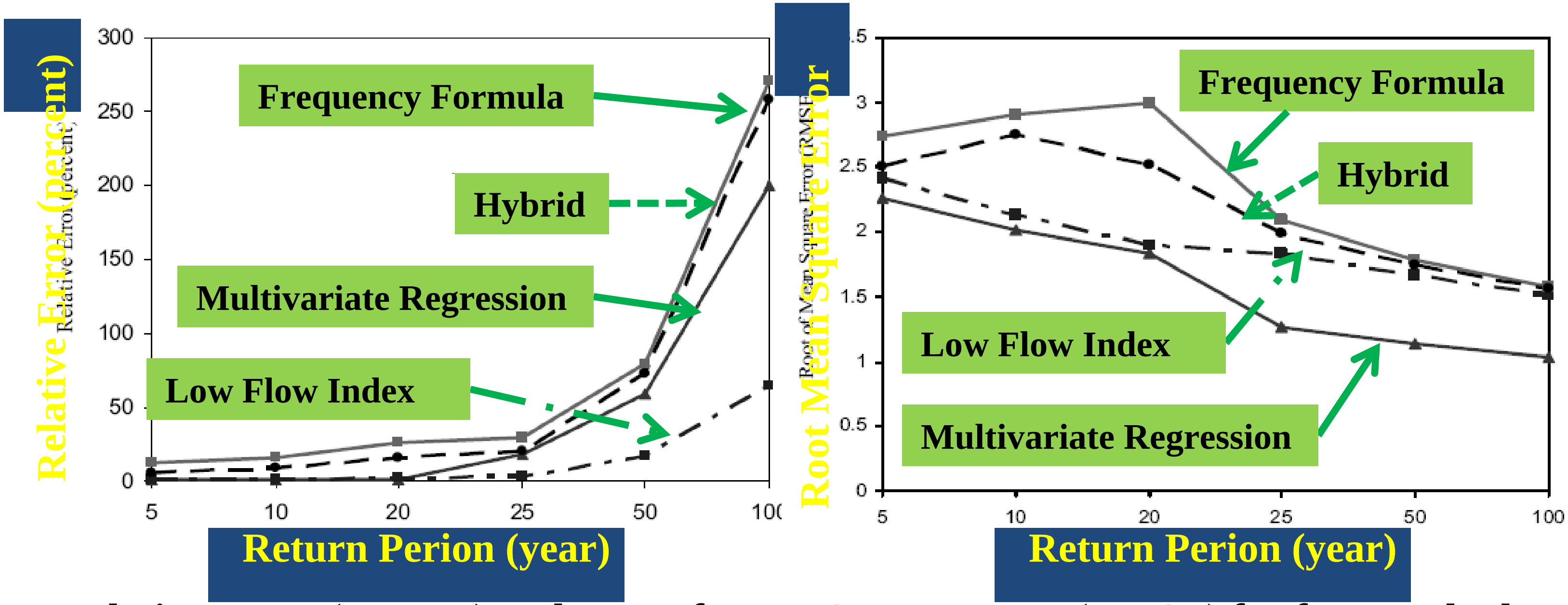
$$Q_{50} = 1.03\,A^{-0.00}S^{-0.06}$$

$$Q_{100} = 0.78\,A^{-0.00}S^{-0.02}$$

A: Area (km^2), S: Slope (%)

...RESULTS AND DISCUSSION

- ***Validation step***



Relative Error (percent) and Root of Mean Square Error (RMSE) for four methods

➢ For all of return periods, the multivariate regression and low flow index methods have more accuracy in comparison with regionalizing the frequency formula parameters and Hybrid methods.

CONCLUSIONS

- Multivariate regression and low flow index methods are more suitable than Hybrid model.

- Using climatic data (for example Precipitation, Temperature and ..., that are important in low flows) instead of physiographic data (Area and Slope) in Hybrid method, maybe have more accuracy for applying this model (it can consider in future researches)

THANKS FOR YOUR ATTENTION

Karkheh Dam