
()
() **Thin Plate Smoothing Splines (TPSS) Weighted Moving Average (WMA)**

MAE) WMA (MAE) TPSS
(
WMA TPSS :

(Email: Mahdavi@nrf.ut.ac.ir)

...

() Tabios.()

() Abtew .

() Nalder & Wein (GIDS)

/ GIDS

() Price .

GIDS TPSS

(Root Mean Square Error) RMSE

GIDS TPSS

()

() Goovaerts

(GIS)

Cross Validation

() Hargrove .

Smooth Tension

Splin

¹ Geostatistics

()
 ()
 ()

HYFA

WMA ,KRIGING , TPSS

SPSS

()

o o / o / o

/	/	/	/	() ()
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()

(+ + + +)

() ()

R*								
/							/	
/								
/								
/								
/				/ /				
/								
/								
/								
/							/	
/								+ +++

:R*

...

h

$$\gamma(h) + C(h) = \sigma^2$$

()
: σ^2
: $\gamma(h)$
: $C(h)$

$$\gamma(h) = \frac{1}{2n(h)} \sum_{i=1}^{n(h)} [z(x_i) - z(x_i + h)]^2$$

()
: $\gamma(h)$
h
: $n(h)$
: $z(x_i)$
 $z(x_i + h)$

Cross-

Validation

x h

$\gamma(h)$

h
h
h

(MAE)

(MBE)

$$MAE = \frac{1}{n} \sum_{i=1}^n |Z^*(x_i) - Z(x_i)|$$

$$MBE = \frac{1}{n} \sum_{i=1}^n (Z^*(x_i) - Z(x_i))$$

()

()
: Z^*
: Z
: n
: MAE
: MBE

(Isotropic)

(Anisotropic)

(C_0)

(R)

(Sill = $C_1 + C_0$)

TPSS

WMA

¹- Mean Absolute Error
² Mean Bias Error

¹- Semi - Variogram

()

$$\sum_{i=1}^n \lambda_i = 1 \quad ()$$

()

()

WMA

$$\lambda_i = \frac{D_i^{-\alpha}}{\sum_{i=1}^n D_i^{-\alpha}}$$

()

$$Z^*(xi) = \sum_{i=1}^n \lambda_i \cdot Z(xi) \quad ()$$

x

: z*(xi)

x

: z(xi)

: Di

: λ i

i

: i

: α

: n

: n

WMA	Weighted Moving Average
WMA -	α* =
WMA -	α =
WMA -	α =
WMA -	α =
WMA -	α =
OK	Ordinary Kriging
OK - LO	
OK - CO	
TPSS	Thin Plate Smoothing Splines
TPSS -	α =
TPSS -	α =
TPSS -	α =
TPSS -	α =
TPSS - CO	α =
TPSS - CO	α =
TPSS - CO	α =
TPSS - CO	α =

= α*

...

$F(x_i, y_j)$: $F''(x)$

: \emptyset

TPSS ()

:()

$C(h) = h^k \log(h)$ ()

OK

$C(0) = \emptyset$

λ

(smoothing) : \emptyset

$m-1 : k$

$K \lambda_i = b$ ()

: m

: h

: K

: b

: λ_i

TPSS

()

TPSS

(+)

(+)

()

()

$$\frac{\sum_{i=1}^n [y_i - F(x_i / y_j)]^2}{n\sigma^2} + \emptyset \int_0^1 F''(x)^2 dx = \text{minimum}$$

: y_i

: $F(x_i, y_j)$

: n

: σ^2

Archive of SID

OK

()		()		
MAE	MBE	MAE	MBE	
/	/	/	/	
		/	/	
/	/	/	/	

(+)

()

(+ + +)

()

()

()

C

()

GIS

C₀

()

(C₀ / Sill)

()

Price

(/)

GIDS TPSS

(Root Mean Square Error) RMSE

GIDS

TPSS

WMA

TPSS

()

Hargrove

Tension

Splin

()

()

Smooth

WMA

WMA

(MAE)

TPSS

/

TPSS

TPSS :

TPSS MAE

TPSS

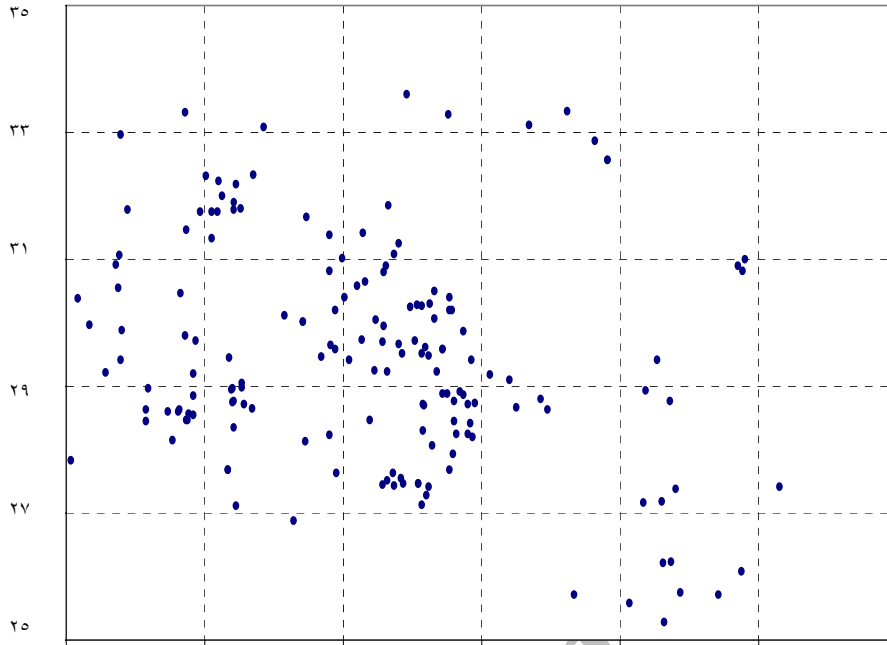
WMA

	C_0 / Sill	R_m	C_1 mm ² or m ²	C_0 mm ² or m ²	
		/			
		/	/	/	
	/	/			
		/	/		
		/			
		/	/	/	
		/	/		
		/	/	/	(+)
		/	/	/	(+)
		/	/		(+)
		/			(+ + +)
		/	/	//	(+ + +)

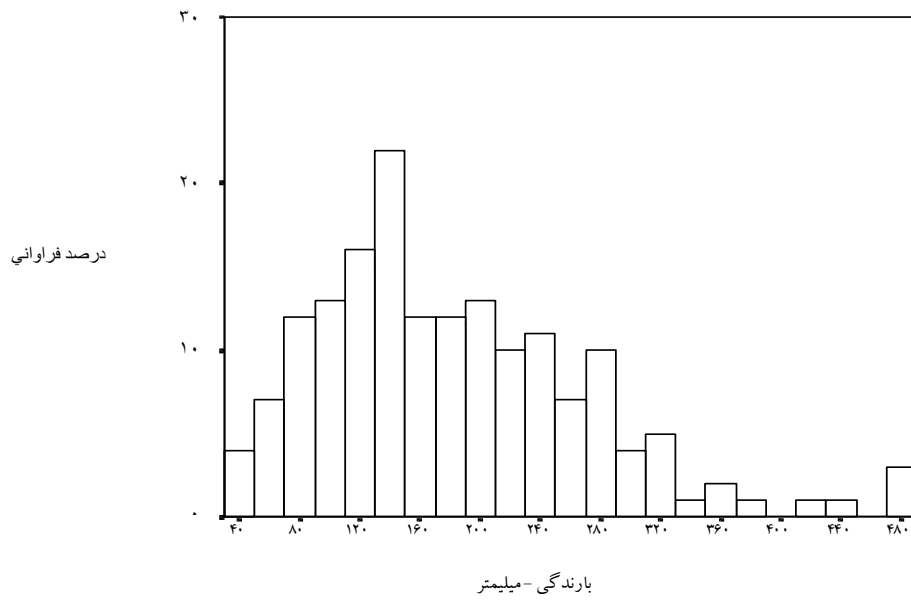
			+++			+					
	/		/	/		/			- /	/	WMA-1
	/		/	/		/	/		- /	/	WMA-2
	/	/	/			/			- /	/	WMA-3
	/	/	/			/	/		- /	/	WMA-4
	/	/	/	/	/	/	/		- /	/	WMA-5
	/	/	/	/	/	/	/		- /	/	OK
	/	/	/	/	/	/	/		- /	/	OK-LOG
	/	/	--	--	--	/	/		/	/	OK-CO
	/	/	- /	/		- /	/		/	/	TPSS-2
	/	/	- /			- /	/		/	/	TPSS-3
	/	/	- /	/		- /	/		/	/	TPSS-4
	/	/	- /	/		- /	/		/	/	TPSS-5
	/	/	--	--	--	-	/		/	/	TPSS-CO2
	/	/	--	--	--	- /	/		/	/	TPSS-CO3
	/	/	--	--	--	- /	/		/	/	TPSS-CO4

	/	/	--	--	--	-/	/	/	/	TPSS-C05
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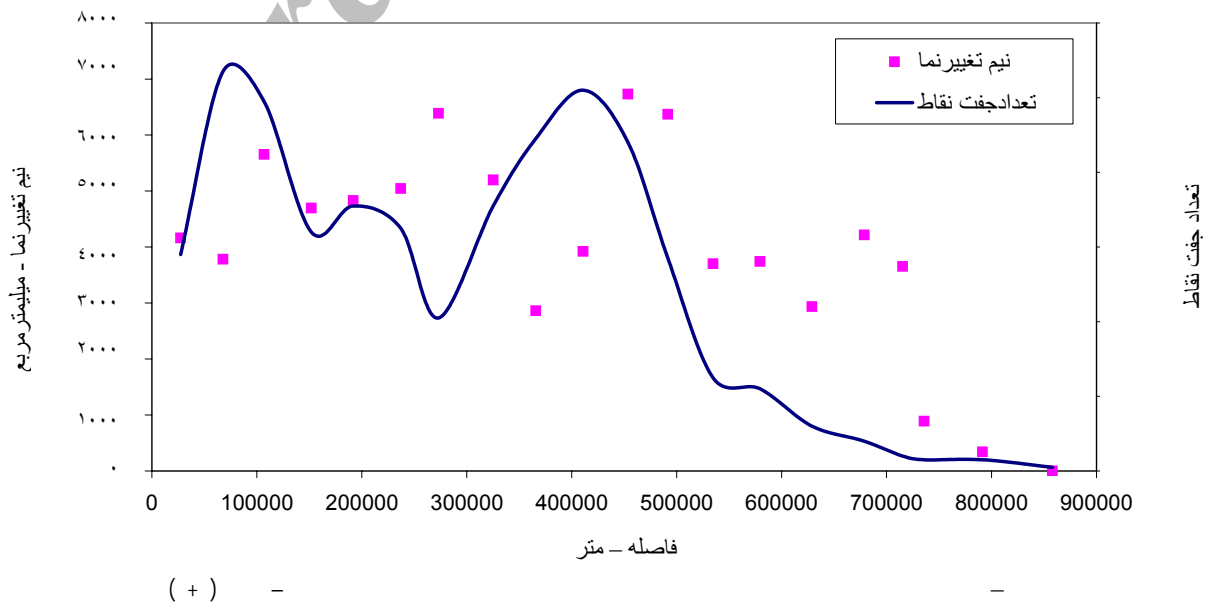
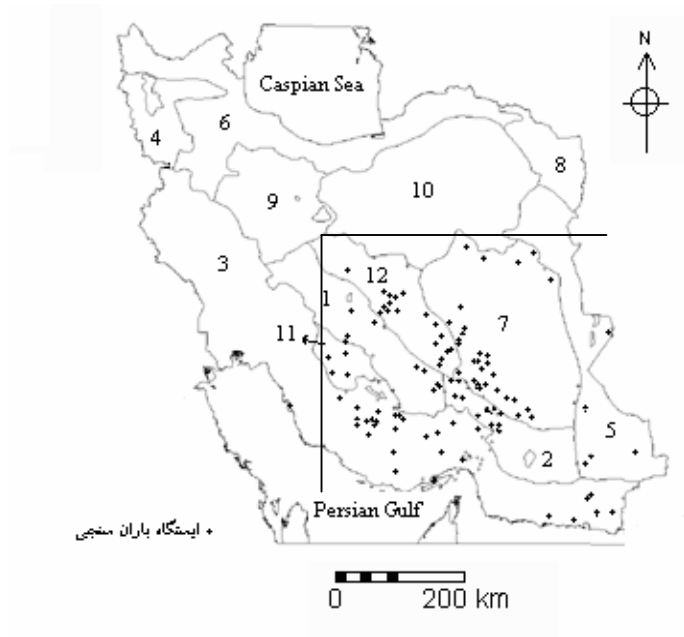
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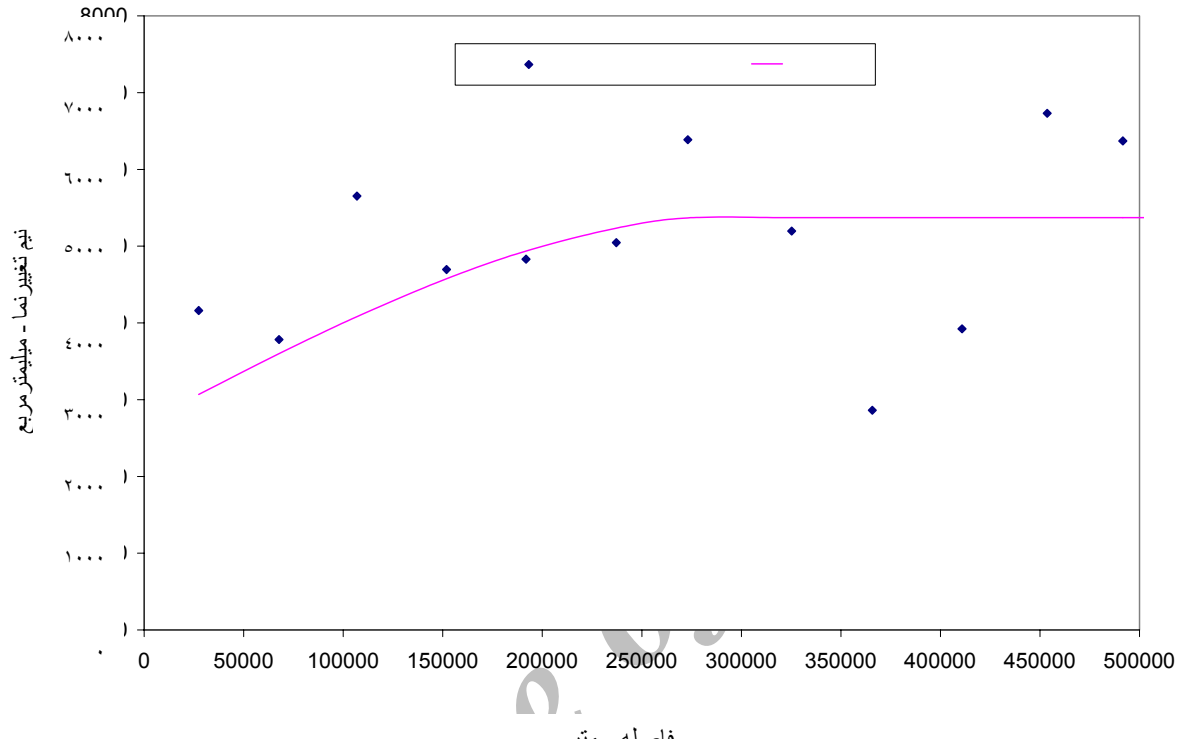
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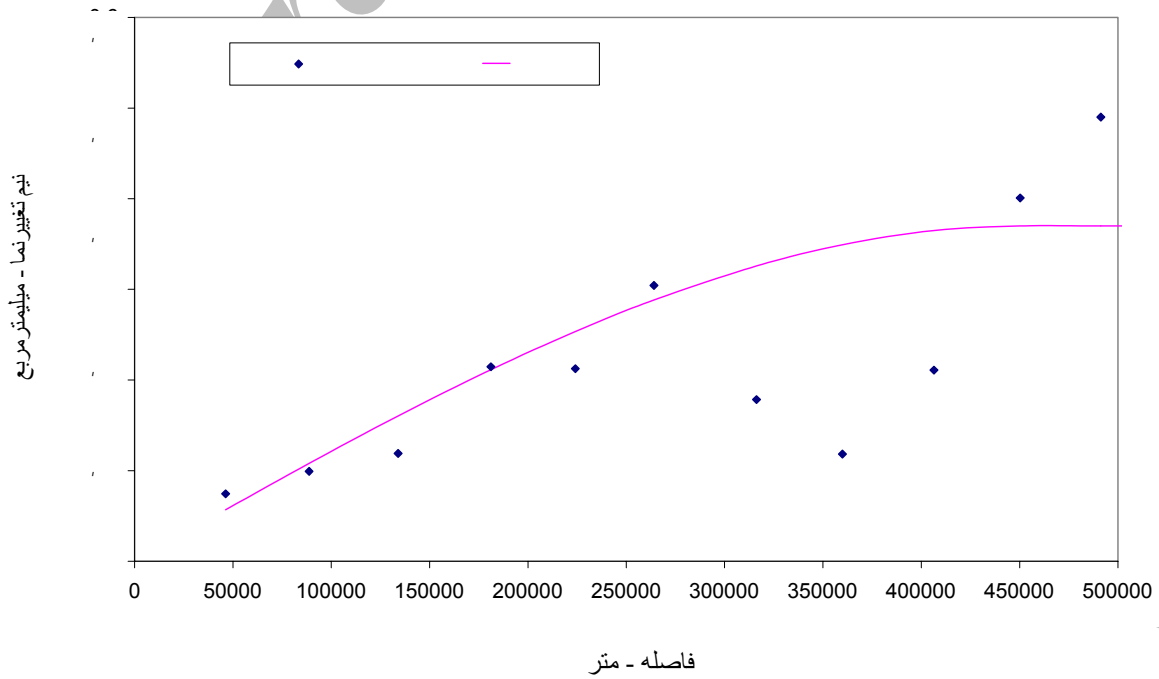
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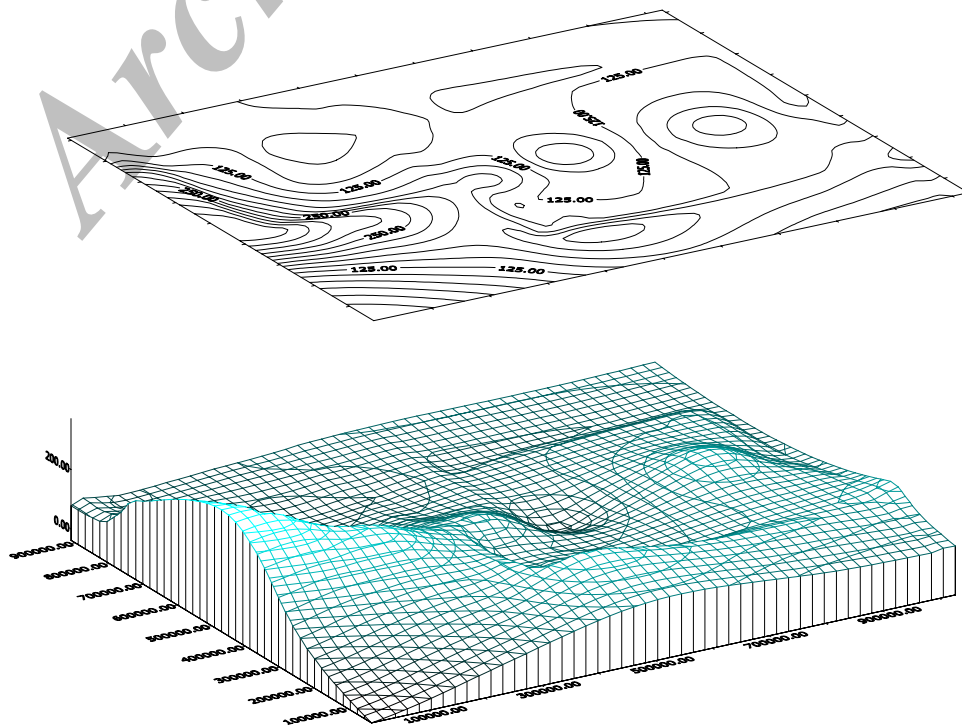
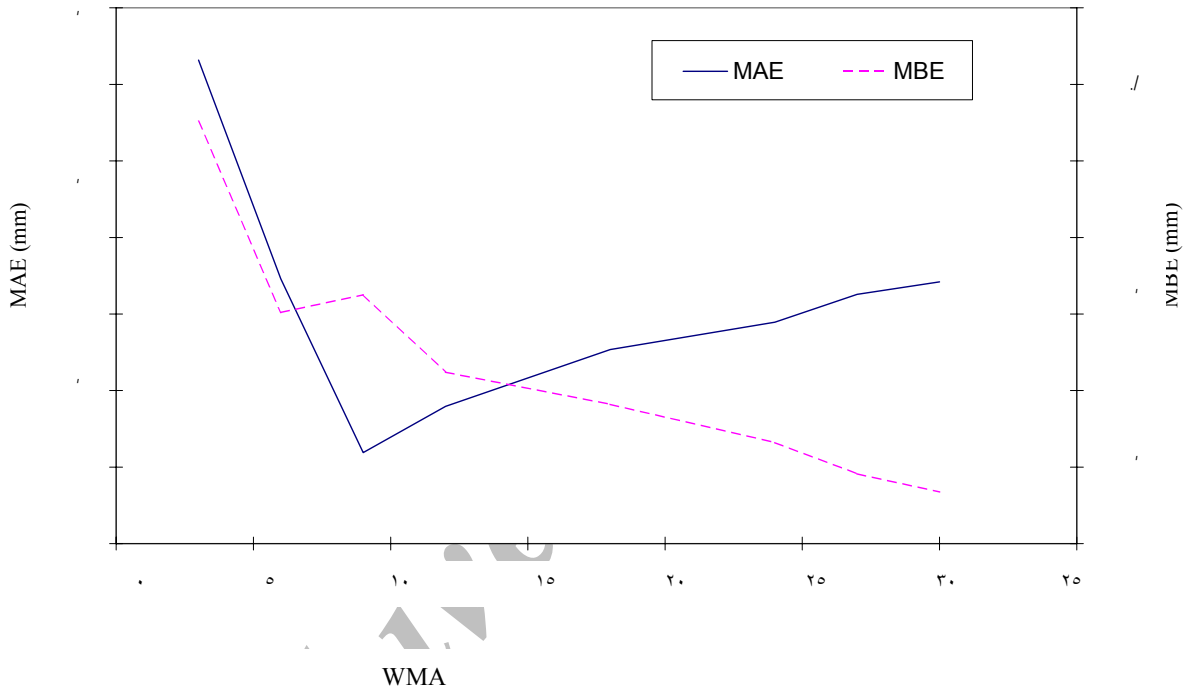
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- 2-Abtew, W., J. Obeysekera, and G. Shih. 1993. Spatial Analysis for Monthly Rainfall in South Florida. *Water Resources Bulletin*. 29(2): 179-188.
- 3-Goovaerts, P. 2000. Geostatistical Approach for Incorporating Elevation into Spatial Interpolation of Rainfall. *Journal of Hydrology*. Amsterdam. 228 (1-2):113-129.
- 4-Hargrove, W.W. 2001. Interpolation of Rainfall in Switzerland Using a Regularized Splines with Tension. Geographic Information and Spatial Technologies Group Oak Ridge National Laboratory. hnw@fire.esd.ornl.gov.
- 5-Nalder, J.A. and R.W. Wein. 1998. Spatial Interpolation of Climate Normal: Test of a New Method. *Canadian Boreal Forest. Agri-Forest*. 94(4): 211-225.
- 6-Price, D.T., D.W. Mckenny, I.A. Nelder, M.F. Hutchinson and J.L. Kestevn. 2000. A Comparison of Two Statistical Methods for Interpolation. *Canadian Monthly Mean Climate Data. Agriculture and Forest*. 101(2-3): 81-94.
- 7-Tabios, G.Q. and J.D. Salas. 1985 A Comparative Analysis of Techniques for Spatial Analysis Precipitation. *Water Resources Bulletin*. (21)3: 365-380.
- 8-Watson, G.S. 1984. Smoothing and Interpolation by Kriging and With Splines. *Mathematical Geology*. 16(6): 601-615.

Abstract

Estimation of rainfall data in many natural resources and agricultural studies is necessary. There are several methods to estimate rainfall along which interpolation methods are useful in this regards. In the most cases, one method is selected and estimation is done with unknown precision. In this study, 3 methods were used to estimate annual rainfall. These methods are: Thin Plate Smoothing Splines (TPSS), with and without co variable, Weighted Moving Average (WMA) and Kriging (ordinary, Cokriging, Log kriging). The data of 167 stations in south east of Iran with 22 years of records were used in this study. Elevation was used as co variable and its correlation with rainfall was calculated. Because of size of the area and dispersing of stations, this coefficient for all stations was low and unacceptable. Therefore, the study area was divided into sub catchments based on watershed catchments. In the cases which a few stations exist in the catchments or regression coefficient between elevation and rainfall for two stations was the same, those two sub catchments was combined. Finally, 3 units were obtained. Regression coefficient between rainfall and elevation was low in one of sub catchments ($R=0.12$) and in two other sub catchments was better (0.7 and 0.8).

These result show that the regression coefficient between rainfall and elevation must be greater than 0.6 in order to improve interpolation accuracy using elevation as co variable. These result also show that the TPSS method with elevation as co variable is the most precise method to estimate annual rainfall (MAE=13 – 38 mm). The kriging method (MAE= 29-50 mm) and the WMA method (26 57 mm) were in second and third order.

Key word: Geostatistics, Interpolation, Rainfall, Kriging, TPSS, WMA, Iran, Rainfall.