SPATIAL INTERPOLATION

Course : Hydro Informatics

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What is Spatial Interpolation ?

- A method for turning discrete points into a continuous surface (raster)
- A method for estimating or forecasting values of a variable (such as temperature, height, or rainfall) at any place by using values that have been seen or measured elsewhere

Example :

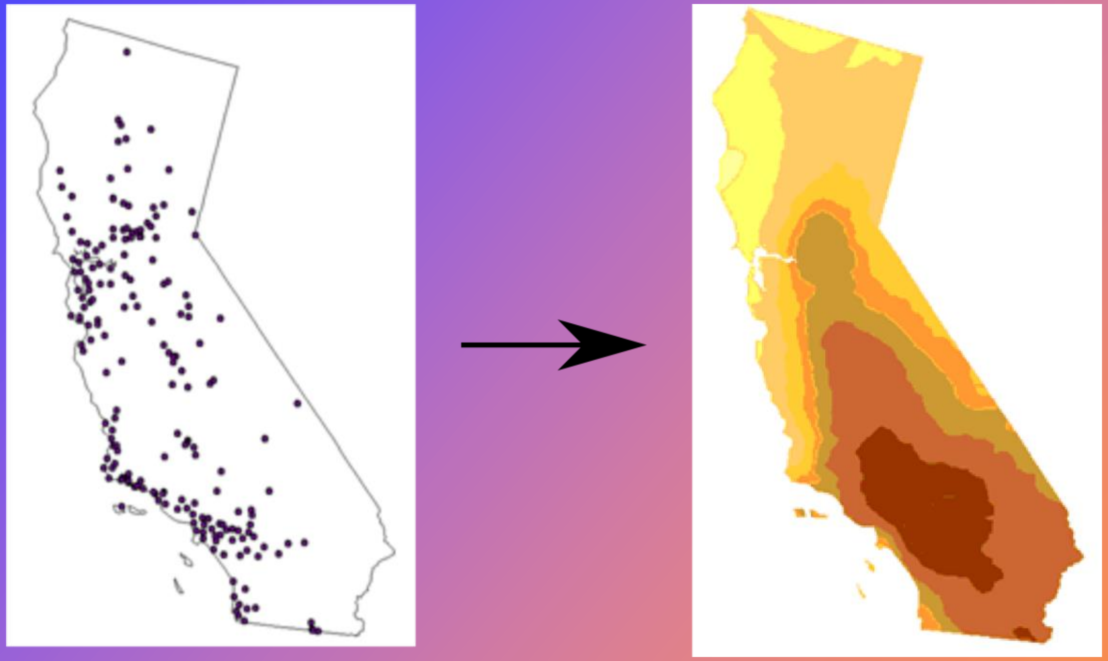
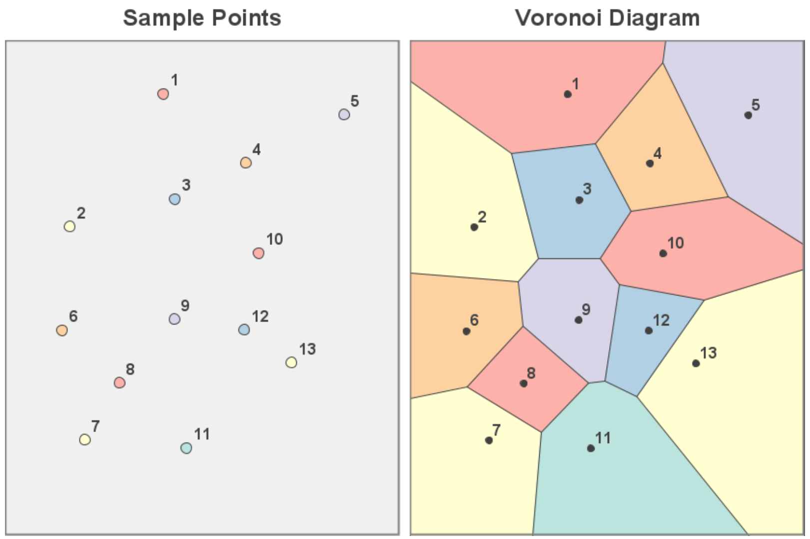


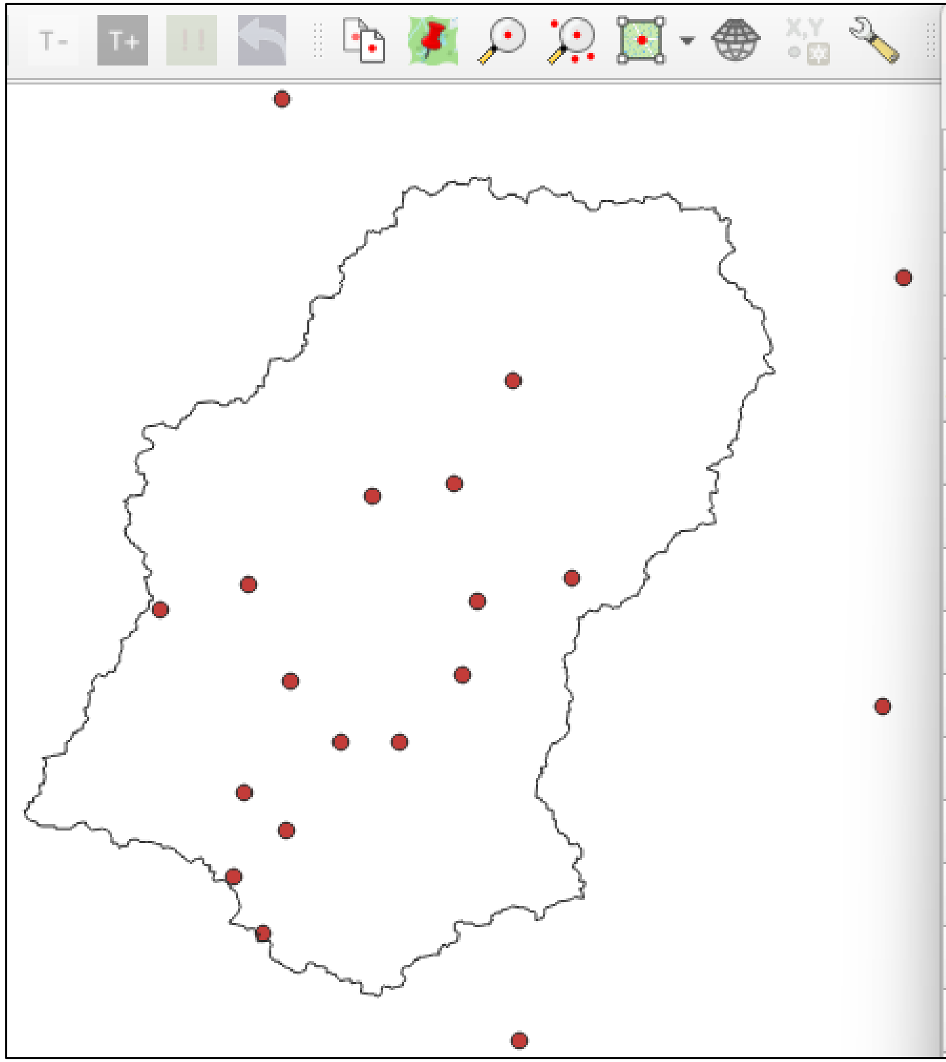
Figure showing conversion of Ozone monitoring locations data into a continuous raster using spatial interpolation

Voronoi Polygon Method



- Natural Neighbor interpolation utilizes Voronoi diagrams to identify neighboring polygons around a query point
- Weighting in Natural Neighbor interpolation is based on the proportion of overlap between the new Voronoi polygon around the query point and the existing polygons
- This method allows for more nuanced interpolation by considering the spatial distribution of sample points and their proximity to the query point
- In contrast, distance-based methods like IDW assign weights solely based on distances, potentially overlooking variations in sample point distribution

Voronoi Polygon Method - Example



Kukatpally boundary shapefile

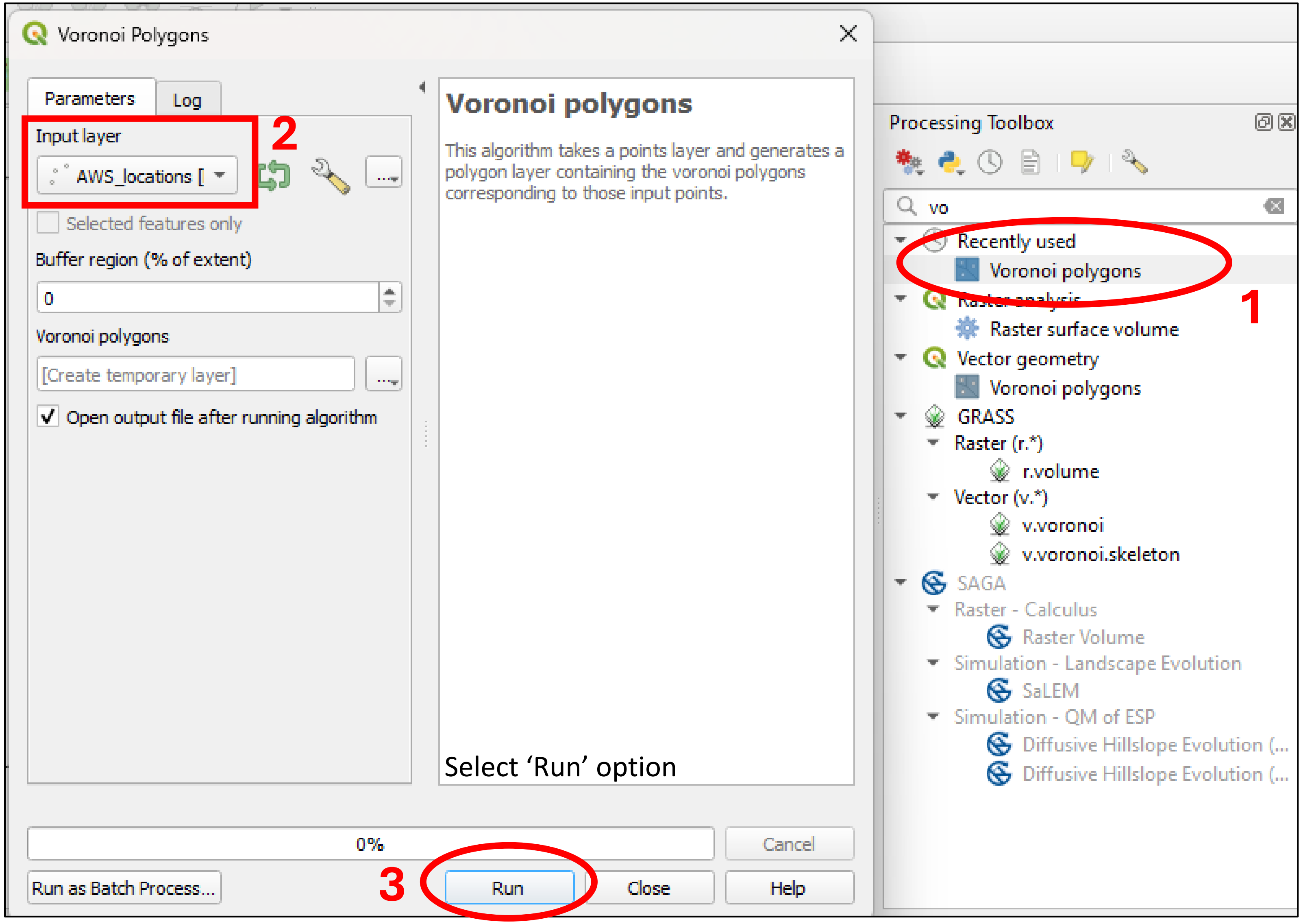
AWS_locations — Features Total: 21, Filtered: 21, Selected: 0

	id	Name	Rainfall
1	1	Jubilee Hills	2.300
2	2	Kakatiya Hills	2.900
3	3	Pillidarga Ward	1.560
4	4	Community Ha...	9.680
5	5	ESS HMT Hills: ...	10.550
6	6	PHC Centre: Ba...	8.663
7	7	Ward Office,All...	3.580
8	8	GHMC office	10.000
9	9	ESS Balanagar	18.700
10	10	Adarash Nagar	14.800
11	11	ESS Khuthubula...	9.700
12	12	Gayathri Nagar	13.890
13	13	ESS Gajularama...	19.547
14	15	Shapur Nagar	25.390

Attribute table consists of Rainfall data at each station

Voronoi Polygon Method - Example

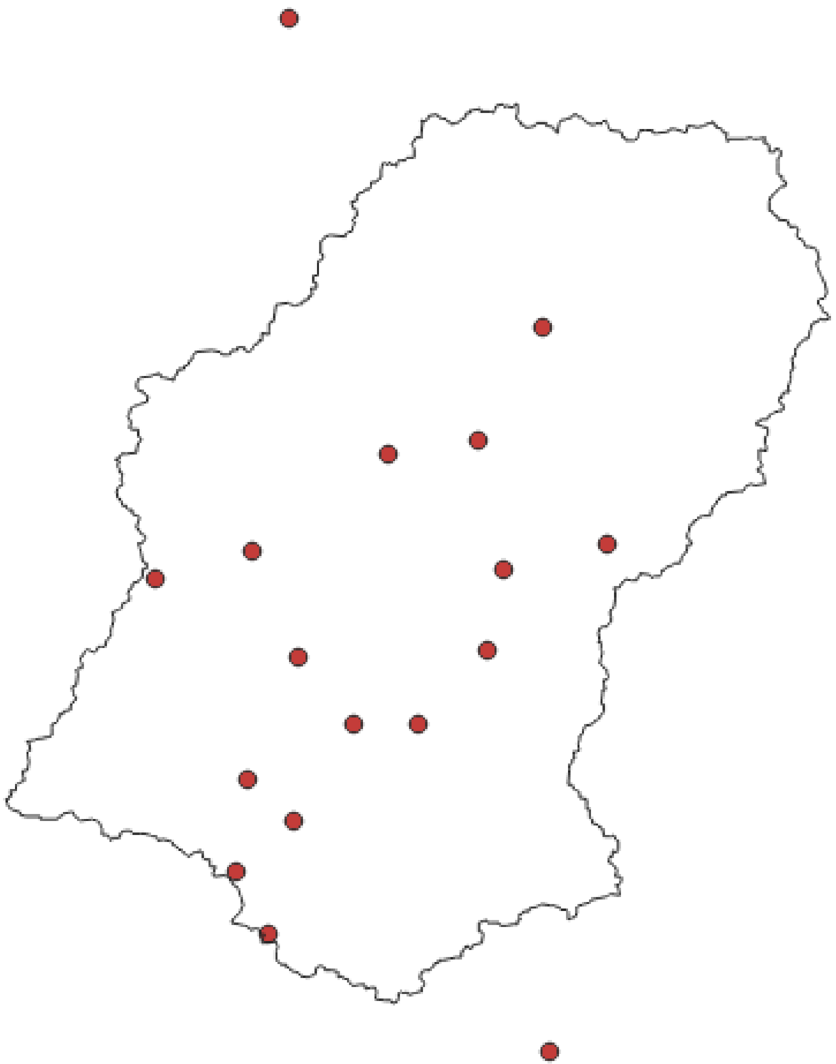
Select the layer with the data to be interpolated



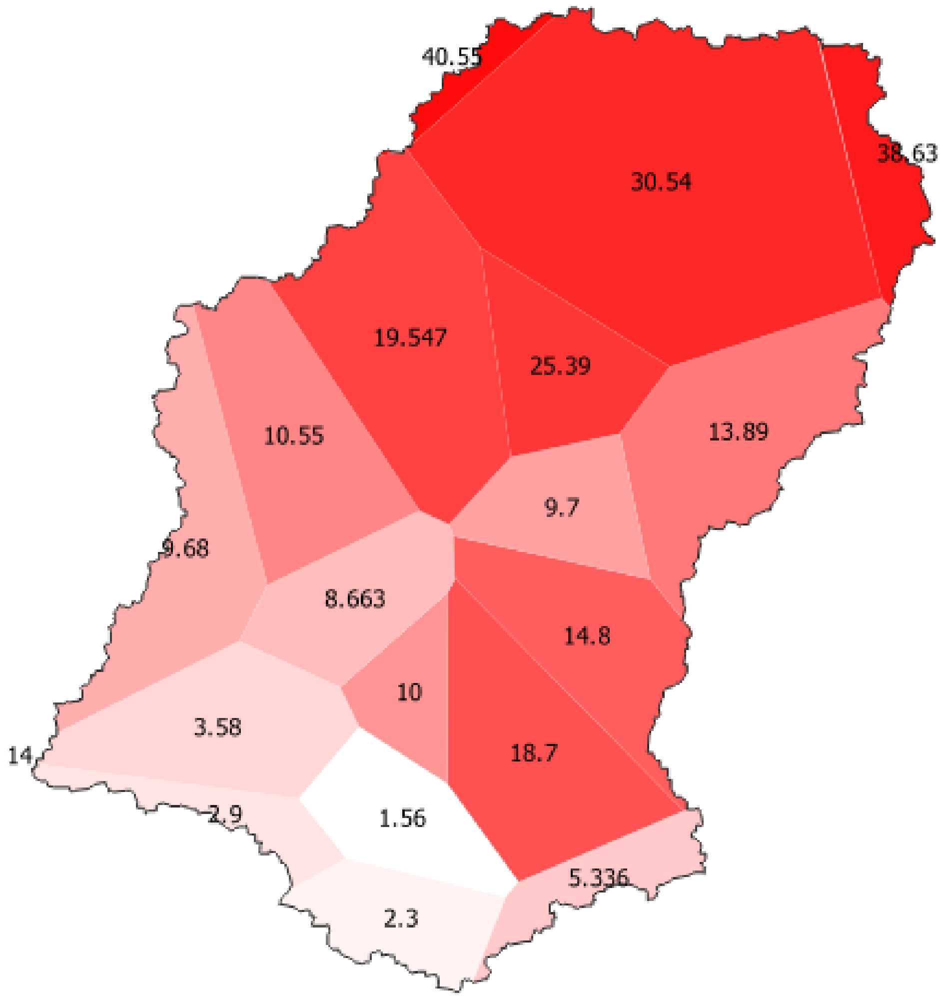
Type the required function in the 'Processing Toolbox' Window

Interpolation using 'Voronoi Polygon'

Voronoi Polygon Method - Example



Kukatpally Boundary with Rainfall Gauge points



Spatial Interpolation Raster generated with Voronoi polygon method

Natural Neighbor

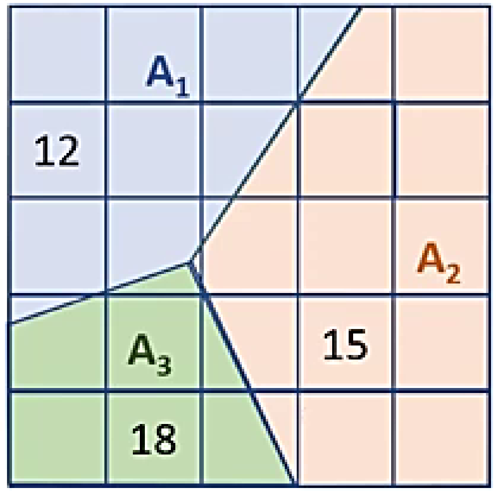
Estimate or prediction at point X (z_X) is give by the following expression

$$z_X = \sum_{i=1}^{N} \lambda_i z_i,$$

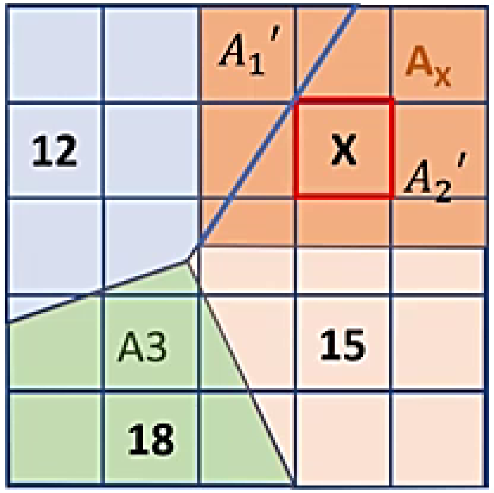
where z_i ($i = 1,2,\ldots,N$) are the observations at N points, and the λ_i are weights given by the following expression

$$\lambda_i = \frac{A_i'}{A_X}$$

A_i is the area of the Voronoi (Thiessen) polygon associated with point *i* before addition of X. Ax is the area of the Thiessen polygon of X, A_i' is the area of overlap between *Ax* and *Ai*

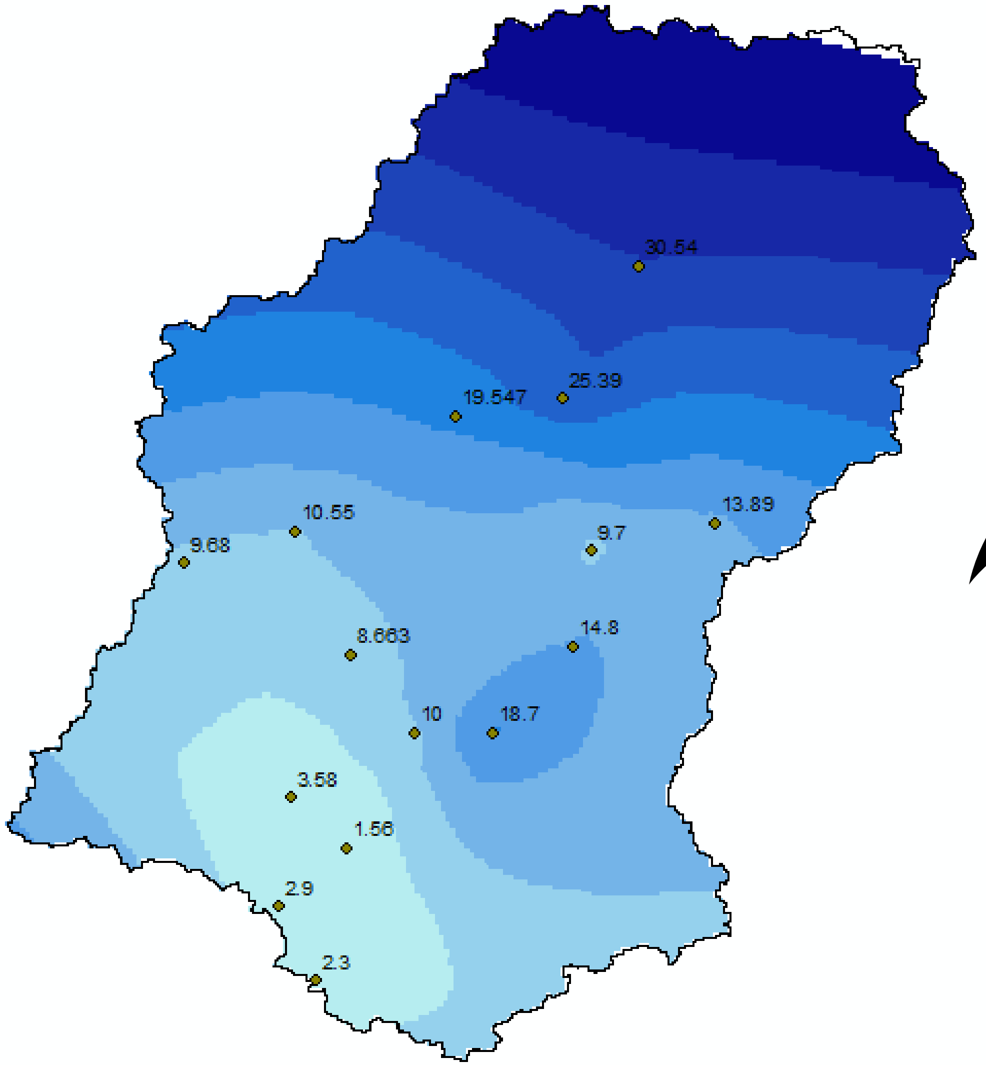


Voronoi (Thiessen) polygons for observed points

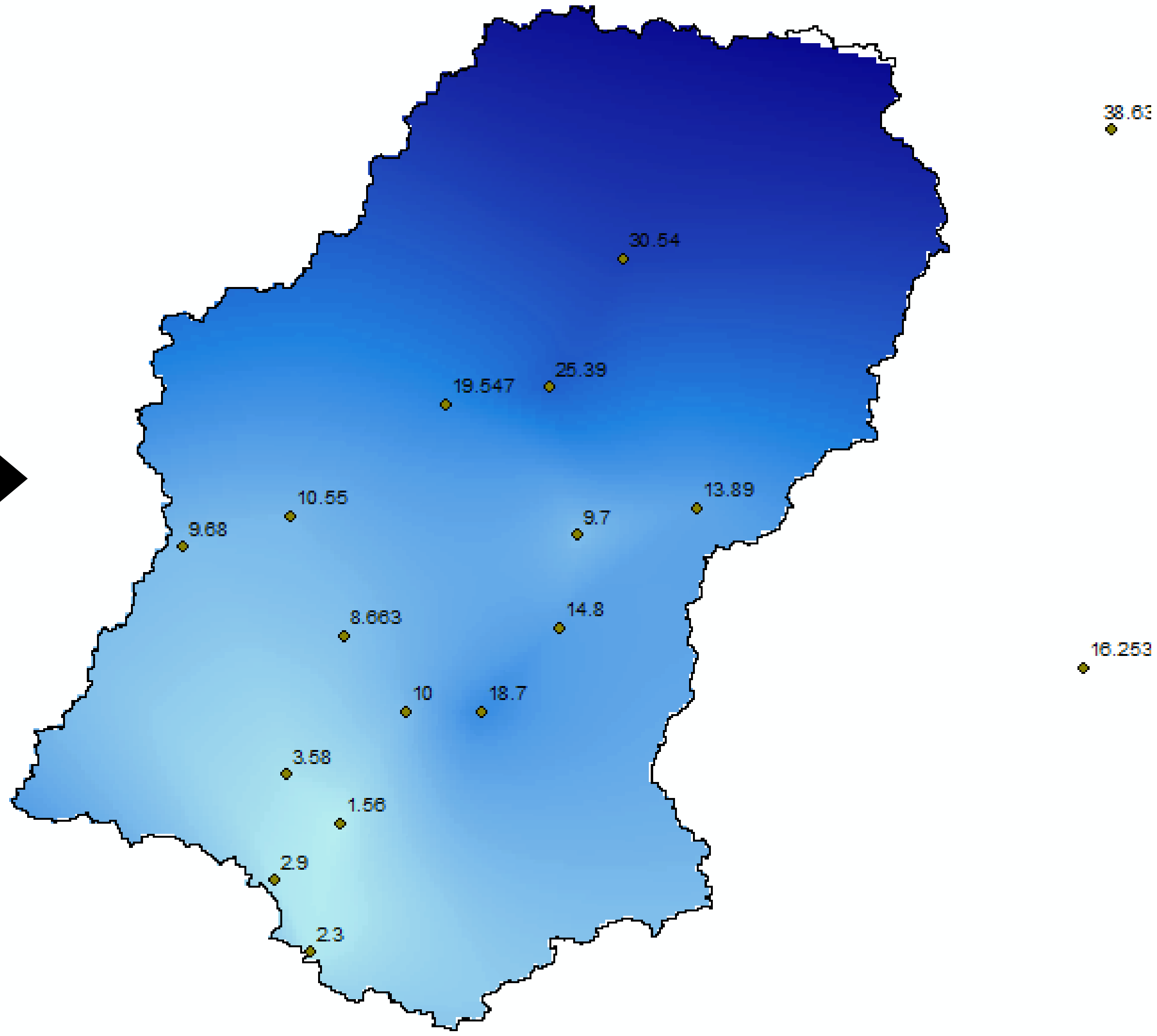


Modified Voronoi (Thiessen) polygons after including X

Natural Neighbor Interpolation



Spatially interpolated map of rainfall (Kukatpally) using Natural neighbor method



A more smoothened raster using 'categorized' representation.

Inverse Distance Weighting (IDW)

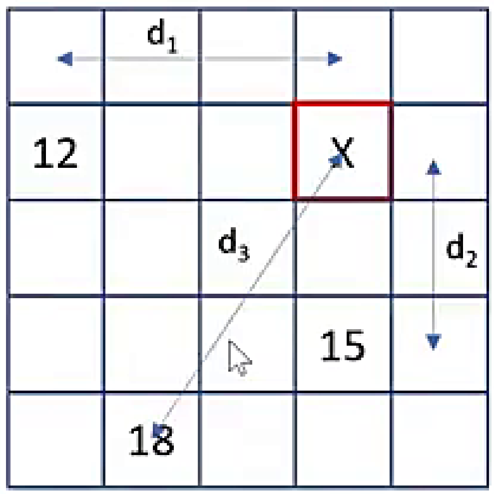
Estimate or prediction at point X (z_X) is give by the following expression

$$z_X = \sum_{i=1}^{N} \lambda_i z_i,$$

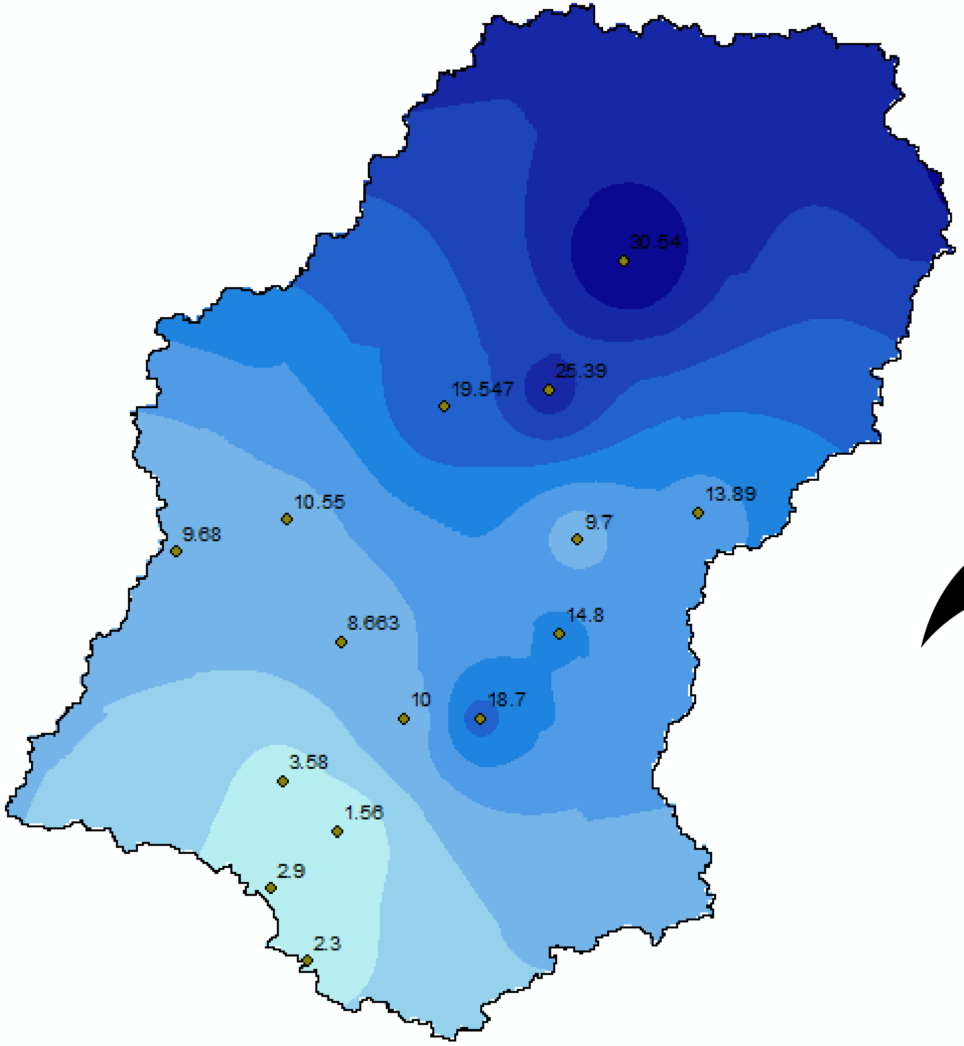
where z_i ($i = 1,2,\ldots,N$) are the observations at N points, and the λ_i are weights given by the following expression

$$\lambda_i = \frac{\frac{1}{{d_i}^p}}{\sum_{i=1}^{N} \frac{1}{{d_i}^p}}$$

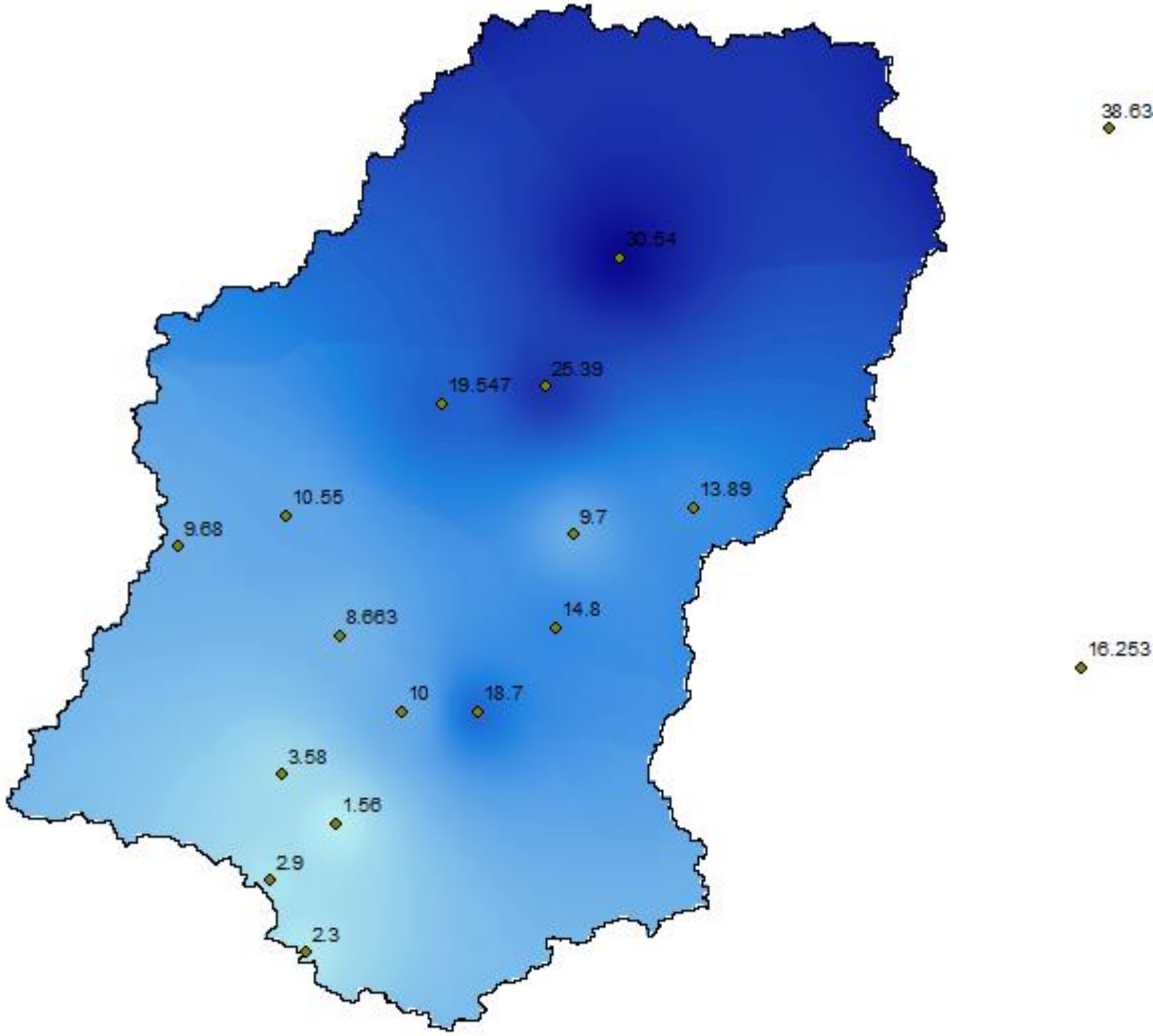
where d_i is the distance between i^{th} sampled point (z_i) and the unsampled point (z_x), and p is the power (exponent) variable. p = 2 is commonly used (squared inverse distance weighting)



IDW Method - Example



Spatially interpolated map of rainfall (Kukatpally) using IDW



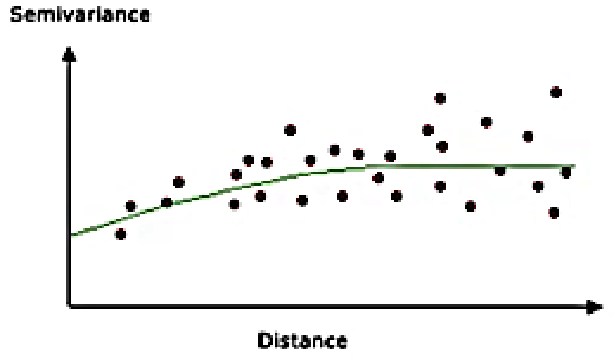
A more smoothened raster using ‘categorized’ representation

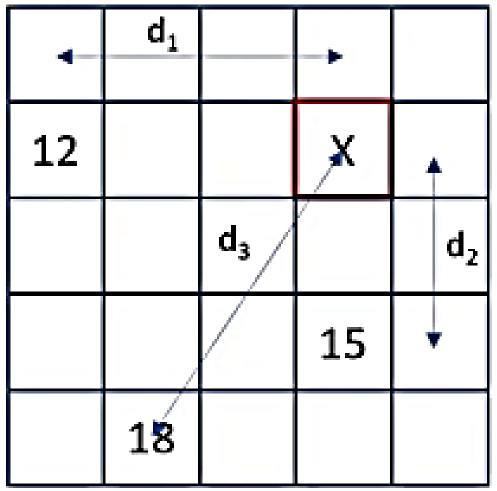
Ordinary Kriging

Estimate or prediction at point X (z_X) is give by the following expression

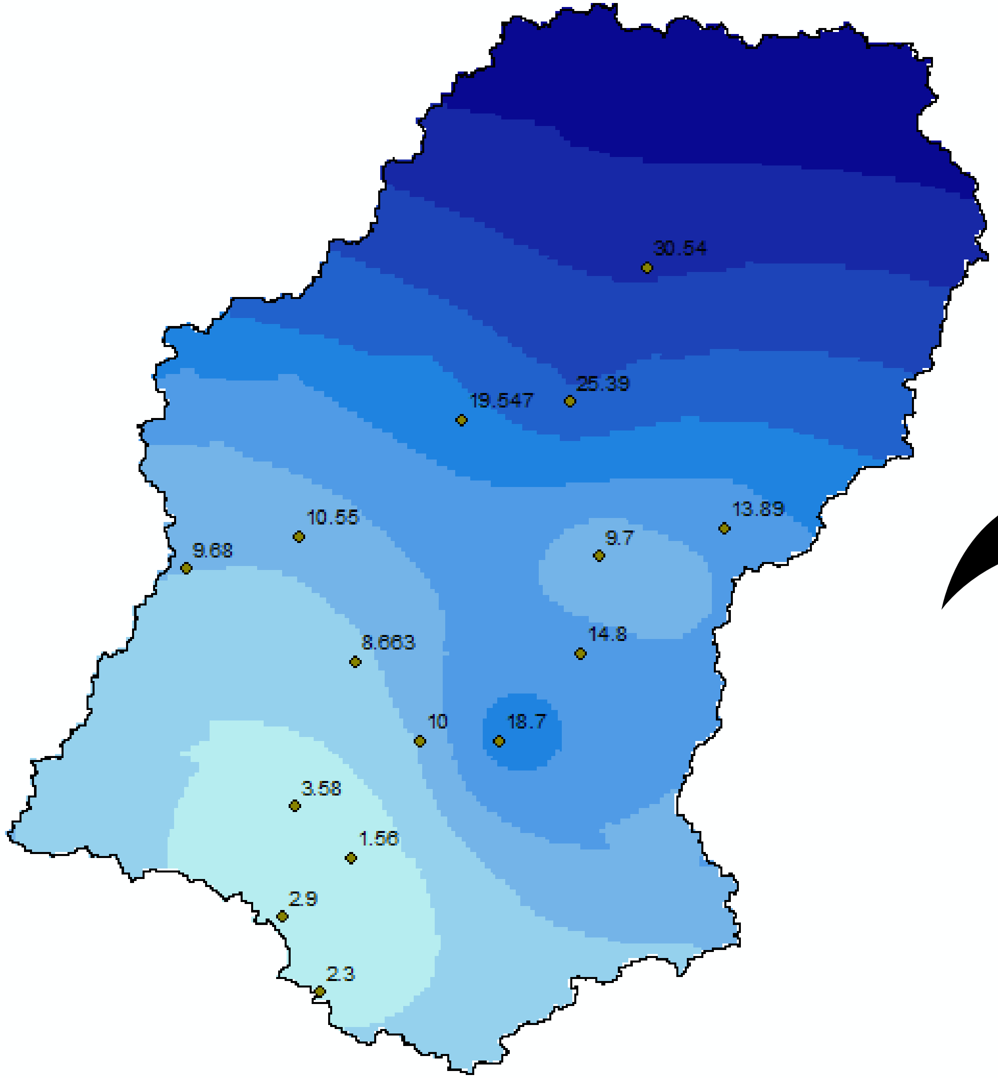
$$z_X = \sum_{i=1}^{N} \lambda_i z_i,$$

where z_i ($i = 1,2,\ldots,N$) are the observations at N points, and the λ_i are weights. Weights are computed based on distance and also on spatial auto-correlation, which is computed by fitting a semi-variogram to the data as shown below.

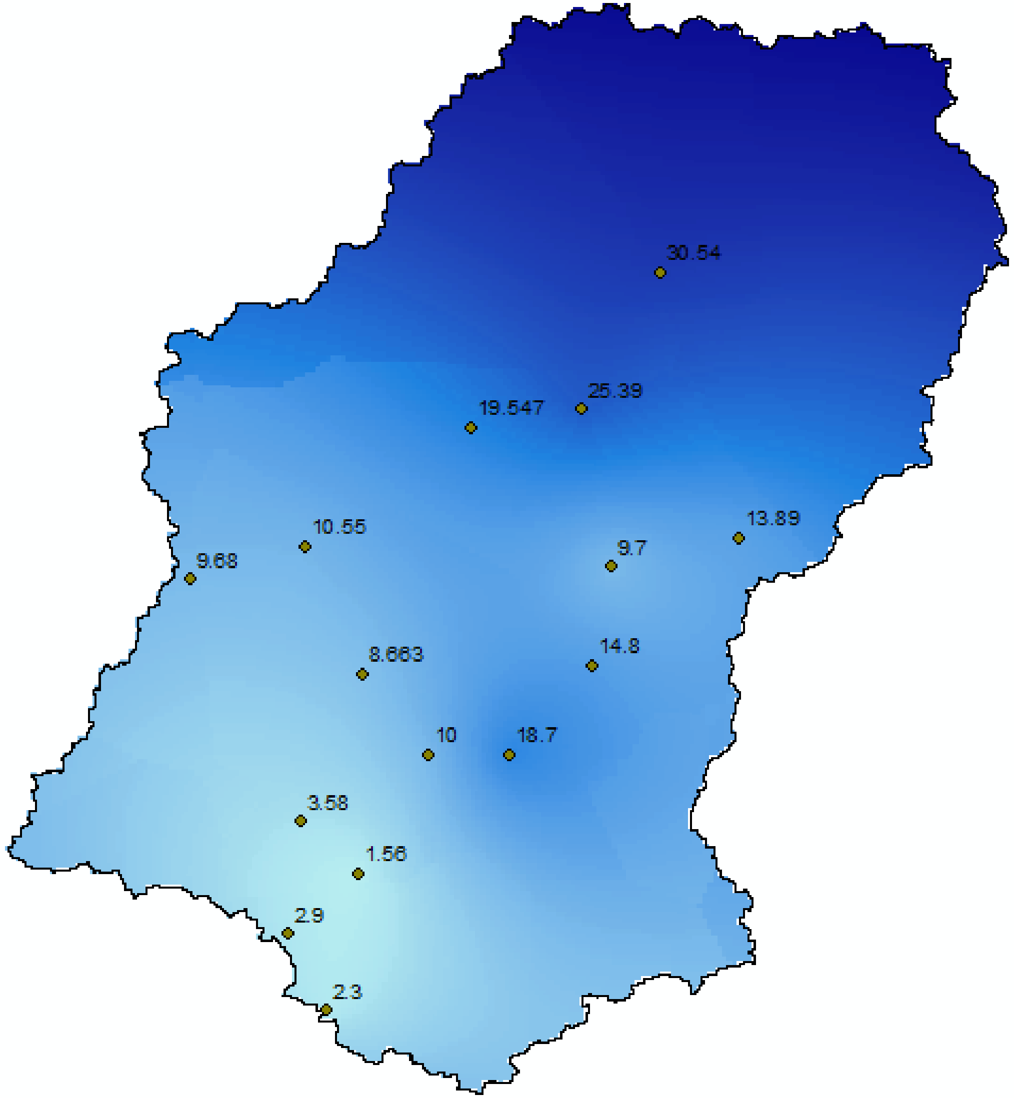




Ordinary Kriging



Spatially interpolated map of rainfall (Kukatpally) using Kriging



Smoothened raster using 'categorized' representation

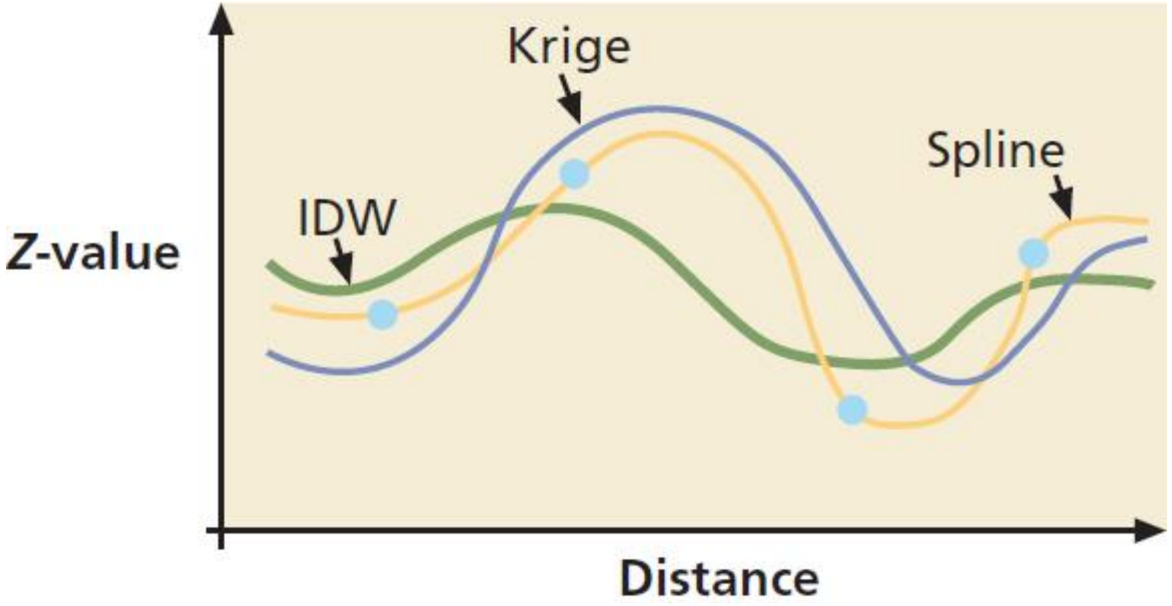
Spline Interpolation Technique

The Spline tool uses an interpolation method that estimates values using a mathematical function that minimizes overall surface curvature, resulting in a smooth surface that passes exactly through the input points.

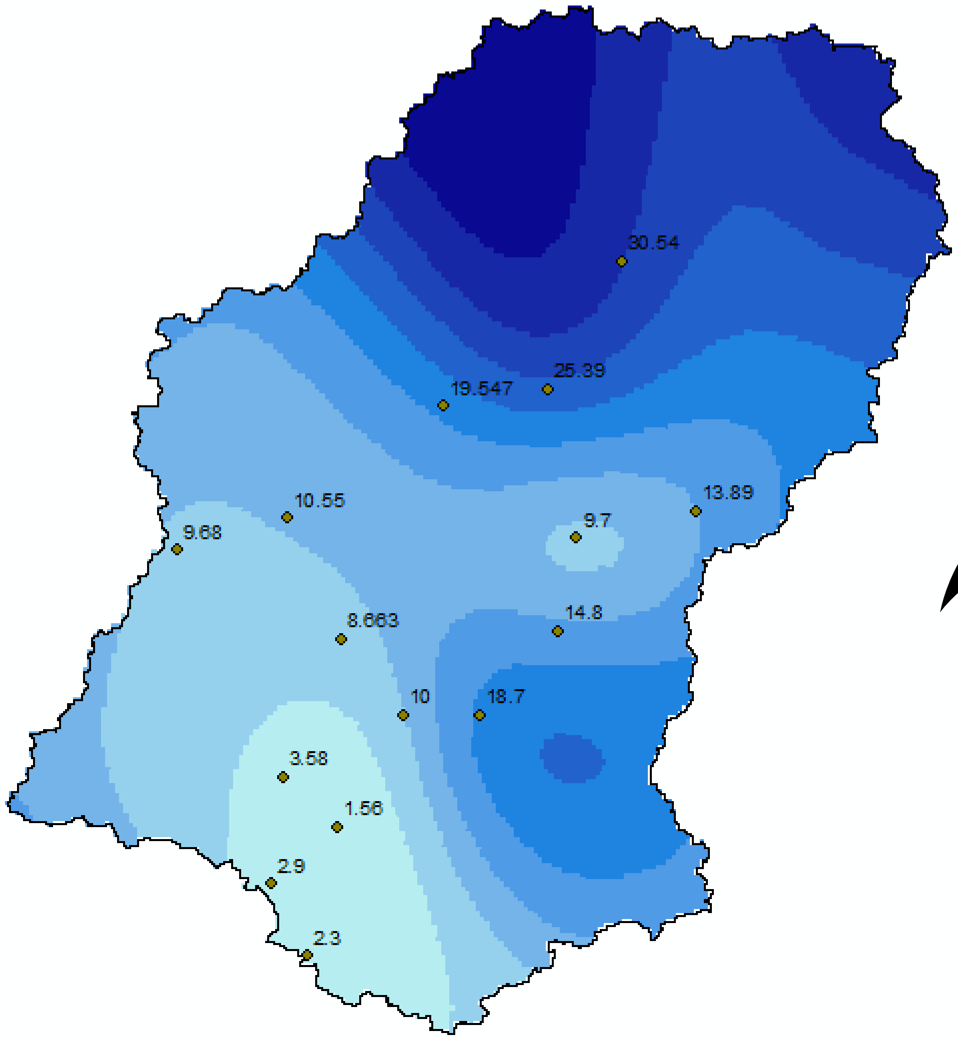
The algorithm used for the Spline tool uses the following formula for the surface interpolation:

$$S(x,y) = T(x,y) + \sum_{j=1}^{N} \lambda_j R(r_j)$$

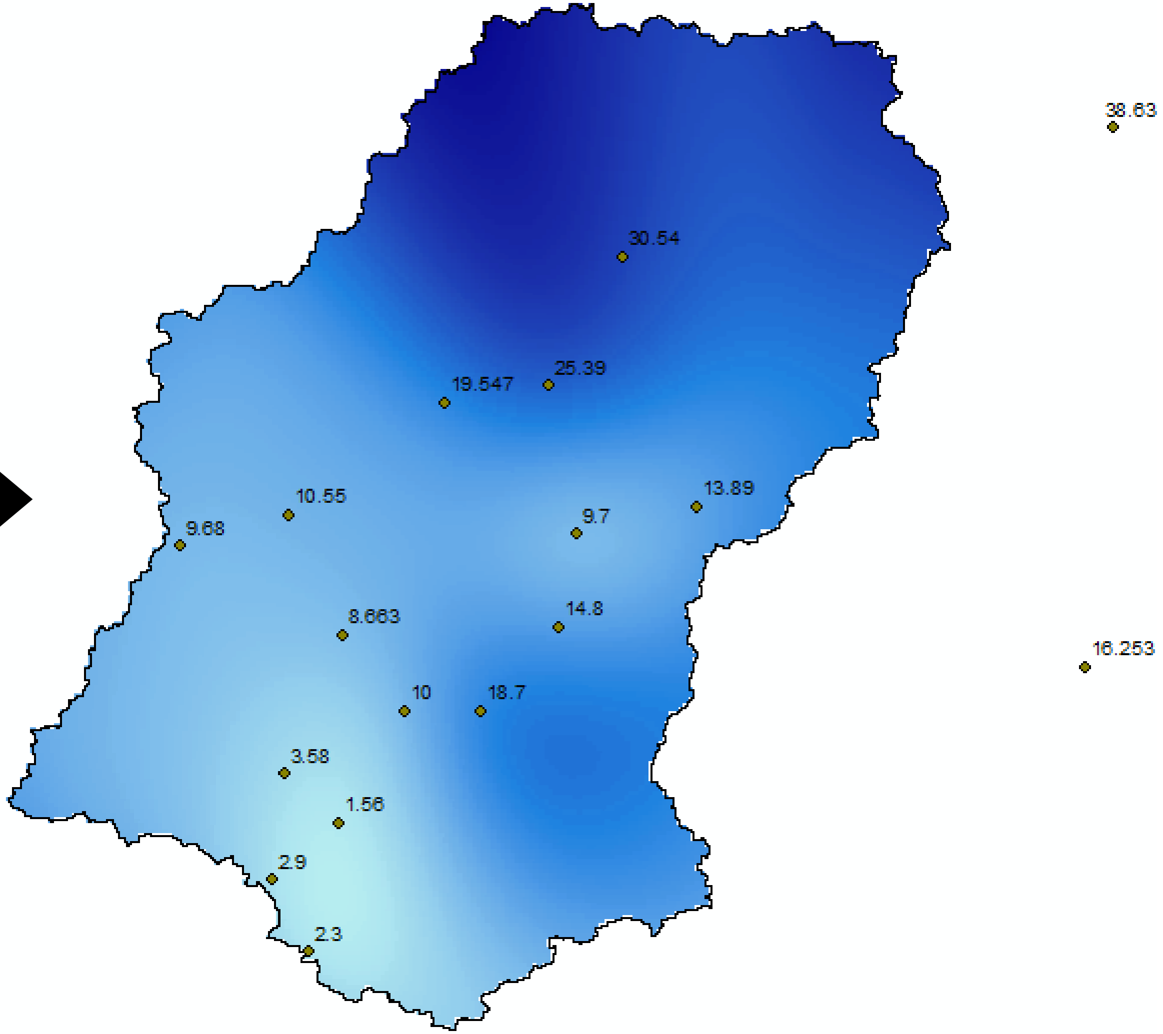
- where:j = 1, 2, ..., N.
- N is the number of points.
- λ_j are coefficients found by the solution of a system of linear equations
- r_j is the distance from the point (x,y) to the j^{th} point



Spline Interpolation Technique



Spatially interpolated map of rainfall (Kukatpally) using Spline



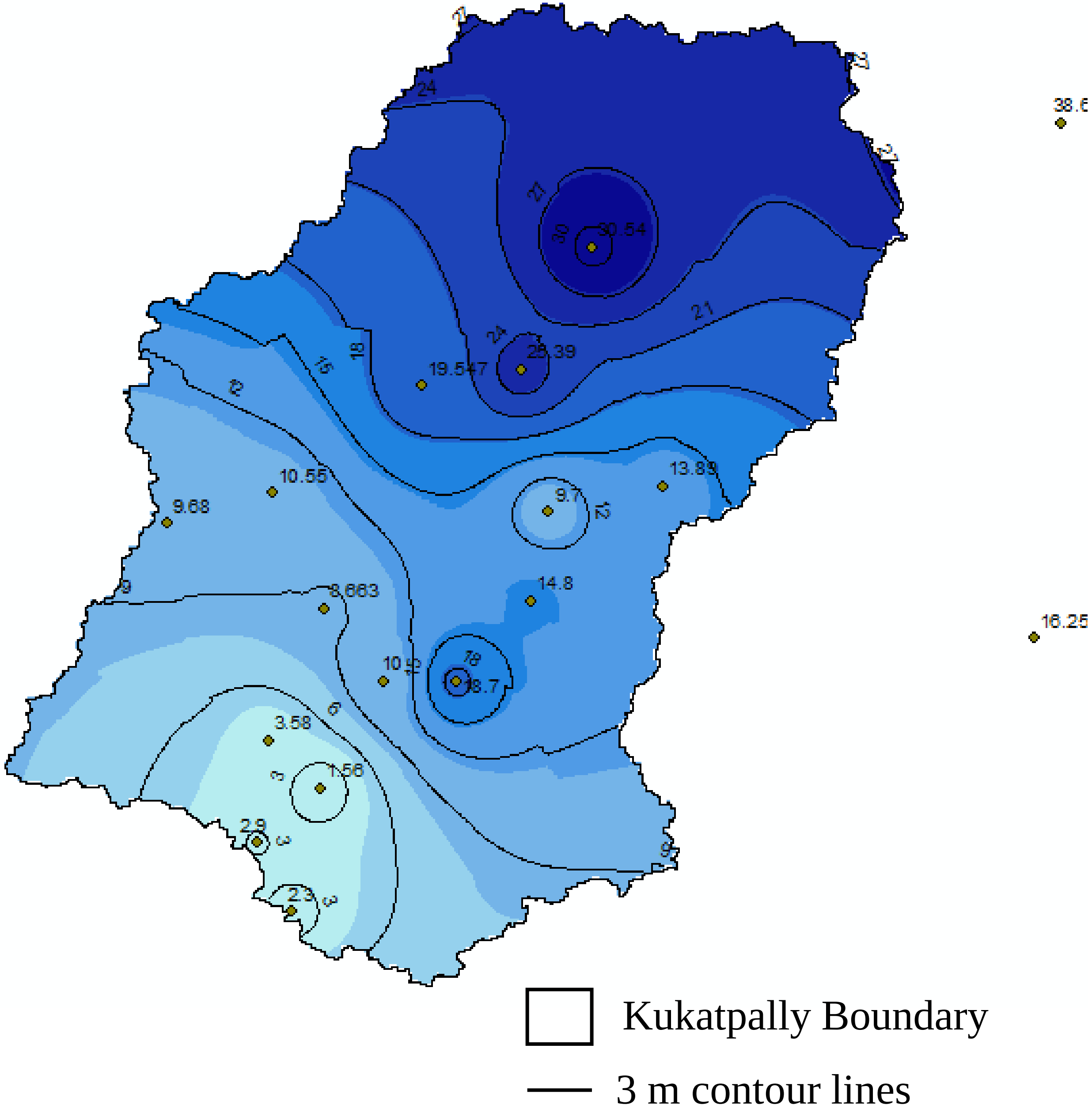
Smoothened raster using ‘categorized’ visualization

Generation of Contours

Contour Generation:
Utilize the "Contour" tool in QGIS to create contour lines from the interpolated surfaces

Adjusting Contour Parameters: Fine-tune contour parameters such as interval spacing, elevation range, and line style to tailor the visualization to specific needs

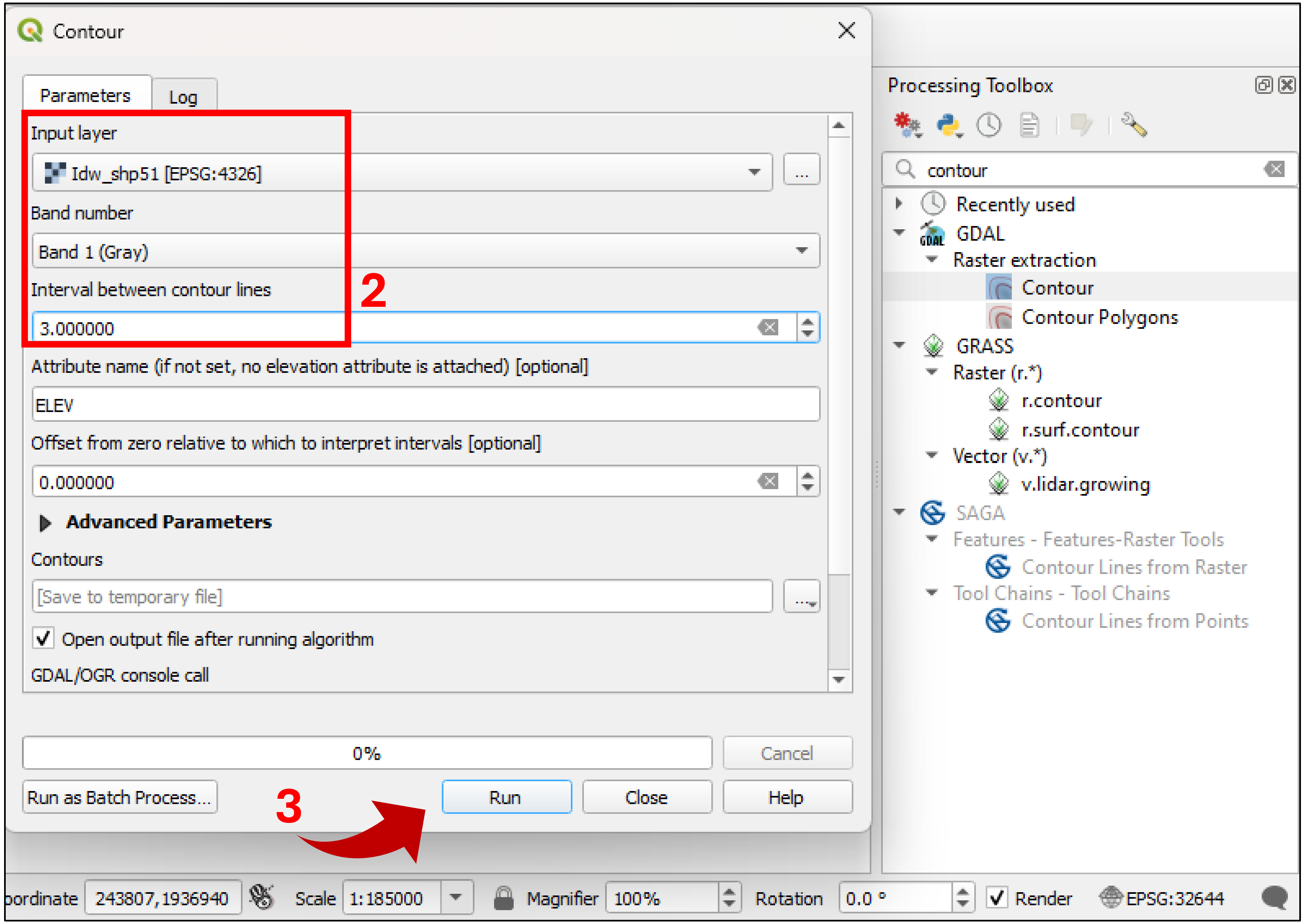
Visualizing Contours: Display generated contour lines on maps to represent elevation, temperature, or other continuous spatial phenomena, aiding in analysis and visualization



Generation of Contours

Feed the interpolated surface under 'Input Layer'

Give the desired contour interval value



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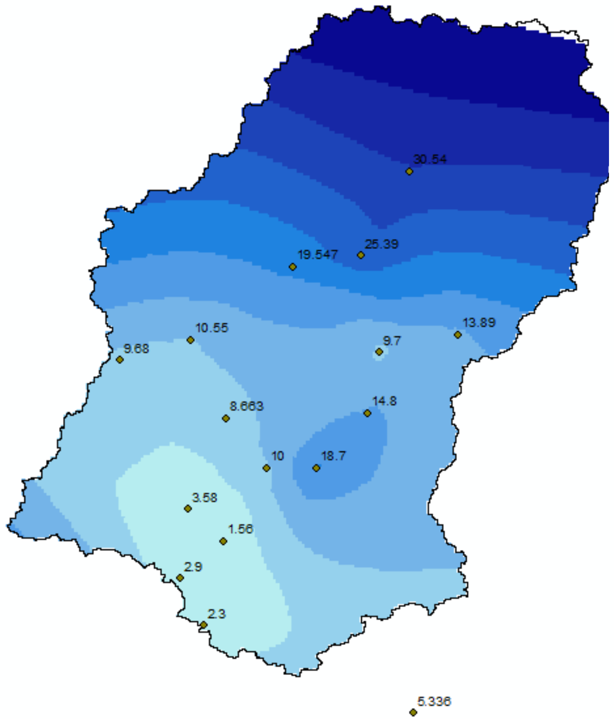
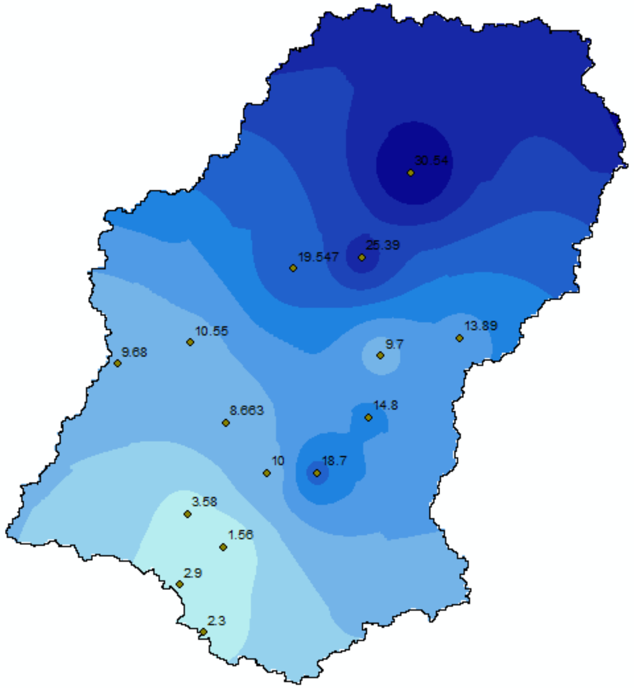
Type the required function in the 'Processing Toolbox' Window

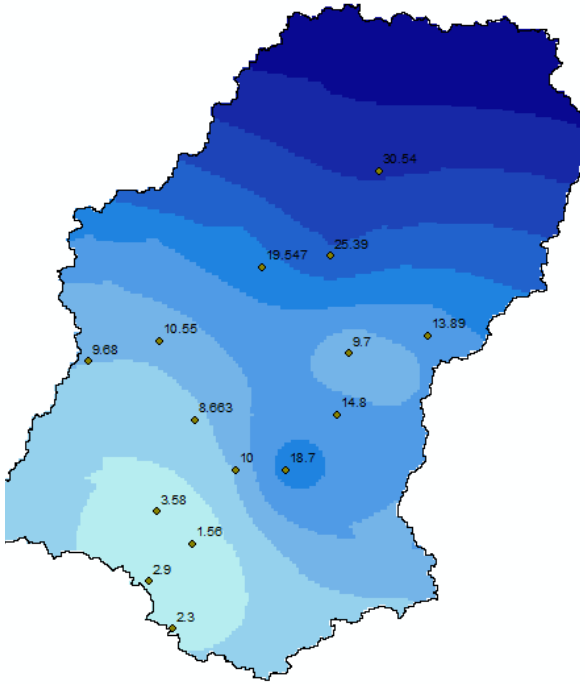
COMPARISION



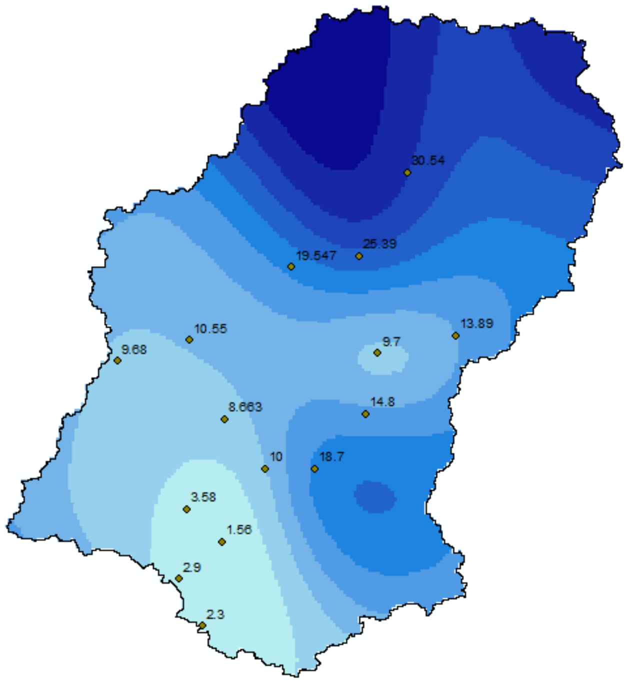
Natural Neighbor



IDW



Spline Interpolation



Ordinary Kriging

Root Mean Square Error (RMSE)

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(Pi - O_i)^2}{n}}$$

P_i is the predicted value of data not used for interpolation
O_i is the observed value of the validation points
n is the number of points in the validation dataset

When are these methods used !?

- **Ordinary Kriging:**

Ordinary kriging is suitable when the mean of the variable being interpolated is not known

- **Spline Interpolation Method:**

Spline interpolation is used in a variety of situations where accurate and smooth interpolation between data points is required

- **Natural Neighbor Interpolation Method :**

This method is most appropriate where sample data points are distributed with uneven density

- **Inverse Distance Weighted (IDW) Method :**

IDW works well when sample points are evenly distributed across the study area. This ensures that each point contributes to the interpolation in a consistent manner, without biasing the results towards clustered or sparse areas

Thank You !