Chapter 9: Theissen's and Isohyetal Methods

Introduction

In hydrology, estimating the **average precipitation** over a catchment or a drainage basin is crucial for design and analysis tasks such as flood estimation, reservoir operation, and water resource planning. Since rainfall is recorded at discrete stations, we need techniques to interpolate or estimate how rainfall varies over the entire area. Two of the most commonly used methods for such are:

- **Theissen Polygon Method**
- **Isohyetal Method**

These methods provide spatial averaging of rainfall based on either geometrical approximation (Theissen) or contouring based on observed values (Isohyetal). This chapter explores these two methods in full detail, covering construction, assumptions, advantages, and applications.

9.1 Theissen Polygon Method

9.1.1 Concept and Purpose

The **Theissen Polygon Method** (also known as the **Thiessen Method**) is a geometrical approach used to estimate **area-weighted average rainfall** from point observations at rain gauge stations. It assumes that each station is responsible for rainfall over a specific area, bounded by polygons constructed around the stations.

9.1.2 Steps of Construction

1. **Plot the catchment area** on a map and mark the location of all rain gauge stations.
2. **Connect adjacent stations** with straight lines to form triangles (Triangulation).
3. **Draw perpendicular bisectors** of each line connecting two adjacent stations.
4. **The intersection of perpendicular bisectors** creates **polygons** around each station.
5. Each **polygon defines the area of influence** of that rain gauge.
6. **Measure the area** of each polygon using a planimeter or CAD tools.

7. Calculate **weighted average rainfall** as:

$$P_{avg} = \sum_{i=1}^{n} \left(\frac{A_i}{A_{total}} \times P_i \right)$$

- where:
  - A_i = area of the ith polygon
  - A_{total} = total catchment area
  - P_i = precipitation at ith station

9.1.3 Assumptions

- Rainfall is uniformly distributed within each polygon.
- No orographic or topographic influence is considered.
- The catchment area is adequately covered by rain gauges.

9.1.4 Merits

- Simple and easy to apply.
- Useful for small to medium-sized catchments.
- Accounts for spatial variability better than the arithmetic mean method.

9.1.5 Demerits

- Ignores elevation and topographical features.
- Accuracy depends on the proper distribution of stations.
- Sharp boundaries are unrealistic in natural rainfall distribution.

9.2 Isohyetal Method

9.2.1 Concept and Purpose

The **Isohyetal Method** is a **contouring technique** used to estimate areal precipitation. It involves drawing **isohyets**, which are lines connecting points of **equal rainfall depth**, based on measurements from different stations.

This method is considered **more accurate** than Theissen's because it incorporates **spatial rainfall gradients** and allows interpolation between stations.

9.2.2 Steps of Construction

1. **Plot the catchment boundary** and mark all rain gauge stations with recorded rainfall values.
2. **Interpolate rainfall** between nearby stations and draw **isohyets** (contour lines of equal rainfall).

3. **Divide the catchment** into **zones between isohyets**.
4. **Measure the area** between each pair of isohyets.
5. Assign the **average precipitation** to each zone, calculated as the **mean of the two bounding isohyets**.
6. Compute the **area-weighted average rainfall** as:

$$P_{avg} = \sum_{i=1}^{n} \left(\frac{A_i}{A_{total}} \times P_i \right)$$

- where:
  - A_i = area between two isohyets
  - P_i = average rainfall between two isohyets

9.2.3 Key Considerations in Isohyetal Drawing

- Use interpolation between stations to place isohyets accurately.
- Rainfall contours must follow logical patterns (e.g., they should not cross unless justified by topography).
- The denser the station network, the more reliable the isohyets.

9.2.4 Merits

- Most accurate among the non-instrumental methods for estimating areal rainfall.
- Considers spatial variations and gradients of rainfall.
- Can reflect topographic influences when isohyets are drawn carefully.

9.2.5 Demerits

- Time-consuming and requires experience.
- Subjective element in drawing isohyets—results may vary with person.
- Needs a dense network of rain gauge stations for better accuracy.

9.3 Comparison Between Theissen and Isohyetal Methods

Feature	Theissen Polygon Method	Isohyetal Method
Basis	Geometric (polygonal division)	Contour (lines of equal rainfall)
Accuracy	Moderate	High
Data Requirement	Moderate (location and rainfall data)	High (more stations needed)

Feature	Theissen Polygon Method	Isohyetal Method
Computation Time	Low to moderate	High
Subjectivity	Low	High
Spatial Distribution Considered	Yes (simplified)	Yes (detailed)
Topography Influence	Not considered	Can be considered (qualitatively)
Preferred Use	Preliminary studies, simple basins	Detailed studies, complex basins

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9.4 Application Scenarios

- **Theissen Method** is commonly used in **small watersheds**, or where **time/resources** are limited.
- **Isohyetal Method** is preferred in **hydrologically important** or **mountainous regions** where **rainfall gradients are steep** and need accurate spatial representation.

9.5 Modern Enhancements and GIS Integration

Both methods can now be implemented using **GIS tools** like ArcGIS or QGIS, allowing for:

- Faster area calculation
- Improved accuracy through digital elevation models (DEMs)
- Automated isohyet drawing using spatial interpolation algorithms (e.g., Kriging, IDW)

Such integration reduces subjectivity and enhances the reproducibility of results, particularly for large and complex watersheds.
