Impacts of precipitation interpolation on hydrologic modeling in data scarce regions

Paul D. Wagner[1], Shamita Kumar[2], Florian Wilken[1], Peter Fiener[1] and Karl Schneider[1]

[1] Hydrogeography and Climatology Research Group, Institute of Geography, University of Cologne, Germany

[2] Institute of Environment Education & Research, Bharati Vidyapeeth University, Pune, India

1. Motivation

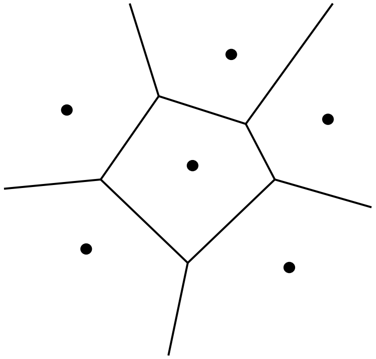
1. Precipitation is one of the most important model inputs
2. Precipitation patterns are important, particularly for spatially distibuted modeling
3. Precipitation measurements are scarce in many regions of the world

Suitable interpolation method is required

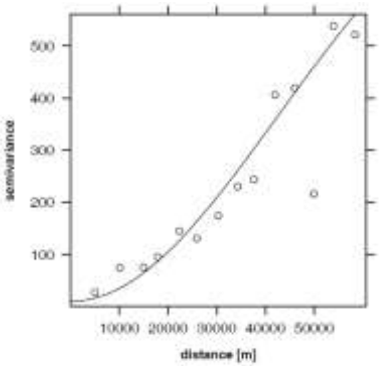
1. Objective

Which interpolation method is most suitable for hydrologic modeling with SWAT in data scarce regions?

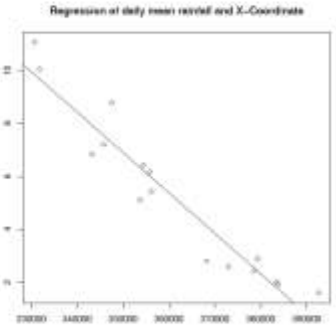
Thiessen polygons



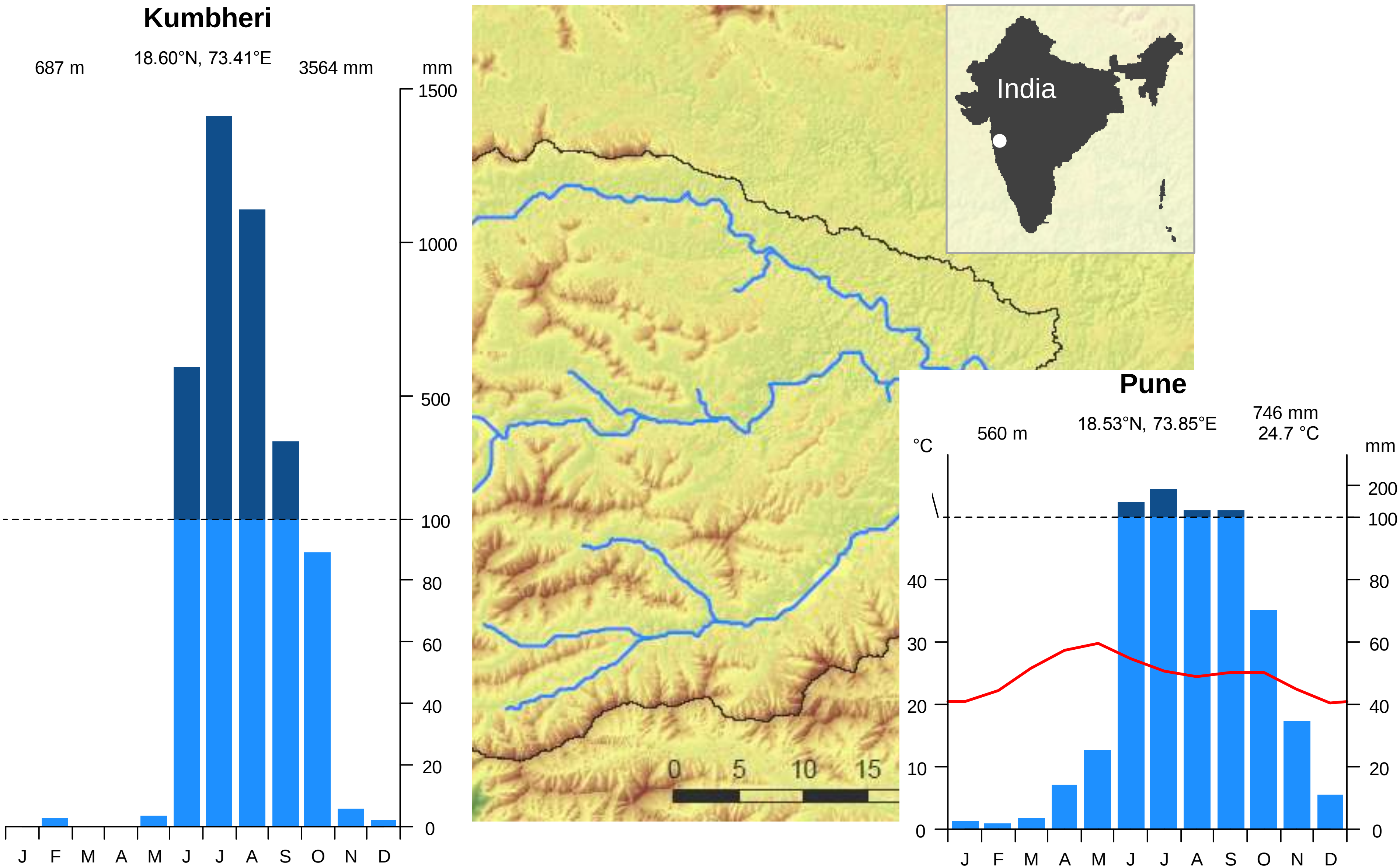
Ordinary kriging



Regression approach



2. Study area


Kumbheri
687 m
18.60°N, 73.41°E
3564 mm
mm
1500
1000
500
100
80
60
40
20
0
J F M A M J J A S O N D
India
0 5 10 15
Pune
560 m
18.53°N, 73.85°E
746 mm
24.7 °C
°C
mm
200
100
40
30
20
10
0
80
60
40
20
0
J F M A M J J A S O N D

2. Study area: Rain gauges

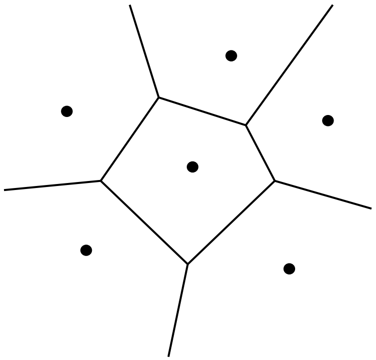
Gauge density: (gauges/1000 km²)	
Study area	~ 3
India	~ 2
Germany	~ 9

2. Data preparation

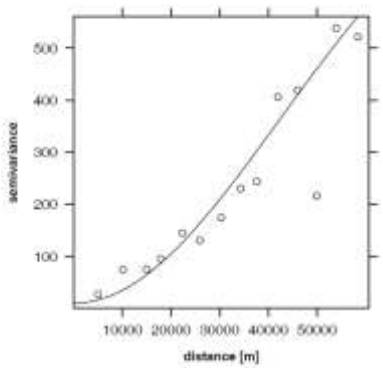
1. Consistency and homogeneity check using double mass curves
2. Removement of questionable data
3. Filling of measurement gaps and of removed questionable data
4. Correction of systematic measurement errors (e.g. wind loss; Richter 1995)

2. Interpolation methods

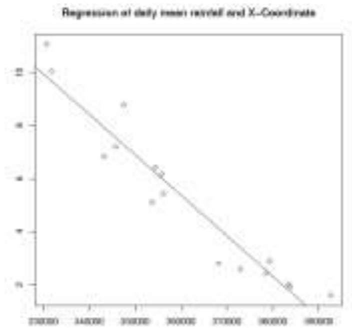
Thiessen polygons

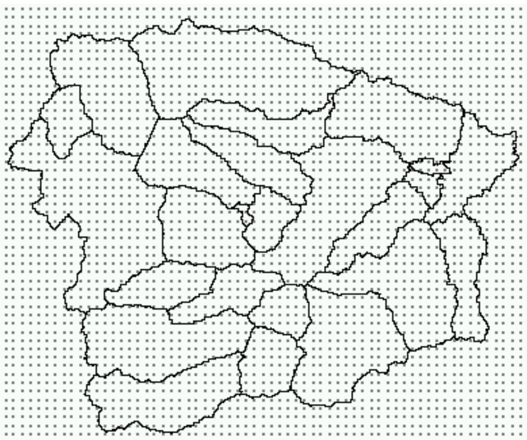


Ordinary kriging



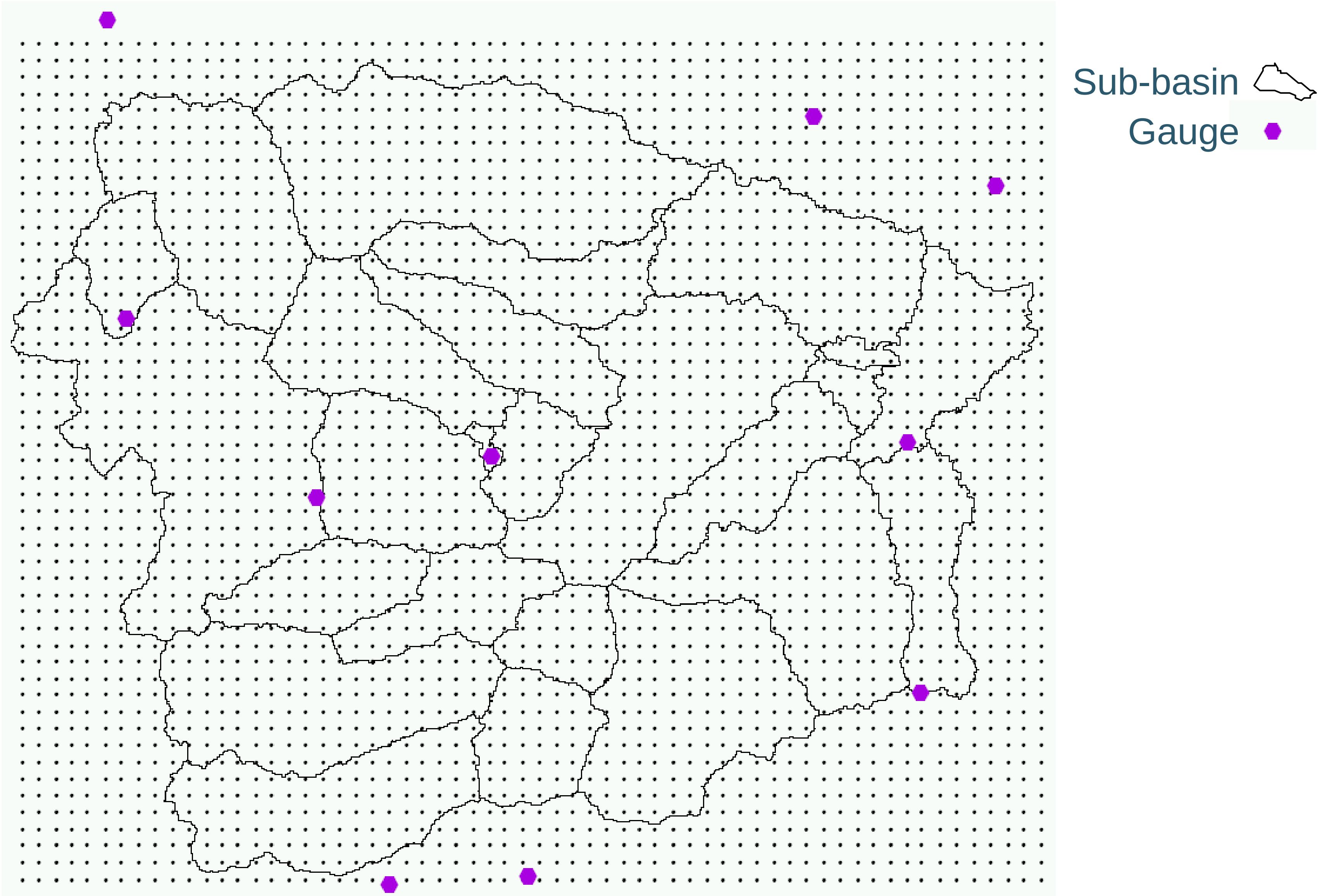
Regression approach





1 km² point grid

2.1 Thiessen polygons



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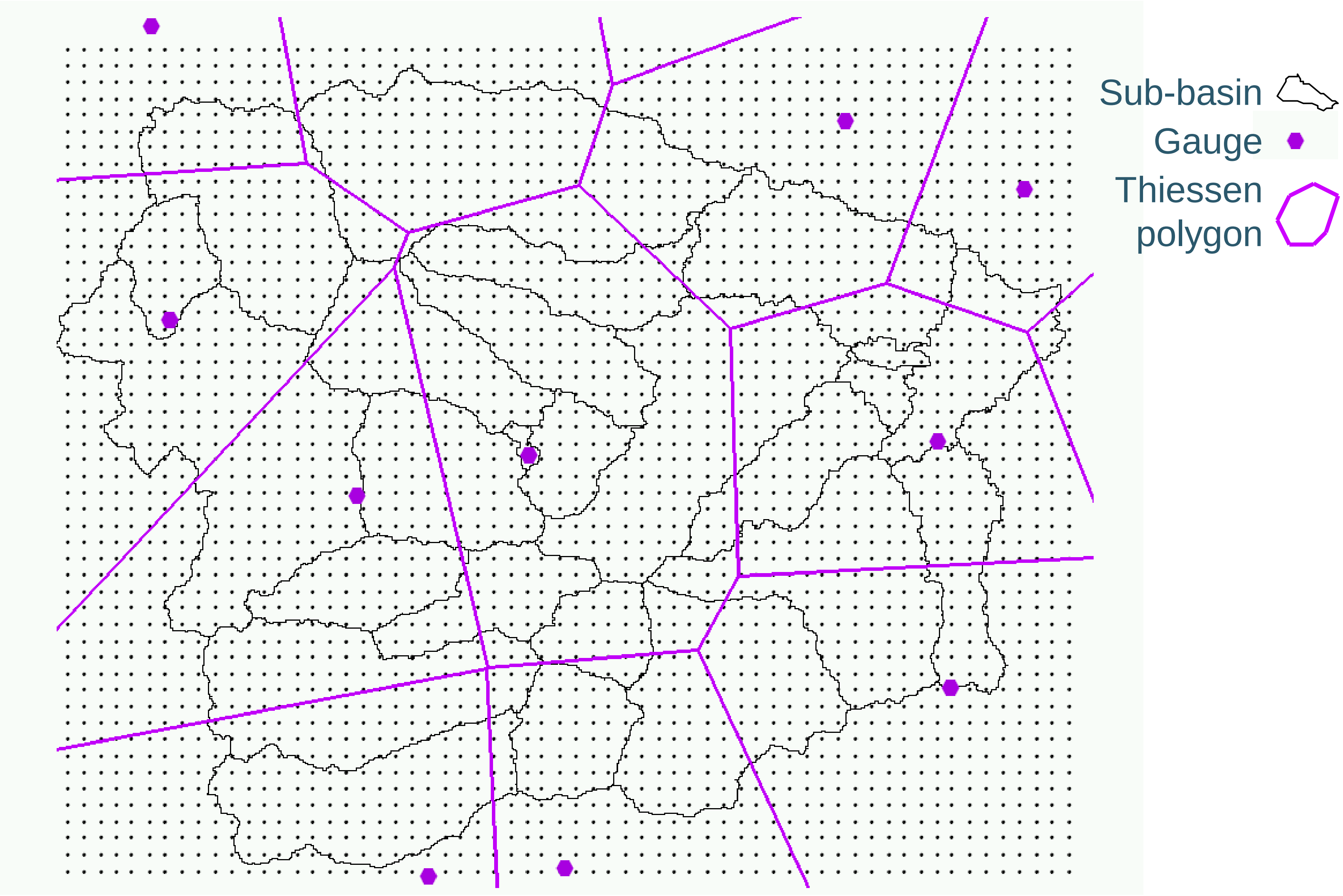

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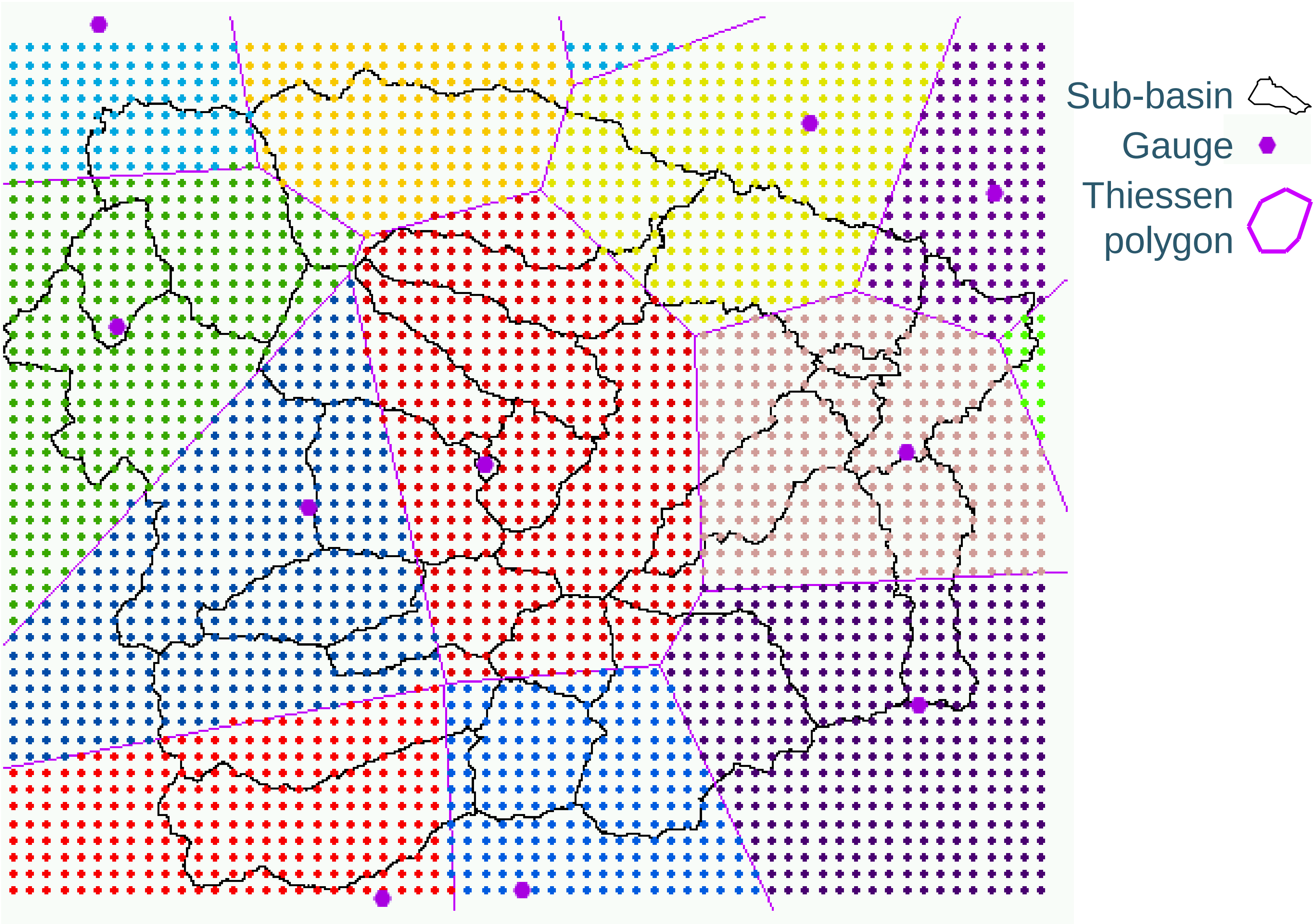
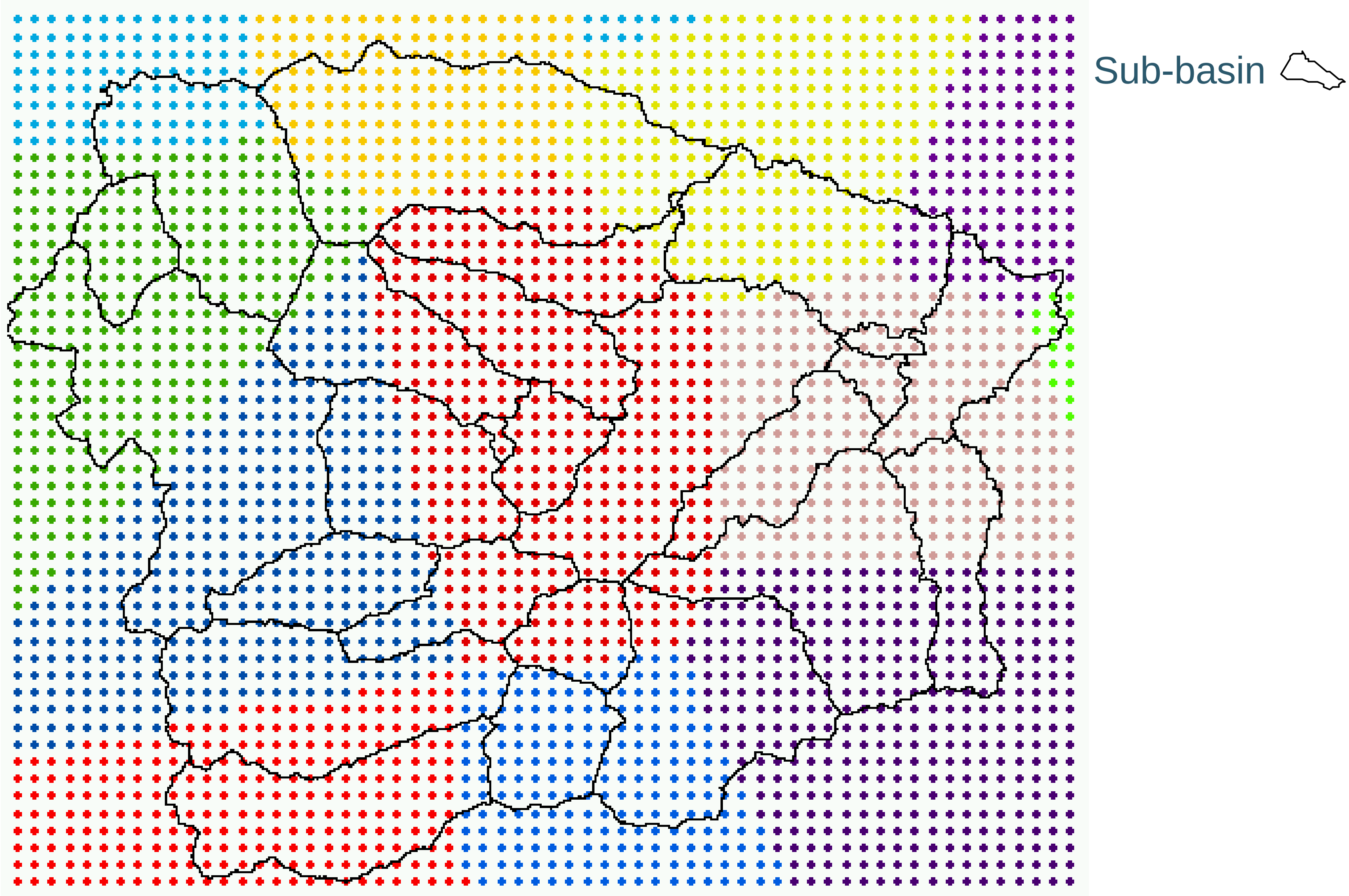


2.1 Thiessen polygons



2.2 Ordinary kriging

Requirements	Local conditions
Large number of measurement locations	16 rain gauges
Careful analysis of semivariograms	Daily timestep

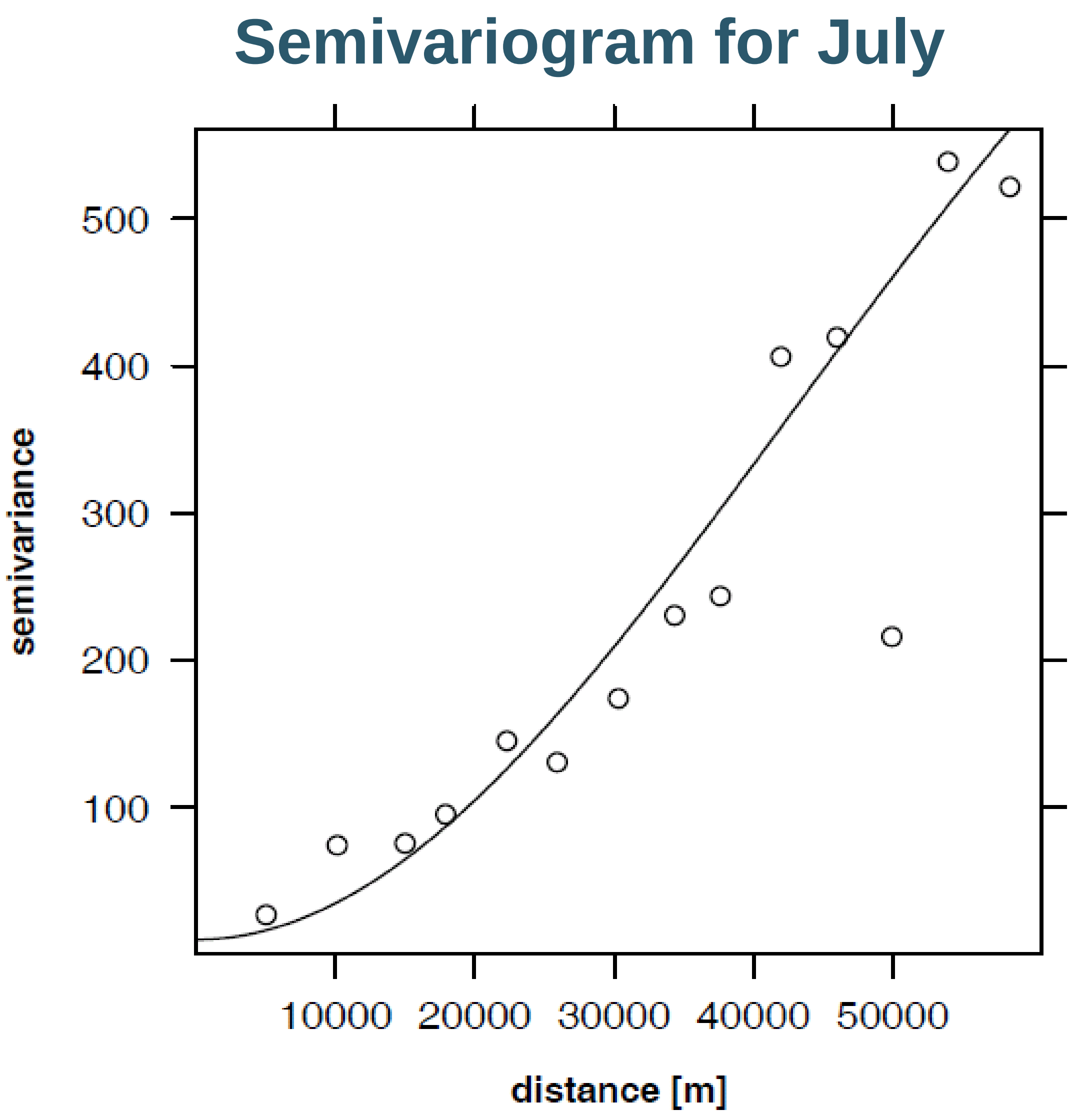
Rain Gauge: Pune

Month	Mean daily rainfall
Jul 1988	10.2
Jul 1989	6.4
Jul 1990	8.5
Jul 1991	6.7
Jul 1992	4.7
Jul 1993	6.0
⋮	⋮
Jul 2005	11.3
Jul 2006	13.7
Jul 2007	10.1

Pooling of mean daily values for every month and year

- 312 data sets (21 years * 16 gauges – missing values)
- 12 semivariograms

2.2 Ordinary kriging



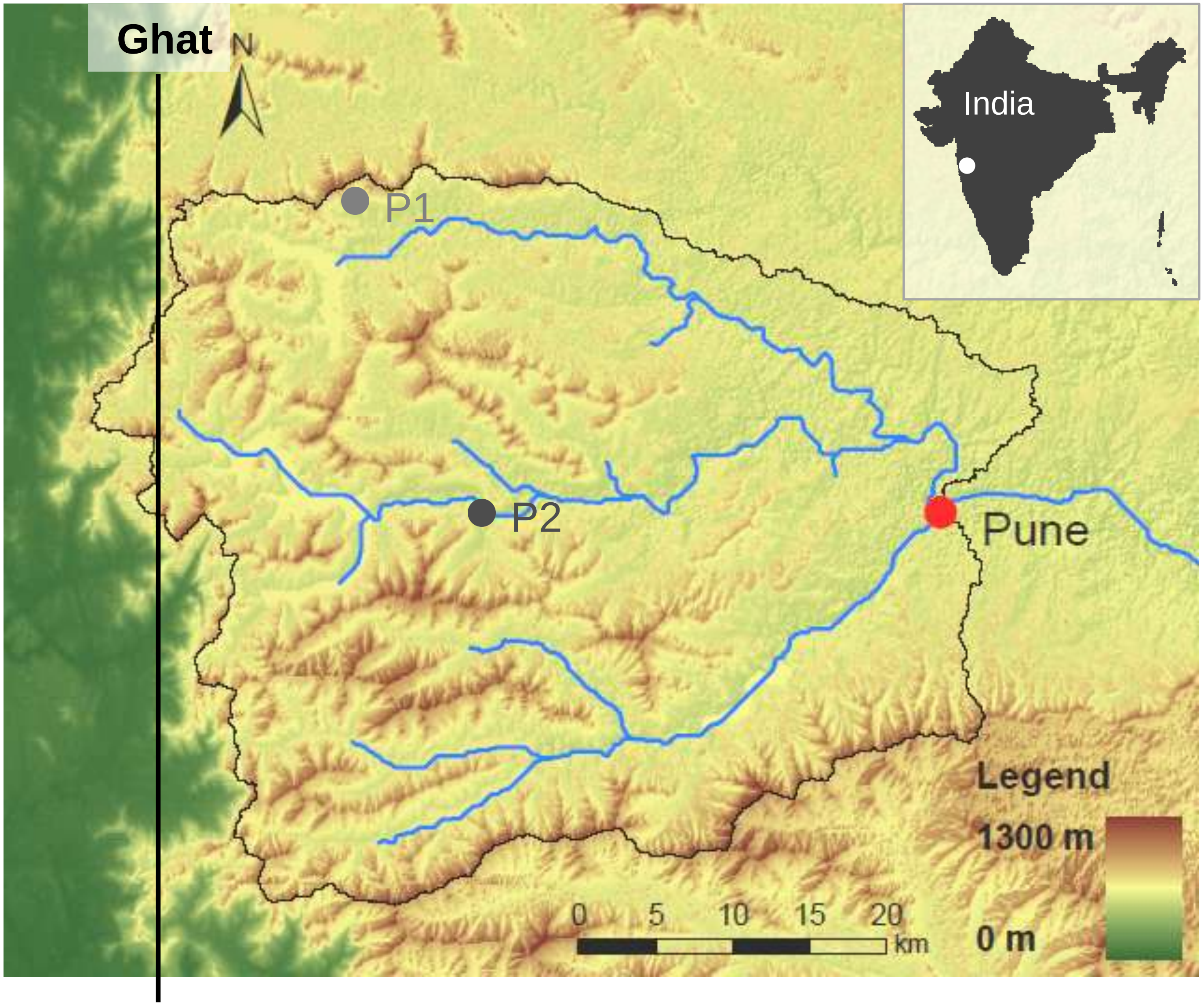
June – September:

Ordinary kriging

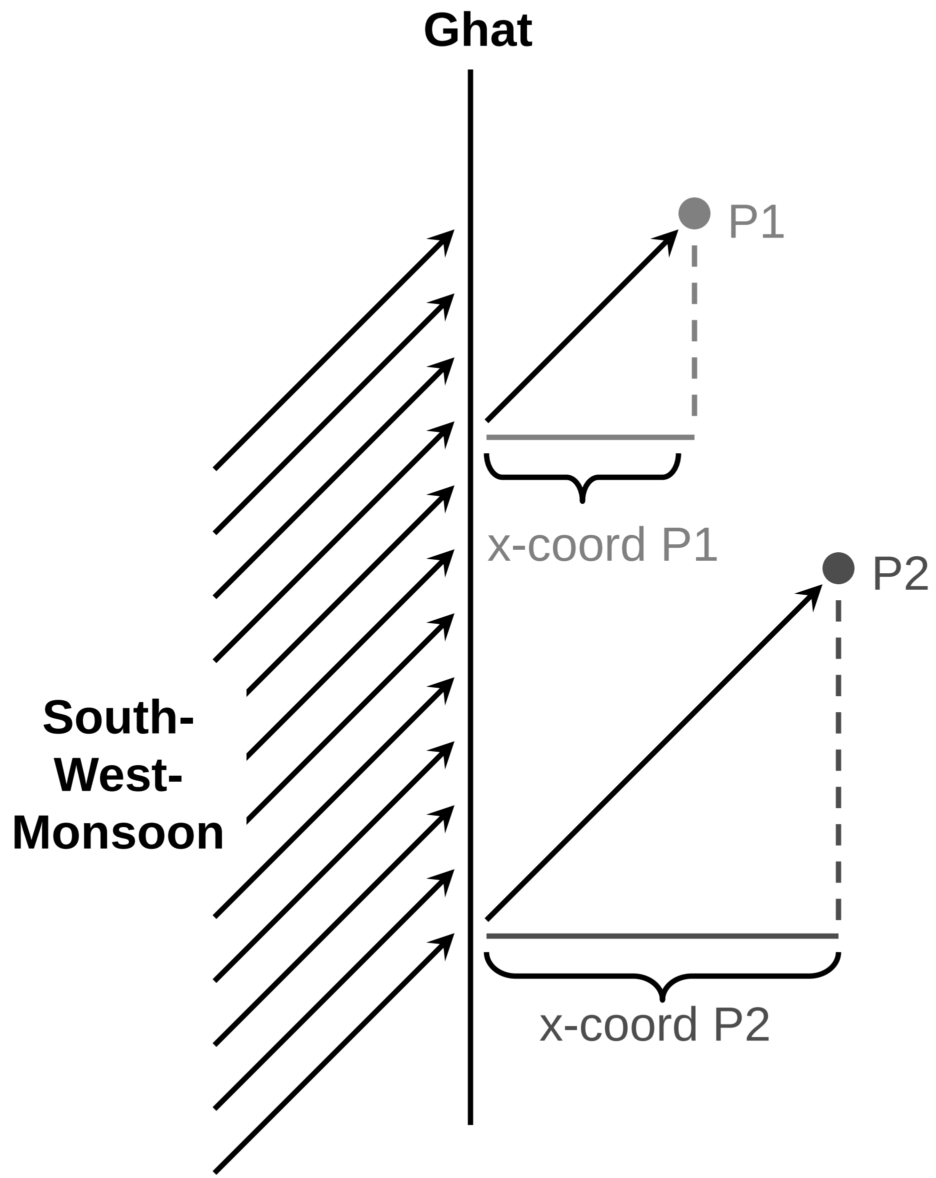
October – May:

Inverse distance weighting (IDW)

2.3 Regression method



2.3 Regression method

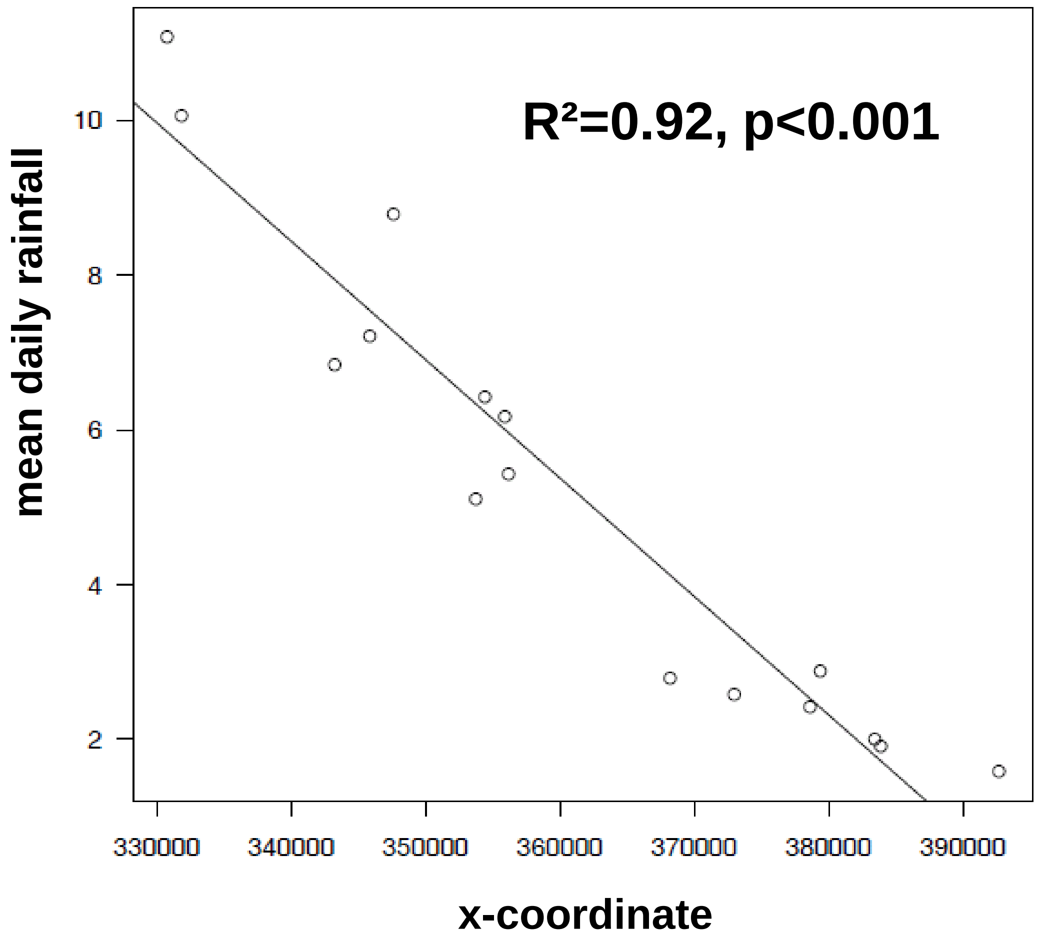


Precipitation decreases with distance in wind direction from the Ghat

X-coordinate represents this downwind fetch

2.3 Regression method

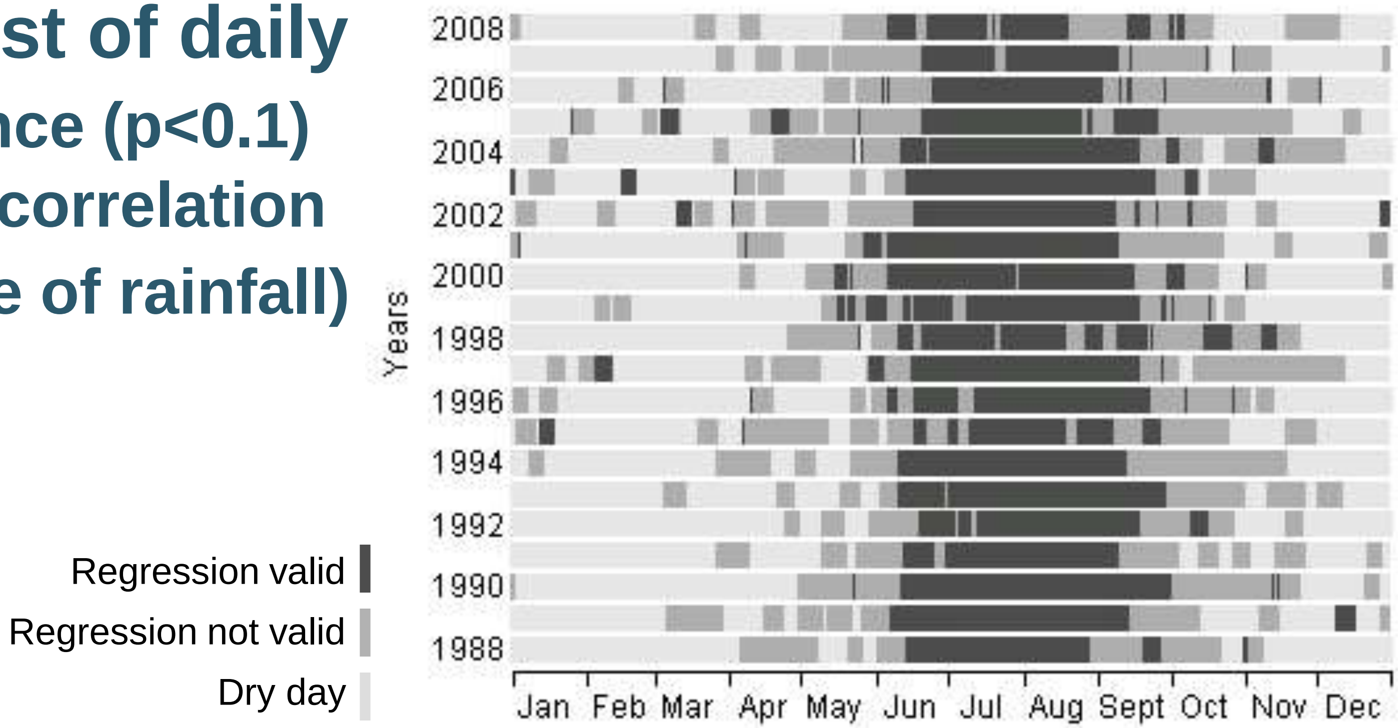
X-coordinate shows high correlation with precipitation



2.3 Regression method

1. Calculation of regression equation for every day, using a mean precipitation value for 7 days (+ - 3 days)

2. Validity test of daily
   a) significance (p<0.1)
   b) negative correlation (W-E decline of rainfall)



2.3 Regression method

Regression valid:

a) Calculate mean rainfall by regression equation

b) Interpolate the residuals with IDW

c) Add mean rainfall and interpolated residuals

Regression not valid:

Inverse distance weighting (IDW)

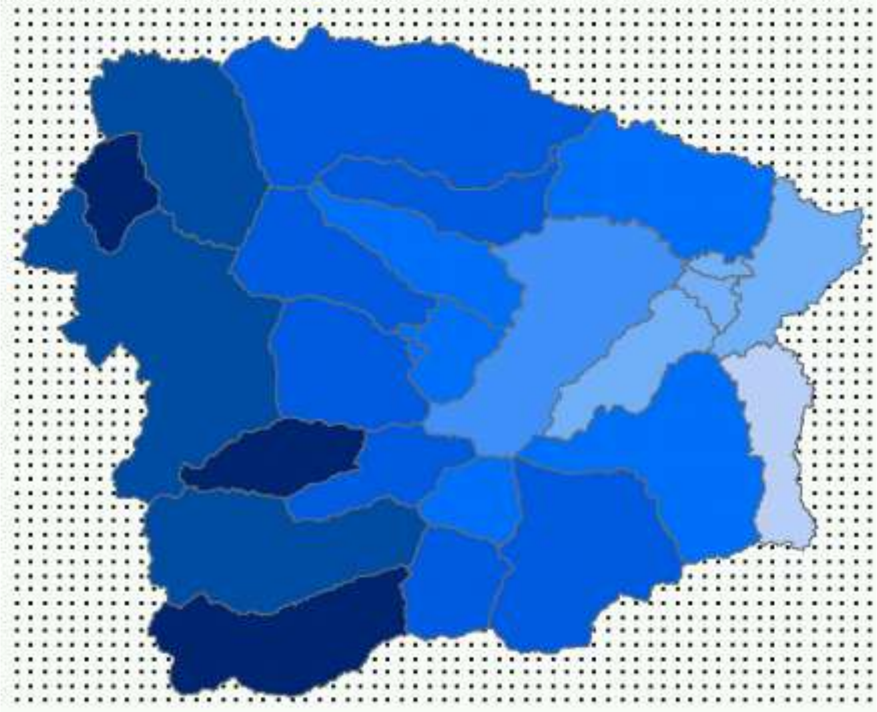
2.4 Evaluation

1. Cross-validation: Ability to reproduce measured precipitation data
2. Differences in model results:
   - water balance
   - runoff dynamics

2.4 Evaluation

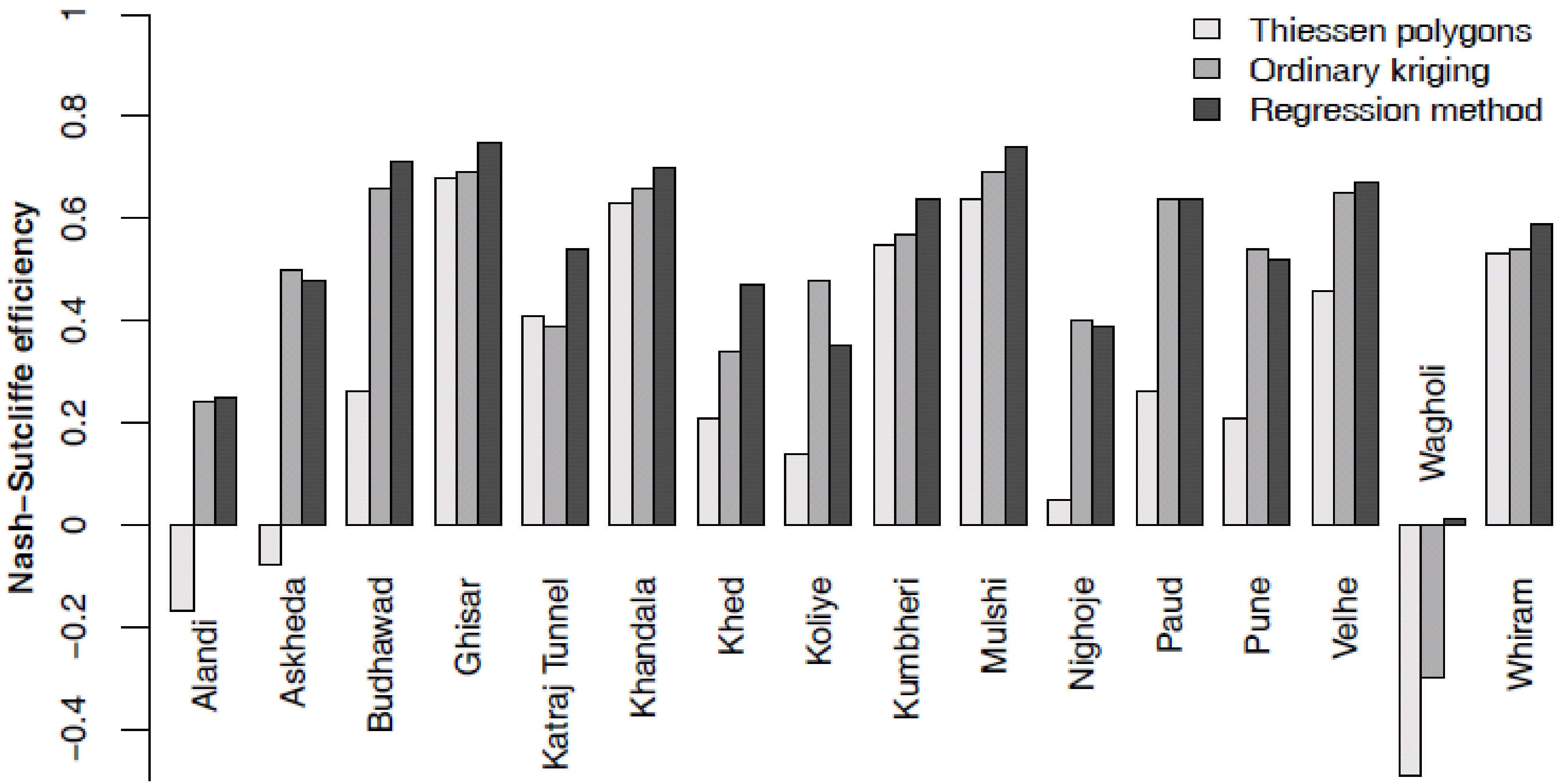
- SWAT model by Wagner et al. 2011, with different precipitation input

- Sub-basin precipitation input was derived as an average from 1 km² grid



3. Results

Cross-validation: Ability to reproduce measured precipitation



Regression method is most accurate, used as reference

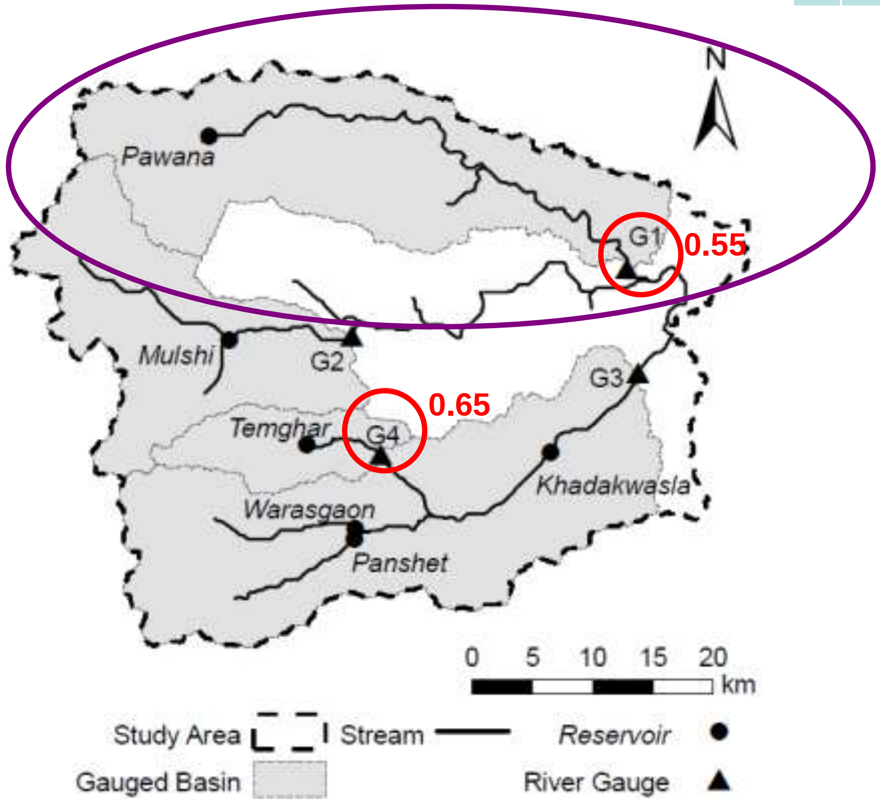
3. Results

Catchments‘ water balance

Interpolation scheme	Precipitation	Water yield	Evapo-transpiration
Thiessen polygons	2285 mm **(-2.3 %)**	1523 mm **(-2.4 %)**	691 mm **(-2.0 %)**
Ordinary kriging	2321 mm **(-0.7 %)**	1545 mm **(-1.0 %)**	706 mm **(+0.1 %)**
Regression	2338 mm	1560 mm	705 mm

3. Results

Runoff dynamics: Comparison with regression model run

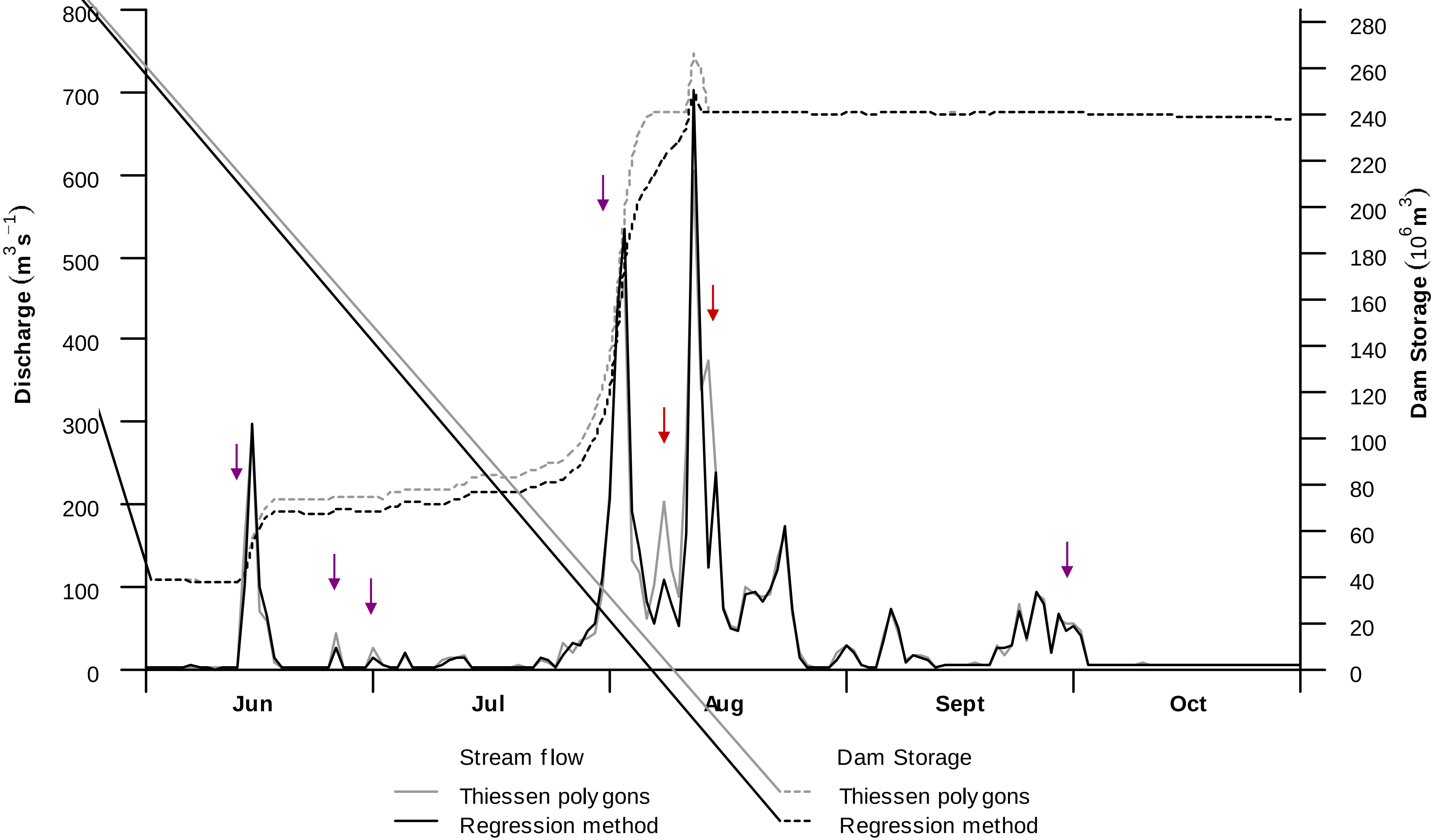


Nash-Sutcliffe efficiency at gauges

Interpolation scheme	G1	G4
Thiessen polygons	0.96	0.92
Ordinary kriging	0.99	0.98

3. Results

Runoff at G1 in rainy season 2004



4. Conclusions

- **More complex methods perform better**
- **Catchment‘s modeled water balances is less affected by the interpolation method**
  - ***Thiessen polygons are sufficient***
- **Runoff dynamics are more affected by the interpolation method**
  - ***Complex methods should be used***
- **Kriging based on pooled variograms performed almost as good as the regression approach**
  - ***Alternative for application in other catchments***

Thank you very much for your attention!

Questions welcome…

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