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Application of a Nearest Neighbour Method to a Conceptual Rainfall-Runoff Model

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Outline of the Talk

1. Motivation & Objective
2. Study area
3. Methodology
4. Discussions & Outlook

Parsimony is a principle:

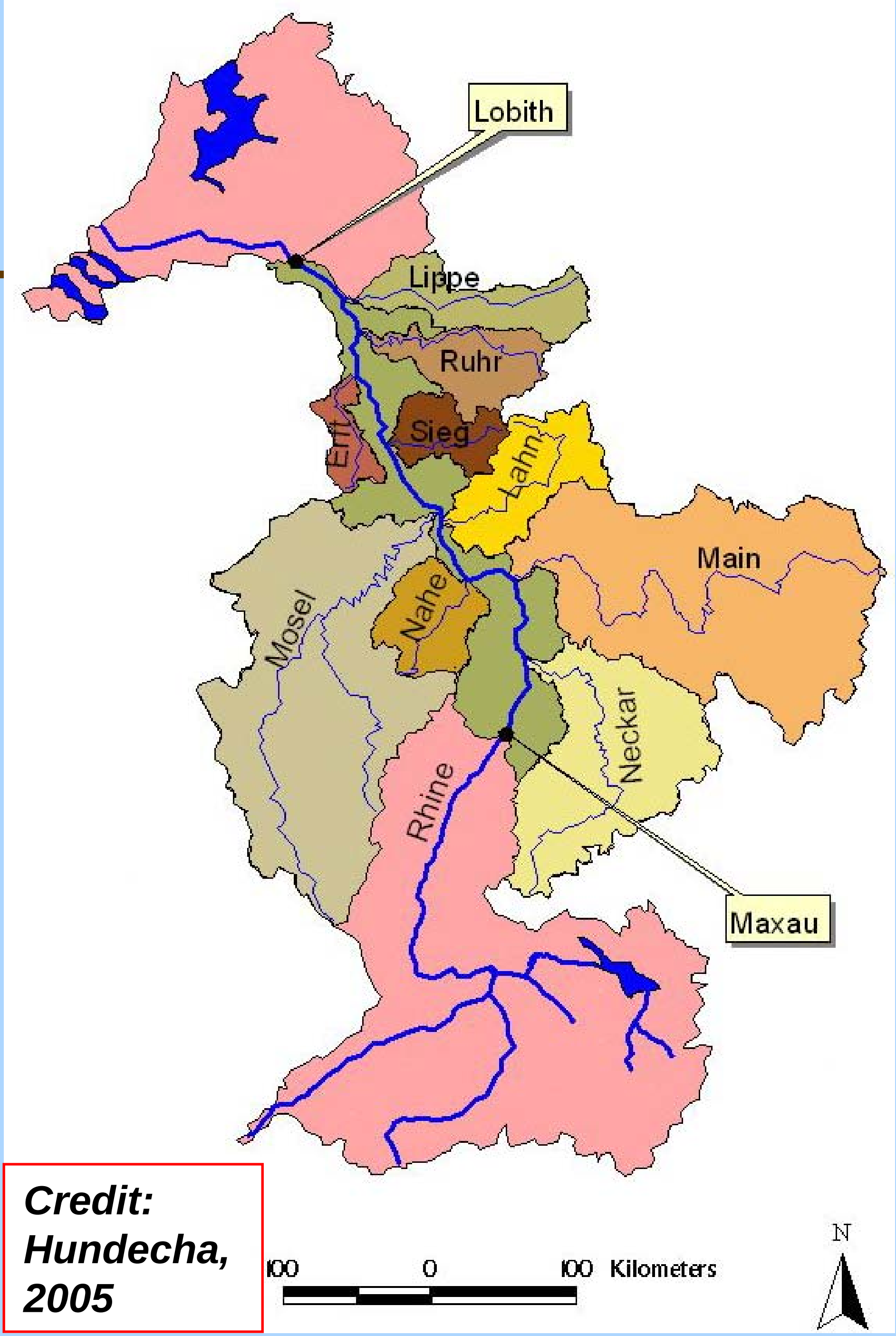
The simplest explanation that explains the greatest number of observations is preferred to more complex explanations.

Study Domain

Entire German Section of the Rhine Basin

109,330 km^2

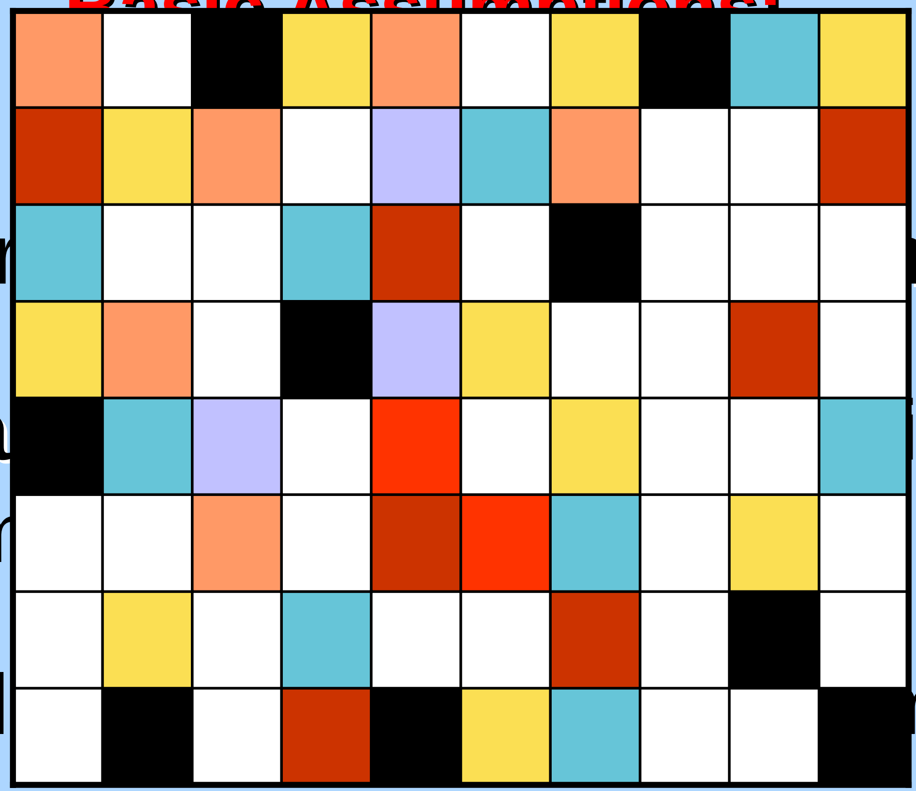
12 sub-basins;
101 catchments



Credit: Hundecha, 2005

Nearest Neighbor Method 5

Basic Assumptions:



Similar ... **nilarly**

Simila ... ith

catchm

Model ... nilarity

as in this example...

Application in Hydrology 6

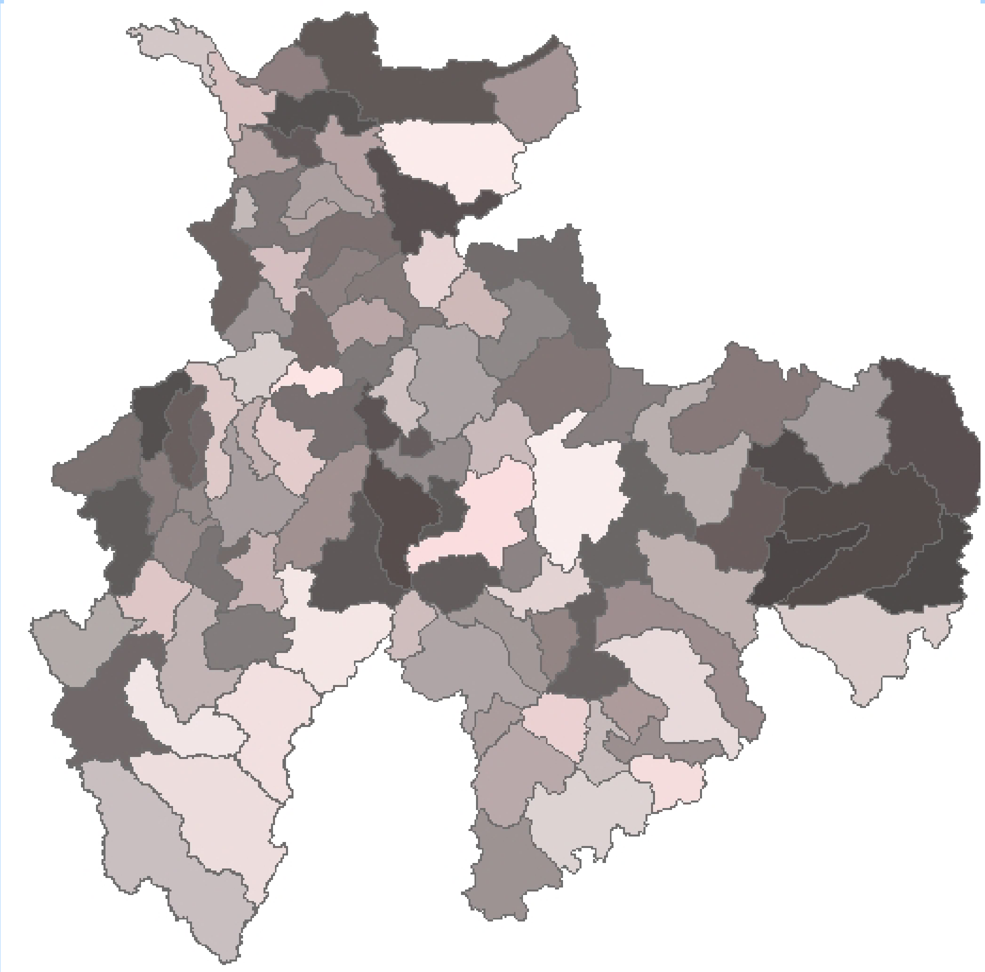
Using

Hydrological Units

i.e.

- **CATCHMENTS** -

& Considering them as Neighbors



Application in Hydrology *cont.* 7

$$U = B \cdot [X]$$

$$if \;\; U_1 \approx U_2 \;\; and \;\; [V_1] \approx [V_2]$$

$$then \; f(X_1 / V_1) \approx f(X_2 / V_2)$$

$$\bar{Q}_1 \Leftrightarrow \bar{Q}_2 ,$$

$$std(Q_1) \Leftrightarrow std(Q_2)$$

[**V**]: HBV-IWS model parameters

$$Q_{sim} = f(X_{k=1,K} / V_{i,i=1,I})$$

Propose: **non-parametric approach**, use a transformation matrix **B**

[**X**]: independent and readily available catchment attributes, e.g. area, shape, slope, soil, etc.

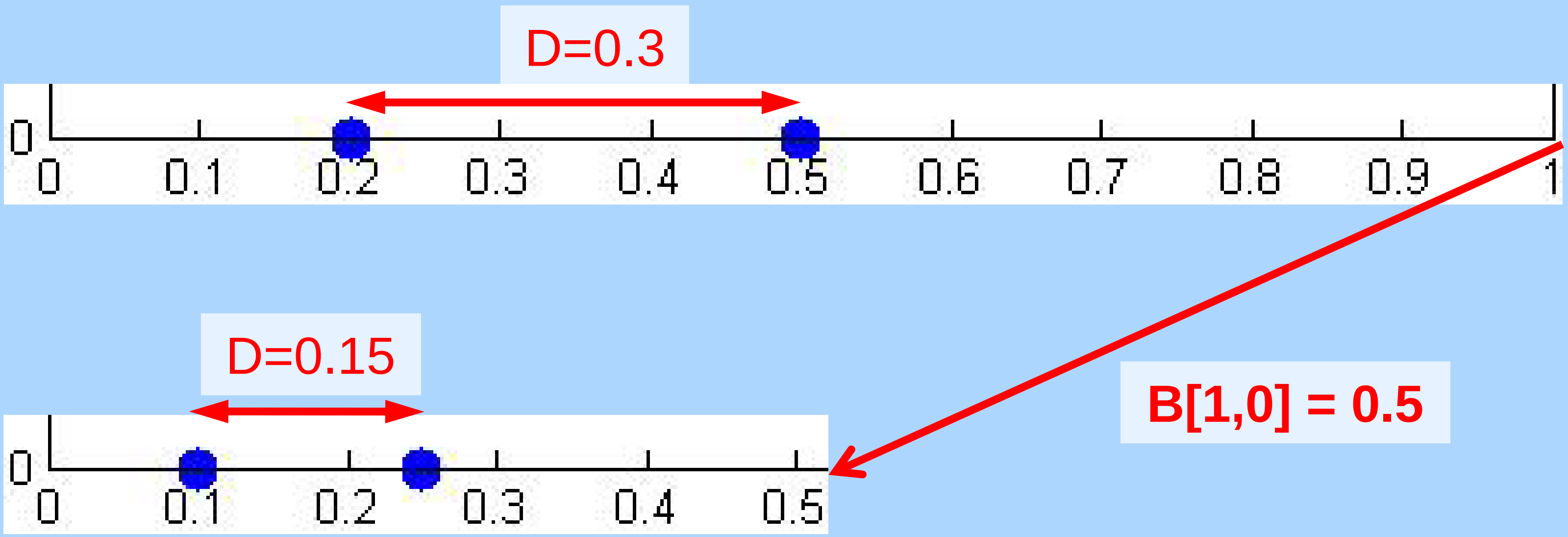
- Close distance/Similarity of Y=***f***(X,V)
- Close distance/Similarity of U =**B**(X)
- A non-parametric matrix **B** is to mimic the ***f*** and in the mean time maintain the distance between a pair of catchments' responses.

B

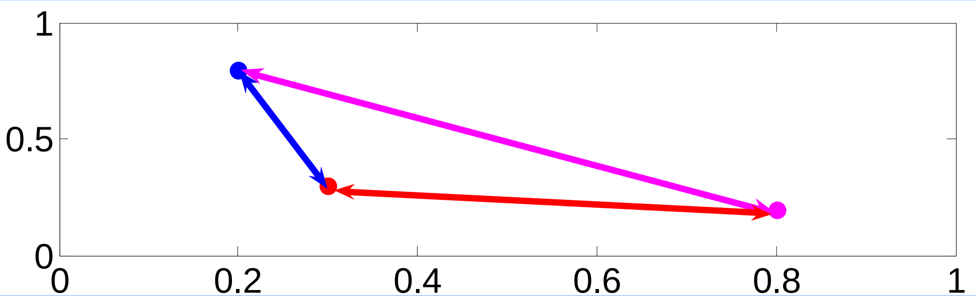
Bridging the gap…

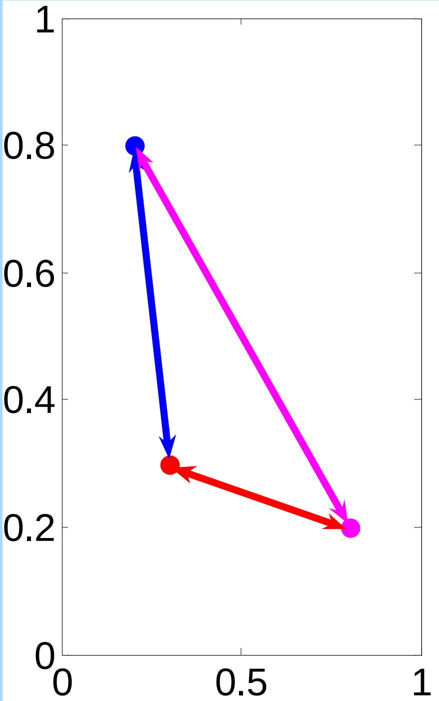
- Be careful! Not to do modeling directly with **B**, rather to reproduce a similarity by introducing **B**.

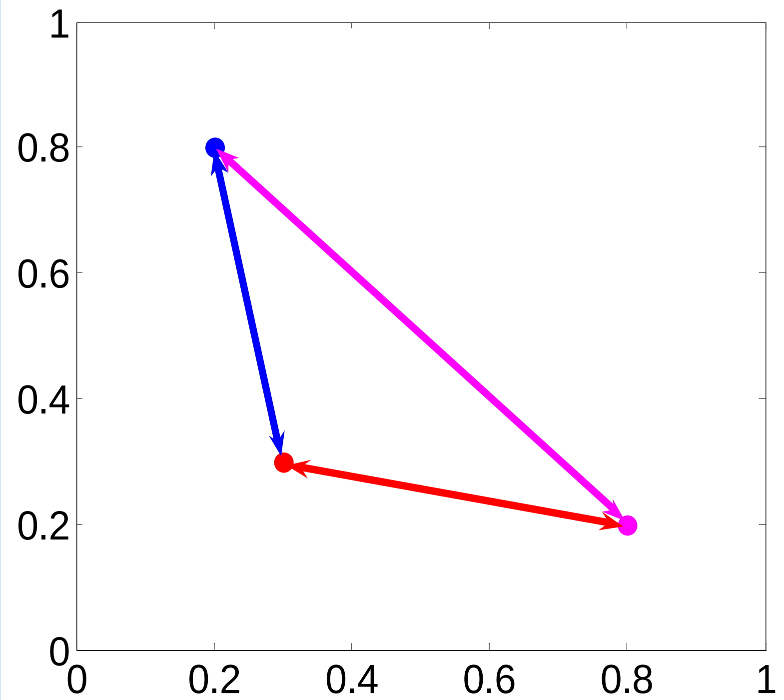
Transformation Matrix **B**



Transformation Matrix B



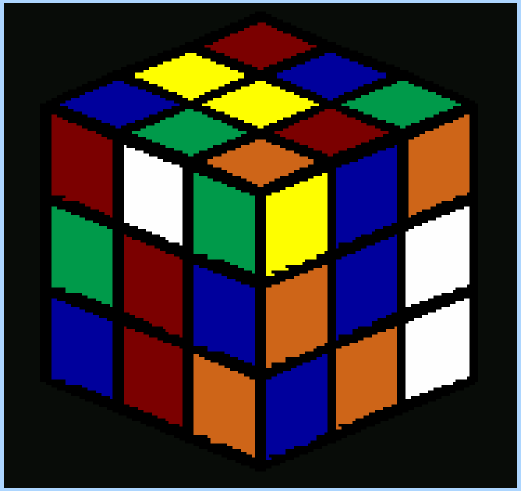




Transformation Matrix B *cont.* 11

ONE MORE EXAMPLE

Rubik‘s Cube



Application in Hydrology *cont.* 12

BA's Third Law:

Original Space

Models are able to capture similarity

$$Y = f(X_{k=1,K} / V_{i,i=1,I})$$

$$if\ [X_1] \approx [X_2]\ \&\ [V_1] \approx [V_2]$$
$$then\ Y_1 \approx Y_2$$

Transformed Space

distance

$$U = B \cdot [X]$$

$$if\ [X_1] \approx [X_2]$$
$$then\ U_1 \approx U_2$$

Transformation Matrix B *cont.* 13

X [9 *para*, 22 *catch.*]

1. Drainage Ar

2. Annual Mea … p.(1982-88);

…gt

7. Urban area;

8. Agricultural land;

9. Water Bodies

B(1,1) B(1,2) … B(1,9)
B(2,1) B(2,2) … B(2,9)
B(3,1) B(3,2) … B(3,9)
B(4,1) B(4,2) … B(4,9)

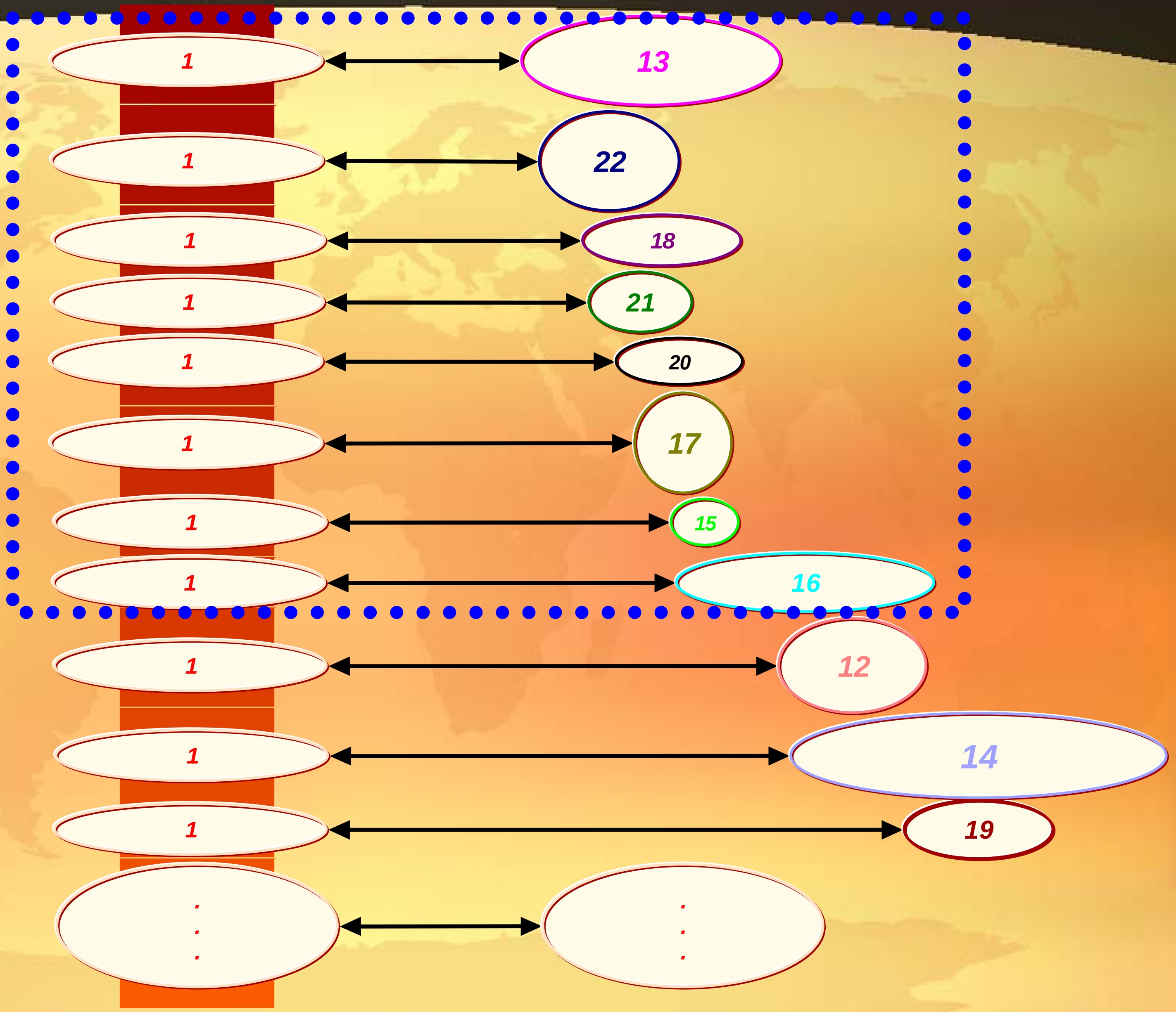
x

X(1,1) X(1,2) … X(1,22)
X(2,1) X(2,2) … X(2,22)
X(3,1) X(3,2) … X(3,22)
X(4,1) X(4,2) … X(4,22)
X(5,1) X(5,2) … X(5,22)
X(6,1) X(6,2) … X(6,22)
X(7,1) X(7,2) … X(7,22)
X(8,1) X(8,2) … X(8,22)
X(9,1) X(9,2) … X(9,22)

=

U(1,1) U(1,2) … U(1,22)
U(2,1) U(2,2) … U(2,22)

Sorted Distance (accending)



Application in Hydrology *cont.* 15

1st attempt:

$$D = \sum (NS_i - NS_j) \rightarrow \min$$

FC, DD, β, α, K_1, K_2, K_{PERC}, MAXBAS

2nd attempt:

$$D = \sum ({}_{sim}ET_i - {}_{sim}ET_j) \rightarrow \min$$

FC, DD, β, TT, C_E, PWP

3rd attempt:

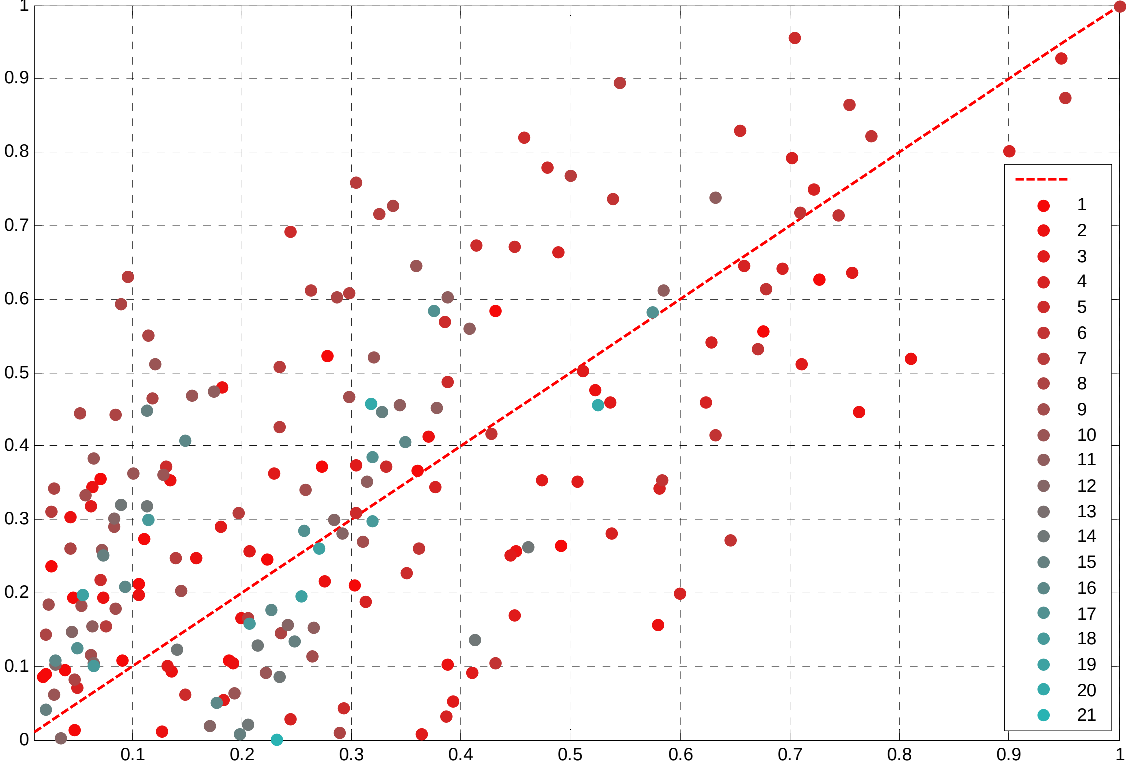
$$D = \sum ({}_{sim}Q_i - {}_{sim}Q_j) \rightarrow \min$$

FC, DD, β, TT, C_E, PWP

α, K_1, K_2, K_{PERC}, MAXBAS

4th attempt:

$$D = \sum ({}_{obs}Q_i - {}_{obs}Q_j) \rightarrow \min$$



BEFORE Optimizing B

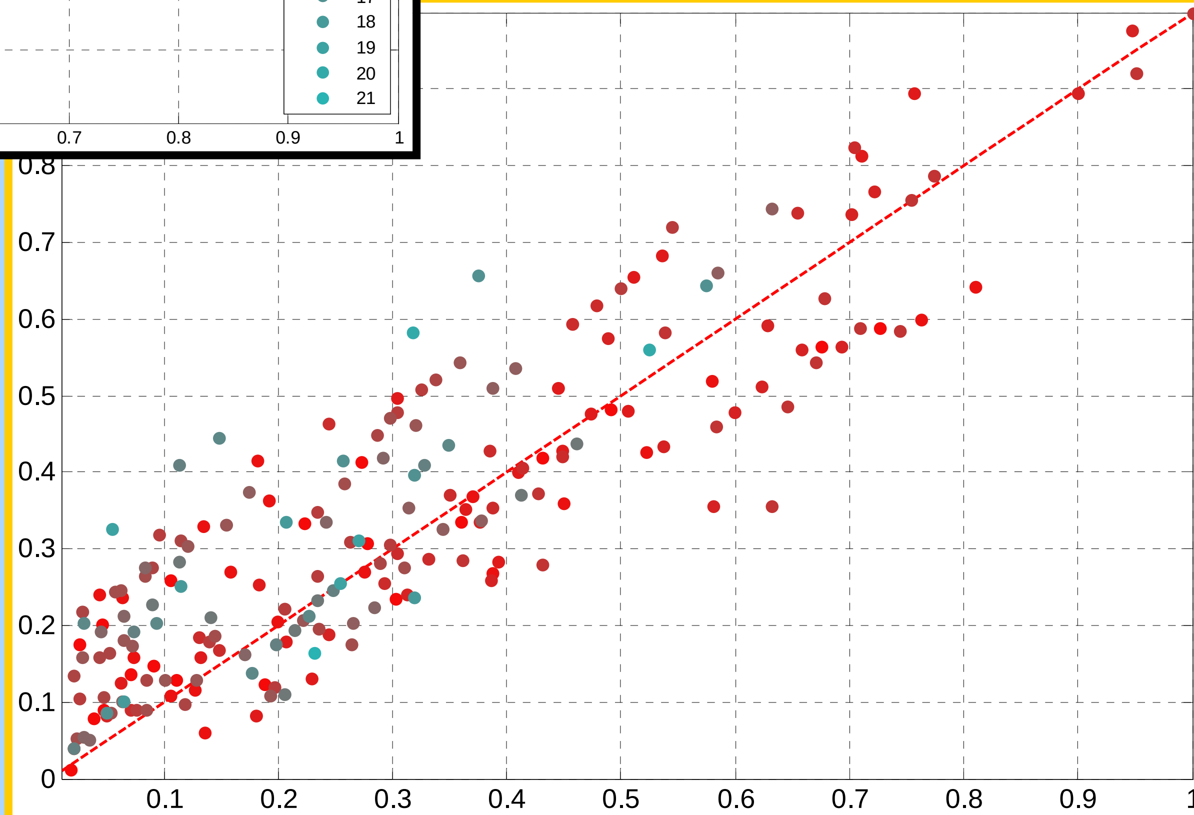
3rd attempt:

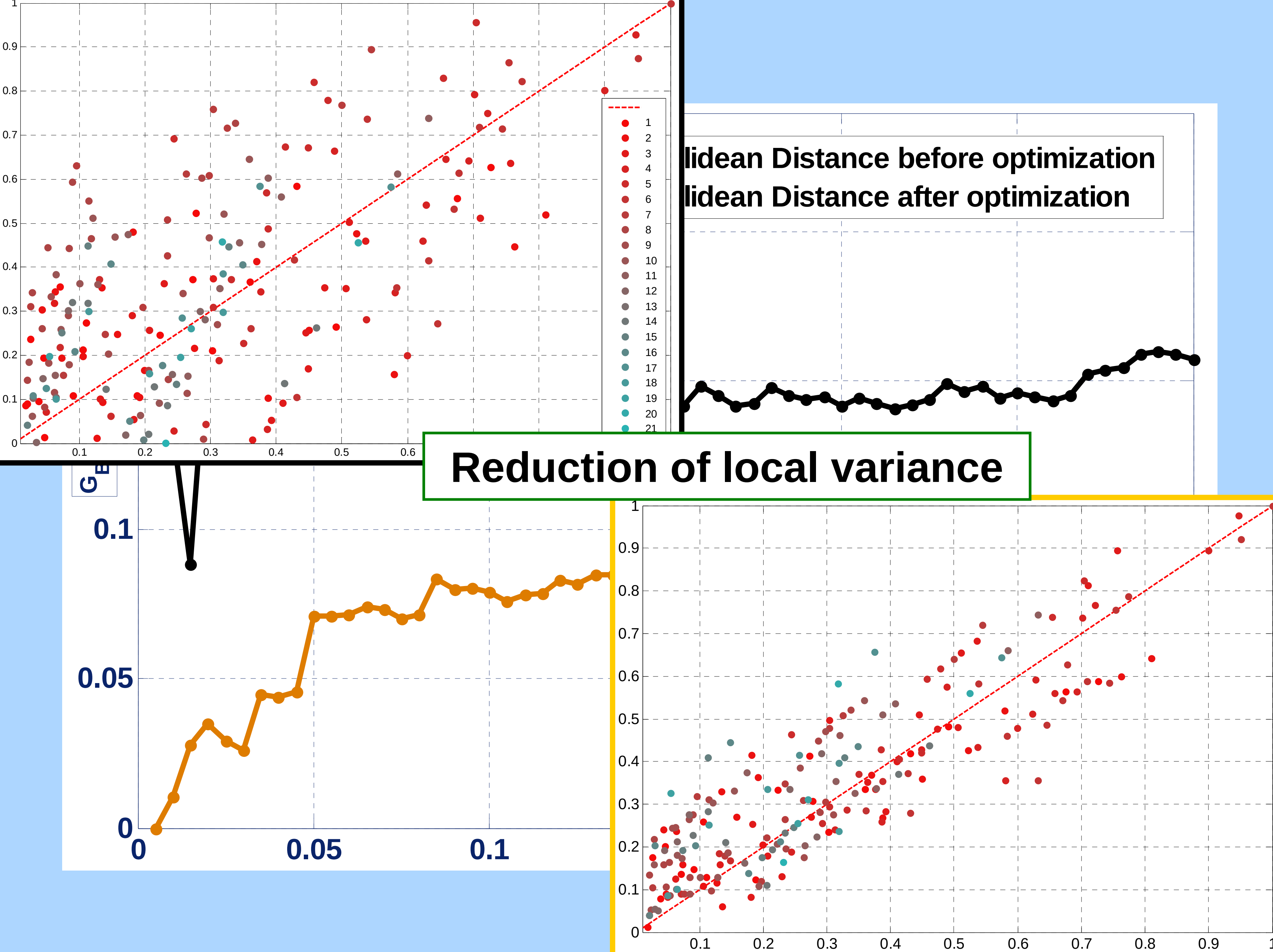
FC, DD, β, TT, C_E, PWP

α, K_1, K_2, K_{PERC}, MAXBAS

$$D = \sum \left({}_{sim}Q_i - {}_{sim}Q_j \right) \rightarrow \min$$

AFTER Optimizing B




Reduction of local variance
lidean Distance before optimization
lidean Distance after optimization
0
0.05
0.1
0
0.05
0.1
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

Discussions *cont.*

Entire catchment's response forms the criteria for selecting neighbors

$$Q = f(X_{k=1,K} / V_{i,i=1,I})$$

A partial catchments' or a component response, eg. P_{eff} or ET_A

$$PE_A = f(X_{k=1,K} / V_{i,i=1,I})$$

A model parameter

$$DD = f(X_{LANDUSE})$$

$$\alpha = f(X_{LANDUSE} / X_{SOIL})$$

Discussions *cont.*

- To improve the robustness of the ***B***, more catchments with a variety of characteristics should be used to identify the ***B***.
- Validation will be carried out in the near future to further verify the efficacy and transferability of the proposed methodology.
- Uncertainties based on the proposed method shall also be quantified

We come nearest to the great when we are great in humility

- Tagore, Rabindranath