



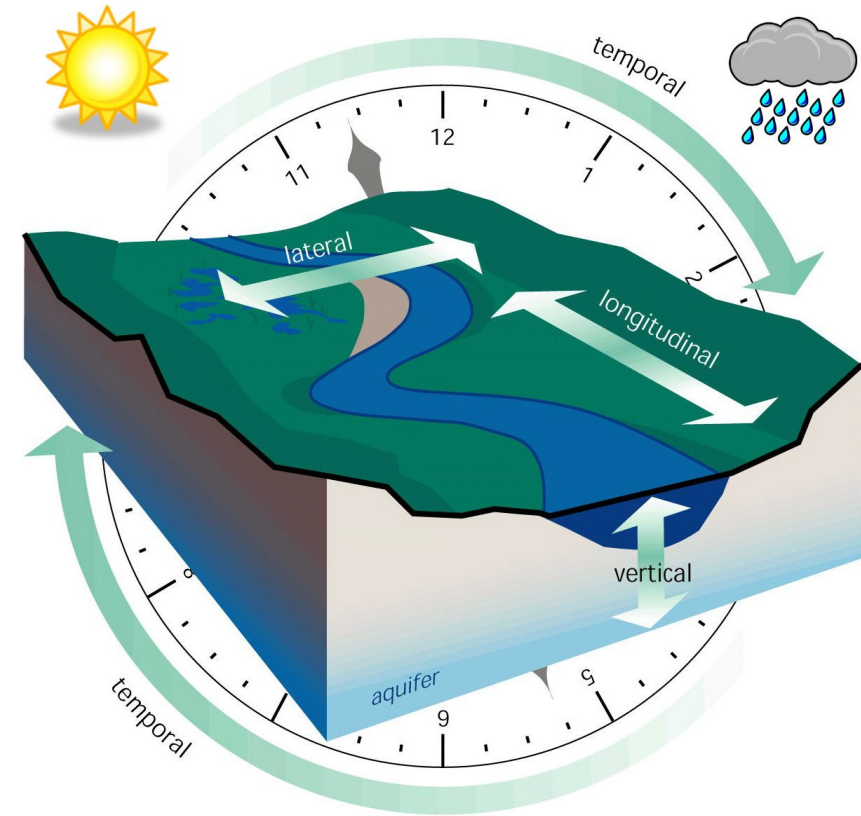
# RNConnect

A new tool for river network connectivity assessment

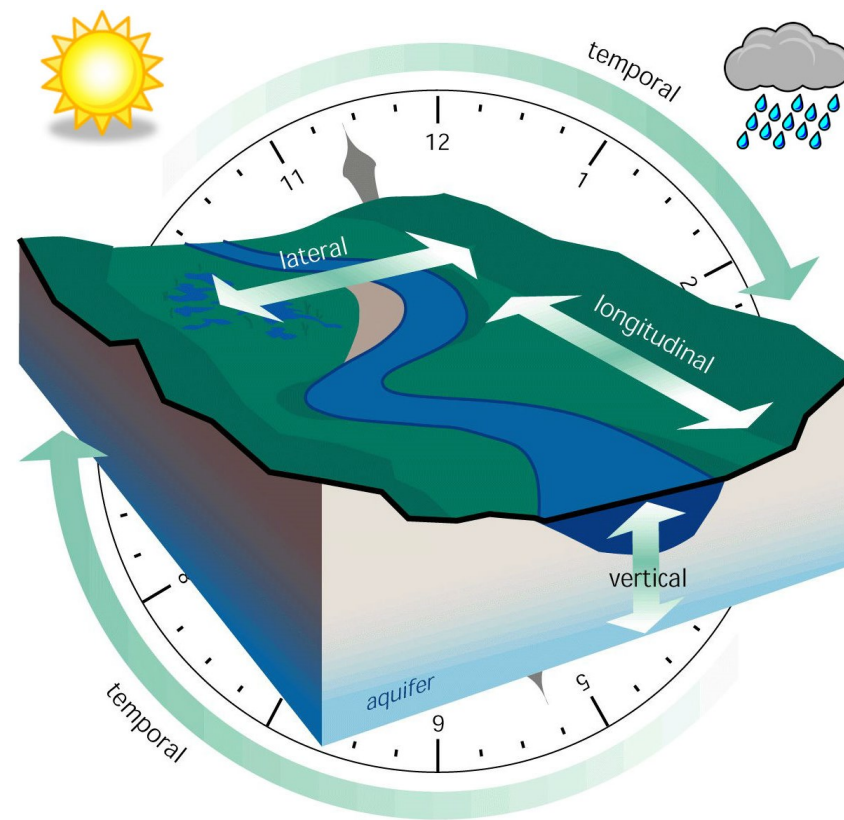
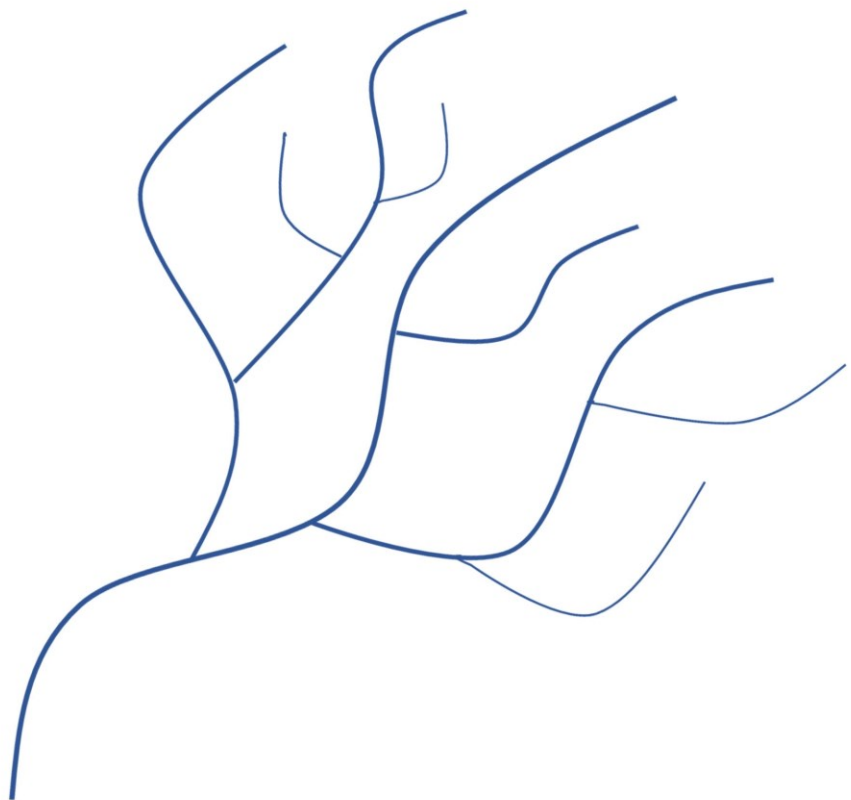
Gonçalo Duarte

*Tamara Leite, Daniel Mameri, Pedro Segurado, Maria Teresa Ferreira & Paulo Branco*

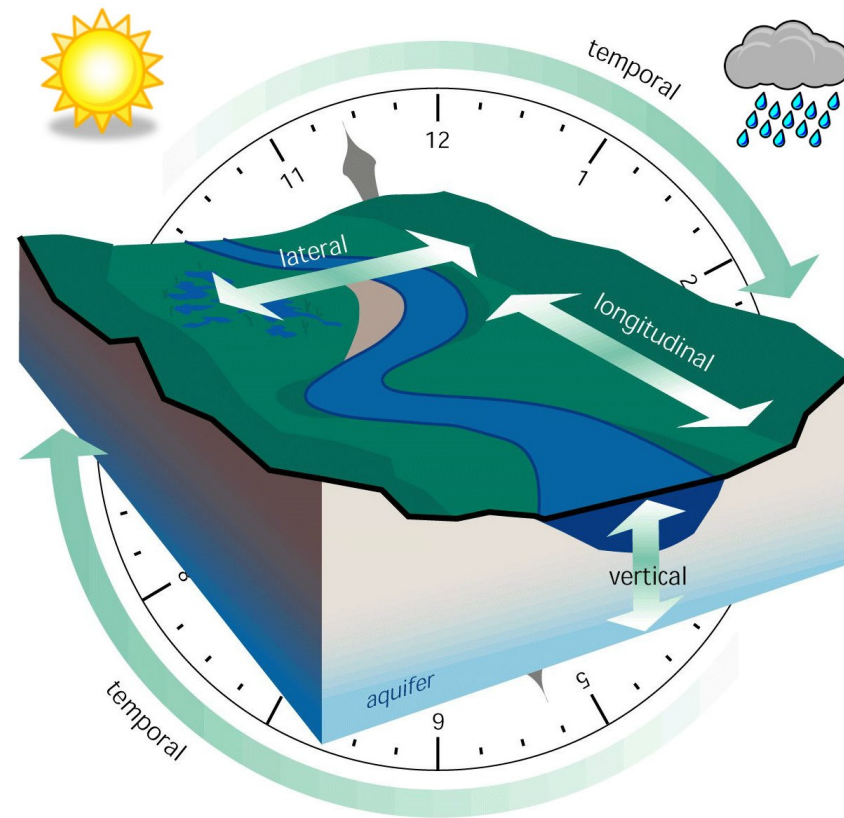
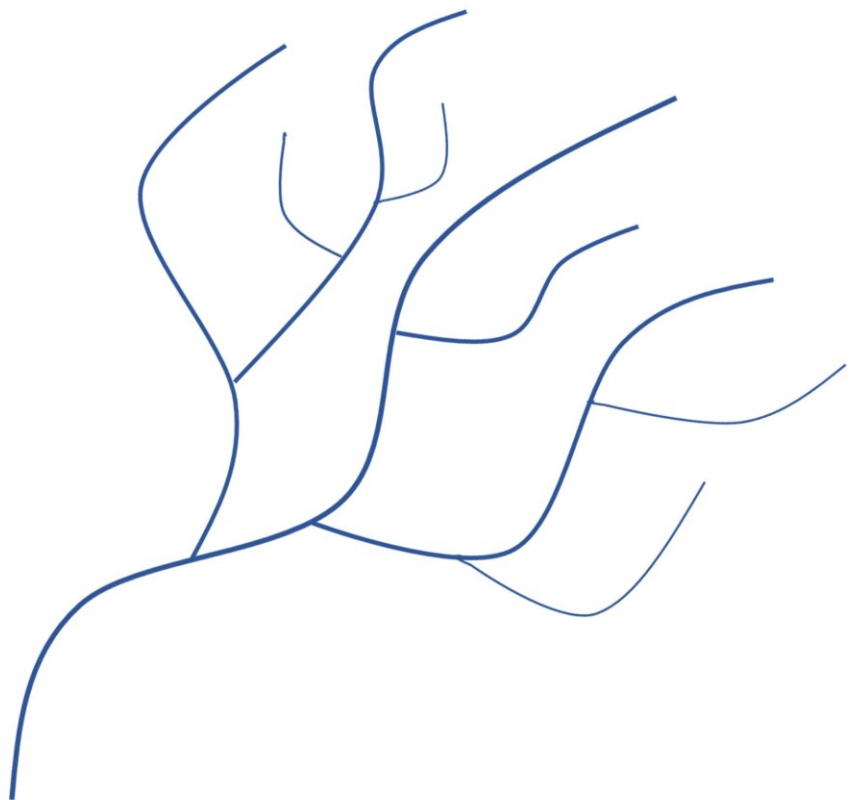
- Connectivity is a crucial attribute of riverscapes



- Connectivity is a crucial attribute of riverscapes
- Longitudinal is the most relevant for freshwater fish



- Connectivity is a crucial attribute of riverscapes
- Longitudinal is the most relevant for freshwater fish



**Calculation solutions exist but...**

**not user friendly**

**OBJECTIVE**

**Build a user-friendly and fast app to enable calculating multiple longitudinal connectivity metrics along rivers**

**Fast performing user-friendly app to work with river networks**

**Adequate platform to develop new plug-ins**



**<http://rivtoolkit.com/>**

**RIV**Connect

## Functions:

- Connectivity Basic Stats
- Connectivity Fragment basic stats
- Probability of Connectivity
- Dendritic Connectivity Index diadromous
- Dendritic Connectivity Index diadromous
- combined Dendritic Connectivity Index
- Flux
- Area Weighted Flux
- Length Weighted Flux
- Integral Index of Connectivity
- Harary Index
- Betweenness centrality

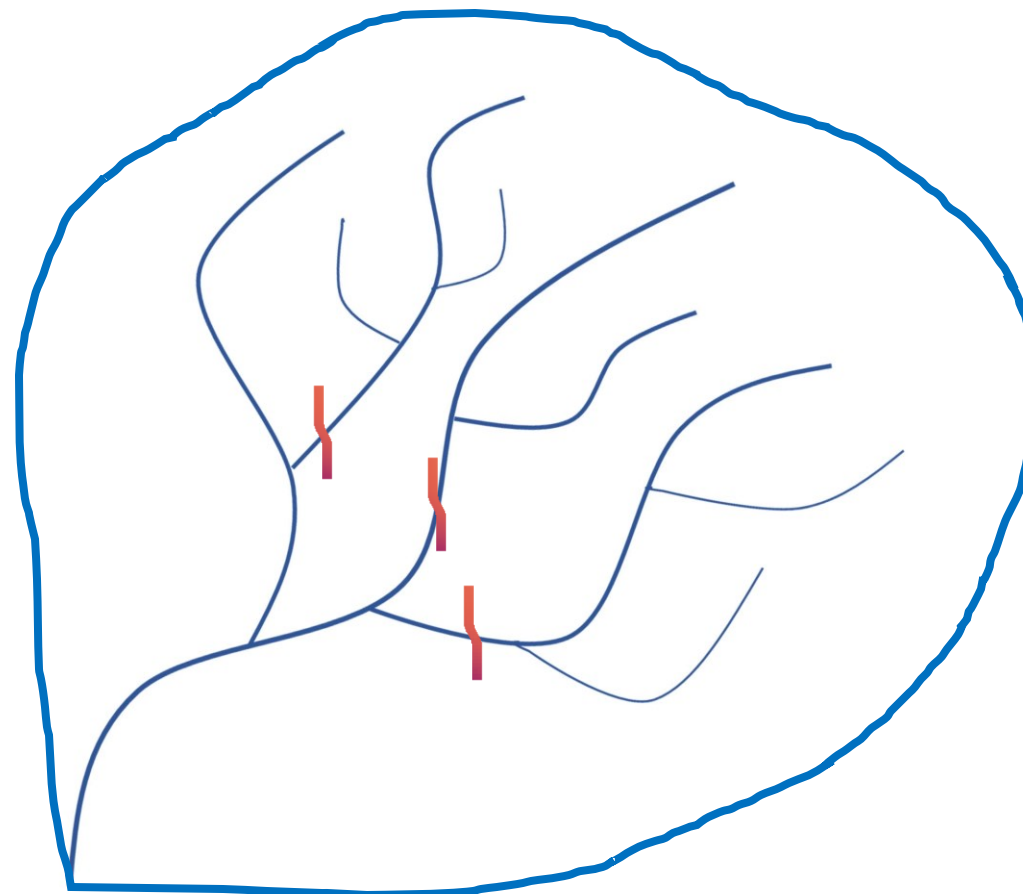
**2 basic stats functions**



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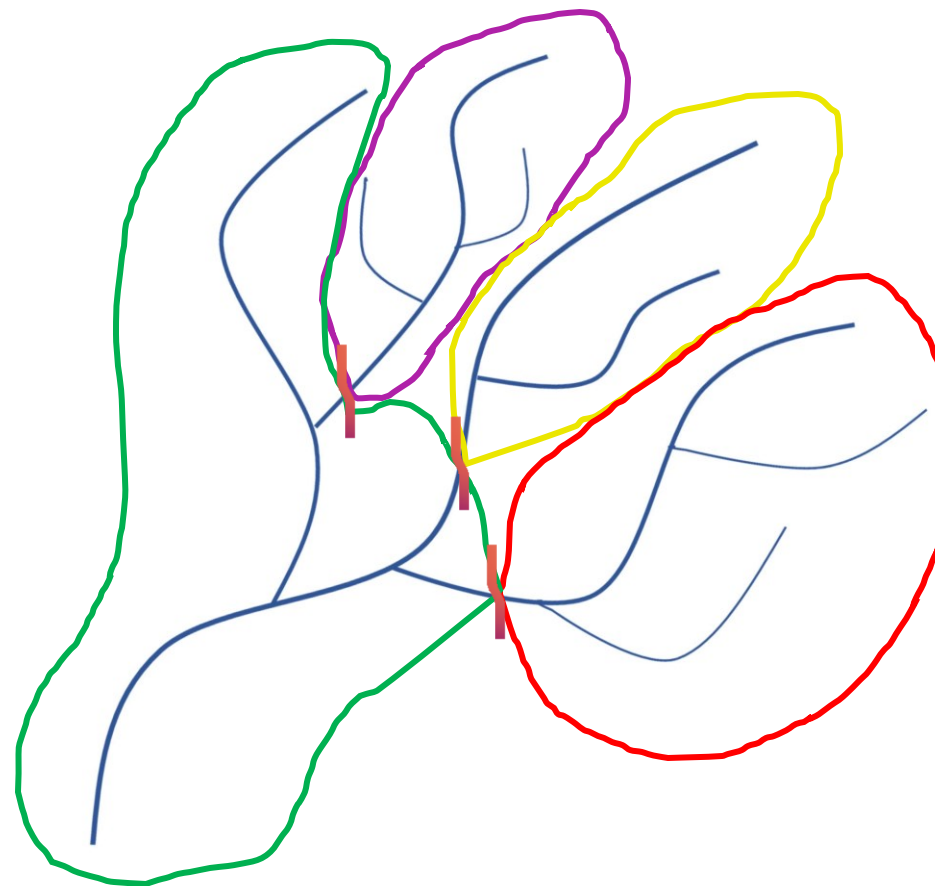
Calculates number of fragments, barriers, segments (nodes) & connections (between segments) per river network



## Functions:

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Calculates length, area, number of segments & connections per fragment with a river network



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**2 basic stats functions + 10 Indexes**

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**Provide outputs per river basin**

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**Provide outputs per river basin**

**Provide outputs per fragment within a river basin**

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**Provide outputs per river basin**

**Provide outputs per fragment within a river basin**

**Provide outputs per barrier**

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Use drainage area has weighing value

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Use drainage area has weighing value

Use river length has weighing value



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Use drainage area has weighing value

Use river length has weighing value

No weighing value

## Functions:

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Probability of Connectivity

$$PC = \frac{\sum_{i=1}^n \sum_{j=1}^n a_i \cdot a_j \cdot p_{ij}^*}{A_L^2}$$

← Using drainage area

Dendritic Connectivity Index diadromous

$$DCI_p = \sum_{i=1}^n \sum_{j=1}^n c_{ij} \frac{l_i l_j}{L L}$$

← Using river length

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← Using river length

**Allow user-defined variable**

Functions:

- CBS
- CFBS
- **PC**
- **DCId**
- **DCIp**
- **cDCI**
- **Flux**
- **AWF**
- **LWF**
- **IIC**
- **H**
- BC

Probabilistic connection



Binary connection

Probability of Connectivity

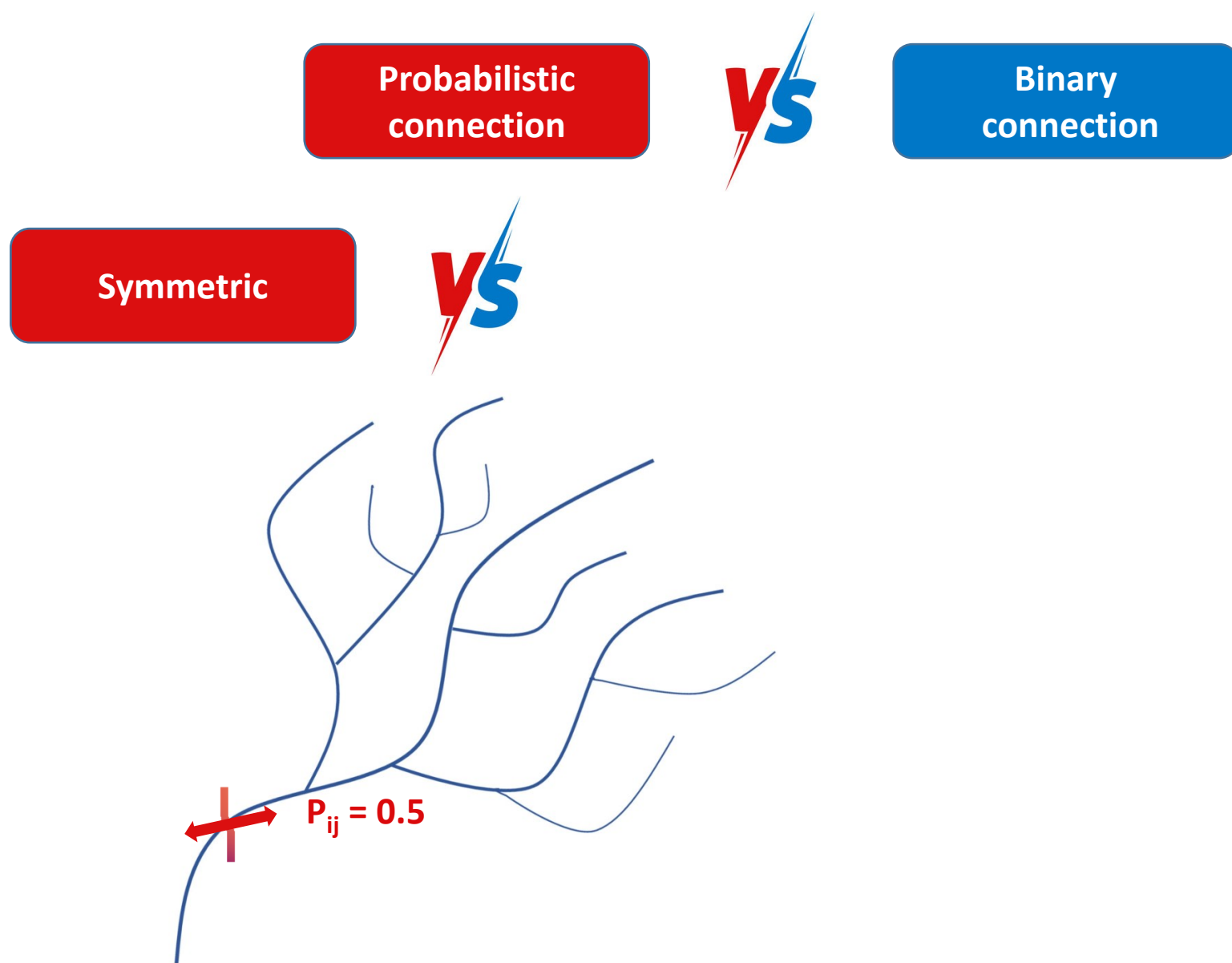
$$PC = \frac{\sum_{i=1}^n \sum_{j=1}^n a_i \cdot a_j \cdot p_{ij}^*}{A_L^2}$$

Integral Index of Connectivity

$$IIC = \frac{\sum_{i=1}^n \sum_{j=1}^n \frac{a_i \cdot a_j}{1 + nl_{ij}}}{A_L^2}$$

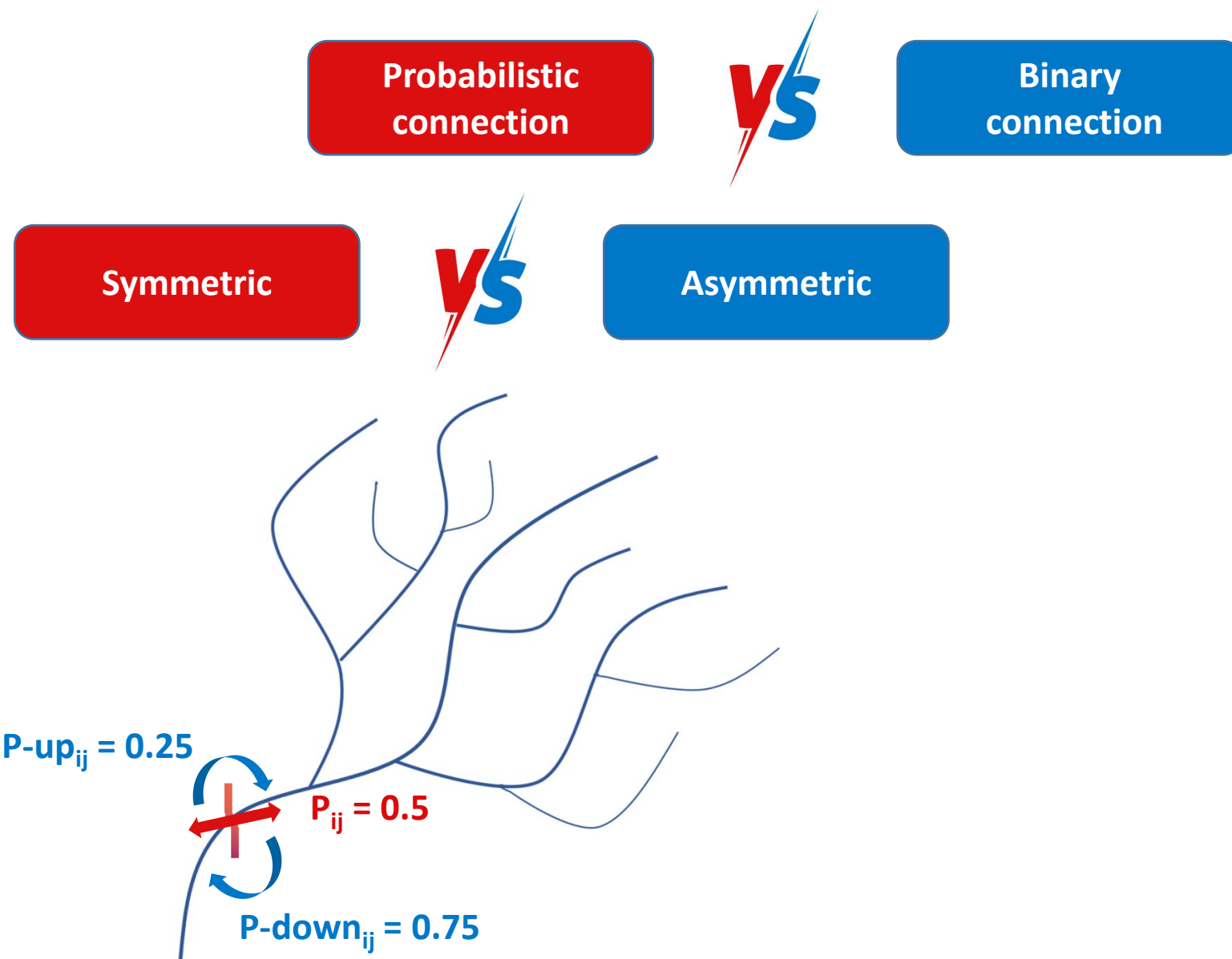
Functions:

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Probabilistic connection

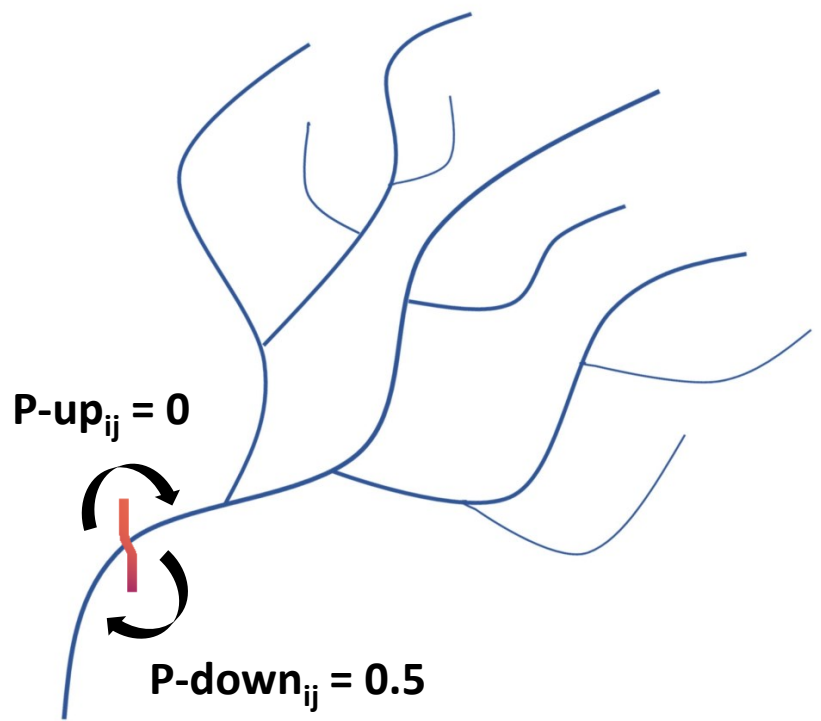


Binary connection

Symmetric



Asymmetric



Functions:

- CBS
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Probabilistic connection

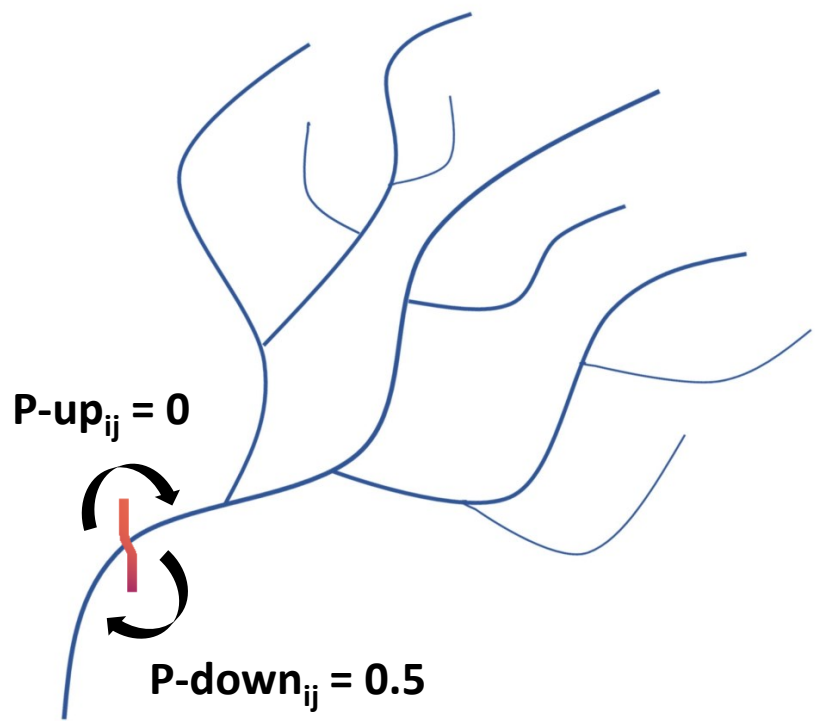


Binary connection

Symmetric



Asymmetric



$$DCI_p = \sum_{i=1}^n \sum_{j=1}^n c_{ij} \frac{l_i l_j}{L L}$$

$$c_{ij} = \prod_{m=1}^M p_m^u p_m^d$$

$C_{ij}$  – connection probability  
 $p_m^u$  – upstream probability of passage  
 $p_m^d$  – downstream probability of passage



Functions:

- CBS
- CFBS
- PC
- DCId
- DCIp
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- Flux
- AWF
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Probabilistic connection



Binary connection

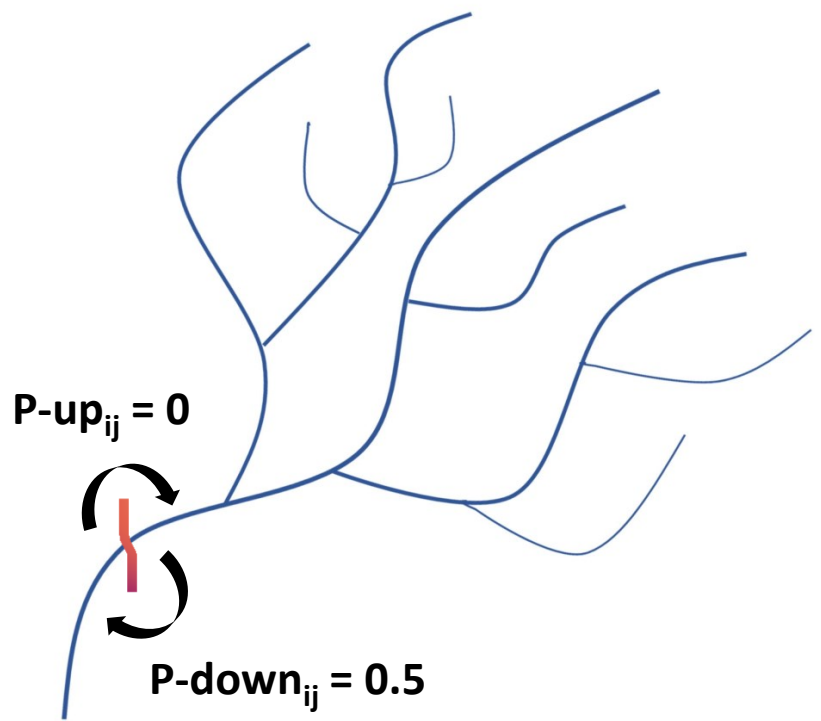
Symmetric



Asymmetric



Adirectional



$$DCI_p = \sum_{i=1}^n \sum_{j=1}^n c_{ij} \frac{l_i l_j}{L L}$$

$$c_{ij} = \prod_{m=1}^M p_m^u p_m^d$$

$c_{ij} = 0$

$C_{ij}$  – connection probability  
 $p_m^u$  – upstream probability of passage  
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Functions:

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Probabilistic connection



Binary connection

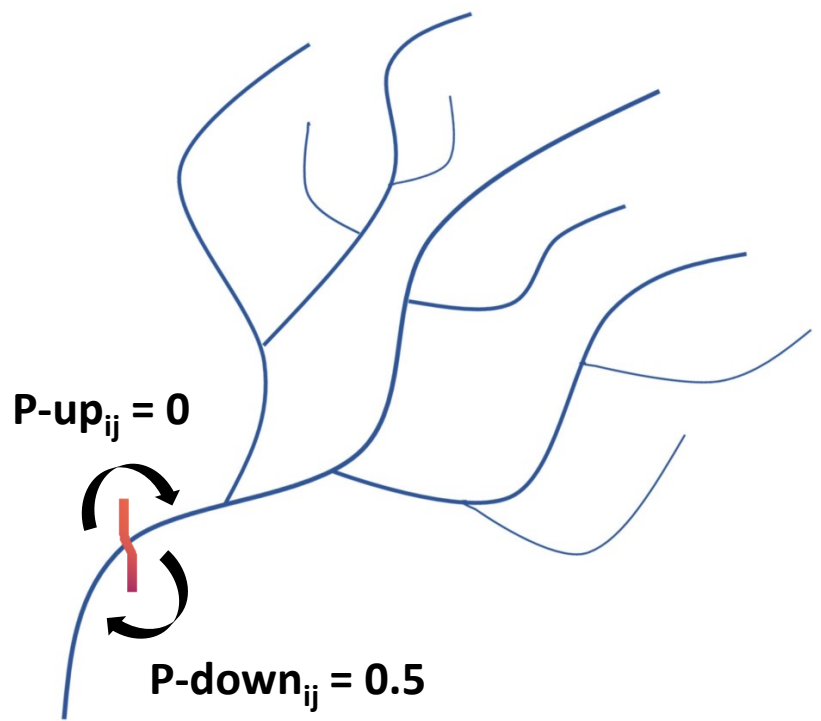
Symmetric



Asymmetric



Adirectional



$$p\text{-up}_{ij} \perp\!\!\!\perp p\text{-down}_{ji}$$

$$DCI_p = \sum_{i=1}^n \sum_{j=1}^n c_{ij} \frac{l_i l_j}{L L}$$

$$c_{ij} = \prod_{m=1}^M p_m^u p_m^d$$



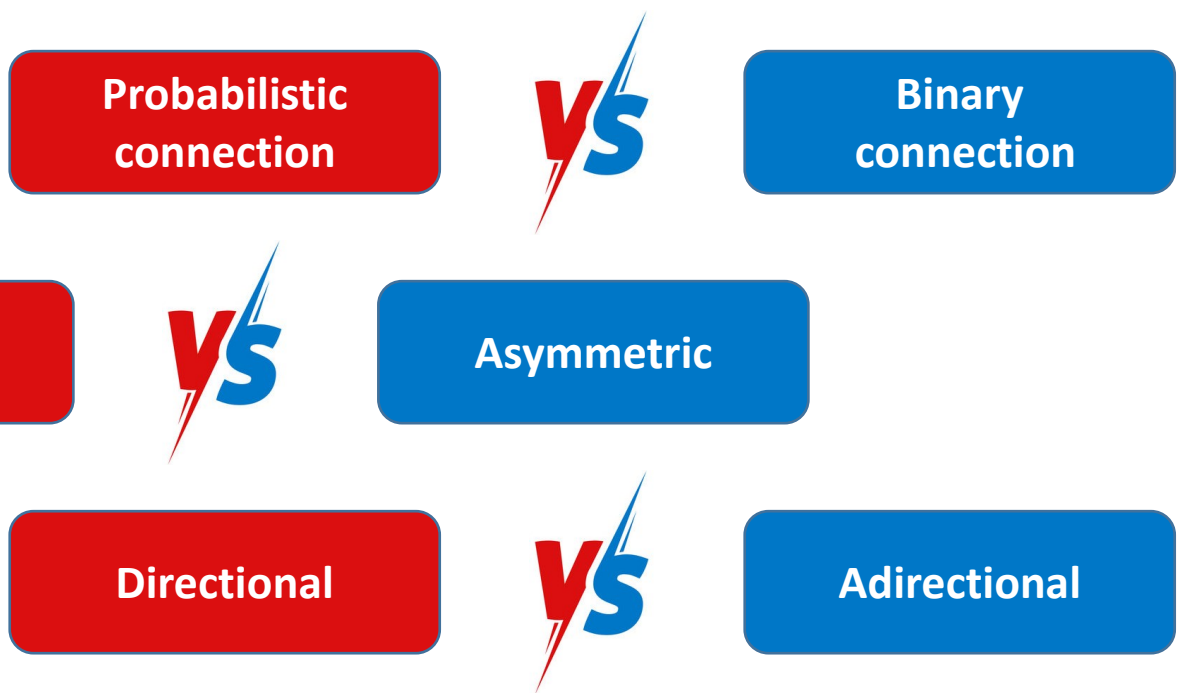
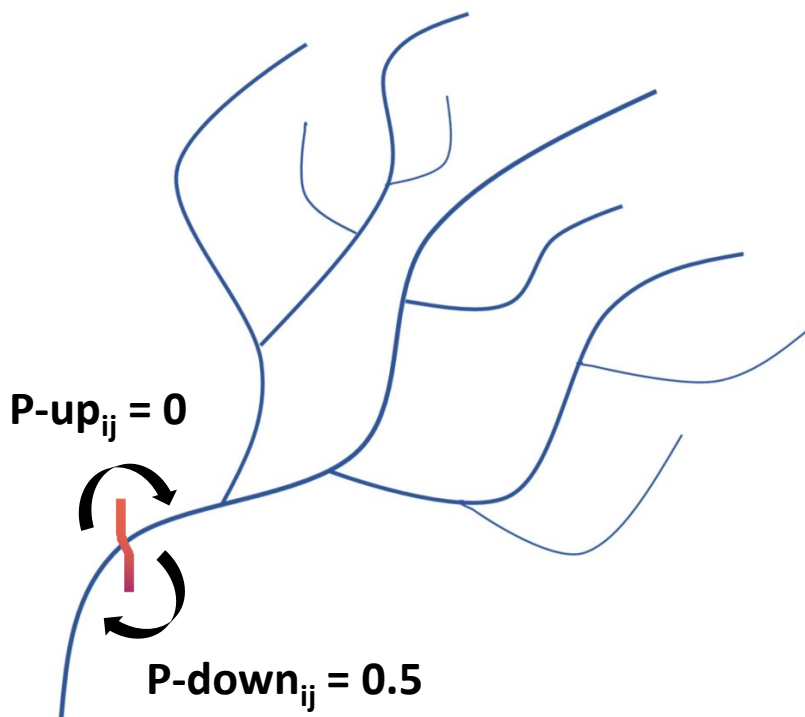
$c_{ij} = 0$



$C_{ij}$  – connection probability  
 $p_m^u$  – upstream probability of passage  
 $p_m^d$  – downstream probability of passage

Functions:

- CBS
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$p\text{-up}_{ij} \perp p\text{-down}_{ji}$

$c_{ij} \text{ up} = 0$

$c_{ij} \text{ down} = 0.5$

$$DCI_p = \sum_{i=1}^n \sum_{j=1}^n c_{ij} \frac{l_i l_j}{L L}$$

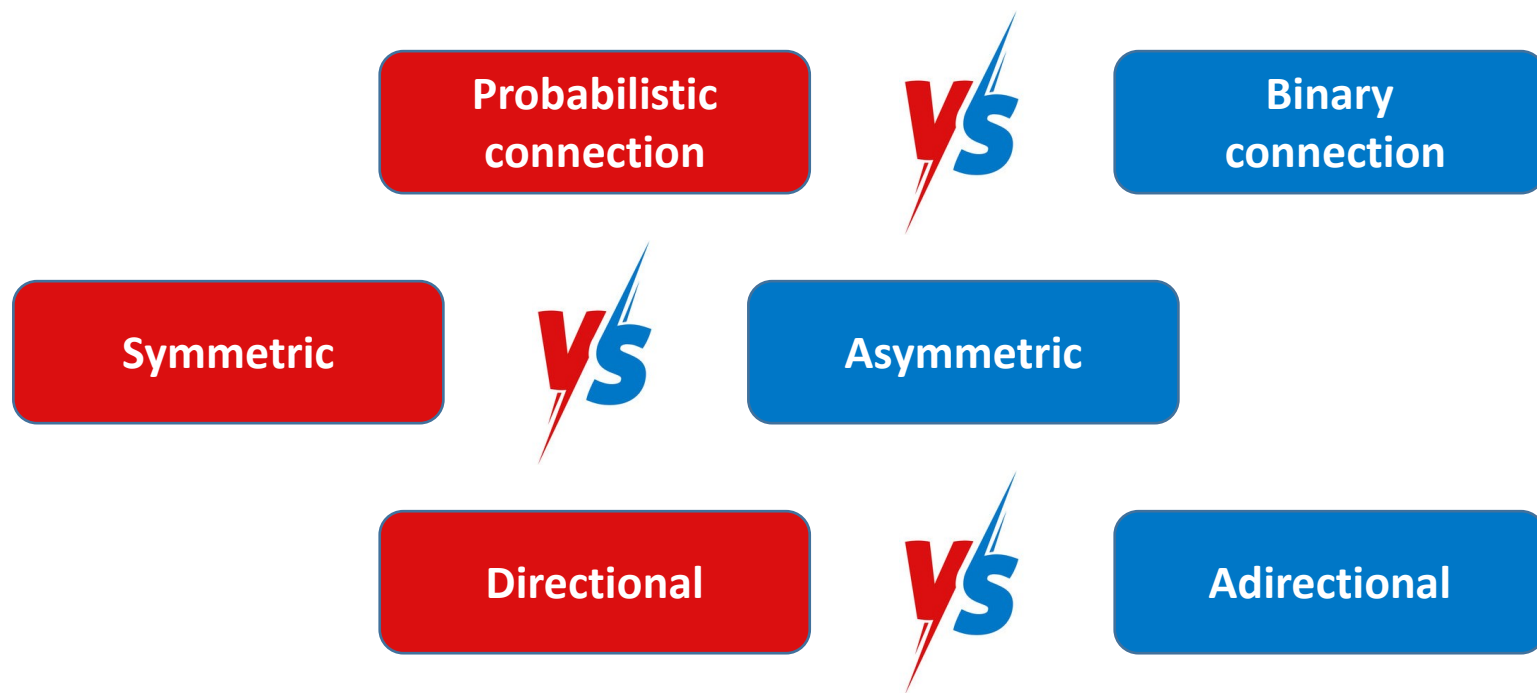
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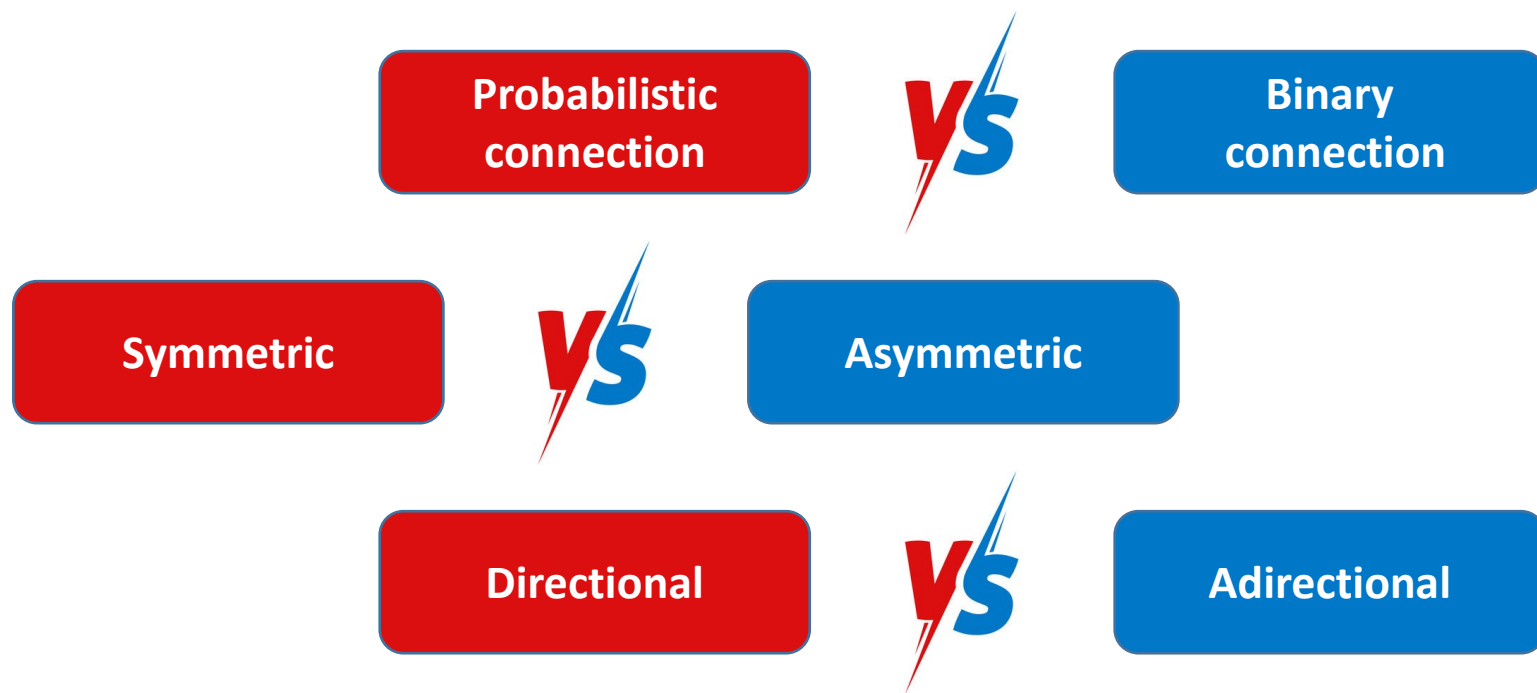
**2 basic stats functions + 10 Indexes**

**7 indexes with user-defined weighing variable**

**7 indexes with 4 calculation modes**

Functions:

- CBS
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**2 basic stats functions + 10 Indexes**

**7 indexes with user-defined weighing variable**

**7 indexes with 4 calculation modes**

**31 standard connectivity metrics**

# User friendly Interface

RivToolKit
— □ ×

Inputs	Network data	Data	Labels	Connectivity
Calculations	Load custom	Load custom	Load custom	Load barriers
RivConnect	Load from library	Load from library	Load from library	Load probability links
Settings				
Help				

# Load River network

RivToolKit

Inputs	Network data	Data	Labels	Connectivity
Calculations	Load custom	Load custom	Load custom	Load barriers
RivConnect	Load from library	Load from library	Load from library	Load probability links

Settings

Help

# Load Barriers

RivToolKit

Inputs

Calculations

RivConnect

Settings

Help

Network data	Data	Labels	Connectivity
Load custom	Load custom	Load custom	Load barriers
Load from library ✓	Load from library	Load from library	Load probability links

Load Barriers



# Optional inputs

RivToolkit

**Inputs**

Calculations

RivConnect

Settings

Help

Network data	Data	Labels	Connectivity
Load custom	Load custom	Load custom	Load barriers
Load from library ✓	Load from library	Load from library	Load probability links

↑ Load Data

↑ Probability Links File

# Use RivConnect

RivToolKit

	Network data	Data	Labels	Connectivity
Inputs				
Calculations	Load custom	Load custom	Load custom	Load barriers ✓
RivConnect ←	Load from library ✓	Load from library	Load from library	Load probability links
Settings				
Help				

# Select the Function

RivToolKit

	Network data	Data	Labels	Connectivity
Inputs				
Calculations	Load custom	Load custom	Load custom	Load barriers ✓
PrConnect...	Load from library ✓	Load from library	Load from library	Load probability links

- Connectivity basic stats
- Connectivity fragment basic stats
- Probability of connectivity
- Flux
- Dendritic connectivity index diadromous
- Dendritic connectivity index potamodrom...
- Area weighted flux
- Length weighted flux
- Integral index of connectivity
- Harary index
- Betweenness centrality
- Combined dendritic connectivity index

# Set up the function

RivToolKit
— □ ×

Inputs
Network data
Data
Labels
Connectivity

### Probability of connectivity

$$PC = \frac{\sum_{i=1}^n \sum_{j=1}^n a_i \cdot a_j \cdot p_{ij}^*}{A_L^2}$$

The Probability of Connectivity (PC) is based on the habitat availability concept and dispersal probabilities between segments in a river network. In the PC formula, n refers to the total number of habitat nodes (segments), ai and aj are the attributes (area or length) of segments i and j, AL is the maximum landscape attribute (total area or length of the river basin), and p\*ij is the maximum product probability of all paths between segments i and j. The outputs include the PC score, ranging from 0 (no connectivity) to 1 (full connectivity), and the formula numerator (Num).

Saura, S.; Pascual-Hortal, L. (2007). A new habitat availability index to integrate connectivity in landscape conservation planning: Comparison with existing indices and application to a case study. *Landscape and Urban Planning* 83(2-3): 91–103.  
<https://doi.org/10.1016/j.landurbplan.2007.03.005>

### Settings

Name \* 
Data ▼

---

Directional asymmetry
 Use total basin attribute

---

Add calculation
Cancel

# Calculate

RivToolKit

Inputs

Calculations

RivConnect

Settings

Help

Calculations

- PC  
Probability of connectivity
- DCId  
Dendritic connectivity index  
diadromous
- DCIp  
Dendritic connectivity index  
potamodromous

Results

Calculate

Reset

Delete

Combined dendritic connectivity index

Search term

# Visualize results

RivToolKit
— □ ×

Inputs

Calculations

RivConnect

Settings

Help

Calculations

- PC 

Probability of connectivity  
Duration: 0h 0m 6s
- DCId 

Dendritic connectivity index diadromous  
Duration: 0h 0m 5s
- DCIp 

Dendritic connectivity index potamodromous  
Duration: 0h 0m 6s

Results

Basin ID	Probability of connectivity	Num
1000042	1	1157776000000000
1000291	1	1918440000000000
1000384	1	194546704000000000
1000409	1	2044900000000000
100082	1	2275290000000000
100088	1	3069160000000000
100123	1	1721344000000000
1001543	1	1932100000000000

Search term  1 - 100 of 19941 < >

Calculate
Reset
Delete
Open file
Open exports folder
PC\_20240411143826.txt

# Example

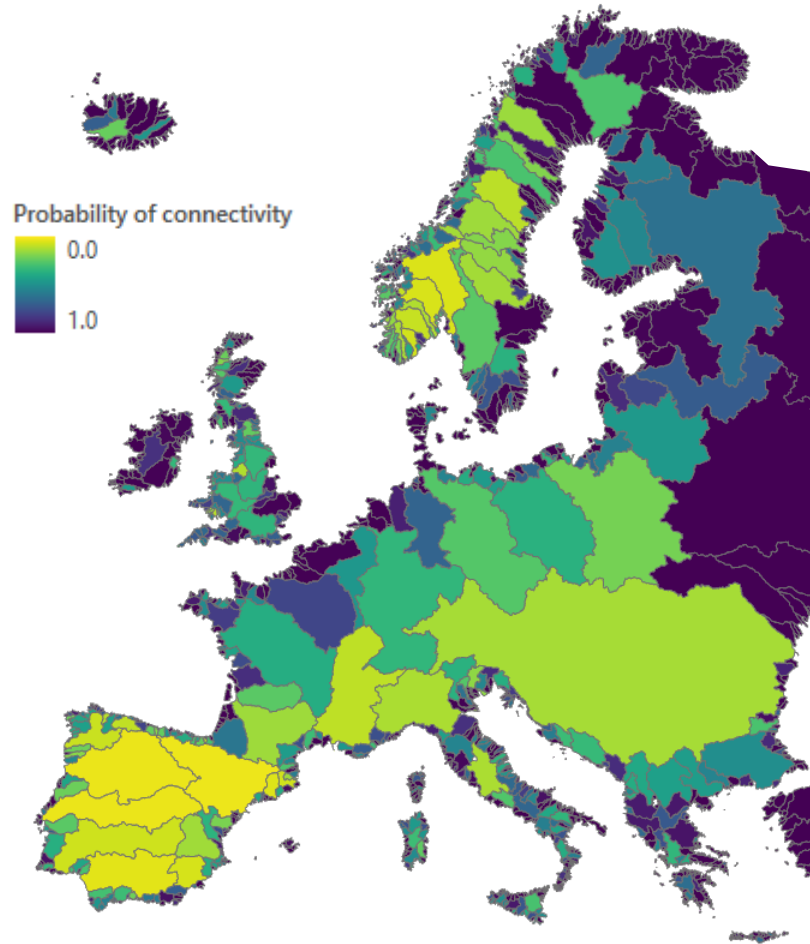
- Amber barrier data above 5m
- CCM2 sea outlet basins with at least strahler 3
- BC representation: Tagus basin

The screenshot shows the RivToolKit interface. On the left, there is a sidebar with 'Inputs', 'Calculations', 'RivConnect', 'Settings', and 'Help'. The 'Calculations' section is active, showing three options: 'PC' (Probability of connectivity), 'BC' (Betweenness centrality), and 'cDCI' (Combined dendritic connectivity index). The 'Results' panel on the right displays a table with the following data:

Basin ID	Probability of connectivity	Num
1000042	1	1157776000000000
1000291	1	1918440000000000
1000384	1	194546704000000000
1000409	1	2044900000000000
100082	1	2275290000000000
100088	1	3069160000000000
100123	1	1721344000000000
1001543	1	1932100000000000
1001593	1	8353960000000000
100194	1	1267876000000000
100197	1	1239040000000000
100239	1	2856100000000000
100270	1	6400900000000000

At the bottom of the interface, there are buttons for 'Calculate', 'Reset', and 'Delete'. A search bar is visible with the text 'Search term' and a magnifying glass icon. Below the search bar, there are buttons for 'Open file' and 'Open exports folder', followed by the file path 'PC\_20240414103708.txt'. The bottom right corner shows '1 - 100 of 19941' and navigation arrows.

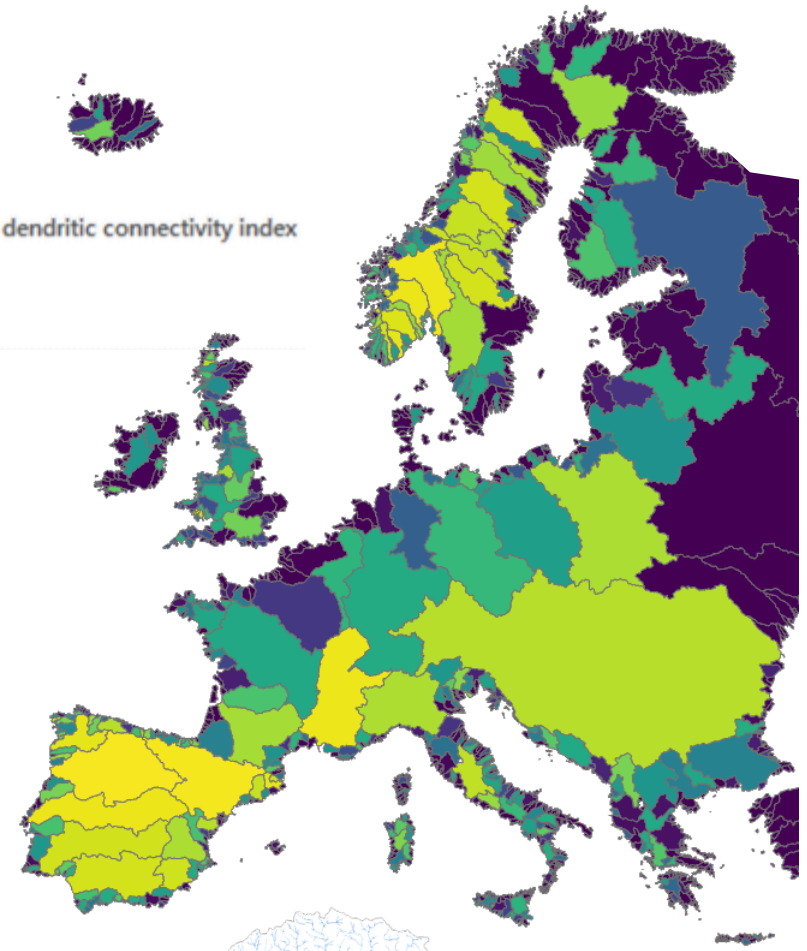
PC



Example representation

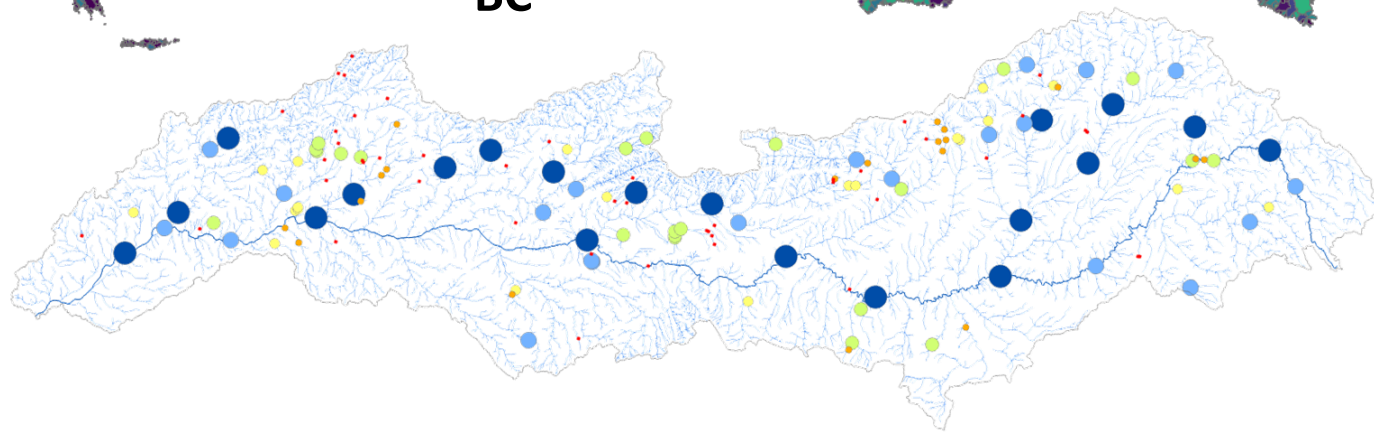
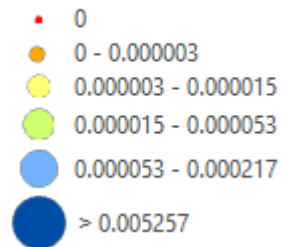


cDCI



BC

Betweenness centrality





## Future developments:

- Fully integration into the RivTool platform 


# RivConnect



<https://shorturl.at/cOU39>

**Download and help us improve**

## Future developments:

- Fully integration into the RivTool platform 
- New functions
  - Catchment Area-based Fragmentation Index (CAFI)
  - Catchment Area- and Rainfall-based Fragmentation Index (CARFI)
  - River Regulation Index (RRI)
  - River Connectivity Index (RCIvol; RCIclass; RCIrange)
  - Biodiversity Index (BI)


# RivConnect



<https://shorturl.at/cOU39>

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- Graphic representations for enhanced visualization
- Online workshops


# RivConnect



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- Graphic representations for enhanced visualization
- Online workshops
- Integration with other plug-ins

# RivConnect



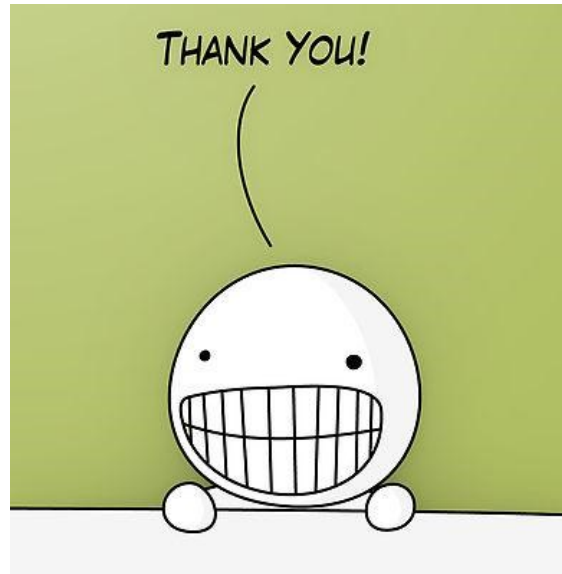
<https://shorturl.at/cOU39>

**Download and help us improve**





# RIVConnect



**Gonçalo Duarte**  
([goncalo.f.duarte@campus.ul.pt](mailto:goncalo.f.duarte@campus.ul.pt))