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A practical, objective, robust technique to directly estimate time of concentration

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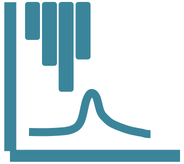
Classes of available methods to estimate time of concentration



Direct methods

Estimate of time of concentration as time difference of hyetograph and hydrograph features

$$v = \frac{dx}{dt}$$

Velocity method

Estimate of time of concentration from the flow velocity in the river network

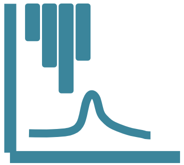
Empirical formulae

Estimate of time of concentration as regression of catchments' descriptors

For the same catchment time of concentration estimates can differ by up to 500%!*

*Grimaldi et al., Hydr. Sc. J., 2012

Issues with the available classes of methods



$$v = \frac{dx}{dt}$$

$$v = \frac{dx}{dt}$$

Direct methods

- Selection of representative number and kind of events
- Separation of hyetograph and hydrograph are highly subjective

Velocity method

- Velocity is estimated only in the principal river network
- It doesn't take into account water storage
- Subjective choice of flow velocity formula

Empirical formulae

- For calibration they rely on Tc estimates from the other methods
- Their applicability is highly uncertain outside the calibration sites

What's the proposed solution?

Detrending Moving-average Cross-correlation Analysis (DMCA) based methodology*

Timeseries analysis technique: it requires only rainfall and streamflow records

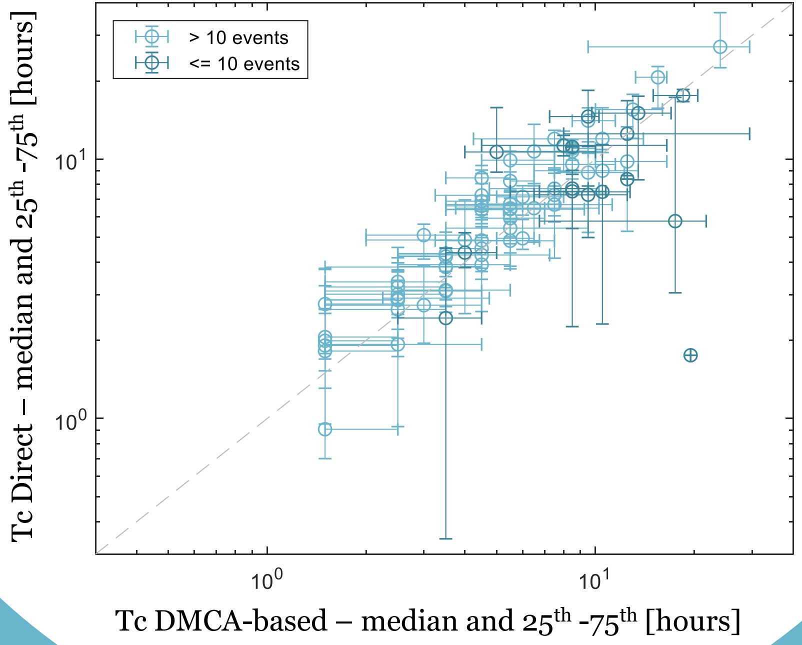
- No need to select rainfall-streamflow events
- No assumption about rainfall-runoff transformation
- Parameter free
- Fully objective and reproducible

* transferred from field of Economics, Kristoufek, Physic A, 2014

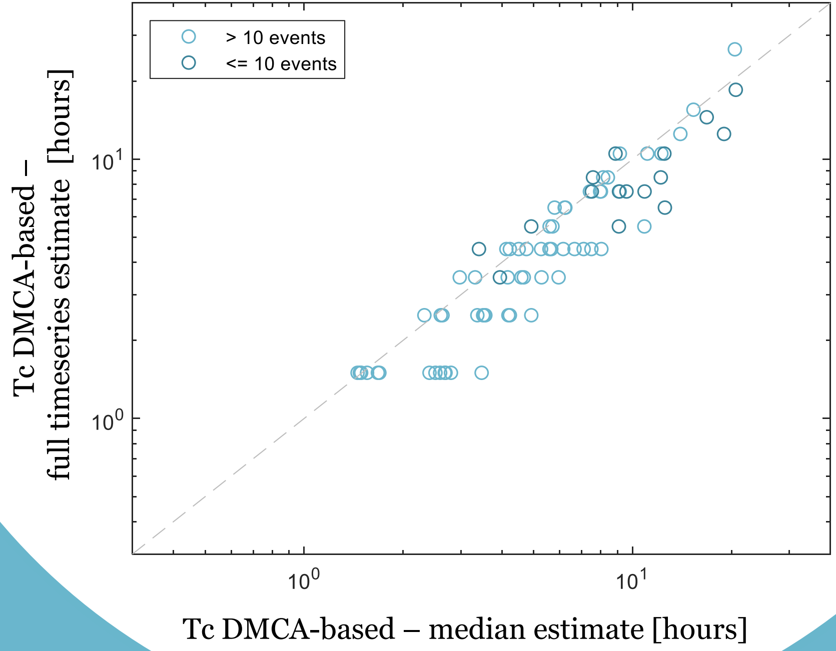
Note: for the comparison with the Direct method which can be applied only on an event basis, we have applied the DMCA-based method to timeseries made by copies of the same event repeated multiple times.

DMCA-based method vs Direct method in 79 catchments in the UK

The time scale produced by the DMCA-based method can be considered a reliable estimate of Time of concentration as intended by the traditional method



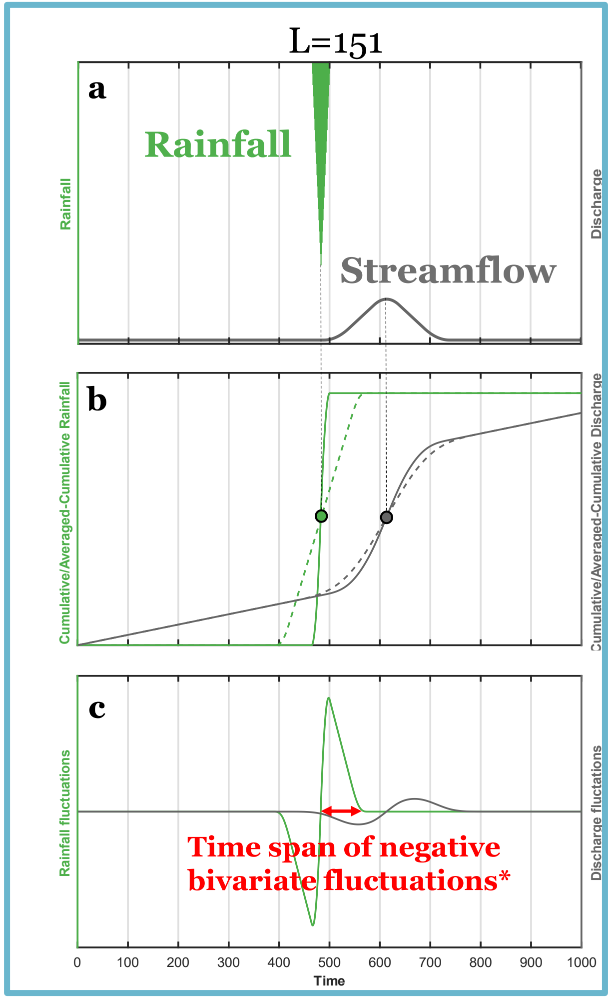
DMCA is intended for application to the entire time series, but can also be applied to individual events



DMCA-based method is able to produce reliable estimates of Time of concentration without selecting rainfall-streamflow events

Additional information on DMCA-based method

(Answering comment by Björn Guse, 03 May 2020)

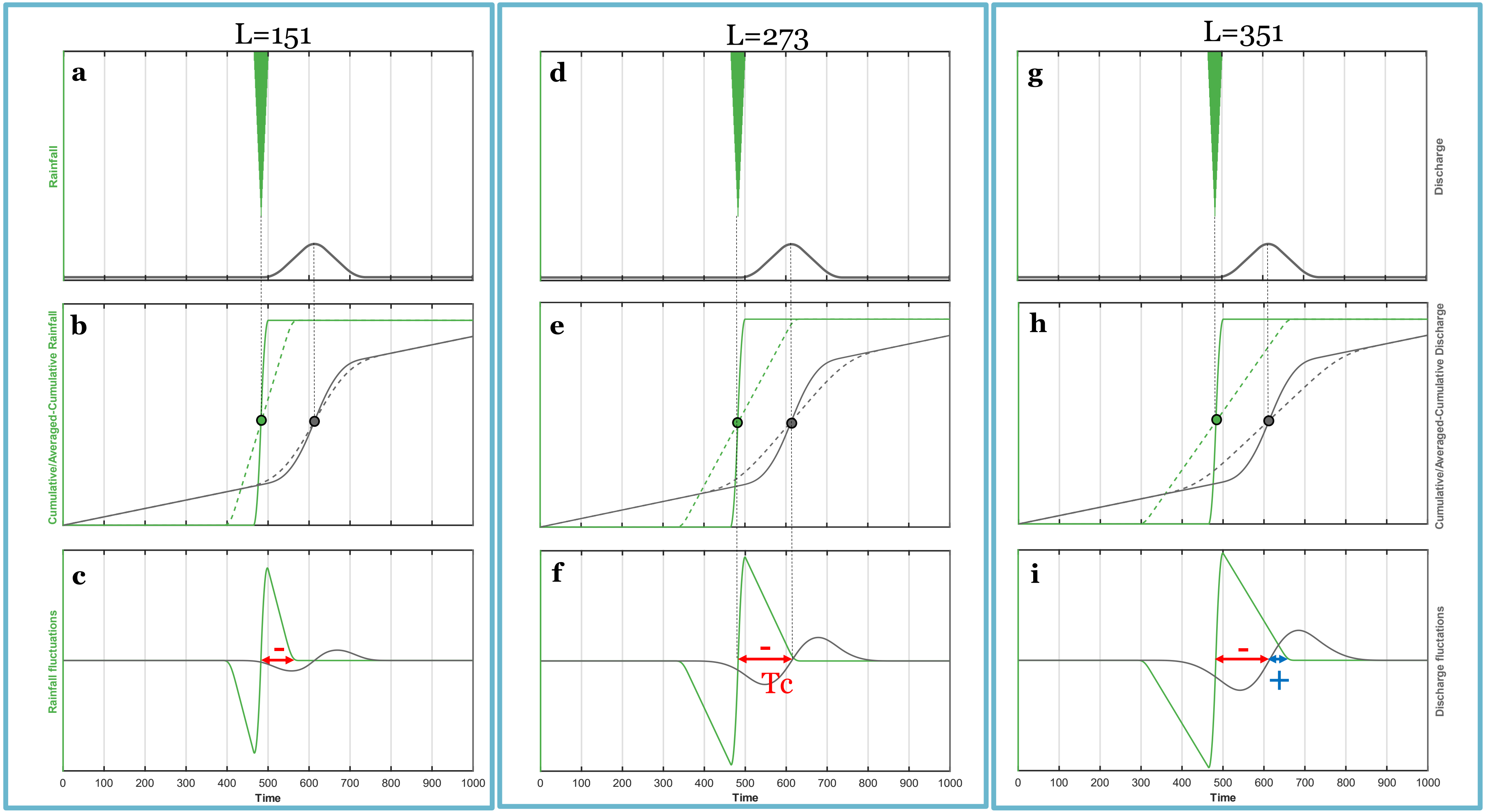


Original signals

Integrated signals (solid lines) and moving averages with L=151 on integrated signals (dash lines)

Fluctuations of the integrated signals compared to their moving averages

***bivariate fluctuations: product of rainfall and streamflow fluctuations**



L=151
L=273
L=351
a
b
c
d
e
f
g
h
i
Rainfall
Cumulative/Averaged-Cumulative Rainfall
Rainfall fluctuations
Discharge
Cumulative/Averaged-Cumulative Discharge
Discharge fluctuations
Tc
-
+
0
100
200
300
400
500
600
700
800
900
1000
Time

Tc is equal to half of the moving average window which is able to produce the minimum of bivariate fluctuations by covering the time span from centre of mass of rainfall to centre of mass of streamflow.