Hortonian runoff modeling with the Representative Elementary Watershed approach: identifying and testing the closure relation with observed watershed characteristics

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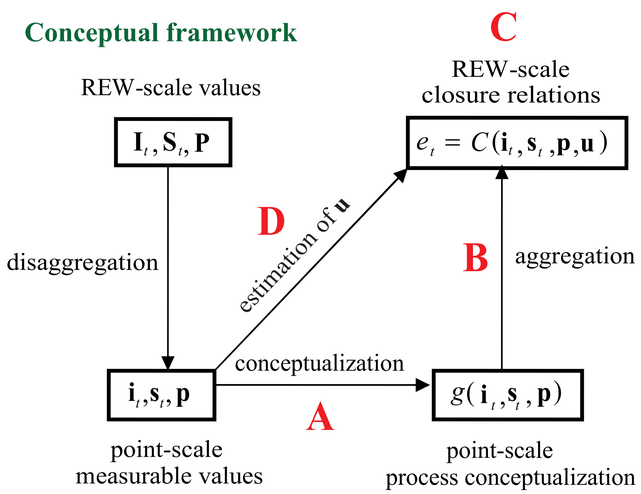
Introduction

A key to success in the Representative Elementary Watershed (REW) approach is the proper identification of the'closure relation' to quantify the hydrological flux exchanges within REW units. This study presents the derivation of the closure relation for concentrated overland flow (i.e. Hortonian runoff) based on the aggregation-disaggregation approach. This approach allows a direct estimation of the parameters at REW scale in the closure relation using measureable watershed (or REW) characteristics observed at a point scale. These parameters in the closure relation (i.e. scaling parameters) represent sub-REW process heterogeneity and scaling effect of REW size and geometry on the hydrologic reponses as the closure relation is essentailly a lumped model.

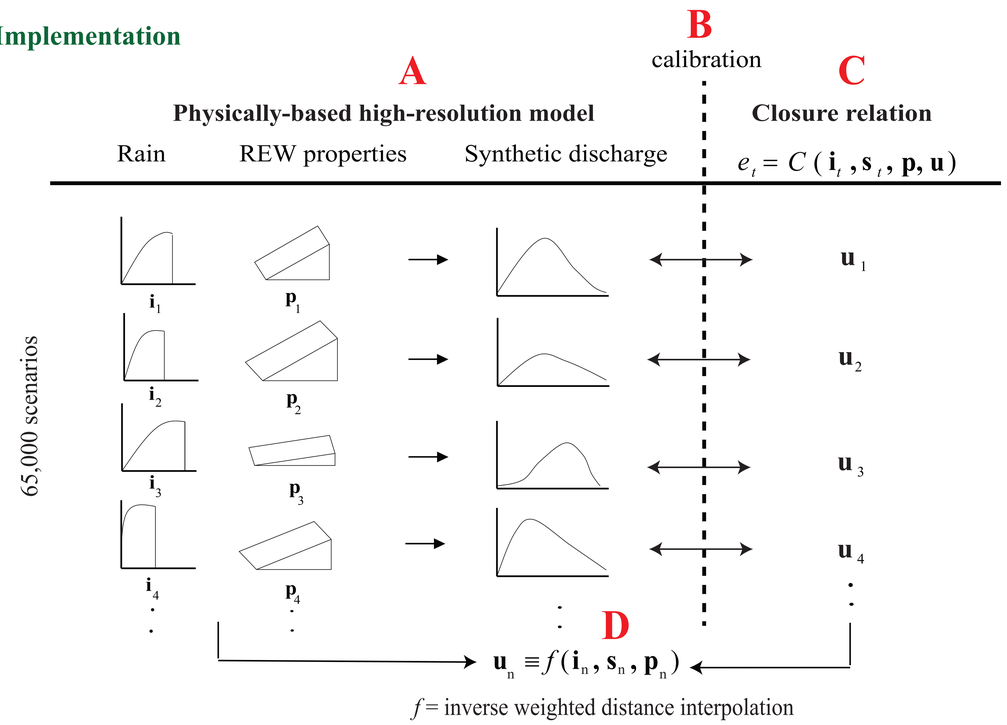
Methodology

Conceptual framework



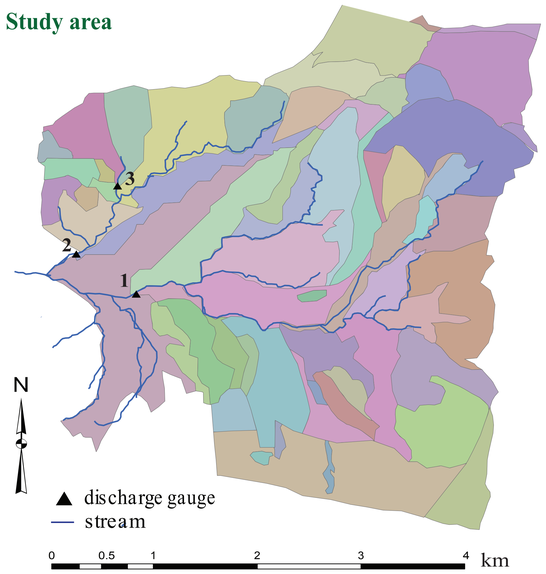
C	closure relation
g	process description at point scale
e_t	flux at REW scale at t
$\mathbf{I}_t$, $\mathbf{i}_t$	input at t
$\mathbf{S}_t$, $\mathbf{s}_t$	state variables at t
$\mathbf{P}$, $\mathbf{p}$	a set of REW physical properties
$\mathbf{u}$	a set of scale-transfer parameters

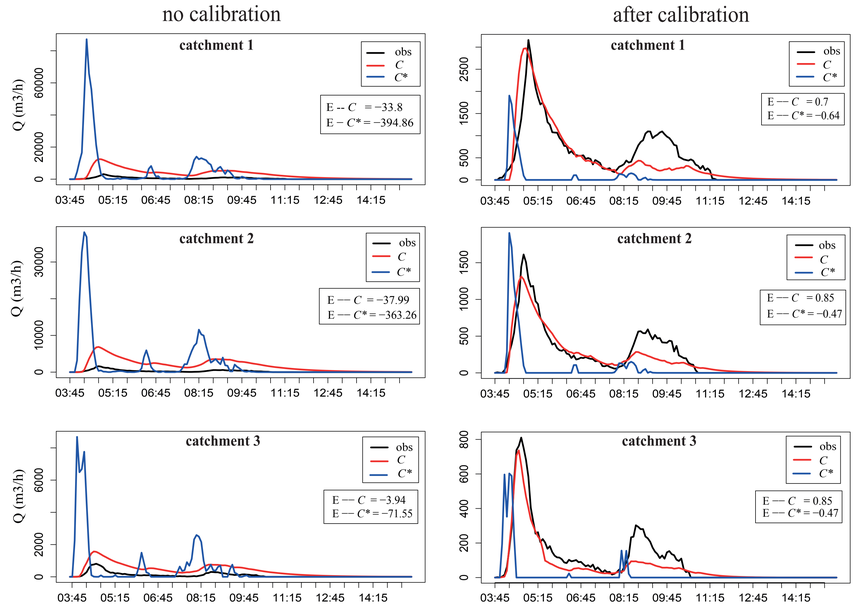
Implementation



Evaluation of the closure relation with field data

Study area





Modeling Approach

- 15 km^2 catchment in French Alps (3 sub-catchments with total 60 REWs)
- 12 rain gauges, 3 discharge gauges, 1 meteostation
- event-based runs (~40 events)
- simulate discharge for individual REWs with C
- discharge routing from individual REWs to the outlets using Manning's equation
- evaluation, using Nash-Sutcliffe index (E), against the observed discharge and discharge simluated from C that do not contain $\mathbf{u}$ (C*), as a benchmark.
- calibrate (i.e. brute force & split sample approach) the saturated hydraulic conductivity for C and C*
- evaluate the performance of C and C* after calibration

Findings & Conclusion

- C proposed in this study is capable of simulating the discharge. More than 30% of events, mostly from the small homogeneous subcatchment (3) has E > 0 without calibration.
- C* is not capable of simulating the hydrograph even after calibration.
- $\mathbf{u}$ is an important component in C. The closure relation should contain a set of parameters to represent the scaling effect and sub-REW processes.
- Performance of C increases with the runoff coefficient (results not shown).

Performance of the closure relation for all events