Even event-scale hydrological response characterization benefits from high density rain gauge observations - *Supplementary Material, Part 1*

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**Summary:**

This Section 1 contains first of all supplementary figures describing the case study (hydrograph in Figure S1, rating curve in Figure S2 and a picture of the streamflow gauging station disturbed by a rock in Figure S3), followed by an illustration of the evolution of initial streamflow per streamflow event over the course of the year (Figure S4) and the shape of the 15 streamflow reactions of the river (Figure S5). Next, is found the distribution of all distance metrics for all rainfall events over the entire catchment (Figure S6) and in the northern and southern part for the hillslope distance (Figure S7). The Figure S8, Figure S9 and Figure S10 present the results of the model simulations, and Figure S11 shows a detailed comparison between the two spatial rainfall interpolation methods used in this paper. The Figure S12, Figure S13 and Figure S14 show the evolution of *I*ASYM, *D*HILLS and *D*STREAM, respectively, for the 15 rainfall events causing a streamflow reaction.

Next is a complete listing of all geomorphological distance metrics (Table S1), a table summarizing the correlation coefficient between distance metrics for all rainfall events (Table S2), and additional statistics about the raingauge network configuration analysis (Table S3 and Table S4).

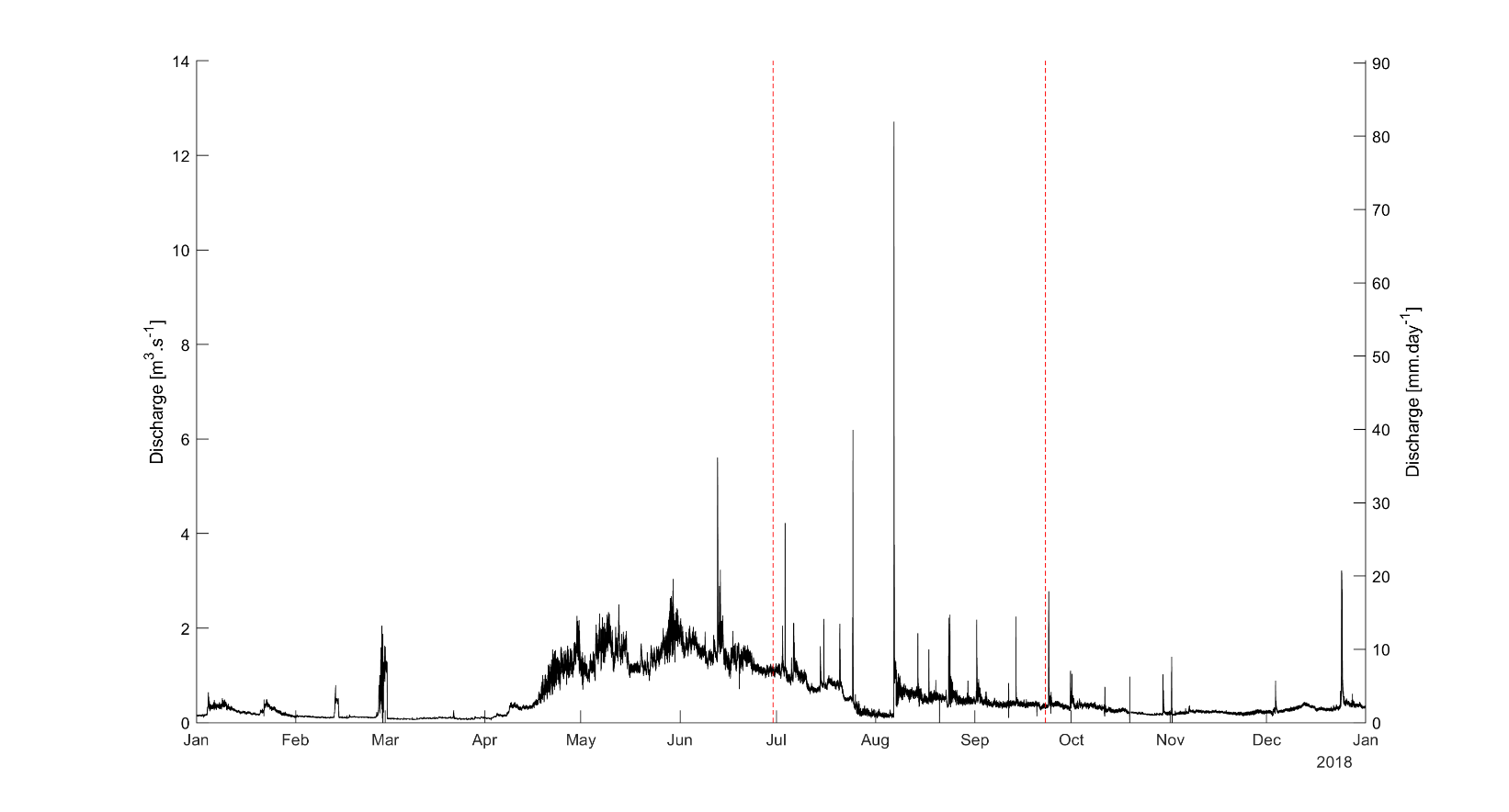


Figure S1. River discharge measured at the Vallon de Nant outlet (in m3.s-1 and mm.day-1) over 2018. The study period (from July 1st 2018 to September 23th 2018) is marked out by the two red dashed lines.

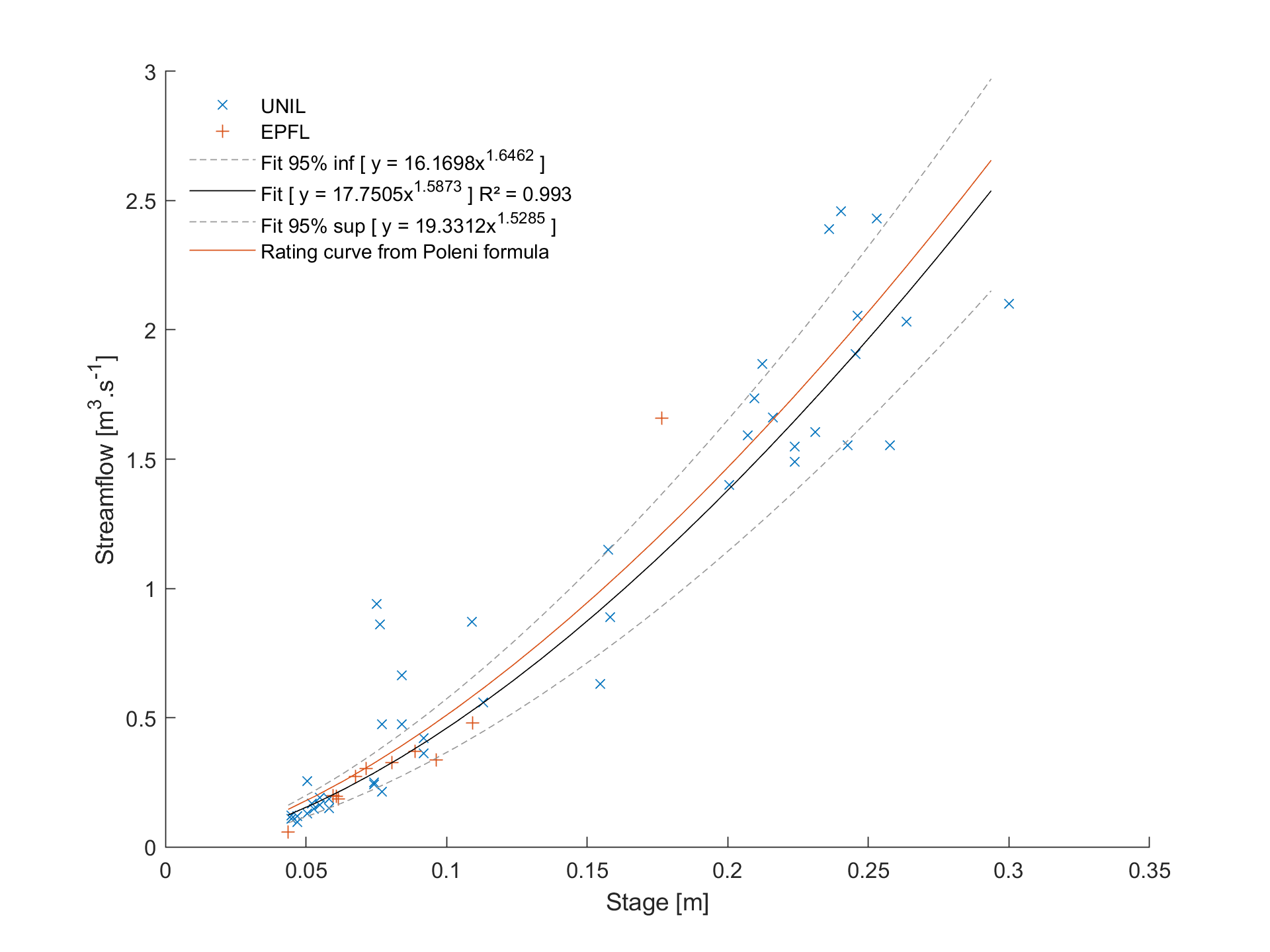


Figure S2. Rating curve for the Avançon de Nant river at the outlet of the Vallon de Nant based on 55 salt streamflow measurements realized by the Institute of Earth Surface Dynamics from the University of Lausanne (UNIL) and the Stream Biofilm and Ecosystem Research Laboratory, from the Ecole Polytechnique Fédérale de Lausanne (EPFL). We fit a power-relationship using the nonlinear least squares fitting algorithm of MatLab's "fit" function with the trust region algorithm and least absolute residual method to obtain a 95% confidence interval.



Figure S3. Automatic picture of the Avançon de Nant measurement station at the Vallon de Nant outlet on July 30th 2018. The river stage is averaged over a minute since September 2015 using an optical height gauge (VEGAPULS WL-61, VEGA, Schiltach, Germany) located above the middle point of the river. On the picture the measure is temporarily disturbed by a rock carried by the last flood event (July 24th 2018).

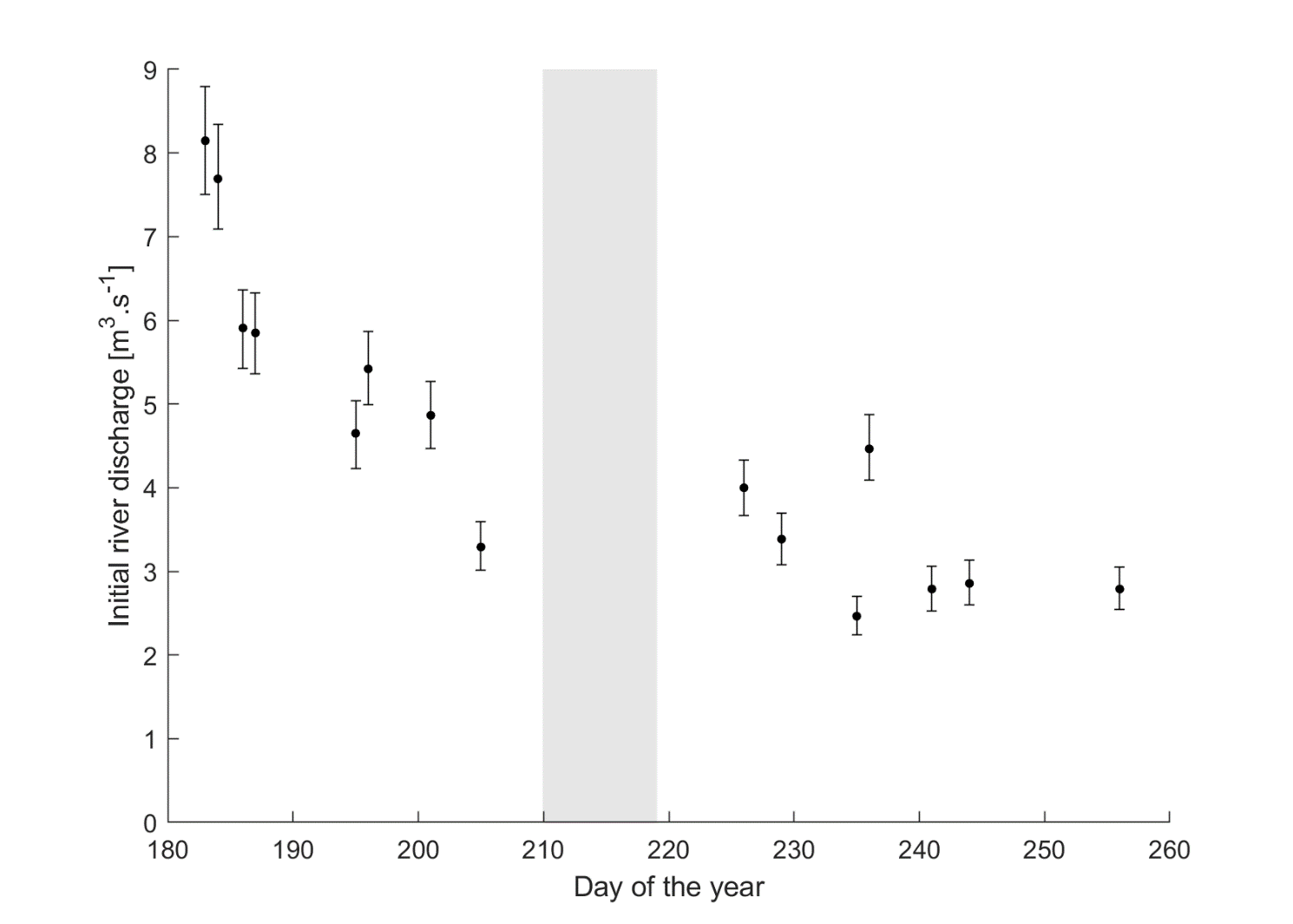


Figure S4. Initial streamflow for the 15 rainfall events causing a river reaction as function of the day of the year. The grey area corresponds to the period when the streamflow gauge readings were perturbed and thus discarded from the present analysis.

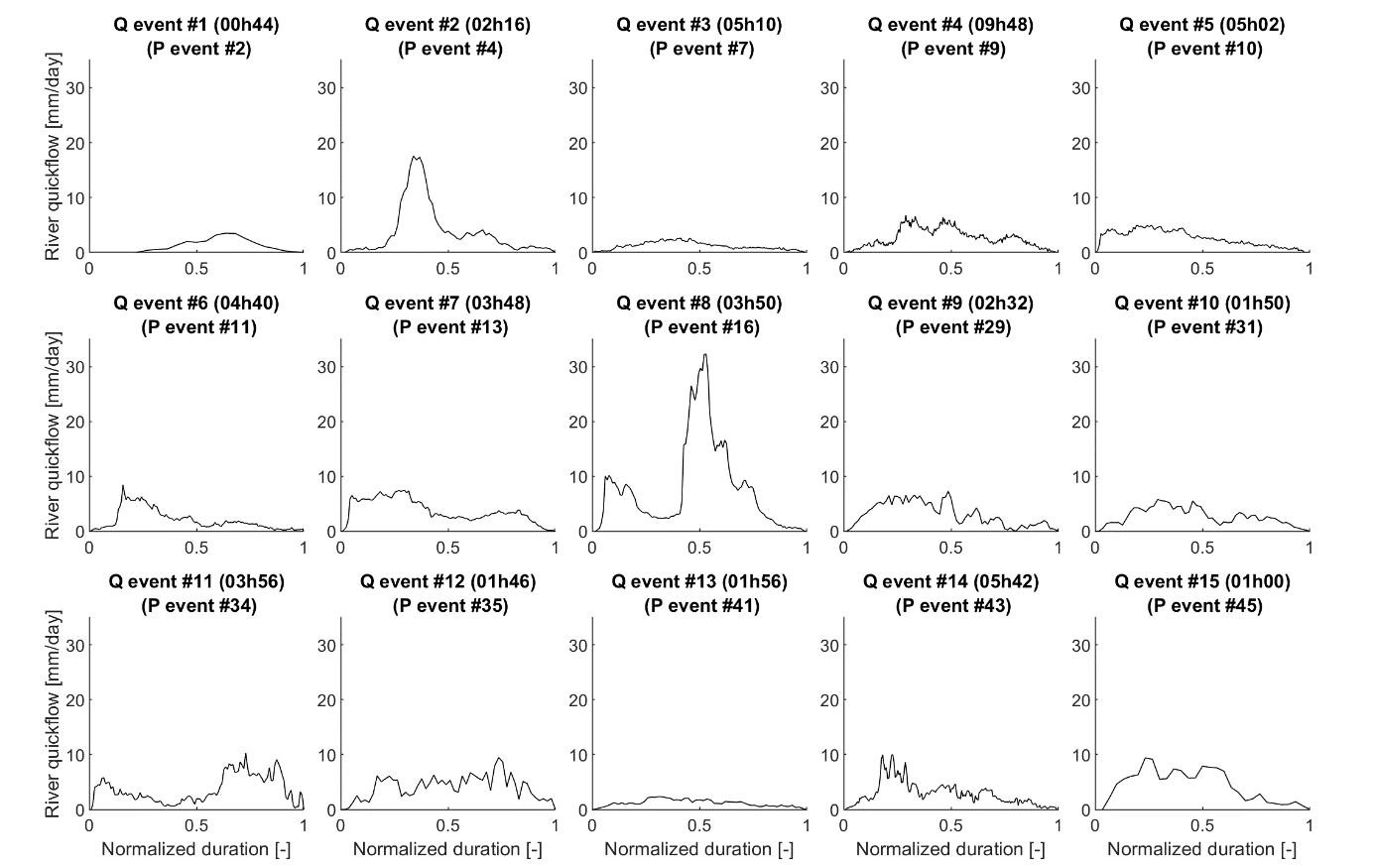


Figure S5. River quickflow for 15 rainfall events (P event) causing a noticeable river reaction (Q event). The length of events is normalized.

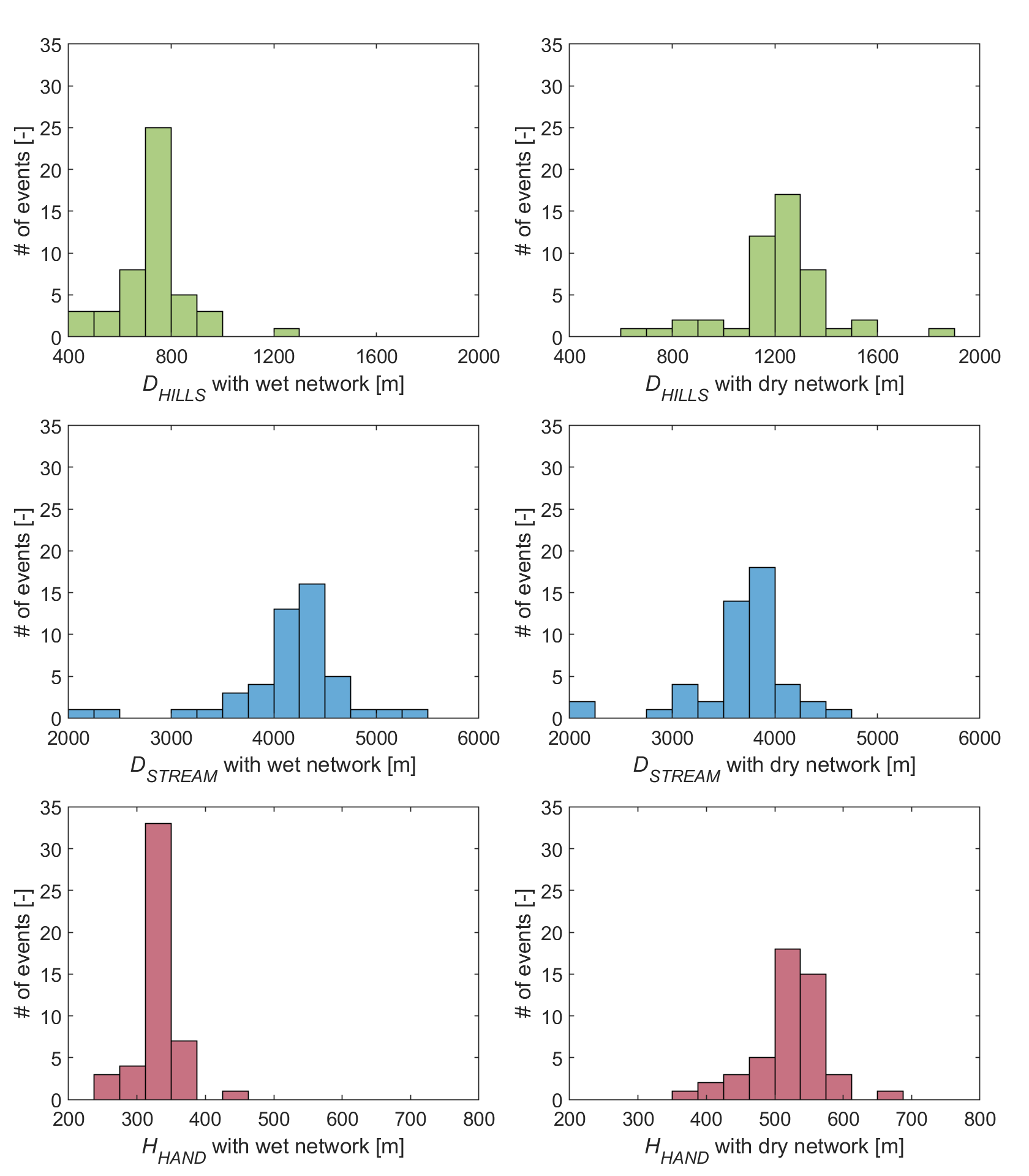


Figure S6. Distribution of the distance metrics *D*HILLS, *D*STREAM and *H*HAND for all 48 rainfall events.

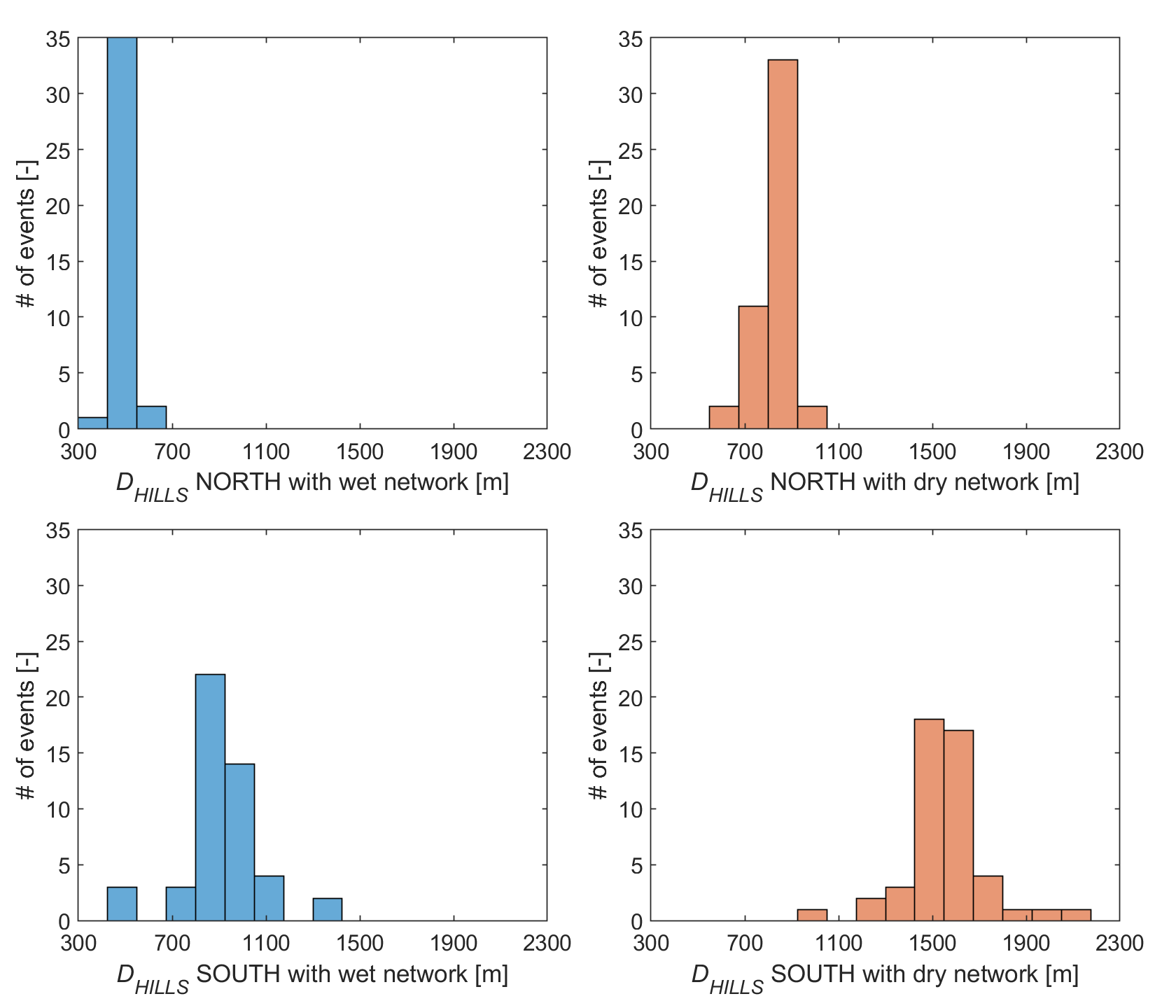
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Figure S7. Distribution of *DHILLS* for the northern part (left column) and the southern part (right column) of the catch men, with respect to the wet network (top row) and the dry network (bottom row). The median of the wet distances are 329 m shorter than the dry distances in the northern part (top), in the southern part (bottom) they are 634 m shorter.

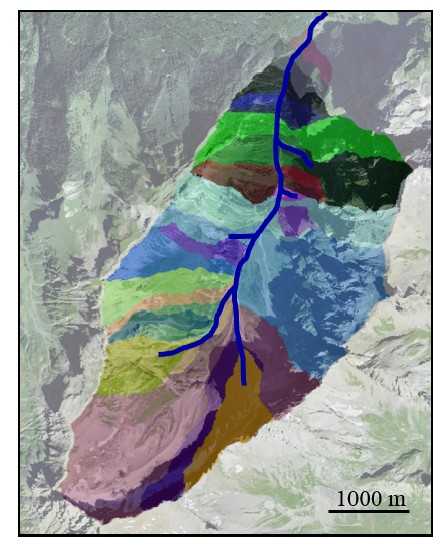


Figure S8. Map of the Vallon de Nant (Map data from www.map.geo.admin.ch, © CNES, Spot Image, swisstopo, NPOC) showing the 25 subcatchments and the stream network geometry used for the modelization.

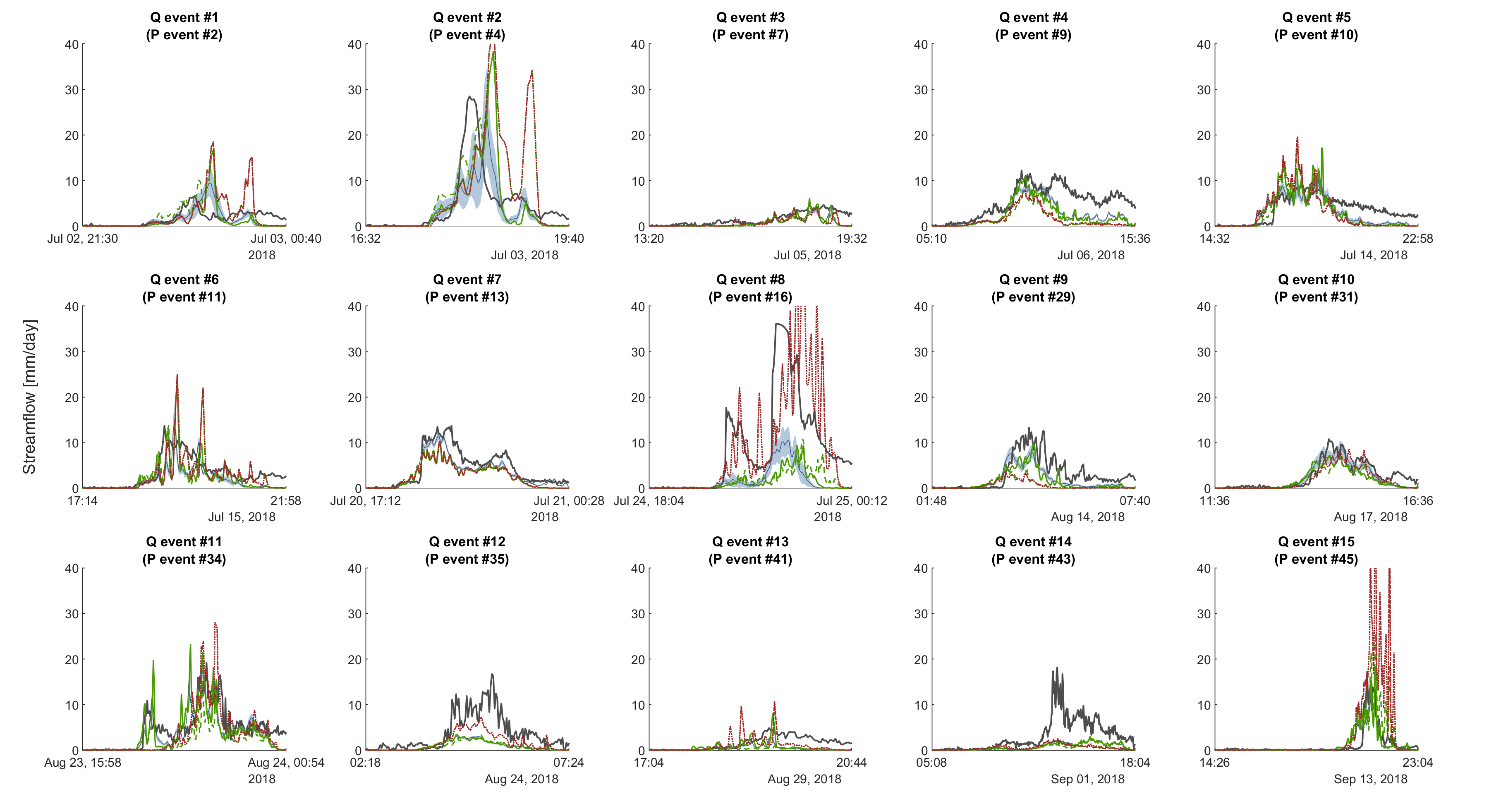


Figure S9. Results of simulation. For each of the 15 events having a streamflow reaction is plotted the observed streamflow (black curve), the simulated streamflow based on stochastic rainfall fields (blue curve and band), the simulated streamflow based on the best 3-station and 1-station network (respectively with plain and dashed green curves), and the simulated streamflow based on the worst 3-station network (dotted red curve).

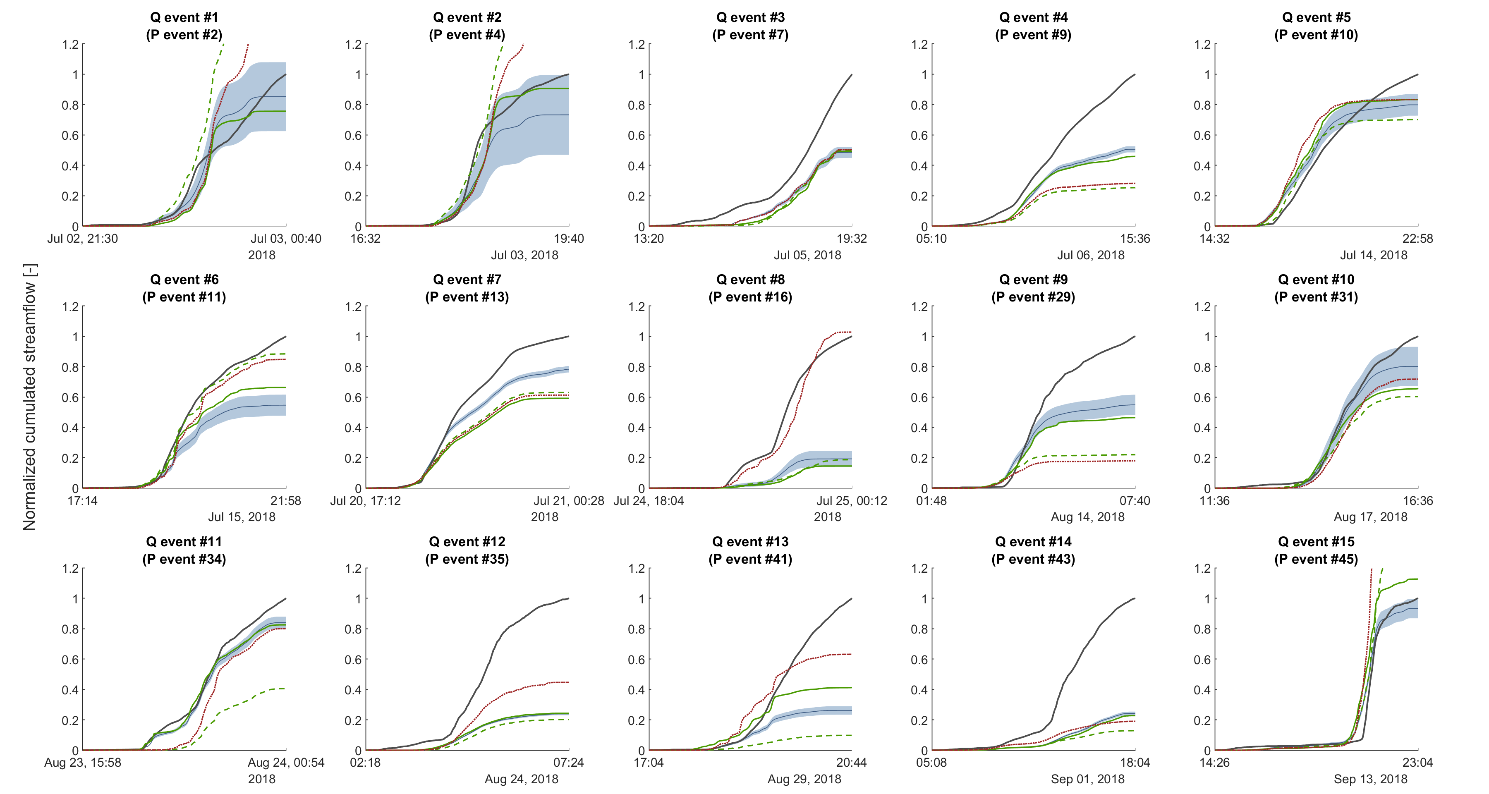


Figure S10. Cumulated results of simulation. For each of the 15 events having a streamflow reaction is plotted the cumulated observed streamflow (black curve), the cumulated simulated streamflow based on stochastic rainfall fields (blue curve and band), the cumulated simulated streamflow based on the best 3-station and 1-station network (respectively with plain and dashed green curves), and the cumulated simulated streamflow based on the worst 3-station network (dotted red curve). The amounts of streamflow are normalized by the cumulated amount of observed streamflow.

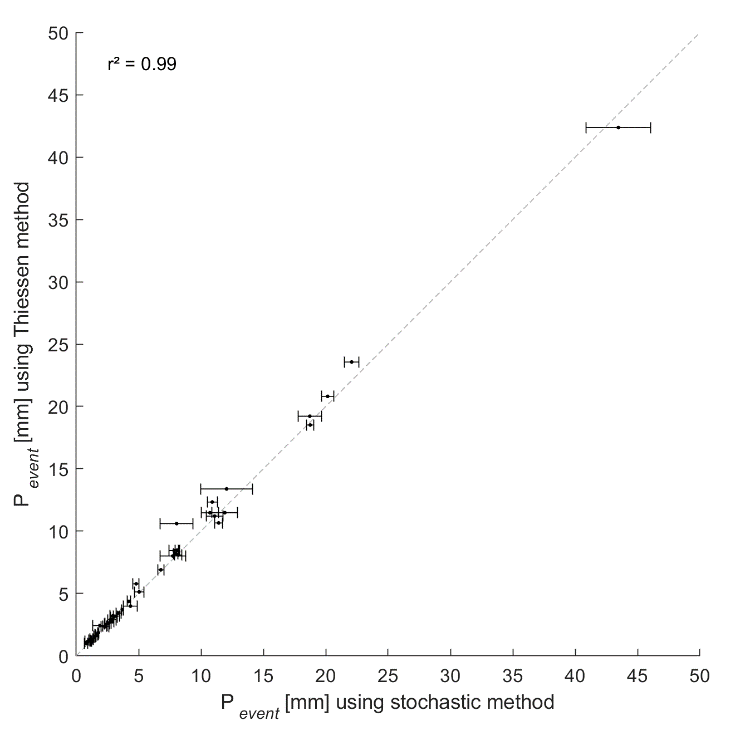
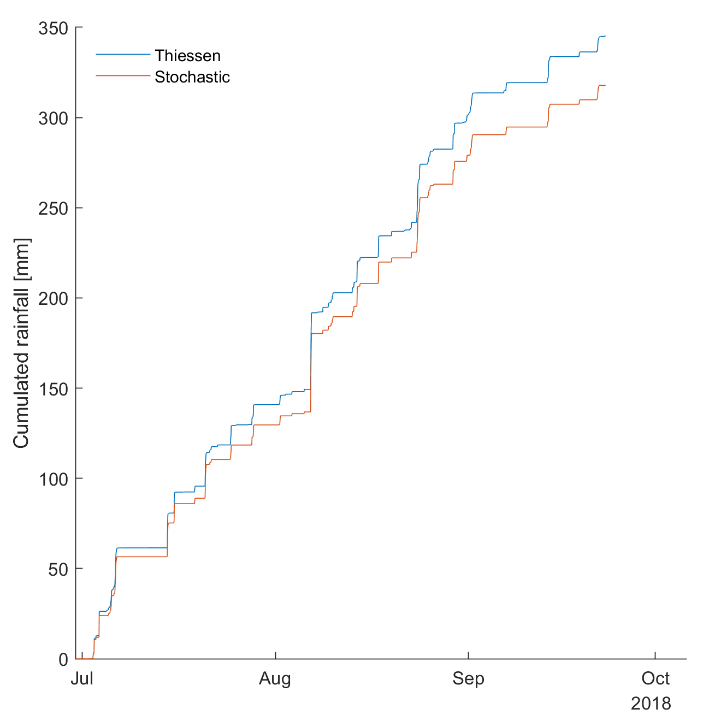


Figure S11: Deviation between the two spatial rainfall interpolation methods used in this paper, in terms of cumulated rainfall (left) and per event (right).

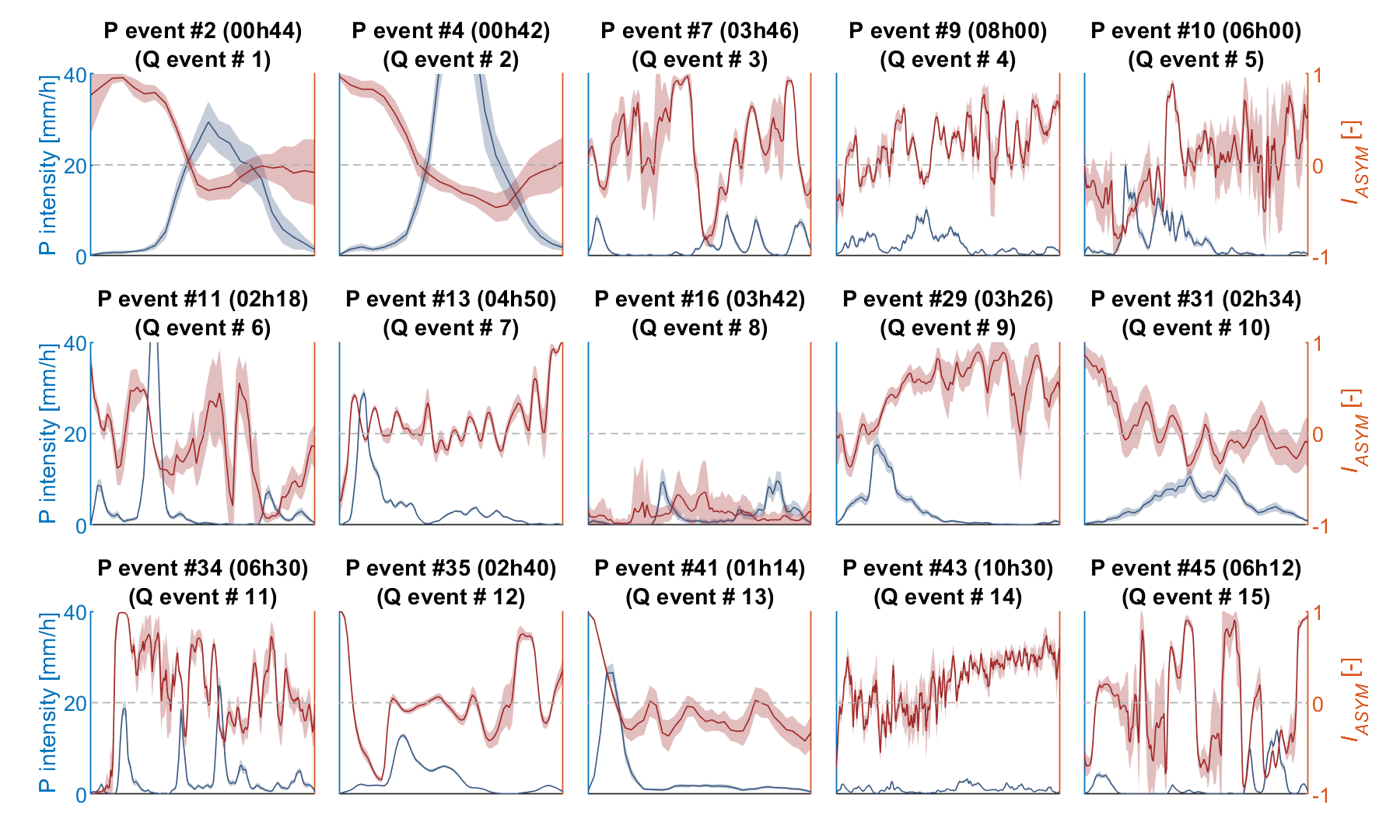


Figure S12. Evolution of rainfall intensity and IASYM for the 15 rainfall events (P event) associated with a river reaction (Q event).

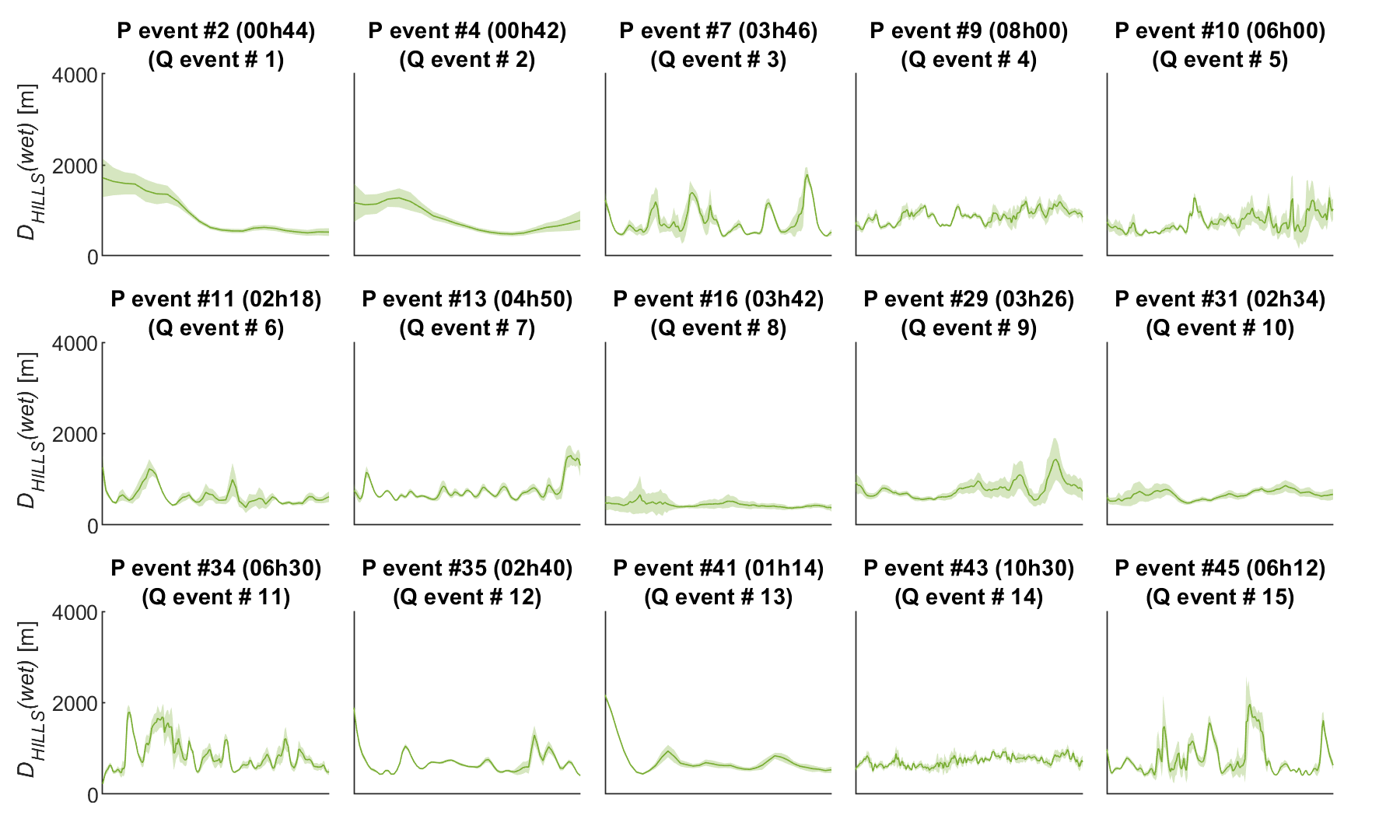


Figure S13. Evolution of DHILLS for the 15 rainfall events (P event) associated with a river reaction (Q event).

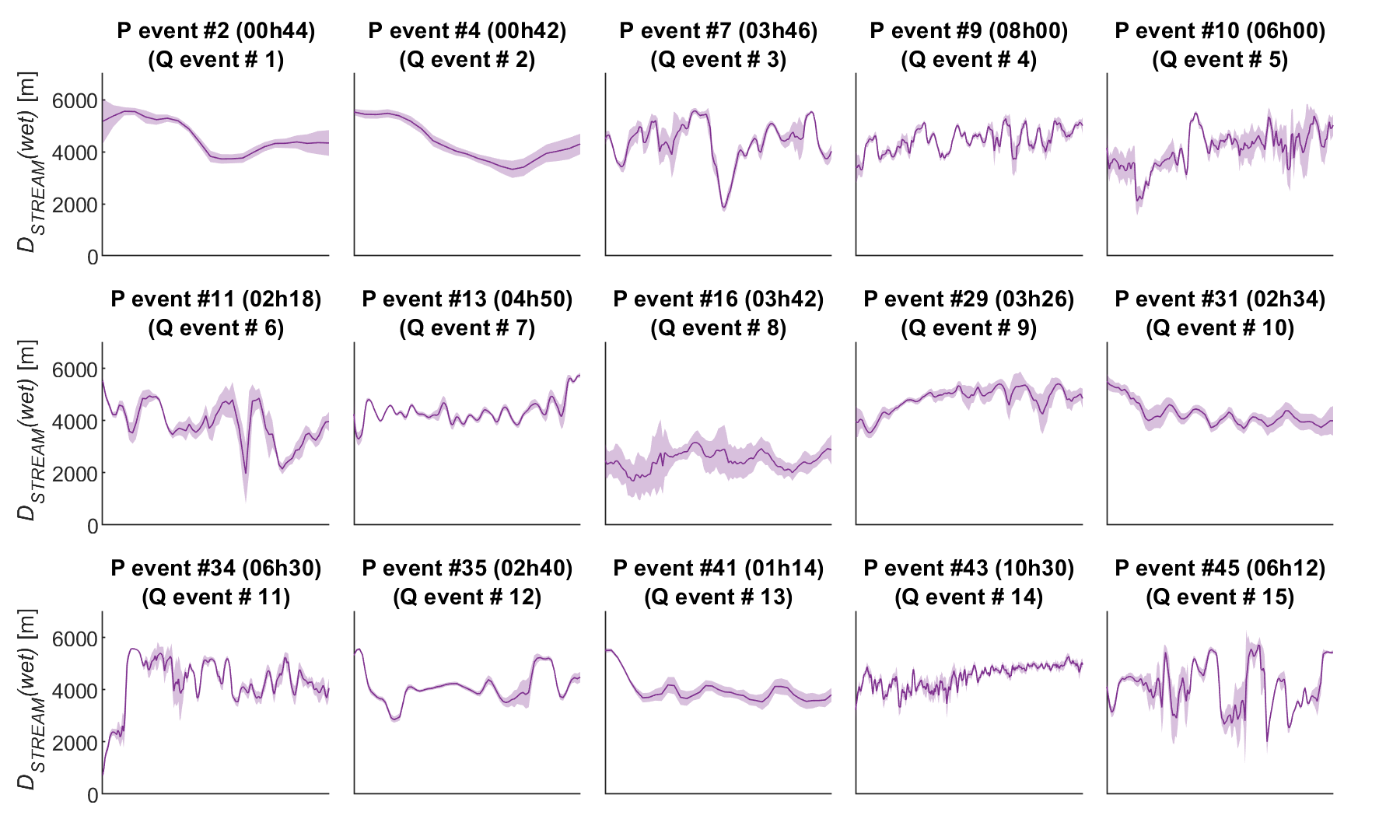


Figure S14. Evolution of DSTREAM for the 15 rainfall events (P event) associated with a river reaction (Q event).

Table S1. Distance metrics for each streamflow event with respect to the extended (wet) and the retracted (dry) network and the combined distance if a threshold of antecedent precipitation of 20 mm is applied.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *D*HILLS [m] | | | *D*STREAM [m] | | | *H*HAND [m] | | |
| Network | *wet* | *dry* | *pseudo-dynamic* | *wet* | *dry* | *pseudo-dynamic* | *wet* | *dry* | *pseudo-dynamic* |
| 2-Jul-18 | 925 | 1521 | 1521 | 4604 | 4008 | 4008 | 378 | 611 | 611 |
| 3-Jul-18 | 817 | 1336 | 1336 | 4361 | 3842 | 3842 | 350 | 550 | 550 |
| 5-Jul-18 | 755 | 1287 | 755 | 4374 | 3842 | 4374 | 350 | 557 | 350 |
| 6-Jul-18 | 874 | 1352 | 874 | 4450 | 3972 | 4450 | 355 | 536 | 355 |
| 14-Jul-18 | 736 | 1263 | 1263 | 4100 | 3574 | 3574 | 345 | 554 | 554 |
| 15-Jul-18 | 628 | 1122 | 1122 | 3871 | 3377 | 3377 | 326 | 528 | 528 |
| 20-Jul-18 | 758 | 1282 | 1282 | 4348 | 3823 | 3823 | 336 | 541 | 541 |
| 24-Jul-18 | 443 | 740 | 740 | 2481 | 2184 | 2184 | 278 | 419 | 419 |
| 14-Aug-18 | 784 | 1286 | 1286 | 4806 | 4305 | 4305 | 354 | 540 | 540 |
| 17-Aug-18 | 662 | 1122 | 1122 | 4240 | 3780 | 3780 | 313 | 490 | 490 |
| 23-Aug-18 | 854 | 1371 | 1371 | 4273 | 3756 | 3756 | 362 | 563 | 563 |
| 24-Aug-18 | 692 | 1155 | 692 | 4114 | 3651 | 4114 | 320 | 503 | 320 |
| 29-Aug-18 | 739 | 1207 | 1207 | 3995 | 3526 | 3526 | 336 | 524 | 524 |
| 01-sept-18 | 725 | 1271 | 725 | 4487 | 3941 | 4487 | 331 | 545 | 331 |
| 13-sept-18 | 782 | 1291 | 1291 | 4103 | 3594 | 3594 | 352 | 556 | 556 |

Table S2. Correlations between distance metrics for all the rainfall events (subset #1, Table 4 in the main text). Absolute values equal or over 0.60 are in bold.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | *D*HILLS | *D*HILLS | *D*STREAM | *D*STREAM | *H*HAND | *H*HAND | *D*HILLS | *D*STREAM | *H*HAND |
|  | River network | *Wet* | *Dry* | *Wet* | *Dry* | *Wet* | *Dry* | *pseudo-dynamic* | *pseudo-dynamic* | *pseudo-dynamic* |
| *D*HILLS | *Wet* | - |  |  |  |  |  |  |  |  |
| *D*HILLS | *Dry* | **0.97** | - |  |  |  |  |  |  |  |
| *D*STREAM | *Wet* | **0.78** | **0.87** | - |  |  |  |  |  |  |
| *D*STREAM | *Dry* | **0.76** | **0.85** | **1.00** | - |  |  |  |  |  |
| *H*HAND | *Wet* | **0.95** | **0.95** | **0.70** | **0.68** | - |  |  |  |  |
| *H*HAND | *Dry* | **0.87** | **0.95** | **0.79** | **0.75** | **0.94** | - |  |  |  |
| *D*HILLS | *pseudo-dynamic* | 0.51 | 0.57 | 0.42 | 0.38 | 0.57 | **0.63** | - |  |  |
| *D*STREAM | *pseudo-dynamic* | **0.72** | **0.77** | **0.92** | **0.93** | **0.61** | **0.65** | 0.04 | - |  |
| *H*HAND | *pseudo-dynamic* | 0.28 | 0.36 | 0.22 | 0.18 | 0.40 | 0.48 | **0.96** | -0.18 | - |

Table S3. For the 23 events measured by the full network setup: number of stations wrong by a factor 2 compared to the average of all the stations.

|  |  |
| --- | --- |
| **P event No.** | **Number of stations wrong by a factor 2** |
| 16 | 9 |
| 17 | 0 |
| 18 | 0 |
| 20 | 4 |
| 21 | 7 |
| 23 | 11 |
| 24 | 1 |
| 25 | 0 |
| 26 | 0 |
| 28 | 4 |
| 29 | 2 |
| 30 | 0 |
| 31 | 0 |
| 32 | 7 |
| 33 | 0 |
| 34 | 1 |
| 35 | 0 |
| 36 | 2 |
| 37 | 2 |
| 38 | 4 |
| 39 | 11 |
| 40 | 0 |
| 41 | 1 |

Table S4. For the 23 events measured by the full network setup: number of events for which the station is wrong by a factor 2 compared to the average of all the stations.

|  |  |
| --- | --- |
| **Station No.** | **Number of events for which the station is wrong by a factor 2** |
| 1 | 8 |
| 2 | 2 |
| 3 | 5 |
| 4 | 5 |
| 5 | 3 |
| 6 | 4 |
| 7 | 8 |
| 8 | 6 |
| 9 | 7 |
| 10 | 4 |
| 11 | 7 |
| 12 | 7 |