



## *Supplement of*

# **When and where does near-surface runoff occur in a pre-Alpine headwater catchment?**

**Victor Aloyse Gauthier et al.**

*Correspondence to:* Victor Aloyse Gauthier ([victor.gauthier@lilo.org](mailto:victor.gauthier@lilo.org))

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**Table S1: Characteristics of the 27 events: *P*: total precipitation (mm), *I*<sub>10</sub>: 10-min maximum precipitation intensity (mm h<sup>-1</sup>), *I*<sub>mean</sub>: mean precipitation intensity over every 30 min period with precipitation (mm h<sup>-1</sup>), *I*<sub>class</sub>: precipitation intensity class; *D*: event duration (time between the start and end of the event; h), *ASI*: antecedent soil moisture index for the top 5 cm of soil (mm), *ASI+P*: antecedent soil moisture index plus total precipitation (mm), *Plots OF* percentage of plots for which there was a measurable amount of OF, and *Plots TIF* percentage of plots for which there was a measurable amount of TIF.**

Event	Date	P	I <sub>10</sub>	I <sub>mean</sub>	I <sub>class</sub>	D	ASI	ASI+P	Plots OF	Plots TIF
-	dd/mm/yy	(mm)	(mm/h)	(mm/h)	-	(hh:min)	(mm)	(mm)	%	%
E1	31/05/22	7	5.4	1.8	Low	03:15	24	31	0	0
E2	03/06/22	20	34.8	5.1	High	03:05	24	45	40	40
E3	05/06/22	17	39.6	2.9	Medium	04:15	24	42	20	40
E4	06/06/22	43	49.8	2.5	Medium	11:45	25	68	75	100
E5	09/06/22	22	15.6	2.0	Low	06:35	26	48	40	40
E6	12/06/22	11	15.6	2.3	Medium	02:35	24	34	20	0
E7	24/06/22	38	63.0	5.4	High	05:35	23	61	67	92
E8	27/06/22	10	13.2	1.9	Low	03:25	23	33	25	33
E9	30/06/22	49	27.6	3.6	Medium	10:35	24	72	80	100
E10	20/07/22	10	28.2	2.8	Medium	02:05	16	26	43	15
E11	25/07/22	20	22.8	2.1	Medium	05:45	18	38	50	46
E12	28/07/22	5	4.8	2.5	Medium	01:55	21	26	29	8
E13	29/07/22	9	4.8	1.8	Low	04:15	22	31	36	23
E14	01/08/22	7	16.8	1.9	Low	02:25	20	28	14	0
E15	15/08/22	28	48.0	5.6	High	03:35	17	45	79	83
E16	18/08/22	98	25.2	6.5	High	13:50	25	123	86	92
E17	26/08/22	9	15.6	3.1	Medium	02:35	21	30	50	50
E18	27/08/22	12	48.6	3.8	Medium	01:25	22	33	14	7
E19	30/08/22	20	22.2	3.0	Medium	07:05	24	44	93	86
E20	02/09/22	8	34.8	1.9	Low	01:40	23	31	7	7
E21	06/09/22	29	30.0	4.1	High	05:45	24	53	79	93
E22	14/09/22	20	25.2	2.5	Medium	05:35	23	42	50	64
E23	16/09/22	51	10.2	2.0	Low	19:55	25	75	57	83
E24	26/09/22	18	12.0	1.6	Low	08:45	25	43	57	79
E25	01/10/22	34	7.2	2.0	Low	13:45	25	58	43	67
E26	02/10/22	25	11.4	2.2	Medium	09:25	25	50	64	77
E27	08/10/22	6	7.8	0.9	Low	07:25	24	30	8	22

**Table S2: Average values and range (min-max) for the soil properties for plots in forest and clearing and for the grassland and wetland plots, as well as the number of measurements for each property (*n*). Note that we grouped the plots in the forest and clearings and the plots in the grasslands and wetlands for this analysis because of the small number of samples (i.e., low *n*). The porosity, water content at field capacity and water content at wilting point are based on measurements for soil cores with the Hydroprop (METER Group; Data: Sonja Eisenring, 2023). The saturated hydraulic conductivity ( $K_{sat}$ ) values are based on steady state infiltration rates at the surface using a 22 cm diameter double ring infiltrometer (Data: Wadman, 2023).**

	Depth (cm)	Forest and Clearing			Grassland and wetlands		
		Mean	Range	<i>n</i>	Mean	Range	<i>n</i>
Porosity (%)	10-15	78	67-94	8	75	52-91	4
Water content at field capacity (%)	10-15	51	41-78	8	64	49-73	4
	10-15	31	15-52	8	30	20-34	4
Drainable porosity (%)	2-7	22	8-42	9	11	8-17	3
	10-15	19	4-35	8	24	1-68	4
Carbon content (%)	2-7	28	19-69	8	43	32-54	2
	10-15	22	11-48	8	21	3-43	4
Sand content (%)	2-7	11	6-22	7	25	-	1
	10-15	14	6-28	6	20	18-21	2
Silt content (%)	2-7	38	31-44	7	40	-	1
	10-15	35	32-55	6	53	41-66	2
Clay content (%)	2-7	52	47-57	7	35	-	1
	10-15	52	18-58	6	27	15-39	2
Bulk density (g/cm <sup>3</sup> )	2-7	0.5	0.15-0.57	9	0.52	0.21-0.78	4
	10-15	0.6	0.16-0.86	8	0.57	0.23-1.27	5
$K_{sat}$ (mm/h)		122	8-320	6	345	-	1
Depth A (cm)		17	10-20	9	12	5-15	5
Depth B (cm)		35	30-40	9	37.2	31-42	5

**Table S3: Spearman rank correlation between the site characteristics and the statistical significance of the relation (\*\*:  $p:0.01-0.05$ ).**

	TWI	Slope	Vegetation	Depth A horizon	Depth B horizon	OM (%)
<b>TWI</b>	-	-0.27	0.60**	0.42	0.01	0.56**
<b>Slope</b>		-	-0.44	-0.35	0.25	-0.39
<b>Vegetation</b>			-	0.02	-0.18	0.30
<b>Depth A horizon</b>				-	0.02	-0.40
<b>Depth B horizon</b>					-	0.36
<b>OM (%)</b>						-

**Table S4: Spearman rank correlation ( $r_s$ ) between the soil characteristics measured for soil cores taken at 10-15 cm depth, as well as the depth of the bottom of the A and B horizon at the location of the trench and the topographic wetness index (TWI) and vegetation (ordered as in the manuscript: 0: forest, 1: clearing, 2: grassland, 3: wetland).  $n$  represents the number of data points used for the correlation.**

	n	TWI		Vegetation	
		$r_s$	p-value	$r_s$	p-value
Porosity	13	0.55	0.05	0.30	0.32
Water content at field capacity	13	0.41	0.17	0.16	0.60
Water content at wilting point	13	-0.25	0.42	-0.31	0.30
Drainable porosity	13	-0.21	0.50	0.02	0.94
Carbon content	13	0.56	0.05	0.30	0.33
Sand content	9	0.21	0.61	0.24	0.57
Silt content	9	-0.12	0.78	0.43	0.29
Clay content	9	-0.55	0.16	-0.50	0.20
$K_{sat}$	7	-0.14	0.76	0.42	0.35
Depth A horizon	14	0.42	0.14	0.02	0.96
Depth B horizon	14	0.22	0.45	0.14	0.63

**Table S5: Correlation matrix showing the Spearman rank correlation between the event characteristics and the statistical significance of the relation (\*:  $p:0.05-0.1$ ; \*\*:  $p:0.01-0.05$ ; \*\*\*:  $p<0.01$ ).  $P$ : total precipitation (mm),  $I_{10}$ : 10-min maximum precipitation intensity ( $\text{mm h}^{-1}$ ),  $I_{mean}$ : mean precipitation intensity for every 30 min period with precipitation ( $\text{mm h}^{-1}$ ),  $D$ : event duration (time between the start and end of the event; h),  $ASI$ : antecedent soil moisture index for the top 5 cm of soil (mm),  $ASI+P$ : antecedent soil moisture index plus precipitation (mm).**

	P	$I_{10}$	$I_{mean}$	D	ASI	ASI+P
P	-	0.39**	0.53***	0.77***	0.50***	0.96***
$I_{10}$		-	0.70***	-0.04	-0.11	0.30
$I_{mean}$			-	-0.05	-0.06	0.42**
D				-	0.69***	0.83***
ASI					-	0.65***
ASI+P						-

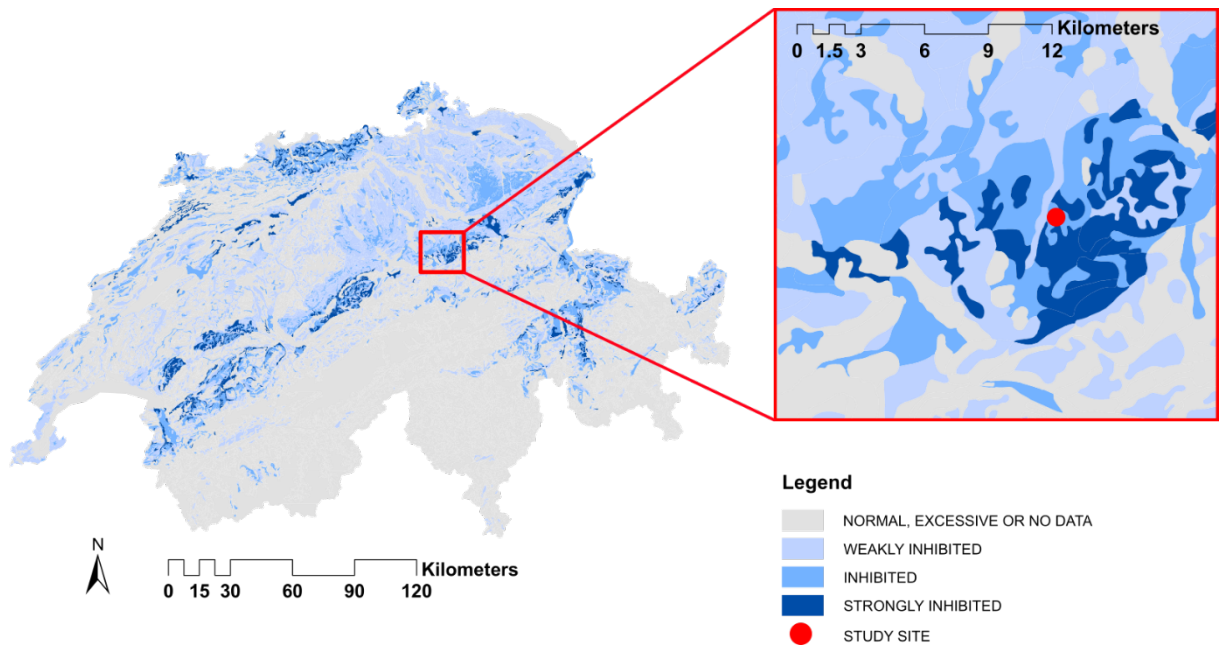
**Table S6: Number of events (out of 27) for which there was a positive (+) or negative (-) significant ( $p < 0.1$ ) Spearman rank correlation between the soil properties measured for a core taken at 10-15 cm below the soil surface or in the field and the runoff ratio for OF or TIF.**

<b>Flow pathway</b>	<b>OF</b>		<b>TIF</b>	
<b>Positive (+) or negative (-) correlation</b>	<b>+</b>	<b>-</b>	<b>+</b>	<b>-</b>
Porosity	6		3	0
Water content at field capacity	2	1	0	2
Water content at wilting point		2	0	3
Drainable porosity	0	0	0	0
Carbon content	5	0	4	0
Sand content	6	0	0	4
Silt content	6	0	2	0
Clay content	0	11	0	0
$K_{sat}$	0	0	0	0
Depth A	3	1	3	1
Depth B	0	0		

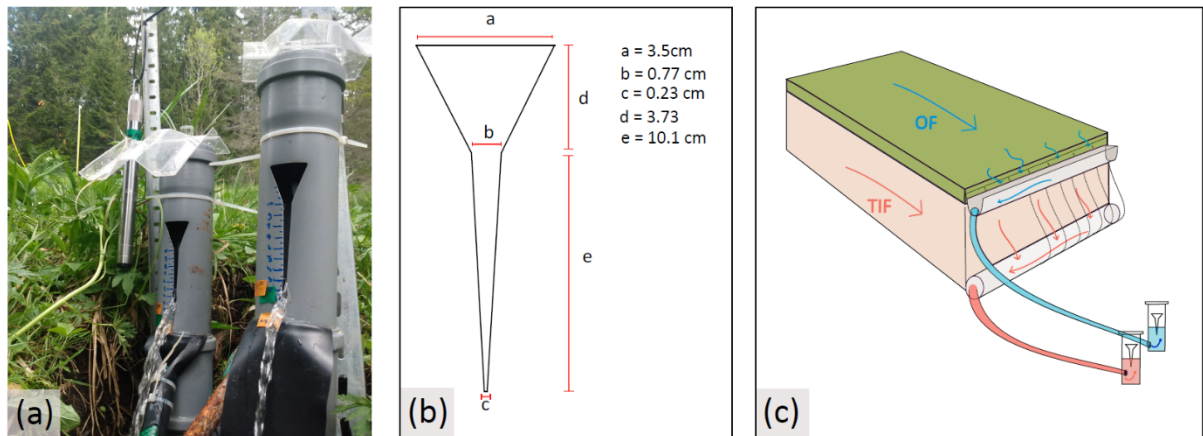
## References

Sonja Eisenring: Spatial Variation in Soil Hydraulic Properties in the Studibach Catchment and its Effects on Simulated Infiltration, University of Zurich, Zurich, 2023.

Wadman, M.: Spatial variability of infiltration in a pre-alpine catchment, Wageningen University, Wageningen, 2023.

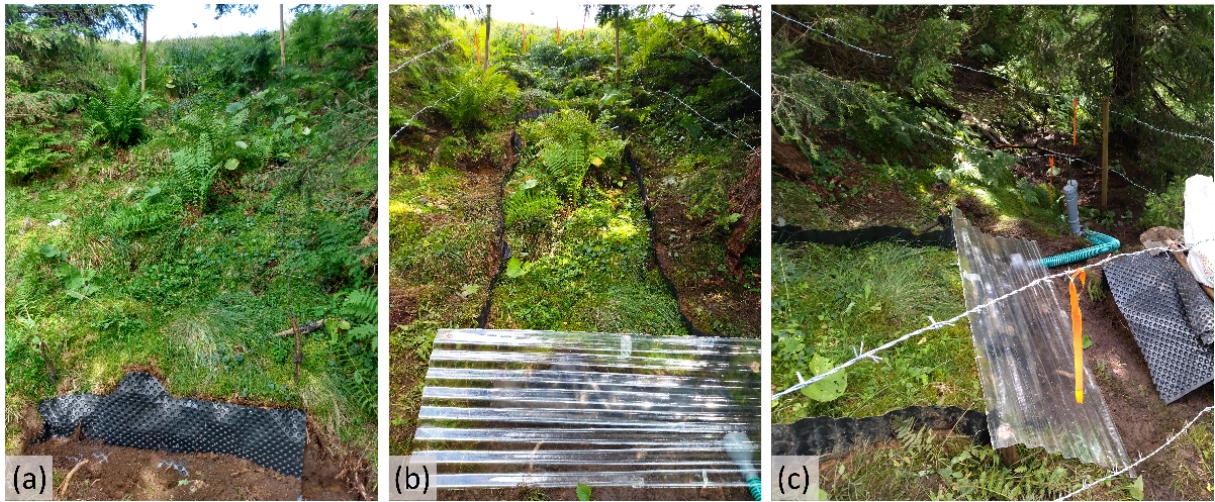


**Figure S1:** Map of Switzerland showing areas with inhibited vertical drainage in the upper 0.50 m of the soil profile (in different shades of blue) and the location of the Studibach. Data: Carte des aptitudes des sols de la Suisse OFAG [BLW, 1980].

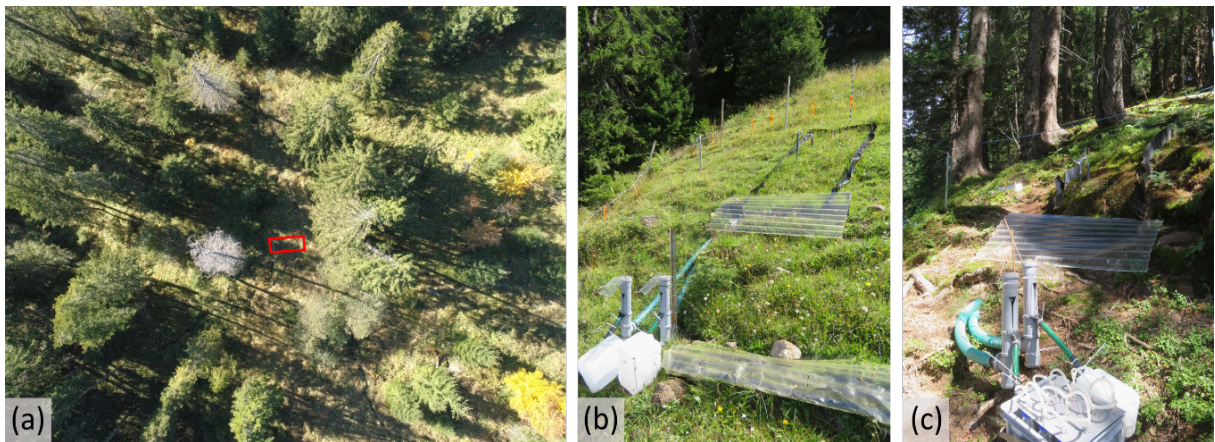


**Figure S2:** Photos of the UBeTubes in the field (a), sketch of the UBeTubes with the dimensions (b), and schematic representation of the plot setup and connection to the UbeTubes (c).

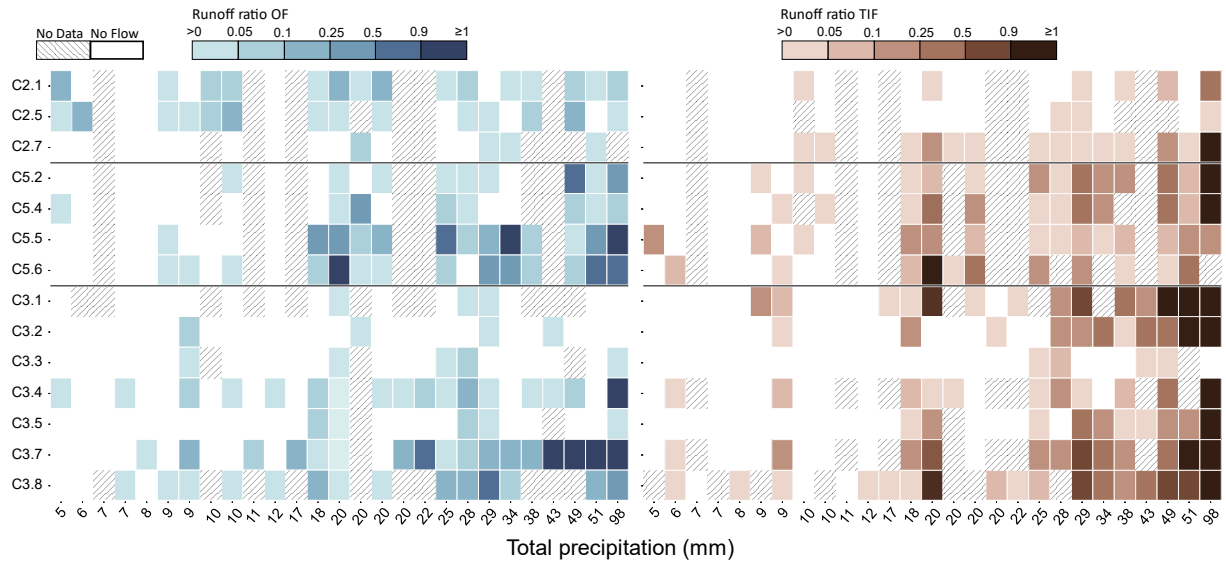




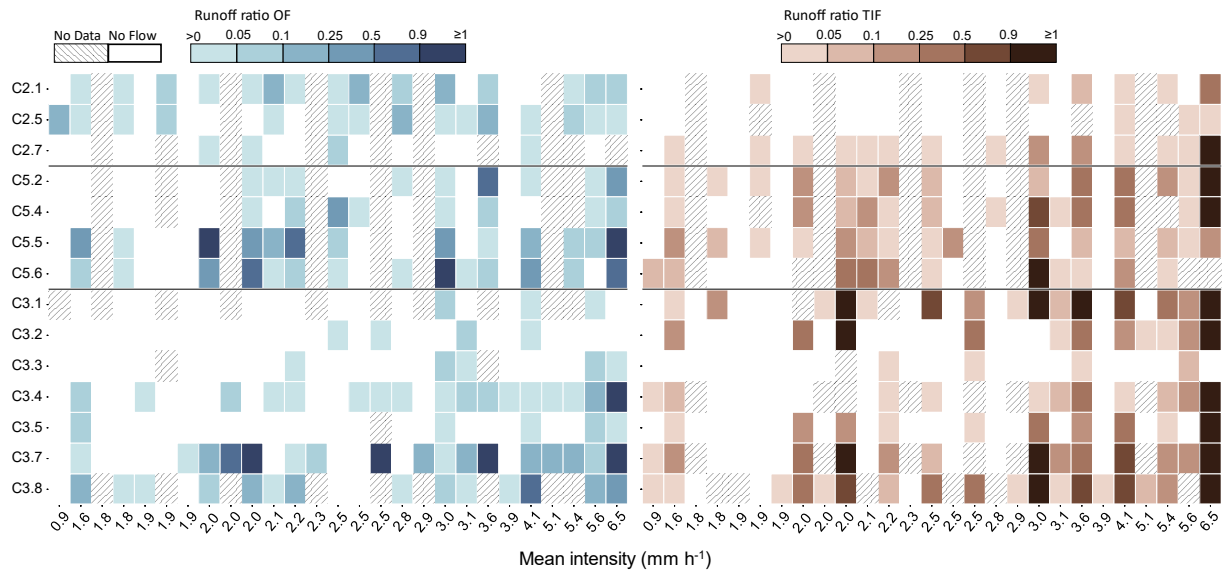
**Figure S3:** Photos of the plot setup, showing the trench with the drainage mat (a), gutter covered with a roof and plot borders (b), and the hoses connecting the runoff plot to the UBeTubes in the back for plot C2.5(c).



**Figure S4:** Photos of the plots: location C3.7 (red rectangle 1 x 3 m) showing the typical cover of the open coniferous forest in the lower catchment C3 (a), C5.2 (b), and C2.1 (c).

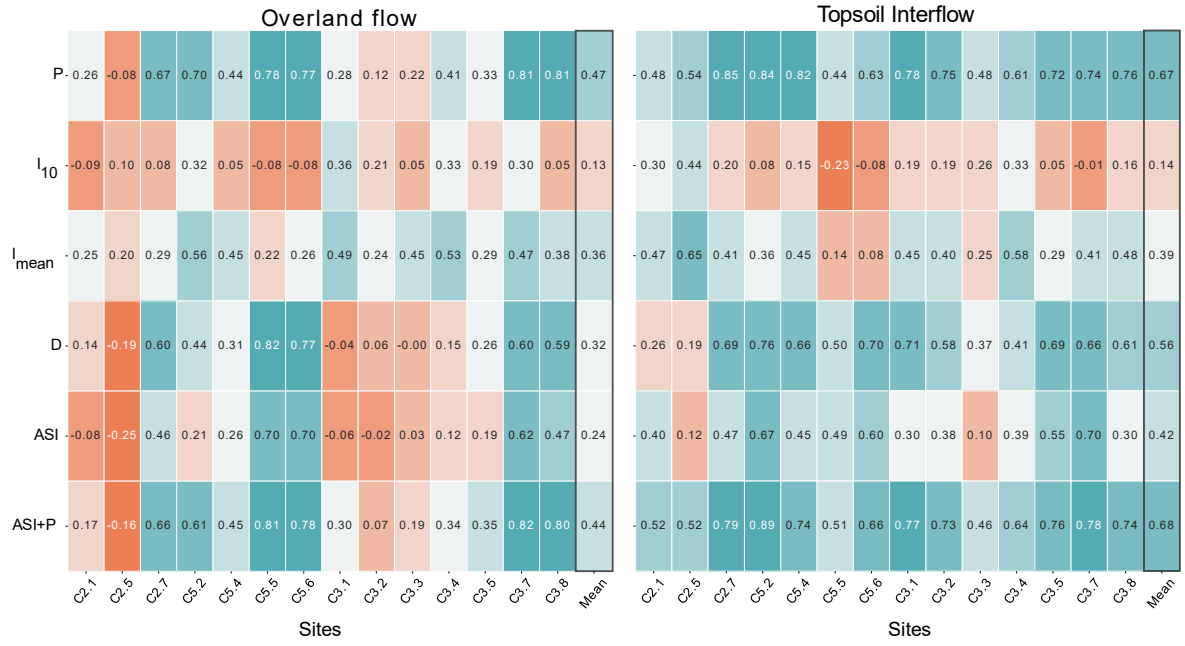


**Figure S5:** Heatmap of the runoff ratio ( $R$ ) for OF ( $R_{OF}$ ; left) and TIF ( $R_{TIF}$ ; right) for each event (ordered by total precipitation; x axis) and each plot (y axis). All runoff ratios  $> 1$  were set to 1 for plotting. Events for which no flow occurred are shown in white. Events for which data are missing are indicated by the shaded area.

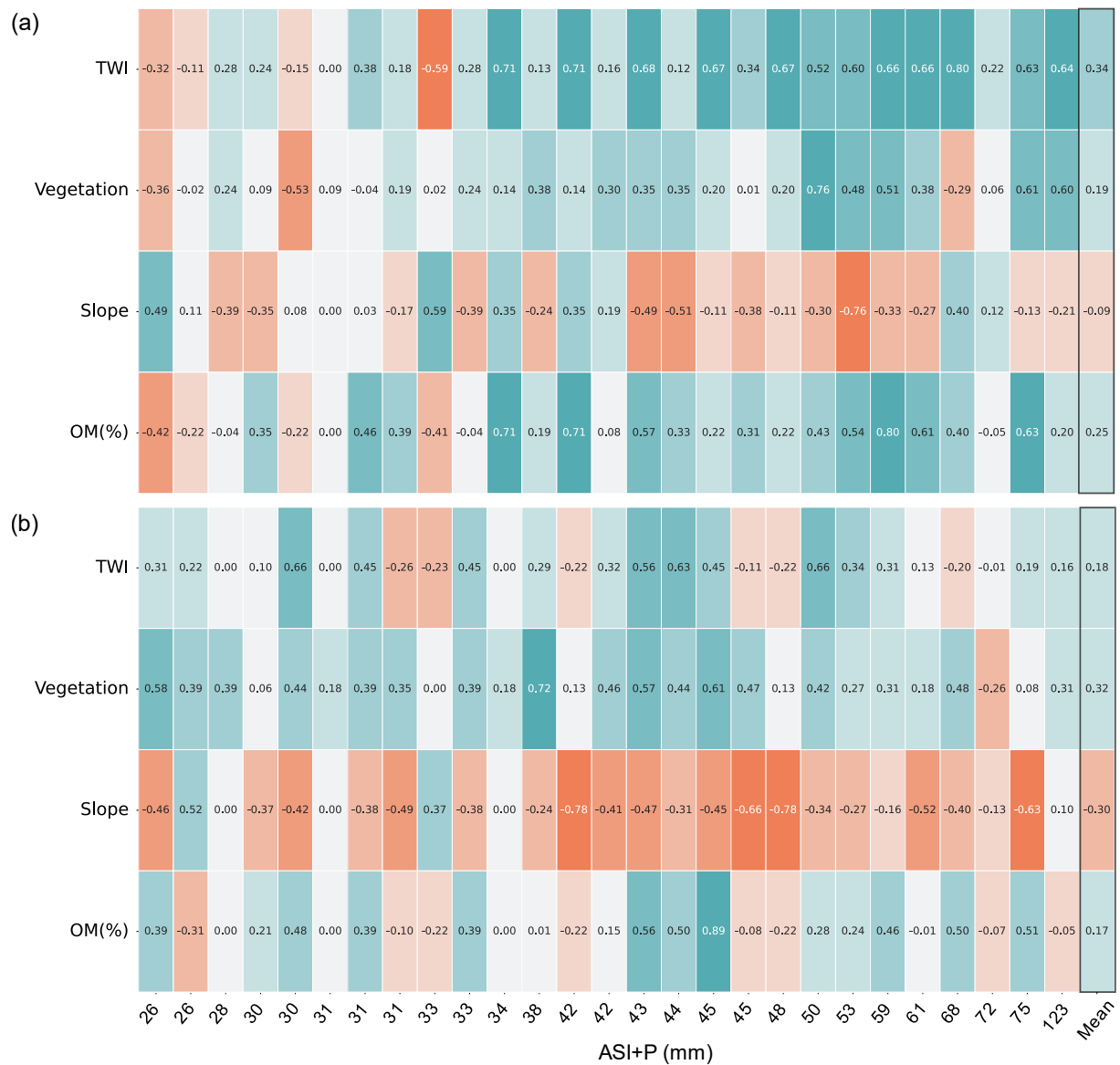


**Figure S6:** Heatmap of the runoff ratio ( $R$ ) for OF ( $R_{OF}$ ; left) and TIF ( $R_{TIF}$ ; right) for each event (ordered by mean intensity; x axis) and each plot (y axis). All runoff ratios  $> 1$  were set to 1 for plotting. Events for which no flow occurred are shown in white. Events for which data are missing are indicated by the shaded area.

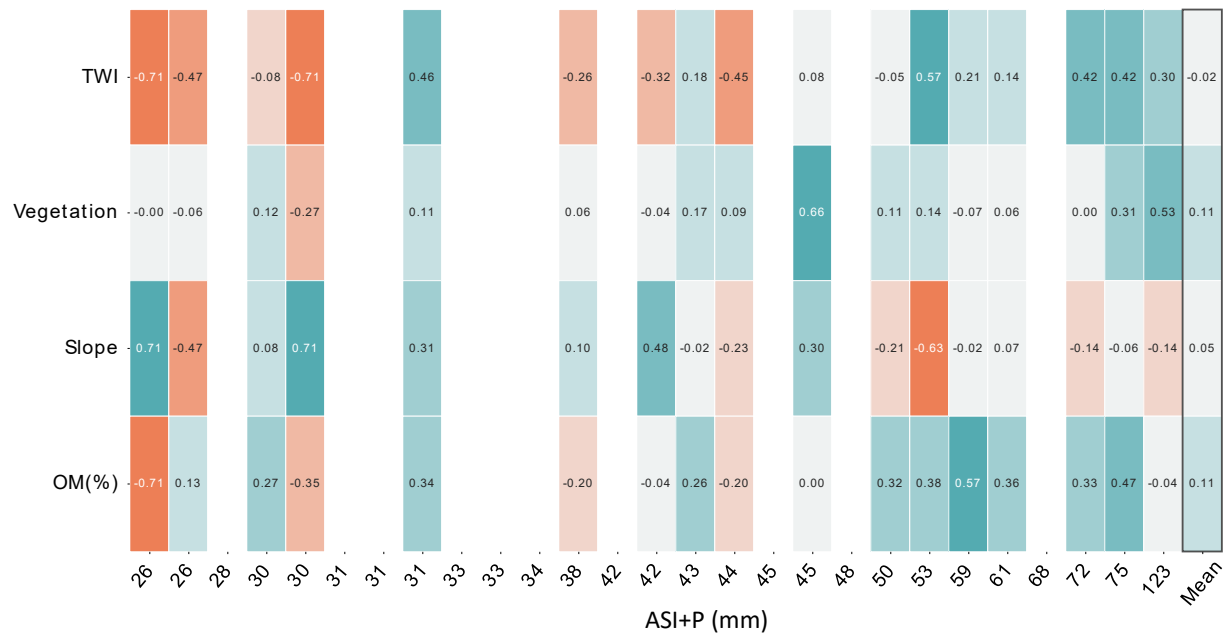




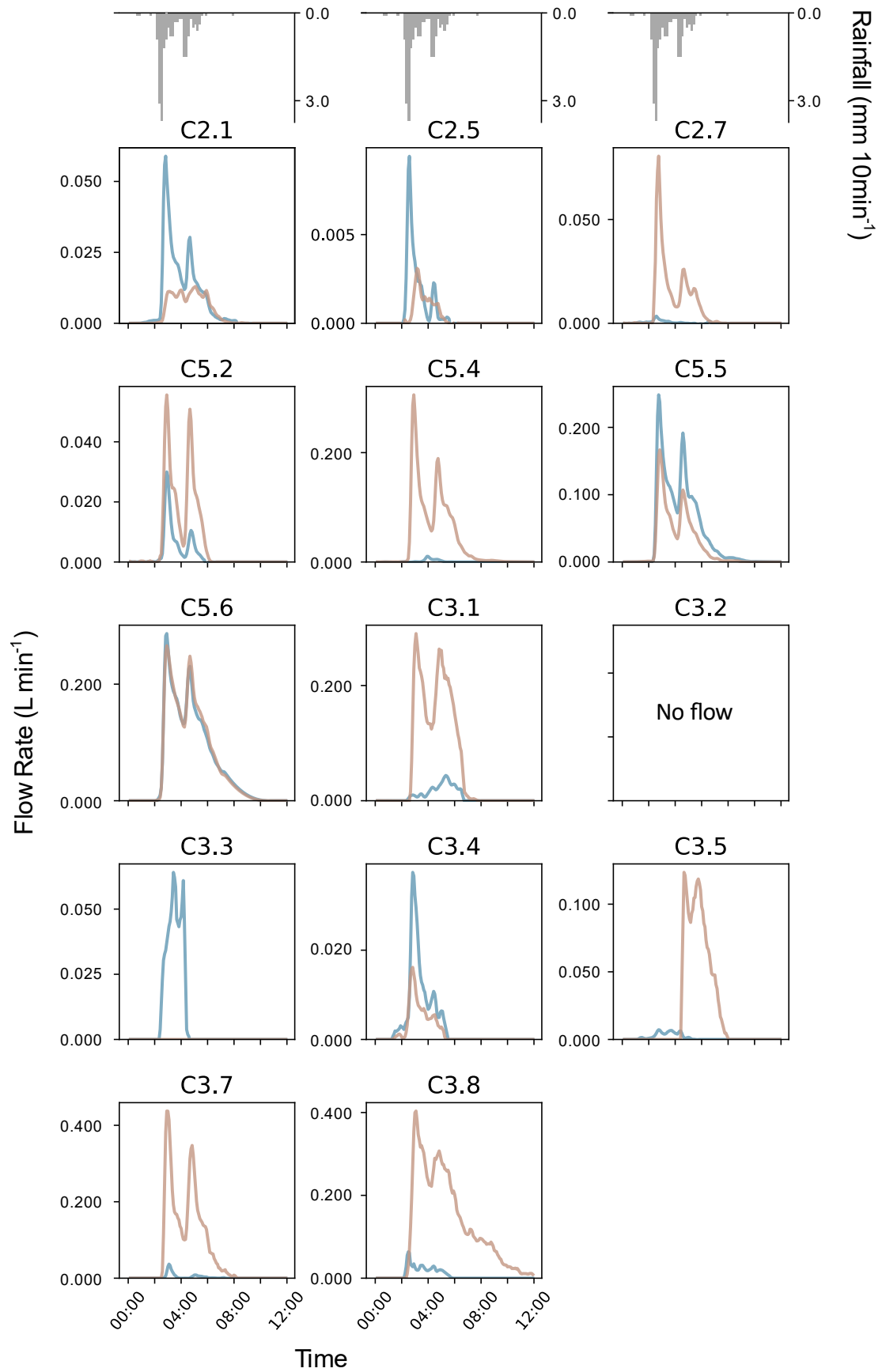
**Figure S7: Heatmap of the Spearman rank correlation between the runoff ratio for OF ( $R_{OF}$ ; left) and TIF ( $R_{TIF}$ ; right) and six event characteristics for each plot, as well as the mean for all plots:  $P$ : total precipitation (mm),  $I_{10}$ : 10-min maximum precipitation intensity (mm h<sup>-1</sup>),  $I_{mean}$ : mean precipitation intensity over every 30 min period with precipitation (mm h<sup>-1</sup>),  $D$ : event duration (time between the start and end of the event; h),  $ASI$ : antecedent soil moisture index for the top 5 cm of soil (mm),  $ASI+P$ : antecedent soil moisture index plus precipitation (mm).**



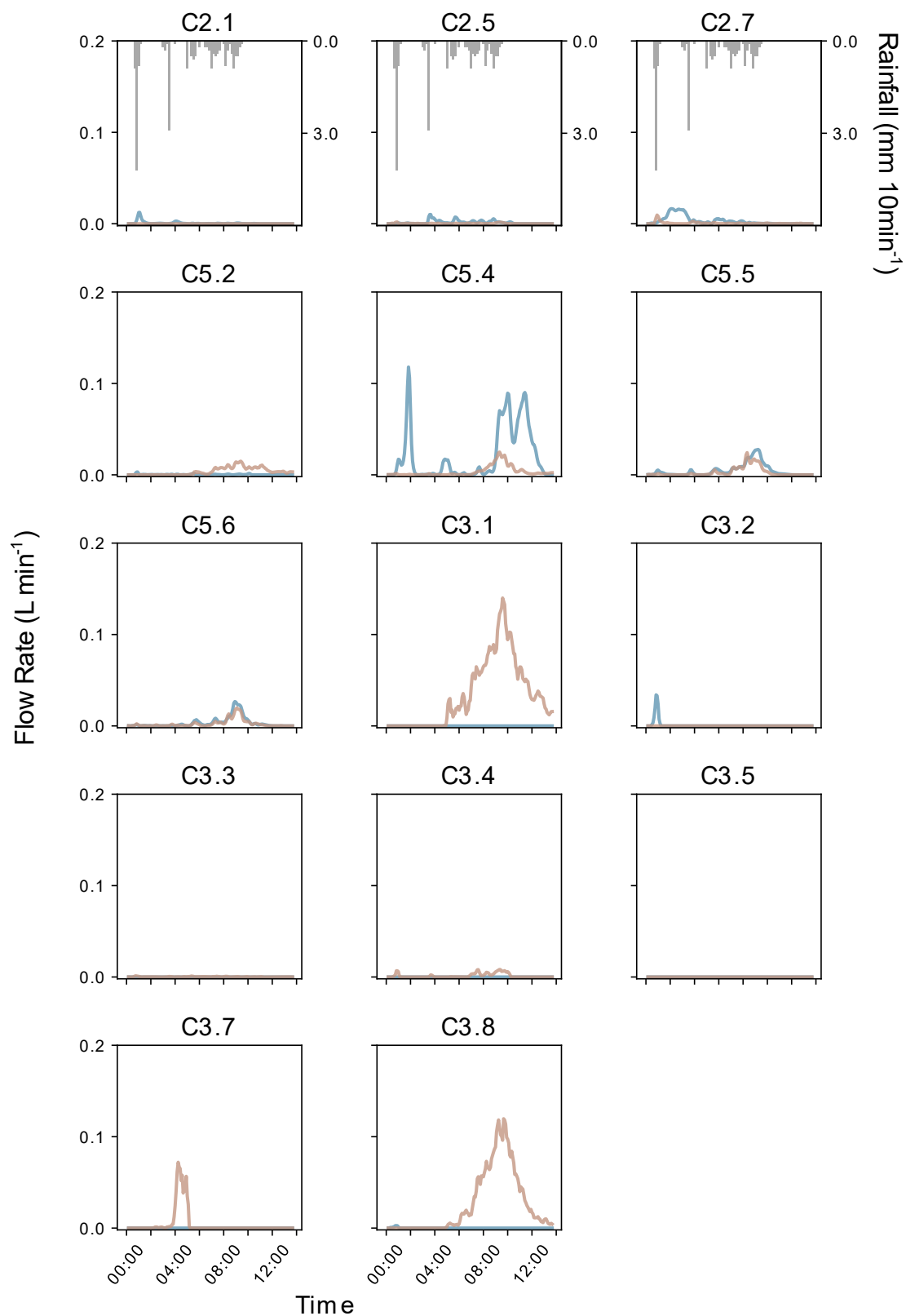
**Figure S8: Heatmap of the Spearman rank correlation between the runoff ratio for OF ( $R_{OF}$ ; a) or and TIF ( $R_{TIF}$ ; b) and four site characteristics for each event for which OF or TIF was recorded at more than 4 plots (ordered by  $ASI+P$ ; x-axis), and the mean for all events: topographic wetness index ( $TWI$ ), vegetation, slope and organic matter content ( $OM$  (%)).**



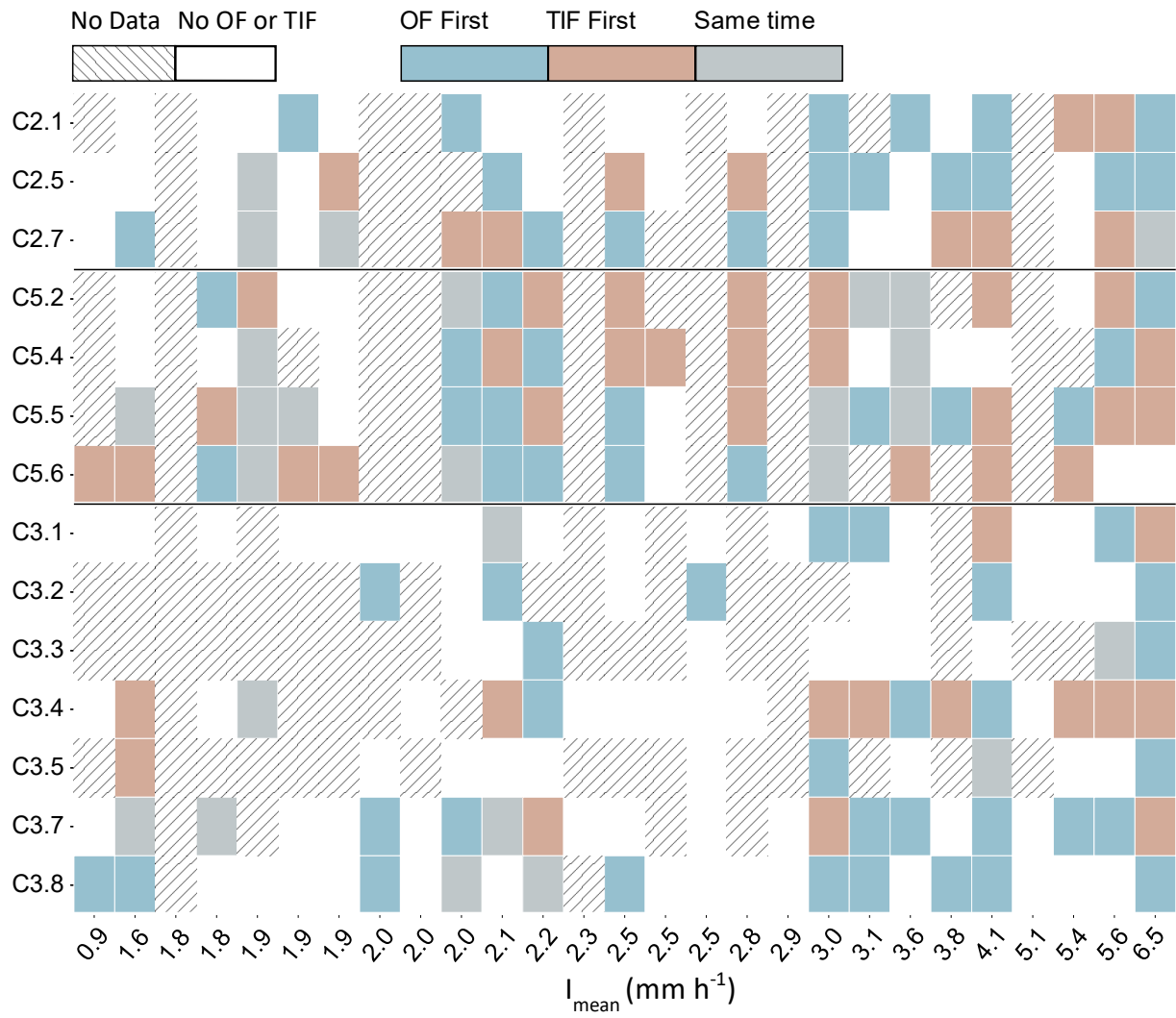
**Figure S9: Heatmap of the Spearman rank correlation between the fraction of OF for near surface flow ( $P_{OF}$ ) per plot, and four plot characteristics for each event for which there was a measurable amount of OF and TIF (ordered by  $ASI+P$ ) and the mean for all events: topographic wetness index (TWI), vegetation, slope and organic matter content (OM (%)). White cell indicates an insufficient number of plots with OF or TIF for that event to determine the Spearman rank correlation.**



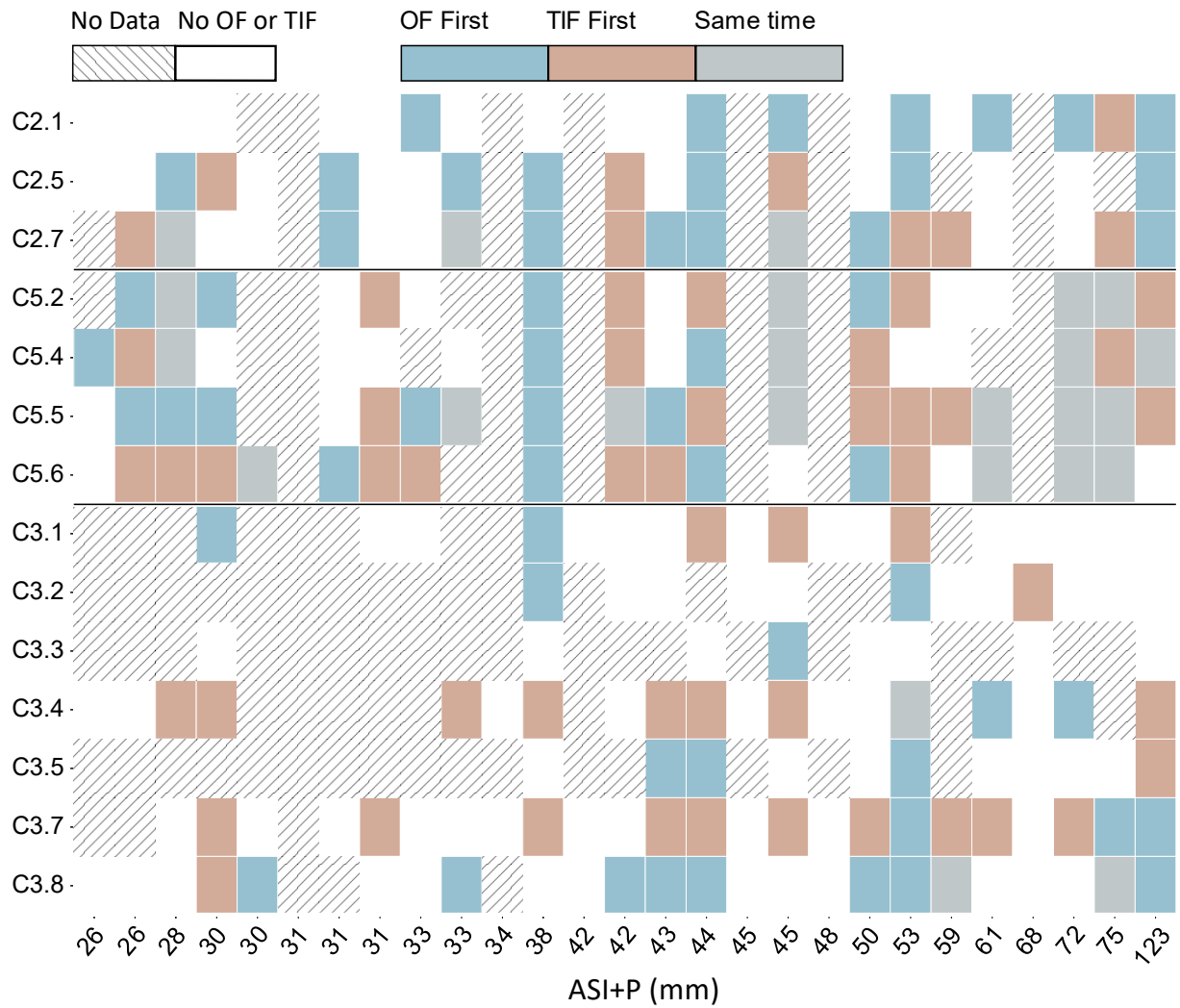
**Figure S10: Hydrographs for overland (OF; blue) and topsoil interflow (TIF; brown) for each plot during the 20 mm event on the 30<sup>th</sup> of August, 2022 (event E19), as well as precipitation intensity (mm 10-min<sup>-1</sup>; only shown for the upper row of figures). The plot name is indicated above each subplot. Note the different y-axis scale for each subplot.**



**Figure S11: Hydrographs for overland (OF; blue) and topsoil interflow (TIF; brown) for each plot during the 20 mm event on the 14th of September 2022 (event E22), as well as precipitation intensity (mm 10-min<sup>-1</sup>; only shown for the upper row of figures). The plot name is indicated above each subplot. All loggers recorded data during the event, but for many plots there was either no flow or a very small flow rate, which appears as a horizontal line at zero.**

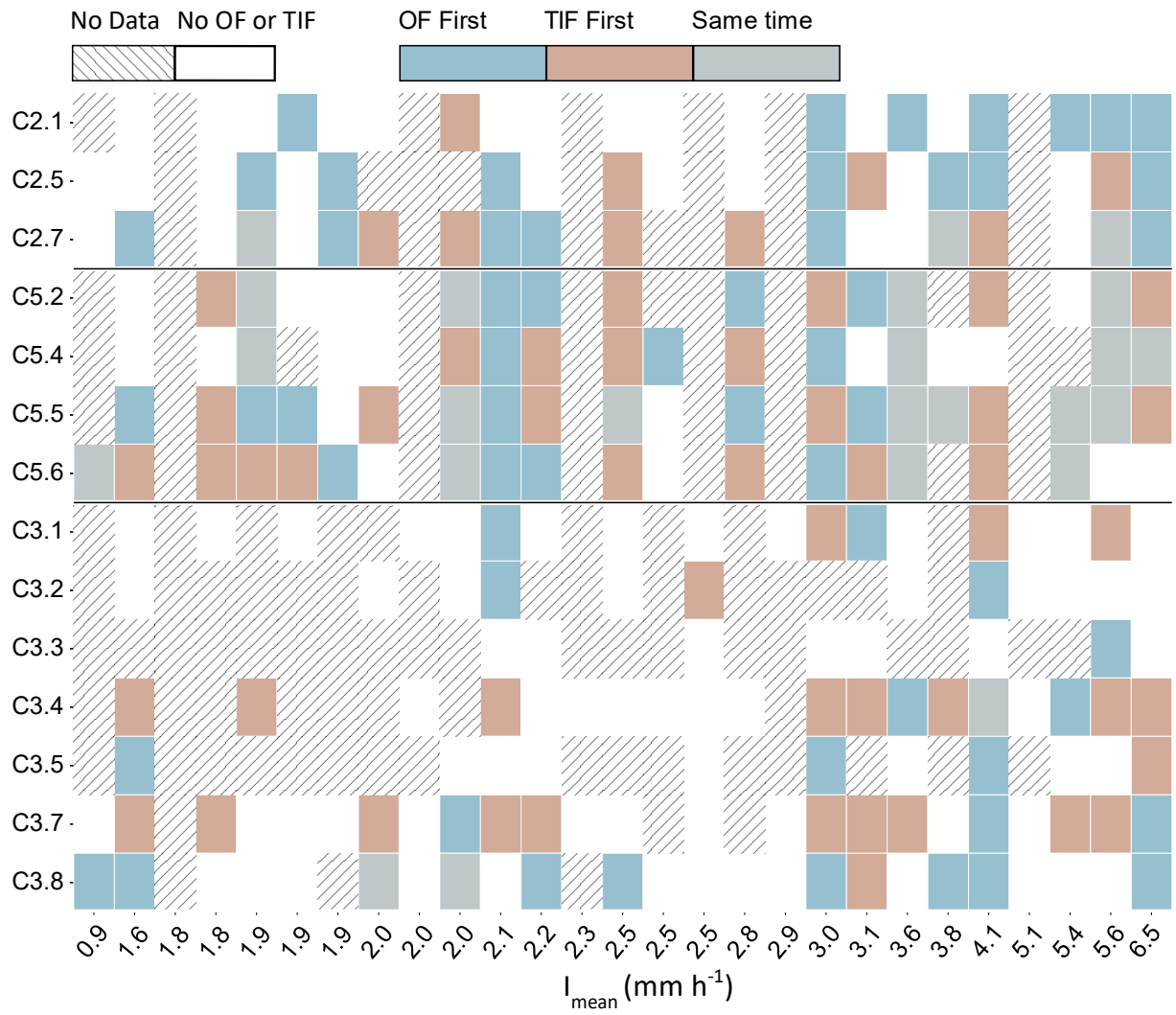


**Figure S12:** Heatmap showing whether overland flow (OF, blue) or topsoil interflow (TIF, brown) responded first or if both responded within 5 min (same time, gray) for each rainfall events (ordered by increasing mean intensity, x-axis) and plot (y-axis). Dashed lines indicate the lack of OF and TIF for that particular plot and event, while white cells indicate a lack of data for either OF or TIF.

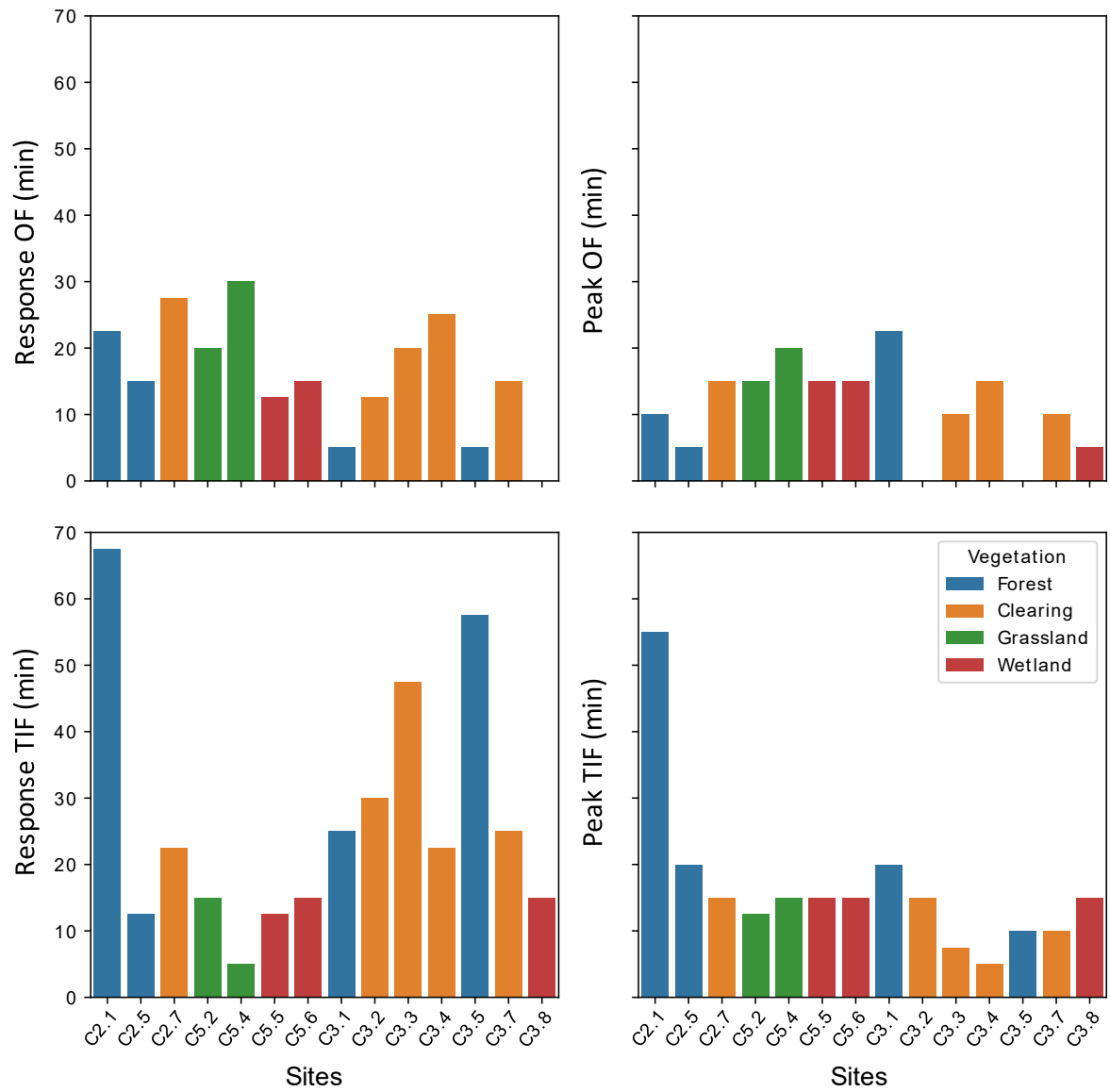


**Figure S13:** Heatmap showing whether overland flow (OF, blue) or topsoil interflow (TIF, brown) peaked first or if both responded within 5 min (same time, gray) for each rainfall event (ordered by increasing *ASI+P*; x-axis) and plot (y-axis). Dashed lines indicate the lack of OF and TIF for that particular event, while white cells indicate a lack of data for either OF or TIF.





**Figure S14:** Heatmap showing whether overland flow (OF, blue) or topsoil interflow (TIF, brown) peak first or if both responded within 5 min (same time, gray) for each rainfall events (ordered by increasing mean intensity; x-axis) and plot (y-axis). Dashed lines indicate the lack of OF and TIF for that particular event, while white cells indicate a lack of data for either OF or TIF.



**Figure S15: Median of the time to rise (left) and time to peak (right) for OF (upper row) and TIF (lower row). Locations are ordered by TWI within each sub-catchment and are coloured by their vegetation classes.**