



Supplement of

Runoff thresholds, runoff generation mechanisms, and catchment characteristics: a global synthesis

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Supplementary Table and Figure.

Table S1. Harmonization rules and operational criteria for classifying reported runoff generation mechanisms.

Class	Terms harmonized under this class	Classification rule
HOF	Hortonian overland flow; infiltration-excess overland flow; infiltration-limited runoff	Used when the source study explicitly interpreted surface runoff as infiltration-excess/Hortonian
SOF	Saturation-excess overland flow; return flow; saturated-area runoff	Used when the source study interpreted surface runoff as saturation-excess or saturated-area expansion
SSF	Subsurface stormflow; lateral subsurface flow; interflow; macropore/pipe flow	Used when lateral event-scale subsurface flow was reported
GWF	Shallow groundwater flow; weathered/fractured bedrock groundwater contribution	Used only for event-scale shallow groundwater contribution to stormflow
Mixed	HOF–SOF, SOF–SSF, SSF–GWF, etc.	Used when co-dominance or switching was explicitly reported

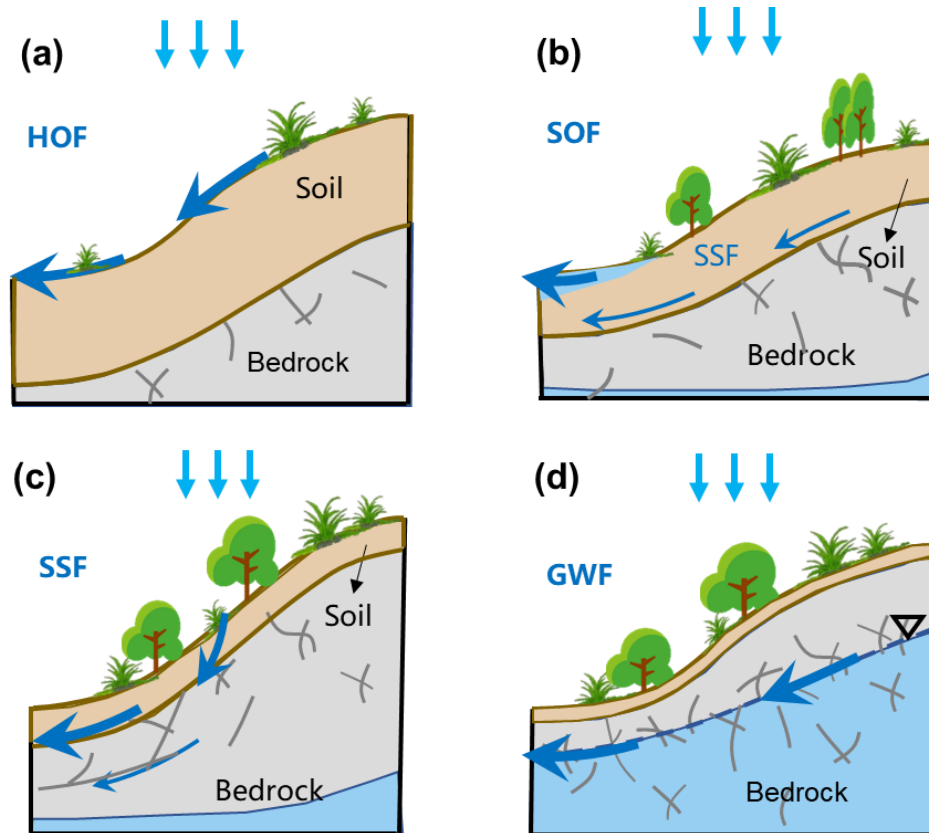


Figure S1. Conceptual schematic of runoff generation mechanism classes used in this review. HOF denotes infiltration-excess surface runoff; SOF denotes runoff from saturated or near-saturated source areas; SSF denotes event-scale lateral subsurface stormflow through soil, regolith, preferential pathways, or restrictive interfaces; and GWF denotes event-scale shallow groundwater flow within weathered bedrock or fractured regolith contributing to stormflow. The schematic is intended to clarify classification terminology and does not imply that all catchments contain all pathways or that these mechanisms are mutually exclusive.

15 **Table S2.** Summary of watershed and reported threshold and runoff generation mechanisms.

Watershed	Country	Threshold variable	State variable	Dominant runoff generation mechanism
ARW	India	Pi	AMC	HOF
Izas	Spain	-	-	HOF
LCC	Italy	-	AMC	SOF
Andit Tid	Ethiopia	P	AMC	SOF
Anjeni	Ethiopia	P	AMC	SOF
La Tigra	Honduras	P	AMC	SOF & SSF
Lake Enriquillo	Dominican Republic	P	AMC	SOF
Lake Saumatre	Haiti	P	AMC	SOF
Maybar	Ethiopia	P	AMC	SOF
Uhlířská	Czech Republic	P	AMC	SOF & SSF
LMW	USA	SWC	Storage	SOF
Saalach	Austria	-	AMC	SSF
USR	USA	ASI & P	Storage	SSF & GWF
XEW	China	ASI & P	Storage	GWF
Plynlimon	United Kingdom	-	Storage	SOF
LGC	New Zealand	ASI & P	SWC	SOF
Bongsunsa	Korea	ASI & P	SWC	SSF
MSRB	Japan	API	AMC	SSF
RRC	USA	-	AMC	SSF
FSSF	Brazil	-	SWC	SOF & SSF
Yingtian	China	ASI & P	SWC	SOF
Araguás	Spain	-	-	HOF
Arnás	Spain	-	AMC	SOF & SSF
SSC	Spain	-	AMC	SSF & GWF
Girnock	UK	P	AMC	SOF & SSF
HJA	USA	P	AMC	SOF & SSF
Hubbard Brook	USA	P	AMC	SOF & SSF

Krycklan	Sweden	P	AMC	SOF & SSF
Mharcaidh	UK	P	-	SOF & SSF
Sleepers River	USA	P	AMC	SOF & SSF
BBC	United Kingdom	-	Storage	SOF
Lutzito	Panama	Storage	AMC	SOF
SNWR	USA	-	AMC	SOF & SSF
LEC	Germany	Storage	Storage	SOF
CCW	Canada	P	AMC	SOF
HRM	Canada	P	AMC	SOF & SSF
MRC	New Zealand	P	AMC	SOF & SSF
Baratz	Italy	SWC & GWL	Storage	SOF & SSF
Pinios	Greece	P	-	SOF
HM	Luxembourg	-	-	SOF & SSF
KOE	Luxembourg	-	AMC	SOF & GWF
L1	Japan	ASI & P	SWC	SSF
JPG	China	ASI & P	SWC	SSF
SEO	Germany	-	-	SSF
SIR	Chile	P	SWC	SOF
Maimai	New Zealand	P	-	SSF
Toro	USA	-	-	HOF & SOF
Utulado	USA	-	SWC	SSF
Uhlirska	Czech Republic	-	AMC	SSF
GCC	France	SWC	SWC	SSF
C3	USA	-	-	SSF
CB	USA	-	-	SSF
R5	USA	-	-	HOF & SOF
TW	Australia	-	SWC	SOF
GCEW	USA	ASI & P	SWC	SSF
PC1-08	Canada	GWL	GWL	SOF & SSF
Marcell	USA	-	SWC	SOF & SSF

WS10	USA	P	AMC	SSF
PLB	Canada	-	AMC	SSF
PEC	United Kingdom	-	SWC	SOF & SSF
URHB	Switzerland	P	AMC	SOF & SSF
Liz	Czech Republic	SWC	SWC	SSF
PSC	USA	P	-	SSF
Westcreek	Canada	SWC	SWC	SSF
URSA	Canada	ASI & P	SWC	SSF
Ponderosa	USA	SWC	SWC	SSF
Hermine	Canada	Storage	Storage	SSF
RBF	Australia	ASI & P	SWC	SOF & SSF
Odersprung	Germany	GWL	GWL	SOF
CHL	USA	ASI & P	SWC	SSF
SHW	USA	ASI & P	SWC	GWF
HOAL	Austria	SWC	SWC	SOF
BEC	Australia	-	GWL	SSF
Tannhausen	Germany	SWC	SWC	SOF
Weierbach	Germany	SWC	SWC	SSF
RCRW	Canada	GWL	AMC	SSF
Woldong	Korea	API	AMC	SSF
ASW	Panama	-	-	SSF
WWC	Australia	SWC	SWC	SOF & SSF
Schäfertal	Germany	-	AMC	GWF
Fenghuoshan	China	SWC	SWC	SOF & SSF
Inzing	Austria	SWC	SWC	SOF
Mösern	Austria	SWC	SWC	SOF
Yanglou	China	P	AMC	GWF
MWYW	USA	Pi	-	HOF
WGEW	USA	Pi	-	HOF
Mulian	China	ASI & P	SWC	SSF
Corbeira	Spain	P	AMC	SSF

HRW	Canada	-	-	SOF & SSF
Baru	Malaysia	-	-	SSF
Greenholes	United Kingdom	-	-	SSF
	United Kingdom	-	-	SSF
Hafre	United Kingdom	-	-	SSF
NCB	United Kingdom	-	-	SSF
Saimane	India	-	-	SSF
SCB	Australia	-	-	SSF
UEC	Czech Republic	P	SWC	SSF
Alptal	Switzerland	-	GWL	SOF
HMD	UK	SWC	SWC	SSF
Ina	Japan	P	AMC	SSF & GWF
MNC	Japan	ASI & P	SWC	SSF
CVC	Spain	SWC	SWC	SOF
AEB	Brazil	P	-	HOF
VSC	Argentina	P	AMC	SSF
Jiufeng	China	SWC	SWC	HOF
Matalom	Philippines	P	SWC	SOF & SSF
Ressi	Italy	ASI & P	SWC	SSF
DFP	USA	SWC	SWC	SOF
LZW	Mexico	SWC	SWC	SSF
CRC	Spain	P	AMC	SOF
Mahurangi	New Zealand	P	SWC	SOF & SSF
BCC	Italy	ASI & P	SWC	SSF & GWF
WAWC	Austria	P	Storage	SOF & SSF
Weierbach	Luxembourg	Storage	Storage	GWF
Nanxiaohe	China	ASI & P	SWC	HOF
LXR	China	ASI & P	SWC	SSF
HOEW	Japan	API	AMC	SSF
SDSC	China	ASI & P	SWC	SSF
GRC	USA	Storage	Storage	SSF

SH	USA	SWC	Storage	SOF & SSF
TSF	New Zealand	-	AMC	SSF
UASW	USA	Pi	-	HOF
HEB	Japan	P	-	GWF
MEW	Côte d'Ivoire	-	SWC	SSF
RDN	Spain	P	-	HOF
RVB	Italy	SWC	SWC	SSF
PEW	Spain	SWC	SWC	SOF & SSF
CERB	China	P	SWC	SSF
WS3	USA	ASI & P	SWC	SSF
KREW	USA	ASI & P	SWC	SSF
PMRW	USA	P	SWC	SSF
DCD	USA	ASI & P	AMC	SSF
UGCC	Canada	GWL	SWC	SSF
Quinuas	Ecuador	SWC	-	SSF
Ciciriello	Italy	-	SWC	GWF
OCR	USA	SWC	-	SSF
UP1	Canada	Storage	Storage	SOF
HBEF	USA	-	SWC	SOF & SSF

Note: antecedent moisture condition (AMC), soil water content (SWC), groundwater level (GWL),
and integrated storage state

Table S3. Synonym normalization of hydrological state descriptors and threshold indicators used in Fig. 3.

Category in Fig. 2	Original terms reported in literature	Standardized descriptor used in this study
Hydrological state domain	antecedent wetness, antecedent moisture condition, wet/dry condition, antecedent precipitation index, antecedent baseflow	Antecedent moisture condition
	antecedent soil moisture, antecedent soil water content, initial soil moisture, initial soil water content, soil moisture, soil water content, volumetric water content	Soil water content
	groundwater level, groundwater table, water-table level, water-table depth	Groundwater level
	catchment storage state, storage deficit, soil-water storage, catchment water storage, coupled soil moisture and groundwater level	Integrated storage state
	event precipitation, event rainfall, storm rainfall, total rainfall, rainfall amount, cumulative rainfall	P
	rainfall intensity, storm intensity, maximum rainfall intensity, peak rainfall intensity, precipitation intensity	Pi
	antecedent precipitation index, antecedent rainfall index, API	API
	soil water content, soil moisture, volumetric water content, antecedent soil moisture threshold	SWC
	groundwater level, groundwater table, water-table depth, groundwater-level threshold	GWL
	catchment storage, storage deficit, storage threshold	Storage
Threshold indicator	rainfall plus antecedent wetness, rainfall plus soil moisture, rainfall plus API, rainfall plus storage, rainfall plus groundwater level, combined rainfall–state index	Composite indicator

Table S4. Quantitative summary of threshold-indicator reporting in the reviewed catchments

Panel A. Broad threshold-indicator classes by reported dominant runoff-generation mechanism

Mechanism	Total n	Rainfall-only n (%)	Hydrological-state n (%)	Composite n (%)	None/unspecified n (%)
HOF	11	6 (54.5%)	1 (9.1%)	1 (9.1%)	3 (27.3%)
SOF	27	9 (33.3%)	11 (40.7%)	2 (7.4%)	5 (18.5%)
SOF–SSF	29	14 (48.3%)	5 (17.2%)	2 (6.9%)	8 (27.6%)
SSF	57	8 (14.0%)	17 (29.8%)	14 (24.6%)	18 (31.6%)
GWF	7	2 (28.6%)	1 (14.3%)	2 (28.6%)	2 (28.6%)
SSF–GWF	4	1 (25.0%)	0	2 (50.0%)	1 (25.0%)
HOF–SOF	2	0	0	0	2 (100%)
SOF–GWF	1	0	0	0	1 (100%)
All catchments	138	40 (29.0%)	35 (25.4%)	23 (16.7%)	40 (29.0%)

Panel B. Specific standardized threshold variables across all reviewed catchments

Threshold variable	Broad class	Catchments n	% of all 138 catchments	% of catchments with identified indicator (n=98)	Interpretation
P	Rainfall-only	36	26.1%	36.7%	Event rainfall amount
Pi	Rainfall-only	4	2.9%	4.1%	Rainfall intensity
SWC	Hydrological-state	22	15.9%	22.4%	Soil water content / soil moisture
Storage	Hydrological-state	6	4.3%	6.1%	Catchment or profile storage metric
GWL	Hydrological-state	4	2.9%	4.1%	Groundwater level / water-table metric
API	Hydrological-state	3	2.2%	3.1%	Antecedent precipitation index
ASI & P	Composite	22	15.9%	22.4%	Composite antecedent-state + event-rainfall indicator
SWC & GWL	Composite	1	0.7%	1.0%	Coupled soil-moisture + groundwater indicator

Note: Percentages in Panel A are calculated within each mechanism class. Panel B reports the frequency of standardized threshold indicators; it does not pool the numerical threshold values because the source studies use different physical quantities and units.

30 **Table S5.** Synonym normalization of soil–geology descriptors used in the literature synthesis.

Original terms reported in literature	Standardized descriptor used in this study
shallow regolith, thin soils, shallow soils, shallow earth	shallow soil
deep permeable soil, thick soil profile, thick organic matter layer, deep loess	deep soil
high hydraulic conductivity, high infiltration capacity	high conductivity
low hydraulic conductivity shallow impermeable horizon	low conductivity impermeable layer
fractured bedrock, fractured rock, tectonic fracture, structural fracture, high fractures	fractured bedrock
bedrock exposure, bare bedrock, exposed bedrock, rocky outcrops	rock outcrop
shallow water table, shallow groundwater level, shallow water table depth	shallow groundwater level
macropores, macroporous	macropores
low permeability substrate, low-permeability layer, low permeability soils	low permeability
high permeability, highly permeable soils	high permeability

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