

An enhanced method for determining hotspots of soil moisture increase and decline in a headwater catchment

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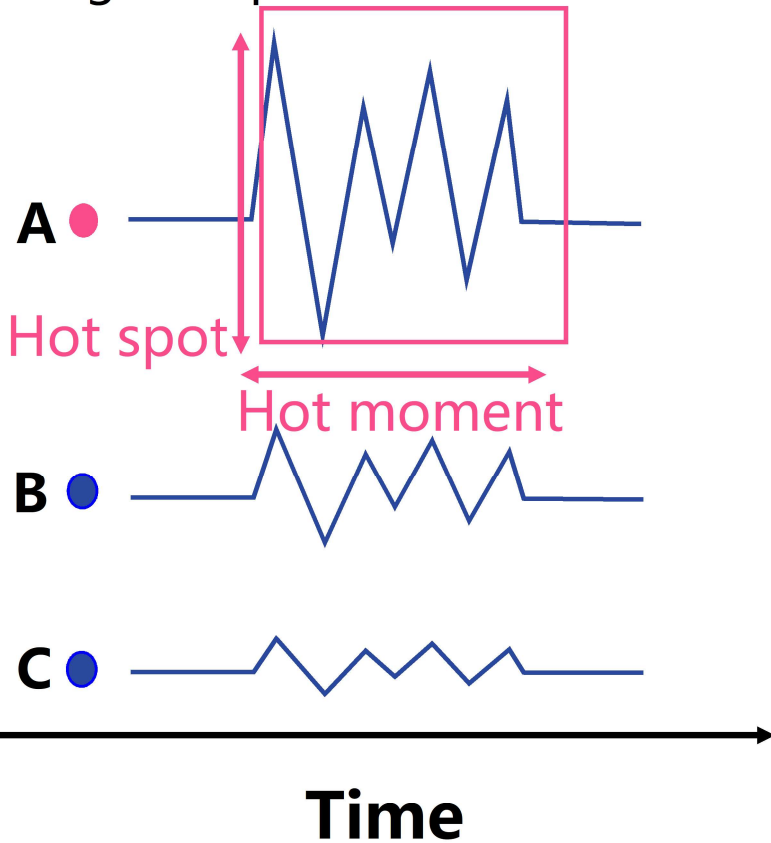
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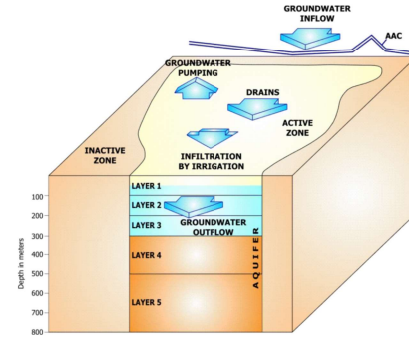
The definition

HSMV

Hot spots of soil moisture variations
High temporal variation rate

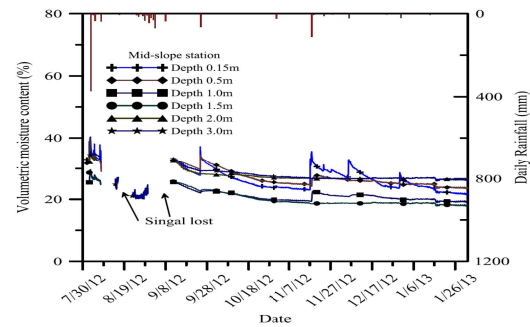


The mechanisms



Soil moisture increasing

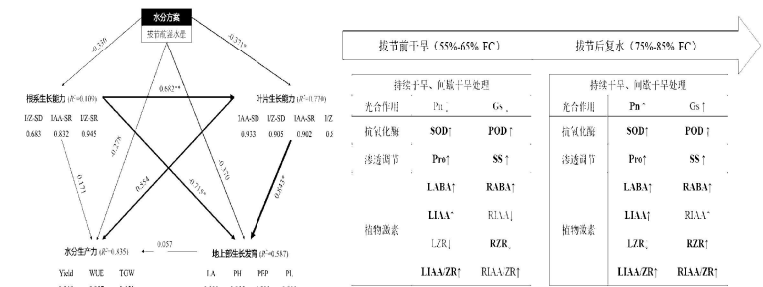
- Infiltration
- Rain-runoff



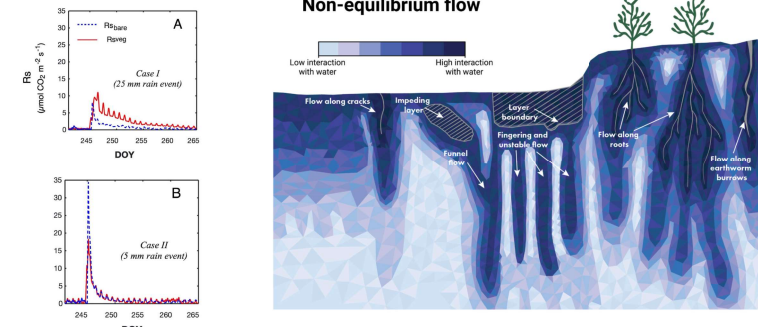
Soil moisture declining

- Evapotranspiration
- Groundwater recharge

The significance



- **Plant water use efficiency**
(Mu et al., 2022)



- **Ecohydrological & Biogeochemical processes**
(Franklin et al., 2021)

The established method

Step 1. Calculation of SMVI

A			B			C		
A	B	C	A	B	C	A	B	C
1	$VR_{i,t}$	$VR_{i,t}$	1	$VR_{i,t}$	$VR_{i,t}$	1	$VR_{i,t}$	$VR_{i,t}$
2	$VR_{i,t}$	$VR_{i,t}$	2	$VR_{i,t}$	$VR_{i,t}$	2	$VR_{i,t}$	$VR_{i,t}$
1	A	B	1	A	B	1	A	B
2	$VR_{i,t}$	$VR_{i,t}$	2	$VR_{i,t}$	$VR_{i,t}$	2	$VR_{i,t}$	$VR_{i,t}$

A			B			C		
A	B	C	A	B	C	A	B	C
1	$SMVI_{i,t}$	$SMVI_{i,t}$	1	$SMVI_{i,t}$	$SMVI_{i,t}$	1	$SMVI_{i,t}$	$SMVI_{i,t}$
2	$SMVI_{i,t}$	$SMVI_{i,t}$	2	$SMVI_{i,t}$	$SMVI_{i,t}$	2	$SMVI_{i,t}$	$SMVI_{i,t}$
1	A	B	1	A	B	1	A	B
2	$SMVI_{i,t}$	$SMVI_{i,t}$	2	$SMVI_{i,t}$	$SMVI_{i,t}$	2	$SMVI_{i,t}$	$SMVI_{i,t}$

$$\overline{VR}_{i,T} = \overline{VR}_{m,T} \equiv SMVI_i$$

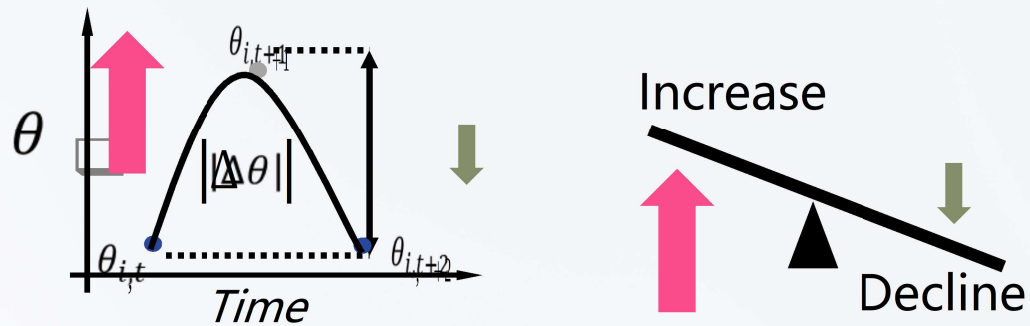
Step 2. Determination of HSMV

➔ NB
(Natural Breaks)



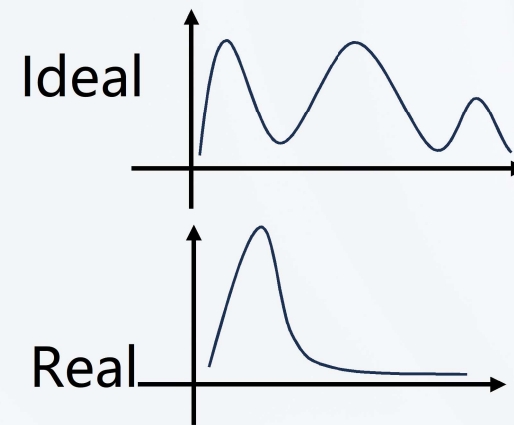
(Lv et al., 2010)

The research gap



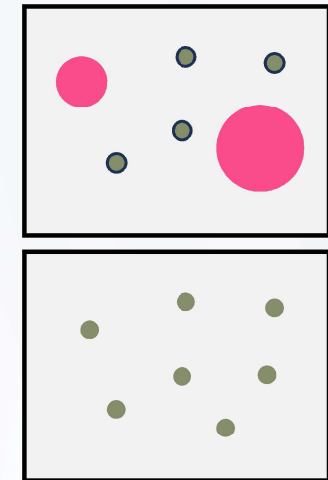
$$\overline{VR}_{i,t} = \frac{|\theta_{i,t+1} - \theta_{i,t}|}{\theta_{i,t}} = \frac{|\Delta\theta|}{\theta_{i,t}}$$

VR: Variation rates SMVI (Soil moisture variation index)
i: site I; t: the time step; T: the sum of time steps



(Mei et al., 1997)

?
Natural Breaks



The new method

Step 1. Calculation of *ESMVI*

A			B			C		
1	$VR_{i,t}$	$VR_{i,t}$	1	$VR_{i,t}$	$VR_{i,t}$	1	$VR_{i,t}$	$VR_{i,t}$
2	$VR_{i,t}$	$VR_{i,t}$	2	$VR_{i,t}$	$VR_{i,t}$	2	$VR_{i,t}$	$VR_{i,t}$

A			B			C		
1	$ESMVI_{i,t}$	$ESMVI_{i,t}$	1	$ESMVI_{i,t}$	$ESMVI_{i,t}$	1	$ESMVI_{i,t}$	$ESMVI_{i,t}$
2	$ESMVI_{i,t}$	$ESMVI_{i,t}$	2	$ESMVI_{i,t}$	$ESMVI_{i,t}$	2	$ESMVI_{i,t}$	$ESMVI_{i,t}$

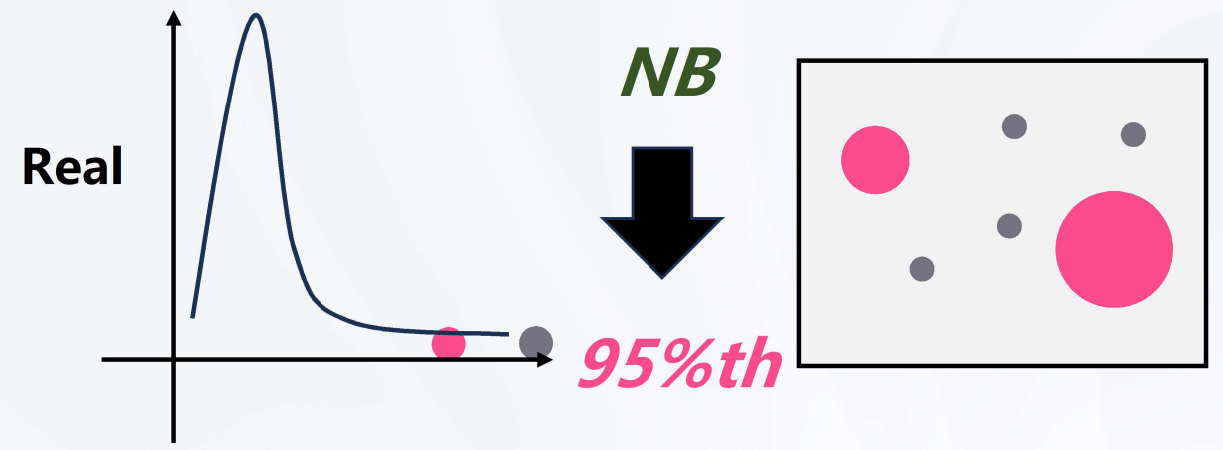
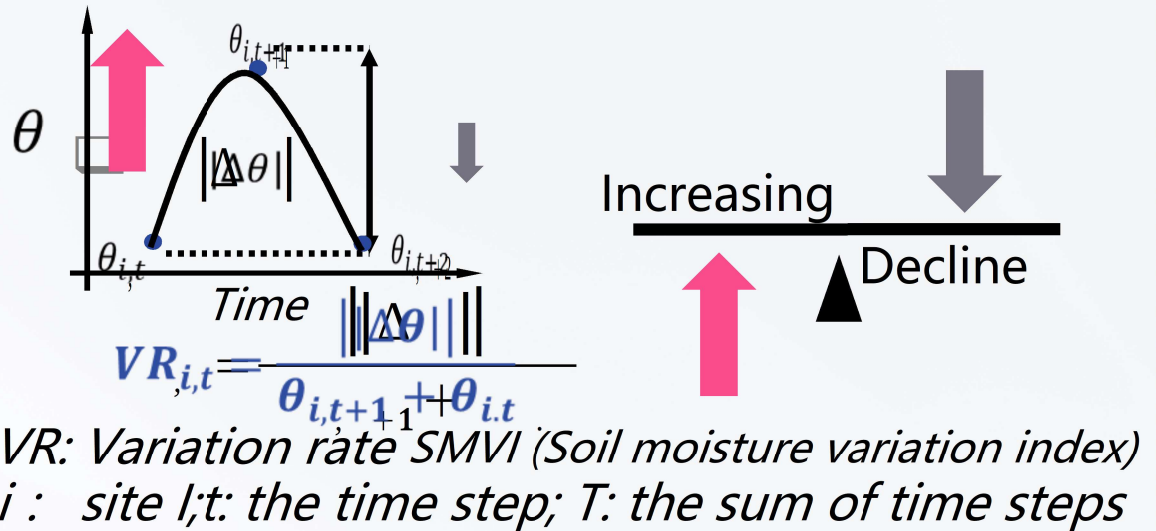
$$\overline{VR_{i,T}} = \overline{VR_{m,T}} = ESMVI_i$$

Step 2. Determination of HSMV

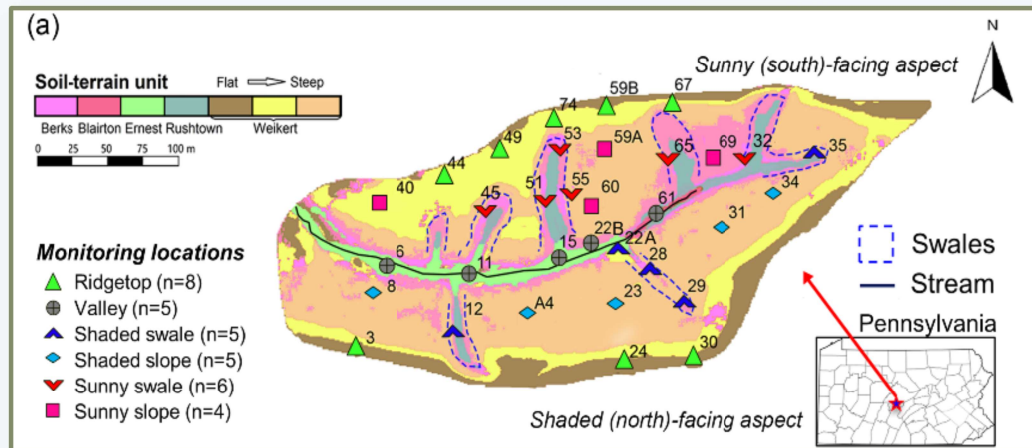


(Lv et al., 2010)

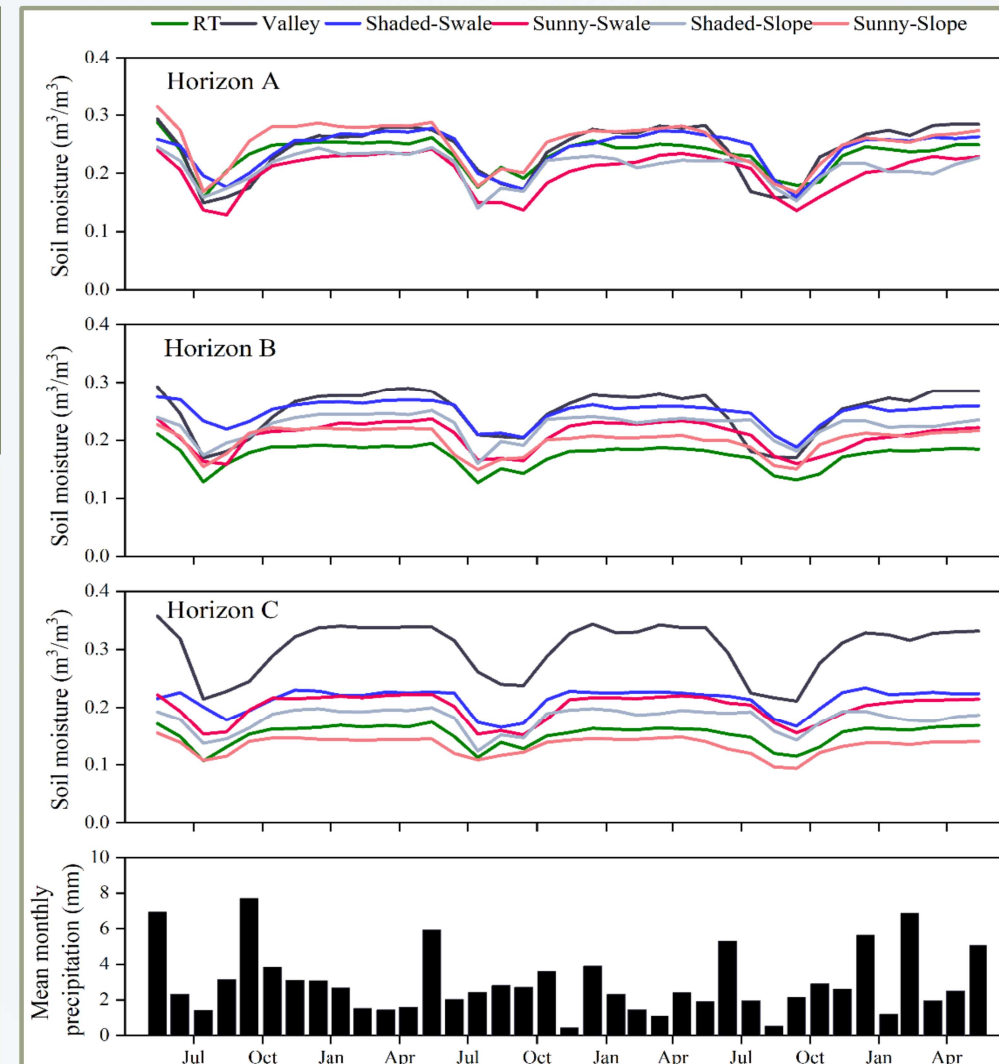
The advantage



Study area



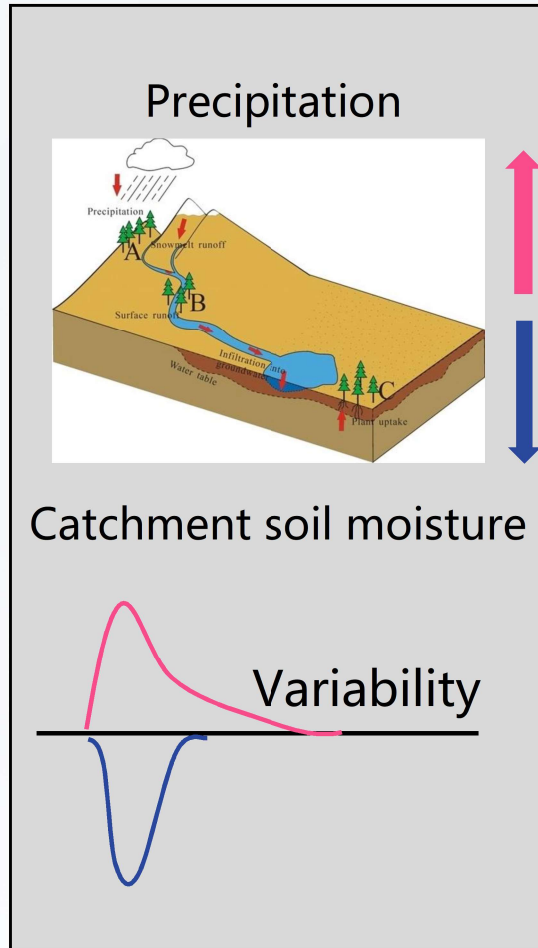
- **Complex terrains**
6 soil-landscape units
Sunny aspect/Shaded aspect
- **Meteorological feature**
Evenly precipitation distribution
- **Soil moisture spatiotemporal pattern**
Horizon A > Horizon B > Horizon C
Wet seasons/Dry seasons

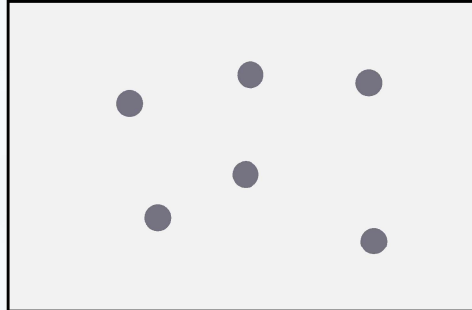
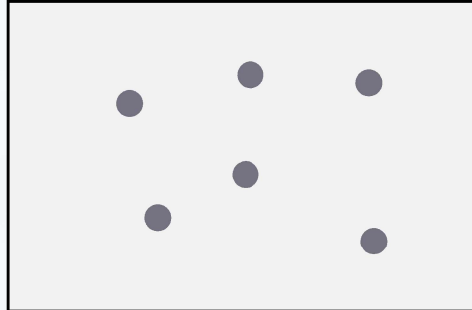
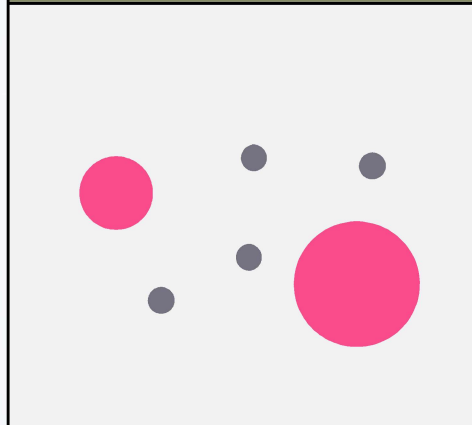
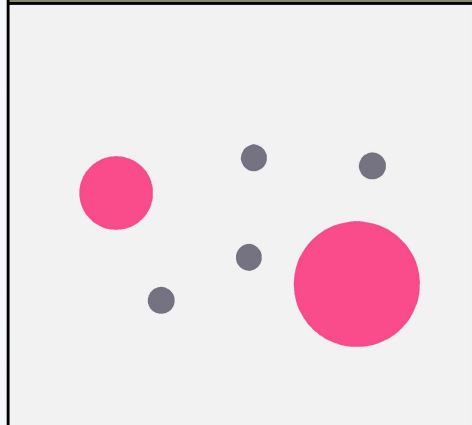


Soil moisture dynamics

Scenarios

Improvement program Criteria

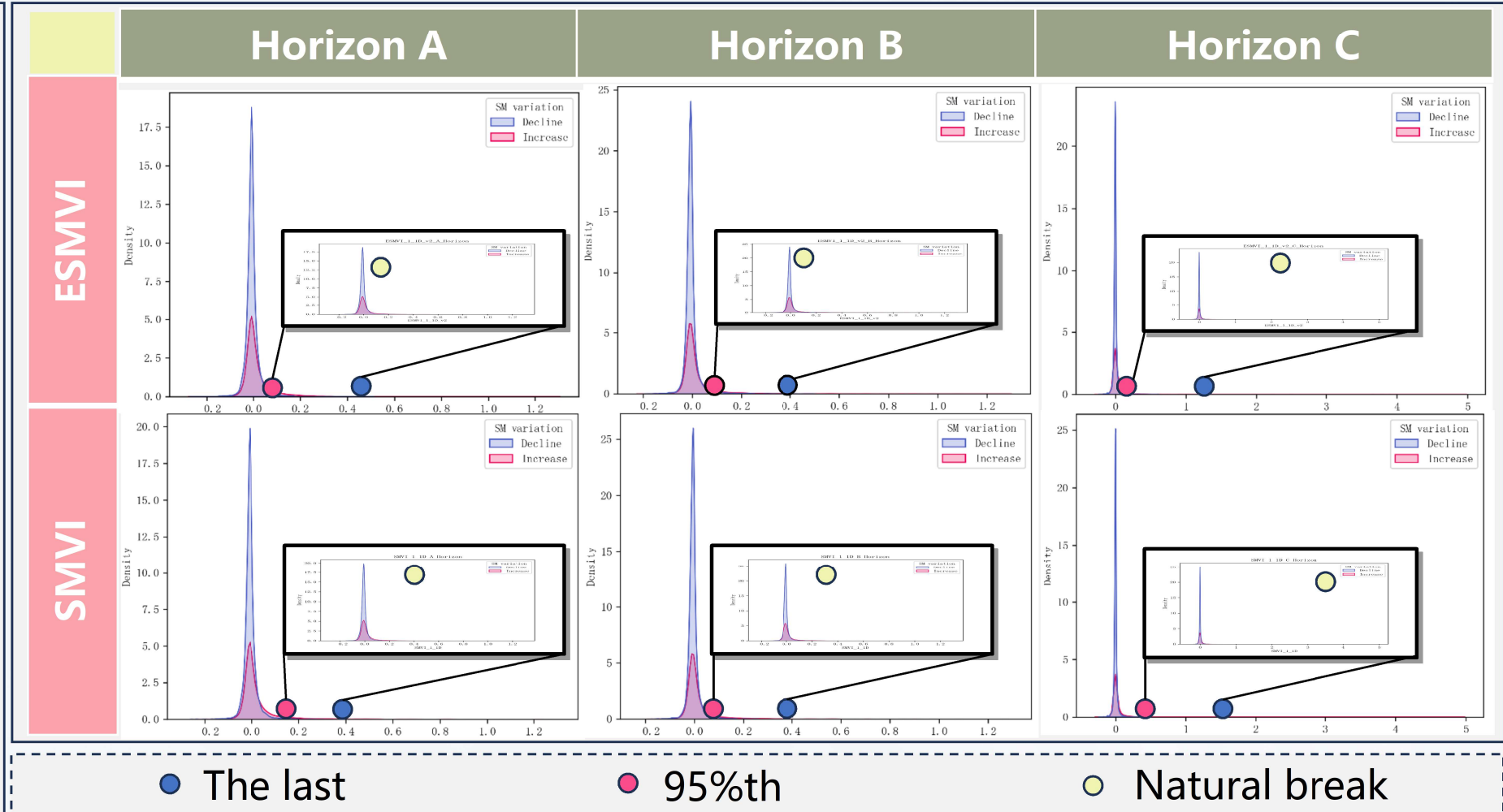


Scenario 1-Precipitation		NB vs. 95%th		Random
Category	0-10mm/10-20mm /20-30mm	Natural break	SMVI	
			ESMVI	
Variation	Soil moisture increase	95%th	SMVI	
			ESMVI	
Scenario 2-Soil wetness condition		SMVI vs. ESMVI		Spatial autocorrelation
Category	Wet:0.25-0.4 m ³ /m ³ Dry: 0-0.25 m ³ /m ³	SMVI	95%th	
			Natural break	
Variation	Soil moisture decrease	ESMVI	95%th	
			Natural break	

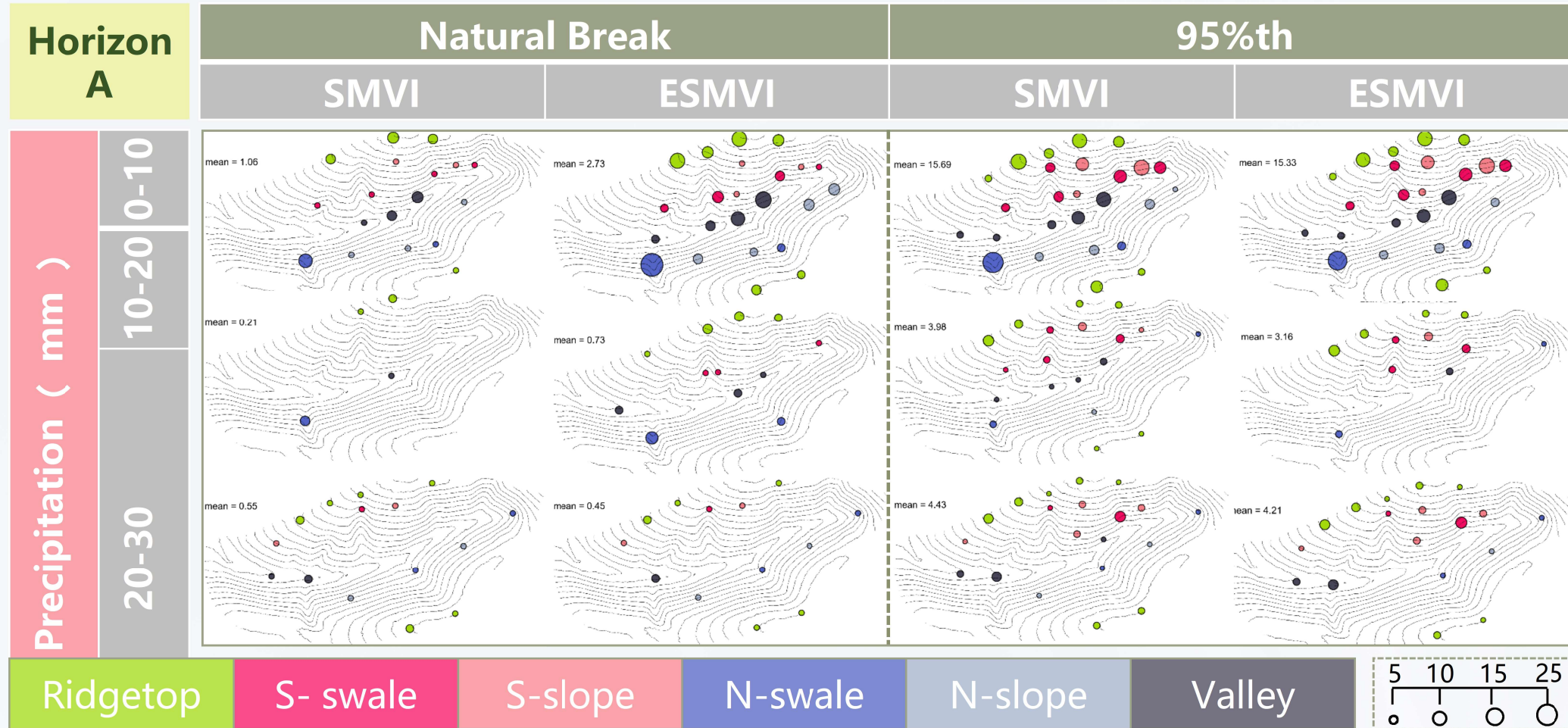
5.1 The distribution of ESMVI and SMVI

- The distribution of Indexes for **soil moisture increase** had a **longer and smoother tail**. This may **affect the recognition of Natural break(Horizon C).**

- ESMVI vs. SMVI**
For all horizons, after the 95% for indexes, HSMV amounts for soil moisture decline increased.

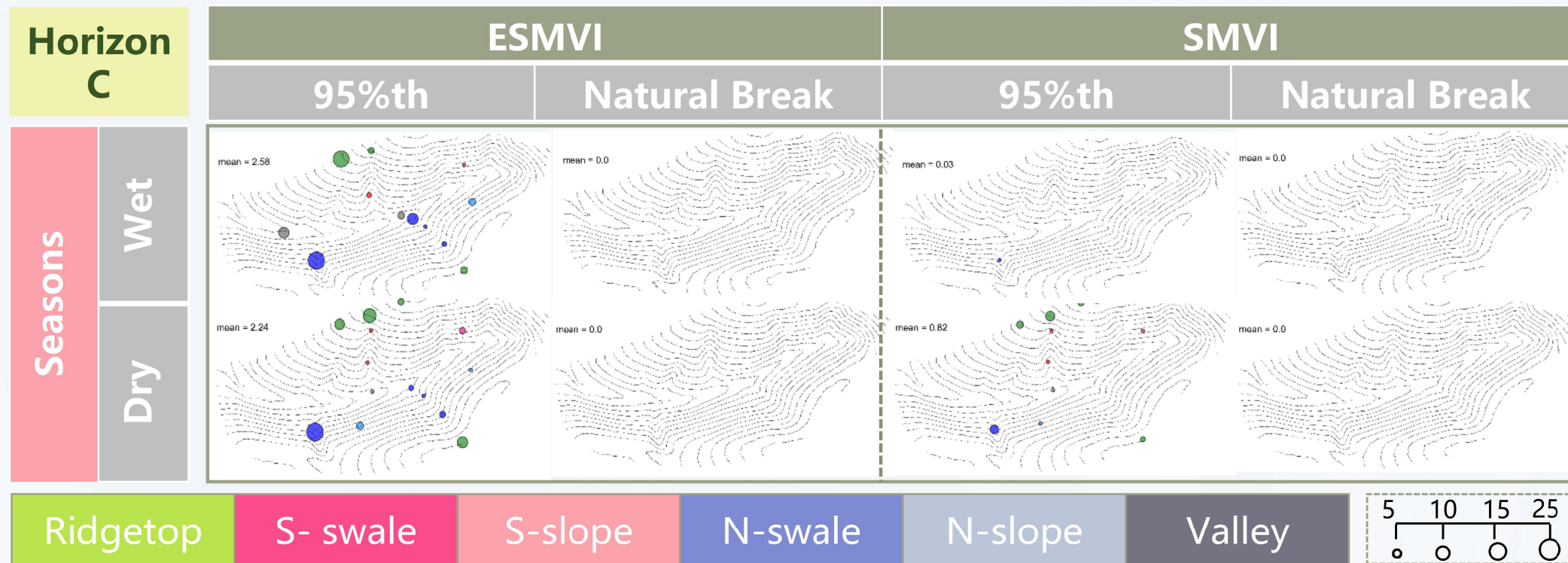


5.2 The HSMV pattern for soil moisture increase under different precipitation levels



- The 95% relative threshold approach **outperforms** NB in identifying HSMV patterns for soil moisture increase at relatively larger rainfall events.

5.3 The HSMV pattern for soil moisture decline under different catchment soil moisture



- The ESMVI **outperforms** SMVI in identifying HSMV patterns for soil moisture decrease.

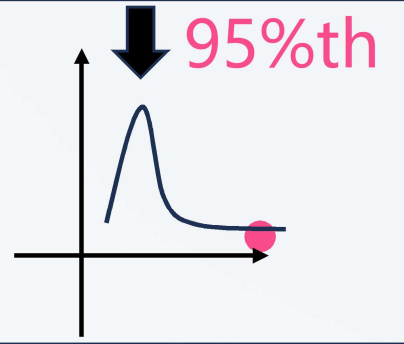
New Method

Step 1. Calculation of *ESMVI*

		A			B			C				
1	1	$SMVI_{i,t}$	$SMVI_{i,t}$	$SMVI_{i,t}$	1	$SMVI_{i,t}$	$SMVI_{i,t}$	$SMVI_{i,t}$	1	$SMVI_{i,t}$	$SMVI_{i,t}$	$SMVI_{i,t}$
	2	$SMVI_{i,t}$	$SMVI_{i,t}$	$SMVI_{i,t}$	2	$SMVI_{i,t}$	$SMVI_{i,t}$	$SMVI_{i,t}$	2	$SMVI_{i,t}$	$SMVI_{i,t}$	$SMVI_{i,t}$
2	1	$SMVI_{i,t}$	$SMVI_{i,t}$	$SMVI_{i,t}$	1	$SMVI_{i,t}$	$SMVI_{i,t}$	$SMVI_{i,t}$	1	$SMVI_{i,t}$	$SMVI_{i,t}$	$SMVI_{i,t}$
	2	$SMVI_{i,t}$	$SMVI_{i,t}$	$SMVI_{i,t}$	2	$SMVI_{i,t}$	$SMVI_{i,t}$	$SMVI_{i,t}$	2	$SMVI_{i,t}$	$SMVI_{i,t}$	$SMVI_{i,t}$

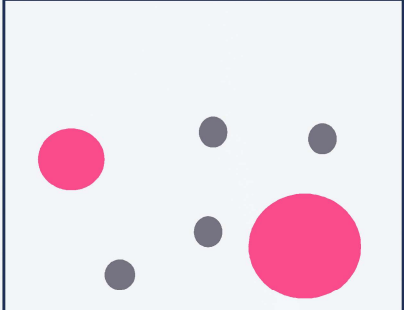
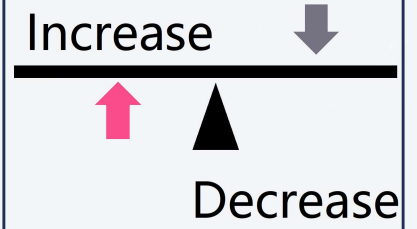
$$\overline{VR_{i,T}} - \overline{VR_{m,T}} = ESMVI_i$$

Step 2. Determination of HSMV



- Complex terrains
- Large storm
- Recession stage

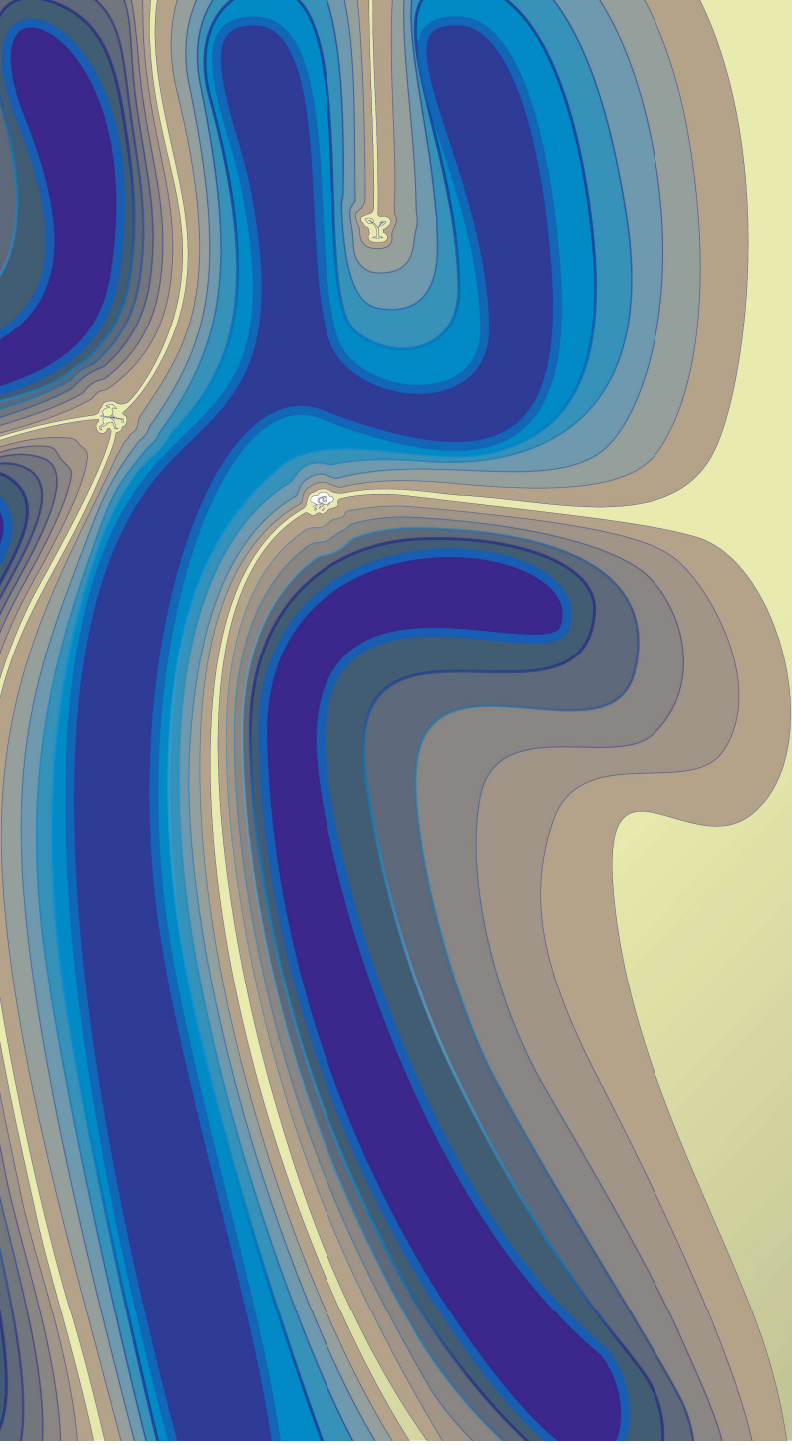
Advantage



Future application scenario

Storm	Ground water	Side slope
Storm trend	Flow → Groundwater	Accident pattern

- Infiltration/Run-off/Groundwater recharge
- Flood/Groundwater dynamics/Geological structure



Thank you

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