

Decoding multicomponent hydrochemical anomalies: A synergy anomaly detection model for earthquake forecasting in active tectonic zone

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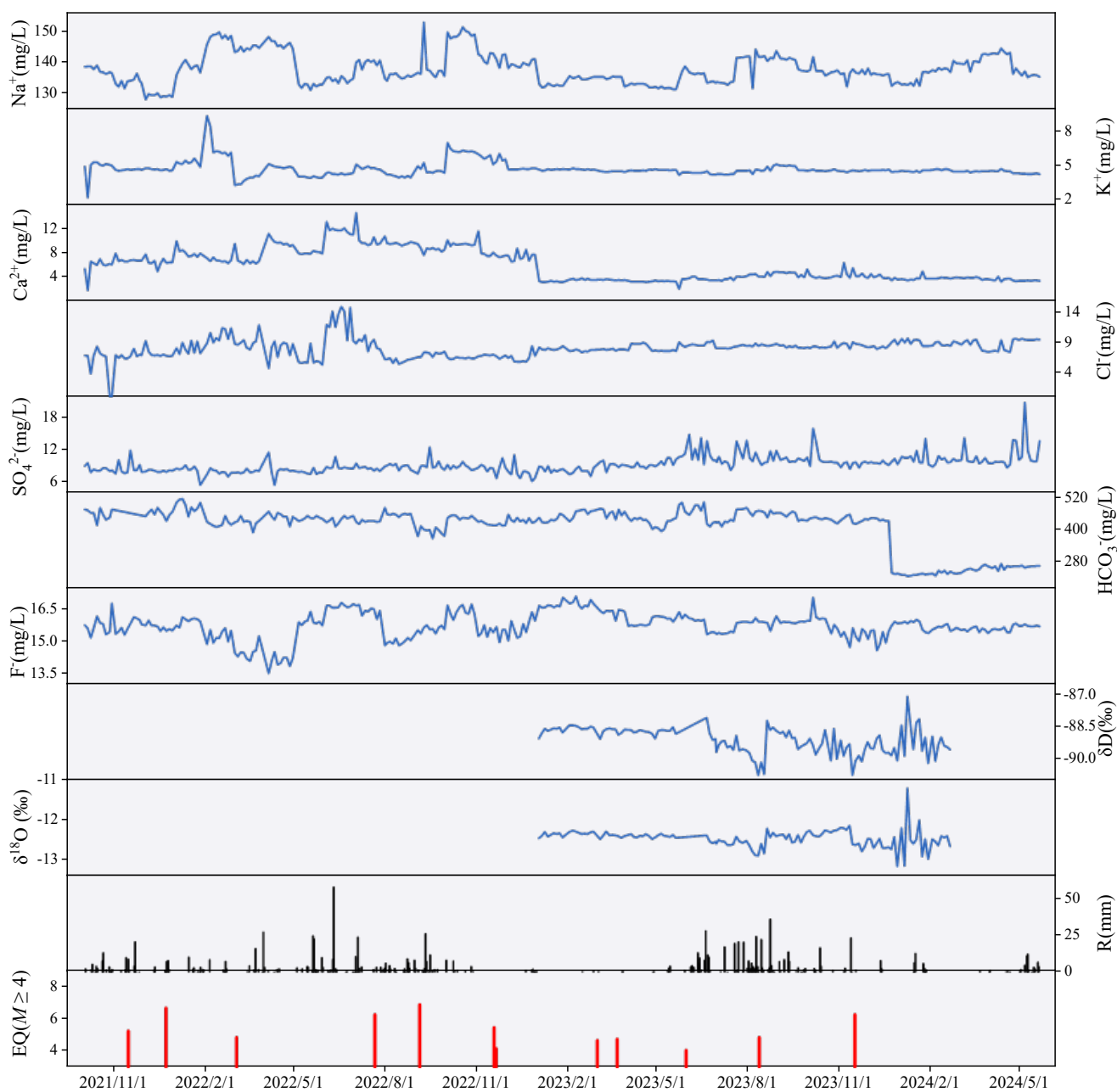
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25 **Supplementary Information for Figure**



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27 **Figure S1.** Time series of hydrochemical components of Wana spring, rainfall and earthquake events.

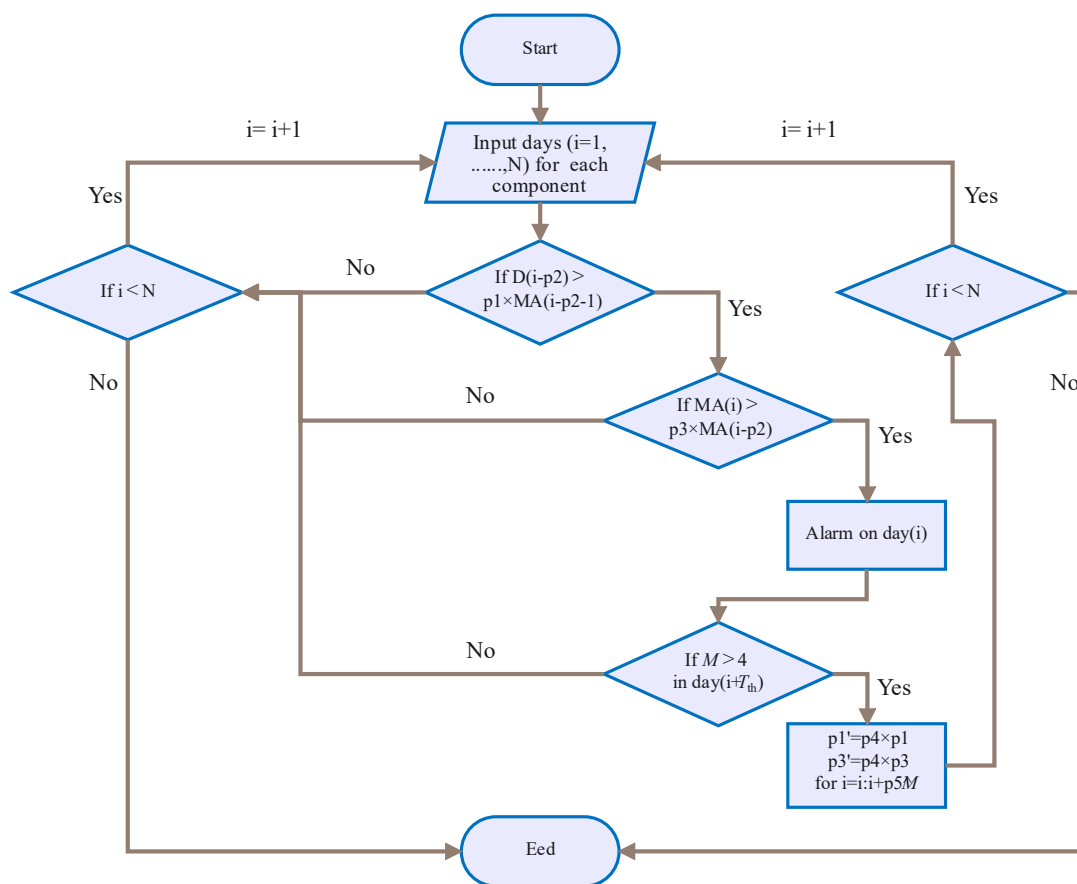


Figure S2. Flow chart of anomaly detection algorithm (modified based on Piersanti et al., 2016). D and MA are the daily value and the 15-day moving average of each hydrochemical component time series, respectively.

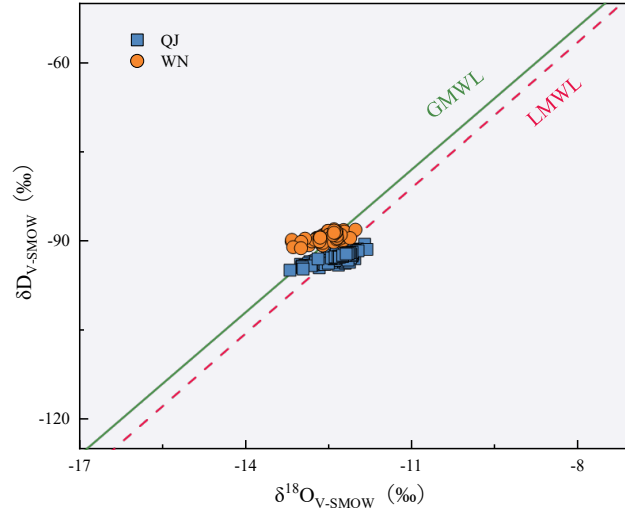


Figure S3. Plot of δD versus $\delta^{18}O$ for thermal springs. GMWL: Global Meteoric Water Line (Craig, 1961); LMWL: Local Meteoric Water Line (Li et al, 2016).

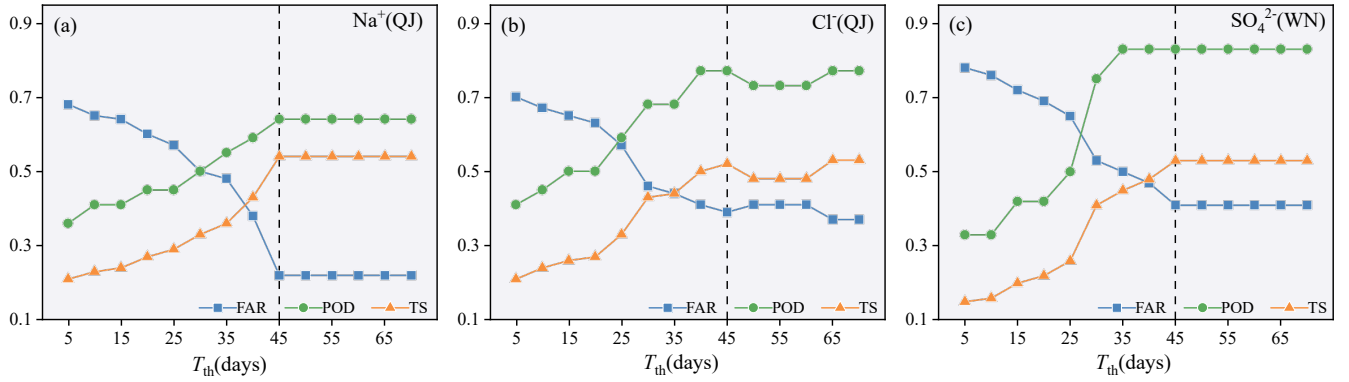


Figure S4. Variations in the false alarm rate (FAR), probability of detection (POD), and threat score (TS) as a function of the seismic response time threshold (T_{th}).

Supplementary Information for Table

Table S1. Catalog of earthquakes meeting the selection criteria during the thermal spring monitoring period.

Date	Lon.	Lat.	Depth (km)	M	Δ (km)		Response sites
					QJ	WN	
2019/06/24	101.64	24.93	10	5.2	161	—	QJ
2019/08/31	101.95	23.34	13	4.3	109	—	QJ
2019/11/01	102.79	24.39	13	4.0	51	—	QJ
2020/01/15	103.12	25.55	8	4.8	182	—	QJ
2020/01/23	101.86	23.37	15	4.0	115	—	QJ
2020/04/11	101.89	23.67	12	4.1	97	—	QJ
2020/06/16	102.72	22.64	9	5.2	144	—	QJ
2020/07/12	102.52	22.86	11	4.8	123	—	QJ
2021/05/21	99.88	25.70	10	6.7	354	—	QJ
2021/06/10	101.92	24.35	8	5.6	100	—	QJ
2021/06/16	101.90	24.34	8	4.8	101	—	QJ
2021/06/28	101.89	24.31	8	4.9	101	—	QJ
2021/11/16	101.68	22.32	10	5.2	213	135	QJ/WN
2021/12/24	101.68	22.34	10	6.6	211	133	QJ/WN
2022/03/05	101.63	22.37	8	4.8	191	131	QJ/WN
2022/07/22	99.90	21.10	10	6.2	434	338	QJ/WN
2022/09/05	102.09	29.59	16	6.8	632	676	QJ/WN
2022/11/19	102.29	23.40	8	5.4	79	42	QJ/WN
2022/11/21	102.27	23.43	14	4.1	—	39	WN
2023/03/03	102.60	22.55	10	4.6	156	129	QJ/WN
2023/03/23	100.69	22.62	10	4.7	—	159	WN
2023/05/31	102.65	24.20	16	4.0	33	108	QJ/WN
2023/08/13	101.86	24.32	10	4.8	104	89	QJ/WN
2023/11/17	99.35	21.20	10	6.2	467	368	QJ/WN

“—” means no data.

60 **Table S2.** Parameters of anomaly detection models for each hydrochemical component.

Parameter	Na ⁺	K ⁺	Ca ²⁺	Cl ⁻	SO ₄ ²⁻	HCO ₃ ⁻	F ⁻	δD	δ ¹⁸ O	Sites
p1	1.02	1.05	1.04	1.04	1.01	1.01	1.06	0.994	0.989	QJ
p3	1.01	1.01	1.04	1.02	1.02	1.02	1.01	0.997	0.997	
p1	1.04	1.07	1.06	1.02	1.04	1.06	1.02	1.001	1.001	WN
p3	1.02	1.04	1.01	1.03	1.01	1.02	1.01	1.002	1.002	
p2					18					QJ/WN
p4					1.5					
p5					1.6					
T _{th}					45					

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62 **References**

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