



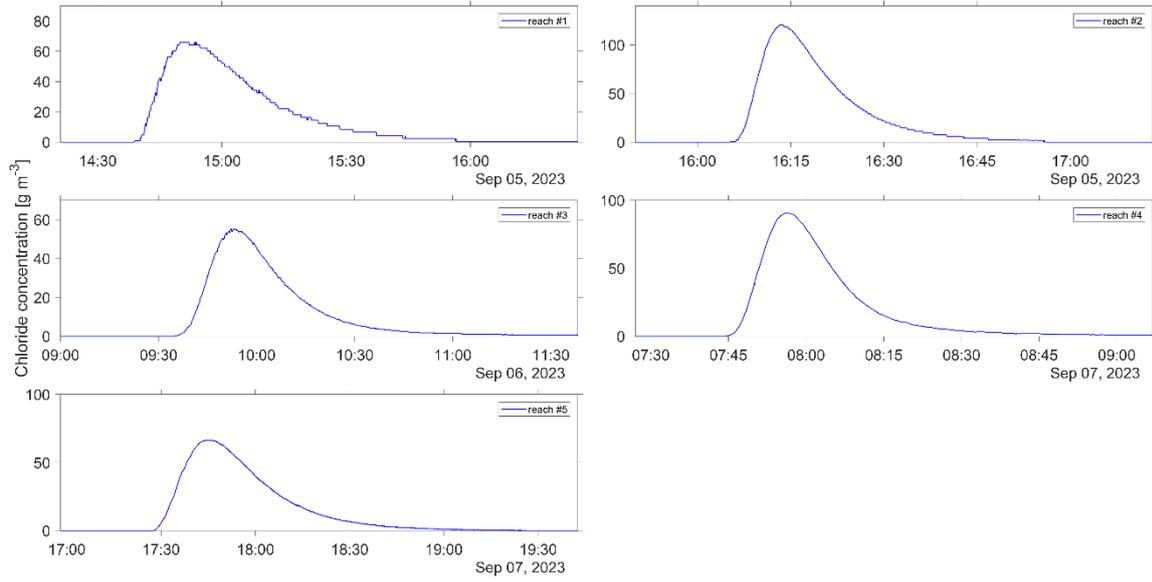
*Supplement of*

## **Different tracer, different bias: using radon to reveal flow paths beyond the Window of Detection**

**Johanna Bacher et al.**

*Correspondence to:* Clarissa Glaser ([cglaser@uni-bonn.de](mailto:cglaser@uni-bonn.de))

The copyright of individual parts of the supplement might differ from the article licence.



**Figure S1: Breakthrough curves measured at the downstream end of each reach (reaches #1 - #5)**

**Table S1: Radon activities measured in Oak Creek. The labeling of the sampling sites indicates the downstream and upstream locations of the respective reach (for example, sampling sites #1 and #2 are downstream and upstream of reach #1, respectively).**

Sampling site	Radon activity [Bq m <sup>-3</sup> ]
#1	288 (±22)
#2	285 (±22)
#3	290 (±22)
#4	337 (±26)
#5	325 (±25)
#6	265 (±21)

**Table S2: Information content (top 10%) for reaches #2 - #5**

Parameter	Q <sub>fix</sub>					Q <sub>LHS</sub>					Q <sub>out</sub>				
	D	$\alpha$	A <sub>TS</sub>	q <sub>i</sub>	SUM	D	$\alpha$	A <sub>TS</sub>	q <sub>i</sub>	SUM	D	$\alpha$	A <sub>TS</sub>	q <sub>i</sub>	SUM
Reach #2															
$H(X)$	3.91	3.91	3.91	-		3.91	3.91	3.91	0.00		3.91	3.91	3.91	3.91	
$H(X \text{chloride})$	1.48	3.81	3.77	-		1.54	3.81	3.75	0.00		1.76	3.81	3.74	2.49	
$H(X \text{radon})$	3.87	3.77	1.92	-		3.90	3.90	3.84	0.00		3.89	3.90	3.80	0.95	
$H(X \text{radon} \cap \text{chloride})$	1.49	2.18	1.95	-		1.56	3.80	3.74	0.00		1.81	3.81	3.75	0.83	
$D_{KL}(X \text{chloride}, X)$	2.42	0.10	0.14	-	2.67	2.37	0.10	0.15	0.00	2.63	2.15	0.09	0.16	1.42	3.83
$D_{KL}(X \text{radon}, X)$	0.04	0.14	1.99	-	2.17	0.01	0.01	0.07	0.00	0.08	0.01	0.01	0.11	2.96	3.09
$D_{KL}\left(\frac{X \text{radon} \cap \text{chloride}}{X}\right)$	2.42	1.73	1.96	-	6.10	2.35	0.11	0.16	0.00	2.62	2.09	0.10	0.16	3.08	5.43
Reach #3															
$H(X)$	3.91	3.91	3.91	-		3.91	3.91	3.91	0.00		3.91	3.91	3.91	3.91	
$H(X \text{chloride})$	1.85	3.85	3.78	-		1.88	3.85	3.77	0.00		1.96	3.86	3.76	2.93	
$H(X \text{radon})$	3.90	3.72	1.67	-		3.90	3.86	3.18	0.00		3.91	3.90	3.84	1.20	
$H(X \text{radon} \cap \text{chloride})$	1.76	2.14	1.65	-		1.81	3.39	3.56	0.00		1.82	3.85	3.80	0.80	
$D_{KL}(X \text{chloride}, X)$	2.05	0.06	0.13	-	2.24	2.03	0.06	0.14	0.00	2.22	1.95	0.04	0.15	0.98	3.12
$D_{KL}(X \text{radon}, X)$	0.01	0.18	2.24	-	2.43	0.01	0.04	0.73	0.00	0.78	0.00	0.00	0.07	2.71	2.78
$D_{KL}\left(\frac{X \text{radon} \cap \text{chloride}}{X}\right)$	2.15	1.77	2.25	-	6.17	2.10	0.51	0.34	0.00	2.96	2.09	0.05	0.10	3.11	5.35
Reach #4															
$H(X)$	3.91	3.91	3.91	-		3.91	3.91	3.91	0.00		3.91	3.91	3.91	3.91	
$H(X \text{chloride})$	1.99	3.86	3.75	-		1.67	3.85	3.81	0.00		1.71	3.86	3.80	3.90	
$H(X \text{radon})$	3.89	3.70	1.61	-		3.89	3.84	2.98	0.00		3.90	3.89	3.76	2.46	
$H(X \text{radon} \cap \text{chloride})$	1.81	2.28	1.55	-		1.67	3.35	3.39	0.00		1.64	3.78	3.83	1.91	
$D_{KL}(X \text{chloride}, X)$	1.92	0.05	0.16	-	2.13	2.24	0.05	0.10	0.00	2.39	2.20	0.05	0.11	0.00	2.36
$D_{KL}(X \text{radon}, X)$	0.02	0.21	2.29	-	2.52	0.01	0.07	0.93	0.00	1.01	0.00	0.01	0.15	1.45	1.61
$D_{KL}\left(\frac{X \text{radon} \cap \text{chloride}}{X}\right)$	2.10	1.62	2.36	-	6.08	2.24	0.56	0.52	0.00	3.31	2.27	0.13	0.08	2.00	4.48
Reach #5															
$H(X)^a$	3.91	3.91	3.91	-		3.91	3.91	3.91	0.00		3.91	3.91	3.91	3.91	
$H(X \text{chloride})$	1.77	3.86	3.77	-		1.80	3.86	3.77	0.00		1.74	3.87	3.73	1.89	
$H(X \text{radon})$	3.91	3.77	1.71	-		3.90	3.90	3.78	0.00		3.90	3.91	3.57	0.79	
$H(X \text{radon} \cap \text{chloride})$	1.64	2.54	1.93	-		1.81	3.89	3.67	0.00		1.69	3.89	3.46	0.78	
$D_{KL}(X \text{chloride}, X)$	2.14	0.05	0.14	-	2.32	2.11	0.05	0.14	0.00	2.29	2.17	0.04	0.17	2.01	4.40
$D_{KL}(X \text{radon}, X)$	0.00	0.14	2.20	-	2.34	0.00	0.00	0.12	0.00	0.13	0.00	0.00	0.34	3.11	3.45
$D_{KL}\left(\frac{X \text{radon} \cap \text{chloride}}{X}\right)$	2.27	1.37	1.98	-	5.61	2.10	0.02	0.24	0.00	2.36	2.21	0.01	0.45	3.12	5.80

**Table S3: Overview of the sensitivity based on the K-S test for all model parameters ( $D$ ,  $\alpha$ ,  $A_{TS}$ , and the groundwater inflow ( $q_I$ )) from the individual calibration of the TSM with chloride and radon. The terms 'high', 'moderate', 'poor', and 'non-sensitive' refer to the classification of parameter sensitivity based on the K-value and  $p$ -value (see Section 2.6), following the methodology of Ouyang et al. (2014). Results from all three calibration approaches are shown here, which differ in how groundwater inflow was calibrated ( $Q_{fix}$ ,  $Q_{LHS}$ , and  $Q_{out}$ ). Results are presented for the top 10% behavioral parameters. For simplicity, we show the  $k_{low}$  model setup for calibrating the TSM with radon only.**

Reach	Parameter	$Q_{fix}$		$Q_{LHS}$		$Q_{out}$	
		chloride	radon	chloride	radon	chloride	radon
Reach #1	D	high	poor	high	poor	high	poor
	$\alpha$	moderate	moderate	poor	poor	poor	poor
	$A_{TS}$	high	high	moderate	high	moderate	moderate
	$q_I$					moderate	high
Reach #2	D	high	poor	high	poor	high	poor
	$\alpha$	high	moderate	high	poor	moderate	poor
	$A_{TS}$	high	high	high	moderate	high	moderate
	$q_I$					moderate	high
Reach #3	D	high	poor	high	poor	high	poor
	$\alpha$	non-sensitive	moderate	moderate	poor	moderate	poor
	$A_{TS}$	moderate	high	moderate	high	high	poor
	$q_I$					poor	high
Reach #4	D	high	poor	high	poor	high	poor
	$\alpha$	moderate	moderate	moderate	poor	moderate	poor
	$A_{TS}$	moderate	high	moderate	high	moderate	non-sensitive
	$q_I$					poor	high
Reach #5	D	high	poor	high	poor	high	poor
	$\alpha$	moderate	moderate	moderate	poor	moderate	poor
	$A_{TS}$	moderate	high	moderate	moderate	high	poor
	$q_I$					poor	poor

**Table S4: Spearman rank correlation coefficients for all parameters across all reaches. Only the top 1% of results are shown. Statistically significant correlations are marked with an asterisk (\*)**

Reach #1		chloride			radon ( $k_{low}$ )	
Parameter	$Q_{fix}$	$Q_{LHS}$	$Q_{out}$	$Q_{fix}$	$Q_{LHS}$	$Q_{out}$
D - $\alpha$	0.57*	0.55*	0.52*	0.01	0.04	-0.01
D - $A_{TS}$	-0.10*	-0.10*	-0.02	-0.01	-0.003	-0.05*
D - $q_I$		-0.10*	-0.11*		-0.02	0.07*
$\alpha$ - $A_{TS}$	-0.26*	-0.27*	-0.23*	-0.91*	-0.22*	-0.08*
$\alpha$ - $q_I$		-0.04	0.03		-0.07*	-0.04
$A_{TS}$ - $q_I$		-0.05	-0.26*		-0.86*	-0.84*
Reach #2		chloride			radon ( $k_{low}$ )	
D - $\alpha$	0.12*	0.07*	0.04	-0.04	-0.04	-0.01
D - $A_{TS}$	-0.16*	-0.05	-0.03	0.02	0.03	0.11*
D - $q_I$		-0.25*	-0.21*		-0.05	-0.16*
$\alpha$ - $A_{TS}$	-0.56*	-0.51*	-0.45*	-0.92*	-0.14*	-0.09*
$\alpha$ - $q_I$		0.13*	0.04		0.08*	0.10*
$A_{TS}$ - $q_I$		-0.22*	-0.11*		-0.70*	-0.61*
Reach #3		chloride			radon ( $k_{low}$ )	
D - $\alpha$	0.62*	0.58*	0.43*	-0.01	-0.03	-0.004
D - $A_{TS}$	-0.38*	-0.29*	-0.02	-0.03	0.01	0.10*
D - $q_I$		-0.03	-0.32*		-0.005	-0.18*
$\alpha$ - $A_{TS}$	-0.47*	-0.40*	-0.22*	-0.91*	-0.39*	-0.10*
$\alpha$ - $q_I$		0.04	0.05		-0.13*	0.05*
$A_{TS}$ - $q_I$		-0.17*	-0.52*		-0.72*	-0.77*
Reach #4		chloride			radon ( $k_{low}$ )	
D - $\alpha$	0.52*	0.52*	0.39*	0.02	0.02	0.01
D - $A_{TS}$	-0.24*	-0.28*	-0.10*	-0.01	-0.01	-0.03
D - $q_I$		-0.03	-0.28*		0.01	0.04
$\alpha$ - $A_{TS}$	-0.33*	-0.41*	-0.27*	-0.91*	-0.50*	-0.11*
$\alpha$ - $q_I$		-0.01	-0.10*		-0.15*	-0.02
$A_{TS}$ - $q_I$		-0.12*	-0.34*		-0.65*	-0.86*
Reach #5		chloride			radon ( $k_{low}$ )	
D - $\alpha$	0.53*	0.53*	0.40*	0.004	0.005	-0.02
D - $A_{TS}$	-0.16*	-0.10*	0.08*	0.21*	-0.005	0.28*
D - $q_I$		-0.14*	-0.29*		0.17*	0.30*
$\alpha$ - $A_{TS}$	-0.32*	-0.30*	-0.12*	-0.87*	-0.09*	-0.05
$\alpha$ - $q_I$		-0.01	-0.01		0.05	0.01
$A_{TS}$ - $q_I$		-0.21*	-0.37*		-0.53*	-0.39*