



Supplement of

A global algorithm for identifying changing streamflow regimes: application to Canadian natural streams (1966–2010)

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Supplement

Supplement A. The detailed description of selected RHBN stations used in this study

Table S1. Summary information for the selected RHBN stations in the Pacific Basin.

RHBN ID	Station ID	Station Name	Province	Lat.	Long.	Basin area (km ²)	Sub-basin	Basin
09BC001	S72	Pelly River at Pelly Crossing	YT	62.8	-136.6	48900	Yukon	Pacific Ocean
09AC001	S74	Takhini River Near Whitehorse	YT	60.9	-135.7	7050	Yukon	Pacific Ocean
09AE003	S77	Swift River Near Swift River	BC	59.9	-131.8	3390	Yukon	Pacific Ocean
09AA006	S75	Atlin River Near Atlin	BC	59.6	-133.8	6860	Yukon	Pacific Ocean
08CD001	S71	Tuya River Near Telegraph Creek	BC	58.1	-130.8	3550	Seaboard	Pacific Ocean
08CG001	S82	Iskut River Below Johnson River	BC	56.7	-131.7	9500	Seaboard	Pacific Ocean
08FB006	S87	Atnarko River Near The Mouth	BC	52.4	-126.0	2550	Seaboard	Pacific Ocean
08OA002	S78	Yakoun River Near Port Clements	BC	53.6	-132.2	480	Seaboard	Pacific Ocean
08HB008	S83	Sproat River Near Alberni	BC	49.3	-124.9	351	Seaboard	Pacific Ocean
08GA010	S84	Capilano River Above Intake	BC	49.4	-123.1	173	Seaboard	Pacific Ocean
08HA001	S81	Chemainus River Near Westholme	BC	48.9	-123.7	355	Seaboard	Pacific Ocean
08HA003	S79	Koksilah River at Cowichan Station	BC	48.7	-123.7	209	Seaboard	Pacific Ocean
08JE001	S95	Stuart River Near Fort St. James	BC	54.4	-124.3	14200	Fraser	Pacific Ocean
08JB002	S96	Stellako River At Glenannan	BC	54.0	-125.0	3600	Fraser	Pacific Ocean
08LA001	S89	Clearwater River Near Clearwater Station	BC	51.6	-120.1	10300	Fraser	Pacific Ocean
08LD001	S88	Adams River Near Squilax	BC	50.9	-119.7	3210	Fraser	Pacific Ocean
08MA002	S102	Chilko River At Outlet Of Chilko Lake	BC	51.6	-124.1	2130	Fraser	Pacific Ocean
08MG005	S85	Lillooet River Near Pemberton	BC	50.3	-122.8	2100	Fraser	Pacific Ocean
08MH006	S80	North Alouette River 232 nd Street Maple Ridge	BC	49.2	-122.6	37.3	Fraser	Pacific Ocean
08MH016	S86	Chilliwack River At Outlet Of Chilliwack Lake	BC	49.1	-121.5	335	Fraser	Pacific Ocean
08NB005	S99	Columbia River At Donald	BC	51.5	-117.2	9700	Columbia	Pacific Ocean
08NF001	S101	Kootenay River At Kootenay Crossing	BC	50.9	-116.0	416	Columbia	Pacific Ocean
08ND013	S90	Illecillewaet River At Greeley	BC	51.0	-118.1	1150	Columbia	Pacific Ocean
08NE006	S93	Kuskanax Creek Near Nakusp	BC	50.3	-117.7	330	Columbia	Pacific Ocean
08NE077	S91	Barnes Creek Near Needles	BC	49.9	-118.1	204	Columbia	Pacific Ocean
08NH005	S94	Kaslo River Below Kemp Creek	BC	49.9	-117.0	442	Columbia	Pacific Ocean
08NH084	S98	Arrow Creek Near Erickson	BC	49.2	-116.5	78.3	Columbia	Pacific Ocean
08NJ130	S97	Anderson Creek Near Nelson	BC	49.5	-117.3	9.07	Columbia	Pacific Ocean
08NN015	S100	West Kettle River Near Mcculloch	BC	49.7	-119.1	233	Columbia	Pacific Ocean
08NL007	S92	Similkameen River At Princeton	BC	49.5	-120.5	1810	Columbia	Pacific Ocean

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Table S2. Summary information for the selected RHBN stations in the Atlantic Basin.

RHBN ID	Station ID	Station Name	Province	Lat.	Long	Basin area (km ²)	Sub-basin	Basin
02YC001	S11	Torrent River At Bristols Pool	NL	50.6	-57.2	624	Seaboard	Atlantic Ocean
02YL001	S13	Upper Humber River Near Reidville	NL	49.2	-57.4	2110	Seaboard	Atlantic Ocean
02YQ001	S17	Gander River At Big Chute	NL	49.0	-54.9	4450	Seaboard	Atlantic Ocean
02YR001	S15	Middle Brook Near Gambo	NL	48.8	-54.2	275	Seaboard	Atlantic Ocean
02ZB001	S14	Isle Aux Morts River Below Highway Bridge	NL	47.6	-59.0	205	Seaboard	Atlantic Ocean
02ZF001	S8	Bay Du Nord River At Big Falls	NL	47.7	-55.4	1170	Seaboard	Atlantic Ocean
02ZG001	S10	Garnish River Near Garnish	NL	47.2	-55.3	205	Seaboard	Atlantic Ocean
02ZH001	S18	Pipers Hole River At Mothers Brook	NL	47.9	-54.3	764	Seaboard	Atlantic Ocean
02ZK001	S9	Rocky River Near Colinet	NL	47.2	-53.6	301	Seaboard	Atlantic Ocean
02ZM006	S20	Northeast Pond River At Northeast Pond	NL	47.6	-52.8	3.63	Seaboard	Atlantic Ocean
01FB001	S53	Northeast Margaree River At Margaree Valley	NS	46.4	-61.0	368	Seaboard	Atlantic Ocean
01FB003	S50	Southwest Margaree River Near Upper Margaree	NS	46.2	-61.1	357	Seaboard	Atlantic Ocean
01FA001	S33	River Inhabitants At Glenora	NS	45.7	-61.3	193	Seaboard	Atlantic Ocean
01EO001	S45	St. Marys River At Stillwater	NS	45.2	-62.0	1350	Seaboard	Atlantic Ocean
01DP004	S52	Middle River Of Pictou At Rocklin	NS	45.5	-62.8	92.2	Seaboard	Atlantic Ocean
01DG003	S51	Beaverbank River Near Kinsac	NS	44.9	-63.7	96.9	Seaboard	Atlantic Ocean
01EF001	S47	Lahave River At West Northfield	NS	44.4	-64.6	1250	Seaboard	Atlantic Ocean
01EC001	S49	Roseway River At Lower Ohio	NS	43.8	-65.4	495	Seaboard	Atlantic Ocean
01BV006	S44	Point Wolfe River At Fundy National Park	NB	45.6	-65.0	130	Seaboard	Atlantic Ocean
01BU002	S46	Petitcodiac River Near Petitcodiac	NB	45.9	-65.2	391	Seaboard	Atlantic Ocean
01BS001	S40	Coal Branch River At Beersville	NB	46.4	-65.1	166	Seaboard	Atlantic Ocean
01CA003	S35	Carruthers Brook Near St. Anthony	PE	46.7	-64.2	46.8	Seaboard	Atlantic Ocean
01BO001	S38	Southwest Miramichi River At Blackville	NB	46.7	-65.8	5050	Seaboard	Atlantic Ocean
01BP001	S37	Little Southwest Miramichi River At Lyttleton	NB	46.9	-65.9	1340	Seaboard	Atlantic Ocean
01BQ001	S43	Northwest Miramichi River At Trout Brook	NB	47.1	-65.8	948	Seaboard	Atlantic Ocean
01BC001	S55	Restigouche River Below Kedgwick River	NB	47.7	-67.5	3160	Seaboard	Atlantic Ocean
01BE001	S48	Upsalquitch River At Upsalquitch	NB	47.8	-66.9	2270	Seaboard	Atlantic Ocean
01BJ003	S36	Jacquet River Near Durham Centre	NB	47.9	-66.0	510	Seaboard	Atlantic Ocean
02VC001	S12	Romaine (Riviere) Au Pont De La Q.I.T.	QC	50.3	-63.6	13000	St. Lawrence	Atlantic Ocean
02UC002	S16	Moisie (Riviere) A 51 Km En Amont Du Pont Du Q.N.S.L.R.	QC	50.4	-66.2	19000	St. Lawrence	Atlantic Ocean
02RF001	S19	Chamouchouane (Riviere) A La Tete De La Chute Aux Saumons	QC	48.7	-72.5	15300	St. Lawrence	Atlantic Ocean
02QA002	S39	Rimouski (Riviere) A 3 7 Km En Amont Du Pont-Route 132	QC	48.4	-68.6	1610	St. Lawrence	Atlantic Ocean
02PB006	S25	Sainte-Anne (Riviere) (Bras Du Nord De La) En Amont	QC	47.0	-71.9	642	St. Lawrence	Atlantic Ocean
02OE027	S57	Eaton (Riviere) PresDeLaRiviere Saint-Francois-3	QC	45.5	-71.7	642	St. Lawrence	Atlantic Ocean
02NF003	S32	Matawin (Riviere) A Saint-Michel-Des-Saints	QC	46.7	-73.9	1390	St. Lawrence	Atlantic Ocean
02LB007	S58	South Nation River At Spencerville	ON	44.8	-75.5	246	St. Lawrence	Atlantic Ocean
02KB001	S21	Petawawa River Near Petawawa	ON	45.9	-77.3	4122.32	St. Lawrence	Atlantic Ocean
02HL004	S22	Skootamatta River Near Actinolite	ON	44.5	-77.3	677.65	St. Lawrence	Atlantic Ocean
02EA005	S29	North Magnetawan River Near Burks Falls	ON	45.7	-79.4	328.84	St. Lawrence	Atlantic Ocean
02EC002	S60	Black River Near Washago	ON	44.7	-79.3	1510.27	St. Lawrence	Atlantic Ocean
02FB007	S62	Sydenham River Near Owen Sound	ON	44.5	-80.9	182.97	St. Lawrence	Atlantic Ocean
02FC001	S59	Saugeen River Near Port Elgin	ON	44.5	-81.3	3953.52	St. Lawrence	Atlantic Ocean
02GA010	S61	Nith River Near Canning	ON	43.2	-80.5	1034.28	St. Lawrence	Atlantic Ocean
02AB008	S24	Neebing River Near Thunder Bay	ON	48.4	-89.3	187	St. Lawrence	Atlantic Ocean
01AQ001	S41	Lepreau River At Lepre	NB	45.2	-66.5	239	Saint John- St. Croix	Atlantic Ocean
01AP004	S34	Kennebecasis River At Apohaqui	NB	45.7	-65.6	1100	Saint John- St. Croix	Atlantic Ocean
01AP002	S42	Canaan River At East Canaan	NB	46.1	-65.4	668	Saint John- St. Croix	Atlantic Ocean
01AK001	S54	Shogomoc Stream Near Trans-Canada Highway	NB	45.9	-67.3	234	Saint John- St. Croix	Atlantic Ocean
01AD002	S56	Saint John River At Fort Kent	NB	47.3	-68.6	14700	Saint John- St. Croix	Atlantic Ocean

30 **Table S3.** Summary information for the selected RHBN stations in the Arctic Basin.

RHBN ID	Station ID	Station Name	Province	Lat.	Long.	Basin area (km ²)	Sub-basin	Basin
10PB001	S7	Coppermine River At Outlet Of Point Lake	NT	65.4	-114.0	19200	Seaboard	Arctic Ocean
10RC001	S1	Back River Above Hermann River	NU	66.1	-96.5	93900	Seaboard	Arctic Ocean
10CB001	S68	Sikanni Chief River Near Fort Nelson	BC	57.2	-122.7	2180	Lower Mackenzie	Arctic Ocean
10BE004	S76	Toad River Above Nonda Creek	BC	58.9	-125.4	2540	Lower Mackenzie	Arctic Ocean
10CD001	S65	Muskwa River Near Fort Nelson	BC	58.8	-122.7	20300	Lower Mackenzie	Arctic Ocean
07LE002	S5	Fond Du Lac River At Outlet Of Black Lake	SK	59.2	-105.5	50700	Lower Mackenzie	Arctic Ocean
07OB001	S3	Hay River Near Hay River	NT	60.7	-115.9	51700	Lower Mackenzie	Arctic Ocean
10EB001	S73	South Nahanni River Above Virginia Falls	NT	61.6	-125.8	14500	Lower Mackenzie	Arctic Ocean
07RD001	S6	Lockhart River At Outlet Of Artillery Lake	NT	62.9	-108.5	26600	Lower Mackenzie	Arctic Ocean
07FB001	S66	Pine River At East Pine	BC	55.7	-121.2	12100	Peace Athabasca	Arctic Ocean
07CD001	S64	Clearwater River At Draper	AB	56.7	-111.3	30799.4	Peace Athabasca	Arctic Ocean
07FC003	S67	Blueberry River Below Aitken Creek	BC	56.7	-121.2	1770	Peace Athabasca	Arctic Ocean

Table S4. Summary information for the selected RHBN stations in the Hudson Bay Basin.

RHBN ID	Station ID	Station Name	Province	Lat.	Long.	Basin area (km ²)	Sub-basin	Basin
04NA001	S28	Harricana (Riviere) 3 1 Km En Aval Du Pont-Route 111 A Amos	QC	48.6	-78.1	3680	Western & Northern HB	Hudson Bay
04LJ001	S27	Missinaibi River At Mattice	ON	49.6	-83.3	8574.38	Western & Northern HB	Hudson Bay
04JC002	S26	Nagagami River At Highway No. 11	ON	49.8	-84.5	2178.36	Western & Northern HB	Hudson Bay
06CD002	S31	Churchill River Above Otter Rapids	SK	55.6	-104.7	119000	Northern Quebec & Ontario	Hudson Bay
06GD001	S4	Seal River Below Great Island	MB	58.9	-96.3	48100	Northern Quebec & Ontario	Hudson Bay
06LC001	S2	Kazan River Above Kazan Falls	NU	63.7	-95.9	70000	Northern Quebec & Ontario	Hudson Bay
05PB014	S30	Turtle River Near Mine Centre	ON	48.9	-92.7	4767.74	Nelson	Hudson Bay
05TD001	S23	Grass River Above Standing Stone Falls	MB	55.7	-97.0	15400	Nelson	Hudson Bay
05LH005	S63	Waterhen River Near Waterhen	MB	51.8	-99.5	55100	Nelson	Hudson Bay
05AD005	S70	Belly River Near Mountain View	AB	49.1	-113.7	319.2	Nelson	Hudson Bay
05AD003	S69	Waterton River Near Waterton Park	AB	49.1	-113.8	612.7	Nelson	Hudson Bay
05AA008	S103	Crowsnest River At Frank	AB	49.6	-114.4	402.7	Nelson	Hudson Bay
05BB001	S104	Bow River At Banff	AB	51.2	-115.6	2209.6	Nelson	Hudson Bay
05DA007	S105	Mistaya River Near Saskatchewan Crossing	AB	51.9	-116.7	248	Nelson	Hudson Bay

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Supplement B. The distribution of selected RHBN stations in major Canadian drainage basins and sub-basins

Table S5. Main sub-basins of the four Canadian major drainage basins along with their drainage areas, abbreviations and the number of RHBN stations within their territory used in this study.

Major Basin	Sub-basin	Area (1000 km ²)	# of stations	Abbreviation
Pacific	Yukon	330.4	4	P1
	Seaboard	334.2	8	P2
	Fraser	232.5	8	P3
	Columbia	102.8	10	P4
Atlantic	Seaboard	499.7	28	At1
	St. Lawrence	860.1	16	At2
	Saint John- St. Croix	41.9	5	At3
Arctic	Seaboard	1,739.3	2	Ar1
	Lower Mackenzie	1,321.1	7	Ar2
	Peace Athabasca	482.7	3	Ar3
Hudson Bay	Western & Northern HB	1,243.9	3	H1
	Northern Quebec & Ontario	1,889.2	3	H2
	Nelson	1,138.5	8	H3

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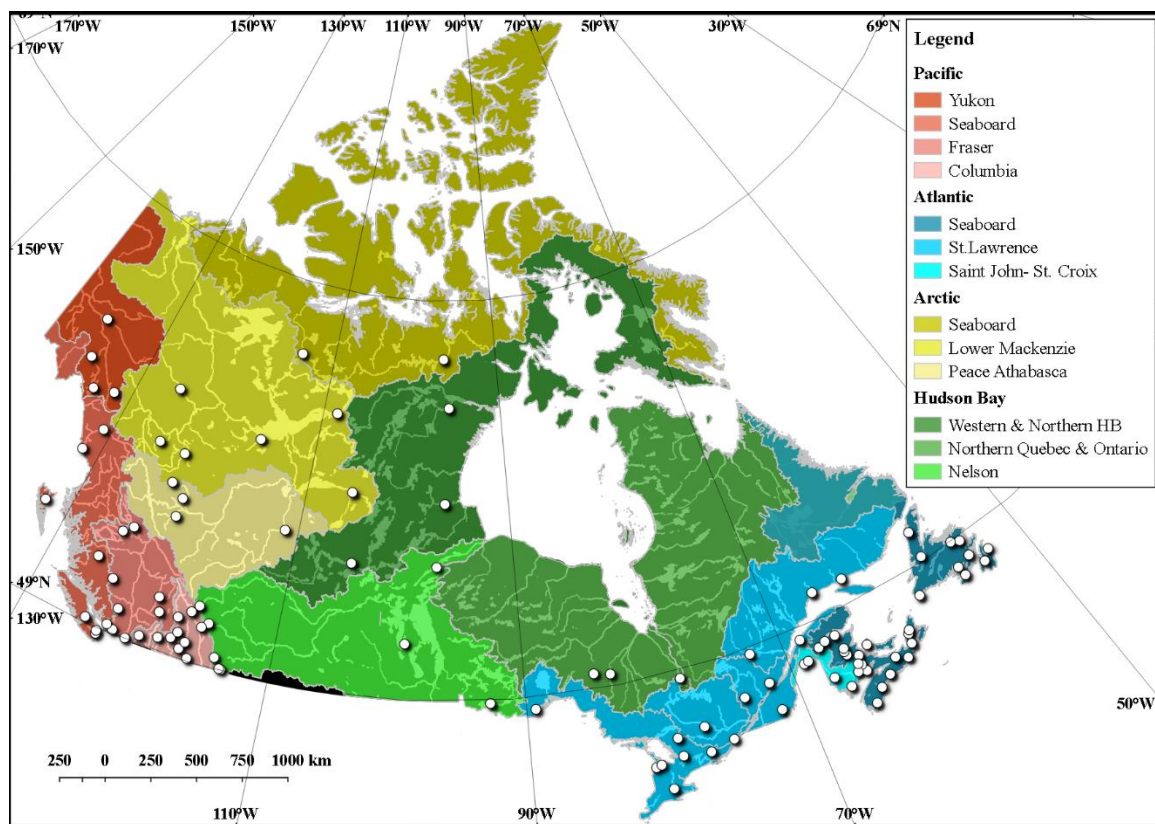


Figure S1. The distribution of the selected 105 RHBN streamflow stations across the major Canadian drainage basins and sub-basins.

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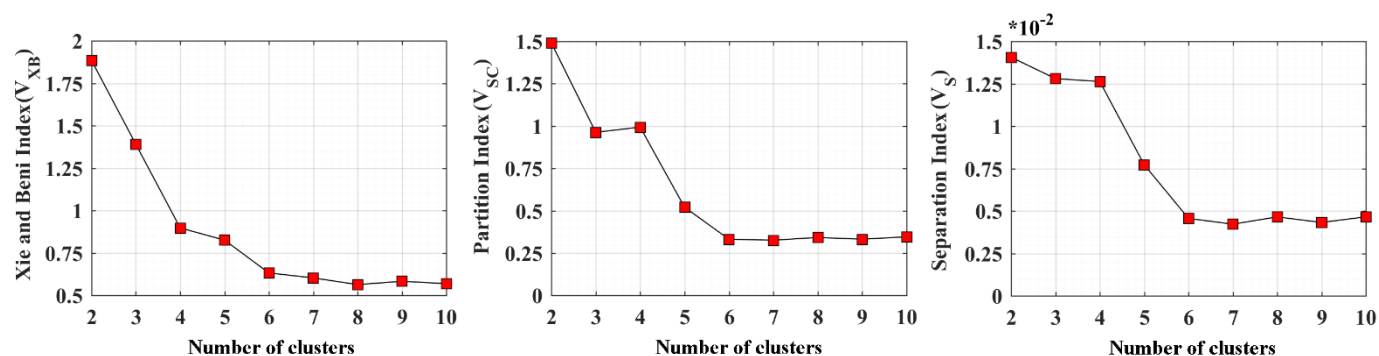


Figure S2. Variation in the Xie and Beni, Partition, and Separation indices by altering the numbers of clusters.

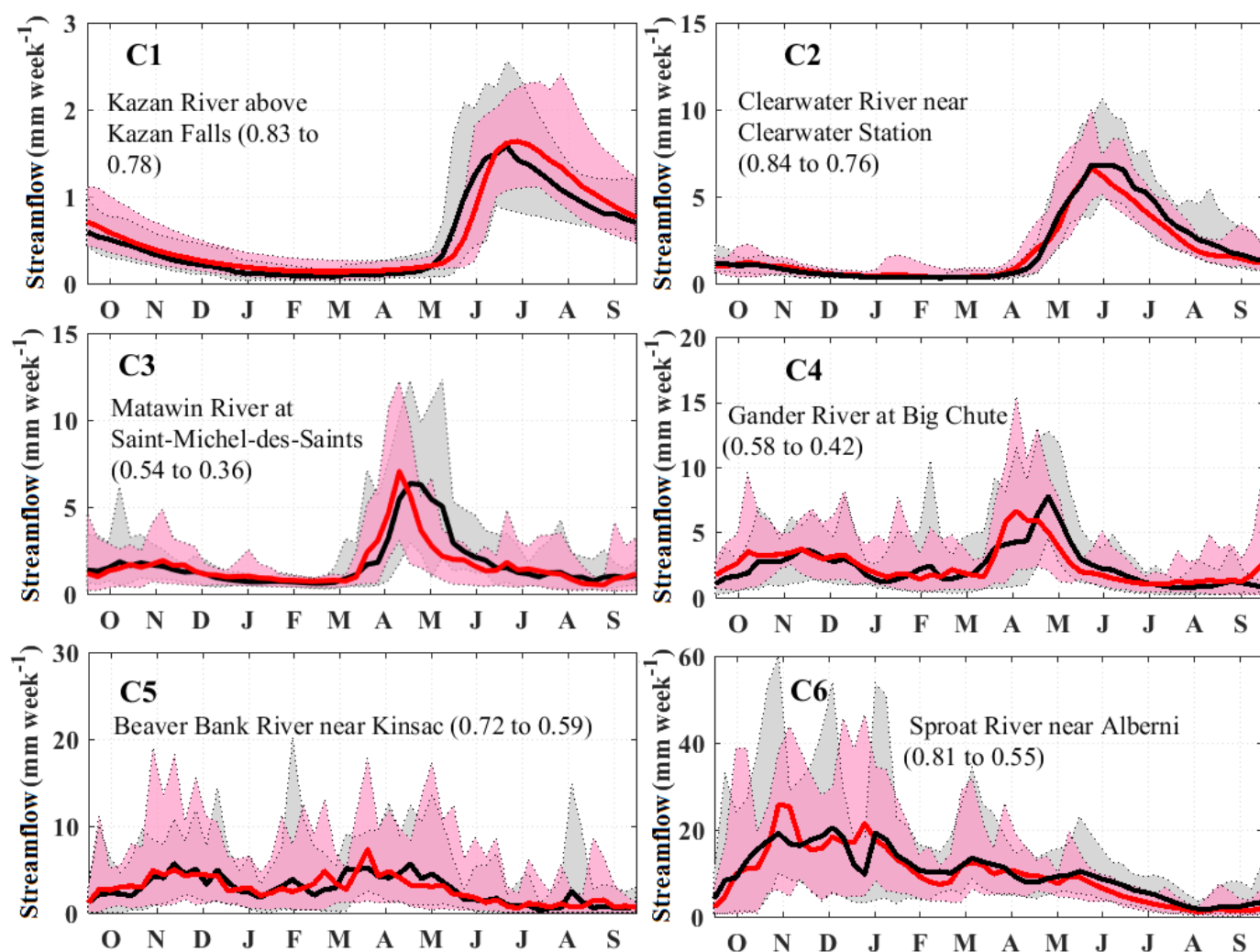


Figure S3. Alterations in the decadal streamflow regimes at the archetype streams through time. The envelopes of annual hydrographs for the earliest (1966 to 1975) and the latest (2001 to 2010) decadal episodes in archetype streams are shown with grey and pink colors, respectively. The expected annual hydrographs during the earliest and the latest decadal periods are shown in solid black and solid red lines. The change in the membership degree of each archetype stream is shown within parentheses.

Supplement D. The detailed analysis of trend and evolution of decadal memberships

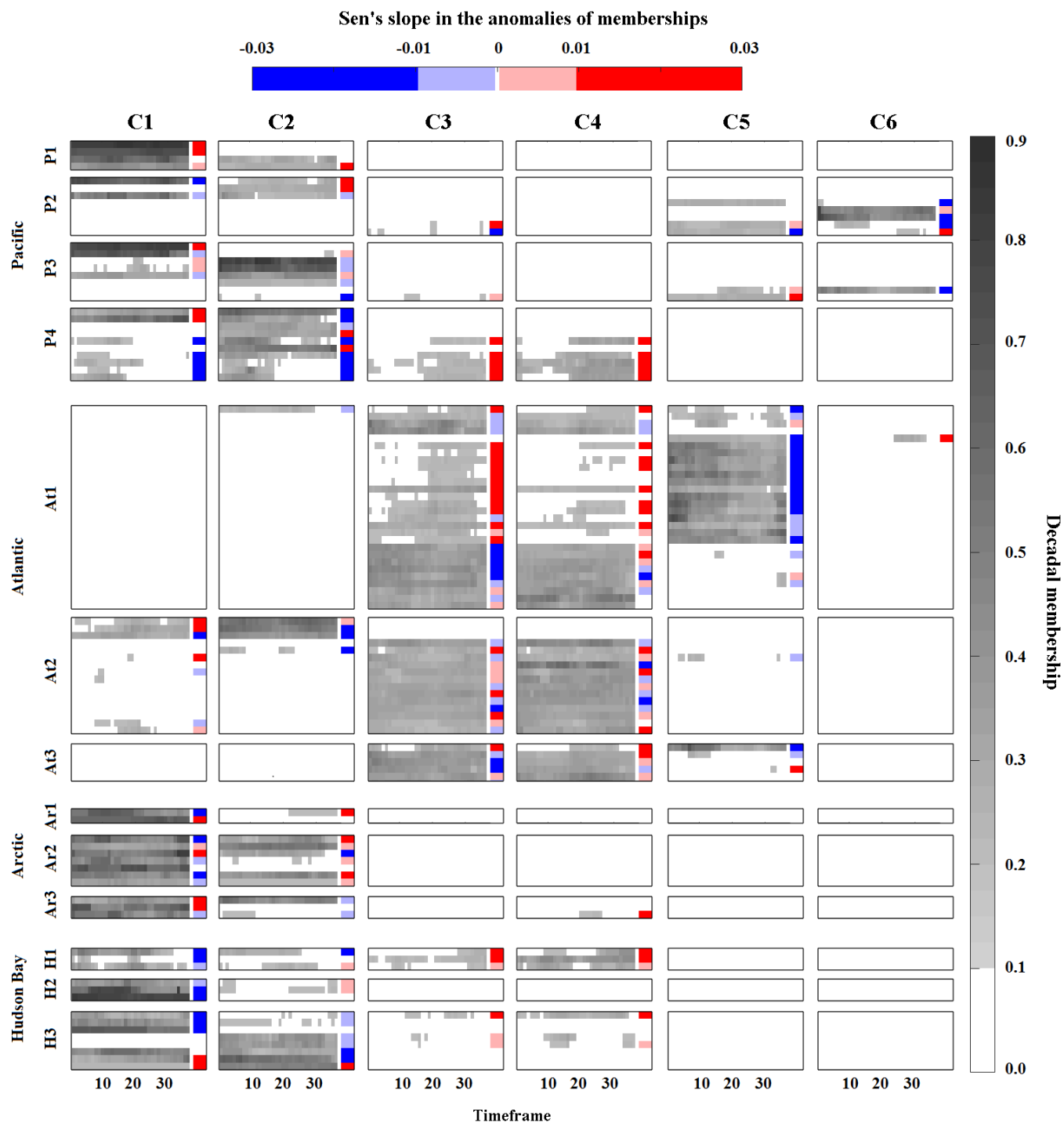
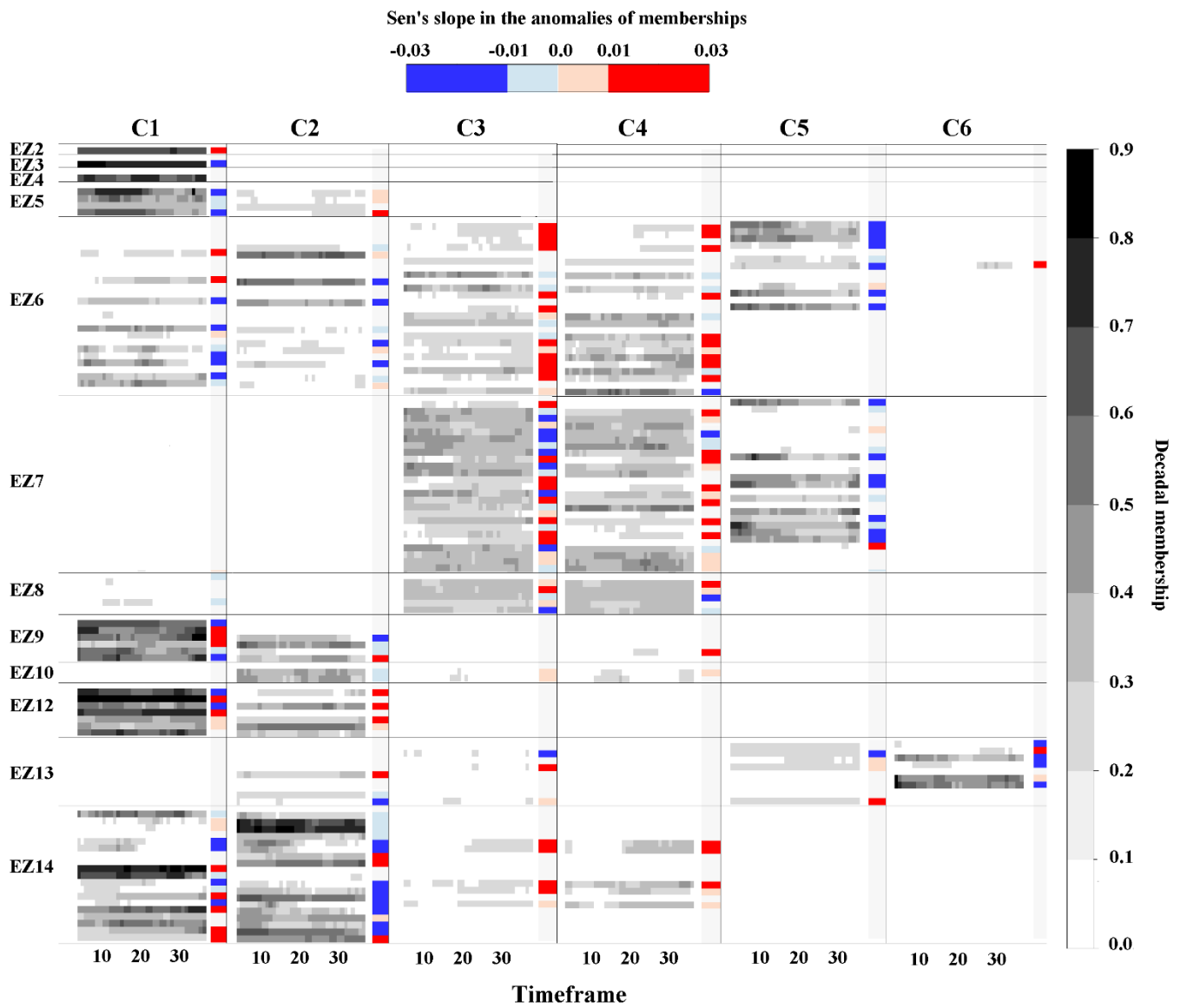


Figure S4. Evolutions in the degrees of membership to each regime type in 105 considered RHBN streams grouped in major basins/sub-basins, along with the corresponding Sen's slope. For each stream, the shades of grey show decadal memberships over the period of 1966 to 2010. The color bar shows the direction and significance of the Sen's slope of the trend in the anomalies of memberships. Positive and negative trends are shown with red and blue colors, respectively. Sharper colors show significant cases. In each sub-basin, stations are sorted from north to south from the top to the bottom.



80 **Figure S5.** Evolution in degrees of membership to each regime type in the 105 considered RHBN streams grouped according to ecozones, along
 85 with the corresponding Sen's slopes. For each stream, shades of grey show decadal memberships over the period of 1966 to 2010. The color bar
 shows the direction and significance of the Sen's slope of the trend in the anomalies of memberships. Positive and negative trends are shown
 with red and blue colors, respectively. Sharper colors show significant trends. The RHBN stations at each ecozone are sorted from the lowest to
 the highest elevations from the top to the bottom.

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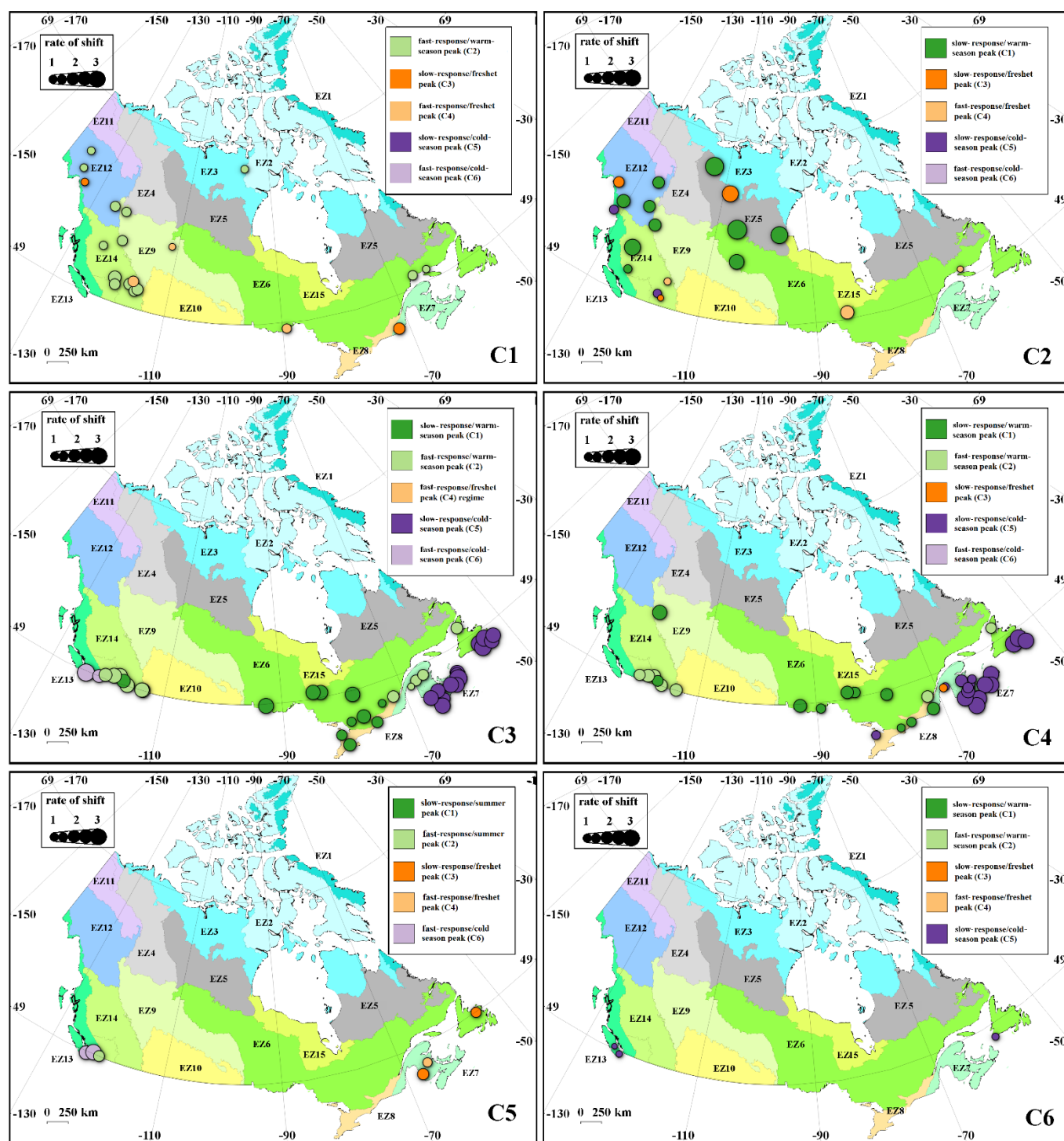


Figure S6. Mapping shifts in natural streamflow regime throughout Canada from 1966 to 2010. In each panel, circles identify the streams in which the regime is shifted. Colors show the initial regime type from which the streamflow is departed toward the reference cluster, which is given in each panel. Rates of the shifts between regime types in each stream are proportional to the size of each circle.

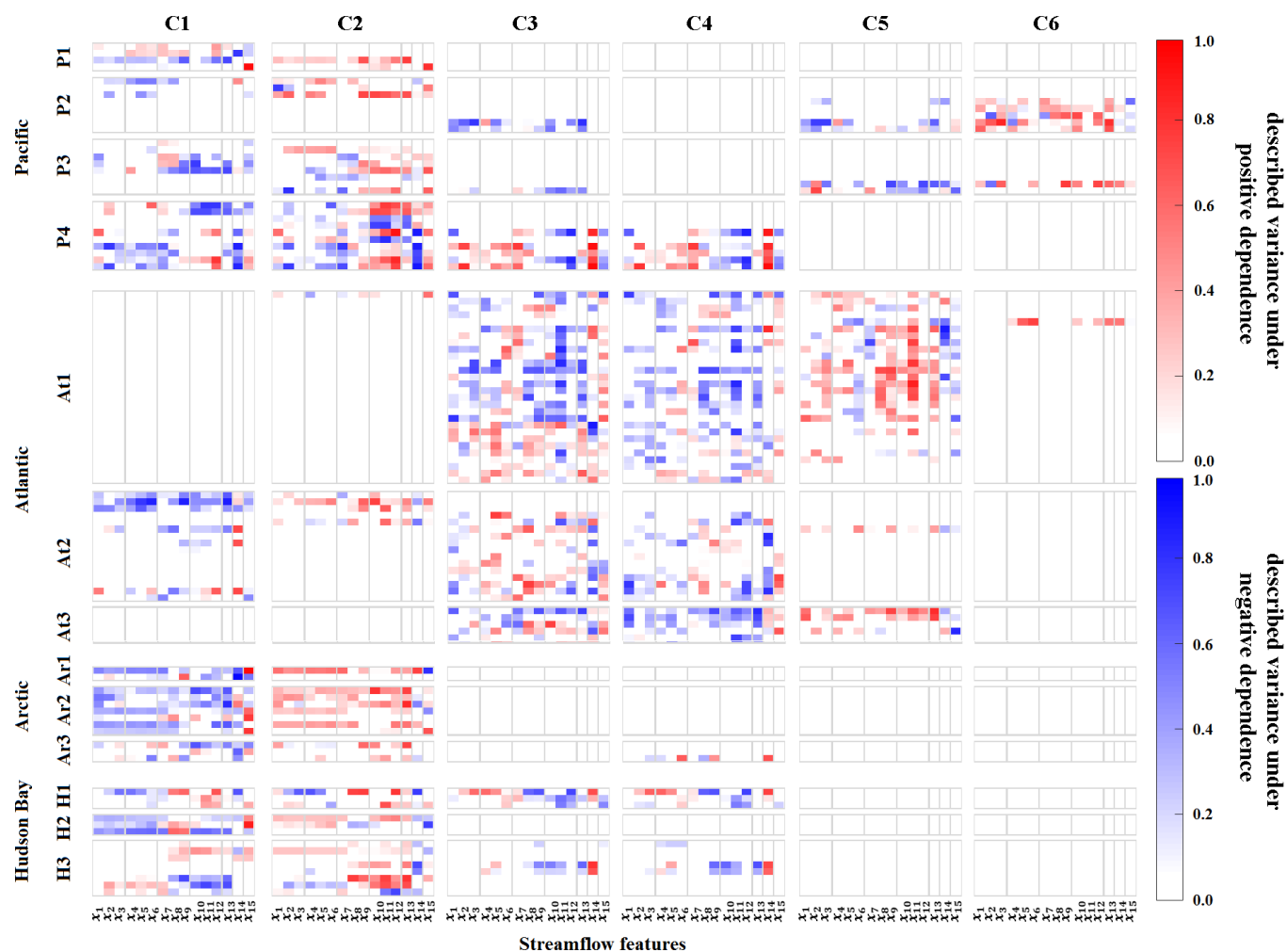


Figure S7. The alterations in regime types for 105 RHBN streams attributed to the first moments of the 15 IHA considered. Shades of red and blue show the positive and negative dependencies between changes in streamflow features and the degrees of membership, respectively. Color saturation shows the coefficient of determination between changes in the streamflow features and the degrees of membership representing the percentage of described variance in changes of streamflow regime by changes in streamflow features.

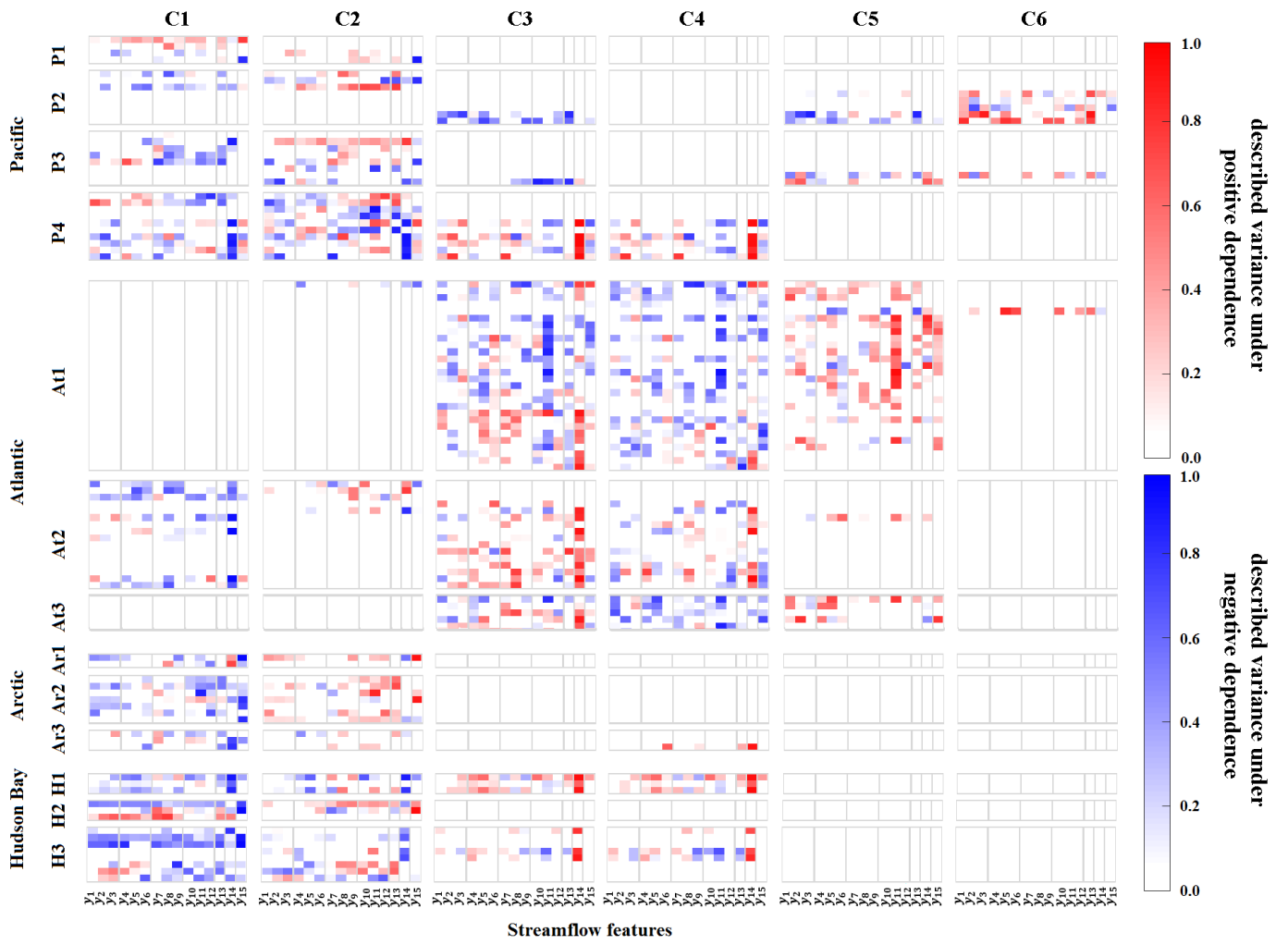


Figure S8. The alterations in regime types for 105 RHBN streams attributed to the second moments of the 15 IHA considered. Shades of red and blue show the positive and negative dependencies between changes in streamflow features and the degrees of membership, respectively. Color saturation shows the coefficient of determination between changes in the streamflow features and the degrees of membership representing the percentage of described variance in changes of streamflow regime by changes in streamflow features.

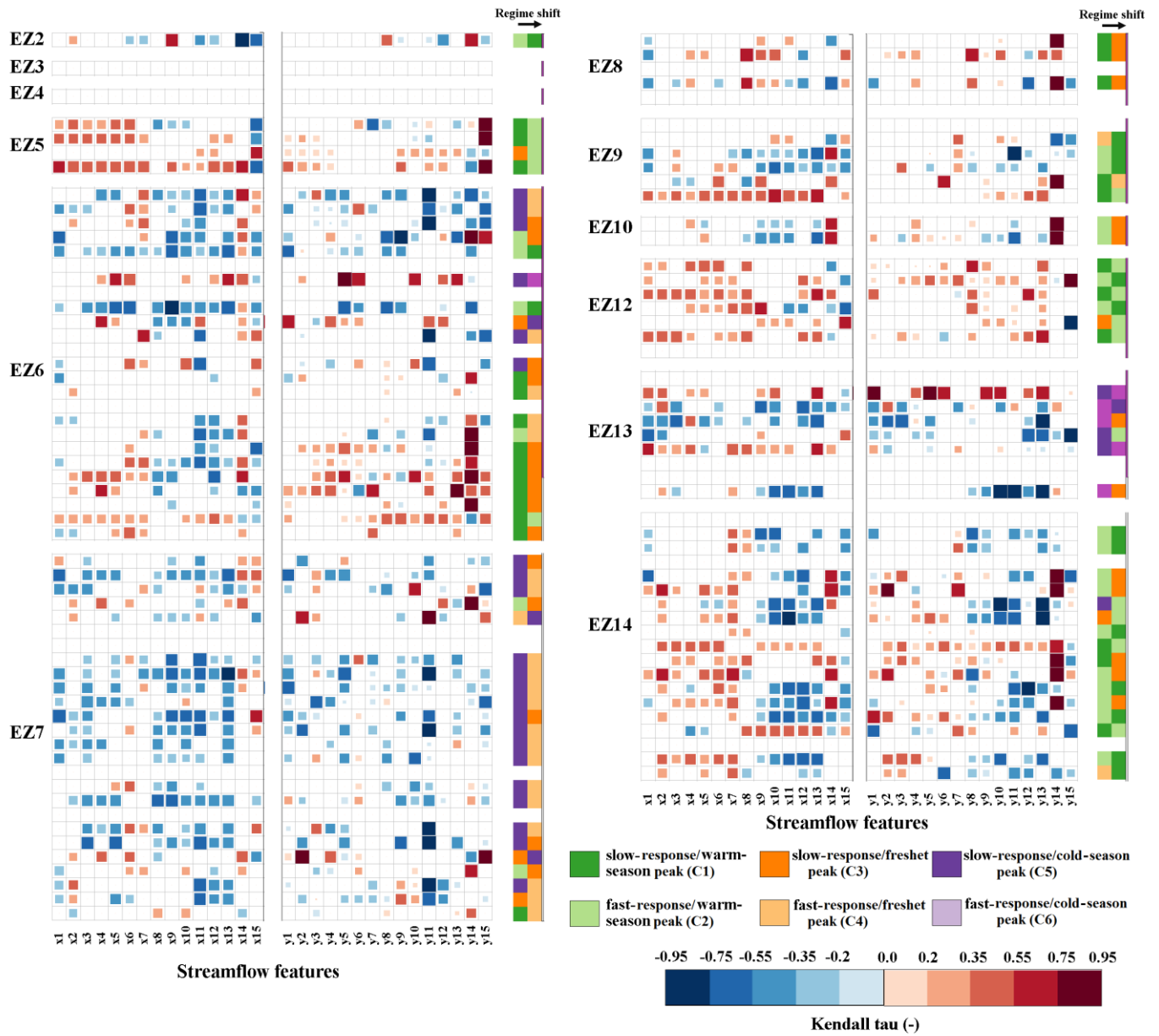


Figure S9. Dominant regime shifts across 105 RHBN streams in Canada attributed to the first and second moments of the 15 IHAs considered. Shades of red and blue show the values of squared of Kendall's tau between changes in streamflow features and degrees of membership. The dominant regime shift at each stream is identified by the color scheme described in the legend. Streams are grouped in ecozones and ordered from low (top) to the high (bottom) elevations.

Table S6. Summary information for the nine unseen stations in the Prairies ecozone.

Station	Station ID	Station Name	Province	Lat.	Long.	Basin area (km²)	Sub-basin	Basin
05OB021	P1	Mowbray Creek Near Mowbray	MB	49.0	-98.4	263	Nelson	Hudson Bay
05OB016	P2	Snowflake Creek Near Snowflake	MB	49.0	-98.6	975	Nelson	Hudson Bay
05LL014	P3	Pine Creek Near Melbourne	MB	49.9	-99.2	225	Nelson	Hudson Bay
05MF001	P4	Little Saskatchewan River Near Minnedosa	MB	50.4	-99.9	2610	Nelson	Hudson Bay
05MD005	P5	Shell River Near Inglis	MB	51.0	-101.3	1970	Nelson	Hudson Bay
05HD036	P6	Swift Current Creek Below Rock Creek	SK	49.8	-108.5	1430	Nelson	Hudson Bay
05EA005	P7	Sturgeon River Near Villeneuve	AB	53.6	-113.7	1890	Nelson	Hudson Bay
05CB001	P8	Little Red Deer River Near The Mouth	AB	52.	-114.1	2580	Nelson	Hudson Bay
05BL014	P9	Sheep River At Black Diamond	AB	50.7	-114.2	592	Nelson	Hudson Bay