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CANADIAN CASE STUDY

IDENTIFICATION OF PHYSICAL
HETEROGENEITIES IN HIGH-FREQUENCY
AIR TEMPERATURE RECORDS

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Air Temperature Heterogeneity: Key Points

NON-PHYSICAL vs PHYSICAL AIR TEMPERATURE HETEROGENEITY

INTRO

SUSCEPTIBILITY OF EXTREMA IDENTIFICATION METHODS TO INTRODUCTION OF SYSTEMATIC BIASES

METHOD

AIR TEMPERATURE RE-SAMPLING FOR PATTERN DISCRIMINATION

IDENTIFICATION OF AIR TEMPERATURE SAMPLE COMPONENTS

RESULTS

MAIN FEATURES OF A "HOMOGENEOUS" AIR TEMPERATURE SAMPLE

Non-Physical vs Physical Heterogeneity

LONG TERM HIGH FREQUENCY AIR TEMPERATURE RECORDS

NON-PHYSICAL HETEROGENEITIES ORIGINATING IN A MEASUREMENT PROCESS OR DATA PROCESSING TECHNIQUES

MEASUREMENT ERRORS

MISCHARACTERIZATION OF MINIMA

OBSERVATIONAL INCONSISTENCIES

OMISSION OF WARMER MINIMA

STATION LOCATION CHANGES

COLDER MINIMA DOUBLECOUNTING

CHANGES IN AVERAGING TECHNIQUES

LARGE TEMPERATURE ADJUSTMENTS

PHYSICAL HETEROGENEITIES ORIGINATING IN DIFFERENT PHYSICAL PROCESSES DRIVING THE MEASURED QUANTITY

MORE THAN ONE PHYSICALLY DISTINCT POPULATION IN AIR TEMPERATURE SAMPLE CHARACTERIZED BY A SPECIFIC DIURNAL AIR TEMPERATURE PATTERN

Extrema Observing Window: Related Biases

CLIMATOLOGICAL OBSERVING WINDOW
(COW_{0-24})

0-24 EXTENT OF A SEARCH WINDOW

NIGHTTIME FRAGMENTATION

DIURNAL ENDPOINT EXTREMA
(DEE)

SUPPRESSION OF DIURNAL MINIMA

ARTIFICIAL COLD BIAS

CLIMATOLOGICAL OBSERVING WINDOW
(COW_{N-D})

MINIMA – NIGHTTIME SEARCH WINDOW
MAXIMA – DAYTIME SEARCH WINDOW

CONFORMITY WITH RADIATIVE
TEMPERATURE PATTERN

DIURNAL MATHEMATICAL EXTREMA
(DME)

MISIDENTIFICATION OF REVERSE
ORDERED DIURNAL EXTREMA

MINOR MAXIMA BIAS

NEW DIURNAL OBSERVING WINDOW SUGGESTED AS A TOOL FOR EXTREMA CLASSIFICATION

Re-Sampling the Air Temperature Data

LONG TERM HIGH FREQUENCY (LTHF) AIR TEMPERATURE RECORDS

COW_{0-24}

$0-24$ MINIMA AND MAXIMA

$(T_{min}, t_{min}), (T_{max}, t_{max})$

DISRUPTED DIURNAL
EXTREMA SEQUENCE

UNDIAGNOSTIC DIURNAL
EXTREMA POPULATION

COW_{N-D}

NOCTURNAL
MINIMA

(NT_{min}, Nt_{min})

CHRONOLOGICALLY ORDERED
DIURNAL EXTREMA SEQUENCE

EXTREMA POPULATION SUITABLE
FOR SAMPLE SPLITTING

DAYTIME
MAXIMA

(DT_{max}, Dt_{max})

IMPORTANCE OF CORRECT IDENTIFICATION OF DIURNAL AIR TEMPERATURE EXTREMA PAIRS FOR PRESERVATION OF A CHRONOLOGICALLY ORDERED DIURNAL EXTREMA SEQUENCE

Linear Pattern Discrimination (LPD) Algorithm

COW_{N-D}

CHRONOLOGICALLY ORDERED DIURNAL EXTREMA SEQUENCE (T,t)

LPD

IDENTIFICATION OF LINEAR ADVECTIVE TEMPERATURE CASES

ATC

SEPARATION OF ADVECTIVE AIR TEMPERATURE COMPONENT

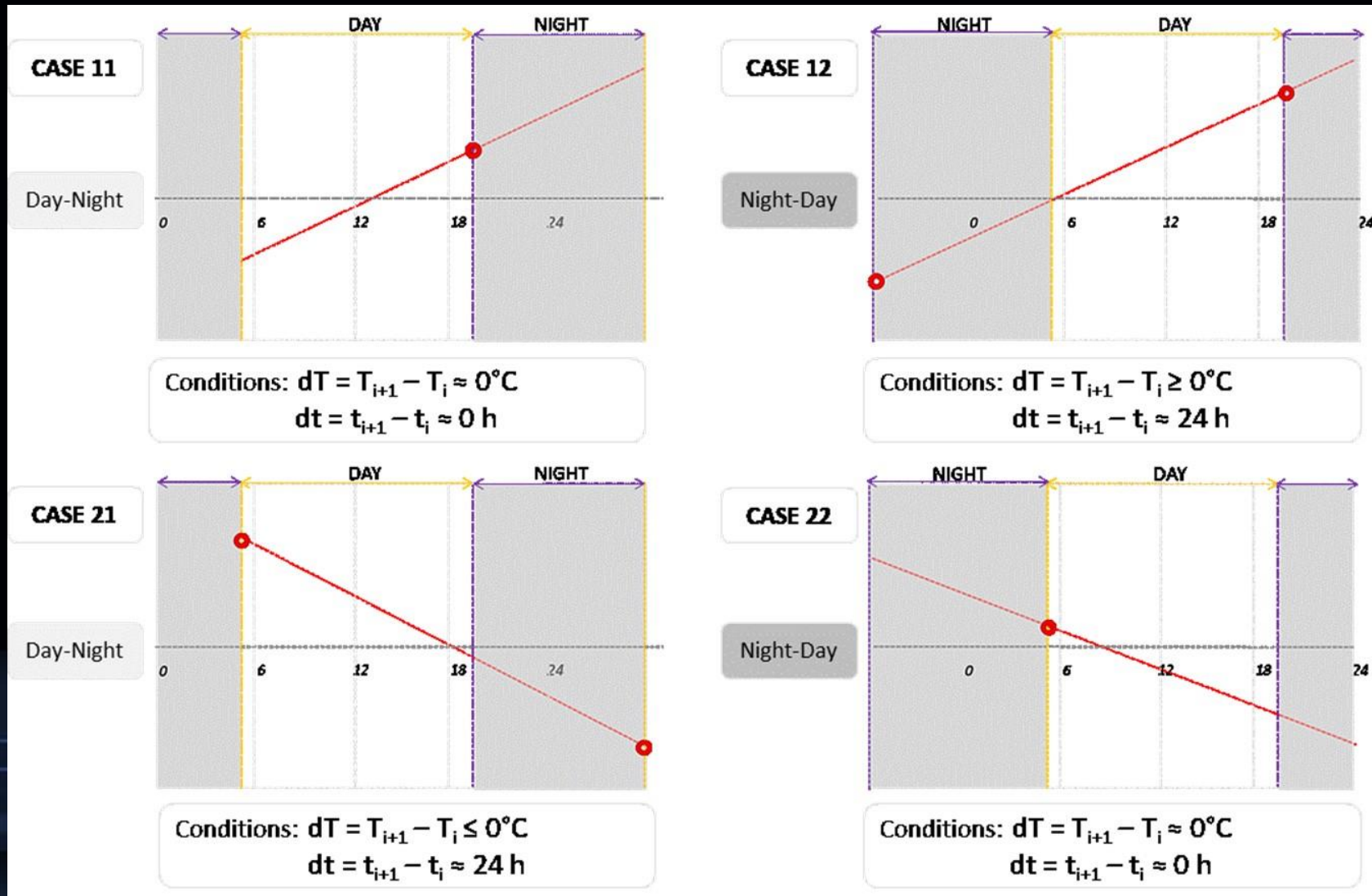
RAD_{N-D}

CONFIRMATION OF RADIATIVE TEMPERATURE EXTREMA CASES

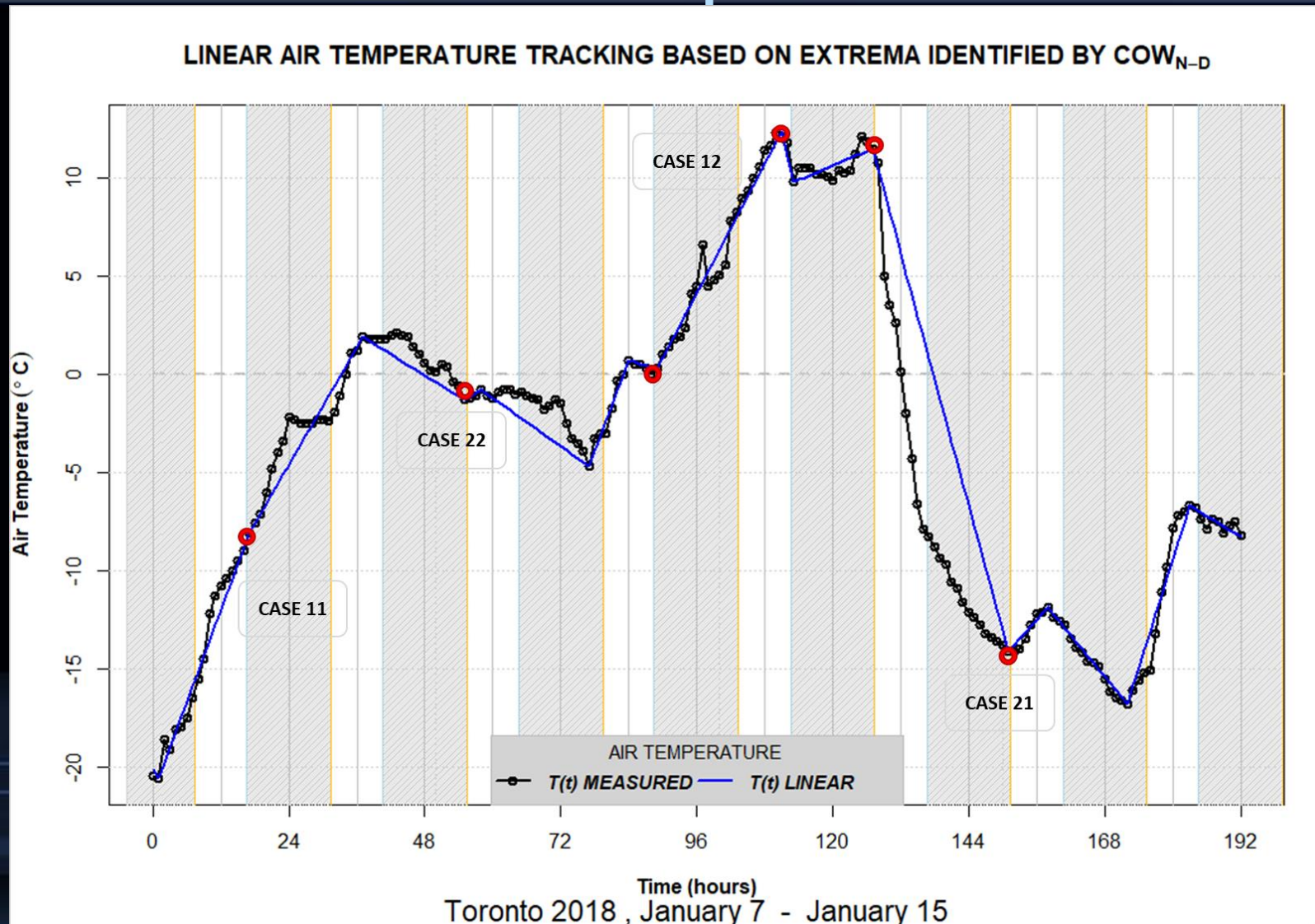
RTC

CONFIGURATION OF RADIATIVE AIR TEMPERATURE COMPONENT

Identification of Different Diurnal ATC Cases



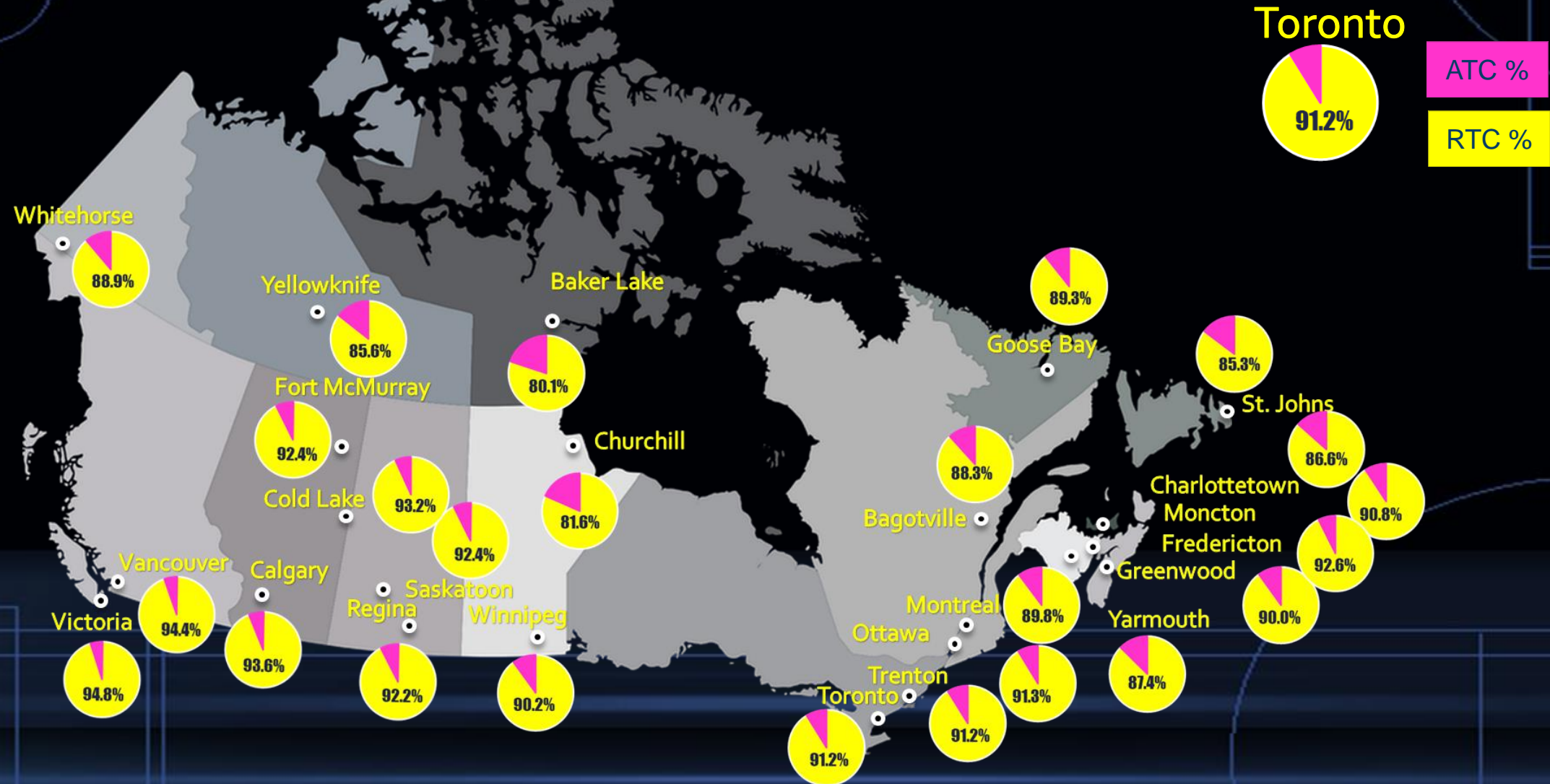
Advective Air Temperature Pattern



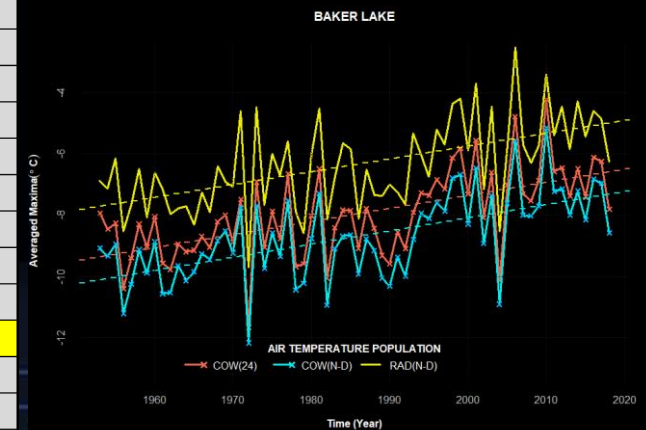
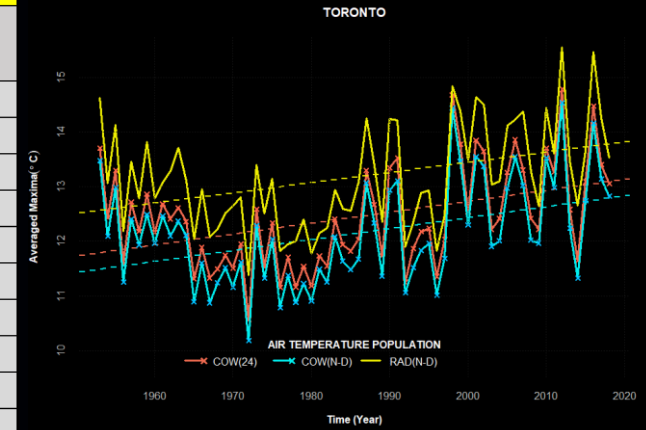
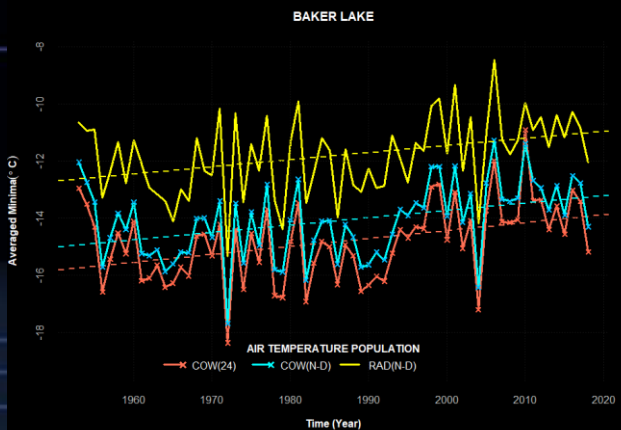
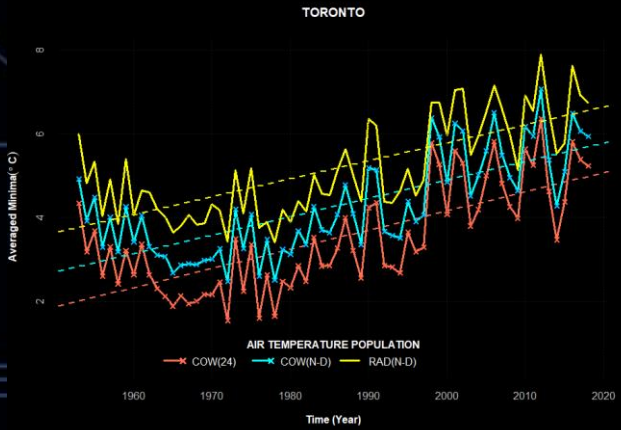
RADIATIVE AND ADVECTIVE AIR TEMPERATURE COMPONENT COUNTS

PROVINCES & TERRITORIES	STATIONS	RADIATIVE		ADVECTIVE TEMPERATURE COMPONENT									
		DAYS	%	DAYS	%	WIN	SPR	SUM	FAL	CS11	CS12	CS21	CS22
AB	Calgary	22,559	93.6	1,545	6.4	729	158	98	560	339	299	488	419
	Cold Lake	21,784	93.2	1,590	6.8	763	126	87	614	436	363	434	357
	Fort McMurray	22,267	92.4	1,837	7.6	866	129	71	770	522	421	493	401
BC	Vancouver	22,751	94.4	1,354	5.6	610	84	62	598	417	434	282	221
	Victoria	22,862	94.8	1,243	5.2	560	78	65	539	408	419	237	178
MB	Churchill	19,684	81.6	4,421	18.4	1562	708	524	1626	1044	820	1367	1190
	Winnipeg	21,740	90.2	2,364	9.8	1197	234	83	849	695	568	597	503
NB	Fredericton	22,315	92.6	1790	7.4	849	179	81	682	534	408	519	330
	Moncton	21,895	90.8	2,209	9.2	1054	263	97	794	610	430	714	454
NL	Goose Bay	21,529	89.3	2,575	10.7	1100	276	235	964	770	607	685	512
	St. John's	18,682	85.3	3,231	14.7	1391	405	287	1147	822	702	897	810
NS	Greenwood	21,689	90	2,415	10	1238	217	95	865	614	438	811	552
	Yarmouth	21,070	87.4	3,033	12.6	1468	319	190	1056	755	596	976	706
ON	Ottawa	21,998	91.3	2,106	8.7	1045	218	90	753	596	503	575	431
	Toronto	21,979	91.2	2,125	8.8	1059	239	96	731	565	473	612	474
	Trenton	21,978	91.2	2,127	8.8	993	235	133	766	592	467	643	425
PE	Charlottetown	20,862	86.6	3,242	13.4	1513	372	158	1198	869	699	924	749
QC	Bagotville	21,280	88.3	2,824	11.7	1257	250	165	1151	761	643	820	600
	Montreal	21,647	89.8	2,457	10.2	1226	257	116	858	702	563	687	504
SK	Regina	22,221	92.2	1,883	7.8	998	183	76	626	493	399	532	459
	Saskatoon	22,280	92.4	1,824	7.6	958	165	60	640	501	420	480	423
NT	Yellowknife	20,624	85.6	3,480	14.4	1444	235	197	1603	1026	923	813	717
NU	Baker Lake	19,519	80.1	4,586	19.9	1882	552	253	1899	1284	1104	1148	1049
YT	Whitehorse	21,434	88.9	2,670	11.1	1293	44	47	1285	870	808	524	467

Canadian Radiative to Advective Days Ratios



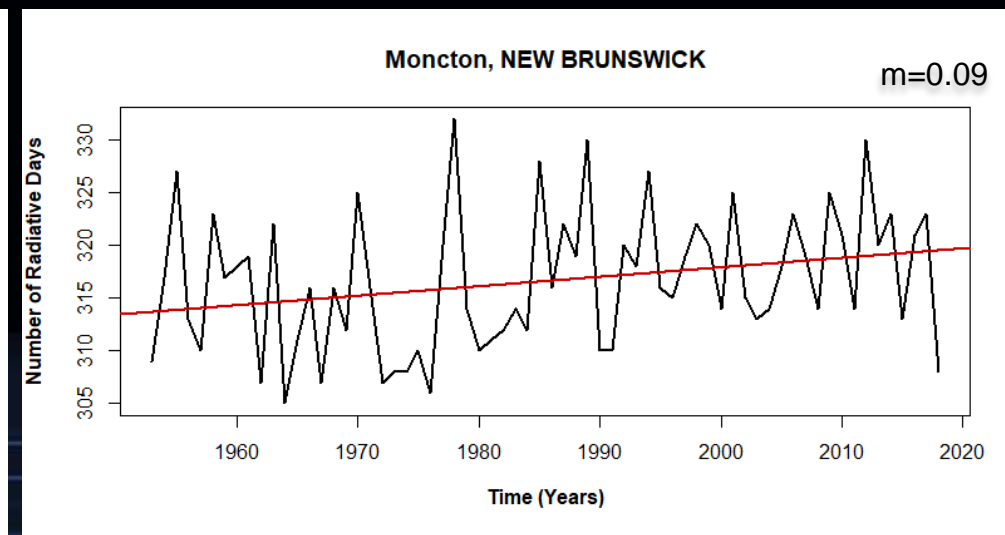
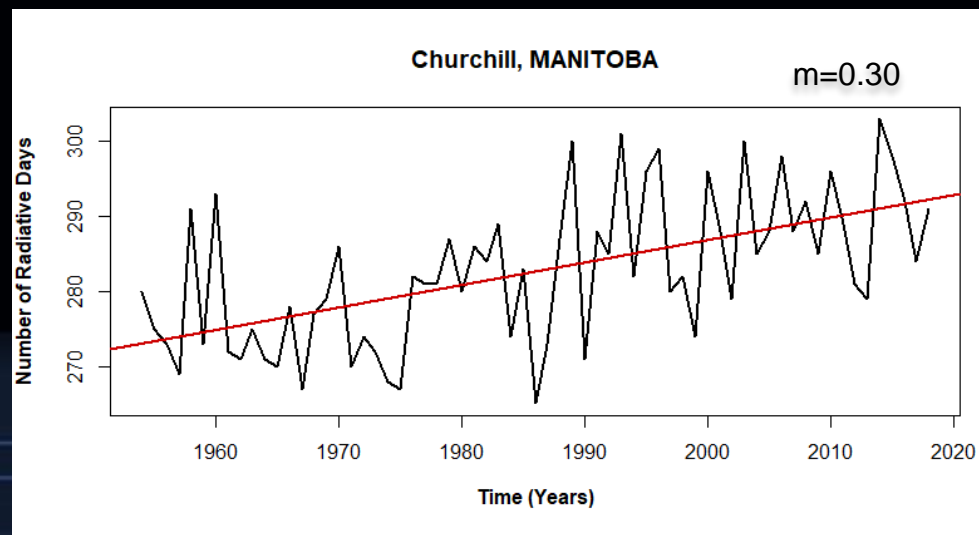
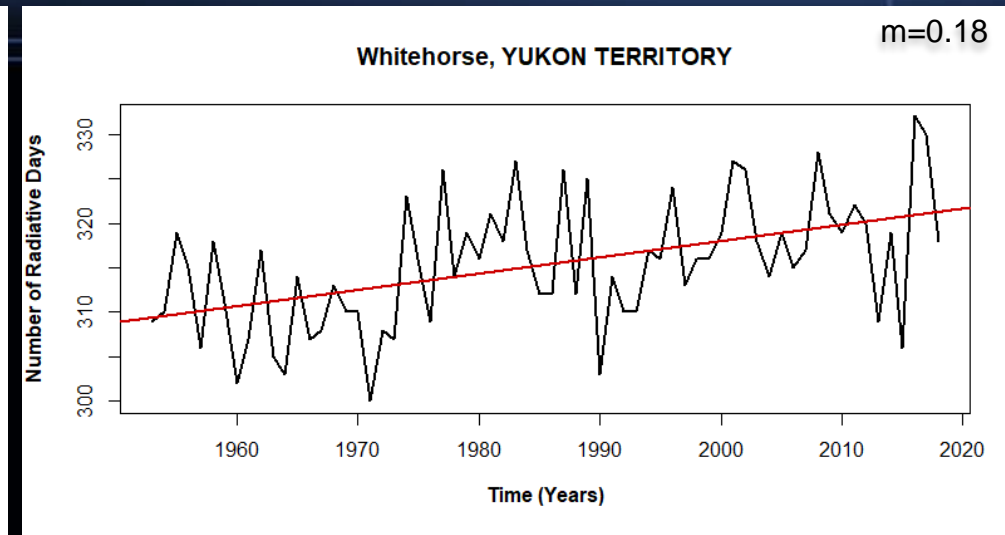
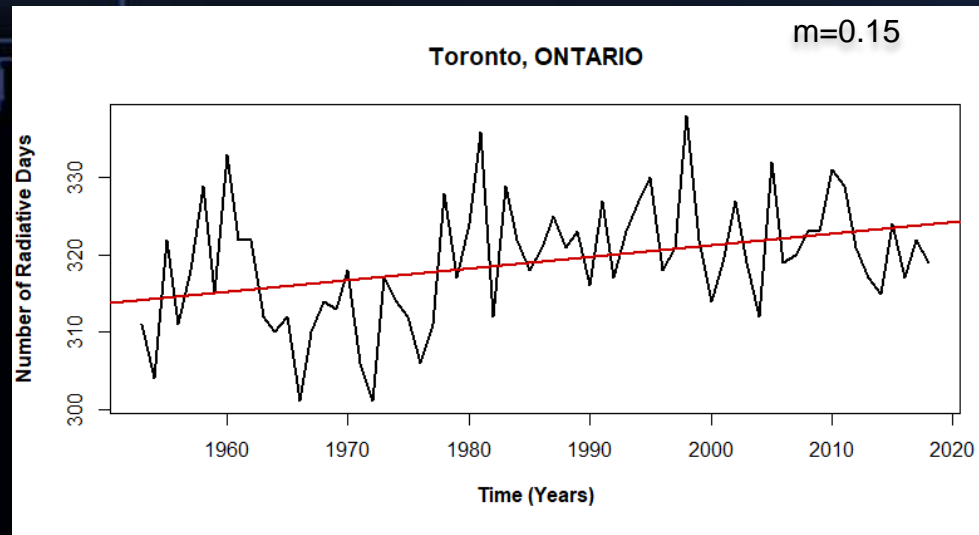
ANNUAL AVERAGES OF COW_{0-24} , COW_{N-D} AND RAD_{N-D} DAILY MINIMA AND MAXIMA



CANADIAN PROVINCES	STATIONS	COW ₀₋₂₄		COW _{N-D}		RAD _{N-D}	
		MIN (°C)	MAX (°C)	MIN (°C)	MAX (°C)	MIN (°C)	MAX (°C)
	Calgary	-1.51	9.88	-0.77	9.53	0.14	10.54
Alberta	Cold Lake	-3.39	6.85	-2.69	6.53	-1.70	7.63
	Fort McMurray	-5.05	6.22	-4.17	5.85	-3.02	7.14
	Vancouver	6.95	13.31	7.22	13.24	7.51	13.66
British Columbia	Victoria	5.98	13.76	6.35	13.68	6.58	14.08
	Churchill	-10.40	-2.79	-9.53	-3.51	-8.15	-2.16
Manitoba	Winnipeg	-2.49	7.96	-1.53	7.51	-0.07	9.09
	Fredericton	0.63	11.08	1.46	10.75	2.14	11.45
New Brunswick	Moncton	0.73	10.30	1.56	9.92	2.33	10.72
Newfoundland & Labrador	Goose Bay	-4.16	4.67	-3.37	4.20	-2.48	5.10
	St. John's	1.50	8.54	2.22	8.05	2.90	8.71
	Greenwood	2.49	11.99	3.32	11.57	4.17	12.50
Nova Scotia	Yarmouth	3.74	10.67	4.32	10.24	5.06	10.91
	Ottawa	1.71	10.85	2.41	10.47	3.44	11.56
Ontario	Toronto	3.49	12.44	4.27	12.14	5.17	13.17
	Trenton	2.85	11.96	3.61	11.64	4.46	12.52
Pr. Edw. Island	Charlottetown	1.91	9.57	2.69	9.09	3.77	10.15
Quebec	Bagotville	-2.05	7.60	-1.09	7.09	0.21	8.37
	Montreal	2.45	11.03	3.16	10.60	4.34	11.87
	Regina	-3.06	8.58	-2.08	8.17	-0.78	9.66
Saskatchewan	Saskatoon	-3.33	7.82	-2.44	7.45	-1.17	8.87
PROVINCES AVE		-0.05	9.16	0.71	8.77	1.66	9.79
NW Territories	Yellowknife	-8.66	-0.57	-7.86	-1.16	-5.83	0.90
Nunavut	Baker Lake	-14.83	-7.97	-14.10	-8.72	-11.82	-6.35
Yukon	Whitehorse	-5.28	4.08	-4.45	3.66	-3.07	5.40
TERRITORIES AVE		-9.59	-1.49	-8.80	-2.07	-6.91	-0.02

RADIATIVE EXTREMA AVERAGES HIGHER THAN FULL-TEMPERATURE SAMPLE EXTREMA AVERAGES

ANNUAL RADIATIVE DAYS: COUNTS AND SLOPES



TOTAL ANNUAL NUMBER OF RADIATIVELY-DRIVEN DAYS ON THE INCREASE

Air Temperature Heterogeneity: Highlights

LTHF

PRESENCE OF PHYSICALLY DISTINCT AIR TEMPERATURE POPULATIONS

COW_{N-D}

DIURNAL OBSERVING WINDOW - A TOOL FOR EXTREMA CLASSIFICATION

IMPORTANCE OF CORRECT DIURNAL AIR TEMPERATURE EXTREMA PAIRS

RAD_{N-D}

HIGH EXTREMA AVERAGES OF A HOMOGENEOUS TEMPERATURE SAMPLE

NUMBER OF RADIATIVELY-DRIVEN DAYS ON THE INCREASE IN CANADA