CLIMATE CHANGE SCENARIOS FOR ATLANTIC CANADA UTILIZING A STATISTICAL DOWNSCALING MODEL BASED ON TWO GLOBAL CLIMATE MODELS

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ABSTRACT

Values of daily maximum temperature (Tmax), daily minimum temperature (Tmin), and total daily precipitation (Pcpn), were downscaled using the Statistical Downscaling Model (SDSM) and predictors based on the Canadian Coupled General Circulation Model version 2 (CGCM2) and the Hadley Research Center's Hadley Climate Model version 3 (HadCM3) running the SRES emission scenario experiment B2 for 14 sites in Atlantic Canada. As an example of an extreme event, the maximum 24-hour precipitation was generated using the extreme value analysis (EV1) method of Gumbel, to determine any change in return period between the base climate values and the projected values. In addition, 52 extreme weather indices were defined using Stardex software, and a selected index (growing season length) was generated for the base climate period (1961-90) and values projected for three future periods, namely the 2020's (2010-2039), the 2050's (2040-2069), and the 2080's (2070-2099). All of these values were compared by examining the generated results from downscaling to the model output. The results confirm the conclusion that more than one model output must be utilized to determine appropriate views of future climate, as the main source of uncertainties comes from the various sources of GCM driven conditions.

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CLIMATE CHANGE SCENARIOS FOR ATLANTIC CANADA UTILIZING STATISTICAL DOWNSCALING BASED ON TWO GLOBAL CLIMATE MODELS.

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1.0 INTRODUCTION

1.1 Background

In order to best assess the expected climate change impacts on a species, ecosystem or natural resource in a region, climate variables and climate change scenarios must be developed on a regional or even site-specific scale (Wilby et al, 2001). To provide these values, projections of climate variables must be 'downscaled' from the GCM results, utilizing either dynamical or statistical methods (IPCC, 2007)

Downscaling can be accomplished by using either a Regional Climate Model (RCM), or a statistical technique. Statistical approaches are preferred when time and computer power are limted.

This study utilized the Statistical Downscaling Model (SDSM), developed by Wilby, Dawson and Barrow (2001), which was downloaded from the SDSM UK website (http://www-staff.lboro.ac.uk/~cocwd/sdsm.html).

Observed data sets of daily maximum temperature (Tmax), daily minimum temperature (Tmin), and total daily precipitation (Pcpn) were used as predictands. SDSM was calibrated using physically related 'predictor' variables, i.e. meteorological variables capable of being accurately simulated into the future by a GCM, fully realizing that some variables (temperature or atmospheric circulation) are more confidently projected than humidity or other variables related to precipitation or soil moisture processes (Gachon, 2005).

Calibrated models were tested and fine tuned against known data. These validated models were then used to construct suites of downscaled climate variable projections at selected sites in Atlantic Canada. Predictor values from the Canadian Coupled General Circulation Model version 2 (CGCM2) (Boer et al., 2000; Flato et al., 2000) and the Hadley Research Center's Hadley Climate Model version 3 (HadCM3) running the SRES emission scenario experiment B2 were obtained from the Canadian Climate Change Scenarios Network website (http://www.cccsn.ca).

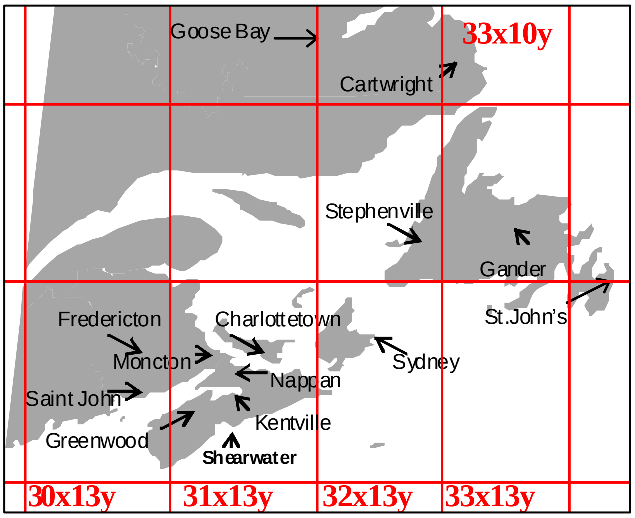

Fig 1. Sites in Atlantic Canada and numbered grid boxes

1.2 Geographic Background

Atlantic Canada consists of four provinces (Nova Scotia, New Brunswick, Prince Edward Island and Newfoundland & Labrador) and is situated along the northeast coast of North America covering nearly 20 degrees of latitude and 20 degrees of longitude (Fig 1).

The climate of the region is varied, including Atlantic, Boreal, and Sub-Arctic climates and is strongly influenced by both the warm Gulf Stream and the cold Labrador Current. Utilizing GCM output over this region limits the researcher to a small number of grid-boxes to cover all sites of interest. Six were used in this study, spanning 300 x 400km each according to the horizontal resolution of the CGCM1/2. Some of these boxes are defined as 'ocean' boxes' (e.g. box 33x10y, which is closest to Cartwright), and where the climate variables respond as if the surface boundary is North Atlantic Ocean water.

1.3 Modeling Approach

On a global scale, mean annual surface temperature has increased over the past century by 0.6°C (IPCC, 2007). Within the climate change scientific community, there is consensus that this increase, especially during the past 50 years, can be attributed partly to Greenhouse Gas (GHG) emissions due to human activity. Global Climate Models (GCMs), which are capable of providing credible projections of climate changes into the next 100 years use a coarse global grid scale (IPCC, 2007). Temperature and precipitation trends however, differ on a regional scale due to the different feedbacks appearing at the synoptic down to the local scale. This results in differing impacts at different regional scales with respect to the large scale climate change signal.

To date, impacts researchers frequently find that the horizontal resolution of most GCM's is too coarse for most applications. For example, in the Canadian General Circulation Model (CGCM2) described in Flato et al (2000) and Boer et al (2000), global grid box size is approximately 300x400km, or 120,000 square km, which is about the area of New Brunswick (Fig 1). In some cases, ecosystems under climatic stress have habitats of 100 km^2 or less, and thus global scale output is not suitable when studying climate change at individual species scales.

The ideal solution would be to increase horizontal resolution by using Regional Climate Models (RCM's). Their output has also not been as widely applied and tested as GCM results. Statistical models on the other hand, are more parsimonious, and when used in conjunction with readily available GCM output, can be trained to produce downscaled scenarios.

1.4 SDSM Downscaling

This study utilized the downscaled results obtained by using the Statistical Downscaling Model (SDSM) developed by Wilby et al (2002). A detailed discussion of downscaling using SDSM is described in the above paper and by Lines and Barrow (2003), and what follows is only a brief overview of the procedure.

SDSM may be described as a hybrid of multiple regression and stochastic downscaling techniques. Observed data sets of daily maximum temperature (Tmax), daily minimum temperature (Tmin), and total daily precipitation (Pcpn), the **predictands**, were regressed against statistically selected **predictors** using National Centre for Environmental Prediction (NCEP, 2005) data sets from 1961-75. The resulting regression equations were then validated against 1976-90 data. The accuracy of the resulting equations can be verified when the current climate (1961-90) is downscaled and compared to observed values for the same period. These validated models were then used to construct suites of downscaled climate variable both for the current climate and projections for future periods at selected sites in Atlantic Canada.

A major limitation of regression techniques is the assumption of time-invariance in the predictand-predictor relationships. Studies have shown that this has already been violated in the current climate (Wilby, 1997). Furthermore GCM models may have a certain bias for specific climate variable, such as low-level air temperature in most current models (Gachon, 2005) due to identified problems in simplified land surface scheme (ex. one layer bucket model used in the CGCM2).

2. DATA

Daily maximum temperature (Tmax), daily minimum temperature (Tmin), and total daily wet day precipitation >0.25mm/day (Pcpn) for the 30 year period 1961-90 at 14 sites in Atlantic Canada were used in this study. The sites are shown in Fig 1.

2.1 Observed temperature and precipitation data sets

The observed temperature and precipitation data sets were extracted from the Adjusted Historical Canadian Climate Database (AHCCD). The AHCCD consists of daily minimum, maximum, and mean temperatures for 210 stations across Canada (Vincent, 1998). The data have been adjusted for inhomogeneities caused by non-climatic factors, such as station relocation and changes in observing practices, using a regression model technique. Monthly adjustment factors from previous work were interpolated to generate daily factors. These factors were used to obtain the adjusted daily temperature and precipitation values resulting in the reliable long-term daily data set used in this analysis.

2.2 Reanalysis predictor sets used for the calibration process

To provide gridded reanalysis data sets used in the calibration process of SDSM, the National Centre for Environmental Prediction (NCEP) products were interpolated to the CGCM2 grid over the entire Canadian continental area. Both the GCM variables and the NCEP data sets were made available for the grid-boxes illustrated in Fig 1.

2.3 Forecast predictor sets

The projected GCM output over Atlantic Canada, for both the CGCM2 and HadCM3 were taken from the Canadian Climate Change Scenarios Network website (CCCSN). Predictors ranged from basic variables such as mean surface temperature, mean sea level pressure, and specific humidity, to geopotential heights and geostrophic winds reconstructed from pressure gradients, all at three different levels in the troposphere (i.e. at 1000, 850 and 500 hPa). The predictor sets are available for three future tri-decadal periods; the 2020s (2010-2039), the 2050s (2040-2069), and the 2080s (2070-2099). They are in the form of daily data from the SRES B2 emission experiment normalized with respect to 1961-1990.

3. METHODOLOGY

The methodology used in this study followed the procedure previously outlined by Lines et al. (2005). The methodology is also fully described in the SDSM 'Users Manual', by Wilby Dawson and Barrow (2001), which can be downloaded from the SDSM web site.

This study also used Stardex (STatistical And Regional dynamical Downscaling of EXtremes) version 3.2.6 which produced 250 analyses of 52 indices (see Appendix Table A1). The software calculated all indices seasonally as well as annually (except degree days, growing season length, and frost season length). Results of Growing Season Length are noted in Table 4.

The return periods of an extreme value such as 24-hour precipitation (Table 3) were analyzed, using the method of moments developed by Gumbel (1941) and adapted to precipitation extremes by Bruce (1966). A template developed by B. Morris at Environment Canada (2001), containing an Excel macro, was used to determine the return period of any size event.

It is recommended that when climate change scenarios are utilized that more than one GCM results be used to frame the future properly. All GCMs provide a version of the future, based on which emission scenario (SRES, see Nakinocevic et al., 2000) and time frame the researcher is interested in. In this study, the SRES B2 emission scenario was used for the 2 models noted.

4. RESULTS

4.1 Results of temperature and precipitation change based on CGCM2:

Table 1 (CGCM2)																		
Annual Projected Change in Downscaled Variables with respect to 1961-1990 baseline period																		
	Tmax (°C)						**Tmin (°C)**						**Pcpn (%)**					
	SDSM			**CGCM2**			**SDSM**			**CGCM2**			**SDSM**			**CGCM2**		
Tri-decade	**20**	**50**	**80**	**20**	**50**	**80**	**20**	**50**	**80**	**20**	**50**	**80**	**20**	**50**	**80**	**20**	**50**	**80**
Nova Scotia																		
Nappan	1.91	2.69	3.83	1.16	1.67	2.47	1.54	2.15	3.08	1.77	2.40	3.36	-1	3	4	0	6	3
Kentville	1.99	2.85	3.98	1.16	1.67	2.47	1.46	2.06	2.97	1.77	2.40	3.36	4	7	8	0	6	3
Greenwood	1.76	2.58	3.68	1.16	1.67	2.47	1.54	2.13	3.04	1.77	2.40	3.36	15	17	19	0	6	3
Shearwater	1.52	2.15	3.11	1.16	1.67	2.47	1.54	2.09	2.88	1.77	2.40	3.36	8	12	12	0	6	3
Sydney	1.18	1.92	3.37	1.06	1.42	2.12	1.76	2.52	3.69	1.12	1.49	2.21	14	16	19	3	3	4
New Brunswick																		
Fredericton	1.68	2.30	3.31	1.19	1.65	2.32	1.72	2.25	3.06	1.84	2.46	3.50	8	13	18	-2	5	5
Moncton	1.99	2.80	3.91	1.16	1.67	2.47	1.72	2.36	3.30	1.77	2.40	3.36	2	3	6	-1	5	4
Saint John	1.46	1.99	2.82	1.19	1.65	2.32	1.61	2.06	2.77	1.84	2.46	3.50	10	13	16	-2	5	5
Prince Edward Island																		
Charlottetown	1.70	2.46	3.51	1.16	1.67	2.47	1.69	2.33	3.34	1.77	2.40	3.36	13	16	18	0	5	4
Newfoundland and Labrador																		
Gander	1.97	2.77	3.94	1.31	1.85	2.67	1.49	2.14	3.09	1.97	2.82	3.96	3	4	7	2	3	3
St Johns	0.43	1.36	3.02	0.44	0.86	1.64	1.16	2.0	3.45	0.49	0.92	1.72	18	22	26	2	-3	1
Cartwright	2.25	2.92	4.34	0.84	1.29	2.05	2.04	2.90	4.16	1.77	2.62	3.79	-12	-8	-5	1	4	2
Goose Bay	2.25	2.95	4.01	1.96	2.73	3.87	1.95	2.78	3.87	2.31	3.34	4.83	3	6	10	1	3	5
Stephenville	0.67	1.67	2.83	1.14	1.84	2.75	1.84	2.58	3.63	1.93	2.67	3.62	12	16	20	-1	5	1

4.2 Results of temperature and precipitation change based on HadCM3:

Table 2 (HadCM3)

Annual Projected Change in Downscaled Variables

	Tmax (°C)						**Tmin (°C)**						**Pcpn (%)**					
	SDSM			**HadCM3**			**SDSM**			**HadCM3**			**SDSM**			**HadCM3**		
Tri-decade	**20**	**50**	**80**	**20**	**50**	**80**	**20**	**50**	**80**	**20**	**50**	**80**	**20**	**50**	**80**	**20**	**50**	**80**
Nova Scotia																		
Nappan	1.62	2.64	4.12	1.03	1.75	2.74	2.41	3.40	4.86	1.11	1.89	2.88	11	8	7	2	-2	5
Kentville	1.63	2.73	4.25	1.03	1.75	2.74	2.16	3.14	4.64	1.11	1.89	2.88	8	7	4	2	-2	5
Greenwood	1.52	2.60	4.14	1.03	1.75	2.74	1.78	2.67	4.09	1.11	1.89	2.88	7	7	-4	2	-2	5
Shearwater	1.17	2.12	3.51	1.03	1.75	2.74	1.87	2.73	4.00	1.11	1.89	2.88	17	14	12	2	-2	5
Sydney	1.60	2.35	4.46	0.92	1.15	2.17	1.94	2.51	4.17	1.03	1.39	2.40	8	4	1	3	-3	4
New Brunswick																		
Fredericton	1.33	2.24	3.37	1.25	2.22	3.37	1.42	2.10	3.16	1.51	2.52	3.74	18	14	14	3	2	7
Moncton	1.57	2.66	4.19	1.03	1.75	2.74	2.43	3.47	4.96	1.11	1.89	2.88	11	7	5	2	-2	5
Saint John	1.34	2.15	3.17	1.25	2.22	3.37	1.26	1.94	3.01	1.51	2.52	3.74	16	13	12	3	2	7
Prince Edward Island																		
Charlottetown	1.66	2.30	4.04	1.05	1.39	2.57	1.84	2.43	4.18	1.09	1.52	2.66	12	11	10	0	-2	4
Newfoundland and Labrador																		
Gander	1.70	2.47	3.57	1.71	2.46	3.54	1.54	2.12	3.06	1.9	2.7	3.86	8	8	6	4	2	7
St Johns	2.50	3.16	4.88	1.28	1.73	2.51	2.47	3.04	4.55	1.39	1.91	2.71	28	27	28	1	2	5
Cartwright	1.69	2.26	3.28	1.90	2.70	3.7	2.09	2.53	3.53	2.20	2.94	4.07	6	6	6	4	5	11
Goose Bay	2.18	3.06	4.32	1.63	2.46	3.46	2.17	2.86	4.15	1.87	2.69	3.82	6	5	7	7	7	13
Stephenville	1.7	2.02	3.65	0.90	0.98	2.06	1.76	2.01	3.69	1.04	1.19	2.27	10	8	9	2	-3	3

4.3 Results for Return Periods for Extreme Precipitation Amounts:

Table 3a

Return Period Projections for Extreme 24-hour Precipitation Amounts (mm)

Return Period	**10 Years**				**50 Years**				**100 Years**			
	Hist	**2020s**	**2050s**	**2080s**	**Hist**	**2020s**	**2050s**	**2080s**	**Hist**	**2020s**	**2050s**	**2080s**
Nova Scotia												
Greenwood CGCM2	78.7	122.3	105.1	99.9	100.8	166.6	140	129.7	110.2	185.3	154.7	142.3
Greenwood HadCM3	78.7	94.2	79.9	86.3	100.8	127.9	101.3	112.8	110.2	142.1	110.3	124
Shearwater CGCM2	102.1	148.9	130.1	132.8	135.1	202.6	165.8	175.6	149.1	225.4	180.8	193.7
Shearwater HadCM3	102.1	120.9	103.7	109.8	135.1	157	131	141.5	149.1	172.2	142.6	154.9
Sydney CGCM2	N/A	135.1	137.8	129.2	N/A	186.5	180.6	165.3	N/A	208.2	198.6	180.5
Sydney HadCM3	N/A	109.4	108	113.8	N/A	137.9	140.1	143.5	N/A	150	153.7	156.1
New Brunswick												
Fredericton CGCM2	86.2	93.2	96.7	111.1	113.2	121.5	123.8	146.7	124.3	133.5	135.2	161.8
Fredericton HadCM3	86.2	89.1	94.5	93.5	113.2	113	118.2	119.3	124.3	123.1	128.3	130.1
Moncton CGCM2	86.8	93.3	103.1	132.8	113.7	122.6	135.1	175.6	125.1	134.9	148.7	193.7
Moncton HadCM3	86.8	89.9	104.3	103.5	113.7	112.9	136.3	141.5	125.1	122.6	149.9	157.5
Saint John CGCM2	100	119.7	107.4	118.8	143.4	153	133.2	149.8	157.1	167.1	144.1	162.9
Saint John HadCM3	100	117.5	128.6	124.8	143.4	148.3	168.6	159.6	157.1	161.4	185.5	174.3
Prince Edward Island												
Charlottetown CGCM2	74	120.7	107.7	99.8	94.2	168.4	144.8	128.6	102.7	188.6	160.6	140.7
Charlottetown HadCM3	74	86.4	93.7	79.1	94.2	110.3	121.1	97.2	102.7	120.4	132.7	104.8

Table 3b

Return Period Projections for Extreme 24-hour Precipitation Amounts (mm)

Return Period	**10 Years**				**50 Years**				**100 Years**			
	Hist	**2020s**	**2050s**	**2080s**	**Hist**	**2020s**	**2050s**	**2080s**	**Hist**	**2020s**	**2050s**	**2080s**
Newfoundland and Labrador												
Gander CGCM2	59.4	65.8	65.5	62.1	72.8	82.8	82.9	76.4	78.5	89.9	90.3	82.5
Gander HadCM3	59.4	61.7	70.7	81.3	72.8	77.5	89.7	108.8	78.5	84.2	97.7	120.5
St Johns CGCM2	75.9	113.2	118.5	107.2	92.2	149.2	160.3	134.5	99.1	164.4	178	146
St. Johns HadCM3	75.9	103.5	139.1	110.8	92.2	128.6	199	147.1	99.1	139.1	224.3	162.4
Cartwright CGCM2	62.7	44.7	50.5	56.5	80.2	54.6	64.8	74.6	87.6	58.8	70.8	82.3
Cartwright HAdCM3	62.7	56.8	61.6	62.2	80.2	69	78.7	77	87.6	74.9	85.9	83.2
Goose Bay CGCM2	59.6	75.1	73	68.1	76.5	98.6	96.7	83.7	83.7	108.6	106.7	90.6
Goose Bay HadCM3	59.6	46.5	50.8	43.7	76.5	58	64	62.1	83.7	62.8	69.6	67.1
Stephenville CGCM2	69.8	83.7	86.3	93.8	89.2	106.9	109	121.5	97.3	116.7	118.6	133.2
Stephenville HadCM3	69.8	73.2	95.6	78.5	89.2	94	132.7	101.8	97.3	102.7	148.2	111.6

4.4 Results for Growing Season Length (as an example of a STARDEX extreme climate index):

Table 4

Growing Season Length (days)

Period	Hist	2020s	2050s	2080s
Nova Scotia				
Nappan CGCM2	170	181.3	190.6	196.2
Nappan HadCM3	170	209.1	215.1	226.9
Kentville CGCM2	186	195.9	207.4	213
Kentville HadCM3	186	220.4	229.6	236.5
Shearwater CGCM2	184	194.3	200.2	207.4
Shearwater HAdCM3	184	221.7	227.3	234.8
Greenwood CGCM2	181	190.9	200.5	211.6
Greenwood HadCM3	181	221.5	227.3	237.3
New Brunswick				
Fredericton CGCM2	172	178	186	191
Fredericton HadCM3	172	204	206	212
Moncton CGCM2	173	184	192	200
Moncton HadCM3	182	207	211	229
Saint John CGCM2	182	184.5	189	198
Saint John HadCM3	182	207.5	216	219
Prince Edward Island				
Charlottetown CGCM2	184	184	191	201
Charlottetown HadCM3	184	200	208	221
Newfoundland and Labrador				
Gander CGCM2	170	181.7	192	196.9
Gander HadCM3	170	170.7	178.3	185.3
St Johns CGCM2	182	187.6	194.4	218.9
St. Johns HadCM3	182	210.4	214.2	228.4
Cartwright CGCM2	135	168.8	167.6	180.9
Cartwright HAdCM3	135	139.3	147.3	159.4
Goose Bay CGCM2	138	150.5	157.1	161.3
Goose Bay HadCM3	138	147.7	168.8	166.8

5.0 Comments on Results

Results were generated by month, season and annually for the temperature and precipitation change values at all 14 sites. Results for the extreme precipitation return periods and the growing season length were done annually at 12 sites. Due to space considerations, only the annual results are published in this report. Impact researchers interested in accessing the other data sets can contact the lead author.

Two approaches were used to compare these results. First is the comparison of the downscaled (SDSM) value to the model output value, for either the CGCM2 or the HadCM3. In other words how different is the downscaled value from the model output for each of the three climate variables; maximum temperature, minimum temperature and precipitation. Second, how do the downscaled results based on each model compare, i.e. do the downscaled results from the CGCM2 differ from the HadCM3 results?

For the SDSM versus model output comparison, we simply note if the value is higher or lower. In the case of SDSM and CGCM2 results, the SDSM values for change in maximum temperature are higher while the change values for minimum temperature are lower. This implies that local climate forcings are driving the maximum temperature projections higher than the model output while at the same time not warming the minimum temperatures as much. The physical rationale is not obvious but could be related to the predominance of marine climate characteristics in the regional forcings.

For precipitation, larger percent changes are projected by the downscaling when compared to the CGCM2 output values. This is very site dependent but does seem to reflect particular regional forcings. For example, when examining the seasonal values, most sites show relatively high change values in autumn compared to other seasons. It is suspected that the tropical cyclone signal is being reflected in the downscaling of those sites.

For the SDSM comparison to HadCM3 similar differences are occurring. The downscaled results show higher values of temperature and precipitation change for all sites.

When examining the extreme precipitation values the most obvious conclusion is that the overall value of precipitation amount increases with each return period. Some sites show a very consistent increase in precipitation amount from the more frequent period (10-year) to the more rare occurrence (100-year). However, other sites vary from a high value to a lower value as the event becomes more rare. The physical rationale for this variation is not clear and may be due to internal variability problems in the models themselves. Also the SDSM approach, being statistical, implies that the regression is based on the stationary nature of the variables while it is clear that change is occurring through the entire time period.

Finally the growing season length is examined and provides a consistent pattern of lengthening season as we progress through the century. Since this is a temperature based index this pattern is expected. However the comparison between the models provides some sense of how the variation may occur.

In conclusion, the comparisons support the concept that more than one model results should be considered when utilizing projections over the next 50 to 100 years. Even when we downscale these projections there are sufficient differences to indicate that these results should be taken as ranges of possibilities and not simply one definitive result. These results also support the use of techniques such as SDSM that can produce multiple sets of projections so that such comparisons between models can be made in a timely and economic way.

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APPENDIX TABLE A1

STARDEX Diagnostic Extremes Indices (Core indices highlighted in yellow)

Old Name	***New Name***	***Description***
Txav	txav	Mean Tmax
Tnav	tnav	Mean Tmin
Tav	tav	Mean Tmean
Trange_mean	trav	mean diurnal temperature range
Trange10p	trq10	10th percentile diurnal temperature range
Trange90p	trq90	90th percentile diurnal temperature range
tmax10p	txq10	Tmax 10th percentile
tmax90p	txq90	Tmax 90th percentile
tmin10p	tnq10	Tmin 10th percentile
tmin90p	tnq90	Tmin 90th percentile
125Fd	tnfd	Number of frost days Tmin < 0°C
114Id	txice	Number of days without defrost (ice days) Tmax < 0°C
135GD	tgdd	Growing degree days > threshold
141ETR	tiaetr	Intra-annual extreme temperature range
143GSL	tgsl	Growing Season Length
144HWDI	txhwd	Heat Wave Duration
txhw90	txhw90	90th Percentile Heat Wave Duration
145CWDI	tncwd	Cold Wave Duration
tncw10	tncw10	10th Percentile Cold Wave Duration
147FSL0	tnfsl	Frost Season Length (0°C)
191Tx10	txf10	% days Tmax < 10th percentile
192Tx90	txf90	% days Tmax > 90th percentile
193Tn10	tnf10	% days Tmin < 10th percentile
194Tn90	tnf90	% days Tmin > 90th percentile
601R	pav	Mean climatological precipitation (mm/day)
prec20p	pq20	20th percentile of rainday amounts (mm/day)
prec40p	pq40	40th percentile of rainday amounts (mm/day)
prec50p	pq50	50th percentile of rainday amounts (mm/day)
prec60p	pq60	60th percentile of rainday amounts (mm/day)
prec80p	pq80	80th percentile of rainday amounts (mm/day)
prec90p	pq90	90th percentile of rainday amounts (mm/day)
prec95p	pq95	95th percentile of rainday amounts (mm/day)
frac20p	pf20	Fraction of total precipitation above annual 20th percentile
frac40p	pf40	Fraction of total precipitation above annual 40th percentile
frac50p	pf50	Fraction of total precipitation above annual 50th percentile
frac60p	pf60	Fraction of total precipitation above annual 60th percentile
frac80p	pf80	Fraction of total precipitation above annual 80th percentile
frac95p	pf95	Fraction of total precipitation above annual 95th percentile
606R10	pn10mm	No. of days precip >= 10mm
641CDD	pxcdd	Max no. consecutive dry days
642CWD	pxcwd	Max no. consecutive wet days
frac90p	pf90	Fraction of total precipitation above annual 90th percentile
pww	ppww	Mean wet-day persistence
persist_dd	ppdd	Mean dry-day persistence
persist_corr	ppcr	Correlation for spell lengths
wet_spell_mean	pwsav	mean wet spell lengths (days)
wet_spell_perc	pwsmed	median wet spell lengths (days)
wet_spell_sd	pwssdv	standard deviation wet spell lengths (days)
dry_spell_mean	pdsav	mean dry spell lengths (days)
dry_spell_perc	pdsmed	median dry spell lengths (days)
dry_spell_sd	pdssdv	standard deviation dry spell lengths (days)
643R3d	px3d	Greatest 3-day total rainfall
644R5d	px5d	Greatest 5-day total rainfall
645R10d	px10d	Greatest 10-day total rainfall
646SDII	pint	Simple Daily Intensity (rain per rainday)
691R90T	pfl90	% of total rainfall from events > long-term 90th percentile
692R90N	pnl90	No. of events > long-term 90th percentile