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Evaluation of ClimateBC V5

ClimateBC V5 is an update of ClimateBC V4 and the BC component of ClimateWNAV472. ClimateBC V5, like previous versions, is a software page that produces high-resolution estimates of temperature and precipitation and a number of derived climate variables for historic and future climates. Values for individual points are obtained by interpolation based on latitude, longitude and elevation from a base layer of temperature and precipitation normals. Time periods other than the base period are obtained by the delta method using grids of change in temperature and precipitation from the base period.

This document evaluates ClimateBC V5 estimates of climate normals and various derived variables for Meteorological Service of Canada weather stations and a selection of points within Biogeoclimatic Classification System units (variants). ClimateBC V5 is also compared to estimates from ClimateBC V5 and the BC component of ClimateWNA V472.

Changes to ClimateBC V5

PRISM base layers: The old PRISM base layers of monthly temperature and precipitation at were at 4 km resolution, for 1961-1990 normals and were created in 2002. The new layers are at 800 m resolution for 1971-2000 period. Improved methodology (Daly et al. 2008) and information from a substantially increased number of weather stations in BC were used to generate the base layers. The work was done by Faron Anslow of the Pacific Climate Impacts Consortium in conjunction with Chris Daly's Climate Analysis Group at Oregon State University.

Downscaling temperature to individual locations: Previous versions of the software obtained temperature lapse rates from a BC-wide equation of temperature lapse rates as a function of latitude, longitude and elevation (Wang et al 2006, 2012). ClimateBC V5 uses local lapse rates calculated dynamically based on temperature elevation of surrounding grid cells.

Downscaling precipitation to individual locations: Previous versions of the software only had precipitation lapse rates that were inherent in the 4 km base layer grid. No further downscaling was done. ClimateBC V5 uses local lapse rates calculated dynamically based on precipitation and elevation of surrounding grid cells.

Solar radiation: This variable was absent from Previous versions of the software. ClimateBC V5 contains a historic solar layer to allow monthly historic time series and adjustment of GCM predictions of solar radiation. The source of the historic solar layer is Hember (2013).

CMIP5 projections of climate change: Previous versions of the software used the AR4 climate change projections and scenarios. ClimateBC V5 includes projections from CMIP5.

Monthly time series for CMIP5 projections of climate change: Previous versions of the software only had climate projections for the 2020s, 2050s and 2080s period normals. ClimateBC V5 adds monthly time series of projections of temperature, precipitation and solar radiation for 2014 to 2100 for three projects form one GCM.

Results

This analysis looks in detail at the effects of the first three improvements listed above on point estimates of various climate variables. It also briefly considers the solar radiation layer. There is no evaluation of the climate change projections against previous estimates from earlier versions of the software.

Monthly temperature and precipitation for 562 stations for 1951-80: The first comparison is for the 800 m PRISM without downscaling and with dynamical downscaling to the station elevation (Appendix 1). Downscaling consistently improves the predictions for temperature and precipitation. The comparison between the old and new PRISM base layers, i.e., ClimateBC V4 versus ClimateBC V5, shows a marginal improvement in temperature (greater R^2) for the new PRISM, but a slight degradation for precipitation (Appendix 2). There appears to be a reduction in bias using the new PRISM layers with calculations closer to the 1:1 line and intercept closer to zero.

Annual temperature and precipitation and derived variables for 185 stations for 1961-90 normals: As with the 1951-90 analysis ClimateBC V5 is a slight improvement over the previous software (in this case ClimateWNA V472) for temperature (Appendix 3). However, it is appears that temperature at some lighthouse stations is underestimated. There is some minor degradation in precipitation. Some outlier precipitation values, e.g., Glacier NP, were corrected. Derived variables such as heat:moisture indices, degree days and evaporation reflect the slight improvements over ClimateWNA V472. The 4 points well above the regression line on the frost free period at lighthouse stations. This is a result of the new PRISM having cooler temperatures near the ocean that the original PRISM (see next section).

Spatial differences in calculated values between ClimateBC V5 and ClimateBC V4: It is expected that the software should predict weather station values reliably because these values went into generating the PRISM base layers. The strength of PRISM is its estimates of temperature and precipitation in areas far removed from points of measurement. Maps of BC for the difference between ClimateBC V5 and ClimateBC V4 for selected variables were generated at ?? grid. Appendix 4 shows that the new PRISM has created some different climates in parts of BC compared to the original PRISM layers. It should be noted that ClimateBC4 (and ClimateWNA) used splined weather station data (Anusplin) for northeastern BC and northern Alberta rather than the original PRISM data. It was thought at the time that PRISM was too warm. This may not have been a valid assumption.

In general, the new PRISM has a warmer interior for BC at high elevations and cooler for the coast. There are some areas of northern BC that are cooler. The histogram plots show that on annual basis most of the points fall within ± 1°C of previous estimates. The majority of the maximum and minimum temperatures are within ± 3°C of previous estimates. Changes in mean annual precipitation are greatest in coastal BC with some areas drier and other areas wetter than the previous estimates. The histograms show that most points are within 50 mm of previous estimates (Appendix 4).

Impact of changes on calculations of climates for BEC units: This work uses a set of grid points created by Arian Walton. There are 60 points per BEC variant distributed around the province and such that they are a t least 100 m from boundaries of other units. It is useful to have a comparison of past and current models for an actual application of ClimateBC. Appendix 5 mirrors the tendencies shown by the maps in

Appendix 4. The greatest differences are in precipitation. Most changes are within 20% but there are a few outliers.

Solar radiation: The solar data provided is does not fully cover BC. Certain coastal headland and islands are missing. This was seen in the inability to predict solar radiation for specific lighthouse stations.

References

Daly,C., M. Halbleib, J.I. Smith, W.P. Gibson, M.K. Doggett, G.H. Taylor, J. Curtis and P.P. Pasteris. 2008. Physiographically sensitive mapping of climatological temperature and precipitation across the conterminous United States. *International. J. Climatol*. DOI: 10.1002/joc.1688.

Hember 2013:

Wang, T., A. Hamann, D.L. Spittlehouse and S.N. Aitken. 2006. Development of scale-free climate data for western Canada for use in resource management. *International J. Climatology* 26:383-397.

Wang, T, A. Hamman, D.L. Spittlehouse and T.Q. Murdock. 2012. ClimateWNA—High-resolution spatial climate data for Western North America. *J. Applied Meteorology and Climatology* 51:16-29.

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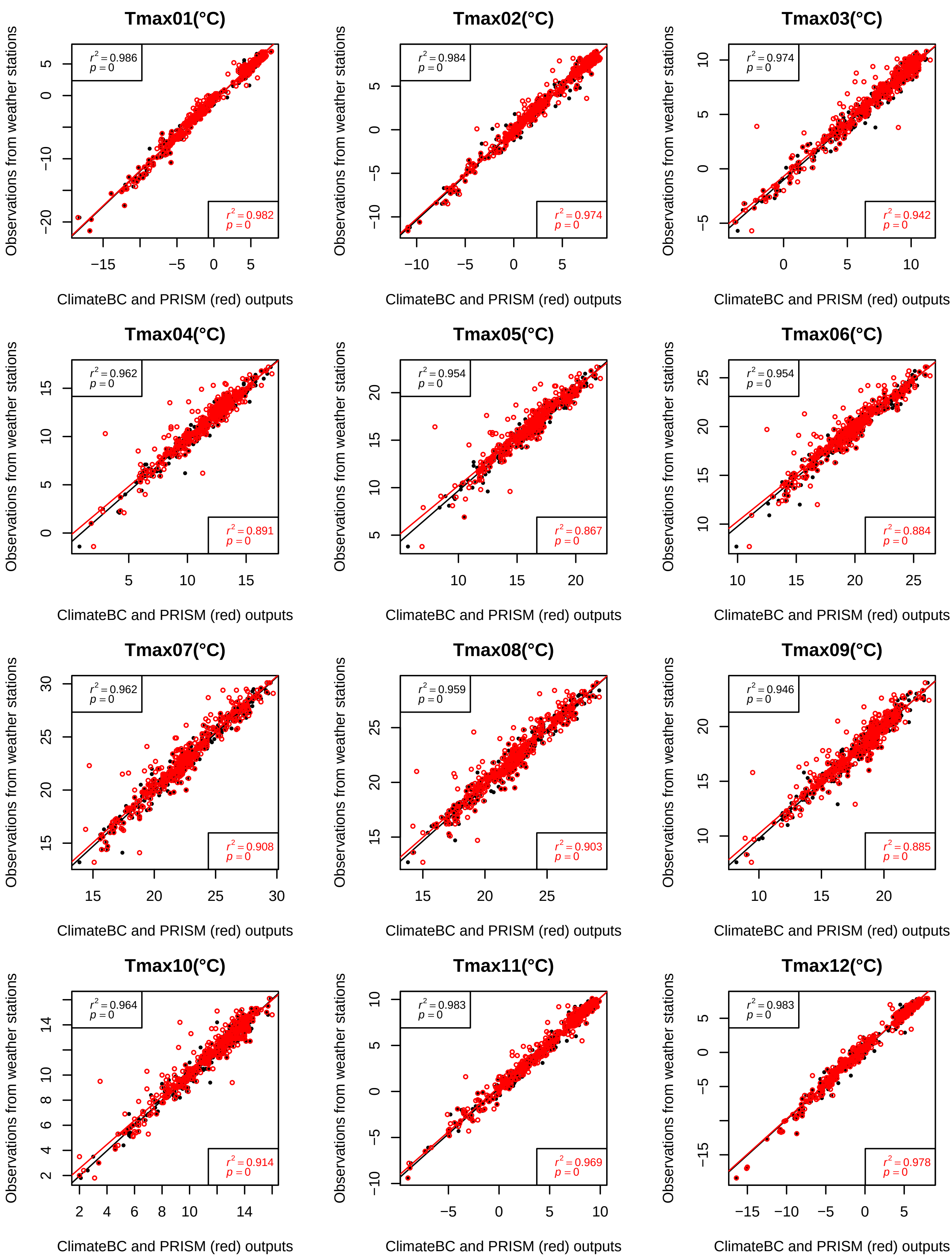
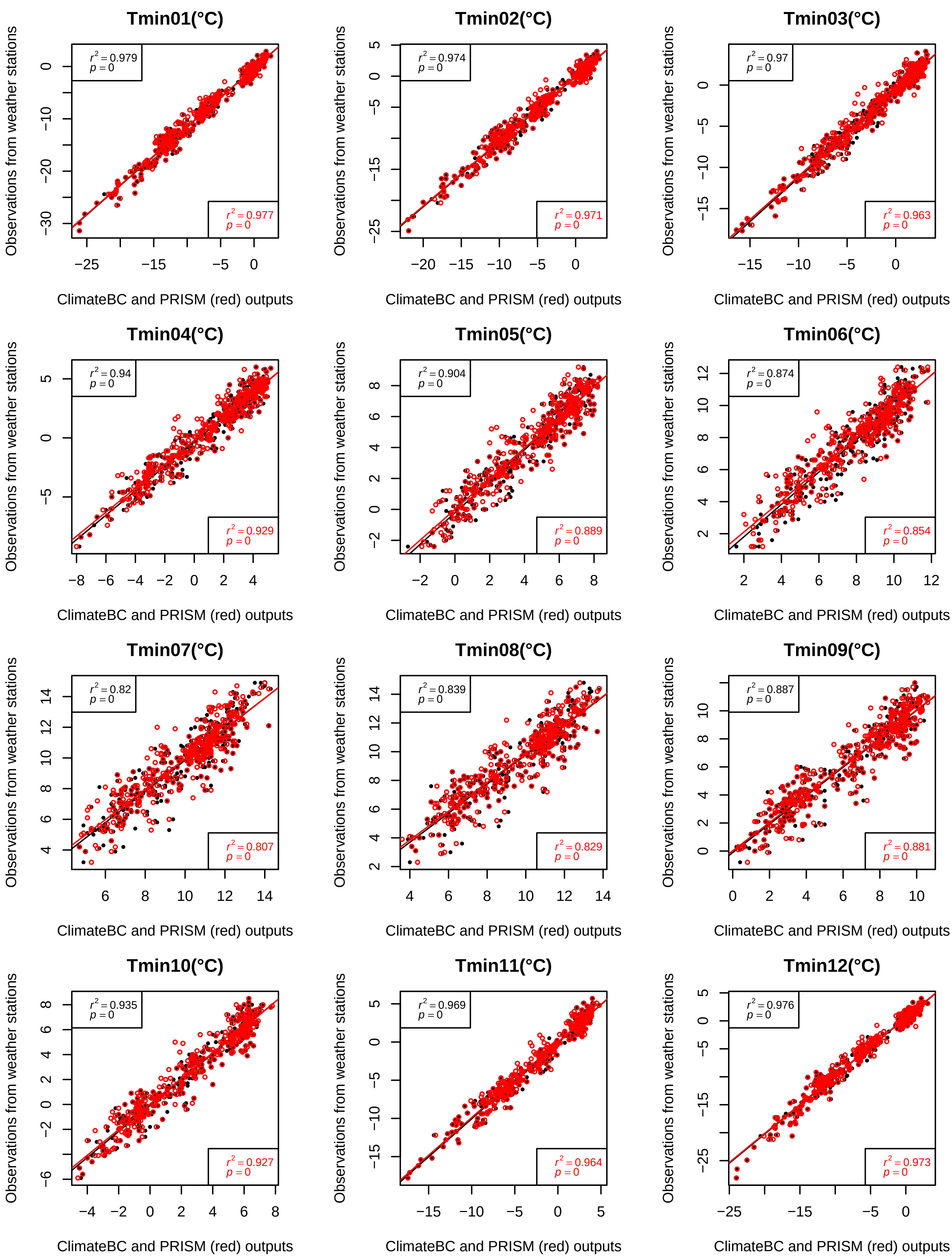
Appendix 1

Monthly temperature and precipitation for 562 Meteorological Service of Canada weather stations for 1951-80 for the *00 m PRISM with no downsaling and with dynamical downscaling to the station elevation with ClimateBC V5 (black points).

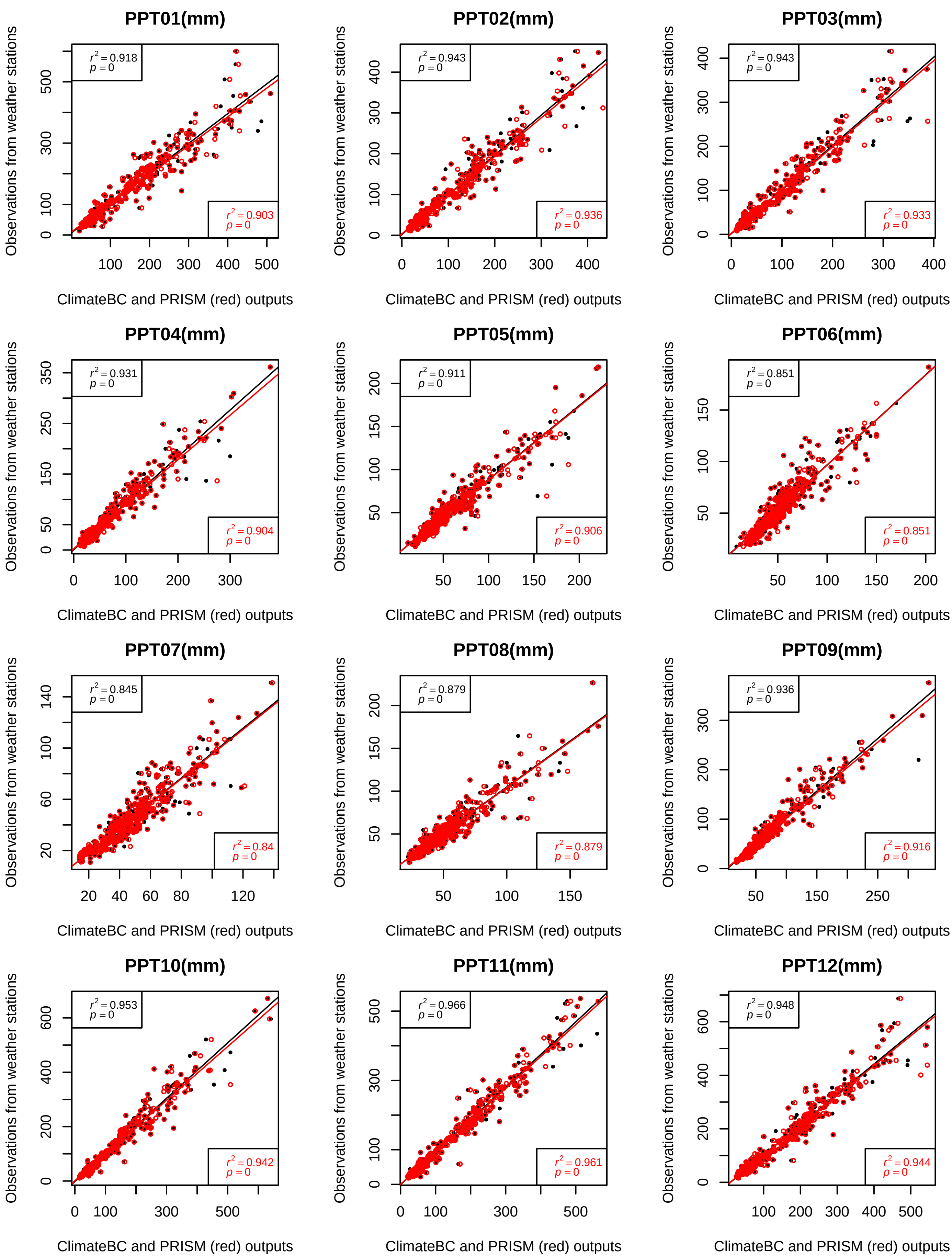
Relationships between predicted and observed Tmax



Relationships between predicted and observed Tmin



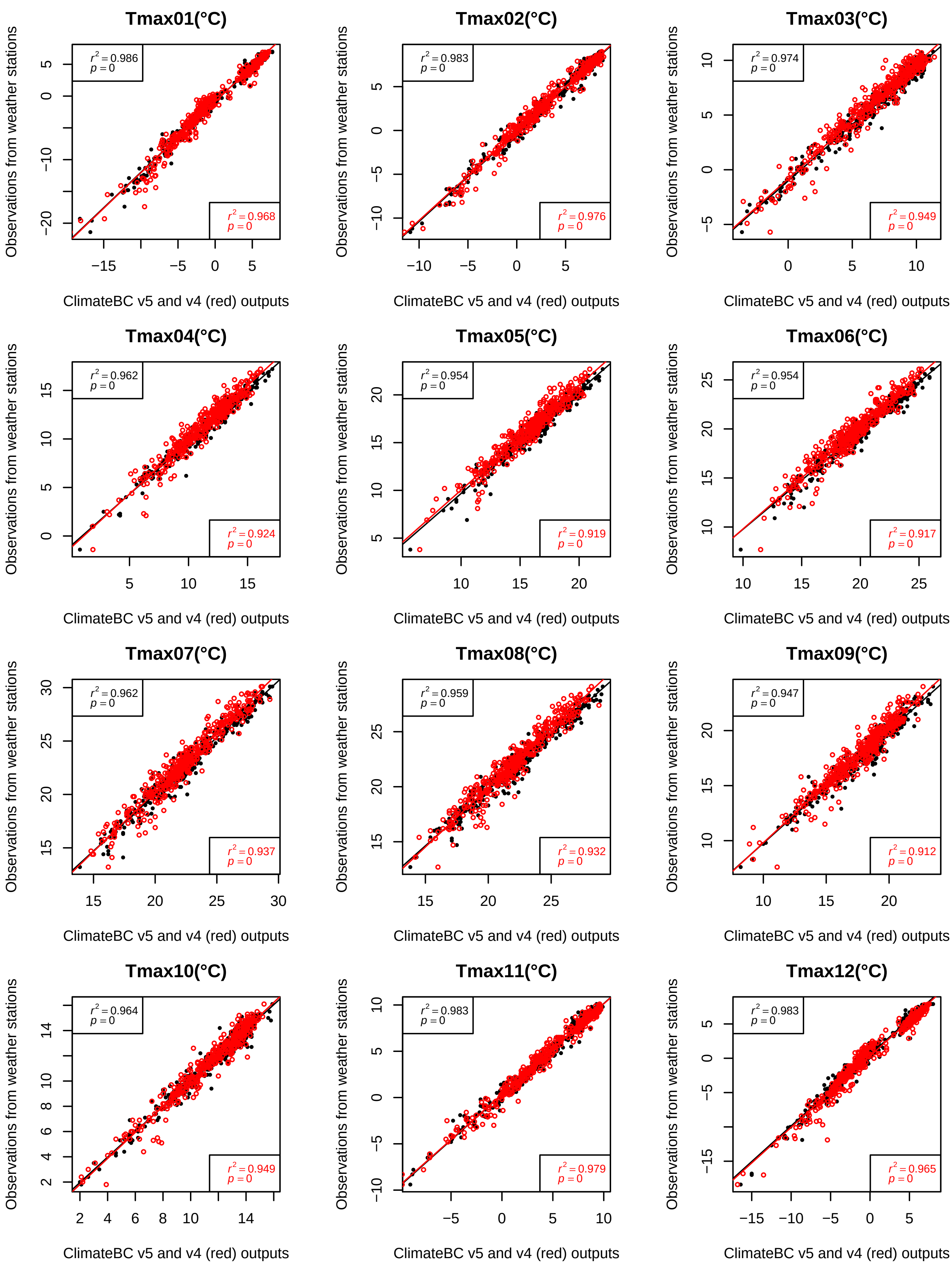
Relationships between predicted and observed PPT



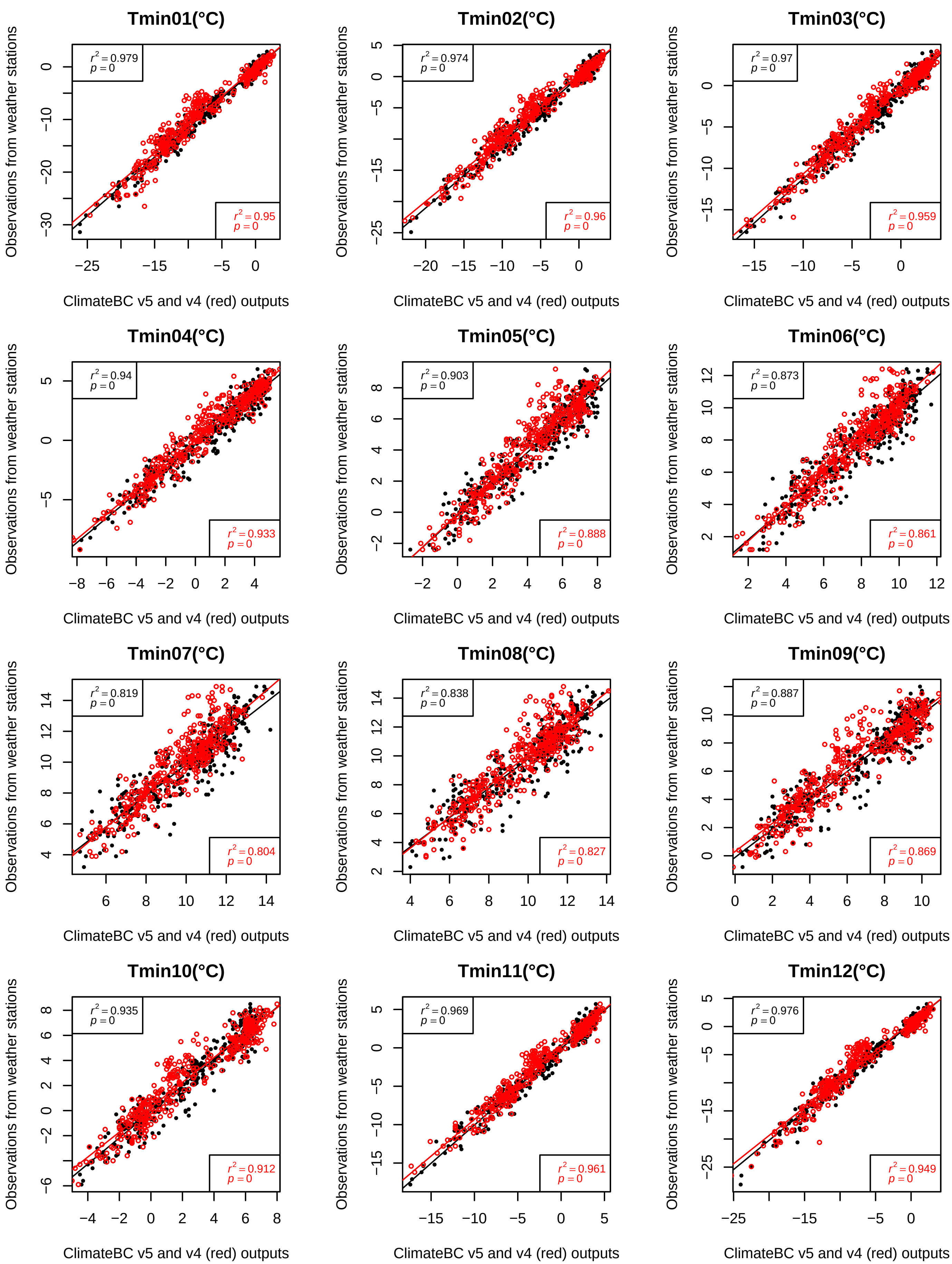
Appendix 2

Monthly temperature and precipitation for 562 Meteorological Service of Canada weather stations for 1951-80 for ClimateBC V5 (black points) and ClimateBC V4 (red points) and measured at the weather stations.

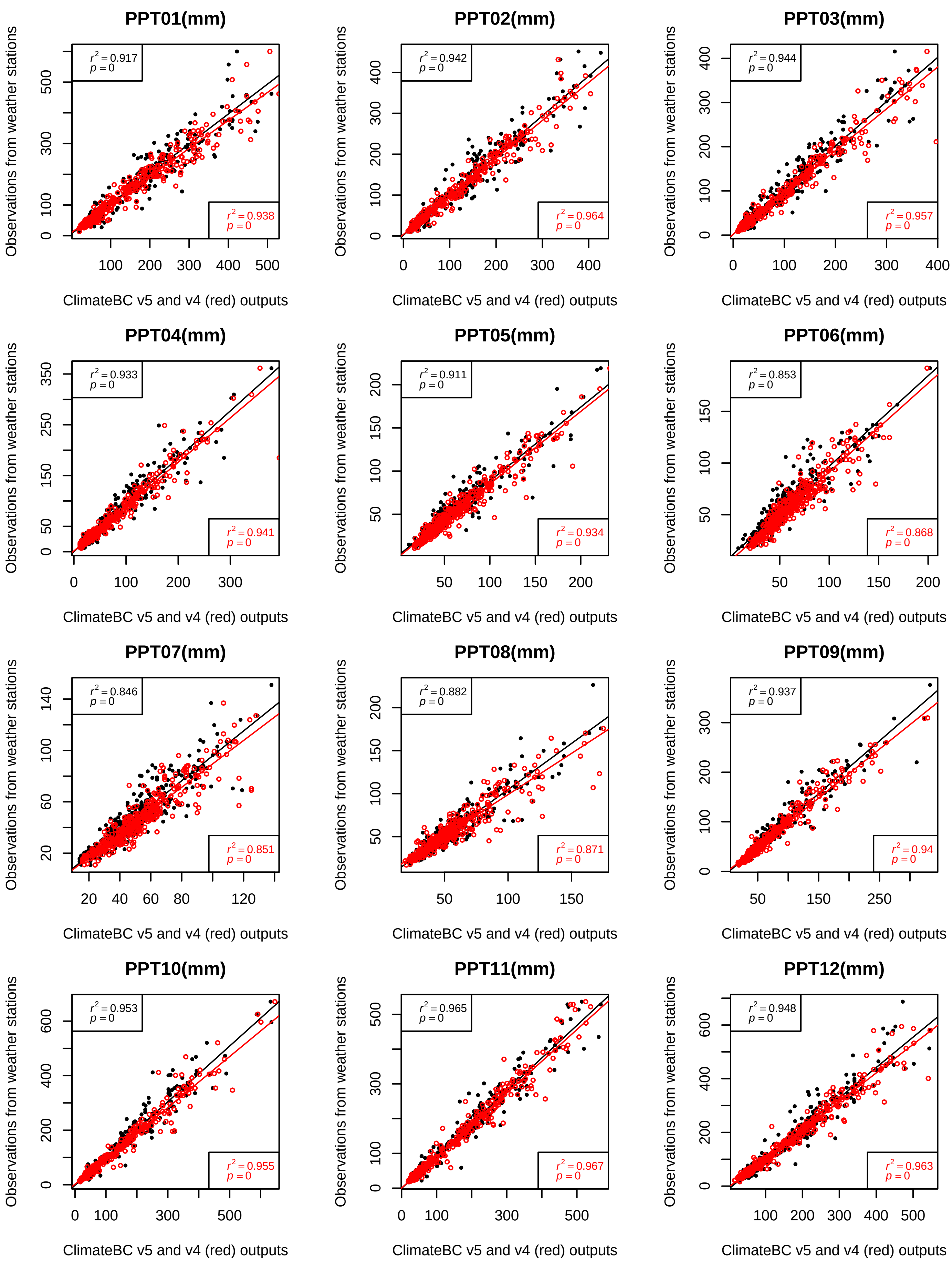
Comparison between ClimateBC v5 and v4 for Tmax



Comparison between ClimateBC v5 and v4 for Tmin



Comparison between ClimateBC v5 and v4 for PPT



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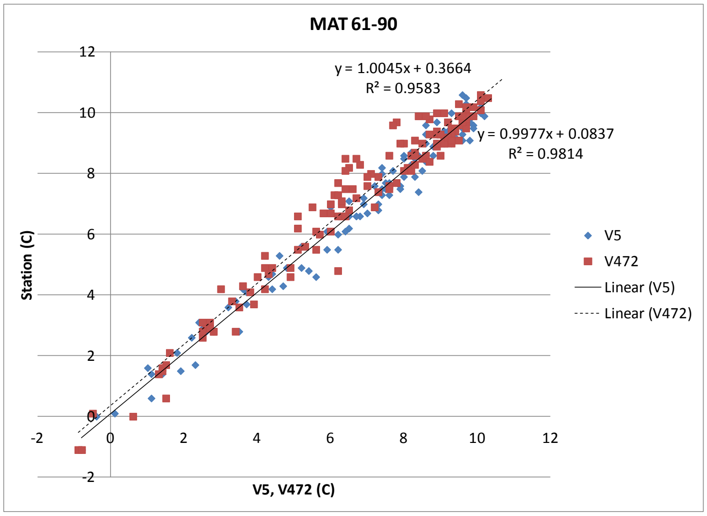
Appendix 3

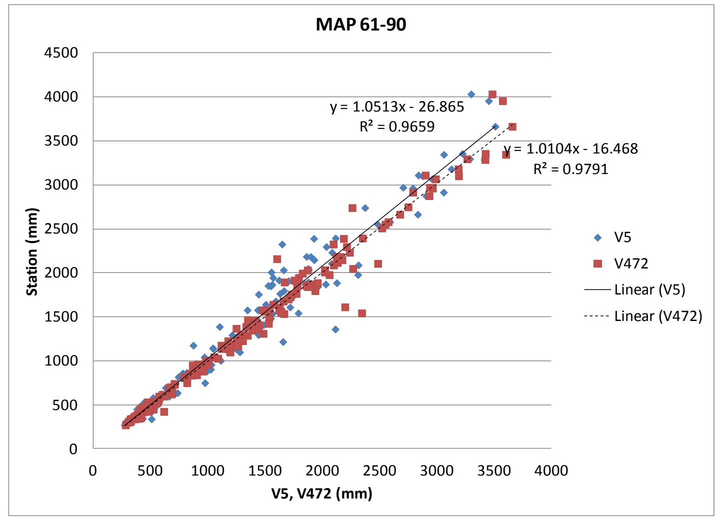
Comparisons of 1961-90 normals of annual variables from ClimateBC V5 and ClimateWNA V472 with values for Meteorological Service of Canada weather stations.

Mean annual temperature (°C)
Mean annual precipitation (mm)
Mean warmest month temperature (°C)
Mean coldest month temperature (°C)
May to September precipitation (mm)
Precipitation as snow (mm)
Annual heat:moisture index
Summer heat:moisture index
Degree days below 0 °C (days)
Degree days above 5 °C (days)
Degree days below 18 °C (days)
Degree days above 18 °C (days)
Frost free period (days)
Beginning of frost free period (day of year)
End of frost free period (day of year)
Continentality (°C)
Reference evaporation (mm)
Climatic moisture deficit (mm)

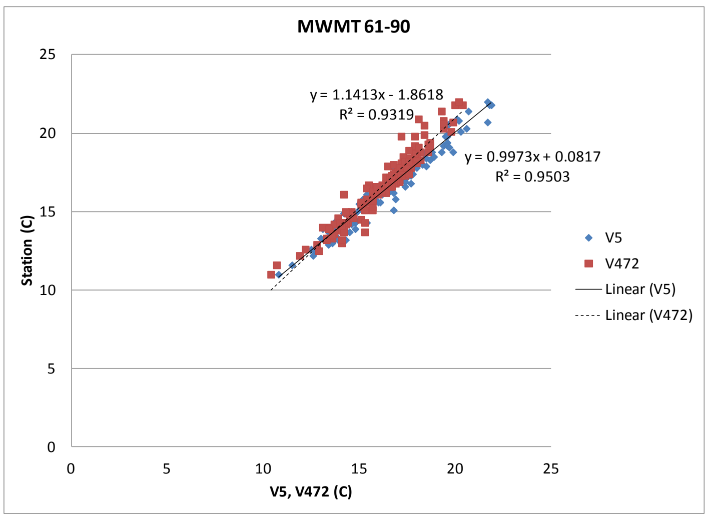
Other annual variables were not available for the weather stations.



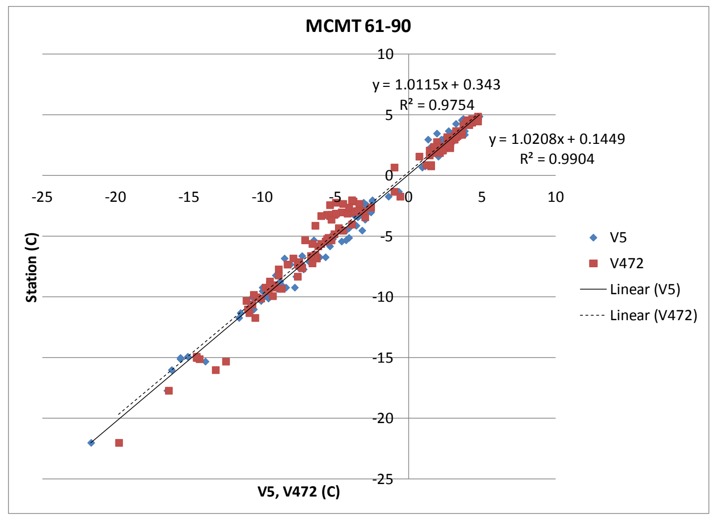
Mean annual temperature (C)



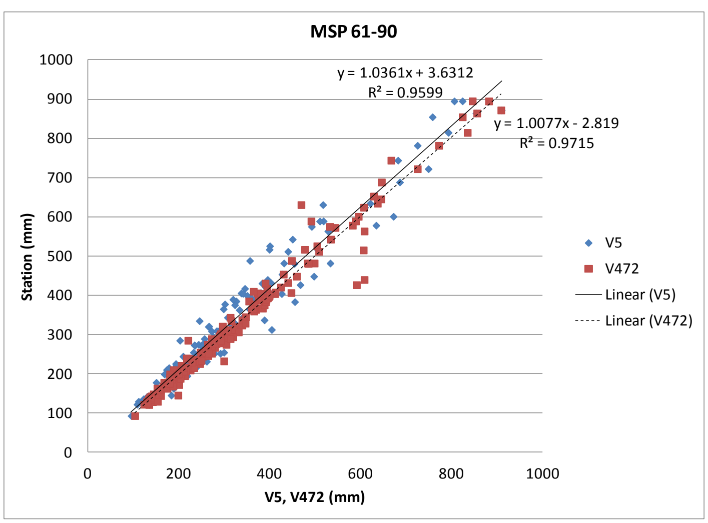
Mean annual precipitation (mm)



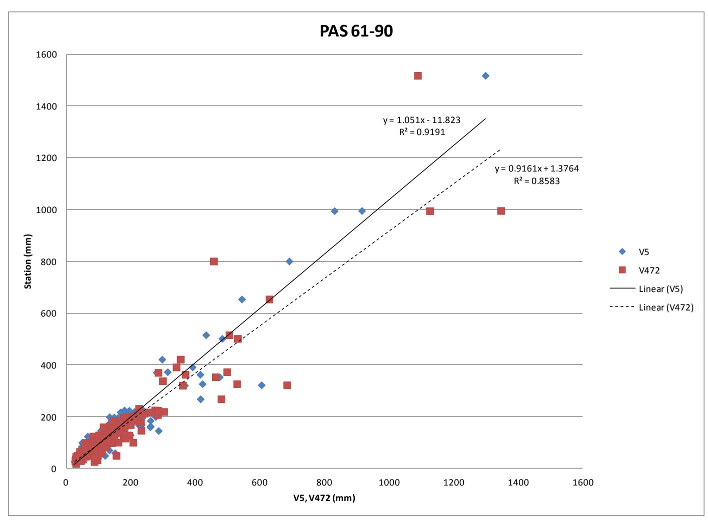
Mean warmest month temperature (C)



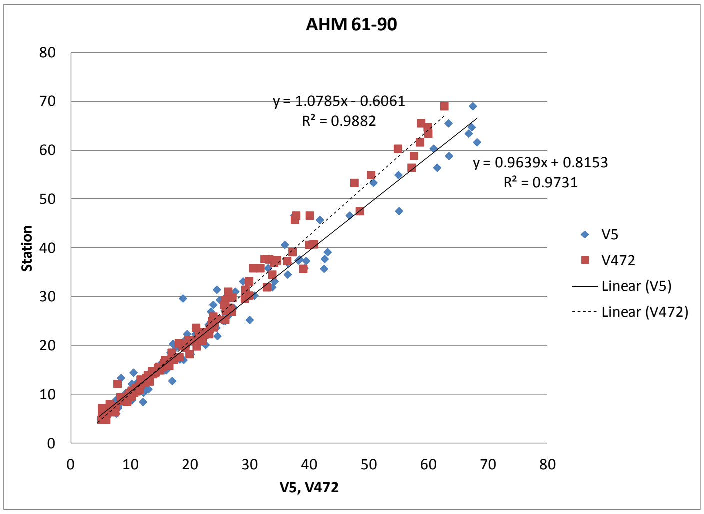
Mean coldest month temperature (C)



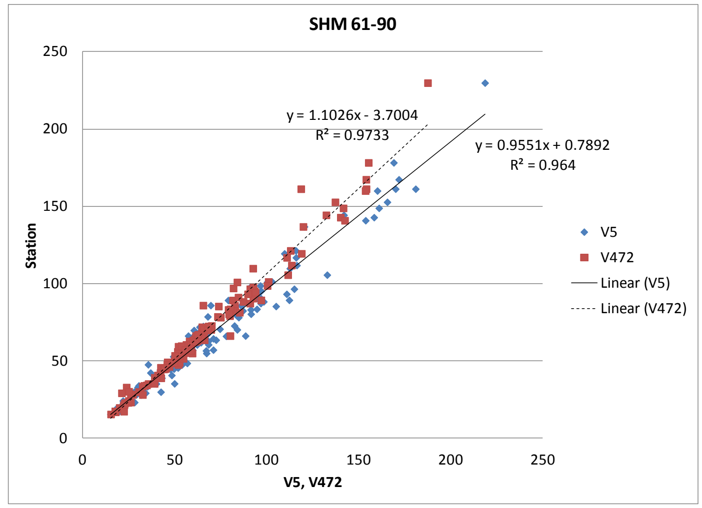
May to September precipitation (mm)



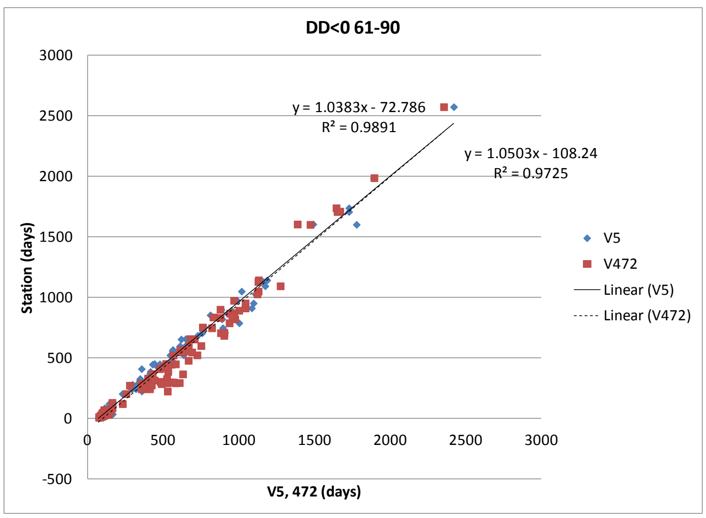
Precipitation as snow (mm)



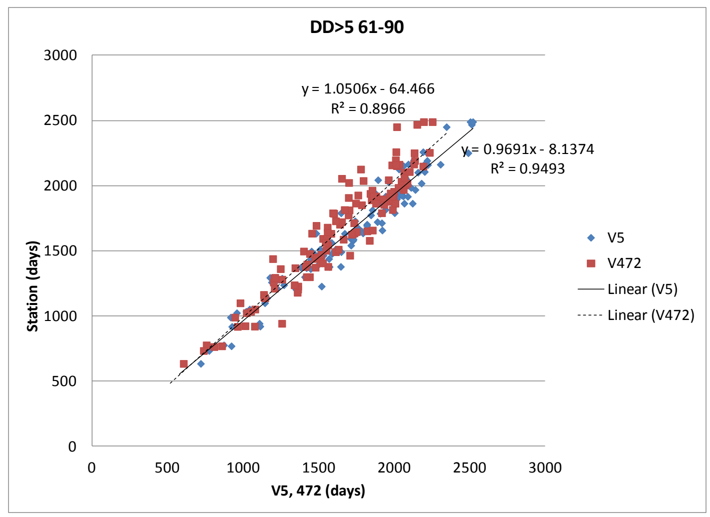
Annual heat:moisture index.



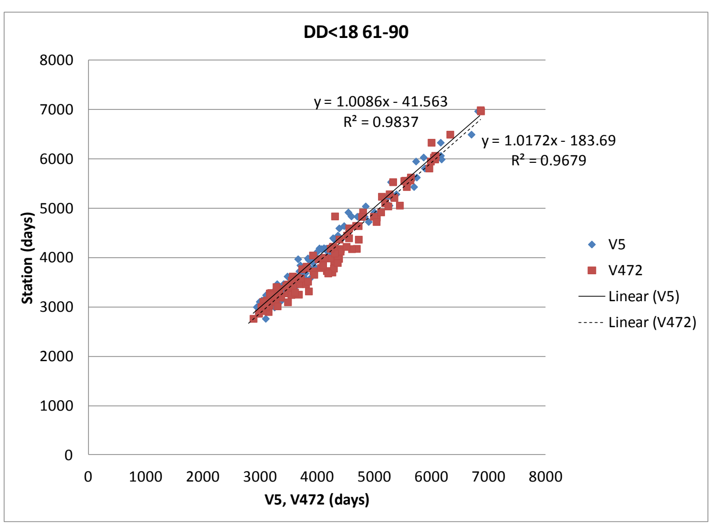
Summer heat:moisture index



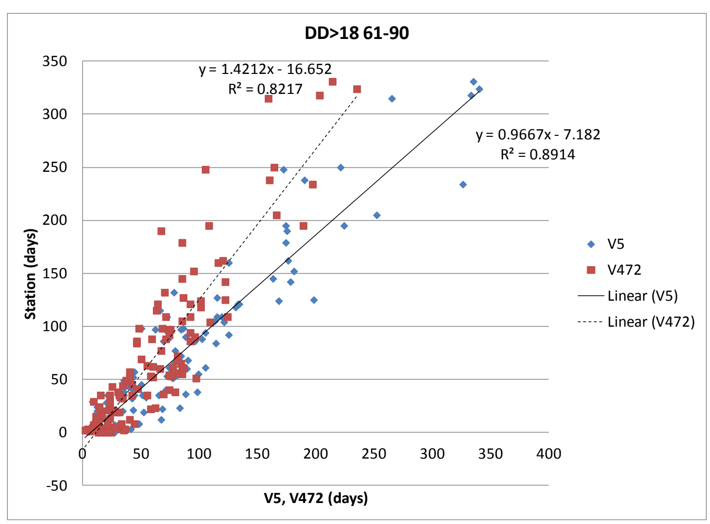
Degree days less than 0°C (days)



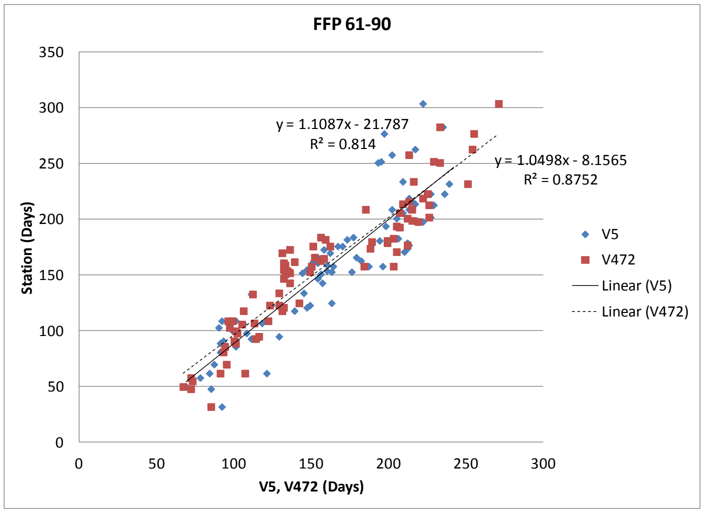
Degree days above 5°C



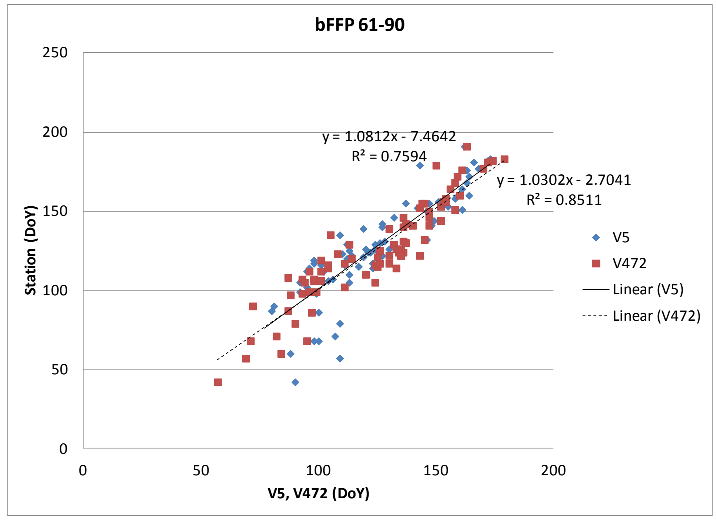
Degree days less than 18°C (days)



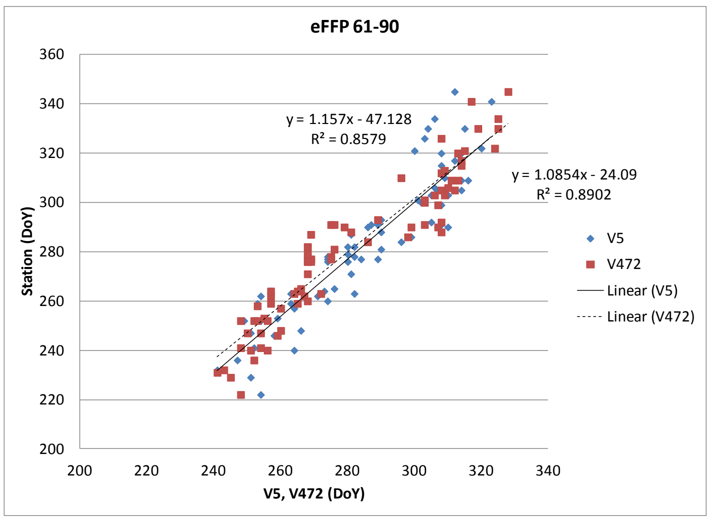
Degree days above 18°C (days)



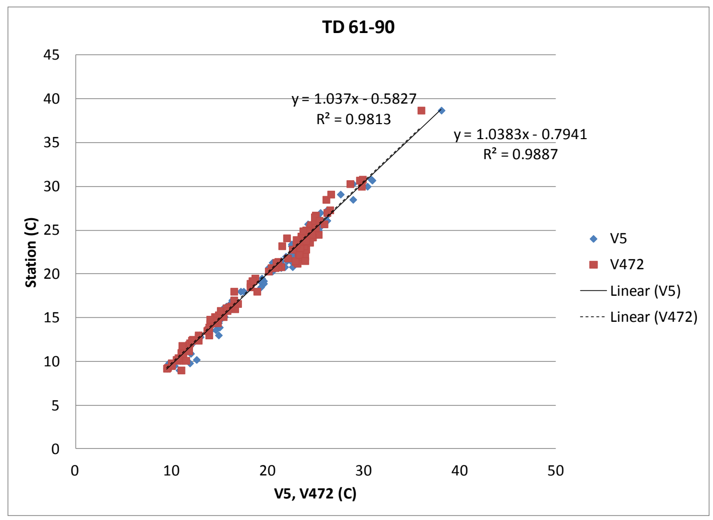
Frost free period (days)



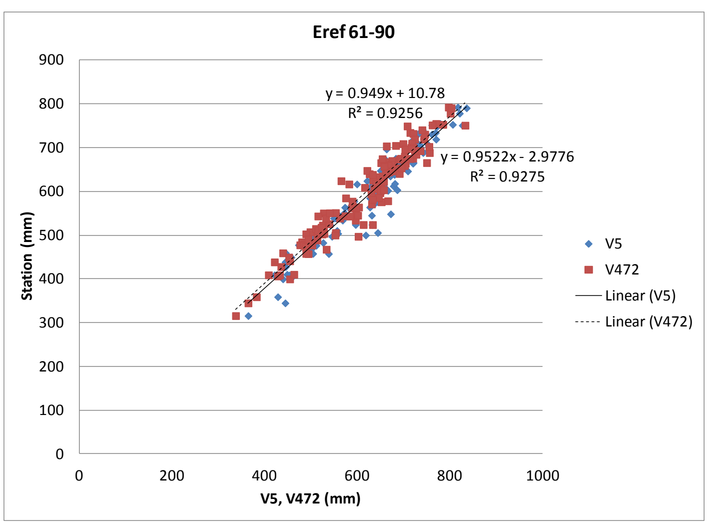
Start of frost free period (day of year)



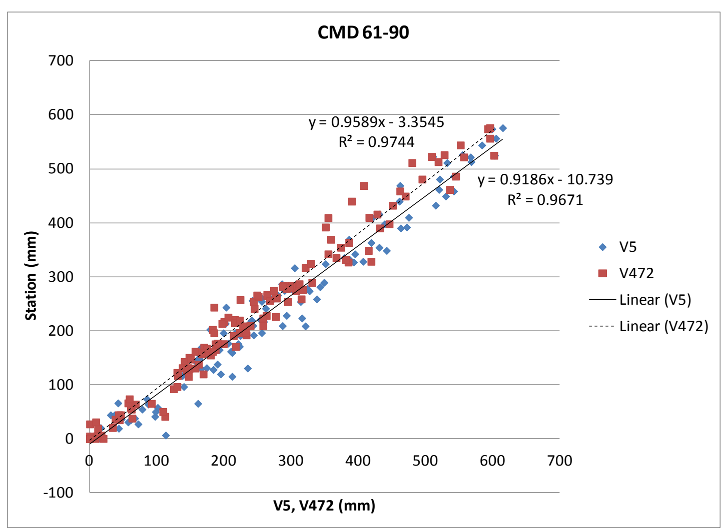
End of frost free period (day of year)



Continentality (MWMT-MCMT) (°C)



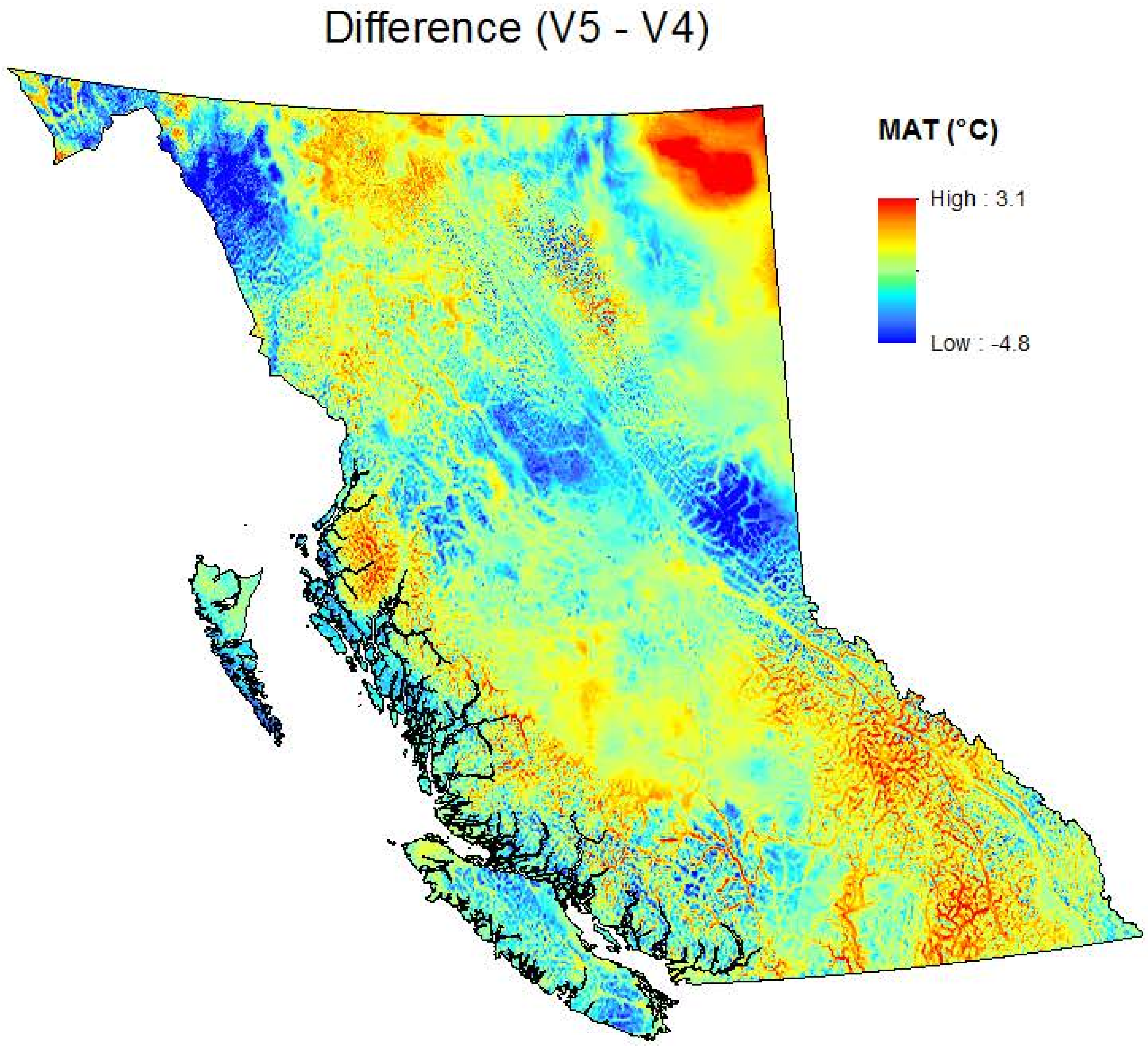
Reference evaporation (mm)

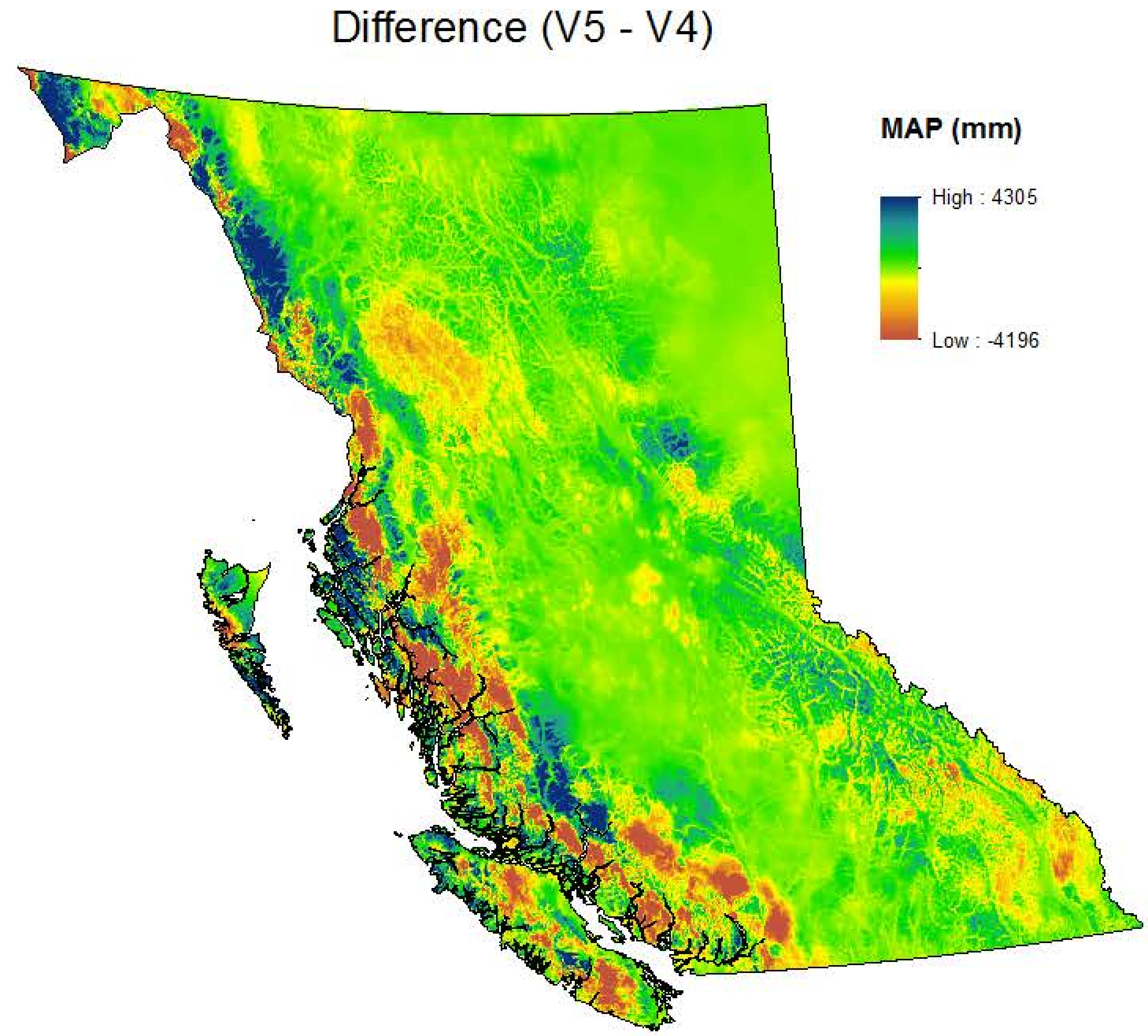


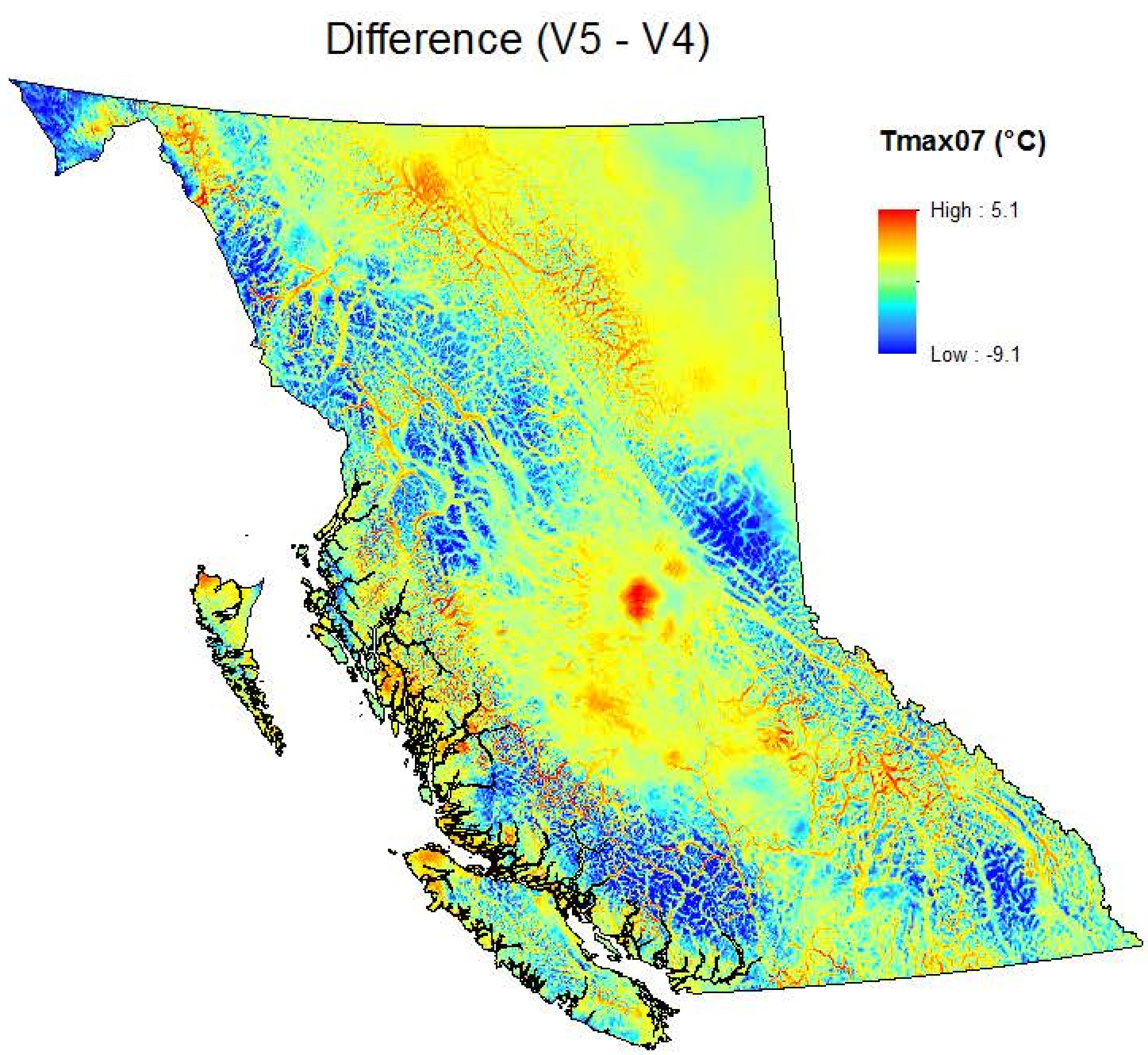
Climatic moisture deficit (mm)

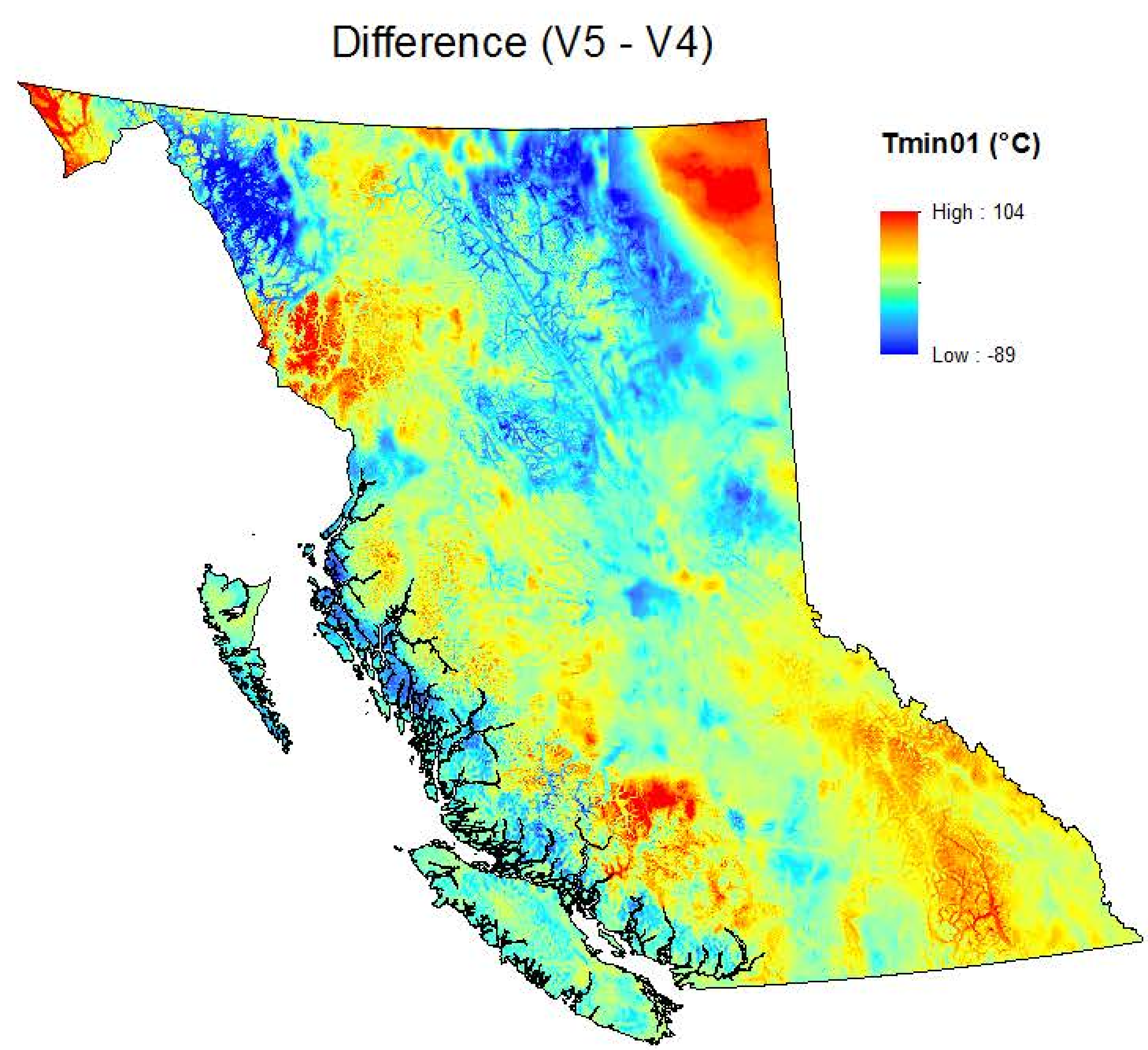
Appendix 4

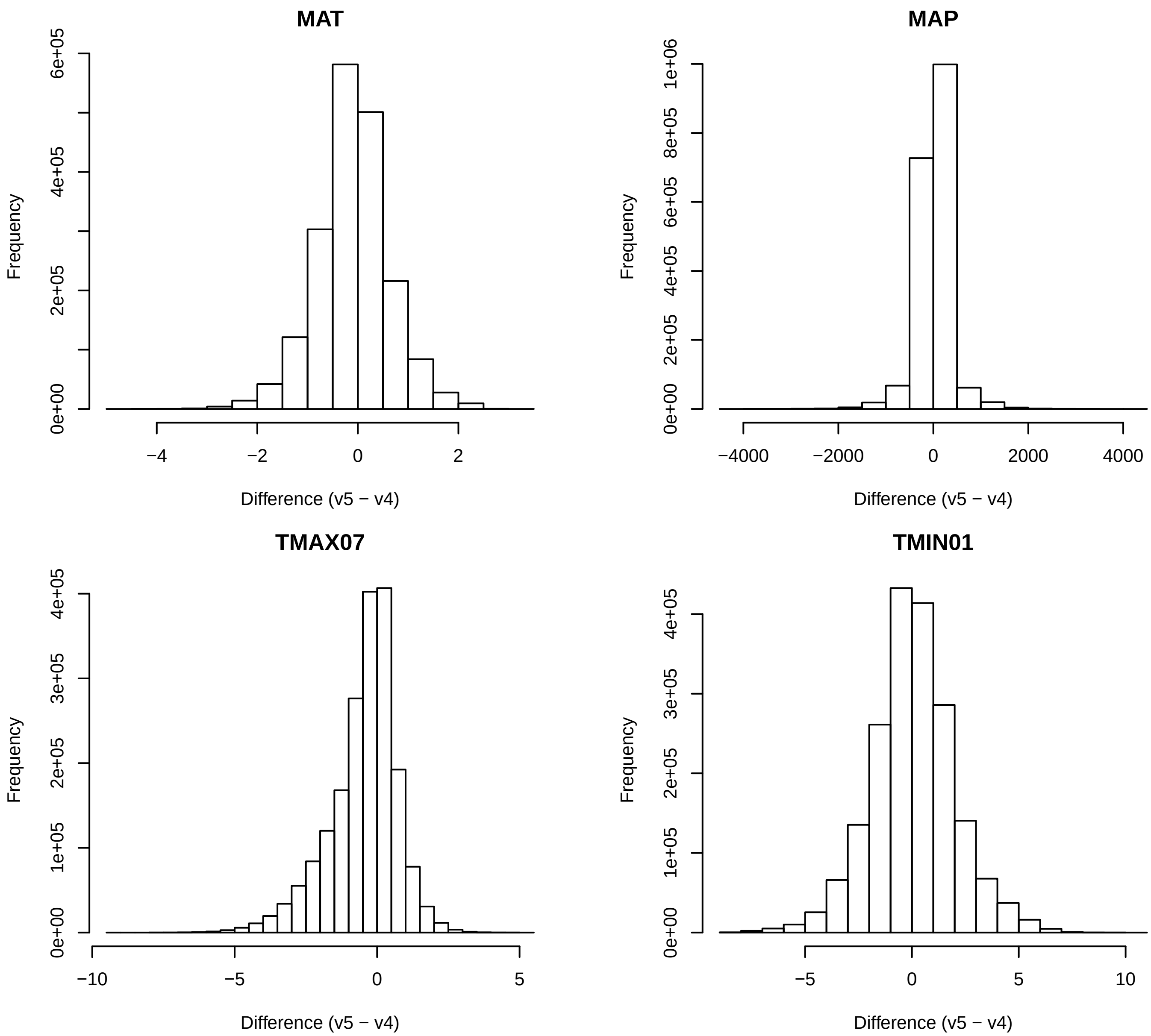
Maps of BC showing the difference between ClimateBC V5 and ClimateBC V4/ClimateWNA V472 for 4 variabkles for 1951-80 normals. Variables are mean annual temperature (MAT °C), mean annual precipitation (MAP mm), July maximum temperature (Tmax07 °C) and January minimum temperature (Tmin01 °C). Histograms of differences are also shown.


Difference (V5 - V4)
MAT (°C)
High : 3.1
Low : -4.8


Difference (V5 - V4)
MAP (mm)
High : 4305
Low : -4196


Difference (V5 - V4)
Tmax07 (°C)
High : 5.1
Low : -9.1


Difference (V5 - V4)
Tmin01 (°C)
High : 104
Low : -89


MAT
Frequency
0e+00
2e+05
4e+05
6e+05
−4
−2
0
2
Difference (v5 − v4)
MAP
Frequency
0e+00
2e+05
4e+05
6e+05
8e+05
1e+06
−4000
−2000
0
2000
4000
Difference (v5 − v4)
TMAX07
Frequency
0e+00
1e+05
2e+05
3e+05
4e+05
−10
−5
0
5
Difference (v5 − v4)
TMIN01
Frequency
0e+00
1e+05
2e+05
3e+05
4e+05
−5
0
5
10
Difference (v5 − v4)

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Appendix 5

Selected annual variables (1961-90 normals) for BEC zones determined with ClimateBC V5 and ClimateBC V472. Examples of differences for variants and examples are presented as histograms.

Table A5.1: Difference between ClimateBC V5 and ClimateWNA 4.72

	MAT	MAP	MSP	SHM	DD5	PAS	FFP	EMT	Eref	CMD
BAFA	-0.4	159	-13	-2.5	-76	182	-4	0.8	-21	-1
BG	0.7	-21	-14	15.8	176	-11	12	1.4	19	30
BWBS	-0.2	108	7	-0.8	-48	76	-7	0.4	1	3
CDF	0	-2	-5	2.2	16	4	0	-0.1	0	10
CMA	-0.3	-49	-119	0.2	-52	70	15	0.6	-55	-6
CWH	0	-118	-41	3.5	18	-9	2	-0.4	0	18
ESSF	-0.1	-18	-44	2.4	-39	20	8	1.4	-32	1
ICH	0.6	-2	-24	5	88	-14	10	1.9	5	23
IDF	0.4	-12	-16	7.9	75	-6	8	1	7	18
IMA	-0.6	5	-70	1.3	-122	96	8	2.1	-61	-3
MH	-0.4	285	1	0.7	-58	269	4	-1.1	-39	5
MS	0.2	-21	-22	3.1	11	-4	7	0.6	-6	9
PP	0.6	-12	-9	9.7	133	-10	13	1.6	3	12
SBPS	0.2	33	-12	2.6	33	28	6	-0.1	-1	9
SBS	0	6	-21	2.9	-1	21	-2	-0.2	4	19
SWB	-0.3	124	-2	-1.8	-103	108	-10	0.8	-12	5

Table A5.2: 1961-80 normals for climate variables from ClimateBC V5

	MAT	MAP	MSP	SHM	DD5	PAS	FFP	EMT	Eref	CMD
BAFA	-2.7	993	437	21.8	357	589	51	-46.3	293	18
BG	6.2	341	160	116.8	1709	88	128	-35.2	707	484
BWBS	0.1	667	338	42.2	900	277	89	-45.2	424	96
CDF	9.5	1118	210	84.5	1986	48	211	-17.1	655	262
CMA	0.1	3221	821	14.9	511	1972	63	-39.5	374	16
CWH	6.1	2423	530	33.6	1337	478	152	-25.8	541	83
ESSF	0.5	1172	390	31.5	656	688	70	-41.7	432	72
ICH	3.2	896	338	46	1127	398	99	-39.1	554	166
IDF	4.4	535	207	77.9	1313	198	105	-37.2	622	343
IMA	-1.1	1565	457	22.8	457	1035	54	-43.3	362	43
MH	3.1	3386	842	16.3	821	1270	108	-31.8	435	13
MS	2.4	768	250	55	917	383	80	-39.4	531	225
PP	6.4	385	166	112.6	1726	103	129	-34.2	724	482
SBPS	1.8	497	238	55.2	868	204	64	-43.4	539	252
SBS	2.3	673	294	49.2	1020	287	92	-41	513	180
SWB	-0.9	1004	422	30.4	615	528	77	-44.6	342	40

MAT = Mean annual temperature (°C), MAP= Mean annual precipitation (mm), MSP= May to September precipitation (mm), SHM= Summer heat:moisture index, DD5 = Degree days above 5°C (days,. PAS = Precipitation as snow (mm), FFP = Frost free period (days), Eref = Reference evaporation (mm), CMD = Climatic moisture deficit (mm).

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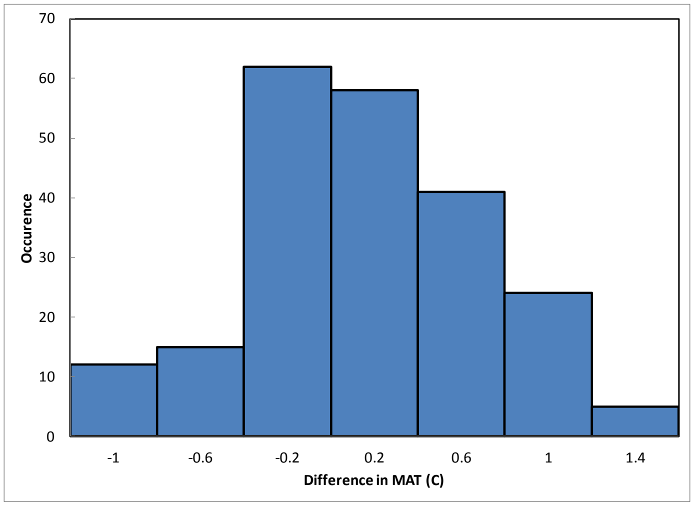
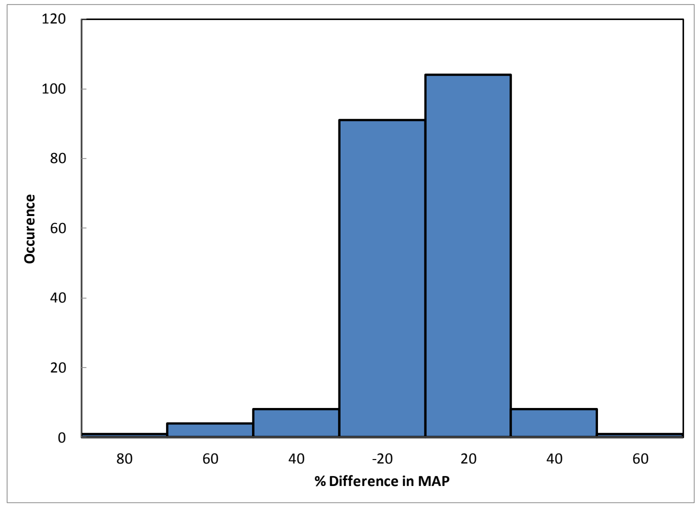
BAFA = Boreal Alti Fescu Alpine, BG = Bunch Grass, BWBS = Boreal White and Black Spruce, CDF = Coastal Douglas-fir, CMA = Coastal Mountain-heather Alpine, CWH = Coastal Western Hemlock, ESSF = Engelmann Spruce Sub-alpine Fir, ICH = Interior Cedar Hemlock, IDF = Interior Douglas-fir, IMA = Interior Mountain-heather Alpine, MH = Mountain Hemlock, MS = Montane Spruce, PP = Ponderosa Pine, SBPS = Sub-Boreal Spruce Pine, SBS = Sub-Boreal Spruce, SWB = Spruce Willow Birch.

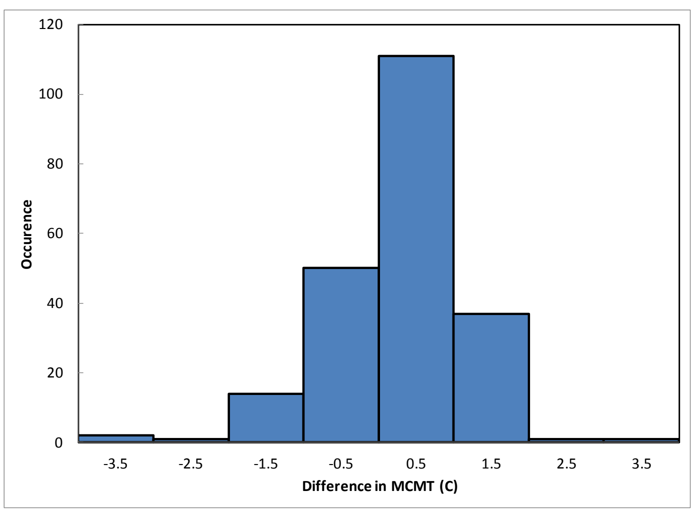
Histograms of differences between ClimateBC V5 and ClimateWNA V472 for the 217 BEC variants.



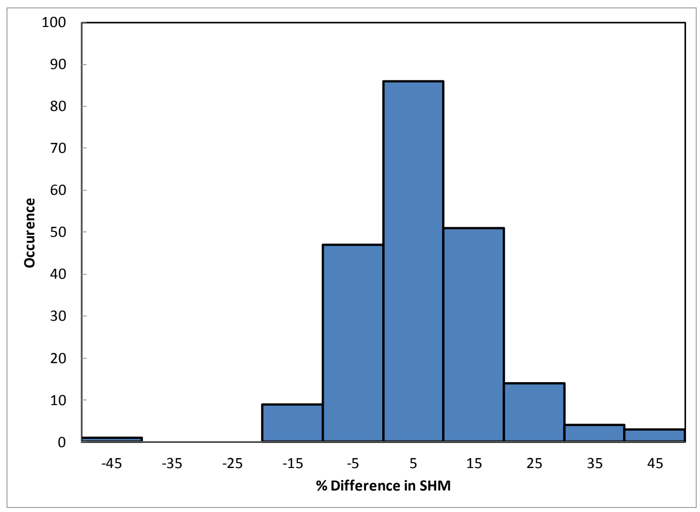
Difference in mean annual temperature (°C)



% difference in mean annual precipitation



Difference in mean temperature of the coldest month (°C)



% difference in summer heat: moisture index