Climate Overview Update and Errata

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31 March 2009

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Pacific Climate Impacts Consortium ... ... University of Victoria ... ... British Columbia

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Introduction

This update and errata provides replacement figures for **Section 2.2 Climate variability**, **Section 4.2 RCM projections** and **Section 4.3 High definition climate projections**. These figures were published originally in the *Climate Overview, Hydro-climatology and Future Climate Impacts in British Columbia* (Rodenhuis et al., 2007)[1], hereafter referred to as the Climate Overview. Some additional analysis is also included for **Section 2.2 Climate variability**. The details for these revisions are outlined in each section of this update. Some interpretation is provided to explain the updates and changes.

The Climate Overview report will be updated, and both the 2007 version and the revised version will be available for download from the PCIC website www.PacificClimate.org. The revised version will contain all the figures that are included in this update. However, none of the text in the Climate Overview report required adjustment.

PCIC staff members who assisted with spatial analysis and programming are acknowledged; David Bronaugh, Aquila Flower, and Harpreet Jaswal. We are grateful to a few individuals for detecting the issues described in this update, including Rick Dawson, Richard Hebda and Jen Turner. Thank you.

Suggested Citation: K.E. Bennett, T.Q. Murdock, D.R. Rodenhuis. 2009. Update and Errata, Climate Overview. Pacific Climate Impacts Consortium, University of Victoria, Victoria BC. 16pp.

[1] Rodenhuis, D.R., Bennett, K.E., Werner, A.T., Murdock, T.Q., Bronaugh, D. 2007. Hydro-climatology and future climate impacts in British Columbia. Pacific Climate Impacts Consortium, University of Victoria, Victoria BC, 132 pp.

Section 2.2 Climate variability

This section provides replacement figures for **Section 2.2. Climate Variability** (page 22-31), originally published in the Climate Overview, based on reanalysis of the 2007 CANGRID data set. The issues and changes included in this update are, in summary:

- The figure *captions* for **Figure 2.2.1** and **Figure 2.2.2** in the Climate Overview incorrectly read 90% (gray) and 95% (black). These have been updated to read 95%, and 99%, respectively. Also, these figures have been made larger and are now spread out across several pages (**Figure 2.2.1a, b** and **Figure 2.2.2a, b)**.
- Many sites above 60° north were excluded in the Climate Overview because the original analysis utilized strict criteria for missing values, and therefore data were clipped to the BC border. A data record threshold (85%) was applied in this reanalysis, and no clipping was used. Hence, data now extends beyond the BC border (**Figure 2.2.3** to **Figure 2.2.5)**.
- The figures for winter mean temperature of ENSO and PDO climate variability were spatially correct but incorrect in magnitude. These maps have been corrected **(Figure 2.2.3**).

In addition, several improvements have been made to the original analysis of climate variability. Three additional years (2005 – 2007) of information used in this update added one El Niño year to the record (2007). Statistical significance reporting is now included for spatial results across BC (**Figure 2.2.3** to **Figure 2.2.5**). An analysis of strong ENSO (La Niña 1995-1996 and El Niño 1997-1998) events in BC is illustrated with new maps (**Figure 2.2.6**).

Barplots (**Figure 2.2.1a, b** to **2.2.2a, b**) illustrate differences in mean temperature and precipitation during El Niño versus La Niña, and PDO warm phase versus cool phase responses. Plots illustrate the response over the water year (October to September) for hydrologic comparison. The three additional years of data altered results in terms of magnitude and, in some regions, the statistical significance of responses changed. For example, the three additional years increase the significance of the December mean temperatures across BC (99% percentile, versus 95% in the Climate Overview, **Figure 2.2.1a**). The update reveals BC temperatures during El Niño were warmer in December through June (+0.5°C to +2.9°C), whereas BC temperatures during the positive phase of PDO were warmer in January through August, and significantly greater than +3.0°C in some locations (**Figure 2.2.1a** and **Figure 2.2.1b**).

Figure 2.2.3 illustrates how winter mean temperatures during El Niño events (**2.2.3a**) in BC are warmer (+0.5°C to +2.0°C), while winter mean temperatures during La Niña events (**2.2.3b**)

are cooler (-1.0°C to +2.0°C) than the long term average (1900–2007). The winter mean temperature during the PDO warm phase (**2.2.3c**) is statistically significant in the North and on Vancouver Island (+0.5°C to +1.5°C). In the cool phase of PDO (**2.2.3d**), only a few places in BC show a statistically significant signal in winter, although cooler mean temperatures (+0.0°C to -1.0°C) are noted.

Precipitation in winter and spring (**Figure 2.2.4** and **Figure 2.2.5**) illustrate the same variability as shown in the Climate Overview; however the lack of statistically significant differences during ENSO and PDO across most of BC are now apparent. Precipitation response is illustrated for both winter and spring, as the signals are coherent (i.e. clusters of similar response) during winter ENSO and spring PDO, despite the lack of statistical significance. The winter ENSO response extends beyond the border of BC into Alberta, but spring ENSO response is often stronger in the Yukon and the Northwest Territories (**Figure 2.2.4a to Figure 2.2.4d**). The PDO response is not strong during winter in BC, as much of BC experiences no change (gray, -2 to 2% difference), although there is some coherency in Alberta. Spring PDO signals are coherent in southern BC, with no change in the North. Results are summarized for seasons across BC for each teleconnection (i.e. ENSO and PDO) in **Table 2.2.1**.

Figure 2.2.6 presents an example of a strong El Niño (1997-1998**)** and La Niña **(**1995-1996**)** event in BC. Although Environment Canada classified the 1995-1996 La Niña event as "weak"[2], even though the impact response (temperature and precipitation) was substantial in BC. The 1997-1998 El Niño winter mean temperatures were (+1.0°C to +4.0°C) warmer, while the 1995-1996 La Niña winter mean temperatures were (-0.0°C to -4.0°C) cooler than the long term average. Drier conditions were experienced for most of BC during the 1997-1998 El Niño winter, although the coast was wetter. Precipitation during the 1995-1996 La Niña winter was wetter, except at some locations along the coast and in the Fraser and the Peace Basin regions. These 'strong event' analogues illustrate the severity of changes that may be experienced in BC during different phases of climate variability.

[2] http://www.smc-msc.ec.gc.ca/education/elnino/comparing/enso1950_2002_e.html

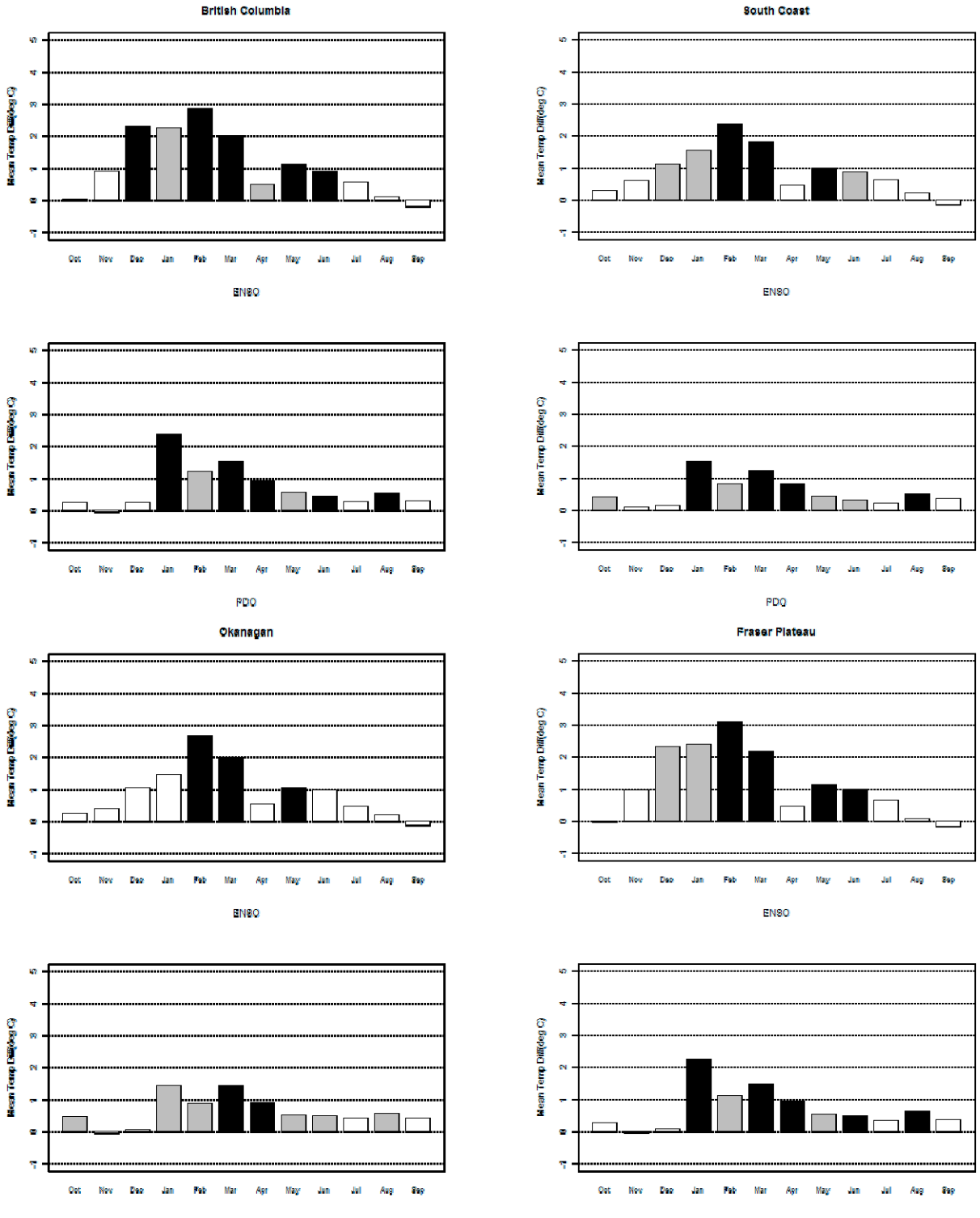

Figure 2.2.1a revised March 2009 - Differences in mean temperature (°C, 1900-2007) between El Niño subtracted from La Niña, and mean temperature (°C, 1900-1998) positive PDO phase subtracted from negative PDO phase across the three different regions of BC and for all of British Columbia for each month (October to September, x-axis). Statistical significance is indicated by gray (95%) or black (99%) shading. Source: CANGRID (50 km) 2007 data, CIG 2006.

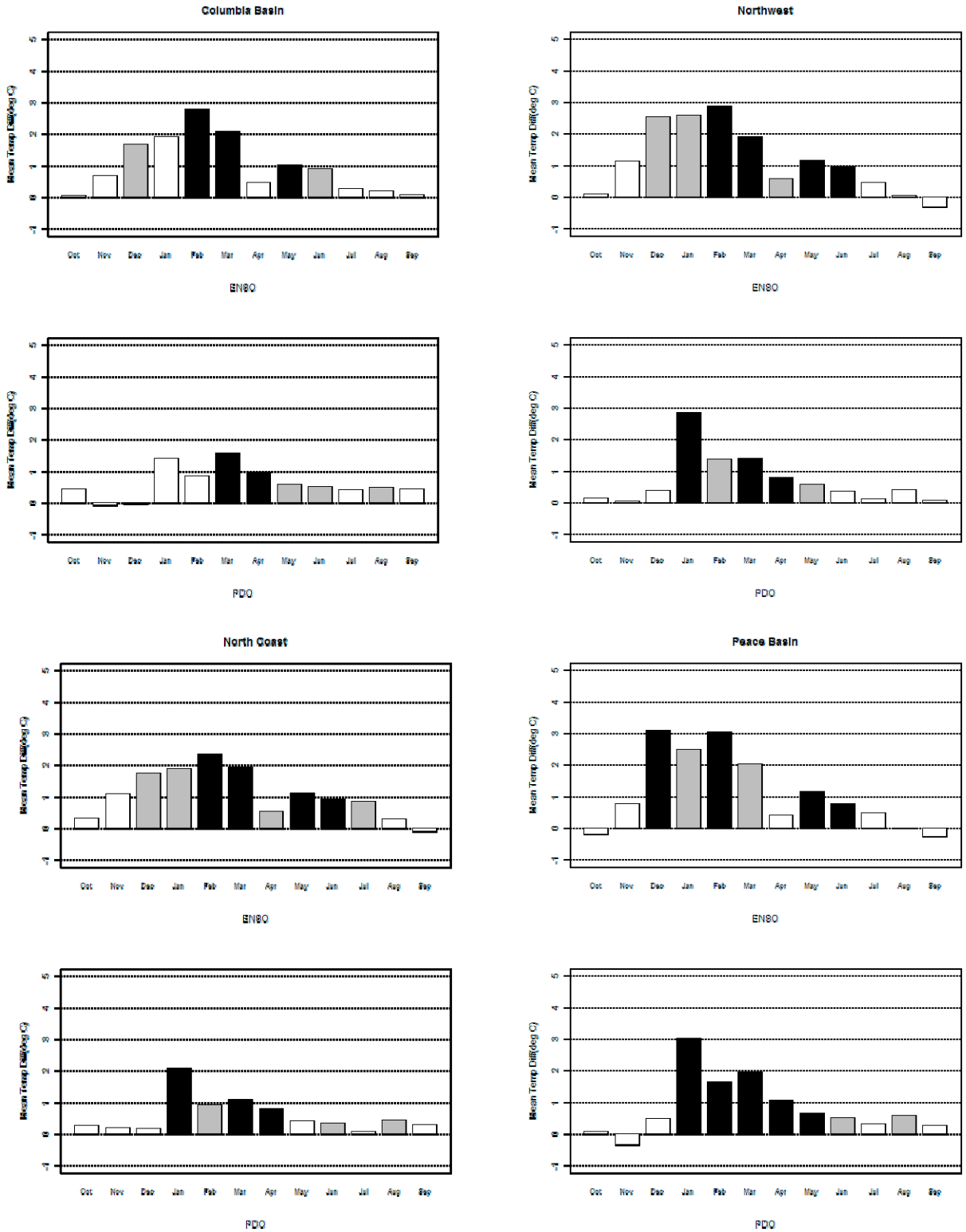

Figure 2.2.1b revised March 2009 - Differences in mean temperature (°C, 1900-2007) between El Niño subtracted from La Niña, and mean temperature (°C, 1900-1998) positive PDO phase subtracted from negative PDO phase across the four different regions of BC for each month (October to September, x-axis). Statistical significance is indicated by gray (95%) or black (99%) shading. Source: CANGRID (50 km) 2007 data, CIG 2006.

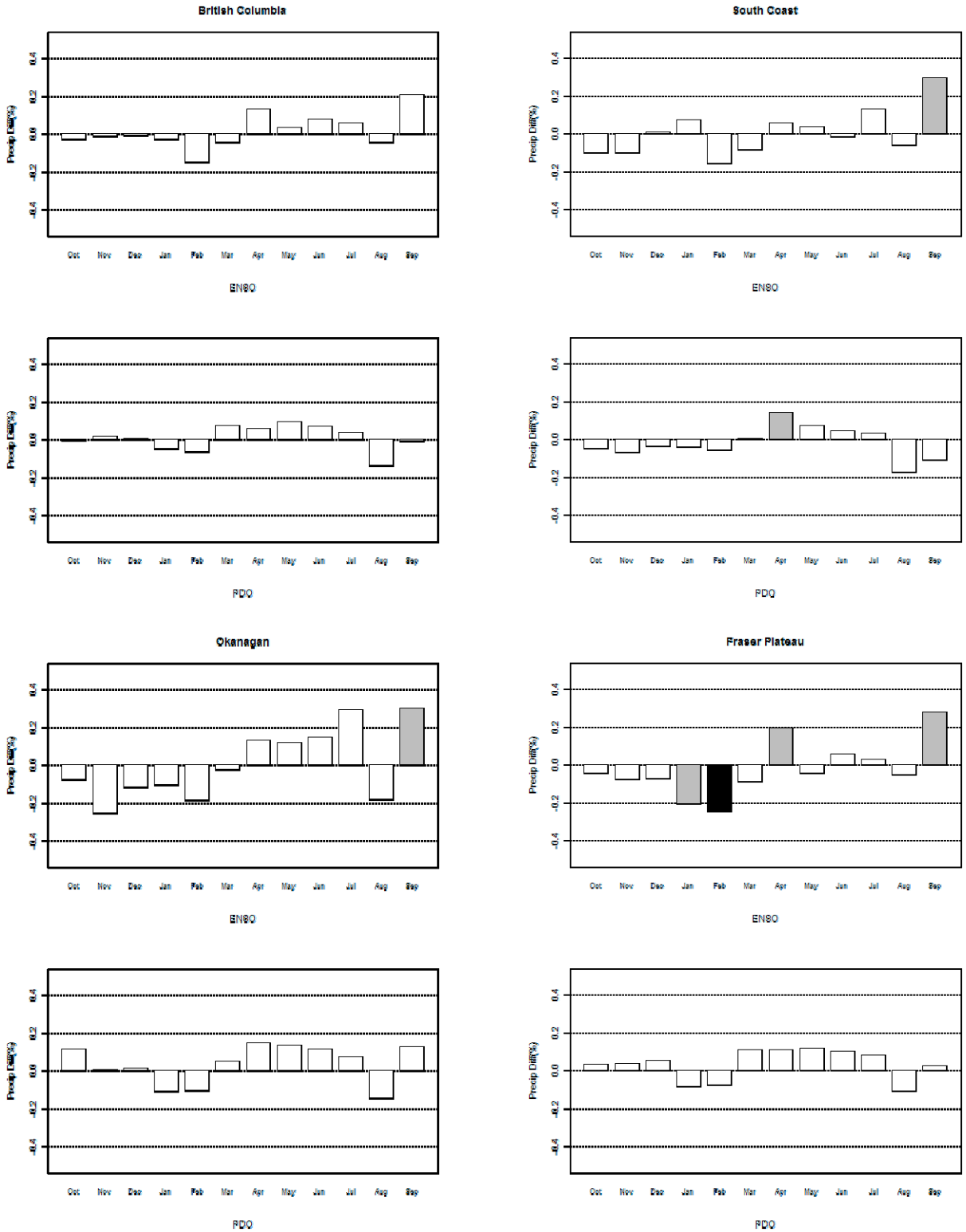

Figure 2.2.2a revised March 2009 - Differences in precipitation (1900-2007) El Niño subtracted from La Niña precipitation and precipitation (1900-1998) positive PDO phase subtracted from negative PDO phase, shown as a percentage of the 1961 – 1990 climatology. Results illustrated for the seven different regions of BC and for all of British Columbia for each month (October to September, x-axis).. Statistical significance is indicated by gray (95%) or black (99%) shading. Source: CANGRID 2007 (50 km) data, CIG 2006.

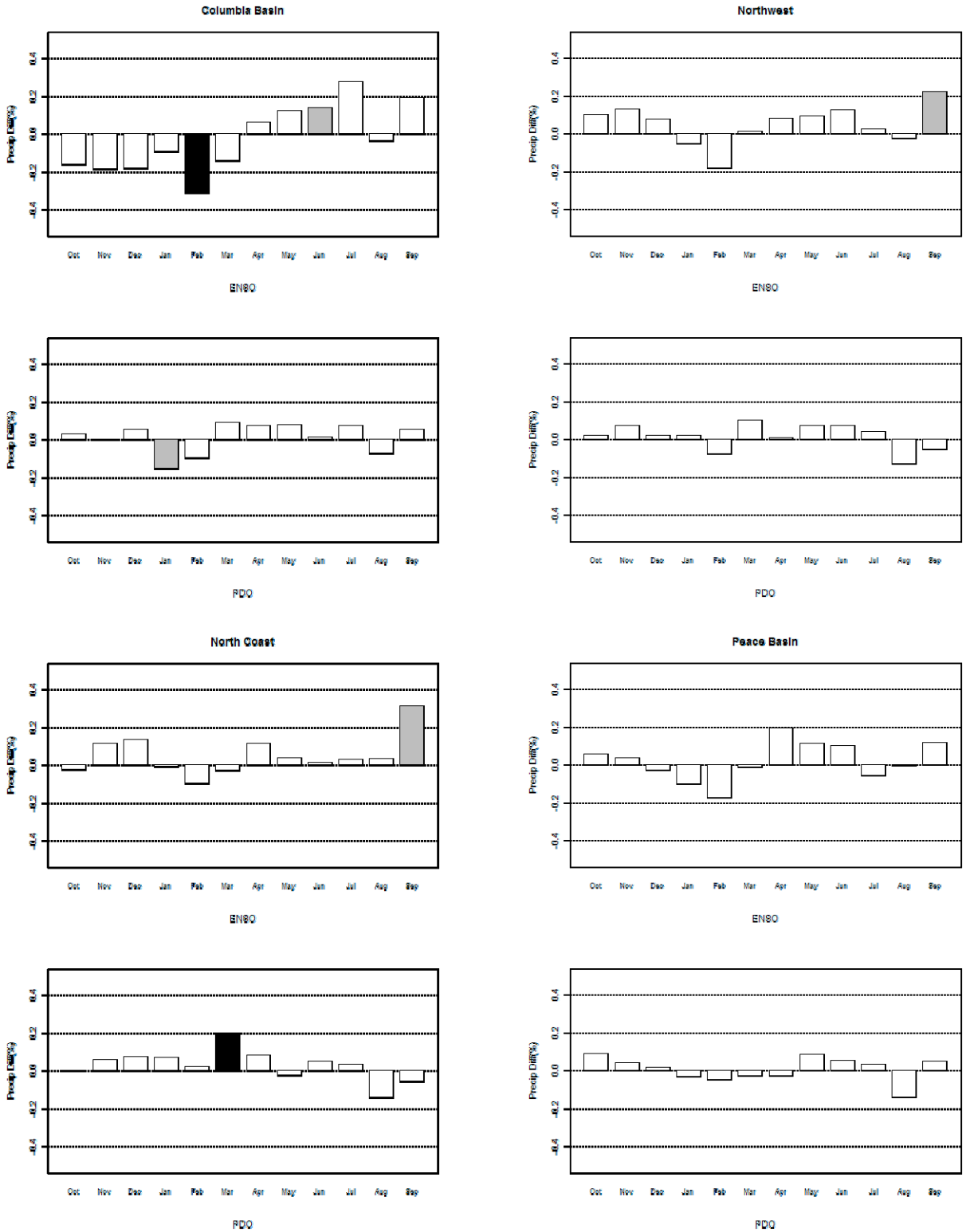

Figure 2.2.2b revised March 2009 - Differences in precipitation (1900-2007) El Niño subtracted from La Niña precipitation and precipitation (1900-1998) positive PDO phase subtracted from negative PDO phase, shown as a percentage of the 1961 – 1990 climatology. Results illustrated for the seven different regions of BC and for all of British Columbia for each month (October to September, x-axis).. Statistical significance is indicated by gray (95%) or black (99%) shading. Source: CANGRID 2007 (50 km) data, CIG 2006.

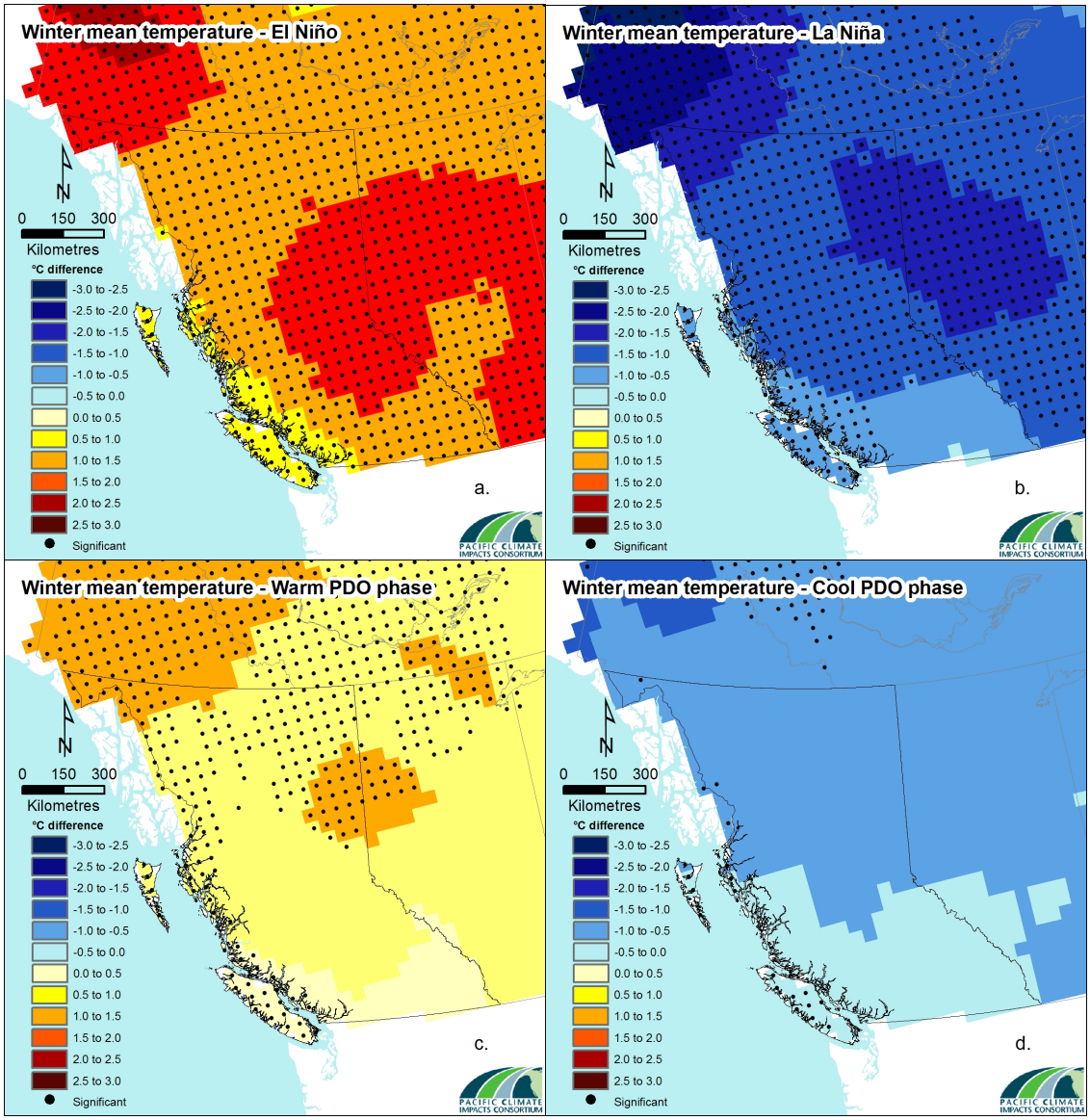

Figure 2.2.3 updated March 2009 - Seasonal climate variability for mean temperature (a) El Niño winter, (b) La Niña winter, (c) warm PDO winter and (d) cool PDO winter for British Columbia. Results are composites from the 1900 – 2007 (ENSO) and 1900 – 1998 (PDO) and calculated as degree Celsius differences from the long-term average. Black solid circles indicate statistically significant results (95 % confidence level) compared to normal. Source: CANGRID (50 km) data.

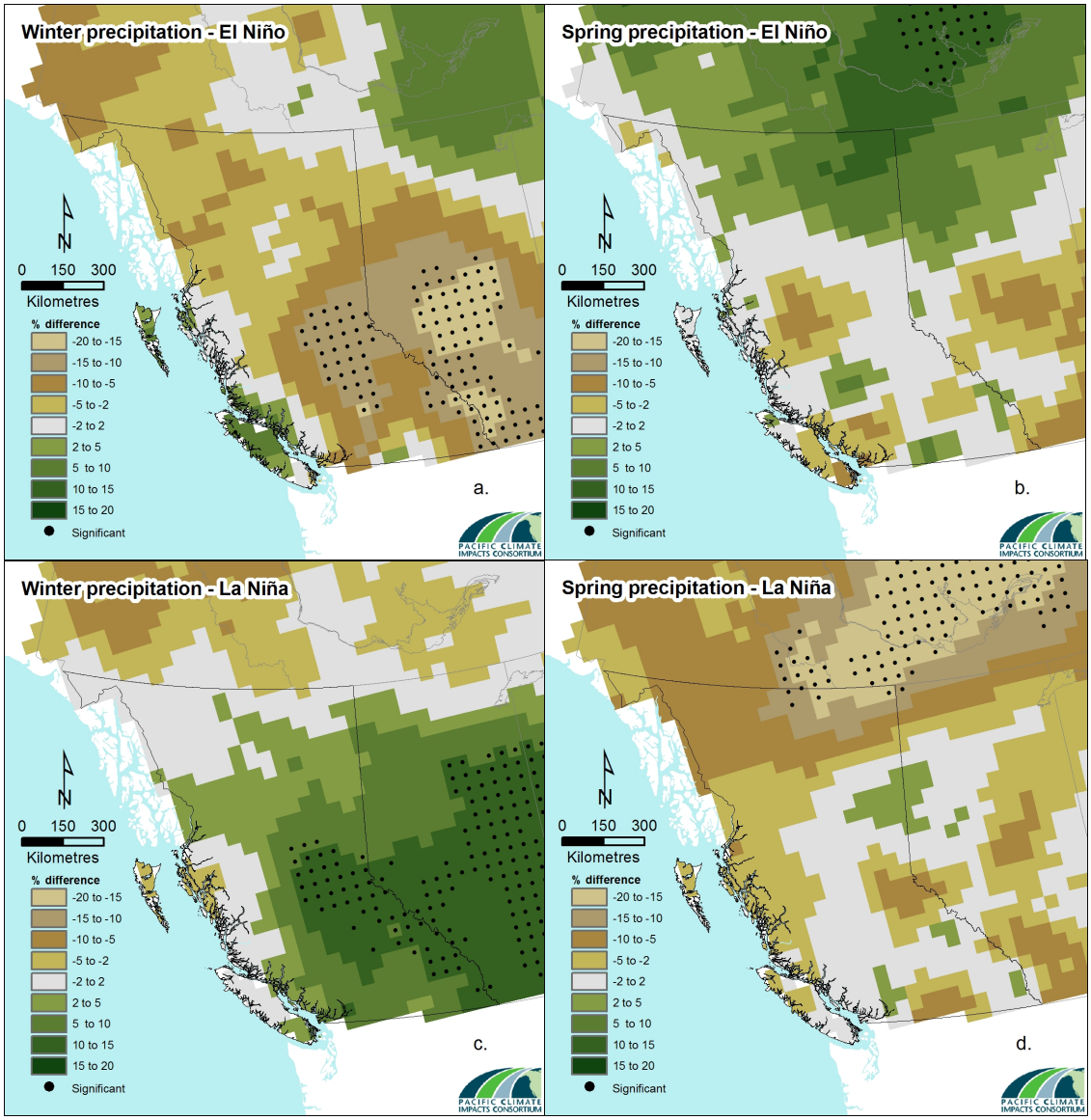

Figure 2.2.4 revised March 2009 - Seasonal climate variability for precipitation (a) El Niño winter, (b) El Niño spring, (c) La Niña winter and (d) La Niña spring for British Columbia. Results are based on 1900 to 2007 (ENSO) and calculated as a difference from the long-term average, percent of the 1961 – 1990 climatology. Source: CANGRID (50 km) data.

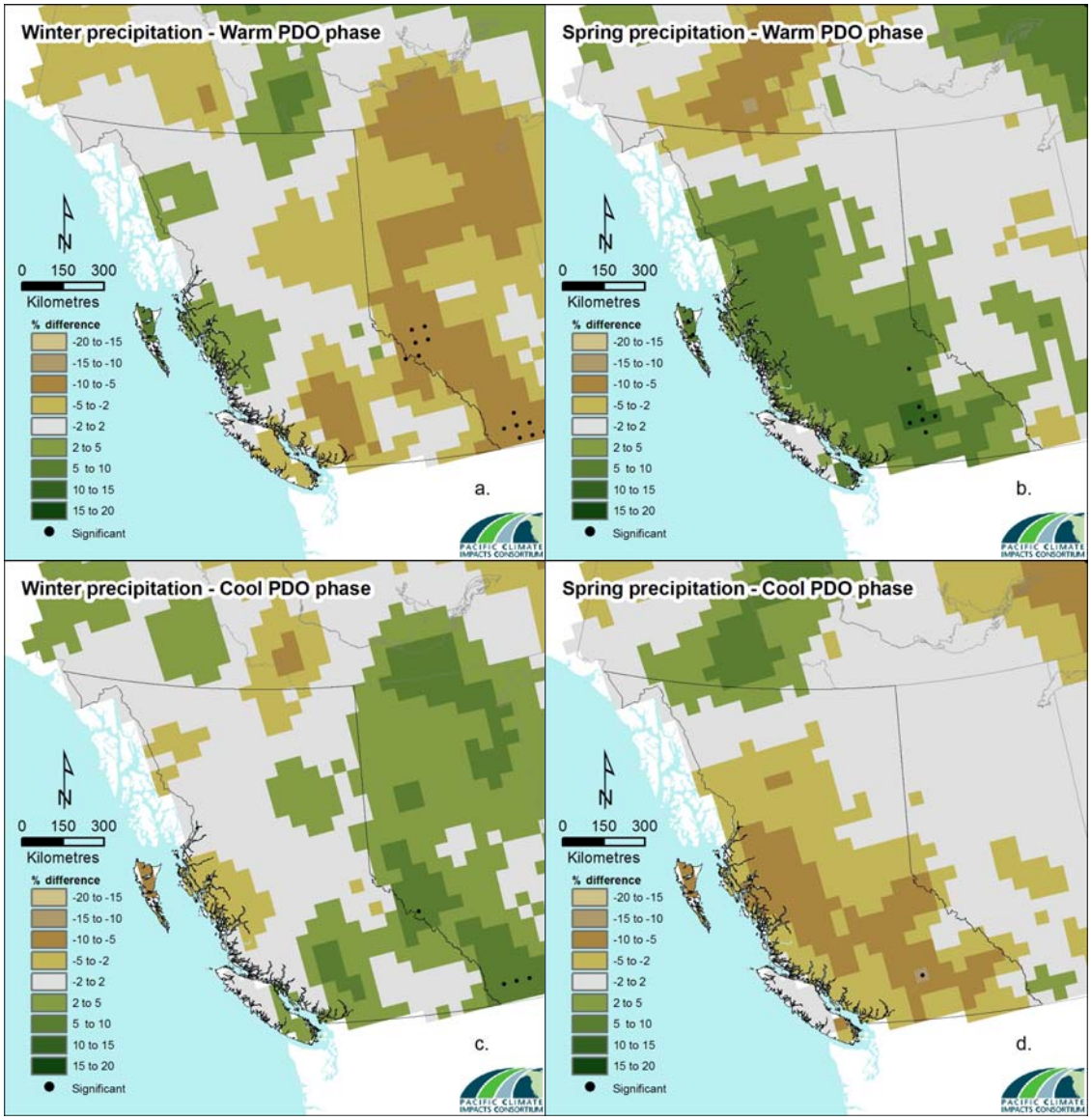

Figure 2.2.5 revised March 2009 - Seasonal climate variability for precipitation (a) warm PDO phase winter, (b) warm PDO phase spring, (c) cool PDO phase winter and (d) cool PDO phase spring for British Columbia. Results are based on 1900 to 1998 (PDO) and calculated as a difference from the long-term average, percent of the 1961 – 1990 climatology. Source: CANGRID (50 km) data.

Table2.2.1 revised March 2009 - Seasonal mean temperature (°C difference from the long-term average) and precipitation (% difference of the 1961-1990 climatology from the long-term average) for four teleconnections (El Niño, La Niña, Warm PDO, and Cool PDO). Results are composites from the 1900 – 2007 (ENSO) and 1900 – 1998 (PDO). Italicized values are mapped for BC (see Figure 2.2.3 to 2.2.5). Source: CANGRID (50 km) data.

Teleconnection		Temperature (°C)				Precipitation (%)			
		Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
El Niño	Min	*-0.3*	-0.4	-0.2	-0.4	*-19*	*-12*	-20	-12
	25th Percentile	*0.6*	0.2	0.1	-0.2	*-4*	*-2*	-3	-2
	Median	*1.0*	0.5	0.1	-0.1	*1*	*2*	1	1
	Mean	*1.0*	0.5	0.2	0.0	*0*	*2*	0	0
	75th Percentile	*1.4*	0.7	0.2	0.1	*4*	*6*	3	3
	Max	*2.3*	1.2	0.7	0.6	*16*	*25*	14	11
La Niña	Min	*-2.6*	-0.8	-0.5	-0.4	*-23*	*-27*	-18	-12
	25th Percentile	*-1.3*	-0.5	-0.2	-0.1	*-2*	*-7*	-4	-3
	Median	*-0.8*	-0.3	-0.1	0.0	*2*	*-2*	-1	-1
	Mean	*-0.8*	-0.3	-0.1	0.1	*2*	*-3*	-1	-2
	75th Percentile	*-0.3*	-0.1	0.0	0.3	*6*	*1*	2	1
	Max	*0.2*	0.4	0.2	0.7	*28*	*18*	12	14
Warm PDO	Min	*-0.6*	-0.2	-0.2	-0.4	*-12*	*-10*	-8	-7
	25th Percentile	*0.1*	0.2	0.1	-0.2	*-2*	*0*	-1	2
	Median	*0.5*	0.5	0.2	-0.1	*1*	*3*	1	3
	Mean	*0.4*	0.4	0.2	-0.1	*3*	*4*	1	4
	75th Percentile	*0.8*	0.6	0.3	0.0	*6*	*7*	3	5
	Max	*1.4*	1.0	0.4	0.2	*33*	*31*	16	17
Cool PDO	Min	*-1.5*	-0.8	-0.3	-0.2	*-35*	*-26*	-14	-15
	25th Percentile	*-0.7*	-0.5	-0.2	0.0	*-5*	*-7*	-3	-5
	Median	*-0.4*	-0.4	-0.2	0.1	*-1*	*-2*	-1	-3
	Mean	*-0.3*	-0.3	-0.1	0.1	*-3*	*-4*	-1	-3
	75th Percentile	*-0.1*	-0.2	-0.1	0.1	*2*	*0*	1	-1
	Max	*0.7*	0.3	0.2	0.3	*10*	*9*	6	6

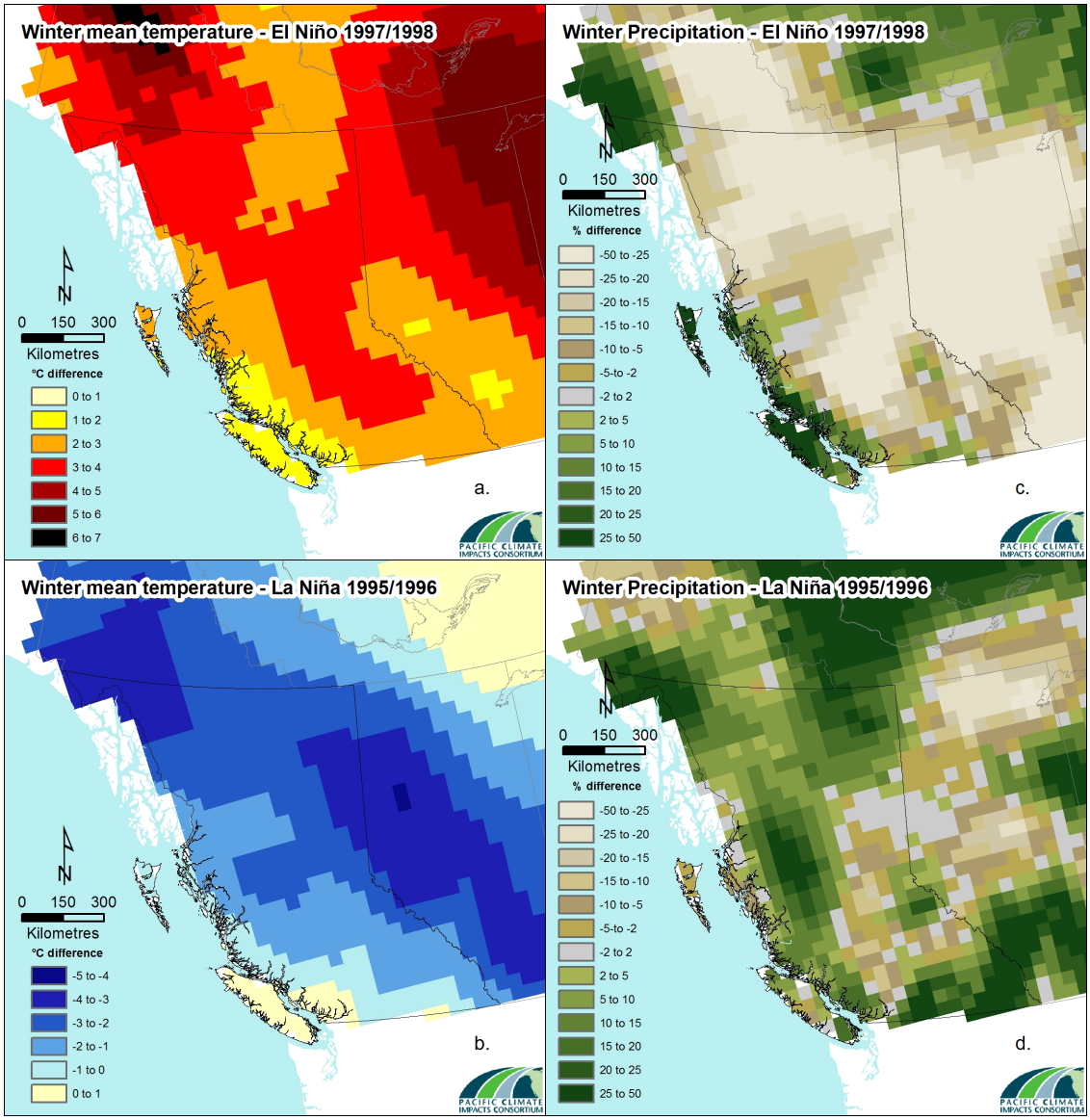

Figure 2.2.6 added March 2009 - Seasonal climate variability for mean winter temperature (a) El Niño 1998 and (b) La Niña 1996 and winter precipitation (c) El Niño 1998 and (d) La Niña 1996. Results are calculated as °C difference (temperature) and % differences (precipitation, from the 1961 – 1990 climatology) from the long term average. Source: CANGRID (50 km) data. Means are calculated for December to February inclusive (El Niño 1997-1998, La Niña 1995 - 1996).

Section 4.2 RCM Projections

The figure below replaces **Figure 4.2.1** (page 89) within **Section 4.2 RCM projections**, originally published in the Climate Overview. The figure colour scheme is revised to allow for improved comparison to **Figure 4.1.2a** in **Section 4.1 GCM projections**.

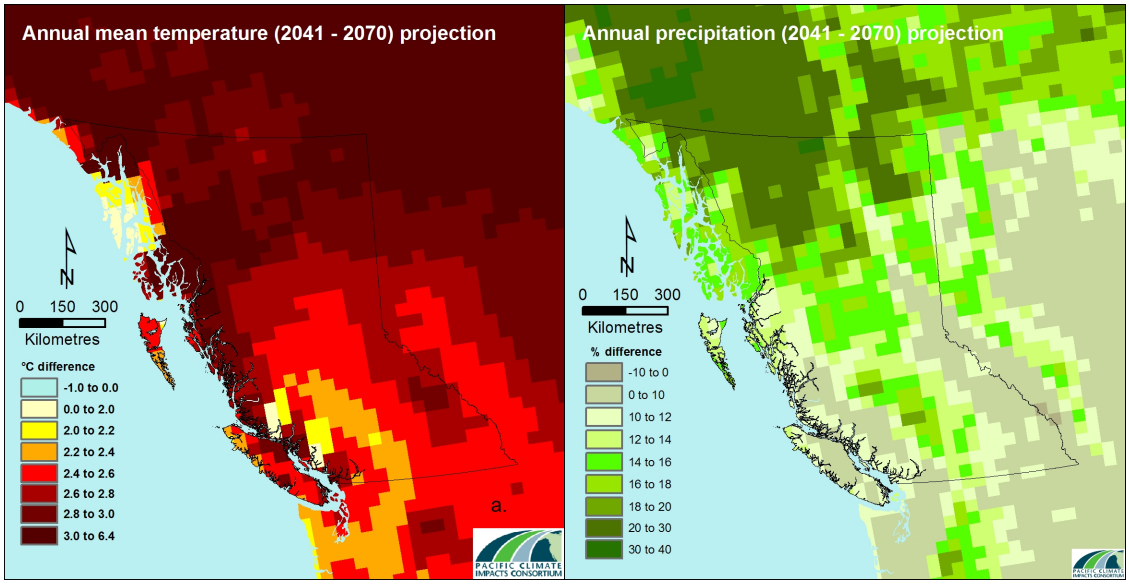

Figure 4.2.1 revised March 2009 – 2050s (2041-2070) climate anomaly projections from CRCM4 forced with CGCM3 and A2 emissions scenario (a) annual mean temperature. Source: Ouranos Consortium data.

Section 4.3 High definition climate projections

The following figures replace and update those originally published in **Section 4.3. High definition climate projections** (pages 95-96) of the Climate Overview. The following changes and updates are summarized below:

- The interpolation of GCM anomalies contained an error. The magnitude of differences in annual temperature and precipitation depends on the projection. The average difference over the domain is, for CGCM3 A2 run 4 is 0.2°C and 58 mm/year; and, for HadCM3 B1 run 1 is 1.4°C and 4 mm/year.
- The effect of the error is small in most locations because total values rather than anomalies are illustrated in **Figure 4.3.1** and **Figure 4.3.2**. Additionally, the categories are relatively wide in comparison to the magnitude of the error. Ninety-five percent of differences are less than 0.8°C and 170 mm/year for CGCM3 A2 run 4 and 1.8°C and 73 mm/year for HadCM3 B1 run 1.
- The difference is more visible for growing degree days (GDD) at locations where the annual temperature is near 5°C, a threshold for GDD. However, the result in **Figure 4.3.4** is a change of one category or less at all locations and 95% of the differences are less than 230 GDD for CGCM3 A2 run 4.
- All figures in this section include projections that cover a wider geographical extent (all of Alberta, further South in the U.S., more of Yukon, and part of the Northwest Territories).
- GDD projections are provided for two Global Climate Models (**Figure 4.3.4**), consistent with temperature and precipitation (**Figure 4.3.1** and **Figure 4.3.2**).

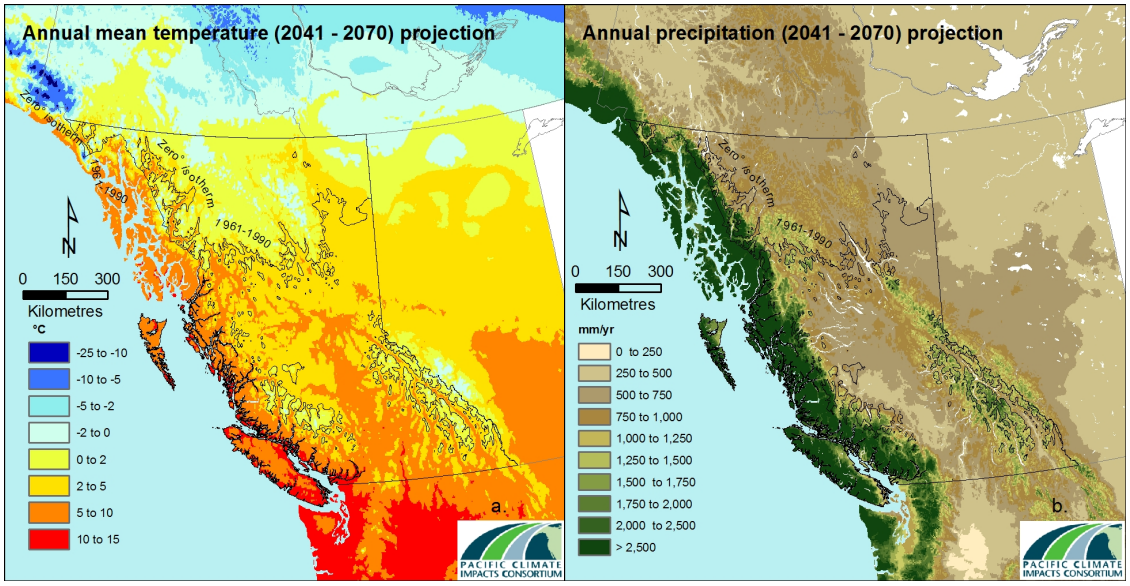

Figure 4.3.1 revised March 2009 – 2050s (2041-2070) high-resolution climate projections using PRISM climatology delta-method using CGCM3 A2 emissions scenario (a) annual mean temperature, (b) annual precipitation. Source: LLNL (IPCC AR4) data, ClimateBC.

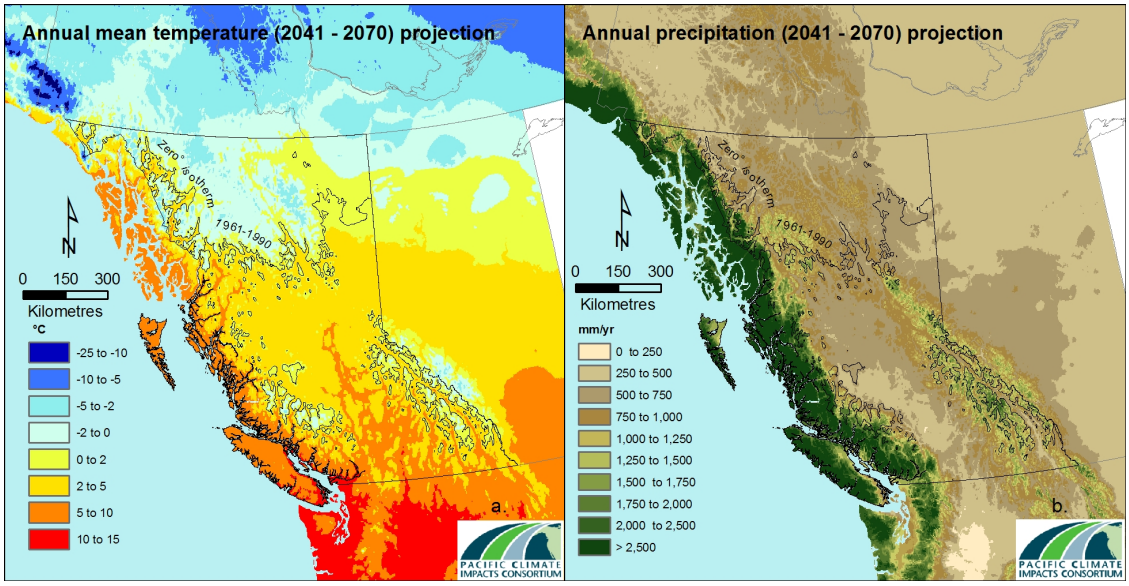

Figure 4.3.2 revised March 2009 – 2050s (2041-2070) high-resolution climate projections using PRISM climatology delta-method using HadCM3 B1 emissions scenario (a) annual mean temperature, (b) annual precipitation. Source: LLNL (IPCC AR4) data, ClimateBC.

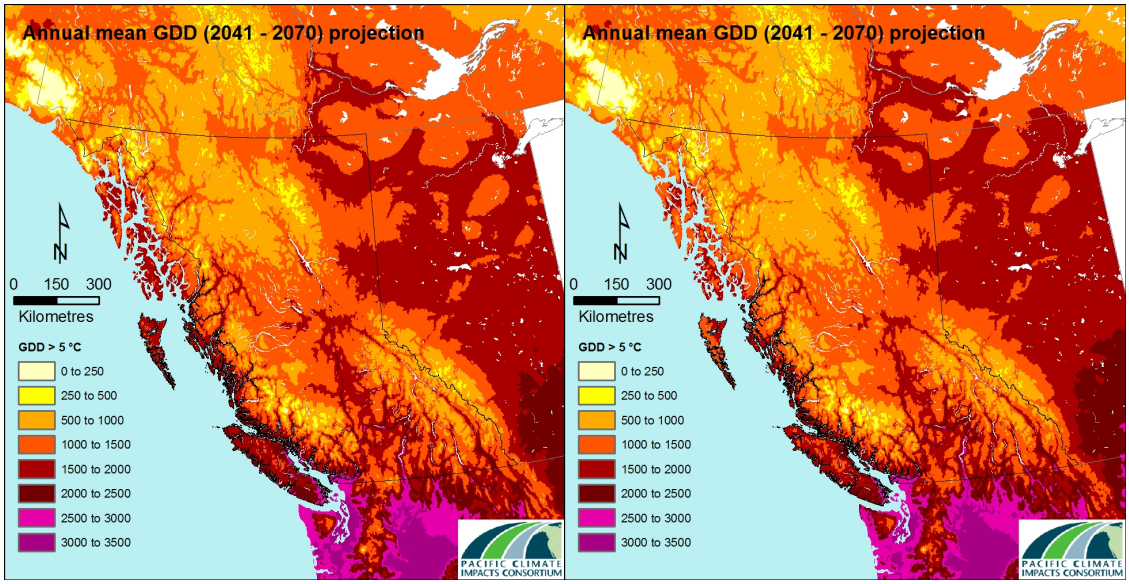

Figure 4.3.4 revised March 2009 – 2050s (2041- 2070) high-resolution climate projection of mean annual growing degree days using downscaled temperature with PRISM climatology delta method using (a) CGCM3 following A2 emissions scenario and (b) HadCM3 B1 emissions scenario. Source: LLNL (IPCC AR4) data, ClimateBC.