CLIMATE CHANGE REPORT SERIES

Mapping the Spatial Patterns of Precipitation in Prince Edward Island

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Executive Summary

The agricultural activities in Prince Edward Island (PEI) are heavily relying on rainfall. In recent years, farmers in PEI have been experiencing increasingly erratic weather which brought unprecedented challenges to crop production across the island. Many farmers have raised concerns about whether these erratic weather patterns will become a new normal in the future as they are navigating the ways to sustain their agricultural businesses. In particular, local growers are eager to know whether there are some consistent spatial patterns in precipitation across PEI (e.g., dry and wet spots) in support of their agricultural planning for crop selection and irrigation demands. In this study, we attempt to address this question by using a 1km x 1km high-resolution dataset to map out the spatial patterns of annual, seasonal, and monthly precipitations across PEI. We only focus on the historical precipitation patterns during the recent period of 1970-2000. The future patterns of precipitation under various greenhouse gases emission scenarios will be explored in our future studies. The results from this study can provide some references to help quantify the potential changes in precipitation patterns under future climate scenarios.

Acknowledgements

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1. Introduction

Prince Edward Island (PEI) is the smallest province in Canada situated in the Gulf of St. Lawrence with a total area of 5,660 km^2. Although PEI is a small island, its climate is milder than inland locations owing to the strong influences by the surrounding seas and can thus present significant spatial variations. As precipitation plays a critical role for PEI's agriculture sector, here we will focus on the spatial patterns of precipitation during the historical period of 1970-2000. Specifically, the purpose of this study is to investigate: (1) is there a spatially-consistent rainfall pattern across PEI (i.e., some areas are always drier or wetter than others)? (2) if yes, where are the dry and wet spots located?

2. Data

Since PEI is a small island, the spatial resolutions of some commonly-used climate reanalysis datasets, such as the North American Regional Reanalysis (NARR, with a resolution of ~ 32 km, website: https://www.ncdc.noaa.gov/data-access/model-data/model-datasets/north-american-regional-reanalysis-narr) and the Climate Research Unit gridded dataset (CRU, with a resolution of ~ 50 km, website: https://sites.uea.ac.uk/cru/data), are too coarse to capture its local climate. Here, we will use the 1km x 1km high-resolution gridded dataset provided by the WorldClim (website: https://worldclim.org) to explore the precipitation patterns across PEI. The WorldClim dataset is developed by applying the thin-plate splines spatial interpolation method to weather station data with covariates including elevation, distance to the coast and three satellite-derived covariates (i.e., maximum and minimum land surface temperature as well as cloud cover) obtained with the MODIS satellite platform.

3. Results

The spatial pattern of annual precipitation for PEI during the period of 1970-2000 is shown in Figure 1. It can be seen that there is a consistent spatial pattern for annual precipitation in PEI: the east receives more precipitation than the west does (hereinafter called as an east-wet and west-dry pattern). In particular, the annual total precipitation in the east is typically between 1,130 mm and 1,250 mm, while the west generally receives an annual total precipitation between 1,030 mm and 1,130 mm. This indicates that the average difference in annual precipitation between the east and the west can be about 100 mm. The wet spots (i.e., areas receiving more precipitation than the majority) are mainly located in the Morell River watershed

and several watersheds in the regions of Souris, North Lake, and South Lake. The dry spots (i.e., areas receiving less precipitation than the majority) are mostly located in the areas among Summerside, Kensington, and Victoria.

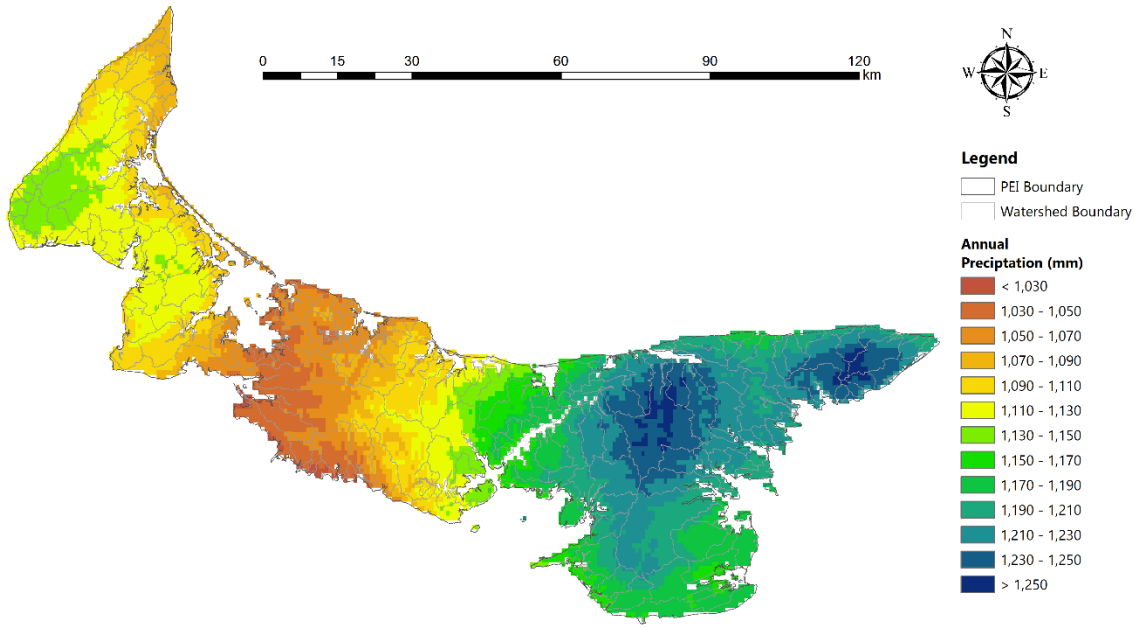

Figure 1. Spatial pattern of annual precipitation in PEI during the period of 1970-2000.

The seasonal patterns of precipitation during the period of 1970-2000 are shown in Figure 2. The results indicate that the total precipitations in Spring and Summer (about 260 mm) are generally less than those in Fall and Winter (above 300 mm). The highest seasonal precipitation usually occurs in Fall while the Summer precipitation is the lowest among four seasons. As for the spatial patterns of seasonal precipitation, it appears that the east-wet and west-dry pattern revealed in annual precipitation also manifests for four seasons. Furthermore, the dry spots in the west are more remarkable in Winter while the wet spots in the east are more notable in Fall. In addition, Table 1 presents the statistics for annual and seasonal precipitations in PEI during 1970 and 2000. The large standard deviations in Winter and Fall precipitations suggest larger spatial variations of precipitation in these two seasons (i.e., wet areas tend to receive more precipitation while dry regions expect less precipitation). The relatively small standard deviations in Spring and Summer precipitations imply that the difference in total precipitations received in wet and dry areas during these two seasons is less significant compared to Fall and Winter. This is likely to be caused by the ocean-effect snow which is a common occurrence mostly in the Fall and early Winter in the Maritimes. The ocean-effect snow usually takes place when the cold continental air moving into the region meets the warmer open waters in the Gulf of St. Lawrence, Bay of Fundy, and Atlantic Ocean.

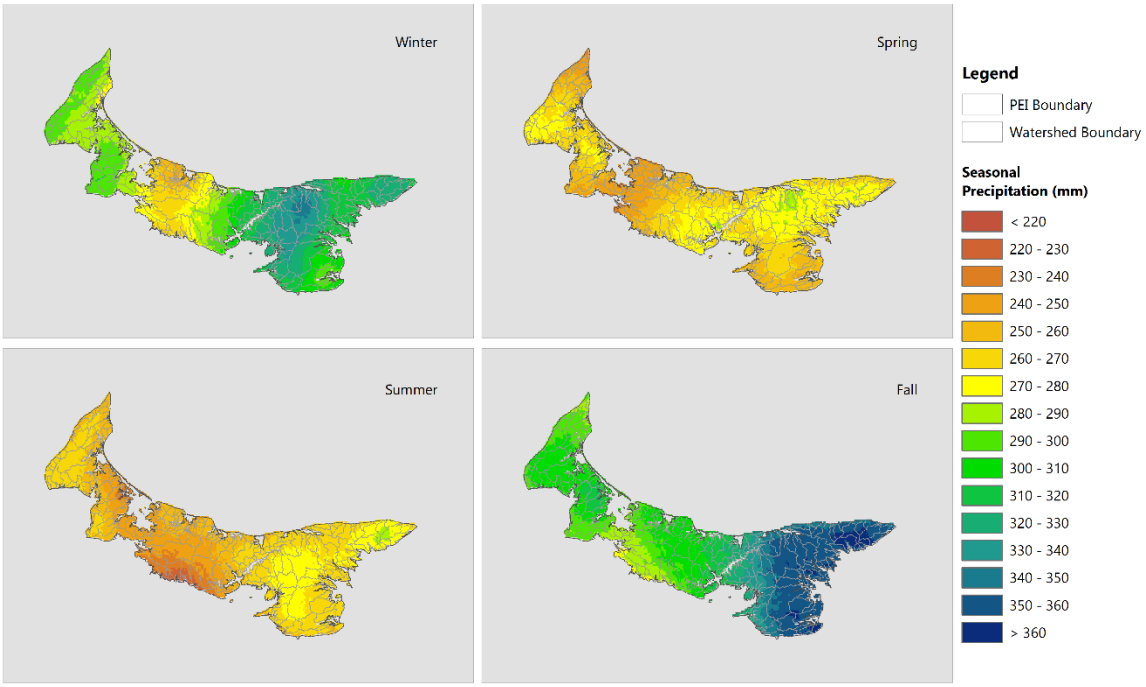

Figure 2. Spatial patterns of seasonal precipitation in PEI during the period of 1970-2000.

Table 1. Statistics for annual and seasonal precipitations in PEI, 1970-2000 (units: mm).

	Winter	Spring	Summer	Fall	Annual	Growing Season (Jun - Sep)
Minimum	248	231	218	276	1021	313
Maximum	347	288	285	368	1265	400
Mean	301	264	259	323	1148	361
Standard Deviation	23	10	12	26	63	18

The spatial patterns of monthly precipitation are further explored to help understand the seasonality of precipitation patterns in PEI (see Figure 3). Besides, the statistics about monthly precipitation are presented in Table 2 and the visualization of these monthly statistics is shown in Figure 4. It appears that the east-wet and west-dry pattern mostly manifest during the months between September and February (i.e., Fall and Winter), while this pattern is less significant during the months in Summer and Fall. This indicates that the ocean-effect snow tends to dominate the spatial pattern of local precipitation across PEI. It is also notable that the precipitation received in Summer months is obviously less than that for Fall months. This suggest that the local farmers may face some drought issues during the crop growing season while more precipitation in Fall months would potentially make it difficult to harvest crops.

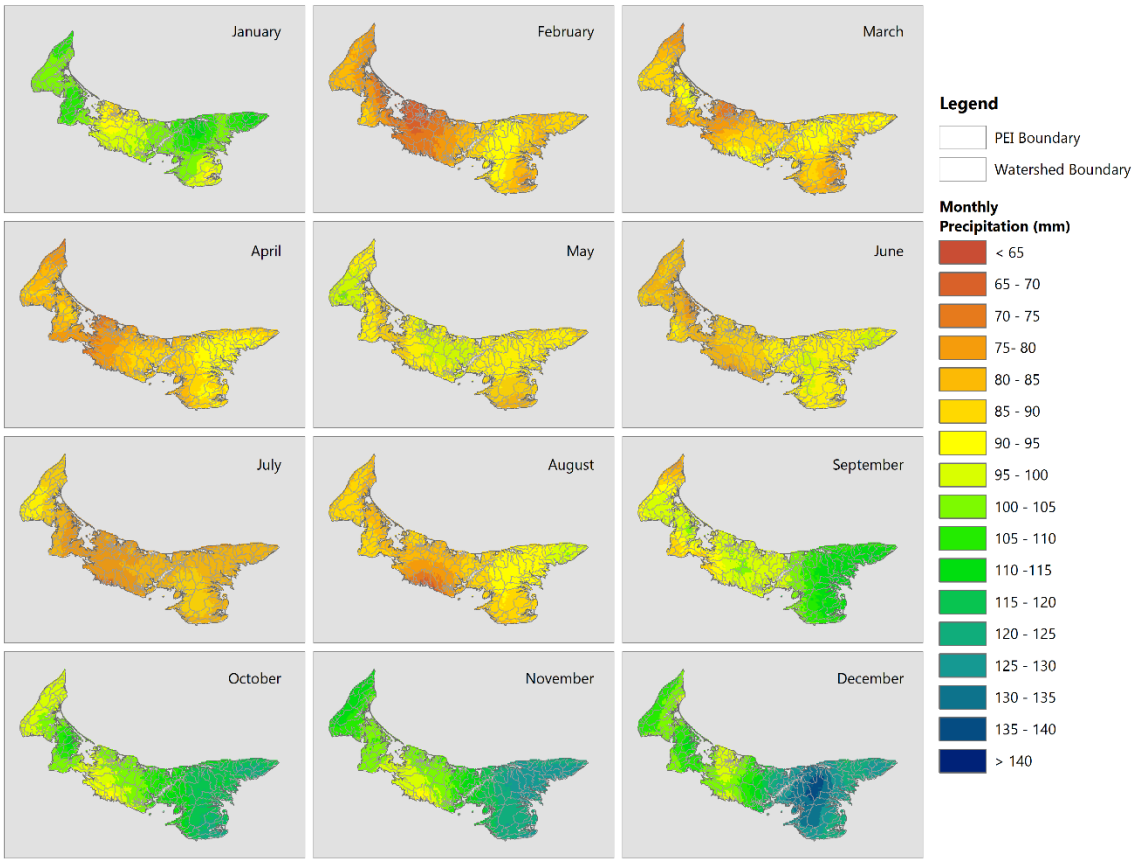

Figure 3. Spatial patterns of monthly precipitation in PEI during the period of 1970-2000.

Table 2. Statistics of monthly precipitations in PEI, 1970-2000 (units: mm).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	87	65	69	69	82	76	74	66	78	91	91	95
Maximum	115	95	100	97	102	99	95	101	118	126	129	137
Mean	102.5	81.8	86.5	85.1	92.8	89.2	83.2	86.8	101.5	108.6	112.9	116.7
Standard Deviation	5.1	7.2	5.1	5.3	3.5	4.8	4.1	5.6	8.0	8.8	10.3	12.2

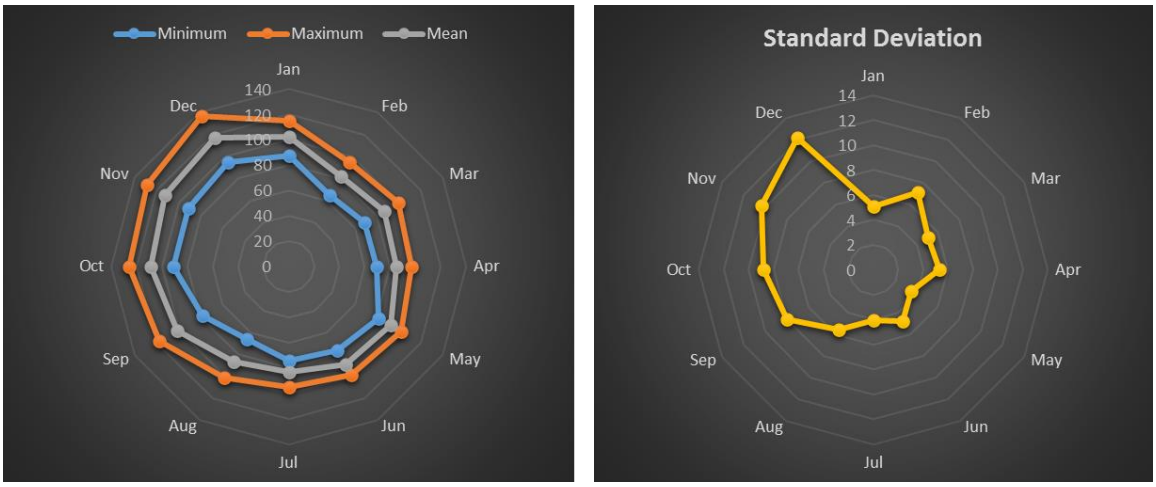

Figure 4. Radar plots for the statistics of monthly precipitations in PEI, 1970-2000.

The precipitation pattern for growing season (between June and September) is shown in Figure 5 and the statistics about growing season precipitation are listed in Table 1. Although the spatial pattern of precipitation for growing season presents a similar east-wet and west-dry pattern as the annual precipitation does, we should mention that some notable differences in terms of the locations of wet spots and dry spots are observed. In particular, the wet spots for growing season are mostly situated in the watersheds to the northeast of Souris while the dry spots for growing season are mainly located along with the coastlines near Victoria.

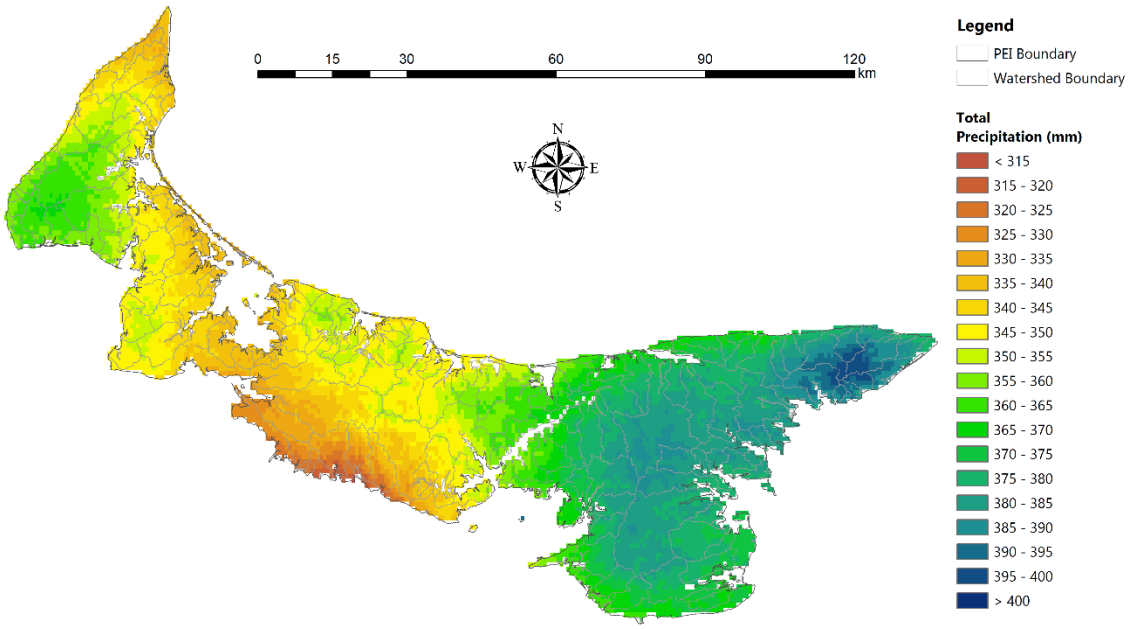

Figure 5. Precipitation pattern for growing season in PEI during the period of 1970-2000.

4. Conclusions

In this study, we have generated high-resolution maps of annual, seasonal, and monthly precipitations in PEI during the period of 1970-2000 to help explore the spatial patterns of local precipitation across PEI. Our results suggest that there is a consistent east-wet and west-dry pattern for precipitation in PEI. The wet spots for annual precipitation are mainly located in the Morell River watershed and several watersheds in the regions of Souris, North Lake, and South Lake, while the dry spots are mostly located in the areas among Summerside, Kensington, and Victoria. The locations of wet and dry spots for growing season precipitation can vary slightly but no significant change is observed for the general pattern.

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