Thailand Statistician
January 2017; 15(1): 97-103
http://statassoc.or.th
Short communication

Centre of Population of Saskatchewan, Canada

Arzu Sardarli*[a], Thuntida Ngamkham [b] and Andrei Volodin [c]

[a] Department of Indigenous Science, the Environment, and Economic Development, First Nations University of Canada, Prince Albert, Saskatchewan S4S7K2, Canada.

[b] Department of Mathematics and Statistics, Faculty of Science and Technology, Thammasat University, Rangsit Center, Pathum Thani 12120, Thailand.

[c] Department of Mathematics and Statistics, Faculty of Science, University of Regina, Regina, Saskatchewan S4S0A2, Canada.

*Corresponding author; e-mail: asardarli@firstnationsuniversity.ca

Received: 29 February 2016
Accepted: 5 September 2016

Abstract

For many years the temperature and its temporal and spatial dynamics have been one of the determinants of demographic processes. Some scholars classify the temperature as of the environmental factors correlating with births seasonality in human population. Usually researchers use the value of temperature averaged over a territory (country, state or province). Perhaps for cases, where the territory is relatively small size of, or the temperature is homogenous over the territory, the spatial averaging of the temperature can be found reasonable. In case of Canada and Canadian provinces, where the temperature difference between the south and north is much greater than in the most of other countries, the spatial averaging of temperature over the large areas leads to significant increase of the uncertainty of measurement. The use of temperature values measured at the centre of population could significantly increase the accuracy of birth vs. temperature correlation analysis. Within the reported studies we have determined the center of population of the province of Saskatchewan of Canada.

Keywords: Weiszfeld procedure, population center, coordinates of the centre of population, Saskatchewan, Canada.

1. Introduction

Determination of coordinates of the centerpoint is one of the classic problems analyzed in Physics and Mathematics. In demographics, the center of population (or population center) of a region is a geographical point that describes a centerpoint of the region's population (Kumler and Goodchild 1992). Practical uses for finding the center of population include locating possible sites for forward capitals, observation of human migration within the countries (states, provinces), etc. Hilgard (1872) was one of the first scholars who attempted to estimate the center of population of United States. He considered the centers of population at different periods for getting some idea of the rate at which the country was filling up. One of the first studies on the centre of population of Canada was done by Kensit (1934). He analyzed the correlation between the movements of the

centres of population and the economic factors such as industry and water development. The dynamics of the movement of the centre of population still remains an object of studies. Evaluation of coordinates of the centre of population of Saskatchewan was done within our project on birth seasonality (Sardarli et al. 2015).

Human birth seasonality first was recognized about 170 years ago (Quetelet 1842). Today, this phenomenon remains an important object of intensive study. Two broad types of factors determining birth seasonality have been explored in the literature: social demographic (i.e., economy, customs, traditions) and environmental (i.e., temperature, latitude, photoperiod). The birth seasonality phenomenon has been analyzed for a number of industrialized countries (see Seiver 1985, Werschler and Halli 1992, Trovato and Odynak 1993, Bobak and Gjonca 2001, Régnier-Loilier and Rohrbasser 2011), and also in the context of some less developed regions (e.g., Pascual et al.2005). A glaring feature of this literature is that there is no firm consensus regarding which of these two sets of factors is most dominant in forming the observed seasonal birth oscillations. Some authors have stressed the primacy of social demographic factors (e.g., Bobak and Gjonca 2001), while others give greater importance to biological (e.g., Pascual et al.2005) and environmental factors (e.g., Seiver 1985).

Usually researchers use the value of temperature averaged over a territory (country, state or province). Perhaps for cases, where the territory is relatively small size of, or the temperature is homogenous over the territory, the spatial averaging of the temperature can be found reasonable. In case of Canada and Canadian provinces, where the temperature difference between the south and north is much greater than in the most of other countries, the spatial averaging of temperature over the large areas leads to significant increase of the uncertainty of measurement. It also has to be taken into account that the majority of Canadians live in urbanized areas (cities), situated on the central part or south of the provinces; and this segment of population (making much higher contribution to the birth seasonality) in fact, is not affected by the temperature changes occurring in the north. However spatial averaging of temperature over a whole province creates altered picture of temperature dependence of the fertility patterns. In our opinion the accuracy of this type averaging cannot be high enough considering the large sizes of the investigated regions and non-homogenous density of population. Perhaps this averaging is caused by the fact that the monthly fertility data is usually available for the regions (provinces, states) and not for the metropolitan centres.

We have attempted to use a novel approach for reducing the inaccuracy caused by the averaging the temperature over large areas such as Canadian provinces. Considering that the majority of Canadian population live in cities, in our calculations we used the temperature data collected for the stations closest to the centres of population of provinces.

2. Method

In our calculations we used the Weiszfeld procedure (Weiszfeld 1937). This procedure was applied by Kumler and Goodchild for evaluating the coordinates of the population centre of Canada (Kumler and Goodchild 1992). Within this procedure, the location of a point on the Earth sphere is determined in geographic coordinate system by geographic latitude and longitude. This can be shown using the following conversion formulae,

$$x = \cos\varphi \cos\lambda$$
$$y = \sin\varphi$$
$$z = \cos\varphi \sin\lambda,$$

where φ is the latitude, λ is the longitude of the point. The coordinates of the centre of population are computed as

$$\hat{x} = \frac{\sum \frac{x_i}{\left[(\hat{x}-x_i)^2+(\hat{y}-y_i)^2\right]^{1/2}} pop_i}{\sum \frac{pop_i}{\left[(\hat{x}-x_i)^2+(\hat{y}-y_i)^2\right]^{1/2}}}$$

$$\hat{y} = \frac{\sum \frac{y_i}{\left[(\hat{x}-x_i)^2+(\hat{y}-y_i)^2\right]^{1/2}} pop_i}{\sum \frac{pop_i}{\left[(\hat{x}-x_i)^2+(\hat{y}-y_i)^2\right]^{1/2}}} \quad (1)$$

until the loop becomes stable; where x_i and y_i are coordinates of a population centre i, pop_i is the population of this population centre.

3. Results

In our calculations we used the data for the population centres of Saskatchewan whose population exceeds 1000 people according to Census 2011 (Census of Canada 2011). There were 63 of them. The table below represents the population and geographic coordinates of the population centres.

Table 1 Population Centres of Saskatchewan

Geographic name	Population, 2011	Latitude, N (deg)	Longitude, W (deg)
Saskatoon	222035	52.133333	-106.683333
Regina	192756	50.454722	-104.606667
Prince Albert	35552	53.2	-105.75
Moose Jaw	33617	50.393333	-105.551944
Lloydminster (SK part)	9772	53.278333	-110.005
North Battleford	17595	52.7575	-108.286111
Yorkton	15795	51.213889	-102.462778
Swift Current	15503	50.288056	-107.793889
Estevan	11054	49.139167	-102.986111
Weyburn	10484	49.661111	-103.8525
Martensville	7716	52.289722	-106.666667
Warman	7084	52.321944	-106.584167
La Ronge	5905	55.1	-105.3
Humboldt	5678	52.201944	-105.123056
Flin Flon (SK part)	229	54.768056	-101.864167
Melfort	5576	52.856389	-104.61
Meadow Lake	5045	54.124167	-108.435833
Kindersley	4678	51.467778	-109.156667
Melville	4517	50.930556	-102.807778
Nipawin	4330	53.3572	-104.0192

Table 1 (Continued)

Geographic name	Population, 2011	Latitude, N (deg)	Longitude, W (deg)
Tisdale	3185	52.85	-104.05
White City	3098	50.435278	-104.357222
Pelican Narrows	2703	55.188333	-102.934167
Moosomin	2485	50.142	-101.67
Esterhazy	2472	50.65	-102.066667
Assiniboia	2418	49.616667	-105.983333
Unity	2389	52.433333	-109.166667
Rosetown	2317	51.55	-107.983333
Canora	2219	51.63394	-102.43691
Outlook	2204	51.5	-107.05
Maple Creek	2176	49.55	-109.28
Biggar	2146	52.059	-107.979
Fort Qu'Appelle	2044	50.7667	-103.7833
Watrous	1857	51.677778	-105.464167
Pilot Butte	1848	50.466667	-104.416667
Kamsack	1825	51.565	-101.894722
Indian Head	1815	50.32	-103.4
Stanley 157	1812	55.4125	-104.568889
Wynyard	1767	51.766667	-104.183333
Shaunavon	1756	49.651	-108.412
Dalmeny	1702	52.341111	-106.773333
Regina Beach	1636	50.79	-104.99
Lumsden	1631	50.3846	-104.52
Balgonie	1625	50.291938	-104.155929
Rosthern	1572	52.666667	-106.333333
Hudson Bay	1477	52.851	-102.392
Carlyle	1441	49.376	-102.16
Shellbrook	1433	53.223056	-106.388333
Macklin	1415	52.2	-109.57
Lanigan	1390	51.85	-105.033333
Wadena	1306	51.945833	-103.801389
Wilkie	1301	52.409	-108.7
Langham	1290	52.37	-106.97
Oxbow	1285	49.233333	-102.166667
Kimosom Pwatinahk 203 (Deschambault Lake)	1194	54.916667	-103.366944
Langenburg	1148	50.833333	-101.7
Foam Lake	1148	51.65	-103.53
Carnduff	1126	49.167	-101.783

Table 1 (Continued)

Geographic name	Population, 2011	Latitude, N (deg)	Longitude, W (deg)
Gravelbourg	1116	49.874	-106.555
Osler	1088	52.37	-106.54
Preeceville	1070	51.958022	-102.667316
Caronport	1068	50.458889	-105.816667
Birch Hills	1064	52.983333	-105.433333

The geographical coordinates of population centers of Saskatchewan are publically available from World Geodetic System (WGS) database.

For carrying out the computations we used the MATLAB software (see Appendix). We have obtained the following results for the coordinates of the centre of population of Saskatchewan,

$$\hat{x} = -0.172126431502783$$

$$\hat{y} = 0.785721832548557.$$

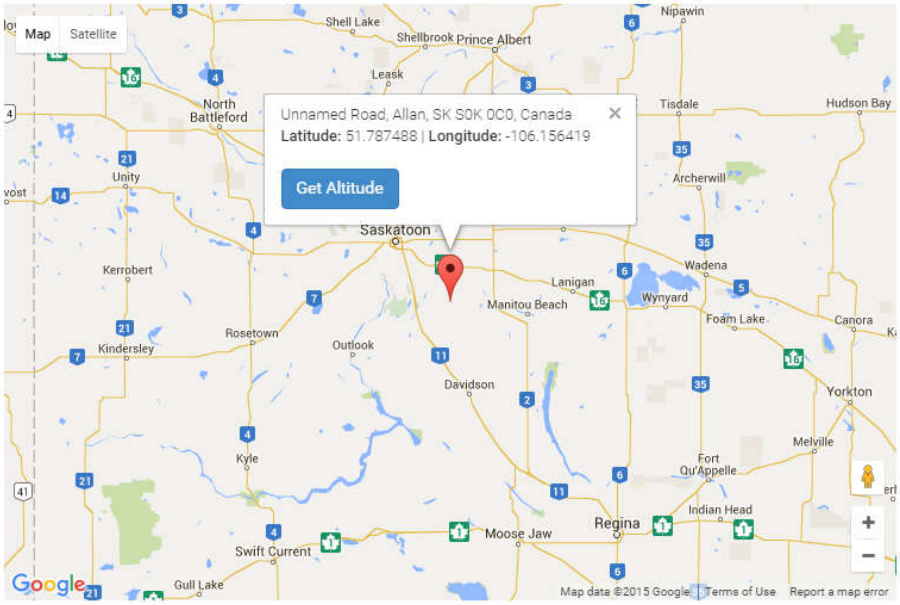

Figure 1 Centre of population of Saskatchewan (Canada)

Using the results of the calculations and formula (1) one can determine the geographic coordinates of the centre of population,

$$\hat{\phi} = \arcsin\left(\hat{y}\right) = 0.903862182 \; rad \; = \; 51.787488290214^{\circ} \; W$$

$$\hat{\lambda} = \arccos\left(\frac{\hat{x}}{\sqrt{1-\hat{y}^2}}\right) = 1.852779026 \; rad \; = \; -106.15641856042^{\circ} \; N.$$

These coordinates correspond to the population centre Allan of Saskatchewan (Figure 1). The closest temperature measurement facility to this location was the weather station of Saskatoon

Diefenbaker International Airport. In our studies on fertility vs. temperature, we have used the temperature data obtained from this weather station (Sardarli et al. 2015).

4. Conclusions

Within the presented studies we have determined the coordinates of the centre of population of province of Saskatchewan (Canada) using the Weiszfeld procedure (Weiszfeld 1937). In our computations we used the data (population, latitude and longitude) of 63 population centres whose population exceeds 1000 according to Census 2011. This result will be used in our future studies on the role of temperature oscillations in forming the birth seasonality.

Acknowledgements

The authors are grateful to the referee for carefully reading the manuscript and for offering substantial suggestions which enabled them to improve their paper.

References

Bobak M, Gjonca A. The seasonality of live birth is strongly influenced by sociodemographic factors. Hum. Reprod. 2001; 16: 1512-1517.

Census of Canada 2011. [cited 2016 February 29] Available from: http://www12.statcan.ca/census-recensement/index-eng.cfm.

Hilgard JE. The advance of population in the Unites States. Scribner's Monthly. 1872; 4: 214-218.

Kensit HEM. The centre of population moves west. Can. Geogr. 1934; 9: 262-269.

Kumler MP, Goodchild MF. The population center of Canada-Just north of Toronto. Geographical snapshots of North America: Commemorating the 27th Congress of the International Geographical Union and Assembly, edited by Janelle DG, The Guilford Press. 1992; 275-279.

Pascual J, García-Moro CE, Hernández M. Biological and behavioral determinants of fertility in Tierra del Fuego. Am. J. Phys. Anthropol. 2005; 127: 105-113.

Quetelet A. A treatise on man and the development of his faculties. William and Robert Chambers: Edinburgh; 1842.

Régnier-Loilier A and Rohrbasser J. Is there a childbearing season?. Popul Soc. 2011; 474: 1-4.

Sardarli A, Trovato F, Volodin A. Role of Environmental Factors in Forming Seasonal Fertility Oscillations. Annual Meeting of Canadian Population Society. Ontario: University of Ottawa; 2015.

Seiver D. Trend and variation in the seasonality of U.S. fertility, 1947-1976. Demography. 1985; 22: 89-100.

Trovato F, Odynak D. The seasonality of birth in Canada and the province, 1881-1989: Theory and analysis. Can. Stud. Popul. 1993; 20: 1-41.

Werschler T, Halli S. The Seasonality of births in Canada: A comparison with the northern United States. Popul. Environ. 1992; 14: 85-94.

Weiszfeld E. Sur le point pour lequel le somme des distances de n points donnés est minimum. Tohoku Math J. 1937; 43: 355-386.

Appendix

x_hat= -0.172126431502783
y_hat= 0.785721832548557
Number of iterations= 58
Criterion to stop: Euclidian distance between points (x_hat, y_hat) from the previous and new iterations is less than 10^(-6).

Program codes in MatLab version 2015A

```
clc;
load SK_PC_calculations_for_Andrei_150726.mat;
x_h=-0.16864;
y_h=0.780365;
X=data(:,1);
Y=data(:,2);
P=data(:,3);
K=0;
D=1;
while D>10^-6
   x_new=sum((X.*P)./(sqrt((x_h-X).^2+(y_h-Y).^2)))/sum((P)./(sqrt((x_h-X).^2+(y_h-Y).^2)));
   y_new=sum((Y.*P)./(sqrt((x_h-X).^2+(y_h-Y).^2)))/sum((P)./(sqrt((x_h-X).^2+(y_h-Y).^2)));
   D=sqrt((x_h-x_new)^2+(y_h-y_new)^2);
   K=K+1;
   x_h=x_new;
   y_h=y_new;
end;
format long;
disp('x_hat');
disp(x_h);
disp('y_hat');
disp(y_h);
disp('Number of Iteration');
disp(K);
```