Multivariate Methods Assignment: Canadian Weather

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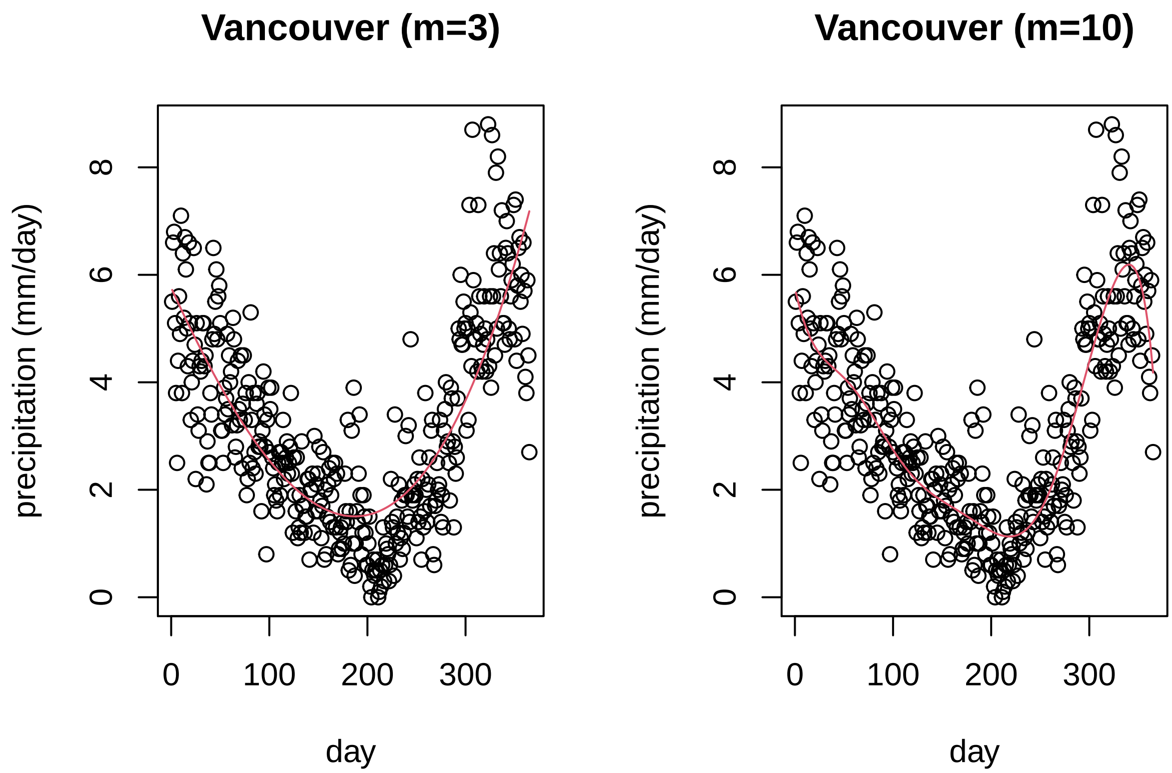
1. Introduction

Climate can be difficult to forecast. One of the possible approaches to studying climate includes looking at weather data and finding similarities in weather patterns across different cities. We can accelerate policy decisions relating to climate change by implementing similar solutions in cities with similar weather patterns. In the following analysis, we aim to utilize a two-dimensional representation to help us identify cities with similar weather patterns and visually quantify and contrast their differences. The data set used consists of 35 cities in Canada with one year (365 days) of precipitation data.

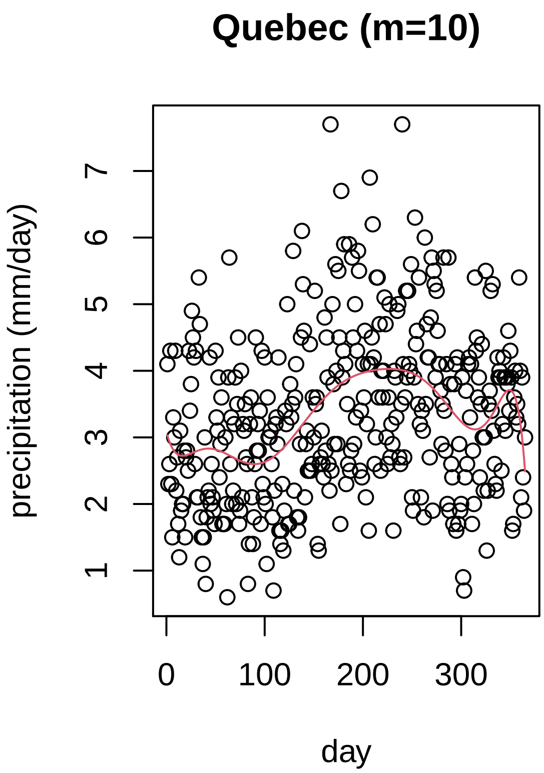
2. Functional Data Analysis

In order to perform a polynomial fitting, we first needed to determine the optimal degree d for the polynomial function. The below plot shows the sum of squared residuals vs the model degree m. We can tell that with a higher degree polynomial a better fit is achieved.

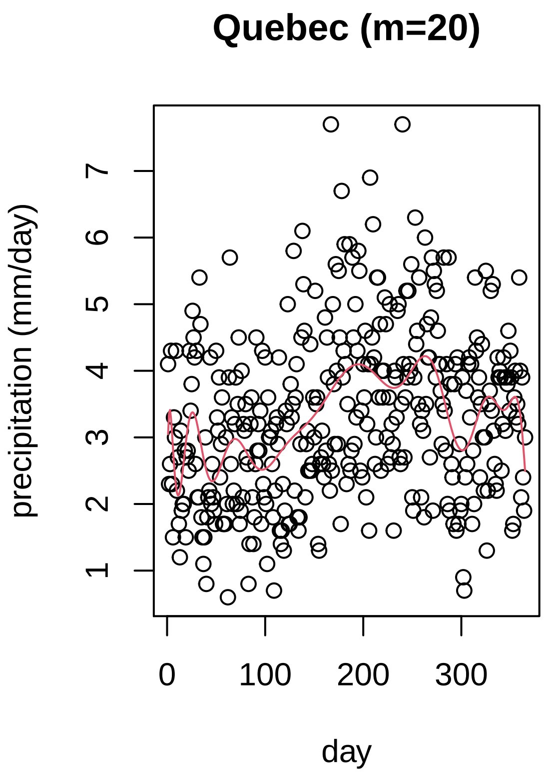
From the above plot we chose two values as the degrees of the polynomial and compared the fit of the model to the data. Looking at degree 3 and degree 10, we can clearly see that the degree 10 polynomial fits closer to the data than the degree 3 when setting the location equal to Vancouver.



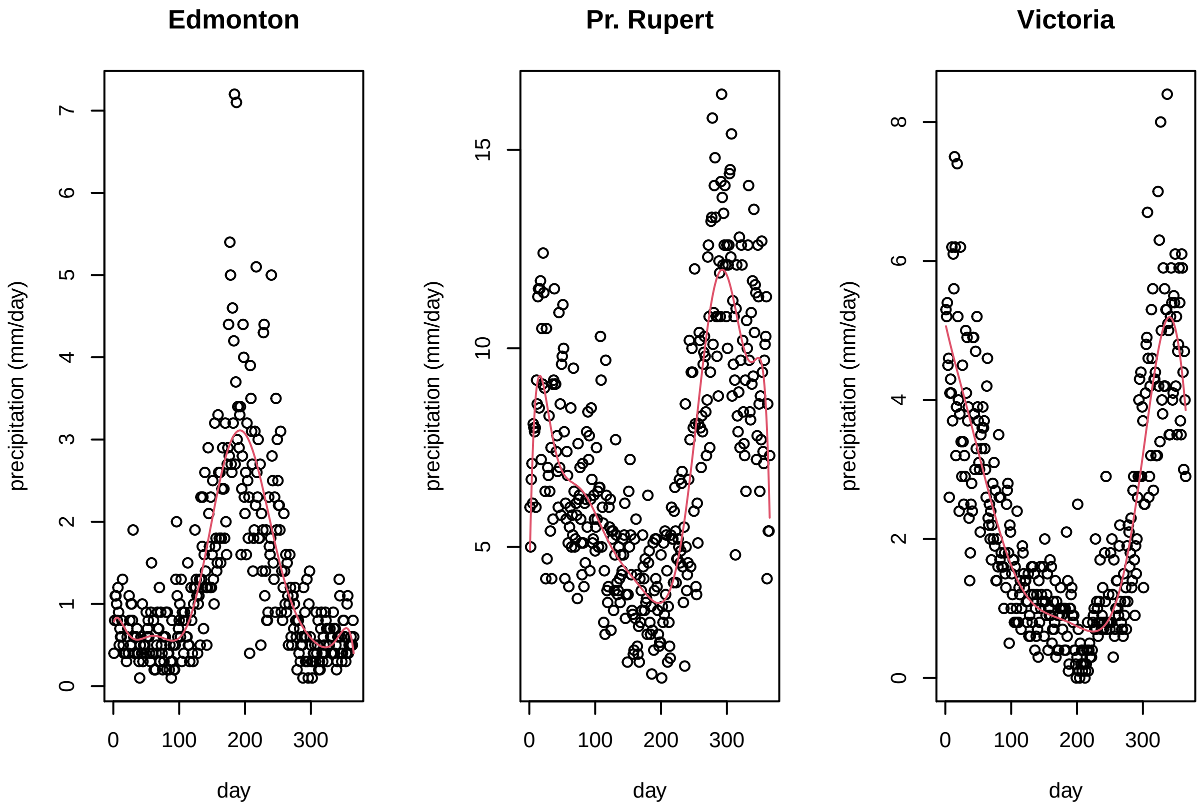
The choice is not as obvious for Quebec where even a 10 degree polynomial seems to be slightly over-fitting. However, contrasted with the 20 degree polynomial it is a more suitable choice. After looking at a few more locations namely Prince Rupert, Edmonton and Victoria, we concluded that $m = 10$ appears to be a good choice of degree for the polynomial fitting to the data.



Quebec (m=10)
precipitation (mm/day)
day



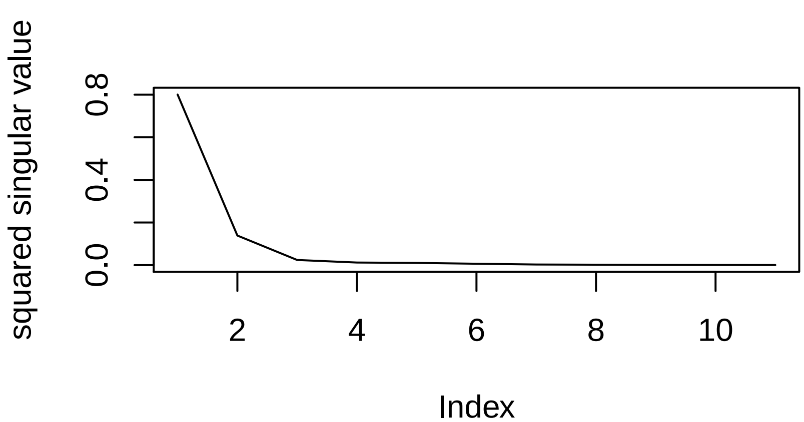
Quebec (m=20)
precipitation (mm/day)
day



The next step is to generate the matrix with the cities and the corresponding parameters.

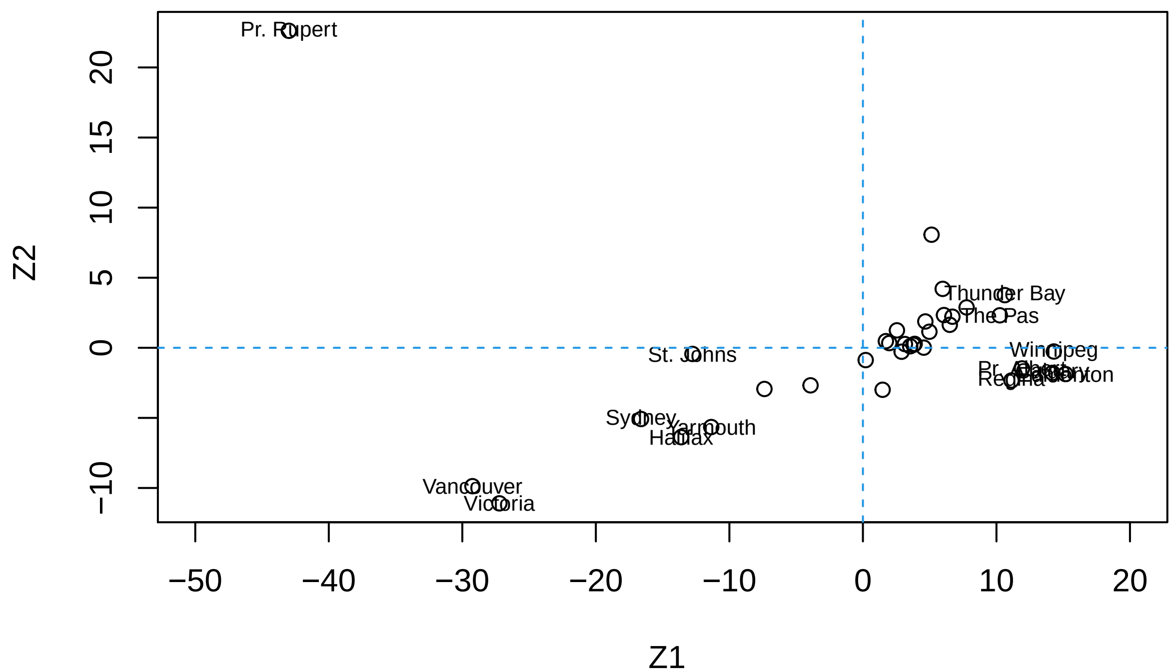
3. Multidimensional Scaling

The MSD is performed. First, we apply the column centering on the parameters matrix and then we obtain the SVD of this matrix. The plot below shows that in the first few dimensions we capture most of the information in the theta matrix.



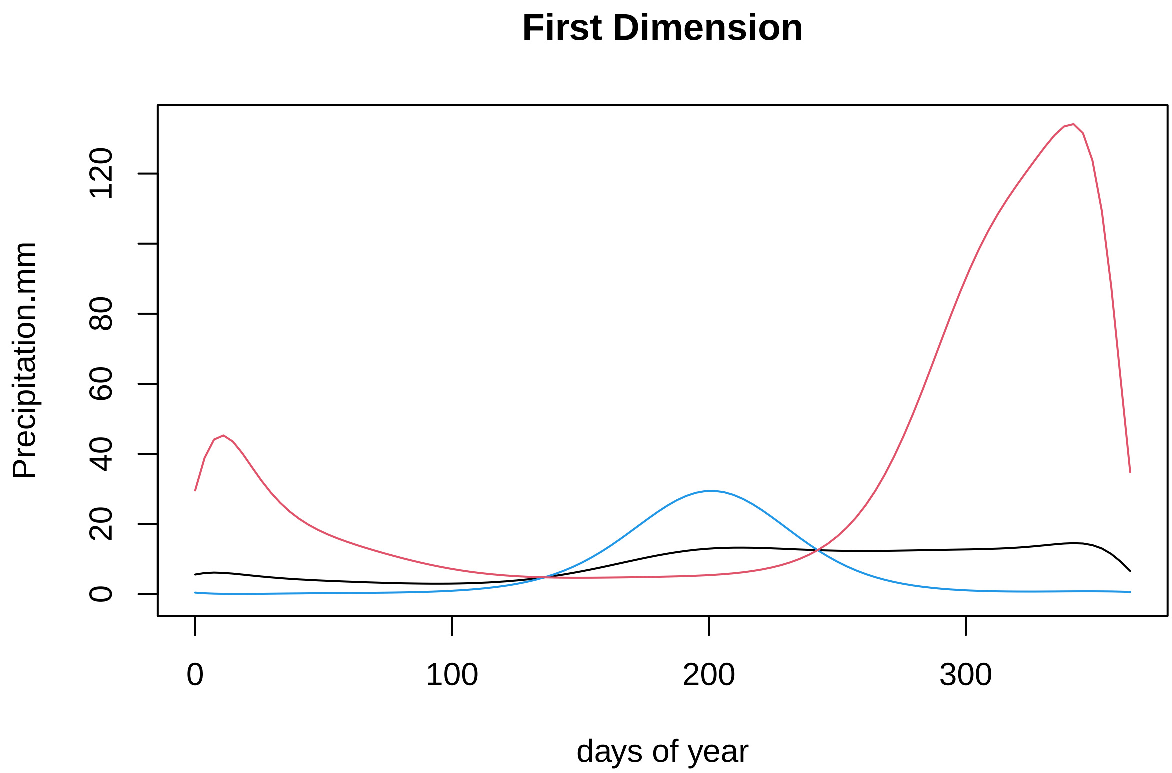
4. Functional Biplot

When transforming the singular value decomposition back into the original function space, each dimension has a score which translates to the component captured by that dimension. Here we construct the scores matrix Z_k with k=2 and then plot these scores. Each city has a score in each dimension which is captured by the 2x2 scatter plot, called a functional biplot. From this plot we can visualize which cities share similar precipitation characteristics.



It can be seen that the origin ((0, 0)) corresponds to the average precipitation/day function. The plot shows also that there are some cities with positive scores in the first dimension (e.g. Edmonton, Winnipeg and Scheffervll). The city of Pr. Rupert has a large positive score in the second dimension but a large negative score in the first dimension.

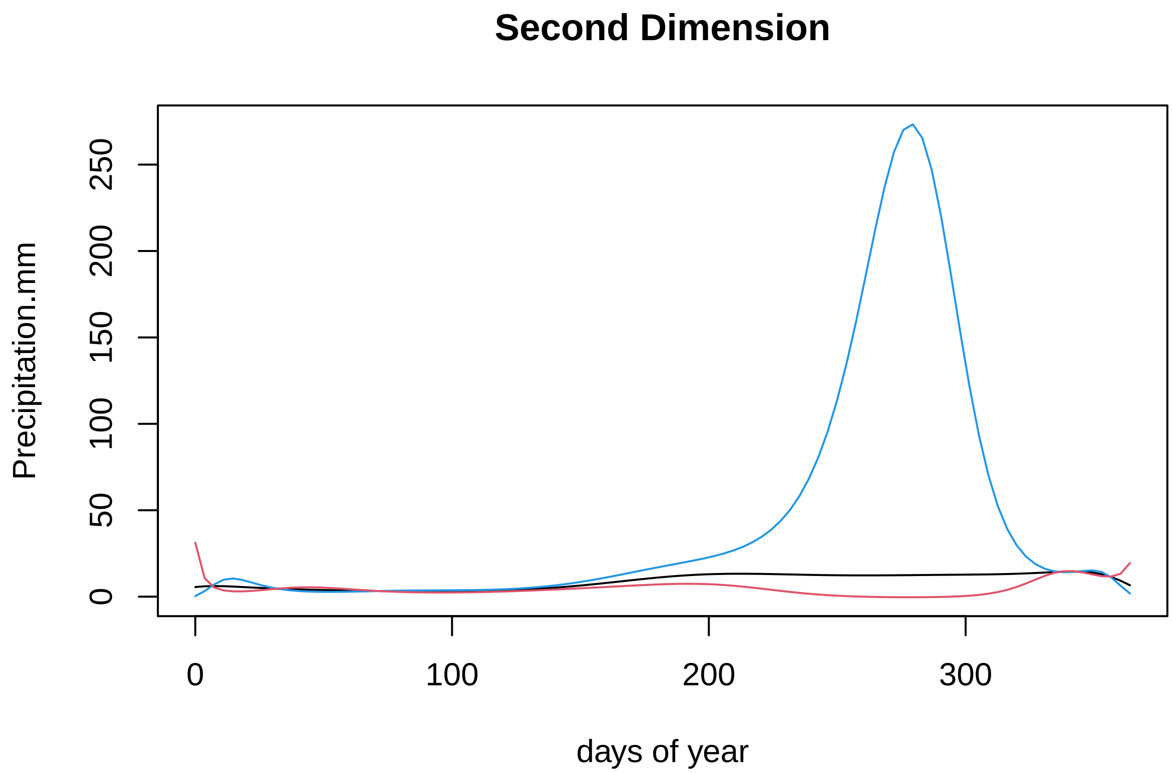
To better understand what large Z1 or Z2 scores mean, we will back-transform the SVD to the original function space.



We can conclude that cities that have a large negative score in the first dimension tend to have high precipitation amount at the end and beginning of the year, in other words during the winter months. On the other hand, cities with a large positive score have their high precipitation in the middle of the year during the Canadian summer.

Referring back to the functional biplot, we can interpret that that particularly Pr. Rupert, Vancouver and Sydney have high precipitation during the winter, while cities as Edmonton, Winnipeg, Pr. Alpert and Regina have high precipitation in the summer.

We can repeat the procedure for the second dimension.



The graph allows us to conclude that cities with large positive scores in the second dimension have high overall amounts of precipitation. Cities with large negative scores have a lower overall total precipitation. From the score plot we can see that Pr.Rupert have the largest positive score in the second dimension, and therefore it has the highest overall amount of precipitation.