# Portfolio Project

ENVR 300
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# Individual Learning Plan

ENVR 300 fits perfectly into my educational plan as upon completing my undergraduate degree I aspire to pursue a Master's Degree in Urban Planning and the goals that I have in mind for this course will aid me in this pursuit. My goals for this course are to become confident in oral presentations, to become more environmentally conscious, and to be self-reflective. Oral presentations have never been my forte, yet I feel that being adept at them will benefit me in other courses as well as in the professional field. I expect that the data analysis presentations will help me gain such confidence. In regard to environmental consciousness, I feel that it is one of those goals that is never attained as every day, we learn something new pertaining the environment and its issues. I imagine that the content we assess in this course will continue the advancement of this knowledge that will make me informed when conducting my own research and will affect me personally such that my previous judgements will be altered. Lastly, my goal for being self-reflective, may seem unusual for an environmental science course, yet assignments such as the journals, the peer reviews and the portfolio will be beneficial in allowing me to look back at my work and my thoughts. I think that this is important, as being self-reflective will help me advance as an individual by making me become more self-accepting and allow me to challenge my own thoughts.

# Reading Scientific Papers Assignment 2: Summary

"Communication of the role of natural variability in future North American climate," by Deser, Knutti, Solomon, and Phillips is written for the purpose of emphasizing the fact that there should be less promise held in the current and potential accuracy of climate projections on the basis of irreducible natural variability. This paper unlike most on climate change, answers how much natural variability can conceal anthropogenic climate change, regionally and continentally over varying periods of time particularly in North America. To answer this question, a 40-member collection of climate change simulations for the period of 2000 – 2060 coupled with a general circulation model were conducted. Each simulation experienced the same conditions and began with identical environments, thus anomalies experienced following the year 2000 were accounted for by uncertainty based on natural variability and not on errors attributable to the model itself. One of the conclusions drawn in this paper was that individual simulations of climate change in terms of temperature and precipitation vary significantly among each other. This is highlighted by figures with temperature and precipitation trends where an average, a largest trend, and a smallest trend of the 40 model runs for North America over the period of 2005-2060 was depicted. These show that often times the average temperature or precipitation depictions are very different from those in the smallest and largest trends. These differences can be attributable to fluctuations in atmospheric flow patterns. Another conclusion made was that natural variability can vary from region to region as well as between continents and their respective regions. This is emphasized in graphs of temperature anomalies as it can be seen that overall in the US, natural variability in winter and summer is projected to be significant, yet in areas such as Mexico this natural variability is miniscule in comparison. This also underlines the conclusion that regional averaging does not remove uncertainty from climate predictions. The overarching message in this paper, is that these climate projections, should be applied with caution as they may be more definitive for some regions in comparison to others.

# PLAN 341 Paper

Discourse into The Perils of Land Ownership and The Need for Inclusivity in an Era of Emerging Smart Cities in India

As a Sikh, farming is very significant to my heritage. In fact, the festival of Vaisakhi that occurs yearly in April marks the birth of Sikhism with a grand celebration in which farmers harvest wheat and pray for prosperous crops. While, I have never been to India and don't have a strong connection to farming, hearing the stories of the farmers that are to give up their land for the smart city Dholera, was upsetting ("India's Smart City" 00:07:04-00:09:32). It made me think of my grandmother's family that currently reside in a small village in Jalandhar. I cannot imagine what my family would do without their farm as it is their only source of income and sustenance. Their land allows them to cultivate vegetables, produce milk from buffalos, and grow wheat. But more than this, their land is significant for it has been in the family for decades. Thus, I think that the implementation of smart cities in regions of India that rely on ancestral and agricultural land isn't smart because it puts the inhabitants of this land in a vulnerable position both mentally and financially.

Land exchange in return for money or smaller plots of land is not a good compromise for the farmers of India. Often times, these landowners give up their land without giving consent or without understanding of what is happening ("India's Smart City" 00:25:30-00:25:46). If the concept of a smart city is difficult for us to define as an educated and tech-dependent society, how could it be explained to farmers with little schooling or understanding of the technological world. My grandmother's brothers finished school in the third grade and consider climate change to be foreign, let alone smart cities. Here, governance and planning take advantage of the farmers lack of knowledge and effectively exclude them from the planning process leaving them in a vulnerable state. The city of Magar Pata seems to have a better system where landowners receive shares for their land. But, the experience of the landowner depicted in the video about India's smart cities seems to me to be rare ("India's Smart City" 00:11:26-00:12:58). Not all landowners can be as business-savvy or as enthusiastic to assimilate into a modernized city. Without education or without a desire to leave the village, my family in India would be left behind in an increasingly tech-reliant and urbanized India in this scenario. Therefore, I believe there should be more inclusive and participatory planning in these smart cities. If India's target is to advance using smart cities, it has to do so in conjunction with the landowners who are giving up their livelihoods to make this happen.

Prior to knowing about India's 100 smart cities mission, I imagined these smart cities to focus on the wellbeing of India's inhabitants. Yet, the predominant outcome of this mission seems to be tech-based cities focussed on nothing else but money and modernity. The Gujarat International Finance Tec-City is an example where the city was built on farmland from three villages, yet the finance centric atmosphere isn't inclusive of the landowners who gave up their land for it (New Delhi. Housing and Land Rights Network). In Dharamshala, it was proposed that homes be constructed for slum dwellers, but in the wake of being classified as a smart city, a slum settlement was demolished (Asher). Then there is Magar Pata that consists of a secure environment, but one that is in the form of an unaffordable gated community rendering an exclusionary atmosphere ("India's Smart City" 00:16:50-00:20:40). Thus here, those in poverty are vulnerable alongside farmers. The common shortcoming I see within these cities is the principle of inclusion. In regard to farming in particular, the planning process needs to include farmers in all decisions regarding their land to ensure no one faces eviction due to these smart cities. I understand that farming won't be feasible based on resource availability in the future, but urbanization cannot happen overnight. Ultimately, instead of replacing villages with skyscrapers, India should focus on addressing the basic needs that are lacking in these regions such as access to water. But, if farmland must be taken away, there should be decisive thought put into compensation such as preserving part of the land or creating job opportunities for these individuals through urban farming. Moreover, there should be resources to aid in the transition to these smart cities. To implement these facilities, governance and planning should inform farmers of their plans through workshops and then subsequently hold meetings to allow the farmers to participate and voice their concerns. A board of ethics should also be hired to ensure that the farmers are being treated fairly. In short, smart cities may allow India to become advanced like many developed countries but the current lack of inclusivity of many in its population from landowners to the poor will result in a nation divided by those residing in smart cities and those who get left behind.

## Works Cited

Asher, Manshi. "Is There No Place for the Poor in Dharamshala "Smart" City?" *Himdhara Environment and Research Collective*. 17 Sep. 2017. Web. 18 Feb. 2019.

"India's Smart City Plan and What It Means for Indians." *Youtube*, uploaded by Svetlana Aceuedo. 6 Jan 2018. https://www.youtube.com/watch?v=Wr40k6dXtc4. Accessed 12 February 2019.

New Delhi. Housing and Land Rights Network. *India's Smart Cities Mission: Smart for Whom? Cities for Whom?* City of New Delhi. 2017. Web. 18 Feb. 2019.

# Data Assignment Report

Analysis of Spatial Differences in Natural Temperature Variability and Temperature Trends Projected by GCMs across Canada by David Park, Tobias Schmidt, Jasmin Senghera, and Augusta Wong

Abstract:

Temperature data from 5 Global Climate Models (GCM's) (CanESM2, CSIRO-MK3.6.0, GFDL-CM3, MIROC-ESM, MPI-ESM-LR) for 10 climate stations across Canada for the years 2006-2025 has been used to determine the relationship between interannual temperature variability and continentality, between projected temperature trends and continentality, and between interannual temperature variability and projected temperature trends. Upon calculating the variables of continentality, interannual temperature variance, and yearly temperature trends for a sample size of n =20, these variables were each correlated. The significance of these correlations was further computed utilizing the t-test. The correlation data depicts that there is a strong (r > 0.5) and significant correlation between continentality and temperature variability for the GFDL model with a 90% confidence interval. Additionally, there is a strong (r > 0.5) and significant correlation between temperature variability and temperature trends for the GFDL and MIROC models with a 90% confidence interval.

Introduction**:**

Based on the climate projections of GCM's, it appears that the future of Earth will be one of rapid shifts based on the rise of climatic variability and temperature extremes (Vázquez, Gianoli, Morris, & Bozinovic, 2017). However, influences of this temperature variability are difficult to pinpoint as there could be many factors interfering from the shifting angles of incoming solar radiation to the differing continentality indices of climate stations to the natural variability that climate encounters (Brooks, 1919). The rising variability associated with the future temperature trends is concerning because it can alter the state of food security, human wellbeing, and water supply (Thornton, Ericksen, Herrero, & Challinor, 2014). These adverse effects are especially heightened in developing countries as these regions are especially vulnerable to anthropogenic climate change and they are unable to withstand the financial burden to alleviate these issues (Thornton et al., 2014). Thus, it is important to analyze what factors may influence this temperature variability in order to better prepare for the future.

One such factor that might be related to the temperature variability is the continentality index. This index is defined as the difference between the monthly average temperature of the warmest and coldest month per year (Hirschi, Sinha, & Josey, 2007). This variable is heavily influenced by factors such as latitude, proximity to the ocean, and atmospheric circulation (Stonevicius et al., 2018). Continentality is an especially important measure as it is a distinguishing factor between marine and continental climates (Vlăduţ, Nikolova, & Licurici, 2018). Continental climates are represented by overall higher temperatures, warmer summers, and colder winters. Marine climates on the other experience cooler summers and less extreme winters (Szymanowski, Bednarczyk, Kryza, & Nowosad, 2016). Thus continentality has merit in being a measure that incorporates a lot of factors that could contribute to temperature variability. While there has been a previous study investigating the predictability of monthly temperature variance by continentality, they utilize a continentality index formulated uniquely that is primarily a function of latitude for Europe (Hodgewind & Bissolli, 2010). Additionally, this study uses multiple regression to account for the variance with respect to continentality, latitude, longitude, and altitude. In other studies too, there has been some discussion surrounding continentality and its influence, but little in the way of the relationship between continentality and interannual temperature variability or temperature trends (VilÄek, Škvarenina, Vido, Nalevanková, Kandrík, & Škvareninová, 2016; Szymanowski et al, 2017; Stonevicius et al., 2018).

The purpose of this paper then is to determine three relationships based on data from 5 GCM's (CanESM2, CSIRO-MK3.6.0, GFDL-CM3, MIROC-ESM, and MPI-ESM-LR) for 10 climate station locations (Agssiz, Fort Nelson, Dawson, Fort Reliance, Moosomin, Earlton, Fredericton, Kuujjuaq, Baker Lake, Eureka) across Canada for the years 2006 - 2025. The first relationship investigated is between the interannual variability depicted in the GCM's of the climate models and an index of continentality of the locations (Q1). This will determine whether or not certain stations have greater or lesser temperature fluctuations in comparison to others based on their location. This should allow these locations to be better equipped for climate change as variability can be tied to specific locations rather than regions. The second relationship analyzed is between the temperature trend slopes of projected temperatures by the GCM's and the continentality of the locations to conclude how the rising slopes of projected temperature changes are related to location (Q2). This will allow for knowledge on whether the rate of increase in temperature is location-dependent and how location may be interfering with the steepness of projected trends. The third relationship then is between the interannual variability and trendline slopes (Q3). This will aid in understanding whether it is continentality that is correlated with interannual variability or temperature trends, and not the interannual variability correlated with temperature trends. Initially, the proposal was focussed on aspects of seasonal expansion and variability in GCM's with regard to the crop growing season, however it was determined that continentality was a more appropriate variable based on the data provided.

## Methods:

The dataset we are using originates from 5 global climate models or GCM's. They are: the CanESM2 GCM formulated in the Canadian Centre for Climate Modeling and Analysis, the CSIRO-MK3.6.0 GCM formulated in the Queensland Climate Change Centre of Excellence and Commonwealth Scientific and Industrial Research Organization, the GFDL-CM3 GCM formulated in the NOAA Geophysical Fluid Dynamics Laboratory, the MIROC-ESM GCM formulated in the University of Tokyo, the National Institute for Environmental Studies, and the Japan Agency for Marine-Earth Science and Technology, and finally the MPI-ESM-LR GCM formulated in the Max Plank Institute for Meteorology. Each of these GCM's contains data from 10 weather stations across Canada. They are numbered and named: 1) Agassiz, 2) Fort Nelson, 3) Dawson, 4) Fort Reliance, 5) Moosomin, 6) Earlton, 7) Fredericton, 8) Kuujjuaq, 9) Baker Lake, and 10) Eureka. Their latitudes in degrees north are: 1) 49.25, 2) 58.83, 3) 64.05, 4) 62.72, 5) 50.13, 6) 47.7, 7)

45.87, 8) 58.1, 9) 64.3, 10) 79.98. Each station contains monthly temperature averages for all 12 months from 2006-2100.

We began our analysis of our models' outputs by creating indices of continentality for all 10 Canadian weather stations in all 5 GCM's. We elected to define an index of continentality (k) as:

$$k = \frac{1.7A}{\sin(\phi + 10°)} - 14, \tag{1}$$

Which is the standard definition given in the American Meteorological Society's Glossary of Meteorology (2012). "ϕ" is defined as the latitude in degrees. We will use the latitudes of the stations given with the model data. "A" is the difference between the average temperature for the warmest month and the average temperature for the coolest month in a year measured in Kelvin. For our purposes we decided to take the differences of temperatures from averages of the warmest and coolest months over the first 20 years of our models' ranges. We selected this 20-year period in order to keep the natural error we would expect from GCM's (that would occur with long-range forecasting) down to a minimum. We used this time-period for all following variables. Calculating the indices of continentality results in 50 datapoints.

After having produced our Indices of Continentality, we moved on to calculate the interannual temperature variance for each station in each GCM. We achieved this by first calculating yearly averages by averaging the 12 months' temperatures for each year in our time-period. We then defined sample variance as:

$$\frac{\sum (x-\bar{x})^2}{(n-1)} \tag{2}$$

Which is Microsoft Excel's built in sample variance function ("VAR.S function", n.d.). Here "*x*" is each individual yearly temperature average for a specific station and GCM. "*x*" is iterated through each individual year each time the expression is summed. "$\overline{x}$" is the mean of all our yearly temperature averages. "*n*" is the number of data points in the sample, which in our case is equal to 20. This process again results in 50 datapoints.

Next, we needed to calculate the yearly temperature trends. To accomplish this, we used the ordinary least-squares method where the slope formula is the correlation of yearly average temperature and time in years * standard deviation of yearly average temperatures / standard deviation of time in years. We defined correlation as:

$$Correl(X,Y) = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}} \tag{3}$$

Which is Microsoft Excel's built in correlation function ("CORREL function", n.d.). Again, here "*x*" is each individual yearly temperature average for a specific station and GCM. "*x*" is iterated through each individual year each time the expression is summed. "$\overline{x}$" is the mean of all our yearly temperature averages. "*y*" is each individual year and is also iterated through with each sum. "$\overline{y}$" is the mean of all 20 years. We then defined standard deviation as:

$$\sqrt{\frac{\sum (x-\bar{x})^2}{(n-1)}} \tag{4}$$

Which is Microsoft Excel's built in sample standard deviation function ("STDEV.S function", n.d.). For standard deviation of yearly average temperatures, please refer to the segment on sample variance for variable use, as these variables were used identically. For the standard deviation of time "*x*" is the specific year, "$\overline{x}$" is the mean of all 20 years, and "n" is again 20. Calculating the yearly temperature results in 50 total datapoints once again.

Then, after producing all 3 of these variables, we generated 3 separate scatterplots in Microsoft Excel ("Present your data in a scatter chart or a line chart", n.d.). One plotted interannual temperature variance with continentality, the second was interannual temperature trend with continentality, and the last was interannual temperature trend with interannual temperature variance. (See results)

Finally, we calculated the correlation for each of the graphical comparisons and performed t-tests for each to show significance. We used the same Excel formula (formula 3) for calculating the correlation as the one discussed above. This time however, the "*x*" variables were each station's continentality for figure 1 and interannual temperature trend for both figures 2 and 3. The "*y*" variables were each station's interannual temperature variance for figure 1, continentality for figure 2, and interannual temperature variance for figure 3. We repeated this for all 5 models in each figure for a total of 15 correlations. We then defined a t-value as:

$$t = r\sqrt{\frac{n-2}{1-r^2}} \tag{5}$$

Which is the definition given by Janda (2001). We used "*r*" as the correlations calculated above, and "*n*" is the number of total weather stations, which is 10. This also meant our degrees of freedom is equal to 8 because degrees of freedom is equal to *n-2* (Janda, 2001). It should be noted the null-hypothesis is when our correlation coefficients = 0 (Janda, 2001). Now that we have calculated our t-values we decided to select a critical value of $T_{critical} = 1.86$ for 90% confidence at 8 degrees of freedom. We determined this value from a table supplied by Van Belle, Fisher, Heagerty, and Lumley (2004). All results and t-tests are displayed below in the results section.

<u>Results:</u>

Here are the 3 figures we generated. They are a potential insight into each of our 3 questions respectively:

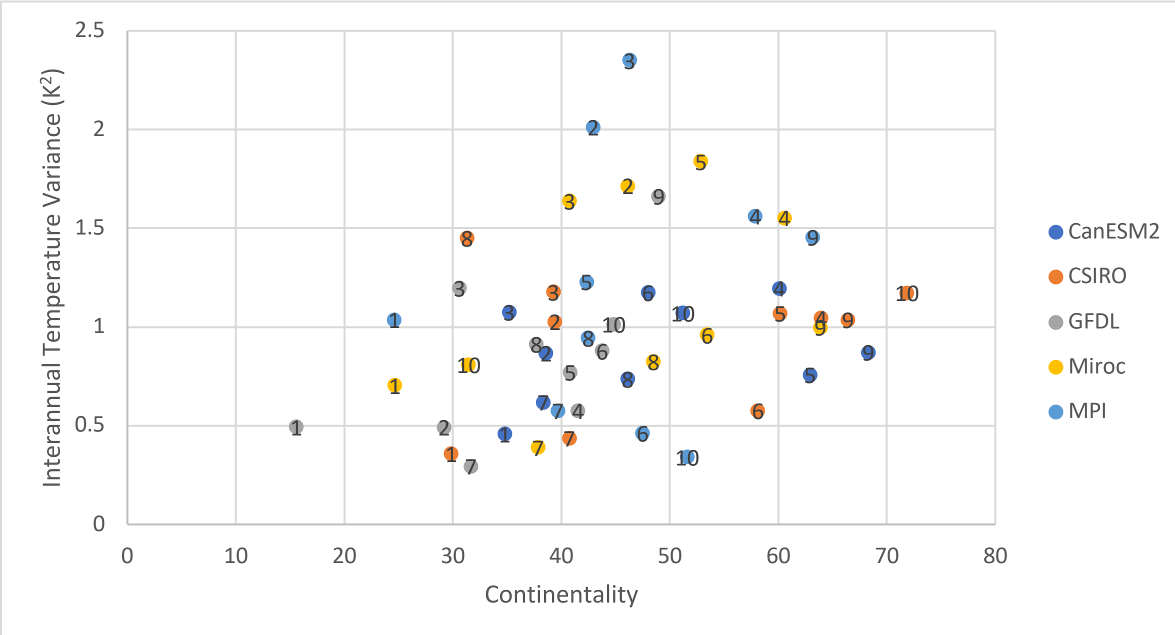



**Figure 1.** Interannual temperature variance plotted against the continentality index at 10 Canadian weather stations forecasted by 5 GCM's for 2006-2025. Interannual temperature variance is in units of Kelvin$^2$ while the continentality index is unitless. Blue, orange, grey, yellow and sky-blue dots represent the models CanESM2, CSIRO-MK3.6.0, GFDL-CM3, MIROC-ESM, and MPI-ESM-LR respectively. The numbers on the dots represent weather stations (refer to methods for weather stations details).

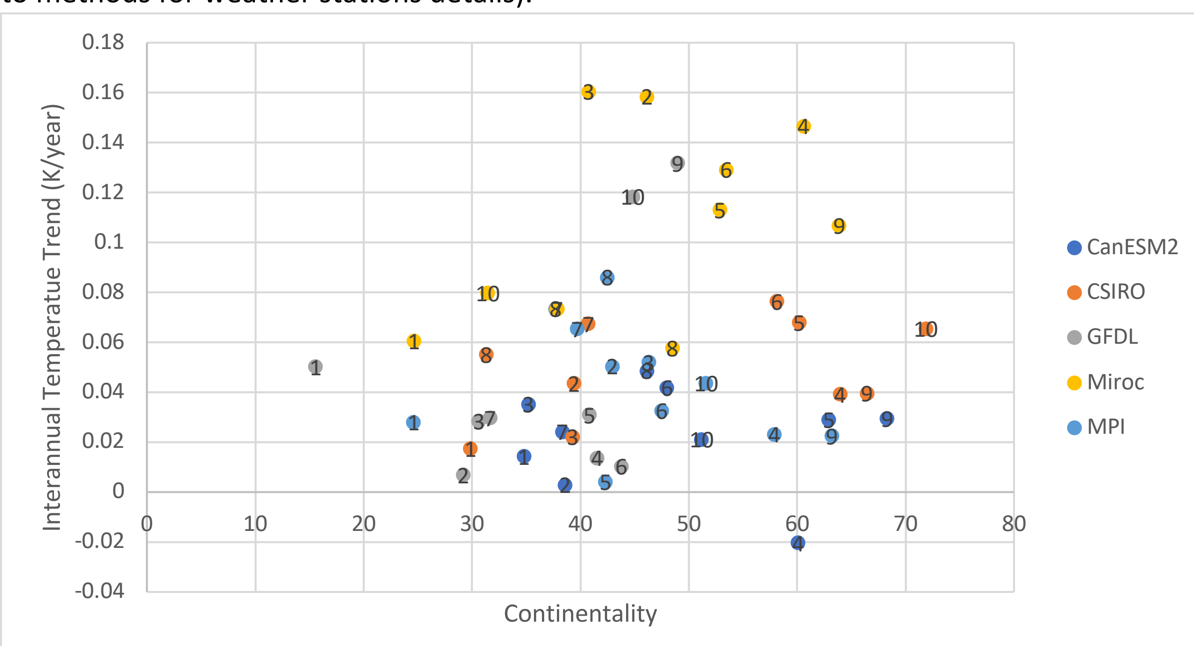



**Figure 2.** Interannual temperature trends plotted against the continentality index at 10 Canadian weather stations forecasted by 5 GCM's for 2006-2025. Interannual temperature trends are in units of Kelvins per year. Blue, orange, grey, yellow and sky-blue dots represent the models CanESM2, CSIRO-MK3.6.0, GFDL-CM3, MIROC-ESM, and MPI-ESM-LR respectively.

The numbers on the dots represent the weather stations (refer to methods for weather stations details).

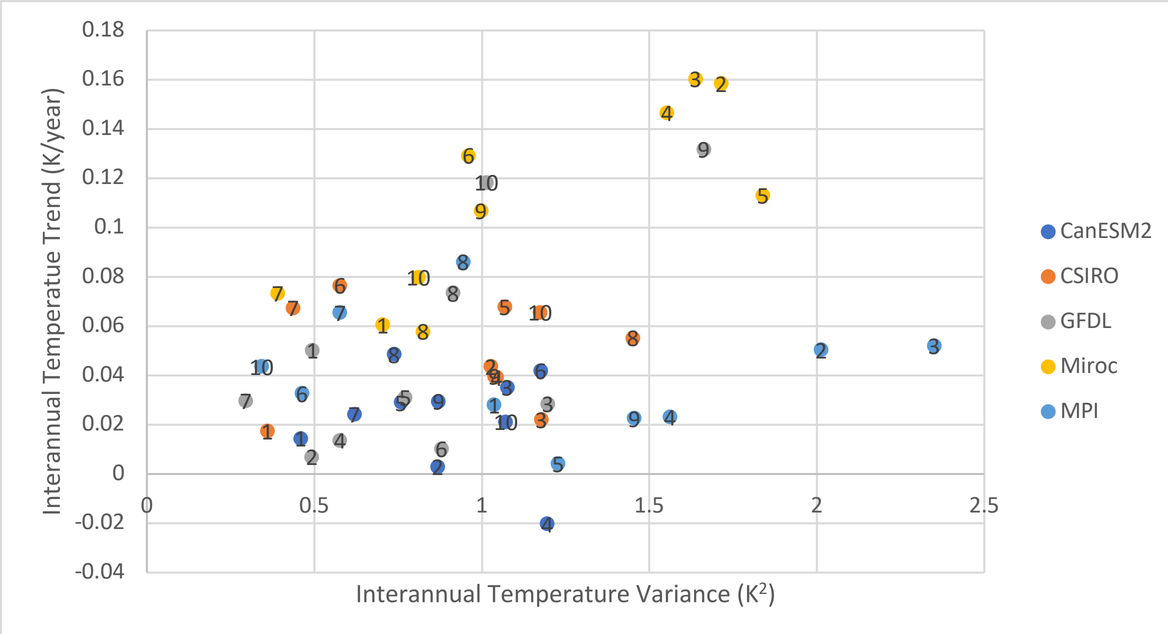



**Figure 3.** Interannual temperature trends plotted against interannual temperature variance for 10 Canadian weather stations forecasted by 5 GCM's for 2006-2025. Interannual temperature trends are in units of Kelvins per year, and interannual temperature variance is in units of $K^2$. Blue, orange, grey, yellow and sky-blue dots represent the models CanESM2, CSIRO-MK3.6.0, GFDL-CM3, MIROC-ESM, and MPI-ESM-LR respectively. The numbers on the dots represent the weather stations (refer to methods for weather stations details).

**Table 1.** Calculated correlation coefficients and t-values addressing the 3 objectives. T-values that show significance ($T>T_{critical}$) and that can reject the null-hypothesis are shown in green. Red otherwise. Refer to the introduction for the questions.

| Correlation Coefficients | Q1 | Q2 | Q3 |
|---|---|---|---|
| CanESM2 | 0.3137 | -0.1007 | -0.1566 |
| CSIRO | 0.1981 | 0.4163 | -0.0042 |
| GFDL | 0.5834 | 0.4043 | 0.6722 |
| MIROC | 0.4241 | 0.4617 | 0.8033 |
| MPI | 0.1411 | -0.2007 | -0.0897 |

| T-values | Q1 | Q2 | Q3 |
|---|---|---|---|
| CanESM2 | 0.9345 | -0.2864 | -0.4486 |
| CSIRO | 0.5719 | 1.2951 | -0.0119 |
| GFDL | 2.0318 | 1.2502 | 2.5685 |
| MIROC | 1.3248 | 1.4722 | 3.8155 |
| MPI | 0.4031 | -0.5796 | -0.2547 |

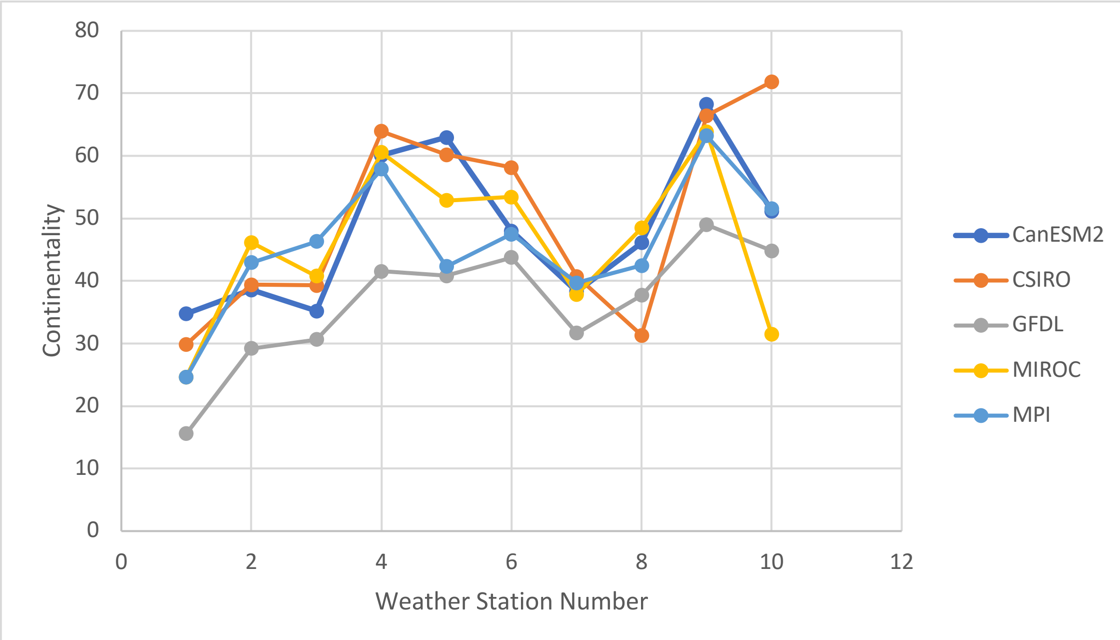



**Figure 4.** Continentality plotted against the 10 weather stations for 5 GCM's showing the differences between continentality indices (K) for each model. Blue, orange, grey, yellow and sky-blue dots with lines represent the models CanESM2, CSIRO-MK3.6.0, GFDL-CM3, MIROC-ESM, and MPI-ESM-LR respectively. Refer to methods for details of weather stations.

Discussion:

Based on the correlation and significance test conducted for each relationship there doesn't appear to be a conclusive agreement of these variables. Rather, the correlation values appear to depict weak relationships as indicated by the correlation values less than 0.5 in Table 1. Yet, there are some distinctions to note. In particular, the GFDL model depicts a strong correlation ($r > 0.5$) between continentality and interannual temperature variability as well as between temperature trends and interannual temperature variability. These relationships are further strengthened by their significance as indicated by their t-values being greater than $T_{critical}$ at a 90% confidence interval. There is also a significant and strong relationship for the MIROC models between interannual temperature variability and temperature trends. But for the other models, there is little correlation between these variables. This could be attributed to the fact that these models are inherently different. Upon looking at Figure 5, it is evident that these models have considerable differences in continentality values for each station. Significance of continentality is seen to vary in different regions where it is more significant in the coastal areas in the Eastern part of Canada and weakens in the western regions (Stonevicius et al., 2018). Additionally, the validity of the continentality index declines in relation to higher altitudes. The continentality formula utilized starts losing its validity at latitudes greater than 80$^{o}$ N/S (Conrad, 1946); however, station 10 is only located at 79.98$^{o}$N, and there already appears to be a large spread in continentality values. Its continentality varies as much as 41 Kelvins between the MIROC and CSRIO models.

Differences in the significance of relationships between different variables are also likely the result of the unique derivations of each model. Each model is created with specific equations and algorithms which ensures that results vary quite a bit between models. These differences in significance could also be associated with the biases of the models. Although all five models are based on the same RCP8.5 greenhouse gas emissions scenario, each model might be associated with different “storylines” and subsequently project different results (Moss et al., 2010). As the RCP scenarios are based on projections of future development, population growth, and societal responses, they assume emission targets to be achieved with policy actions based on different countries which could cause variations between models (Taylor, Stouffer, & Meehl, 2012). This could explain the lack of correlation in the relationships. Furthermore, this lack of correlation among these variables could have been improved with the utilization of more stations as only 10 were provided in the data. With more locations, it is possible that the relationships between continentality, temperature trends, and variability could become more evident as it very likely that certain locations’ temperature can be influenced by other local factors. It is important to take into consideration that although continentality is one measure to relate to location, location alone may not be a good indicator for temperature. For instance, Global Climate Oscillations like El Niño and other factors, could have taken place which can cause a temperature anomaly. Due to local drivers of temperature, having more locations will allow one to observe whether it is a particular location that gives anomalies due to other factors or several locations (Arblaster & Alexander, 2012). Regardless having more stations would have increased our confidence and perhaps allowed for more significance to be declared.

## Conclusion:

In conclusion, this study did not provide conclusive results on the prevalence of relationships between interannual temperature variability and continentality, temperature trends and continentality, and temperature trends and interannual temperature for the 5 GCM’s provided. For the first objective, only one model out of the 5 GCM’s at 10 weather station locations showed statistically significant correlation between interannual temperature variability and continentality. This allows for the conclusion that continentality and interannual variability are not statistically related. However, this could be due to a limitation of this study, such as the lack of locations or potentially due to the differences in continentality for the climate station locations or even on the basis that continentality is not a strong indicator of temperature variability. Nonetheless, the significance of this relationship for the GFDL model is intriguing and it implies that continentality and interannual temperature variability are in fact related for this instance. Further research should be done to explore these model-based differences in continentality. Additionally, research could be done to analyze the GFDL model to understand its prevalent correlation value for this relationship in comparison to other models. For the second objective which is highlighting the relationship between temperature trends and continentality, no single models depicted any correlation. This implies that there is no statistically significant relationship between temperature trends and continentality. Yet, given the fact that the dataset was limited, this could be further validated with the addition of more station locations. Lastly, for the third objective determining the relationship between interannual temperature variability and temperature trends, which is used to determine which one of these variables was more correlated with continentality, the results were once again inconclusive. The results show statistically significant correlation between these variables for the GFDL model and MIROC model only, thereby indicating that these variables are statistically related. Yet there is no statistical correlation for the other models. Thus, this relationship cannot be solidified with this data. The assumption going into this study was that statistically significant correlation would be found for Q1 and Q2, but this is not the case as this study consists of limitations. Continentality did not prove to be a strong indicator of temperature trends or variability. Therefore, it is recommended that model evaluations should consider local environments more strongly in the future; more locations should be added into the dataset and that atmospheric circulation should be taken into account alongside continentality for future research.

References:


Arblaster, J. M., & Alexander, L. V. (2012). The impact of the el Niño-Southern oscillation on maximum temperature extremes. *Geophysical Research Letters, 39*(20), 1-5.doi:10.1029/2012GL053409

Brooks, C. E. P. (1919). Continentality and temperature. *Monthly Weather Review*, *47*(9), 653-54. doi:10.1175/1520-0493(1919)47<653:CAT>2.0.CO;2

Conrad, V. (1946). Usual formulas of continentality and their limits of validity. *Eos, Transactions American Geophysical Union*, *27*(5), 663-64. doi:10.1029/TR027i005p00663

American Meteorological Society. (2012, February 20). Continentality. In *Glossary of Meteorology*. Retrieved February 11, 2019, from http://glossary.ametsoc.org/wiki/Continentality

CORREL function. (n.d.). Retrieved February 11, 2019, from https://support.office.com/en-us/article/correl-function-995dcef7-0c0a-4bed-a3fb-239d7b68ca92

Deser, C., Knutti, R., Solomon, S., & Phillips, A. S. (2012). Communication of the role of natural variability in future north american climate. *Nature Climate Change*, *2*(11), 775-79. doi:10.1038/nclimate1562

Hirschi, J. J., Sinha, B., & Josey, S. A. (2007). Global warming and changes of continentality since 1948. *Weather, 62*(8), 215-21. doi:10.1002/wea.88

Janda, K. (2001). *Significance of the Correlation Coefficient* [web page]. Retrieved from http://janda.org/c10/Lectures/topic06/L24-significanceR.htm?fbclid=IwAR3rbW0o7mwWigIYzU7OHy1ESum8e9BV7EpO3O6xFBusyo2qysGBellnB3Y

Moss, R. H., Edmonds, J. A., Hibbard, K. A., Manning, M. R., Rose, S. K., van Vuuren, D. P., . . . Wilbanks, T. J. (2010). The next generation of scenarios for climate change research and assessment. *Nature, 463*(7282), 747-56. Retrieved from doi:10.1038/nature08823

Present your data in a scatter chart or a line chart. (n.d.). Retrieved February 11, 2019, from https://support.office.com/en-us/article/present-your-data-in-a-scatter-chart-or-a-line-chart-4570a80f-599a-4d6b-a155-104a9018b86e

STDEV.S function. (n.d.). Retrieved February 11, 2019, from https://support.office.com/en-us/article/stdev-s-function-7d69cf97-0c1f-4acf-be27-f3e83904cc23

Stonevicius, E., Stankunavicius, G., & Rimkus, E. (2018). Continentality and oceanity in the mid and high latitudes of the northern hemisphere and their links to atmospheric circulation. *Advances in Meteorology*, 2018, 1-12. doi:10.1155/2018/5746191

Szymanowski, M., Bednarczyk, P., Kryza, M., & Nowosad, M. (2016). Spatial interpolation of ewert's index of continentality in poland. *Pure and Applied Geophysics, 174*(2), 623-42. doi:10.1007/s00024-016-1413-x

Taylor, K. E., Stouffer, R. J., & Meehl, G. A. (2012). An overview of cmip5 and the experiment design. *Bulletin of the American Meteorological Society, 93*(4), 485-98. doi:10.1175/BAMS-D-11-00094.1

Thornton, P. K., Ericksen, P. J., Herrero, M., & Challinor, A. J. (2014). Climate variability and vulnerability to climate change: A review. *Global Change Biology, 20*(11), 3313-28. doi:10.1111/gcb.12581

Van Belle, G., Fisher, L., Heagerty, P. J., & Lumley, T., (2004). *Biostatistics: A methodology for the health sciences* (2nd ed.). Hoboken, NJ: John Wiley & Sons.

VAR.S function. (n.d.). Retrieved February 11, 2019, from https://support.office.com/en-us/article/var-s-function-913633de-136b-449d-813e-65a00b2b990b

Vázquez, D. P., Gianoli, E., Morris, W. F., & Bozinovic, F. (2017). Ecological and evolutionary impacts of changing climatic variability. *Biological Reviews, 92*(1), 22-42. doi:10.1111/brv.12216

VilÄek, J., Škvarenina, J., Vido, J., Nalevanková, P., Kandrík, R., & Škvareninová, J. (2016). Minimal change of thermal continentality in slovakia within the period 1961–2013. *Earth System Dynamics*, *7*(3), 735-744. doi:10.5194/esd-7-735-2016

Vlăduţ, A., Nikolova, N., & Licurici, M. (2018). Evaluation of thermal continentality within southern romania and northern bulgaria (1961-2015). *Geofizika, 35*(1), 1-18. doi:10.15233/gfz.2018.35.1

Appendix – Student Contributions:

David- Methods, Discussion, working on excel to derive correlation and other variables, graph and chart creation
Tobias-Methods, Discussion, working on excel to derive correlation and other variables, graph and chart creation
Jasmin – Abstract, Introduction, Discussion, Conclusion
Augusta – Introduction, Result (Figures and table captions), Discussion, Citations

Modelling Assignment Oral Presentation

# Modelling the Impact of Different Anthropogenic $CO_2$ Scenarios on the Internal Energy of Earth from 1850-2100

ENVR 300 201
Modeling project E

Jasmin Senghera,
Lisa Xu,
Shuting Zhao,
Andersen Ko

## Introduction

**Research Questions:**
a) What is the internal energy of the Earth?
b) What is the evolution in time of Earth's temperature?

**Relevance:**
These questions are relevant to be answered now as globally there continues to be a rise in greenhouse gas emissions. $CO_2$ emissions are particularly concerning as atmospheric $CO_2$ was at 320 ppm in 1960 and is at 410 ppm today. This increase of atmospheric $CO_2$ contributes to the GHG effect, resulting in global warming. Thus, investigating the internal energy and temperature of Earth over time could provide insight on potential GHG mitigation options.

**Model Assumptions:**
-there are only two reservoirs (internal energy of atmosphere and internal energy of Earth)
-the atmosphere reservoir is always in a steady state
-Earth is roughly in a steady state with a temperature of 287.8 K
-changes of $f_a$ (fraction of outgoing radiation from Earth that is absorbed by atmosphere) indirectly represent changes due to anthropogenic emissions of $CO_2$
-that values of $K_E$, $K_A$, a, $f_b$, $R_a$, and S are constant

# Model Description: Model Parameters/Initial Conditions

The initial conditions were such that $f_a$ was 0.898. The parameter values were:

$K_E$ - a constant heat capacity of earth = 1.68 x $10^{10}$ J/K

$T_E$ - temperature of earth reservoir = 287.8 K or 14.65 degree Celsius

a - the total albedo of the Atmosphere-Earth system = 0.313

$f_b$ - the fraction of incoming solar energy absorbed by A = 0.200

$f_a$ - the fraction of outgoing radiation from E that is absorbed by A = 0.898

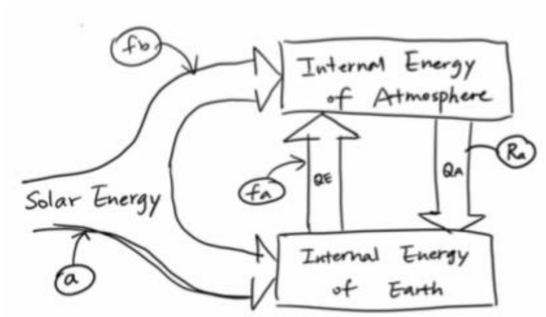
$R_a$ - the fraction of atmospheric radiation that is radiated toward and absorbed by E = 0.507

S - the total solar flux entering the earth-atmosphere system = 342 W $m^{-2}$

$Q_E$ - the earth energy flux or longwave radiation radiated from E =$\sigma$ $T_E^4$ ($\sigma$ = 5.67 x $10^{-8}$ W/$m^2K^4$)

delta t - the timestep of 1 year (31536000 seconds)

## Model Description




**Transition From Conceptual to Mathematical Model**

To move from this conceptual model to the mathematical model we derived the following mathematical relationships between the processes (the inflows and outflows of the atmosphere & Earth) and converters (a, $f_b$, $R_a$,$f_a$):

Solar energy coming into the Earth-Atmosphere system= S

Solar energy absorbed by Atmosphere = S*$f_b$* (1-a)

Solar energy absorbed by Earth = (S(1-a)) x (1-$f_b$)

Energy radiated from Earth absorbed by Atmosphere = $Q_E$ x $f_a$

Energy radiated from Atmosphere absorbed by Earth = $Q_A$x $R_A$

## Model Description: Mathematical Model

To determine the mathematical model then, we utilized the above relationships to create an equation for the change in internal energy of the Earth and the temperature of the atmosphere. Since we weren't dealing with the temperature of the atmosphere we substituted the equation for it, into the Earth equation to eliminate $T_A$.

The resulting equation was: $K_E dT_E/dt = S(1-a)*(1-f_b + f_b*R_a) + \sigma\ T_E^4(f_a R_a - 1)$

The forward difference equation used in modelling was:
$dT_E(t + \text{delta } t) = [(S(1-a)*(1-f_b + f_b*R_a) + \sigma\ T_E^4(f_a R_a - 1))/K_E]*\text{delta } t$

## Results: Question 1

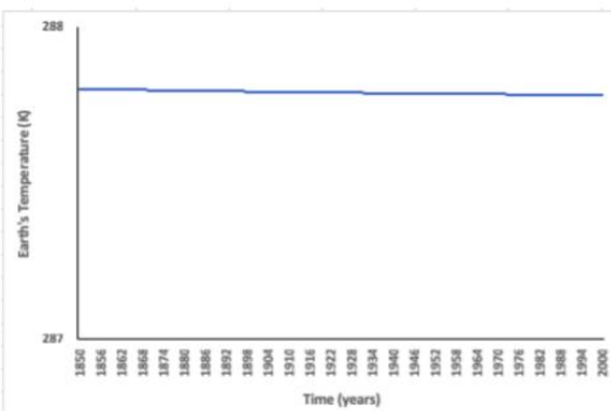
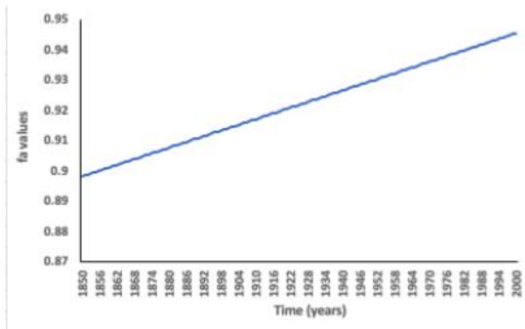



**Figure 1**. Change in Earth's temperature (K) from 287.80K in 1850 to 287.78K in 2000

**Answer:** While the Earth's temperature does decline by approx. 0.02K from 1850 to 2000, it does so at an order of less than 0.001K/yr and can therefore considered negligible. Thus, Earth's temperature effectively reaches a steady state at 287.8K when we start the run with $T_E$=287.8K

# Results: Question 2



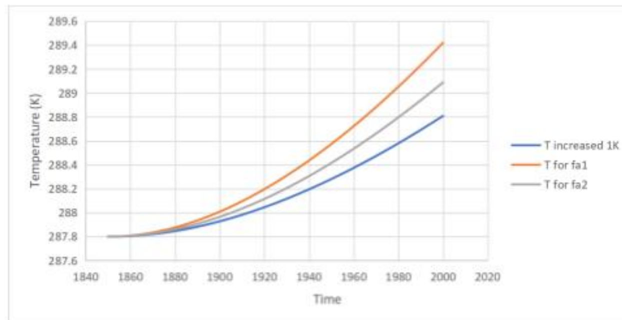




**Figure 2.** The increase fa (the fraction of outgoing radiation by Earth absorbed by atmosphere) must encounter to create a 1K increase in the Earth's temperature between 1850 and 2000. The alpha value utilized is 0.000315.

**Answer:** To raise Earth's temperature by 1K between 1850 and 2000, fa must increase by 0.000315 on a yearly basis. Thus, over these 150 years fa increases by 0.04725.

# Results: Question 3

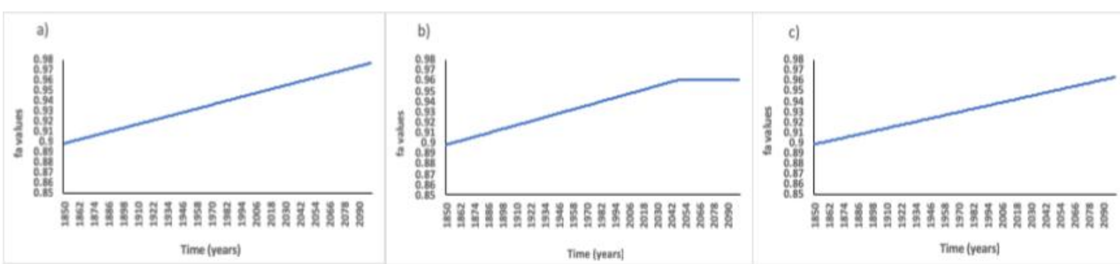



**Figure 3.** A representation of how fa changes with different scenarios from 1850 to 2100. Scenario a) represents the business as usual scenario, scenario b) represents the mitigation scenario and scenario c) represents the scenario that would limit global warming since 1850 to 2K by the end of 2100. In scenarios a and b, alpha is 0.000315, while in c it is 0.00026.

**Answer:** The change in $f_a$ relates to change in atmospheric carbon dioxide (ppm) per year via the equation 3968.3x - 3381 = y, where y represents $CO_2$ and x represents fa.

# Results: Question 4

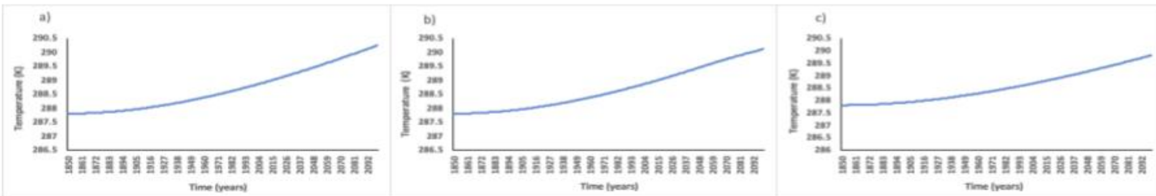



**Figure 4.** A representation of how $T_E$ changes with different scenarios from 1850 to 2100. Scenario a) represents the business as usual scenario, scenario b) represents the mitigation scenario and scenario c) represents the scenario that would limit global warming since 1850 to 2K by the end of 2100. In scenarios a and b, alpha is 0.000315, while in c it is 0.00026.

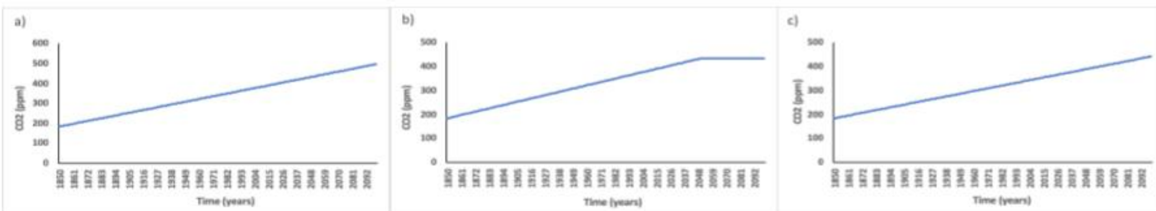



**Figure 5.** A representation of how $CO_2$ changes with different scenarios from 1850 to 2100. Scenario a) represents the business as usual scenario, scenario b) represents the mitigation scenario and scenario c) represents the scenario that would limit global warming since 1850 to 2K by the end of 2100. In scenarios a and b, alpha is 0.000315, while in c it is 0.00026.

**Answer:** For scenario b it takes approximately 250 years to reach a new steady state

# Conclusion

### Summary of the Results

- $T_E$ changes with $f_a$ over time, the more $f_a$ increseas, the more $T_E$ increseas.
- The internal energy of earth equals to [incoming solar energy absorbed by Earth] + [atmospheric radiation absorbed by Earth] – [radiation from Earth radiated to space]
- So earth temperature has been increasing over time and it increases with anthropogenic $CO_2$ concentrations.

### Discussion & Limitations & Implication

- In our model, $T_E$ is only affected by the value of $f_{a,}$ while in real world, solar energy, albedo, and other minor components of the atmosphere also affect climate, like aerosols.
- We assumed that changes of $f_a$ indirectly represent the changes due to the anthropogenic emissions of $CO_2$, however, $f_a$ can be affected by other greenhouse gases such as methane, nitrous oxide and ozone.
- One of our limitations is that we only investigate the anthropogenic CO2 concentration, and we didn't determine whether the natural CO2 concentration increases. For future research, scientists can consider how to make CO2 as an alternative sources of fuels and other technology.
- There is an implication that a higher CO2 concentration will stimulate the photosynthetic process, therefore helps plants grow.( Goudriaan, J., & Unsworth, M. H. ,1990.)

# Reference

Goudriaan, J., & Unsworth, M. H. (1990). Implications of increasing carbon dioxide and climate change for agricultural productivity and water resources. *Impact of carbon dioxide, trace gases, and climate change on global agriculture*, (impactofcarbond), 111-130.

# Appendix

Jasmin Senghera - Q1, intro, title, model description

Lisa Xu- Q2, conclusion, ppt arranging.

Shuting Zhao - Q3, limitation, implication

Andersen Ko - Q4

# Research Proposal Final Version

**Working Title:**

A Comparative Analysis between Hydroponic and Traditional Greenhouse Methods of Red Tomato Production Using Different Light Sources in Nezahualcóyotl, Mexico.

**Summary:**

This proposal aims to determine the feasibility of cultivating red tomatoes (*Solanum lycopersicum*) via traditional greenhouse methods and three types of hydroponic methods using natural sunlight and LED lighting in Nezahualcóyotl, Mexico. This feasibility will be investigated based on financial costs, environmental strains, and energy parameters. This investigation is relevant at this point in time as the land of Nezahualcóyotl is infertile, external food sources are unreliable, and water is a limited resource. Thus, food security is an increasingly heightened issue faced by the residents. This investigation will then allow the government to determine if these urbanized forms of agriculture could persist in Nezahualcóyotl.

**Introduction:**

With projections of a world population being 70% urbanized by 2050, there are growing concerns for the food security of cities (Al-Chlabi, 2015). Nezahualcóyotl in Mexico is a city that alongside poverty faces these food security issues due to land unsuitable for traditional agriculture and due to the scarcity of water (Anda & Shear, 2017). Hydroponics, the crop cultivation method that utilizes nutrient solutions instead of soil could have potential in this region (Lee & Lee, 2015). Similarly, traditional greenhouse methods could be plausible based on the availability of land to implement greenhouses (USAID, 2017). Yet, little research has been conducted to determine the environmental strains or the cost-effectiveness of these agricultural methods in a city like Nezahualcóyotl where field-based farming is not viable. Furthermore, with red tomatoes (*Solanum lycopersicum*) being such a staple component of Mexican cuisine, there hasn't been much research involving production of these tomatoes in Mexico via urban agricultural methods either (Lares-Michel et al., 2018).

Based on this gap of literature, this research project aims to conduct an experiment using three types of hydroponic methods and a traditional method to cultivate red tomatoes (*Solanum lycopersicum*) using different light sources to determine the feasibility of such methods in Nezahualcóyotl. Subsequently there will be an analysis of the financial costs, the environmental strain via energy and water usage, and the quality of the crops via various quality parameters. Thus, the following research questions need to be addressed:

- What are the differences in quality (based on yield, tomato size, ascorbic acid content, beta-carotene content) of the tomatoes produced between traditional

greenhouse methods and hydroponic methods with natural light and LED lighting?
- What are the differences in energy consumption and cost in tomato production between traditional greenhouse methods and hydroponic methods with natural light and LED lighting?
- What are the differences in water consumption and cost in tomato production between traditional greenhouse methods and hydroponic methods with natural light and LED lighting?
- Based on the previous questions which production method is most cost-effective and environmentally sustainable for a city like Nezahualcóyotl, while maintaining quality?

Currently in Mexico over half the land is insufficient for agricultural farming and there appears to be an increasing scarcity of water. From 2007 up until 2017, Mexico's rural crop productivity has been less than 1.1% (Anda & Shear, 2017). This is concerning since the majority of its population suffers from nutritional health problems (Rivas & Galicia, 2017). Nezahualcóyotl is a city of particular interest due to its history of slum-like conditions where there has been difficulty in providing basic services to its low-income population (Aguilar, 2002). Moreover, this region isn't very well-suited to agriculture due to its presence on what was the Lake Texcoco (Mazur, 1994). Salt deposits left behind from the lake have rendered the land infertile (Yee, 2017). This means that there is no local source of fruits and vegetables and those that are bought from rural regions in Mexico are not entirely safe due to the prevalence of untreated sewage in irrigation and that which is rising into the air (Mazur, 1994). The cultivation of red tomatoes in particular is problematic within field-based agriculture due to frequent pesticide usage (Lares-Michel et al., 2018). Thus, investigating the feasibility of hydroponics and traditional greenhouse production of tomatoes, which are both culturally significant and nutritious, is relevant at this point in time because Nezahualcóyotl is not at all food secure.

**Methods:**

This experiment will be advised to occur on a plot of land adjacent to the Cinema in Nezahualcóyotl. It will be proposed that 2 separate 8 X 12 greenhouses be constructed on this land to facilitate the experiment. There will be effectively four different treatments in which each treatment will consist of 50 seeds in individual pots which are in 5 replications of 10 seeds each. The treatments are traditional greenhouse tomato production methods and three types of hydroponic tomato production methods.

The hydroponic methods are the wick system, the drip system, and the aeroponic system. The wick system utilizes a wick to deliver both the nutrient solution and water. The drip system utilizes a pipe system in which an electrical motor delivers nutrients and water through a pipe to the plant once a day (Kaur et al., 2018). These two methods will require a medium of peat and vermiculite (Kaur et al., 2018). The aeroponic system on the other hand does not require any medium (Lee & Lee, 2015). The water and nutrient solution are delivered via a misting system where they are misted towards the roots based on an electrical timer once a day. The greenhouse method will use organic production methods where the medium utilized is soil combined with peat and vermiculite (Carballo-Mendez et al., 2018). Additionally, for the greenhouse methods water and nutrients will be delivered once on a daily basis while compost will be supplemented prior to the growing season (Carballo-Mendez et al., 2018).

Within these treatments there are 2 different scenarios one in which only natural sunlight is utilized to supply energy to the plants and the other in which LED light is constantly provided as energy to retain consistency. These scenarios will occur in separate greenhouses. The hydroponic system will not require pesticides as it is noted to be resilient in the face of pests and disease (Anda & Shear, 2017). In terms of pest production in the greenhouse methods, there also will be no synthetic pesticides or herbicides utilized. Pests will be treated only if necessary, with microbials such as Safer Soap which includes potassium salts of fatty acids (Letourneau & Goldstein, 2001). Overall, the crops will be examined twice on a daily basis to ensure that there are no active production risks such as pests or disease.

The winter crop will be sown in July and is expected to be harvested in December. While the summer crop will be sown in October and is expected to be harvested in April (Kaur et al., 2018). Once the tomatoes are harvested, they will be analyzed for each method based on yield, weight, ascorbic acid content, beta carotene content. Yield will be determined based on the amount of tomatoes produced per plant, weight will be determined by the average weight of the tomatoes per plant, and ascorbic acid and beta carotene content will be determined using spectrophotometry (Gautier et al., 2008; Kaur et al., 2018). These quality parameters will be quantitatively compared to determine which method produced the healthiest tomatoes. Subsequently the energy and water consumption for the tomato production methods in natural and LED light will be computed. This will allow the determination of the financial costs associated with these environmental strains, thereby allowing for a cost-effectiveness analysis.

**Budget:**

The budget values mentioned below in USD were computed based on a case study of a hydroponics farm in Brazil (Souza et al., 2019).

| Item | Cost |
|---|---|
| Greenhouse Production (192 $m^2$) | \$11,000 USD |
| Electric System | \$6,600 USD |
| Hydraulic System | \$5,000 USD |
| Misting System | \$1,700 USD |
| Soil (1250$m^2$) | \$600 USD |
| Nutrient Solution | \$2,600 USD |
| Pesticides (if needed) | \$800 USD |
| Seeds | \$900 USD |
| Compost | \$1,600 USD |
| Peat and Vermiculite | \$1,600 USD |
| Pots | \$250 USD |

| | |
|---|---|
| Cotton Wicks (for drip system) – (Kaur et al., 2018) | $20 USD |
| HPS 600 W lamp lights – (Al-Chlabi, 2015) | $800 USD |
| Water Consumption – 1L required per square foot daily in hydroponics (Al-Chlabi, 2015) | $8,000 USD |
| Energy Consumption via Lighting – for hydroponics the crops require 18 hours of lighting a day (Al-Chlabi, 2015) | $6,000 USD |
| Spectrophotometry (for ascorbic acid/beta-carotene content) – (Kaur et al., 2018) | $200 USD |
| Field Assistants – 2 for 2 years | $40,000 |
| Total | $87, 670 |

**Timeline:**

- A month must be allotted to the construction of the greenhouse and preparation of supplies
- The winter crop will be sown in July in 2020 and 2021, harvest should occur around November/December of 2020 and 2021 (Kaur et al., 2018)
- Following the harvesting process, the quality parameters as well as the consumption parameters will be determined immediately
- The summer crop will be sown in October in 2020 and 2021, harvest should occur around March/April of 2020 and 2021 (Kaur et al., 2018)
- Following the harvesting process, the quality parameters as well as the consumption parameters will be determined immediately

**Implications:**

This comparative analysis will allow the government of Nezahualcóyotl to understand how traditional greenhouse and hydroponic crop production work. Subsequently, it will help them determine whether either of these methods are viable in Nezahualcóyotl based on the needs of this region. In terms of the general public, this investigation will be impactful as it too will allow them to be more educated in regard to these forms of protected urban agriculture. Furthermore, it will draw more attention to the need for food security within Nezahualcóyotl. In the academic world, this kind of research can allow for further analyses in other parts of Mexico or even around the world either using the same hydroponic methods or different ones. Research could also be done growing different fruits and vegetables to compare the economic and environmental costs.

Total word count: 1620

**Revisions:**

a) Change the title to include the “when” component

My peer reviewer suggested that I change my proposal title to include the “when” component. I actually ended up not making this change on the basis that I felt my title was already informative. Since I’m not looking back at the past or projecting for the future, I didn’t feel the need to include my timeline in the title. I do understand why my peer reviewer made this suggestion as time is really helpful in understanding the purpose of a research paper. However, as I mentioned before my project will occur in present time and so I don’t think that needs to be explicitly stated in the title.

b) Explain why red tomatoes are chosen to be the experimenting species

I’m really glad that my peer reviewer brought this suggestion up, as I had completely forgotten about it. Explaining why I choose red tomatoes is very important in my proposal. Thus, I took this advice and I included some reasoning in the introduction to explain the significance of red tomatoes to my project. This was important because I imagine that if I proposed my project as it was, it would have been very confusing, and it would have weakened the proposal.

c) Include complete and explicit costs of all requirements

This was another suggestion that I was really thankful for. I initially felt a bit stressed thinking about the costs associated with my project as I felt the need to make them as accurate as possible. But I realized that after reading my peer reviewer’s proposal, it would be okay to make some estimates. Thus, I included complete costs for my budget. This was a necessary adjustment to make as when proposing research, I would need to be fully aware of the costs associated so I can apply for necessary research grants.

d) Add more to the implications in regard to the general public

This was a suggestion that I didn’t actually think about. I didn’t realize how important it would be to appeal to the general public in my research project. As my peer reviewer mentioned, this is important to do so because it would allow the public to feel connected to the project as it has the potential of changing their lives. Thus, I added a few sentences within the implications to mention the impact in relation to the public.

e) Add to the implications, what your experiment has not done yet

While I understand this suggestion, I felt that the implications already encompassed this. I did mention in the implications already what other research could be conducted; thus I did not make any further changes.

**References:**

Aguilar, M. (2002). Identity and daily space in two municipalities in Mexico City. *Environment and Behaviour*, 34, 111-121. Retrieved from https://journals-sagepub-com.ezproxy.library.ubc.ca/doi/pdf/10.1177/00139165020340010 08

Al-Chlabi, M. (2015). Vertical farming: Skyscraper sustainability? *Sustainable Cities and Society*, 18, 74-77. http://dx.doi.org/10.1016/j.scs.2015.06.003

Anda, J., & Shear, H. (2017). Potential of vertical hydroponic agriculture in Mexico. *Sustainability,* 9, 1-17. https://doi.org/10.3390/su9010140

Carballo-Mendez, F., Rodriguez-Ortiz, J., Alcala-Jauregui, J., Rodriguez-Fuentes, H., & Preciado-Rangel, P. (2018). Comparison of two organic determinate tomato production systems in a controlled environment. *Intercencia,* 1, 62-65.

Gautier, H., Diakou-Verdin, V., Benard, C., Reich, M., Buret, M., Bourgard, F., . . . Genard, M. (2008). How does tomato quality (sugar, acid, and nutritional quality) vary with ripening stage, temperature, and irradiance? *Journal of Agricultural and Food Chemistry,* 56, 1241-1250. https://doi.org/10.1021/jf072196t

Kaur, H., Bedi, S., Sethi., V., & Dhatt, A. (2018). Effects of substrate hydroponic systems and different N and K ratios on yield and quality of tomato fruit. *Journal of Plant Nutrition*, 41, 1547-1554. https://doi.org/10.1080/01904167.2018.1459689

Lares-Michel, M., Housni, F., Cervantes, V., Nava, R., Del Toro, H., Canedo, C., & Carmona, M. (2018). The relationship between consumption, socioeconomic level and reasons of tomato intake in Mexico. *Agricultural Sciences,* 9, 777-791. https://doi.org/10.4236/as.2018.97055

Lee, S., & Lee, J. (2015). Beneficial bacteria and fungi in hydroponic systems: Types and characteristics of hydroponic food production methods. *Scientia Horticulturae,* 195, 206-215. http://dx.doi.org/10.1016/j.scienta.2015.09.011

Letourneau, D., & Goldstein, B. (2001). Pest damage and arthropod community structure in organic vs. conventional tomato production in California. *Journal of Applied Ecology,* 38, 557-570. https://doi.org/10.1046/j.1365-2664.2001.00611.x

Mazur, L. (1994). *Beyond the numbers: A reader on population, consumption, and the environment.* Washington, DC: Island Press

Orsini, F., Kahane, R., Nono-Womdim, R., & Gianquinto, G. (2013). Urban agriculture in the developing world: A review. *Agronomy for Sustainable Development*, 33, 695-720. https://doi.org/10.1007/s13593-013-0143-z

Page, G., Ridoutt, B., & Bellotti, B. (2011). Carbon and water footprint tradeoffs in fresh tomato production. *Journal of Cleaner Production*, 32, 219-226. https://doi.org/10.1016/j.jclepro.2012.03.036

Rivas, M.J., Galicia, L. (2017). Rethinking food security in Mexico: Discussing the need for sustainable transversal policies linking food production and food consumption. Investigaciones Geograficas, 94, 106-121. https://doi.org/10.14350/rig.57538

Souza, S., Gimenes, R., & Binotto, E. (2019). Economic viability for deploying hydroponic system in emerging countries: A differentiated risk adjustment proposal. *Land Use Policy,* 83, 357-369. https://doi.org/10.1016/j.landusepol.2019.02.020

USAID. (2017). Mexico. *LandLinks*. https://www.land-links.org/wp-content/uploads/2011/03/USAID_Land_Tenure_Mexico_Profile_Revised-December-2017.pdf

Yee, D. (2017). Shantytown Mexico: A visual history of Ciudad Nezahualcóyotl. *The Center for the Study of Inequalities*. https://inequality.studies.stonybrook.edu/wordpress/writing-ine-j/graduate-affiliate-research-reflections/david-yee/

# ENVR Journal 1

Throughout university reading papers has been a form of agony for me. Analyzing pages upon pages of vernacular with few simplified visuals is a dreadful process. Thus, when I read papers, I typically resort to skimming. Naturally, when I came across the Deser paper, I went in with this same defeatist mindset. Rather than focussing on the summary assignment at hand with the clear components already outlined, I sifted through the paper and formulated a summary without truly understanding what the conclusions were. But it was Thursday's class that made me realize that understanding scientific papers doesn't have to be all that difficult. The way in which the class was divided into groups, which each had to translate their designated component of the paper was visually very helpful for me. The moment of realization was very significant because often times when it comes to analyzing science, I enter the scenario with a negative attitude, but by utilizing the process of science, the constituents of a paper from the motivation to the objective to the method and to the results, I was readily able to determine what the conclusions made were and how they were formulated. This will impact the way I do things forward as I will no longer perceive papers as impossible, rather I will use the process of science to dissect the paper into its parts to make sense of it. In general I will work to not approach any scenario with a pessimistic attitude.

# ENVR Journal 2

This week we were tasked with formulating a proposal for a data analysis project in groups. We were provided with temperature data from 10 stations across Canada for past years as well as for future years projected by global climate models. While, we haven't done any data analysis yet, we have experienced difficulties in the proposal stage. Issues arose especially when it came to outline our research questions. The questions we formulated were very ambitious and didn't really account for the data analysis process. After talking to the professor, we actually got rid of our previous questions and made new ones. With hopes to go to graduate school, this was eye-opening as it made me realize that data analysis is no easy task and it requires a lot of thought about the outcomes of the analysis and the process of it. Knowing this, will help me in the future when I plan on conducting my own research and analyzing data that I retrieve. In terms of deciding what data analysis would be right for our project we realized that it was important to understand what exactly the objectives were by including the relationships we wanted to determine as well as the variables we wanted to correlate. Additionally, we needed to think about the statistics we were going to use to quantify these relationships. For example, in our project we are going to determine the correlation between interannual temperature variability and continentality in these GCM's and to do this we will need to calculate standard deviations of the temperatures, continentality of these locations, and a correlation coefficient to determine if there is some sort of relationship between these variables. Thus, in choosing the correct methods for analyzing data one must have specific research questions in order to align them with the necessary statistics for analysis.

# ENVR Journal 3

These past two weeks of focussing on the individual research proposals were somewhat stressful. I found it particularly difficult to transition from conceptual thinking to the practical detail needed to achieve my research goal. My initial topic of interest was urban agriculture based on an article I had read about Nezahualcóyotl, Mexico, rising as a city from being previously dubbed as one of the worst slums. I was particularly interested in how urban agriculture could aid this city. Initially my proposal was focussed on determining mainly the feasibility of hydroponics in Neza. But what I had not realized was that agriculture isn't viable at all in this region based on soil infertility. I had also planned on having LED lighting only in the hydroponics methods. But this wouldn't have made it a fair and controlled experiment. It became apparent that I needed to do some more research. This moment was very significant to me because it made me realize that research projects and proposals involve a lot of thought and effort. As someone who is interested in attending graduate school, knowing of the difficulties of this process is very important. After talking with the professor, I did manage to refine my proposal by focussing on the feasibility of both hydroponics methods and traditional greenhouse methods, but it was a tumultuous process thinking of all the expenditures and the time it would take to conduct this project. Thus, this experience will definitely impact me in how I propose my own research in the future as it will allow me to be more confident and aware of the process.

# ENVR Journal 4

My group and I were tasked with modelling the internal energy of Earth with different $CO_2$ scenarios this week. Having no experience or understanding of climate change modelling, this was a very enlightening and challenging process. For the first component of the project, I really struggled with figuring out the mathematical equation of the model. It seemed so difficult to me to understand how to account for all the processes that occur in the atmosphere and Earth. Instead of creating a conceptual model, I went straight to thinking about equations which made it even more frustrating. However, after talking to the professor I quickly realized that I needed to start with baby steps. I also had some difficulty in applying the mathematical equation to the questions we needed to answer. Once again, I kept on rushing to get the questions answered, but in the process, I was making mistakes. Here, I realized again that I needed to be patient when working through climate modelling. Thus, I would say that the most difficult part of this modelling project was dealing with the mathematical equations as it requires a lot of patience and focus. This process made me realize that I need to work on being more patient when working with conceptual models and try not to rush things. I also learned that building a conceptual and mathematical model of a system like the Earth's is very challenging. Moving forward, I will work on taking a more relaxed approach when working on modelling projects or any project for that matter.

# Written Explanation

Coming into ENVR 300, my main goals consisted of gaining confidence in oral presentations, becoming more environmentally conscious, and devoting time to self-reflection. In making this portfolio, I've realized that not only have I achieved these goals, but I have also grown as an individual. Reading through my journals and assignments I can see that I have become more aware of the environment and I have become comfortable in expressing my thoughts to others. Additionally, I have learned a lot about the nuances of environmental research within modelling and manipulating data. Thus, completing this portfolio was exciting as it allowed me to reflect on my experience in ENVR 300 and it has made me think differently about how I will move forward in my environmental science career.

The first component of this portfolio is my reading scientific papers assignment. I chose this assignment because it aligns with my goals of being environmentally aware and self-reflecting. I had never realized that climate projections models could be so affected by natural variability making them less definitive for particular regions. This was fascinating to discover, and it made me realize that we need to be careful when applying climate models. This assignment also embodies my growth in thinking. While completing this assignment, I had a negative mindset as I do not enjoy reading scientific papers. Thus, initially I had quickly sifted through the paper and formed conclusions without understanding them. However, an activity we completed in class where we divided the paper into its components taught me that reading papers isn't all that difficult. Since then, I have adopted this method and I have successfully read multiple scientific papers.

The second component is a paper I wrote in response to a video about smart cities in India for a planning course. I chose this paper because it also encompasses my goals of self-reflection and increased environmental consciousness. Prior to watching the video, I imagined that smart cities in India were focussed on using technology to improve the environment and subsequently improve the welfare of their citizens. But, the outcome of India's smart city agenda is these tech-based cities focused on money at the expense of the environment by destroying ecosystems and building skyscrapers. This made me reflect on myself and how fortunate I am to live in a country where the environment and accessibility to basic resources are of utmost importance. This assignment also made me realize my interest for social and community planning as I feel strongly about helping to make citizens and the environment a priority in India.

The third and fourth components of my paper are the data and modelling assignments we completed in groups. I chose these assignments because they allowed me to gain confidence in presentations and learn about environmental research. For the data assignment, our goal was to determine whether continentality was an indicator of temperature. We found that our results were inconclusive which was upsetting, yet we realized that there could be valid reasoning behind these results. This taught me that often times in research you won't get the results you anticipate and that is okay. In terms of the oral presentation for the modelling assignment, it was very nerve-wracking as our peers were to ask us questions following the presentation. But I found that I felt comfortable presenting and was able to answer the questions with an ease I did not possess at the start of the semester.

The last assignment I included was my research proposal. This assignment is important to me because I put so much effort into researching and planning for it. I had never realized the extent to which I would have to plan. Thus, this assignment taught me that research proposals are time-consuming and require a lot of detail. I also learned a lot about urban agriculture as I realized that it has huge potential in regions where traditional agriculture is no longer feasible or where land isn't suitable. This was fascinating to learn given that I am interested in urban planning. Lastly, this assignment made me reflect on myself and how I want to progress with my career after graduating. I was initially set on pursuing a Master's Degree in Urban Planning, but this assignment made me rethink this. I feel that if my initial plan doesn't work out, I would be open to the potential of a research-based degree.

Overall, every assignment I have done in this course has been significant. But the assignments included in this portfolio in particular, highlight how I have grown as an individual and as an environmental science student.